Update on Detector Development for the PARIS Project

Oliver J. Roberts

PARIS Meeting, IFJ PAN Krakow, Poland 2009

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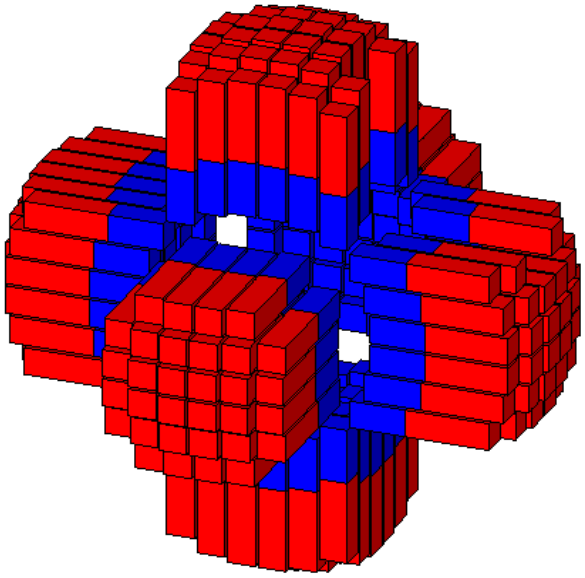
Outline



- Motivation
- Apparatus & Signals
- Phoswich Tests
- Pile-Up Test
- Non-Linearity
- Tests with a Novel SensL LAAPD
- Summary & Conclusions
- Future Work

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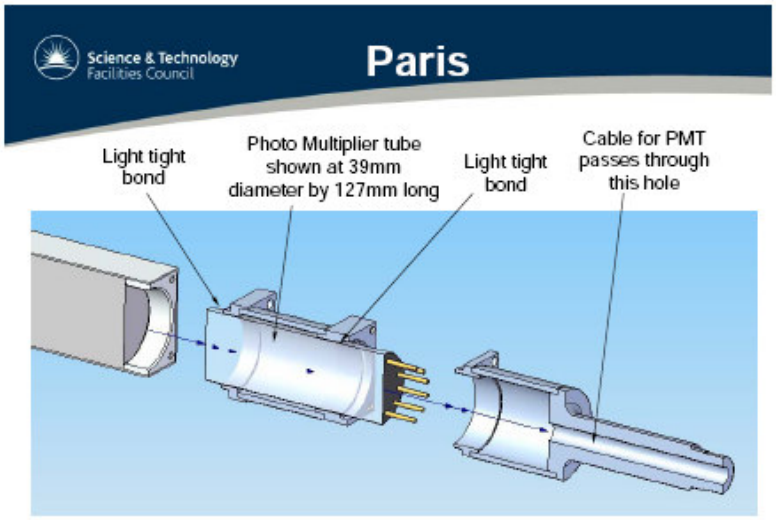
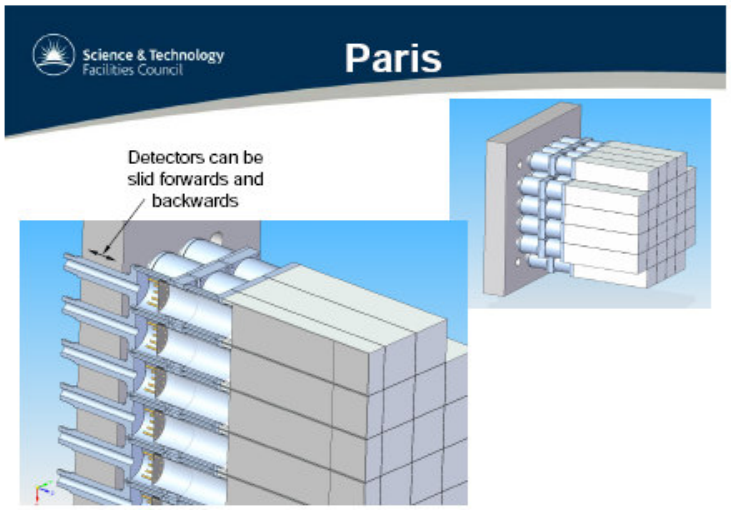
Motivation: PARIS

- Energy range between 100keV and 50MeV
- Two shells of $LaBr_3(Ce)$ and CsI(Na) crystals
- Different decay times allow for discrimination of signals
- Moveable source distance, more physics cases





Images courtesy of J.Strachan (STFC)

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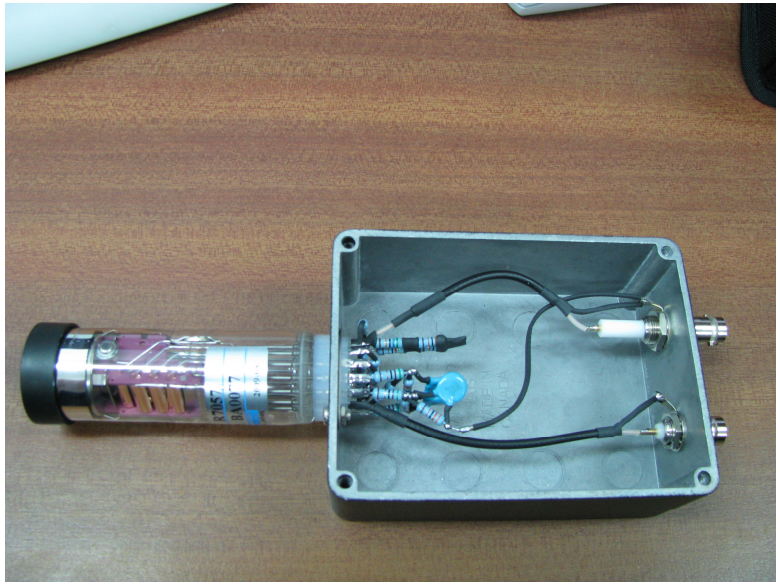
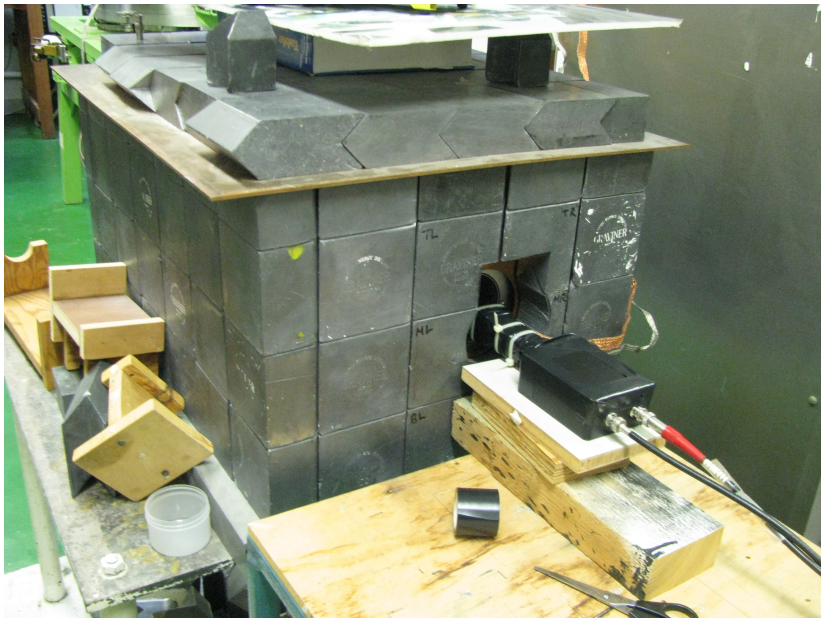
Apparatus & Signals



- A Hamamatsu R7057 PMT was bought and a voltage divider was built to a the specifications of a compatible V.D used in previous experiments.

