



University
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Synchrotron and pion beam tests of 3D Medipix2 and TimePix Detectors

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- Introduction
 - 3D double sided detectors substrates
 - Medipix / Timepix description
- Micro-focussed **X-ray beam**
 - Set-up
 - Background subtraction
 - Efficiency and Charge Sharing
- **Pion-beam** from SPS
 - Set-up
 - Efficiency and Charge Sharing
- Conclusions

Medipix unit cell
55 μm on the side
Maximum drift length is 38.9 μm

Detectors are fabricated at Centro Nacional de Microelectronica, Barcelona

Columns are etched from opposite sides of substrate
 Column fabrication

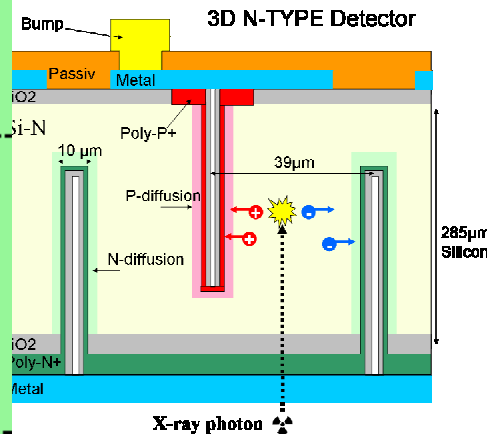
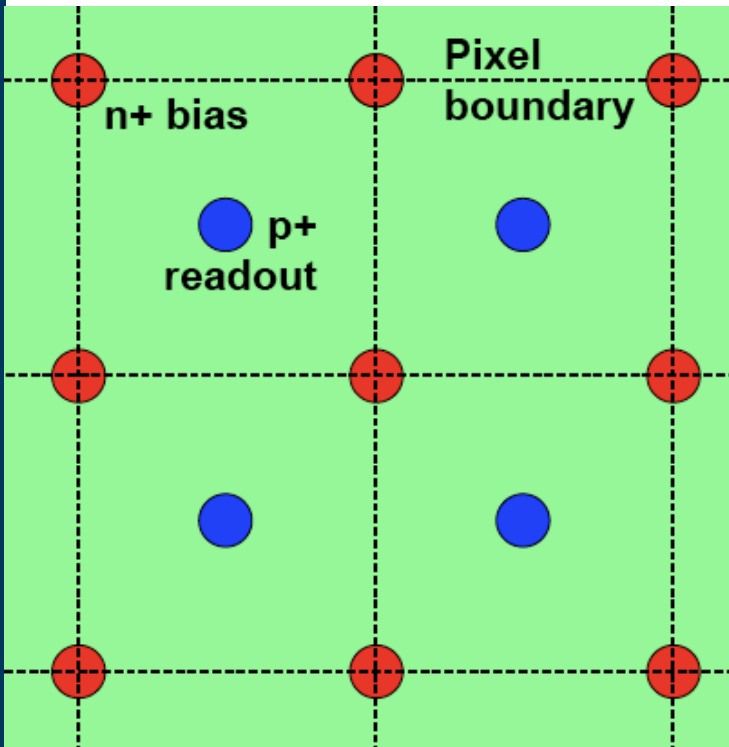
- » Reactive ion etching
- » Partial filling with polysilicon then doping

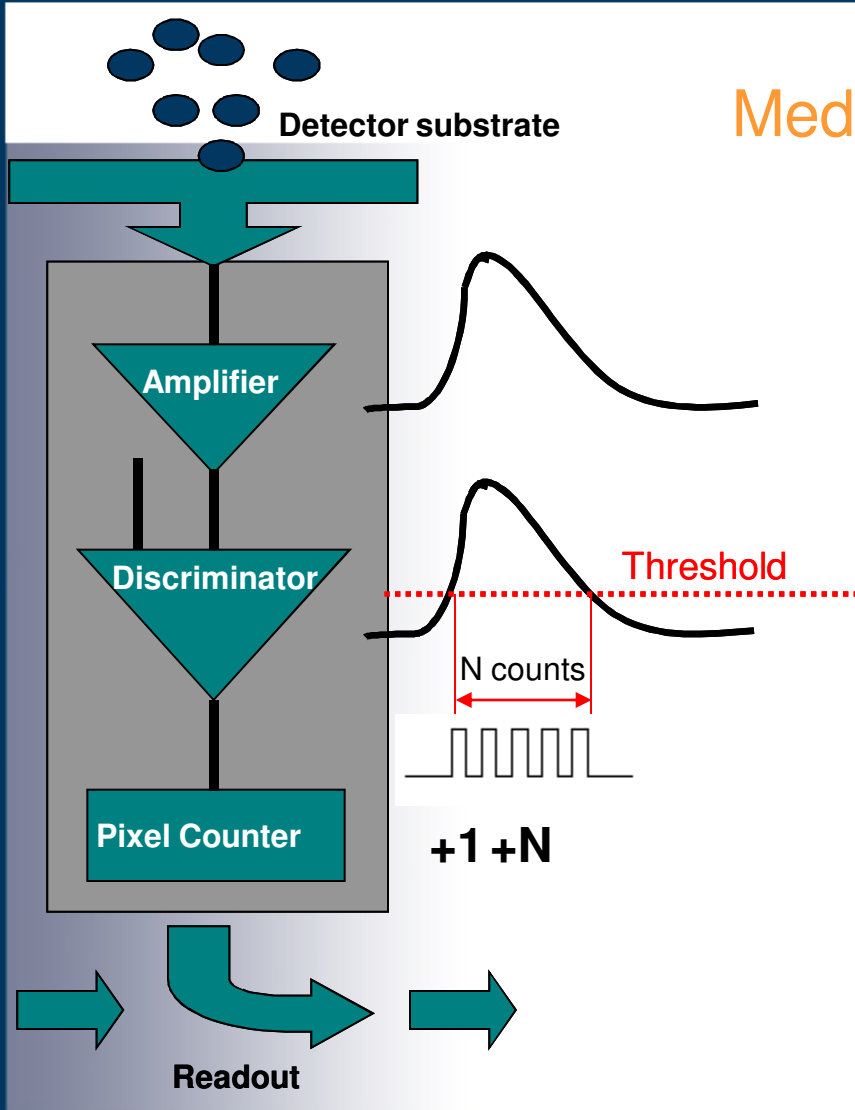
Radiation Hardness

Reduced Charge Sharing

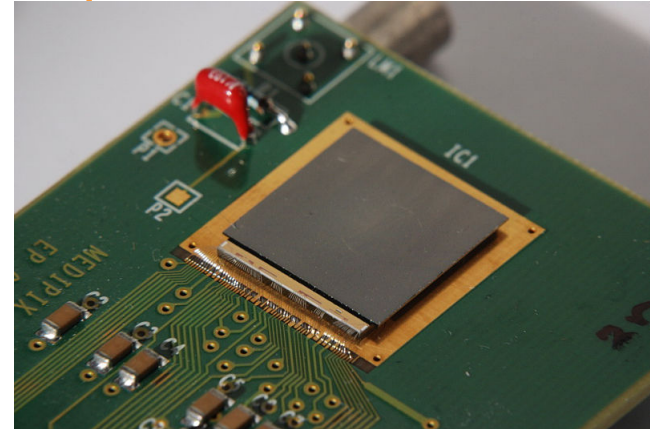
Charge sharing in double-sided 3D Medipix2 detectors

