Giant Monopole Resonances

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What are Giant Resonances?

• Giant Resonance discovered in 1940s with gamma rays isovector dipole (IVGDP)

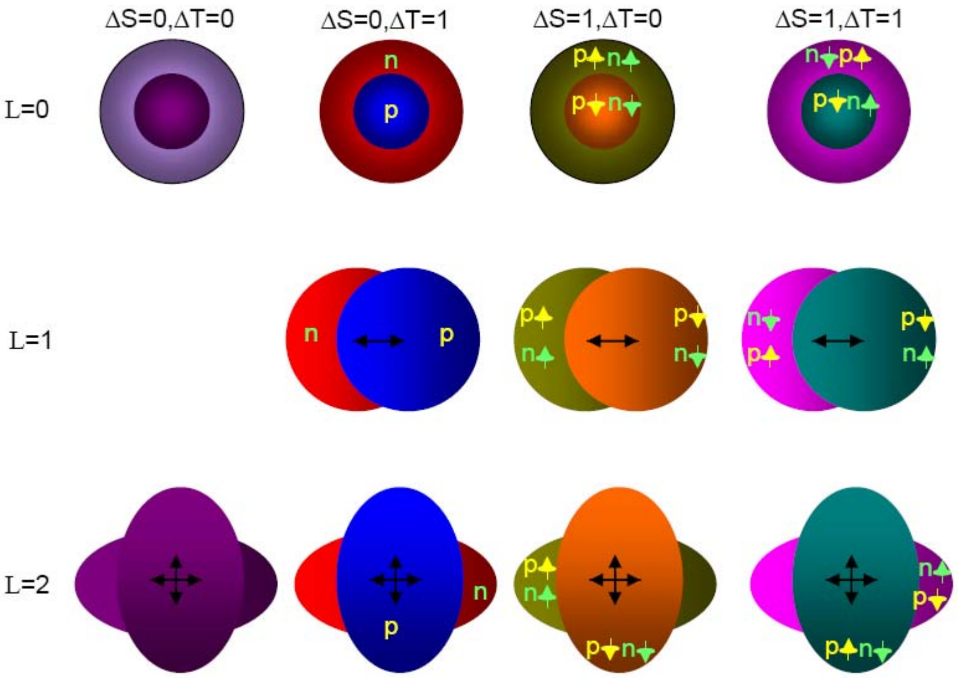
•Isovector Quadruple (IVGQR) discovered in 1972 by electron scattering with ^{90}Zr

•In 1977 Isoscalar Monopole (ISGMR) discovered in ^{144}Sm and ^{208}Pb.

•Resonance - an excitation of a nucleus

•Giant Resonance - collective modes of excitation of a nucleus.

- •Classified by quantum numbers S, T, and L



How do we find K_{nm}?

•Finding the Isoscalar Giant Monopole Resonance (ISGMR), K_A for specific nuclei

$$E_0 = \sqrt{\frac{\hbar^2 A K_A}{m\langle r^2\rangle_0}}$$

•Then there are two ways of finding $K_{nm.}$

•Macroscopic approach Liquid drop model and the semi-empirical mass formula.

$$K_A = K_{nm} + K_{surf} A^{-\frac{1}{3}} + K_{sym}\left(\frac{N-Z}{A}\right)^2 + K_{coul}\frac{Z^2}{A^{\frac{4}{3}}}$$

