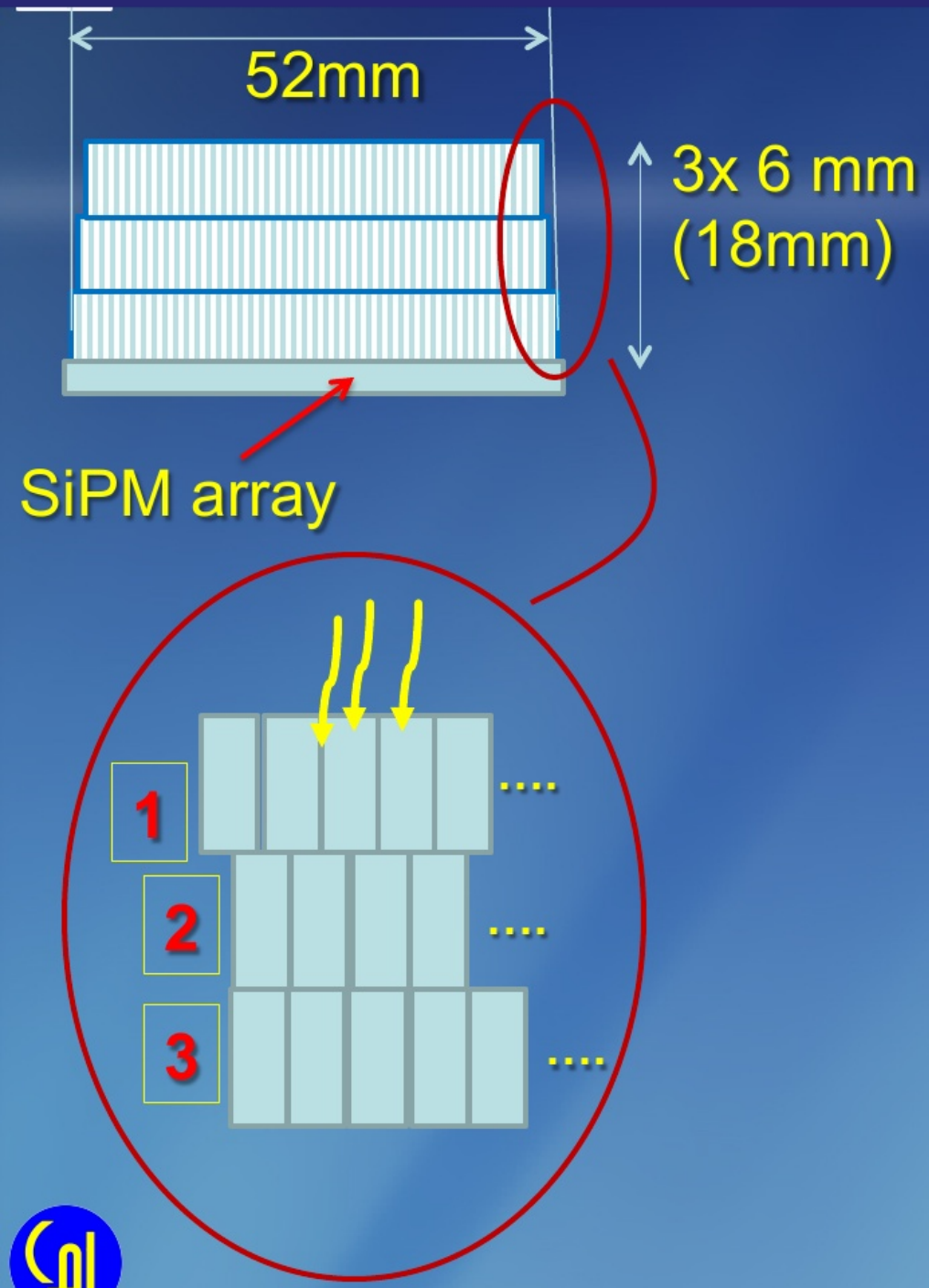
# Array stack module studies with the ArrayB-30035-144P-PCB




**Approach: stack of 3 arrays:**

- 1.5 mm pixel size
- 6 mm per layer
- Layers are staggered
- Total thickness: 18mm of LYSO
- "As-cut" side surface treatment
- @ 21 deg. C
- R&C readout
- Truncated COG algorithm

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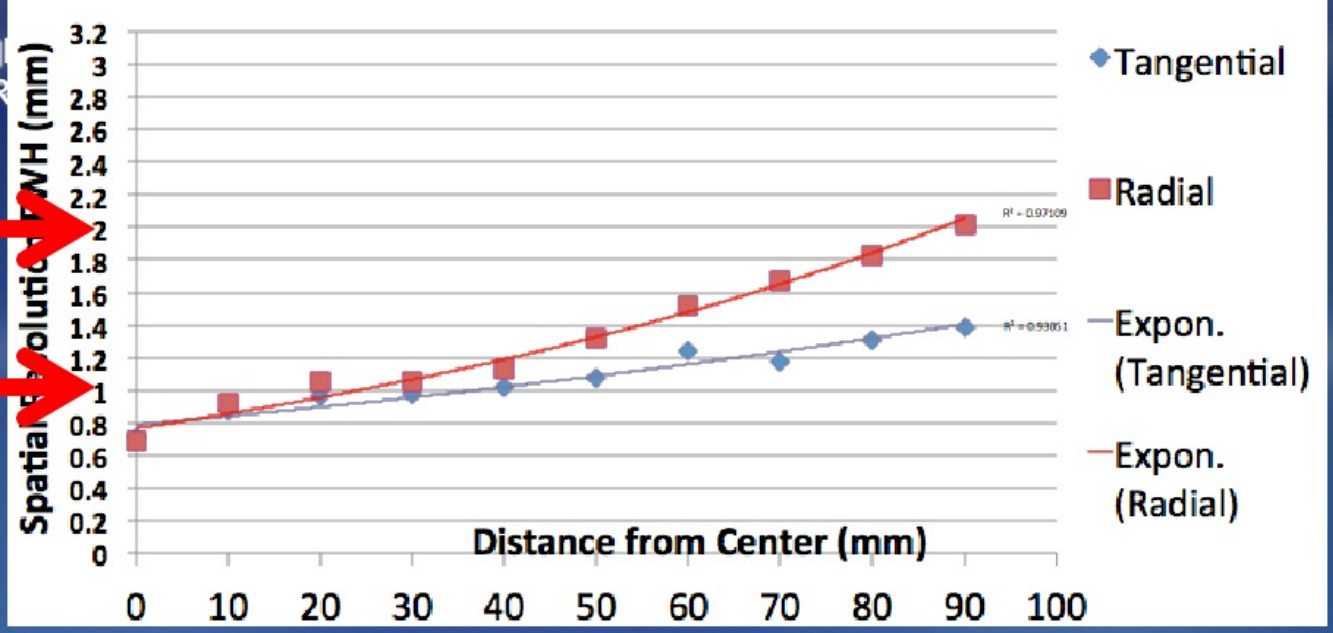
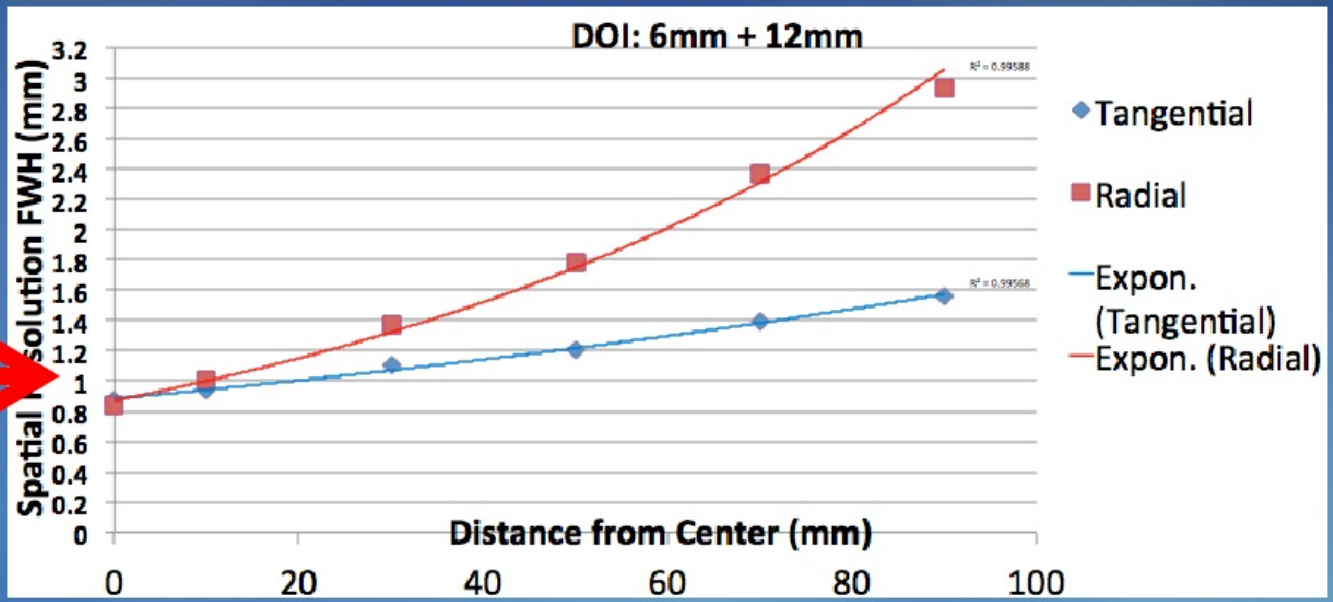
2mm