Apparatus & Signals



- Phoswich detector contains 2”x2”x2” $LaBr_3$:Ce and 2”x2”x6” CsI:Na detectors coupled with Epoxy resin.

- ORTEC 572 Amplifier used for shaping, HV -1200V used.

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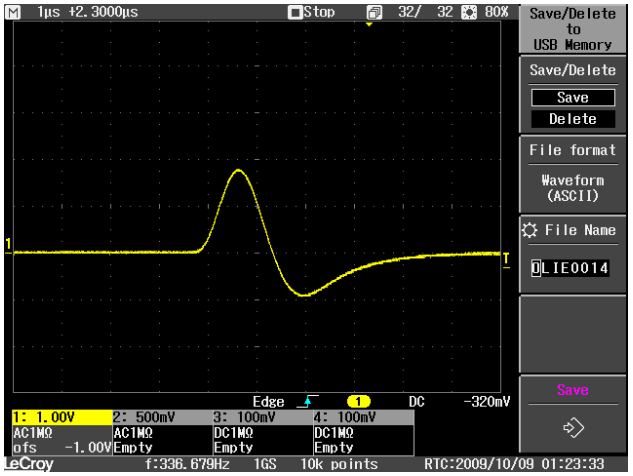
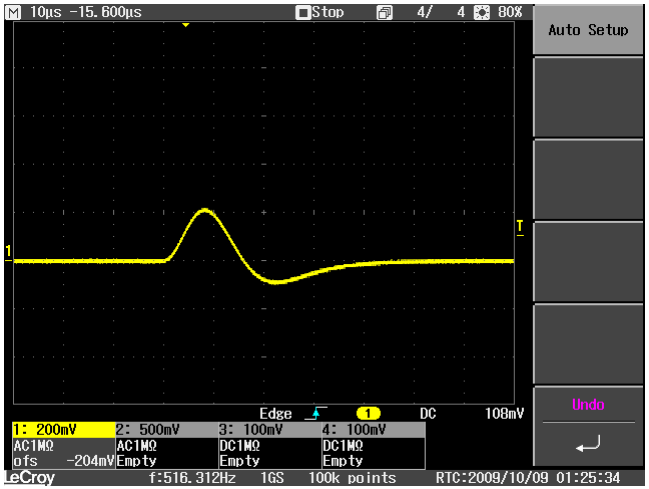
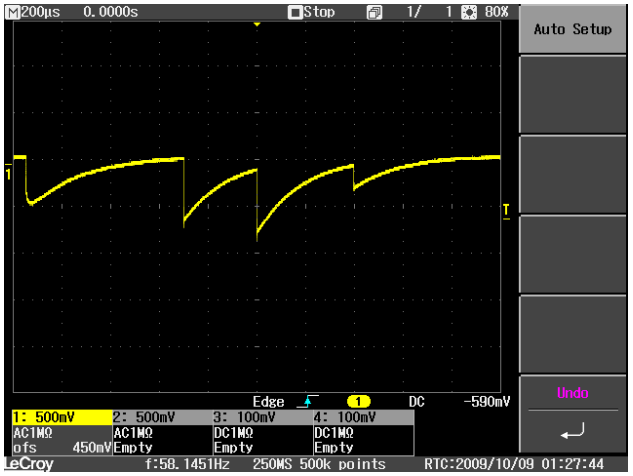
Apparatus & Signals







- With Unipolar output from Amp, see Bipolar distribution.

- An Amplifier with a faster S.T might be needed to read off the last dynode.

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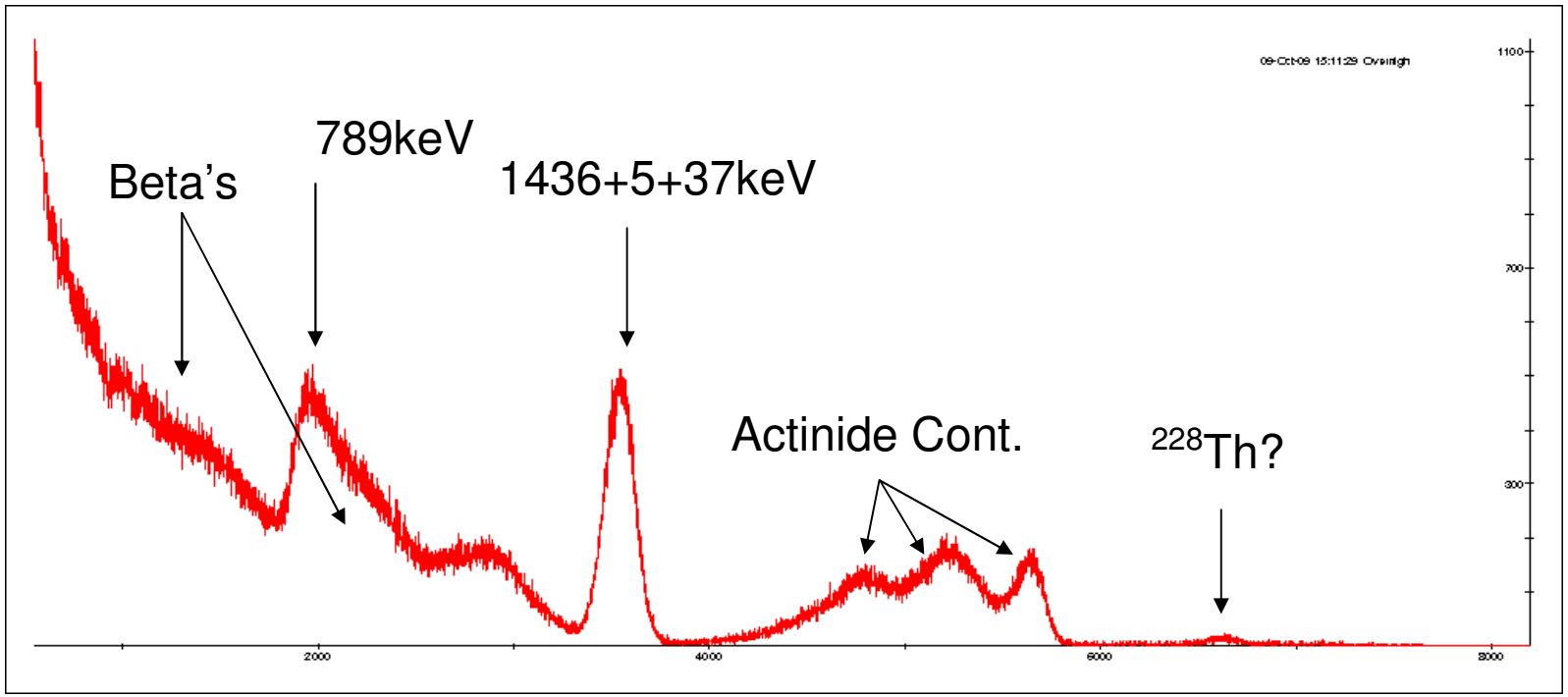
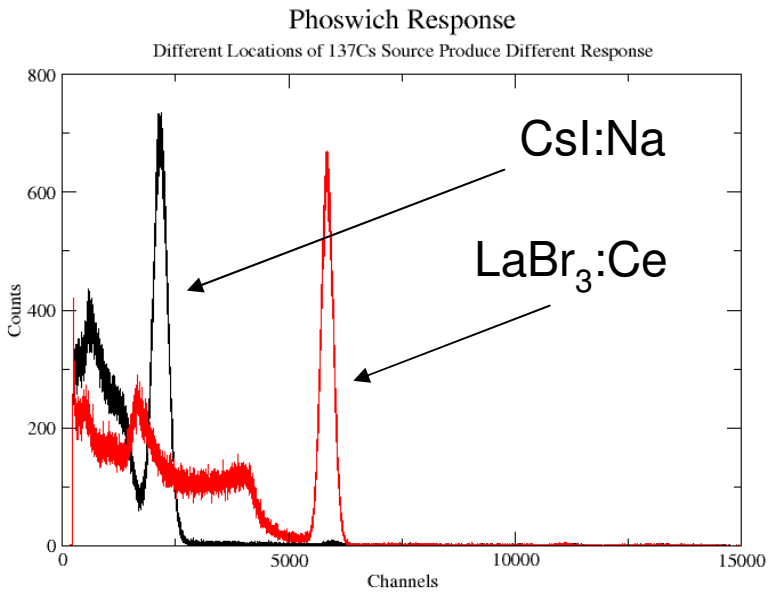
Phoswich Tests: Background Spec.



