Radiation Environment at Final Optics of Small Materials Test Facility

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Objective and Approach

Objective:

Provide preliminary estimate of nuclear environment at the final optics

Previous 3-D neutronics calculations performed for final optics

SIRIUS-P with KrF laser and Aluminum GIMM

[M. Sawan, "Three-Dimensional Neutronics Analysis for the Final Optics of the Laser Fusion Power Reactor SIRIUS-P," Proc. IEEE 16th Symposium on Fusion Engineering, Champaign, IL, Sept. 30- Oct. 5 1995, IEEE Cat. No. 95CH35852, Vol. 1, pp. 29]

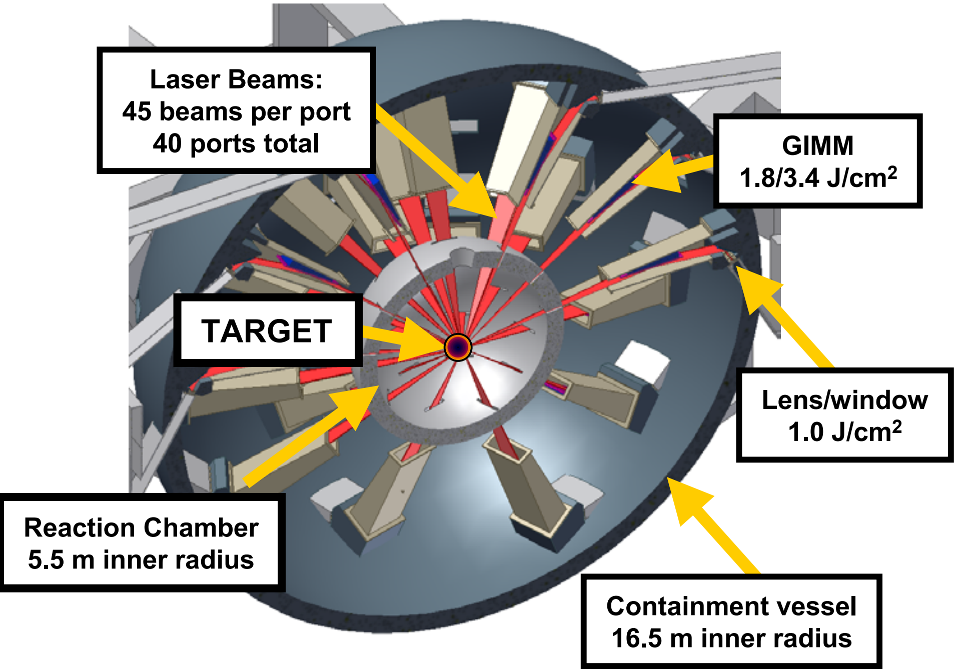
Modified version of SOMBRERO with DPSSL and fused silica transmissive wedges

