10th November 2026

RT04 – Physics based machine generic systems for an integrated control of plasma discharge

Priorities 2027

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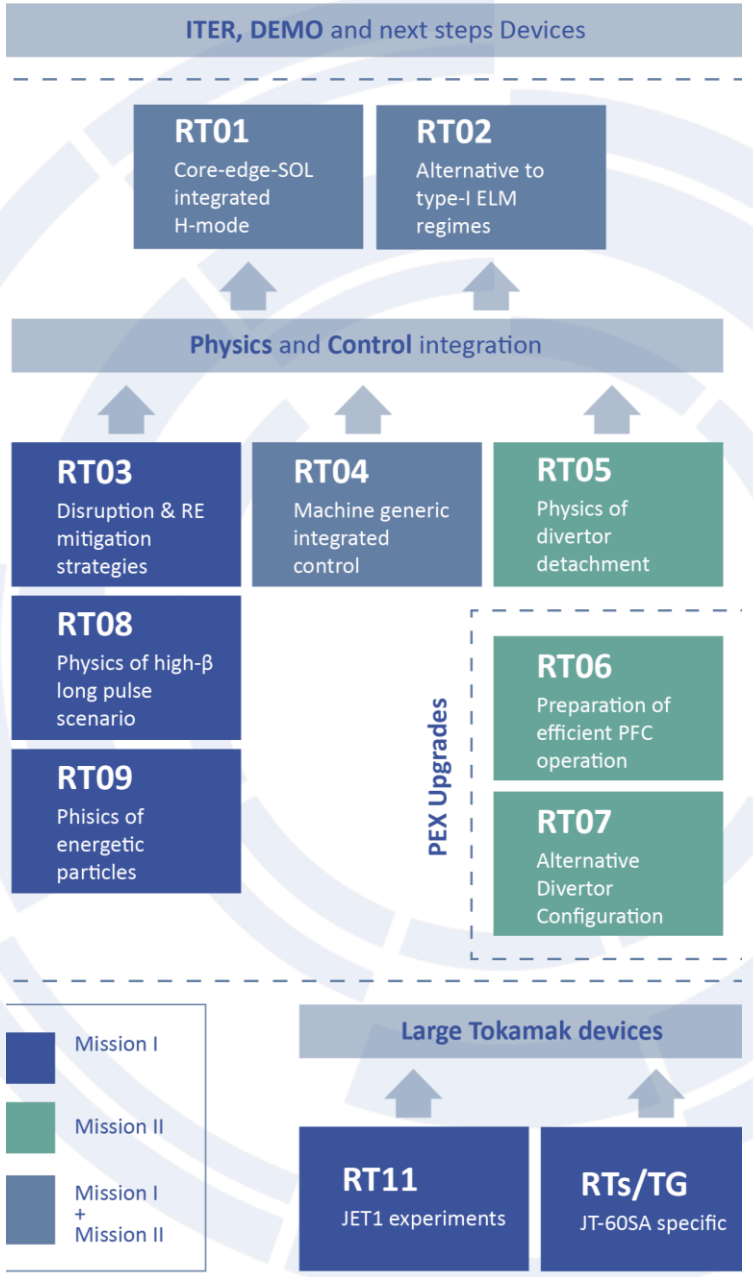
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This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Introduction

- RT-049 is bridges missions 1 and 2, with a focus on controlling various aspects of the plasma discharge and integrating control techniques.

- RT-04 has experimental branches across all TE devices.



Scientific Objectives and Machine Time

*Sci Objs were revised for 2026-27 due to excellent progress meaning previously defined objectives were all reaching high SSRLs

#	
D6	Develop generalized controllers and state observers designed for application to a variety of devices
D7	Develop integrated control algorithms and techniques for pulse trajectory optimization in view of possible applications to next step device controller
D8	Optimize off normal events handling and disruption avoidance strategies for machine protection
D9	Integrate machine learning and physics driven techniques for control augmentation and performance boosting

	AUG	TCV	MAST-U	WEST
Shots ’26: allocated/ run useful	15/8 (+6)	60/68	16/16	30/20
Tentative allocation 2027	25	120	0	30

From Jan 26 strategy: P1 proposals vs. Sci. Objective

Proposal Name	D6	D7	D8	D9	Comments
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design					Continuation 2025
P77: Continuation of exhaust control demonstration in ADCs					Relevance to RT07, RT05
P79: Development of model predictive control for power exhaust					Uncertain due to hardware development requirements
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation					Backup, cross-machine proposal for 2027
P60: Real time ICRF coupling control					Relevance to ITER tasks, cross-machine proposal
P64: Model-based observer of kinetic profiles and safety factor					
P75: MIMO control electron density and magnetic shape					
P93: Continuous control from attachment to XPR					
P65: Standardisation of camera based front control					
P78: Generalized radiator control via energy balance in the boundary					
P80: Multi-machine, model-based profile control of kinetic profiles and safety factor					Matched with P64, should work closely together
P85: Advanced magnetic control					Continuation of 2025; backbone for TCV control, related to RT07
P86: Integrated Control and Plasma Trajectory Optimization					Only “big” proposal on full integrated control in RT04
P87: Psep/PLH control using heating power and impurity radiation					
P57: Coil current optimisation for trapped particle configuration					Technology transfer from work on MAST-U
P59: ICRF-assisted plasma start-up					Matched with P57 for work on TPC
SSRL					

Note on arrangement of Proposals/Sci. Objectives in RT-04

- RT-04 matches a number of proposals to Sci. Objectives and experiments are carried out under a proposal number
- This is a convenience for this RT since, whereas a number of research ‘threads’ lead to the achievement of the Sci. Objective, the different aspects were proposed under separate proposals
- Subsequent prioritisation, grouping, and shot allocation ensures that the “multi-machine” purpose of WPTE, along with integrated experiments is fully embraced, whilst keeping individual ‘threads’ listed under their original proposal number.

P1 2026 proposals shot allocation (Results, Pending, Planned 2027)

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design		4			4
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation		4 (backup)			4
P60: Real Time ICRF coupling control	10			5	15
P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor			8	5	13
P93: Continuous control from attachment to XPR				5	5
P65: Standardisation of camera based front control			10-> ~6		10
P75: integrated magnetic and kinetic control			~6	~6	
P78: Generalized radiator control via energy balance in the boundary			10		10
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		6
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

P1 2026 proposals shot allocation (Results, Pending, Planned 2027)

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design		4			4
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation		4 (backup)			4
P60: Real Time ICRF coupling control	10			5	15
P64: Model-based observer of pl				5	13
P93: Continuous control from att				5	5
P65: Standardisation of camera b					10
P75: integrated magnetic and kinetic control				~6	
P78: Generalized radiator control via energy balance in the boundary			10		10
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		6
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

Note: "Results obtained" does not necessarily mean experiment completed.
Further shots in 2027 required in many cases.

Note: Implementation of control algorithms (from WPTE proponents)

Proposals requiring implementation of algorithms in machines' control software:

- Modifications must be fully assessed for feasibility and any potential safety implications by local tech. team
- Installation and any necessary offline testing requires additional effort by local team

This work is is recognized as an additional task to "normal" session preparation activities and needs to arranged specifically.
To address this, TFLs propose holding a **dedicated meeting well in advance** to discuss the proposed implementation for control algorithms.

Participants:
- One of the TFLs (meeting chair)
- Proponents of the proposed work
- Control group experts (from the host lab)
- Machine representative (from the host lab)

Expected outcome from the first meeting:

- An initial assessment of the feasibility of the proposed implementation
- The manpower required to carry it out

For RT-04, this will likely include experiments on AUG and WEST in 2027

D6 2026/27: Develop generalized controllers and state observers designed for application to a variety of devices

P1 2026 proposals for D6:

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design		4			4
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation		4 (backup)			4
P60: Real Time ICRF coupling control	10			5	15
P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor			8	5	13
P93: Continuous control from attachment to XPR				5	5
P65: Standardisation of camera based front control			10-> ~6		10
P75: integrated magnetic and kinetic control			~6	~6	
P78: Generalized radiator control via energy balance in the boundary			10		10
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		6
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

D6 2026/27: Magnetic control [TCV]

Results, Pending 26, Planned 2027

- **P85** large proposal on magnetic control

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
85	D6	Magnetic control developments			50		50	Adriano Mele	

- (Also partially related to magctrl in **P75** included in D7 strategy)
- Expts 2026
  - [TCV]: P85

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P85: Advanced magnetic control			14		12

- Further TCV expts planned in 2026, continuing priorities in 2027:
  - Priority 2027: shape controller with improved switching logic and automated target equilibria from shot preparation – commission and exploit.

D6 2026/27: Core density and/or profile control

Results, Pending 26, Planned 2027

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
64	D6	Kinetic and q profile observer and control using RAPTOR	10		20	10	40	Simon Van Mulders	
80	D6	Development of model-based internal profile control			15	10	25	Simon Van Mulders	P2 AUG

- **Expts 2026:**
  - **[TCV]: P64,P80**
  - **[TCV+AUG]: P64 (, P75)**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor			8	5	13
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		8
(P75: integrated magnetic and kinetic control)			~6	~6	

Priority 2027:

- TCV: RAPTOR-EKF observer deployed, local control of Te/ne (core), control of ne(rho=0.95), initial limited trial of qmin control
  - Priority 2027: Control methodologies to be extended on TCV
- AUG: RAPDENS/RAPTOR observers developed
  - Working with AUG to understand if developed controllers may be implemented
  - If so, v. high priority for expts
  - Otherwise, expts under P64 irrespective of above conditions

D6 2026/27: Heating & auxiliaries

Results, Pending 26, Planned 2027

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
53	D6	Stray radiation minimization via real-time polarization control			10		10	Fabio Graziano	
60	D6	Real-time ICRF coupling control for ITER	20			20	40	Ernesto Lerche	• Relevance to ITER tasks, cross-machine proposal • 2027 AUG
61	D6	ICRH coupling control with density profiles from real-time reflectometry	18				18	Maylis Carrard	1 session in 2026, 1 session in 2027 NB: P61 combined with P60

- **Expts 2026:**
  - **[TCV]: P53**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P60 (+P61): Real Time ICRF coupling control	10			5	15

Priority 2027:

- Initial expts. on TCV under P53, to be completed with RT-ECE including polarization control
- Work begun on P60/61 WEST, to be completed 2027, AUG branch pending

D6 2026/27: Exhaust (1)

Results, Pending 26, Planned 2027

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
81	D6, D8	First wall temperature estimation and heat load control			20		20	Federico Pesamosca	Continuation of 2024-25
78	D6	Generalized radiator control via energy balance in the boundary	10		10	10	30	Hao Yang	P2 AUG
65	D6,D9	Standardization of camera based front control for physics studies		8	16		24	Gijs Derks	P2 MAST-U
77	D6,D7	Continuation exhaust control in ADC's		8			8	Paulo Figueiredo	
79	D6, D9	Development of model predictive control for power exhaust		14	30		44	Paulo Figueiredo	Uncertain due to hardware development requirements
93	D6, D7	Continuous control from attachment to XPR				4	4	Pierre David	2026 AUG

- A large topic within D6 on all 4 active machines

D6 2026/27: Exhaust (2)

Results, Pending 26, Planned 2027

- Expts 2026
  - **[TCV]: P81, P78, P65**
  - **[MAST-U]: P77, P79**
  - **[AUG]: P93**
  - **[WEST]: P78**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P81: First wall temperature estimation and heat load control					
P78: Generalized radiator control via energy balance in the boundary			10		10
P65: Standardisation of camera based front control			10-> ~6		10
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P93: Continuous control from attachment to XPR				5	5

Priority 2027:

- Analysis of results obtained from from MAST-U/TCV in 2026
- Experimental priority on WEST/AUG for 2027
  - Focus on P78 (also P64)
  - NB AUG requires preparatory software installation – feasibility of P93/AUG depends on this step.
- Further priority work on TCV under P79/81
- Note: SILO baffles config. Relevant for detachment access.

