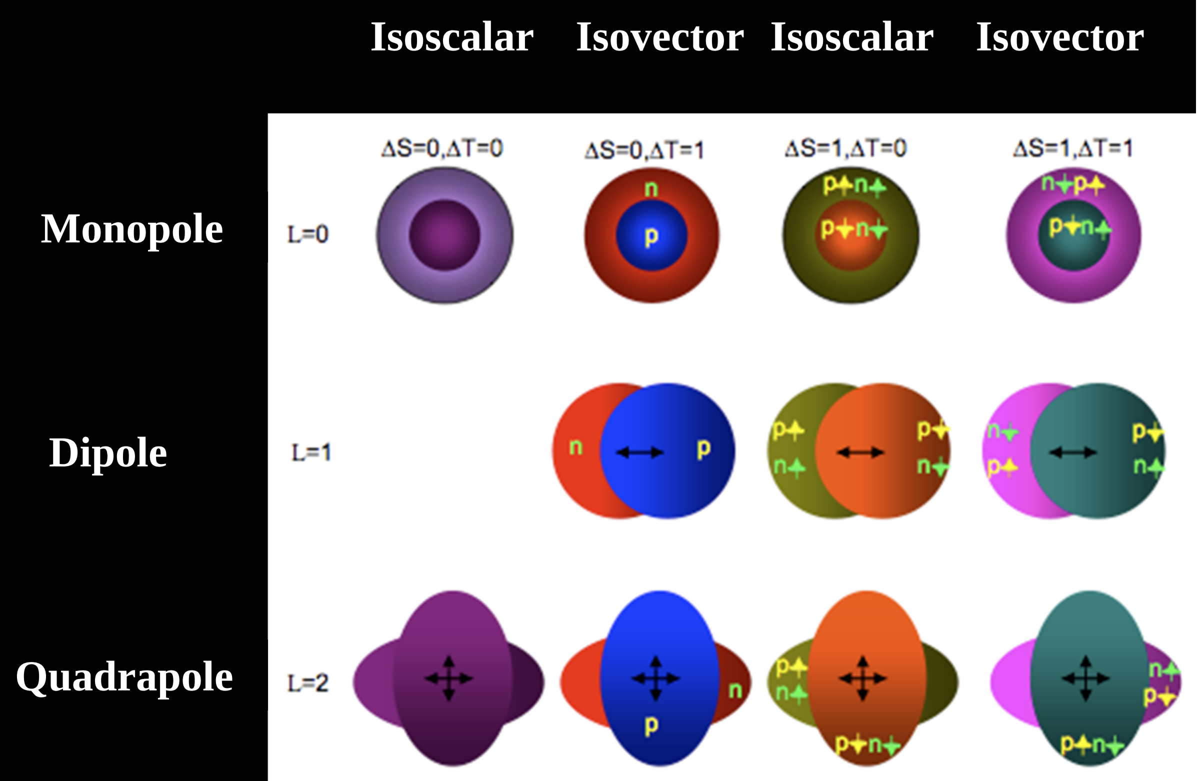
Light Collection Efficiency in Thin Strip Plastic Scintillator for the Study of ISGMR in Unstable Nuclei

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



Isoscalar Giant Monopole Resonance (ISGMR)

- ISGMR: the breathing mode

➢From studying the Isoscalar Giant Monopole Resonance (ISGMR), E_{GMR} can be determined

