Neutronics Issues for Final Optics of HAPL

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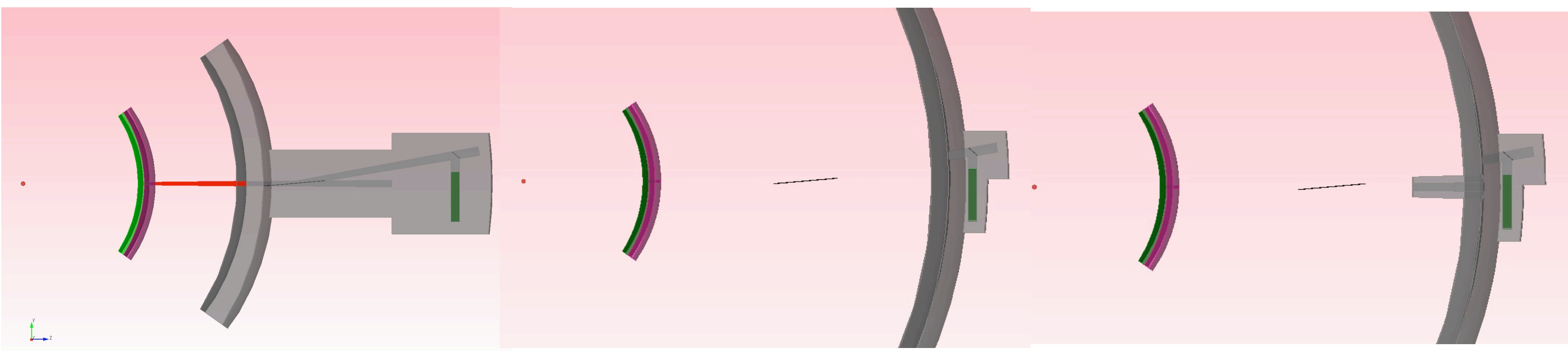
HAPL Final Optics Issues Addressed

- Determine nuclear environment at steel vacuum vessel lining the final optics ducts as well as possible steel support for GIMM
- Assess impact of shielding configuration options on nuclear environment at final optics



