ITM Task Force meeting
19-21 September 2007

EFDA
EUROPEAN FUSION DEVELOPMENT AGREEMENT
Task Force
INTEGRATED TOKAMAK MODELLING

2D Fluid Modeling of the ASDEX Upgrade Far SOL

F. Subba, X. Bonnin[1], D. Coster[2] and R. Zanino

Dipartimento di Energetica, Politecnico di Torino, Italy
[1] University of Paris, France
[2] IPP Garching, Germany

Outline

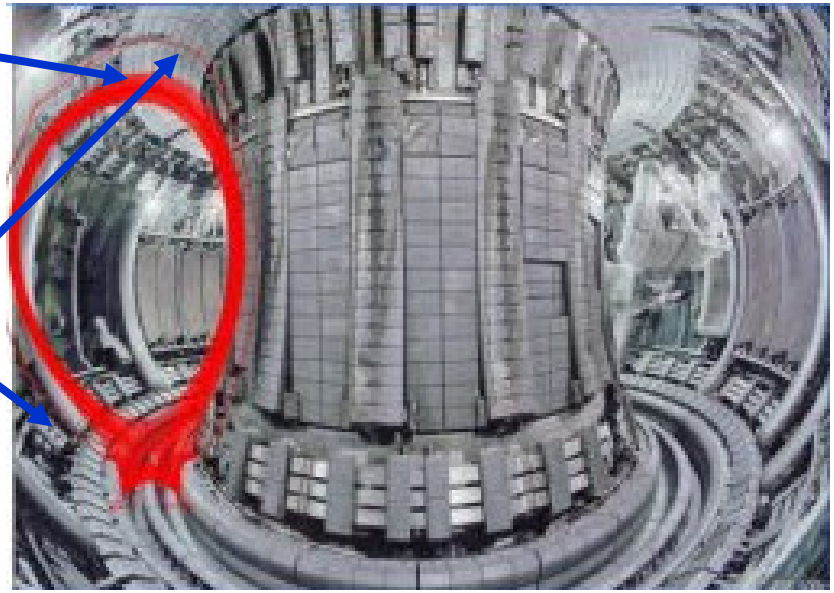
- Motivation
- Strategy for SOL modelling up to FW
- Models
- Mesh
- Near-far SOL coupling
- Application to ASDEX Upgrade
- Conclusions

Motivation (I)

