Non-1/R TF Options

W. Reiersen

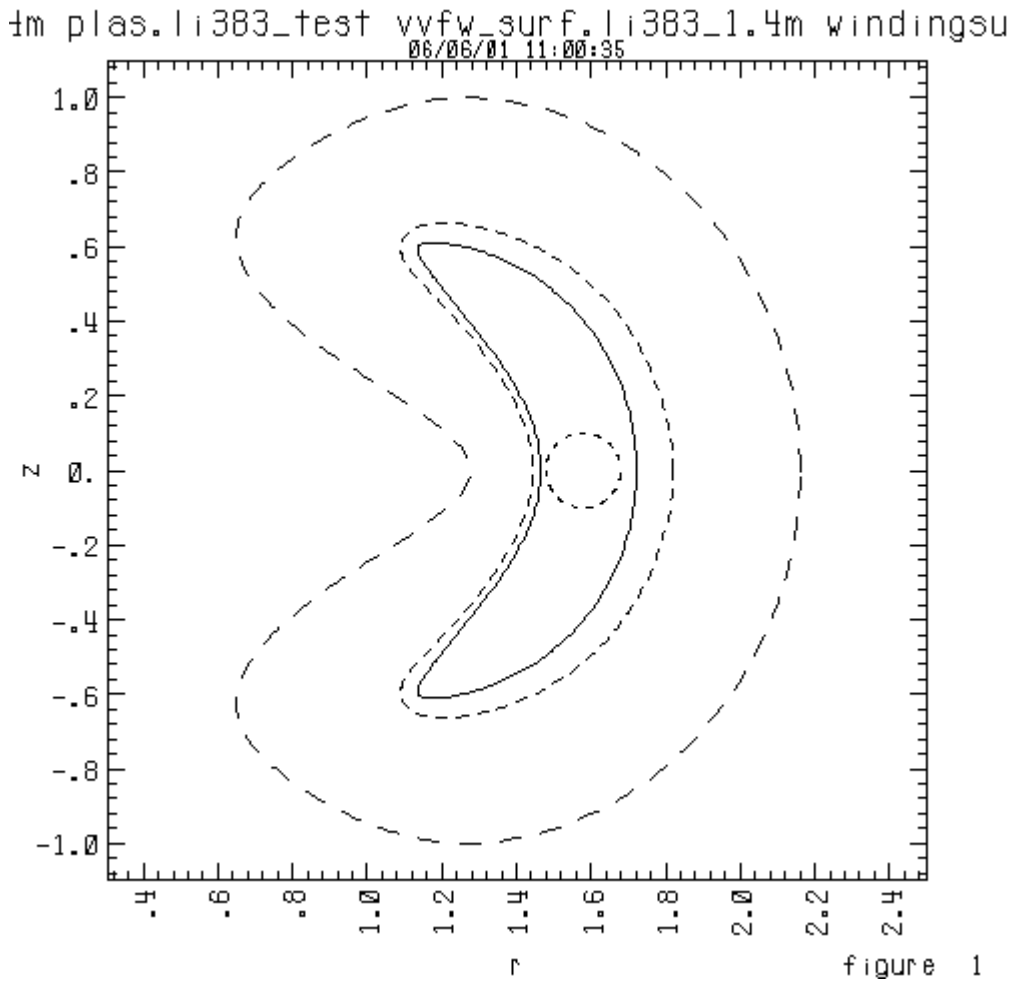
16 July 2001

Motivation

- A 1/R background toroidal field has been used in studies to date, primarily for flexibility
  - May be a good match to magnetic axis in traditional (large A, many field period) stellarators
  - Not so for small A, few field periods
- NCSX magnetic axis is non-circular, non-planar
  - R = 1.47 ± 0.10 m
  - Z = ± 0.06 m
- Improve core quasi-symmetry with non-1/R background field? Improve access with fewer coils?

Methodology

- Described at June 10 project meeting
- Place 10cm radius surface around magnetic axis
- Place TF outside winding surface for modular coils
- Design TF to minimize B_n
- Compare flexibility and access



