UNIVERSITÀ DEGLI STUDI DI CATANIA

Area dei Rapporti Istituzionali e con il Territorio

Catania, 18/01/2013

Prot. n. 5995
All. n. 2
N.B. Nella risposta vanno citati il numero di protocollo della presente e l'Area di provenienza

Al Direttore del Dipartimento di Ingegneria Elettrica Elettronica e Informatica

e, p.c. Al Chiar.mo prof. Luigi Fortuna
lfortuna@diees.unict.it

Al Dirigente dell'Area della ricerca

Al Direttore responsabile del Bollettino d'Ateneo

Al Direttore generale

Oggetto: Atti aggiuntivi con ENEA.

Con la presente si trasmettono le copie degli atti aggiuntivi nn. 4 e 5 del contratto con l'ENEA, sottoscritti dal rettore in data 17.12.2012, deliberati dal consiglio di codesto dipartimento nella seduta del 19.12.2012.

Nel precisare che un originale di ciascuno dei suddetti atti aggiuntivi si trova depositato presso l'ufficio convenzioni dell'area scrivente, l'occasione è gradita per porgere distinti saluti.

Il dirigente
(avv. Rosanna Branciforte)

V.M.

ATTO AGGIUNTIVO N. 4

AL CONTRATTO

Tra

AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE,

e

DIPARTIMENTO DI INGEGNERIA ELETTRICA, ELETTRONICA E INFORMATICA DELL'UNIVERSITA' DEGLI STUDI DI CATANIA

L'Agenzia nazionale per le nuove tecnologie l'energia e lo sviluppo economico sostenibile, (qui di seguito denominata ENEA), con sede in Roma, Lungotevere Thaon di Revel, 76 Codice Fiscale 01320740580, Codice Anagrafe Ricerche 1002, che per la firma del presente Accordo è rappresentata dal Capo Gruppo Ricerca ENEA dell'Associazione EURATOM/ENEA, Ing. Aldo Pizzuto

da una parte,

e

l'Università degli Studi di Catania per tramite del Dipartimento di Ingegneria Elettrica, Elettronica e Informatica con sede in Viale Andrea Doria, 6, 195125 Catania (qui di seguito denominato DIEEI), codice fiscale n. 02772010878, che per la firma del presente Accordo è rappresentato dal Rettore pro-tempore Prof. Antonino Recca

dall'altra parte;

VISTO l'emendamento al Contratto di Associazione EURATOM/ENEA per gli anni 2008-2013 con il quale la Commissione ha stabilito il nuovo contributo finanziario per l'anno 2011;

VISTO L'Atto Aggiuntivo n. 3 al Contratto principale di collaborazione stipulato tra l'ENEA ed il DIEEI in data 29.08.2011,

CONSIDERATI i positivi risultati ottenuti per effetto ed in virtù di detto Contratto,

CONSIDERATO che l'ENEA e il DIEEI intendono continuare la cooperazione nella ricerca nel campo della fusione termonucleare controllata,

STIPULANO QUANTO SEGUE:

In virtù del presente Atto Aggiuntivo il testo del Contratto ENEA/DIEEI, per quanto riguarda l'articolo 5, viene modificato come segue:

Articolo 5 - Disposizioni finanziarie

L'articolo 5 è modificato come segue:

"L'ENEA trasferirà al DIEEI il contributo EURATOM relativo all'esecuzione delle attività previste dal presente Contratto secondo le modalità di finanziamento previste dall'Art. 8 del Contratto di Associazione EURATOM/ENEA. Per il 2011 il contributo EURATOM, per le sole attività a Supporto Generale, non potrà superare l'importo di 20.321,00 (ventimilatrecentoventuno) EURO al netto dell'importo di 7.678,78 Euro per contributo al JET per il 2011. Il trasferimento dei fondi al DIEEI avverrà sulla base delle previsioni di spesa e dei consuntivi approvati dalla Commissione Europea, tenuto conto degli anticipi già trasferiti."

Tutti gli altri articoli del Contratto principale rimangono inalterati.

Per l'Università degli Studi di Catania	Per l'ENEA
Il Rettore pro-tempore	Il Capo Gruppo Ricerca
Prof. Antonino Recca	Ing. Aldo Pizzuto
.....	.....
Data 17 GEN. 2013	Data 14 NOV. 2012

ATTO AGGIUNTIVO N. 5

AL CONTRATTO

Tra

AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE,

e

DIPARTIMENTO DI INGEGNERIA ELETTRICA, ELETTRONICA E INFORMATICA DELL'UNIVERSITA' DEGLI STUDI DI CATANIA

L'Agenzia nazionale per le nuove tecnologie l'energia e lo sviluppo economico sostenibile, (qui di seguito denominata ENEA), con sede in Roma, Lungotevere Thaon di Revel, 76 Codice Fiscale 01320740580, Codice Anagrafe Ricerche 1002, che per la firma del presente Accordo è rappresentata dal Capo Gruppo Ricerca ENEA dell'Associazione EURATOM/ENEA, Ing. Aldo Pizzuto

da una parte,

e

l'Università degli Studi di Catania per tramite del Dipartimento di Ingegneria Elettrica, Elettronica e Informatica con sede in Viale Andrea Doria, 6, 195125 Catania (qui di seguito denominato DIEEI), codice fiscale n. 02772010878, che per la firma del presente Accordo è rappresentato dal Rettore pro-tempore Prof. Antonino Recca

dall'altra parte;

VISTO l'emendamento al Contratto di Associazione EURATOM/ENEA per gli anni 2008-2013 con il quale la Commissione ha stabilito il contributo finanziario per l'anno 2012;

VISTO L'Atto Aggiuntivo n. 4 al Contratto principale di collaborazione

stipulato tra l'ENEA ed il DIEEI;

CONSIDERATI i positivi risultati ottenuti per effetto ed in virtù di detto Contratto,

CONSIDERATO che l'ENEA e il DIEEI intendono continuare la cooperazione nella ricerca nel campo della fusione termonucleare controllata,

STIPULANO QUANTO SEGUE:

In virtù del presente Atto Aggiuntivo il testo del Contratto ENEA/DIEEI, per quanto riguarda gli articoli 1, 2, 3, e 5 viene modificato come segue:

Articolo 1 – Oggetto

L'Articolo 1 è modificato come segue:

"In base ai termini del presente Atto Aggiuntivo, le Parti contraenti convengono di eseguire in comune il Programma di Ricerca per l'anno 2012, che viene riportato in allegato I. Il Programma di Ricerca potrà essere soggetto ad aggiornamenti alle condizioni stabilite dall'Art. 6."

Articolo 2 - Documenti contrattuali

L'articolo 2 è modificato come segue:

"Le parti sono soggette all'osservanza del presente Atto Aggiuntivo ed ai seguenti documenti allegati:

Allegato I	Programma di Ricerca per il 2012 (allegato al presente Atto Aggiuntivo)
Allegato II	Work Plan per gli anni 2012-2013 (allegato al presente Atto Aggiuntivo)
Allegato III	Contratto di Associazione EURATOM/ENEA e relativi Allegati (rimane in vigore quello allegato al Contratto

	principale ENEA/DIEEI integrato dall'Amendment qui allegato)
Allegato IV	Accordo EFDA (rimane in vigore quello allegato al Contratto principale ENEA/DIEEI)
Allegato V	Mobility Agreement per gli anni 2009-2013 (allegato all'Atto Aggiuntivo n. 2)
Allegato VI	JIA (Jet Implementing Agreement), Atto Aggiuntivo n. 8 (allegato al presente Atto Aggiuntivo)
Allegato VII	Tabelle per presentazione previsioni e consuntivi (rimangono in vigore le tabelle allegate all'Atto Aggiuntivo n. 1)"

Articolo 3 - Durata

L'Articolo 3 è modificato come segue:

"In virtù del presente Atto Aggiuntivo la nuova scadenza contrattuale è fissata al 31.12.2012.

Potrà essere rinnovata attraverso la sottoscrizione di atti aggiuntivi che faranno riferimento ai programmi di attività per ciascun anno successivo."

Articolo 5 - Disposizioni finanziarie

L'articolo 5 è modificato come segue:

"L'ENEA trasferirà al DIEEI il contributo EURATOM relativo all'esecuzione delle attività previste dal presente Contratto secondo le modalità di finanziamento previste dall'Art. 8 del Contratto di Associazione EURATOM/ENEA. Per il 2012 il contributo EURATOM, per le sole attività a Supporto Generale, non potrà superare l'importo di 24.500,00 (ventiquattromilacinquecento) EURO al netto dell'importo di 4.503,97 Euro

per contributo al JET per il 2012. Il trasferimento dei fondi al DIEEI avverrà sulla base delle previsioni di spesa e dei consuntivi approvati dalla Commissione Europea, tenuto conto degli anticipi già trasferiti."

Tutti gli altri articoli del Contratto principale rimangono inalterari.

Per l'Università degli Studi di Catania	Per l'ENEA
Il Rettore pro-tempore	Il Capo Gruppo Ricerca
Prof. Antonino Recca	Ing. Aldo Pizzuto
.....	.....
Data 17 GEN. 2013	Data 25 OTT. 2012

All. I

Doc. 4C
S.C. 14.12.2011

EURATOM/ENEA ASSOCIATION
University of Catania Dipartimento di Ingegneria Elettrica Elettronica e Informatica
Principal Investigator: Prof. L. Fortuna

ACTIVITIES PROGRAMME 2012

Pulse validation on reliable measurements

The experimental result of a single discharge can be characterized by means of the measurements performed during the pulse. In particular, it is necessary to classify the reliability of measurements and on the basis of this the effectiveness of the single experiment. Our aim is to identify new strategies to assist FTU users in the interpretation of pulse data.

Objectives

The first objective is the definition of new algorithms for the classification of pulse results, involving the design of suitably trained neural networks and complex structure able to discern the different sets of measurement and categorize them on the basis of their features. These algorithms will receive as inputs reliable measurements separated from the discarded ones by means of specific validation algorithms.

Deliverables and milestones

- Definition of new algorithms for the classification of pulse results
- Classification of reliable measurement sets
- Classification of pulse results

Modelling of plasma instabilities (ELMs, MARFE)

The Edge Localised Modes (ELMs) are instabilities that appear when the plasma is in the high confinement mode (H-mode) configuration. The higher plasma energy in these configurations is partly due to a "pedestal" at the edge of the pressure profile. This pedestal results from pedestals on both the density and temperature profiles. While it is obvious that the pedestal is advantageous to achieve higher confinement, the price is paid by the inevitable steep gradients at the plasma edge which leads to instabilities – the ELMs. The other parameter we will take in consideration is the electron temperature in the plasma core. The electron temperature is a good way to probe the plasma energy in the core. One of the main macroscopic modes in a Tokamak is the sawtooth instability, which is present over a wide range of operating conditions. This is observed as a relaxation oscillation in the centre of the plasma which appears most clearly in the time evolution of the electron temperature and density but also of other quantities. In the case of the temperature the clear signature is sawtooth-like behaviour of the time series waveform in the central region of the plasma, with inverted behaviour in the outer region. The abrupt collapse of the temperature is attributed to a central, helical instability which causes the expulsion of particles and energy, detected as a heating pulse propagating in the outer

region. Aim of this activity is to extend the work already proposed during the year 2011 in which a new strategy based on recurrent neural networks has been adopted to model such kind of instability in JET plasmas.

Objectives
The results obtained during the year 2011 will represent the basis on which new techniques will designed by refining the neural network structures, considering also different topologies and training algorithms as well as using neurons with more complex nonlinear characteristic. This will lead to networks of smaller size, more accurate and reliable.
Furthermore, a similar approach will be adopted to model a different kind of plasma instability, i.e. the MARFE, which can be observed in smaller size tokamak, such as the FTU.

Deliverables and milestones
- Definition of new models, based on neural networks, for the prediction of ELMs instabilities at JET
- Definition of new models, based on neural networks, for the prediction of MARFE instabilities at FTU

Improving of the new discharge management system at the FTU
The management of plasma experiments in Tokamak sites requires a series of preliminary activities through which the characteristic parameters and references involved in a single pulse are defined. The choice of parameters and references is performed by the user, but it must always be automatically validated in order to avoid potential damages to the experimental site.

Objectives
The software platform which provides the management of the experiments have to be interfaced with different parts of the Tokamak, hence it must be implemented using a standardized architecture. This task has been accomplished during the year 2011, being part of the activity already planned. During the year 2012, new features will be designed for the new discharge management system and implemented on the FTU site. In particular, aim of this activity is to extend the querying capabilities giving the user the possibility to access the discharge database on the basis of the results given by previous pulses. In this way, the user may adopted the needed changes to the original parameter sets.

Deliverables and milestones
Definition of new procedures for managing and retrieving discharge operation parameters from pulse results.

Work Programme 2012 for the Contract of Association
ASSOCIATION EURATOM – ENEA

The "Co-operation" column indicates where all or part of the work towards a particular objective is to be carried out within the framework of one of the fusion programme's co-operative structures. The codes used are:

JET Task Forces:	JET-E1	JET-FT (Fusion Technology)
	JET-E2	
EU Task Forces:	TF-ITM (Integrated Tokamak Modelling)	TF-PWI (Plasma Wall Interaction)
EU Topical Groups:	TG-D (Diagnostics)	TG-H&CD (Heating and Current Drive)
	TG-M (Materials)	TG-MHD (MHD)
	TG-T (Transport)	
EU IA coordination:	PPP&T (Power Plant Physics & Technology Implementing Agreement)	
ITPA Topical Groups:	IT-T&C (Transport and Confinement)	IT-EP (Edge Pedestal)
	IT-S (Stability)	IT-S&D (SOL and Divertor)
	IT-EPP (Energetic Particle Physics)	IT-IOS (Integrated Operational Scenarios)
	IT-D (Diagnostics)	
Other international:	IEA (IEA Implementing Agreement)	BL (Bilateral Agreement, please show partner country)

As well as the codes, please enter in the "Co-operations" column an indicative PPY for the contribution of your Association to the EFDA co-ordinated activities under JET-, TF-, TG and PPP&T (not required for IT and other international).

ENEA, RFX, CNR, UNIVERSITY OF CATANIA, UNIVERSITY ROMA TRE, POLITECNICO DI TORINO, CREATE, UNIVERSITY TOR VERGATA ROMA, UNIVERSITY OF FLORENCE

(The EURATOM/ENEA Association Steering Committee recognizes the high scientific value of the foreseen experimental activities to be carried out with FTU and RFX. However, in view of the budget limitations for the year 2012, it is agreed that the costs of operation of both experimental devices, and for any investment in their maintenance and refurbishing, will be borne by the Associate, whereas costs related to the experimental activities remain eligible for EURATOM support.)

1 Provision of support to the advancement of the ITER and DEMO Physics Basis

	Specific Objectives	Co-operations (see page 1)	Milestones
1.1 Development of candidate operating scenarios	• **Development of the Hybrid regime and AT regimes in JET with new Iter Like Wall (ILW)**	• **JET-E2** • **JET-E1/E2 CEA**	• **Current profile control** • **Be/W accumulation avoidance** • **Optimisation of MHD and Transport** • **Study of possible optimization of Hybrid scenario performance using ICRH in 3He-D minority at high BT, also in perspective of a D-T campaign**
	• **Development of AT (high Bootstrap) regime in JET with ILW**	• **JET-E2**	• **Re-establish target for the AT Scenario at low power** • **Contribution to experimental campaign on advanced scenarios**
	• **Development of Base Line H-mode in JET with ILW**	• **JET-E2**	• **Develop robust H-mode regime at 2.5MA** • **Baseline demonstration at q95=3**

			• Go to high current at low triangularity • Contribution to experimental campaign on L&H mode campaign
	• L to H-mode threshold studies	• JET-E1/E2	• Assess dependence on plasma-shape, strike point location, wall gaps and heating systems. • Study the impact of the different impurity composition
	• Optimization of Non-inductive current fraction by controlling the edge physics before the beginning of the main heating phase.	• JET E1–E2, TG-H&CD, ITPA IT-IOS	• Modelling of kinetic profiles of plasma periphery in different conditions of plasma fuelling and wall materials
	• Contribution to plasma operation on JET	• JET E1-E2	• Coordination of diagnostics set as essential for the experimental campaigns 2012 • on L-H power threshold • current profile control • hybrid scenario development
	• Contribution to Plasma Operation on JET	• JET-E1, JET-E2	• Session Leadership in the 2012 experimental campaign
	• Tokamak configuration in RFX with single and double null	•	• H-mode in RFX in tokamak configuration
	• Studies of different FAST H mode and Hybrid scenarios, without any external momentum input: a) Only ICRH; b)	• Oxford University • JET	• Compare the developed scenarios with the latest experimental results • Assess the intrinsic Rotation role by

	15MW ICRH and 15MW ECRH and with different radial deposition of the heating • **Optimization of the FAST H mode and Hybrid scenario, with some fraction of NNBI momentum input: 10MW and with different radial deposition of the beam** • **Preliminary analysis of the induced perturbations generated by a quasi isotropic population of Fast Particles (produced by ICRH+NNBI)**	• **TEKES**	**using different transport models.** • **Study of the momentum transport and comparison with the experiments**
	• **Study of the FAST ITB scenarios, controlling the q profile by using different LHCD frequencies** • **Analysis of the relative role of the magnetic shear and of the plasma rotation to get a reliable improved confinement** • **Study of FAST Long Pulses (LP), at intermediate and very high beta**	• **Oxford University** • **JET** • **TEKES**	• **Study the robustness of the scenarios with different transport scaling** • **Insert the intrinsic Rotation as foreseen from the present experimental scaling and extrapolation to the FAST and ITER regimes** • **Study the possibility of an active Current density Profile Control** • **Study the possibility to use an NNBI system**
	• **Plasma scenarios in ITER operation**	• **CCFE**	• **Plasma scenarios and poloidal field coils system analysis and optimization** **FOR INFORMATION ONLY (F4E)**
1.2 Energy and particle	• **Ion and electron thresholds and stiffness**	• **JET-E2, IT-**	• **Study of the effect of impurities on ITG**

confinement/ transport		T&C, TG-T • IPP, GA and MIT for expt • CCFE, GA, IPP, Chalmers, CEA and Univ. Bayreuth	threshold in JET with ILW • Study of the dependences of electron transport on q profile and rotation in JET • Carry on ITPA joint experiments with JET, AUG, C-MOD and DIII-D on ion stiffness and analyze and model data
	• Coordination activity as deputy TG-T Chair	• TG-T	• Coordinate and promote transport work within EFDA
	• Characterization of L-mode particle and energy transport: compare Be/W with Carbon wall	• JET-E1/E2	• Asses changes due to new wall and monitor evolution towards a totally Carbon free machine • Document discharge evolution from low to high recycling up to detachment and density limit.
	• Particle deposition and transport in pellet fuelled discharges at JET	• JET-E1/E2	• Document the effects of the new wall on pellet injection including impurity response
	• Operation above Greenwald limit in ASDEX	• IPP	• Stabilization of MHD activitity by means of ECRH
	• Study of the MARFE activity on FTU	• ASIPP	• Continue the study of the MARFE physics comparing measurements with theoretical model.
	• Study of density peaking in high-density FTU regimes	•	• Determine density peaking dependence on average density and safety factor.