D. Pennicard, et al. ,NIM A, Vol. 604, Issues 1-2, 1 June 2009, Pages 412-415



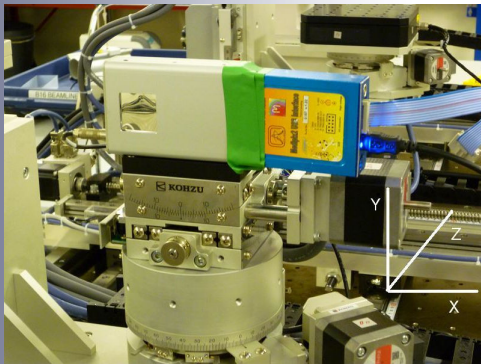
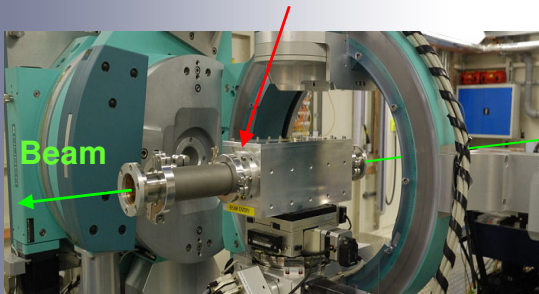


Medipix Timepix



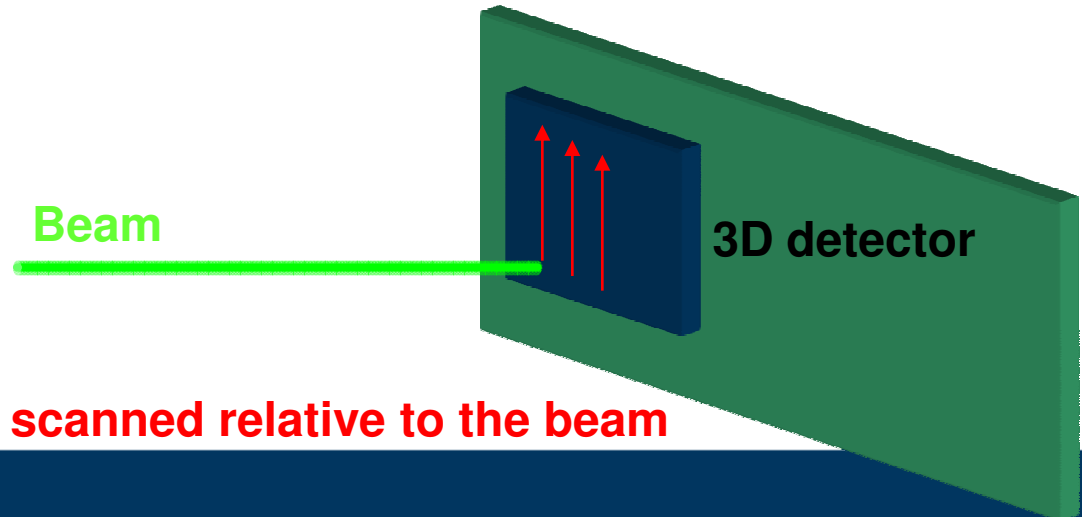
- 65k single-photon counting pixel array
- Square pixel size of $55\mu\text{m}$
- Electron or hole collection
- Threshold equalisation
- Count rate of $\sim 100\text{kHz}$
- Readout in $300\mu\text{s}$
- High dynamic range

Compound refractive lens



- B16 Test beamline at the Diamond
- Monochromatic **X-ray beam of 14.5keV**
- Beam size FWHM were measured as
 - $4.5 \pm 0.3 \mu\text{m}$ in x
 - $6.7 \pm 0.3 \mu\text{m}$ in y
- Six degrees of freedom, $0.1 \mu\text{m}$ translational and $5 \mu\text{rad}$ rotational
- Alignment of 0.3° in x and 0.9° in y

Beam

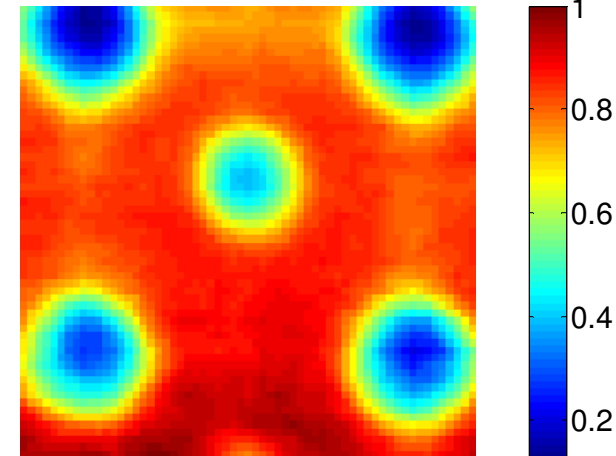


3D detector

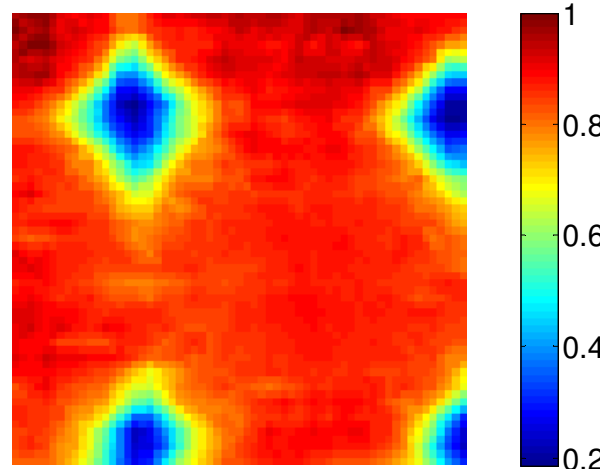
Detector substrate raster scanned relative to the beam

- $77.5\mu\text{m}$ square scans ($55\mu\text{m}$ pixel)
- $2.5\mu\text{m}$ steps
- Background subtracted
- Interpolated
- THL ~ 50% of beam energy

