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Assessment of radiation effects on diagnostics and electronic devices in the National Ignition Facility

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Assessment of Radiation Effects on Diagnostics and Electronic Devices in the National Ignition Facility

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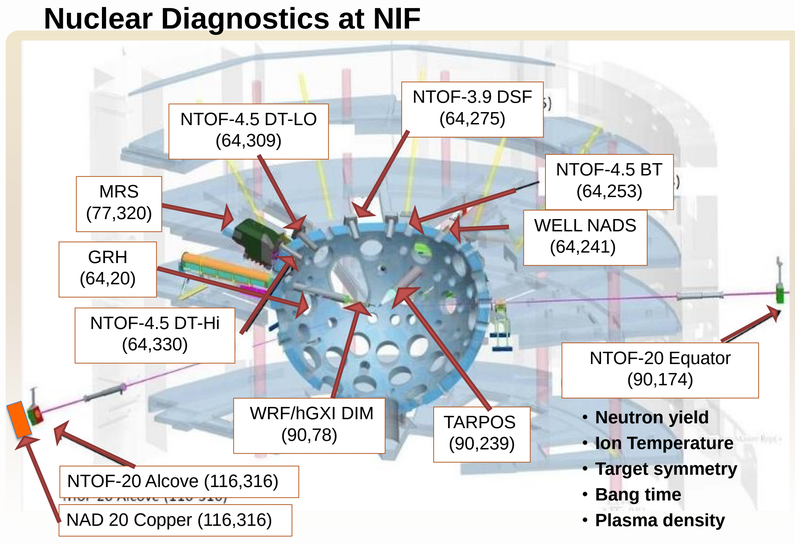
Abstract

Experiments resulting in a significant neutron yield are expected in 2012 at the National Ignition Facility (NIF). A wide range of diagnostics will be used to measure several parameters of implosion such as the core and fuel shape, temperatures and densities, and neutron yield. These diagnostics must be able to operate properly during several types of shots with varying neutron yields. Components like CCD cameras and several electronic devices are sensitive to the neutron and gamma backgrounds expected during shots. Fusion neutrons generated by fuel burn and secondary neutrons resulting from the fusion neutrons interaction with structures present inside and outside the Target Chamber contribute to the neutron background. A detailed model has been developed for the NIF facility and it includes most of the major structures inside the Target Bay. The model has been utilized in the simulation of expected neutron and gamma fluences throughout the NIF. Radiation damage to electronic devices in terms of rad-Si has also been calculated for large number of locations inside the facility. These data are being used to provide options for shielding of critical diagnostics and electronics devices to ensure that high precision measurements of neutrons and gammas will be possible during high yield shots.

Nuclear Diagnostics at NIF



Radiation Mitigation Strategies

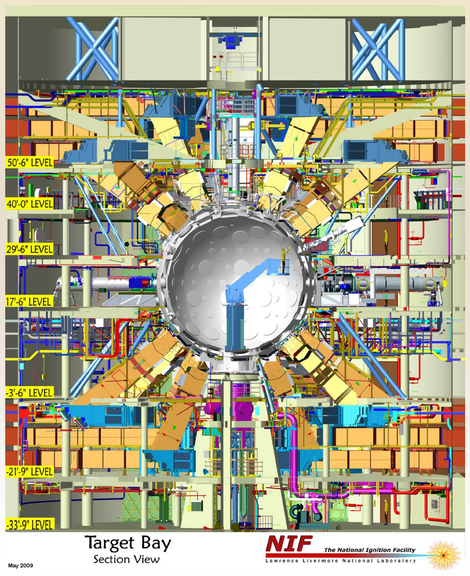
- Reduce exposure by removing vulnerable electronics outside the Target bay before shots
- Locate sensitive electronics in low radiation area outside the Target Bay
- Provide additional shielding to allow for certain electronics to stay inside the Target bay during high yield shots
- Use radiation hardened systems that are capable of surviving a challenging radiation environment

