NSTX

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Is there any confinement degradation going to NSTX-Upgrade Elongation and Aspect Ratio? (XP-1103)

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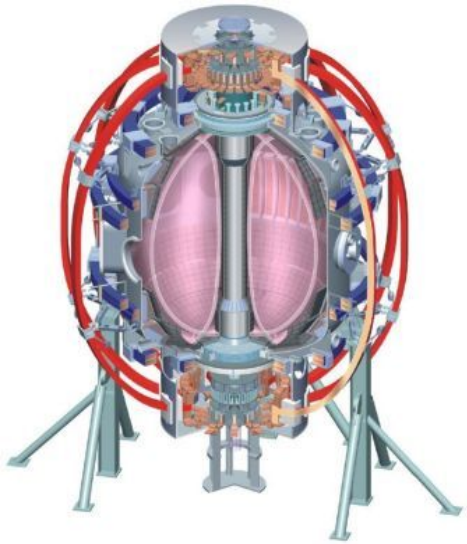


Big Picture Description

- 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
  - κ scan at fixed A
  - Push to very high A and κ
- Goals:

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

H_{98}=1 is accessible?

Ion transport remains neoclassical?

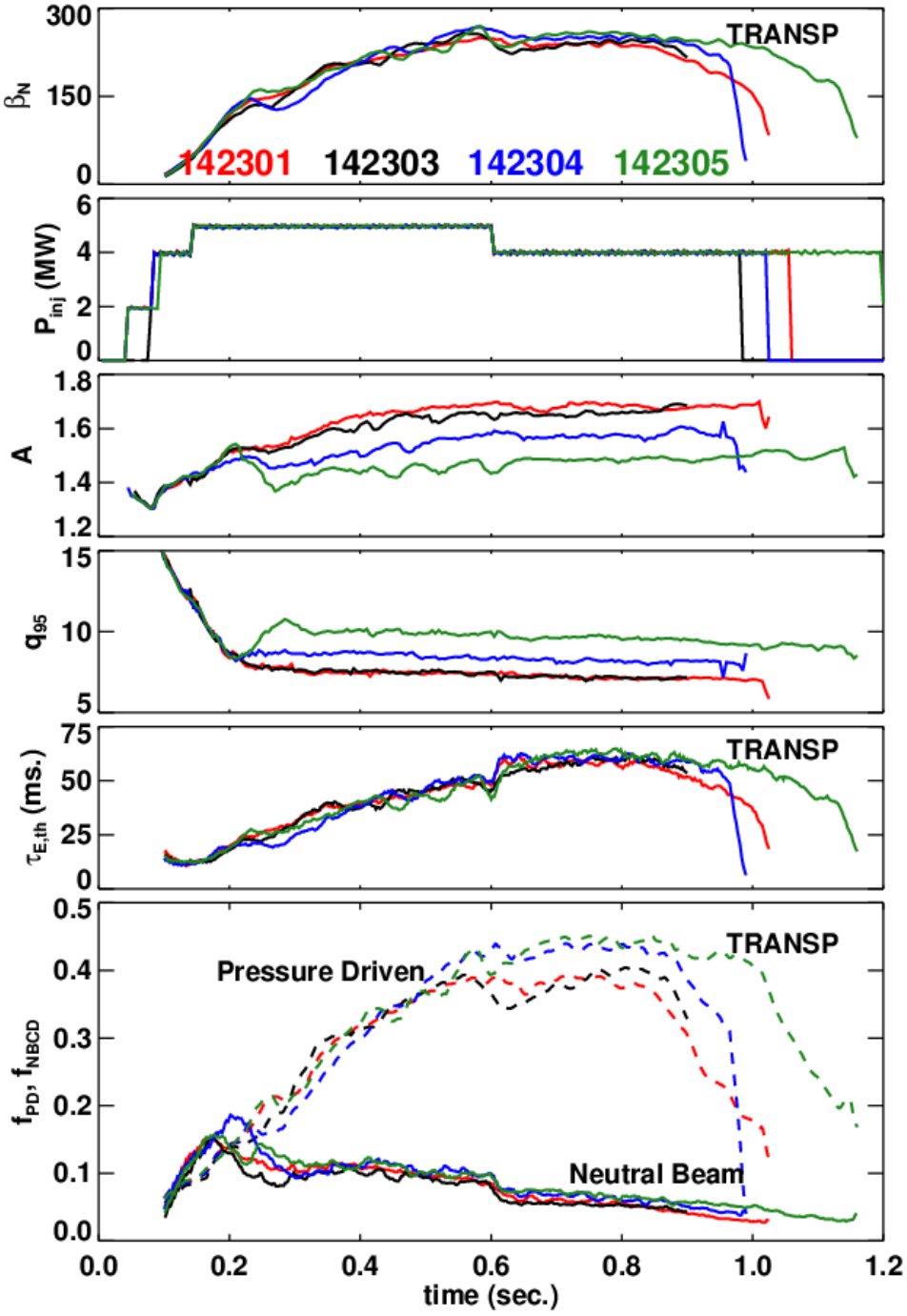
NUBEAM+Sauter BS+V_{loop} analysis can predict the current profile?

2: Determine if there is a strong A or κ dependence of the above.

