SupraThermal Electrons and Protons (STEP) on Solar Orbiter
- Trigger levels and iron detection -

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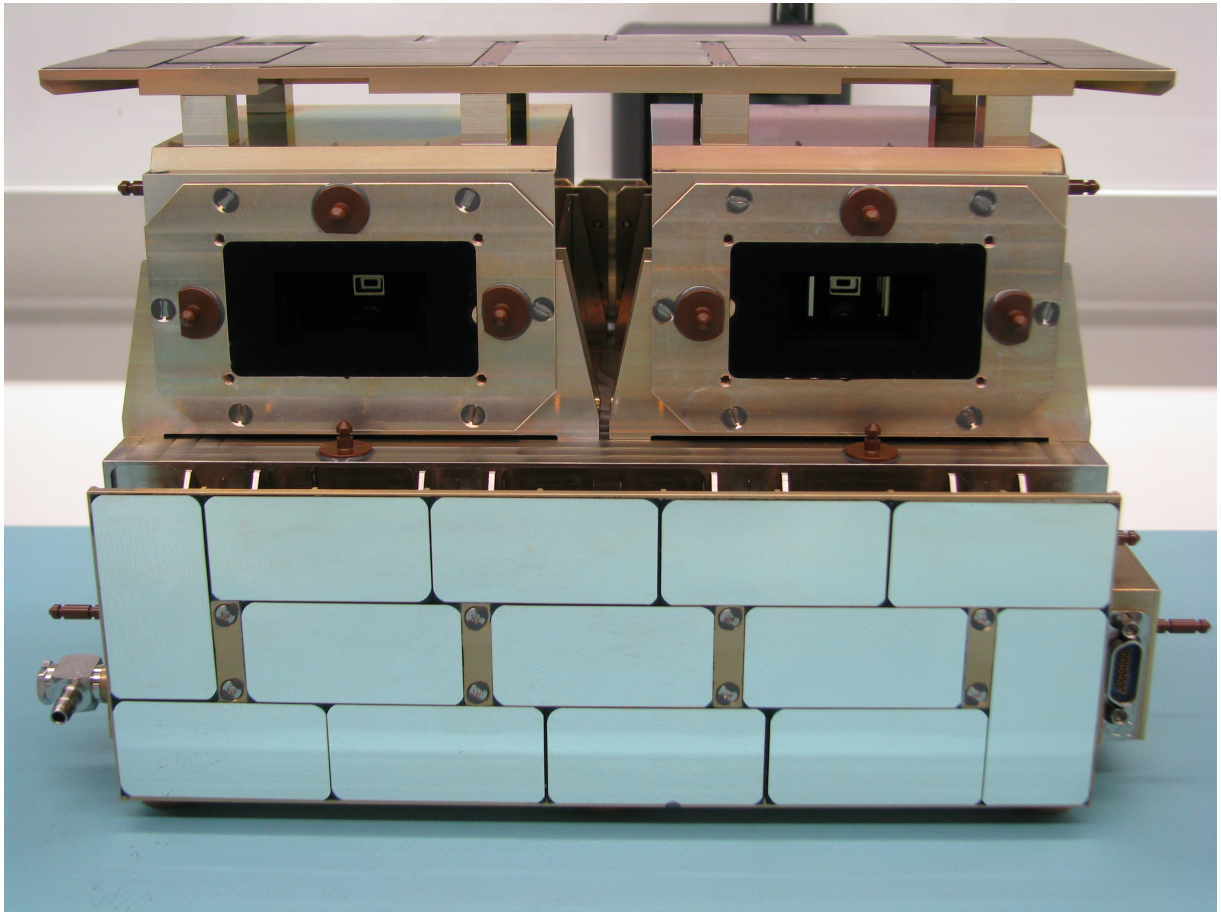
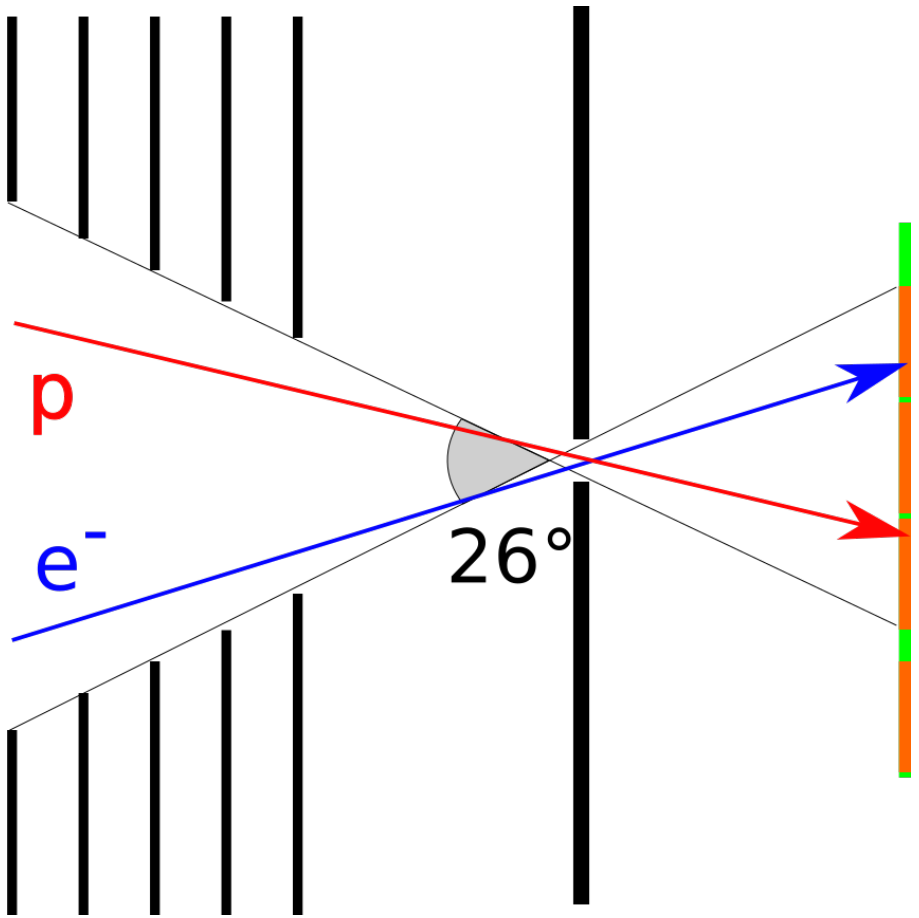
Outline

