2-D Analysis of Neutron Streaming Through Helium Access Tubes

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Issues and Concerns

Manifolds reweldability:

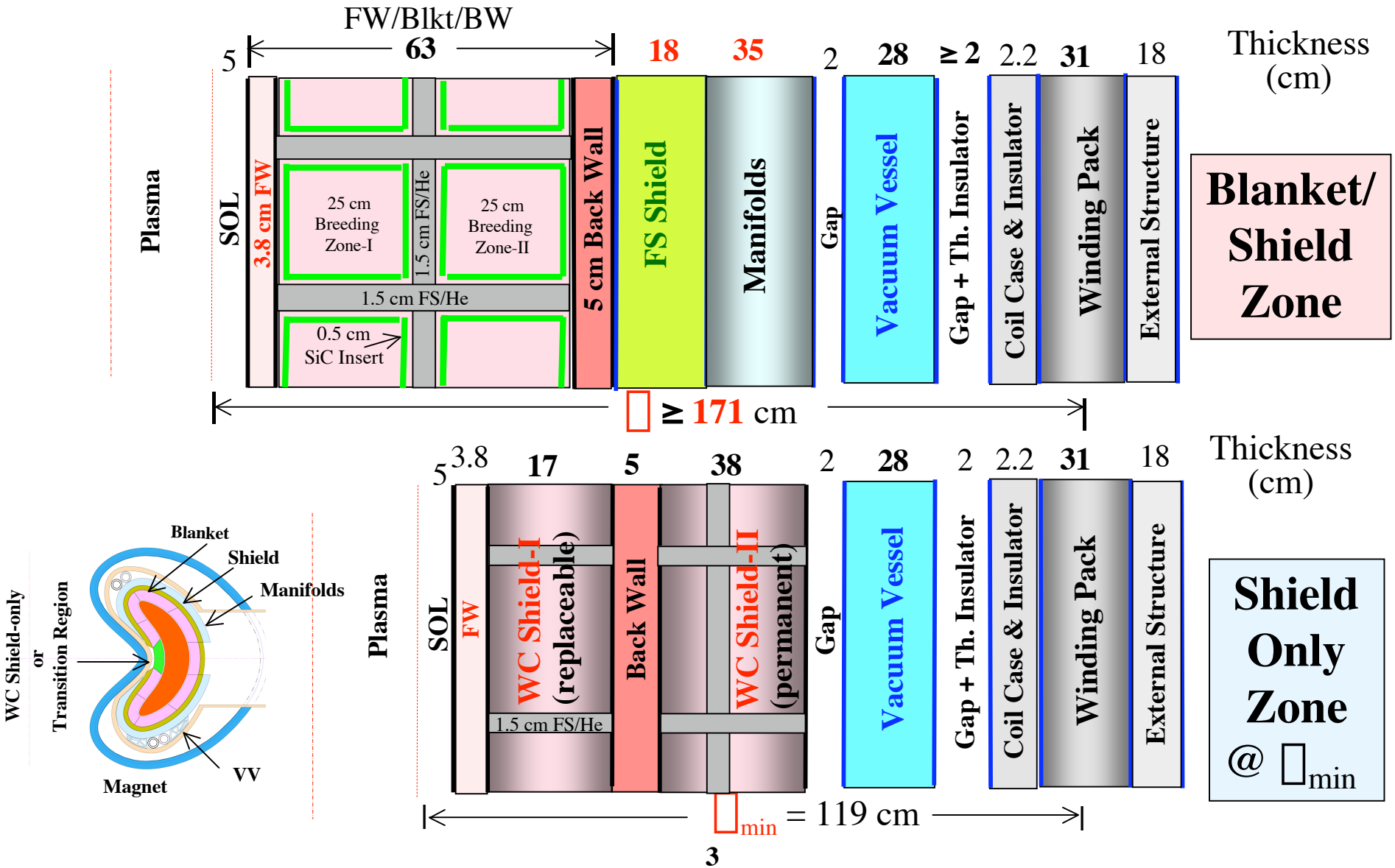
- Previous ARIES designs did **not** require reweldability of manifolds
- Last February, Malang/Wang indicated a need to cut and reweld manifolds at He and LiPb access tubes. Could ARIES-CS design meet reweldability limit without adding more shield to protect manifolds?

Neutron streaming through He access tubes (32 cm OD) :

- Streaming results in Hot spots at VV and magnets. How to fix the problem?

