Shielding Requirements for Flibe/SiC Blanket with Magnetic Intervention

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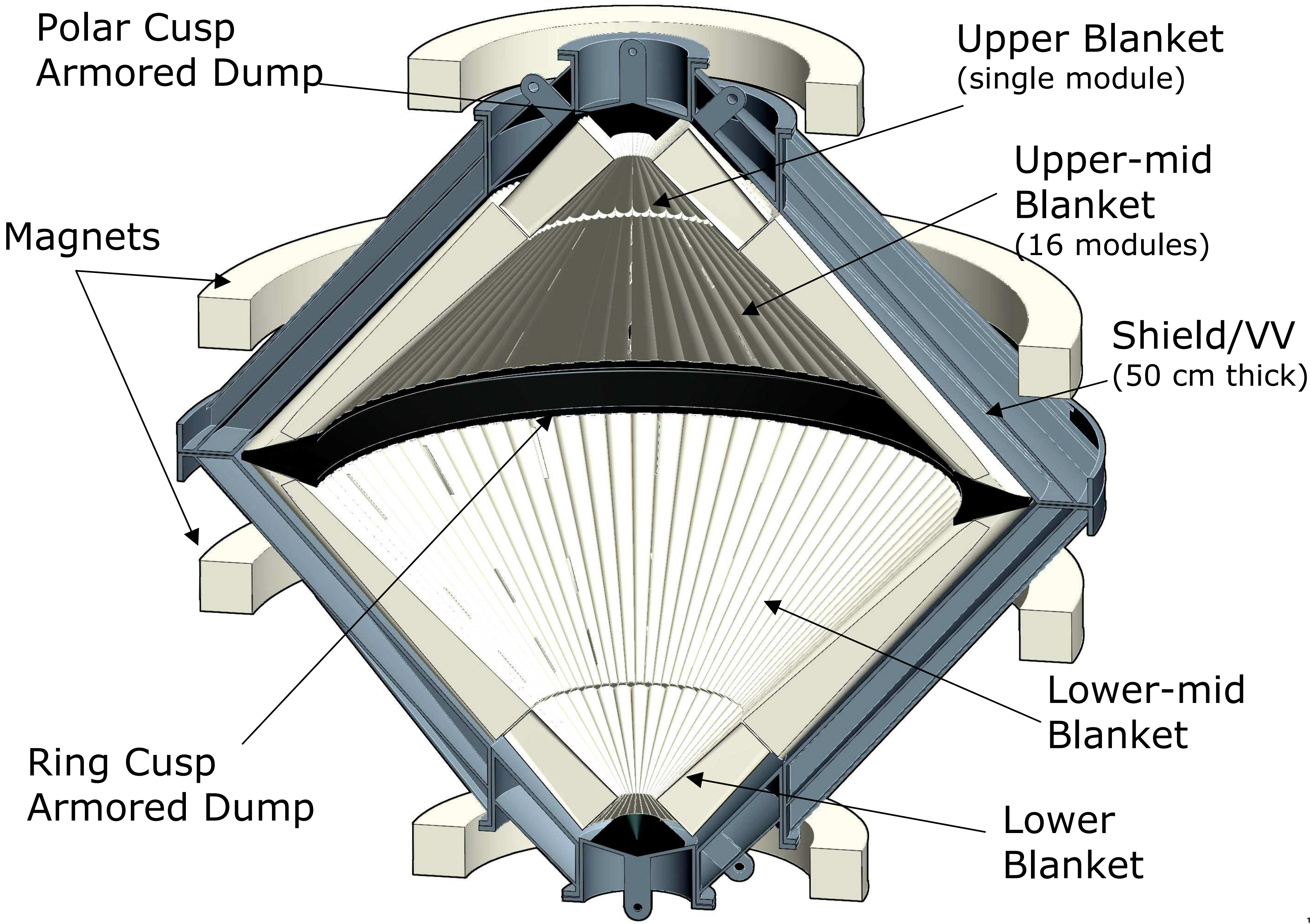
Chamber Configuration



Design Requirements for SS/water Shield

End-of-life (40 FPY) peak He production at back of shield/VV <1 He appm to allow for rewelding

Peak fast neutron fluence in magnets is limited to 10^{19} n/cm^2 (E>0.1 MeV) due to degradation in J_c of superconductor

Peak dose in magnet insulator is limited to 10^{10} Rads due to degradation of mechanical properties