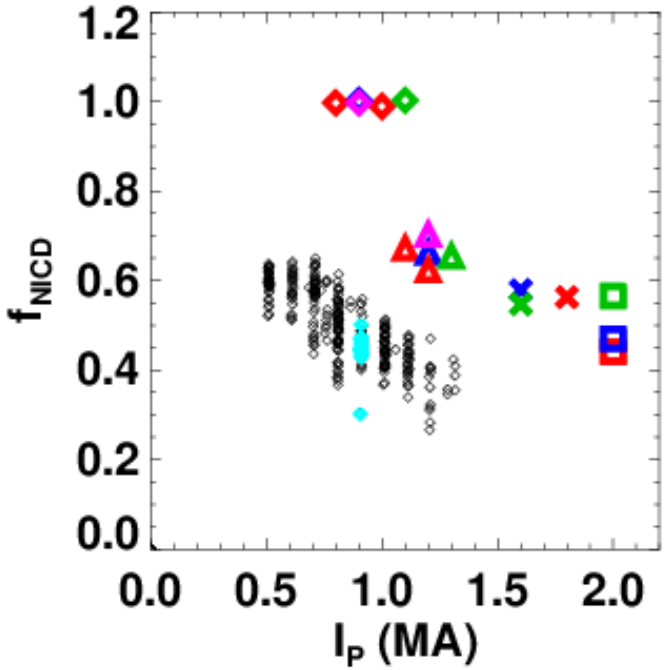
3: Develop the shapes to be used in further XPs targeting R11-2, JRT, Upgrade support.

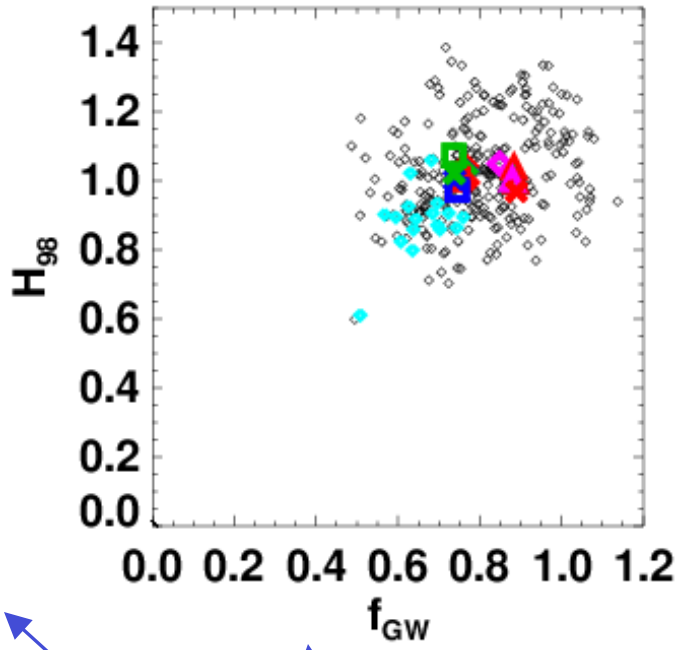
Limited Data Set Last Year Showed a Reduction in Confinement When A & κ Were Increased

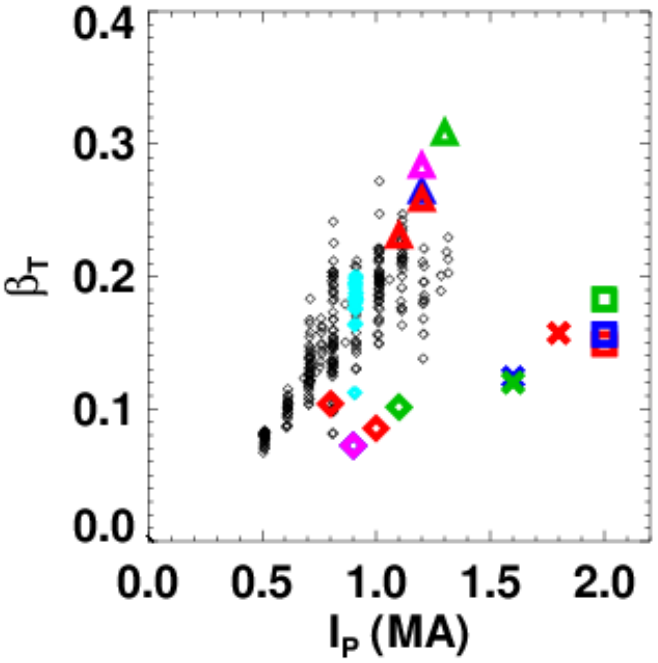
- I_P=900 kA, B_T=0.45 T
- Some drop in β_N at higher A (for fixed P_{inj}).
- Big hit in q_{95}. (10->7.5)
- Confinement is degraded by ~10%.
  - H from 1.02 to 0.85.
- T_e is a bit lower, which hurts the NBCD.
- Data collected at the end of the run when machine performance was sub-optimal.



