JET requirements from WPCD

J. Garcia on behalf of the JET TFI

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Main objectives for JET1 in 2019-2020 endorsed by GA

- Prepare and perform integrated scenarios for fusion performance (PFUS=15MW for 5s) and alpha physics in DTE2
- Determine the isotope dependence of H-mode physics with a W/Be first wall
- Demonstrate integrated pedestal-SOL-wall solutions and validate predictive edge and divertor physics models for ITER
- Deliver High Priority items for ITER

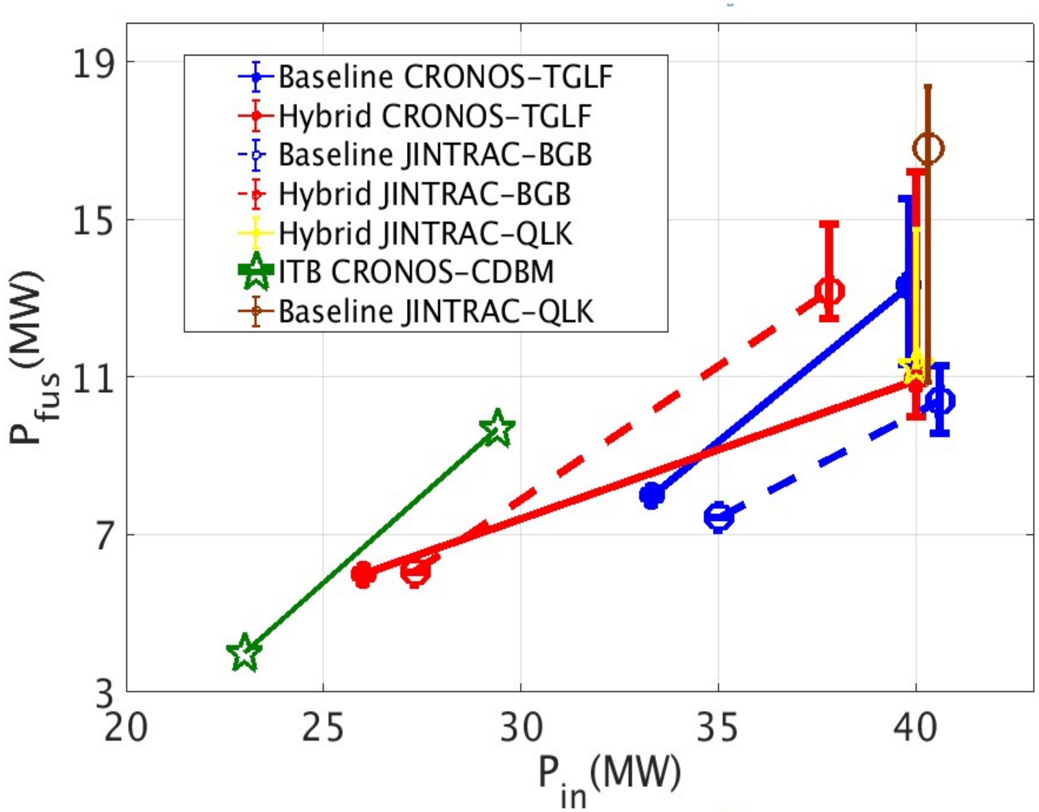
Strong modelling activity in support of these objectives:

1) **Modelling in each experiment**
2) **Specific modelling performed in dedicated tasks**

Modelling tasks at JET

T17-03	MHD analysis and modelling in support of scenario development	ETS, TRANSP, JETTO/SANCO
T17-05	Pedestal analysis and isotope effect	P-B, EPED, EUROPED, JOREK,K-EFIT, GENE,GKW
T17-06	Impact of ICRH on impurities for optimisation of scenarios	TOPICA, SSWICH
T17-07	DT scenario extrapolation	CRONOS, JINTRAC, TRANSP, ASTRA
T17-12	Isotope wall content control and long term erosion/migration interpretation	SOLEDGE2D-EIRENE, ERO, SOLPS-ITER
T17-13	Disruptions and runaway modelling	JOREK,METIS, CODE, M3D, CREATE
T17-15	Equilibrium reconstruction	EFIT++, IMAS
T18-01	Improved diagnostic analysis and intershot codes	BEAST, RAPTOR, METIS,
T18-02	Scrape-off layer and SOL-pedestal interaction	COREDIV, SOLEDGE2D-EIRENE, SOLPS-ITER, EDGE2D-Eirene
T18-03	Transport modelling with isotopes	GENE, GKW, GS2, TGLF, QLK

