Giulio Lucchetta
on behalf of the IFAE group

PSD meeting
13^{th} October 2022

IFAE
25 years 1991-2016
Institut de Física d'Altes Energies
EXCELENCIA SEVERO OCHOA
BIST Barcelona Institute of Science and Technology

Topics

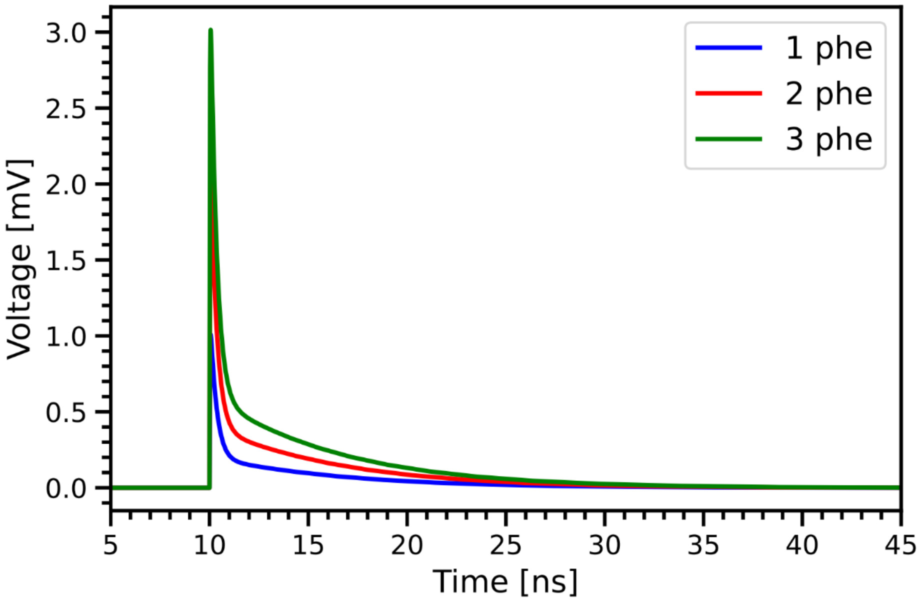
1) Consideration about Beta ASIC trigger comparator.

2) Preliminary calculation of the expected in-orbit rates.

SiPM pulse shape

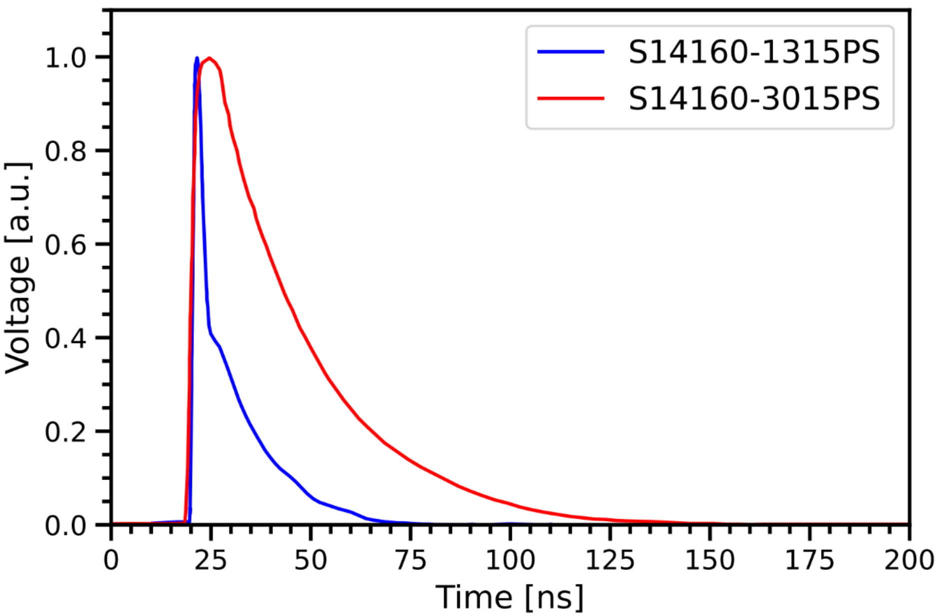
- Beta ASIC provides the input trigger signals and read-out for FIT and PSD.
- SiPM pulse shape: very fast exponential rise and fall made by the sum of two components (fast and slow component), typically in the range 10ns – 100ns.

