



EUROfusion

Progress on integrated modelling with ETS on IMAS

Jorge Ferreira and the TSVV-10 & ACH teams

TSVV#10 progress meeting, 3 February 2023



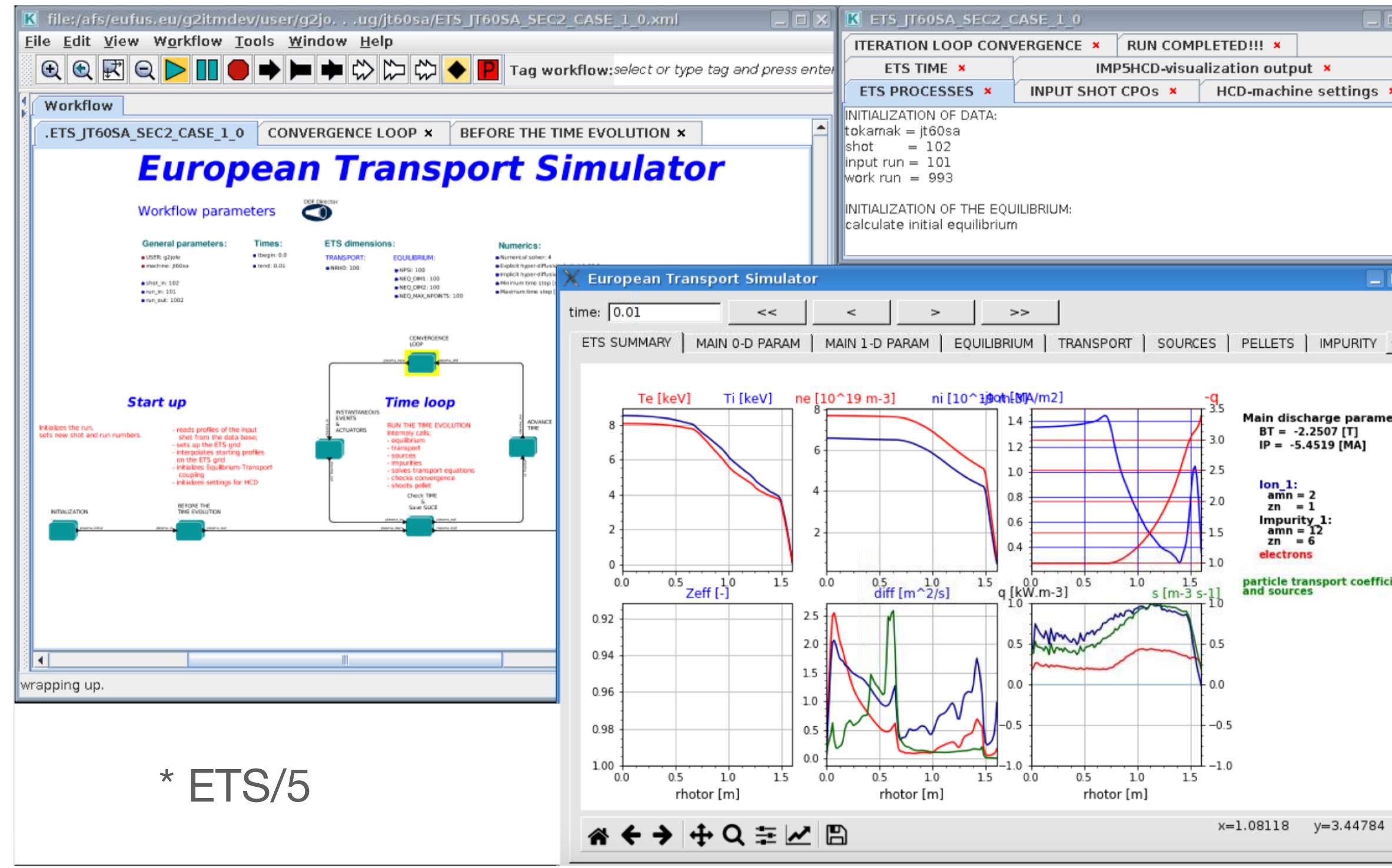
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INSTITUTO DE PLASMAS
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European Transport Simulator



* ETS/5

Highlights

1) Standard procedures to get INPUT DATA

Routinely available tools to prepare experimental data of JET / TCV / AUG / MAST / ITER in either IMAS or CPO standard format

2) Easy framework for Verification and Validation

Integrated workflows have been verified & validated (in progress), tracking data provenance in IMAS data format. Using a standard data abstraction to interface codes and tools is crucial for portability and interoperability.

3) Easy integration of new codes / models

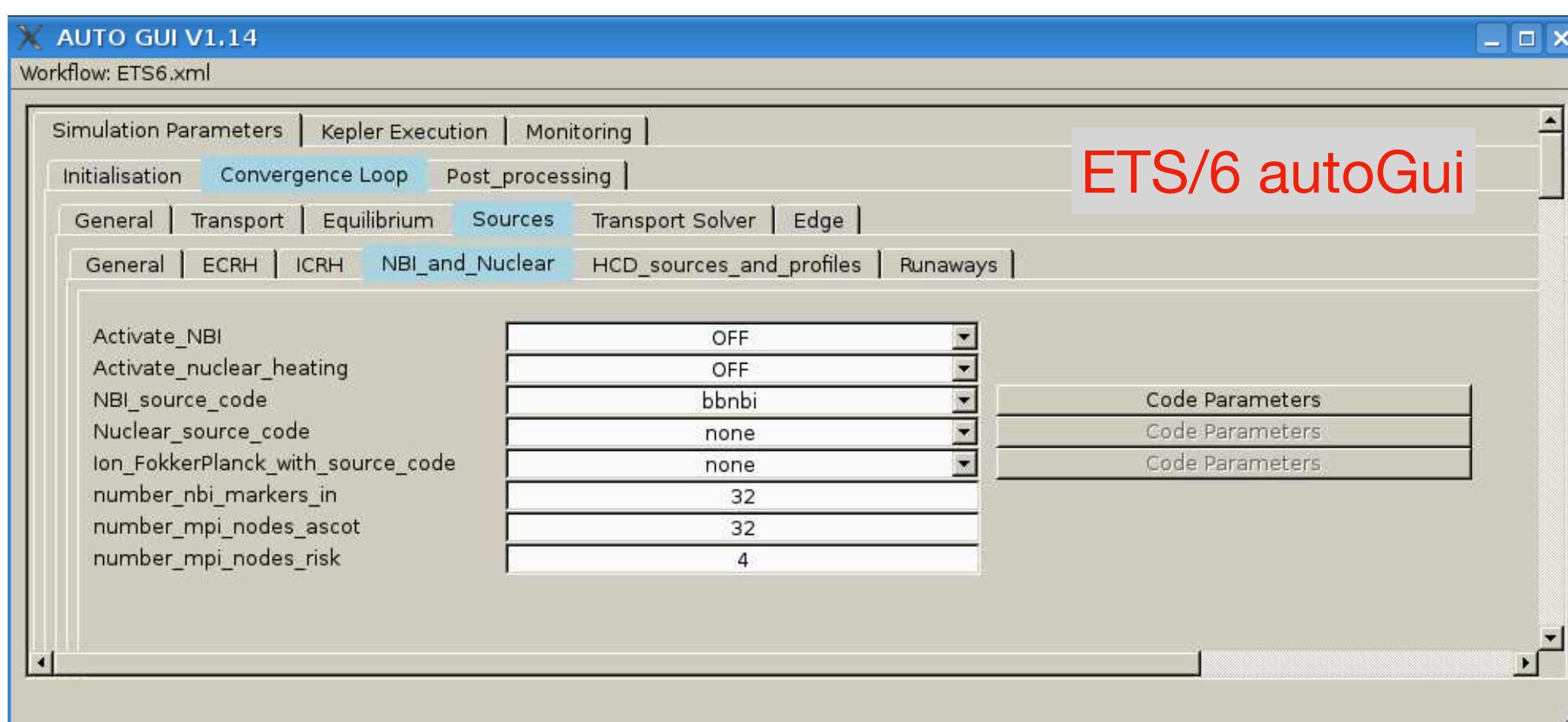
IMAS provides this capability

4) High-fidelity modelling (selective levels of)

ETS is reaching a level similar to state-of-the-art transport codes such as TRANSP (and surpassing in some areas)

5) Visualisation and data processing

tools are available to easily visualise input, simulated and machine data, and export data to other formats.