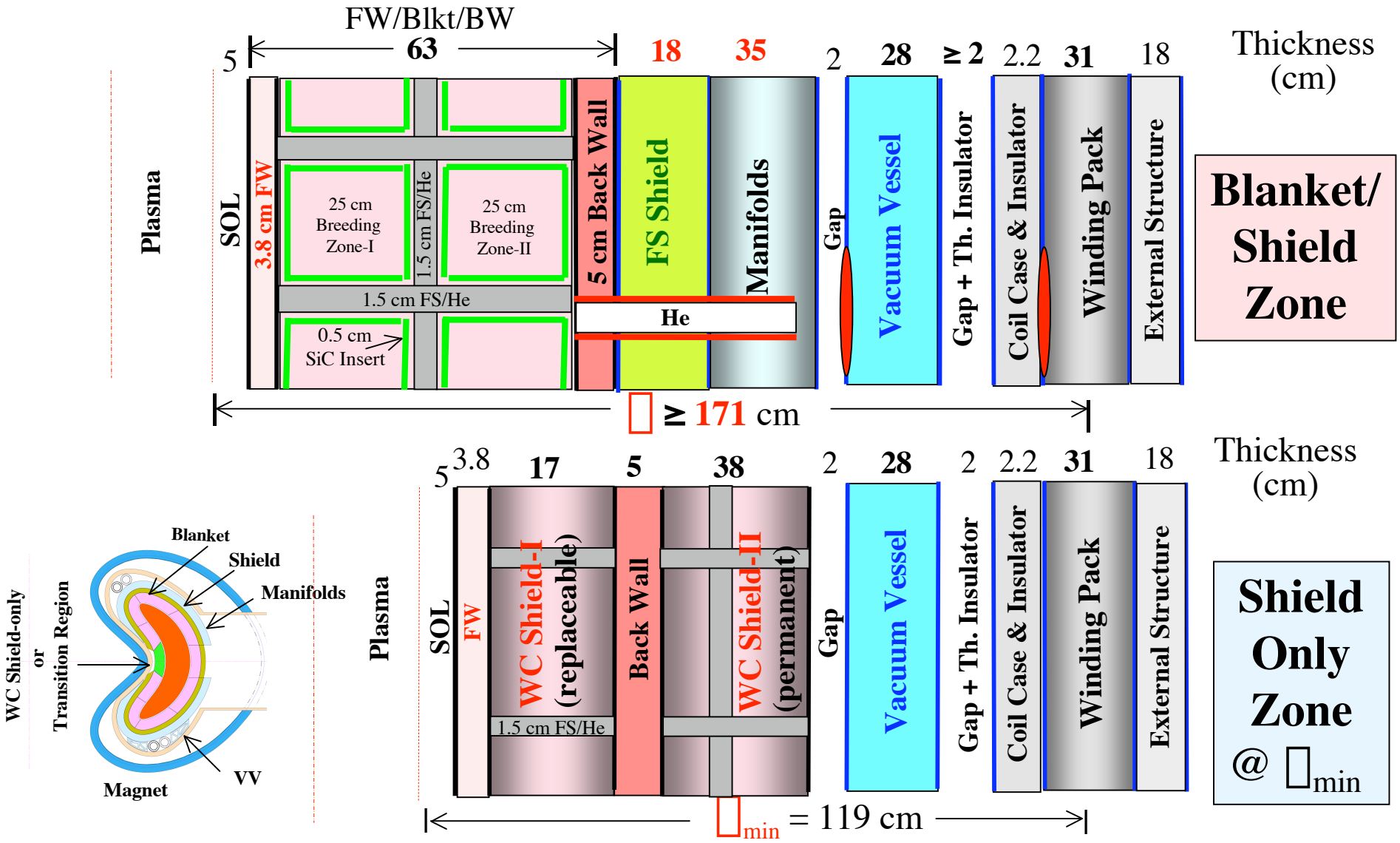
Reference Radial Build

(3 MW/m^2 peak □)



Xn through He Access Tube

(3 MW/m^2 peak □)



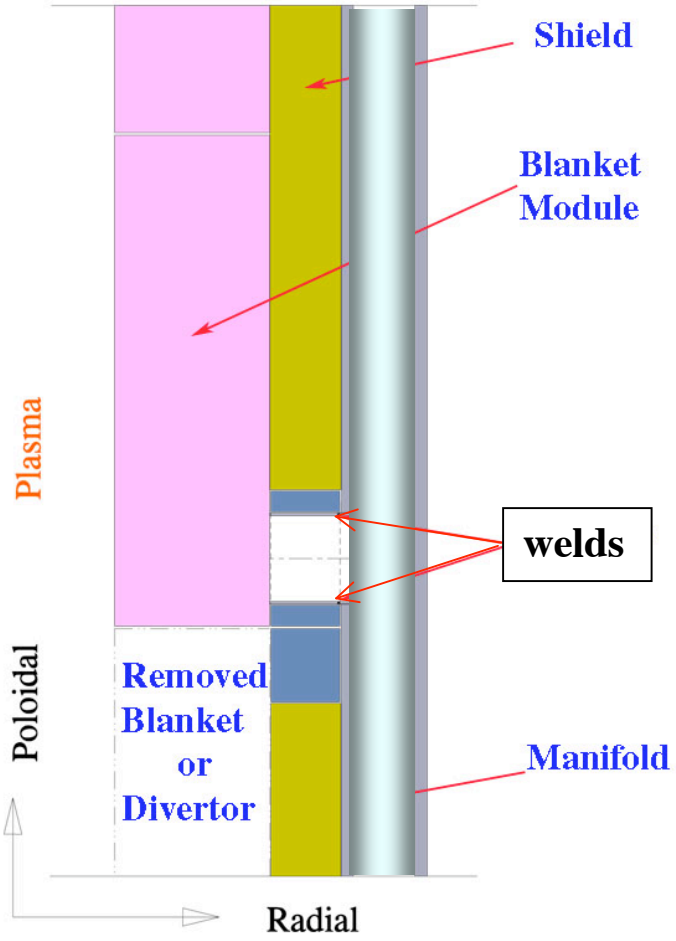
He access Tubes

Design Approach	Port Maintenance	FP Maintenance
Total # of Tubes	206	144
# of Tubes per m*	~ 4	~ 3

