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MS TSG Pre-Forum Meeting Comments on R11-2

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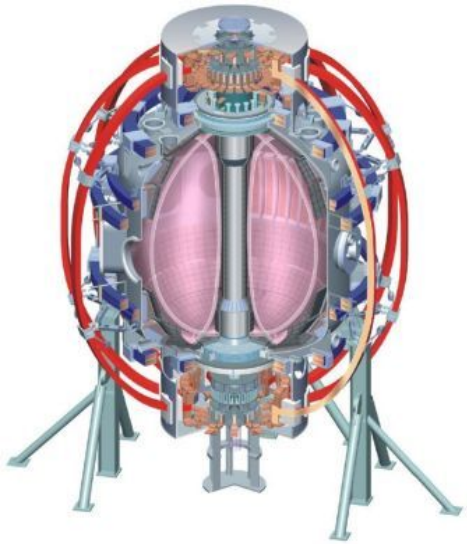

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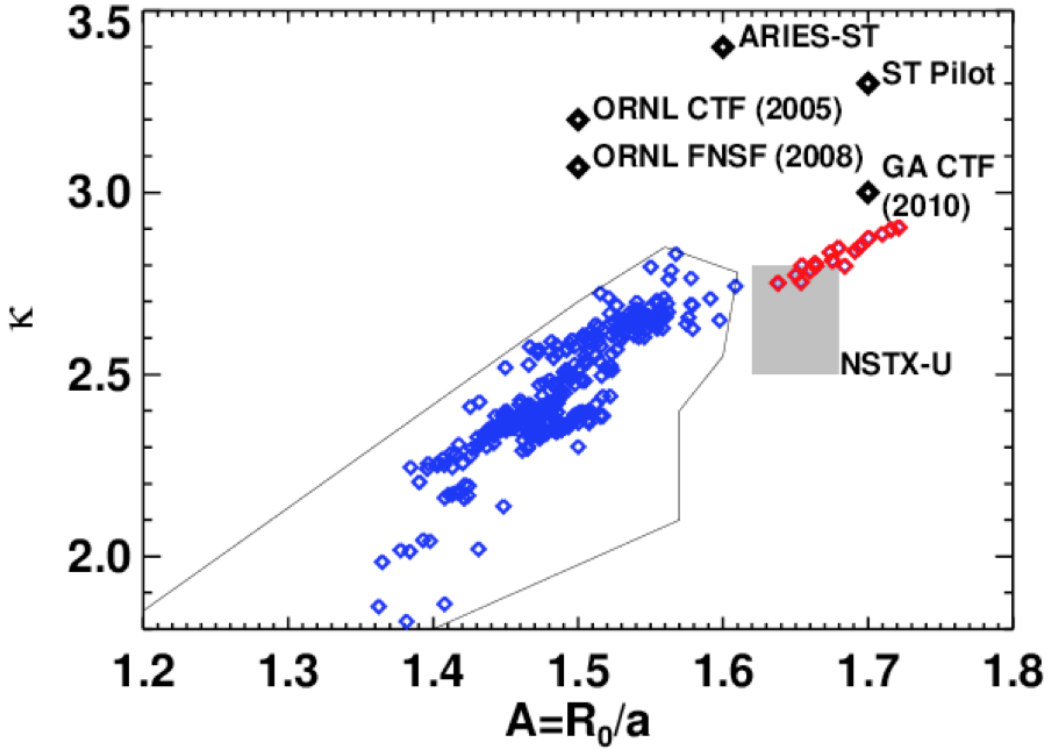
Some Background