FIT



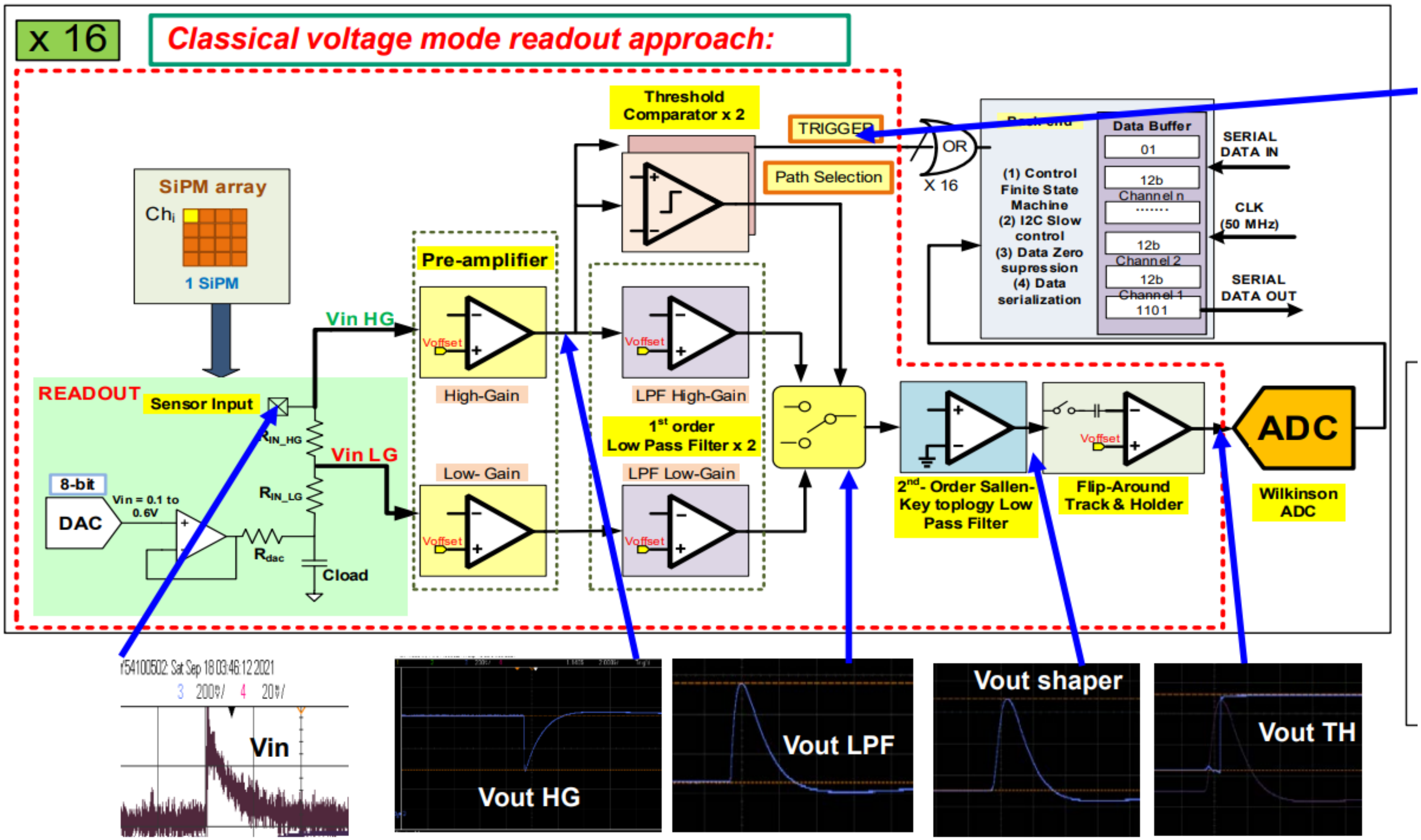
Data provided by the UB group

PSD



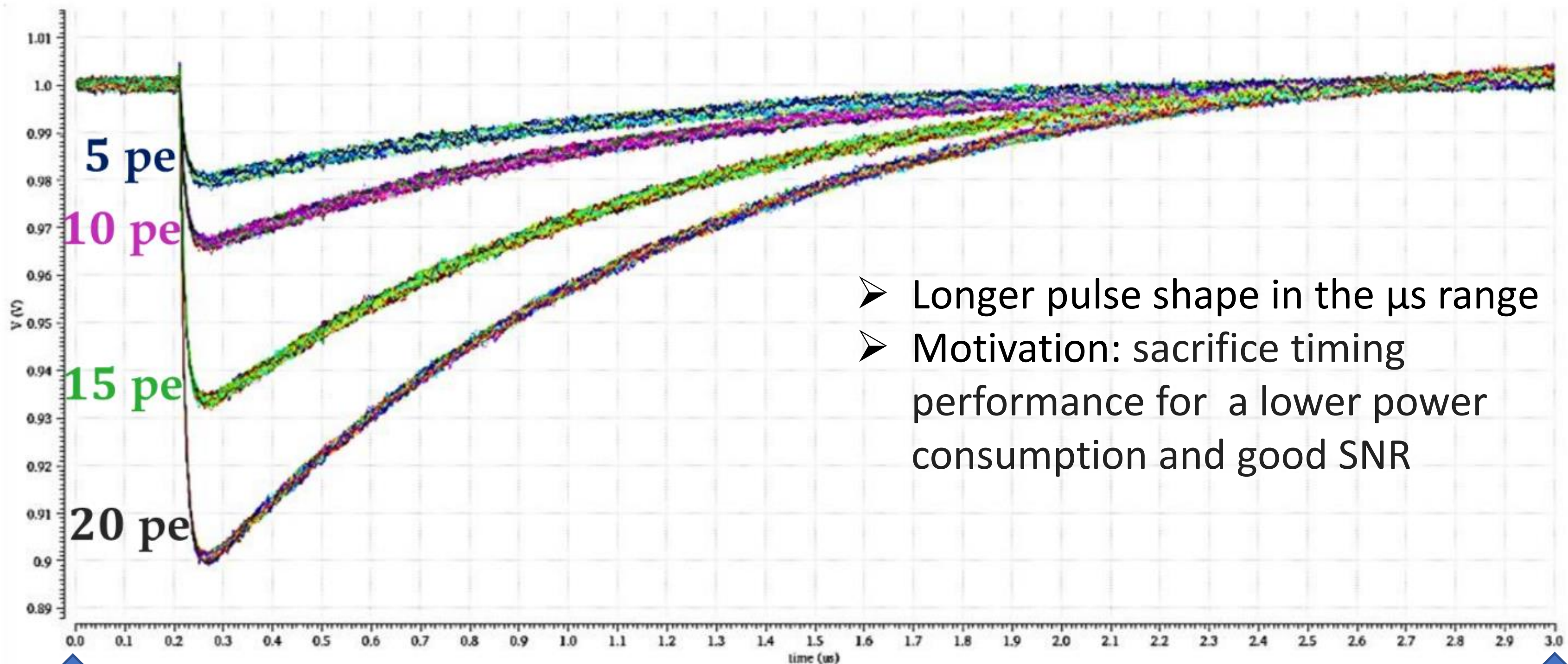
Data taken from Hamamatsu datasheet

Beta ASIC comparator



Beta ASIC comparator

- From Master thesis of Aitor Iraola Zapiain: "Development of Analogue circuits for the BETA ASIC HERD-FIT detector"



- Longer pulse shape in the µs range
- Motivation: sacrifice timing performance for a lower power consumption and good SNR