Traditional approach to edge plasma modelling

Near SOL: well represented by edge modelling codes

Far SOL: usually not included



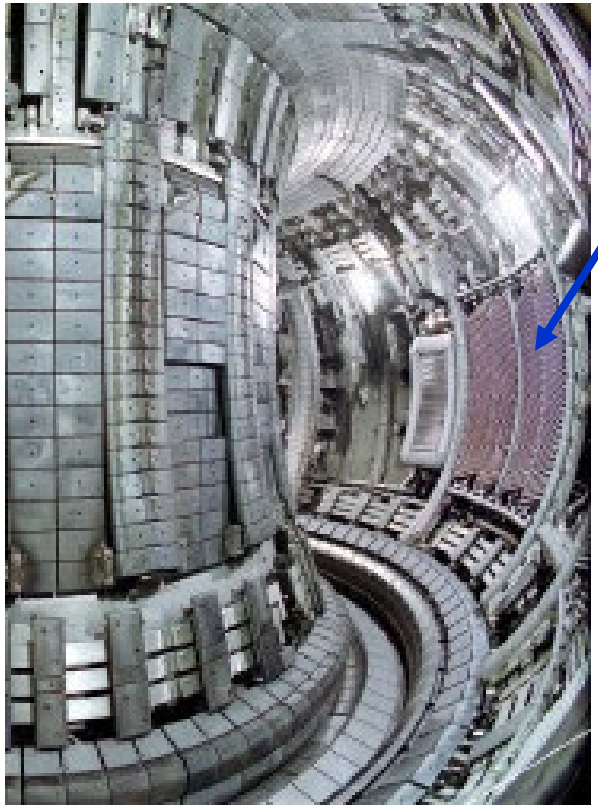
Source:www.eirene.de

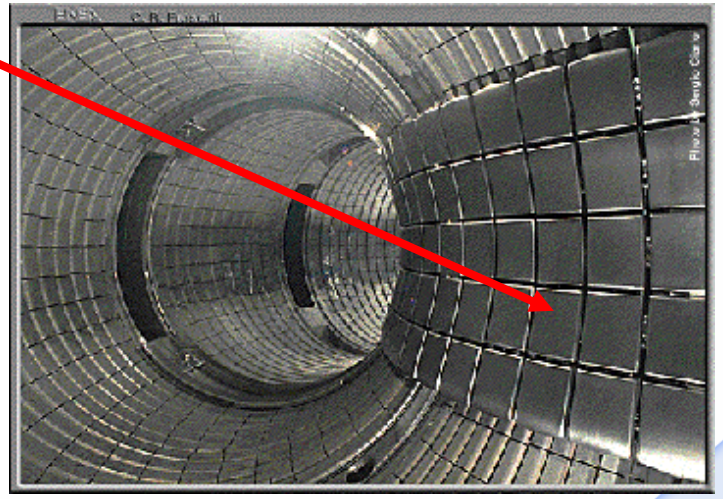
Motivation (II)

Reasons to focus interest on the far SOL

Plasma conditions in the far SOL affect analysis and prediction of ITER ICRH antenna performance

Limiter plasmas, e.g. First Wall/Limiter (FTU, IGNITOR, …) and/or divertor start-up (ITER, …) require FW description





Source: http://ftu.frascati.enea.it

Strategy for SOL Modelling up to FW

- Well developed codes (e.g., B2) exist for near-SOL modelling
  - Finite Volume schemes
  - Structured quadrilateral meshes
- The ASPOEL code is being developed at PoliTo, with emphasis on the far SOL [F. Subba, et al., *J. Nucl. Mater.* (2007)]
  - Control Volume Finite Element (CVFE) schemes (conservative)
  - Triangular (in principle unstructured) meshes ➔ increased geometrical flexibility

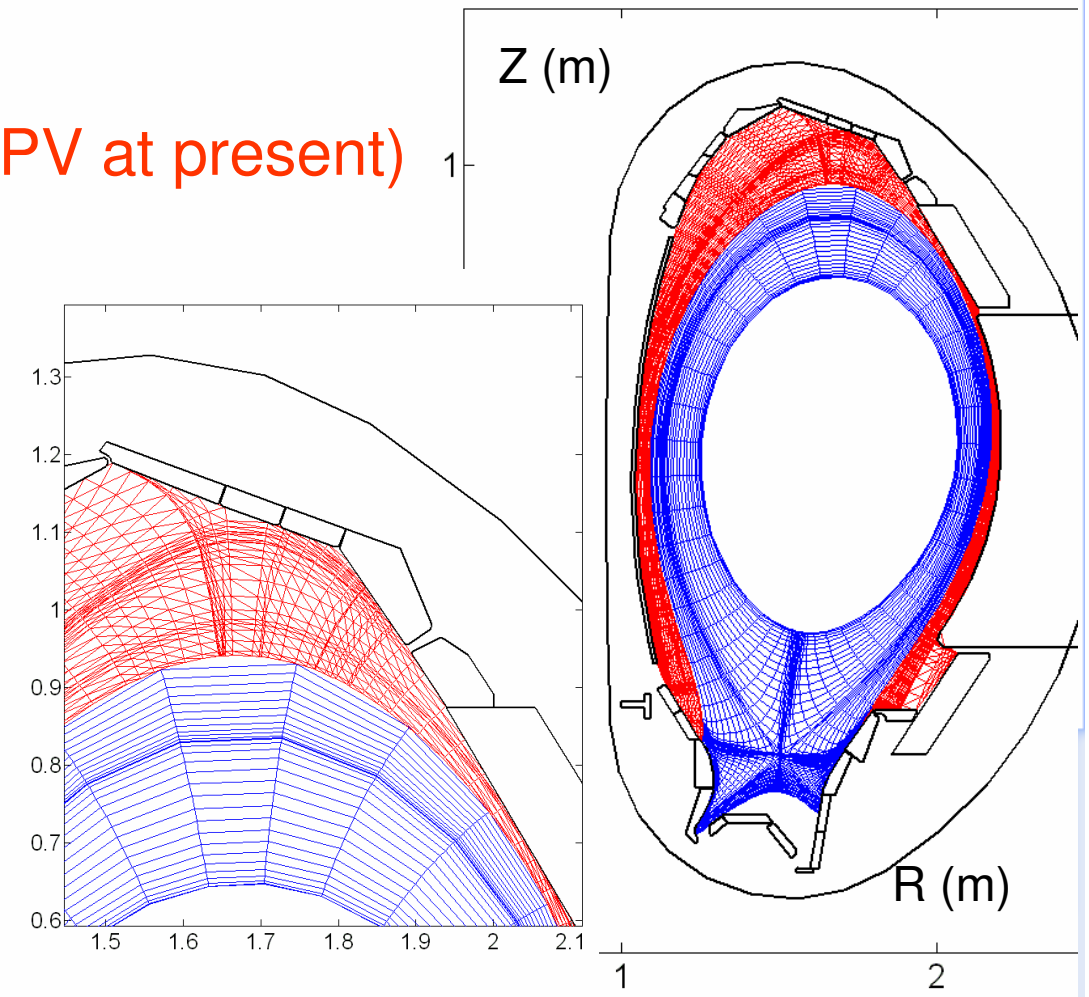
Use different codes for different SOL regions

