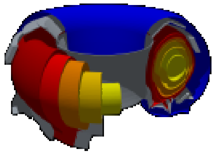


Integrated modelling of L-H transition and ELMy H-mode: what do we have and what do we need?

David Coster

Max Planck Institute for Plasma Physics,
EURATOM Association, Garching, Germany

Three Areas

What do we have? What do we need?

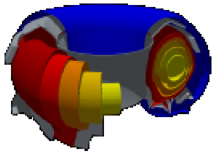
1. 1st principles based theory
2. Experiment
3. Modelling

Theory

- What is the pedestal? What stabilizes it?
  - Responsibility of IMP4
    - Personally think it will be a while before we get answers that everybody agrees on
    - Still some dispute whether anybody has achieved a true H-mode pedestal
      - Let alone ELMs on top of that
- What are ELMs?
  - Partly IMP4, partly IMP2
    - Definitive answers lie in the future
    - And will need to be tested

Experiment

- Large amount of data out there
  - Perhaps need to pre-digest/select for the modellers
- Key data
  - On the L-H transition
  - On the pedestal
  - On ELMs
- Also want the “strange” results!



L-H transition

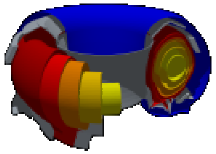
- Dependence on
  - B_t
  - n_e
  - H, D, T, He
  - Ion grad-B direction
  - Geometry
  - ….

Pedestal Characteristics

- For each of
  - Te, ne, Ti
- Need
  - Pedestal width
  - Pedestal height
- And dependencies on
  - Geometry
  - n_e, T_e, T_i or P_{sol}, or ρ^*, ν^*, β
  - Species
  - …

ELM characterization

- When does an ELM occur?
- What is the effect of the ELM on
  - Particles
    - Main
    - Impurities
  - Energy
    - Electron
    - Ion
  - Momentum?
  - What are the scalings of frequency, size etc?



Action Item

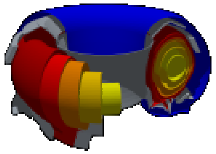
- Can we identify somebody who can act as a point person on the experimental data?
  - Preferably in liaison with ITPA and other similar activities
- Could also be two people
  - Pedestal data
  - ELM data

Modelling

- Models for the pedestal
  - When does it get established?
  - What are its characteristics (size, transport levels)
  - How does it breakdown (ELMs, back transition)
- Needs to be confronted by experimental data

ELM Modelling

- Different approaches
  - Linear pedestal stability (IMP1)
    - Can help determine when it occurs
    - Might give an indication of size
  - Non-linear ELM models (IMP2)
    - Should (eventually) give complete answers
  - Semi-empirical
    - 1d
    - 2d
  - Need to be compared to the experimental data!



Action Item

- Can we standardise the features of a pedestal model? [Kalupin?]
  - Inputs
  - Outputs
- Can we standardize on the features of an ELM model? [Parail?]
  - Inputs
  - Outputs

What tool development is necessary? (Within IMP3)

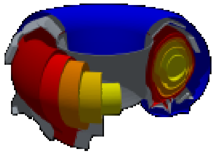
- To what extent are 1d codes satisfactory?
- To what extent are the 2d codes satisfactory?
- What features are we missing?
- What priority should be placed on further core-edge coupling?

Benchmarking of 2d codes

- Ongoing effort underway
  - Agreement for simplest cases
  - More complicated cases still being actively pursued

Benchmarking of 1d codes

- If I use the 1d codes in interpretive mode to analyse the same shot, will I get the same transport profiles?
- If I use the 1d codes in predictive mode, will I get the same result?
  - Including prediction of the density?
  - Including prediction of the pedestal?
  - Including prediction of L-H transition?
- Do we need to increase Benchmarking effort?



Are 1D/2D transport codes the right path?

- For analyzing some problems, the 1- or 2-D codes might not be the right approach
  - But will we really be able to afford the alternatives?
- Need more sophisticated approaches --- but will probably need to come back to the 1- or 2-D approaches because of speed.