European Transport Simulator - EUROfusion GATEWAY and documentation

EUROfusion Gateway

- **Wiki / Portal**
<https://wiki.eufus.eu/doku.php>
- **General repository (for hardware issues use link above)**
<https://gitlab.eufus.psnc.pl/users>

WPCD

- **General WPCD documentation**
<https://wpcd-workflows.github.io>

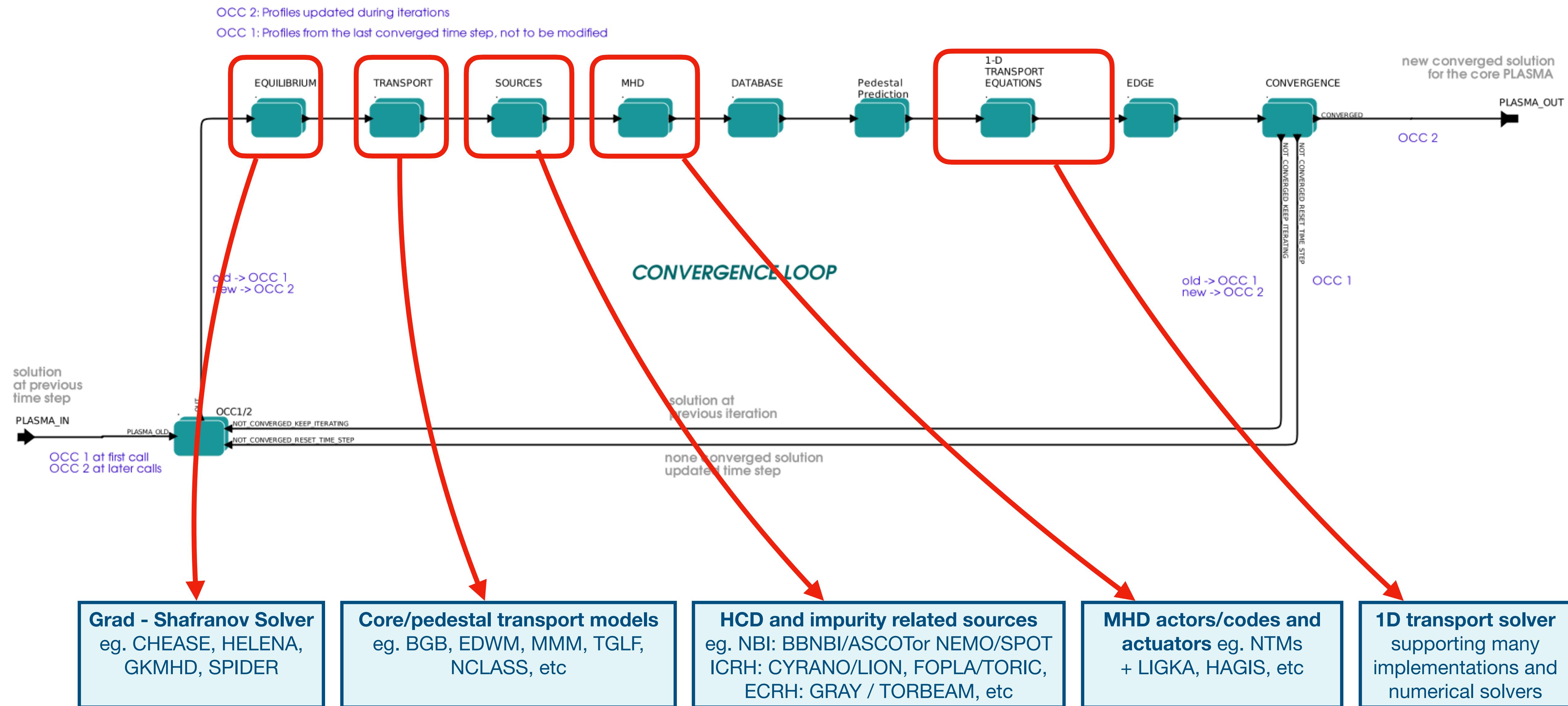
ETS 6 (on IMAS)

- **Documentation**
https://iterphysicswiki.euro-fusion.org/index.php?title=ETS-6_Documentation
- **Last training and modelling session - 23 Nov to 4 Dec 2020**
https://iterphysicswiki.euro-fusion.org/index.php?title=ETS_training_and_modelling_session_23_November_-_4_December_2020
- **ETS developer guide**
https://iterphysicswiki.euro-fusion.org/index.php?title=ETS-6_Developers_guide

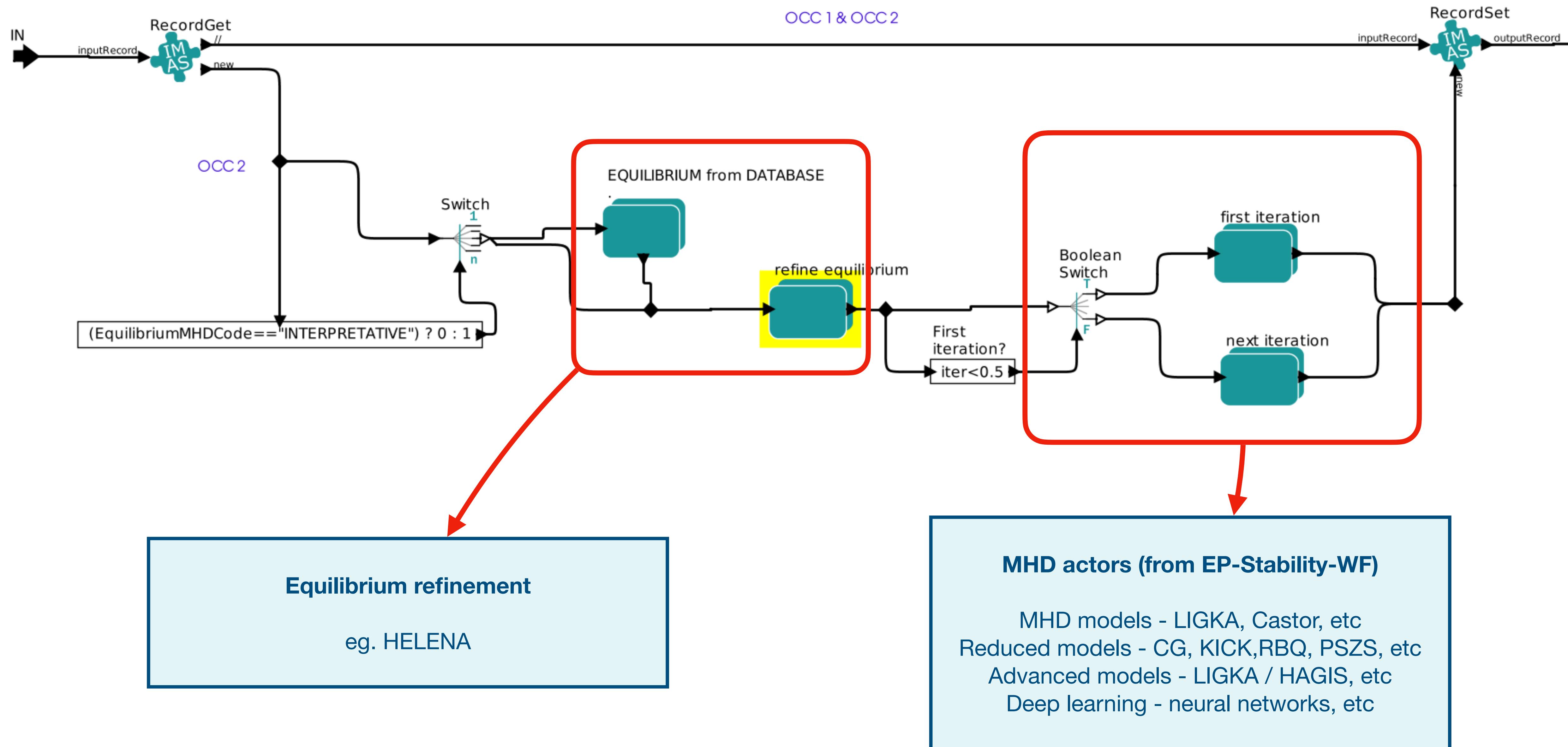
Coupling EP actuator to ETS - progress and issues

- **Testing EP-Stability-WF workflow and actors on the GATEWAY**
No outstanding issues were found. This is one of the advantages of using IMAS.
- **Coupling EP-Stability-WF actors to ETS**
No major problem was found. The only issue was related to the interpretation of plasma content, in particular on how to tag each plasma species. Different logics are used in ETS and EP-Stability-WF. Should ITER provide a standard/logic? Is there anything agreed?
- **Agree on a few use cases and test a simple reduced model**
 - A simple test of ETS6 coupled to Helena/Ligka was done using IMAS data based on AUG and ITER scenarios. ETSviz has an additional visualisation tab for MHD content. Distributions will be added this year.
- **Modelling of NBI fast-ion and alphas was improved by the ASCOT team (Seppo Sipilä)**
 - Distributions for NBI slowing-down and alphas resulting from thermal-thermal, thermal-beam and beam-beam nuclear reactions are now generated in 4D with independent resolutions and limits for each thermal/non-thermal species.

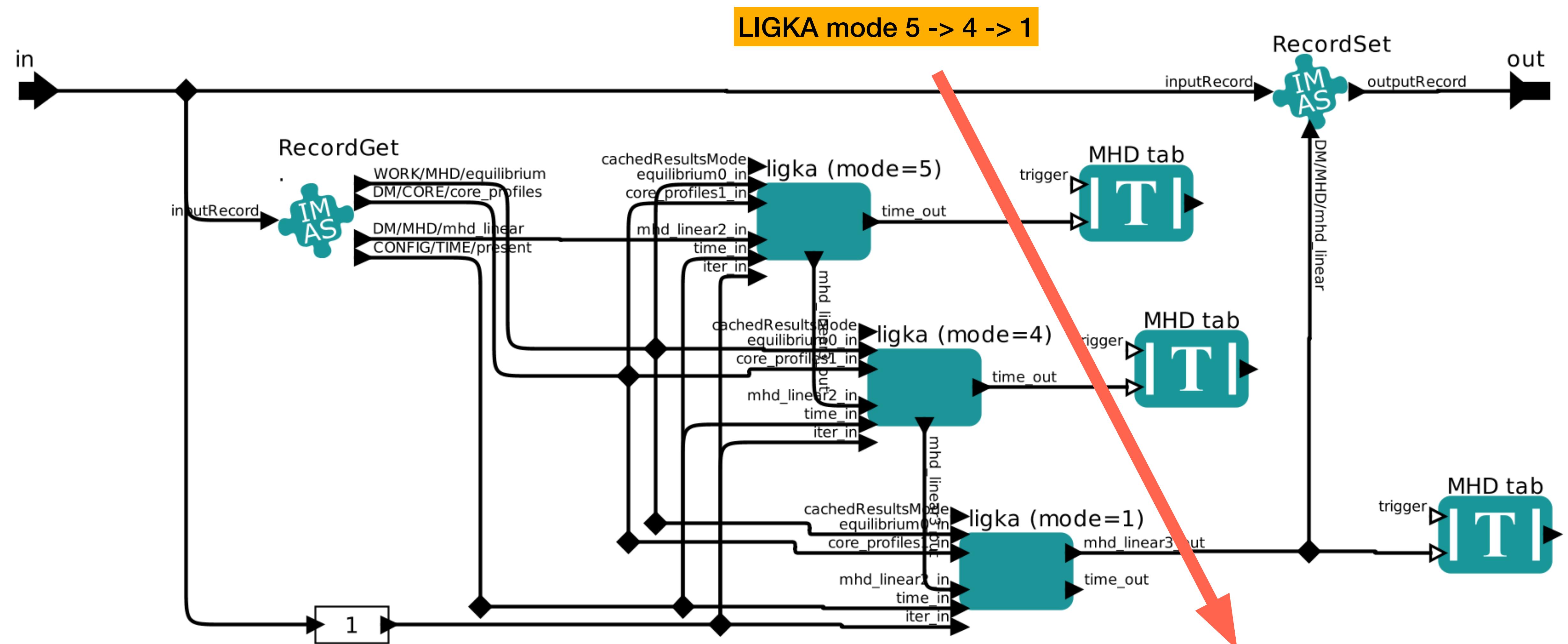
European Transport Simulator - Kepler workflow / convergence loop



