Final Radial Build and Composition for LiPb/FS/He System

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http://fti.neep.wisc.edu/aries-cs/builds/build.html

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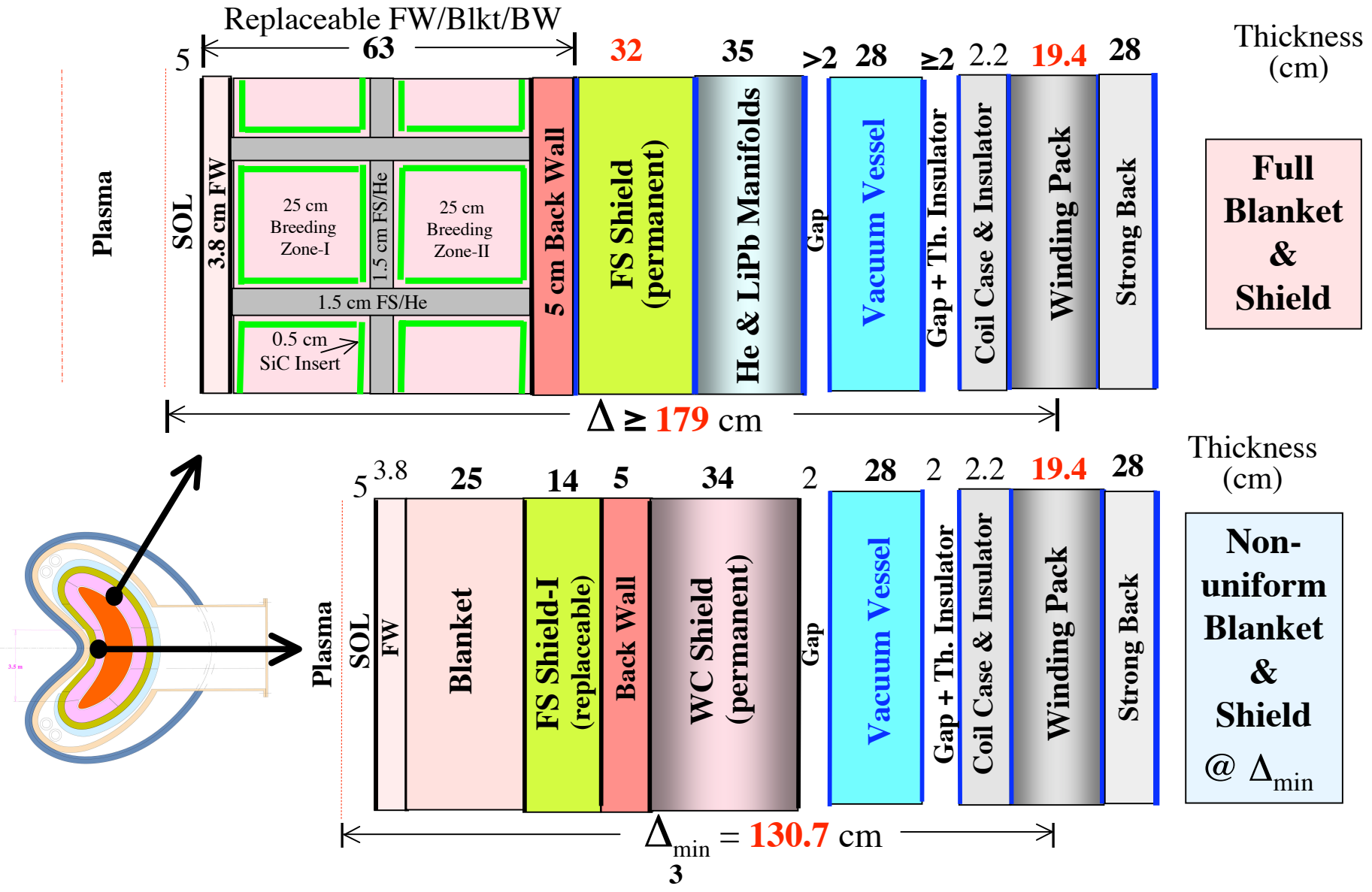
Blanket Concepts