➢E_{GMR} can be used to find K_A,

➢K_A can be used to find K_{NM}

•K_{nm} is a quantity which describes a ground state property of nuclear matter

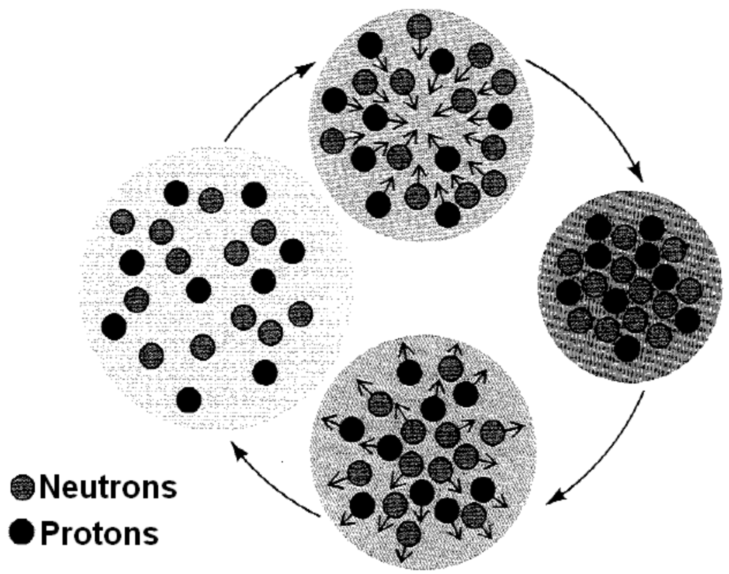
•Uses include:

➢Determining the nuclear equation of state

➢Neutron Stars

➢Supernova collapse

➢Heavy ion collisions



$$E_{GMR} = \sqrt{\frac{\hbar^2 A K_A}{m \langle r^2 \rangle}}$$

Unstable Nuclei

ISGMR in unstable nuclei:

- Determine the dependence of the nuclear incompressibility on (N-Z)/A
- Cannot successfully make a target out of unstable nuclei
- Study the inverse reaction

Normal Kinematics:

$$^{26}Si(^{6}Li,^{6}Li)^{26}Si*$$

Inverse Kinematics:

$$^{6}Li(^{26}Si,^{26}Si*)^{6}Li$$

Experimental Setup

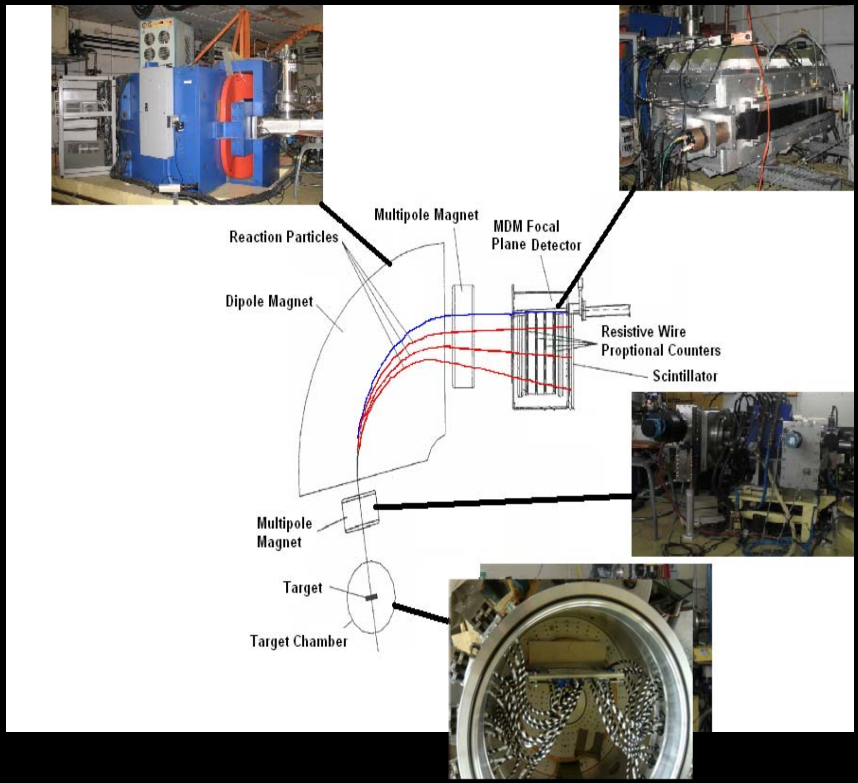
Decay detector:

- Detects decay by proton and alpha emission
- Particle type
- Angle
- Energy

Gas detector:

