



Revised Radial Build Data; Breeding and Streaming Concerns

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ARIES-CS Project Meeting

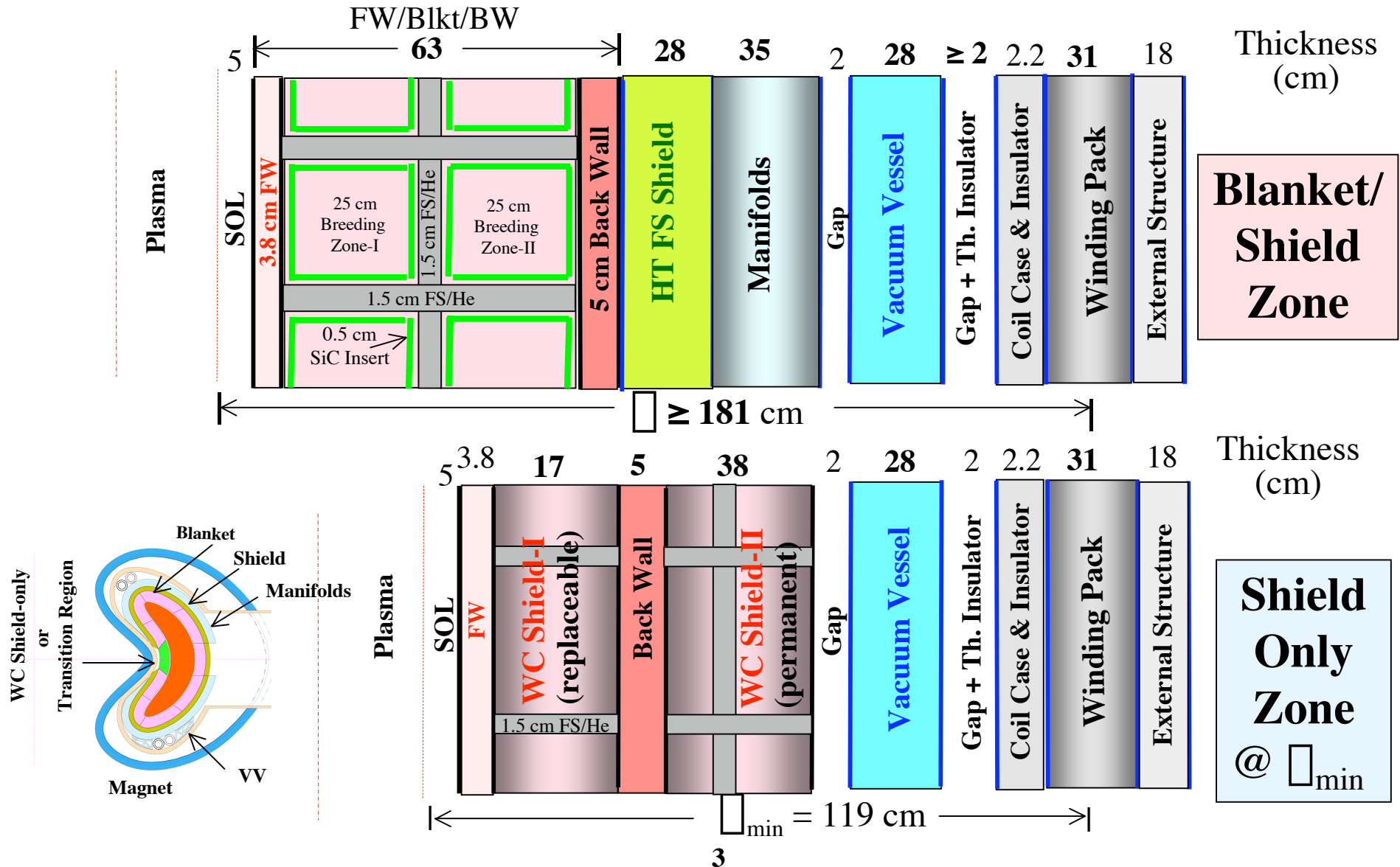
January 23, 2006
UCSD

Contents

- Plasma - midcoil separation **contours for $R = 7$ m** baseline case.
- **Breeding concern** due to less blanket coverage.
- Shielding requirement for **He access tubes**.
- Recommended **design changes** to solve breeding and streaming problems.

