WIR SCHAFFEN WISSEN – HEUTE FÜR MORGEN

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MYTHEN III: The new microstrip detector for powder diffraction

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Update of MYTHEN II after 14 years

- Single photon counting microstrip (1D) detector for powder diffraction
  - Fewer channels, higher frame rates, lower cost, high angular resolution
- After more than 13 years of user operation Mythen II required an upgrade
  - Outdated readout electronics and software difficult to support
  - Performance still OK, but not state of the art any longer
- Mythen III is a good playground to test new solutions for single photon counters

	MYTHEN II	MYTHEN III	
Noise (FWHM)	700-1250 eV	**350-900 eV**	Lower energies detectable Better fluorescence suppression
Threshold dispersion	ca. 140 eV	**down to 20 eV**	Better flat field
Count rate capability	0.4-3 MHz @80%	3.5-7.5 MHz (29 MHz) @80%	Higher fluxes
Frame rate	0.1-1 kHz	**400 kHz**	Time resolved experiments
Temperature stability	???	ca. 0.3%/deg	Reliable calibration

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Mythen III for powder diffraction

- Same sensors as Mythen II: 1280 strips/module, 50 µm pitch, 8 mm length
- 120 degrees on two rows without gaps (24 x 2 modules)
  - 76 cm distance from diffractometer center
  - 4 mdeg intrinsic angular resolution
- 70 degrees on one row already in user operation
- Mythen used also as beam intensity and polarization (+position?) monitor
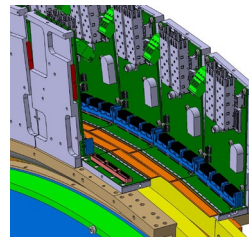
Copper oxalate powder @ 17.5 keV

*threshold 12.5 keV*

threshold 8.75 keV
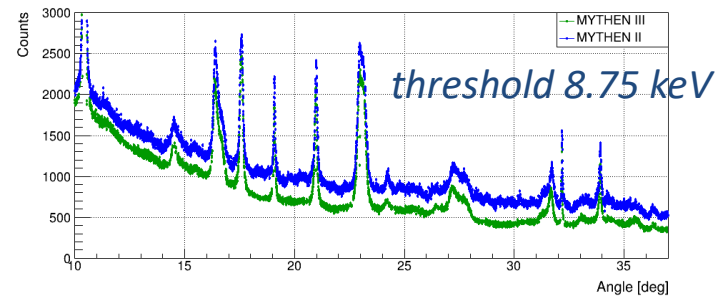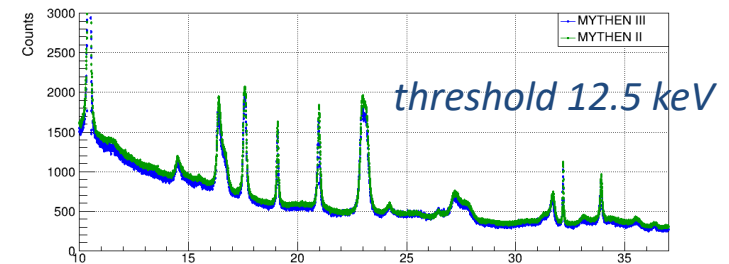
Multiple comparators and counters

