



2-D Analysis of Neutron Streaming Through Helium Access Tubes

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PPPL

Issues and Concerns

Manifolds reweldability:

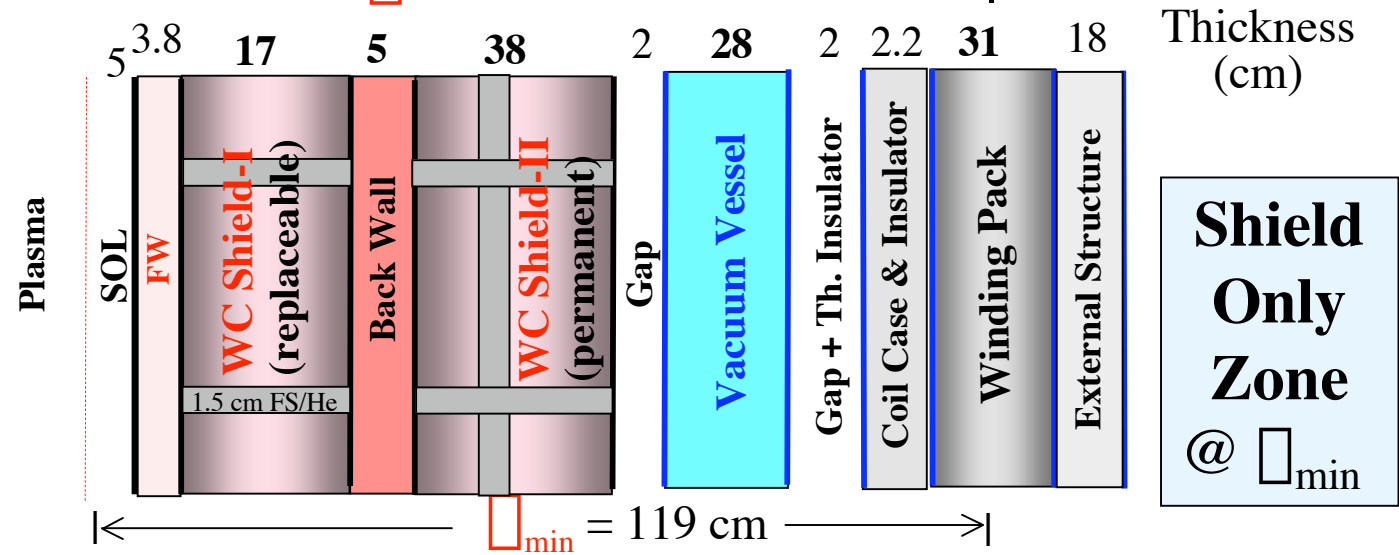
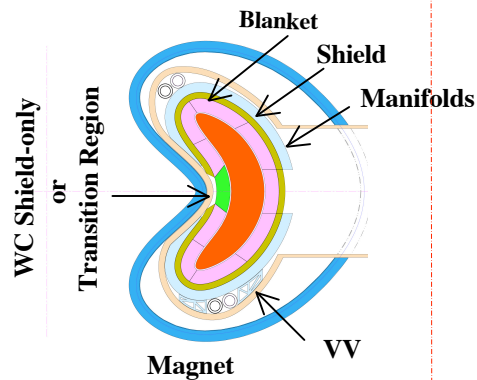
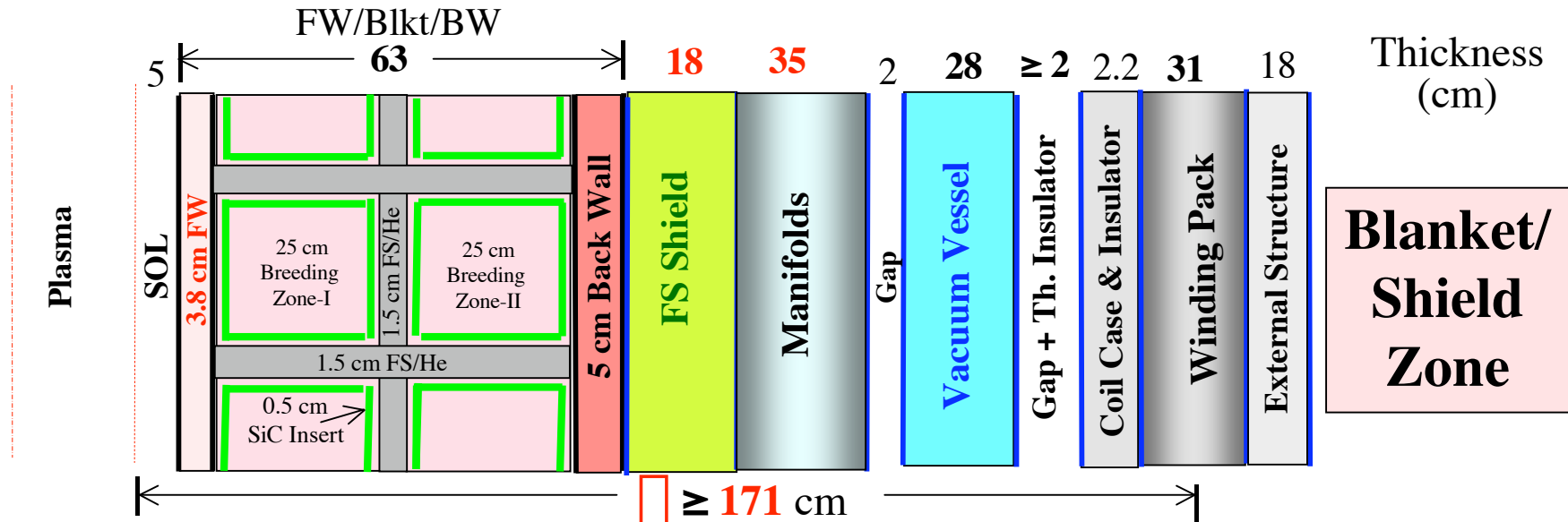
- Previous ARIES designs did **not** require reweldability of manifolds
- Last February, Malang/Wang indicated a **need to cut and reweld manifolds** at He and LiPb access tubes. Could ARIES-CS design meet reweldability limit without adding more shield to protect manifolds?