	• **Properties of particle confinement with ECRH on FTU** • **Particle confinement in RF heated plasma** • **Particle confinement in full CD regimes**	•	• **Density peaking factor vs collisionality with and without strong ECRH** • **Understanding the LLL effect on plasma performance** • **Measure particle transport with different LH/CD mix**
	• **Transport barriers in helical configuration**	•	• **Understanding transport barrier**
1.3 MHD stability and plasma control	• **MHD real time control experiments with ECRH/ECCD on FTU tokamak**		• **(N)TM control in real time** • **validation of RT algorithm for TMs control** **(coll. Politecnico di Milano)**
	• **Saw-tooth control by ECRH/ECCD in FTU** • **Experiments to avoid TM onset on FTU**	• **ITPA-S TG-MHD**	• **Optimisation of resonance location and threshold power in ohmic plasmas.** • **Modelling of the ohmic results.** • **Saw-tooth destabilisation by ECRH/ECCD in LHCD-driven plasmas.** • **Sawteeth destabilization by ECRH/ECCD to avoid TM onset**
	• **Experiments on triggerless onset of NTMs on TCV**	• **CRPP**	• **Use of NBI/ECRH/ECCD to study effect of changes of rotation on triggerless onset of NTMs (change of sign of polarisation current) on TCV tokamak**
	• **Study of optimal identification strategies**	• **TG-MHD**	• **Development of optimized in NTM**

	of MHD modes for real time control experiments with ECH/ECCD		control loops.
	• Tearing modes and RWM control in RFX • m = 0 control in RFP configuration • m = 2, m = 1 control in Tokamak	• TG-MHD • " • "	• Reduction of system latency • Control of edge magnetic topology • Improvement of MHD control
	• Study of tearing modes activity in JET baseline H-modes with ILW.	• JET-E1	• Determination of experimental stability boundaries in reference scenarios with carbon first wall. • Analysis of experiment with ILW. • Comparison between ILW and carbon-wall results.
	• ELM control by pellet pacing	• JET-E1/E2	• Demonstrate the feasibility of pellet ELM pacing up to the ITER relevant plasma target • Integrate the technique into main scenarios while minimizing confinement deterioration and fuelling side effects.
	• Study of high beta stability limits in hybrid JET regimes with ITER-like wall (ILW).	• JET-E1	• Analysis of beta-limiting MHD activities with ILW. • Comparison with beta-limits found in previous JET experiments with carbon first wall.
	• Real-time control of ECRH/ECCD deposition for disruption avoidance		• Disruption avoidance in FTU • Studies on low-q disruption avoidance • Density limit • Studies of scenarios for runaway generation after disruption events

		• IPP	• Impurity emission studies during disruptions • Disruption avoidance in AUG • Studies on high-beta disruption avoidance • Power threshold determination • Comparison of the effectiveness of ECRH and ECCD
	• Establish a sound disruption precursor signal to be used for disruption avoidance	• WP 2012 EFDA Proposal • TG-MHD	• Identification and exploitation of a set of signals related to MHD activity to provide an optimized disruption precursor
	• Active runaway current control and shutdown strategies at disruption	• WP 2012 EFDA Proposal,	• Investigate shutdown strategies to ameliorate the potential runaway damage. • (In coll. con Universita` Roma 2 T.V.)
	• Runaway electron studies using the FTU neutron camera	• WP 2012 EFDA Proposal	• Study space, time and energy evolution of runaway electrons
	• Runaway energy deposition on plasma facing components	• WP 2012 EFDA Proposal	• Study runaway energy deposition
	• Similarity experiment to study behaviour of runaways in different tokamaks	• WP 2012 EFDA proposal, Universidad Carlos III de Madrid	• Determine the scaling of runaway production with Bt, ne and Ip and machine size. • Analyze the magnetic energy flows during the current quench and termination of the disruption.
	• Study of the FAST Equilibrium and	•	• Optimize the magnetic configuration, at the present major radius

	shaping flexibility to obtain different divertor configurations. • **Study of the FAST Shaping Control System** • **Study of the FAST Vertical Control System**		• **Realization of Snow Flakes configurations** • **Study the control problems for the options of superconductor toroidal and poloidal coils** • **Analysis of the passive structures (with possible 3-D effects) by using different preliminary deign of the passive structure**
	• **Optimization of an active control of the FAST toroidal field ripple.**	•	• **Complete the analysis of the field perturbation introduced by the connection bars** • **Study the actual effect on all the experimental scenarios**
	• **Study RWM on the FAST high beta (advanced mode) scenario.**	•	• **Study of the RWM stability and dynamics** • **First and rough design of an active control system**
	• **Improve the plasma density control by studying hybrid techniques with resets**	•	• **Simulation and preliminary settings, on FTU, of new hybrid strategies for gas density control**
	• **Study of the Inner/Outer dynamic input allocation features (robustness/numerical stability)**	• **CCFE**	• **Extensive testing on experimental data of the Inner/Outer allocator, to quantify the performances on FTU/MAST facilities**
	• **Plasma modelling, diagnostics and control**	• **CCFE**	• **Application to MAST upgrade**

	• **System-level optimization of the ITER magnetics diagnostic and R&D/Design of magnetics sensor**	• **CCFE**	• **Complete task 1.4. Complete subtask 1.4-3 and 1.4-5.** • **Task 3.4 – Proposal of a set of revised target specification for the magnetic** • **Task 3.8- Estimation of the failure rate and uncertainty of the various types of sensors.** • **Task 3.11 – Definition of a new electrical connection scheme for the approved set of magnetic sensors** **FOR INFORMATION ONLY (F4E)**
1.4 Power and particle exhaust, plasma-wall interaction	• **JET ILW exploitation** • **Bulk W Tile Power Handling (JET)** **(Participation as deputy SC to the ex1.2.3)**	• **JET-E2**	• **Test the geometrical design of Tungsten tiles (Ohmic plasmas, move strike points)** • **Model Scraoe Off Layer particle and power dynamics** • **Assess power handling capabilities.**
	• **Plasma fluxes on PFCs during disruptions**	• **TF-PWI**	• **Estimation of the fraction of pre-disruptive energy content of the discharge released to the FTU toroidal limiter during disruptions.** • **Dependence of this fraction on the disruption type.** **(extension in 2012)**
	• **Plasma wall interaction studies on FAST**	• **ASIPP** • **JET**	• **Use of fluid codes EDGE2D-EIRENE, SOLPS) for evaluating the divertor heat load.**

	• Plasma wall interaction studies on FAST	• IPP	• Use the EDGE2D/B2/ASPOEL codes to study the dynamic of the fluxes on the FAST edge, with different geometry of the First Wall and Divertor. • Study of the edge behavior with different divertor materials, considering the impurities effects • Data analysis from previous AUG experiment
	• Impact of edge parameters on LHCD efficiency in regimes of gas-fuelled and pellet-fuelled discharges (JET)	• JET-E1/E2	• Optimise LH-CD efficiency tuning edge parameters according to FTU experience • Push to high density/ high power for clear direct evidence of non-inductive current drive.
	• Measurements of LH wave non-linear behaviour using RF probes and reflected power spectra analysis	• JET-E1	• Verify if the LH interaction with plasma core can be improved by reducing the non-linear effects with suitable edge and SOL conditions
	• Initial Studies of the Problem of Power Exhaust in a Demonstration Fusion Power Reactor (DEMO)	• PPP&T	• Assessment of the gaps and needs of new facilities for the development of divertor/ first wall for DEMO
	• Mitigation of Mo contamination by means of Ne seeding in FTU	•	• Measure the Mo concentration for different levels of Ne puffing.
	• Plasma –Wall interaction in presence of LLL	•	• 2D Plasma edge simulation
	• Liquid Lithiun Limiter exploitation	•	• Experiments with LHCD and ECRH

	• Lithization in RFX with liquid limiter and Li pellet	•	• Density control improvement
	• Test of tungsten limiter	•	• Plasma wall interaction improvement
	• Impact of edge parameters on LHCD efficiency in regimes of gas-fuelled and pellet-fuelled discharges (JET)	• JET-E1/E2	• Optimise LH-CD efficiency tuning edge parameters according to FTU experience • Push to high density/ high power for clear direct evidence of non-inductive current drive.
	• Measurements of LH wave non-linear behaviour using RF probes and reflected power spectra analysis	• JET-E1	• Verify if the LH interaction with plasma core can be improved by reducing the non-linear effects with suitable edge and SOL conditions
	• Initial Studies of the Problem of Power Exhaust in a Demonstration Fusion Power Reactor (DEMO)	• PPP&TPS	• Assessment of the gaps and needs of new facilities for the development of divertor/ first wall for DEMO
	• Mitigation of Mo contamination by means of Ne seeding in FTU	•	• Measure the Mo concentration for different levels of Ne puffing.
	• Hydrogen retention in mixed materials and in W-alloys	• TF-PWI	• D permeation in plasma sprayed layers (W, W/Ta) will be studied by monitoring the permeation flux through layers. (extension in 2012)
	• Gas balance studies: comparison of fuel retention with reference plasmas with C walls	• JET-E2, WG10	• Gas balance studies with gas chromatography and mass spectrometry analysis (coll. IENI-CNR)

	• Measurements of fast dust particles and analysis of results	• VR-KTH • Imperial College • University of Napoli "Federico II"; • University of Molise	• Calibration of fast dust diagnostic for the use in FTU and other devices; • Measure fast particle in SOL of FTU by means of an Electro-Optical probe • Improvement of the theory of ion drag and dust acceleration to hypervelocities, taking into account different boundary conditions. Upgrade a numerical code for dust dynamics in SOL of FTU (coll. IENI-CNR)
	• Optimization of the wall-conditioning procedures in RFX-mod and minimization of tritium and deuterium co-deposition by scavenger techniques	•	• Surface analysis of graphite and Si specimens by SIMS, XPS, FT-IR, AES • Minimization of tritiated carbon impurities by the injection of nitrogen-based active species as scavengers • Design of an RF glow discharge reactor for laboratory studies on Boronization and Lithization
	• Improvement in understanding the D retention in post mortem analysis	• FBK • TEKES • PWI-WP2012 A3.1	• Calibration of SIMS with D implanted standards. • SIMS measurements of AUG samples • Comparison with RBS and NRA analyses
	• Study of the erosion of nanostructured W and W alloy on W substrate by means of the interaction with hydrogen RF plasmas (also mixture with noble gases)	• FOM	• Deposition of W films by Pulsed Laser • Deposition on W substrates. • Characterization of chemical composition, morphology and structure

			by X-ray diffraction and SEM • **Asses the role of nanostructure in the interaction with divertor-like plasma** **(coll. Politecnico di Milano)**
	• **Deposition of nanostructured W coatings on different substrates for ITER and DEMO applications**	•	• **Data and knowledge on D retention in multi-layer materials to more reliable prediction of tritium accumulation in ITER and DEMO** **(coll. IENI-CNR and Politecnico di Milano)**
	• **Study of the erosion of codeposited materials (a-CW/Mg:H) in N, O and/or H RF plasmas (also mixture with noble gases)**	•	• **assess the sensitivity of mixed material layers to exposure to N_2, O_2 and/or H_2 plasmas** • **deposited coatings by PLD** • **chemical composition, morphology and structure will be characterized by X-ray diffraction, SEM, EDX and Raman Spectroscopy at Milan-Polytechnic**
	• **Laser Cleaning studies of W droplet, C and mixed materials on different substrates**	•	• **Study the removal efficiency of W, C and mixed materials varying film morphology** **(coll. Politecnico di Milano)**
1.5 Physics of plasma heating and current drive	• **Exploitation of ECRH&CD capabilities of the new EC launcher in FTU**	•	• **ECRH&CD performances in FTU with the new EC launcher** • **test of the new fast steerable antenna in FTU** • **EC polarization control in FTU**
	• **ECCD optimisation in FTU**	•	• **Determination of ECCD efficiency as a**

			function of launching wave polarisation.
	• Study of EC assisted Plasma start-up in ITER	• IPP	• Provide FTU data for 0-D code simulation • Evaluation of status of EC assisted present experiments • Modelling of experiments on FTU and ASDEX • Extrapolation to ITER FOR INFORMATION ONLY (F4E grant)
	• ECH assisted start-up in FTU	• •	• Scan injection angle • Scan resonance-null distance • Control of plasma start-up localization with ECRH assisted breakdown • Comparative studies of O1/X2 absorption schemes • Studies of transformer flux saving with ECRH assisted start-up
	• ECH Experiments on FTU on O-X-B conversion of ECW	•	• Determine whether ECRH under this scheme is effective to heat the FTU plasmas in high density regimes
	• Kinetic effects with ECRH	•	• Compare ECE and TS data at Te>10keV
	• LHCD at high density in FTU	• WP11-HCD-01-02-01-03	• Extend the power range of LHCD at high density

		• ITPA-IOS	
	• Control the spectral broadening of radiofrequency power (lower hybrid waves) at reactor grade high plasma density	• JET E1– E2 • TG-H&CD • ITPA IT-IOS	• Modelling of kinetic profiles of tokamak plasma periphery in different conditions of plasma fuelling, plasma – wall interactions, and in presence of electron cyclotron resonant radiofrequency power
	• Study of ICRH and LHCD coupling to FAST scenarios	• JET • IPP • ASIPP	• Compare the most recent experimental results of LHCD coupling at high density with that envisaged in FAST scenarios • Optimize the ICRH antenna design to maximize the coupling in all the scenarios
	• Beam-plasma interaction in FAST		• Optimization of NBI system for FAST
1.6 Energetic particle physics	• Testing of advanced numerical codes for analyzing low frequency Alfvénic fluctuations in collisionless compressible plasmas of fusion interest	• IFTS/ZJU/ UCI	• Providing the simplest yet relevant model for interpreting numerical simulation results (HMGC and its extended version XHMGC) and for identifying key control physical parameters. • Verification of XHMGC vs. analytic theories and global gyrokinetic codes (GTC)
	• Analysis of low frequency MHD fluctuations by trapped /barely circulating electrons	•	• Assess condition to excite MHD via fast electron generated by Lower Hybrid and Electron Cyclotron heating/current

			drive. Establishing a basis for understanding transport processes involving thin orbit fast particles in burning plasmas.
	• **Study of energetic particles with gamma ray and neutron spectroscopy in JET, AUG and ITER plasmas.**	• **JET-E1** • **IPP**	• **Simulation of gamma ray and neutron spectrum produced by confined fast ions.** • **Study of the relation with the fast ion distribution function (tail temperature).** • **Experimental exploitation on JET and AUG.** **(coll. Università Milan-Bicocca)**
	• **Diagnostics for measurements of energetic ions on FAST**	•	• **Conceptual design of diagnostics for confined energetic ion for FAST, based on neutron spectroscopy, gamma spectroscopy and CTS** **(coll. University Milano-Bicocca)**
1.7 Theory and modelling for ITER and DEMO	• **ECRH&CD modelling in ITER and DEMO conditions**	• **IPP** •	• **ECRH&CD calculations in different ITER and DEMO scenarios** • **update and benchmark of beam tracing codes for heating and current drive in high temperature plasmas**
	• **Investigation of the physics performance of the ITER EC Upper Launcher (UL)**	• **Consortium CRPP, IPP, KIT, FOM for F4E Grant GRT-161**	• **Analysis of the design of the ITER UL, physics evaluations and feedback control proposals** • **Analysis of the physics performance performances of the UL for baseline and additional capabilities**

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	• Studies of NTM dynamics and on the role of polarization current	• CRPP	• Evaluations of shear flow and mode coupling for NTM dynamics modelling • Study of the polarization current term in the Rutherford equation for trigger-less onset of NTM
	• Nonlinear and Diamagnetic Effects in a Neoclassical Model of Magnetic Reconnection under ECCD control	•	• Validation and use of new nonlinear Extended MHD code in cylindrical geometry (in coll. with Politecnico di Torino)
	• Sawteeth control	• ITPA-S	• Modelling of saw-teeth destabilization by modulated ECRH/ECCD for comparison with experimental results using JETTO transport code
	• Physics and modelling for JT60-SA	• EFDA WP 2012	• Transport calculations • Studies of NTM stabilization • ECRH&CD in JT60-SA scenarios
	• Physics and modelling for JT60-SA	• EFDA WP • TF-ISM • CEA	• Preliminary assessment of a possible LHCD proposal in JT60-SA • Simulation of current rump-up in the presence of LHCD
	• Physics and modelling for FAST • Develop physics understanding of	• TEKES	• Transport calculations • Studies of NTM stabilization • ECRH&CD in FAST scenarios • Comparison of different transport

	transport processes in burning plasmas in the presence of strong auxiliary heating power	CEA	codes and transport models • Use of the above codes to compare the ITER predictions with the FAST ones, in view of designing realistic DEMO scenarios
	• Contribution and participation to the ITM activities	• ITM - IMP12 •	• Integration of equilibrium code into European Transport Solver (ETS). • Maintenance and improvement of existing codes
	• Application of the "Thermodynamic Field Theory" (TFT) to plasma physics	• ULB	• Integration of a transport coefficient module based on TFT in the ETS: benchmarking phase with other codes
	• Integration of NTM module in ITM	• TF-ITM	• Integration in the ETS • Control workflow development
	• Integration of the ECRH&CD beam tracing code GRAY in ITM, GRAY benchmarking and validation	• TF-ITM	• GRAY integration in the ETS), verification& validation • ECRH&CD modelling in tokamak scenarios
	• Contribution to ITM	• TF-ITM	• Contribution to equilibrium, MHD stability and integrated scenarios modeling
	• Contribution to ISM	• TF-ISM	• Interpretative modelling of JET discharge with LHCD in the current rump-up phase.
	• Leadership of ITM-IMP5 Project on Heating Current Drive and Fast particle Physics	• TF-ITM	• Coordination of the ITM-IMP5 activities

