EUROfusion

MHD stability of JT-60SA Initial Scenarios

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Motivation and goals

- Investigate MHD stability of Initial research phase scenarios of JT-60SA
  - JT-60SA initial research phase I and II, in H and D, with reduced power and C-PFC are "approaching"
  - Despite the "reduced power", it entails already 33 MW (N-NB of 10 MW, P-NB of 20 MW, ECRF of 3 MW). The high heating power and high plasma current will enable access to the ITER and DEMO regimes of β_N, f_{BS}, ρ^* ν^* and electron heating ratio !
  - It is relevant to characterize the ***hierarchy*** of potentially hazardous ***MHD modes*** (from internal kink in the deep core up to peeling-ballooning at the pedestal) i.e. which modes dominate ?
- Use routinely MHD stability workflow for the analysis
  - Provide training on usage

Summarizing Scenarios 2-5

- In *all scenarios* q_0<1 so *ST activity* is already accounted for.
- In *all scenarios* pedestal pressure and J_{BS} is noticeable → ELM-y plasmas
- ***Scenarios 2-3*** (inductive, highest I_p) have noticeable plasma pedestal pressures/currents → PB pedestal dominated ($\gamma\tau_A \sim 0.12\ for\ scenario 2, scenario 3\ less\ unstable$).
- ***Scenario 4*** (hybrid, internal ion temperature ITB) is dominated by ideal infernal-ballooning very unstable modes ($\gamma\tau_A \sim 0.2$ at highest ∇p region), PB at $\gamma\tau_A \sim 0.07$
- ***Scenario 5*** also unstable to internal ballooning modes $\gamma\tau_A \sim 0.08$ (*for n=30, n→∞ might hover ~0.12 though*)

Core MHD phenomenology presented at EPS2022

Scenarios used for EPS2022

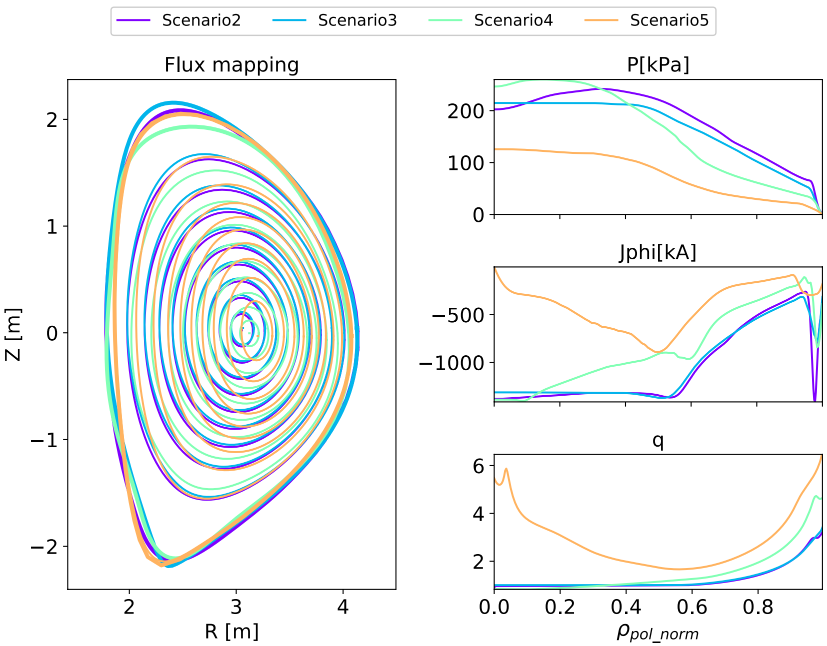


Figure 1 – Plasma cross section and flux surfaces for the 4 operational scenarios (left) and some radial plasma profiles. The radial coordinate is the squared root of the normalized poloidal magnetic flux.

