Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Ignitor 2006

General Meeting of the American Physical Society

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MIT (LNS) Report HEP 06/06

Cambridge, MA, July 2006

Physics of High Energy Plasmas

Thermonuclear Plasmas

Plasma Astrophysics

Abstract Submitted
for the DPP06 Meeting of
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Sorting Category: 5.6.1 (Theoretical)

Validity of the Objectives and Solutions of the Ignitor Program* A. AIROLDI, CNR, Italy, B. COPPI, MIT, F. BOMBARDA, ENEA, Italy, G. CENACCHI, P. DETRAGIACHE — The validity of the objectives of the Ignitor Program[1] and its design solutions have been reaffirmed recently[2]: i) in order to prove the scientific feasibility of relevant fusion reactors, burning plasmas with $Q \geq 50$ should be produced and studied, ii) copper magnets are the most convenient solution for machines capable of reaching this objective, iii) experiments that do not include a divertor are the most efficient, at producing the highest plasma currents with the best confinement parameters. Ignitor is in fact designed to operate with either an "extended-limiter" configuration or with a double X-point configuration (X-points on the first wall). The experiment can reach the conditions where the thermonuclear instability is excited ($Q \to \infty$) or where the plasma can be kept under quasi-stationary conditions with large values of Q and the input of modest amounts of ICRH power. The maximum plasma currents with reasonable safety factors are up to 11 MA, corresponding to average poloidal fields $B_p \approx 3.4$ T. The latest physics and technology developments are presented.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

[1]B. Coppi, A. Airoldi, et al. *Nucl. Fusion* **41** (9), 1253 (2001)
[2]P.H. Rebut, *EPS Conference on Plasma Physics, Rome, 19 June 2006*

☐ Prefer Oral Session
☒ Prefer Poster Session

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Special instructions: Ignitor poster session #1

Date submitted: July 24, 2006

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Abstract Submitted
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Sorting Category: 5.6.1 (Computational/Simulation)

Ignitor Plasma Performance in the H-mode with New Scalings* P. DETRAGIACHE, ENEA, Italy, B. COPPI, M.I.T. — Ignitor can operate with a double-null configuration with the relevant X-points laying close to the first wall, $B_T \simeq 13$ T, $I_p \simeq 9$ MA, $R_0 \simeq 1.32$ m, $a \simeq 0.44$ m. The power threshold to access the H-regime has been found to be considerably lower on the basis of recent scalings[1] than originally assessed. The expected plasma parameters in this regime are estimated by using a global O-D model. The operating space corresponding to $Q \simeq 10$ is verified to be relatively broad, even considering the pessimistic case of rather flat density profiles, and far from density and β operational limits. Moreover, the analysis of JET experimental data[2] indicates that relatively peaked density profiles (e.g. $n_0/\langle n \rangle \simeq 1.5$) can be obtained in the H-regime. With these profiles, the attainable plasma parameters are found to improve considerably and values of Q much larger than 10 can be attained. The adoption of scalings[3] for the energy confinement time with a weak dependence on β does not change the operating space significantly in the case of Ignitor.
*Work supported in part by ENEA of Italy and by the US DOE.

[1] D. C. McDonald et al., *Plasma Phys. Control. Fusion* **48**, A439 (2006);
[2] H. Weisen et al., *Plasma Phys. Control. Fusion* **48**, A457 (2006);
[3] J. W. Cordey et al. *Nucl. Fusion* **45**, 1078 (2005).

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☐ Prefer Oral Session
☒ Prefer Poster Session

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Abstract Submitted
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Sorting Category: 5.6.1 (Computational)

Importance of the Ideal Ignition Conditions and Intermediate Objectives of Ignitor* G. CENACCHI, ENEA, Italy, A. AIROLDI, D. FARINA, B. COPPI, MIT — At the ideal ignition temperature, in D-T plasmas where the produced α-particles can be confined by the necessary current, the energy loss by bremsstrahlung emission is compensated for by the α-particles heating. Once this condition is reached, the plasma density can be raised during the plasma heating phase without encountering a radiation barrier. This is a meaningful intermediate objective for Ignitor operating with $B_T \simeq 9$ T, a double X-point (on the first wall) configuration, and $I_p \simeq 6$ MA, as well as in the 'extended limiter' configuration with $B_T \simeq 9$ T and $I_p \simeq 7$ MA. Numerical simulations have been performed considering volume average $n_e \simeq 2 \times 10^{20}$ m^{-3}, average $Z_{eff} \simeq 1.5$, and 5 MW of ICRH power absorbed by the plasma. Even without accessing the H-regime and with pessimistic assumptions about the energy confinement time (such as that corresponding to the ITER97L scaling) the peak temperatures are 5.5 to 6.5 keV and the α-heating power can be as high as 2 MW. The available ICRH power, combined with the Ohmic and α-particle heating, makes the access to the H-regime possible in this case as well as in that for which full ignition can be approached ($B_T \simeq 13$ T, $I_p \simeq 9$ MA).
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