	• Study of LHCD in ITER	•	• Analysis of plasma edge parametric instabilities in LH operations
	• LHCD modelling for DEMO	• WP11-DAS-HCD-LH1-2	• Study of parasitic absorption of LH wave power by α particle and collisional absorption
	• Beam plasmas interaction in ITER	•	• Optimisation of NBI system for ITER
	• Numerical investigation of charged fusion products and energetic ions confinement properties in ITER reference scenarios	• TF-ITM	• Implementation of the new hybrid MHD-gyrokinetic code (HYMAGYC) in a version conforming ITM-TF standards. • Using the new hybrid MHD-gyrokinetic code (HYMAGYC) for validating previous results obtained by HMGC for circular flux surfaces • Application of the extended version of HMGC (XHMGC) for the simultaneous kinetic analysis of energetic particles and thermal ions or of two different fast particle populations, including supra-thermal electrons.
	• Linear and Nonlinear benchmarking of global codes for collective mode simulation	• IT-EPP	• Benchmarking activities will be pursued within the framework of ITPA Energetic Particle Topical Group
	• Excitation of MHD and Alfvénic fluctuations by energetic particles in	•	• Characterization of self-consistent energetic particle transport in FAST

	FAST and corresponding transport processes		**scenarios, with emphasis on peculiar properties of Alfvénic fluctuation spectra and spatio-temporal energetic particle redistribution in ITER-relevant plasma conditions**
	• Statistical and stability properties of wave particle models in plasma physics.	• University of Marseille	• Out of equilibrium dynamics in long range interacting systems. Numerical and analytical studies of HMF like models. • Global stability analysis by covariant vectors of HMF and FPU like models. • Statistical mechanics of wave-particles models. Effect of a small population of fast particles on the dynamics of the system.
	• Modelling transport phenomena in plasmas	• University of Marseille	• Minimal deterministic and stochastic models for heat transfer mechanisms in burning plasmas • Cross diffusion in reaction diffusion models relevant to transport in burning plasmas. Role of finite size corrections in the process of patterns formation.
	• **Assessment of ITER magnetic diagnostics**	• **CCFE**	• **Development of codes for the assessment of the magnetic diagnostics** **FOR INFORMATION ONLY (F4E)**
	• **Assessment of plasma magnetic control system in ITER**		• **Simulations with accurate modelling of the power supplies**

			FOR INFORMATION ONLY (F4E)
	• **Plasma Control System for ITER**	• **General Atomics** • **IPP**	• **Development of simulators for PCS** **FOR INFORMATION ONLY (ITER IO)**
	• **Disruption modeling**	• **TF-ITM**	• **Implementation of integrated modelling tools.** **FOR INFORMATION ONLY (F4E)**

2 Development of plasma auxiliary systems

	Specific Objectives	Co-operations (see page 1)	Milestones
2.1 Heating and current drive systems	• **Optimization of the launching optics for the EC Upper Launcher (UL) for ITER**	• **Consortium : CRPP, IPP, KIT, FOM for F4E Grant GRT-161**	• **Implementation of latest design of the Upper Launcher for producing beam data for beam tracing input.** • **Study of possible changes on the mirror focal length to optimize beam overlapping** **FOR INFORMATION ONLY (F4E)**
	• **Development of the EU gyrotron for ITER**	• **Consortium : CRPP, KIT, Hellas for F4E Grant GRT-049**	• **Participation to the tests of coaxial cavity prototype gyrotron at CRPP EC Test Facility, measurements with the bolometric load designed for a power of 2MW** • **Delivery of a short-pulse load at 170 GHz for test of the modular gyrotron at**

			KIT. FOR INFORMATION ONLY (F4E)
	• Development of a RF diplexer/beam combiner for advanced ECRH on ITER	• IPP • IPF (Stuttgart)	• Design of a diplexer/combiner compatible with ITER requirements
	• Development of NBI for ITER	• KIT, IPP, CCFE	• Complete NBI design FOR INFORMATION ONLY (F4E)
	• Construction of NBTF	•	• Construction of NBI test facility FOR INFORMATION ONLY (F4E)
	• NBI system for DEMO	• PPP&T	• Assessment High Voltage holding
	• LHCD system for DEMO	• WP11-DAS-HCD-LH1-3	• Analysis of bends in oversized circular waveguide: choice of geometrical parameters to reduce every kind of losses and maintain a good transmission performance
	• Detailed design of the ITER ICRF Antenna	•	FOR INFORMATION ONLY (F4E)
	• Antenna modelling and design • Integrated design and realization of an ICRH antenna relevant for ITER, FAST and EAST	• IPP • IPP • CEA • ASIPP	• Design of a low parallel electric field IC antenna for ASDEX (TBC)
	• Optimization of the ECRH system in EAST	• Chinese Academy of Sciences (BL China)	• First contacts with Hefei RF group to define the collaboration
	• ECRH of overdense plasmas by the OXB	•	• Detection of mode-converted emission

	conversion scheme		**in overdense plasmas** • **Heating experiments**
	• **Generalization of the "extremum seeking" technique with hybrid model to minimize the LH reflected power.**	•	• **Implementation and experimental testing on FTU of the extremum seeking technique proposed in 2010.** • **Development of a hybrid control system for automatically improving the coupled LH power on FTU.**
2.2 Plasma diagnostics	• **First mirrors for ITER**	• **IT-D**	• **Exposure of Rh coated mirrors in FTU tokamak in deposition dominated conditions.**
	• **Laser based techniques for trapped fuel measurements.**	• **PPP&T**	• **Measurements of retained fuel in ITER relevant calibration samples by Laser Induced Breakdown Spectroscopy (LIBS)**
	• **Exploitation of the Oblique ECE Emission on JET (KK5)**	• **JET-E1, JET-E2**	• **To provide reference plasma data to monitor slow changes in the sensitivity of the ECE diagnostics, related to different causes: Berillium deposition on antennas, change of the reflectivity of the wall.** • **Characterization of fast electron emission under LH current drive/ experimental assessment of the LHCD efficiency** • **Calibration of the ECE diagnostics**
	• **Exploitation of Plasma Position Reflectometry in view of F4E Grants**	•	• **Microwave calculations and technologies**

			FOR INFORMATION ONLY
	• Neutron Spectroscopy at JET	• JET-E1	• Experimental exploitation at JET of neutron spectroscopy and of the neutron camera (coll. Università Milano-Bicocca)
	• Gamma ray Spectroscopy at JET	• JET-E1	• Experimental exploitation of gamma ray spectroscopy at JET with the new GRS spectrometers (coll. Università Milano-Bicocca)
	• JET Compact Neutron Spectrometer	• JET (JW6-PM-EP2-CNS-05)	• Phyiscs exploitation after diagnostic commissioning completion
	• Neutron measurements at AUG	• IPP	• Theoretical and experimental exploitation of high time resolution neutron measurements at AUG (coll. Università Milano-Bicocca)
	• Neutron spectra measurements during TAE events	• AUG	• Study of fast ion loss dynamics
	• High resolution neutron spectroscopy for ITER	• VR	• Study of the TPR spectrometer technique as potential candidate for high resolution neutron spectroscopy on ITER (coll. Università Milano-Bicocca)
	• Development of the ITER radial neutron camera (RNC)	•	• Design, diagnostic performance and and neutron detector development FOR INFORMATION ONLY (F4E)
	• Simulation of neutron spectra	• WP 2012	•

	components due to fast ions produced by auxiliary heating	EFDA Proposal, TRINITI	
	• Experiments with GEM gas detector for neutrons	• LNF-INFN, WP11-DIA-03-01-01/ENEA_Frascati	• Develoment of GEM-based neutron detector for 2.5 and 14 MeV neutrons
	• Development of Diamond based detector for neutrons:	• TG-D • JET-E	• Test with 14 MeV at FNG and other neutron sources (e.g. accelerator) and development of artificial diamond as fast and compact spectrometer for the neutron camera of ITER • Test at JET to extrapolate their response to ITER environment • Development of a dedicated fast electronics for fast acquisition and high resolution neutron spectrometry using diamond detectors • Design and realization of diamond neutron detectors for spectroscopic measurements in the energy range 1 to 8MeV
	• Analysis of data collected from detectors installed in JET (4 for neutron, 1 for UV/VuV and 1 for X-ray)	• JET-E2	• Analysis of data and comparison with the "official" detectors of JET; • Consequent validation of the prototype detection capabilities of diamond based devices in view of their application to

			ITER.
	• CTS on FTU high density plasma	• RISØ • IPP • Institute of Applied Physics (RF)	• Experiments with new ECRH launcher in high-density (ITER relevant) FTU plasmas and new scattering geometries. • Analysis of anomalous scattering data in view of the validation of the diagnostic capability in presence of magnetic islands. • Experiments at higher time resolution to resolve island rotation
	• Feasibility of CTS on dust in a gap between SOL and wall on FTU	• KTH • University of Naples "Fed.II" • Univ. Molise	• Use the new 140 GHz ECRH launcher on FTU
	• MSE measurements in FTU	•	•
	• Analysis of current profile measurements in Advanced Tokamak Scenarios in JET with ITER-like wall	• JET E1	• Assessment of accuracy of measurements q-profiles by Motional Stark effect and polarimetry used as constraints in Equilibrium analysis and rational-q island MHD analysis
	• Analysis of polarimetry measurements in JET with ITER-like wall	• JET E1	• Analysis polarimetry measurements with application to measurements of plasma density and q-profile determination.Comparison with theory
	• q-profile determination by consistency	• JET-E1	• Collect data parasitically

	between MSE and MHD markers: assessment of the role of poloidal rotation (JET)		• Perform the analysis • If needed plan ad hoc experiments
	• Development of diagnostics for dust in tokamak edge plasmas	• KTH • University of Naples "Fed.II" • Univ. Molise	• Modelling of trajectories of single dust particles; study of ion-drag forces • Calibration and use of a newly designed electro-optical probe for the detection of hyper-velocity particles • Measurements of dust fluxes by aerogel targets,
	• Study of the neutron detection efficiency of Boron-like coatings deposited by radiofrequency plasma sputtering.	•	• deposition of Boron-like coatings • assess the adhesion properties of coatings to metallic substrates (coll. Università Milano-Bicocca) • chemical composition, morphology, adhesion and structure will be characterized by XPS, X-ray diffraction, AFM, (SEM, EDX and Raman Spectroscopy) (coll. Politecnico di Milano)
	• LIDAR system for ITER	•	• FOR INFORMATION ONLY (F4E)
	• Magnetic sensors for ITER	•	• FOR INFORMATION ONLY (F4E)
	• JET diagnostics coordination	• JET	• JET TF diagnostics leadership
	• Dust detection after disruption with the HRTS in the ILW of JET	• JET-E2	• Collect HRTS data after disruptive events (parasitic) • Compare with former Carbon wall

			• If needed devise ad hoc experiments
	• Electro-Optics probe for dust measurements	•	• Test and exploit the new electro-optic probe on FTU.
	• Dust trajectory using visible fast camera	•	• Fast camera will be used to monitor dust trajectory in 2012 campaign.
	• Aerogel exposition to the plasma	•	• Dust distribution can be detected exposing aerogel to the plasma.
	• Temperature measurements comparison in high Te experiments in FTU	• IT -D	• Measurements of consistency of Te measurements between ECE (electron cyclotron emission) and Thomson scattering
	• ECE diagnostics on FTU and EAST tokamaks	• Chinese Academy of Sciences (BL China)	• Design of a possible new radiometer for tracking of magnetic islands • Oblique ECE measurements • Interpretation of ECE measurements in EAST by means of SPECE code
	• Pulse validation on reliable measurements	•	• Definition of new algorithms for the classification of pulse results • Classification of reliable measurement sets • Classification of pulse results
	• Diagnostics of FAST	•	• Simulation of fast particles, neutron and gamma production for the relevant scenarios • Simulation of γ and neutrons measurements and first draft design of

			γ and neutrons diagnostics. • Study of the layout of the FAST diagnostics
	• Realization of ITER consistent new diagnostic for Soft X-ray Tomography and 2D Imaging	• CEA-France • INFN-LNF-Italy	• EFDA Task Agreement WP2011 – Diagnostic Topical group (extended to 2012) • Characterization of a polycapillary lens as a tool for transport the soft X-ray (SXR) radiation far from the machine: tests of reliability in harsh environment • Characterization of a C-MOS Imager and a gas GEM detectors testing also their reliability in harsh environment • Realization and characterization of a prototype by coupling of a GEM detector and a silicon based C-MOS imager with a polycapillary lens
	• Development of the NBI for ITER	•	• Development of neutron 2D imaging measurements for the development of the ITER NNBI system (coll. Università Milano-Bicocca) FOR INFORMATION ONLY (F4E)
	• Development of the ITER Radial Neutron Camera (RNC) (provided F4E Grant/contract will be issued)	• VR	• Implementation of gamma spectroscopy measurements in some channels of the RNC (coll. Università Milano-Bicocca) FOR INFORMATION ONLY (F4E)

	• **Development of the ITER High Resolution Neutron Spectrometer (HRNS) (provided F4E Grant/contract will be issued)**	• **VR**	• **Development of the HRNS (coll. Università Milano-Bicocca) FOR INFORMATION ONLY (F4E)**
2.3 Plasma fuelling	• **Fuelling efficiency and density scan under new wall conditions at JET**	• **JET-E1**	• **Document gas fuelling capabilities and density response with new ILW** • **Make comparison with carbon wall** • **Prepare for fuelling optimisation in ITER relevant scenarios**
	• **Pellet fuelling efficiency in comparison with gas puffing at JET**	• **JET-E1**	• **Compare fuelling efficiency and gas throughput between different tracks and gas puffing.** • **Assess the range of plasma densities achievable under dominant pellet fuelling conditions** • **Consolidate grad(B) drift observations and document ablation and particle deposition profiles for code benchmarking.**
	• **Dust detection after disruption with the HRTS in the ILW of JET**	• **JET-E1**	• **Collect HRTS data after disruptive events (parasitic)** • **Compare with former Carbon wall** • **If needed devise ad hoc experiments**
	• **Fuelling and impurity seeding studies**	• **JET-E1/E2**	• **Re-establish reference plasma baseline from C wall at High Triangularity with D2 fuelling scans.** • **Obtain new data with D2 fuelling and**

			Ne or N2 seeding for comparison with C-wall • **Repeat in the more ITER-like configuration with strike points on vertical targets**
2.4 Real Time Measurement and Control	• **Feedback control system for the new launcher in FTU**	•	• **Implementation and test of the RT control logic and system for the new launcher** • **Real time control of oblique EC wave injection for O-X-B mode conversion experiments in FTU** • **Real time control of EC injected polarization**
	• **Real time beam steering for ECRH/ECCD**	•	• **Launcher commissioning** • **Real time control**
	• **Real-time control of tearing modes in FTU**	•	• **Test of real-time mode location.** • **Test of real-time control.**
	• **Provide a real time density signal, from refractometry, for density control**	•	• **Develop a fast algorithm for the real-time elaboration of the two frequencies refractometer signal**
	• **Advanced exploitation of Soft X-ray emissions to achieve Real Time Control in Tokamak operations**	• **CEA**	• **Feasibility study of a new tomography resolved in energy bands as an application for real-time monitoring of the operations of the main parameters as magnetic axis, impurity content and effective charge profile**
	• **Arc detection system**	• **IPP**	• **Validation of an innovative arc detection system based on RADAR**

	• Arc detection system	• IPP	technology.
	• Development and Testing of MARTe real-time architecture for the plasma control system (PCS)	•	• Extensive tests of the PCS via GAM functions in MARTe on FTU
	• On-line estimate of the plasma shape/position by nonlinear observer design, particle filter and Kalman filtering	•	• Studies on the effectiveness of different observer designs to estimate, on-line, the plasma position/shape on FTU
	• Image processing to extract plasma features (shape/position)	•	• Data from fast cameras in FTU will be processed via image and path reconstruction algorithms to state real-time feasibility of plasma shape/position reconstruction.
	• Nonlinear temperature control of the Litium Limiter Modules (LLL)	•	• Extensive simulations preceding the actual implementation on FTU of the algorithms to control the LLL temperatures
	• EPICS architecture will be further investigated	•	• Simulations to show feasibility and issues of EPICS based distributed control
	• 3D plasma dynamics studies	• TG-MHD	• Investigations about the coupling of 3D conducting structures with plasma dynamics, and related implementation into the codes
	• Disruption mitigation/avoidance	• JET-E1/E2	• Implementation of a current limit

			avoidance system at JET • **Commissioning of the current limit avoidance system at JET** • **Real time control of plasma parameters to reduce the risk of disruptions**
	• **Upgrade of feedback control of MHD stability in RFX**	•	• **Upgrade of hardware and software**
	• **Improving a new discharge management system in FTU**	•	• **New procedures for managing and retrieving operation parameters from pulse results.**

3 Development of concept improvements and advances in fundamental understanding of fusion plasmas

(also includes the establishment of databases needed for the interpretation of diagnostics or experiments eg atomic data for spectroscopy, atomic/molecular data for PWI studies)

	Specific Objectives	**Co-operations (see page 1)**	**Milestones**
3.1 Optimization of operational regimes for improved concepts	• **Optimization of high current regimes in RFX**	•	• **Improvement of confinement parameters**
3.2 Understanding of plasma characteristics for improved concepts	• **Study of internal and external transport barriers**	•	• **Understand role of flow shear and q profile**
	• **Study of edge turbulence and electric fields**	•	• **Understand role of flow and ambipolar electric field**