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

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

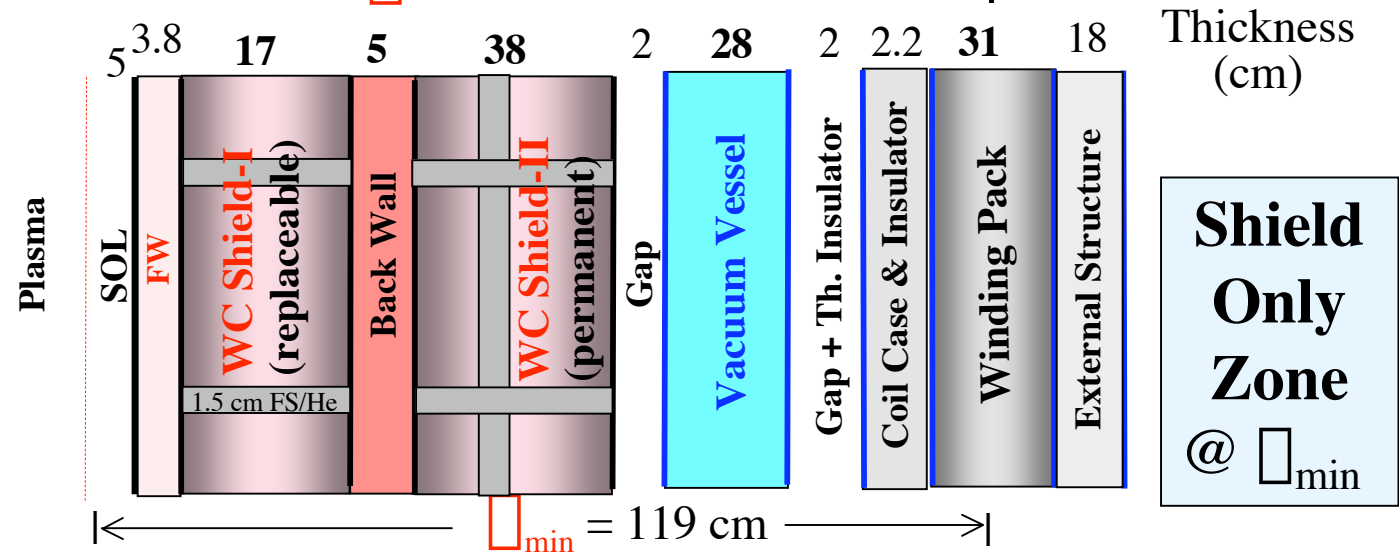
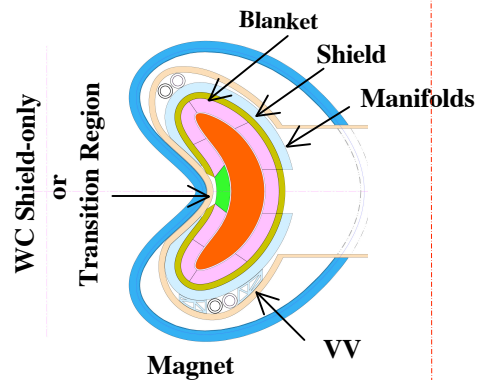
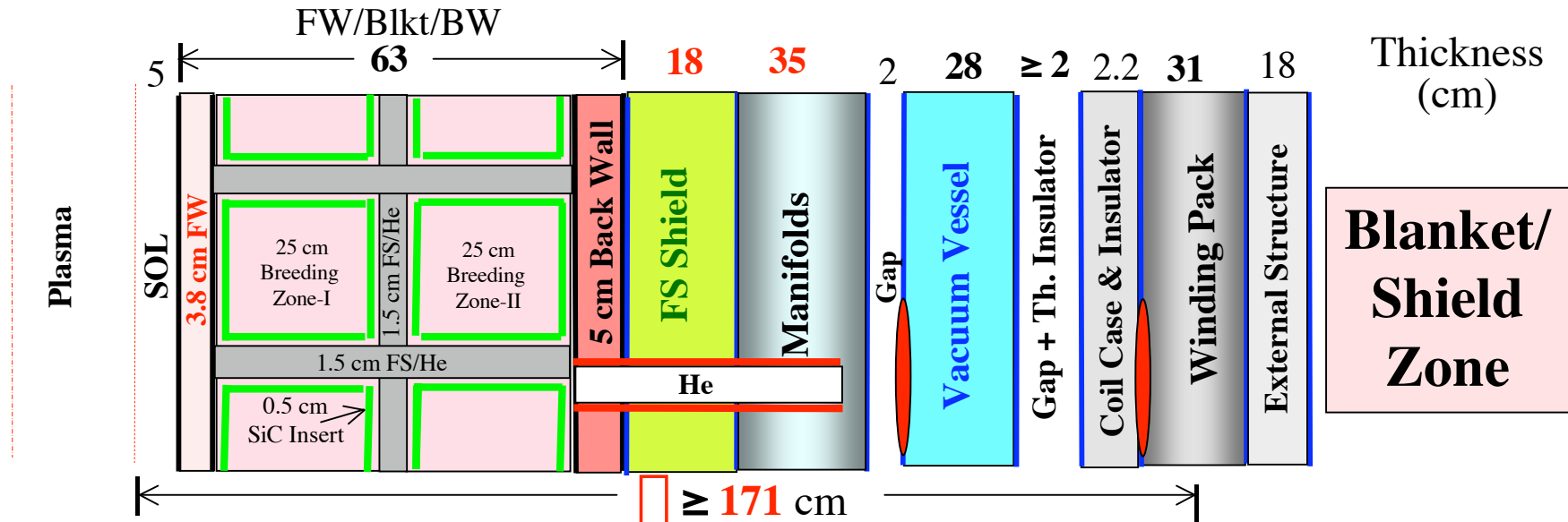
Reference Radial Build

