



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”

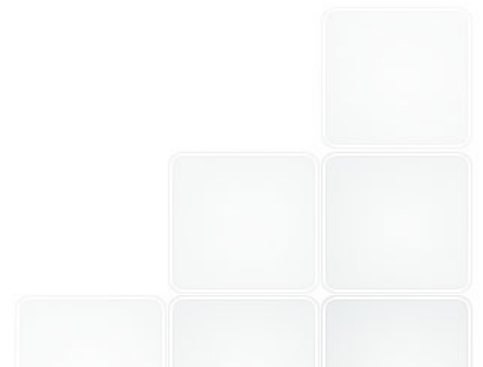
ENEA+Università Tor Vergata (1.5 ppy)

CNR-IFP-Milano (0.4 ppy)

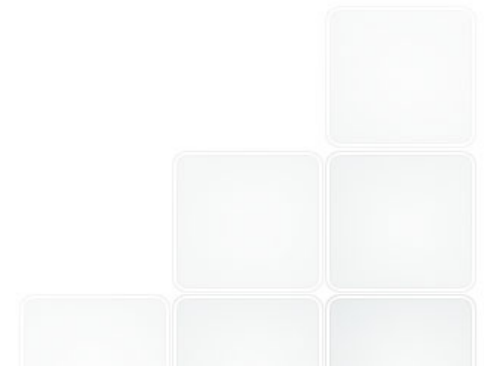
NAME	Association	PPY	Involvement in the project execution
Basilio Esposito		ENEA-FRASCATI	Project Leader
Daniele Carnevale	TOR VERGATA		RT Plasma Control
Luca Boncagni		ENEA-FRASCATI	Plasma Control System, RT D:
Marco Riva		ENEA-FRASCATI	RT Gamma camera diagnosti
Daniele Marocco		ENEA-FRASCATI	Gamma 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		

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

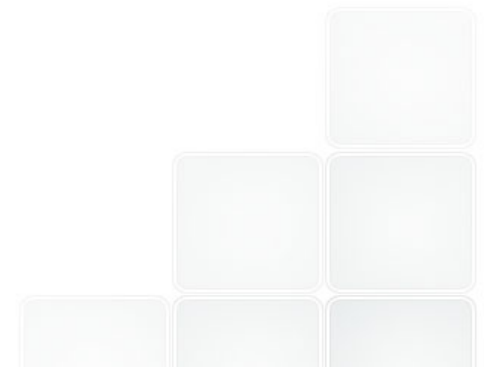
- **Expand the parameter space of experiments of critical electric field runaway generation** to investigate the presence of additional loss mechanisms (e.g. synchrotron radiation).
- Work at **2T/350 kA** , **3 T, 4.5 T/500 kA**: this low range of B_t has not been investigated yet in the previous FTU 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



- 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 I_p 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



- 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)



4 Critical Electric Field Experiments

- 15 shots** $B_T = 2.0 \text{ T} - I_p = 350 \text{ kA}$ - zero, **2x** ne ramp-down (RE generation), **2x** ne ramp-up (RE suppression) (**5 shots**)
 $B_T = 3.0 \text{ T} - I_p = 500 \text{ kA}$ - S30M50A12I, zero, **2x** ne ramp-down (RE generation), **2x** ne ramp-up (RE suppression) (**5 shots**)
 $B_T = 4.5 \text{ T} - I_p = 500 \text{ kA}$ - 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** $B_T = 4.0 \text{ T} - I_p = 500 \text{ kA}$ - 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** $B_T = 4.0 - I_p = 500 \text{ kA}$ - [I_p ramp down 300 ms, $R_{ext_des}=1.11 \text{ m}$], (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)
 $B_T = 4.0 - I_p = 500 \text{ kA}$ - standard shot (**1 shot**)
 $B_T = 4.0 - I_p = 500 \text{ kA}$ - [(I_p ramp down 300 ms, $R_{ext_des}=1.11 \text{ m}$), 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