EUROfusion

3rd – 6th November 2025

# RT-09: Physics understanding of energetic particles confinement and their interplay with thermal plasma


## D. Keeling

On behalf of RT-09 Team:

TFLs: D. Keeling, M. Baruzzo

**Research Topic Coordinators**

**Y. Kazakov, J. Galdon-Quiroga, A. Jansen van Vuuren, R. Ochoukov**



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.

# Scientific Objectives

| Scientific objectives | Status as reported end of 2024 |
|---|---|
| D1: Provide high quality demonstration of diagnostic techniques for the characterization of confined and lost fast ions with fast ion characteristics relevant for ITER and JT60-SA, qualify further diagnostic techniques required for deployment on JT-60SA | Mature - needs underpinning |
| D2: Quantify ion and electron heating and core-turbulence stabilisation by fast ions in view of JT-60SA, ITER and DEMO including tailored FI energy profiles and radial locations relevant to JT-60SA | Judgemental |
| D3: Quantify the impact of fast ions and fast ion driven MHD instabilities on transport in various scenarios including those relevant to JT-60SA | Judgemental |
| D4: Integrate the available heating, fast-ion and transport modelling tools for interpretation of experimental results in view of extrapolation of results to ITER and DEMO | Exploratory |
| D5: Quantify fast-ion losses and associated heat load from edge perturbations (ELMs and RMPs) | Judgemental |
| D7: Identification of AE control actuators and assessment for ITER and JT-60SA relevant scenarios | Judgemental |

# Proposals (summary table in here)

| Proposal # | Title | Proponent(s) |
|---|---|---|
| 191 | Study of hot ion mode on MAST-U | F. Orsitto, S. Blackmore, et al. |
| 192 | Optimization of fast-ion confinement in tokamaks with externally applied 3D fields | Joaquin Galdon |
| 193 | Fast-ion losses induced by edge instabilities across different confinement regimes | Joaquin Galdon |
| 194 | Impact of Toroidal Alfvén Eigenmodes on Plasma Core Turbulence and Confinement | Paulo Puglia, Samuele Mazzi. |
| 195 | Development of alpha-particle measurements in support of JT-60SA and ITER rebaseline | Yevgen Kazakov, Massimo Nocente |
| 196 | Travelling Wave Array dual-frequency operation as a flexible tool to tailor fast ion populations and excite Alfvén Eigenmodes | Samuele Mazzi,Laurent Colas, et al. |
| 197 | high frequency Alfven eigenmode studies with ITER and JT-60SA relevant AE actuators | Roman Ochoukov |
| 198 | Stability and space structure of n=0 modes driven by energetic particles | Mykola Dreval |
| 199 | Cross machine study of core ICE during sawtooth cycle | Mykola Dreval |
| 200 | Alfvén Eigenmode Control in TCV via Systematic ECRH Scans | Anton Jansen van Vuuren |
| 201 | Impact of Plasma Shaping on Fast-Ion Confinement and Alfvén Eigenmode Control in the TCV Tokamak | Anton Jansen van Vuuren |
| 202 | Investigation of Upward Sweeping Fishbone modes on TCV | Sergei Sharapov |
| 203 | Investigation of internal transport barriers induced on TCV | Sergei Sharapov |
| 204 | Measurements of Ion Cyclotron Emission in WEST | Bernard B.C.G. Reman, Dmitry Moseev, et al. |
| 205 | Optimization of active control of Alfvén Eigenmodes with externally applied 3D fields | Javier Gonzalez-Martin |
| 206 | Study of phase-space islands induced by MHD fluctuations using the INPA diagnostic | Alex Reyner-Viñolas |
| 207 | Exploitation of FILD4 real-time positioning capabilities | Lucia Sanchis |
| 208 | Fast-ion effects on core turbulence at different Qi/Qe on ASDEX Upgrade | Roberto Bilato |
| 209 | Fast-ion stabilization of ITG in WEST with TWA | Riccardo Ragona Roberto Bilato et al. |
| 210 | Interplay of Fast Ion MHD ELMs | Javier Gonzalez-Martin |

# Summary of pulse requests vs. allocation

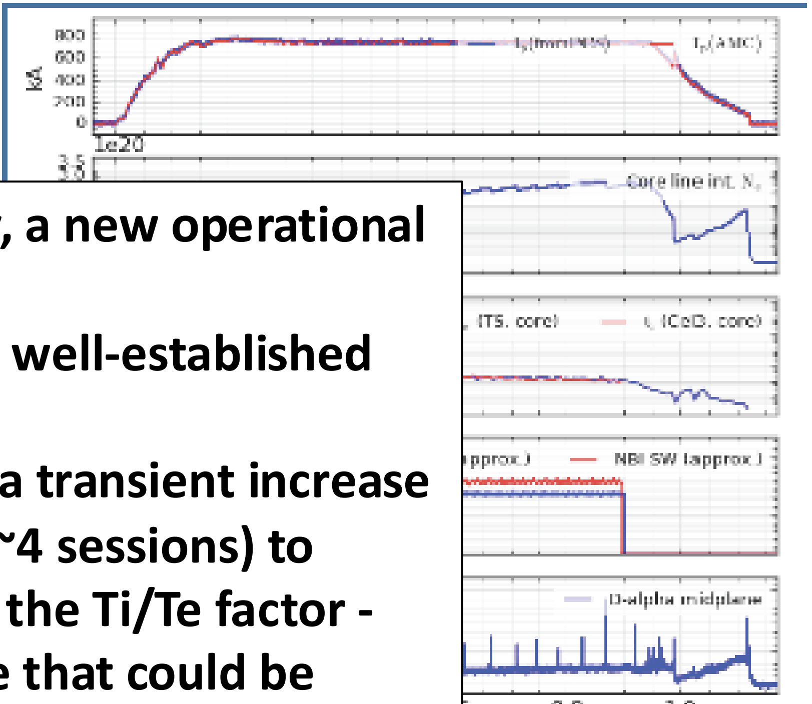
| | TCV (Scientific) | TCV (Sce dev.) | TCV (Total) | AUG | AUG (Pulse for Sce Dev) | AUG (Session total) | MAST-U (Scientific) | MAST-U (Sce dev.) | MAST-U (Total) | WEST (Scientific) | WEST (Sc. Dev) | WEST (Total) (Total 2026) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tot. Requested | 200 | 90 | **290** | 115 | 10 | **125** | 98 | 20 | **118** | 112 | 28 | **140** |
| Prov. Alloc. | | | **160** | | | **32** | | | **16** | | | **15** |
| Factor | | | **1.8** | | | **3.9** | | | **7.4** | | | **9.3** |

# Proposal Details

# Title: STUDY OF HOT ION MODE ON MAST-U (#191)

- Propon…
  - francesco…
    fulvio.auri…
- Scienti…
  - HOT
    Fusio…
    a ST(…
    Volu…
    The p…
    check…
    time
    prop…
    found…
    RT09-D3 context.
  - E.g.
  - -Determine the dependence of confinement time on plasma current , NBI heating power and energy, plasma density .

- An interesting proposal looking to establish, effectively, a new operational scenario on MAST-U relevant to a proposed VNS
- Whilst relevant to VNS, relevance to ITER/DEMO is less well-established and links to RT Sci. Obj. also not clear.
- Strategy also appears rather speculative, starting from a transient increase of Ti over Te and looking to spend a great many shots (~4 sessions) to perform parameter scans around this point to improve the Ti/Te factor - chances of success appear limited within the expt. time that could be given to this topic.
- P3




…lse #45244

…

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

- Experimental Strategy/Machine Constraints and essential diagnostic
  - Reference shots are 52625 and 49244. Ip=750kA , Bt=0.65T
  - Plasma current , NBI power and Density scan in low-delta plasma with NBI heating
  - Standard set of diagnostic

