EUROfusion

18th November 2024

RT-07 “Physics understanding of alternative divertor configurations as risk mitigation for DEMO”

Discussion on proposals and allocated priorities

A. Hakola

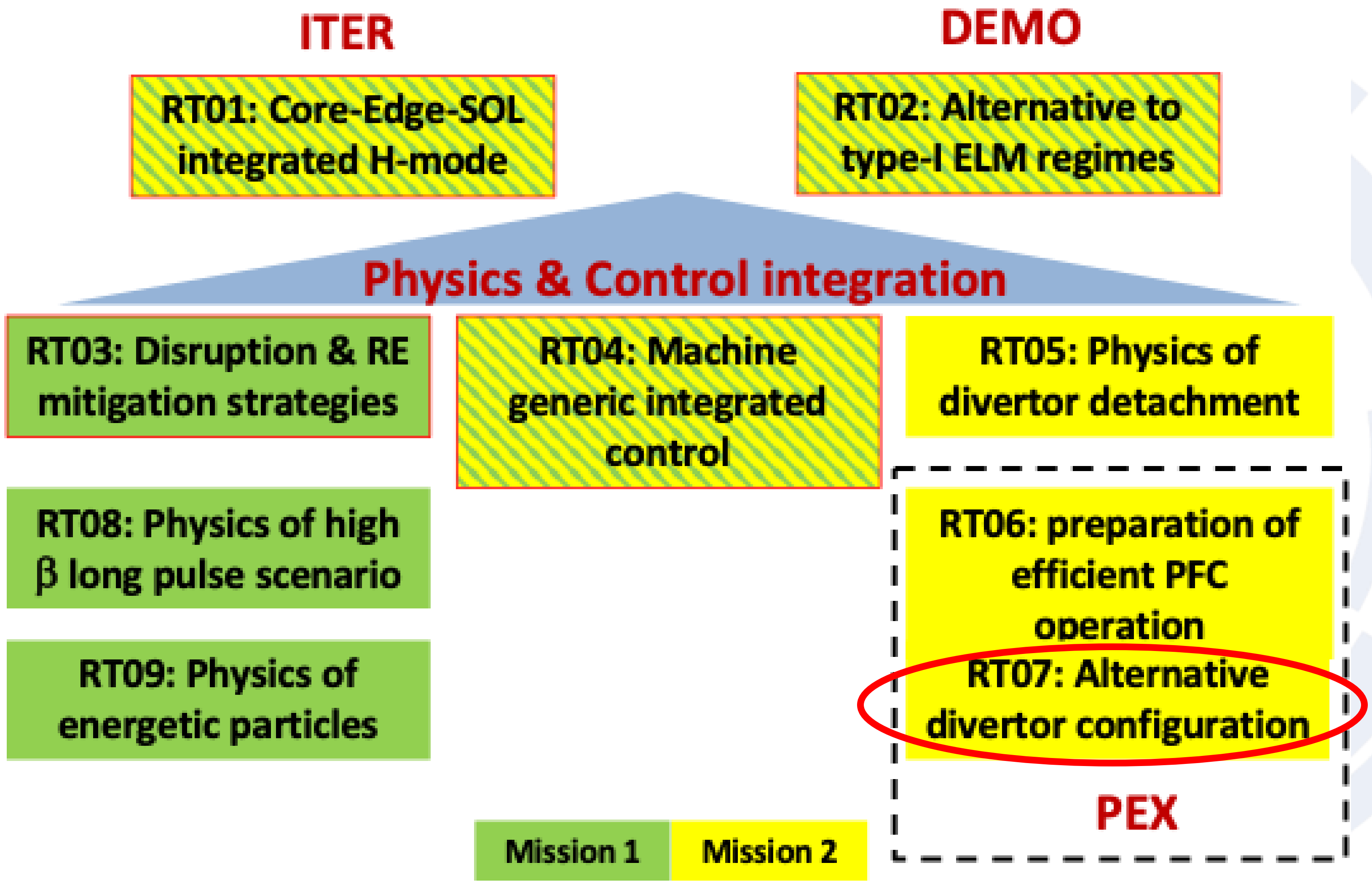
On behalf of WPTE TFLs
E. Tsitrone, N. Vianello, M. Baruzzo, V. Igochine, D. Keeling, A. Hakola, B. Labit

Research Topic Coordinators
D. Brida, C. Theiler, K. Verhaegh

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-07 is mainly providing input for DEMO but also for other fusion devices (e.g., DTT)
- 2025 will be the first year that RT-07 program is carried out on all the WPTE machines – the new upper-divertor coils of AUG in full operation



Scientific Objectives and Machine Time

Scientific Objectives	
D1	Determine detachment onset, radiated power fractions, and core compatibility in H-mode for different alternative divertor configurations (ADCs) and characterization of ELM activity in view of pedestal, heat flux and control in ADCs
D2	Characterize possible benefits of snowflake and other ADCs with multiple X-point configurations for X-point radiation stability and dissipated power in H-mode
D3	Quantify the degree of heat load mitigation during transients (including ELMs) achievable by impurity seeding and investigate the dependences on relevant machine parameters
D4	Evaluate reduced SOL models against ADCs

Allocation of discharges (tentative)

	AUG	TCV	MAST-U	WEST
2025	120	170	48	15
Proposed	133 + 84	303 + 80	249 + 73	35 + 2
Overbooking	1.8	2.3	6.7	2.5

Overview of proposals

#	Title	Proponents
167	Commissioning ADCs in AUG DivIIo	Tilmann Lunt
149	Physics, performance and stability of the X-Divertor in AUG DivIIo	Ou Pan
150	Physics, performance and stability of the Low-field side snowflake minus in AUG DivIIo	Ou Pan
151	Physics, performance and stability of the Compact Radiative Divertor in AUG DivIIo	Ou Pan
159	Preparation for the Tightly-Baffled Long-Legged Divertor on TCV	Benjamin Brown
170	Impact of pumping speed on plasma conditions and detachment	James Harrison
145	ADCs in high power ELMy plasmas	Massimo Carpita
146	ADCs in QCE plasmas	Massimo Carpita
152	Exploration and understanding of the ELM-free XPR regime in SF- configuration	Holger Reimerdes
153	RMP effects on the access of detachment in super-x divertor and X-divertor configurations	Yunfeng Liang
160	Standard and advanced X-point target configurations and their radiating regimes on TCV and MAST-U	Kenneth Lee
164	Alternative Divertor Configurations in Negative Triangularity in high-performance NT scenarios.	Olivier Février
165	Effect of magnetic balance and fuelling/seeding location on radiation in Double-Nulls plasmas.	Olivier Février
26	I-mode access in alternative divertor configurations in ASDEX Upgrade	Davide Silvagni
27	High-radiative and detached I-mode in alternative divertor configuration in ASDEX Upgrade	Davide Silvagni

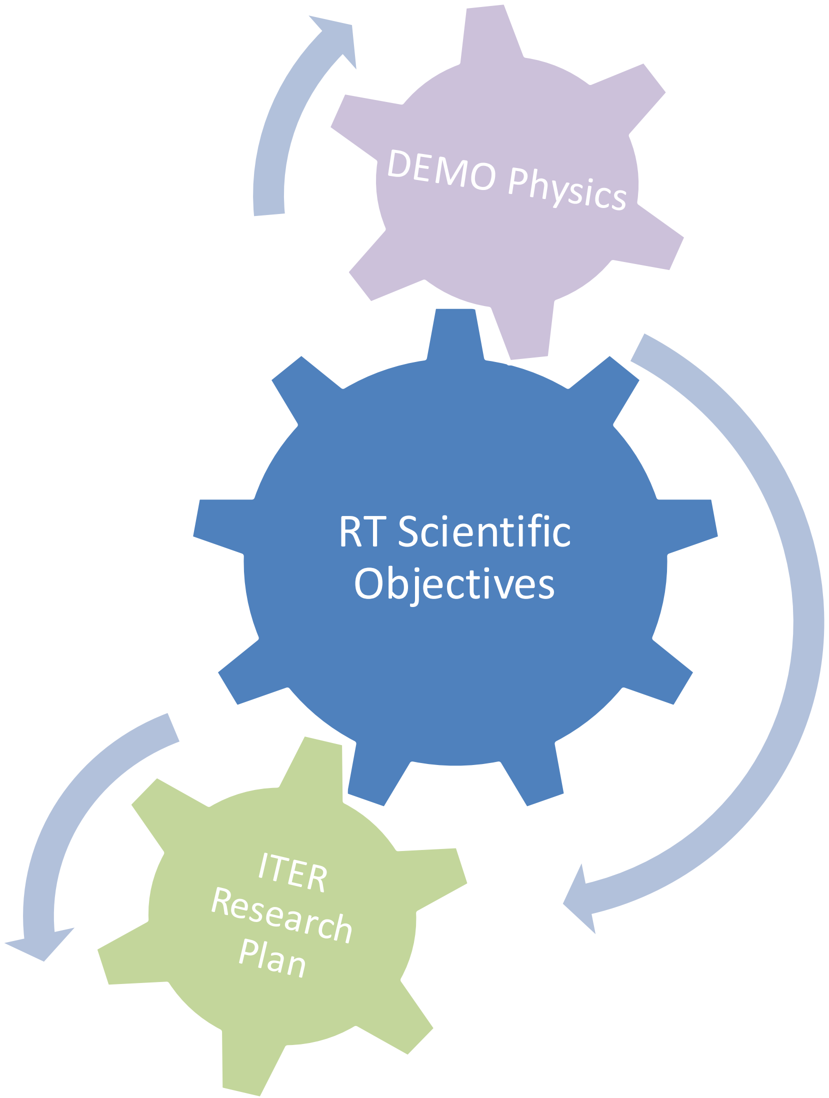
Moved from RT-02

Overview of proposals

#	Title	Proponents
143	Validation of reduced models for detachment and reattachment in ADCs	Stuart Henderson
155	Comparison of high flux expansion (XD) divertor configurations between MAST-U and AUG	Dominik Brida
157	ELM buffering in ADCs in AUG, TCV, and MAST-U	Davide Silvagni
158	Investigations of outer target radius scans and impact on core performance	Kevin Verhaegh
161	Investigation of poloidal leg length effects on power exhaust on TCV and MAST-U	Kenneth Lee
166	Detachment characteristics in neutral-driven and impurity-driven detachment with tightly baffle	Lingyan Xiang
168	Poloidal flux expansion and flaring in long-legged divertors	Kevin Verhaegh
147	ADCs impact on divertor flows	Massimo Carpita
156	Characterization of SOL electric field and turbulence in AUG SF- and XD configurations	Dominik Brida
163	Characterization of turbulence in X-point radiator H-mode scenarios on TCV	Yinghan Wang
148	Influence of power fall-off length on SF- configuration in ASDEX Upgrade	Michael Faitsch
162	Investigating the impact of alternative divertor configurations on broadening of the scrape-off-layer power channel	Peter Ryan
154	Assessment of magnetics for exhaust control on AUG, TCV, and MAST-U.	Bob Kool
169	Supporting ADC reactor integration with experimental studies	Kevin Verhaegh
144	Operation above Greenwald density limit	Eleonore Geulin

Moved to RT-01

Prioritization scheme and criteria



Proposals 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

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

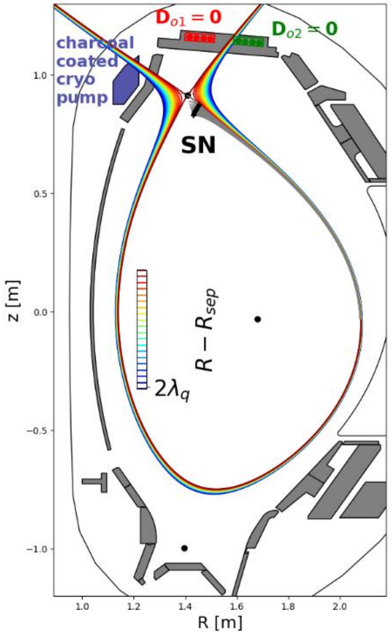
P3: back-up programme/not possible in 2025

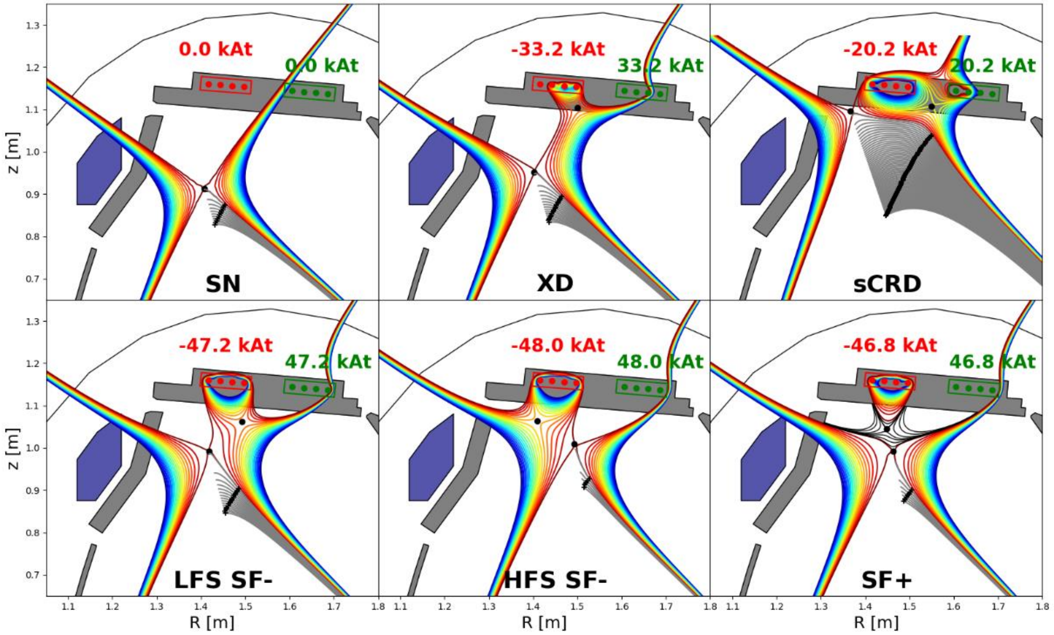
PB: piggy-back experiment/pure analysis proposal

Machine-specific ADC proposals

#167: Commissioning ADCs in AUG DivIIo

- **Proponents and contact person:**
  Tilmann Lunt et al.
- **Scientific Background & Objectives**
  - ✓ Commission the AUG DivIIo coils
  - ✓ Commission the newly installed diagnostics
  - ✓ Access the possible different alternative divertor configurations: X-divertor, Low-Field Side Snowflake minus, High-Field Side Snowflake minus, Snowflake plus, Compact Radiative Divertor and the Welding torch
  - ✓ Test the stability of the aforementioned configurations
  - ✓ Validate the function parameterization (FP) regression required for real time control
  - ✓ Test the accuracy of the strike line determination
  - ✓ Test the influence of the magnetic field direction
  - ✓ Test the influence of the magnetic field strength (2.5 T vs. 1.8T)

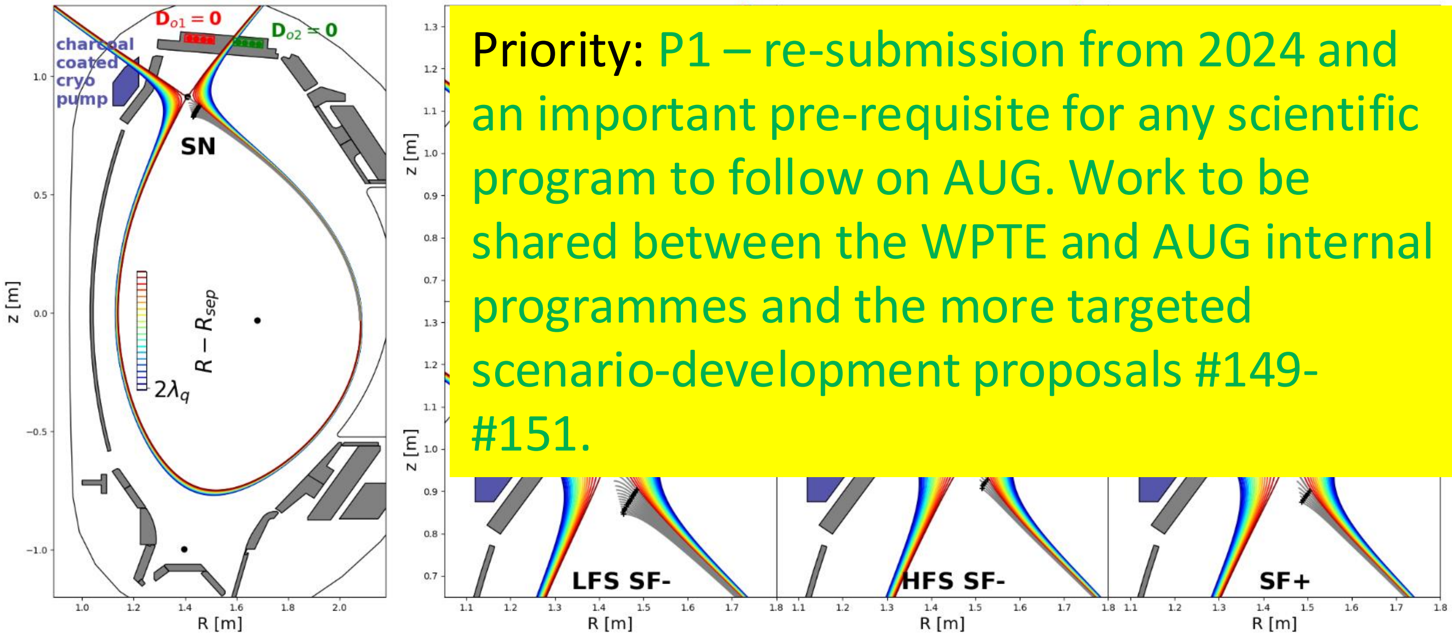




Device	# Pulses/Session	# Development
AUG	0	60

#167: Commissioning ADCs in AUG DivIIo

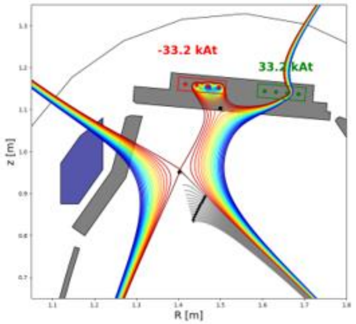
- **Proponents and contact person:**
  Tilmann Lunt et al.
- **Scientific Background & Objectives**
  - ✓ Commission the AUG DivIIo coils
  - ✓ Commission the newly installed diagnostics
  - ✓ Access the possible different alternative divertor configurations: X-divertor, Low-Field Side Snowflake minus, High-Field Side Snowflake minus, Snowflake plus, Compact Radiative Divertor and the Welding torch
  - ✓ Test the stability of the aforementioned configurations
  - ✓ Validate the function parameterization (FP) regression required for real time control
  - ✓ Test the accuracy of the strike line determination
  - ✓ Test the influence of the magnetic field direction
  - ✓ Test the influence of the magnetic field strength (2.5 T vs. 1.8T)

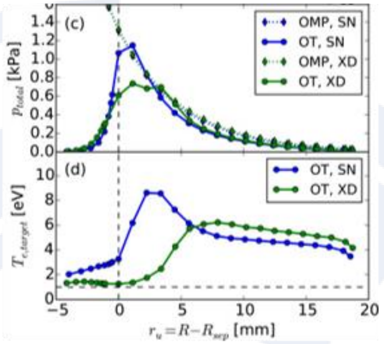


Priority: P1 – re-submission from 2024 and an important pre-requisite for any scientific program to follow on AUG. Work to be shared between the WPTE and AUG internal programmes and the more targeted scenario-development proposals #149-#151.

Device	# Pulses/Session	# Development
AUG	0	60

#149: Physics, performance and stability of the X-Divertor in AUG DivIIo



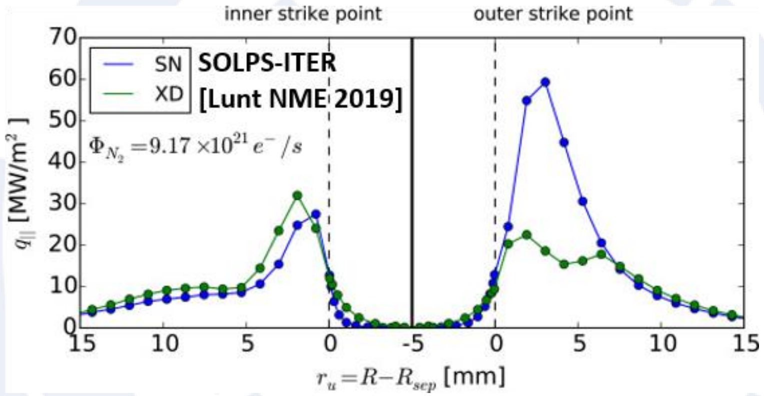


- **Proponents and contact person:**
- Ou Pan (ou.pan@ipp.mpg.de), Michael Faitsch, Dominik Brida, Athina Kappatou, Antonello Zito, Tilmann Lunt

- **Scientific Background & Objectives**

The X-divertor configuration aims at exploiting the poloidal flux expansion as a heat flux mitigation method. Under the influence of magnetic error fields and/or target surface imperfections these shallow angles might lead to toroidal asymmetries. In detachment these asymmetries are expected to vanish.

