

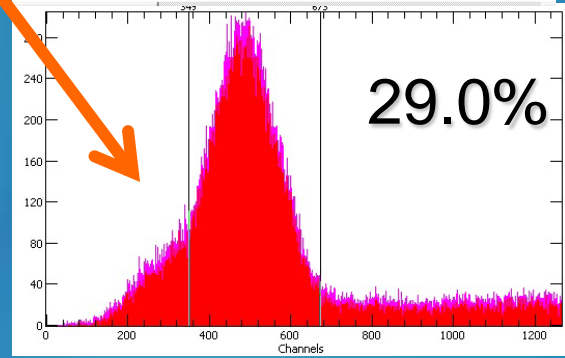
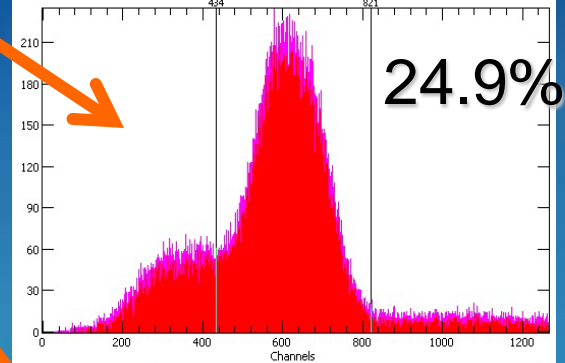
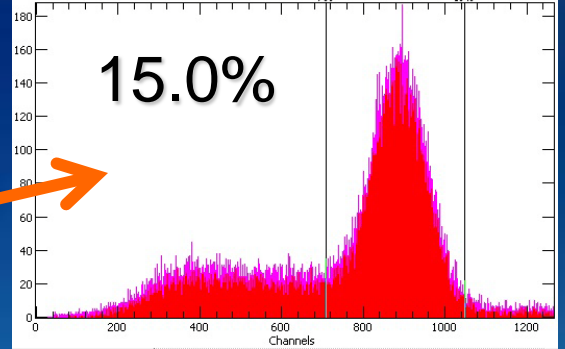
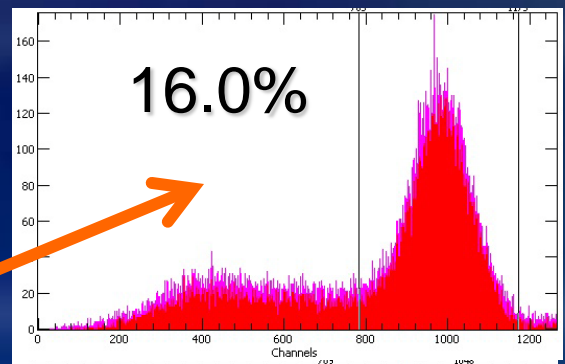
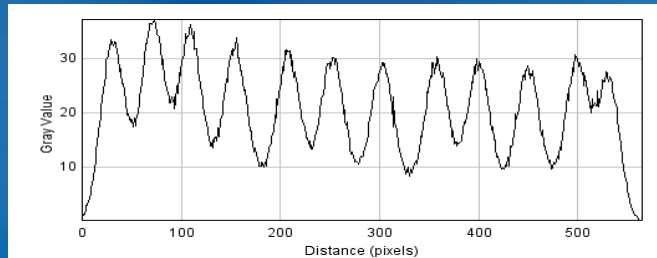
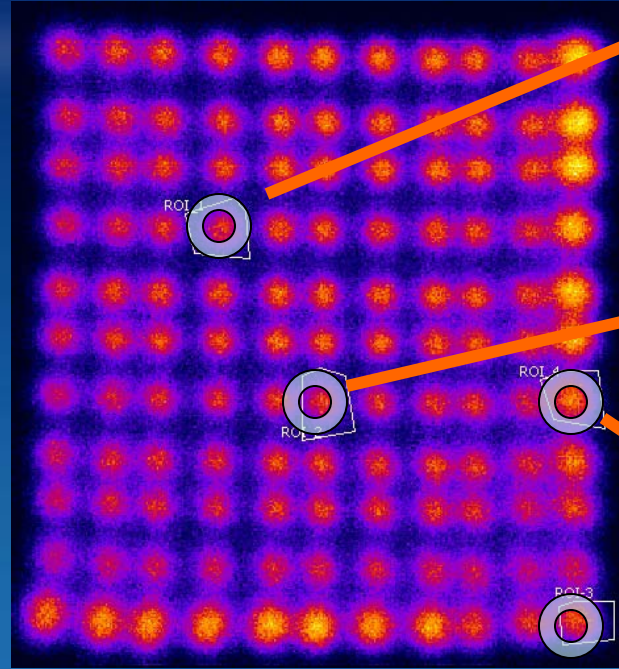
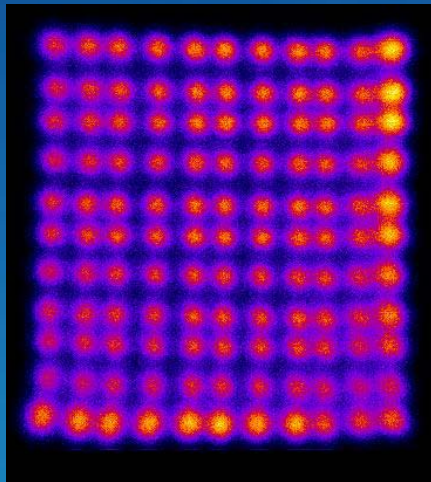
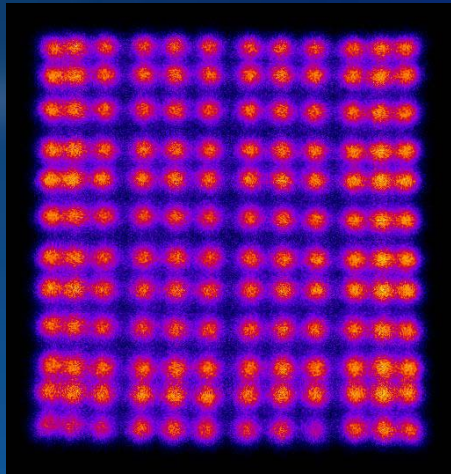
Studies of SiPM Arrays with BGO