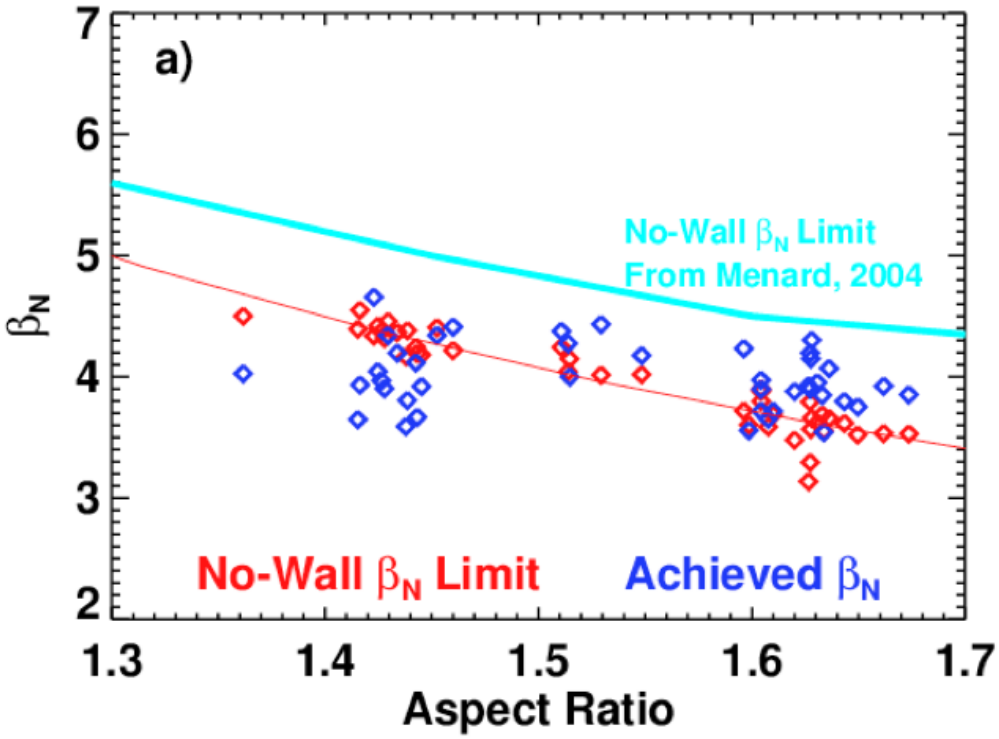
- NSTX typically scans A and κ simultaneously.
- No inner gap control (at present).

- Calculations (using experimental profiles) show a reduced ideal no-wall limit when A and κ are increased.
- Have never done a dedicated experiment to test the experiment beta limit vs. (high) κ and A.

