Summary of Chapter 2: Theoretical models and simulation codes

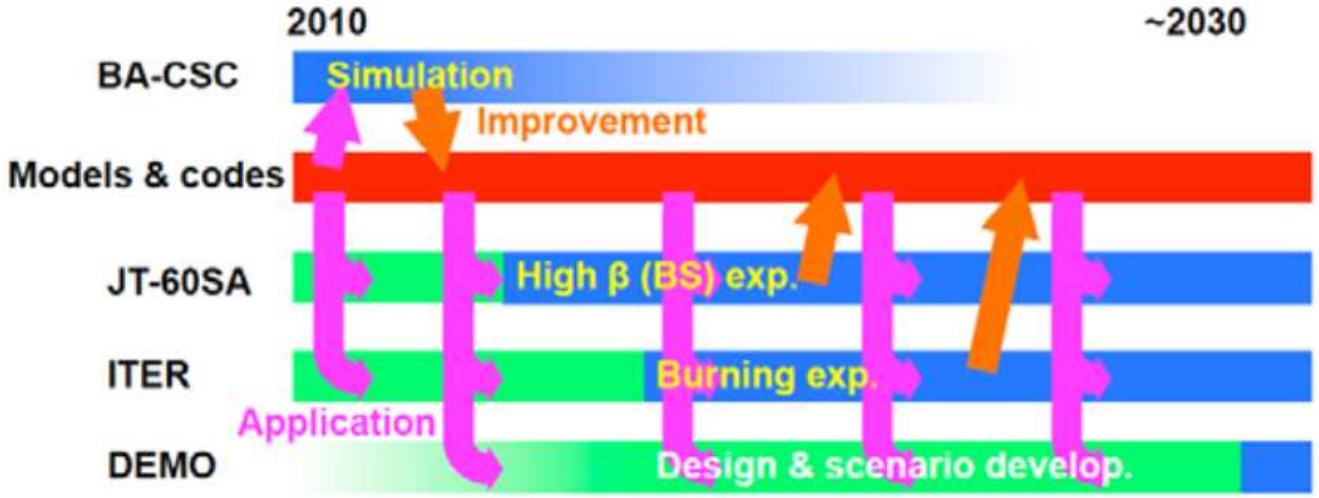
G. Giruzzi

IRFM, CEA (France)

- Now only a short part of Chapter 2
- It concerns the use of JT-60SA as a test-bed for theoretical models
- This chapter could be also used as a container for the extensive modelling work planned in the next few years

Theoretical models and simulation codes

- JT-60SA strategy : *'ITER + JT-60SA + modelling/simulation = DEMO'*
- BA-funded **Computer Simulation Centre**, active from 2012 to 2016
- Development of actuator and **diagnostics** modelling
- Development of a **tokamak simulator** and a data exchange framework
- Use of simulator to develop **plasma control** systems



Using JT-6SA for validation of theory and models

- **Physics issues:**
  - related to the various ITER scenarios
  - related to DEMO and the fusion reactor

- **Engineering issues:**
  - external coil current/voltage
  - diagnostic modelling
  - integrated control system

- **To complete this part of the Research Plan:**
  - identify the items on which JT-60SA could be particularly useful for model validation
  - think of specific experiments to be performed on JT-60SA for model validation
  - how this integrates with analogous R&D performed in EU ?

Modelling of JT-60SA plasmas

- Modelling of JT-60SA plasmas has already started this year, in the framework of the **ITER Scenario Modelling** group (ITM-Task Force)
- This should be a **multiannual activity**, accompanying the preparation, then the operation phase of the JT-60SA project
- It presently consists of:
  - **0-D** modelling to check the main scenario parameters
  - **1.5 D** modelling using EU integrated tokamak modelling codes
  - **edge** and **divertor** modelling
  - **LHCD** modelling

Work plan on modelling of JT-60SA scenarios

- Simulations of JT-60SA scenarios should be based on the two machines that are the most similar, for size and configuration: **JT-60U** and **JET**
- **First steps:**
  - define **reference** JT-60U and JET shots (H-mode, hybrid, advanced) and give **access to databases**
  - these shots should be mainly based on **NBI** H&CD
  - establish a **simulation data exchange** method
  - define transport, pedestal, rotation **models**
  - benchmark actuator computations (should be OK, but…)
  - run **predictive simulations** for the reference shots
- Try to find a **unified modelling framework** that works for both machines: this should give the maximum confidence for prediction of JT-60SA
- Run **predictive simulations for JT-60SA** with both JA and EU codes
- For the predicted scenarios, perform linear **MHD analysis**; for the most interesting cases, try non-linear MHD analysis

Proposed list of JET shots
(17 May, waiting for approval)

- **Standard H-mode :**

#73344 (high triangularity at 0.8 Greenwald density), #74175 (low triangularity),
#77070 (low triangularity)
#73342 (high triangularity at high density above the Greenwald limit)