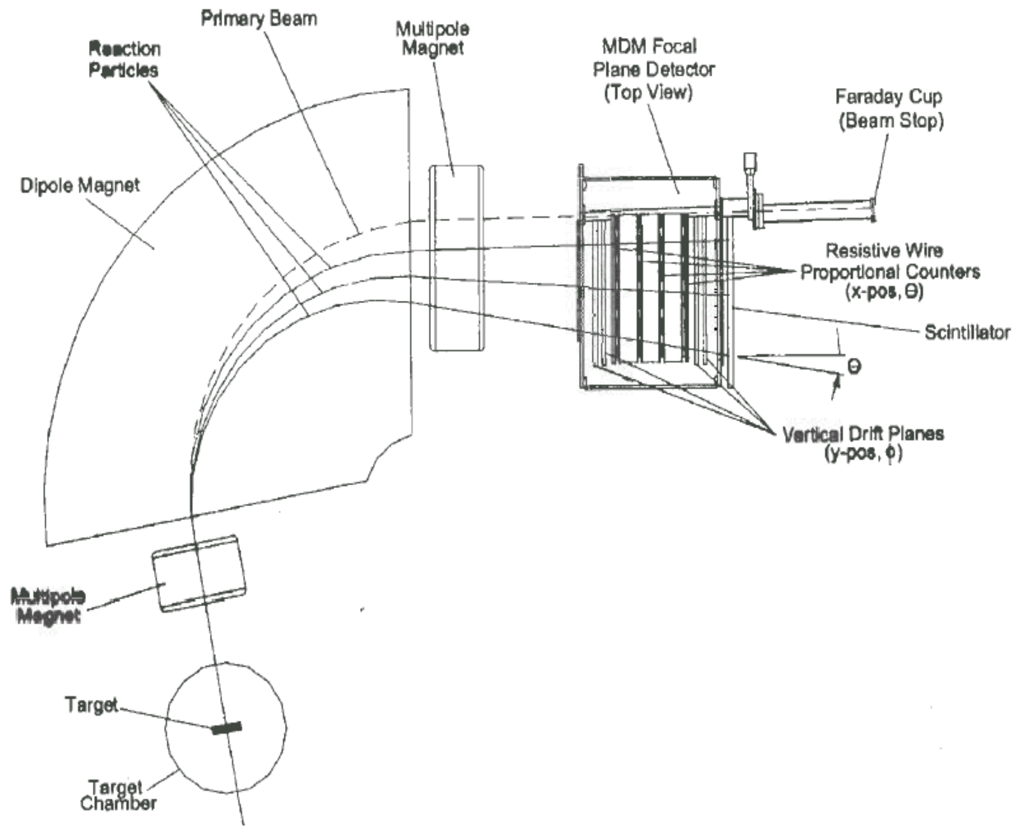
•But the K_{Vol} term is hard to interpret for smaller nuclei.

•Microscopic approach Hartree-Fock Random Phase Approximation is used. and compared to experimental data.

$$K_{nm} = 9\rho_0^2 \left.\frac{\mathrm{d}^2 E/A}{\mathrm{d}\rho^2}\right|_{n_0} = k_f^2 \left.\frac{\mathrm{d}^2 E/A}{\mathrm{d}k_f^2}\right|_{k_{f0}}$$