# Optimization of fast-ion confinement in tokamaks with externally applied 3D fields (#192)

- **Proponents and contact person:**
  - J.Gald

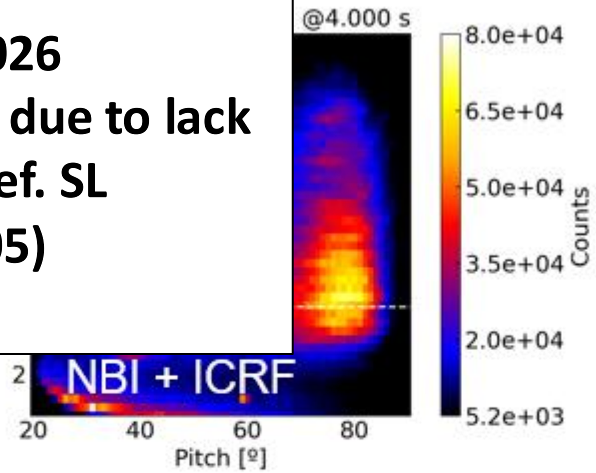
- **Scientifi**
  - Meas
  - Meas ELM s

## In MAST-U

- Investigat
- Extend to MP ELM suppressed plasmas (n=3)
- Extend to high-beta 1MA scenario

- **Continuation of P1 expt begun in previous year(s)**
- **Directly linked to RT Sci. Obj. and ITPA JEX**
- **Important to complete the dataset, especially on MAST-U in 2026**
- **Note that extn. To 1MA on MAST-U may pose some difficulties due to lack of internal prog. Scenario development, to be discussed with ref. SL**
- **Basis of expt. "block" on 3D magnetic fields (combine with #205)**
- **P1-MASTU, P1.5-AUG**

*First measurements of ICRF ($3^{rd}$ harmonic D) fast- UG [July 2025]*




## In AUG:

- Continue with investigation of MPs on ICRF fast-ion distribution function ($3^{rd}$ harmonic D scheme) → **MPs + ICRF are unique capabilities of AUG!**
- Effect of MPs on NBI confinement in ELM suppressed plasmas (n=2)
- Scans in MP intensity, differential phase and toroidal phase (for 3D effects)

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - FILD, FIDA and other fast-ion diagnostics are essential
  - In MU, special settings for IR thermography
  - Scans in MP differential phase and intensity

**Proposed pulses**

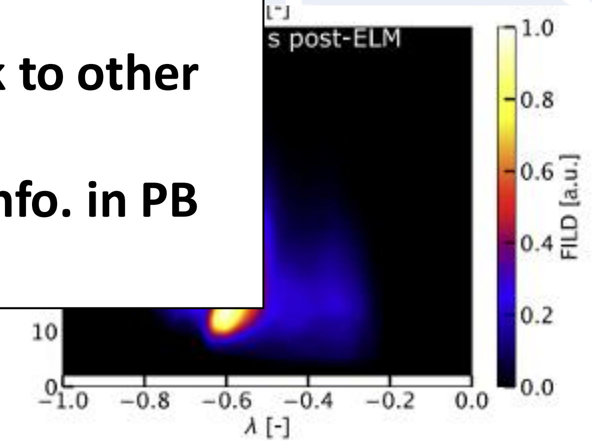
| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | 14 | |
| **MAST-U** | 24 (3 sessions) | |

# Fast-ion losses induced by edge instabilities across different confinement regimes (#193)

- **Proponents and contact person:**
  - **J.Gald**
- **Scientif**
  - Backg
  - This p
    regim

- **Continuation of P1 expt begun in previous year(s)**
- **Directly linked to RT Sci. Obj.**
- **Proposed shots include small quantity of dedicated + piggy-back to other studies, principally RT-02 expts but also other RT-09 pulses**
- **Careful planning should be able to gather majority of required info. in PB**
- **PB (P1 but data to be gathered in PB)**

*Velocity-space of FI losses induced by type-I ELM in*
*y tail indicative of fast-ion*
*uan, Nuclear Fusion 2025]*




| Machine | Already explored | More work needed |
|---|---|---|
| AUG | Type-I ELMs, MP mitigated & suppressed ELMs, QCE, I-mode, QH-mode | I-mode (with PREs), MP ELM suppressed |
| TCV | Type-I ELMs (NBI 1) | Type-I ELMs (NBI2 higher energy); QCE |
| MAST-U | Type-I and Type-III ELMs (750 kA scen.) | Type-I ELMs (1MA scenario); MP mitigated / suppressed ELMs; QCE |

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - FILD as essential diagnostic
  - Mostly piggyback shots. Only specific dedicated shots for completing scans.

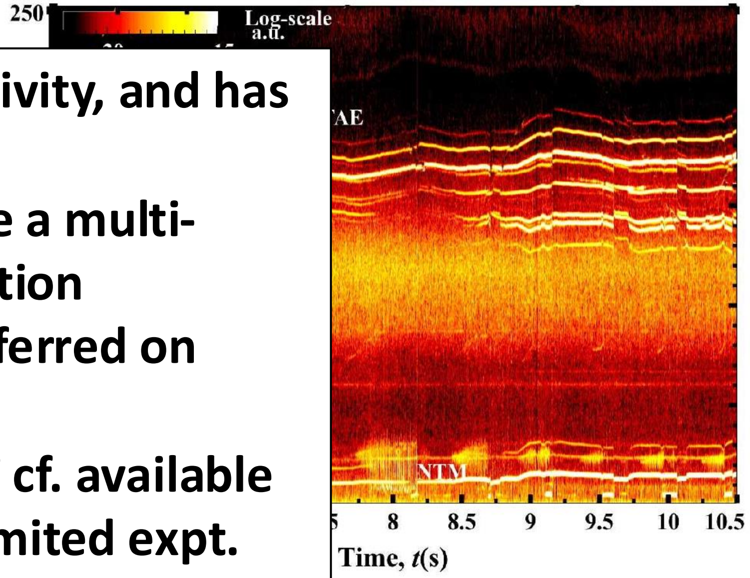
**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | 5 (+ piggyback) | |
| **MAST-U** | 5 (+ piggyback) | |
| **TCV** | 10 (+ piggyback) | |

# Impact of Toroidal Alfvén Eigenmodes on Plasma Core Turbulence and Confinement (#194)

- Proponen
  - Paulo Puglia (
    Anton Jansen
    - Alexander K
      Colas, Rolar
      Sharapov, S
- Scientific
  - Goal: Explore
    microturbulen
  - Based on rece
    turbulence sta
  - Fast ions drive
  - Recent eviden
    regarding opti
  - Scientific Obj
  - Measure the i
  - Compare NBI
  - Assess TAE am
  - Explore control mechanisms for long-pulse integration.

- Proposal is well-aligned with RT Sci. Obj.s (D2/3), ITPA-EP activity, and has a sound theoretical background also including JET
- Combination of results with previous JET work would provide a multi-machine dataset to demonstrate the ITG turbulence stabilisation
- Proposal was recognised previously as high prio but to be deferred on WEST.
- Significant investment of shots needed, particularly on WEST cf. available expt. time, careful assessment of what may be achieved in limited expt. time needed – e.g. Can scenario development be carried out in int. prog?
- P1-TCV, P1-WEST




ram of a JET pulse with fast-ion-
onfinement improvement

[Garcia Nat. Comm. 2024]

- Experimental Strategy/Machine Constraints and essential diagnostic
  - TCV:
    - Use reference scenario with unstable TAEs, move TAE position towards core via ECRH/ECCD.
    - Flip current direction for counter NB2 injection (higher fast ion energy).
    - Optimize density profile with NBI modulation/gas puffing for SPR measurements.
    - Configure plasma for turbulence diagnostics (Correlation-ECE, TPCI).
  - WEST:
    - Develop low magnetic field scenario for 2nd harmonic ICRH heating with H-minority.
    - Perform scenario scans with 20 pulses, adjusting H-minority concentration and ICRH power.
    - Use ECE/C-ECE diagnostics to measure core turbulence affected by TAEs.

