EFDA Task Force Integrated Tokamak Modelling

EUROPEAN FUSION DEVELOPMENT AGREEMENT

Linking Integrated Modelling to Tokamak Control Toolbox

Motivation: realistic modelling of a Tokamak experiment

– Accurate plasma, actuators and sensors models

– Using the same control algorithms as the real experiment

Means

– Provide maximum Interoperability between the Integrated Modelling Framework and the tools used to design the Plasma Control System (PCS), typically: Simulink, Scicos

Applications

– Preparation of tokamak experiments by physicists

– Design and Test PCS algorithms with an accurate suite of plasma, actuators and sensors models

- The PCS algorithms developed with the Modelling Framework can be plugged in directly into the real PCS of the experiment

– All these applications are geared towards ITER needs

Tokamak Plant	Tokamak Simulator
• Plasma & plant response	• Plasma & plant models
• Real-time measurements	• Synthetic diagnostics
CONTROL toolbox	**Control algorithms**
• Plasma Control System	• Plasma Control System Emulator
• Actuators	• Actuator models

ITM-TF Approach

– The Tokamak is simulated by the Integrated Modelling Framework

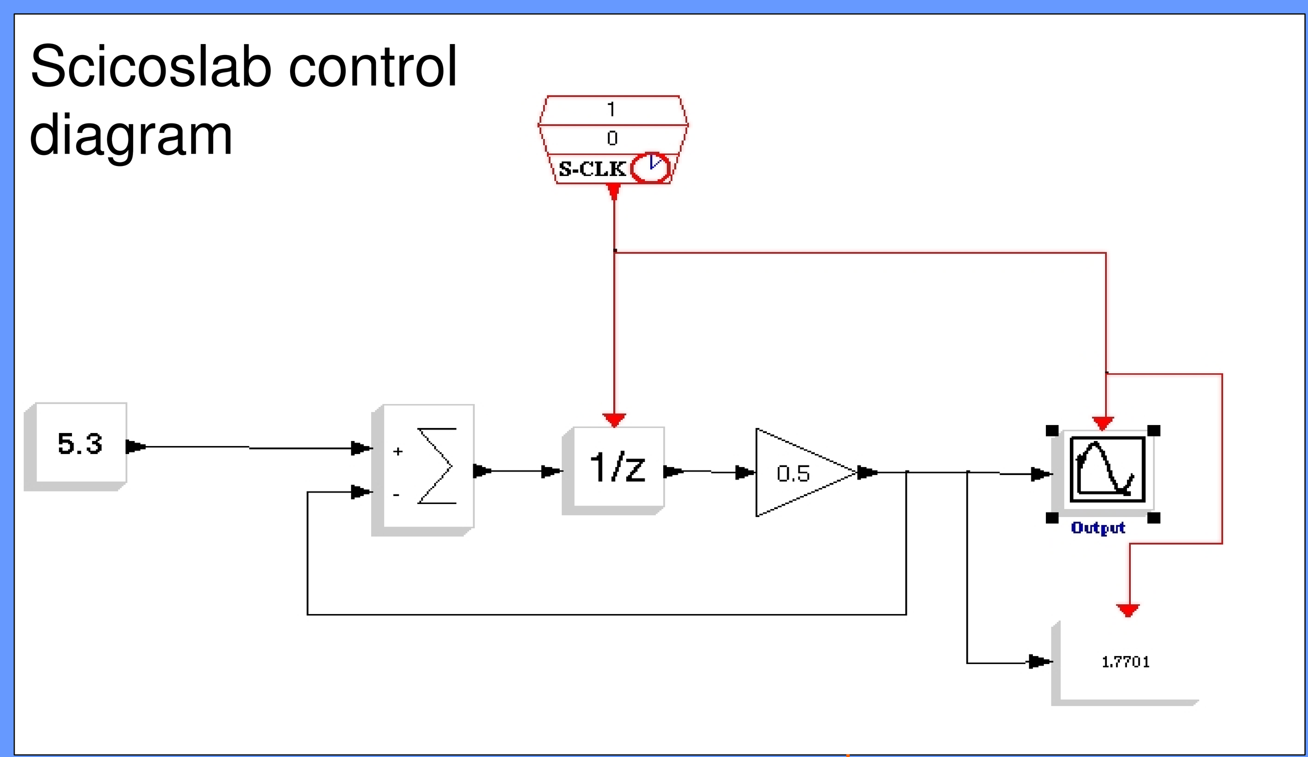
- Handles Plasma, actuator and sensor models as usual
- PCS emulator also included as a component of the Integrated Modelling workflow

