NSTX

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Is there any confinement degradation going to NSTX-Upgrade Elongation and Aspect Ratio

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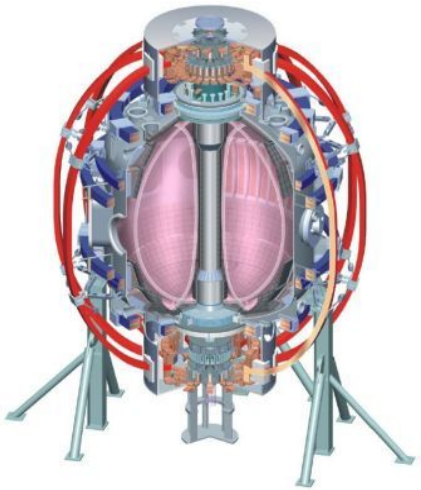
NSTX 2011 & 12 Research Forum
ASC Breakout Session
Wed. March 16th, B318 PPPL



Big Picture Description

- Aspect (A) ratio and elongation (κ) are the lowest order shape parameters in a tokamak…and their impact on the ST is the focus of R11-2.
- NSTX has a large database of confinement with A<1.55 and κ<2.4.
  - NSTX upgrade 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 may be the last chance.
- Propose to do three scans:
  - A scan at fixed κ
    - at constant I_P, and/or
    - at constant q (this very interesting for possible/inevitable decreased tearing stability at higher A)
  - κ scan at fixed A
    - at constant I_P, and/or
    - at constant q
  - Push to very high A and κ
- Goals:

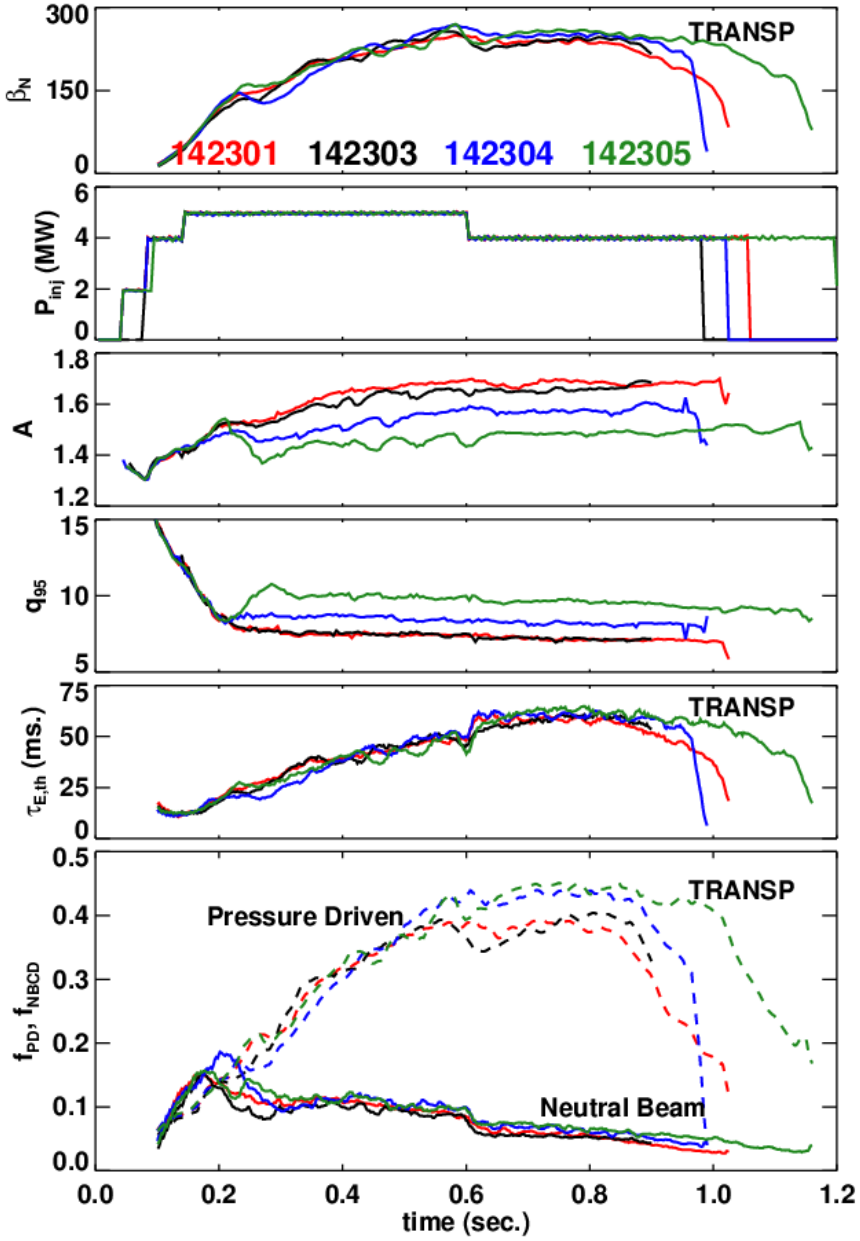
  1: Confirm (or not) confinement and current drive assumptions used in Upgrade modeling.