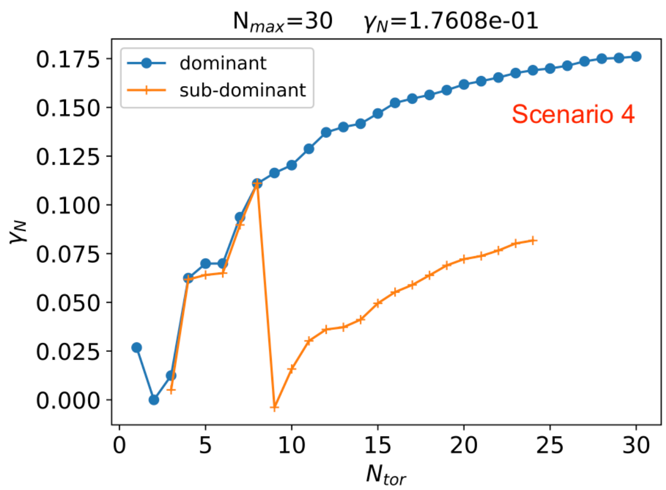
- Fully inductive scenarios at low (Scenario 2) and high (Scenario 3) electron plasma density.
- Hybrid scenario (Scenario 4) and advanced scenario with core magnetic shear reversal (Scenario 5).

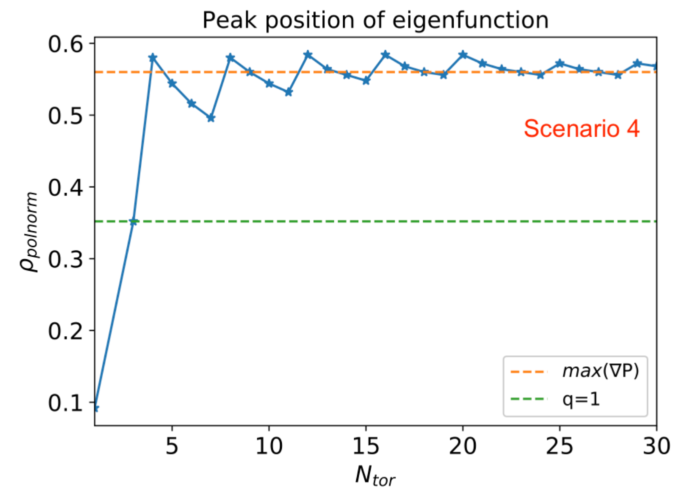
	Scenario 2	***Scenario 3***
Ip / B_T	5.5MA / 2.25T	5.3MA / 2.05T
	Scenario 4 (CDBM)	***Scenario 5***
Ip / B_T	3.6MA / 2.28T	2.3MA / 1.72T

The same data (basic self-consistent equilibrium) is needed for the Initial research phase scenarios !!!

