ACD @ CERN PS results

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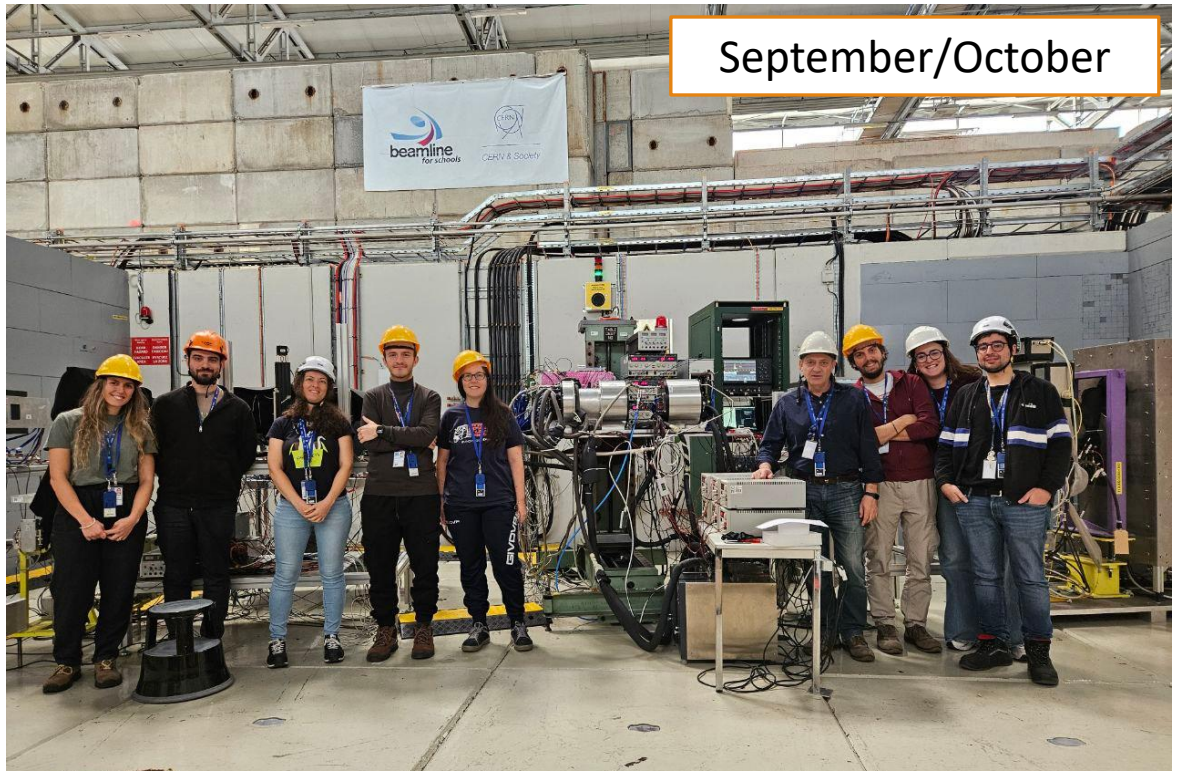
ADAPT COLLABORATION MEETING – BARI, ITALY – 4, 7 NOVEMBER 2025

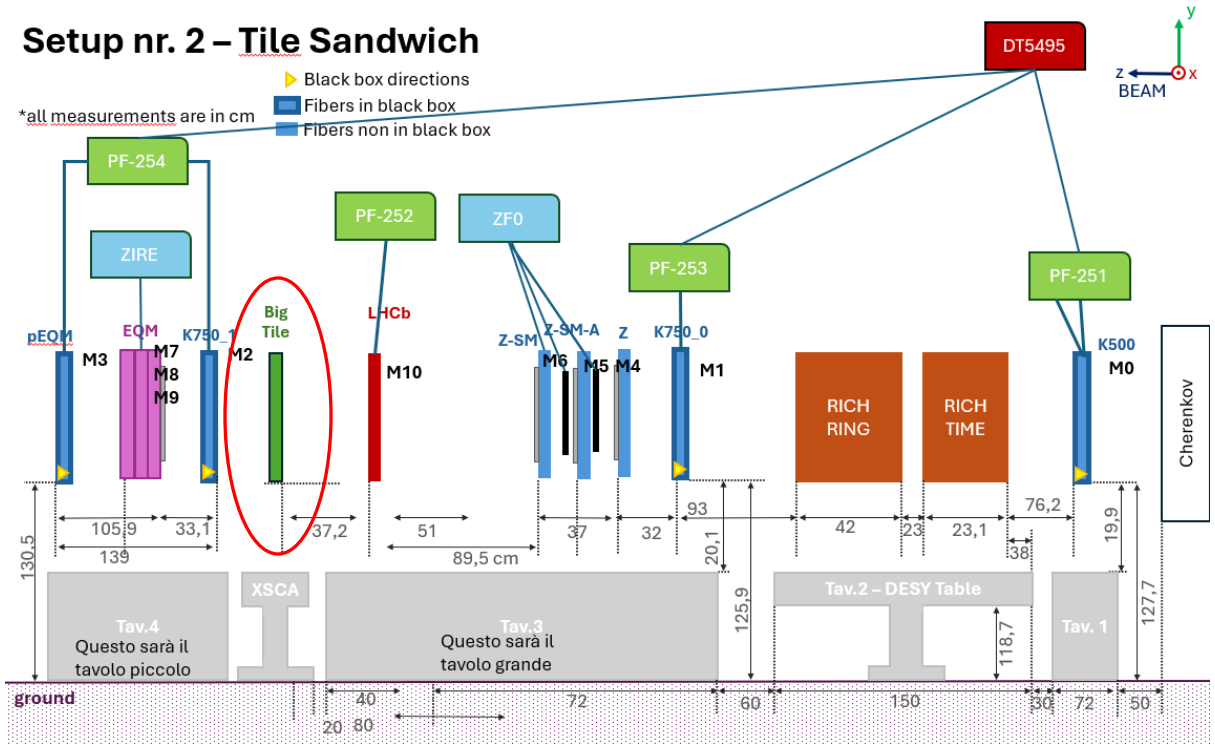
The team (not all of it)



September/October

July

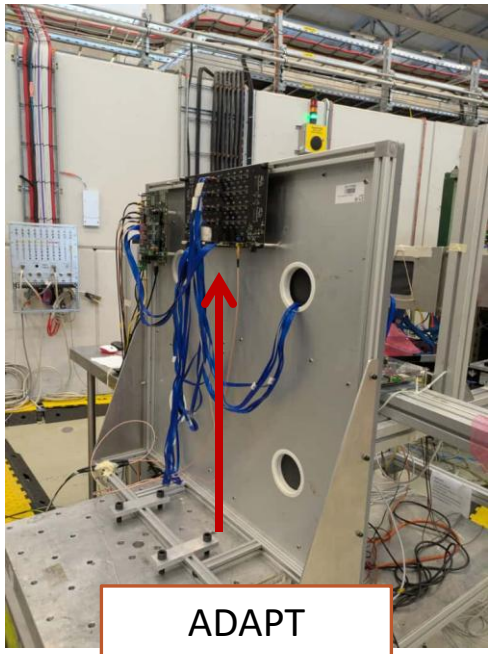
On the beamline



By. R. Pillera

Front view with LHCb module

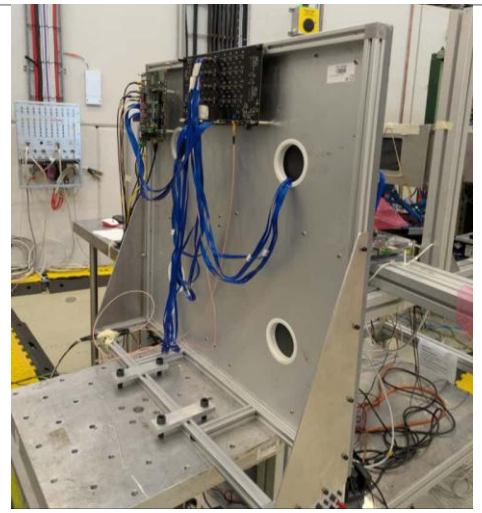
Back view

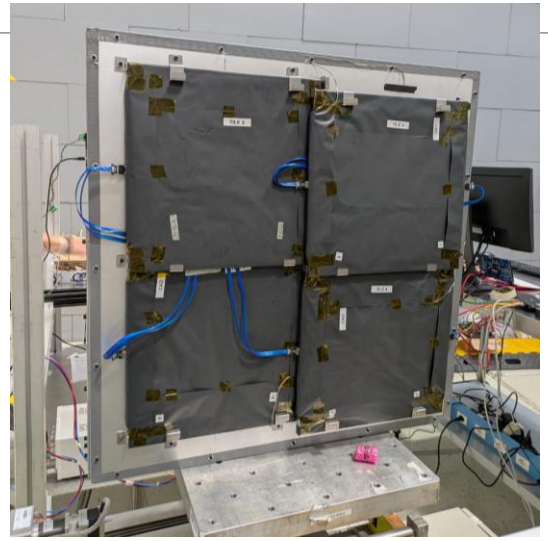


ADAPT concentrator

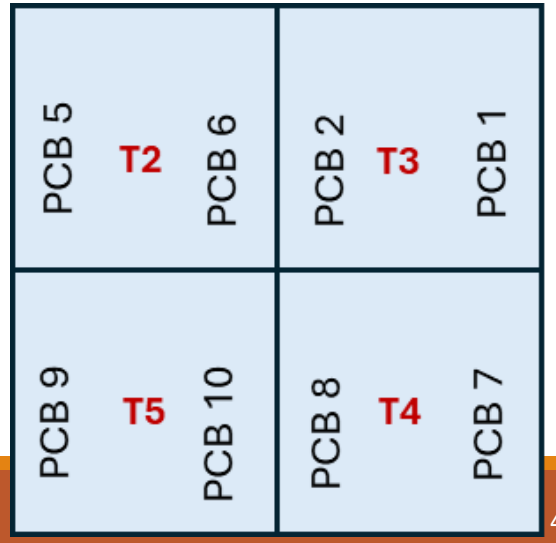
Tile and readout layout

- Four tiles mounted on a panel with stand-offs
- BETA board and concentrator placed on the back of the panel
- Support mounted on XSCA table