NSTX-U Scenarios Need H~1.0 at Higher A to Meet Aggressive Scenario Goals

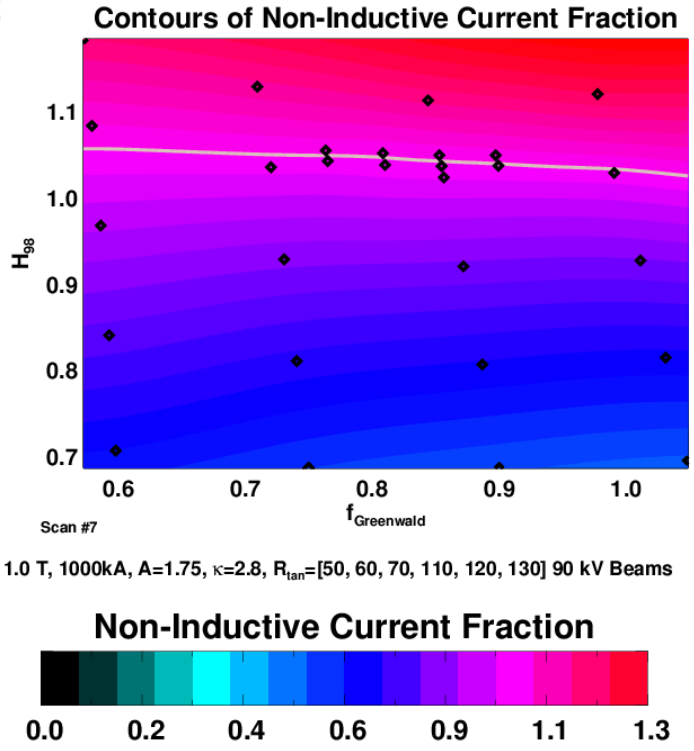






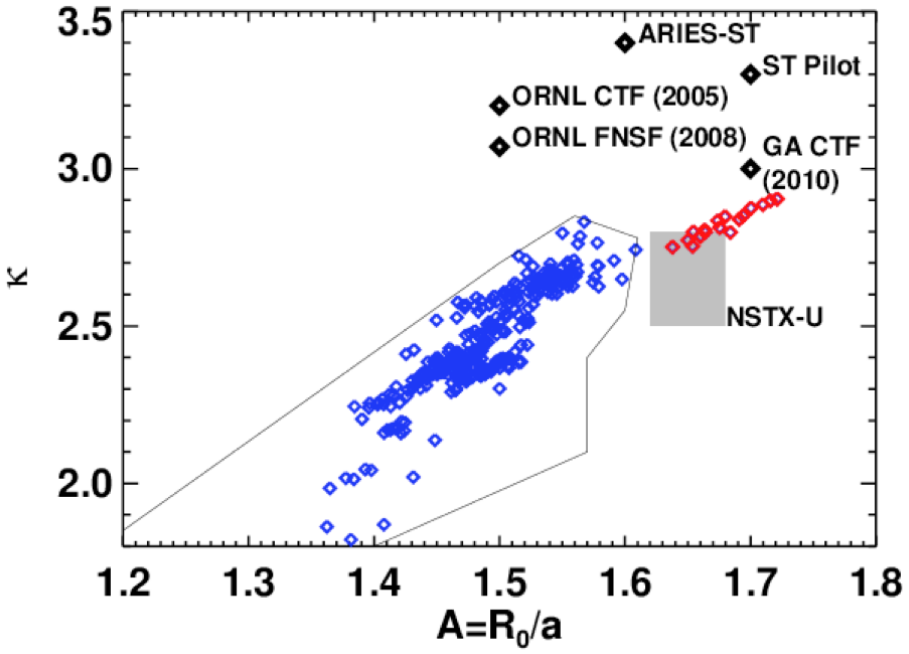
Comparisons of Upgrade Scenarios To Existing Data

Effect of degraded confinement on NSTX-Upgrade 100% non-inductive scenarios.