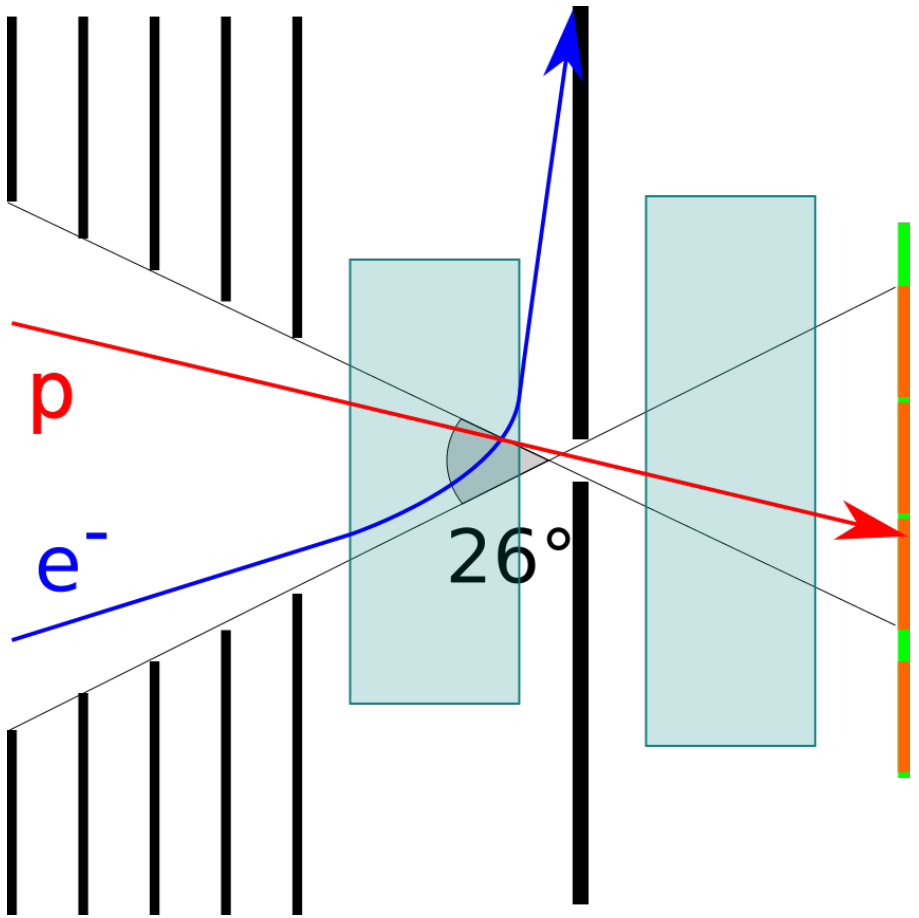
Reminder: STEP - Entrance system



Reminder: STEP - integral sensor head

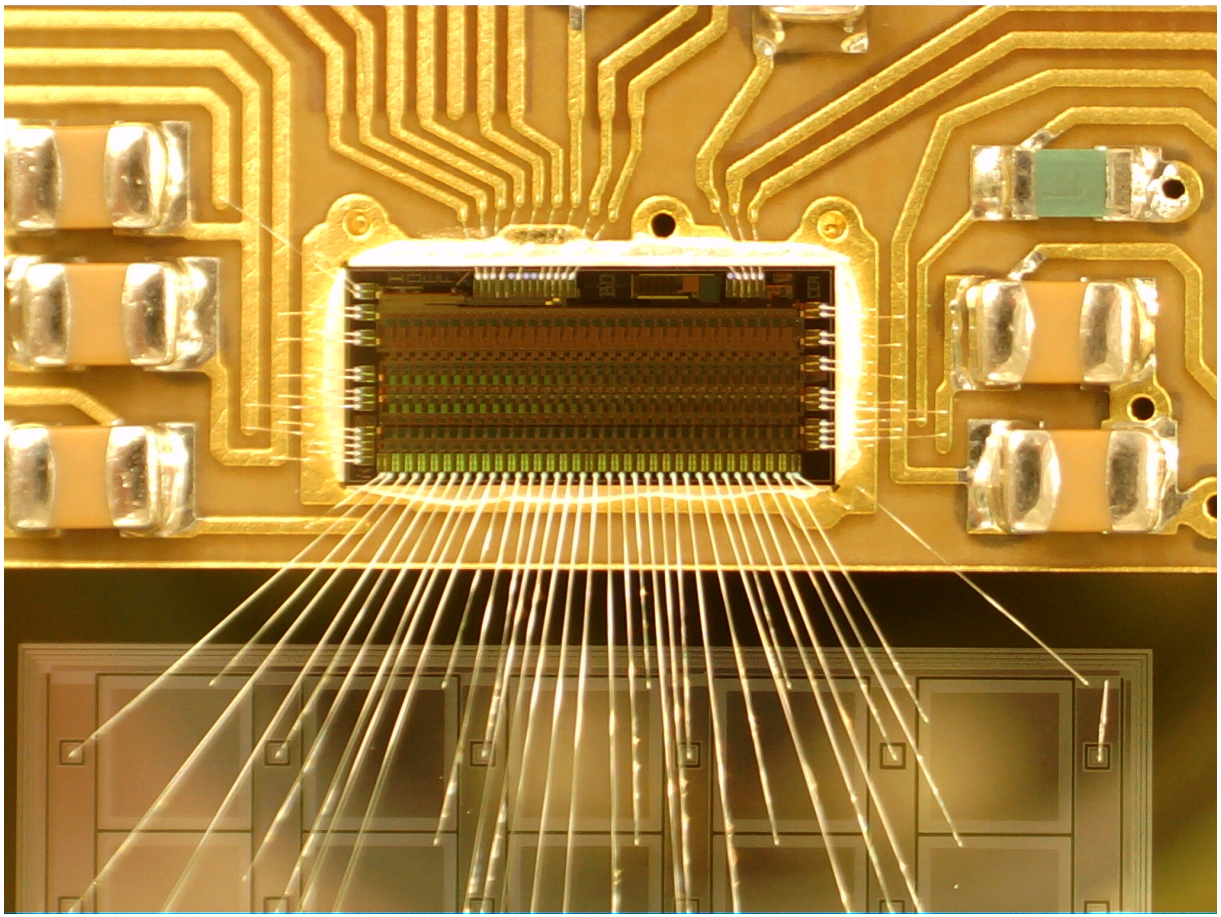


Reminder: STEP - magnet sensor head

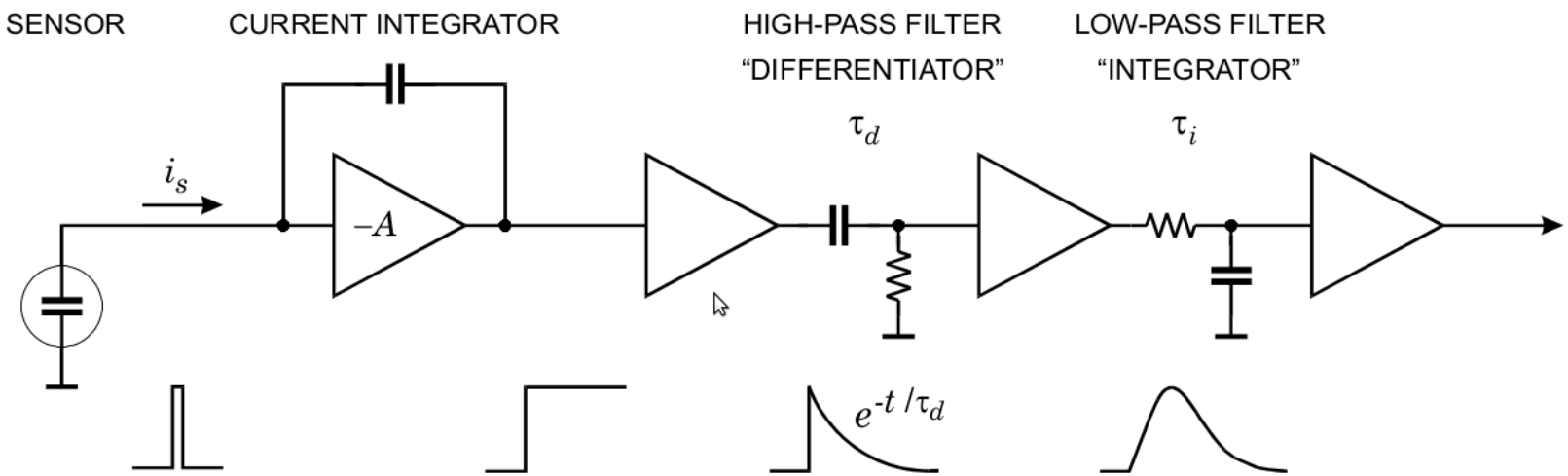


Level 1 trigger - ASIC

Detector pixels are bonded to Ide-Fx ASIC, which acts as charge-sensitive-amplifier, pulse shaper and our Level 1 trigger.

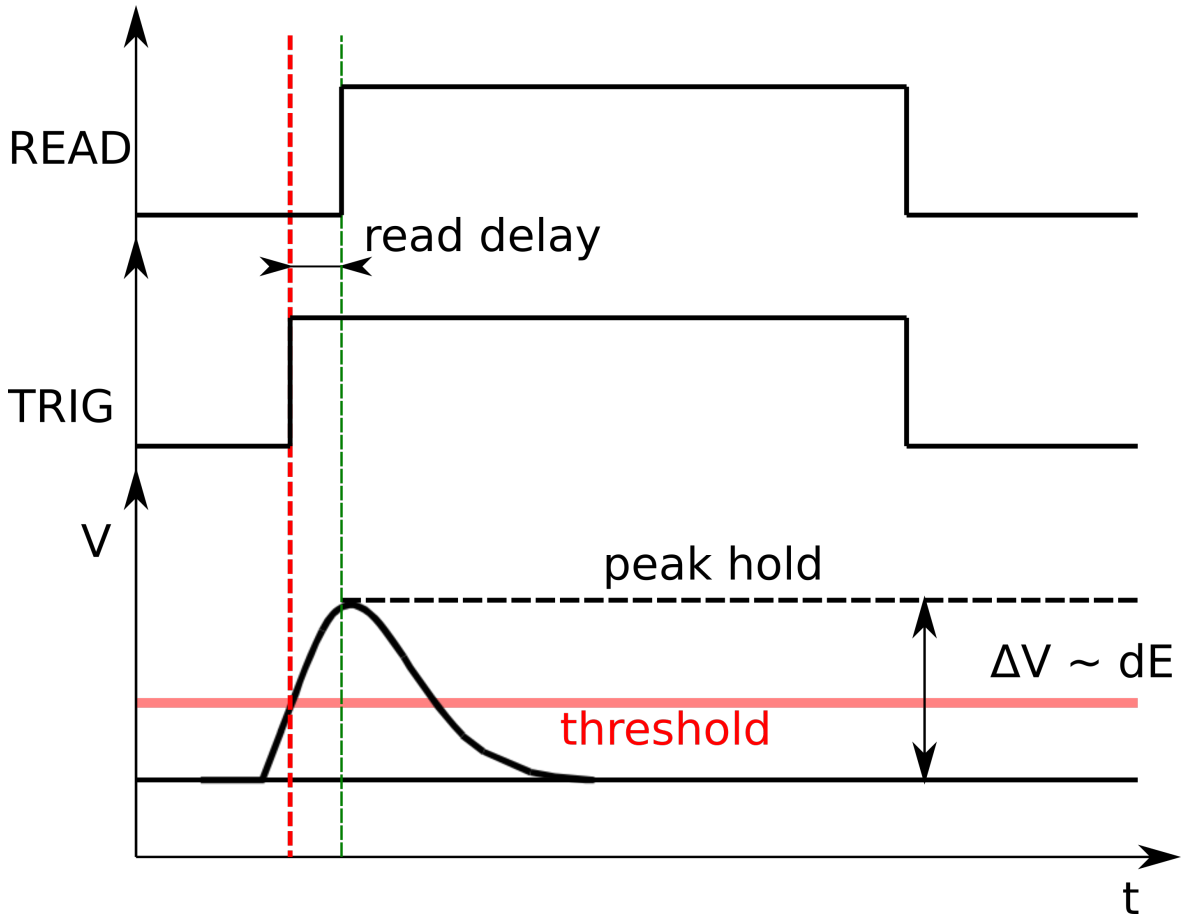


Level 1 trigger - Shaper principle



Basic pulse shaper principle [*Spieler - Semiconductor Detectors*]

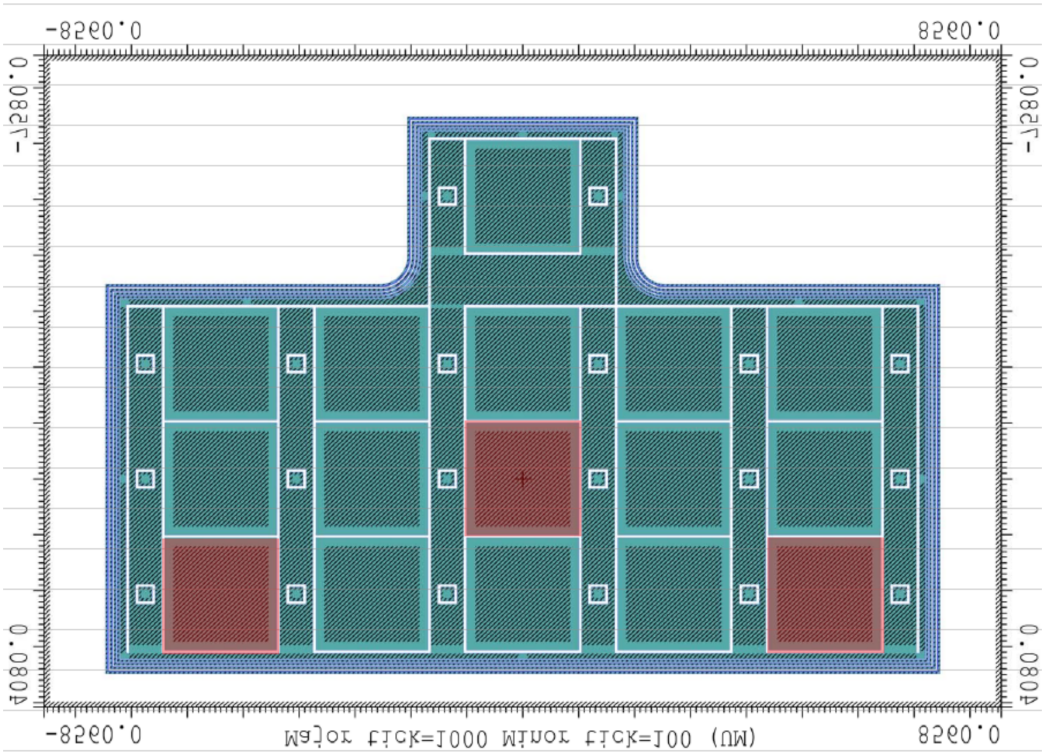
Level 1 trigger - Single pixel hit



Detection principle of a single pixel hit

Level 1 trigger - Results

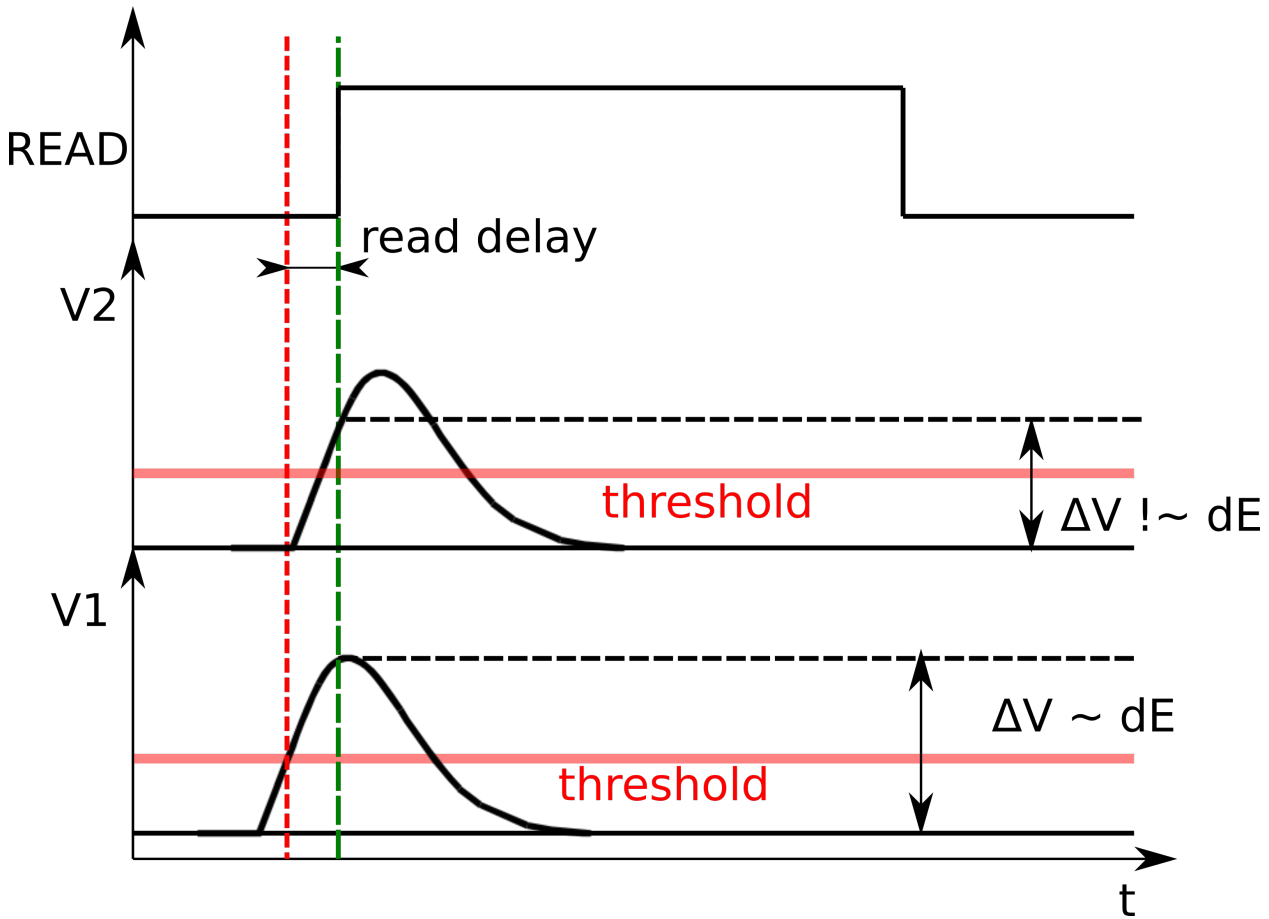
- Trigger mask: Digital 32 bit value of hit pixels
- Analog signal(s) proportional to energy loss in every hit pixels*



