Super scintillator arrays
(New high-resolution materials, high-energy gammas)

Working group breakout session – Agenda February 20

[chair: Partha Chowdhury*****/U. Massachusetts Lowell] [***Conveners**]

- Introduction and comments on international context [Walter Reviol*****/Washington U.]
- Application I: Giant resonance studies with large scintillator arrays [Robert Varner/Oak Ridge National Lab.]
- Application II: Spectroscopy with CsI(Na) array using fast beams [Dirk Weisshaar/Michigan State University]
- Application III: Electronic-timing lifetime measurements in-beam and decay [Volker Werner*****/Yale U.]
- Application IV: Experiences with the DANCE BaF_2 calorimeter [Aaron Couture/Los Alamos National Lab.]
- Advances in scintillators and related technologies ***and*** Investigations of new neutron scintillators [Jarek Glodo/Radiation Monitoring Devices]
- Liquid xenon detector [Dan McKinsey/Yale U.]
- Related issue: Ge strip detector [Kim Lister/Argonne National Lab.]

Questionnaire: ***http:/fribusers.org/3_GROUPS/13_SCINT/scint_quest.pdf***

Super Scintillator Arrays – general observations

Philosophy: Discuss a versatile scintillator array using emerging technologies

Start without "pre defined" project (like e.g. GRETA, HELIOS)

Encompasses a broad range of physics topics

Identified four principal applications - see agenda (More out there.)

Considerable overlap with other groups: decay-station, low-energy neutron detection

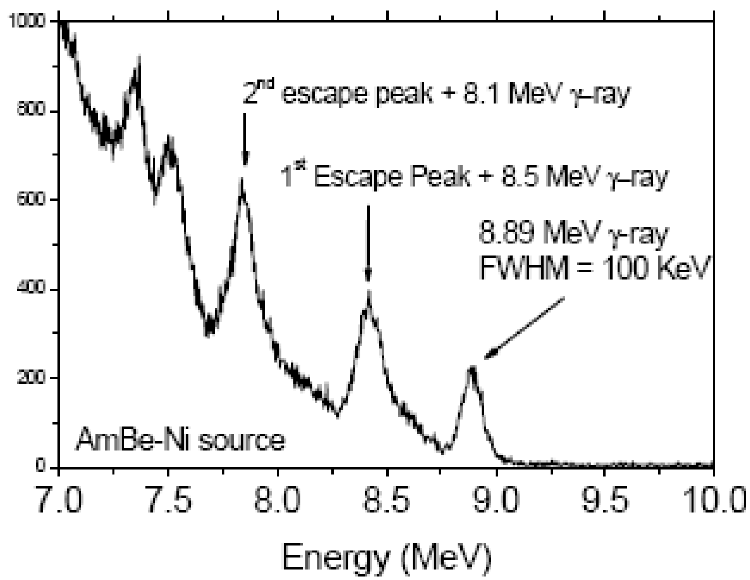
Decisions of detector material and principal geometry will eventually be driven by specifics of physics application

Why LaBr3?

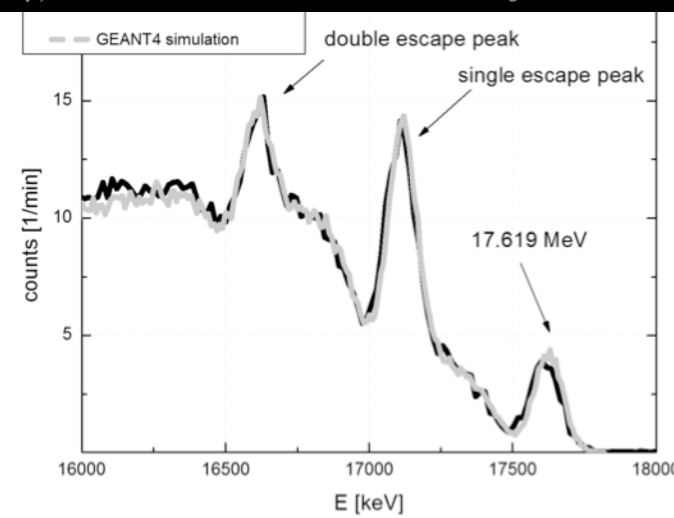
PARIS
European project
Contact: A. Maj

- large light output (>60000 ph/MeV)
- high efficiency (>60% up to 10 MeV)
  - spectroscopy far from stability
- energy resolution (3% at 662 keV, 0.6% at 18 MeV)
  - spectroscopy far from stability
- time resolution (~250 ps)
  - discrimination against neutrons by TOF
- fast light pulse decay (~16 ns)
  - high counting rate capability
- very good temperature stability,worldwide interest, also in medical sector

