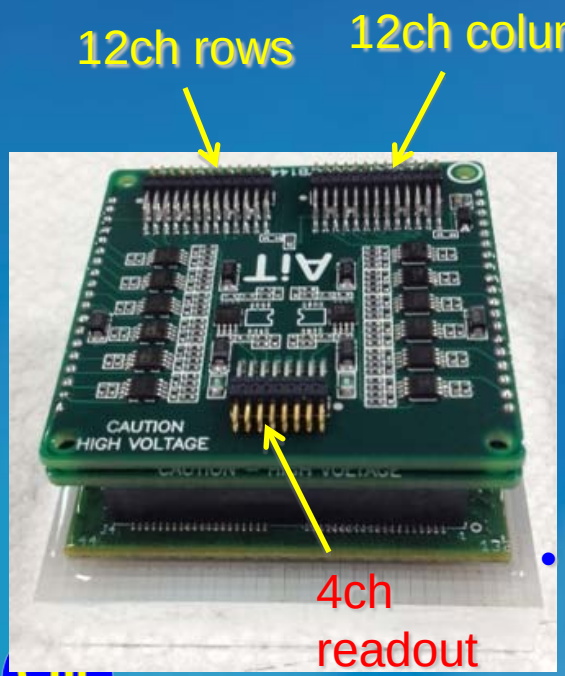
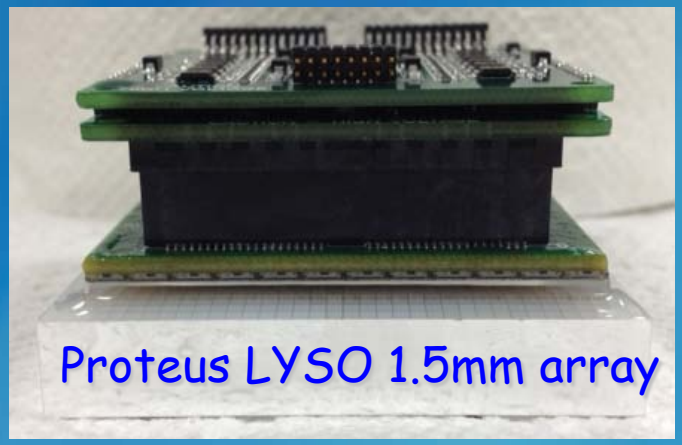
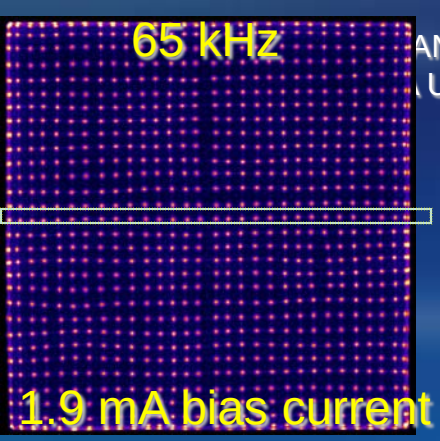
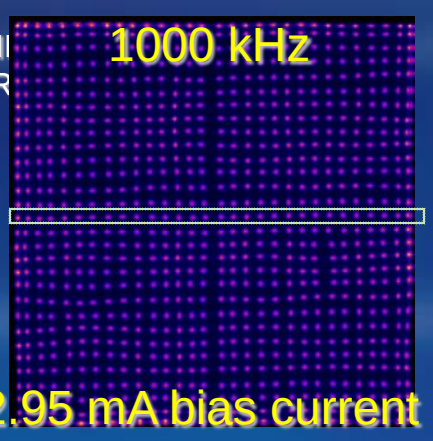
SiPM Rate Studies

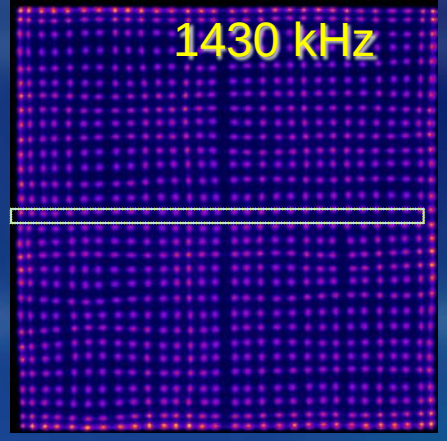
- AiT Instruments 4ch and 12x12 row-and-column readouts
- Proteus LYSO 1.5mm array
- Rate range: 50 kHz – 2.0 MHz (Na22+F18)

