Economical SiPM Option for H8500 PSPMT Replacement in PET modules

May 08, 2013

Motivation:
MRI-compatibility
Compactness
Cost

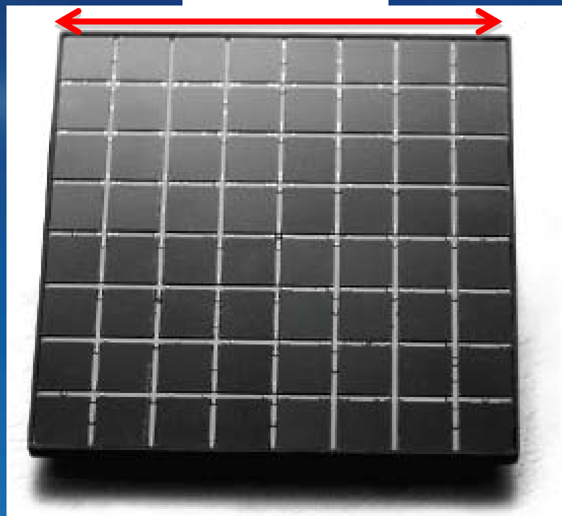
Approach: Develop multiplexing readout schemes minimizing the number of readout channels, while maintaining high performance (primarily spatial resolution).

First stage: definition of the performance limits using 4ch charge division readout

Second stage: develop DOI module designs using multiplexed readout

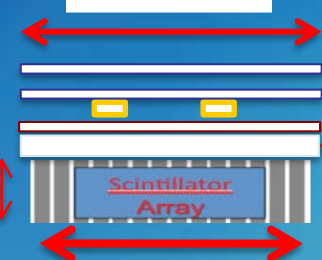
ArraySB-8

~57mm

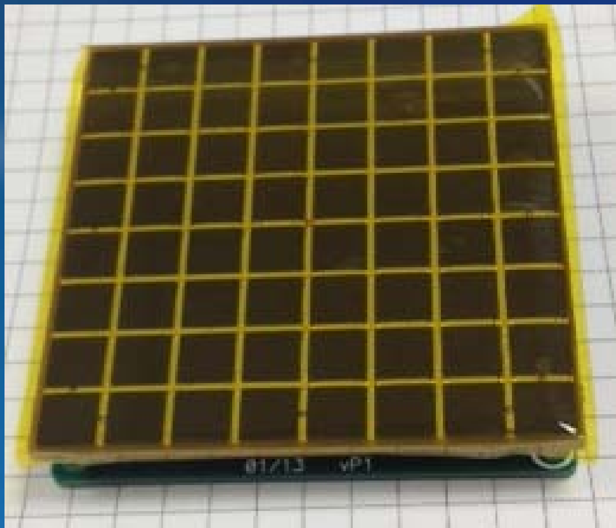


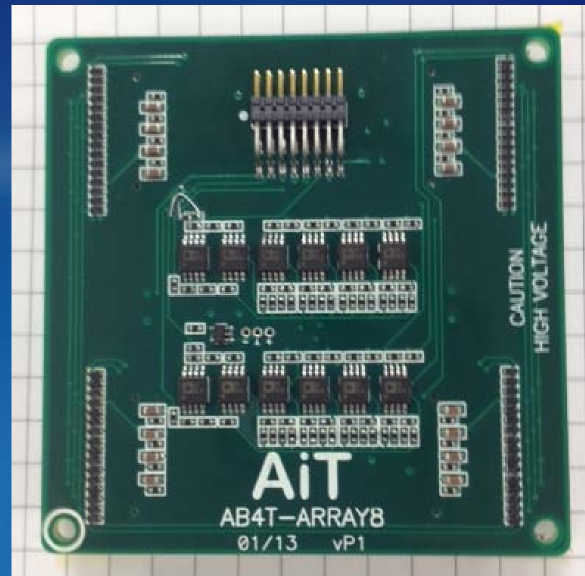
Parameter	Value [a]
Number of pixels	8x8
Pixel active area	$6x6mm^2$
PCB size	$56.6x56.6mm^2$
Pixel pitch	7mm
No. of microcells per pixel	18980
Operating voltage (V_{op})	28.9V
Gain [b]	$2.4x10^6$
Pixel dark current	11μA
Microcell recovery time	90ns
Temperature dependence of V_{br} [b]	20mV/°C

