BACKGROUND
One main problem in ITER operation is the need of reducing the dangerous effects of runaway electrons (RE) during disruptions that are considered to be potentially intolerable when having currents larger than 2MA. A possible strategy in case of disruption with RE beam formation is based on RE beam current ramp-down.

OBJECTIVES OF THIS WORK

- Development of a dynamical model of the RE beam current and horizontal position during the RE plateau in order to design/improve a robust controller to minimize RE interaction with the Plasma Facing Components (PFC) during RE plateau phase.
- Real time implementation of the scanning interferometer CO/CO2 to estimate the position of RE beam (envelop by cold plasma).
- Real time implementation of new controllers (vertical and radial position, plasma current). Detection algorithm of the RE plateau on TCV and the new current ramp-down reference in case on RE plateau is detected.
- Real time implementation of the policy to show the hysteresis phenomena of the runaway electrons (generation and creation).
- Offline implementation of the algorithm to discover the runaway plateaus in FTU and TCV.

DYNAMIC MODEL OF RE BEAM CURRENT

Objective: Improve the tracking performance of the \( \dot{r}_p \) current ramp-down.

Method: We propose a simplified dynamical model of the RE beam current during RE plateau given by

\[
\dot{r}_p(t) = -|p_1| \dot{p}_1(t) - p_2 \dot{p}_2(t) - p_3 \dot{p}_3(t) - p_4 \dot{p}_4(t) - p_5 \dot{p}_5(t) - p_6 \dot{p}_6(t) - p_7 \dot{p}_7(t) - p_8 \dot{p}_8(t)
\]

where \( p_i \) are the unknown parameter, \( \dot{r}_p \) is the runaway electron current, parameters have been optimized for each single shot by PFM (Prediction Error Method).

Results
- The double integrator allows to improve the tracking performance during RE beam current ramp-down reducing the tracking error amplitude as shown in the right plot of Figure 2a.

DYNAMIC MODEL OF THE HORIZONTAL POSITION OF RE BEAM

Objective: To minimize the RE interaction with the PFC during RE beam current ramp-down.

Method: In order to design a robust controller witch improved RE beam (key feature at FTU) tracking performance, we propose a simplified dynamical model in the RE beam horizontal position given by

\[
S_1 \dot{x}_1 + S_2 \dot{x}_2 + S_3 \dot{x}_3 = 0
\]

where \( x_1 \) is the estimated Rex, \( x_2 \) is the velocity and \( x_3 \) is a rough estimate of the RE energy around an asymptotically equilibrium point.

Identification results
- Parameters mean and standard deviation, obtained by PFM are \([c_1; c_2; c_3; c_4; c_5; c_6; c_7] = [4.3E3; 2.96E0; 8.21E2; 7.67E3; 6.46E3; 6.6; 1.8E6; 3.84E5; 1.21; 1.65; 6.6; 3.82e] \), respectively.
- Model refinements are under investigation to decrease the parameter dispersion among different shots.

SCANNING BEAM INTERFEROMETER

Objective: Analysis of the time evolution of the interferometer radial profiles (scanning interferometer) in order to estimate the position of the RE beam barycenter.

Figure 4a: Pulse \#35865: (a) some of the interferometer LOS at different radii compared with the scaled FC signal (black dashed); (b) external Rex (red solid) and internal Rind (pink dashed) estimated plasma radial at equatorial plane, major radius of the density profile highest peak (black, interferometer barycenter) and the one of the Gaussian functions (blue dashed, Gaussian barycenter), magnetic axes reconstructed via ODIN equilibrium code [18] (green solid with circle marks, available up to 0.795 s); (c) scaled SSR central line of sight (R = 0.935 m, blue) and HXR (red) compared with FC counts (black); (d) Mirnov coil related to MHD activity; (e) density line integrals at different times (solid) and the fitted Gaussian functions (dashed).

REFERENCES