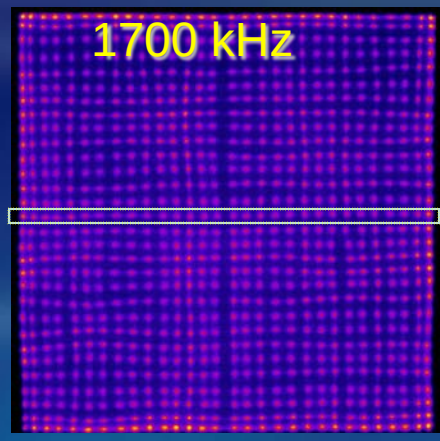






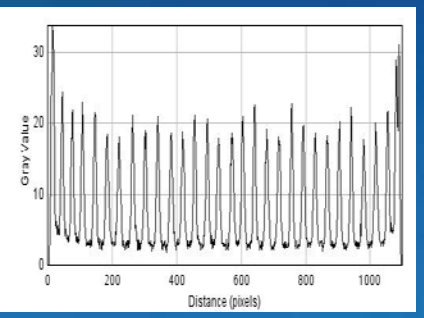


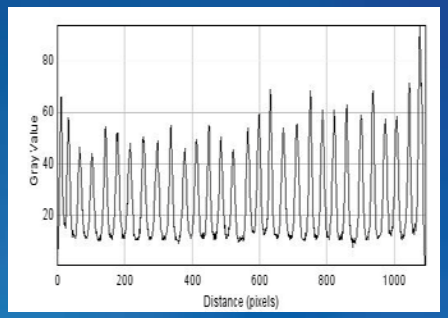


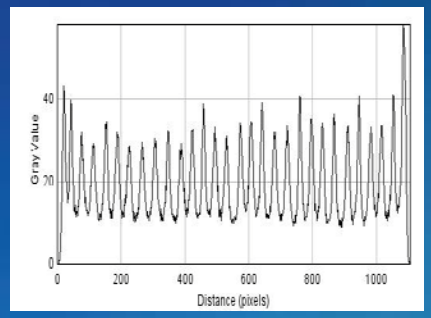


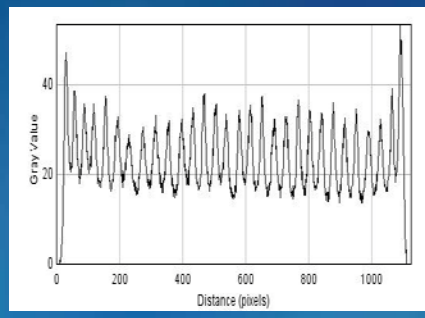
1.9 mA bias current

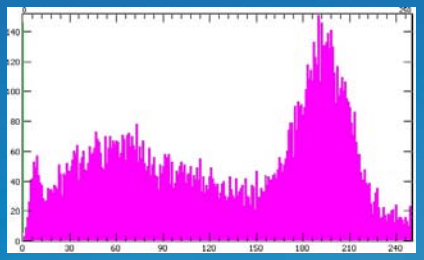
2.95 mA bias current

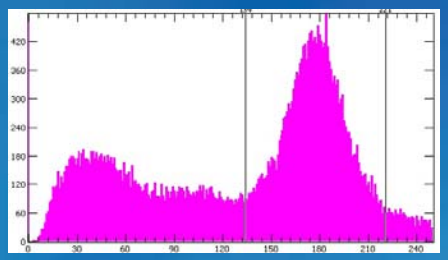


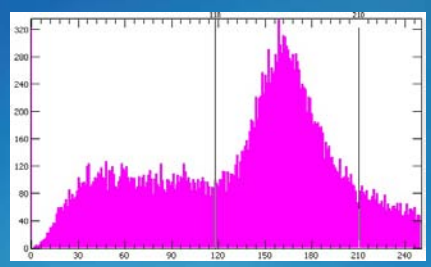


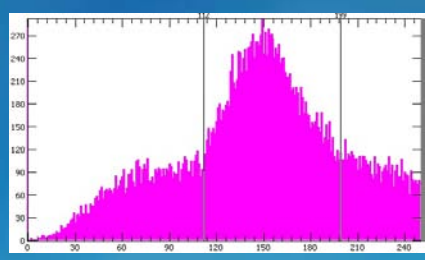












1.57mm pitch Proteus LYSO array. 21.5 deg. C, 30.8V bias on array, AiT Instruments 12x12ch R&C readout, 2.35mm coupling window, 145ns ADC integration window, Truncation factor 0.085. Raw images and energy spectra from a single LYSO pixel.

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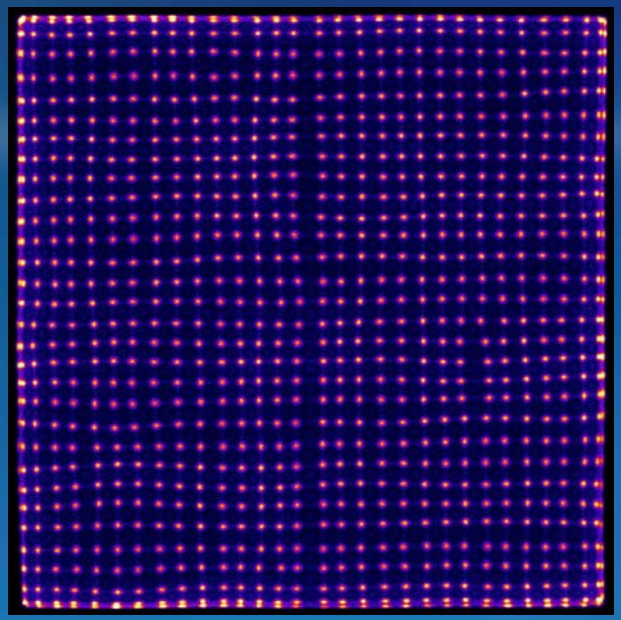
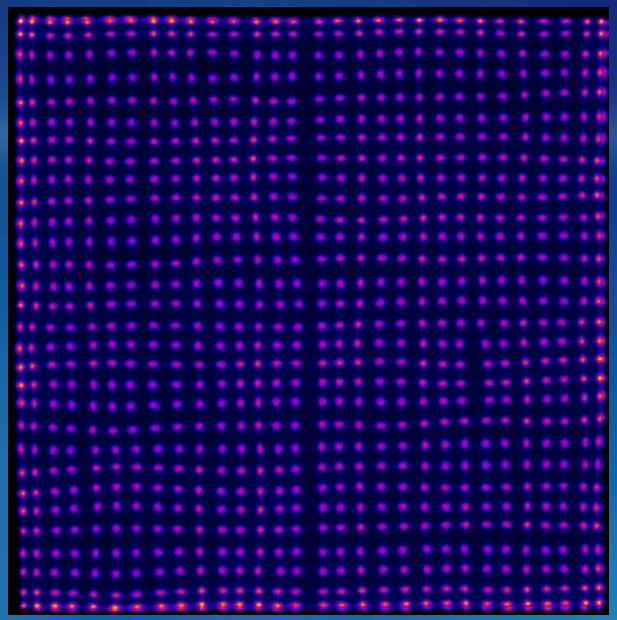
AT WEST VIRGINIA UNIVERSITY