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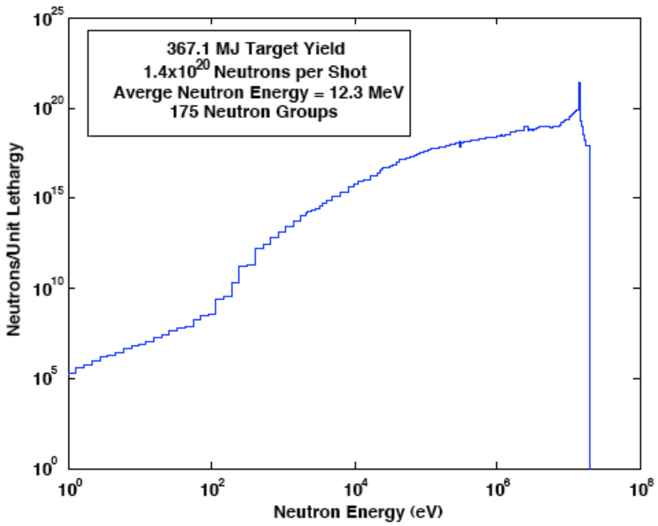
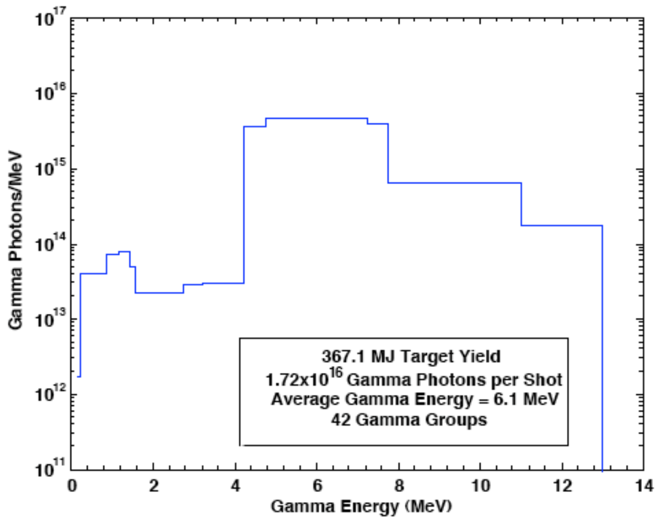
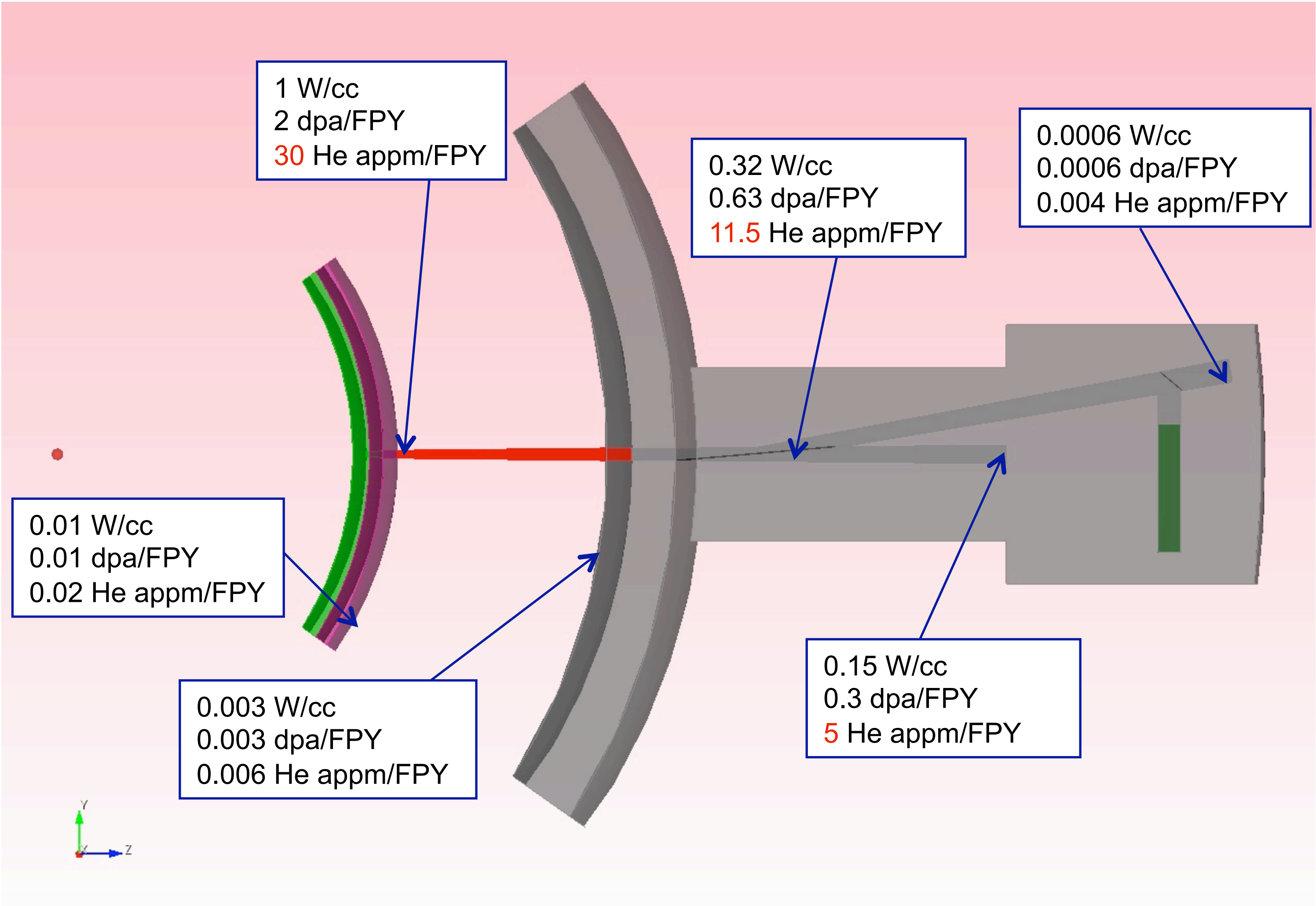
Design Parameters Used in Analysis

