EUROfusion

18th November 2024

RT-01 "Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER"
Discussion about proposals and allocated priorities

B. Labit

On behalf of WPTE TFLs
E. Tsitrone, N. Vianello, M. Baruzzo, V. Igochine, D. Keeling, A. Hakola, B. Labit

Research Topic Coordinators
C. Giroud, L. Frassinetti, D. King, S. Wiesen

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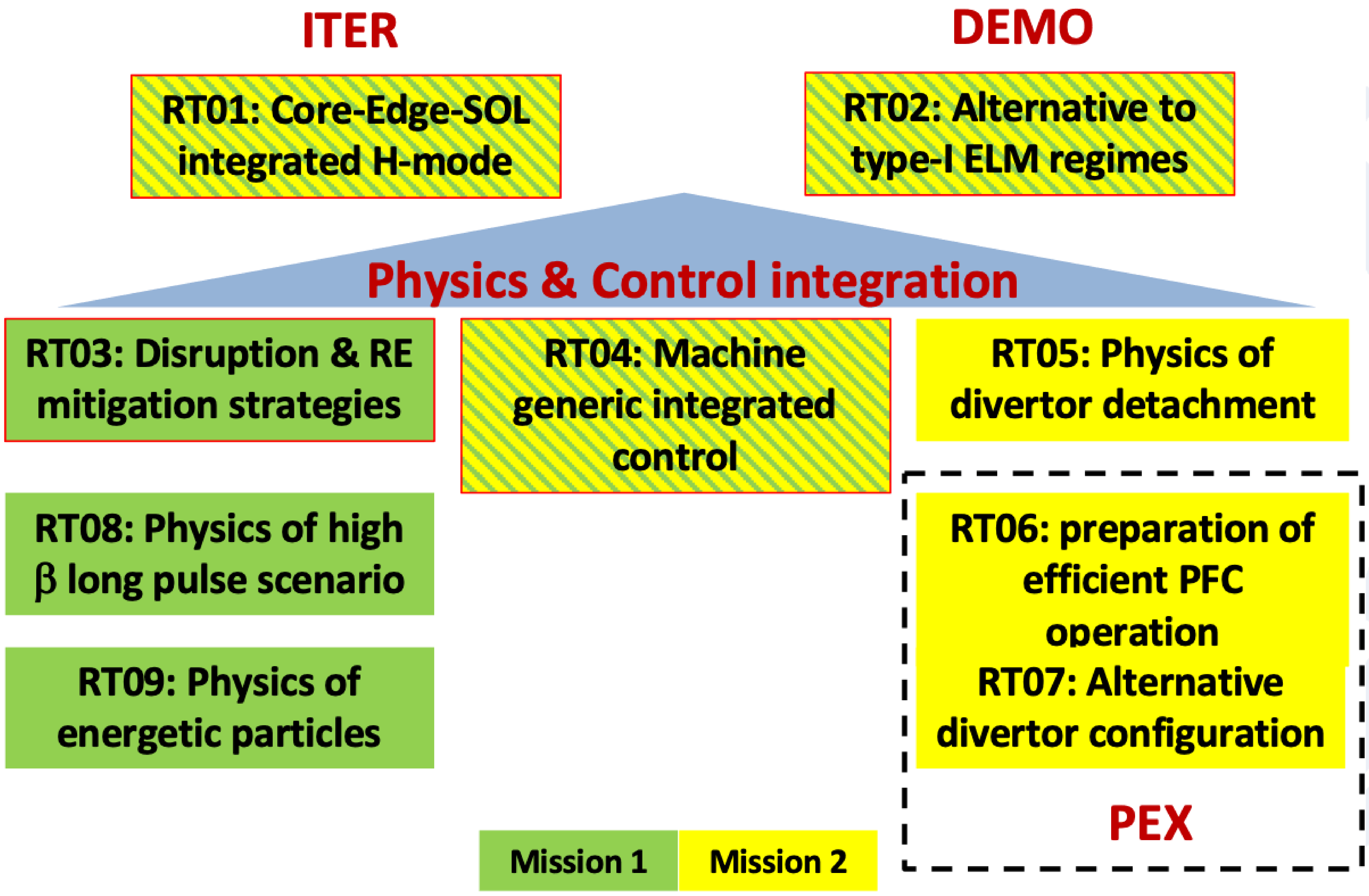
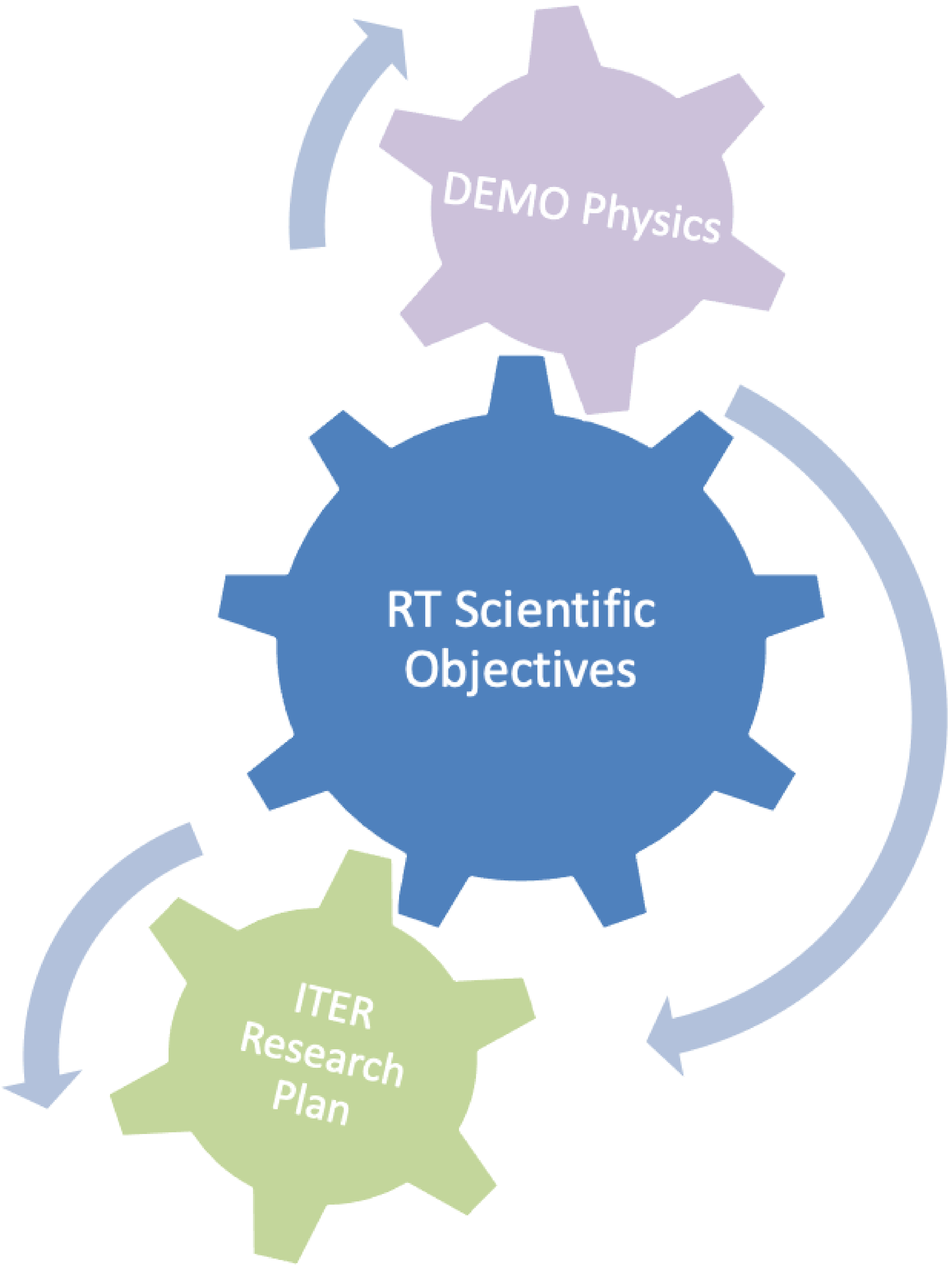
Introduction

- RT01 is linked to the exploitation of the scenarios and exploration of the physics mostly linked to ITER operation also in view of ITER re-baselining



Prioritization scheme and criteria



Proposal Evaluated according to the criteria:

Adherence to the Scientific Objectives

Team effort

Size and feasibility

All these aspects were considered by the TFLs when setting the priorities – according to the following scheme

P1: experimental priority for 2025: machine time granted but pulse budget might need reduction

P2: will be done if time allows after Prio 1 experiments are completed

P3: back-up programme

PB: piggy-back experiment/pure analysis proposal

Summary of proposals (16)

#	RT	Proposal	Main Proposer
1	RT01	Investigate the Ramp-Down of the IBLS in the precence of seeded Ar (work in progress)	T. Pütterich et al
2	RT01	Pedestal studies with dominant electron heating	L. Frassinetti
3	RT01	Peeling limited pedestal	L. Frassinetti
4	RT01	Intra ELM pedestal fluctuations in peeling limited pedestal scenario at TCV	Miriam La Matina et al
5	RT01	Particle transport in long-pulse WEST plasmas	Tuomas Tala
6	RT01	Core-Edge integrated scenario for IBL on TCV	B. Labit et al
7	RT01	Demonstration of impurity (W) screening at the edge of ASDEX Upgrade plasmas	A. Kappatou et al
8	RT01	Momentum transport in mixed turbulence regimes and intrinsic torque and NTV sources	Tuomas Tala
9	RT01	Hydrogen isotope transport in low-collisionality H-mode plasmas	J. Rasmussen
10	RT01	Pellet injection in WEST and AUG for HPI2	A. Panera Alvarez
11	RT01	Sustaining H-mode performance in a tungsten environment	Jorge Morales
12	RT01	Examining the impact of transitioning to electron heated dominated plasma on the turbulence in AUG	Bhavin Patel
13	RT01	Core-Edge integrated scenario for IBL on AUG in light of JET IBL	S. Wiesen C.Giroud et al
14	RT01	L2H Btor vs Bpol scaling studies	emilia.solano@ciemat.es
15	RT01	L2H Studies with Impurity seeding	emilia.solano@ciemat.es
16	RT01	Flows and turbulence: Sensitivities of edge Er x B flow and its link with turbulence	L. Vermare
144	RT07	Operation above Greenwald limit	E. Geulin

➡ Moved to RT05 (row 15)

➡ Coming from RT07 (row 144)

Scientific Objectives and Machine Time

#	
D1	Develop and understand stationary H-mode scenario at low collisionality and with dominant electron heating
D2	Provide physics-based cross-field transport coefficients to TSVVs (1, 3, 4 and 11) for turbulence modelling
D3	Determine the impact of different impurity mixes for partially detached divertors in high power operations in view of ITER radiative scenarios
D4	Assess pedestal performances in condition closer to future devices including large SOL opacity, low pedestal collisionality, peeling limited plasma
D5	Quantify impurity screening for high temperature pedestals

2025	AUG	TCV	MAST-U	WEST
Tentative allocation	45	120	24	15
Total proposed	212	157	44	138
Scientific/dev.	156/56	139/18	44/0	111/27

#1 Investigate the Ramp-Down of the IBLS in the precence of seeded Ar

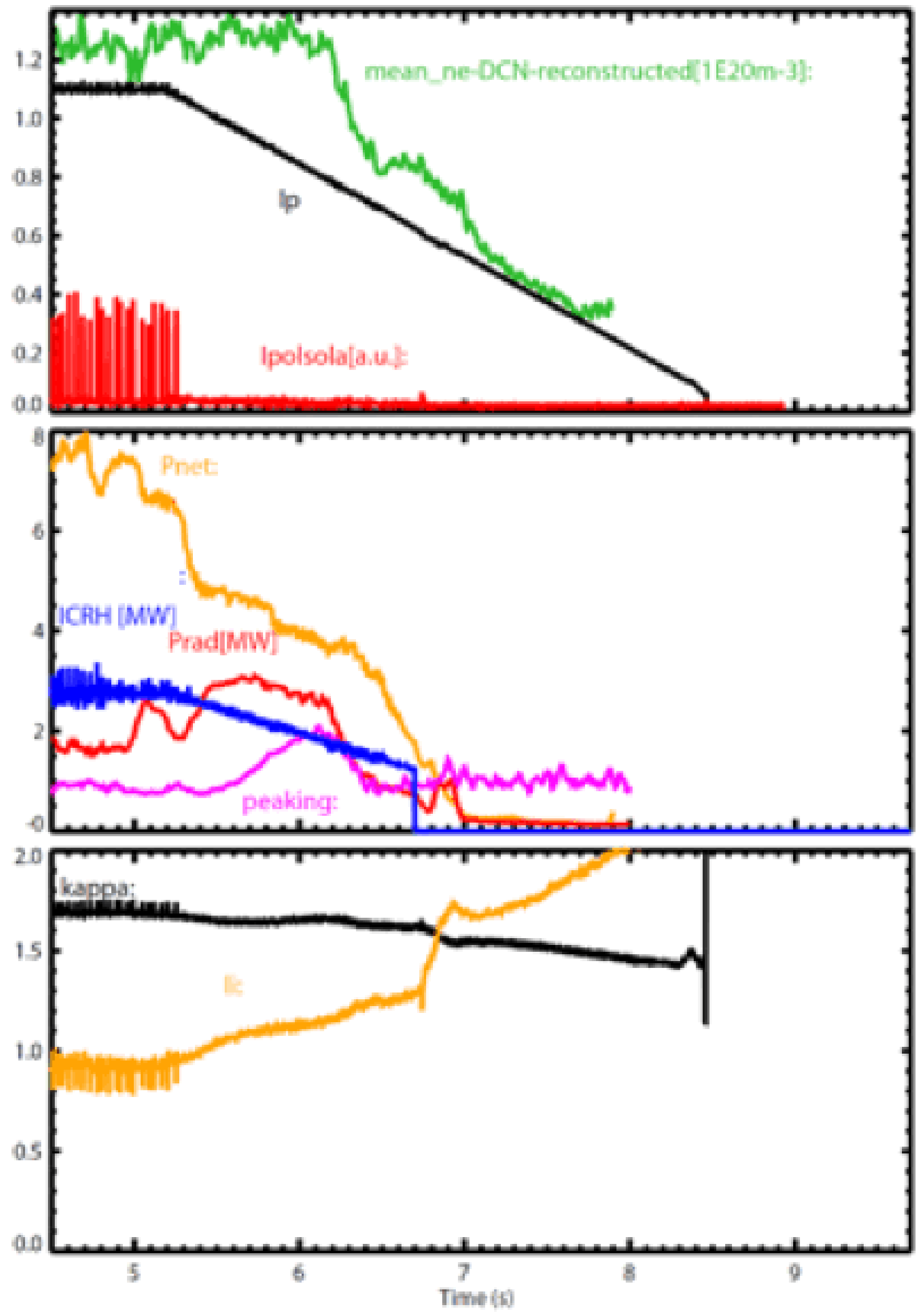
- **Proponents and contact person:**
  - Thomas Pütterich Thomas.puetterich@ipp.mpg.de
  - Olivier Sauter Olivier.Sauter@epfl.ch
  - Lea Hollendonner Lea.Hollendonner@ipp.mpg.de

- **Scientific Background & Objectives**

  Ramp-down of ITER BL scenario in AUG:
  - Stability for type-I ELMy H-modes? Confirm JET observations?
  - Parameter Map: small ELMs vs. type-I ELMs
  - Type-I ELMs ramp-down after Ar-seeded flattop
  - Parameter Map for ramp-downs after Ar seeded flattop

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Rerun 40840 (ramp-down with small ELMs)
  - Find transition parameter (heating/gas) for achieving type-I ELMs during ramp-down
  - Probe stability of type-I ELMy H-mode in ramp-down after flattop with Ar-seeding
  - Find transition to small ELMs in ramp-down after flattop with Ar-seeding

#40840 ELM small ELM ramp-down



Device	# Pulses/Session	# Development
AUG	12	2
MAST-U		
TCV		
WEST		

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  - Thomas Pütterich Thomas.puetterich@ipp.mpg.de
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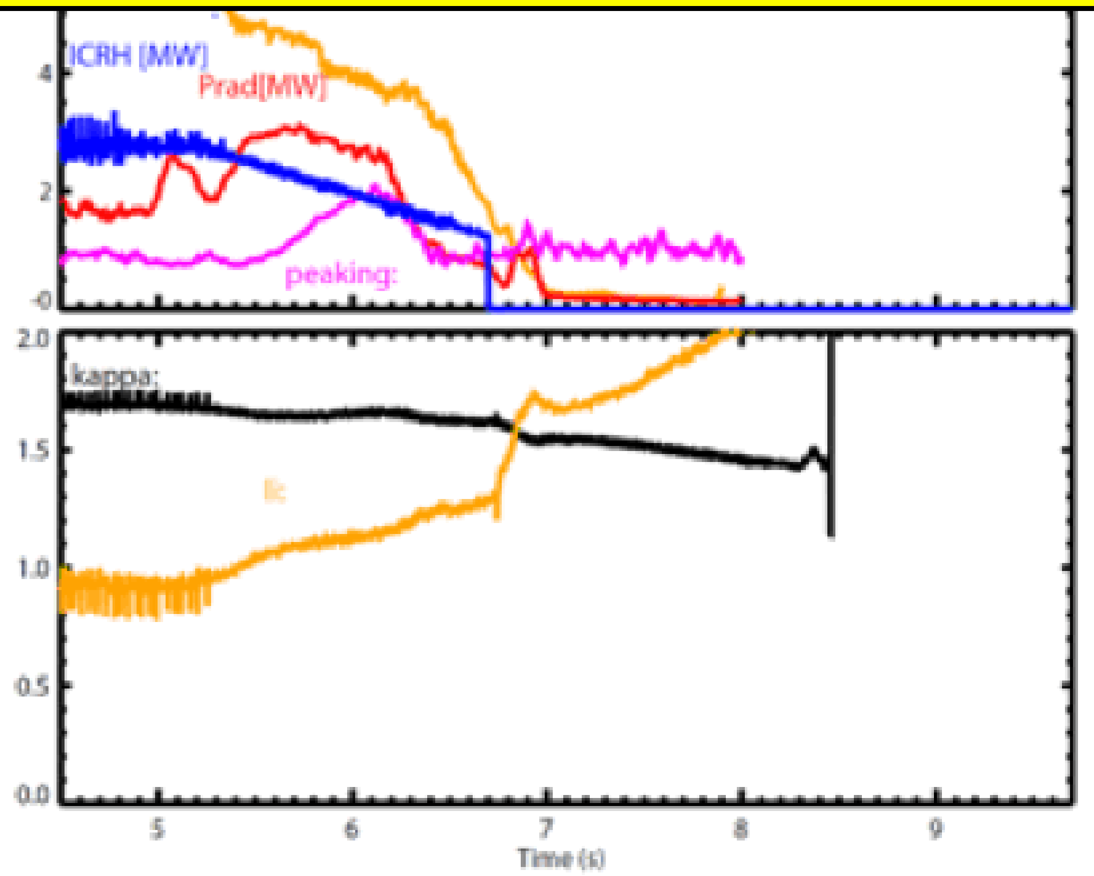
#40840 ELM small ELM ramp-down

- TFL assessment: **P2**
- No dedicated time
- Assess if it can be integrated within other proposals

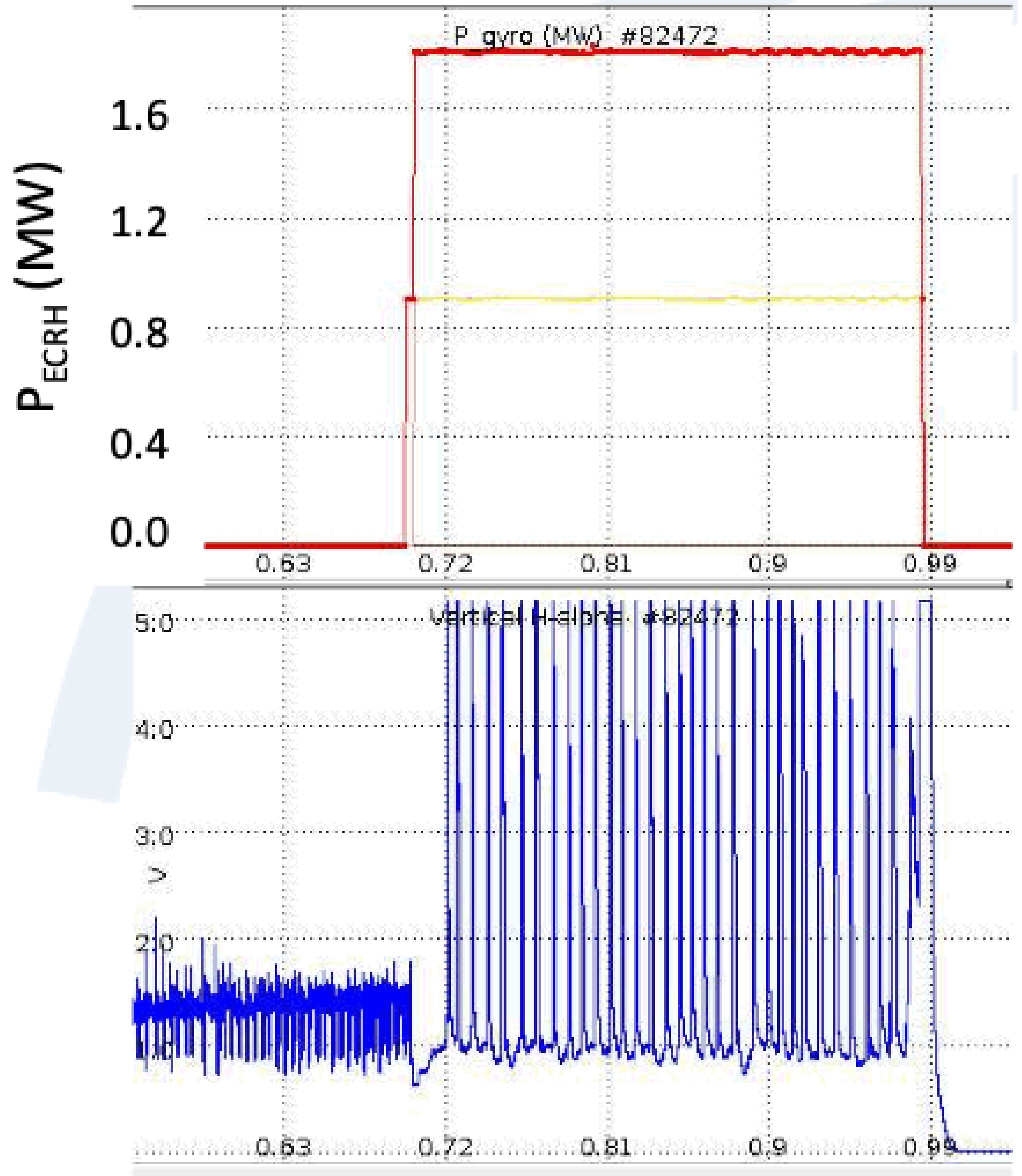


Device	# Pulses/Session	# Development
AUG	12	2
MAST-U		
TCV		
WEST		

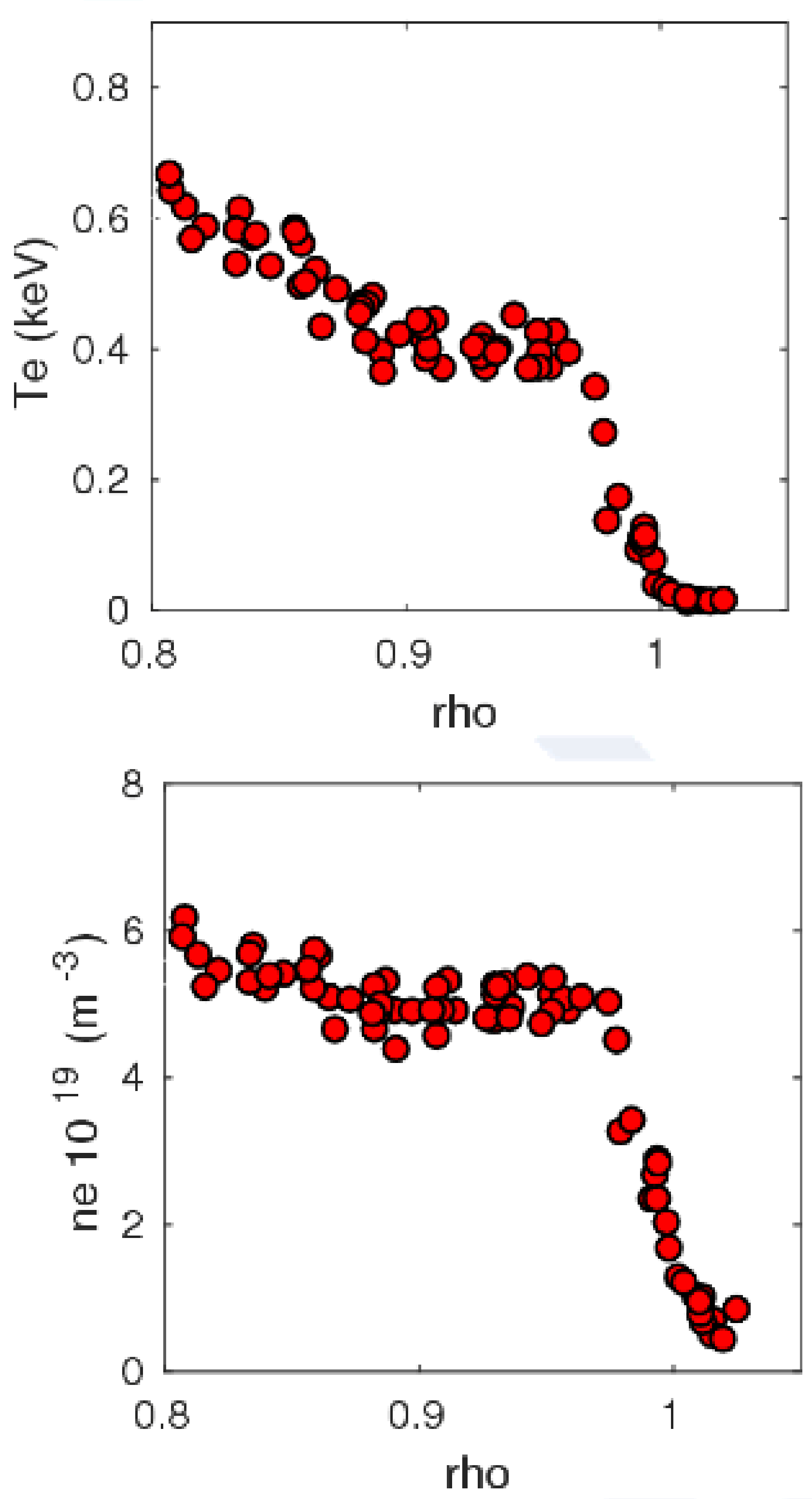
#2 Pedestal studies with dominant electron heating