– Control algorithms are designed with standard tools of the Plasma Control community, i.e. Simulink or Scicos

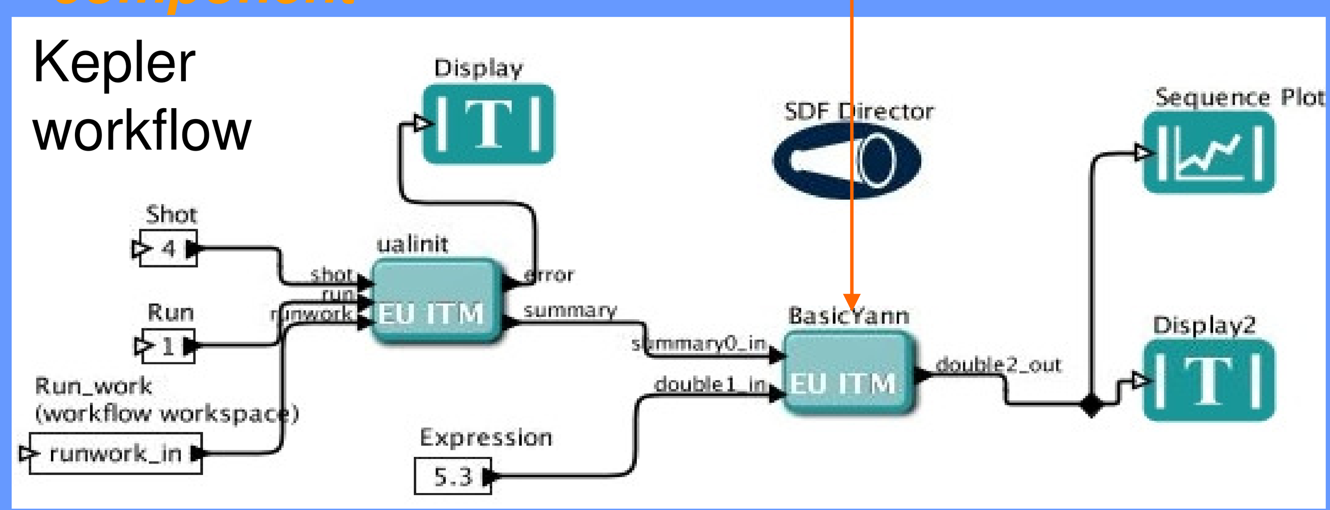
– The PCS Emulator is automatically generated from Simulink/Scicos and used as a component of the Integrated Modelling Framework

– **This Approach has been implemented for both Simulink and Scicos under the ITM-TF framework**

The ITM-TF Approach: Scicos or Simulink control diagrams are turned into a Kepler actor (or «component») and can then be used in the Integrated Modelling workflow