Goals:

- Separate 2mm BGO pixels @ 511 keV
- Achieve 15% FWHM @ 511 keV
- Consider cooling if necessary to achieve the above goals



Reference: Studies with H8500 PSPMT

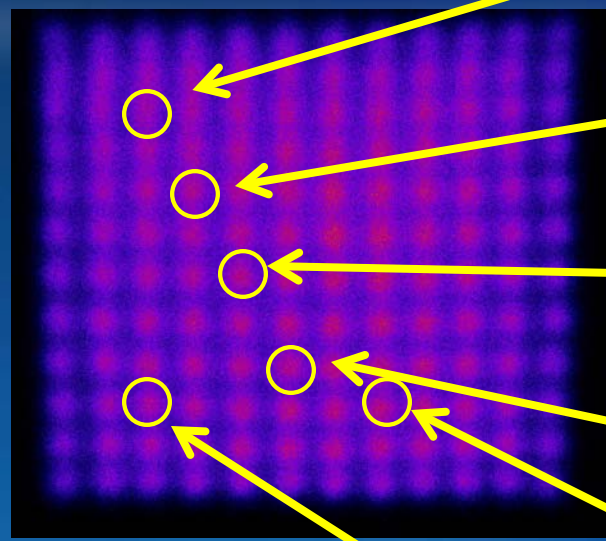


Raw images at left for the central (top image) and corner (bottom image) locations of the 2x2x15mm BGO array. FWHM energy resolution @511 keV indicated next to the four spectra. Plot for one of the pixel rows in the center.



