Engineering Update

January 31, 2001

NCSX Project Meeting

W. Reiersen

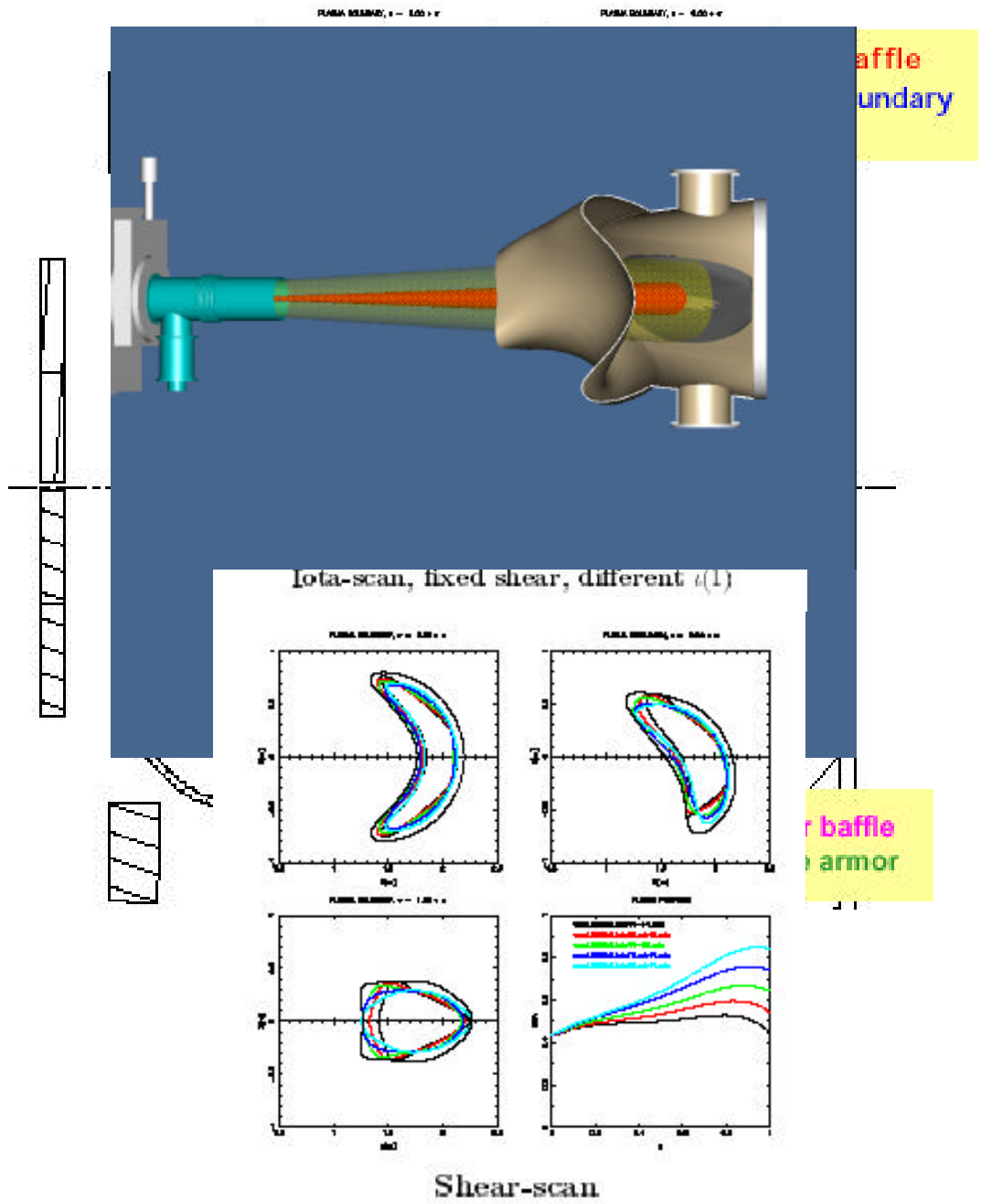
We are under tight time constraints in our PVR preparations

- Today
  - Complete *initial* cost estimate assembled by Simmons
  - All outstanding design choices made
- February 7
  - Interface requirements finalized
- February 14
  - Complete and final cost data submitted to Simmons
- February 21
  - Design description submitted to Reiersen
- February 28
  - Complete first drafts of write-ups due