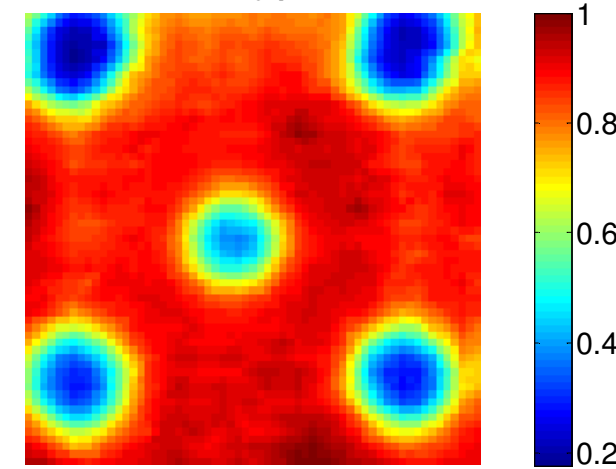
N-Type

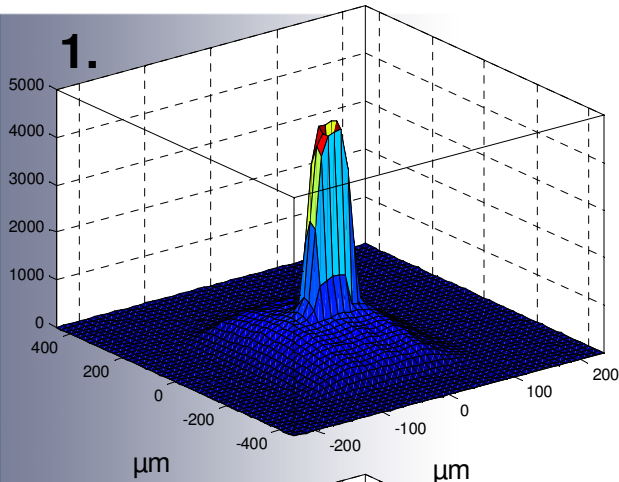


Planar



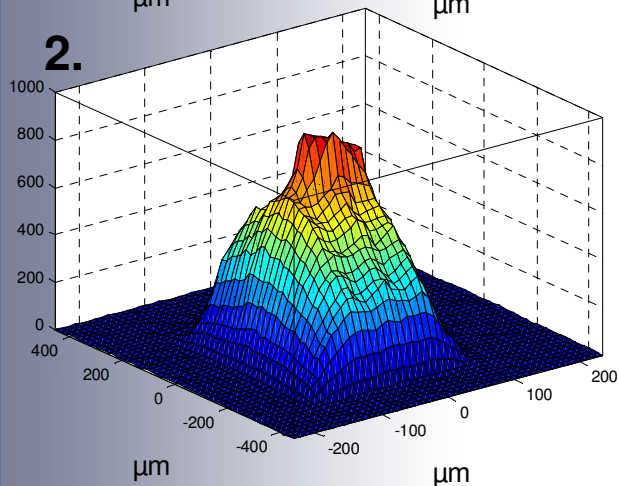
P-Type



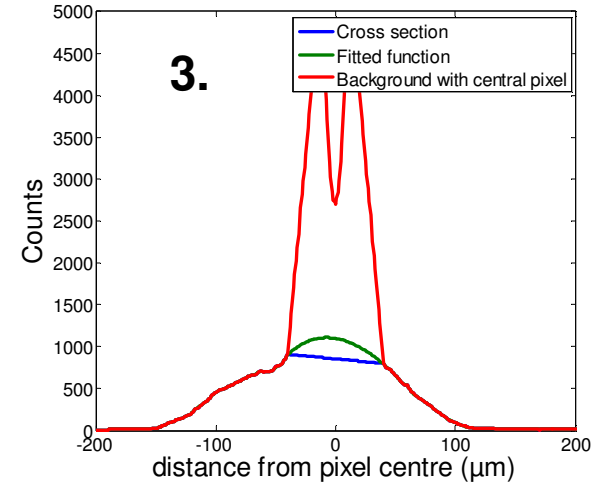


1. Build up scan

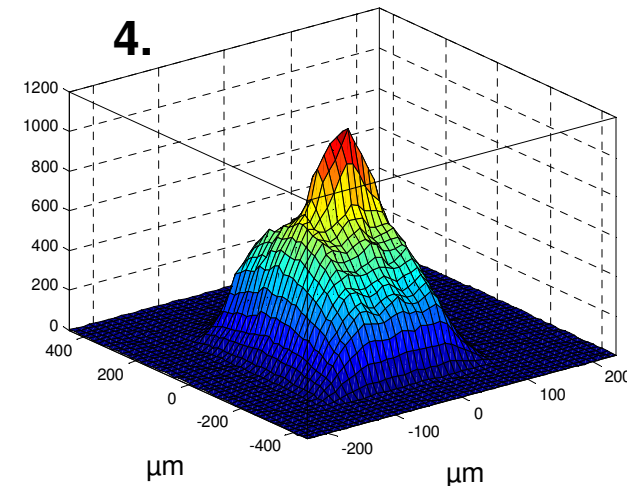
**2. Remove central pixel/
micro-focused beam.**



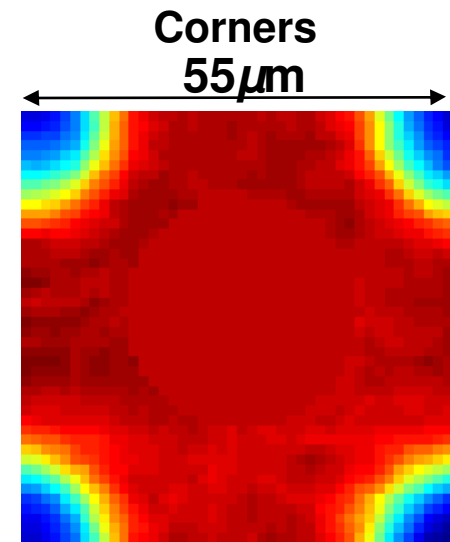
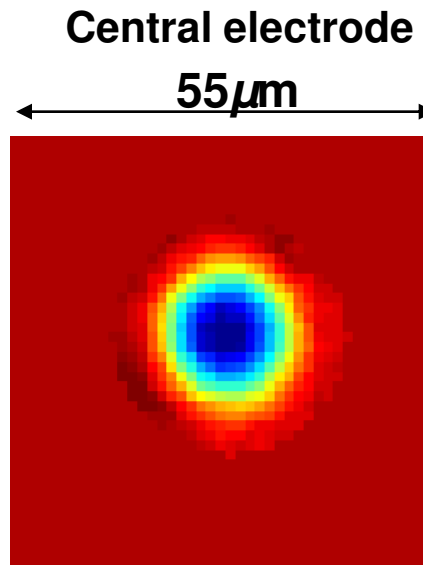
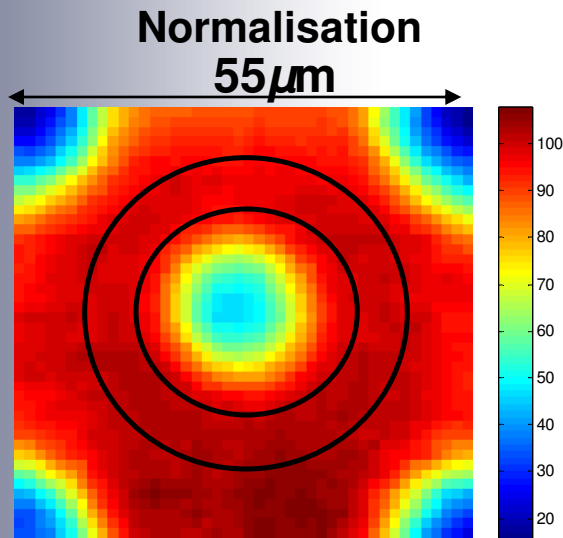
**3. Perform cross sections to
estimate background in
central pixel**



