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# Future Detector Technologies for Ultimate X-ray Spectroscopy Applications

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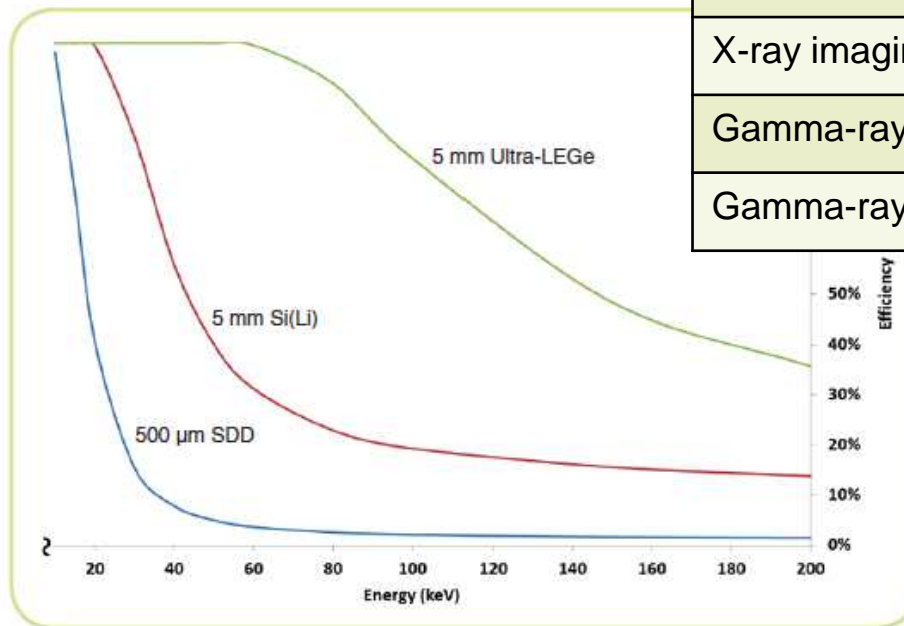
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# Current technologies at CANBERRA



## ► Semiconductor technologies of interest

Application \ Technology	Si	Si(Li)	HPGe
X-ray spectroscopy	x	x	x
X-ray imaging	x		x
Gamma-ray spectroscopy		x	x
Gamma-ray imaging		x	x



## ► More information on:

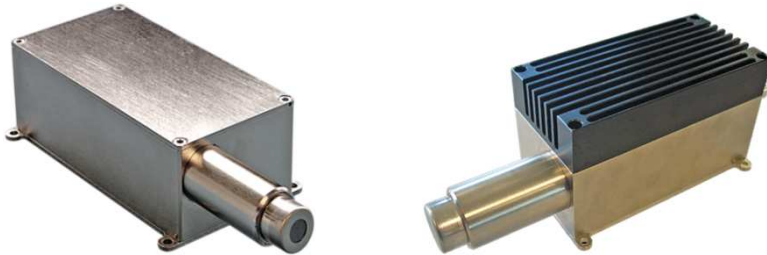
[www.canberra.com/products/detectors/synchrotron.asp#1](http://www.canberra.com/products/detectors/synchrotron.asp#1)

# Silicon detectors



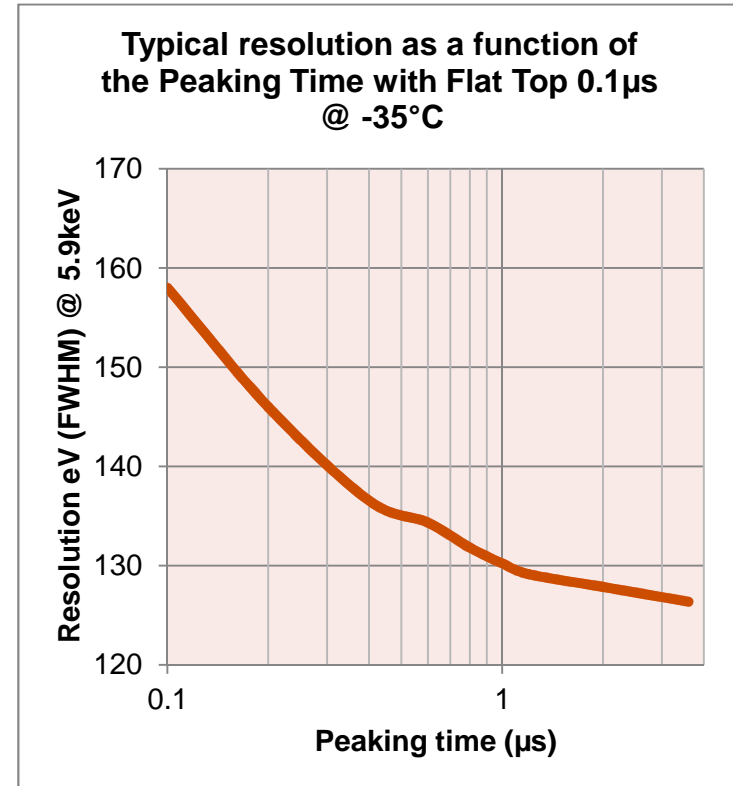
## ▶ X-PIPS™(SDD)