Models

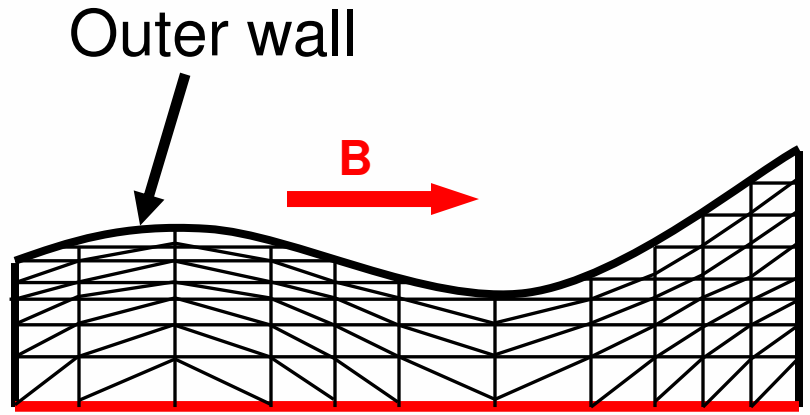
- ASPOEL
  - Two fluids, single ion species + electrons
  - Conserve particles, momentum and energy
  - No neutrals
- B2 (as used here)
  - Reduced to roughly same plasma model as ASPOEL
  - Neutrals (fluid approximation)

Mesh (I)

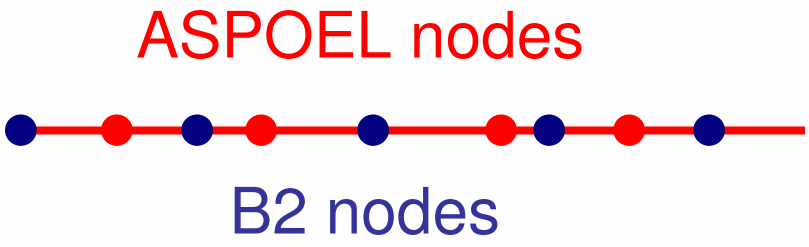
- ASPOEL
  - Fills the far SOL (no far PV at present)
  - ~ 6000 elements
  - Triangular
- B2
  - Fills the near SOL
  - ~ 3700 cells
  - Quadrilateral



Mesh (II)

