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Silizium Labor Bonn

DEPFET
Active Pixel Detector

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Synchrotron Radiation Detectors for BEAST II

Belle II

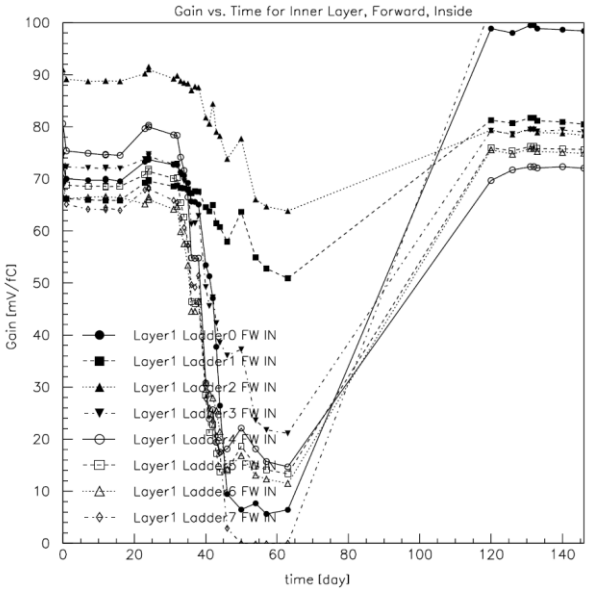
13th International Workshop on DEPFET Detectors and Applications
12-15 June 2013 - Ringberg Castle

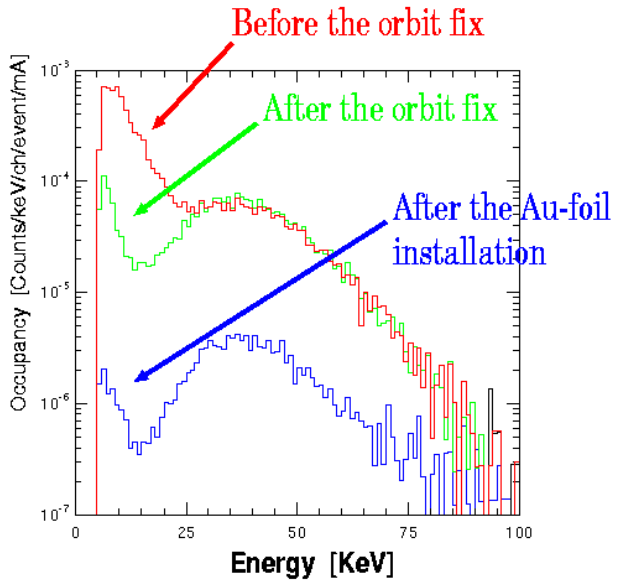
The Great Wave off Kanagawa (神奈川沖浪裏 Kanagawa-oki nami-ura) - **Katsushika Hokusai** (葛飾 北斎)

Synchrotron Radiation at Belle

- Harsh radiation background, especially SR at low energies, which resulted in the damage of the SVD front end electronics within two months.
- A safe environment must be ensured before the installation of the VXD

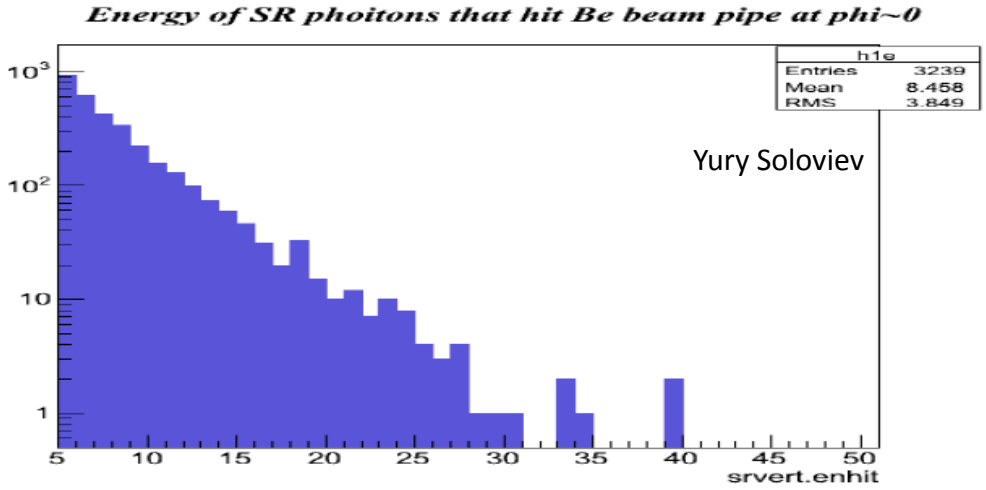
→ Measure SR spectrum and rates during the BEAST II phase.



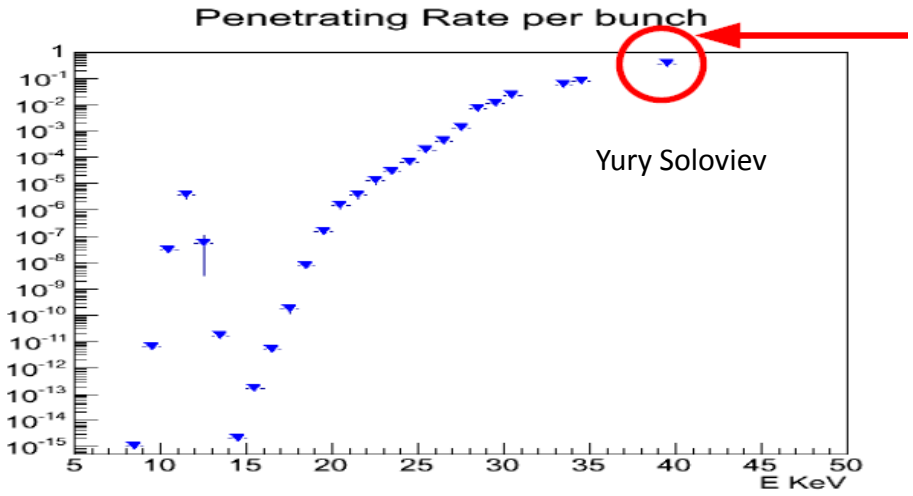


Synchrotron Radiation at Belle II

- Energy spectrum of SR photons that hit Be part of beam pipe at Φ ~ 0 (one ladder 98% of all hits).



- Energy spectrum weighted with the probability to pass through 10 µm of gold and 1 mm of Be (hits per bunch).