Milan group: Source and 3”x3” crystal



Debrecen-Sofia-Orsay-Krakow group: (p,γ) reaction and 2”x2” crystal

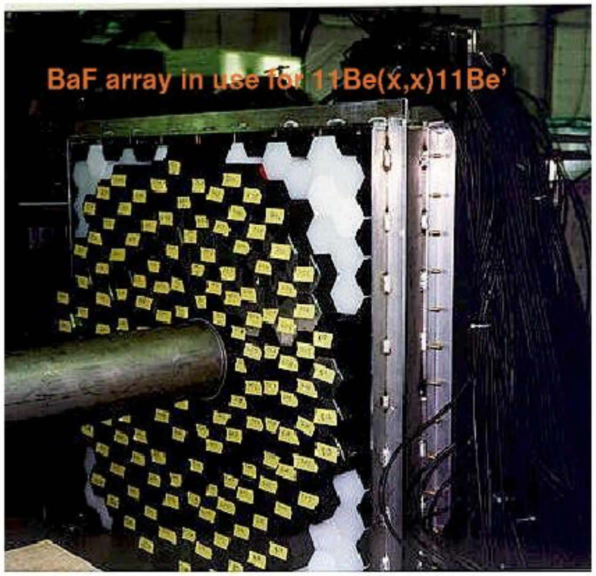


M. Ciemała et al., NIM A608, 76 (2009)

R. Varner

Super Scintillator array needs

- Large solid angle
- High stopping power
- High Efficiency
  - Trigger
  - Full pulse energy
- Neutron-gamma separation – time-of-flight?
  - Neutrons emitted in the rest frame of projectile are 100 MeV neutrons in the laboratory frame.
  - Use BaF_2 at forward angles?
- Distinguish background
  - Internal radioactivity
  - Cosmic rays



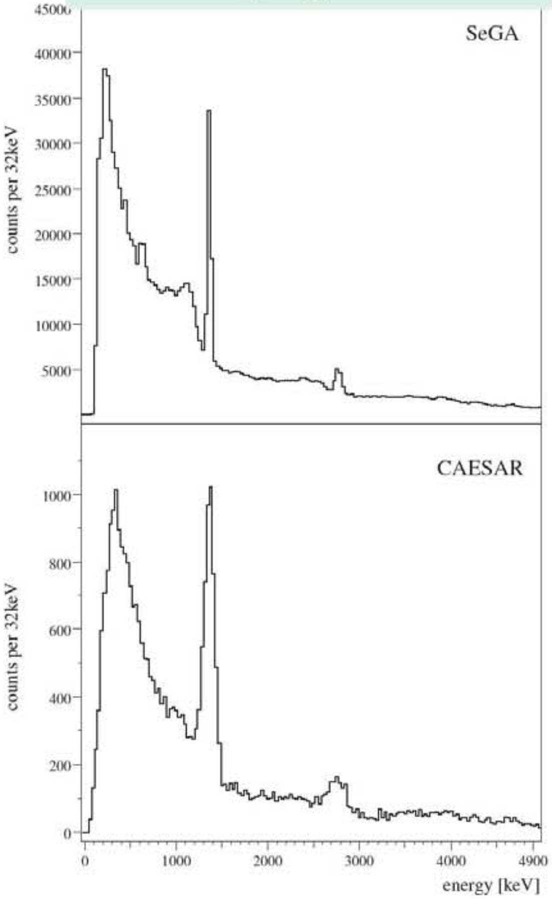
Present ORNL BaF_2 array
Used different configuration