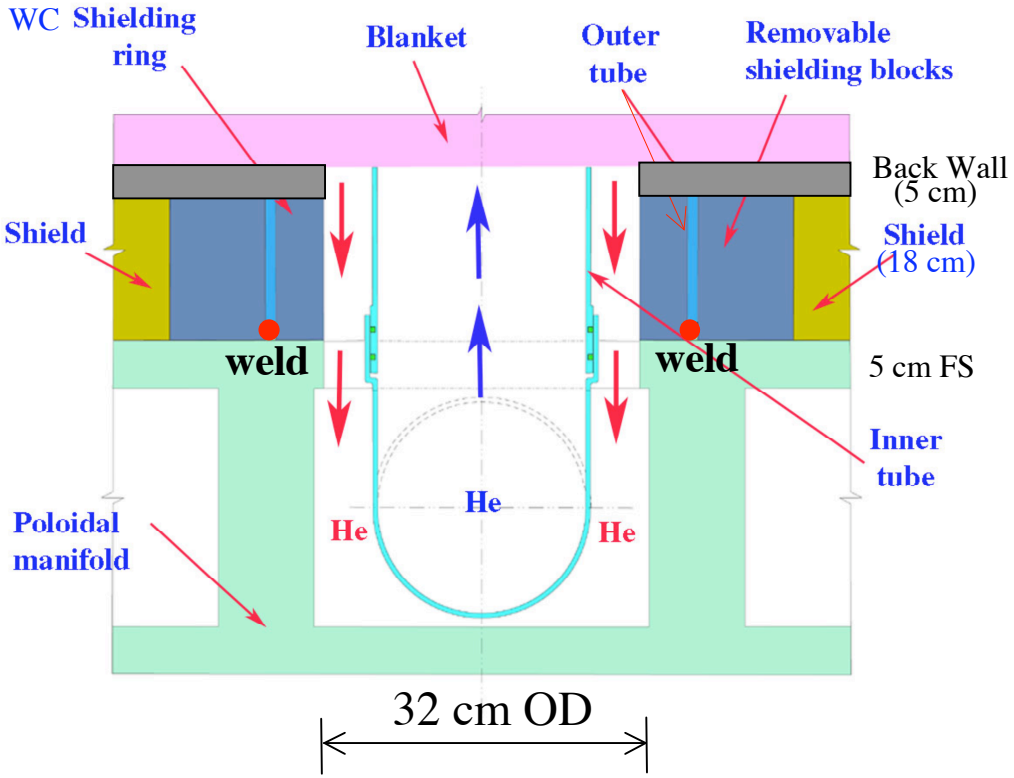
* Toroidal length. Assuming R= 8.25 m.

- Streaming problem encountered in both designs.
- Reported results pertain to port maintenance approach.

Innovative Manifold Design
(S. Malang)



