

Performance of a single photon counting microstrip detector for strip pitches down to $10\ \mu\text{m}$

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Outline

→ The Mythen II detector

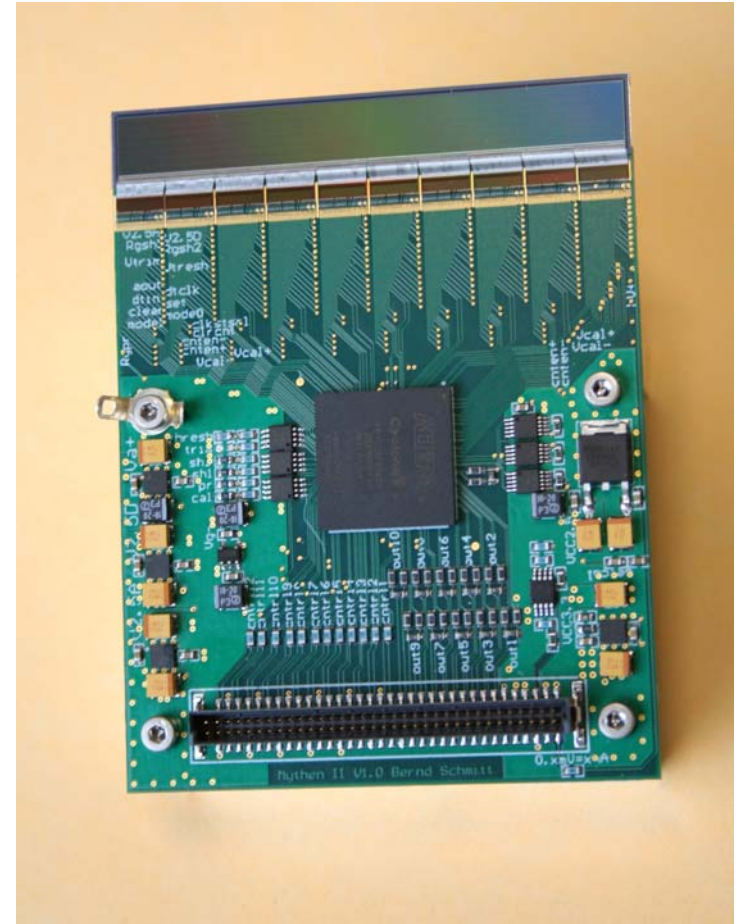
- Characteristics
- Performances

→ Measurements with a test structure with strip pitches down to 10 μm

- Calibration and noise
- Spatial resolution

Mythen II overview

- Silicon microstrip sensor
 - Direct conversion
 - 50 μm strip pitch
 - 8 mm long strips
- Single photon counting readout
 - 128 independent channels per chip
 - 24 bits dynamic range
 - Minimum threshold ~ 3 keV
 - High rate performances
 - Gateable down to 80 ns
 - 6 bits threshold trimming
 - 10-300 μs readout time