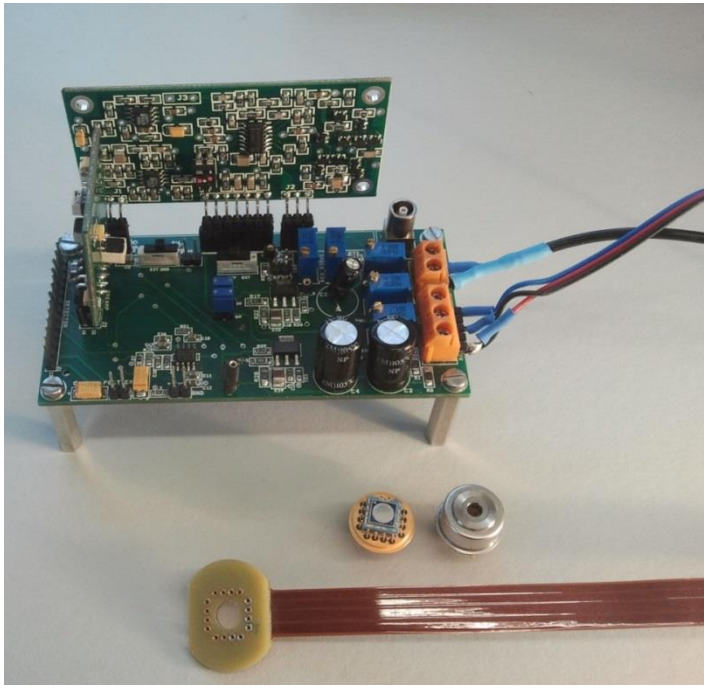


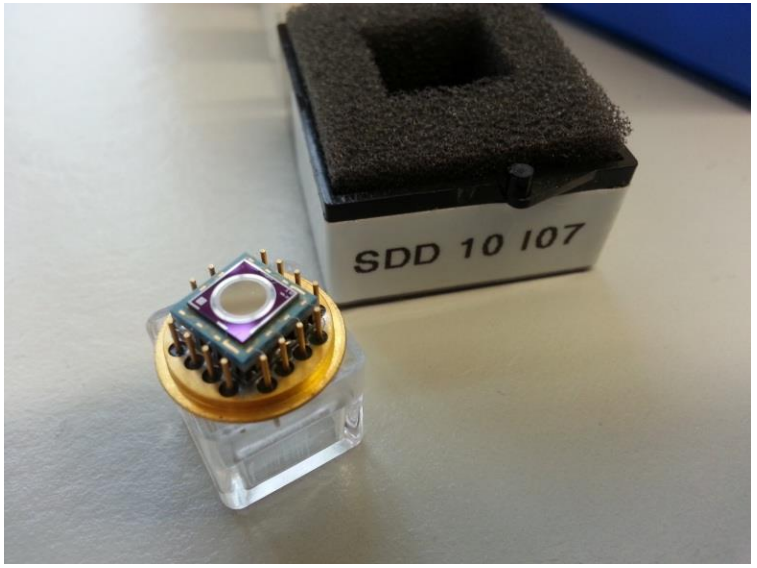
The detectors therefore need to fulfill two main characteristics:

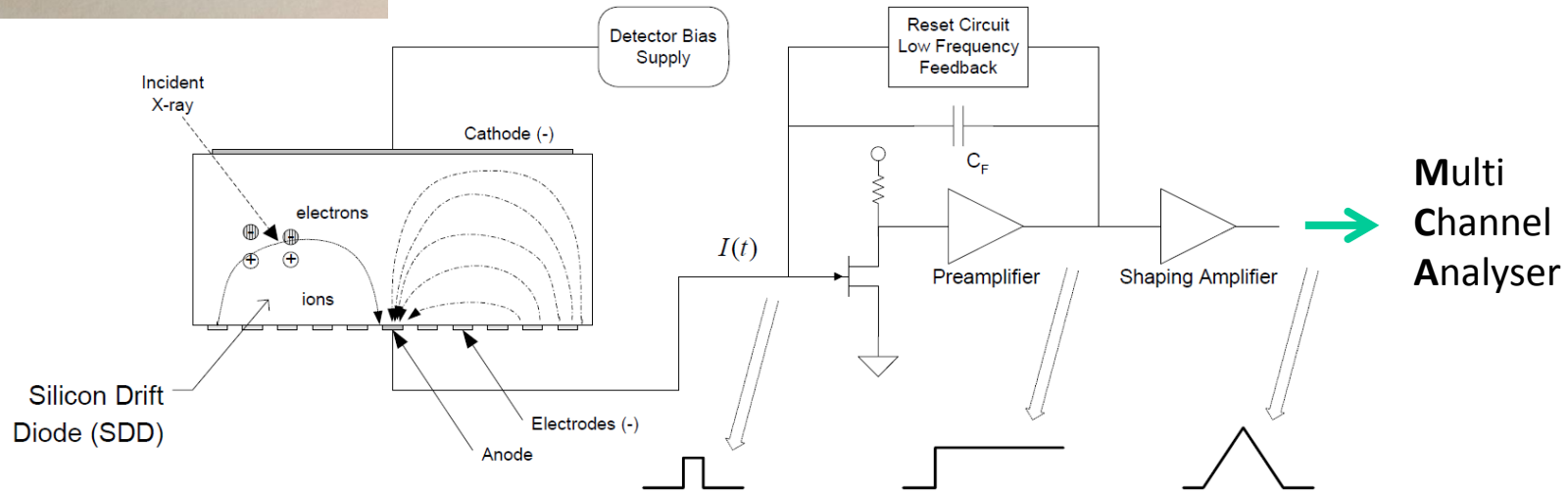
- Dynamic range of 5-45 keV
- Able to cope with high hit rates