European Transport Simulator - coupling of the EP actors to ETS



European Transport Simulator - LIGKA workflow

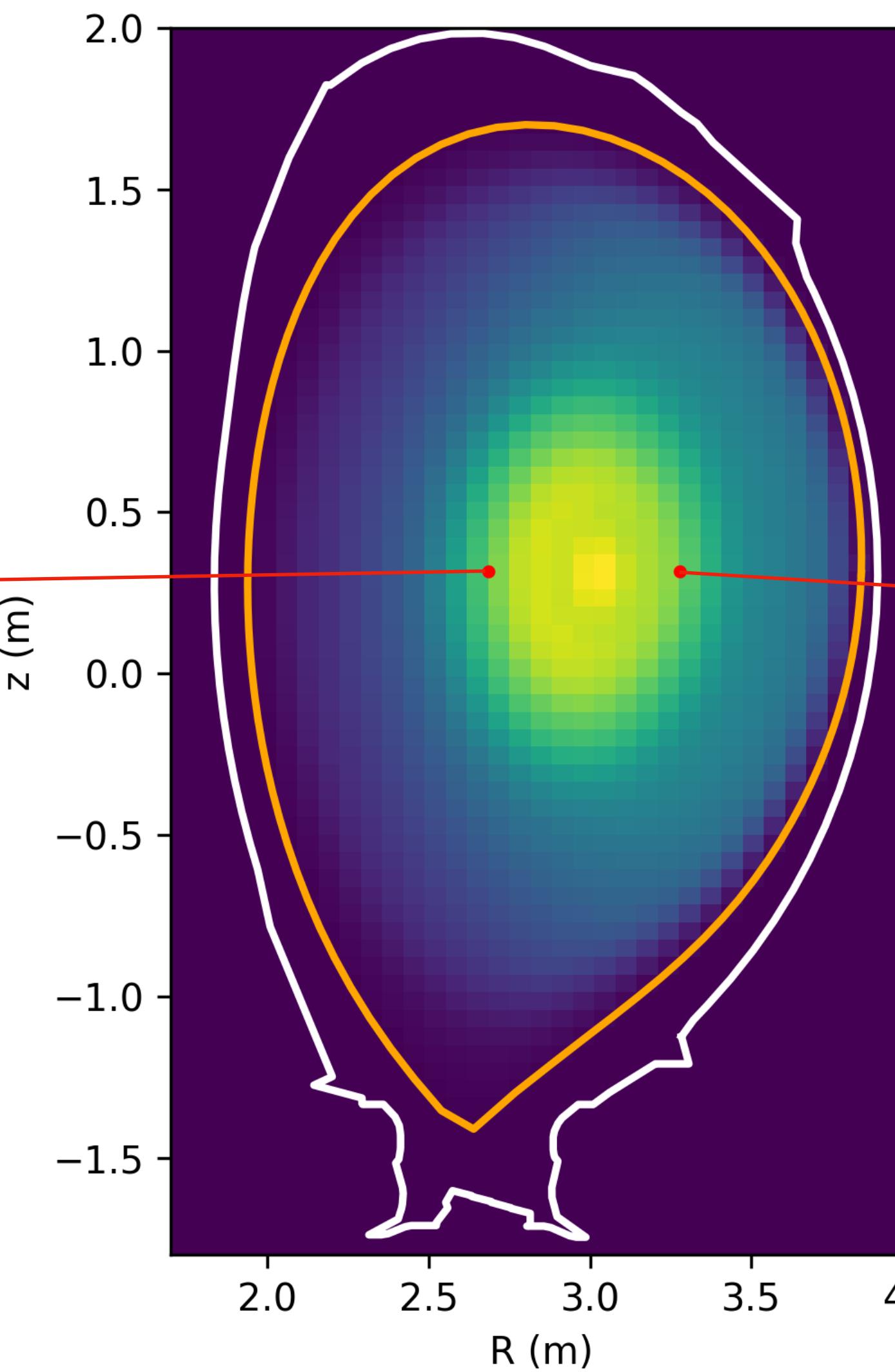
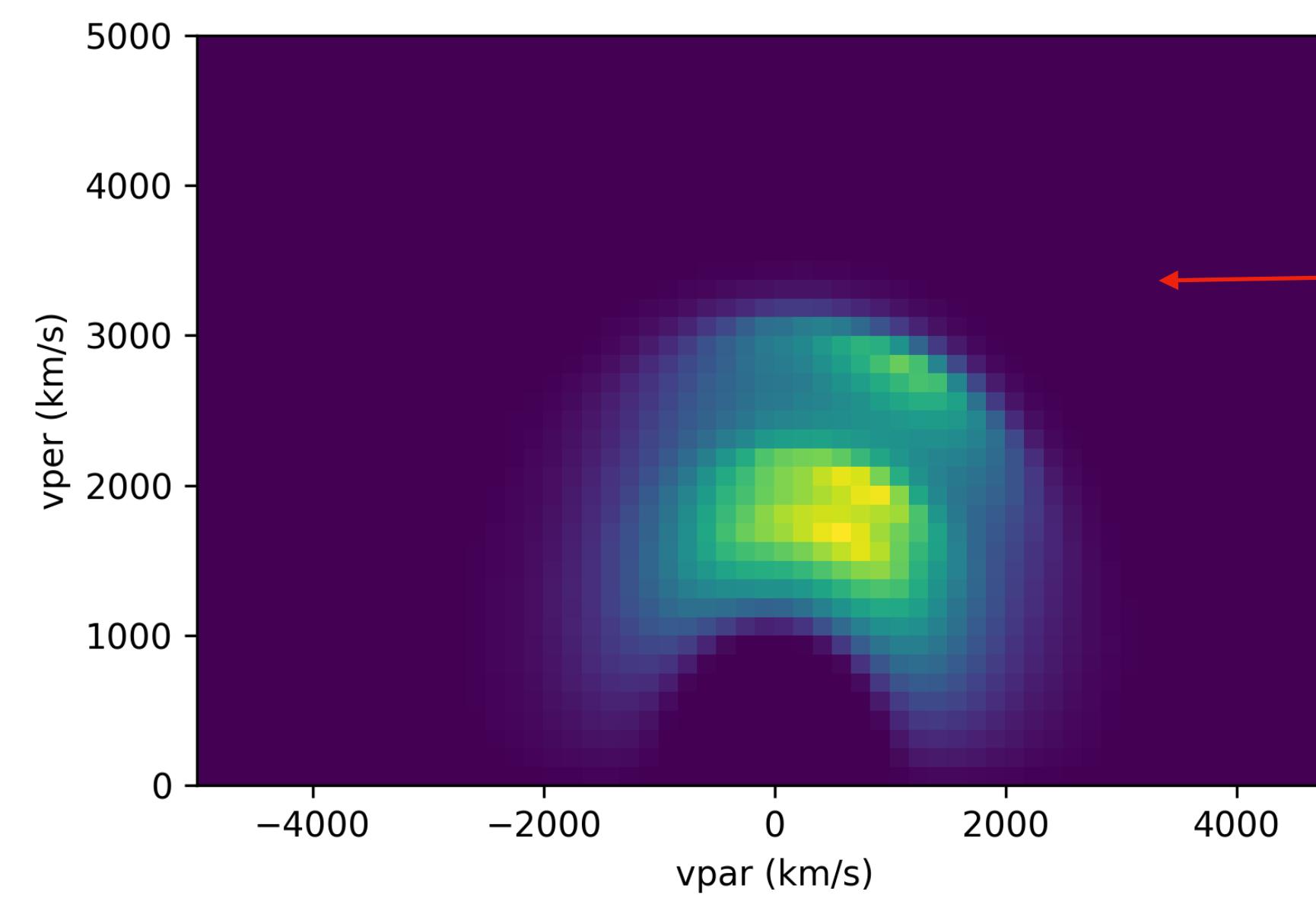