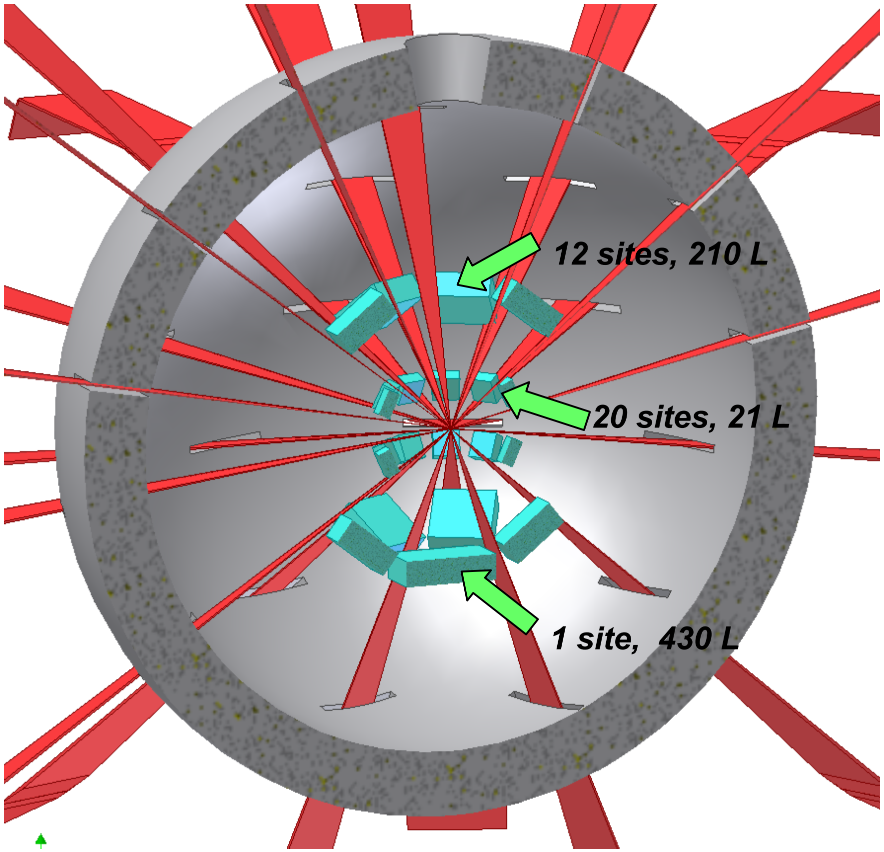
[S. Reyes, J. Latkowski, and W. Meier, "Radiation Damage and Waste Management Options for the SOMBRERO Final Focus System and Neutron Dumps", UCRL-JC-134829, August 1999]

- Results and conclusions of both studies were consistent
- A preliminary estimate of nuclear environment at final optics of small materials test facility will be determined by scaling from results of SIRIUS-P

Design Parameters for the Small Materials Test Facility

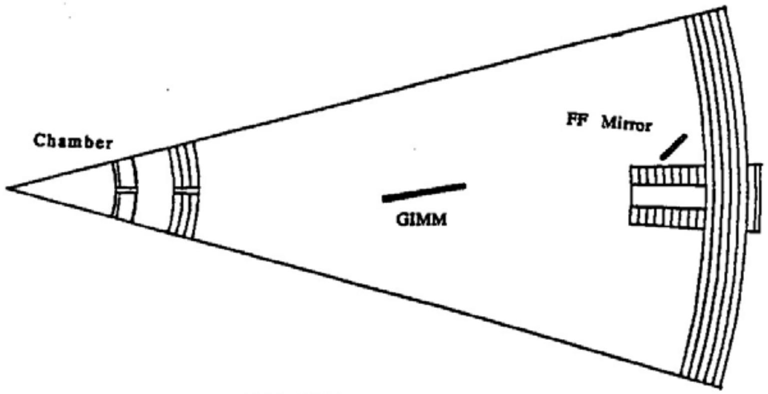
Laser energy:	250 - 500 kJ
Fusion power:	30 -150 MW
Rep Rate:	5 Hz
Energy partionning	2% x-rays, 28% ions, 70 % neutrons
Chamber radius	5.5 m
NWL @ FW	0.055 - 0.28 MW/m^2