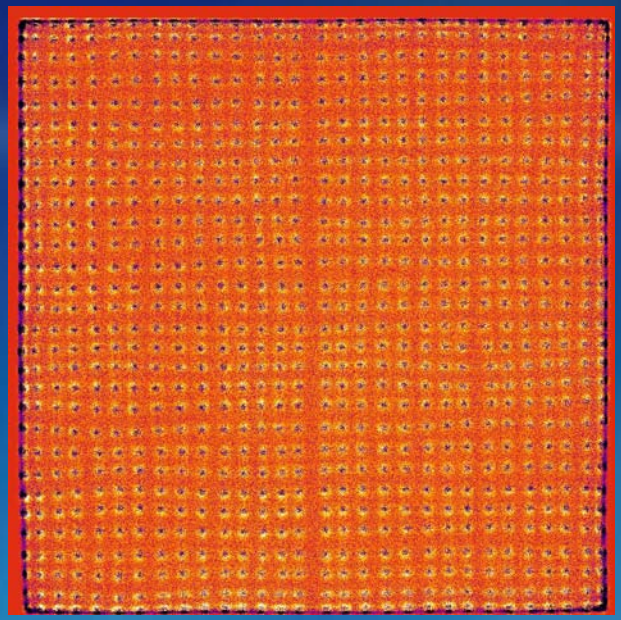
65 kHz



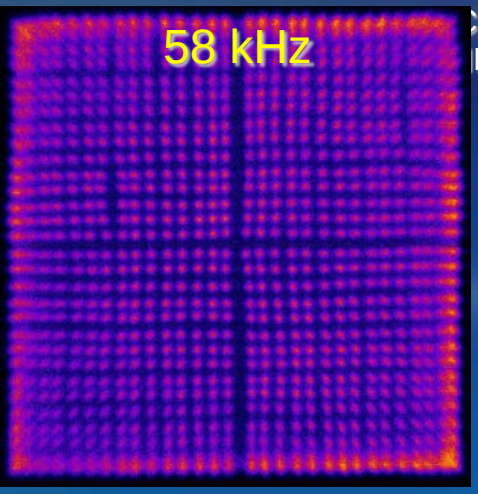
1000 kHz

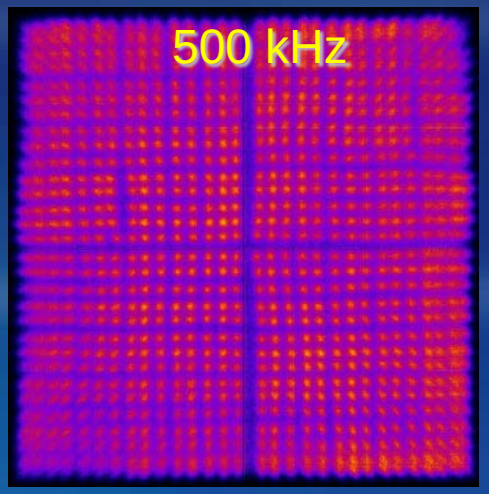


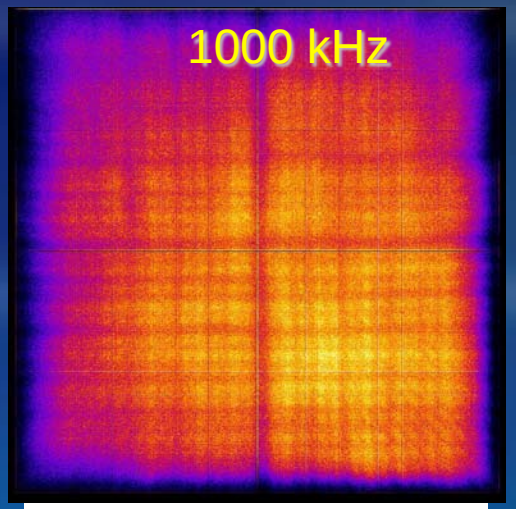
1000 kHz – k x 65 kHz

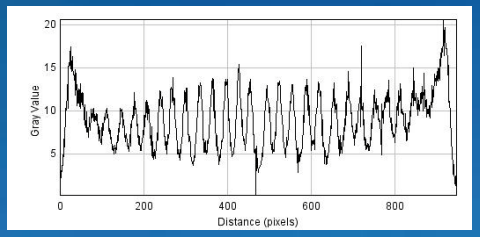


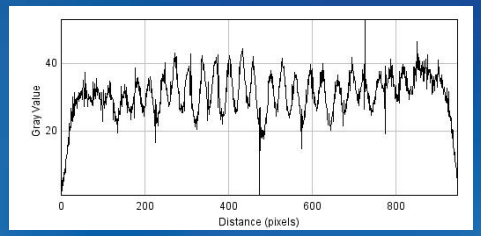
Raw images at 65 kHz and 1 MHz obtained with 12x12 channel row-and-column readout. At right the image obtained by subtracting the multiplied image collected at 65 kHz from the image at 1 MHz. The multiplication factor k was adjusted to make the pixel count numbers similar in both images, before subtraction. The residual image demonstrates that indeed no changes were observed in the raw image due to rate increase in the tested range. The positions of the individual 1.5mm LYSO pixels remained the same.