	•	•	•
3.3 Other experimental activities	• **Studies of low frequency turbulence in the linear device GyM under similarity conditions** • **Comparative studies in linear and toroidal magnetic devices** • **Acquisition of modelling tools** • **Development of new probe systems**	• **CRPP** • **St. Kliment Ohridski University of Sofia (EURATOM-INRNE Ass.)**	• **Identification of plasma regimes where blobs are produced** • **Turbulence structure imaging** • **Development of Diagnostic Techniques for turbulence characterizations** • **Comparison of the turbulent structures observed in different magnetic configurations**
	• **Construction of a high density ECR plasma source by a 28 GHz-15kW microwave radiation**	• **RAS-IAP (RF)** • **LNS-INFN**	• **Test of magnetic system** • **Commitment of the macrowave and vacuum components** • **Construction of a prototype**
	• **Protosphera**	•	• **Commission of the vacuum System.** • **Installation of basic diagnostics** • **Realisation of DAS system** • **Delivery and Installation of PS**
3.4 Theory and modelling	• **Particle kinetics and transport properties**	• **M2P2 lab Marseille** • **CEA** • **CSDC Università di Firenze**	• **Investigation of simplified one-dimensional models for energy and charge transport** **(coll. ISC-CNR, Firenze)**
	• **Algebraic of plasma theories with dissipation**	• **CPT Marseille**	• **General formulation of the metriplectic formalism for the 3D dissipative MHD** • **Metriplectic formulation for dissipation**

	• Algebraic of plasma theories with dissipation	• CPT Marseille	in non-isolated plasma systems • Application of the metriplectic framework to specific fusion plasma configurations (coll. ISC-CNR, Firenze)
	• Modelling of plasma instabilities (ELMs, MARFE)	• JET-E1-E2 •	• Definition of new models, based on neural networks, for tpredicting • ELMs instabilities at JET • MARFE instabilities at FTU
	• Propagation and absorption of RF waves in toroidal geometry	•	• Assessing the respective roles of linear propagation properties and nonlinear effects at the plasma edge for the correct interpretation of LH experiments both in JET and FTU • Development of novel theoretical – analytical techniques for investigation of propagation and absorption if RF waves in toroidal geometry
	• Geodesic Acoustic Mode physics and low frequency Alfvén waves	• IFTS/ZJU	• Excitation of Geodesic Acoustic Modes and Drift Alfvén Waves by Energetic Particles and their nonlinear interaction with drift wave turbulence.
	• Theoretical investigation of nonlinear dynamics of burning plasmas	•	• Theoretical description of self-consistent dynamics of coherent nonlinear structures interacting with energetic particles

			• Development of nonlinear dynamic models for analyzing strongly driven Self Organized Criticality states of relevance to burning plasmas
	• New gyrokinetic closures for linear and nonlinear studies of shear Alfvén waves	• IFTS/ZJU	• Derivation of a hierarchy of fluid equations with gyrokinetic closures that are valid at arbitrary wavelengths. This allows extending the validity limits of present codes based on the hybrid model for treating plasma interactions with energetic particles.
	• Extended MHD modelling	•	• Study of toroidal effect, non linear coupling, chaos healing, comparison tokamak and RFP
	• Resistive wall mode studies	•	• Simulation with full kinetic effects integrated self-consistently
	• Transport and microturbulence	•	• Study of TEM, simulation by gyrokinetic codes
	• Study of magnetic island evolution under ECCD	•	• 2D analysis of the magnetic island control through a RRMHD model in comparison with Rutherford equation
	• 2D reconnection in the small Δ' regime	• CCFE, IPP	• Benchmarking of three different codes; analysis of the nonlinear evolution of the process
	• Basic theory of magnetic reconnection phenomena	• IFS, CPT-CNRS	• FLR and ion velocity effects by adopting a gyrofluid approach including gradient pressure

	• **Study of magnetic chaos**	•	• **Identification of tranpsort barriers in RFX chaotic magnetic field**
	• **Study of electron dynamics in reconnection events by means of test-particle code**	• **CFSA-Warwick**	• **Testing of the new 3D test particle code in the single helicity approximation**
	• **Asymmetry effects in viscoresistive magnetic reconnection**	•	• **Investigation of the variation of the instability threshold with the asymmetry parameter**
	• **Identification of coils linear dynamics and nonlinear map between coils current and Plasma position/current, during the FLAT-TOP phase**	•	• **Development of a linear time-invariant model of coils current and neural-network for plasma current/position in FTU**
	• **Systematic use of well calibrated polarimetric signals as constraints in EFIT for better quality equilibrium reconstructions.**	•	• **Calibration of polarimetric measurements with the new calibration code.** • **Assessment of the signal quality (of the polarimetric channels)** • **Runs of EFIT with the good recalibrated polarimetric chords as constraints.**

4 Emerging technologies

Technologies at a mature stage, liable to contribute to ITER or to project-oriented applications under the Joint Undertaking for "fusion for energy" are excluded.

	Specific Objectives	Co-operations (see page 1)	Milestones
4.1 Development of material science and advanced materials for DEMO	• **Lithium loop: Lifus 6**	•	• **A new lithium loop for Erosion/Corrosion in high purity lithium (Lifus 6) has been designed. The procurement is ongoing. It will be completed by mid 2012.** • **First Erosion/corrosion tests in high purity lithium will be performed.**
	• **Study of Nb3Sn electro-mechanical properties**	•	• **Experimental study of the effects of mechanical loads on a microscopic scale in Nb3Sn multi-filamentary wires, and proposed improvements of their strain tolerance.**
	• **Feasibility study of a water-cooled divertor for DEMO based on the optimisation of the ITER W-mono-block design and technology (WP11-PEX-01-ACT2)**	• **EFDA** • **CEA-KIT** • • **EFDA**	• **Report on the copper alloy properties review: HHF and irradiation testing results analysis, temperature influence** • **2013- Design and manufacturing of a small scale water-cooled divertor W-mock-up optimized for DEMO and based on the ITER W-monoblock design and technology**

	• **Reliability Growth and Risk Minimisation of In Vessel Components**	• **PPPT**	• **Reliability & Availability (R&A) growth process for DEMO and definition of R&A guidelines**
	• **Development of high tensile and creep strength steel for supporting structure for DEMO**	• **PPP&T WP11-MAT-ODSFS**	• **Uniaxial creep tests with creep lives between 100-5000h** • **microstructure analysis** • **attempt to develop a constitutive equation** **(coll. IENI-CNR)**
	• **Study of alternative innovative divertor concepts for DEMO.**	• **ASIPP**	• **Studies of the W mono-block divertor tiles** • **Studies of different W coating for the First Wall**

	• **R&D on SiC/SiC composites for the IRFERC Project**	•	• **Characterization of physical/chemical and mechanical properties of SiC/SiC composites and ceramics** • **Study of the erosion/corrosion of SiC/SiC in liquid metal** **FOR INFORMATION ONLY (F4E)**
4.2 Materials modelling	• **Demonstrate effective deposition of polycrystalline diamond-like-C (DLC) by means of DC micro-jet discharges**	•	• **Deposition over a single spot and characterization by Raman, SEM and EDX** • **Designing a software to move a sample for different pattern of deposition** • **Study of the sample uniformity over the deposition** • **Investigation on the deposition parameters (including metal and dielectric substrates) in order to obtain DLC, Graphite and Graphene** **(coll. Politecnico di Milano)**
	• **Study of thermodynamic of deposition of polycrystalline diamond-like-C (DLC) by means of DC micro-jet discharges**	•	• **Calculation of the equilibrium phase diagrams for low pressure diamond via free energy minimization.** • **Determination of T e P range via chemical potential diagram** • **Deposition of a detector size diamond film**

	• **Study of thermodynamic of deposition of polycrystalline diamond-like-C (DLC) by means of DC micro-jet discharges**	•	**(coll. Politecnico di Milano)**
	• **Studies of physico-chemical properties of W and W-alloys in interaction with plasma flows**	• **INRNE**	•
	• **Mechanical characterization of tungsten armours**	•	• **The physical origin of the different properties of the two types of tungsten (prepared by Plansee and Polema) will be investigated by X-ray diffraction (XRD) measurements at high temperature.** • **XRD experiments will be also performed to assess the possible recovery of defective structures and re-crystallization.** • **The same experiments will be repeated on tungsten obtained by Plasma Spraying**
4.3 Techniques for controlling tritium inventory, fuel cycle	• **Characterization of hydrogen permeation retention properties of W and W alloy films with different crystalline structures, under exposure at neutral hydrogen flux**	• **JSI (Lubjana, SFA)**	• **Deposition of W and W-alloys coatings with different structural properties by Pulsed Laser Deposition on EUROFER** • **Characterisation of hydrogen permeation properties** **(coll. ENEA, IENI-CNR and Politecnico di Milano)**
	• **Study on tritium extraction with TRIEX**	•	• **The pumping system of the loop was**

	• **Study on tritium extraction with TRIEX**	•	**completely refurbished and the commissioning tests are ongoing** • **Experimental campaign will be concluded in 2012**
	• **Nudata experiments: the main driver for this work is to enable design and safety studies on ITER, TBMs and IFMIF**	• **IEA**	• **The present strategy for the nuclear data development and validation focuses on three main areas:** • **transport data (EFF),** • **activation data (EAF)** • **development of calculation tools.**
	• **Study of the properties of diamond based tritium production monitors as a function of the operating temperature**	•	• **Test of diamond detectors under neutrons and α-particles irradiation at different temperatures up to 200°C.**
	• **European Breeding Blanket Test Facility: EBBTF**		• **Completion of commissioning tests by February 2012.** **FOR INFORMATION ONLY**
	• **Investigation of hydrogen isotopes in PbLi and permeation technology.**	•	• **First experiments will be carried out by mid 2012.** **FOR INFORMATION ONLY (F4E Grant)**
4.4 Development of HT superconductors for DEMO	• **Assessment study on Re-BCO conductor joints**	• PPP&T: **WP11-DAS-HTS-05-01**	• **Report on the state-of-the-art of Re-BCO joints. Proposed recommendations and planning for the joint development of HTS fusion cahle, at the DEMO scale**
	• **Low resistance joint in HTS tapes and cables**	•	• **Development of a reliable procedure for low resistance splice suitable for fusion application**

	• **HTS conductors**	•	• **Design of a kA-range cable based on HTS tapes** • **Manufacturing and test of a cable prototype**
	• **Modelling of HTS superconducting tapes during thermal and electromagnetic transient**	• **KIT**	• **Developing of a suitable numerical model for the model of the quench in a HTS tape** **(coll. University of Bologna)**
	• **Investigation of different metallic substrates supporting YBCO.**	•	• **The characterization is going to be carried out utilizing Auger depth profiling and Low Energy Electron Diffraction**
	• **Reducing losses in superconducting HTS materials for high-performance tapes**	•	• **Measurements of high-frequency (microwave) response in samples grown by scalable chemical deposition: determination of pinning constant and flux flow losses.** • **Determination of the field orientation dependence in pinning properties of superconducting YBaCuO with nano-precipitates for coated conductors.**
4.5 High flux Helium cooling	• **Development of HETS based Helium cooled divertor system**	•	• **Testing results analysis by FE comparison** • **Design optimization of HETS** • **Experimental activity proposal**
	• **Lithium advanced DEMO divertor**	• **EFDA grant**	• **Testing of CPS modules in the FTU** • **Analysis of the results** • **Conceptual design of a full Lithium divertor**

			FOR INFORMATION ONLY
	• **Development of a manufacturing technology for the DEMO and FAST W-mono-block divertor**	•	• **ASIPP**
4.6 Techniques for waste recycling	•	•	•
4.7 Fusion safety issues	• **EFDA-JET Technology program:** • **Development of CVD detectors for neutron measurements outside JET vessel during DT phase** • **Development of special diamond diagnostic detectors (e.g. on-line tritium monitor) and experimental set up for future (2012-14) JET irradiations** • **Study of Self-powered detectors for fusion application**	• **JET-FT** • **TG-D** • **TG-D**	• **Irradiation tests of CVD detectors with neutron sources to optimise the parameters for out-vessel measurements at JET** • **Study of the response of diamond detectors covered with ^{6}LiF as active on-line tritium monitors** • **Study of self powered detector under DT neutronics and optimization of its parameters for operation as neutron monitor in the ITER TBM** **FOR INFORMATION ONLY (F4E)**
	• **Fusion Component Failure Rate Database (FCFR DB)**	• **F4E Procurement**	• **Conclude transfer of the ENEA FCFR DB to a F4E server and perform maintenance of the system** **FOR INFORMATION ONLY (F4E)**
	• **Validation of software code to predict Activated Corrosion Products in cooling systems of fusion devices**	• **JET-FT**	• **Activated Corrosion Products in JET cooling systems: data estimated by computer code compared against**

			experimental data
	• **Velocity and thermal measurements inside STARDUST facility using optical method in ITER like configuration.**	•	• **Preliminary tests in a small-scale experimental facility to estimate thermal and flow field during a LOVA**
	• **CFD simulation carried on with the same boundary condition of the STARDUST experimental campaign.**	•	• **Provide an experimental validation of CFD LOVA code by using small-scale facility data.**
4.8 Technology development for burning plasmas*	• **Pulsed DEMO models**	• **EFDA /PPPT-DAS-PLS**	• **Assessment of pulsed DEMO model: literature study on SS and Pulsed reactors, study creep-fatigue in Pulsed**
	• **W low temperature spectroscopy to benchmark the emission from the edge-divertor region of burning plasmas**	• **Johns Hopkins University (USA)**	• **Operation of the Transmission Grating spectrometer** • **Study of tungsten emission in the Soft X-ray-XUV range by the TG spectrometer**
4.9 Remote handling.	• **Remote handling for ITER, DEMO**	• **VTT**	• **Conceptual studies** • **Development of simulation tools in virtual reality**
	• **and FAST**	• **ASIPP TEKES**	• **Preliminary studies about the flexible replacement of the FAST Divertor** • **Preliminary studies about the possibility of replacing the full FAST plasma wall.** • **Preliminary studies on the remote handling of the FAST internal coils.**
4.10 Control and acquisition data	• **EPICS**	• **ITER**	• **Test of the EPICS architecture on PLC S7 Siemens adopted by ITER**

	• FAST design development	• ASIPP	• CAD design of the FAST First Wall (FW) • Active cooling of FW with different hypothesis for the W coating • Optimization of the FAST divertor cassette design • Preliminary design of a divertor snow flake compatible • 3D electromagnetic analysis of the FAST divertor and FW for the worst possible disruption • 3D Forces on the FAST divertor and FW or the worst possible disruption • Complete analysis of the non planar forces on support FAST support structure • First planimetry of the FAST buildings, including the NNBI • First draft design of the active coils within the FAST Vacuum Vessel • First rough electromagnetic analysis of the FAST metallic criostat.
	• Design of the FAST power supply system	• TERNA	• Design of the 400KV line • Preliminary design of the power supply for the superconductor option • Design of the power supply for active ripple control by using the Toroidal

			Field Power Supply
4.11 Nb3Sn Conductors for inductive DEMO	• **Nb3Sn Conductors**	• **WP11-DAS-PLS-10**	• **Review of Nb3Sn Cable-in-Conduit Conductors concepts in view of an inductive DEMO, and definition of a possible development and trial programme.**
4.12 Neutronic analysis of inductive DEMO scenarios	• **Neutronic study for magnet shielding**	• **WP11-DAS-PLS-11**	• **Estimation of nuclear heating in inductive DEMO scenarios, and heat load to superconducting coils**

* with reference to specific work for ITER through the Joint Undertaking for information only.

5 Training and career development

	Specific Objectives	**Co-operations (see page 1)**	**Milestones**
5.1 Collective training of young engineers and scientists	• **Education and training of II level university (master) students on fusion plasma engineering and physics**	•	• **Courses delivery on Fusion Plasma Engineering and Physics:** • ***Plasma Diagnostics for Magnetic Fusion*** **(At University of Roma II Tor Vergata)** • ***Electrical Engineering*** **(At the University of Basilicata)** • ***Nuclear Energy Physics*** **(At the University of Roma 2)** • ***Plasma diagnostics*** **(At the University of Pisa)** • ***Plasmas and Controlled Fusion***

			• *Numerical methods in electro-magnetic* (At University of Napoli "Federico II") • *Plasmas and Controlled Fusion* (At University of Cassino) • *Plasma Physics I+II* (10 ECTS-credits) (At Politecnico di Milano) • *Direct Energy Conversion (MHD)* (At Politecnico di Milano) • Delivery Courses in *Fusion and diagnostics* A t Università Milano-Bicocca • Master Thesis at Politecnico di Milano and visits to Italian Fusion facilities (coll. Università of Milano-Bicocca and Politecnico di Milano)
	• Training of PhD Students		• 3 PhD thesis research activities at Politecnico di Milano (1 funded from CNR, 2 from Politecnico di Milano) (coll. Politecnico di Milano) • 3 PhD thesis research activities at University of Napoli "Federico II" • 1 PhD thesis research activities at University of Cassino • 1 PhD thesis research activities at ENEA, at Univ.` of Roma I,.