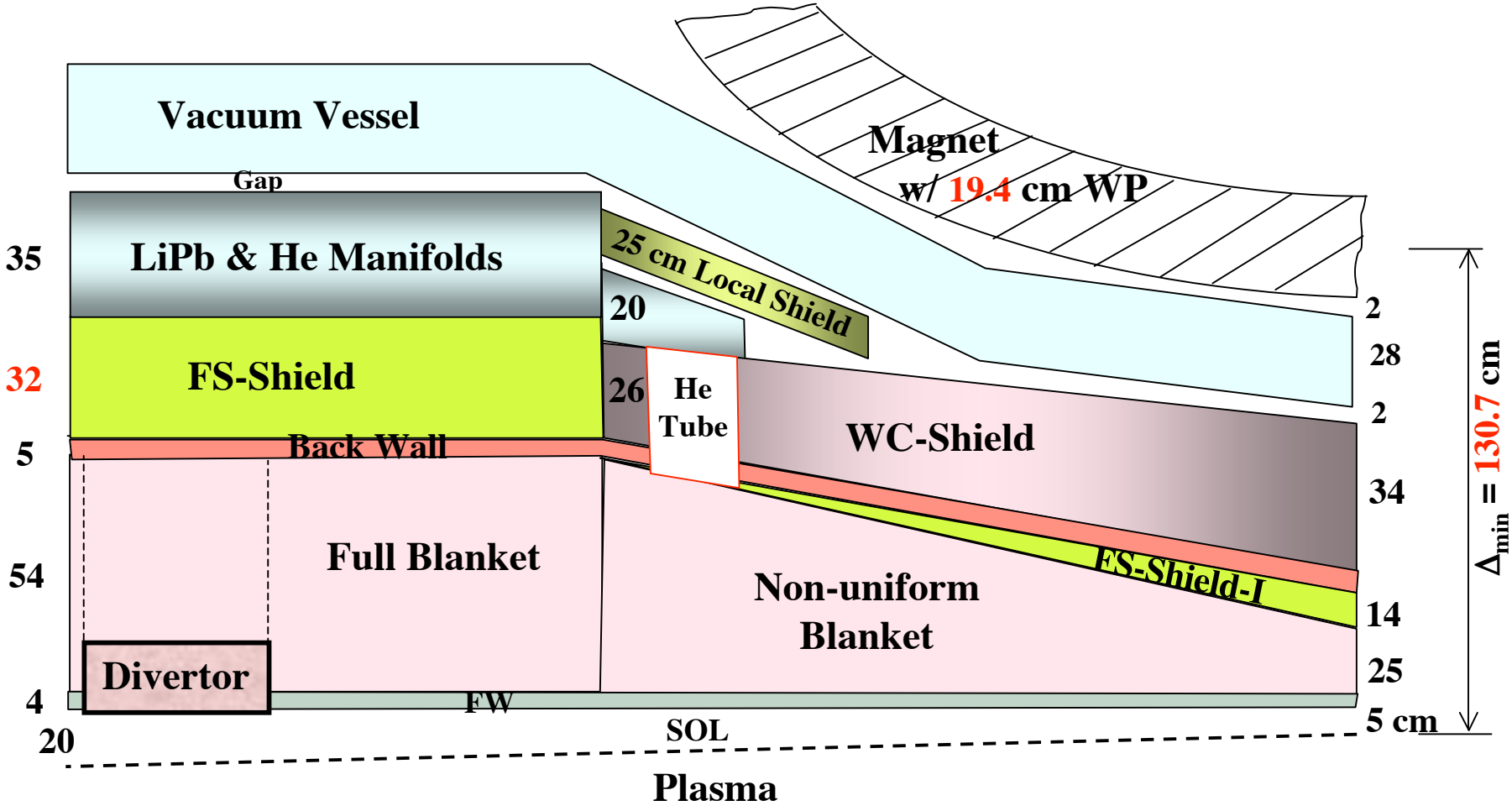
Breeder	Structure	FW/Blanket Coolant	Shield Coolant	VV Coolant
LiPb (reference)	**FS**	**He/LiPb**	**He**	**H_2O**
LiPb (back-up)	**SiC**	**LiPb**	**LiPb**	**H_2O**

