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

Stefan Gerhardt,…

NSTX Team Review

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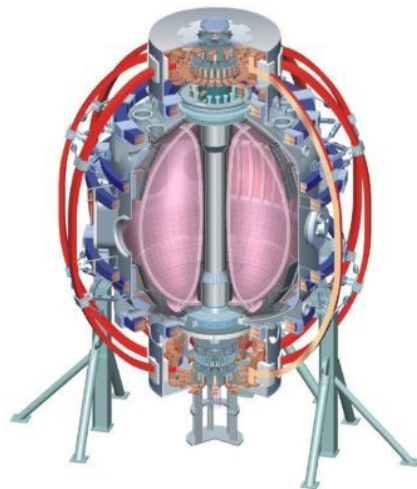
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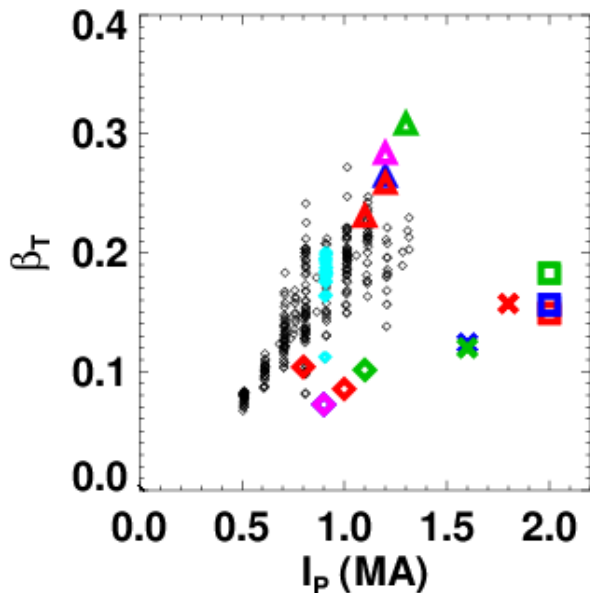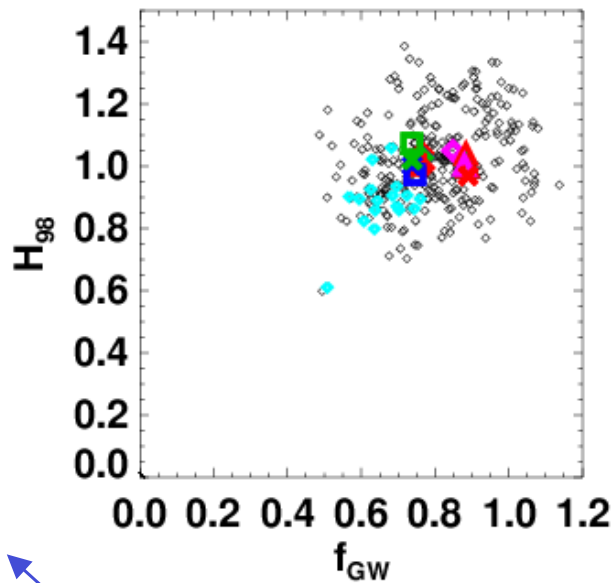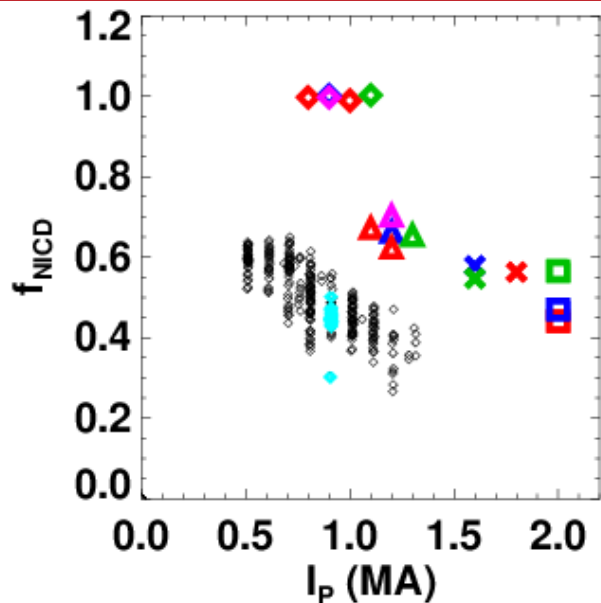U Quebec