Fluence Level to Initiate Upset

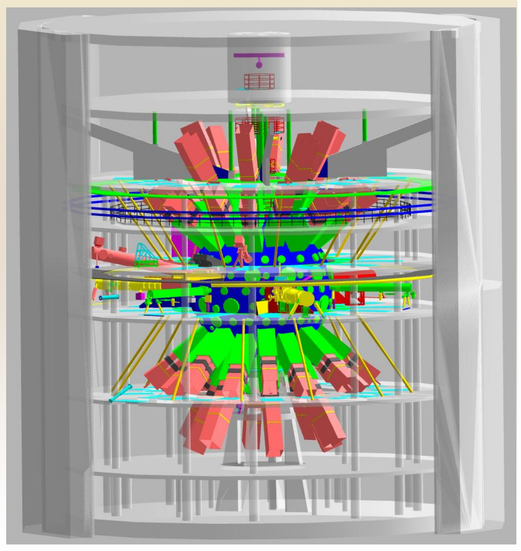
Components	One event thresholds* (per device)
SRAM, SDRAM, Microprocessor	3-8x10^8 n/cm^2
DRAM	2x10^8 n/cm^2
SRAM	0.2-4x10^8 n/cm^2
Tektronix scopes	2-4x10^8 n/cm^2

* 50% probability of an upset (courtesy of Jim McNaney)

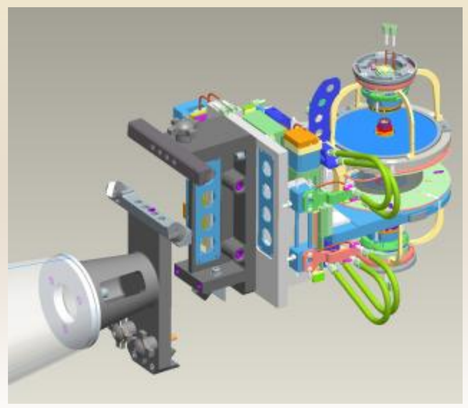
Sectional View of the Target Bay

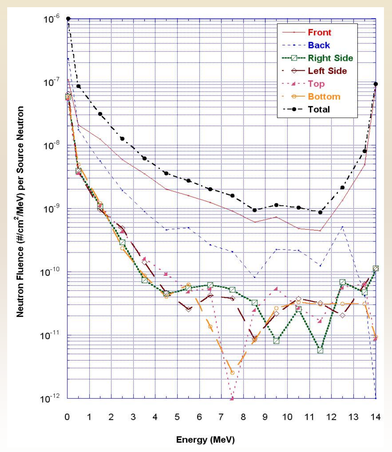


NIF Target Bay Model

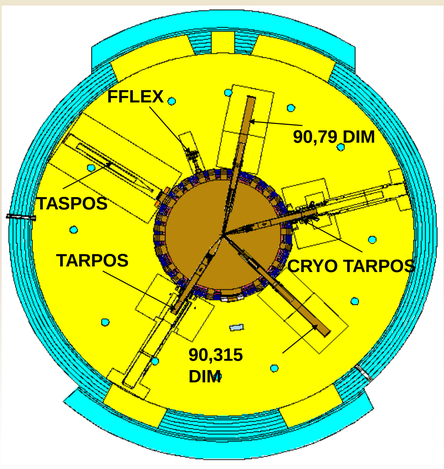


Target Alignment System (TAS) is Removed Before High Yield Shots due to Difficulty of Shielding