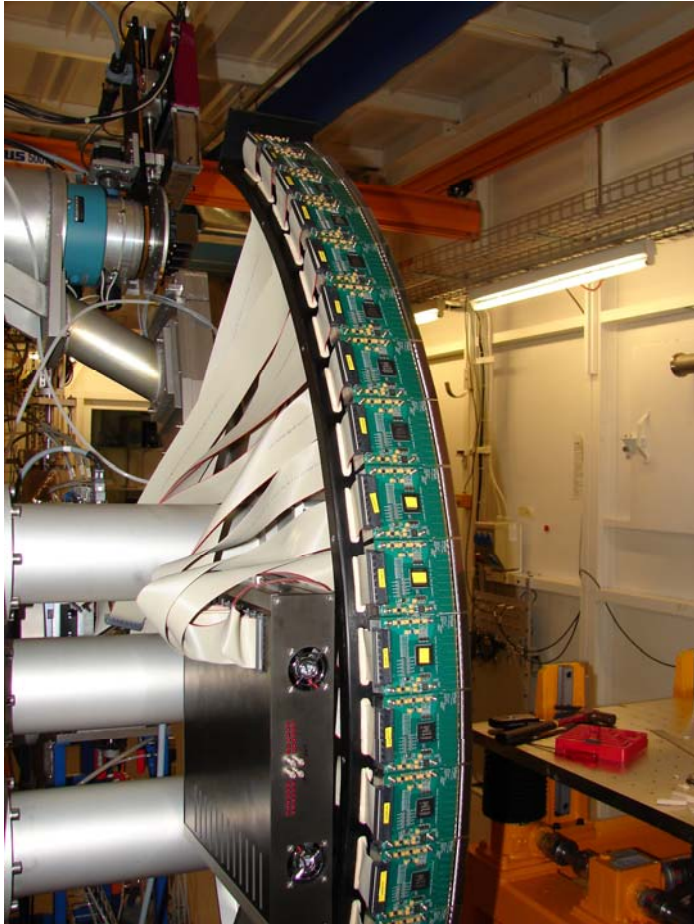


The single module system

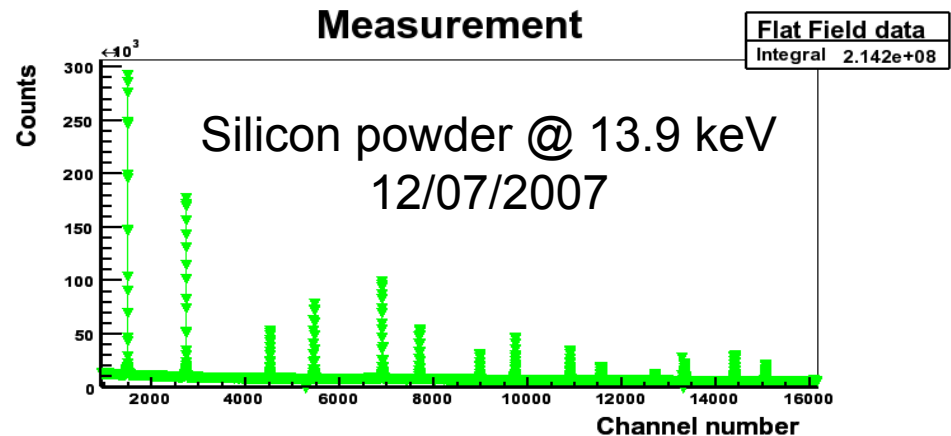


- 1280 independent channels
- 64x7 mm² sensitive area
- 100 frames per second
 - Perspective 10 kHz
- Needs only electrical and network connection to a PC
 - RPC communication
 - Web interface

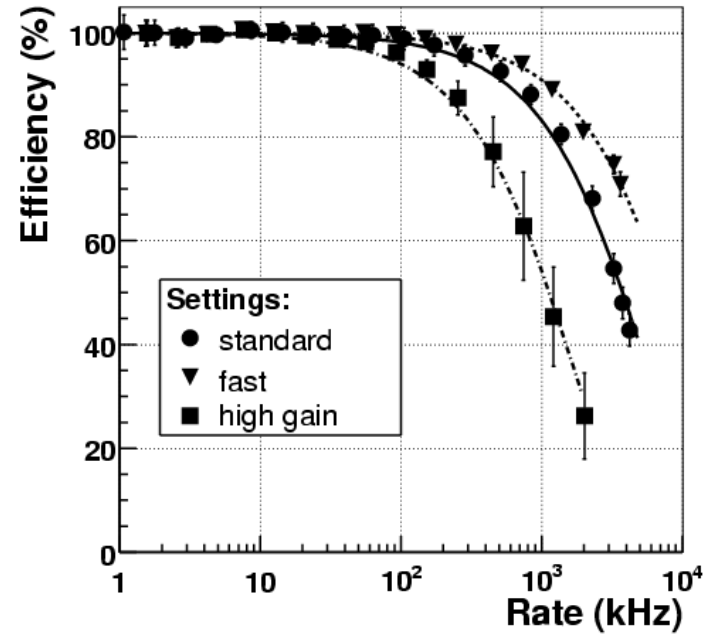
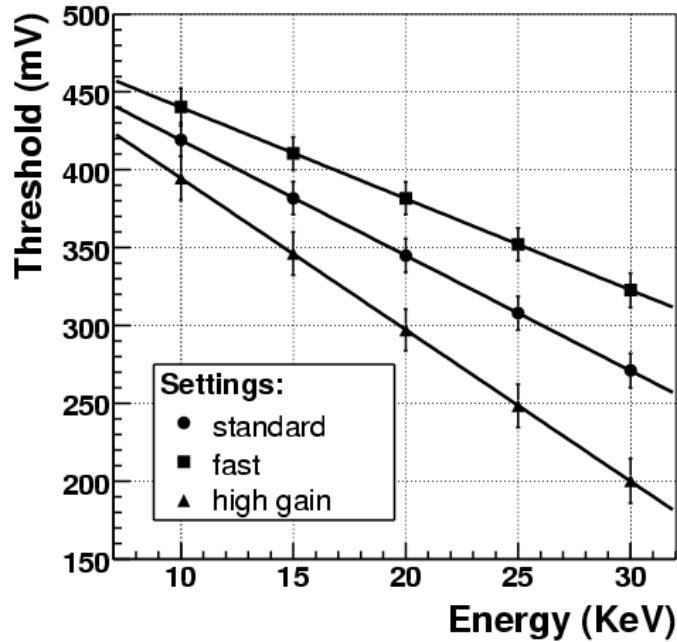
The SLS diffractometer



- 24 modules
- 30720 channels on 120 degrees
 - Less than 0.1% bad
 - 4 mdeg resolution, usually limited by the sample size
- 5 frames per second
 - Perspective 1 kHz



