



WPSA CM - Summary

WPSA Project Planning Meeting, 6-9 September 2022

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This meeting CM sessions – 2023 activity planning



- **IC related topics:**

ECWC, breakdown modelling, startup runaway detection

Wed 7th @11h

Topic session: IC 2023 preparation - First plasma

- ✓ **Scenario modelling** - all aspects: discharge simulator, core transport/turbulence, MHD and fast particles stability

- discussion shall focus on scenario revision to identify feasibility, limits and needs for advanced modelling
- definition of use cases for trainings

Wed 7th 14h-18h

Topic session: Discharge simulator and scenario modelling

- ✓ **Edge/SOL divertor modelling** (including **Langmuir probes** design) interface to equilibrium

Thu 8th 14h30-16h Room 2

Parallel session: Edge/divertor modelling

- **Disruption** trigger alarm / disruption modelling

Thu 8th 16h30 Topical session: Disruption avoidance techniques

- **EDICAM & synthetic diagnostics (TPCI, FILD)** during the respective enhancement sessions

Thu 8th 10h30 & 14h Room 1 ENH sessions



TOPIC	Plans	ACTIONS	Open questions / issues	NEW TASKS/ EXPERTISE / DATA REQUIRED
Breakdown modelling	See M Mattei/D Ricci slides Add impurities	Progress meeting with F4E 12/09	Source of 3D fields? Scan on prefill pressure	Provision of case A data by Japanese
ECWC	See Buermans slide 4 Modeling of ECWC to complement experimental observations			Pressure gauges, magnetic field configuration, injected power Availability of density profiles: Use of EDICAM camera data for ECWC modelling Tomographic reconstruction Ratios of the emission intensities of various atomic spectral lines Interferometry, Thomson scattering, spectroscopy to complement the density profiles?
Cryo & Magnets	See Nicollet slides	Meeting with F4E/QST to agree on needs / task		Modelling with rapid CEA codes
Startup RE		Address first scenario cases	DREAM/STREAM validation needed Assess if EDICAM can detect RE @lower current ! Need simulate distribution functions	Startup RE modellers DREAM + SOFT (Hoppe) STREAM



TOPIC	Plans	ACTIONS	Open questions / issues	NEW TOPICS EXPERTISE REQUIRED
Discharge simulator for pulse preparation	<p>See Joffrin/Mattei slides</p> <p>Verification of improved strongly coupled non linear simulator (by 2022).</p> <p>Improve the nominal scenario test cases with the strongly coupled simulator.</p> <p>Implement kinetic control.</p>	<p>Provide outputs sequence of equilibria in IMAS for further modelling.</p> <p>Input from ET : phasing of scenarios</p> <p>Identify use cases</p> <p>Define cases for test users / prepare training.</p> <p>Demonstration to session leaders / QST?</p>	<p>Extend / aim at RT control?</p> <p>Ramp up control – oscillations to be addressed.</p> <p>Ramp down open questions on controller.</p> <p>JT-60SA shape very sensitive to li.</p> <p>Shape of transport coefficients relevant.</p> <p>How to construct the ramp up phase – with / without current.</p> <p>Use TS data for integrated control + kinetic ?</p>	
Scenario development transport analysis	<p>Use QLK transport module.</p> <p>Implement time dependent sequence of equilibria from pulse simulator.</p> <p>Scans eg on ramp-up rate.</p> <p>Scan beam composition eg gyrotrons at different frequency.</p> <p>Include impurities (ETS tbd)</p> <p>Predict first: prepare ahead of call for exp campaigns specific exps & scenarios/validate tools & scenarios</p>	<p>Address ramp-up up to flat-top for scenario 2 nominal B field case.</p> <p>Provide outputs in IMAS.</p>	<p>Robust equilibrium solver for rather unconventional scenarios.</p> <p>Automatic calculation of MHD stability during ramp up.</p> <p>Transport models valid in high beta regime?</p> <p>RE trigger module?</p>	<p>Support from module experts (transport/heatings)</p> <p>Core edge integration</p> <p>Propose JT-60SA relevant exps on existing tokamaks</p> <p>Modelling beyond research plan / further ENH: eg what additional ECRH power could provide in terms of physics, higher beta, T</p> <p>What ICRH antenna could provide</p>