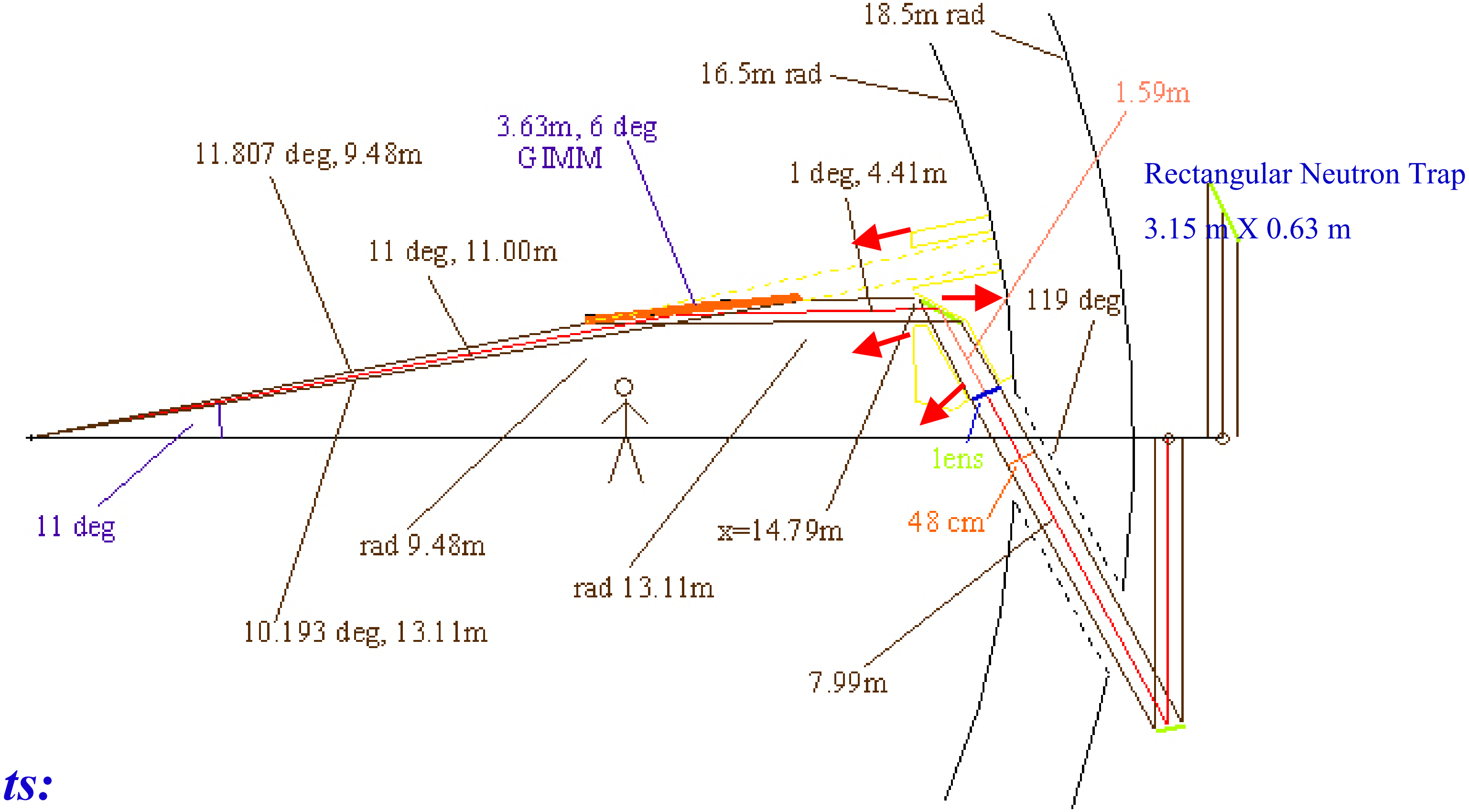
Conclusions from Previous Analysis of SIRIUS-P

2444 MW fusion power
Containment building @ R = 42 m
GIMM @ 25 m and FF mirror @ 40 m
Trap diameter 1.3 m and depth 4 m
Thicker shield (3.3 m) behind neutron trap



- Fast neutron flux at GIMM is contributed mostly by direct source neutrons
- Direct source neutron scattering by the GIMM result in increasing the neutron flux at the dielectric coated FF mirror by a factor of ~2. To reduce that use materials with low densities and low scattering cross sections
- Using neutron traps behind the GIMM in the direct line-of-sight of source neutrons significantly reduces the flux at the FF mirror. The lifetime of the FF mirror can be increased by about an order of magnitude with a neutron trap with aspect ratio (depth divided by diameter) of ~3. Largest lifetime is obtained when FF mirror is placed as close as possible to the containment wall
- Sides of neutron trap should be inclined along the line-of-sight of direct source neutrons to have all source neutrons impinging at the bottom of trap with reduced chance of secondary neutrons scattering back from the trap
- Lining the neutron trap and beam ducts by a strong neutron absorber (e.g. Boral) can help reduce neutron flux at mirrors, lens, and windows