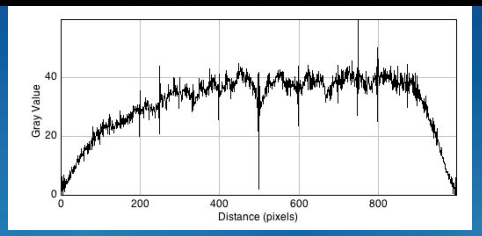


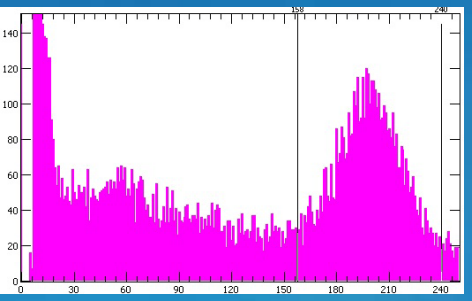


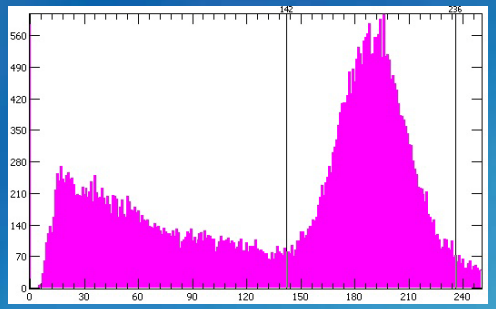


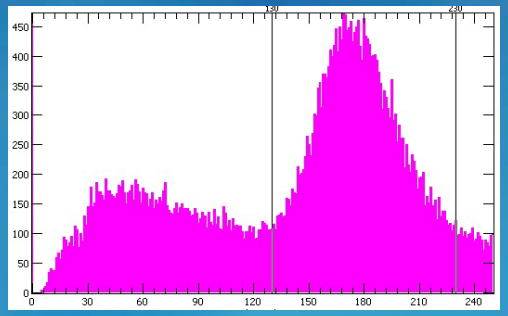




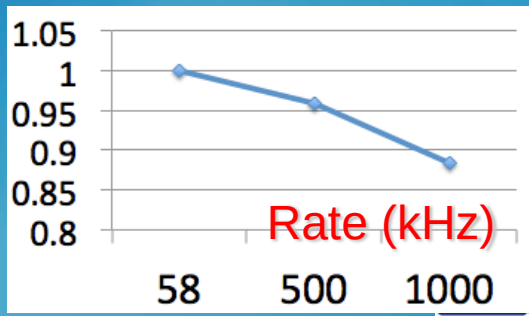






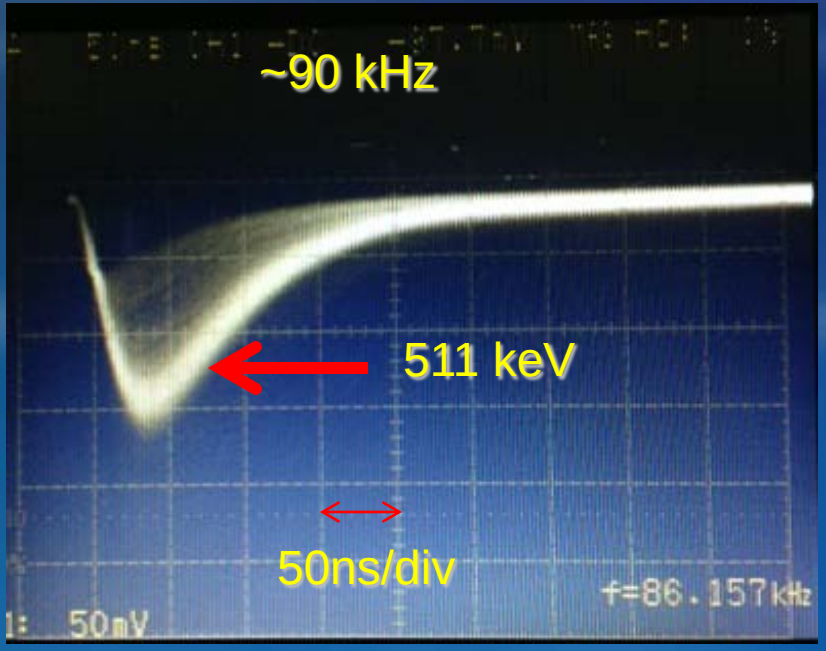


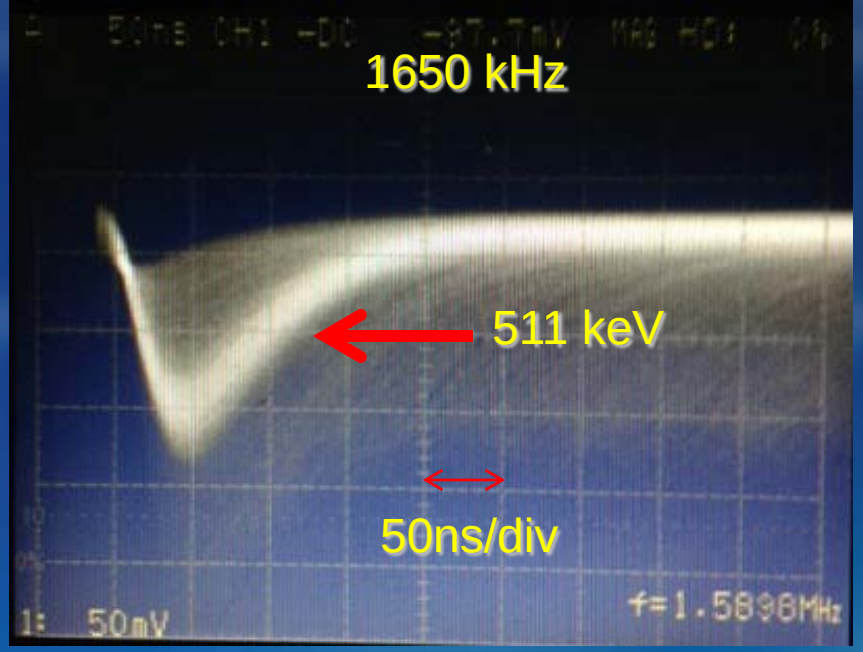
1.57mm pitch Proteus LYSO array. 21.5 deg. C, 30.8V bias on array, 4ch AiT Instruments charge division readout, 2.35mm coupling window, 145ns ADC integration window, truncation factor 0.025. Raw images and energy spectra from a single LYSO pixel. (Change of event distribution at 1 MHz due to close, ~central placement of the F18 source).

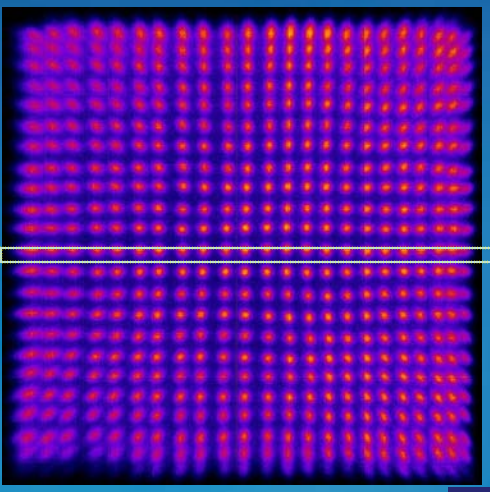


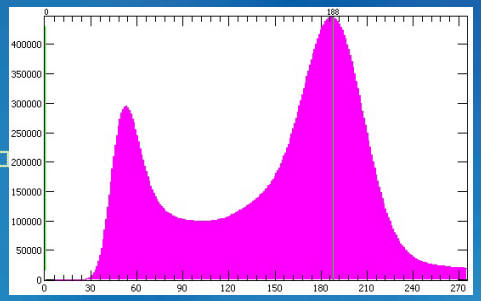
Partial rate tests results summary

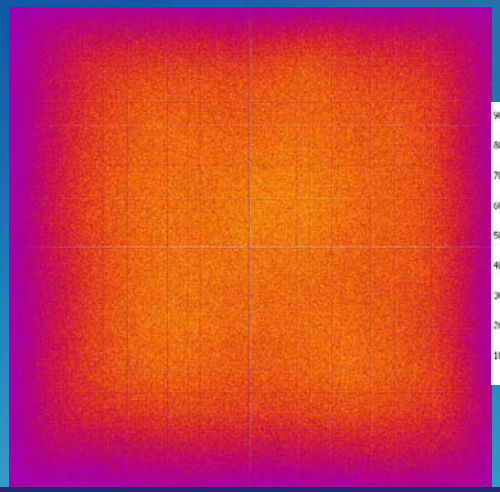
- 12x12 channel R&C readout: in the rate range 50 kHz – 1700 kHz operation is stable with no image distortion and with the amplitude decrease at 1000 kHz by ~10%
- 4ch charge division readout: rate range 50 kHz – 500 kHz operation is stable with no image distortion and with the amplitude decrease at high rate by <5%
- At ~1 MHz pileup effects limit the performance independently of readout

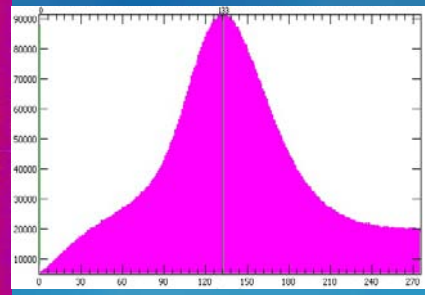


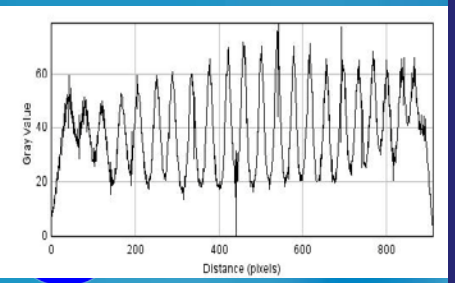






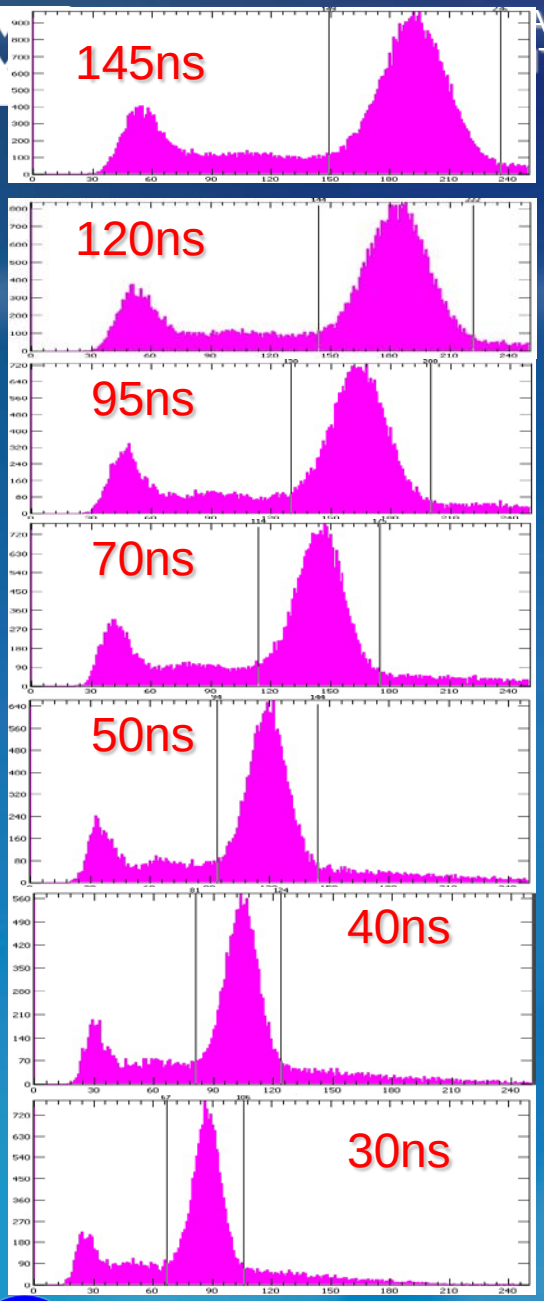






Proteus 2 mm LYSO array. 21.5 deg. C, 30.8V bias on array, AiT Instruments 4ch charge division readout, 2.35mm coupling window, 145ns ADC integration window, truncation factor 0.025. Average detector amplitude measured in ADC decreased by 30% at 1.65 MHz. Lost pixel separation at high rate.