PFC Issues

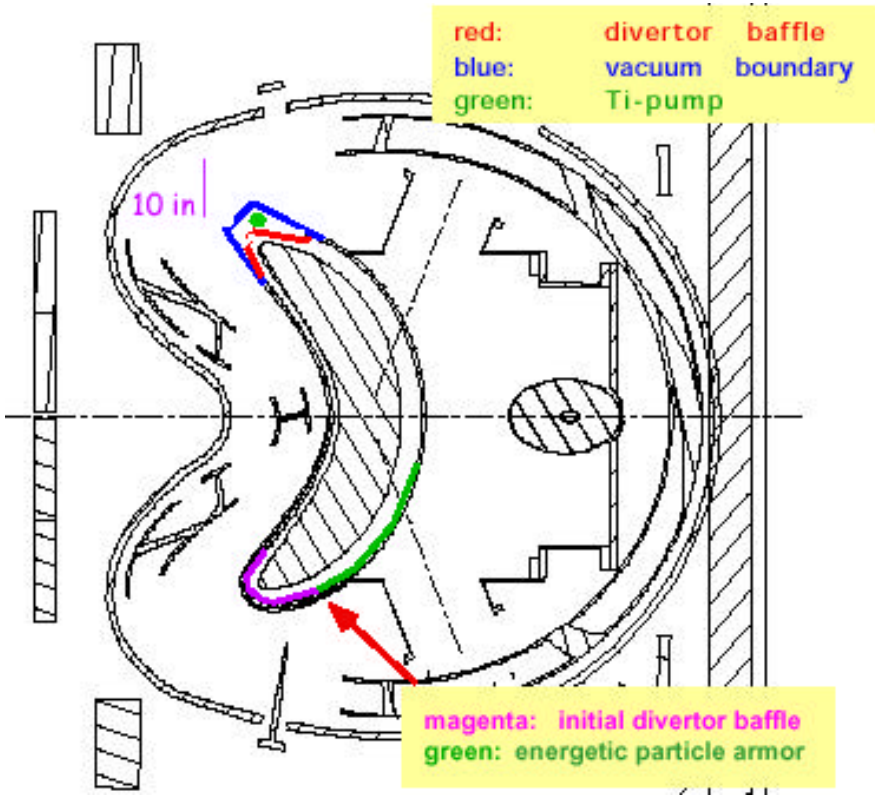
- Differences in description of physics concepts and engineering design still exist
- Geometry of first wall is not optimized – arbitrary 2cm inboard, 10cm outboard SOL imposed
- Engineering design approach not yet finalized
  - Favor stand-alone liner w/ formed CFC panels bakeable to 350C – cost is the main concern
  - Present cost estimate based on discrete tile approach
- Radial build requirements with stand-alone liner may increase - not yet folded into overall configuration

- Physics concepts
  - Inboard limiter
  - Pumped divertor
  - Armor for energetic particles
- Other requirements
  - Protect trim coils and other in-vessel hardware
  - NB armor
  - Shape flexibility



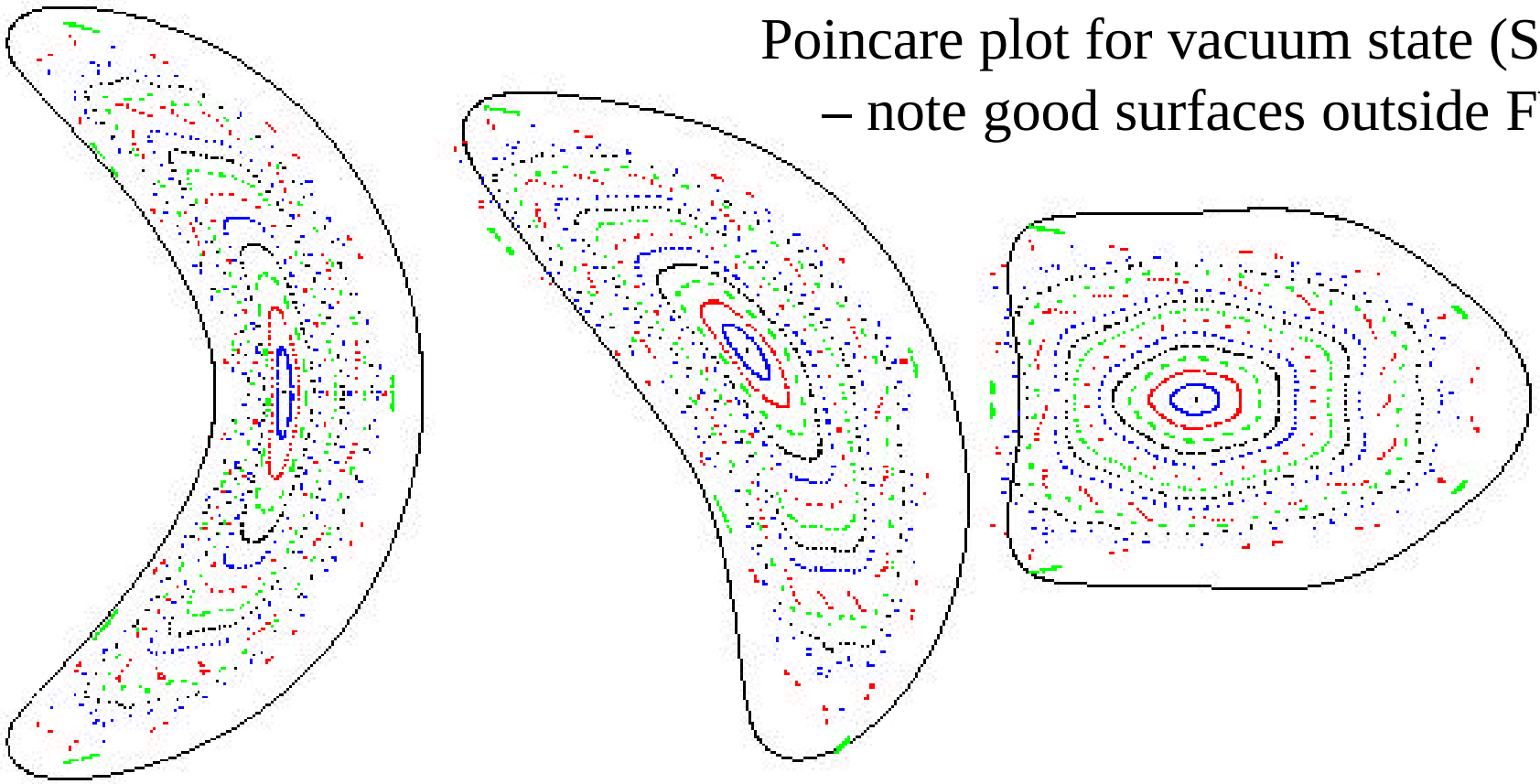
Favored engineering design addresses these requirements with a continuous FW

