Istituto per la Scienza e Tecnologia dei Plasmi
Consiglio Nazionale delle Ricerche

Briefing F13 session 21/05/2019 and 22/05/2019
F13: EC assisted start-up
20-05-2019

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Team

21/05

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22/05

- SC: G. Granucci, D.Ricci
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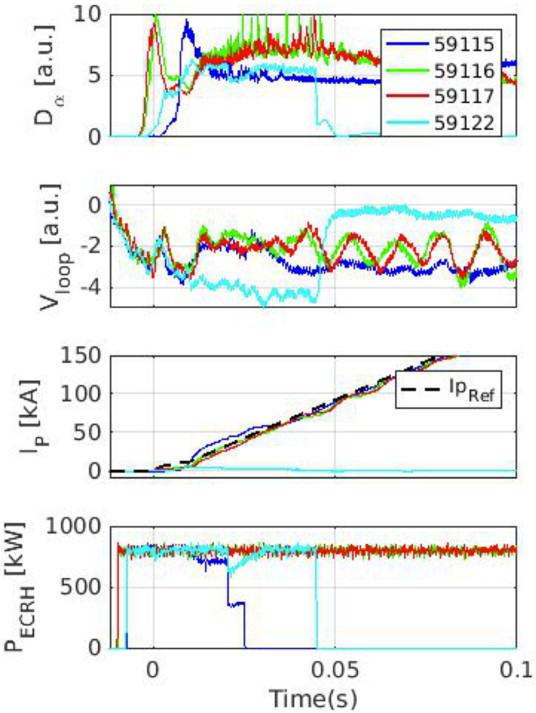
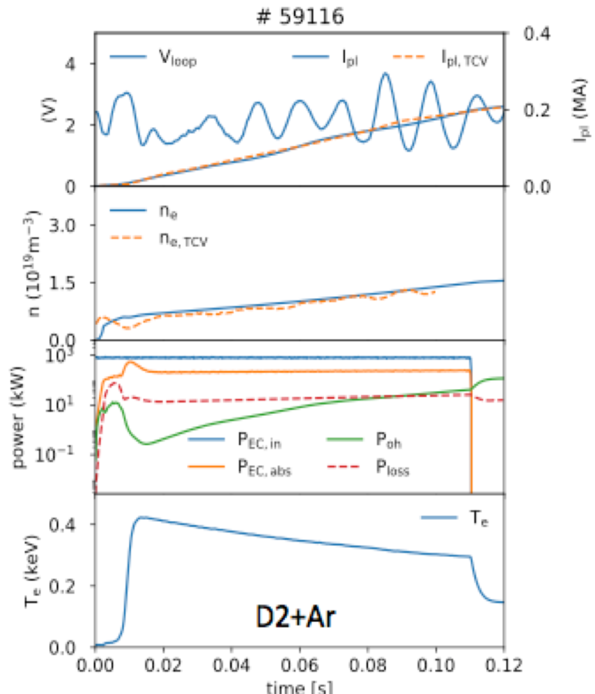
- PIC: P. Buratti, C. Meineri
- F13: V. Mellera, S. Garavaglia (remote), L.Figini (remote) ….

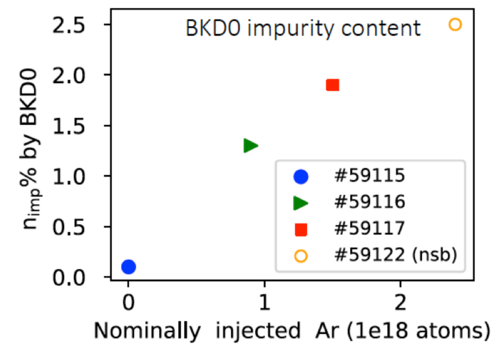
Background 1: Comparison with TCV experiment

Experiment:
D_2 plasma with Ar impurity.



BKD0+GRAY simulation:
D_2 plasma with Ar impurity.





n_{Ar} / n_{D2} used in BKD0 simulation to reproduce the corresponding shots, plotted as a function of the nominal injected Ar atoms

#59115 no Ar (for comparison)
#59116 D2+1.3%Ar
#59117 D2+2.0%Ar
#59122 D2+2.5%Ar not sustained and required more power than the maximum available.