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.
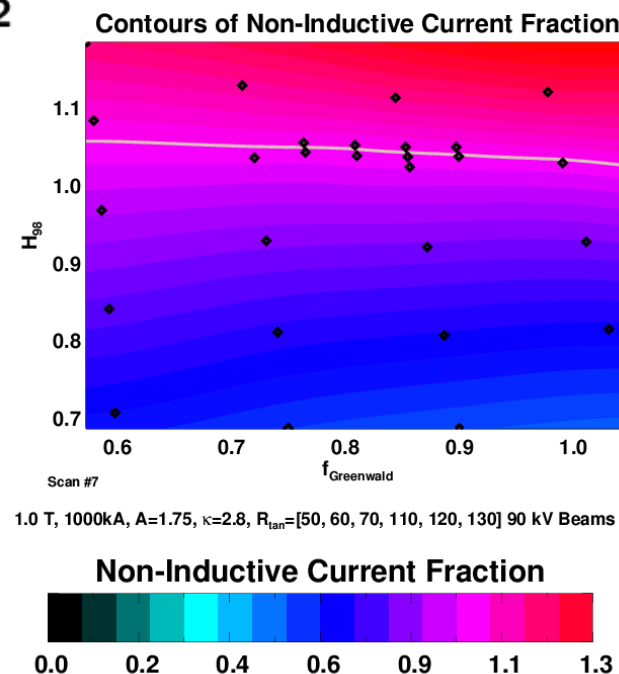- Data collected at the end of the run when machine performance was sub-optimal.
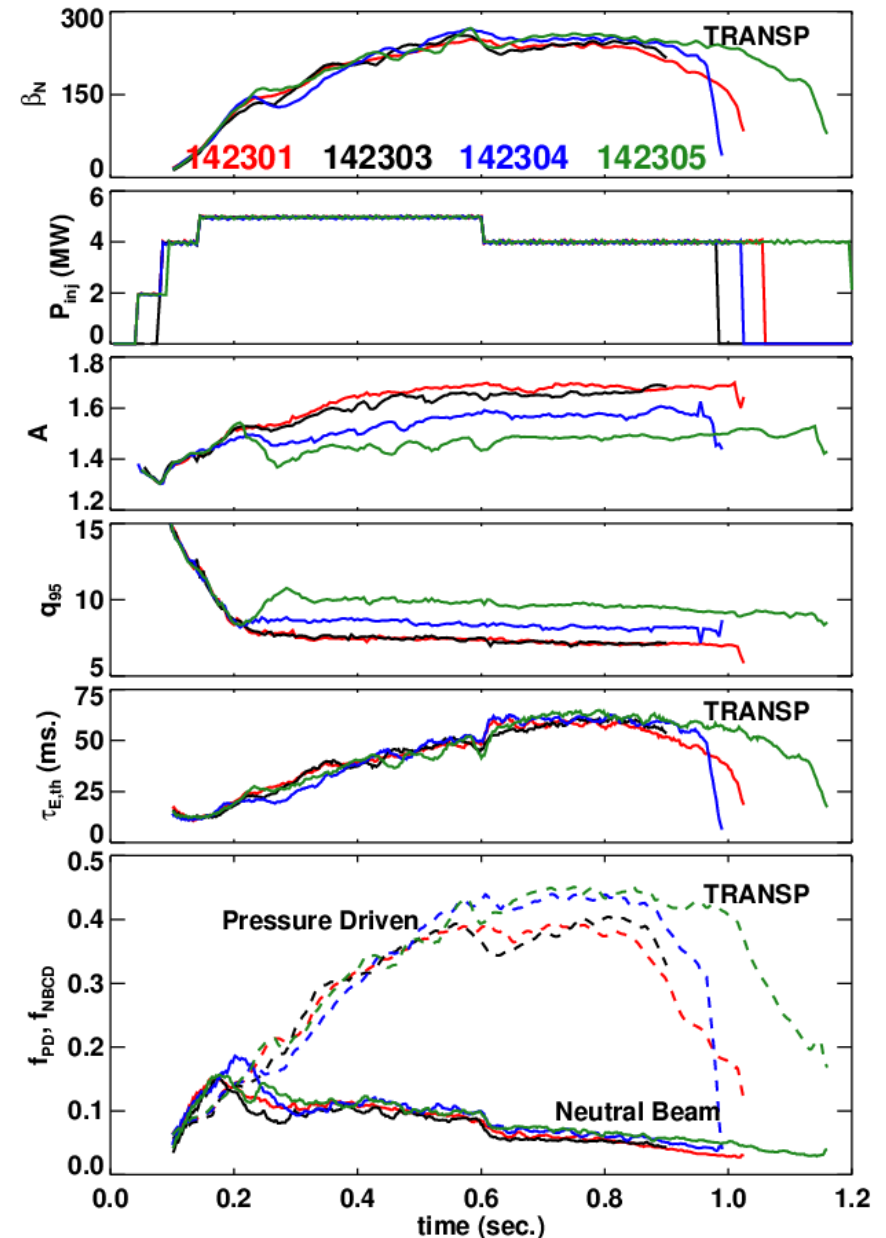
NSTX-U Scenarios Need H~1.0 at Higher A to Meet Aggressive Scenario Goals