4. Perform surface fit

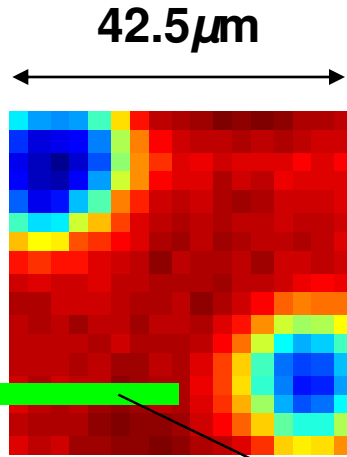


Inefficiencies	Centre	Corners*
Planar	0%	7%
3D N –Type	3%	7%
3D P –Type	4%	7%

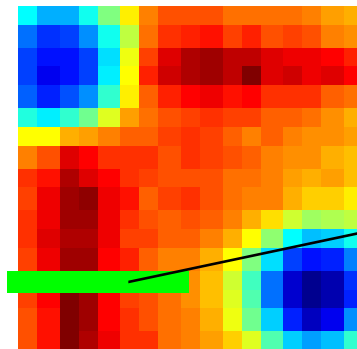


*efficiencies at the corners due to electrodes structures and charge sharing

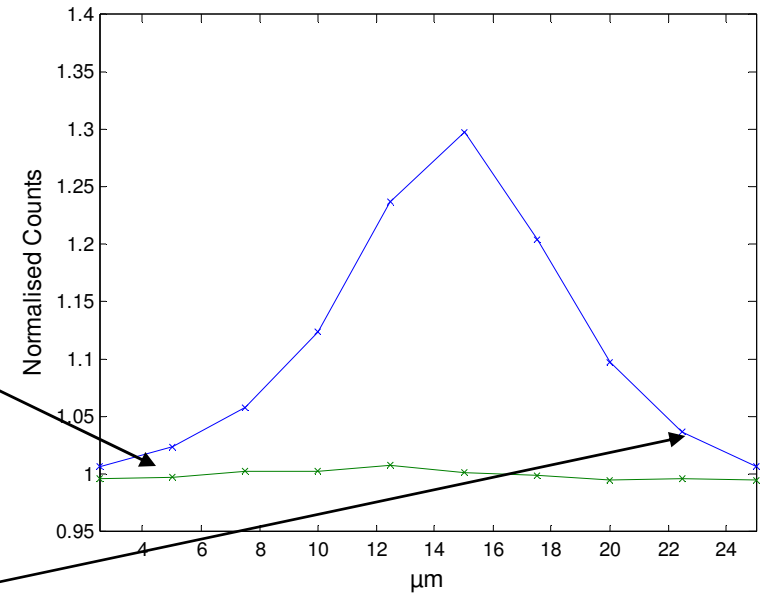
THL level
~50% beam energy



THL level
~25% beam energy



Line Sections



Double counting

Planar: 0.5 photons

3D: 0.25 photons

FWHM

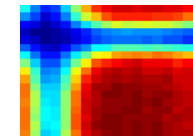
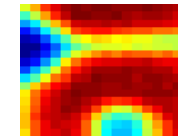
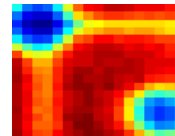
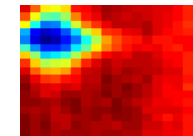
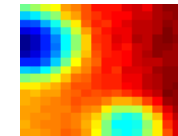
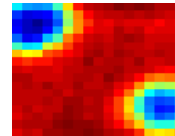
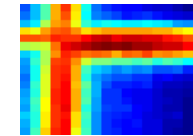
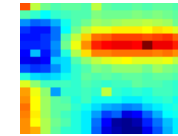
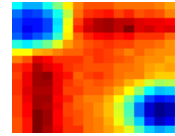
Planar: $\sim 12\mu\text{m}$

3D: $\sim 8\mu\text{m}$

THL~25%

THL~50%

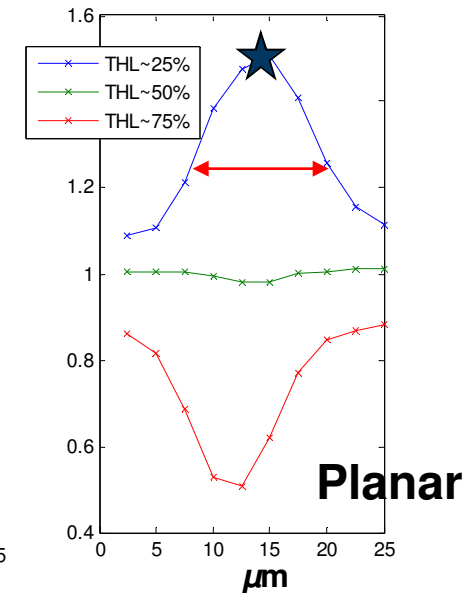
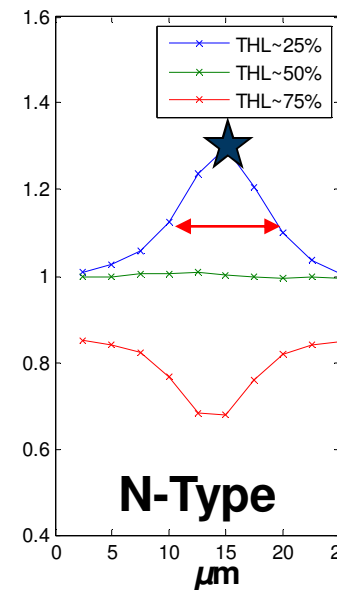
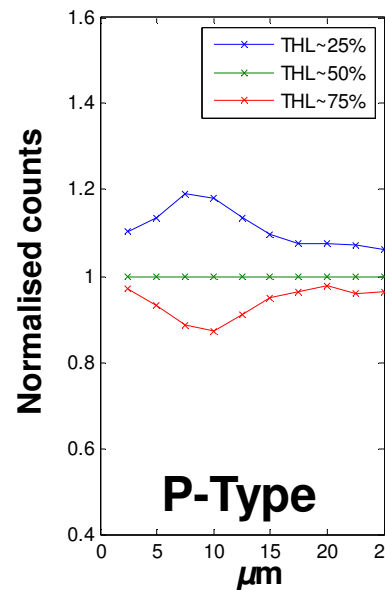
THL~75%



Reduced level of over counting and under counting in 3D

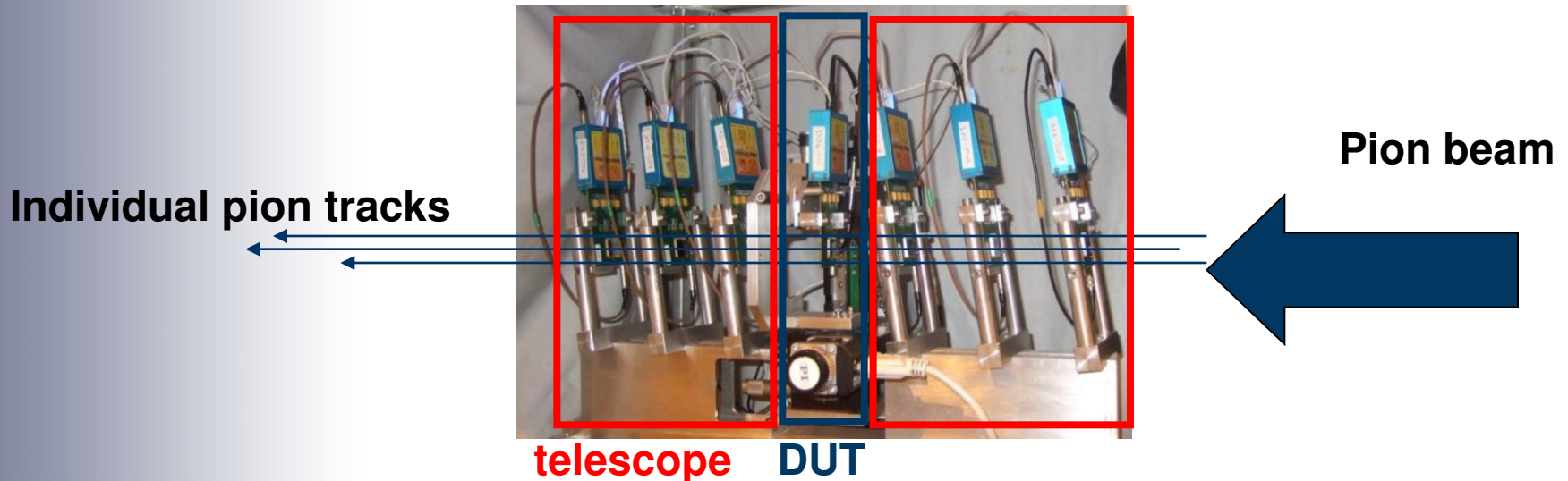
= Reduced Charge Sharing

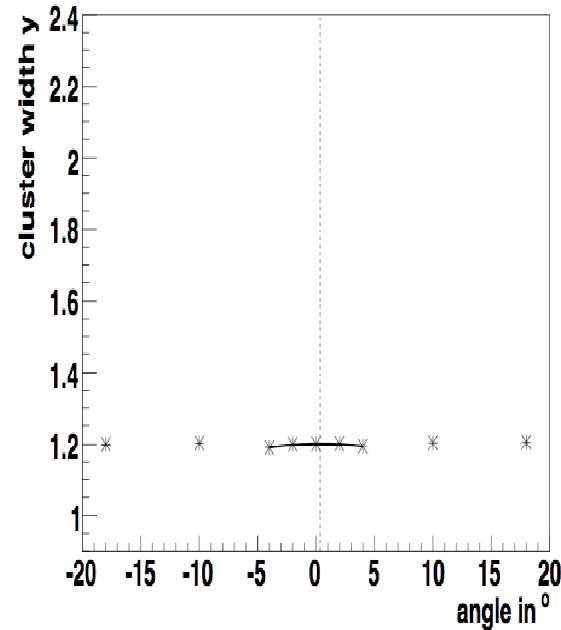
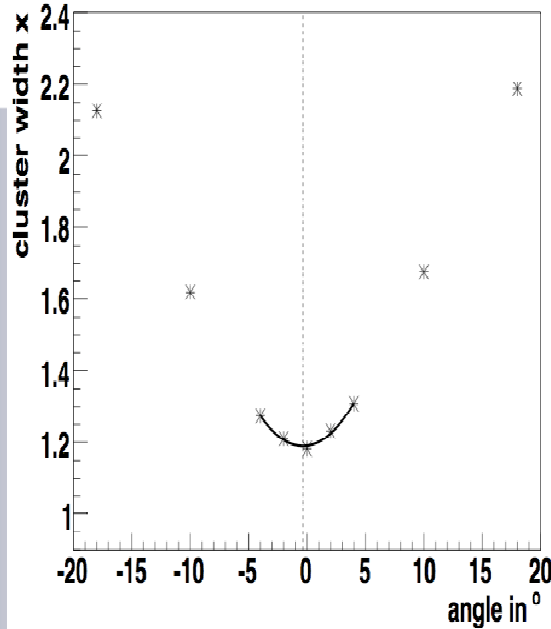
Note : at 14.5keV – gets worse for thicker Silicon & higher energy X-rays in Planar device



