

High Energy and Position Resolution CdTe Diode Double-Sided Strip Detectors

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Introduction

High Precession Astrophysics Observation

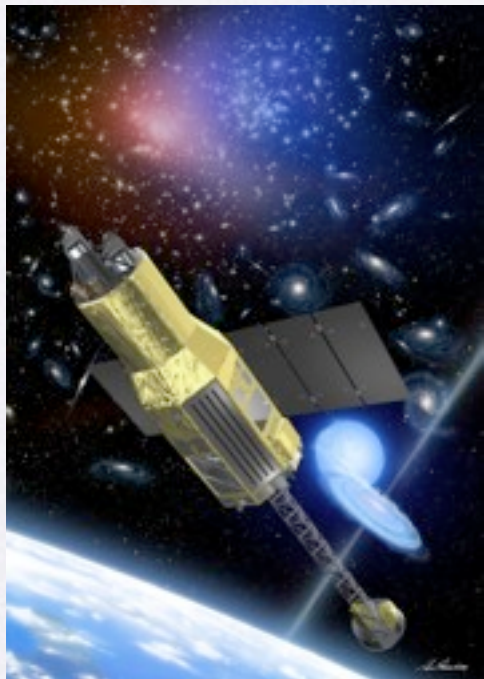
Hard X-ray / Gamma-ray Imaging Spectrometers

Requirements

- a few hundred micrometer position resolution
- FWHM 1--2 keV or 1 % energy resolution



ASTRO-H(2014)



CdTe Diode Double-sided Strip Detectors

- large area and fine position resolution with relatively small number of readout channels
- simple
- low power consumption
- 1 dim. ASIC (2 dim. ASIC is difficult)

ASTRO-H Hard X-ray Imager(HXI) [focal plain imager of hard X-ray mirrors]

CdTe DSD for ASTRO-H HXI

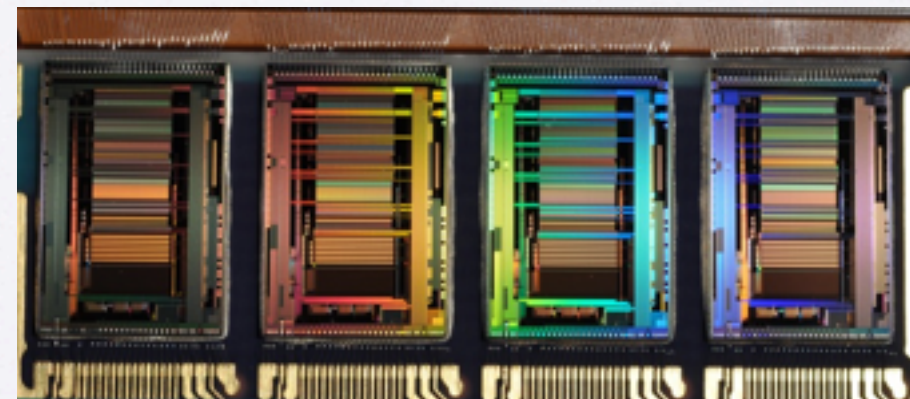
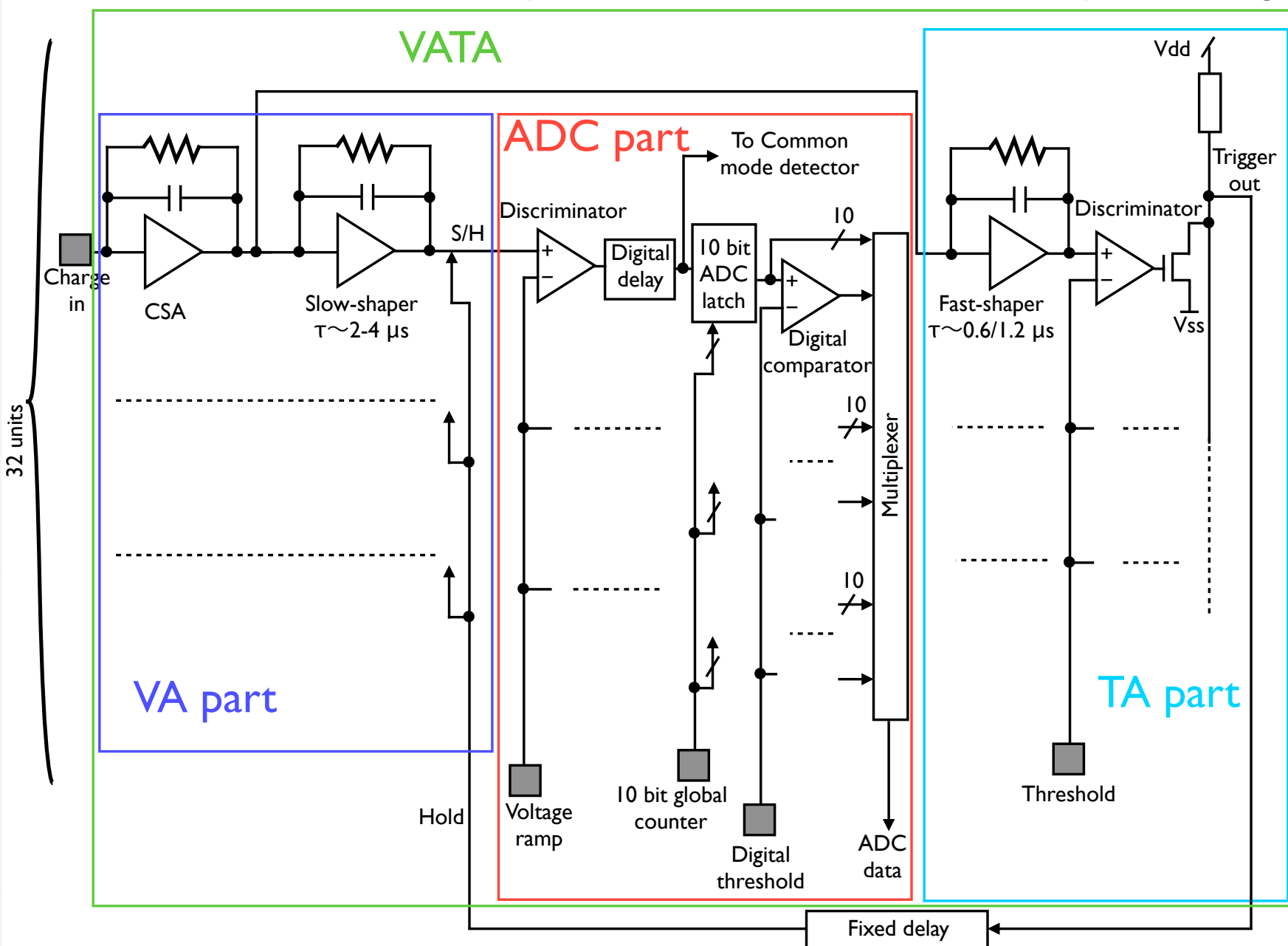
ASTRO-H HXI Flight Model Design



**3.4 cm wide CdTe diode device (Al/CdTe/Pt type) [ACRORAD]
250 μm strip pitch, 200 μm wide strip electrodes
128 strips on each side, imaging area 3.2 cm x 3.2 cm, 0.75 mm thick**

LSI (VATA chip)

We have developed with GM-IDEAS (Norway).



- 32ch signal processing
- CSA and two Shapers (Spectroscopy & Trigger)
- Internal ADC (Wilkinson type)
- Data suppression (only hit ch data are output)
- Inside Common mode Noise Calculation
- only Digital I/O

Low Power Consumption: 0.3 mW/ch or 1 mW/ch (selectable)

Good Noise Performance: 41 e⁻ (0 pF), 77 e⁻ (6 pF, 10 pA) [designed]

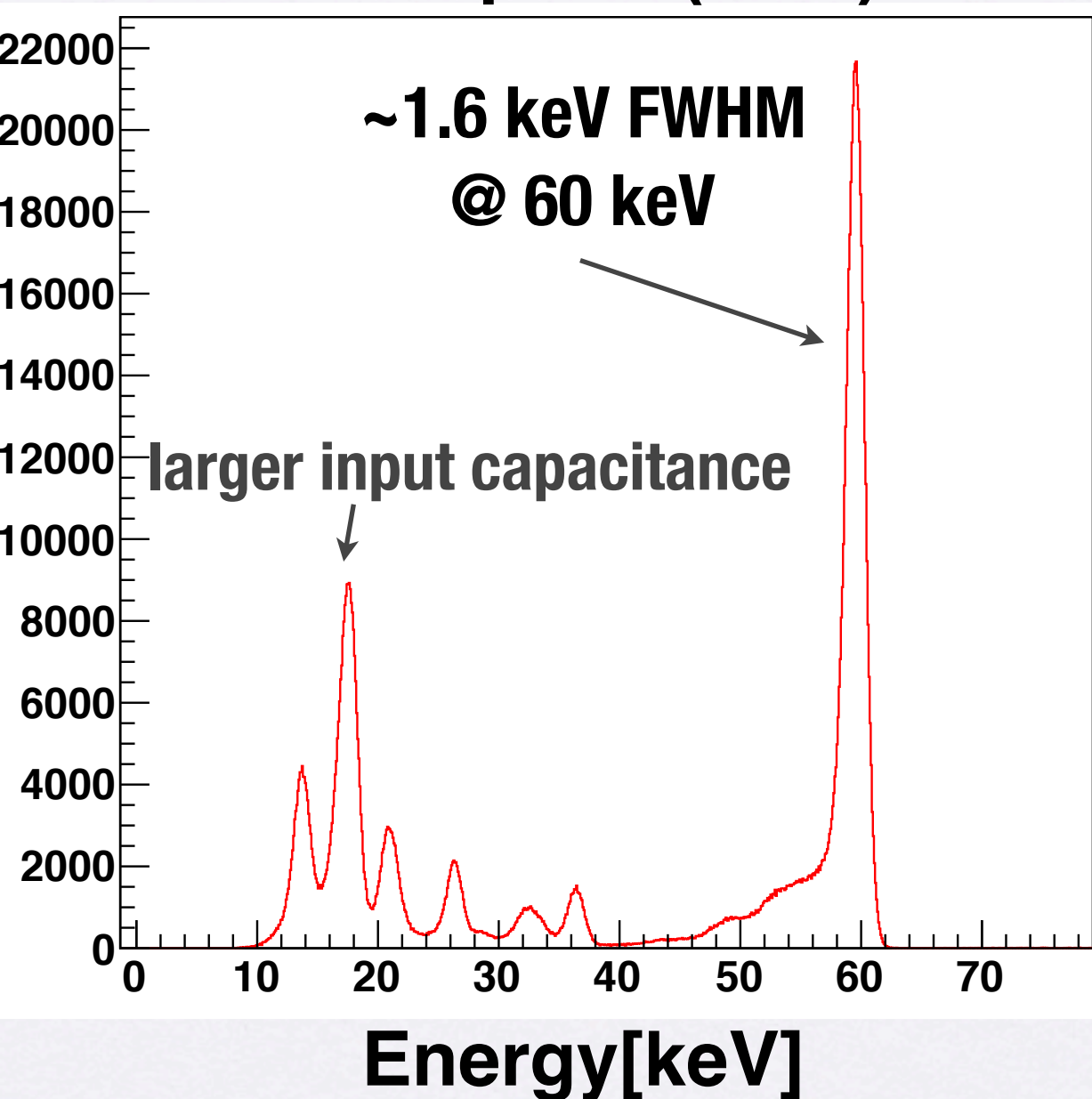
110 e⁻ (10 pF, 10 pA) [measured]

Spectroscopy Performance

-20°C, Bias 250V

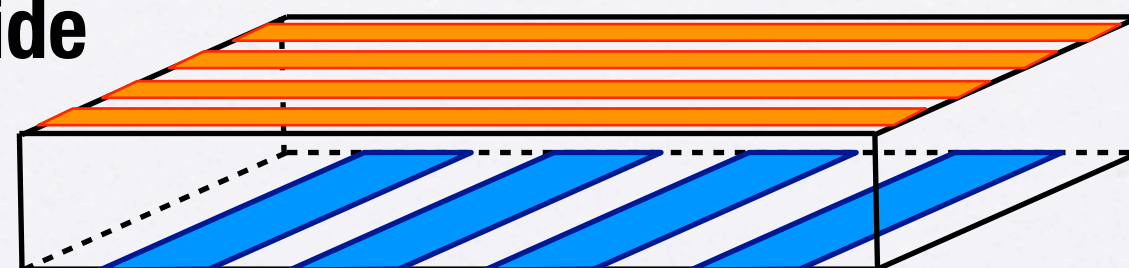
1 hit events

Al strip side (+H.V.)