1mm

# Simulation results: resolution plots




1mm




GATE simulation results. FWHM spatial resolution versus distance from the center of a 24 cm PET ring composed of 16 modules ~5cm (wide) x10cm (high) each, with intrinsic pixel resolution of 1.5mm and with two (6mm + 12mm, bottom plot) and three 6mm (top plot) scintillation layers. It is assumed that the layers can be separated and this provides the Depth of Interaction (DOI) measurement with 6mm resolution. Predicted spatial resolution in the central region is less than 1mm FWHM and increases to ~2 mm at the outer region, in the case of 3x6mm layers.

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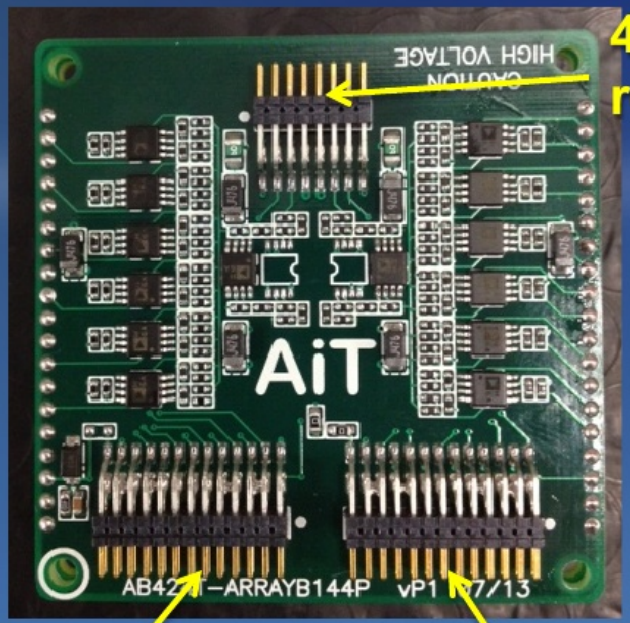
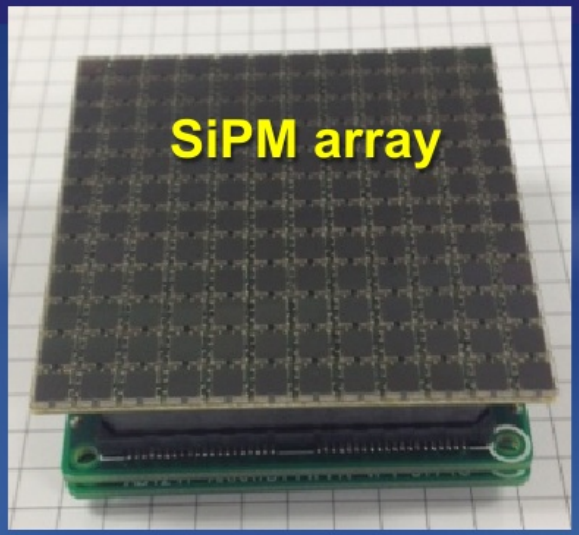
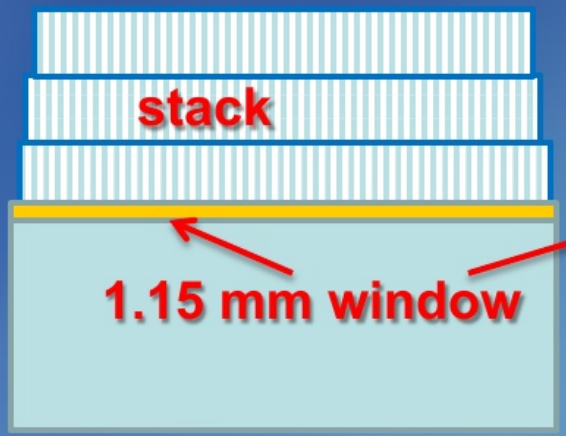
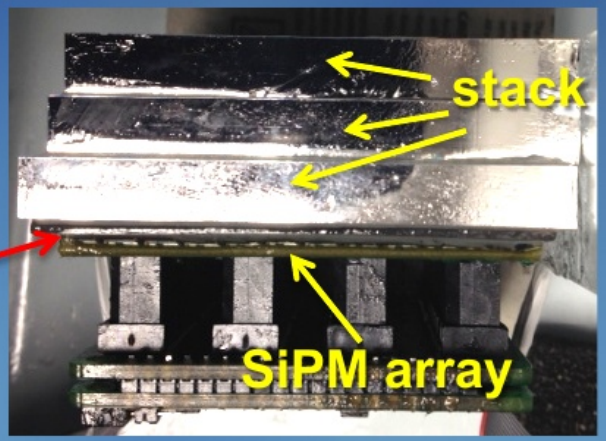



Hybrid readout board from AiT Instruments with the row-and-column readout and 4ch readout.