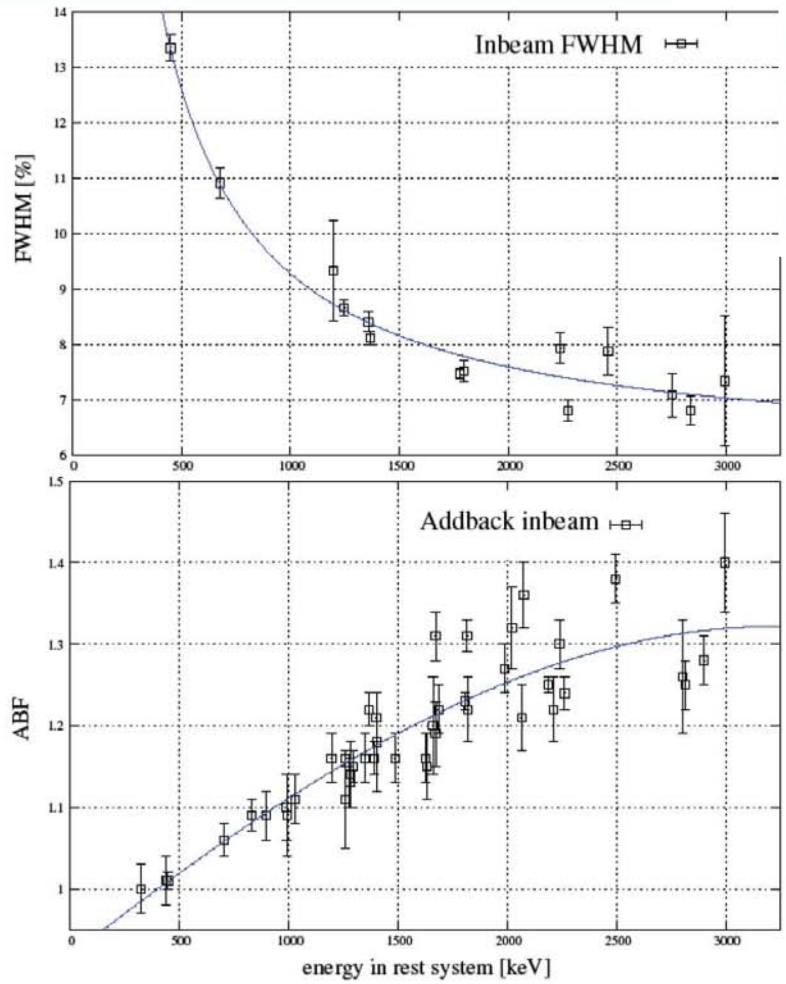
Main application:
Giant-resonance studies

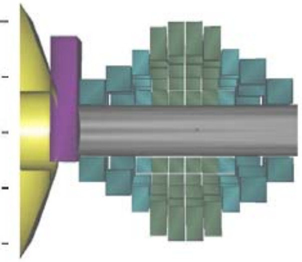
D. Weisshaar et al. CAESAR array, fast beams, thick targets

In-beam performance

^{24}Mg, v/c=0.35
via secondary fragmentation on Be







Would profit from better Energy and Time resolution.

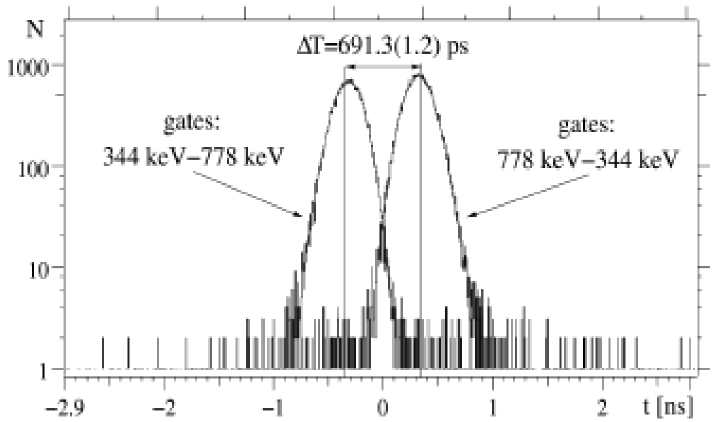
Costs?

CAESAR = 144 + 48 CsI(Na) crystals
Simple detector shape, large s.a. coverage (40% efficiency)
Not spherically symmetric