- **Stand-alone liner with formed CFC panels bakeable to 350C**
- **Simple, robust, allows 150C limit for VV and other in-vessel components**
- **Primary issues are $ and space**
  - Feedback from BFG Aerospace expected momentarily on the cost of formed CFC panels
  - ORNL to determine radial build requirements for stand-alone liner
- No provisions yet for pumped divertor – space may be OK



FW geometry should be optimized in post-PVR time frame

Poincare plot for vacuum state (S1)
– note good surfaces outside FW

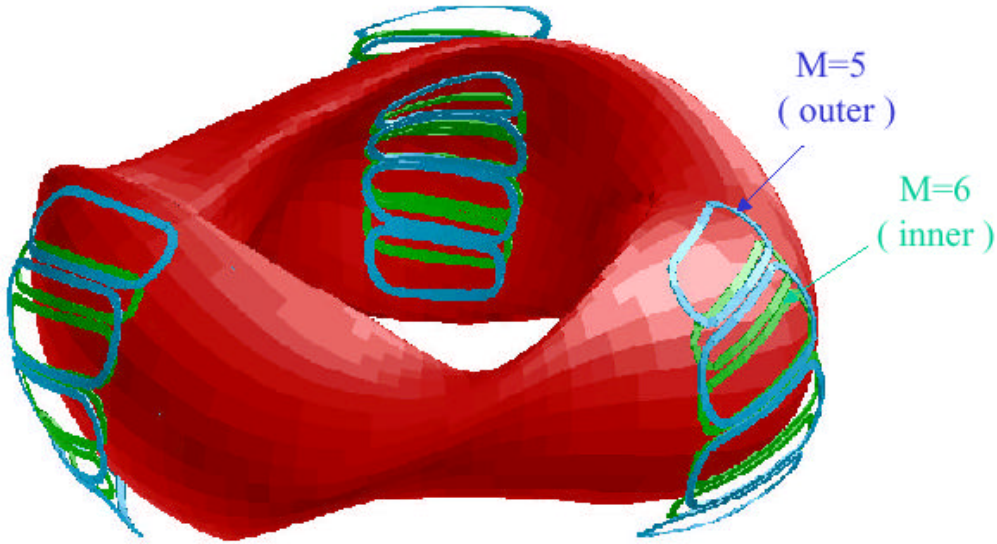


Recommendations for PVR - PFCs

- Keep present FW geometry (2cm/10cm)
- Develop and cost engineering design based on continuous FW
- Physics references should be to continuous FW (unless this option does not work or is prohibitively expensive) rather than discrete components
- Refer to the following as WIP
  - Optimization of FW geometry
  - Accommodating a pumped divertor
  - Accommodating radial build requirements in modular coil design

Trim Coils

- In-vessel (7cm, 15cm) surface selected for locating trim coils
- Protected by continuous first wall
- 4 window panes inboard and 4 outboard at v=0 for m=5 and m=6 resonances
- Symmetry breaking resonances not addressed yet

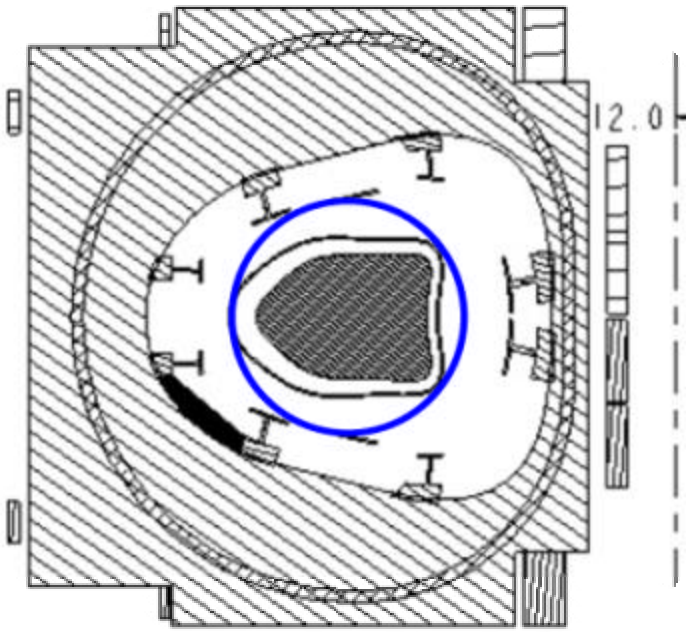


Recommendations for PVR – Trim Coils

- Assess effectiveness of reference coil design, develop current v. time requirements (Brooks, Zarnstorff)
- Develop design concepts for symmetry-breaking resonances (Brooks, Zarnstorff)
- Develop engineering designs for m=5, m=6, and symmetry-breaking trim coils, re-estimate costs (ORNL)
  - Current cost estimate is $1.4M for 12 “panel coil” assemblies
- Update radial build requirements, pass on to Physics (ORNL)
- Develop power supply design and cost estimate (Neumeyer)

VV Issues

- Bakeout temperature (150C or 350C) contingent on PFCs
- Inconel selected as material choice for PVR – no compelling $ advantage for SS
- Bolted joint in v=0.5 plane is highly desirable for assembly and maintenance – may be circular
- VV shape needs optimization
  - More space required for stand-alone liner and trim coils, inboard RF, pumped divertor, plasma, etc.
  - Improve NB access, avoid large flat regions and creases, enhance fabricability, etc.