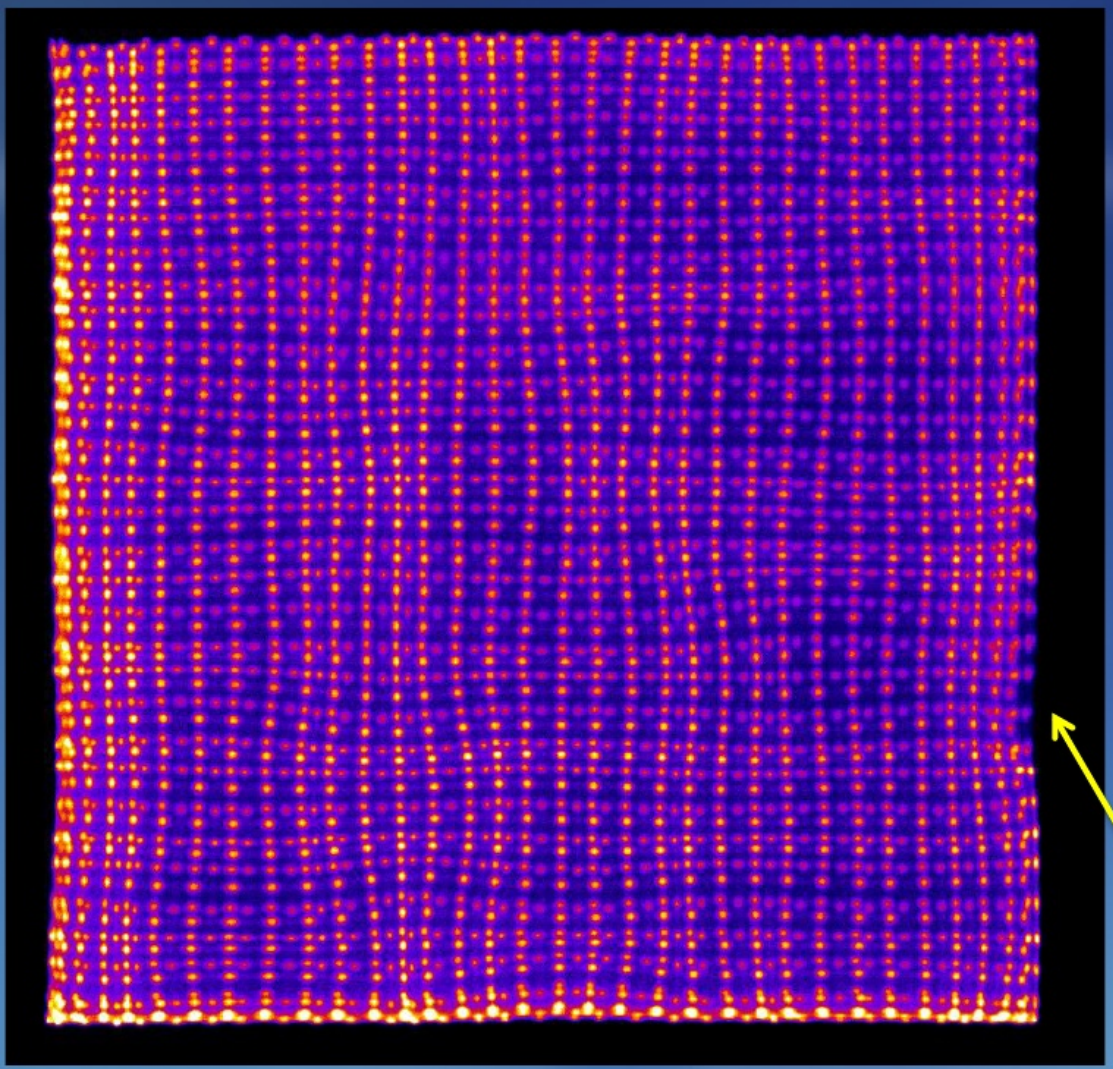




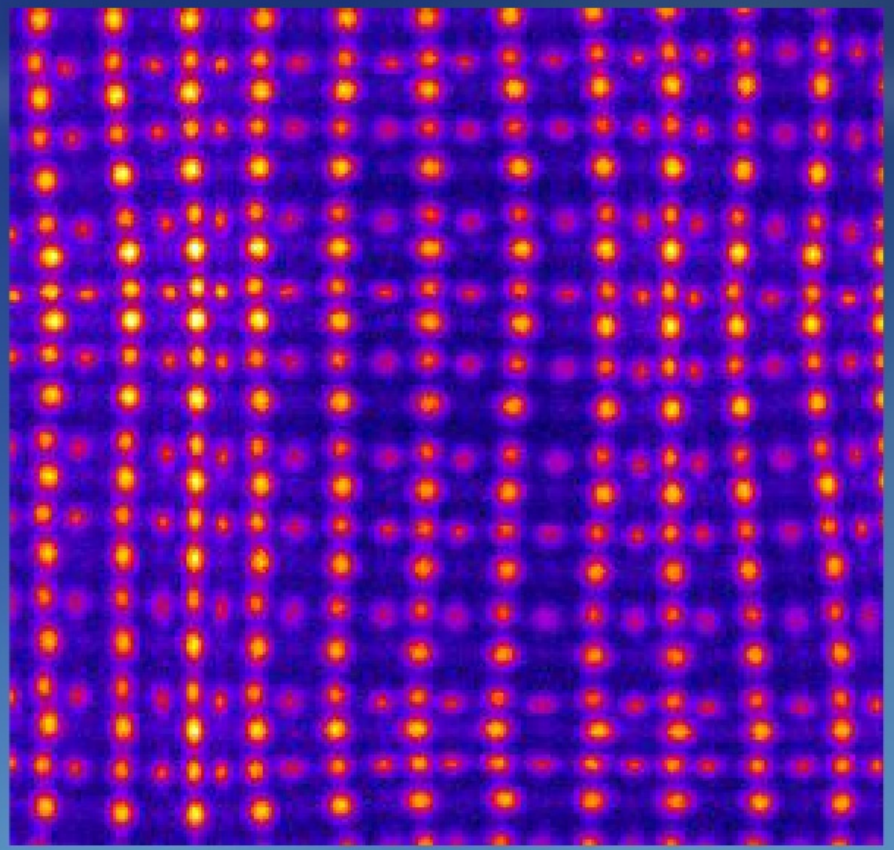

SiPM array was tested with the stack of three shifted 1.5mm LYSO arrays (from Proteus) coupled through an additional 1.15mm optical window. Visilox V-788 optical coupling compound was used between all optical surfaces.