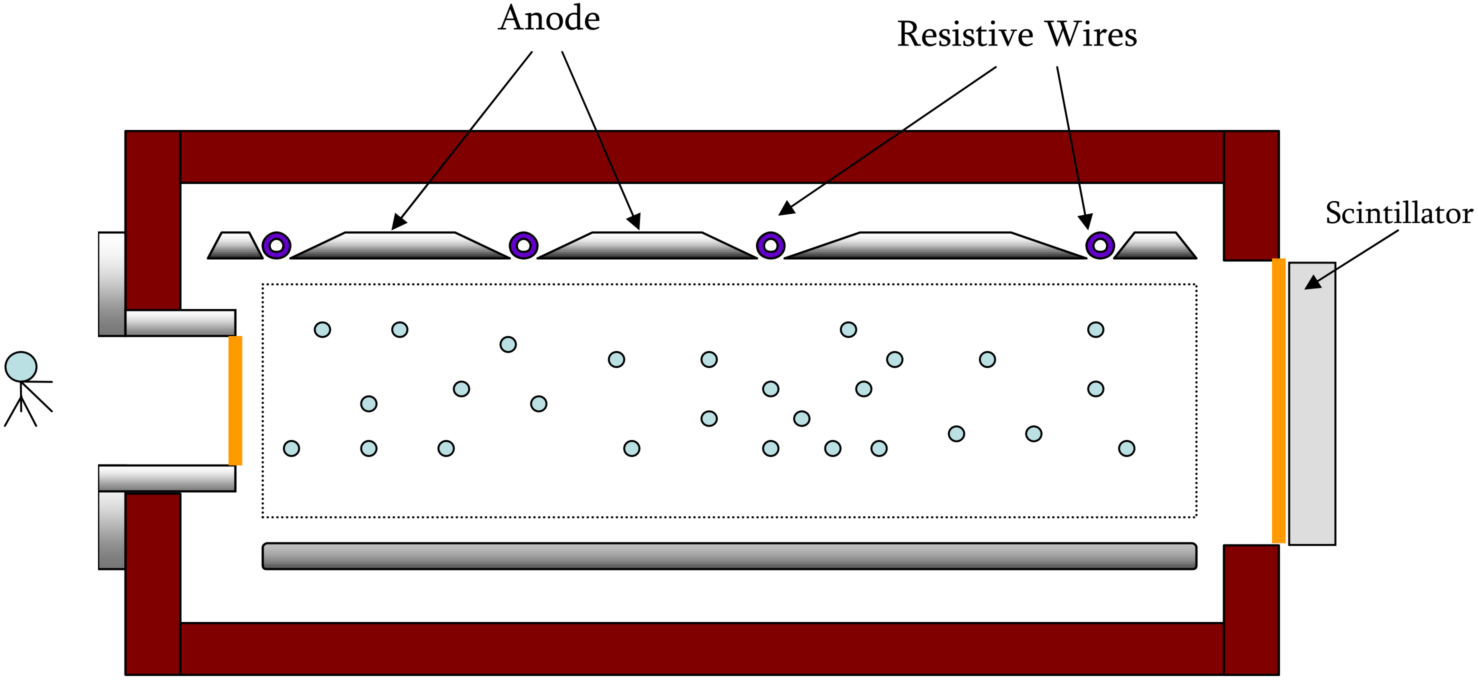
Experimental Setup

- To find the ISGMR particles are scattered in inelastic collisions with the target.
- The MDM spectrometer then separates the particles by energy and size.
- The Focal Plane detector then sends a read out to the counting room.