Target yield	367.1 MJ
Rep Rate	5 Hz
Fusion power	1836 MW
Chamber inner radius	10.75 m
Thickness of Li/FS blanket	0.6 m
Thickness of SS/B_4C/He shield	0.5 m
Chamber outer radius	11.85 m
GIMM angle of incidence	85°
GIMM distance from target	24 m





Nuclear Environment at SS VV Lining Beam Duct and Possible GIMM Support



Observations on Nuclear Environment Results at SS VV

- All steel lining the laser beam ducts will survive the full 40 FPY plant lifetime with total cumulative damage << 200 dpa
- For a 1 He appm rewelding limit, rewelding will not be possible for the SS vacuum vessel lining the beam ducts except at
  - Steel lining of the duct around the focusing and turning mirrors

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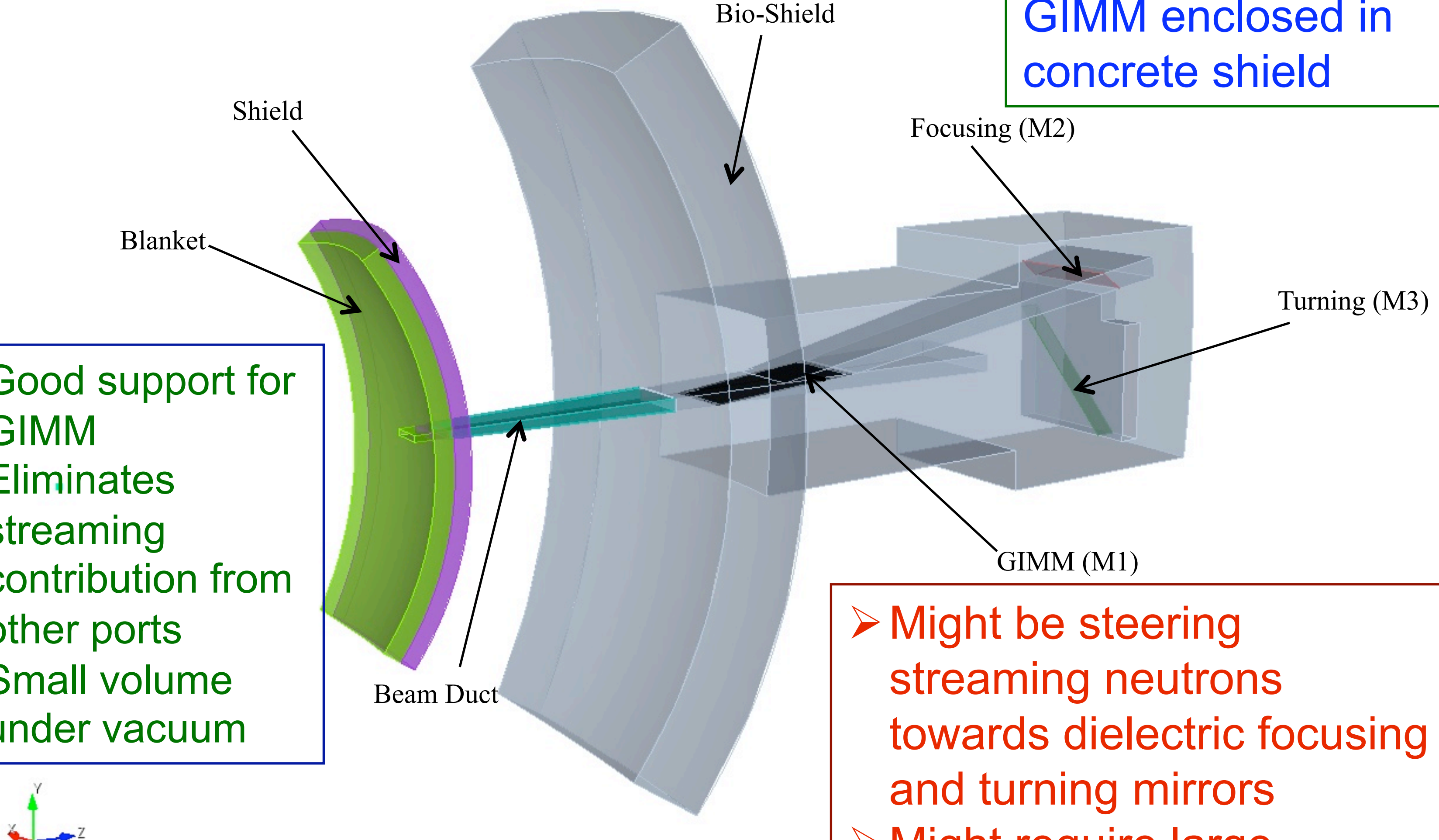
Shielding Configuration Options Assessed