☐ Prefer Oral Session
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Special instructions: Ignitor poster session #3

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Abstract Submitted
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Sorting Category: 5.6.1 (Theoretical)

ICRH Physics and IGNITOR Experiments with Reduced Parameters* A. CARDINALI, ENEA, Italy, G. CENACCHI, A. AIROLDI, CNR I.F.P., Italy, B. COPPI, M.I.T. — In Ignitor, preparatory experiments with reduced machine parameters are planned before full performance operation. A transport analysis has been carried out to verify that the ideal ignition conditions in D-T plasmas are determined, a significant physics objective. The relevant Ion Cyclotron Heating applied for these regimes is studied in order to identify the power deposition profiles to be used in the transport analysis. The Ignitor ICRH system can operate with a large frequency band (80-120 MHz) in a sufficiently broad range (4-12 MW) of delivered power. This frequency band, is consistent with the use of magnetic fields in the range 9-13 T. In the considered reduced parameter scenarios the magnetic field is 9T with a plasma current of 7 MA in the extended limiter configuration and 6 MA in the double X-point configuration. A parametric study of the power deposition profiles is presented as function of the minority concentration, minority species, frequency band for both configurations, by using a full wave code in plane and toroidal geometry. An optimum frequency band is found in the range 85-95 Mhz with a delivered power of 8 MW (limiter configuration) and 5 MW (X-point). The power is essentially absorbed by the minority and redistributed collisionally to the ion species of the bulk plasma.
*Sponsored in part by C.N.R. and E.N.E.A. of Italy and by the US DOE.

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☐ Prefer Oral Session
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Special instructions: Ignitor poster session #4

Date submitted: July 24, 2006 Electronic form version 1.4

Abstract Submitted
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Sorting Category: 5.4.0 (Experimental)

Performance of the High Speed Ignitor Pellet Injector*

S. MIGLIORI, A. FRATTOLILLO, F. BOMBARDA, ENEA, Italy, L.R. BAYLOR, J.B.O. CAUGHMAN, S.K. COMBS, D. FEHLING, C. FOUST, J.M. MCJILL, ORNL, G. ROVETA, CRIOTEC Impianti, Italy

— The construction of the four barrel, two-stage pellet injector for the Ignitor experiment, a collaboration between the ENEA Laboratory at Frascati and ORNL, is nearly completed. Initial testing of the ORNL subsystems (cryostat, pellet diagnostics and control system) were carried out with D_2 pellets. New light gate and microwave cavity mass detector diagnostics were developed specifically for this application. The ENEA pneumatic propelling system, which includes innovative pulse shaping valves and uses fast valves in the independent gas removal lines to prevent the propulsion gas from reaching the plasma chamber, was extensively tested in Italy and is ready for shipping to ORNL. The injector will deliver pellets of different sizes with velocities up to 4 km/s, capable of penetrating near the center of the plasma column when injected from the low field side in Ignitor. The new injector could be tested on existing experiments, such as JET. Our simulations show that a pellet of 5 mm in diameter could reach the inner plasma region in an actual 9 keV discharge that had an internal transport barrier.

*Sponsored in part by ENEA of Italy and by the U.S. DOE.

- [ ] Prefer Oral Session
- [X] Prefer Poster Session

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Special instructions: Ignitor poster session #5

Date submitted: July 21, 2006

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Abstract Submitted
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Sorting Category: 5.6.1 (Experimental)