Trigger mask: 8, 11, 15

Level 1 trigger - * Caveat

In case of multiple hits, each of the hit pixel could have deficient energy loss:



Level 2 trigger

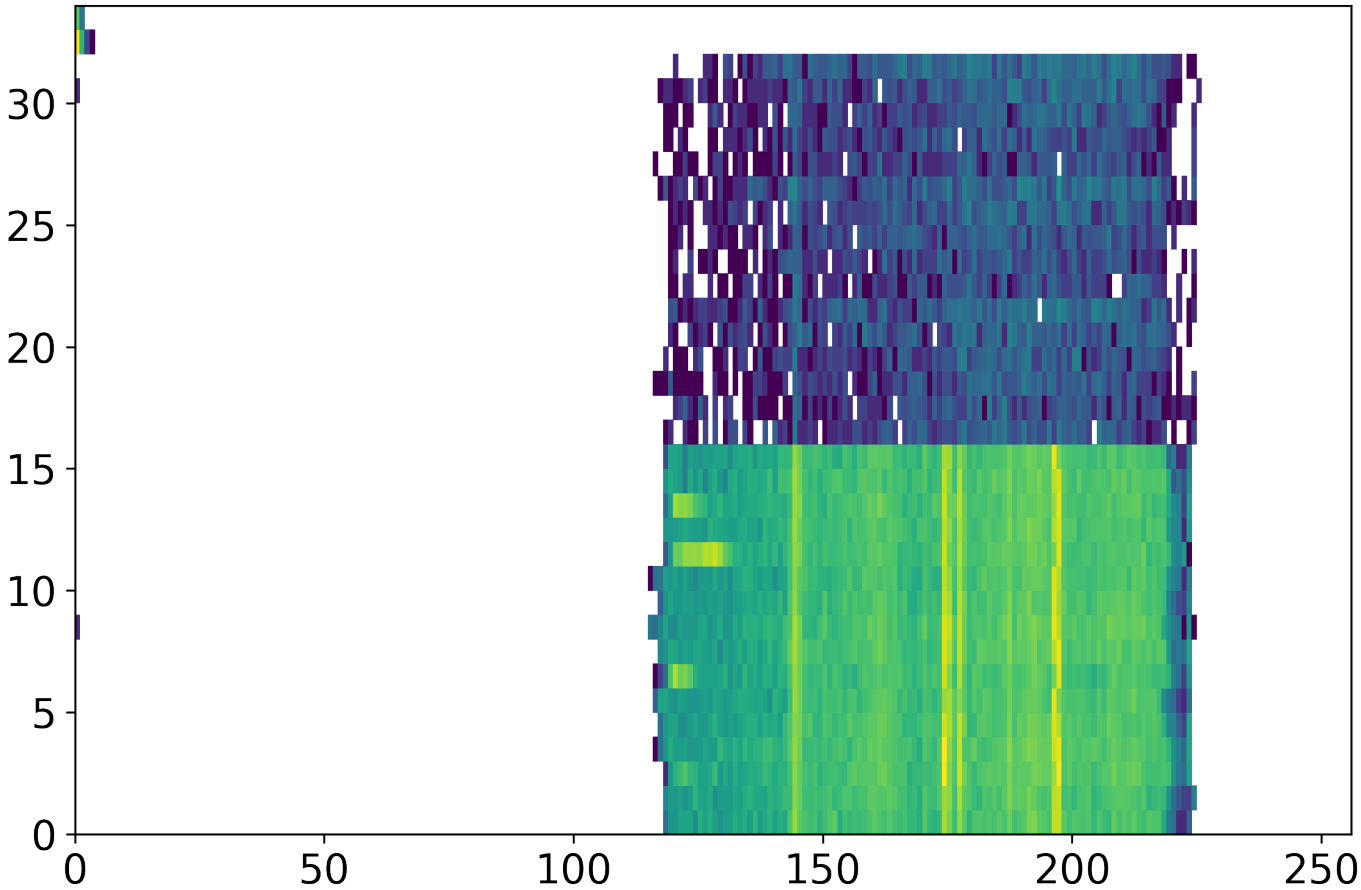
Level 2 trigger gets the hitmask and selects the appropriate Level 3 trigger to run:

Trigger class	Detector ID	No. of hits	Hist base address
0	0	1	0x4000
1	1	1	0x5000
2	0	≥ 2	0x6000
3	1	≥ 2	0x6100

Level 3 trigger

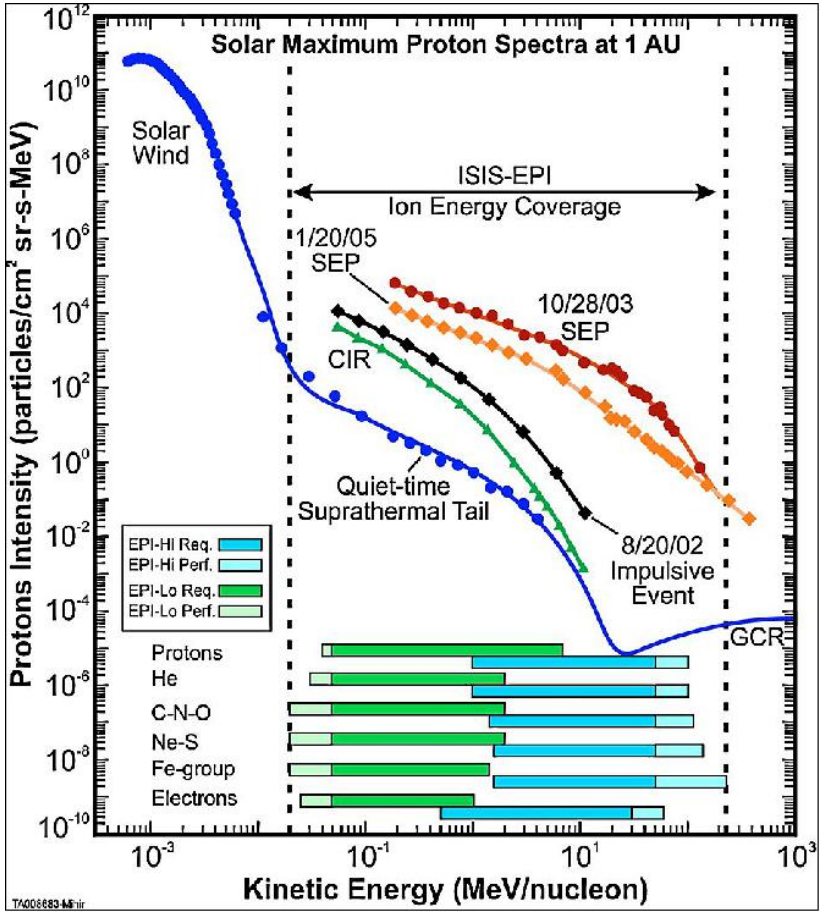
Demonstration on laptop

Level 3 trigger - Calibration Data Result



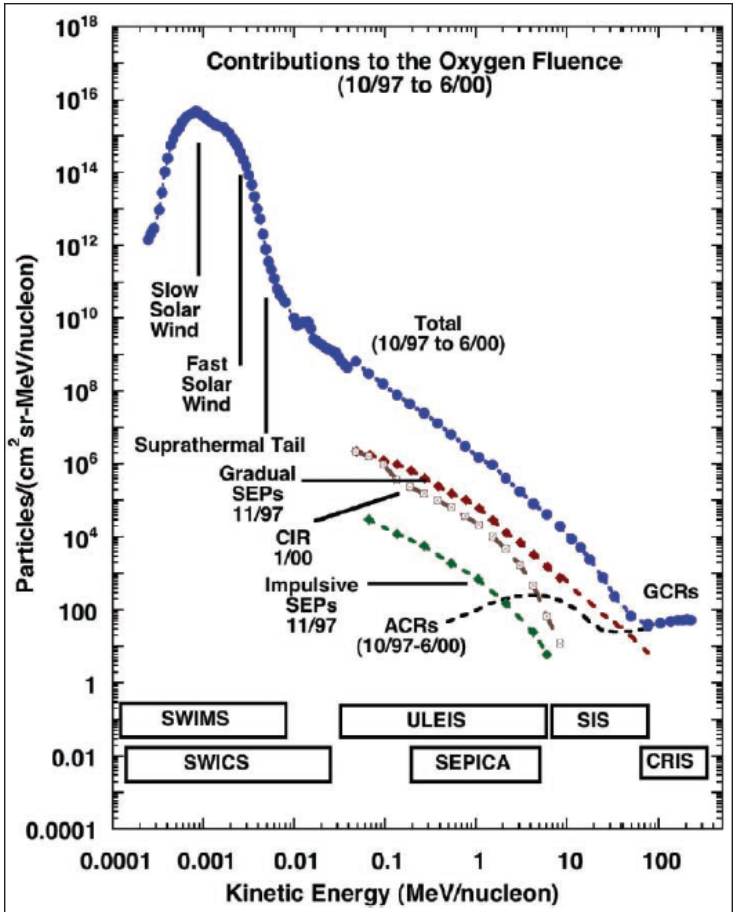
Result of level 3 trigger for FM calibration data using Ba133 radioactive source @ address 0x4000

Proton spectrum during solar maximum at 1 AU



(image credit: ISIS-EPI collaboration) [`https://directory.eoportal.org/web/eoportal/satellite-missions/p/psp`]

Fluence of O



(image credit: Richard Mewaldt, Caltech)
[https://en.wikipedia.org/wiki/Advanced_Composition_Explorer]

