The Athena High-Energy Particle Monitor – AHEPaM

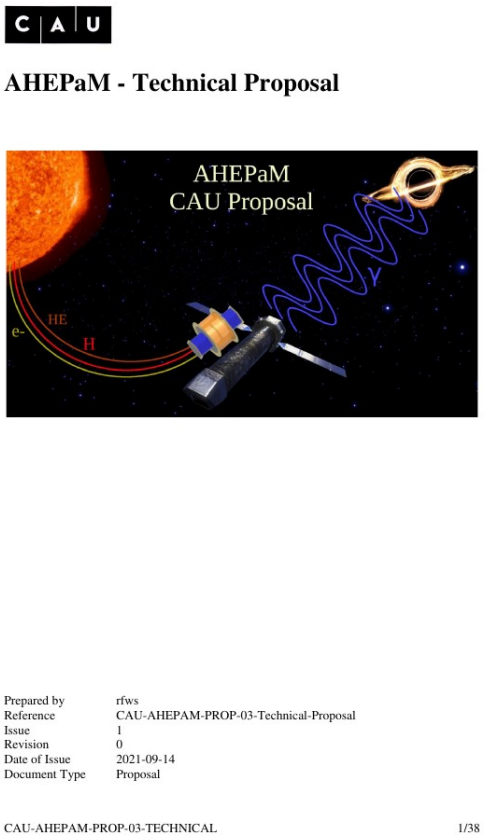
AHEPaM PRR:

14:00 – 14:30 presentation of design studies performed

14:30 – 15:15 review of measurement requirements

15:15 – 15:45 presentation of the current status

15:45 – 16:15 closeout, MoMs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AHEPaM - Technical Proposal

AHEPaM
CAU Proposal

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Prepared by	rfws
Reference	CAU-AHEPAM-PROP-03-Technical-Proposal
Issue	1
Revision	0
Date of Issue	2021-09-14
Document Type	Proposal

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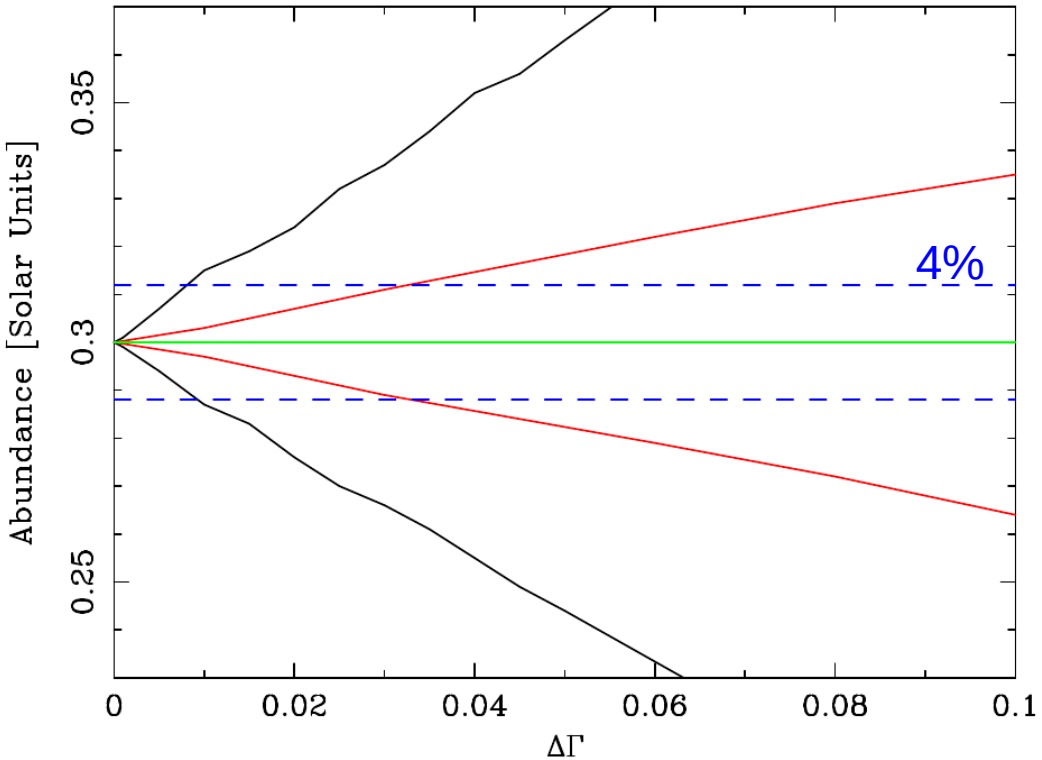
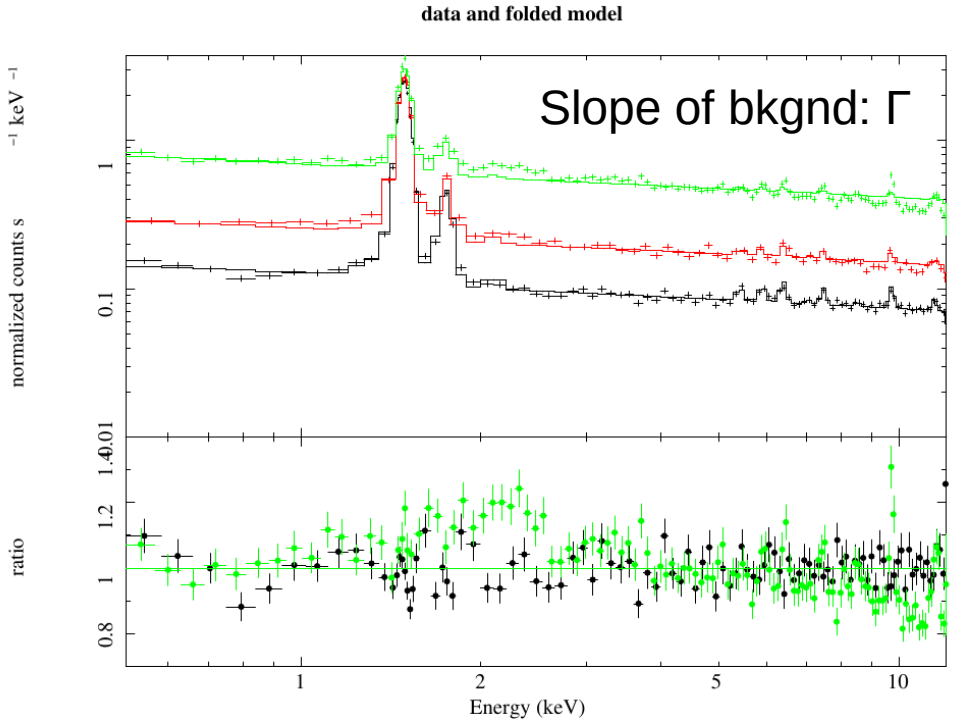
Need to understand X-ray background

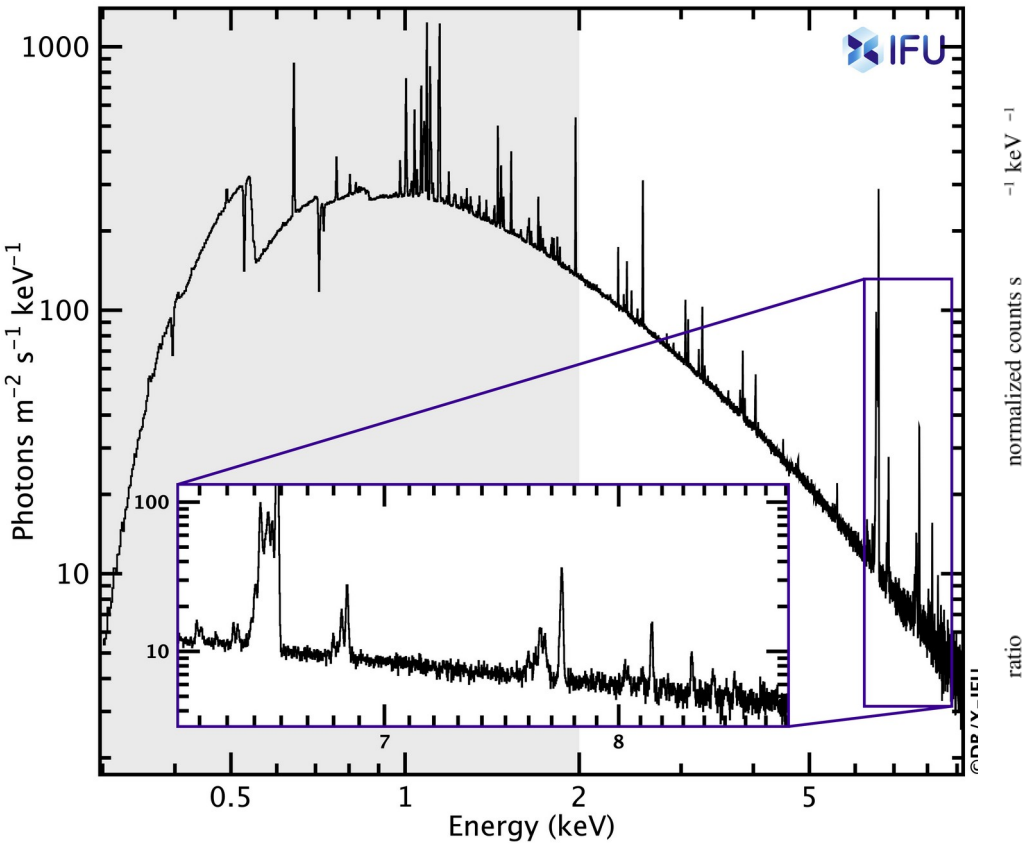
“Metal” abundance vs. ΔΓ (sim-fit)

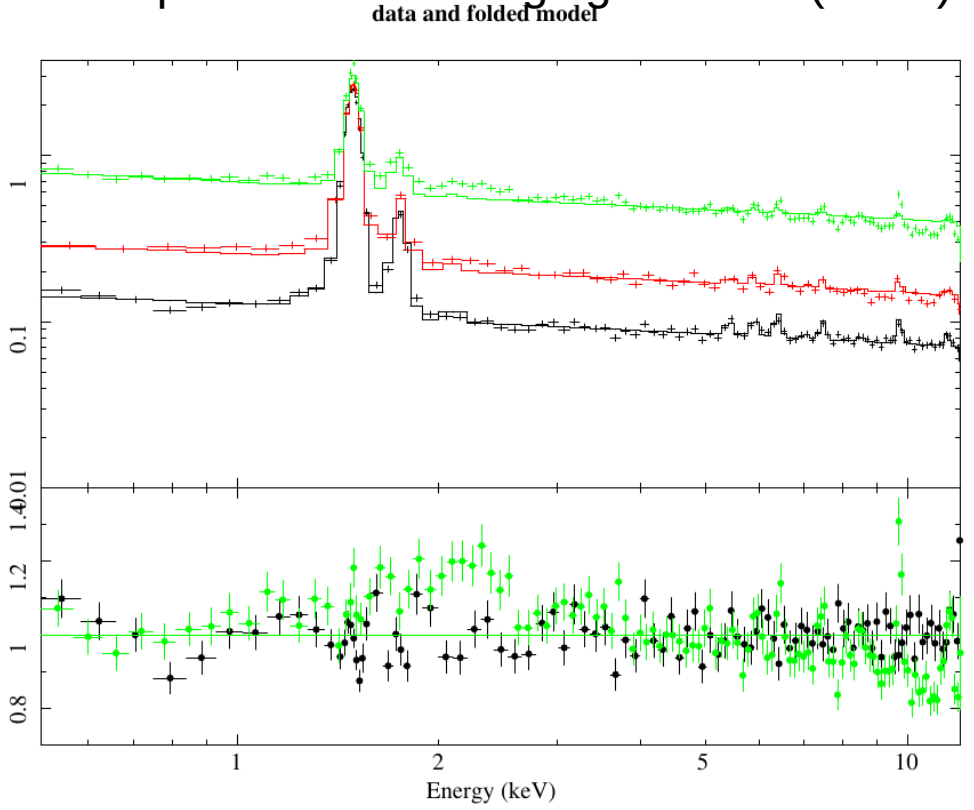




Need to understand X-ray background

XMM Newton:
European Photon Imaging Camera (EPIC)





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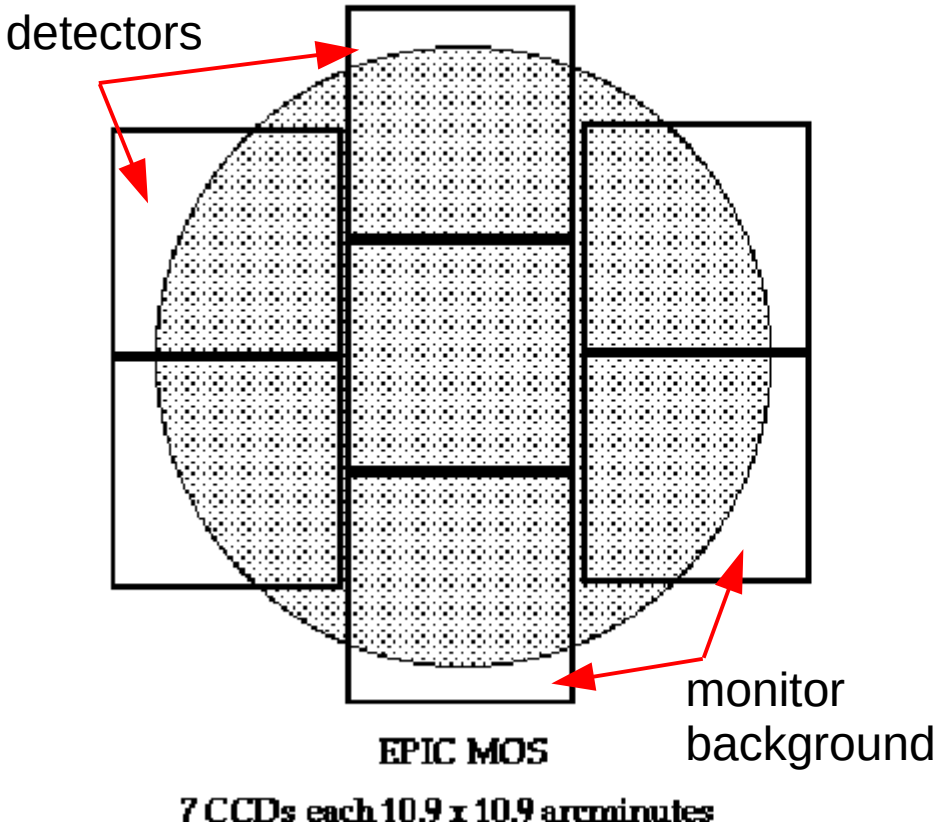
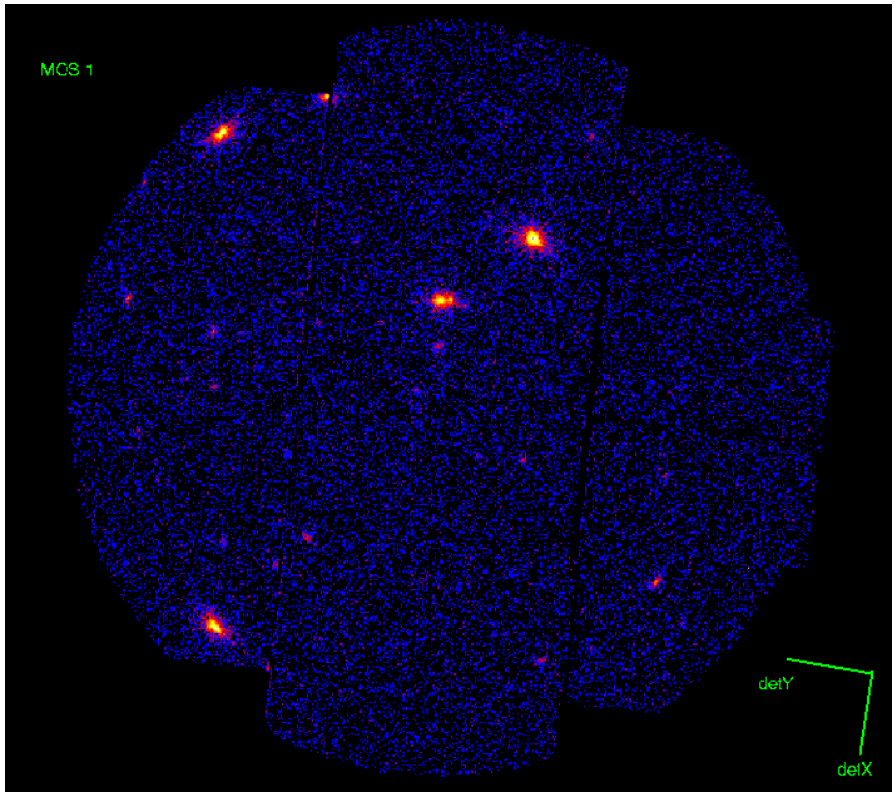
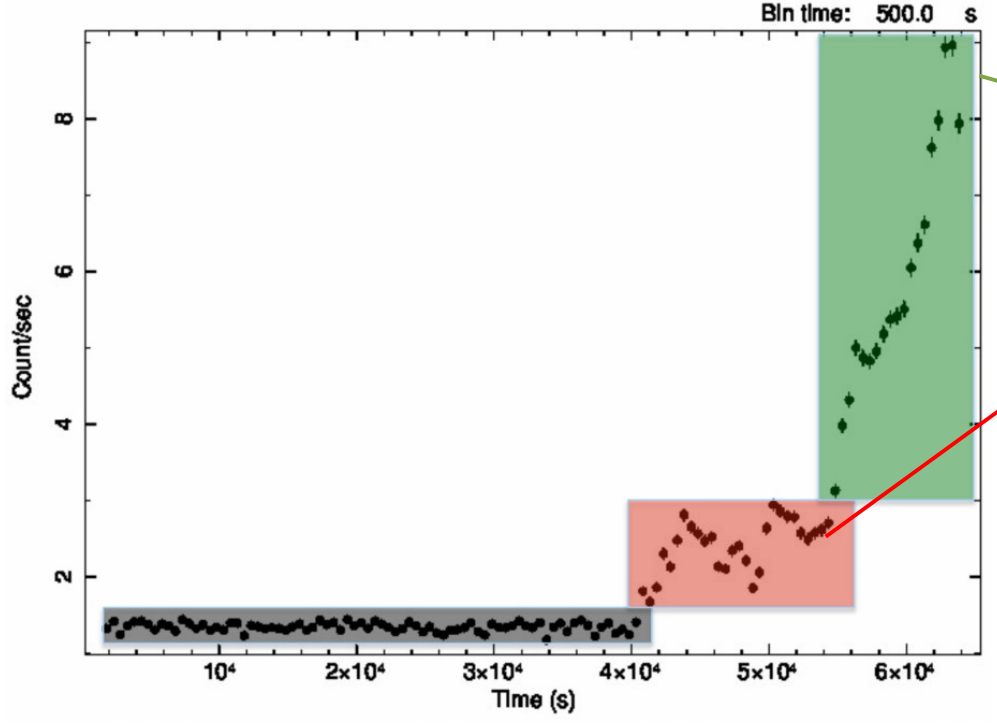