  2: Study toroidal physics of confinement.

  3: Develop the shapes to be used in further XPs targeting R11-2, JRT, Upgrade support.

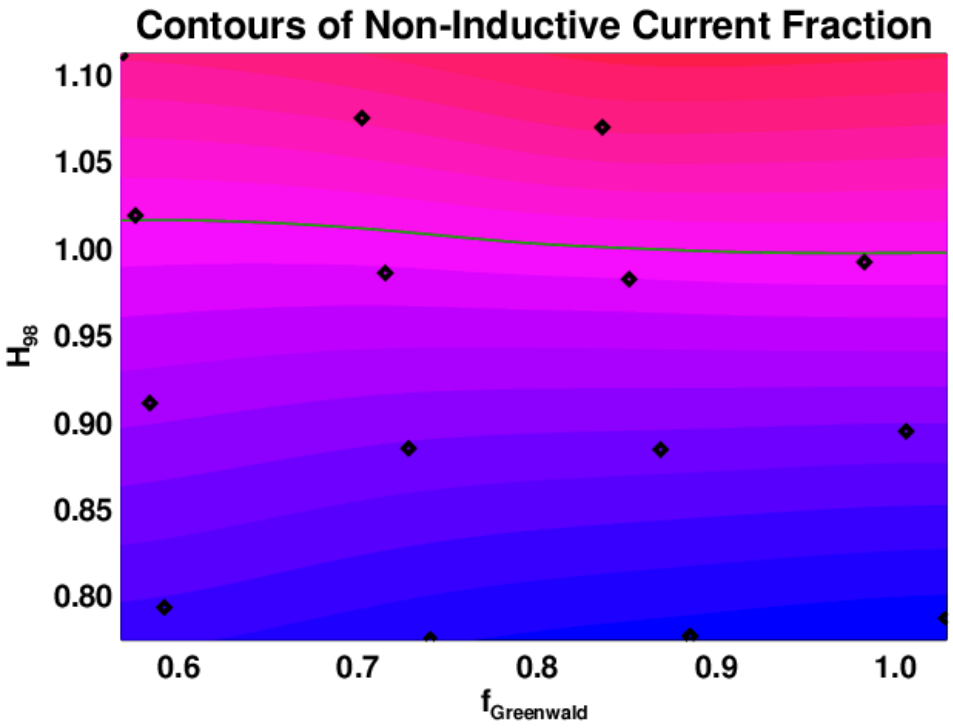
Limited Data Set Last Year Showed a Reduction in Normalized Confinement When A & κ Were Increased

- I_P=900 kA, B_T=0.45 T
- Some drop in β_N at higher A (for fixed P_{inj}).
- Big hit in q_{95}. (10->7.5)
- Confinement is degraded by ~10%.
  - H from 1.02 to 0.85.
- T_e is a bit lower, which hurts the NBCD.
- Data collected at the end of the run, when machine performance was sub-optimal.

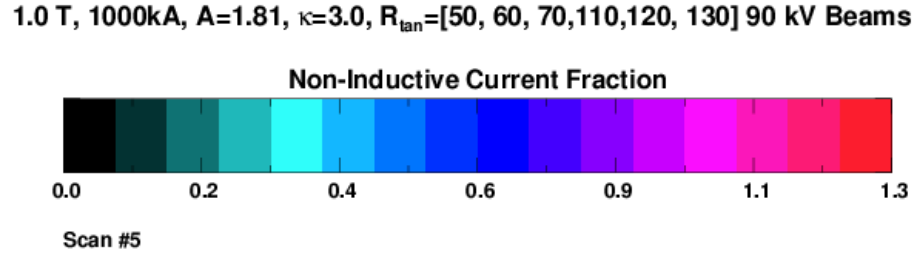


NSTX-U Scenarios Need H>1.0 to Meet Non-Inductive Targets At High Current

- Free-boundary TRANSP calculations
  - Z_{eff}=2, D_{FI}=0.
- Scale the T_e profile and use neoclassical ion transport.
- Current profile is fully relaxed.
- All six sources at 90 kV.
- A=1.81, κ=2.9, gap_out=20 cm
  - Large gap helps with off-axis NBCD.