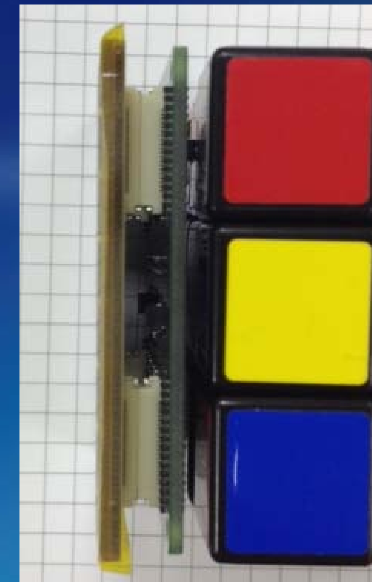
[a] *measured at V_{op} and 20°C*
[b] *measured on a MicroSL-10035*



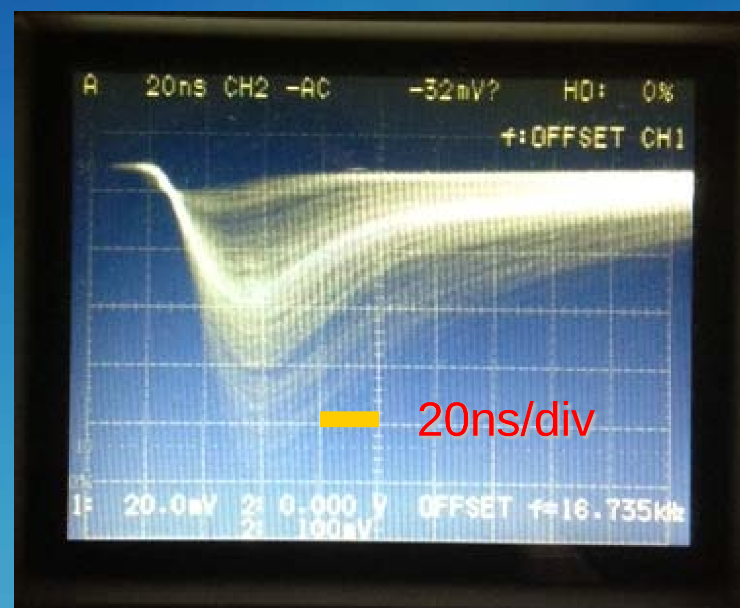
ArraySB-8 4ch readout





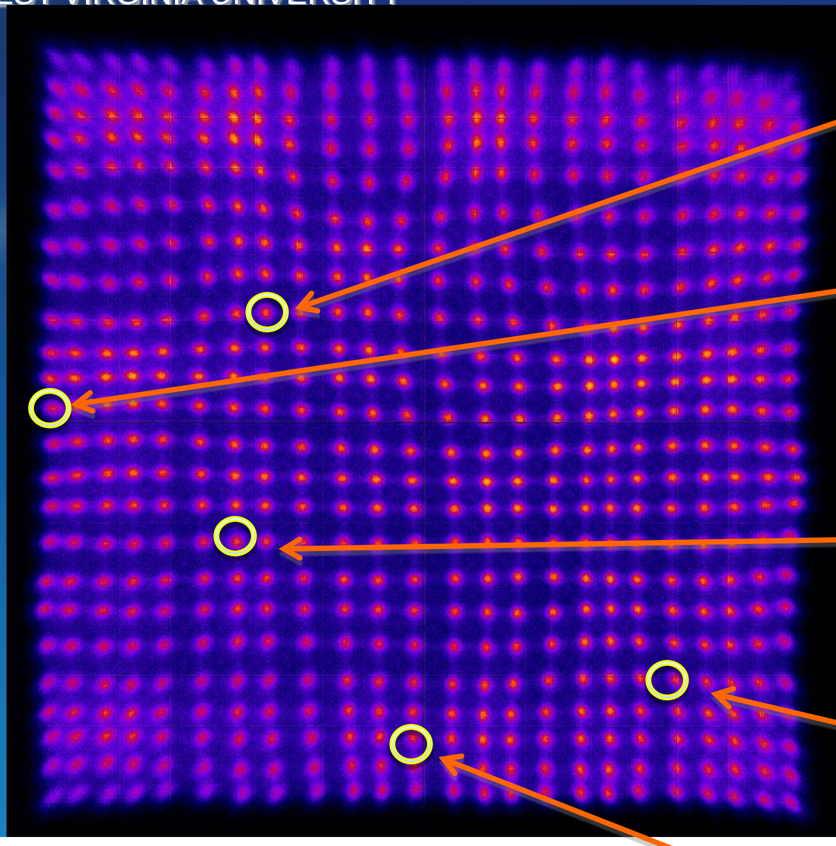


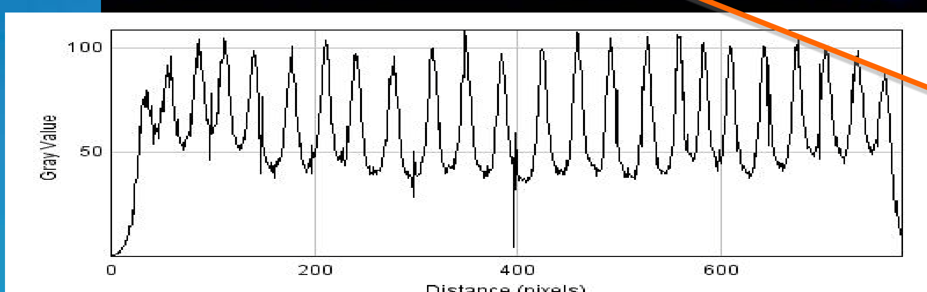
The Array8 module from SensL equipped with charge division 4ch readout from AiT Instruments. The output channels integrated and digitized in the AiT Instruments 64ch FPGA DAQ module.