European Transport Simulator - fast ion distributions, NBI and alphas

4D distributions with independent limits and resolutions for each species

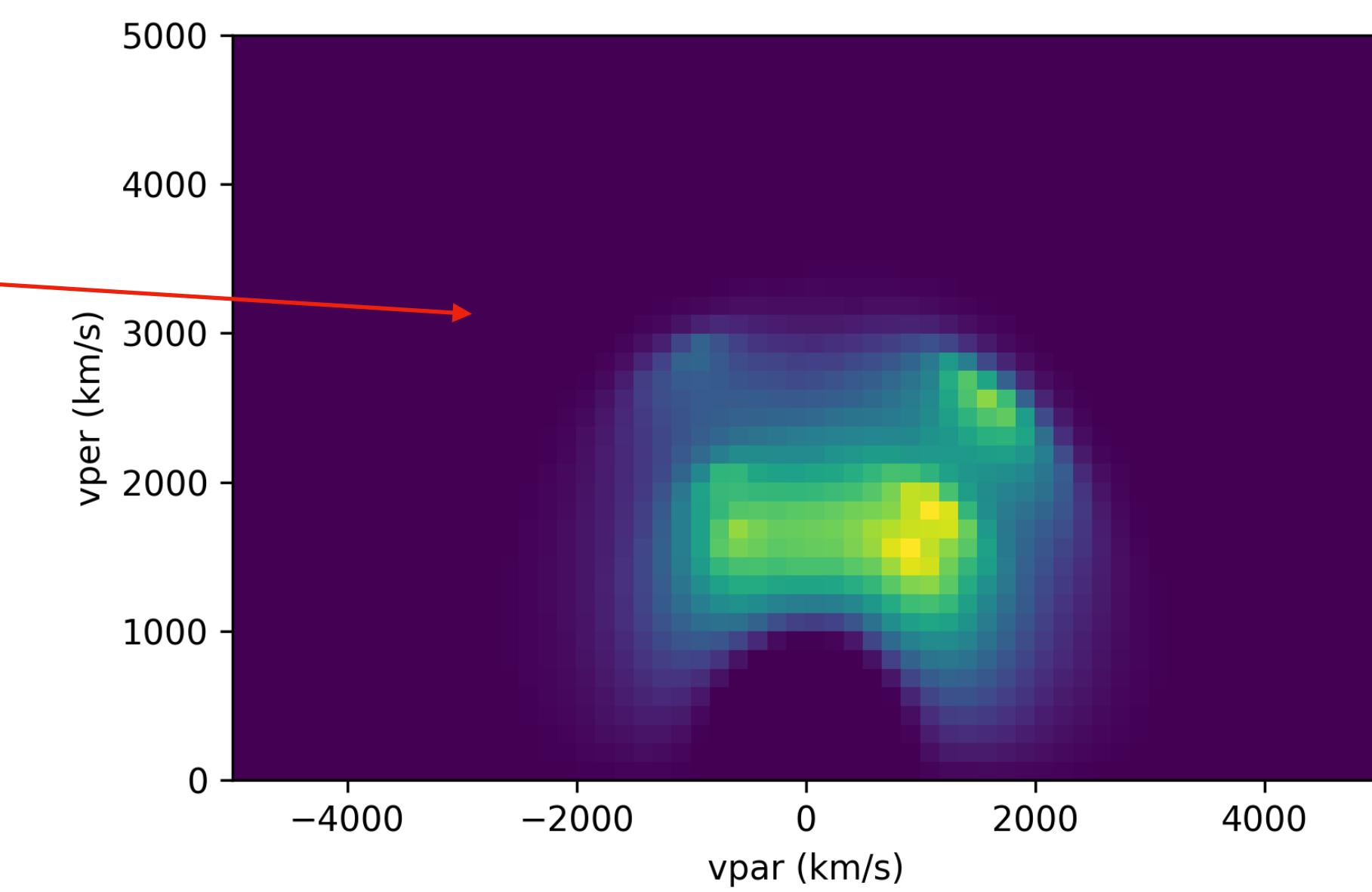
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NBI



codes

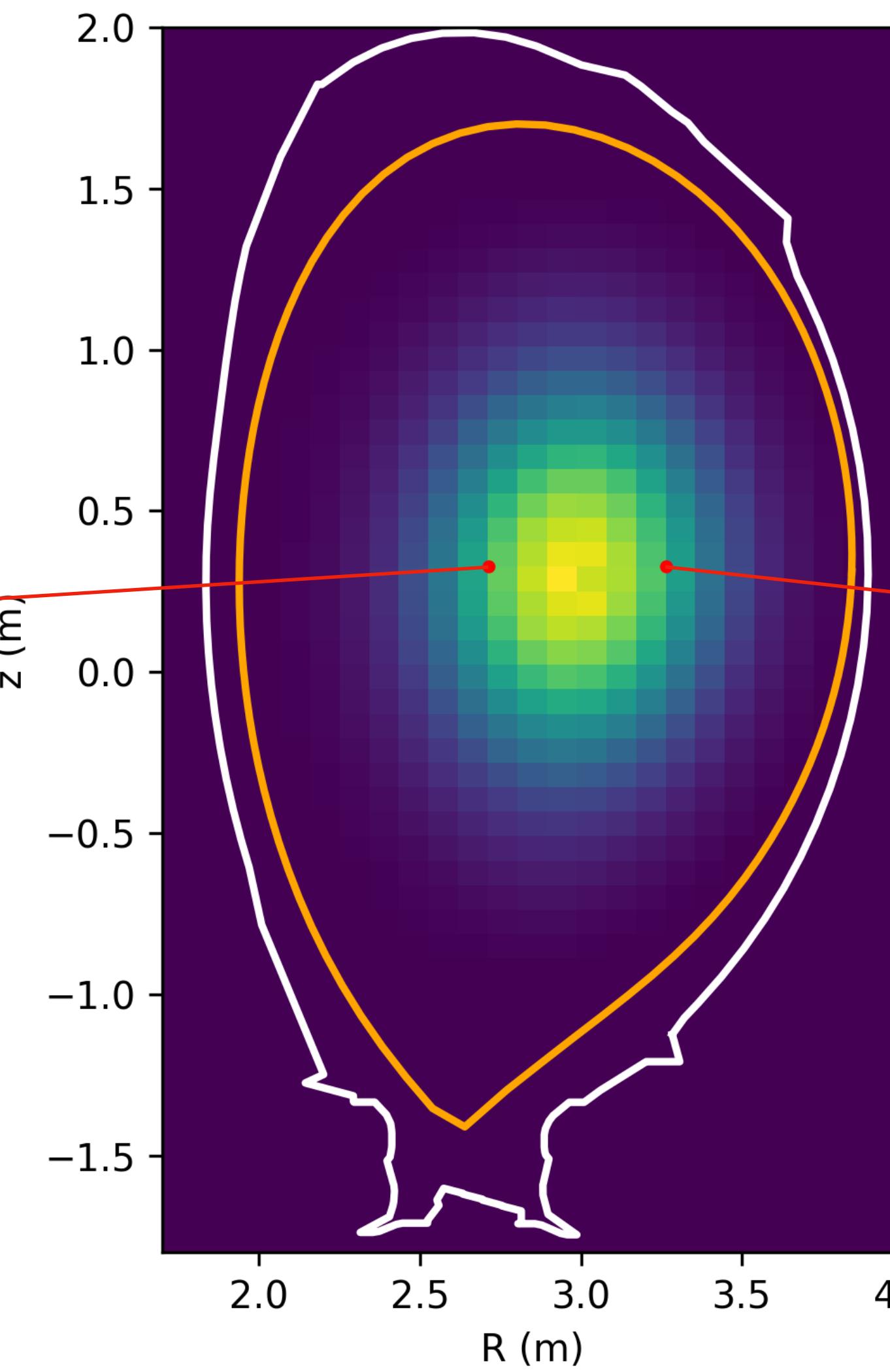
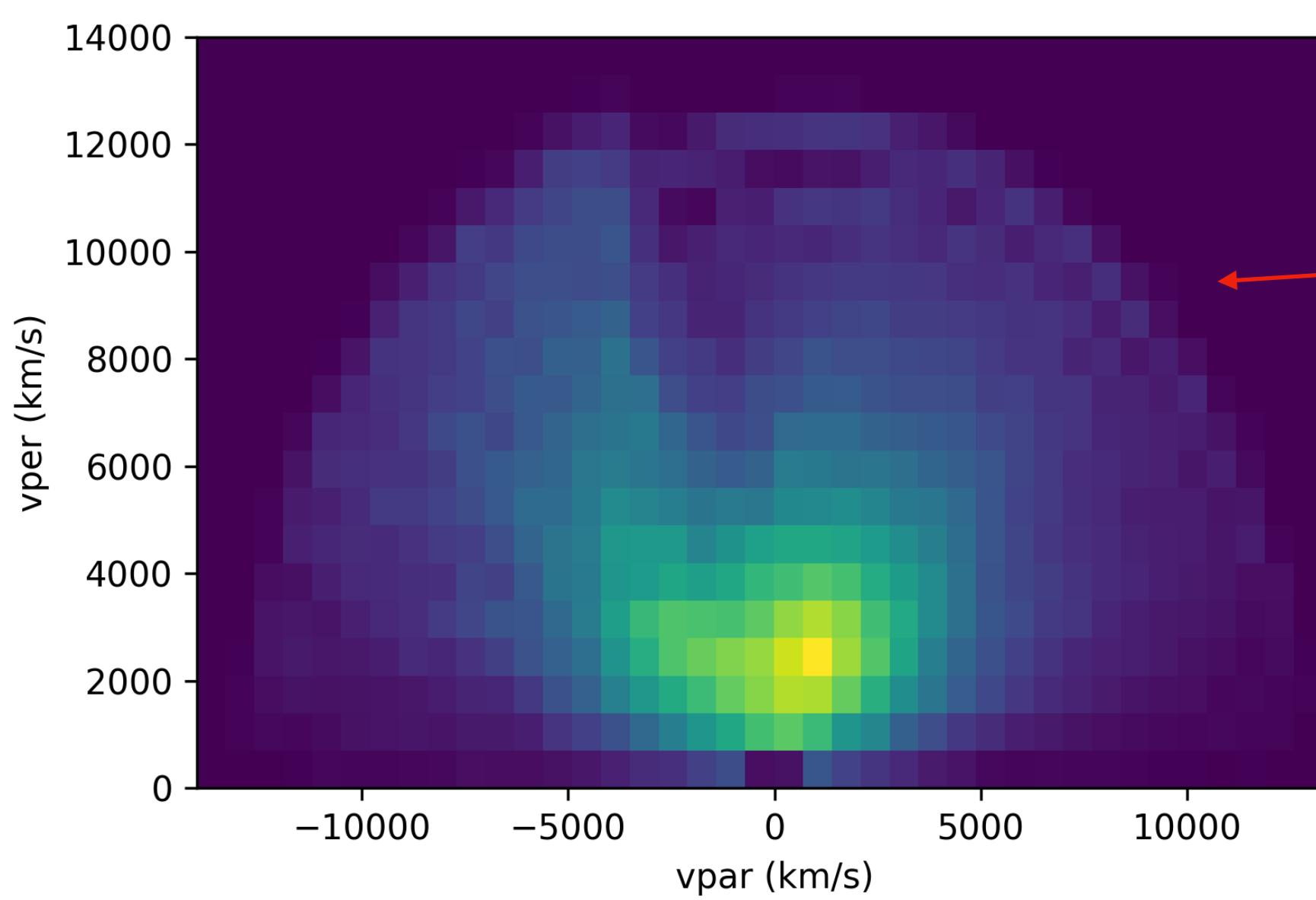
BBNBI / ASCOT



