# The MYTHEN III strip detector prototypes

## Microstrip sYstem for Time rEsolved experimeNts

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Wir schaffen Wissen – heute für morgen

## The new Mythen III chip

**What is MYTHEN?**

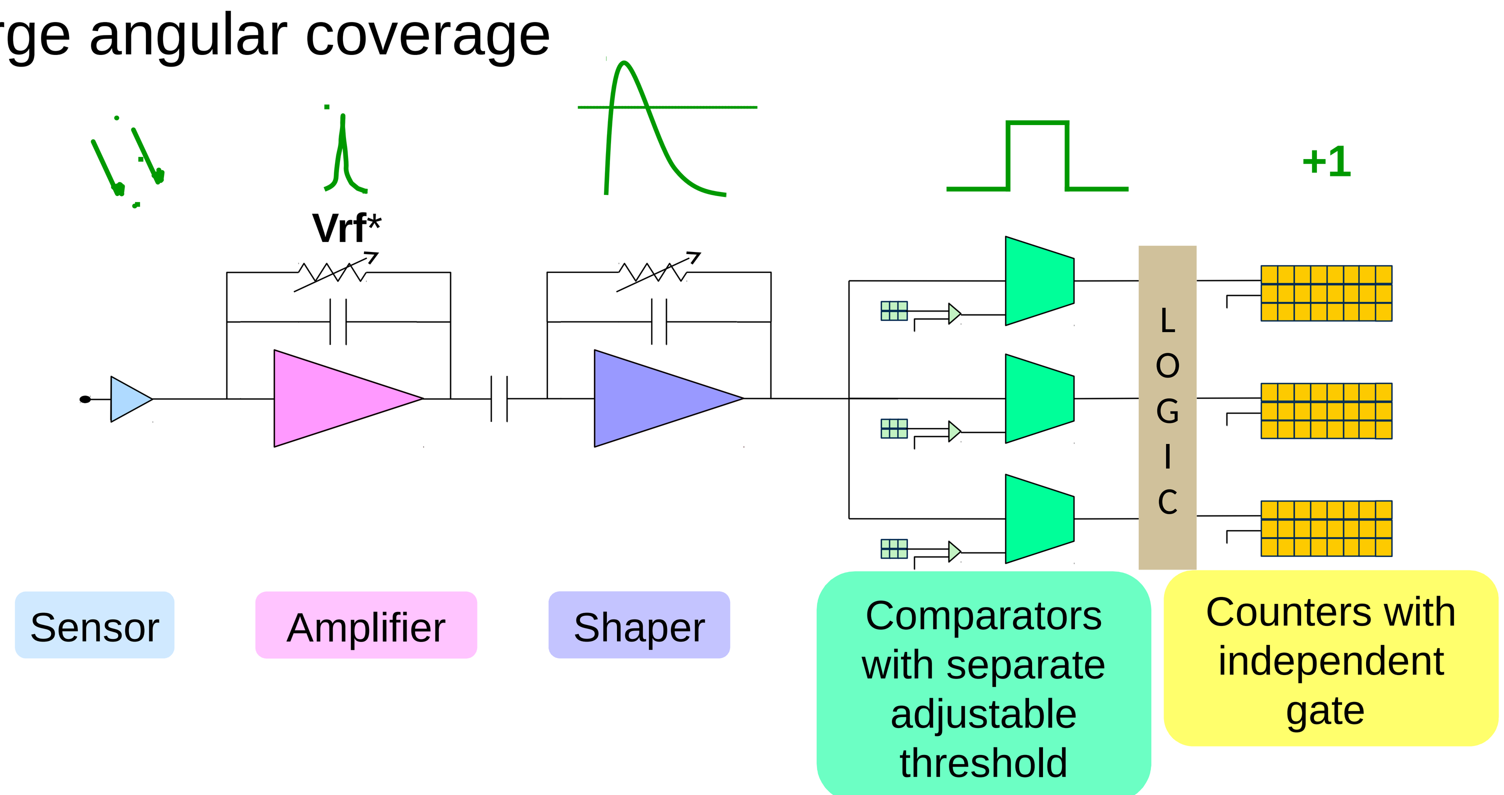
- silicon microstrip detector with 50 µm pitch, 8 mm long strips
- single photon counting
- for time-resolved powder diffraction, medical imaging, etc