- **Proponents:** Frassinetti, Saarelma, Labit, Dunne, Kappatou, Solano
- Contact person: lorenzof@kth.se
- **Scientific Background & Objectives**
  - The ITER start of research operation (SRO) will use ECRH and ICRH. It is important to characterize the H-mode access and its pedestal properties to be sure SRO will have a robust plan. In view of ITER DT-1, it will be important to learn how to optmize SRO.
  - **Objectives:**
    1. Compare pedestal structure, stability, transport, ELMs between dominant electron heating and dominant NBI heating scenarios (at similar power and/or similar betaN)
    2. Validate pedestal predictions
    3. Identify condition to access H-mode with dominant electron heating in TCV and AUG
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - TCV:
    - Starting point: scenario with pure ECRH heated H-modes #82472 or #83315.
    - Perform P_{ecrh} power scan to quantify P_{LH}, pedestal structure and ELM type
    - perform gas scan to asses pedestal behaviour vs neutrals and nesep
    - take reference pulses with NBI heating only (match power or betaN of the dominant electron heated scenario) (2-3 pulses)
  - AUG
    - starting point: dominant electron heated H-mode have been studied in Sommer NF2012, Sommer NF2015 (core transport studies at max P_{ecrh}=4MW).
    - check if the Sommer NF2012/15 dataset has useful data for pedestal studies, then complement and extend the dataset:
      - Perform P_{ecrh} power scan to quantify P_{LH}, pedestal structure and ELM type
      - perform gas scan to asses pedestal behaviour vs neutrals and nesep
      - take reference pulses with NBI heating only (match power and/or betaN)

TCV example of pure ECRH H-mode (from RT-02)



#82472 pre-ELM profiles



Proposed pulses

Device	# Pulses/Session	# Development
AUG	15	2-3
MAST-U	-	-
TCV	15	<5
WEST	-	-

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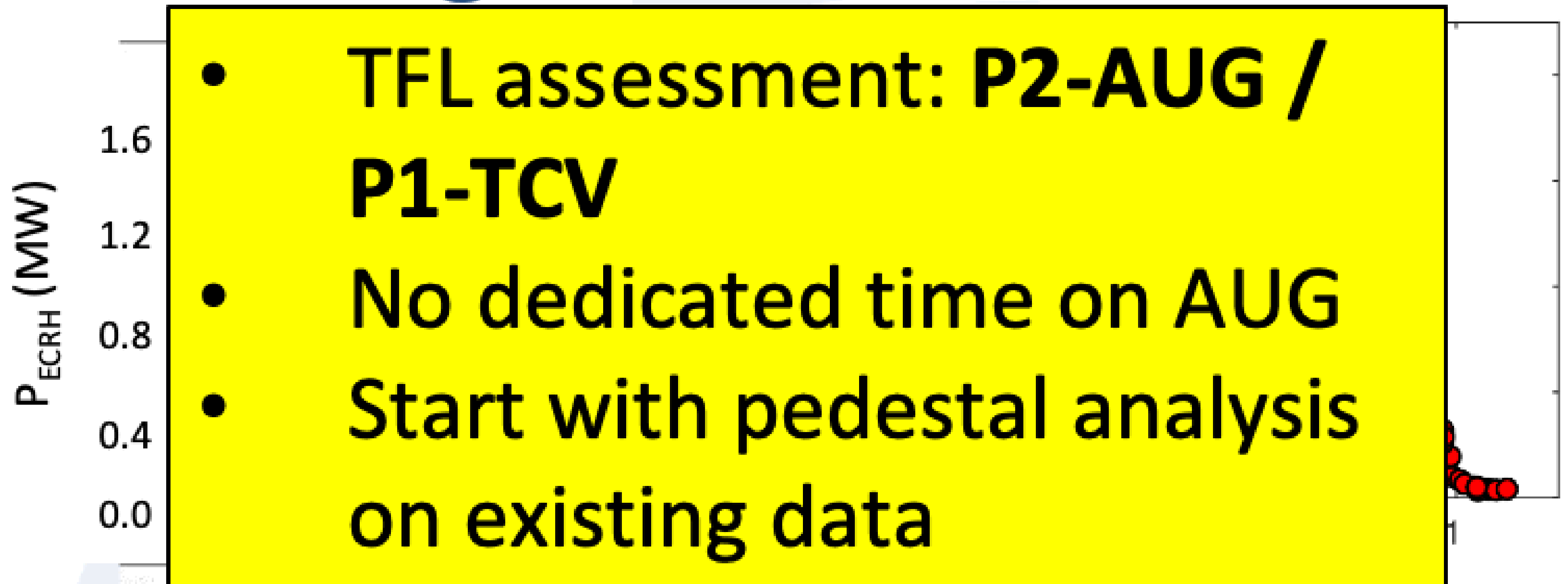
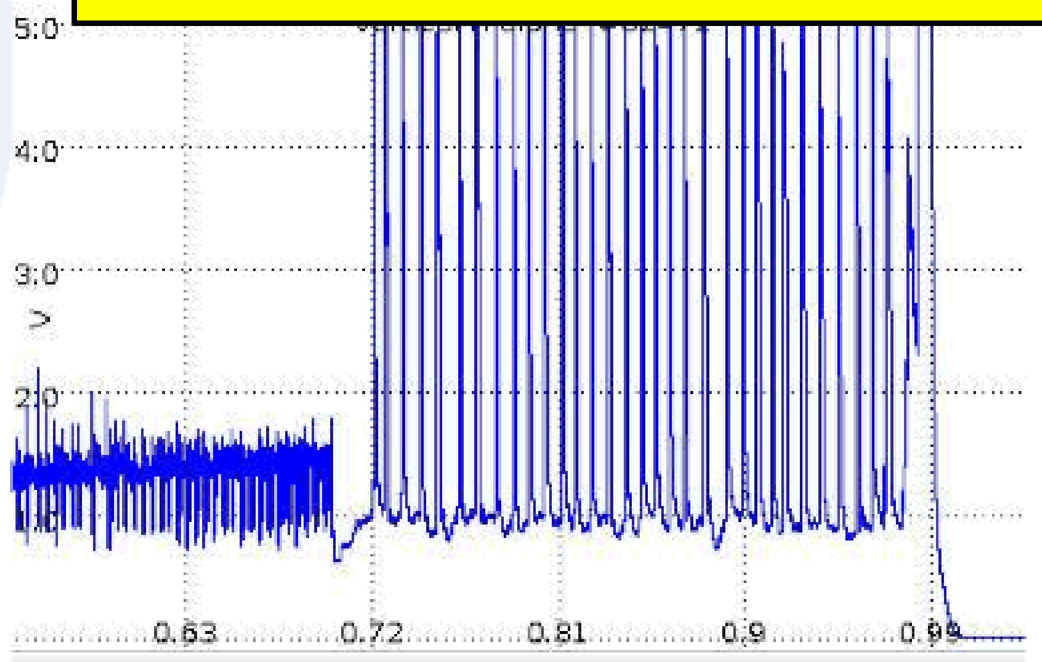
      - take reference pulses with NBI heating only (match power and/or betaN)

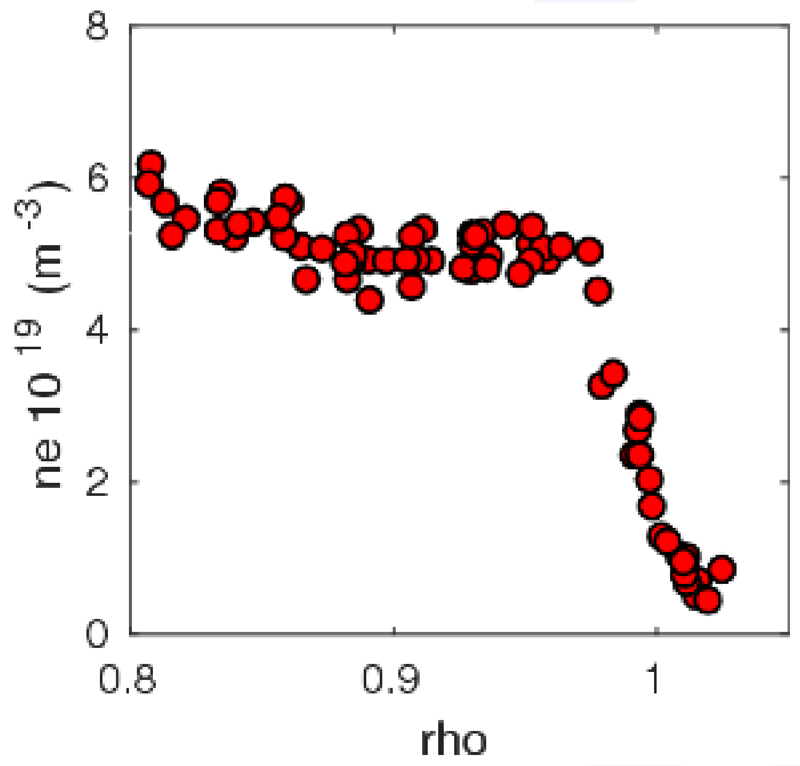
TCV example of pure ECRH H-mode (from RT-02)

#82472 pre-ELM profiles



- TFL assessment: **P2-AUG / P1-TCV**
- No dedicated time on AUG
- Start with pedestal analysis on existing data



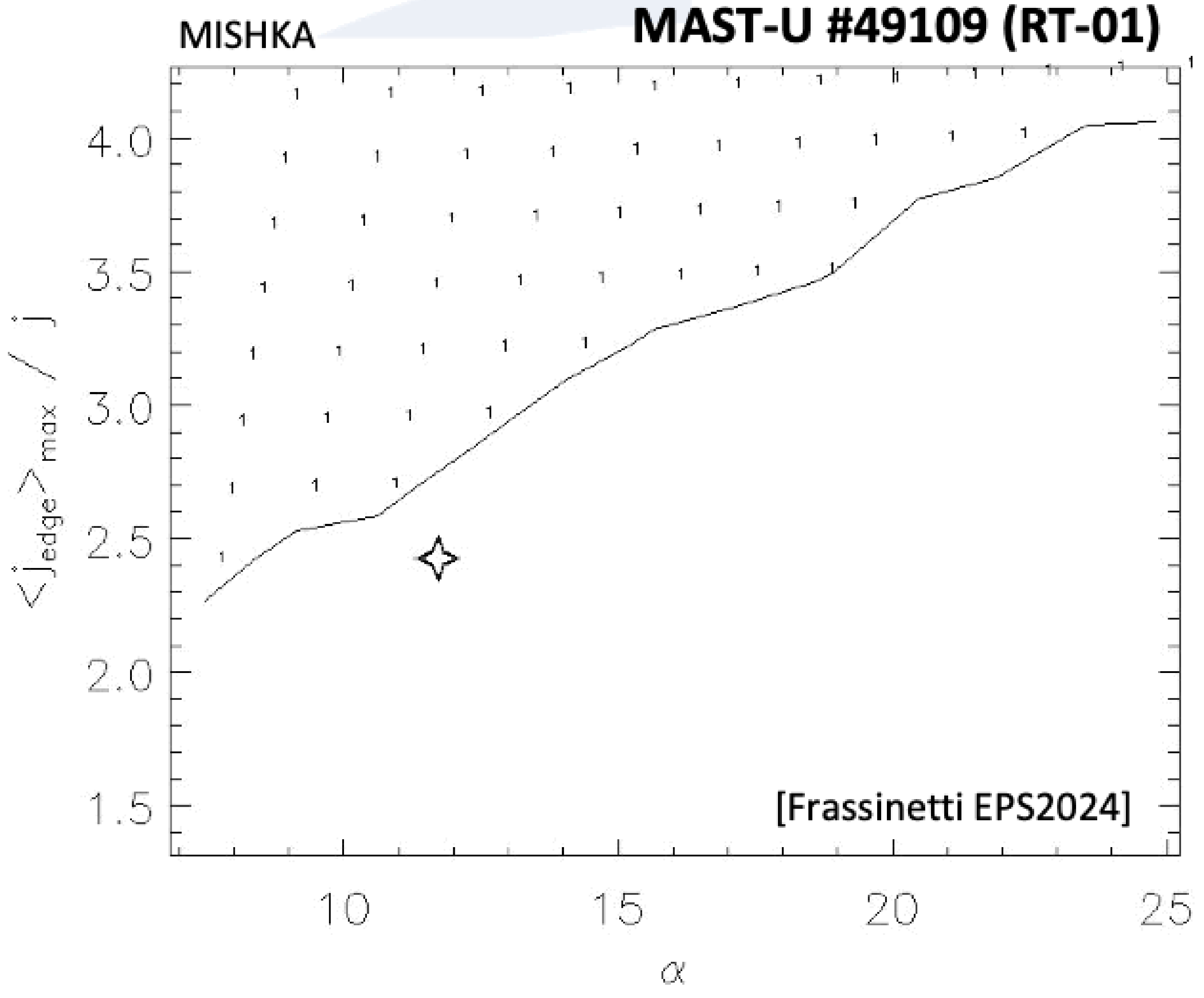


Proposed pulses

Device	# Pulses/Session	# Development
AUG	15	2-3
MAST-U	-	-
TCV	15	<5
WEST	-	-

#3 Peeling limited pedestals

- **Proponents:** Frassinetti, Saarelma, Labit, Blackmore, Imada, Kappatou, Dunne, Dunai, Henderson
- Contact person: lorenzof@kth.se
- **Scientific Background & Objectives**
  - ITER will operate with peeling limited pedestals and high n_e^{sep}/n_e^{ped}.
  - **Objectives:**
    1. Measure pedestal structure in peeling limited scenarios in TCV, MAST-U, AUG
    2. Quantify pedestal structure, stability, pedestal turbulent transport and ELMs in peeling limited scenarios and compare with experimental results
    3. Validate pedestal predictive modelling
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - TCV:
    - Only corner achieved in RT-01 (but still limited by low-n peeling modes)
    - High elongation and squar. will help to reach peeling scenario→ start with predictive modelling
    - Select best shape from above and use maximum NBI+ECRH (starting from RT-01 reference)
    - Perform power and gas scan
    - Repeat key pulses from 2022-2024 to collect information on pedestal fluctuations for comparison with on-going GK analysis
  - MAST-U
    - Olny 4 pulses with requested NBI in RT-01, but peeling limited
    - Start from RT-01 peeling limited reference
    - Use max power and cryo to reach lower ν*
    - Perform gas scan, Bt scan, seeding scan
  - AUG
    - Start from A. Kappatou proposal→if peeling reached, likely no need of new experiments in 2025
    - Otherwise: use JET approach increase Bt to reach q95 ≈ 6 (high q95 will extend the peeling boundary to higher density)



Proposed pulses

Device	# Pulses/Session	# Development
AUG	0-10	0-5
MAST-U	20	0
TCV	25	5
WEST	-	-

#3 Peeling limited pedestals

- **Proponents:** Frassinetti, Saarelma, Labit, Blackmore, Imada, Kappatou, Dunne, Dunai, Henderson
- Contact person: lorenzof@kth.se
- **Scientific Background & Objectives**
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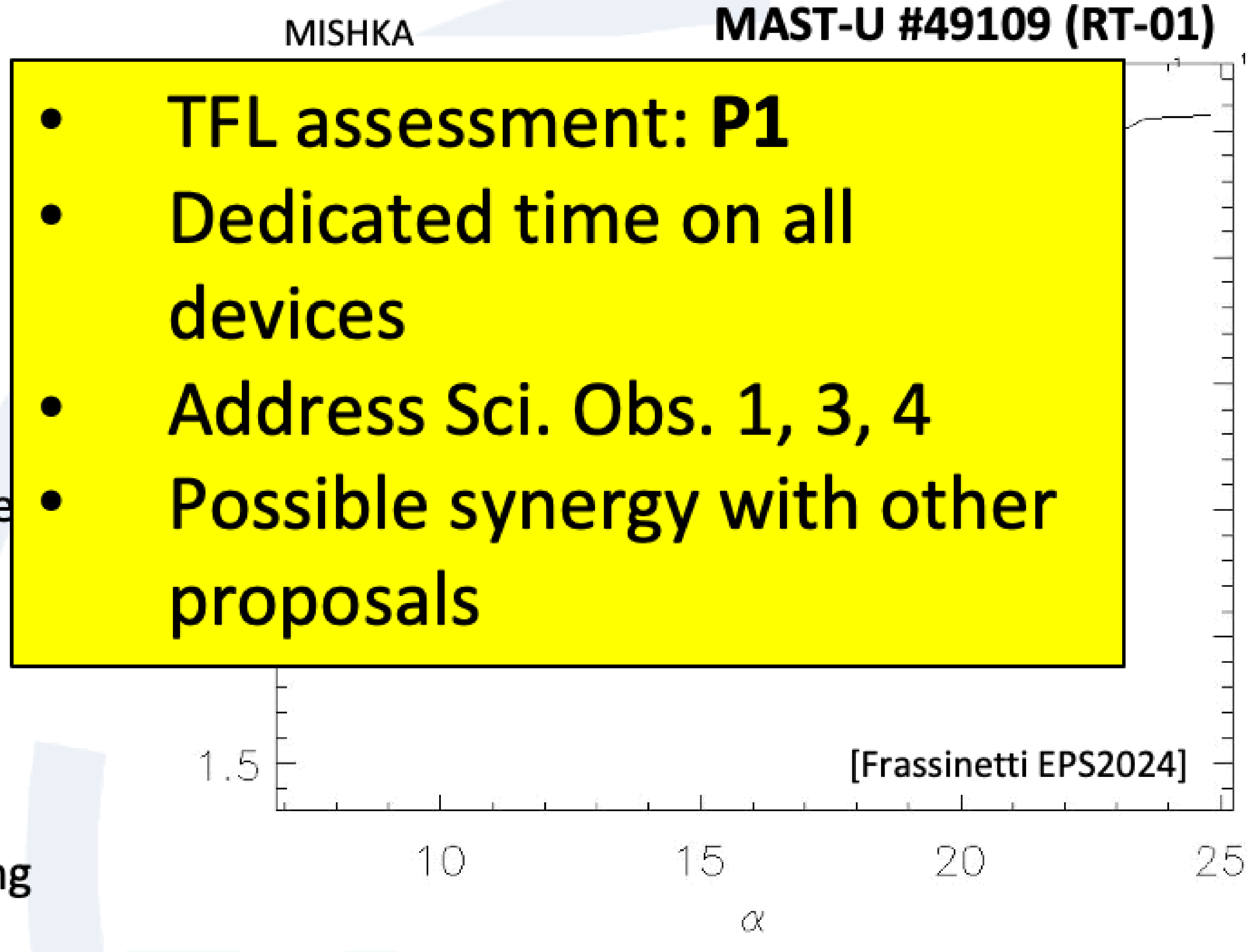
  - MAST-U
    - Olny 4 pulses with requested NBI in RT-01, but peeling limited
    - Start from RT-01 peeling limited reference
    - Use max power and cryo to reach lower ν*
    - Perform gas scan, Bt scan, seeding scan
  - AUG
    - Start from A. Kappatou proposal→if peeling reached, likely no need of new experiments in 2025
    - Otherwise: use JET approach increase Bt to reach q95 ≈ 6 (high q95 will extend the peeling boundary to higher density)



- TFL assessment: **P1**
- Dedicated time on all devices
- Address Sci. Obs. 1, 3, 4
- Possible synergy with other proposals

Proposed pulses

Device	# Pulses/Session	# Development
AUG	0-10	0-5
MAST-U	20	0
TCV	25	5
WEST	-	-

#4 Intra ELM pedestal fluctuations in peeling limited pedestal scenario at TCV

- **Proponents and contact person:**
  - Miriam La Matina (miriam.lamatina@igi.cnr.it)
  - Matteo Agostini
  - Margherita Ugoletti
  - Lorenzo Frassinetti
  - Mack Van Rossem
  - Yinghan Wang
- **Scientific Background & Objectives**

Extensive characterization of pre-ELM oscillations and detailed pedestal profiles reconstruction in peeling limited pedestal scenario at TCV using as primary diagnostic the Thermal helium Beams, together with SPR diagnostic and midplane GPI diagnostic that will be used to:

  - Characterize edge instabilities: in particular intra-ELM modes;
  - Characterize the fluctuation activity across the pedestal and the separatrix to better identify/discriminate instability regimes, reconstructing the electron temperature and density fluctuations;
  - Characterize the pedestal transport and the turbulent activity;

Link the fluctuations measured via the THB with pedestal structure, stability, and transport will be done by:

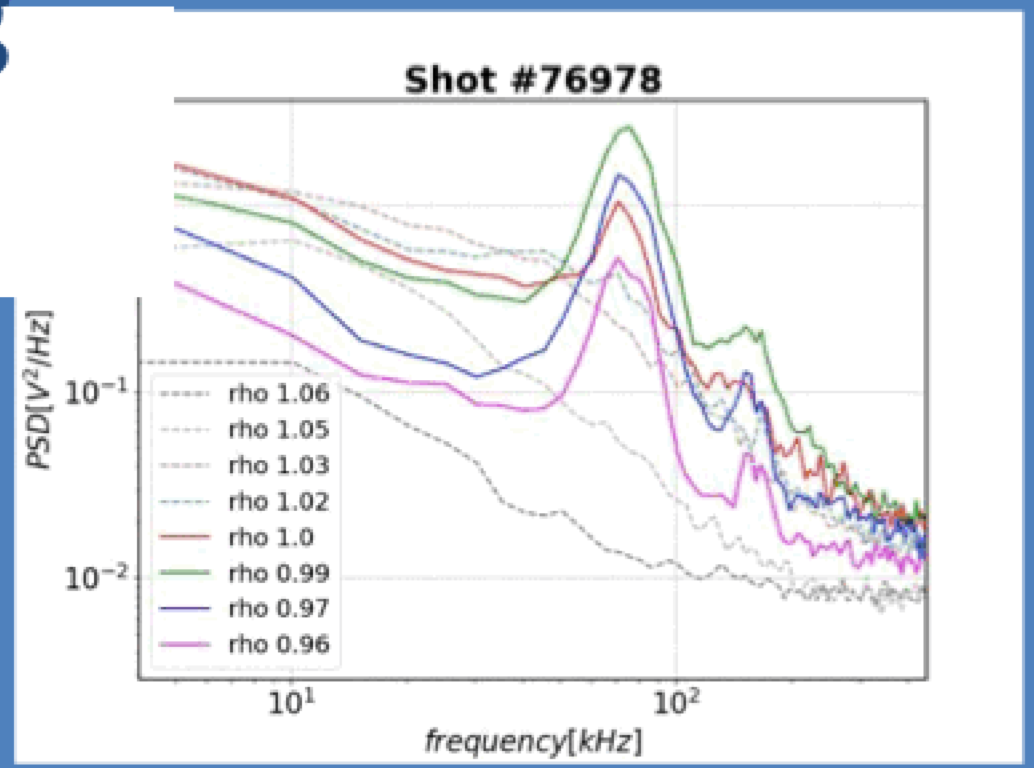
  - comparing THB results with reflectometry and GPI results and GK analysis for turbulent transport
  - Measuring pedestal structure in peeling limited scenarios in TCV
  - comparing experimental trends between peeling and ballooning limited pedestals