- Determine the detachment threshold and the maximum radiative fraction with different impurities while monitoring the core impurity pollution
- Measure the power deposition footprint and compare with predictions from SOLPS-ITER and EMC3-EIRENE simulations
- Measure the radiation distribution and ionization front
- Study the neutral plug-in effect and the influence on upstream profiles
- Test the influence of the magnetic field direction and strength
- Characterize the He exhaust capabilities with the new cryopump
- Test the stability of the configuration



- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Scan the currents in the DivIIo coils to optimize the configuration
  - Scan impurity seeding level to induce detachment
  - Scan heating power, plasma density
  - Change the magnetic field direction and strength
  - Diagnostics: bolometry, AXUV, reflectometry, ECE, CXRS, Thomson scattering, spectroscopy, Helium beam, magnetic coils, IR camera, LPs

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

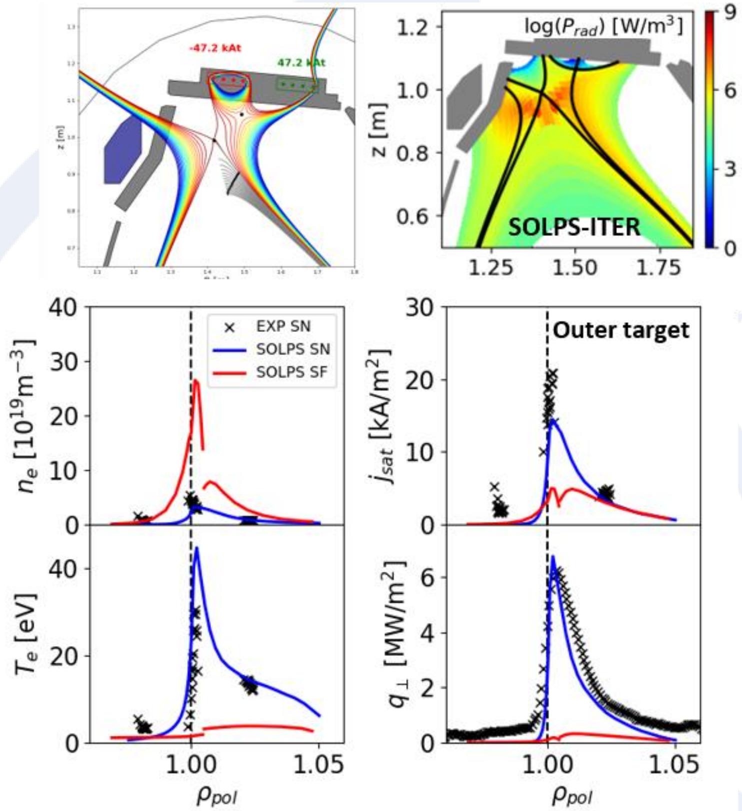
#150: Physics, performance and stability of the Low-field side snowflake minus in AUG DivIIo

- **Proponents and contact person:**
- Ou Pan (ou.pan@ipp.mpg.de), Michael Faitsch, Dominik Brida, Athina Kappatou, Matthias Bernert, Bernhard Sieglin, Antonello Zito, Tilmann Lunt

- **Scientific Background & Objectives**

The low-field side snowflake-minus divertor configuration is designed to dissipate power and pressure in the outer divertor using a SOL splitting geometry, along with increased connection length and radiative volume, while minimizing impurity contamination in the confinement region. Numerical simulations predict significantly reduced power and particle fluxes, as well as lower pressure at the outer target, along with a higher radiative fraction and a reduced detachment threshold compared to the single-null configuration. The power flux distribution across different strike points varies depending on the position of the secondary X-point, gas-puffing locations and the direction of the magnetic field. Additionally, it is easier to achieve an X-point radiator in a snowflake configuration in SOLPS-ITER simulations.

- Measure the power deposition footprint and target profiles, compare with predictions from edge transport code simulations
- Determine the detachment threshold, XPR access and the maximum radiative fraction with different impurities while monitoring the core impurity pollution
- Measure the radiation distribution and ionization front
- Compare different puffing locations
- Characterize the He exhaust capabilities
- Test the influence of the magnetic field direction and strength
- Test the stability of the configuration in particular during ELMs



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

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Scan the currents in the DivIIo coils to optimize the configuration
  - Scan impurity seeding level to induce detachment
  - Scan heating power, plasma density
  - Change puffing locations
  - Change the magnetic field direction and strength
  - Diagnostics: bolometry, AXUV, reflectometry, ECE, CXRS, Thomson scattering, spectroscopy, Helium beam, magnetic coils, IR camera, LPs

#151: Physics, performance and stability of the Compact Radiative Divertor in AUG DivIIo

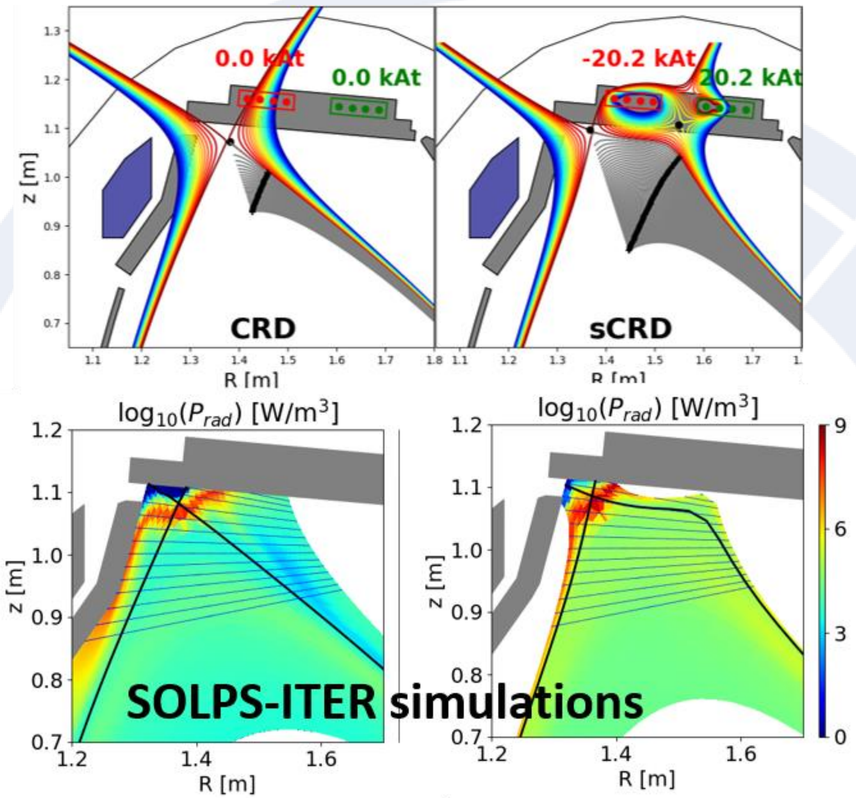
- **Proponents and contact person:**
- Ou Pan (ou.pan@ipp.mpg.de), Michael Faitsch, Dominik Brida, Athina Kappatou, Matthias Bernert, Bernhard Sieglin, Antonello Zito, Tilmann Lunt

- **Scientific Background & Objectives**

The compact radiative divertor aims at dissipating the power via an X-point radiator (XPR) before it reaches the target tolerating a certain acceptable level of impurity pollution of the confinement region. Experiments in the previous upper divertor and SOLPS-ITER simulations have shown that the X-point region is becoming so cold that it can be moved very close to the target surface. With the in-vessel coils, the high-flux-expansion region can be further extended to create a 'super' CRD configuration. It would be valuable to test how the XPR characteristics, power exhaust capabilities and upstream parameters change with varying flux expansion near the primary X-point.

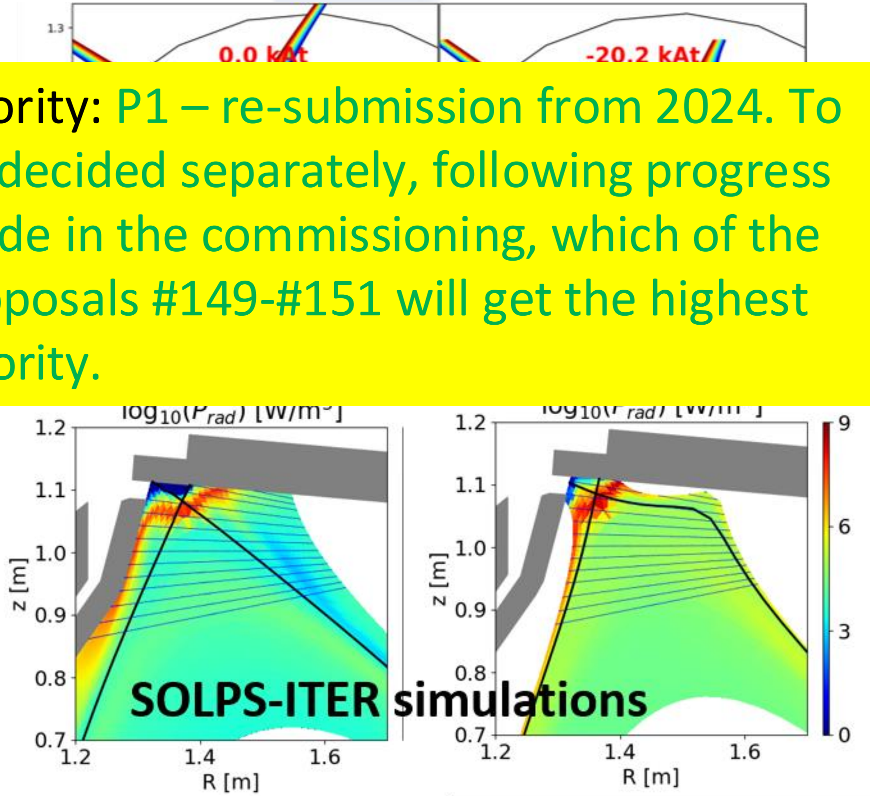
- Measure the power deposition footprint at divertor targets and compare with predictions from SOLPS-ITER simulations
- Determine the XPR access condition and the maximum radiative fraction with different impurities while monitoring the core pollution
- Measure the radiation distribution and ionization front
- Test the influence on confinement and ELM mitigation
- Characterize the He exhaust capabilities
- Test the influence of the magnetic field direction and strength
- Test the stability of the configuration

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Scan the currents in the DivIIo coils to optimize the configuration
  - Scan impurity seeding level to induce XPR
  - Scan heating power, plasma density
  - Change the magnetic field direction and strength
  - Diagnostics: bolometry, AXUV, reflectometry, ECE, CXRS, Thomson scattering, spectroscopy, Helium beam, magnetic coils, IR camera, LPs



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

#151: Physics, performance and stability of the Compact Radiative Divertor in AUG DivIIo



Priority: P1 – re-submission from 2024. To be decided separately, following progress made in the commissioning, which of the proposals #149-#151 will get the highest priority.

- **Proponents and contact person:**
  - Ou Pan (ou.pan@ipp.mpg.de), Michael Faitsch, Dominik Brida, Athina Kappatou, Matthias Bernert, Bernhard Sieglin, Antonello Zito, Tilmann Lunt

- **Scientific Background & Objectives**

The compact radiative divertor aims at dissipating the power via an X-point radiator (XPR) before it reaches the target tolerating a certain acceptable level of impurity pollution of the confinement region. Experiments in the previous upper divertor and SOLPS-ITER simulations have shown that the X-point region is becoming so cold that it can be moved very close to the target surface. With the in-vessel coils, the high-flux-expansion region can be further extended to create a 'super' CRD configuration. It would be valuable to test how the XPR characteristics, power exhaust capabilities and upstream parameters change with varying flux expansion near the primary X-point.

- Measure the power deposition footprint at divertor targets and compare with predictions from SOLPS-ITER simulations
- Determine the XPR access condition and the maximum radiative fraction with different impurities while monitoring the core pollution
- Measure the radiation distribution and ionization front
- Test the influence on confinement and ELM mitigation
- Characterize the He exhaust capabilities
- Test the influence of the magnetic field direction and strength
- Test the stability of the configuration

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Scan the currents in the DivIIo coils to optimize the configuration
  - Scan impurity seeding level to induce XPR
  - Scan heating power, plasma density
  - Change the magnetic field direction and strength
  - Diagnostics: bolometry, AXUV, reflectometry, ECE, CXRS, Thomson scattering, spectroscopy, Helium beam, magnetic coils, IR camera, LPs

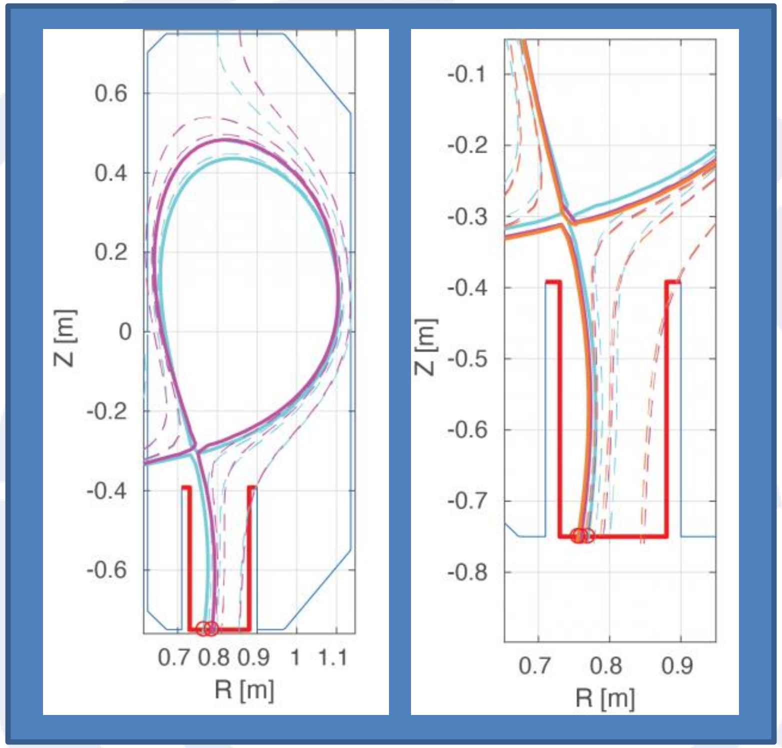
Device	# Pulses/Session	# Development
AUG	20	
MAST-U		
TCV		
WEST		

#159: Preparation for the Tightly-Baffled Long-Legged Divertor on TCV

- **Proponents and contact person:**
  Benjamin Brown (Benjamin.brown@epfl.ch), Olivier Février, Holger Reimerdes, Christian Theiler

- **Scientific Background & Objectives**
  - Characterize Tightly-Baffled Long-Legged Divertor (TBLLD) **compatible scenarios** for comparative analysis **ahead** of the 2026 TBLLD upgrade on TCV
    - Characterize detachment-onset, neutral compression, and impurity transport in L and H mode discharges

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Must be performed on TCV with complete diagnostic coverage including the Diverter Spectroscopy System (DSS), Reciprocating Divertor Probe Array (RDPA) sweeps, and the MANTIS multispectral imaging system.
  - Must be performed with **no divertor baffles**



Device	# Pulses/Session	# Development
AUG	-	-
MAST-U	-	-
TCV	25	8
WEST	-	-

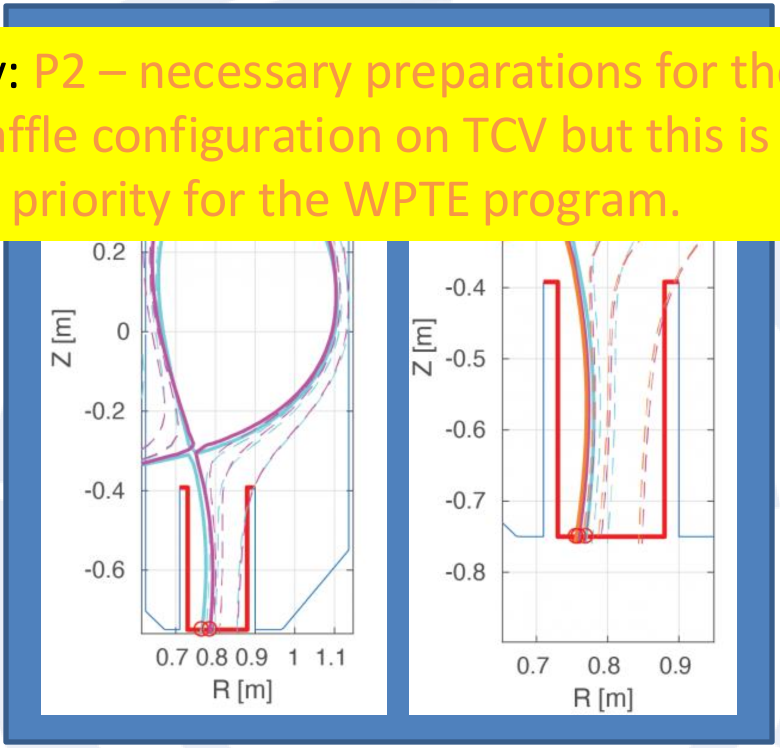
#159: Preparation for the Tightly-Baffled Long-Legged Divertor on TCV

- **Proponents and contact person:**
  Benjamin Brown (Benjamin.brown@epfl.ch), Olivier Février, Holger Reimerdes, Christian Theiler

- **Scientific Background & Objectives**
  – Characterize Tightly-Baffled Long-Legged Divertor (TBLLD) **compatible scenarios** for comparative analysis **ahead** of the 2026 TBLLD upgrade on TCV
    - Characterize detachment-onset, neutral compression, and impurity transport in L and H mode discharges

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  – Must be performed on TCV with complete diagnostic coverage including the Diverter Spectroscopy System (DSS), Reciprocating Divertor Probe Array (RDPA) sweeps, and the MANTIS multispectral imaging system.
  – Must be performed with **no divertor baffles**

Priority: P2 – necessary preparations for the next baffle configuration on TCV but this is still 2nd priority for the WPTE program.



Device	# Pulses/Session	# Development
AUG	-	-
MAST-U	-	-
TCV	25	8
WEST	-	-

#170: Investigation on the impact of pumping speed on plasma conditions and detachment

- **Proponents and contact person:** James Harrison
- **Objectives**
  - Measure the impact of divertor pumping speed on plasma conditions in the divertor chambers and detachment onset in MAST-U
  - Derive scalings between divertor pumping speed and detachment threshold (in terms of fuelling and/or seeding) in conventional and Super-X divertor configurations
  - Compare scalings against those derived from modelling and ASDEX Upgrade data (e.g. A Kallenbach *et al* 2018 Plasma Phys. Control. Fusion **60** 045006)
- **Experimental Strategy/Machine Constraints and essential diagnostic**

  MAST-U:

  1) Execute NBI heated H-mode and L-mode scenario with a Super-X divertor configuration and optimal alignment of the outer divertor leg with the divertor Thomson scattering system on MAST-U with optimal diagnostics coverage (e.g. for multi-wavelength imaging, Langmuir probes, IR thermography).
  2) Perform fuelling and N_2 seeding scans to ascertain the dependence of divertor plasma conditions and detachment onset on pumping speed
  3) Ascertain the impact of divertor pumping speed on pedestal temperature and density profiles

Device	# Pulses/Session	# Development
MAST-U	28 (w/ and w/o cryo)	0

#170: Investigation on the impact of pumping speed on plasma conditions and detachment

- **Proponents and contact person:** James Harrison
- **Objectives**
  - Measure the impact of divertor pumping speed on plasma conditions in the di
  - Derive scalings between divertor pumping speed and detachment threshold (i Super-X divertor configurations
  - Compare scalings against those derived from modelling and ASDEX Upgrade da Fusion **60** 045006)
- **Experimental Strategy/Machine Constraints and essential diagnostic**

  MAST-U:

  1) Execute NBI heated H-mode and L-mode scenario with a Super-X divertor configuration and optimal alignment of the outer divertor leg with the divertor Thomson scattering system on MAST-U with optimal diagnostics coverage (e.g. for multi-wavelength imaging, Langmuir probes, IR thermography).
  2) Perform fuelling and N_2 seeding scans to ascertain the dependence of divertor plasma conditions and detachment onset on pumping speed
  3) Ascertain the impact of divertor pumping speed on pedestal temperature and density profiles

Priority: P2/PB – pumping characteristics are an important ingredients to continue the physics studies but would these be more suitable for the internal programme? Could be combined with other MAST-U proposals.