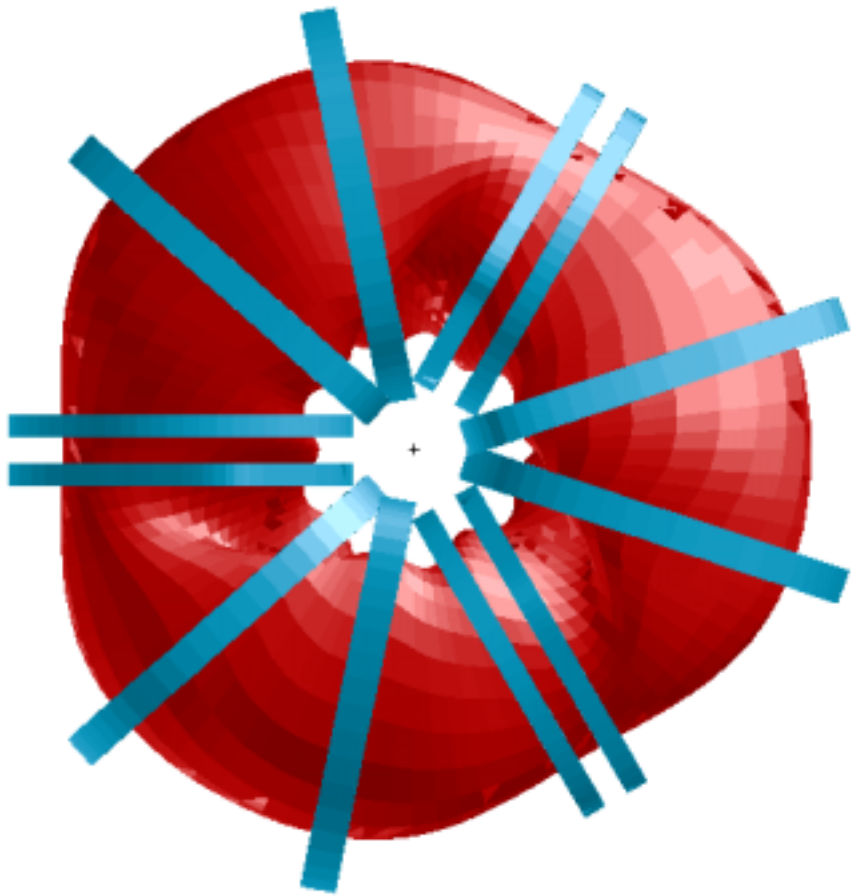
Options

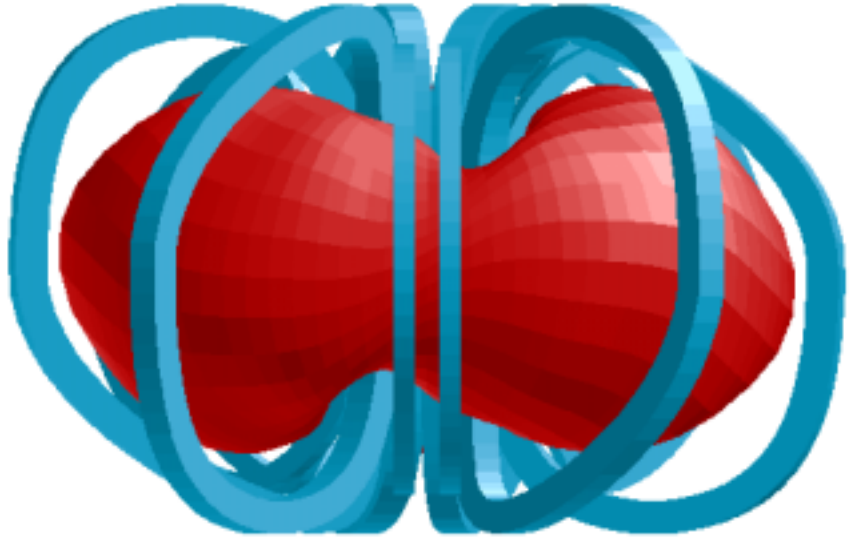
- Reference 21-coil TF
  - Closely approximates 1/R field
  - Blocks access at v=0.5
- 12-coil TF
  - Access at v=0.5 provided via split coil
  - Additional coil at v=0.14 (optimally positioned)
  - Vertical, planar TF coils offset from modular coil winding surface
  - Twist [z-rotation] allowed by optimum appears to be near zero
- 18-coil TF
  - Coil at v=0.14 replaced with coils at v=0.07, 0.21 to preserve machine segmentation for 18 and 21 modular coil options (ref. Williamson presentation today)