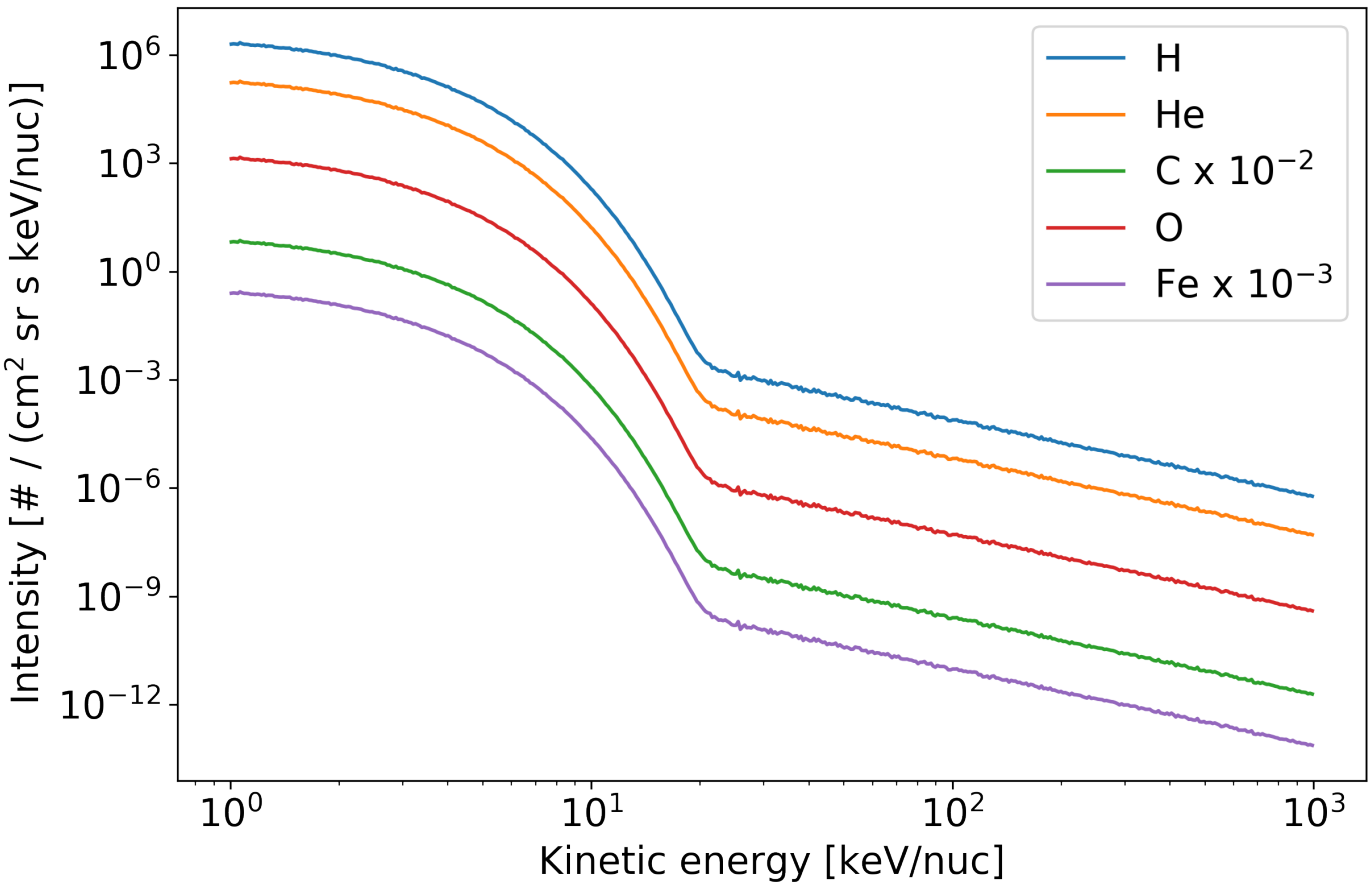
Use coronal abundances as solar wind abundances

Element	Coronal abundance
H	1.5×10^6
He	1.28×10^5
C	493
O	1000
Fe	187

[**Reames 2014**] *Element Abundances in Solar Energetic Particles and the Solar Corona*

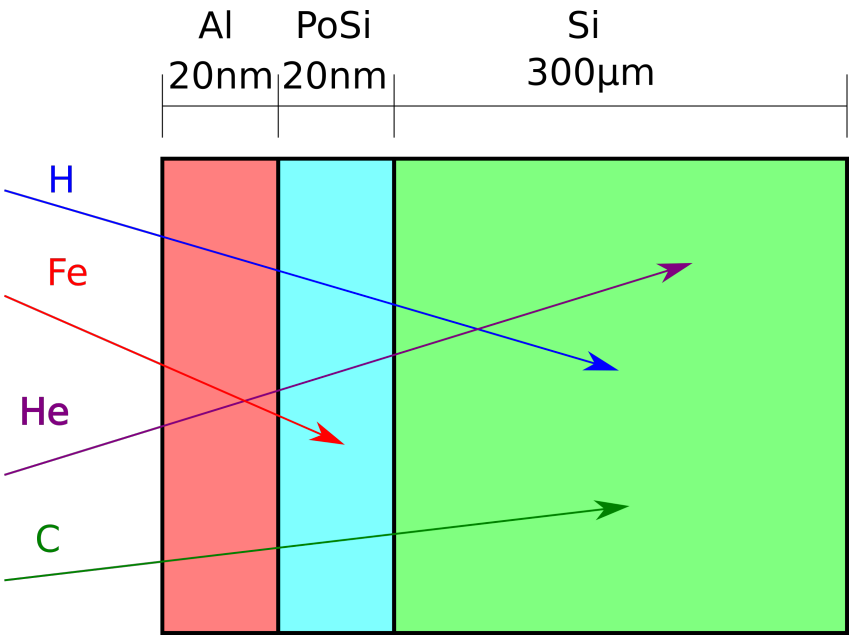
Modeling of solar spectrum

based on proton spectrum by Mewaldt, assume $v_{sw} = 500 \frac{\mathrm{km}}{\mathrm{s}}$ and $\sigma_{v_{sw}} = 40 \frac{\mathrm{km}}{\mathrm{s}}$ for core.



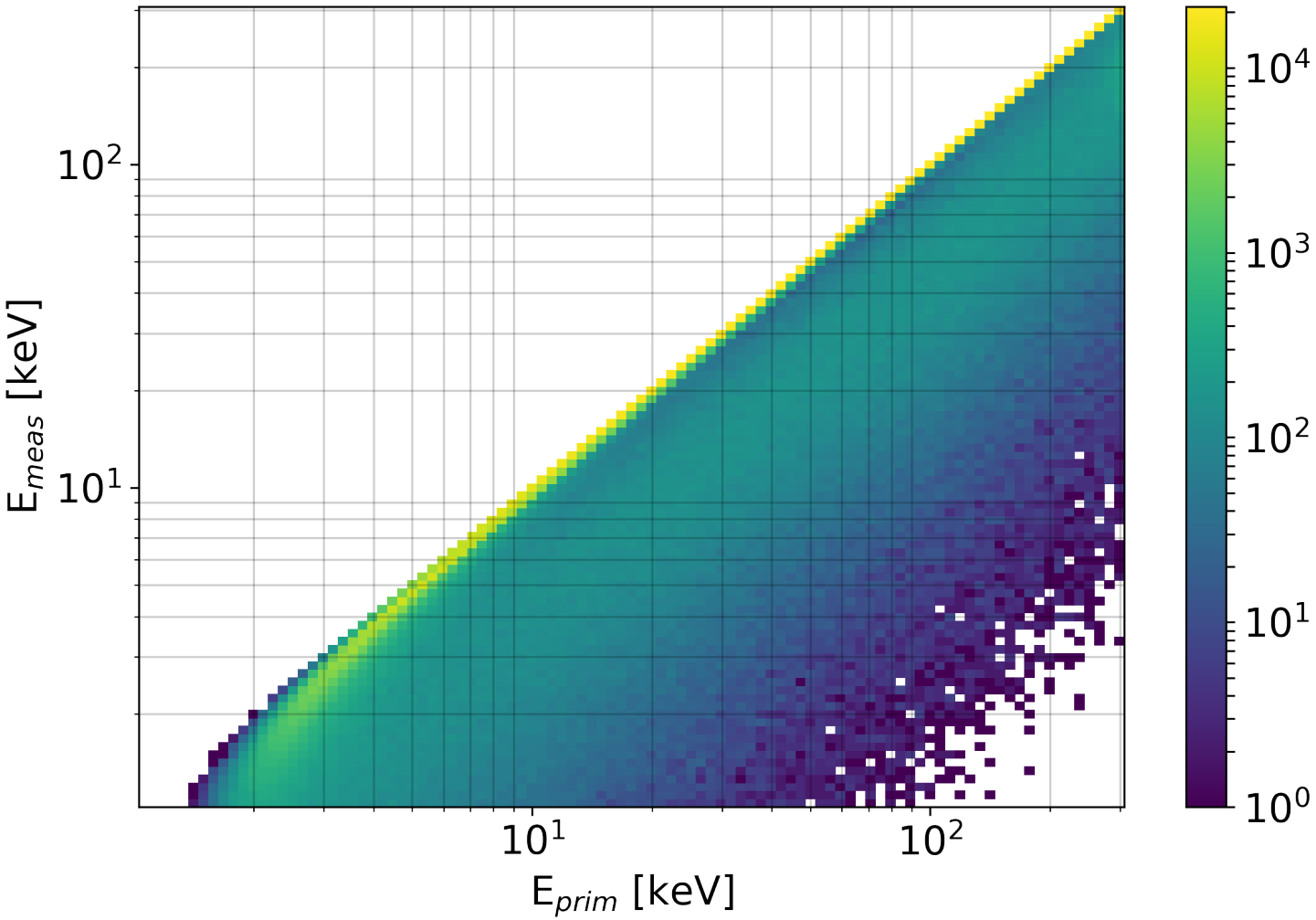
GEANT4 Simulation setup

Simulate response of a single pixel:

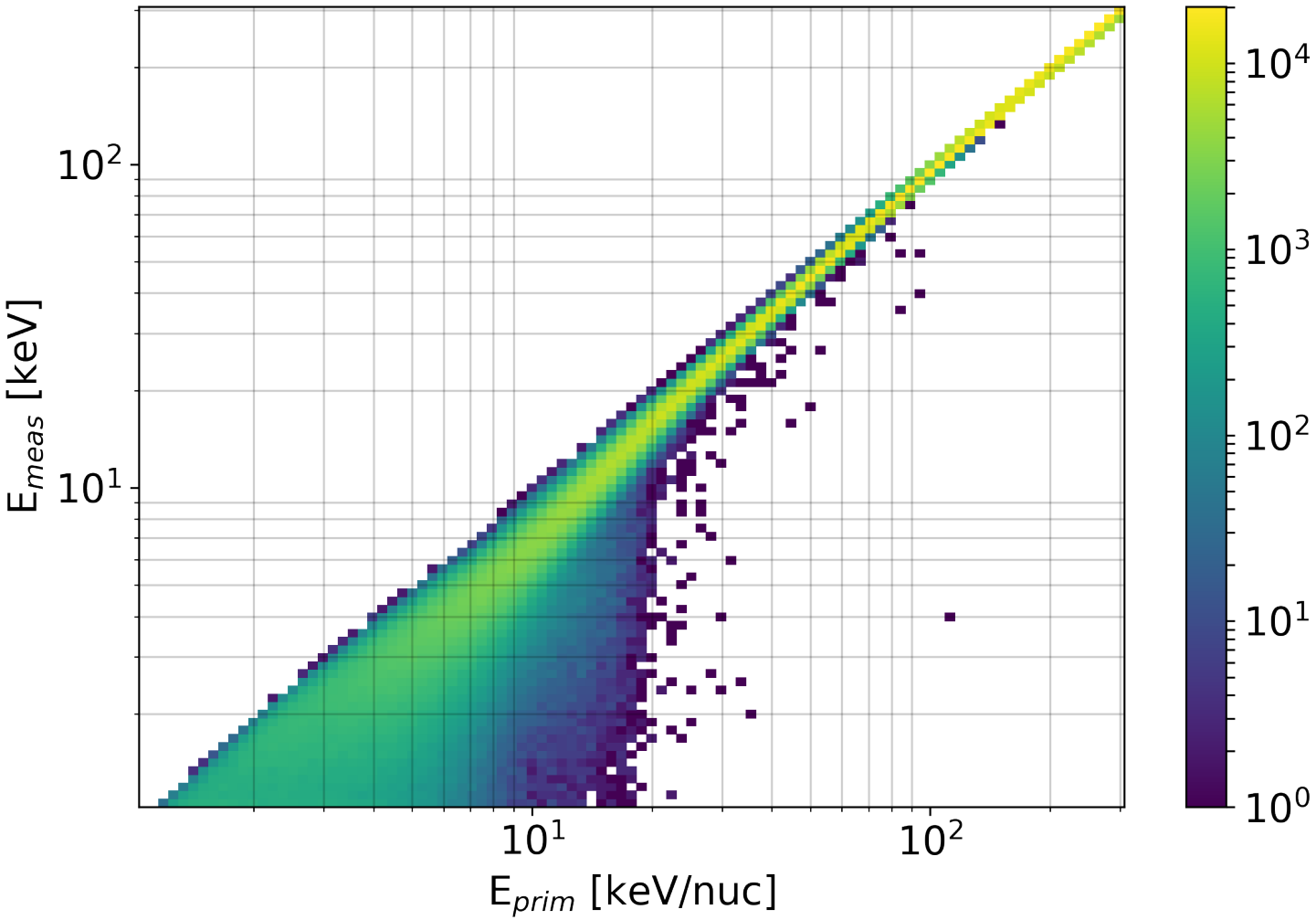


- Particles: e-, H, He, C, O, Fe
- E_{kin} = 1 keV ... 10 MeV
- N = 4000000

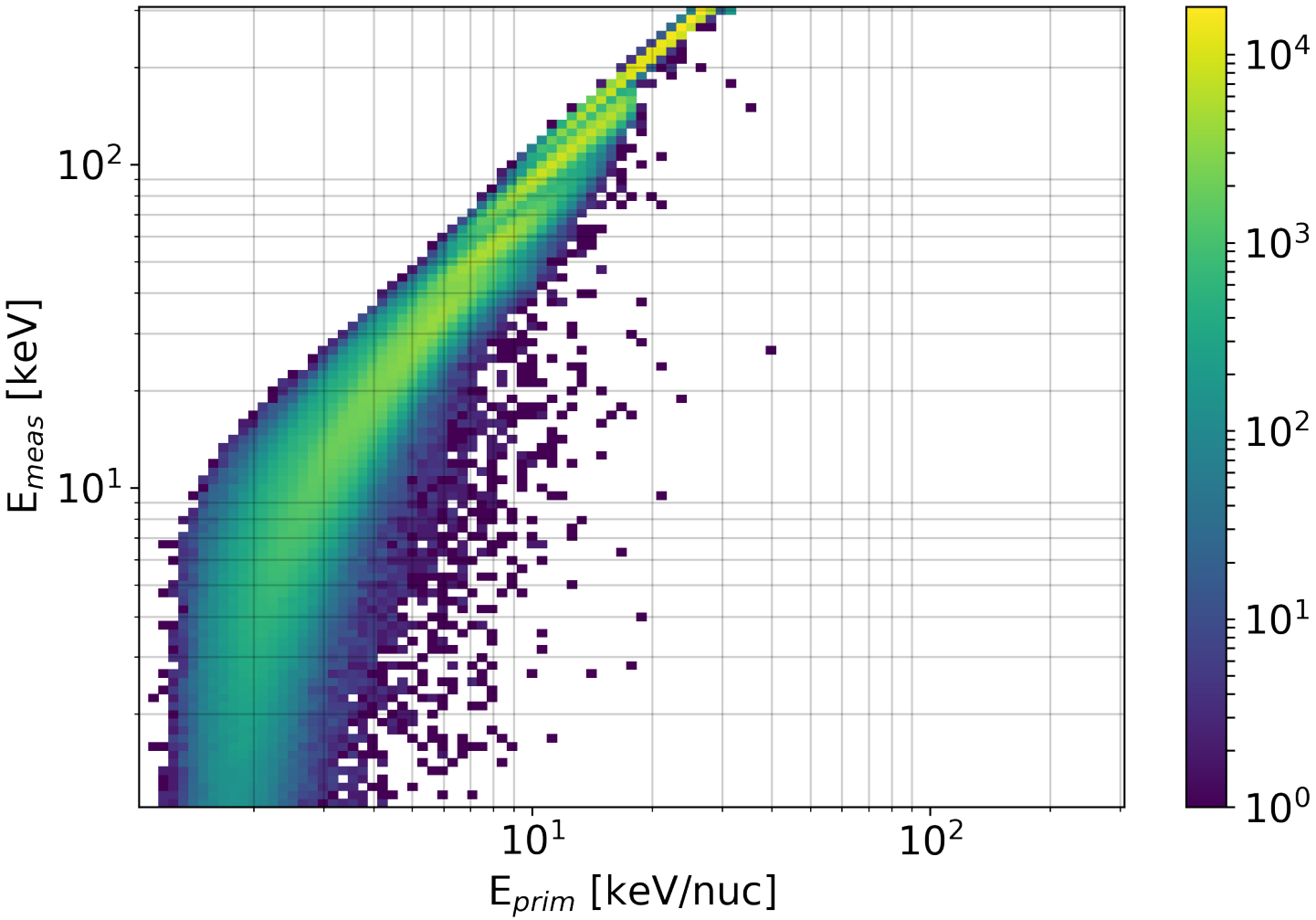
Response function of electrons



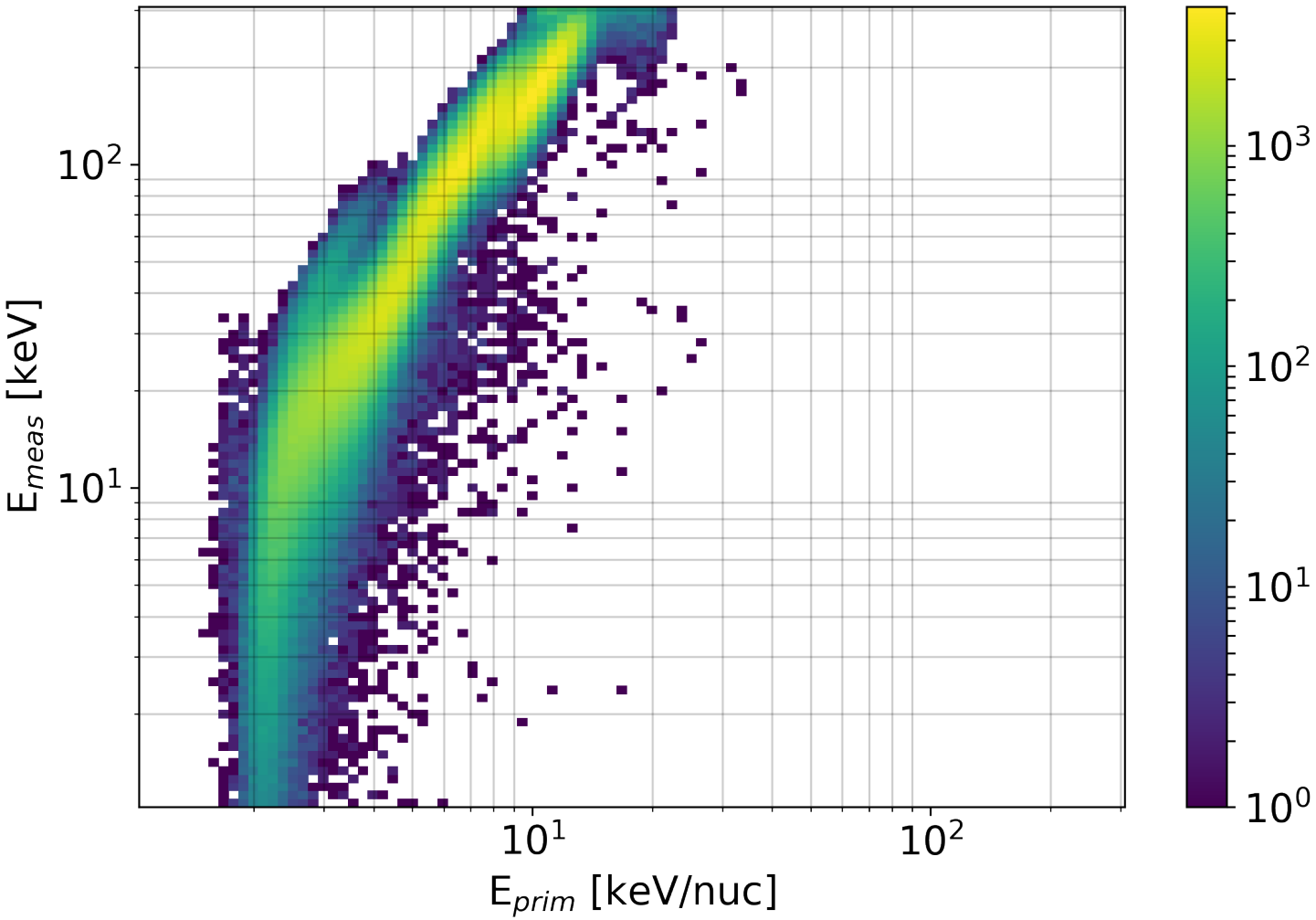
Response function of protons



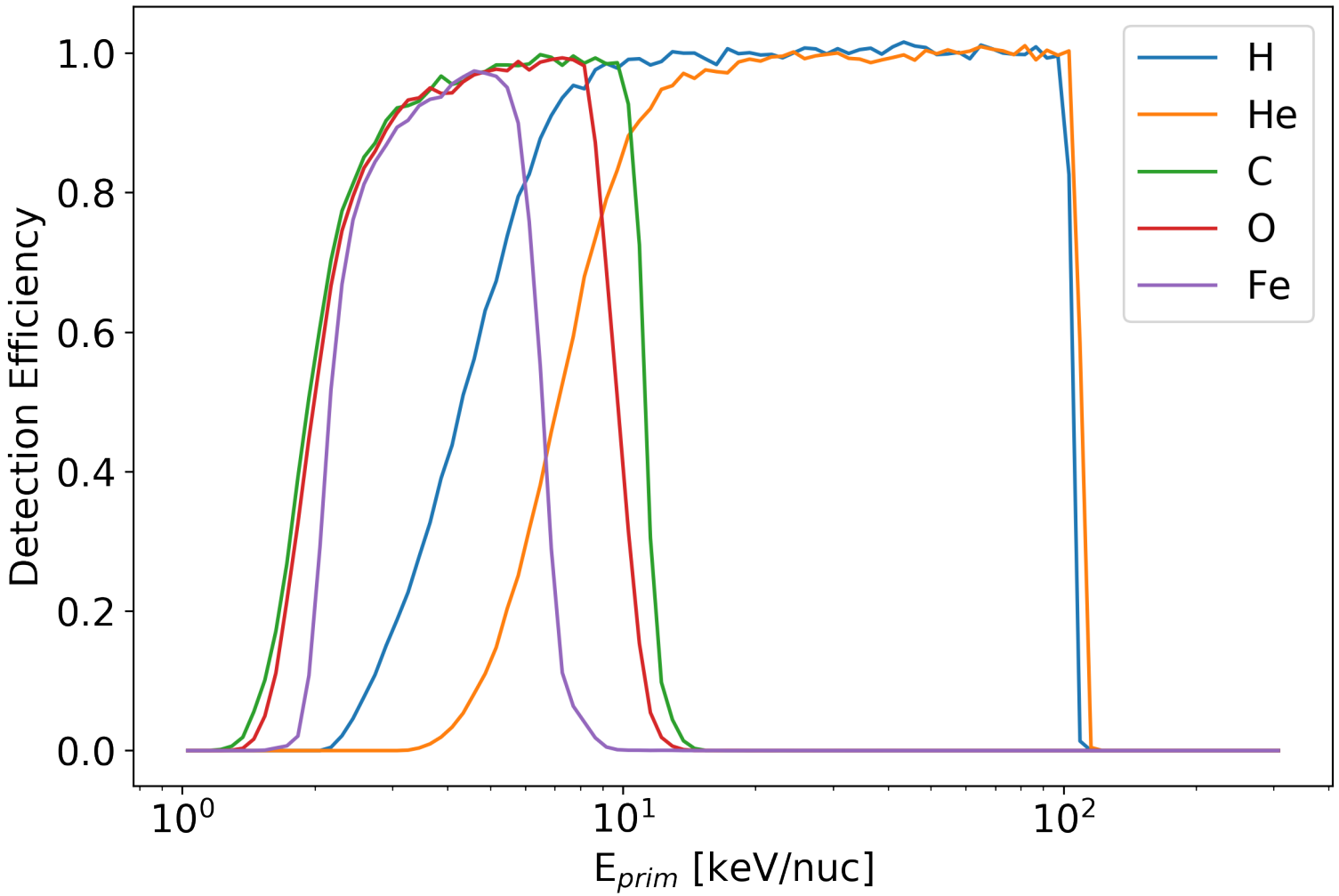