Candidates: SDDs and silicon hybrid planar sensor FE-I4 based

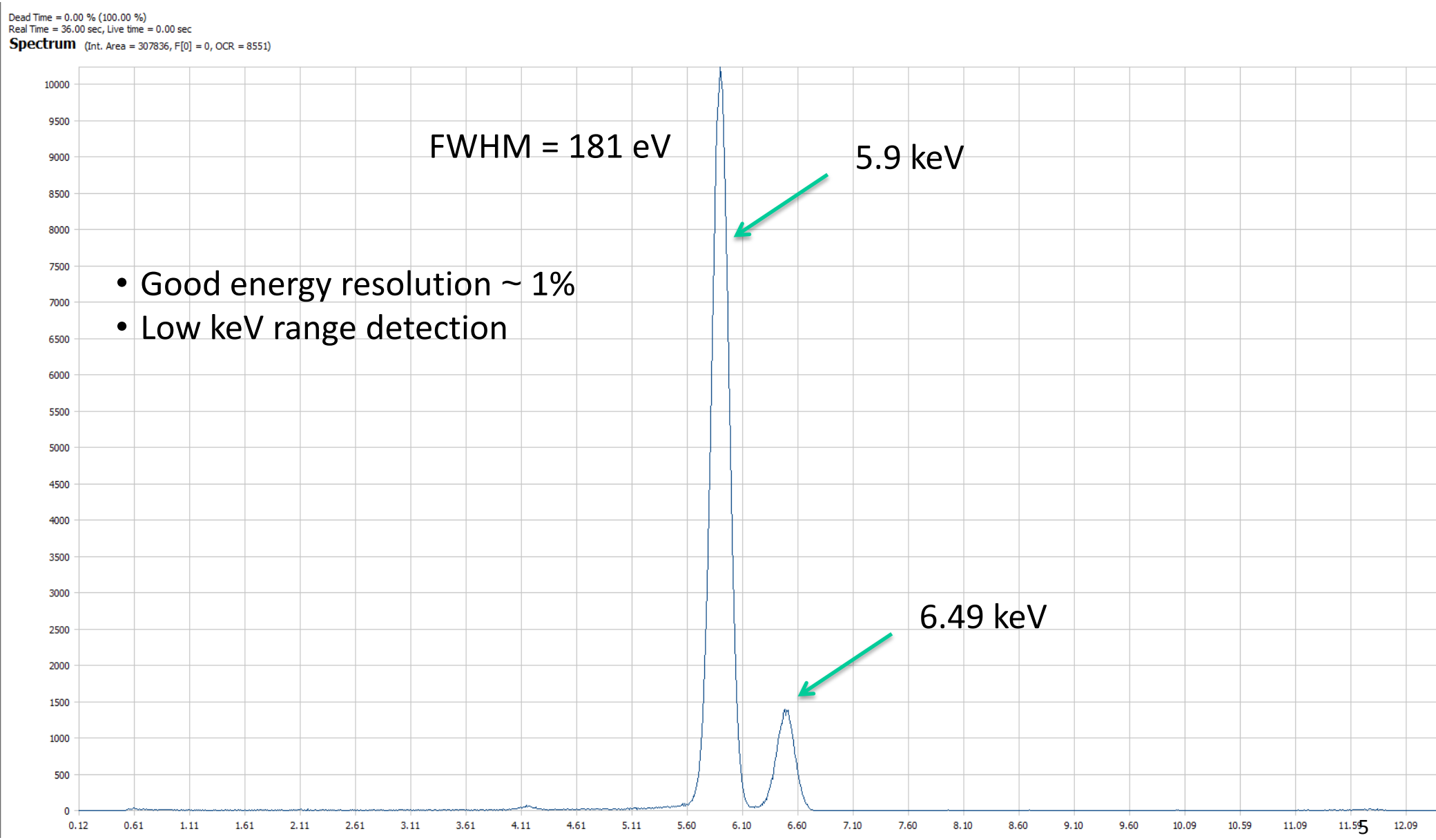
Silicon Drift Detector



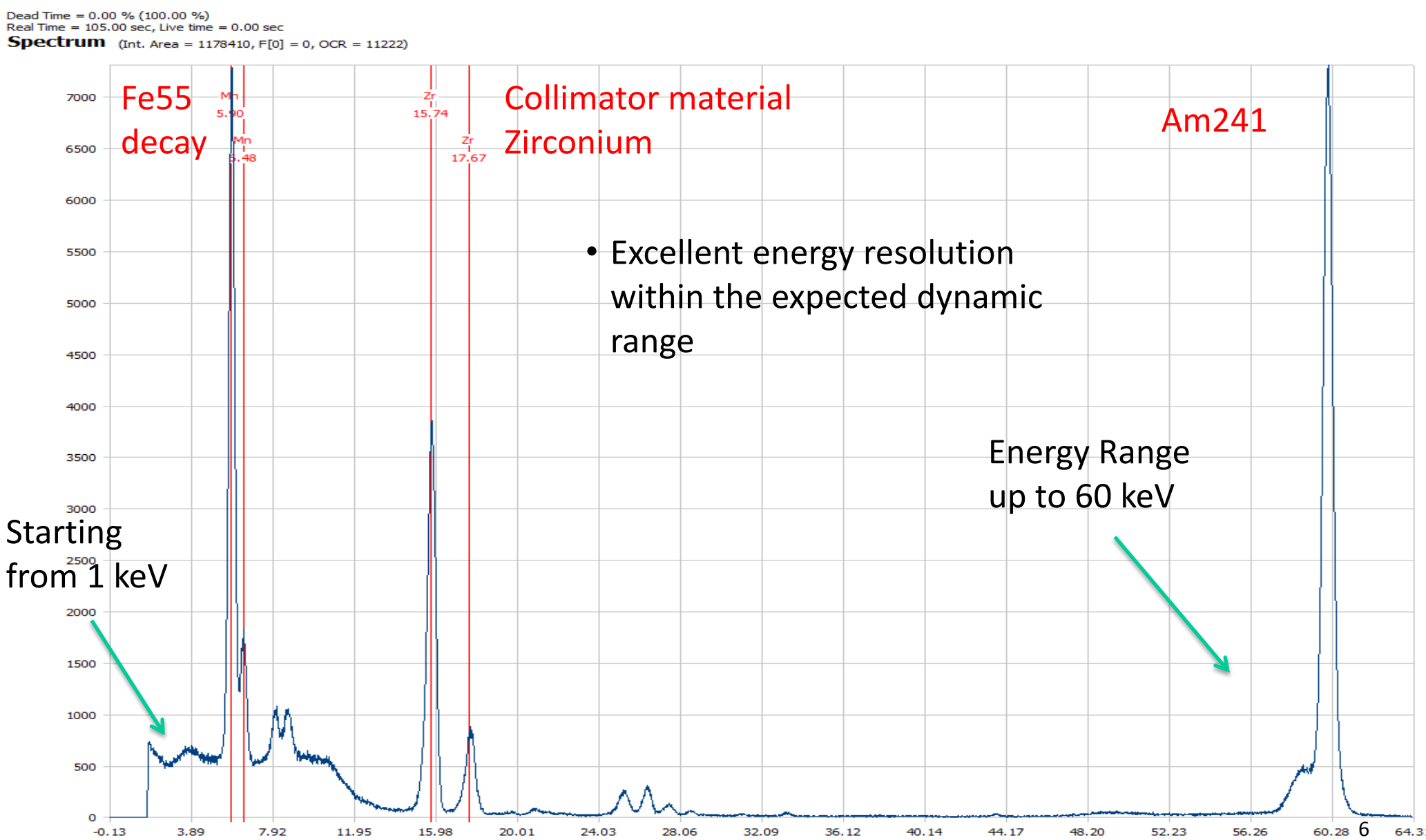




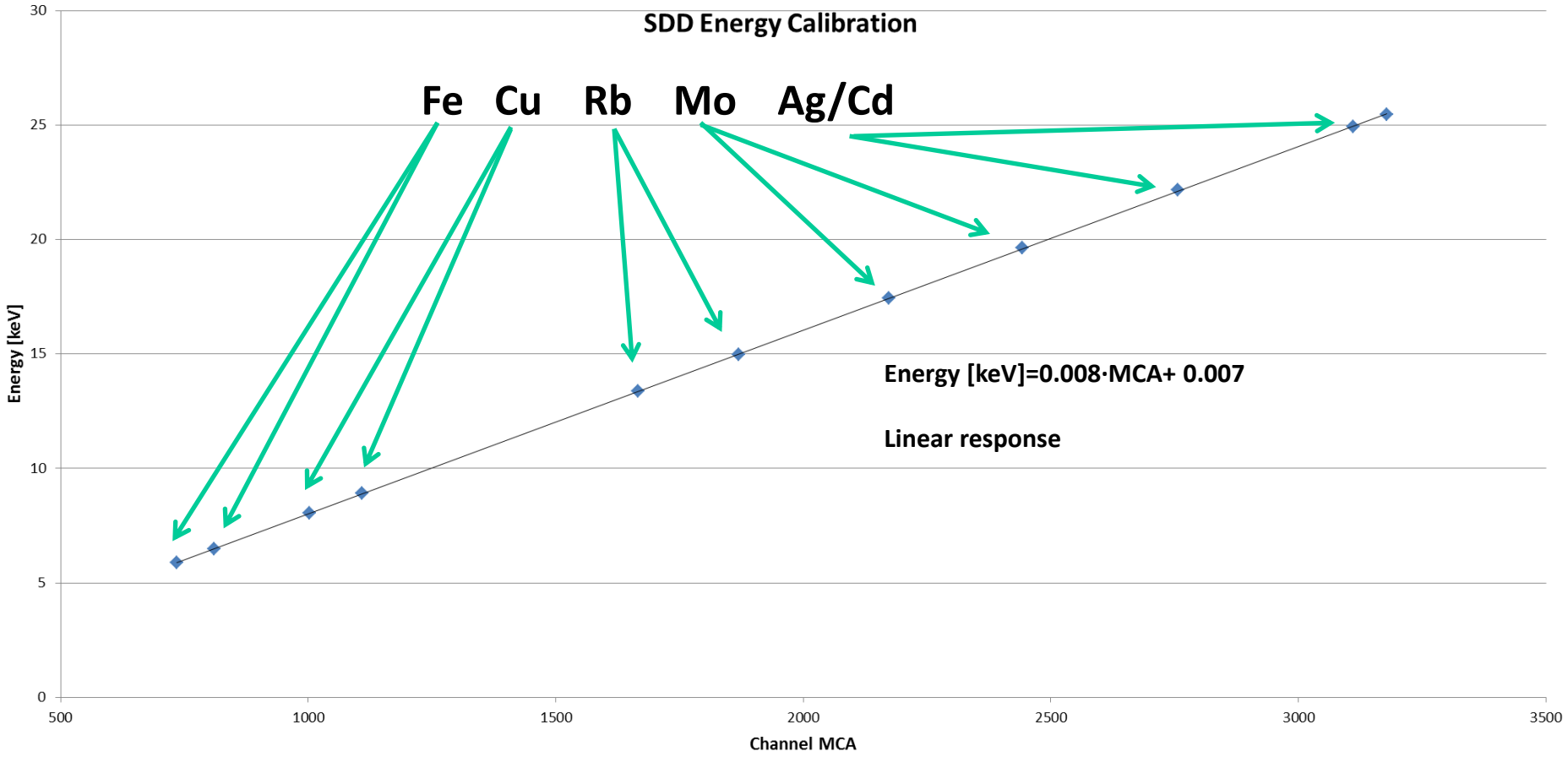