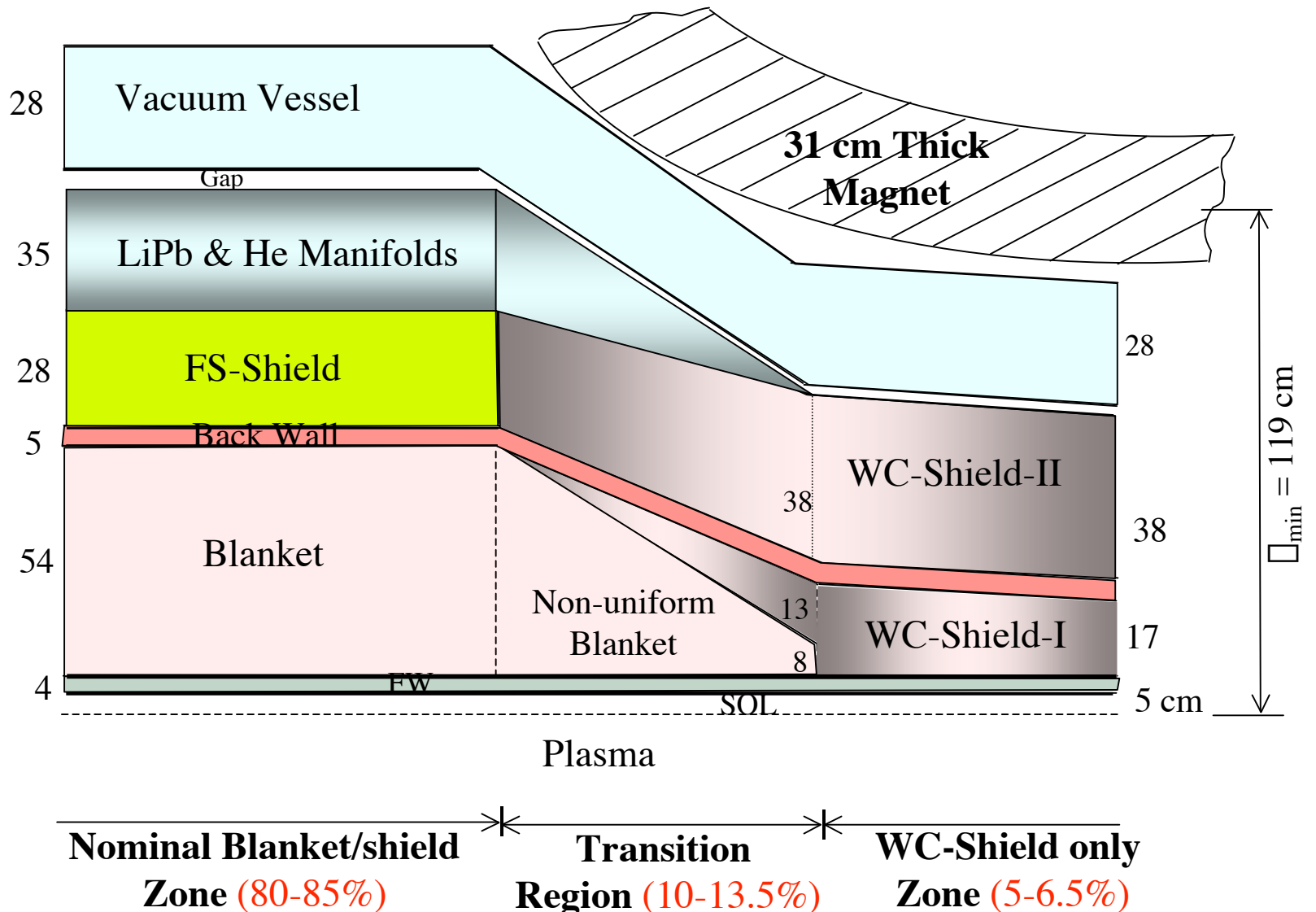
Previous Radial Build - $R = 8.25$ m

(3 FP Configuration; LiPb/FS/He System; 3 MW/m² peak $\square$)

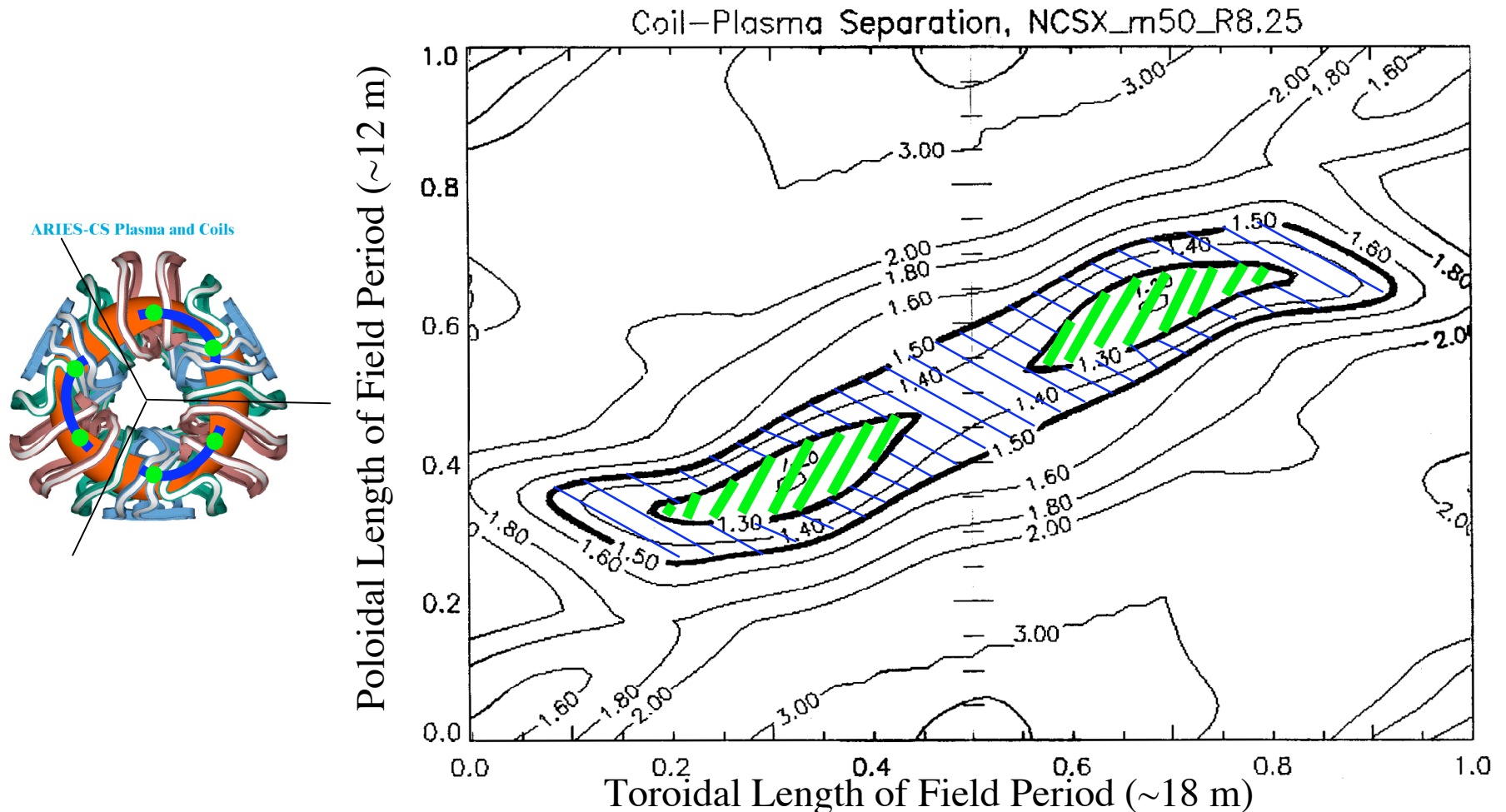


Previous Case - $R = 8.25$ m

(peak $\dot{q} = 3$ MW/m²)