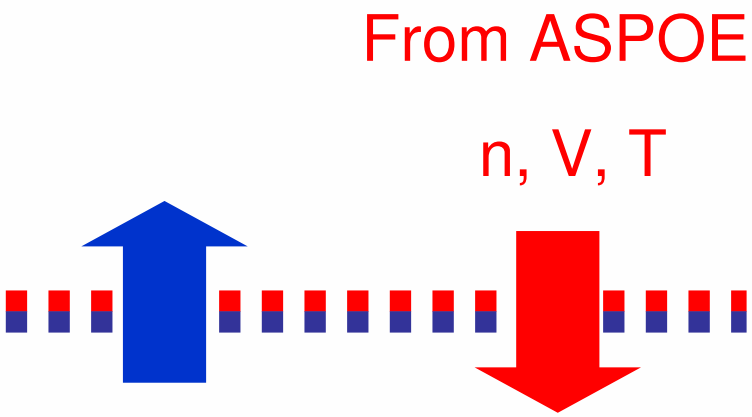


ASPOEL meshes are accurately aligned to B and interpolate the FW geometry



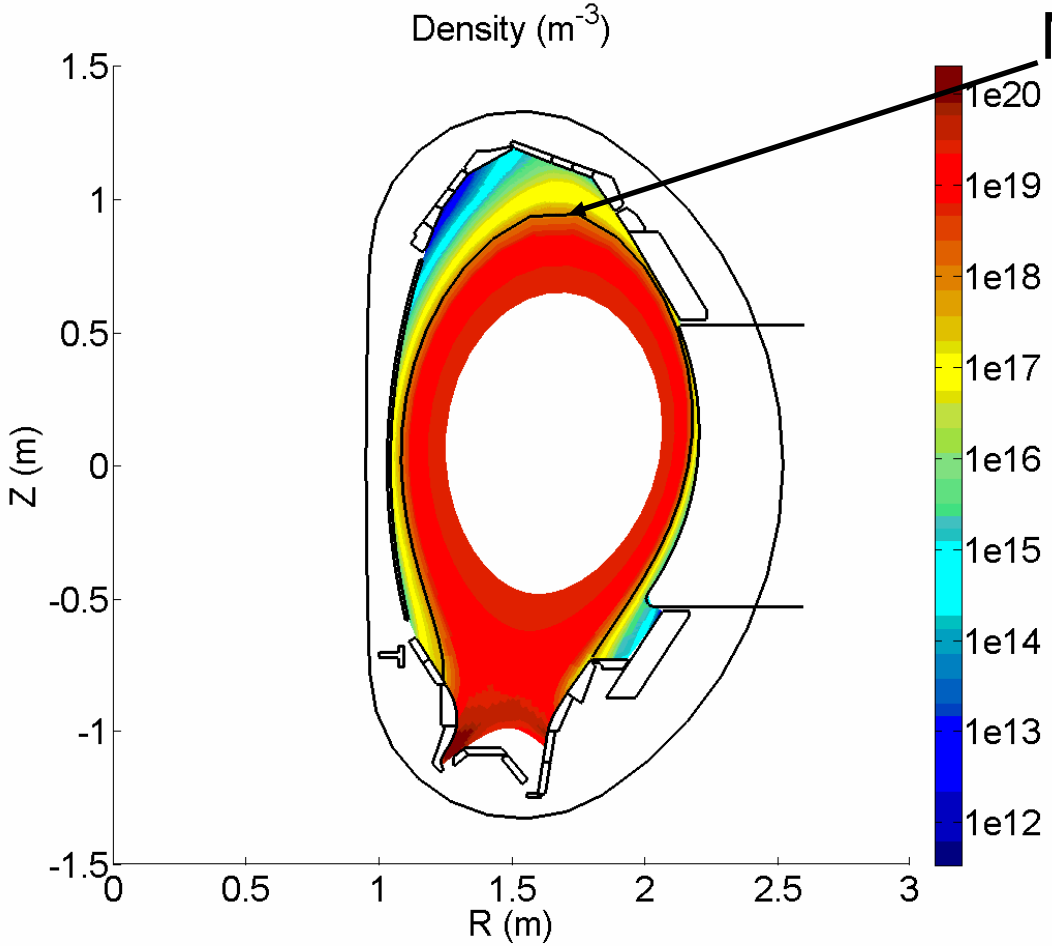
Nodes are not coincident at the interface surface ➔ interpolation is needed

B2-ASPOEL coupling (I)



- B2 and ASPOEL are coupled through an interface magnetic surface
- A consistent solution is produced via an **iterative procedure**
- Information sharing:
  - ASPOEL: use B2 computed fluxes as boundary condition at the interface
  - B2: use ASPOEL computed profiles as boundary condition at the interface

Application: ASDEX Upgrade (I)