Option I:

All optics including GIMM enclosed in concrete shield



- Good support for GIMM
- Eliminates streaming contribution from other ports
- Small volume under vacuum

- Might be steering streaming neutrons towards dielectric focusing and turning mirrors
- Might require large amount of concrete

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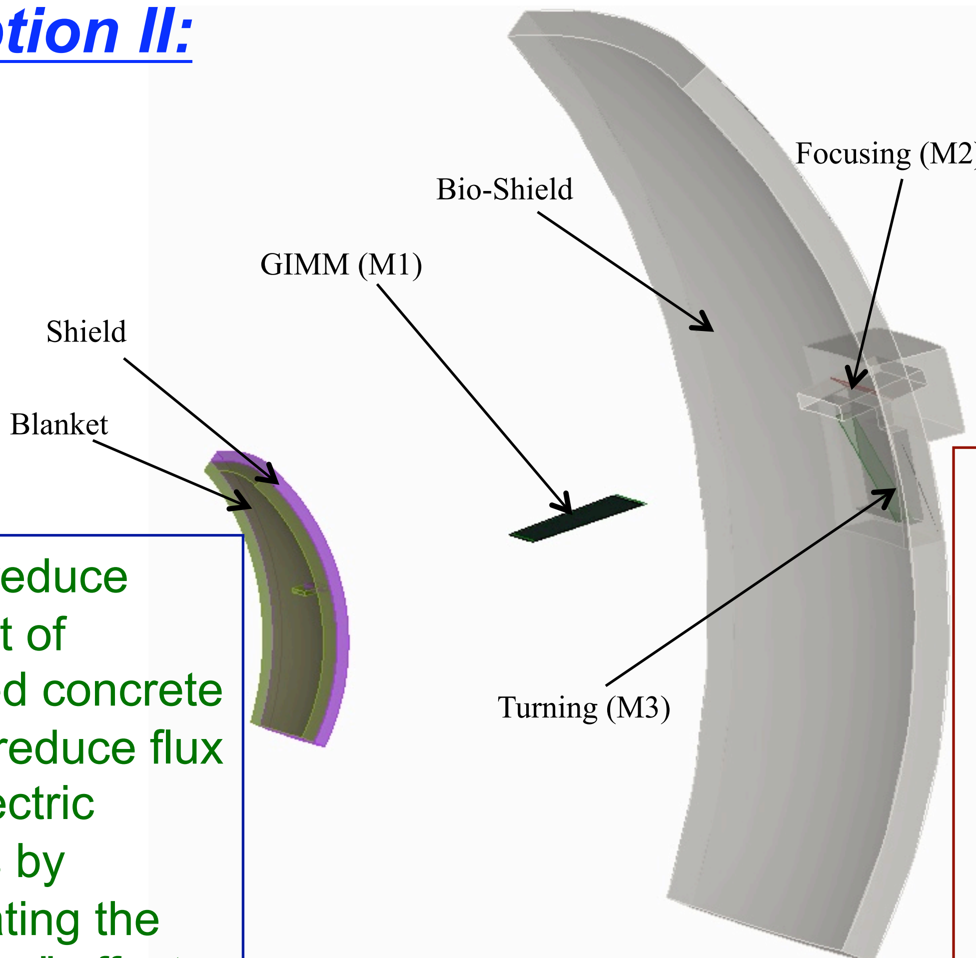
Shielding Configuration Options Assessed