Arrangement of Final Optics in Small Materials Test Facility



Comments:

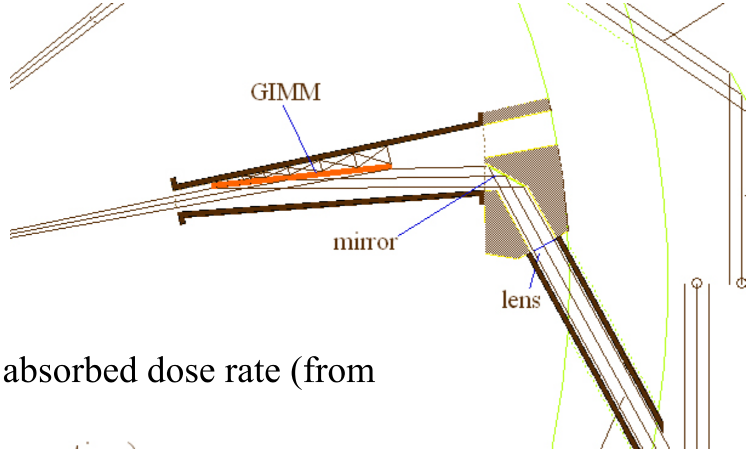
- Use as thin as possible GIMM with minimal support structure to reduce neutron scattering
- Place FF dielectric mirror as close as possible to containment wall
- Increase depth of neutron trap as much as feasible
- Reduce bend angle of beam at FF mirror

Preliminary Estimate of Nuclear Environment at Final Optics of Small Materials Test Facility

Fusion power (MW)	150
GIMM radial location (m)	9.5
Fast neutron (E>0.1 MeV) flux @ GIMM (n/cm^2s)	$4.9x10^{12}$ (only 4% from secondary neutrons)
Lifetime for 10^{20} n/cm^2 fast neutron fluence limit	0.65 FPY (No annealing) 3.25 FPY (80% recovery with annealing) 6.5 FPY (90% recovery with annealing)
Radial location of dielectric FF mirror (m)	14.8
Fast Neutron (E>0.1 MeV) Flux @ FF mirror (n/cm^2s)	$2.5x10^{10}$
Lifetime for 10^{18} n/cm^2 fast neutron fluence limit	1.3 FPY
Fast Neutron (E>0.1 MeV) Flux @ lens (n/cm^2s)	$1.7x10^9$

- Lifetime of GIMM is sensitive to neutron fluence limit and damage recovery with annealing. Fluence limits in the range 10^{20} - 10^{22} n/cm^2 were considered in past studies. Lifetime increased by factors of 5 with 80% recovery and 10 with 90% recovery

- Lifetime of dielectric FF mirror is sensitive to fluence limit. Limits in the range 10^{18} - 10^{19} n/cm^2 were considered in past studies



  - From past studies simple correlations can relate absorbed dose rate (from neutrons and gamma) to fast neutron flux

$D\ (Rad/s) =\sim 3x10^{-9}\ \Phi_{fast\ n}\ (n/cm^2s)$

Summary

- 3-D neutronics calculations for laser final optics in past studies were scaled for small materials test facility conditions to determine a preliminary estimate of the nuclear environment at final optics
- Using neutron traps behind the GIMM enhances lifetime of dielectic FF mirror and lens/windows by about an order of magnitude
- Comments regarding neutron trap configuration and placement of the dielectic FF mirror in small materials test facility were made
- Lining the neutron trap and beam ducts by a strong neutron absorber (e.g. Boral) can help reduce neutron flux at mirrors, lens, and windows
- Lifetime of GIMM, FF mirror, and lens is sensitive to fluence limit that needs to be well defined from experimental data