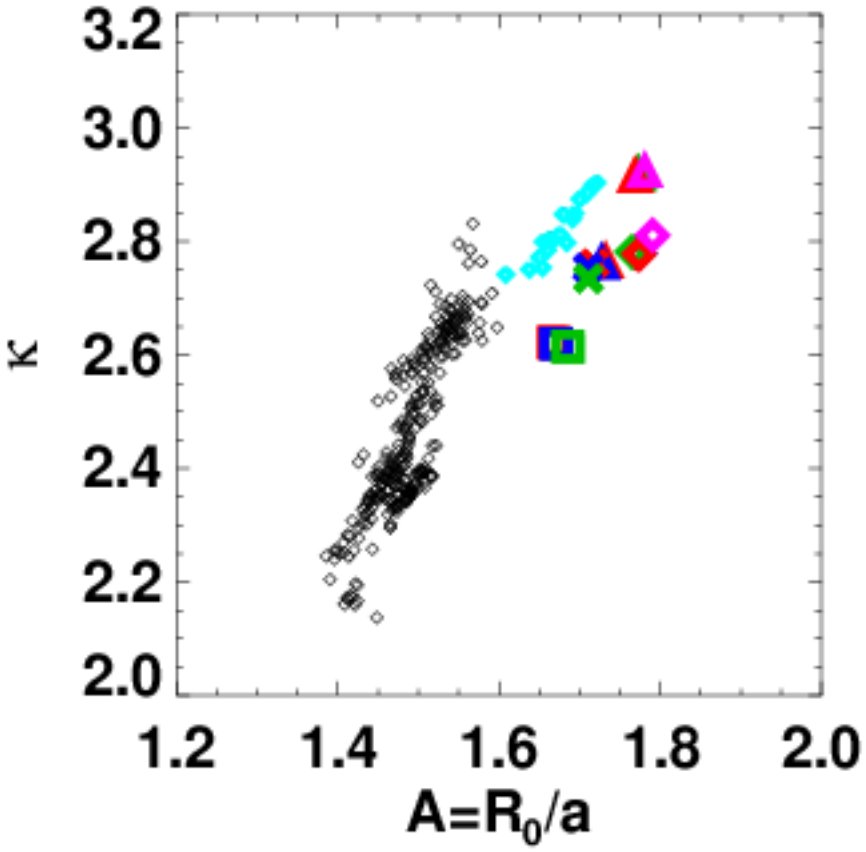


In General, It is Hard to Scan A and κ Independently

Space of aspect ratio and elongation for NSTX and some proposed next step devices.

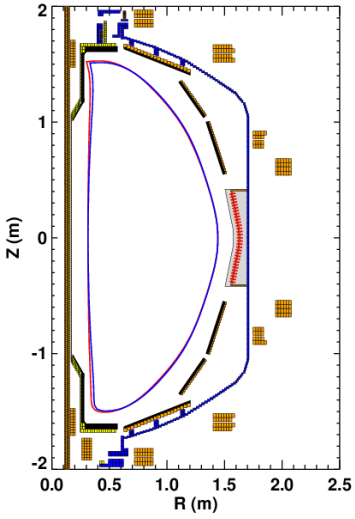


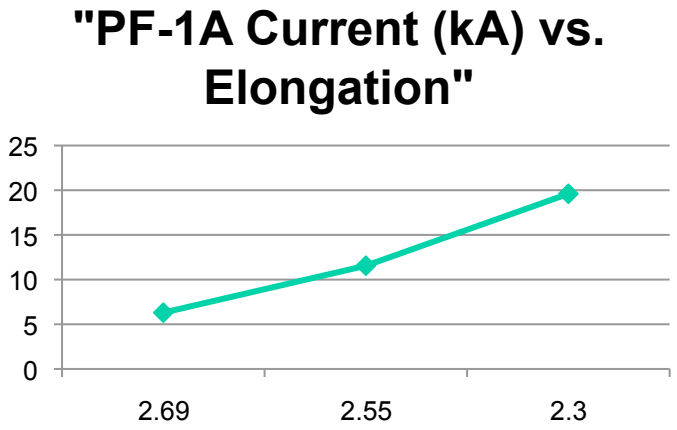
Space of aspect ratio and elongation for NSTX and interesting upgrade scenarios.



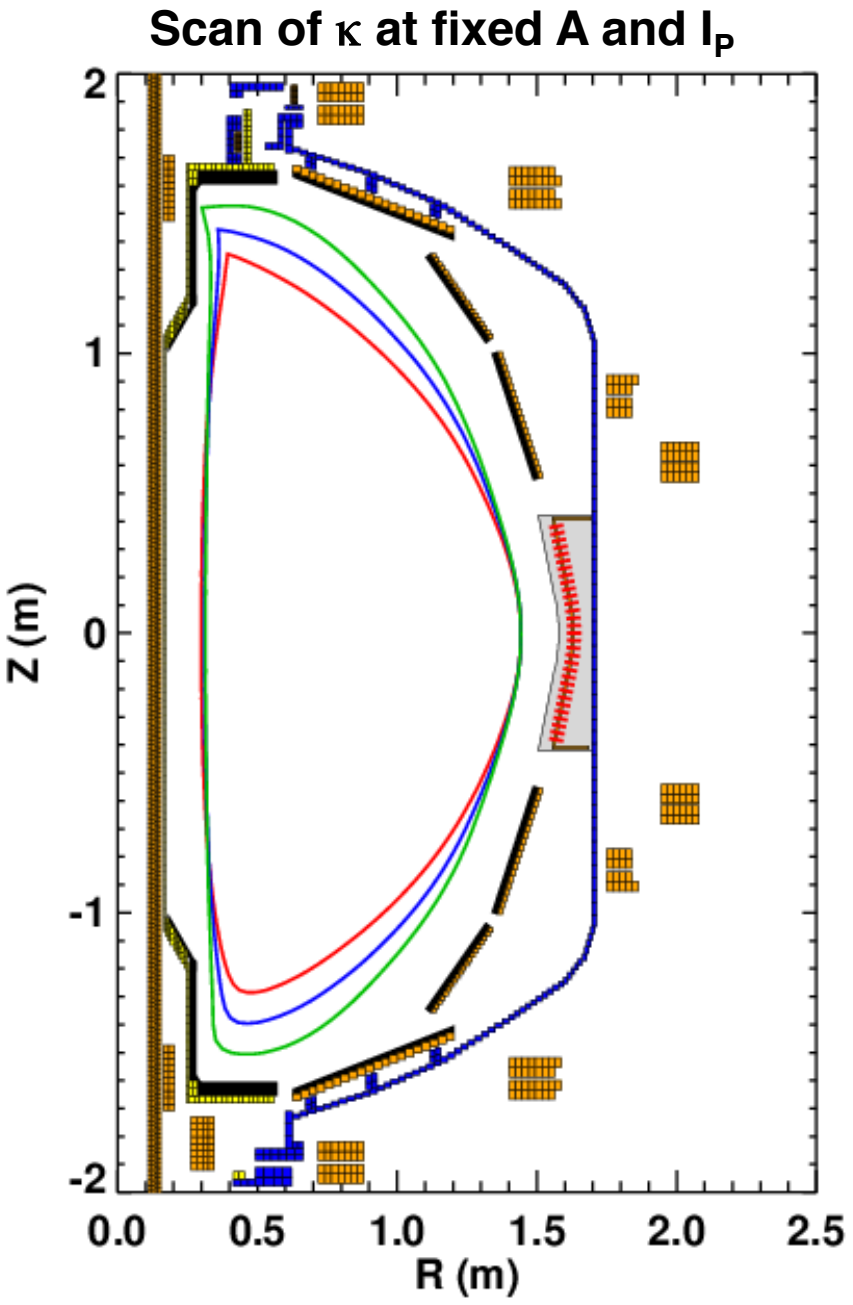
Scan of Kappa At Fixed A. With Constant I_P or Constant q_{95}