Fabrication Techniques for the Magnetic Diagnostics of Ignitor* G. PIZZICAROLI, F. ALLADIO, F. BOMBARDA, ENEA, Italy, A. LICCIULLI, Universita' di Lecce, Italy, M. FERSINI, D. DISO, SALENTEC, Lecce, Italy — The design of the full set of electromagnetic diagnostics for the Ignitor experiment and their integration with the plasma chamber has been completed. The estimated neutron flux at the first wall during an ignition discharge is expected to cause a sensible, although reversible, degradation of the inorganic insulators surrounding the conductors that are positioned in the shade of the Mo first wall tiles. The measurement of fundamental plasma parameters such as current and position by means of electromagnetic diagnostics can thus be problematic. This ongoing R&D program is aimed at the selection of insulator materials with higher damage threshold and to the development of effective and affordable fabrication procedures. Two prototype coils suitable for testing in existing experiments have been manufactured. The first prototype is made of a pre-insulated nickel wire immersed in a magnesium oxide weakly bonded powder. The wire is contained in a fully sintered alumina case sealed with a glass ceramic powder. In the second prototype the nickel wire is immersed in a MgO powder and is wrapped in an oxide ceramic composite layer infiltrated with a glass ceramic matrix.
*Sponsored in part by ENEA of Italy and by the U.S. D.O.E.

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Abstract Submitted
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Sorting Category: 5.6.1 (Experimental)

The ICRH System for the Ignitor Experiment* M. SASSI, Italy, A. COLETTI, ENEA, Italy, R. MAGGIORA, Politecnico di Torino, B. COPPI, MIT — The ICRH system is an integral part of the Ignitor experiment as it provides the flexibility to reach ignition regimes following different paths in parameter space and, in particular, by shortening the time needed for this. Another important use of the ICRH is to maintain the plasma in a slightly sub-ignited state, avoiding the excitation of the thermonuclear instability, under quasi-stationary conditions, for the entire duration of the plasma current flat-top. The ICRH system is structured with a modular configuration and launches the power into the plasma through RF strap-antennas based on 4 straps, grouped in two poloidal pairs, per port. The system is designed to operate in the frequency band 80-120 MHz delivering a total power up to 12 MW at the lower frequencies. Each module consists of 4 high power generators whose power is split over two ports (8 straps) in order to keep the maximum electric field (especially in the vacuum region of the straps and transmission line) below 5kV/cm. A 30Ω vacuum transmission line, including the feedthrough, tranfers the power of 0.4 MW to each strap with a total power of 1.6 MW per port. The RF configuration of the modules allows a full phase controls (toroidal and poloidal) of the straps though a PLL phase control. Two modules, distributed over 4 ports, can produce about 6 MW at 120 MHz in order to attain ignition with a limited RF pulse during the plasma heating phase.
*Sponsored in part by ENEA of Italy and the U.S. DOE.

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Abstract Submitted
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Sorting Category: 5.7.0 (Experimental)

X-ray Imaging for Plasma Position Control in the Ignitor Experiment* F. BOMBARDA, ENEA, Italy, E. PAULICELLI, Universita' di Bari, Italy, B. COPPI, M.I.T. — In a burning plasma environment, traditional magnetic measurements may be expected to fail because of the high neutron and gamma radiation background. Light extraction and detection will also be more difficult than in present day tokamaks. In general, it will not be possible to keep detectors in the proximity and in direct view of the plasma. In this work we propose a diagnostic system for plasma position control using a multilayer mirror (MLM) as the dispersing element for the soft X-ray radiation emitted from the plasma outer region, and a Gas Electron Multiplier (GEM) detector. In the proposed layout, the radiation of the lower and upper region of the plasma is diffracted by cylindrical MLMs at shallow Bragg angles, and is collected by 2D detectors placed outside the machine horizontal port. GEM detectors are suitable for radiation in the 0.2-8 KeV range, and they are characterized by a very high counting rate. This system should measure the plasma position and detect any plasma movement with sufficient time resolution to be used for real-time feedback control of the vertical plasma position.

*Sponsored in part by ENEA and Universita' di Bari of Italy, and by the US DOE.

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[ ] Prefer Oral Session
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Abstract Submitted
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Sorting Category: 7.1.4 (Experimental)

Control Optimization for the Position and Shape of the Ignitor Plasma Column* F. VILLONE, R. ALBANESE, G. AMBROSINO, A. PIRONTI, G. RUBINACCI, CREATE, Napoli, Italy, A. COLETTI, A. CUCCHIARO, G. MADDALUNO, A. PIZZUTO, G. RAMOGIDA, M. ROCCELLA, M. SANTINELLI, ENEA, Frascati, Italy, B. COPPI, MIT — The performance of the control system for the position and shape of the elongated, tight aspect ratio plasma column of Ignitor has been analyzed using the CREATE_L linearized MHD deformable plasma response model[1]. The possible failure of the relevant electromagnetic diagnostics has been taken into account by considering the feasibility of vertical control by other means, employing X-ray emission and thermography to evaluate displacements of the center of the plasma column and deformations of its outer surface interacting with the first wall. A realistic description of the power supplies has been introduced in the simulation scheme, thus allowing the optimization of the PID (Proportional-Integral-Derivative) controller. Both a voltage and a current loop control scheme have been analyzed: the first has been found to be only marginally better than the second one. The problem of controlling the shape of the plasma cross section has been dealt with by considering shape deformations induced by varying one of the plasma macroscopic parameters (eg., I_p, β_{pol}, l_i) by a few percent.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