Offset calibration measurements using the standard ^{152}Eu γ-ray source

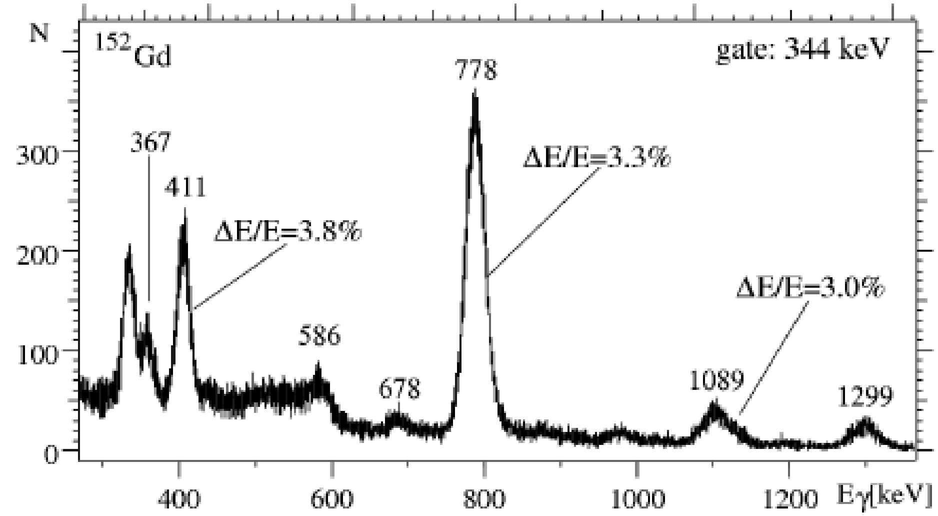
The first 2^+ state at 344 keV in ^{152}Gd;
NNDC: τ=46.8(2.5) ps

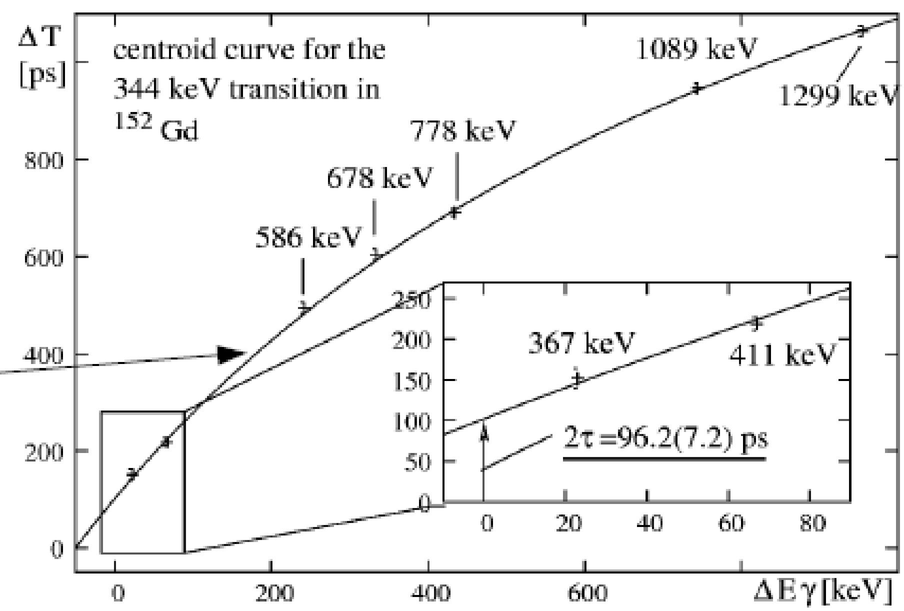
γ–γ time spectra



ΔT=offset+2τ

LaBr$_3$(Ce) coincidence γ-ray spectrum





fit function f(ΔE) from
J.-M. Régis, Diploma Thesis (2007)

Courtesy J.-M. Regis, Cologne

V. Werner, Electronic timing with BaF$_2$ and LaBr$_3$

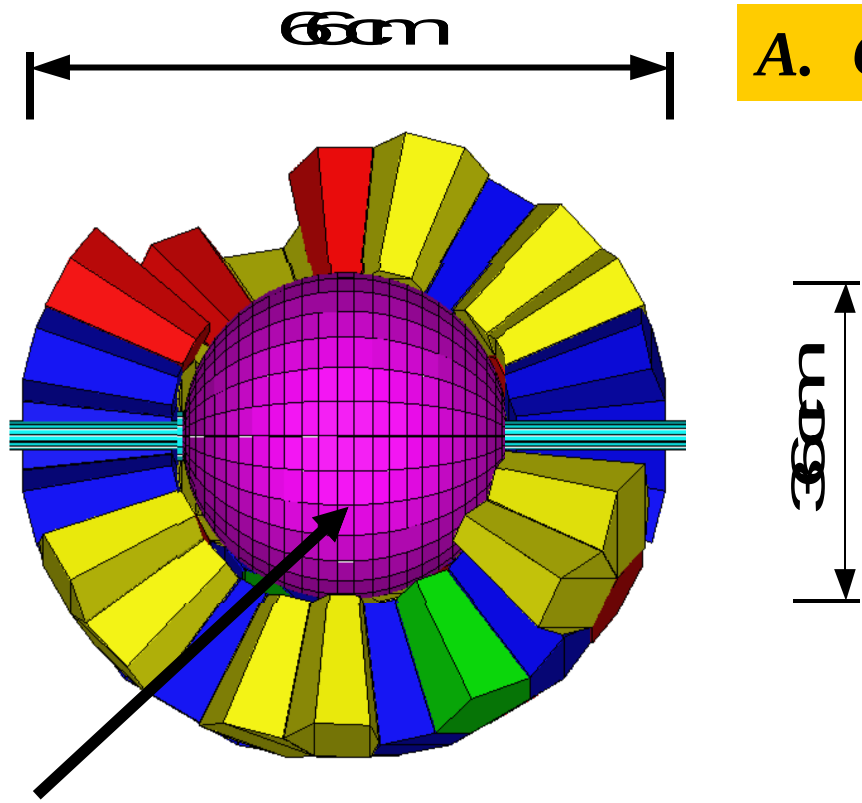
The Detector for Advanced Neutron Capture Experiments (DANCE)