Medipix & LHCb

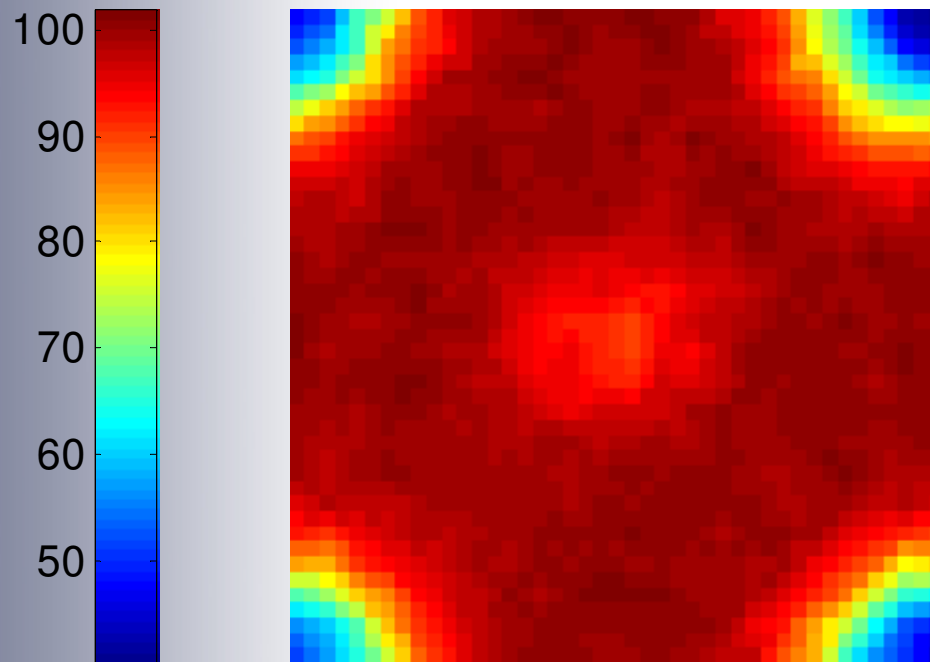
- Secondary 120 GeV pion beam from SPS
- 4 Timepix, 2 Medipix planes in **telescope**
- **DUT**: double sided 3D N-type sensor from CNM/Glasgow
- Expected track extrapolation error: $< 3 \mu\text{m}$





- Fit to determine perpendicular position: -0.32 degrees
- Flat distribution in y
- Ratio ~ 1 at perpendicular

	Centre	Corner
Inefficiencies	0.5%	5%

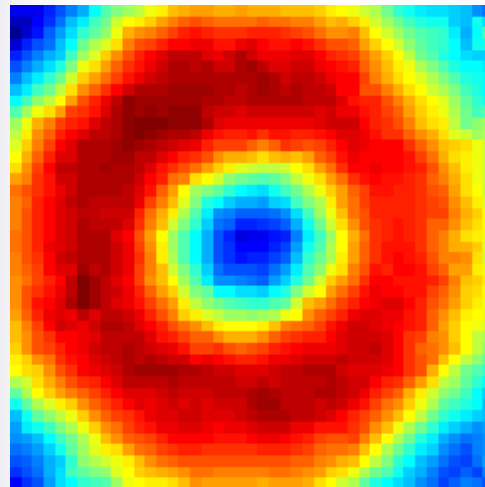


Absolute efficiencies

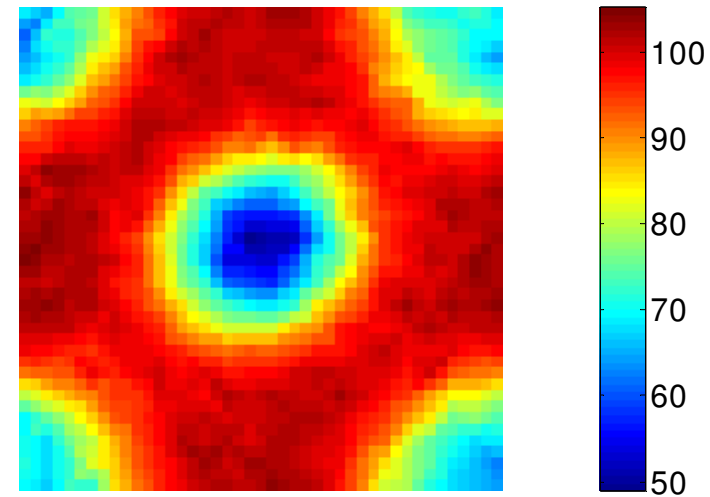
- Averaged result over all pixels
- Drop in efficiency at the electrode positions
- Here: efficient if hit in 3x3 pixel array around intercept point
- MIPs give a much higher efficiency than with x-rays due to track nature of charge deposition