From TRANSP database of high-performance discharges

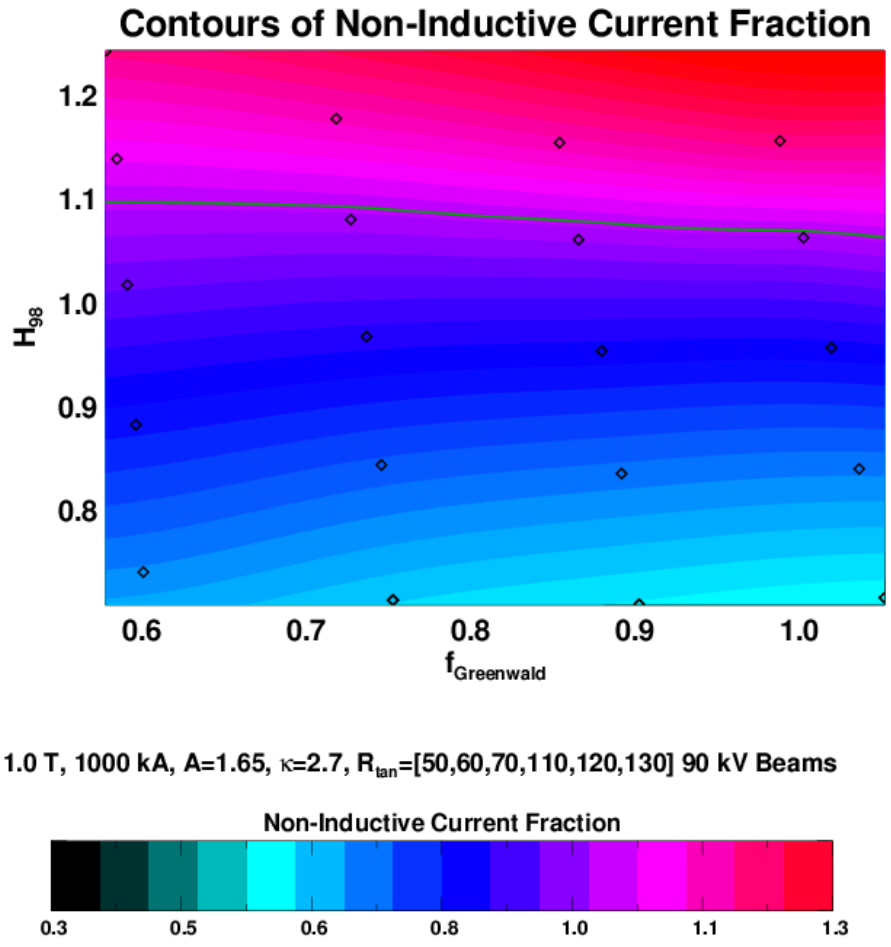


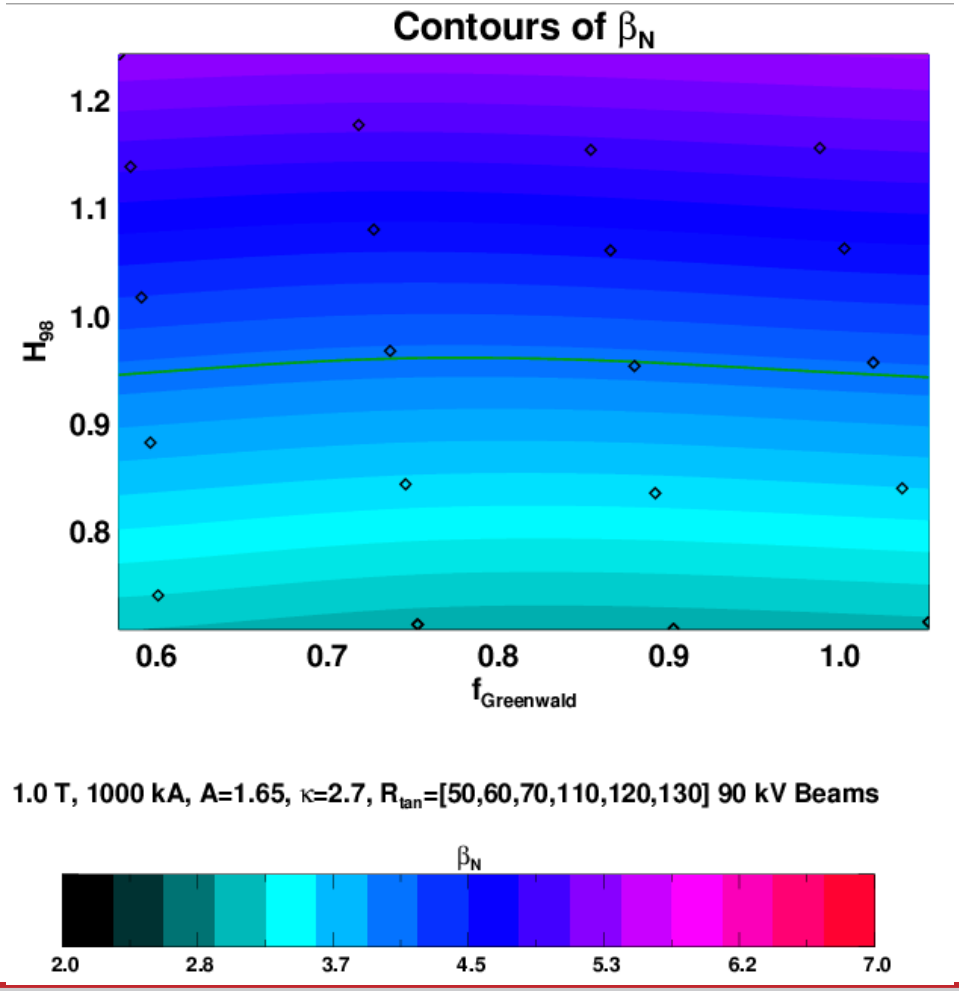
CHEASE fixed boundary + DCON



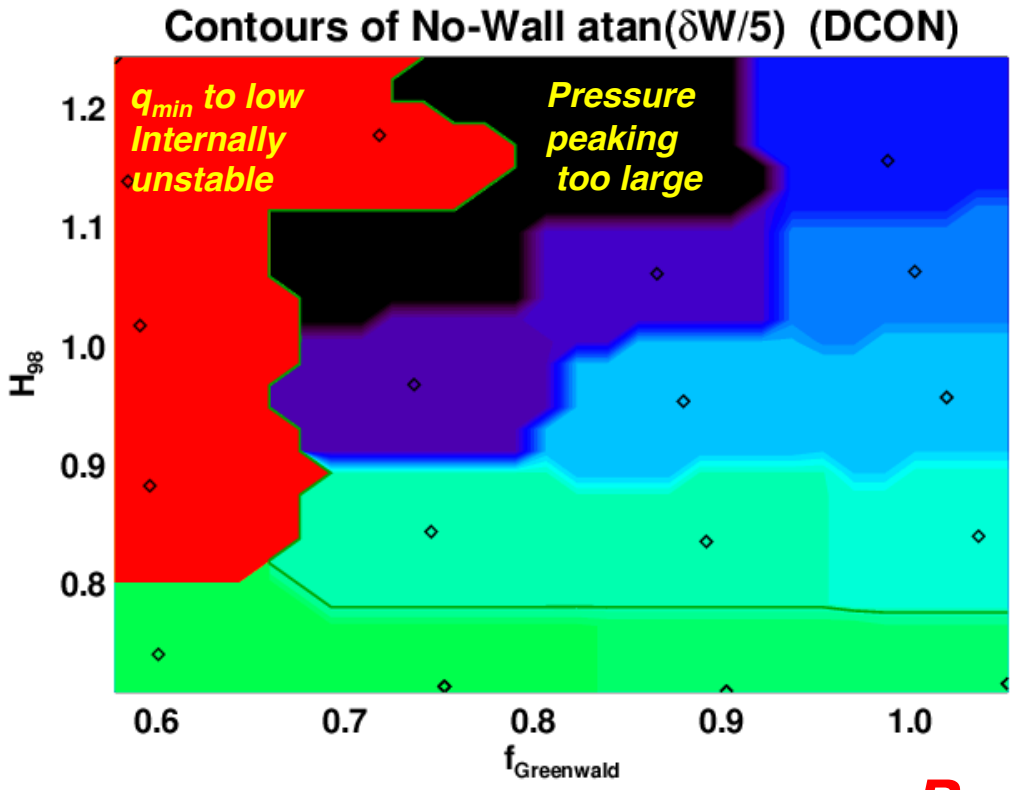
We need to robustly sustain β_N=4.5-5 at high A and κ