IMP3: Transport code and discharge evolution

Topic 3A: MHD equilibrium and stability modules (**G. Perverzev**)

Topic 3B: Non-linear modules (saw-teeth, ELMs, NTMs) (**V. Parail**)

Topic 3C: Transport models (**D. Kalupin**)

Topic 3D: Sources and sinks (**V. Basiuk**)

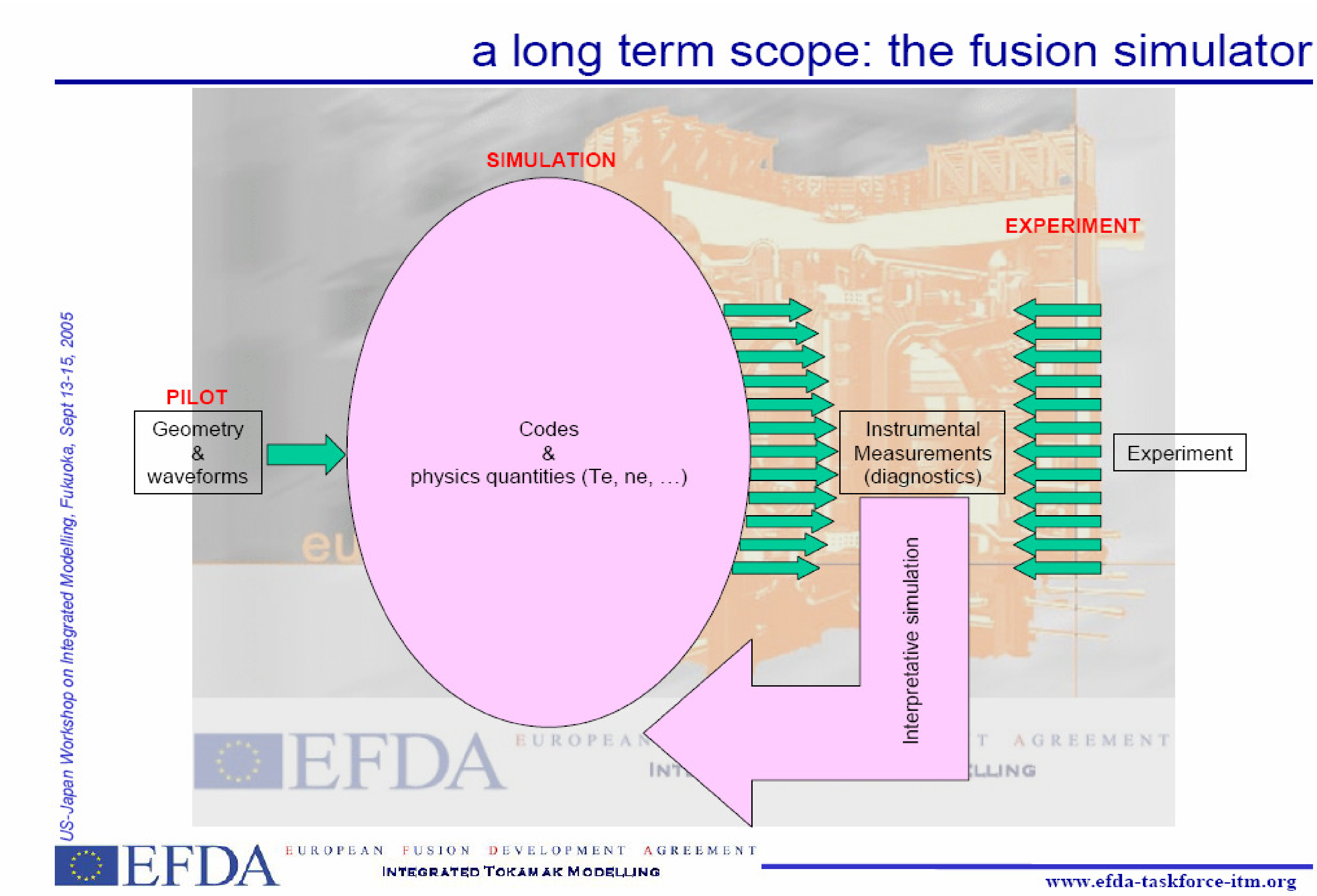
Topic 3E: Interfaces to boundaries (**D. Coster**)

Remind you of the goal of the Task Force?

