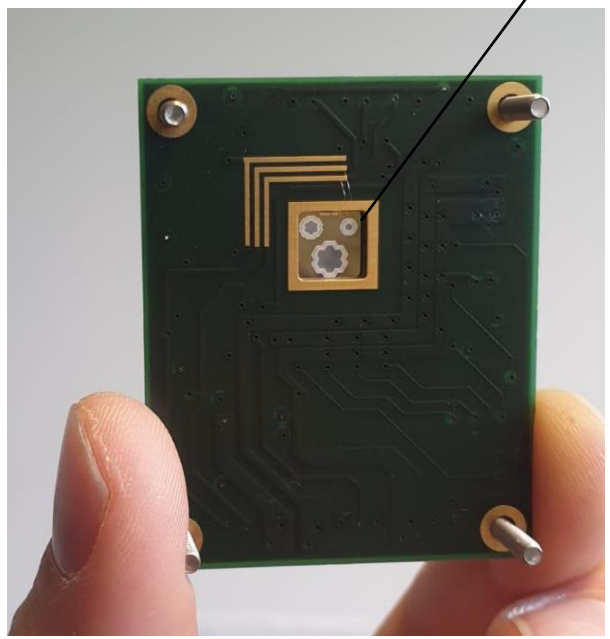
Technical University of Munich
Department for Physics

TRISTAN Radiation Damage Test Status

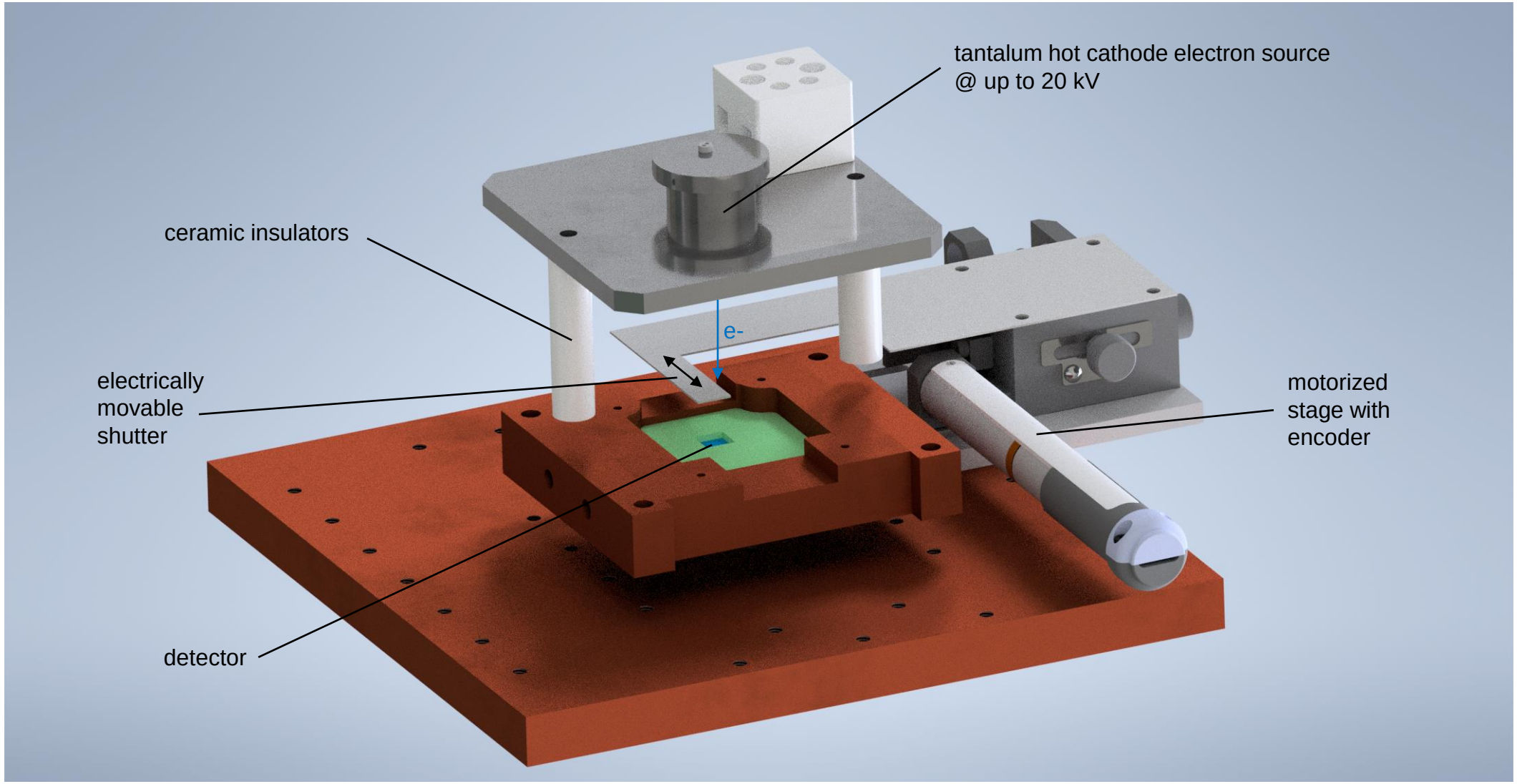
TRISTAN workshop 2022 – Karlsruhe

Idea

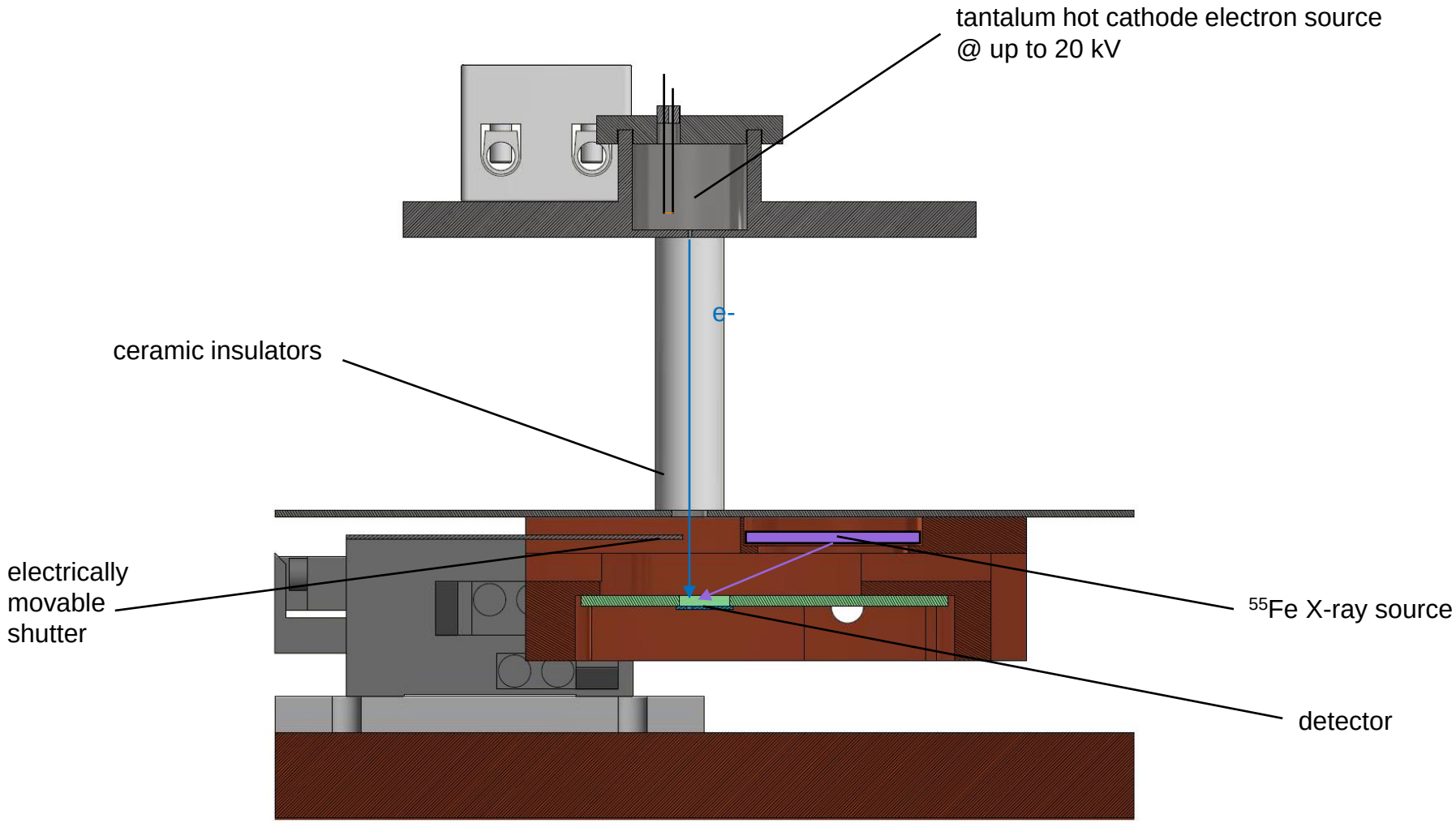
- shoot 10^{11} electrons per pixel on a detector and compare performance
- detector: same geometry as FBM
- how to measure small change in detector performance?
  → only illuminate half of the detector