- ◆ Integrated PA and Peltier Cooler



Model	Active area (mm <sup>2</sup> )	Collimator	PTB	
			Typical	Max
SXD80M-160-500	80	multilayer	12000	> 10000
SXD30M-150-500	30	multilayer	15000	> 12000
SXD15M-150-500	15	multilayer	15000	> 12000

- ◆ Thickness: 500µm
- ◆ Multi-element configurations available



## ▶ Special application

- ◆ Photo-diodes: single or multiple junction, 50 to 550mm<sup>2</sup> area, 200 to 1000µm thick
- ◆ Edgeless Pixel Detectors (e.g. for Medipix)

# HPGe / Si(Li) detectors

## Single and discrete array



### ▶ Ultra-LEGe

- ◆ Large energy range: 0.3 to 300 keV
- ◆ Excellent energy resolution at short shaping time
- ◆ Throughput up to 1Mcps

Model Number	Area (mm <sup>2</sup> )	Thickness (mm)	Be Window Thickness mm (mils)	Guaranteed energy resolution (eV FWHM)*	
				5.9 keV	122 keV
GUL0035	30	5	0.025 (1)	140	550
GUL0055	50	5	0.025 (1)	140	550
GUL0110	100	10	0.025 (1)	150	550

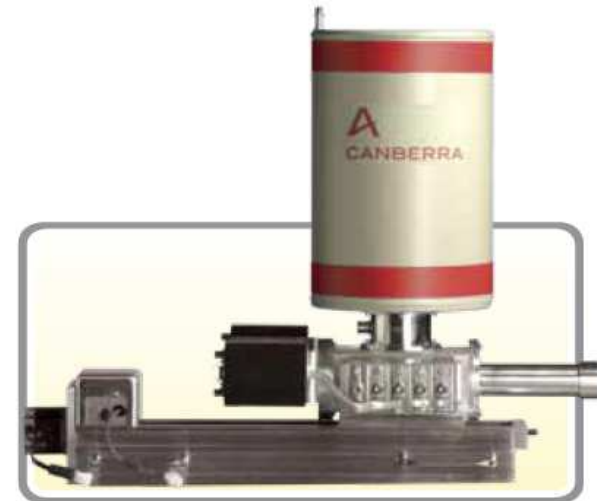


### ▶ Si(Li)

Model Number	Active Area (mm <sup>2</sup> )	Nominal Thickness (mm)	Resolution (eV) FWHM @ 5.9 keV
SSL12135	12.5	2	135
SSL30145	30	3	145
SSL80155	80	5	155

