Gamma-Ray Probes and Transfer Reactions

A. Couture

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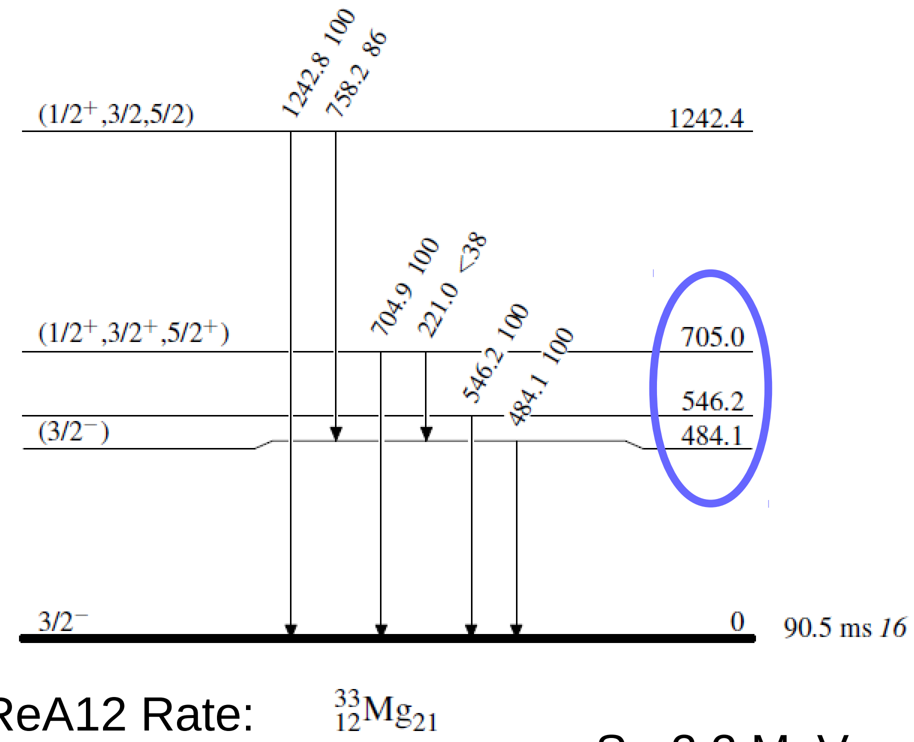
Opportunities with Gamma-Ray Detection

- Studies of statistical properties
  - Jack discussed in detail
- Level tagging for structure studies
  - Resolution enhancement for S_p studies
- Diagnostics
  - Isomer Populations
  - Contaminant population
- Each of these questions drives design decisions

Structure of ^{33}Mg

- Several state are closely spaced, making clean identification difficult, even with a HELIOS like instrument
- Additional gamma tagging can disentangle near-by states
- Photo-peak efficiency, resolution critical