Old

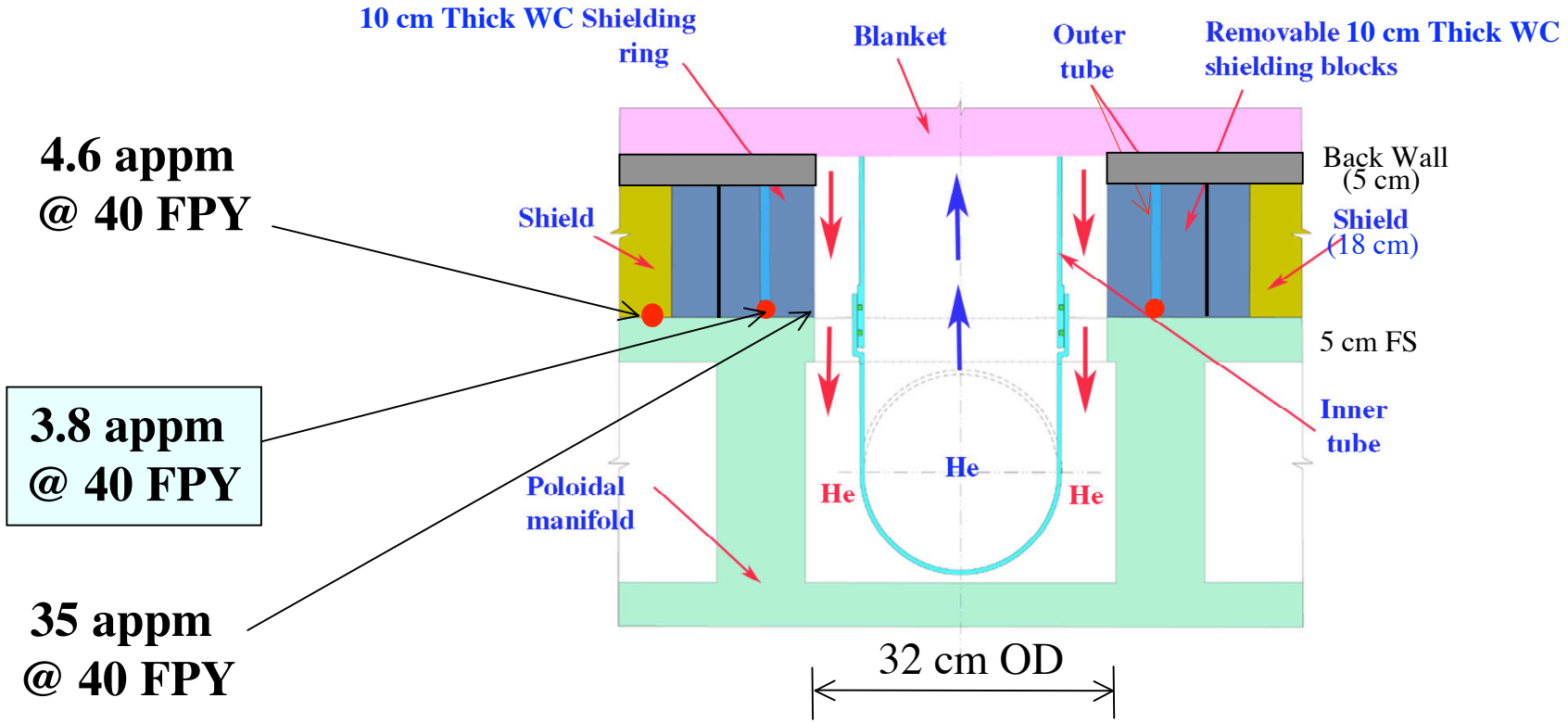


New

Welds moved away from tube surface and protected by 10 cm thick WC ring

He Production at Manifolds

(2-D results; 3 MW/m^2 peak □)

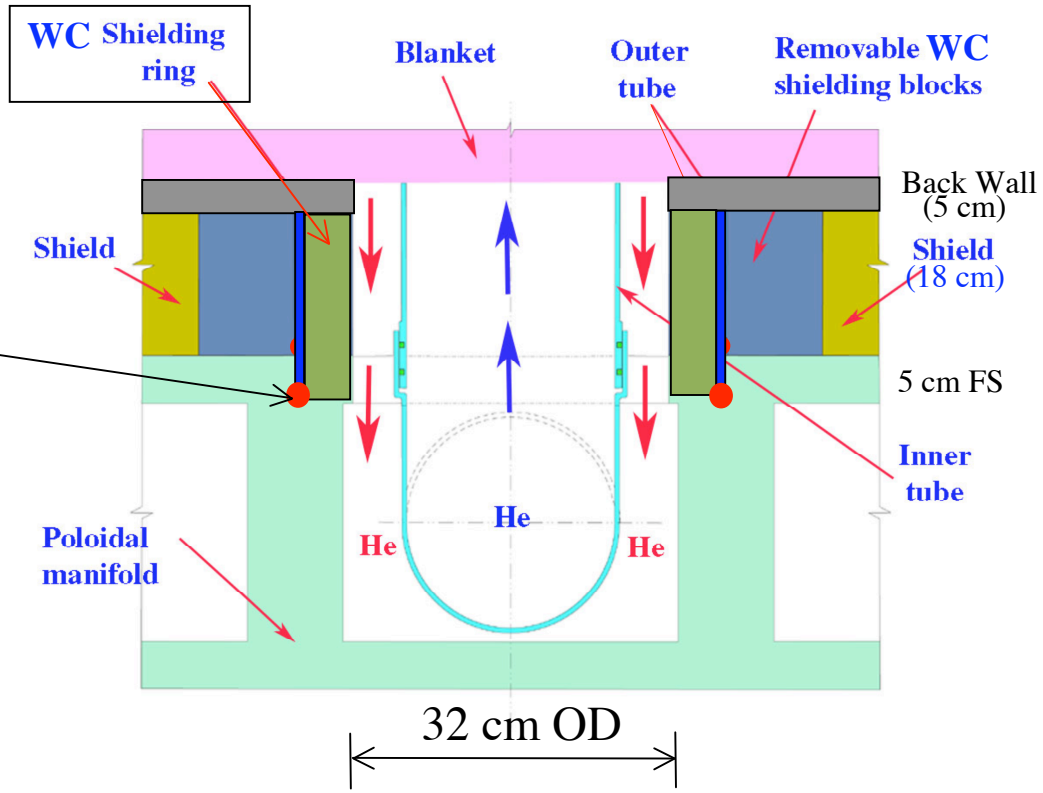


- He level at welds still exceeds reweldability limit (1 appm).
- Thickening WC ring (> 10 cm) does not help.
- 2-D analysis could overestimate damage
  □ perform 3-D analysis for better estimate.

He Production at Manifolds (Cont.)