# Array stack module studies with the ArrayB-30035-144P-PCB



Full

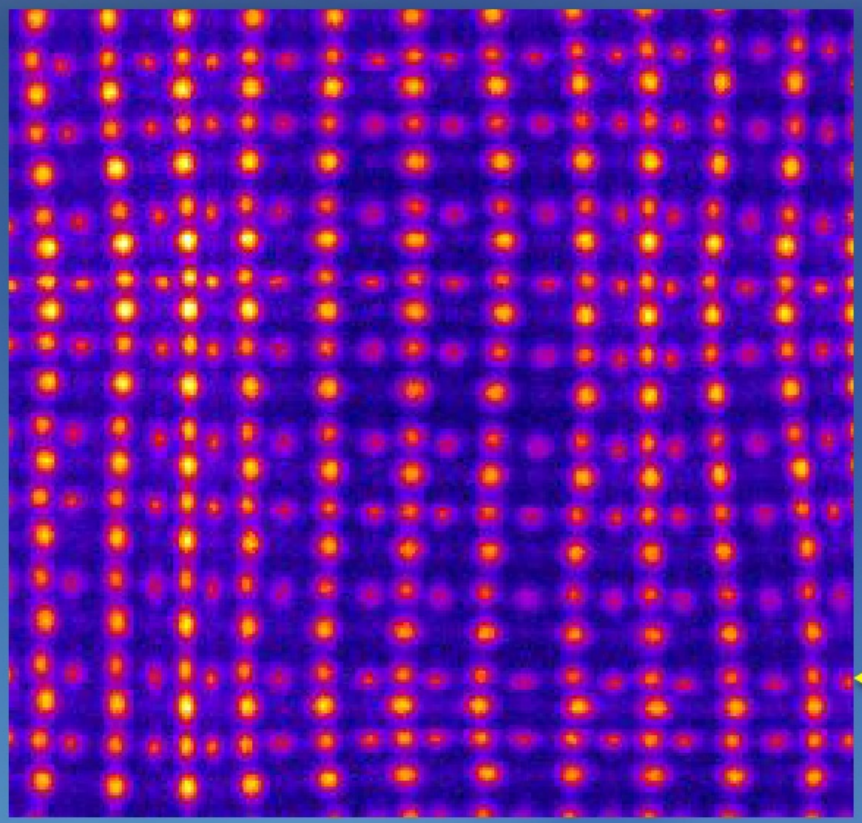
Air bubble

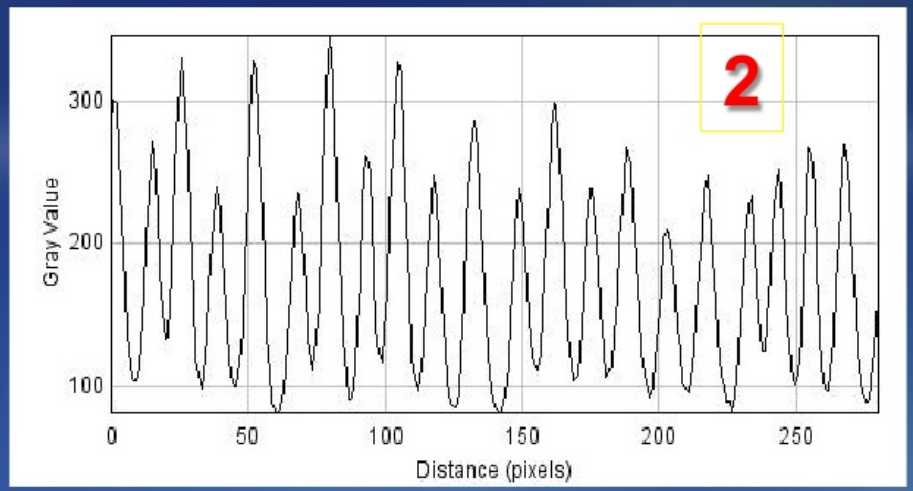


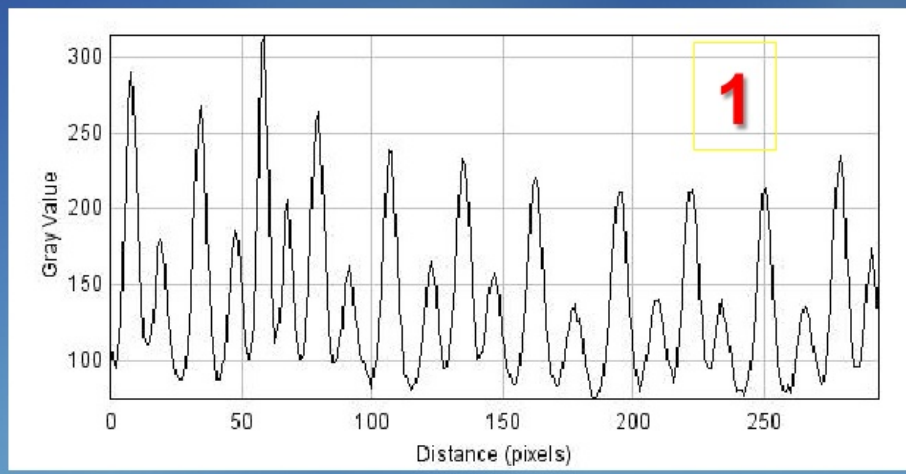
Zoom

Pixels of the three arrays separate in the raw images. The arrays are shifted relative to each other by ½ of the pixel pitch (1.50mm/2) in the x and z (into the slide) directions. (Conditions: Bias 30.5 V, Temp 21 deg C, Row-and-Column readout, 520 ns integration gate to ADC, ADC attenuator 4.0, DC coupling of the signal to ADC. Truncation COG factor 0.025).

# Array stack module studies with the ArrayB-30035-144P-PCB




Pixels of the three arrays separate in the raw image and in plots. (Conditions: Bias 30.5 V, Temp 21 deg C, Row-and-Column readout, 520 ns integration gate to ADC, ADC attenuator 4.0, DC coupling of the signal to ADC. Truncation COG factor 0.025).

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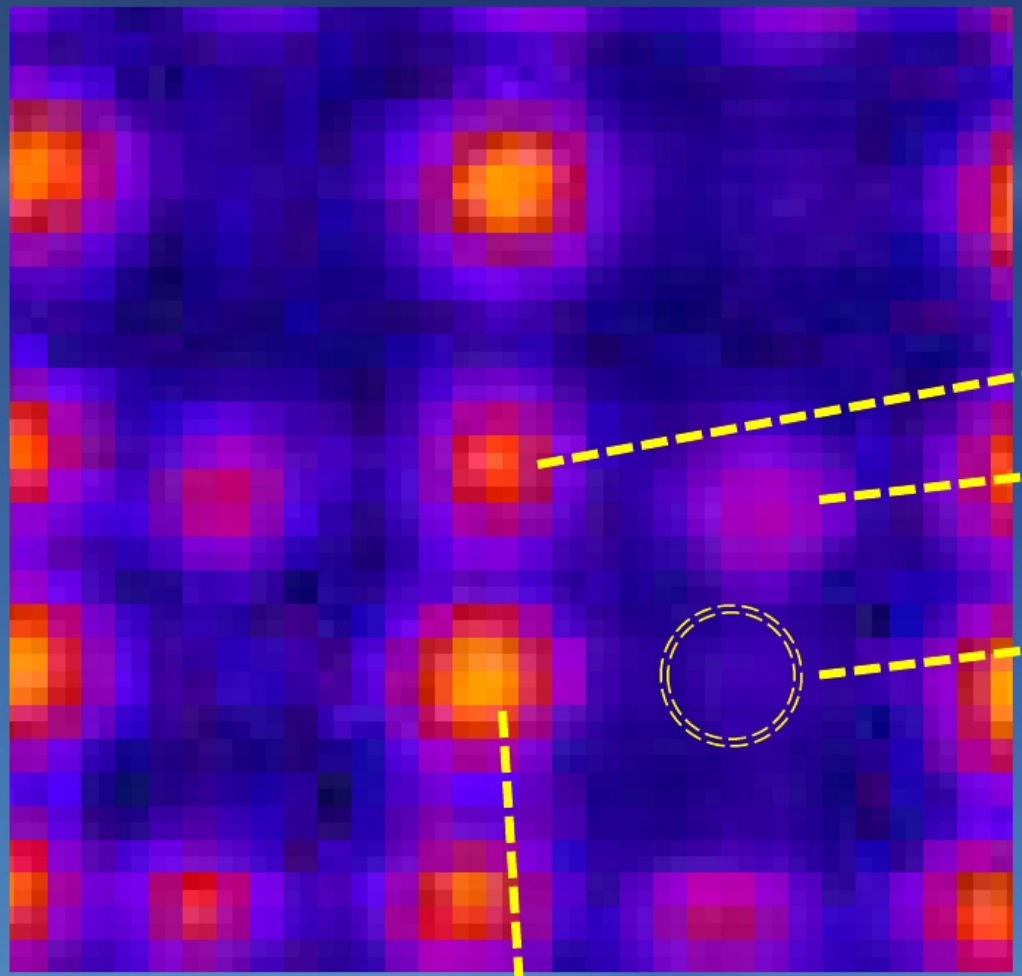
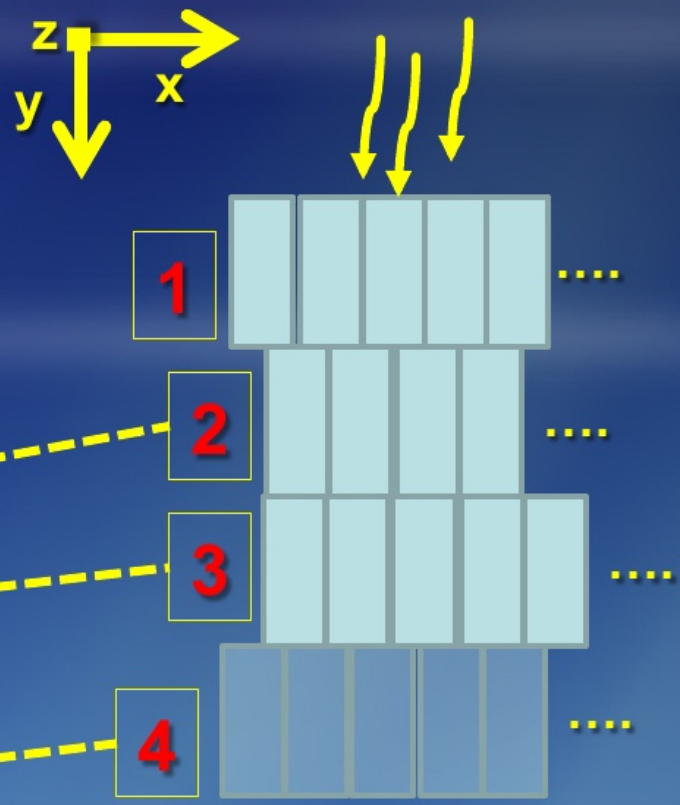
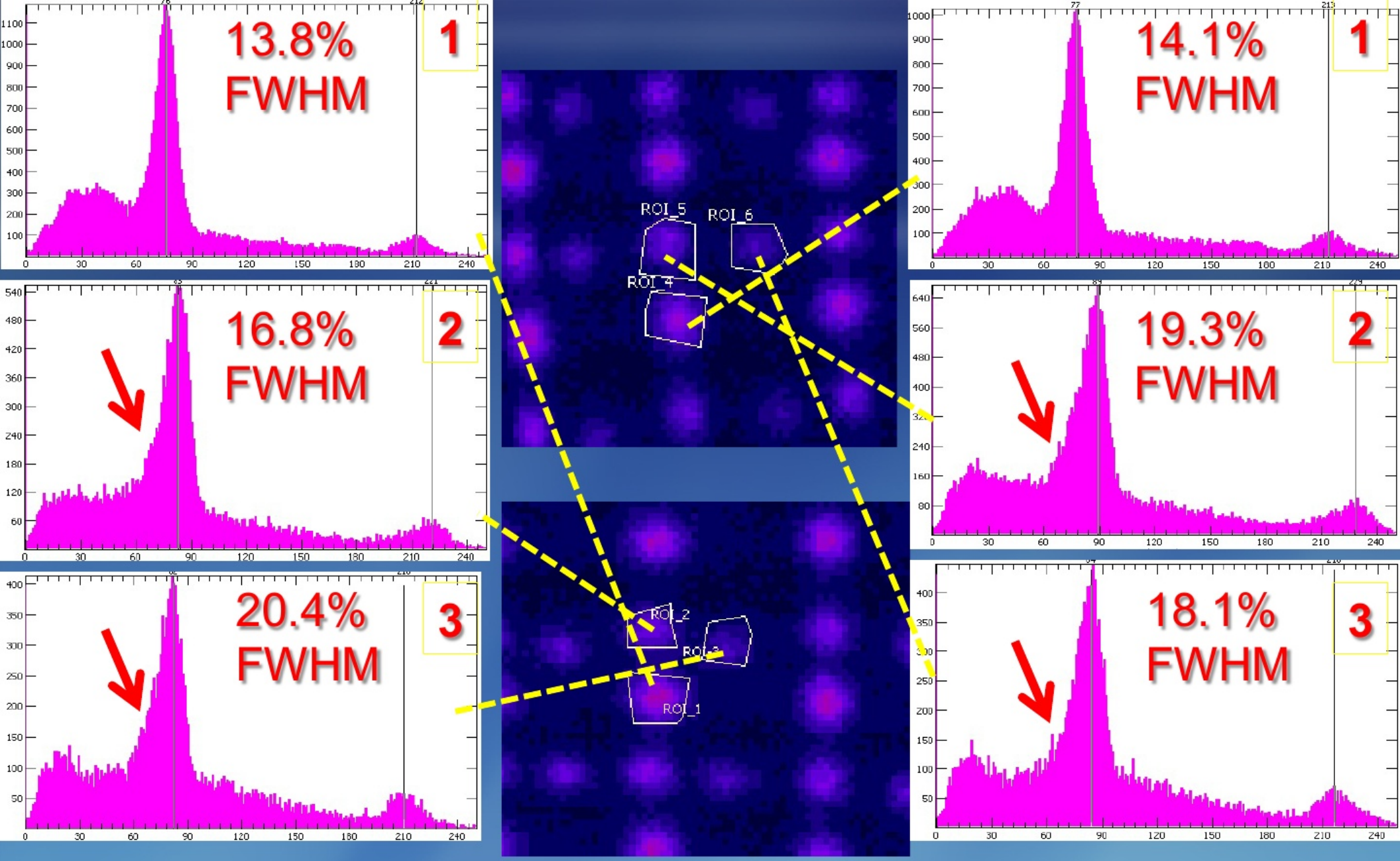