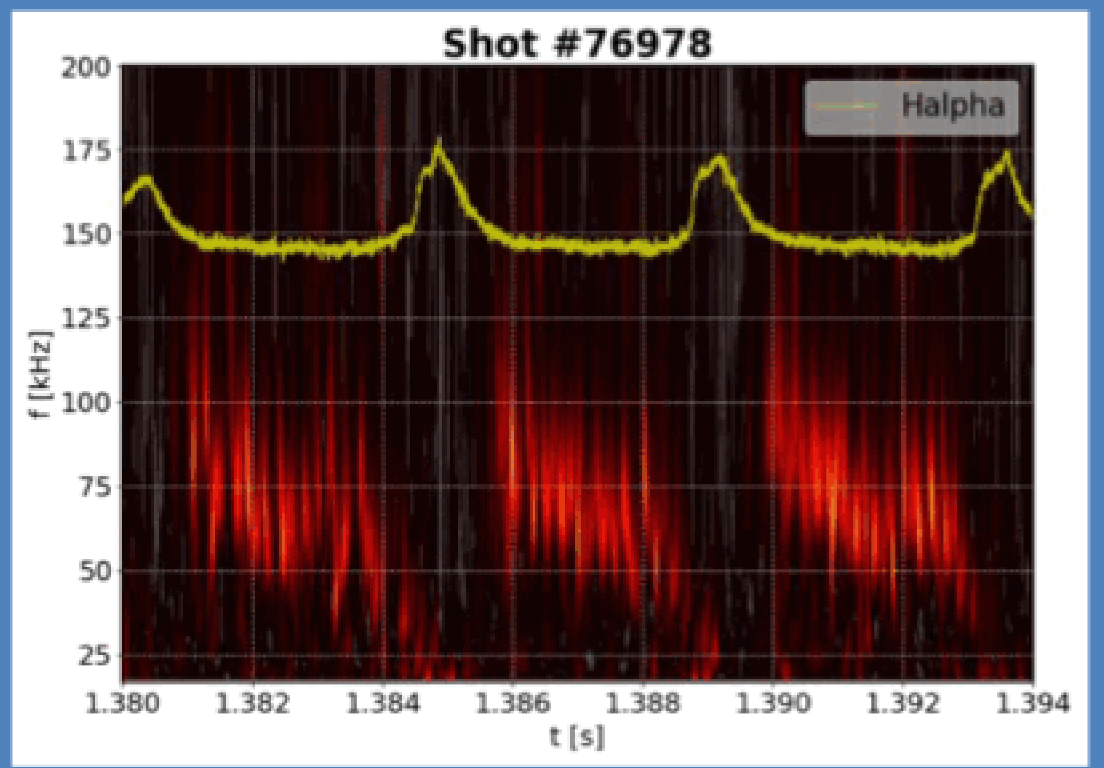
- **Experimental Strategy/Machine Constraints and essential diagnostic**

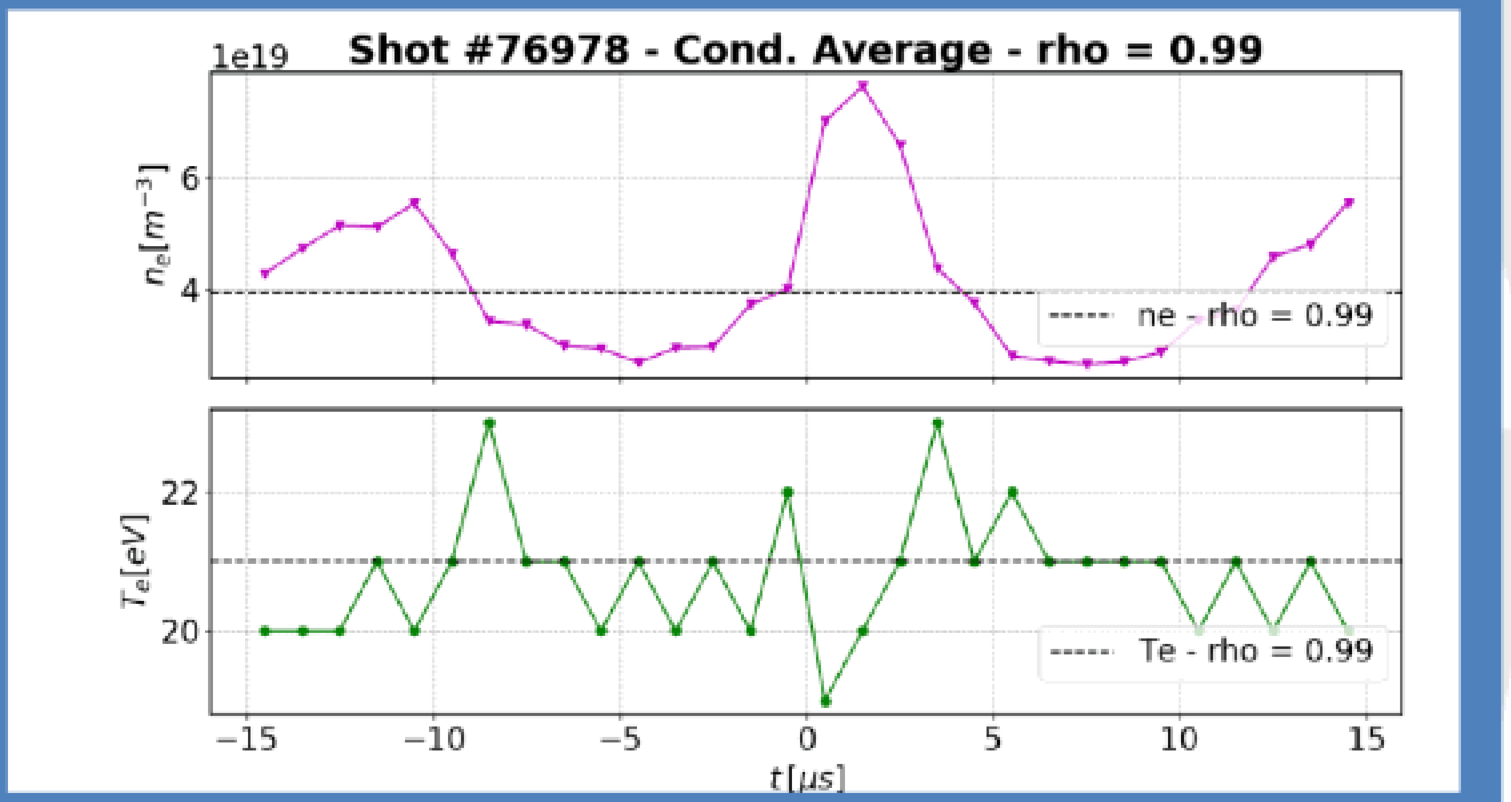
Starting from reference shots # 71718 and 71715 (which reached low collisionality in earlier RT-01 experiments), the plan is to:

  - adapt the plasma shape to optimize the plasma position to the THB lines of sight. The optimization will require around 5 pulses (5 development pulses requested)
  - Perform parameter scans (heating power, fueling, plasma current) (around 4 pulses for each scan).
  - Vary the plasma shape and study its influence on the regime (4 pulses).
  - Repeat the key pulses with optimized diagnostic settings for detailed characterization of plasma and demonstration of scenario robustness (4 pulses).

Required non-standard diagnostics: THB, SPR and midplane GPI





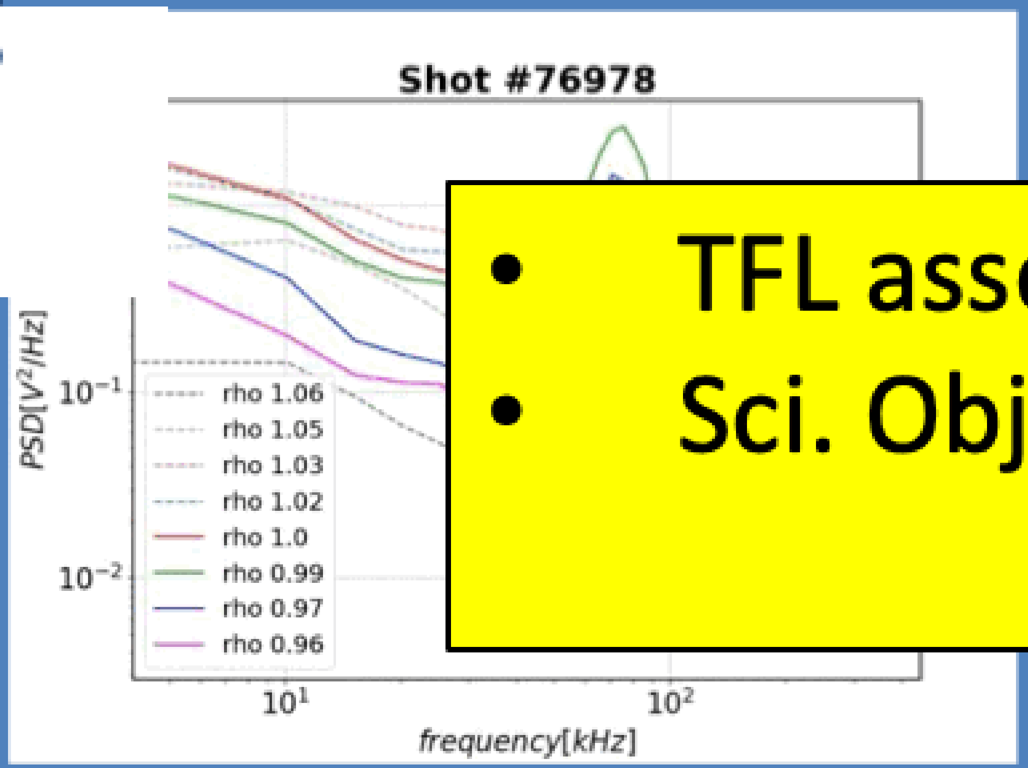


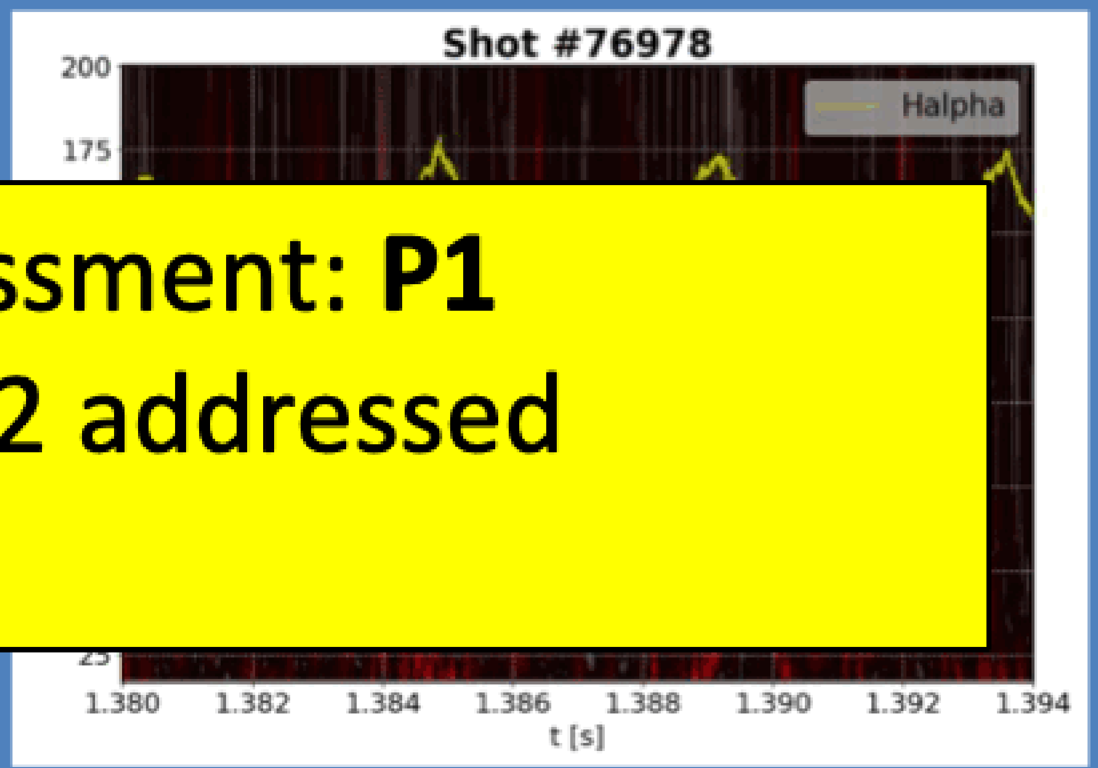
Proposed pulses

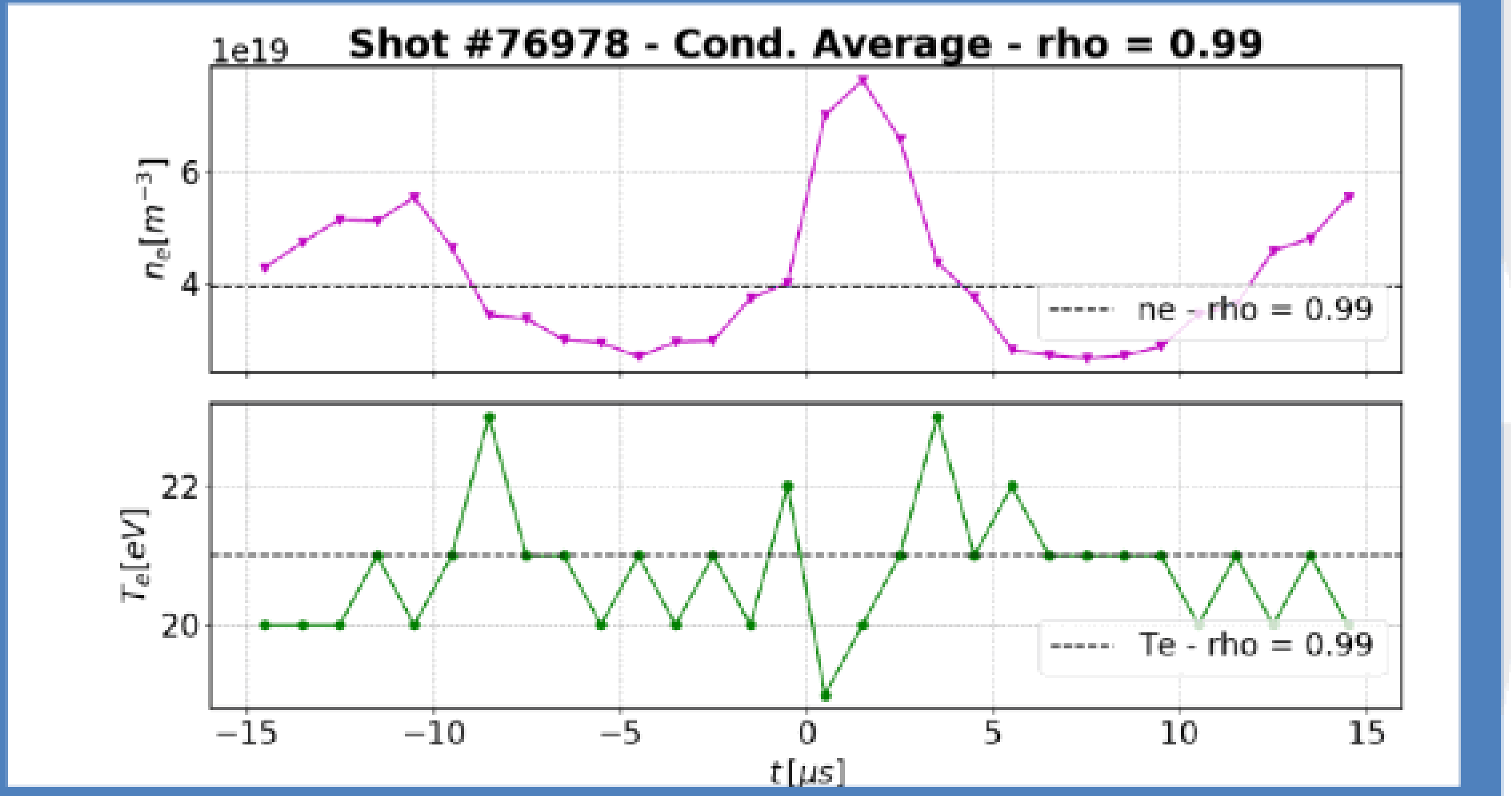
Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	20	5
WEST		

#4 Intra ELM pedestal fluctuations in peeling limited pedestal scenario at TCV

- **TFL assessment: P1**
- Sci. Obj. 2 addressed







- **Proponents and contact person:**
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  - Matteo Agostini
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- Characterize the pedestal transport and the turbulent activity;

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- comparing THB results with reflectometry and GPI results and GK analysis for turbulent transport
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- **Experimental Strategy/Machine Constraints and essential diagnostic**

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- Repeat the key pulses with optimized diagnostic settings for detailed characterization of plasma and demonstration of scenario robustness (4 pulses).

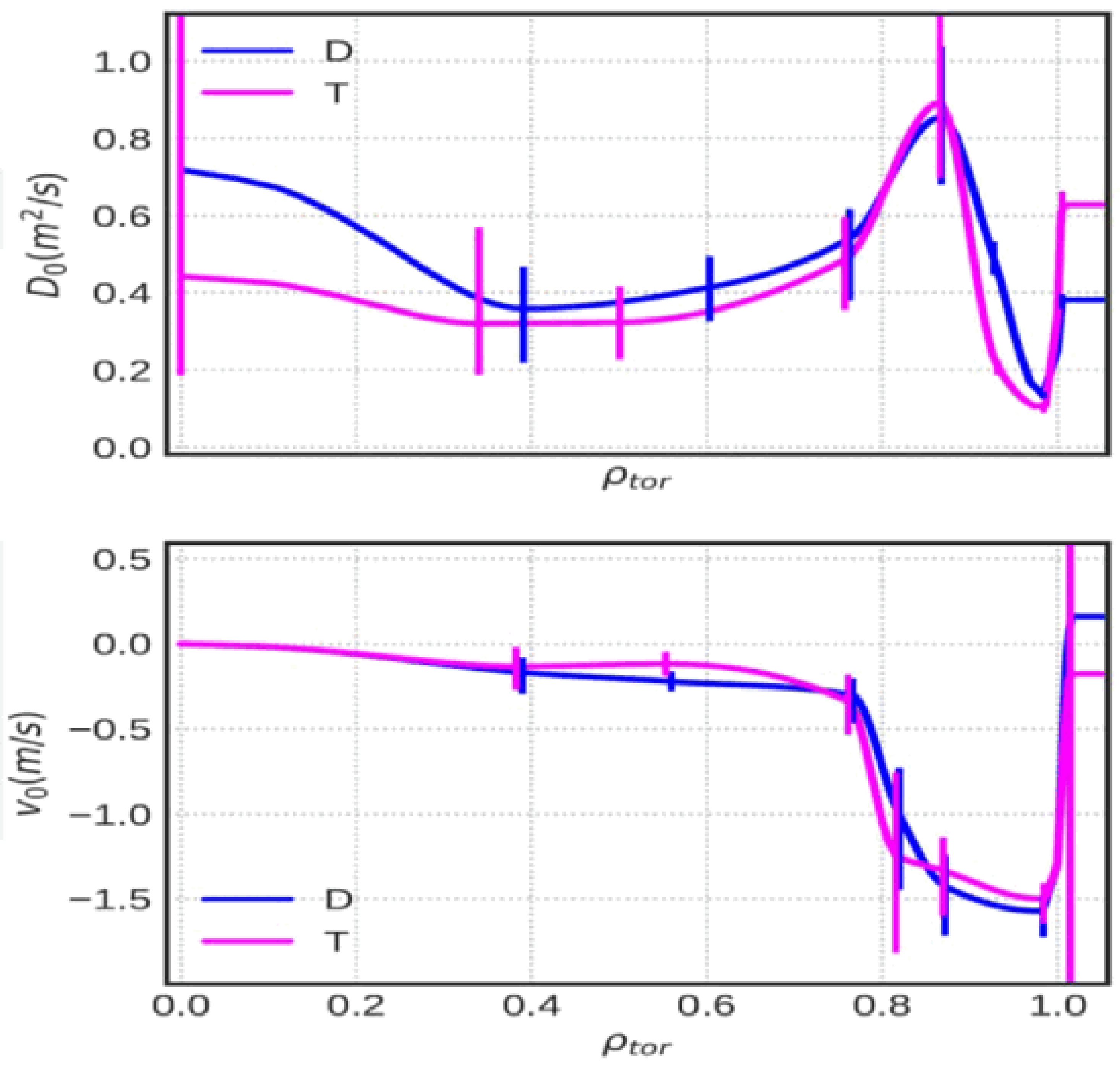
Required non-standard diagnostics: THB, SPR and midplane GPI

Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	20	5
WEST		

#5 Particle transport in long-pulse WEST plasmas

Tala et al., JET DT Nucl. Fusion spec. Issue



- Proponents and contact person:
  Tuomas.Tala@vtt.fi + 9 co-authors

- Scientific Background & Objectives
  - Finalise the perturbative particle transport modulation technique on WEST long pulse plasma scenario using gas puff modulation technique and also test feasibility of the recommissioned SMBI system for particle transport studies.
  - Test ECRH modulation technique for electron heat transport studies for comparison of electron particle and heat transport studies.
  - The following physics scans are planned:
    - density scan (up to limit where LHCD still is centrally absorbed)
    - LHCD power scan
    - triangularity scan (up to negative triangularity)
    - isotope scan between D and H
  - Quantify the electron particle transport coefficients (pinch and diffusion) as a function of the scanned physics quantities
  - Compare the particle transport coefficients with the electron heat transport coefficients, and document the similarities and differencies
  - Validation of GENE gyro-kinetic code and TGLF and QuaLiKiz transport models (both standalone and HFPS integrated modelling) against the core electron particle and heat transport coefficients

- Experimental Strategy and essential diagnostic
  - 1) Dial-up the reference plasma discharge no 59716 where the gas puff modulation created a good density modulation signal seen by the edge profile reflectometry.
  - 2) Extend it to a longer pulse and control density better than in the reference plasma and try some SMBI puffs toward the end of the discharge. In addition, perform ECRH power modulation at the second part of the discharge to study electron heat transport.
  - 3) Perform the physics scans listed above with gas puff modulation (and ECRH modulation)
  - 4) Perform 2-3 pulses per physics parameter point in each of the scan. Obtaining the good modulation data under stationary enough conditions requires 2-3 pulses as keeping the pulses in steady-state conditions is not trivial.