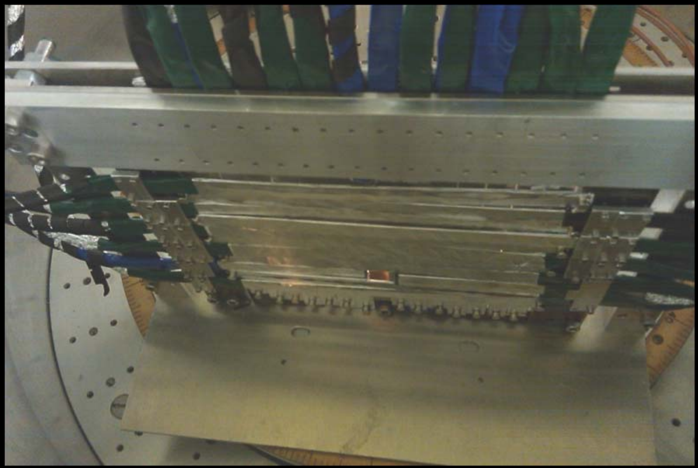
- Detects heavy ions
- Energy
- Angle

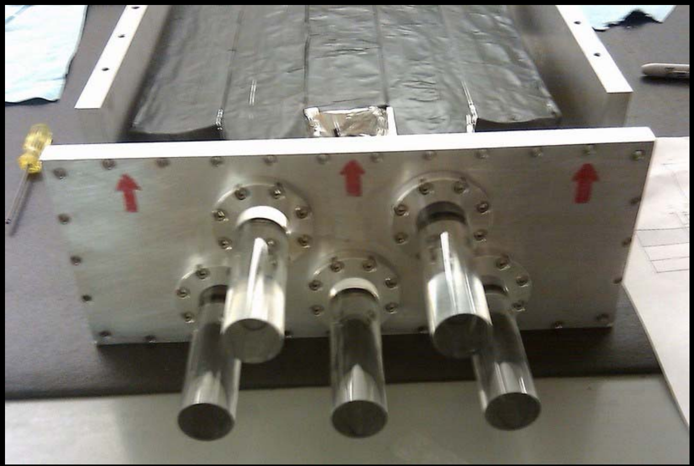
MDM



Measuring Protons and Alphas from Decay of ISGMR

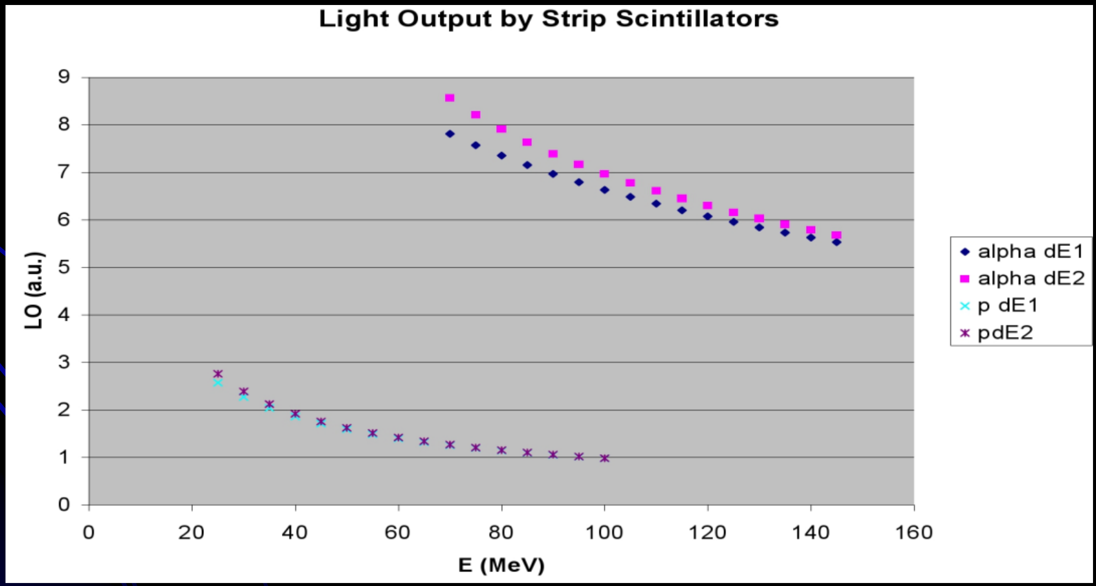
- Detector:
  - Layer of horizontal 1 mm thick scintillator strips
  - Layer of vertical 1 mm thick scintillator strips
  - 5 block scintillators
- Scintillator strips:
  - Angle
  - Energy loss
- Block scintillators:
  - Total energy
- Angular resolution ~4^{o}