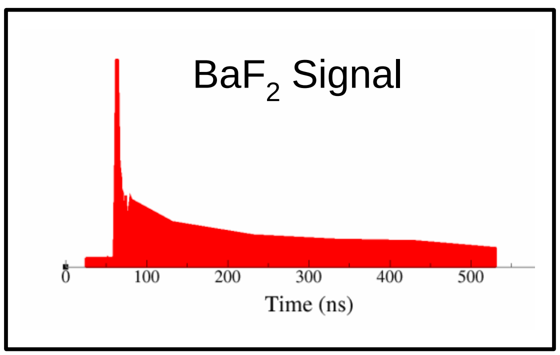
A. Couture

160 BaF_2 Scintillators

4 Detector Shapes each
covering the same
solid angle

90 % efficiency





^{6}LiH Shell Surrounds Sample (6cm)

gamma calorimetric expts. to determine n-capture cross section

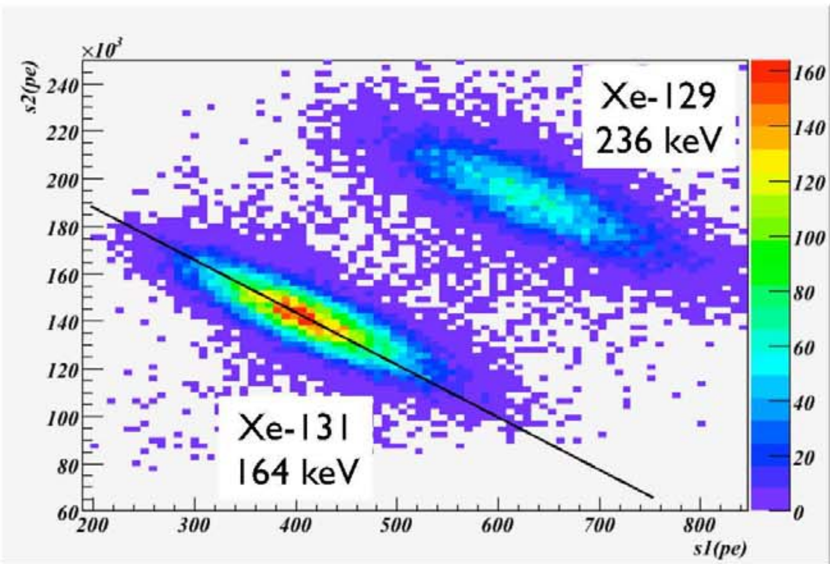
related to calorimetry to determine gamma feed/strength function