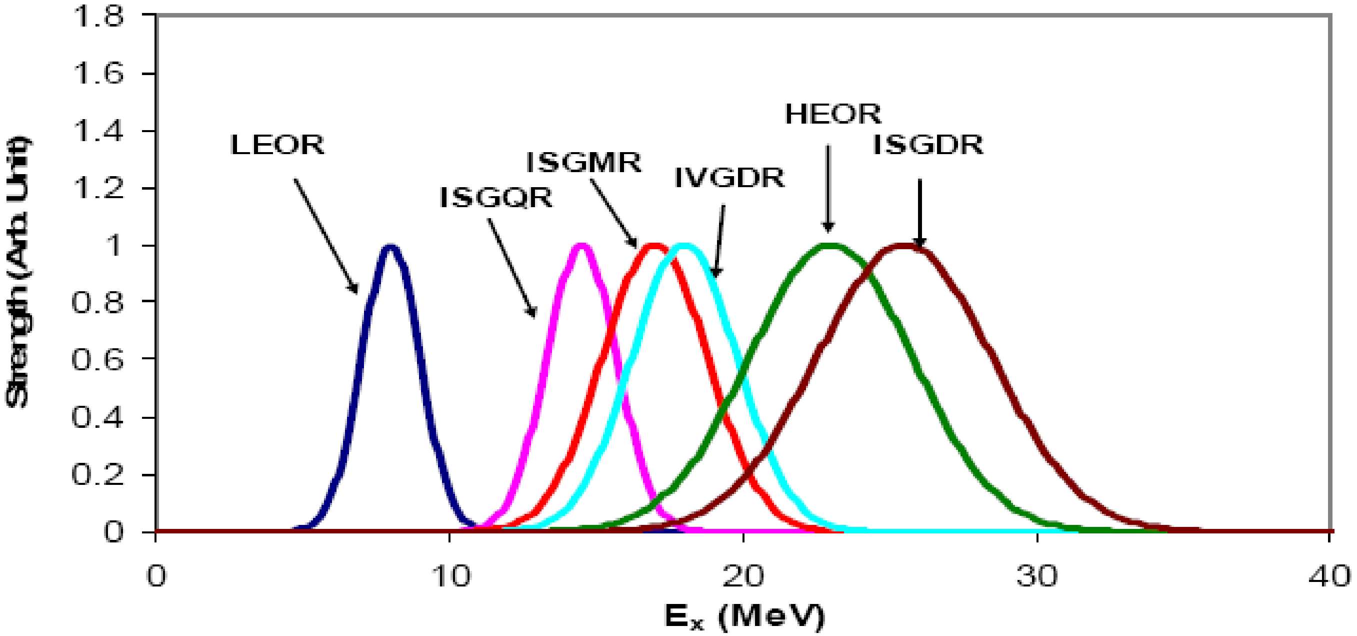
The Focal Plane Detector

- The detector is filled with isobutene gas which is ionized and detected by the resistive wires and anodes which measure the position
- A scintillator then measures the residual energy and from the two the type of particle and its energy can be determined



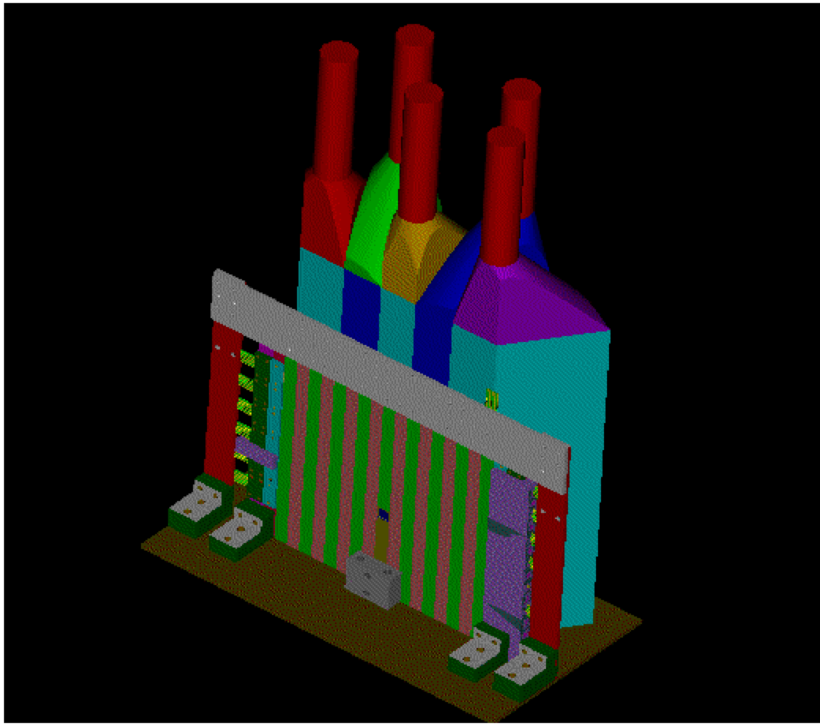
Finding the ISGMR

- Then the ISGMR must be distinguished from other Giant Resonances.
- Multiple Analysis using the distorted wave Born approximation can separate the different Giant Resonances