### ▶ Multi-element arrays

- ◆ 1-32 individual HPGe or Si(Li) elements

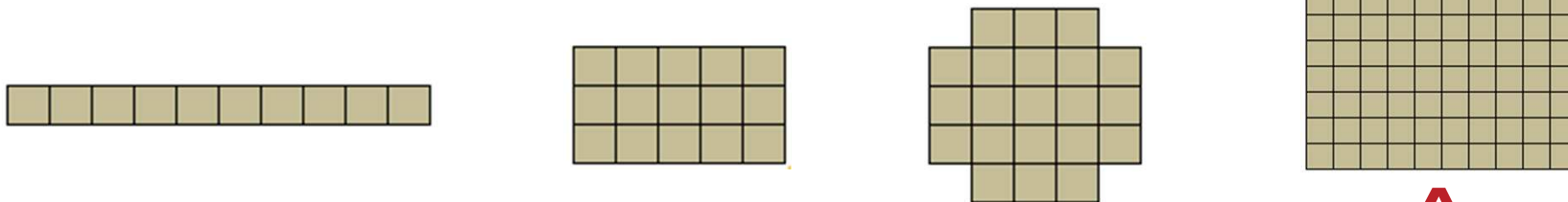
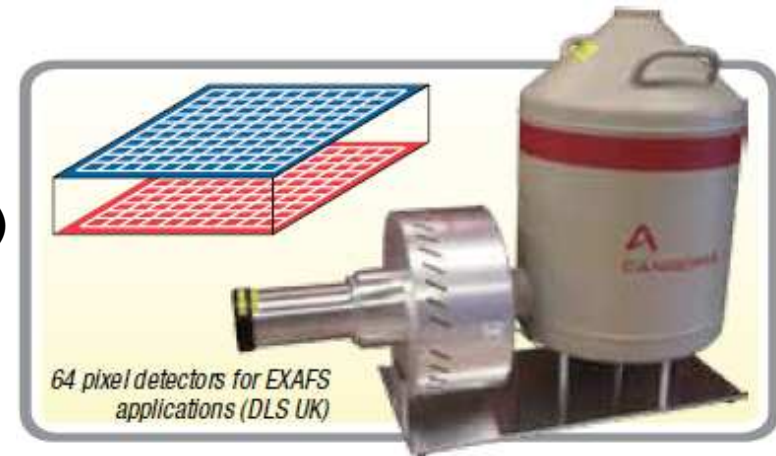


# HPGe / Si(Li) Detectors Monolithic Arrays



## ▶ HPGe Pixel Detectors

- ◆ 3 to 100 pixels on a single segmented crystal
- ◆ Pixel size
  - Usually square 8x8mm<sup>2</sup> or 5x5mm<sup>2</sup>
  - Other sizes and shapes upon request
- ◆ Performance (with respect to discrete arrays)
  - Better packing density (active area >90%)
  - Built-in synchronous reset preamplifiers
  - High level of EMI immunity
  - SAFE function (Self Adaptive Feature Enabling)
- ◆ Custom mechanical design to fit user constraints
- ◆ Selected materials available for minimal fluorescence