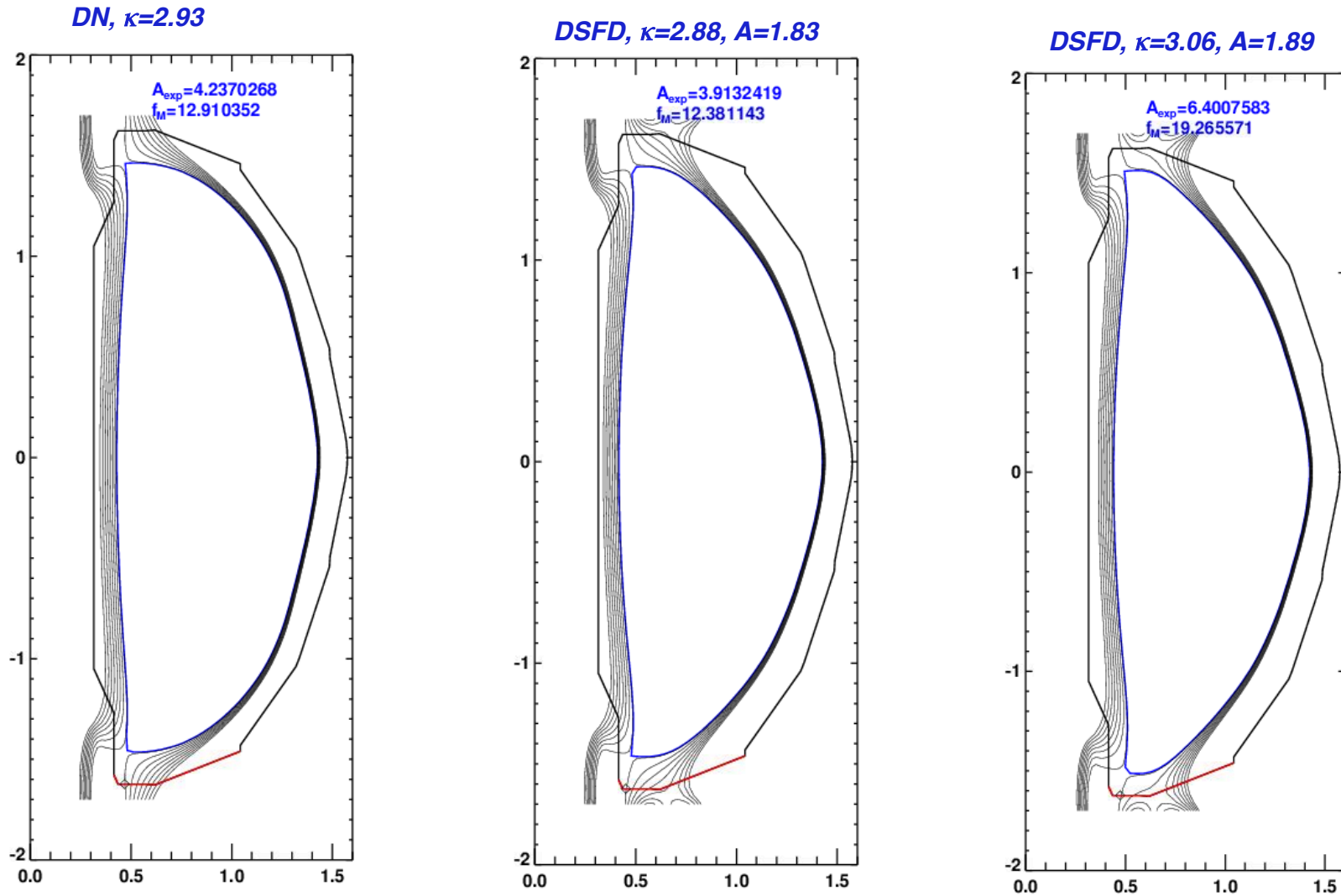*Effect of degraded confinement on NSTX-Upgrade 100% non-inductive scenarios.*