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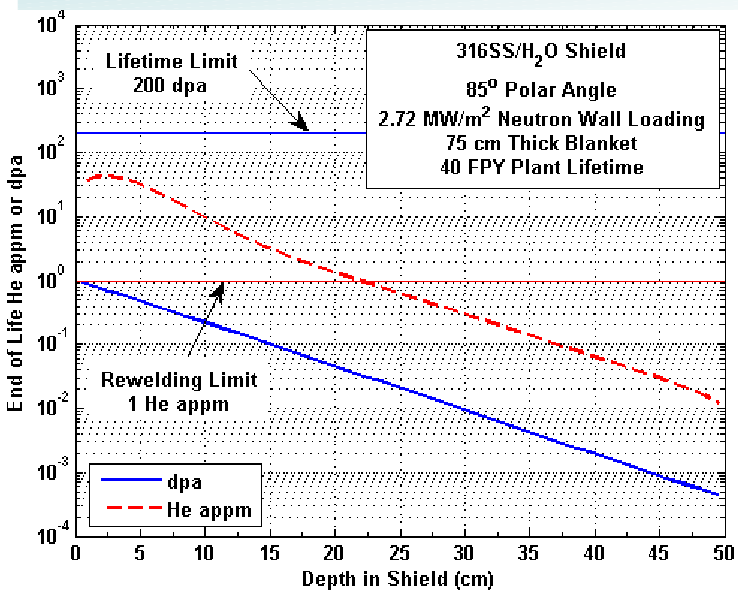
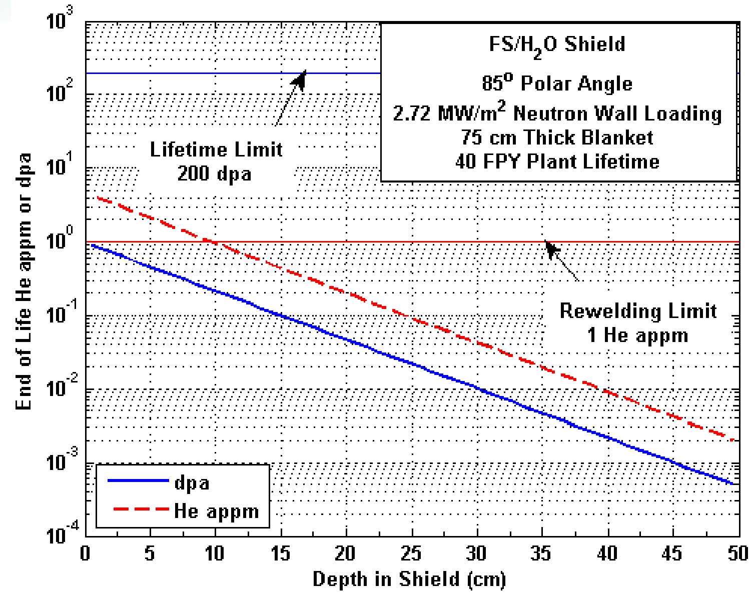
Radiation Damage in Shield

A 50 cm thick steel (316SS or FS) shield that doubles as VV is used with 25% water cooling

Largest damage occurs at location with thinnest blanket





Peak end-of-life radiation damage in shield is only ~1 dpa ⇒ lifetime component

He production in 316SS shield is ~ an order of magnitude higher than in FS

Back of the shield/VV is reweldable

If FS is used rewelding is possible at locations at least 10 cm deep in shield. If 316SS is used rewelding is possible at locations at least 20 cm deep in shield

Peak Damage Parameters in Superconducting Cusp Coils

	45° polar angle FS shield	45° polar angle 316SS shield	85° polar angle FS shield	85° polar angle 316SS shield	**Radiation limit**
End of life fast neutron fluence (n/cm^2)	3.63x 10^{17}	2.82x 10^{17}	**7.93x 10^{17}**	6.20x 10^{17}	**10^{19}**
End of life insulator dose (Rads)	6.77x 10^{8}	5.44x 10^{8}	**1.14x 10^{9}**	1.14x 10^{9}	**10^{10}**
Peak power density (mW/cm^3)	0.027	0.022	**0.054**	0.044	**1**

316SS shield provides slightly better magnet shielding

The cusp coils are well protected with the 50 cm shield (either FS or 316SS)

No restriction on location of the coils

Can We Have Personnel Access For Maintenance Behind Shield/VV?