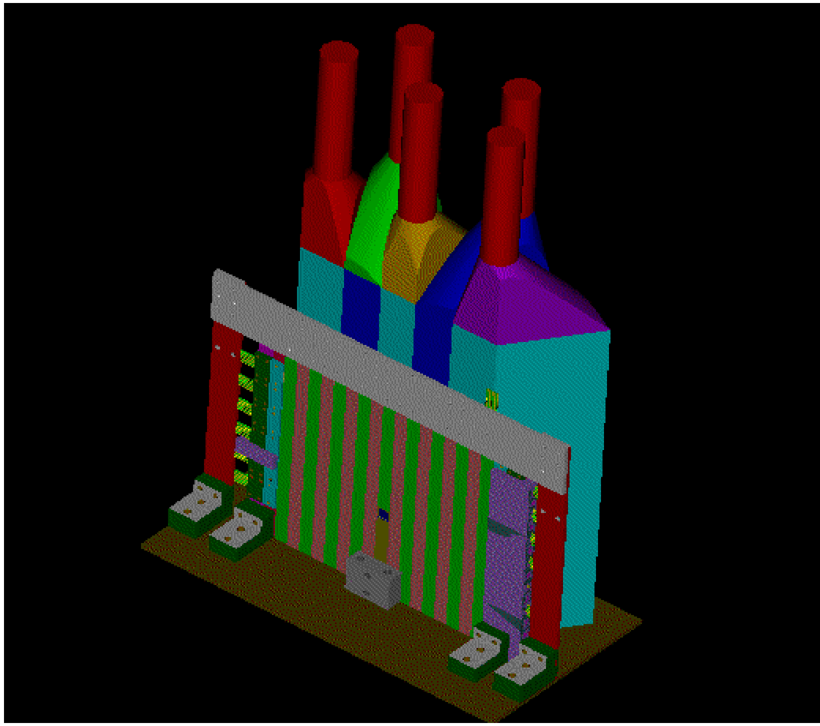
Stable isotopes to unstable

- To verify the K_{nm} found from the ISGMR we need to survey a wide range of nuclei from light to heavy and stable to unstable.
- Work has been done for medium to heavy nuclei but with a radioactive beam study can move from stable isotopes to unstable ones.
- But for this to work the inverse reaction needs to be studied.
- Normally alpha scattering is used to find the ISGMR but a target of ^{4}He is troublesome.
- Lithium (^{6}Li) can be used as a target because it has similar properties to ^{4}He.
- But with the lighter particle as a target there are more products of the reaction that need to be measured so the Decay Detector is needed.

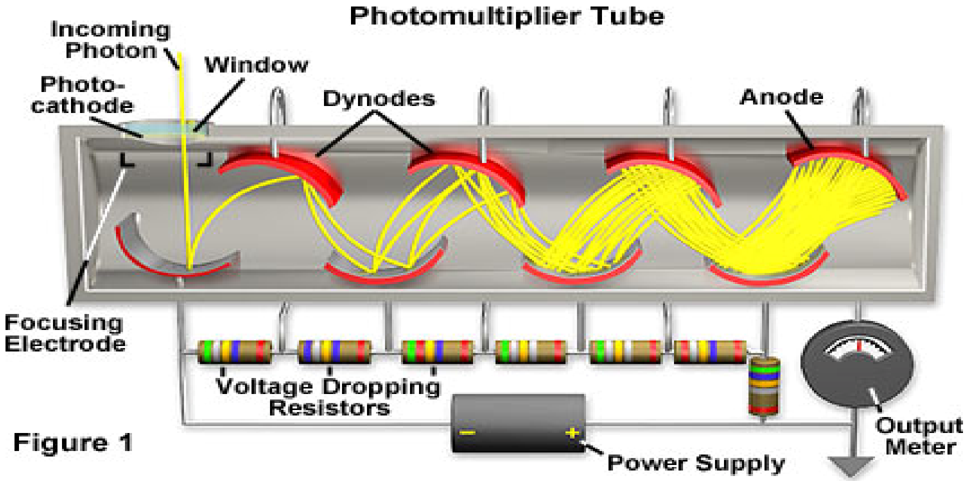


The Decay Detector

- The decay detector is made up of two layers of 1mm thin plastic scintillators one vertical and one horizontal to determine position.
- These scintillators are connected by fiber optics to photomultiplier tubes (PMTs)
- Also five larger scintillators to determine the energy of the products.