[1]R. Albanese, F. Villone *Nucl. Fusion* **38** 723 (1998)

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[ ] Prefer Oral Session
[X] Prefer Poster Session

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Abstract Submitted
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Sorting Category: 5.4.0 (Computational)

Plasma-wall Interaction Analysis for the Ignitor Experiment* F. SUBBA, R. ZANINO, Politecnico di Torino, Italy, A. AIROLDI, IFP-CNR, Italy, F. BOMBARDA, G. MADDALUNO, ENEA, Italy — The thermal wall load on the first wall has been analysed for the set of plasma parameters that correspond to ignition. The "extended limiter" configuration of the Ignitor First Wall and the need to analyse the effect of possible off-nominal 3D configurations, does not allow standard edge plasma analysis techniques to be used, such as the B2 code. Thus, the development of a new 2D fluid edge plasma model[1] has been adopted to carry out an analysis[2] that has verified the low level of the peak heat flux (for the nominal configuration) finding it slightly larger than previous predicted analyses. The presence of a significant deposition localized at the inboard mid-plane plasma-wall tangency point, due to cross field diffusion, is also consistent with previous analyses, where the radial contributions to the heat load deposited onto the wall was introduced as an *ad hoc* hypotesis. A 3D analysis of the thermal loads during the start-up phase of the discharge is being undertaken together with a sensitivity study of the thermal loads obtained under different transport assumptions.
*Sponsored in part by ENEA of Italy and by the US DOE.

[1]F. Subba, R. Zanino, *et al.*, Bull. Am. Phys. Soc., **50** (8), 201 (2005).
[2]F. Subba, *et al.*, 17th Inter. Conf. on Plasma Surface Interactions in Cont. Fus. Devices, Hefei Anhui, China, May 22 - 26, 2006

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[ ] Prefer Oral Session
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Sorting Category: 5.6.1 (Computational)

Structural Analysis of the Ignitor Load Assembly* A. BIANCHI, Ansaldo, Italy, B. PARODI, A. CUCCHIARO, ENEA, Italy, R. FROSI, A. PIZZUTO, G. RAMOGIDA, F. BOERT, KM, Germany, H.G. WOBKER, B. COPPI, MIT — The structural analysis of the IGNITOR machine Load Assembly has been completed taking into account the friction coefficients at the interfaces between its main components. A Finite Element ANSYS model was used to analyze the non-linear mechanical behavior of the structure. The calculation shows stresses within the allowable limits at the operating temperature. Interlaminar shear stresses values on the insulators of the toroidal field coils have been validated by the results of tests performed by Ansaldo. The non-linear analysis takes into account both the in-plane and the out-of-plane loads. Under normal operating conditions the assumed friction coefficient on the wedging surfaces is adequate to assure the structural stability of the Load Assembly. Furthermore, once unloaded, the structure comes back without any permanent deformation. The safety factors of the average shear stresses against the insulation shear rupture strength at the beginning of Ignitor life is always greater than 3, while at the end of life this is reduced to about 2 because of the degradation of mechanical properties due to the neutron dose. Keys of proper dimensions between the 30° extension of the C-clamps modules have been adopted to assure structural stability.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

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☐ Prefer Oral Session
☒ Prefer Poster Session

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Abstract Submitted
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Sorting Category: 5.6.1 (Experimental)

First Wall Design for the IGNITOR Machine* A. CUCCHIARO, ENEA, Italy, P. FROSI, A. PIZZUTO, G. MADDALUNO, G. RAMOGIDA, A. BIANCHI, Ansaldo, Italy, A. PARODI, F. LUCCA, L.T.C., Italy, A. MARIN, B. COPPI, MIT — A detailed 3D finite element model has been developed in order to evaluate the electromagnetic loads on the (mechanical) carriers of the tiles that constitute the First Wall of Ignitor during a reference Vertical Disruption Event. A thermostructural analisys of the most stressed tile carrier with a cycled load has been completed. The study employed a non-linear ANSYS Code. The results show a temperature increase up to 341°C for a single step of 4 sec. The stresses and deformations on the component which has undergone a cycled load are within the limits of the allowable values. The design layout of the First Wall has been finalized, taking into account all requirements of the IGNITOR Machine. The electrical diagnostics placed inside the plasma chamber have been included in the tile carrier design. The First Wall has been tailored with special consideration for the Faraday Shield facing the ports through which ICRH is injected.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