- Three counters with independent gate
  - Stroboscopic measurements with multiple counting slots
  - Pumped-unpumped measurements to remove beam instabilities
- Three comparators with independent threshold and trimbits
  - Energy binning
    - High harmonic suppression
    - Monochromator-free operation at undulator beamlines
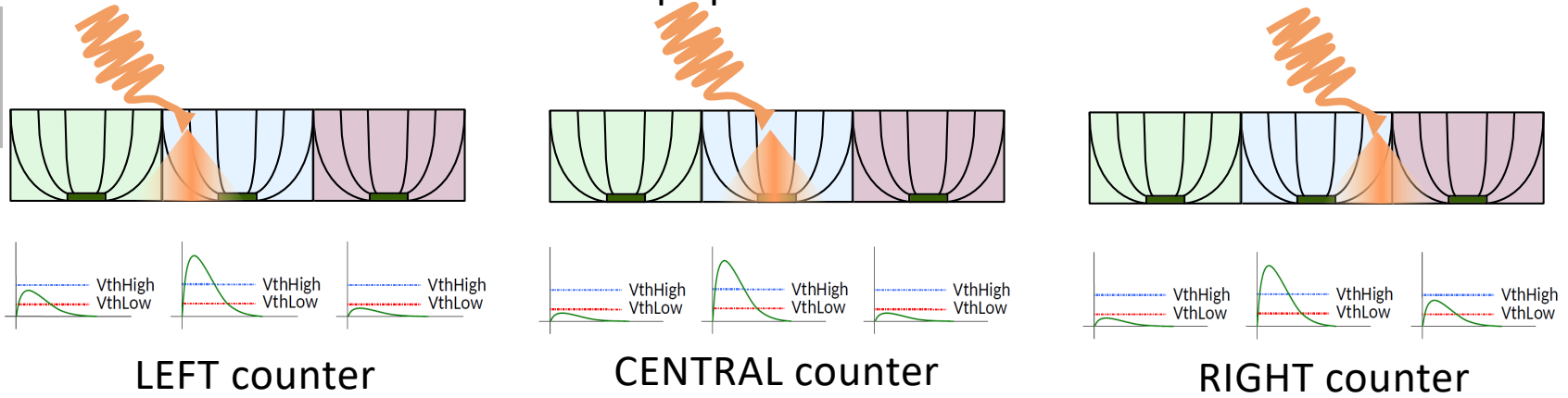 - **Pile-up tracking**
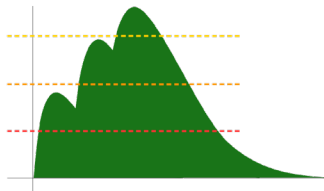
Improvement from 7.5 MHz to 29 MHz/strip with 80% counting efficiency with fast settings
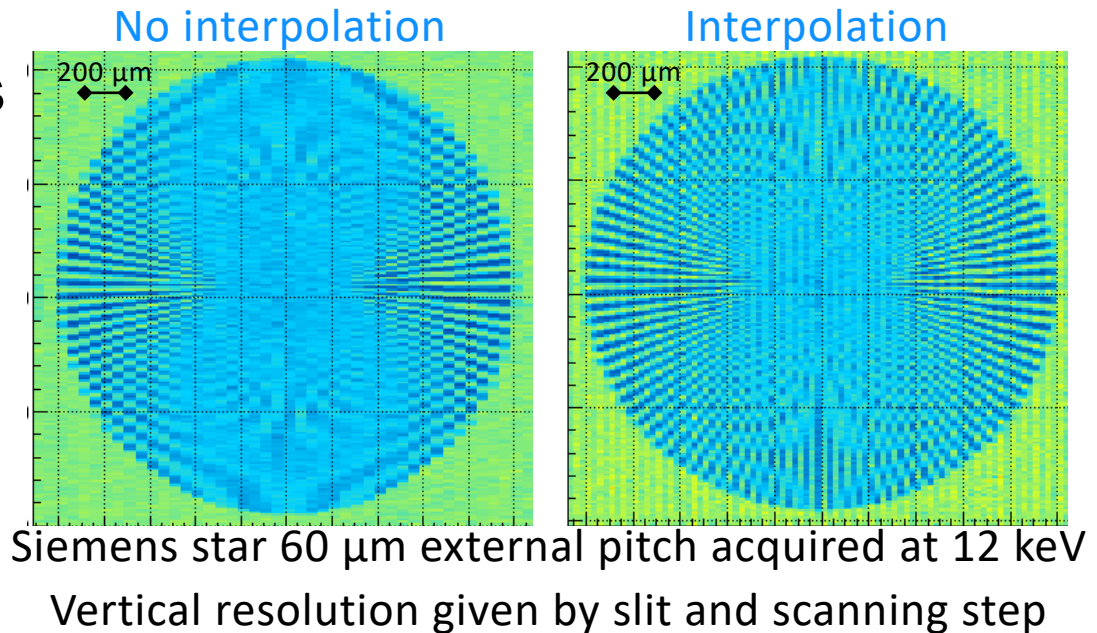
Andrä M, *et al. JINST* (2019) 14: C11028
https://doi.org/10.1088/1748-0221/14/11/C11028
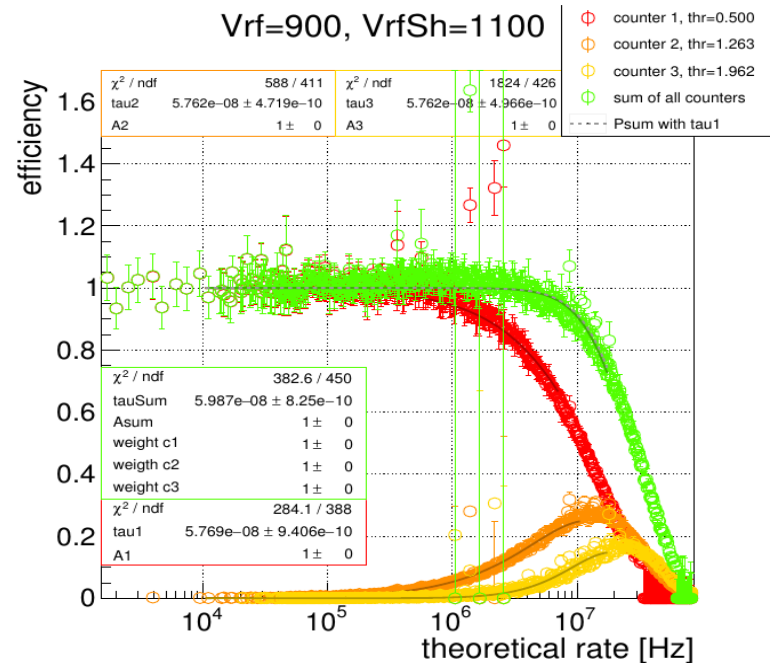
On-chip interpolation

Use the three counters (Left, Right, Center) and exploit charge diffusion to obtain sub-strip spatial resolution.

LEFT counter   CENTRAL counter   RIGHT counter

- # Proof of principle works
  - Optimization of low threshold value required
- Left and right counters are summed for 50 μm strip pitch in order to equalize bin size
  - Test with smaller strip pitches and sensor thicknesses ongoing

No interpolation   Interpolation

Siemens star 60 μm external pitch acquired at 12 keV
Vertical resolution given by slit and scanning step

Measured improvements

	Settings	MYTHEN II	MYTHEN III
Noise [eV FWHM]	Fast	2220± 60	2200 ± 180
	Standard	1950 ± 60	1380 ± 50
	High gain	1650 ± 60	964 ± 40
Threshold dispersion [eV]		85.2 ± 0.4	20.2 ± 0.4
Count rate [MHz] at 90% efficiency with one (three) counter(s)	Fast	0.96 ± 0.08	3.52 ±0.07 (20.87 ± 0.41)
	Standard	0.62 ± 0.03	1.38 ± 0.03 (8.20 ± 0.17)
	High gain	0.14 ± 0.01	1.26 ± 0.03 (7.44 ± 0.17)
Maximum frame rate [kHz] of one (24) module(s)		1 (0.020)	300 (50)