**Why a strip detector?**

- less channels per area: fast frame rates
- small pitches possible: high resolution
- large angular coverage

**Why photon counting?**

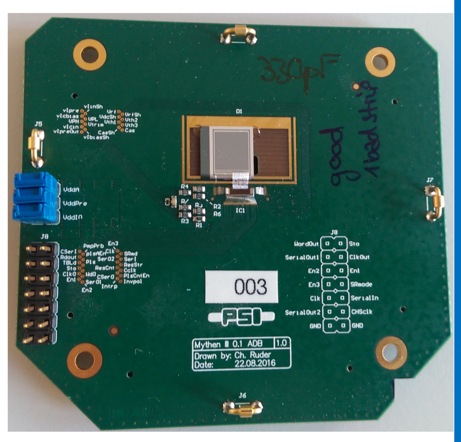
- ideally noiseless
- large dynamic range
- fluorescence suppression




*Vrf changes the feedback resistance, i.e. the gain and shaping time

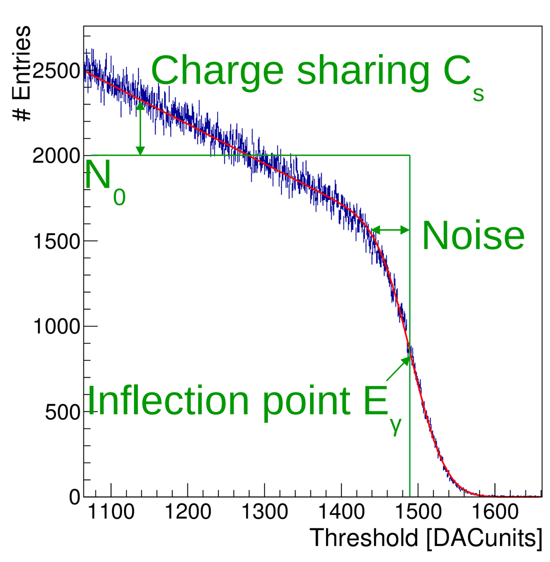
**What is new?**

- three comparators and three 24-bit-counters for:
  - energy-windowing
  - count rate improvement (track pile-up)
  - pump-probing with multiple time slots, counters are independently gateable
- reduced threshold dispersion
- improved noise performance
- small dead time → increased count rate capability



## Threshold scans

**All data are taken with a preliminary readout system !**

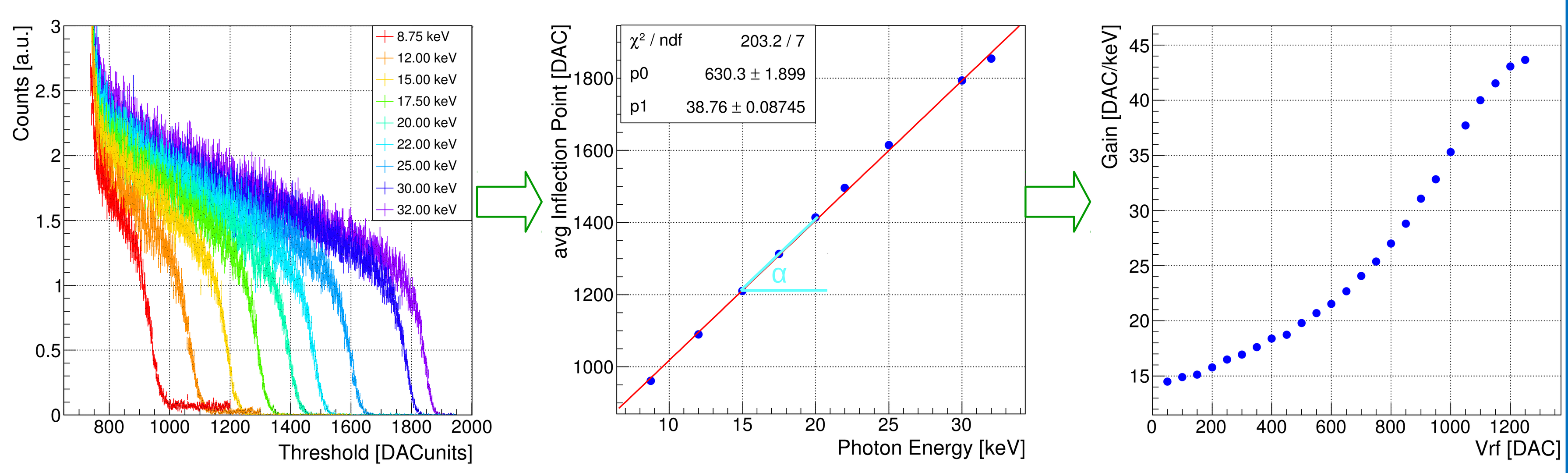



The number of photon hits is a function of the threshold:

$$N_\gamma(E_{thr}) = \frac{N_0}{2}\left(1+C_s(E_\gamma - E_{thr})\right)\left(1+Erf\left(\frac{E_\gamma - E_{thr}}{\sqrt{2}Noise}\right)\right)$$

*Noise = extra counts due to pulse height variations overcoming the comparator threshold [1]

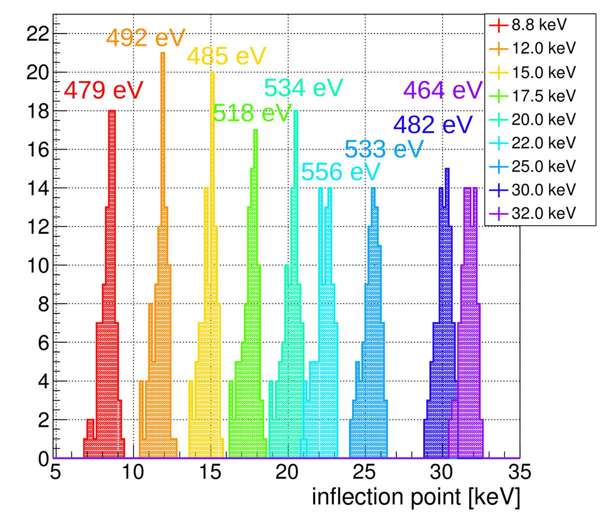
## Gain Calibration



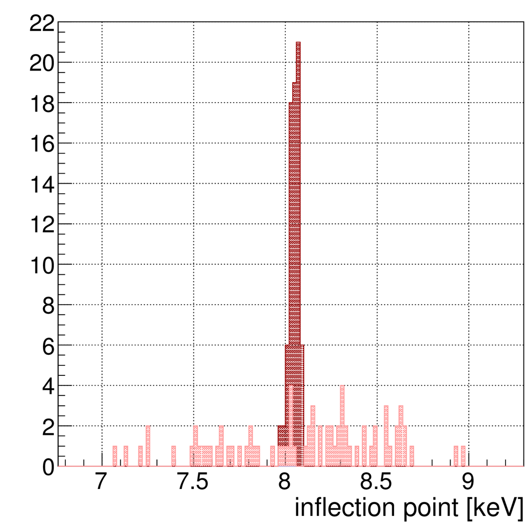

1. Take threshold scans at different photon energies
2. Extract the inflection points
3. Calculate the gain [DACunits/keV] for every Vrf-setting