Threshold just above noise level

ADC hit in pixel



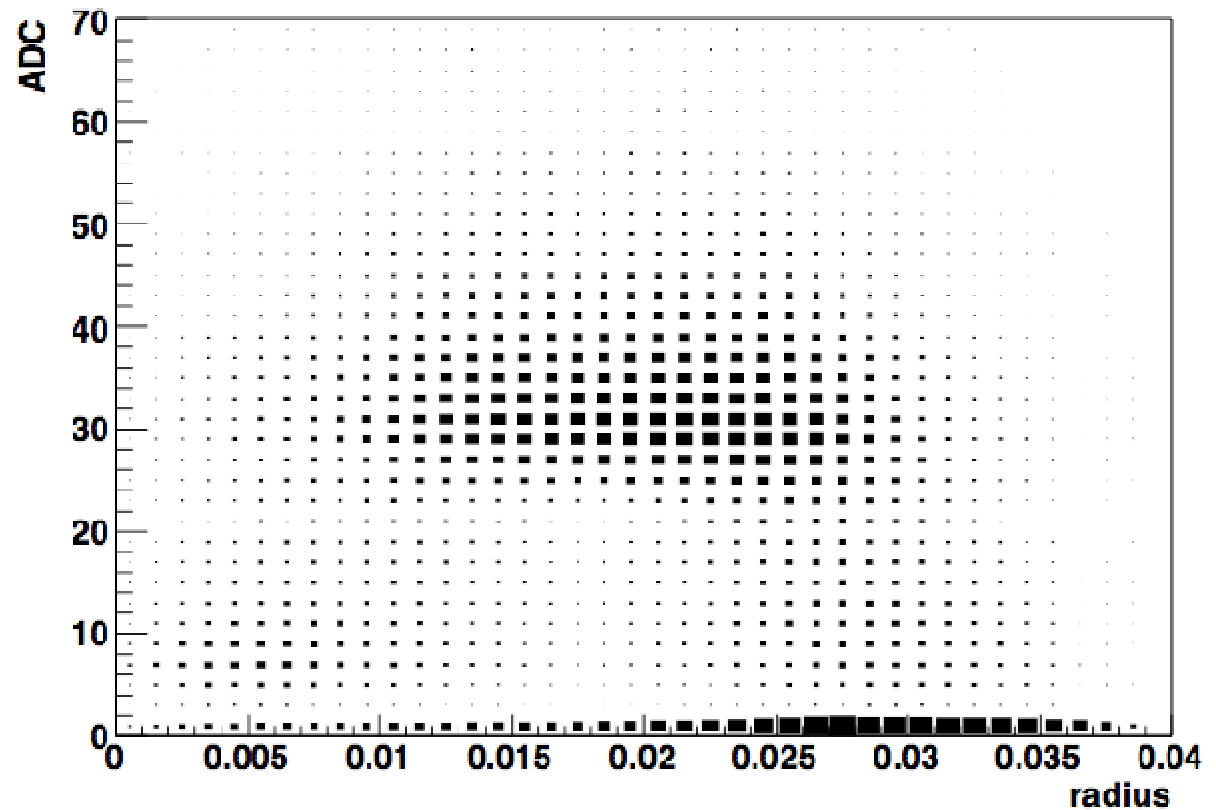
ADC hit in 3x3 pixel



average
ADC
vs
(x,y)

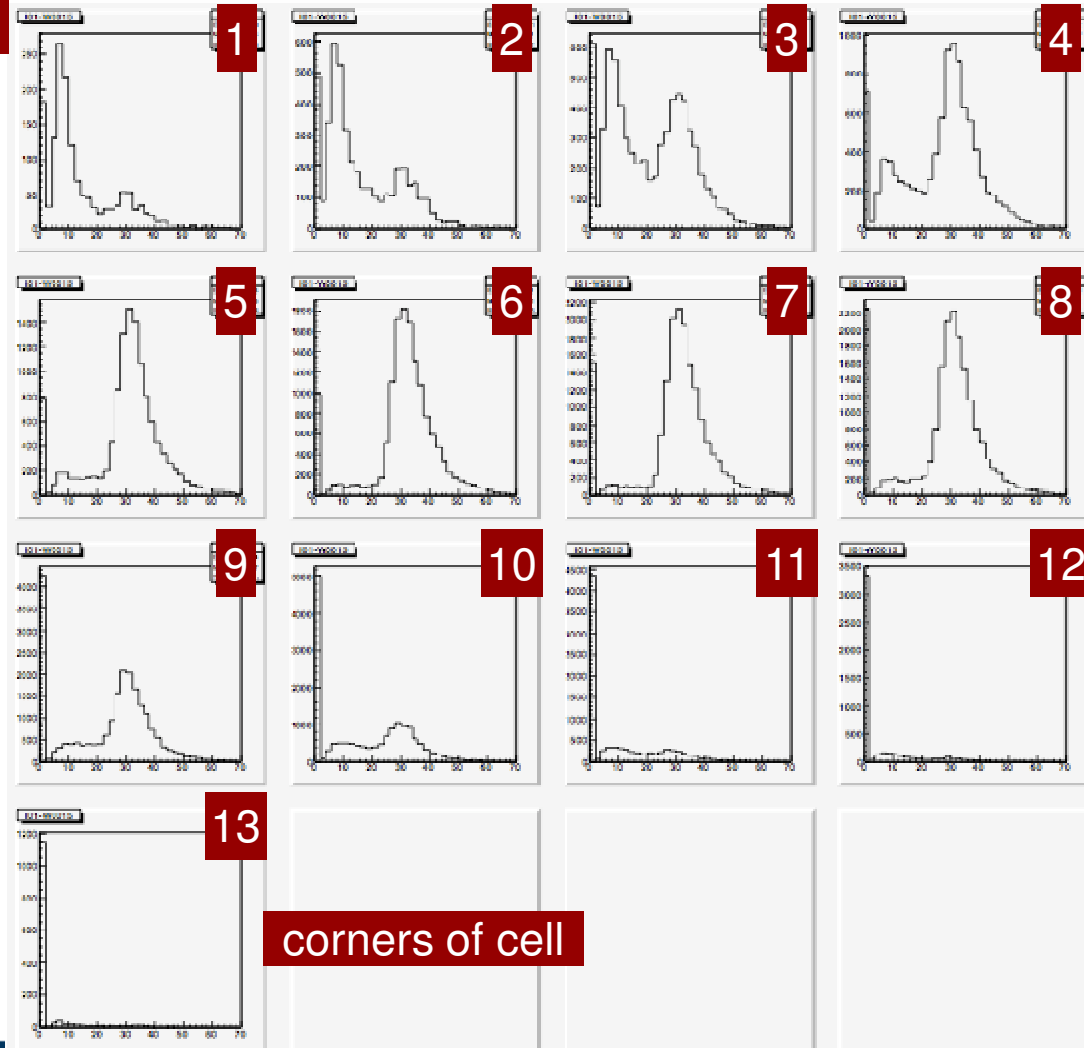
- Same picture as before:
Two column types have different signal size

- ADC counts (ToT) as function of distance from centre of cell

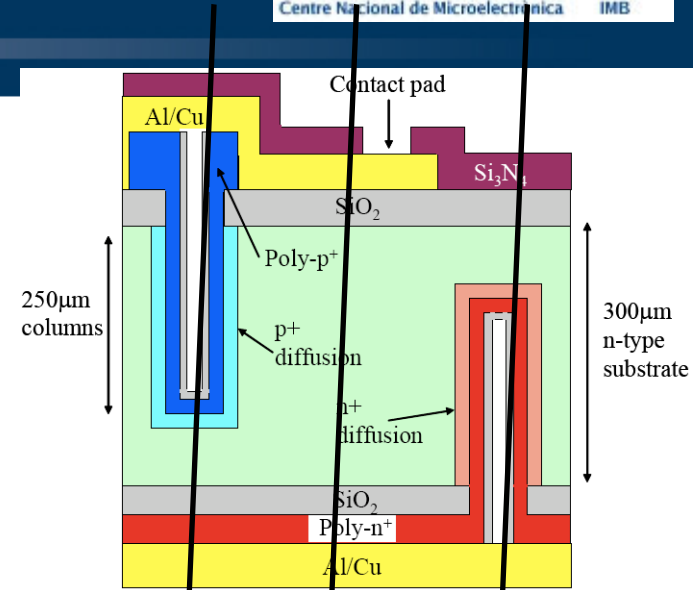
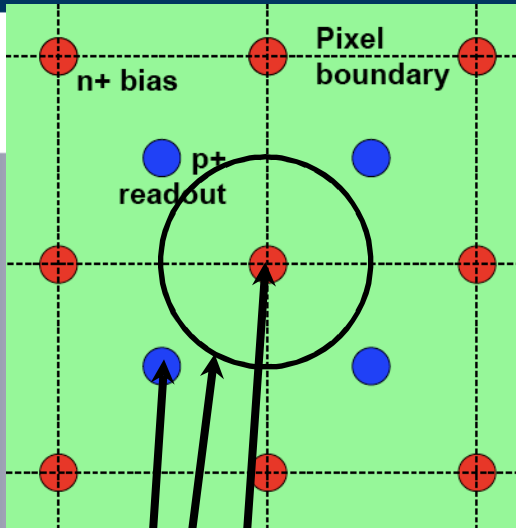