DT fusion power JET extrapolation: 15MW fusion power possible



J Garcia et al 2017 Plasma Phys. Control. Fusion 59 014023

J. Garcia et al 2019 Nucl. Fusion 59 086047

Casson F.J. et al 2018 JET 27th IAEA Fusion Energy Conf. (Ahmedabad, India, 22–27 October 2018) p TH/3-2

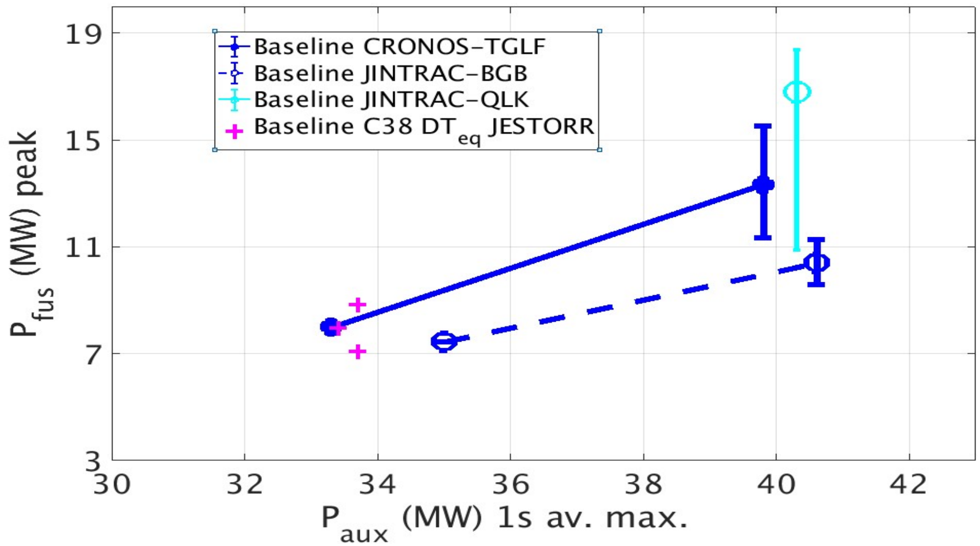
S. Saarelma et al. Phys. Plasmas 26, 072501 (2019)

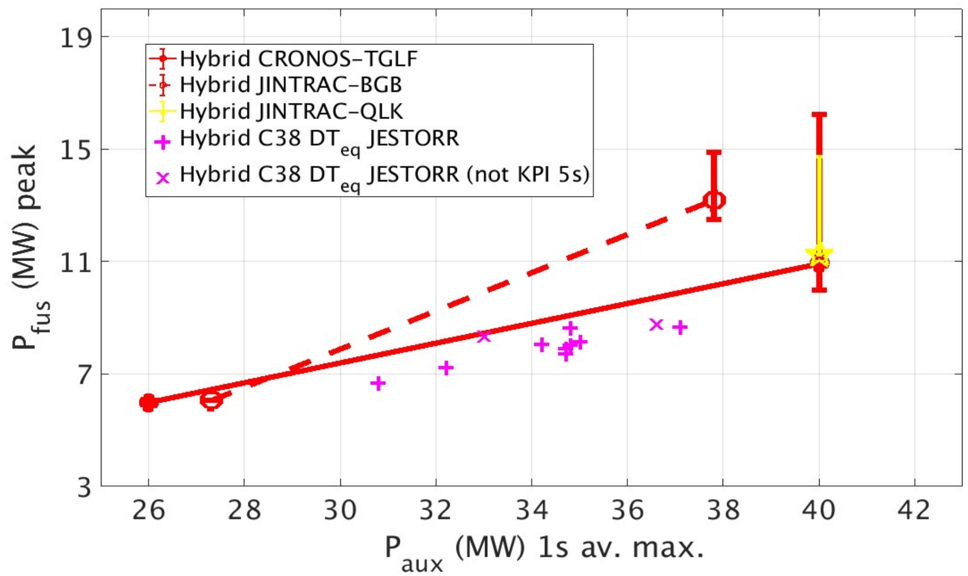
Morales J. et al 2018 45th EPS Conference on Plasma Physics P4.1077