The gain
- increases with Vrf
- starts to saturate at high Vrf

## Threshold dispersion

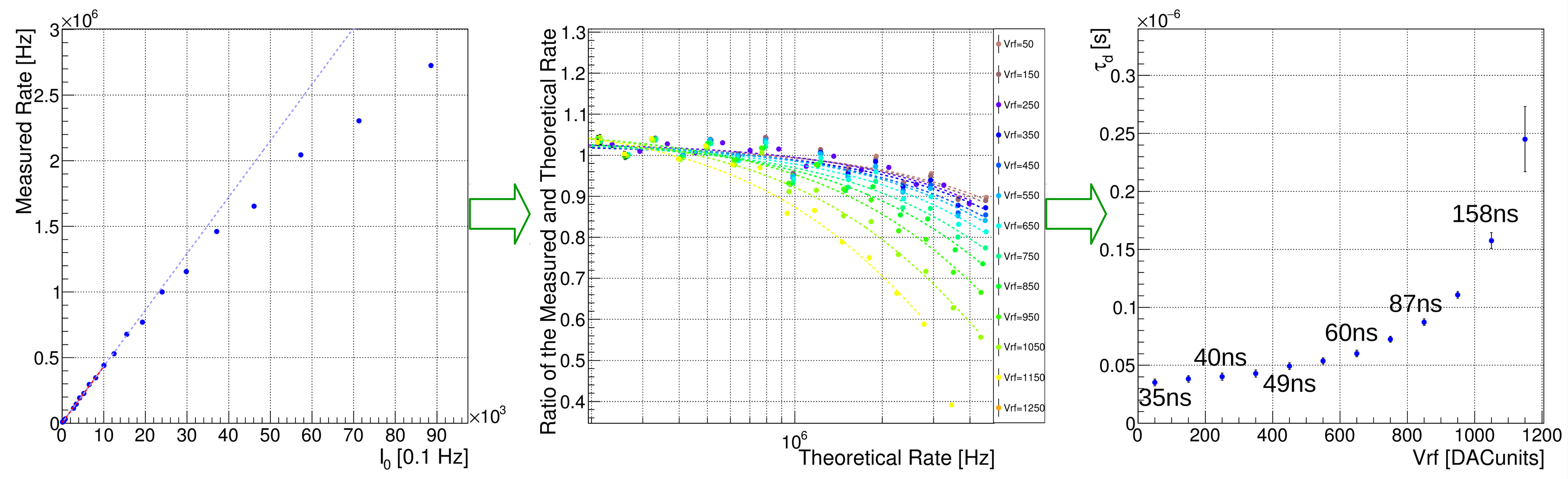



The threshold dispersion is given by the spread of the inflection points, i.e. the resulting thresholds, over all sensor-strips.




The threshold dispersion
- depends on the gain (Vrf)
- is less than 6% (untrimmed)
- is independent of the photon energy
- is reduced to 0.3% by trimming

## Rate capability

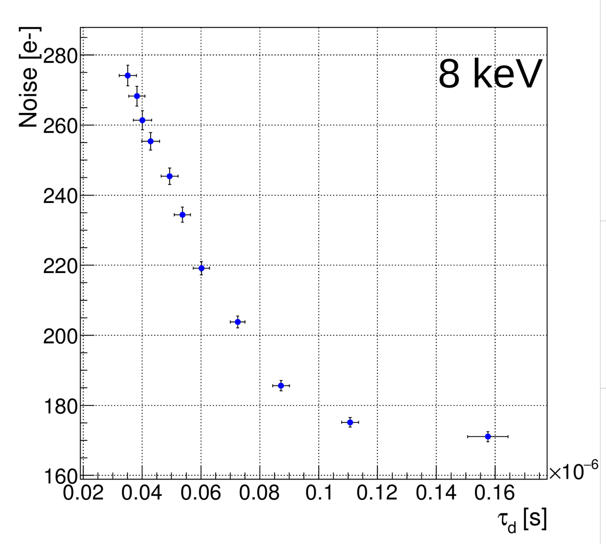



1. Plot the measured rate vs the reference rate $I_0^*$
   *given by the beamline
2. Estimate the ideal theoretical rate with a linear fit
3. Fit the ratio ε of the measured and theoretical rate Φ to find the dead time $\tau_d$ with: $\varepsilon = \exp(-\tau_d \Phi)^*$
   *paralyzable counter model [1]

The dead time
- increases with the gain (Vrf)
- allows for fast count rates

## Conclusion

The noise decreases with increasing dead time:




| | MYTHEN II @ 8.75 keV, Standard settings, Fast settings [1] | MYTHEN III.01 @ 8.0 keV, Vrf = 950 DACunits, Vrf = 250 DACunits |
|---|---|---|
| Untrimmed threshold dispersion [eV] | 1623 ± 6<br>1761 ± 7 | 476 ± 3<br>721 ± 4 |
| Noise [e-] | 230 ± 7<br>262 ± 7 | 175 ± 1<br>261 ± 3 |
| Dead time $\tau_d$ [ns] | 170 ± 10<br>110 ± 10 | 111 ± 3<br>40 ± 3 |

2017 – Submission of MYTHEN 3.01; 1st proto-type
2018 – Submission of MYTHEN 3.02; Module design
2019 – 3rd proto-type
2020 – Installation of the detector

## Mythen 3.02

- 2nd prototype with 8 different architectures
→ tune the Signal-to-Noise-Ratio
→ test different design options
- the chip is functional and under test

## References

[1] A. Bergamaschi et al, The MYTHEN detector for X-ray powder diffraction experiments at the Swiss Light Source (2010), J. Synchrotron Rad.(2010) 17, 653-668