- Lower channels cut due to K-Shell X-Rays Intensity.
- FWHM @ 1436keV is 169.10keV, Resolution 4.77%
- Gamma from ^{228}Th evident at ~2.6MeV?

Phoswich Tests: Previous



- $LaBr_3(Ce)$ ~ 5%, CsI(Na) ~ 7.7% @662keV.
- Shaping Time 250ns (much faster), HV = -1500V
- Tests were done at the IPHC in Strasbourg.

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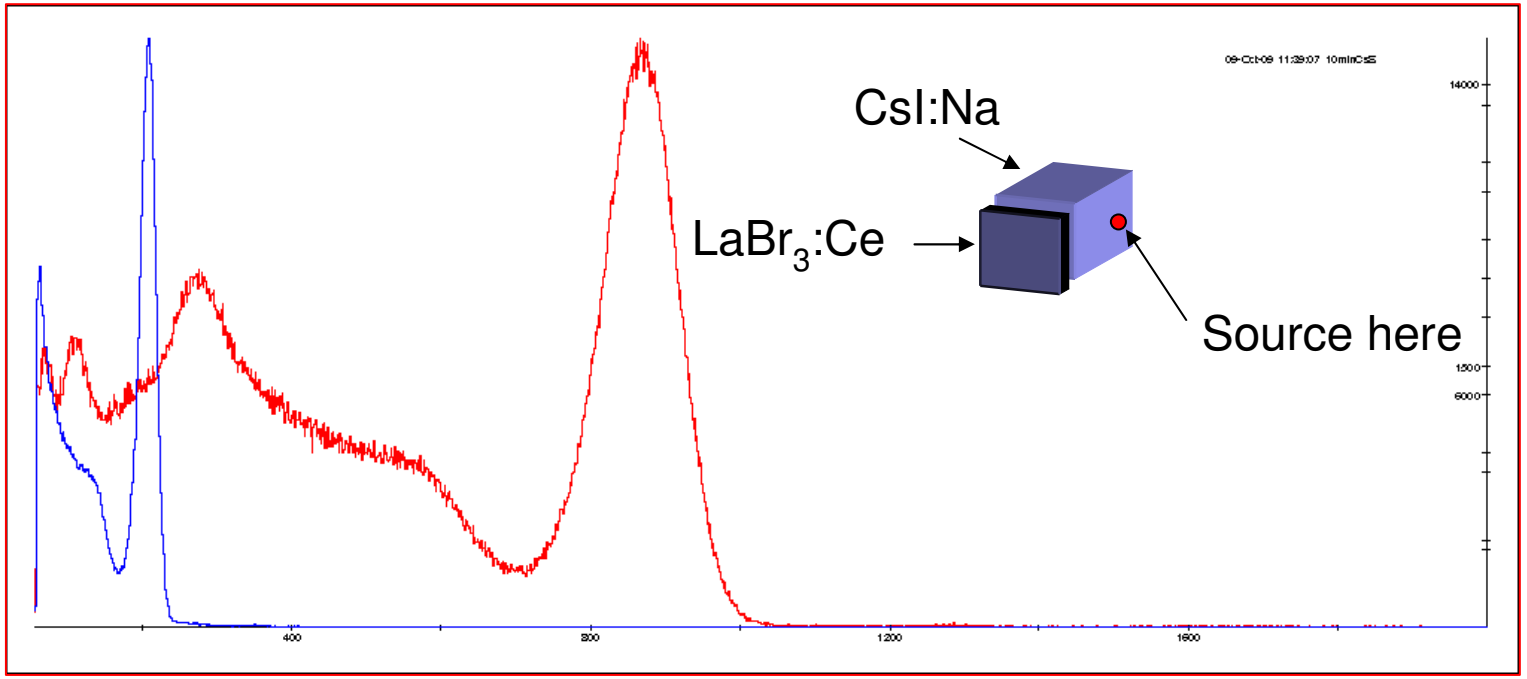
Phoswich Tests: Shaping Times



- Source placed near the end of Phoswich
- Red: S.T = 0.5us, Resolution: 13.09%
- Blue: S.T = 6us, Resolution: 11.69%