Proposed pulses

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

#5 Particle transport in long-pulse WEST plasmas

Tala et al., JET DT Nucl. Fusion spec. Issue

- TFL assessment: **P1**
- Completion of experiment started in 2024
- Address Sci. Obj. 2

- Proponents and contact person:
  Tuomas.Tala@vtt.fi + 9 co-authors

- Scientific Background & Objectives
  - Finalise the perturbative particle transport modulation technique on WEST long pulse plasma scenario using gas puff modulation technique and also test feasibility of the recommissioned SMBI system for particle transport studies.
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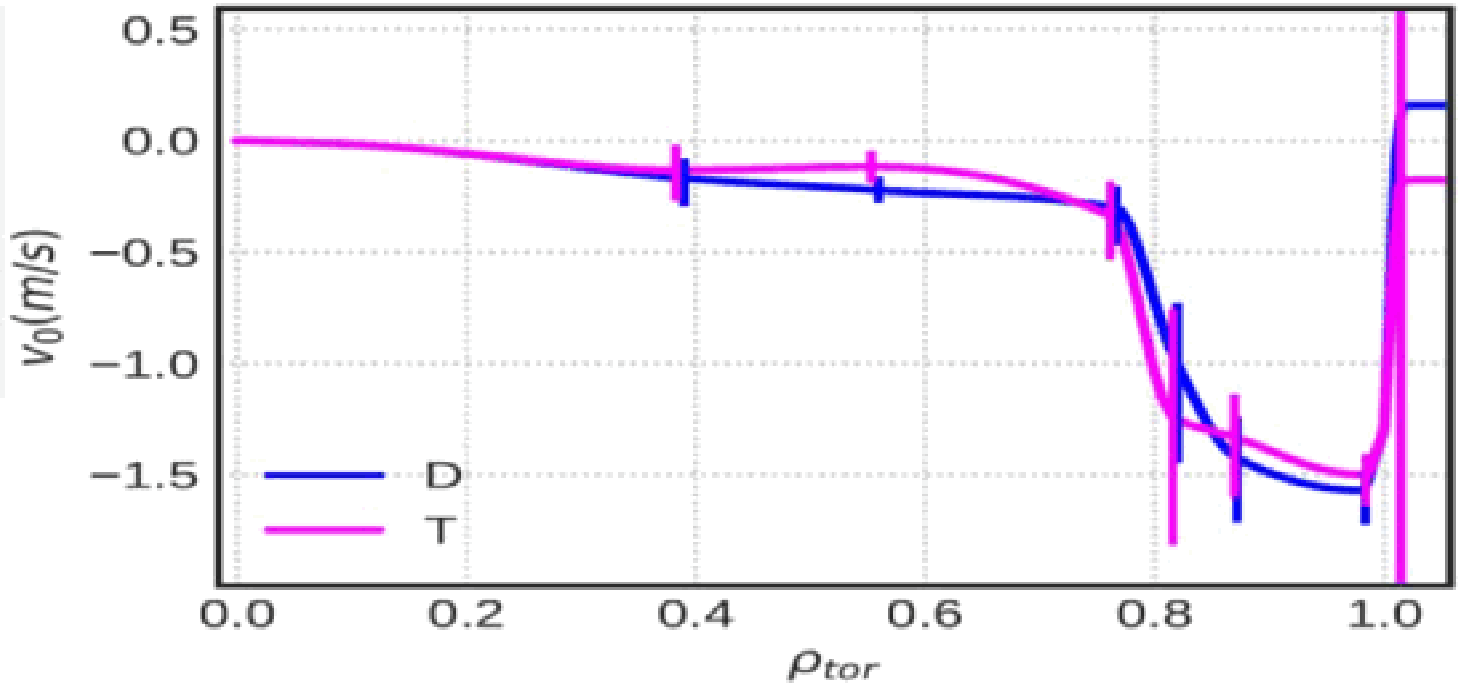


Proposed pulses

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

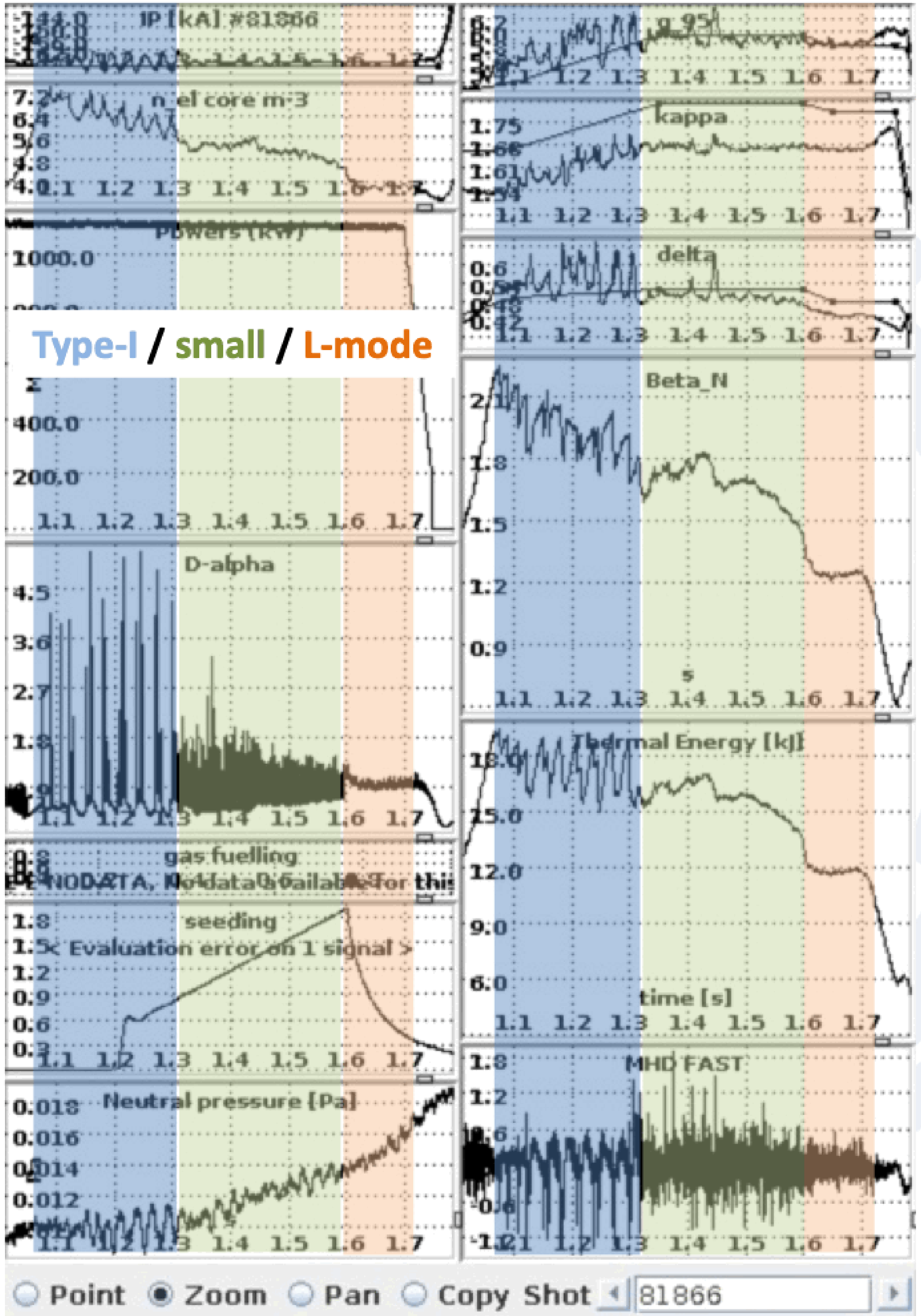
#6 Core-edge integrated IBL scenarios in TCV

- **Proponents and contact person:**
  - Benoit Labit, benoit.labit@epfl.ch
- **Scientific Background & Objectives**
  - Background: In 2024 campaign, first experiments (1 pulse!) with Ar seeding showed good confinement with reduced ELM size.
  - Sci. Objectives: Better understand this scenario:
    - Operational space: power range? Argon range? Impurity accumulation?
    - Level of detachment? XPR?
  - Contribution to D1 and D3

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - LSN ELMy H-mode with ITER shape (κ=1.6, δ=0.5, q_{95}>4)
  - Scan in Argon level + scan with impurity mix
  - Scan in power (both NBI and ECRH)
  - Constrains:
    - Seeding valve calibrated for Argon
    - Unbaffled TCV preferred

Proposed pulses

Device	# Pulses/Session	# Development
TCV	20	0



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  - Constrains:
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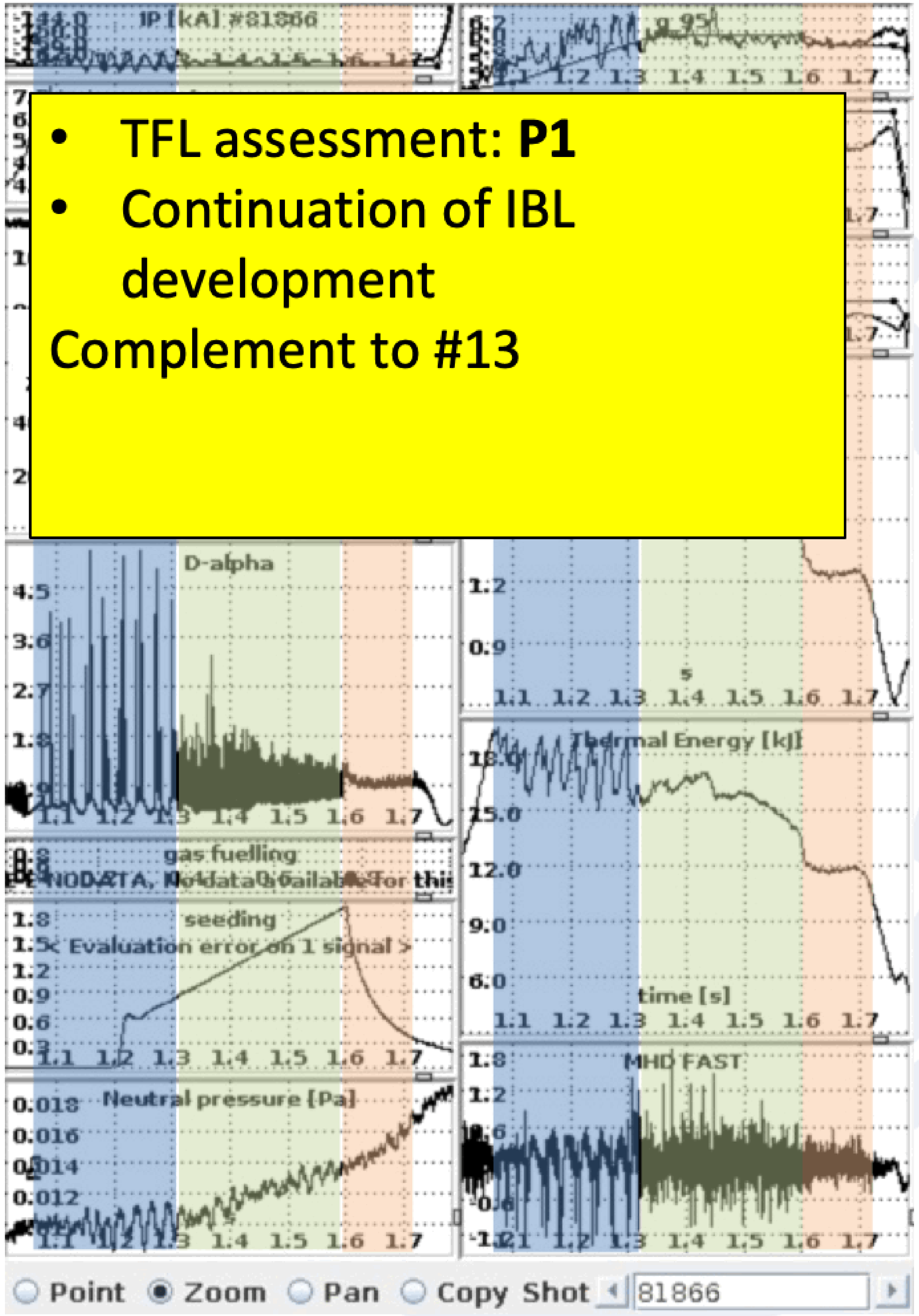
    - Unbaffled TCV preferred

Proposed pulses

Device	# Pulses/Session	# Development
TCV	20	0

- TFL assessment: **P1**
- Continuation of IBL development

Complement to #13

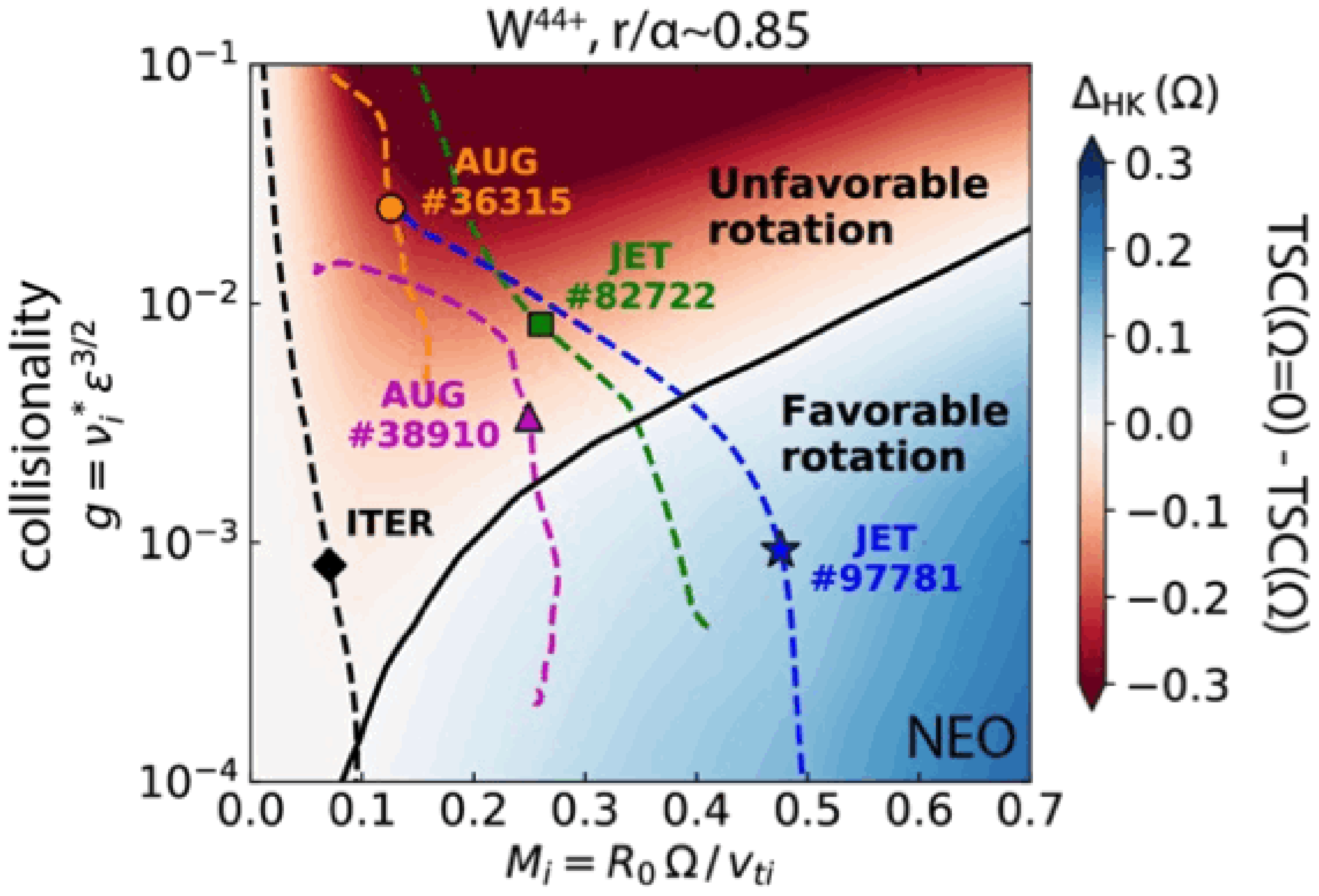


#7 Demonstration of impurity (W) screening at the edge of ASDEX Upgrade plasmas

Proponents and contact person:
A. Kappatou (Athina.Kappatou@ipp.mpg.de), J. Hobirk, D.B. King, C. Angioni, D. Fajardo, M. Bernert, C. Giroud, L. Frassinetti, A.R. Field, E. Lerche, T. Gleiter, …

Scientific Background & Objectives
High performance hybrid scenario pulses at JET *[J. Hobirk et al, NF SI 2023]* achieved temperature screening of W at the plasma periphery *[A. Field et al, NF 2023]* due to outward convection inside the pedestal top, enhanced by the strong rotation in low collisionality conditions *[D. Fajardo et al, PPCF 2023]*.

- Develop AUG plasmas demonstrating W screening at the plasma edge (high T_i^{ped}, low ν, strong v_φ)
- Investigate the behavior of trace seeding impurities (Ne, or N) in such conditions
- Explore pedestal stability and transport in low collisionality plasmas



[Adapted from D. Fajardo et al, PPCF 2023]

Experimental Strategy
Considered approaches:

- Improved H-modes with high β
- Advanced Tokamak scenarios
- Other scenarios aiming to reach very low collisionality

Machine Constraints and essential diagnostics
Relatively fresh boronisation, both NBI, CXRS, spectroscopy, GIW, bolometry, …

Proposed pulses

Device	# Pulses	# Development
AUG	~14 pulses	~20 pulses

#7 Demonstration of impurity (W) screening at the edge of ASDEX Upgrade plasmas

- TFL assessment: **P1**
- Sci. Obj 2, 4, 5 addressed
- Complement JET results and help interpretation

Proponents and contact person:
A. Kappatou (Athina.Kappatou@ipp.mpg.de), J. Hobirk, D.B. King, M. Bernert, C. Giroud, L. Frassinetti, A.R. Field, E. Lerche, T. Gleite

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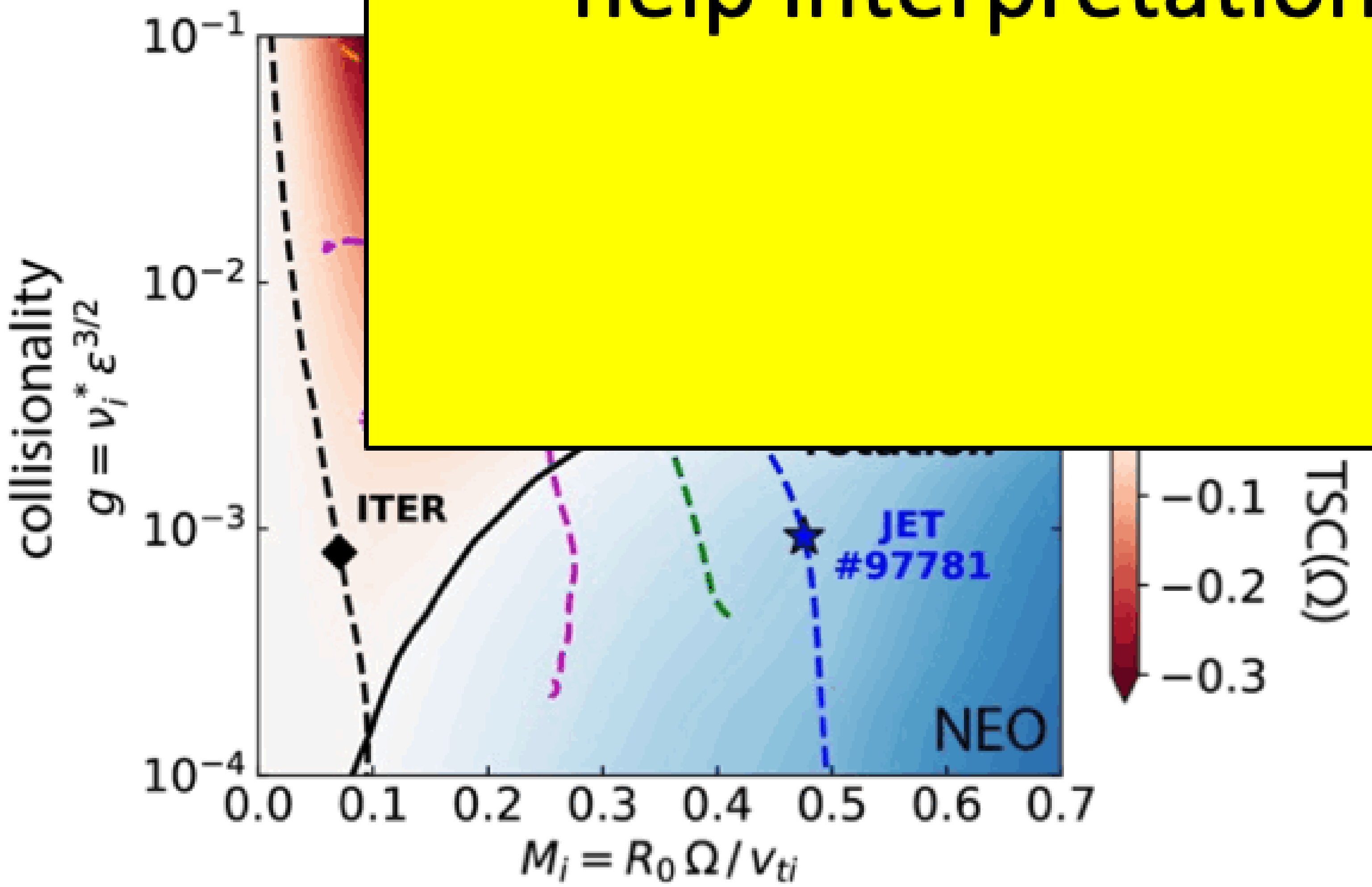

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Considered approaches:

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- Advanced Tokamak scenarios
- Other scenarios aiming to reach very low collisionality

Machine Constraints and essential diagnostics
Relatively fresh boronisation, both NBI, CXRS, spectroscopy, GIW, bolometry, …

Proposed pulses

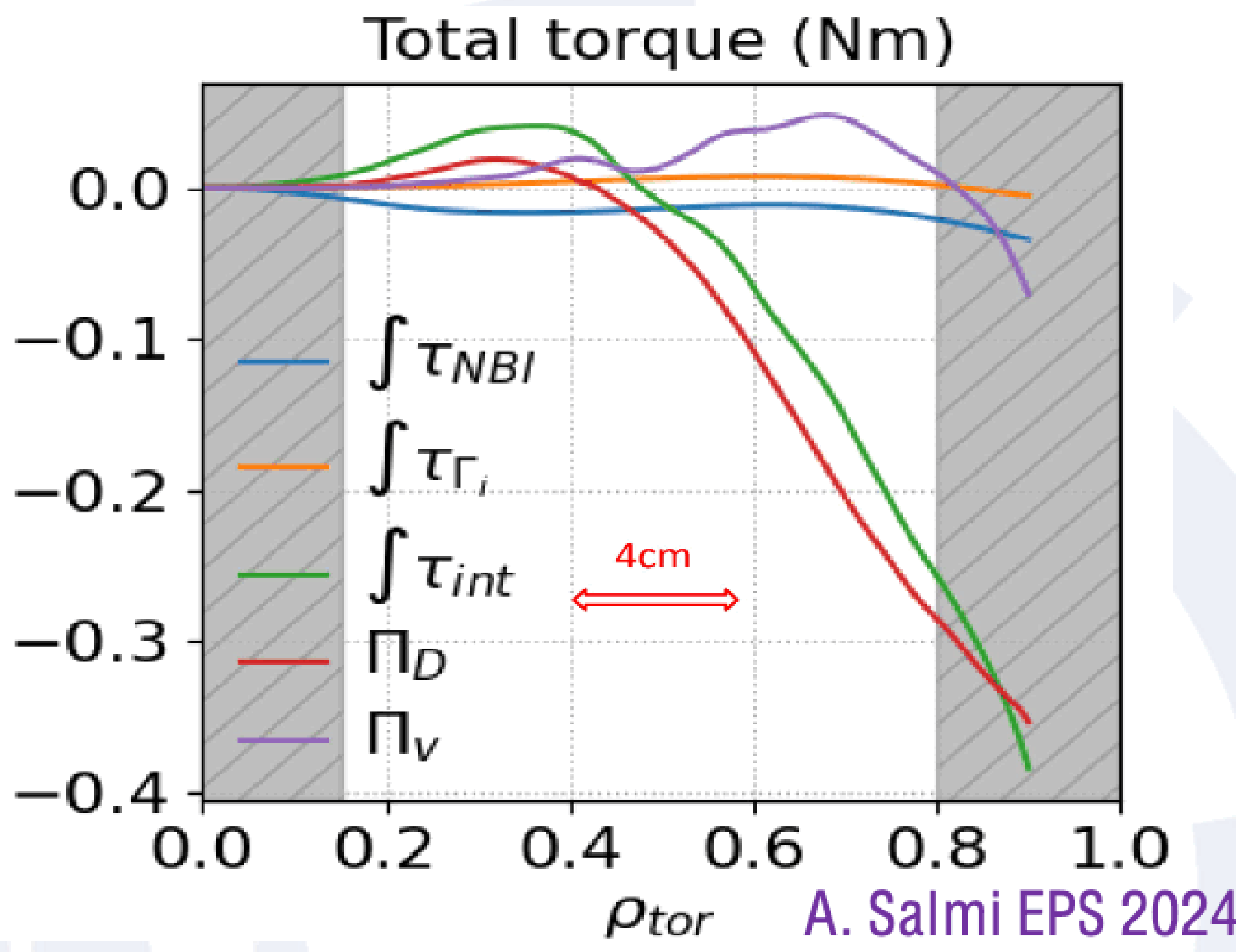
Device	# Pulses	# Development
AUG	~14 pulses	~20 pulses

#8 Momemtum transport in mixed turbulence regimes including intrinsic torque and NTV sources

- Proponents and contact person:
  Tuomas.Tala@vtt.fi + 24 co-authors

- Scientific Background & Objectives
  - Improve predictive capability of rotation, its sources and momentum transport, in particular in electron heated plasmas and spherical tokamaks
  - Experimental analysis methods of momentum transport and intrinsic torque progressed massively in a recent years
  - Objective is to understand momentum transport in various turbulence regimes (ITG/TEM/KBM/MTM) and also measure momentum sources and sinks (intrinsic and NTV)
  - Data for code validation of momentum transport and intrinsic torque and NTV on the level of transport coefficients (GENE, GKW, STELLA, TGLF, MARS-F, GPEC/Pent, Neo2 NTV)

- Experimental Strategy and essential diagnostic
  - MAST-U: Measure momentum transport coefficients and intrinsic torque on MAST-U by using the NBI modulation technique (developed in November 2024 MAST-U experiment) in non-ITG dominated/mixed turbulence conditions in KBM/MTM dominated plasmas.
  - AUG: Measure momentum transport coefficients and intrinsic torque in TEM dominated plasma regime. Study momentum transport and intrinsic torque towards the edge in QCE or XPR scenario. Perform RMP coil modulation experiment to obtain the NTV torque under varying AUG conditions with either small ELM or ELM-free scenarios. Comparison of NTV torque between MAST-U and AUG.
  - TCV: Perform a comparison of intrinsic torque profiles between negative and positive triangularity plasmas by exploiting the NBH2 beam together with NBH1 to zero-out/minimise the rotation. Study intrinsic torque in H-mode plasmas, using the small ELM or no ELM scenario (QCE now the leading candidate scenario for this), and perform a power and density scans.