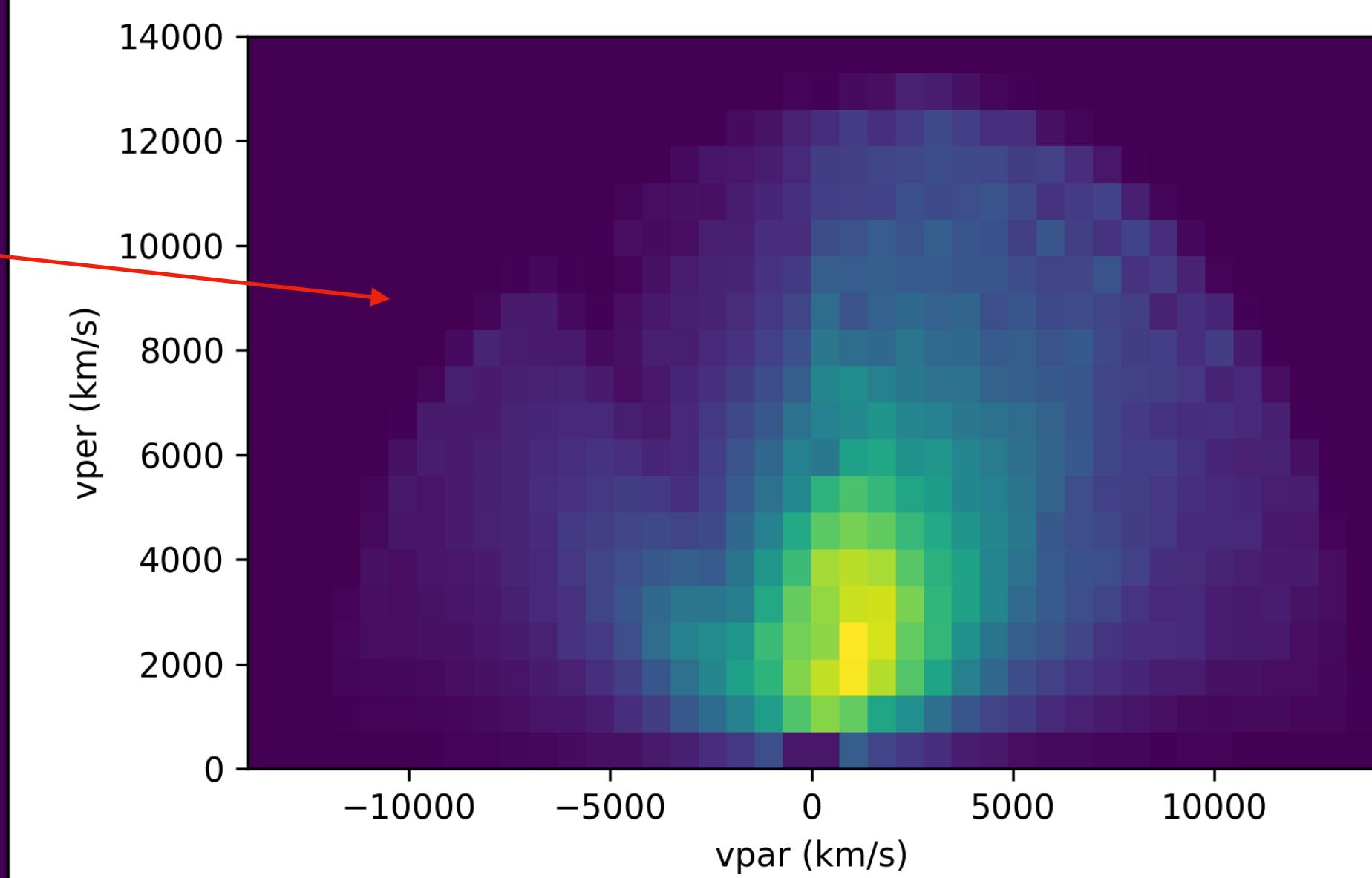
European Transport Simulator - fast ion distributions, NBI and alphas