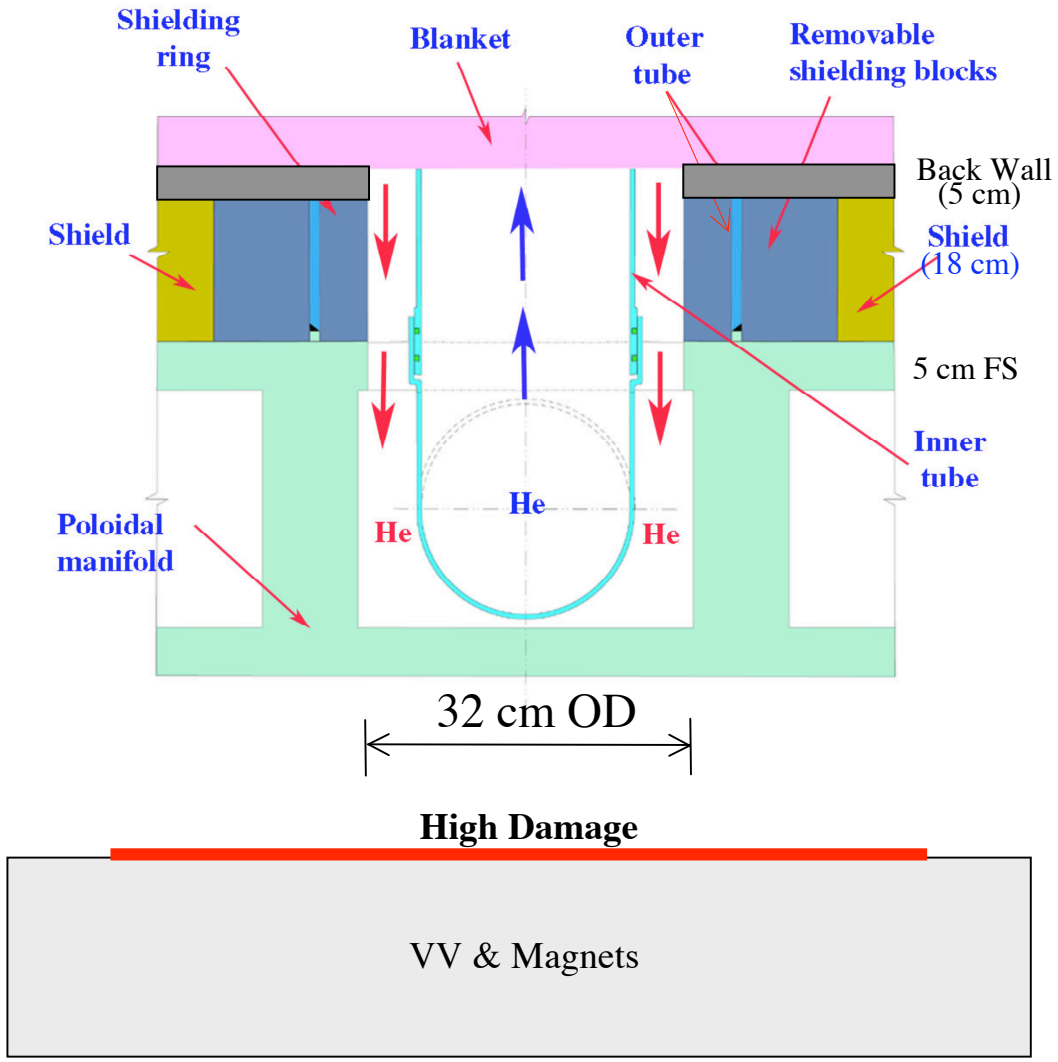
Potential solutions:

- Move welds radially out. Practical?
- Thicken HT shield by ~ 10 cm
  - ⇒ 28 cm shield.



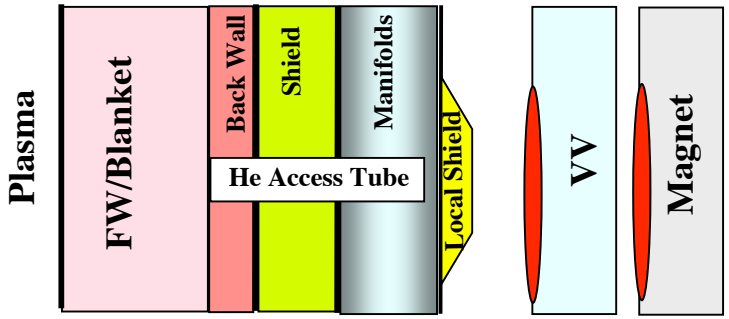
Neutron Streaming Through He Access Tubes

- 18 cm thick shield along with He manifolds protect VV and magnet.
- Radially, He access tube replaces 25 cm of FS/He damage behind He access tubes exceeds limit.
- There are 206 He access tubes (4 He access tubes / toroidal m).
- Other He tubes are needed for divertor.
- 2-D **and** 3-D analyses needed to address streaming problem as 1-D overestimates damage.