D7 2026/27: Develop integrated control algorithms and techniques for pulse trajectory optimization in view of possible applications to next step device controller

P1 2026 proposals for D7:

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design		4			4
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation		4 (backup)			4
P60: Real Time ICRF coupling control	10			5	15
P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor			8	5	13
P93: Continuous control from attachment to XPR				5	5
P65: Standardisation of camera based front control			10-> ~6		10
P75: integrated magnetic and kinetic control			~6	~6	
P78: Generalized radiator control via energy balance in the boundary			10		10
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		6
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

D7: Plasma Startup

ID	SD	Brief	WEST	MAST-U	TCV	ASDEX	Total	Proponent	Comment
57	D7	Current optimised Trapped Particle Configuration for ICRF assisted start-up	20	8			28	Charles Vincent	P2 MAST-U
59	D7	ICRF assisted plasma start-up in WEST (continuation)	20				20	Ernesto Lerche	2 sessions in 2026

- **Expts 2026:**
  - **[MAST-U]: P56 (offline work)**
  - **[WEST]: P55, P59**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

Priority 2027:

- The P57 WEST part of this Sci. Objective is pending, could be allocated priority time in 2027 if not completed

D7: Integrated control

ID	SD	Brief	WEST	MAST-U	TCV	ASDEX	Total	Proponent	Comment
75	D7	MIMO controller for regulating electron density profile with gas puffing, pellet injection and magnetic coils	19		22	19	60	Loes Jansen	2027 AUG Combine with 63
86	D7, D8, D9	Integrated Control for Disruption-Free Operations and Robust Plasma Trajectory Optimization			45		45	Alessandro Pau	

- **Expts 2026:**
  - **[TCV, WEST, AUG, MAST-U]**: **P75, (related: P77, P64/80)**
  - **[JET-TFTR]: (Expt. Data Analysis)** Dud-detection methods proposed

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P75: integrated magnetic and kinetic control			~6	~6	
P86: Integrated control and plasma trajectory optimization			12		12

Priority 2027:

- TCV: P86 – integrate systemID work to controllers and demonstrate on plasma with all power available
- AUG: P75 – demonstrate integrated control (requires software integration – see “D6: density ctrl.”))

D7: Scenario performance/optimization

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
87	D7, D9	Psep/PLH control using heating power and impurity radiation			12	12	24	Spyridon Aleiferis	P2 AUG
93	D6, D7	Continuous control from attachment to XPR				4	4	Pierre David	2026 AUG

- **Expts 2026:**
  - **[AUG, MAST-U]**
  - **Modelling [AUG+MAST-U, TCV]**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P93: Continuous control from attachment to XPR				5	5

Priority 2027:

- TCV: P87, P LH threshold control experiments
- AUG: P93 – requires software integration

D8 2026/27: Optimize off normal events handling and disruption avoidance strategies for machine protection

P1 proposals for D8:

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design		4			4
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation		4 (backup)			4
P60: Real Time ICRF coupling control	10			5	15
P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor			8	5	13
P93: Continuous control from attachment to XPR				5	5
P65: Standardisation of camera based front control			10-> ~6		10
P75: integrated magnetic and kinetic control			~6	~6	
P78: Generalized radiator control via energy balance in the boundary			10		10
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		6
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

D8 2026/27: Optimize off normal events handling and disruption avoidance strategies for machine protection

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
58	D8	Mitigation of tungsten dust ingress with ECRH	38				38	Patrick Maget	
66	D8, D9	Design and test of a novel DUD detection based on TFTR and JET DT plasmas			5		5	Lidia Piron	Carry-on from 2025
81	D6, D8	First wall temperature estimation and heat load control			20		20	Federico Pesamosca	
86	D7, D8, D9	Integrated Control for Disruption-Free Operations and Robust Plasma Trajectory Optimization			45		45	Alessandro Pau	

D8 2026/27: Optimize off normal events handling and disruption avoidance strategies for machine protection

- **Expts 2026:**
  - **[TCV]: P66, P86**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P58: Mitigation of tungsten dust ingress with ECRH					
P66: Design and test of a novel DUD detection based on TFTR and JET DT plasmas					
P81: First wall temperature estimation and heat load control					
P86: Integrated control and plasma trajectory optimization			12		12

Priority 2027:

- [WEST]: P58 – requires ECRH, commissioning imminent.
- [TCV]: P81/86 – requires Auxiliary power available
- [TCV]: P66 – Detector designed via modelling, to be applied to TCV in 2027

D9 2026/27: Integrate machine learning and physics driven techniques for control augmentation and performance boosting

P1 proposals for D9:

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P53: Stray radiation minimization via real-time polarization control					
P56: Integration of RAPTOR and CREATE-ILC for advanced pulse design		4			4
P77: Continuation of exhaust control demonstration in ADCs		4			4
P79: Development of model predictive control for power exhaust		8			8
P72: EF detection studies in AUG and MAST-U in preparation to ITER operation		4 (backup)			4
P60: Real Time ICRF coupling control	10			5	15
P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor			8	5	13
P93: Continuous control from attachment to XPR				5	5
P65: Standardisation of camera based front control			10-> ~6		10
P75: integrated magnetic and kinetic control			~6	~6	
P78: Generalized radiator control via energy balance in the boundary			10		10
P80: Multi-machine, model based profile control of kinetic profiles and safety factor			8		6
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiatoion			8		2
P57: Coil current optimisation for trapped particle configuration	10				10
P59: ICRF-assisted plasma start-up	10				10

D9 2026/27: Integrate machine learning and physics driven techniques for control augmentation and performance boosting

ID	SD	Brief	Requested pulses					Proponent	Comment
			WEST	MAST-U	TCV	ASDEX	Total		
65	D6,D9	Standardization of camera based front control			12		12	Gijs Derks	
66	D8, D9	Design and test of a novel DUD detection based on TFTR and JET DT plasmas			5		5	Lidia Piron	Carry-on from 2025
85	D6, D9	Magnetic control developments			50		50	Adriano Mele	Extension of ML techniques implemented in 2025 foreseen
86	D7, D8, D9	Integrated Control for Disruption-Free Operations and Robust Plasma Trajectory Optimization			45		45	Alessandro Pau	
87	D7, D9	Psep/PLH control using heating power and impurity radiation			12	12	24	Spyridon Aleiferis	P2 AUG

D9 2026/27: Integrate machine learning and physics driven techniques for control augmentation and performance boosting

- **Expts 2026:**
  - **P65, 66, 75, 77, 85, 86, 87 include relevant data**

Proposal Name	WEST	MAST-U	TCV	ASDEX	Total
P65: Standardisation of camera based front control			10-> ~6		10
P66: Design and test of a novel DUD detection based on TFTR and JET DT plasmas					
P75: integrated magnetic and kinetic control			~6	~6	
P77: Continuation of exhaust control demonstration in ADCs		4			4
P85: Advanced magnetic control			14		12
P86: Integrated control and plasma trajectory optimization			12		12
P87: Psep/PLH control using heating power and impurity radiation					

Priority 2027:

- Experimental work for relevant proposals organised under D6/D7 section
- Subsequent analysis tasks for D9 organised offline.

Priority expt summary by machine (1)

The following proposals, in full or in part and appropriately combined, therefore form the basis of the priority 2027 experimental program by machine:

TCV:

- P85: shape controller with improved switching logic and automated target equilibria from shot preparation – commission and exploit.
- P64/80: Control methodologies to be extended on TCV
- P53: Work begun in 2026 to be completed with RT-ECE including polarization control
- P79/81: model predictive control for power exhaust and 1st wall heat load control
- P86: integrate systemID work to controllers and demonstrate on plasma with all power available
- P87: P LH threshold control experiments
- P66: Dud detector designed via modelling, to be applied to TCV in 2027

WEST:

- P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor
- P78: Generalized radiator control via energy balance in the boundary
- P60/61: RT ICRF coupling control, to be completed 2027
- P58:Mitigation of tungsten dust ingress with ECRH
- (P57: coil current optimisation for trapped ptcl. Config. - WEST part of this Sci. Objective is pending in 2026, could be allocated priority time in 2027 if not completed.)

Priority expt summary by machine (2)

The following proposals, in full or in part and appropriately combined, therefore form the basis of the priority 2027 experimental program by machine:

AUG:

- P75: integrated magnetic and kinetic control
- P64: Model-based observer of plasma profiles enabling integrated control over kinetic profiles and safety factor
- P80: Multi-machine, model based profile control of kinetic profiles and safety factor
- P93: Continuous control from attachment to XPR

Summary

- Great work done in 2026 enabling a plan to build on these results in 2027 towards high SSRL in all Sci. Objectives

- You are invited to make strong bids in all areas where you can support the indicated priority experimental and/or analysis work.