- 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





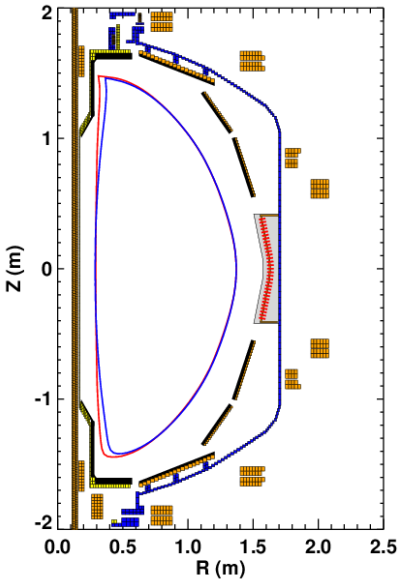
A	κ	I_P	q_{95}	I_{PF-1A}
1.56	2.66	825	12.1	10.7
1.55	2.69	700	17.9	6.3
1.55	2.55	700	13.9	11.6
1.52	2.3	700	12.03	19.6



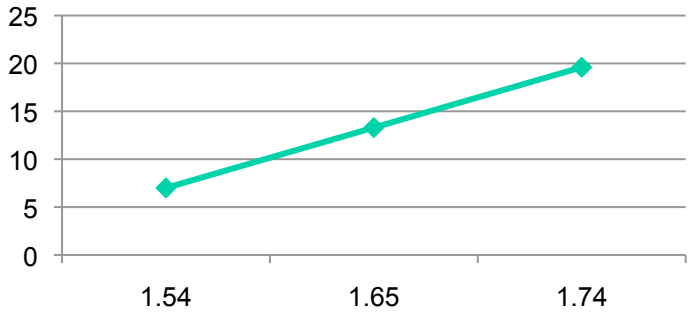
Scan of A at Fixed Kappa With Constant I_P or Constant q_{95}