Performances



Standard

> 8 keV, < 1 MHz

Fast

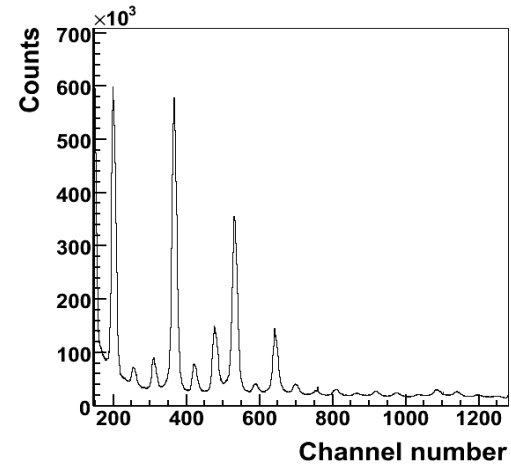
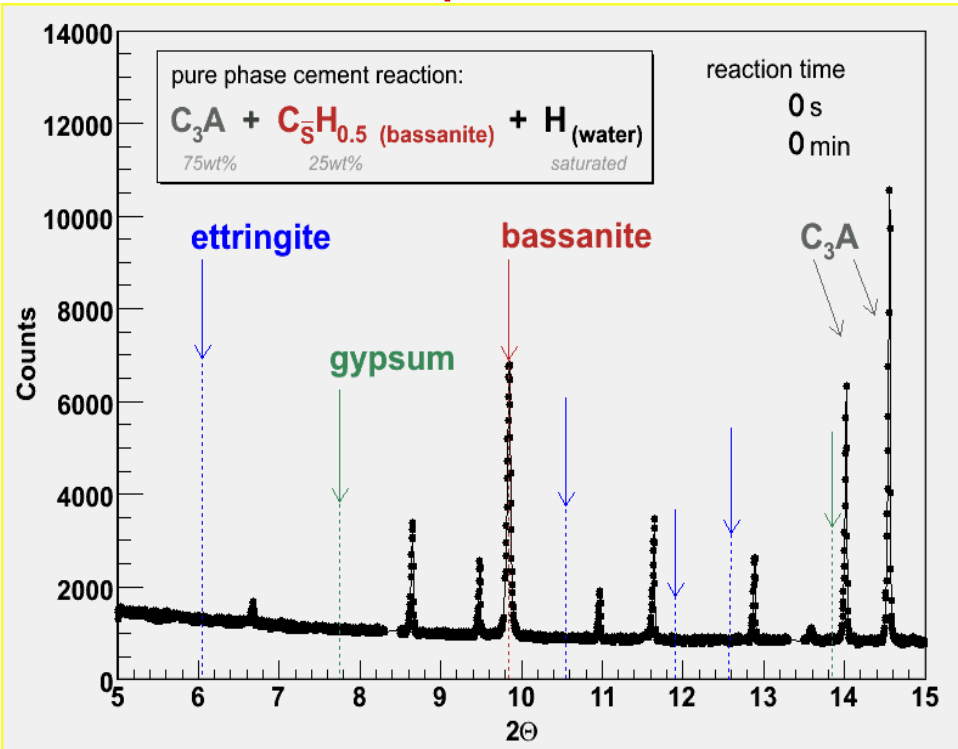
>10 keV, < 3 MHz