Fe55 spectrum measured with SDD



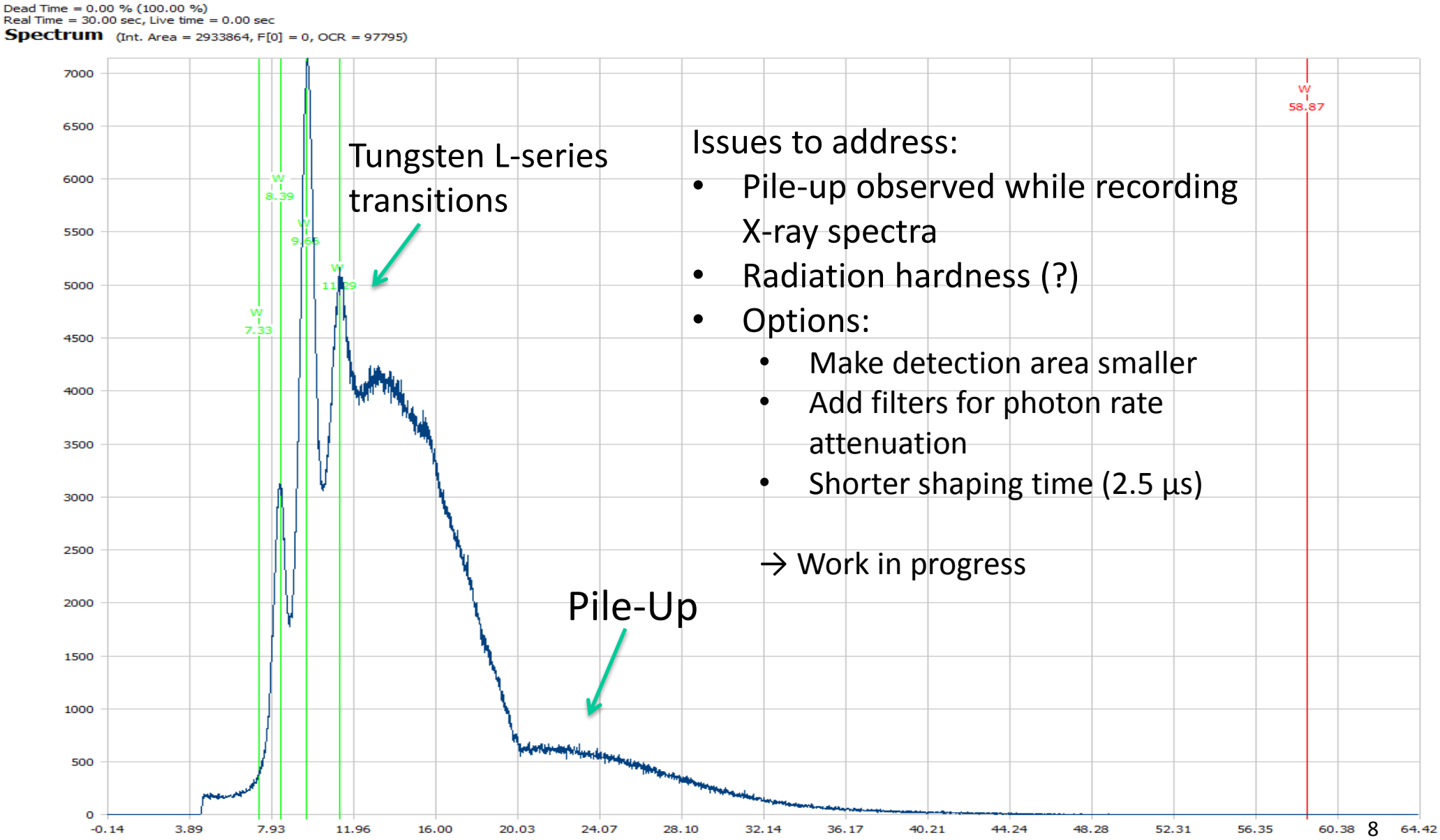
Fe55 + Am241 spectra measured with SDD



SDD Energy Calibration



X-Ray Spectrum 20 kV, 5 µA, Tungsten Anode

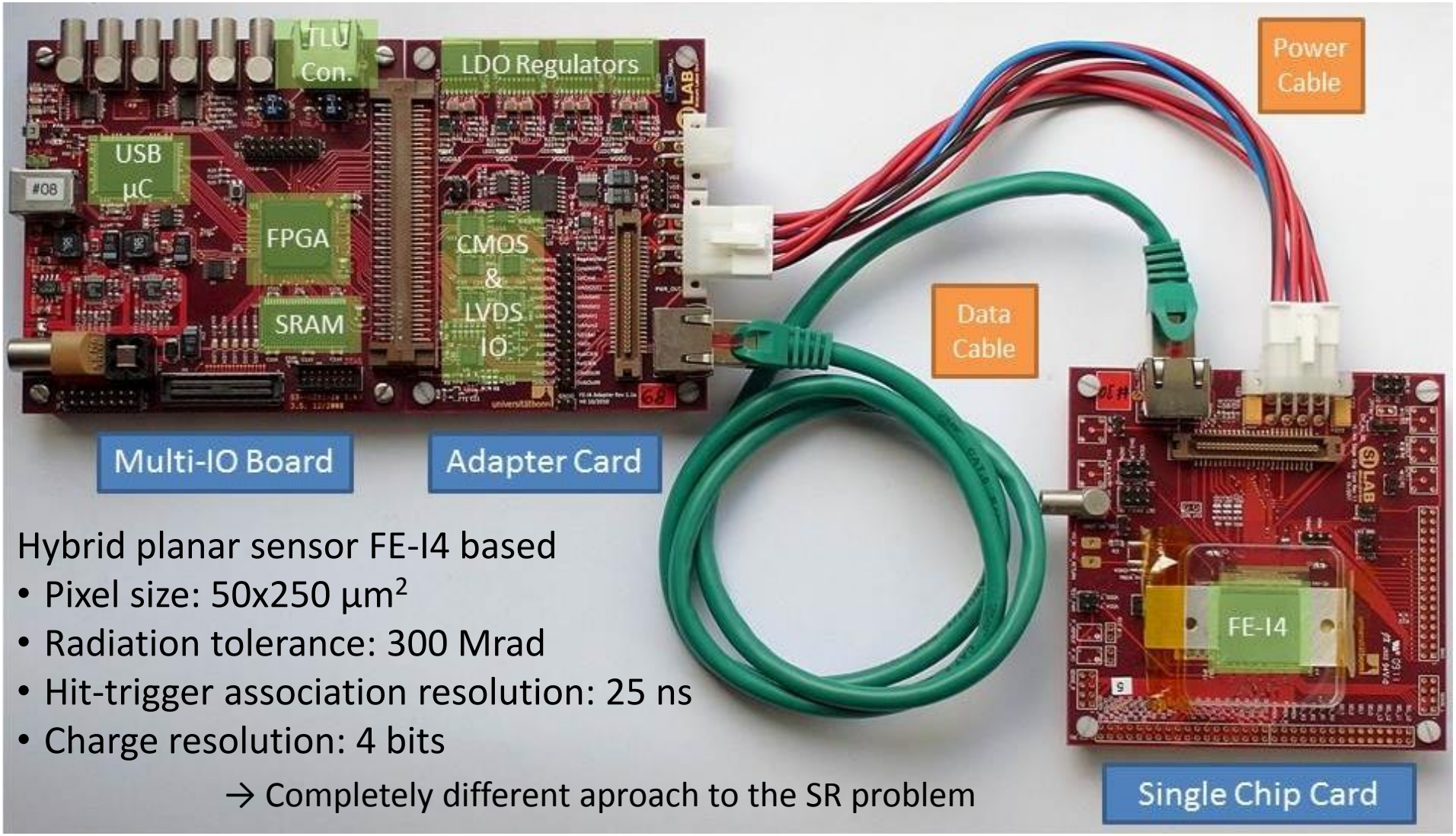


Issues to address:

- Pile-up observed while recording X-ray spectra
- Radiation hardness (?)
- Options:
  - Make detection area smaller
  - Add filters for photon rate attenuation
  - Shorter shaping time (2.5 µs)

→ Work in progress

Front End I4 – Setup



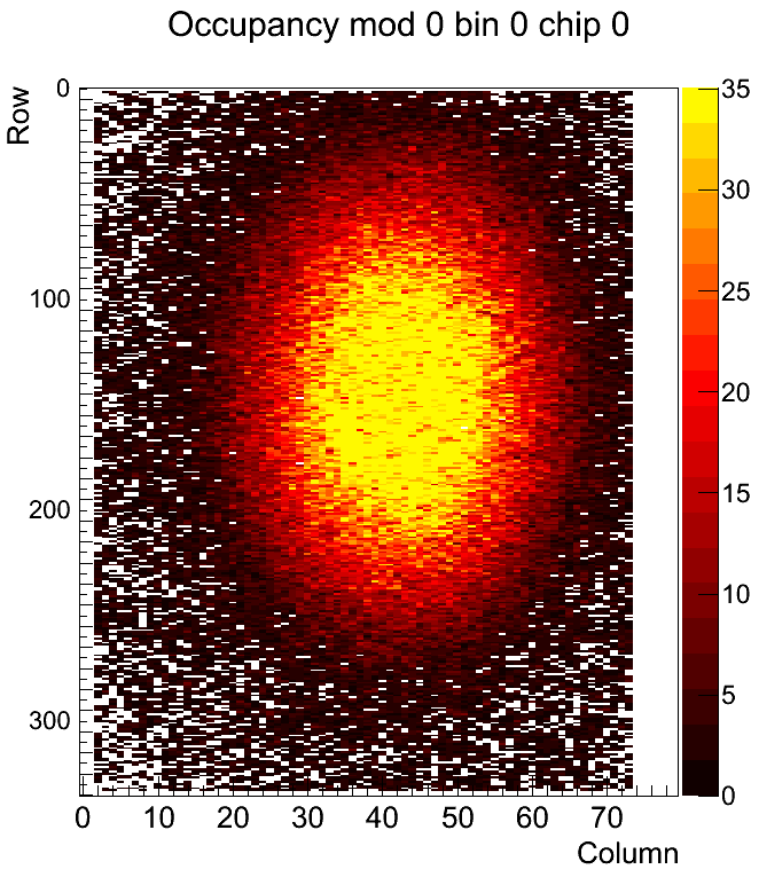
Hybrid planar sensor FE-I4 based

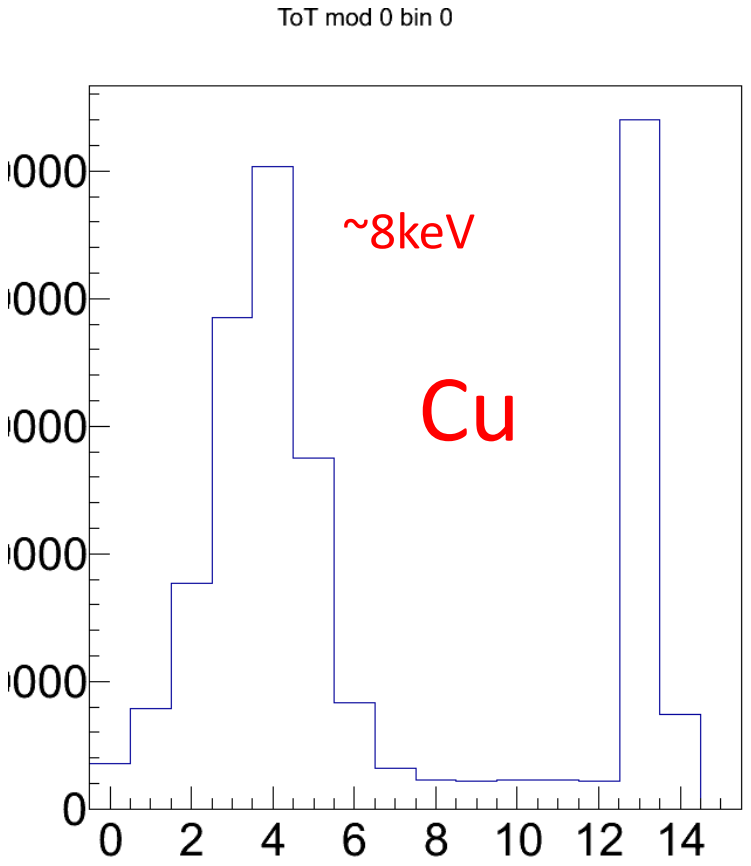
- Pixel size: 50x250 µm²
- Radiation tolerance: 300 Mrad
- Hit-trigger association resolution: 25 ns
- Charge resolution: 4 bits

→ Completely different aproach to the SR problem

Front End I4 – Time over Threshold

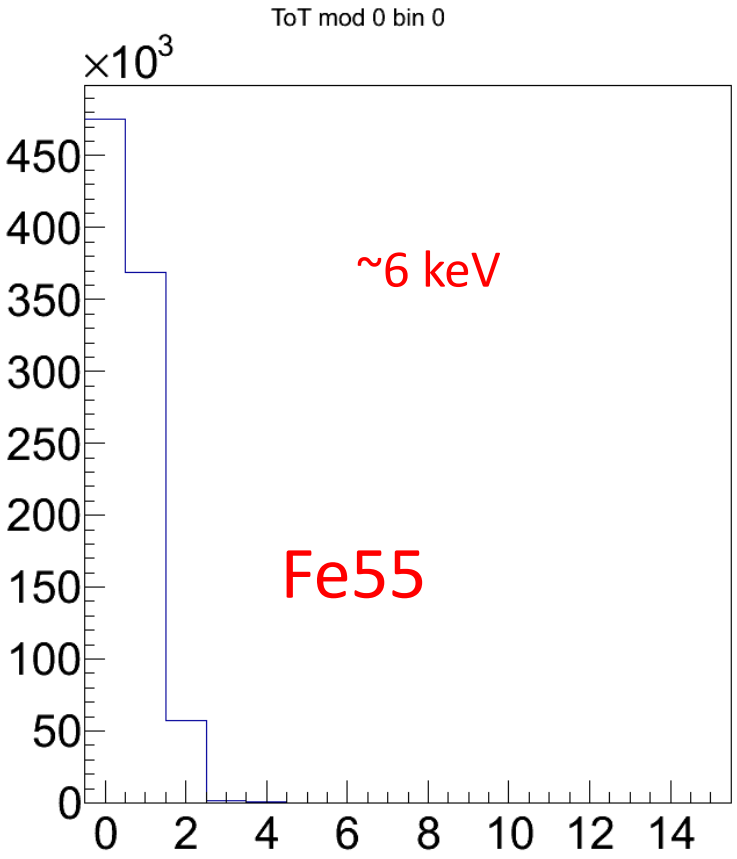
- Chip tuned to operate away of the ATLAS nominal conditions (700 electrons threshold)