- Error bars account for: sensitivity to bootstrap current models, isotope effects, Ip
- Maximum P_{fus} for baseline at highest Ip.
- For hybrid an optimum appears depending on the pedestal density
- Critical role of Ip for hybrid route
- P_{fus} ~ 10-16MW for hybrid and baseline
- Strong isotope effects for hybrid in the core

JET

Predictions vs peak DT-eq from C38





- Comparison between predictions and peak DT equivalent fusion power with JESTORR
- Some models provide remarkable good trends
- Deviations in the hybrid also linked to an increase of Prad
- In present conditions, the peak fusion power is 8-9MW

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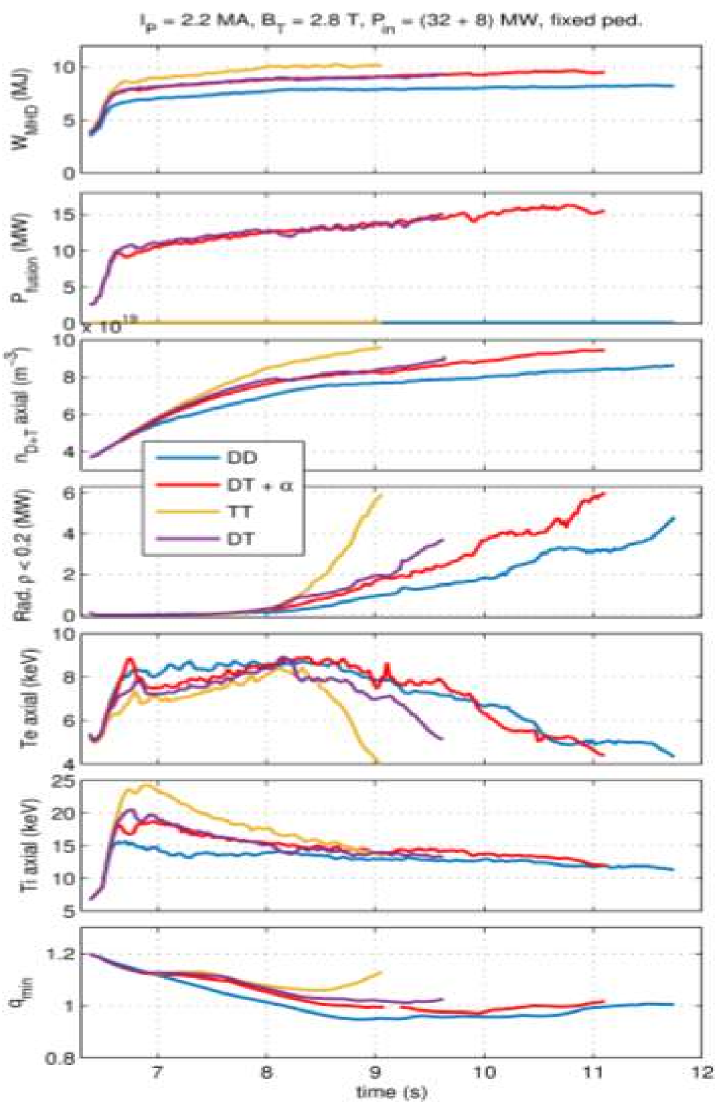
7 channels extrapolation with JINTRAC: one step beyond



Casson F.J. et al 2018 JET 27th IAEA Fusion Energy Conf. (Ahmedabad, India, 22–27 October 2018) p TH/3-2