TOPIC	Plans	ACTIONS	Open questions / issues	NEW TASKS/ EXPERTISE REQUIRED
MHD and control	RWM active control – aiming at high beta steady state operation See Pigatto slides – plan completed by 2022	Stability study of resistive modes	Include fast ions	
	EQSTABIL workflow – test cases exist for kepler wf all tokamaks including JT-60SA Provide training	- Address 2022 task using JINTRAC scenarios ramp-up data	Limits in high beta regime Extend to low shear region Compare to realistic first principle modelling / expected ITB?	
	Non-linear MHD – pellet triggered ELMS JOREK self consistent modelling	Share data eg background for BES synthetic diagnostics		JOREK experts – S Pamela
	RE heat loads on PFC		CAD models for other PFC? MHD spectra RE energy & pitch angle energies	
Pedestal and edge			H mode accessible in Initial Phase Scenarios?	Sensitivity scan evaluate L-H threshold
				EPED calculations integrated to core scenario – to improve edge/SOL predictivity
Energetic Particle modelling	Analyse EP stability in initial phase during ramp up + flat top phase: with very high current and density		Equilibria cannot be used in automated fashion / q profile to be tailored EP stability at the end of startup phase critical. Impact of higher energetic ions on modes? Investigate low frequency region? Address balance of power btw PNBI NNNBI – requires ASCOT team	



TOPIC	Plans	ACTIONS	Open questions / issues	NEW TASKS/ EXPERTISE / DATA REQUIRED
Benchmark of SOLPS_ITER to SONIC	Code benchmark in D D+C D+C+Ar (one to one verification on identical conditions not validation on realistic case)	Dedicated meeting to address discrepancies possible causes.	Chemical & physical sputtering? Data missing for reflection of Ar on Cu Boundary conditions? Transport coefficient profile – for H mode? Drift effects?	Mission to analyse benchmark /discrepancies together with Yamoto san > 2weeks
scenario 2 initial phase SOLEDGE modelling integrated to core conditions	Pedestal params & P influx from JINTRAC – refine/optimize- requires further iterations with core modellers	Verify pump location/surface Verify chemical sputtering values Sensitivity scans (eg see work from Galazka with SOLEDGE3X)	!NB ITER indicated that neutral penetration from outside to core (from edge modelling) not reliable. Adress options to avoid P sweeping : change ne separatrix Ar/Ne puff to substain plasma Investigate if initial phase shots can be prolonged by seeding. Optimize on ne sep to easy detachment Explore the possible configurations	EPED calculations integrated to core scenario – to improve edge/SOL predictivity
SOLPS_ITER scenario 2 in C modelling with Ar	Adress 2022 Task with improved model (higher mesh resolution, profiled transport coeffs, BC on particle flux) , Ar puff scan	Verify: puff/pumping, wall T Detachment achieved Radiation maps		Puffing and pumping speed range
Langmuir probe design assessment		Next meeting with F4E – invite Y Liang, D Coster ET identify scientific cases (eg RMP?)	! Assumption of toroidal symmetry Tile shaping?	Field line tracing for toroidal position and shading.

SYNTHETIC DIAGNOSTICS

Thu 8th 10h30 & 14h Room 1 ENH sessions



TOPIC	Plans	ACTIONS	Open questions / issues	NEW TASKS/ EXPERTISE / DATA REQUIRED
PCI GENE modelling	Equivalent study of scenario 2 (full Ip inductive SND)	Share GENE data eg background for BES synthetic diagnostics	Compatibility of initial scenario set-up from scenario modelling with reduced transport model to high beta use case ? Capability of PCI to detect pellets or electron turbulence?	New manpower to be appointed/hired SPC opening for post-doc & graduate student
FILD	See J Ayllon slides	Kick-off the task		Scenario data from JINTRAC+ASCOT modelling
Gamma diagnostics	See M Nocente slides			TRANSP+ASCOT data

Operation related

Thu 8th 16h30 Topical session: Disruption avoidance techniques

Disruption prediction for mitigation	See J Vega slides	TGL: organize dedicated meeting agree on purposes and prepare unified common EU view	Disruption database: same as for IC? which data & purposes? (eg EF disruption database by Pau is not aimed at prediction) Disruption trigger trained on IC data will be relevant for following operation? Eg no lock mode data in IC but later yes No signals in IC for slowing down of modes (see Pigatto IC presentation) How general is detection based on line integrated ne? MGI for mitigation? See Eva slides on desired tools for operation purposes	Disruption database
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Extended modelling - using developments from TSVV ?