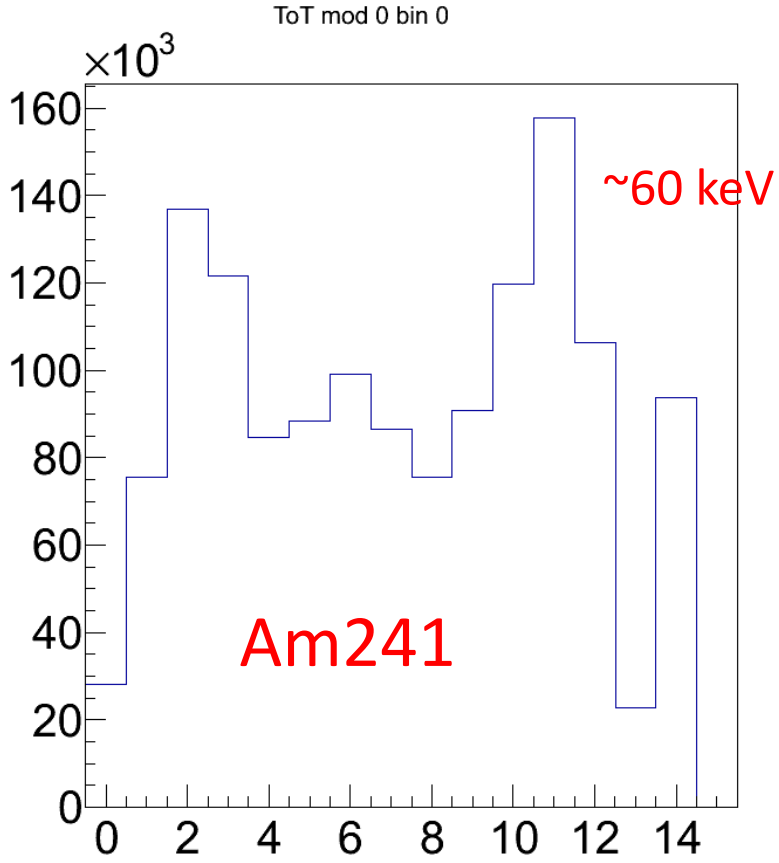




Front End I4 – Time over Threshold

- Time Over Threshold tuned to accomodate the expected dynamic range (3000e/5DAC)





→ Although with coarse energy resolution, could be used during the BEAST II phase
+ time structure of backgrounds (i.e. noise injection) under study

Conclusion

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- Silicon Drift Detectors

Good X ray energy resolution

➢ Radiation hardness?
➢ Particle rate?

- Hybrid planar sensor FE-I4 based

Fast and radiation hard + timing information

➢ Coarse energy resolution

- Search for the optimal solution is still ongoing

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Thank You for Your Attention!

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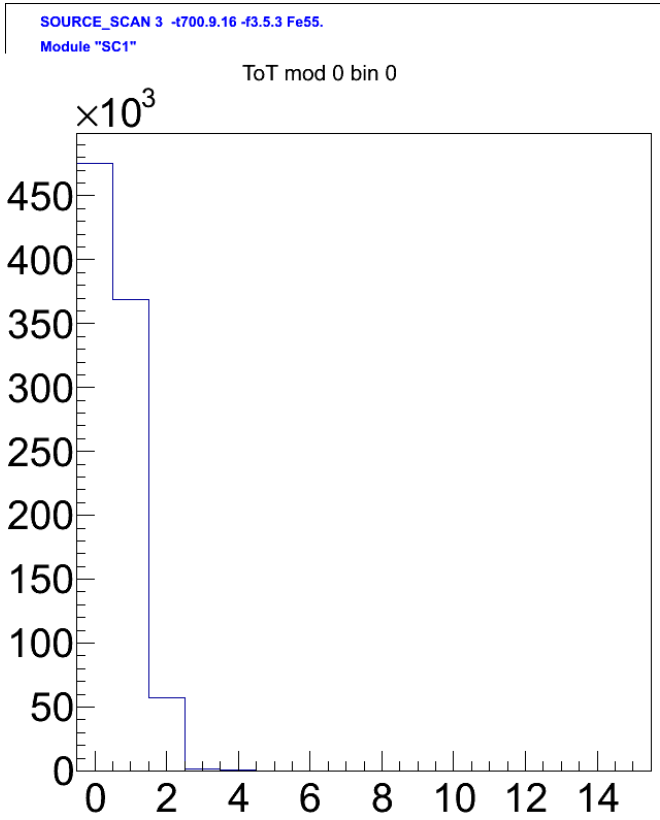
Backup

Front End I4 – Time over Threshold

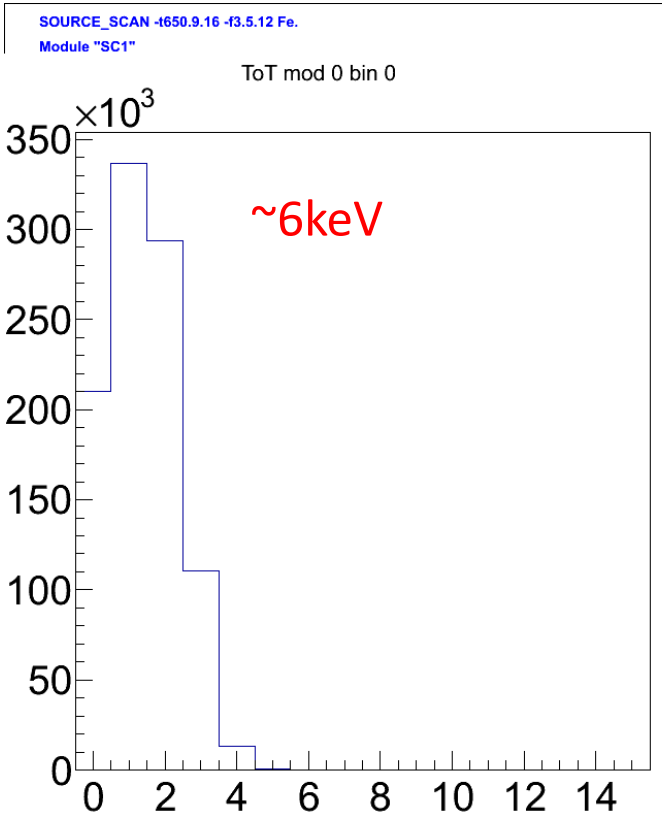


Threshold 700e
Calibration 3000e/5DAC

Fe55

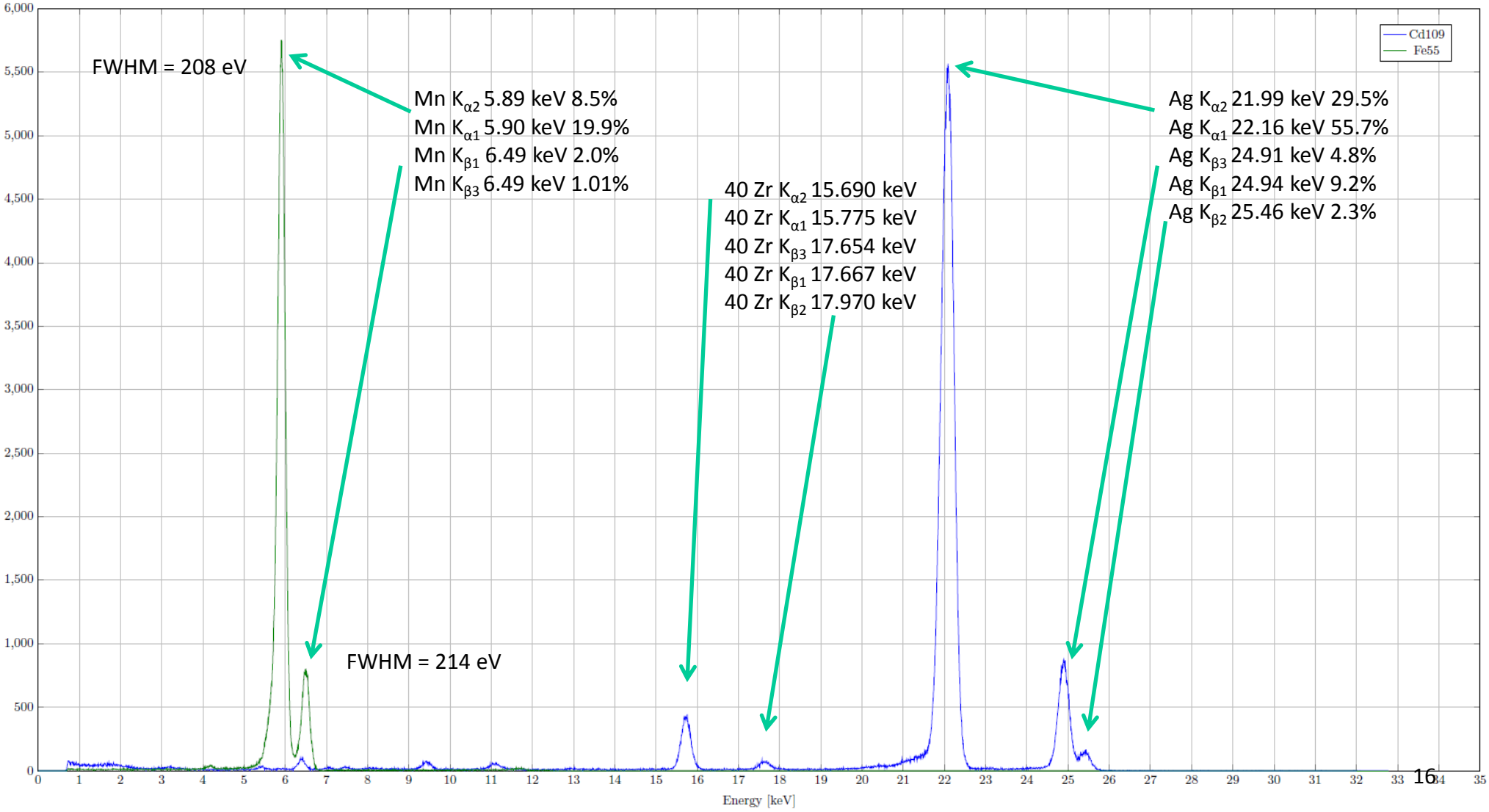
Decreasing the charge per DAC gives a better energy resolution, but you limit yourself to lower energies