- From C to metallic wall machine
- **Ar** for comparison with TCV results
- **Ne** (MST1-X01 exp in sep 2019): radiative cooling rate is 10-30eV, roughly similar to C, N (seeding gas) and O2 (often dominant impurity).

[Mavrin, A.A. J Fusion Energ (2017) 36: 161]

Background 2: null/EC beam position study

In future machine the position of the EC resonance (frequency) will be optimized for the flat top phase, not for the start-up.

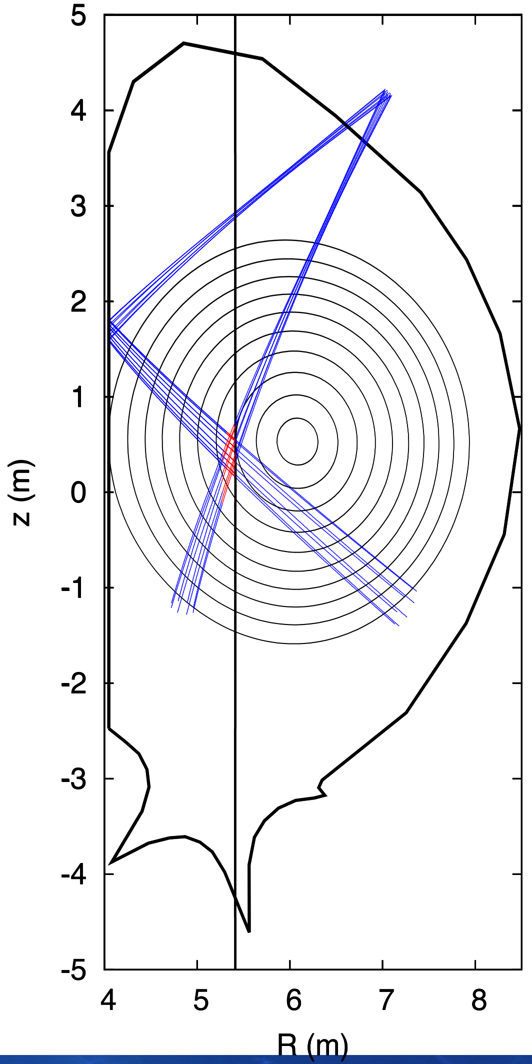
In BKD0 :

- Plasma region is assumed circular, coincident with the null (simulation region)
- EC power deposition (calculated by GRAY) occurs only in the simulation region

- It is relevant for the simulation of the EC assisted start-up of future devices to understand if this assumption is correct or if it is necessary to include in the code some extra-modelling.