Scintillators

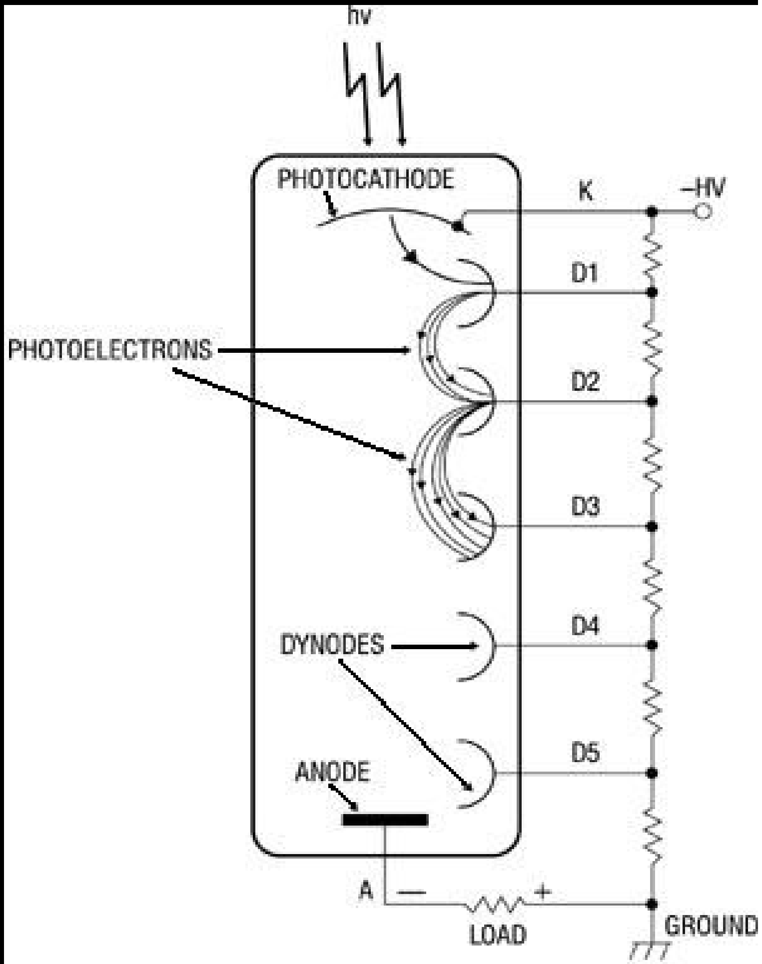
- Scintillator:
  - absorbs energy
  - emits light
- Particle:
  - Excites electrons
  - Photons are emitted as electrons return to low energy states.
- Photons are translated into an electrical signal by a photomultiplier which is coupled to the scintillator.



Calculation of light output in ΔE1 and ΔE2 for protons and alpha ions

Photomultiplier

- Photomultiplier:
  - Absorbs light
  - Releases Electrons via photoelectric effect at the photocathode
  - The cathode, dynodes, and anodes create a potential “ladder”
  - Electrons travel from the photocathode to the first dynode and excite more electrons in the dynode
  - Excited electrons leave the dynode and travel to the next dynode in sequence and repeats the process
  - At the anode all the electrons are collected and then amplify to create a readable current
- Increasing light collection efficiency:
  - Wrap the scintillators in reflective material