Backup

NB: Previous GPM presentation including assessment of all proposals can be found at the Indico page:

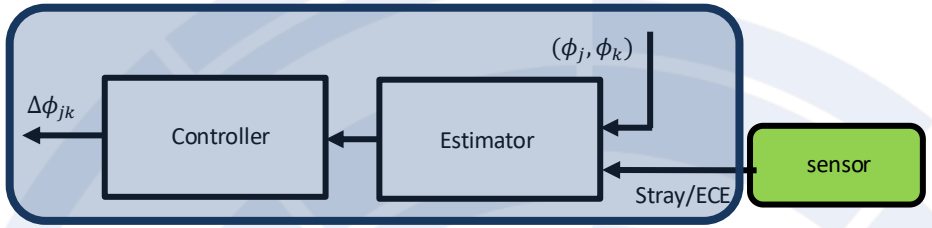
https://indico.euro-fusion.org/event/3646/timetable/#all

P53: Stray radiation minimization via RT polarization control

- **Scientific Background & Objectives**
  - Minimizing stray radiation is crucial to ensure efficient ECRH power coupling and prevent component damage, especially during long plasma pulses.
  - Testing advanced control strategies for proper beam alignment and polarization is essential for current and future devices such as DTT, ITER, and Wendelstein 7-X.
  - Develop and validate a real-time polarization control scheme for ECRH coupling optimization and stray radiation minimization, assessing its dynamics and performance on TCV.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Commission the real-time ECRH polarization closed-loop control scheme using ECE diagnostics or stray detectors.
  - Start with a basic extremum seeking controller, then progressively integrate advanced features such as Kalman-based gradient estimation
  - Evaluation of ECE–stray data fusion a

- TFL assessment: P1-TCV
- Aligned with D6



- (ϕ_j, ϕ_k): mechanical polarizers angles
- $\Delta\phi_{jk}$: polarization corrective term

Proponents and contact person:

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Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	10	
WEST		

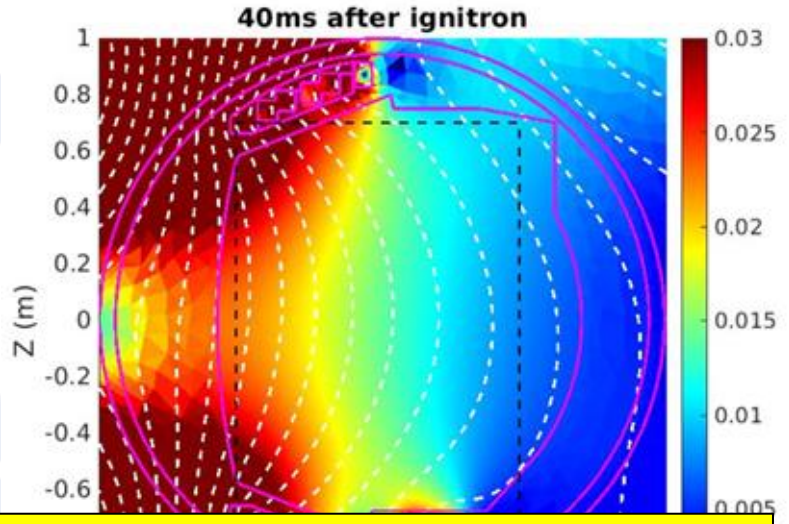
P57: Coil current optimisation for trapped particle configuration

- **Proponents and contact person:**

C. Vincent, L. diGrazia, D. Frattolillo, M. Mattei, A. Fil, E. Lerche, J. Hillairet, T. Wauters, P. Maget, F. Maiden, S. Freethy

- **Scientific Background & Objectives**
  - Non-inductive heating assisted start-up critical for ITER to reduce v_loop requirements, with TPC showing potential for more efficient IC breakdown
  - WEST explored IC-assisted start-up v-loop limits but TPC attempts unsuccessful; CREATE-ILC proven effective on MAST-U
  - Apply CREATE-ILC to optimize TPC on MAST-U and WEST for cross-machine validation and demonstration on ITER-like device
  - Objectives:
- Show breakdown and burnthrough of the TPC configuration with NBI assisted heating on MAST-U to validate the magnetic configuration for WEST
- Apply CREATE-ILC to the TPC on WEST and compare to previous shots to compare the coil current trajectories
- Successfully breakdown with TPC on WEST and apply IC pre-ionisation to show reduced vloop requirements for startup

- **Exp. Strategy/Machine Constraints and diagnostics**
- Use WEST TPC to generate coil current trajectories for MAST-U
- Use MAST-U optimised TPC field to generate coil current trajectories on WEST
- Compare vloop lower limit with TPC and IC to conventional WEST null experiments already performed



- TFL assessment: P2-MAST-U, P1-WEST
- Aligned with D7
- NBI in startup on MAST-U to be checked

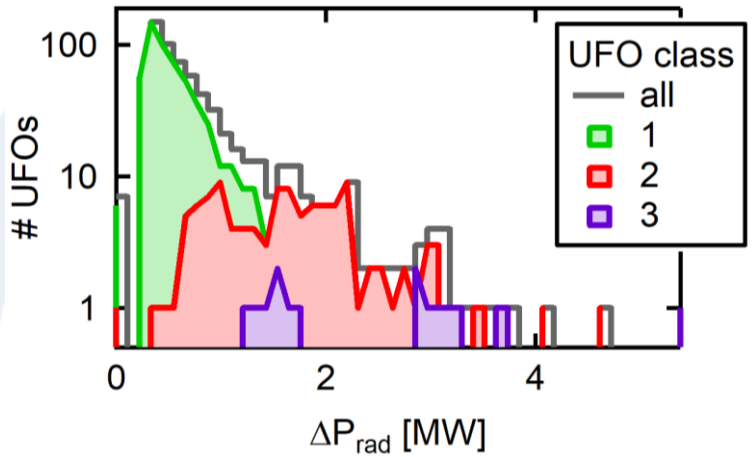
Device	# Pulses/Session	# Development
MAST-U	8 shots	8 shots
WEST	20 shots	10 shots

P58: Mitigation of tungsten dust ingress with ECRH

- TFL assessment: P1-WEST
- Aligned with D8
- Reduce by 50%, first part parasitic?

- **Proponents and contact person:** P. Maget (*patrick.maget@cea.fr*), R. Dumont, Guirlet, P. Manas, R. Nouailletas, S. Mazzi, P. Devynck, L. Delpech, E. Lascar (IRFM), Gaspar (AMU), M. Schneider (IO), R. Granetz & H. Wietfeldt (MIT)

- **Scientific Background & Objectives**
  - Tungsten deposits can generate dust ingresses with large operational impact *[Gaspar NME'24, Maget PPCF'25]*
    - ***These events could be mitigated with appropriate core ECRH heating***
  - Objectives :
    - ***Evaluate the scaling of the ECRH power needed with the dust size on WEST,***
    - ***Implement a control scheme dedicated to this issue in the PCS***
    - ***Design integrated simulations to extrapolate to larger devices***
  - WP TE RT04 (experiment), TSVV-H (modelling and extrapolation), ITPA-MDC-JA-4
- **Experimental Strategy/Machine Constraints and essential diagnostic**
- L-mode plasma with Laser Blow Off (LBO) on tungsten and Ni/Fe/Al targets
  - *Ohmic and LHCD / ICRH heated plasmas,*
  - *scan LBO intensity, ECRH power and delay (feedforward)*
  - *Test triggers for activating ECRH power in the PCS: core bolometry line / core ECE*
- Essential diagnostics: real time bolometry / ECE, VUV, standard diagnostics



Distribution of radiation peaks due to tungsten ingresses in WEST high fluence campaign (class 1 within scenario resilience domain, classes 2 / 3 lead to delayed / immediate disruptions)

Proposed pulses

Device	# Pulses	# Develop
WEST	20	18

P59: ICRF-assisted plasma start-up

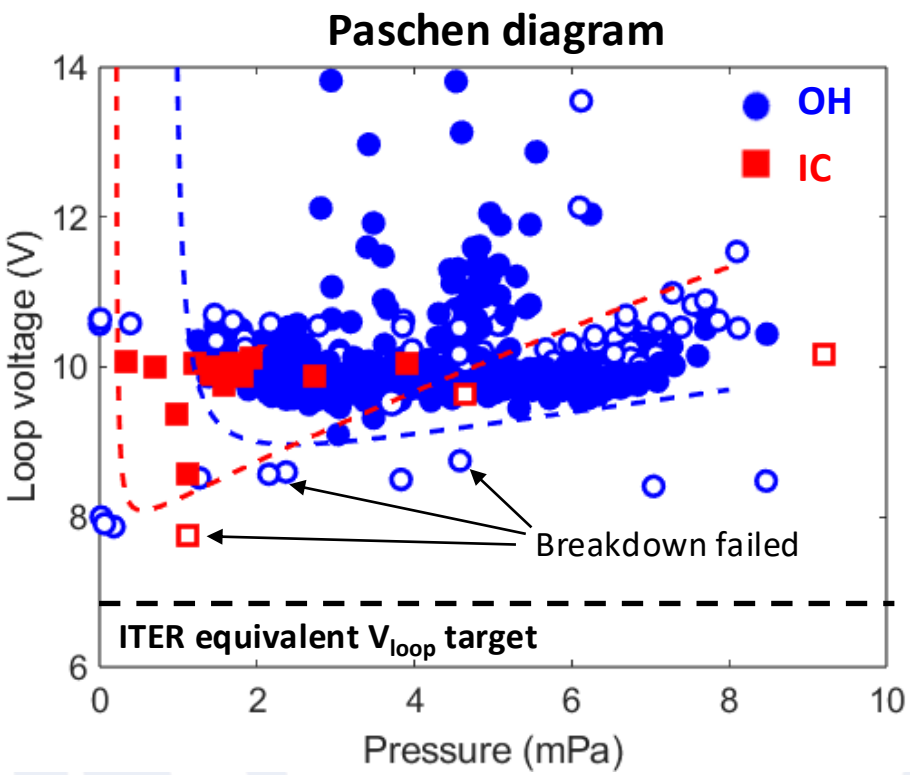
In collaboration with ITPA-IOS JEX 2.4, WP-TSVV and ITER PWI group

- **Proponents and contact person:**

  E. Lerche, J. Hillairet, T. Wauters, L. Colas, P. Dumortier, A. Fil, C. Vincent, …

- **Scientific Background & Objectives**
  - ITER considers IC-assisted start-up as one of the options for plasma breakdown at low V_{loop} or when the machine conditions are unfavorable
  - IC-assisted breakdown was successfully developed in WEST extending the pressure and V_{loop} domain w.r.t. to standard OH breakdown
  - However, the equivalent ITER target V_{loop} was not yet achieved and improved magnetic configurations (e.g. TPC) were not tested
  - Objectives:
    - Extend the IC-assisted breakdown results to lower V_{loop} values
    - Test more complex magnetic configurations for breakdown as the Trapped Particle Configuration (TPC); Collaboration with CREATE team.
    - Provide feedback to the ITPA-IOS task 2.4, to the TSVV breakdown modelling team and to the ITER PWI group