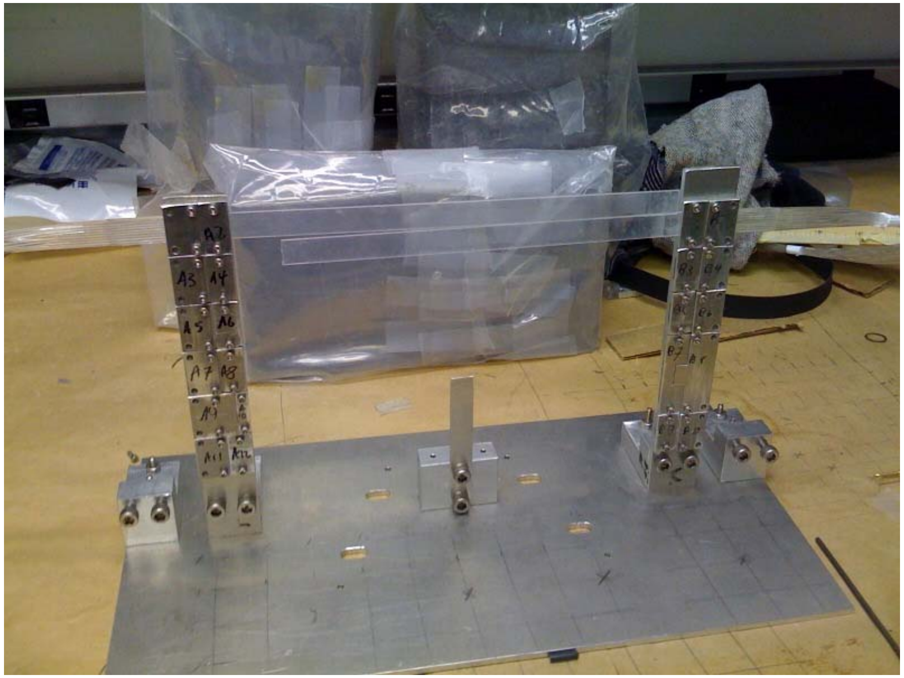
Photomultiplier Tubes



- Allows low numbers of photons to be detected.
- Incoming photons produce electrons by the photoelectric effect at the photo-cathode.
- These electrons are accelerated by a voltage difference between the dynodes.
- Also other electrons are emitted and accelerated eventually read at anode as a voltage pulse