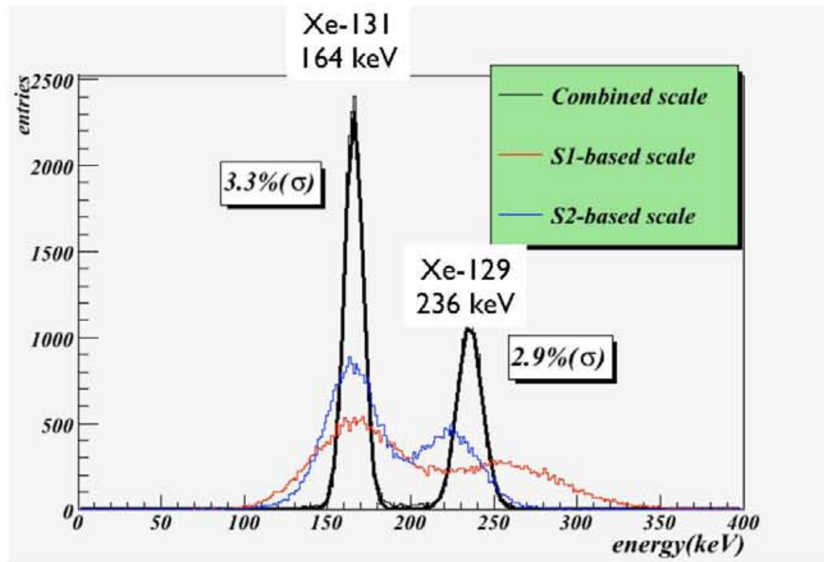
D. McKinsey

<u>Liquid Xe (available in large quantities, $1000/kg)</u>

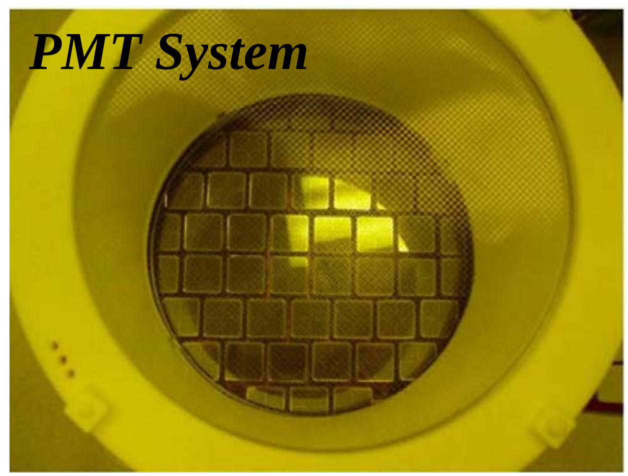
excellent stopping power (atten. length = 6cm @ 1 MeV); brightness comparable with NaI(Tl)

mm-position resolution (if needed) using wire readout, -n discrimination capabilities