- **Exp. Strategy/Machine Constraints and diagnostics**
  - Start from previous results with low pressure (~1 mPa) and V_{loop}=10V.
  - Gradually reduce V_{loop} until reaching the ITER equivalent target (V_{loop}=7V); Adjust the prefil pressure if necessary.
  - Test / develop a more favorable magnetic configuration (TPC-like) and assess whether it's easier to reduce V_{loop} in these conditions
  - Study the benefits / drawbacks of IC-assisted start-up in the I_p ramp-up and flat-top phases



Paschen curve illustrating IC-assisted vs. OH

- TFL assessment: P1-WEST
- Aligned with D7
- Reduce by 50%

Device	# Pulses/Session	# Development
WEST	2 Sessions (two in 2026)	Scenario is ready

P60: Real time ICRF coupling control

In collaboration with ITPA-IOS JEX 5.1/5.2 and with ITER PCS development

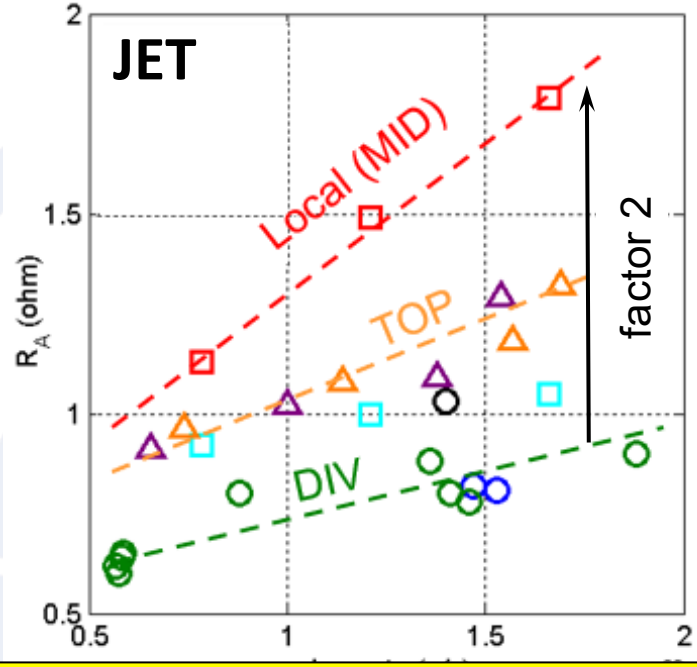
- **Proponents and contact person:**

  E. Lerche, L. Colas, J. Hillairet, V. Bobkov, R. Ochoukov, P. Dumortier, W. Helou, …

- **Scientific Background & Objectives**
  - Local gas injection is one of the main actuators for optimizing the ICRF coupling in tokamaks, but closed-loop real-time control based on this was never tested
  - ITER foresees local IC gas injection and they want to integrate this procedure in the PCS (Plasma Control System) controller in real-time
  - Objectives:
  - Implement real-time control of the IC coupling based on local gas injection
  - Study the dynamics and efficiency of the control systems in various devices and provide feedback to the ITPA-IOS tasks 5.1/5.2 and to the ITER team designing the global PCS control system

- **Exp. Strategy/Machine Constraints and diagnostics**
  - The first step is to develop & commission the real-time control network for IC coupling; This can be done off-line but requires ~1 week work with 2 specialist. The staff is available in WEST and in AUG and is aware of the strategy.
  - Start with the simplest possible RT network (input=R_c, output=gas rate) and increase complexity with time (2027), e.g. include outer gap control (ROG), PWI aspects, etc …
  - Plasma target: Standard plasma with large clearance; ROG/shape scans; Low ICRH power ~1MW.
  - Basic diagnostics only. IC coupling resistance available in real-time. Edge / PWI diagnostics desired.
  - In WEST, real-time information and control of the SOL density via reflectometry is available. This can add to the assessment and physics understanding of the real-time coupling control technique.

E. Lerche et al 2015 *Journal Nucl. Mat.* **463** p634



- TFL assessment: P1-2027-AUG,P1-WEST
- Aligned with D6

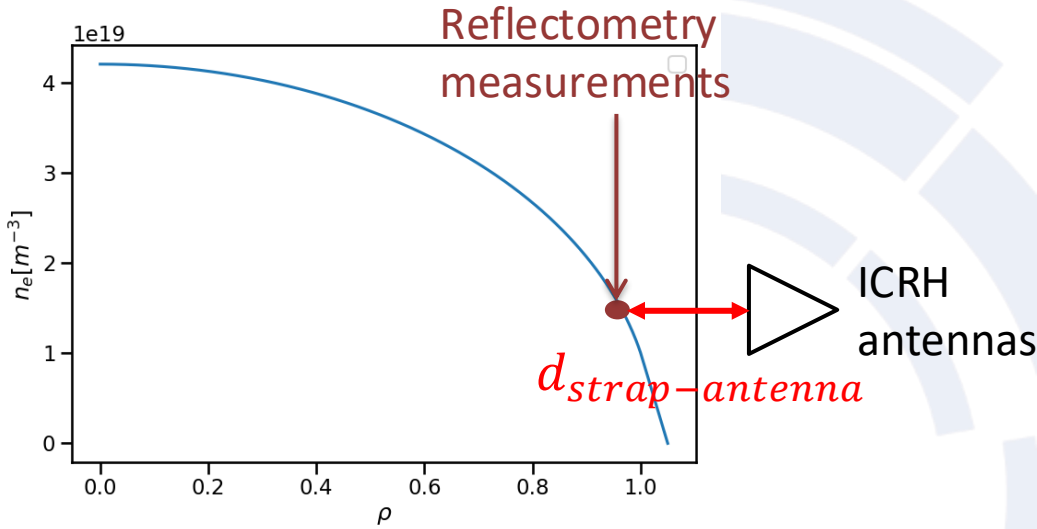
Device	# Pulses/Session	# Development
AUG	2 Sessions (one 2026, one 2027)	1 week off-line and 1-2 days on plasma (parasitic)
WEST	2 Sessions (one 2026, one 2027)	1 week off-line and 1-2 days on plasma (parasitic)

P61: ICRH coupling control with density profiles from real-time reflectometry

- **Proponents and contact person:**
- maylis.carrard@cea.fr
- laurent.colas@cea.fr

- **Scientific Background & Objectives**
  - Reflectometry envisaged as a multi-purpose sensor for real-time control in ITER.
  - ICRH wave coupling depends on distance $d_{strap-cutoff}$, the distance to the critical density $n_{e\ strap}$
  - WEST reflectometry provides in real-time local density profiles and radial position R_{cutoff} of the critical density layer. Proof-of-principle experiments carried out in 2025 [Carrard PPCF 2025]

→ Goal: As part of ITPA task IOS 5.2 & WP-TE RT04, control ICRH coupling using real-time estimates of R_{cutoff}



Proposed pulses

Device	# Pulses/Session	# Development
WEST	1 session/16 pulses	2 pulses

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Double real-time control of core density using interferometer and plasma position (R_{ext}) using reflectometer.
  - Fixed I_p, increase requested core density during pulse and request R_{ext} control to maintain fixed cutoff position R_{cutoff}, as measured in real-time by reflectometer.
  - Fixed core density, vary requested I_p during pulse and request R_{ext} control to maintain fixed cutoff position R_{cutoff}, as measured in real-time by reflectometer.
  - Check variations of ICRH coupling resistance over the pulse.

- TFL assessment: P1-WEST
- Aligned with D6
- Combine with P60

P64: Model-based observer of the internal plasma profiles enabling integrated control over kinetic profiles and safety factor

- **Proponents and contact person:**

simon.vanmulders@epfl.ch et al.

- **Scientific Background:**

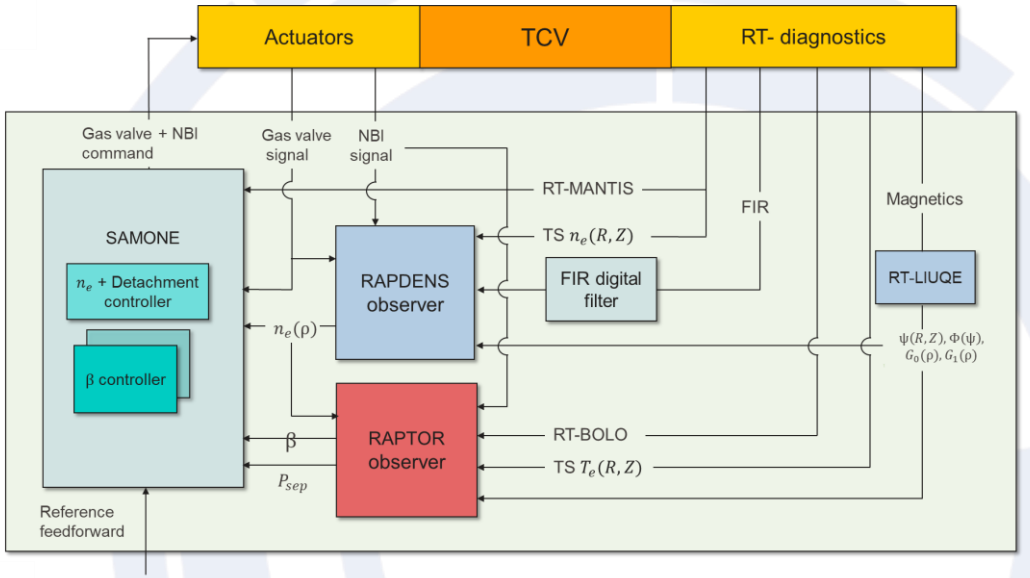
- Model-based observers are essential for coordinated control of the dynamic evolution of kinetic and safety factor profiles.
- The Extended Kalman Filter combines diagnostic data and physics models, improving real-time plasma state knowledge while accounting for uncertainties.
- The RAPTOR solver enables faster-than-real-time profile prediction, supporting both feedforward scenario design and feedback control during experiments.