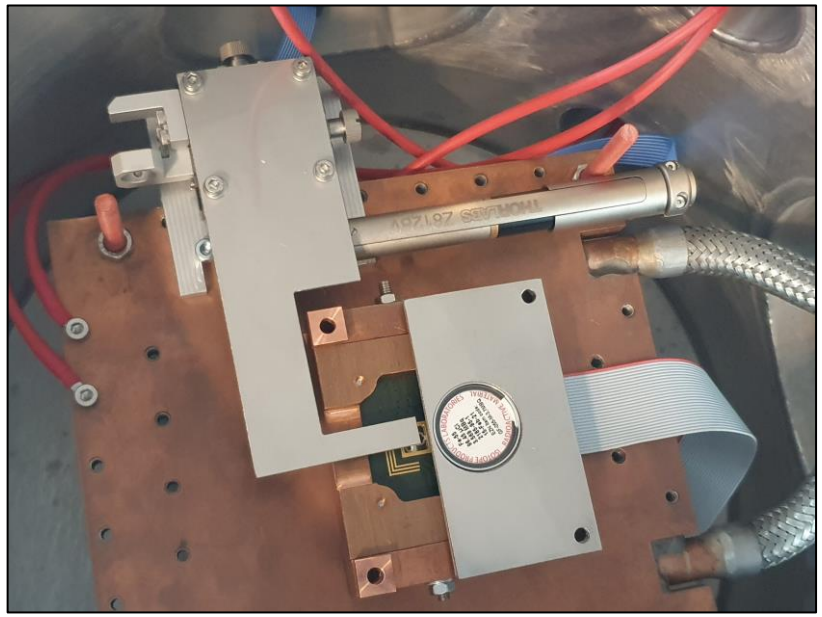
Radiation damage test setup (THC setup)

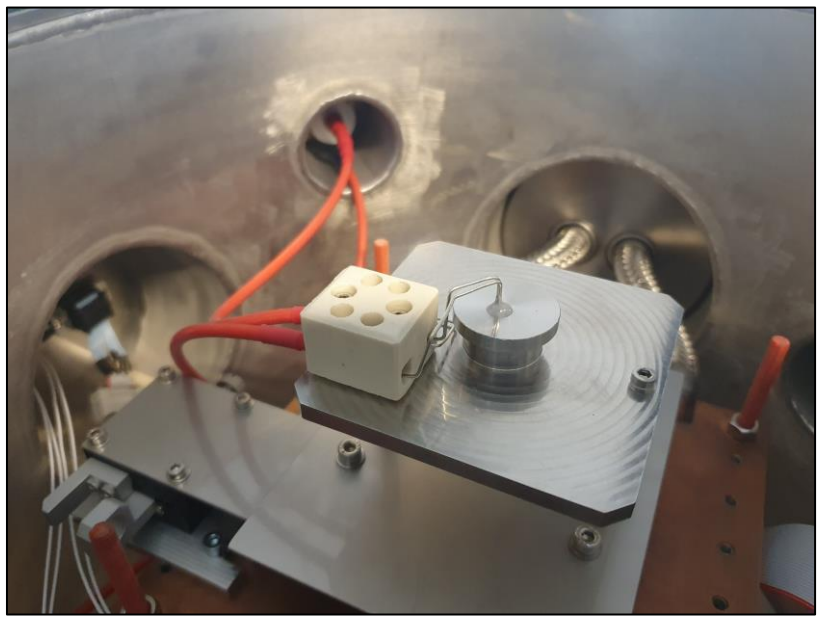


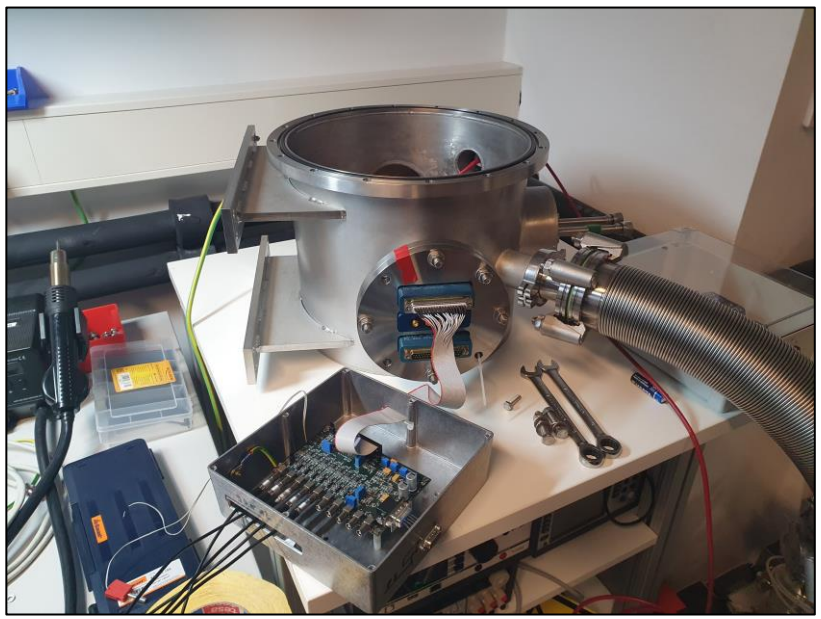
Radiation damage test setup (THC setup)