Option II:



Only focusing and turning mirrors enclosed in concrete shield with GIMM left in open space between chamber and larger containment building

- Might reduce amount of required concrete
- Could reduce flux at dielectric mirrors by eliminating the "steering" effect in long duct

- GIMM support is challenging
- Large volume between chamber and containment building should be maintained under vacuum (could be reduced by using steel beam duct between chamber and bio-shield)
- Possible large contribution from neutrons streaming through other ports

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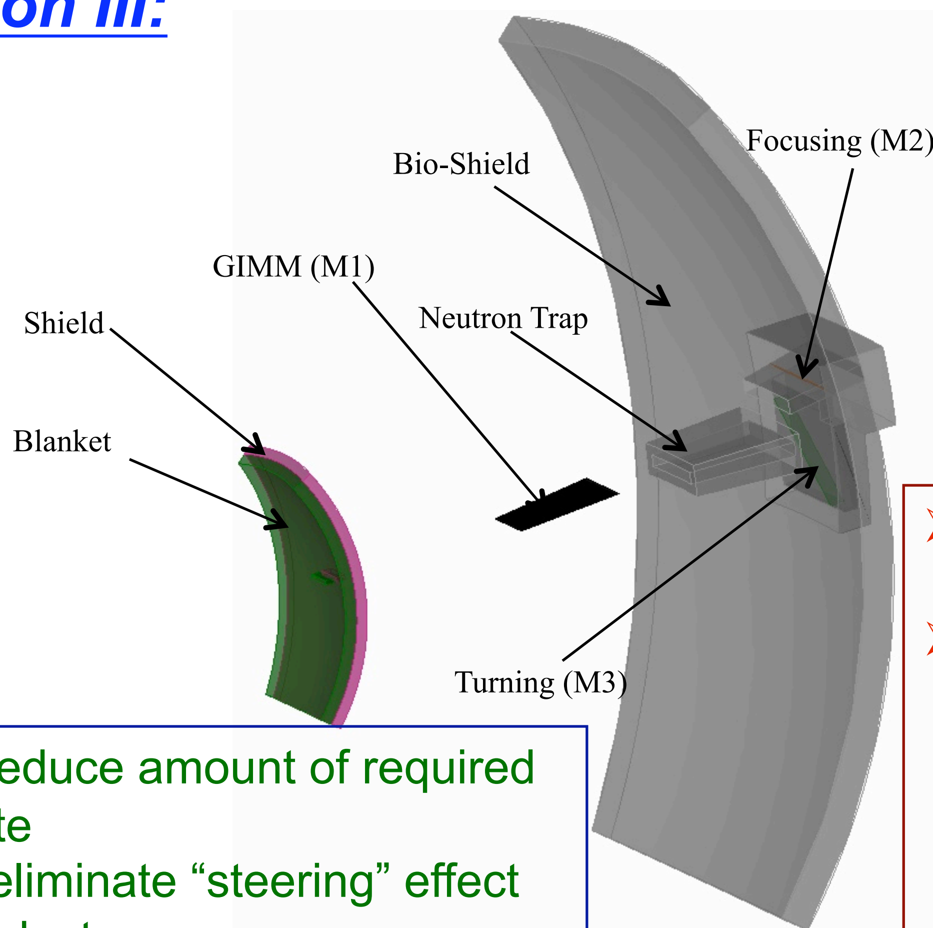
Shielding Configuration Options Assessed