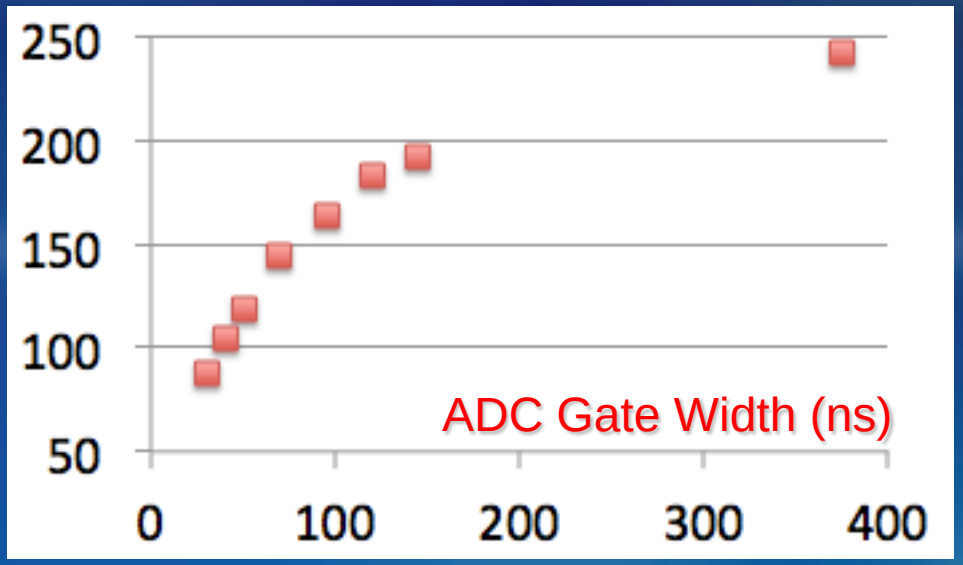
AGING
TY

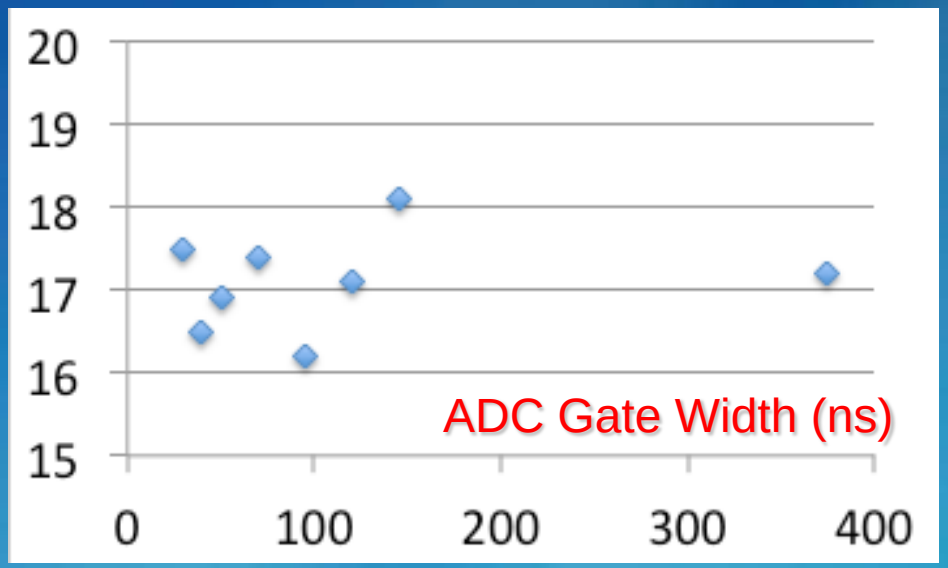


Study of ADC gate width @ 90 kHz

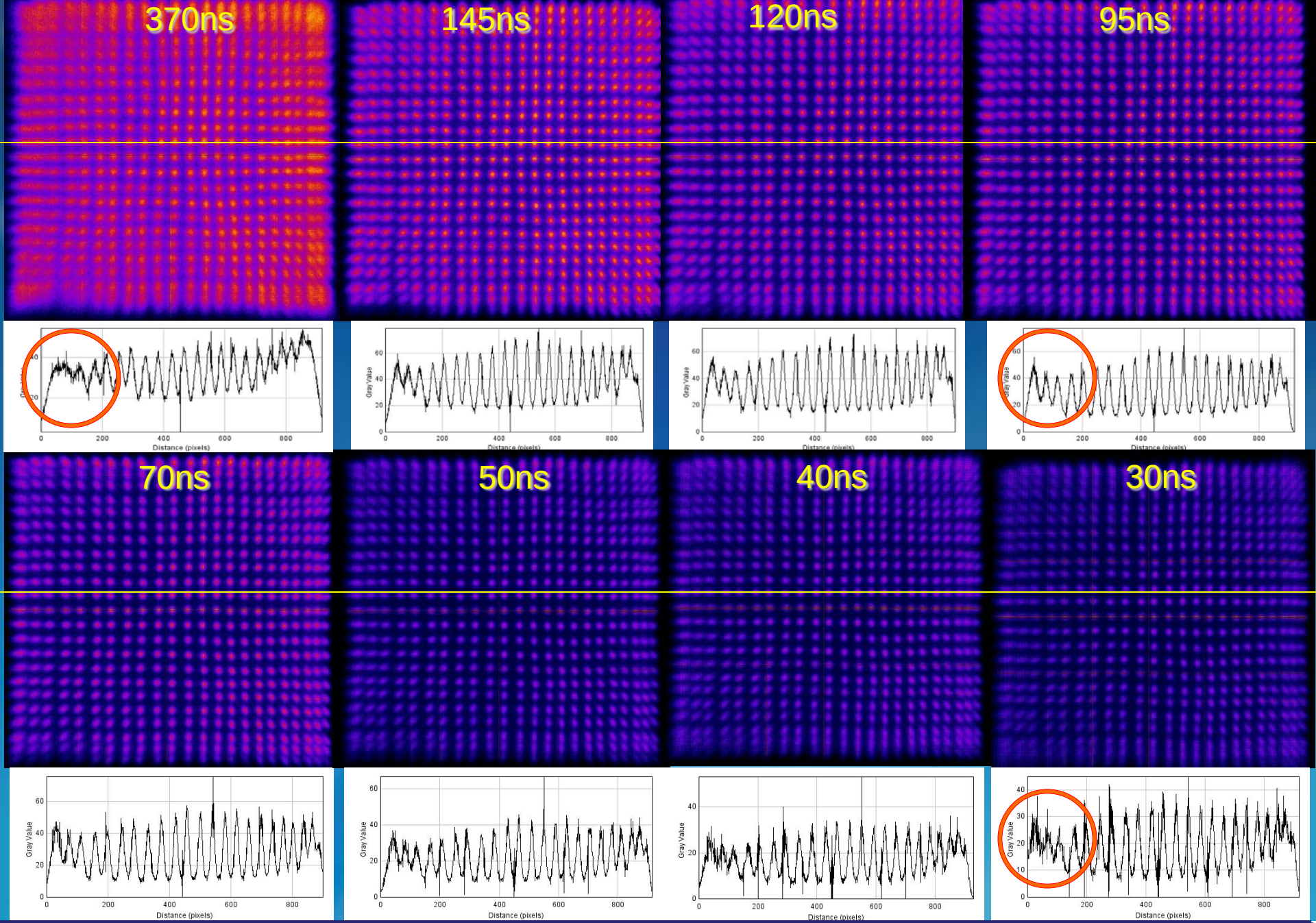
FWHM 511 keV photopeak energy resolution (%)