Device	# Pulses/Session	# Development
MAST-U	28 (w/ and w/o cryo)	0

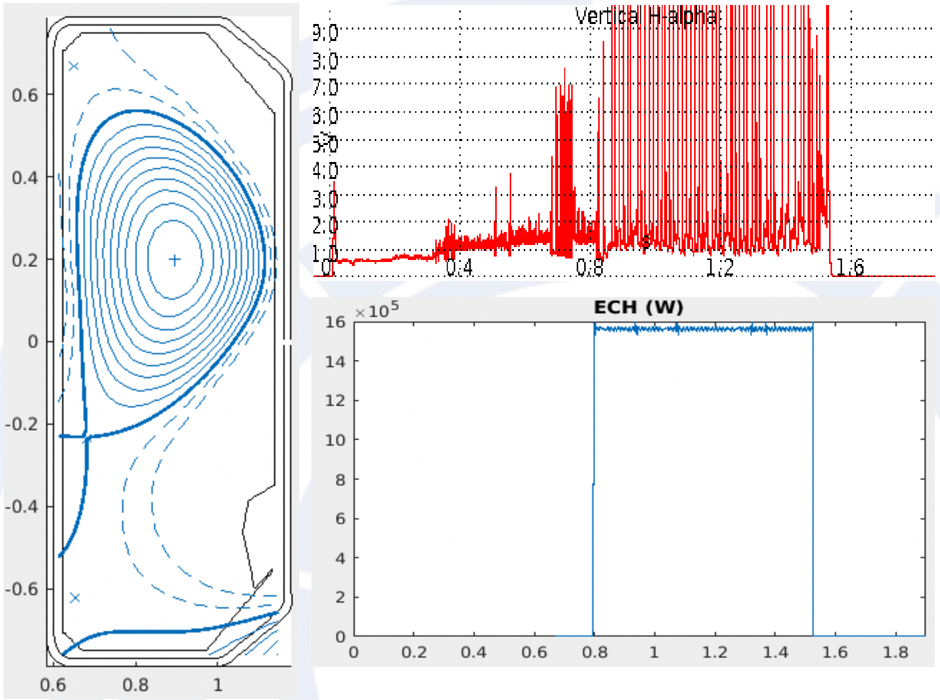
ADCs in varying operational scenarios

#145: ADCs in high power ELMy plasmas

- **Proponents and contact person:**
  - Massimo Carpita (massimo.carpita@epfl.ch)
  - O. Février, K. Lee, H. Reimerdes, C. Theiler, M. Zurita, D. Silvagni

- **Scientific Background & Objectives**
  – Develop ELMy scenario with challenging inter-ELMs conditions
  – Test ADCs (XD, SXD, XPT) in ELMy scenario, with N_2 seeding & baffles
  - SOLPS-ITER modeling to integrate the analyses

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  – Start from existing references EDA H-mode references (high ECH power, low upstream n_e, high upstream T_e)
  – Modify outer leg equilibrium



Proposed pulses

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

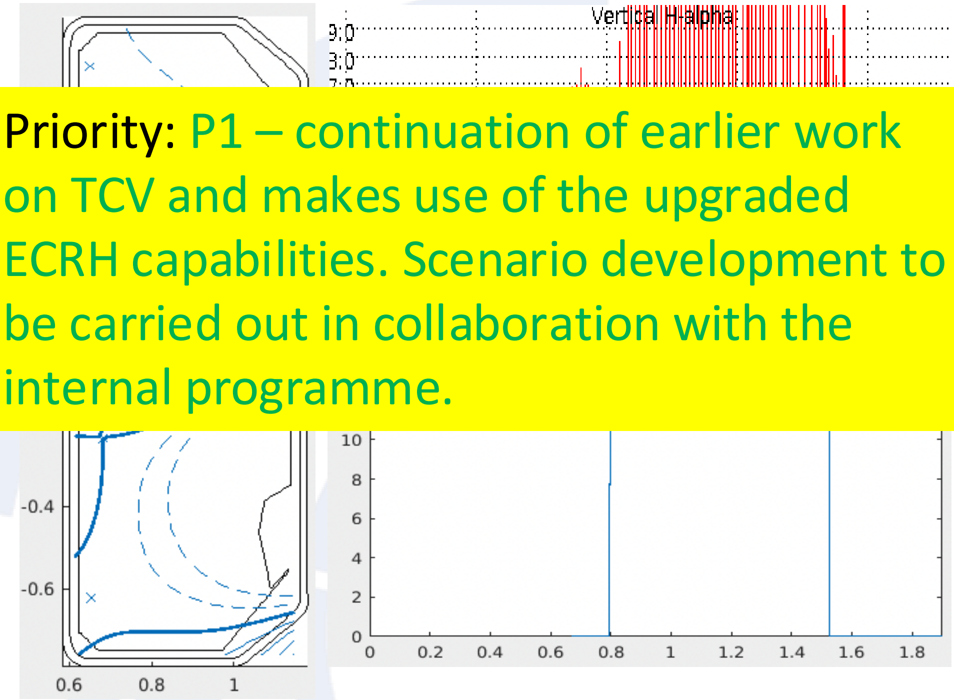
#145: ADCs in high power ELMy plasmas

Priority: P1 – continuation of earlier work on TCV and makes use of the upgraded ECRH capabilities. Scenario development to be carried out in collaboration with the internal programme.

- **Proponents and contact person:**
  - Massimo Carpita (massimo.carpita@epfl.ch)
  - O. Février, K. Lee, H. Reimerdes, C. Theiler, M. Zurita, D. Silvagni

- **Scientific Background & Objectives**
  - – Develop ELMy scenario with challenging inter-ELMs conditions
  - – Test ADCs (XD, SXD, XPT) in ELMy scenario, with N_2 seeding & baffles
  - SOLPS-ITER modeling to integrate the analyses

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - – Start from existing references EDA H-mode references (high ECH power, low upstream n_e, high upstream T_e)
  - – Modify outer leg equilibrium



Proposed pulses

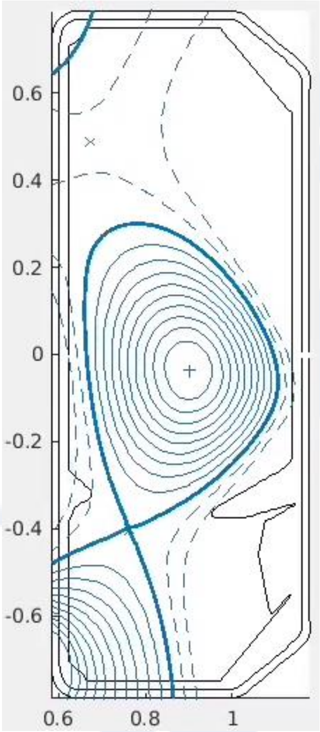
Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	10	10
WEST		

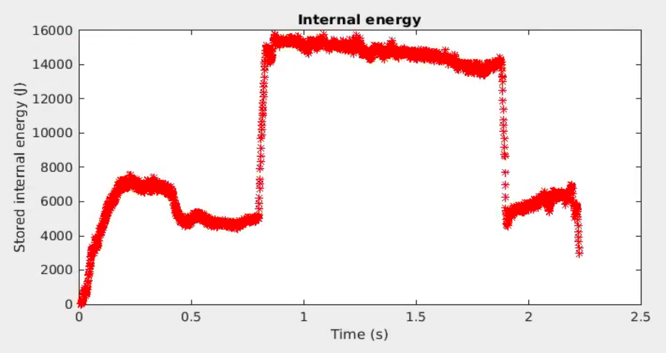
#146: ADCs in QCE plasmas

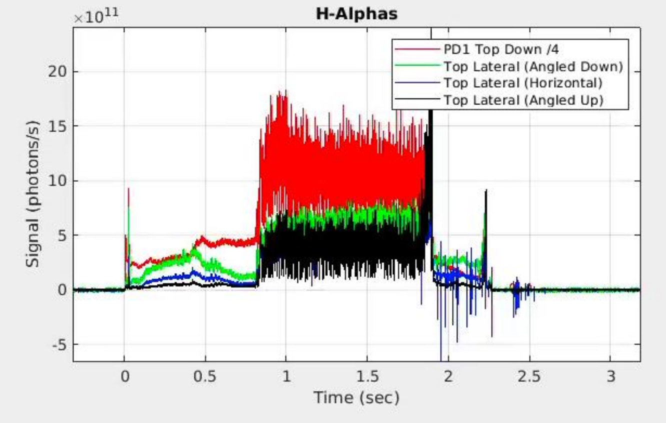
- **Proponents and contact person:**
- Massimo Carpita (massimo.carpita@epfl.ch)
- O. Février, K. Lee, H. Reimerdes, C. Theiler, M. Faitsch

- **Scientific Background & Objectives**
  – Test ADCs in QCE scenario, with N2 seeding & baffles
  – Complete / refine dataset from RT07 2024 and internal missions (XD, SXD, XPT):
    - SEEDED SXD EXPERIMENTS
    - POLOIDAL LEG LENGTH SCAN
    - REPEATS FOR DIAGNOSTIC COVERAGE / DATASET REFINEMENT
  - SOLPS-ITER modeling to integrate the analyses

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  – Start from existing references (170 kA, 1.1 MW, N2 seeding)
  – Modify outer leg equilibrium







Proposed pulses

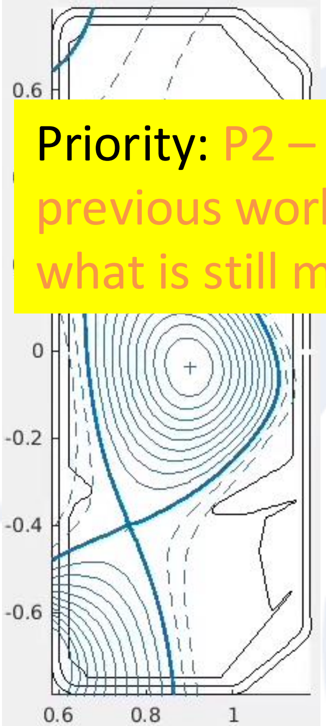
Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	10	-
WEST		

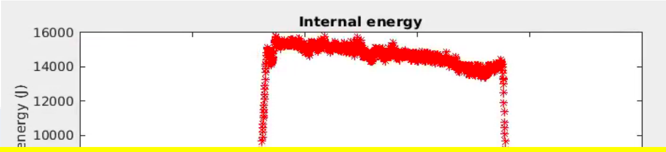
#146: ADCs in QCE plasmas

- **Proponents and contact person:**
- Massimo Carpita (massimo.carpita@epfl.ch)
- O. Février, K. Lee, H. Reimerdes, C. Theiler, M. Faitsch

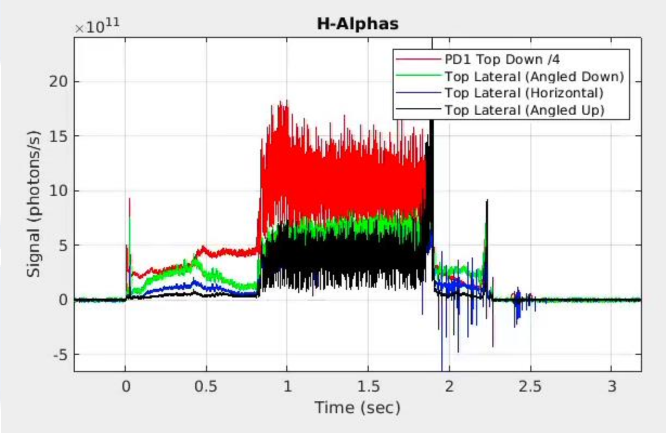
- **Scientific Background & Objectives**
  – Test ADCs in QCE scenario, with N2 seeding & baffles
  – Complete / refine dataset from RT07 2024 and internal missions (XD, SXD, XPT):
    - SEEDED SXD EXPERIMENTS
    - POLOIDAL LEG LENGTH SCAN
    - REPEATS FOR DIAGNOSTIC COVERAGE / DATASET REFINEMENT
  - SOLPS-ITER modeling to integrate the analyses

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  – Start from existing references (170 kA, 1.1 MW, N2 seeding)
  – Modify outer leg equilibrium





Priority: P2 – also this one is continuation of previous work but here it is not that clear what is still missing.

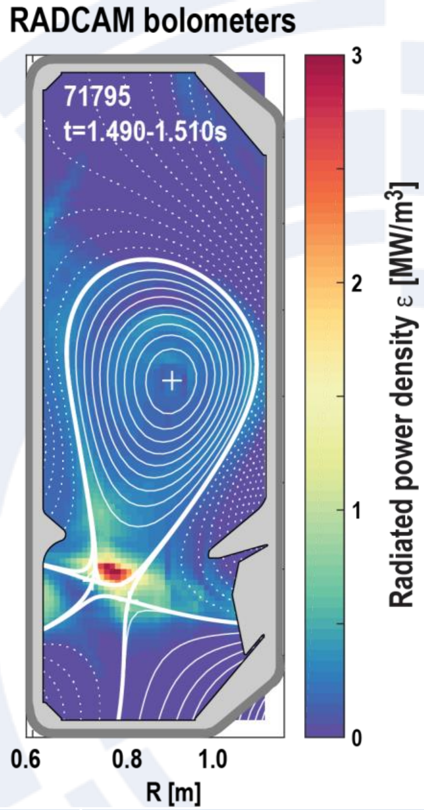


Proposed pulses

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

#152: Exploration and understanding of the ELM-free XPR regime in SF- configuration

- **Proponents and contact person:**
  H. Reimerdes, M. Bernert, O. Février, D. Hamm, J. Harrison (MAST-U), J. Lovell (MAST-U), A. Mele, O. Pan, V. Soukhanovskii (MAST-U), C. Theiler, K. Verhaegh, Y. Wang
- **Scientific Background & Objectives**
  - A snowflake minus configurations with both X-points close to the separatrix found to facilitate access to an ELM-free XPR in TCV
  - This proposal seeks to
    1. Document the profile changes that determine the ELM stability
    2. Investigate the role of carbon as the main radiator
    3. Find evidence for an additional transport mechanism that takes over the particle transport from ELMs
    4. Verify the universality of the facilitated XPR access in this particular SF- configuration
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Diagnose stationary ELMy and ELM-free phases in SF-
  - Carry out experiments in a freshly boronised device, add N_2
  - Compare baffle-GPI measurements in stationary ELMy and ELM-free phases in SF-
  - Explore regime in AUG and MAST-U



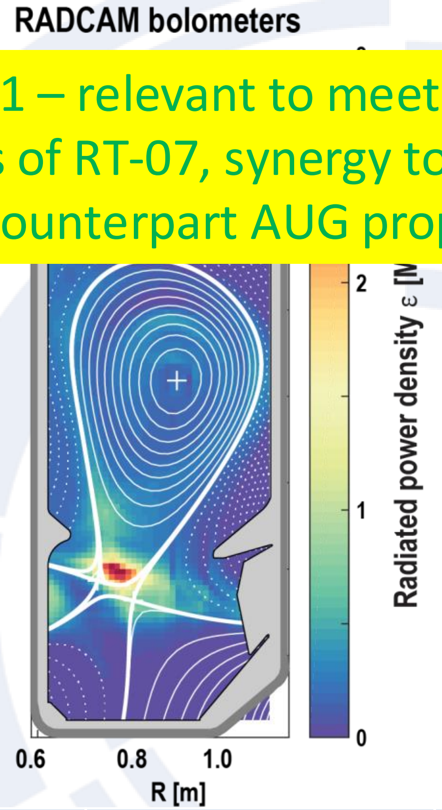
[H. Reimerdes, et al., PSI 2024, submitted to NME]

Device	# Pulses/Session	# Development
AUG	Separate proposals	
MAST-U	Coordinate with internal campaign	
TCV	26	-
WEST	-	-

#152: Exploration and understanding of the ELM-free XPR regime in SF- configuration

Priority: P1 – relevant to meet the main objectives of RT-07, synergy to be found with the counterpart AUG proposal #150.

- **Proponents and contact person:**
  H. Reimerdes, M. Bernert, O. Février, D. Hamm, J. Harrison (MAST-U), J. Lovell (MAST-U), A. Mele, O. Pan, V. Soukhanovskii (MAST-U), C. Theiler, K. Verhaegh, Y. Wang
- **Scientific Background & Objectives**
  – A snowflake minus configurations with both X-points close to the separatrix found to facilitate access to an ELM-free XPR in TCV
  – This proposal seeks to
    1. Document the profile changes that determine the ELM stability
    2. Investigate the role of carbon as the main radiator
    3. Find evidence for an additional transport mechanism that takes over the particle transport from ELMs
    4. Verify the universality of the facilitated XPR access in this particular SF- configuration
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  – Diagnose stationary ELMy and ELM-free phases in SF-
  – Carry out experiments in a freshly boronised device, add N_2
  – Compare baffle-GPI measurements in stationary ELMy and ELM-free phases in SF-
  – Explore regime in AUG and MAST-U

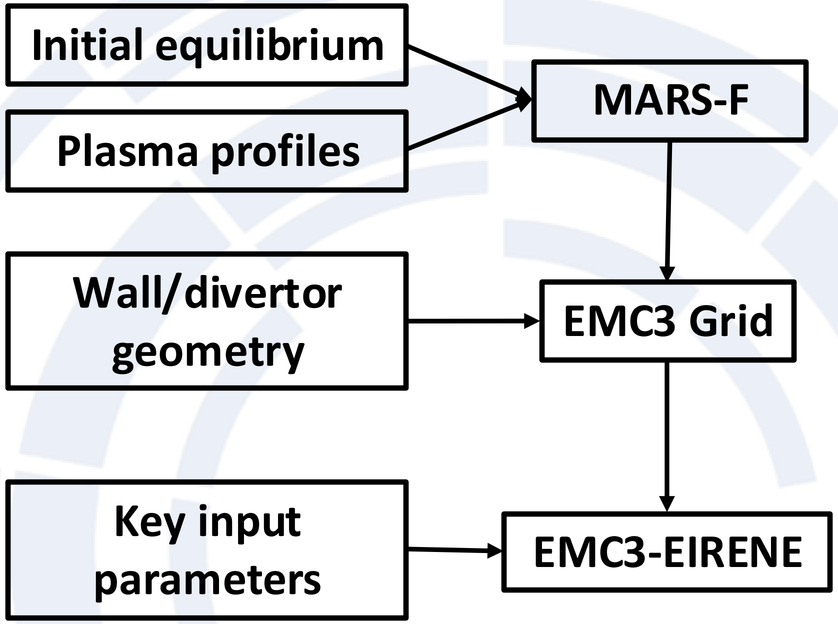


[H. Reimerdes, et al., PSI 2024, submitted to NME]

Device	# Pulses/Session	# Development
AUG	Separate proposals	
MAST-U	Coordinate with internal campaign	
TCV	26	-
WEST	-	-

#153: RMP effects on the access of detachment in super-x divertor and X-divertor configurations

- **Proponents and contact person:**
  y.liang@fz-juelich.de
- **Scientific Background & Objectives**
  – Previous studies have found that RMPs has significant impacts on accessing detachment in traditional divertor configurations
  – Evaluating the effect of RMPs on detachment in super-X (MAST-U) and XD (ASDEX-U) configurations
  – Investigating the influences of plasma response on divertor heat flux distributions under different RMP phases
  – Validating the MARS/EMC3-EIRENE modeling strategy by comparisons with experimental data
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - On MAST-U with super-X divertor, focusing on n=1 RMPs with a phase of ΔΦ = 180
    - Perform density ramp-up from attached to detached plasmas with mid-plane puffing (or divertor puffing) without RMPs and with RMPs in L-mode plasmas
    - Perform divertor puffing without RMPs and with RMPs in H-mode plasmas
  - On ASDEX-U with X-divertor, focusing on the n=2 RMPs
    - Perform the n=2 RMPs with ΔΦ scan in L-mode plasmas
    - Perform the Nitrogen puffing without and with n=2 RMPs in L-mode plasmas
    - Repeat the last step in H-mode plasmas
  - Diagnostics: IR cameras, CXRS, TS, bolometer, divertor Langmuir probes, ECE, Reciprocating probes, visible imaging, coherence imaging diagnostic, …



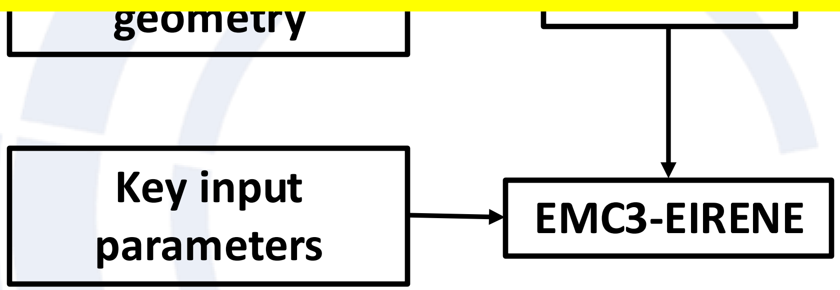
Proposed pulses

Device	# Pulses/Session	# Development
AUG	5	
MAST-U	7	
TCV		
WEST		

#153: RMP effects on the access of detachment in super-x divertor and X-divertor configurations

- **Proponents and contact person:**
  y.liang@fz-juelich.de
- **Scientific Background & Objectives**
  - Previous studies have found that RMPs has significant impacts on accessing detachmen traditional divertor configurations
  - Evaluating the effect of RMPs on detachment in super-X (MAST-U) and XD (ASDEX-U) configurations
  - Investigating the influences of plasma response on divertor heat flux distributions under different RMP phases
  - Validating the MARS/EMC3-EIRENE modeling strategy by comparisons with experimental data
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - On MAST-U with super-X divertor, focusing on n=1 RMPs with a phase of $\Delta\Phi$ = 180
    - Perform density ramp-up from attached to detached plasmas with mid-plane puffing (or divertor puffing) without RMPs and with RMPs in L-mode plasmas
    - Perform divertor puffing without RMPs and with RMPs in H-mode plasmas
  - On ASDEX-U with X-divertor, focusing on the n=2 RMPs
    - Perform the n=2 RMPs with $\Delta\Phi$ scan in L-mode plasmas
    - Perform the Nitrogen puffing without and with n=2 RMPs in L-mode plasmas
    - Repeat the last step in H-mode plasmas
  - Diagnostics: IR cameras, CXRS, TS, bolometer, divertor Langmuir probes, ECE, Reciprocating probes, visible imaging, coherence imaging diagnostic, …

Priority: P2 – even though RMPs are included in the ITER baseline, ADCs may not necessarily be that high in the priority. In addition, on AUG the scenario development may take time beyond 2025.

