



Calibration of X-ray set in Oxford

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LBL lab meeting
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X-ray setup in Oxford

- X-ray set delivered and set up in Oxford
- Specifications:
 - X-ray tube is Comet MXR-160/22
 - Tungsten target
 - Peak X-ray flux at 50kV, 60 mA (3kW)
 - 60x60x100cm space
 - Movable platform to bring samples close to source



Calibration setup

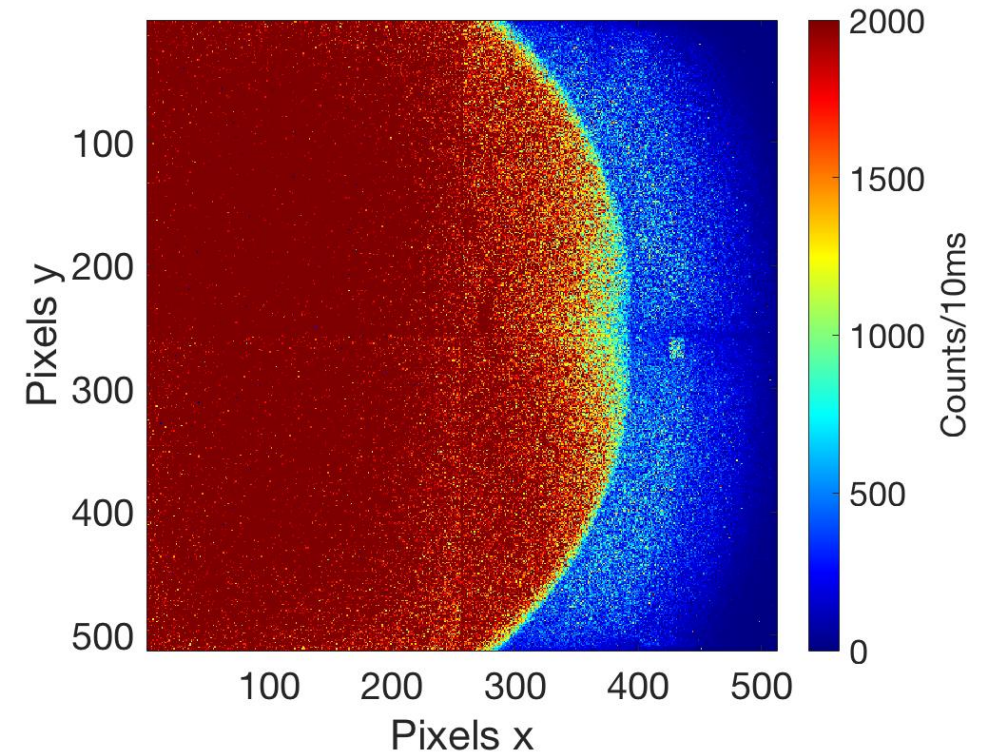
- Merlin detector:
 - Commercially available photon counting detector
 - Using Medipix3 ASIC
 - 55 μm pixel pitch, 300 μm thickness
 - kHz frame rates possible
 - Quad system
 - Used to determine number of photon counts/time for different configurations
- Timepix detector:
 - Allows measurement of ToT
 - Used for energy calibration



Part I: Intensity vs experimental parameters

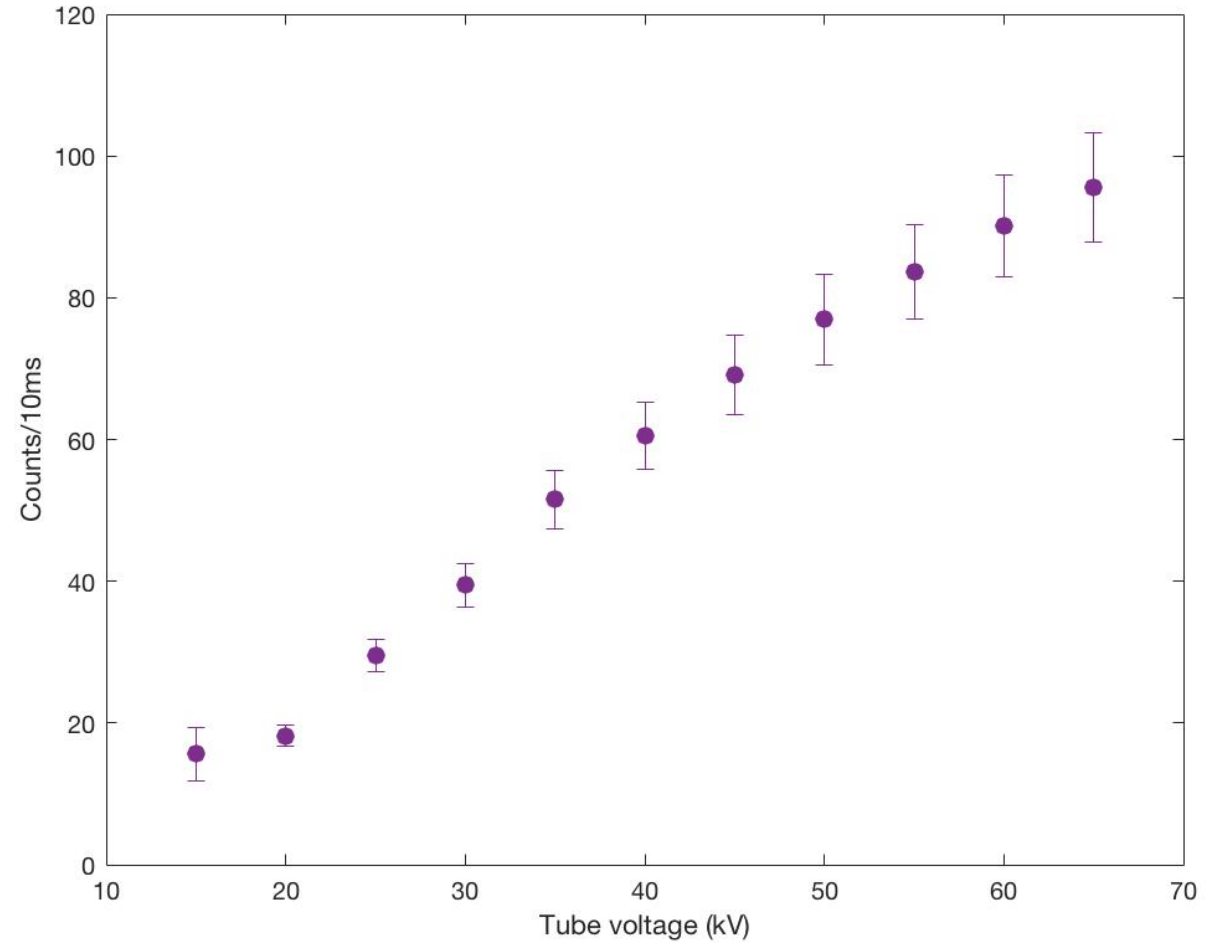
- Merlin detector used to characterise intensity as a function of the different experimental parameters:
 - X-ray tube: Voltage and current
 - Distance from the source
 - xy-profile of the beam
- Take images of beam at different positions
- Detector threshold 6.5 keV
- Counts/10ms as measured parameter