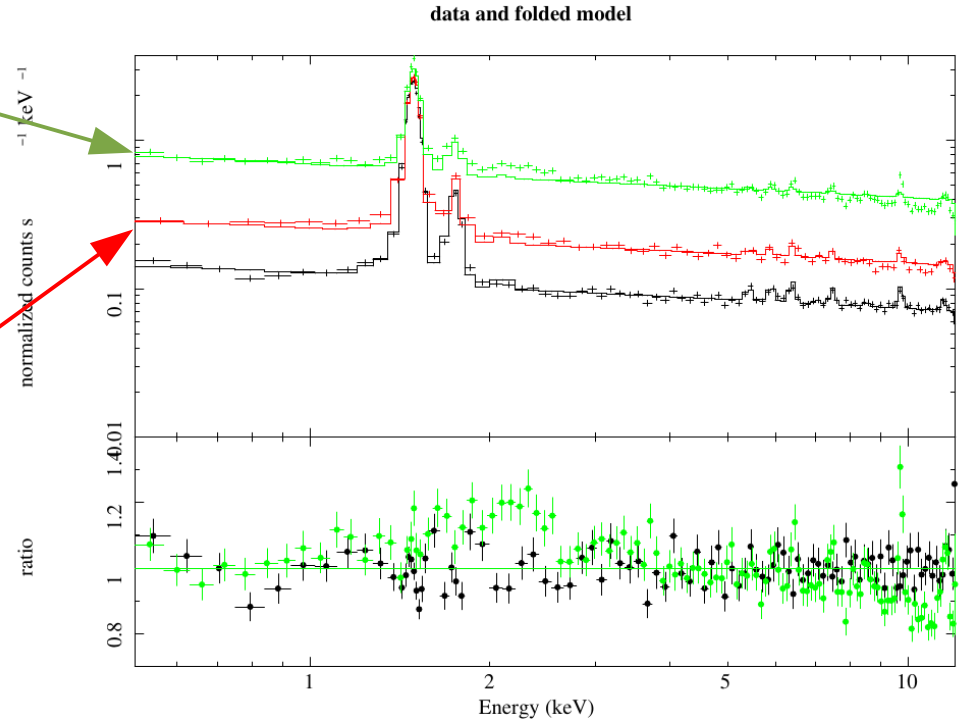
XMM Newton:
European Photon Imaging Camera (EPIC)



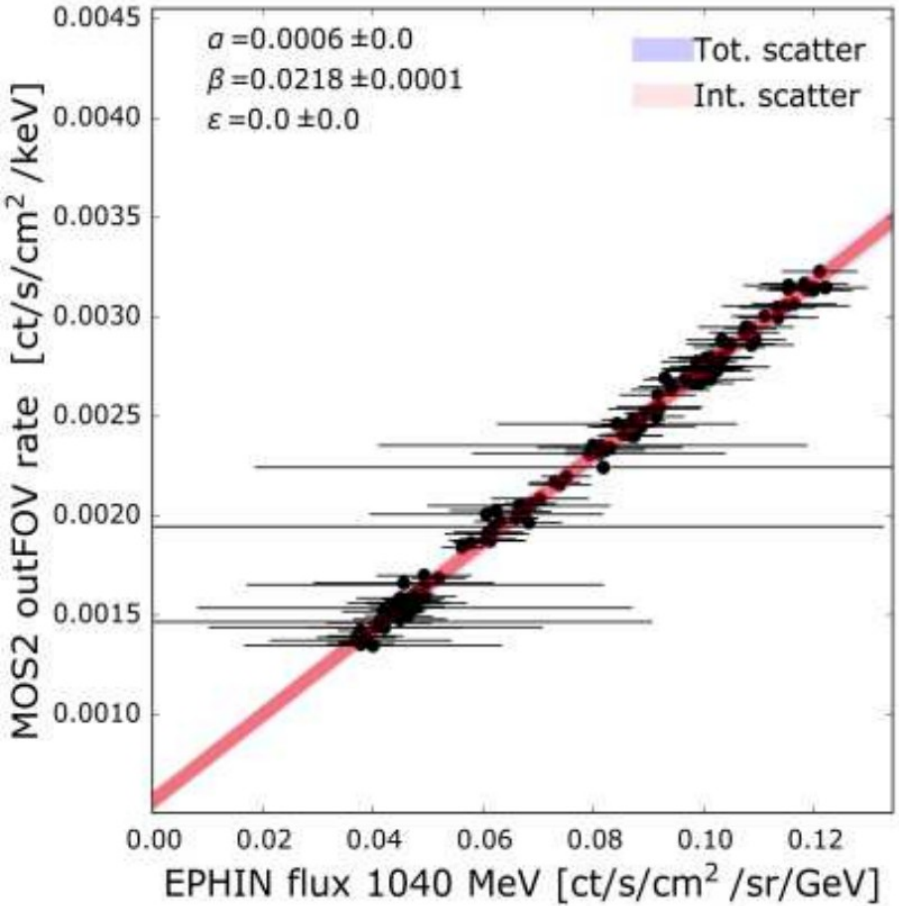
Need to understand X-ray background

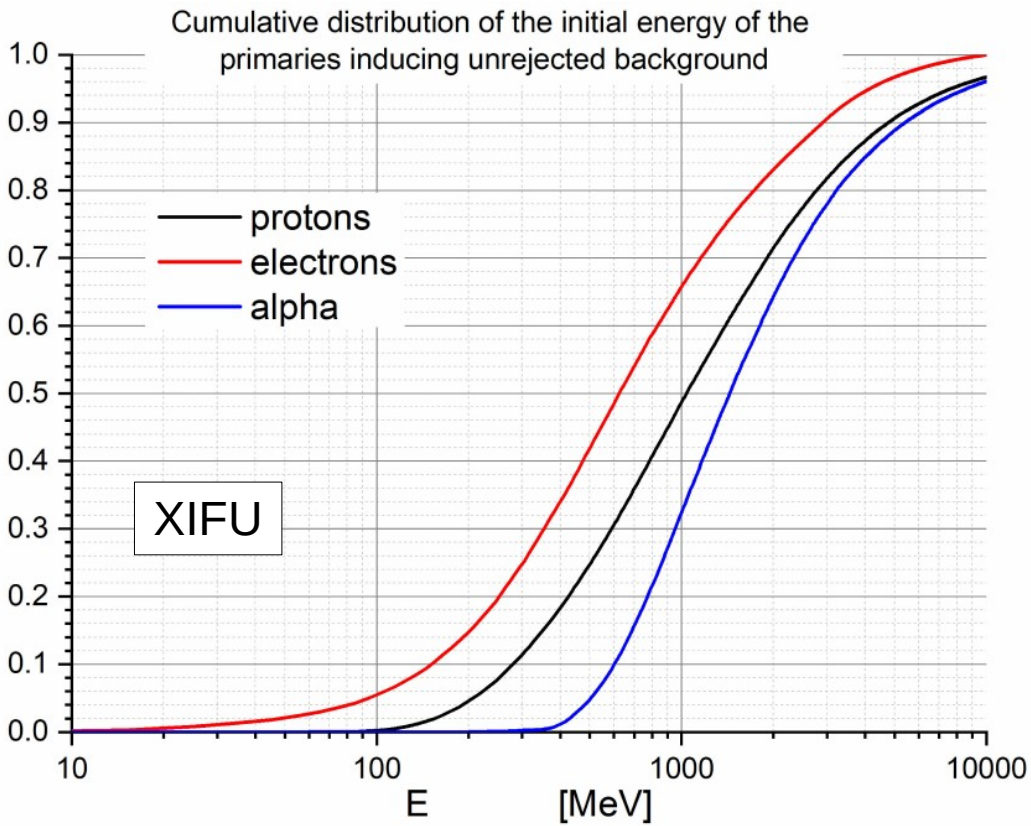
Electrons from outer radiation belt



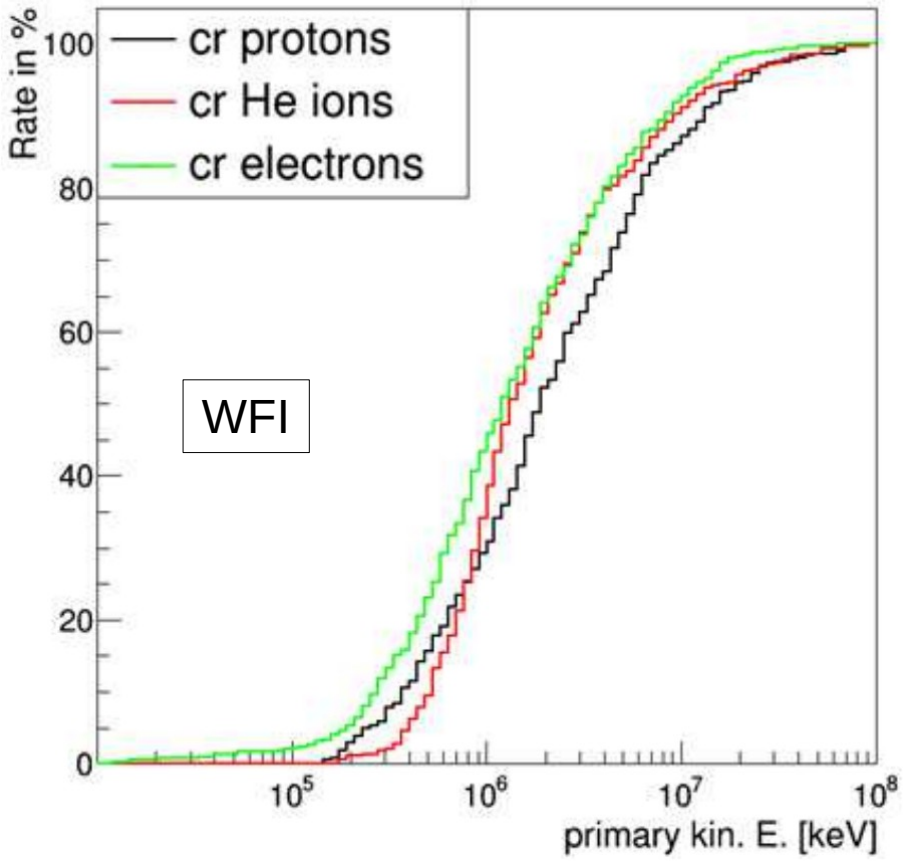


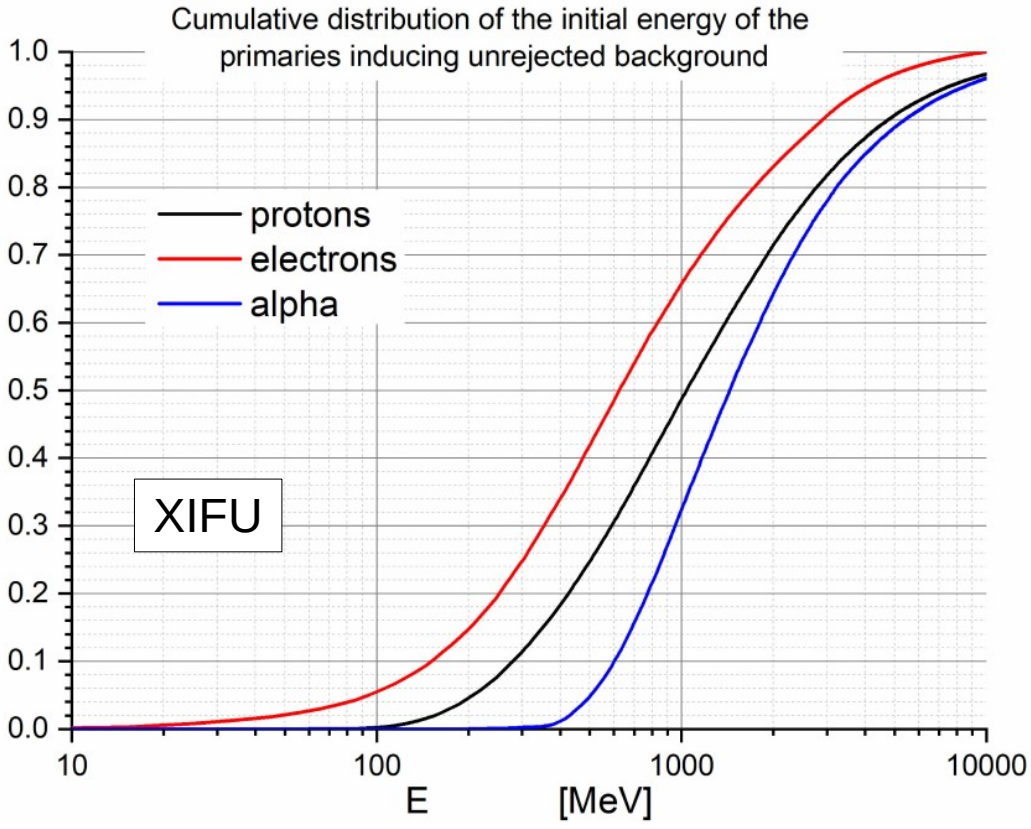
Need of AHEPaM





Need of AHEPaM

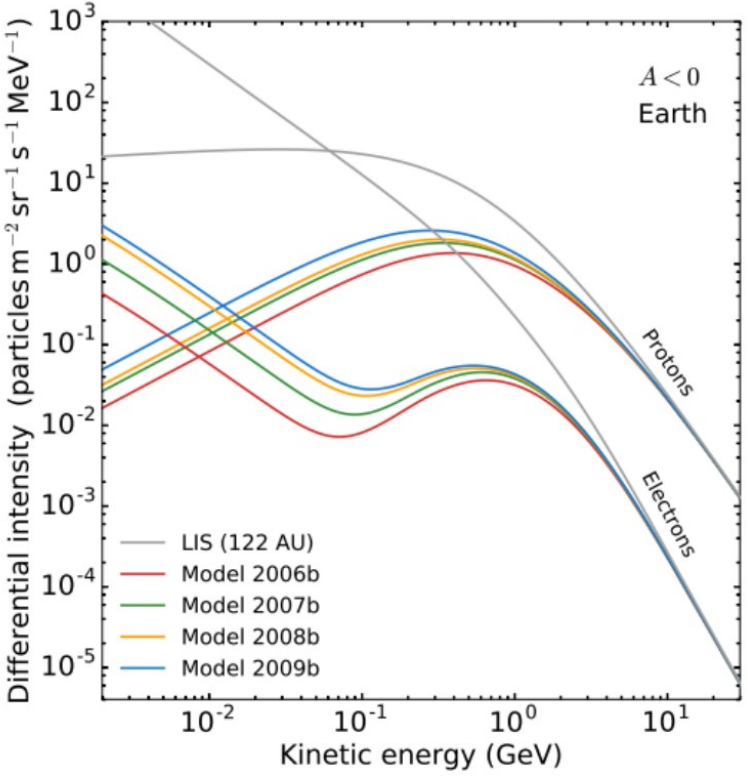




Need of AHEPaM

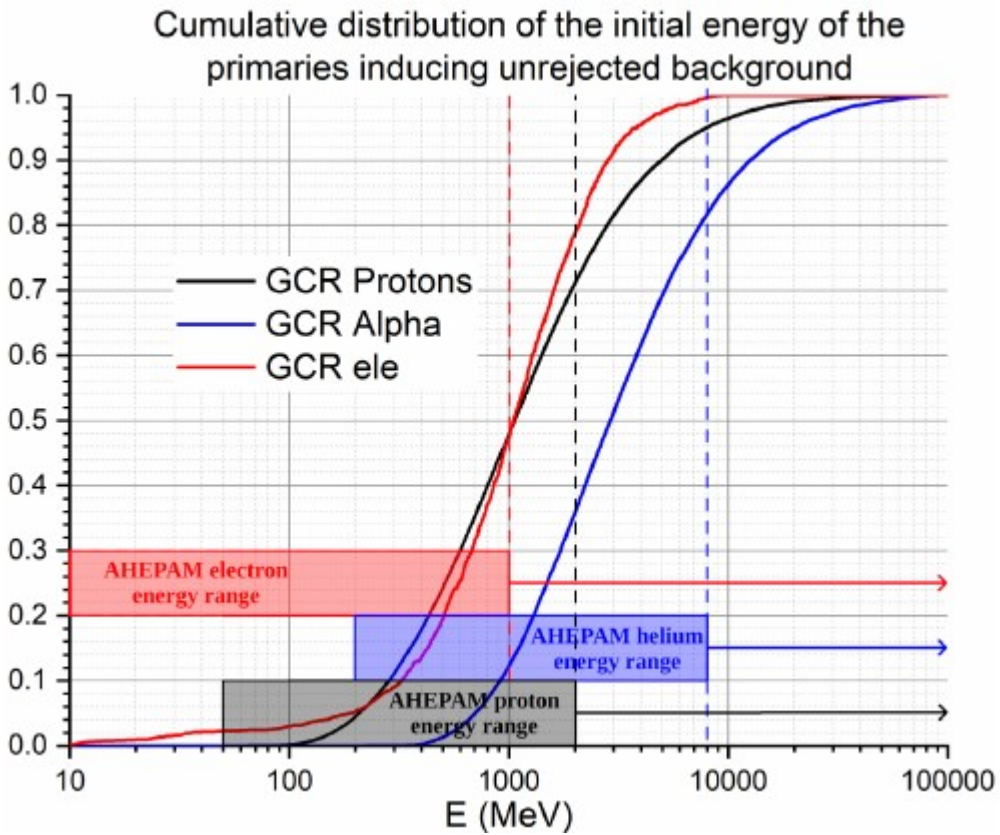
7 Bullet point summary

Here is a bullet point summary of the main issues discussed in this note.