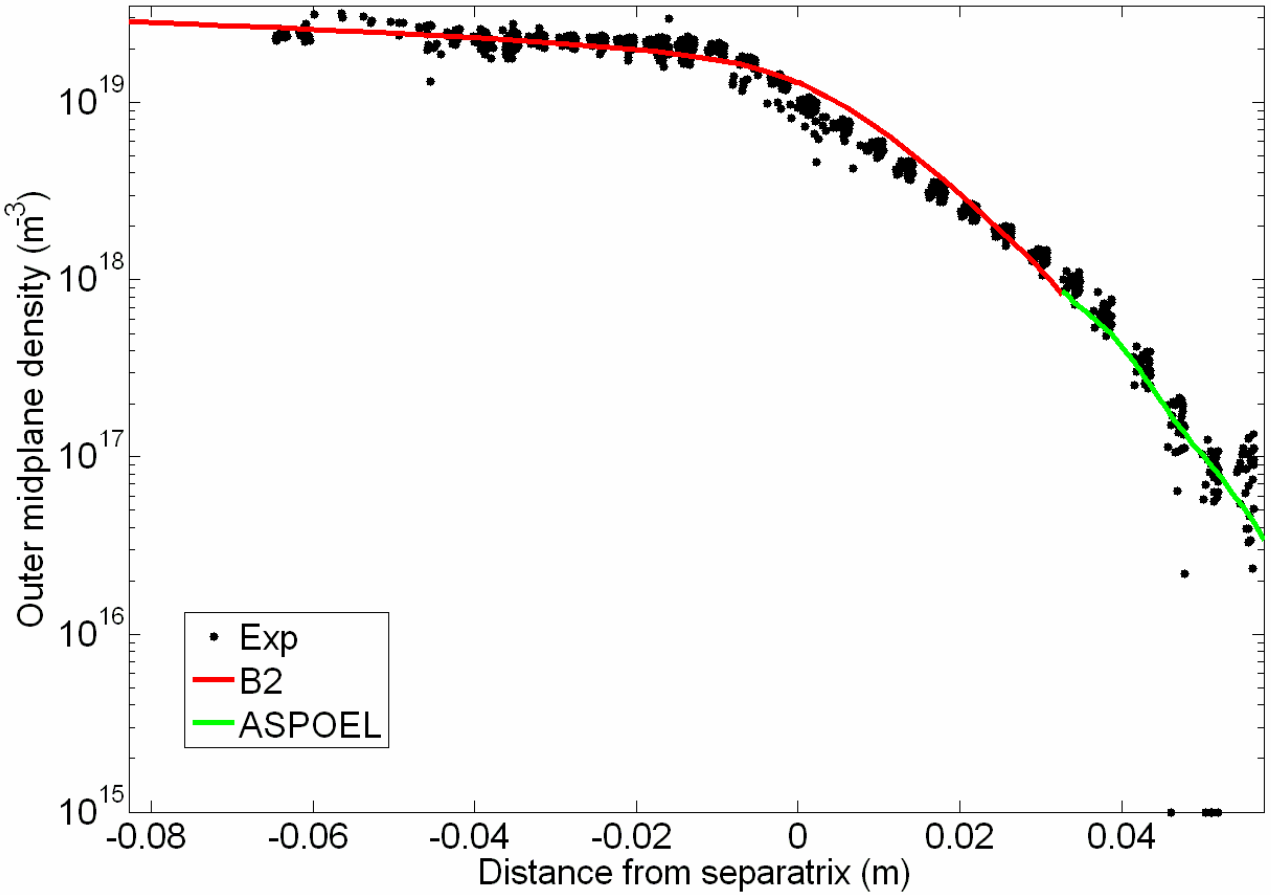


Near-far SOL interface

Very low density/vacuum in the farthest regions

Application: ASDEX Upgrade (II)