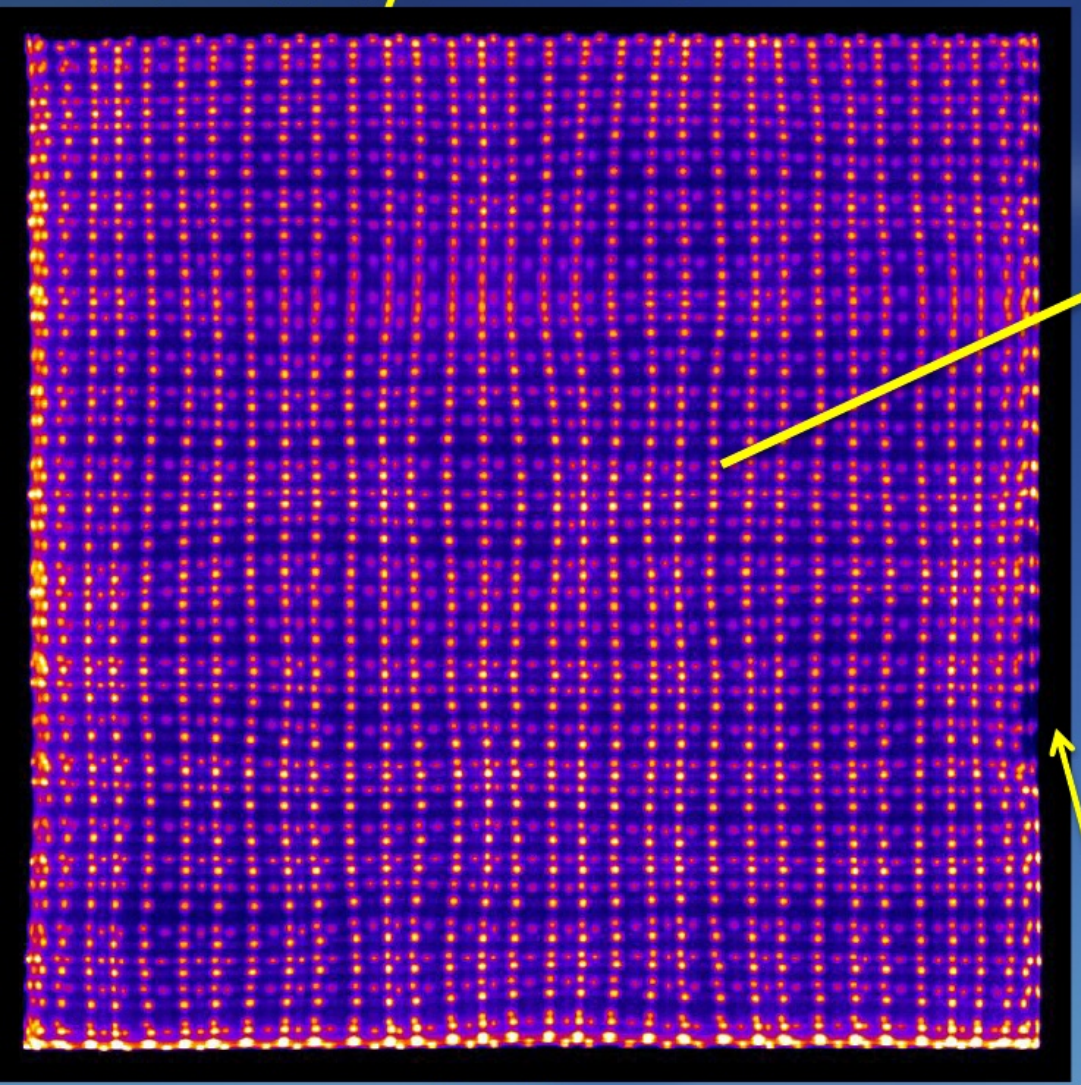

1

Pixels of the three arrays separate in the zoom images The arrays are shifted relative to each other by about half of the pixel pitch (1.50mm/2) in the x and z (into the slide) directions. There is room in principle for another array, number four. (Conditions: Bias 30.5 V, Temp 21 deg C, Row-and-Column readout, 520 ns integration gate to ADC, ADC attenuator 4.0, DC coupling of the signal to ADC. Truncation COG factor 0.025).