(3 MW/m² peak $\square$)



Xn through He Access Tube

(3 MW/m² peak □)



He access Tubes

Design Approach

Port Maintenance

FP Maintenance

Total # of Tubes

206

144

of Tubes per m*

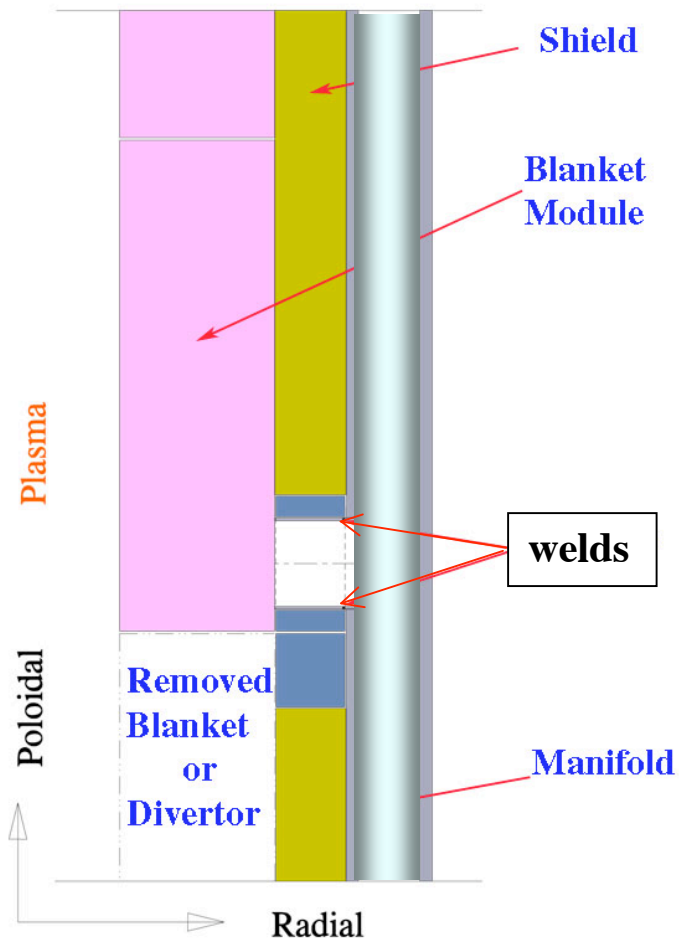
~ 4

~ 3

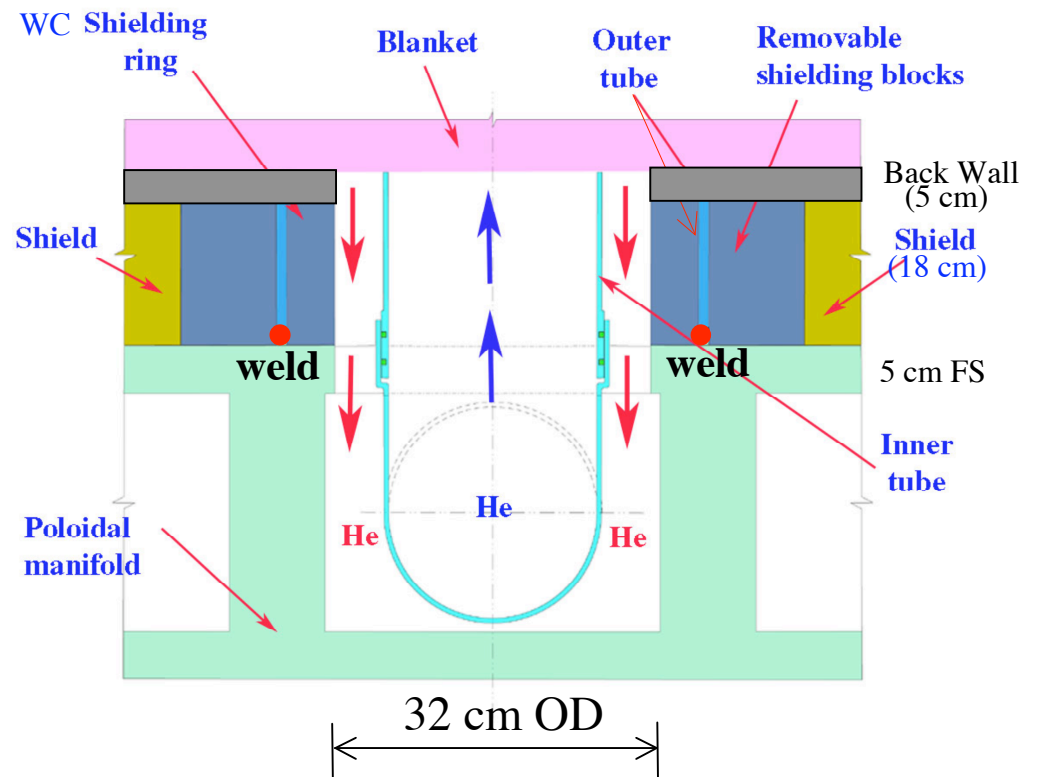
* Toroidal length. Assuming $R = 8.25$ m.