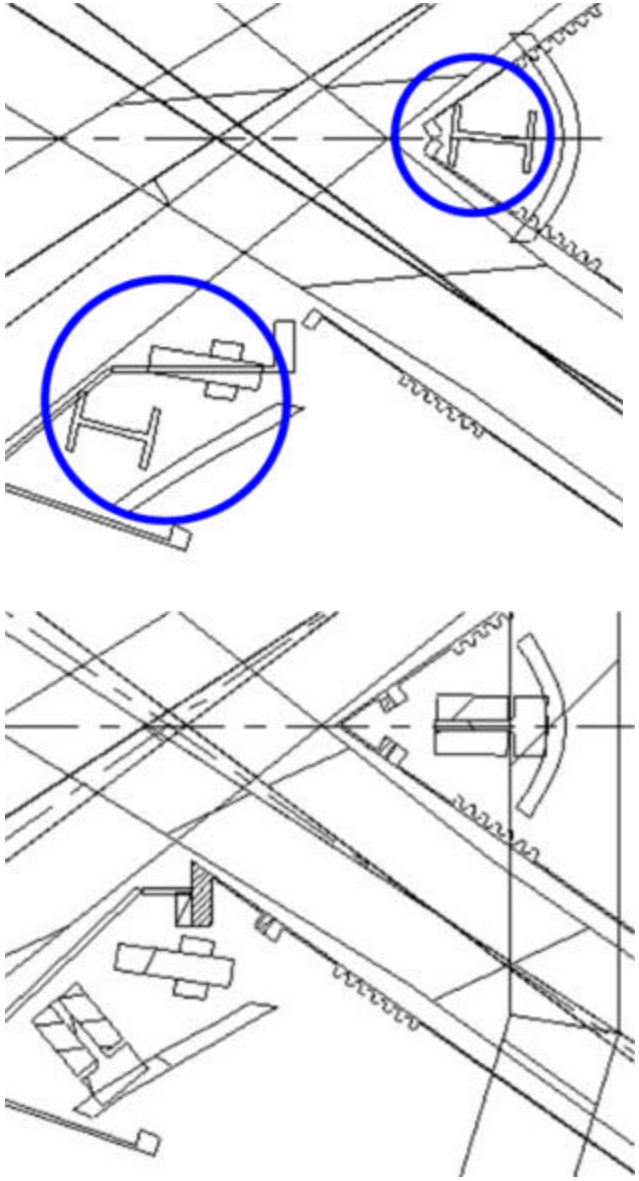
Recommendations for PVR - VV

- Resolve bakeout temperature ASAP
- Stick with current geometry for assessing fab, assembly, and cost
- Decision on whether to go to bolted joint or stick with welded joint at ORNL's discretion for PVR – re-visit afterwards
- Track required modifications for post-PVR implementation

Modular/TF Coil Issues

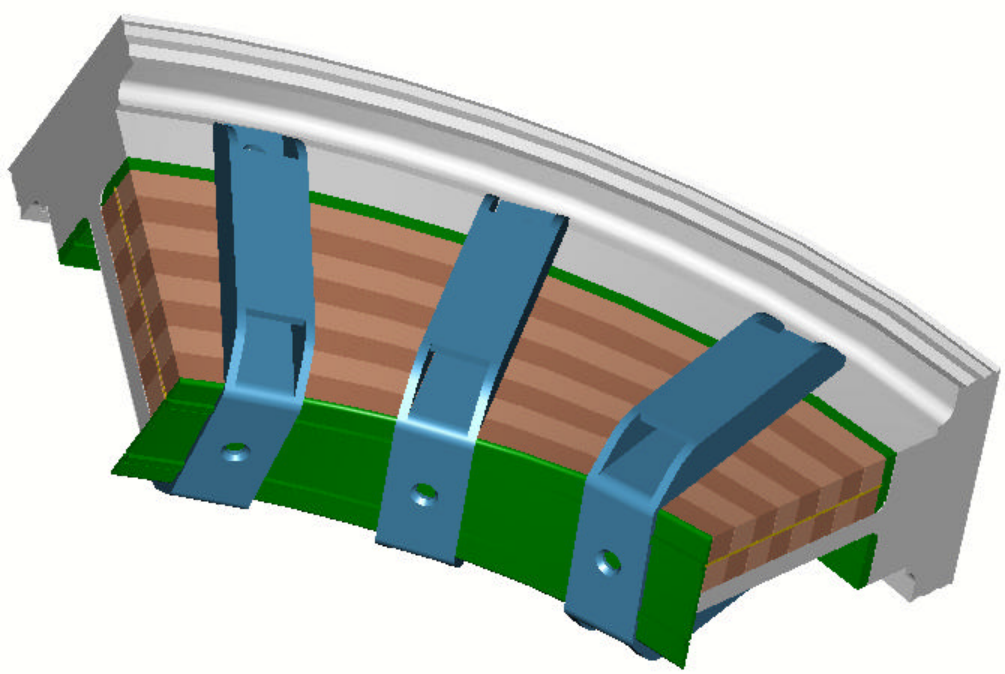
- NB access
  - Acute interferences resolved in vicinity of NB port resolved by modifying VV
  - Need to assure adequate space exists for assembly, insulation, coil-to-coil clearances, etc.