Response function of Carbon



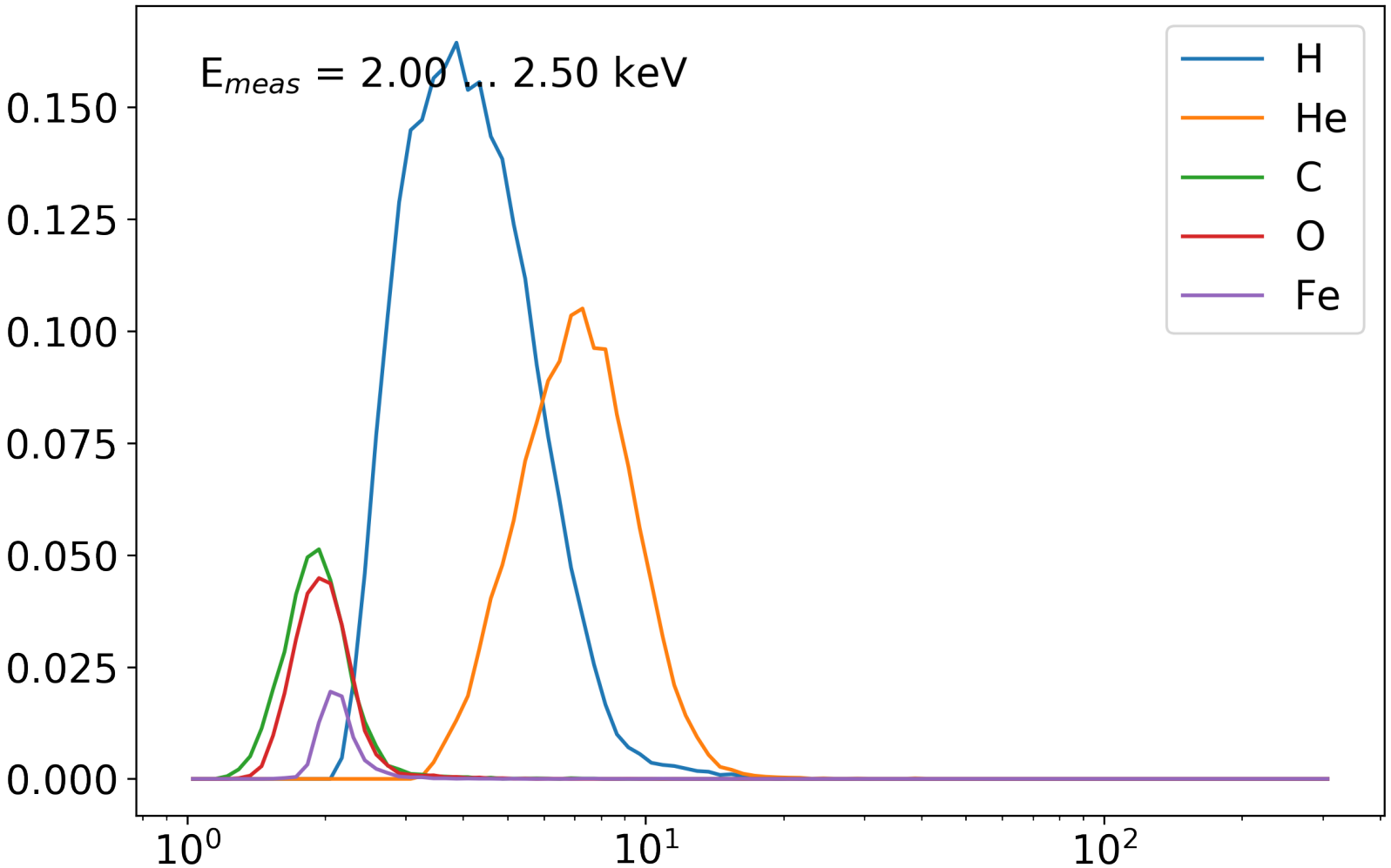
Response function of Iron



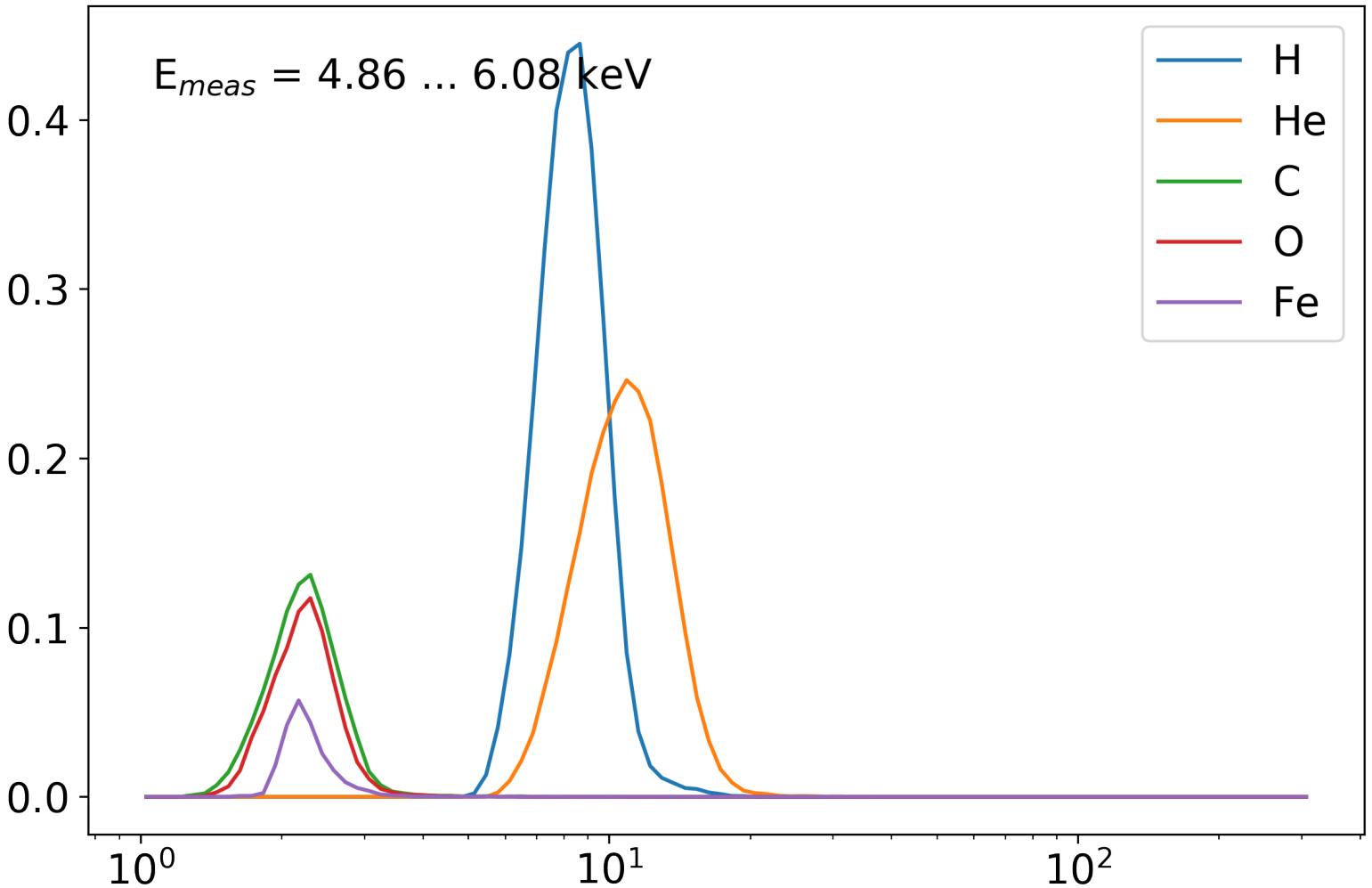
Detection efficiency of elements



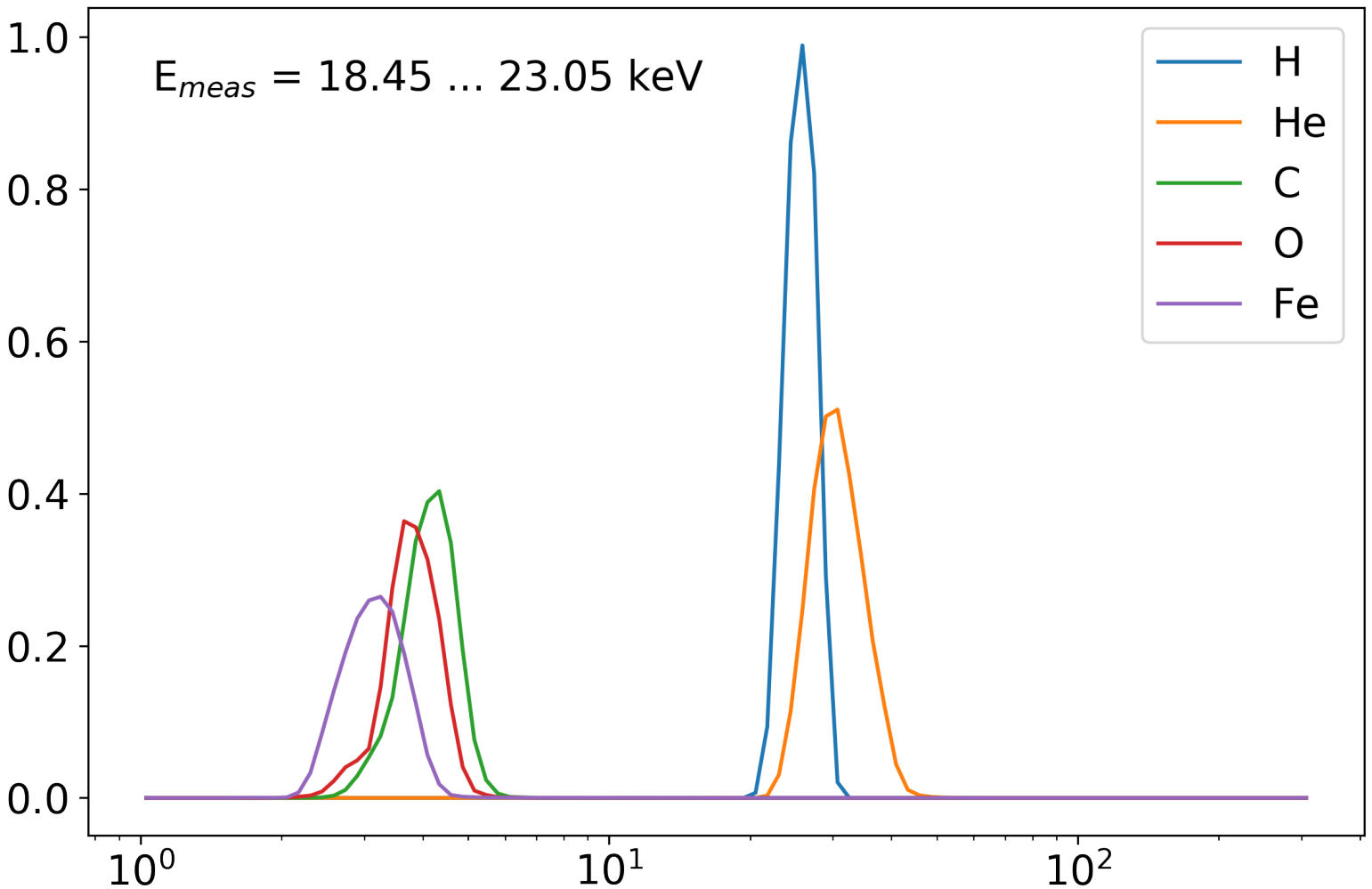
Response for different energy channels