Fig. 7 Comparator input signals mixed with noise

0 µs

3 µs

Beta ASIC comparator

- From Master thesis of [Aitor Iraola Zapiain: "Development of Analogue circuits for the BETA ASIC HERD-FIT detector"]

1pe

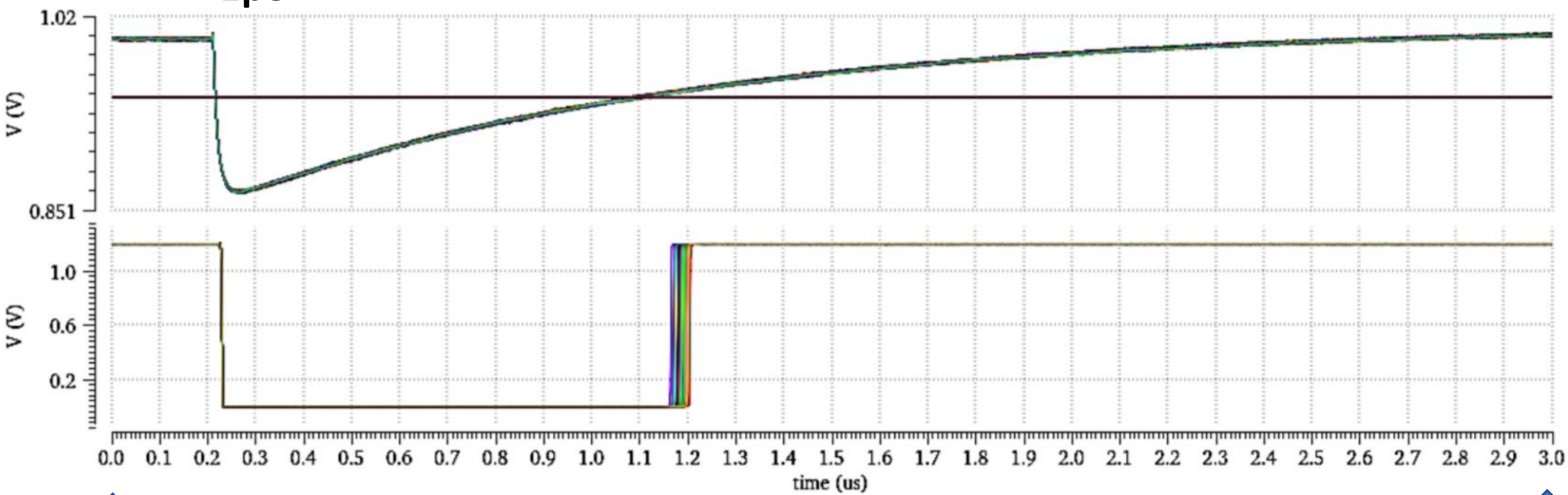


Fig. 8 Comparator input and output signals mixed with noise

0 µs

3 µs

- Comparator width: time over threshold of the pre-amplifier signal.