High gain

> 5 keV, < 300 kHz

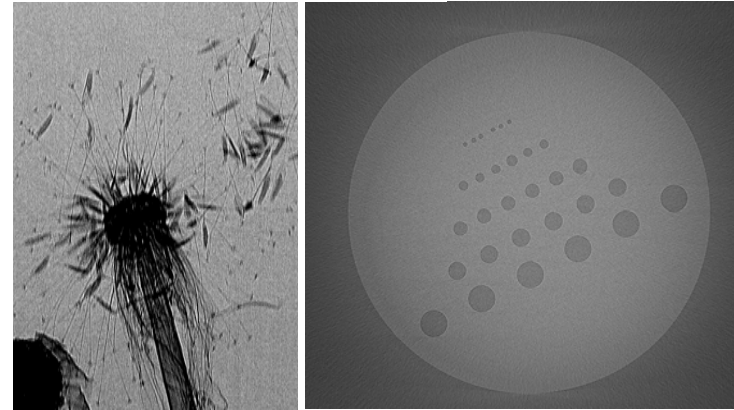
Applications

Time resolved powder diffraction



Small angle
scattering

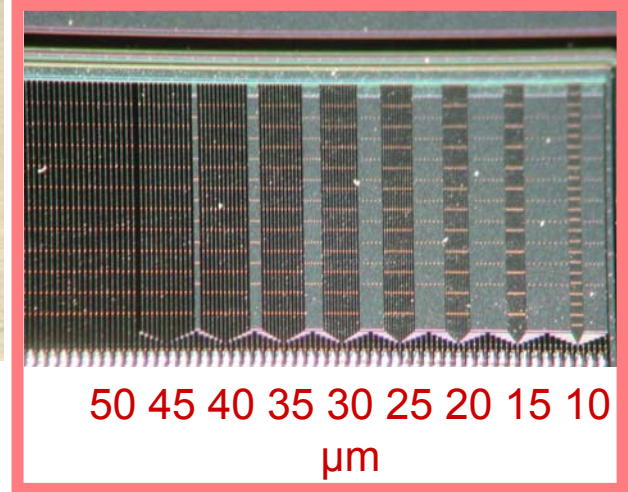
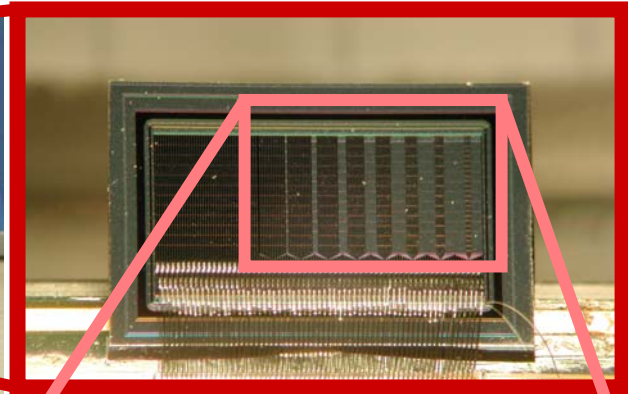
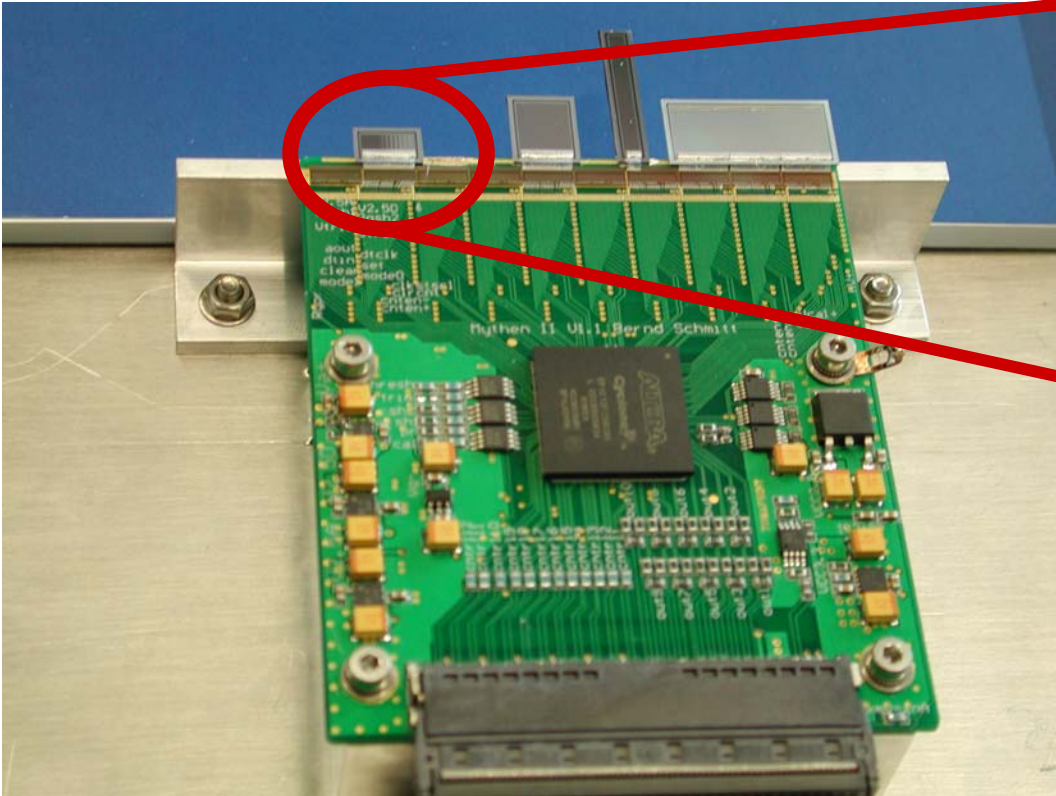
Imaging



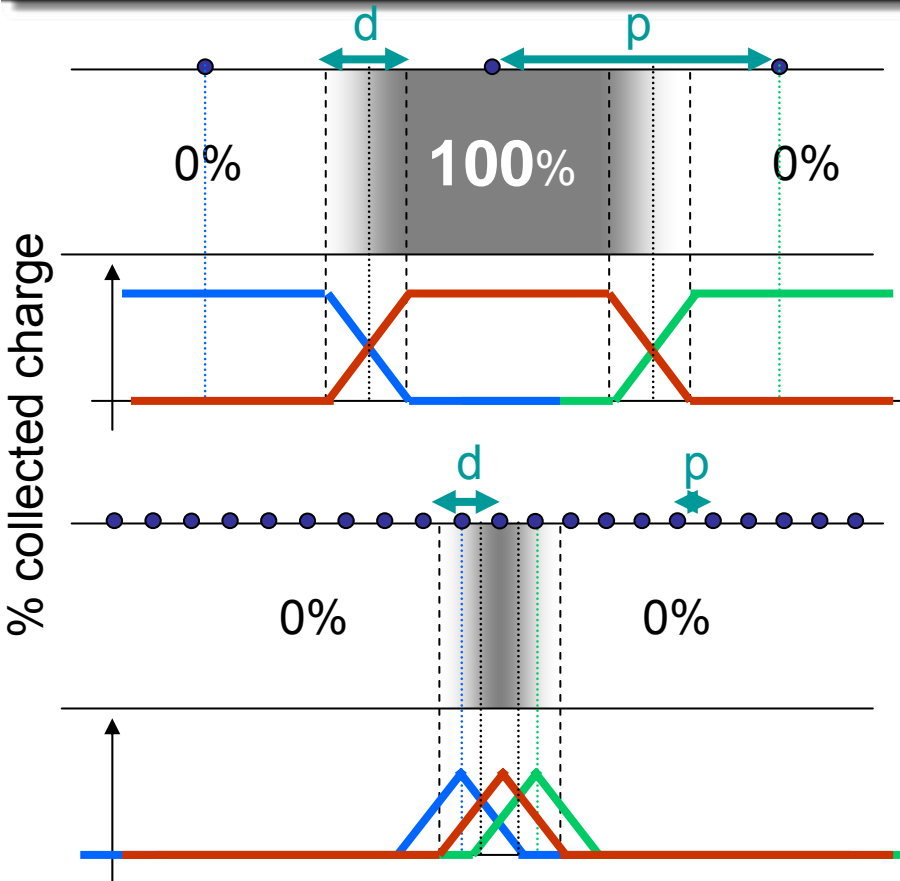
Conclusions – part I

- The Mythen II detector works very well
 - X-ray energy $> 5\text{keV}$
 - Threshold dispersion $< 200\text{ eV}$
 - Counting rate rate $< 3\text{ MHz}$ per channel
- The 120° detector has recently been installed at the SLS
 - Stable and user friendly operation
 - Integration with the beamline controls
 - New range of experiments will be possible