4D distributions with independent limits and resolutions for each species

source
alphas

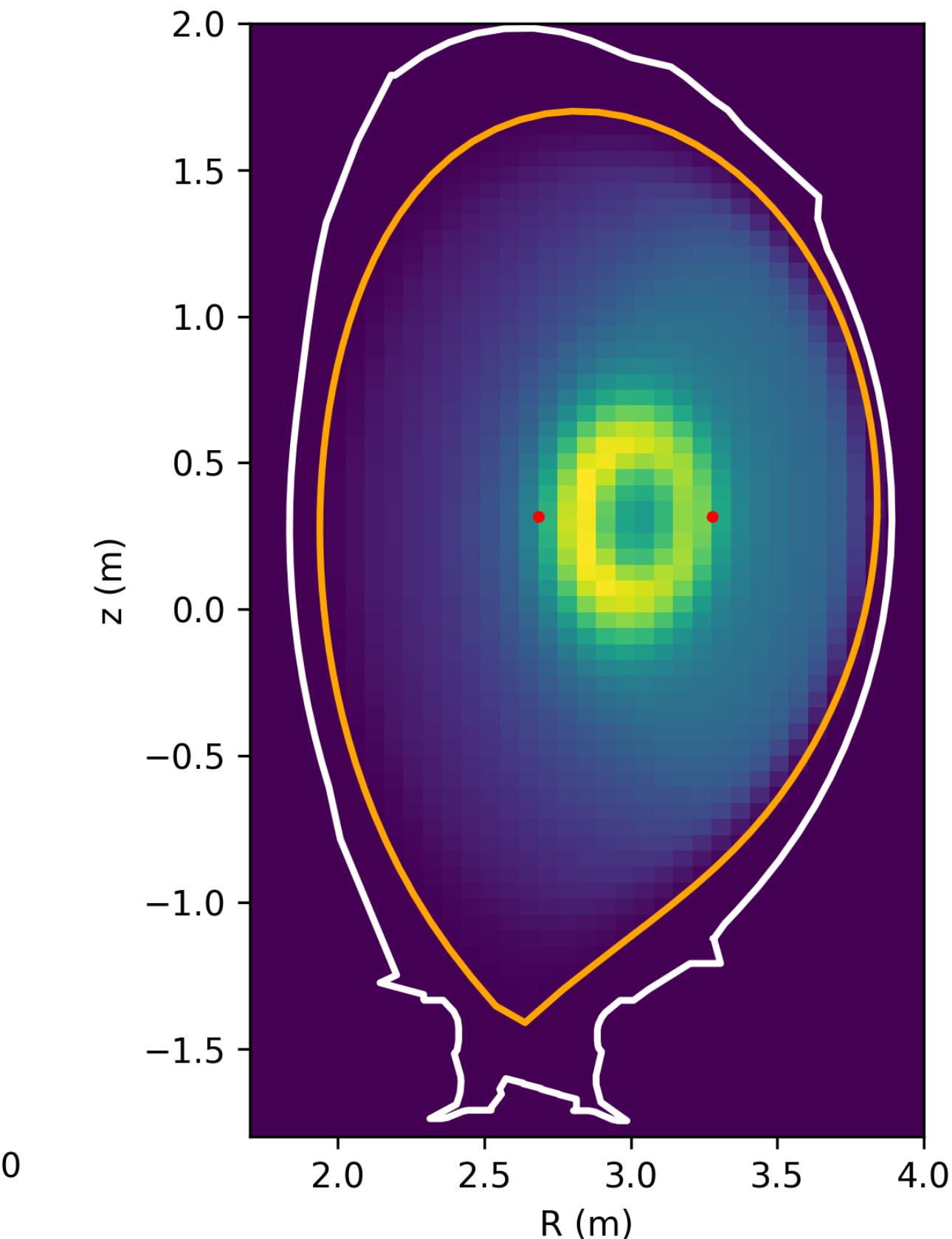
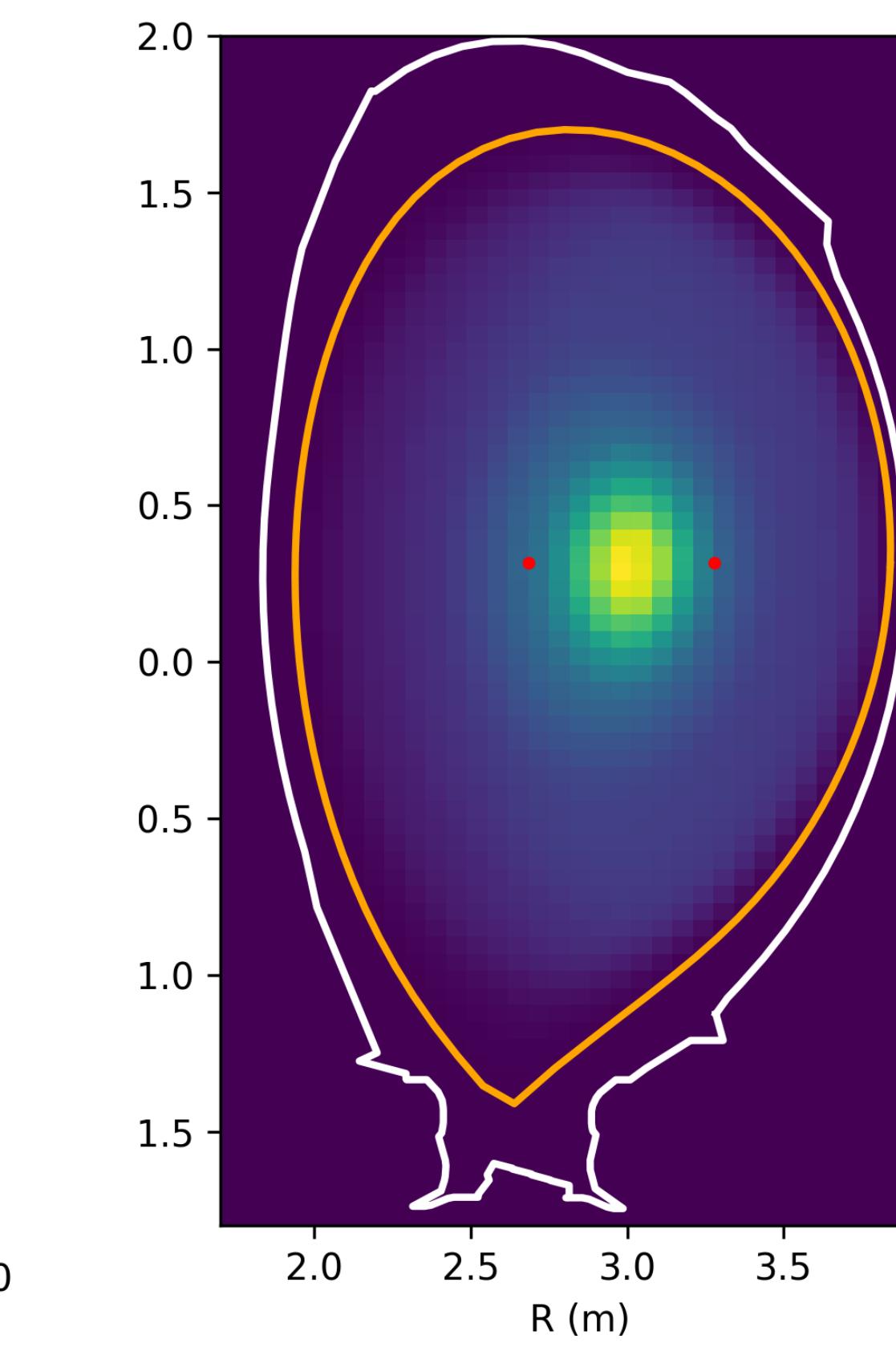
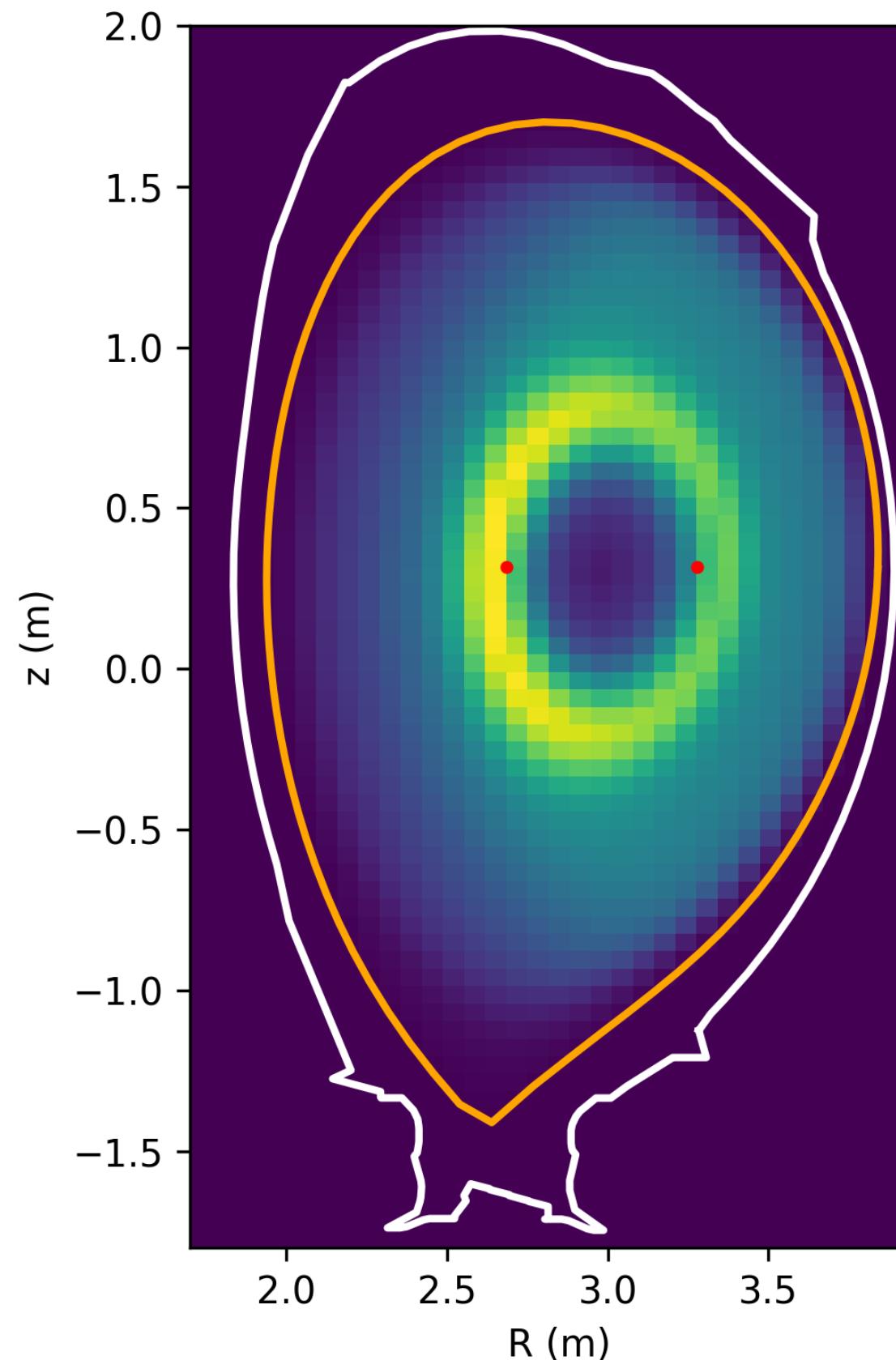
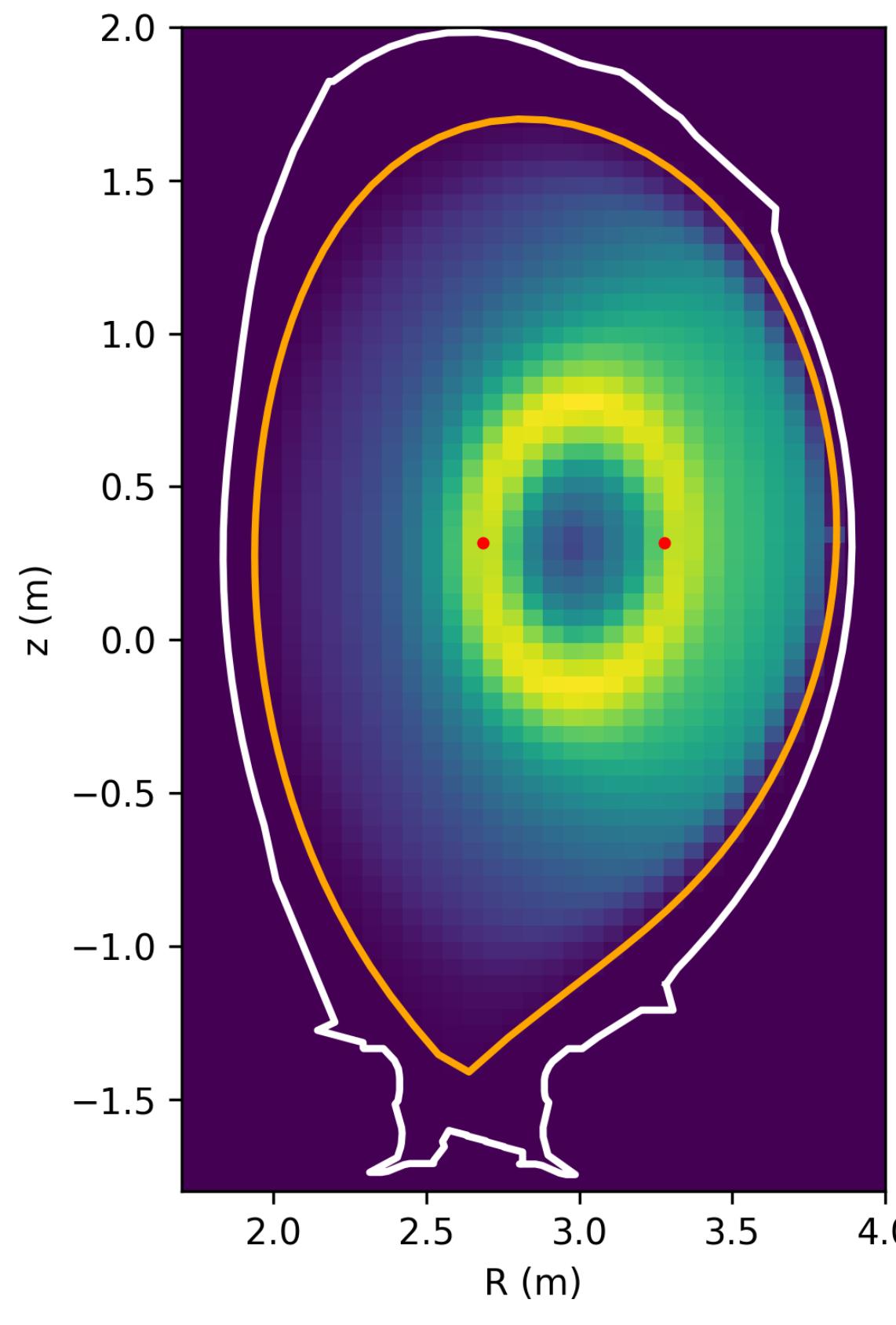