The aim of the task force is to co-ordinate the development of a coherent set of validated simulation tools for the purpose of benchmarking on existing tokamak experiments, with the ultimate aim of providing a comprehensive simulation package for ITER plasmas.

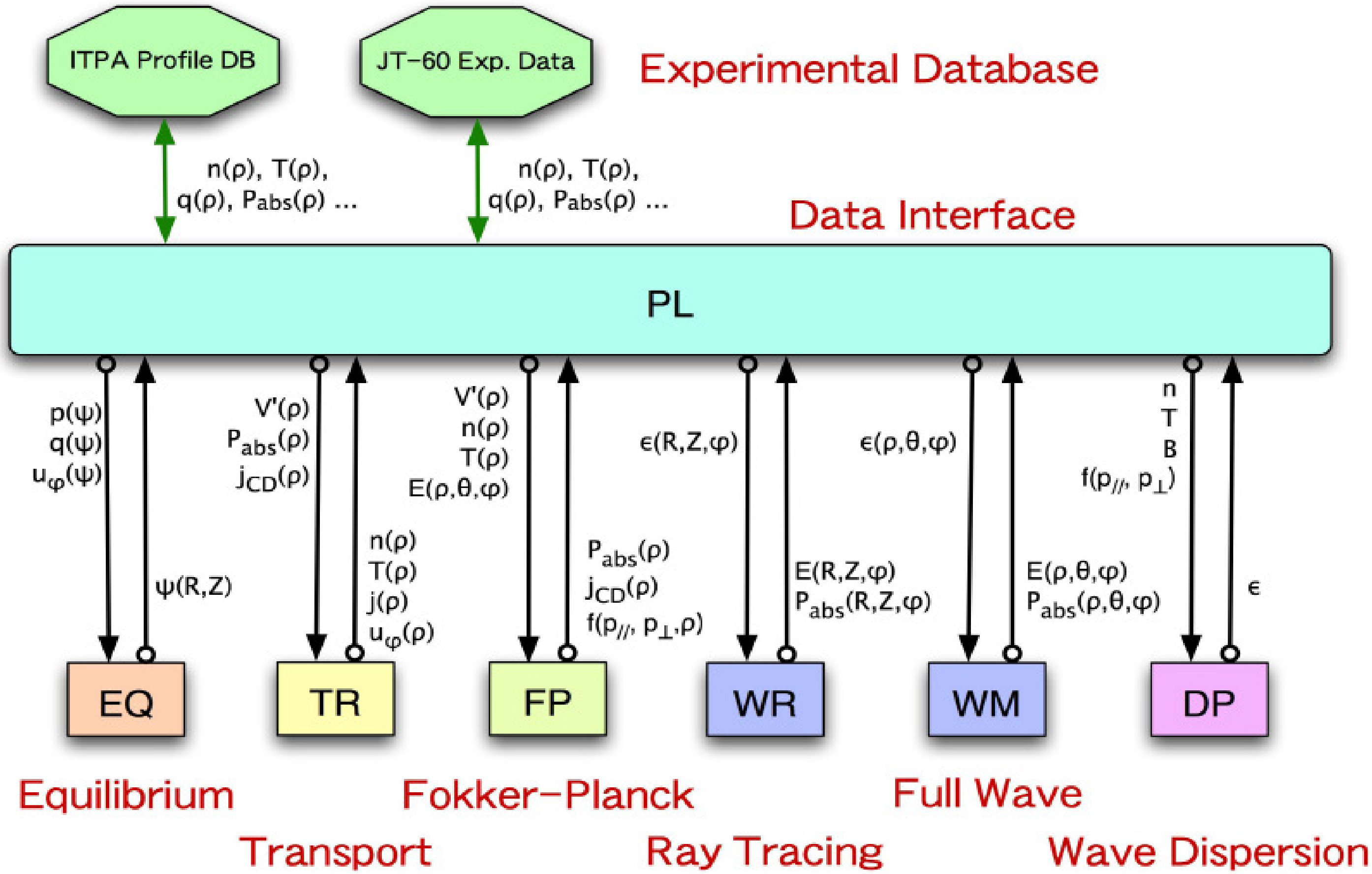
Backup

Vision 1: Becoulet



Vision 2: Fukuyama

New Modular Structure of TASK



Vision 3: Suttrop

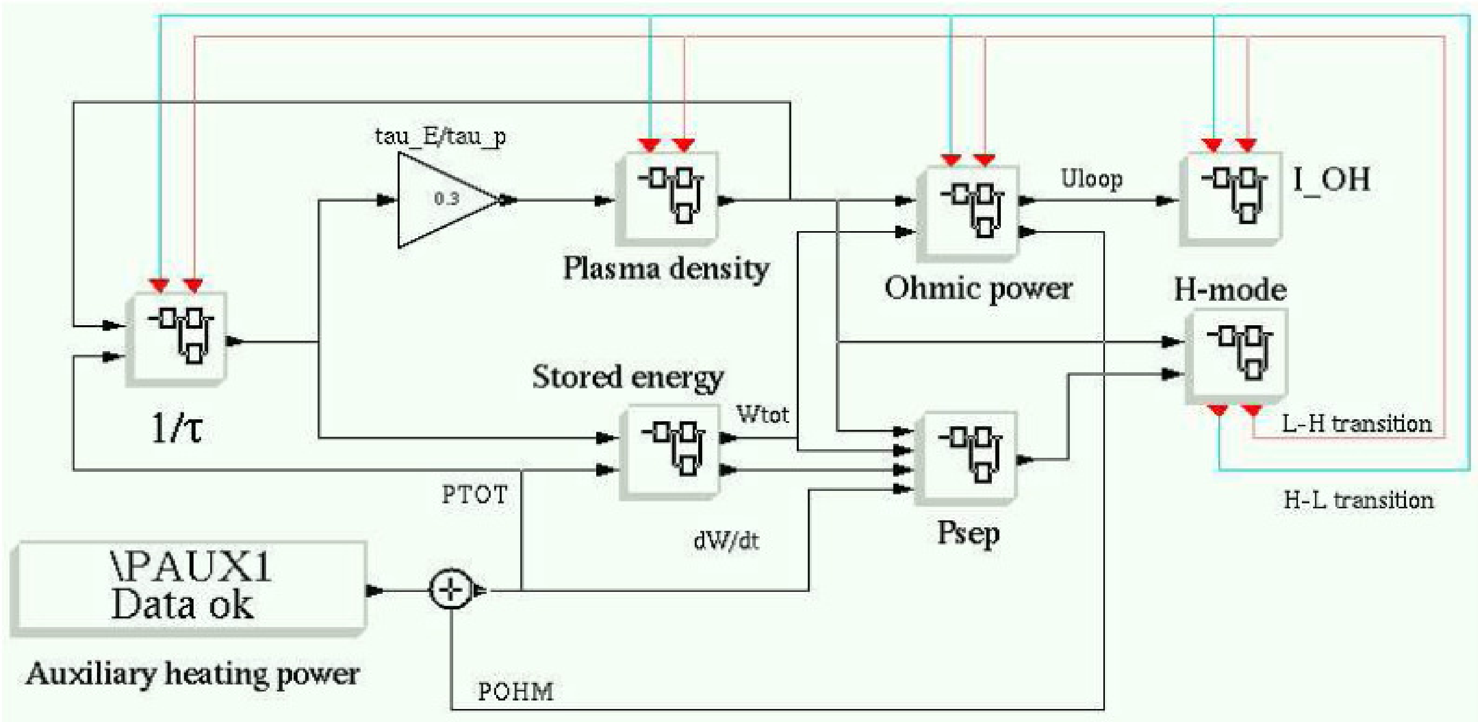
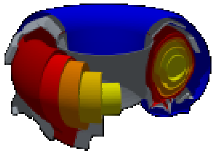