- While useful, current strategies to control background systematics are not guaranteed to achieve the required reproducibility requirements.
- High energy proton flux provides the tightest known proxy for instrumental background rate.
- A high energy particle monitor capable of tracking high energy protons, electrons and alpha particles will contribute decisively to reaching the reproducibility requirement.
- A comparison of background rates with AHEPaM fluxes will allow us to reach the required degree of background reproducibility.
- We have put forth a set of requirements for an ATHENA High Energy Particle Monitor (AHEPaM).
- We have provided information to help understand the logic that has lead to the formulation of the requirements.

AHEPaM proposal



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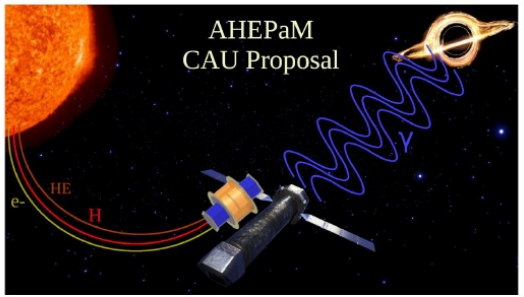
AHEPaM - Technical Proposal



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Critical Measurement Requirements

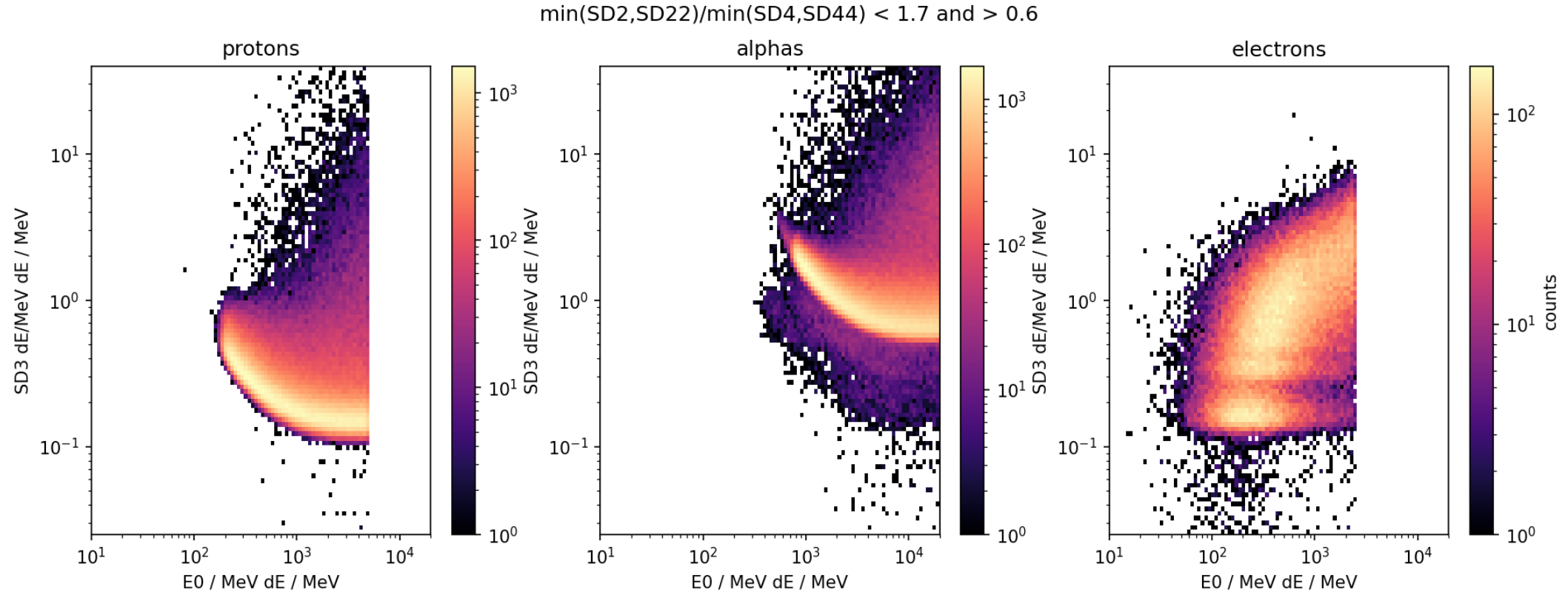
- Principal aim of AHEPaM is to provide an assessment on the GCR- and SEP-induced contamination/background of XIFU and WFI.
- Discriminate electrons from protons
- Upper energy range (penetrating particles)
- Protons: Now 2% accuracy in 40 ks in 5 energy bands
- Electrons: Similar relaxations, *but electrons are driving the instrument design*.
- Helium nuclei: We don’t see helium turning into a problem.
- Repetition: The principal aim of AHEPaM is to provide an assessment on the GCR- and SEP-induced contamination/background of XIFU and WFI.

Species	XIFU	WFI
Protons	1.00[a]	1.0[a]
Electrons	0.08	0.20
He ions	0.10	0.10

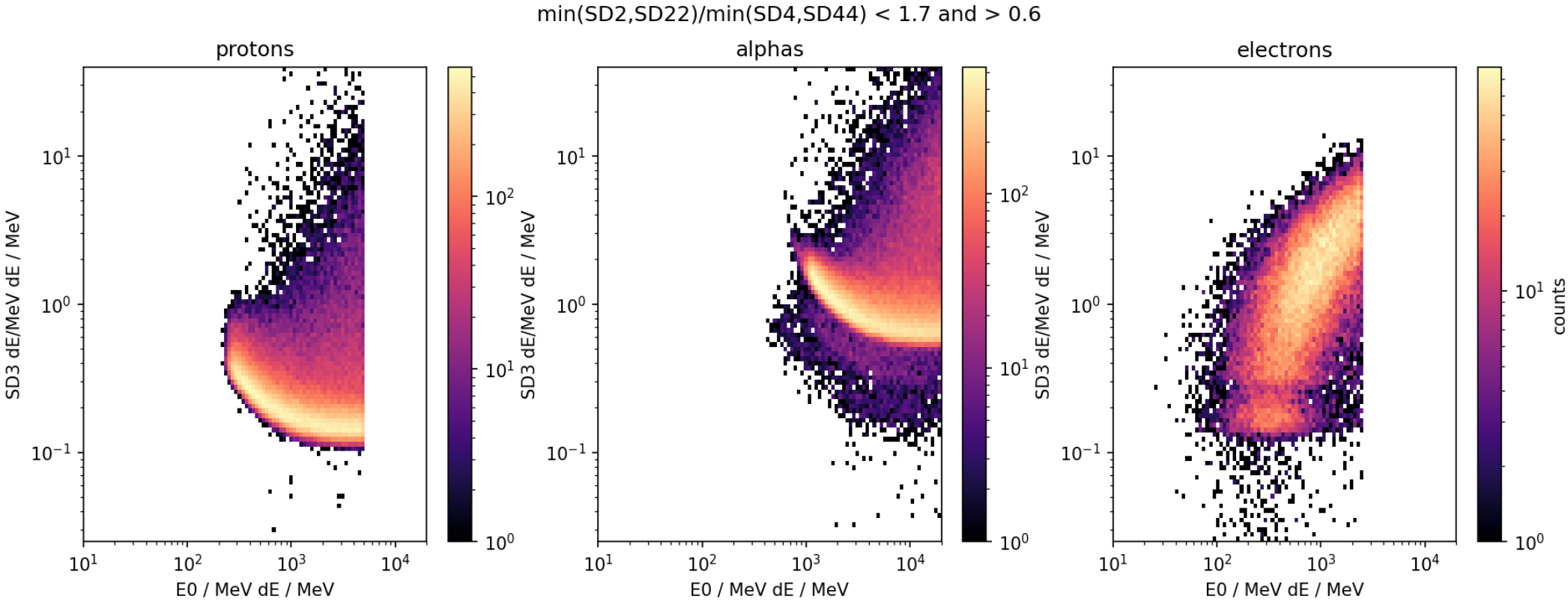
Design studies performed

- Various thicknesses of BGO scintillators
- Need for Cerenkov
- Geometry factors, sizes of detectors
- Need for scintillator tube (“anti-coincidence”)

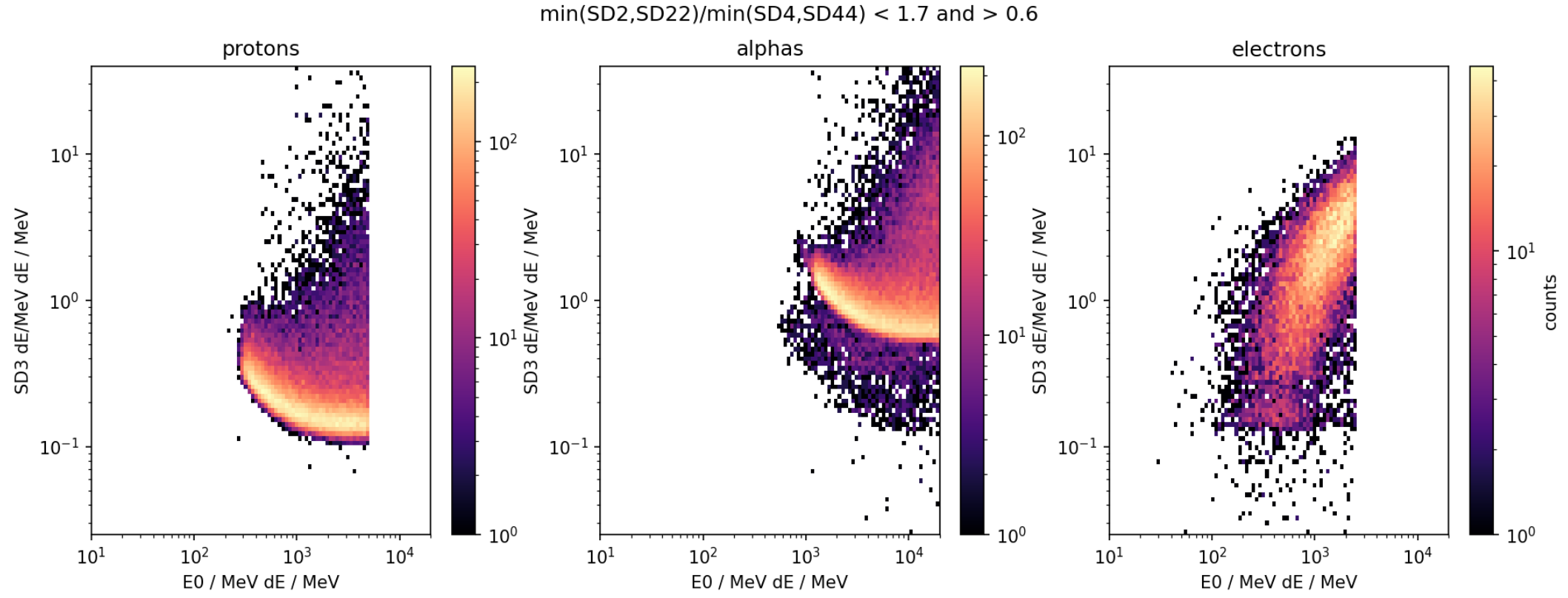
AHEPaM design studies (penetrating particles, 2cm)



AHEPaM design studies (penetrating particles, 3 cm)



AHEPaM design studies (penetrating particles, 4 cm)

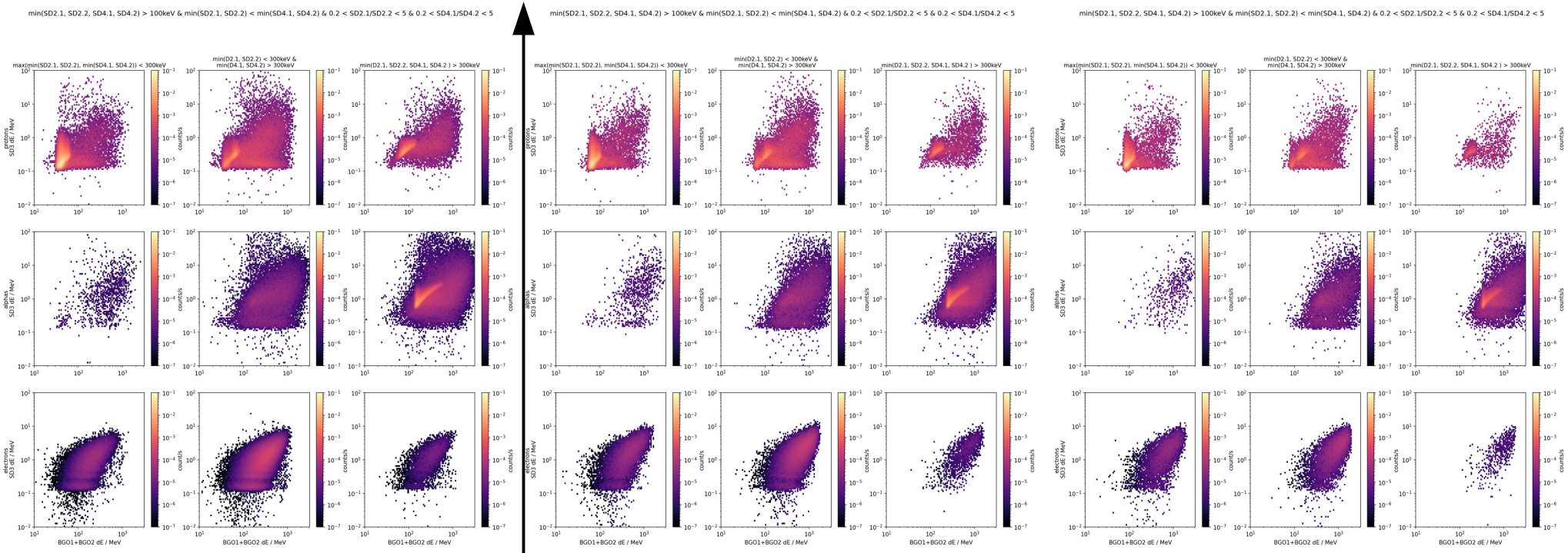


AHEPaM design studies (penetrating particles)

2 cm BGO

3 cm BGO

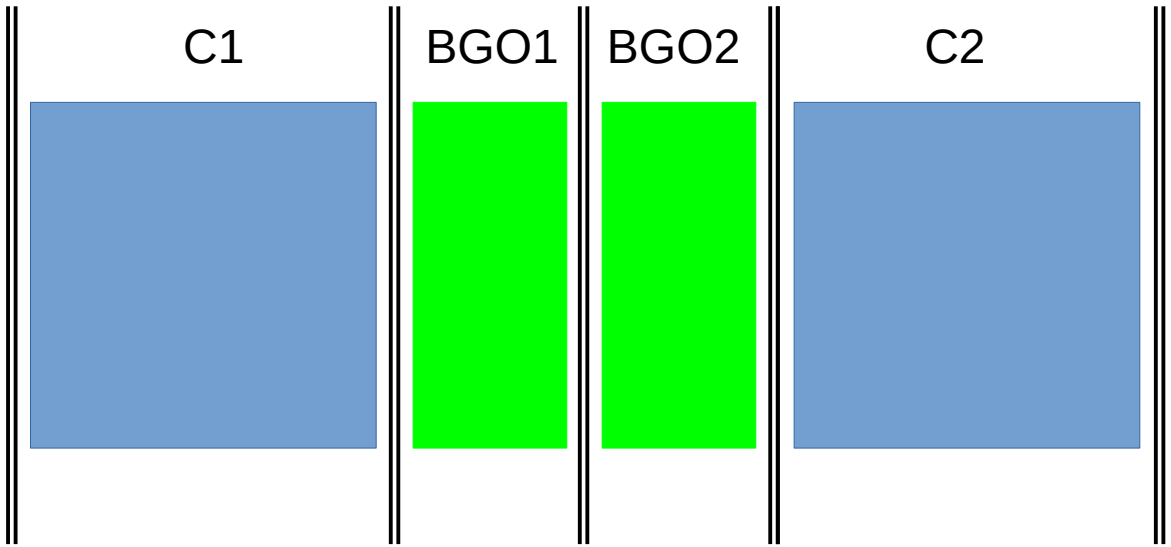
4 cm BGO

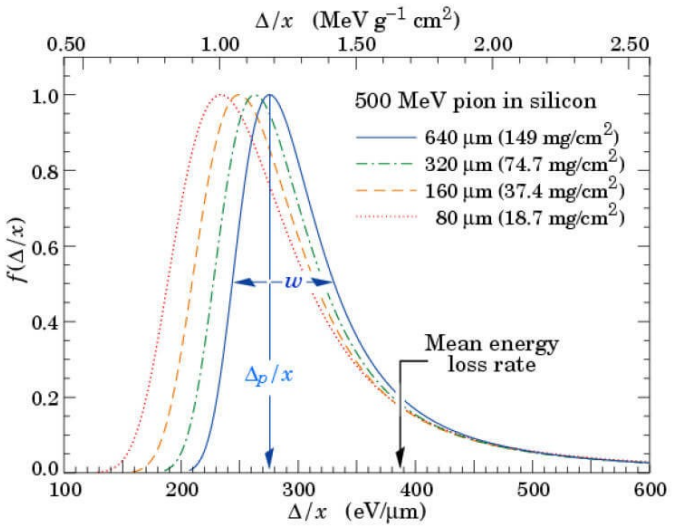


SD3

BGO1 & BGO2

AHEPaM current design (*not* to scale)