Comparisons of Upgrade Scenarios To Existing Data

Contours of Non-Inductive Current Fraction

Scan #7

1.0 T, 1000kA, A=1.75, κ=2.8, R_tan=[50, 60, 70, 110, 120, 130] 90 kV Beams

Non-Inductive Current Fraction

0.0   0.2   0.4   0.6   0.9   1.1   1.3

Use of SFD in NSTX-Upgrade Will Mandate High Elongation

DN, κ=2.93

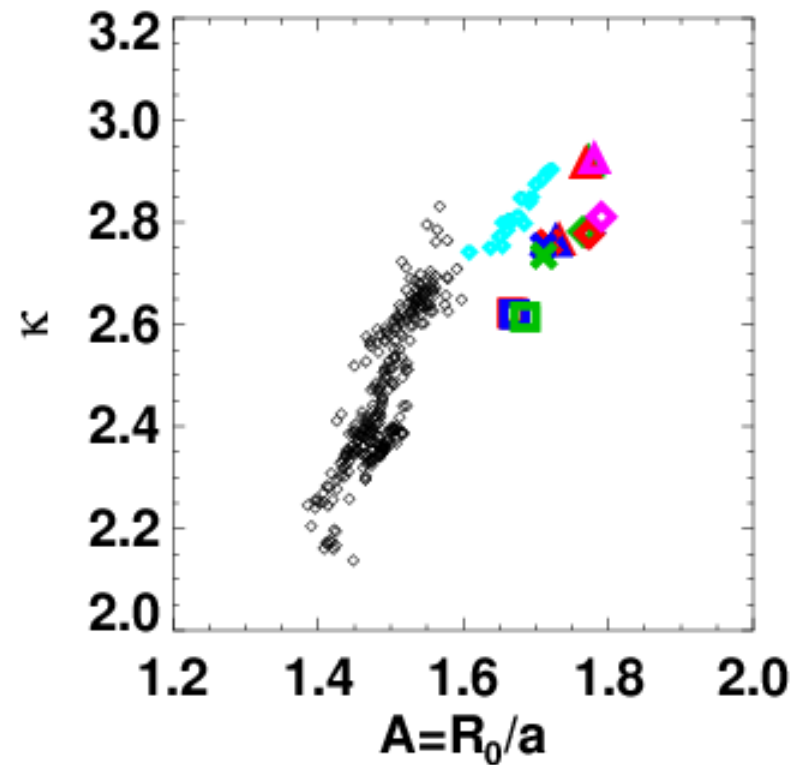**DSFD, κ=2.88, A=1.83**

DSFD, κ=3.06, A=1.89

(D)SFD Works Best with Small Top/Bottom Gaps