Beta ASIC comparator

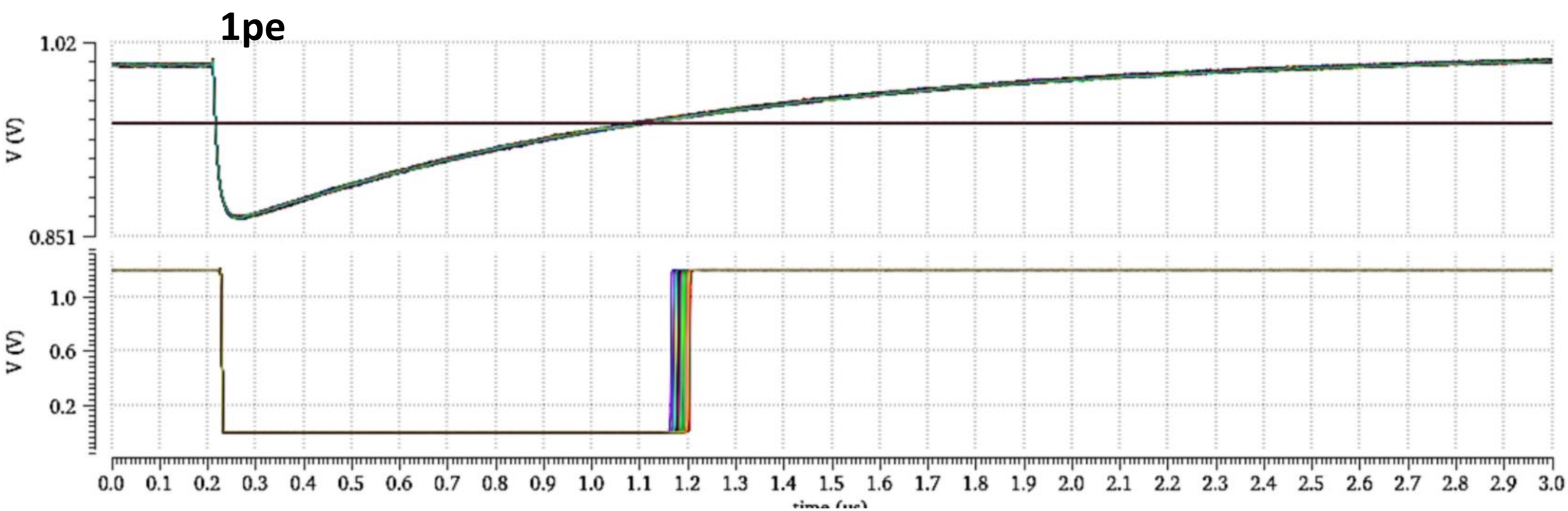
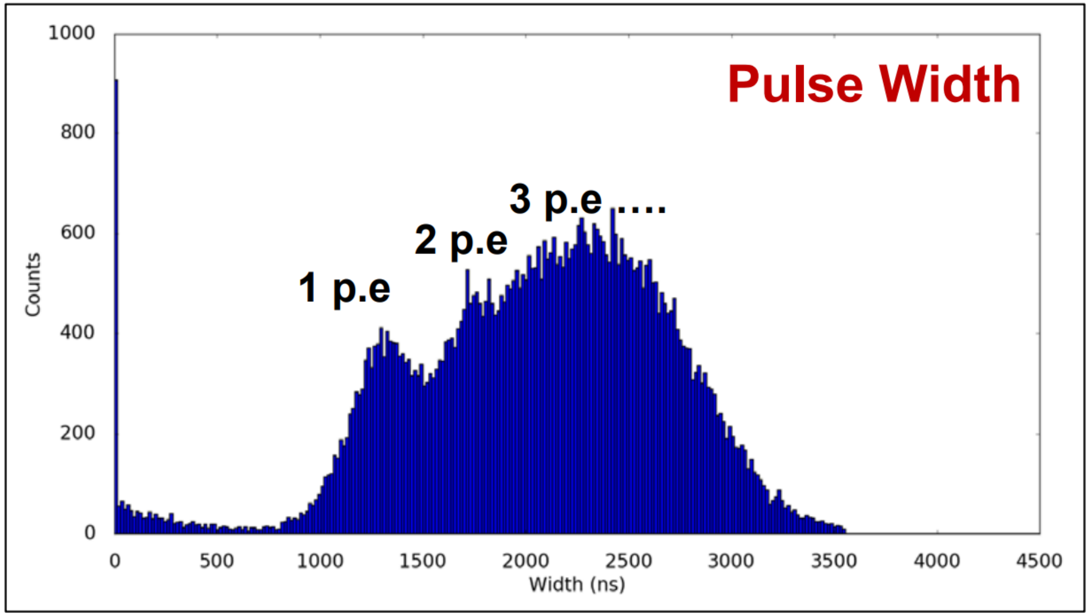
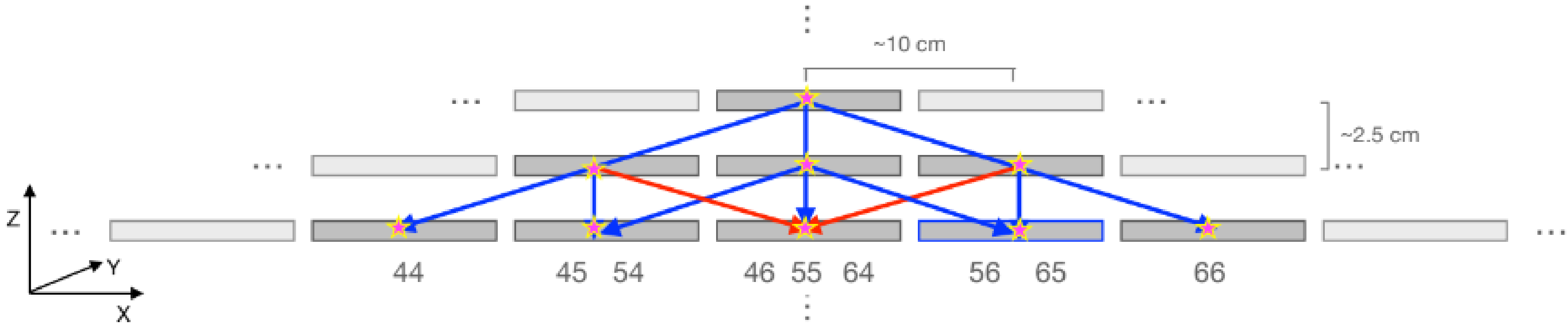