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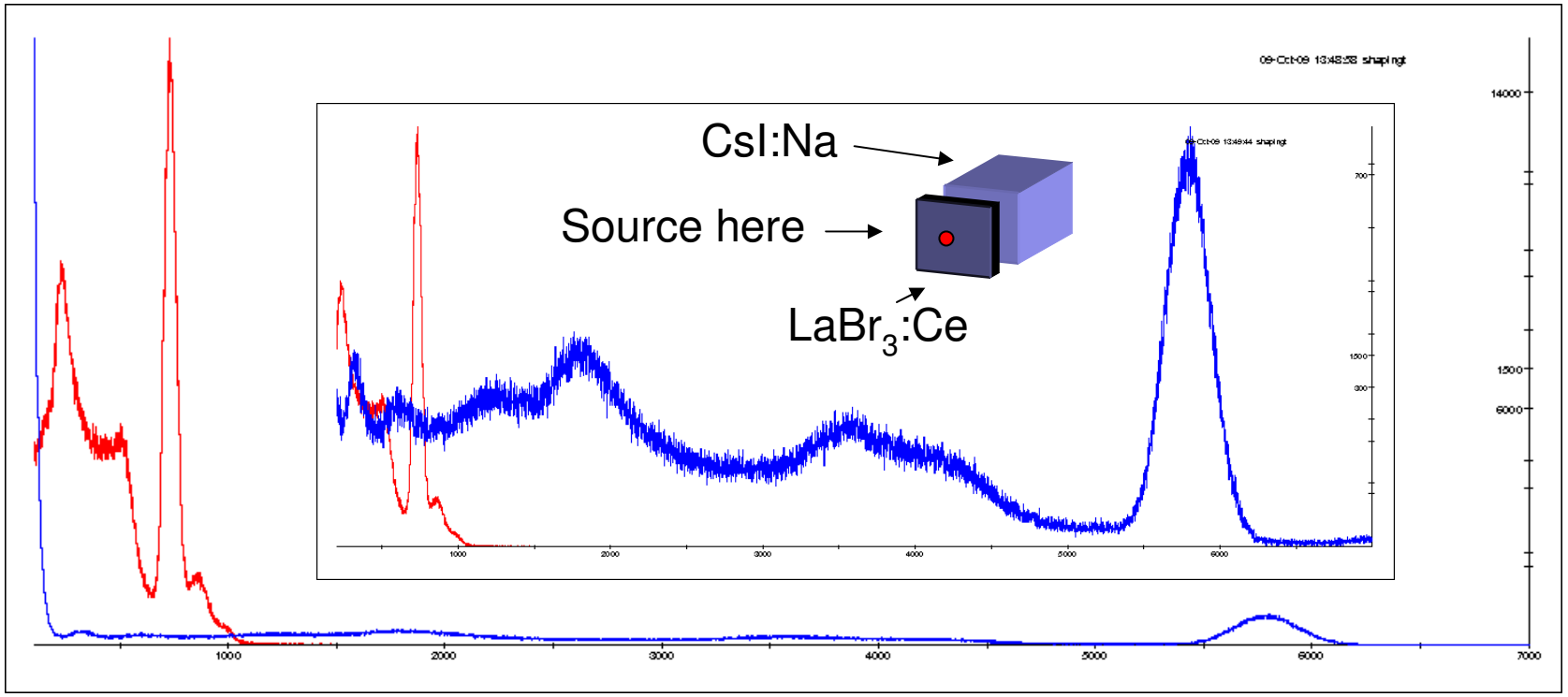
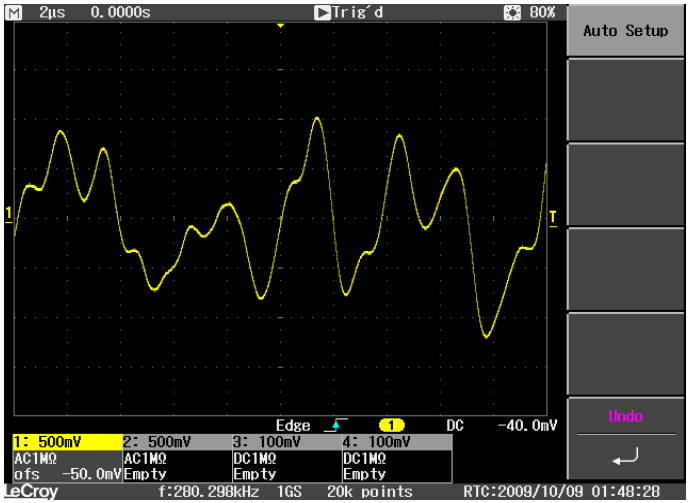
Phoswich Tests: Shaping Times



- Source placed near the front end of Phoswich
- Red: S.T = 6us, Resolution: 8.16%
- Blue: S.T = 0.5us, Resolution: 5.50%

Pile-Up Test: ^{57}Co Source

- A hot 10mCi (3.7×10^8Bq) source was used
- Signals were observed to see if fast timing of $LaBr_3$:Ce can allow for discrimination of individual pulses.



- L: Raw Signal ($LaBr_3$:Ce),R: S.T of 0.5us

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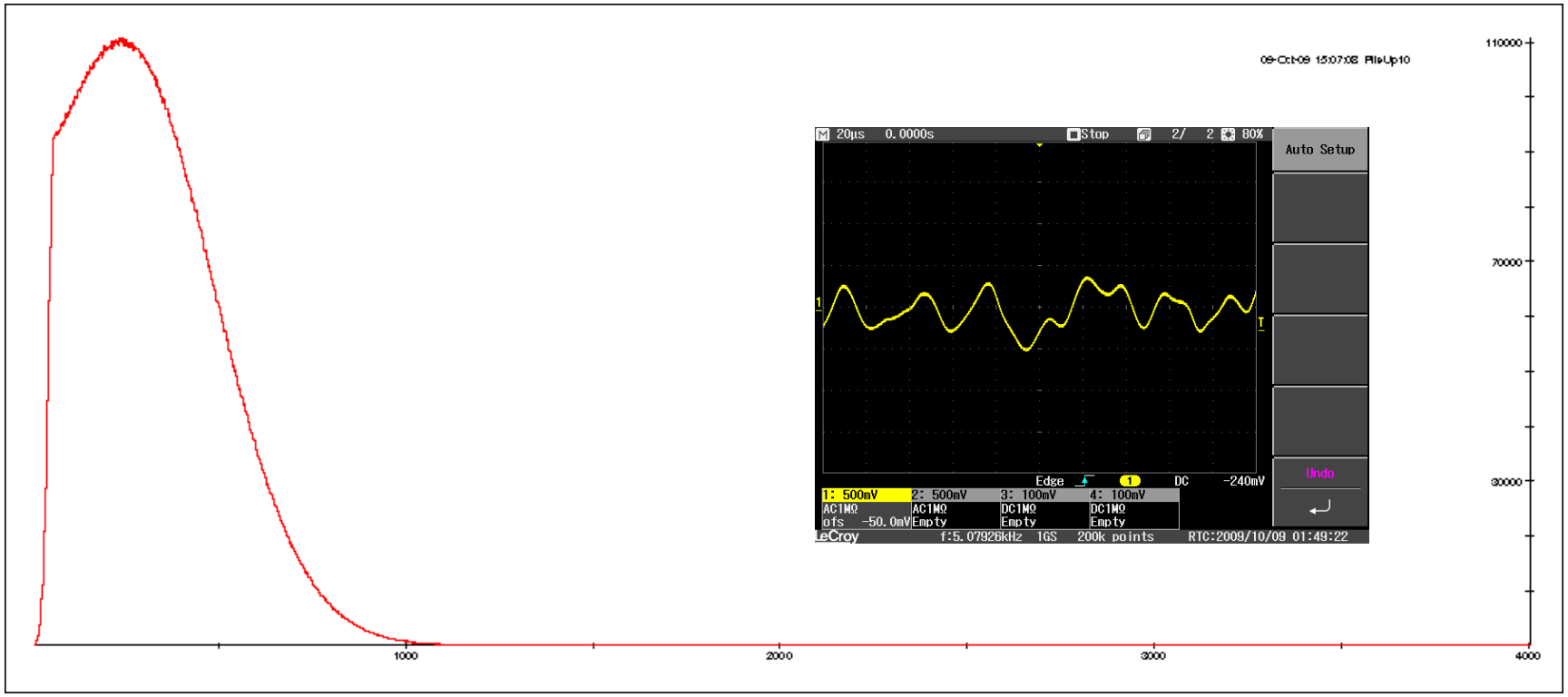
Pile-Up Test

There is little to see in the spectrum, complete saturation with this source.