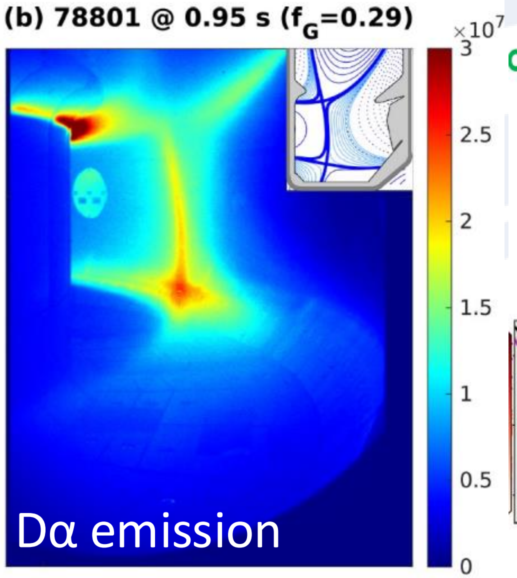


Proposed pulses

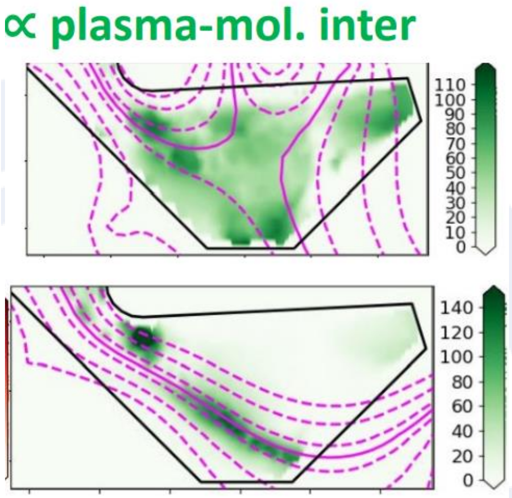
Device	# Pulses/Session	# Development
AUG	5	
MAST-U	7	
TCV		
WEST		

#160: Standard and advanced X-point target configurations and their radiating regimes on TCV and MAST-U

- **Proponents and contact person:**
  - Kenneth Lee (kenneth.lee@epfl.ch), C. Theiler, K. Verhaegh, M. Carpita, G. Durr-Legoupil-Nicoud, O. Février, J. Harrison, N. Lonigro, A. Mele, F. Pastore, H. Reimerdes, M. Zurita
- **Scientific Background & Objectives**
  – X-point target (XPT) configurations found to feature a stable radiating regime – the X-point target radiator (XPTR).
  – Explore XPT/XPTR power exhaust physics in high performance scenarios and other advanced configurations: double-null XPT, long-legged XPT, snowflake target (SFT).
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  – TCV:
    - Develop EC-heated scenario in long-legged SN, XPT and SFT with N_2 seeding.
    - Develop EC heated scenarios in standard SN and XPT with N_2 seeding.
    - Optimise DN and DN XPT shapes, add NBI/EC with N_2 seeding.
  – MAST-U:
    - From a high performance high elongation DN SXD scenario, establish XPT attached condition alongside an SXD reference. Cryopumping preferred.
    - Divertor fuelling / PFR fuelling / impurity seeding in the established scenarios.



TCV
[Lee et al, in prep]



MAST-U
[Lonigro et al]

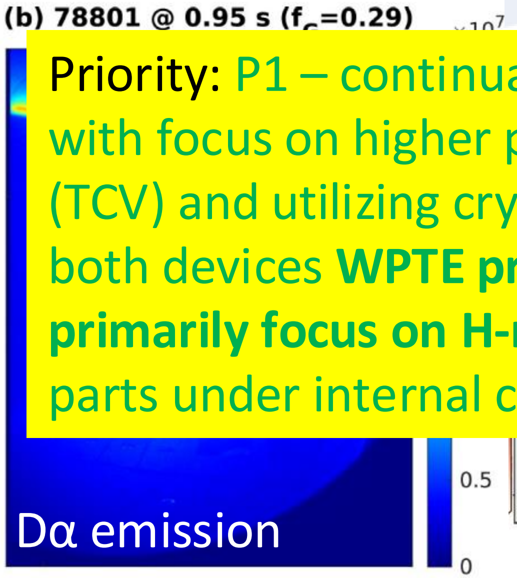
Proposed pulses

Device	# Pulses/Session	# Development
AUG	/	/
MAST-U	10	3
TCV	25	10
WEST	/	/

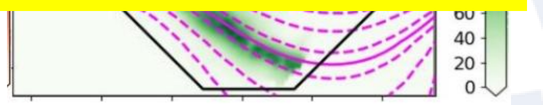
#160: Standard and advanced X-point target configurations and their radiating regimes on TCV and MAST-U

- **Proponents and contact person:**
  - Kenneth Lee (kenneth.lee@epfl.ch), C. Theiler, K. Verhaegh, M. Carpita, G. Durr-Legoupil-Nicoud, O. Février, J. Harrison, N. Lonigro, A. Mele, F. Pastore, H. Reimerdes, M. Zurita
- **Scientific Background & Objectives**
  - X-point target (XPT) configurations found to feature a stable radiating regime – the X-point target radiator (XPTR).
  - Explore XPT/XPTR power exhaust physics in high performance scenarios and other advanced configurations: double-null XPT, long-legged XPT, snowflake target (SFT).
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - TCV:
    - Develop EC-heated scenario in long-legged SN, XPT and SFT with N_2 seeding.
    - Develop EC heated scenarios in standard SN and XPT with N_2 seeding.
    - Optimise DN and DN XPT shapes, add NBI/EC with N_2 seeding.
  - MAST-U:
    - From a high performance high elongation DN SXD scenario, establish XPT attached condition alongside an SXD reference. Cryopumping preferred.
    - Divertor fuelling / PFR fuelling / impurity seeding in the established scenarios.

Priority: P1 – continuation of XPT studies with focus on higher powers/performances (TCV) and utilizing cryopumps (MAST-U). On both devices **WPTE program should primarily focus on H-mode** – L-mode/ohmic parts under internal campaigns.



TCV
[Lee et al, in prep]



MAST-U
[Lonigro et al]

Proposed pulses

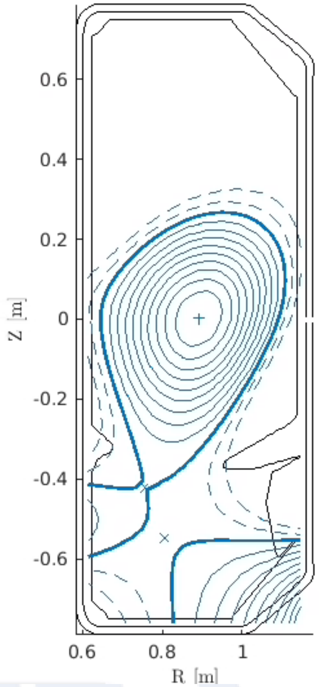
Device	# Pulses/Session	# Development
AUG	/	/
MAST-U	10	3
TCV	25	10
WEST	/	/

#164: Alternative Divertor Configurations in Negative Triangularity in high-performance NT scenarios

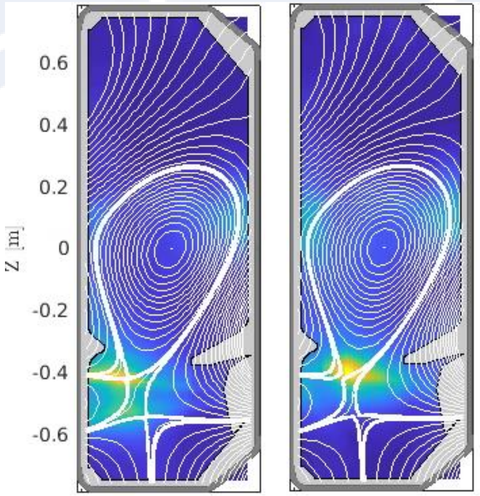
- **Proponents and contact person:**
  - Olivier Février (olivier.fevrier@epfl.ch), G. Durr-Legoupil-Nicoud, O. Sauter, C. Theiler

- **Scientific Background & Objectives**
  - Detachment in NTs difficult to achieve in TCV due to smaller λ_q short connection length. Alternative Divertor Configurations favor access to detachment
  - Ohmic L-Mode : quantify if ADC favors achievement of detached regime with either density ramps or impurity seeding (N_2). In SF, probe inter-Xpoints region with Thomson Scattering.
  - NBH-heated L-Mode (NT, with performances similar to that of PT H-Modes) : quantify if ADC favors achievement of detached regime with impurity seeding (N_2), and if they may mitigate confinement degradation at high levels of seeding. Check the existence of XPR in NT.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Ohmic L-Mode
    - Perform detachment studies using core density ramps
    - Perform detachment studies using N2 injection, at two core densities
  - NBH-heated L-Mode
    - Explore SF-, XD, and an XPT in high-performance scenario (synergy with RT02), at various levels of input power and impurity seeding. SF- already demonstrated on TCV.



NT-SF scenario TCV, with 550 kW NBH & steady-state conditions.



Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	23	9
WEST		

#164: Alternative Divertor Configurations in Negative Triangularity in high-performance NT scenarios

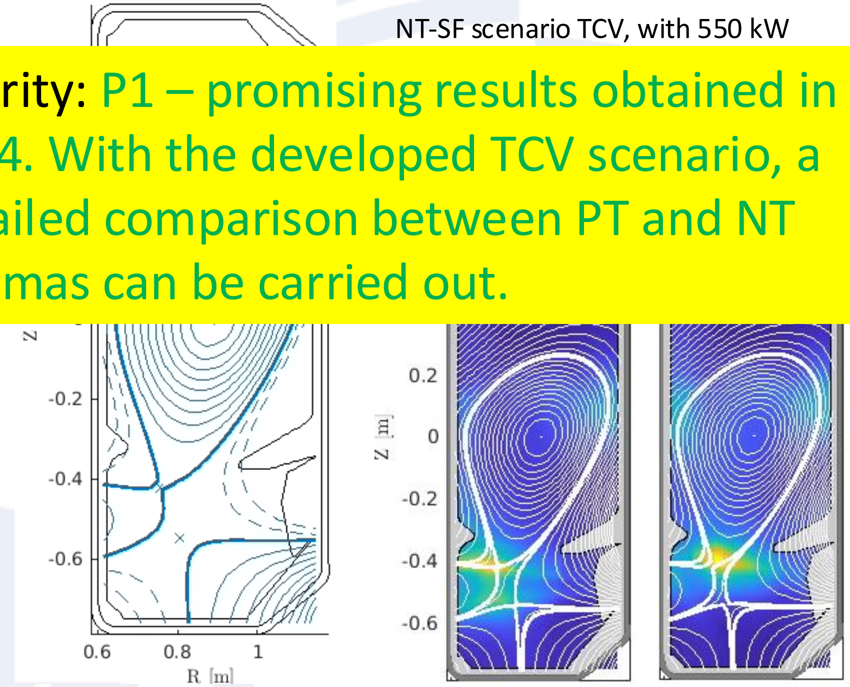
- **Proponents and contact person:**
  - Olivier Février (olivier.fevrier@epfl.ch), G. Durr-Legoupil-Nicoud, O. Sauter, C. Theiler

- **Scientific Background & Objectives**
  - Detachment in NTs difficult to achieve in TCV due to smaller λ_q short connection length. Alternative Divertor Configurations favor access to detachment
  - Ohmic L-Mode : quantify if ADC favors achievement of detached regime with either density ramps or impurity seeding (N_2). In SF, probe inter-Xpoints region with Thomson Scattering.
  - NBH-heated L-Mode (NT, with performances similar to that of PT H-Modes) : quantify if ADC favors achievement of detached regime with impurity seeding (N_2), and if they may mitigate confinement degradation at high levels of seeding. Check the existence of XPR in NT.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Ohmic L-Mode
    - Perform detachment studies using core density ramps
    - Perform detachment studies using N2 injection, at two core densities
  - NBH-heated L-Mode
    - Explore SF-, XD, and an XPT in high-performance scenario (synergy with RT02), at various levels of input power and impurity seeding. SF- already demonstrated on TCV.

NT-SF scenario TCV, with 550 kW

Priority: P1 – promising results obtained in 2024. With the developed TCV scenario, a detailed comparison between PT and NT plasmas can be carried out.



Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U		
TCV	23	9
WEST		

#165: Effect of magnetic balance and fuelling/seeding location on radiation in Double-Nulls plasmas

- **Proponents and contact person:**
  Olivier Février (olivier.fevrier@epfl.ch), D. Moiraf, C. Theiler, L. Xiang
- **Scientific Background & Objectives**
  - Investigate the role of the seeding/fuelling location as well as magnetic balance (dR_{sep}) on DN divertors (top and bottom) detachment behavior
  - Assess level of cross-talk between divertors (does seeding in the upper divertor influence the lower divertor?)
  - What is the radiation pattern in a Double-Null ? Can double-XPR exist, and, if so, under what conditions ?
  - How does different seeded impruties impact the radiation pattern and core contamination?
- **Experimental Strategy/Machine Constraints**

TCV : Ohmic L-Mode and NBH-heated H-Mode on TCV in DN (10 shots)

N_2 seeding from top and bottom divertors

The 10 shots should fill possible gaps identified in the RT07-2024, TCV internal dataset

WEST :

In LSN/DN/upper-biased DN/USN: Ne seeding from midplane LFS (4 shots). Repeat with Ar (4 shots). Repeat with mix Ar-N or Ar-Ne mix (4 shots)

In upper-biased DN: Ar, Ne, mix seeding from upper PFR (3 shots). Repeat in DN, USN and LSN (seeding from lower PFR) (3-6-9 shots)

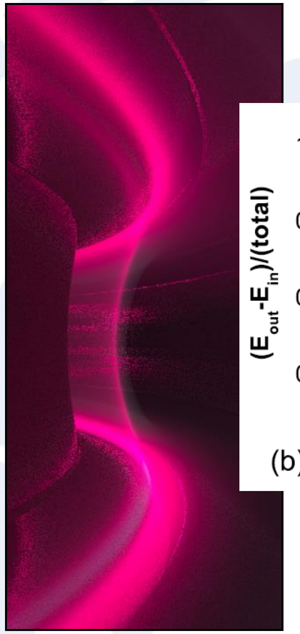
MAST-U: ref scenario: NBI-heated H-mode SXD in DN with detached divertors

scan dR_{sep}: 0 => +2cm => -2cm with midplane fueling, no seeding. (5 shots)

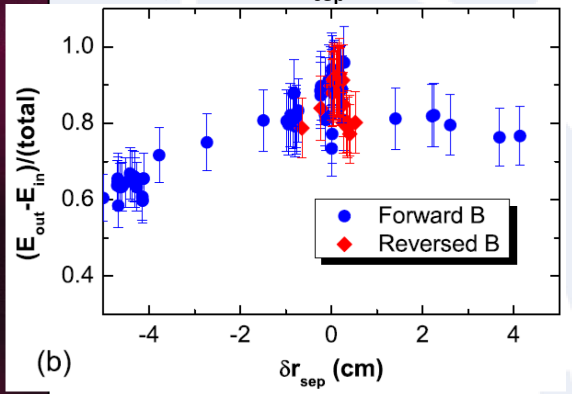
scan dR_{sep}: 0 => +2cm => -2cm, midplane fueling, N_2 seeding in outer divertor (7 shots)

TCV: radiation at lower&upper xpts

Double radiation front in WEST from SOLEDGE3X simulation



Power asymmetry inner/outer changes with dR_{sep} on MAST



Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U	15	3
TCV	10	0
WEST	15	0

#165: Effect of magnetic balance and fuelling/seeding location on radiation in Double-Nulls plasmas

- **Proponents and contact person:**
  Olivier Février (olivier.fevrier@epfl.ch), D. Moiraf, C. Theiler, L. Xiang
- **Scientific Background & Objectives**
  - Investigate the role of the seeding/fuelling location as well as magnetic balance (dR_{sep}) on DN divertors (top and bottom) detachment behavior
  - Assess level of cross-talk between divertors (does seeding in the upper divertor influence the lower divertor?)
  - What is the radiation pattern in a Double-Null ? Can double-XPR exist, and, if so, under what conditions ?
  - How does different seeded impruties impact the radiation pattern and core contamination?
- **Experimental Strategy/Machine Constraints**

  TCV : Ohmic L-Mode and NBH-heated H-Mode on TCV in DN (10 shots)

  N_2 seeding from top and bottom divertors

  The 10 shots should fill possible gaps identified in the RT07-2024, TCV internal dataset

  WEST :

  In LSN/DN/upper-biased DN/USN: Ne seeding from midplane LFS (4 shots). Repeat with Ar (4 shots). Repeat with mix Ar-N or Ar-Ne mix (4 shots)

  In upper-biased DN: Ar, Ne, mix seeding from upper PFR (3 shots). Repeat in DN, USN and LSN (seeding from lower PFR) (3-6-9 shots)

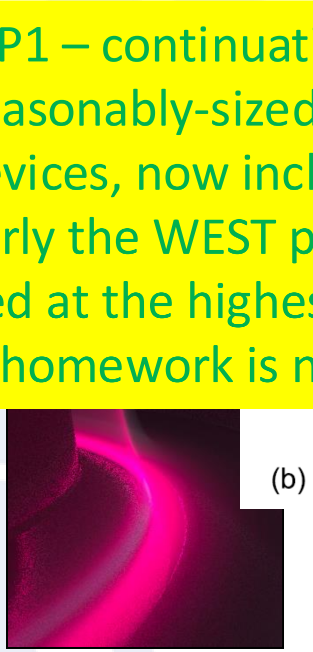
  MAST-U: ref scenario: NBI-heated H-mode SXD in DN with detached divertors

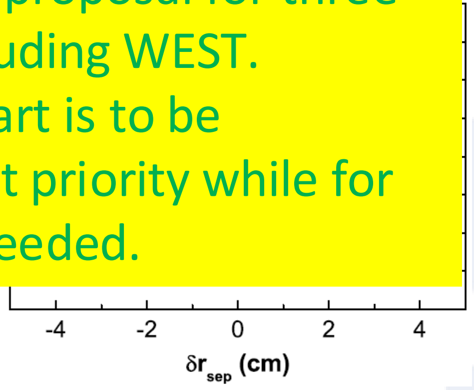
  scan dR_{sep}: 0 => +2cm => -2cm with midplane fueling, no seeding. (5 shots)

  scan dR_{sep}: 0 => +2cm => -2cm, midplane fueling, N_2 seeding in outer divertor (7 shots)

TCV: radiation at lower&upper xpts

Double radiation front in WEST from SOLEDGE3X simulation





Priority: P1 – continuation of the 2024 work with a reasonably-sized proposal for three WPTE devices, now including WEST. Particularly the WEST part is to be supported at the highest priority while for MAST-U homework is needed.

Proposed pulses

Device	# Pulses/Session	# Development
AUG		
MAST-U	15	3
TCV	10	0
WEST	15	0

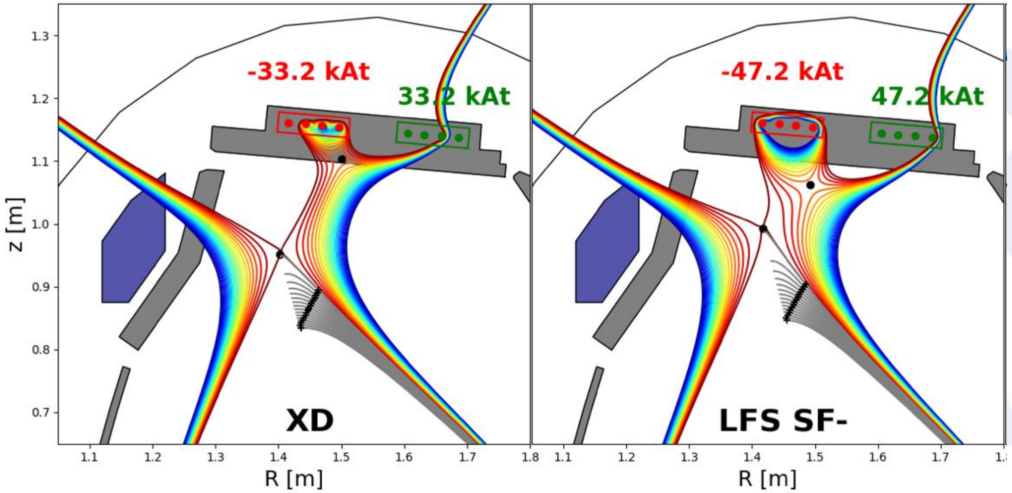
#26: I-mode access in alternative divertor configurations in ASDEX Upgrade

- **Proponents and contact person:**

D. Silvagni (davide.silvagni@ipp.mpg.de), T. Happel, A. Hubbard, M. Komm, O. Grover … (full list in wiki)

- **Scientific Background & Objectives**

I-mode compatibility with divertor detachment and high-radiation fractions of uttermost importance for DEMO. ADC could facilitate detachment achievement, and allow high-radiation fraction in the SOL in I-mode plasmas. This proposal aims at accessing stable I-modes in X-divertor (XD) and low field side snowflake minus (LFS SF-) configurations at different density levels. The most promising I-mode scenario and divertor configuration to be used for detachment studies will be determined.



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

For each divertor configuration (XD and LFS SF-):

- Start from a well developed ADC shape at 0.8 MA / 2.5 T in reversed field (- 2.5 T) with slow NBI power scan and constant density to find I-mode window [1]
- Repeat at three different constant densities [3]
- Keep I-mode stationary with beta_pol feedback control at the most promising density level (unseeded reference) [1]

Therefore 10 shots in total (5 for XD and 5 for LFS SF-).