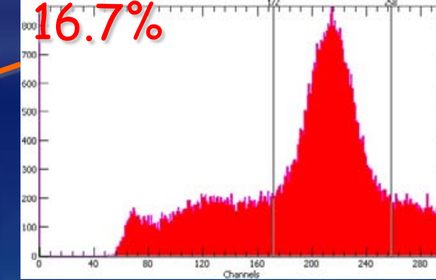


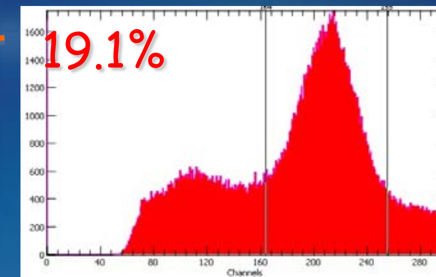
ADC Gate ~125ns

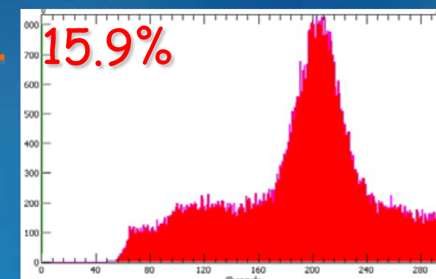
2mm LYSO array

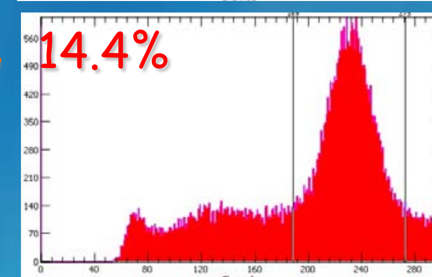


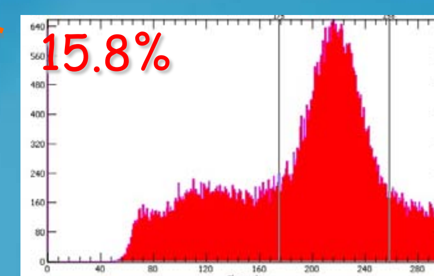






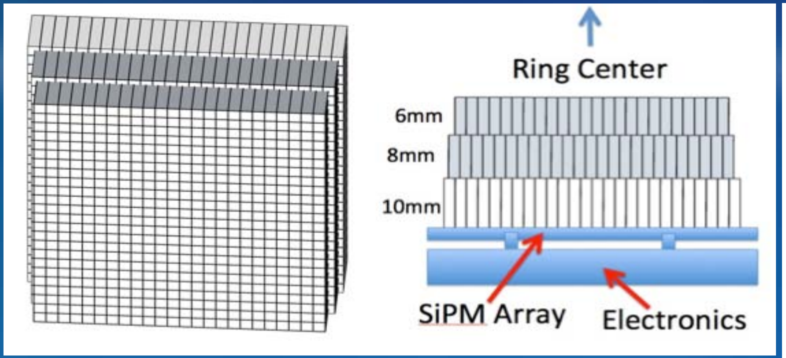


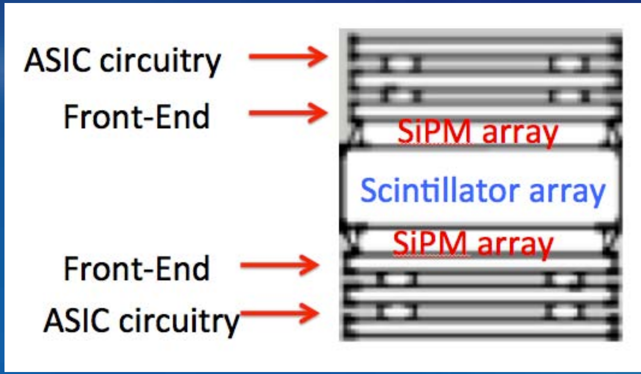


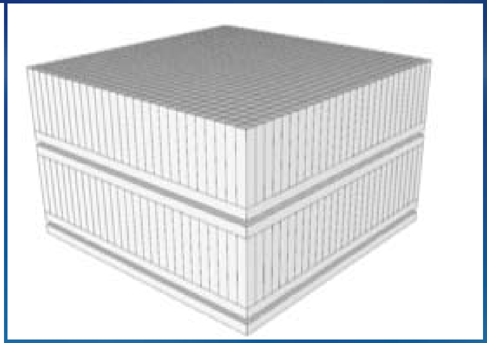


LYSO array of 24x24 2x2x15mm pixels coupled to SiPM module through 4.6mm thick acrylic window. Bias ~27V. ~20 C. "100" ns signal integration gate. F18 energy spectra from five of the selected LYSO pixels, FWHM energy resolutions are in fact lower than measured due to the "thresholding" effect.