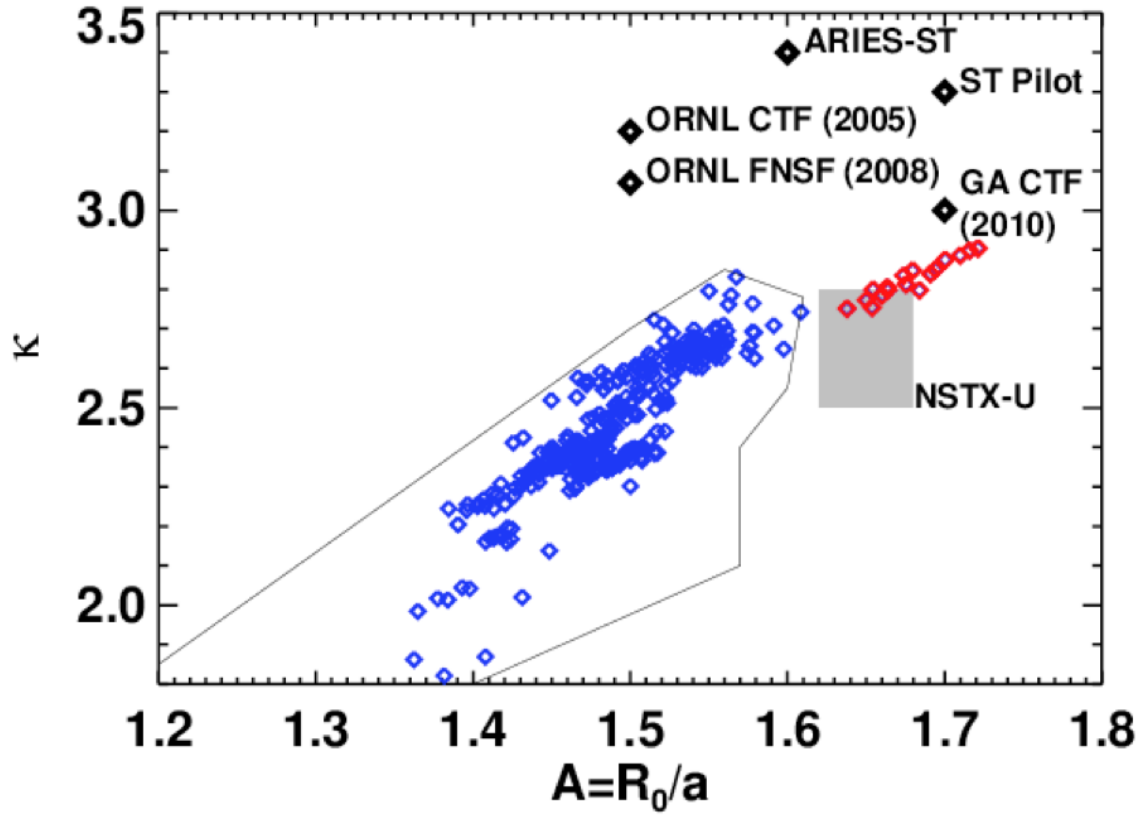


- Can be fully non-inductive at 1000 kA with H~1.0.
- H=0.85 drops f_{NI} to ~70%.
- *Want to get new/better confinement data in these configurations.*



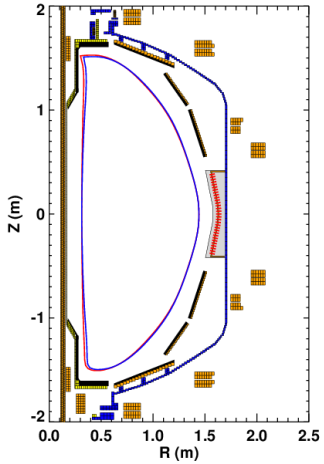
In General, It is Hard to Scan A and κ Independently

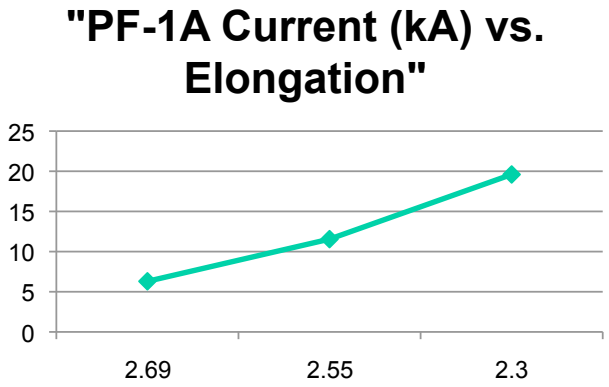
- Fundamental Issue: the inner gap is not an independently controlled quantity.