Automated generation of an IM workflow component

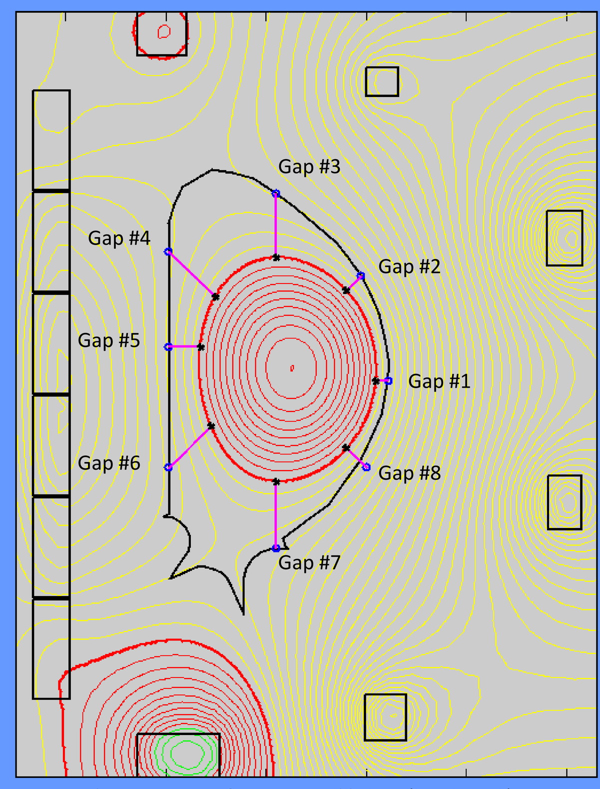


Test case: ITER plasma shape control

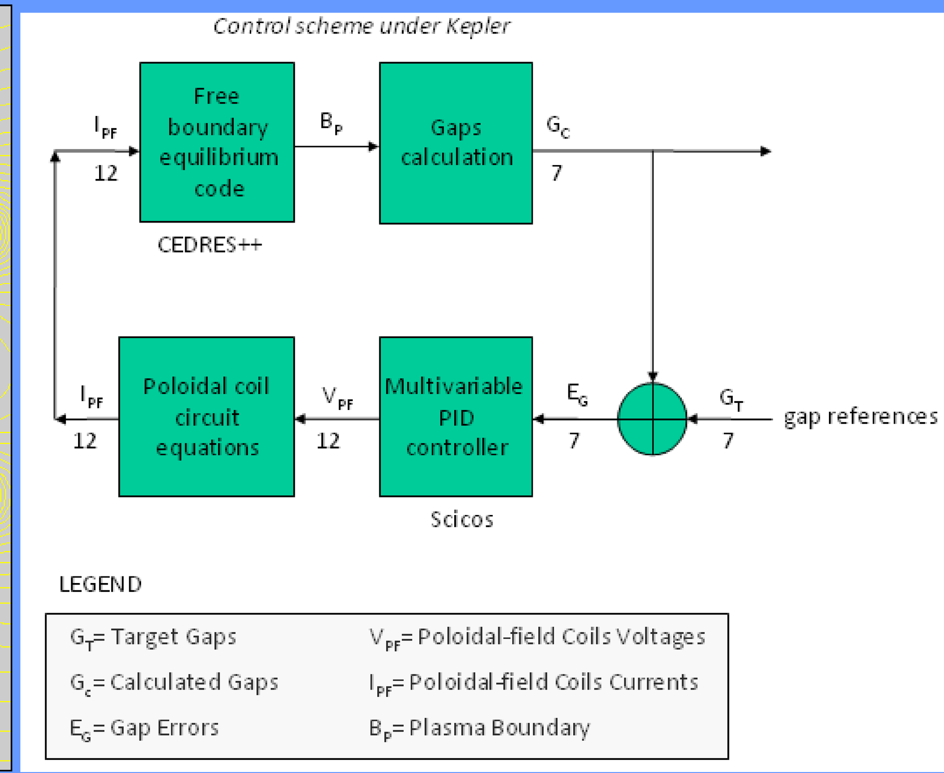
– Control plasma shape via currents in the Poloidal Field (PF) coils

- Free boundary equilibrium evolution and PF circuit equations
- PID algorithm to control the PF voltages

– Plasma shape characterized by « gaps »