*Example of Merlin image
5cm from source, low intensity*



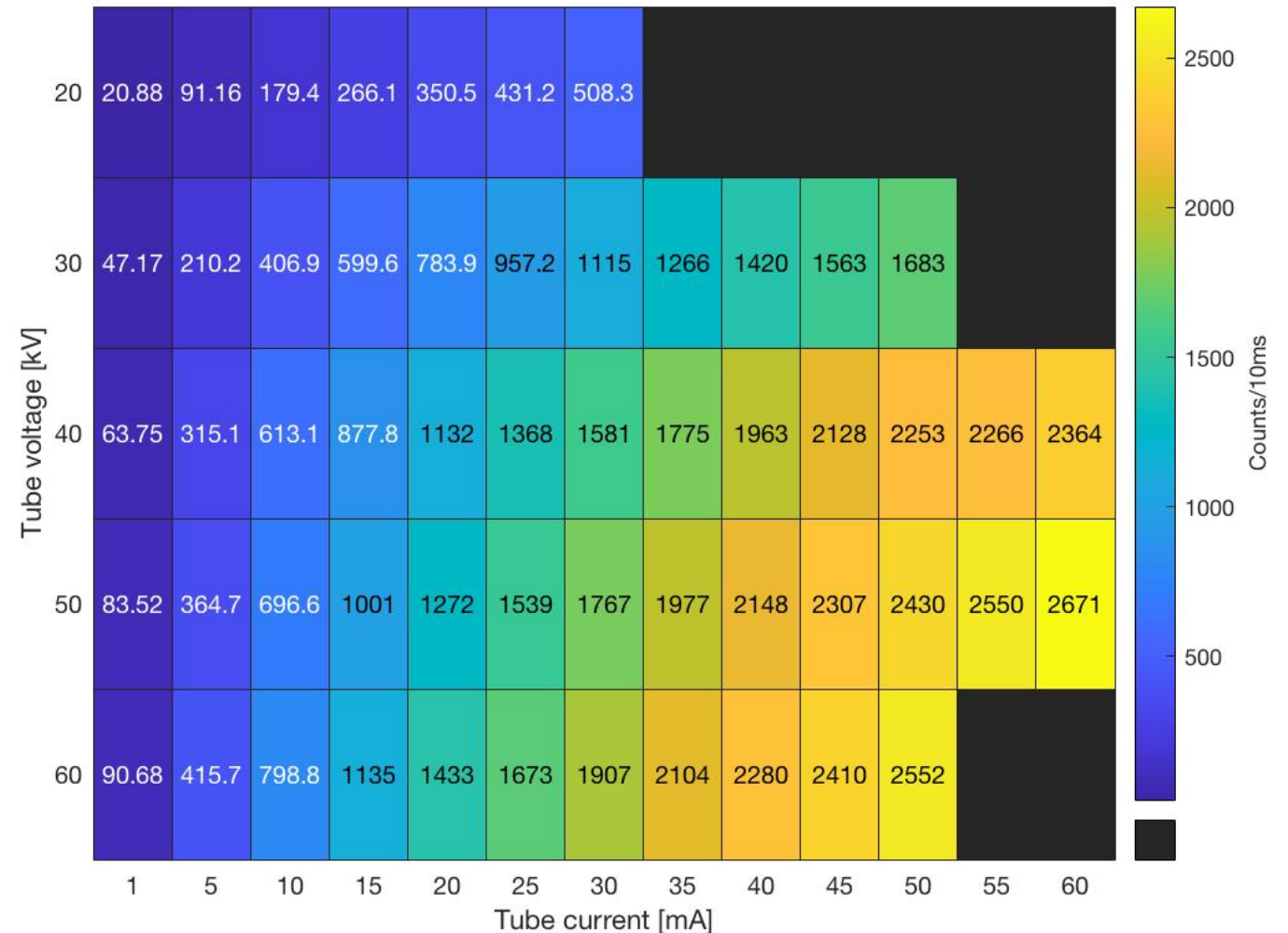
Characterisation of tube parameters

- Place detector in the center of the beam spot and vary voltage of the X-ray tube
- Here for low (1.1 mA) current and large distance from source (~60 cm)



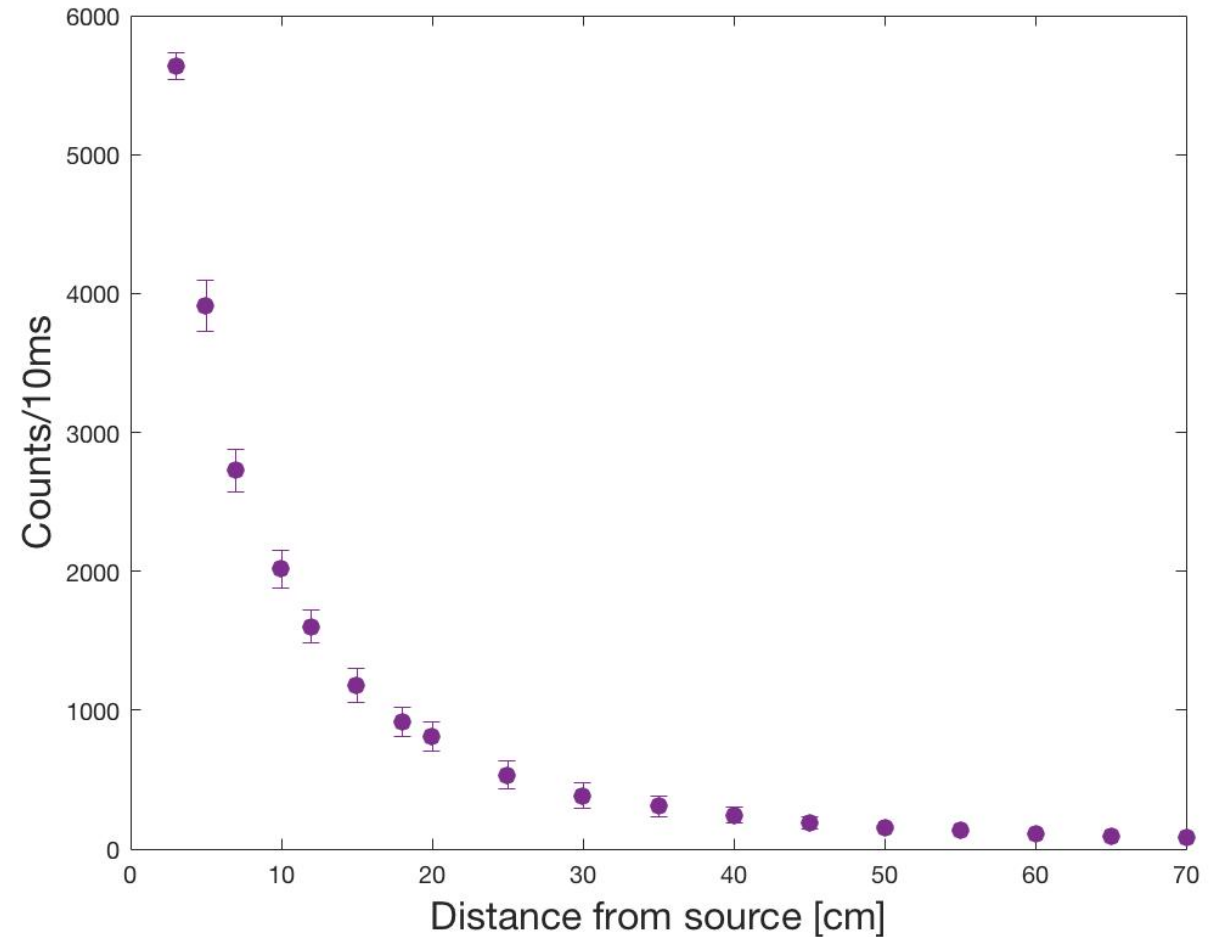
Characterisation of tube parameters

- Vary both voltage and current
 - Still at a large distance from the source (~60 cm)
 - Peak intensity at 50 kV and 60 mA
- As expected from specifications



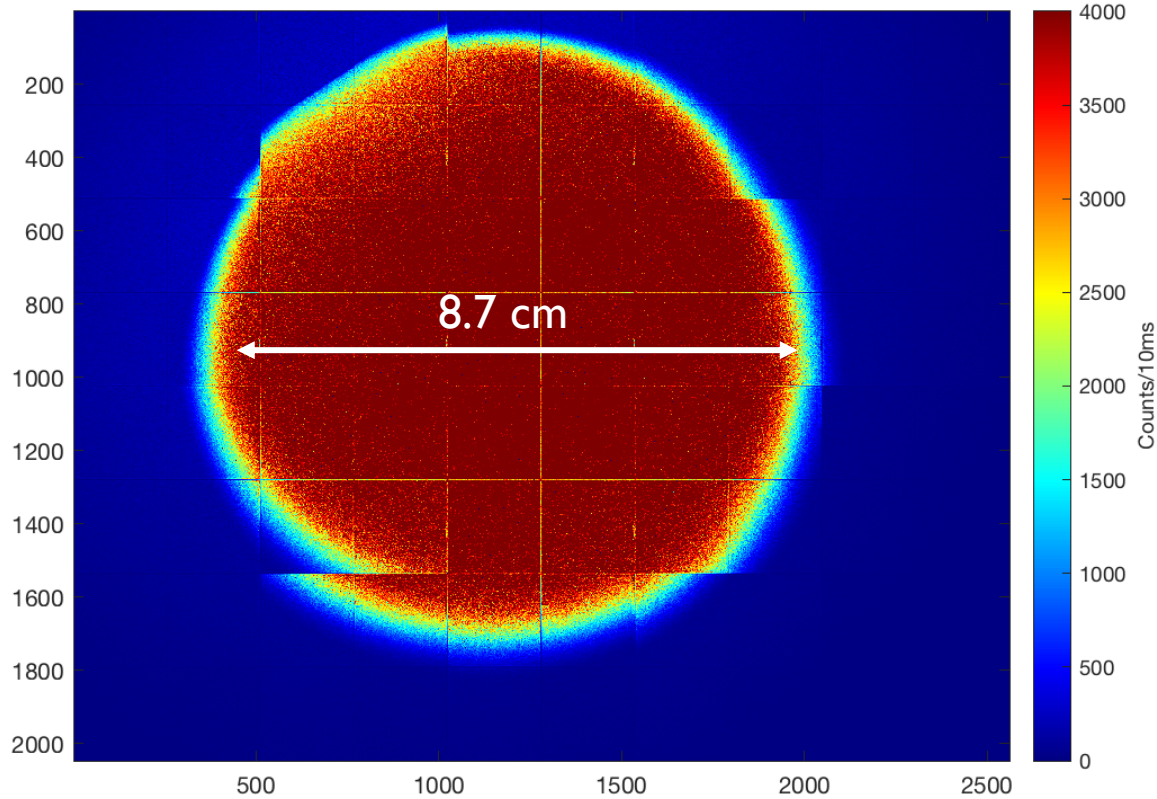
Intensity vs height

- Vary height wrt to source while keeping current and voltage constant
- Error on heights $\pm 0.5\text{cm}$
- Still to do: repeat measurement closer to source, with more precise positions