A. Salmi EPS 2024

Proposed pulses

Device	# Pulses/Session	# Development
AUG	20	10
MAST-U	24	0
TCV	30	0
WEST		

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  Tuomas.Tala@vtt.fi + 24 co-authors

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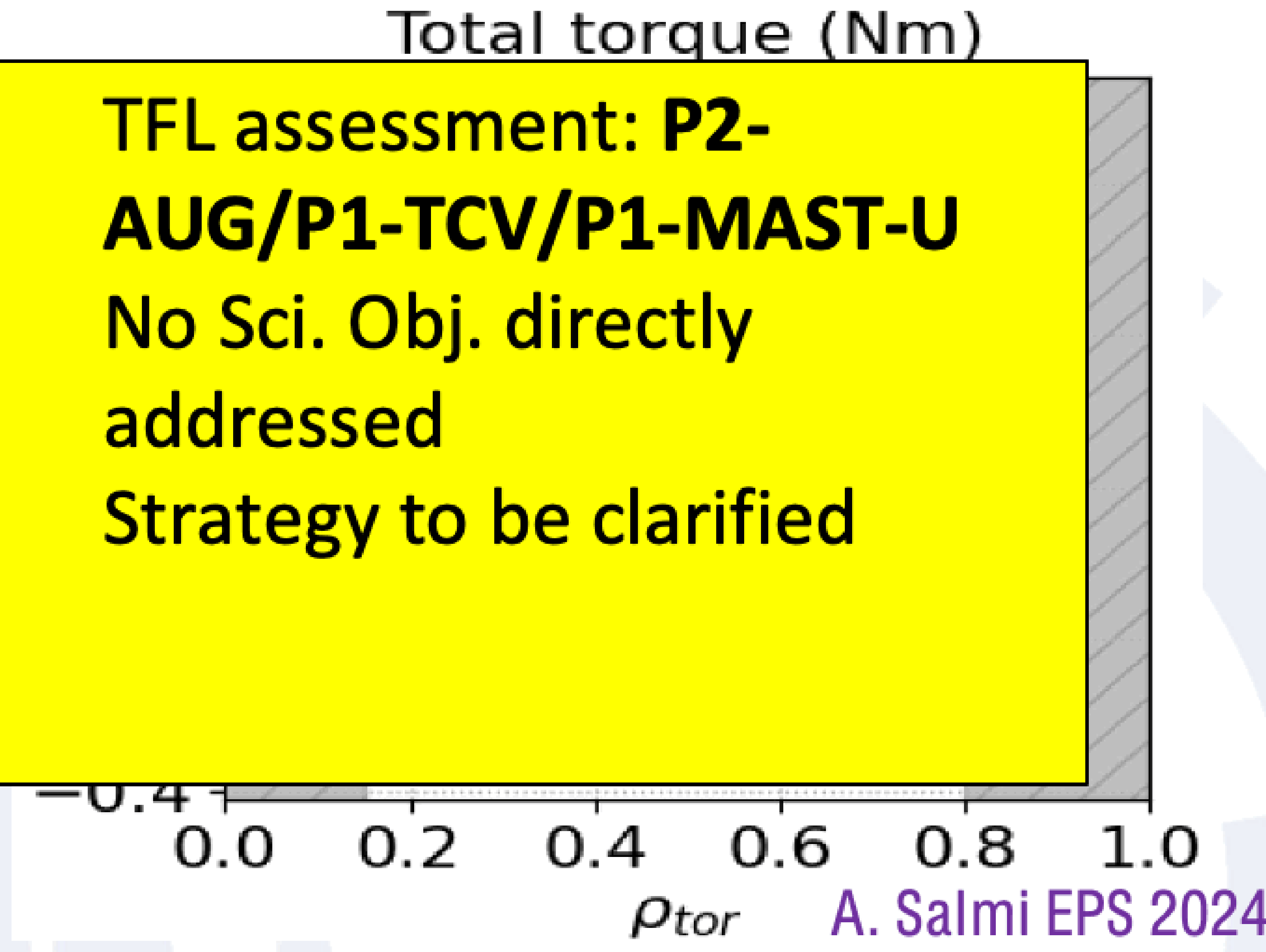


- TFL assessment: **P2-AUG/P1-TCV/P1-MAST-U**
- No Sci. Obj. directly addressed
- Strategy to be clarified

A. Salmi EPS 2024

Proposed pulses

Device	# Pulses/Session	# Development
AUG	20	10
MAST-U	24	0
TCV	30	0
WEST		

#9 Hydrogen isotope transport in H-mode plasmas

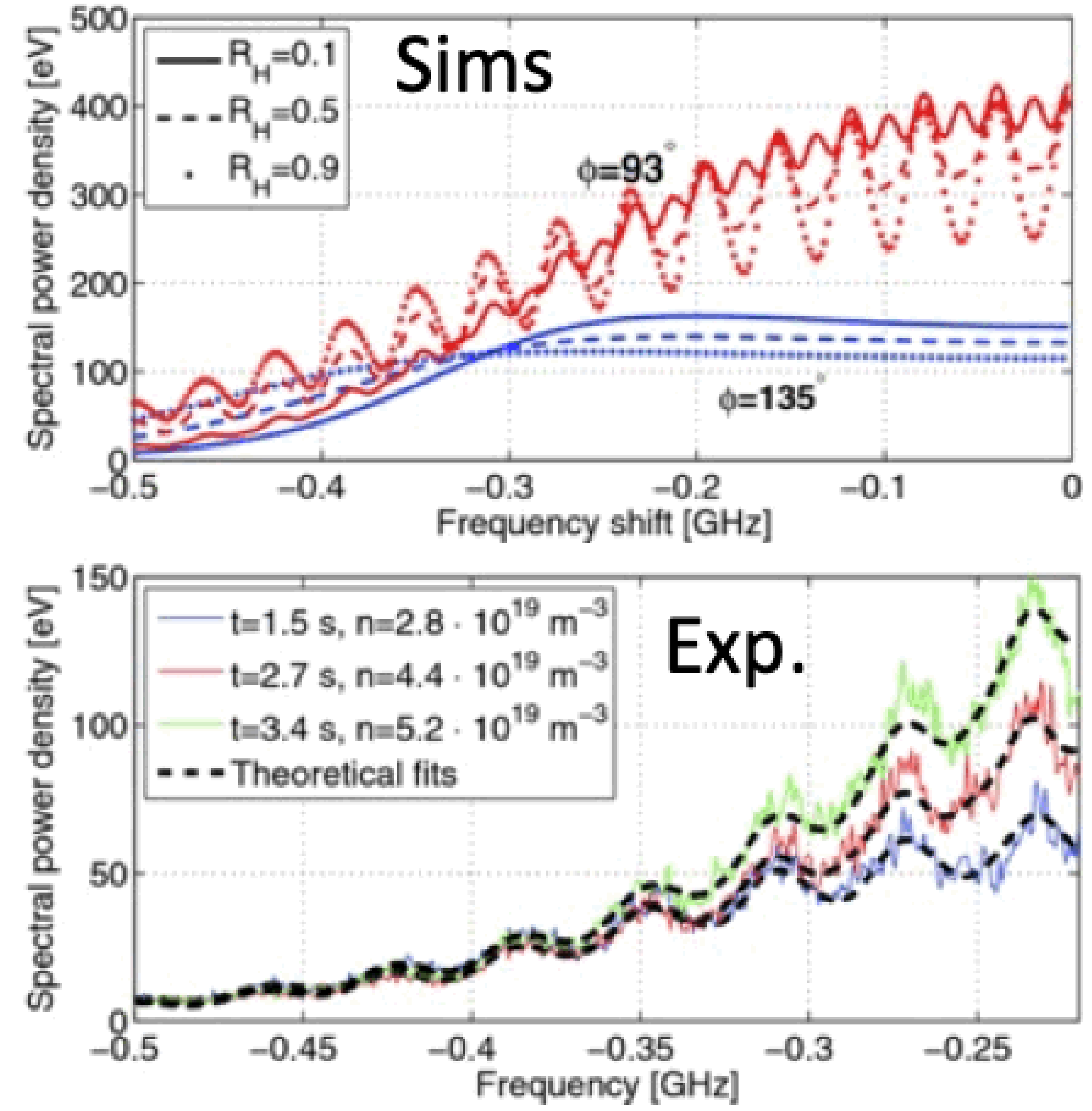
- **Proponents and contact person:**

J. Rasmussen (DTU), S.B: Korsholm (DTU), P. Schneider (IPP), M. Weiland (IPP) et al. jeras@fysik.dtu.dk

- **Scientific Background & Objectives**

Spatially resolved hydrogen isotope ratios have not been measured at the core of H-mode plasmas. As a result, core D/H ratios, core D/H transport, and their impact on the L-H power threshold, have not been experimentally assessed. We will use CTS on AUG (Figure) for this to improve understanding of H-mode plasmas and

- Provide the first spatially resolved measurements of n_D/n_H in low-collisionality H-mode plasmas
- Quantify convective and diffusive core transport coefficients for hydrogen isotopes in ITER-/DEMO-relevant H-mode discharges
- Quantify the impact of *core* D/H ratio on the L-H power threshold.



Simulated and measured CTS spectra in TEXTOR (M. Stejner+ 2012 RSI) and their dependence on plasma composition $R_H = n_H/(n_H+n_D)$ and on the CTS measurement angle φ relative to ***B***. For φ close to 90° , the spectra are highly sensitive to R_H.

- **Experimental Strategy & constraints**

- Bt = 2.65 T for CTS, line-integrated $n_e \approx 3 \times 10^{19}$ m^{-2}
- ≥2.5 MW ECRH for low ν*, 2.5 MW NBI for core fuelling + H-mode
- Sweep CTS volume from ρ = 0.1 ⟶ 0.8 to get n_H/n_D profiles
- Gyr 6, 7, 8 for CTS at 105 GHz + new CTS fast digitizer
- Gas: D with minority H (or H with He4), including cleaning discharge

Proposed pulses

Device	# Pulses/Session	# Development
AUG	6	1

#9 Hydrogen isotope transport in H-mode plasmas

- TFL assessment: **P2**
- To be re-evaluate if Hydrogen operation

- **Proponents and contact person:**

J. Rasmussen (DTU), S.B: Korsholm (DTU), P. Schneider (IPP), M. Weiland (IPP) et al. jeras@fysik.dtu.dk

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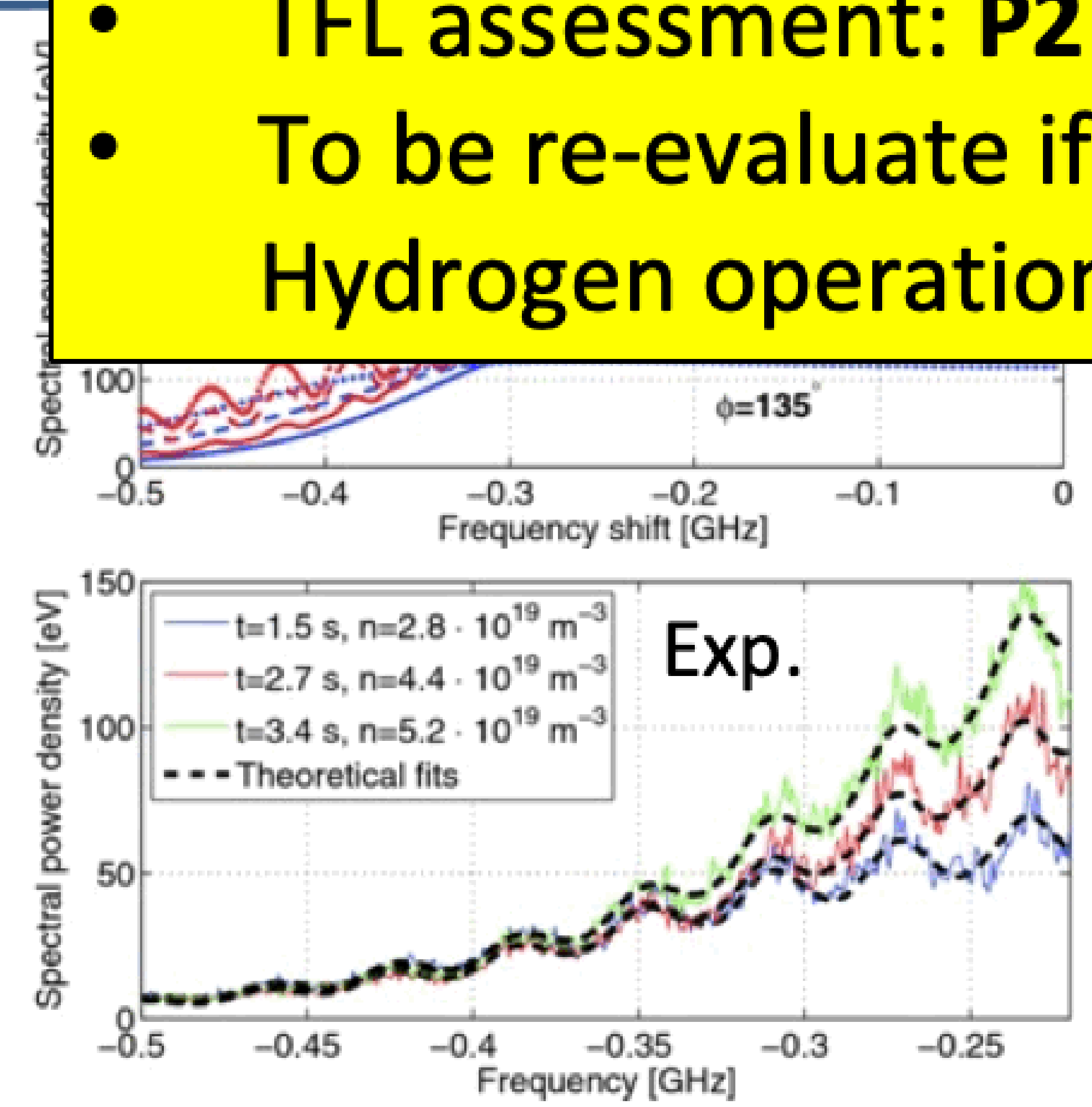

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- Gyr 6, 7, 8 for CTS at 105 GHz + new CTS fast digitizer
- Gas: D with minority H (or H with He4), including cleaning discharge

Proposed pulses

Device	# Pulses/Session	# Development
AUG	6	1

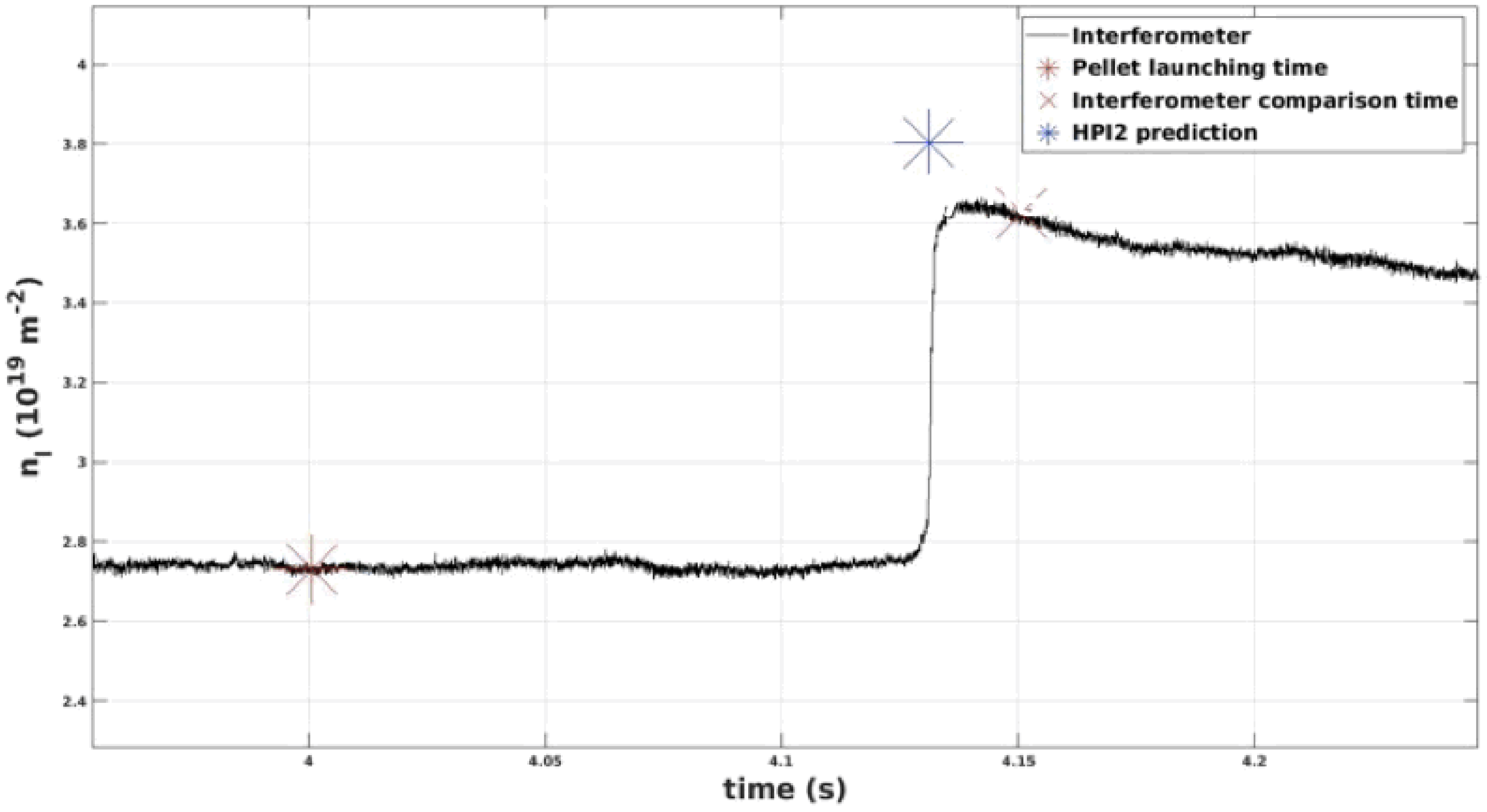
#10 Pellet injection in WEST and AUG for HPI2 and HPI2-NN validation and improvement.

- **Proponents and contact person:**

Alex Panera Álvarez (a.paneraalvarez@differ.nl) , Eléonore Geulin, Sven Wiesen, Peter Lang, Clarisse Bourdelle and Jean-François Artaud

- **Scientific Background & Objectives**
  - Pellets are a crucial tool for getting fuel to the plasma core in large devices.
  - For modelling their effect: HPI2 model and the AI based HPI2-NN model are the main tools
  - Objective:
    - Validating these tools in integrated modelling suites
    - Applying transfer learning techniques to HPI2-NN using experimental data
  - Need: Better diagnosed Ohmic shots in both WEST and AUG tokamaks

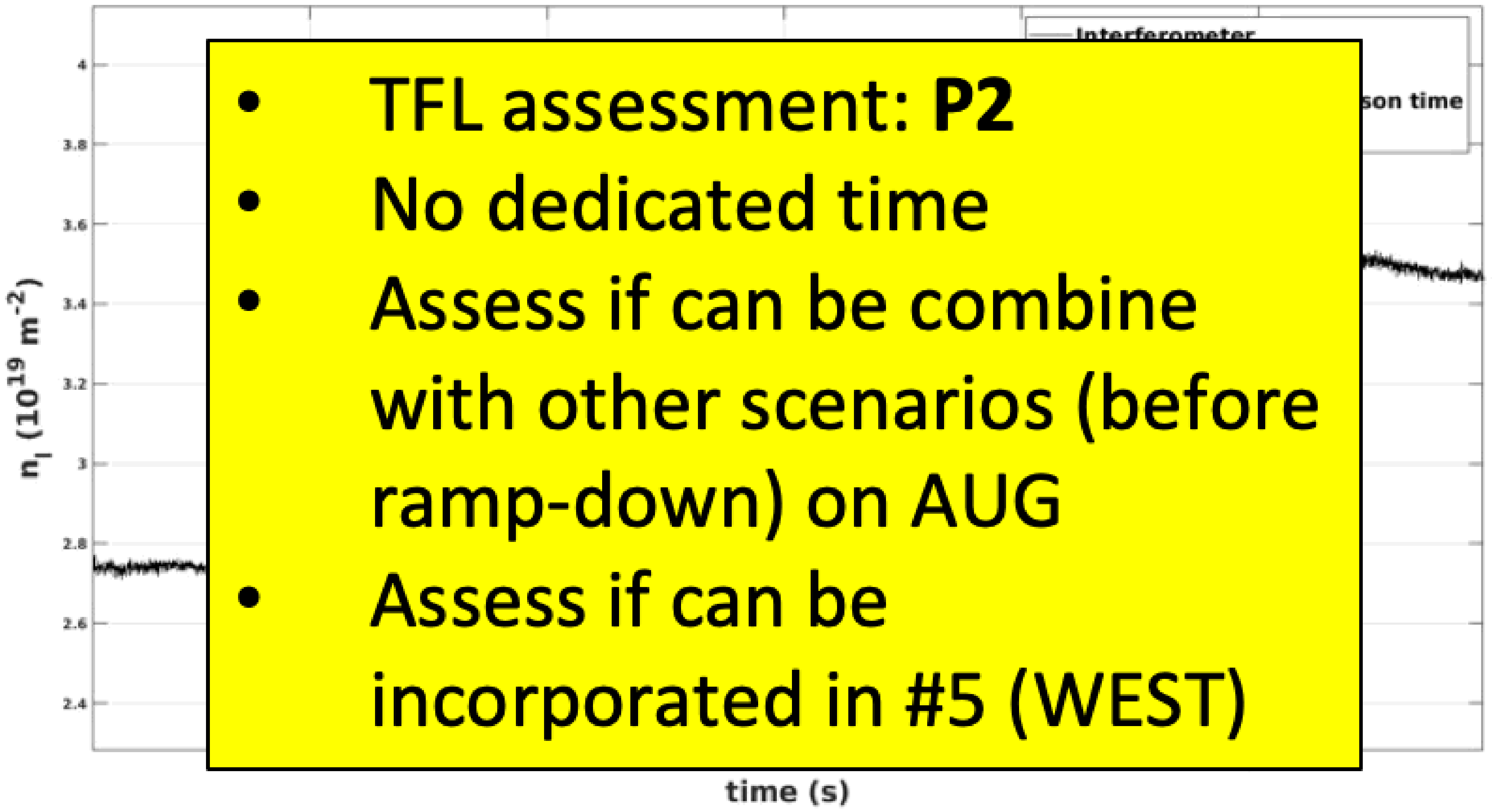
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Ohmic shots: with scan in pellet velocity, mass and injection point (the last one just in WEST). 3 to 5 pellets per shot at a low repetition rate.
  - Ohmic shots: scan for different densities and temperatures profiles
  - Essential diagnostic: Langmuir probes, IR cameras, Thomson scattering, Li-beams, ECE, Divertor neutral gas manometer, DCN->DCR, ILK to Bremsstrahlung



Proposed pulses

Device	# Pulses/Session	# Development
AUG	6	2
MAST-U		
TCV		
WEST	15	2

#10 Pellet injection in WEST and AUG for HPI2 and HPI2-NN validation and improvement.



- TFL assessment: **P2**
- No dedicated time
- Assess if can be combine with other scenarios (before ramp-down) on AUG
- Assess if can be incorporated in #5 (WEST)

- **Proponents and contact person:**

Alex Panera Álvarez (a.paneraalvarez@differ.nl) , Eléonore Geulin, Sven Wiesen, Peter Lang, Clarisse Bourdelle and Jean-François Artaud

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Proposed pulses

Device	# Pulses/Session	# Development
AUG	6	2
MAST-U		
TCV		
WEST	15	2

#11 Sustaining H-mode performance in a tungsten environment

- **Proponents and contact person:**

Jorge Morales (jorge.morales2@cea.fr), Patrick Maget, Gregor Birkenmeier, Jean Cazabonne, Theo Fonghetti, Pierre Manas, Rémi Dumont, Annika Ekedahl, Léna Delpech, Julien Hillairet, Laure Vermare, Loïc Schiesko, Samuele Mazzi, Nicolas Fedorczak, Alexandre Fil, Jamie Gunn, Laurent Colas, Jean-François Artaud, Philippe Moreau, Xavier Litaudon, Sascha Rienacker, Pascale Hennequin

- **Scientific Background & Objectives**
- **Background**: In a tungsten environment, ECRH should allow a better control of impurity influx (e.g. ASDEX, EAST). Also, off-axis ECCD modifies q-profile and potentially improves core confinement. In WEST, the synergy between ECRH and LHCD can be leveraged (synergy improves by a factor 4 ECCD efficiency **[Giruzzi, PRL, 2004]**). In addition, ITER baseline requires to extend current ECRH studies.
- **Questions addressed:**
  - Taking into account LHCD and ICRH heated plasmas interacting with a full tungsten wall, what is the impact of <u>**on-axis**</u> ECRH on impurity transport, L-H transition and H-mode performance?
  - What is the <u>**off-axis**</u> ECRH/ECCD effect?
- **Experimental Strategy/Machine Constraints and essential diagnostic**
- <u>*Early 2025*</u>: one gyrotron is available, add 1 MW of ECRH <u>on-axis</u> to LHCD and ICRH heated plasmas. Add EC power early on discharge, characterize L-H transition, impurity transport and resulting H-mode. Use two magnetic field strengths, full and half field, to better characterize L-H transition.
- <u>*Late 2025*</u>: more ECRH power is available, 1 MW will be kept for <u>on-axis</u> heating (to mitigate W contamination), the rest of the power will be injected <u>off-axis</u> to assess modifications on q-profile. With 1 MW of power (or more) deposited <u>off-axis</u> characterize: L-H transition, impurity transport and resulting H-mode performance.
- <u>Main diagnostics</u>: Thomson scattering (edge and core), bolometry, Doppler reflectometry and UV/Visible spectroscopy.