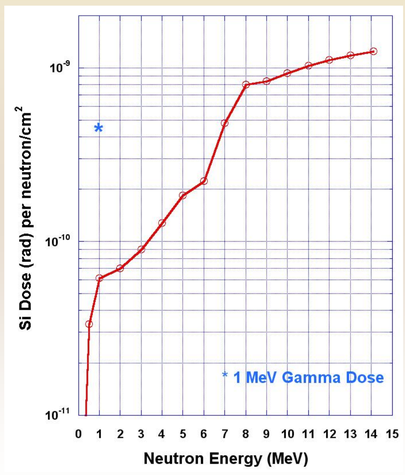




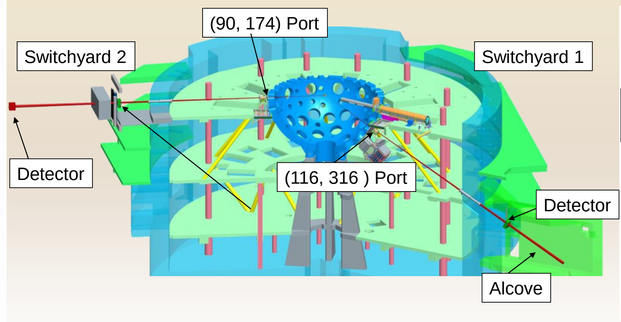
MCNP Model of the TB Equator

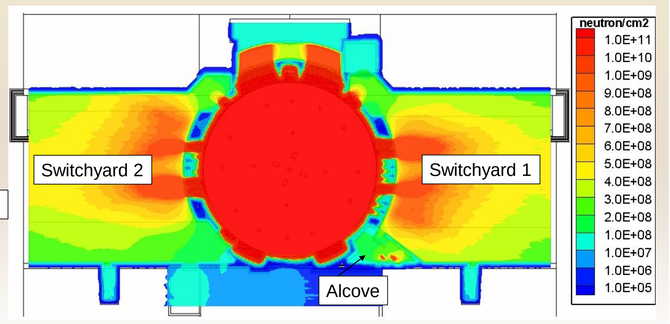


Dose as a function of Energy

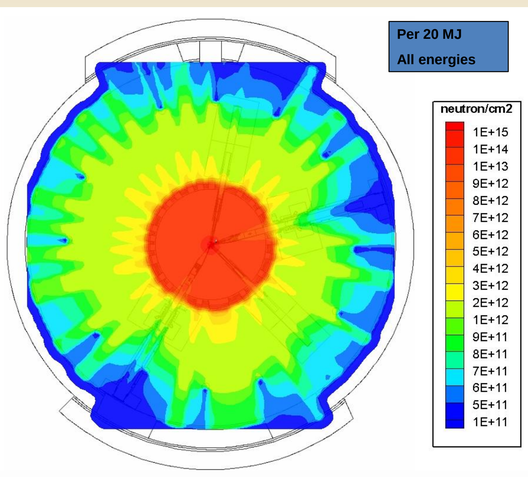


nToF20 Electronics are Located in Low Radiation Background Environment outside the Target Bay