Proposed pulses

| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | | |
| MAST-U | | |
| TCV | 30 / 2 | |
| WEST | 40 / 2 | 20 (within the 40 proposed) |

# Development of alpha-particle measurements on AUG in support of JT-60SA and ITER rebaseline (#195)

- Proponents and contact person

Y. Kazakov (LPP-E
Full team: see th

- Scientific Back
  - ITER with
  - High-prior
    measurem
  - Essential i
  - 2025: star
    COSMON
  - Synergy w
  - (developme
- Experimental
  - Step 1 (e.g.
    - ✓ Sourc ... .8MHz;
      preference: 2.5T/~1MA with core ECRF, if ICRF 55MHz available)
    - ✓ Source of B impurities: boron dropper (different BD settings tested i
  - Step 2 (e.g. 2027): demonstrate $\alpha$-particle measurements with GRS
    - ✓ Source of alphas (#1): D-$^3$He fusion, $E_D$ ~ 500keV with $\omega=3\omega_{ci}$(D) as in step #1, **add 5-10% of $^3$He**
    - ✓ Source of alphas (#2): $p$-$^{11}$B fusion, hydrogen minority ICRF (2.5T/~1MA)
    - ✓ Source of B impurities: boron dropper

**Proposed pulses**

| | | Step 1 (e.g. 2026) | Step 2 (e.g. 2027) |
|---|---|---|---|
| | | 8 | 10 |

-particle

ctrometer

$(E_\gamma = 4.44\text{MeV})$

$^4$He + $^{10}$B → $^{13}$C + $p$ + $\gamma$ $(E_\gamma = 3.85\text{MeV}/3.68\text{MeV}/3.09\text{MeV})$

- **Proposal directly linked to a specific open question for ITER (Cat 1 R&D item in ITER re-baselining) which also prompted a new ITPA JEX (EP27)**
- **Follows on from 2025 activity demonstrating COSMONAUT measurements on AUG**
- **Second step (measurements with energetic alphas) requires $^3$He for 3 of 4 options. Will need careful scheduling within campaign.**
- **Full proposal requires ~half AUG pulse allocation – careful planning to see what other work may be successfully combined without compromising result.**
- **Unlike preliminary work in 2025, pulses need to be in Deuterium (not H) for compatibility with B-dropper.**
- **P1-AUG**

# Travelling Wave Array bi-frequency operation as a flexible tool to tailor fast ion populations and excite Alfvén Eigenmodes (#196)

- **Proponents and contact person:**

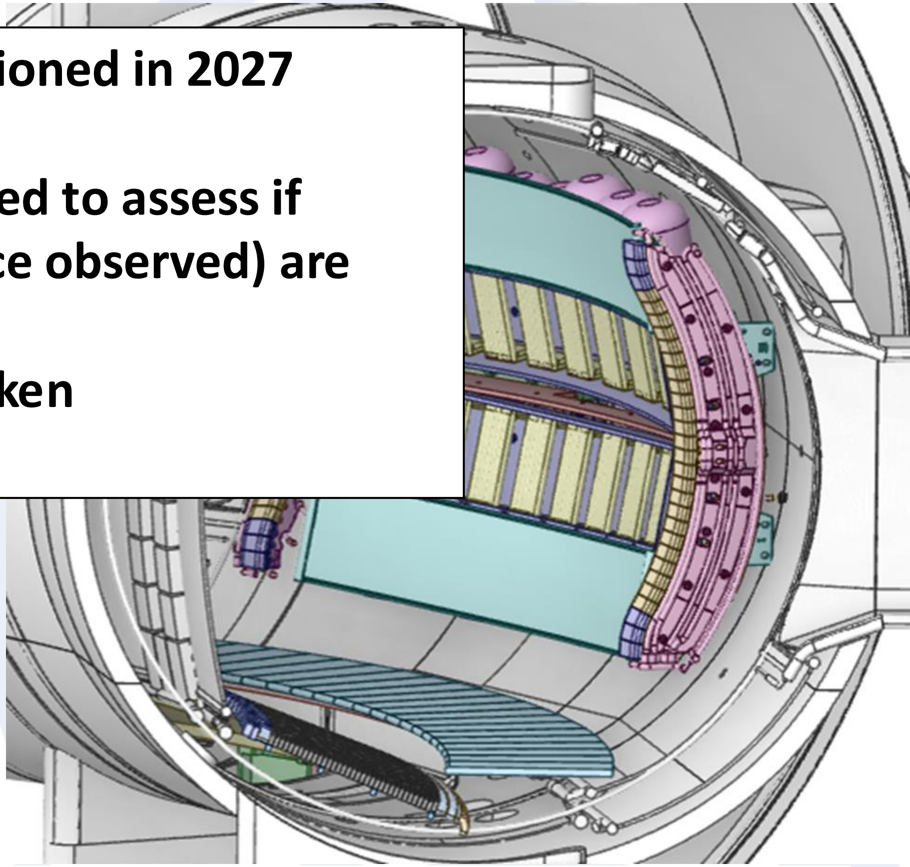
R. Ragona, L. Colas, V. M

- **Scientific Back**
  - A Travelling WEST in 20 generators. deposition.
    - spread t fast-ions
    - excite A
  - Bi-frequenc bandwidth

- **Proposal aims to exploit TWA hardware to be commissioned in 2027**
- **Aimed at D7: identify AE control actuators**
- **Quite speculative for now: wide parameter scans needed to assess if technique has required effects and if those effects (once observed) are significant**
- **Careful planning of #194 may allow some data to be taken**
- **P2 (TWA 2027)**

  - Objectives: demonstrate in open loop flexible
    - RF heating optimization
    - Control of temperature profile shapes and core MHD
    - Flexible alternative method for Alfvén eigenmode excitation

- **Exp. Strategy / Machine Constraints and diagnostics**
  - LSN L-mode plasma of interest for scenario development. High Ip preferable for sawteeth.
  - One TWA array operated at fixed frequency, fixed power for central heating.
  - Session 1. Fixed frequency of second array scanned from pulse to pulse. Power modulations and/or breaks in slope to assess off-axis power deposition. Monitor core profiles, sawteeth and ion ripple losses over frequency scan. Try frequency steps / ramps in 1 pulse.
  - Session 2. Fixed power levels scanned from pulse to pulse. Dynamic frequency wobulations of second array. Monitor Alfvénic activity destabilized by beat-waves using Mirnov coils, fast diagnostic acquisitions (ECE, interferometry), fast ion losses.



CAD of 2-array TWA in WEST vacuum chamber

**Proposed pulses**

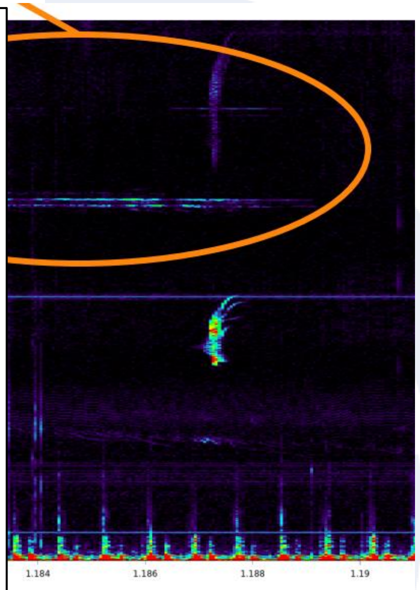
| Device | # Pulses/Session | # Development |
|---|---|---|
| **WEST** | 2 Sessions (2027) | Scenario is ready, antenna to be commissioned |

# High frequency Alfvén eigenmode studies with ITER and JT-60SA relevant AE actuators (#197)

#84657, with possible GAE on TCV

- Propo
- roo
- Scient
  - Addre
  - - Estab
  - - Mod
- Experi
  essential diagnostic
  - For TCV: use 84657 to establish scenario with steady GAE
  - Modulate plasma parameters ($B_t$, $n_e$, $T_e$, NBI) to determine GAE stability boundary
  - For both AUG and TCV: apply ECCD to discharge with steady GAE (36607 for AUG reference, 84657 for TCV reference), to modulate q-profile
  - Rely on iMSE to measure q-profile modifications in presence of ECCD
  - Rely on ICE diagnostic to characterize hf AE mode

- **The addition/improvement of ICE diagnostics to all machines has meant a good start to investigation of ICE←→FI interaction during 2025.**
- **hf AEs are an area less well-documented from previous RT-09 work – diagnostics only available in more recent ops periods**
- **This proposal therefore has merit from p.o.v. of D1 as well as well as D3/7**
- **Combines well with #199 – TCV branch may be executed, AUG branch will need careful consideration – a number of required results can be obtained in PB**
- **TCV part shots can be allocated., AUG part high prio but with reduced allocation of shots cf. request.**
- **P1-TCV, P2-AUG**



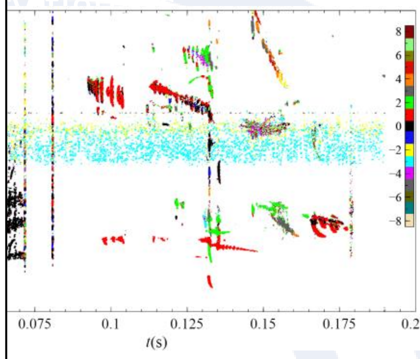

| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | 15 | |
| MAST-U | | |
| TCV | 20 | 5 |
| WEST | | |