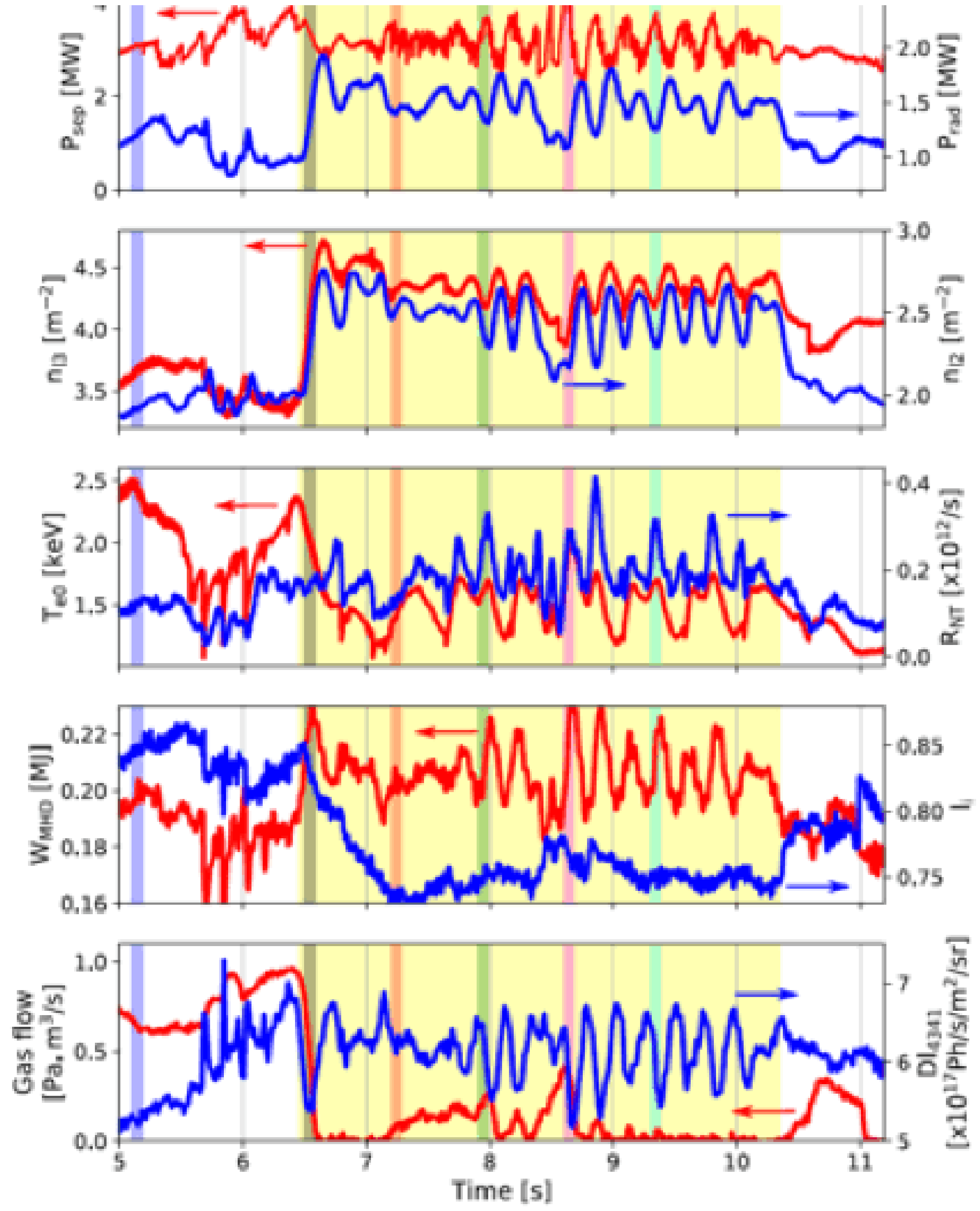

Fig. WEST 55564 discharge with an L-H transition at t=6.45s. The yellow area shows oscillatory phase where H-mode is not stable due to increased radiation (impurities are as well confined as bulk plasma) **[Vermare, NF, 2022]**. ECRH will help to mitigate the observed impurity contamination.

Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV		
WEST	60/3	15

#11 Sustaining H-mode performance in a tungsten environment

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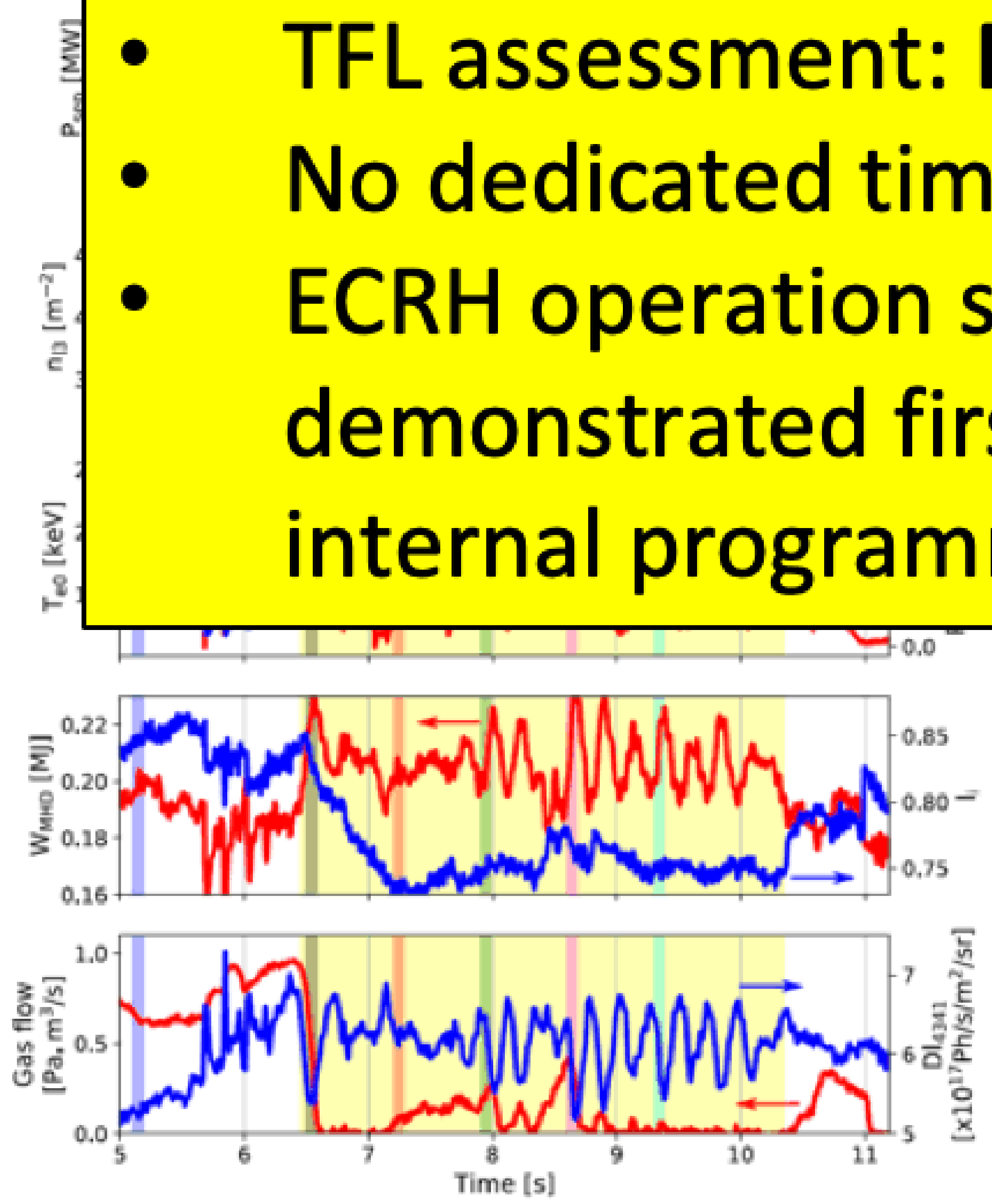
  - What is the **off-axis** ECRH/ECCD effect?
- **Experimental Strategy/Machine Constraints and essential diagnostic**
- *Early 2025*: one gyrotron is available, add 1 MW of ECRH on-axis to LHCD and ICRH heated plasmas. Add EC power early on discharge, characterize L-H transition, impurity transport and resulting H-mode. Use two magnetic field strengths, full and half field, to better characterize L-H transition.
- *Late 2025*: more ECRH power is available, 1 MW will be kept for on-axis heating (to mitigate W contamination), the rest of the power will be injected off-axis to assess modifications on q-profile. With 1 MW of power (or more) deposited off-axis characterize: L-H transition, impurity transport and resulting H-mode performance.
- Main diagnostics: Thomson scattering (edge and core), bolometry, Doppler reflectometry and UV/Visible spectroscopy.

- TFL assessment: **P2**
- No dedicated time
- ECRH operation should be demonstrated first in internal programme



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Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV		
WEST	60/3	15

#12 Examining the impact of transitioning to electron heated dominated plasma on the turbulence in AUG (RT01)

- **Proponents and contact person:**
  - Bhavin Patel: bhavin.s.patel@ukaea.uk
  - Tobias Goerler, Simon Freethy

- **Scientific Background & Objectives**
  - As we transition to reactor relevant scenarios, the plasma we will examine by necessity will have significant alpha heating. The alphas impart most of their energy to the electrons as they slow down meaning we will need to transition towards electron heating dominated plasmas [1]. Understanding the impact of this on the turbulence will be critical in the optimization for future experiments. Current NBI systems inject neutrals at lower energies compared to ITER which will result in them imparting most of their energy to the ions, leading to a different heating mixture. To address this issue, we propose to vary the ratio of NBI and ECH (Electron Cyclotron Heating) such that we approach ITER/DEMO-like heating composition.
  - Examine a high-powered NBI H-mode and modify the ratio of NBI to ECRH throughout the shot at fixed power like F. Sommer et al 2015 Nucl. Fusion 55 033006. This experiment will build upon this by performing this at more than double higher injected power pushing towards a higher performance scenario at higher beta, changing the character of the turbulence. Using integrated modelling the performance of the plasmas will be quantified in these different heating regimes.
  - Furthermore, to gain a deeper understanding on the nature of the core turbulence, these plasmas will be examined using linear/nonlinear gyrokinetic codes like GENE/CGYRO. These simulations will be used to make direct comparisons to experimental measurements from turbulence diagnostics using synthetic diagnostics of the CECE/DBS, This will allow for the validation of the use of these first principle-based models.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - H mode scenario similar to 28116 but at >15MW of NBI power. Throughout shot increase level of ECRH from 0 up to 8MW of ECRH whilst reducing the NBI power in several stages to maintain a constant total power
  - Perform several repeats whilst modifying diagnostic viewing position to obtain turbulent characteristics over full plasma profile
  - Repeat experiments with RMP turned on to examine plasma impact at a lower plasma rotation
  - Repeat at lower density (L mode upper single in unfavourable configuration like FIRE mode in KSTAR)
  - NBI, ECRH, turbulence diagnostics (DBS, BES, CECE), MSE, Thomson scattering, charge exchange, bolometry
  - 2.5T, 1MA, 8 second pulse duration

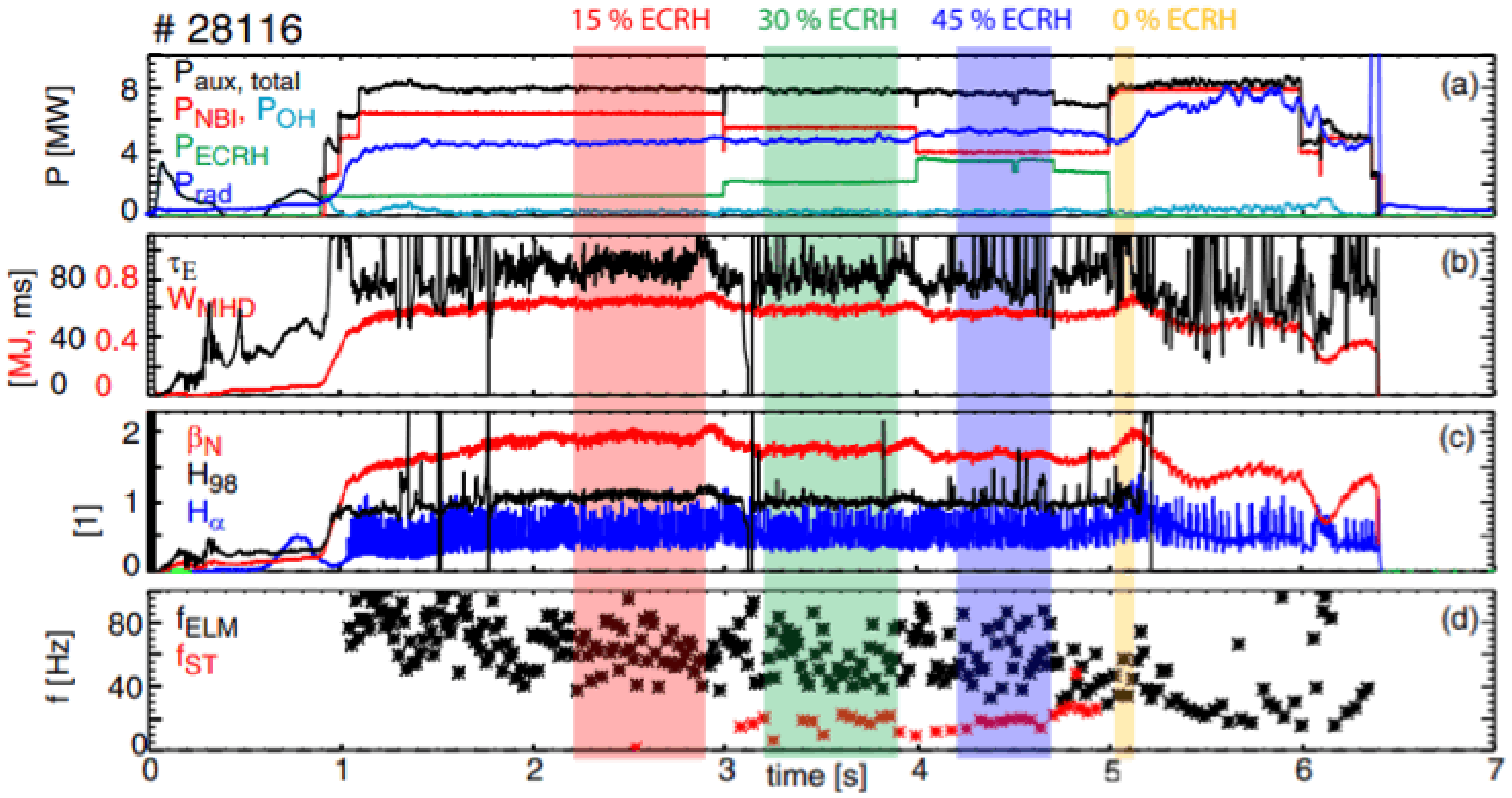

Figure 1. Overview plot of a low collisionality discharge. (*a*) Total auxiliary (black), NBI (red), central ECRH (green), ohmic power (light blue) and radiated power (blue); (*b*) stored energy W_{MHD} (red), and energy confinement time τ_E (black); (*c*) normalized beta β_N (red), confinement factor H_{98} (black) and H_α radiation in the divertor (blue); (*d*) ELM frequency (black) and sawtooth frequency (red).

Proposed pulses

Device	# Pulses/Session	# Development
AUG	16 pulses	8 development
MAST-U		
TCV		
WEST		

#12 Examining the impact of transitioning to electron heated dominated plasma on the turbulence in AUG (RT01)

- **Proponents and contact person:**
  - Bhavin Patel: bhavin.s.patel@ukaea.uk
  - Tobias Goerler, Simon Freethy

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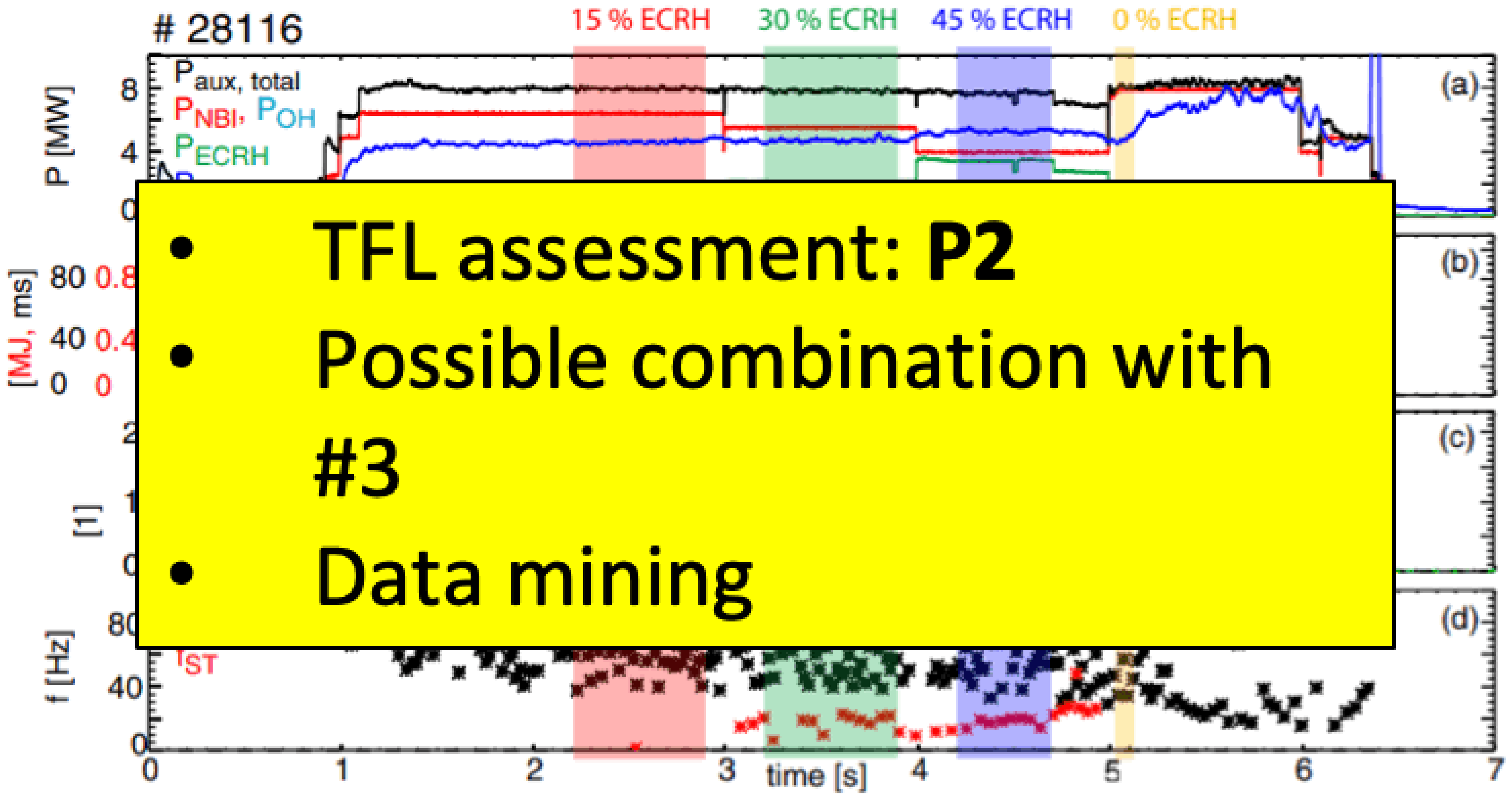
  - Examine a high-powered NBI H-mode and modify the ratio of NBI to ECRH throughout the shot at fixed power like F. Sommer et al 2015 Nucl. Fusion 55 033006. This experiment will build upon this by performing this at more than double higher injected power pushing towards a higher performance scenario at higher beta, changing the character of the turbulence. Using integrated modelling the performance of the plasmas will be quantified in these different heating regimes.
  - Furthermore, to gain a deeper understanding on the nature of the core turbulence, these plasmas will be examined using linear/nonlinear gyrokinetic codes like GENE/CGYRO. These simulations will be used to make direct comparisons to experimental measurements from turbulence diagnostics using synthetic diagnostics of the CECE/DBS, This will allow for the validation of the use of these first principle-based models.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - H mode scenario similar to 28116 but at >15MW of NBI power. Throughout shot increase level of ECRH from 0 up to 8MW of ECRH whilst reducing the NBI power in several stages to maintain a constant total power
  - Perform several repeats whilst modifying diagnostic viewing position to obtain turbulent characteristics over full plasma profile
  - Repeat experiments with RMP turned on to examine plasma impact at a lower plasma rotation
  - Repeat at lower density (L mode upper single in unfavourable configuration like FIRE mode in KSTAR)
  - NBI, ECRH, turbulence diagnostics (DBS, BES, CECE), MSE, Thomson scattering, charge exchange, bolometry
  - 2.5T, 1MA, 8 second pulse duration



- TFL assessment: **P2**
- Possible combination with #3
- Data mining

Figure 1. Overview plot of a low collisionality discharge. (*a*) Total auxiliary (black), NBI (red), central ECRH (green), ohmic power (light blue) and radiated power (blue); (*b*) stored energy W_{MHD} (red), and energy confinement time τ_E (black); (*c*) normalized beta β_N (red), confinement factor H_{98} (black) and H_α radiation in the divertor (blue); (*d*) ELM frequency (black) and sawtooth frequency (red).