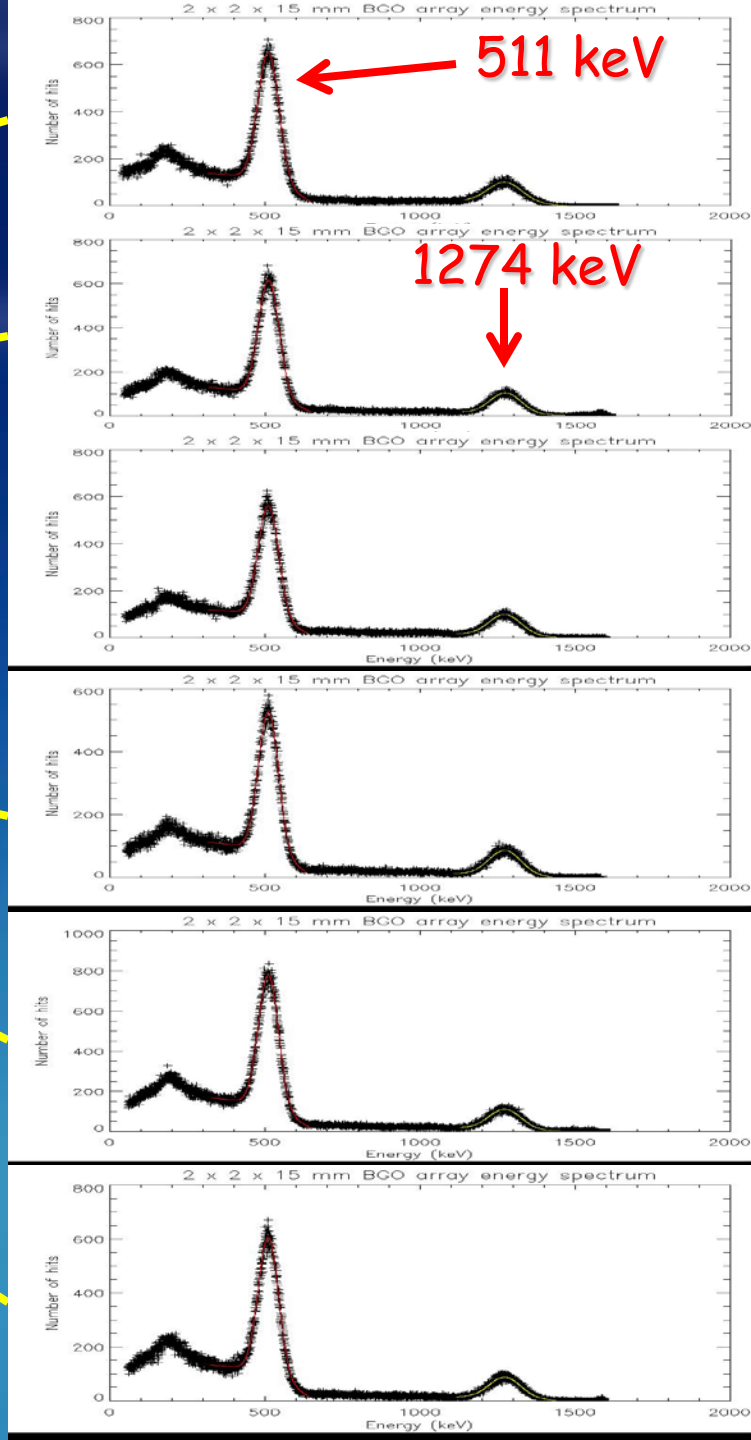
Reference: H8500 PSPMT + 2x2x15mm BGO array with NIM electronics