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

700 & 1000 kA

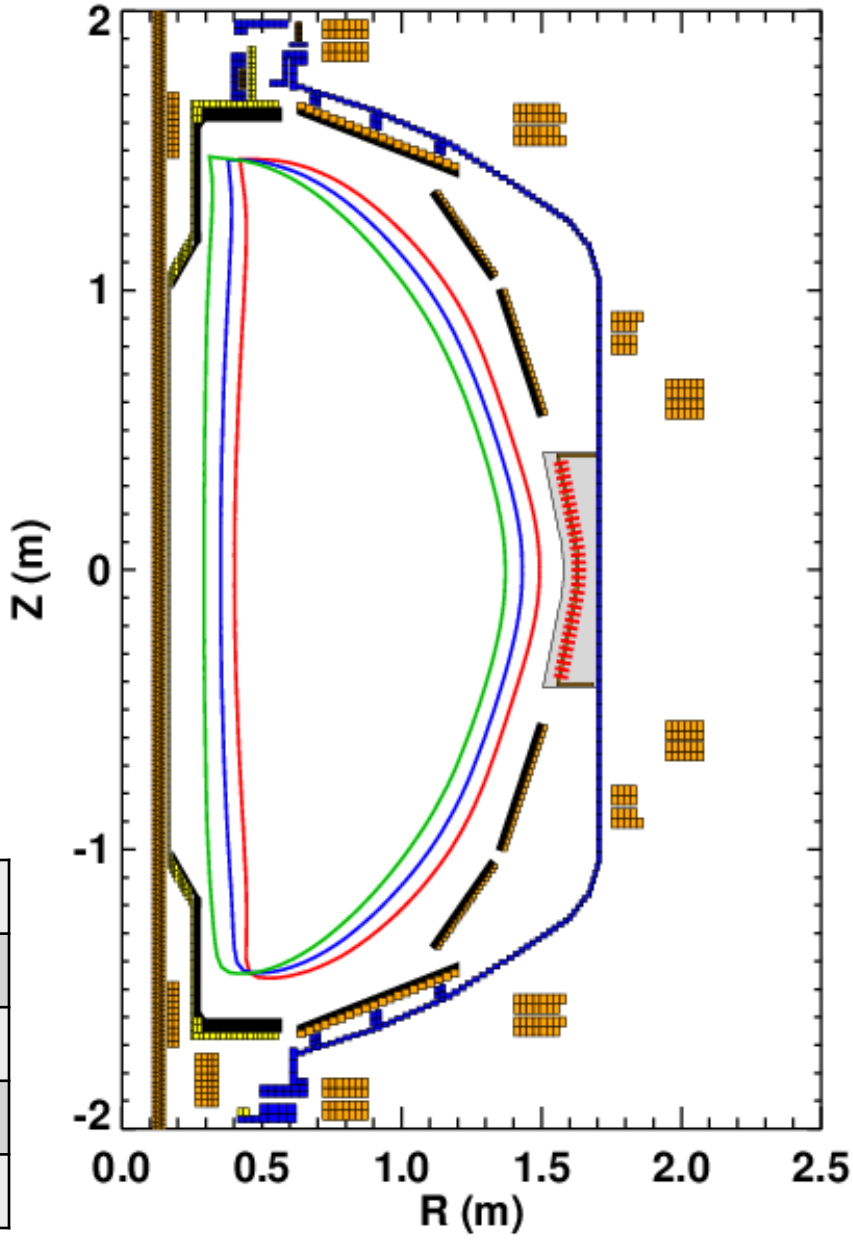


PF-1A Current (kA) vs. Aspect Ratio



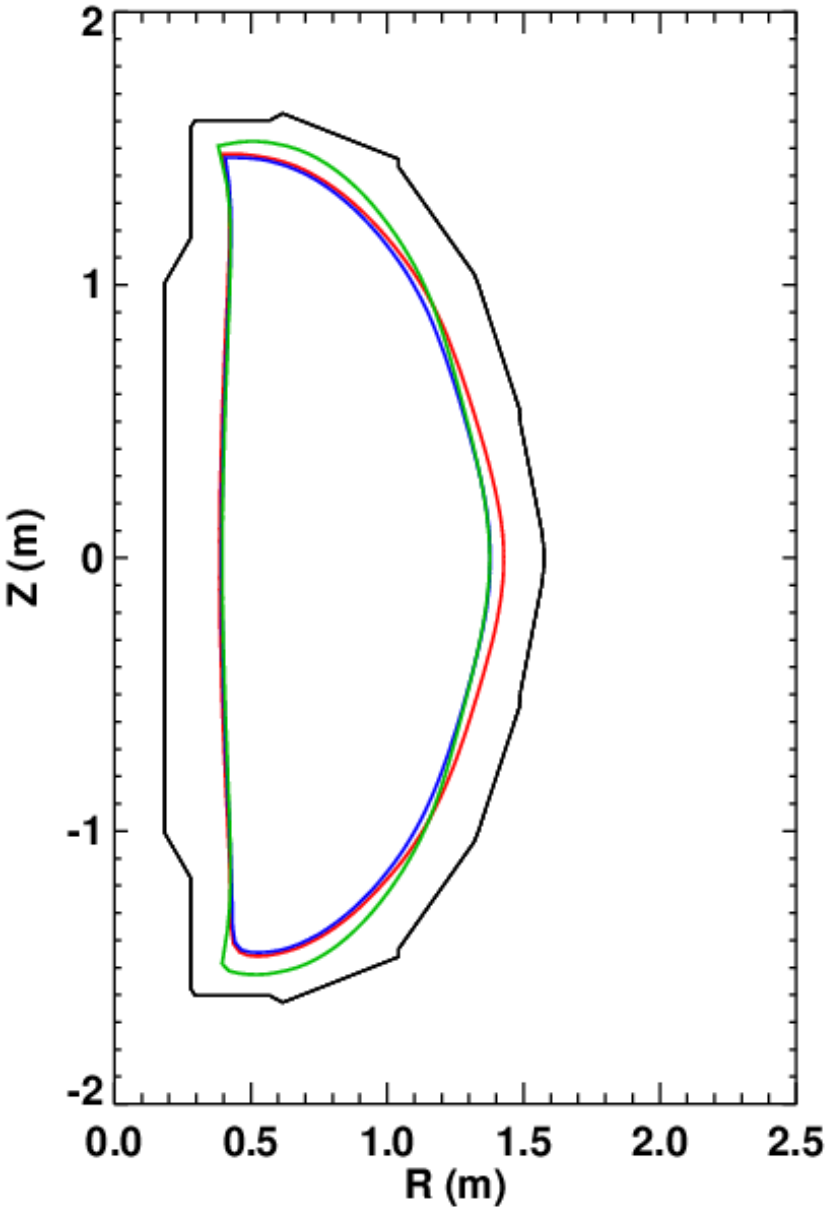
A	κ	I_P	q_{95}	I_{PF-1A}
1.53	2.64	1000	9	18.9
1.54	2.7	700	18	7
1.65	2.69	700	12	13.3
1.74	2.67	700	9.5	19.6

Scan of A at fixed κ and I_P



Maximal Aspect Ratio and Kappa Can Be Studied.