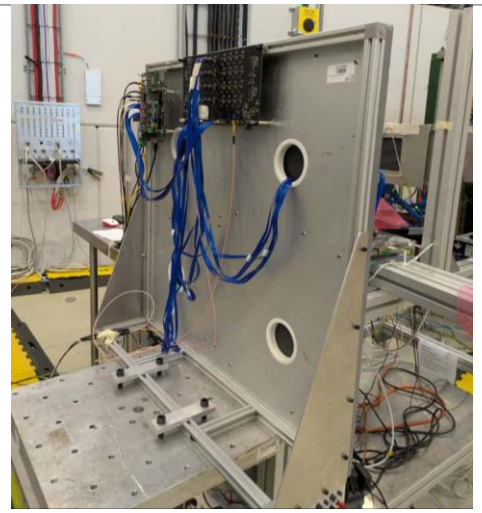


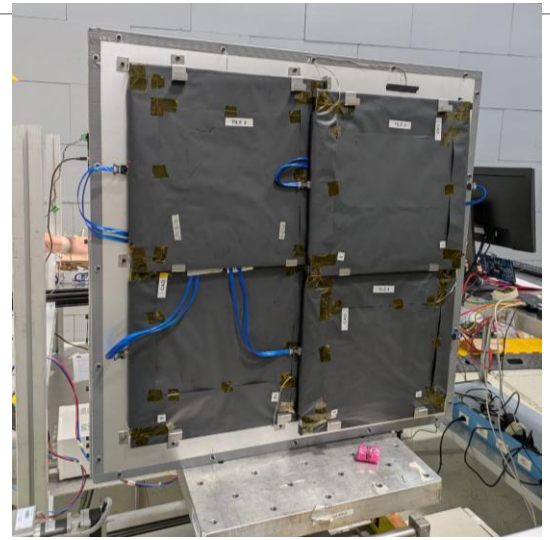
- Acquisition in external trigger
- Trigger distributed by DT5495 board
- Trigger as an AND of several Scintillating Fiber Tracker modules along the beam line

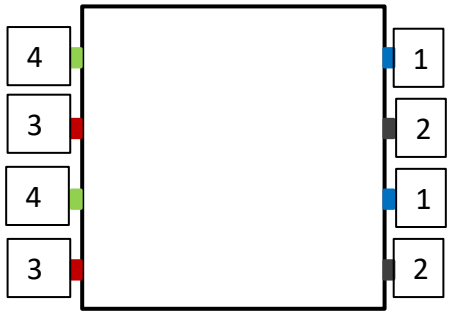


Tile and readout layout (PS September)

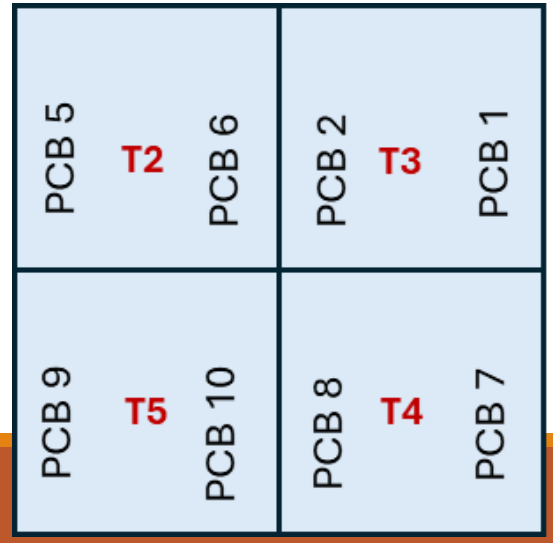
- Each scintillator tile is readout by 16 SiPMs located on two SiPM edge carriers
- Each channels is an analog OR between two SiPMs (6x6 mm^2 - 3x3 mm^2), done at the concentrator level
- 1 quadrant = 32 channels





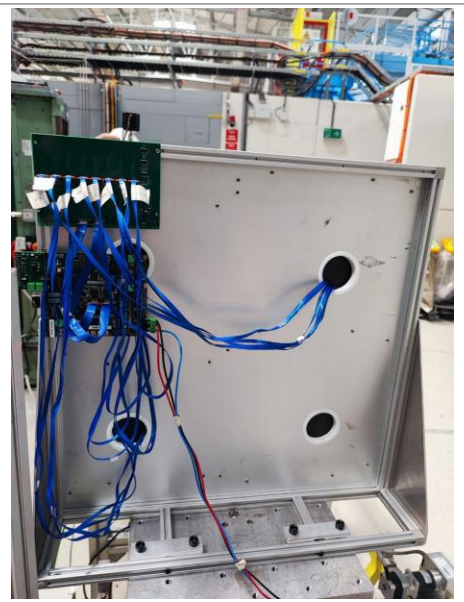


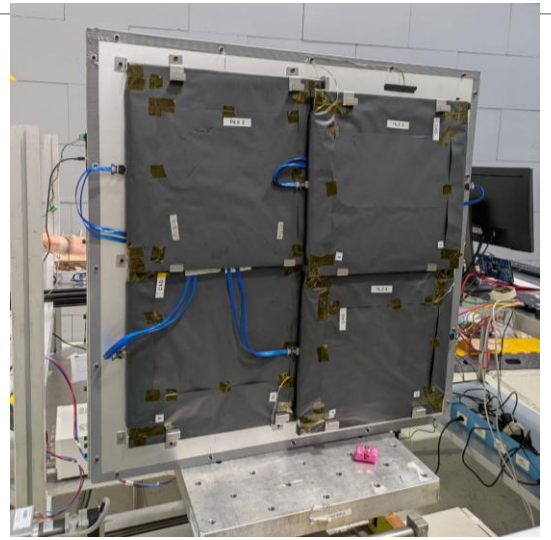
«ADAPT» definitive version of cables, concentrator, SiPM edge carriers

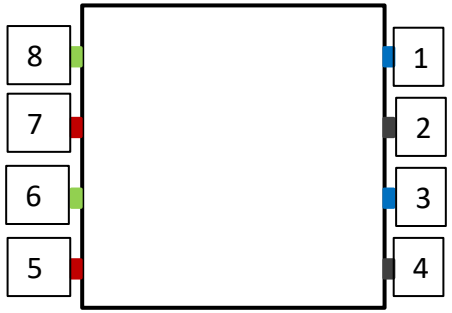


Tile and readout layout (PS July)

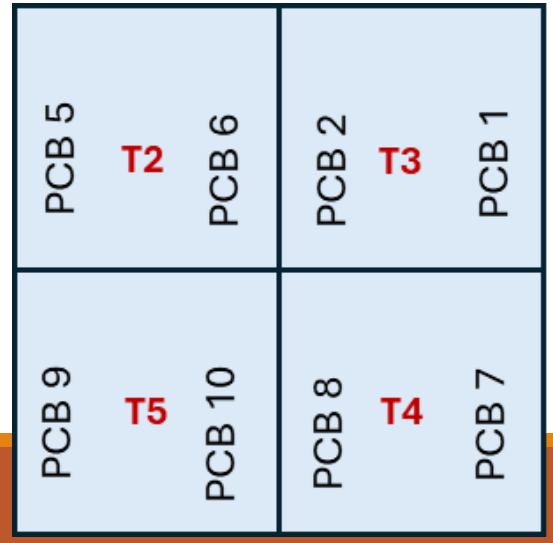
- Each scintillator tile is readout by 16 SiPMs located on two SiPM edge carriers
- Each channels is correspond to a single SiPM
- 1 quadrant = 64 channels







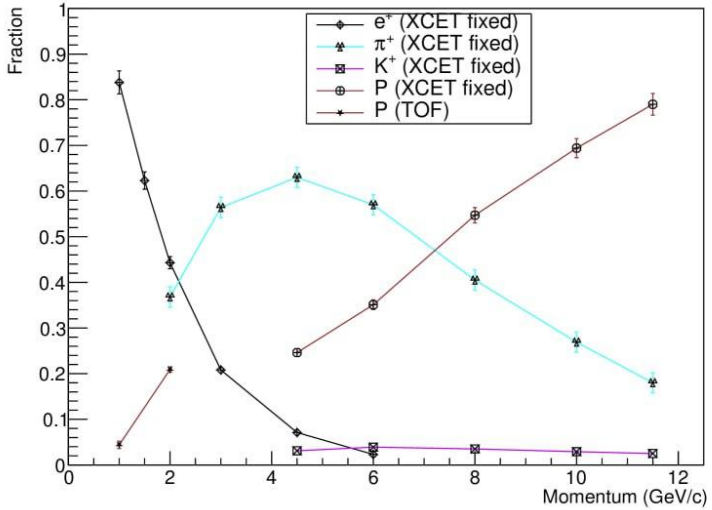
«ADAPT» definitive version of cables, ~~concentrator,~~ SiPM edge carriers



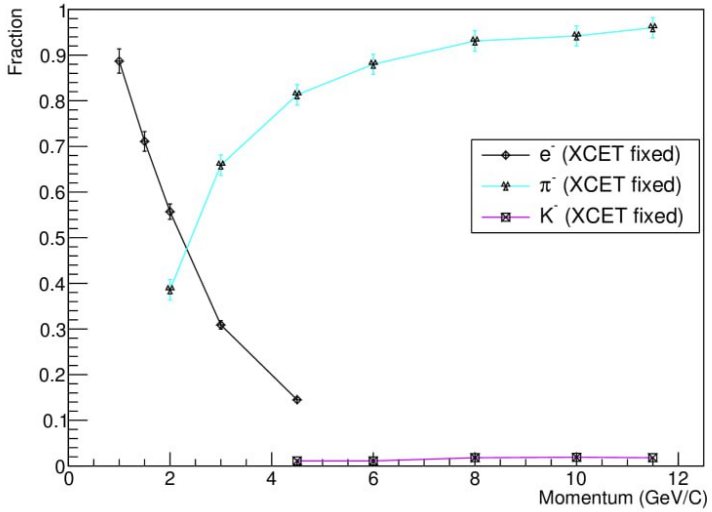
Particle production and identification for the T10 secondary beamline of the CERN East Area

Beams and acquisitions

- Several beams selected within positive and negative beams
- Beam size, intensity, composition vary with the selected momentum



- Check tile response with the Or-ed concentrator
- Study tile/quadrant efficiency with digitized charge
- Study tile/quadrant efficiency with trigger (validation)
- Repeat studies on critical positions (interfaces between tiles)



Beams and acquisitions

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- Beam size, intensity, composition vary with the selected momentum

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This is a preliminary analysis !!!

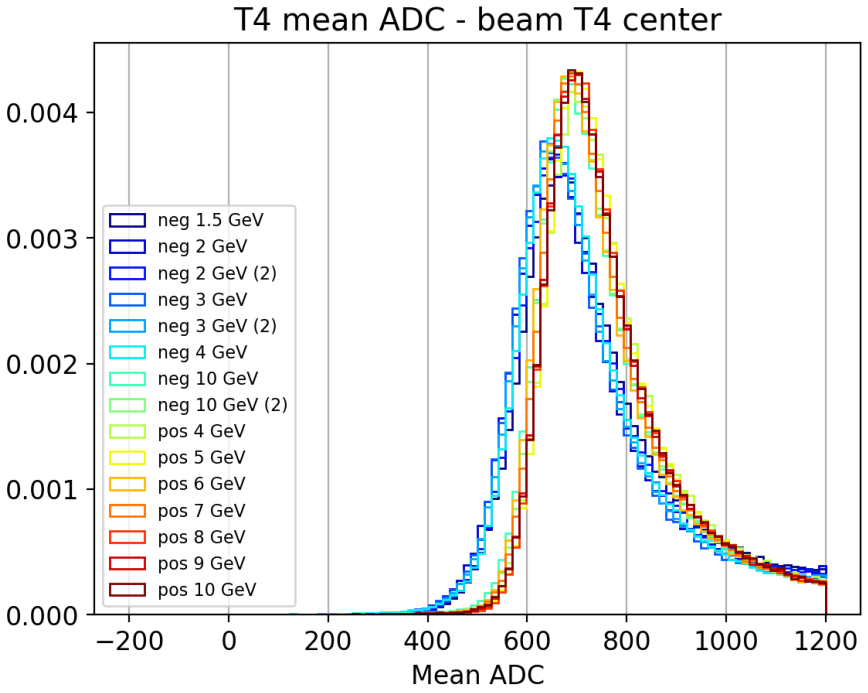
A more detailed and in-depth study is required, combining data from all subdetectors throughout the beam test.