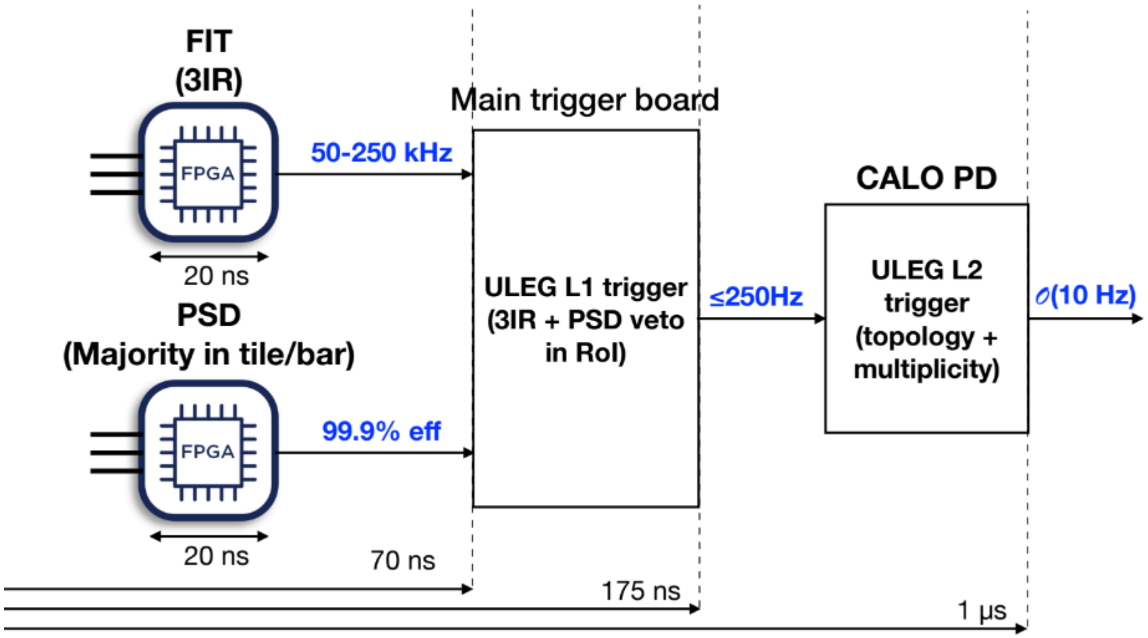
Fig. 8 Comparator i



- Time window non optimal for trigger.
- Possibility to have a fixed width comparator and lower width?

