



Lithium Borohydride for Hydrogen Propellant Storage

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Lithium Borohydride for Hydrogen Propellant Storage

- **Research Focus**

- Development and characterization of lithium borohydride for the dual hydrogen propellant storage and neutron shielding applications

- **Research Tasks**

- Measure and compile physical and thermodynamic property data for lithium borohydride at room temperature.
- Perform thermal stability analysis of lithium borohydride at temperatures up to the total dissociation point ($\sim 700\text{K}$) for the compound.
- Performance and microstructural characterization of lithium borohydride under intense radiation field.



Lithium Borohydride for Hydrogen Propellant Storage

- **Basic Properties**

- 19.6% H content
- Molecular weight 21.78 g/mol (LiBH_4)
- 20.22 g/mol ($^6\text{Li}^{10}\text{BH}_4$)
- Density .66 g/cm³
- Melting point @ .1 MPa 541 K
- Boiling point @.1 MPa 551 K
- Decomposition point @.1 MPa 473 K



Lithium Borohydride for Hydrogen Propellant Storage

- **Basic Properties**

- White crystalline solid
- X-ray power diffraction: Orthorombic symmetry
- Stable in dry air or vacuum ($T < 473 \text{ K}$)
- Transition to hexagonal structure ~381K
- Hydrogen desorption peak 700K
- 19.5% H content
- Primary solvent Tetrahydrofuran (THF)



Lithium Borohydride for Hydrogen Propellant Storage

- **LiBH₄ Preparation and Dissociation properties**

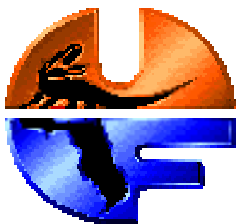
- **Preparation**

- $\text{NaBH}_4 + \text{LiB} \longrightarrow \text{LiBH}_4 + \text{NaB}$
(under nitrogen, 18 h at 298 K and .5 h at 308 K)
- $\text{Li} + \text{B} + 2\text{H}_2 \longrightarrow \text{LiBH}_4$
(Heat of formation ~ -194 KJ/mol)

- **Hydrogen Desorption reaction**

- $\text{LiBH}_4 \longrightarrow \text{LiH} + \text{B} + 3/2 \text{H}_2$
(Reaction proceed mainly above 573 with SiO₂ as catalyst)

