Status of Current Profile Control Studies via Sawtooth Modification with MCCD and LHCD

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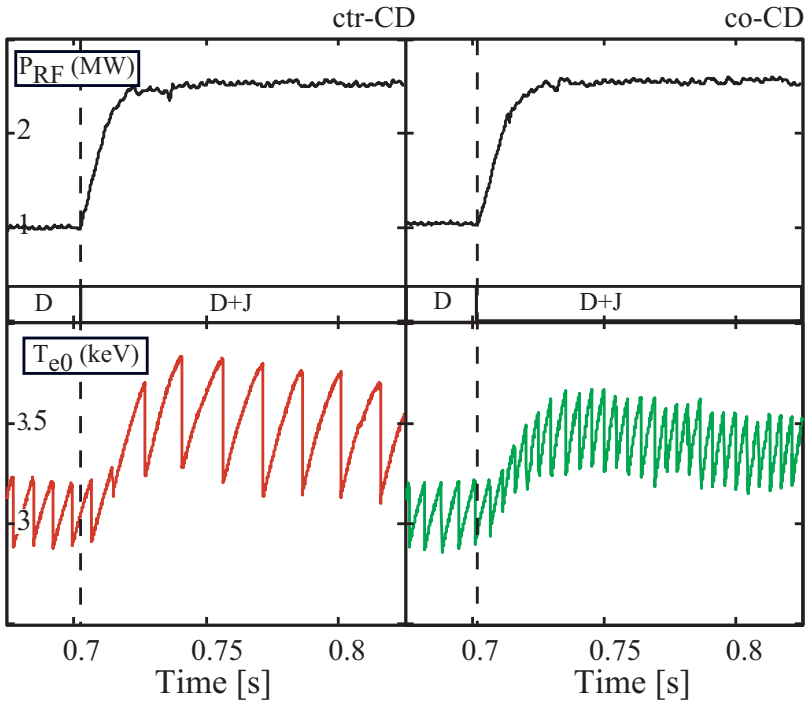
Outline

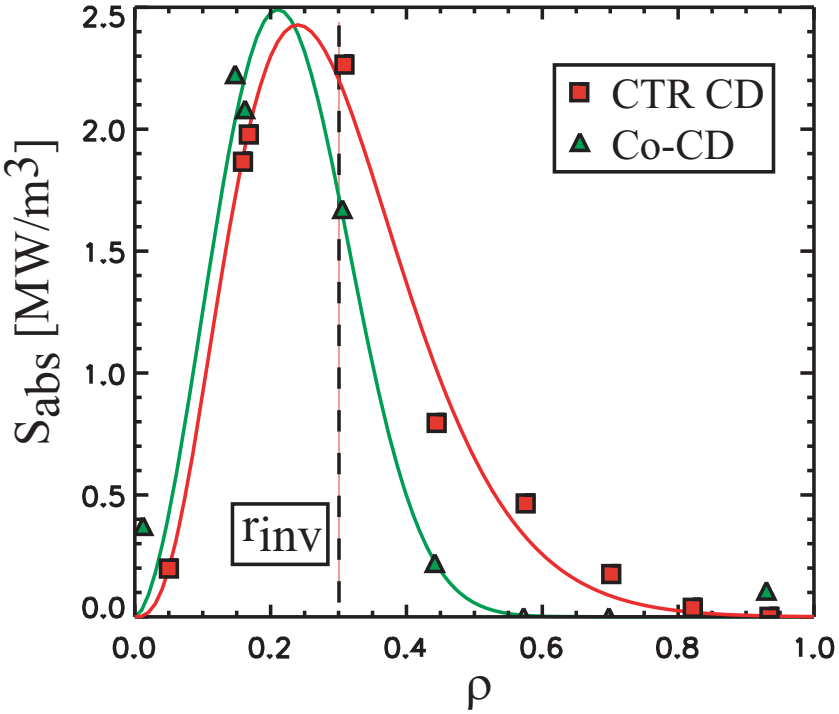
- 1) What are the physics issues to be addressed?
- 2) What experimental data is to be compared, or what validations studies will be done?
- 3) What components are needed for the work?
- 4) What development is needed to complete the studies? - physics code development, component script development, generalization of IPS time stepping logic ...
- 5) What are the major milestones toward completion and what is the schedule?
- 6) Who is going to do what in the study and when will they do it?
- 7) What publications/presentations are envisaged? What is the schedule for that?

Current Profile Control via Mode Conversion Current Drive

- Physics issues to be addressed:
  - Stabilization / destabilization mechanism for sawtooth control.
    - Does ICRF full-wave model predict CD in correct spatial location.
    - Is stability mechanism linear or nonlinear.
- Experimental data:
  - Sawtooth “pacing” experiments from C-Mod:
    - Clear variation in sawtooth period with phasing and deposition location.

Sawtooth Modification via Mode Conversion Current Drive in Alcator C-Mod





Current Profile Control via Mode Conversion Current Drive

- Components Needed:
  - TSC simulation to evolve the discharge.
  - RF TORIC component:
    - Ehst-Karney parameterization of CD efficiency.
    - Electron and ion heating sources.
  - Linear MHD stability component
- Requisite code development:
  - RF and MHD components already in place.
  - May need load balancing strategy since full-wave MCCD computations will require about 2000 CPU hours per CD calculation per time step:
    - (20 toroidal modes) × (100 CPU hours / mode)
    - Use ≈ 5120 processors @ 256 processor cores / toroidal mode
  - May want to invoke MHD stability component while full-wave CD calculation is in progress.