- Detailed extrapolations performed to maximum power in DT with with JINTRAC and self-consistent core modelling of Ti, Te, j, n_D, n_T, n_{Be}, n_{Ni}, n_W, ω
- Self-consistent sources for NBI, ICRH and fusion power
- Change of isotope leads to important confinement increasing specially in TT
- Changes in confinement (mainly density peaking): strong impact on W accumulation
- Mild α effects but fast ion impact on turbulence and neoclassical transport for W not included
- Pfus can reach 15MW with all the effects included

Actions from the past

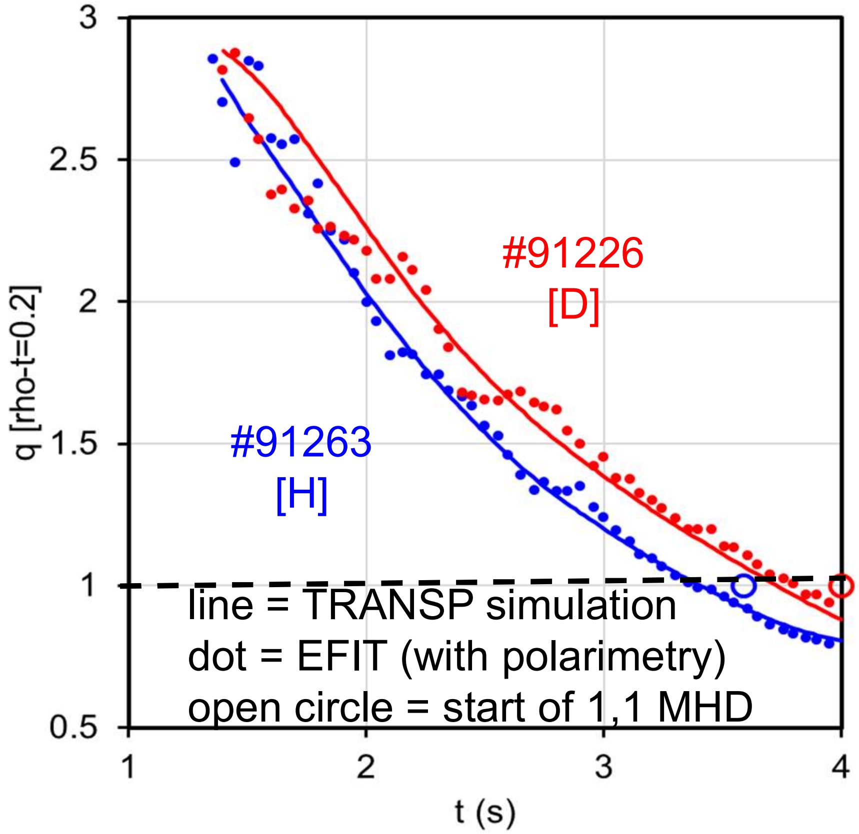
- JET requirements shown in WPCD APM 2019
- Basically: WPCD should be able to match well stablished IM tools used for JET and provide more advanced tools to seduce new users
- JET ETS users meetings held monthly to follow the ETS activity at JET and monitor the WPCD state