- **Objectives:**

- **Real-time q min control:** Perform experiments on TCV (≈10 shots) to regulate $q$min between 0.9 and 1.2, observing sawtooth behavior. This controller will support access to flux pumping and high-$q$min/negative shear regimes (link with RT08 topic).
- **Real-time Ti/Te control at constant Wmhd:** Extend previous inter-discharge RAPTOR results to real-time implementation on TCV (≈10 shots), maintaining constant total stored energy.
- **Pre-LHCD profile shaping on WEST:** Simultaneous control of $Te0$ and $q0$ to achieve a peaked q-profile before lower hybrid heating, mitigating harmful MHD activity.
- **Control of ne0 and Te0 at AUG:** Simultaneous control of density and temperature at AUG with the improved state observers, using pellets, gas valve and ECRH actuators.

- **Experimental Strategy/Machine Constraints and essential diagnostic:**

- RT-RAPTOR, RT-CXRS, RT-TS, RT-ECE, RT-BOLOMETRY, ECRH, PELLETS (AUG)



Proposed pulses

Device	# Pulses/Session	# Development
AUG	10	0
MAST-U	-	-
TCV	20	0
WEST	10	0

- TFL assessment: P1-2026-AUG,P1-WEST-2027,P1-TCV
- Aligned with D6,D7

P65: Standardisation of camera based front control

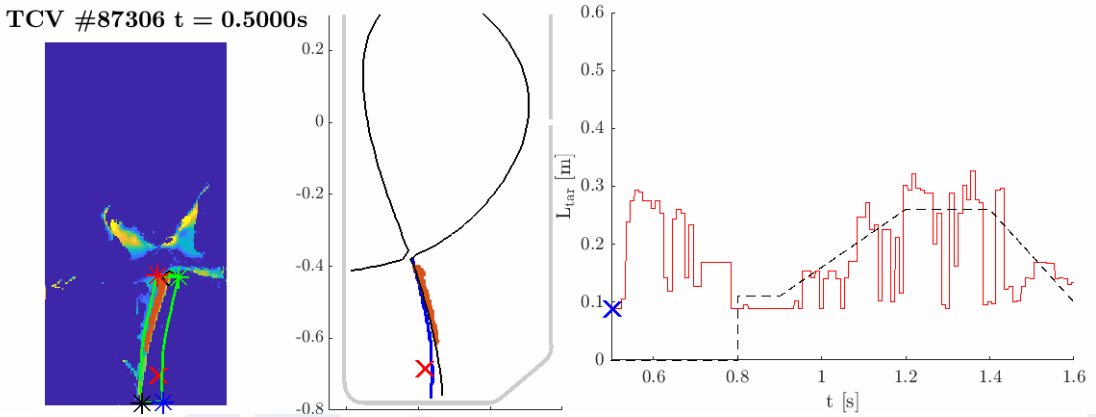
Multi-spectral camera system MANTIS may/will be installed on JT-60SA

ENR11, WPTE RT05-2025 inference exhaust control

- **Proponents and contact person:**
- G.l.derks@differ.nl
- **Scientific Background & Objectives**

- D6 - Develop generalized controllers and state observers designed for application to a variety of devices
- D9 - Integrate machine learning and physics driven techniques for control augmentatior performance boosting
  - MANTIS real-time ML inversions and inferences used for front control on TCV.
  - Outcome ENR11 and last WPTE campaign.
  - Provide real-time 2D poloidal plasma reconstructions, Te, ne, nD, nHe, etc (3 at a time) .
  - Front tracking without shot2shot tuning for projection to poloidal plane.
  - Multi-Wavelength-Imaging pc (a copy of the MANTIS pc) on MAST-U will get GPU.
  - MAST-U cameras installed in upper and lower divertor and looking at Xpoint.
  - MANTIS installed on AUG and may be on JT-60SA
  - **Support: front control on TCV in (totally baffled) long-legged divertor, X-point target and H-mode with ELM filter and MARFE mitigation.**
  - **Support: front control on MAST-U SXD and possibly XPR with Xpoint imaging**
  - **Support: inversion and inference pipeline on AUG for physics analysis.**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - On TCV commission inversion based control in new shapes required by RT05 and RT07 and for H-mode (4 shots per config, LLD, TBLLD, XPT, H-mode) (16 shots total)
  - On MAST-U install GPU capabilities and commission front output to PCS. (given a scenario, 4 shots per camera MWI bottom, X-point imaging maybe rewired to bottom MWI pc for GPU) (8 shots total)
  - On AUG run density/impurity ramps to tes
    disruption (4 shots)



Proposed pulses

Device	# Pulses/Session	# Development
AUG		4
MAST-U	8 pulses	RT05/RT07
TCV	16 pulses	RT05/RT07
WEST		

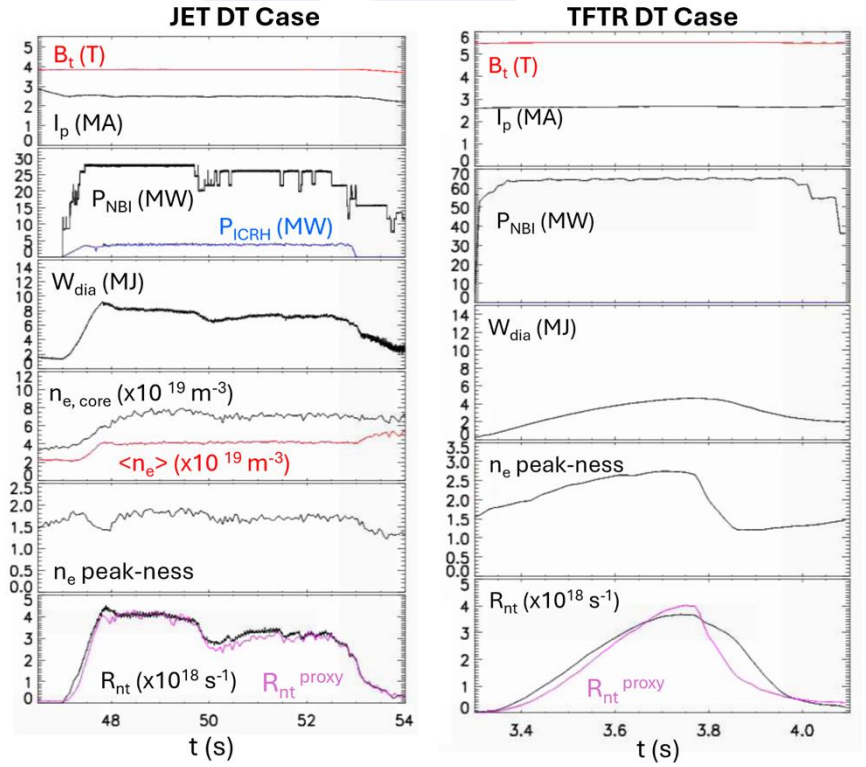
- TFL assessment: P1-TCV, P2-MAST-U Aligned with D6

P66: Design and test of a novel dud detection based on TFTR and JET DT plasmas

- **Scientific Background & Objectives**
  - Among the burning plasma controllers for magnetic fusion reactors, the dud detector will be of primary importance as it will discriminate if the plasma is performing well or if it is a dud.
  - To this scope, a monitor which follows the plasma performance behavior will be included in the plasma control system of next step fusion reactors.
  - TFRT and JET Deuterium-Tritium plasmas have been analyzed with the scope of identifying new empirical dud detection methods. A new metric, based on the density peakedness and the diamagnetic energy, proves to be a good proxy of the neutron rate.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Design the empirical dud detection based on density peakedness, based on RAPDENS, and the diamagnetic energy.
  - Test this new dud detection algo
    plasma termination.

- TFL assessment: P1-TCV
- Aligned with D8,D9



Proponents and contact person:

Lidia Piron (lidia.piron@unipd.it), Alessandro Pau, Olivier Sauter, Nicolò Ferron,

Proposed pulses

Device	# Pulses/Session	# Development
TCV	5	

P72: EF detection studies in AUG and MAST-U in preparation to ITER operation

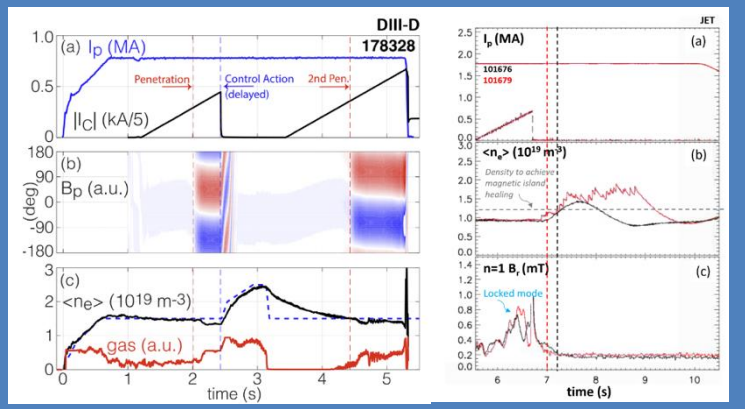
- **Proponents and contact person:**
  - lidia.piron@igi.cnr.it & Carlos Paz-Soldan

- **Scientific Background & Objectives**
  - **Test the non-disruptive compass scan method in plasmas with various q=2 positions in AUG and in MAST-U**
  - **Test the magnetic island healing by RF in AUG**

- **Experimental Strategy/Machine Constraints and essential diagnostic**

  - In AUG, starting from the Ohmic 0.8MA/1.5T scenario,
    - execute the non-disruptive compass scan and test magnetic island healing by gas and by pellet
    - execute the non-disruptive compass scan and test magnetic island healing by ICRH and ECRH
    - execute the non-disruptive compass scan in plasmas with q=2 at various radial positions
  - In MAST-U, starting from the Ohmic 0.75MA/1.5T scenario,
    - execute the non-disruptive compass scan in plasmas with q=2 at various radial positions
  - This experiment er

- TFL assessment: P1-2027-AUG,P2-MAST-U
  Aligned with D7, D8

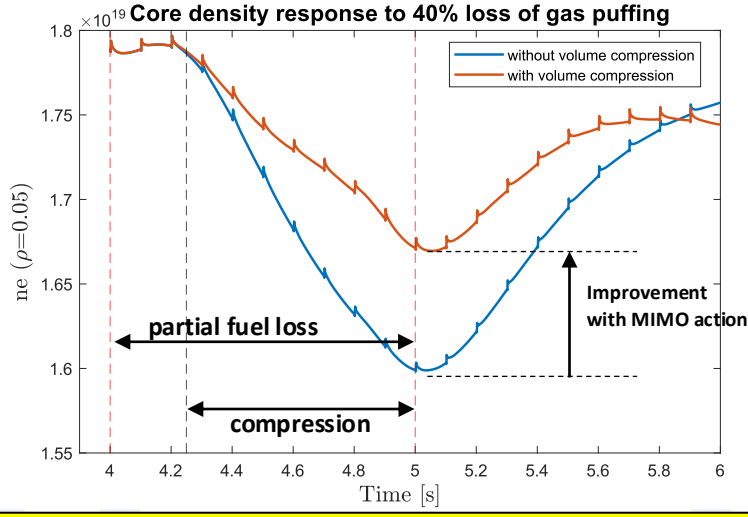


Proposed pulses

Device	# Pulses/Session	# Development
AUG	12	
MAST-U	6	
TCV		
WEST		

P75: MIMO controller for regulating electron density profile with gas puffing, pellet injection and magnetic coils

Proponents and contact person: L. Jansen(L.L.T.C.Jansen@differ.nl),
H. Varadarajan(h.varadarajan@differ.nl), L. Ceelen, C. Orrico, M. van Berkel, D. Frattolillo, L. Di Grazia, M.Mattei, O. Kudlacek



Scientific Background & Objectives

Core density control is done with gas and pellets. However, the magnetic topology (plasma boundary and shape) also influences the density, which is currently underexplored. Combining these actuators that work on different timescales and locations requires an integrated MIMO (Multi-Input Multi-Output) controller.