- 3 FP configuration
- Major Radius = 7.75 m
- Minor Radius = 1.7 m
- Peak Γ = 5.3 MW/m^2
- Average Γ = 2.6 MW/m^2
- 15% of FW for divertor system
- Internal VV (located inside magnets)
- Port maintenance approach.

Final Radial Build



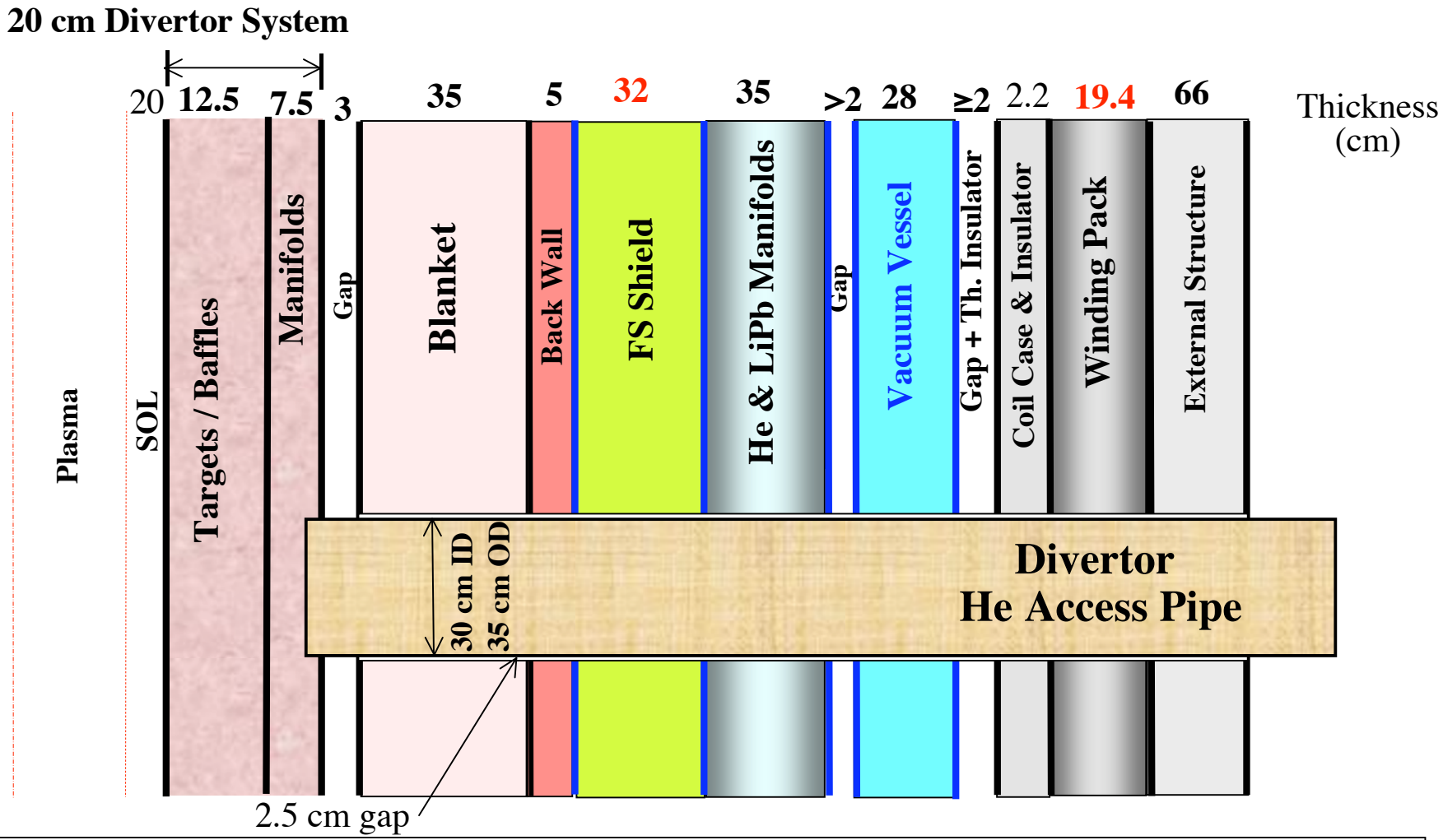
Radial / Toroidal Xn



Full Blanket/shield **and** Divertor
(61%+15%= 76% of FW area)

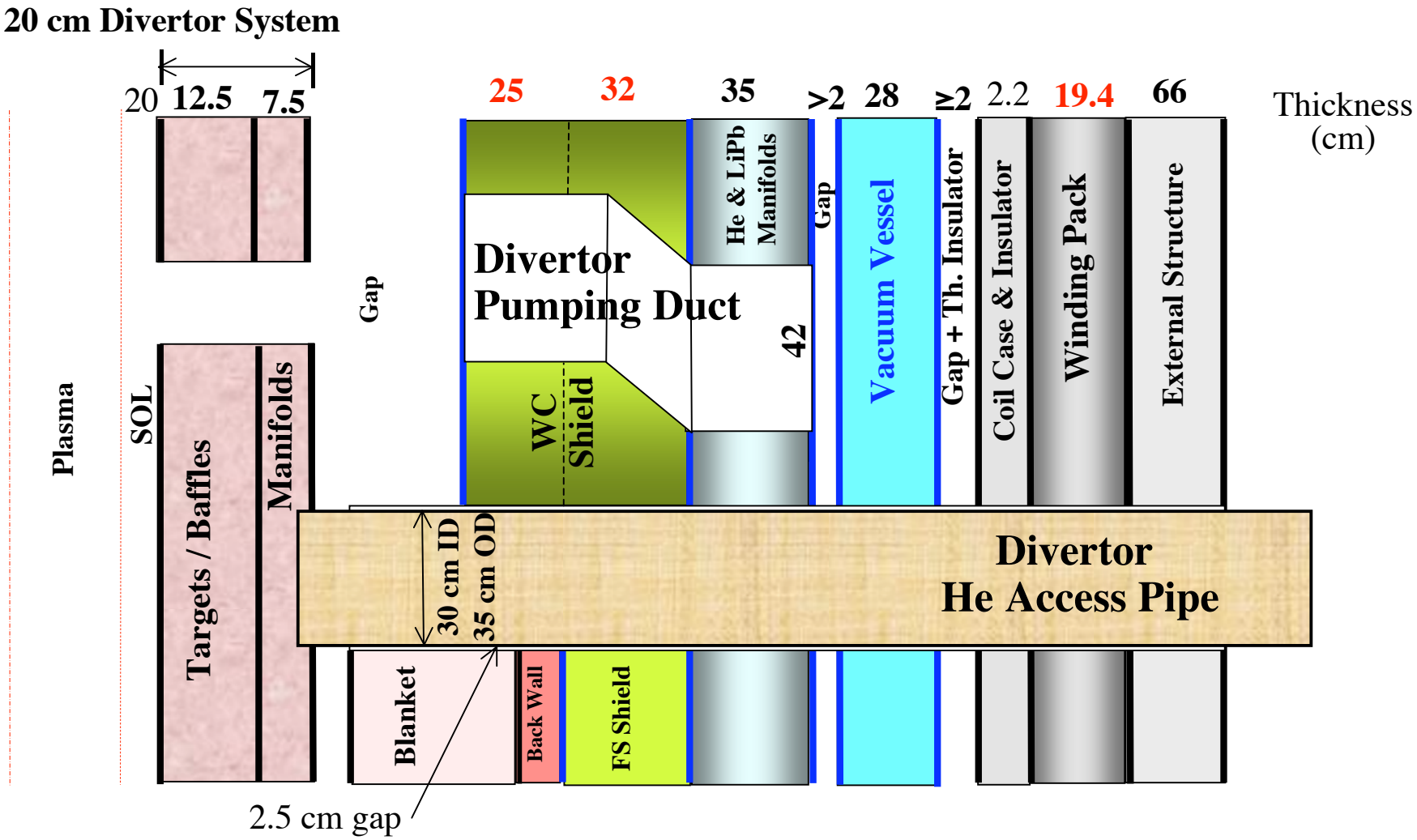
Non-uniform, Tapered Blanket/Shield
(24% of FW area)