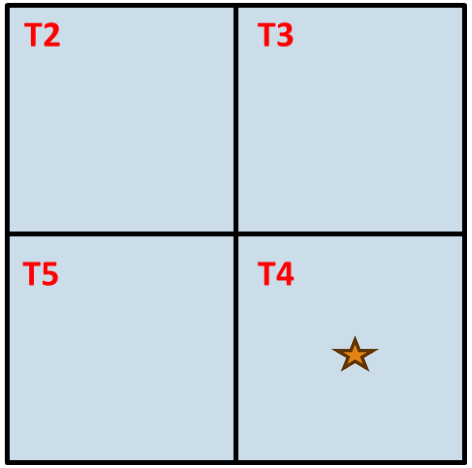
BETA Digitized Charge

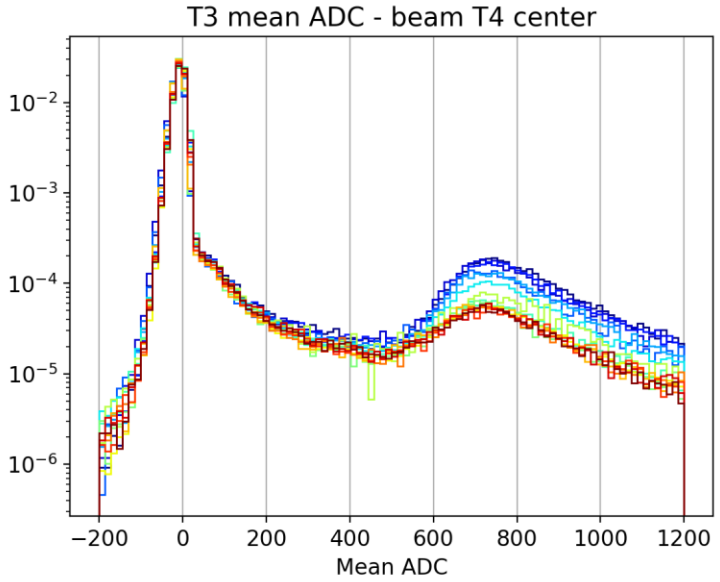
Tile centers – T4

- Tile T4 experienced several beam types. Two families appears
- Not an issue of BETA configurations or for a specific slot of runs.
- Beams in the lower charge distribution family:

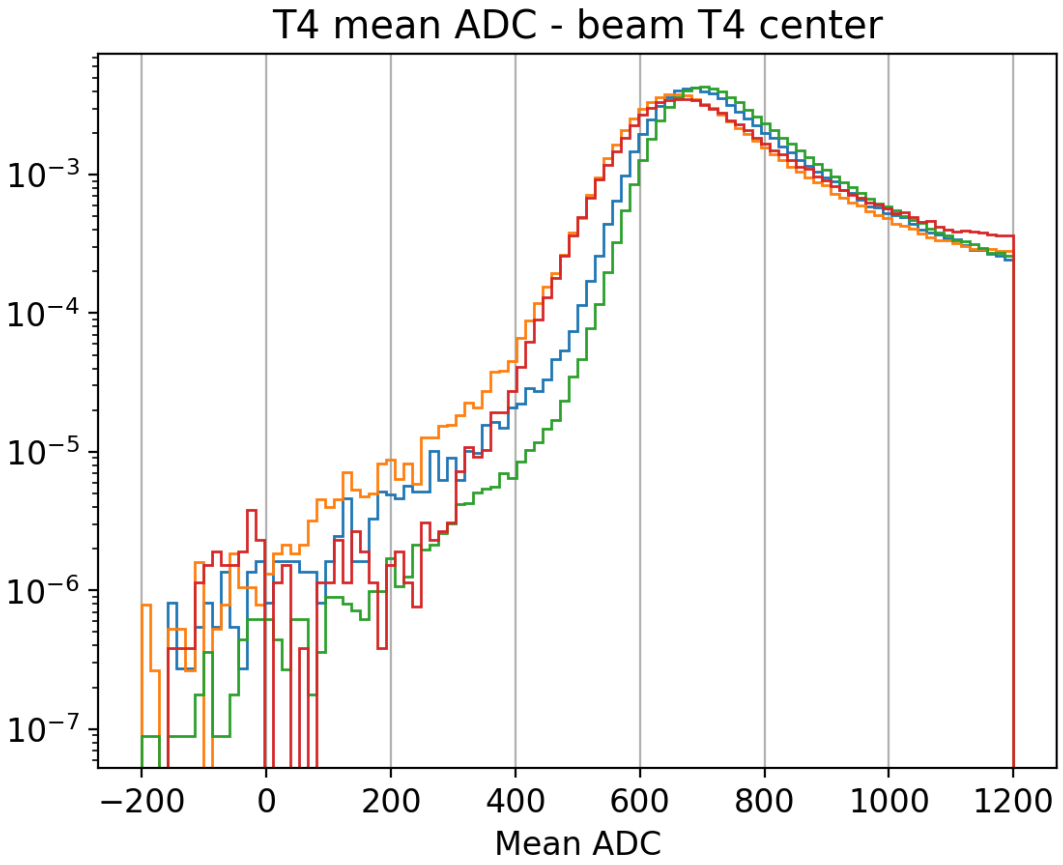
  -2 GeV, -3 GeV, -1.5 GeV, -4 GeV, -3 GeV
- Looking at other tiles off-beam, the MPV for asyncronous (?) charge is unchanged