TSVV	Objective/topic	When
1. Physics of the L-H Transition and Pedestals	Interpretative and predictive capability of L-H transitions	Before/after first H mode plasma (2025?)
3. Boundary plasma modelling	neutrals/recycling modelling, impurities in edge turbulent codes	~2025
8. MHD Transients	Disruption modeling, SPI and MGI mitigation, ELM triggering and pacing	Possibly from 2023
9. Dynamics of Runaway Electrons in Tokamak Disruptions	Validation of RE generation model	Possibly from 2023
10. Physics of Burning Plasmas	Energetic Particle stability and transport, N-NBI distribution function modeling, ramp-up scenario with NBI	Ongoing, data ~2025

- Proposals of EUROfusion Research Grants (ERG) welcome

**Modelling aims and needs to be defined
in coordination with Experiment Team
TG dedicated working groups/meetings**



- BACKUP



*Please keep your Task
wikipage up-to-date*

- <https://wiki.euro-fusion.org/wiki/WPSA: Code Management and Simulation>
- The **EUROfusion Gateway** cluster is the home of WPSA code development work and shared simulation tools
 - **Gateway access request** please follow the procedure on: <https://wiki.eufus.eu/doku.php>
 - Gateway login (X2Go, NoMachine, ssh) g2username@login.eufus.eu
 - A training on the Gateway setup and use (as well as on IMAS) provided by ACH is available, links on: <https://wiki.euro-fusion.org/wiki/ACH-04>
- A **gitlab** has been setup: <https://gitlab.eufus.eu/>
- A repository for WPSA Gateway users has been created : [/afs/eufus.eu/gw/wpsa](https://afs.eufus.eu/gw/wpsa)
you can request access to **admins**: mail to rcoelho@ipfn.ist.utl.pt; CC gloria.falchetto@cea.fr
- Previous JT-60SA modelling data is stored here:
[/afs/gw/wpsa/groupoffice/users/MODELING](https://afs/gw/wpsa/groupoffice/users/MODELING)
- Documentation tutorials on discharge simulator METIS / CREATE_EGENE
 - https://wiki.euro-fusion.org/wiki/WPSA_CM: Discharge simulator
- Gateway repository : [/afs/gw/wpsa/applications/](https://afs/gw/wpsa/applications/)

Investigate storing simulations on simDB



- ACTIONS FROM MAY GENERAL MEETING



❖ Discharge Simulator

Actions: work with QST on feasibility of the scenarios in the PID

- test cases data list & links on wiki
- output data in IMAS for use by other codes/workflows

❖ Scenarios:

LG: EC frequency used in Research Plan to be revised? should be ok with steerable ECH launcher

JG suggestions:

- assess if auxiliary power enough to access H-mode in H – extrapolated to D – to help ITER
- ✓ shintough addressed in JINTRAC? it was estimated in the past
- assess if enough ECRH power to tailor the q-profile? Eg relevant for hybrid scenario 4.2

GP: which resistivity used? Impact on ramp-up. Neoclassical? Spitzer?
effect of ramp up speed on the profile? Relevant for hybrid scenario
reversed q –profile during EC deposition ?

In ETS: **effect of impurities? Can affect ramp up.**

Actions:

- cross verify output profiles from JINTRAC/ETS to provide unique IMAS/IDS data for eg EP stability calculations
- modelers/TGLs provide requests for more advanced modelling if needed
 - use ASCOT instead of PENCIL for NBI
 - assess QL models for L-mode eg use TGLF/QLK **2022 deliverable**



❖ Energetic Particles

- Investigate differences in EP stability btw Scenario 2 and high density
EP studies ITER relevant very important if fast ions do or not drive the (TAE?) modes

❖ RWM control

- Sensitivity scans over some parameters
 - Interesting to know what limits the scenario eg NBI power ? Beta?

❖ ELMs –pellets

- Investigate topics for collaboration using MIPS code (Suzuki san) – synergetic not superposing to his RMP –ELM stabilization studies
- PB + gradients complex interplay with current on ELM triggering; also depending on injection time of the pellet
 - Stronger pellet shading on JT-60SA?
- Use more realistic parameters (eg resistivity) in JOEUK
- Comparison of physics models eg Resistive MHD in JOEUK vs MIPS could be interesting

❖ MHD stability chain

- Can address the resistive infernal mode or PB with resistivity?
 - Investigate an extension of the wf with calculation of δ'
 - Investigate (feasibility/resources) of implementation of MARS-F or CARMA in the chain

Actions Provide the analysed scenarios cases / data outputs

identify interested test users and set up dates for a training



- ❖ **WPDIV** **Needed data from the modeling (WPSA/PWIE): to be discussed at FSD planning meeting**
 - **Pumping efficiency (W vs C) (2023) -> definition of the target geometry**
 - **Assessment of the neutron activation (2023) -> definition of the structural material**
 - What is the **surface shaping** needed (2024) -> **choice of the armor material** (machining tolerances) and **final drawing**

- ❖ **Edge/SOL modelling**
 - Requirements:**
 - Magnetic equilibrium (including divertor legs) and wall data (chamber + subdivertor)
 - Machine Data : puffing valve positions and available gases, auxiliary heating power
 - Power and particle flux through the inner simulation boundary
 - Reliable prediction of transport based on
 1. Experimental findings and previous simulations from C-wall JET
 2. Estimations from core and pedestal modelling
 3. Existing scalings