SDA/SDA1 SDB/SDB2 SDD/SDD4 SDE/SDE5
SDC/SDC3

Landau distribution:
Use minimum of energy deposited in SDx/SDxx

Presentation of Current Status: Requirements

Discuss using Requirements Spreadsheet:

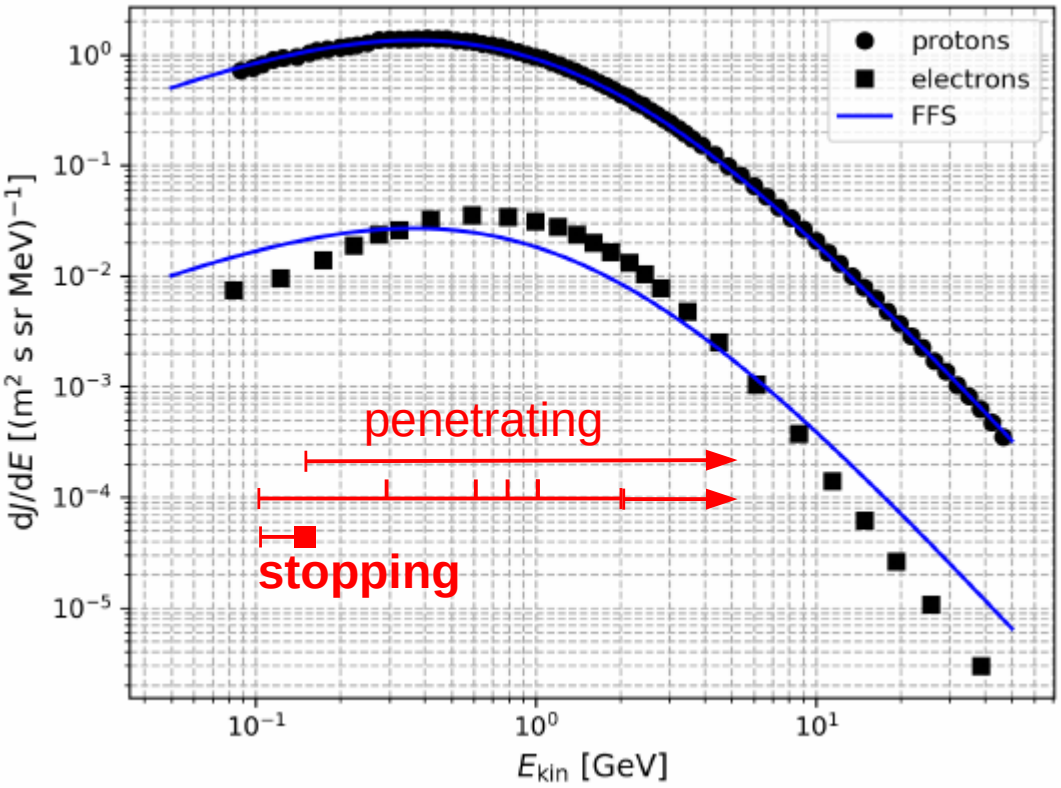
Measurement Requirements: (M-R-010 – M-R-090), see also next viewgraphs

IF Requirements (IF-R-010 – IF-R-090)

Thermal IF Requirements (T-IF-R-010 – T-IF-R-060)

Mechanical IF Requirements (M-IF-R-010 – M-IF-R-040)

Review of Measurement Requirements



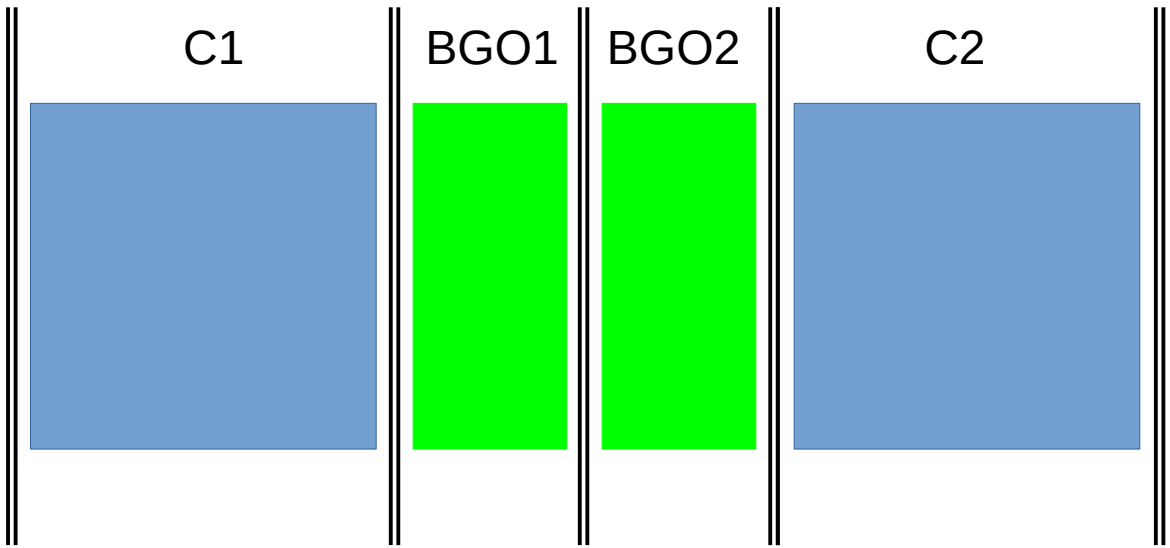
Flux of particles is small.

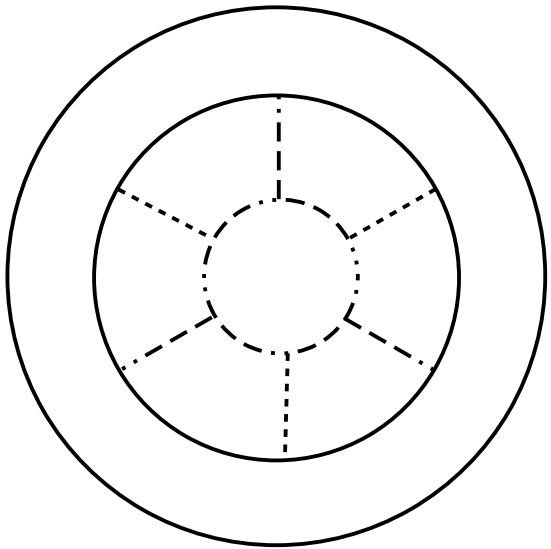
Protons per cm^2 sr s:

100 – 300 MeV:	0.02
300 – 600 MeV:	0.03
600 – 800 MeV:	0.02
800 – 1000 MeV:	0.02
1000 – 2000 MeV:	0.1
> 2000 MeV:	0.3

(notional energy bands in red)

AHEPaM current design study (*not* to scale)





SDA/SDA1 SDB/SDB2 SDC/SDC3 SDD/SDD4 SDE/SDE5

Cerenkov detector “simulated” by ignoring protons E<2 GeV when needed.

AHEPaM measurements of stopping particles

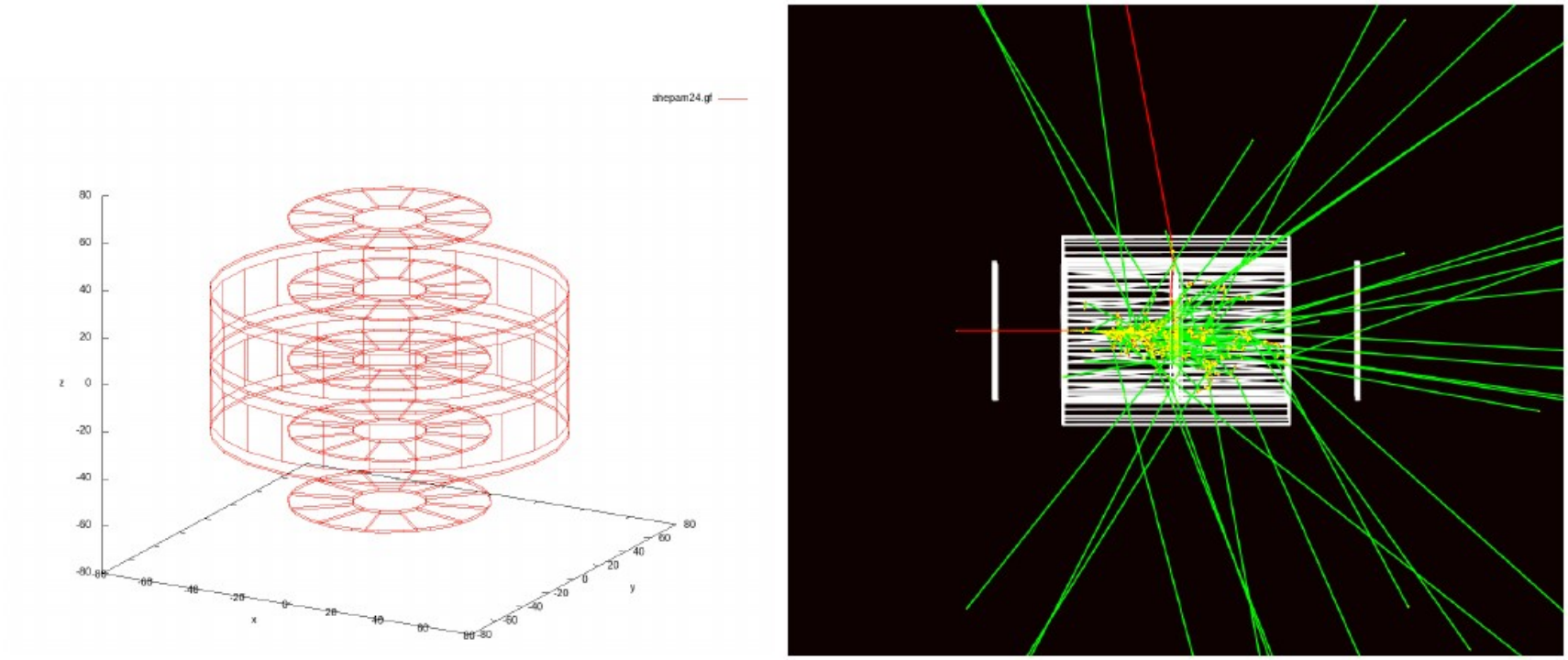
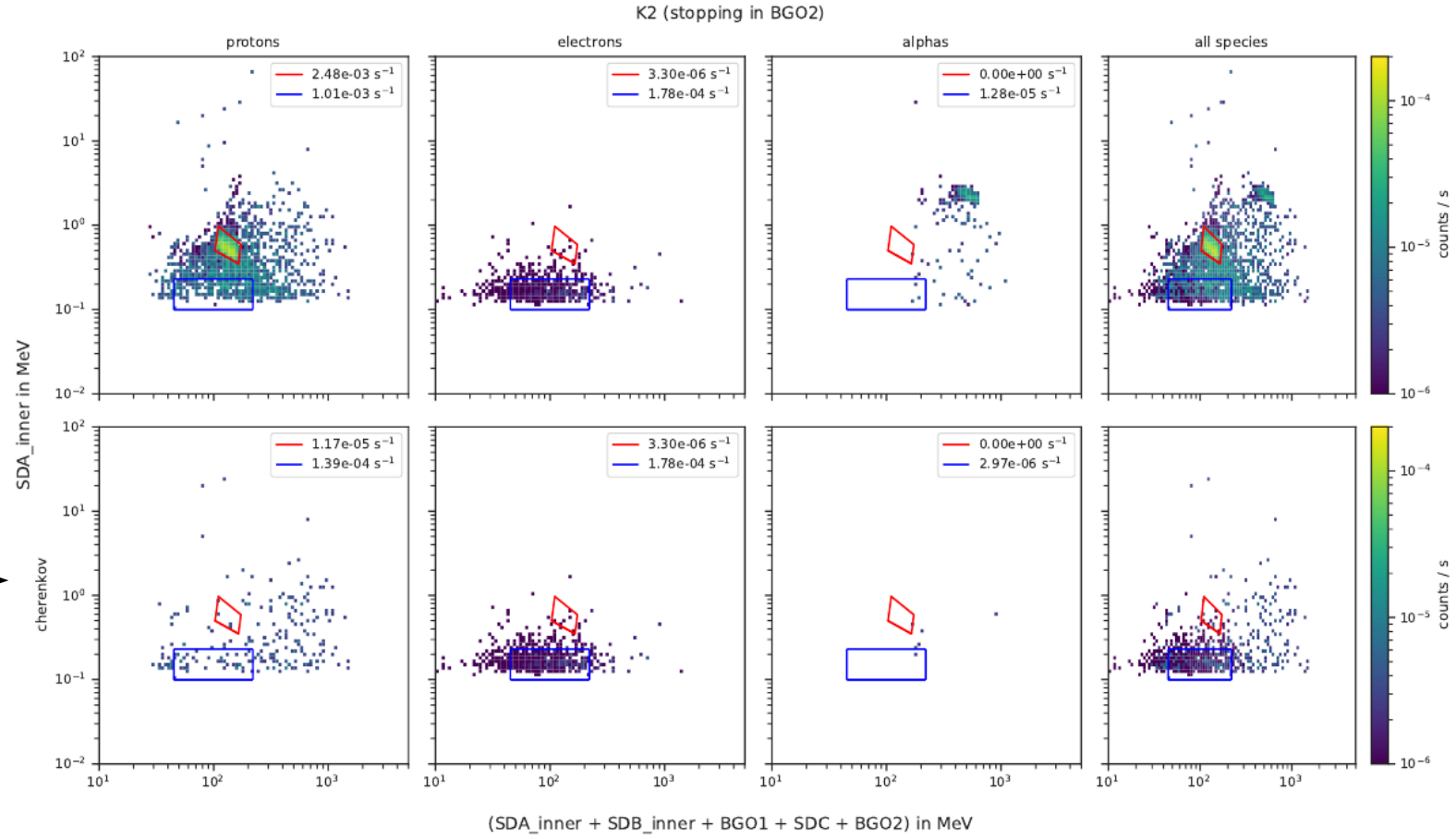


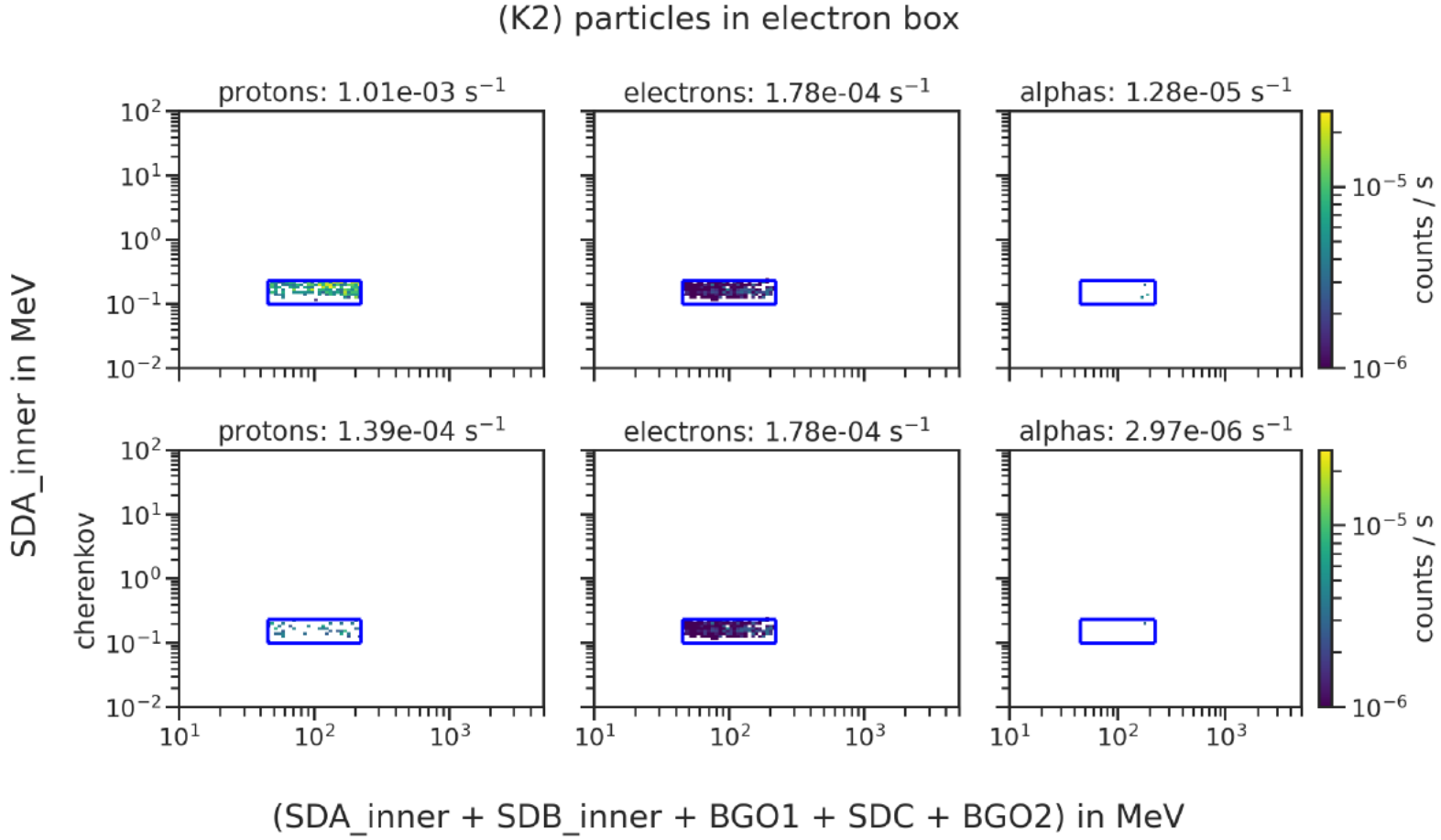
Figure 5: left: Sketch of the geometry as integrated in the GEANT4 simulation. Right: Visualisation of a simulation run with an electron (500 MeV).