DOI module designs

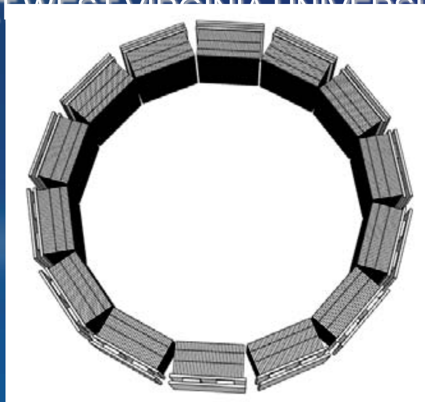




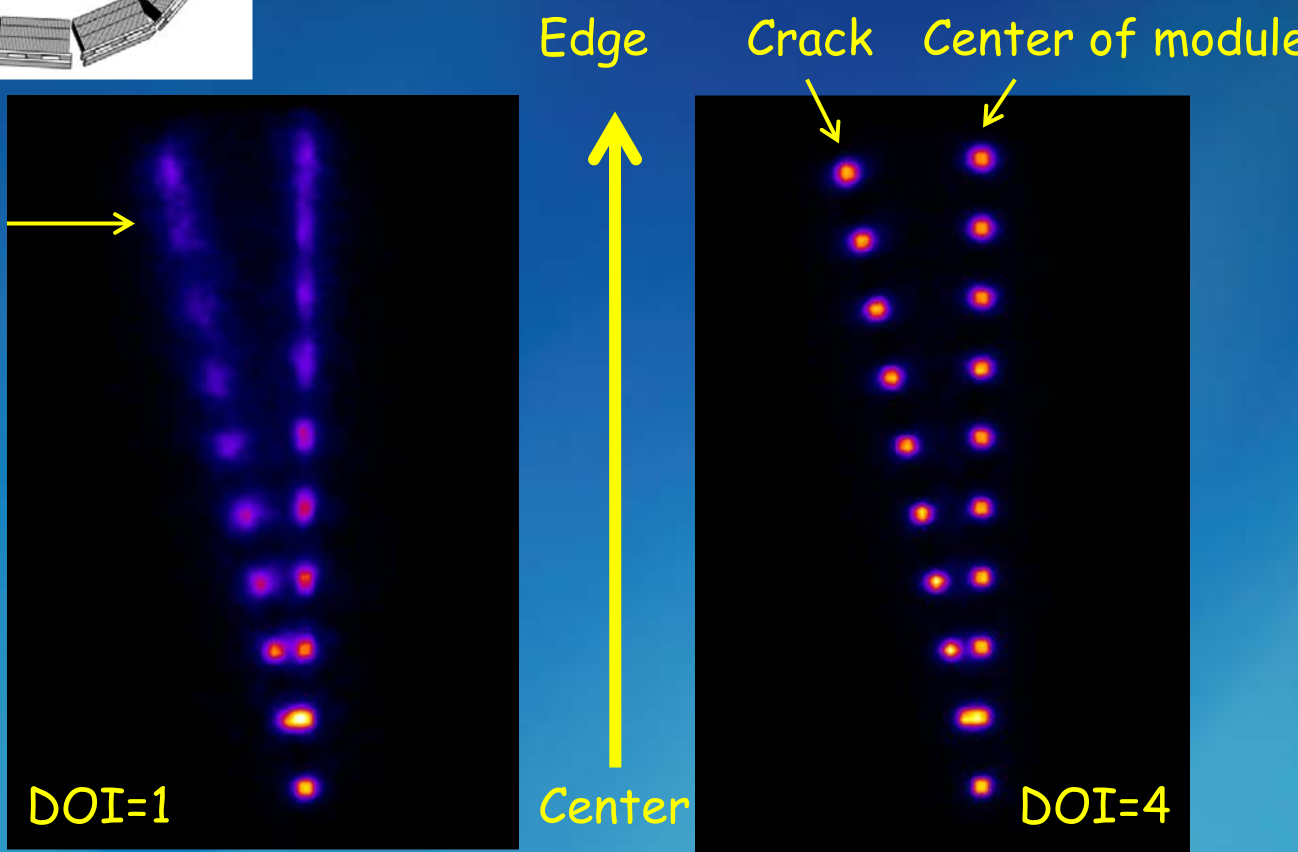


Scintillator module options. Left: A stack of three scintillator arrays with one-sided ASIC based readout and some multiplexed (row-and-column) variants. The separation of the arrays is based on the spatial shift and scintillation light cone spread differences. Center: Design with double-sided SiPM readout of a scintillation array of 25 x 25 LYSO with 2.0 mm x 2.0 mm x 25 mm pixels and a special surface treatment optimized for signal dependence on the event position. Right: potential backup solution with two stacked modules with separate SiPM arrays and electronics coupled to 2 mm x 2 mm scintillation arrays and using multiplexed readout. The corresponding output channels from the two modules in this stack can be wired together, while the differentiation between top and bottom array can be achieved by separate registration of the sum of all pixel signals for the top and bottom modules, respectively.

Importance of DOI



Smearing



Simulated 19 points in a 14 module ring. Left: 25mm thick scintillator - one layer. Right: scintillator subdivided in four 6.25mm layers.