			• **1PhD thesis at Univ. of Roma II** • **1 PhD Fellowship at ENEA-UT-FUS-MAG theory group during 2012, sponsored by the China Scholarship Council**
	• **European doctoral network in Fusion Science and Engineering**	• **IST, IPP**	• **Courses in Plasma Physics and Engineering**
	• **Participation to the Fusenet training programme of *Hands-on-Experiments* (depending on the conditions under which it will be possible to participate to the extension of the Fusenet activities)**	•	• **Deposition of diamond film and study of thermodynamic of plasma microjet** • **Training programme on *in-house* plasma devices**
5.2 Career development fellowships	• **Training of Post Doctoral Researchers**	•	• **6 internal post doctoral research contracts** • **2 Post Doctoral Fellowship at ENEA-UT-FUS-MAG theory group during 2012, sponsored by ENEA International Fellowship Program**
5. 3 Training under GOTP	• **EFDA-GOTP**	• **EFDA WP2012** • **VR**	• **Training on diagnostic techniques: radial neutron camera/gamma spectrometry, high resolution neutron spectroscopy** • **Training on FTU plasma operations In collaboration with ENEA)**
	• **EFDA GOTP. task WP08-GOT-TRI_TOFFY (Sept. 2008-May 2012)**	• **KIT, CEA, CCFE,**	• **Training of Alessia Santucci on fuel cycle technologies and processes**

		ICIT, MTA ATOMKI	• Training of Alessia Santucci on fuel cycle technologies and processes
	• EFDA-GOT LITE	•	• 1 (3y) RF engineer (to be completed in 2012)
	• EFDA GOT PSE	• CEA, KIT, CCFE	• Training of 2 engineers on Power Supply Engineering (In collaboration with ENEA)
	• EFDA GOT NIPEE	• IPP, KIT	• Training of 1 physicist and 3 engineers on Neutral Beam Physics and Technology

6 Other activities in magnetic confinement fusion

	Specific Objectives	Co-operations (see page 1)	Milestones
6.1 Public Information	• Plasma physics and fusion science dissemination	• EFDA PIN	• Seminars and conferences in different public and private environments • Organization of topical conferences, workshops and schools • Participation to a working group of the EFDA Public Information Network
	• Inform the general public, in particular students	•	• Seminars, visits to facilities, websites

	• **Industry Liaison Officer (ILO) for ITER in the frame of F4E ILO Network**	•	• **Organization of events dedicated to Industry** • **Raise awareness and transmit information, to potential contractors, about F4E or ITER calls for tender.** • **Assist and advise the potential contractors upon technical, contractual and financial aspects.** • **Encourage the participation of Italian industry to fusion projects.** **FOR INFORMATION ONLY (ITER)**
	• **Progress Report of EURATOM- ENEA Association on Fusion**	•	•
6.2 Technology transfer	• **Procurements of bolometric matched loads to other fusion labs. in the frame of a consortium with a private company**	•	•
	• **Extend plasma technologies to other applications**	•	• **MHD plasma propulsion, biomedical applications**
6.3 Collaborative activities	•	•	•
6.4 Socio-Economic research	• **Energy Strategies**	•	• **Pulsed reactor studies**
6.5 ITER design	• **ITER Preliminary Safety Report**	• **ITER Procuremen t**	• **Analysis of plant Occupational Radiation Exposure FOR INFORMATION ONLY**
	• **Design of ITER vent and detritiation systems for tokamak and hot cell**	• **ITER Procuremen**	• **HAZOP and RAMI analyses FOR INFORMATION ONLY**

	buildings	**t**	
	• **Design of ITER Water Detritiation System**	• **F4E grant**	• **HAZOP and RAMI analyses FOR INFORMATION ONLY**
6.6 Broader Approach	• **Coordination of Diagnostics system Development**	• **EFDA/F4E/ JAEA**	• **Coordination of EU contribution to Technical design review of JT-60SA diagnostics systems in the context of EFDA /F4E/JAEA collaboration FOR INFORMATION ONLY**
	• **Scenario development**	• **EFDA/F4E/ JAEA**	• **Analysis of JT-60SA scenarios FOR INFORMATION ONLY**
6.7 Broader Approach: IFMIF	• **Procurement of the back plate bayonet concept. Action delayed due to earthquake in Japan**	• **JAEA**	• **Detailed design and fabrication of the back plate bayonet concept, to be installed on the EVEDA Lithium loop (Oarai Japan) (completed by 2012).**
	• **Installation and commissioning of the online monitoring systems for the EVEDA Lithium loop. Action delayed due to earthquake in Japan**	• **JAEA**	• **Installation and commissioning (by mid 2012) of:** • **online measurement system of N concentration in the EVEDA Lithium loop** • **monitoring system for the cavitation phenomena occurrence.**
	• **Refurbishment of the R.H. equipments for target assembly system of IFMIF**	•	• **Completion of fabrication of the target assembly system and ancillary components for the Remote handling purpose (to be completed by 2012).** • **Development of the remote handling procedures for the refurbishment of the**

			target assembly system (to be completed by mid 2012). • Development and manufacturing of the Remote handling equipment (not completed by 2012). • Note: the target design and the test cell design were not completed and the ENEA actions delayed correspondingly
	• Engineering design activities for IFMIF	•	• Thermo mechanical andfluid dynamic analyses (to be completed by 2012). • Assessment of the back plate lifetime. (to be completed by mid 2012)
6.8 Fusion neutron source	• Development of concepts for fusion neutron source for different application	•	• Study of systems models

7 Coordination, in the context of a keep-in-touch activity, of the Member State's civil research activities on Inertial Fusion Energy

Topic	Specific Objectives	Co-operations	Milestones
7.1 Scientific Developments in inertial confinement	• Study of laser absorption and pressure transmission in porous materials • Shock wave propagation	• Lebedev Institut - Moscow, Russia	• Lebedev Institut -Moscow, Russia • Modeling and production of targets • Experiments in the ABC installation •
	• Measurements of fusion cross sections (S-factor) in Laser produced plasmas	• Kore-University	• Experiments in ABC • Participation to experimental

		of Enna, INFN Catania, • **University of Austin, Texas/University of College Station, Texas/ INfN Catania**	**campaigns on UT-Petawatt laser**
	• **Developments on X-Spectroscopy**	• **Lebedev Institut - Moscow, Russia**	•
	• **Laser diode development**	•	• **Optimisation of laser diode pumping**
7.2 Coordination Activities	•	•	•
7.3 Community Development	• **Training, &scholarships**	• **University of Rome, University of Catania, University of Bordeaux**	•
7.4 Maintain a watching brief on inertial confinement civil research activities	• **Participation to experiments on Laser Facilities**	• **Petal (France)** • **Petawatt (UT)**	• **Data Analysis, study of diagnostic methods**

Inventory of major equipment in the Association procured with preferential support which will be available to the programme

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Annex I to the Contract of Association

Work Plan 2012-2013 for the Contract of Association ASSOCIATION EURATOM – ENEA

Indicative allocation of resources between the major areas of activity

Area of Activity	Percentage Resources %
1. Provision of support to the advancement of the ITER and DEMO Physics Basis	39 40 23 15 40 30 100
2. Development of plasma auxiliary systems	26 25 45 40 32 40 80
3. Development of concept improvements and advances in fundamental understanding of fusion plasmas	14 20 20 15 32 20 40
4. Emerging technologies	13 6 30 32 10 20
5. Training and career development	5 6 10 4 10 10
6. Other activities in magnetic confinement fusion	3 3 2

The activity "Coordination, in the context of a keep-in-touch activity, of the Member State's civil research activities on Inertial Fusion Energy" does not need to be included in this indicative breakdown.

Description of the major areas of activity

The tables on the following pages show, for each area of activity: the specific objectives, the activities to be followed and where the activities may contribute to co-operations with other Associations or to co-ordinated activities under EFDA, including those to be carried out under the provisions of the Power Plant Physics and Technology (PPP&T) Implementing Agreement.

1 Provision of support to the advancement of the ITER and DEMO Physics Basis

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
1.1 Development of candidate operating scenarios	• **Scenarios Developments:**		
	• **at JET with the new ITER Like Wall (ILW)**	• **(Re)-Establish targets for Hybrid, AT (high bootstrap) and Base Line H-mode regimes** • **Study ITB and Hybrid regimes with dominant electron heating on JET**	• **JET** • **JET, TG-T**
	• **at EAST**	• **Study H mode, Hybrid and AT scenarios**	• **ASIPP**
	• **at FAST (in relevant burning plasma and integrated physics conditions)**	• **Study reliable Steady SS scenarios with:** - **LH+ECRH** - **Full non inductive SS LH+EC+NNBI**	• **CEA, IPP-LM, ASIPP**

	• Study of the L to H-mode threshold, • Study of fuelling and impurity seeding	• Study the dependence on geometrical parameters, impurity composition, heating systems • Ne seeding experiments	• JET
	• Optimising LHCD by the edge parameters control • LHCD experiments and modelling in EAST	• LHCD modelling including linear and non linear physics • Tests on experiments	• JET TF E1– E2, TG-H&CD, ITPA IT-IOS • ASIPP
	• Contribution to plasma operation on JET	• Coordination of diagnostics and Session leadership in experiments campaign 2012	• JET • TG-T
	• Plasma scenarios operation in JET	• PF current limit avoidance • Improvement of plasma breakdown	•
	• Tokamak configuration in RFX with single and double null	• Operation in Tokamak configuration	

1.2 Energy and particle confinement/ transport	• **Studies of energy, momentum and particle transport in fusion plasmas**	• **Effect of impurities on ITG threshold on JET** • **Electron transport studies and rotation effects** • **Ion stiffness studies and experiments on different tokamaks** • **JET and FTU data analysis** • **Coordination activity as Deputy TG-T**	• **JET, IT-T&G, TG-T** • **IPP, GA, MIT**
	• **L-mode energy transport in JET**	• **Study the effects of ILW on energy confinement during L mode**	• **JET**
	• **Particle confinement studies in** • **JET**	• **Study the effects of ILW on pellet injection and L mode particle confinement.**	• **JET**
	• **ECRH heated plasmas**	• **Operation above Greenwald limit in ASDEX ECRH shots** • **Density peaking studies**	• **IPP** •

		in ECRH shots on FTU	
	• **Full CD FTU plasmas** • **LLL FTU plasmas**	• **Measure particle transport with different LH/CD mix** • **Understanding the effect of LLL on plasma performance**	
	• **Study the effect of MARFE on plasma confinement and density limit in FTU**	• **Produce high density discharges without MARFE** • **Related transport modelling activity**	•
	• **Transport barriers in helical configuration**	• **Operation at different plasma currents**	
1.3 MHD stability and plasma control	• **MHD Stabilization via ECRH/CD**	• **(N)TM control and avoidance experiments in real time on FTU and ASDEX** • **(Development and validation of real time NTM control loops on FTU** • **Study of optimal**	• **IT-S, TG-MHD, IPP**

		identification strategy of MHD modes for real time control) • Sawtooth control in FTU • Sawtooh destabilization in LHCD-driven plasmas	• IT-S, TG-MHD, IPP
	• Trigger-less NTM experiments on TCV • O-X-B exp	• Experiments on plasma rotation effects on NTM onset on TCV (coll. Politecnico di Milano)	• CRPP
	• Tearing modes and RWM control in RFX • m = 0 control in RFP configuration • m = 2, m = 1 control in Tokamak	• Operation in RFP and Tokamak configuration	• JAEA TG-MHD, EFDA Tasks
	• Tearing modes in JET baseline H-modes with ILW	• Determination of experimental stability boundaries in reference scenarios. Comparison with previous (carbon wall) results.	• JET-E1-E2
	• ELM control by pellet pacing	• Feasibility of pellet ELM pacing up to the ITER relevant plasma	• JET

	• ELM control by pellet pacing	target.	• JET
	• High beta limits in hybrid JET regimes with ILW.	• Analysis of beta-limits in ILW and comparison with previous results (with carbon wall)	• JET-E1-E2
	• Disruption avoidance	• Real-time control of ECRH/ECCD deposition in FTU and AUG for disruption mitigation and extrapolation to ITER	• IPP
		• Provide optimized disruption precursor	• EFDA proposal
		• Active runaway current control and shutdown strategies at disruption (by runaway beam control technique)	• EFDA proposal
		• Impurity emission during disruptions	
	• Runaway electron studies	• Study space, time and energy evolution of runaway electrons, using the FTU neutron camera	• EFDA proposal

		• Study runaway energy deposition on PFCs • Similarity experiment to study behaviour of runaways in different tokamaks (in coll. Universita' di Tor Vergata) • Analyse the possible techniques for detection and confinement of runaways	• EFDA Universidad Carlos III de Madrid • EFDA
	• New technique for plasma density control in FTU • Study of the Inner/Outer dynamic input allocation features (robustness/ numerical stability)	• Simulation and preliminary settings of hybrid techniques with resets, for gas density control • Extensive testing on experimental data of the Inner/Outer allocator to quantify performances on FTU and MAST.	• CCFE

	• New technique for plasma density control in FTU • Study of the Inner/Outer dynamic input allocation features (robustness/ numerical stability)	• Simulation and preliminary settings of hybrid techniques with resets, for gas density control • Extensive testing on experimental data of the Inner/Outer allocator to quantify performances on FTU and MAST.	
	MHD stability assessment studies on FAST	• Equilibrium flexibility also in view of DEMO requirements • Snow Flakes Configurations, by using the standard external coils • RWM in high Beta scenarios	• ASIPP
	• System-level optimization of the ITER magnetic diagnostics and R&D/Design of magnetic sensor		• CCFE FOR INFORMATION ONLY (F4E Grant 047, 2009 (to be completed in 2013))

1.4 Power and particle exhaust, plasma-wall interaction			
	• **JET ILW exploitation**	• **Participation as deputy SC to the ex-1.2.3 (Bulk W tile power handling).**	• **JET**
	• **Plasma fluxes on PFCs during disruptions**	• **Estimate the fraction of pre-disruptive energy content of the discharge released to the FTU toroidal limiter** • **Study of the the dependences on the disruption type**	• **TF-PWI**
	• **Plasma wall interaction study** • **In FAST** • **In RFX, FTU in the presence of LLL**	• **Evaluation of the divertor heat load in FAST scenarios using fluid codes (EDGE2D-EIRENE, SOLPS)** • **2D Plasma edge simulation in RFX, FTU**	• **ASIPP, SWIP**
	• **Liquid Lithiun Limiter exploitation in FTU** • **Lithization in RFX with liquid limiter and Li pellet** • **Test of tungsten limiter**	• **Experiments with LHCD and ECRH** • **Operation with limiter and pellet**	•
	• **Study the Impact of edge**	•	• **JET-E1/E2**

	parameters on LHCD efficiency		
	• **Mitigation of Mo contamination by means of Ne seeding in FTU**	• **Measure the Mo concentration for different levels of Ne puffing**	•
	• **Hydrogen retention in mixed materials and in W-alloys**	• **Study of D permeation in plasma sprayed layers (W, W/Ta) by monitoring the permeation flux through layers. (Extension in 2012)**	• **TF-PWI**
	• **Study of the erosion of W, W alloys and of codeposited materials (a-CW/Mg:H) in nitrogen, oxygen and/or hydrogen radio frequency plasmas.** • **Deposition of nanostructured W coatings**	• **Deposition of coatings by PLD** • **characterization by XRD, SEM, EDX and Raman Spectroscopy** • **characterization of D retention in multi-layer materials (coll. IENI-CNR and Politecnico of Milano)**	• **TF-PWI FOM**
	• **Laser Cleaning studies of W droplet, Carbon and mixed materials on Silicon and Rh substrates**	• **Study the removal efficiency of W, C and mixed materials with laser varying film**	• **PWI-TF**

		morphology	
	• Optimization of the wall-conditioning in RFX-mod and minimization of deuterium co-deposition by scavenger technique	• Surface analysis of graphite and Si specimens • Minimization of deuterated carbon impurities by the injection of nitrogen • Design of an RF glow discharge reactor for studies on Boronization and Lithization	•
	• Measurements of D retention in post-mortem analysis	• SIMS measurements of AUG samples	• FBK • TEKES
	• Gas balance studies	• Analysis with gas chromatography and mass spectrometry analysis (coll. IENI-CNR)	• JET-E2
	• Investigations of fast dust-particle dynamics	• Exploit new electro-optical probe and aerogel in tokmak SOL. • Develop data interpretation code (coll. IENI-CNR)	• VR-KTH • Imperial College • University of Naples • University of Molise

1.5 Physics of plasma heating and current drive	• **Exploitation of the ECRH system in FTU** • **ECCD optimisation in FTU**	• **Exploitation of ECRH&CD capabilities of the new EC launcher in FTU** • **Studies on different heating and CD schemes.** • **Control of plasma start-up with ECRH assisted breakdown on FTU** • **Modelling of experiments on FTU and ASDEX** • **Determination of ECCD efficiency as a function of launching wave polarisation.**	• **IPP**
	• **ECH assisted start-up in ITER** • **and in FTU**	• **Extrapolation of the present database on ECH assisted start-up to ITER**	• **IPP** **FOR INFORMATION ONLY (F4E GRT-346)**
	• **LHCD at high density in FTU**	• **Extend the power range of LHCD at high density**	• **WP11-HCD-01-02-01-03** • **ITPA-IOS**
	• **LHCD at high density in**	• **Modelling of linear and**	• **JET Task Forces E1– E2, TG-H&CD,**

	JET	**non-linear wave physics and tests on experiments** • **Optimise the kinetic profiles at the plasma periphery**	**ITPA IT-IOS**
	• **Study of the ICRH and LHCD power coupling in FAST scenarios**	•	• **CEA, IPP, ASIPP**
	• **Beam-plasma interaction in FAST**	• **Simulation by CRONOS code**	• **CEA**
1.6 Energetic particle physics	• **Investigation of complex behaviours and cross-scale phenomena due to the existence of significant energetic particle populations** ***(Preparing ITER operation and promoting early DEMO design)***	• **Use of the eXtended version of the HMGC code for testing new gyro-kinetic closure models and benchmark test for HYMAGYC** • **Bring HYMAGYC to the production mode as tool embedded within the ITM framework** • **Use analytic-theoretical results as test for HYMAGIC/HMGC and for pursuing new discoveries**	• **ASIPP**
	• **Scientific exploitation of gamma ray and neutron spectroscopy of fast ions**	• **Feasibility studies and experiments in JET and AUG**	• **IPP** • **JET**

	in JET, AUG and ITER plasmas		
1.7 Theory and modelling for ITER and DEMO	• **ECRH&CD capabilities on ITER and DEMO conditions**	• **ECRH&CD modelling in different ITER and DEMO scenarios** • **Investigation of the physics performance of the ITER EC Upper Launcher (UL)**	• **Consortium: CRPP, IPP, KIT, FOM, CNR for F4E Grant GRT-161** **FOR INFORMATION ONLY (F4E)**
	• **Study of MHD instabilities dynamics and control**	• **Modelling by JETTO code of sawteeth destabilization by modulated ECRH/ECCD** • **Development &validation of new Nonlinear Extended MHD code (including Rutherford term in the NTM equation)**	• **EFDA (PPP&T)** • **IPP**
	• **Physics and modelling for JT60-SA**	• **Transport calculations, NTM stabilization and ECRH&CD studies** • **Preliminary assessment of a possible LHCD proposal in JT60-SA**	• **EFDA** • **CEA**
	• **Contribution and participation to ITM**	• **Integration of a** • **Equilibrium module** • **NTM module**	• **TF-ITM**