Xn Through Divertor System
(He Access Pipe)



Damage at shield/manifolds TBD. Part of shield surrounding pipe needs to be replaceable. Avoid rewelding manifolds and VV close to pipe.

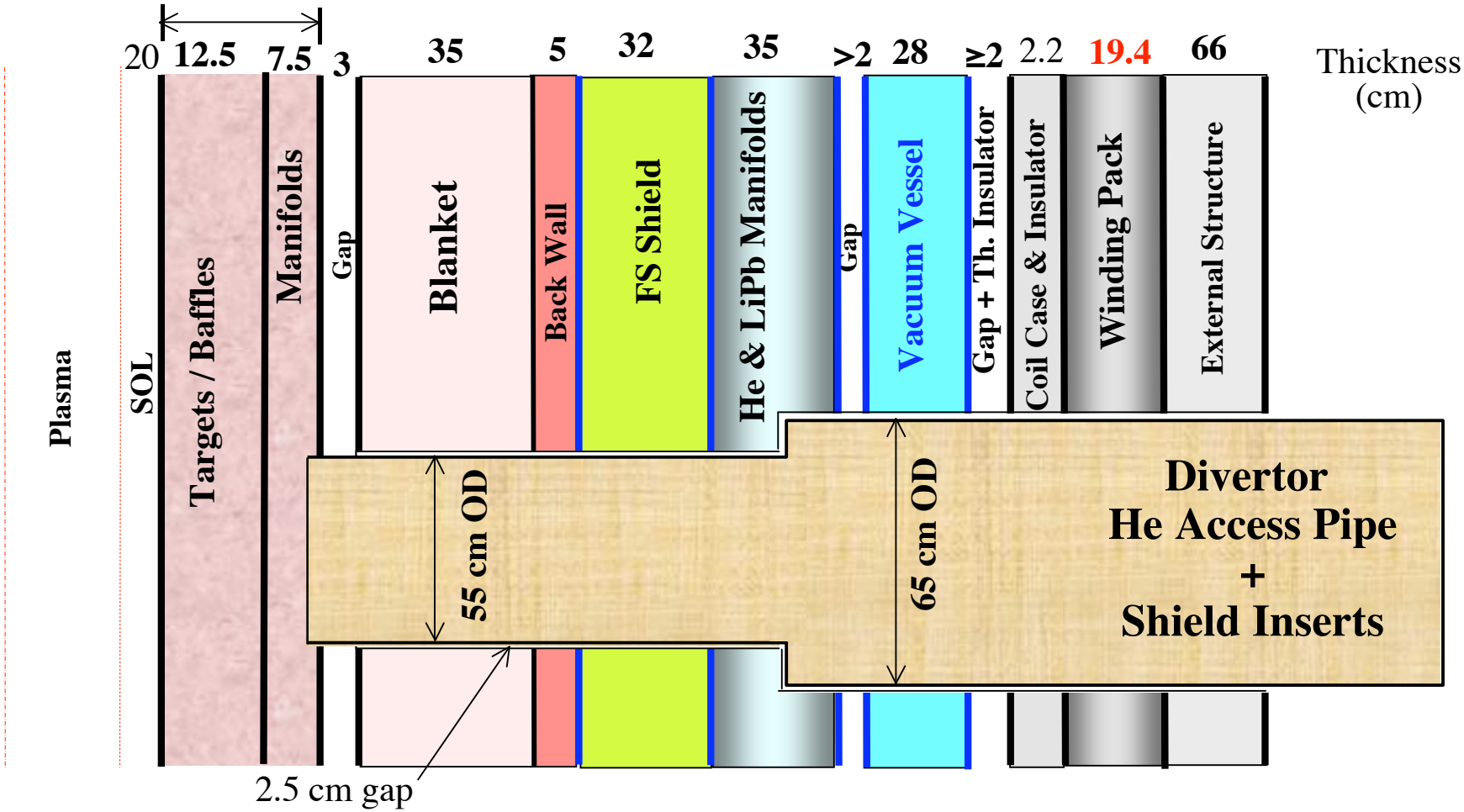
Xn Through Divertor System
(He Access Pipe & Pumping Duct)