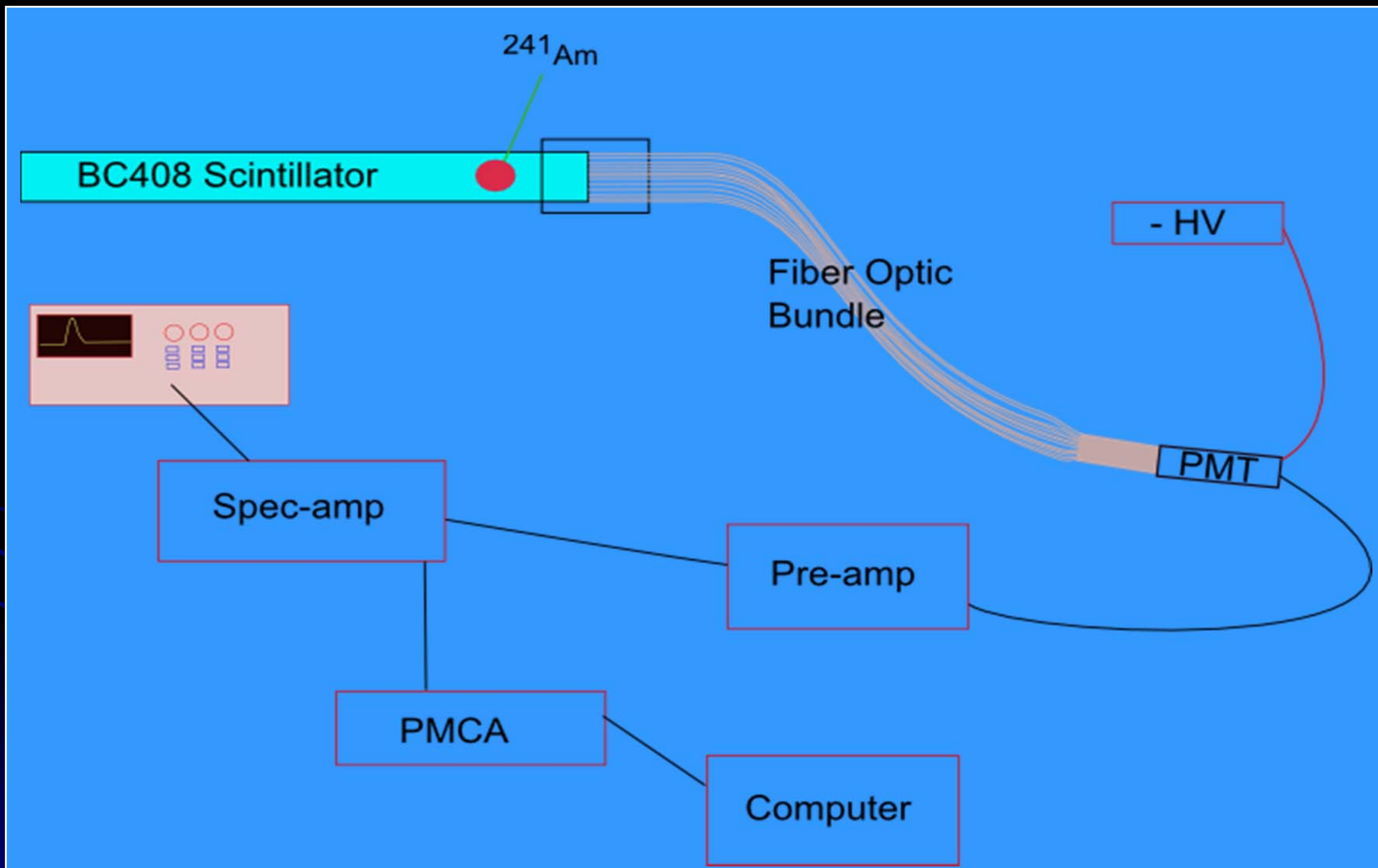
Scintillator Wrapping

- Wrapping:
  - Light tight
  - Reflective
- Reflective material:
  - Ensures the maximum number of photons enter the photomultiplier.
- Optimize the improved signal vs. the energy lost by the particle.