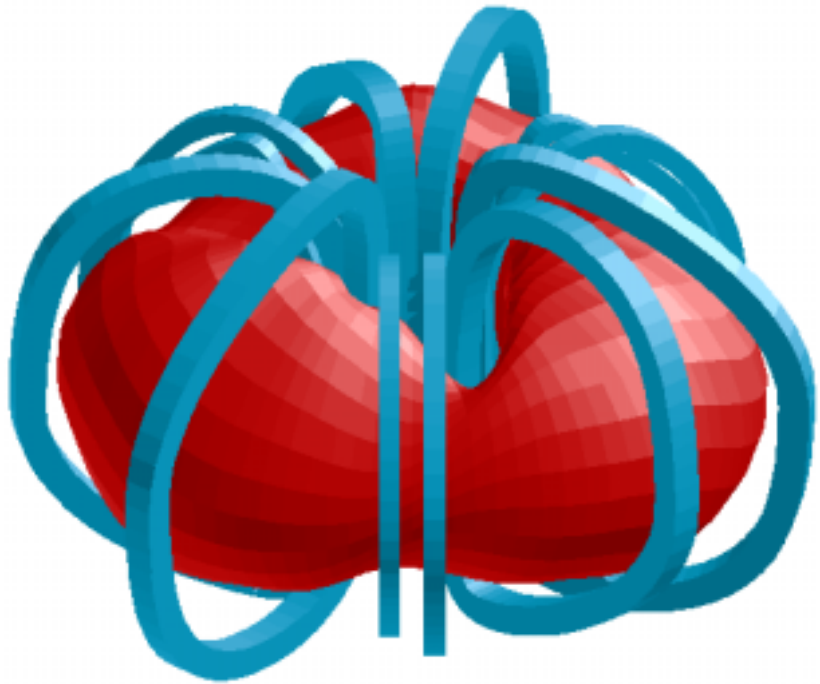
Fit comparison

Description	Bavg (Rel.)	Bmax (Rel.)	Amp-m (Rel.)
1/R background field	2.3%	4.9%	-
Ref. 21-coil TF design (equal size, equal spacing, equal currents)	2.3% (1.00)	4.9% (1.00)	22.5 (1.00)
Ref. 21-coil TF design (optimized currents peak at v=0.5, 0.07, zero in between)	2.1% (0.91)	4.8% (0.98)	22.5 (1.00)
Ref. 21-coil TF design (optimized currents, not constrained to be positive)	1.8% (0.78)	4.8% (0.98)	**48.1** (2.14)
12-coil TF design (1 pair straddles v=0.5 and 1 pair located at v=0.14)	**1.6%** (0.70)	4.1% (0.84)	24.1 (1.07)
18-coil TF design (1 pair straddles v=0.5; additional pairs at v=0.07 and v=0.21)	**1.6%** (0.70)	4.2% (0.86)	23.4 (1.04)