Damage at shield/manifolds TBD. Streaming through duct calls for replaceable WC shield and non-reweldable manifolds. Local shield needed to protect VV.

Xn Through Divertor System
(Alternate Design for He Access Pipe)

20 cm Divertor System



Ability of shield inserts to protect shield and manifolds is being assessed.

Compositions and Coverage Fractions
(R= 7.75 m)

Component	Thickness	Coverage Fraction		Composition (vol %)
FW*	3.8 cm	85%	100%	34% FS Structure 66% He Coolant
Divertor System*	20 cm	15%		32.6% FS Structure 4.0% W 63.4% He Coolant
Blanket Behind Divertor*	35 cm	15%	100%	75% LiPb (≤ 90% enriched Li) 9% SiC Inserts 8% FS Structure 8% He Coolant
Non-uniform Blanket*	25 - 54.3 cm	24%		76% LiPb (≤ 90% enriched Li) 8% SiC Inserts 8% FS Structure 8% He Coolant
Full Blanket*	54.3 cm	61%		79% LiPb (≤ 90% enriched Li) 7% SiC Inserts 6% FS Structure 8% He Coolant
Back Wall*	5 cm	100%		80% FS Structure 20% He Coolant
FS Shield	32 cm	76%		15% FS Structure 10% He Coolant 75% Borated Steel Filler
Manifolds	35 cm	80%		52.0% FS Structure 22.7% LiPb (≤ 90% enriched Li) 24.0% He Coolant 1.3% SiC Inserts

* Replaceable component.

Compositions and Coverage Fractions (Cont.)

Component	Thickness	Coverage Fraction	Composition (vol %)
FS Shield-I*	0 -14 cm	24%	15% FS Structure 10% He Coolant 75% Borated Steel Filler
WC Shield	26 - 34 cm	24%	15% FS Structure 10% He Coolant 75% WC Filler
Vacuum Vessel	28 cm	100%	28% FS Structure 49% Water 23% Borated Steel Filler
Inner Coil Case (in front of WPs only)	2 cm	28%	95% JK2LB Structure 5% LHe Coolant
Winding Pack @ 4K	19.4 cm	28%	18.5% JK2LB Structure 48.2% Cu 12.8% Nb_3Sn 10.0% Insulator 10.5% LHe Coolant
Strong Back (behind WPs only)	28 cm	28%	95% JK2LB Structure 5% LHe Coolant
Intercoil Structure (between WPs)	20 cm#	72%	95% JK2LB Structure 5% LHe Coolant
Cryostat	5 cm	100%	100% 304-SS Structure

100%

* Replaceable component.

~16 cm for outboard and ~28 cm for inboard, per Xueren.

