Predictive capability needed for CAEs/GAEs ⇒ Experimental Validation of HYM

- CAEs/GAEs play role in fast-ion and electron thermal transport ⇒ need predictive capability for CAEs/GAEs
- Leading model for CAEs/GAEs is Hybrid kinetic MHD code, HYM
  - 3-D nonlinear.
  - Several different physical models:
    - Resistive MHD & Hall-MHD.
    - Hybrid (fluid electrons, particle ions).
    - **MHD/particle (one-fluid thermal plasma + energetic particle ions)**.
  - Full-orbit kinetic ions & Drift-kinetic electrons.
  - For particles: δf / full-f numerical scheme.
- Need to validate HYM with experiment
  - requires agreement with experiment for mode frequencies, numbers and structures
    - mode numbers and frequencies from edge B-dot arrays
    - structures from BES, reflectometry, polarimetery
  - agreement required over wide range of conditions
    - new beams allow more tangential injection – anisotropy important to stability
    - higher B_T -> higher f_c & V_A
- Experimentalists must learn to run HYM – *theory support needed*
  - many experimentalists (e.g. A. Bortolon, N. Crocker, E. Fredrickson, K. Tritz), but ONLY one theorist (E. Belova, half-time)

Experiments to validate HYM motivate and prioritize development ⇒ Theory support needed

- Possible *near-term* area of development: fast-ion distribution
  - multiple "beams": current model approximates NUBEAM for single beam
    - superpostion of "beams" is more realistic and straightforward to implement
  - more accurate beam deposition model
    - requirements for distribution function allow flexibility — must be continuous and differentiable in terms of constants of motion (with finite Larmor radius corrections)
- Possible *long-term* areas of development:
  - toroidal rotation & rotation shear
    - rotation profile may significantly effect mode structure and stability
  - 2-fluid effects
    - kinetic Alfvén waves at ρ_s scale – may affect stability and energy channeling
    - $(\omega/\omega_c)^2$ corrections to mode structure and frequency
  - self-consistent drift-kinetic electrons
    - self-consistent inclusion of electron effect on stability (e.g. Landau damping)
    - self-consistent calculation of electron transport by resonant orbit modification
- Validation efforts prioritize *long-term* development – significant effort required in each area
  - δf sovler already includes effects – effort principally required for equilibrium solver