12-coil TF option



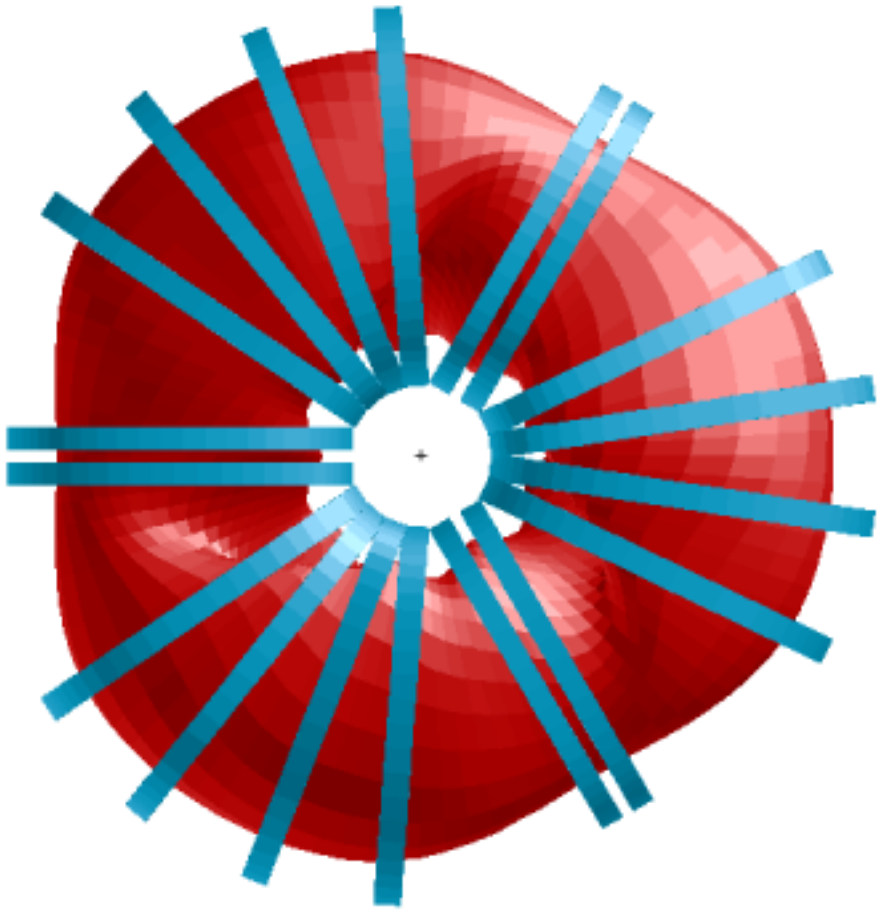


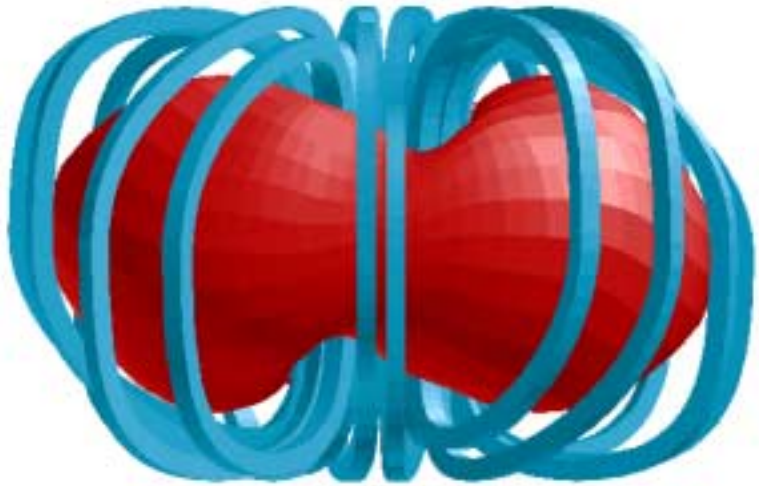


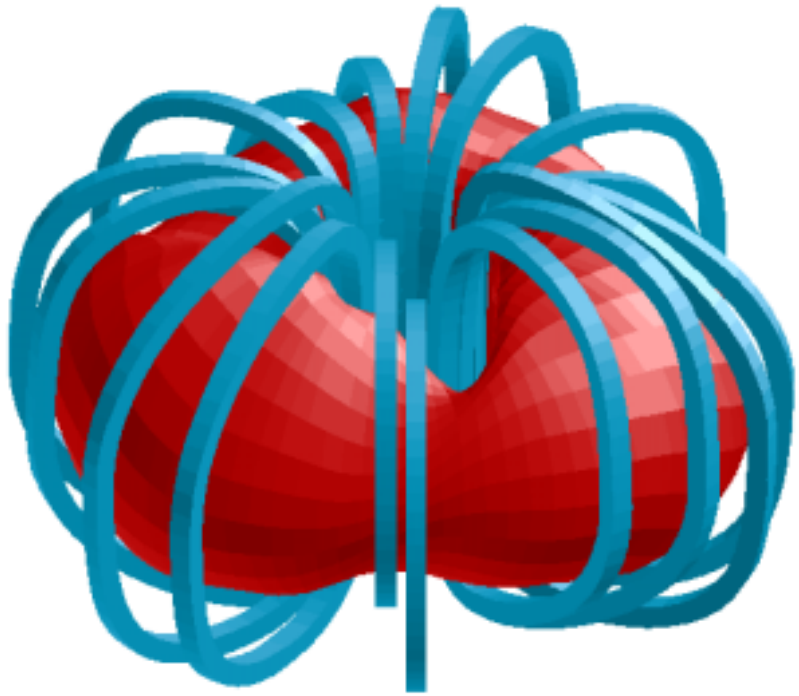
Pros and cons of 12-coil option

- **Better fit to magnetic axis (Bavg down by 30%), improved quasi-symmetry in core**, possibly worse in edge
- **Diagnostic access provided at v=0.5**
- **Fewer coils (effectively, 9) may provide better access than with 21**
- May be run in single circuit on Day One (with a turn ratio of 3:7), just like reference TF
- Reduced cost (2 coil types, 12 coils total)
- Fewer circuits (2 v. 4) simplify control, reduce power supply cost but maybe with loss of flexibility
- **V=0.14 location inconsistent with present segmentation scheme (?)**
- Taller coils (1.54m v. 1.27m) may negatively impact PF performance

18-coil TF option







Pros and cons of 18-coil option

- **Consistent with segmentation scheme in reference TF design (v=0.35 coil is missing)**
- **Better fit to magnetic axis (Bavg down by 30%), improved quasi-symmetry in core**, possibly worse in edge
- **Diagnostic access provided at v=0.5**
- **Fewer coils (effectively, 15) may provide better access than 21**
- Fewer circuits (3 v. 4) simplify control, reduce power supply costs
- **More difficult to run in single circuit on Day One (awkward turn ratios required)**
- Probably no significant cost saving (3 coil types, 18 coils)
- Taller coils (1.53m v. 1.27m) may negatively impact PF performance

Next steps

- Check impacts on access and segmentation for 12 and 18-coil options, propose improvements for 18-coil (e.g. 0628) and 21-coil (e.g.1017) options [ORNL]

- Check flexibility against 1/R (1-circuit) and 4-circuit options using reference TF coils [NP]