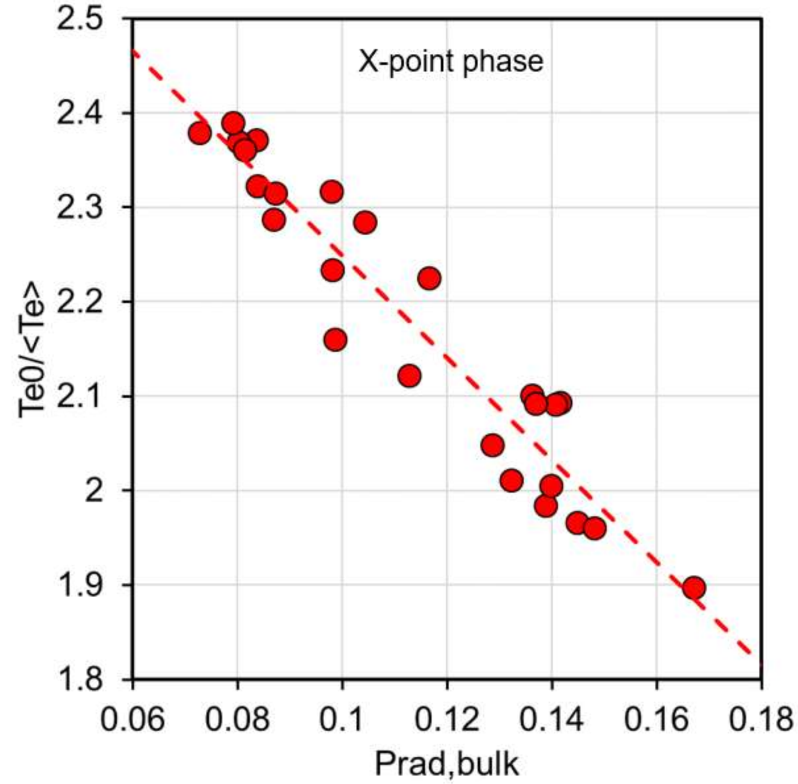
JET requirements from 2019

- **Interpretative simulations**
- H/CD workflow: NBI and ICRH heating in DT extrapolated plasmas with alpha heating (thermal,beam-target,beam-beam) and neutron rate modules.
  - Neutron predictions of reference existing discharges ☺ *but more comparisons to TRANSP with new reference shots needed*
  - Benchmark with JINTRAC/CRONOS/TRANSP for extrapolated DT plasmas 😐

- Current diffusion simulations (including ramp-up and ramp-down, therefore evolving equilibrium and possibly with NBI and/or ICRH). ☹

Why q profile analyses needed





- Significant isotope dependence of the q profile evolution
- Decrease in T_e peaking with P_{rad} suggests central radiative cooling→ Disruption in the current ramp-up phase: central ICRH remedy?

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JET requirements from 2019

Predictive simulations: main requirements

1) TCI with TGLF/Qualikiz. Use for multi ions plasmas (H isotopes and Impurities) ☺ *But extra efforts for benchmark are necessary*

2) NEO model for addressing W transport ☹

3) Link between ETS and H/CD (NBI and ICRH) for self-consistent simulations ☺

4) Models for specific edge transport requirements (pedestal pressure, pedestal density, ELMs) in order to perform true core-edge simulations. ☹

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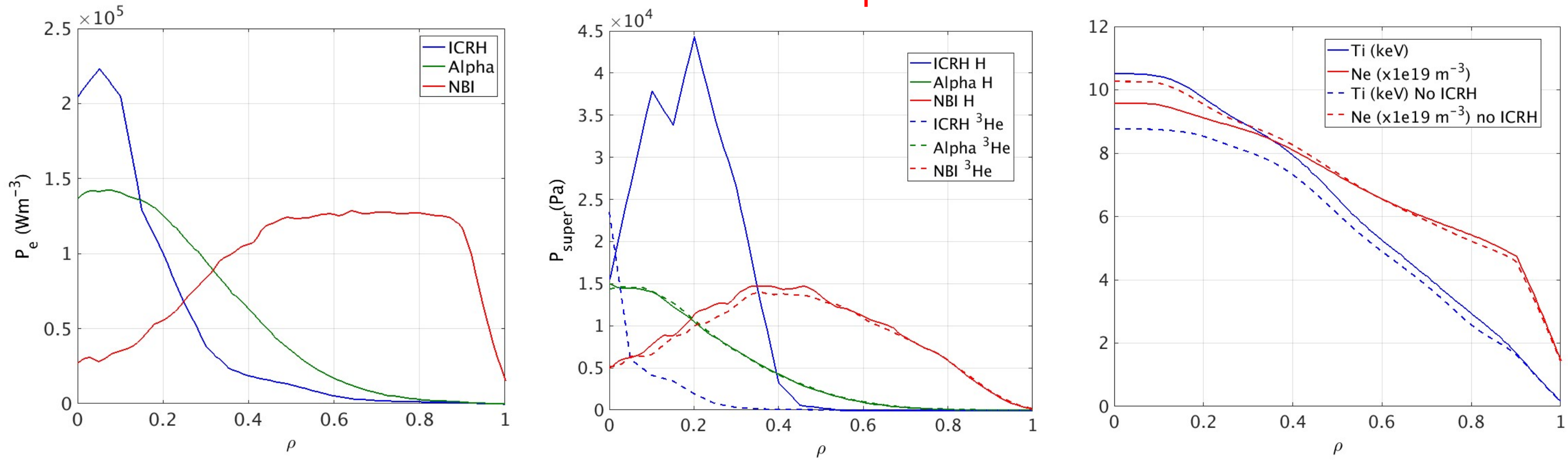
JET requirements from 2019: Alpha physics