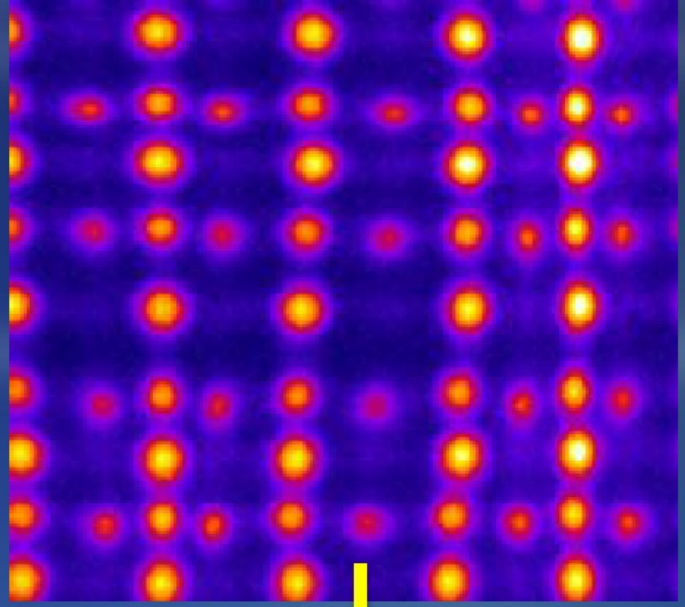


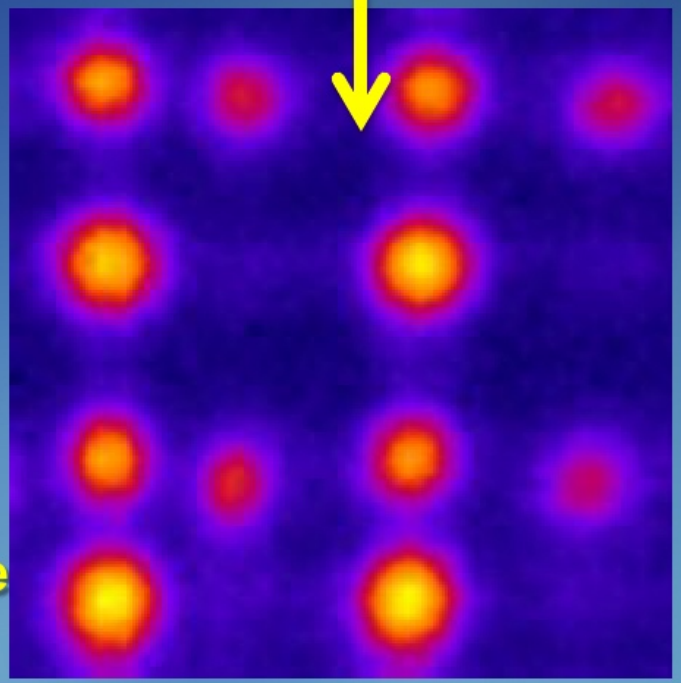

Examples of energy spectra. Zoom raw images in two regions. The red arrows indicate peaks in layers 2 and 3 with less than 511 keV energy deposit due to scattered gammas in layer 1. (Conditions: Bias 30.5 V, Temp 21 deg C, Row-and-Column readout, 520 ns integration gate to ADC, ADC attenuator 4.0, DC coupling of the signal to ADC. Truncation COG factor 0.025).

# Array stack module studies with the ArrayB-30035-144P-PCB



Full

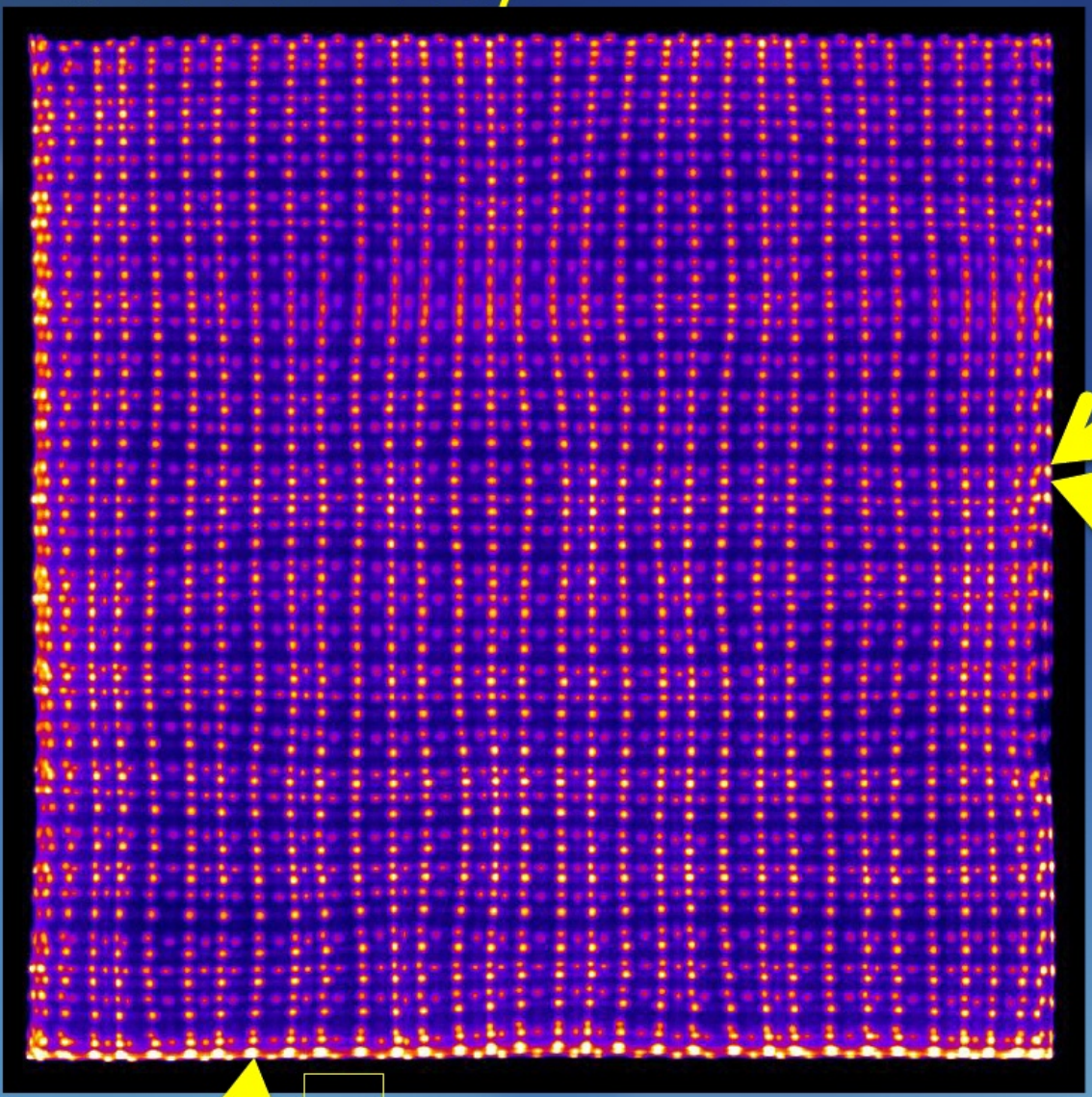


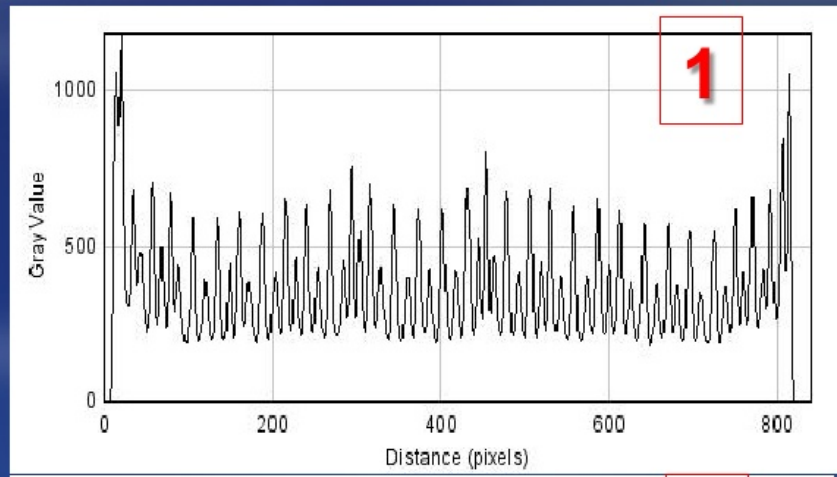


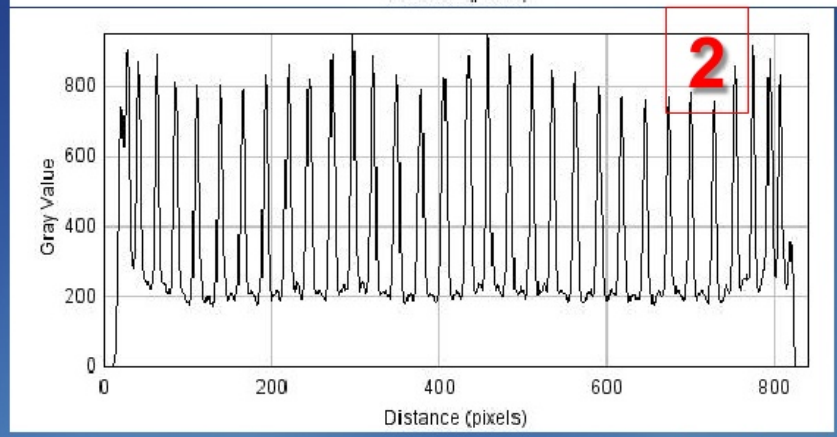
Air bubble

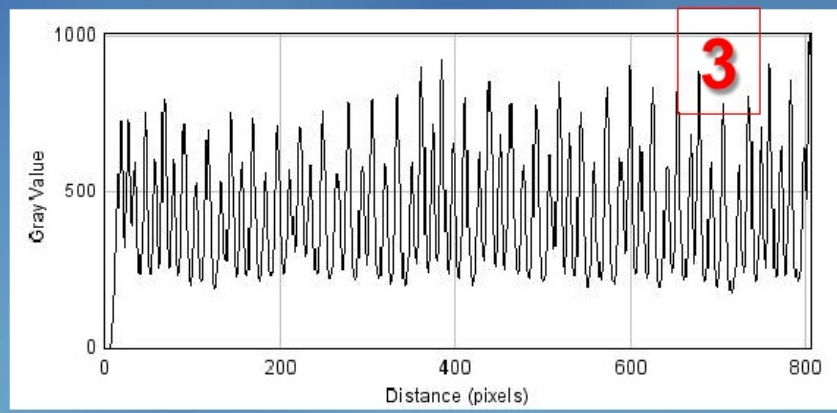
Pixels of the three arrays separate in the raw images. The arrays are shifted relative to each other by ½ of the pixel pitch (1.50mm/2) in the x and z (into the slide) directions. (Conditions: Bias 29.5 V, Temp 21 deg C, Row-and-Column readout, 170 ns integration gate to ADC, ADC attenuator 4.0, DC coupling of the signal to ADC. Truncation COG factor 0.025).