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.**
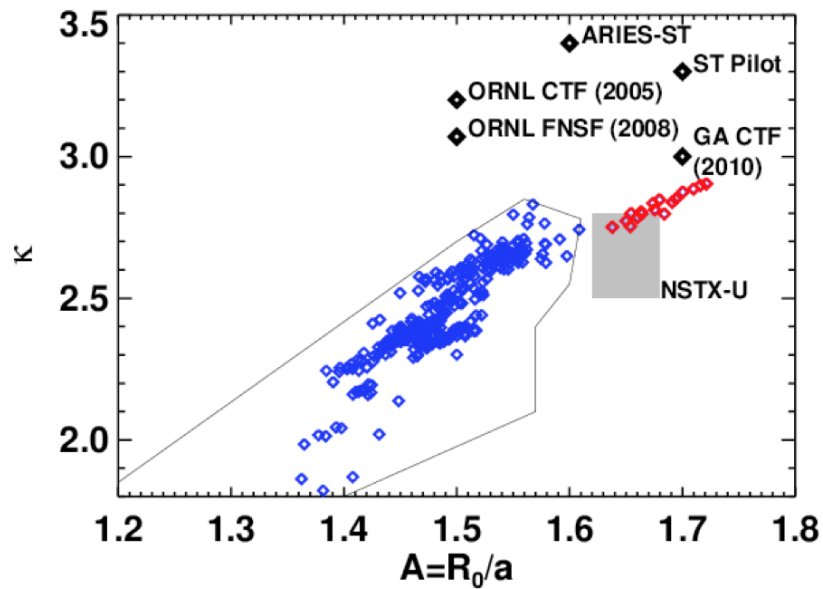
Space of aspect ratio and elongation for NSTX and interesting upgrade scenarios.
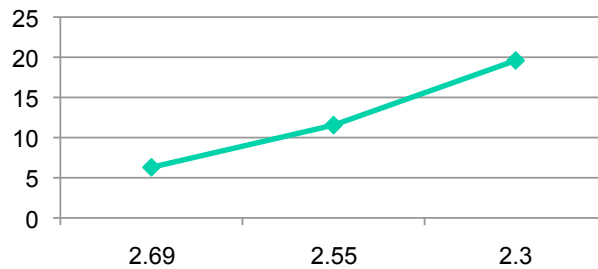
Scan of Kappa At Fixed A.
With Constant I_P or Constant q_{95}

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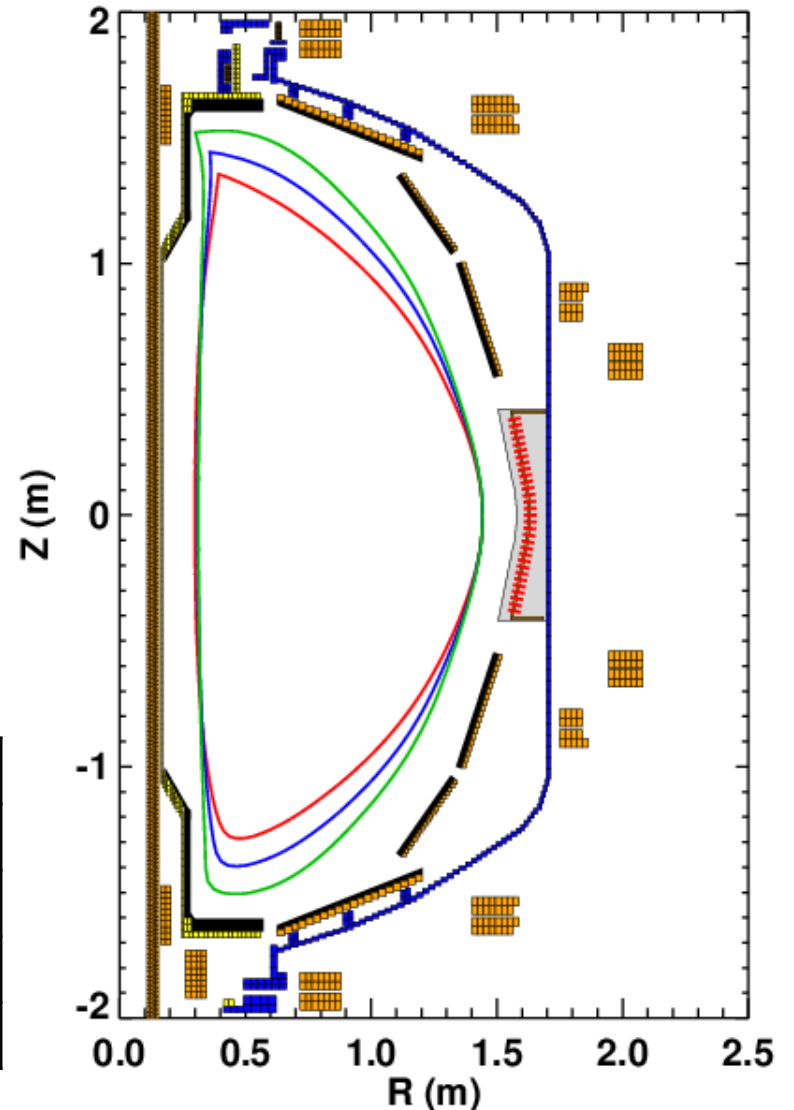 - 700 kA plasma need 19.6 kA of PF-1A