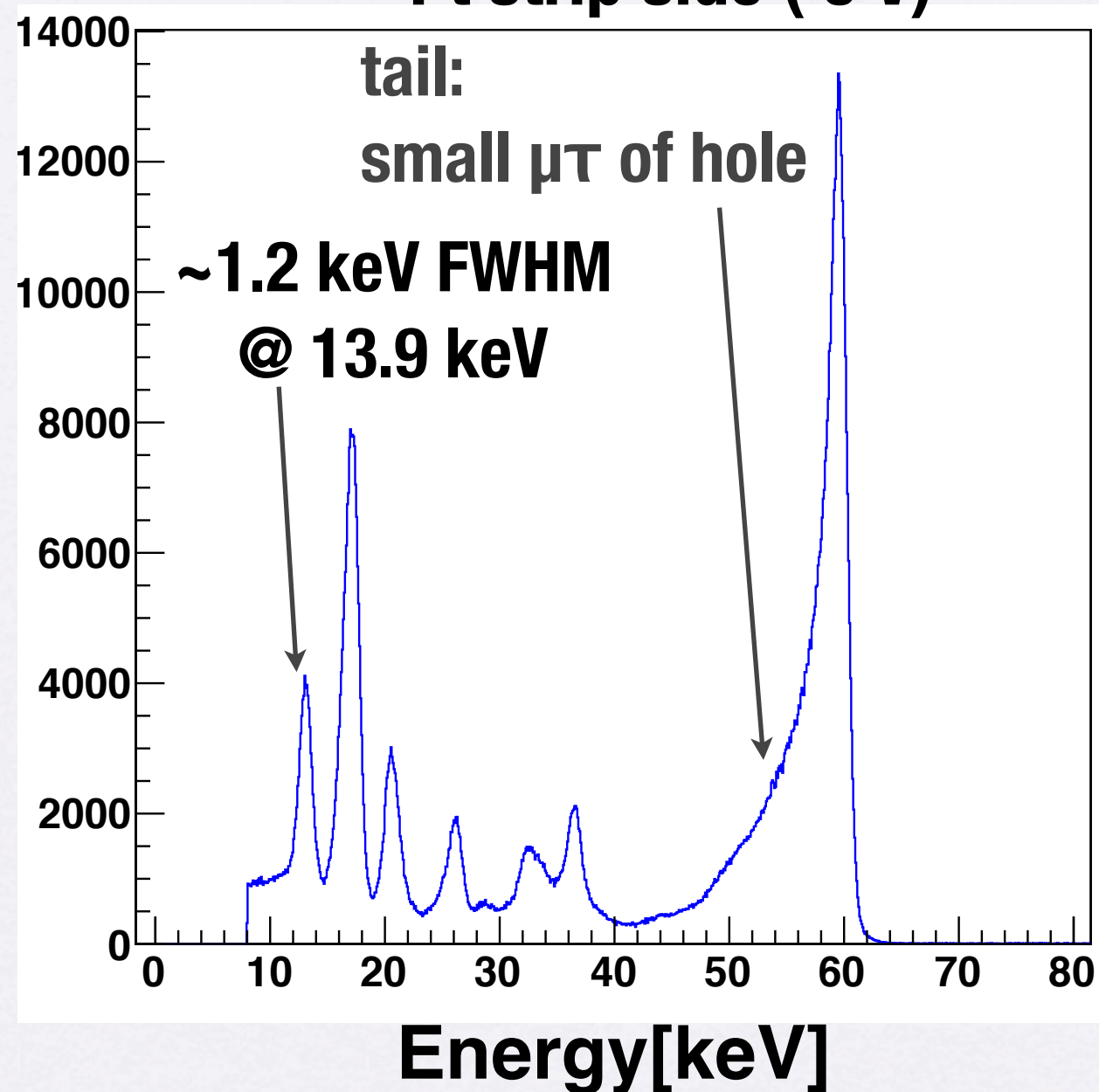


^{241}Am Spectra

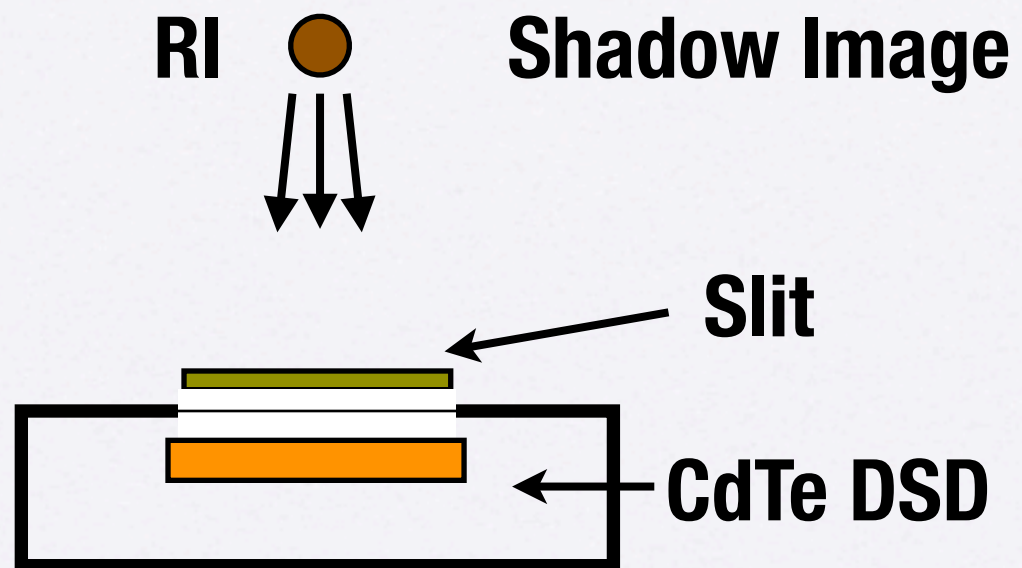
Pt side



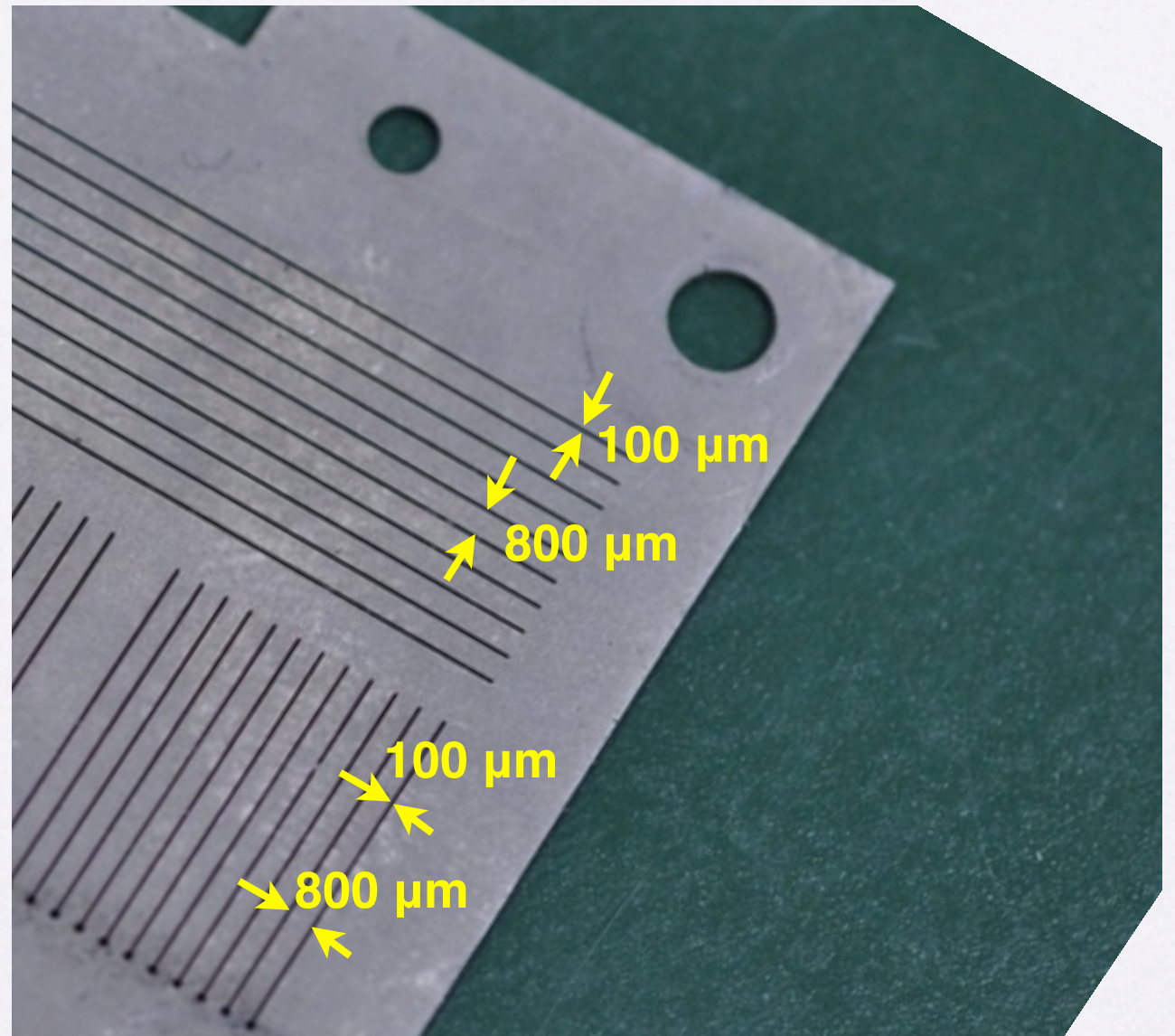
Pt strip side (0 V)