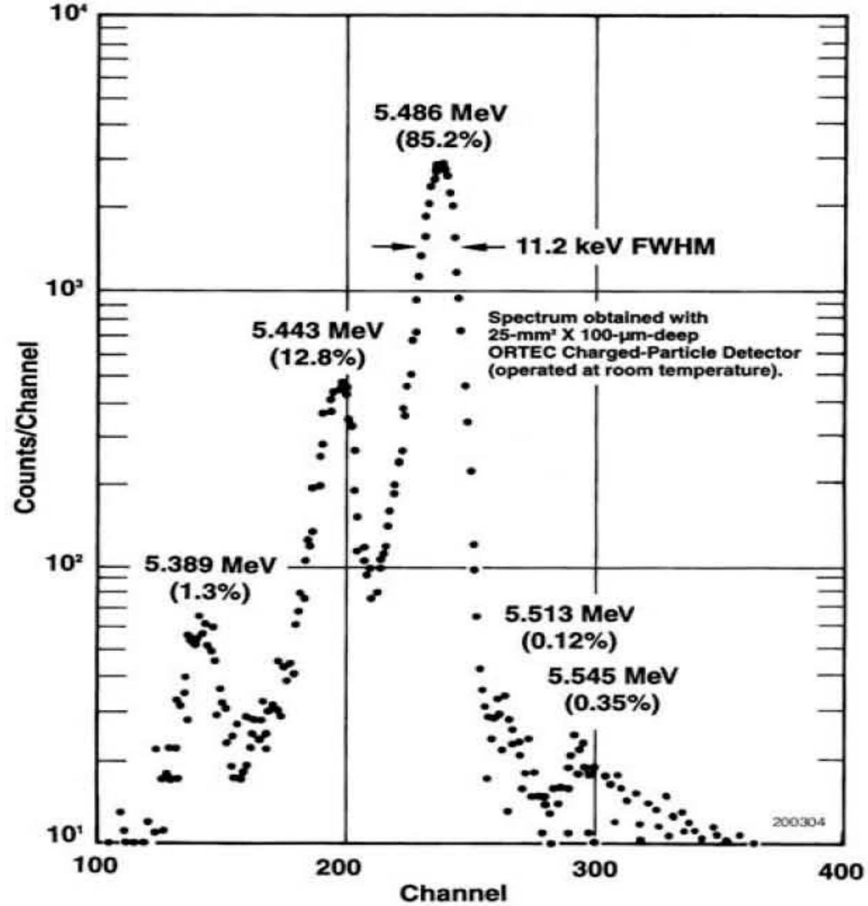
Types of Wrapping

- Aluminum foil
- Aluminized Mylar
- 3M Tyvek
- reflective paint

Scintillator Testing Setup