# Investigation of stability and space structure of n=0 modes driven by energetic particles. (#198)

- **Proponents and contact person:**
  - Mykola D
  - mdreval@

- **Scient**
  - Clarify wh
    unstable
  - Clarify co
  - Compare
  - Role of q
    and TCV
  - Clarify wh
    frequency *n*=0 VDOM and GAE modes

- **Principally aligned with D7: Identify AE control actuators, with some relevance also to D3/4**
- **n=0 modes observed previously on TCV and MAST-U… proposal is to start from previously identified scenarios and perform systematic scans.**
- **Good starting point but could be expensive on shots to make significant progress**
- **MAST-U part will combine well #193, TCV part should also combine reasonably with #200/201**
- **P2**




. 2: *n*=0 in MAST-U

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

-Vertical plasma position (NBI deposition region) scan, elongation scan, ECRH power scan
-Mirnov coils used for *n* and magnetic field structure
-SXR used for spatial structure of mode density perturbations
- FILD, neutrons, ICE, FIDA, CNPA, (C-)ECE, (I-)MSE

**Proposed pulses**

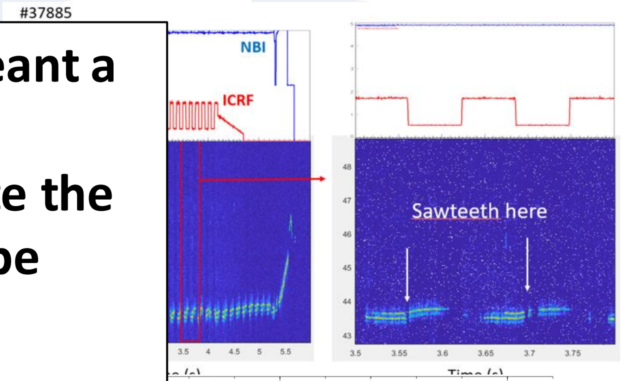
| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | | |
| **MAST-U** | 15 | 10 |
| **TCV** | 30 | 15 |
| **WEST** | | |

[1]M.B. Dreval et al 2025 Nucl. Fusion **65** 016037

# Cross-machine study of core ICE during sawtooth cycle (#199)

AUG 37885

MU 52493

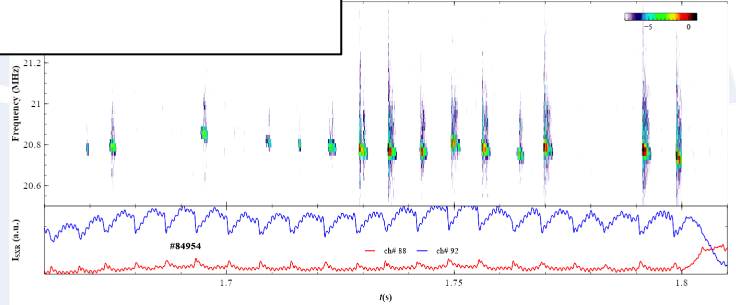



- Prop
- r

- The addition/improvement of ICE diagnostics to all machines has meant a good start to investigation of ICE←→FI interaction during 2025.
- Further exploitation of these diagnostics is a high priority to elucidate the
- Combines well with #197 though AUG/MAST-U branch will need to be carefully considered
- P1.5-TCV, P2-AUG/MAST-U

- Scie
  - Ac
  - - AU
  - - Results show co- and anti-correlation between core ICE strength and sawtooth cycles
  - - Recently installed ICE diagnostics on TCV and MU now also detect core ICE in presence of sawteeth.
  - Goal: determine dependence of core ICE activity on sawtooth phase/cycle

TCV 84954




- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Establish reference discharge with sawteeth and steady core ICE: MU 52493, AUG 43009 (-2.5 T) or 37885 (-3.0 T), TCV 84954
  - Use available actuators to modulate sawtooth cycle, such as NBI, ECCD, ICRF
  - Monitor core ICE dynamics via ICE diagnostic
  - Track q-profile via iMSE diagnostic

**Proposed pulses**

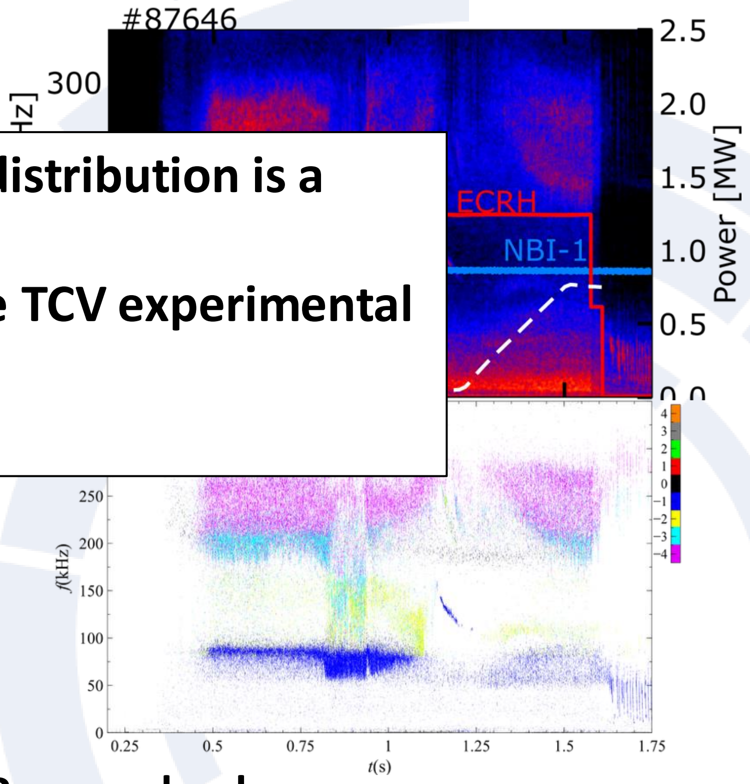
| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | 10 | |
| **MAST-U** | 10 | |
| **TCV** | 20 | |
| **WEST** | | |

# Systematic Control of Alfvén Eigenmodes in TCV Using Electron Cyclotron Resonance Heating (ECRH) (#200)

- Anton Jansen van Vuuren (EPFL-SPC)
  Co-proponents:
  Podestà, D. Test
- **Scientific Bac**
  Alfvén Eigenm
  heating efficie
  experiments c
  underlying sta
  modification–

> - **Control/suppression of AEs and the resultant FI loss/redistribution is a primary aim of RT-09**
> - **This proposal should therefore feature highly within the TCV experimental branch.**
> - **P1-TCV**

  **Main objectives:**
  – Perform **systematic ECRH deposition scans** in an established AE-active TCV scenario.
  – Use the **new Motional Stark Effect (MSE)** diagnostic to measure q-profile and magnetic shear evolution.
  – Correlate AE suppression with local shear changes to identify the dominant control mechanism.




- **Experimental Strategy/Machine Constraints and essential diagnostic**
  **Scenario:**
  – Established AE-active TCV plasma with NBI drive ($I_p$ = 120 kA, $B_t$ = 1.3–1.5 T, δ ≈ +0.3).
  – Systematic ECRH scans: ρ= 0.2–0.7, multiple power levels.
  – ~20 shots (≈ 10 development).
  **Essential diagnostics:**
  - Mirnov arrays – AE amplitude and spectra
  - MSE – q-profile & magnetic-shear evolution
  - FILD / FIDA / ICE – fast-ion losses and redistribution
  - Thomson / ECE – Te, ne, and ECRH deposition validation