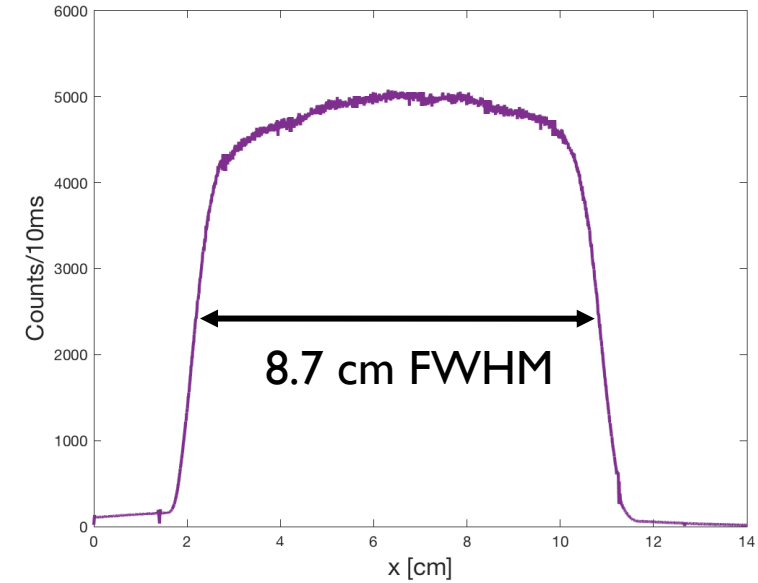
Beam spot

10 cm from the source

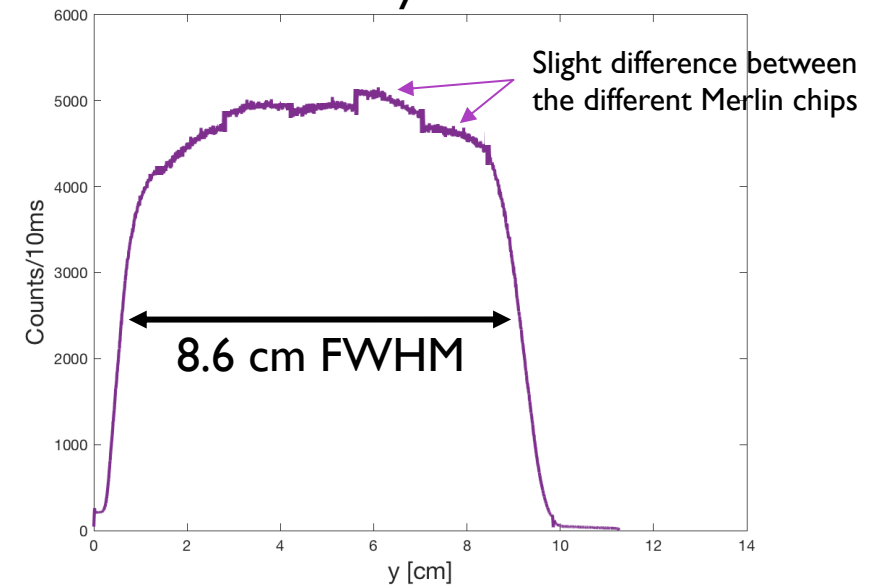


- Move Merlin in xy-grid (by hand)
- Very circular and uniform beam spot

Profile in x-direction

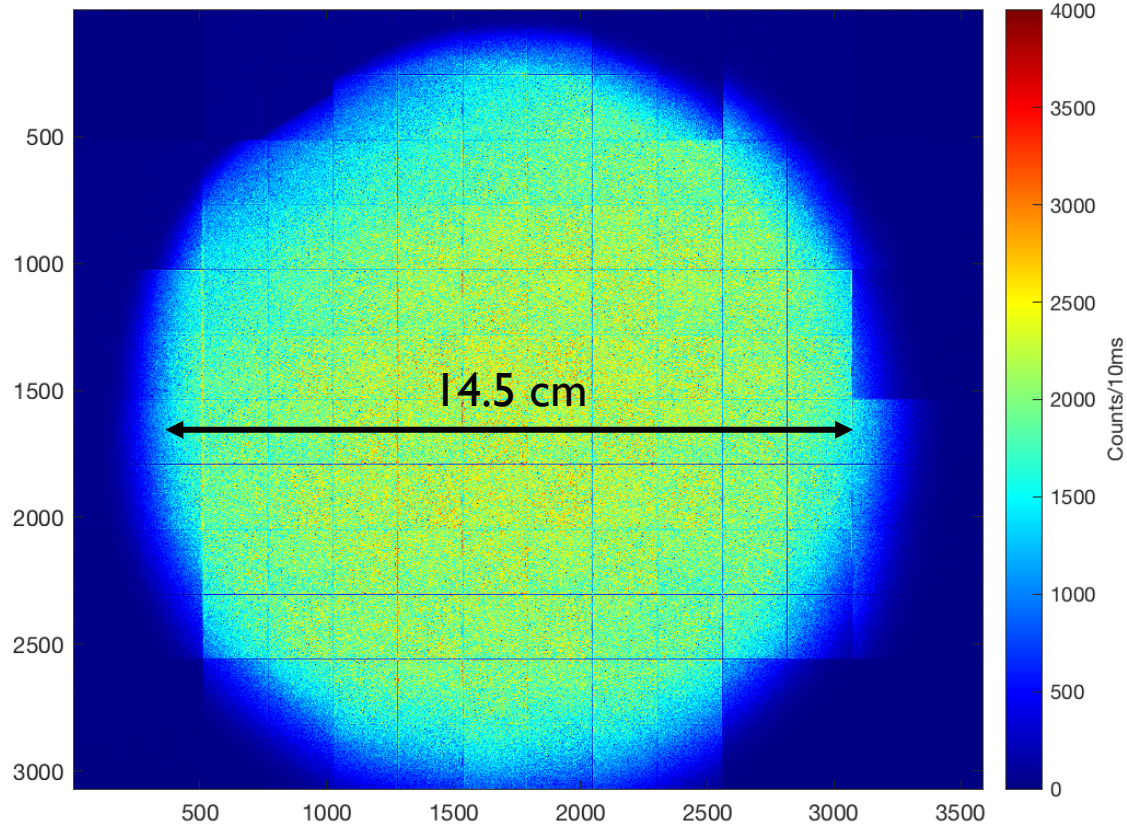


Profile in y-direction



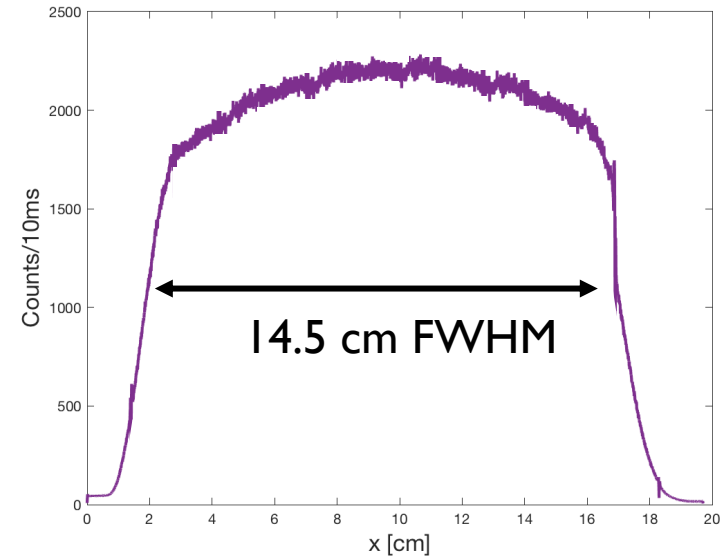
Beam spot

20 cm from the source

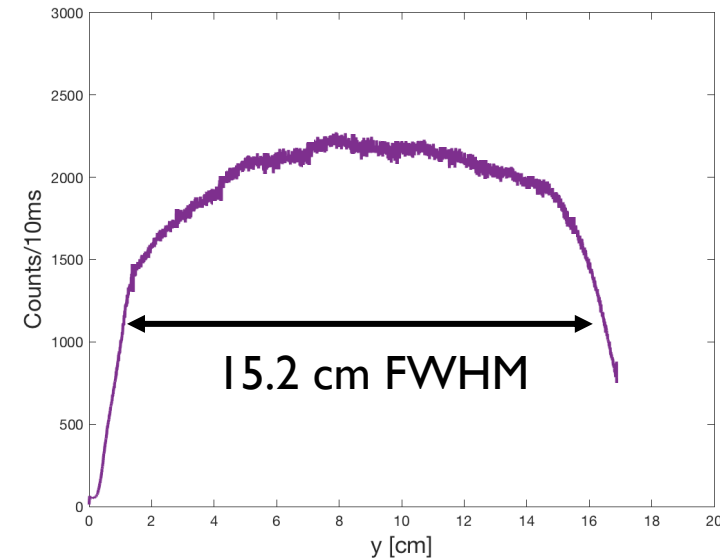


- Move Merlin in xy-grid (by hand)
- Slightly less uniform beam spot

Profile in x-direction



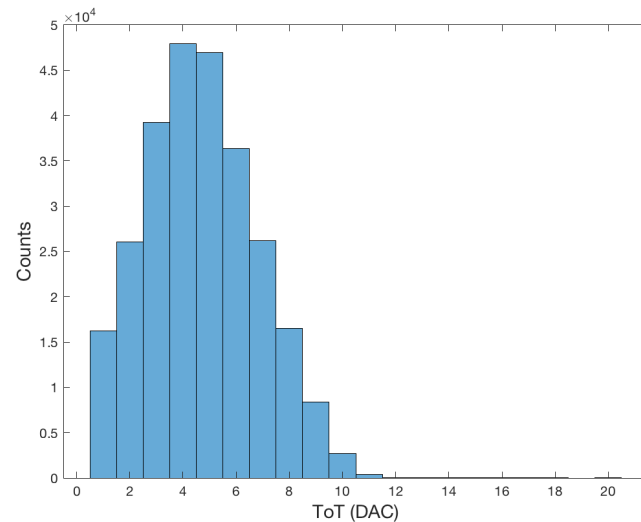
Profile in y-direction



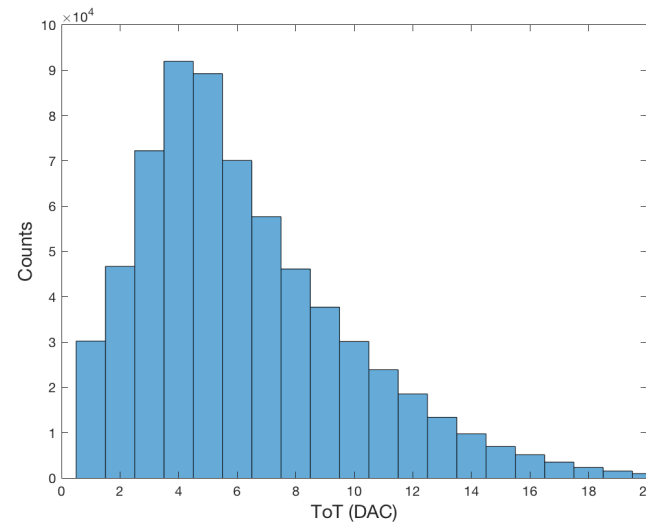
Part II: Energy calibration

- Determine energy spectrum at different settings to find dose rate
- Measure ToT spectrum using Timepix3 detectors
- Threshold set to 6.5 keV
- Main changes to ToT spectrum in tail with increasing voltage