Option III:



Only focusing and turning mirrors enclosed in concrete shield with neutron trap added at inner surface of containment building behind GIMM

- GIMM support is challenging
- Large volume between chamber and containment building should be maintained under vacuum (could be reduced by using steel beam duct between chamber and bio-shield)

- Might reduce amount of required concrete
- Could eliminate "steering" effect in long duct
- Neutron traps reduce contribution from neutrons streaming through other ports

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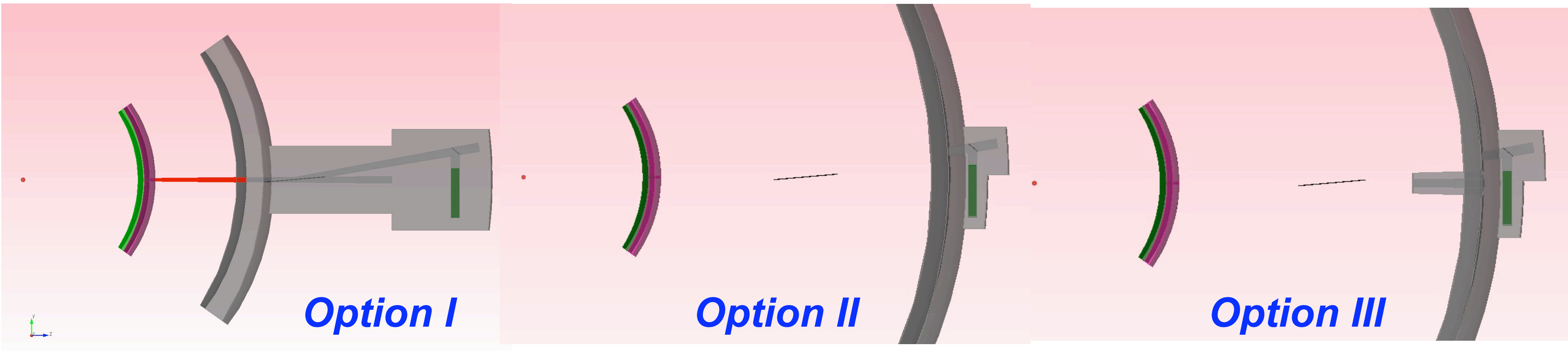
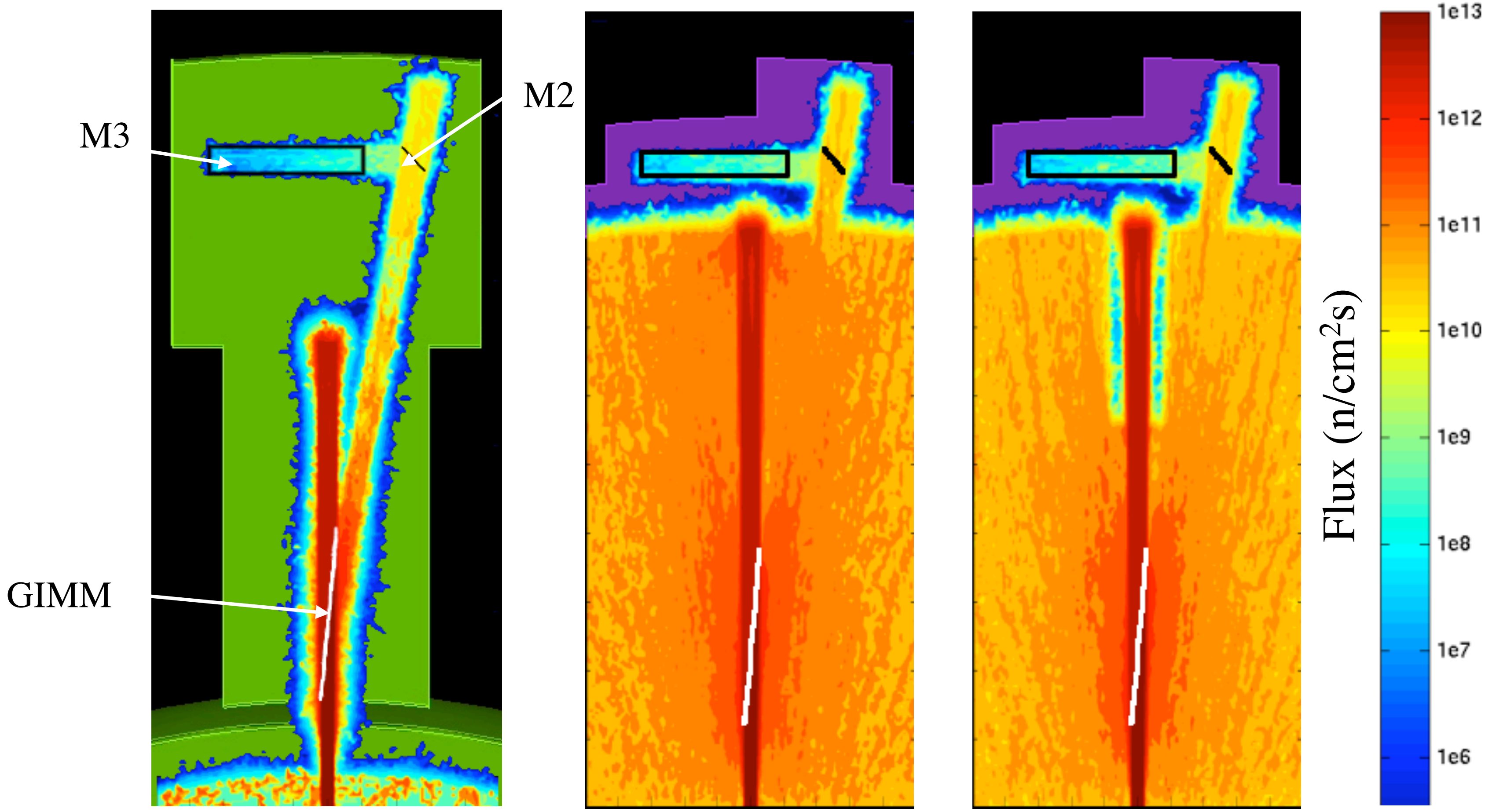
Fast Neutron Flux at Final Optics with Different Shielding Configuration Options