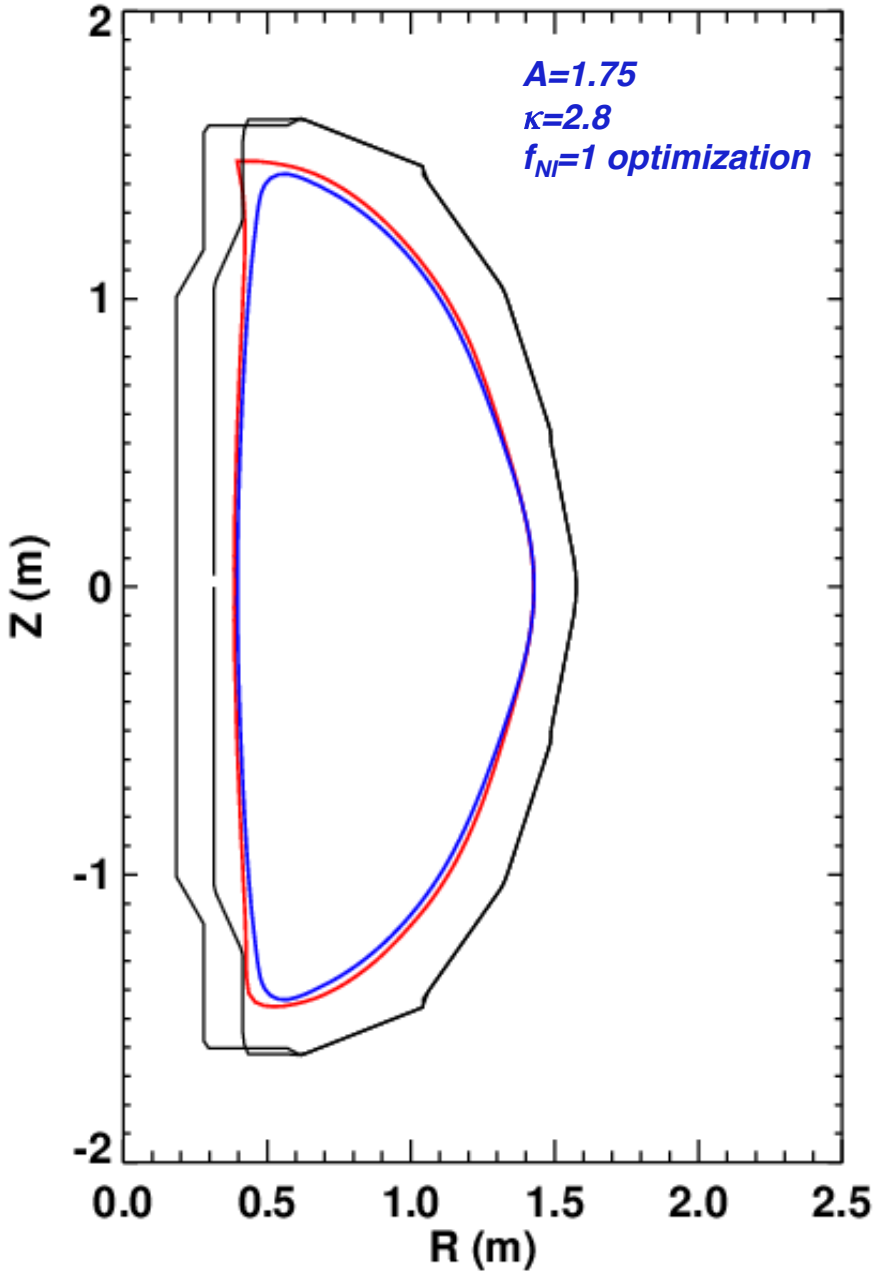
- Three cases here
  - κ=2.8, A=1.75,I_P=750 kA shape typical of f_{ni}=1 in NSTX-upgrade. 15 cm outer gap. (Should get this in the other scans)
  - κ=2.95, A=1.81, I_P=750 kA shape typical of high-β_T in NSTX-upgrade. 20 cm outer gap helps elevate q_{min} at high I_N.
  - κ=3.1, A=1.81, I_P=850 kA shape with 20 cm outer gap…a shape approaching the needs of next-step STs. For κ>3, should we minimize the inner or outer gap? Trade aspect ratio against proximity to plates? May get some indication in A scans.