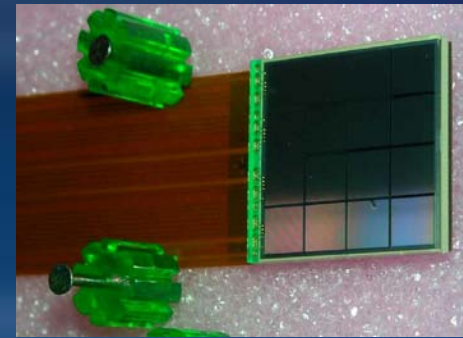
Raw image @1274 keV



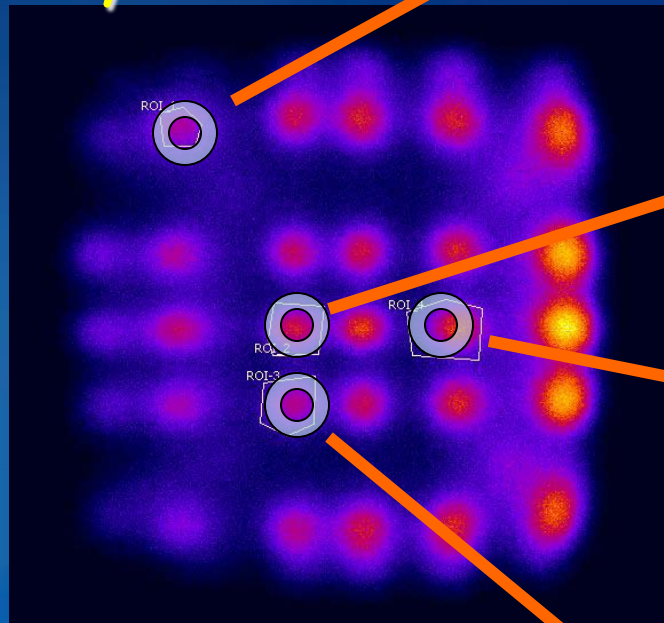
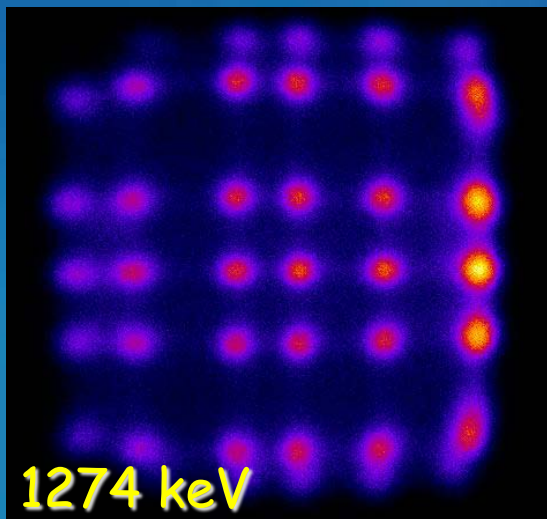
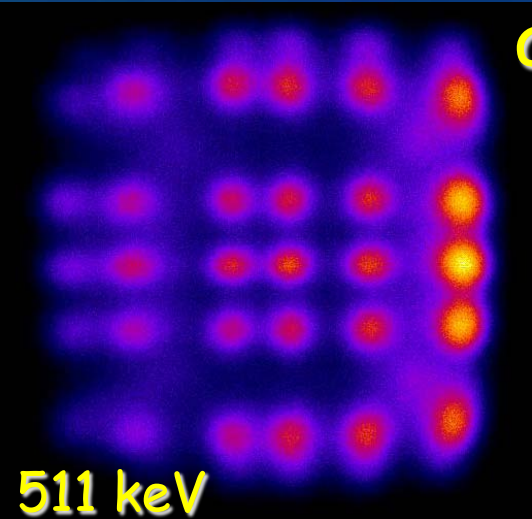
PIXEL	FWHM(%)
1	15.7
2	15.2
3	15.0
4	15.0
5	15.0
6	15.0

To establish operational limit, post-amplifier system was implemented with spectroscopic EG&G/Ortec amplifiers. 1 microsec shaping was applied to pulses from the original Jefferson Lab charge division H8500 circuitry, before digitizing the four signals in the standard DAQ module with integrating ADCs. Energy spectra for six selected 2x2x15mm BGO pixels were recorded using 1500 nsec ADC gate. Energy resolution FWHM @511 keV for each of these pixels is indicated in the table above.