Previous Design - $2 \square_{\min}$ per Field Period ($R = 8.25$ m)



Shield-only zone (**green**), transition region (**blue**), and nominal blanket zone cover **>5%**, **>10%** and **<85%** of FW area, respectively

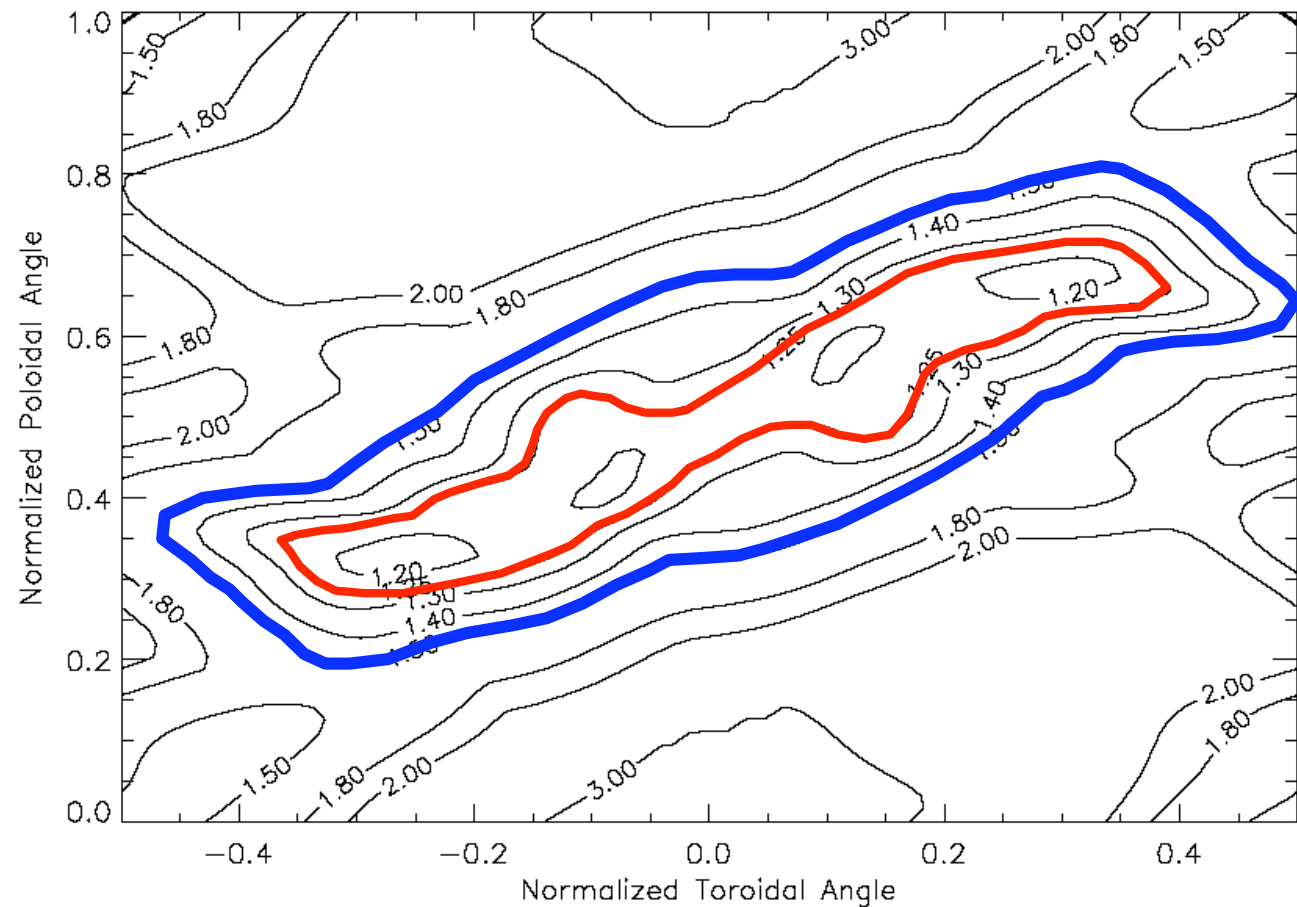
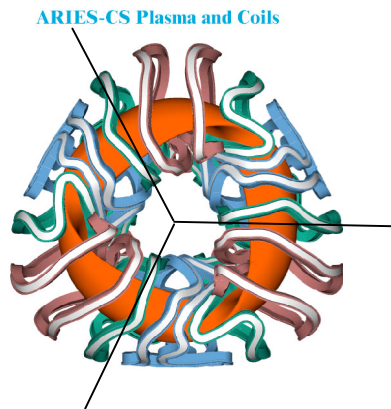


New Baseline Design ($R = 7$ m)

- 4 $\square_{\min}$ per field period $\square$ Less blanket coverage $\square$ less breeding.
- ~ 5 MW/m² peak neutron wall loading $\square$ more shielding
- 18 cm thick magnet, not 31 cm $\square$ 6 cm free space at $\square_{\min}$
- $\square_{\min} = 118$ cm, not 119 cm
- Per Siegfried:
 - No He/LiPb manifolds at $\square_{\min}$
 - He/LiPb access tubes placed at least 1 m away from $\square_{\min}$
 - $\square$ streaming problem
 - No cut/reweld of VV sections near $\square_{\min}$.

New Baseline Design - $R = 7\text{ m}$

$4\beta_{\text{min}}$ per Field Period



- Shield-only zone (red) **and** transition zone (blue) cover large area ($\sim 35\%$).
- Nominal blanket covers only $\sim 65\%$ of area, raising **breeding concern**.



FW Coverage Fraction (%)

	UW Estimate	CAD	UW Estimate	CAD
R (m)	8.25	8.25	7	7
Shield-only zone	~ 5	6.5	~ 10	?
Transition zone	~ 10	13.5	~ 25	?
Full blanket	~ 85	80	~ 65	?