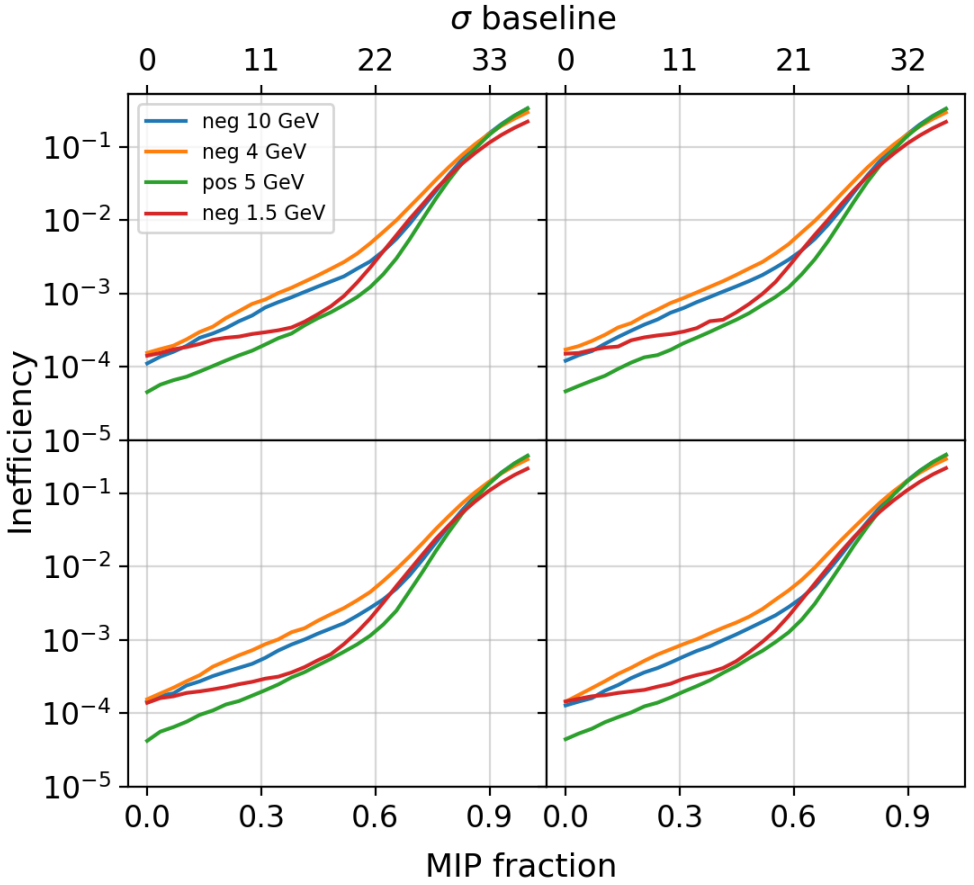




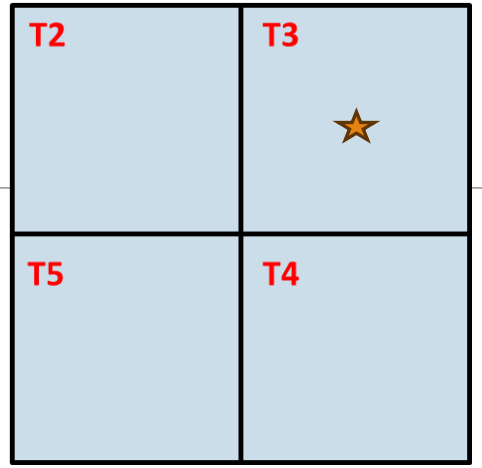


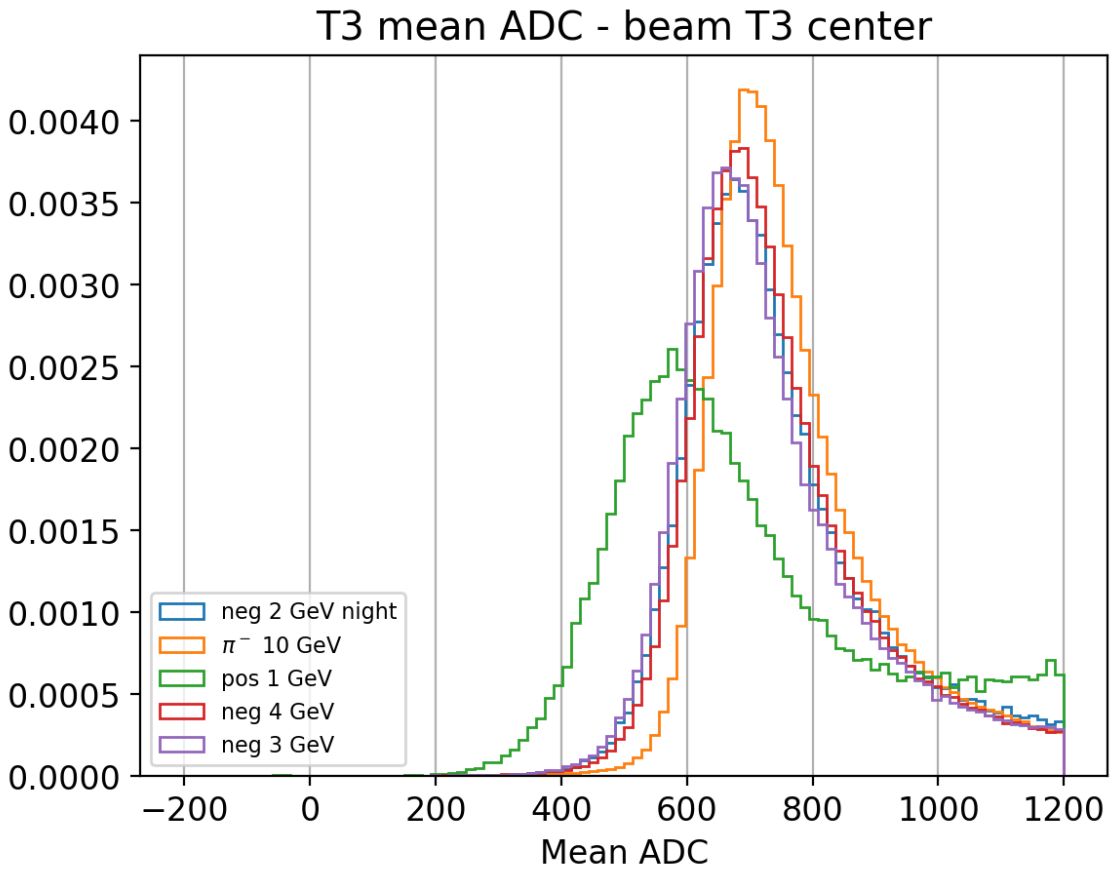
Tile centers – T4

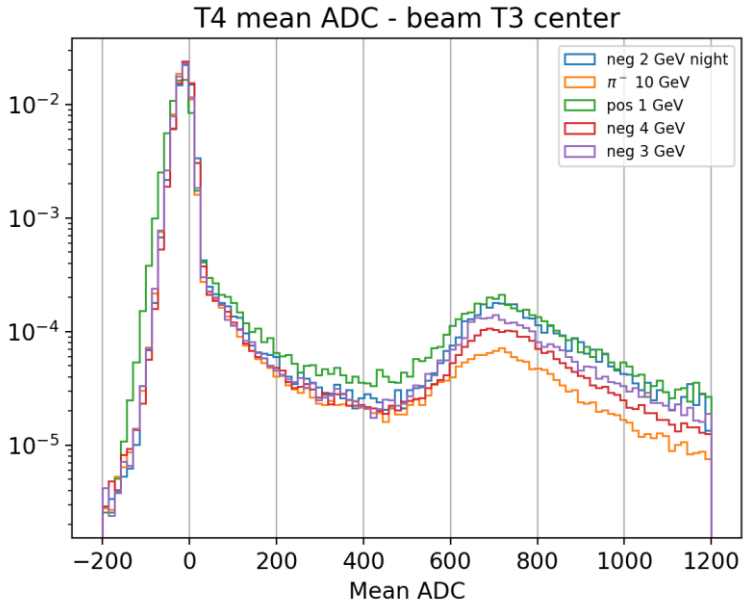




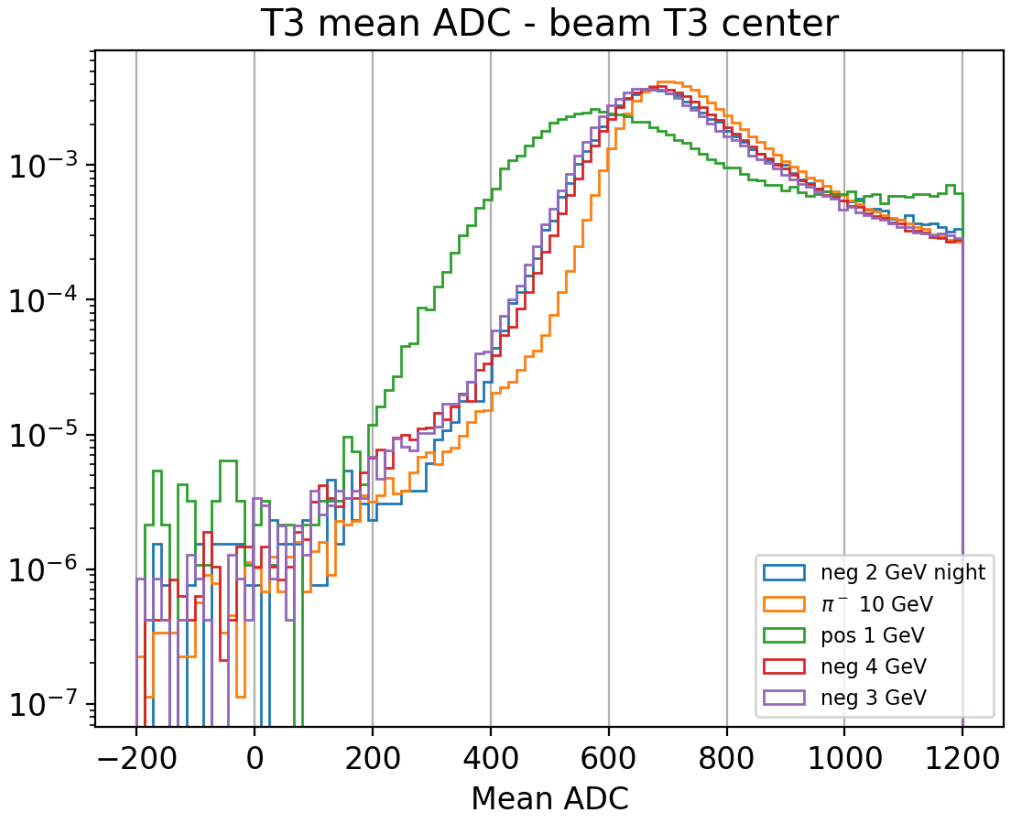
Tile centers – T3

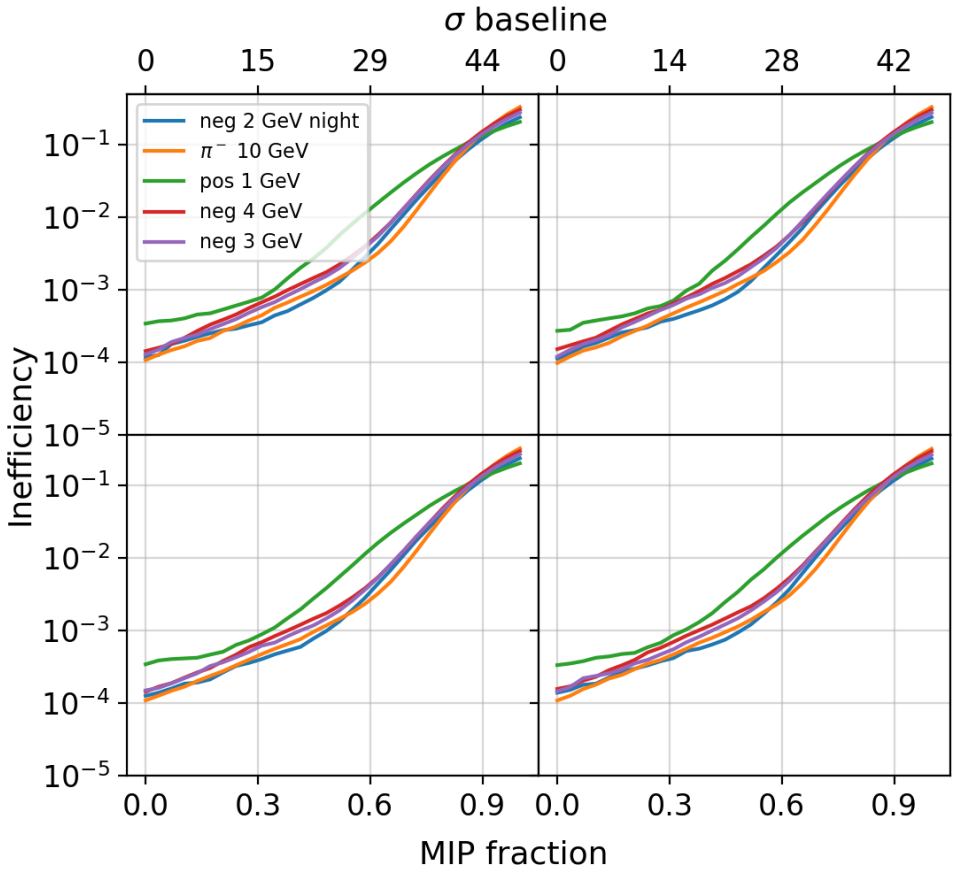




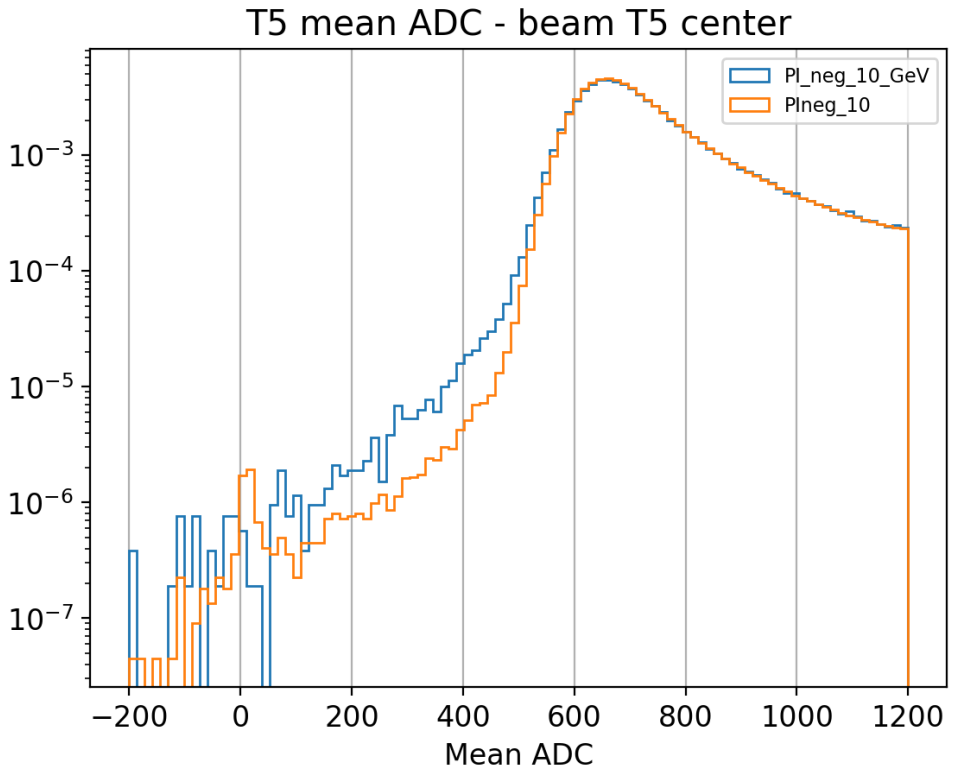


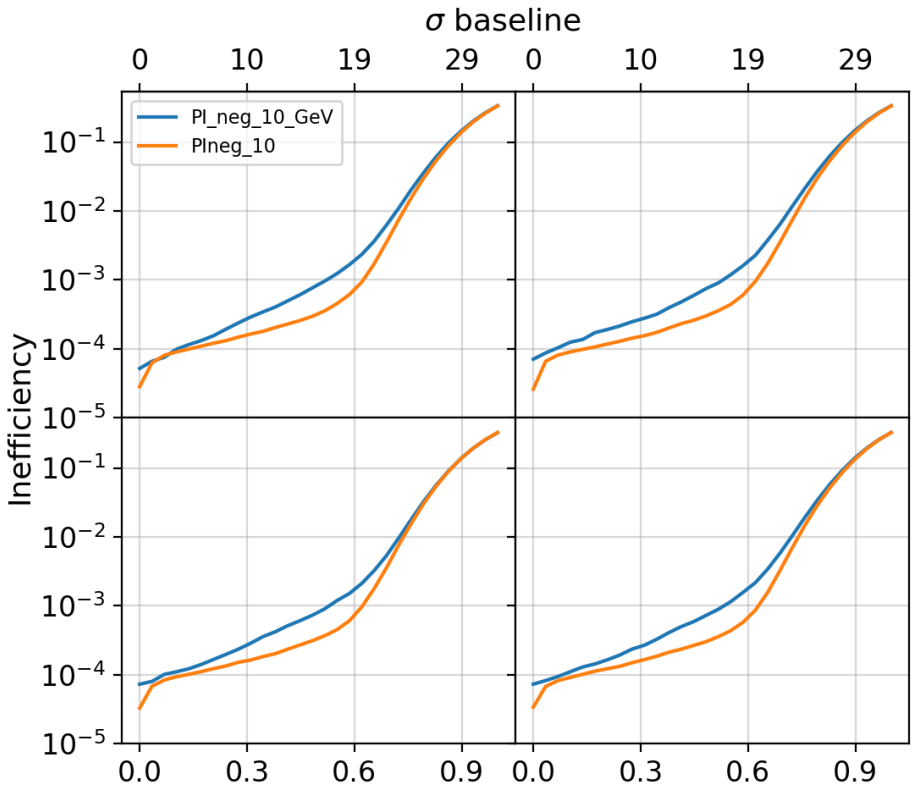
Tile centers –T3

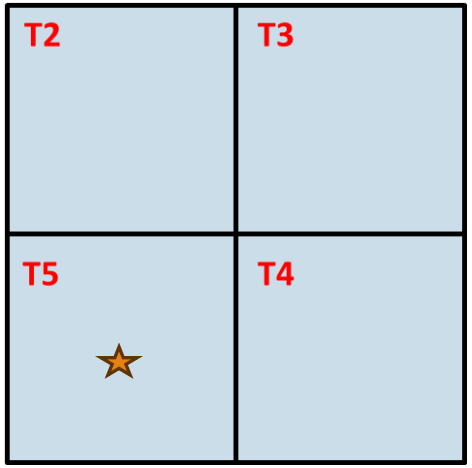




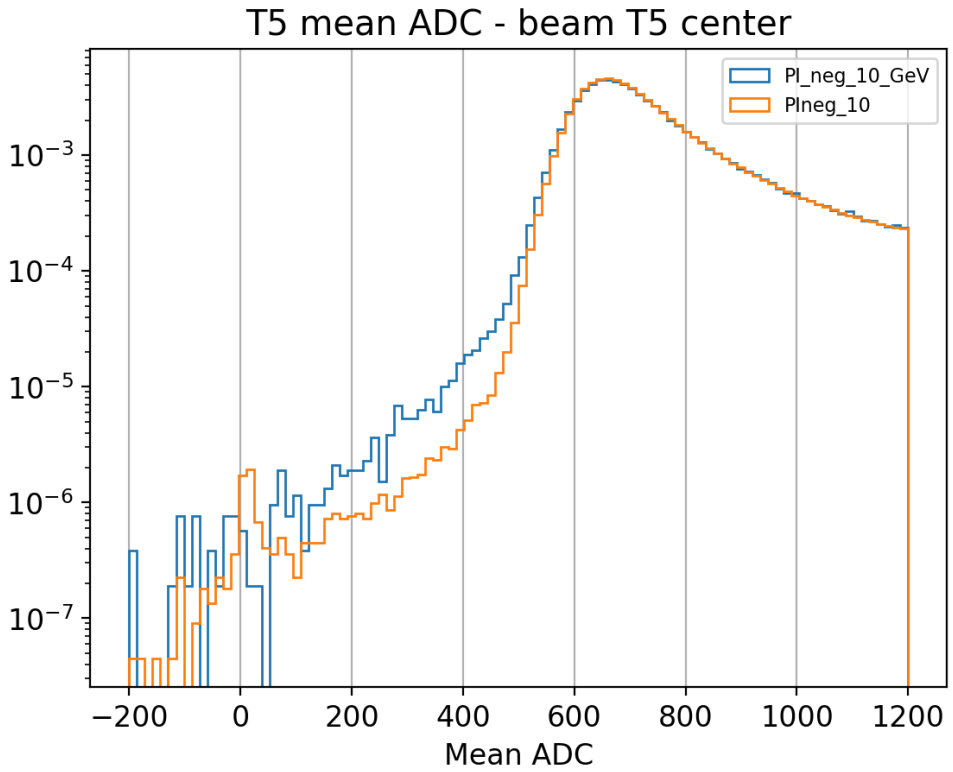
Tile centers – T5

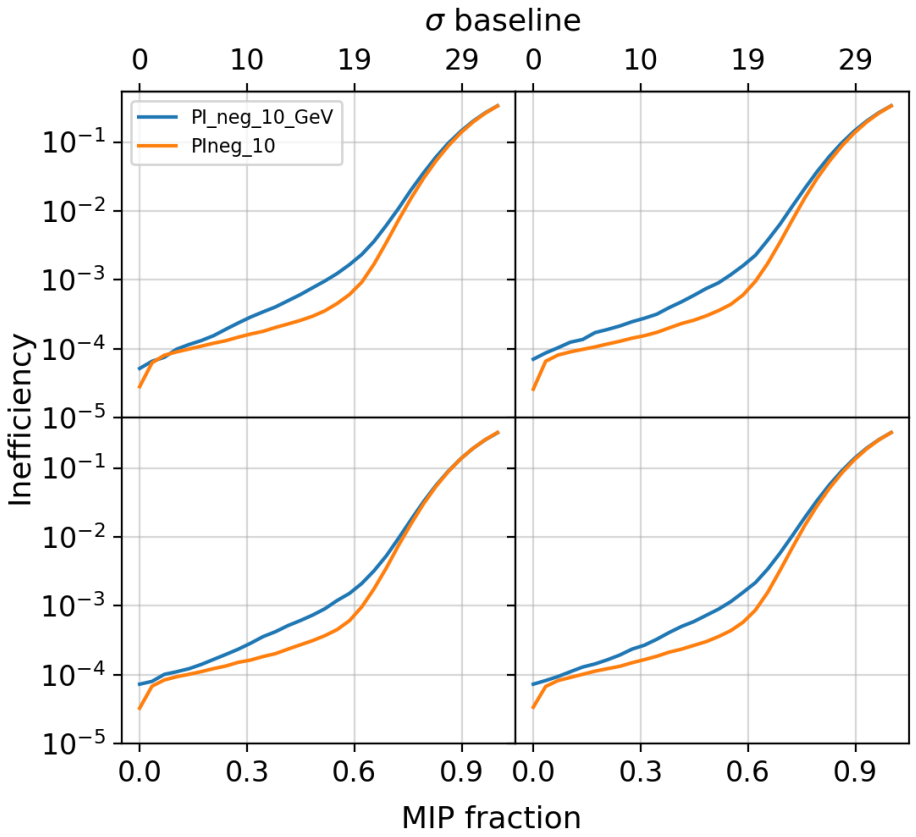


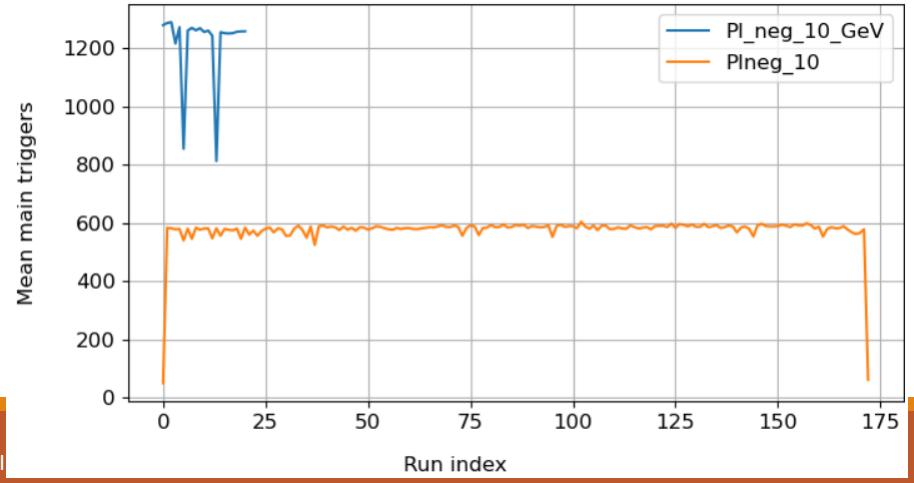




Tile centers – T5

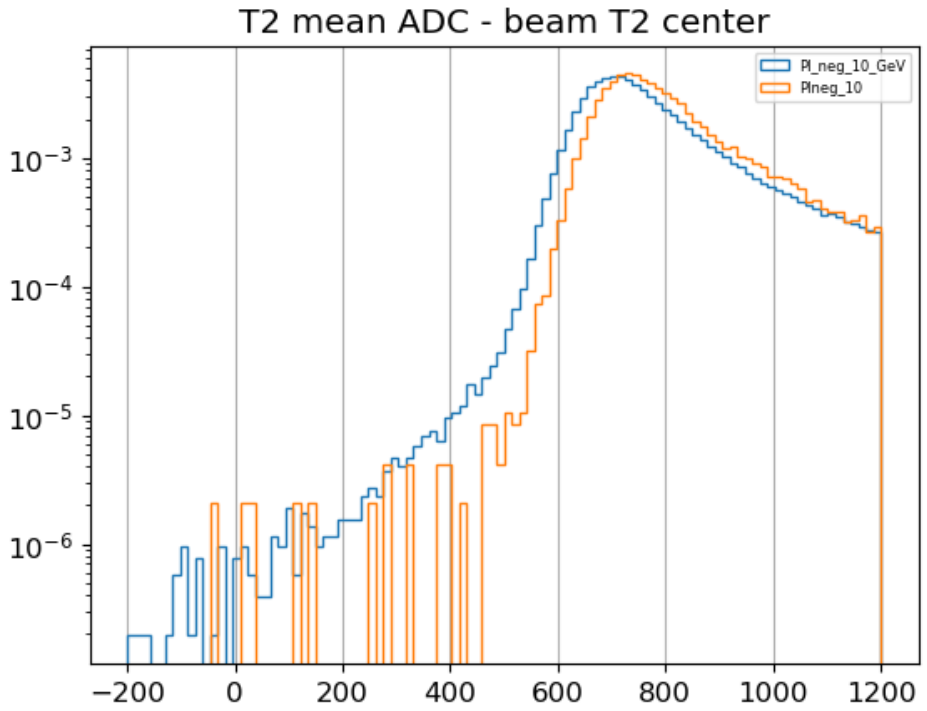


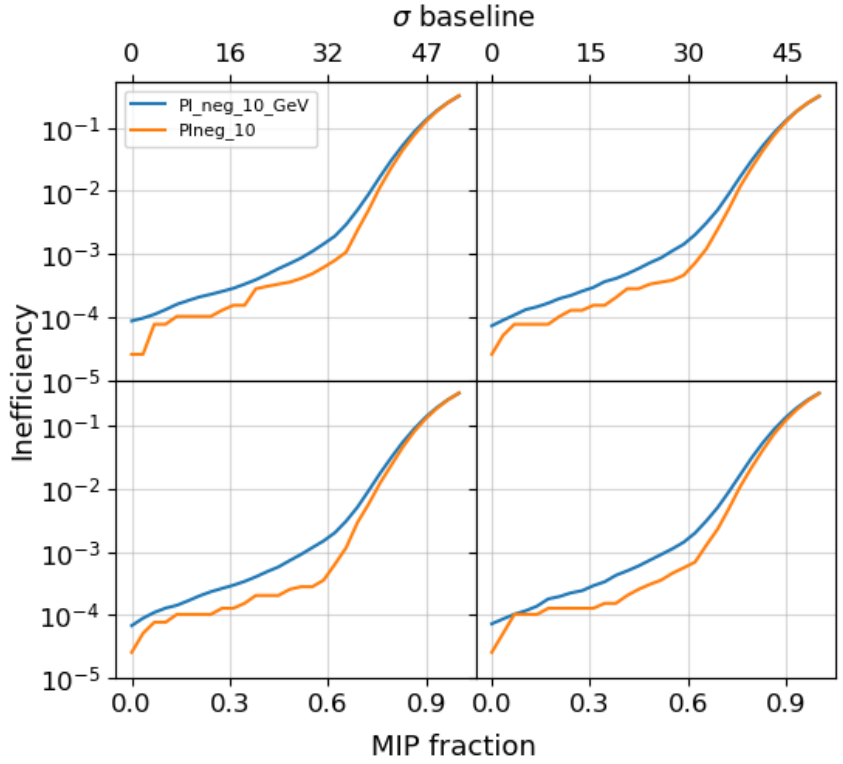




Tile centers – T2

This needs to be checked. Orange distribution is the sum of just 4 low statistics run.





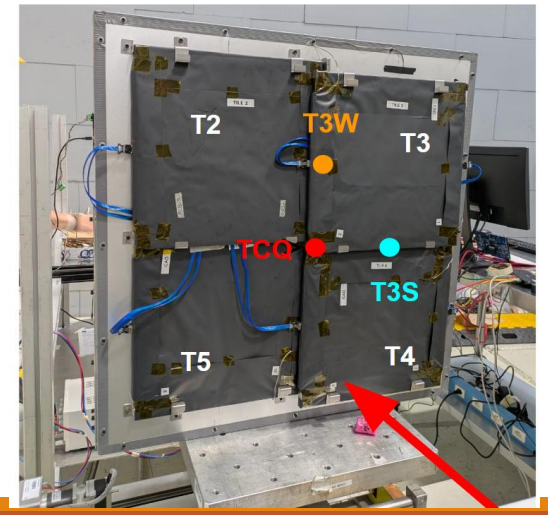