**Proposed pulses**

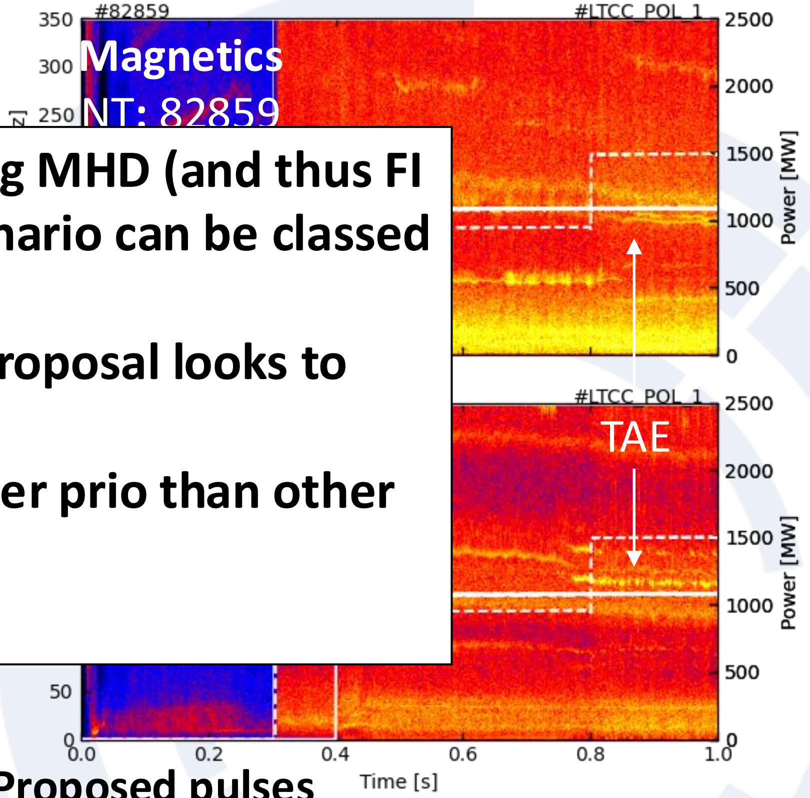
| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | | |
| MAST-U | | |
| TCV | 20 | 10 |
| WEST | | |

# Impact of Plasma Shaping on Fast-Ion Confinement and Alfvén Eigenmode Control in the TCV Tokamak (#201)

- **Proponents**
  - Anton Ja
    Karpusho
- **Scientific E**
  - Plasma s
    impact o
  - Previous
    NT and P
    profile co
  - This prop
    frequency spectrum, and damping, and to identify conditions for AE suppression using ECRH/ECCD.

- **Understanding the role of plasma shaping in moderating MHD (and thus FI loss/redistribution) is related to D7 as shaping and scenario can be classed as an actuator.**
- **Work started in 2024/25 investigating PT vs. NT – this proposal looks to extend the work**
- **A sound extension to work done previously though lesser prio than other proposals.**
- **P2**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Perform shaping scans (δ ≈ –0.4 → +0.4, κ ≈ 1.3–1.8) in NBI-heated plasmas to study AE stability and fast-ion confinement.
  - Apply localized **ECRH/ECCD** to test AE suppression and q-profile sensitivity.
  - Use **FIDA**, **FILD**, **ICE coils**, **Mirnov arrays**, and **reflectometry** for comprehensive AE and fast-ion characterization.




**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | | |
| **MAST-U** | | |
| **TCV** | 25 | 5 |
| **WEST** | | |

# Fishbones with Upward Sweeping on TCV (#202)

- **Proponents and contact person:**
- Sergei.Sharapov@ukaea.uk

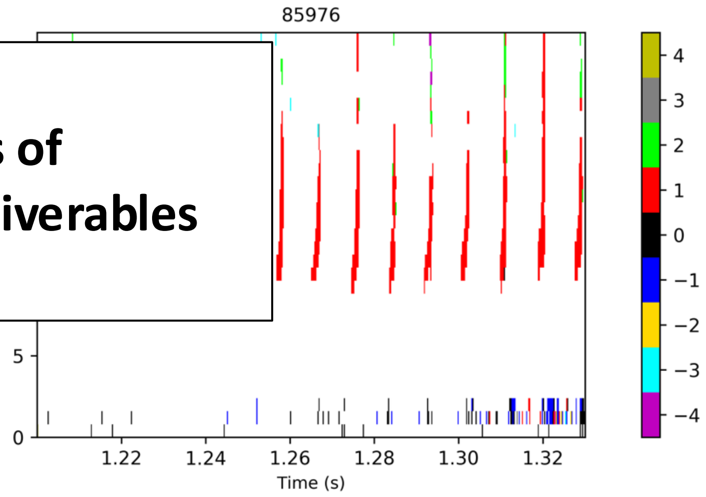
- **Sc**
  - –

- **Upward frequency sweeping is a newly observed phenomenon**
- **Whilst recognised that this is an important observation in terms of confirmation of a point of theory, not directly relevant to RT deliverables**
- **P2**

fishbones in 2001. The possible change in the frequency sweeping is likely to be caused by the dominant role of MHD nonlinearity in the vicinity of the q=1 surface. This is in contrast to the "usual" fishbones with dominant wave-particle nonlinearity that causes a down-sweep of the frequency.
  - Objectives: establish the parameter space and conditions for the upward sweeping fishbones. Investigate possibly very different nonlinear effects in such fishbones (e.g. a sawtooth-type reconnection followed by NTM triggering, in contrast to the radial redistribution of energetic ions in the usual fishbones).

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - The Reference discharge is #85976
  - Density scan in similar plasma configuration
  - Thomson scattering, CXRS, NPA, SXR, ECE imaging as essential diagnostic

An example of the upward-sweeping fishbones




**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | | |
| MAST-U | | |
| TCV | 20/2 | 10/1 |
| WEST | | |

# Density versus Temperature ITBs in TCV (#203)

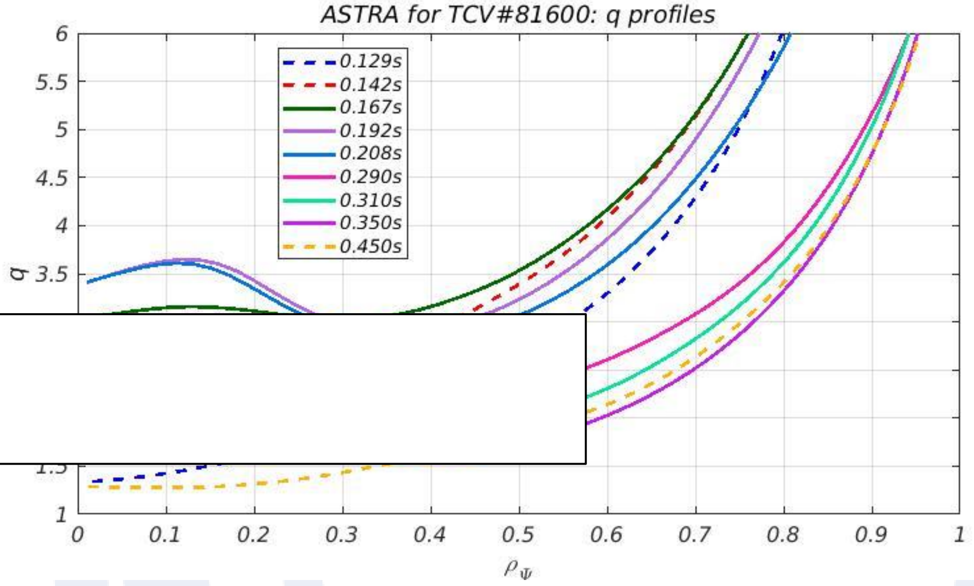
- **Proponents and contact person:**
- Sergei.Sharapov@ukaea.uk

- **Scientific Background & Objectives**
  - During previous RT09 experiments on TCV on "Physics unde and transient ITBs was observed. Some of these ITBs were in plasma density, but not in temperature (similar to, e.g. C-MOD), and other – in temperature, but not in density (like on JET). Technically, the switch on TCV was simple. However, we still don't understand how this switch works as not all diagnostics were available and more data is needed.

- **ITBs not a topic within the RT-09 deliverables.**
- **Propose move to RT-08**

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Type of plasma scenario or parameter explored to answer the main questions: Reference pulse #81511
  - Scan in vertical position of plasma with dominant NBI heating
  - Thomson scattering, CXRS, MSE, and NPA are essential diagnostic

Evolution of q-profile in these reversed-shear TCV plasmas




**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | | |
| **MAST-U** | | |
| **TCV** | 20/2 | 10/1 |
| **WEST** | | |

# Measurement of ion cyclotron emission (ICE) (#204)

- ICE measurements are a topic of interest for RT-09 on TCV/AUG/MAST-U
- Potential to extend this to WEST is attractive
- Limited expt. Time and lack of other FI diagnostics on WEST makes this potentially less viable
- Suggest experimental diagnostic technique is implemented via internal prog. Utilised in PB with RT-09 WEST experimental branch.
- Careful planning of #194 may allow some data to be taken
- PB (TWA 2027)

**Proponent**

**B. Reman,** ... J. Hillairet, R. ...

**Scientific ...**

TWA has th...

- Detect IC... distributio...