Need coverage fraction from UCSD to check TBR for R= 7 m.

Overall TBR

- 1-D and 3-D TBR comparison indicated good agreement for **full** blanket coverage (no blanket variation, no divertor system, no penetrations) - refer to June 05 presentation.
- Overall TBR is based on 1-D results combined with blanket coverage.
- **Assumptions:**
 - **Divertor/baffle system** covers 10% of FW area:
 - 12.5 cm thick divertor/baffle system covers 8% of FW area followed by 42 cm thick blanket.
 - Divertor He manifolds cover 2% of FW area without blanket behind manifolds.
 - **Penetrations** occupy 1% of FW area.



Baseline Design

($R = 7$ m, peak $\dot{q} = 5$ MW/m²)

- Limited blanket coverage

□ unacceptable overall TBR

- 6 cm free space available @ $\dot{q}_{\min}$

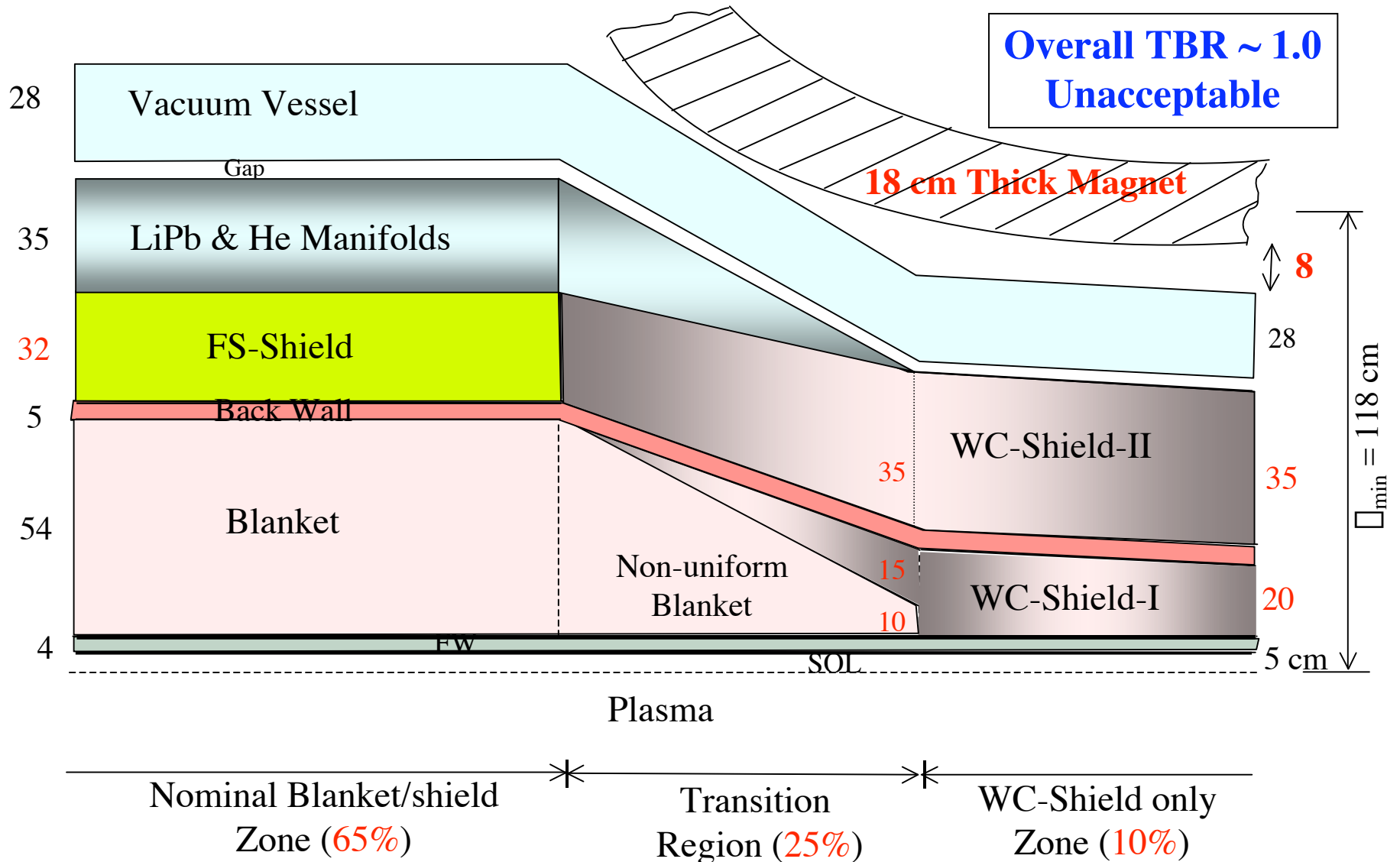
□ install thin blanket at $\dot{q}_{\min}$