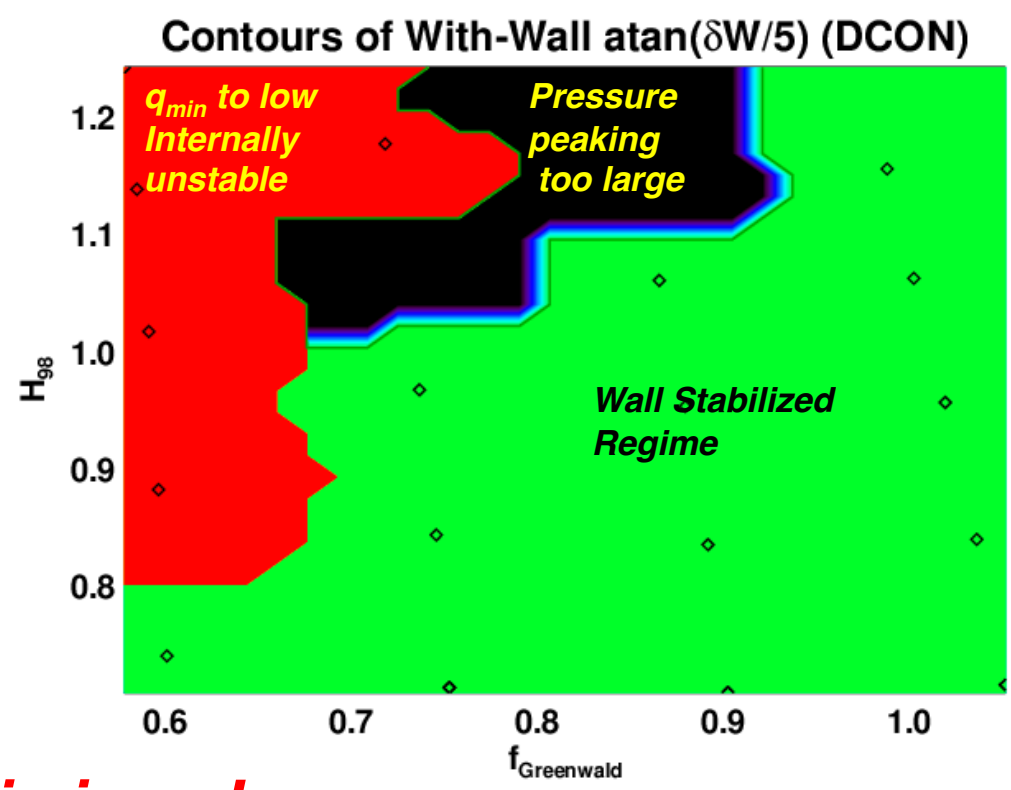
- Simulations for 1.0 T, 1.0 MA, κ=2.7, A=1.65, 12 MW
  - Need β_N=4.5-5, at H_{98}=1.1, for fully non-inductive operation.
- Scenarios with lower current and more NBCD will likely need A~1.8, κ~2.9-3.0 for more off-axis CD.