AHEPaM measurements of stopping particles

With Cerenkov →



AHEPaM measurements of stopping particles



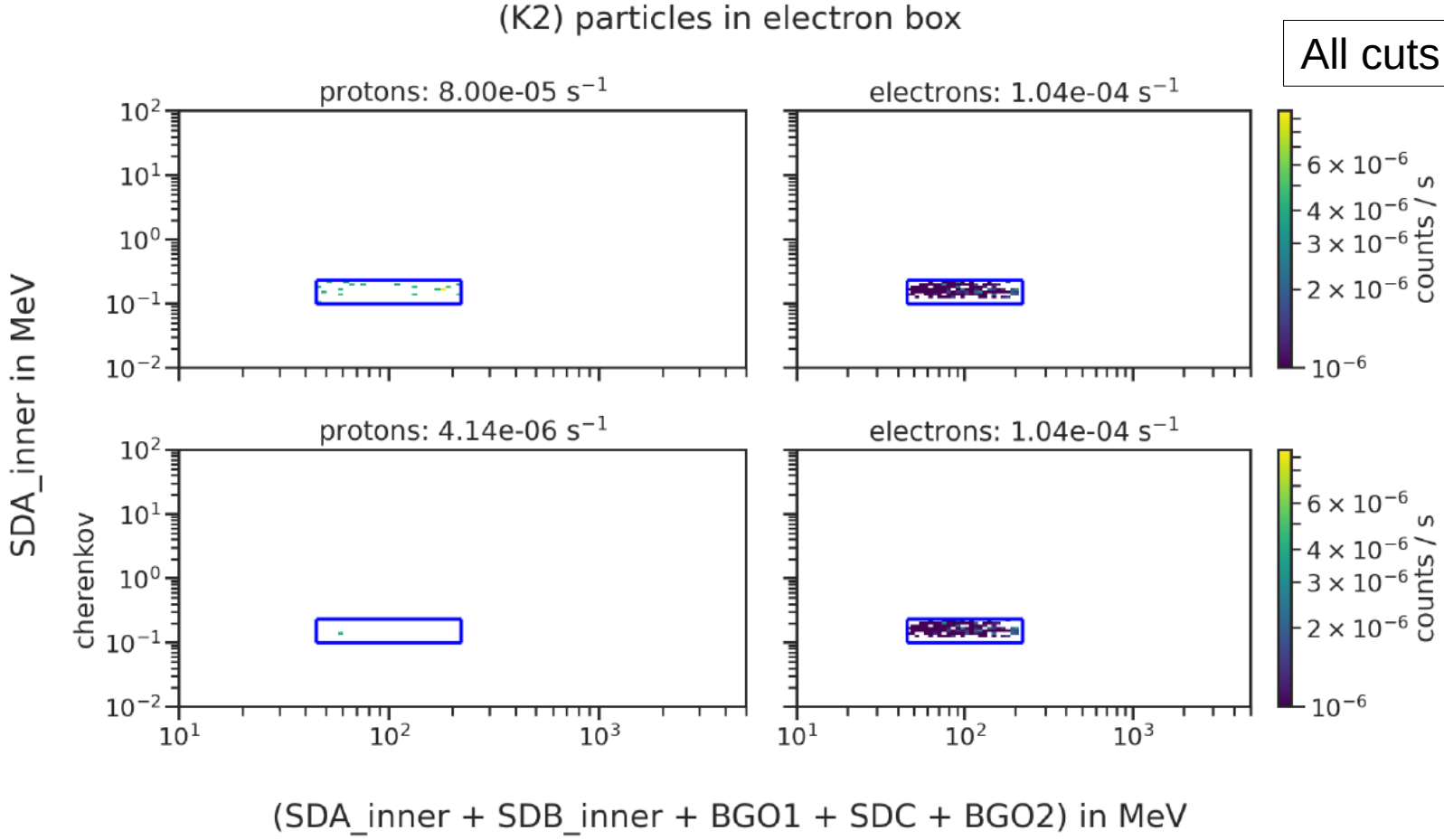
AHEPaM measurements of stopping particles

Apply additional cuts to identify electrons more clearly:

In order to further improve our particle separation, several additional cuts have been introduced:

- A lower limit of the ratio of energy depositions in a BGO over the energy loss in SDB has been defined for both BGOs
- The ratio of the energy depostion in the BGOs has been limited to an interval
- An upper limit for the accepted energy deposition in detector C has been defined
- An upper limit for the accepted energy deposition in detector B has been defined

AHEPaM measurements of stopping particles



AHEPaM measurements of stopping particles

Comparison of count rates with various cuts applied:

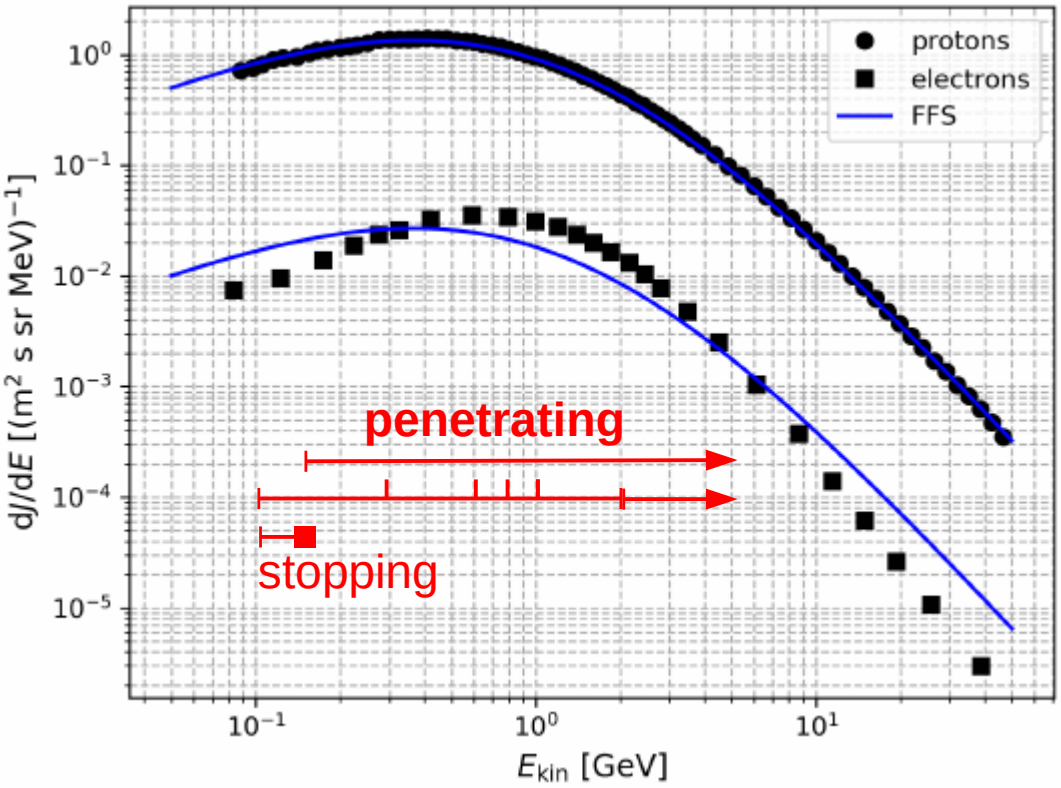
			Cerenkov	
	ebox	ebox+cuts	ebox+ch	ebox+cuts+ch
p counts / ks	1.01	0.080	0.139	0.0041
e counts / ks	0.178	0.104	0.178	0.104
C_a= e+p counts / ks	1.188	0.184	0.317	0.108
r=p/(p+e)	0.85	0.43	0.44	0.04
$\Delta C_e/C_e$ (t=100ks)	0.83	0.48	0.37	0.27
$\Delta C_e/C_e$ (t=3000ks)	0.15	0.08	0.068	0.05

Table 6: Expected count rates in the electron box (column 1), including the improved cuts (2), utilizing the Cherenkov detector (3) and with cuts and the Cherenkov (4) based on protons and electrons.

C_a: total number of counts (e + p)

C_e: electrons only, i.e., $C_e = C_a$ – bkgnd protons

AHEPaM measurements of penetrating particles



Majority of particles is penetrating

Flux of particles is small.

Protons per cm² sr s:

100 – 300 MeV:	0.02
300 – 600 MeV:	0.03
600 – 800 MeV:	0.02
800 – 1000 MeV:	0.02
1000 – 2000 MeV:	0.1
> 2000 MeV:	0.3

(notional energy bands)

AHEPaM measurements of penetrating particles

Define the following cuts for penetrating particles:

proton cut: max(SDB,SDD)<230 keV - proton are expected to deposit 150 keV in 500μm silicon. Since they are less likely to create secondary particle shower in the BGO than electrons, the energy loss in the SSD behind the BGOs is expected to remain below 230 keV as well.

electron cut: SDB<230 keV and SDD>230 keV - electrons at these high energies (they require $>$ 250 MeV to penetrate the instrument) are also expected to deposit 150 keV in 500μm silicon. However, they are producing a cascade of secondary particles in the BGO and hence, the detector behind the BGOs is more likely to see several (secondary) electrons which in sum are causing higher energy depositions in the SSD.

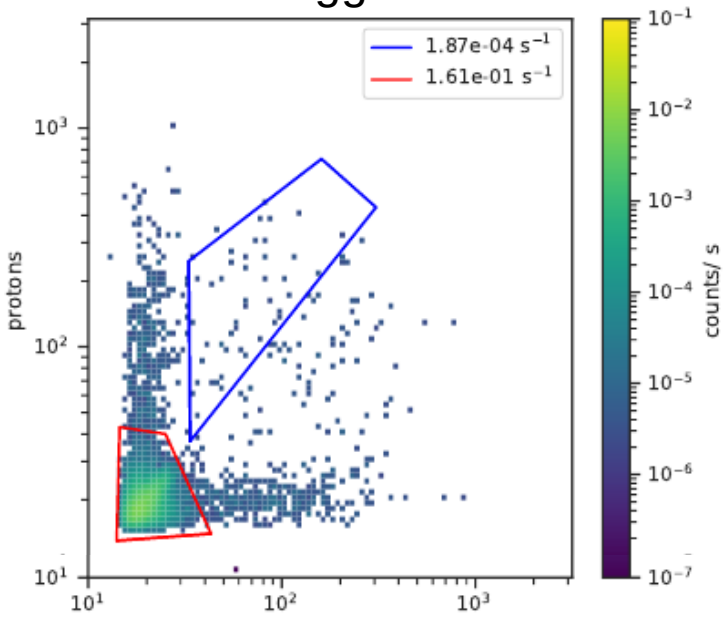
helium cut: min(SDB,SDD)>230 keV - helium particles with energy sufficient enough to penetrate the instrument are expected to cause energy losses of 600 keV in 500μm silicon and hence, the SSDs before and behind the BGO should see high energy depositions

AHEPaM measurements of penetrating particles

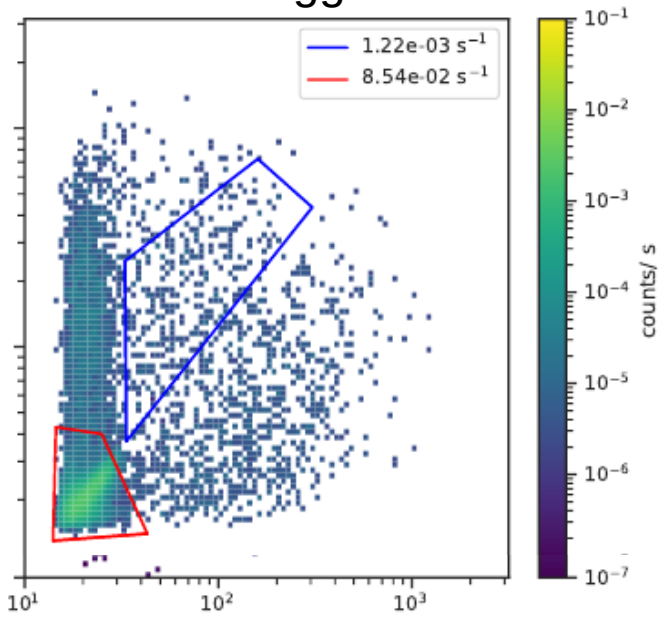
Measurements of protons

Y-axis: E in BGO2

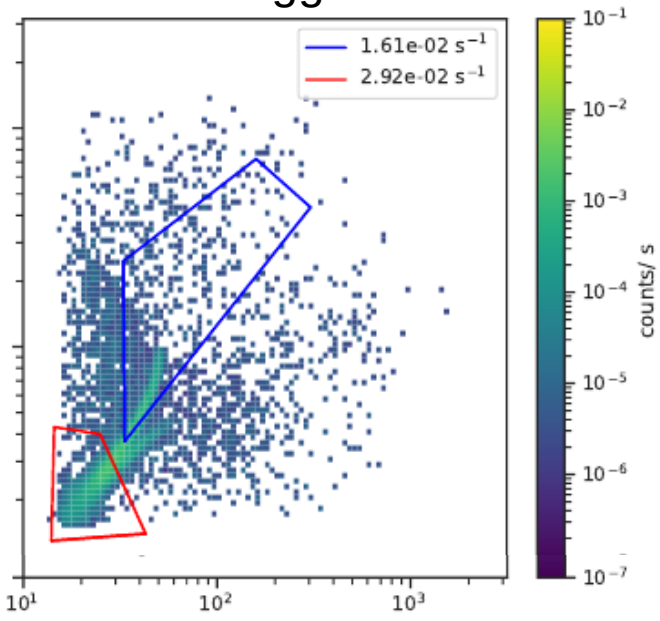
Proton trigger



Electron trigger



Helium trigger

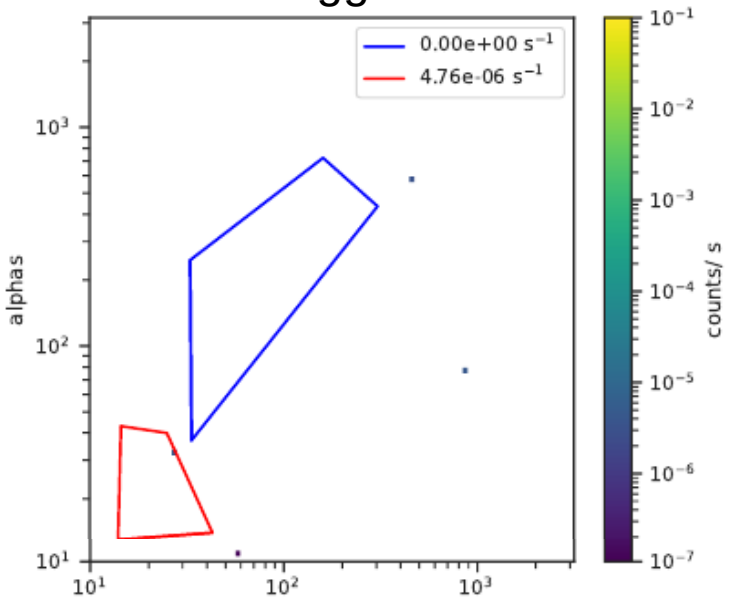


BGO1 in MeV

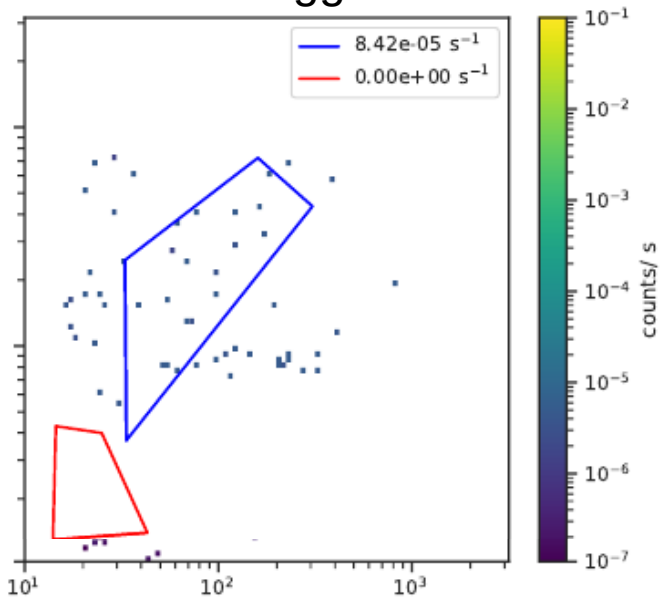
AHEPaM measurements of penetrating particles