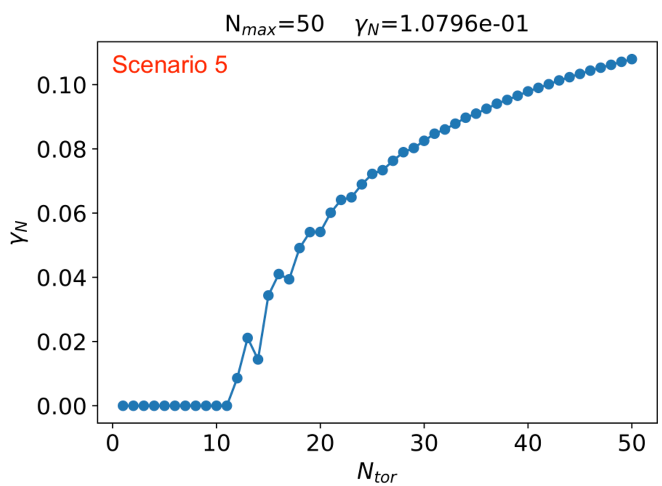
Some highlights on results

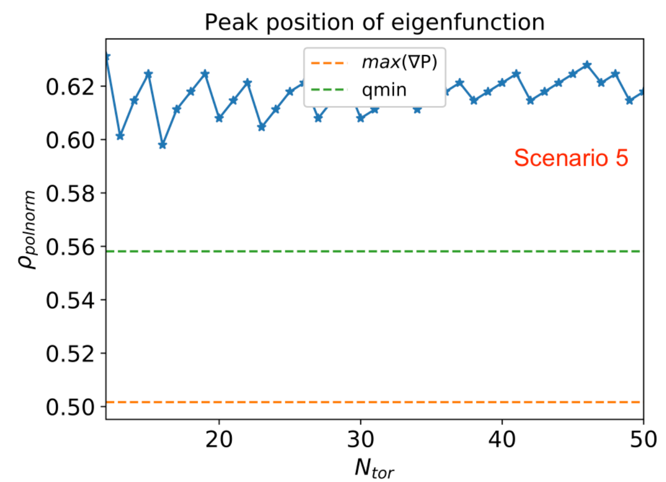
- Scenario 4 (hybrid-ITB) with clear ideal ballooning unstable character dominating