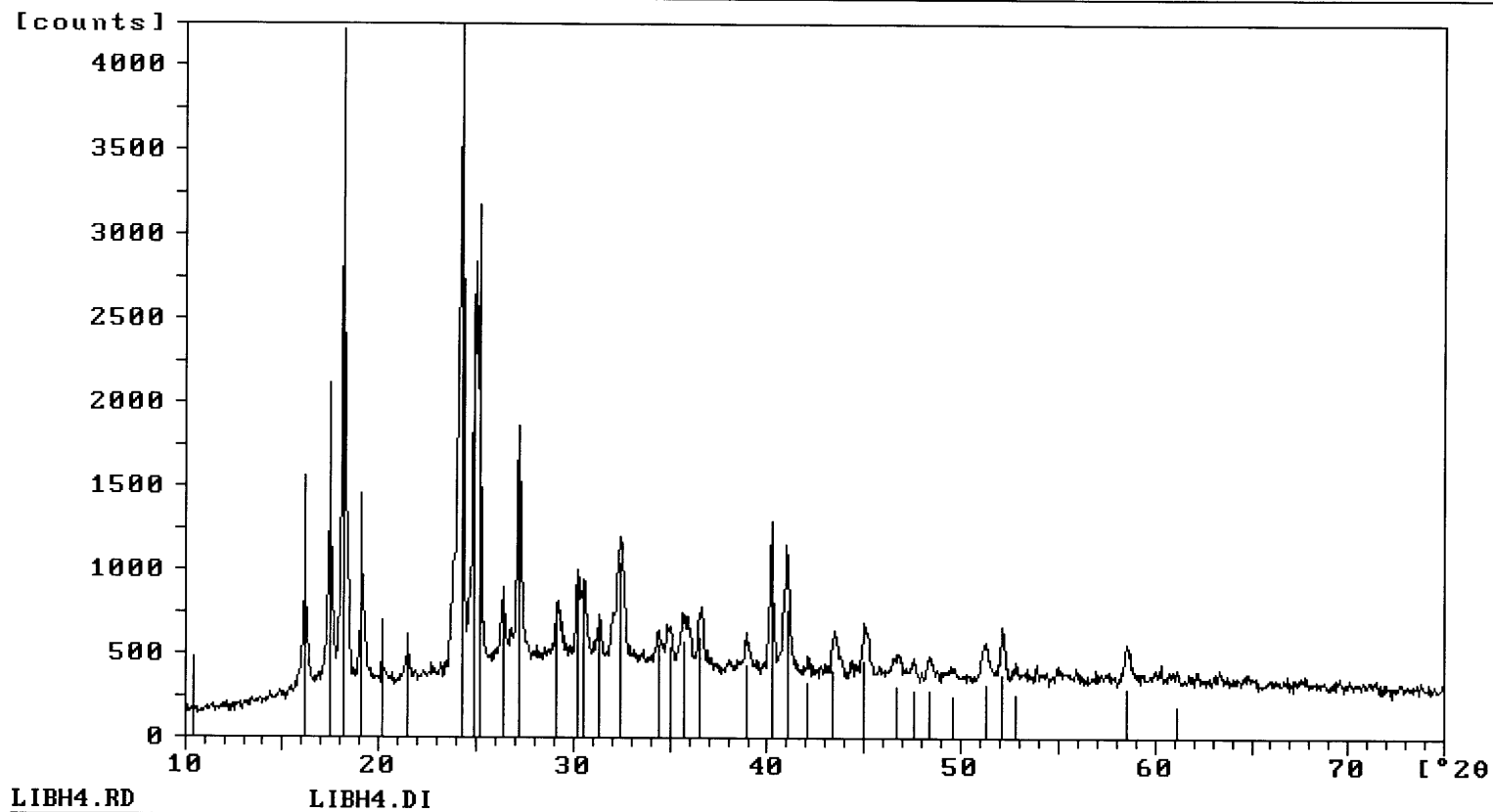
- **Raman spectroscopy analysis**



LiBH₄ X-Ray Diffraction Pattern

Sample identification LIBH4

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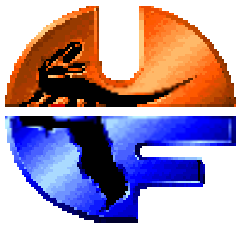
Lithium Borohydride for Hydrogen Propellant Storage

- **High energy reaction of Lithium Borohydride with air and moisture resulted in two lab fires**
- **Measured properties at room temperature agreed with reported data**
- **X-ray analysis was performed to measure the moisture absorption and reaction**
- **Due to need for additional safety measures and equipment, no high temperature or in-reactor test have yet been conducted**



Lithium Borohydride for Hydrogen Propellant Storage

- **White, odorless powder, water-reactive and is corrosive in the presence of moisture.**
- **Reaction with water generates flammable hydrogen gas, causing ignition or explosion.**
- **Thermal decomposition of Lithium Borohydride produces hydrogen gas, lithium and boron oxides, and borane.**
- **Lithium Borohydride will react with water, carbon dioxide, and oxygen in air to form other inorganic compounds.**



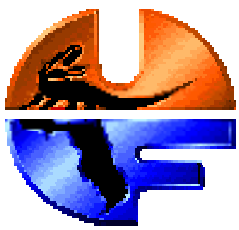
Applications of Lithium Borohydride

- **Lithium Borohydride features outstanding potential for:**
 - Hydrogen storage
 - Light weight & compact radiation shielding for space reactors
 - Propellant storage for Nuclear Thermal Rocket (NTR)
 - Rocket fuel
- **Potential application as combined shielding – fuel material for Moon and/or Mars exploration.**
 - Light shielding material for NTR
 - Oxygen production from moon or martian rocks using nuclear reactor
 - Rocket fuel for lift up from Moon or Mars surface