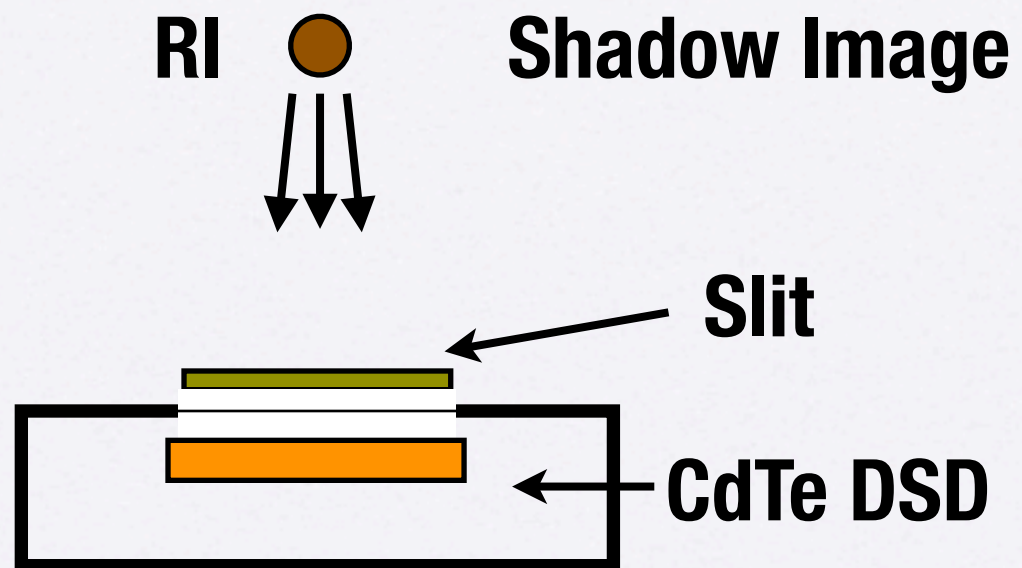
Imaging



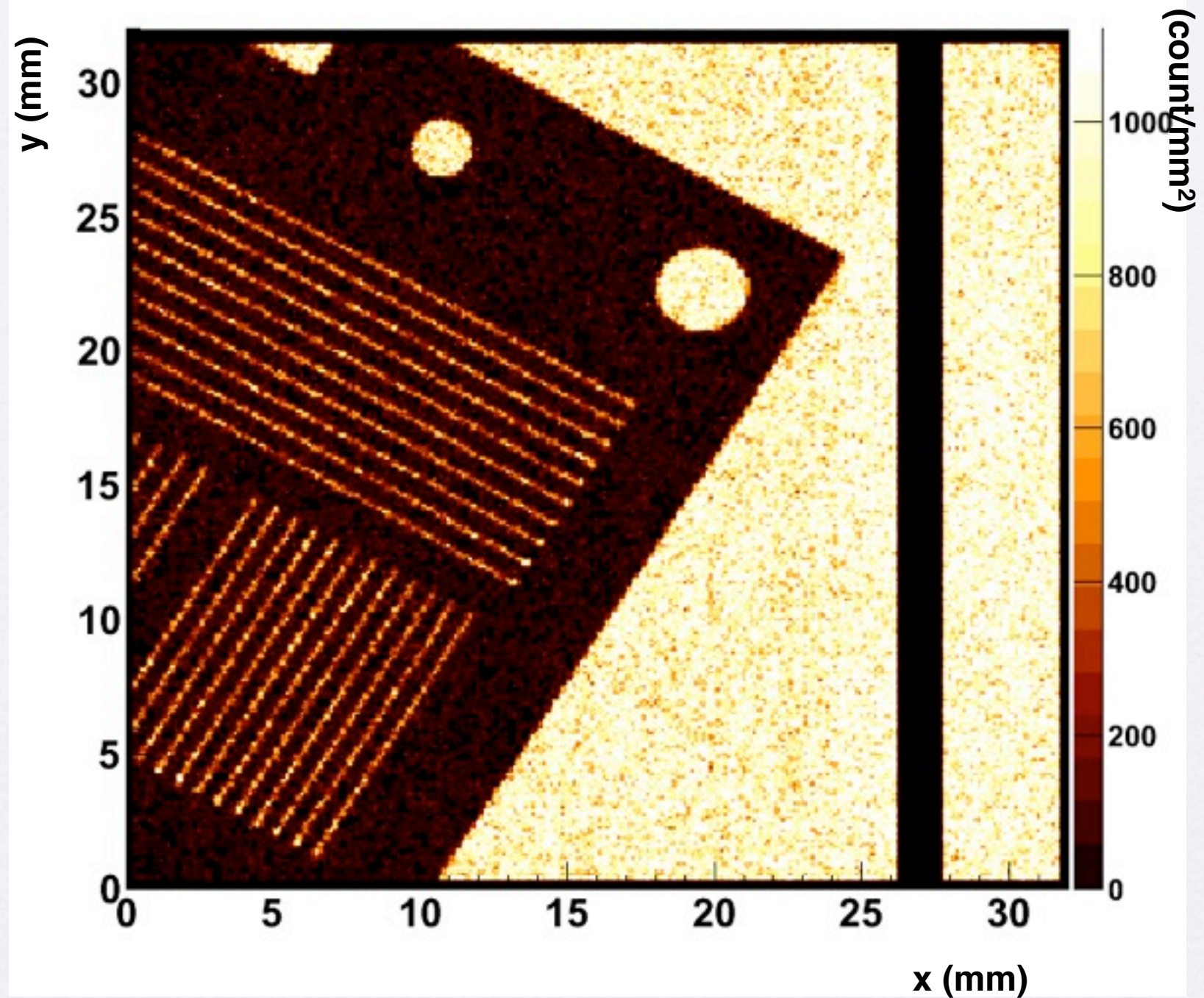
^{241}Am 60 keV gamma-ray Image



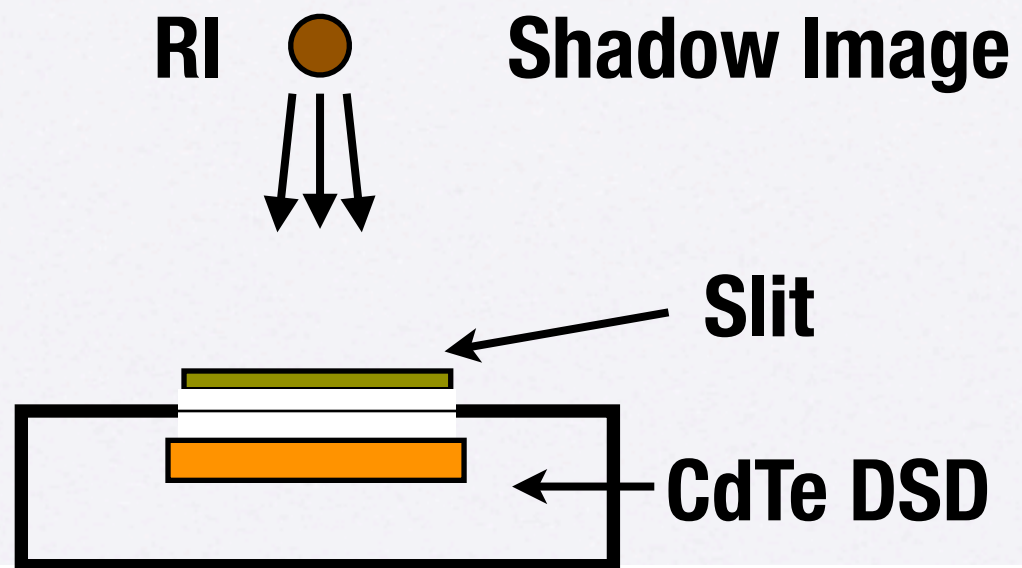
Imaging



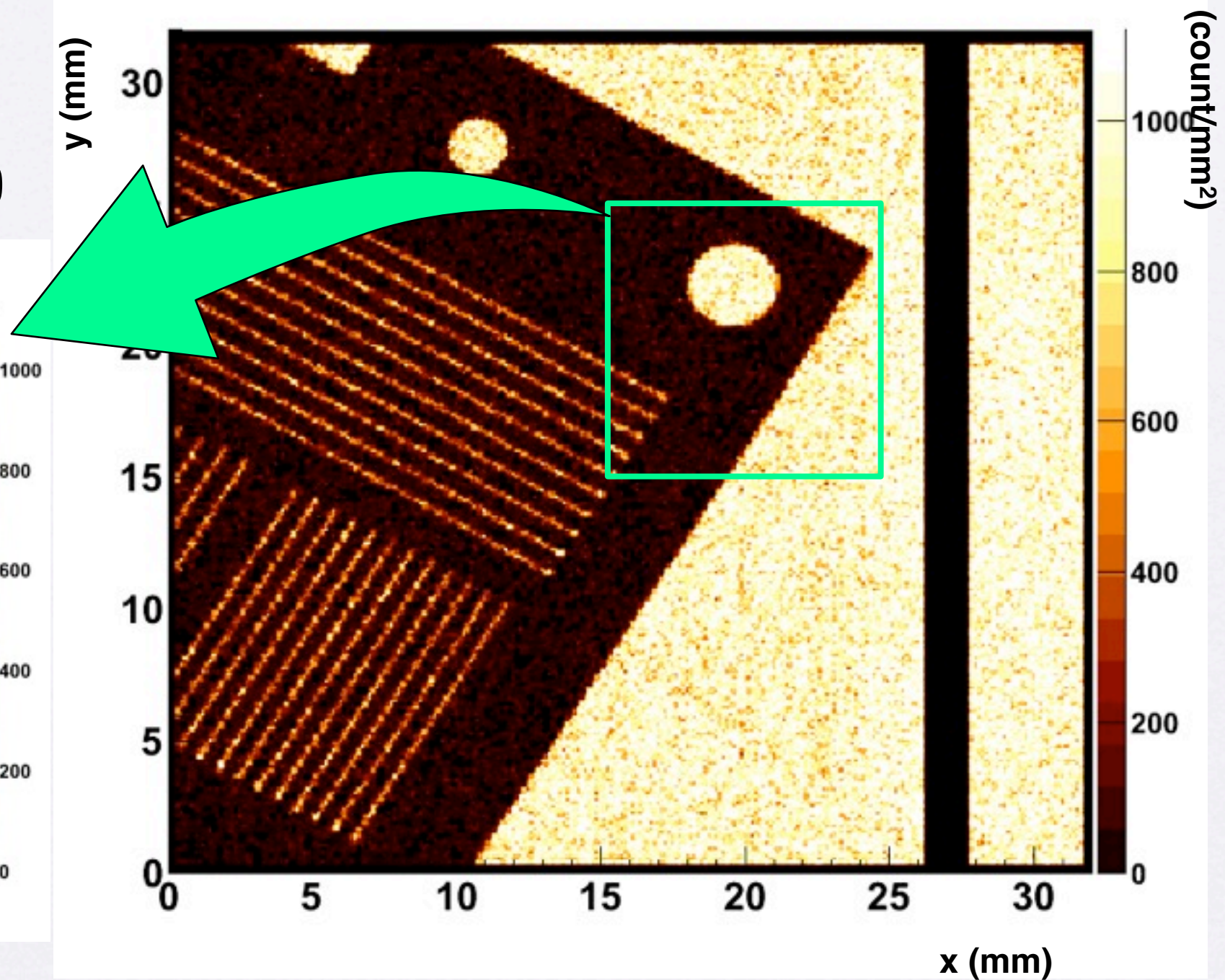
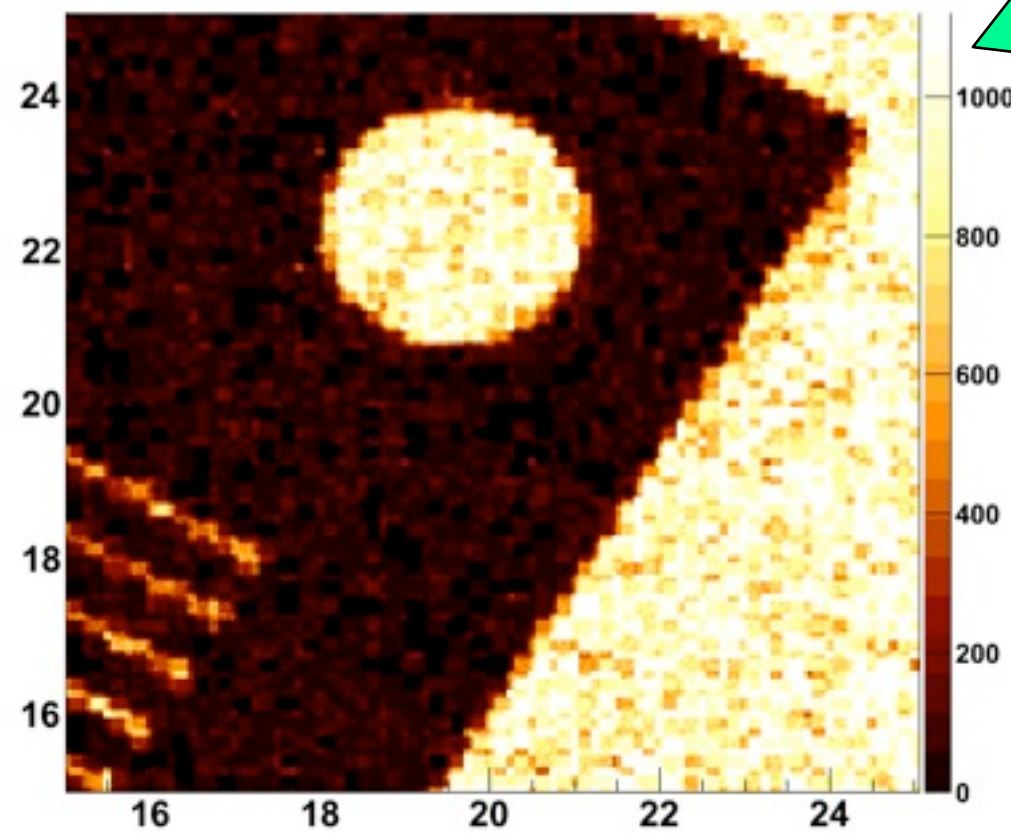
^{241}Am 60 keV gamma-ray Image