- Machine support concept being developed



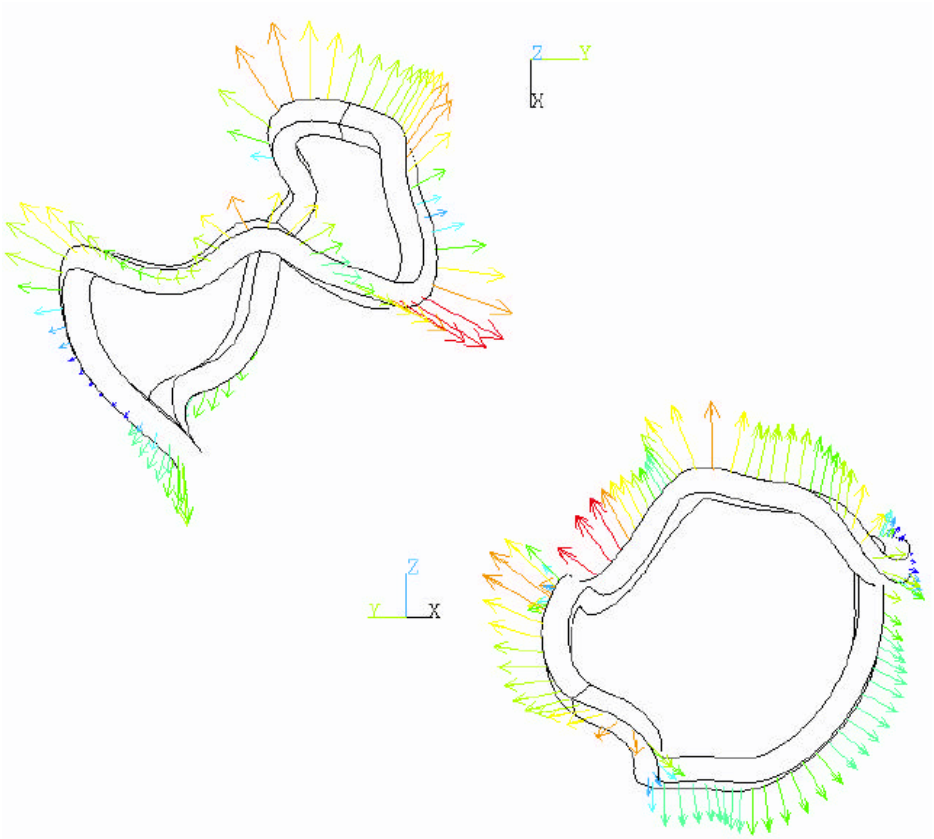
Modular/TF Coil Issues (2)

- An attractive design concept is emerging
  - Load carrying capability is sensitive to orientation of applied load



Modular/TF Coil Issues (3)

- Our structural design concept is not yet firmly underpinned by FEA
- Loads are large with odd orientations, may drive twist in winding form