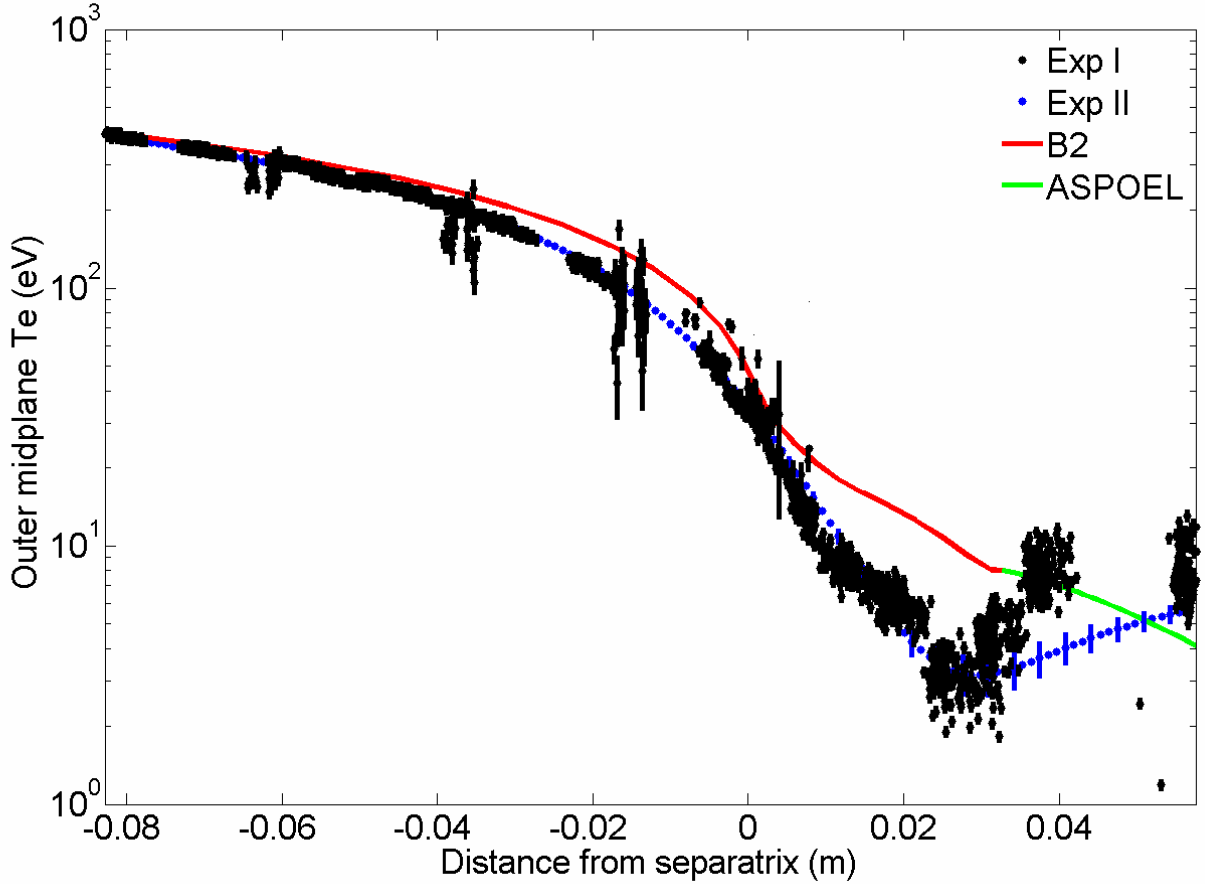
Density profile @ outer mid-plane



Excellent agreement with experimental data

Application: ASDEX Upgrade (III)

