Background Assessment for the PROSPECT Short-Baseline Reactor Experiment

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Assessing PROSPECT Sites Close to Reactor Cores

- PROSPECT will deploy detectors close to research reactor cores
- Limited overburden and possible reactor correlated background
- Background measurements have been performed at 3 sites:
  - HFIR (ORNL)
  - ATR (INL)
  - NBSR (NIST)

Gamma Ray Results

Reactor correlated activity observed:
- $^{16}$O(n,p)$^{17}$O, 6.1, 7.1, 8.9 MeV γ-rays (water)
- $^{54}$Mn(n,γ)$^{55}$Mn, 5.5-9.3 MeV γ-rays (steel)
- $^{27}$Al(n,γ)$^{28}$Na, 2.75 MeV γ-ray
- ... volatile fission products, $^{14}$H(n,γ)$^{15}$H, ...

Spatial and Temporal Background Variations

Significant variation in γ-ray/neutron flux observed:
- Irregular shielding and/or localized leakage paths
- Proximity to piping carrying activated materials
- Operation of nearby neutron beam experiments

Spatial variation in γ-ray/neutron flux is important to optimize shielding design.

Conclusions

- Background measurements have been performed at potential near and far detector locations for PROSPECT at 3 U.S. reactor sites
- Reactor correlated γ-ray and neutron background sources have been identified
- Cosmic rays vary with elevation and overburden as expected
- Considerable spatial and temporal variations were encountered at all sites
- Extensive site characterization is therefore essential to shielding design
- Targeted shielding applied to localized sources could have large impact
- Localized thermal neutron shielding could reduce high energy γ-ray fluxes

See also:
K. Heeger: PROSPECT Summary & Physics Potential
T. Langford: PROSPECT Scintillator Development

Background Measurements Performed

- Neutron Rate/Spectrum
- μon Rate/Distribution
- γ-ray Rate/Spectrum

Fast Neutron and Muon Results

- Fast neutron and muon fluxes vary with elevation and overburden as expected
- ATR near has high elevation and limited overburden → highest flux
- Greater overburden at ATR far compensates for elevation
- NIST, HFIR similar
- Measured fast neutron spectra consistent with surface reference data

Shielding Concept Responds to Background Sources, Size & Weight Constraints

- γ-rays: 4e-3
- Neutrons: 2e-5 (fission)

Shielding Factors from MCNP Simulation:
- Layer 1: Borated poly attenuates fast neutrons, captures thermal neutrons prior to high-Z material
- Layer 2: Lead attenuates γ-ray flux
- Lithiated poly attenuates muon induced neutrons from Pb, produces no capture γ-rays close to target

Spatial variation in γ-ray/neutron flux is important to optimize shielding design.

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