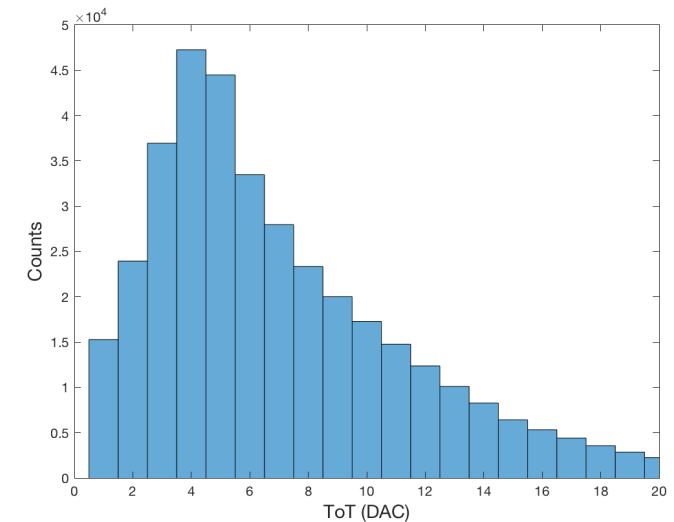
15 keV



30 keV

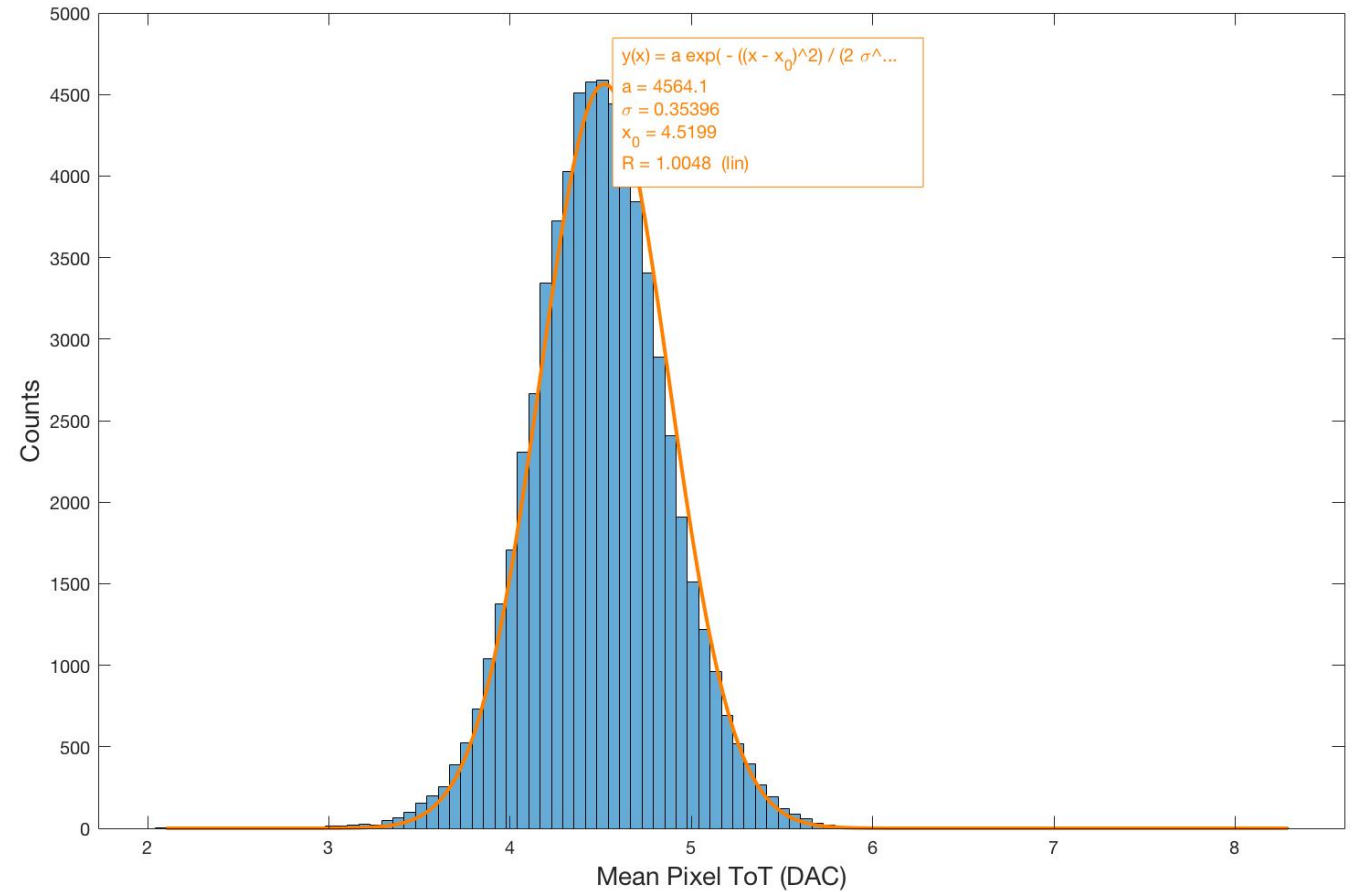


60 keV



Reference measurement

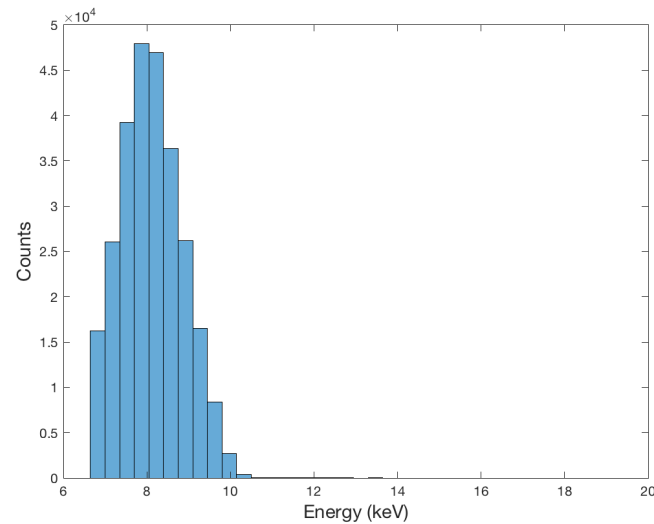
- Threshold set to 6.5 keV
- Measure ToT spectrum of source with known energy to convert from ToT to energy
- Copper X-ray source ~ 8.1 keV and a roughly Gaussian peak
- Peak corresponds to ~ 4.5 ToT



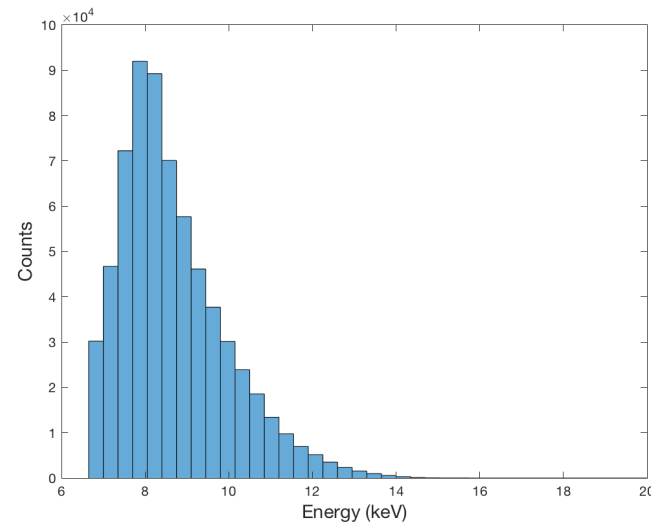
Energy spectra

- Convert ToT to energy spectra
- Peak at ~ 8 keV
- Rapidly falling tail \rightarrow partly due to low absorption of high energy X-rays in silicon

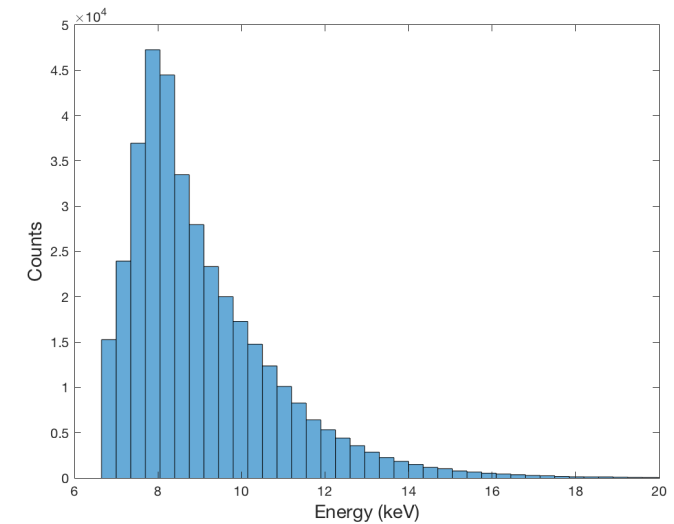
15 keV



30 keV

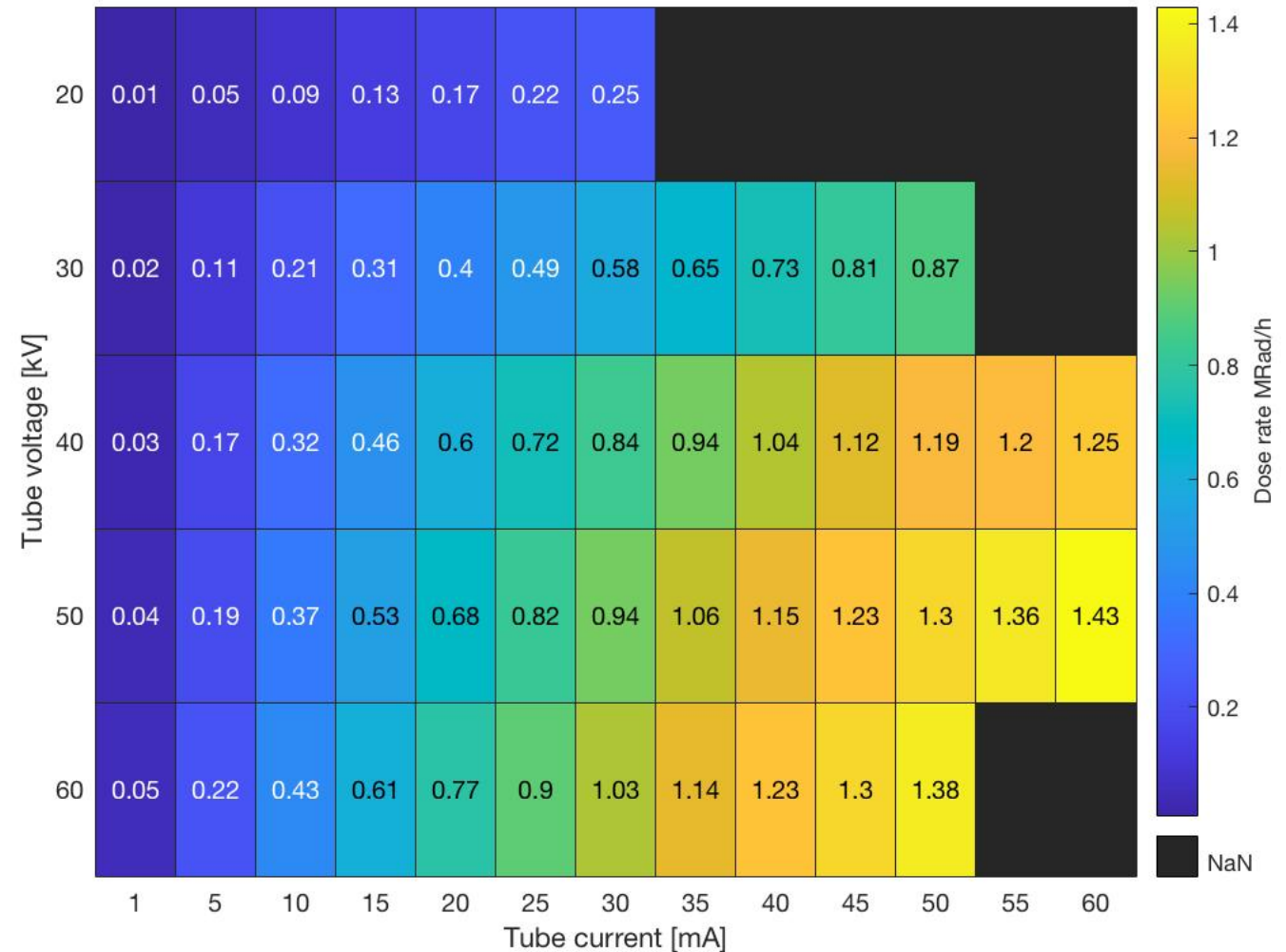


60 keV



Dose rate @ 10 cm