Proposed pulses

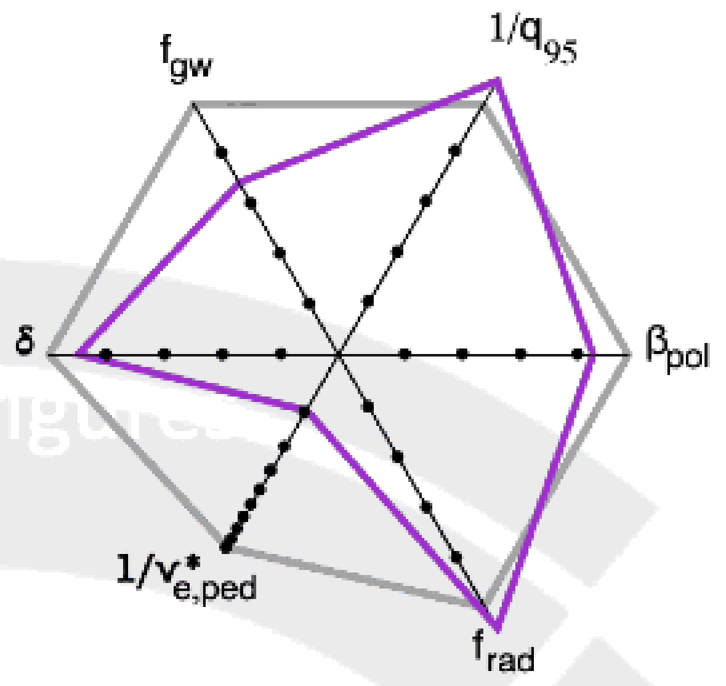
Device	# Pulses/Session	# Development
AUG	16 pulses	8 development
MAST-U		
TCV		
WEST		

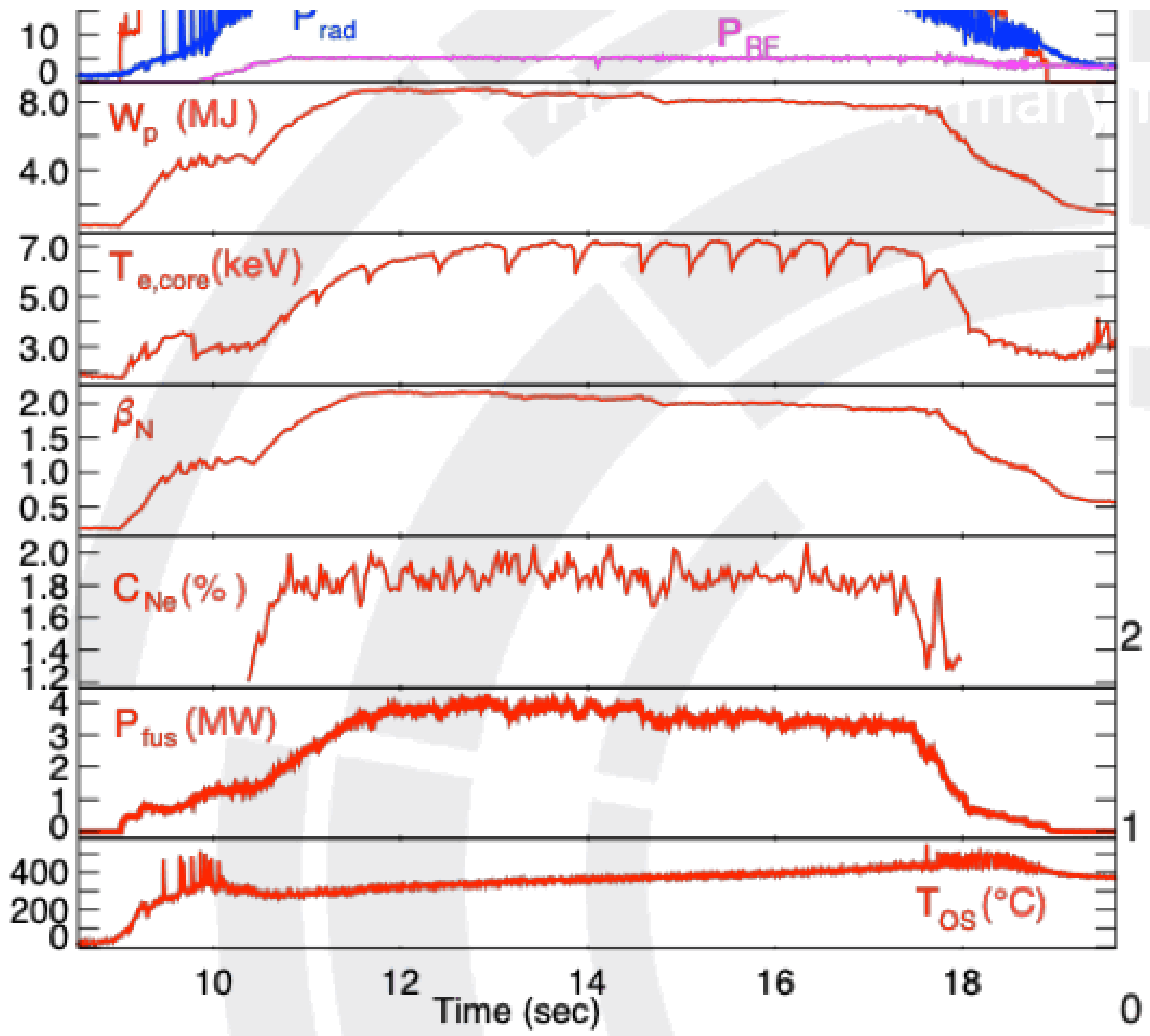
#13 Core-edge integrated scenario for IBL in AUG in support of the JET IBL results

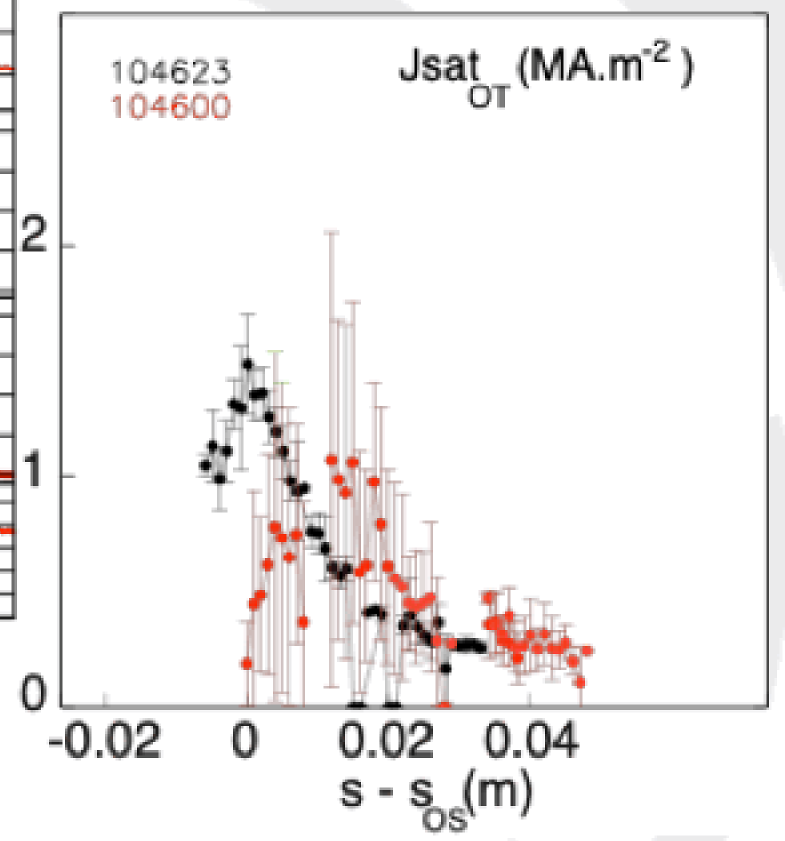
- **Proponents and contact person:**
- S.Wiesen, C. Giroud, T. Putterich, JET ITER baseline team
- **Scientific Background & Objectives**
  - JET ITER baseline achieved best integrated scenario with Neon-seeding, over N and Ar.
  - Detailed analysis and modelling activities on core-edge-sol/div integration being carried out for different current and D/D-T environment, impurity.

1) **Test the physics identified to be a play in the core-edge-SOL** integration in JET ITB (expected also in AUG) (different imp. , mix)
2) **Complement information obtained on JET such as the impact of fuelling pellets** (M. Valovic) in detached plasmas
3) **Obtain additional information no avail on JET: W wall erosion**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Start from AUG ITER baseline plasmas
  - Establish or re-use Ar-seeded ITER baseline
  - Scan Ar up to partial detachment with different throughput (impact on confinement, pedestal pressure, ELM size changes, Elm freq, distance from H to L back transition)
  - Similar assess Ne or Ar/Ne
  - Pellets in partially detached plasma







Proposed pulses

Device	# Pulses/Session	# Development
AUG	20	5
MAST-U		
TCV		
WEST		

#13 Core-edge integrated scenario for IBL in AUG in support of the JET IBL results

- **Proponents and contact person:**
- S.Wiesen, C. Giroud, T. Putterich, JET ITER baseline team
- **Scientific Background & Objectives**
  - JET ITER baseline achieved best integrated scenario with Neon-seeding, over N and Ar.
  - Detailed analysis and modelling activities on core-edge-sol/div integration being carried out for different current and D/D-T environment, impurity.

1) **Test the physics identified to be a play in the core-edge-SOL** integration in JET ITB (expected also in AUG) (different imp. , mix)
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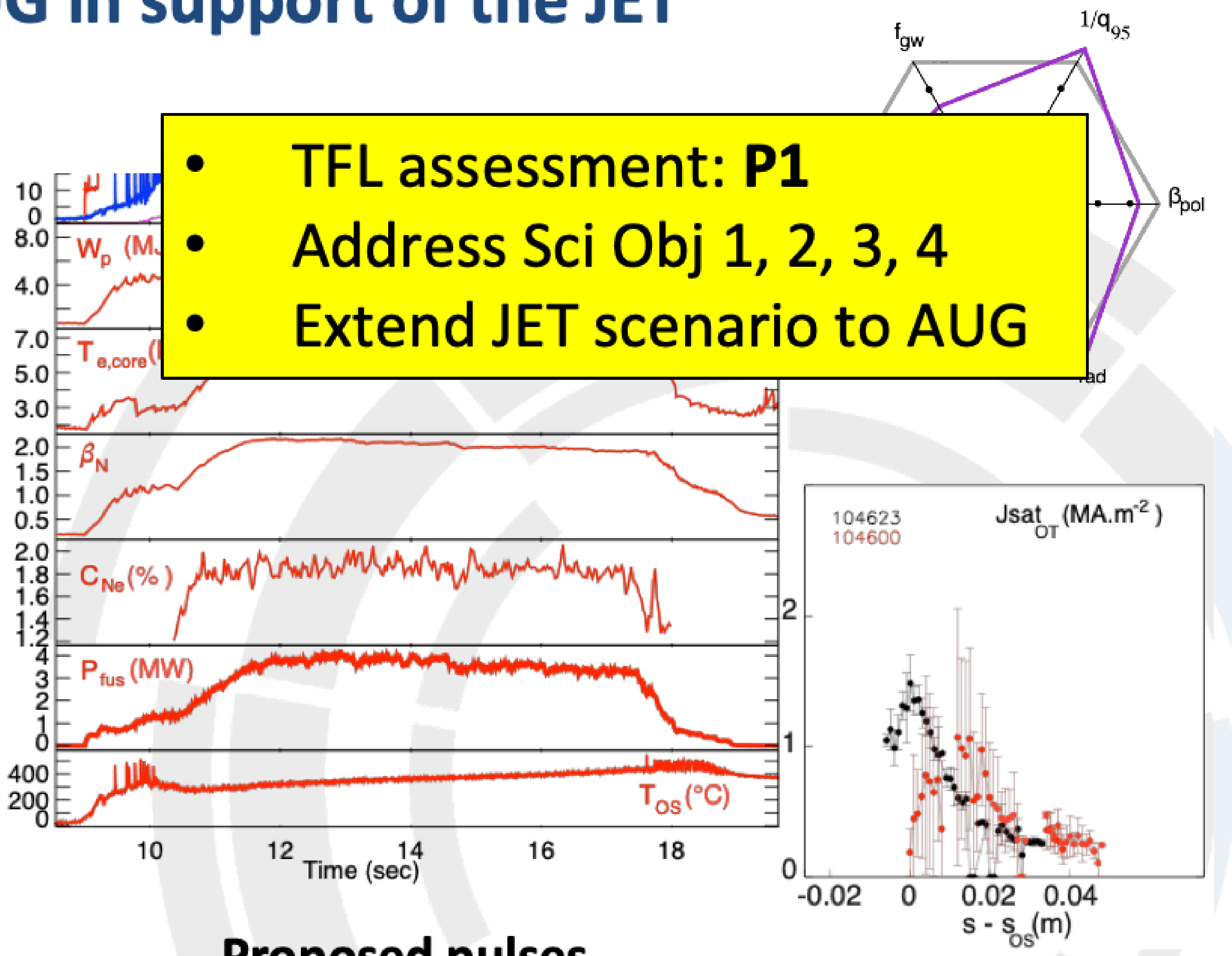
3) **Obtain additional information no avail on JET: W wall erosion**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Start from AUG ITER baseline plasmas
  - Establish or re-use Ar-seeded ITER baseline
  - Scan Ar up to partial detachment with different throughput (impact on confinement, pedestal pressure, ELM size changes, Elm freq, distance from H to L back transition)
  - Similar assess Ne or Ar/Ne
  - Pellets in partially detached plasma

- TFL assessment: **P1**
- Address Sci Obj 1, 2, 3, 4
- Extend JET scenario to AUG

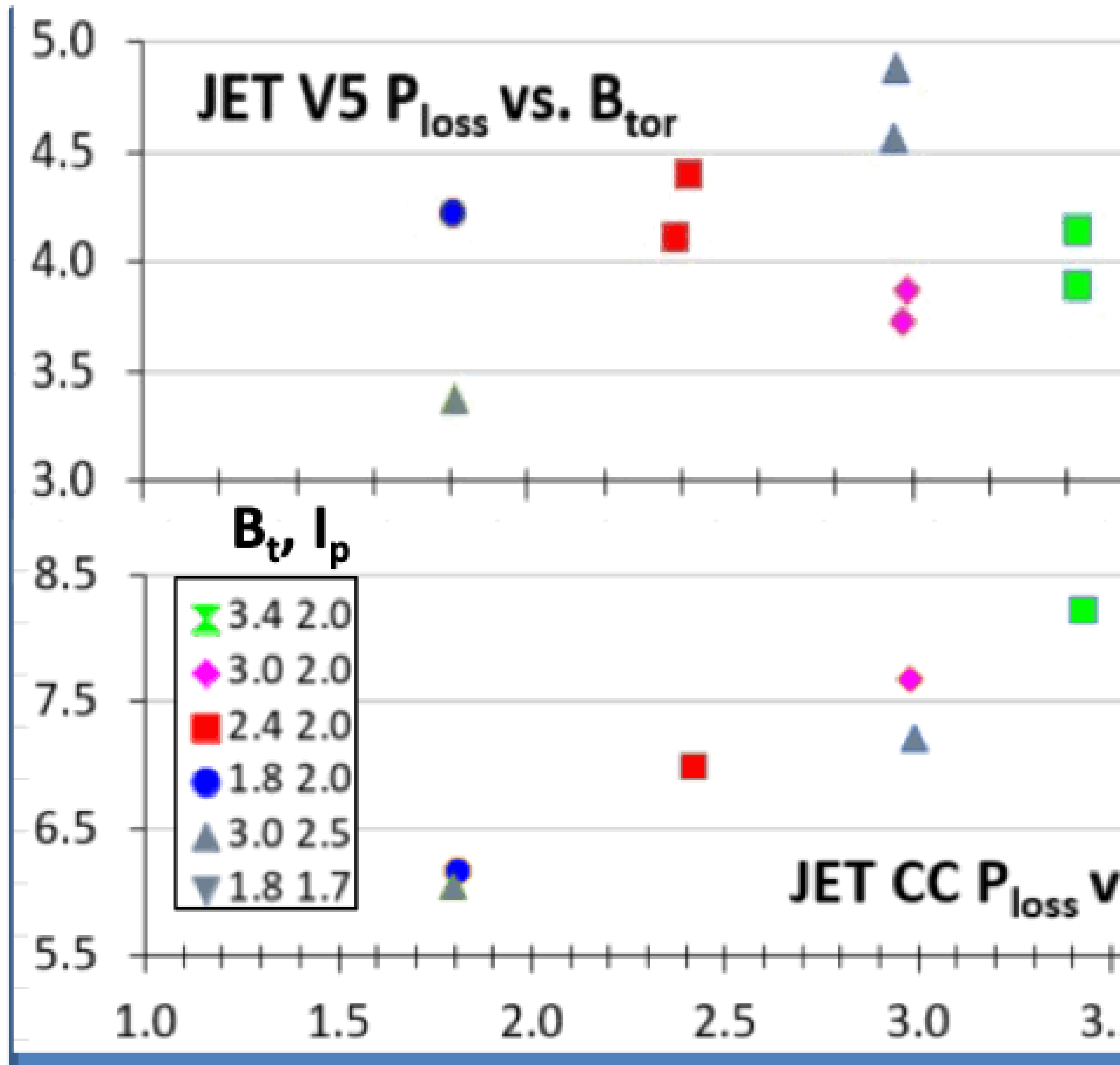


Proposed pulses

Device	# Pulses/Session	# Development
AUG	20	5
MAST-U		
TCV		
WEST		

#14 L2H B_{tor} vs B_{pol} scaling studies

- **Proponents and contact person:**
  emilia.solano@ciemat.es, gregor.birkenmeier@ipp.mpg.de, ephrem.delabie@ukaea.uk, marco.cavedon@unimib.it, pietro.vincenzi@igi.cnr.it, clemente.angioni@ipp.mpg.de, ivo.carvalho@iter.org, many more
- **Scientific Background & Objectives**
  - P_{LH} determines size and operating choices for ITER and DEMO
  - B_t scaling of P_{LH} in question: C-Mod, JET-ILW, multimachine, Cavedon
  - B_{pol} fits data better? Work in progress
  - AUG L2H db lowest q_{95}=3.6, sparse. n_e scan for q_{95}~3, like ITER
  - TCV: ion heat flux and $n_{e,min}$ vs. I_p characterization
- **Experimental Strategy/Machine Constraints and essential diagnostics**
  - AUG, JET: B_t q scan at fixed I_p, n_e
  - AUG, JET: Ip scan at fixed B_t, n_e
  - AUG and TCV ne scan at low q95, identify ne,min
  - AUG Diags: PNET. CXRS (blibs), HEB, ECE, Li-BES, Thomson scattering, HES, Doppler reflectometer, reflectometry and He beam for fluctuations.
  - JET diags: Bolometry, HRTS, CX, KG10, KG8C, KK3, KK1, …
  - TCV diags: All profile diagnostics, expecially TS and CX (also system 4)

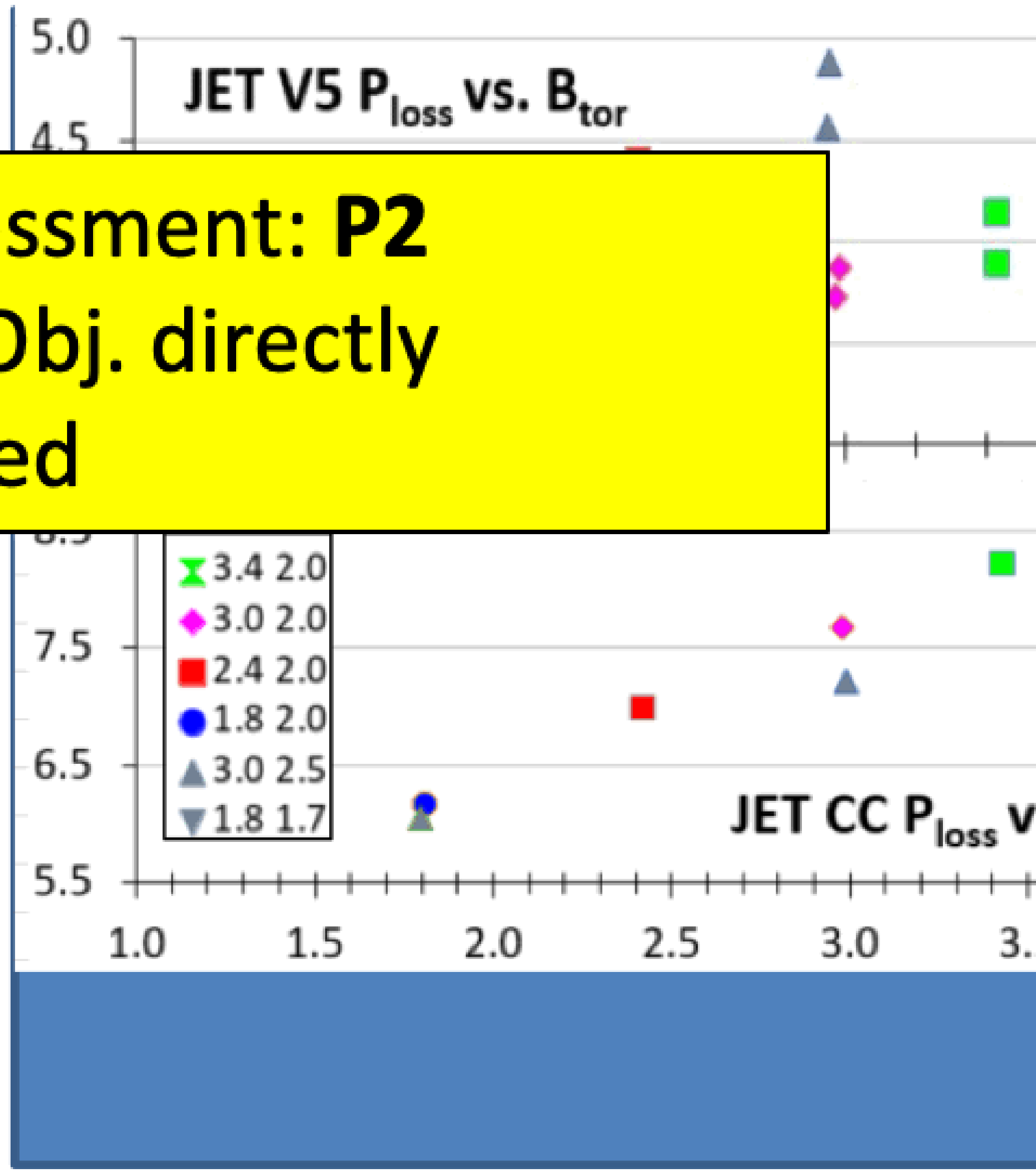


Proposed pulses

Device	# Pulses/Session	# Developm
AUG	23	5
MAST-U		
TCV	15	3
WEST		
JET	20	5

#14 L2H B_{tor} vs B_{pol} scaling studies

- TFL assessment: **P2**
- No Sci. Obj. directly addressed



- **Proponents and contact person:**

emilia.solano@ciemat.es, gregor.birkenmeier@ipp.mpg.de, ephrem.delabie@ukaea.uk, marco.cavedon@unimib.it, pietro.vincenzi@ig clemente.angioni@ipp.mpg.de, ivo.carvalho@iter.org, many more

- **Scientific Background & Objectives**
  - P_{LH} determines size and operating choices for ITER and DEMO
  - B_t scaling of P_{LH} in question: C-Mod, JET-ILW, multimachine, Cavedon
  - B_{pol} fits data better? Work in progress
  - AUG L2H db lowest q_{95}=3.6, sparse. n_e scan for q_{95}~3, like ITER
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- **Experimental Strategy/Machine Constraints and essential diagnostics**
  - AUG, JET: B_t q scan at fixed I_p, n_e
  - AUG, JET: Ip scan at fixed B_t, n_e
  - AUG and TCV ne scan at low q95, identify ne,min
  - AUG Diags: PNET. CXRS (blibs), HEB, ECE, Li-BES, Thomson scattering, HES, Doppler reflectometer, reflectometry and He beam for fluctuations.
  - JET diags: Bolometry, HRTS, CX, KG10, KG8C, KK3, KK1, …
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Proposed pulses

Device	# Pulses/Session	# Developm
AUG	23	5
MAST-U		
TCV	15	3
WEST		
JET	20	5

#16 Flows and turbulence: Sensitivities of edge Er x B flow and its link with turbulence

- **Proponents and contact person:**
  laure.vermare@lpp.polytechnique.fr
- **Scientific Background & Objectives**

Which are the dominant mechanisms involve In the formation of the Er well ?

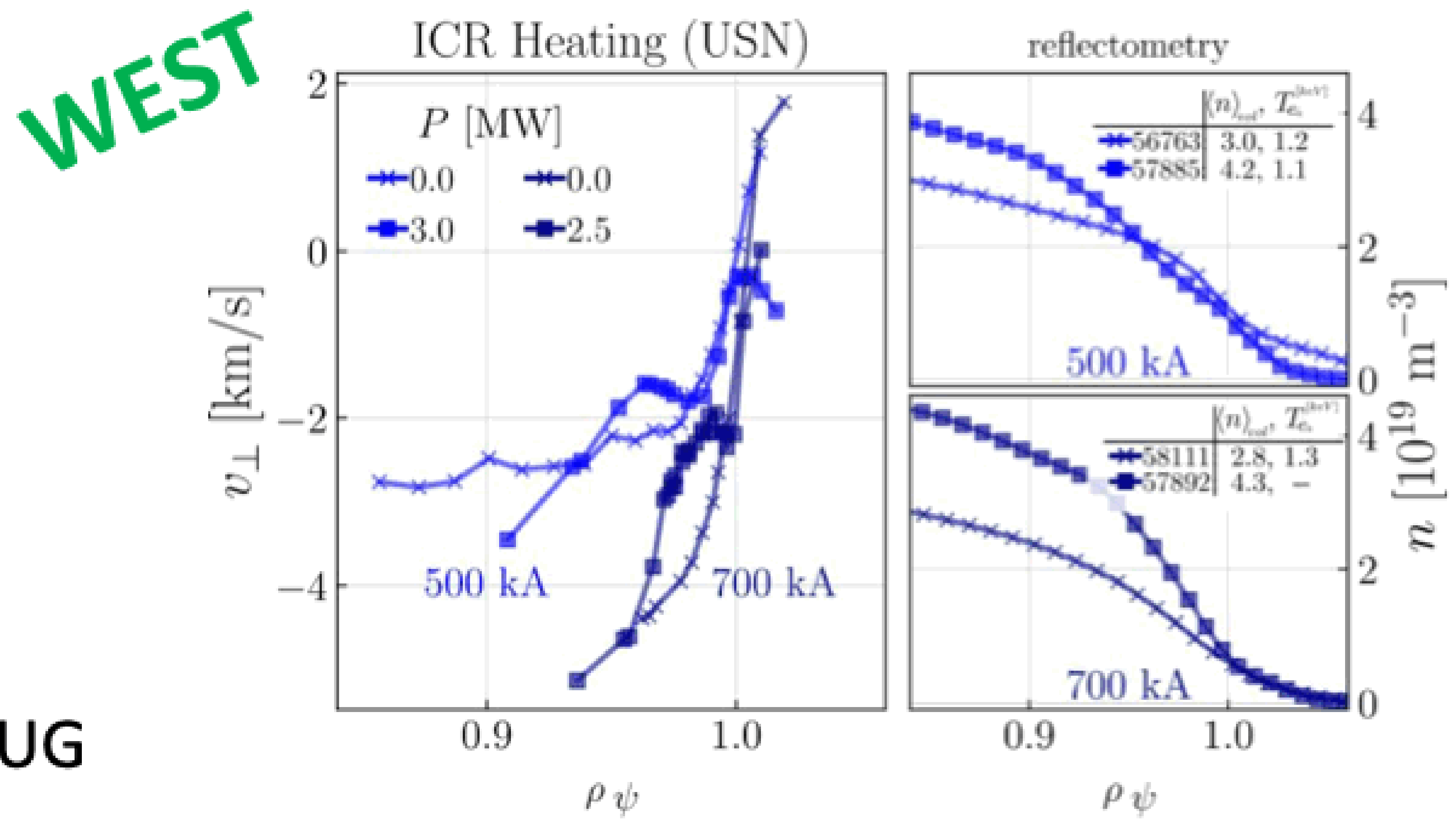
- So far no explanation of the difference observed in Er well between fav. and unfav. configuration in WEST, AUG and TCV
- Er well depends on Ip on WEST, especially in unfav. configuration while no clear trend is observed on TCV
- How these trends are sensitive to collisionality, shape and ρ* ?