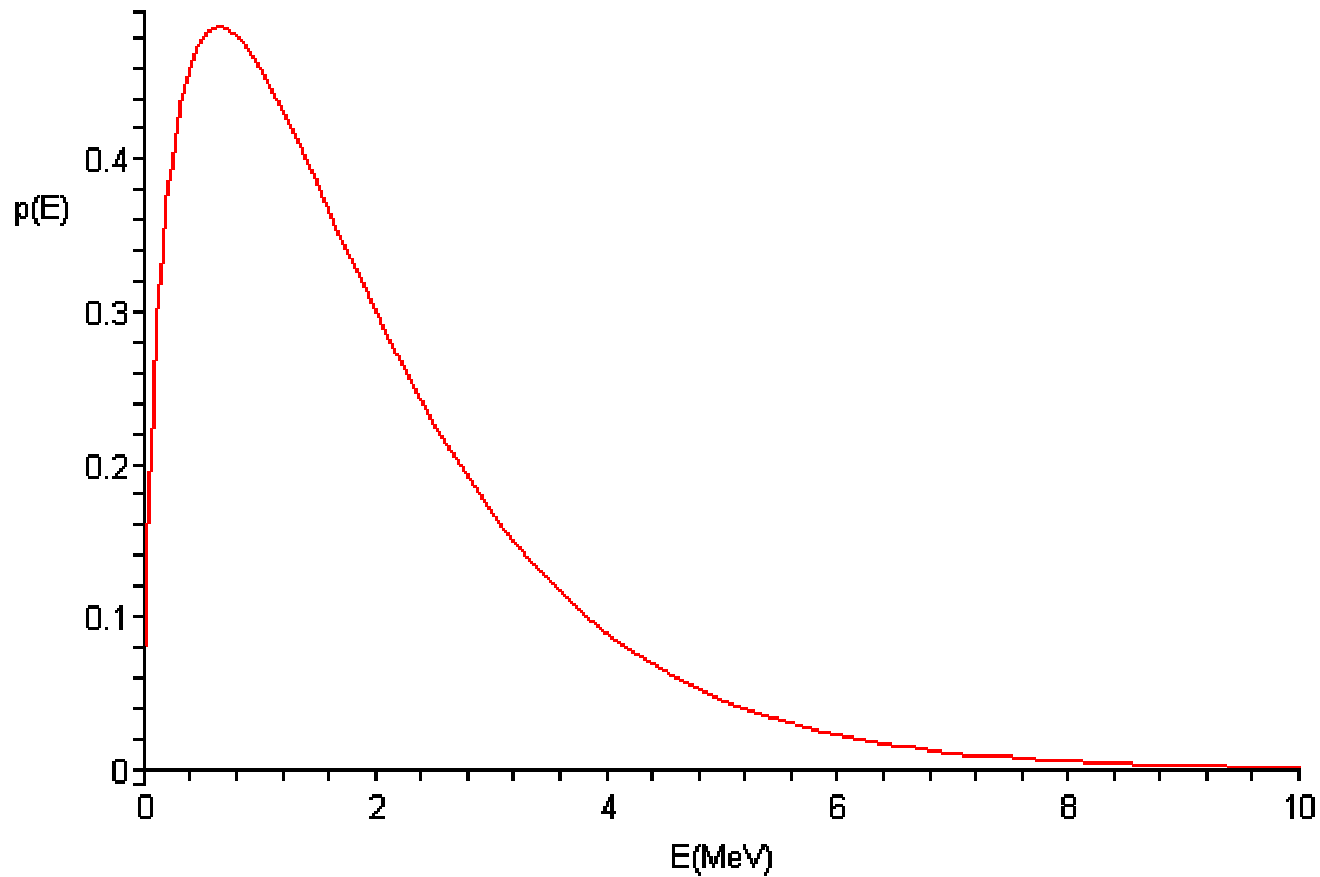


Unique Nuclear Features of Lithium Borohydride

- LiBH_4 with natural isotopic constituents is an exceptionally excellent neutron shielding material
- Enrichment of natural B and Li to ^{10}B and ^6Li , respectively, further enhances neutron shielding property of LiBH_4
- Monte Carlo analysis is performed to quantify the enhanced neutron shielding behavior of $^6\text{Li}^{10}\text{BH}_4$