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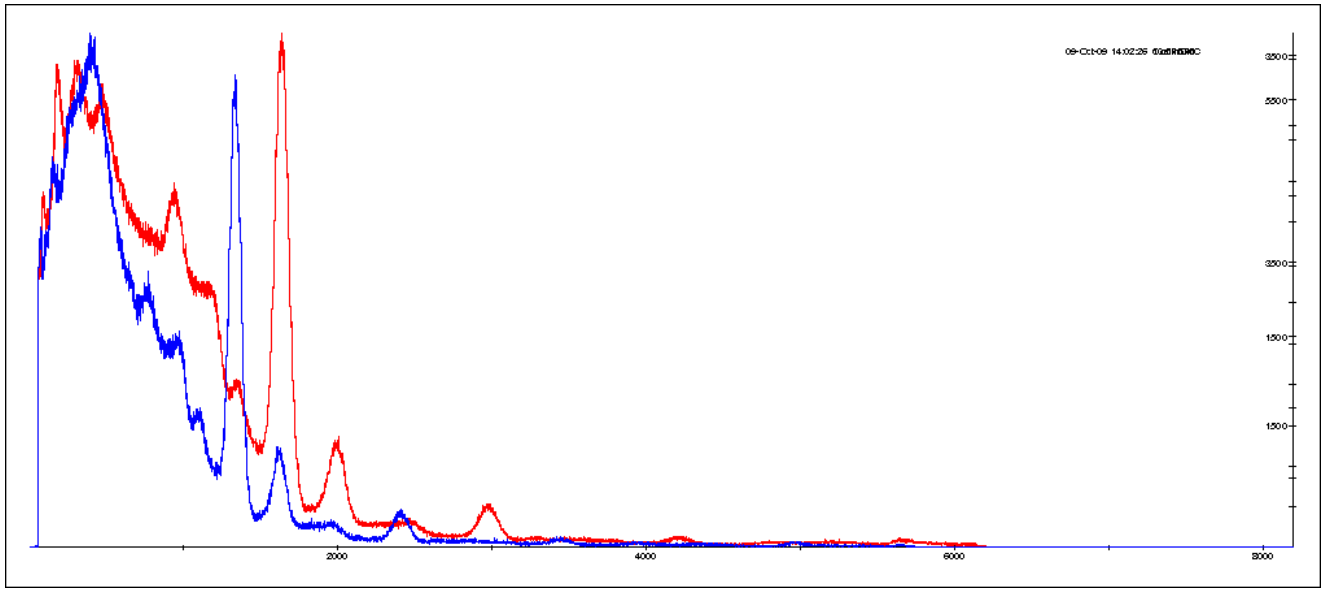
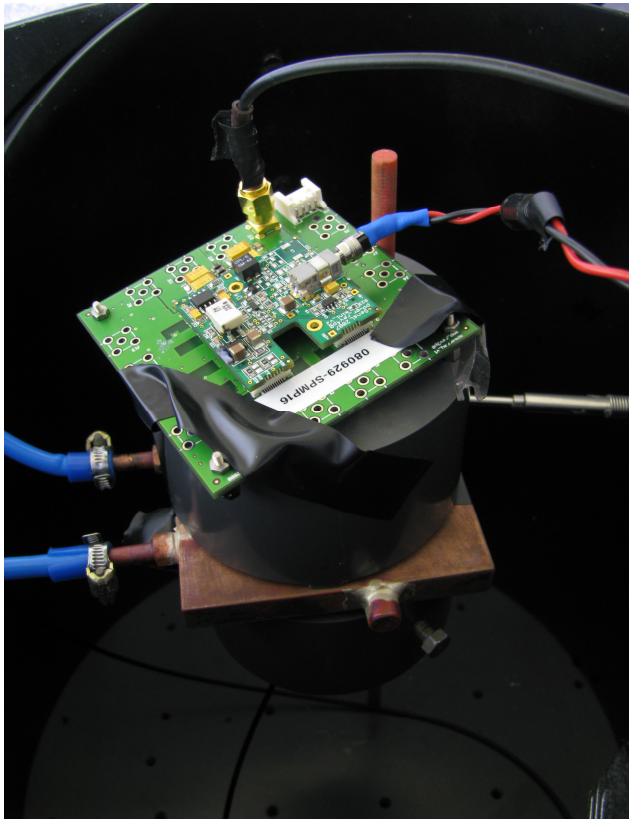
Non-Linearity



- Two ^{57}Co graphs. Amplifier settings and other conditions set exactly the same. We see a shift based on number of gammas only.

Large Area APD's

- Newly developed SiPMs from SensL provide high gain and low dead space.
- Built in Preamp takes 5V and creates VB~30V
- Sensitive between 400-850nm, peaks @ ~565nm.
- Collectively, large amount of noise, S/N is very small.



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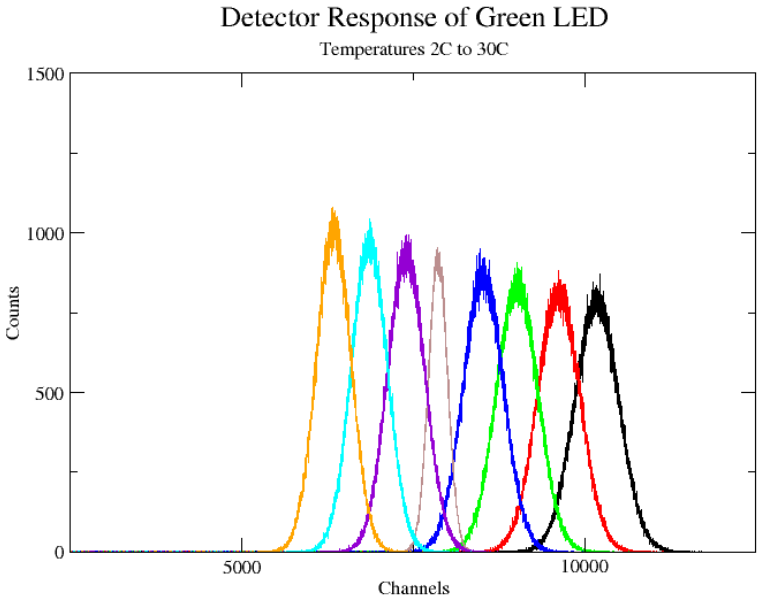
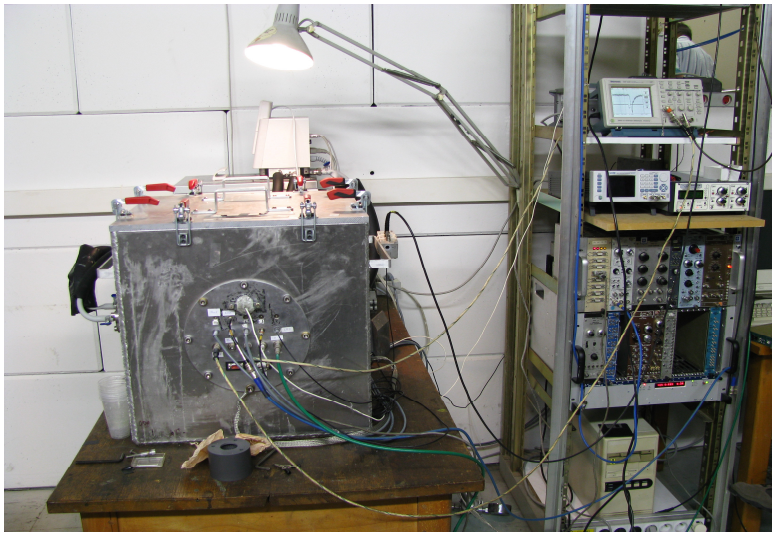
Temperature Response of LAAPD





- Labyrinth in the copper plate is pumped with cooled alcohol
- Temperature tests between 2℃ and 30℃ shows linear degradation in the FWHM of Green LED Signal.