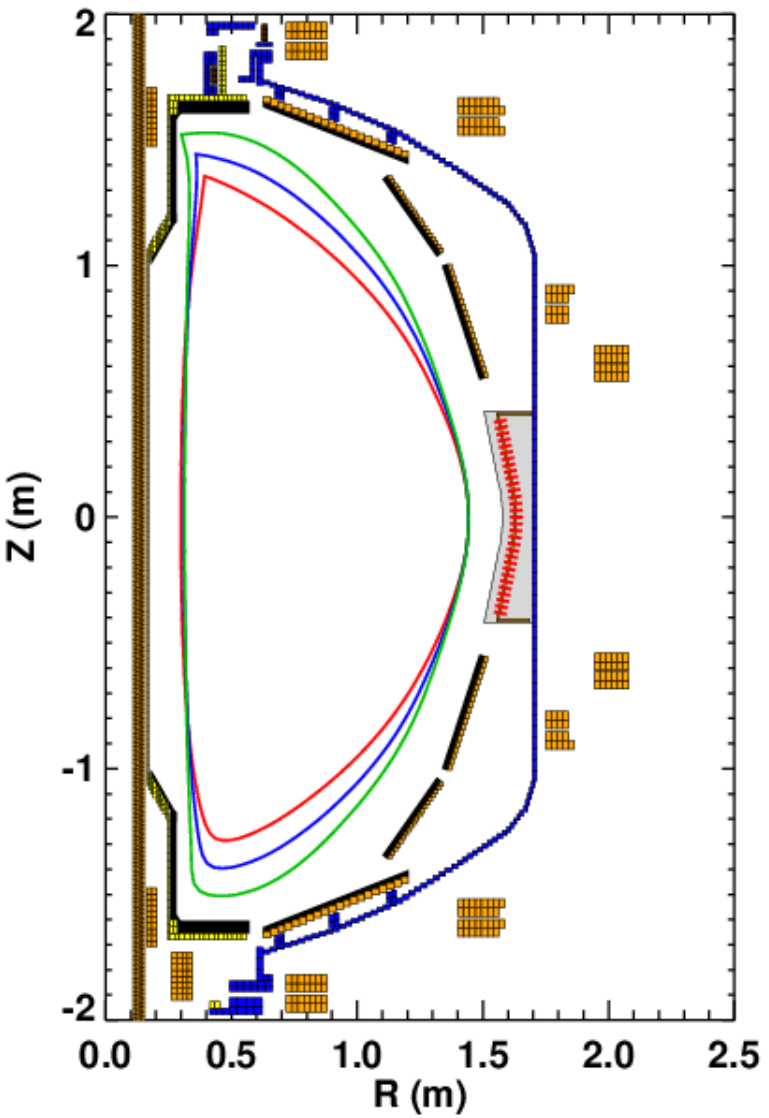
Scan of Kappa At Fixed A. With Constant I_P or Constant q_{95}

- Low elongation limit is set by current limit on the PF-1A coil.
  - Otherwise the inner gap shrinks
  - 700 kA plasma need 19.6 kA of PF-1A





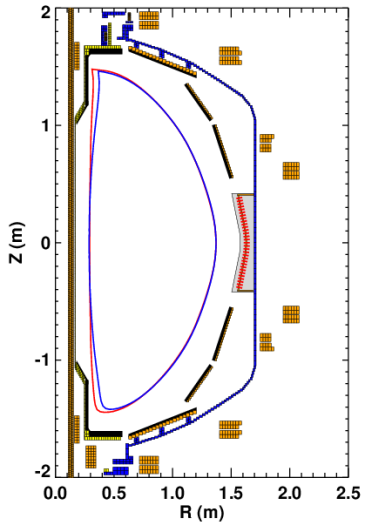
A	κ	I_P	q_{95}	I_{PF-1A}
1.56	2.66	825	12.1	10.7
1.55	2.69	700	17.9	6.3
1.55	2.55	700	13.9	11.6
1.52	2.3	700	12.03	19.6



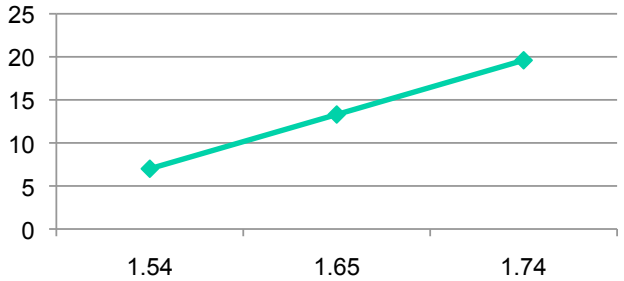
Scan of A at Fixed Kappa With Constant I_P or Constant q_{95}

- High aspect ratio limit set by the PF-1A coil current limit.