Relative 511 keV photopeak amplitude

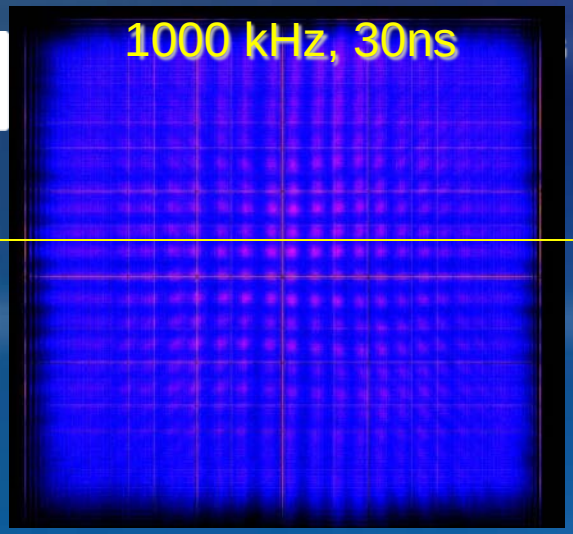


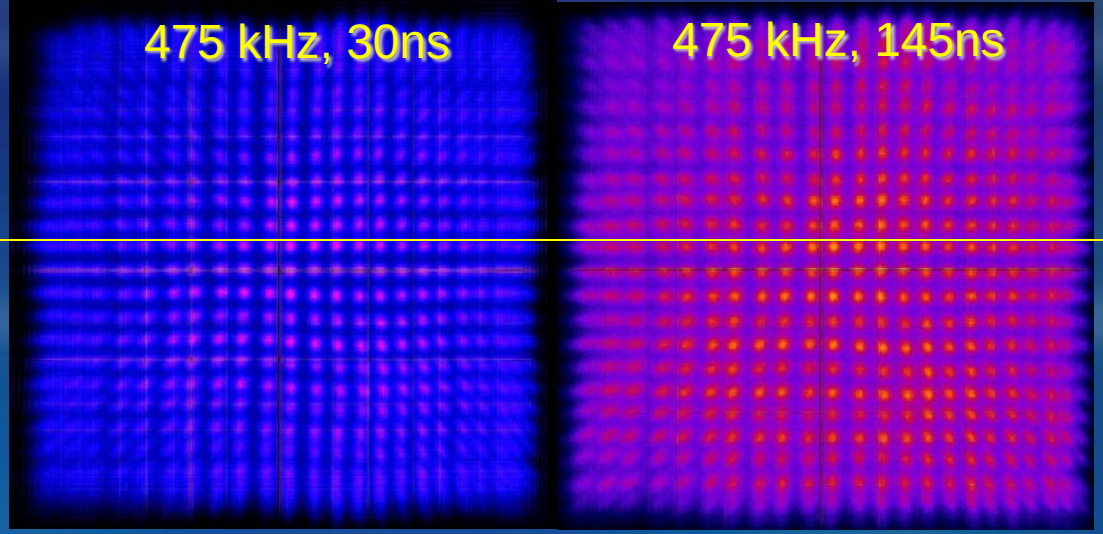


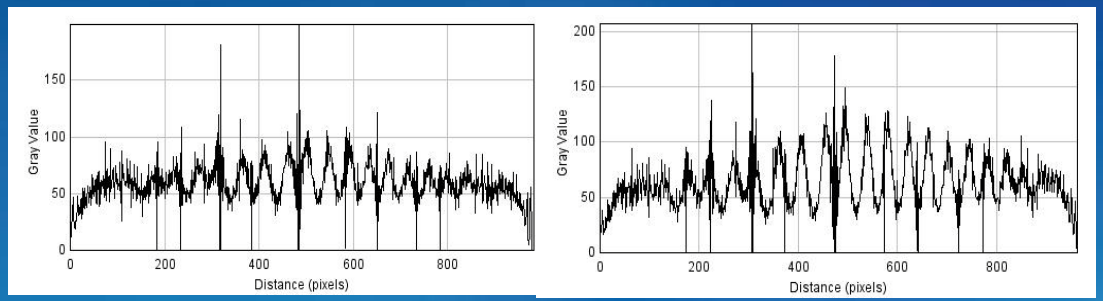
Proteus 2x2x15mm LYSO array. 21.5 deg. C, 30.8V bias on array, AiT Instruments 4ch charge division readout. Energy spectra measured for a single LYSO pixel.

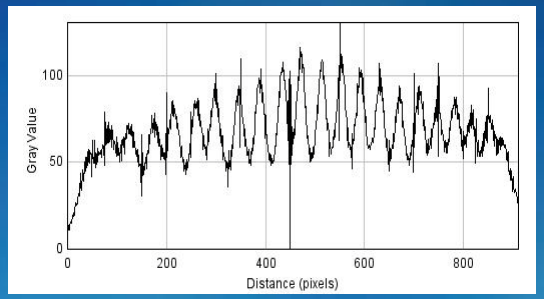


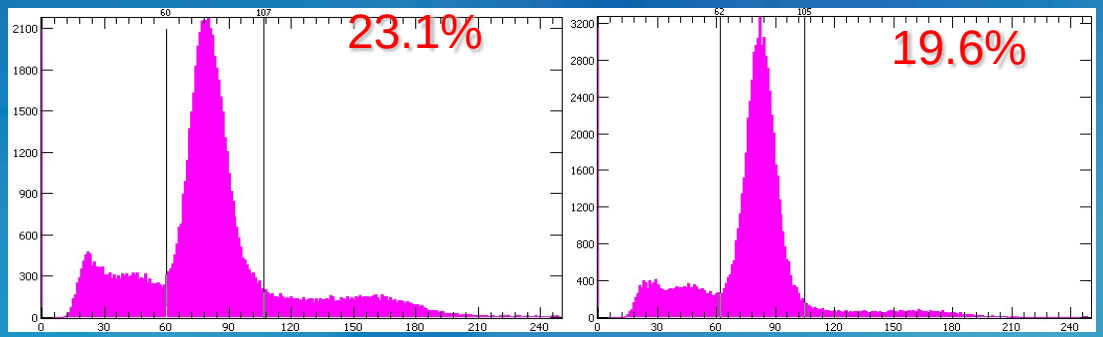
Cont'd. 4ch readout. Raw images @90 kHz for different ADC integration gates.

