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)$^{15}$N, 6.1, 7.1, 8.9 MeV $\gamma$-rays (water)
- $^{54,55}$Fe(n,$\gamma$)Fe, 5.5-9.3 MeV $\gamma$-rays (steel)
- $^{27}$Al(n,\alpha)$^{24}$Na, 2.75 MeV $\gamma$-ray
- ... volatile fission products, $^4$H($\gamma$)H, ...

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

Spatial and Temporal Background Variations

- Significant variation in $\gamma$/neutron flux observed:
  - Irregular shielding and/or localized leakage paths
  - Proximity to piping carrying activated materials
  - Operation of nearby neutron beam experiments
Neutron leakage can lead to significant localized $\gamma$-ray sources
- Detailed background characterization is therefore essential to optimize shielding design.

Shielding Concept Responds to Background Sources, Size & Weight Constraints

Shielding factors from MCNP simulation:
- $\gamma$-rays: 4e-3
- Neutrons: 2e-5 (fission)
Fast neutron attenuation

Conclusions

- Background measurements have been performed at potential near and far detector locations for PROSPECT at 3 U.S. reactor sites
- Reactor correlated $\gamma$-ray and neutron background sources have been identified
- Cosmogenic backgrounds 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 $\gamma$-ray fluxes

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

Background Measurements Performed

Neutron Rate/Spectrum

• Moderate Resolution: Same NaI(Tl) detectors used at all sites to provide relative comparison High-resolution: Different HPGe and LaBr$^3$ spectrometers used to identify background sources

Fast neutron Recoils integrated in (4-14) MeV range

Relative measured muon rates

Site elevations and expected surface fast neutron flux

Muon rate/distribution

Telescope was tilted to measure angular distribution

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This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory Contract DE-AC52-07NA27344.

LLNL-POST-654856