The high resolution test structure



Linear charge collection model



$d < p$

→ The spectrum indicates d/p

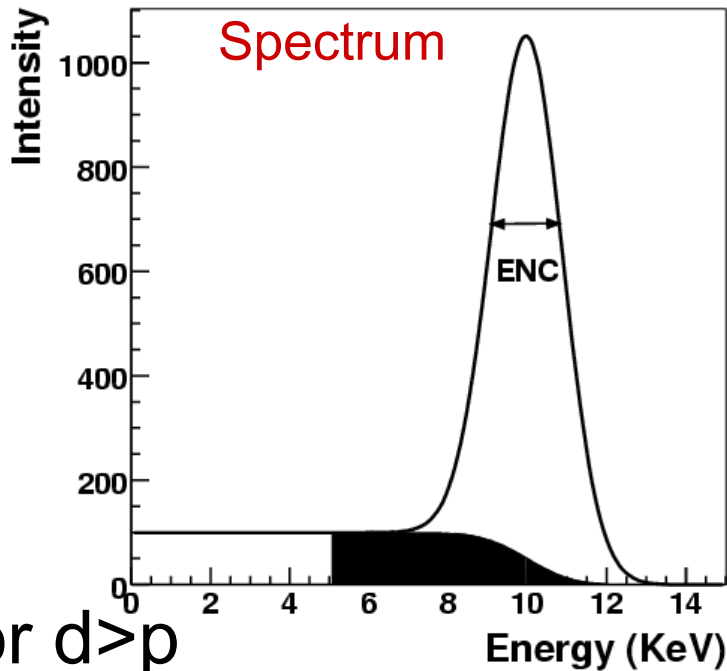
$d > p$

→ The charge is always shared

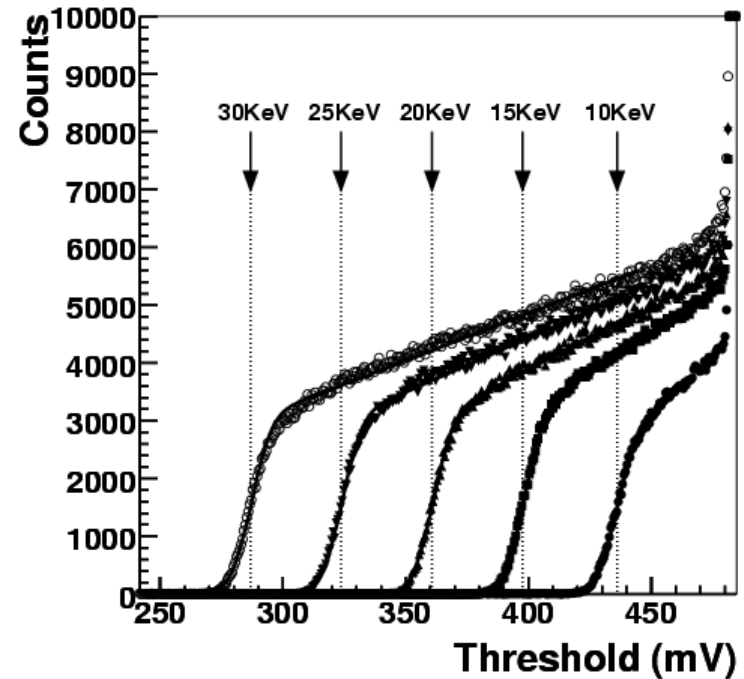
- The maximum collected charge by a single channel is only a fraction of the total