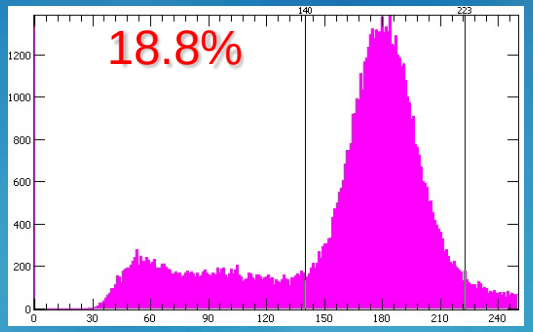




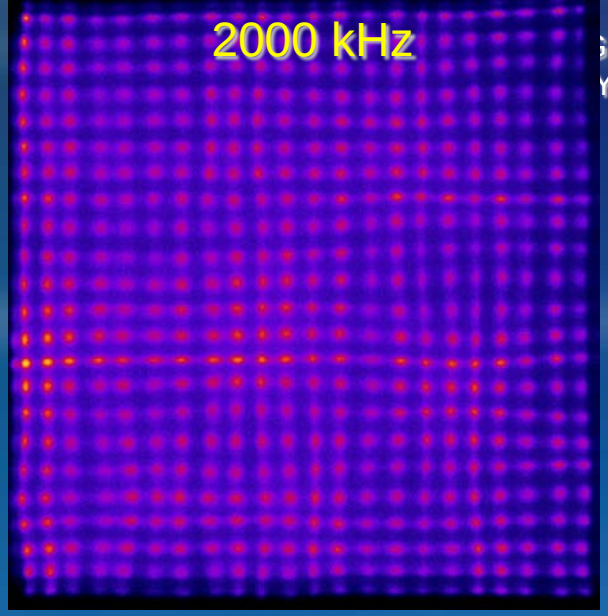


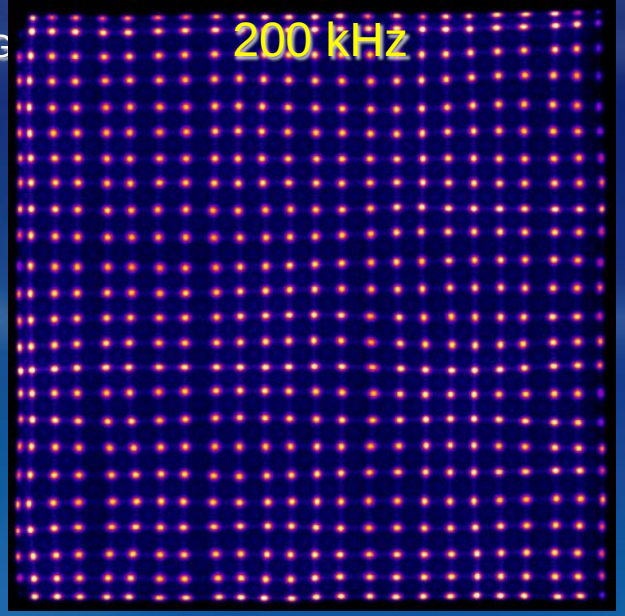


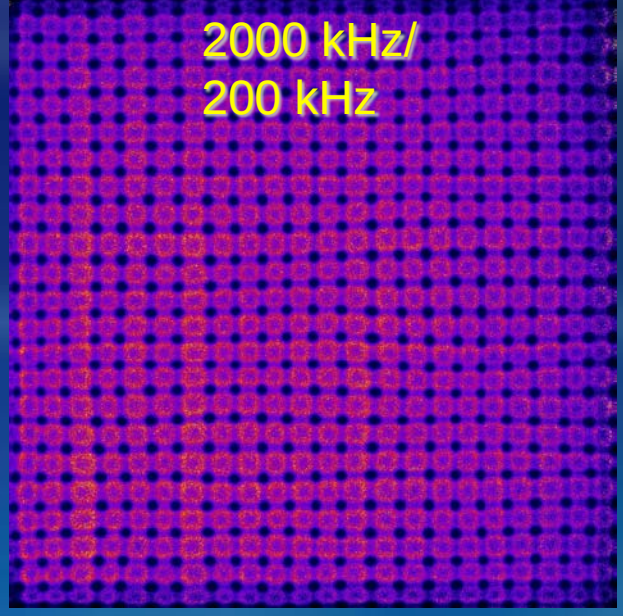


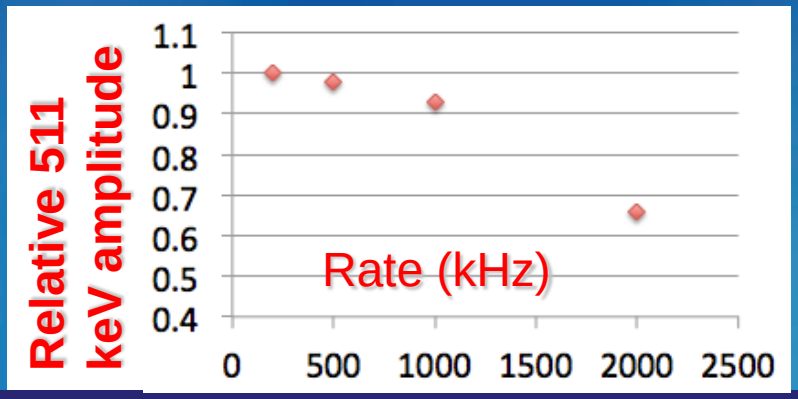


Ibid. 2mm LYSO array. 4ch readout. Part of the performance optimization vs width of the integrating ADC gate.