#92436 extrapolation



J. Garcia et al IAEA18

- Alpha physics analyses possible in JET-DT scenarios
- Quite significant alpha heating to the electrons and fast ions pressure…
- … but direct competition of ICRH: how to clearly see alpha effects?
- Two possible solutions:
  - Using ^{3}He as alternative to H minority (ITER scheme)
  - Removing ICRH for two slowing down time→ W accumulation?
- **Physics of alphas (heating, FI distribution function, losses) required** 😐

JET requirements from 2019: Fast ion modes

Fast models for Alfven modes calculations

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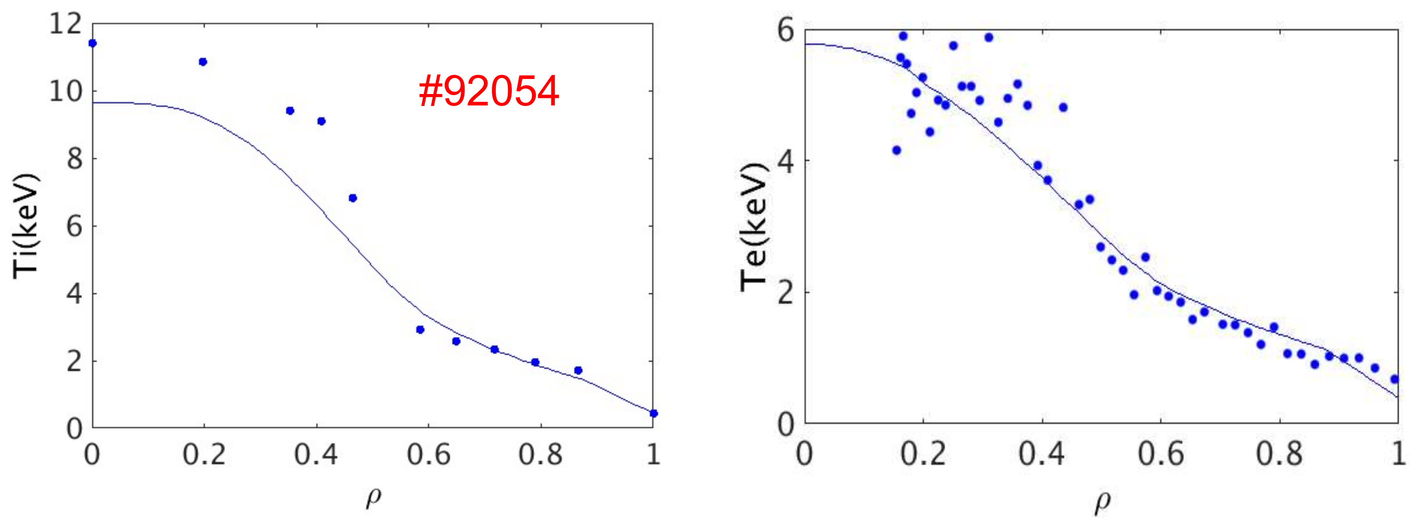