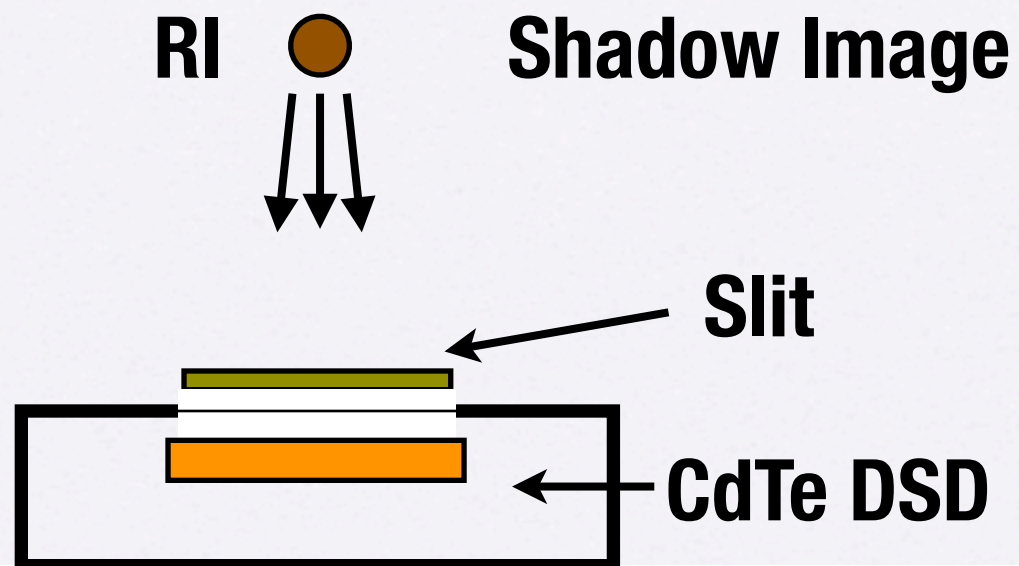
Imaging



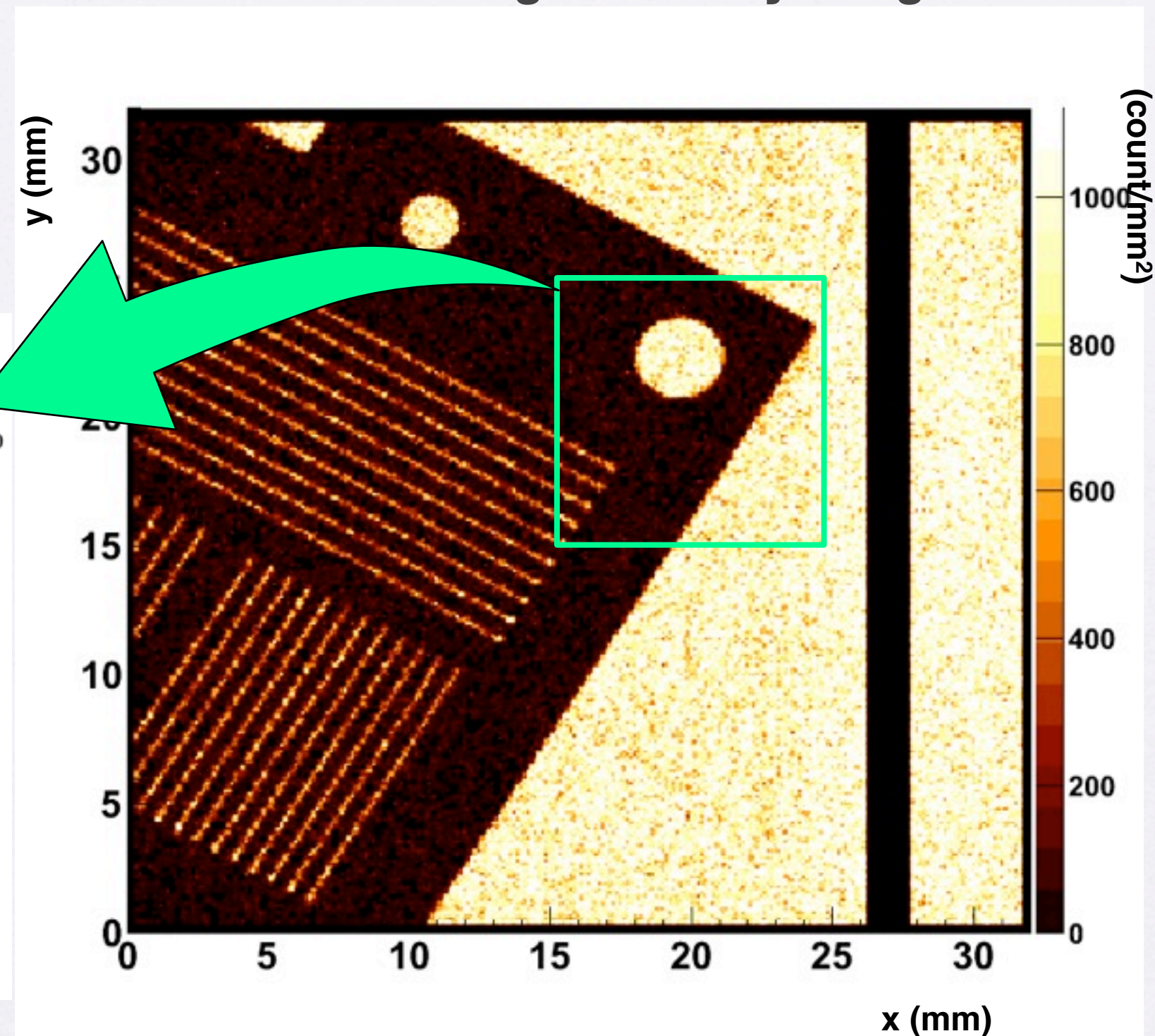
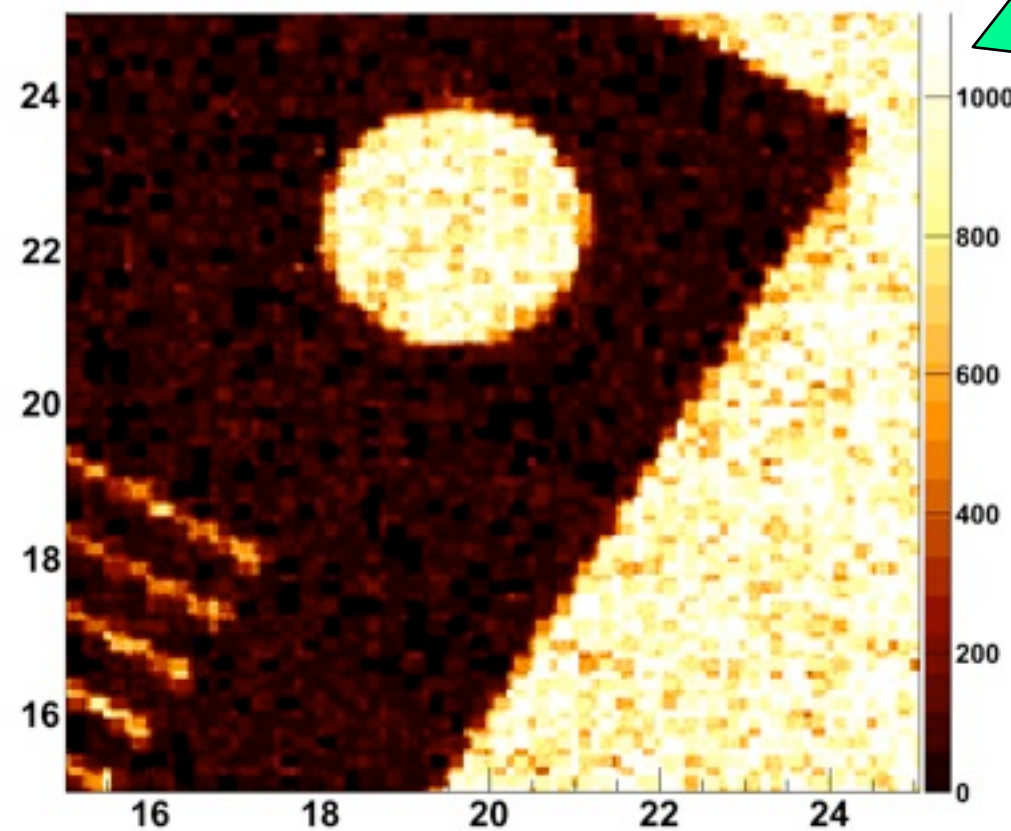
^{241}Am 60 keV gamma-ray Image



Imaging

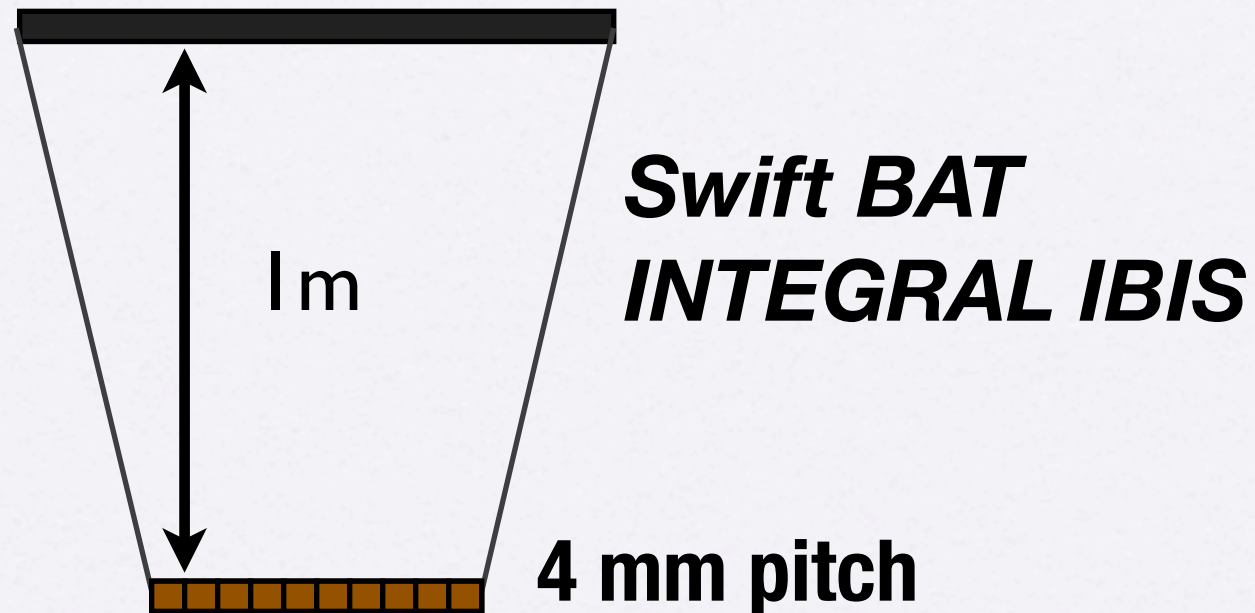


^{241}Am 60 keV gamma-ray Image



By using one hit/ two hits information, sub-strip position resolution was achieved.

Application1: Coded Mask Camera



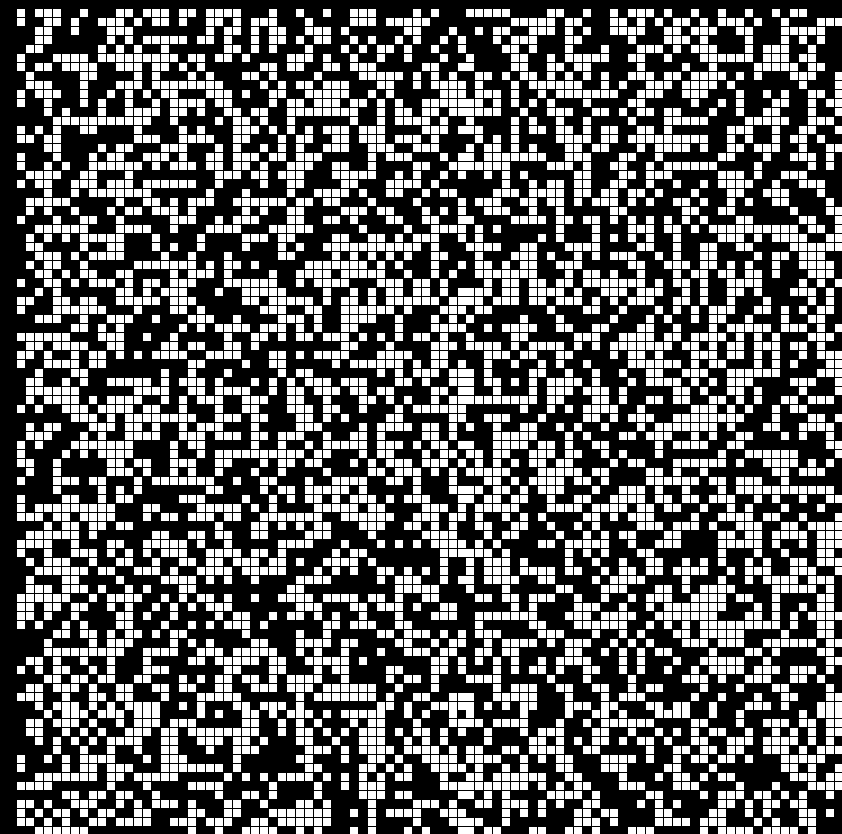
fine pitch imager & mask

$\approx$



250 μm pitch

very Compact Cameras



5.0 mm

46.75mm

0.40 mm pitch
0.35 mm hole

newly designed fine pitch coded mask

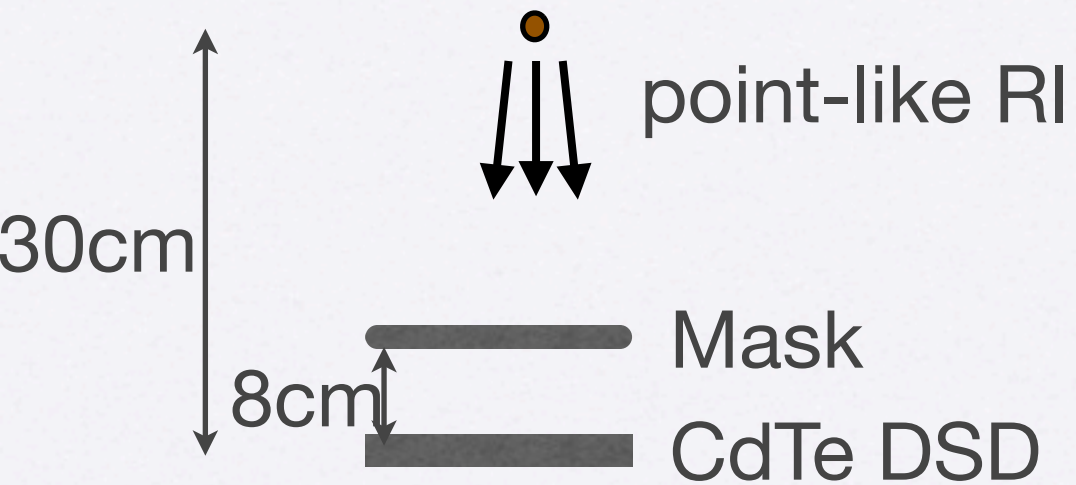
(50 μm thick Ni + 2-3 μm gold plating)