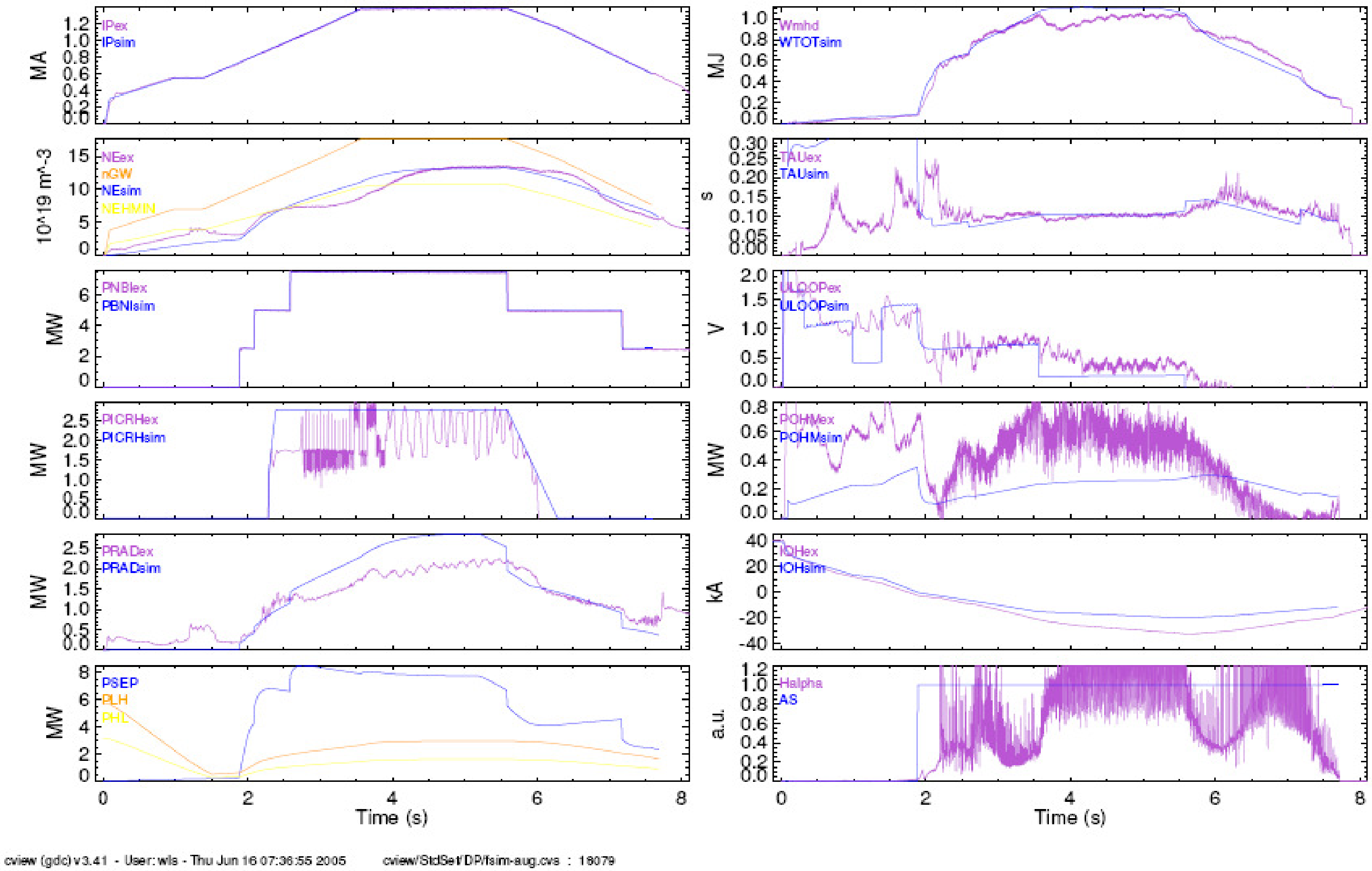
Figure 3: *Scicos model for L- and H-mode plasma density, stored energy and ohmic transformer flux consumtion.*

0d, time dependent model for AUG

W. Suttrop, L. Hoellt, and the ASDEX Upgrade Team: EPS 2005



Vision 3: Suttrop



W. Suttrop, L. Hoellt, and the ASDEX Upgrade Team: EPS 2005

Figure 4: *Comparison of predicted and measured waveforms of ASDEX Upgrade shot 18079*

Vision 4: Jardin

Login:

A.Physicist

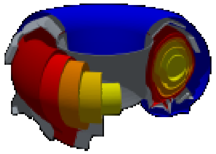
Password:

****

Define new project

Continue with existing project

S. Jardin, FSP Meeting

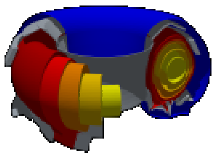


New project definition page

Project Type:

- Whole Device Modeling
- Pellet Injection
- Global Stability Analysis
- Coupled MHD-RF
- Turbulence Modeling
- Coupled MHD-turbulence
- RF Heating
- Coupled MHD-Edge
- Edge Physics
- Coupled Edge-turbulence

S. Jardin, FSP Meeting



Global Stability Home Page

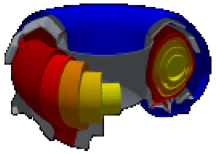
Initial Equilibrium:

- From WDM Simulation
- From Exp. reconstruction
- Define-fixed boundary
- Define-free boundary

Run Log number

ITER003912

record	time	q(0)	Te(0)	IP
1	50.0	5.2	3.2	10.0
2	100.	1.01	3.5	20.0
3	101.	0.99	10.2	20.0
4	102.	0.98	12.1	20.0
5	103.	0.97	12.2	20.0
6	104.	0.96	12.3	20.0
7	200.	1.01	15.0	20.0
8	250.	1.01	5.0	18.0
9	300.	1.01	3.0	10.0



Initial equilibrium from WDM simulation ITER003912

Record = 5, time=1.03, q(0) = 0.97, Te(0) = 12.2, I_p *= 20MA*

Choose Global Stability Simulation Package

NIMROD — info

M3D — info

M3D-C1 — info

LBNL AMR Code — info

Graph 1

Graph 2

Graph 3

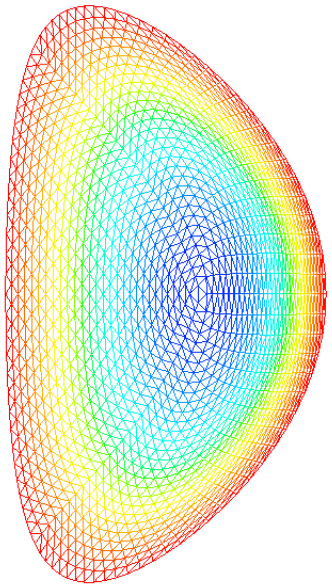
Graph 4

S. Jardin, FSP Meeting

Initial equilibrium from WDM simulation ITER003912

Record = 5, time=1.03, q(0) = 0.97, Te(0) = 12.2, I_p *= 20MA*

M3D Initial Grid Definition:



Align with surfaces

Geometric packing

quad

Triangular

Graph 1

Graph 2

Graph 3

Graph 4

Radial points:

Poloidal points:

Number of packing surfaces

q-values

Compute and draw

Manual adjust

Save and continue

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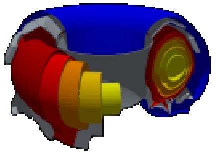

Initial equilibrium from WDM simulation ITER003912

Record = 5, time=1.03, q(0) = 0.97, Te(0) = 12.2, I_p *= 20MA*

Graph 1

Graph 2

Graph 3

Graph 4

M3D Extended MHD Model definition:

Ion equation	Electron equation
Gyroviscous stress tensor	Hall Term Included
Drift ω* approximation	Electron inertia included
Neoclassical parallel	Neoclassical parallel

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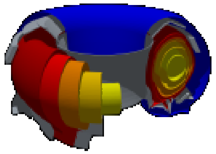

Initial equilibrium from WDM simulation ITER003912

Record = 5, time=1.03, q(0) = 0.97, Te(0) = 12.2, I_p *= 20MA*

M3D Additional Input Parameters:

quantity	default	input	
Problem run time			description
Output frequency			description
Timestep factor			description
Hyperviscosity coeffficient			description
Number of toroidal modes			description
……..			description
……..			description
……..			description
……..			description

Graph 1

Graph 2

Graph 3

Graph 4

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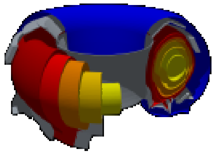

Initial equilibrium from WDM simulation ITER003912

Record = 5, time=1.03, q(0) = 0.97, Te(0) = 12.2, I_p *= 20MA*

Final Review of M3D Problem Setup:

Grid drawing

N = …..

M = ….

Etc……

Extended MHD Model:….

Problem time:…..

Output disposition:…..

Graph 1

Graph 2

Graph 3

Graph 4

submit