Scan of κ at fixed A and I_P
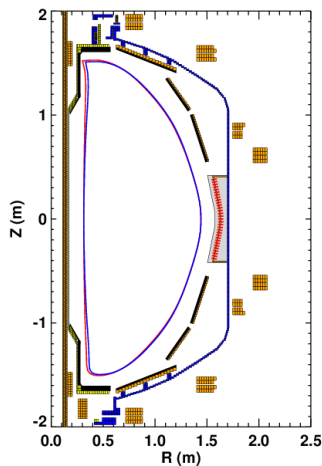
"PF-1A Current (kA) vs. Elongation"

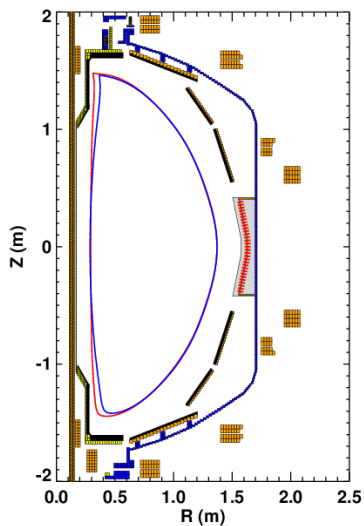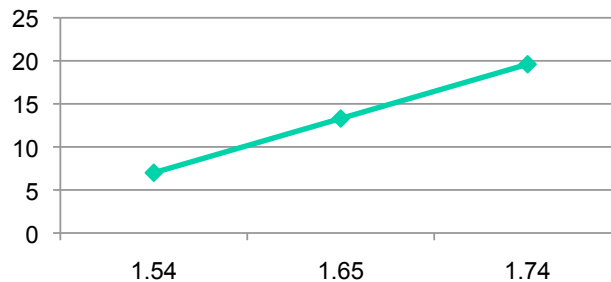| A	κ	I_P	q_{95}	I_{PF-1A}
1.56	2.66	825	12.1	10.7
1.55	2.69	700	17.9	6.3
1.55	2.55	700	13.9	11.6
1.52	2.3	700	12.03	19.6

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

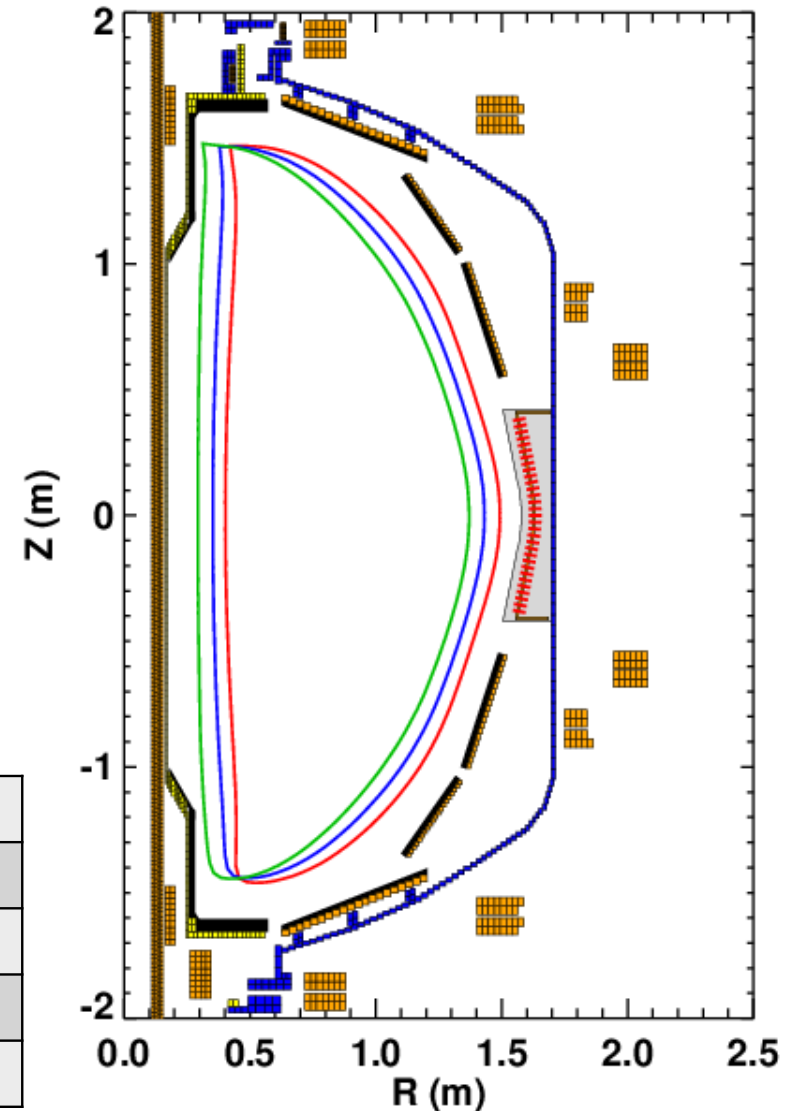- ## High aspect ratio limit set by the PF-1A coil current limit.