-> Course energy resolution, need only cover 5-45 keV



Threshold 650e
Calibration 1200e/5DAC

Fe55 and Cd109 Spectra Measured with SDD



Spectra Variable X-Ray Source Measured with SDD

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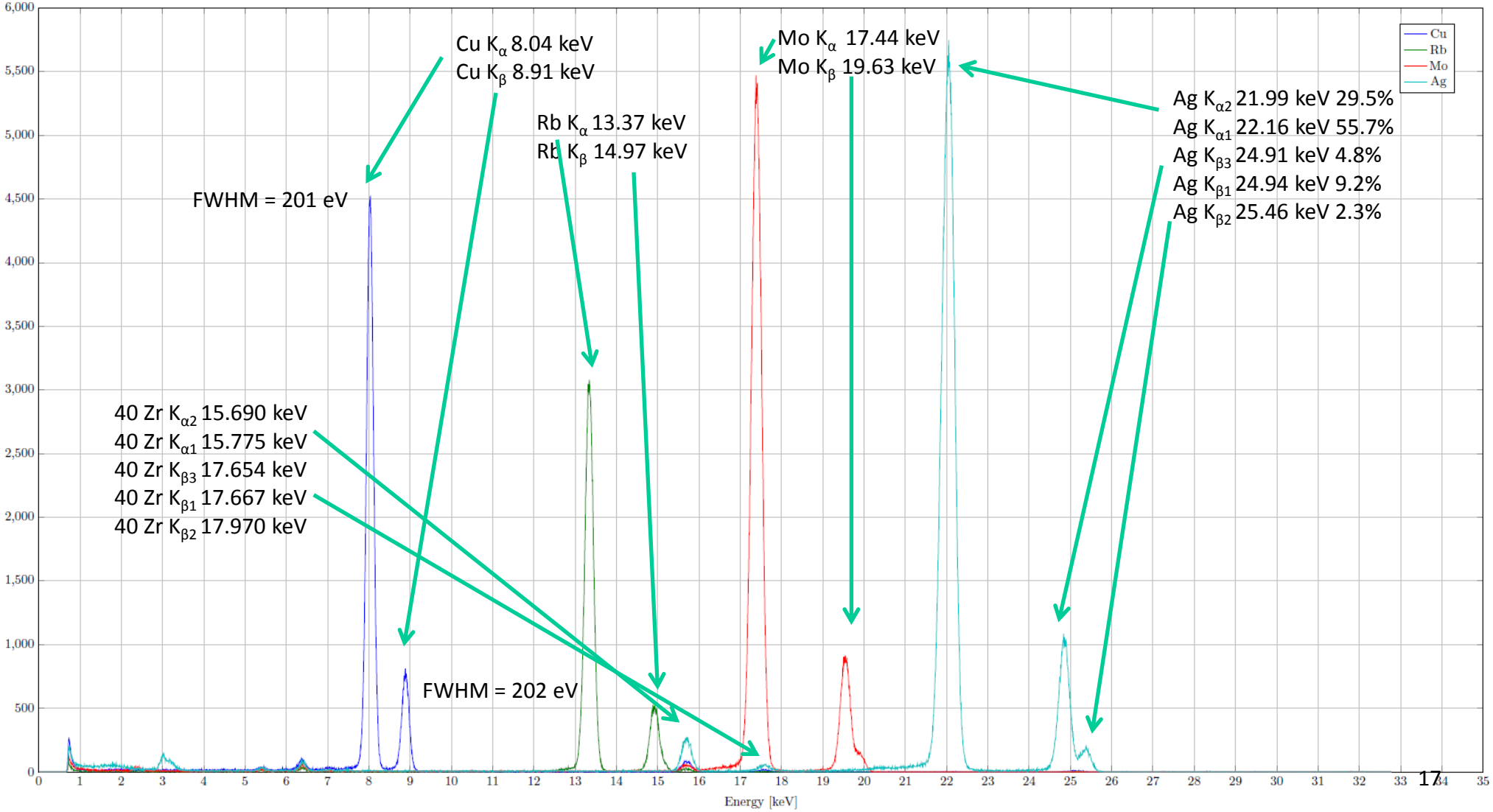
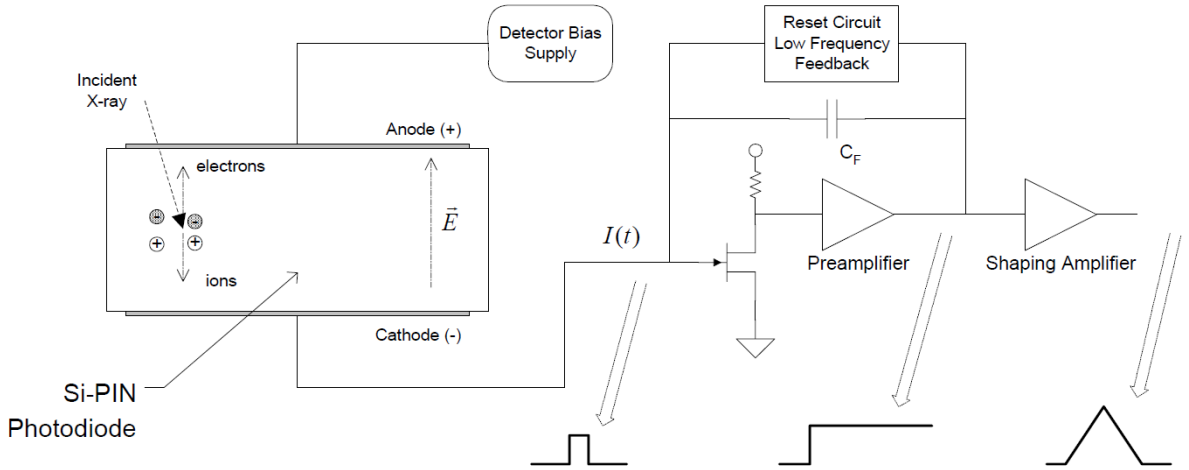
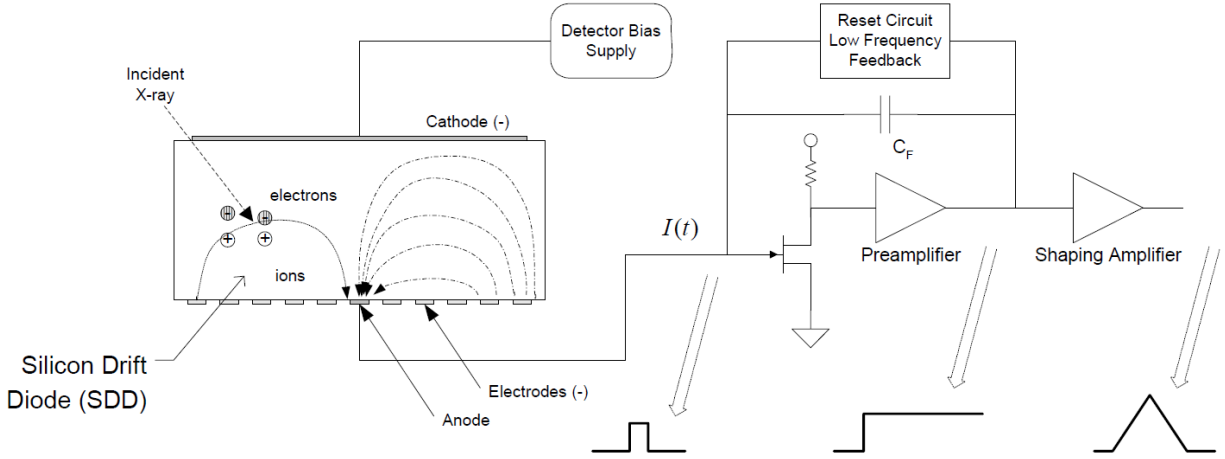