 - SOLEDGE activate drifts ?
 - SOLPS-ITER Ar puffing modelled
 - Peter Lang : what about modelling Ar from the inboard? Eg by pellet (different then puffing from core) which is found to radiate more efficiently
 - Balbinot: Ar puffing location studied with SOLEDGE : puffing from dome lead to detachment at lower density
 - Rubino: tested in SOLPS-ITER on Ni – would need to recover old data
 - SOLPS-ITER benchmarck
 - ✓ contact with Yamoto san re-established ongoing analysis of discrepancies on D case and get SONIC results from case with C



❖ ECWC

- Needed input data: EDICAM tomography
- Density profile wished at some locations for crosscheck if possible

❖ Camera tomography

- EDICAM raw data access required

❖ Breakdown modelling for IC

- BD very sensitive to error fields can this be investigated?
 - 3D currents in the passive structures negligible

❖ Breakdown simulator

- Include impurities in the prefill? Yes foreseen with different impurities and C
- Influence of different absorption layer ?

❖ RE impact on PFC

- Use equilibrium including RE

❖ RE detection by camera tomography

Open points on possibility of detection on JT-60SA

- RE energy range ? RE radiate in visible?
- EDICAM view is co current ?
- Asymmetries?
- reflections
- Inversion method?

Actions EB GF organize dedicated meeting on RE: with all experts/interested



❖ Disruption DB

- Sergei : main question is the definition of what is a disruption

Actions: disruption WG MHD TGL G Pucella

- Resume contacts with QST
 - Agree on database
 - Support/responsibility to collect data & check the data quality?
 - Resources for infrastructure implementation

❖ Disruption trigger

- **Eva:** need is a very simple tool for control room – run on previous shots for confidence

❖ CIEMAT proposal

- ✓ Will there be locked mode signal in JT-60SA? No data during IC

- It is noted that locked mode is not a disruption trigger for MGI but information on plasma in ill conditions
- Use locked mode signal normalized to plasma current? More physical meaning

❖ ENEA IAP indicators

- Indicator on magnetics: is there a threshold? On pulse calibration it is a statistical method
- MARFE not necessarily leads to disruption : threshold? Use with supervision

❖ NTUA proposal

- JET C wall appropriate large database available (as a note not much C in JT-60SA at IC)
- transfer learning to another machine data, so to be able to have a trigger ready when JT-60SA data available

- ✓ **Action JV** organise task work progress meeting

❖ Disruption EM force modelling

Needs of data from IC for validation of CARMA0NL



- ❖ **TPCI**
 - Synergy with BES synthetic diagnostics
 - Action** investigate sharing of GENE simulations- as background fluctuation data

- ❖ **FILD**
 - Action** interact with scenario modelling Task coord.: scenarios from JINTRAC with ASCOT available



❖ IDAV

- A good connection with diagnosticians is required 1ppy/y appears as a very small manpower for the considered work
 - Tool is meant to be used in intershot analysis
 - Use of raw data is preferred but also treated data eg with calibration included is usable
 - Equilibrium is also included uncertainty can be provided

- Investigate inclusion of 3D equilibrium

- Is IDAV able to take into account fast events or only usable in steady state? Eg eddy currents, noise of ECE?
 - In AUG 1ms time scale equil reconstruction, diagnostics sampling rates (MHz, GHz) fast enough
 - There might be issue for ELMS

- **NEXT STEPS**
 - Detailed presentation and dedicated discussion in specific working group is foreseen under ET

☹ EEG project proposed not selected by EF



Beyond the research plan: Exploratory ideas



- Is central heating in JT-60SA enough at high density?
- Would more ECRH be required?
- Is ICRH a possibility for JT-60SA? What would be its impact?
- Can experiments be proposed in European tokamaks to address JT-60SA physics?
- Is the strong electron heating a problem for confinement in JT-60SA?
- Is it needed a full assessment of transport & confinement in L-mode plasmas?



- Interaction with QST/ET to acquire the reference data needed for modelling – some interaction with Nakano/Hayashi san
- Task work progress meetings, involving TGLs as relevant for future planning/focus – to be started
 - Dedicated meeting on edge/SOL modelling support to Langmuir probe design assessment (WPSA CM ENH reporting to WPDIV F4E)
 - Dedicated meeting on RE modelling / detection (WPSA CM OP ENH TGL) – tbd
 - FILD modelling
- Planned contributions to conferences/publications ? Inform WPSA PL **remember to priorly upload on EUROfusion Pinboard**
Joint publications with QST encouraged
- Deliverable reports due by December 2022
- **Training** / code camp to be organized (spring 2023 ?)
 - Discharge simulator
 - MHD chain
 - EP workflow ?
 - ETS ?