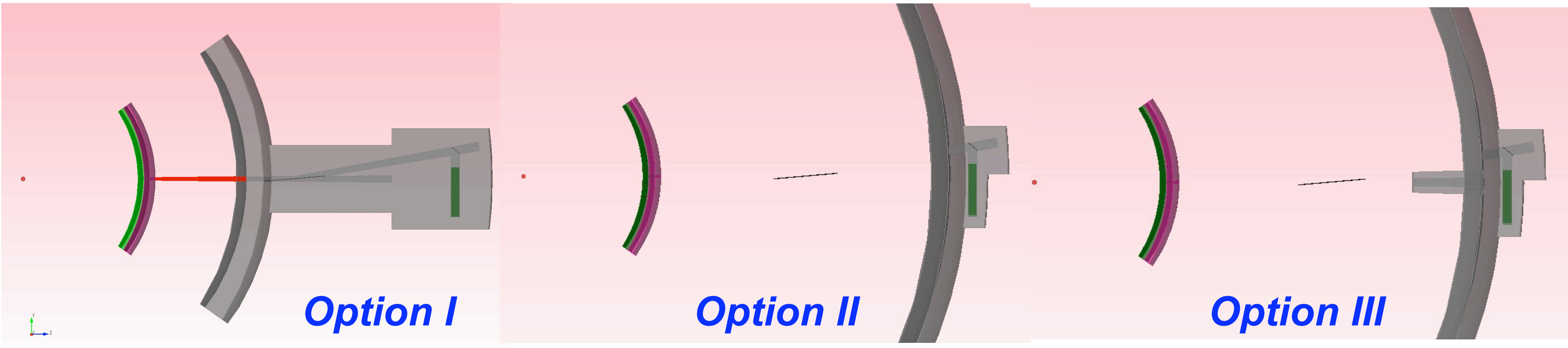
	Peak Fast Neutron Flux (n/cm^2s)		
	Option I	Option II	Option III
GIMM	1.39×10^{13}	1.37×10^{13}	1.37×10^{13}
Focusing Mirror	2.36×10^{10}	4.27×10^{10}	4.03×10^{10}
Turning Mirror	3.18×10^{8}	4.30×10^{8}	8.32×10^{8}