		• ECRH&CD module into the European Transport Solver (ETS) • Participation to the ITM activities and code camps. • Validation, maintenance and improvement of existing codes and tools already ported to the ITM • Project Leadership of ITM-IMP5 • Integration and benchmark of codes	• TF-ITM
	• Contribution to ISM	• Modelling of JET and JT60-SA discharge with LHCD in the rump up	• TF-ISM
	• Study of LHCD in ITER	• Analysis of plasma edge parametric instabilities in LH operations	•
	• LHCD modelling for DEMO	• Parasitic absorption calculations	• WP11-DAS-HCD-LH1-2
	• Beam plasmas interaction in ITER • Disruption modelling	• Integration and benchmark of codes	• ITM, JET
	• Theoretical investigations and numerical	• Theory and modelling activities for FAST as	

	simulations of burning plasmas in reactor relevant conditions ***(Preparing ITER operation and promoting early DEMO design)***	**option for the EU ITER Satellite** • **Transport calculations, NTM stabilization and ECRH&CD studies in FAST**	
	• Study of self-consistent models of wave particle interactions • Topology and geometry of phase-space in transient and steady state regime of long range systems. • Analysis of normal and anomalous transport regimes. • Stochastic versus deterministic models of transport.	• Theoretical study of EPM/fishbone • Computation of angular distribution among manifolds in many-body system • Stochastic patterns formation • Characterization of transport coefficients and correlations	• University of Marseille (PIC)

2 Development of plasma auxiliary systems

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
2.1 Heating and current drive systems	• **Optimization of the launching optics for the EC Upper Launcher (UL) for ITER** • **Development of the EU gyrotron for ITER** • **Participation to the development of a Fast Directional Switcher/Beam Combiner for advanced ECRH on ITER (provided F4E Grants and/or IO contracts will be issued)**	• **mmw design of the ITER Upper Launcher for producing beam data for beam tracing input.** • **Participation to the tests of coaxial cavity prototype gyrotron at CRPP EC Test Facility, measurements with the bolometric load designed for a power of 2MW.**	• **Consortium: CRPP, IPP, KIT, FOM, CNR for F4E Grant GRT-161** • **Consortium: CRPP, KIT, HELLAS, CNR for F4E Grant GRT-049** **FOR INFORMATION ONLY (F4E)**
	• **Development of NBI for ITER** • **Construction of NBTF**	• **Design and procurement** • **Development of neutron 2D imaging measurements for ITER NNBI system (coll. Università Milano-Bicocca)**	• **IPP, CCFE, CEA, KIT, JAEA, ITER FOR INFORMATION ONLY** • **IPP, CCFE, CEA, KIT, JAEA, ITER FOR INFORMATION ONLY**
	• **NBI system for DEMO**	• **Assessment High Voltage**	• **PPP&T**

		Holding	
	• **LHCD system for DEMO**	• **Analysis of special components in oversized circular waveguide: bends and mode converters**	• **WP11-DAS-HCD-LH1-3**
	• **Analysis and design of IC and LH launchers**	• **IC and LH antennas design for ITER and FAST** • **JET IC antennas analysis** • **AUG IC antenna design**	• **CEA, IPP, UKAEA, ERM** • **TG-H&CD**
	• **Optimization of the ECRH system in EAST**	• **Exchange of scientists** • **Design of millimetre wave components**	• **Chinese Academy of Science**
	• **ECRH of overdense plasmas by the OXB conversion scheme**	• **Detection of mode-converted emission in overdense plasmas** • **Heating experiments**	•
	• **Generalization of the "extremum seeking" technique with hybrid model to improve LH wave coupling in FTU**	• **Implementation and experimental testing of the extremum seeking.** • **Development of a hybrid control system for automatic maximization of coupled power via LH antennas.**	•
2.2 Plasma diagnostics	• **First mirrors for ITER**	• **Exposure of Rh coated**	• **IT-D**

		mirrors in FTU tokamak in deposition dominated conditions. (Politecnico Milano, INFN)	
	• Laser based techniques for trapped fuel measurements.	• Measurements of retained fuel in ITER relevant calibration samples by Laser Induced Breakdown Spectroscopy (LIBS)	• EFDA (PPP&T)
	• Exploitation of the oblique ECE Emission on JET (KK5) • ECE diagnostics on FTU and EAST tokamaks	• Calibration and sensitivity studies of the ECE diagnostics KK5. • Design of a possible new radiometer for tracking of magnetic islands on FTU • Analysis of ECE spectra from EAST	• JET • Chinese Academy of Sciences
	• Exploitation of Plasma Position Reflectometry in view of F4E Grants	• Antenna design, millimetre wave propagation, quasi-optics, laboratory measurements, surface measurements and analysis	• Consortium: CIEMAT, IST, CEA • FOR INFORMATION ONLY (F4E)
	• Neutron and gamma-ray	• Experimental exploitation	• JET

	Spectroscopy at JET	at JET of neutron spectroscopy and of the neutron camera • Experimental exploitation of gamma-ray spectroscopy at JET with the new GRS spectrometers (coll. Università Milano-Bicocca)	• VR
	• JET Compact Neutron Spectrometer and Upgrade of JET neutron profile monitor	• Physics exploitation after diagnostic commissioning completion	• JET
	• Neutron measurements at AUG	• Theoretical and experimental exploitation of high time resolution neutron measurements at AUG (coll. Università Milano-Bicocca) • Study of fast ion loss dynamic during TAE events	• IPP
	• High resolution neutron spectroscopy for ITER	• Study of the TPR spectrometer technique as potential candidate for	• VR FOR INFORMATION ONLY

	• High resolution neutron spectroscopy for ITER	high resolution neutron spectroscopy on ITER (coll. Università Milano-Bicocca)	• VR FOR INFORMATION ONLY
	• Development of the ITER Radial Neutron Camera (RNC)	• Development of gamma-ray line • Design, diagnostic performance and and neutron detector development	• VR FOR INFORMATION ONLY (F4E)
	• Effect of auxiliary heating on neutron spectra components of RNC • Experiments with GEM gas detector for neutrons	• Simulation of neutron spectra components due to fast ions produced by auxiliary heating • Development of GEM-based neutron detector for 2.5 and 14 MeV neutrons	• TRINITI • LNF-INFN, WP11-DIA-03-01-01/ENEA_Frascati
	• Development of Diamond based detector for neutrons	• Test on JET • Extrapolation to ITER	• JET
	• Neutron spectroscopy in the 1-8 MeV energy range • Plasma diagnostic in the Extreme UV and Soft-X ray spectral range	• Design and realization of diamond neutron detectors for spectroscopic measurements in the energy range 1 to 8 MeV. • Analysis of data collected	•

		from detectors installed in JET (4 for neutron, 1 for UV/VuV and 1 for X-ray) • Validation of the detection capabilities of these devices in view of their application to ITER.	
	• CTS measurements in FTU and JET and data interprétation	• Experiments with new ECRH launcher in FTU high-density plasmas • Analysis of anomalous scattering phenomena in the presence of magnetic island • Experiments at higher time resolution to resolve island rotation. • CTS (using ECRH gyrotrons) for polarimetry measurements in JET (with ILW) • Measurements of consistency of Te measurements in FTU	• RISØ • IPP • Applied Physics Institute (RF) • JET
	• MSE measurements in FTU	•	•

	• Polarimetry measurements	• In High Te experiments on FTU • Current profile measurements in Advanced Tokamak Scenarios in JET with ILW	• TF-D • JET
	• q-profile determination by consistency between MSE and MHD markers: assessment of the role of poloidal rotation	• Data analysis of parasitic experiments	• JET
	• Deposition of Rhodium thin films for diagnostic mirrors	• Optimization of deposition on metallic samples using the Pulsed Laser technique (coll. Politecnico di Milano)	•
	• Boron-like coatings deposited by radiofrequency plasma sputtering for neutron detection	• Deposition and assessment of the adhesion properties of B coatings to metallic substrates • Chemical composition, morphology, adhesion and structure characterization (coll. Politecnico di Milano and Università Milano-	•

		Bicocca)	
	• Magnetic sensors for ITER • LIDAR system for ITER	• R&D and design • R&D and design	• CRPP, CEA, CIEMAT • CCFE et al. (FOR ONFORMATION ONLY, F4E)
	• JET diagnostics coordination	• JET TF diagnostics leadership	• JET
	• Dust detection after disruption with the HRTS in the ILW of JET	• Collect HRTS data after disruptive events and compare with former Carbon wall	• JET
	• Dust detection by an Electro-Optical probe and dust collection by aerogel	• Assessment of aerogel potentiality • Test of the EO probe	•
	• Pulse validation on reliable measurements • Improving of the new discharge management system at the FTU	• Classification of reliable measurement and definition of new algorithms for the classification of pulse results • Definition of new procedures for managing and retrieving discharge operation parameters from pulse results.	• JET
	• Realization of ITER	• Characterization of a	• WP11-DIA-03-01-03

	consistent new diagnostic for Soft X-ray Tomography and 2D Imaging	**polycapillary lens as a tool for transport the soft X-ray (SXR) radiation far from the machine.** • **Experiments with a C-MOS Imager and gas GEM detectors** • **Realization and characterization of a prototype and its installation and commissioning on a Tokamak**	• **WP11-DIA-03-02-01** • **WP11-DIA-03-01-03**
2.3 Plasma fuelling	• **Pellet fuelling efficiency**	• **Fuelling efficiency and density scan in JET with ILW and comparison with gas puff efficiency**	• **JET**
2.4 Real Time Measurement and Control	• **Real time beam steering for ECRH/ECCD in FTU**	• **Launcher commissioning** • **Real time control**	•
	• **Real Time Control of Tokamak operation by Advanced exploitation of Soft X-ray emissions**	• **Feasibility study of a new tomography, resolved in energy bands, for real-time monitoring of main parameters** • **Software test and debugging during the Tokamak operation**	•
	• **Arc detection for IC systems**	• **Development of an innovative arc detection system to be tested and**	• **TG-H&CD, IPP, ORNL, GA**

		applied on any IC system (AUG and DIII-D)	
	• Provide a density signal without fringes jump	• Assembling a real-time system • Develop real-time algorithm	•
	• Development and Testing of MARTe real-time architecture for the plasma control system (PCS)	• Investigation of the nonlinear observer design, particle filter and Kalman filtering to estimate on-line the plasma shape/position • Image processing to extract plasma features (shape/position) • Nonlinear temperature control of LLL exploiting hybrid algorithms • Further investigation of EPICS architecture	•
	• Upgrade of feedback control of MHD stability in RFX	• Hardware and software upgrade	• JAEA, ITER, TG-MHD

3 Development of concept improvements and advances in fundamental understanding of fusion plasmas

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
3.1 Optimization of operational regimes for improved concepts	• **Optimization of high current regimes in RFX**	• **Operation at 2MA**	•
3.2 Understanding of plasma characteristics for improved concepts	• **Study of internal and external transport barriers** • **Study of edge turbulence and electric fields**	• **Improved measurements of Te profile**	•
3.3 Other experimental activities	• **Studies of low frequency turbulence in GyM under similarity conditions**	• **Comparative studies in linear and toroidal (TORPEX) magnetic devices**	• **CRPP** • **St. Kliment Ohridski University of Sofia (EURATOM-INRNE Ass.)**
	• **Construction of a high density ECR plasma source by a 28 GHz-15kW microwave source**	• **Construction of prototype** • **Test and its exploitation in physics and material technology experiments**	• **Applied Physics Institute (RF)** • **LNS-INFN**
	• **Protosphera**	• **Completion of the systems and commissioning of the facility**	•
	• **Analysis of nonlinear phenomena in thyristors**	• **Experimental evaluation and characterization of**	•

		thyristors nonlinear behavior in high power applications	
3.4 Theory and modelling	• **Particle kinetics and transport properties** • **Algebraic plasma theories with dissipation**	• **Investigation of simplified one-dimensional models for energy and charge transport** • **General formulation of the metriplectic formalism (for the 3D dissipative MHD) and application to specific fusion plasma configurations**	• **CSDC University of Florence,** • **CEA** • **M2P2 lab Marseille** • **University of Marseille**
	• **Develop an integrated framework for theory and modelling of complex behaviours in burning plasmas** **(*Help developing improved scenario and stimulate conceptual design activities for DEMO*)**	• **Analytic-theoretical work for gaining deeper insights into burning plasma physics** • **Application of existing numerical simulation tools and develop of new advanced model for physics integration**	•
	• **Extended MHD modelling** • **Resistive wall mode studies**	• **Upgrade and integration of codes**	•

	• Transport and microturbulence		
	• Modelling of plasma instabilities (ELMs, MARFE)	• Definition of new models, based on neural networks, for predicting • ELMs instabilities at JET • and MARFE instabilities at FTU	• JET-E1-E2 •
	• Basic theory of collisionless magnetic reconnection phenomena	• Magnetic island evolution under ECCD • 2D reconnection in the small Δ' regime • FLR and ion velocity effects • Identification of transport barriers in RFX chaotic magnetic field • Electron dynamics in reconnection events in 3D configurations • Asymmetry effects in viscoresistive magnetic reconnection	• CCFE (Culham), IPP (Garching) • CPT-CNRS (Luminy), IFS (Austin) • CFSA-Warwick
	• Identification of the coils linear dynamics and of the nonlinear map between coils current and	• Development of linear models of the coils current and neural-network for plasma	•

	Plasma position/current, during the FLAT-TOP phase • **Improvement of the Equilibrium code EFIT using polarimetric measurements as constraints.**	**current/position, START-UP and SHUTDOWN, in FTU** • **Systematic study of the best weights of the polarimetric measurements to be given in EFIT for improving the equilibrium reconstruction** • **Sensibility of EFIT reconstructions to the constraints at the edge (pressure, current, ...)**	

4 Emerging technologies ("Emerging technology" activities will be covered by the Contract of Association, only if included in EFDA coordinated activities)

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
4.1 Development of material science and advanced materials for DEMO	• **Lithium loop: Lifus 6**	• **Design and test of new lithium loop for Erosion/Corrosion in high purity lithium**	• **Broader Approach activity**
	• **Nb3Sn electro-mechanical properties**	• **Study of the effect of mechanical loads on Nb3Sn superconducting**	•

	• Nb3Sn electro-mechanical properties	performances on a microscopic scale	•
	• Water-cooled divertor for DEMO	• Feasibility study, based on the optimisation of the ITER W-mono-block design and technology (DEMO PPP&T) • 2012-Report on the copper alloy properties review: HHF and irradiation testing results analysis, temperature influence	• EFDA (WP11-PEX-01-ACT2 • CEA-KIT
	• Reliability Growth and Risk Minimisation of In Vessel Components	• Reliability & Availability (R&A) growth process for DEMO and definition of R&A guidelines	• PPPT
	• Development of high tensile and creep strength steel for supporting structures for DEMO	• Tests and microstructure analysis • Develop models (coll. IENI-CNR)	• PPP&T
	• Studies on matrix composites as SiC_f/SiC	• Joining of dissimilar materials	• EERA- European Energy Research Alliance Joint Programme on Nuclear Materials • Polytechnic of Turin (MAJESTIC Project in 7th Framework Programme)
	• Study of alternative innovative divertor	W+Li configuration study on FAST	• ASIPP

	concepts for DEMO	• **Snow Flake configurations for FAST and DEMO**	
	• **R&D on SiC/SiC composites for the IRFERC Project**	• **Characterization of physical/chemical and mechanical properties of SiC/SiC composites and ceramics** • **Study of the erosion/corrosion of SiC/SiC in liquid metal**	• **FOR INFORMATION ONLY (F4E)**
4.2 Materials modelling	• **Deposition of polycrystalline diamond-like-C (DLC) by means of DC micro-jet discharges**	• **Deposition of a detector size diamond film** • **Deposition of B-doped diamond** • **Characterization** **(coll. Politecnico di Milano)**	•
	• **Study of the physico-chemical properties of W and W alloys interacting with plasmas flows**	•	• **INRNE**
	• **Mechanical characterization of tungsten armours**	• **The physical origin of the different properties of the two types of tungsten (prepared by Plansee and Polema) will be investigated by X-ray diffraction (XRD)**	•

		measurements at high temperature. • **XRD experiments will be also performed to assess the possible recovery of defective structures and re-crystallization.** • **The same experiments will be repeated on tungsten obtained by Plasma Spraying**	
4.3 Techniques for controlling tritium inventory, fuel cycle	• **Characterization of hydrogen permeation retention properties of W and W alloy films**	• **Deposition of W and W-alloys coatings with different crystalline structures by Pulsed Laser Deposition on EUROFER** • **Deposition on graphite** • **Exposure to H plasmas** • **Modelling of retention properties** **(coll. Politecnico di Milano and IENI-CNR)**	• **JSI (Lubjana, SFA)**
	• **Study on tritium extraction with TRIEX**	• **Commissioning tests and experimental campaign**	•
	• **Nudata experiments: design and safety studies on ITER, TBMs and**	• **Transport data (EFF),** • **Activation data (EAF)** • **Development of**	• **IEA**

	IFMIF	**calculation tools.**	• **IEA**
	• **Fabrication of calibrated and reliable tritium production monitor.**	• **Study of the properties of diamond based tritium monitors with ^{6}Li converter.** • **Test of diamond detectors under neutrons and α-particles irradiation at different temperatures.**	•
	• **European Breeding Blanket Test Facility: EBBTF**	• **Completion of commissioning tests by February 2012.**	• **FOR INFORMATION ONLY**
	• **Investigation of hydrogen isotope in PbLi and permeation technology.**	• **First experiments will be carried out by mid 2012.**	• **FOR INFORMATION ONLY (F4E Grant)**
4.4 Development of HT superconductors for DEMO	• **State-of-the-art Re-BCO conductor joints**	• **Assessment study on Re-** • **BCO joints.** • **Recommendations and planning for joints development on HTS fusion cable at the DEMO scale**	• **WP11-DAS-HTS-05-01**
	• **Re-BCO coil**	• **Design and manufacturing of coil made by kA-cable**	•

	• Low resistance joint in HTS tape and cables	• Development of a reliable procedure for low resistance splice suitable for fusion application	•
	• HTS conductors	• Design and manufacturing of a kA-range cable based on HTS tape.	•
	• Modelling of HTS superconducting tapes during thermal and electromagnetic transient	• Developing of a suitable numerical model for the model of the quench in a HTS tape • Validation of the computational tool against dedicated experiments @ KIT (coll. with University of Bologna)	• KIT
	• Investigation of different metallic substrates supporting YBCO.	• The characterization will be made using Auger depth profiling (for the elemental characterization of the interfaces) • and Low Energy Electron Diffraction to check the crystalline surface of MgO	•