Measurements of helium

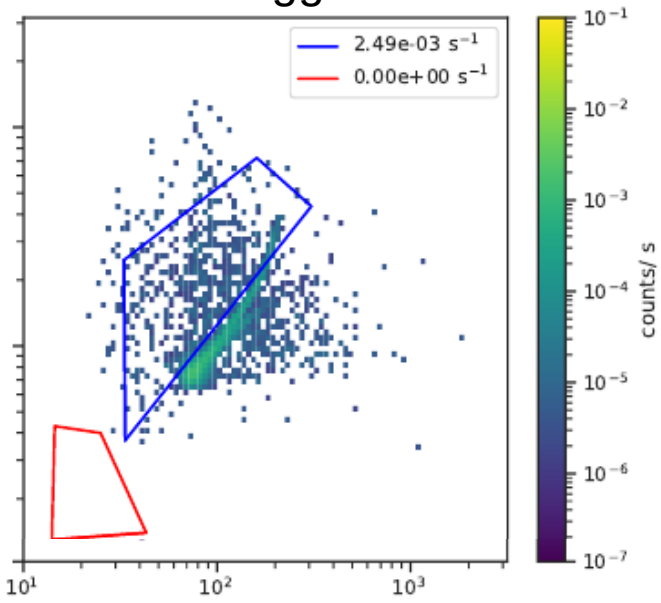
Proton trigger



Electron trigger



Helium trigger

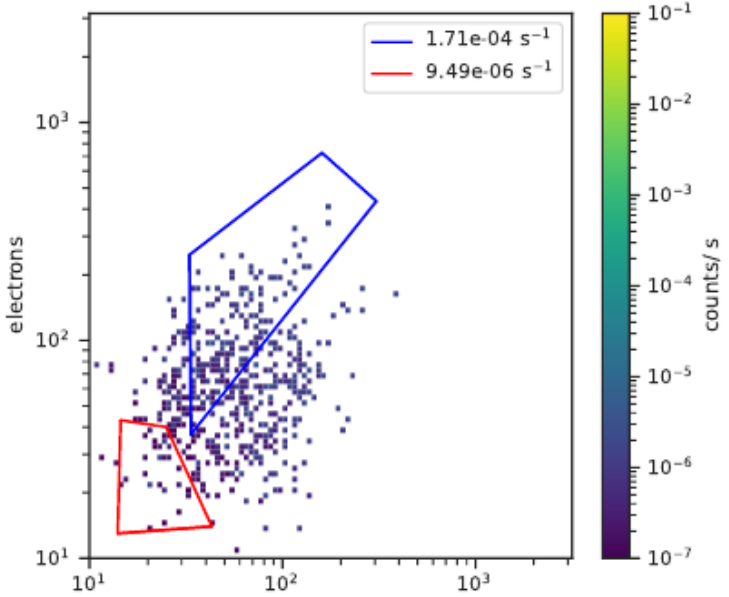


BGO1 in MeV

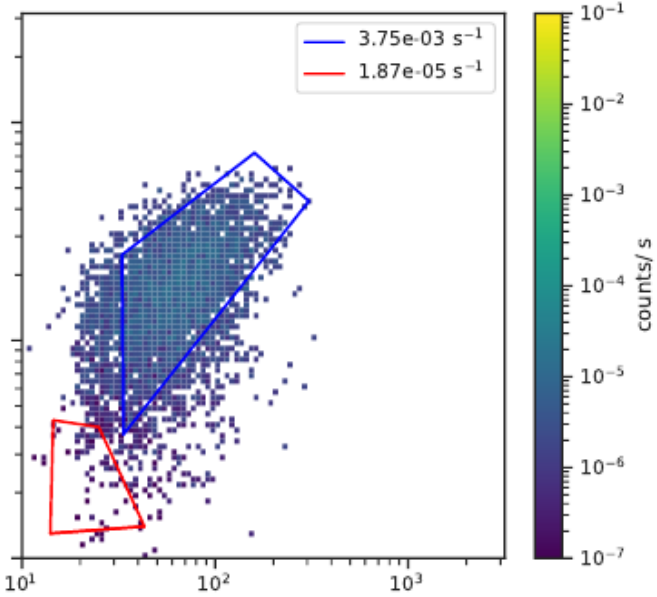
AHEPaM measurements of penetrating particles

Measurements of electrons

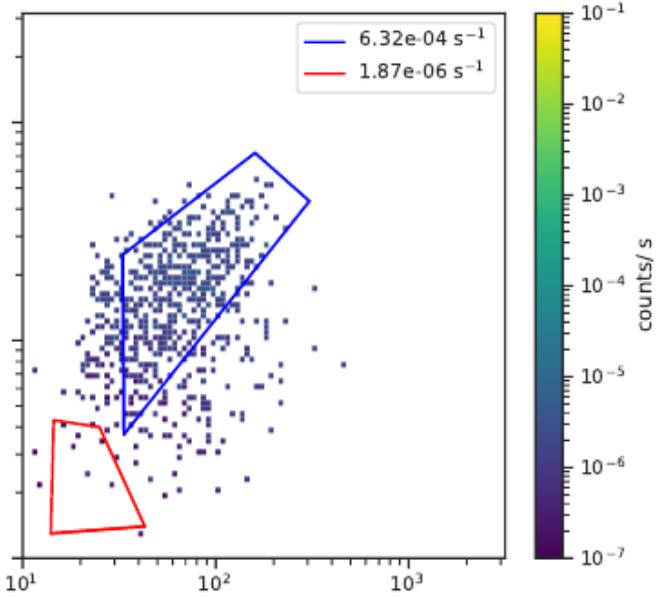
Proton trigger



Electron trigger



Helium trigger

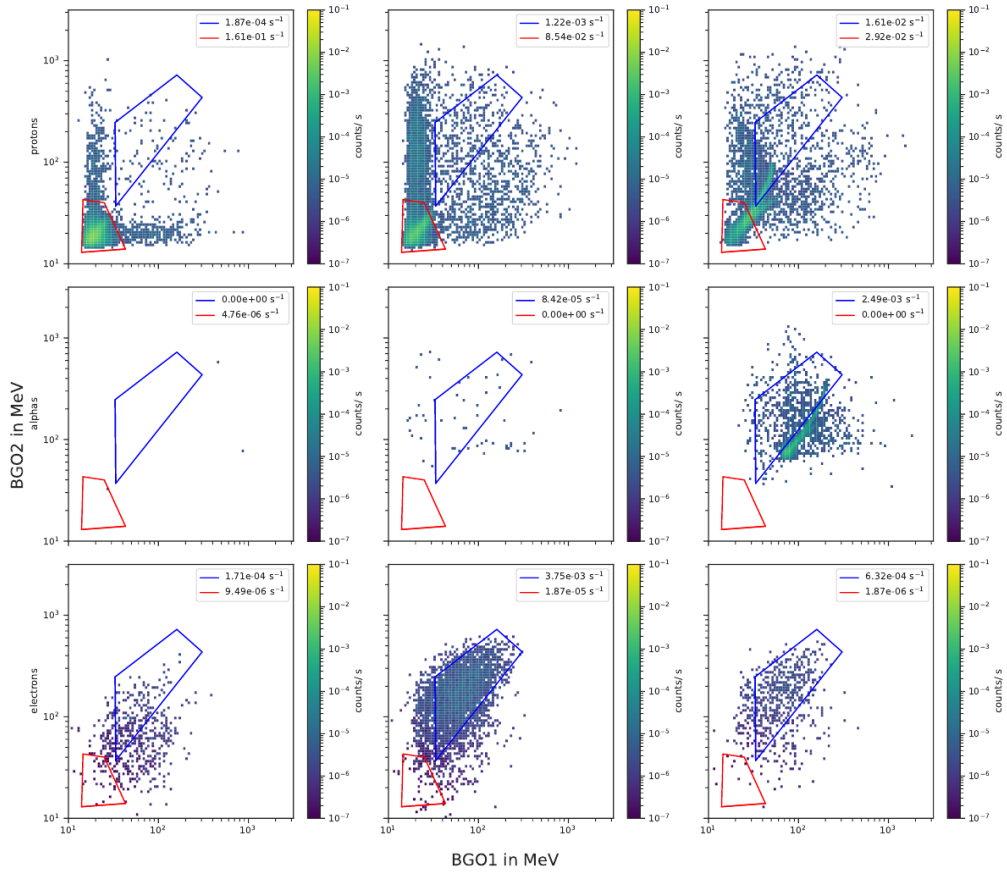


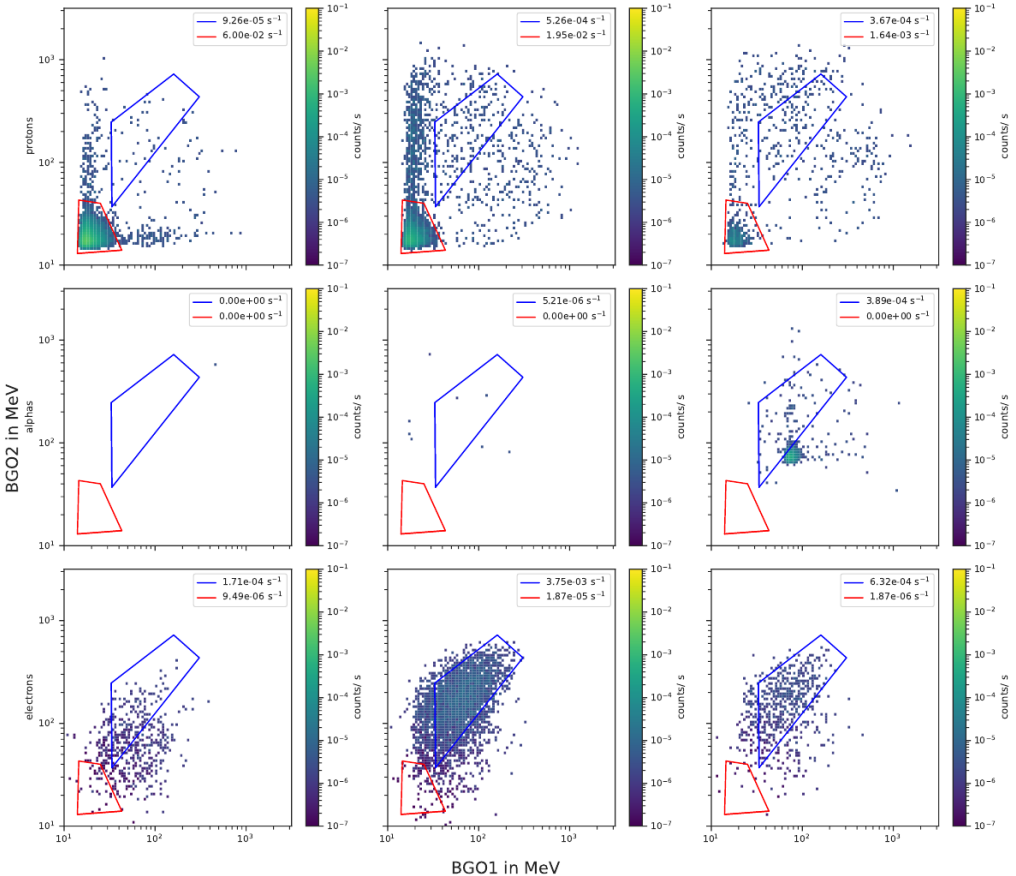
BGO1 in MeV

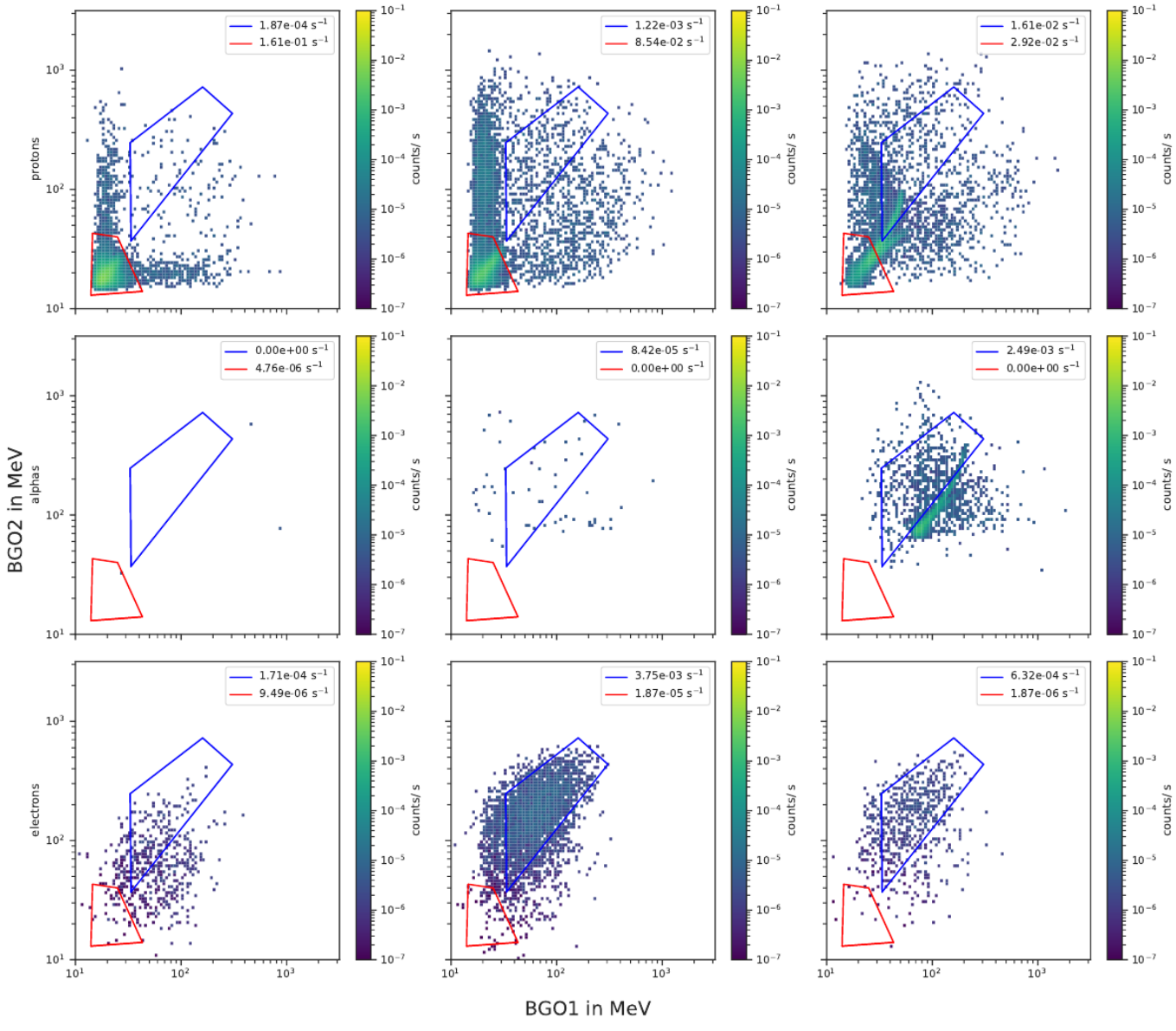
AHEPaM measurements of penetrating particles

No Cerenkov

With Cerenkov



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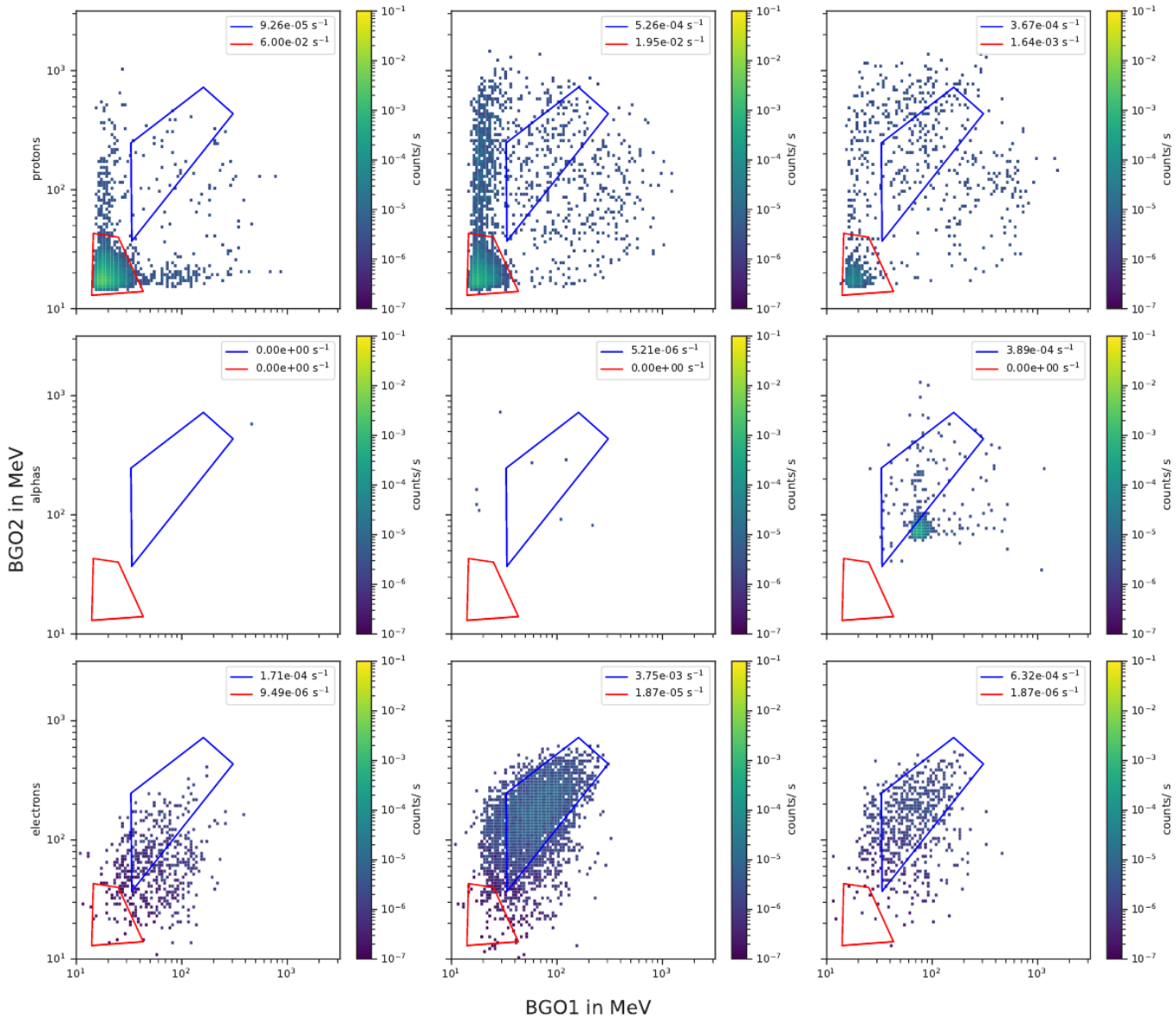
1.61e-01 s⁻¹
1.22e-03 s⁻¹
8.54e-02 s⁻¹
1.61e-02 s⁻¹
2.92e-02 s⁻¹
0.00e+00 s⁻¹
4.76e-06 s⁻¹
8.42e-05 s⁻¹
0.00e+00 s⁻¹
2.49e-03 s⁻¹
0.00e+00 s⁻¹
1.71e-04 s⁻¹
9.49e-06 s⁻¹
3.75e-03 s⁻¹
1.87e-05 s⁻¹
6.32e-04 s⁻¹
1.87e-06 s⁻¹
protons
alphas
electrons
counts/ s
BGO2 in MeV
BGO1 in MeV