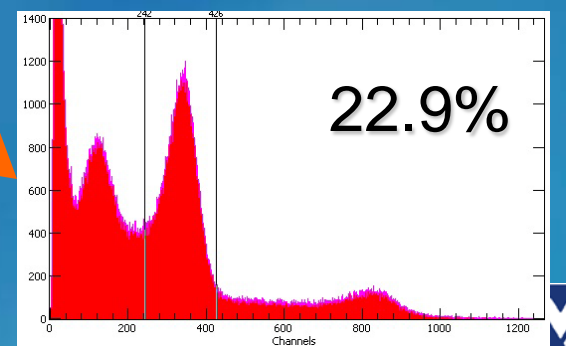
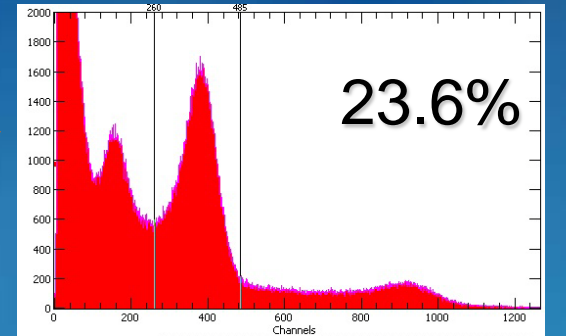
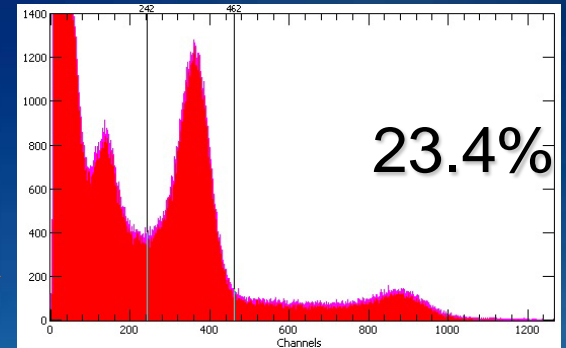
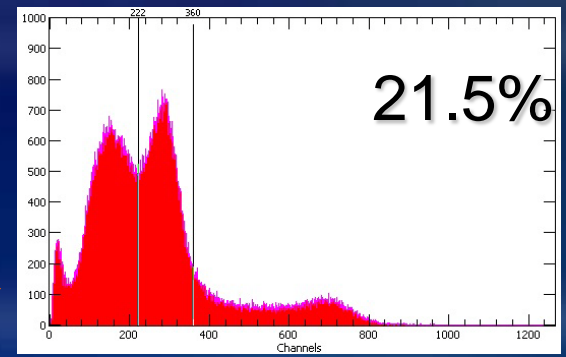