This proposal aims to

- Quantify **coupling** between gas, pellet and magnetic actuators.
- Develop/validate **control-relevant models** across different machines.
- Develop new strategies to enhance the control of the fusion **power output** and to regulate **ex** under **off-normal events**.
- Design **integrated (MIMO) controllers** that distribute control effort among actuators w different dynamic responses.

- P1-AUG 2027, P1-TCV, WEST combine with 63
- Aligned with D7
- Reduce AUG by 50%

Experimental Strategy

System Identification
Measure dynamic core response to:
(i) gas puffing
(ii) pellets
(iii) plasma boundary position

→

Model validation & controller development
(i) Validate control-oriented models and observer.
(ii) Design MIMO controller.
(iii) Test controller in flight simulator.

→

Experimental validation of controllers
(i) Independent controllers.
(ii) Integrated MIMO controller.
(iii) Explore ramp-down control if (i) and (ii) success.

(no shots required for this block)

Device	# Pulses/Session	# Development
AUG	19	0
MAST-U	0	0
TCV	22	0
WEST	19	0

P78: Generalized radiator control via energy balance in the boundary

Proponents and contact person:

- Hao YANG (hao.yang@univ-amu.fr), Nicolas Fedorczak, Nicolas Rivals, Eric Serre, Guido Ciraolo, Umar Sheikh, Olivier Février, Galperti Cristian, Ou Pan

Scientific Background & Objectives (RT04-D6, D9)

- Reliable control of divertor detachment is crucial for divertor protection and long pulse operations.
- The R_D (ratio of radiated power to conductive heat flux in the SOL, as shown in the equation on the right) based on a simplified model is a useful figure of merit for identifying the divertor state and for detachment/XPR control [Hao Yang et al 2024 Nucl. Fusion 64 106039].
- This work is for the project "Advanced control system development for long pulse tokamak operations" supported by the EUROfusion Engineering Grant 2024.
- Use diagnostics to evaluate R_D in real time, or accelerate the process with machine learning for integration into the feedback control system. Identify system dynamics to refine control system tuning.
- Achieve stable detachment control using optimized control variables and controllers, characterize detachment access and core plasma performance, across different operation conditions in mutli machines: WEST (Improvements to get real-time data of bolometry and TS are needed), TCV and AUG.
- Compare experimental data with SOLEDGE
  to develop a simulation workflow for reliab

- P2-AUG, P1-TCV, P1-WEST
- Aligned with D7

Experimental Strategy/Machine Constraints and essential diagnostic

- Detachment control using R_D as the control variable, with the optimized controller adjusting the D gas puff and N seeding rates (reference shot test plus several control tests with iterative controller optimization: 10 pulses in WEST, 10 in TCV, and 10 in AUG).
- Essential diagnostic: Thomson scattering / Helium beam, Bolometry / AXUV / Spectroscopy

$$R_{\mathrm{D}} = \frac{7Rq_{95}^{2}P_{\mathrm{rad}}}{4ak_{0\mathrm{e}}\lambda_{\mathrm{q}}T_{\mathrm{e,sep}}^{7/2}},$$

Real-time Bolometry/ AXUV / Spectroscopy

Real-time TS / Helium beam
$\lambda q \approx 2/7\ \lambda_T$
Or both estimated by simplified model

- R : Major radius [m]
- a : Minor radius a [m]
- q_{95} : Safety factor (at $\psi_N = 0.95$)
- λ_q : Decay length of heat flux [mm]
- k_{0e} : Electron conductivity coefficient = 2000 (for the plasma in tokamak)
- P_{rad} : Radiation at the downstream of LFS
- $T_{e,sep}$: upstream separatrix electron temperature

Proposed pulses

Device	# Pulses/Session	# Development
AUG	10/1	
MAST-U		
TCV	10/1	
WEST	10/1	

P79: Development of model predictive control for power exhaust

Proponents and contact person:
Paulo Figueiredo (P.A.MarinhoFigueiredo@differ.nl), Jorn Veenendaal, Gijs Derks, Thomas Bosman, Matthijs van Berkel

Scientific Background & Objectives: ITER, DEMO and STEP need to operate within save divertor and core operation limits.

Objectives : Develop a two types of Model Predictive Controller (MPC) strategies (linear MPC and SOLPS-based MPC) for the MAST-U & TCV which,

1. Takes divertor operational limits into account,
2. Predicts and counteracts the effect of known transient disturbances on the divertor state,
3. Corrects for unknown transient disturbances using feedback control.

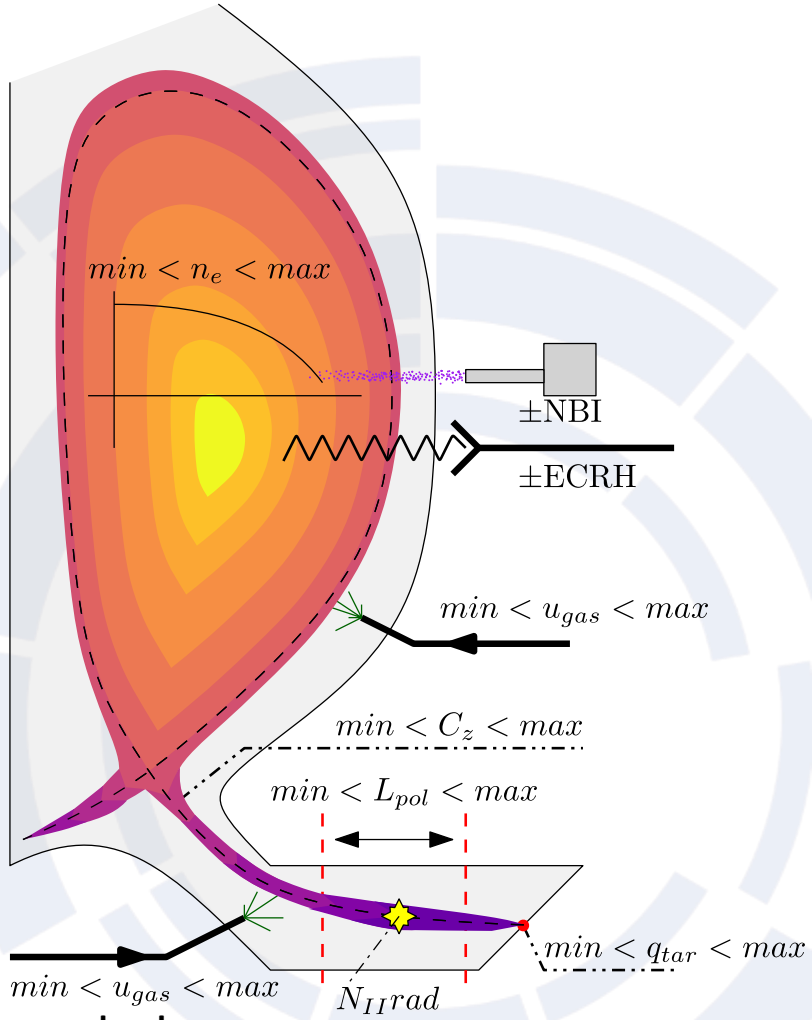
The linear MPC strategy is to show the proof of principle for present day devices with are well diagnosed. The SOLPS-based MPC strategy is aimed towards future reactors which do not feature the same extensive diagnostic coverage.

Experimental strategy:

- **Linear MPC:** Control the Fulcher-band detachment front/NII radiation front, core n_e through direct measurements
- **SOLPS based MPC:** Control the q_{tar} and C_z in the divertor as inferred quantities through a SOLPS-ITER enhanced Kalman observer.
- Compare performance of three controller types: PID based control, linear MPC and SOLPS-based MPC.

Essential diagnostics:

TCV: real-time available MANTIS, interferometer, if possible real-time available bolometry
MASTU-U: real-time available, MWI, interferometer



Proposed pulses

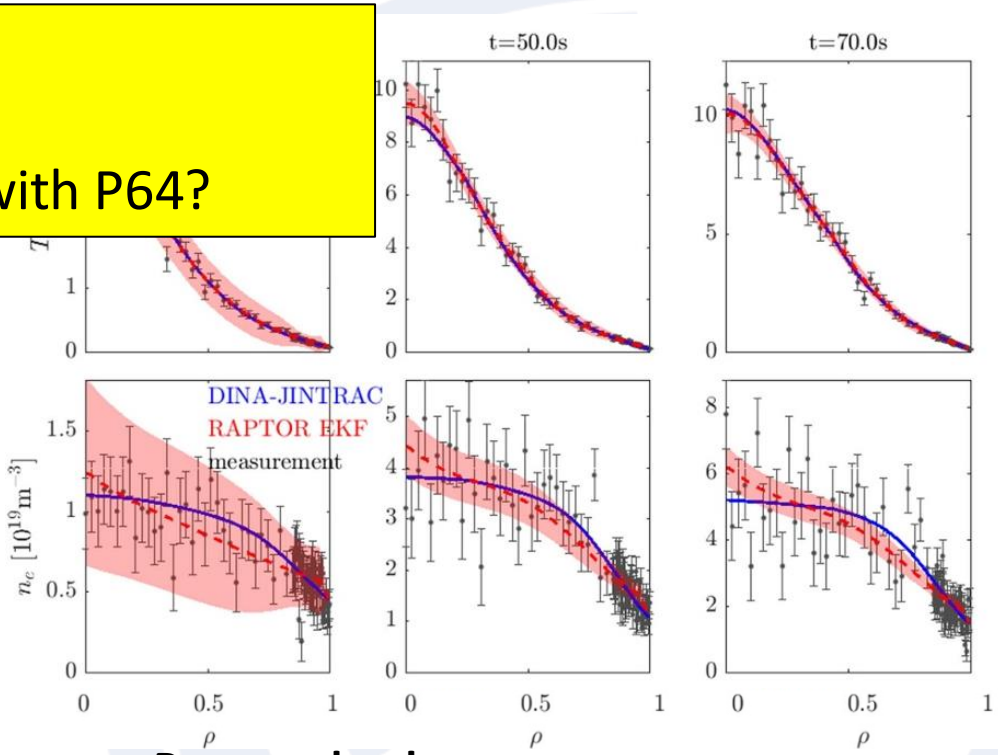
Device	# Pulses/Session	# Development
AUG	-	-
MAST-U	14	-
TCV	30	-
WEST	-	-

- P1-TCV,P1-MAST-U
- Aligned with D7

P80: Multi-machine, model-based profile control of kinetic profiles and safety factor

- P2-AUG,P1-TCV
- Aligned with D7
- AUG part Joined with P64?