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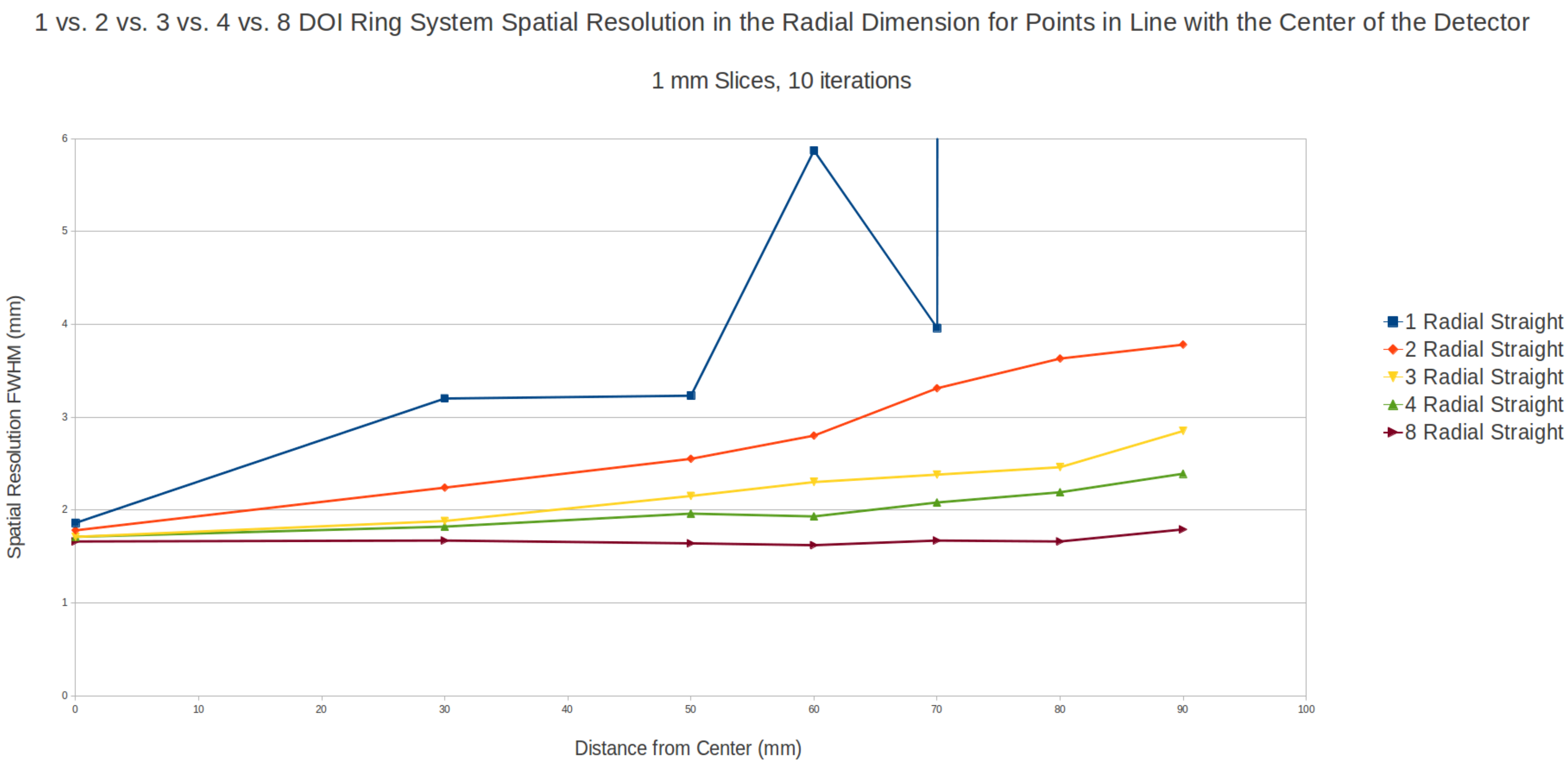