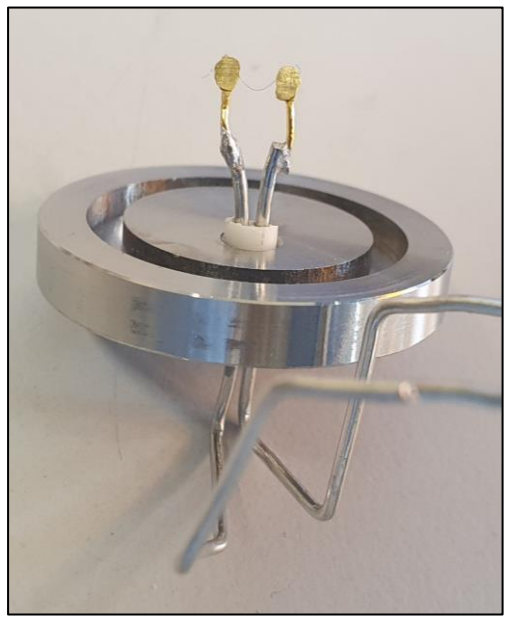


Some pictures

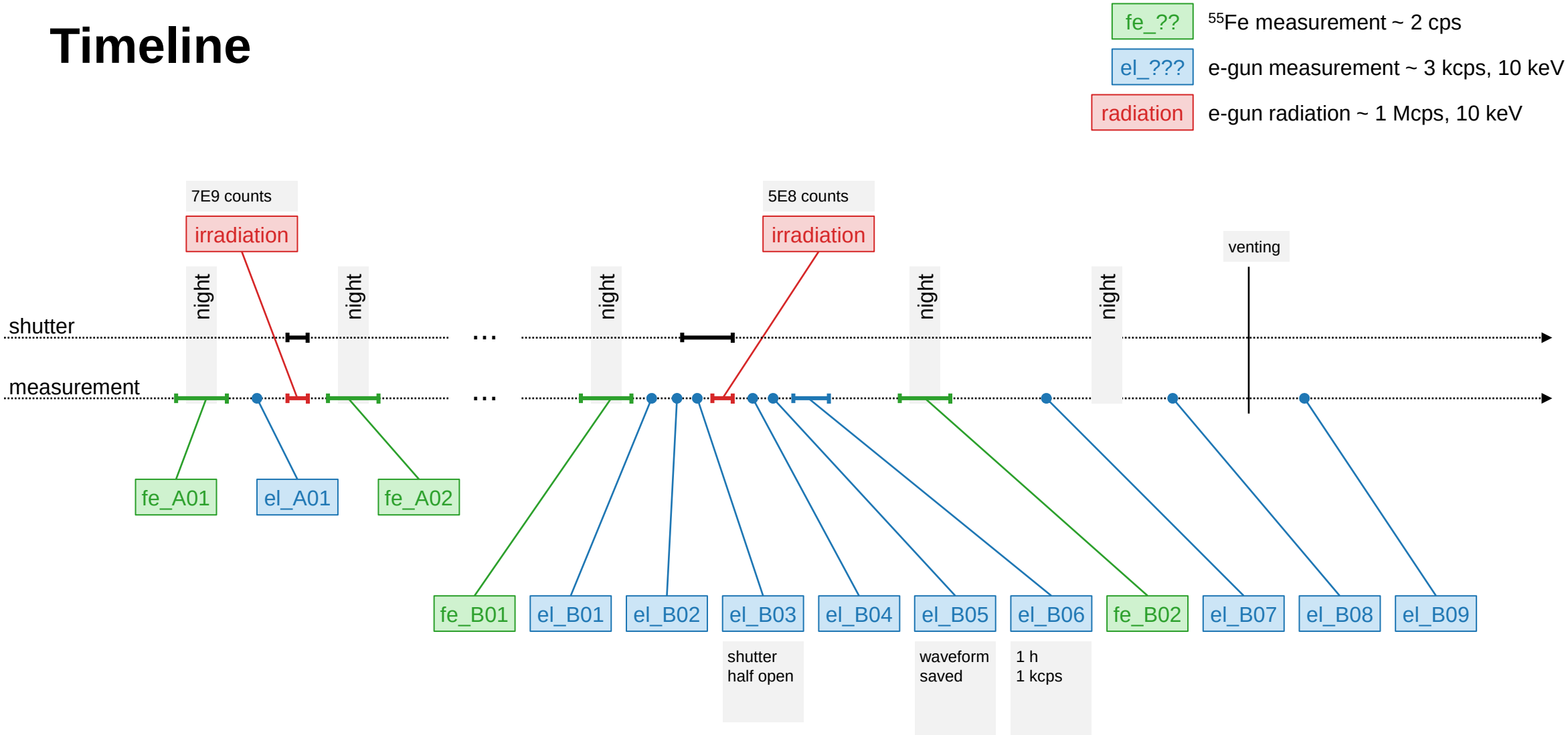




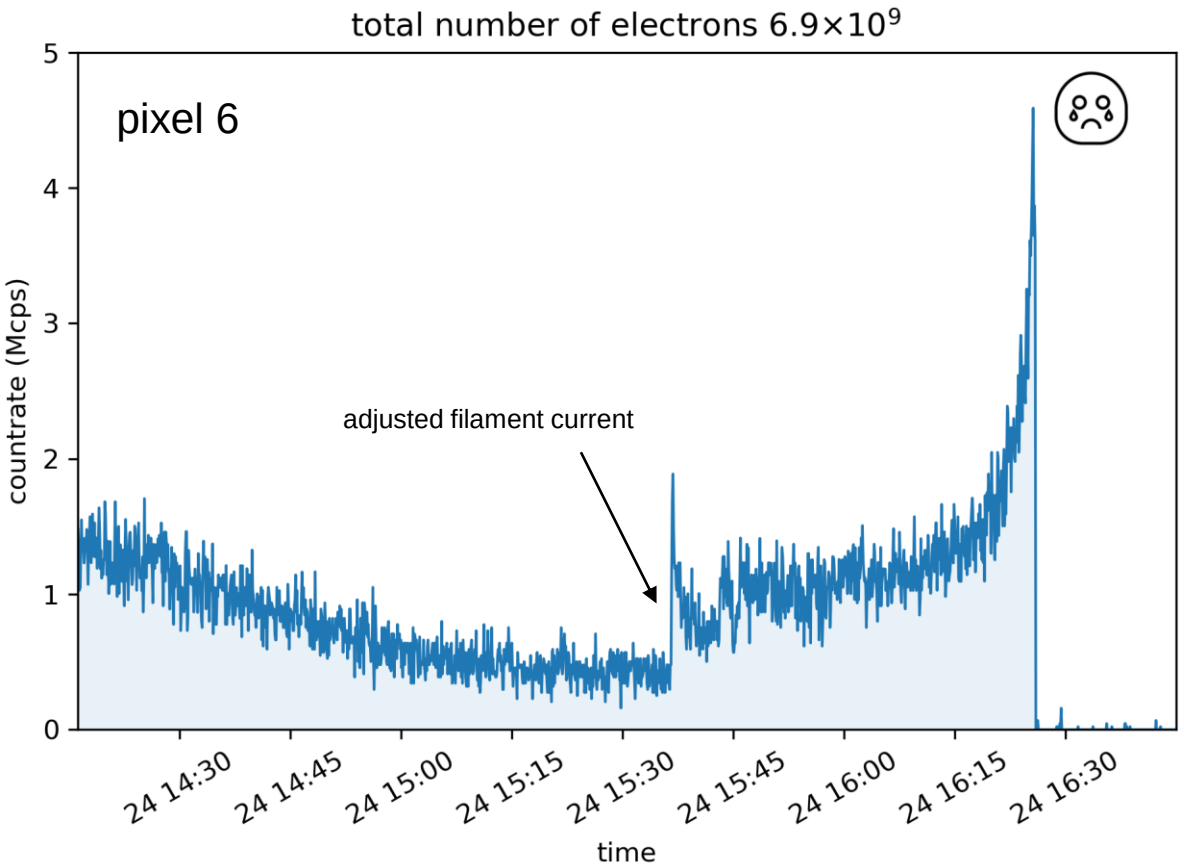


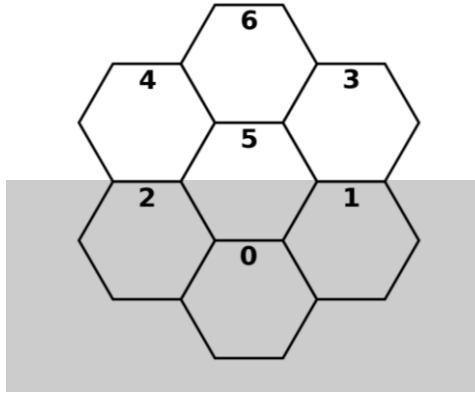


Timeline


fe_??
^{55}Fe measurement ~ 2 cps
el_???
e-gun measurement ~ 3 kcps, 10 keV
radiation
e-gun radiation ~ 1 Mcps, 10 keV
7E9 counts
irradiation
night
night
5E8 counts
irradiation
night
night
night
venting
shutter
measurement
fe_A01
el_A01
fe_A02
fe_B01
el_B01
el_B02
el_B03
el_B04
el_B05
el_B06
fe_B02
el_B07
el_B08
el_B09
shutter half open
waveform saved
1 h
1 kcps