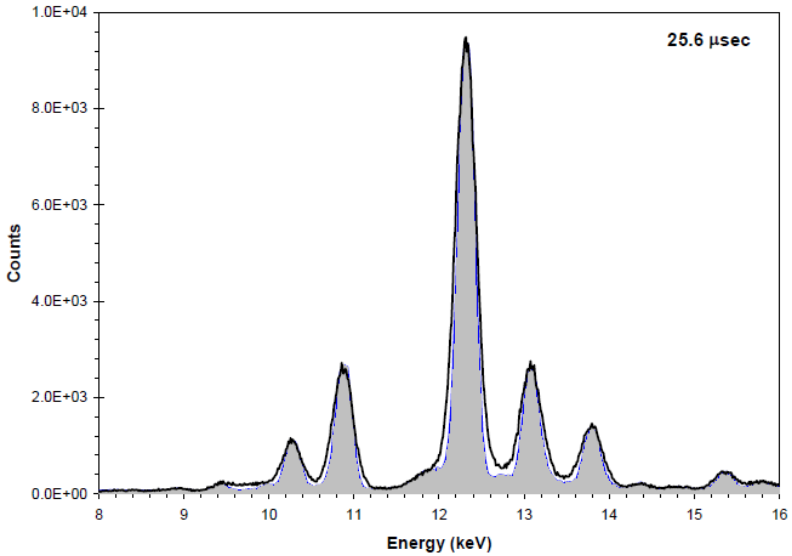
X-Ray Measurements with Pin-Diode and SDD

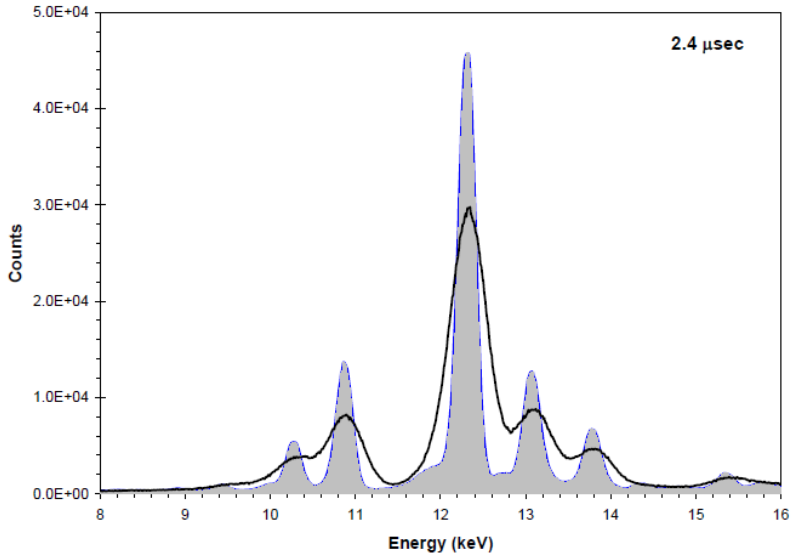




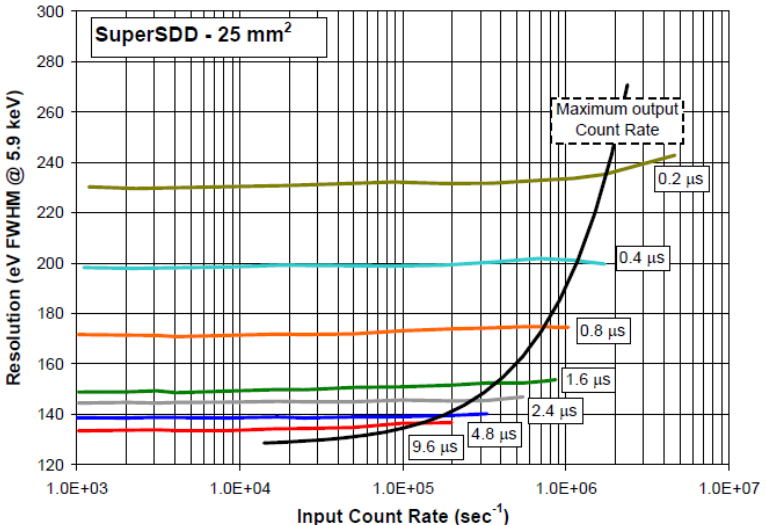
- A silicon drift detector (SDD) is functionally similar to a pin-diode but its unique electrode structure
- Reduces the electronic noise at short peaking times
- Under optimal conditions, the SDD gives a better energy resolution than a comparable pin
- With an SDD, low energy peaks can be measured at a high count rate with little loss of resolution

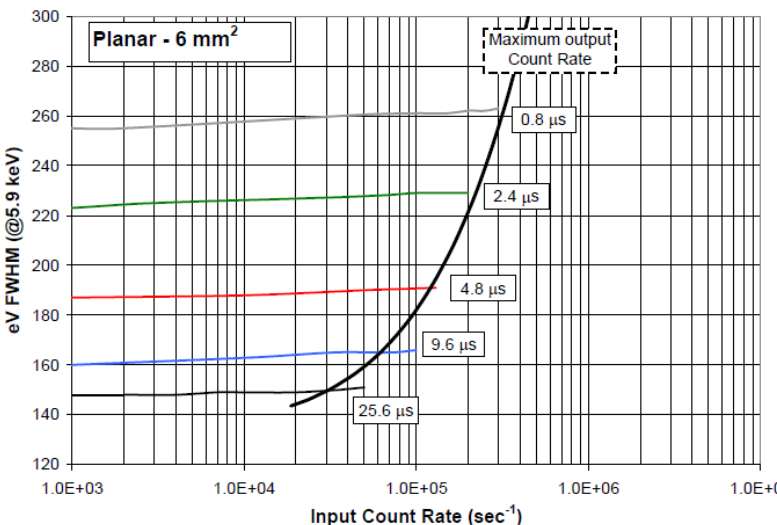
Comparison between Pin-Diode and SDD





Spectra taken by a 25 mm2 SDD (grey filled curve) and a 25 mm2 planar diode (black line) . The spectra on the left were taken using a 25.6 µs peaking time, at 5 kcps, while those on the right were taken at a 2.4 µs peaking time at 25 kcps.





- Plots showing resolution vs. input count rate for a 25 mm2 SDD (left) and a 6 mm2 Si-PIN (right).