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☐ Prefer Oral Session
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Abstract Submitted
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Sorting Category: 5.6.1 (Experimental)

Plasma Chamber Design and Fabrication Activities*

B. PARODI, Ansaldo, Italy, A. BIANCHI, A. CUCCHIARO, ENEA, Italy, A. COLETTI, P. FROSI, G. MAZZONE, A. PIZZUTO, G. RAMOGIDA, B. COPPI, MIT — A fabrication procedure for a typical Plasma Chamber (PC) sector has been developed to cover all the manufacturing phases, from the raw materials specification (including metallurgical processes) to the machining operations, acceptance procedures and vacuum tests. Basically, the sector is made of shaped elements (forged or rolled) welded together using special fixtures and then machined to achieve the final dimensional accuracy. An upgraded design of the plasma chamber's vertical support that can withstand the estimated electromagnetic loads (Eddy and Halo current plus horizontal net force resulting from the worst plasma disruption scenario VDE, Vertical Displacement Event) has been completed. The maintenance of the radial support can take place hands-on with a direct access from outside the cryostat. With the present design, vacuum tightness is achieved by welding conducted with automatic welding heads. On the outer surface of the PC a dedicated duct system, filled by helium gas, is included to cool down the PC to room temperature when needed.

*Sponsored in part by ENEA of Italy and by the U.S. DOE.

- [ ] Prefer Oral Session
- [X] Prefer Poster Session

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Abstract Submitted
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Sorting Category: 5.6.1 (Computational)

Structural Assessment of the Central Solenoid of IGNITOR* G. RAMOGIDA, ENEA, Italy, A. CUCCHIARO, A. PIZZUTO, A. BIANCHI, Ansaldo, Italy, G. GALASSO, B. PARODI, B. COPPI, MIT — A thermo-mechanical analysis of the Central Solenoid of Ignitor has been carried out using the ANSYS code based on a linear 3D Finite Element model. The adopted model takes into account the insulation layers and the epoxy resin fillings required by the coil design. The structural assessment considers, in particular, the transient conditions at both the beginning of the plasma current pulse (heating) and during the cooling phase of the solenoid that follows the end of the plasma current pulse. This transient which causes high shear stresses on the insulation material has led to the design of an optimized feeder connection. The stresses under the most critical conditions (start-up) are within the allowable values found by tests carried out by Ansaldo.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

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☐ Prefer Oral Session
☒ Prefer Poster Session

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Sorting Category: 5.6.1 (Experimental)

Advances in the Fabrication of Toroidal Field Coil Prototypes* A. PIZZUTO, ENEA, Italy, A. CUCCHIARO, R. FROSI, G. RAMOGIDA, F. BOERT, KM, Germany, H.G. WOBKER, A. BIANCHI, Ansaldo, Italy, B. PARODI, B. COPPI, MIT — The Bitter-type Toroidal Field Coils (TFC) adopted for Ignitor consist of plates that are cooled down to 30 K by Helium gas. Copper OFHC has been selected for these plates, allowing for an Electron Beam (EB) welding solution of the cooling channels. Kabel Metal set up the welding parameters and qualified the process to achieve full joint penetration with acceptable metallurgical structure. The qualification covers both the welding of the cooling channels and the inlet/outlet tube made on two full size samples. A metallographic examination and vacuum and pressure tests have been preformed to validate the basic suitability of the EB welding process.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

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☐ Prefer Oral Session
☒ Prefer Poster Session

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Abstract Submitted
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Sorting Category: 5.6.1 (Experimental)

IGNITOR Remote Handling System* L. GALBIATI, ENEA, Italy, A. CUCCHIARO, A. PIZZUTO, A. BIANCHI, Ansaldo, Italy, B. PARODI, B. COPPI, MIT — The detailed design of the in-vessel Remote Handling System, based on the "two port concept" with two operating booms, has been completed. A 3D mock-up of the plasma chamber (PC) has made it possible to simulate the boom. This validates the ability of the boom, equipped with the attached end-effectors, to reach any in-vessel zone by 180°on each side without interferences. Thus, the operating procedures applicable to several interventions have been established. Furthermore, a failure analysis of the boom components has been carried out in order to identify a recovery proceedure. The design of the ex-vessel cabin with the function of holding the boom apparatus and managing the removal and installation of in-vessel components has been completed. The material removed from the PC is treated as radioactive waste material. The boom is made up by a sliding straight arm and articulated links. A structural analysis of both components under a maximum payload of 25 kg has evaluated an acceptable deflection of about 7 mm.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