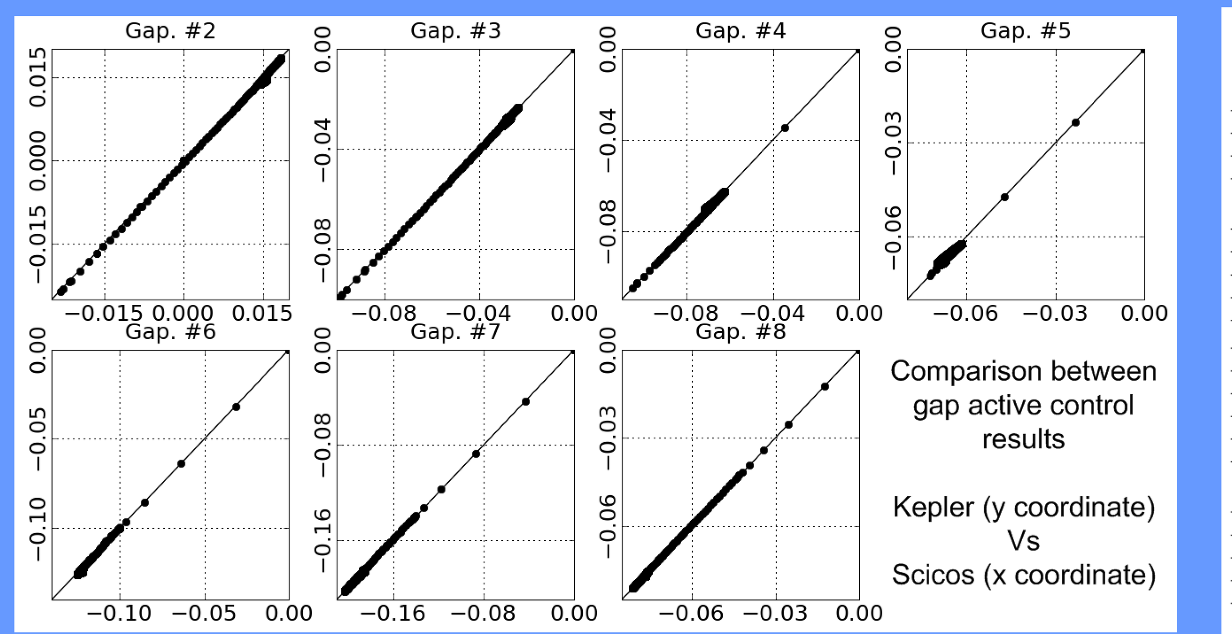


The test case reference equilibrium (I_p = 15 MA).

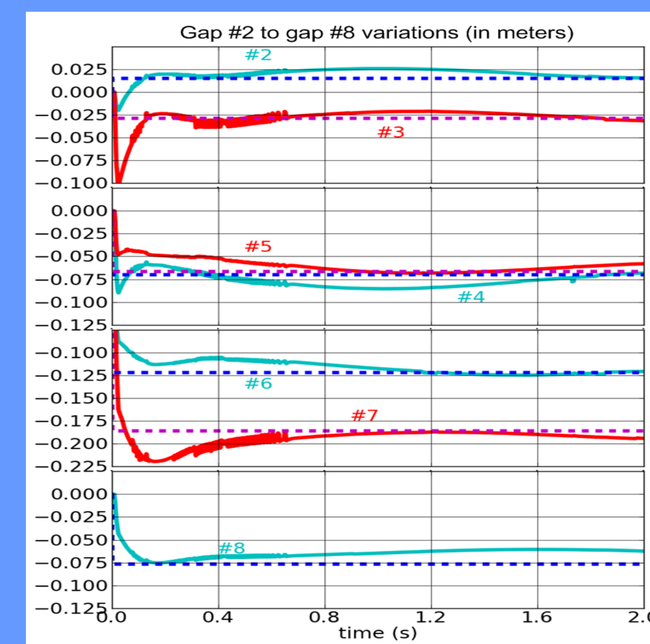


Proof of Principle: for testing purposes, this simple tokamak simulator has been implemented in 3 ways

1. Fully under Scicos with linearized equilibrium model
2. Fully under Kepler, with controller generated from Scicos diagram (ITM-TF approach) and linearized equilibrium model
3. Fully under Kepler, with controller generated from Scicos diagram and direct use of CEDRES++ free boundary equilibrium code



Validation: implementations #1and #2 yield the same results



Implementation #3 using the CEDRES++ model

Perspectives: more complex simulations, involving more sophisticated physics (e.g. full core transport + equilibrium + PF systems evolution) and controllers (fully realistictic PCS algorithms, multiple controllers,…)

[O. Barana et al, FST 2011]

EFDA ITM-TF Expo "The European Integrated Modelling effort : challenges and achievements" – 38th EPS 2011

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