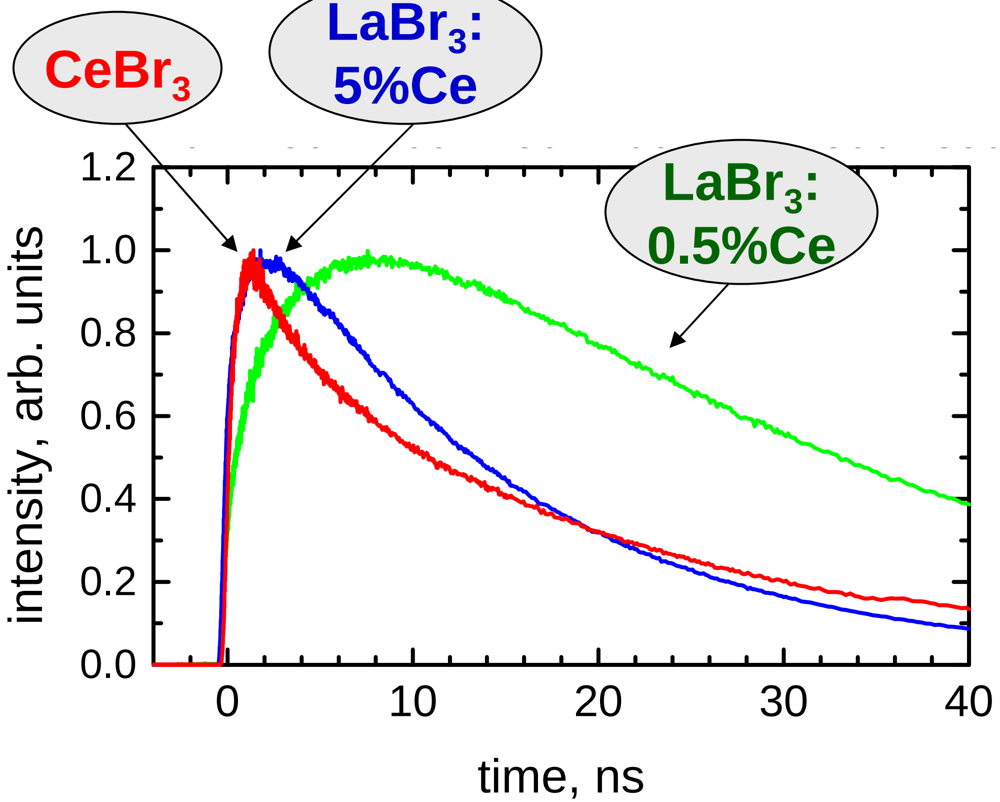


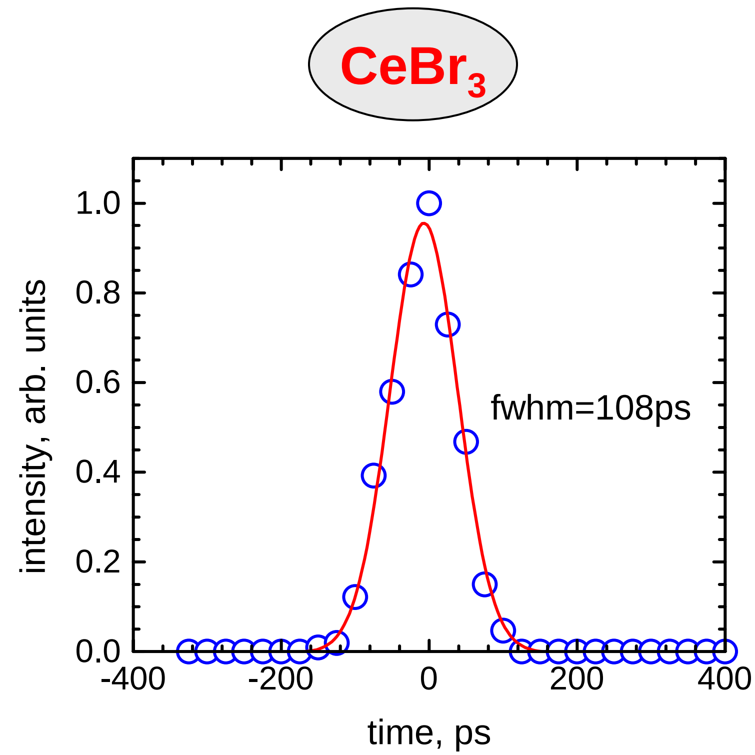
Built for particle-physics applications (WIMP search)