	• **Reducing losses in superconducting HTS materials for high-performance tapes**	• **Measurement of pinning strength and flux flow losses in superconducting YBaCuO with nano-precipitates for coated conductors, by high-frequency (microwave) techniques.**	•
4.5 High flux Helium cooling	• **Development of HETS based Helium cooled divertor system**	• **Testing results analysis by FE comparison and Design optimization of HETS** • **Experimental activity proposal, Design and manufacturing of a new advanced HETS module**	•
	• **Development of a manufacturing technology for the DEMO and FAST W-mono-block divertor**	• **Feasibility study for the application of the HRP technology to the DEMO W-mono-block divertor**	• **ASIPP**
	• **Development of a W coating for the First Wall of FAST and DEMO**	• **Comparison of different coatings made by using different technologies**	• **ASIPP , SWIP**
4.6 Techniques for waste recycling	•	•	•
4.7 Fusion safety issues	• **EFDA-JET Technology program**	• **Development of CVD detectors for neutron**	• **EFDA-JET**

	• EFDA-JET Technology program	measurements outside JET vessel during DT phase • Development of special diamond diagnostic detectors and experimental set up for future JET irradiations • Study of Self-powered detectors for fusion application	• EFDA-JET
	• Fusion Component Failure Rate Database (FCFR DB)	• Transfer of the ENEA FCFR DB to a F4E server and perform maintenance of the system	• FOR INFORMATION ONLY (F4E)
	• Predict Activated Corrosion Products in cooling systems of fusion devices	• Validation of software code Activated Corrosion Products in JET cooling systems.	• JET-FT
	• Exploitation of STARDUST facility for validation of CFD code for LOVA regimes and dust mobilization.	• Velocity and thermal measurements inside STARDUST facility using optical method in ITER like configuration. • CFD and dust mobilization code validation by using small-scale experimental data.	•

4.8 Technology development for burning plasmas*	• **Pulsed DEMO models**	• **Assessment of pulsed DEMO model**	• **EFDA /PPPT-DAS-PLS**
	• **W low temperature spectroscopy to benchmark the emission of burning plasmas from the edge-divertor region**	• **Operation of the Transmission Grating spectrometer** • **Study of tungsten emission in the soft X-ray-XUV range by the TG spectrometer**	• **W low temperature spectroscopy to benchmark the emission of burning plasmas from the edge-divertor region**
4.9 Remote handling	• **Remote Handling on FAST facilities**	• **Preliminary studies about a flexible replacement of the FAST Divertor.** • **Preliminary studies about the possibility of replacing the full FAST plasma wall** • **Preliminary studies on the remote handling of the FAST internal coils**	• **TEKES**
4.10 Data control and acquisition	•	•	•
4.11 Nb3Sn Conductors for inductive DEMO	• **Nb3Sn conductors**	• **Design of a Cable-in-Conduit conductor for DEMO pulsed magnets**	• **WP11-DAS-PLS-10**
4.12 Neutronic study of inductive DEMO scenarios	• **Neutronic study for magnet shielding**	• **Estimation of nuclear heating in inductive DEMO scenarios, and**	• **WP11-DAS-PLS-11**

		proposal for effective shielding of coils	

* with reference to specific work for ITER through the Joint Undertaking for information only.

5 Training and career development

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
5.1 Collective training of young engineers and scientists	• **Education and training of II level university (master) students on fusion plasma engineering and physics**	• **Courses on Fusion Plasma Engineering and Physics at** • **Università and Politecnico di Milano** **(coll. Università Milano-Bicocca and Politecnico di Milano)** • **University of Roma 2** • **University of Pisa** • **University of Napoli "Federico II"** • **University of Cassino**	•
	• **Training of PhD Students**	• **PhD thesis at CNR** **coll. Università Milano-Bicocca and Politecnico di Milano)** • **PhD thesis at Universities coordinated by**	

		Consortium CREATE • **PhD thesis at University of Roma I and II** • **Continuing the exchange programme with IFTS-ZJU on training in theory**	• **Sino-Italian bilateral agreement on magnetic fusion development**
	• **European doctoral network in Fusion Science and Engineering (FUSNET)**	• **Courses on plasma physics and engineering**	•
	• **Participation to the FUSNET training programme of *Hands-on-Experiments*** ***(depending on the conditions under which it will be possible to participate to the extension of the Fusenet activities)***	• **Training on *in-house* plasma devices**	•
5.2 Career development fellowships	• **Training of Post Doctoral Researchers**	• **Internal post Doctoral research contracts**	•
	• **Training of Young Faculty and Researchers**	• **Continuing the exchange programme with IFTS-ZJU on training in theory**	• **Sino-Italian bilateral agreement on magnetic fusion development**
5.3 Training under GOTP	• **EFDA-GOTP**	• **Training on diagnostic techniques** • **Training on FTU plasma operations**	• **VR** • **task WP08-GOT-TRI_TOFFY (Sept.**

	• **EFDA GOTP** • **EFDA GOT LITE** • **EFDA GOT PSE** • **EFDA GOT NIPEE**	• **1 Trainee (Alessia Santucci) on fuel cycle**	**2008-May 2012) - Activity carried out** • **1 (3y) RF engineer (to be completed in 2012)**

6 Other activities in magnetic confinement fusion

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
6.1 Public information	• **Plasma physics and fusion science dissemination**	• **Seminars and conferences in different public and private environments** • **Organization of topical conferences, workshops and schools** • **Participation to a working group of the EFDA Public Information Network**	• **EFDA PIN**
	• **Inform the general public, in particular students**	• **Seminars, visits to facilities, websites**	•
	• **Industry Liaison Officer (ILO) for ITER**	• **Organization of events dedicated to**	• **FOR INFORMATION ONLY (ITER)**

	in the frame of F4E ILO Network	**Industry**	• **FOR INFORMATION ONLY (ITER)**
	• **Activity of EURATOM-ENEA Association on Fusion**	• **Progress Report**	•
6.2 Technology transfer	• **Procurements of bolometric matched loads to other fusion labs. in the frame of a consortium with private companies**	• •	• •
	• **Extend plasma technologies to other applications**	• **Plasma thrusters, atmospheric plasmas for medical applications**	•
6.3 Collaborative activities	•	•	•
6.4 Socio-Economic research	• **Energy Strategies**	• **Reactor model development** • **Role of fusion as base-load electric source**	• **Contribution to EFDA Socio Economic PPP&T**
6.5 ITER design	• **ITER Preliminary Safety Report**	• **Analysis of plant Occupational Radiation Exposure**	**FOR INFORMATION ONLY (ITER)**
	• **Design of ITER vent and detritiation systems for tokamak and hot cell buildings**	• **HAZOP and RAMI analyses**	**FOR INFORMATION ONLY (ITER)**

	• **Design of ITER Water Detritiation System**	• **HAZOP and RAMI analyses**	**FOR INFORMATION ONLY (F4E)**
6.6 Broader Approach	• **Coordination of Diagnostics system Development**	• **Coordination of EU contribution to Technical design review of JT-60SA diagnostics**	• **EFDA/F4E/JAEA FOR INFORMATION ONLY**
	• **Scenario development and analysis**	• **Analysis of JT-60SA scenarios**	• **EFDA/F4E/JAEA FOR INFORMATION ONLY**
6.7 Broader Approach: IFMIF	• **Procurement of the back plate bayonet concept.**	• **Detailed design and fabrication of the back plate bayonet concept, to be installed on the EVEDA Lithium loop (Oarai Japan)**	• **JAEA**
	• **Installation and commissioning of the online monitoring systems for the EVEDA Lithium loop.**	• **Installation and commissioning of online measurement system of N concentration in the EVEDA Lithium loop and monitoring system for the cavitation phenomena occurrence**	• **JAEA**
	• **Refurbishment of the R.H. equipments for target assembly system of IFMIF**	• **Completion of the target assembly and ancillaries for Remote handling** • **Remote handling equipment and procedures for the**	**BA ACTIVITY FOR INFORMATION ONLY**

		refurbishment of the target assembly system (mid 2012).	
	• **Engineering design activities for IFMIF**	• **Thermo mechanical and fluid dynamic analyses (to be completed by 2012).** • **Assessment of the back plate lifetime (to be completed by mid 2012)**	•
6.8 Fusion neutron source	• **Development of concepts for fusion neutron source for different application**	• **Study of systems models**	•

7 Coordination, in the context of a keep-in-touch activity, of the Member State's civil research activities on Inertial Fusion Energy

Topic	Specific Objectives	Activities	Possible contributions to EFDA and other co-operations
7.1 Scientific Developments	• **Study of laser absorption and pressure transmission in porous materials** • **Shock wave propagation**	• **Modeling and production of targets** • **Experiments in the ABC installation**	• **Lebedev Institut -Moscow, Russia**
	• **Measurements of fusion cross sections (S-factor)**	• **Experiments in ABC** • **Participation to**	• **Kore-University of Enna, Infn Catania** • **University of Austin,Texas/University of**

	in Laser produced plasmas	**experimental campaigns on UT-Petawatt laser**	**College Station, Texas/Infn Catania**
	• **Developments on X-Spectroscopy**	•	• **Lebedev Institut -Moscow, Russia**
	• **Laser diode development**	• **Optimisation of laser diode pumping**	•
7.2 Coordination Activities	•		
7.3 Community Development	• **Training & scholarships**	•	• **University of Rome, University of Catania, University of Bordeaux**
7.4 Maintain a watching brief on inertial confinement civil research activities	• **Participation to experiments on Laser Facilities**	• **Data Analysis, study of diagnostic methods**	• **Petal (France)** • **Petawatt (UT)**

AMENDMENT N°8 TO THE

CONTRACT OF ASSOCIATION

between

THE EUROPEAN ATOMIC ENERGY COMMUNITY

and

THE AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

(N° FU07-CT-2007-00053)

The European Atomic Energy Community (EURATOM), hereinafter referred to as "the Community", represented by the Commission of the European Communities, hereinafter referred to as "the Commission", which, for the purpose of signing the present Contract, is in turn represented by its Director-General for Research and Innovation or by his authorised representative,

of the first part;

and the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), with headquarters in Rome, represented by its President, hereinafter referred to as "the Associate",

of the second part;

together referred to as "the Contracting Parties",

HAVING REGARD to Articles 7 and 10 of the Treaty establishing the Community;

HAVING REGARD to the Council Decision 2006/970/Euratom[1] concerning the Seventh Framework Programme of the European Atomic Energy Community (Euratom) on nuclear research and training activities (2007 to 2011);

HAVING REGARD to the Council Decision 2006/976/Euratom[2] concerning the Specific Programme implementing the Seventh Framework Programme of the European Atomic Energy Community (Euratom) for nuclear research and training activities (2007 to 2011);

HAVING REGARD to the Council Regulation 1908/2006/Euratom[3] laying down the rules for the participation of undertakings, research centres and universities in action under the Seventh Framework Programme of the European Atomic Energy Community and for the dissemination of research results (2007-2011);

[1] OJ L 400, 30.12.2006, p.60, republished in OJ L 54, 22.2.2007, p.21.
[2] Council Decision No 976/2006 of 30.12.2006, OJ L 400, 30.12.2006, p. 404, corrigendum published in OJ L 54, 22.2.2007, p.139.
[3] OJ L 400, 30.12.2006, p.1, corrigendum published in OJ L54, 22.2.2007, p.4.

HAVING REGARD to the Council Regulation 1605/2002[4] on the Financial Regulation applicable to the general budget of the European Communities;

HAVING REGARD to the Commission Regulation 2342/2002[5] laying down detailed rules for the implementation of Council Regulation No 1605/2002 on the Financial Regulation applicable to the general budget of the European Communities;

HAVING REGARD to the Contract of Association n° **FU07-CT-2007-00053** with the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA);

WHEREAS by letter of 19 October 2009, the Associate has informed the Commission of the new name "Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA)".

WHEREAS the programme for fusion energy research referred to in the above-mentioned Decisions aims at developing the knowledge base for, and realising ITER as the major step towards, the creation of prototype reactors for power stations which are safe, sustainable, environmentally responsible, and economically viable;

WHEREAS the European Fusion Development Agreement (hereinafter referred to as EFDA), including the JET Implementing Agreement (JIA) and the JET Operation Contract (JOC), is concluded between Euratom and its usual partners to develop and maintain an R&D programme focused on the realisation of fusion power;

WHEREAS it is important that the Community should continue to encourage specific co-operative projects between the Associates, in particular those of relevance to ITER/DEMO, and included in the EFDA Work Programme;

WHEREAS the European Joint Undertaking for ITER and the Development of Fusion Energy is established to provide the contribution of Euratom to the ITER International Fusion Energy Organisation, to provide the contribution of Euratom to Broader Approach Activities with Japan for the rapid realisation of fusion energy, including the International Fusion Materials Irradiation Facility, and a programme of activities in preparation for the construction of a demonstration fusion reactor (DEMO);

WHEREAS the Community has concluded on 14 September 1978 with the Swiss Confederation a Co-operation Agreement in the field of fusion energy and plasma physics;

WHEREAS Contracts of Association were concluded under previous Framework Programmes with the Belgian State, the Centro de Investigaciones Energéticas Medioambientales y Tecnologicas (Spain), the Commissariat à l'Energie Atomique (France), the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (Italy), the Dublin City University (Ireland), the Forschungszentrum Jülich GmbH (Germany), the Karlsruhe Institute of Technology (Germany), the Hellenic Republic, the Hungarian Academy of Sciences, the Institute of Plasma Physics and Laser Microfusion (Poland), the Institute of Plasma Physics in the Czech Republic, the Instituto Superior Tecnico

[4] OJ L 248, 16.9.2002, p. 1, as last modified by Council Regulation (EC, Euratom) No 1995/2006 of 13 December 2006 (OJ L 390 of 30.12.2006, p.1).

[5] OJ L 357, 31.12.2002, p. 1, as modified by Commission Regulation no. 478/2007 of 23 April 2007 (OJ L 111 of 28.4.2007).

(Portugal), the Max-Planck-Institut für Plasmaphysik (Germany), the Ministry of Education, Research and Innovation (Romania), the Ministry of Higher Education Science and Technology of the Republic of Slovenia, the Finnish Funding Agency for Technology and Innovation, the Österreichische Akademie der Wissenschaften (Austria), the Risø DTU-National Laboratory for Sustainable Energy (Denmark), the Stichting voor Fundamenteel Onderzoek der Materie (the Netherlands), the Swedish Research Council, the Swiss Confederation, the United Kingdom Atomic Energy Authority, the University of Latvia, the Lithuanian Energy Institute, the Comenius University (Slovak Republic), and the Institute of Nuclear Research and Nuclear Energy (Bulgaria); these organisations and States are hereinafter referred to as "the Associates" and the laboratories entrusted by the Associates with the execution of the research are hereinafter referred to as "the Associated Laboratories";

WHEREAS, for the implementation of the fusion energy research programme, the Commission had concluded with its Associates, and with Community Member States and Associated Third States (or organisations in those States) which do not have a Contract of Association, the Agreement for the promotion of Staff Mobility;

WHEREAS the activities carried out under this Contract will contribute to the work outlined in the annual Euratom Work Programme established in accordance with Article 6 of the Specific Programme implementing the seventh Euratom Framework Programme;

HAVE AGREED AS FOLLOWS:

By virtue of this **Amendment n° 8** the corresponding provisions of the Contract of Association n° **FU07-CT-2007-00053** shall be amended as follows:

1. In the core provisions of the Contract, under part C. FINANCIAL PROVISIONS, the following subparagraph shall be added to Article 8.1(Baseline support by the Community), first subparagraph, as follows:

For the period **1st January 2012 to 31st July 2012** the Community may participate in the financing of expenditure, as defined in Part A of Annex II, on activities specified in the Annual Work Programme of the Association, at a rate not exceeding 20% Community Support, up to a maximum Community contribution of **EUR 4,077,494.00** within the availability of Community funds.

The above mentioned rate (Baseline support) includes expenditure for the Euratom personnel, for notification(s) relating to S/T work in support of the exploitation of the JET Facilities under Article 6.3 of the EFDA for operational costs of major facilities and for coordinated research activities in the context of "keep in touch" activities".

2. All other provisions of the Contract remain unmodified.

Done at Brussels, 0 8 JUIN 2012
in duplicate,
in the English language.

For the Associate:

ENEA
AGENZIA NAZIONALE
PER LE NUOVE TECNOLOGIE, L'ENERGIA
E LO SVILUPPO ECONOMICO SOSTENIBILE
Il Commissario
(Ing. [illegible])

For the Commission

EUROPEAN COMMISSION
Research
Directorate-General

Ref. ARES (2012) 733242 - 15/06/2012

AMENDMENT N° 9 TO THE

CONTRACT OF ASSOCIATION

between

THE EUROPEAN ATOMIC ENERGY COMMUNITY

and

THE AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

(N° FU07-CT-2007-00053)

The European Atomic Energy Community (EURATOM), hereinafter referred to as "the Community", represented by the Commission of the European Communities, hereinafter referred to as "the Commission", which, for the purpose of signing the present Contract, is in turn represented by its Director-General for Research and Innovation or by his authorised representative,

of the first part;

and the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), with headquarters in Rome, represented by its President, hereinafter referred to as "the Associate",

of the second part;

together referred to as "the Contracting Parties",

HAVING REGARD to Articles 7 and 10 of the Treaty establishing the Community;

HAVING REGARD to the Council Decision 2006/970/Euratom[1] concerning the Seventh Framework Programme of the European Atomic Energy Community (Euratom) on nuclear research and training activities (2007 to 2011);

HAVING REGARD to the Council Decision 2006/976/Euratom[2] concerning the Specific Programme implementing the Seventh Framework Programme of the European Atomic Energy Community (Euratom) for nuclear research and training activities (2007 to 2011);

HAVING REGARD to the Council Regulation 1908/2006/Euratom[3] laying down the rules for the participation of undertakings, research centres and universities in action under the Seventh Framework Programme of the European Atomic Energy Community and for the dissemination of research results (2007-2011);

[1] OJ L 400, 30.12.2006, p.60, republished in OJ L 54, 22.2.2007, p.21.
[2] Council Decision No 976/2006 of 30.12.2006, OJ L 400, 30.12.2006, p. 404, corrigendum published in OJ L 54, 22.2.2007, p.139.
[3] OJ L 400, 30.12.2006, p.1, corrigendum published in OJ L54, 22.2.2007, p.4.