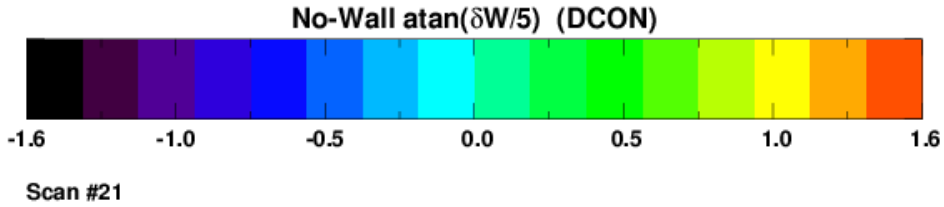
Ideal Stability May Further Limit the Operating Space





Preliminary!

1.0 T, 1000 kA, A=1.65, κ=2.7, R_{tan}=[50,60,70,110,120,130] 90 kV Beams



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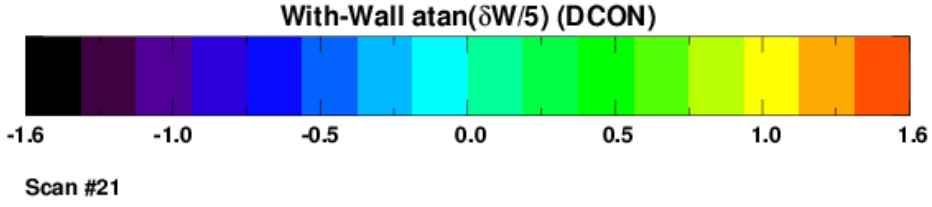


Important future task: re-run with some additional fast ion diffusion to reduce the central NBCD and pressure peaking.
Also would be nice to inmprove the resolution in [H_{98},f_{GW}] space.

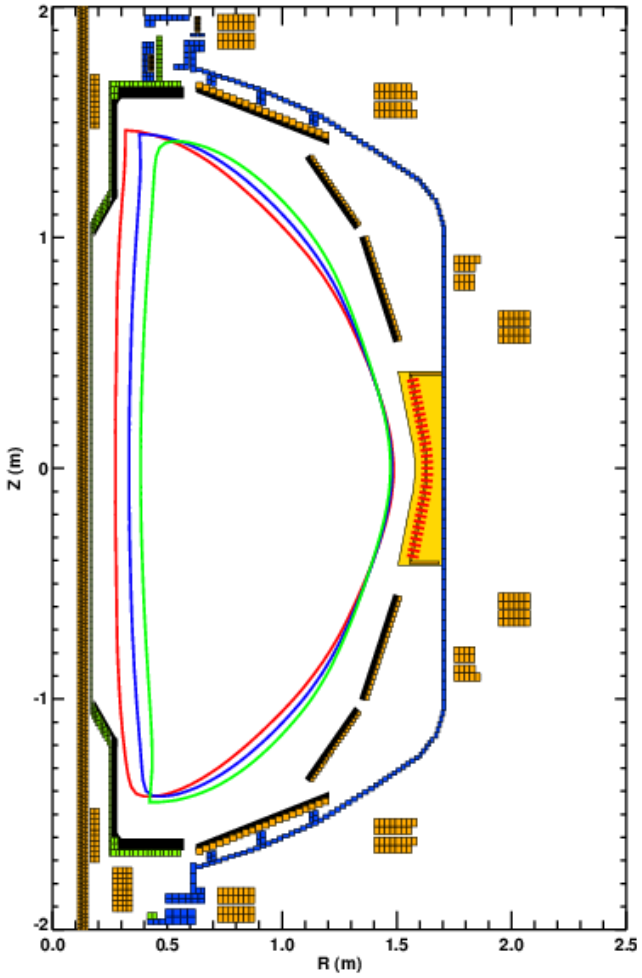
What kind of shape changes are possible?