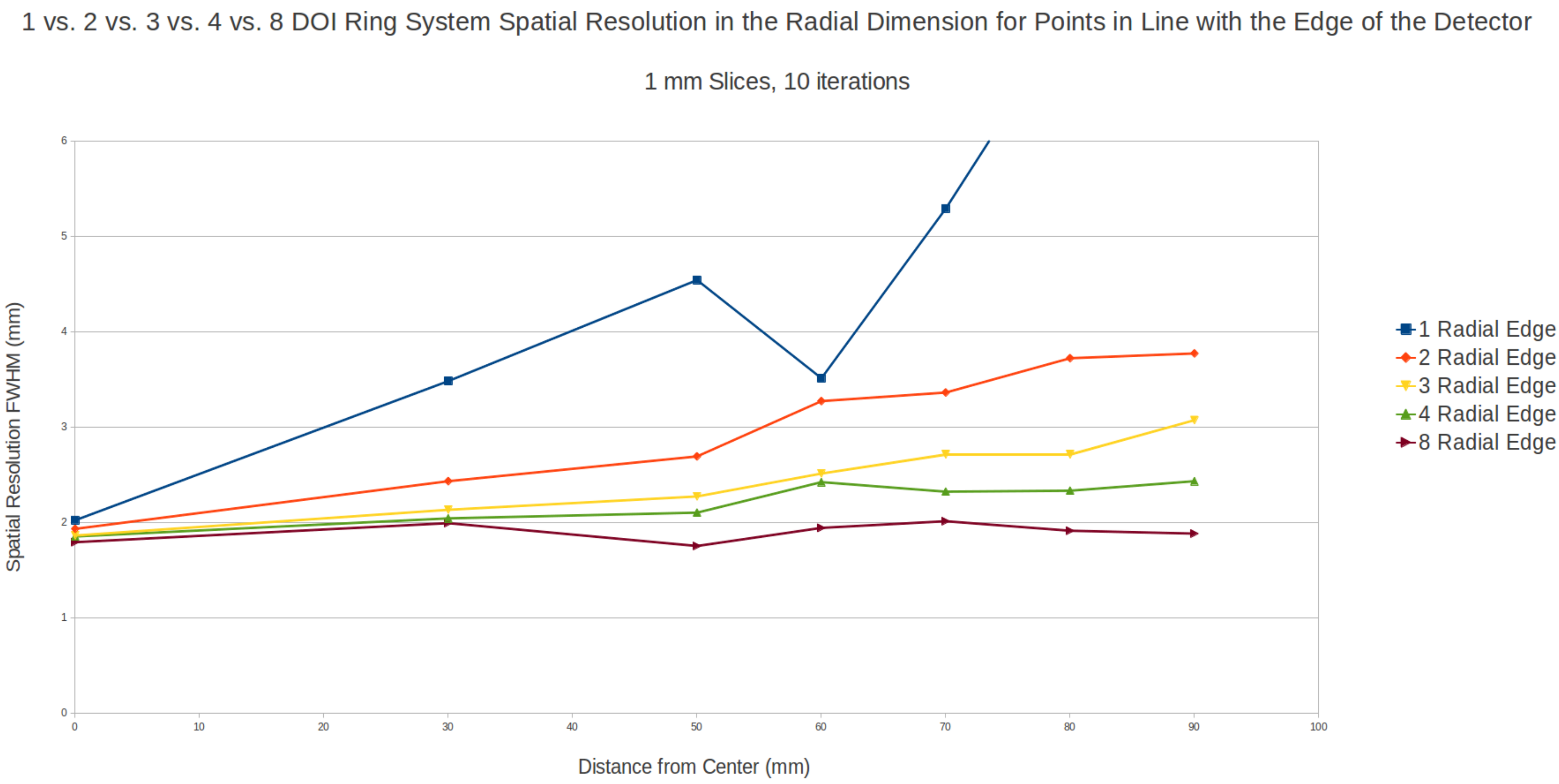
DOI Resolution Simulations