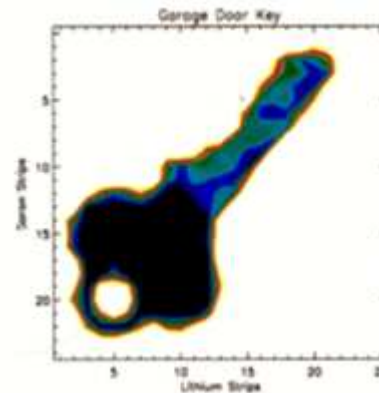


# HPGe / Si(Li) Detectors Special segmentation



## ► Strip Detectors

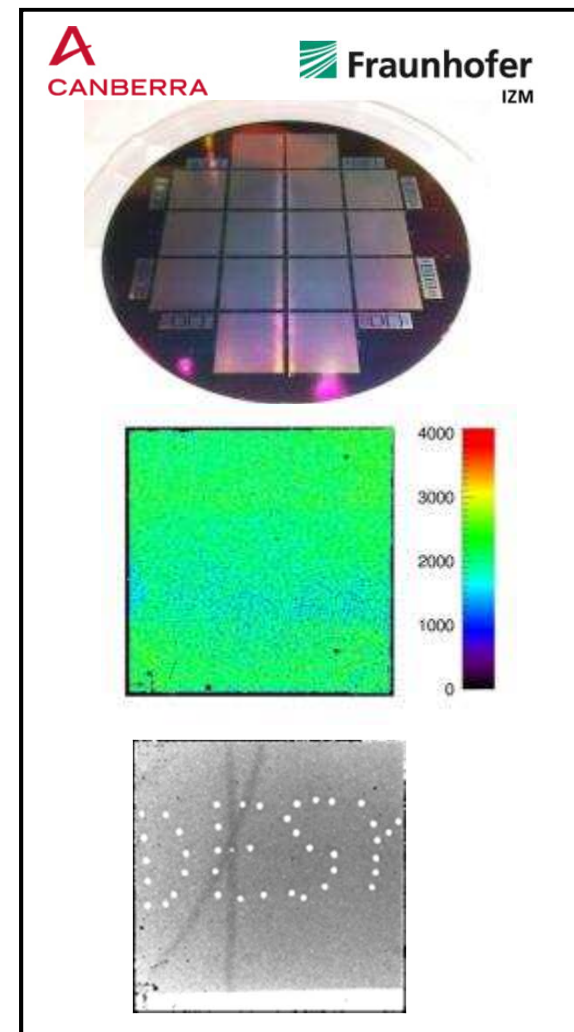
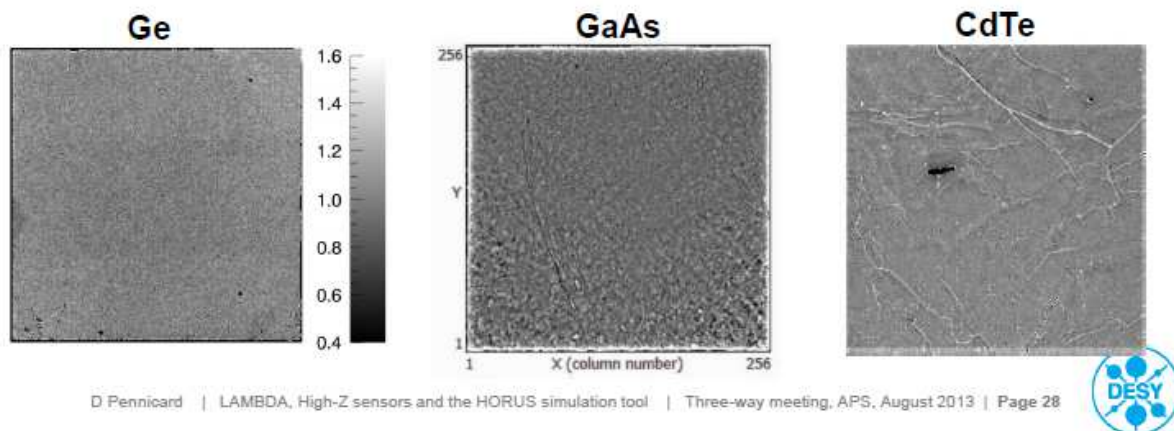
- ◆ Available with HPGe or Si(Li)
- ◆ Highly customizable single sided or sided strips (DSSD)
- ◆ Pitch 2mm down to 100 $\mu$ m
- ◆ No measurable crosstalk effect
- ◆ Applications:
  - Interaction Localization
  - Particles, X and  $\gamma$  radiation imaging
  - Compton camera using crystals stacked in a single cryostat





# Fine pixel monolithic detectors

- ▶ High Z detectors associated with latest available ASICs
- ▶ Pixels technology provides
  - ◆ Higher resolution imaging
  - ◆ High absorption efficiency
  - ◆ 55 micron pixels and bump-bonding
  - ◆ Thin HPGe wafer (700 $\mu$ m).
- ▶ Partnership with Medipix collaboration (HPGe supplier)
- ▶ Application: high spatial resolution (radiography), very high count rate (XFEL)





# HPGe / Si(Li) Detectors Electrical cooling



## ▶ HPGe / Si(Li) detectors (discrete or monolithic) can be cooled electrically

### ◆ LN2-free HPGe cooling solutions

- Maintenance-free (50 000 hours FTBF)
- Active vibration cancelling
- Various cooling powers and form-factor