- Using the energy spectrum at voltage/current setting, convert to dose rate
- Here for a distance of 10 cm from the source
- **Peak dose at 50kV, 60mA: 1.43 MRad/h**



Conclusions and next steps

- Set of calibration results to determine dose rate for any given set of experimental parameters:
 - Voltage and current of the X-ray tube
 - x, y and z positions
- Next steps:
 - Repeat height calibrations closer to source with higher precision
 - Cross-check energy calibrations using 'vortex' silicon drift detector borrowed from Diamond light source
 - Cross-check dose rate calibrations by irradiating RD53A at a previously used dose rate and comparing the ring oscillator measurements

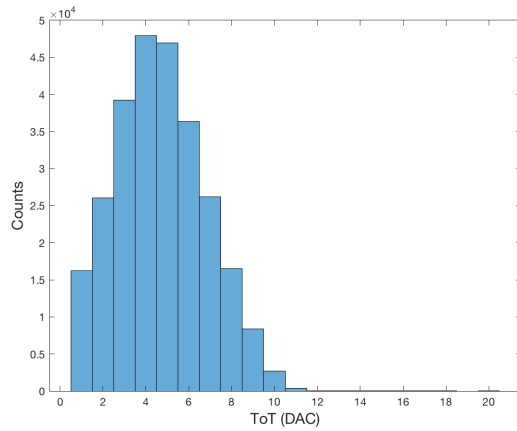
Thank you!