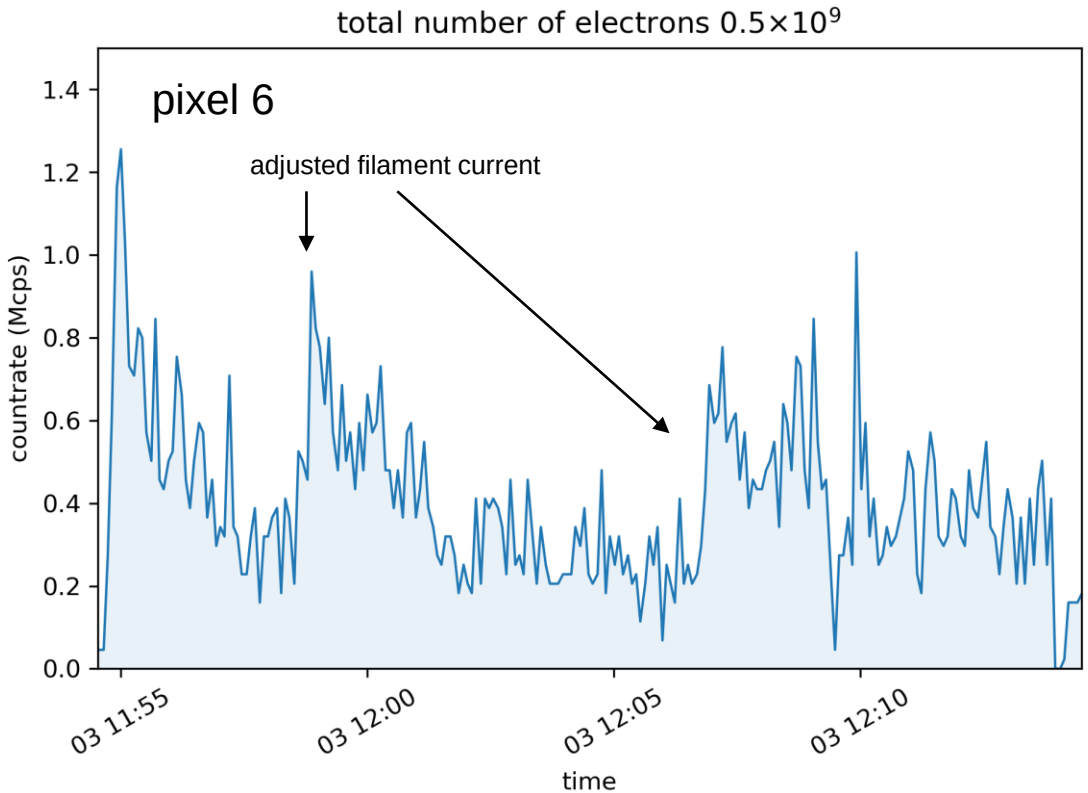
Irradiation #1

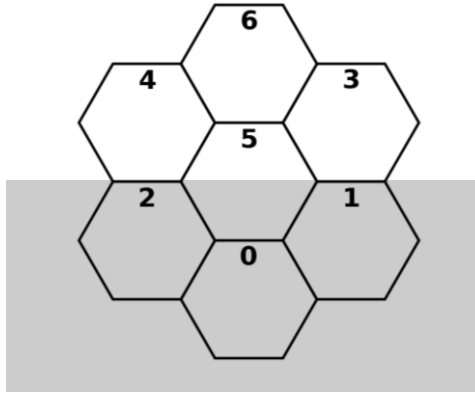




- shutter in half-open position, HV at 10 kV
- total ~7E9 electrons

Irradiation #2



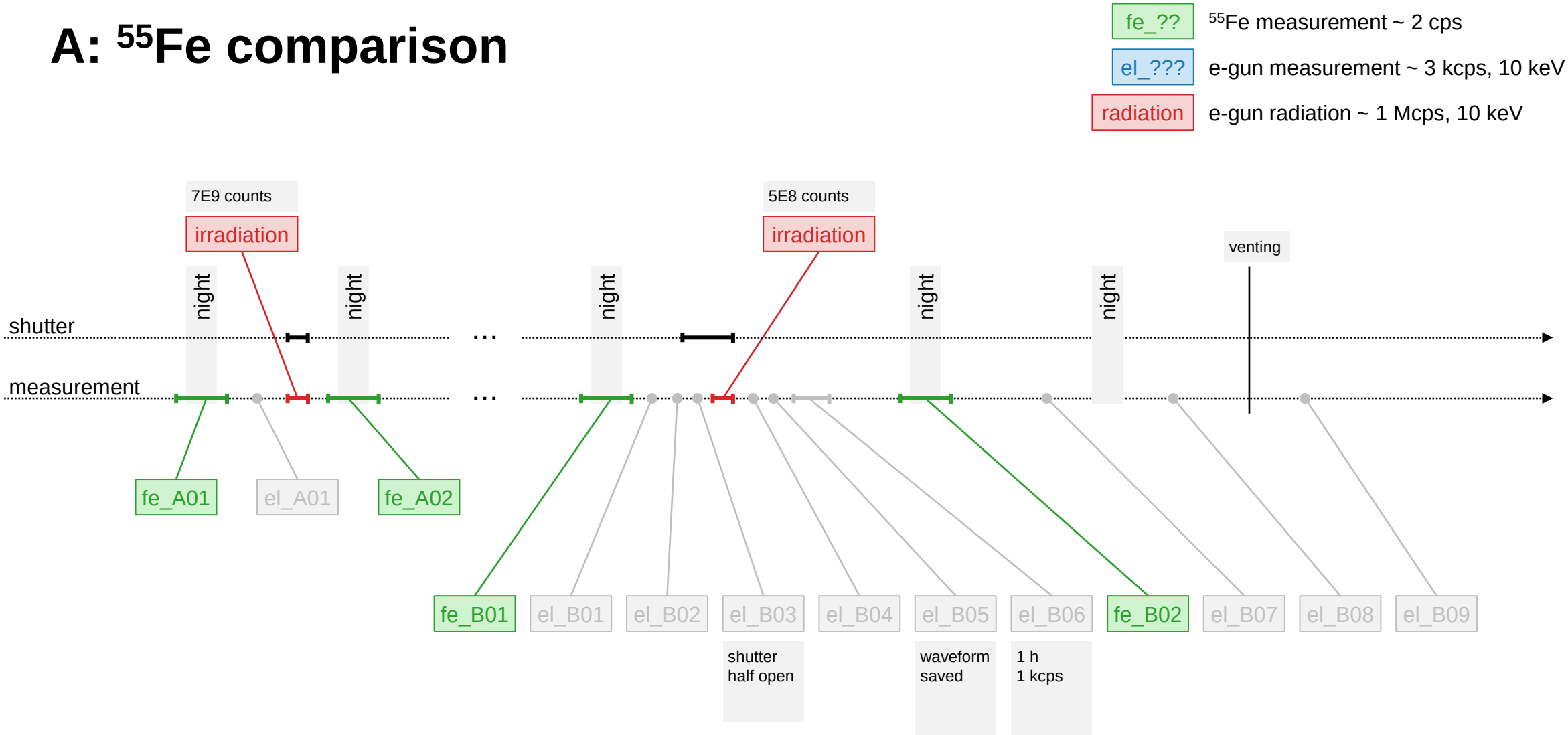


- shutter in half-open position, HV at 10 kV
- total ~0.5E9 electrons

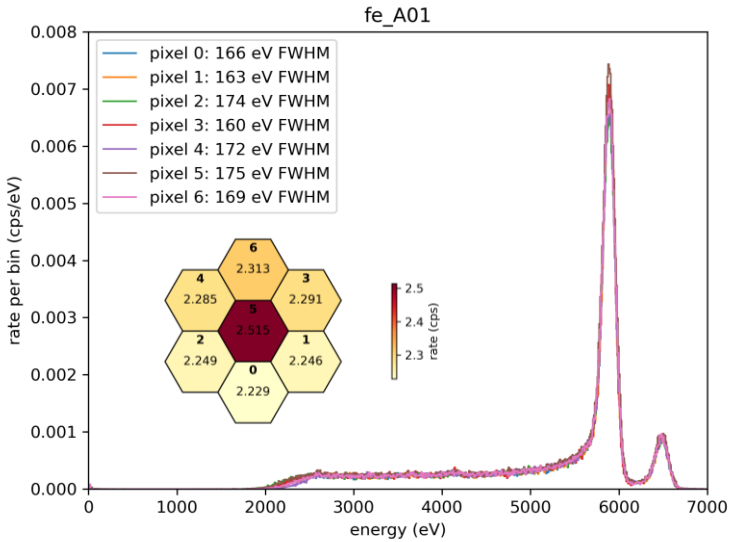
Data comparison

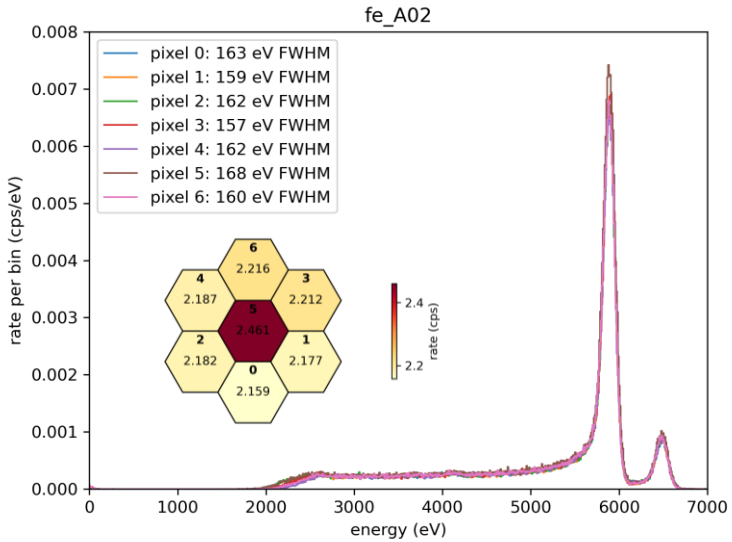
- A: ^{55}Fe comparison
- B: Electron shape comparison
- C: Electron rate comparison

