Testing in Support of Space Radiation Shielding Composed of Nanocomposites

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For the particles composing space radiation, energy deposition is highly localized along the trajectory of each particle.

Galactic Cosmic Ray (GCR) particles of average energy can penetrate a substantial thickness of materials, on the order of several inches of aluminum.

If they suffer nuclear interactions, the lighter secondary products will lose energy at a lower rate, and therefore will be able to penetrate even further.
Shielding Considerations

- Except for physical properties and safety considerations, hydrogen would be the best shield.
- Polyethylene (PE), due to its high hydrogen content relative to its weight, has been shown to be an effective shielding material against galactic cosmic rays and solar energetic particles.
- The present work was funded to address the design, fabrication, and testing (including accelerator-based testing) of novel shielding materials that can be shown (i.e., via measured or simulated radiation transport properties) to approach or improve upon polyethylene’s performance.
Objectives of the Project

- Synthesize multifunctional nanocomposites based on polyethylene with dispersed boron-rich nanophases.
- Experimentally test the radiation shielding properties of these composites and compare with polyethylene and aluminum.
- Evaluate the mechanical properties (especially impact and toughness).
  - Best candidate will also be evaluated for effectiveness as a flame retardant and ballistic/hypervelocity impact performance.
Radiation Shielding Tests of Material

- WNR Neutron Beam on 30L
- University of Maryland Research Reactor Thermal Column
- Fermilab Proton Beam
- Georgia Tech AmBe Neutron Source
Materials

- Aluminum
- Polyethylene
- Polyethylene with Boron Nitride Nanoparticles
- Polyethylene with Boron Nitride
- Polyethylene with Boron Carbide
Attenuation Curves from WNR

NASA Shielding Samples
[Attenuation Factor]

- Aluminum
- Polyethylene
- Boron Carbide
- Boron Nitride
- Nano Boron Nitride
Fermilab Experimental Setup
Attenuation Measurements

- Tissue-Equivalent Ion Chamber
  - 1 cm³ gas volume
  - In center of 30 cm x 30 cm x 30 cm tank of water
- Charge Collected for 4 Different Thicknesses of Shielding Material
- Absorbed Dose Ratio Computed Using Charge Collected with no Shielding Material Interposed
- 120 GeV Proton Beam
Preliminary Results

Attenuation with Samples In the Beam

Ion Chamber Counts/Protons Per Pulse vs. # of Shielding Layers

- Boron Nitride
- Polyethylene
- Nano Boron Nitride
- Boron Carbide
Preliminary Results contd.

Attenuation with Samples Out of the Beam

- Boron Carbide
- Polyethylene
- Nano Boron Nitride
- Boron Nitride
- Aluminum

 Ion Chamber Counts/Protons Per Pulse

# of Shielding Layers
We would like to give a special thanks to all the staff at Fermilab who provided us with enthusiastic support in helping us conclude our project.

Good beam comes from happy protons.  
Happy protons come from Fermilab!