Questions?

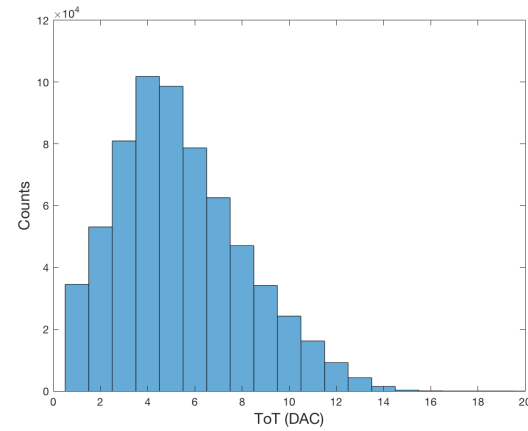
Additional Slides

ToT spectra

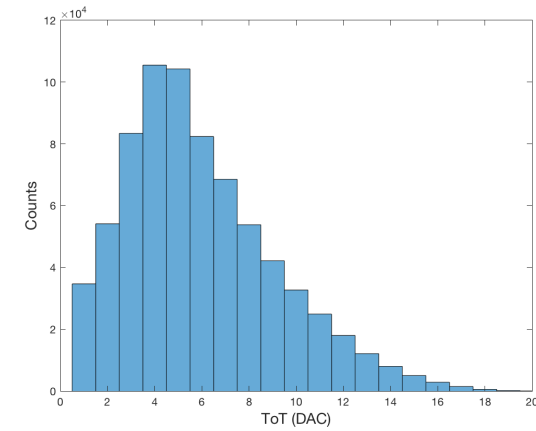
15 keV



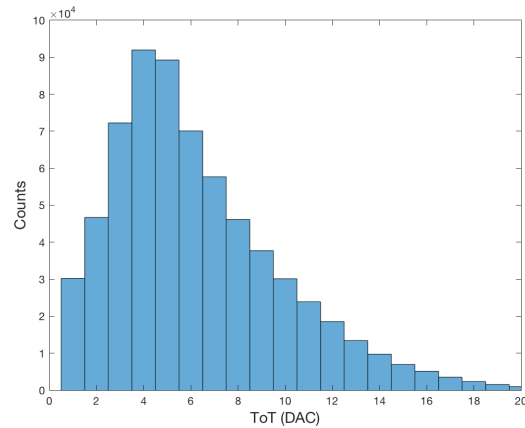
20 keV



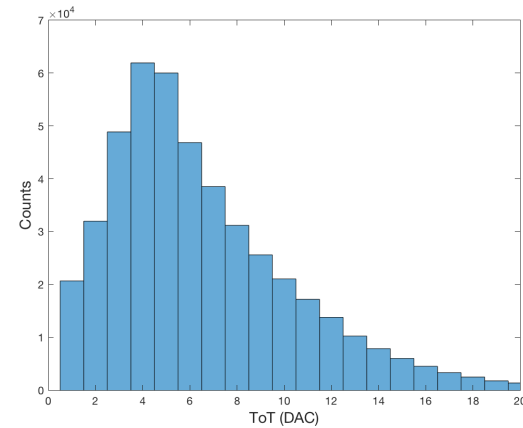
25 keV



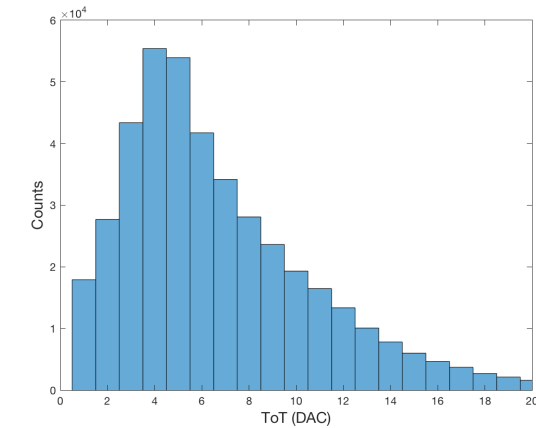
30 keV



35 keV

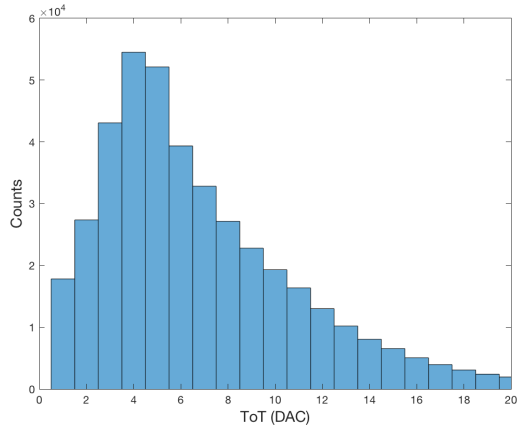


40 keV

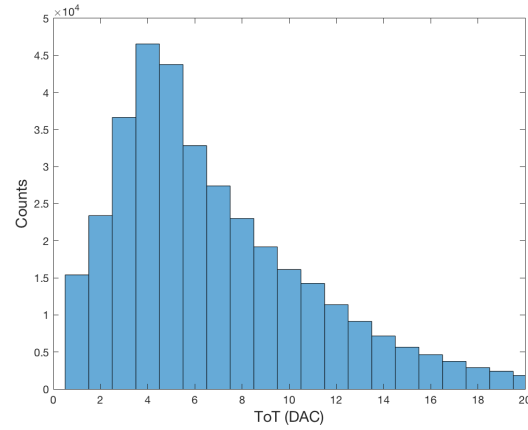


ToT spectra

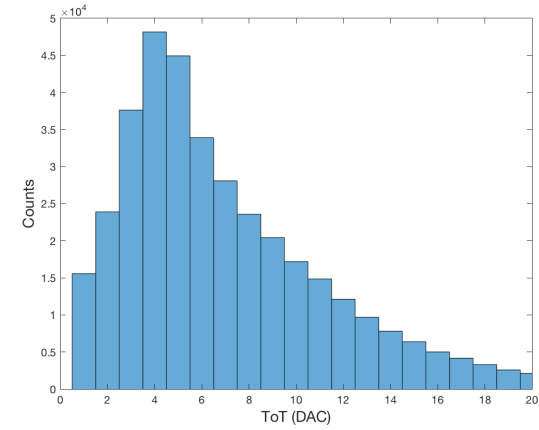
45 keV



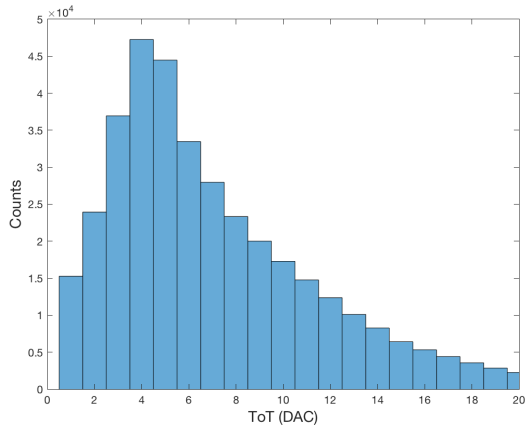
50 keV



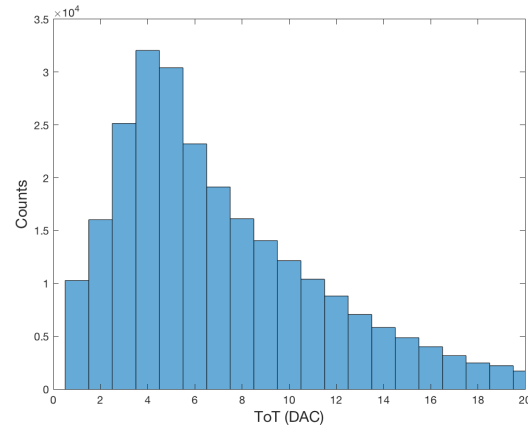
55 keV



60 keV