700 & 1000 kA

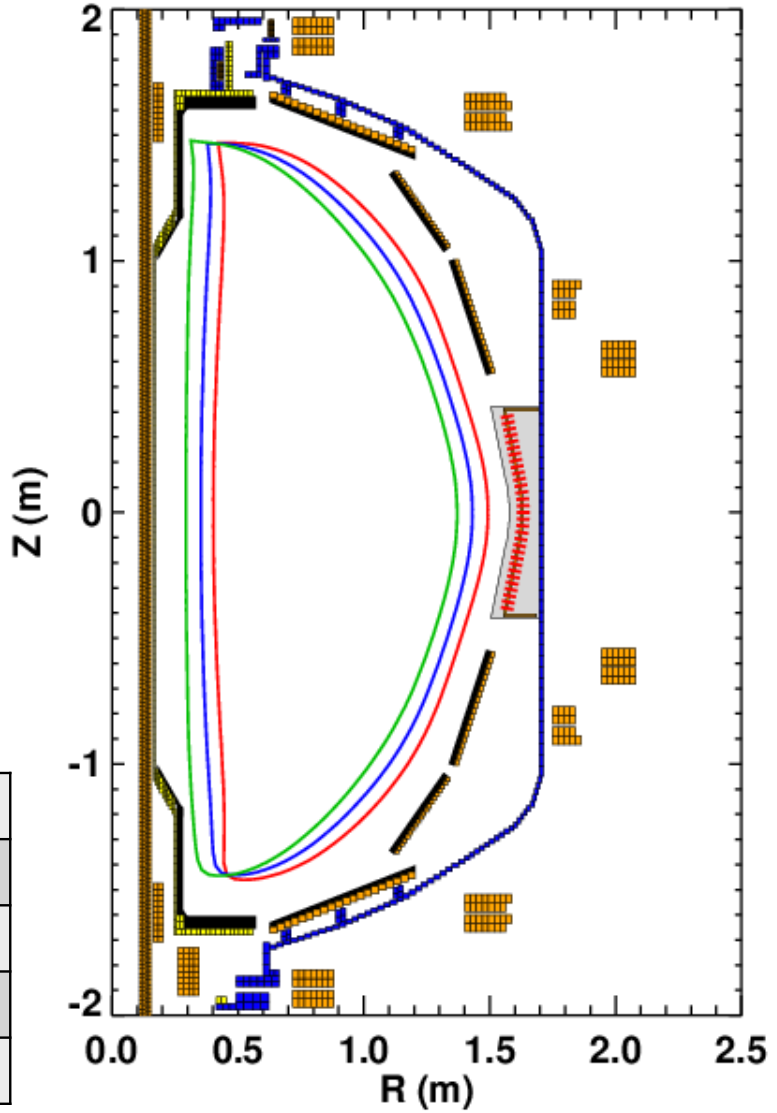


PF-1A Current (kA) vs. Aspect Ratio



A	κ	I_P	q_{95}	I_{PF-1A}
1.53	2.64	1000	9	18.9
1.54	2.7	700	18	7
1.65	2.69	700	12	13.3
1.74	2.67	700	9.5	19.6

Scan of A at fixed κ and I_P



XP Summary

- Part 1: Aspect Ratio Scan at Fixed Kappa
  - Base configuration: 700 kA, κ=2.7
  - Scan of A at fixed I_p (6 shots)
  - Scan of A at fixed q (6 shots)
- Part 2: Kappa Scan at Fixed Aspect Ratio
  - Scan of κ at fixed I_p (6 shots)
  - Scan of κ at fixed q (6 shots)
- Part 3: Go as close as possible to the A=1.8, κ=3 shape indicated earlier. (6 shots)
- Questions:
  - Fix 4 MW input power, or try to fix β? May not be important if β scaling is weak.
  - Which of the turbulence diagnostics can handle the wide range of shapes?
  - How much lithium? Pick the amount thought representative of Upgrade operations?
- Analysis:
  - TRANSP for global confinement and current drive trends.
  - Turbulence measurements?
- Run time request: 1 day, possibly broken into two sub-sections.