Radial resolution for DOI=1 to DOI=8. Along the center line of the module.

DOI Resolution Simulations



Radial resolution for DOI=1 to DOI=8. Along the line into the crack between the modules.

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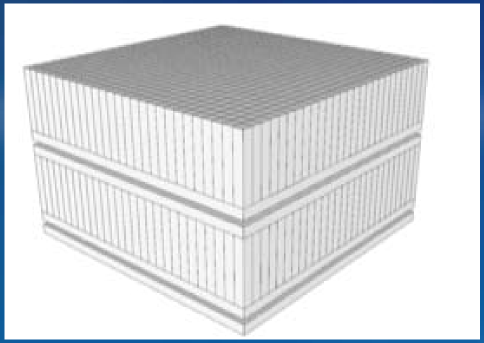
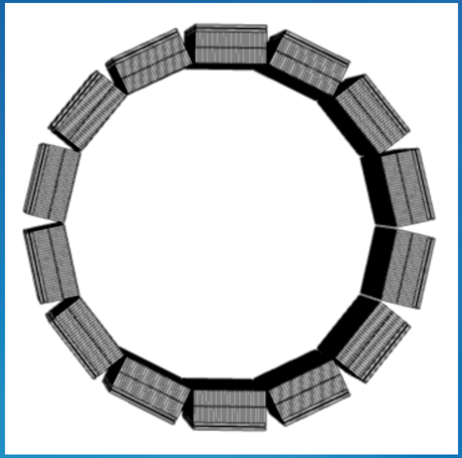
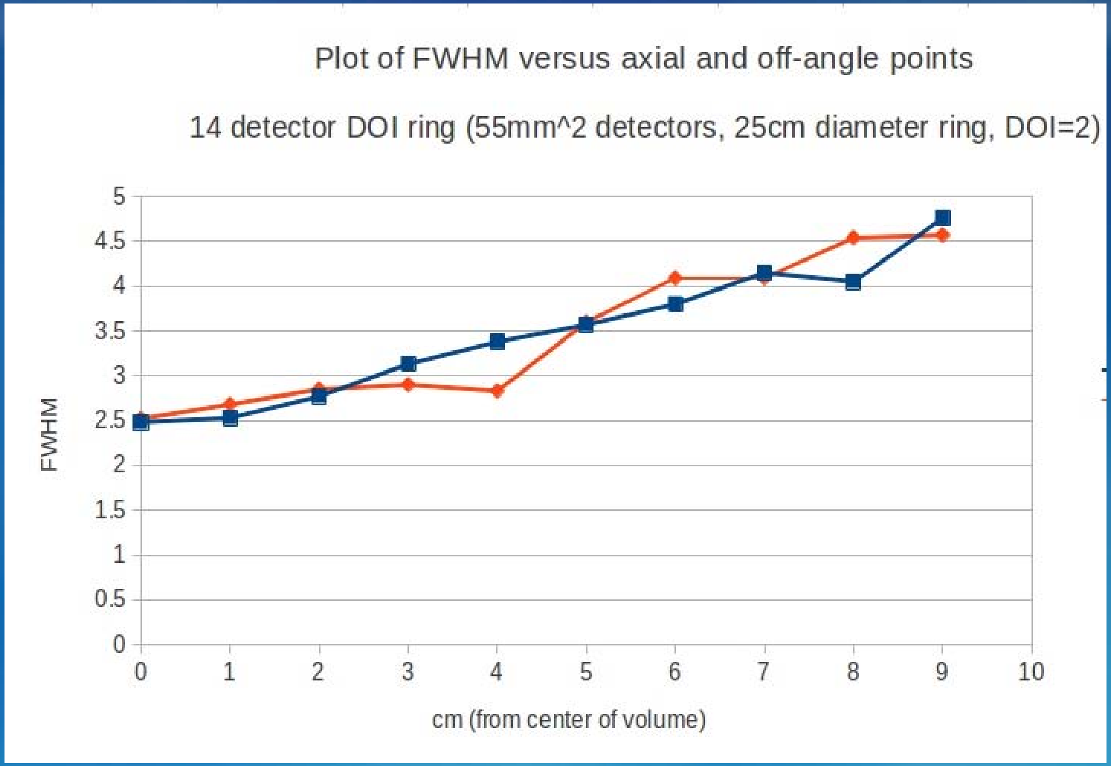
DOI Resolution Simulations







Case of DOI=2. Radial resolution. Red – line of 1cm spaced point sources aligned with the crack, blue – aligned with the module center.