Expected spectra

For $d < p$



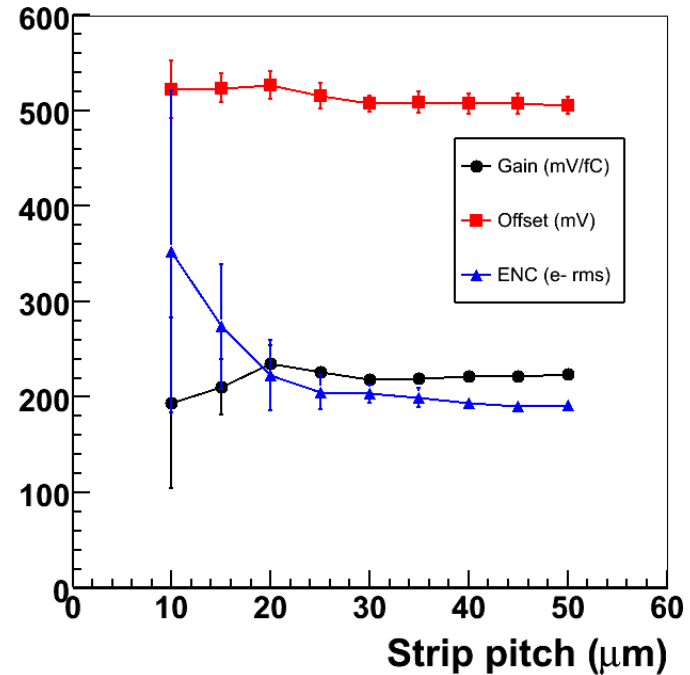
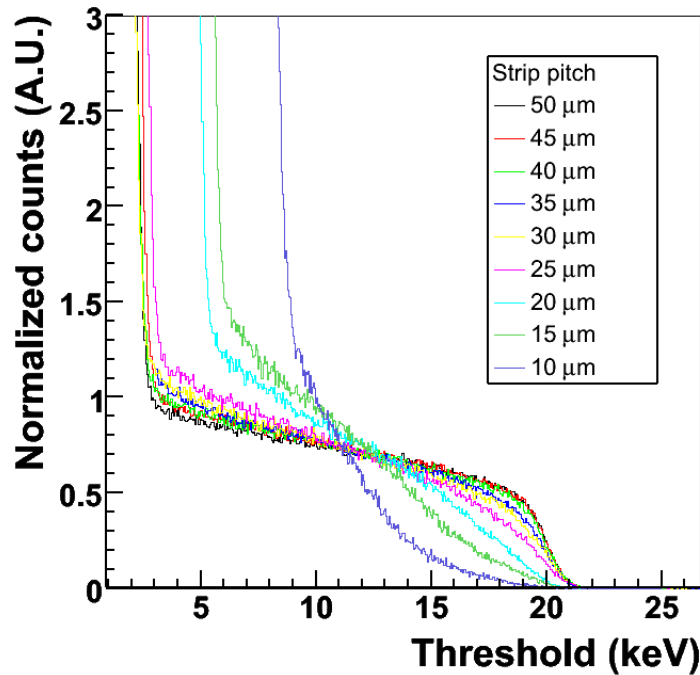
For $d > p$



- there is no gaussian
- the collected charge is smaller

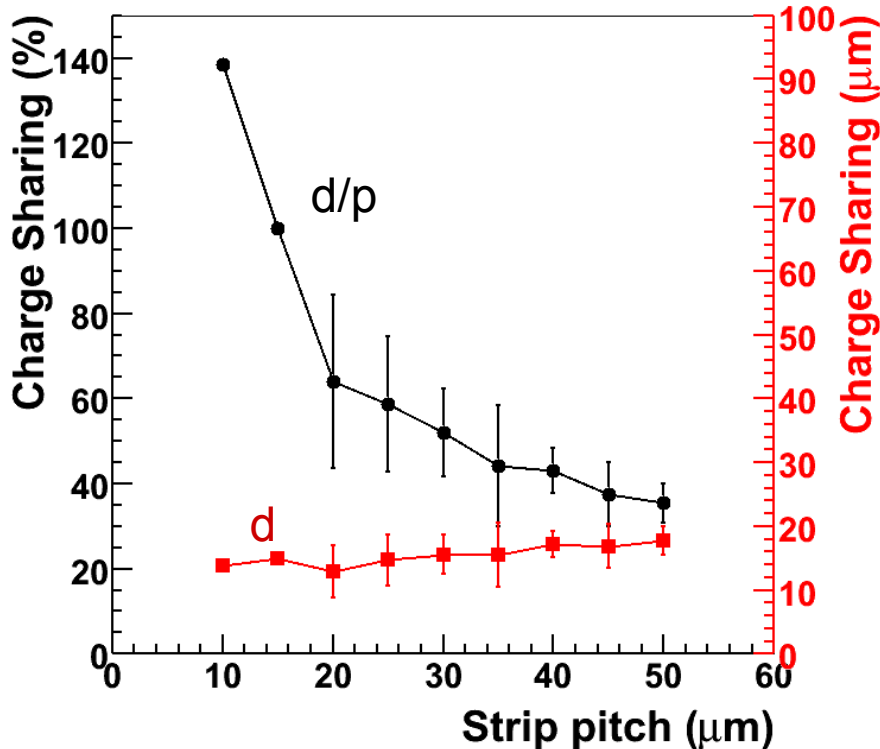
- there is no plateau
- the curve starts at lower thresholds

Calibration



- At small strip pitches the noise is increased and the plateau is not present anymore.
- Separation between the noise and the charge sharing component is more difficult