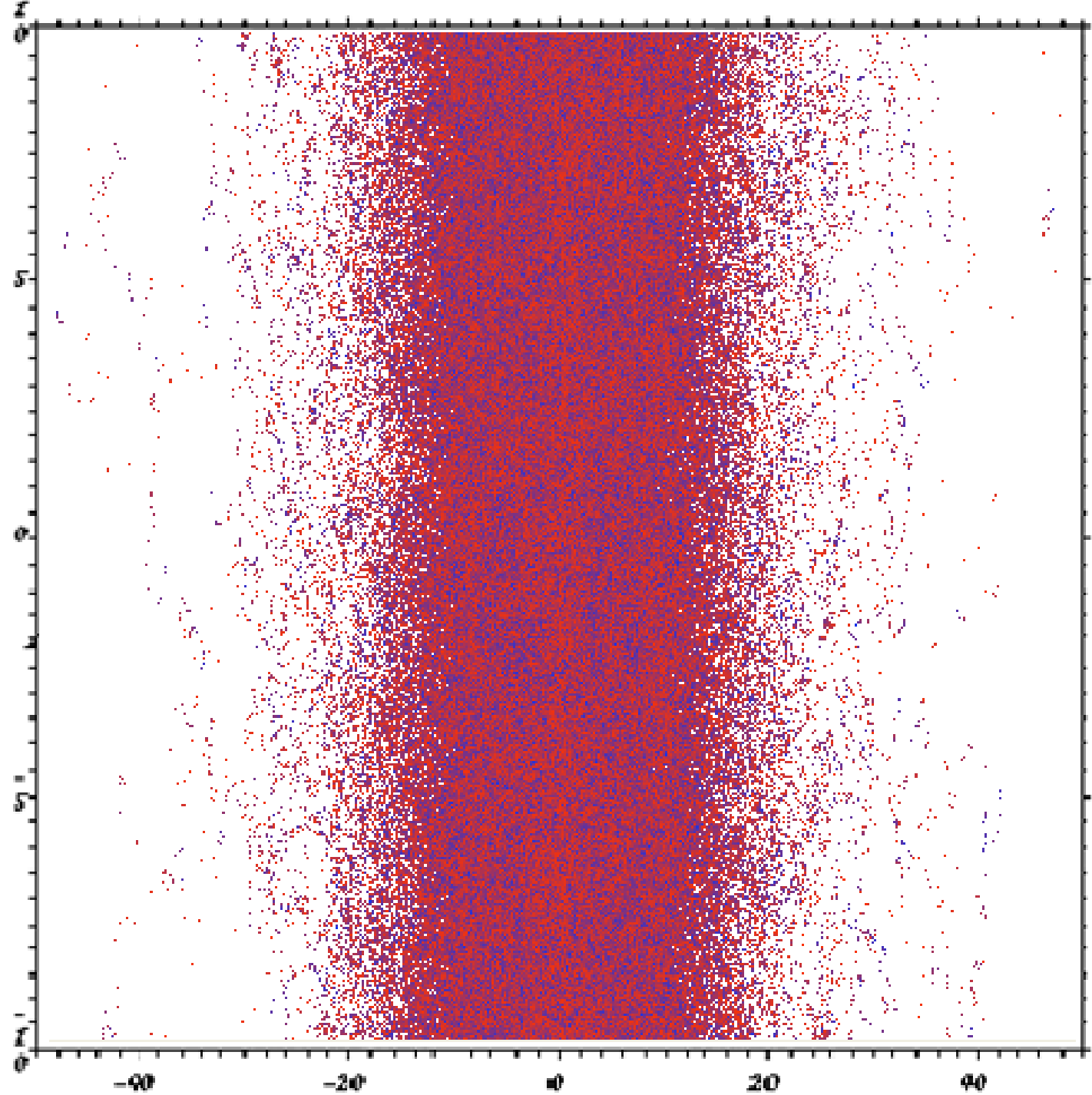


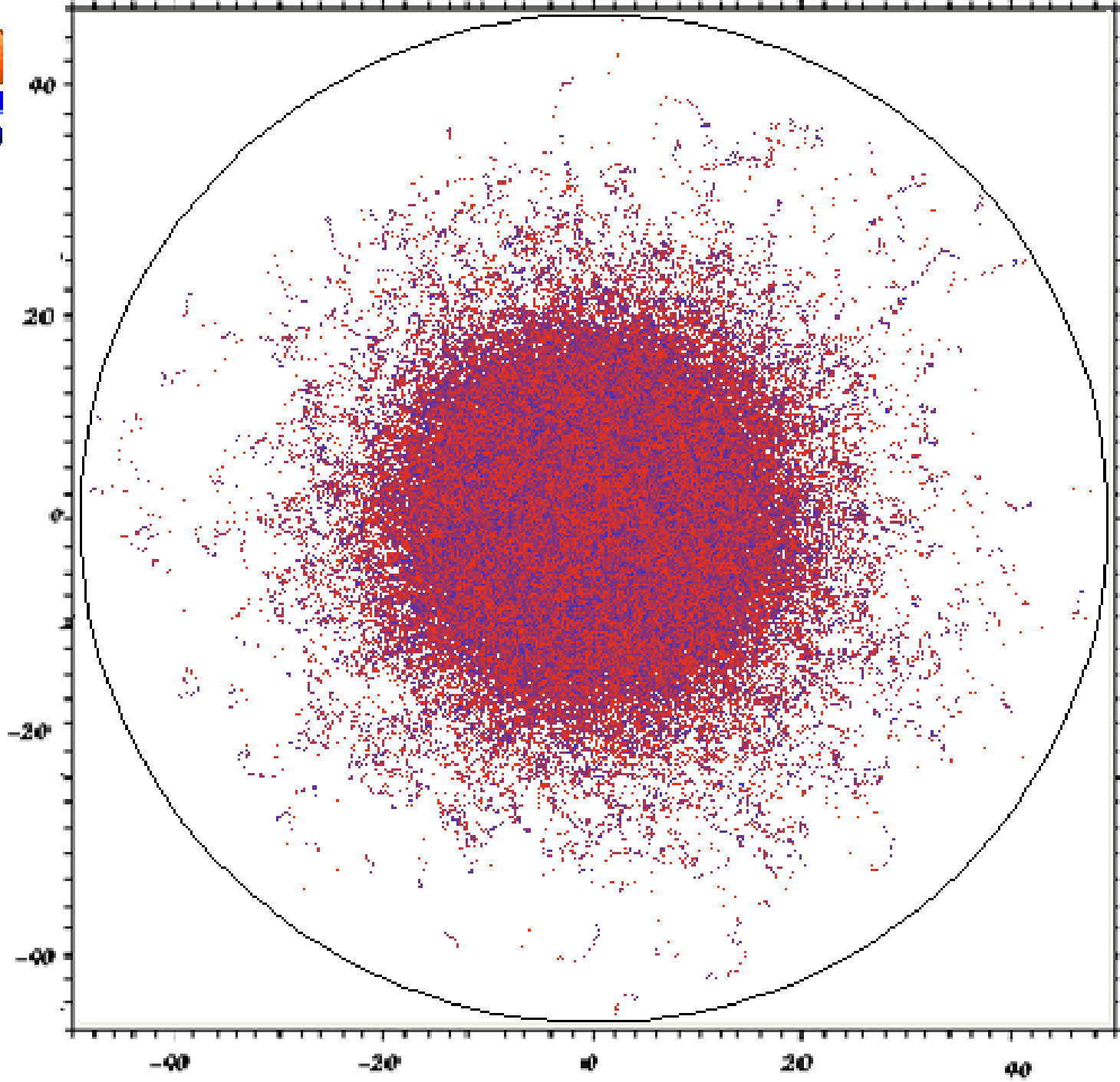