Hands-on access for maintenance behind the shield/VV is not a requirement (only remote handling)

In ITER the limited time hands-on criterion adopted is 100 microSv/h (10 mrem/h) two weeks after shutdown. This roughly corresponds to ~3×10^6 n/cm^2.s fast neutron flux

Fast neutron flux behind 50 cm shield/VV is 5×10^8 n/cm^{2}s

Using 80 cm shield/VV results in fast neutron flux of 10^6 n/cm^{2}s behind it with possible hands-on maintenance

However:

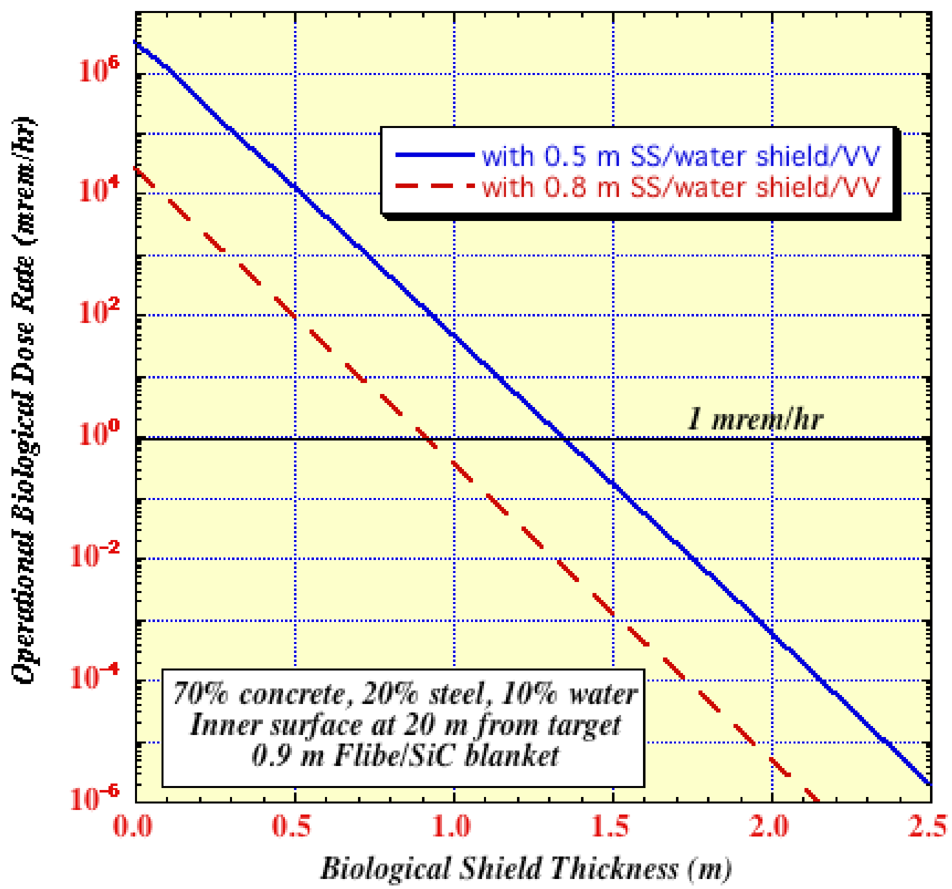
- Activation of thin beam duct could restrict access
- Need to move magnets farther from chamber

Required Biological Shield

Biological dose rate during operation behind the 50 cm shield/VV is 1.5×10^7 mrem/hr (1.2×10^5 for 80 cm shield/VV)

A biological shield is required to allow operational personnel access

A biological shield (containment building) made of 70% concrete, 20% carbon steel C1020, 10% water used with inner surface at 20 m from target