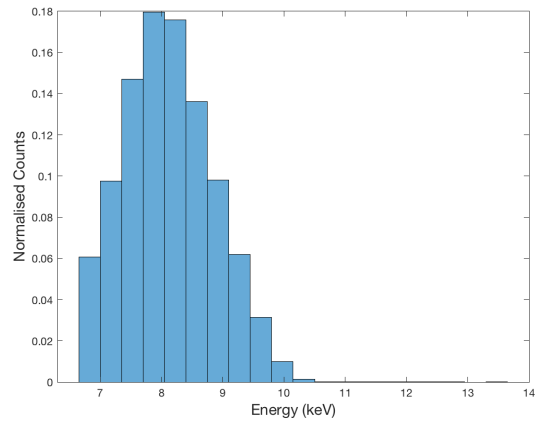


65 keV

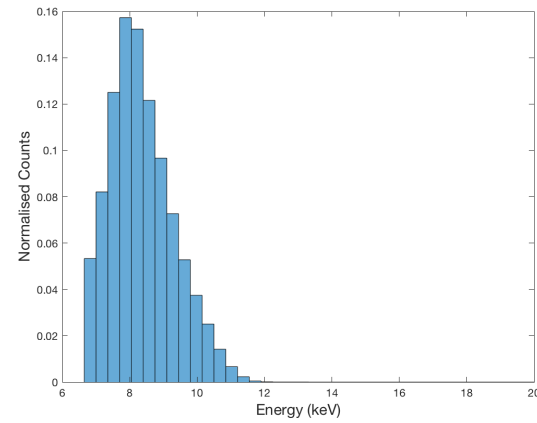


Energy spectra

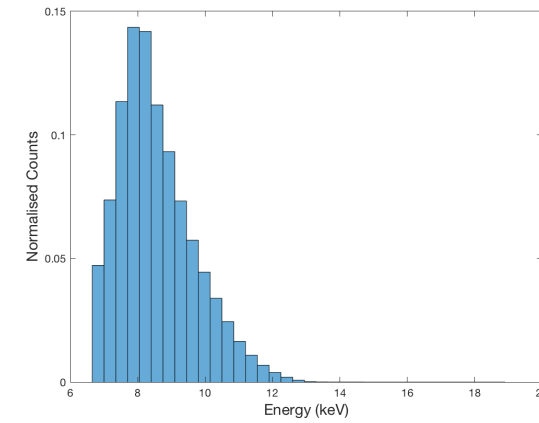
15 keV



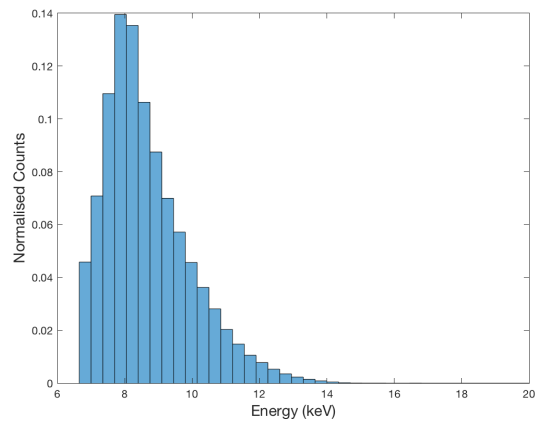
20 keV



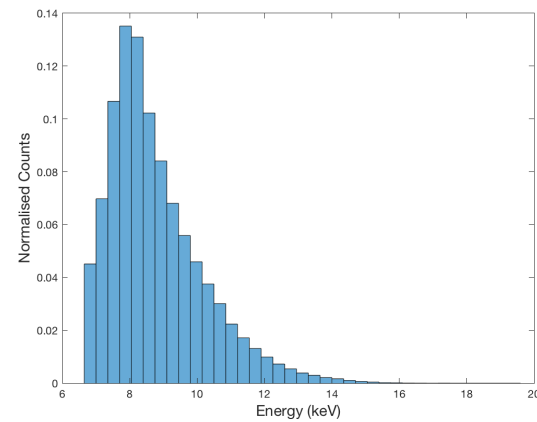
25 keV



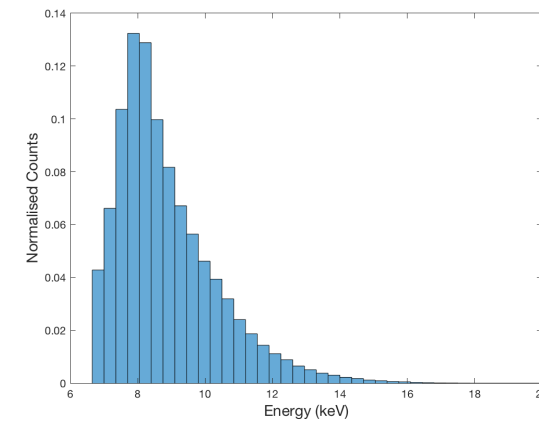
30 keV



35 keV

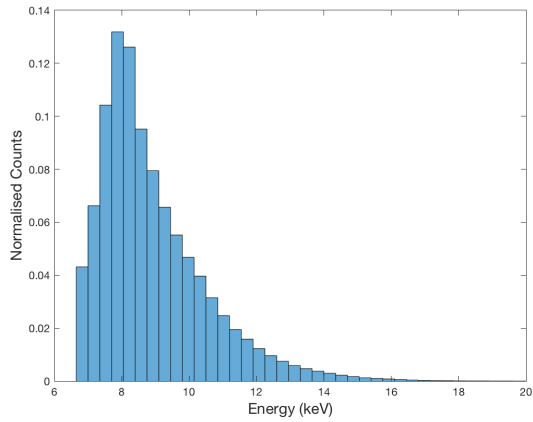


40 keV

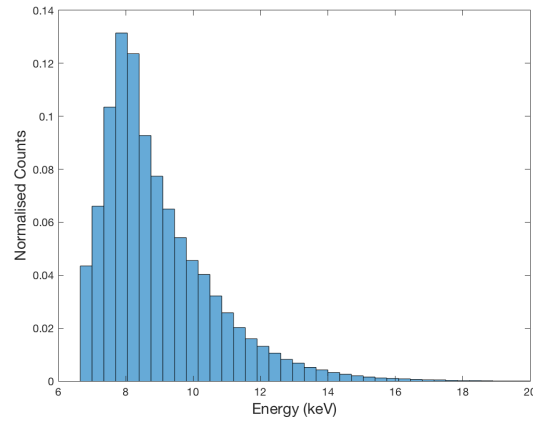


Energy spectra

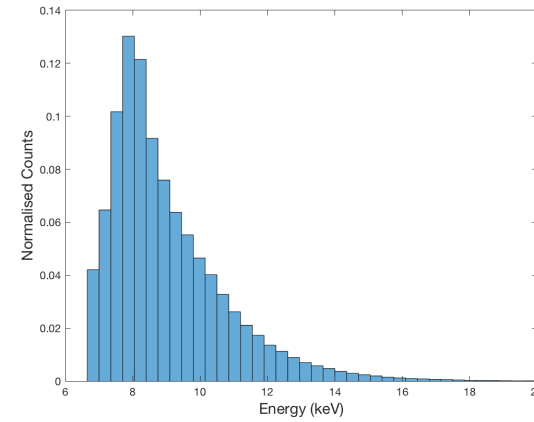
45 keV



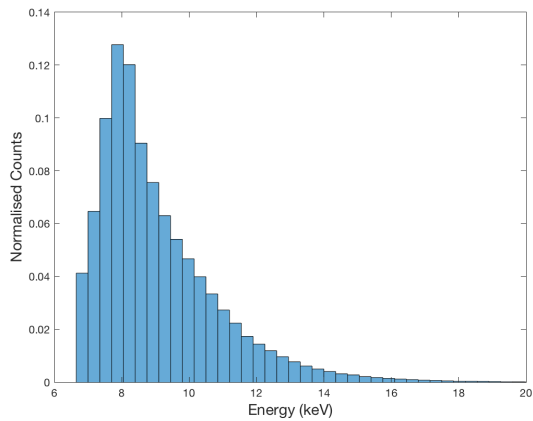
50 keV



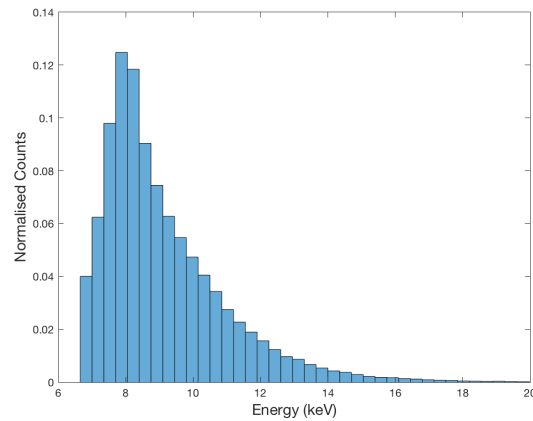
55 keV



60 keV