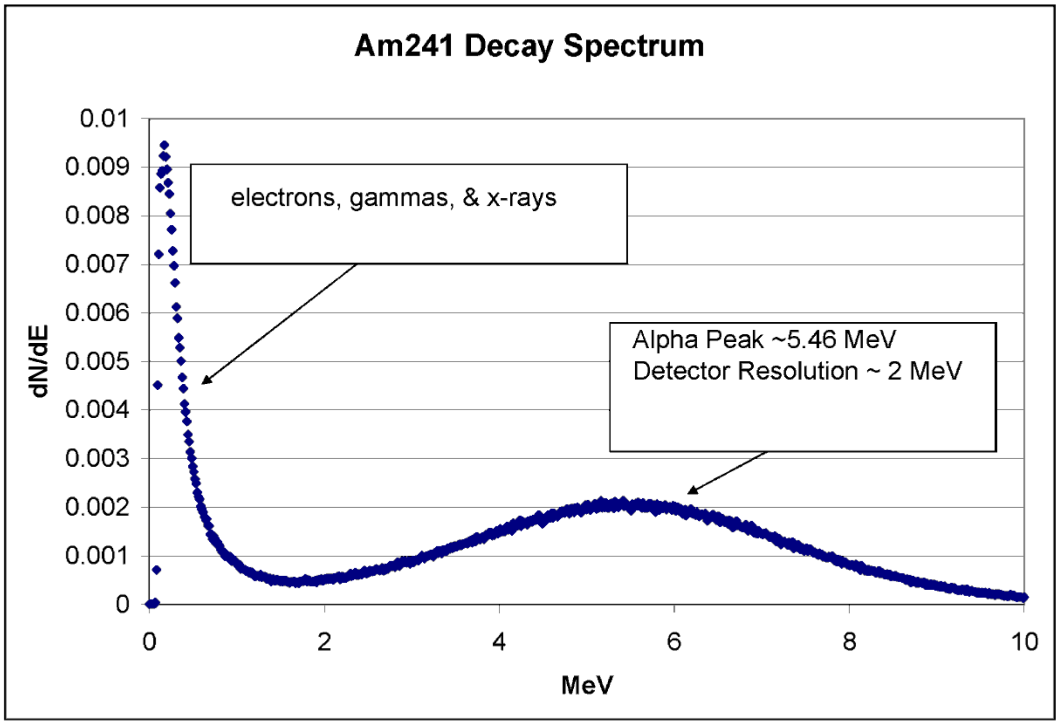


^{241}Am Spectrum

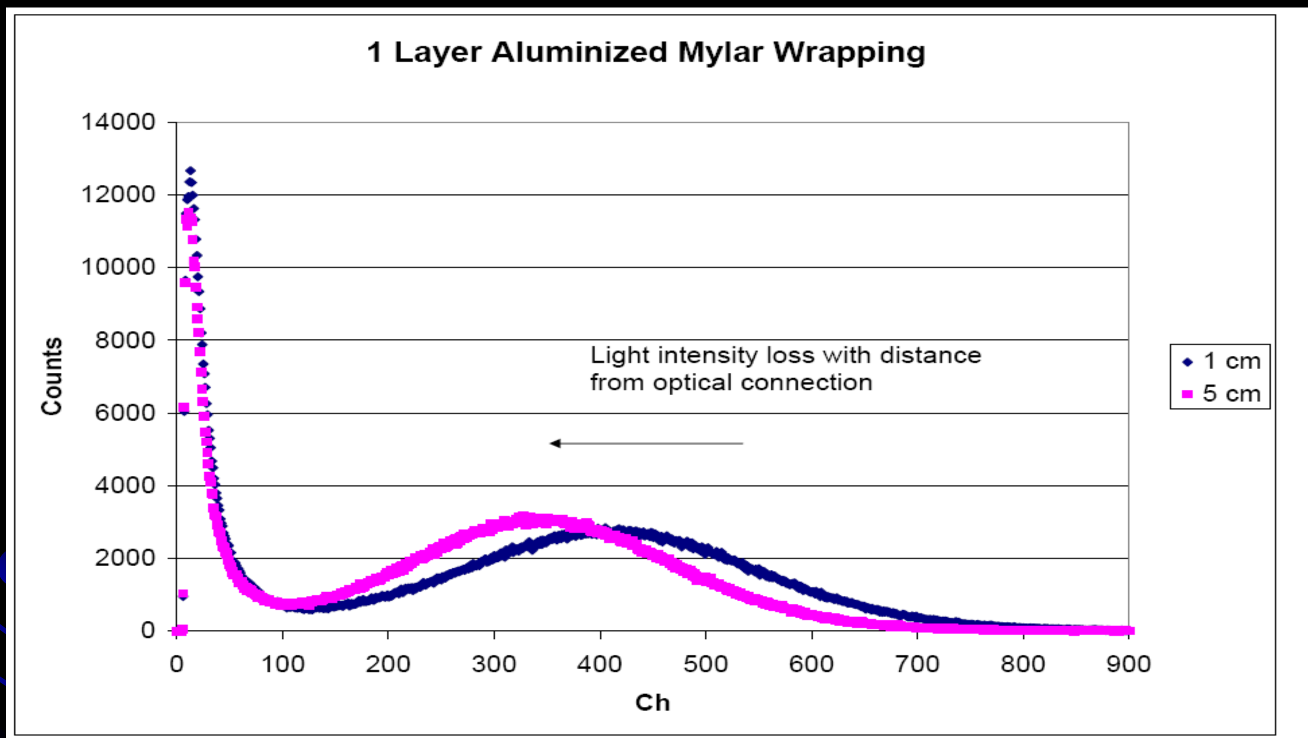


Typical ^{241}Am Spectrum Obtained with an ORTEC Partially-Depleted Detector.