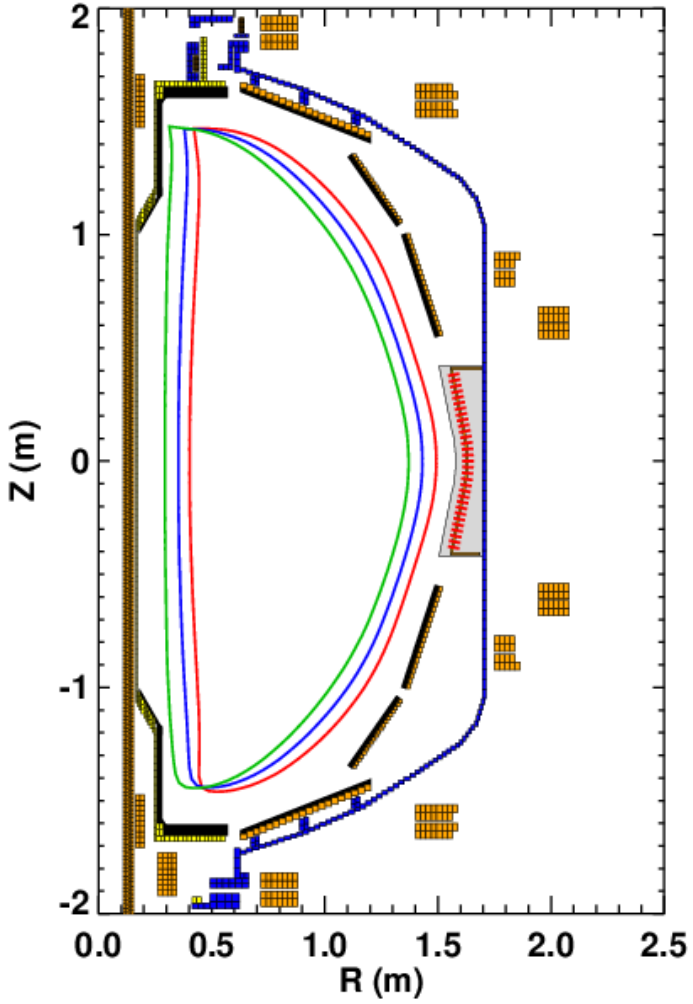
- Inner gap scan at fixed outer gap.
- Simultaneously increases A and κ.
- Maintains (nearly) constant distance to the plates and B_P RWM sensors.
- Increase the outer gap for κ=3, A=1.75