Estimated charge sharing



→ $p \geq 20 \mu\text{m}$

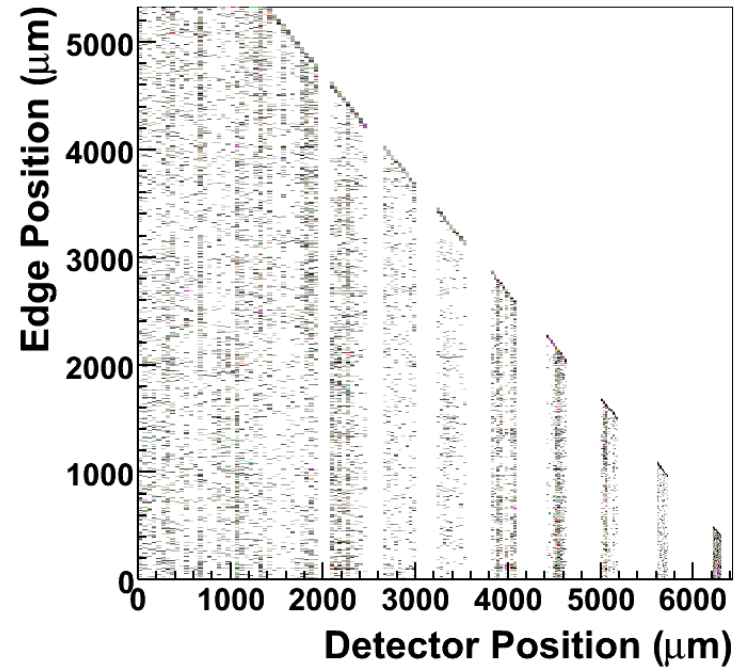
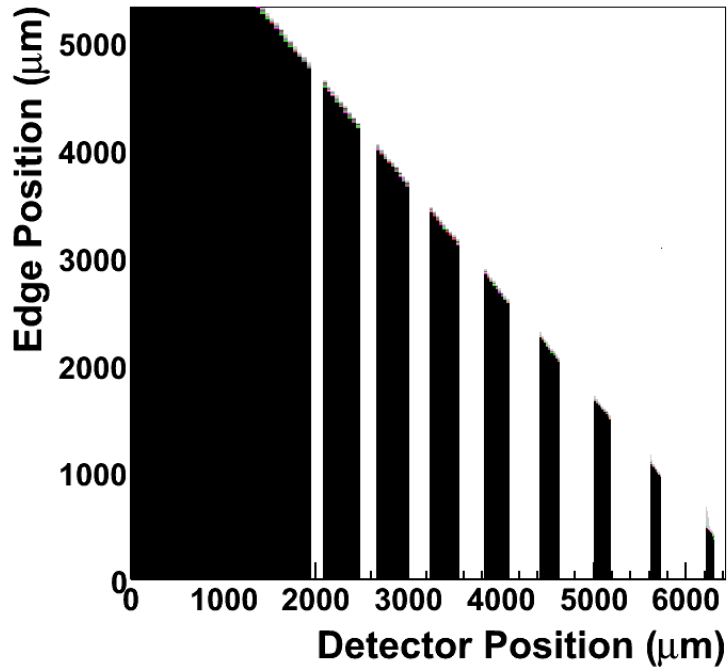
- d is estimated from the shape of the threshold scan curve

→ $p \leq 15 \mu\text{m}$

- d is estimated from the model

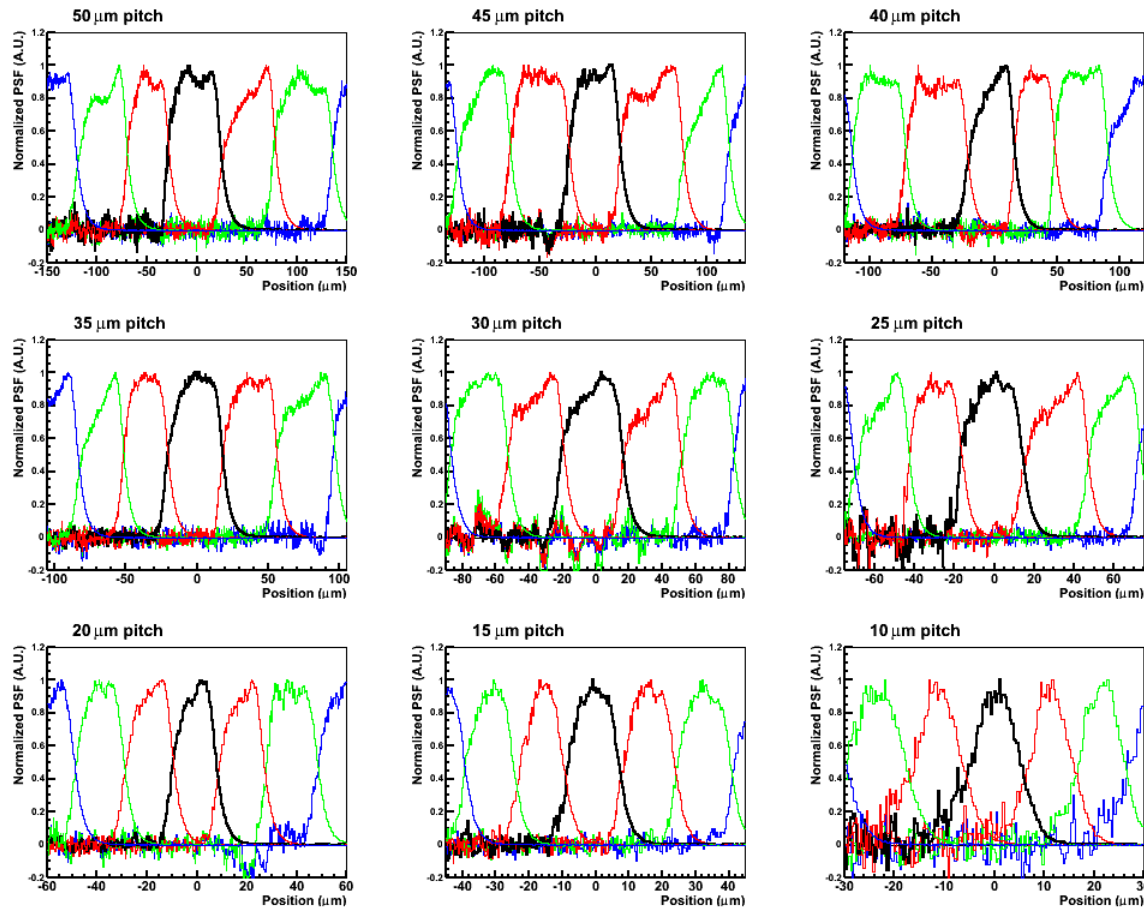
→ The estimated d is approximately constant