Reference: Studies with generation monolithic array. **MPPC**

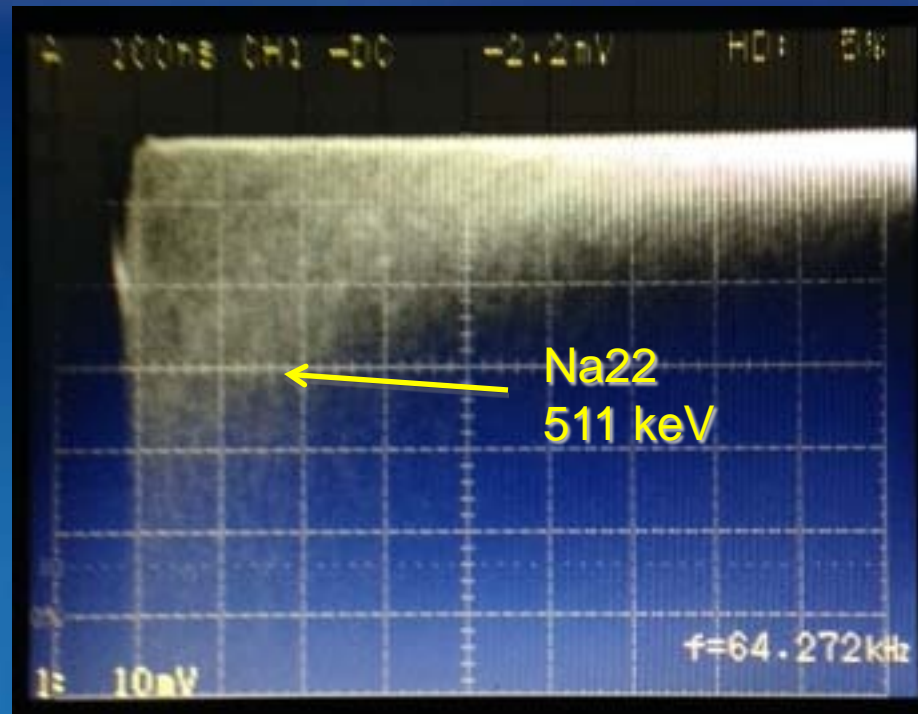


The monolithic MPPC module equipped with 16ch readout from AiT Instruments. FWHM values at 511 keV peak. Room temperature.

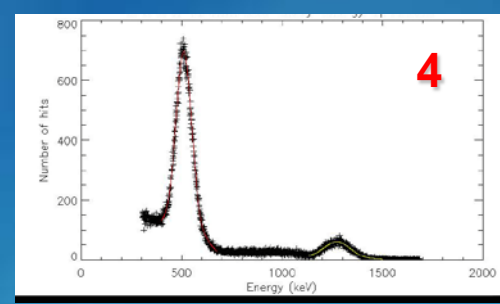
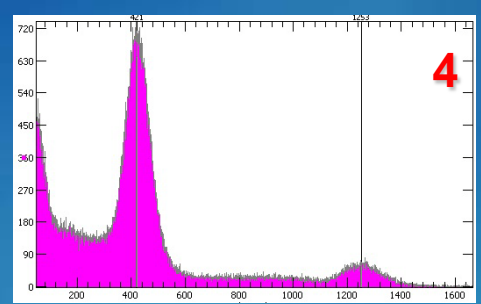
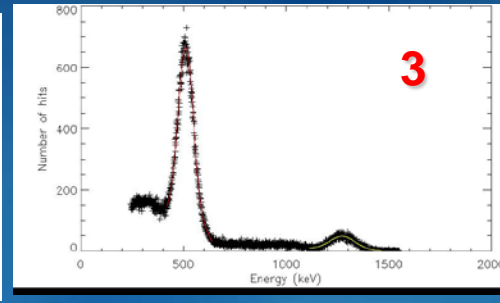
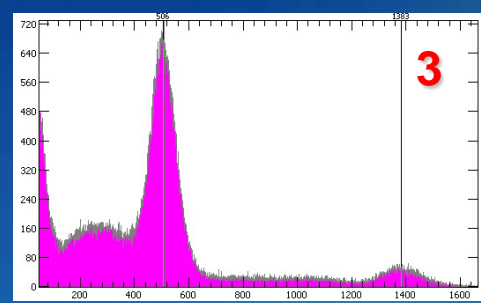
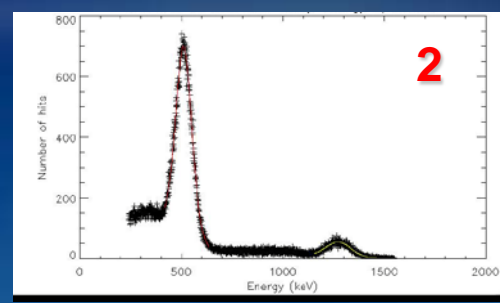
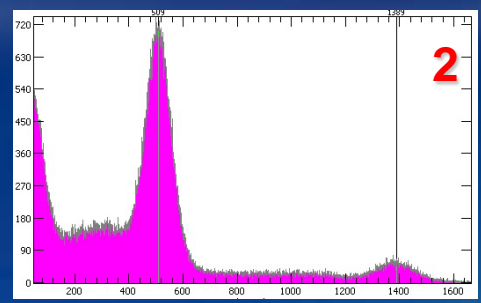
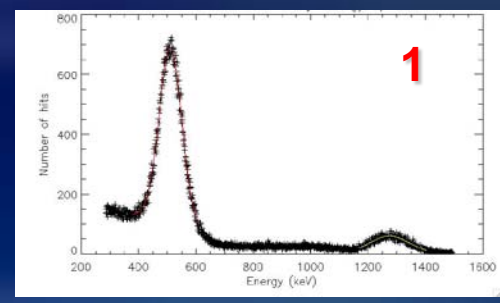
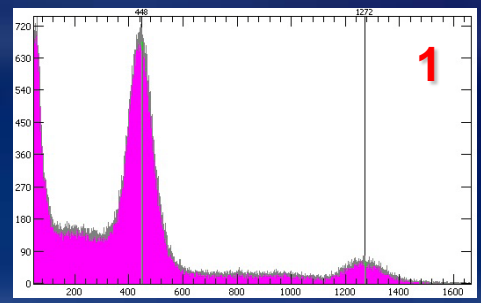
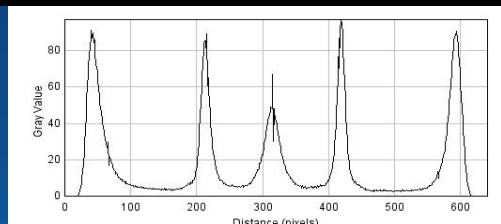
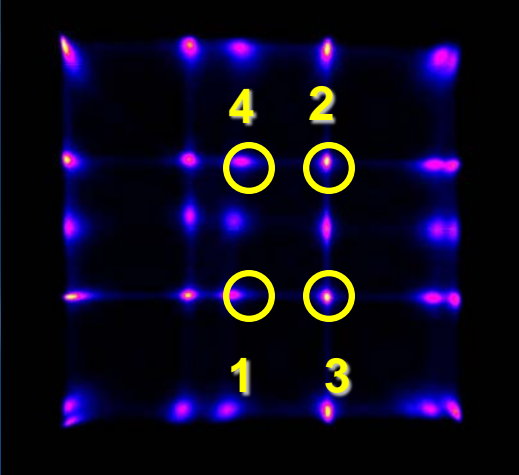