ULEG trigger concept



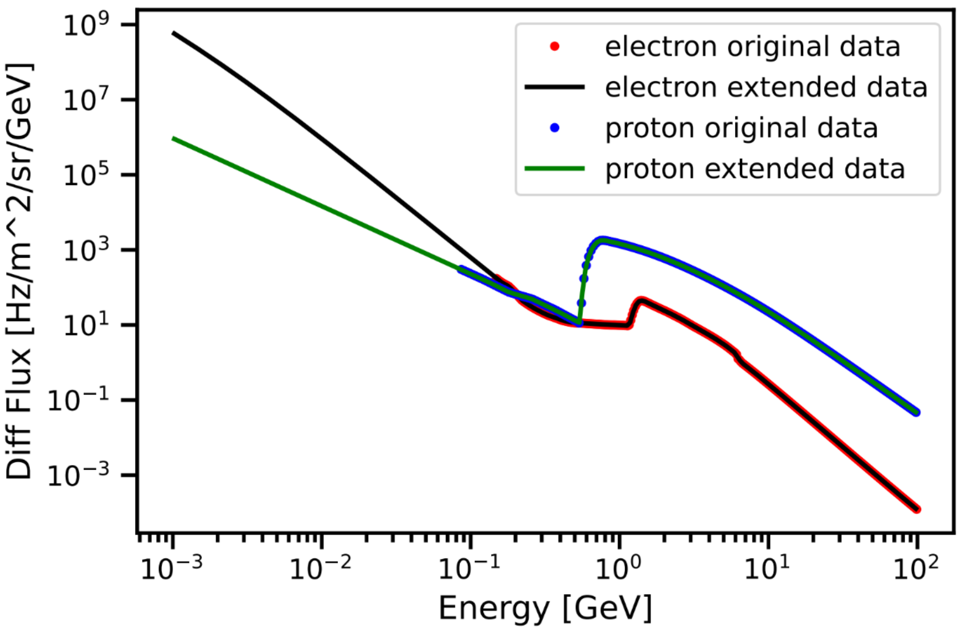


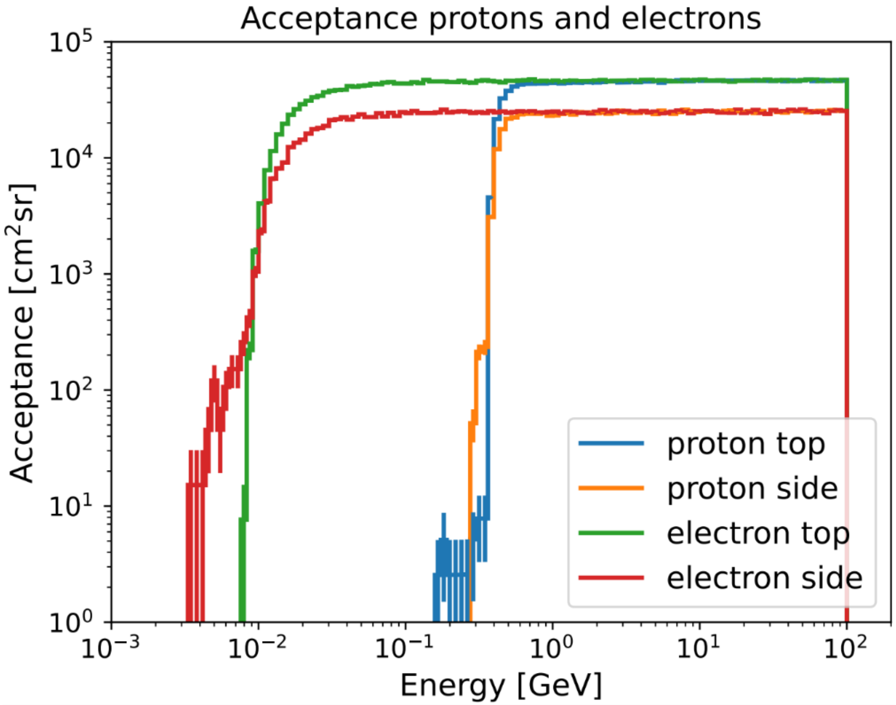
- Search for (at least) 3-in-a-row (3IR) patters in consecutive FIT planes with a maximum mat difference of 1.
- Charged particles vetoed by the PSD.
- Veto efficiency >99.9%.

Trigger rates (3IR)

Data provided by Jorge Casaus based on AMS-01 measurements:

- Flux for each geographical location (lon, lat) and kinetic energy.
- Extended to lower energies (1 MeV).
- Always considered the worst case scenario: minimum solar activity (300MV) and max measured flux/rate.