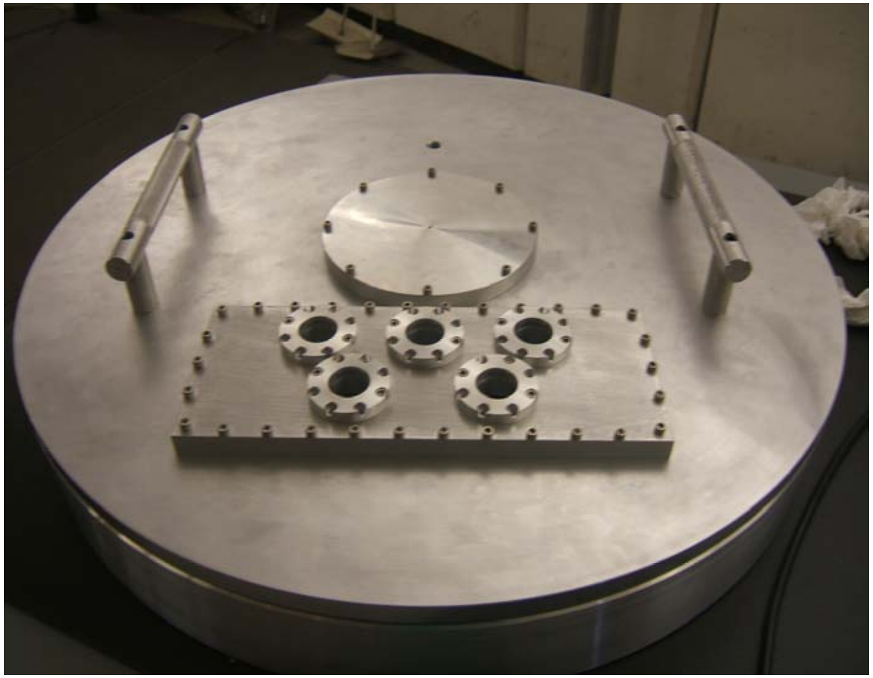
Progress so far…

- The decay detector is being built with lots of progress this summer.
- The horizontal frames are complete and the vertical frame is almost complete.
- The light guides for the larger scintillators are also being built



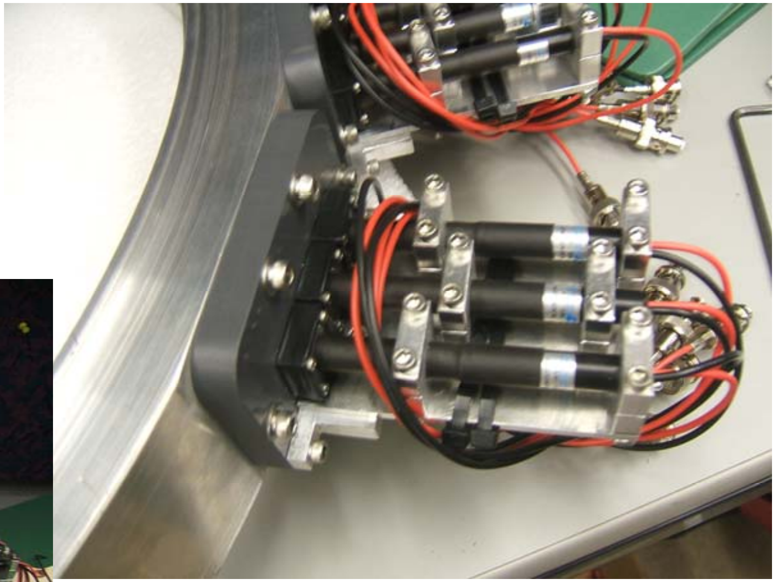
Progress cont.

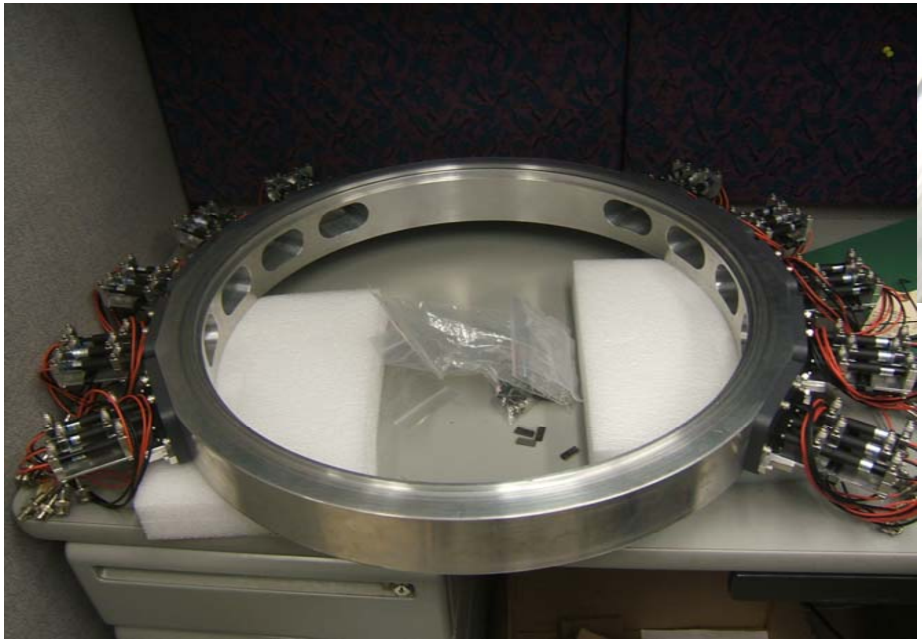
- The new lid for the target chamber with holes for the five larger scintillators is complete.