No Cerenkov



With Cerenkov

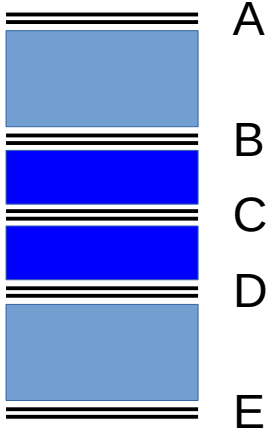
AHEPaM count rates w and w/o Cerenkov

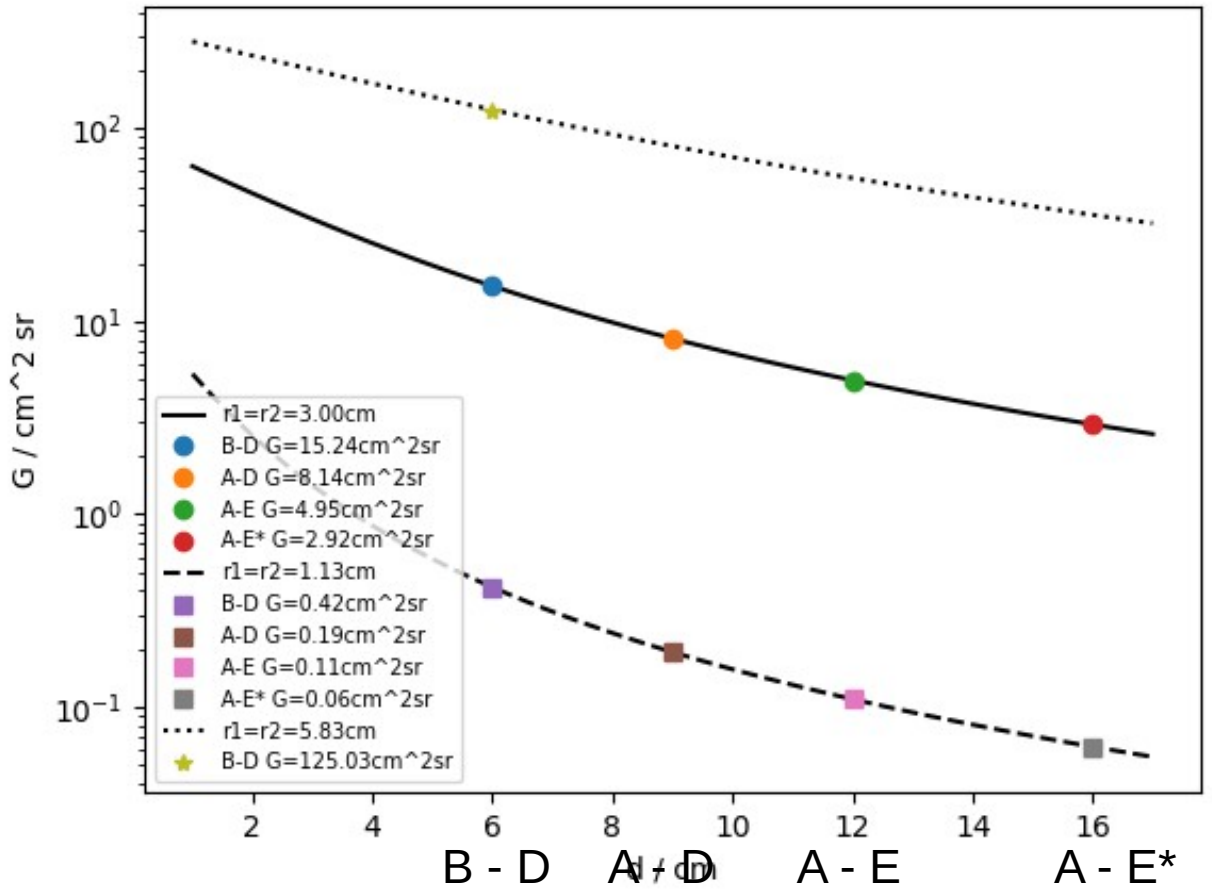
	etrigger+ebox (blue box)	etrigger+ebox+ch (blue box)
p counts / ks	1.22	0.526
e counts / ks	3.75	3.75
C_a= e+p counts / ks	4.97	4.276
r=p/(p+e) counts	0.245	0.123
$\Delta C_e/C_e$ (t=50ks)	0.089	0.074
$\Delta C_e/C_e$ (t=100ks)	0.063	0.053

Table 7: Expected count rates in the electron channel without (first column) and with Cherenkov detector (second column) based on penetrating protons and electrons. Due to the second basic cut (SDB<SDD) these numbers have to be doubled for a bi-directional analysis.

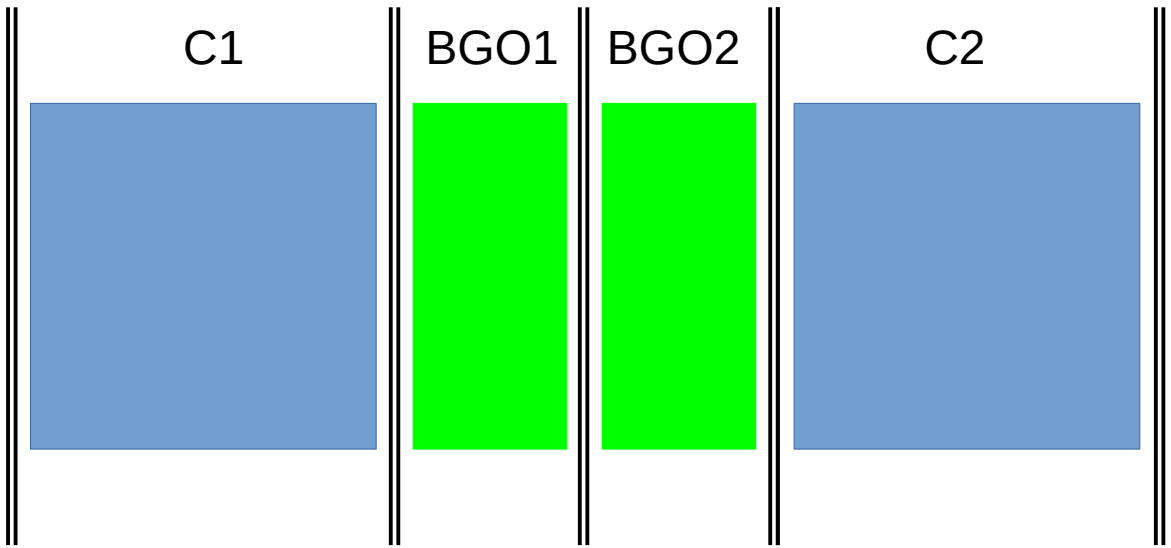
BGO1 dE / MeV

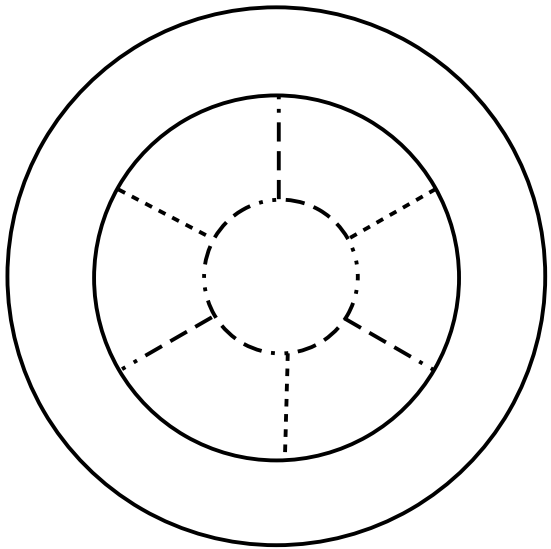
AHEPaM count rates: Geometry factors (onesided)





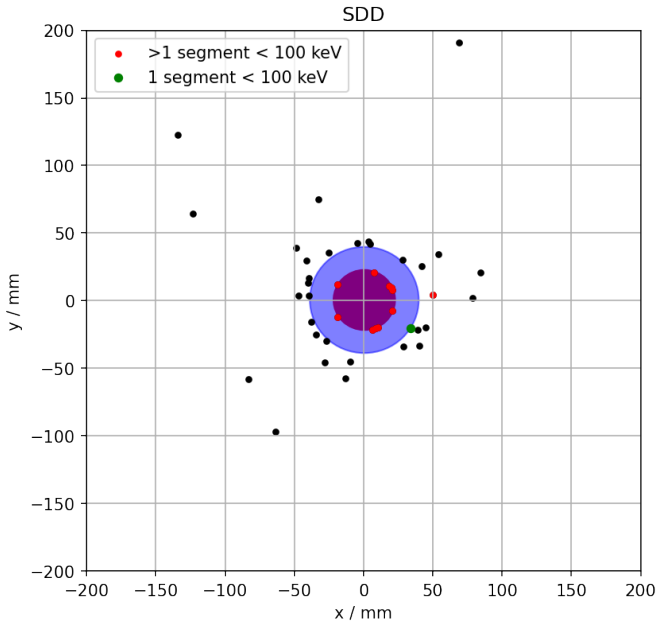
AHEPaM current design (*not* to scale)

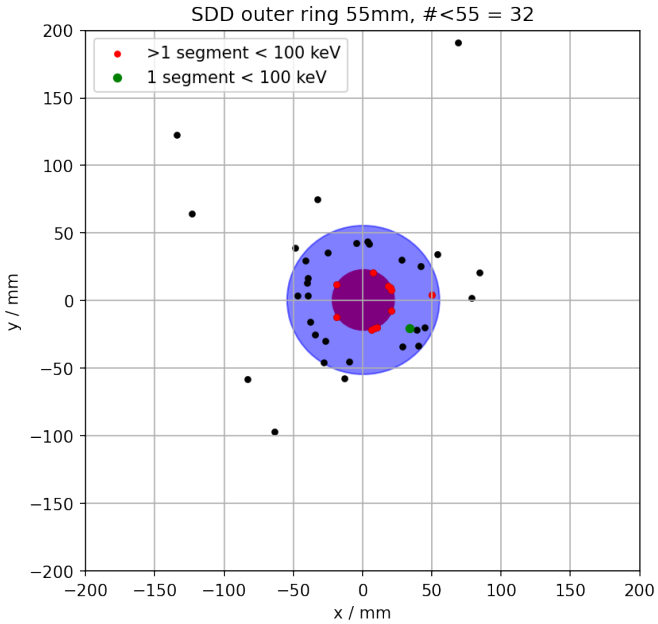


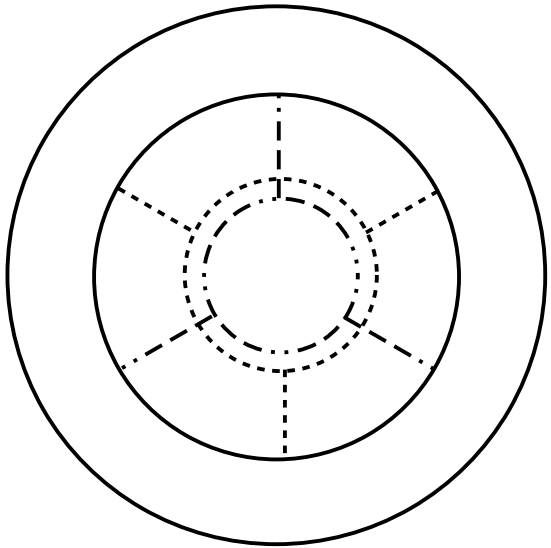


SDA/SDA1 SDB/SDB2 SDD/SDD4 SDE/SDE5
SDC/SDC3

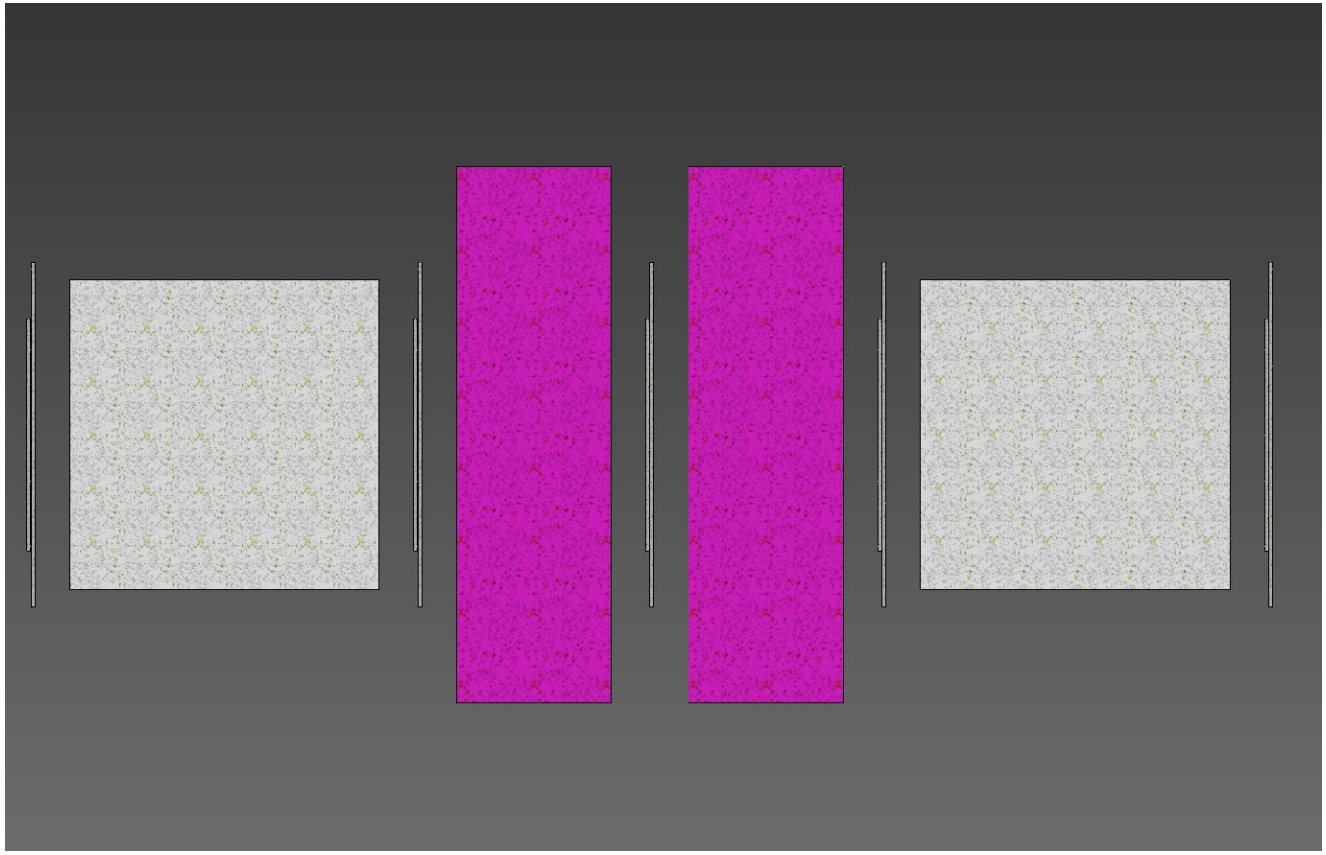
AHEPaM current design (*not* to scale)