700 & 1000 kA

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

Scan of A at fixed κ and I_P

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

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.
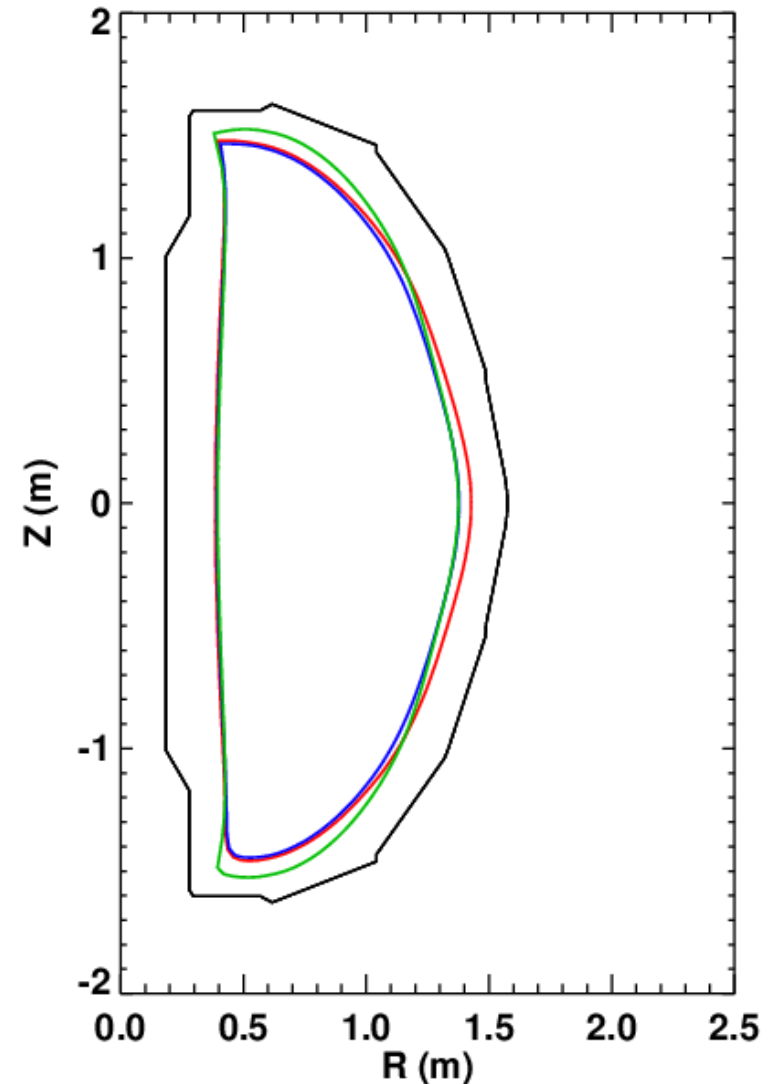
Shapes In Study Are Designed to Mimic Upgrade Scenarios

Proposed Shape   NSTX-Upgrade Scenarios

A=1.75
κ=2.8
f_NI=1 optimization

A=1.8
κ=2.95
High-β_T optimization
Maximize Off Axis NBCD