

TF coil options with 18-modular coils

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Introduction

- ¥ Options with 18 modular coils appear to provide approximately the same performance as 21-coil options and with important engineering advantages:
 - Reduced cost (3 v. 4 modular coil types, 18 v. 21 coils)
 - Improved access (fewer coils -> larger openings, no oversized modular coils required on $v=0$ symmetry plane)
 - Generally improved radius of curvature and plasma-to-coil separation

- ¥ Options with 18 modular coils appear to be the most attractive for a new reference design

The TF wrinkle

- ¥ The most attractive 18-coil options feature no modular coils on the $v=0$ and $v=0.5$ planes (great for NB and diagnostic access)
- ¥ BUT the current configuration would feature TF coils on those planes
 - TF coil at $v=0.5$ not a problem — can be split for radial diagnostic access (MPTS)
 - TF coil at $v=0$ can be incorporated or eliminated
- ¥ Incorporating the $v=0$ TF coil is feasible, but not very desirable because it cuts down on access

Candidate options

¥ 18-coil 1/R TF

- Current configuration (on radial plates between coil modules)
- New configuration and support scheme

¥ 9-coil 1/R TF w/o a coil at $\nu=0$

¥ 15-coil non-1/R TF

Current configuration (18 TF coils on radial plates between coil modules)

- ¥ V=0 TF coil (and maybe the others) would be pulled out to the radius of the v=0 modular coil in 1017 (from 2.5m to 2.9m) for NB access
- ¥ EXTREMELY low ripple by tokamak standards
 - $R(0,0)=1.38\text{m}$, $R(1,0)=0.27\text{m}$ $R_{\text{edge}}\sim 1.65\text{m}$
 - Ideal ripple = $(R_{\text{edge}}/R_{\text{tf}})^{N_{\text{tf}}} = 0.004\%$
 - Even lower than reference 21-coil option (0.016%)
- ¥ Access is sub-optimal
 - Blocks radial access at v=0 (may be important for in-vessel access)
 - Worse access than 9-coil and 15-coil TF options
- ¥ Enlarged TF coil would push PF coils further out

New configuration with 18 TF coils

- ¥ Current configuration features 18 TF coils mounted on radial plates between coil modules
- ¥ Alternatively, the 18 TF coils could be clocked 10 degrees to avoid placement at $v=0$
- ¥ Potential benefits
 - Still provides high quality $1/R$ field
 - Perhaps better diagnostic access than current configuration
- ¥ Drawbacks
 - New support and assembly scheme needs to be worked out
 - Potential interference with NBI
 - Worse access than 9-coil and 15-coil TF options

9-coil 1/R TF w/o a coil at $\nu=0$

- ¥ Pulling the TF leg out to 3.0m (0.1m further than current $\nu=0$ modular coil) allows us to reduce the number of TF coils to 9 while still maintaining a high quality 1/R field
- ¥ Ideal ripple at 1.65m is only 0.46%, still LOW by tokamak standards
- ¥ Potential benefit is much improved access at $\nu=0$ (0_i , 120_i , 240_i) and $\nu=0.33$ and $\nu=0.67$ (40_i , 80_i , 160_i , 200_i , 280_i , 320_i)
- ¥ Enlarged TF coil would push PF coils further away

15-coil non-1/R TF

- ¥ The magnetic access is non-circular
- ¥ May be beneficial to provide a background TF field that follows magnetic axis, rather than circular
- ¥ Procedure
 - 20cm circle constructed about magnetic axis
 - TF coil geometry and currents picked to minimize B_n
 - 15 TF coils used ($V=0.167, 0.333, 0.5$ - no $v=0$ coils)
- ¥ Potential benefits
 - Improved modular coil design and flexibility
 - Improved access and smaller coils over 18 TF options

Access and performance assessment

- ¥ Current configuration (18 TF coils on radial plates)
 - Model Strickler's best 18-modular coil option
 - Add to TF coils to Pro/E model to establish configuration baseline, assess access (DW/MC)
- ¥ New configuration
 - Consider alternatives for supporting TF coils and assembling stellarator core are there attractive, feasible options? (ORNL)
- ¥ 9-coil (1/R) TF w/o $v=0$ coil
 - Assume $R_{out} \sim 3m$, $h \sim 1.5m$ but not to obstruct NB access (DW)
 - Revise TF coils, assess access (DW/MC)
 - Pass coil geometry to Strickler, regenerate modular coils, assess performance (DJS)
- ¥ 15-coil (non-1/R) TF
 - Pass coil geometry to Strickler (WR)
 - Generate modular coil design, assess performance (DW/MC)
 - Model new modular and TF coils, assess access (DW/MC)

Flexibility assessment

- ¥ Flexibility studies to date based on 1017 coil set with 1/R background field (NP)
- ¥ 12-coil non-1/R provided to Pomphrey on 7/17 by Brooks (coils.li383_1017a4_vtf) to determine impact on flexibility