Progress cont.

The ring containing the PMTs for the grid of scintillators was completed this summer.

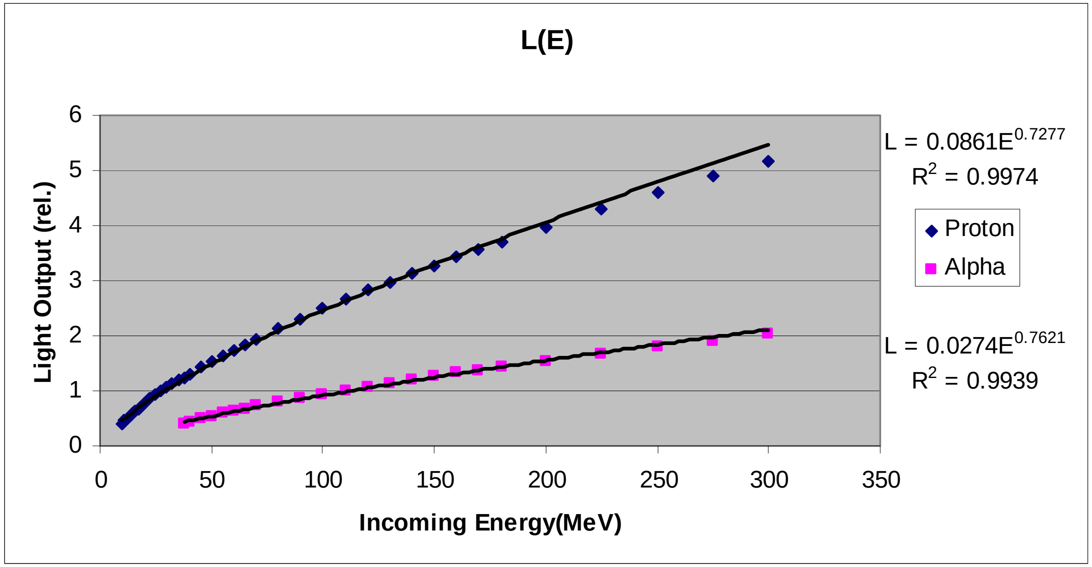


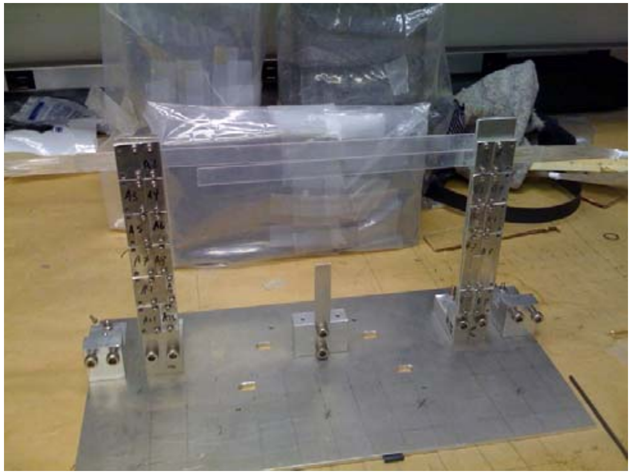


Testing

•Using a Strontium 90 beta source the setup of the scintillators was tested by moving the source around and using different wrapping and shielding of the fiber optics

•Also using SRIM a plot was made of the relative light output of the 1mm plastic scintillators.





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