- **Two Options:**

	I	II
Shield-only zone	✓	---
Transition zone	✓	✓
Full blanket	✓	✓

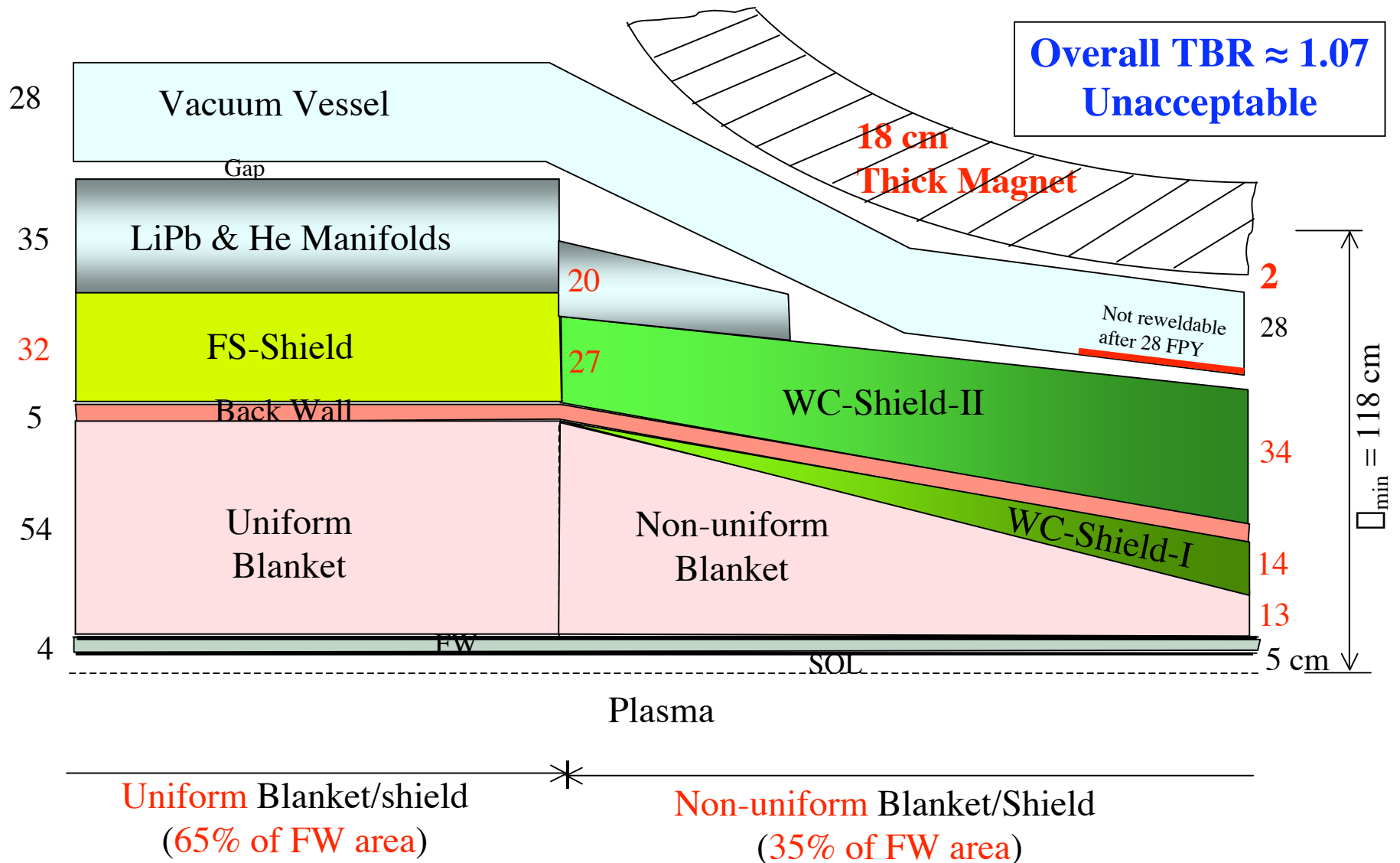
Baseline Design - Option I

(R = 7 m, peak $\dot{q} = 5 \text{ MW/m}^2$)



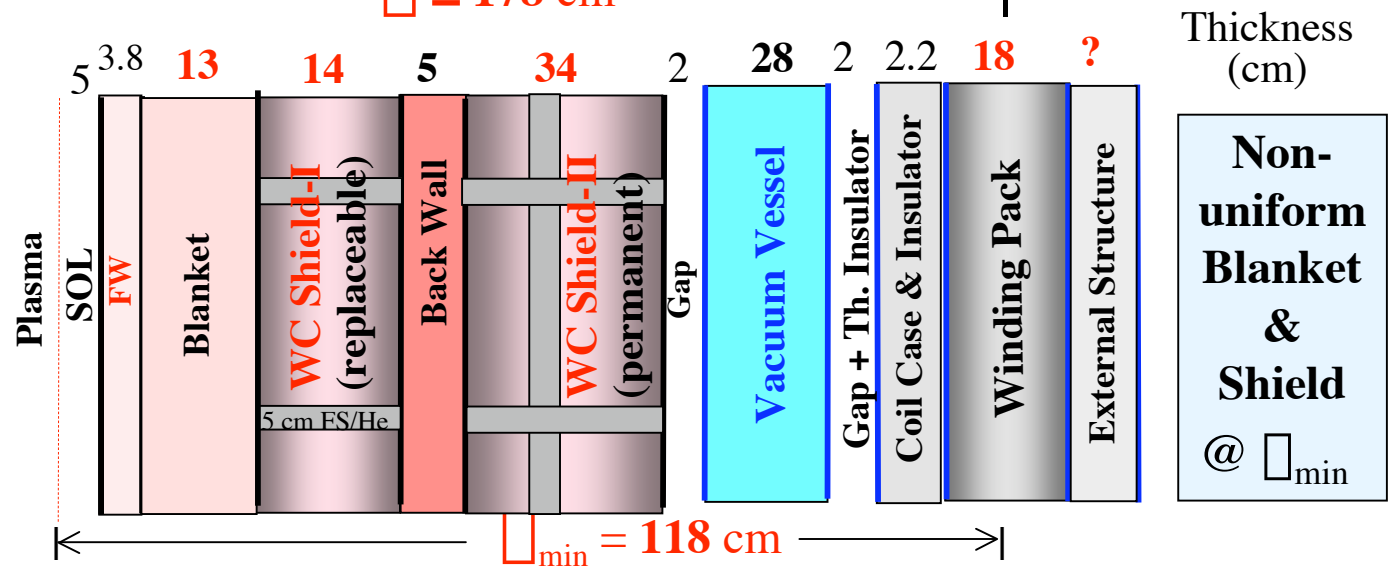
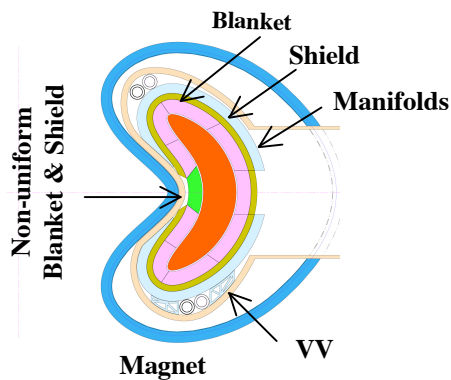
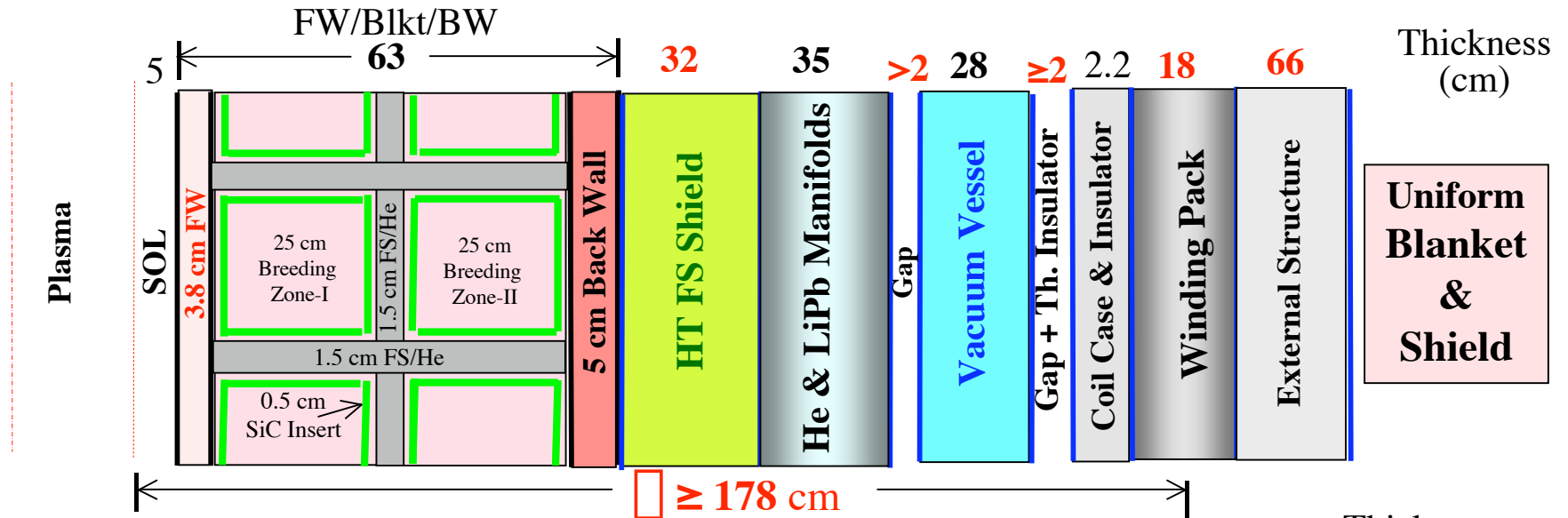
Baseline Design - Option II