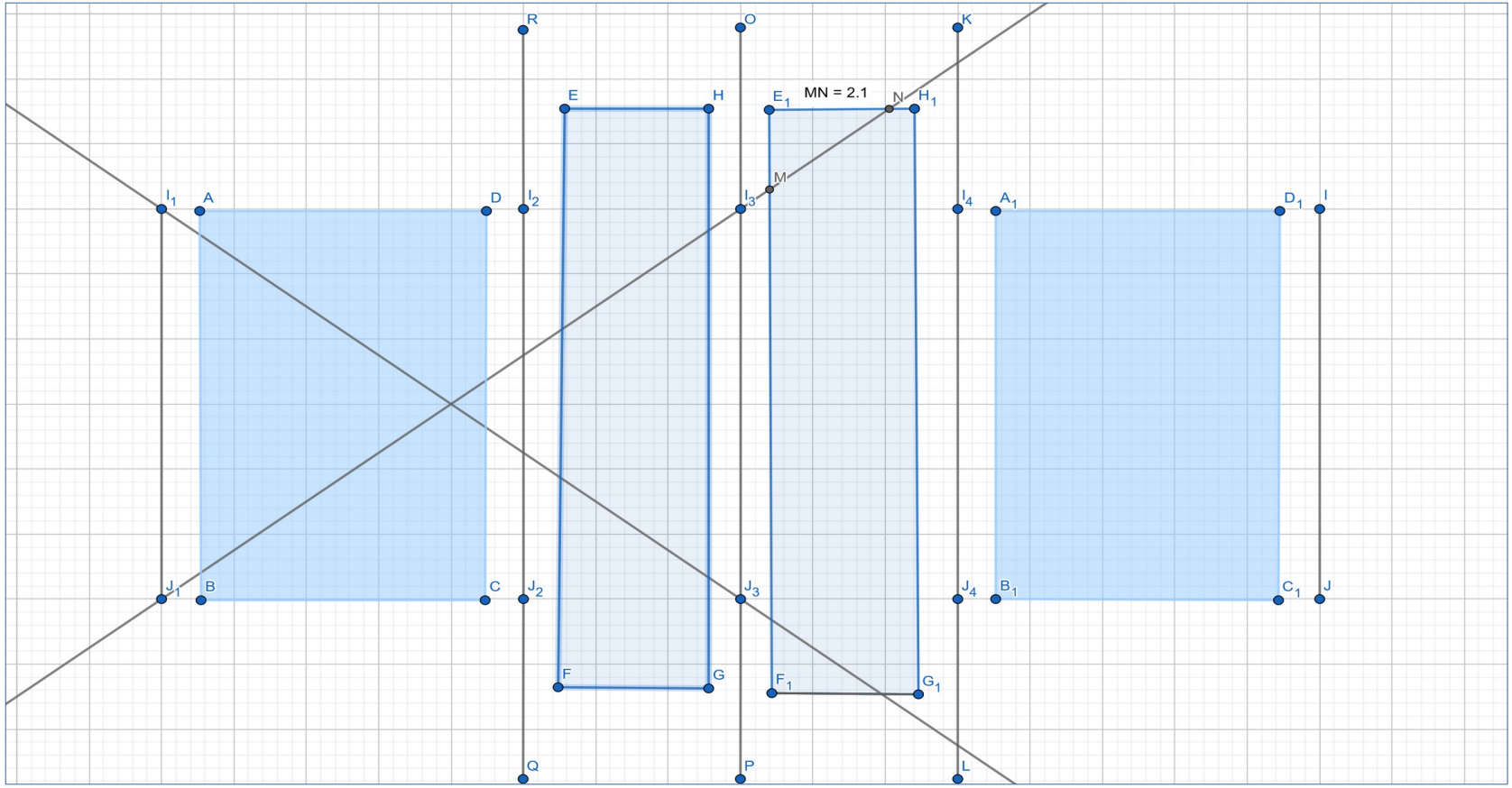




Presentation of Current Status

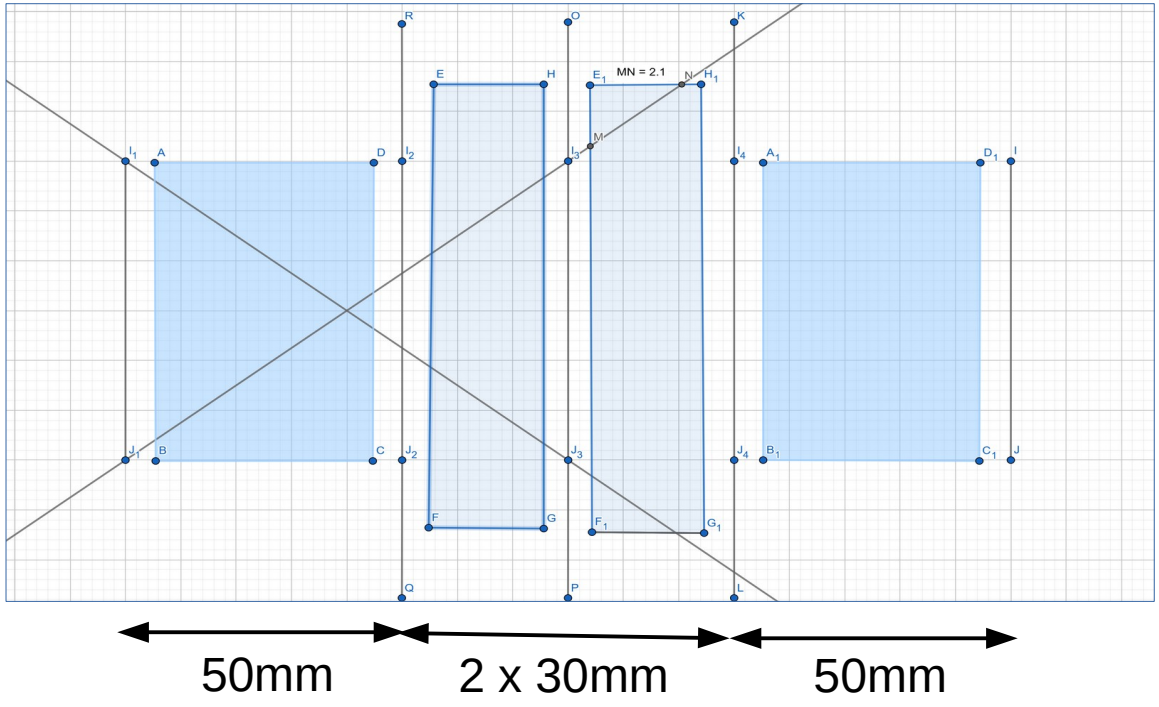


Presentation of Current Status: Geometry

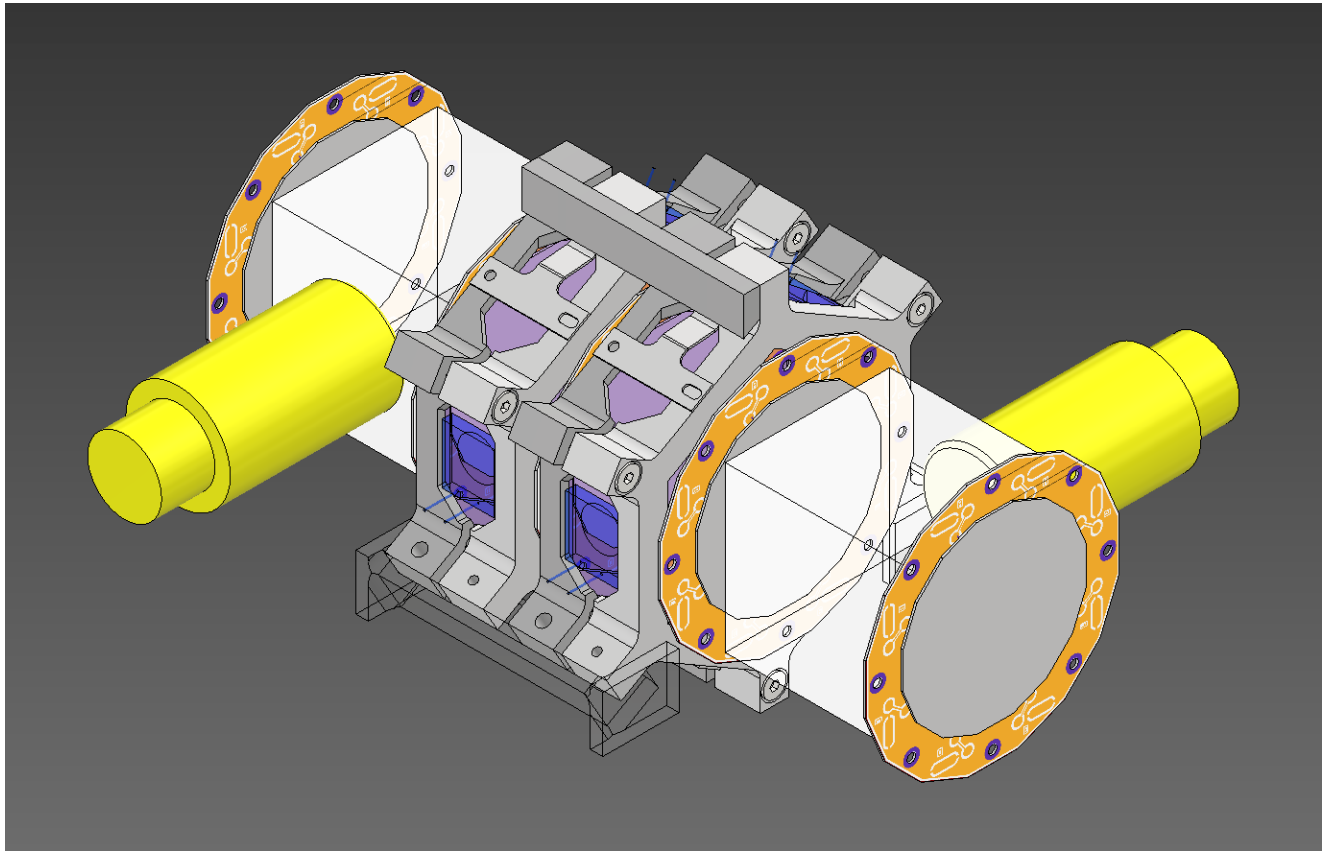


Presentation of Current Status: Geometry

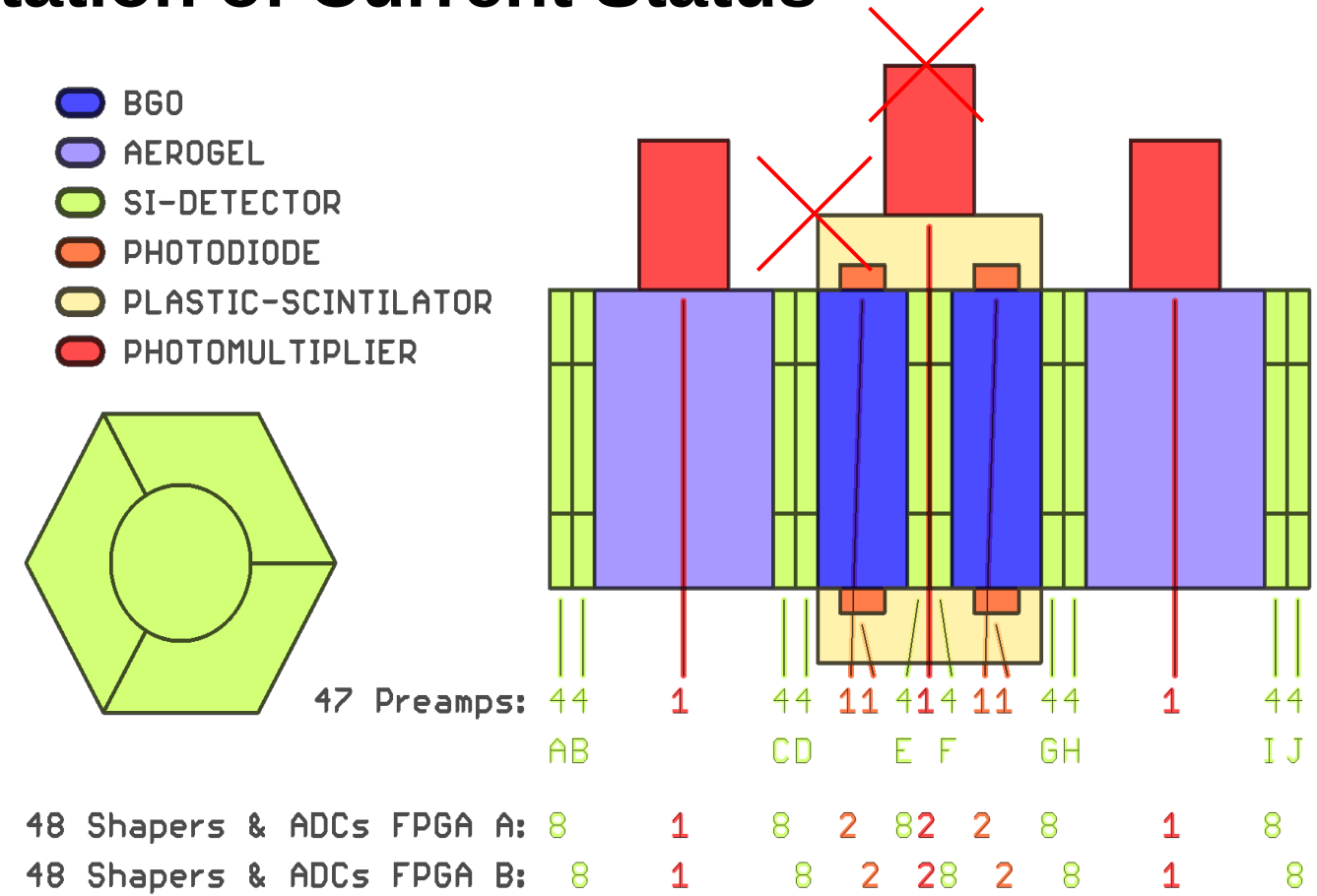
-30 / 50 mm between SSDs
- SSD Segments:
    R_inner: 11.3mm
    R_middle: 30 mm
    R_outer: 58.33mm
BGO: Hexagonal,
    a_bgo:45 mm
Cerenkov: R_middle x R_middle x 40mm



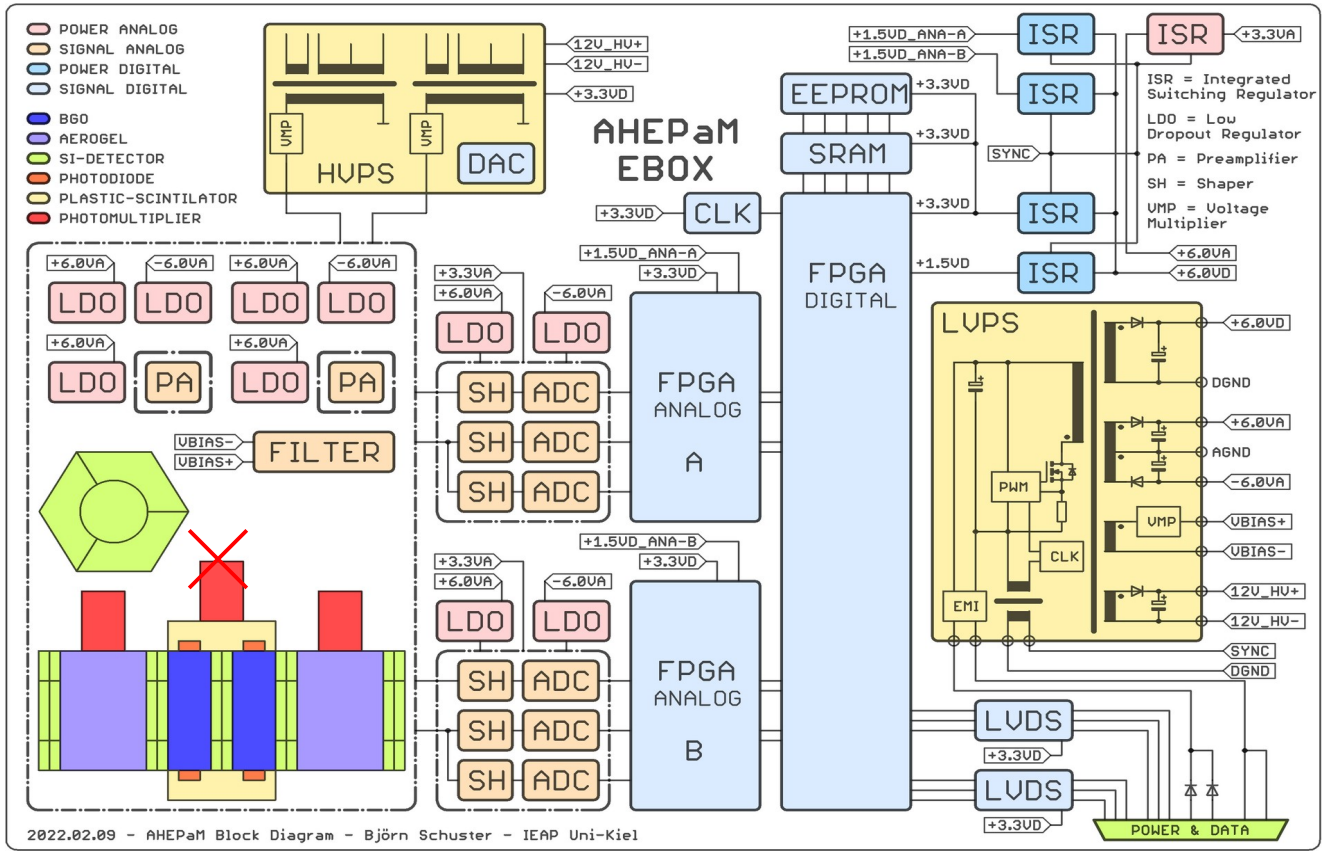
Presentation of Current Status



Presentation of Current Status

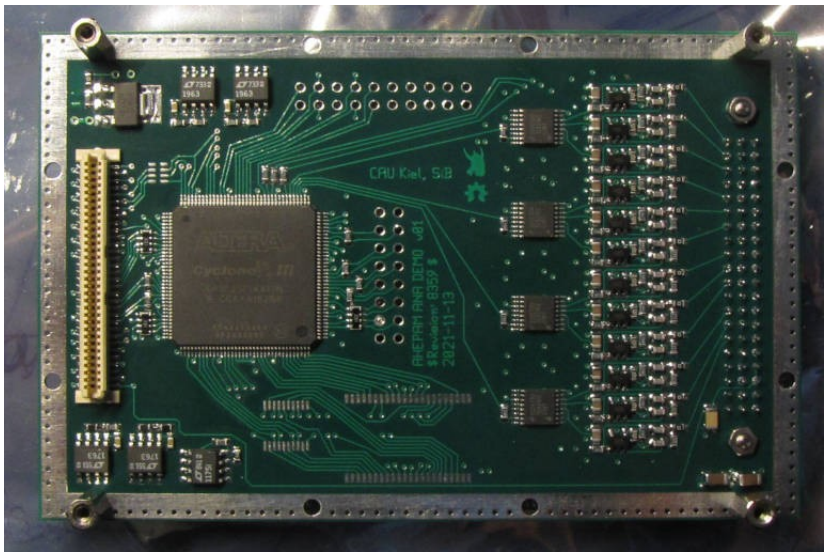


Presentation of Current Status



Presentation of Current Status

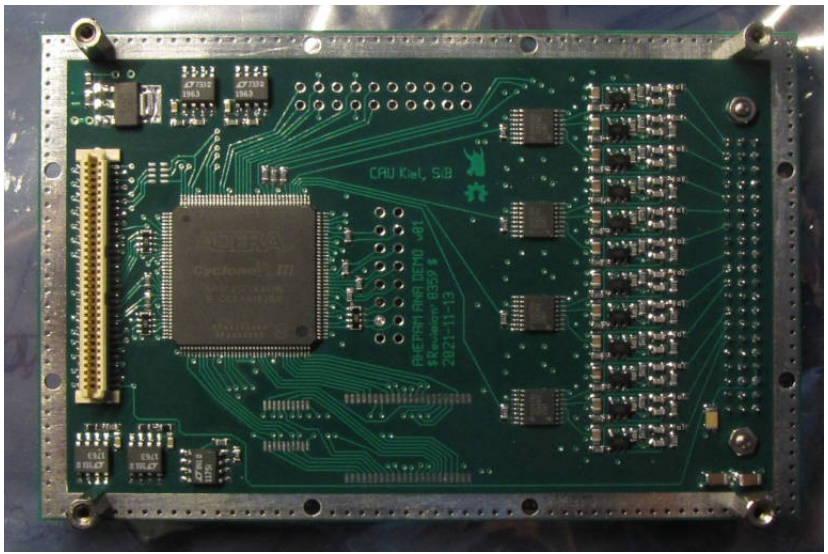
- 1st demo electronics designed and tested for functionality
- Cerenkov detectors ordered
- Ready to place order for some SSDs



- Updated Geant-4 model running, but output not yet analysed
- Working on HV power supply
-

Next Steps

- Place order for BGO scintillators
-



Closeout, MoMs

Actions:
Requirements Document: Who is responsible?
How to treat missing documents