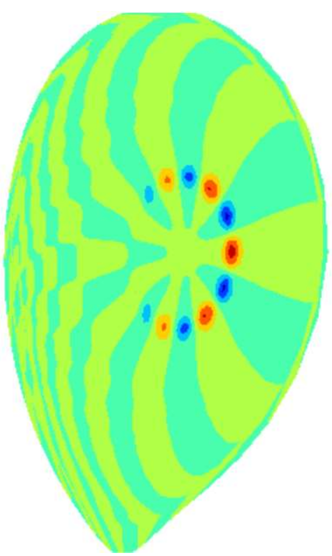

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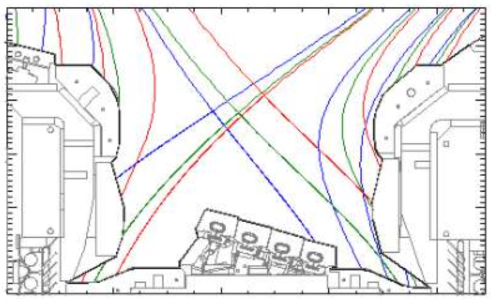
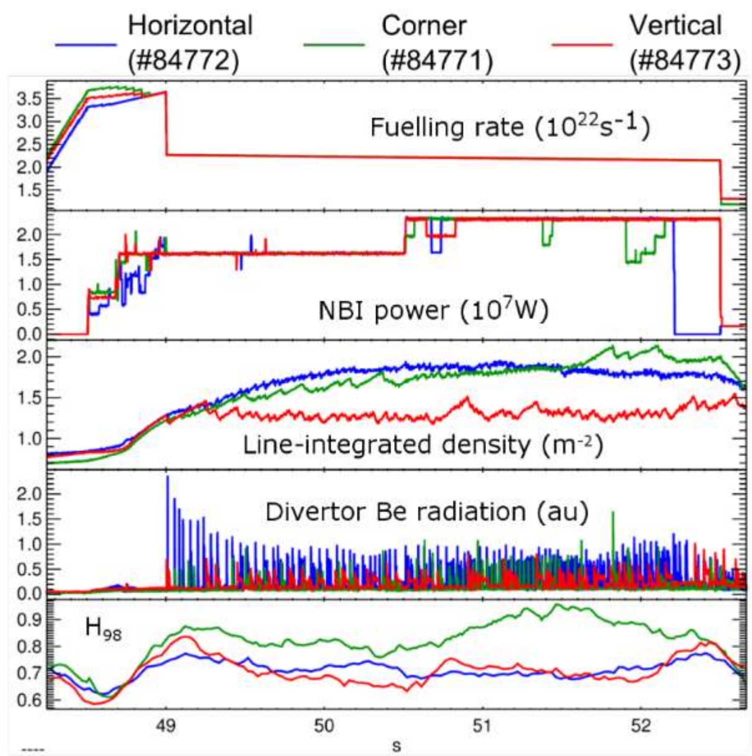
- First ITB's plasmas at ILW used for TAE destabilization
- Validation of models (CDBM) in this conditions performed: **ETS activity started** ☺
- Extrapolated to DT to asses TAE destabilized by alphas wit MISHKA (stability chain can be used?) ☹
- Significant activity carried out with HAGIS, CASTOR-K…
- …but self-consistent simulations needed including fast ion transport with TAE, NBI calculations and thermal transport
- **Fast models for TAE (RSAE,BAE) required** ☹

JET requirements from 2019: Core-edge simulations including SOL

- Many past experiments on JET (starting from M13-30) have showed a strong **impact of divertor configuration on H-mode confinement**

Horizontal ≈ Vertical ≪ Corner





[P. Tamain et al., JNM (2015)]
[E. Joffrin et al., Nucl. Fusion 57 (2017)]

- Explanation not clear yet:
  - edge/divertor modelling required for interpretation

- Self-consistent impact of divertor geometry or external seeding on core profiles is necessary. ☹

