ITALIAN NATIONAL AGENCY
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Density limit studies – 2014 C2

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Context

WORK PROGRAMME 2014
for the implementation of the fusion roadmap

Enabling Research

"Density limit studies"

Consorzio RFX (3.9 ppy)
CIEMAT (1.6 ppy)
ENEA-Frascati (1.1 ppy)
CNR-IFP-Milano (0.2 ppy)

NAME	Association	PPY	Involvement in the project execution
Paolo Buratti	ENEA-FRASCATI	0.2	Design of scenarios for FTU and MHD analysis
Massimo Marinucci	ENEA-FRASCATI	0.2	Transport analysis for FTU with JETTO code
Cristina Mazzotta	ENEA-FRASCATI	0.2	Particle transport analysis and modelling of density peaking
Gianluca Pucella	ENEA-FRASCATI	0.3	Analysis of the MHD instabilities in the high density regime
Onofrio Tudisco	ENEA-FRASCATI	0.2	Density profile measurements on FTU and MARFE analysis
G. Granucci	CNR-IFP-MILANO	0.2	Electron Cyclotron Resonance Heating

Objectives – Experiments – Deliverables

3 **Exploring high density tokamak plasmas in a wide range of plasma current (from 70 to 900 kA), toroidal field (0.6 ÷ 8** T) and edge safety factor q_a (1.5 ÷ 10). The full scan of the toroidal field dependence will be carried by means of experiments on FTU (B_T = 2 ÷ 8T, I_p = 250 ÷ 900 kA) and RFX-mod operated as a tokamak (B_T = 0.6 T, I_p = 70 ÷ 150 kA).

The behaviour of the density limit in tokamak plasmas will be investigated over a wide range of parameters in terms of plasma current (from 200 to 900 kA), applied toroidal field (2 ÷ 8 T) and edge safety factor q_a (> 2) on the FTU device. Such scan will be completed on the RFX-mod operated as a low current (70 ÷ 150kA), low toroidal field (0.6 T) ohmic tokamak, where low q_a (≥ 1.5) plasmas can be safely operated thanks to the sophisticated feedback control system, which has been proven to be very effective on the (2,1) resistive wall mode control.

Obtain the scaling of the high density limit in tokamak plasmas (discriminating edge and core density) with current, magnetic toroidal field and q_a by means of experiments both on FTU and RFX-mod run as Tokamak.

Objectives – Experiments – Deliverables

4 **Heating the magnetic island, with ECRH on FTU, to obtain the suppression of the MHD mode and allow operations above the ohmic density limit**, as theoretically predicted. The comparison between the effects of radiative condensation instabilities with toroidal (tokamak) or poloidal (RFP) symmetry could lead to a more comprehensive analysis of the possibility that radiation driven islands are the physics mechanism responsible for the density limit. In such a scheme, one obvious consequence is that direct heating of the rational surfaces that participate in the radiation driven island phenomena should suppress these islands, so allowing a density limit expansion by MHD instability control, which could be important for burning tokamaks.

Moreover, in FTU we will perform discharges with a direct Electron Cyclotron Resonance Heating of the magnetic island region, in order to suppress these MHD modes and allow operations above the ohmic density limit, which could be important for burning tokamaks.

Explore the possibility of overcoming the density limit by means of ECRH applied to heat the edge island in FTU.

Objectives – Experiments – Deliverables

5 **Compare the understanding of the relation between edge properties and density limit** in Tokamak and RFPs with the results in Stellarator (TJ-II).

In FTU we will operate also with peaked density profiles produced by neon gas puffing, pellet injection or lithium-coated walls. In such a way we could operate with high central density, avoiding the increase in the peripheral density, which is the true parameter related to the density limit disruption.

Obtain the scaling of the high density limit in tokamak plasmas, discriminating edge and core density.

Pulse plan

3 **Exploring high density plasmas in a wide range of plasma current and toroidal field.**

9 shots

B_T = 2.0 T - I_p = 500 kA - zero, n ramp-up, recovery (3 shots)
B_T = 2.5 T - I_p = 250 kA - zero, n ramp-up (2 shots)
B_T = 2.5 T - I_p = 500 kA - n ramp-up, recovery (2 shots)
B_T = 5.2 T - I_p = 250 kA - zero, n ramp-up (2 shots)

4 **Heating the magnetic island with ECRH to obtain the suppression of the MHD mode and allow operations above the ohmic density limit.**

9 shots

B_T = 5.6 T - I_p = 500 kA - zero, n ramp-up, recovery, n_{DL} (4 shots)
B_T = 5.6 T - I_p = 500 kA - n ramp-up - ρ: const, pre, loop (3 shots)
B_T = 5.6 T - I_p = 500 kA - n ramp-up - ρ: central, recovery (2 shots)

5 **Understanding of the relation between edge properties and density limit.**

6 shots

B_T = 4.0 T - I_p = 700 kA - zero, n ramp-up, recovery (3 shots)
B_T = 4.0 T - I_p = 700 kA - n_{MARFE}, n_{MHD}, n_{DL} (3 shots)

24 shots → 3 days