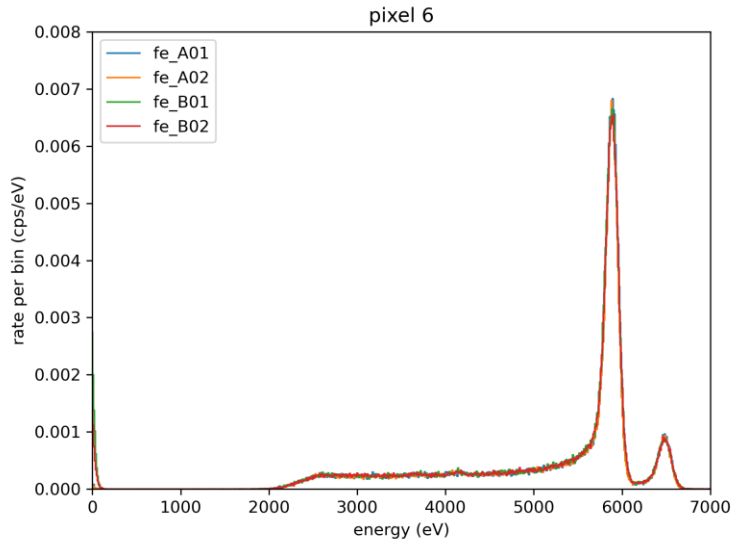
A: ^{55}Fe comparison

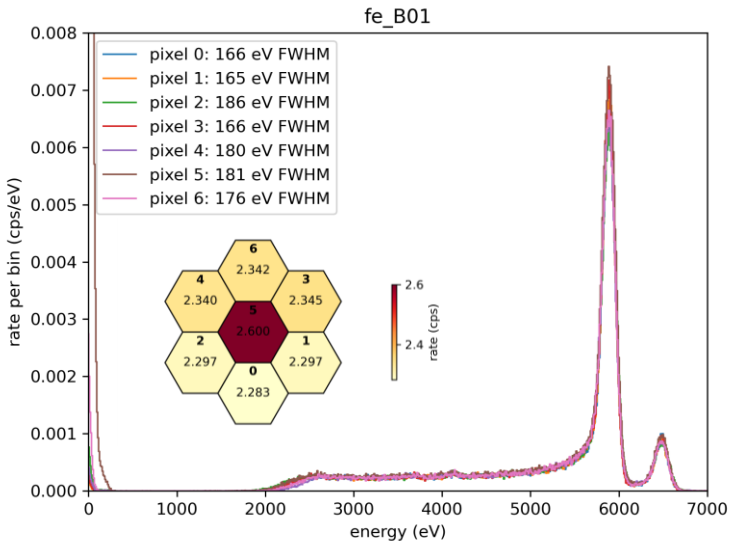


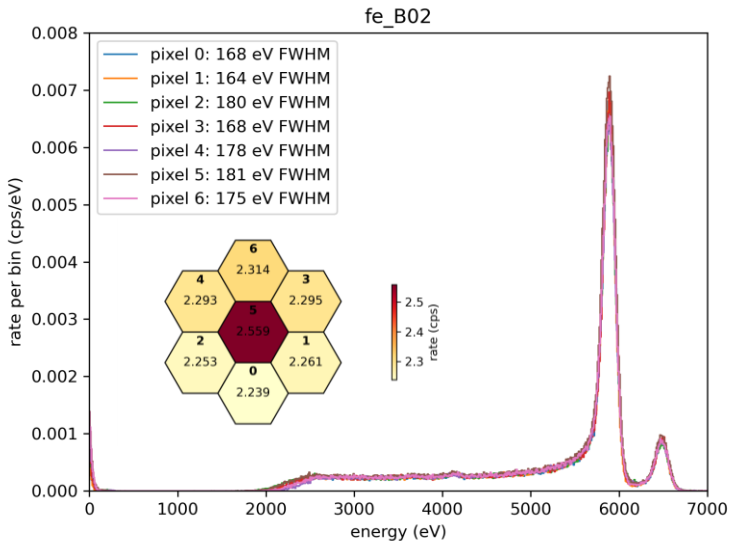
Spectra





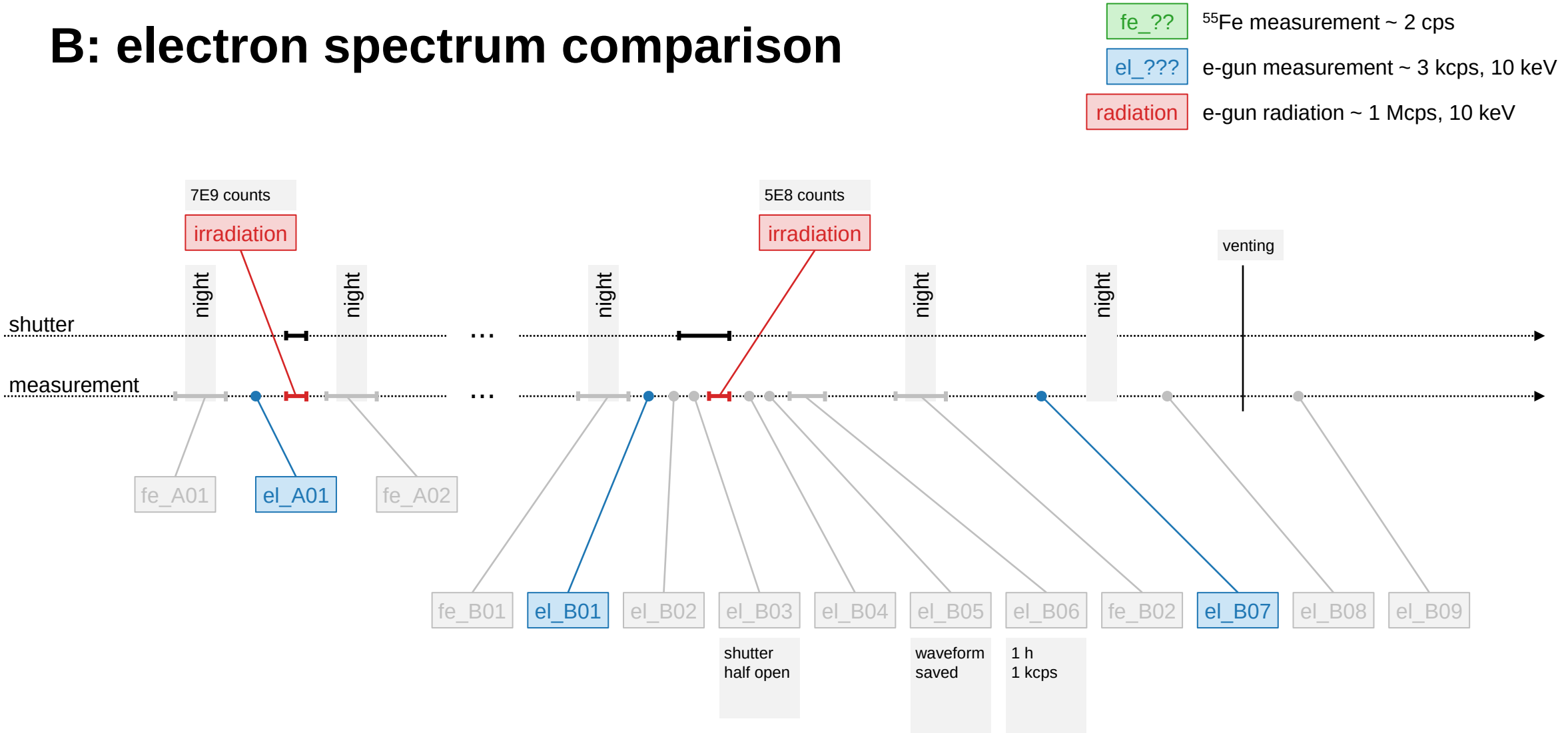




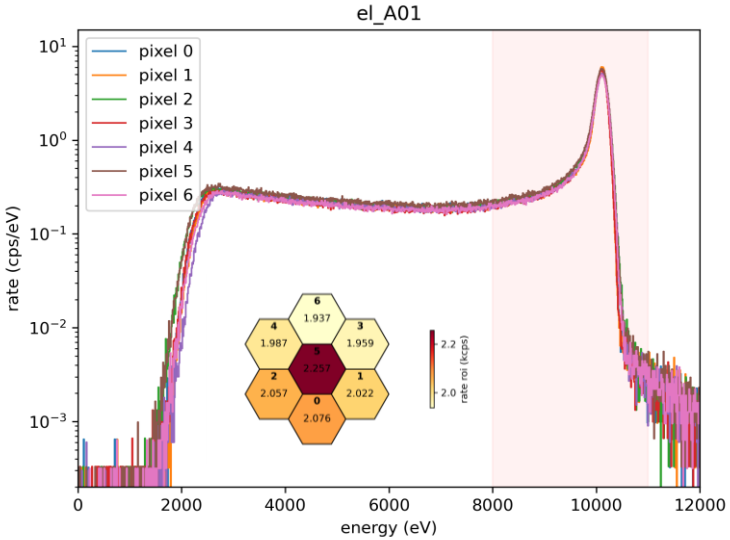


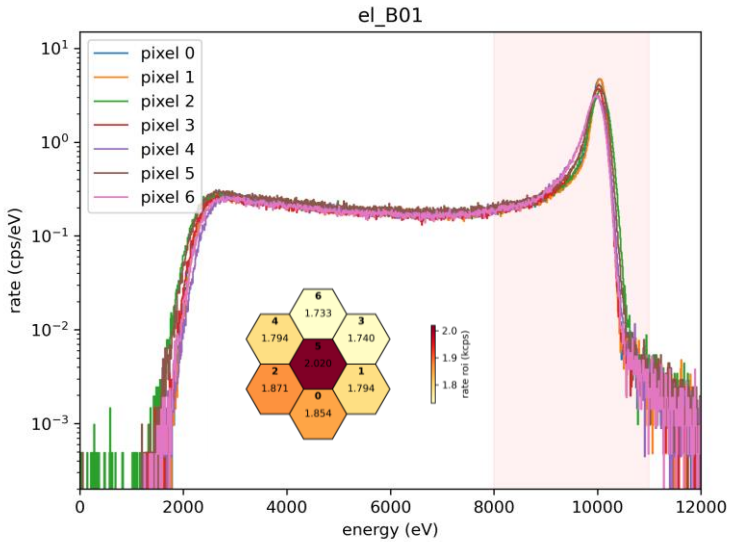
- ^{55}Fe measurements look consistent
- no significant degradation found