Maxwell fission spectrum

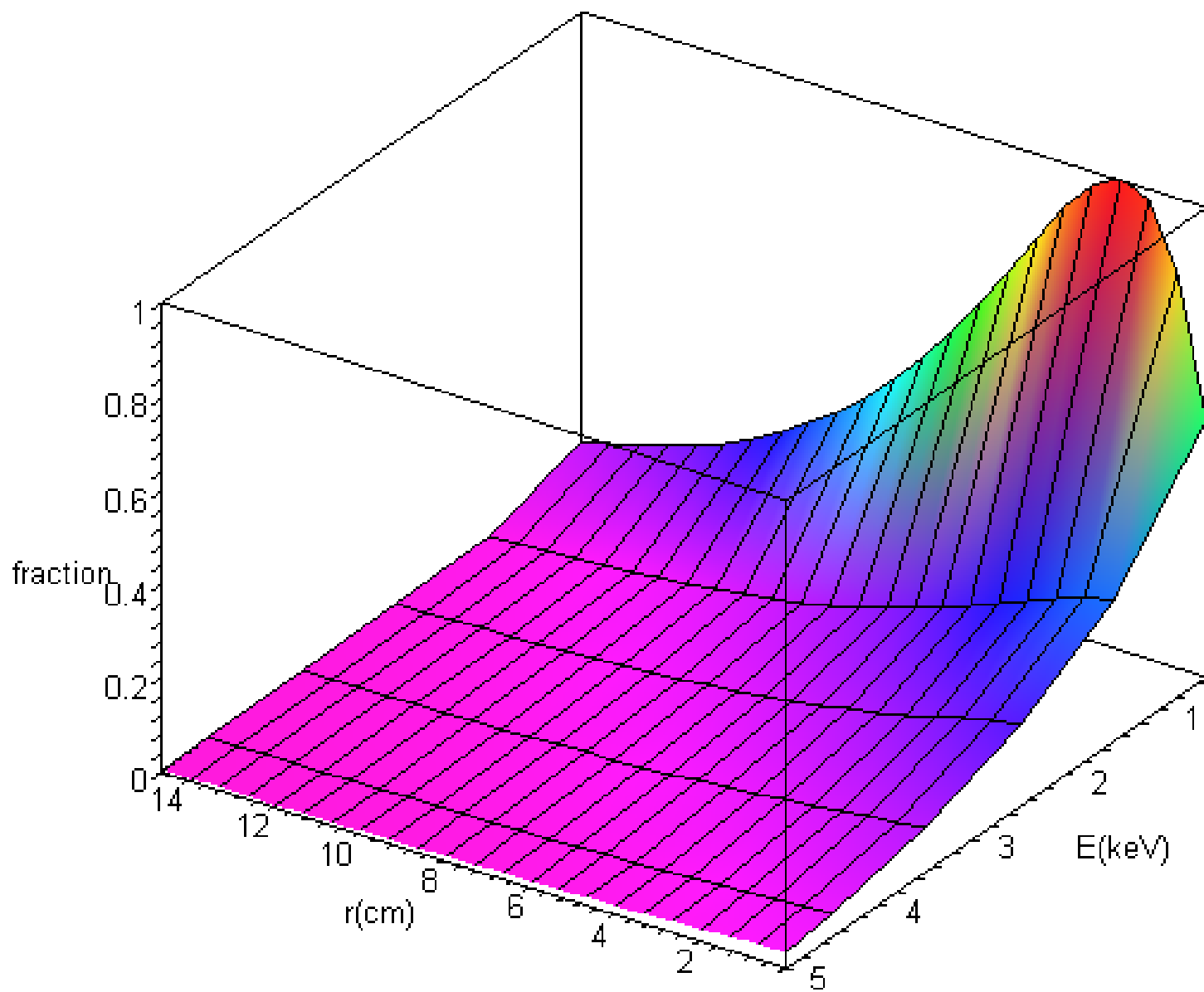


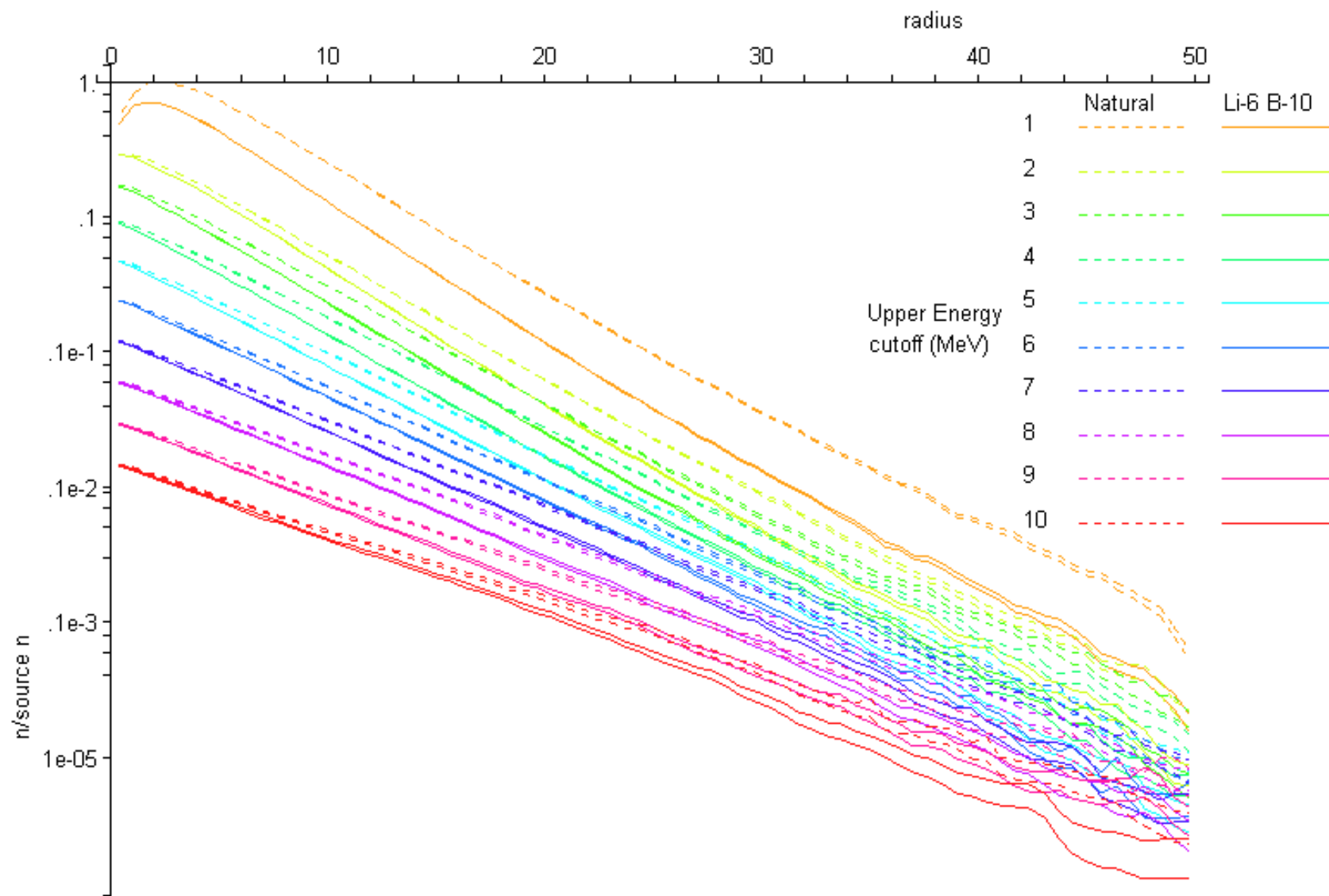
–Fission Spectrum for LiBH_4 vs ${}^6\text{Li}^{10}\text{BH}_4$ Comparative Study