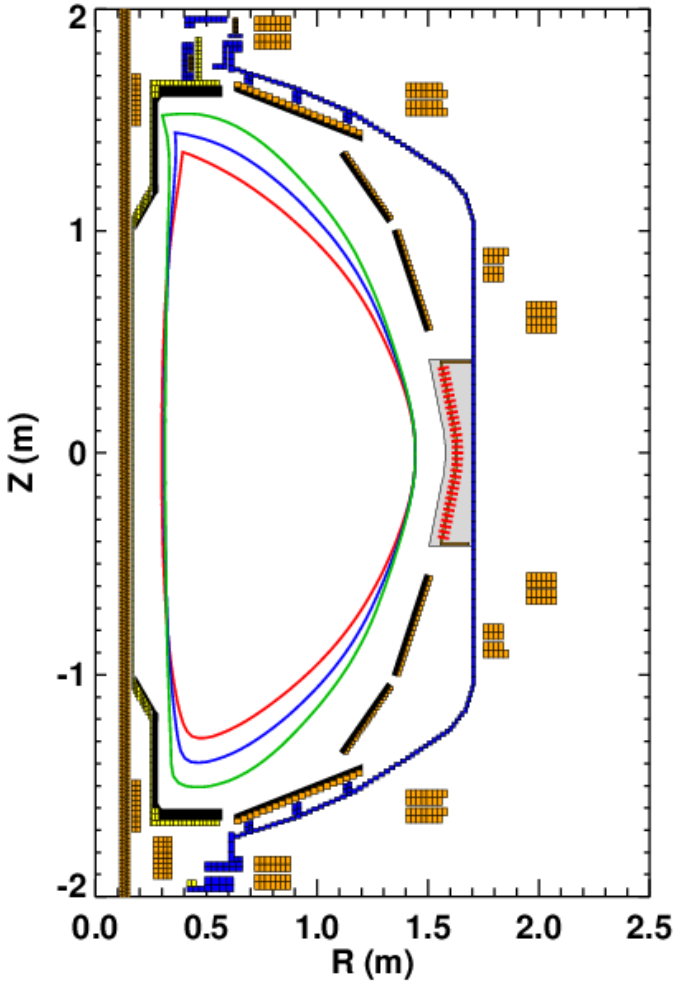
All scans at 700 kA to avoid hitting PF-1A coil current limit!

- Aspect ratio scan at fixed κ.
- Inner and outer gaps change at fixed plasma height

- κ scan at fixed aspect ration.
- Plasma height changes with fixed inner and outer gaps.