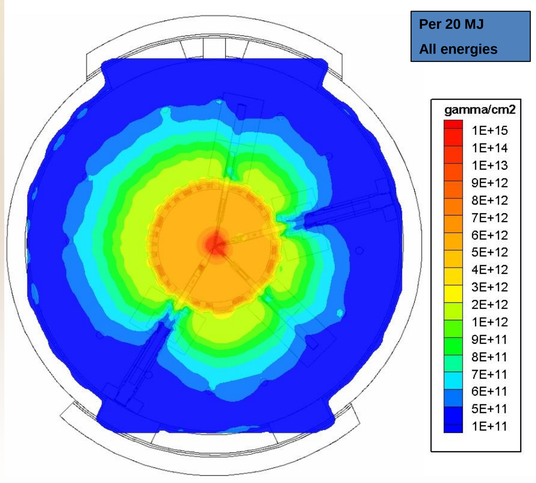




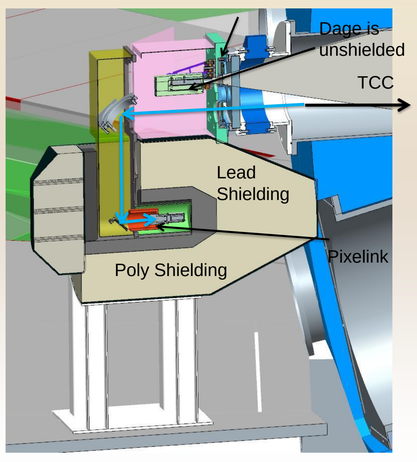
Neutron Fluence at the Equator

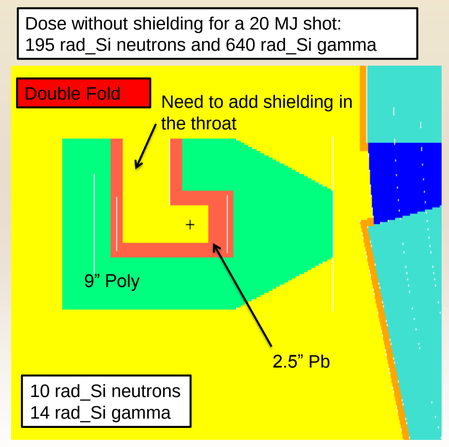


Gamma Fluence at the Equator

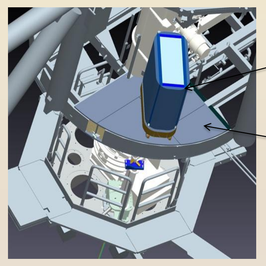


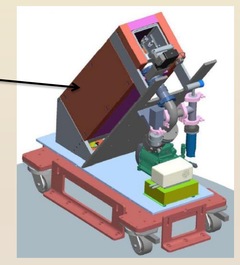
Shielding Design for the Chamber Internal Viewing System (CIVS) Camera



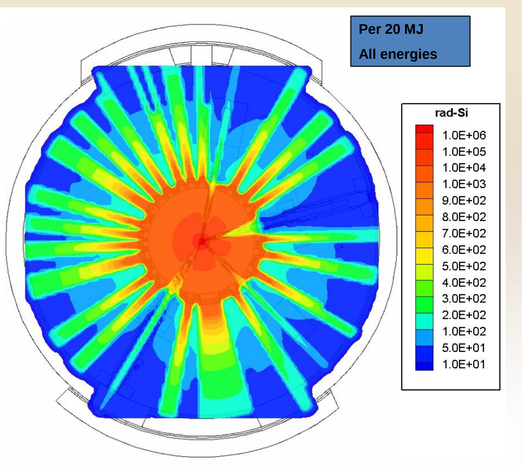


Shielding Design for the Streaked Polar Instrumentation for Diagnosing Energetic Radiation (SPIDER)

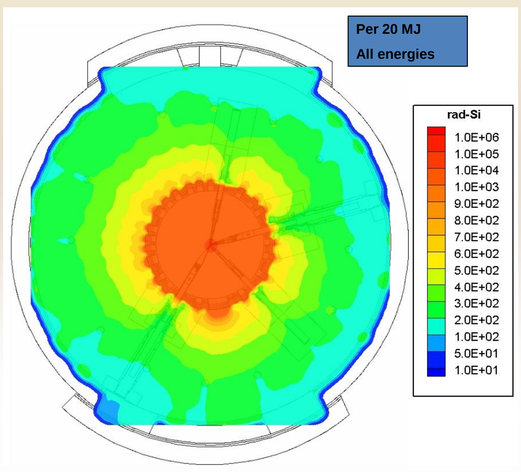




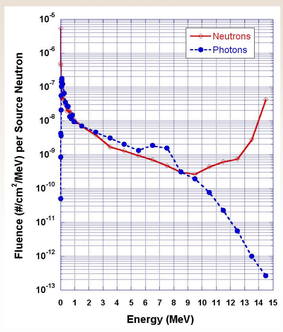
Neutron Dose at the Equator



Gamma Dose at the Equator



Fluence at the CCD Location without Shielding



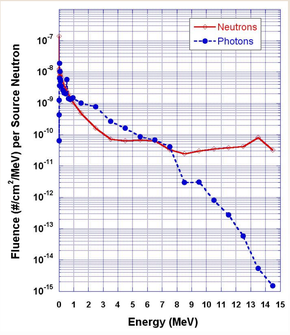
Dose at Y=10^{17} Neutrons

Neutrons=4.1 rad_Si
Photons=2.3 rad_Si

Neutrons=0.04 rad_Si
Photons=0.32 rad_Si

The Goal is to limit the number of stars in the CCD camera by limiting the total dose per shot to <0.4 rad_Si

Fluence at the CCD Location with Shielding



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