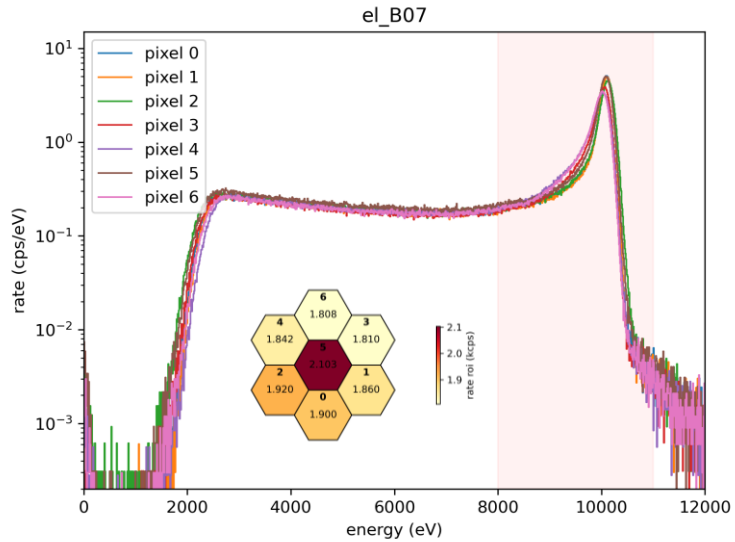
B: electron spectrum comparison

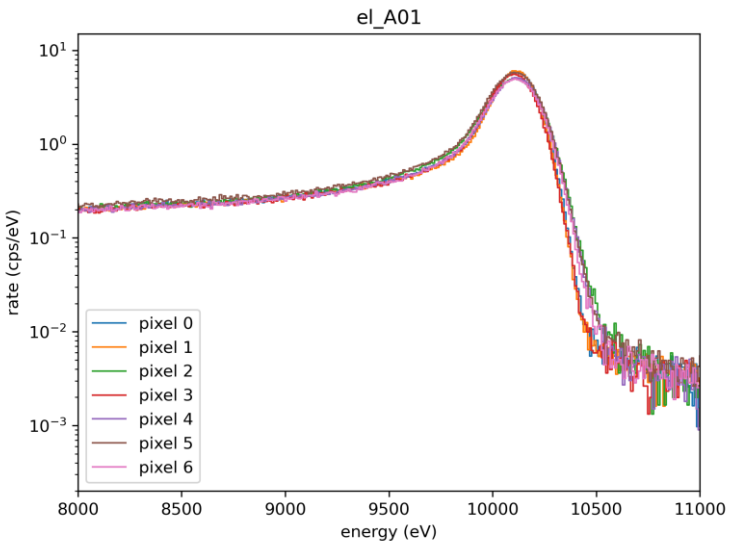


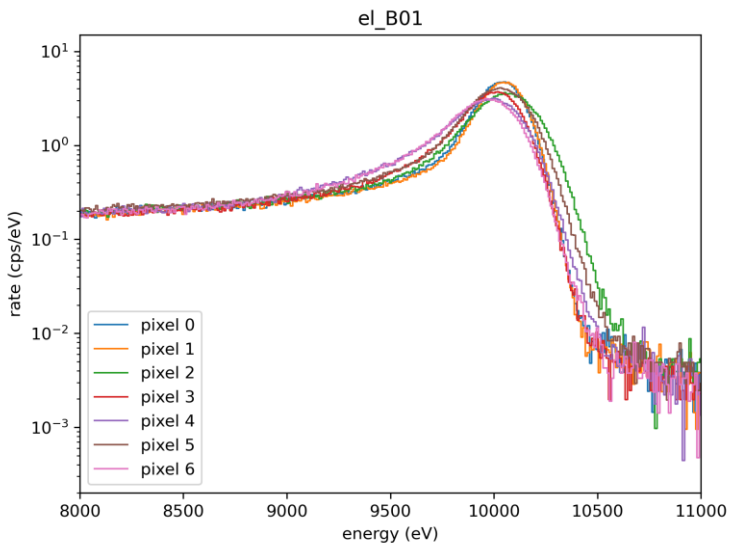
Spectra

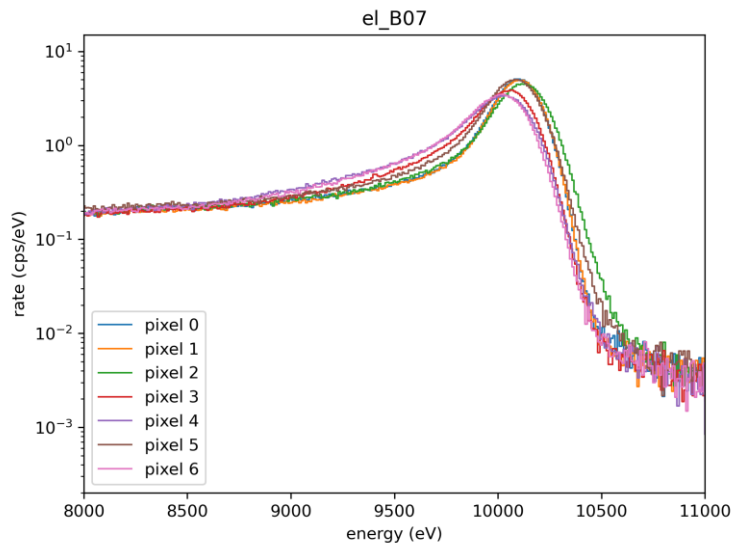

el_A01
pixel 0
pixel 1
pixel 2
pixel 3
pixel 4
pixel 5
pixel 6
rate (cps/eV)
energy (eV)
rate roi (kcps)


el_B01
pixel 0
pixel 1
pixel 2
pixel 3
pixel 4
pixel 5
pixel 6
rate (cps/eV)
energy (eV)
rate roi (kcps)

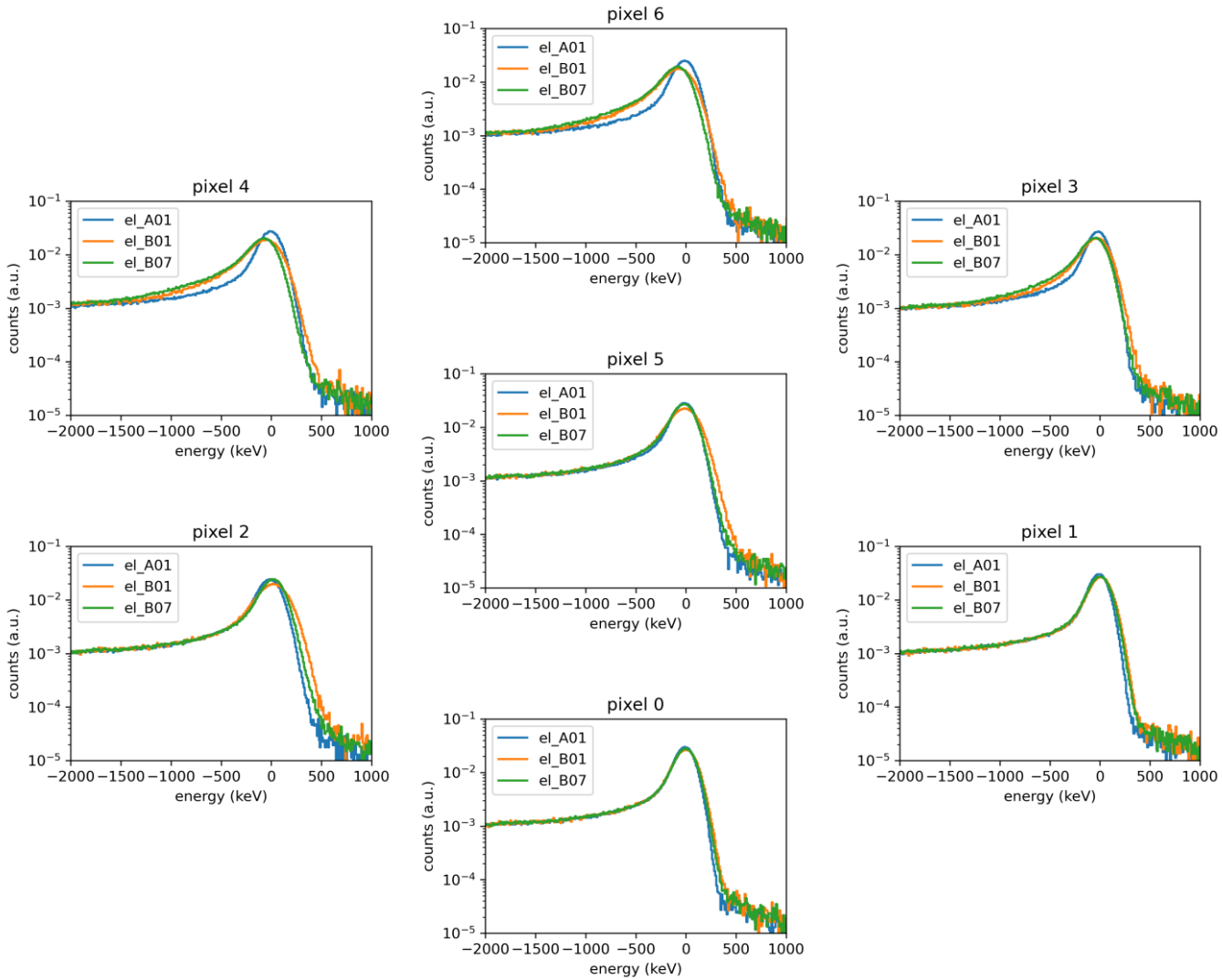

el_B07
pixel 0
pixel 1
pixel 2
pixel 3
pixel 4
pixel 5
pixel 6
rate (cps/eV)
energy (eV)
rate roi (kcps)