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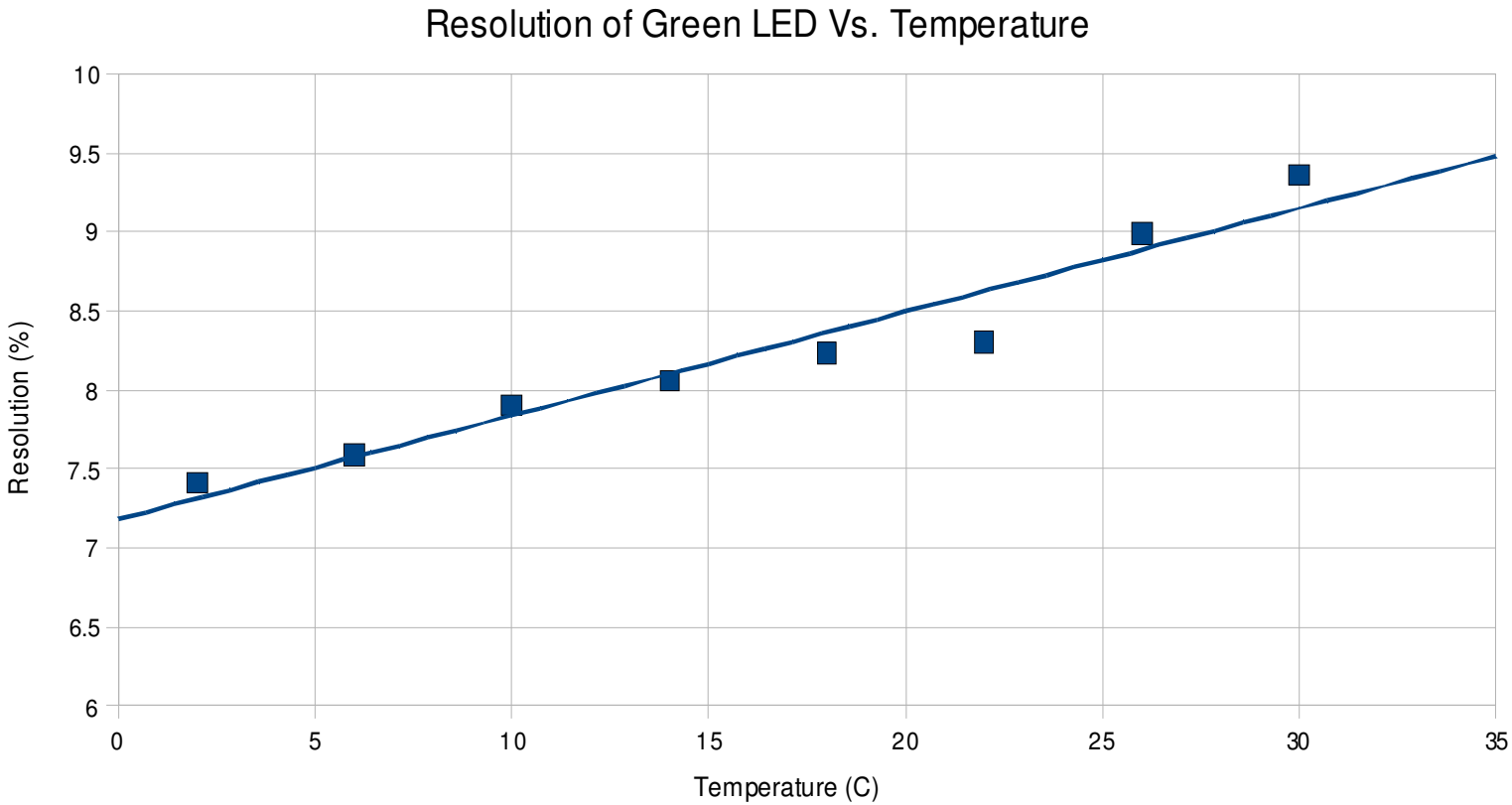
Temperature Response of LAAPD



- Graph to show linear relation between Temperature and Resolution

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Summary & Conclusions

- Phoswich produced slightly worse resolutions than what was expected. Possibly due to Bipolar output.
- Significant Pile-up with High Gamma Sources greater than ~385 kHz.
- Non-Linearity was seen and this also needs to be investigated.
- The SensL SiPM was found to vary linearly with temperature, with a low S/N ratio for γ sources, higher with α sources.

Future Work

- Investigate non-linearity of Phoswich Detector
- Tests with $^{241}Am/^{9}Be$ Neutron Source
- Perform Time Coincidence Measurements with BaF_2 Detector.
- Read individual SensL Pixels to improve S/N in detector

Acknowledgement of Collaborators

P. Joshi[1],D. Jenkins[1], O. Dorvaux[2], M. Rousseau[2], Christian Finck[2] J. Strachan[3], A. Smith[4], B.Wadsworth[1], and the rest of the PARIS collaborators

[1]University of York, United Kingdom
[2]IPHC Strasbourg, France
[3]STFC Daresbury, United Kingdom
[4]University of Manchester, United Kingdom