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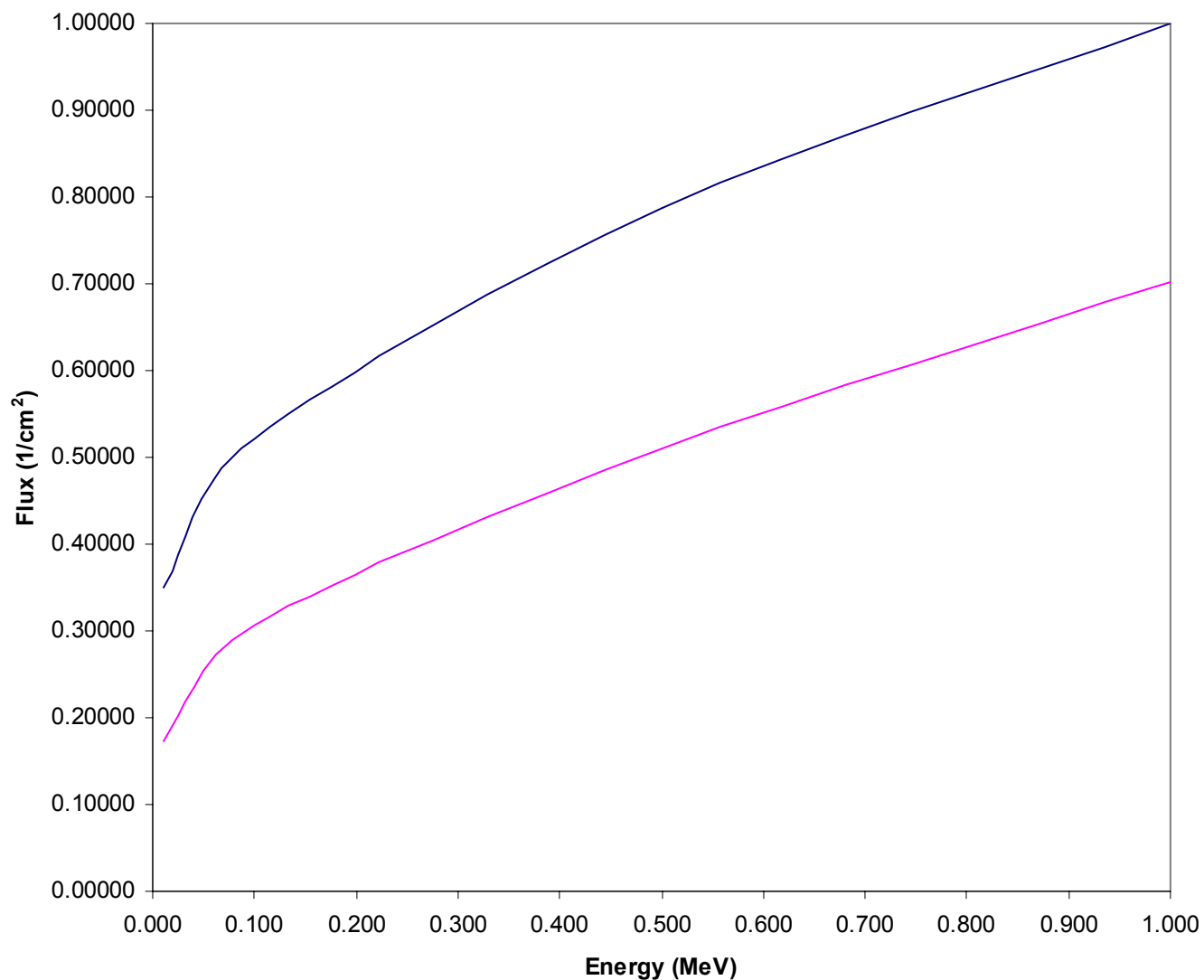




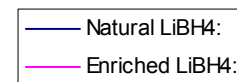




Comparison of particle flux values at the cylinder wall (normalized plots)