2-D Results

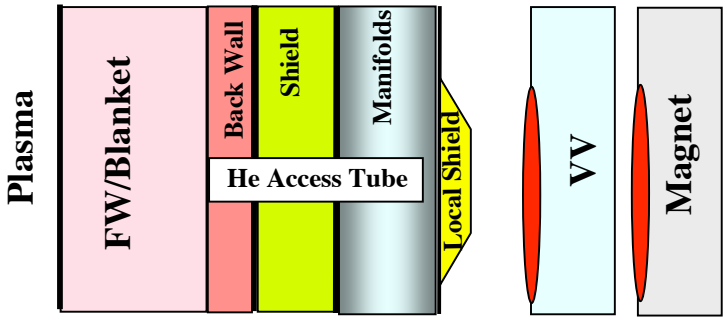
(3 MW/m^2 peak □)

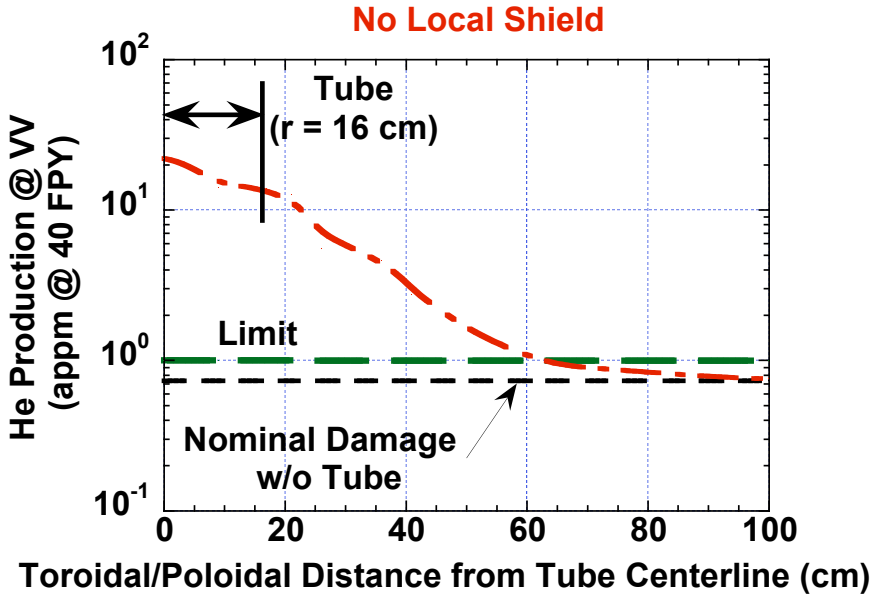


- **20 cm thick local shields** (FS/B/FS/He) attached to manifolds behind 206 He access tubes help protect VV and magnet.
- **Radius** of local shield?

Damage Profile at VV

(2-D results; 20 cm thick local shields, 3 MW/m^2 peak □)