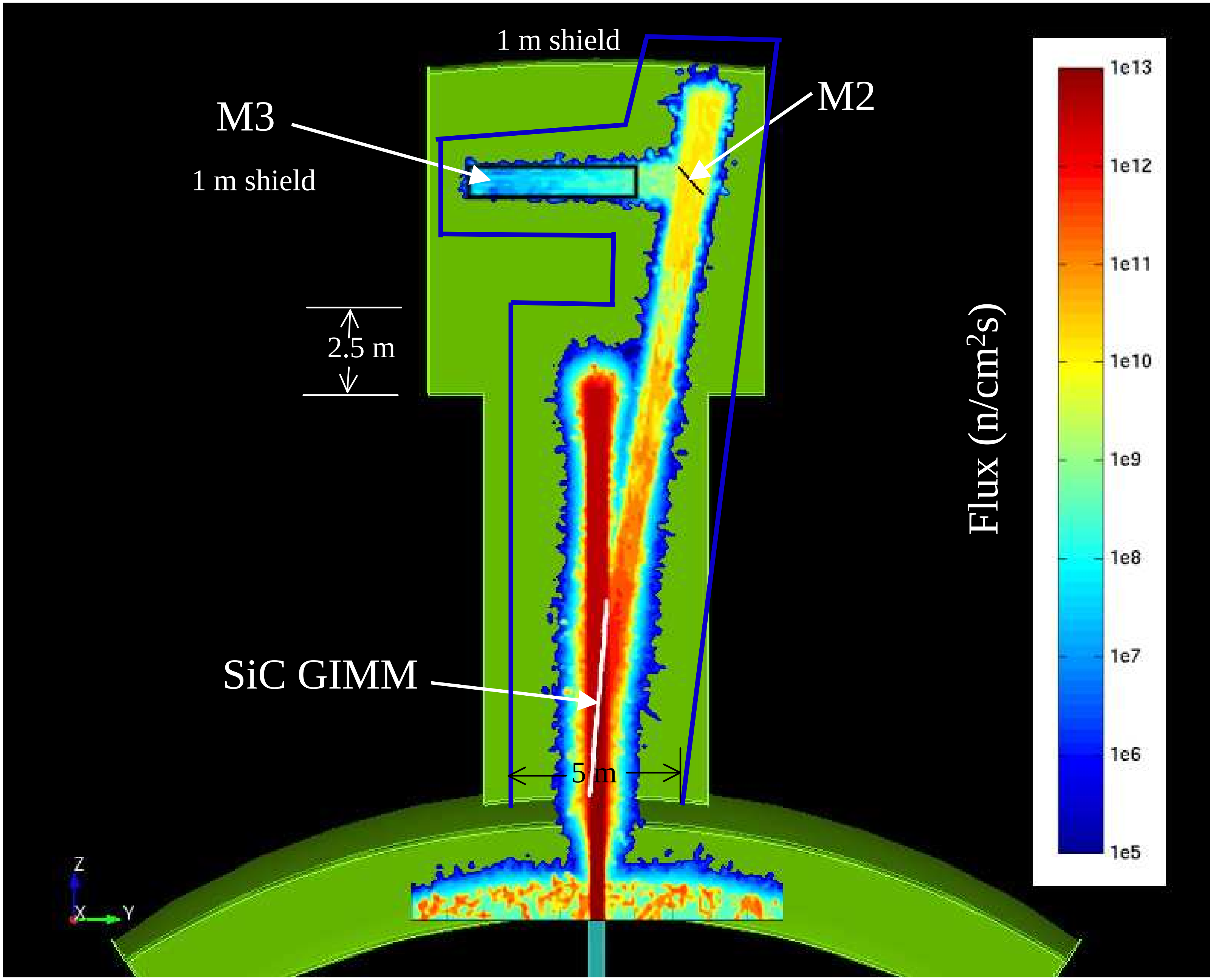


~1.5 thick biological shield is required behind the blanket and shield/VV to allow personnel access outside containment building during operation

Bio-shield required is only ~1m with 80 cm shield/VV

~2.5 m thick concrete is required behind the beam ports to shield personnel from streaming neutrons

Proposed Shield Modification at Final Optics of HAPL



Acceptable operational dose rate of 1 mrem/h corresponds to ~10 n/cm^2s fast neutron flux