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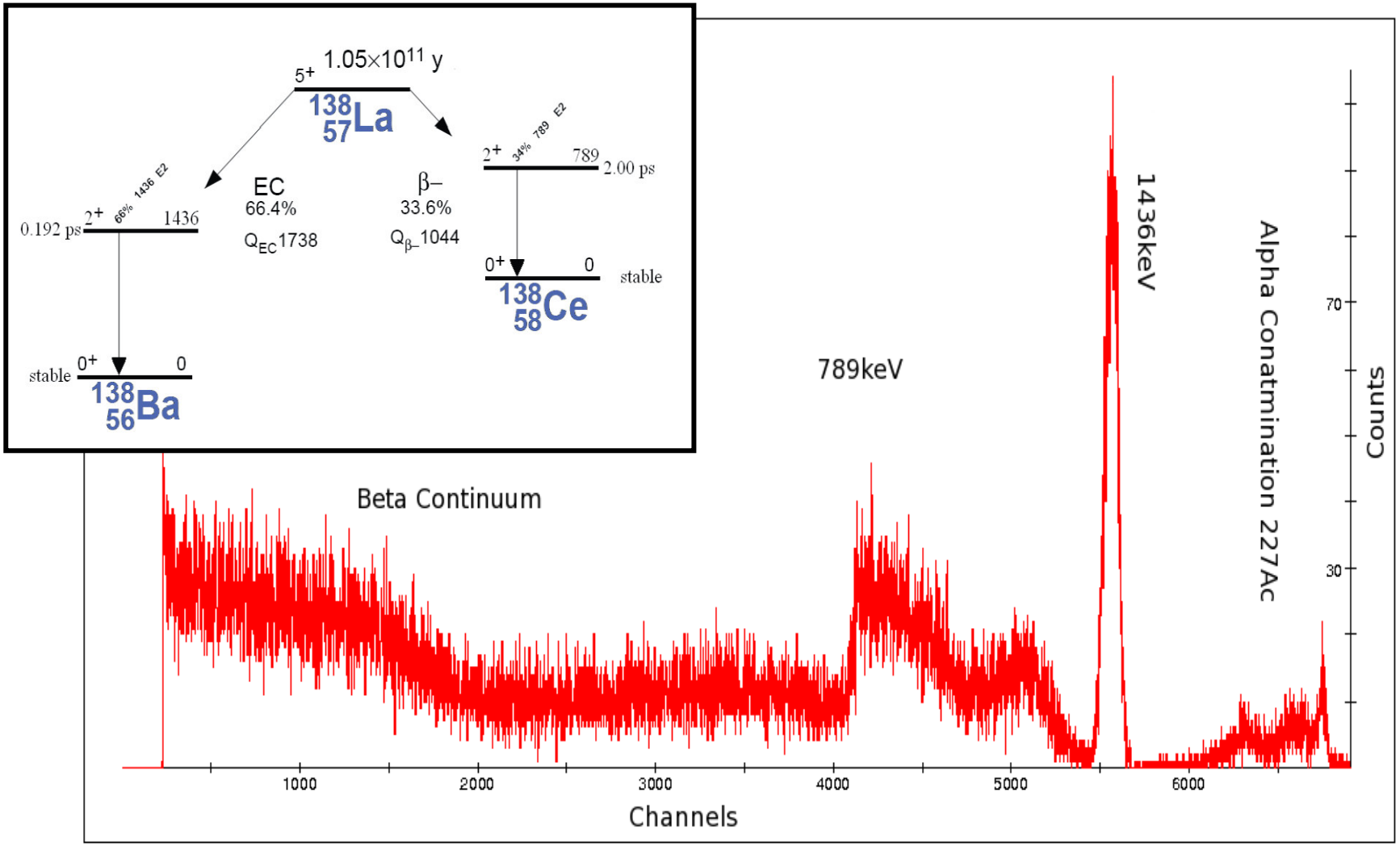
$LaBr_3(Ce)$ Crystals

- High resolution scintillators, ~3% at 662keV
- When doped with cerium, high light output (~60,000 photons/MeV)
- Good Timing resolution of FWHM~260ps
- Fast decay time (~25ns)
- Peak emission wavelength in Blue-UV part of the EM spectrum (380nm), very compatible with PMTs.

Self Activation of ^{138}La



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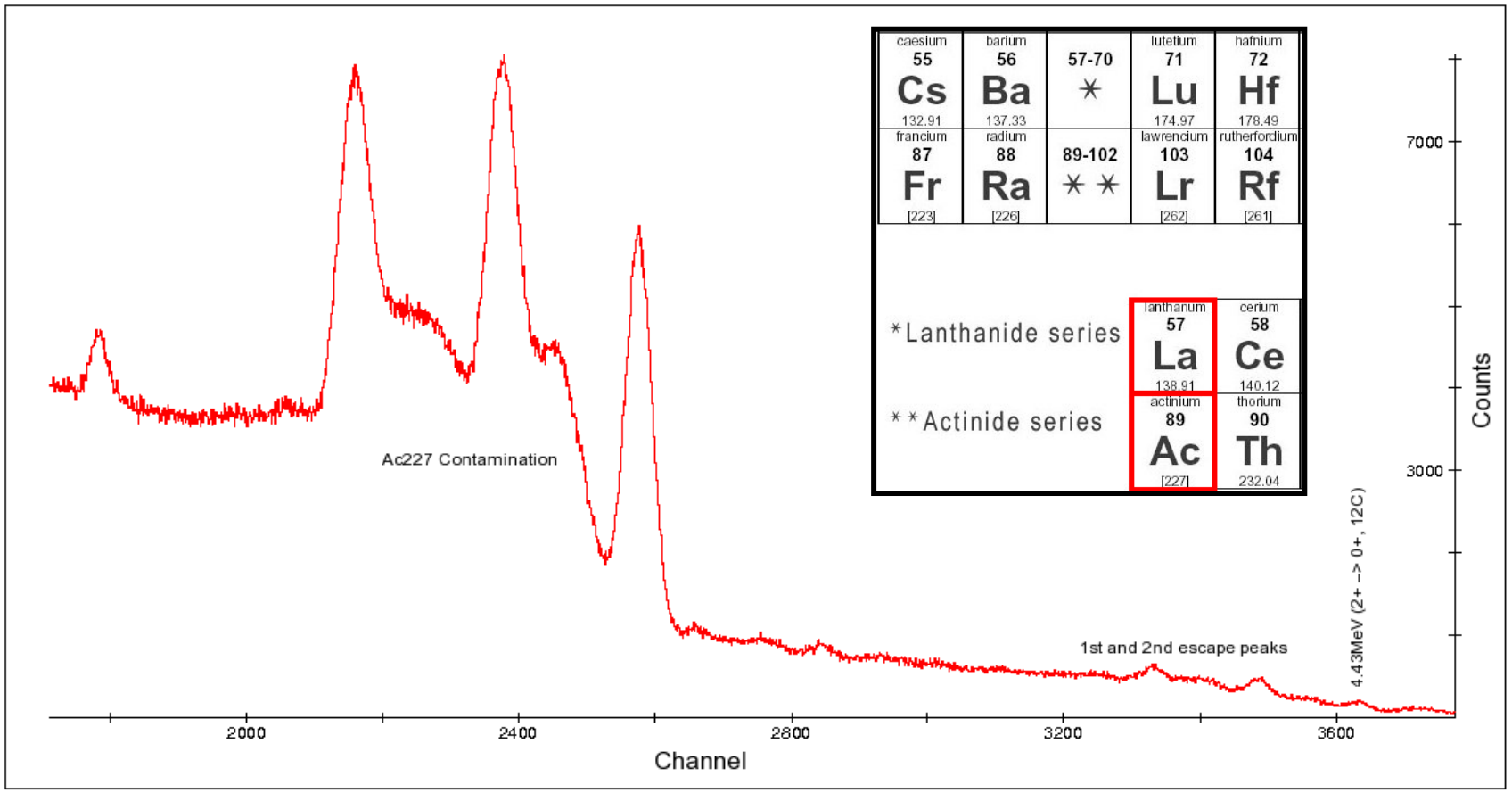
Alpha Contamination