- One of the operational issue of interest for the ITER first plasma

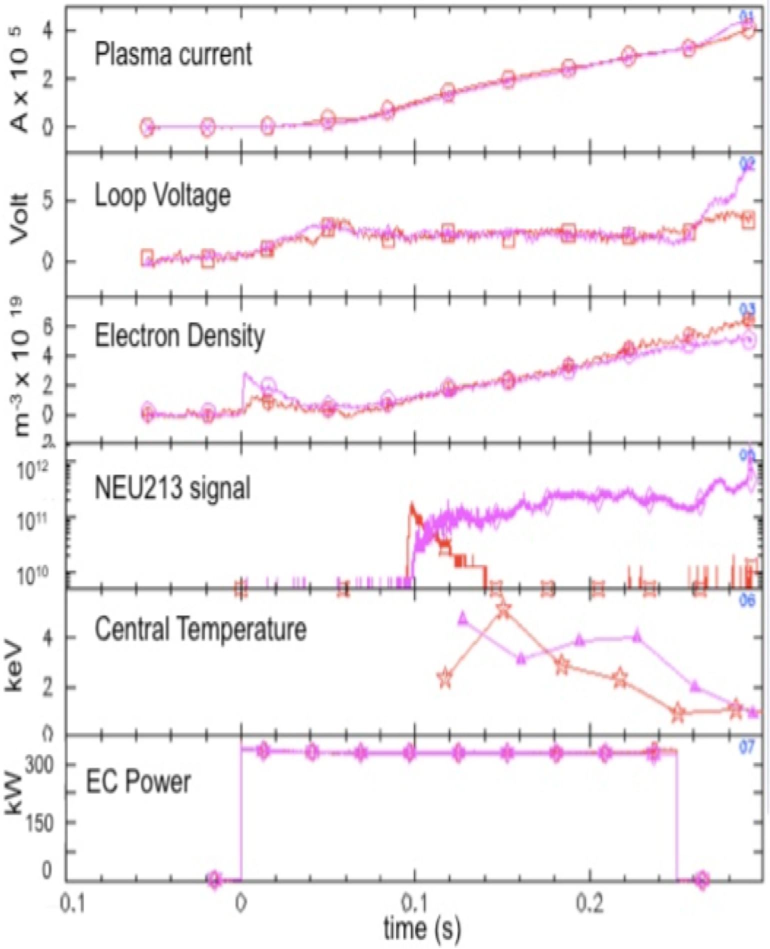
ITER upper Launcher breakdown studies



Background 3: REs formation and suppression at start-up

XM2: From the analysis of the data set at half field (2.5 T) we found that REs are not generated when injecting XM2, reguarless of pressure, toroidal injection angle, electric field (0.6 - 1.3 V/m).

OM1: The REs generation and suppression depends on main discharge parameters (prefilling pressure, polarization and electric field)



[Granucci EPS 2016]

Comparison between EC assisted discharges at OM1 (#38400 magenta) and XM2 (#38418 read) injection (with 20°). All the main parameters are similar, only polarization and magnetic field are changed (p=9e-5 mbar, B0 = 5.3 T and 2.6 T, respectively)

Goal and strategy

Goal

- Study of EC assisted plasma start-up with injection of impurity (mainly Ar and Ne) and null position influence with respect to the EC beam on FTU to compare results with data obtained on TCV (HLT-22 in 2017) in both the first and second harmonics. Moreover, the investigation of runway electron formation and suppression at start-up.
- Modelling of density and temperature time evolution and generated plasma current during discharges with EC-assisted start-up using BKD0. Extrapolation of the results to ITER and DEMO

Experimental strategy

Control of null position wrt EC resonance layer:

Test assisted breakdown with resonance inside or outside the null, by varying the magnetic configuration action on vertical field o by varying the EC resonance position. Use different EC power level

Injection of Impurity:

At low Vloop test different impurity level (Ar, Ne or others) to verify capability of EC power to sustain startup in different gas mixture (mimic post disruption condition)

RE. formation vs pressure/ EC power/ EC polarization/Injection angle

Scan prefill pressure (3 level) at different power (3 level) for the two polarization (OM1, XM2 and OM1 with oblique injection to convert at XM1) to test the formation of RE electrons.

Requirements

Low loop voltage	no SNU
$n_{min} – n_{max}$ (10^{20} particles m^{-3})	0.3 – 0.8
$B_{min} – B_{max}$ (T)	2.56 – 6
$I_{min} – I_{max}$ (kA)	350 - 500
ECRH (kW)	400 – 800
LH (kW)	no
Pellet	no
Special requirements	impurity injection: Ne, Ar, prefill pressure
Essential diagnostics	Electron density and temperature profiles, $D\alpha$, FEB, TSC, Pressure, Video Cameras, Gamma ray, Cherenkov, REIS, SIRIO, Sniffer probes, OMA, UV Spectroscopy, SOFT-X
Modelling:	BKD0,GRAY

Pulse plan

a) EC assisted plasma start-up with impurity injection (**Ar** and **Ne**).

1) Zero at 2.56 T
2) 2.56 T / 350 kA
3) 2 level of injected gas per each type

1) Zero at 5.3 T
2) 5.3 T / 500 kA
3) 2 level of injected gas per each type

b) runway electron formation and suppression at start-up:

9 shots in ITER first plasma relevant configuration (XM2)
9 shots in OM1

c) null position influence with respect to the EC beam (null position as in #36072-36095 10/11/2012)

1) Zero at 5.3 T
2) 5.3 T / 500 kA (target)
3) 3 null position with fixed EC resonance
4) 3 EC resonance with fixed null position
5) in the worst cases increase power in both the configuration