Proposed pulses

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

#26: I-mode access in alternative divertor configurations in ASDEX Upgrade

- **Proponents and contact person:**

D. Silvagni (davide.silvagni@ipp.mpg.de), T. Happel, A. Hubbard, M. Komm, O. Grover … (full list in wiki)

- **Scientific Background & Objectives**

I-mode compatibility with divertor detachment and high-radiation fractions of uttermost importance for DEMO. ADC could facilitate detachment achievement, and allow high-radiation fraction in the SOL in I-mode plasmas. This proposal aims at accessing stable I-modes in X-divertor (XD) and low field side snowflake minus (LFS SF-) configurations at different density levels. The most promising I-mode scenario and divertor configuration to be used for detachment studies will be determined.

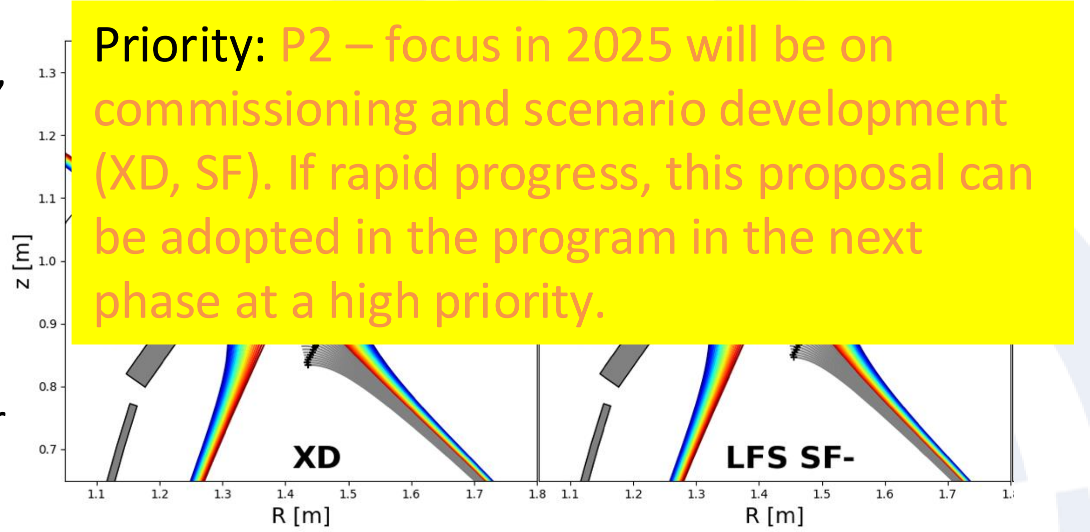
- **Experimental Strategy/Machine Constraints and essential diagnostic**

For each divertor configuration (XD and LFS SF-):

- Start from a well developed ADC shape at 0.8 MA / 2.5 T in reversed field (- 2.5 T) with slow NBI power scan and constant density to find I-mode window [1]
- Repeat at three different constant densities [3]
- Keep I-mode stationary with beta_pol feedback control at the most promising density level (unseeded reference) [1]

Therefore 10 shots in total (5 for XD and 5 for LFS SF-).

Priority: P2 – focus in 2025 will be on commissioning and scenario development (XD, SF). If rapid progress, this proposal can be adopted in the program in the next phase at a high priority.



Proposed pulses

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

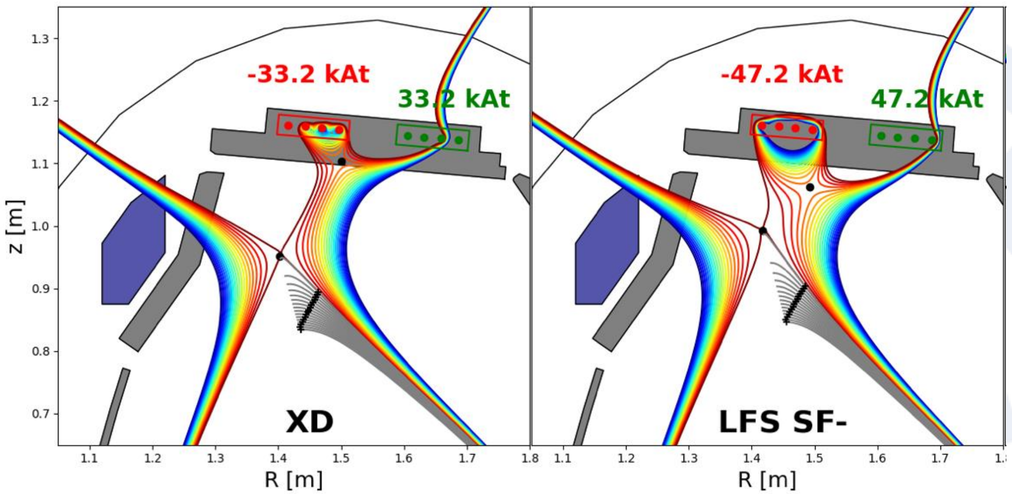
#27: High-radiative and detached I-mode plasmas in alternative divertor configuration in ASDEX Upgrade

- **Proponents and contact person:**

D. Silvagni (davide.silvagni@ipp.mpg.de), T. Happel, A. Hubbard, M. Komm, O. Grover … (full list in wiki)

- **Scientific Background & Objectives**

I-mode compatibility with divertor detachment and high-radiation fractions of uttermost importance for DEMO. ADC could facilitate detachment achievement, and allow high-radiation fraction in the SOL in I-mode plasmas. This proposal aims at obtaining a high-radiative and detached I-mode scenario in an ADC.



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

For the most promising I-mode scenario in terms of divertor configuration and density level (determined in this proposal WPTE wikipages: Call for proposals 2025: RT02 proposals:I-mode ADC):

- Apply nitrogen seeding at different constant seeding rates (four levels), while keeping required beta_pol constant [4]
- If I-L back-transition occurs, apply nitrogen seeding at different seeding rates with linear ramp in beta_pol, i.e. with an increase in heating power (successful strategy in previous single null experiments) [4]
- Optimize nitrogen seeding and required beta_poloidal trajectories, in order to get a stable, detached, high-radiative I-mode plasmas [3]

Therefore 11 shots in total.

Proposed pulses

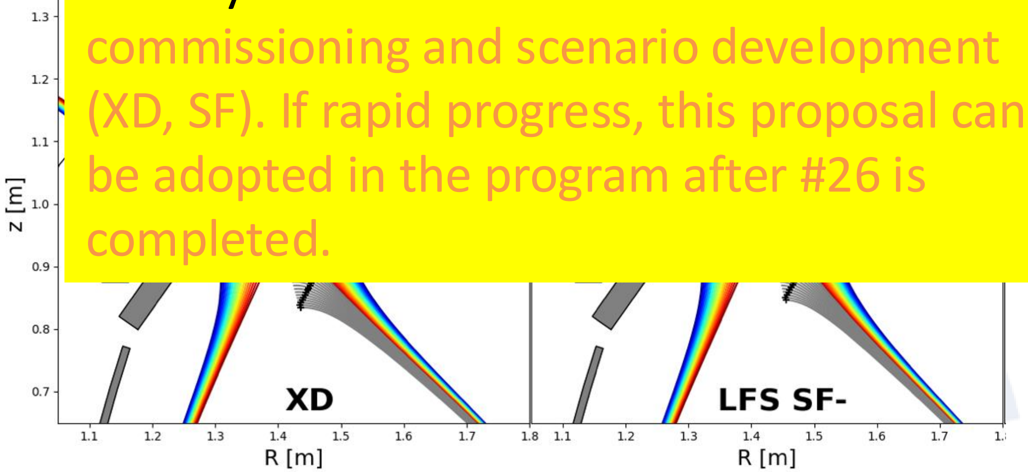
Device	# Pulses/Session	# Development
AUG	11	
MAST-U		
TCV		
WEST		

#27: High-radiative and detached I-mode plasmas in alternative divertor configuration in ASDEX Upgrade

- **Proponents and contact person:**

D. Silvagni (davide.silvagni@ipp.mpg.de), T. Happel, A. Hubbard, M. Komm, O. Grover … (full list in wiki)

Priority: P2 – focus in 2025 will be on commissioning and scenario development (XD, SF). If rapid progress, this proposal can be adopted in the program after #26 is completed.



- **Scientific Background & Objectives**

I-mode compatibility with divertor detachment and high-radiation fractions of uttermost importance for DEMO. ADC could facilitate detachment achievement, and allow high-radiation fraction in the SOL in I-mode plasmas. This proposal aims at obtaining a high-radiative and detached I-mode scenario in an ADC.

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

For the most promising I-mode scenario in terms of divertor configuration and density level (determined in this proposal WPTE wikipages: Call for proposals 2025: RT02 proposals:I-mode ADC):

- Apply nitrogen seeding at different constant seeding rates (four levels), while keeping required beta_pol constant [4]
- If I-L back-transition occurs, apply nitrogen seeding at different seeding rates with linear ramp in beta_pol, i.e. with an increase in heating power (successful strategy in previous single null experiments) [4]
- Optimize nitrogen seeding and required beta_poloidal trajectories, in order to get a stable, detached, high-radiative I-mode plasmas [3]

Therefore 11 shots in total.

Proposed pulses

Device	# Pulses/Session	# Development
AUG	11	
MAST-U		
TCV		
WEST		

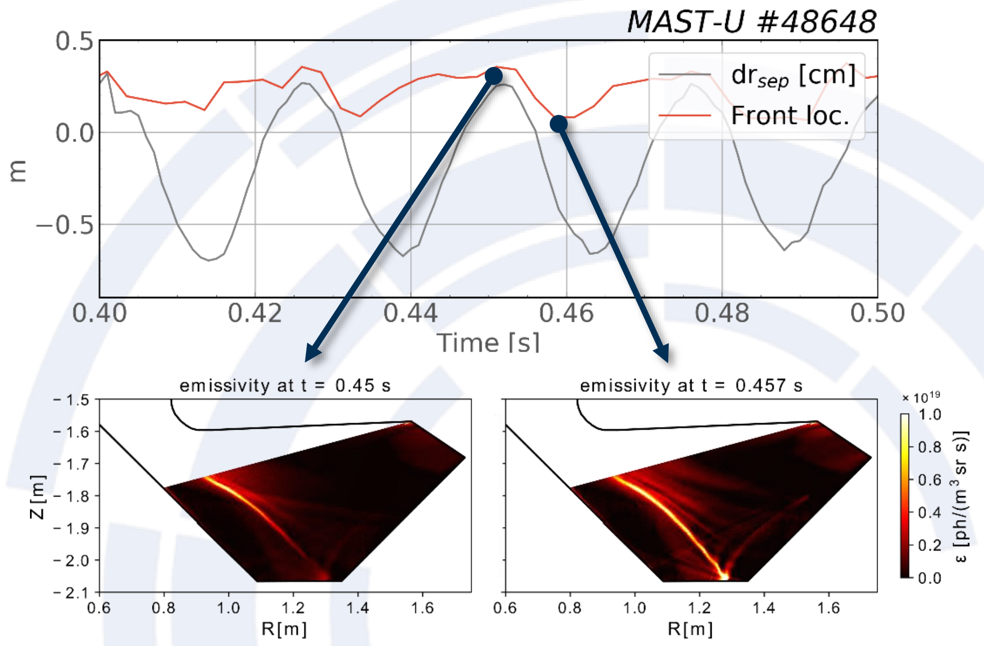
Expanding physics basis of different ADCs and their detachment characteristics

#143: Validation of reduced models for detachment and reattachment in ADCs

- **Proponents and contact person:**
  S. Henderson, D. Moulton, K. Verhaegh, B. Kool, G. Derks, P. Ryan

- **Scientific Background & Objectives**
  Understand how reduced models for divertor detachment and reattachment developed and validated in conventional divertor configurations perform in ADCs:
  - How does sub-divertor pressure scale to divertor pressure
  - Does the inner target impact the outer divertor scaling
  - Can the models be adapted to account for total flux expansion
  - How does reattachment time vary with front position and gas mixture

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Use vertical position (DDN/LSN) to develop an attached SXD
  - Develop a steady divertor pressure at three different levels
  - Gradually replace divertor pressure with radiation through N_2 seeding
  - Apply power transients (downshifts) or N_2 gas cuts to test reattachment at different gas mixtures and front positions



Multi Wavelength Imaging

Proposed pulses

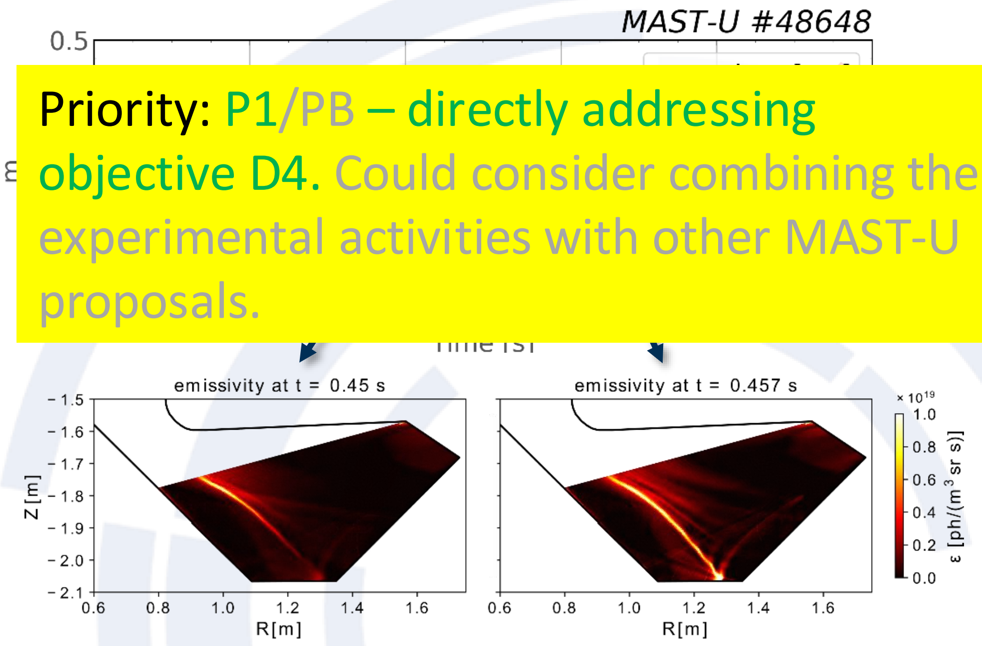
Device	# Pulses/Session	# Development
AUG		
MAST-U	10	6
TCV		
WEST		

#143: Validation of reduced models for detachment and reattachment in ADCs

- **Proponents and contact person:**
  S. Henderson, D. Moulton, K. Verhaegh, B. Kool, G. Derks, P. Ryan

- **Scientific Background & Objectives**
  Understand how reduced models for divertor detachment and reattachment developed and validated in conventional divertor configurations perform in ADCs:
  - How does sub-divertor pressure scale to divertor pressure
  - Does the inner target impact the outer divertor scaling
  - Can the models be adapted to account for total flux expansion
  - How does reattachment time vary with front position and gas mixture

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Use vertical position (DDN/LSN) to develop an attached SXD
  - Develop a steady divertor pressure at three different levels
  - Gradually replace divertor pressure with radiation through N_2 seeding
  - Apply power transients (downshifts) or N_2 gas cuts to test reattachment at different gas mixtures and front positions



Priority: P1/PB – directly addressing objective D4. Could consider combining the experimental activities with other MAST-U proposals.

Multi Wavelength Imaging

Proposed pulses

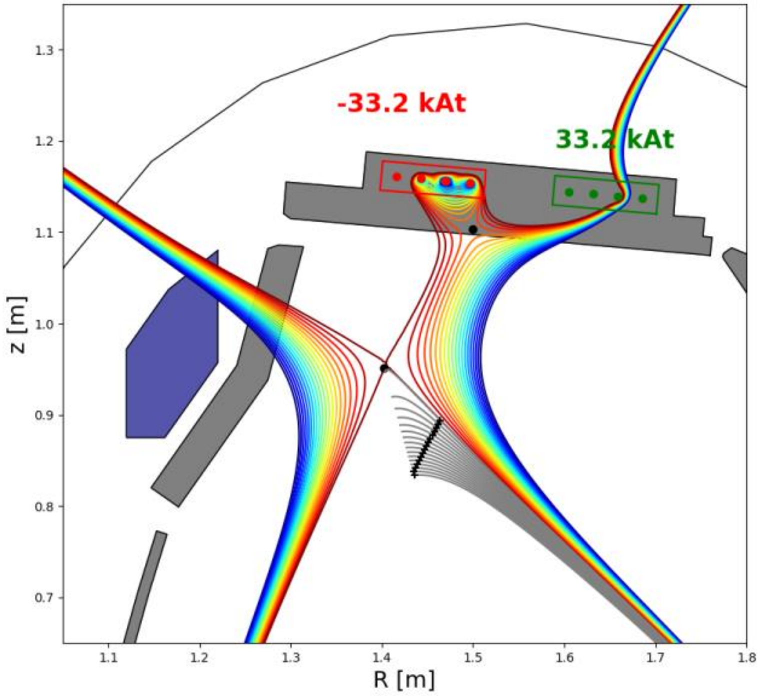
Device	# Pulses/Session	# Development
AUG		
MAST-U	10	6
TCV		
WEST		

#155: Comparison of high flux expansion (XD) divertor configurations between MAST-U and AUG

- **Proponents and contact person:**

D. Brida (IPP), T. Lunt (IPP), K. Verhaegh (UKAEA), M. Faitsch (IPP), P. Ryan (UKAEA), S. Henderson (UKAEA)

- **Scientific Background & Objectives**
  - Compare power and particle exhaust of MAST-U and AUG at a similar divertor field configurations.
  - Disentangle the effects which the magnetic field line configuration has on power exhaust, from other factors such as wall material and neutral buffering.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - L-mode density and power scans in both machines
  - Chracterize divertor and upstream conditions with extensive set of SOL diagnostics (LPs at divertor and reciprocating probe, spectroscopy, MWI, TS, neutral pressure gauges) and determine relevant parameters for power exhaust.
  - Compare divertor conditions between AUG and MAST-U at comparable parameters relevant for power exhaust.



Proposed pulses

Device	# Pulses/Session	# Development
AUG	12	2
MAST-U	20	10
TCV	-	-
WEST	-	-

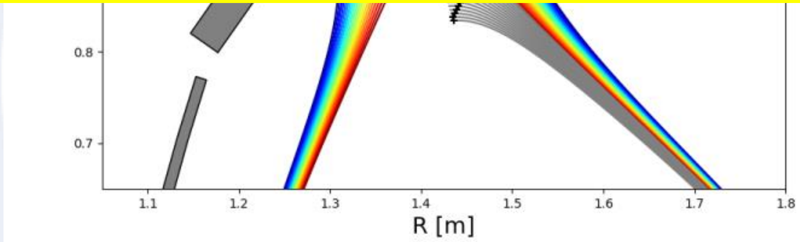
#155: Comparison of high flux expansion (XD) divertor configurations between MAST-U and AUG

- **Proponents and contact person:**

D. Brida (IPP), T. Lunt (IPP), K. Verhaegh (UKAEA), M. Faitsch (IPP), P. Ryan (UKAEA), S. Henderson (UKAEA)

- **Scientific Background & Objectives**
  - Compare power and particle exhaust of MAST-U and AUG at a similar divertor field configurations.
  - Disentangle the effects which the magnetic field line configuration has on power exhaust, from other factors such as wall material and neutral buffering.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - L-mode density and power scans in both machines
  - Chracterize divertor and upstream conditions with extensive set of SOL diagnostics (LPs at divertor and reciprocating probe, spectroscopy, MWI, TS, neutral pressure gauges) and determine relevant parameters for power exhaust.
  - Compare divertor conditions between AUG and MAST-U at comparable parameters relevant for power exhaust.

Priority: P2/PB – comparisons between different machines relevant for DEMO and DTT but this proposal should be best executed once the AUG scenarios are properly developed. Part of the work could be done piggy back/via data mining (on MAST-U).