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☐ Prefer Oral Session
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Sorting Category: 5.6.1 (Experimental)

Optimized Operation and Electrical Power Supply System of Ignitor* A. COLETTI, G. CANDELA, R. COLETTI, P. COSTA, G. CANDELA, G. MAFFIA, M. SANTINELLI, F. STARACE, ENEA, Italy, M. SFORNA, GRTN, Italy, G. ALLEGRA, L. TREVISAN, CESI, Italy, A. FLORIO, Asaldo-Ricerche, Italy, R. NOVARO, ASI Robicon, Italy, B. COPPI, MIT — Two reference sets of parameters for the operation of Ignitor have been identified. One, the main set, involves plasma currents up to 11MA and toroidal fields up to 13T. The reduced parameter set corresponds to 7MA with fields of 9T and considerably longer pulse flat-tops. The evolution of the relevant currents in the toroidal and the poloidal field magnet systems has been optimized in order to minimize the requirements on the electrical power supply and cryogenic cooling systems. Thyristor amplifiers are adapted to drive both the toroidal and poloidal field magnet systems. The total installed power for these systems is 2400 MVA. The connection of this to the terminals, involving two nodes of the 400 kV grid, at the Caorso site, which houses a dismantled nuclear power station, has been analyzed and authorized by the TERNA-GRTN Agency. A particular consideration has been given to the problems involving the control of both the position and the shaping of the plasma column.
*Sponsored in part by ENEA of Italy and by the U.S. DOE.

- [ ] Prefer Oral Session
- [X] Prefer Poster Session

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Abstract Submitted
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Sorting Category: 5.6.1 (Experimental)

The Columbus Concept* M. SALVETTI, MIT, B. COPPI — The Columbus experiment[1] is proposed as a parallel US project to the Ignitor program carried out in Italy. A spectrum of complementary experiments is in fact required for a "Science First" approach to fusion research[2]. The possible discovery of new phenomena and the understanding of known ones, i.e. sawtooth oscillations, under fusion burning conditions will drive the design of future fusion reactors. Columbus is designed to reach ignition conditions in D-T plasmas where the α-particle heating compensates for all energy losses. It takes advantage of the Ignitor R&D effort and the technology acquired during the construction of the full-size prototypes of its main components (the second generation construction of the toroidal field plates has been completed). Columbus is geometrically self-similar to Ignitor, the linear dimensions being multiplied by 25/22 ($R_0 \cong 1.5$ m) and the volume increased by about 50%. The toroidal magnetic field is decreased by the factor 12.6/13 and the average poloidal field produced by the plasma current is about equal to that of Ignitor for comparable values of the magnetic safety factor q_a. The reference plasma current is $I_p \cong 12.2$ MA, the value that ITER would produce for the same q_a but without reaching ignition. The machine is based on cryogenic resistive magnet technologies. *Sponsored in part by the U.S. DOE.

[1]B. Coppi and M. Salvetti, MIT-RLE report PTP(2003)
[2]B. Coppi, MIT-RLE report PTP 02/04 (2002)

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☐ Prefer Oral Session
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Sorting Category: 5.6.1 (Experimental)

The IGNITOR ICRF system R. MAGGIORA, V. KYRYTSYA, V. LANCELLOTTI, D. MILANESIO, G. VECCHI, Politecnico di Torino, Italy — A flexible auxiliary Ion Cyclotron Resonance Heating (ICRH) system (f = 80 120 MHz) has been included in the IGNITOR machine design. ICRH systems have been successfully tested on a number of existing devices especially at high density. Ignition can be accelerated significantly by relatively low levels of ICRH (about 5 MW, a fraction of the final fusion heating) when applied during the current ramp-up. In addition, ICRH provides a useful tool to control the evolution of the current density profile. Four antennas, each composed by 2 straps, 4 tuning stubs, and 2 generators each, can deliver a minimum RF power of about 12 MW for the entire adopted frequency range. The possibility of adding two more antennas has been considered. The antenna design has been based on performance evaluation obtained with the TOPICA simulation suite (Torino Polytechnic Ion Cyclotron Antenna code).

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[ ] Prefer Oral Session
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Special instructions: iGNITOR POSTER SESSION #19

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