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

Innovative Manifold Design (S. Malang)



Old

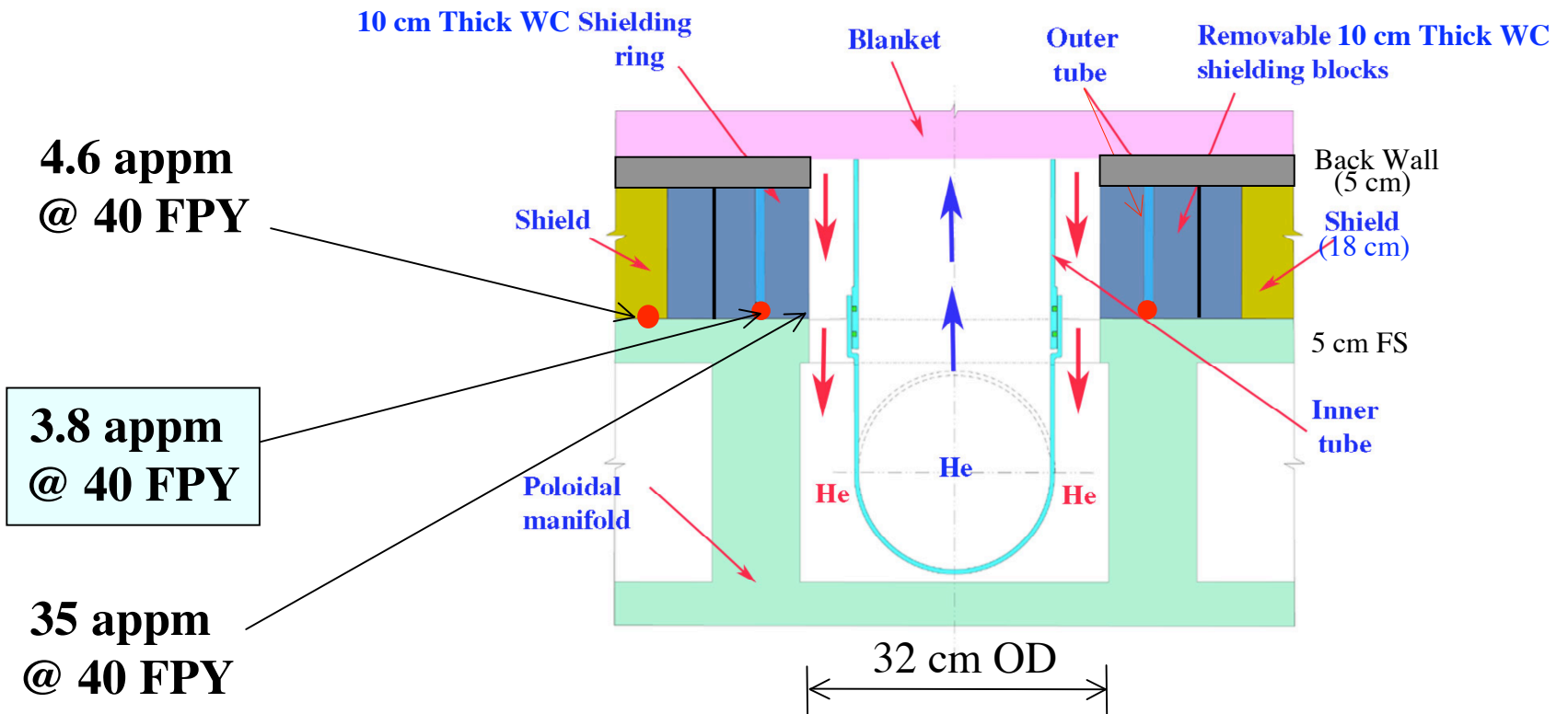


New

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

He Production at Manifolds

(2-D results; 3 MW/m² peak □)