($R = 7$ m, peak $\dot{q} = 5$ MW/m²)



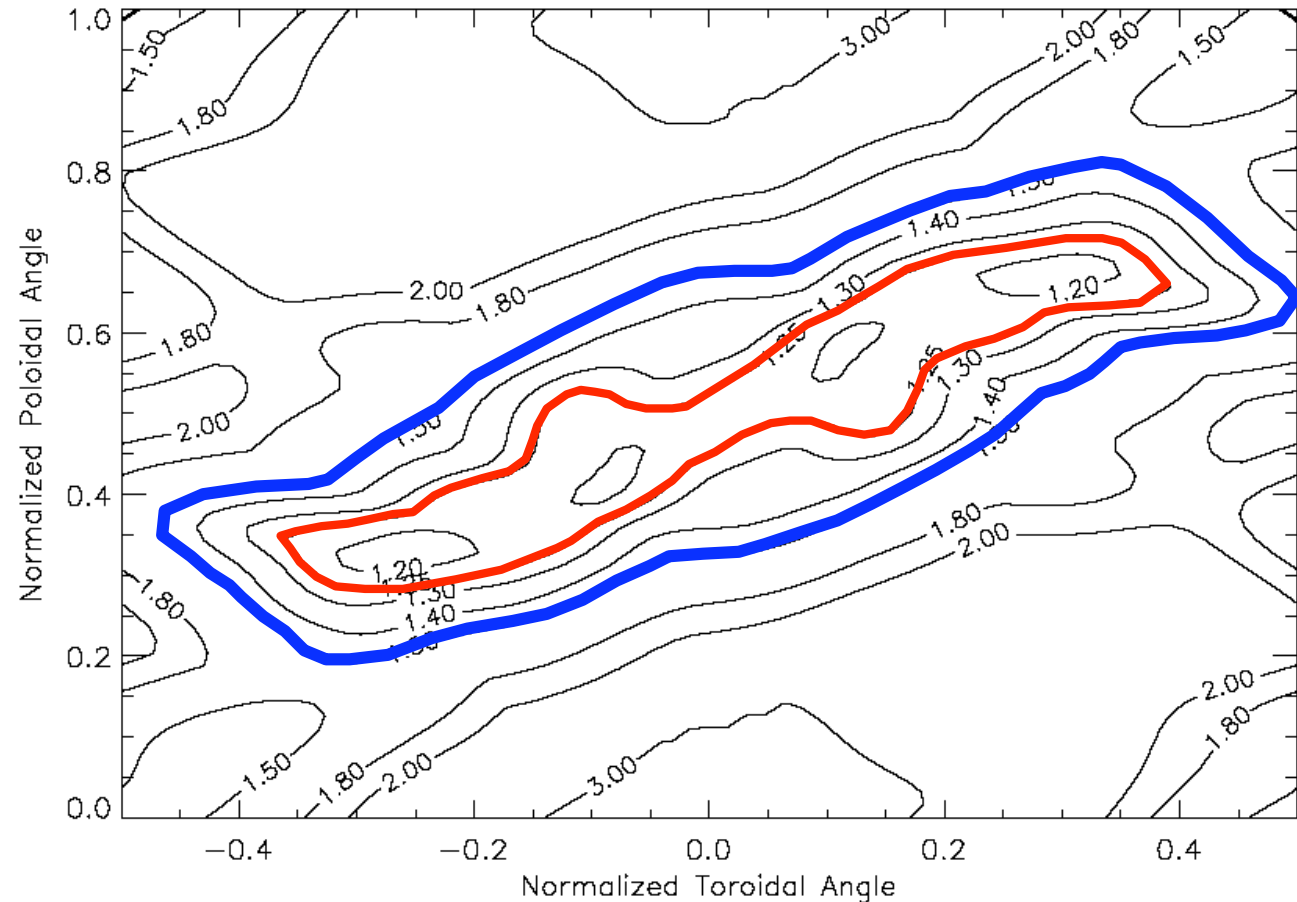
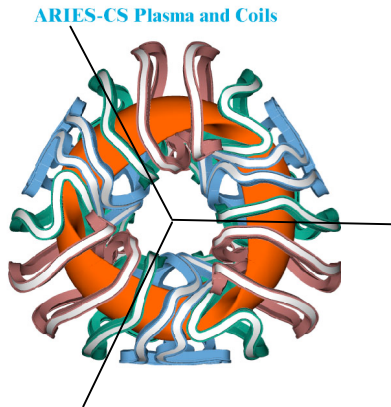
Radial Build – Option II