Proposed pulses

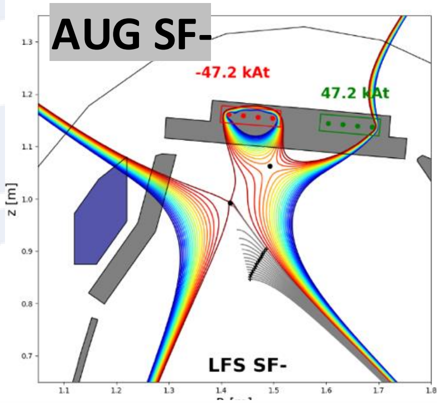
Device	# Pulses/Session	# Development
AUG	12	2
MAST-U	20	10
TCV	-	-
WEST	-	-

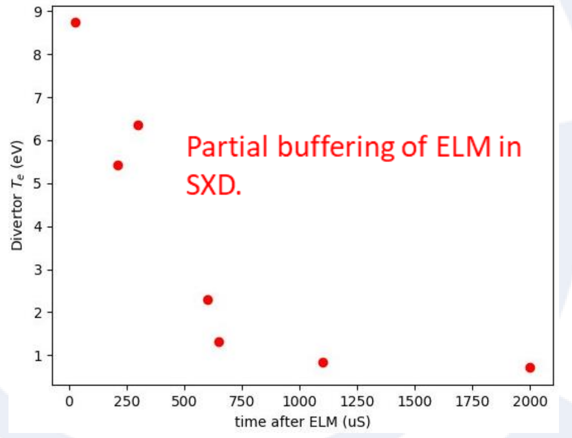
#157: ELM buffering in ADCs in AUG, TCV, and MAST-U

- **Proponents and contact persons**
  D. Silvagni (davide.silvagni@ipp.mpg.de), M. Zurita (martim.zurita@epfl.ch), O. Fevrier (olivier.fevrier@epfl.ch), L. Xiang (lingyan.xiang@ukaea.uk), M. Komm, M. Faitsch, M. Bernert, D. Brida, T. Puetterich, M. Carpita, K. Lee, H. Reimerdes, C. Theiler

- **Scientific Background & Objectives**
  - ELM buffering is fundamental to mitigate energy and particle loads; ADCs are potentially easier to detach. To what extent ADCs can improve ELM buffering? Are the results machine dependent?
  - Determine ELM buffering fraction in an ADC for N, Ar, N+Ar/Ne seeding
  - Determine ELM buffering fraction in conventional SN configuration for N, Ar and N+Ar/Ne seeding (with exactly same engineering parameters as ADC shots)
  - Quantify (potential) benefit of the chosen ADC w.r.t. ELM buffering

- **Experimental Strategy**
  1. ELM buffering in ADC(s) [# shots: 7 (AUG), 12 (MAST-U), 14 (TCV)]:
     - most promising ADC scenario(s) in favorable configuration in terms control w.r.t. ELMs (reference without seeding)
     - N, Ar and N+Ar seeding (AUG & MAST-U) and N, Ar, Ne seeding (TCV)
  2. ELM buffering in conventional divertor [# shots: 7 (AUG), 6 (MAST-U), 7 (TCV)]:
     - SN (reference w/o seeding) with same engineering parameters as ADC shots
     - N, Ar and N+Ar seeding (AUG & MAST-U) and N, Ar, Ne seeding (TCV)
  3. Investigate slower transients (cut impurity seeding, reattachment through NBH) [# shots: 9 (TCV)]



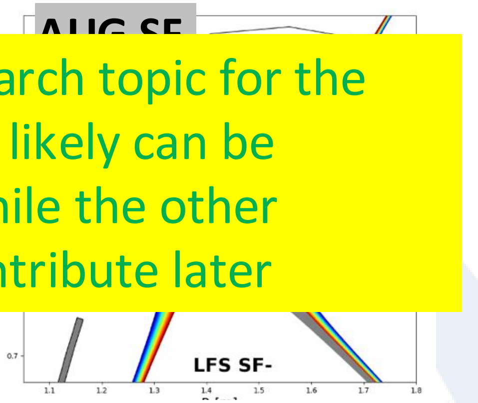


Proposed pulses

Device	# Pulses	# Dev.
AUG	14	2
MAST-U	18	5
TCV	30	6
WEST		

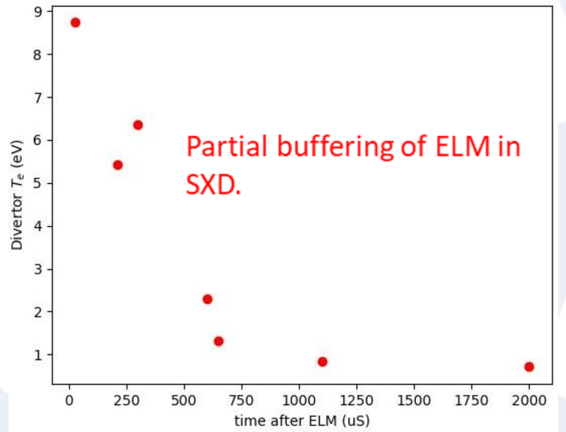
#157: ELM buffering in ADCs in AUG, TCV, and MAST-U

Priority: P1 – a key research topic for the 2025 program but most likely can be initiated fully on TCV while the other devices may start to contribute later



- **Proponents and contact persons**
  D. Silvagni (davide.silvagni@ipp.mpg.de), M. Zurita (martim.zurita@epfl.ch), O. Fevr (olivier.fevrier@epfl.ch), L. Xiang (lingyan.xiang@ukaea.uk), M. Komm, M. Faitsch, M Puetterich, M. Carpita, K. Lee, H. Reimerdes, C. Theiler

- **Scientific Background & Objectives**
  - ELM buffering is fundamental to mitigate energy and particle loads; ADCs are potentially easier to detach. To what extent ADCs can improve ELM buffering? Are the results machine dependent?
  - Determine ELM buffering fraction in an ADC for N, Ar, N+Ar/Ne seeding
  - Determine ELM buffering fraction in conventional SN configuration for N, Ar and N+Ar/Ne seeding (with exactly same engineering parameters as ADC shots)
  - Quantify (potential) benefit of the chosen ADC w.r.t. ELM buffering



- **Experimental Strategy**
  1. ELM buffering in ADC(s) [# shots: 7 (AUG), 12 (MAST-U), 14 (TCV)]:
     - most promising ADC scenario(s) in favorable configuration in terms control w.r.t. ELMs (reference without seeding)
     - N, Ar and N+Ar seeding (AUG & MAST-U) and N, Ar, Ne seeding (TCV)
  2. ELM buffering in conventional divertor [# shots: 7 (AUG), 6 (MAST-U), 7 (TCV)]:
     - SN (reference w/o seeding) with same engineering parameters as ADC shots
     - N, Ar and N+Ar seeding (AUG & MAST-U) and N, Ar, Ne seeding (TCV)
  3. Investigate slower transients (cut impurity seeding, reattachment through NBH) [# shots: 9 (TCV)]

Proposed pulses

Device	# Pulses	# Dev.
AUG	14	2
MAST-U	18	5
TCV	30	6
WEST		

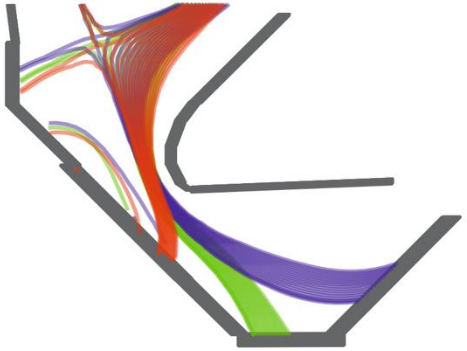
#158: Investigations of outer target radius scans and impact on core performance

- **Proponents and contact person:**
- K. Verhaegh, et al. k.h.a.Verhaegh@tue.nl

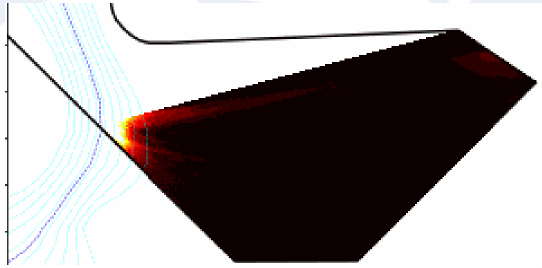
- **Scientific Background & Objectives**
  - Last year: 1) Power exhaust MAST-U **Super-X** **maintained** at more **moderate target radius** (**Elongated div.**); 2) **poloidal leg length/total flux expansion/baffling** **work together** for power exhaust benefits
  - Find at which point tangible total flux expansion ($F_r = R_t/R_{xpt}$) benefits are maintained – **treat ADCs as continuum and find optimization points for reactor integration**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Investigate F_r benefits in **single-null** and **cryopumped** conditions
  - Find **at which R_t** the total flux expansion **benefits become tangible**
  - Investigate power exhaust improvements by **reducing R_{xpt}**
  - Attempt to retrieve F_r benefits TCV by moving closer to MAST-U conditions / tighter effective baffling

Conventional divertor
Elongated divertor
Super-X divertor



Strike point scan
D_2 Fulcher emission – ionisation proxy



If ED and SXD much better than CD when do we get these benefits ?

Proposed pulses

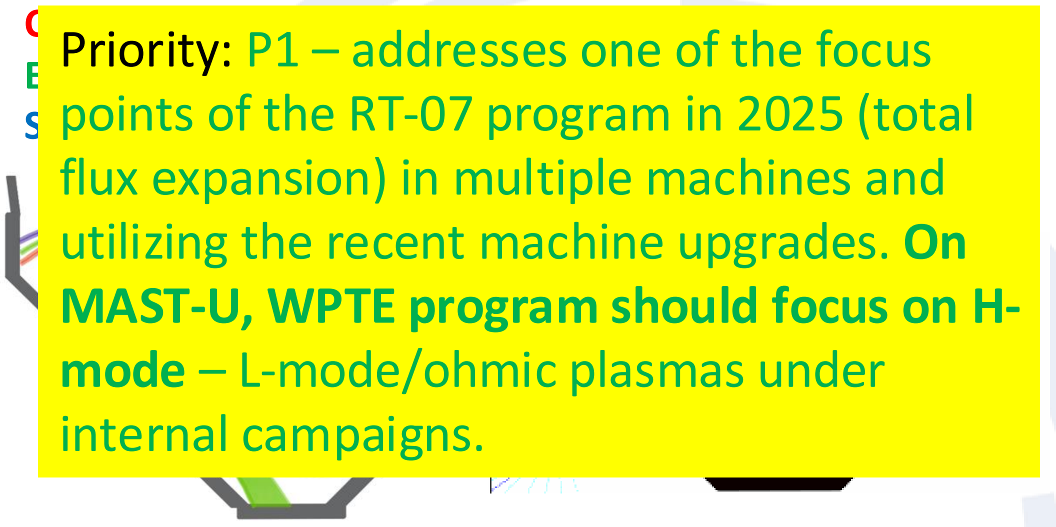
Device	# Pulses/Session	# Development
AUG	?	0
MAST-U	24	10
TCV	8	8
WEST	0	0

#158: Investigations of outer target radius scans and impact on core performance

- **Proponents and contact person:**
  - K. Verhaegh, et al. k.h.a.Verhaegh@tue.nl

- **Scientific Background & Objectives**
  - Last year: 1) Power exhaust MAST-U **Super-X** **maintained** at more **moderate target radius (Elongated div.)**; 2) **poloidal leg length/total flux expansion/baffling work together** for power exhaust benefits
  - Find at which point tangible total flux expansion ($F_r = R_t/R_{xpt}$) benefits are maintained – **treat ADCs as continuum and find optimization points for reactor integration**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Investigate F_r benefits in **single-null** and **cryopumped** conditions
  - Find **at which R_t** the total flux expansion **benefits become tangible**
  - Investigate power exhaust improvements by **reducing R_{xpt}**
  - Attempt to retrieve F_r benefits TCV by moving closer to MAST-U conditions / tighter effective baffling



Priority: P1 – addresses one of the focus points of the RT-07 program in 2025 (total flux expansion) in multiple machines and utilizing the recent machine upgrades. **On MAST-U, WPTE program should focus on H-mode** – L-mode/ohmic plasmas under internal campaigns.

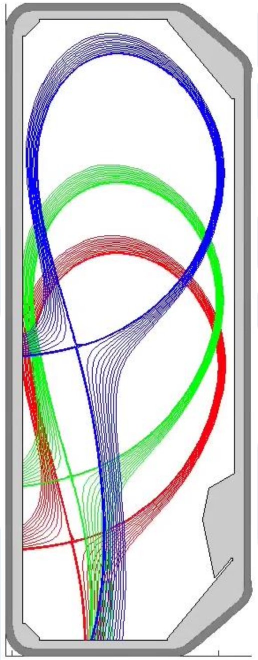
If ED and SXD much better than CD when do we get these benefits ?

Proposed pulses

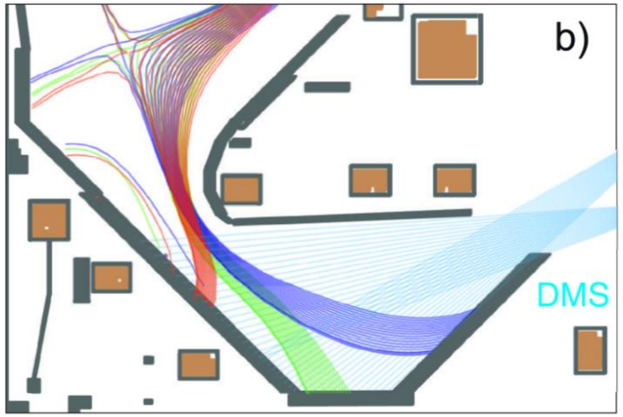
Device	# Pulses/Session	# Development
AUG	?	0
MAST-U	24	10
TCV	8	8
WEST	0	0

#161: Investigation of poloidal leg length effects on power exhaust on TCV and MAST-U

- **Proponents and contact person:**
  - Kenneth Lee (kenneth.lee@epfl.ch), C. Theiler, K. Verhaegh, B. Brown, M. Carpita, G. Durr-Legoupil-Nicoud, O. Février, J. Harrison, N. Lonigro, D. Moulton, F. Pastore, H. Reimerdes, M. Zurita
- **Scientific Background & Objectives**
  - Long-legged configurations can have power exhaust benefits from expanded volume of plasma-neutral interactions, increased divertor cross-field transport, combination with ADCs, etc.
    - Basic, cross-machine investigation of leg length effects on power exhaust, clarification of key physics mechanisms.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - TCV:
    - Develop EC-heated scenarios from established leg length scan shapes, and add N_2 seeding.
    - Ohmic density ramps to test different extent of divertor leg baffling (unbaffled, SILO, LILO).
    - RDPA measurements to collect divertor profiles and fluctuation data
    - Develop long-legged ADC shapes.
  - MAST-U:
    - From NBI-heated SN reference, develop CD, ED, SXD scenarios similar to previous DN experiments (ELMy H-mode or L-mode).
    - Divertor fuelling / PFR fuelling / impurity seeding.



TCV
[Lee et al, in progress]



MAST-U
[Verhaegh et al, submitted]

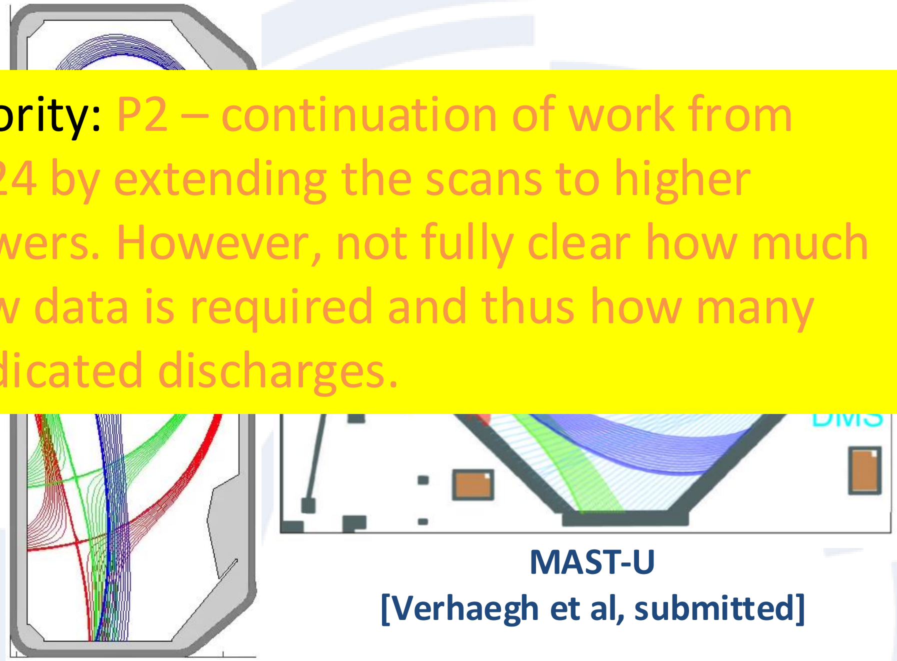
Proposed pulses

Device	# Pulses/Session	# Development
AUG	/	/
MAST-U	20	8
TCV	30	10
WEST	/	/

#161: Investigation of poloidal leg length effects on power exhaust on TCV and MAST-U

- **Proponents and contact person:**
  - Kenneth Lee (kenneth.lee@epfl.ch), C. Theiler, K. Verhaegh, B. Brown, M. Carpita, G. Durr-Legoupil-Nicoud, O. Février, J. Harrison, N. Lonigro, D. Moulton, F. Pastore, H. Reimerdes, M. Zurita
- **Scientific Background & Objectives**
  - Long-legged configurations can have power exhaust benefits from expanded volume of plasma-neutral interactions, increased divertor cross-field transport, combination with ADCs, etc.
    - Basic, cross-machine investigation of leg length effects on power exhaust, clarification of key physics mechanisms.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - TCV:
    - Develop EC-heated scenarios from established leg length scan shapes, and add N_2 seeding.
    - Ohmic density ramps to test different extent of divertor leg baffling (unbaffled, SILO, LILO).
    - RDPA measurements to collect divertor profiles and fluctuation data
    - Develop long-legged ADC shapes.
  - MAST-U:
    - From NBI-heated SN reference, develop CD, ED, SXD scenarios similar to previous DN experiments (ELMy H-mode or L-mode).
    - Divertor fuelling / PFR fuelling / impurity seeding.

Priority: P2 – continuation of work from 2024 by extending the scans to higher powers. However, not fully clear how much new data is required and thus how many dedicated discharges.



MAST-U [Verhaegh et al, submitted]

TCV [Lee et al, in progress]

Proposed pulses

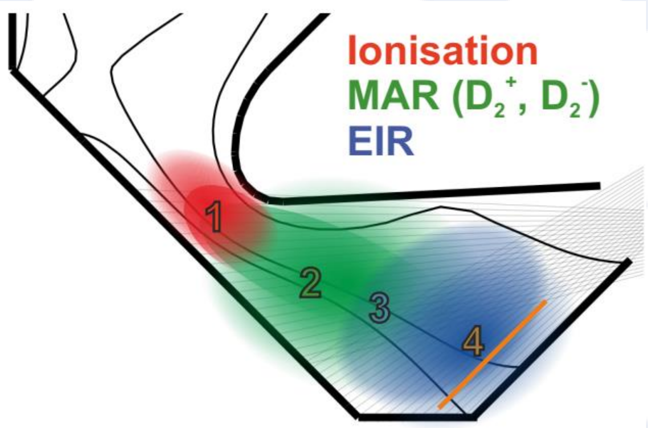
Device	# Pulses/Session	# Development
AUG	/	/
MAST-U	20	8
TCV	30	10
WEST	/	/

#166: Detachment characteristics in neutral-driven and impurity-driven detachment in tightly baffled ADCs

- **Proponents and contact person:**
  L. Xiang (lingyan.xiang@ukaea.uk), K. Verhaegh, D. Moulton, S. Henderson, H. Reimerdes, N. Bundschuh
- **Scientific Background & Objectives**
  Power dissipation by impurities mandatory on DEMO/future reactors. MAST-U with SXD showed important role of neutrals in facilitating complete detachment. Will impurities, by driving detachment via power loss, change the relative role of neutrals?

  Objectives:
  - Identify the differences in how detachment is established between deuterium plasma and impurity seeded plasma => how deep detachment can go, degree of impact on upstream
  - Quantify the relative contribution of power loss (hydrogenic, impurity radiation), momentum loss (atom & molecule) in ADCs w.r.t. in conventional divertor geometry.
- **Experimental Strategy**
  1. ref scenario with attached outer divertor at constant density ➔ 3 development shots
  2. Increase fuelling to drive the outer divertor to profound detachment. ➔ 2 physics shots
  3. Keep density, current, heating, shaping, pumping etc the same, seed nitrogen from the main chamber wall to induce divertor detachment ➔ 4 physics shots
  4. Keep the density, current, heating, shaping, pumping etc the same, seed nitrogen from under the X-point to induce divertor detachment. ➔ 3 physics shots
  5. Repeat (1)-(4) for the CD geometry. ➔ 9 physics shots

neutral driven detachment processes on MAST-U.
[Verhaegh2023]



Proposed pulses

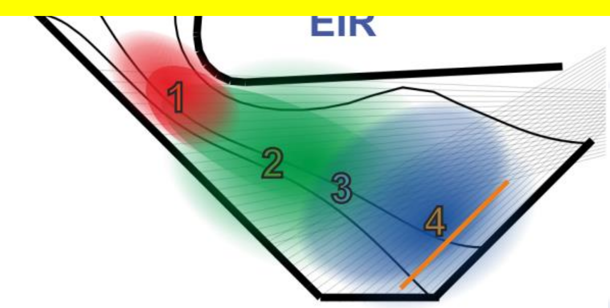
Device	# Pulses	# Dev.
AUG		
MAST-U	20	3
TCV	20	2
WEST		

#166: Detachment characteristics in neutral-driven and impurity-driven detachment in tightly baffled ADCs

- **Proponents and contact person:**
  L. Xiang (lingyan.xiang@ukaea.uk), K. Verhaegh, D. Moulton, S. Henderson, H. Reimerdes, N. Bundschuh
- **Scientific Background & Objectives**
  Power dissipation by impurities mandatory on DEMO/future reactors. MAST-U wit SXD showed important role of neutrals in facilitating complete detachment. Will impurities, by driving detachment via power loss, change the relative role of neutr

  Objectives:
  - Identify the differences in how detachment is established between deuterium plasma and impurity seeded plasma => how deep detachment can go, degree of impact on upstream
  - Quantify the relative contribution of power loss (hydrogenic, impurity radiation), momentum loss (atom & molecule) in ADCs w.r.t. in conventional divertor geometry.
- **Experimental Strategy**
  1. ref scenario with attached outer divertor at constant density ➔ 3 development shots
  2. Increase fuelling to drive the outer divertor to profound detachment. ➔ 2 physics shots
  3. Keep density, current, heating, shaping, pumping etc the same, seed nitrogen from the main chamber wall to induce divertor detachment ➔ 4 physics shots
  4. Keep the density, current, heating, shaping, pumping etc the same, seed nitrogen from under the X-point to induce divertor detachment. ➔ 3 physics shots
  5. Repeat (1)-(4) for the CD geometry. ➔ 9 physics shots

Priority: P1/PB – re-submission from 2024. Main proposal for addressing the impact of seeding on detachment in selected ADCs on MAST-U. Part of the work can be done in combination with other proposals (MAST-U) or be based on data mining (TCV).