Spatial resolution measurements



→ Edge scanned with $0.32 \mu\text{m}$ step at 8 keV

Point Spread Function

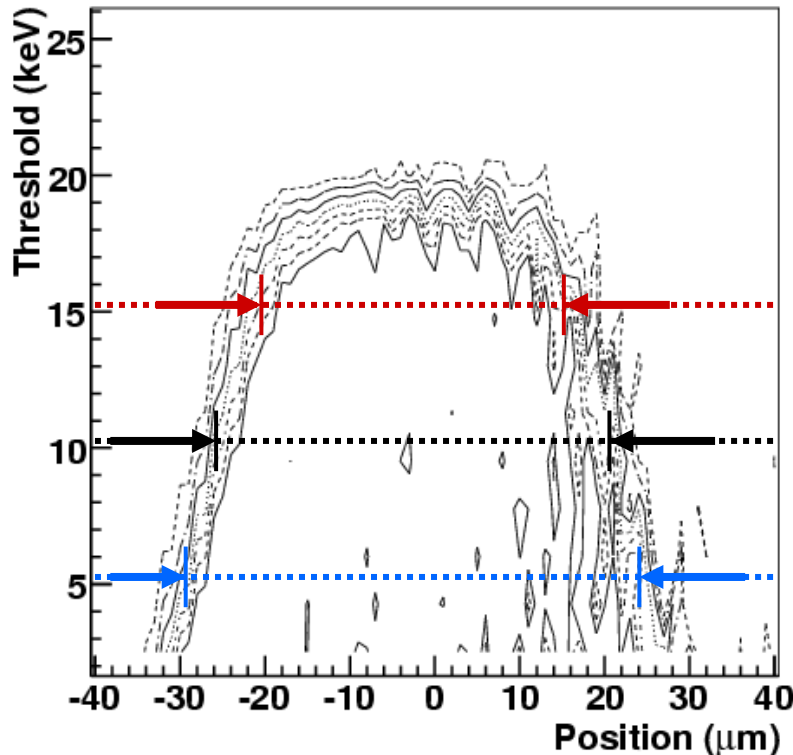


→ In good agreement with the charge sharing estimation

→ For small strip pitches the effective threshold is higher

PSF vs. Threshold

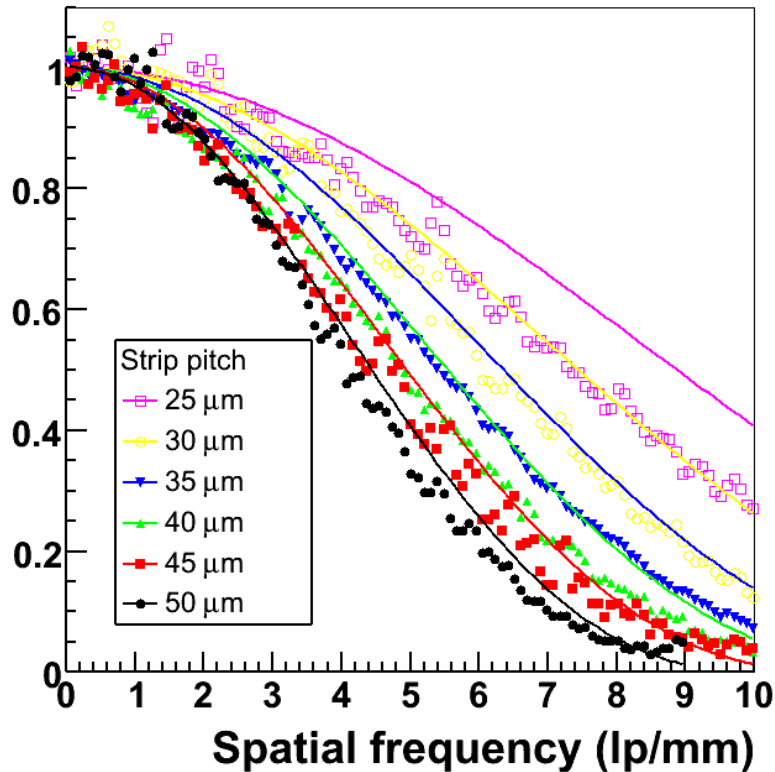
50 μm pitch @20 keV



→ The width of the PSF depends on the threshold

- Higher thresholds have thinner PSF
 - Loss of counts between channels
- Lower thresholds have larger PSF
 - Double counts between channels

Measured MTFs



→ $p > 40 \mu\text{m}$

- ~ box-function

→ $p \leq 40 \mu\text{m}$

- the charge sharing starts to play a major role in the spatial resolution

→ $p \leq 20 \mu\text{m}$

- Bad Normalization at 0 frequency

Conclusions – part II

→ Down to 25 μm

- negligible ENC increase
- No loss of efficiency due to charge sharing

→ For smaller strip pitches

- the minimum detectable energy is higher
 - Higher ENC due to interstrip capacitance
 - Reduced maximum collected charge per channel

▪ Mythen II still works well

- modules with 25 μm strip pitch bonded on both sides

▪ New read out desirable

- Preamp optimized to match the increased input capacitance
- Charge summation between the strips needed

Acknowledgements

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