~25 cm of concrete shield gives an order of magnitude flux attenuation

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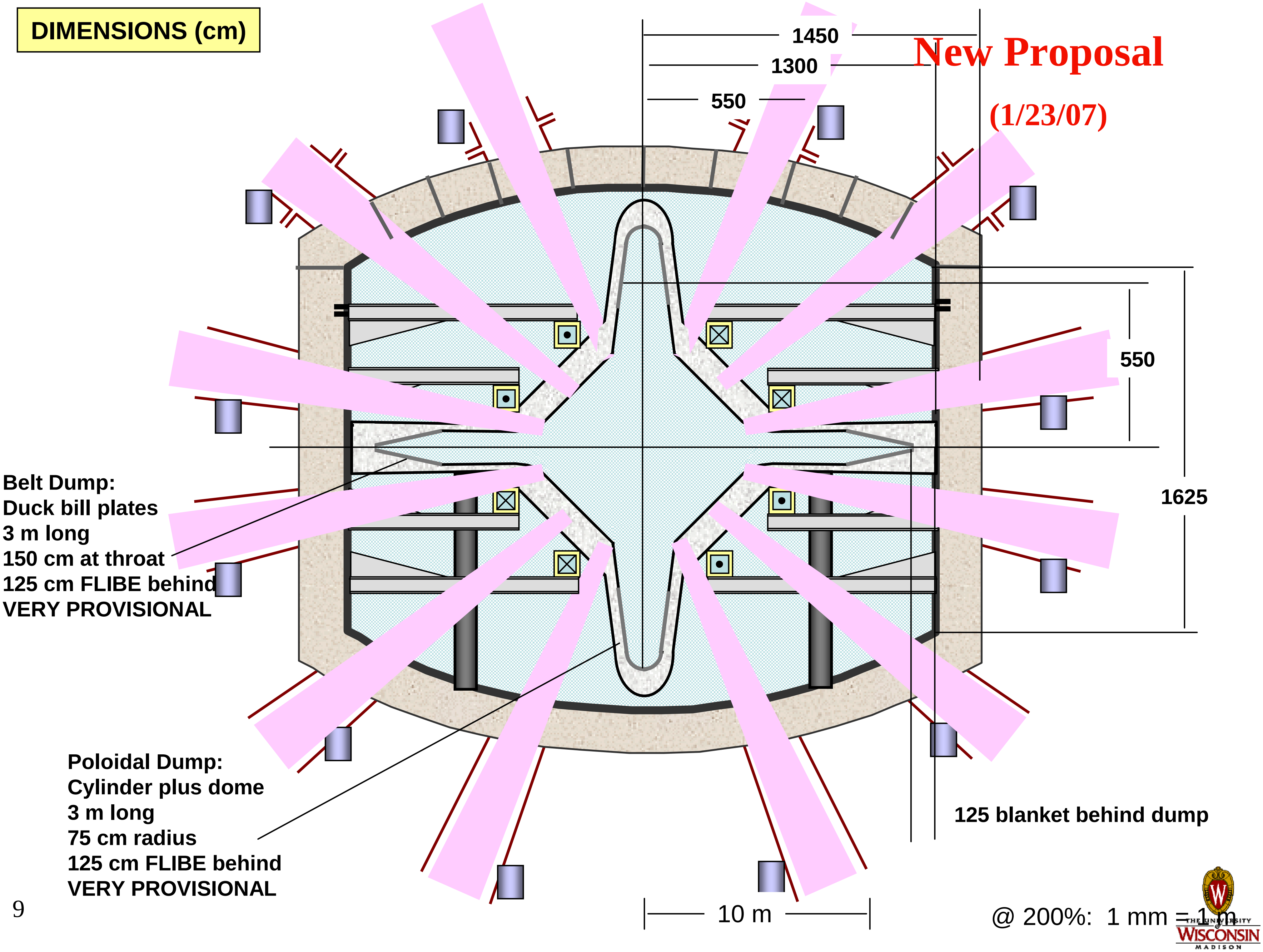
DIMENSIONS (cm)
1450
1300
550
New Proposal
(1/23/07)
550
1625
Belt Dump:
Duck bill plates
3 m long
150 cm at throat
125 cm FLIBE behind
VERY PROVISIONAL
Poloidal Dump:
Cylinder plus dome
3 m long
75 cm radius
125 cm FLIBE behind
VERY PROVISIONAL
125 blanket behind dump
10 m
@ 200%: 1 mm = 1 m

Main Proposed Dimensions

- 125 cm Flibe/SiC blanket (assumed uniform)
- 20 cm SS/water magnet shield
- 10 cm SS/water VV
- 150 cm concrete bio-shield

Expected Nuclear Environment and Relation to Design Requirements

- Local TBR in blanket 1.205

  ⇒ OK

- Peak radiation levels in magnets
  - fast neutron fluence 4.3×10^{17} n/cm^2
  - insulator dose 2.4×10^{9} Rads

  ⇒ OK

- Peak He production in VV
  - 316SS 0.6 appm
  - FS 0.02 appm

  ⇒ OK

- Operational dose rate behind bio-shield 8.3 mrem/h

  ⇒ 1.8 m bio-shield needed