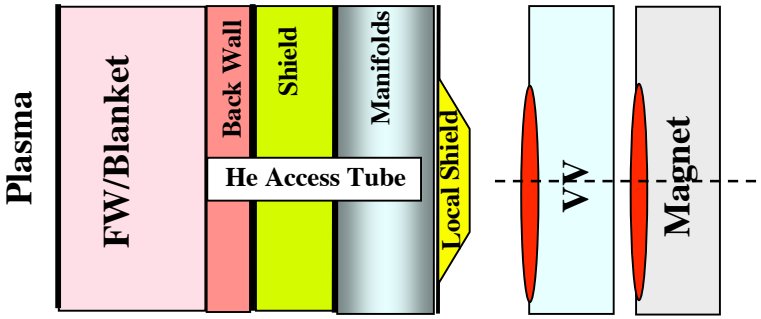


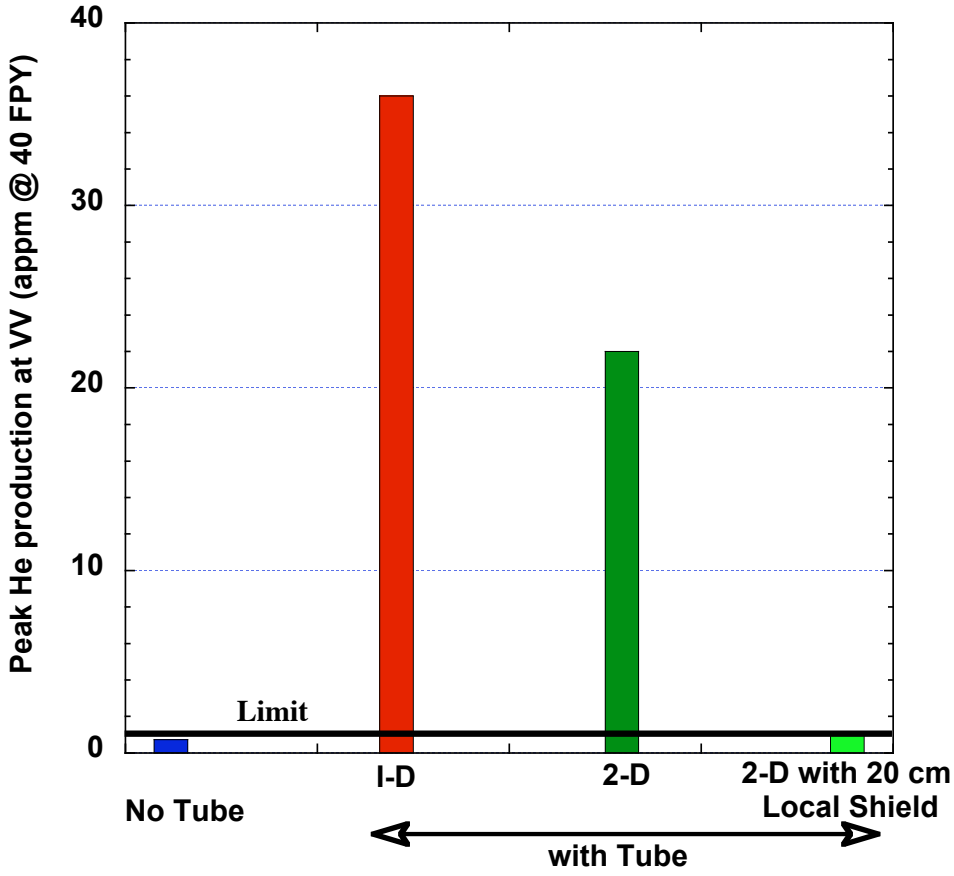


- Poloidal/toroidal damage covers wide range (up to 60 cm radius).
- **Radius** of local shield will be > 16 cm (tube radius). TBD.
- For 25 cm radius, 206 local shields cover ~3% of manifolds' surface area and amount to 8 m^3. Net increase in shield volume is ~ 2%.

He Production at VV @ Tube Centerline

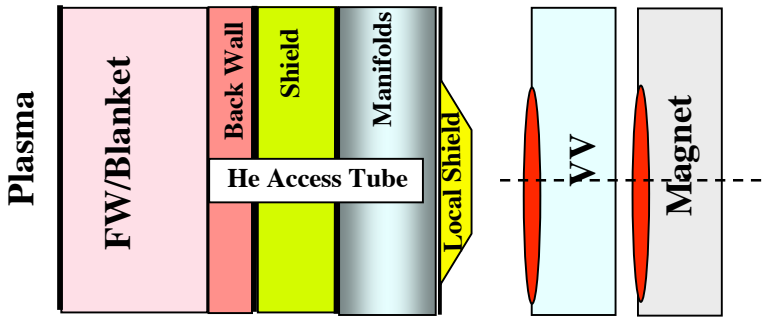
(2-D results; 20 cm thick local shields, 3 MW/m^2 peak □)