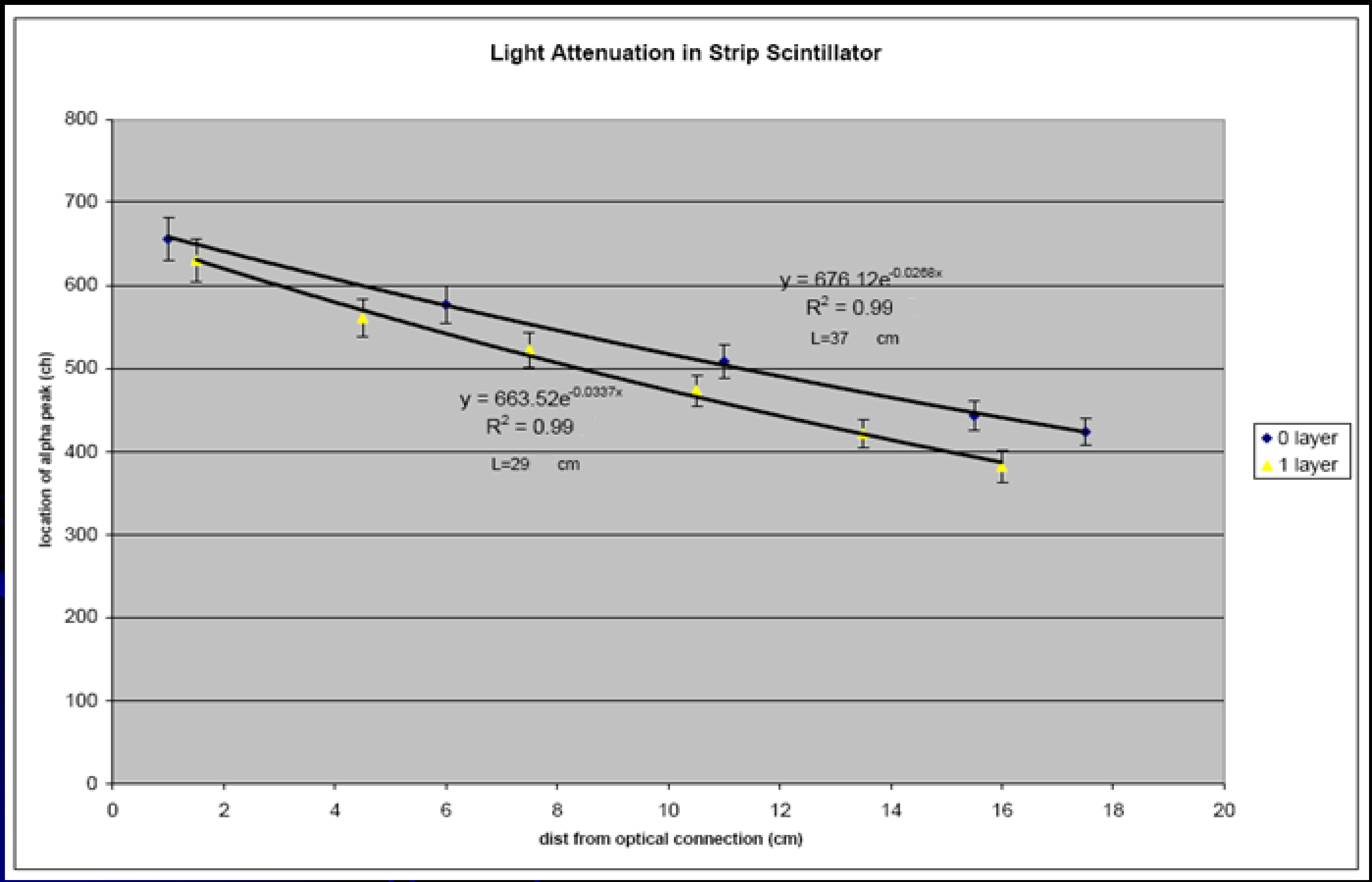
^{241}Am Spectrum



Spectrum Shift with Distance



Data



For 0 layer $A\_0 = 675 \pm 7$

$B\_0 = 37.6 \pm 0.8$

For 1 layer $A\_1 = 661 \pm 13$

$B\_1 = 30.0 \pm 1.5$

Testing

- Light proof box
- Scintillator to PMT coupling
- Calibrating electronics

Continuing Work

- Test various wrapping to determine the most effective type to use in the detector
- Assemble, test and use detector to study ISGMR in various unstable nuclei

Acknowledgements

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