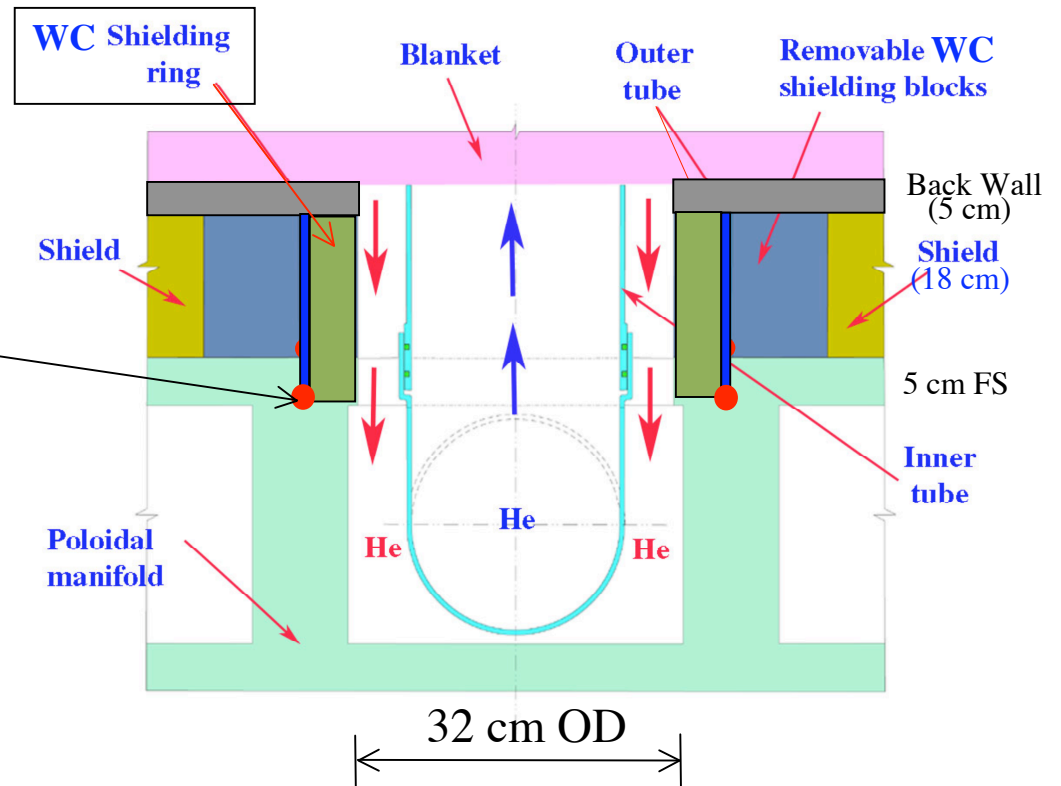


- He level at welds still **exceeds reweldability limit** (1 appm).
- Thickening WC ring (> 10 cm) does not help.
- **2-D analysis could overestimate damage**
□ perform 3-D analysis for better estimate.

He Production at Manifolds (Cont.)

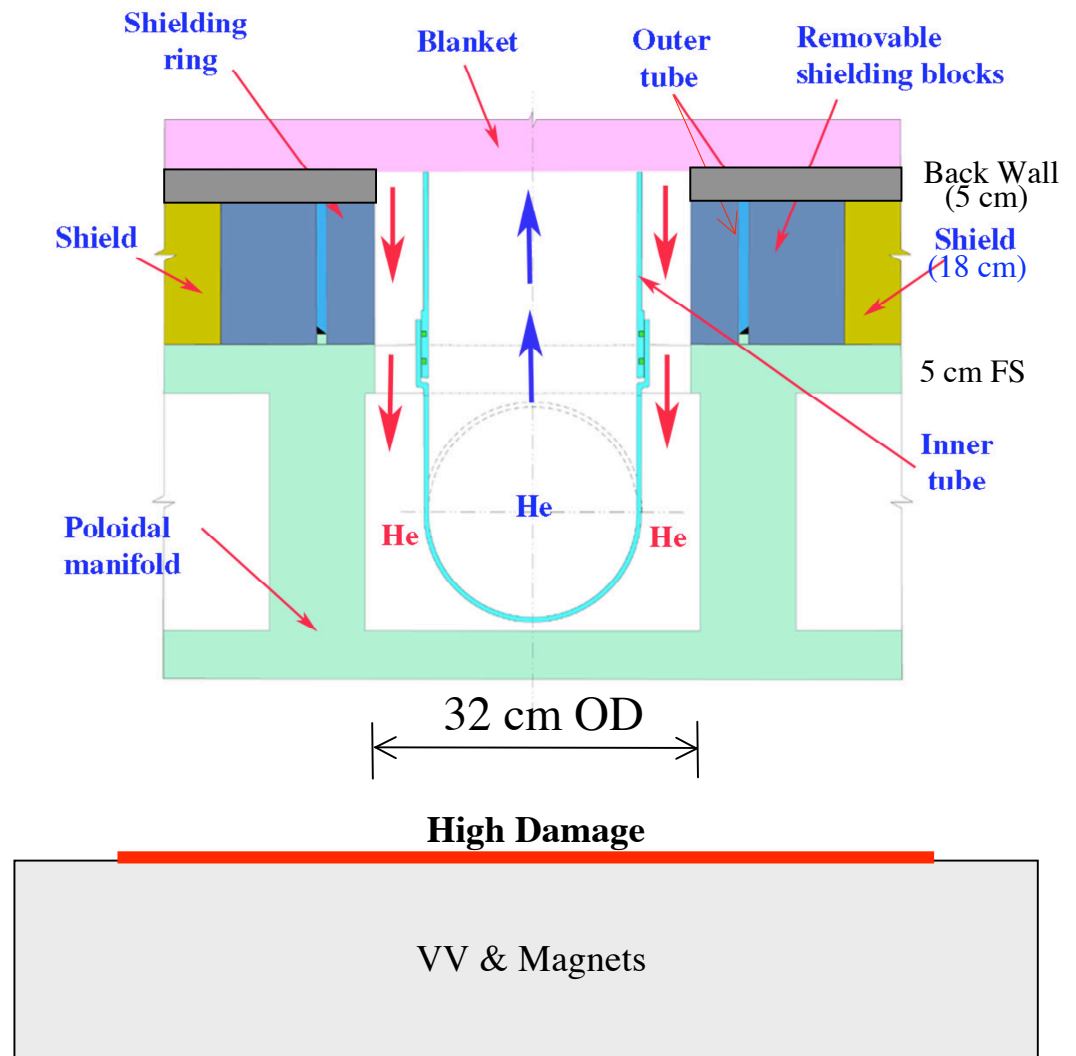
Potential solutions:

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



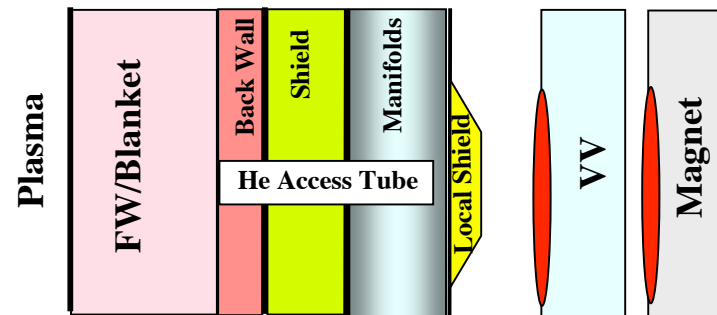
Neutron Streaming Through He Access Tubes

- 18 cm thick **shield** along with He **manifolds** protect VV and magnet.
- Radially, He access tube replaces **25 cm** of FS/He $\square$ 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

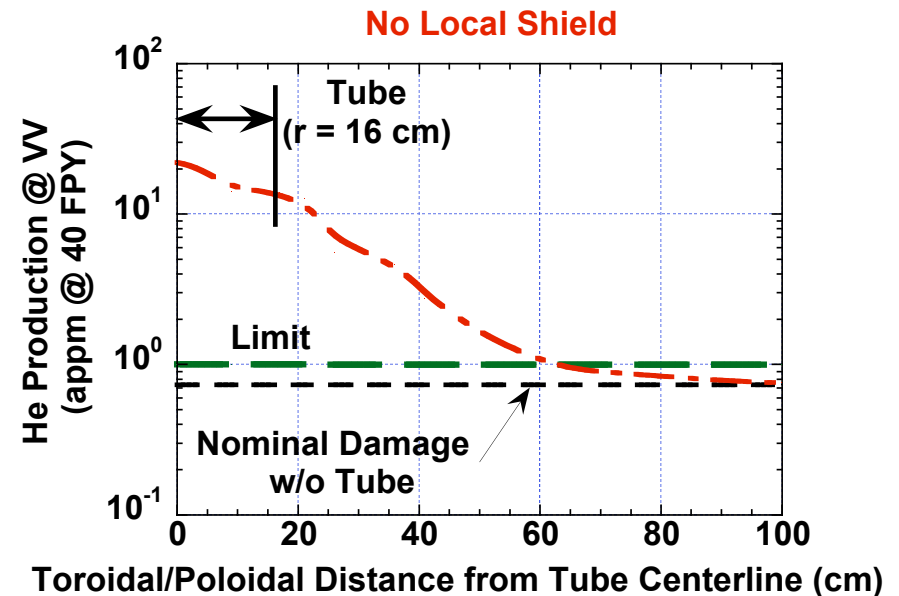
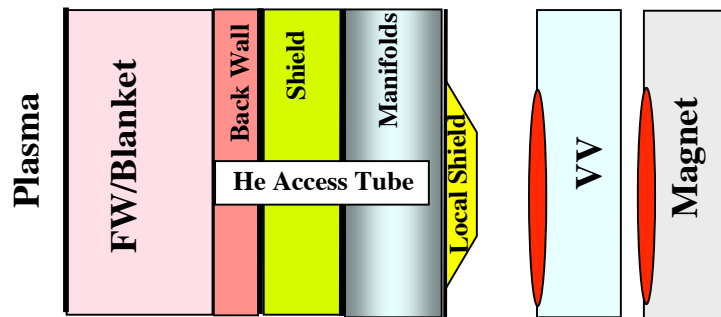
(3 MW/m² peak □)