centre of cell

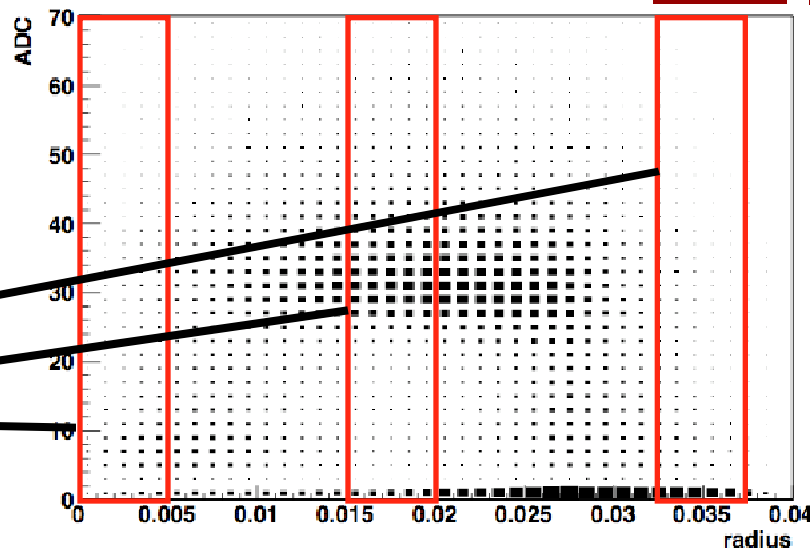
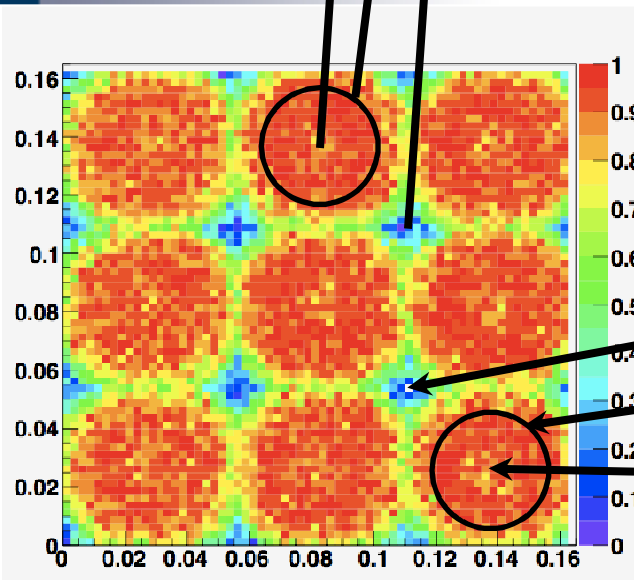
- Just 1D plots of the columns of the plot on the previous slide
- Basically 2 Landaus:
MPVs are ~ 7 and ~ 30
- Now for some explanation...



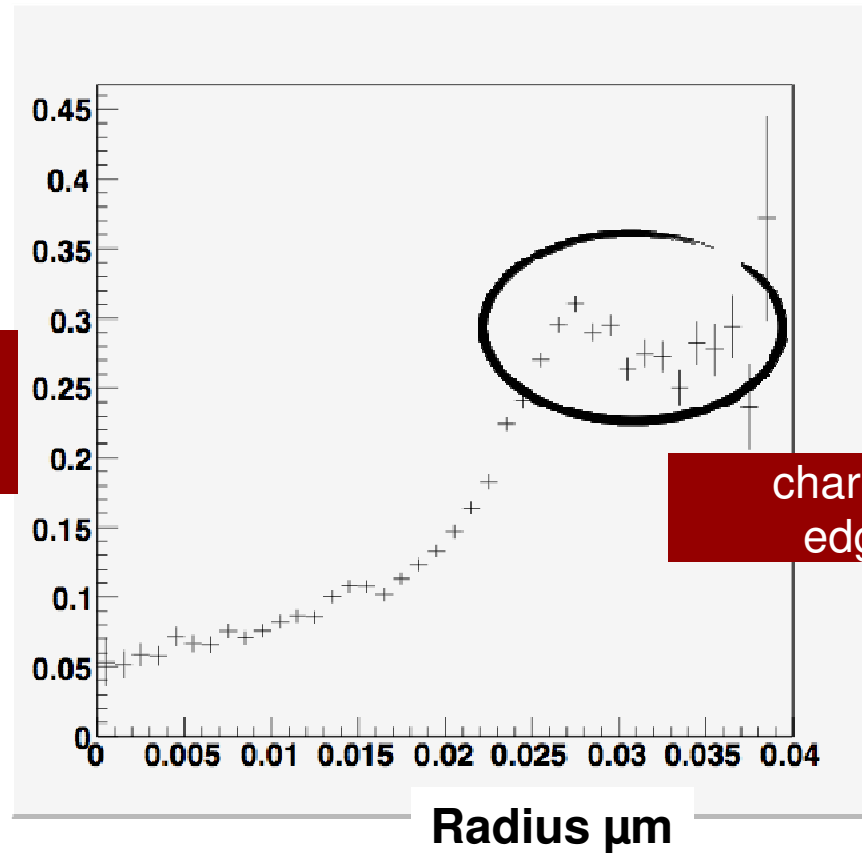
Signal explanation



7 ADC 30 ADC 7 ADC shared



fraction of multi-strip clusters
vs
radius



charge sharing at
edges/corners

- Scans at different bias voltages
- Scans at different angles
- Scans with different thresholds
- Residuals

X-rays

- Pixels successfully mapped
- Efficiencies of the central electrode area found
 - 3 - 4% due to central electrode
 - Efficiency at corners equivalent to planar device
- Trade-off between efficiency and charge sharing
- Evidence of a decrease in charge sharing in 3D shown

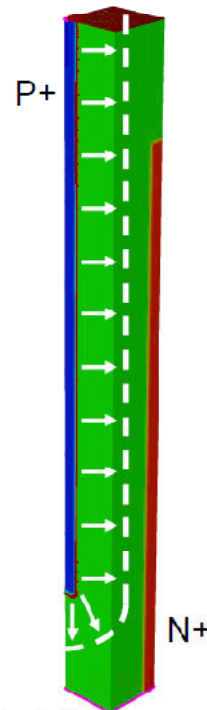
MIPs

- Pion beam results complement X-ray characterisation
- Higher efficiencies shown
- TOT – spectral evidence of charge sharing and efficiencies
- Trade off in between efficiency and radiation hardness

Thank you for your attention

Depletion of Medipix2 3D

Lateral depletion around column

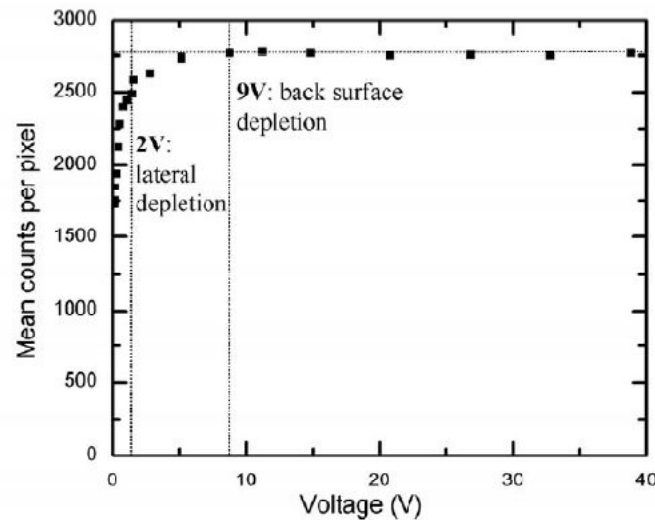


Depletion from column tip to back

Trento Workshop p-type and 3D detectors
C. Fleta, University of Glasgow

- Tested count rate vs bias with 60kV tungsten X-ray tube
 - Rapid increase in count rate up to 2V – lateral depletion
 - Count saturates around 9V – full depletion
 - CVs on test structures follow same pattern