x 8 layers

400 μm pitch, 350 μm square holes

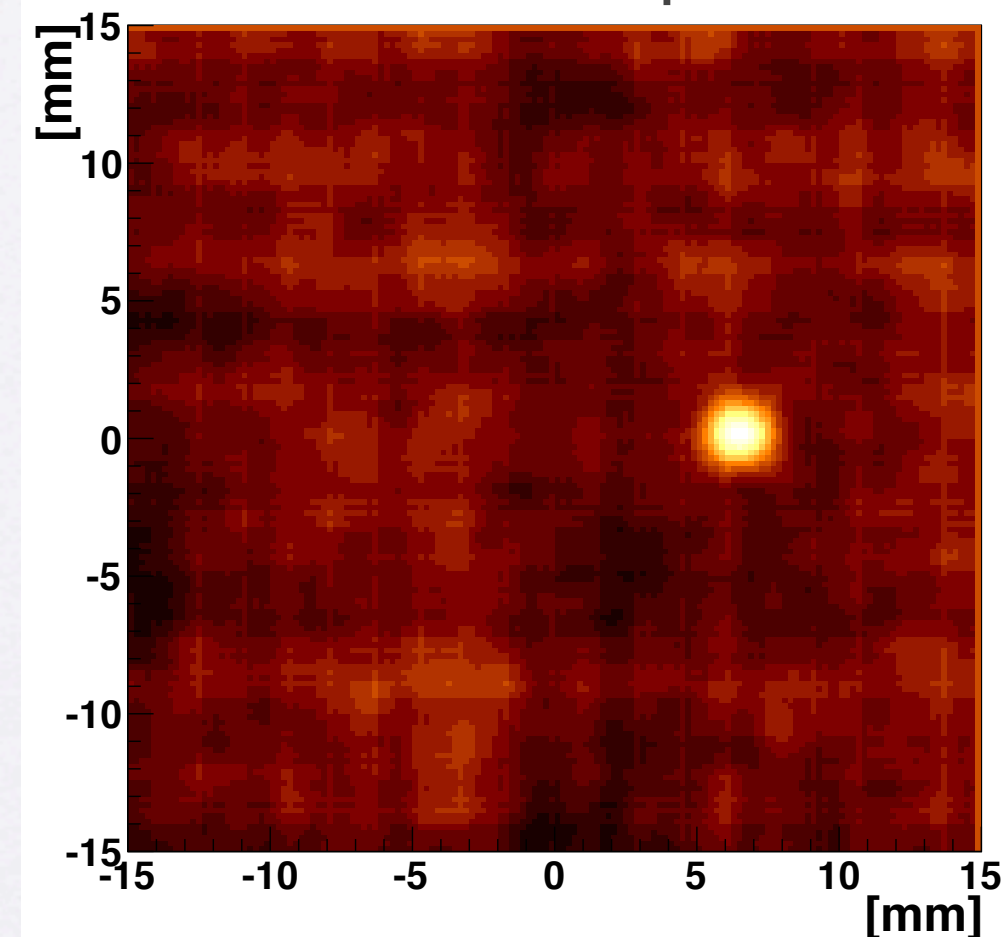
Random pattern (a part of Swift BAT mask pattern)

Coded Mask Camera Imaging



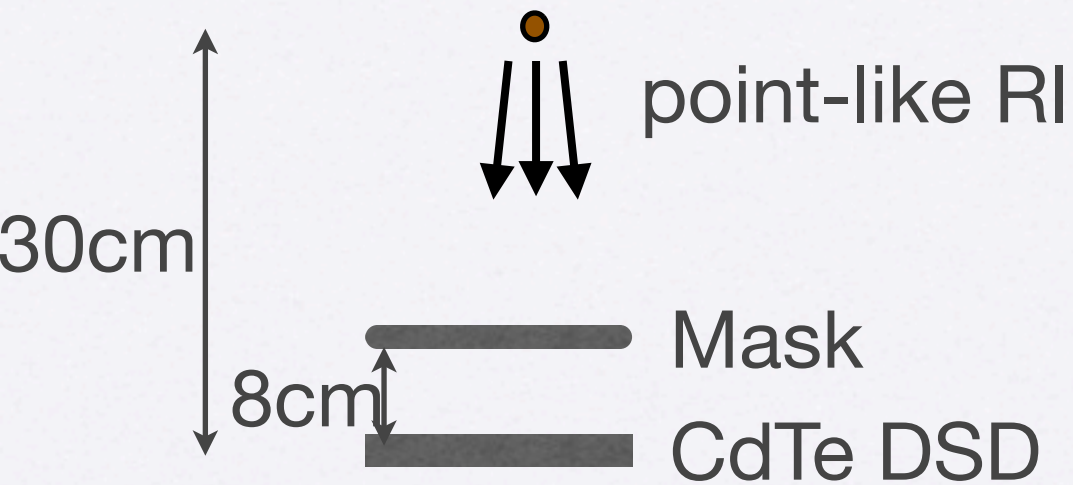
Reconstruction
cross correlation photon tagging

^{241}Am 60 keV peak



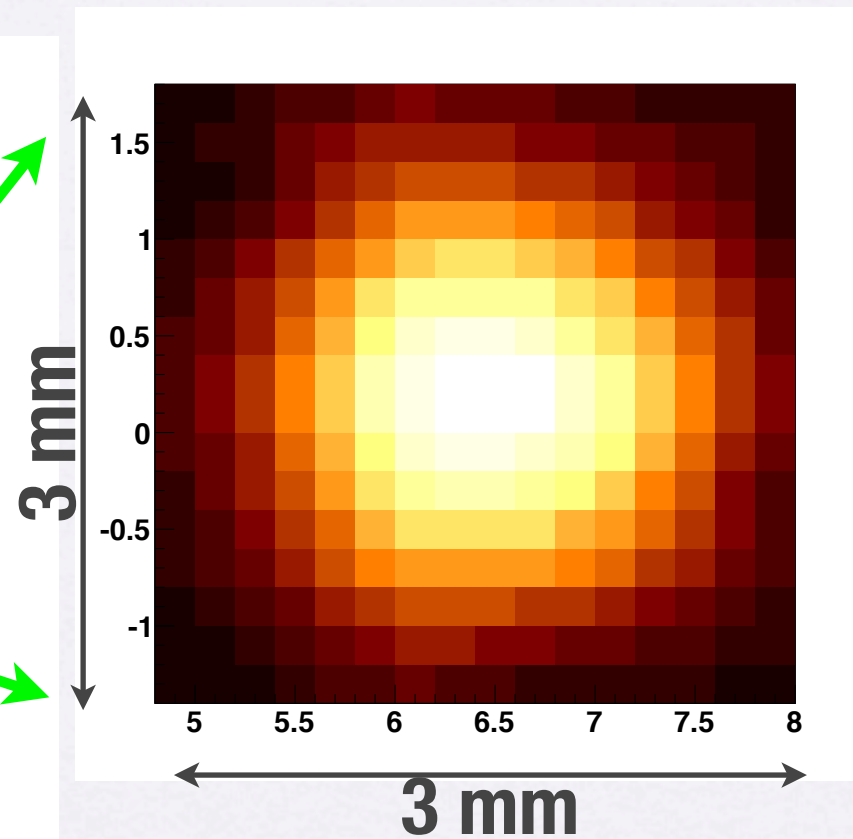
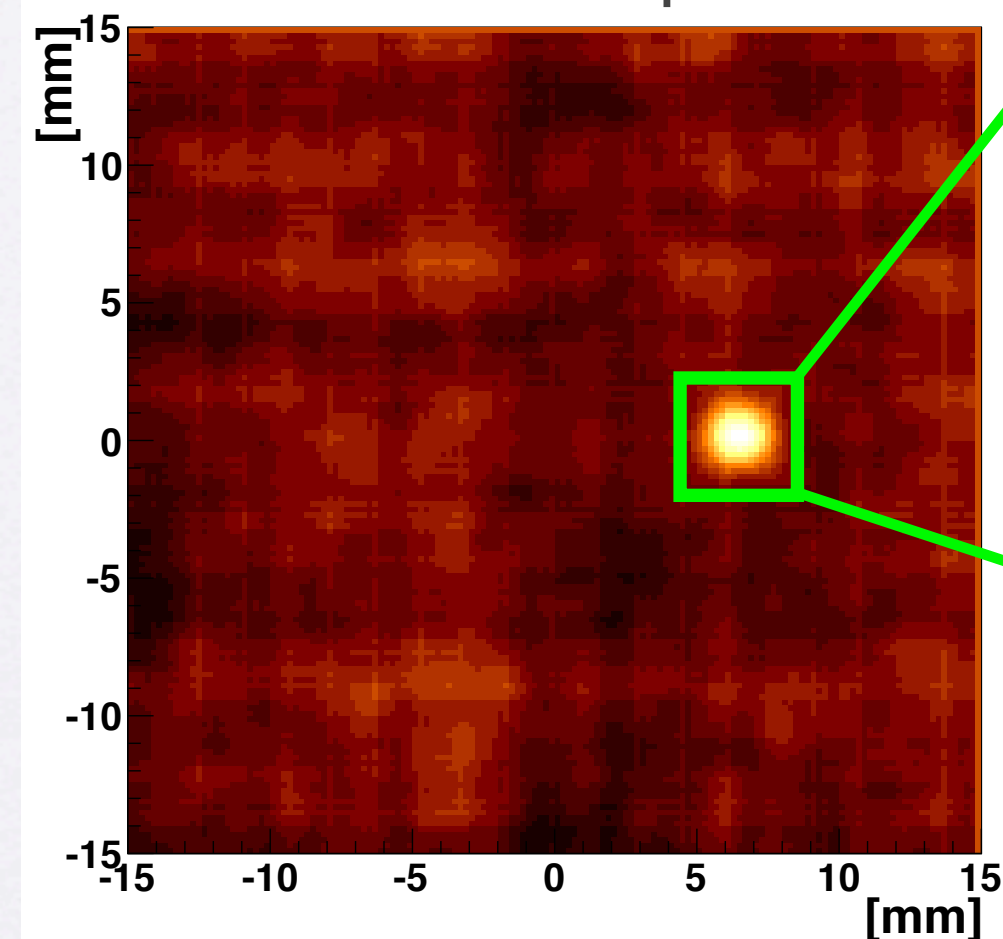
2D-gaussian fitting
sigma = 0.8 mm -> 9.0 arcmin

Coded Mask Camera Imaging



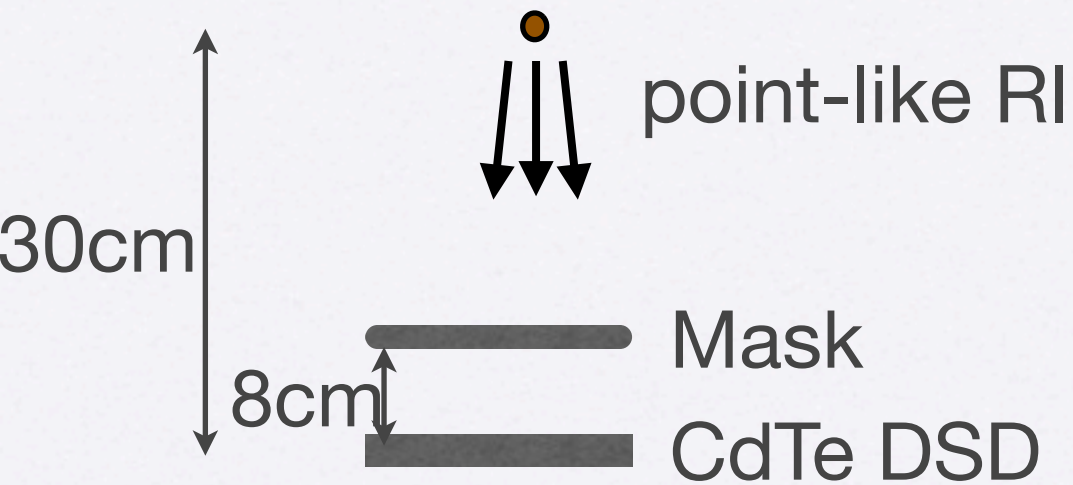
Reconstruction
cross correlation photon tagging