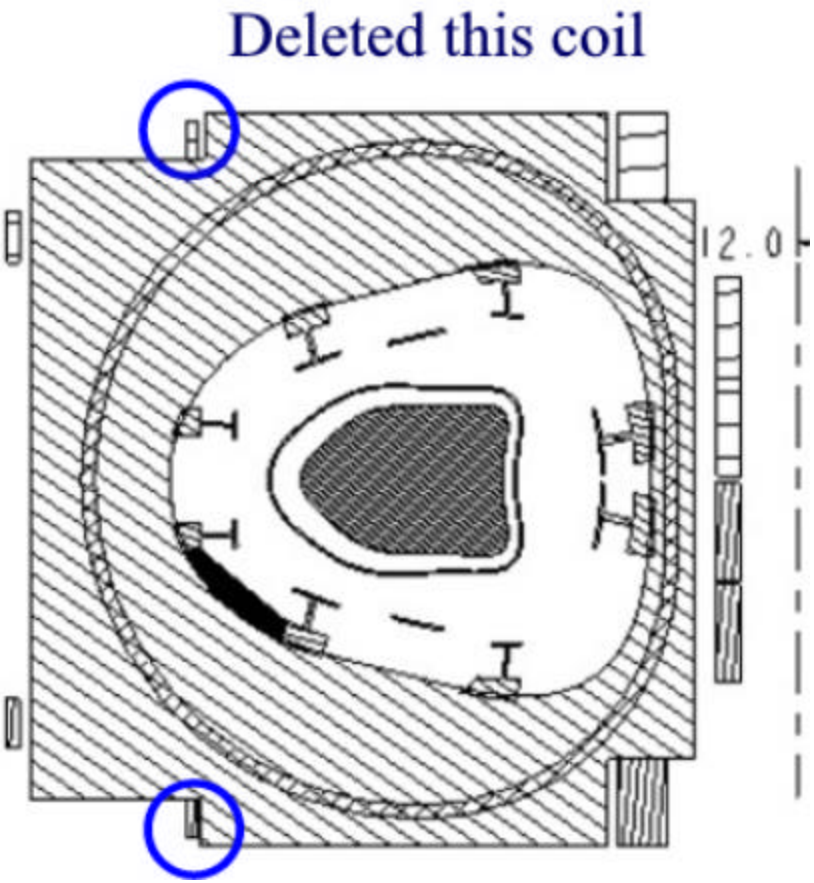


Recommendations for PVR – Modular/TF Coils

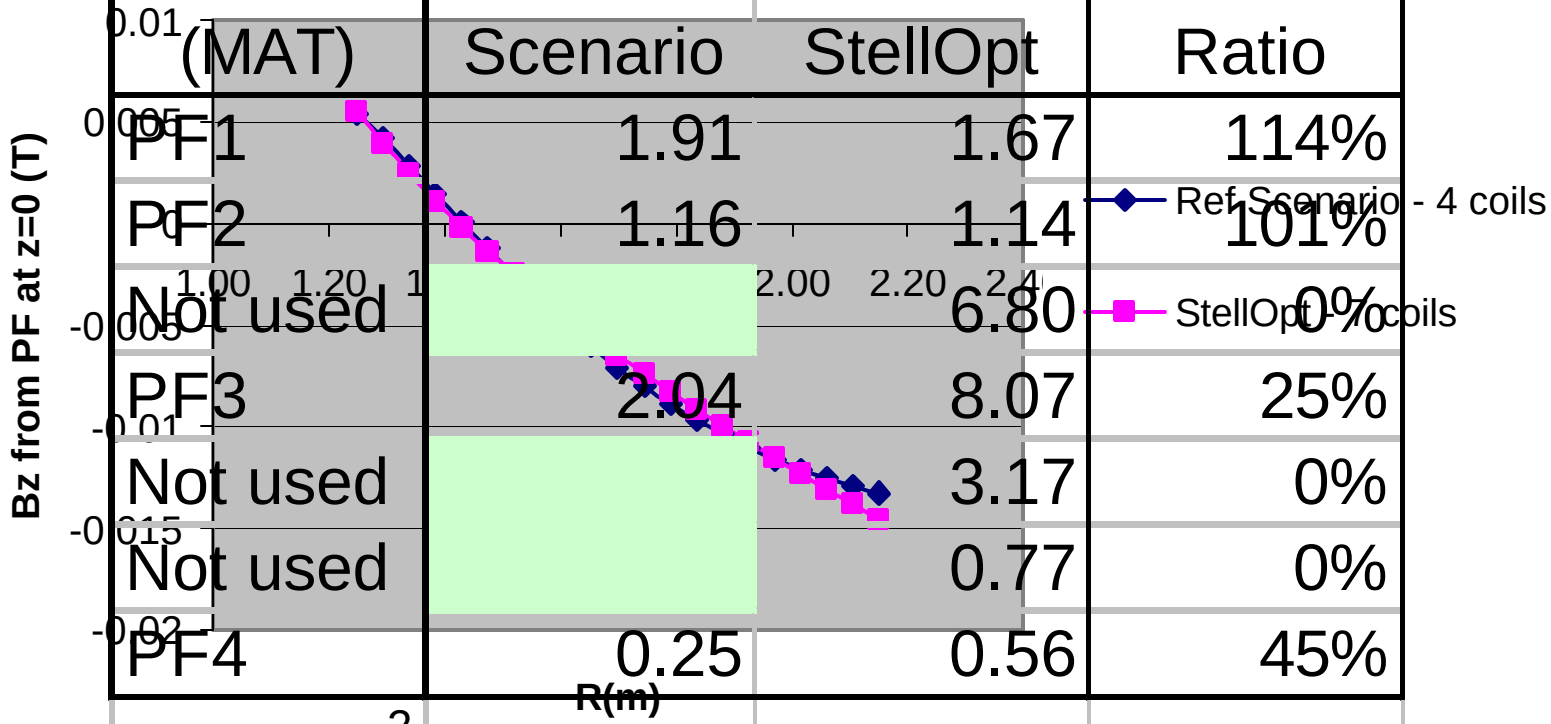
- Assure adequate space exists for assembly, insulation, coil-to-coil clearances, etc
- Complete access study for NBI, RF, diagnostics, and personnel access
- Complete FEA around current design
- Figure out…
  - required section thicknesses
  - how to fabricate the structure/winding form
  - how much it will cost
- Defer assessing engineering impacts of variants until structural design and costing is in hand

PF Coil Issues

- 4 coil PF adopted for reduced cost, improved access
- Appears to provide good OH distribution
- Appears to satisfy requirements for reference scenario and for NP iota scans (almost!)