**Experimental Strategy**

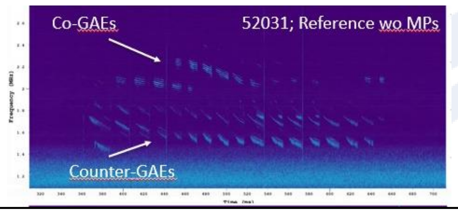
- Use the TWA antenna to heat the plasma and to generate fast ions. Two antennas operated in receiver-mode could pick up the radiation

**Expected Outcomes**

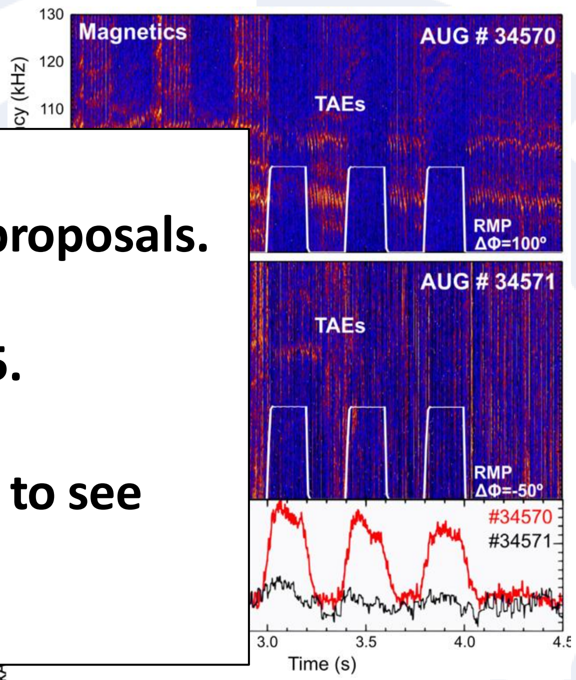
- Qualitative identification of the fast-ion population from measured spectra (localisation, energy)
- Quantitive characterisation with velocity-space tomography (possibly with addition of CTS data)

# Optimization of active control of Alfvén Eigenmodes with externally applied 3D fields (#205)

GAEs Impacted by MPs in MAST-U




**AUG**: AE active control using n=2 [1]




## Proponents and contact person:


J. Gonzalez-Martin jgonzalez62@us.es

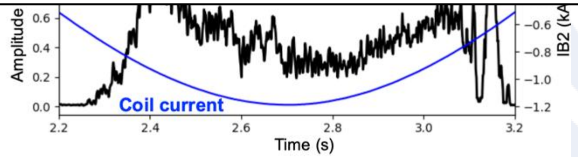
(full list in the wiki)


## Scientific Backgro

- Expand control t
- Study impact on

- In AUG:
- Control of high f
- Control of ICRH-
- Leveraging INPA
- In MAST-U:
- Control of high frequency AEs

- **This can be added to the RT-09 "3D fields block" of experiments**
- **Spans AUG and MAST-U – both considerably oversubscribed by proposals.**
- **Combine with #192**
- **Some of AUG part may be possible to combine with aspects #195. RTCs/TFLs to consider further together with Proponents.**
- **Similarly with all AUG proposals, careful planning will be needed to see what can be achieved amongst hi Prio. proposals in limited shots**
- **P1-AUG, P1-MASTU**




## Experimental Strategy/Machine Constraints and essential diagnostics

- FILD, FIDA, INPA, and other fast-ion diagnostics are essential
- In MU, special settings for IR thermography
- Scans in MP differential phase

**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| MAST-U | 14 | 0 |
| AUG | 17 | 4 |


[1] J. Gonzalez-Martin et al., Phys. Rev. Lett (2023)

# Investigation of phase-space flows induced by TAEs on ICRH heated plasmas (#206)

**Proponents and contact person:**

A. Reyner-\
(full list in t

**Scientific**

- **Backgr**
  [J.Rued
  induced

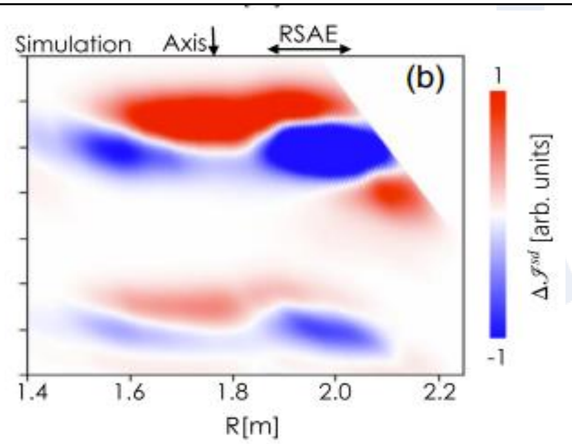
- **Goal**: use **unique capabilities of AUG's INPA** diagnostic to measure this in **ICRF fast-ion populations** with **high temporal resolution**

**Experimental Strategy/Machine Constraints and essential diagnostics**

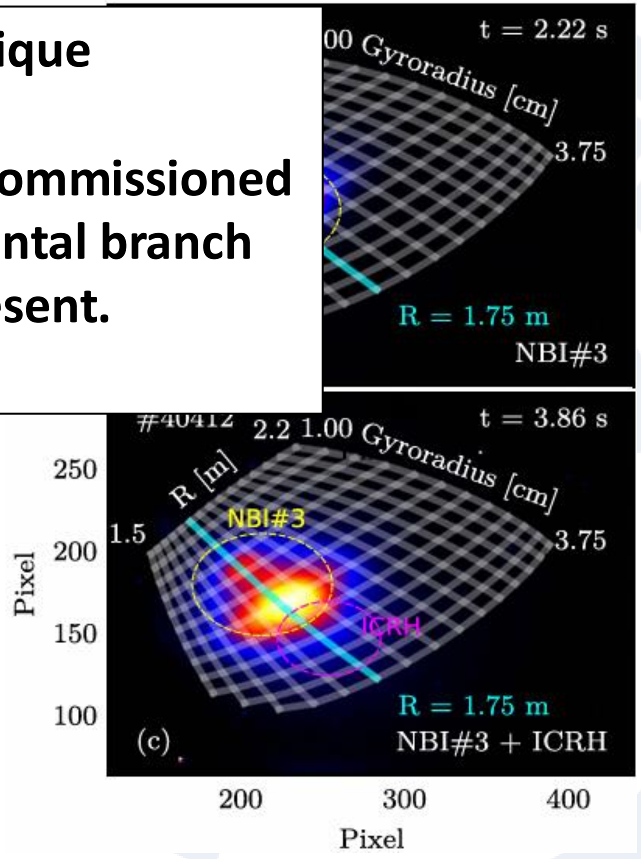
- Reference scenario well established from WPTE 2021/22: ICRF driven TAEs w. counter-ECCD
- Scan NBI power and sources (for 2nd harmonic D heating)
- Monitor fast-ion distribution with whole suite of diagnostics: INPA, FIDA, FILDs, ICE, …

- **Proposed INPA measurements could prove a beneficial technique furthering RT-09 interests**
- **Suggest experimental diagnostic technique is implemented/commissioned via internal prog. and utilised in PB with RT-09 AUG experimental branch with expt's ensuring a suitable RF heated plasma phase is present.**
- PB

**DIII-D INPA measurement vs simulation**




**AUG INPA signals including ICRF**




**Proposed pulses:**

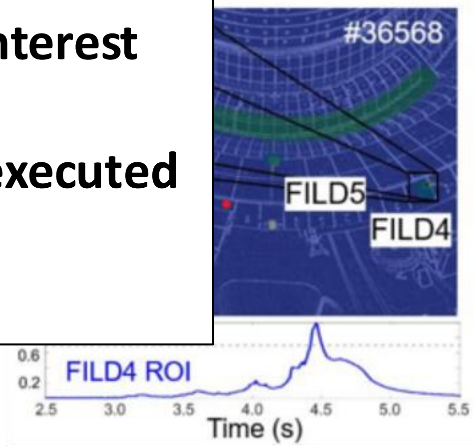
| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | 8 | - |

# Exploitation of FILD4 real-time positioning capabilities (#207)

- **Propon**
  - **L. San**
- **Scientif**
- Backgrou
  and to ra
- This prop
  - Testin
  - Explo
    meas

- **Whilst the diagnostic technique looks potentially useful to RT-09 expts. The commissioning and demonstration of the technique should be an internal prog. activity**
- **Exploitation of the diagnostic, once proven is then potentially of interest to WPTE**
- **To assist, it recommended as much of this proposal as possible is executed in PB to the principal experiments.**
- **PB**

*(Upper). DCS aborts the*
*nal reaches the threshold*
*tin]*




| Machine | Already explored | More work needed |
|---|---|---|
| AUG | FILD 4 capability for radial scans has already been commissioned | Testing the FILD4 real-time control algorithms based on the VRT cameras |

- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - FILD4 as essential diagnostic
  - Mostly piggyback shots. Only specific dedicated shots for testing ICRF power, USN vs LSN comparison and fine-tunning the control algorithm

**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | 6 (+ piggyback) | |

# Fast-ion effects on core turbulence at different $P_i/P_e$ on ASDEX Upgrade (#208)

- **Proponents and contact person:**
  - Roberto Bilato *et al* (see full list in wiki)

- **Scientific Background & Objectives**

The aim is to ...
different leve...
Pe and Pi are...
objective is t...
analysed usin...
FI impact on ...
(*D3*).