- **Proponents and contact person:**
  simon.vanmulders@epfl.ch et al.
- **Scientific Background:**
- TCV and AUG have implemented advanced model-based observers providing real-time estimates of internal kinetic and q-profiles — a foundation for active profile control.
- By integrating Thomson scattering and TORBEAM modeling into RAPTOR, the observer will deliver more accurate q-profiles in ECRH plasmas, enabling precise, model-based profile control.
- A multi-actuator strategy (gas puffing, pellets, RMPs, and heating systems) will be used to dynamically control the particle density profile, expanding control capability in high-performance scenarios.
- The coordinated shaping of kinetic and current profiles will be developed to optimize confinement, limit impurity accumulation, and improve exhaust performance—key steps toward reactor-grade operation.
- **Objectives:**
- **TCV:** Develop and test a q-profile controller based on the RAPTOR linearized model—first in simulation, then experimentally—scanning ECCD deposition to map accessible q-profiles and ITB formation. Apply this controller to regulate $q$min and shape negative-shear or ITB-relevant scenarios.
- **AUG:** Implement a MIMO controller for simultaneous control of the density peaking factor and edge profile, studying the impact of heating on nene as a disturbance. Integrate these effects into the density observer to support the design of a model predictive controller (MPC).
- **Experimental Strategy/Machine Constraints and essential diagnostic:**
  RT-RAPTOR, RT-CXRS, RT-TS, RT-ECE, ERCH, NBI, ICRH (AUG),PELLETS (AUG)



Proposed pulses

Device	# Pulses/Session	# Development
AUG	10	0
MAST-U	-	-
TCV	15	0
WEST	-	-

P81: First wall temperature estimation and real-time heat flux control

- **Proponents and contact person:**
- Federico Pesamosca (federico.pesamosca@iter.org), Adriano Mele, Martim Zurita, Marta Pedrini

- **Scientific Background & Objectives**

ITER First Wall Heat Load Control (FWHLC) prototype modules were deployed on the TCV tokamak digital control system (SCD) leveraging the shared PCSSP/SCDDS technology and the new plasma shape controller. The natural extension of this work involves developing model-based real-time estimation of the FW surface temperature in the TCV SCD. This will enable advanced FWHL control techniques for ITER to be tested on the TCV tokamak.
Objectives:

- Deployment of a real-time capable reduced thermal diffusion model for the first wall surface temperature evolution.
- Validation of real-time estimates of first wall heat flux and temperature against diagnostics data.
- Development of observers combining control-oriented models and diagnostics measurements for the first wall thermal loads
- Refinement of FWHL controllers attempting continuous control of plasma thermal loads on plasma-facing components during a discharge.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
- Develop new PCSSP modules for the wall thermal dynamics to deploy in SCD and test their real-time performance.
- Refine the FWHL controllers in dedicated attached LSN diverted shots including plasma movements and ECH power steps triggering FWHLC action.
- Attempt combined kinetic (auxiliary power variation) and magnetic (plasma shape variation) FWHL control.

- Machine constraints: TCV SILO, SISO or NINO (preferred) baffling.
- Essential diagnostics and systems: ECH, IR, LP, RADCAM, TC, SCD

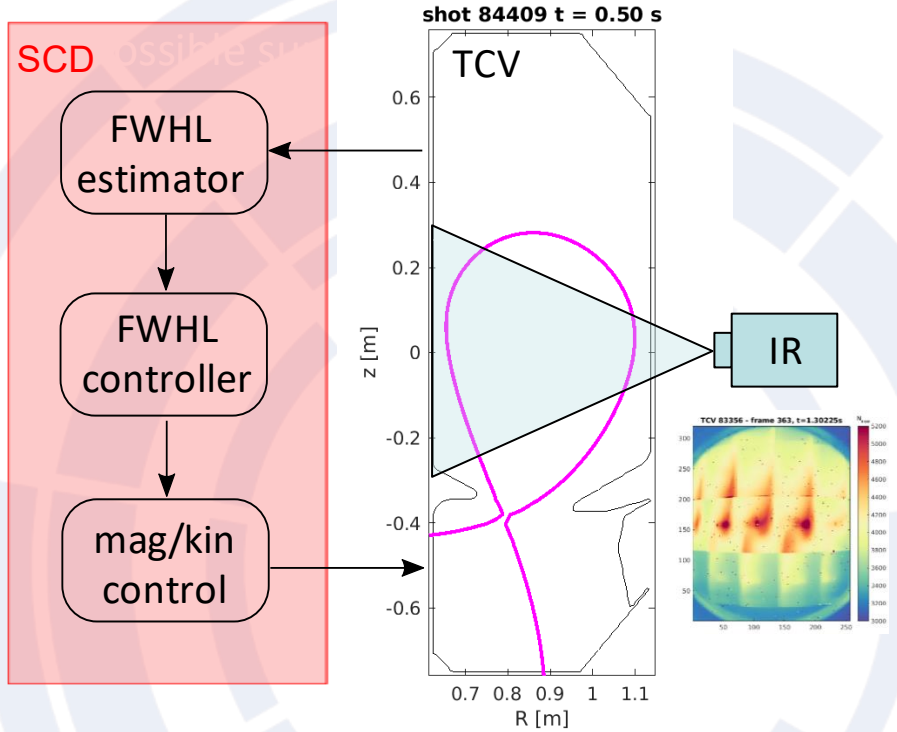


Fig 1: block diagram for FWHLC on TCV.

Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	15	5
WEST		

- P1-TCV
- Aligned with D6

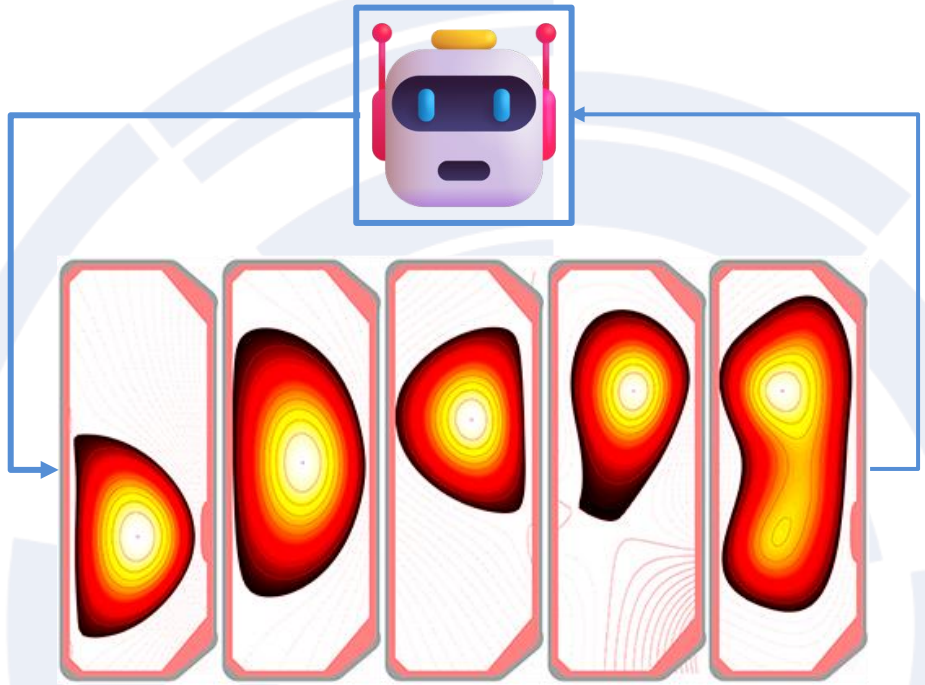
P85: Advanced magnetic control

- **Proponents and contact person:**
  - Adriano Mele (adriano.mele@epfl.ch)
  - Francesco Carpanese
  - Cristian Galperti
  - Cosmas Heiss
  - Allen Wang
  - Matteo Grandin
  - Domenico Frattolillo

- P1-TCV
- Aligned with D6
- Large proposal.
- Decrease pulses of 40%

- **Scientific Background & Objectives**
  - enhance the MPC framework for plasma shape control
  - commission the newly developed Fast MAGnetic controller on use cases of practical relevance
  - design an optimal gain scheduler
  - incorporate machine learning tools to enhance or generalize control performance
  - explore porting to other WPTE devices (e.g. MAST-U) of solutions developed for TCV

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - **Model Predictive Control**
    - further tests of the developed controller on a variety of plasma configurations
    - integration of additional constraints, including coil voltage limits, plasma-wall clearance, and control objectives involving balancing of multiple X-points or drsep
    - exploration of real-time model building or updating for MPC, potentially leveraging machine learning tools, as a step toward nonlinear MPC
    - investigation of alternative MPC paradigms, such as economic or robust MPC
  - **Commissioning of FMag**
    - finalize the validation of the FMag controller on use cases of practical relevance (classic RZIp control, fast shape variations, stabilizing shape control)
    - couple FMag with low-frequency liuqe corrections or a liuqe surrogate model
    - integrate FMag with higher-level controllers such as MPC or CLA-like systems
  - **Machine Learning tools**
    - enhancement of the fbt-nn surrogate with explicit shape feedback
    - incorporation of ML techniques in the MPC framework
    - further development and testing of a (differentiable) liuqe surrogate
  - **Optimal Gain Scheduling**
    - At a fixed desired linear performance metrics, construct a dataset of optimal gain and actuator action from closed loop linear system, given current plasma equilibrium and feedforward target.
    - Train a surrogate model to predict optimal gain given current state.
    - Integrate optimal gain scheduler with the default control system, and test dedicated set of disturbances (deviation from reference scenario) where plasma operation can benefit from improved control.



Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U	0	0
TCV	40	10
WEST		

P86:Integrated Control and P…nization

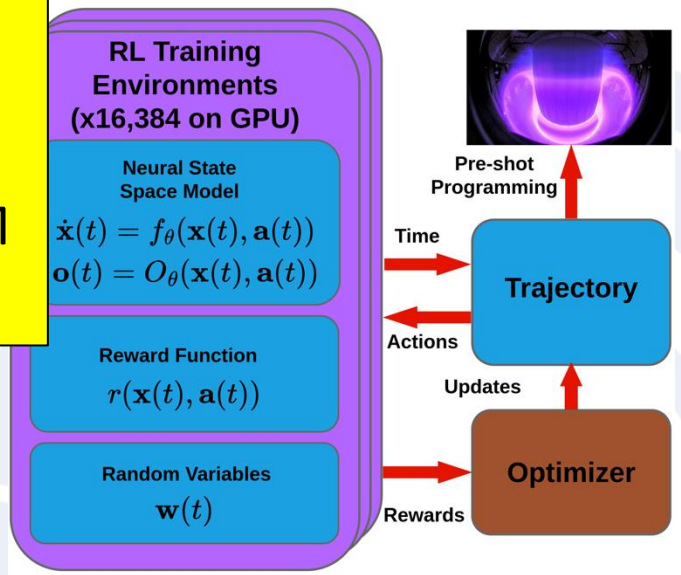
- P1-TCV
- Aligned with D7
- Large proposal
- Include work on data drive models and NTM observers

- **Proponents and contact person:**
  alessandro.pau@epfl.ch et al.

- **Scientific Background:**
- Long-Term Goal: Demonstrate reliable high-performance o…
  tightly integrating plasma state monitoring & control, off-n…
  and machine protection
- The proposal, building upon the high-performance scenario developed in 2024-2025, and aims to bring to maturity integrated control and plasma trajectory optimization tools, integrating NTM, radiation and detachment control.

- **Objectives:**
- Integrate and test Real-Time (RT) observers (e.g., RAPDENS, RAPTOR, RT-MRE, RT-TORBEAM) and proximity monitors within the SAMONE (Supervision and Actuator Manager Off-Normal Events handling) system, focusing on machine-agnostic solutions
- Leverage concurrent work to integrate model- and data-driven models for NTM control (RT-observers for toroidal rotation, pedestal and kinetic profiles and calculation of a tearability proximity monitor).
- Finalize the integration in SAMONE of radiation & detachment control and implement a MARFE observer based on RT
- ◦ Implement adaptive control logic combining confinement state classification models and proximity monitors for MHD/radiative instabilities

- **Experimental Strategy/Machine Constraints and essential diagnostic:**
- RT-RAPTOR, RT-CXRS, RT-TS, co-MRE, RT-BOLOMETRY, ECRH, NBI, SAMONE, SCD



A. Wang, A. Pau et al Nature Comm. (2025)

Proposed pulses

Device	# Pulses/Session	# Development
AUG	-	-
MAST-U	-	-
TCV	35	10
WEST	-	-

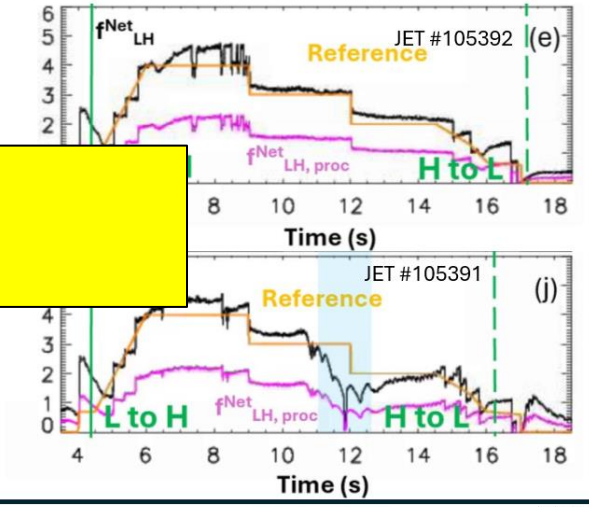
P87: P_{sep}/P_{LH} control using heating power and impurity radiation

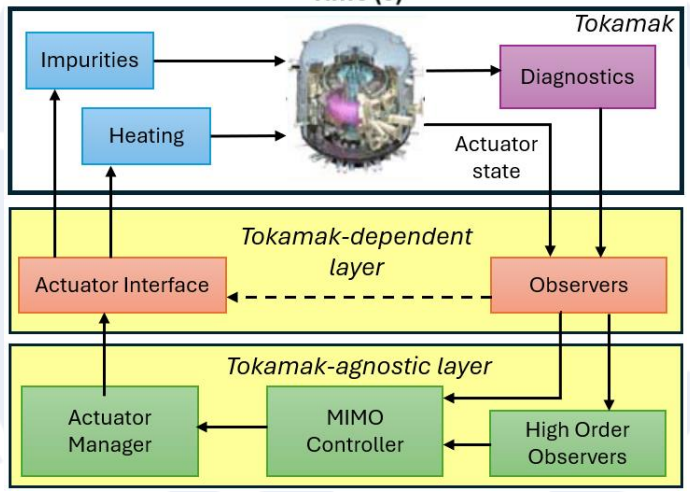
- P2-AUG, P1-TCV
- Aligned with D7

- **Proponents and contact person:**
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- **Scientific Background & Objectives**
  - Background: JET Experiments - P_{sep}/P_{LH} controller was used to enter maintain and exit H-mode safely.
  - In this proposal, enhanced active control scheme is proposed, where both P_{heat} and P_{rad} are controlled, using the heating systems and impurity injection as actuators respectively
  - Scientific Objectives:
    - Develop appropriate, data-driven, state observers monitoring the radiated power that goes into the power balance calculation. (D6, D9)
    - Provide P_{sep}/P_{LH} operating range, optimized for ITER-relevant H-mode operation.
    - Quantify the feed-forward effect of impurity injection as an actuator for the radiated power.
    - Using a data-driven (ML-based) system identification, integrate the dynamic response of heating power and impurity injection, in order to develop an optimization strategy for the desired pulse trajectory. (D7, D9)
    - Demonstrate improved control with optimized dual actuator management during normal operation and scripted off-normal events. (D8, D9)
      - For TCV: comparison with SISO P_{rad} and P_{sep}/P_{LH} controllers deployed simultaneously using SAMONE supervisor.

- **Experimental Strategy/Machine Constraints and essential diagnostics**
  - Verify relevant P_{sep}/P_{LH} range and dynamic response to auxiliary power (2 pulses/device).
  - Quantify the feed-forward effect of impurity injection as an actuator for Prad (2-4 pulses/device).
  - Pulses with dual actuator management to demonstrate improved control (6 pulses/device).
  - For TCV: comparison with SISO P_{rad} and P_{sep}/P_{LH} controllers deployed simultaneously using SAMONE supervisor (2 pulses).
  - This experiment can be performed in 1 MA/1.8 T AUG plasmas and standard H-mode TCV plasmas. TCV experiments would benefit from the availability of MANTIS.
  - Essential Diagnostics:
    - Bulk P_{rad} calculation in real-time





Proposed pulses

Device	# Pulses/Session	# Development
AUG	12	
TCV	12	

P93: Continuous control from attachment to XPR

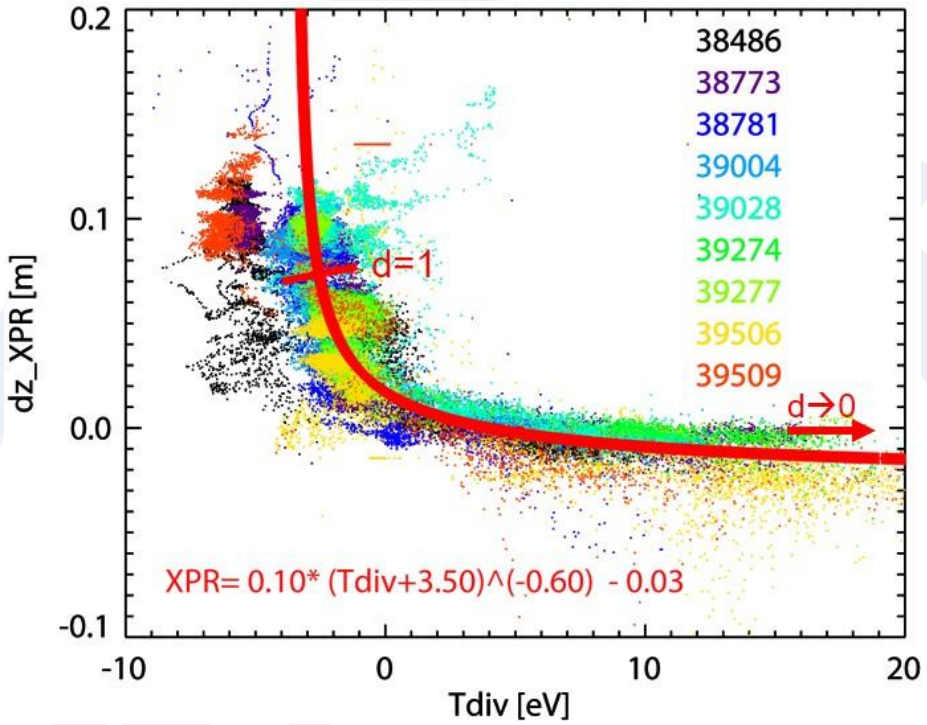
- **Proponents and contact person:**
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  - Bernard.Sieglin@ipp.mpg.de

- **Scientific Background & Objectives**
  - Tdiv control is only valid up to partial detachment, while XPR control requires an XPR present (~full detachment). The aim is to couple both controllers, providing a continuous control from attached to fully detached

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Strong nitrogen seeding
  - AXUV & Tdiv control

  - Strategy:
    - Couple both controller via a new detachment parameter d
    - Develop controller gains to match Tdiv & XPR control at both extremes
    - Demonstrate continuous control for attached to fully detached plasmas [4#]

- P1-AUG 2026
- Aligned with D7



Proposed pulses

Device	# Pulses/Session	# Development
AUG	1	3
MAST-U		
TCV		
WEST		