Studies with MPPC array:

S12642-0404PA-50: 3x3mm², 4x4ch, p50μm



The output from the combined MPPC sum signal of the 4ch AiT charge division circuitry is shown here on the scope screen. Na22 source.



New 4x4 3mm MPPC array from Hamamatsu tested with the 2x2x15mm BGO array. 16.5 deg. C. Bias voltage 66.9V. ADC signal integration time 1000 ns. Truncation factor 0.01, Raw image @ 511 keV with a profile of one of the columns. Energy spectra for four marked single BGO pixels are shown at right. Left column: original spectra. Right column: fitted curves with Gaussian fits. FWHM values are listed at the bottom. (The energy scale was corrected for the zero channel energy shift due to the diode circuitry used in the 4ch AiT readout.)

Resolutions (% FWHM):
 17.8, 17.4, 16.5, 17.8 @ 511 keV
 8.9, 11.1, 11.6, 11.7 @ 1274 keV



Summary of pilot BGO Studies with the latest generation of MPPCs

- Latest generation of MPPCs is performing substantially better with BGO and is approaching the set goal of 15% FWHM energy resolution at 511 keV
- The energy resolution is within 1.5-3% approaching the one obtained with H8500 PSPMT (~15%).
- 2mm pixel separation is excellent at practically any condition (bias voltage or temperature)
- The best energy resolution is obtained at lower bias voltages, and limited by induced electronic noise (not documented in this short summary)
- Energy resolution is better at lower temperatures (not documented in this short summary)