- **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

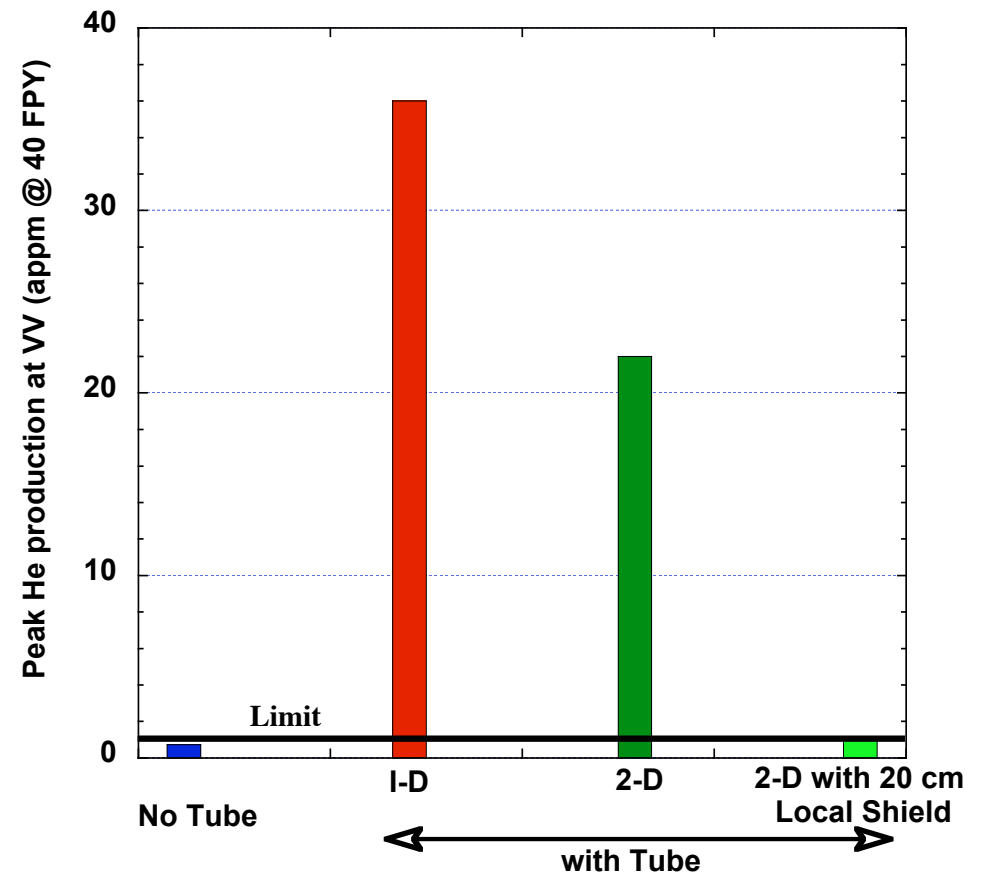
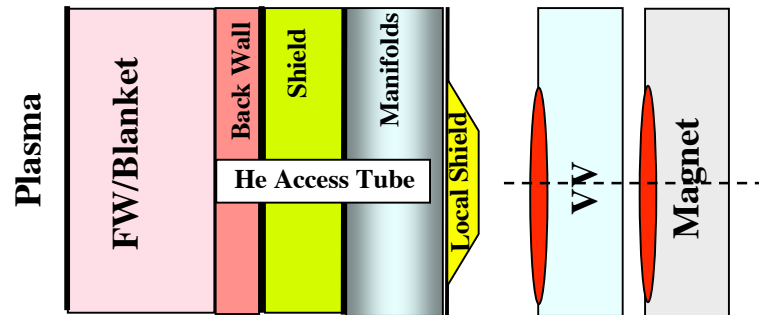
(2-D results; 20 cm thick local shields, 3 MW/m² peak □)



- **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 m³. Net increase in shield **volume** is **~2%**.

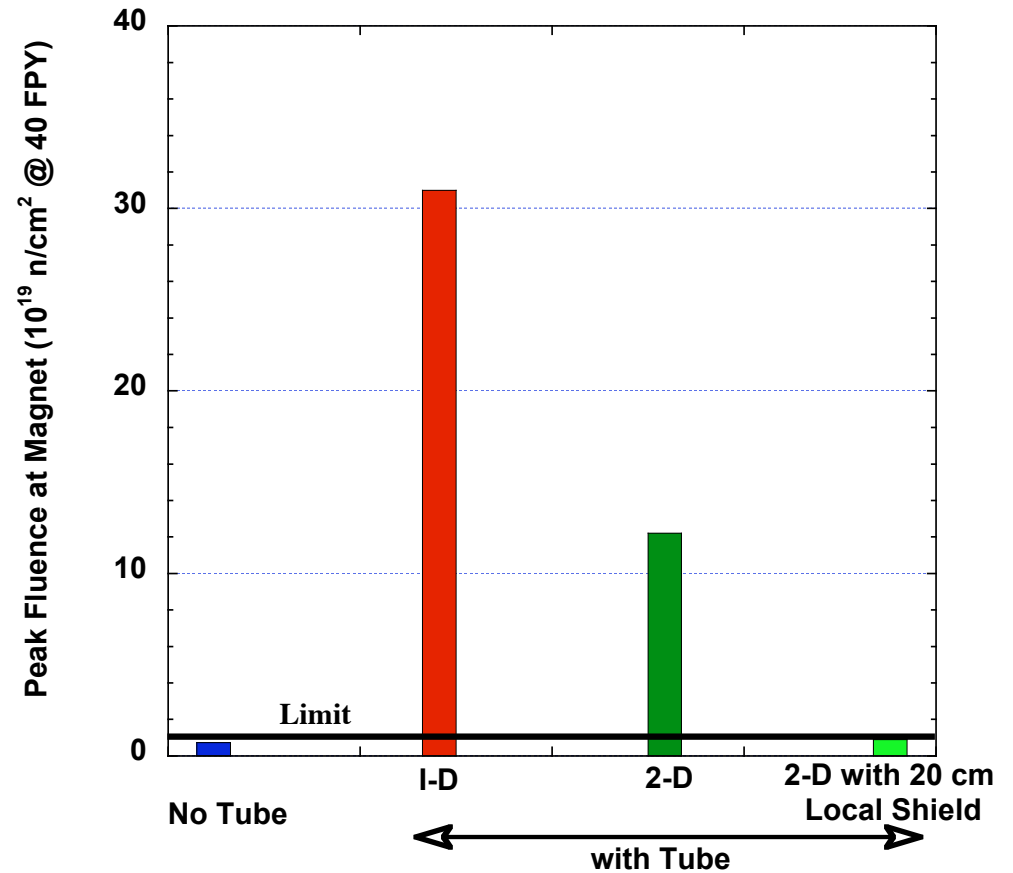
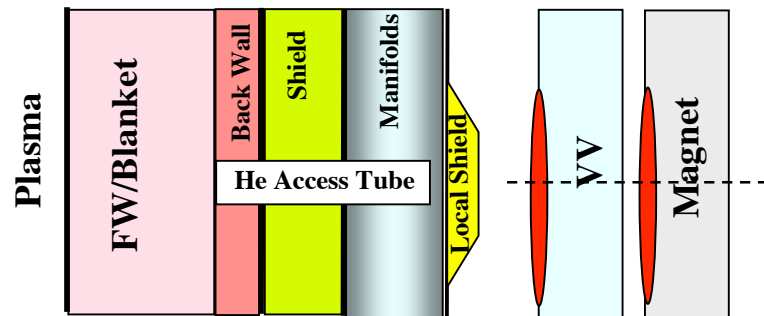
He Production at VV @ Tube Centerline