Fast Neutron Flux Distribution in Final Optics of HAPL



Option I ***Option II*** ***Option III***

Dominating Effect for Fast Flux Level at Focusing Mirror

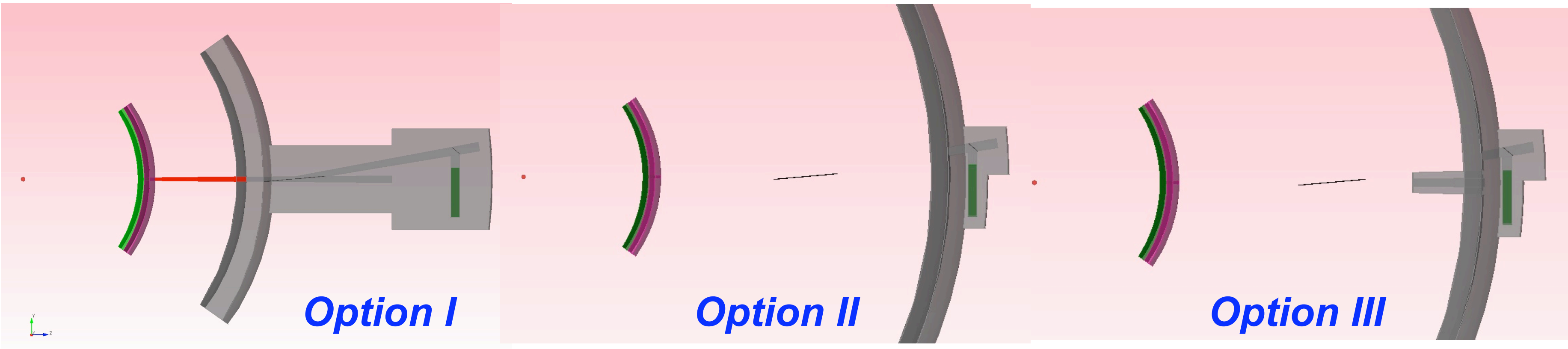


Which of these is the dominant effect?

1. "Steering" of streaming neutrons in beam duct of option I
2. Contribution from neutrons streaming through all ports in the "open" configuration of options II and III

- **Results clearly show that dominating effect is enhanced contribution from other ports in the "open" configuration**
- **This is confirmed by comparing results for options I and II that show increased secondary neutron and gamma fluxes at focusing mirror**
  - E<0.1 MeV neutron flux is x4 higher in option II
  - Gamma flux is x3 higher in option II

Preferred Final Optics Shielding Configuration



Preferred configuration is the original Option I where all optics including the GIMM are enclosed in concrete shield

- **Results in lowest radiation levels at the dielectric focusing and turning mirrors**
- **Allows for better GIMM support**
- **Reduces volume inside containment building maintained under vacuum**
- **Requires the least amount of concrete**

Relative amount of concrete: 1, 1.12, and 1.14 for options I, II, and III

Conclusions

- All steel VV lining laser beam ducts will survive the full 40 FPY plant lifetime
- Rewelding will not be possible for SS VV lining of beam ducts except around the focusing and turning mirrors
- Original shielding configuration with all optics including GIMM enclosed in concrete shield is the preferred option since it yields lowest flux at dielectric mirrors, provides better GIMM support, reduces volume under vacuum, and requires least amount of concrete

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