- ^{227}Ac ($t_{1/2}$=21.2yrs), appears in the same group (IIIB) as Lanthanum

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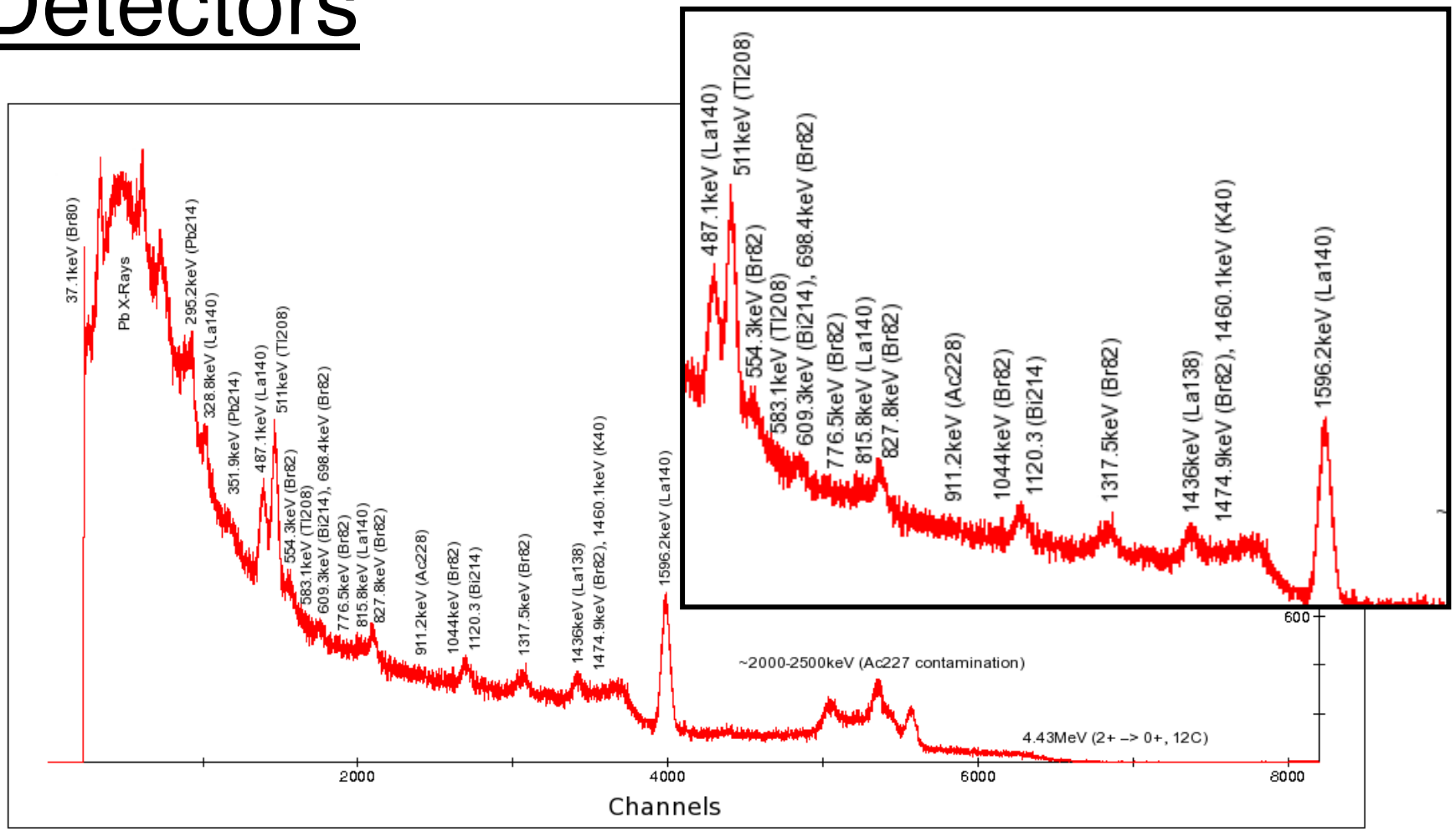
Neutron Response of $LaBr_3$:Ce Detectors



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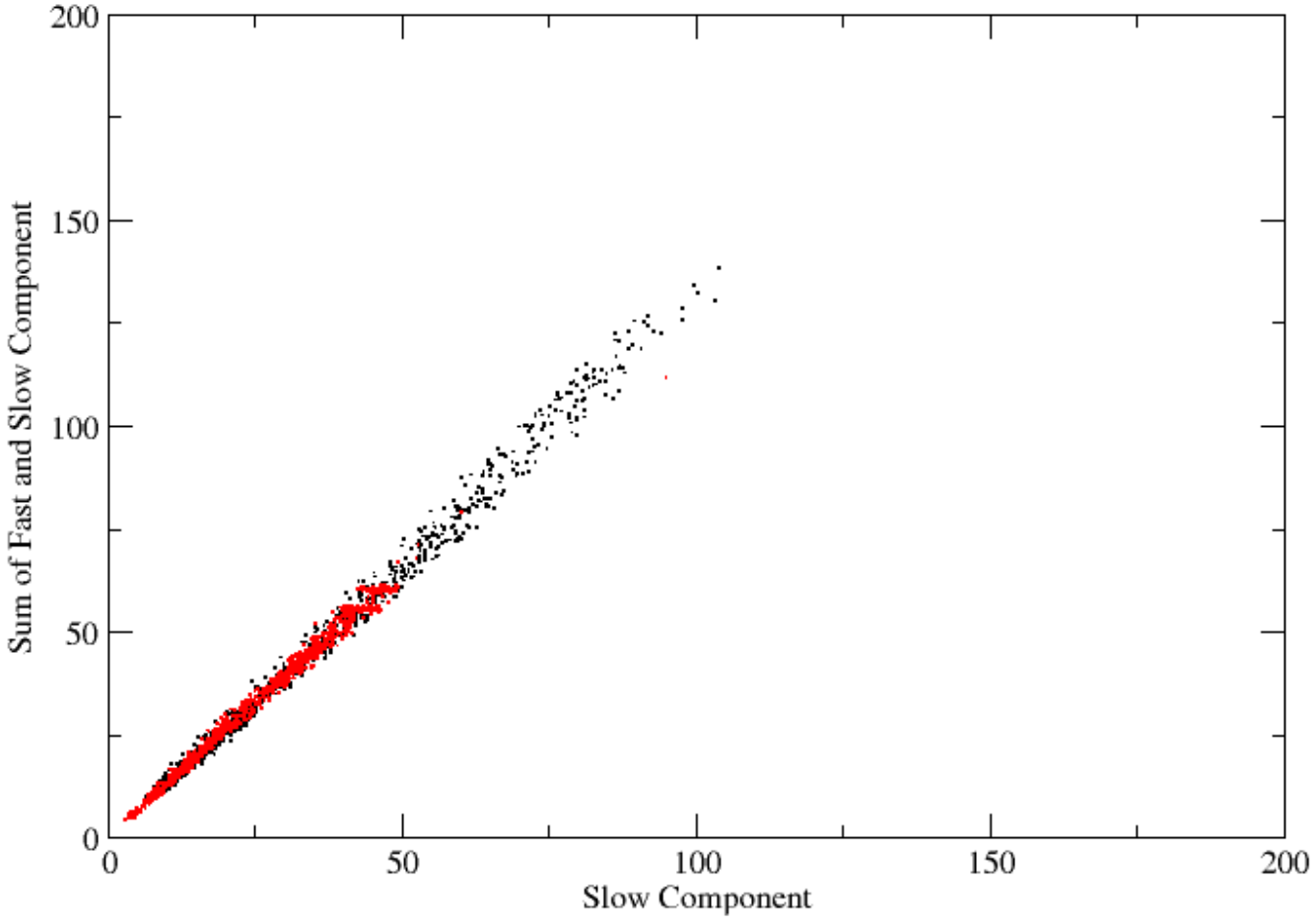
n-gamma PSD in $LaBr_3$:Ce



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385kBq ^{22}Na Spectrum