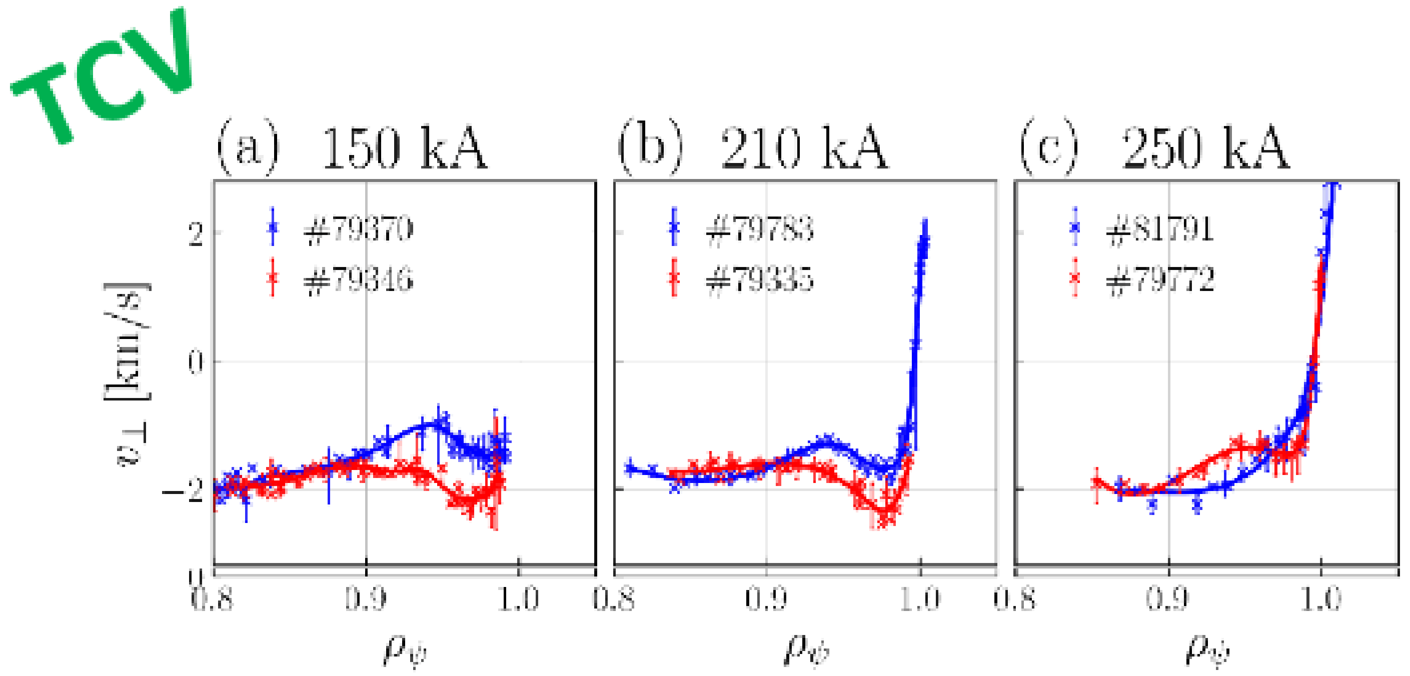
- **Experimental Strategy/Machine Constraints and essential diagnostic**

AUG : to document the Ip sensitivity @ several collisionality
⇒ Ip scan in unfav. and fav. @ different heating powers

TCV : to test the shape (elongation and area in LFS)

WEST : to test the influence of ρ* on Ip sensitivity
=> H/D experiments





Proposed devices /pulses for device

Device	# pulses proposed	# pulses for scenario
AUG	12	
TCV	14	
WEST	16	

#16

Flows and turbulence: Sensitivities of edge Er x B flow and its link with turbulence

- **TFL assessment: P2**
- No Sci. Obj. directly addressed.
- Not clear what is missing on TCV and WEST

- **Proponents and contact person:**

laure.vermare@lpp.polytechnique.fr

- **Scientific Background & Objectives**

Which are the dominant mechanisms involve In the formation of the Er well ?

- So far no explanation of the difference observed in Er well between fav. and unfav. configuration in WEST, AUG and TCV
- Er well depends on Ip on WEST, especially in unfav. configuration while no clear trend is observed on TCV
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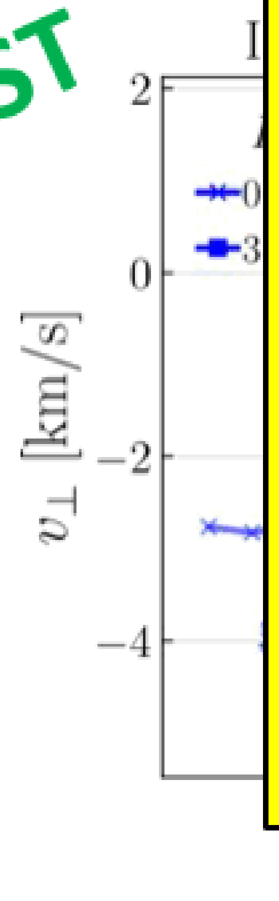
AUG : to document the Ip sensitivity @ several collisionality
⇒ Ip scan in unfav. and fav. @ different heating powers

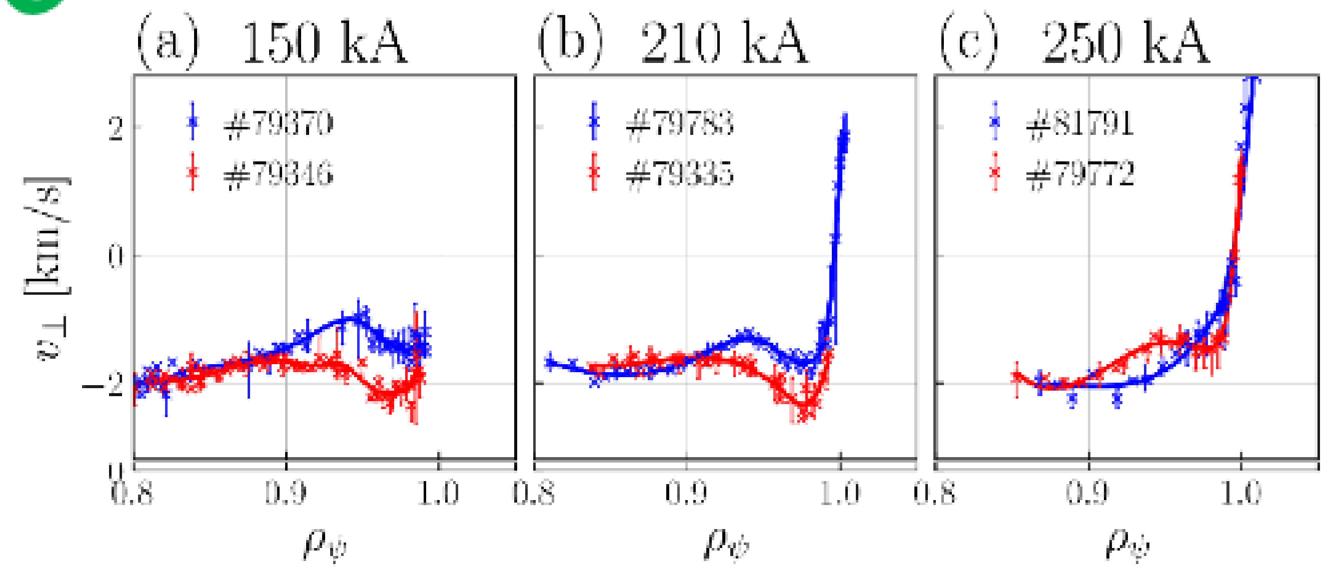
TCV : to test the shape (elongation and area in LFS)

WEST : to test the influence of ρ* on Ip sensitivity
=> H/D experiments

WEST



TCV



Proposed devices /pulses for device

Device	# pulses proposed	# pulses for scenario
AUG	12	
TCV	14	
WEST	16	

#144 Operation above Greewald density limit

Proponent(s)

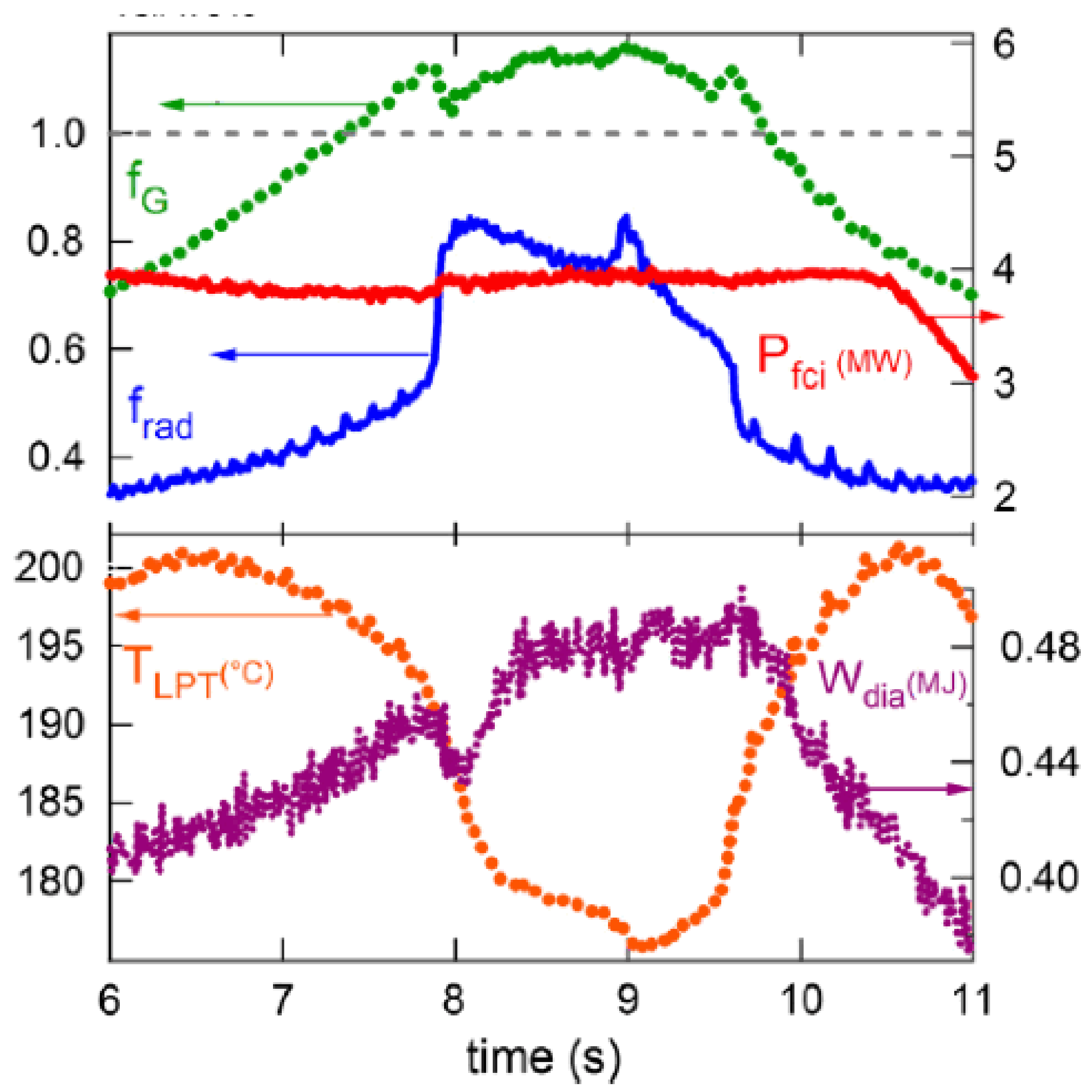
- E. Geulin, J-F Artaud, P. Maget, N. Fedorczak, N. Rivals, C. Orrico, A. Panera Alvarez

Scientific Background & Objectives

- Operation above Greenwald density limit is attractive for a Fusion Power Plant
  - Fusion reactions ~ n_{fuel}^2, density peaking
  - Requires compatibility with low temperature at divertor, and full W environment
- Objectives :
  - Identify operational domain for pellet fuelled discharges above Greenwald limit
    - *Explore conditions for stable MARFE – as in Tore Supra [Dachicourt'13]*
  - Characterize tungsten sources and contamination
  - Validate the RAPDENS observer for pulses using pellets
- WPTE RT07

Experimental Strategy/Machine constraints and essential diagnostics

- Standard L-mode with *ICRH* and ECRH sources
  - Density scan controlled by pellet injection:
    - explore maximum density limit for different additional power settings
  - Magnetic configuration scan: LSN with X-point height exploration
- Density & temperature, core impurity content (bolometry, VUV, SXR), W sources (visible spectroscopy), Langmuir probes, *ECE, reflectometry, high speed camera in front of pellet injection point*



Stable MARFE regime [Dachicourt JNM2013]

Nb of sessions / pulses proposed: 1 session

#144 Operation above Greewald density limit

- TFL assessment: **P3**
- No Sci. Obj. addressed
- L-mode operation

Proponent(s)

- E. Geulin, J-F Artaud, P. Maget, N. Fedorczak, N. Rivals, C. Orrico, A. Panera A

Scientific Background & Objectives

- Operation above Greenwald density limit is attractive for a Fusion Power Plant
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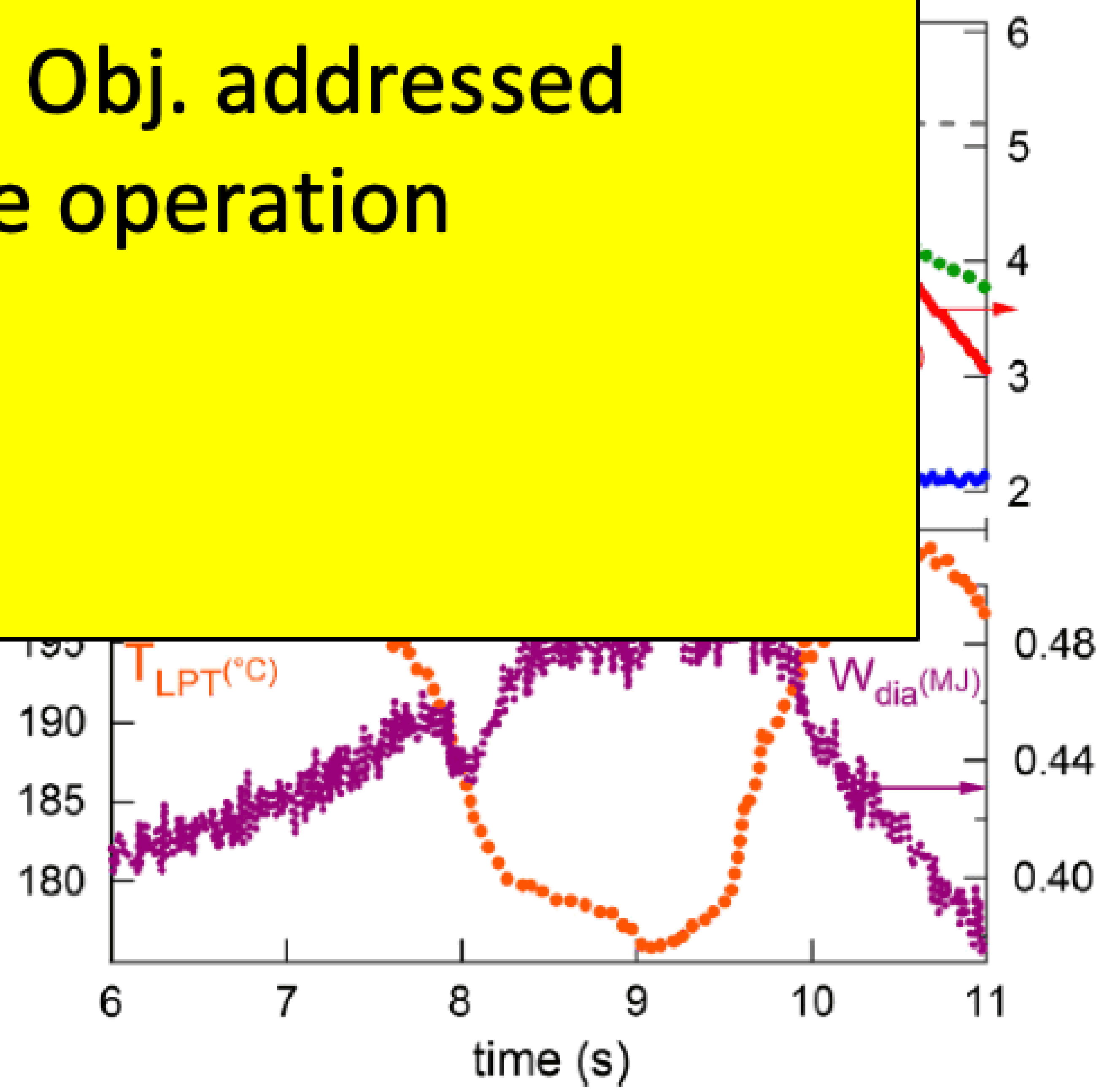

Stable MARFE regime [Dachicourt JNM2013]

Experimental Strategy/Machine constraints and essential diagnostics

- Standard L-mode with *ICRH* and ECRH sources
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  - Magnetic configuration scan: LSN with X-point height exploration
- Density & temperature, core impurity content (bolometry, VUV, SXR), W sources (visible spectroscopy), Langmuir probes, *ECE, reflectometry, high speed camera in front of pellet injection point*

Nb of sessions / pulses proposed: 1 session

Summary of proposals

#	Proposal	Main Proposer	Priority	Comment
1	Investigate the Ramp-Down of the IBLS in the precence of seeded Ar (work in progress)	T. Pütterich et al	P2	To be combined with #13
2	Pedestal studies with dominant electron heating	L. Frassinetti	P2	P2 for AUG / P1 for TCV
3	Peeling limited pedestal	L. Frassinetti	P1	
4	Intra ELM pedestal fluctuations in peeling limited pedestal scenario at TCV	Miriam La Matina et al	P1	To be combined with #3
5	Particle transport in long-pulse WEST plasmas	Tuomas Tala	P1	
6	Core-Edge integrated scenario for IBL on TCV	B. Labit et al	P1	To be coordinated with #13
7	Demonstration of impurity (W) screening at the edge of ASDEX Upgrade plasmas	A. Kappatou et al	P1	Flagship experiment for RT01-AUG
8	Momentum transport in mixed turbulence regimes and intrinsic torque and NTV sources	Tuomas Tala	P2	Missing parts for TCV and MAST-U to be clarified – Strategy not clear
9	Hydrogen isotope transport in low-collisionality H-mode plasmas	J. Rasmussen	P2	To be re-evaluated if H operation is foreseen
10	Pellet injection in WEST and AUG for HPI2	A. Panera Alvarez	P2	Evaluate if can be combined with other proposals
11	Sustaining H-mode performance in a tungsten environment	Jorge Morales	P2	Effort should first start in the internal campaign
12	Examining the impact of transitioning to electron heated dominated plasma on the turbulence in AUG	Bhavin Patel	P2	Possible combination with #3?
13	Core-Edge integrated scenario for IBL on AUG in light of JET IBL	S. Wiesen C.Giroud et al	P1	
14	L2H Btor vs Bpol scaling studies	emilia.solano@ciemat.es	P2	Data mining
16	Flows and turbulence: Sensitivities of edge Er x B flow and its link with turbulence	L. Vermare	P2	Sci. Obj not addressed – Missing parts from TCV and WEST not clear
144	Operation above Greenwald limit	E. Geulin	P3	Sci. obj. not addressed

Summary of P1 proposals

	AUG	TCV	MAST-U	WEST
Low nu* H-mode physics	#3, #7	#3, #2	#3	
Core-edge integrated scenarios	#13	#6		
Core transport				#5
Provisional shot allocation	45	120	24	15

P2 proposals will probably find experimental time on TCV and MAST-U

JET Analysis and Modelling needs

RT-01/D (low ν*/peeling)

- Pedestal structure
  - TS, KG10, KK3, Li-beam,
  - Pedestal stability and predictions
  - linear ideal (MISHKA), linear resistive (CASTOR and JOREK)
  - Europed
- ELMs
  - ELM energy losses
  - Pre-ELM MHD activity
  - Non-linear MHD (JOREK)
- Transport
  - GK analysis in the pedestal (to start soon) and in the core (under consideration)
  - TRANSP
  - Neoclassical transport
- SOL:
  - Understanding n_e^{sep}/n_e^{ped} behavior: SOLPS or EDGE2D and/or JINTRAC

RT-01/A (W screening)

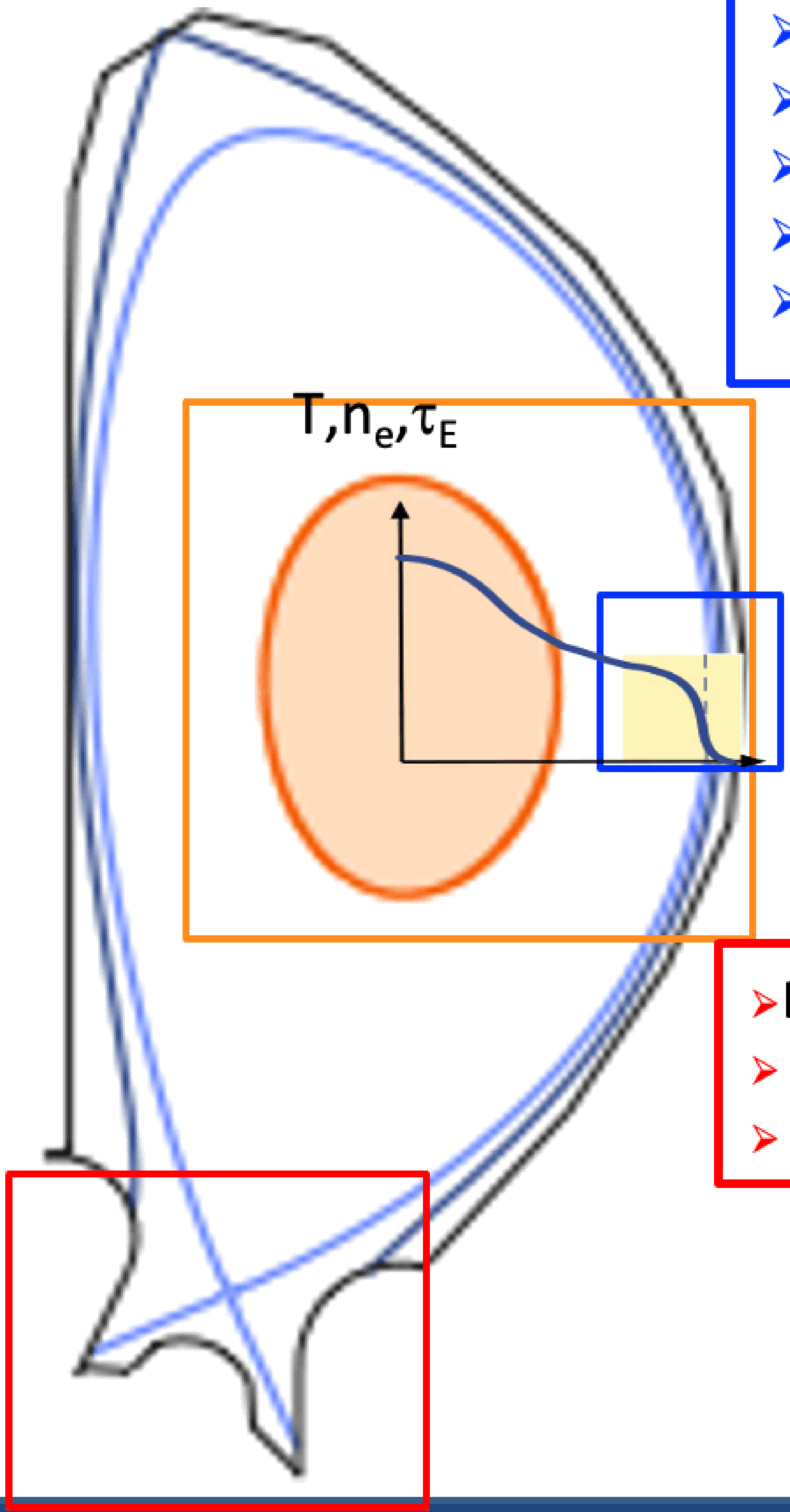
- Screening Analysis
  - Pedestal fitting, Bolometry, TRANSP runs, interpretive JINTRAC runs
- Neoclassical Models
  - FACIT, NEO
- Transport: - screening results so far not explained by neoclassical model, may require further modelling (ideas welcome)

JET Analysis and Modelling needs

RT-01/C deliverables D3 or D2 (ITER baseline)

- Impurity content : medium and high Z
- MHD
- TRANSP.

- Core modelling: JINTRAC-QuaLiKiz , TGLF-ASTRA, COREDIV
- JOREK:
- JINTRAC Coconut



- CXRS, BOLO, KG10, Li-beam,, KT3, IR, LPTS, LID4, KG8, Zeff
- **impurity mix**
- MHD stability: MISHKA, CASTOR, JOREK
- transport pedestal and core : GENE, **NEO, FACIT**
- ELMs: ELM energy losses, JOREK …
- Europed:

- SOL analysis, filaments
- Wall fluxes
- HESEL , **GRILLIX**

- EDGE2D, SOLEDGE, SOLPS-ITER
- Impurity divertor content:
- W erosion and screening :