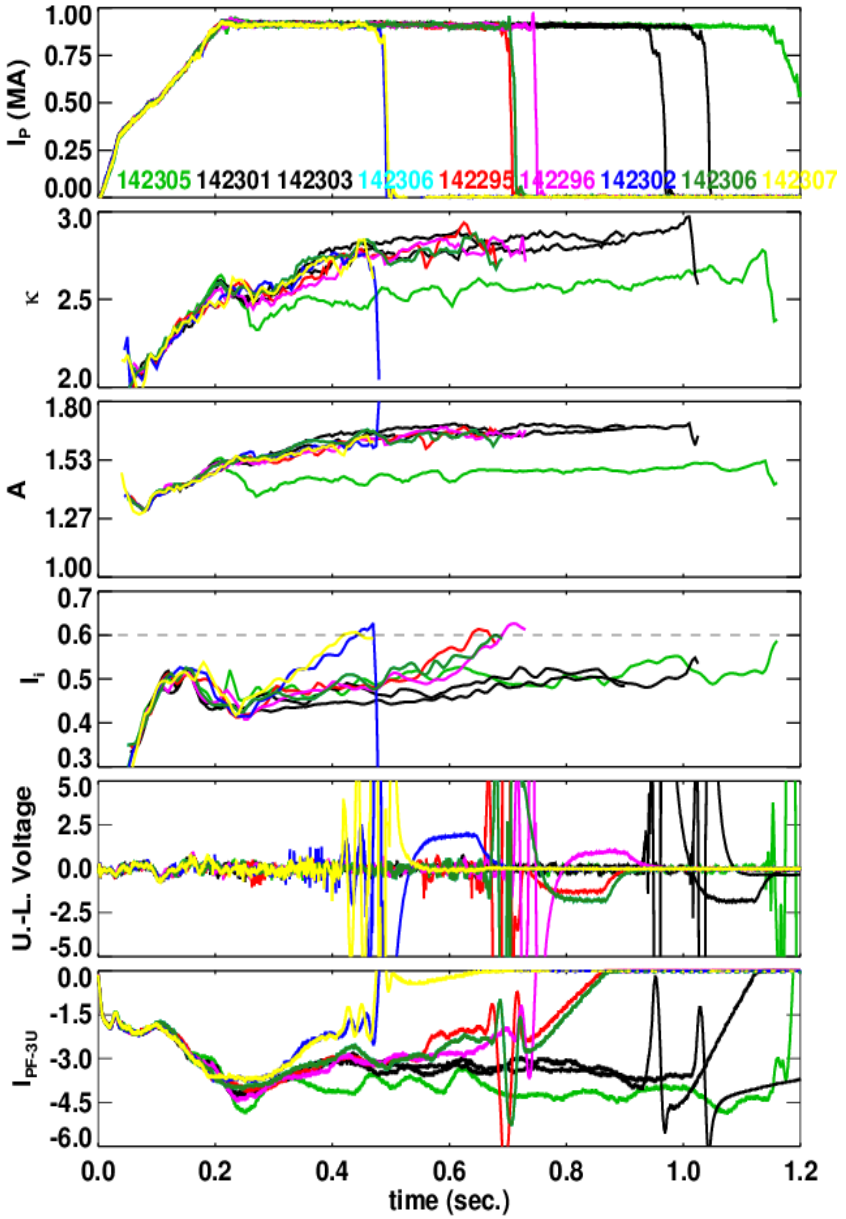




Possible (Likely?) ASC Contributions to R11-2

- Milestone has a component related to n=0 stability and control.
- Improve the vertical controller (SPG).
  - Produce a better realtime estimate of dZ/dt.
  - Optimize the derivative gain.
    - Proportional controller is the ISOFLUX algorithm.
  - If necessary, test use of RWM coils for vertical control.
- Test more advanced shape control algorithms (EK).
  - Use a fully populated "M-Matrix"
  - Use it to develop better inner- and bottom-gap control.
- Performance impact of κ and A (SPG).
  - Scan A at fixed κ, and κ at fixed A.
  - Use reduced input power to avoid disruptions.
  - Test confinement (and current drive) changes due to shape modifications.

Loss of vertical control when l_i>0.6



XP Idea #1: The impact of elongation and aspect ratio on the ideal stability of ST plasmas

- NSTX has a large database of stability results with A<1.55 and κ<~2.4.
  - High-performance NSTX upgrade scenarios will run at larger values of both these parameters.
- It is hard to scan these parameters independently in NSTX…
  - Will be even harder in NSTX-U.
  - This run is the last chance for these types of scans.
- *Relevant Milestone Text: The maximum sustainable normalized beta will be determined versus aspect ratio (up to A=1.7) and elongation (up to 3) and compared to ideal stability theory using codes such as DCON and PEST.*
- Propose to do three types of scans (with fast RWM control off?):
  - Scan #1: Mixed κ & A scan at fixed outer gap (12 shots).
    - Use RFA analysis to look for passive instability.
  - Scan #2: A scan at fixed kappa (10 shots).
    - Test the disruptive β_N limit (use the β_N controller to ramp to a disrupting in a controlled way).
  - Scan #3: Kappa scan at fixed A (10 shots).
    - Test the disruptive β_N limit (use the β_N controller to ramp to a disrupting in a controlled way).
- Goals:
  - Determine if, within the achievable range of A and κ, there is a measurable change in global stability.
    - Compare to ideal stability theory.
  - Collect data validating the β-limit assumptions for NSTX Upgrade.

XP Idea #2:MHD Stability at Very High Toroidal-β and Normalized Current

- ST reactor designs typically assume very high toroidal β.
  - PPPL Pilot: 30-39%, ARIES-ST: 50%, Culham 59%
- It may be time to revisit discharge scenarios with very high β_T.
  - We have made many improvements in control & discharge development since these were last tried in 2005.
    - Reduced PCS latency, RWM control, Li PFC conditioning, stronger shaping, better control during the I_P ramp.
  - We have many new and important diagnostics since 2005.
    - MSE, RWM sensors, better USXR systems.
  - We may have trouble making these shots again.
    - Higher aspect ratio of NSTX-U will lower ideal stability limits.
- Propose to revisit discharges in the β_T~40% regime.
  - Characterize the limiting instabilities.
    - What is the maximum stable β_T at low q* during the phase when q_{min}>~1.1 (i.e. before kink/tearing starts).
    - Can we modify this limit via the profiles? Allow l_i to peak up to improve confinement and stability?
  - Determine to what extent recent operations improvements facilitate this regime.
  - Study disruption precursors.
    - Are disruptions detectable in advance?