J. Glodo (Radiation Monitoring Devices, Inc.)

Timing Properties of $LaBr_3$:Ce/$CeBr_3$



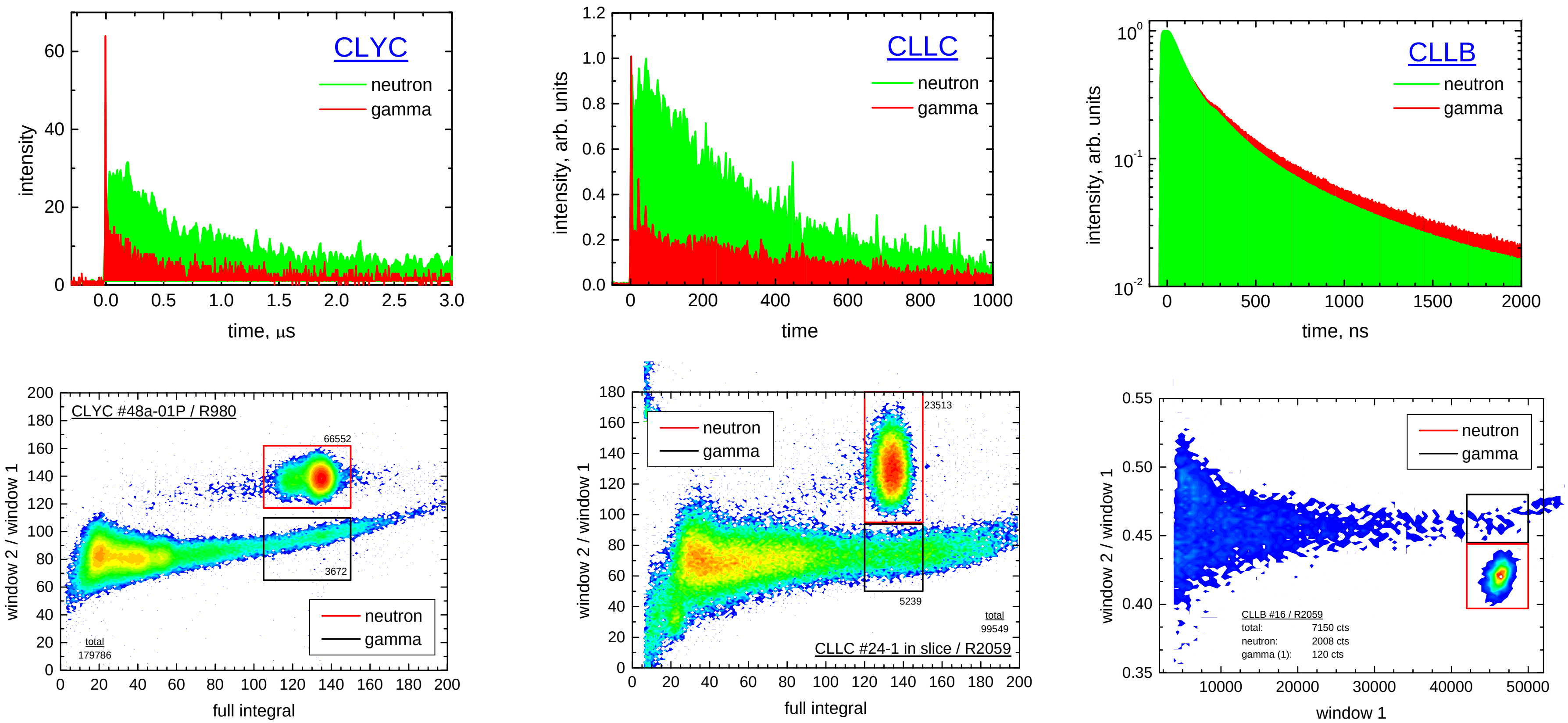


Resolution dependence on dopant concentration

Glodo – continued (“elpasolites”)

Pulse Shape Discrimination – overview

CLYC CLLC CLLB



<u>Example:</u> CLYC = Cs_2LiYCl_6:Ce (n-detection capability based on Li component)

Conclusions about HpGeDSSDs

Kim Lister

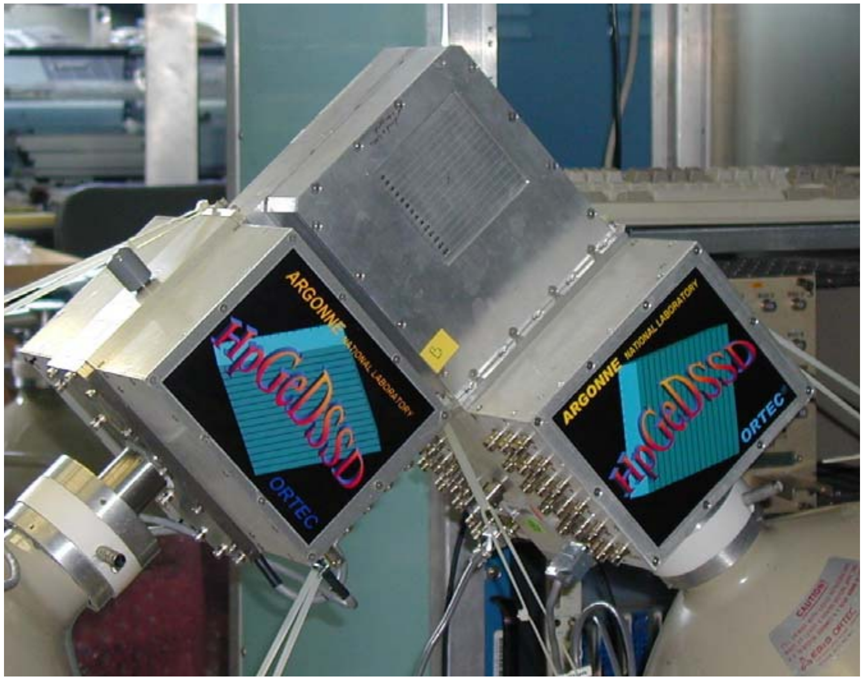
High efficiency, position sensitive gamma arrays are critical for exploiting the physics opportunities offered by FRIB beams.

Planar germanium wafer detectors are STILL in their R&D phase. Many technical issues need more work, but have been demonstrated to be feasible.

HpGeDSSDs have great potential to be used in compact “decay” spectrometer with many attractive features essential for exploiting FRIB beams.

Potential for detection of particles.

NEEDS R&D and INVESTMENT NOW



Super Scintillator Arrays – status, next steps

Equipment ideas compiled, but no consensus/decision on either a specific Detector material or for a principal geometry

Current commercially available materials are $LaBr_3$:Ce , $LaCl_3$:Ce. Alternative materials include CLYC (Cs_2LiYCl_6 , n-gamma PSD)

Need to sharpen physics case (and possibly prioritize various physics applications) to converge on a specific design/concept/proposal

Cost estimates will depend on specific design

Questionnaire: ***http:/fribusers.org/3_GROUPS/13_SCINT/scint_quest.pdf***