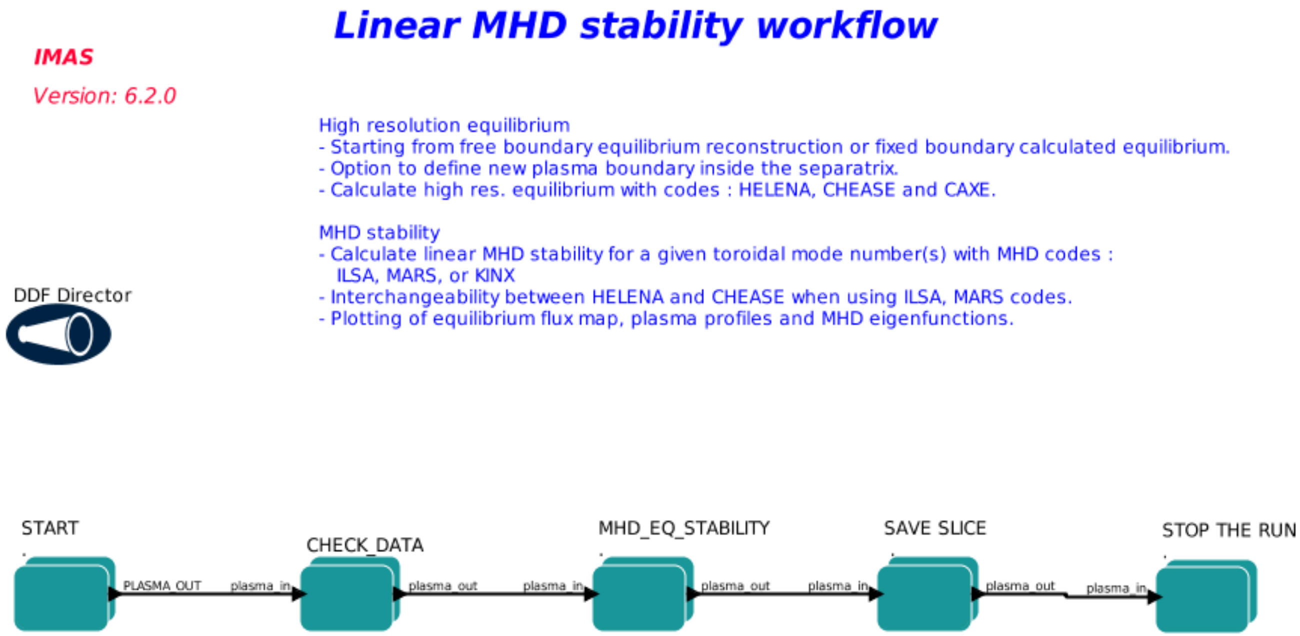


- Scenario 5 (reversed-q) dominated by ballooning unstable at positive shear





Toolset to be used

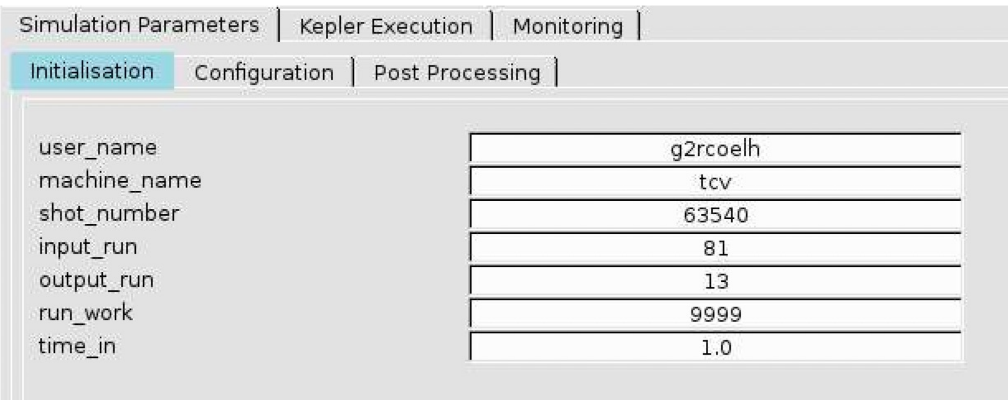


Documentation: *https://iterphysicswiki.euro-fusion.org/index.php?title=EQSTABIL_workflow_documentation*
https://wpcd-workflows.github.io/es.html

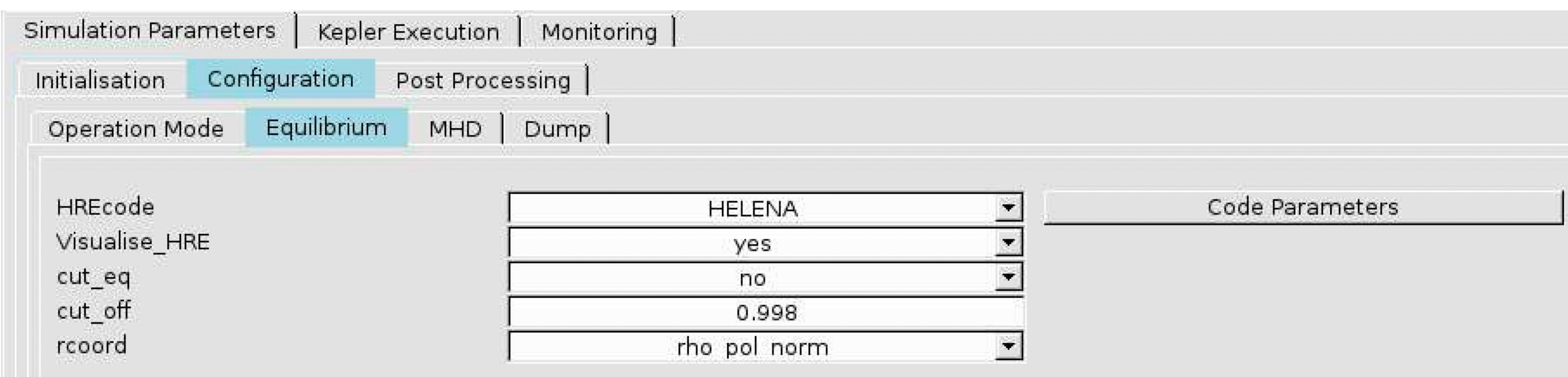
- Consolidated workflow for single mode ideal MHD stability (ITM/WPCD)
- Large case basis (JET, AUG, TCV, JT-60SA)
  - *Training set developed with ideal/resistive test cases on multiple devices*
- Seamless link to the ETS (very similar plasma bundle structure)
- ***KEPLER → AutoGUI*** based interface (***same as ETS workflow***)

AutoGUI based workflow

- Simple interface to set/control/execute the workflow
  - Saved parameter file fully embeds workflow settings + code parameters ensuring subsequent ***traceability*** & ***reproducibility***