codes
AFSI / ASCOT



European Transport Simulator - fast ion distributions, NBI and alphas

NBI fast ion distributions per beamline
(For EP scenario development by tailoring NBI fast ion distribution)



European Transport Simulator - fast ion distributions, NBI and alphas

Outstanding issue related to IMAS data format

In distributions IDS

In distributions IDS																								
<code>distribution(i1)</code>	Set of distribution functions. Every distribution function has to be associated with only one particle species, specified in <code>distri_vec/species/</code> , but there could be multiple distribution function for each species. In this case, the fast particle populations should be superposed	<code>struct_array</code> [<code>max_size=33</code> (limited in MDS+ backend only)]	1- 1...N																					
<code>ggd(itime)</code>	Distribution represented using the ggd, for various time slices {dynamic}	<code>struct_array</code>	1- <code>distribution(i1)/ggd(itime)/time</code>																					
<code>grid</code>	Grid description	<code>structure</code>																						
<p>Only one distribution can be stored per species. This node (grid) should be an array of structures to support multiple representations. (breaks backward compatibility, actual codes need to be updated)</p>	<p>Grid identifier. Available options (refer to the children of this identifier structure) :</p> <table border="1"><thead><tr><th>Name</th><th>Index</th><th>Description</th></tr></thead><tbody><tr><td>unspecified</td><td>0</td><td>unspecified</td></tr><tr><td>linear</td><td>1</td><td>Linear</td></tr><tr><td>cylinder</td><td>2</td><td>Cylindrical geometry (straight in axial direction)</td></tr><tr><td>limiter</td><td>3</td><td>Limiter</td></tr><tr><td>SN</td><td>4</td><td>Single null</td></tr><tr><td></td><td></td><td>Connected</td></tr></tbody></table>	Name	Index	Description	unspecified	0	unspecified	linear	1	Linear	cylinder	2	Cylindrical geometry (straight in axial direction)	limiter	3	Limiter	SN	4	Single null			Connected		<p>To allow multiple representations (transformations), eg. in low-order constant of motions, or other phase-space coordinates</p>
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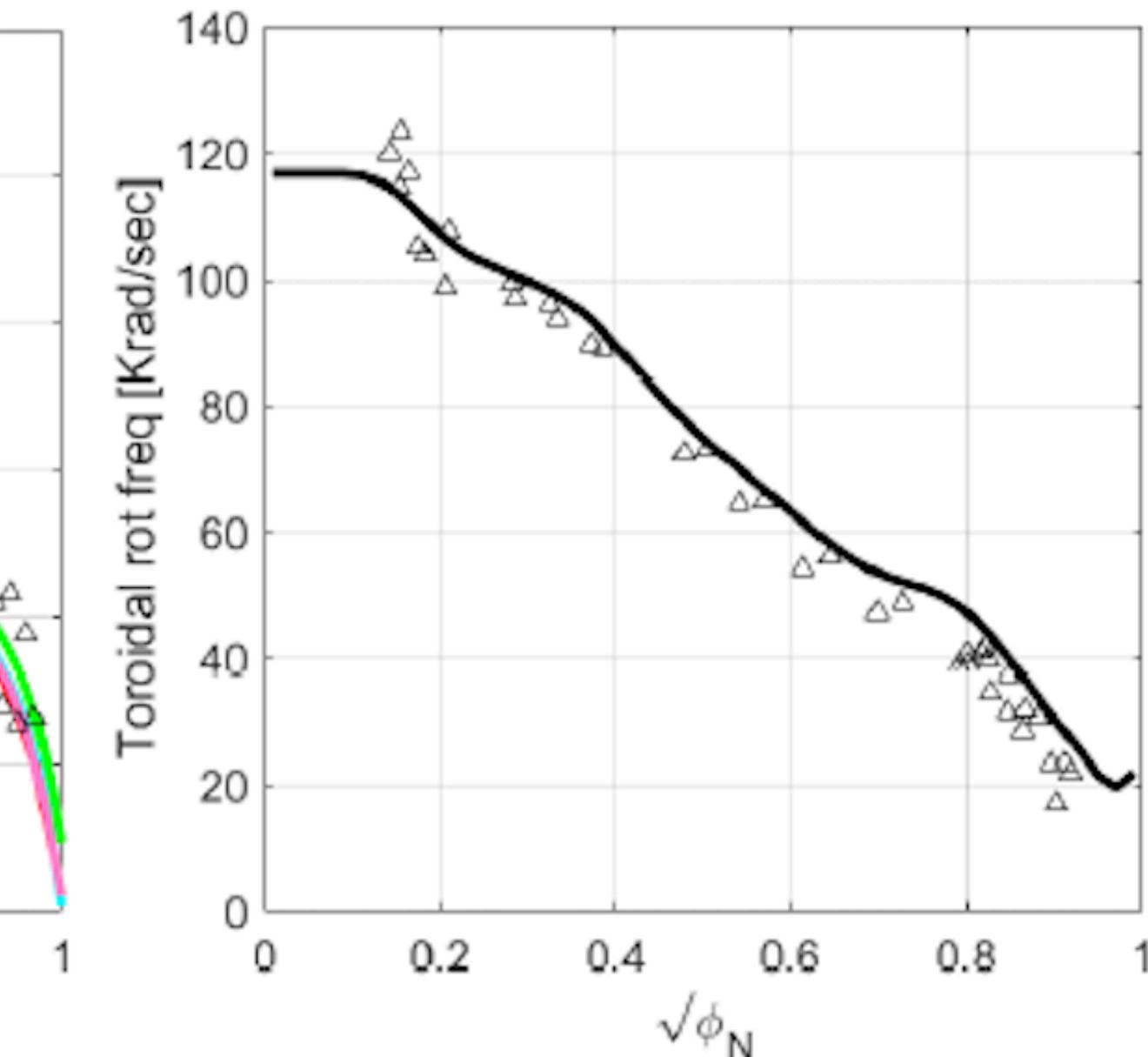
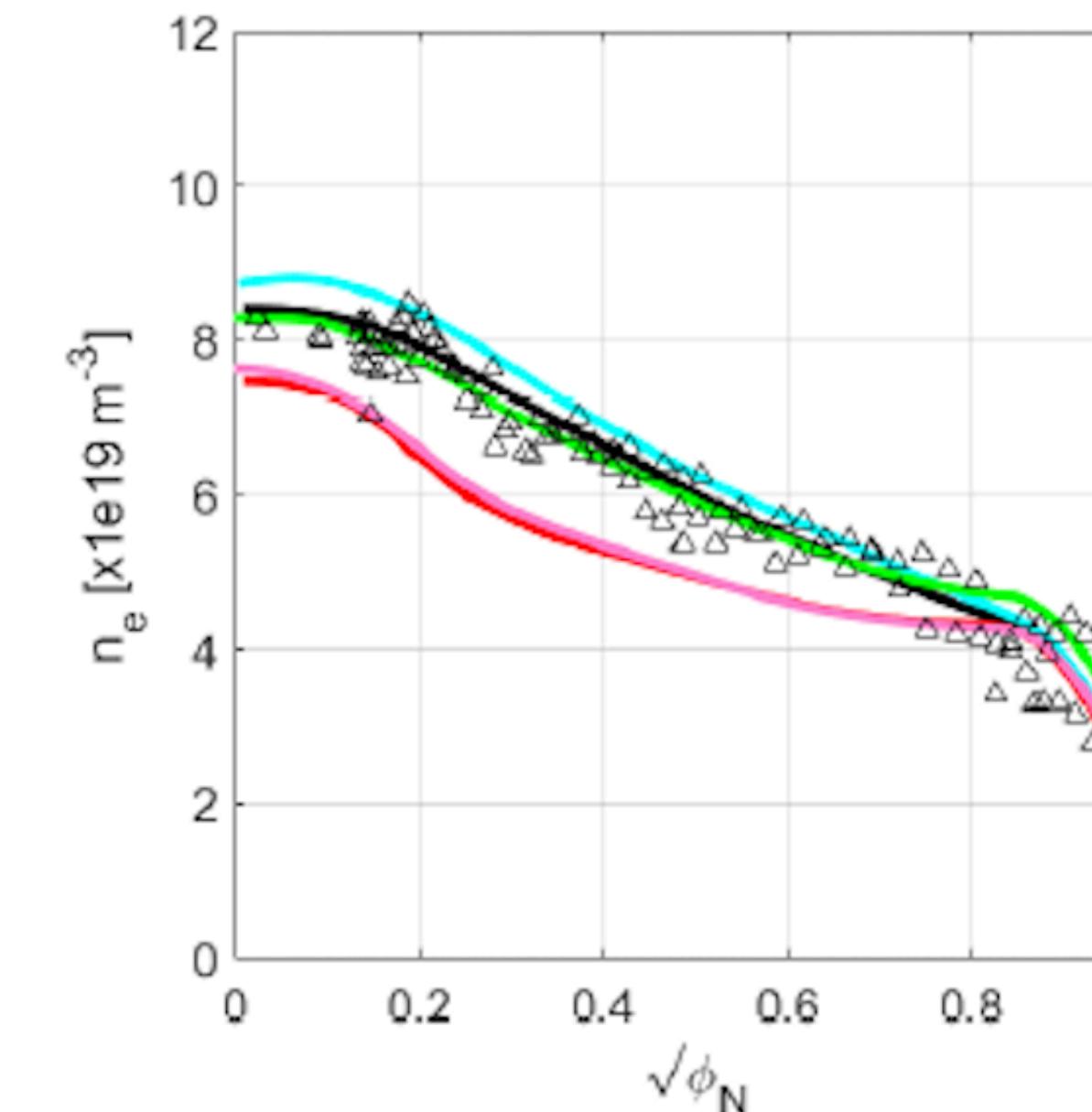
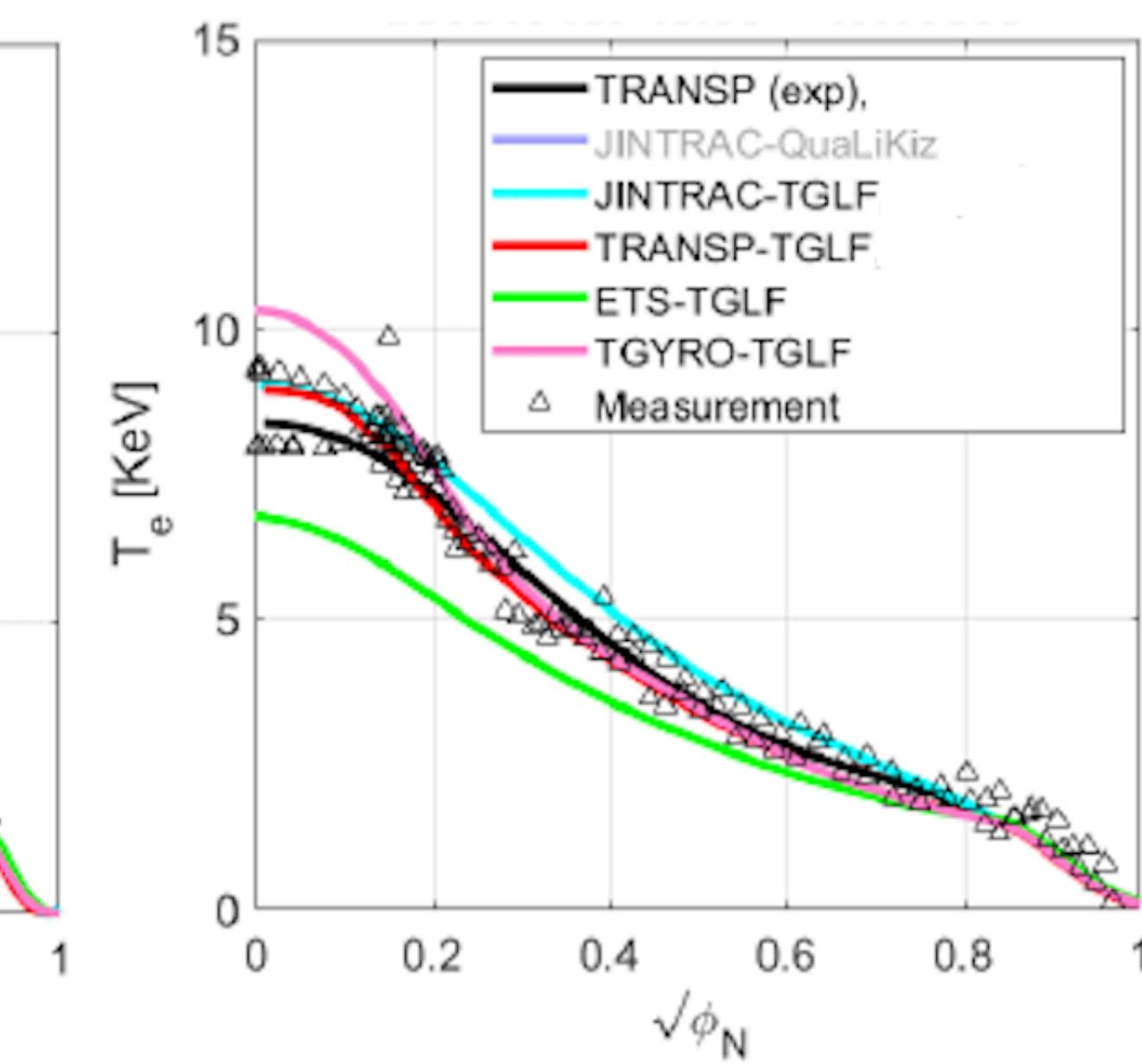
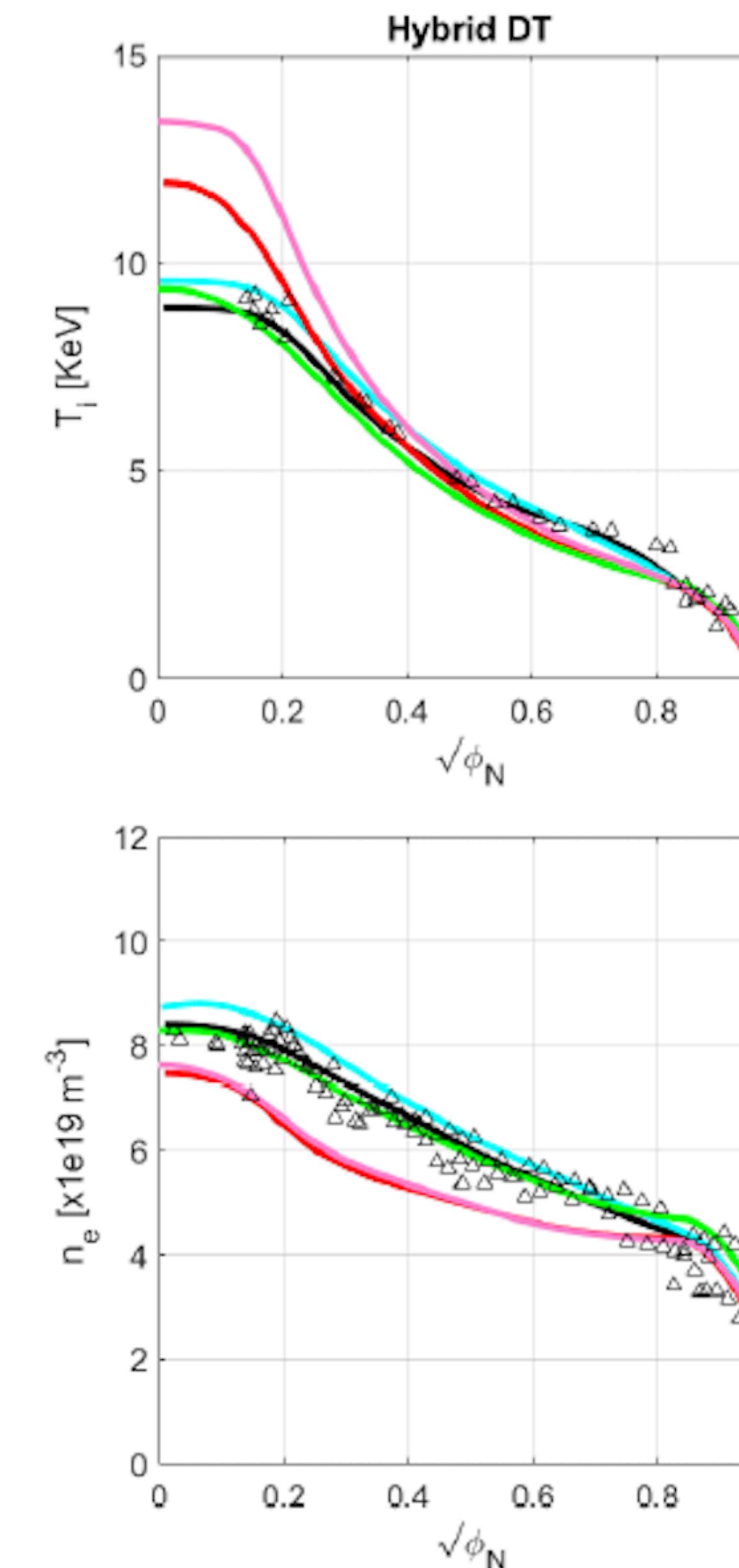
Ongoing Verification and Validation of transport codes on JET DT scenarios

Hybrid DT scenario

transport modelling with ETS,
JINTRAC (HFPS) and TRANSP

Anomalous core transport
is modelled with state-of-the-art
quasi-linear models such as
QuaLiKiz or TGLF,
and HCD sources are fully
consistent with full distributions.

From Validation of DT fusion power
prediction capability against 2021 JET
DT experiments, Hyun-Tae Kim *et all*
NF special issue on *JET DTE2*
(@EUROfusion pinboard).



Integrated modelling of burning plasmas

Thank you!