Key Parameters

Δ_{min}	**1.3 m**
Overall TBR	**~ 1.1#**
Li-6 Enrichment	**≤ 90%#**
Overall Energy Multiplication	**~ 1.155***
He : LiPb Power Ratio	**~ 48 : 52***
FW EOL Fluence	**15.7 MWy/m^2** (for FS)
FW/Blanket/Divertor Lifetime	**~ 3 FPY** (for 5.3 MW/m^2 peak Γ)
Plant Lifetime	**40 FPY**
System Availability	**~ 85%**

To be confirmed with 3-D analysis.

* To be updated.

Design Requirements

Overall TBR (for T self-sufficiency)	1.1	
Damage to FS Structure	200	dpa
Helium Production @ Manifolds and VV (for reweldability of FS)	1	appm
S/C Magnet (@ 4 K):		
Peak fast n **fluence** to Nb_3Sn ($E_n > 0.1$ MeV)	10^{19}	n/cm^2
Peak nuclear **heating**	2	mW/cm^3
Peak **dpa** to Cu stabilizer	$6x10^{-3}$	dpa
Peak **dose** to electric insulator	10^{11}	rads

FS Structure

Composition: Modified F82H Ferritic Steel (8Cr-2WVTaC)
Reference: R. Klueh et al., Impurity effects on reduced-activation ferritic steels developed for fusion applications Journal of Nuclear Materials 280 (2000) 353-359.
Density: ~7.89 g/cm^3

	wt%
C	0.1
Al	14e-4
V	0.2
Cr	7.5
Fe	90.11586
Co	28e-4
Ni	474e-4
Cu	100e-4
Nb	3.3e-4
Mo	21e-4
Pd	0.05e-4
Ag	0.1e-4
Cd	0.4e-4
Ta	0.02
W	2.0
Os	0.05e-4
Ir	0.05e-4
Bi	0.2e-4
Eu	0.05e-4
Tb	0.02e-4
Dy	0.05e-4
Ho	0.05e-4
Er	0.05e-4
U	0.05e-4

SiC/SiC Composites

Based on: SUPERSiC (r)
Reference: S. Sharafat, IPFR/UCLA, ARIES Study: Materials, Sept. 1993, pg 3.
Density: 3.217 g/cm^3 (64th CRC Handbook of Chemistry and Physics B-135).

	wt %		**wt %**
C	29.95	Ag	0.002e-4
Na	0.050e-4	Cd	0.004e-4
Si	70.05	In	0.001e-4
K	0.180e-4	Sn	0.076e-4
Sc	0.013e-4	Sb	0.001e-4
Cr	0.017e-4	Cs	0.001e-4
Fe	0.440e-4	Ba	0.047e-4
Co	0.013e-4	La	0.018e-4
Ni	0.074e-4	Eu	0.001e-4
Cu	0.048e-4	Tb	0.001e-4
Zn	0.043e-4	Vb	0.001e-4
Ga	0.005e-4	Hf	0.001e-4
As	0.003e-4	Ta	0.001e-4
Se	0.001e-4	W	0.032e-4
Br	0.001e-4	Ir	0.001e-4
Rb	0.001e-4	Pt	0.542e-4
Sr	0.012e-4	Hg	0.001e-4
Zr	0.236e-4	Th	0.001e-4
Mo	0.041e-4	U	0.001e-4

LiPb Breeder

Reference: S. Malang & K. Schleisiek, "Dual Coolant Blanket Concept", KFK5424, Karlsruhe, Nov 1994.

Density: 9 g/cm^3 @ 580 ^{o}C

	wt %
Pb	99.29
Li*	0.7
Zn	10e-4
Fe	10e-4
Bi	43e-4
Cd	5e-4
Ag	5e-4
Sn	5e-4
Ni	2e-4

* < 90% Li-6 enrichment. TBD.

JK2LB Steel

Reference: ITER magnet structure.
P. Heizenroeder and R. Reed "Comments on Selection of U.S. ITER CS Coil Jacket Material" (9/12/2005)

Density: 8.0 g/cm^3

	wt%
B	0.002
C	0.02
N	0.2
Si	0.3
P	0.004
S	0.004
Cr	13
Mn	21
Fe	55.47
Ni	9
Mo	1