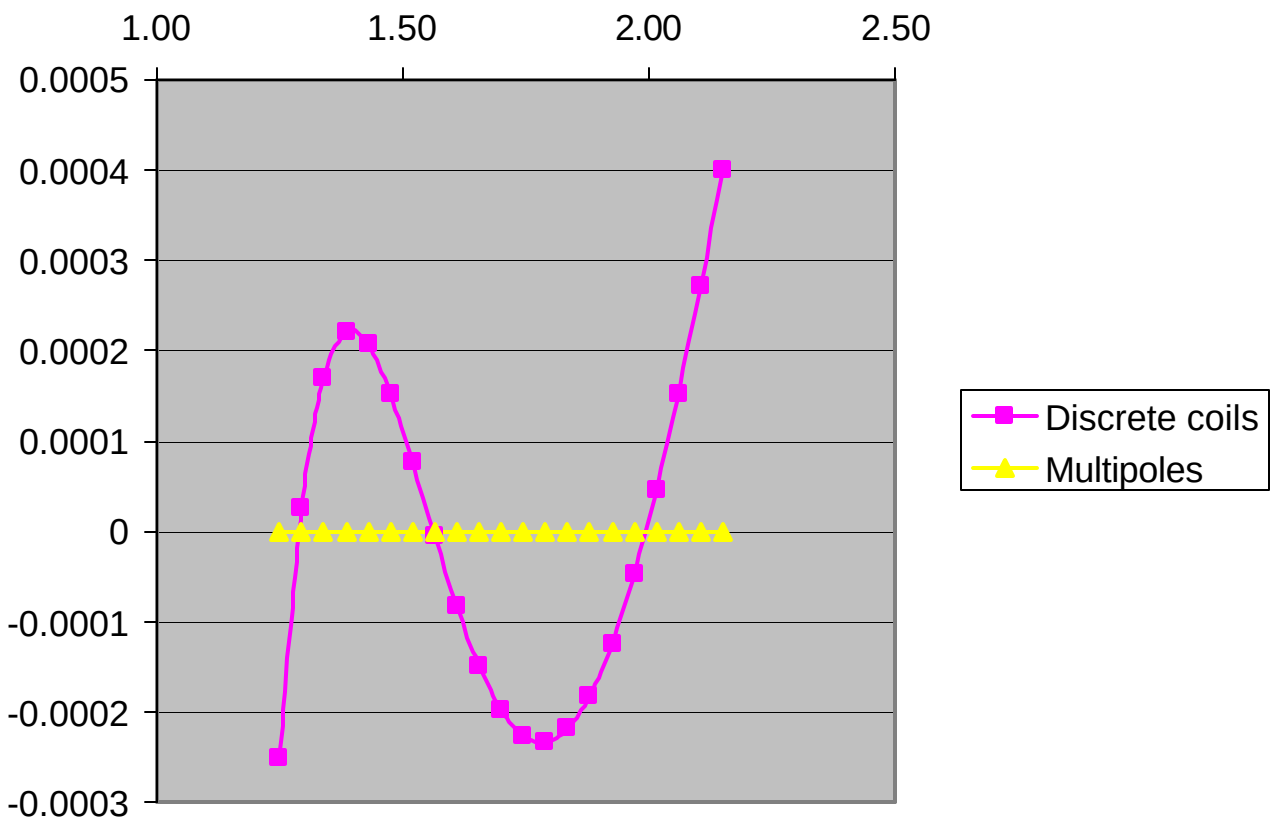


4 PF coils provide good fit to required fields in ref. scenario w/ lower currents

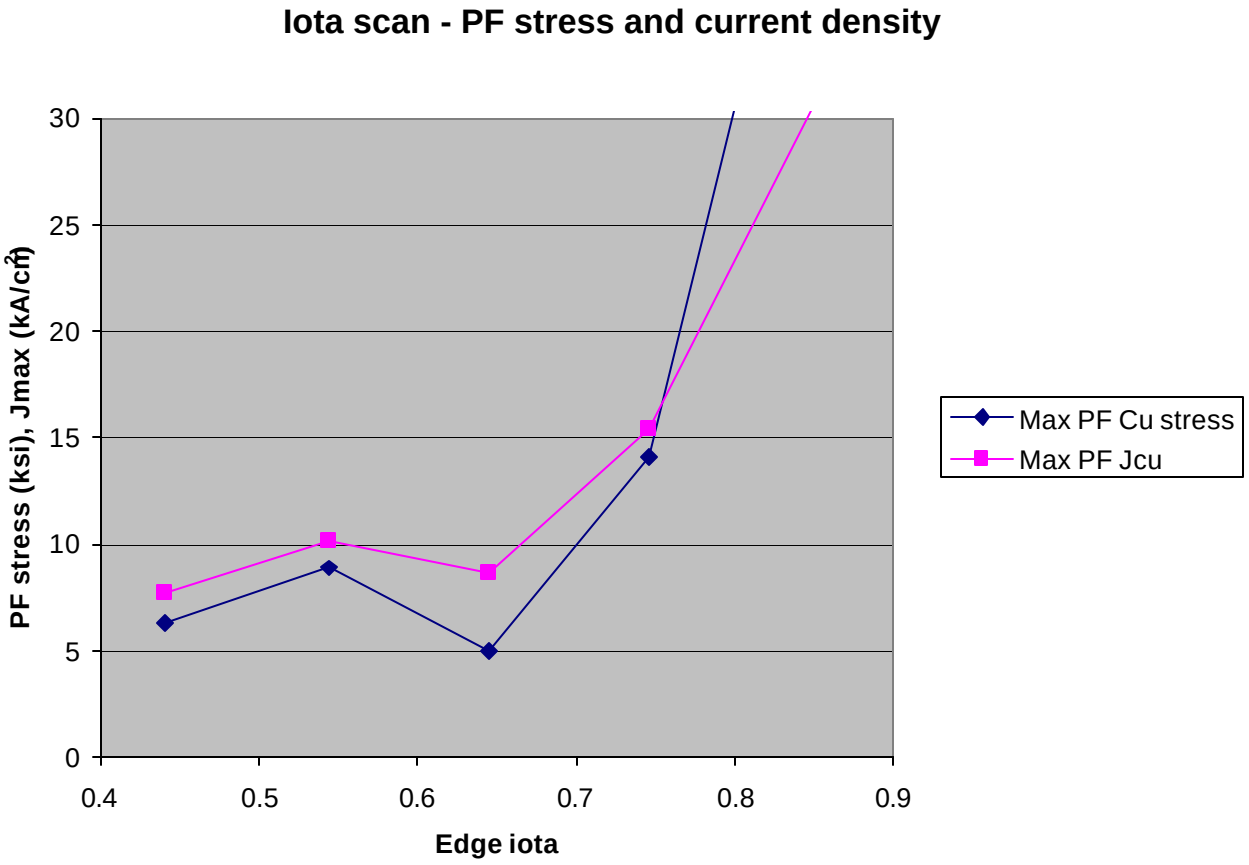


Max Coil Currents (MAT)	Full current, Reference Scenario	full beta (S3) StellOpt	Ratio
PF1	1.91	1.67	114%
PF2	1.16	1.14	101%
Not used		6.80	0%
PF3	2.04	8.07	25%
Not used		3.17	0%
Not used		0.77	0%
PF4	0.25	0.56	45%
? I^2	9.2	126.4	7%