Te profile @ outer mid-plane

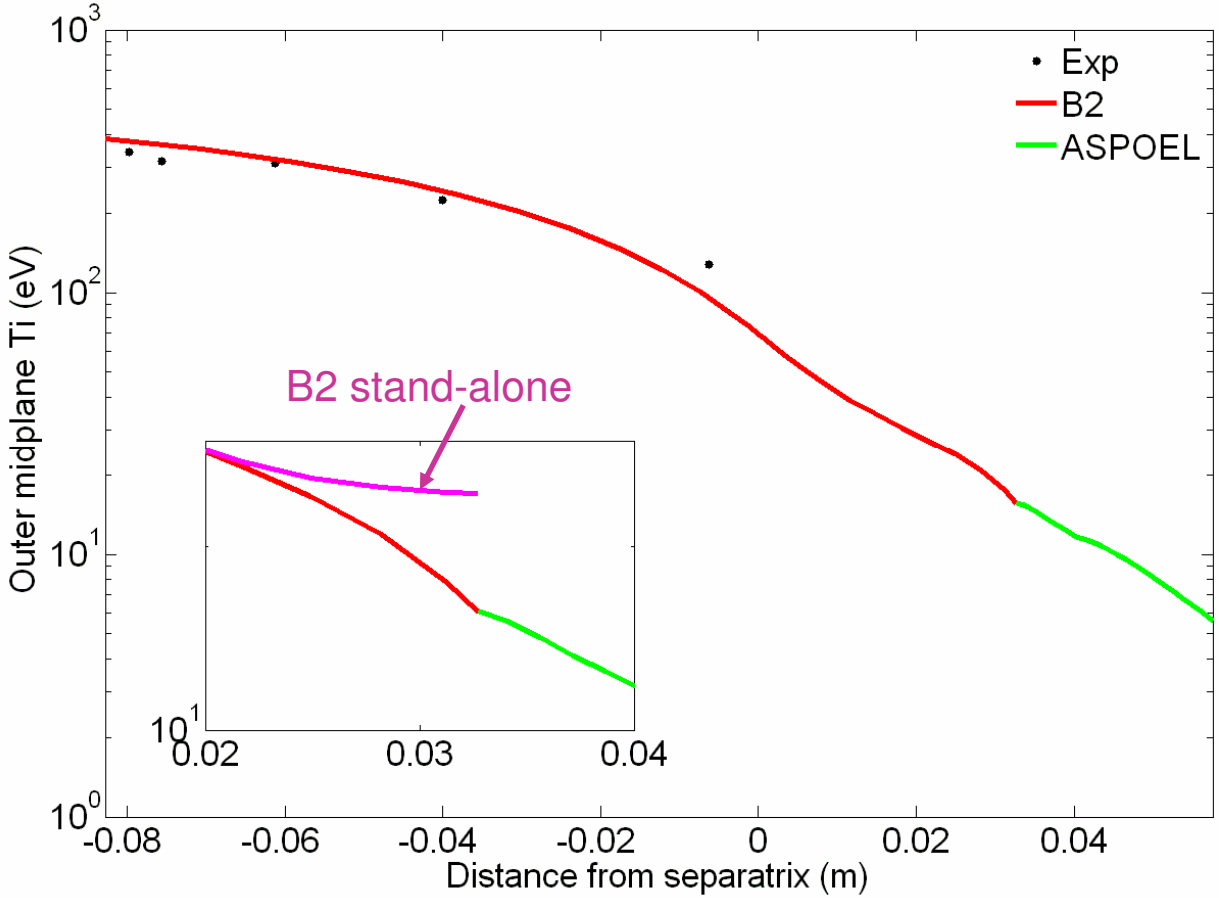


Qualitative agreement in edge and near SOL.

Issues (also diagnostic) in far SOL?!

Application: ASDEX Upgrade (IV)

Ti profile @ outer mid-plane

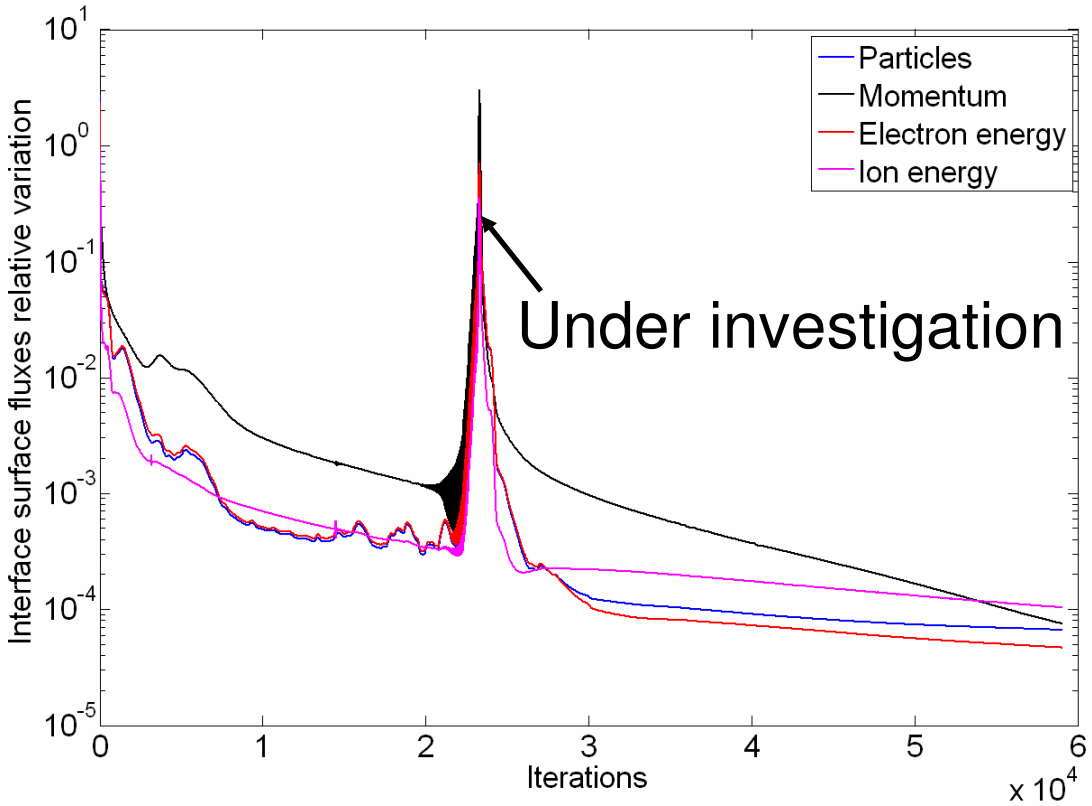


No experimental data available in far SOL

Conclusions

- B2-ASPOEL is proposed as a tool for global SOL modelling up to the first wall
- An iterative procedure provides continuity of fluxes and primary variables
- First application to ASDEX Upgrade shows reasonable agreement with measured profiles
- Perspective: (JET), (ICRH, coupling to TOPICA), ASPOEL/Eirene, ITER

B2-ASPOEL coupling (II)