Charge efficiency with Single-ch interface

Single tile efficiency with charge ADC values.
Condition:

- ADC charge > 5 sigma pedestal
- 2 channels per PCB AND PCBs

Quadrant efficiency = at least one tile fired

Losing ~2 / 10^4 evts



	Position	T5	T4	T2	T3	Quad
0	T50	99.973701	4.784657	5.902256	4.067732	99.975469
1	T30	2.842364	3.345122	3.128897	99.989401	99.989754
2	T20	3.357941	3.017303	99.986769	3.082336	99.987890
3	T40	4.591128	99.969231	3.792461	5.674186	99.971869
4	TCQ	99.959153	82.900337	8.996796	89.563248	99.998357
5	T3S	2.721437	44.821669	2.765841	99.993979	99.996237
6	TCQ_2	41.427148	19.160581	37.720877	99.878313	99.986751
7	T3W	2.712012	3.141353	4.501891	99.988463	99.989287

Inefficiency of ~10^{-4} coherent with what we got with the ADAPT OR-ed concentrator

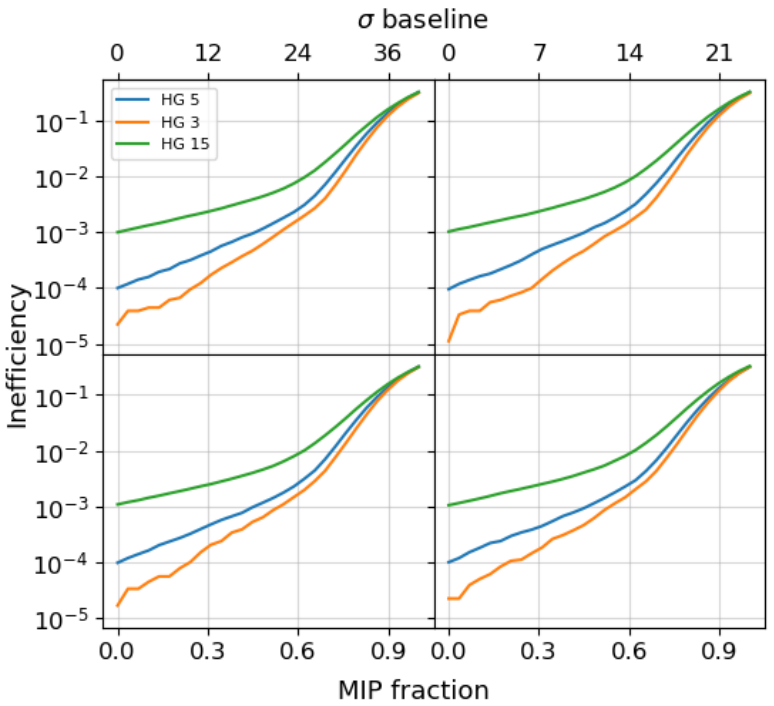