(5 MW/m² peak $\square$; changes marked in red)



Red Contour Designates 10% of VV
near $\square_{\min}$ (not reweldable after 28 FPY)

Option-II

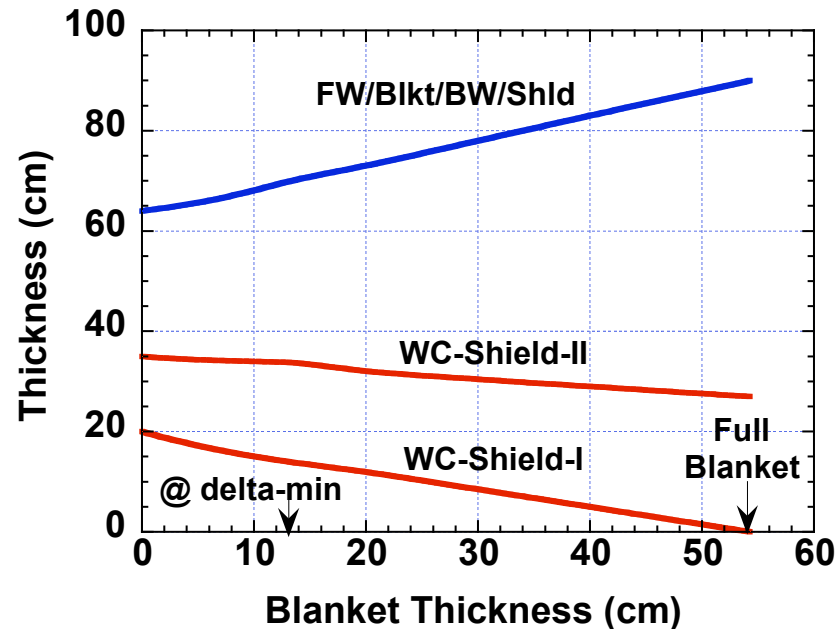


Reweldable VV everywhere requires additional 3 cm WC-shield

$\square$ 121 cm $\square_{\min}$, not 118 cm.

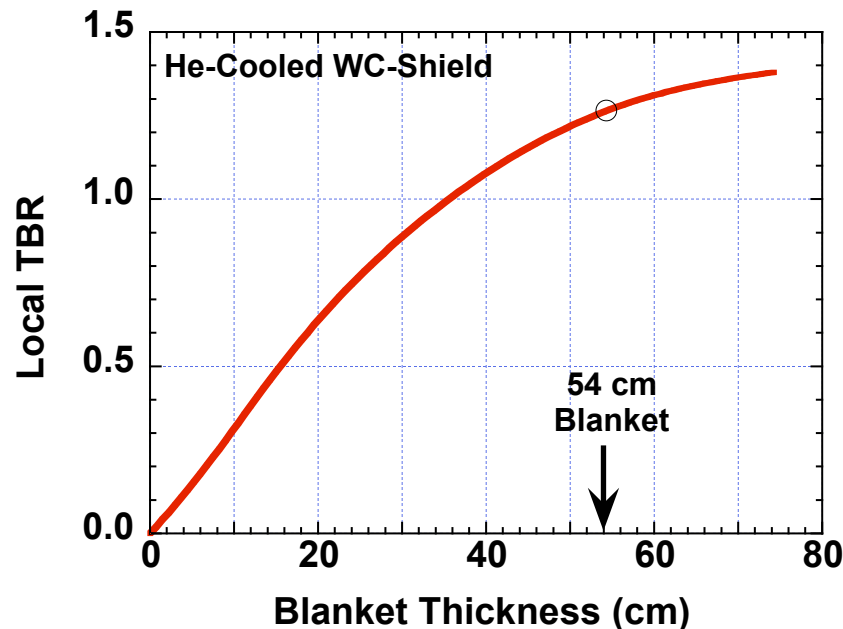
Blanket / WC-Shield Tradeoff

(Non-uniform Blanket/Shield Region - Option-II)



- Replaceable components: FW/blanket, WC-shield-I, back wall.
- WC-shield-II and magnet protected for plant life.
- VV near $\square_{\min}$ is **not** reweldable after 28 FPY.

Insufficient Tritium Breeding Calls for Design Change



Option-II

Overall TBR ~ 1.07

- **Potential solutions to meet breeding requirement (overall TBR = 1.1):**
 - Increase “full blanket” thickness by 10 cm (from 54 cm to 64 cm).
 - Increase major radius ($R > 7$ m) to allow more “full blanket” coverage ($> 65\%$) (preferred option).