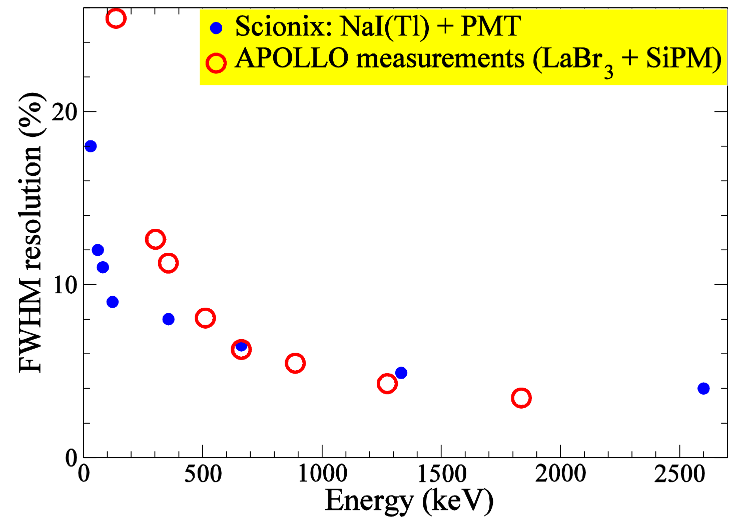


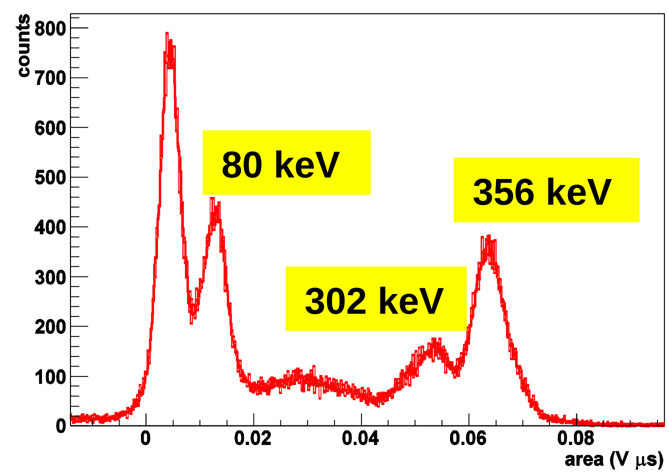
ReA12 Rate: $2x10^6$ pps

S_n=2.2 MeV

These questions *drive* design

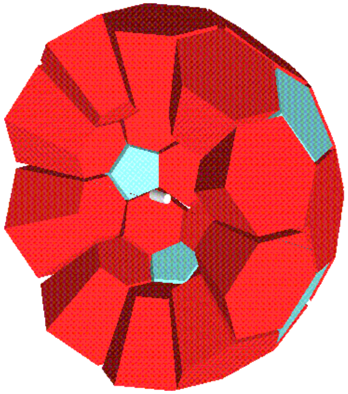
- Crystal type
  - What resolution is needed?
- Crystal depth
  - What energy photons need to be measured?
- Geometry
  - Close-packed vs. open geometry
- Efficiency

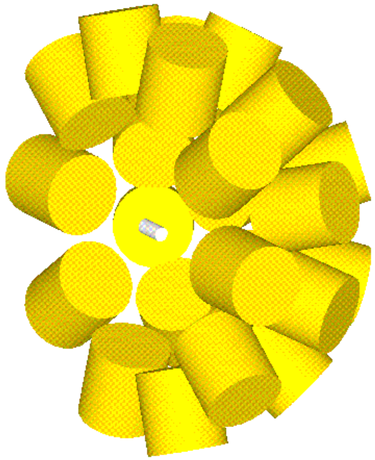




Geometry Options

- "Soccer-Ball"
  - Offers highest efficiency, add-back
  - Discussion of a close-packed array for use with HRS—sharing may be possible
  - Larger areas for light collection
  - More challenging for mounting
- Cylinder Design
  - Easy construction for crystals and array
- Close-Packed Hexagons (MTAS Style)
  - Highest Efficiency
  - Not well suited to solenoid measurements





Material and Crystal Depth:

Are Eγ > 1.5 MeV Needed?

Scintillator	Light Yield (photons/keV)	1/e Decay time t(ns)	F. O. M. √(t/LY)	Wavelength of maximum emission λm (nm)	Refractive index at λm	Density (g/cm^3)	Thickness (cm) for 50% attenuation (662keV)	Resolution 662 keV	Efficiency 1332 keV
NaI(Tl)	38	250	2.6	415	1.85	3.67	2.5	7.00%	"1"
BrilLanCe™ 350	49	28	0.8	350	~1.9	3.85	2.3	3.10%	
BrilLanCe™ 380	63	16	0.5	380	~1.9	5.08	1.8	2.90%	1.43
BaF2	1.8	0.7	0.6	~210	1.54	4.88	1.9	8.50%	1.43
PreLude™ 420	32	41	1.1	420	1.81	7.1	1.1		
BGO	9	300	5.8	480	2.15	7.13	1.0		
CLYC	**20**	**900**		**390**				**5.1**	**~1**

Most data from St. Gobain data sheet, CLYC data from Glodo et al, IEEE Trans. Nucl. Sci. **55** (2008) 1206.

SiPM Technology Advances

- For Apollo
  - Wavelength shifter needed for $LaBr_3$
  - Packaging options limited
- Blue sensitivity has been enhanced
  - Performance near PMT resolution
- Versatile 3-6mm surface mount design allows custom shaping of light readout
  - Improves dark current as well as less “dead” cells
- Technology is changing VERY quickly

Detector Sharing Options

- Apollo detectors are available, though likely not optimal
- Hagrid $LaBr_3$ array was designed with detachable PMTs
  - 2x2" and 3x3" cylinders
  - Is geometry right?
    - 2x2" is too shallow for PSF studies, 3x3" may be difficult to pack
- Scintillator arrays for HRS may have similar concerns (B-field sensitivity)
- Any of these options would want a new SiPM array set

Conclusions

- Gamma-detection should be considered in the physics justification and design process for a solenoid spectrometer
- The proof-of-principle has been completed—at this stage, we should consider in detail the requirements for where we need to be in 10 years
- Beams will always be less intense than hoped—efficiency will always be in short supply