Response for different energy channels



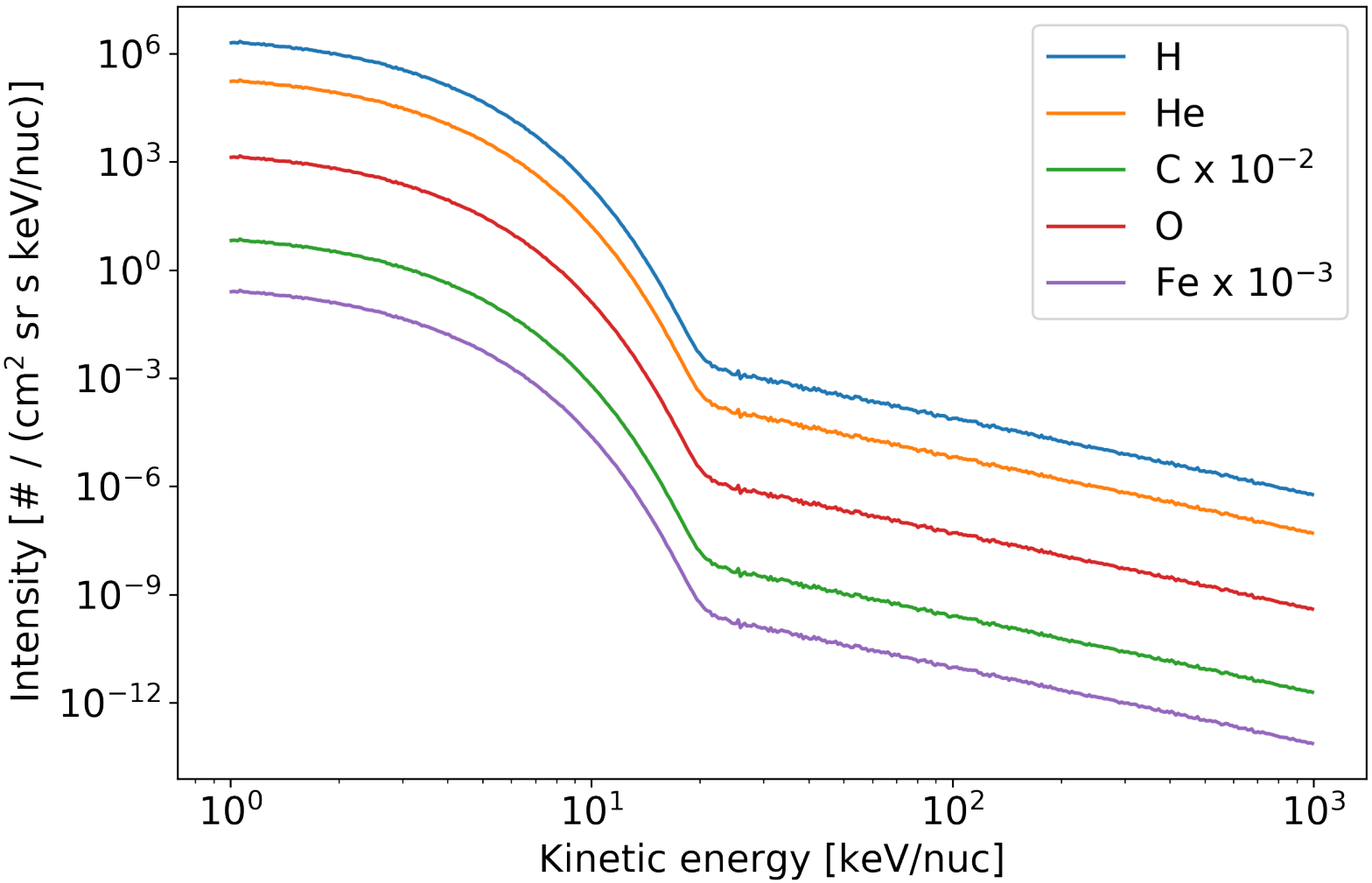
Response for different energy channels



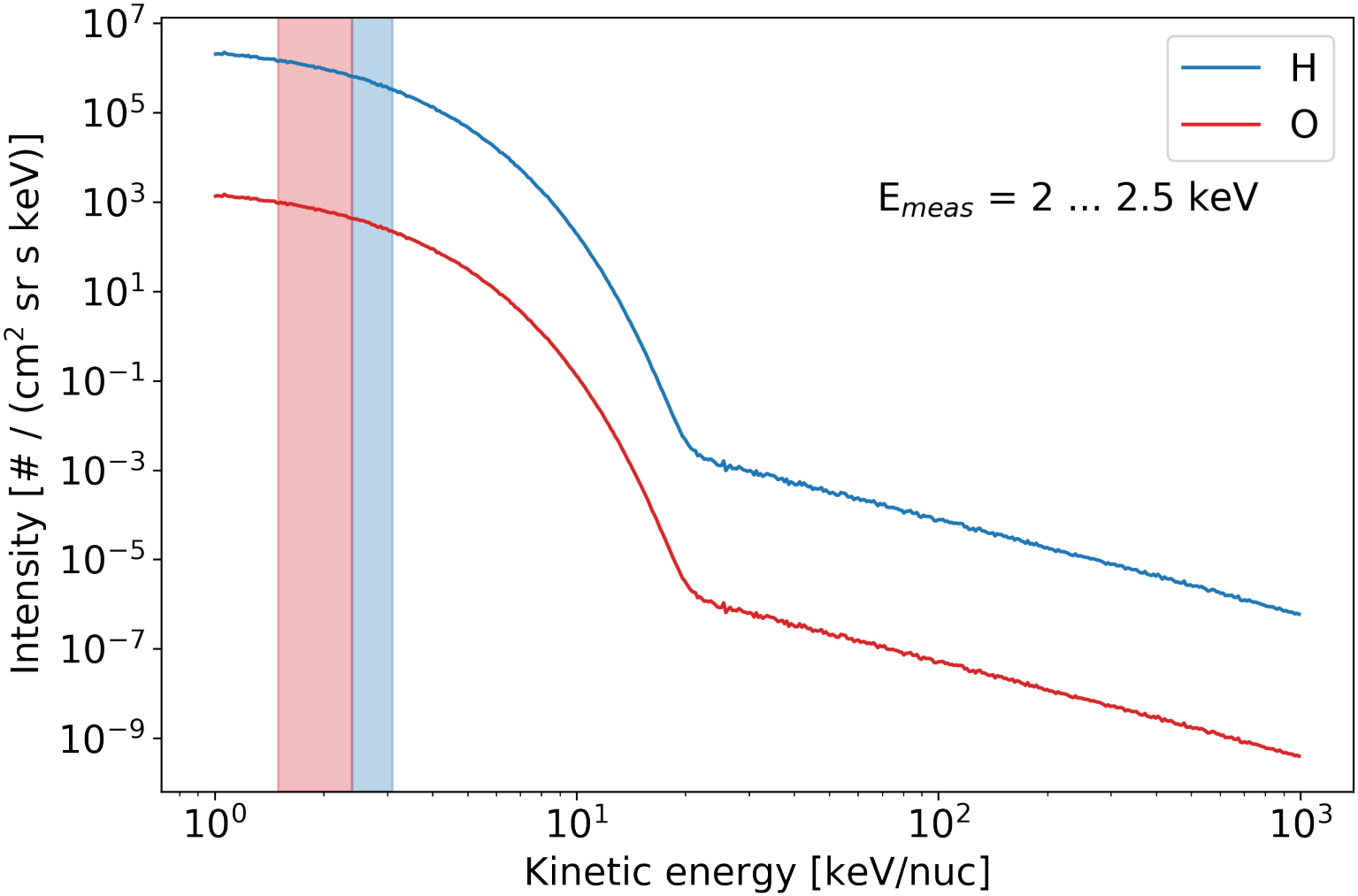
Response for different energy channels

H
eavy elements in the range 1 keV/nuc ... 10 keV/nuc are detected in all energy channels of STEP