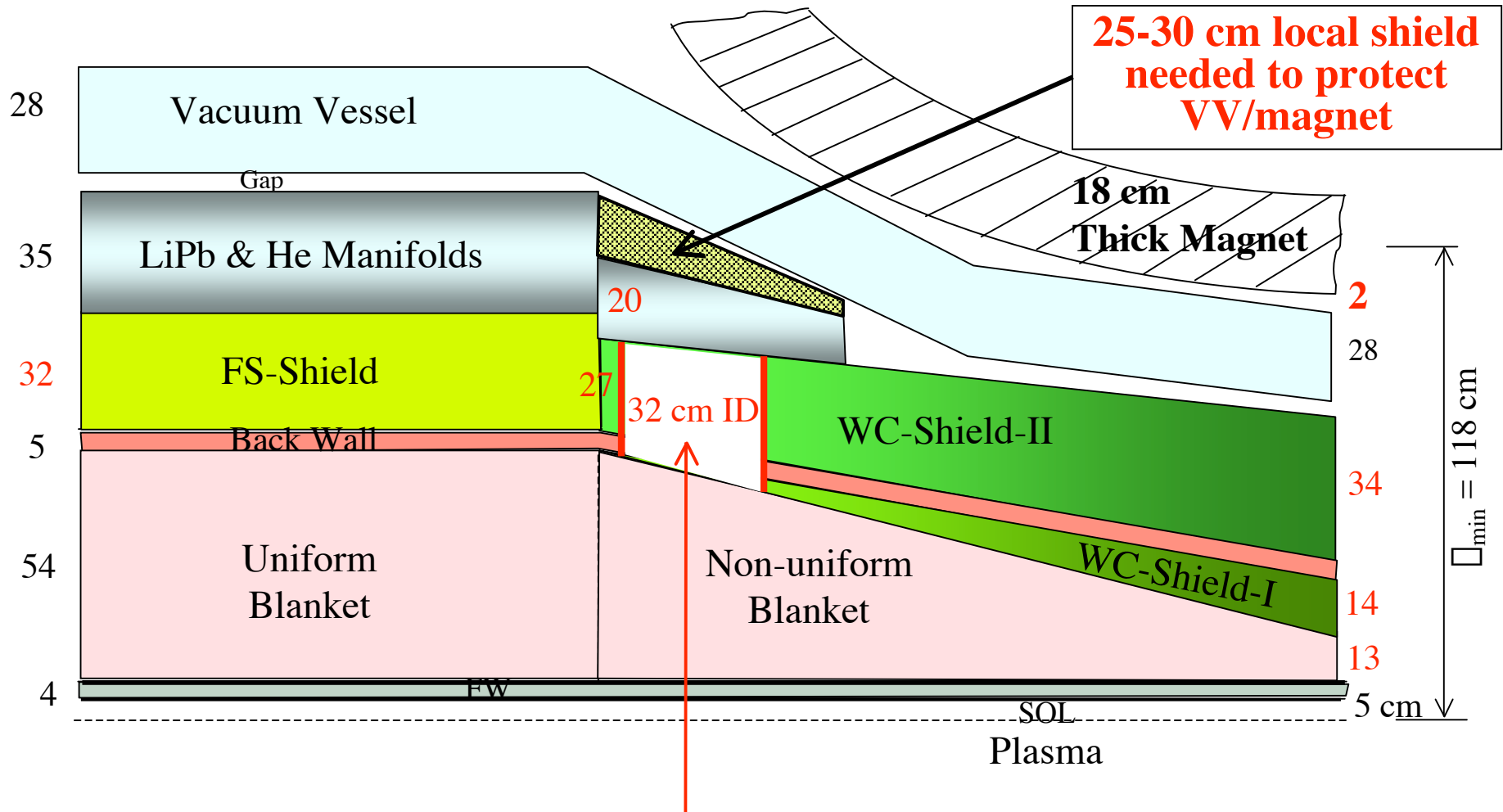


Streaming Through He/LiPb Access Tubes (Non-uniform Blanket Region)

- Each LiPb/He access tube **replaces 32-40 cm of WC-shield and back wall.**
- Neutrons streaming through He tube **increase magnet damage by 1-2 orders of magnitude.**
- **25-30 cm thick local shield** needed between manifolds and VV to protect VV and magnet. To be confirmed by 3-D analysis.
- **Tilted tube** away from $\square_{\min}$ helps reduce size of local shield and relocate it in area of more free space.
- **Q to UCSD:** does radial space allow 25-30 cm of local shield? If not, larger machine with $R > 7$ m is needed.

Xn Through He Access Tube

($R = 7$ m, peak $\dot{q} = 5$ MW/m²)



Most critical shielding space (not at $\Delta_{\min}$)

Conclusions

- **Thin magnet** (18 cm thick) permits installing **thin blanket at $\rho_{\min}$** .
- Baseline design with $R = 7$ m offers low “uniform blanket” coverage, causing **breeding problem** ($TBR < 1.1$).
- Blanket consists of **two main regions**: uniform (≥ 54 cm thick) and non-uniform (13-54 cm). **Need** coverage fractions from UCSD to confirm TBR estimate.
- To fix **streaming problem**, 25-30 cm local shield is needed behind He access tubes.
- Breeding and streaming problems call for **larger machine** with $R > 7$ m. **Need** from L-P Ku: plasma-midcoil separation contours for $R = 7.5$ and 8 m with $\rho_{\min} \sim 1.2$ m.
- **New design could be driven by radial standoff at He access tube**, not at $\rho_{\min}$.
- Designs employing no He coolant (such as **advanced LiPb/SiC system**) could be more suitable for compact stellarators.

No streaming problem and higher ρ_{th}

$\Rightarrow$ smaller machine and lower COE (~ 20 mills/kWh saving).

Future Plan

- Get plasma-midcoil separation **contours** from PPPL for $R > 7$ m and solve breeding and streaming problems.
- **Optimize dimensions of local shield** behind He access tubes and confirm VV/magnet protection with **3-D analysis**.
- **Perform 3-D breeding calculation**. Need CAD input files from UCSD for baseline design with blanket variation, divertor system, and penetrations.
- Update radial build for **LiPb/SiC system**.