HAVING REGARD to the Decision [x] of the Council of 19 December 2011 concerning the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012 - 2013);

HAVING REGARD to the Decision [x] of the Council of 19 December 2011 concerning the Specific Programme, to be carried out by means of indirect actions, implementing the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012 - 2013);

HAVING REGARD to the Regulation (Euratom) [x] of the Council of 19 December 2011 laying down the rules for the participation of undertakings, research centres and universities in indirect actions under the Framework Programme of the European Atomic Energy Community and for the dissemination of research results (2012-2013);

HAVING REGARD to the Council Regulation 1605/2002[4] on the Financial Regulation applicable to the general budget of the European Communities;

HAVING REGARD to the Commission Regulation 2342/2002[5] laying down detailed rules for the implementation of Council Regulation No 1605/2002 on the Financial Regulation applicable to the general budget of the European Communities;

HAVING REGARD to the Contract of Association n° **FU07-CT-2007-00053** with the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA);

WHEREAS the programme for fusion energy research referred to in the above-mentioned Decisions aims at developing the knowledge base for, and realising ITER as the major step towards, the creation of prototype reactors for power stations which are safe, sustainable, environmentally responsible, and economically viable;

WHEREAS the European Fusion Development Agreement (hereinafter referred to as EFDA), including the JET Implementing Agreement (JIA) and the JET Operation Contract (JOC), is concluded between Euratom and its usual partners to develop and maintain an R&D programme focused on the realisation of fusion power;

WHEREAS it is important that the Community should continue to encourage specific co-operative projects between the Associates, in particular those of relevance to ITER/DEMO, and included in the EFDA Work Programme;

WHEREAS the European Joint Undertaking for ITER and the Development of Fusion Energy is established to provide the contribution of Euratom to the ITER International Fusion Energy Organisation, to provide the contribution of Euratom to Broader Approach Activities with Japan for the rapid realisation of fusion energy, including the International Fusion Materials Irradiation Facility, and a programme of activities in preparation for the construction of a demonstration fusion reactor (DEMO);

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[4] OJ L 248, 16.9.2002, p. 1, as last modified by Council Regulation (EC, Euratom) No 1995/2006 of 13 December 2006 (OJ L 390 of 30.12.2006, p. 1).

[5] OJ L 357, 31.12.2002, p. 1, as modified by Commission Regulation no. 478/2007 of 23 April 2007 (OJ L 111 of 28.4.2007).

WHEREAS the Community has concluded on 14 September 1978 with the Swiss Confederation a Co-operation Agreement in the field of fusion energy and plasma physics;

WHEREAS Contracts of Association were concluded under previous Framework Programmes with the Belgian State, the Centro de Investigaciones Energéticas Medioambientales y Tecnologicas (Spain), the Commissariat à l'Energie Atomique (France), the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (Italy), the Dublin City University (Ireland), the Forschungszentrum Jülich GmbH (Germany), the Karlsruhe Institute of Technology (Germany), the Hellenic Republic, the Hungarian Academy of Sciences, the Institute of Plasma Physics and Laser Microfusion (Poland), the Institute of Plasma Physics in the Czech Republic, the Instituto Superior Tecnico (Portugal), the Max-Planck-Institut für Plasmaphysik (Germany), the Ministry of Education, Research and Innovation (Romania), the Ministry of Higher Education Science and Technology of the Republic of Slovenia, the Finnish Funding Ageney for Technology and Innovation, the Österreichische Akademie der Wissenschaften (Austria), the Risø DTU-National Laboratory for Sustainable Energy (Denmark), the Stichting voor Fundamenteel Onderzoek der Materie (the Netherlands), the Swedish Research Council, the Swiss Confederation, the United Kingdom Atomic Energy Authority, the University of Latvia, the Lithuanian Energy Institute, the Comenius University (Slovak Republic), and the Institute of Nuclear Research and Nuclear Energy (Bulgaria); these organisations and States are hereinafter referred to as "the Associates" and the laboratories entrusted by the Associates with the execution of the research are hereinafter referred to as "the Associated Laboratories":

WHEREAS, for the implementation of the fusion energy research programme, the Commission had concluded with its Associates, and with Community Member States and Associated Third States (or organisations in those States) which do not have a Contract of Association, the Agreement for the promotion of Staff Mobility;

WHEREAS the activities carried out under this Contract will contribute to the work outlined in the annual Euratom Work Programme established in accordance with Article 6 of the Specific Programme implementing the Seventh Euratom Framework Programme and with Article 6 of the Specific Programme, to be carried out by means of indirect actions, implementing the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012 - 2013);

HAVE AGREED AS FOLLOWS:

By virtue of this **Amendment n° 9** the corresponding provisions of the Contract of Association n° **FU07-CT-2007-00053** shall be amended as follows:

1. In the core provisions of the Contract, under part A, SUBJECT AND DURATION, Article 1.1 shall be modified as follows:

1. The subject of this Contract is the joint carrying out by the Contracting Parties of activities within the thematic area "fusion energy research" of the Seventh Community (Euratom) Framework Program (2007-2011) and of the Framework Programme of the

European Atomic Energy Community for nuclear research and training activities (2012 - 2013)

2. In the core provisions of the Contract, under part C, FINANCIAL PROVISIONS, the following subparagraph shall be added to Article 8.1(Baseline support by the Community), first subparagraph, as follows:

"For the period **1st January 2012 to 31st December 2012** the Community may participate in the financing of expenditure, as defined in Part A of Annex II, on activities specified in the Annual Work Programme of the Association, at a rate not exceeding 20% Community Support, up to a maximum Community contribution of **EUR 7,315,249** within the availability of Community funds.

The above mentioned rate (Baseline support) includes expenditure for the Euratom personnel, for notification(s) relating to S/T work in support of the exploitation of the JET Facilities under Article 6.3 of the EFDA for operational costs of major facilities and for coordinated research activities in the context of "keep in touch" activities.

3. All other provisions of the Contract remain unmodified.

Done at Brussels, 18 JUIN 2012
in duplicate,
in the English language.

For the Commission: H. PERO
Acting Director

For the Associate:
Signature
Full Name & Function
Official Stamp

ENEA
AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

EUROPEAN COMMISSION
Directorate General
RESEARCH & INNOVATION

AMENDMENT N. 8 TO THE

JET IMPLEMENTING AGREEMENT

Between

The European Atomic Energy Community

And

The Belgian State

The Commissariat à l'Energie Atomique (France)

The Centro de Investigaciones Energéticas Medioambientales y Tecnologicas (Spain)

The Dublin City University (Ireland)

The Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (Italy)

The Forschungszentrum Jülich GmbH (Germany)

The Karlsruhe Institute of Technology (Germany)

The Grand Duché of Luxembourg

The Hellenic Republic

The Hungarian Academy of Sciences

The Institute of Plasma Physics (Czech Republic)

The Institute of Plasma Physics and Laser Microfusion (Poland)

The Instituto Superior Tecnico (Portugal)

The Max-Planck Institut für Plasmaphysik (Germany)

The Ministry of Education, Research and Innovation (Romania)

The Ministry of Higher Education, Science and Technology of the Republic of Slovenia

The Finnish Funding Agency for Technology and Innovation (Finland)

The Österreichische Akademie der Wissenschaften (Austria)

The Risø DTU- National Laboratory for Sustainable Energy (Denmark)

The Stichting voor Fundamenteel Onderzoek der Materie (The Netherlands)

The Swedish Research Council

The Ecole Polytechnique Fédérale de Lausanne (Switzerland)

The United Kingdom Atomic Energy Authority

The University of Latvia

The Lithuanian Energy Institute (Lithuania)

The Comenius University (Slovakia)

The Institute for Nuclear Research and Nuclear Energy (Bulgaria)

The Republic of Cyprus

The Republic of Malta

The Republic of Estonia

The European Atomic Energy Community (EURATOM), hereinafter referred to as the "Community", represented by the European Commission, hereinafter referred to as the "Commission", which is in turn represented by its Director-General for Research or by his authorised representative, of the one part,

The Belgian State (Belgium), acting for its own part (Laboratoire de Physique des Plasmas of the Ecole Royale Militaire - Laboratorium voor plasmaphysica van de Koninklijke Militaire School) and on behalf of the Université Libre de Bruxelles (Unité de Physique Statistique et Plasmas of the ULB) and of the Centre d'Etude de l'Energie Nucléaire/Studiecentrum voor Kernenergie, represented by its Minister for Energy,

the Centro de Investigaciones Energéticas Medioambientales y Tecnologicas (CIEMAT), Spain, with headquarters in Madrid, represented by its General Director,

the Commissariat à l'Energie Atomique (CEA), France, with headquarters in Paris, represented by its Directeur des Sciences de la Matière,

the Dublin City University (DCU), Ireland, with headquarters in Dublin, represented by its President, or authorised representative,

the Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), Italy, with headquarters in Rome, represented by its President,

the Forschungszentrum Jülich GmbH (FZJ), Germany, with headquarters in Jülich, represented by its Board of Directors,

the Karlsruhe Institute of Technology (KIT), Germany, with headquarters at Karlsruhe, represented by two members of its Executive Board,

the Grand Duché of Luxembourg, represented by its Minister for Energy,

the Hellenic Republic, represented by the National Centre for Scientific Research "Demokritos" (NCSR), which is in turn represented by the Director of the Institute of Nuclear Technology and Radiation Protection of NCSR,

the Hungarian Academy of Sciences, with headquarters in Budapest, represented by its President or his authorised representative,

the Institute of Plasma Physics AS CR, v.v.i. (IPP.CR), Czech Republic, with headquarters in Prague, represented by its Director or his authorised representative,

the Institute of Plasma Physics and Laser Microfusion (IPPLM), whose registered office is in Warsaw, represented by the Director,

the Instituto Superior Tecnico, Portugal, represented by its President,

the Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., Germany, represented by the Scientific Director of the Max-Planck-Institut für Plasmaphysik (IPP) at Garching near Munich and the Administrative Director of the IPP,

the Ministry of Education, Research and Innovation (MEdC), Romania, with headquarters in Bucharest, represented by its Minister or his authorised representative,

The Ministry of Higher Education, Science and Technology of the Republic of Slovenia (MHEST), whose registered office is in Ljubljana, represented by the Minister,

the Finnish Funding Agency for Technology and Innovation (Tekes), Finland, with headquarters in Helsinki, represented by its Director General,

the Österreichische Akademie der Wissenschaften (ÖAW), Austria, with headquarters at Vienna, represented by its President and General Secretary or their authorized representatives,

the Risø-DTU National Laboratory for Sustainable Energy (RISØ), Denmark, with headquarters at Lyngby, represented by its Rector or his authorized representative,

the Stichting voor Fundamenteel Onderzoek der Materie (FOM), the Netherlands, whose registered office is in Utrecht, represented by its Management Council, which has authorised the Director of FOM to represent the Stichting,

the Swedish Research Council (VR), Sweden, with headquarters in Stockholm, represented by its Secretary General,

the Ecole Polytechnique Fédérale de Lausanne (EPFL) acting for other Swiss organisations which participate in the fusion energy research programme of Euratom, represented by the Director of the "Centre de Recherches en Physique des Plasmas"(CRPP),

the United Kingdom Atomic Energy Authority (CCFE), with headquarters at Culham, represented by its Chief Executive,

the University of Latvia, Riga, Latvia, with its headquarters in Riga, represented by its President or his authorised representative,

the Lithuanian Energy Institute (LEI), Lithuania, with headquarters in Kaunas, Lithuania,

represented by the HRU of fusion Association or his authorised representative,

the Comenius University (CU), Slovakia, represented by the Dean of the Faculty of Mathematics, Physics and Informatics, or his authorised representative,

the Institute for Nuclear Research and Nuclear Energy (INRNE), Bulgaria, with headquarters at Sofia, Bulgaria, represented by its Director,

the Republic of Cyprus, represented by

the Republic of Malta, represented by

the Republic of Estonia, represented by

hereinafter referred to as "the Associates",

of the other part,

HAVING REGARD to Articles 7 and 10 of the Treaty establishing the European Atomic Energy Community;

HAVING REGARD to the Decision [x] of the Council of 19 December 2011[1] concerning the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012 - 2013);

HAVING REGARD to the Decision [x] of the Council of 19 December 2011[2] concerning the Specific Programme, to be carried out by means of indirect actions, implementing the Framework Programme of the European Atomic Energy Community for nuclear research and training activities (2012 - 2013);

HAVING REGARD to the Regulation (Euratom) [x] of the Council of 19 December 2011[3] laying down the rules for the participation of undertakings, research centres and universities in indirect actions under the Framework Programme of the European Atomic Energy Community and for the dissemination of research results (2012-2013);

HAVING REGARD to the Co-operation Agreement in the field of fusion energy and plasma physics of 14 September 1978[4] between the Community and the Swiss Confederation;

HAVING REGARD to the Contracts of Association concluded between the Community and Member States, the Swiss Confederation and organisations in Member States as part of a long-term programme of co-operation covering all the activities in the field of controlled thermonuclear fusion;

WHEREAS the signatories to this Agreement wish to participate in the collective use of the JET Facilities after 1999 using staff made available by organisations associated with Euratom to obtain further knowledge in preparation for ITER operation, R&D activities for the longer term as well as initiatives aimed at human resources, education and training;

WHEREAS the signatories to this Agreement are parties to the European Fusion Development Agreement (hereinafter referred to as 'the EFDA');

WHEREAS Article 1 of the EFDA provides for the application of that agreement to the collective use of the JET Facilities at Culham, Oxfordshire and requires the adoption of a JET Implementing Agreement to be annexed to the EFDA;

WHEREAS Article 6 of the EFDA specifies the contractual framework for the use of the JET Facilities;

WHEREAS this Agreement has been last amended in order to extend its duration to the end of 2011 and to introduce reviewed figures for the ceilings of the Associates' financial contribution for 2011.

HAVE AGREED AS FOLLOWS:

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1 OJ L, , p (
2 OJ L, , p
3 OJ L, , p
4 OJ L 242 of 4.9.1978

Article 1

– The second paragraph of Article 2.2 (Duration) shall be modified as follows:

"2.2. This Agreement shall expire on 31 December 2012"

– A new paragraph shall be added to Article 5.7 (Associates" Contributions) as follows:

"In 2012, a first amount of 5.78 M EUR shall be paid by CCFE and an amount of 10.48 M EUR shall be divided between the Associates (including CCFE) in proportion to the Euratom financial participation (expressed in EURO) in their expenditure in the frame of the thematic area of research "Fusion Energy" in year 2005 (including the baseline support to priority actions, but excluding any additional support for them and excluding any Euratom contribution under Categories I and III of this Agreement and to the costs of the Close Support Units under Article 8 of the EFDA)."

– A new paragraph and a new column for 2012 shall be added to Article 6 as follows:

"For 2012, the total contributions of each Associate shall not exceed the amounts (ceilings) specified in column 4 of Table I."

Amounts in EUR (Table I)

Designated Entities	Ceiling for the period 2008-2010 (6)	Ceiling for the period 2011(7)	Ceiling for the period 2012(8)
Belgium	600,200	216,000	216,000
CIEMAT	948,400	341,000	341,000
CEA	4,658,900	1,677,000	1,677,000
DCU	143,900	52,000	52,000
ENEA	4,093,000	1,474,000	1,474,000
Grand Duché of Luxembourg (1)	6,700	2,000	2,000
HAS (2)	39,900	14,000	14,000
Hellenic Republic	85,500	31,000	31,000
IST	381,200	137,000	137,000
IPP.CR (2)	86,100	31,000	31,000
MPG.IPP	9,052,000	3,259,000	3,259,000
IPPLM (4)	30,000	10,000	10,000
KIT	1,989,300	716,000	716,000
FZJ	1,580,700	569,000	569,000
MEdC (2)	39,400	14,000	14,000
ÖAW	301,100	108,000	108,000
Risø	220,200	79,000	79,000
FOM	771,000	278,000	278,000
VR	481,500	173,000	173,000
Swiss Confederation	1,451,800	523,000	523,000
TEKES	274,100	99,000	99,000
CCFE	30,434,100	6,410,000	6,410,000
University of Latvia (3)	30,000	10,000	10,000
MHEST (Slovenia) (4)	30,000	10,000	10,000
The Lithuanian Energy Institute (5)	30,000	10,000	10,000
The Comenius University (SK) (5)	30,000	10,000	10,000

Designated Entities	Ceiling for the period 2008-2010 (6)	Ceiling for the period 2011(7)	Ceiling for the period 2012(8)
INRNE (BG) (5)	30,000	10,000	10,000
Total	**57,819,600**	**16,263,000**	**16,263,000**

NOTES

-1- Luxembourg, Cyprus, Malta and Estonia are associated, respectively, through the Belgian State, the Hellenic Republic, ENEA and TEKES; their contribution shall be called through the Associate, to which they are affiliated

-2- The contribution to the JET Joint Fund following recommendation of the CCE-FU under FP6 is calculated at half of the standard rate by counting only half the Association's expenditure. This method of calculation has been reconfirmed by CCE-FU for FP7.

-3- Latvia's contribution as from 2006 (after no contribution in 2005) is calculated at half of the standard rate.

-4- Poland and Slovenia did not contribute to the JET Joint Fund under FP VI following recommendation of the CCE-FU. Commission's proposal for FP VII is that they contribute with a ceiling of 10,000 EUR until 2012.

-5- The Commission proposes that the three new Associates contribute with a ceiling of 10,000 EUR each until 2012.

-6- The figures for contribution in 2008 -2010 are based on the JOC forecast of expenditure as agreed in the 33rd EFDA SC of 6/7 March 2007

-7- The figures for contribution in 2011 are based on the JOC forecast of expenditure as agreed in the EFDA SC of 23rd June 2010 and CCE-FU decision during meeting nr 47 of 6 October 2009.

Undetermined costs of exceptional circumstances that may arise during the shutdown, restart and initial exploitation of the wall are not covered at this stage

-8- The figures for contribution in 2012 are based on the JOC forecast of expenditure as agreed in the EFDA SC of 29 June 2011and include Article 6.3 and 6.5 of EFDA.

Article 2

All other provisions of the Agreement remain unmodified.

Done at Brussels,

For the Associate

Full Name & Function: GIOVANNI LELLI - COMMISSIONER

Signature:

Stamp of the organisation:

For the Commission,

The Director of Energy (Directorate General for Research and Innovation)

Date: 02/10/2012

Signature:

p.o. K. G. Evans

EUROPEAN COMMISSION
Directorate General
RESEARCH & INNOVATION