(2-D results; 20 cm thick local shields, 3 MW/m² peak □)



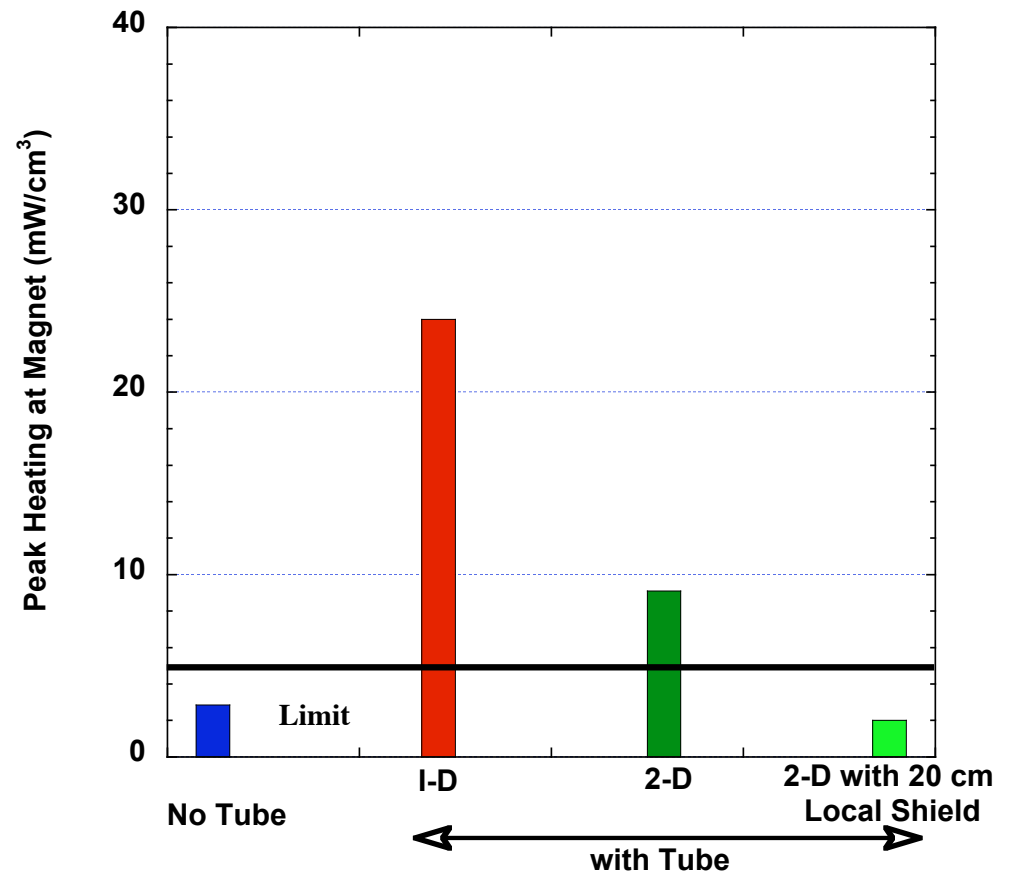
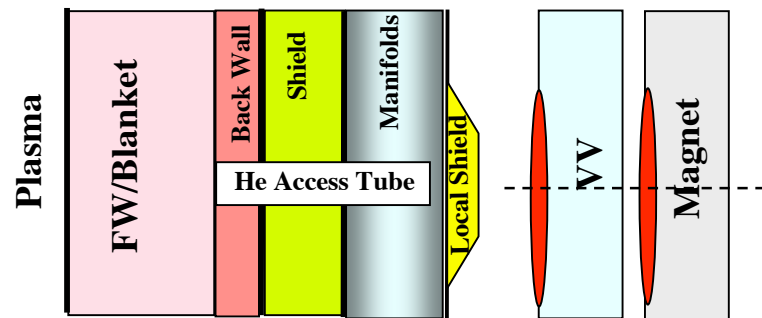
Fluence at Magnet @ Tube Centerline

(2-D results; 20 cm thick local shields, 3 MW/m² peak □)



Heating at Magnet @ Tube Centerline

(2-D results; 20 cm thick local shields, 3 MW/m² 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