Runaway generation and control in FTU

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WORK PROGRAMME 2015
for the implementation of the fusion roadmap

WP MST2-9

"Runaway Electron Studies on FTU"

ENEA+Università Tor Vergata (1.5 ppy)
CNR-IFP-Milano (0.4 ppy)

NAME	Association	PPY	Involvement in the project execution
Basilio Esposito	ENEA-FRASCATI		Project Leader
Daniele Carnevale	TOR VERGATA		RT Plasma Control
Luca Boncagni	ENEA-FRASCATI		Plasma Control System, RT D
Marco Riva	ENEA-FRASCATI		RT Gamma camera diagnosti
Daniele Marocco	ENEA-FRASCATI		Gamma camera diagnostic
Salvatore Podda	ENEA-FRASCATI		Neutron diagnostics
Onofrio Tudisco	ENEA-FRASCATI		Density profile measurements on FTU
Giuseppe Ramogida	ENEA-FRASCATI		Scenario development, plasma operation
Giorgio Maddaluno	ENEA-FRASCATI		Plasma wall interaction
Cristian Galperti	CNR-IFP-MILANO		SVD disruption precursor dev
William Bin	CNR-IFP-MILANO		Scenario development, plasma operation
Edoardo Alessi	CNR-IFP-MILANO		SVD disruption precursor development
Sergio Galeani	TOR VERGATA		RT Control
Mario Sassano	TOR VERGATA		RT Control
Also participating:	J.R. Martin-Solis, Z. Popovic, S. Garavaglia, G. Granucci, C. Sozzi, G. Pucella, C. Cianfarani, E. Giovannozzi, M. Gospadarczyk		

Objectives – Experiments – Deliverables

4 **Determine critical electric field for runaway generation (during Ip flat top)**

- **Expand the parameter space of experiments of critical electric field runaway generation** to investigate the presence of additional loss mechansms (e.g. synchrotron radiation).
- Work at **2T/350 kA** , **3 T, 4.5 T/500 kA**: this low range of B_t has not been investigated yet in the previous FTU experiments: needed to complete database
- Perform both **runaway electron onset** and **runaway electron suppression** experiments
- **REQUEST**: no experiments in week 17-21 november
  → Z. Popovic and J.R Martin-Solis not available this week

Objectives – Experiments – Deliverables

1 Optimize scenarios for reliable RE plateau generation at disruption (for RE control experiments)

- **New scenario for RE plateau generation at disruption must be established** as attempts so far (Ne or disruptions during Ip ramp-up) not easily reproducible
- Options:
  - use of **Argon instead of Neon**
  - use of ECRH (as done is AUG recently) if Ar alone fails (move to 2.5 T (?) needed in this case)
- Use same features as in pulse 38513-19:
  - **extremely low-prefill to have pre-existing runaway population**
  - **poloidal limiter moved inward of 1cm**
  - V and F optimized for large F excursion (allocator since 0.1s, high speed)
  - density reference as in 38513 (essentially zero).
- One recovery shot each 4 shots with S40M50RC01 (standard 500kA)
- Required Systems:
  - **Ar gas injection**
  - ECRH 1 gyrotron (2.5 T needed in this case)
  - gamma camera and neutron detectors
  - fast high resolution camera (also IR camera of LLL)?
  - all valves for (fast) Deuterium injection
  - Interferometer, ECE, Soft-x

Objectives – Experiments – Deliverables

3 **Verify performance of position control algorithm using new control system for disruption-generated RE (position and current ramp down) based on RT FC and Vloop (scan on control model parameters)**

- Controller parameters (scan)
  - I_p desired ramp down slope (from 300 ms to 500 ms)
  - Fixed (initial) desired R_{ext} (as in 38513-19)
  - Tuning of Extremum Seeking-like parameters (continued)
  - V_{loop} thresholds (on?)
  - Final kick tuning (During the final shots 13,19 the RE beam has been lost on the poloidal limiter)
  - New PID-T double integrator active since 0.1 s
  - PID-F gains tuning for RE control (switched)
  - New PID-H active since 0.1 s
  - Deuterium gas injection at RE current plateau/ramp down (RE energy conversion to Ohmic current, final loss mitigation)

Pulse plan

4 Critical Electric Field Experiments

15 shots $B_T = 2.0$ T – $I_p = 350$ kA - zero, 2x ne ramp-down (RE generation), 2x ne ramp-up (RE suppression) (**5 shots**)
$B_T = 3.0$ T – $I_p = 500$ kA - S30M50A12I, zero, 2x ne ramp-down (RE generation), 2x ne ramp-up (RE suppression) (**5 shots**)
$B_T = 4.5$ T – $I_p = 500$ kA - S45M50A12I, 2x ne ramp-down (RE generation), 2x ne ramp-up (RE suppression) (**5 shots)**

1 Optimize scenarios for reliable RE plateau generation at disruption (for RE control experiments)

10 shots $B_T = 4.0$ T – $I_p = 500$ kA - zero (1 shot), standard at 4T (1 shot), repeat (4 shots) adjusting prefill, Ar pressure and puff time, density profile), standard at 4T (1 shot) re-establish good low density conditions and to clean the camera), repeat (4 shots) adjusting prefill, Ar pressure and puff time, density profile) (**10 shots**)

Shot Features: as 38519: extremely low-prefill, poloidal limiter moved inward of 1cm, V and F optimized for large F excursion (allocator since 0.1s, high speed), Ar injection (time, pressure and duration tbd) ECRH power 1gyrotron (usage & time tbd), density reference as in 38513
Objective: obtain as many shots with runaway plateaus as possible

3 Verify performance of position control algorithm using new control system for disruption-generated RE (position and current ramp down) based on RT FC and Vloop (scan on control model parameters).

10 shots $B_T = 4.0$ – $I_p = 500$ kA - [Ip ramp down 300 ms, Rext_des=1.11 m), (FC gain, Vloop gain, controller speed tuning] (**5 shots**), repeat adjusting adjust FC gain, Vloop gain, controller speed, Allocator, PID-F, PID-H, PID-T)
$B_T = 4.0$ – $I_p = 500$ kA - standard shot (**1 shot**)
$B_T = 4.0$ – Ip = 500 kA - [(Ip ramp down 300 ms, Rext_des=1.11 m), D puff (FC gain, Vloop gain, controller speed tunin] (**4 shots**), repeat adjust D puff, FC gain, Vloop gain, controller speed, Allocator, PID-F, PID-H, PID-T)

Shot Features: best shot of D01 used as scenario

35 shots → 4 days