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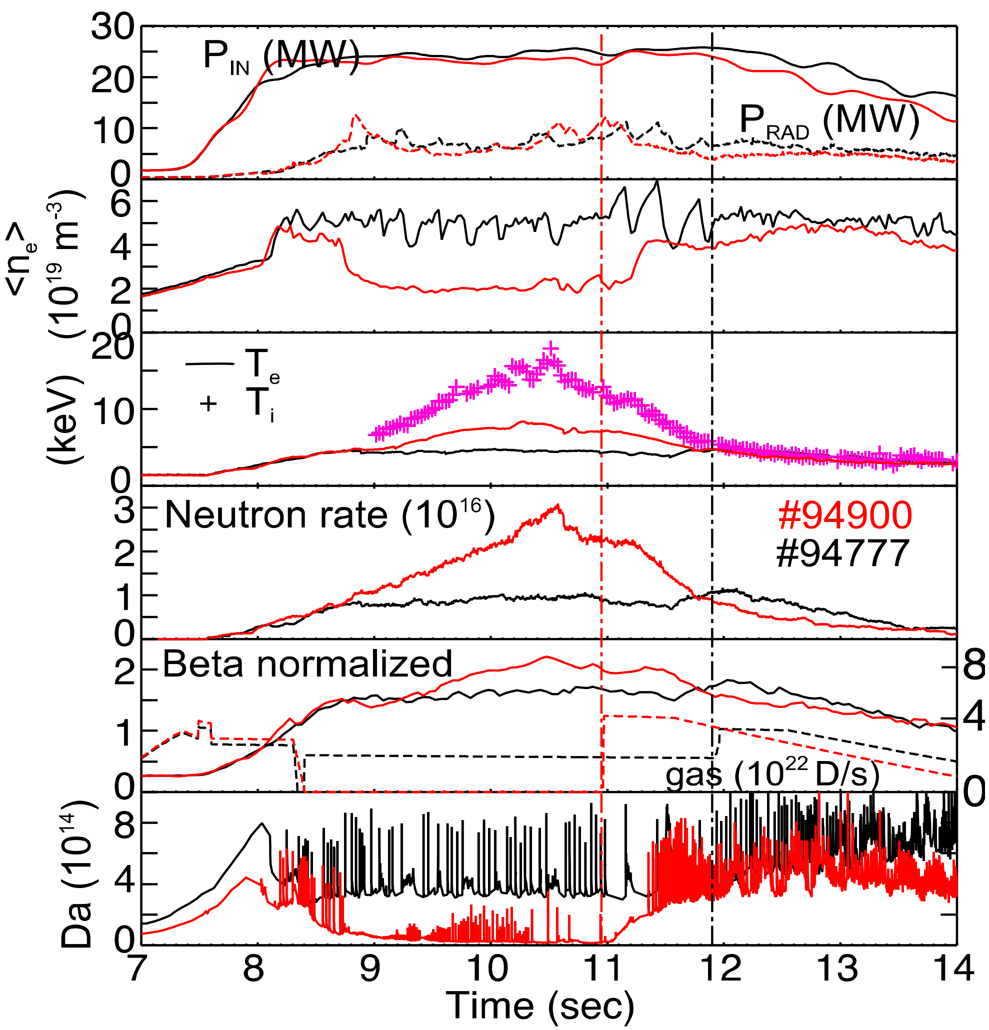
New requiremetns in 2020



- Peculiar behaviour of pedestal found in plasmas with no gas puff or pellets+gas puff
- Small ELMs with high core confinement obtained with no gas puff
- Compounded ELMs in pellets pacing plasmas
- Pedestal density does not follow Ip.
- Extreme density peaking

- **WPCD requirements**:
  - Simple pedestal stability chain with self-consistent equilibrium from interpretative simulations
  - Gas puff models
  - Simple models to adjust edge particle transport
  - Clear splitting of D and Vn

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Final considerations

- WPCD can be significantly useful for JET1
- A strong coordination activity between JET1 and WPCD is necessary (how to improve it?)
- A reliable and user friendly experimental data access is needed
- In addition to JET simulations, ETS can be used to perform ITER extrapolations/analyses but the physics of alpha particles is essential in WPCD
- Very limited number of users available.
- Many resources spent for WPCD code camps but much less resources spent for gathering and promote users
- The users activities are dispersed in different WP→ difficulties to coordinate and to compare results with other codes
- New proposal for multi code multi WP WS on integrated modelling being discussed