- **Advanced Inductive :**

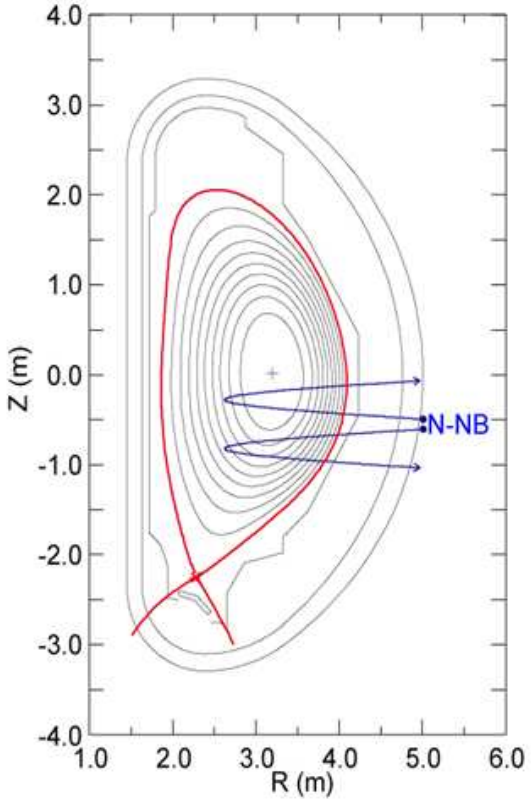
#77922 (high triangularity)
#77914 (low triangularity)
#77280 (20s long pulse Hybrid, low triangularity)

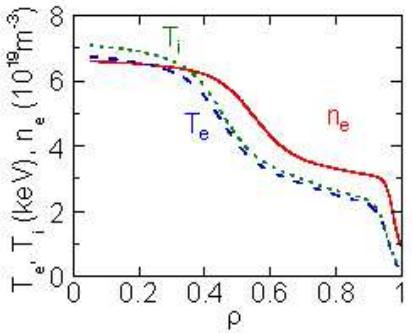
- **Steady State with ITB:**

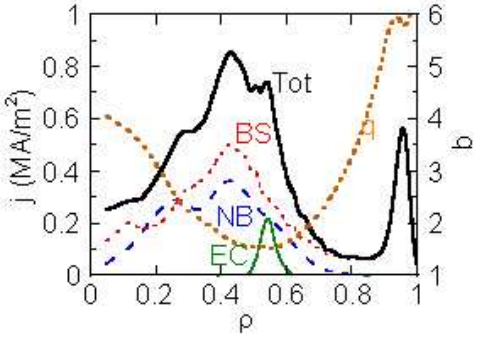
#77895(high triangularity)
#76063 (high b_N)
53521 (low triangularity strong ITB)

Examples of scenarios simulated so far /1

High β_N full CD







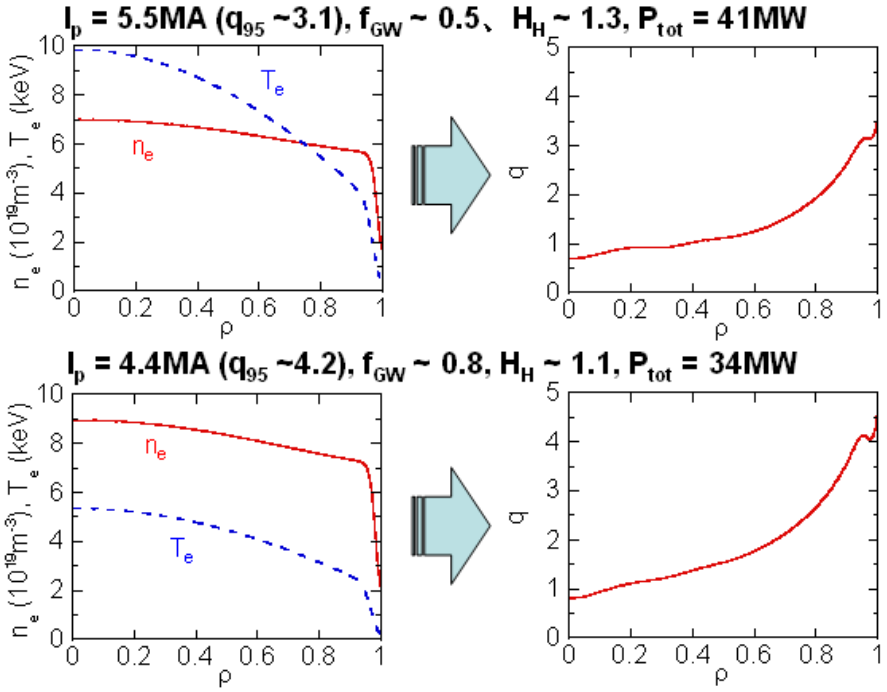
- Shown here is an example of full-CD.
  - I_p/B_t=2.3MA/1.7T, q_{95}=5.8, f_{GW}=0.85, f_{BS}=0.68, β_N=4.3, H_H=1.3
  - I_{BS}=1.57MA, I_{NB}=0.68MA, I_{EC}=0.09MA
  - P_{PNB}=20MW, P_{NNB}=10MW, P_{EC}=7MW
  - With an ideal wall, stable against n≤4, kink ballooning beyond no-wall limit (MARG2D)

Examples of scenarios simulated so far /2

Exploration for Advanced Inductive (Hybrid) operation at high I_p

- Advanced Inductive operation is attractive towards ITER and DEMO.
- A flat q profile with q_0 >~1 is a key feature.

  ⇒ What q profile in JT-60SA, especially at high I_p?



- 5.5MA: a flat and q~1 region up to ρ ~ 0.2
- 4.4MA: q<1 region is very small.

  (Experimentally, advanced inductive plasmas have been obtained at q_{95} ~ 4-5.)

Possible platform for advanced inductive research.