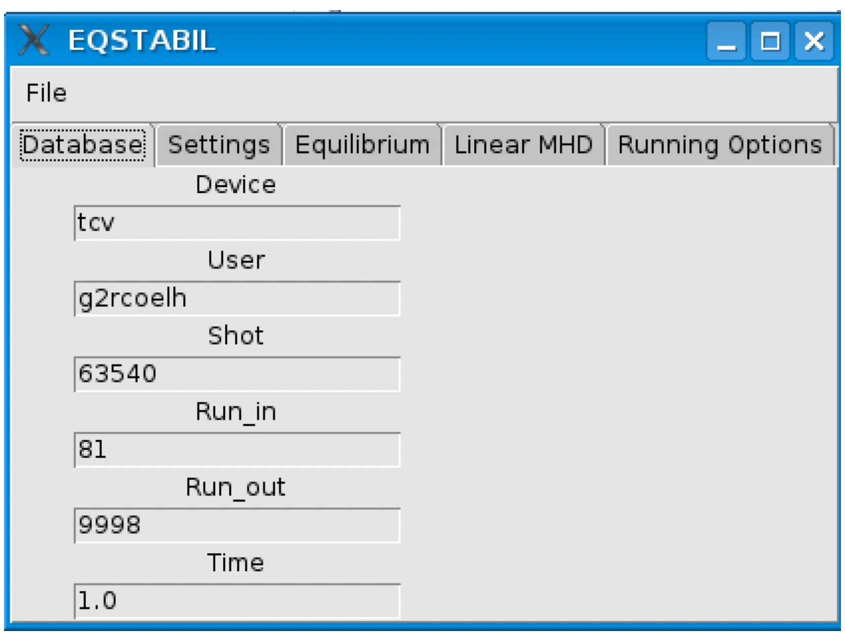


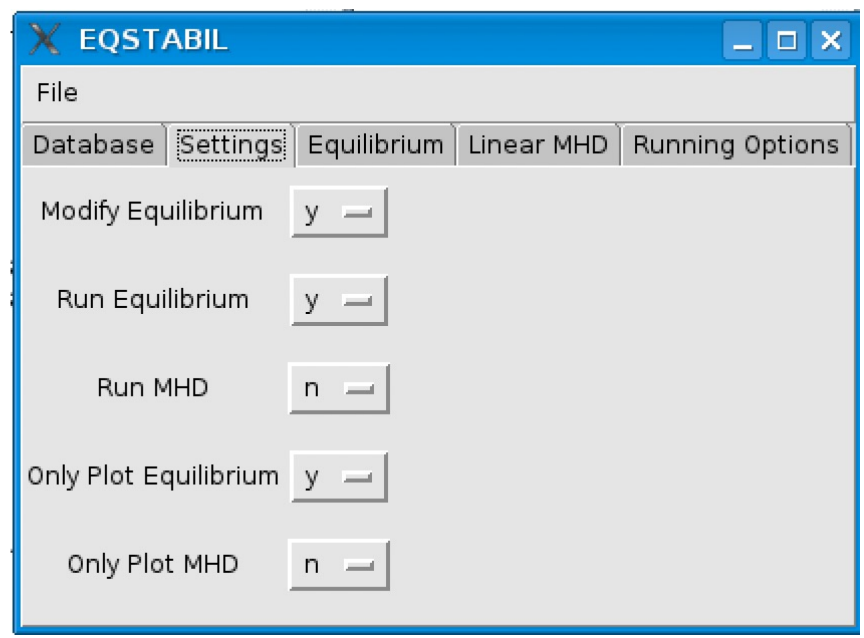
- Fully *multi-device* compatible
- *Multi-code* compatible
- Visualization of results included
- Interactive/batch execution



Python based workflow

- *__Under testing stage, basic but easily upgradeable__*
- Also GUI based but can also be executed on the CLI
- Also fully compliant to IMAS
- Includes same “physics actors” as the Kepler version (*ideal/resistive*)
- Embeds as well post-processing plotting options to check the results
- Fully *__multi-device__* compatible
- *__Multi-code__* compatible





Modelling plans

- Obtain the plasma scenarios from JETTO/ETS (preferably in IDSs)
  - ***Requested in May 2022 → …***
    - *Naming convention is relevant (Scenario 2, 4.2 mean something totally different to me…)*
  - *Equilibrium can even come in EQDSK (just make sure shape/boundary + profiles are consistent with machine + scenario constraints)*
- Perform the stability scan at *time slices of interest to the "community":*
  - Ramp up, flat-top, pre/post heating transitions, wide low shear regions,…
  - Focus on core modes but pedestal might also be considered though flat top might be pre-set/piloted to marginal stability (?)
  - Ideal/resistive where appropriate.
- Determine MHD limits if required e.g. beta limits (*RWM excluded*) and/or transport barrier assessment/limitations.