^{241}Am 60 keV peak



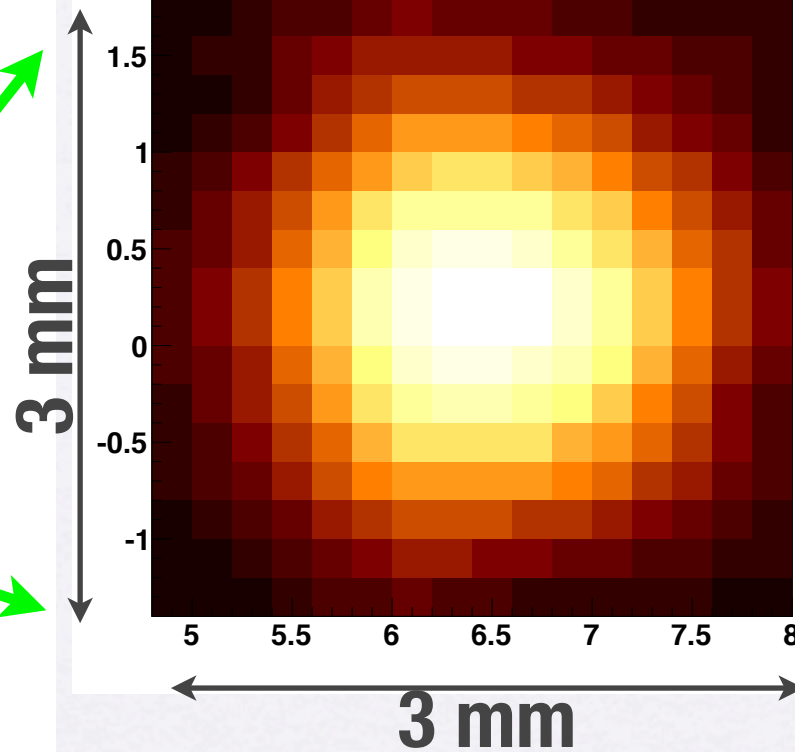
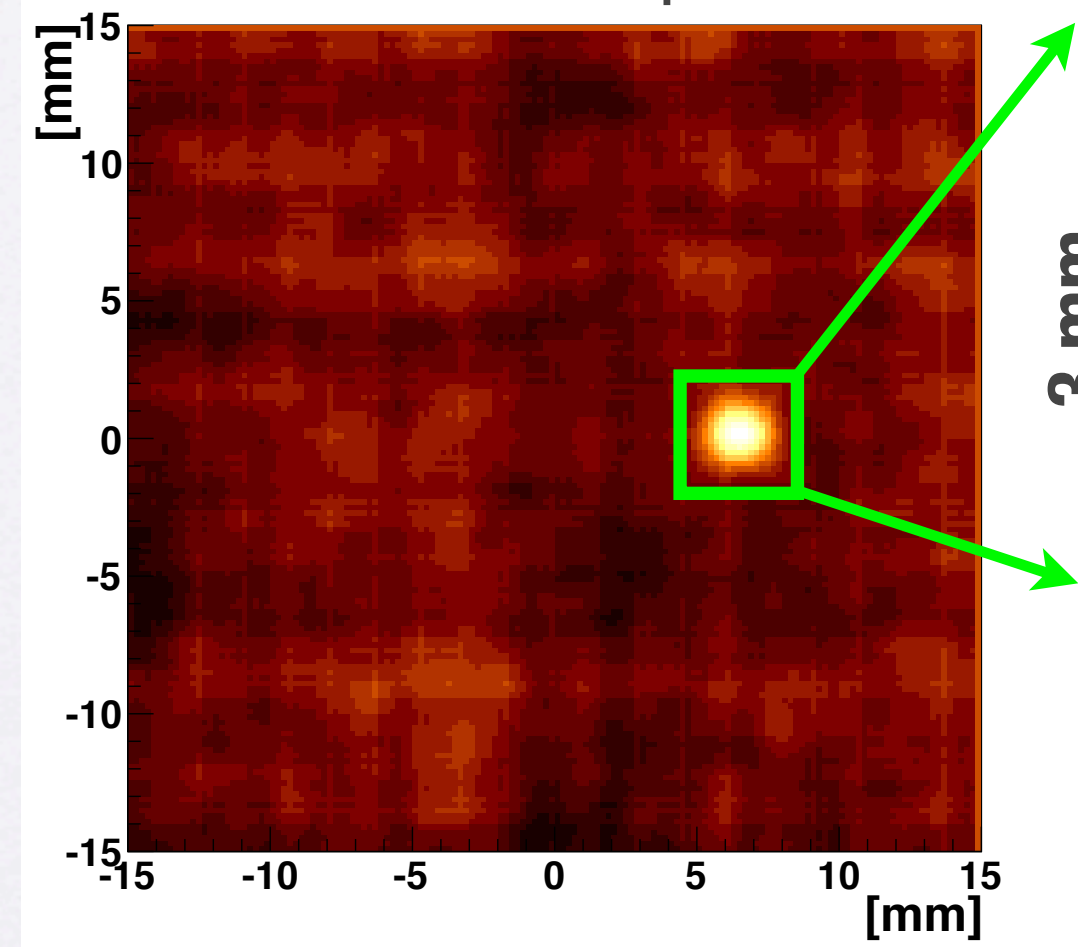
2D-gaussian fitting
sigma = 0.8 mm -> 9.0 arcmin

Coded Mask Camera Imaging

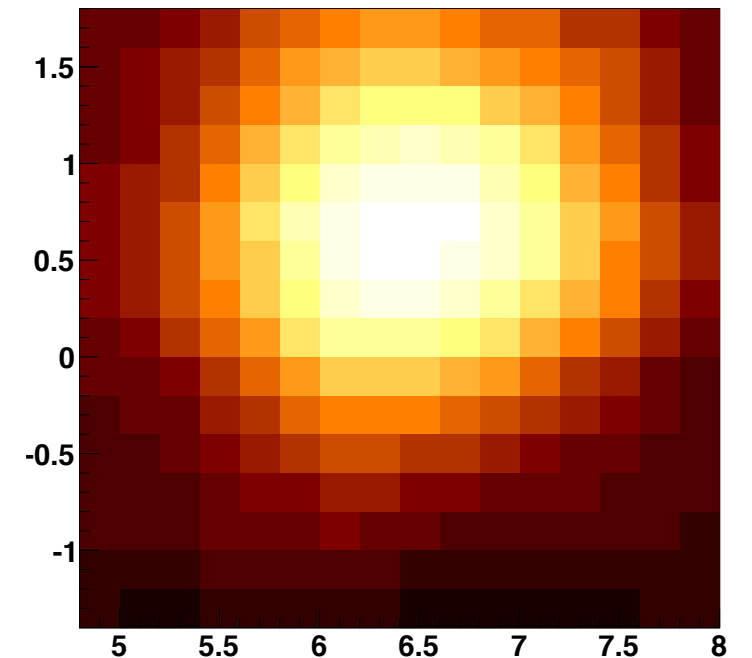


Reconstruction
cross correlation photon tagging

^{241}Am 60 keV peak

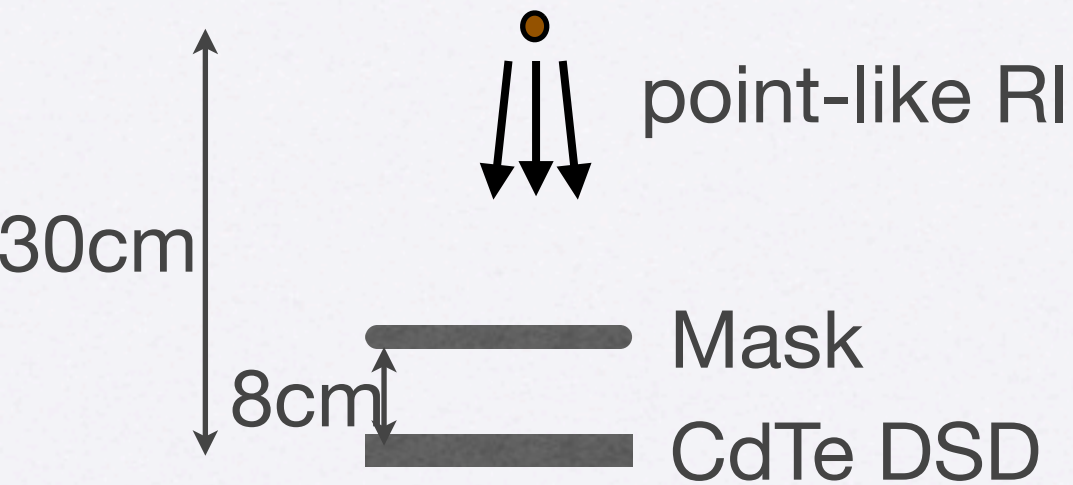


Y+0.5 mm



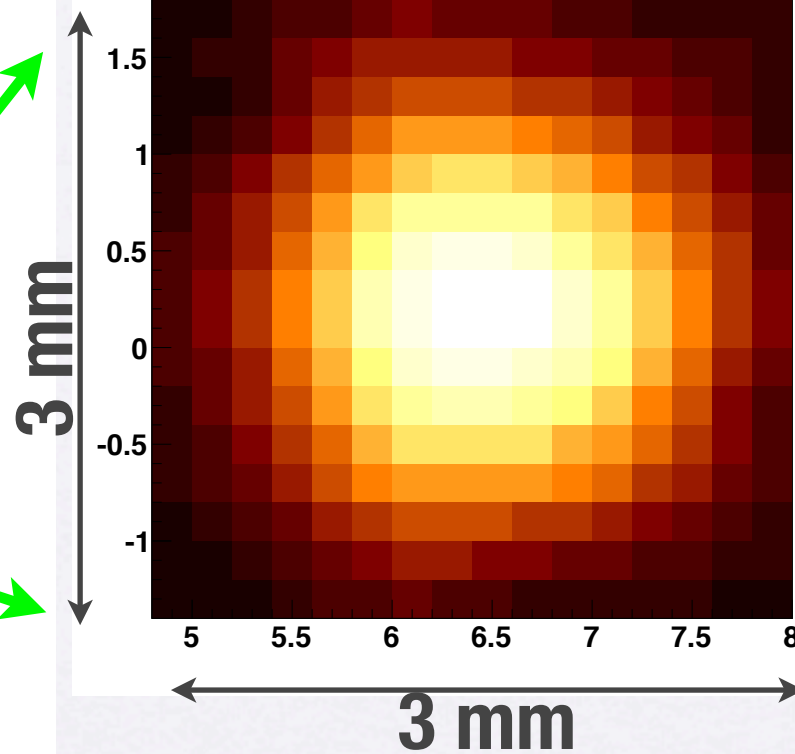
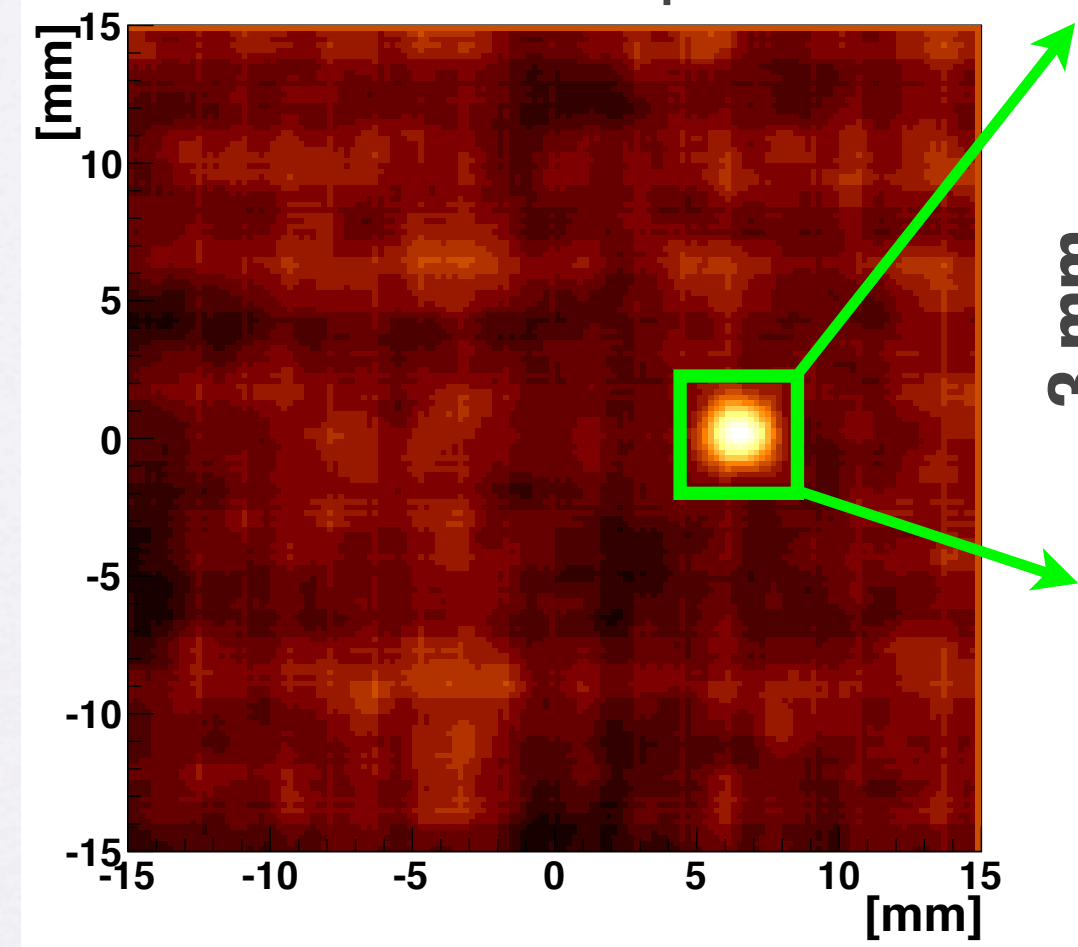
2D-gaussian fitting
sigma = 0.8 mm -> 9.0 arcmin