el_A01
pixel 0
pixel 1
pixel 2
pixel 3
pixel 4
pixel 5
pixel 6
rate (cps/eV)
energy (eV)


el_B01
pixel 0
pixel 1
pixel 2
pixel 3
pixel 4
pixel 5
pixel 6
rate (cps/eV)
energy (eV)


el_B07
pixel 0
pixel 1
pixel 2
pixel 3
pixel 4
pixel 5
pixel 6
rate (cps/eV)
energy (eV)

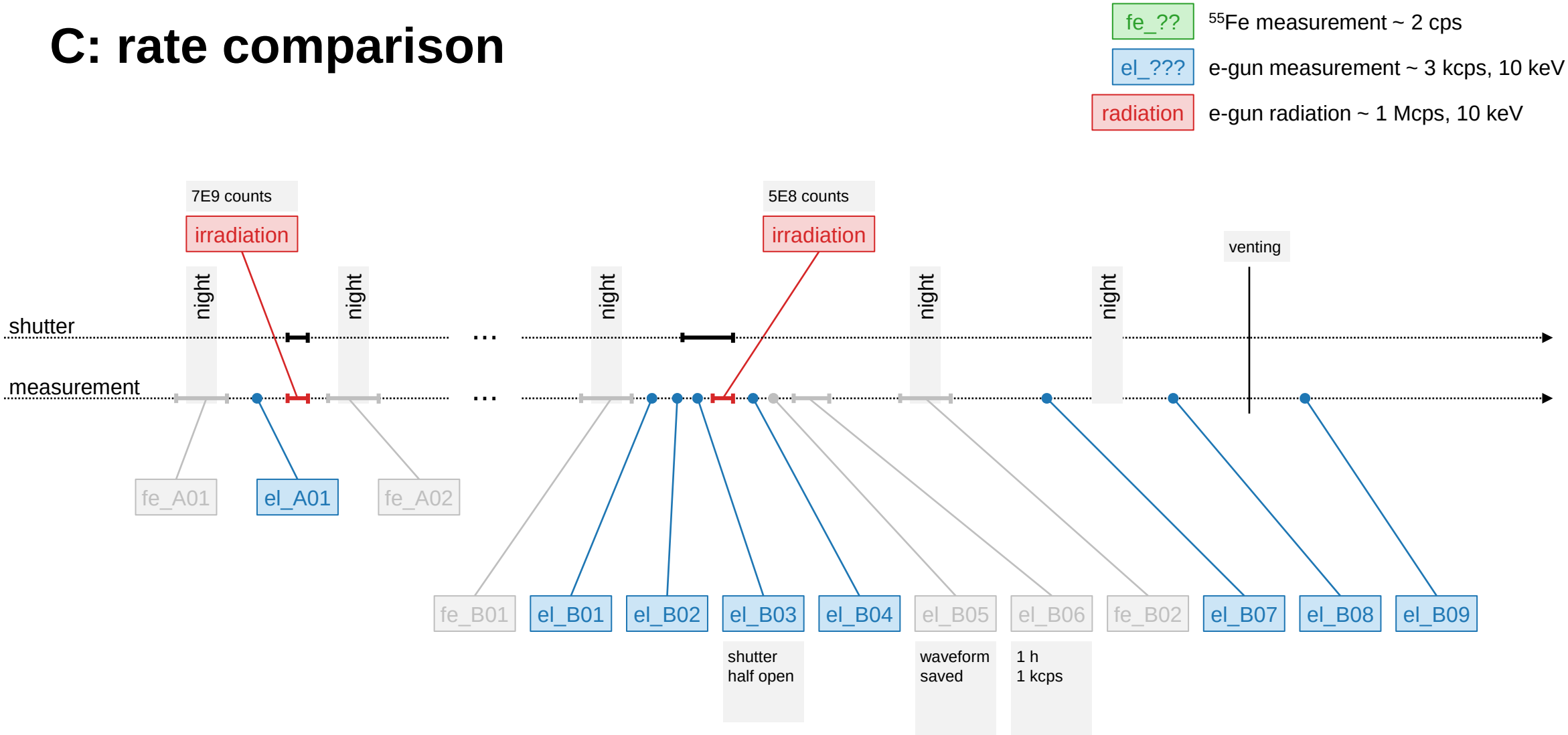
Spectra comparison



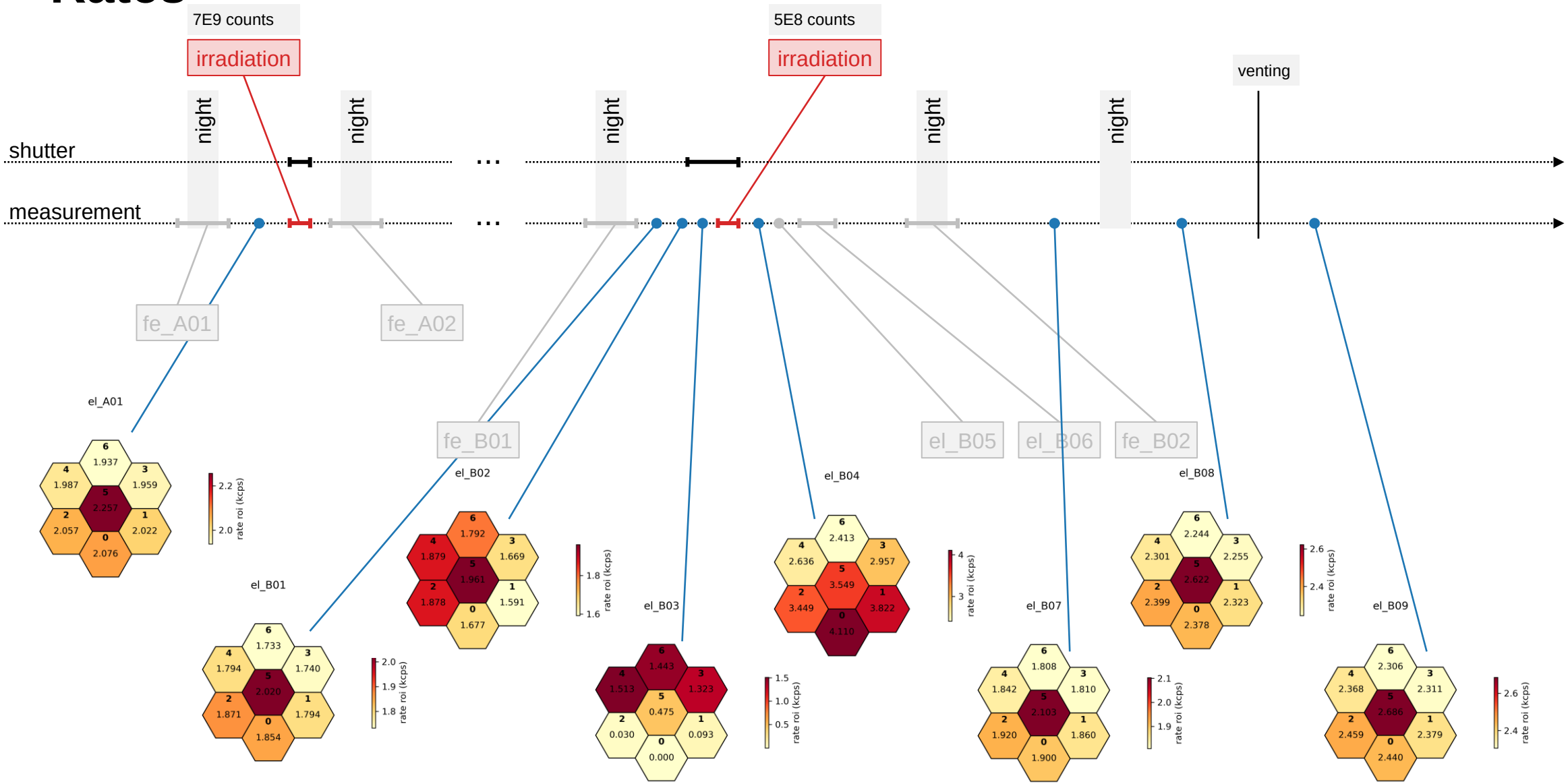
Conclusions (spectra comparison)

- there is a clear shape distortion in the pixel not covered by the shutter
- looks like an increased dead layer
- possible origins:
  - radiation damage?
  - (ballistic) tantalum deposition when filament burnt through?