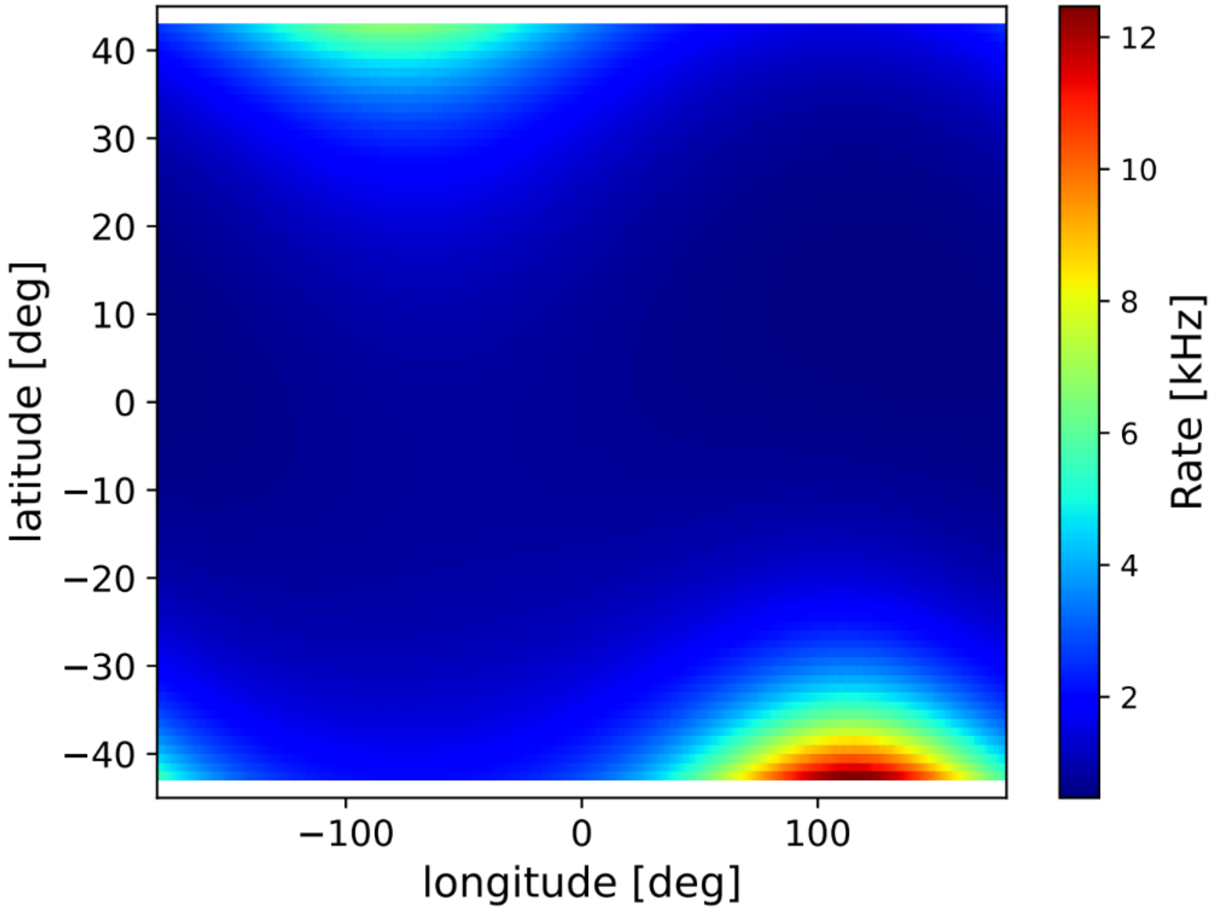




- Knowing the acceptance of the telescope we can compute the rate.
- Different cut-off due to different penetration of particles in matter.
- At higher energies the acceptance converge to the geometrical factor, difference between top and side sector due to different sizes.

Trigger rates (3IR)

Proton, TOP sector



Rates p_top = 12.5kHz, p_side = 6.8kHz, e_top = 8.3kHz, e_side = 4.7kHz …
Overall rate (all particles, all five sectors): O(<100kHz).