Coded Mask Camera Imaging

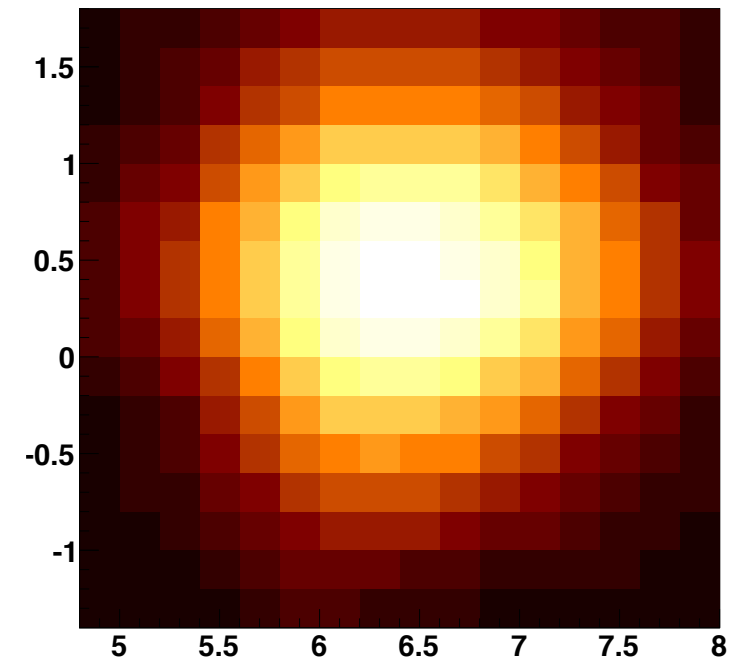


Reconstruction
cross correlation photon tagging

^{241}Am 60 keV peak

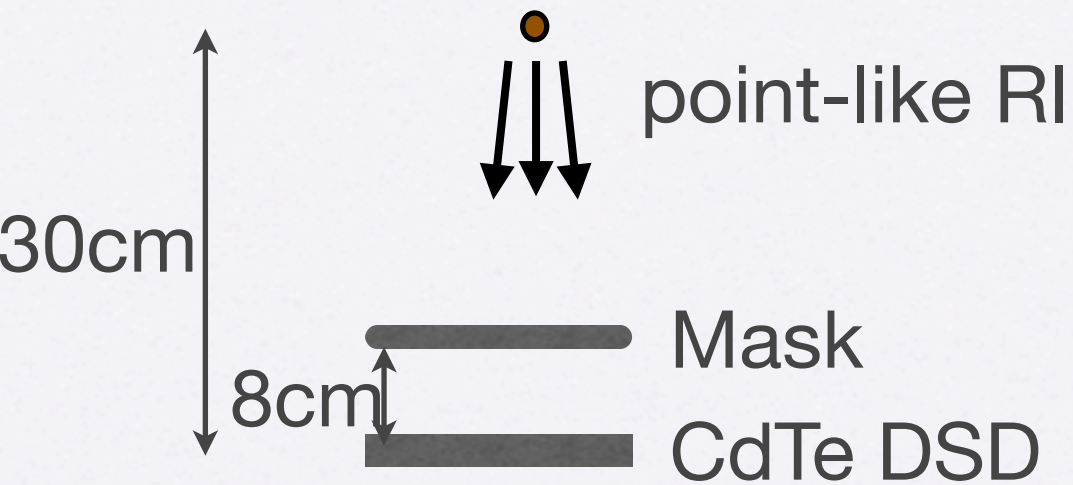


Y+0.2 mm



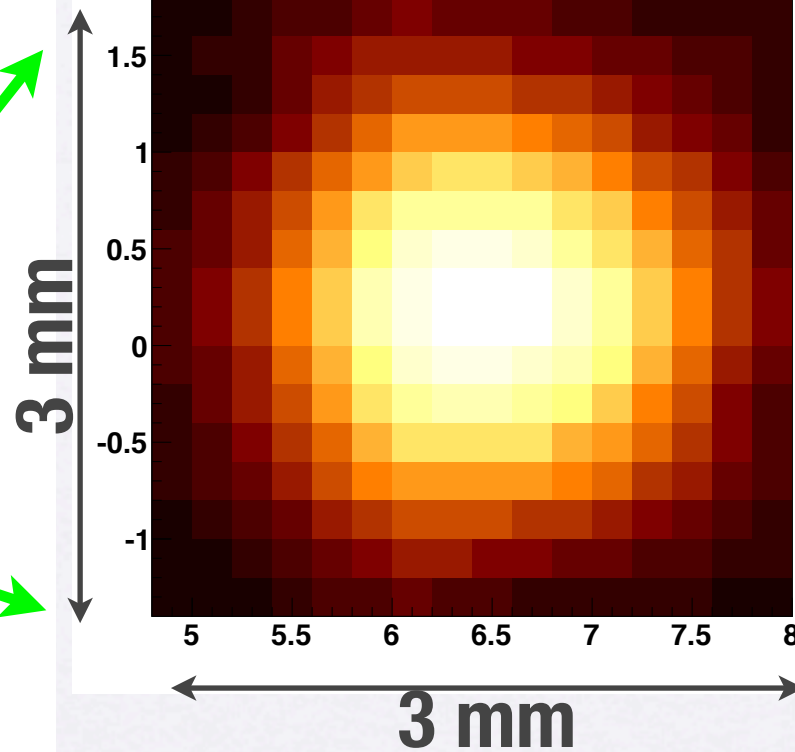
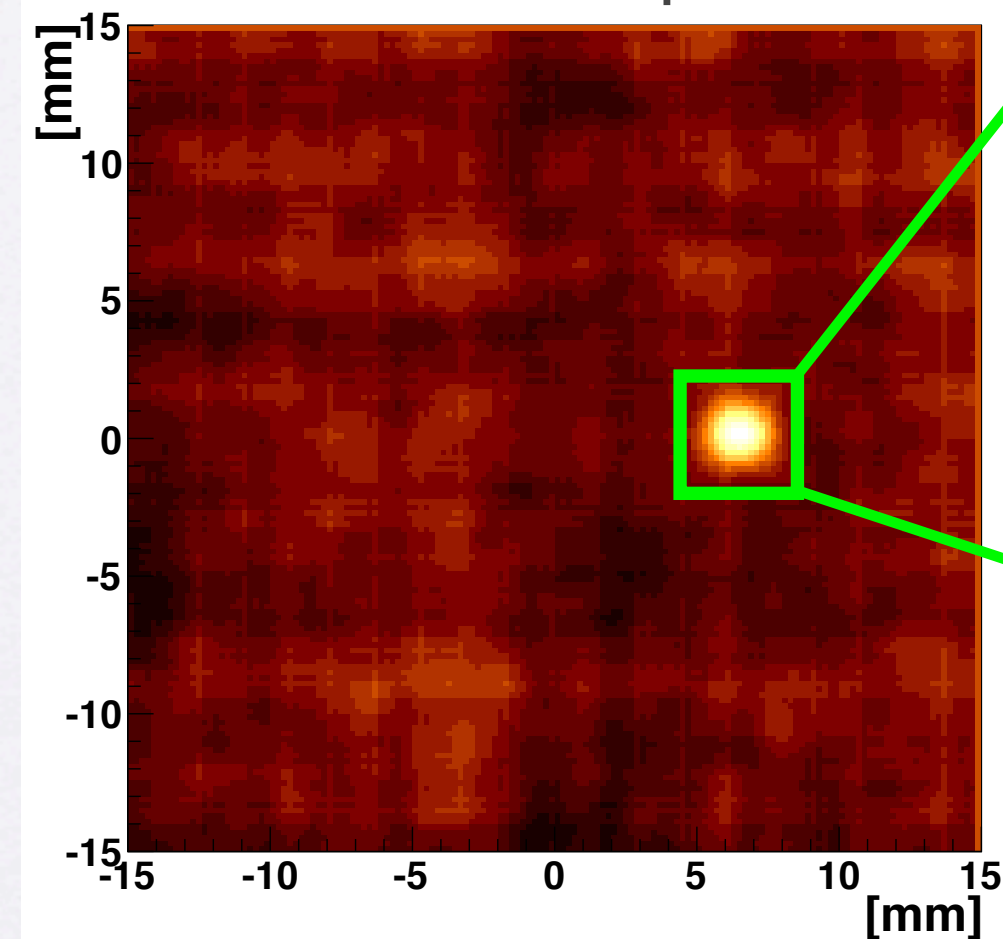
2D-gaussian fitting
sigma = 0.8 mm -> 9.0 arcmin