# Array stack module studies with the ArrayB-30035-144P-

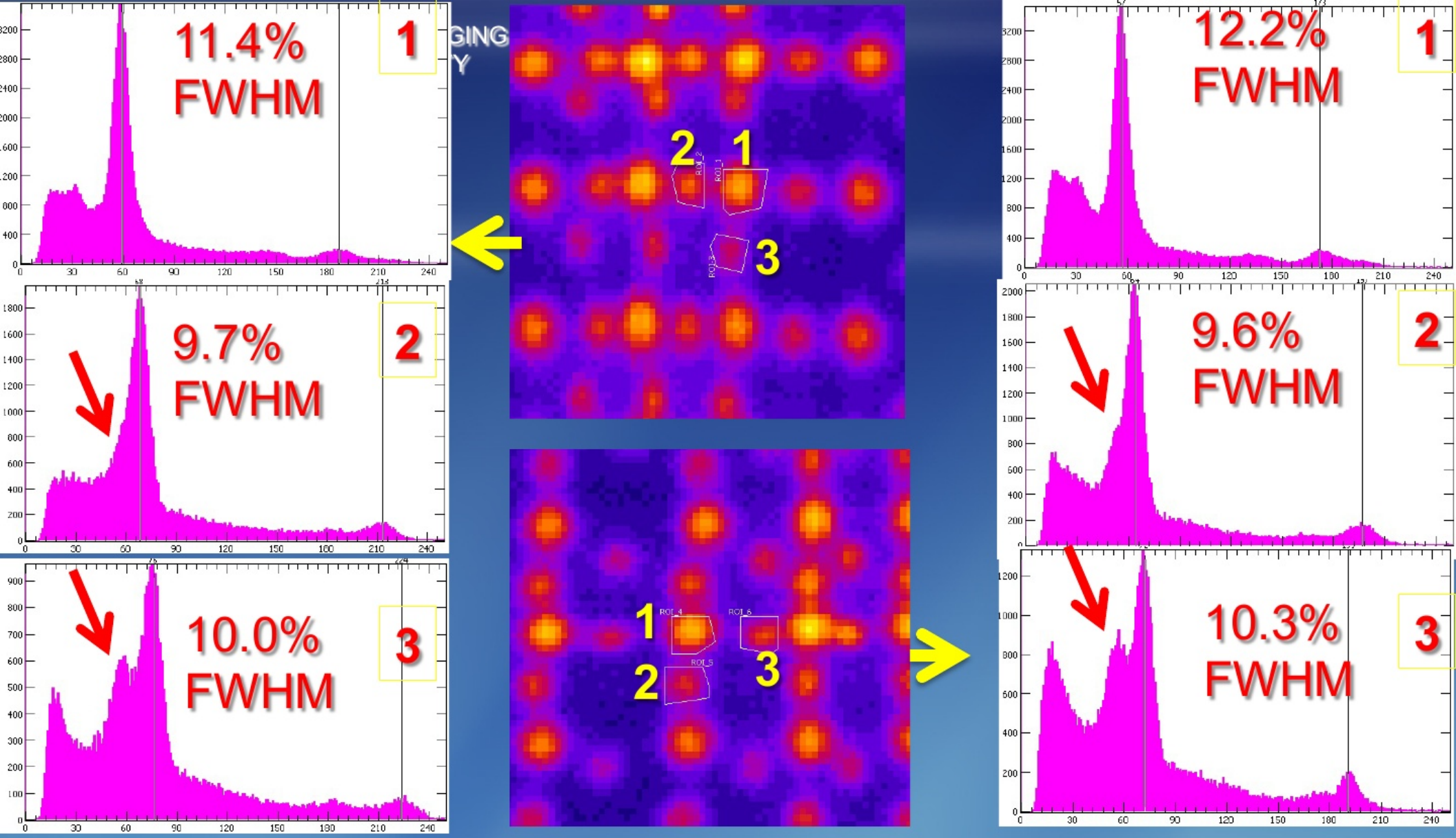


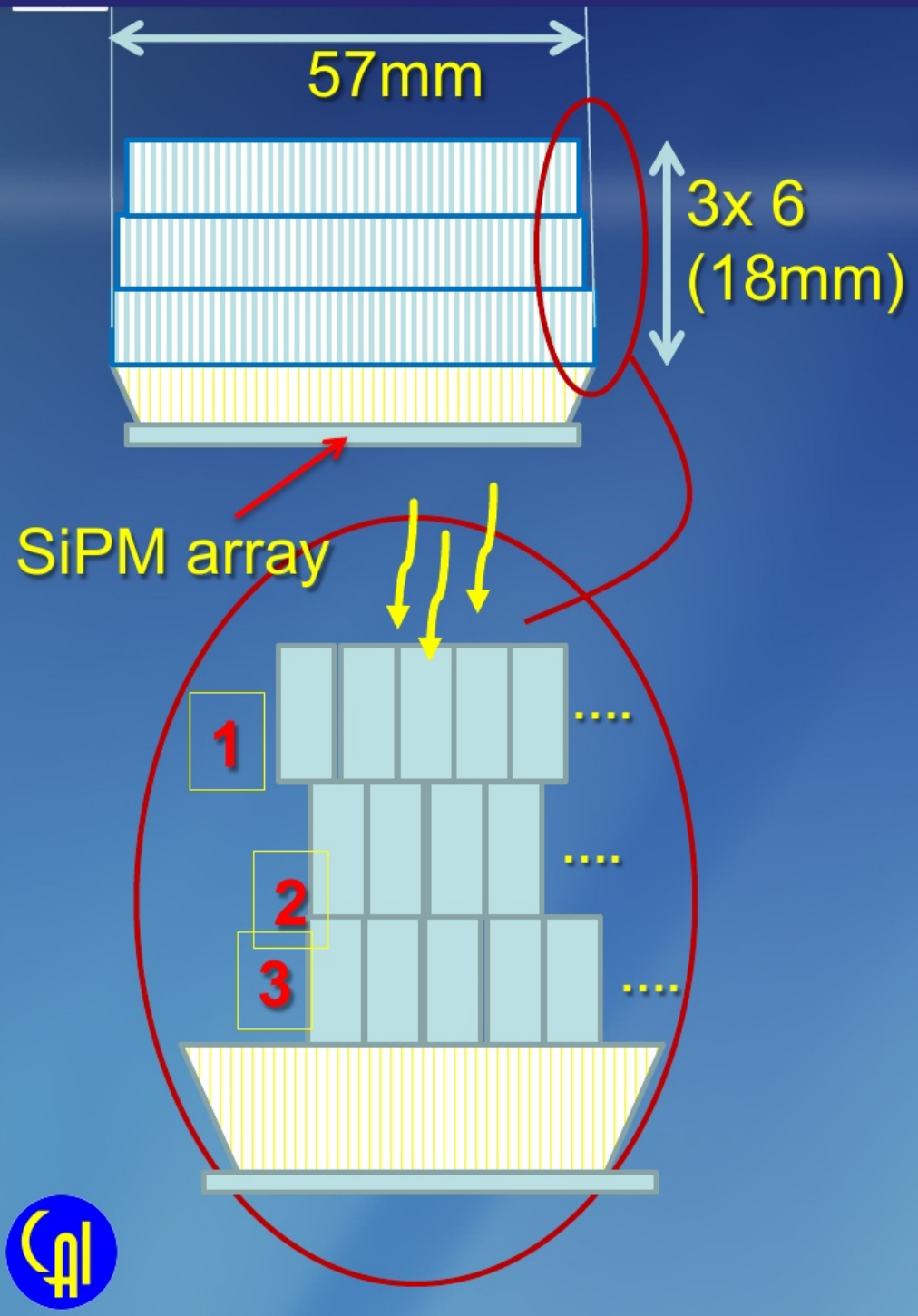




Pixels of the three arrays separate in the raw image and in plots. (Conditions: Bias 29.5 V, Temp 21 deg C, Row-and-Column readout, 170 ns integration gate to ADC, ADC attenuator 4.0, DC coupling of the signal to ADC. Truncation COG factor 0.025).