Consideration on PSD count rate

- Need to consider also the count for the PSD (outer detector)
- Simple (and wrong) calculation, considering all the particles hitting the PSD:

$R = \pi * A * F(>1 MeV)$

- Area from the geometry:

TOP = (14*14)*(10*10) cm^2 = 1.96 m^2

SIDE = (13*9)*(10*10) cm^2 = 1.17 m^2

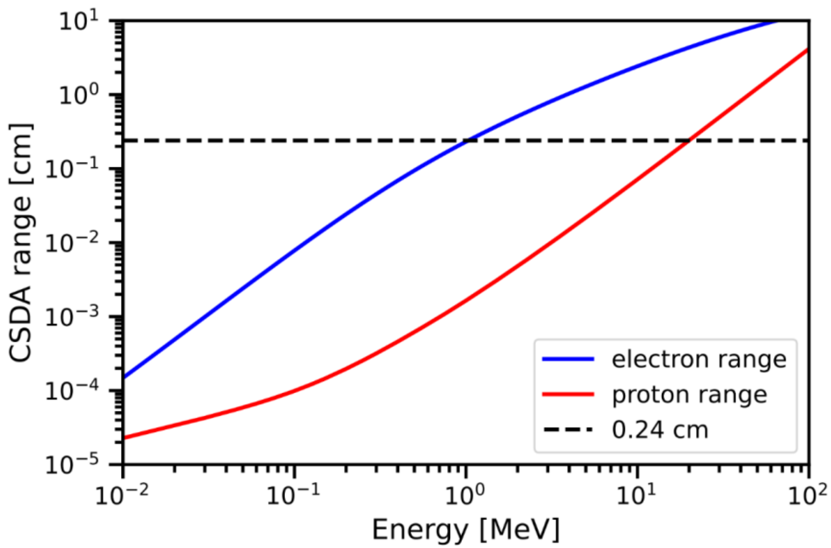
```
---------- INTEGRATED FLUX (>1 MeV) [kHz/(m^2 sr)]
Flux_001MeV_H = 3.90241
Flux_001MeV_He = 0.37693
Flux_001MeV_C = 0.01019
Flux_001MeV_O = 0.00928
Flux_001MeV_Si = 0.00140
Flux_001MeV_Fe = 0.00092
Flux_001MeV_electron = 368.14871
Flux_001MeV_positron = 51.19609
```

```
---------- RATE PSD (>1 MeV) [kHz] ----------
Rate_001MeV_H [TOP, SIDE] = [24.02919105 14.34395588]
Rate_001MeV_He [TOP, SIDE] = [2.32093356 1.38545524]
Rate_001MeV_C [TOP, SIDE] = [0.06276248 0.03746536]
Rate_001MeV_O [TOP, SIDE] = [0.05713392 0.03410545]
Rate_001MeV_Si [TOP, SIDE] = [0.00862716 0.00514988]
Rate_001MeV_Fe [TOP, SIDE] = [0.00567137 0.00338546]
Rate_001MeV_electron [TOP, SIDE] = [2266.88364147 1353.19074516]
Rate_001MeV_positron [TOP, SIDE] = [315.24102656 188.17959238]
```

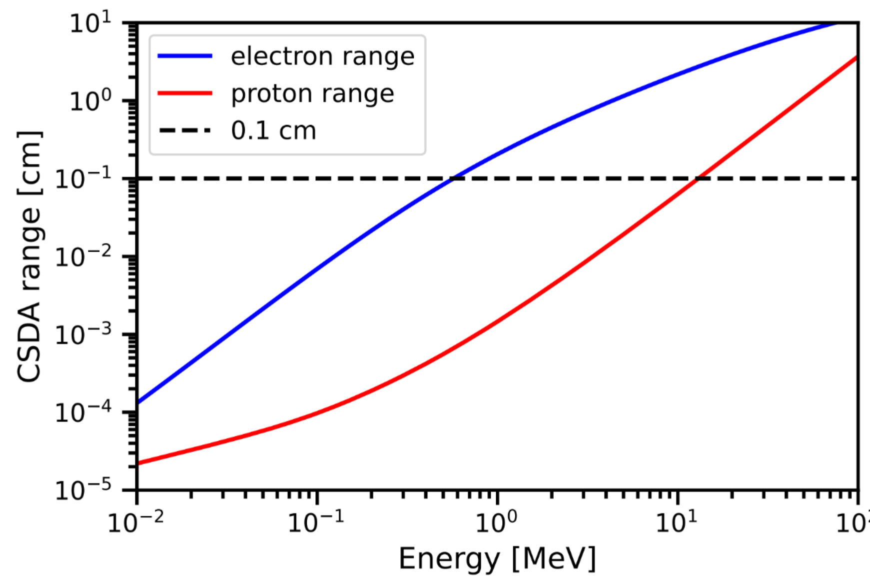
- Sum for all particles [TOP, SIDE] = [2608.6, 1557.2]
- Sum for all sectors (TOP + 4*SIDE) = 8837.3 kHz

Consideration on PSD count rate

- Main problem related to high flux of particles at low energies (1-10 MeV), in particular electrons.
- Need to properly perform a simulation which includes an accurate description of:
  - PSD threshold (1/3 of the energy released by a MIP, around 330 keV).
  - Material before the PSD: SCD + anti-meteorite shield + passive material for SCD and PSD.



Range in Si



Range in Al