Proposed pulses

Device	# Pulses	# Dev.
AUG		
MAST-U	20	3
TCV	20	2
WEST		

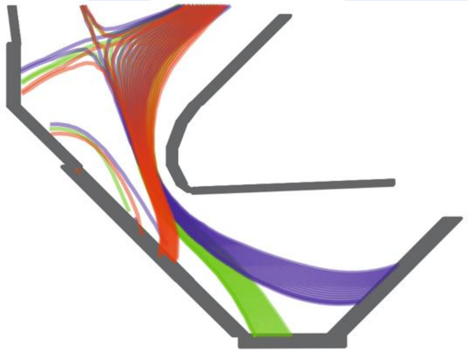
#168: Poloidal flux expansion and flaring in long-legged divertors

- **Proponents and contact person:**
- K. Verhaegh, et al. k.h.a.Verhaegh@tue.nl

- **Scientific Background & Objectives**
  - Last year: Power exhaust benefit poloidal flux expansion limited in TCV experiments -> improved understanding needed
  - **ADCs are a continuum**: find whether **poloidal flux expansion** & **divertor leg length** can **be traded-off** as optimization strategy ?
  - Does **poloidal flux flaring** reduce detachment sensitivity and improve real-time control ? **-> Unknown**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Develop **equilibria** with **different divertor leg lengths** and levels of **poloidal flux expansion** to identify whether the two can be traded off in **high power scenarios** during fueling/seeding scans
  - Perform **system-identification studies** to **identify dynamical benefits flaring**

Conventional divertor
Elongated divertor
Super-X divertor



Shape	F_x (current)	F_x (add)
SXD	9	3
ED	6	3
CD	3.3	6

To what extent can poloidal leg length and flux expansion be traded off ?

Proposed pulses

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

#168: Poloidal flux expansion and flaring in long-legged divertors

- **Proponents and contact person:**
- K. Verhaegh, et al. k.h.a.Verhaegh@tue.nl

- **Scientific Background & Objectives**
  - Last year: Power exhaust benefit poloidal flux expansion limited in TCV experiments -> improved understanding needed
  - **ADCs are a continuum**: find whether **poloidal flux expansion** & **divertor leg length** can **be traded-off** as optimization strategy ?
  - Does **poloidal flux flaring** reduce detachment sensitivity and improve real-time control ? **-> Unknown**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Develop **equilibria** with **different divertor leg lengths** and levels of **poloidal flux expansion** to identify whether the two can be traded off in **high power scenarios** during fueling/seeding scans
  - Perform **system-identification studies** to **identify dynamical benefits flaring**

Priority: P1 – extends the database on the impact of poloidal flux expansion & flaring in ADCs in different machines with focus on higher power levels. **On MAST-U, WPTE program should focus on H-mode** – L-mode/ohmic plasmas under internal campaigns.

To what extent can poloidal leg length and flux expansion be traded off ?

Proposed pulses

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

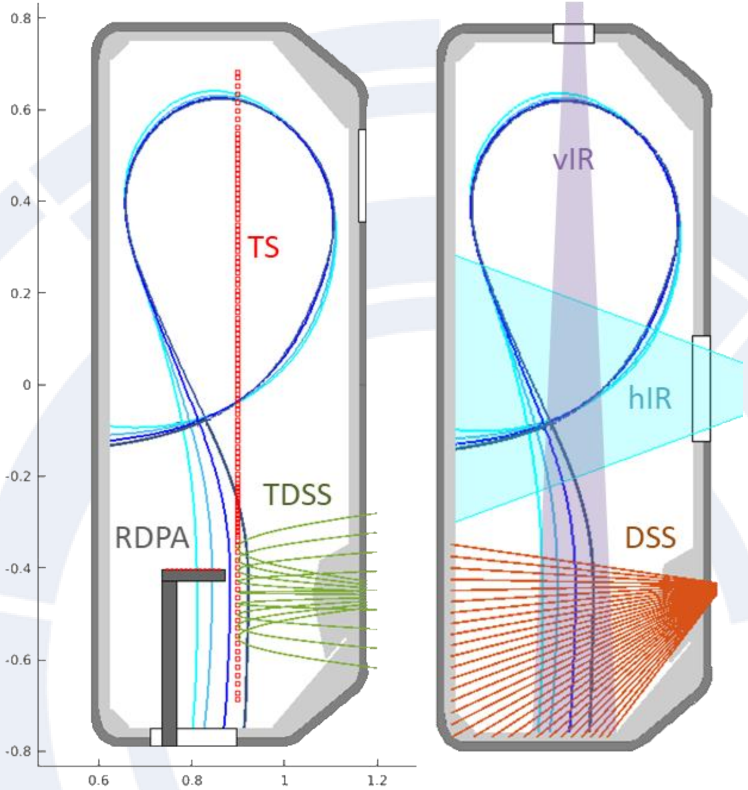
SOL flows, turbulence and heat flux profiles in ADCs

#147: ADCs impact on divertor flows

- **Proponents and contact person:**
  - massimo.carpita@epfl.ch
  - richard.ducker@epfl.ch
  - m.j.h.cornelissen@tue.nl

- **Scientific Background & Objectives**
  - Perform multi-device (TCV, MAST-U, AUG*) characterization of the impact of ADCs on divertor flows.
  - Evaluate the change in parallel flows in the divertor with respect to
    - ❖ Poloidal leg length
    - ❖ Poloidal and total flux expansion
    - ❖ SN, DN, multiple X-points – XPT

- **Experimental Strategy and essential diagnostics**
  - [TCV] Characterization of the ADCs impact on divertor flows in well diagnosed scenario (coupled to RT05 proposal):
    - ❖ TDSS – including new LoS arrangement
    - ❖ CIS – benchmark new diagnostic for 2D flows
    - ❖ RDPA – 2D Langmuir probe measurements
    - ❖ MANTIS & TS – 2D plasma quantities
  - Characterization of the ADC impact on divertor flows in reactor-relevant scenarios (heated L-mode or H-mode).



Proposed pulses

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

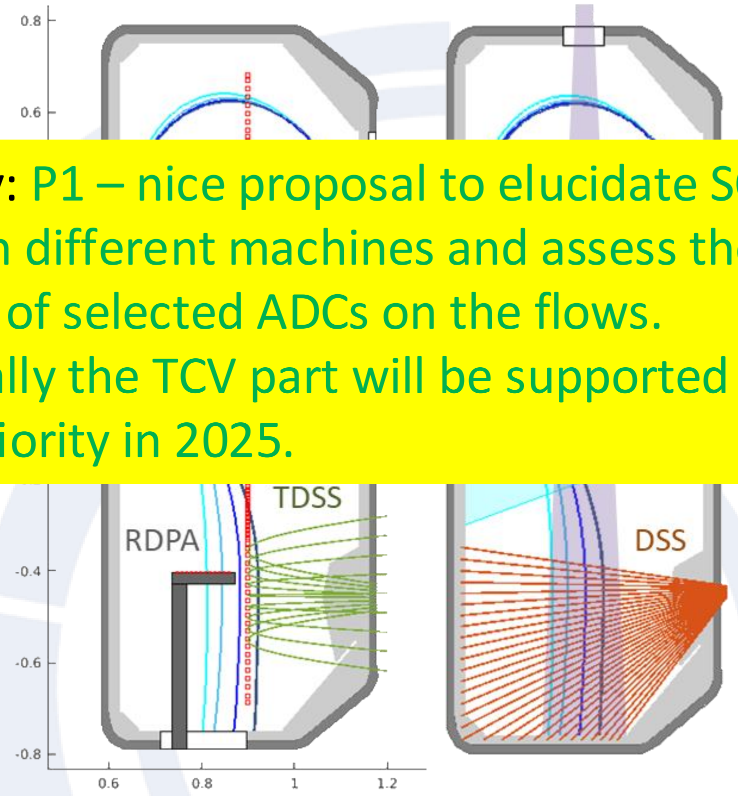
#147: ADCs impact on divertor flows

- **Proponents and contact person:**
  - massimo.carpita@epfl.ch
  - richard.ducker@epfl.ch
  - m.j.h.cornelissen@tue.nl

- **Scientific Background & Objectives**
  - Perform multi-device (TCV, MAST-U, AUG*) characterization of the impact of ADCs on divertor flows.
  - Evaluate the change in parallel flows in the divertor with respect to
    - ❖ Poloidal leg length
    - ❖ Poloidal and total flux expansion
    - ❖ SN, DN, multiple X-points – XPT

- **Experimental Strategy and essential diagnostics**
  - [TCV] Characterization of the ADCs impact on divertor flows in well diagnosed scenario (coupled to RT05 proposal):
    - ❖ TDSS – including new LoS arrangement
    - ❖ CIS – benchmark new diagnostic for 2D flows
    - ❖ RDPA – 2D Langmuir probe measurements
    - ❖ MANTIS & TS – 2D plasma quantities
  - Characterization of the ADC impact on divertor flows in reactor-relevant scenarios (heated L-mode or H-mode).

Priority: P1 – nice proposal to elucidate SOL flows in different machines and assess the impact of selected ADCs on the flows. Especially the TCV part will be supported at high priority in 2025.



Proposed pulses

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

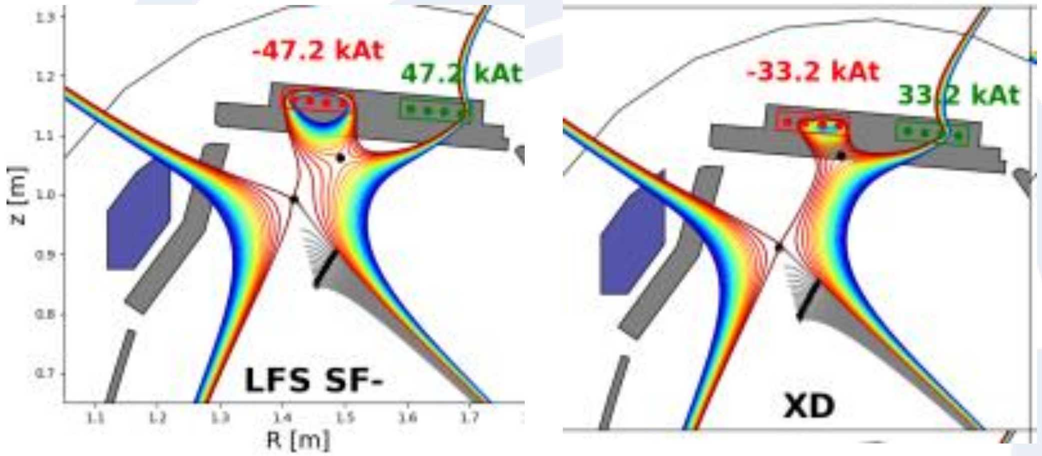
#156: Characterization of SOL electric field and turbulence in AUG SF- and XD configurations

- **Proponents and contact person:**

D. Brida (IPP),. G. Conway (IPP), U. Plank (IPP), G. Grenfell (IPP), T. Lunt (IPP), M. Faitsch (IPP), M. Griener (IPP)

- **Scientific Background & Objectives**
  - Divertor conditions change upstream electric field and tubulence/filament acitvity.
  - Analyzing upstream parameters for ADCs is important to test our current understanding of SOL transport processes and assess the impact of ADCs on upstream conditions.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Density steps with well diagnosed SOL in LFS SF- and XD divertor configurations in L and H-mode. Add SL and Rout scans for better diagnostic coverage.
  - Analyse the dependency of upstream electric field on Greenwald density as well as target temperature.
  - Evaluate turbulence characteristics in dependence of divertor collsionality.

AUG LSF SF- and XD configurations



Proposed pulses

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

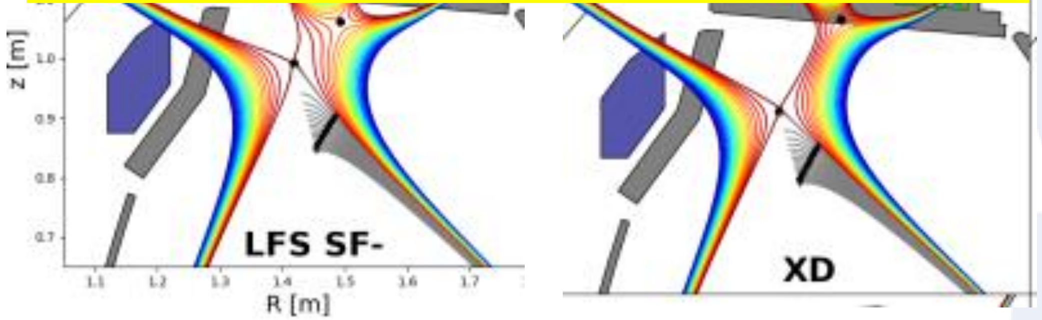
#156: Characterization of SOL electric field and turbulence in AUG SF- and XD configurations

- **Proponents and contact person:**

D. Brida (IPP),. G. Conway (IPP), U. Plank (IPP), G. Grenfell (IPP), T. Lunt (IPP), M. Faitsch (IPP), M. Griener (IPP)

- **Scientific Background & Objectives**
    - Divertor conditions change upstream electric field and tubulence/filament acitvity.
    - Analyzing upstream parameters for ADCs is important to test our current understanding of SOL transport processes and assess the impact of ADCs on upstream conditions.
- **Experimental Strategy/Machine Constraints and essential diagnostic**
    - Density steps with well diagnosed SOL in LFS SF- and XD divertor configurations in L and H-mode. Add SL and Rout scans for better diagnostic coverage.
    - Analyse the dependency of upstream electric field on Greenwald density as well as target temperature.
    - Evaluate turbulence characteristics in dependence of divertor collsionality.

Priority: P2/PB – re-submission from 2024. To be executed once the scenarios are fully developed. Could be combined with proposals #149-#151.



Proposed pulses

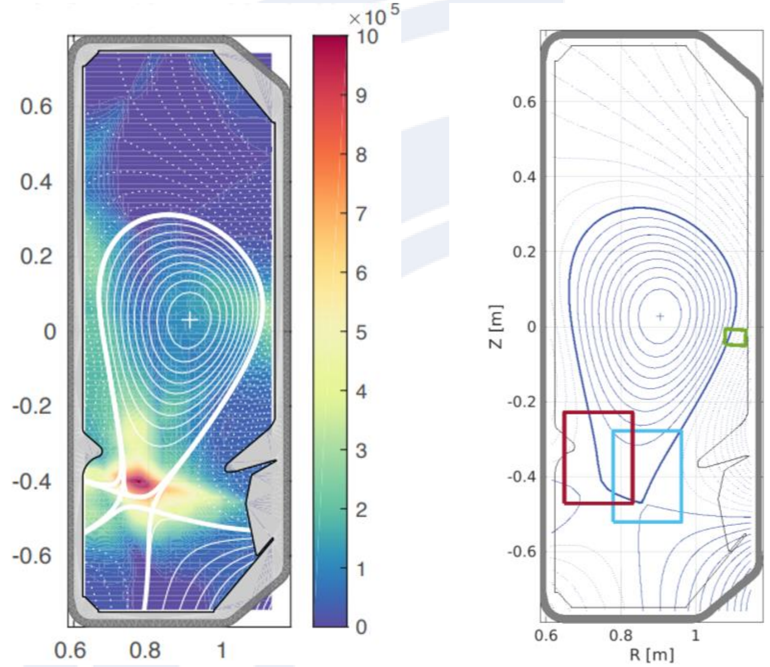
Device	# Pulses/Session	# Development
AUG	15	3
MAST-U	-	-
TCV	-	-
WEST	-	-

#163: Characterization of turbulence in X-point radiator H-mode scenarios on TCV

- **Proponents and contact person:**
- yinghan.wang@epfl.ch

- **Scientific Background & Objectives**
  - **[Background]** The X-point radiator (XPR) regime in H-mode shows potential to combine high confinement with a detached divertor, which is critical for future tokamaks. Turbulence mechanism in this regime still requires exploration.
  - **[Main objective]**
    - Investigate turbulent behavior and existence of ELM suppression phase when X-point radiator is brought inside the separatrix, in single null and snowflake geometry in TCV
    - Study the turbulence behavior in different locations (midplane, X-point) during the ELM suppression phase in the XPR regime, comparing with the ELMy phase.
    - Investigate the previous points as a function of fueling and seeding.
    - Study the particle transport in the XPR regime.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - H-mode XPR, NBI, possible ECRH power for XPR stability
  - midplane and X-point GPI systems (SISO or SILO baffle, LFS and HFS)
  - Monitor detachment and XPR with LPs, MANTIS, bolometry
  - Comparison with L-mode plasma in SN and SF geometry
  - Wide field passive imaging from the high-speed camera
  - Combining with the Wall LP and RDPA to study the particle flux during the ELM free phase.



[Courtesy of Reimerdes et al.]

Proposed pulses

Device	# Pulses/Session	# Development
AUG	0	0
MAST-U	0	0
TCV	12	0
WEST	0	0

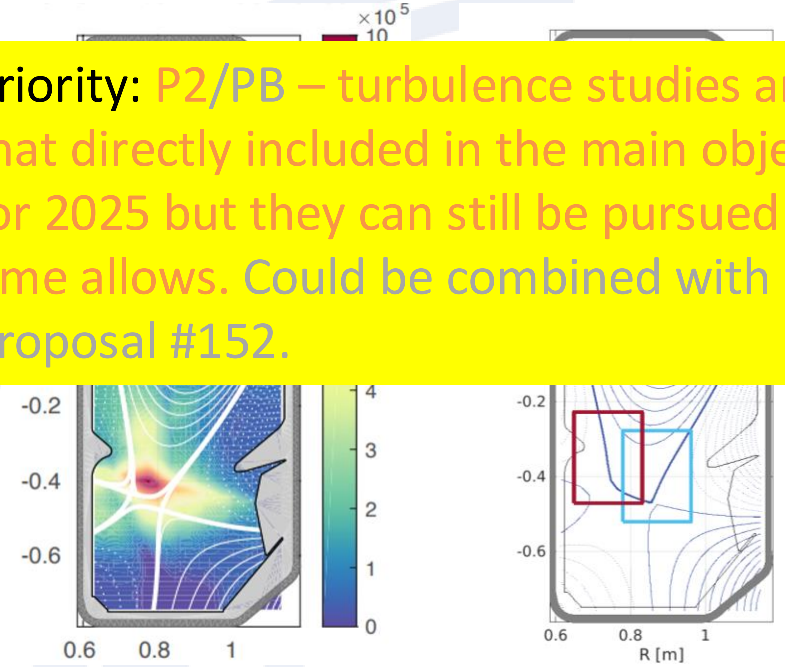
#163: Characterization of turbulence in X-point radiator H-mode scenarios on TCV

- **Proponents and contact person:**
- yinghan.wang@epfl.ch

- **Scientific Background & Objectives**
  - **[Background]** The X-point radiator (XPR) regime in H-mode shows potential to combine high confinement with a detached divertor, which is critical for future tokamaks. Turbulence mechanism in this regime still requires exploration.
  - **[Main objective]**
    - Investigate turbulent behavior and existence of ELM suppression phase when X-point radiator is brought inside the separatrix, in single null and snowflake geometry in TCV
    - Study the turbulence behavior in different locations (midplane, X-point) during the ELM suppression phase in the XPR regime, comparing with the ELMy phase.
    - Investigate the previous points as a function of fueling and seeding.
    - Study the particle transport in the XPR regime.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - H-mode XPR, NBI, possible ECRH power for XPR stability
  - midplane and X-point GPI systems (SISO or SILO baffle, LFS and HFS)
  - Monitor detachment and XPR with LPs, MANTIS, bolometry
  - Comparison with L-mode plasma in SN and SF geometry
  - Wide field passive imaging from the high-speed camera
  - Combining with the Wall LP and RDPA to study the particle flux during the ELM free phase.

Priority: P2/PB – turbulence studies are not that directly included in the main objectives for 2025 but they can still be pursued if time allows. Could be combined with proposal #152.



[Courtesy of Reimerdes et al.]

Proposed pulses

Device	# Pulses/Session	# Development
AUG	0	0
MAST-U	0	0
TCV	12	0
WEST	0	0

#148: Influence of power fall-off length on SF- configuration in ASDEX Upgrade

- **Proponents and contact person:**
  Michael.Faitsch@ipp.mpg.de,

- **Scientific Background & Objectives**

  SF- optimization critically depends on the ratio between lambdaQ and the separation between the X-points

  - QCE allows to vary lambdaQ through fueling which allows to change both parameters independently

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

  An adequate shape (high elongation, high triangularity and with diagnostics coverage) needs to be first achieved in order to robustly reach QCE

  Strategy is two-fold

  - vary lambdaQ at fixed X-point separation
  - Vary X-point separation at fixed lambdaQ

  Main diagnostics

  - IR, LP, TS, equilibrium

Proposed pulses

Device	# Pulses/Session	# Development
AUG	7	7
MAST-U	-	-
TCV	-	-
WEST	-	-

#148: Influence of power fall-off length on SF- configuration in ASDEX Upgrade

- **Proponents and contact person:**
  Michael.Faitsch@ipp.mpg.de,

- **Scientific Background & Objectives**
  SF- optimization critically depends on the ratio between lambdaQ and the separation between the X-points
  - QCE allows to vary lambdaQ through fueling which allows to change both parameters independently

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  An adequate shape (high elongation, high triangularity and with diagnostics coverage) needs to be first achieved in order to robustly reach QCE

  Strategy is two-fold
  - vary lambdaQ at fixed X-point separation
  - Vary X-point separation at fixed lambdaQ

  Main diagnostics
  - IR, LP, TS, equilibrium

Priority: P2 – QCEs indeed are an important area to be studied but applying them to SF requires the scenario to be developed first. If rapid progress, this proposal can be adopted in the program in the next phase at a high priority.

