Decay Detector For The Study of Isoscalar Giant Monopole Resonances

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Giant Resonances

- Collective excitations of the nuclei
- Discovered in the 1940s while bombarding nuclei with gamma rays
- Monopole resonance is a spherical oscillation
- Isoscalar – neutrons and protons move in phase with one another
- Isovector – neutrons and protons move out of phase with one another

Purpose

- From studying the Isoscalar Giant Monopole Resonance (ISGMR), E_{GMR} can be determined
- E_{GMR} can be used to find K_{em}, a main component in the nuclear matter equation of state
- Astrophysics:
  - Supernova collapse
  - Neutron Stars

Decay Detector

- Composed of a layer of horizontal 1 mm thick scintillator strips followed by a layer of vertical 1 mm thick scintillator strips in front of 5 block scintillators

Predicting Light Output

- Two methods for predicting the light output
  - Birks semi-empirical formula:
    \[ \frac{dE}{dx} = \frac{C_d}{1 + C_l} \frac{dE}{dx} \]
  - C_d is the proportion of the molecules that contribute to the light output
  - C_l is the proportion of molecules that are quenching sites
- Energy Deposition By Secondary Electrons (EDSE) Model:
  - Advantageous for calibrations across numerous ion types
  - Takes into account both ionization density and energy transport concepts
  - Assumes that there exists a "quenching density," \( \rho_q \) which defines a "quenching radius," \( r_q \)
  - Below \( r_q \), the scintillator response is assumed to be constant
  - Above \( r_q \), the specific detector response, \( dL/dx \)

Experimental Setup

- Decay particles will hit the decay detector
- Remaining particles will go on to the MDM spectrometer

Stopping Power

- Stopping power is the energy loss per unit length (dE/dx)
- Commonly approximated by the Bethe-Bloch formula
  \[ \frac{dE}{dx} = 2 \frac{m_e c^2 \gamma}{\beta^2} \ln \left( \frac{2m_e c^2 \gamma W_{max}}{\beta^2} \right) - 2\beta^2 - \frac{3}{2} \frac{C_d}{C_l} \]
  - More convenient form is
  \[ \frac{dE}{dx} = \frac{Z^2}{m} \left( 1 + \mu \right) \left( e + \varepsilon \right) \]
  - \( \kappa, \mu, \) and \( \varepsilon \) are medium dependent constants that we fit to SRIM table data
  - For our purposes, \( e \) is equivalent to \( \beta \)

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