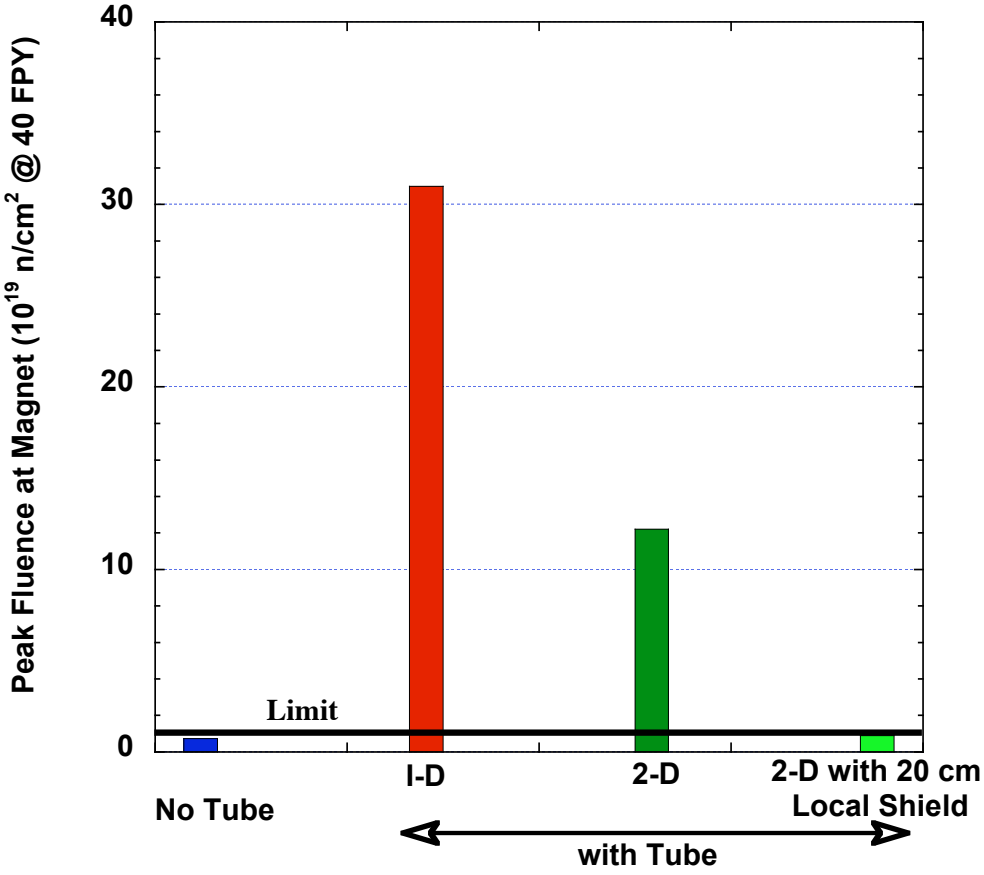




Fluence at Magnet @ Tube Centerline

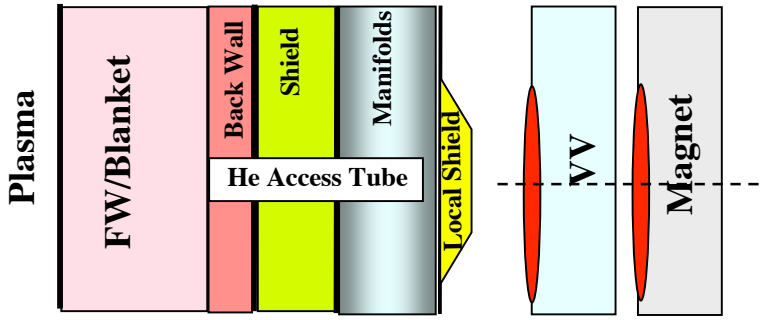
(2-D results; 20 cm thick local shields, 3 MW/m^2 peak □)

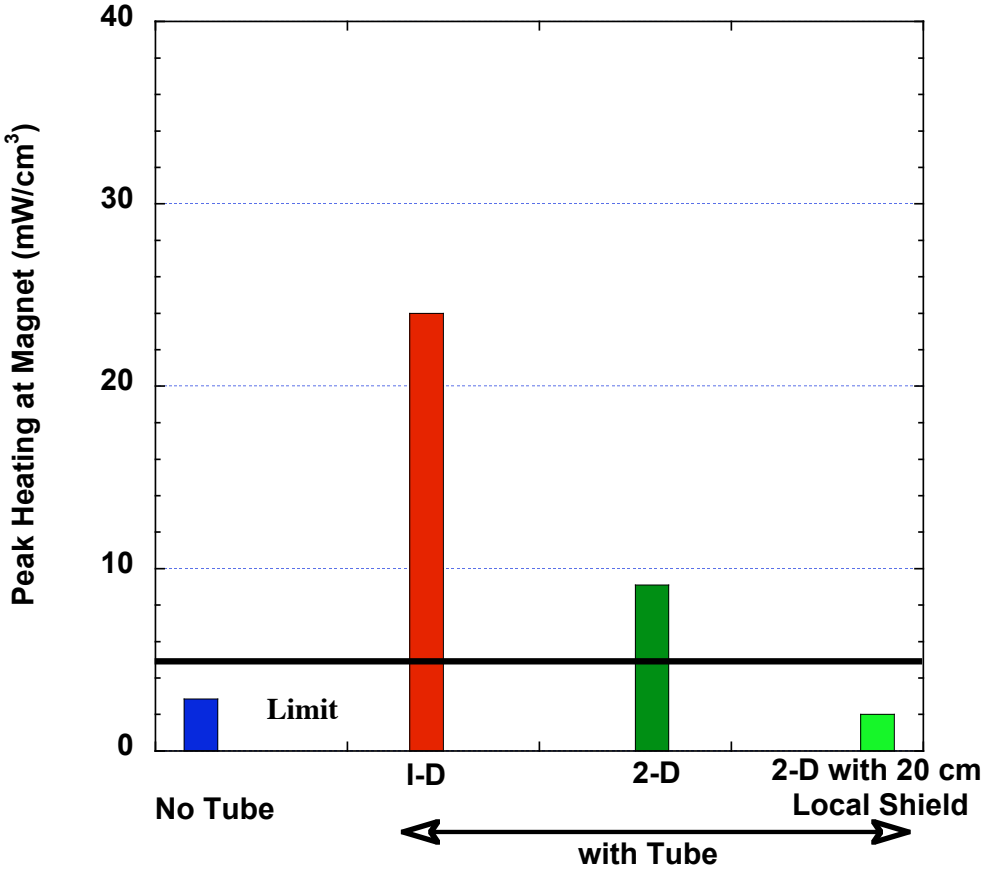




Heating at Magnet @ Tube Centerline

(2-D results; 20 cm thick local shields, 3 MW/m^2 peak □)





Future Plan

- Using 2-D analysis, check effect on reweldability of manifolds due to:
  - Moving welds outward
  - Thickening HT shield by 10 cm.

- Optimize radius of local shield and determine toroidal/poloidal damage profile.

- Perform 3-D analysis for proposed design.

Publications

Submitted final papers to:

- **FS&T journal** :

  Evolution of Clearance Standards and Implications for Radwaste Management of Fusion Power Plants

  L. El-Guebaly, P. Wilson, and D. Paige

- **FED journal**:

  Managing fusion high level waste – a strategy for burning the long-lived products in fusion devices

  L. El-Guebaly

  Potential coatings for Li/V system: nuclear performance and design issues

  L. El-Guebaly

Provided US input for ICFRM-12 manuscript:

The Feasibility of Recycling and Clearance of Active Materials from a Fusion Power Plant

M. Zucchetti, L. El-Guebaly, R. Forrest, T. Marshall, N. Taylor, K. Tobita