Coded Mask Camera Imaging

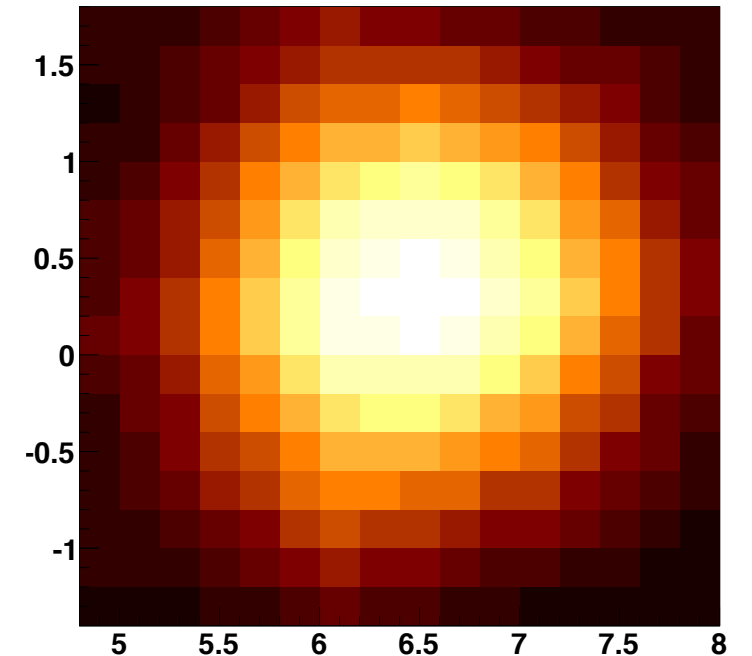


Reconstruction
cross correlation photon tagging

^{241}Am 60 keV peak

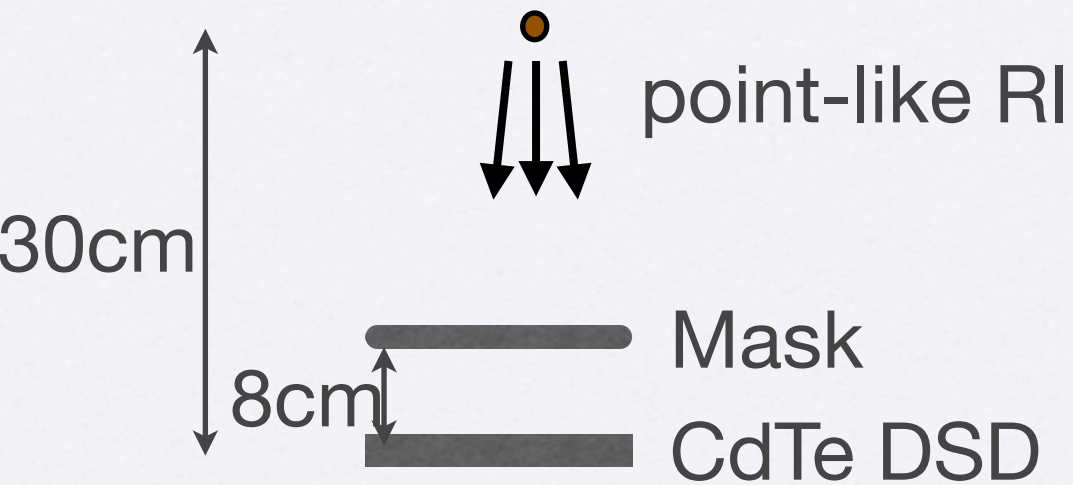


Y+0.1 mm



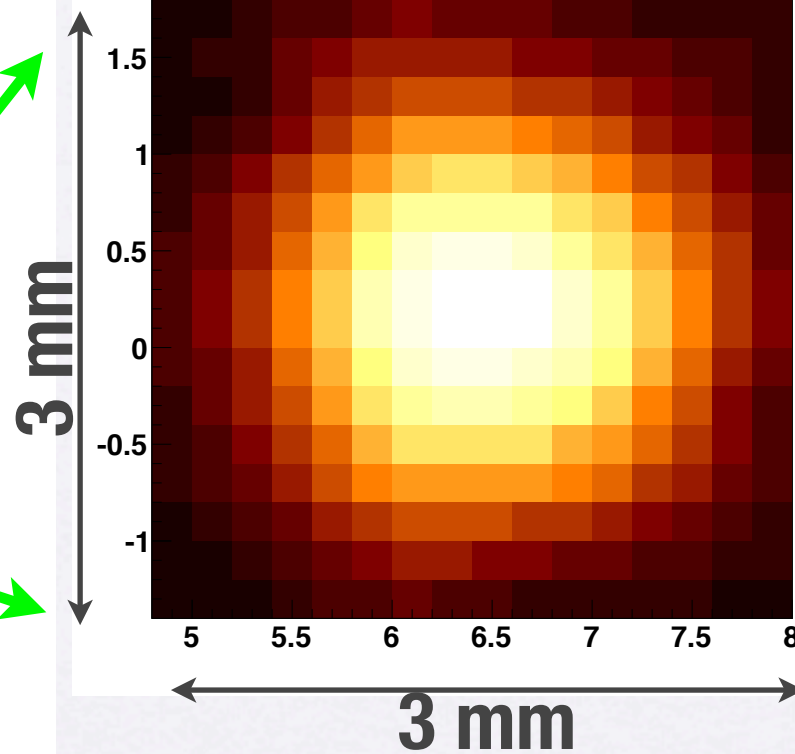
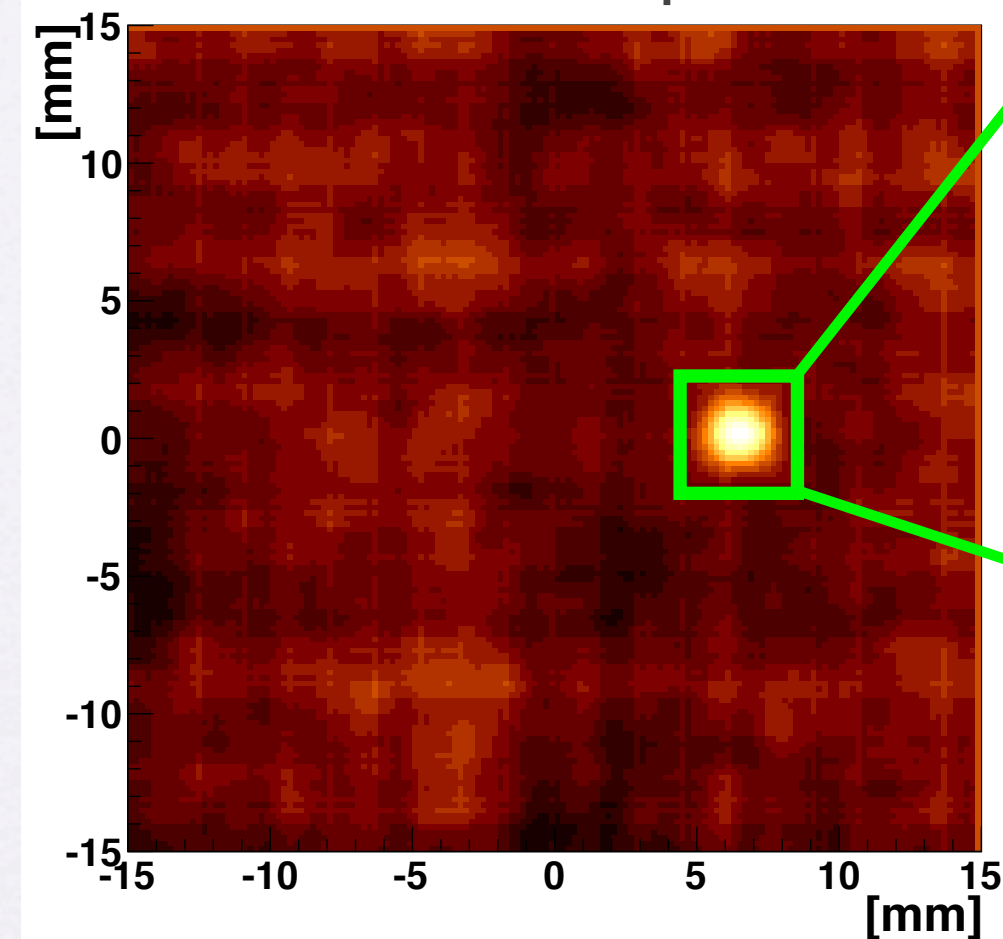
2D-gaussian fitting
sigma = 0.8 mm -> 9.0 arcmin

Coded Mask Camera Imaging

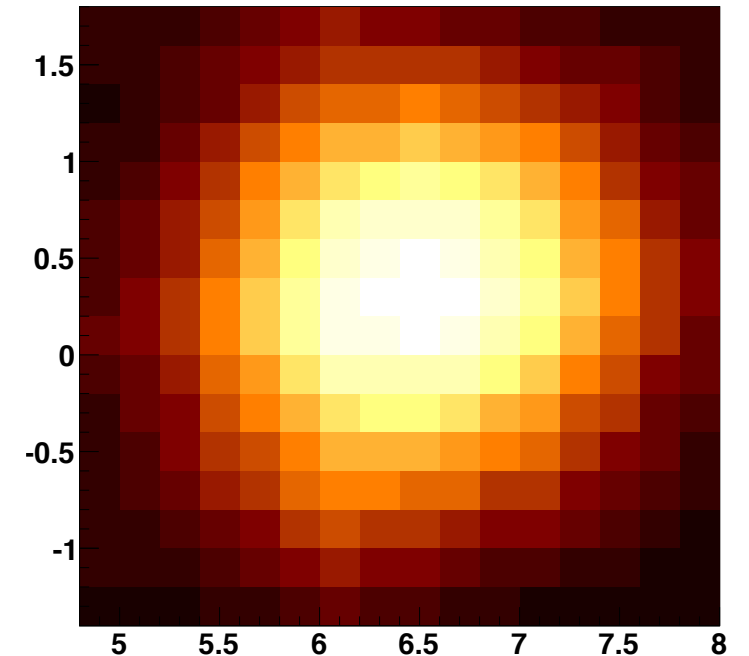


Reconstruction
cross correlation photon tagging

^{241}Am 60 keV peak



Y+0.1 mm



0.1 mm position determination
-> ~1 arcmin

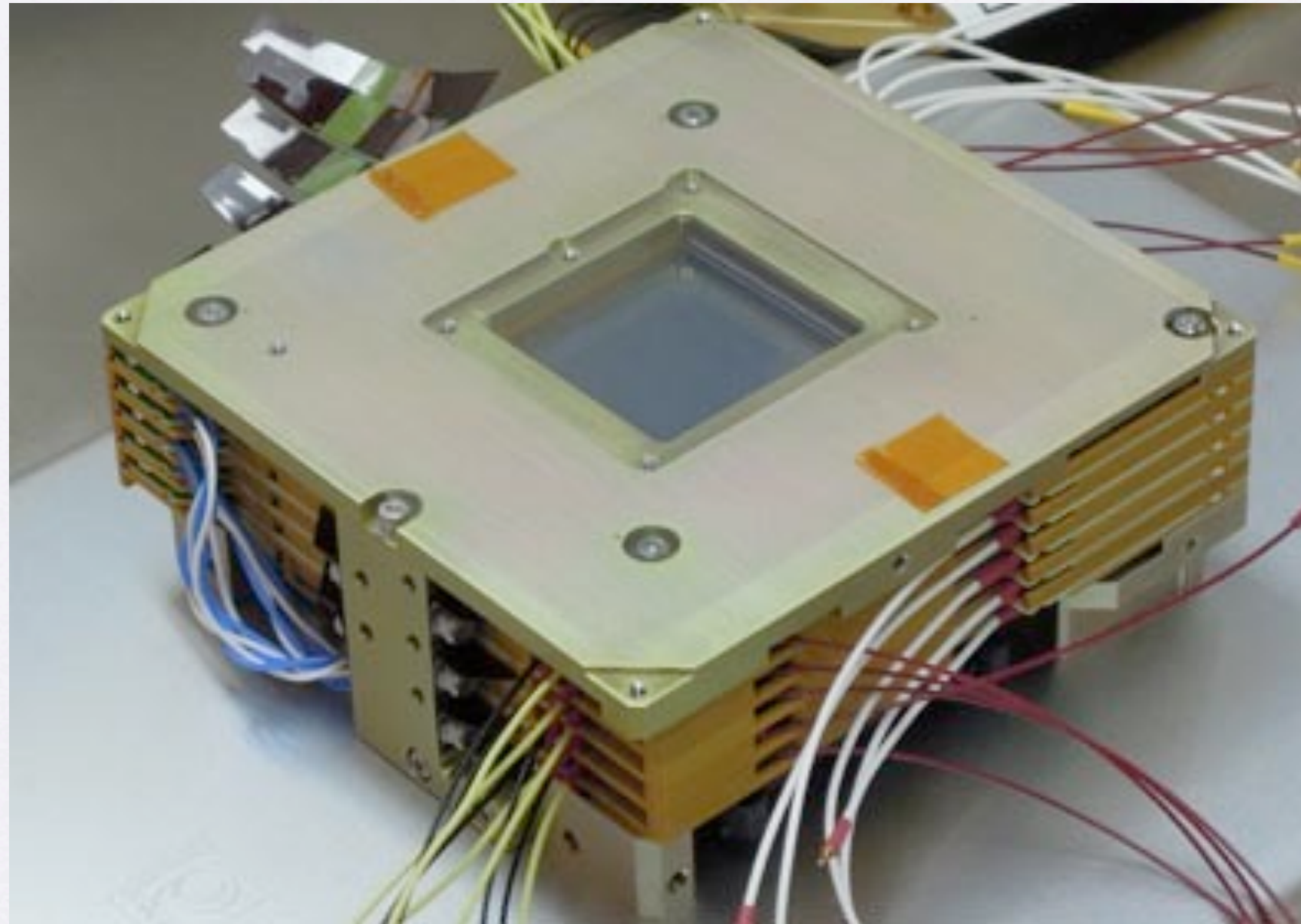
2D-gaussian fitting
sigma = 0.8 mm -> 9.0 arcmin

Application2: Compton Camera

CdTe DSD high energy resolution & fine position resolution

Ideal Compton Camera Detectors

Si/CdTe Semiconductor
Compton Camera



**Double-sided Si Strip
Detectors (same design)
Stacking Compactly
stack pitch 5.4 mm
(5 layers)**

Gamma-ray Imaging Performance

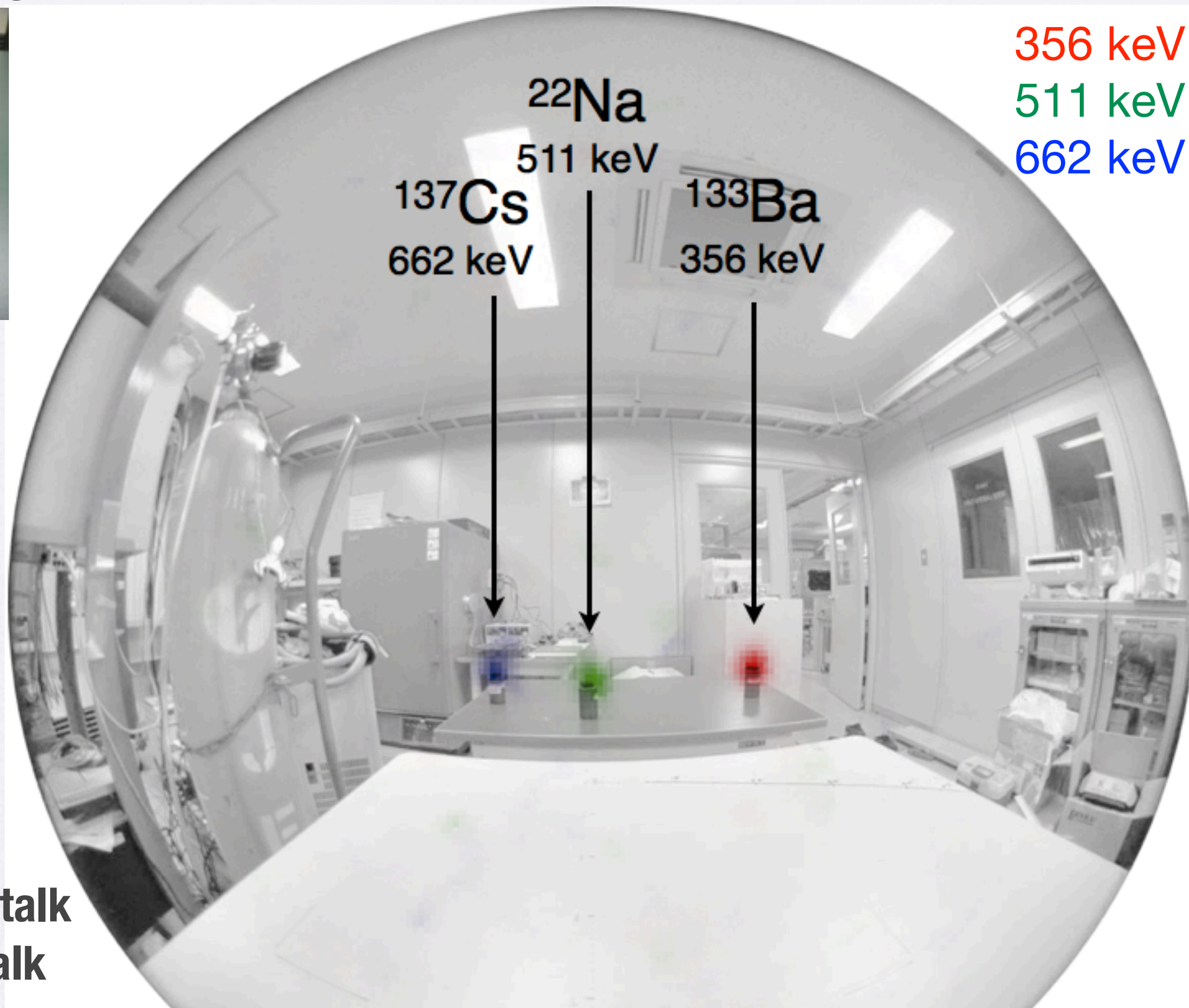
Compton Imaging



Radio Isotope
1 m distance

**Simultaneous
Multi-RI Imaging**

Details:
R09-1 T. Takahashi's talk
MIC5-7 S. Takeda's talk



Summary

- CdTe Diode Double-sided Strip Detectors (ASTRO-H HXI model)
 - CdTe Diode Devices , Al / CdTe /Pt type
 - 250 μm strip pitch, 128 strips / side,
 - 3.2 cm x 3.2 cm imaging area, 0.75 mm thick
 - VATA LSI
- Good Spectral Performance
 - FWHM 1.2 keV @ 13.9 keV, FWHM 1.6 keV @ 60 keV
- Imaging Performance
 - Sub strip position resolution
- Applications
 - compact coded mask cameras
 - Si/CdTe semiconductor Compton cameras