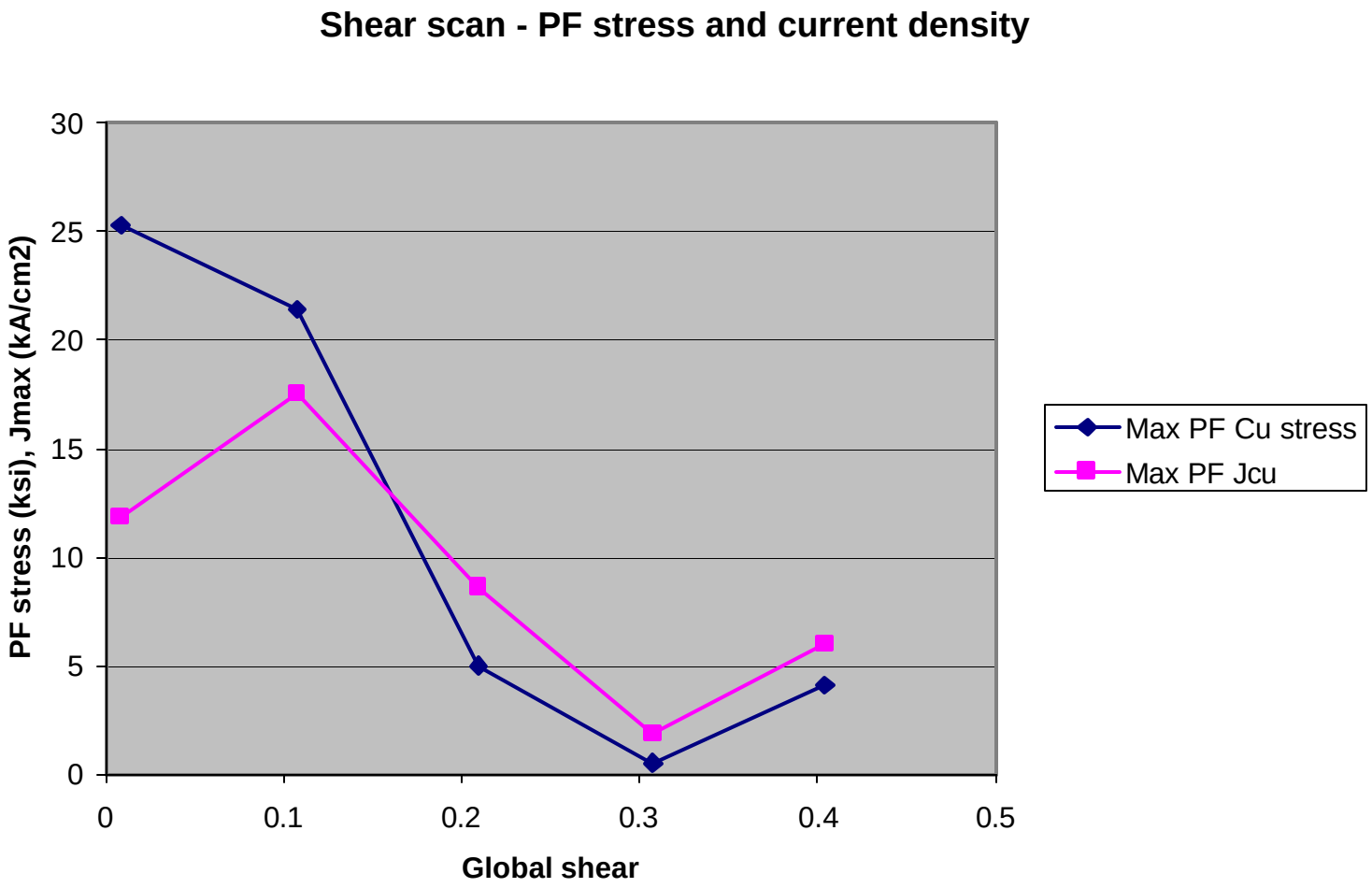
4 PF coils provide good OH distribution



PF coil currents become prohibitive above iota=0.75 (at ? ?=0.2)



PF coil currents become uncomfortable with a global shear < 0.15 (at ?$_0$=0.42)



Recommendations for PVR – PF Coils

- Proceed with design and costing based on present 4 coil design
- Use 4 coil design (with appropriate constraints) in subsequent flexibility studies

Issues in Other Systems

- WBS 2 – proceed with 2 NBs, resolve interferences
- WBS 3 – proceed with access study for diagnostics
- WBS 4 – resolve C-site MG issue

Summary

1. Engineering is on a very tight time schedule and *needs to carefully prioritize work prior to the PVR*

2. We have flagged critical issues and proposed a course of action for the PVR

3. We request feedback from the project ASAP if any course corrections need to be made