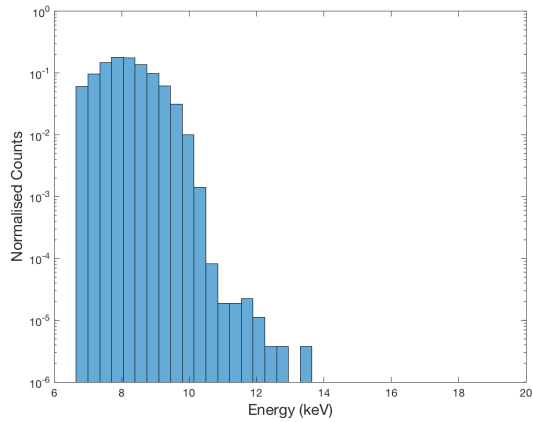


65 keV

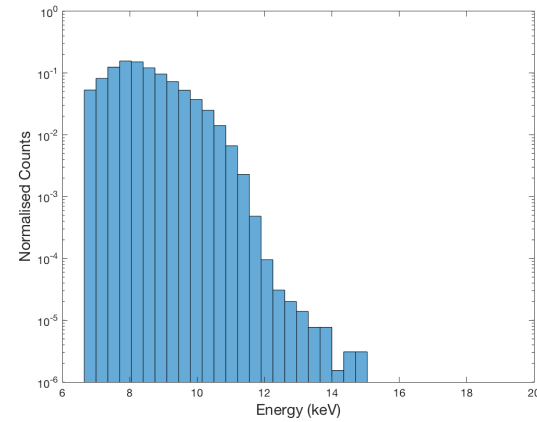


Energy spectra

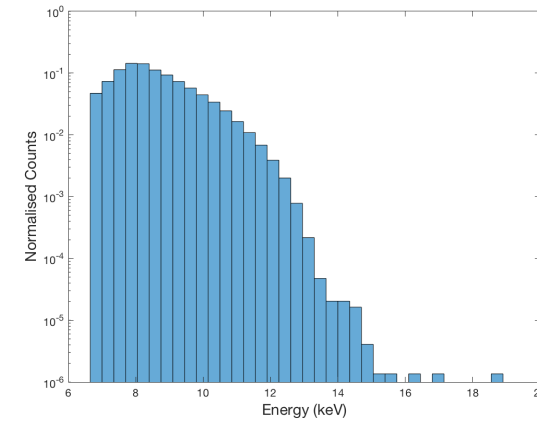
15 keV



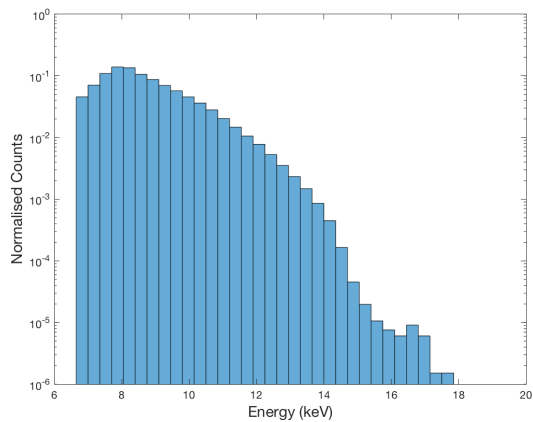
20 keV



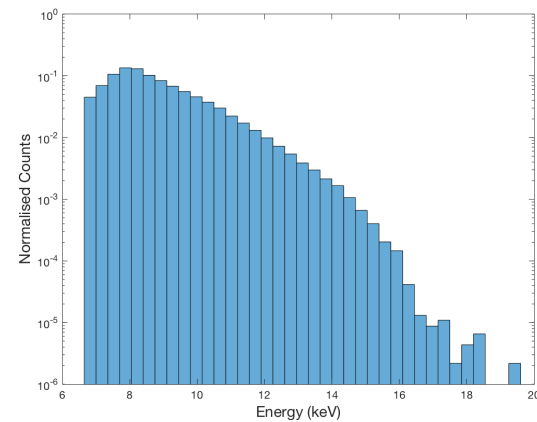
25 keV



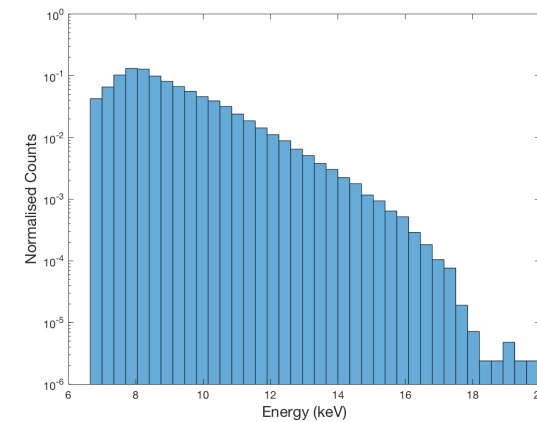
30 keV



35 keV

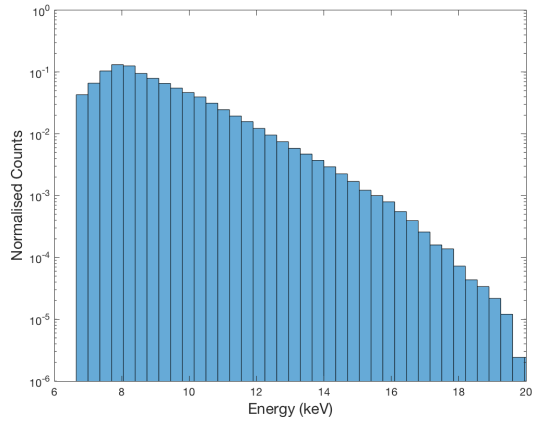


40 keV

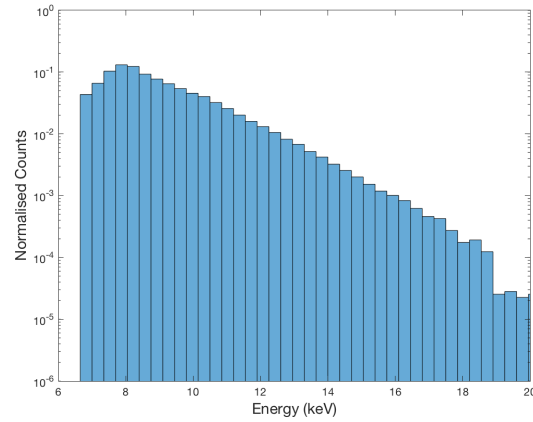


Energy spectra

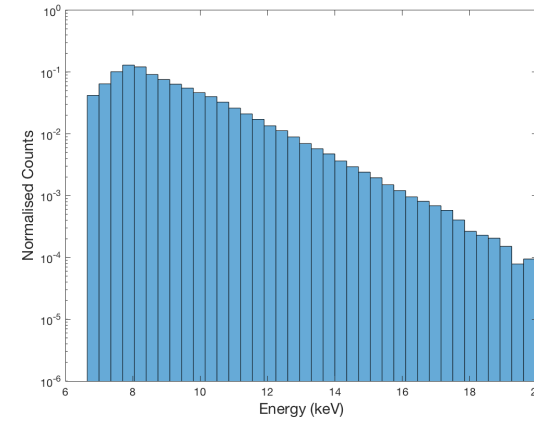
45 keV



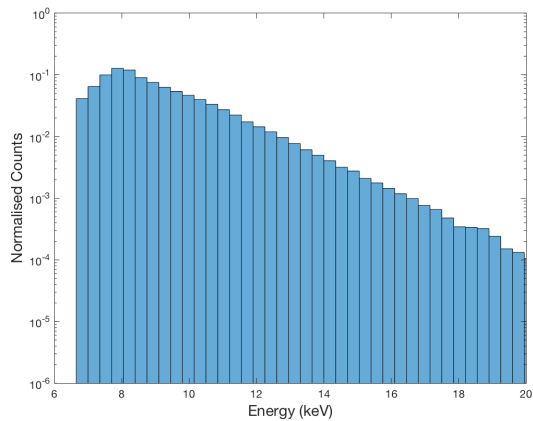
50 keV



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