Integrated tokamak modeling: when physics informs engineering and research planning

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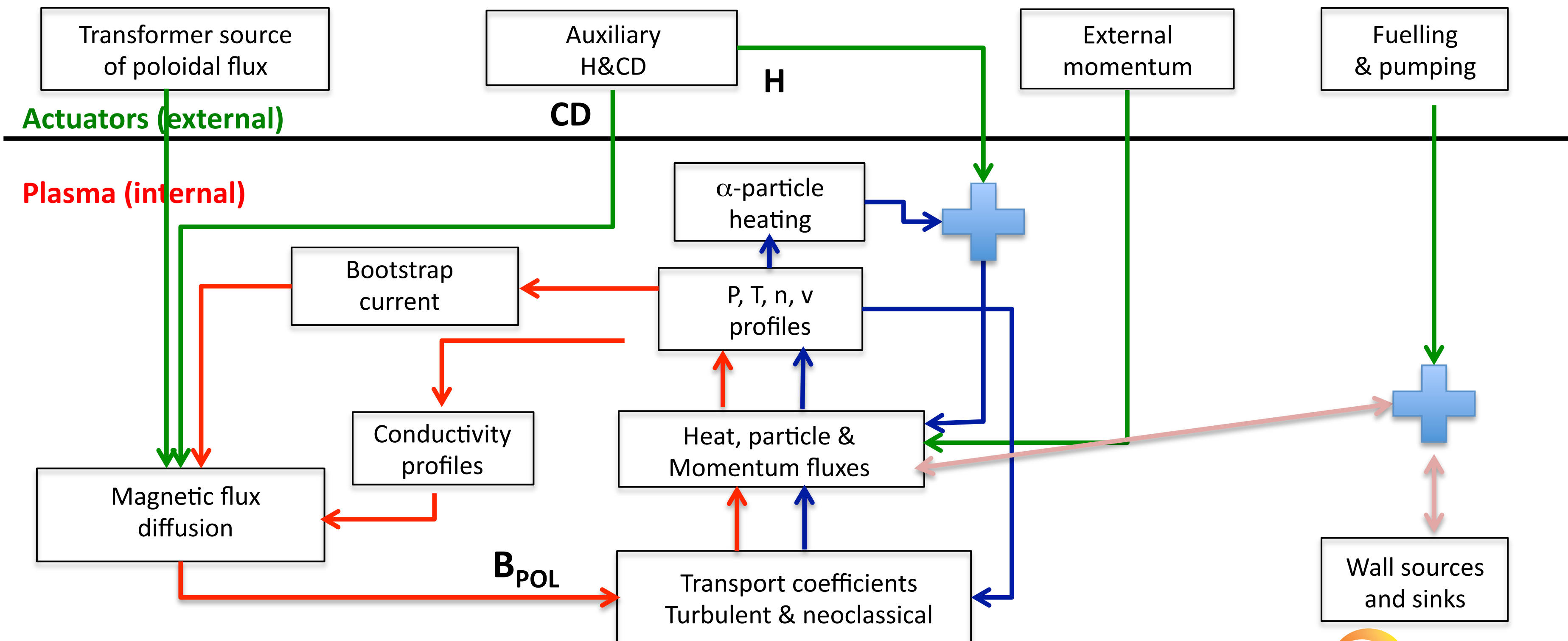
Two case study proposed in the abstract

- ITER inductive => target is fixed (Q=10, burning control)
  - Impurities, core particle+energy transport, divertor perturb plasma from target
  - show how improving self-consistency introduce additional constraints on power management, actuator sharing and control, MHD stability control.
  - How the discharge simulation needs to be modified to achieve the target
  - Can the target be achieved? [list gaps and modeling needed to answer]
- Helium plasma at half-field => broader target (H-mode, commission)
  - Show how an operational point defined from scaling parameters (B, I, n) moves to a different point when core-edge coupling, RF physics and self-consistent transport are taken into account.
- Both will point to relevant experiments for guidance

Key points

- Schematics of building blocks and how they work together
- Equations are introduced when and in the form they are needed
- Will emphasize needs for modeling and existing gaps
- How experiments inform modeling and where difference exist
- Try to answer the question: “do we really need the best physics?”
- Address what physics is needed where
- How advanced simulations can/should be used to set constraints in scenario modeling and examples
- Bottom line: we predict ITER with models that we know cannot even reproduce experiments.

Integrated modeling combines different time scales: fast (transport) vs slow (current diffusion)



adapted from Politzer NF 2005

Baseline path

- Coil control based (no good physics) define operational space and limits
- H&CD, thermal transport, reduced pedestal => dynamic response
- Self-consistent simulations with core-edge [EU]
- Highlight IBL experiments and how different they are from the way we model ITER
- Density predictions (pellets, control) [help from Jai and Xingqiu]
- NTM stability [help from Zhirui, Nate?]
- MHD stability, RMP [help from Nate, Jake]
- EP stability [help from Mario]
- RF-NBI [TORIC, AORSA, help from Nicola]
- How physics can inform control for ITER [help from Dan]
- IDEA behind: how boundary conditions from the above modifies the simulation

Helium plasma

- Start with operational point as originally defined (2.65T/7.5MA, 0.75$n_{G,}$ 80-20 He-H for H-mode access, IC with H minority)
- IC heating imposes H<10% (to avoid mode conversion)
- Core-edge simulations impose n_e~$3x10^{19}$ m^{-3} from He puff [JINTRAC]
  - Reduces density at 0.40n_G
- 3rd harmonics X in plasma => very sensitive to pedestal structure
  - Need to increase field up to 2.85T
- Predict all channels [with Jai and Xingqiu]
- MHD stability [with Zhirui, Nate]
- RF-NBI => distribution function might be highly distorted in this plasma, [with Nicola and Mario]
- EP might be an issue in this plasma [with Mario]