Tile centers – recap

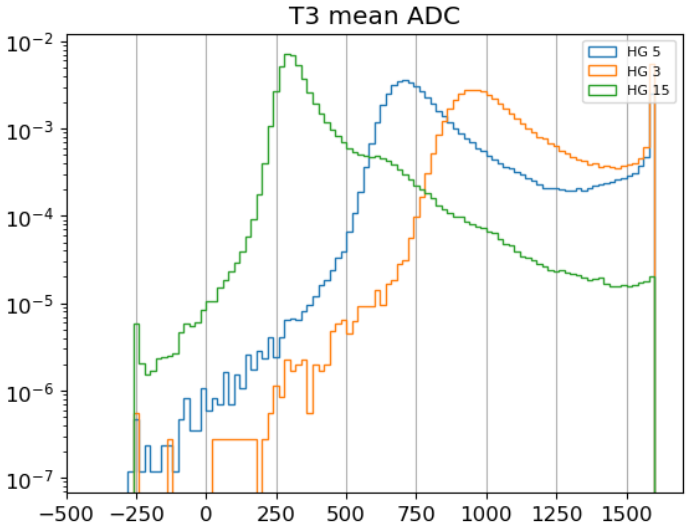
1. Distributions of tile hit by beam shifted to lower charges for -2 GeV, -3 GeV, -1.5 GeV, -4 GeV, -3 GeV , + 1 GeV beams
2. Distributions of other tiles left unchanged. The charge we see in other tiles is due to non synchronous events (scattering, beam profile tails)
3. Even with same beam (same peak), like negative 10 GeV for tile 5, there are differences in the lower energy deposits. Those low-energy charges are probably due to **pile-up effects**.
4. Baseline sigmas were larger for T5 and T4. This are the tiles which probably took more light from the outside. T3 and T2 were well covered with the black blanket

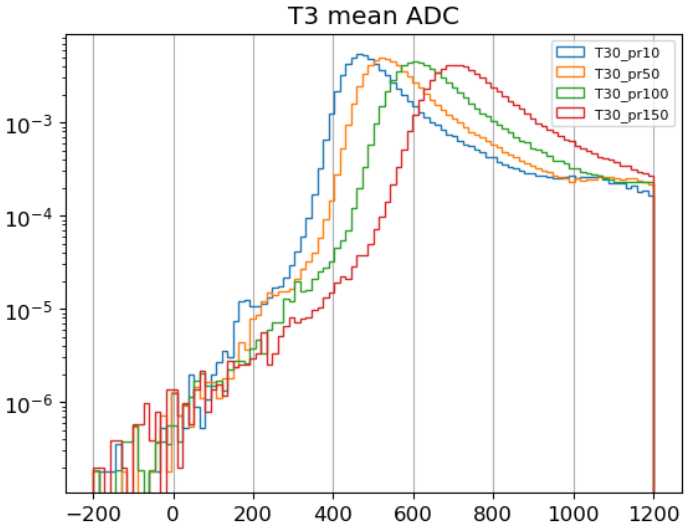
Playing with shaping

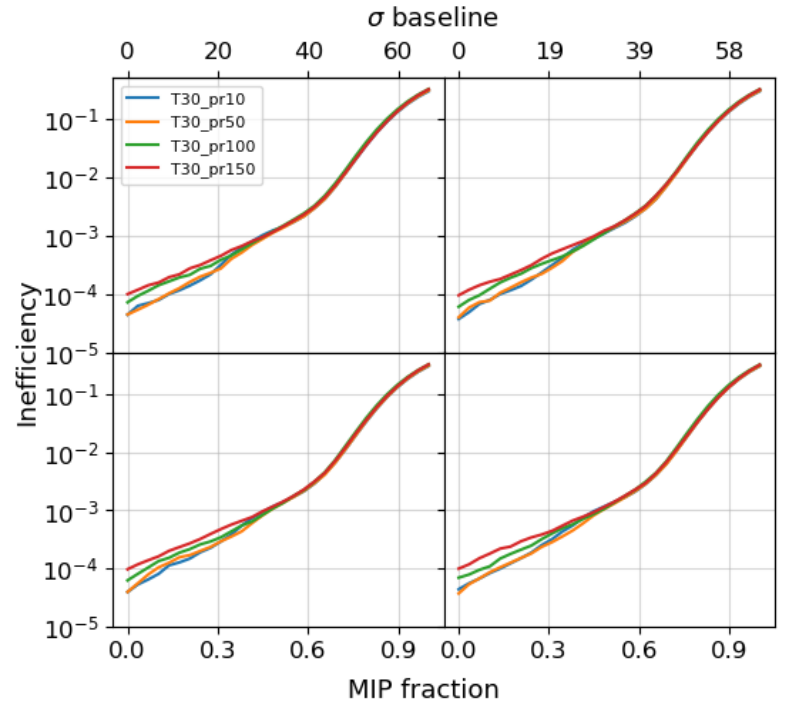
Tested response with different parameters:

- Gain
- Preamplifier current
- Bias voltage

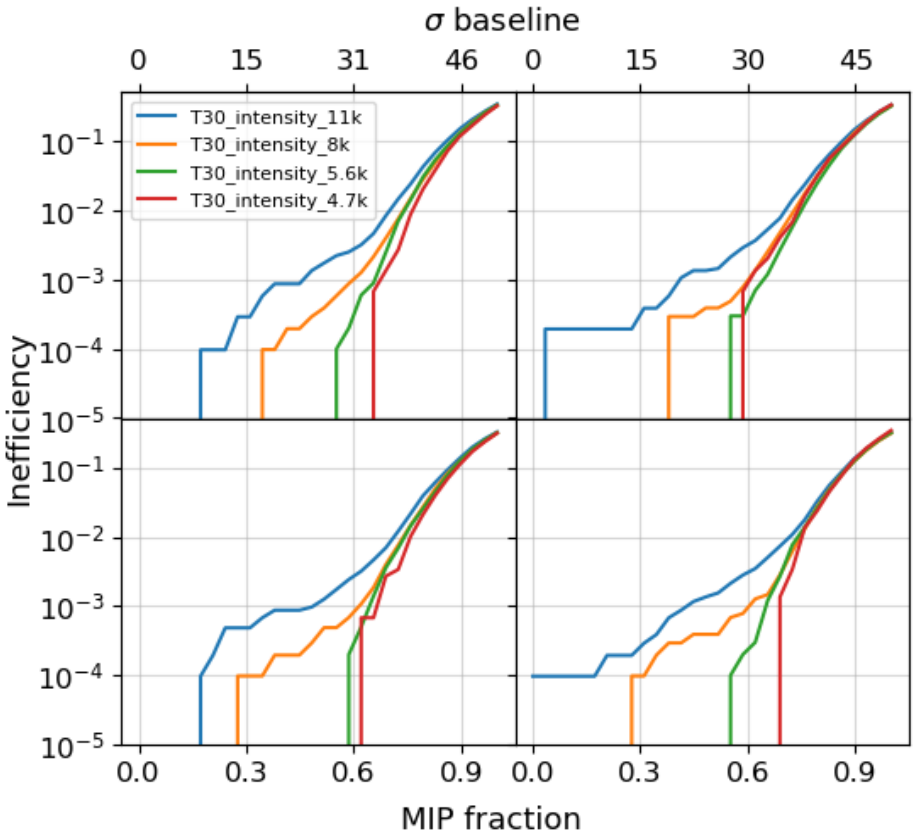




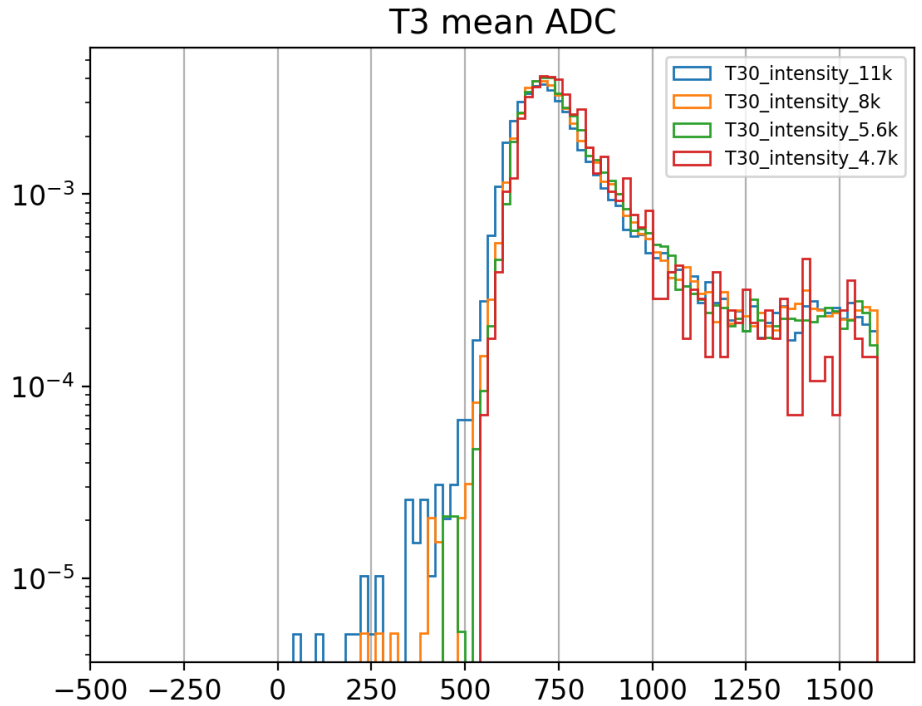


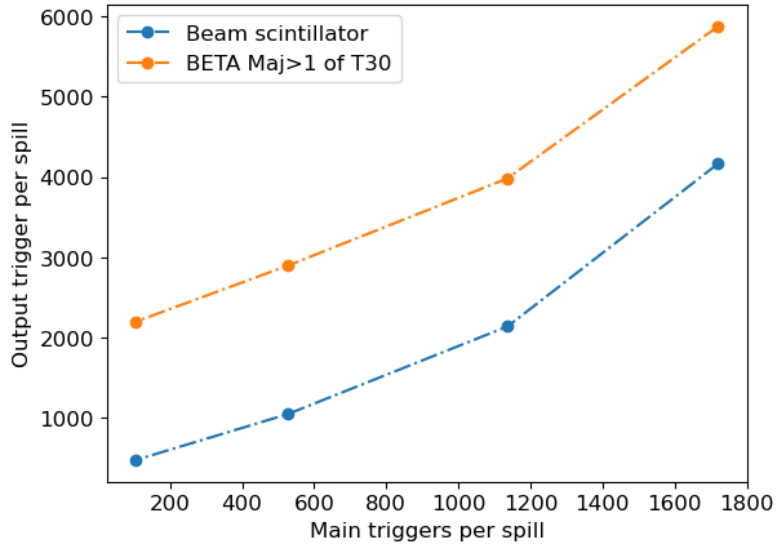


Playing with beam intesity



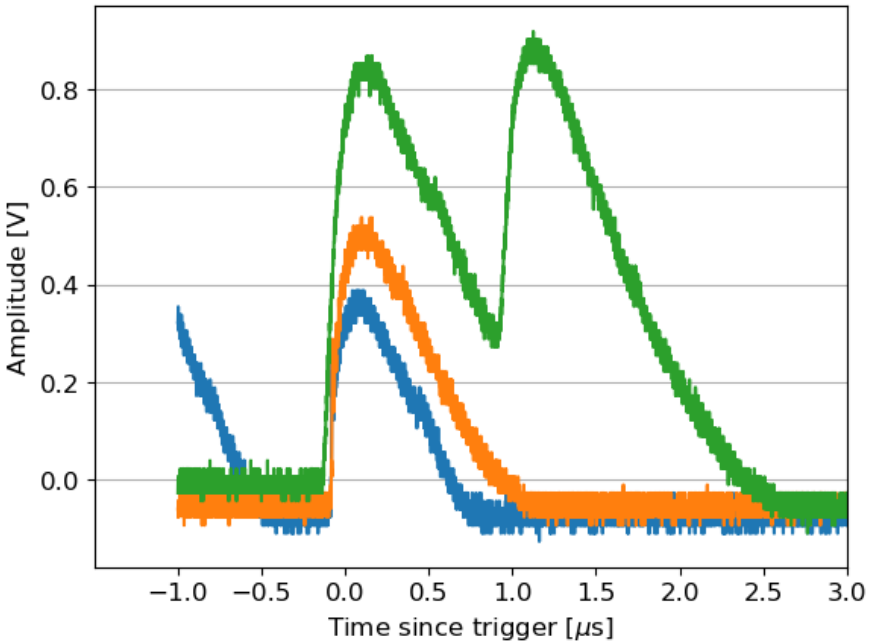
Beam: negative
10 GeV



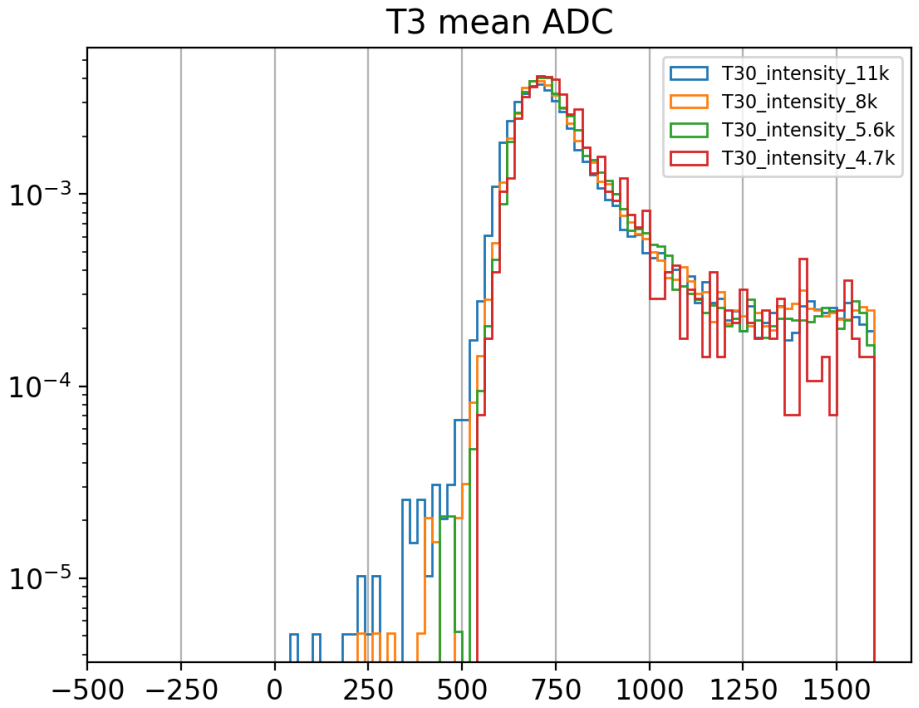


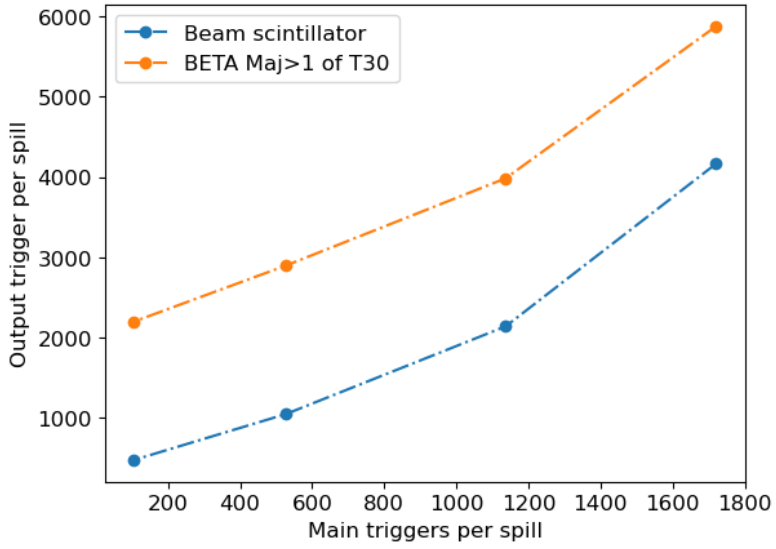
Playing with beam intesity

Acquisition of analog signals of one channel with the oscilloscope



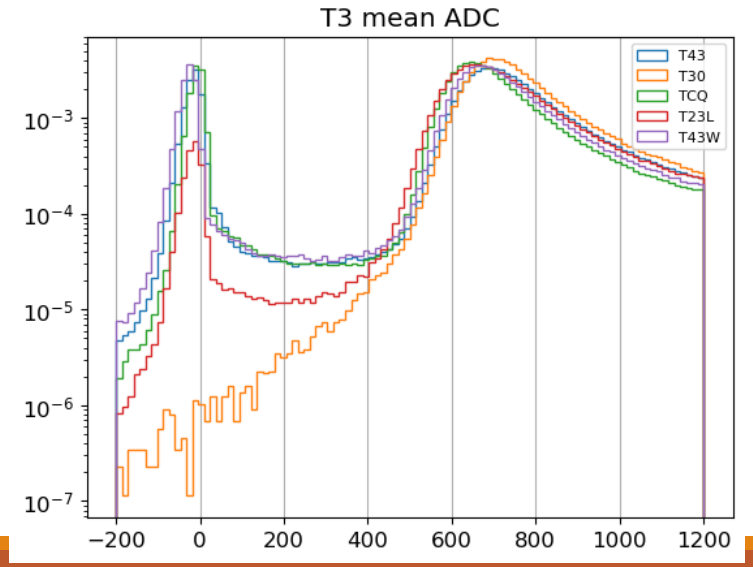
Beam: negative 10 GeV

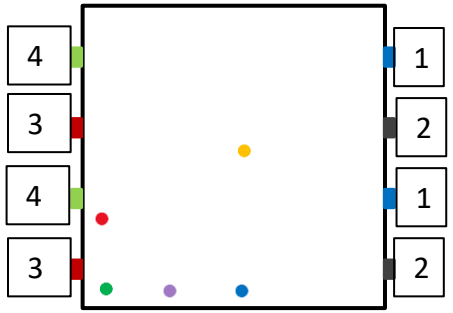