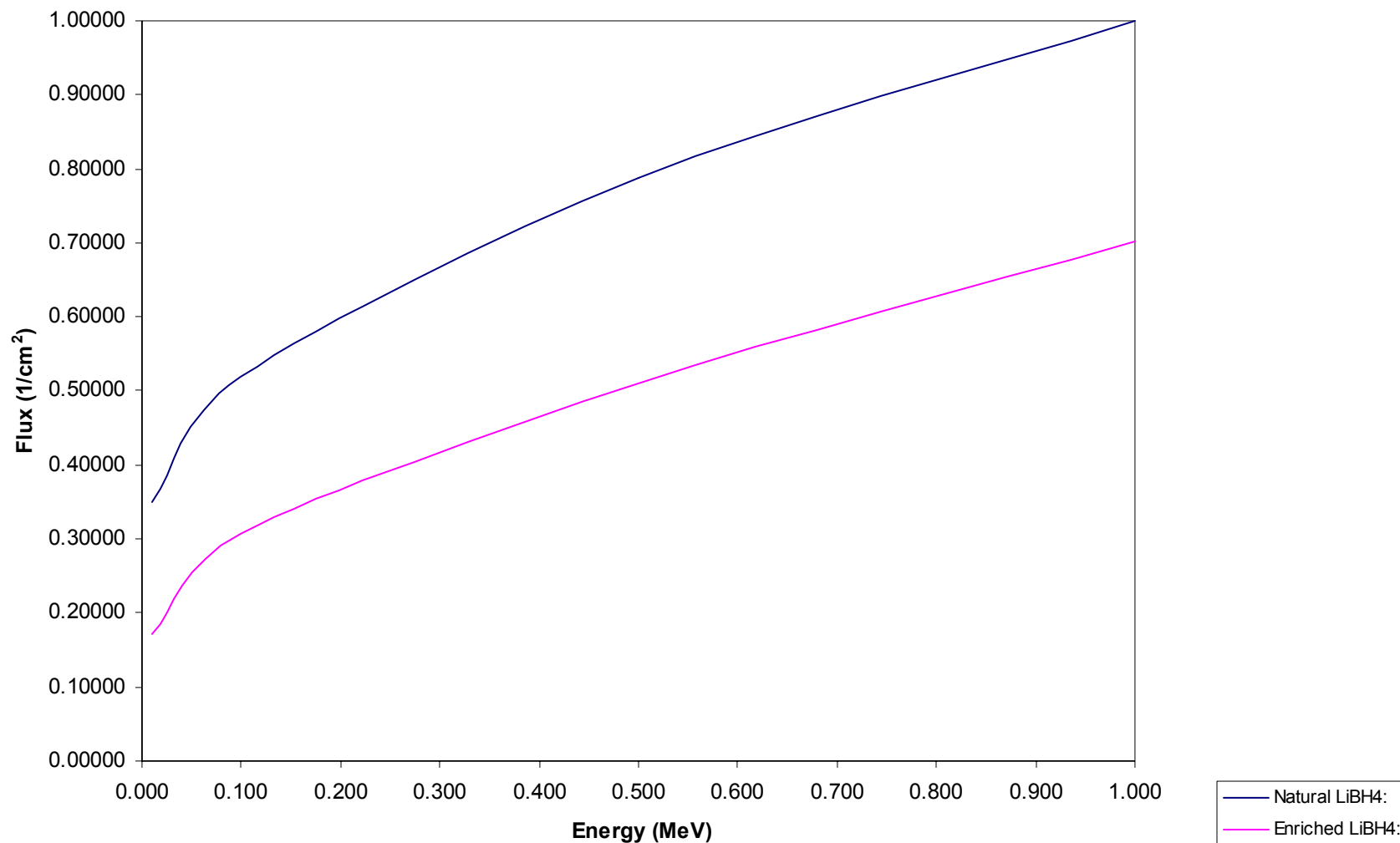


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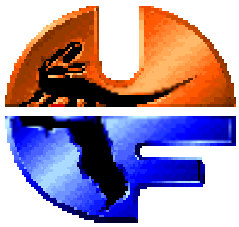




Comparison of particle flux values at the cylinder wall (normalized plots)



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Conclusions

- **Lithium Borohydride features superior properties for**
 - **Hydrogen storage**
 - **Neutron shielding for space reactors**
- **Chemical stability and high energy reaction with water and air limits high temperature and terrestrial applications of Lithium Borohydride**
- **Work in progress includes effect of radiation – neutron and gamma-rays – on properties of Lithium Borohydride**



Conclusio