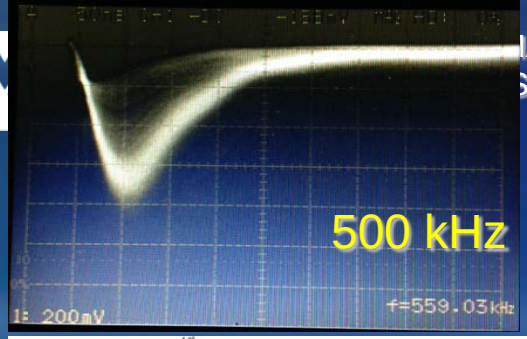


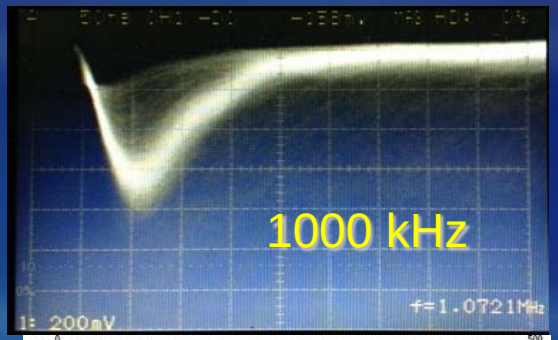


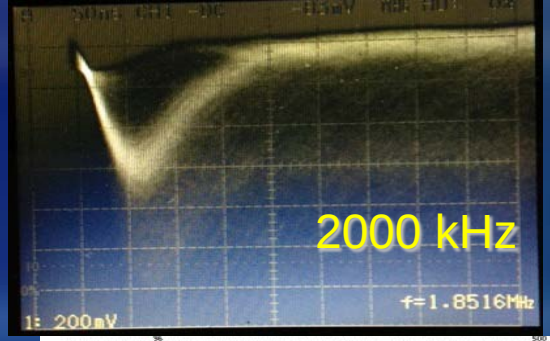


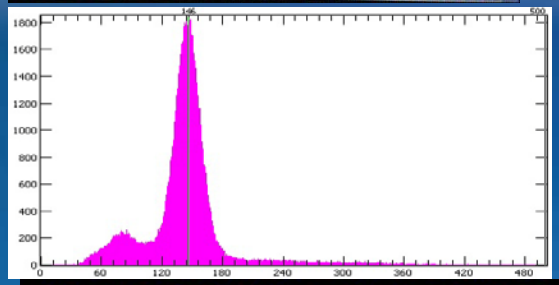


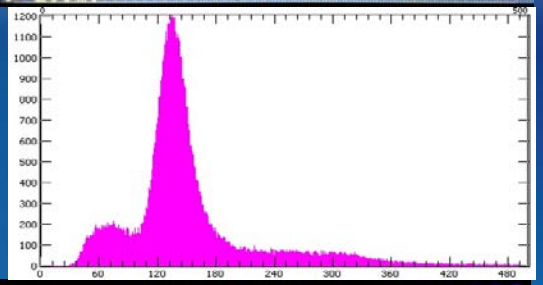
Proteus 2x2x15mm LYSO array. 21.5 deg. C, 30.8V bias on array, AiT Instruments 12x12 ch row-and-column readout, 2.35mm coupling window, 145ns ADC integration window, COG truncation factor 0.085. Good pixel separation even at the highest tested rate. Right image obtained by division of the raw images collected at 2000 kHz and 200 kHz confirms image stability through the whole rate range. The 511 keV photopeak amplitude measured in ADC decreases by < 10% at 1 MHz and by ~ 35% at 2.0 MHz.

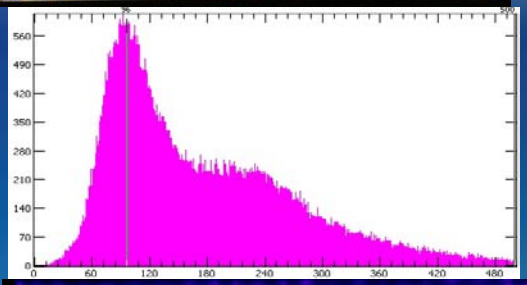


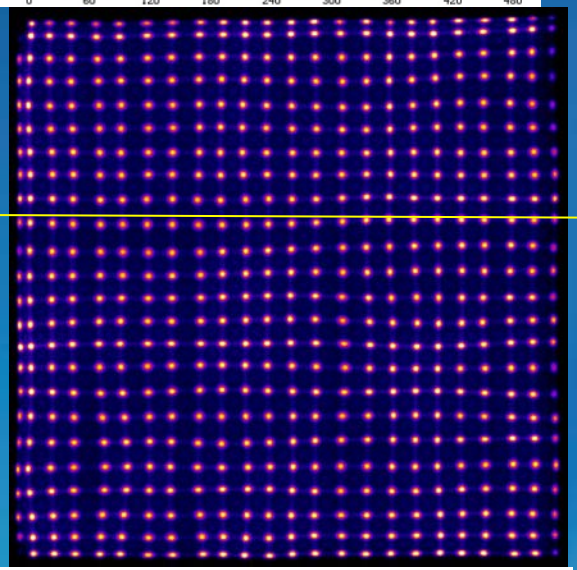


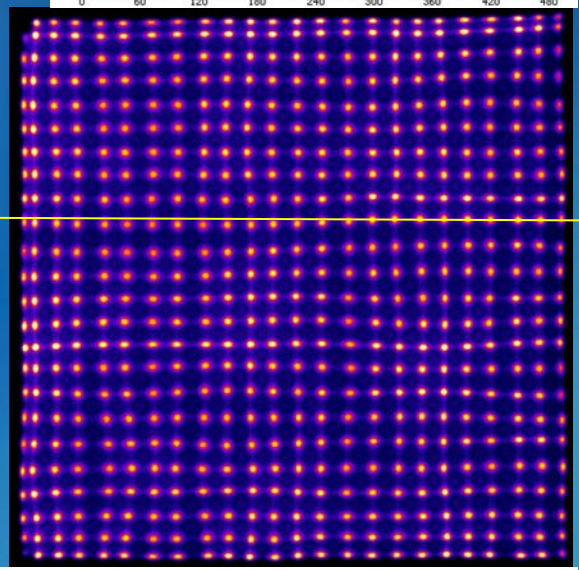


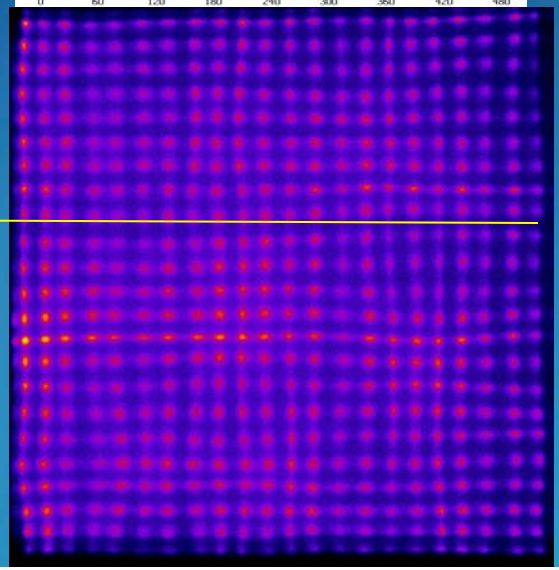


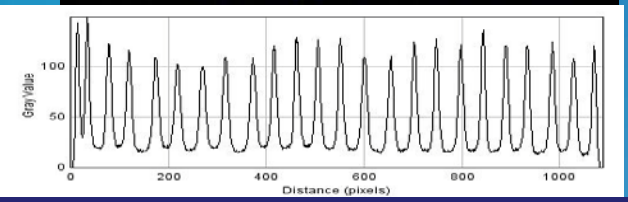


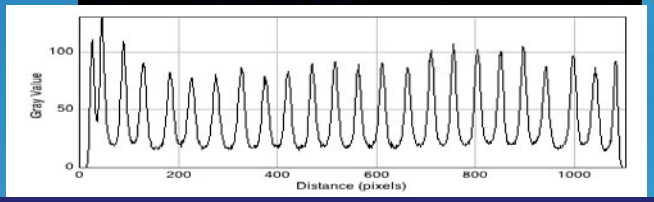


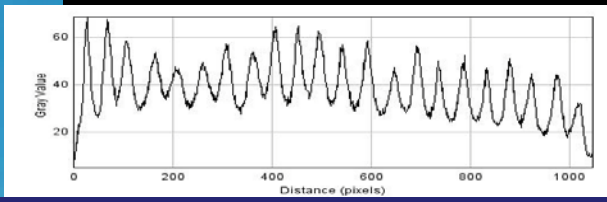












Cont'd. Scope pulses of the sum signals, raw images and single LYSO pixel spectra.

Overall Summary

- Rate capability with 4ch readout is lower than with 12x12 row-and-column readout
- Energy corruption happens at lower rate than image corruption (with 12x12 readout)
- Images are stable and pixel separation is possible up to 500kHz (4ch) and 2 MHz (12x12ch), respectively
- Amplitude decreases with rate by about 10% at 1 MHz
- Useful operational rate limit is set by pileups at about 1MHz with present pulse-shaping