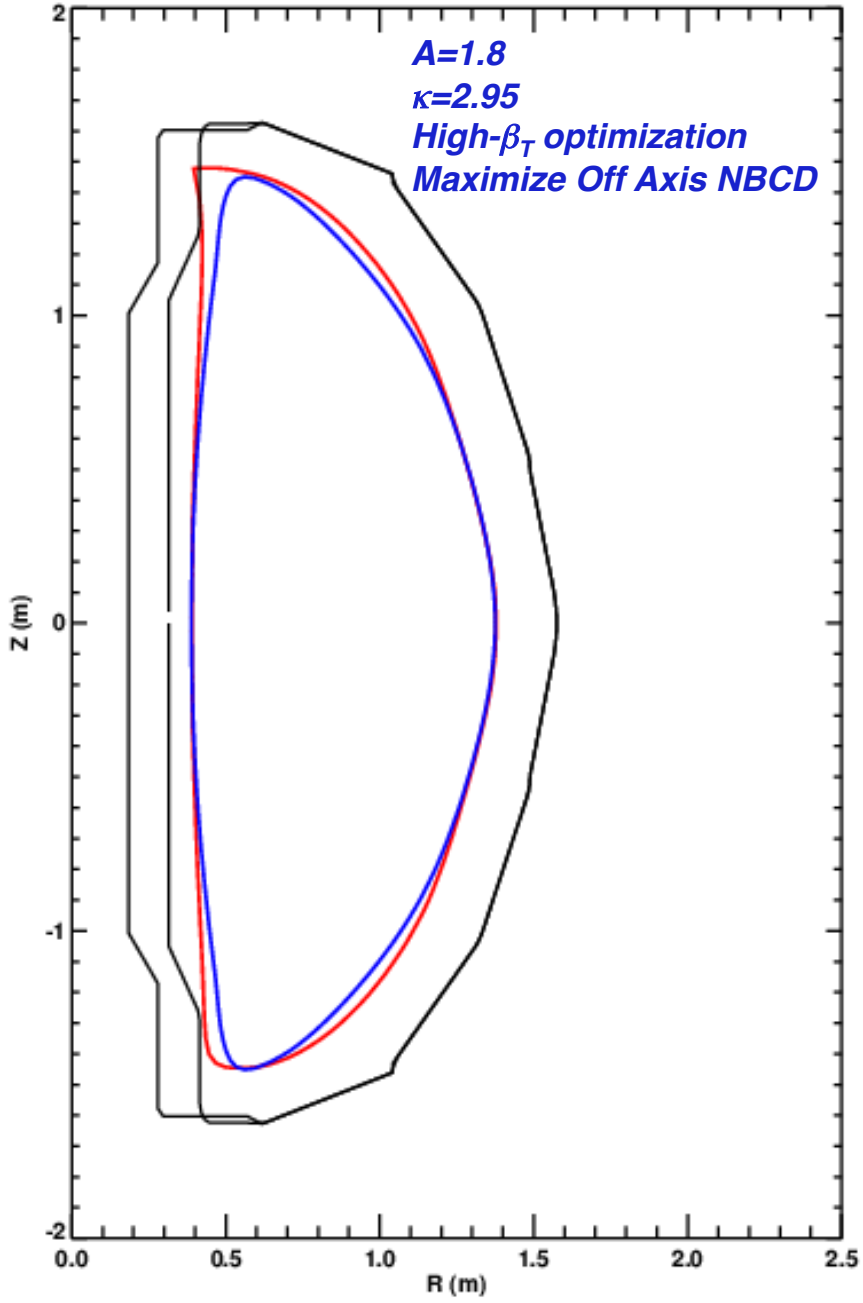


Shapes In Study Are Designed to Mimic Upgrade Scenarios

Proposed Shape

NSTX-Upgrade Scenarios





Shot List

- Part 1: Aspect Ratio Scan at Fixed Kappa and I_P (10 shots)
  - Base configuration: 700 kA, κ=2.7
  - Scan of A at fixed κ (=2.65-2.7) and I_p, 2 shots in each of 3 configurations
- Part 2: Kappa Scan at Fixed Aspect Ratio (8 shots)
  - Scan of κ at fixed A (=1.55) and I_p, 2 shots in each of 3 configurations
- Part 3: Scan to the A=1.8, κ=3.1 shape indicated earlier. (10 shots)
  - Start with κ=2.8, A=1.75 case, then increase the outer gap, then increase the plasma height.
  - Aim for [A,κ,gap_{out}]=[1.8,2.9,20], then [1.76,3.1,20]
- Part 4: Constant q scans…*doesn't fit in single day allocation*. (14 shots)
  - Scan of A at fixed q (7 shots)
  - Scan of κ at fixed q (7 shots)
- Questions/Comments:
  - Fix 4 MW input power, or try to fix β? May not be important if β scaling is weak. SPG inclined to take 4 MW.
  - How much lithium? Pick the amount thought representative of Upgrade operations? SPG inclined to use 150-200 mg/shot on 10 minute shot cycle.
  - Full day or two ½ days? SPG inclined to take two half days….
  - Desire that vertical stability XP be completed prior to this XP.
  - Should we freeze vertical control in each case for n=0 growth rate measurements? If so, adds ~8 shots.
  - This XP must run early, as it feeds other XPs. BUT, it must be run with good machine conditions.

Diagnostics & Analysis

- Diagnostics:
  - MPTS, CHERS, MSE: For detailed equilibrium analysis, including TRANSP calculations.
    - Keep 10 cm gap to maintain good MPTS resolution.
  - RWM sensors and high-n array: rotating and stationary n=1 perturbations.
  - BES in linear array configuration for global low-k turbulence characterization (?).
  - VB-Z_{eff}, for confirmation of CHERS Z_{eff}. Neutrons for confirmation of beam physics.
- Analysis:
  - Equilibrium analysis with EFIT and LRDFIT.
  - TRANSP for confinement characteristics.
  - Home-grown codes for loop-voltage analysis, inductive current profile calculation.