### ◆ No trade-off on detection performance

- Same resolution as LN2-cooled detectors

### ◆ Air or Water heat dissipation

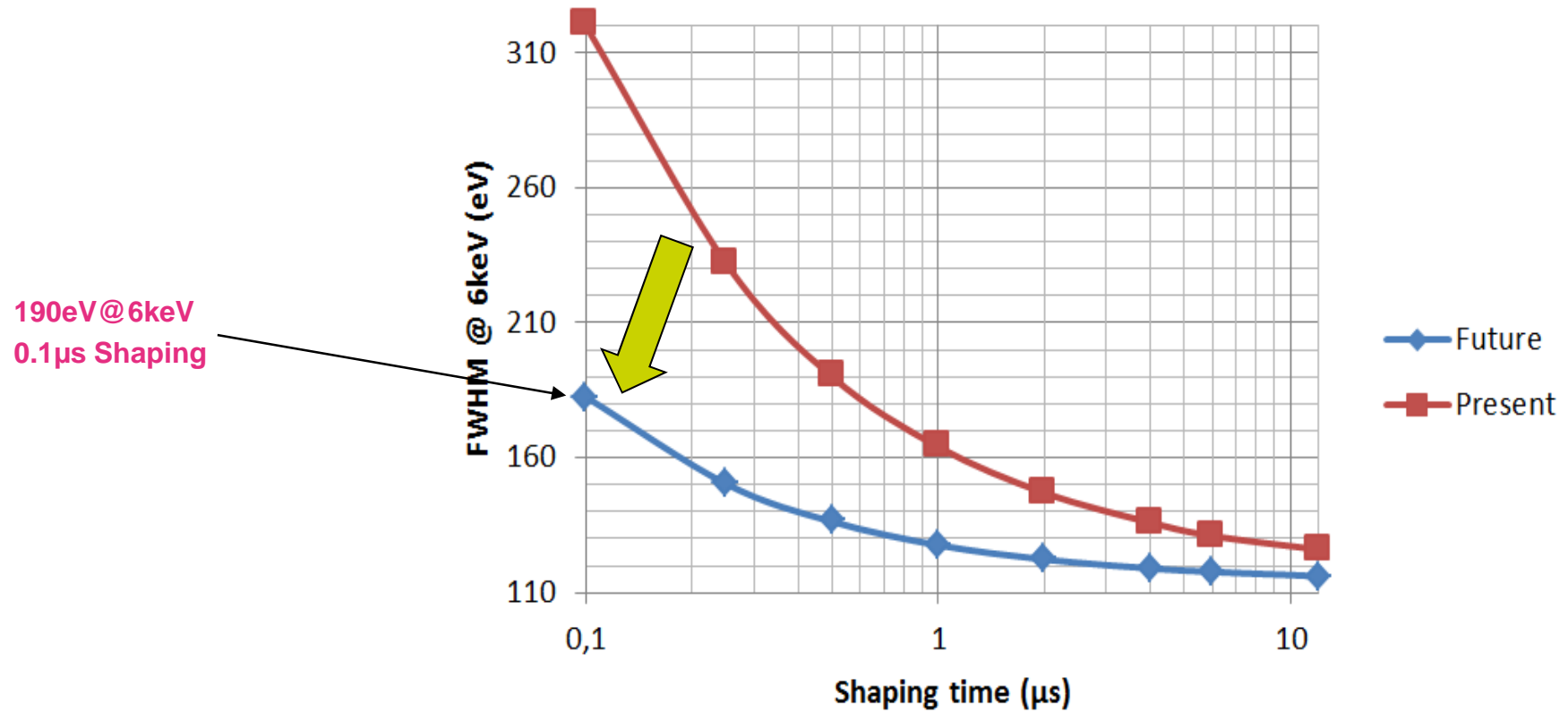
- Adapted to nano beam-lines
- No heat dissipation in the experimental hutch
- No fan vibration



# Future technological challenges for HPGe detectors



## ► Improving energy resolution



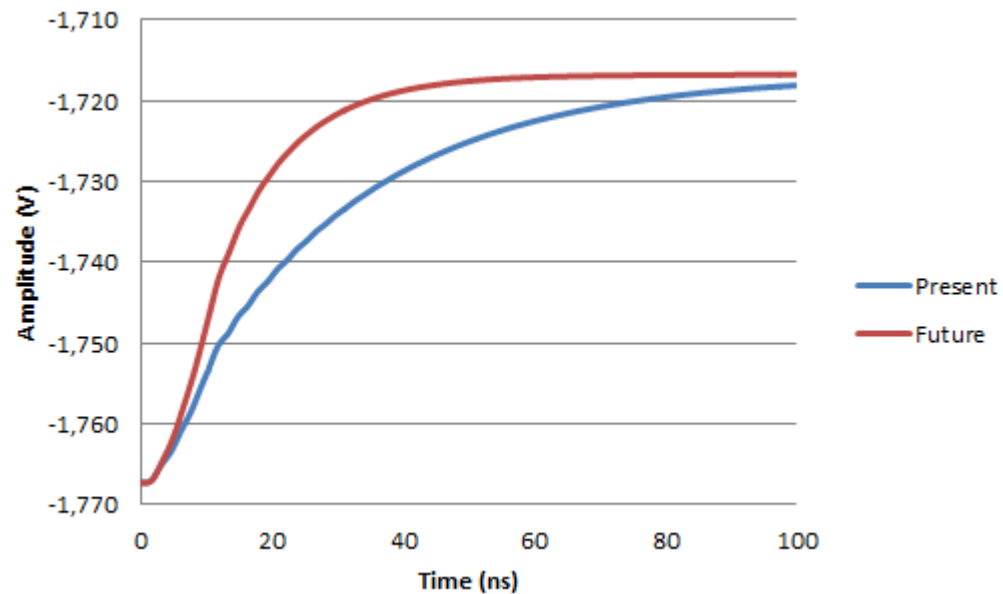
# Future technological challenges for HPGe detectors