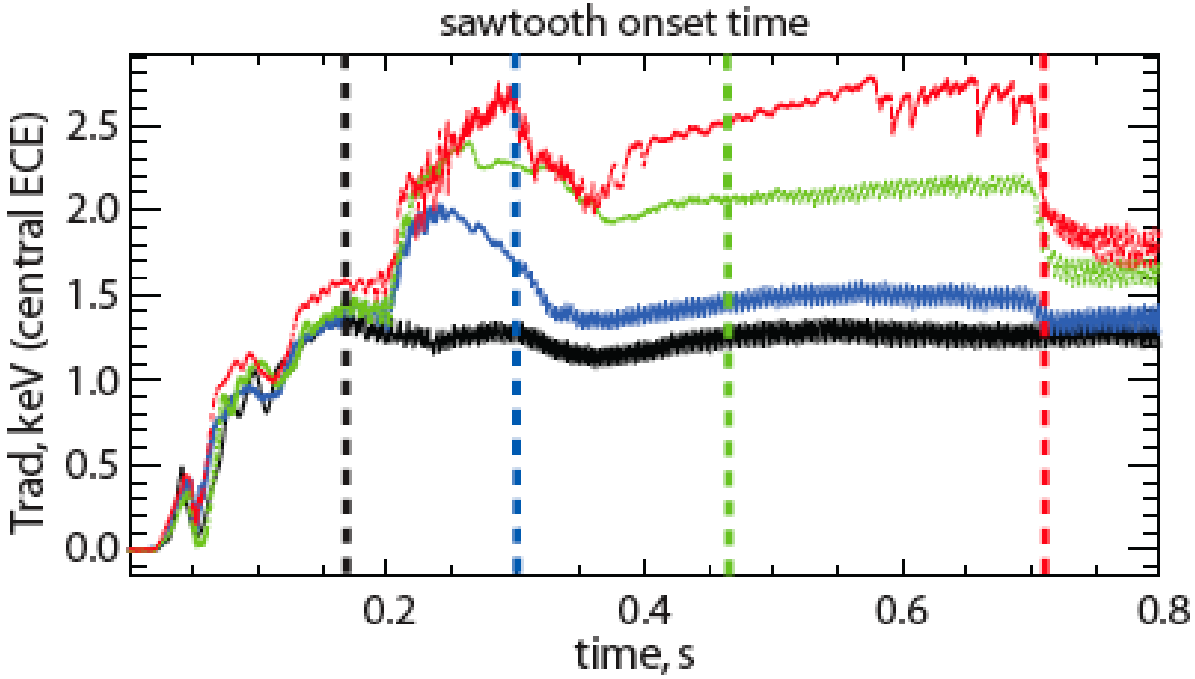
Current Profile Control via Mode Conversion Current Drive

- Major Milestones and Schedule:
  - TSC simulation of plasma using model heating / CD sources.
  - TSC simulation of plasma using model heating / CD sources from TORIC:
    - Run only a few time steps first with 1000's of processors.
  - Simulation with Linear MHD stability component
  - To be completed by middle of Year 2.
  - Publication by end of Year 2 (Plasma Phys. Cont. Fusion).
- Requisite code development:
  - Data mining of two C-Mod discharges with co- and counter-phasing (P. Bonoli)
  - TSC simulation of discharges with model profiles (L.-P. Ku)
  - TSC simulations of discharges invoking the TORIC component (P. Bonoli)
  - Linear MHD stability analysis (S. Jardin).

Current Profile Control via Lower Hybrid Current Drive

- Physics issues to be addressed:
  - Stabilization / destabilization mechanism for sawtooth control.
    - Does ray tracing / Fokker Planck model predict LHCD in correct spatial location.
    - Is stability mechanism linear or nonlinear.
- Experimental data:
  - Sawtooth “delay” experiments from Alcator C-Mod:
    - Clear variation in the onset of sawteeth with density at fixed LH power level.

Current Profile Control via Lower Hybrid Current Drive in Alcator C-Mod



Time evolution of central ECE for 0.5 MW of LH applied to plasmas with $\bar{n}_e=4x10^{19}m^{-3}$ (red) $\bar{n}_e=7x10^{19}m^{-3}$ (green) and $\bar{n}_e=9x10^{19}m^{-3}$ (blue) densities. Ohmic comparison in black with $\bar{n}_e=9x10^{19}m^{-3}$.

Current Profile Control via Lower Hybrid Current Drive

- Components Needed:
  - TSC simulation to evolve the discharge.
  - Ray tracing (GENRAY) and Fokker Planck components:
    - LHCD from coupled GENRAY-CQL3D loop.
    - Electron heating source from CQL3D (no ICRF).
    - Synthetic diagnostic code for ECE (invoked through CQL3D)
  - Linear MHD stability component
- Requisite code development:
  - MHD stability components already in place.
  - Coupled GENRAY and CQL3D from IPS will need to be tested.
  - May want to invoke MHD stability component while full-wave CD calculation is in progress.

Current Profile Control via Lower Hybrid Current Drive

- Major Milestones and Schedule:
  - TSC simulation of plasma using model heating / CD sources.
  - TSC simulation of plasma using model heating / CD sources from GENRAY and CQL3D
  - Simulation with Linear MHD stability component
  - To be completed by end of Year 1.
  - Publication by end of Year 2 (Plasma Phys. Cont. Fusion).
- Requisite code development:
  - Data mining of four C-Mod discharges at different densities (P. Bonoli)
  - TSC simulation of discharges with model profiles (L.-P. Ku)
  - TSC simulations of discharges invoking the GENRAY and CQL3D components (P. Bonoli and R. Harvey)
  - Linear MHD stability analysis (S. Jardin).