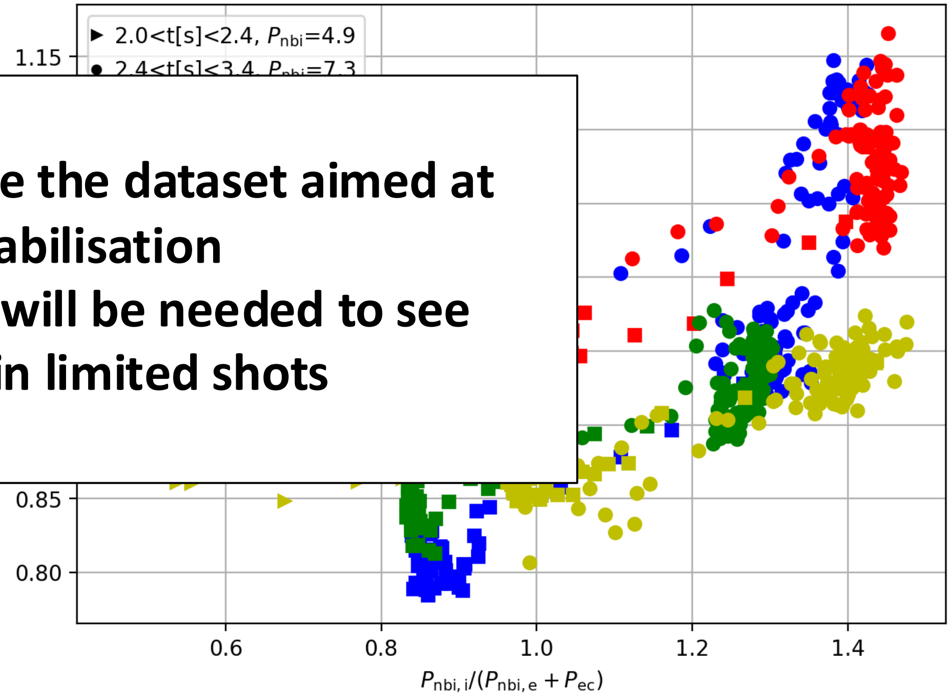
- **Continuation of a successful AUG expt from 2025**
- **Recommend adoption of this proposal to complete the dataset aimed at elucidating the mechanisms of core-turbulence stabilisation**
- **Similarly with all AUG proposals, careful planning will be needed to see what can be achieved amongst hi Prio. proposals in limited shots**
- **P1-AUG**

- **Experimenta...**

This study uses ...
three heating system of AUG should be available. The discharges are divided into three sets for analysis.

- ○ (LSN, 0.8MA, -2.5T) Impact of $P_e$/Pi on plasma profiles when the FI content is kept constant ($P_{nbi}$ and $P_{icrf}$ constant) and $P_e/P_i$ is varied by varying $P_{ec}$ - the total auxiliary power, $P_{aux}$, is not constant.
- ○ (LSN, 0.8MA, -2.5T) Impact of $P_e$/Pi when $P_{aux}$ is the same ($P_{icrf}$ replacing $P_{ecrf}$) and the FI content unavoidably varies.
- ○ (USN, 0.8MA, +-2.5T) Impact of the gradB drifts: fav. vs unfav. configuration.
- ○ (LSN, 0.4MA, -2.5T) Comparison with low-density (low plasma current) discharges where the dilution effect is more important.

Diagnostics:
- Characterization the fast-ion population with NPA, FIDA, and FILD diagnostics.
- Good measurements of plasma profiles for $n_e$, $T_e$, $T_i$, and $v_{tor}$.
- Possibly Er measurements (CXRS and DR).




**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | 10 | |

# Fast-ion stabilization of ITG in WEST with TWA (#209)

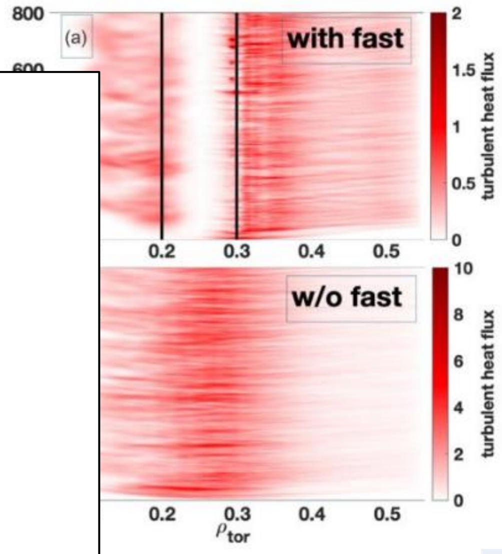
- **Proponents and contact person:**

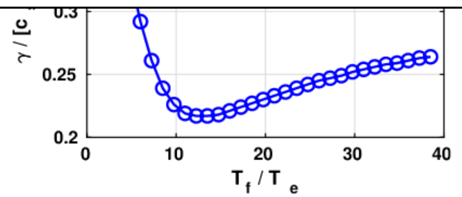
Riccardo Rago

- **Scientific B**

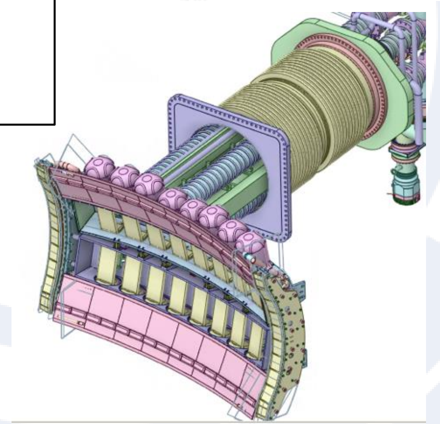
  - ❖ GENE sir turbulen
  - ❖ New (op distribut
  - ❖ Possible
  - ❑ The aim
  - ❑ The mai impact c
  - ❑ An addit simulations interfaced with transport codes (*D4*).

- **TWA commissioned in 2027**
- **Scan over amplitude and frequency to determine effect on possible stabilization of the ITG instability**
- **Potentially addresses several Sci. Obj. (2/3/4) and adds to similar AUG data for the multi-machine "flavour"**
- **Potentially suffers from lack of direct FI diagnostics on WEST – relies on other measurements + modelling to interpret**
- **Careful planning of #194 may allow some data to be taken**
- **P2 (TWA 2027)**




Di Siena POP 26 (2019)



- **Experimental Strategy/Machine Constraints and essential diagnostic**
  - Define WEST scenario (DN or LSN)
    - Variation of dual-frequency scenario, high Ip, EC beneficial (if not essential)
    - AUG as canvas – minority concentration is key
  - Scan f-sweep amplitude and frequency
    - Constant B – different central frequency – power steps (thresholds)
    - Monitor impurity content
  - Main diagnostics for plasma performance
    - TS, fast-ECE, Fis-related PWI coverage (edge spectroscopy, divertor diag., …)

**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| **AUG** | | |
| **WEST** | 1 session (2027) | |

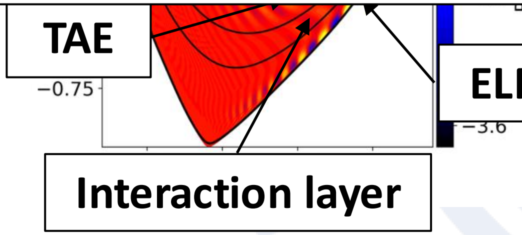
# Characterization of the interplay between fast ions inter-ELM MHD activity and ELMs (#210)