## ► Increasing Throughput

### ◆ Direction 1: better electronics:

- Decreasing front end rise time: current ~100ns/event; future ~50ns/event
- Decrease dead time:
  - New generation readout electronics (faster data acquisition)
  - Improved PHA algorithms (faster pulse processing)



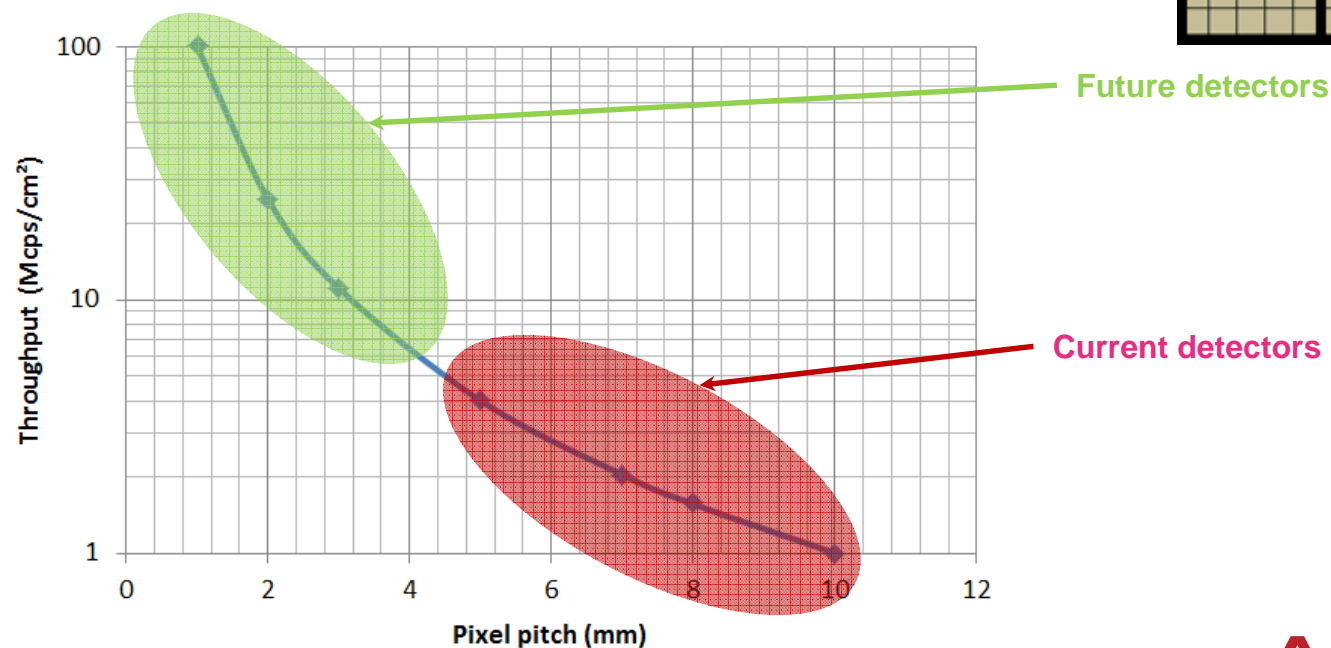
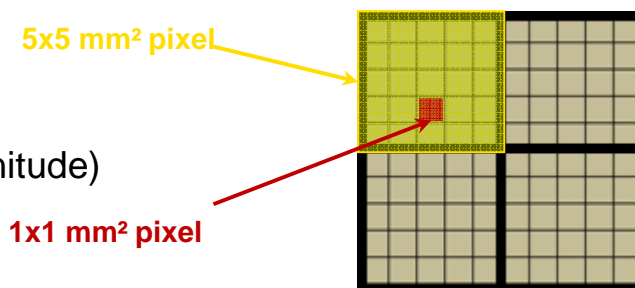
# Future technological challenges for HPGe detectors



## ► Increasing Throughput

### ◆ Direction 2: Decrease segment size

- Similar OCR/pixel but smaller pixel size
- Dramatic increase in total output flux (2 orders of magnitude)
- In parallel: increase number of pixels/detector



# Conclusions



## CANBERRA

- ▶ has long and established expertise in the field of x-ray spectroscopy through Si, Si(Li) and HPGe technologies



- ▶ is willing to address the future challenges of synchrotron applications (spectroscopy and imaging)
- ▶ is looking for partnership opportunities