Proposed pulses

Device	# Pulses/Session	# Development
AUG	7	7
MAST-U	-	-
TCV	-	-
WEST	-	-

#162: Investigating the impact of alternative divertor configurations on broadening of the scrape-off-layer power channel

- **Proponents and contact person:**

peter.ryan@ukaea.uk, k.h.a.verhaegh@tue.nl, stuart.henderson@ukaea.uk, david.moulton@ukaea.uk

See proposal for the full list

- **Scientific Background & Objectives**

➢ A broad SOL power channel is favourable for reducing the peak heat flux entering the divertor(s), but it could be detrimental for the first wall lifetime.

➢ Measure near-SOL λ_T and λ_n during scans of α_t (normalised midplane collisionality) in ADC's (SXD and double-null) and compare with CD results from RT05.

➢ Correlate broadening of λ_T and λ_n and shoulder formation with turbulence measurements.

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

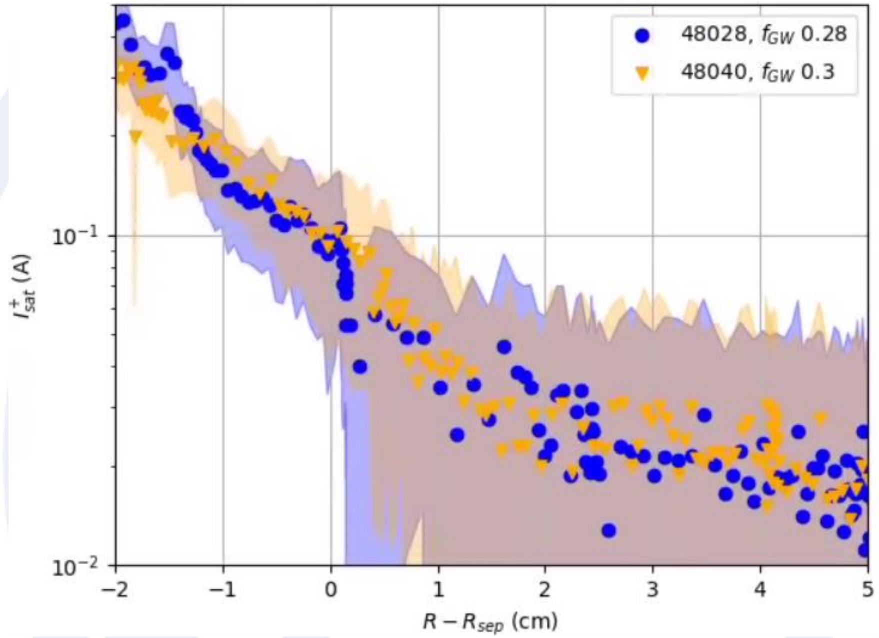
➢ MAST-U: SXD double-null, scan of α_t using midplane fuelling, divertor pressure scan; CD single-null, scan of α_t using midplane fuelling, divertor pressure scan; H-mode if scenarios developed otherwise L-mode.

➢ AUG: H-mode CD double-null, scan of α_t.

➢ TCV: H-mode SXD single-null, scan of α_t, SILO baffles; H-mode CD double-null, scan of α_t, no baffles.

➢ High resolution midplane TS, target IR thermography, far-SOL midplane reciprocating probe.

L-mode MAST-U SXD, midplane RP



Proposed pulses

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

#162: Investigating the impact of alternative divertor configurations on broadening of the scrape-off-layer power channel

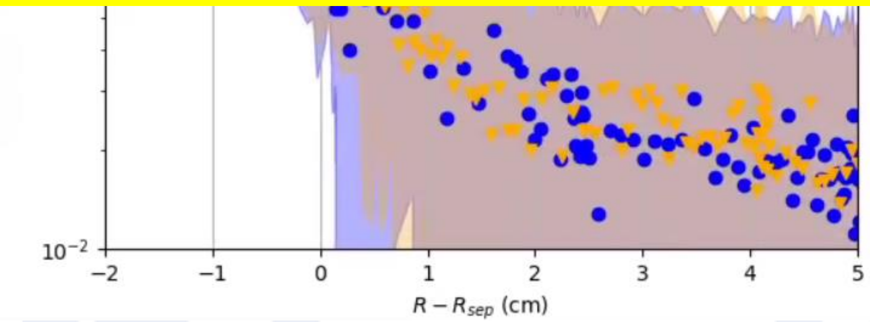
- **Proponents and contact person:**

peter.ryan@ukaea.uk, k.h.a.verhaegh@tue.nl, stuart.henderson@ukaea.uk, david.moulton@ukaea.uk
See proposal for the full list

- **Scientific Background & Objectives**
  - A broad SOL power channel is favourable for reducing the peak heat flux entering the divertor(s), but it could be detrimental for the first wall lifetime.
  - Measure near-SOL λ_T and λ_n during scans of α_t (normalised midplane collisionality) in ADC's (SXD and double-null) and compare with CD results from RT05.
  - Correlate broadening of λ_T and λ_n and shoulder formation with turbulence measurements.

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - MAST-U: SXD double-null, scan of α_t using midplane fuelling, divertor pressure scan; CD single-null, scan of α_t using midplane fuelling, divertor pressure scan; H-mode if scenarios developed otherwise L-mode.
  - AUG: H-mode CD double-null, scan of α_t.
  - TCV: H-mode SXD single-null, scan of α_t, SILO baffles; H-mode CD double-null, scan of α_t, no baffles.
  - High resolution midplane TS, target IR thermography, far-SOL midplane reciprocating probe.

Priority: P1/PB – not directly speaking to the RT-07 objectives in 2025 but has a high relevance for ITER as a counterpart proposal for RT-05 studies. However, due to limited discharge budget should consider starting the work piggy back.



Proposed pulses

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

Towards reactor-relevant ADC scenarios

#154: Assessment of magnetics for exhaust control on AUG, TCV, and MAST-U

Proponents and contact person:

- B. Kool, G. Derks, K. Verhaegh, T, Bosman, C. Theiler, L. Jansen, M. van Berkel, N. Lonigro

Scientific Background & Objectives

- Alternative divertors are promising for exhaust control as they can passively absorb fast transients [1], but their dynamics are not sufficiently understood yet. The detachment sensitivity has been studied from a quasi-steady-state perspective [2,3,4,5], we plan to investigate if these results also hold for a *dynamic* situation. We compare various configurations as well as operating points though system identification techniques.
- Upper triangularity has been demonstrated as a promising, fast actuator for disruption mitigation on AUG [6]. We plan to systematically investigate the dynamics using system identification and demonstrate upper triangularity as an exhaust control actuator to correct fast transients.

Experimental Strategy/Machine Constraints and essential diagnostic

MAST-U

Identify differences in dynamic detachment sensitivity as function of operating points, target radius, and poloidal flux expansion

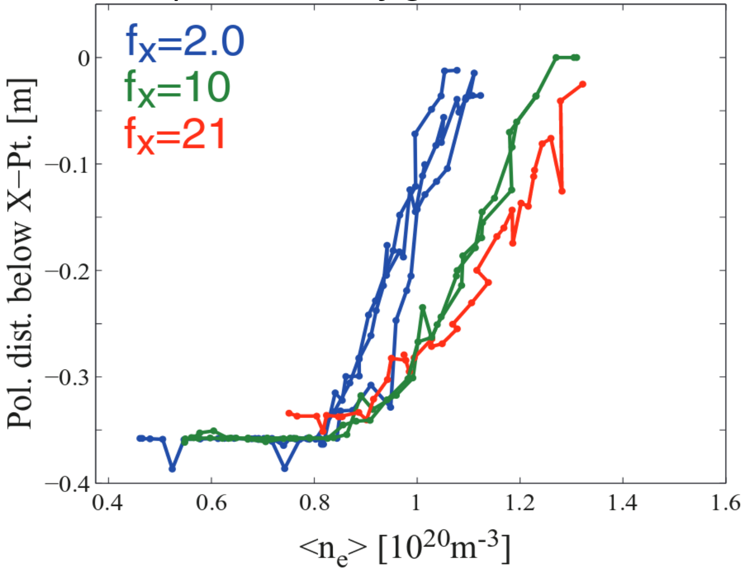
TCV

Identify differences in dynamic detachment sensitivity as function of poloidal flux expansion and baffle closure

AUG

1) Identify dynamics in X-divertor, compact radiator, and/or other t.b.d configurations
2) Identify dynamics from upper triangularity to XPR position

CIII front position as function of line-averaged density for different poloidal flux expansion configurations in TCV



Proposed pulses

Device	# Pulses/Session	# Development
AUG	15	5
MAST-U	25	5
TCV	12	5
WEST		

[1] B. Kool et al. Submitted Nature Energy
[2] O. Fevrier et al. Nuclear Materials and Energy 2021
[3] C. Theiler et al. Nucl. Fusion 2017
[4] K. Verhaegh et al. Submitted Nature communications
[5] D. Moulton et al. Nucl. Fusion 2024
[6] B. Sieglin et al. Nucl. Fusion 2023

#154: Assessment of magnetics for exhaust control on AUG, TCV, and MAST-U

Proponents and contact person:

- B. Kool, G. Derks, K. Verhaegh, T, Bosman, C. Theiler, L. Jansen, M. van Berkel, N. Lonigro

Scientific Background & Objectives

- Alternative divertors are promising for exhaust control as they can passively absor fast transients [1], but their dynamics are not sufficiently understood yet. The detachment sensitivity has been studied from a quasi-steady-state perspective [2,3,4,5], we plan to investigate if these results also hold for a *dynamic* situation. V compare various configurations as well as operating points though system identification techniques.
- Upper triangularity has been demonstrated as a promising, fast actuator for disruption mitigation on AUG [6]. We plan to systematically investigate the dynam using system identification and demonstrate upper triangularity as an exhaust control actuator to correct fast transients.

Experimental Strategy/Machine Constraints and essential diagnostic

MAST-U

Identify differences in dynamic detachment sensitivity as function of operating points, target radius, and poloidal flux expansion

TCV

Identify differences in dynamic detachment sensitivity as function of poloidal flux expansion and baffle closure

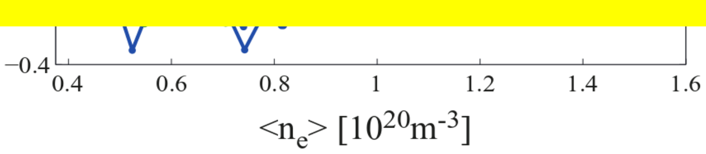
AUG

1) Identify dynamics in X-divertor, compact radiator, and/or other t.b.d configurations
2) Identify dynamics from upper triangularity to XPR position

[1] B. Kool et al. Submitted Nature Energy
[2] O. Fevrier et al. Nuclear Materials and Energy 2021
[3] C. Theiler et al. Nucl. Fusion 2017
[4] K. Verhaegh et al. Submitted Nature communications
[5] D. Moulton et al. Nucl. Fusion 2024
[6] B. Sieglin et al. Nucl. Fusion 2023

CIII front position as function of line-

Priority: P1/PB – control proposal, highly relevant for ensuring ADCs to be operational in a reactor environment. However, more discussion needed on the physics basis. Could consider combining this with other proposals like #160, #161, #168, and #169 to reduce the need for dedicated discharges.



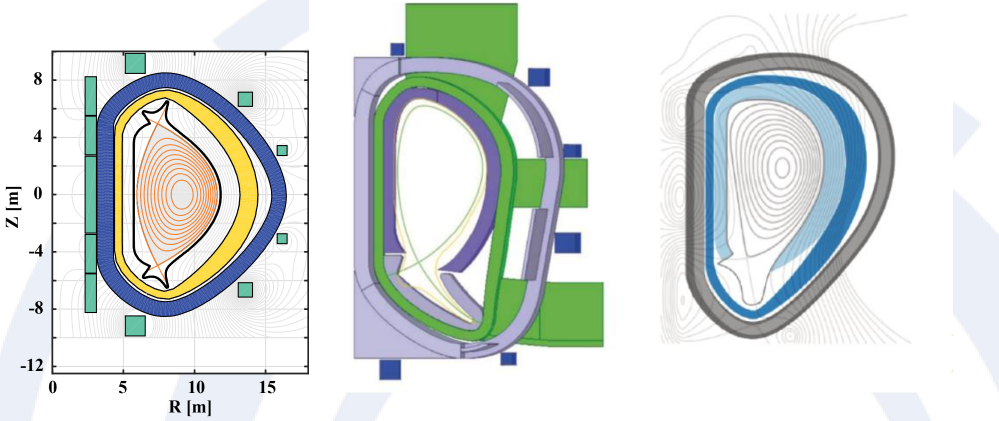
Proposed pulses

Device	# Pulses/Session	# Development
AUG	15	5
MAST-U	25	5
TCV	12	5
WEST		

#169: Supporting integration of Alternative Divertor Configurations for reactors and preparation for DTT operation

- **Proponents and contact person:**
  - K. Verhaegh, et al. k.h.a.Verhaegh@tue.nl

- **Scientific Background & Objectives**
  - **ADCs are a continuum**: optimization strategies are required
  - **Reactor ADC implementation** requires finding a **compromise** between **physical benefits** and **reactor integration**
  - **Study practicalities of ADCs in a reactor** (or reactor-class powers – DTT): cryopumping, fueling asymmetries, magnetic control of DN, …



ADC reactor implementation Examples & studies

H. Reimerdes, Nucl. Fusion 2020

R. Kembleton, Fusion. Eng. Design, 2022

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Investigate the impact of **cryopumping** on **ADC performance** as well as the impact of asymmetric cryopumping (DTT relevant)
  - Investigate **impact toroidal fueling asymmetries** on **ADC performance**
  - Support other experiments that aim to identify ADC optimization strategies for reactors
  - Further experimental strategies to be identified in collaboration with DTT / reactor studies teams

Proposed pulses

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

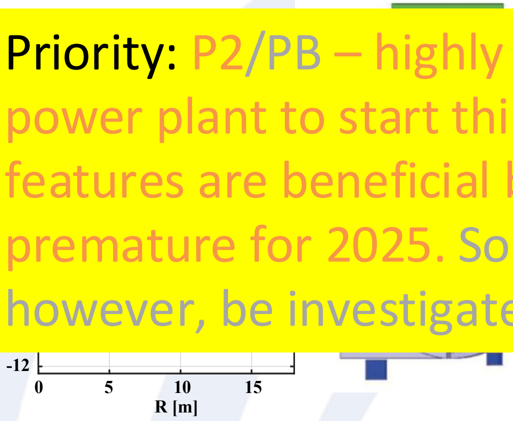
#169: Supporting integration of Alternative Divertor Configurations for reactors and preparation for DTT operation

- **Proponents and contact person:**
- K. Verhaegh, et al. k.h.a.Verhaegh@tue.nl

- **Scientific Background & Objectives**
  - **ADCs are a continuum**: optimization strategies are required
  - **Reactor ADC implementation** requires finding a **compromise** between **physical benefits** and **reactor integration**
  - **Study practicalities of ADCs in a reactor** (or reactor-class powers – DTT): cryopumping, fueling asymmetries, magnetic control of DN, …

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Investigate the impact of **cryopumping** on **ADC performance** as well as the impact of asymmetric cryopumping (DTT relevant)
  - Investigate **impact toroidal fueling asymmetries** on **ADC performance**
  - Support other experiments that aim to identify ADC optimization strategies for reactors
  - Further experimental strategies to be identified in collaboration with DTT / reactor studies teams

Priority: P2/PB – highly relevant for a future power plant to start thinking which ADC features are beneficial but maybe a bit premature for 2025. Some of the ideas can, however, be investigated piggy back.



ADC reactor implementation
Examples & studies

H. Reimerdes, Nucl. Fusion 2020

R. Kembleton, Fusion. Eng. Design, 2022

Proposed pulses

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

Summary of the proposals and their priorities

#	Title	Proponents	Priority
167	Commissioning ADCs in AUG DivIIo	Tilmann Lunt	P1
149	Physics, performance and stability of the X-Divertor in AUG DivIIo	Ou Pan	P1
150	Physics, performance and stability of the Low-field side snowflake minus in AUG DivIIo	Ou Pan	P1
151	Physics, performance and stability of the Compact Radiative Divertor in AUG DivIIo	Ou Pan	P1
159	Preparation for the Tightly-Baffled Long-Legged Divertor on TCV	Benjamin Brown	P2
170	Impact of pumping speed on plasma conditions and detachment	James Harrison	P2/PB
145	ADCs in high power ELMy plasmas	Massimo Carpita	P1
146	ADCs in QCE plasmas	Massimo Carpita	P2
152	Exploration and understanding of the ELM-free XPR regime in SF- configuration	Holger Reimerdes	P1
153	RMP effects on the access of detachment in super-x divertor and X-divertor configurations	Yunfeng Liang	P2
160	Standard and advanced X-point target configurations and their radiating regimes on TCV and MAST-U	Kenneth Lee	P1
164	Alternative Divertor Configurations in Negative Triangularity in high-performance NT scenarios.	Olivier Février	P1
165	Effect of magnetic balance and fuelling/seeding location on radiation in Double-Nulls plasmas.	Olivier Février	P1
26	I-mode access in alternative divertor configurations in ASDEX Upgrade	Davide Silvagni	P2
27	High-radiative and detached I-mode in alternative divertor configuration in ASDEX Upgrade	Davide Silvagni	P2
143	Validation of reduced models for detachment and reattachment in ADCs	Stuart Henderson	P1/PB
155	Comparison of high flux expansion (XD) divertor configurations between MAST-U and AUG	Dominik Brida	P2/PB
157	ELM buffering in ADCs in AUG, TCV, and MAST-U	Davide Silvagni	P1
158	Investigations of outer target radius scans and impact on core performance	Kevin Verhaegh	P1
161	Investigation of poloidal leg length effects on power exhaust on TCV and MAST-U	Kenneth Lee	P2
166	Detachment characteristics in neutral-driven and impurity-driven detachment with tightly baffle	Lingyan Xiang	P1/PB
168	Poloidal flux expansion and flaring in long-legged divertors	Kevin Verhaegh	P1
147	ADCs impact on divertor flows	Massimo Carpita	P1
156	Characterization of SOL electric field and turbulence in AUG SF- and XD configurations	Dominik Brida	P2/PB
163	Characterization of turbulence in X-point radiator H-mode scenarios on TCV	Yinghan Wang	P2/PB
148	Influence of power fall-off length on SF- configuration in ASDEX Upgrade	Michael Faitsch	P2/PB
162	Investigating the impact of alternative divertor configurations on broadening of the scrape-off-layer power channel	Peter Ryan	P1/PB
154	Assessment of magnetics for exhaust control on AUG, TCV, and MAST-U.	Bob Kool	P1/PB
169	Supporting ADC reactor integration with experimental studies	Kevin Verhaegh	P2/PB

Possible usage of the available machine time - indicative

		Shot per machine			
Theme area	**Proposals**	**AUG**	**TCV**	**MAST-U**	**WEST**
ADC commissioning	167	X			
ADC scenario development	149,150,151	X			
XPR and baffle studies	152, 159		X		
Different ADC configurations and scenarios	160, 161, 164, 165		X	X	X
ELM buffering	157		X	X	
Expanding physics understanding of ADCs	143, 158, 166, 168		X	X	
Flows, turbulence, and transport in the SOL of ADCs	147, 162, 163		X	X	
Exhaust control in ADCs	154		X	X	

NB1! Still under discussion and **mainly takes P1 proposals into account**

NB2! AUG shot time tentatively completely allocated to commissioning and scenario development before summer break

Concluding remarks

- Proposals provide **a good basis for addressing all the four objectives** of RT-07
  - ✓ Special focus to be put on utilizing the upper divertor of AUG and extending the studies to higher powers in H-mode
  - ✓ Also linking the ADCs to the varying operational regimes (QCE, DN, NT,…) will be pursued in details
- Strong overbooking on **MAST-U** means that **not even all the P1 proposals can be fully executed**
  - ✓ Many of the proposals need to be combined and piggy-backing to be applied whenever appropriate
  - ✓ Main focus points will be (i) impact of seeding on selected ADCs, (ii) poloidal and total flux expansion investigations, including utilization of the new cryopump, (iii) ELMy H-mode studies and investigating re-attachment and ELM buffering work in detail
  - ✓ Particular emphasis will be put on H-mode while L-mode and ohmic plasma studies under internal campaign
- On **AUG** the work will start with the full **commissioning the new upper divertor and scenario development** (XD, SF, CRD) – the rest of the proposals will be promoted depending on the progress made
  - ✓ This is manifested by many of the proposals labelled as P2 or PB – if scenarios are quickly available, there are high changes that these proposals will get runtime as well