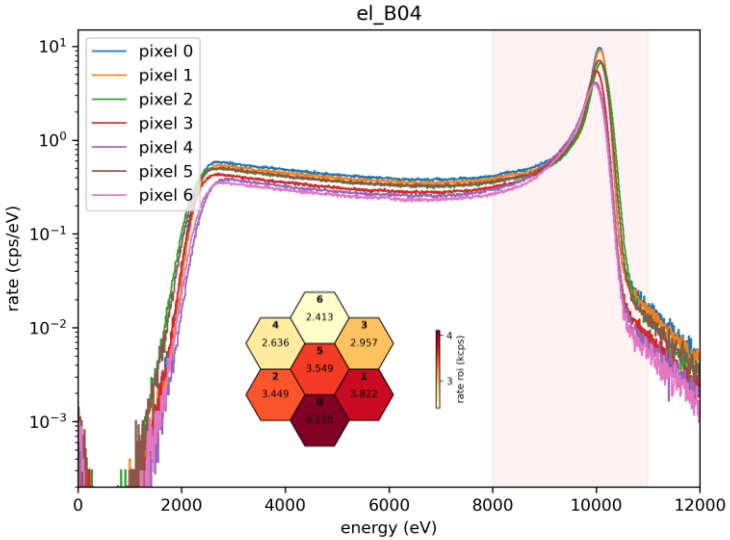
C: rate comparison

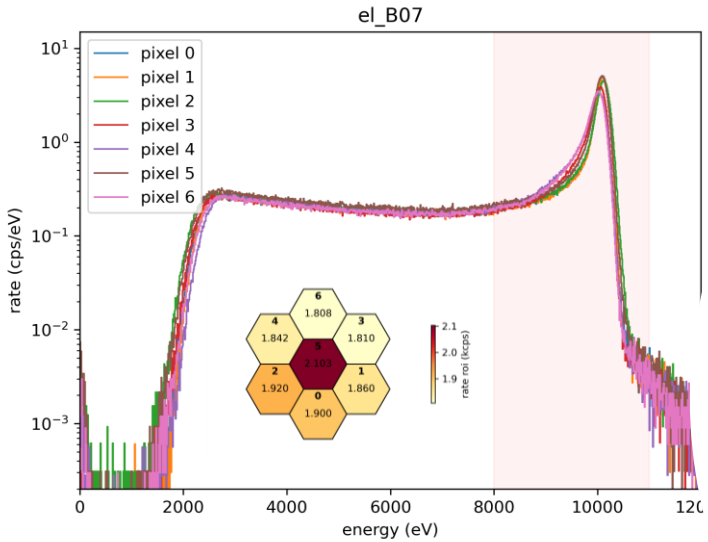


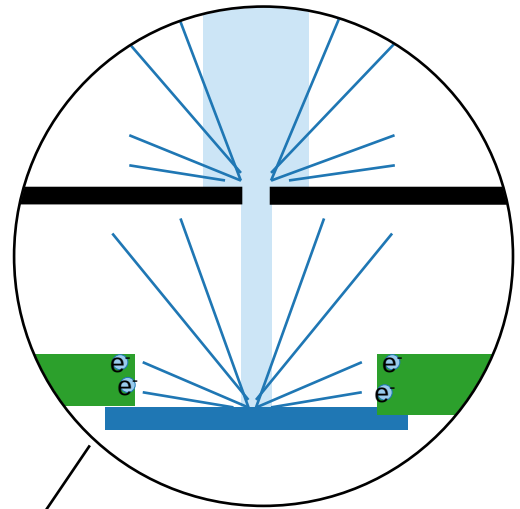
Rates


7E9 counts
irradiation
5E8 counts
irradiation
venting
night
night
night
night
night
shutter
measurement
fe_A01
fe_A02
fe_B01
el_B05
el_B06
fe_B02
el_A01
el_B01
el_B02
el_B03
el_B04
el_B07
el_B08
el_B09
rate roi (kcps)

Example spectra







Conclusions (rate comparison)

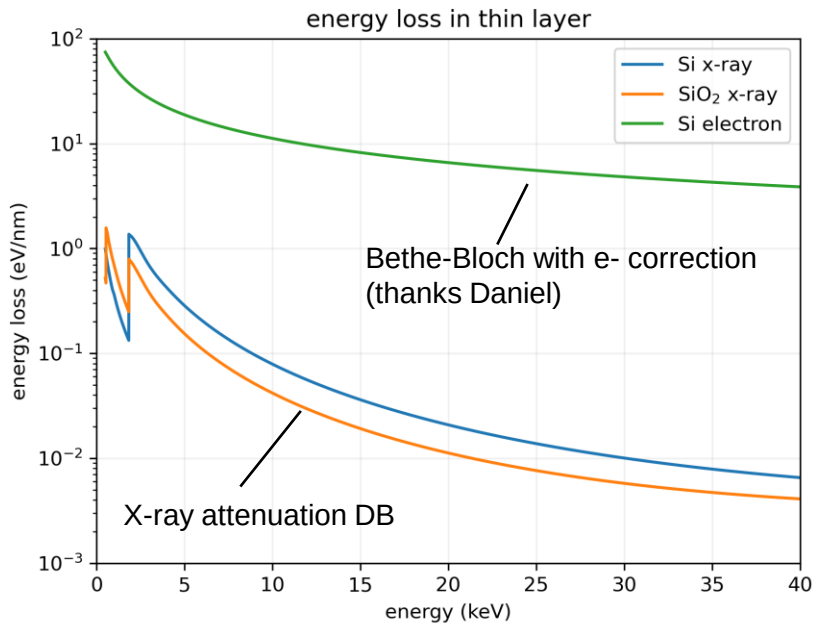
- there is an effect of the high rate irradiation on the homogeneity of the rate
- effect gets restored within hours
- possible origins:
  - degradation of detector?
  - **deflection of e-gun beam due to charge-up close to the beam?**

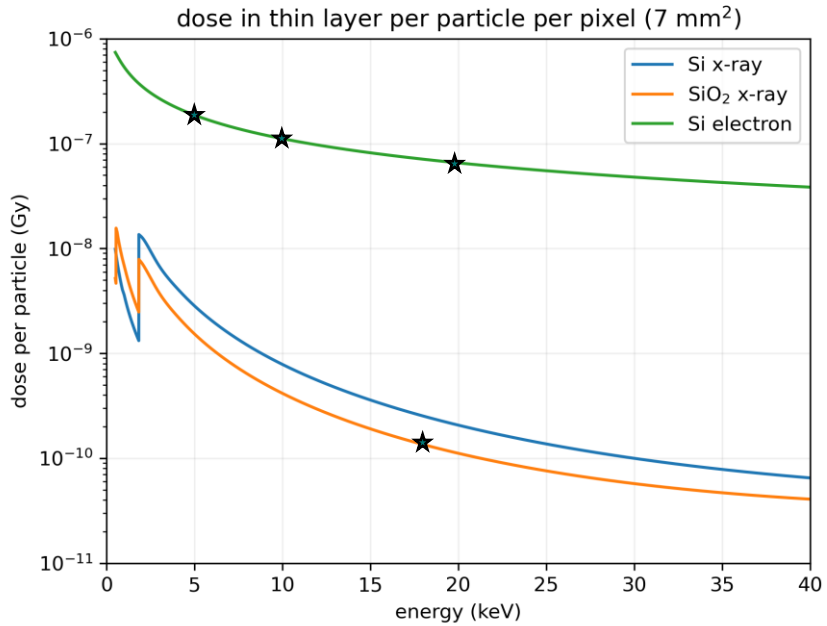
Conclusions

- no degradation observed for X-rays
- two effects observed for electrons:
  1. durable change of response shape (similar to increased dead layer)
     - layer on top (from burn through of filament?) or
     - change of depletion?
  2. non-durable loss of electron rate directly after radiation, vanished after one day
     - effect of detector or
     - electron beam deflection? (charge up of insulator in the setup)
- more measurements planned

Thanks for your attention!

Some dose calculations





3 years at 100 kcps

- Example final TRISTAN: 10E12 electrons (20 keV) on 7 mm² → **700 kGy** at the SiO2

1 years at 30 kcps

- Example KATRIN FBM: 1E12 electrons (5 keV) on 0.05 mm² → **30000 kGy** at the SiO2 slow rate drift observed
- Example THC damage test: 7E9 electrons (10keV) on 0.05 mm² → **100 kGy** at the SiO2