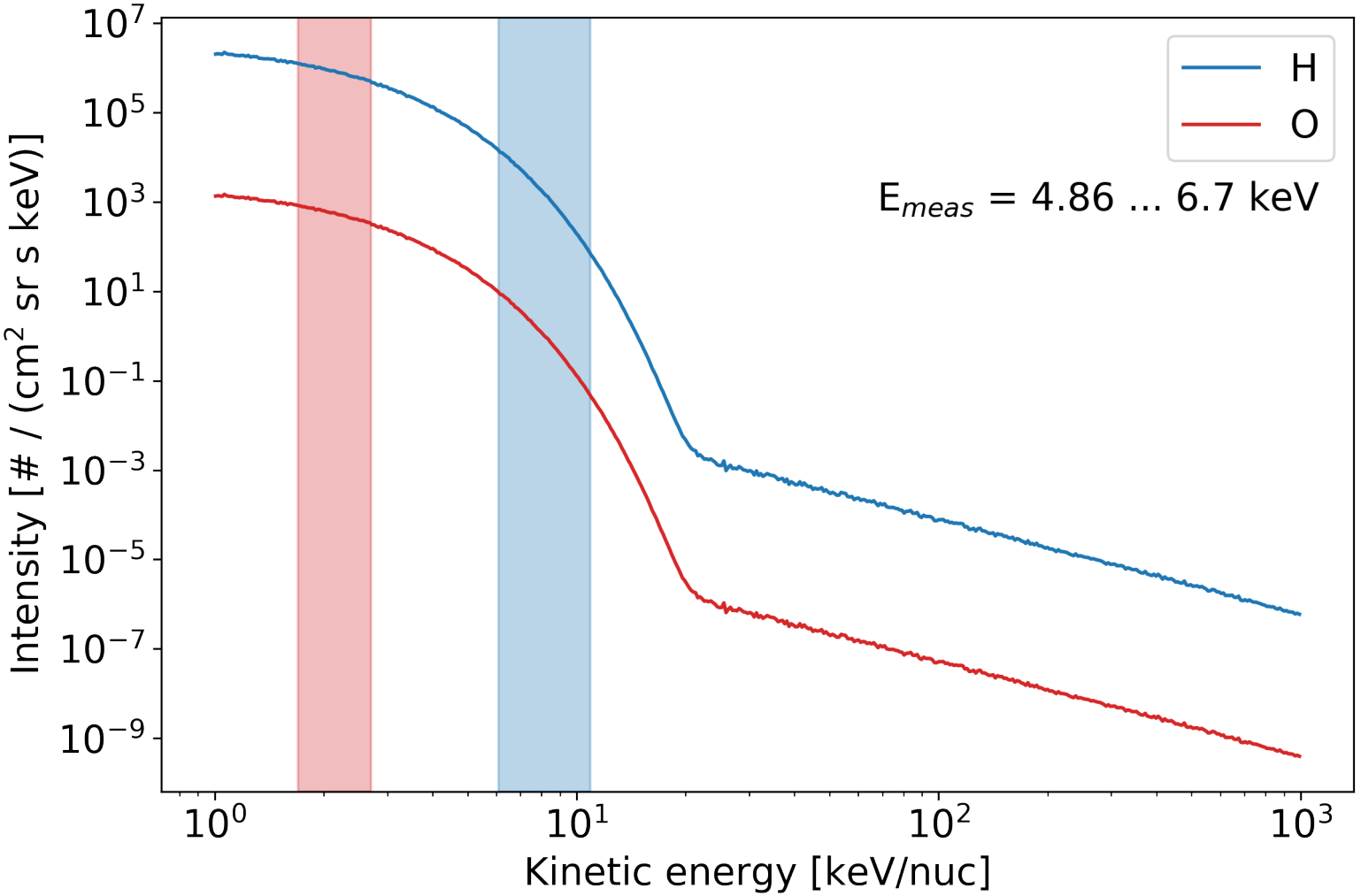
Model spectrum



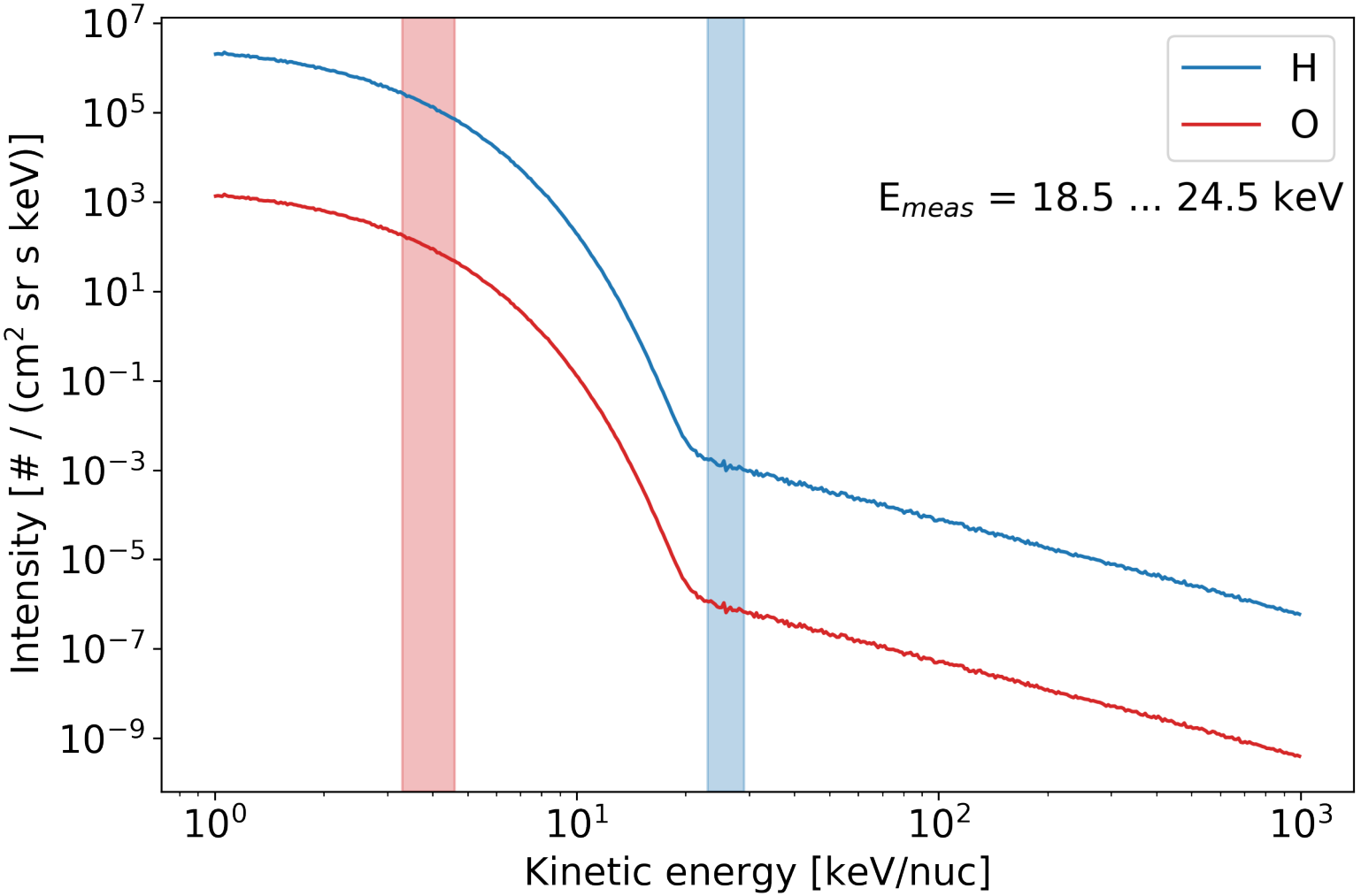
Composition of different energy channels



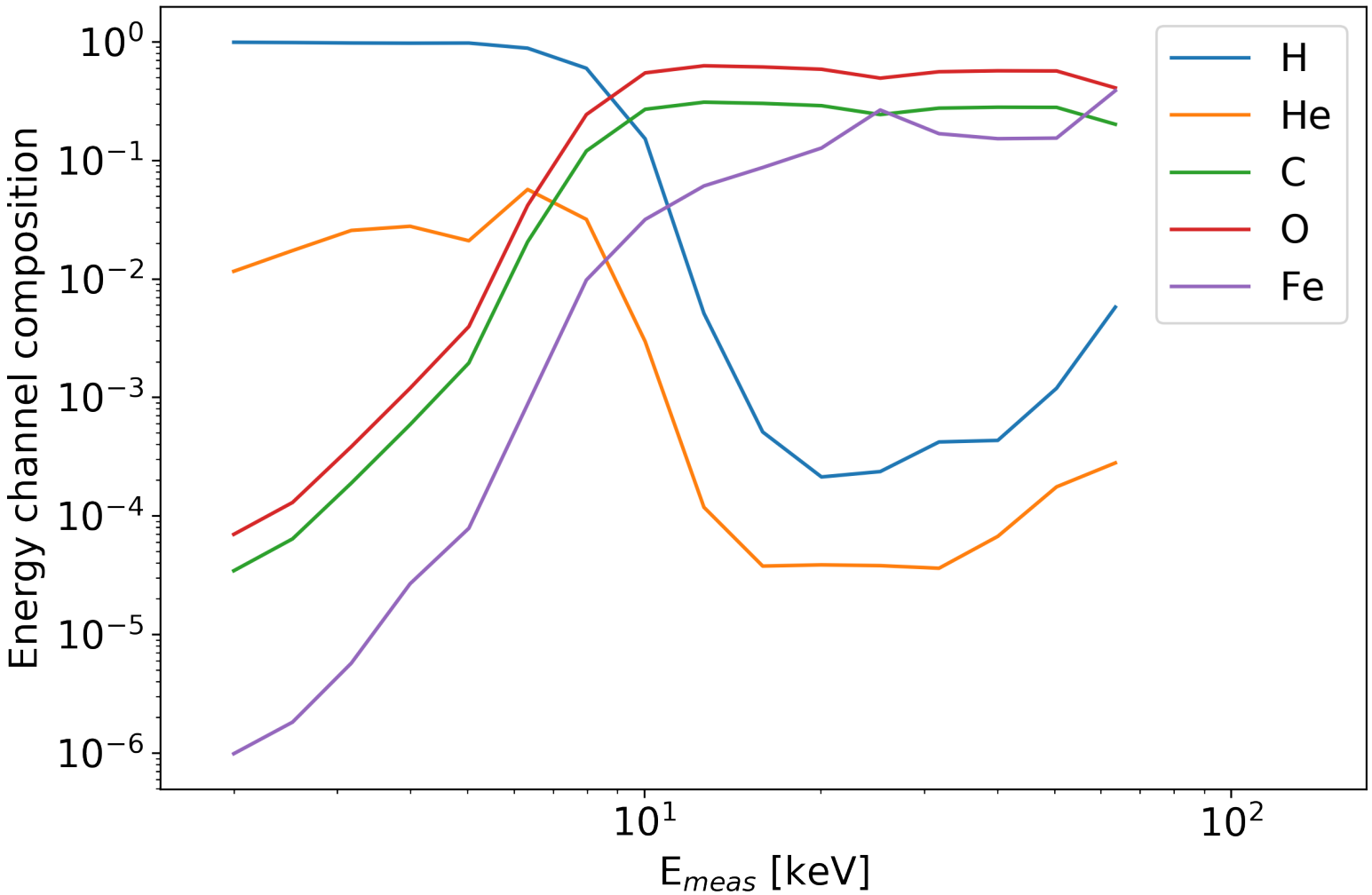
Composition of different energy channels



Composition of different energy channels

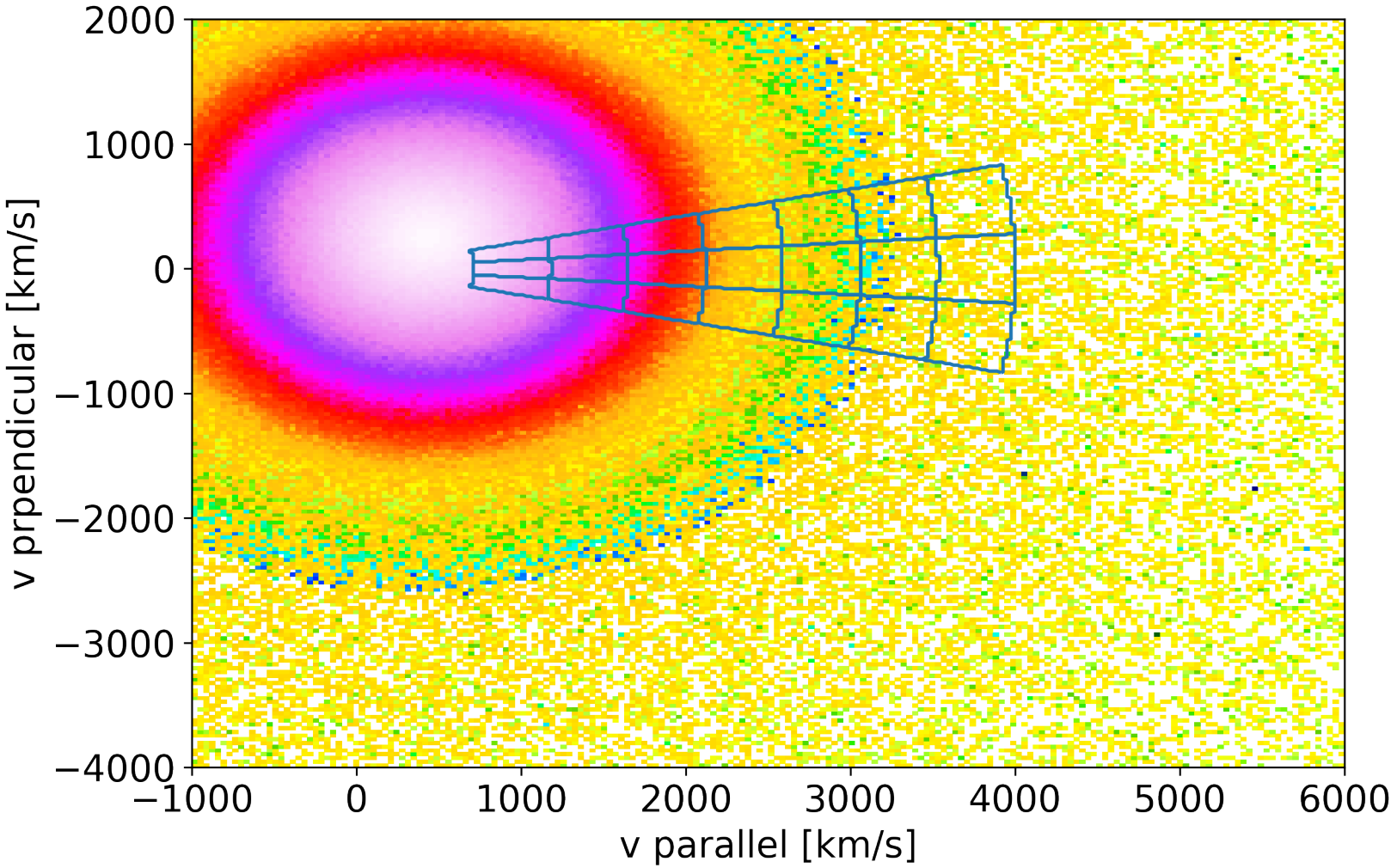


Composition of STEP energy channels



Thank you for your attention!

Phase space


2000
1000
0
−1000
−2000
−3000
−4000
v prpendicular [km/s]
−1000
0
1000
2000
3000
4000
5000
6000
v parallel [km/s]