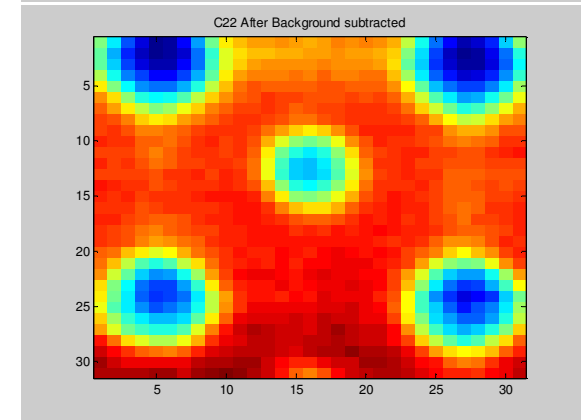
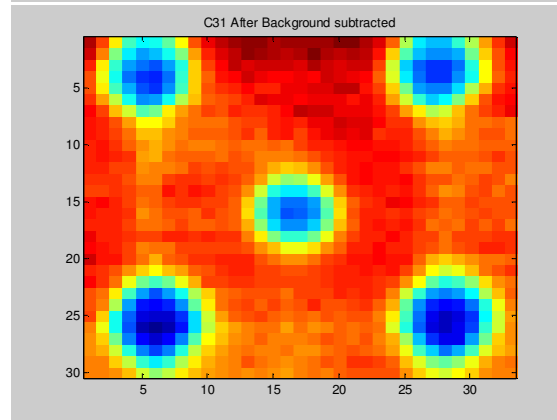
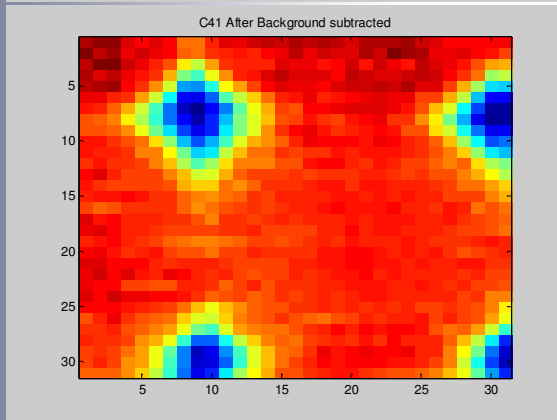
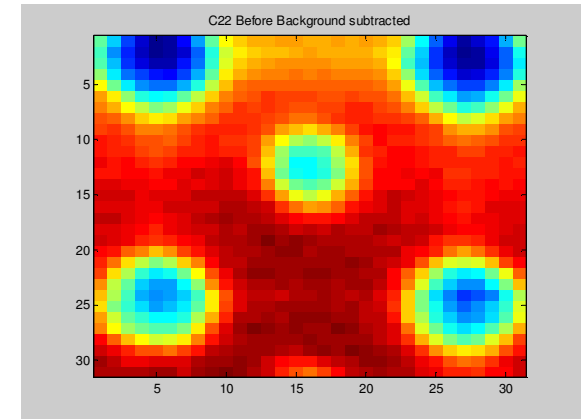
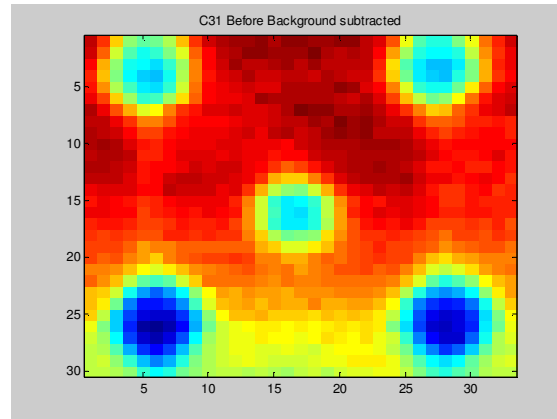
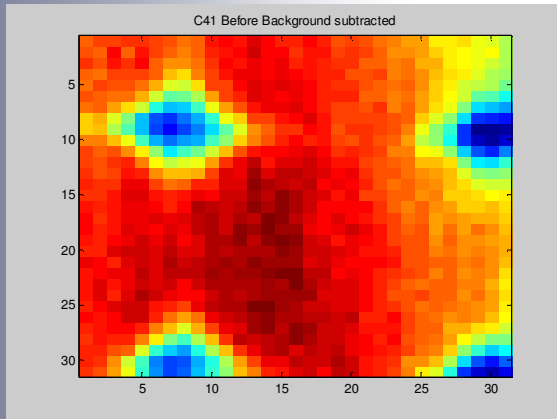
X-ray tube test

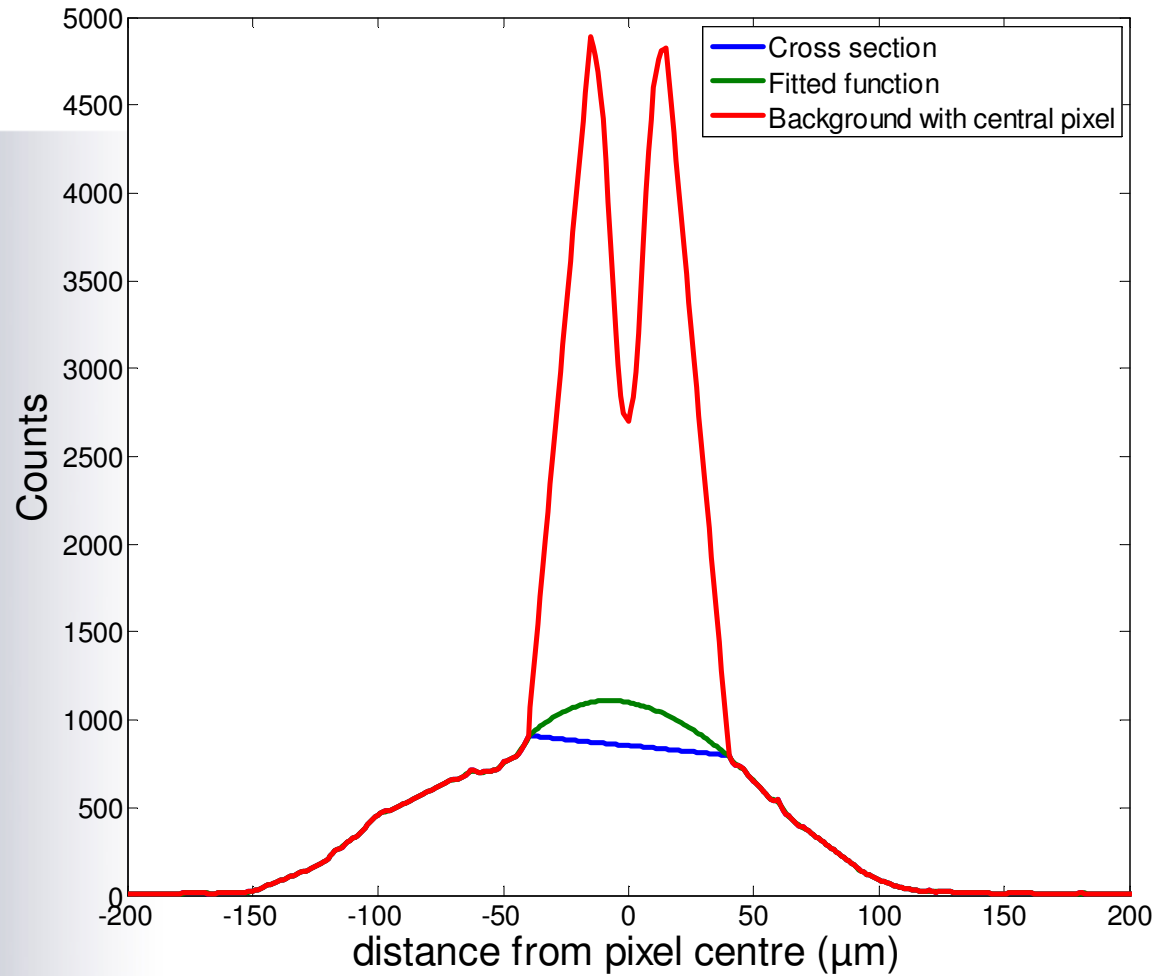


Planar

P-Type

N-Type





Wire scans and their derivatives