Examples of energy spectra. Zoom raw images in two regions. The red arrows indicate peaks in layers 2 and 3 with less than 511 keV energy deposit due to scattered gammas in layer 1. Energy resolutions in layers 2 and 3 are estimates after subtracting the scatter contributions. (Conditions: Bias 29.5 V, Temp 21 deg C, Row-and-Column readout, 170 ns integration gate to ADC, ADC attenuator 2.0, DC coupling of the signal to ADC. Truncation COG factor 0.05).

# Array stack module studies with the ArrayB-30035-144P-PCB



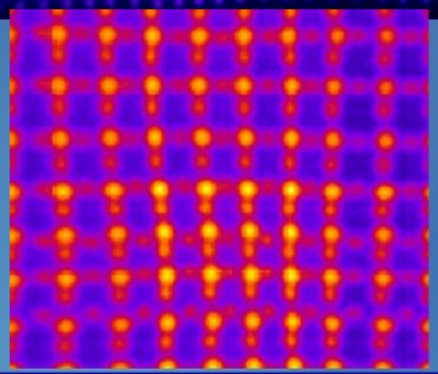

**Approach: stack of 3 arrays plus tapered light guide:**

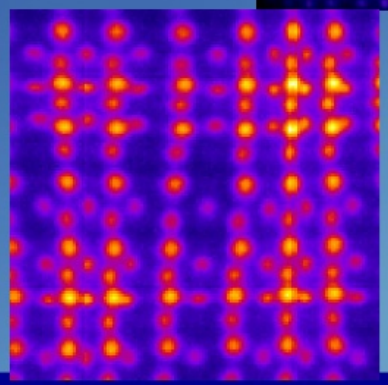
- 1.5 mm pixel size
- 6 mm per layer
- Layers are staggered
- Total thickness: 18mm of LYSO
- "As-cut" side surface treatment
- @ 21 deg. C
- R&C readout
- Truncated COG algorithm

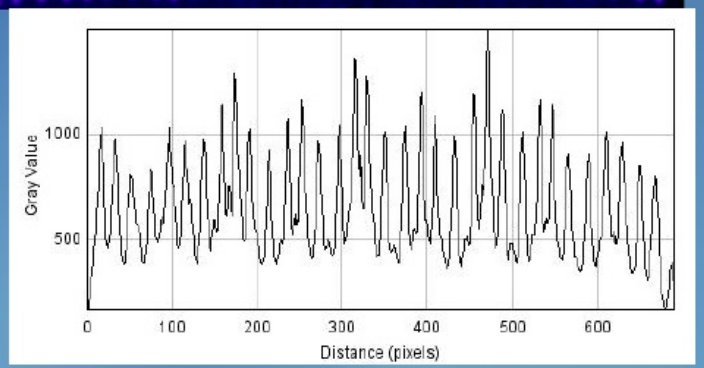
# Array stack with tapered light guide studied with the ArrayB-30035-144P-PCB

1.15 mm window

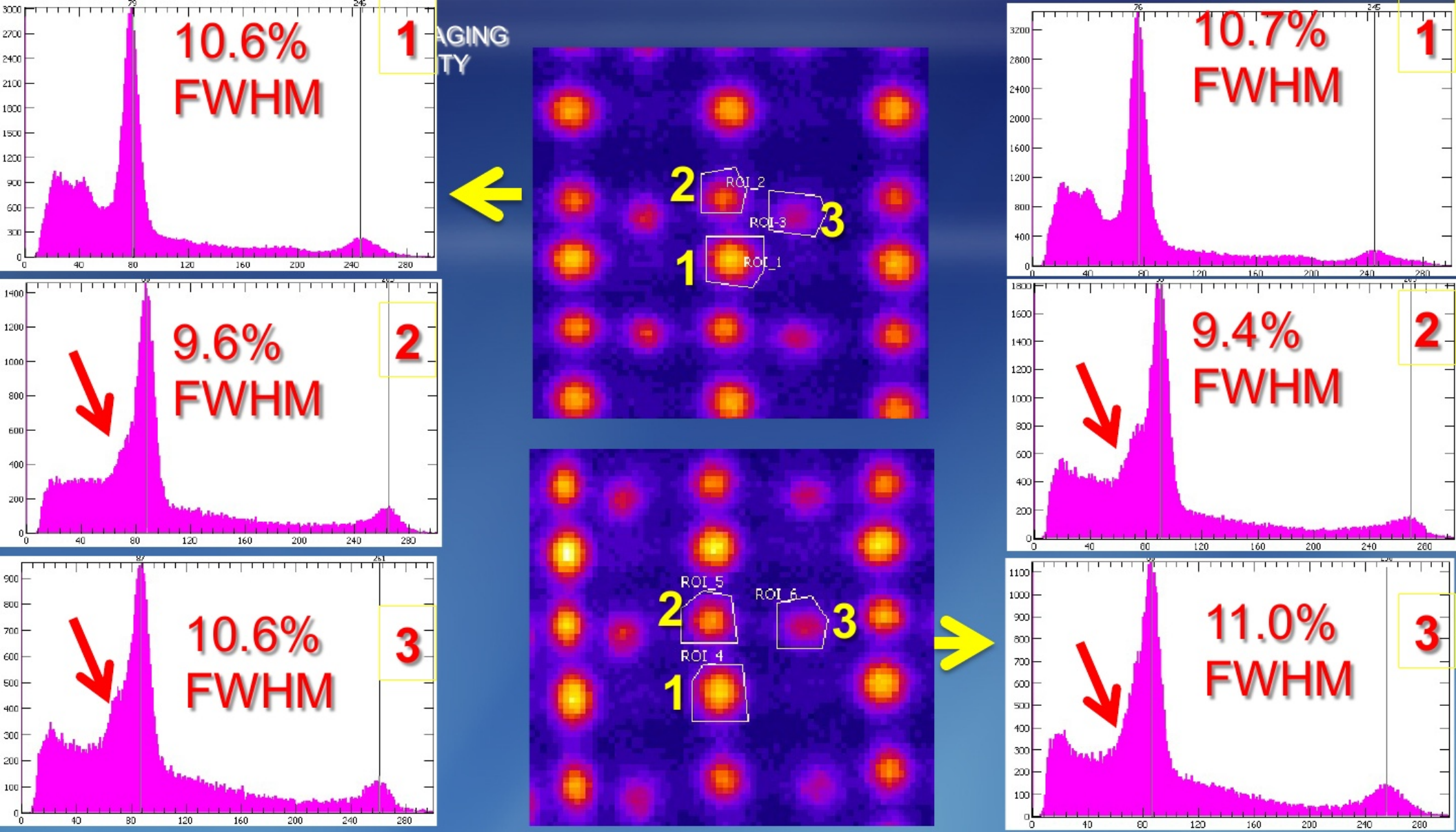
No window








Raw images of the whole stack detector and zoom images with an additional 1.15mm spreader window in front of the SiPM array (left) or with direct coupling (right). Pixels do not separate at left but show undersampling at right. (Conditions: Bias 29.5 V, Temp 21 deg C, Row-and-Column readout, 170 ns integration gate to ADC, ADC attenuator 2.0, DC coupling of the signal to ADC. Truncation COG factor 0.05).

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# Conclusions

- The three arrays are well-separated in the images and have very good energy resolution of FWHM ~ 10% @ 511 keV
- This is a practical, even if expensive (scintillator), solution to obtain high resolution PET modules with 6 mm DOI, assuring sub-mm resolution in the central part of the PET ring imager
- Higher density of SiPM elements will offer better performance in the toughest case of the scintillator stack used with the tapered light guide, based on the comparison with the MPPC array