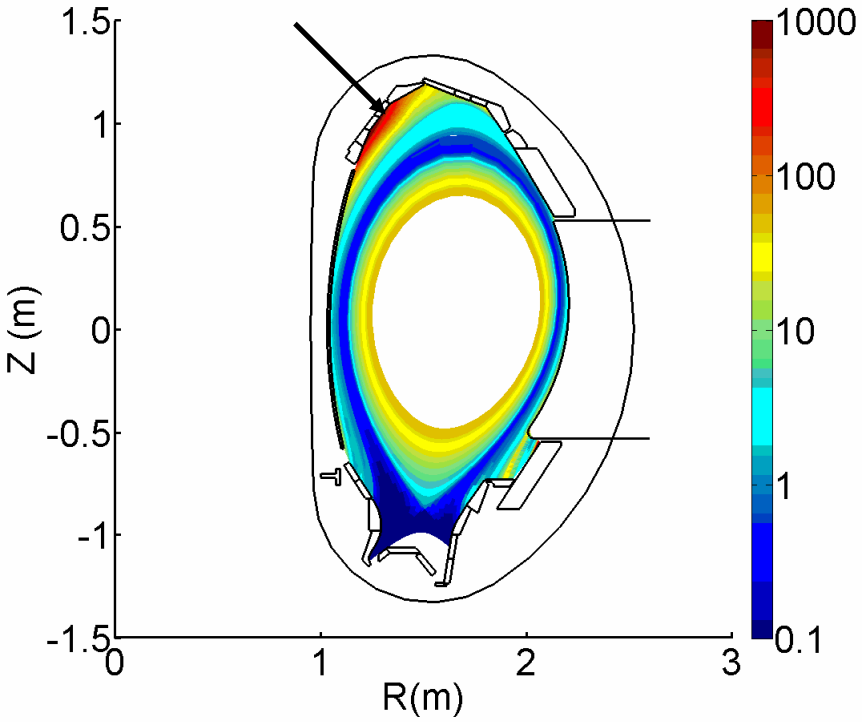


Convergence of B2-ASPOEL interface fluxes

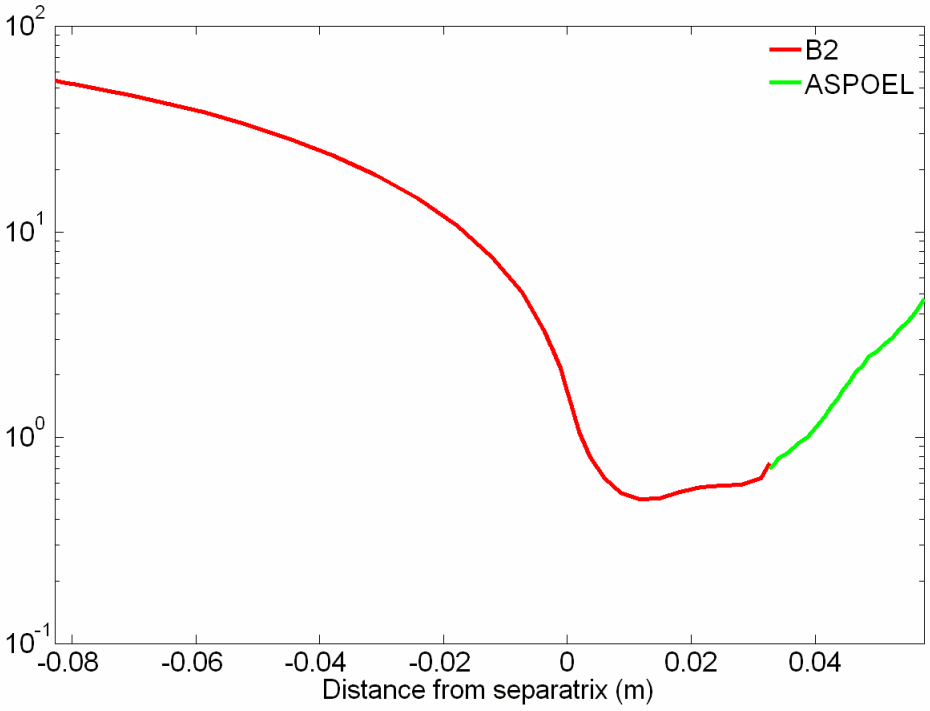
Application: ASDEX Upgrade (V)

Electron mean free path λ_e

Collisionless SOL region



Outer midplane



Connection length ≥ 10 m ➔ Far SOL barely collisional at midplane