- **Proponents and contact person:**
  **J.Poley-S**
  **Cómez (**
- **Scientific**

**Background**
- AUG: hy
  betwee
- TCV: exp
  ELM MH
  plasmas

- **ELM effects on FI loss studied previously – this proposal intends to extend experimental work to a level of control of AE←→ELM loss mechanisms**
- **TCV proposes scans in ECRH position (on to off-axis) and NBI energy.**
- **AUG proposes to shift NBI off-axis by adjusting NBI geom. and plasma posn.**
- **TCV branch looks more feasible – though AUG part may still fit with other proposals in a combined expt.**
- **P2**

**Goals**:
- **Investigate interplay between ELMs, inter-ELM MHD activity and fast-ions.**



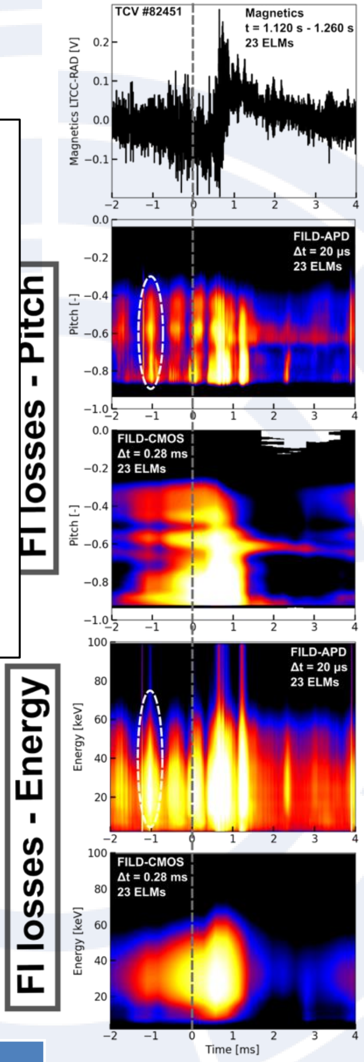

- **Experimental Strategy/Machine Constraints and essential diagnostic**

- **AUG: develop scenario with NBI driven TAEs as much off-axis as possible to maximize ELM-AE interaction**

- **TCV: Follow-up experiments attempting to minimize inter-ELM MHD activity using ECRH (for comparison with previous experiments). Compare scenarios with on- vs off- axis fast-ion distributions.**

**Proposed pulses**

| Device | # Pulses/Session | # Development |
|---|---|---|
| AUG | 12 | 4 |
| TCV | 5 | 10 |



# Prio. Summary and pulse allocation

# Priority ratings

| # | Title | Proponent(s) | Priority |
|---|---|---|---|
| 191 | Study of hot ion mode on MAST-U | F. Orsitto, S. Blackmore, et al. | 3.00 |
| 192 | Optimization of fast-ion confinement in tokamaks with externally applied 3D fields | Joaquin Galdon | P1-MASTU, P1.5-AUG |
| 193 | Fast-ion losses induced by edge instabilities across different confinement regimes | Joaquin Galdon | PB |
| 194 | Impact of Toroidal Alfvén Eigenmodes on Plasma Core Turbulence and Confinement | Paulo Puglia, Samuele Mazzi. | P1-TCV, P1-WEST |
| 195 | Development of alpha-particle measurements in support of JT-60SA and ITER rebaseline | Yevgen Kazakov, Massimo Nocente | P1-AUG |
| 196 | Travelling Wave Array dual-frequency operation as a flexible tool to tailor fast ion populations and excite Alfvén Eigenmodes | Samuele Mazzi,Laurent Colas, et al. | P2 (TWA 2027) |
| 197 | high frequency Alfven eigenmode studies with ITER and JT-60SA relevant AE actuators | Roman Ochoukov | P1-TCV, P2-AUG |
| 198 | Stability and space structure of n=0 modes driven by energetic particles | Mykola Dreval | 2.00 |
| 199 | Cross machine study of core ICE during sawtooth cycle | Mykola Dreval | P1.5-TCV, P2-MASTU |
| 200 | Alfvén Eigenmode Control in TCV via Systematic ECRH Scans | Anton Jansen van Vuuren | P1-TCV |
| 201 | Impact of Plasma Shaping on Fast-Ion Confinement and Alfvén Eigenmode Control in the TCV Tokamak | Anton Jansen van Vuuren | 2.00 |
| 202 | Investigation of Upward Sweeping Fishbone modes on TCV | Sergei Sharapov | 2.00 |
| 203 | Investigation of internal transport barriers induced on TCV | Sergei Sharapov | |
| 204 | Measurements of Ion Cyclotron Emission in WEST | Bernard B.C.G. Reman, Dmitry Moseev, et al. | PB (TWA 2027) |
| 205 | Optimization of active control of Alfvén Eigenmodes with externally applied 3D fields | Javier Gonzalez-Martin | P1-AUG, P1-MASTU |
| 206 | Study of phase-space islands induced by MHD fluctuations using the INPA diagnostic | Alex Reyner-Viñolas | PB |
| 207 | Exploitation of FILD4 real-time positioning capabilities | Lucia Sanchis | PB |
| 208 | Fast-ion effects on core turbulence at different Qi/Qe on ASDEX Upgrade | Roberto Bilato | P1-AUG |
| 209 | Fast-ion stabilization of ITG in WEST with TWA | Riccardo Ragona Roberto Bilato et al. | P2 (TWA 2027) |
| 210 | Interplay of Fast Ion MHD ELMs | Javier Gonzalez-Martin | 2.00 |

# P1 pulses/allocation

| | TCV (Scientific) | TCV (Sce dev.) | TCV (Total) | AUG | AUG (Pulse for Sce Dev) | AUG (Session total) | MAST-U (Scientific) | MAST-U (Sce dev.) | MAST-U (Total) | WEST (Scientific) | WEST (Sc. Dev) | WEST (Total) (Total 2026) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tot. Requested | 60 | 40 | **100** | 64 | 6 | **70** | 43 | 0 | **43** | 40 | 20 | **60** |
| Prov. Alloc. | | | **160** | | | **32** | | | **16** | | | **15** |
| Factor | | | **0.63** | | | **2.2** | | | **2.7** | | | **4** |

**TCV: space to execute also an amount of the Priority 2 proposals (145 pulses total)**
**AUG: some down-selection/combination needed**
**MAST-U/WEST: consolidation of which parts of proposals to execute needed – Some indication shown in assessments (i.e. some machines rated higher prio within individual proposals),but further work for TFL/RTCs**

# Initial grouping

| High level topics | Proposal # |
|---|---|
| 3D Fields and ELMs | 192, 193, 205 |
| Core AE control and suppression | 200, 206, 207, 197, 198, 199, 202 |
| Core turbulence control | 194, 208 |
| AUG alpha measurements | 195 |
| WEST expt. branch | 194, 196, 204, 209 |

- Within a group, RTCs will allocate pulses-per-machine to the group.
- P1 proposals already account for >100% of allocated pulses on AUG/MAST-U/WEST
- Implies careful planning to ensure principal points of P1 proposals are covered: combine shots where possible, select specific physics to dedicate specific pulses where not
- Experiments will be planned principally with P1 proposals in mind but P2 will be included where pulses may be adapted with no risk to P1 or (esp. TCV) where pulses available not required by P1.

# Analysis and Modelling needs

Together with participation proposals for executing experiments based on the presented proposals, analysis & modelling needs for the RT (list defined within the call documents) are as follow:

- Fast Ion Orbits, resonances and distribution function, Heating and fast-ion sources (ICRH, NBI)
  - E.g. ASCOT TRANSP/NUBEAM, TORIC-SSFPQL, PION, Ebdyna,…
- Interpretive modelling
  - E.g. ASTRA, RAPTOR, ETS,…
- Improved/RT equilibrium
  - E.g. CLISTE, CHEASE, CREATE-NL
- Pedestal Stability
  - EPED,Europed,ELITE, MARS,..
- MHD stability and Nonlinear MHD, response to RMP
  - MHD(MISHKA, VMEC,…); Nonlinear(MEGA, JOREK,…); RMP(MARS-F, VMEC,…)
- Synthetic diagnostics and tomography
  - FIDASIM, FILDSIM, Velocity space tomography
- Core Gyrokinetic
  - E.g. GENE, GS2,…