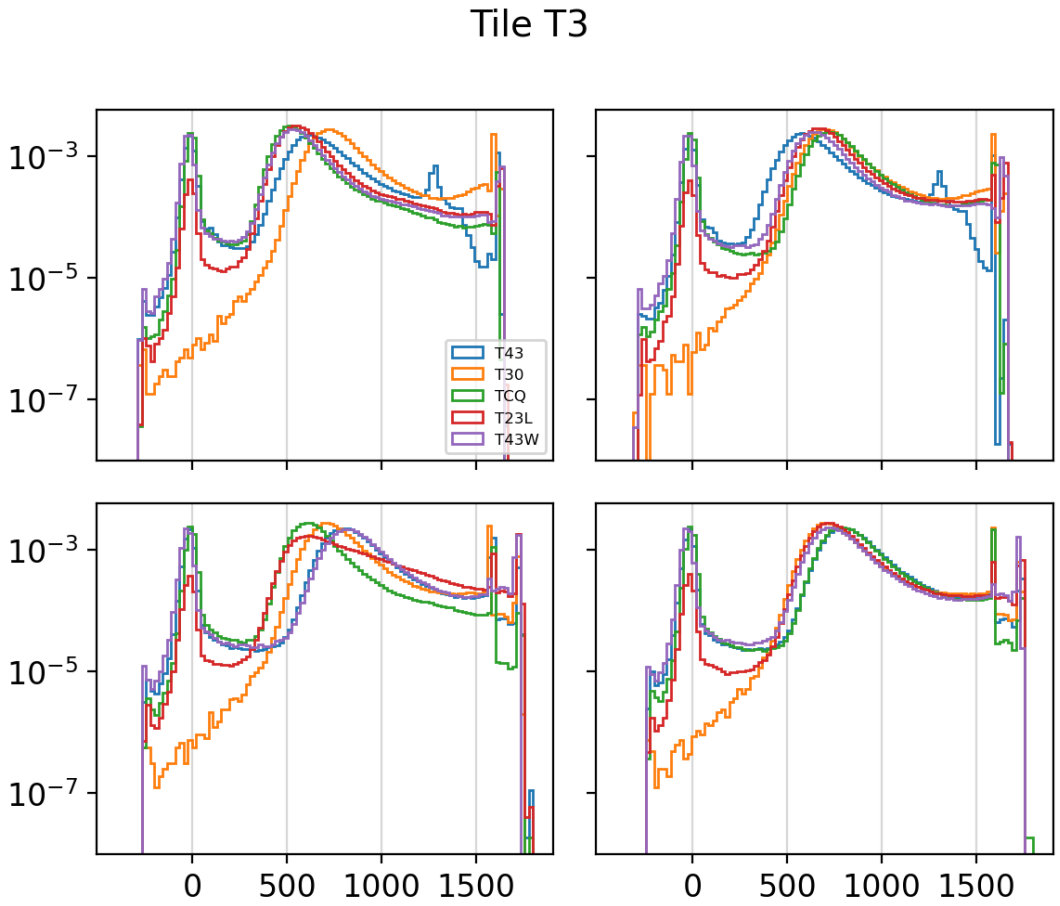


Comparison at different positions – T3

	T43	TCQ	T23L	T43W
Top Left (4)	0.86	0.71	0.75	0.73
Top Right (1)	0.82	1.02	0.94	0.91
Bottom Left (3)	1.12	0.84	0.88	1.15
Bottom Right (2)	1.12	1.11	1.01	1.03

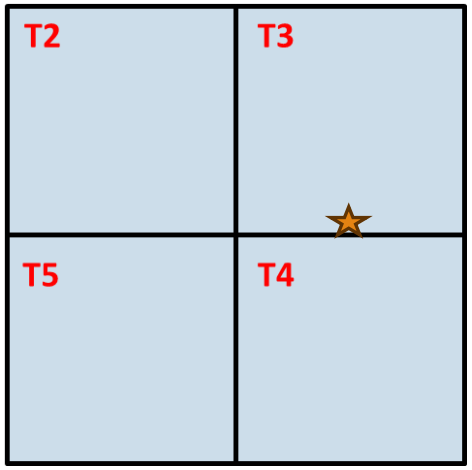


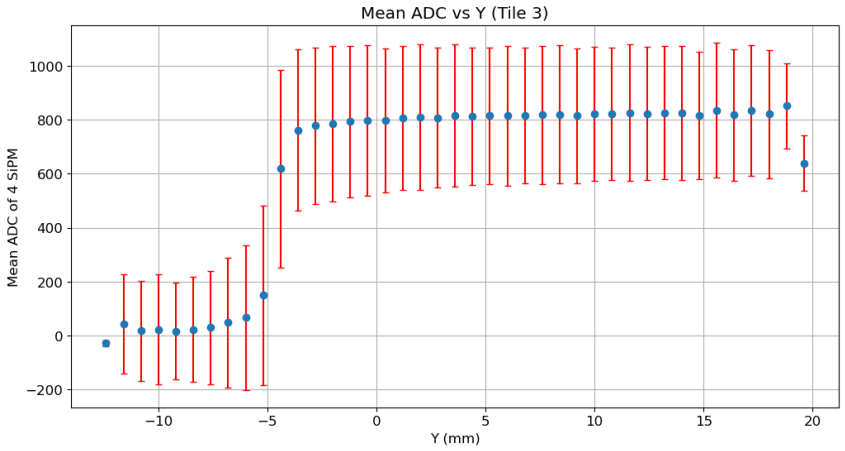


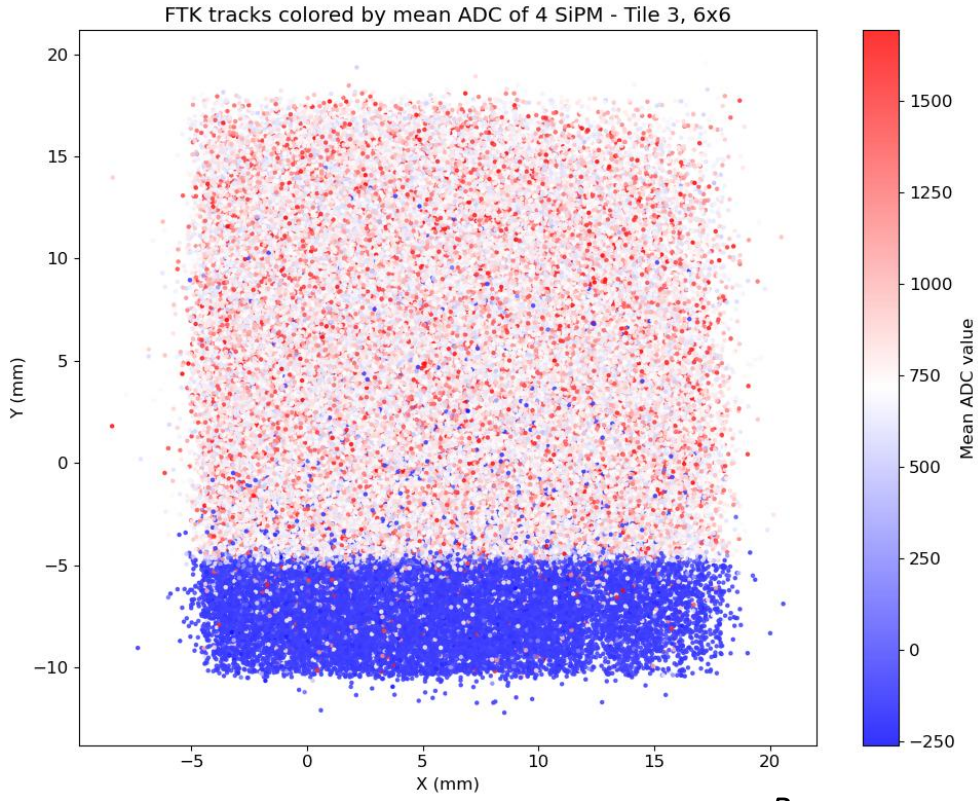


First attempt with SciFi tracker info

- Tile uniformity/response can be tested precisely with tracking information
- This is especially useful when beam was at ACD interfaces
- 97.5 % efficiency requiring events with y>-5 mm



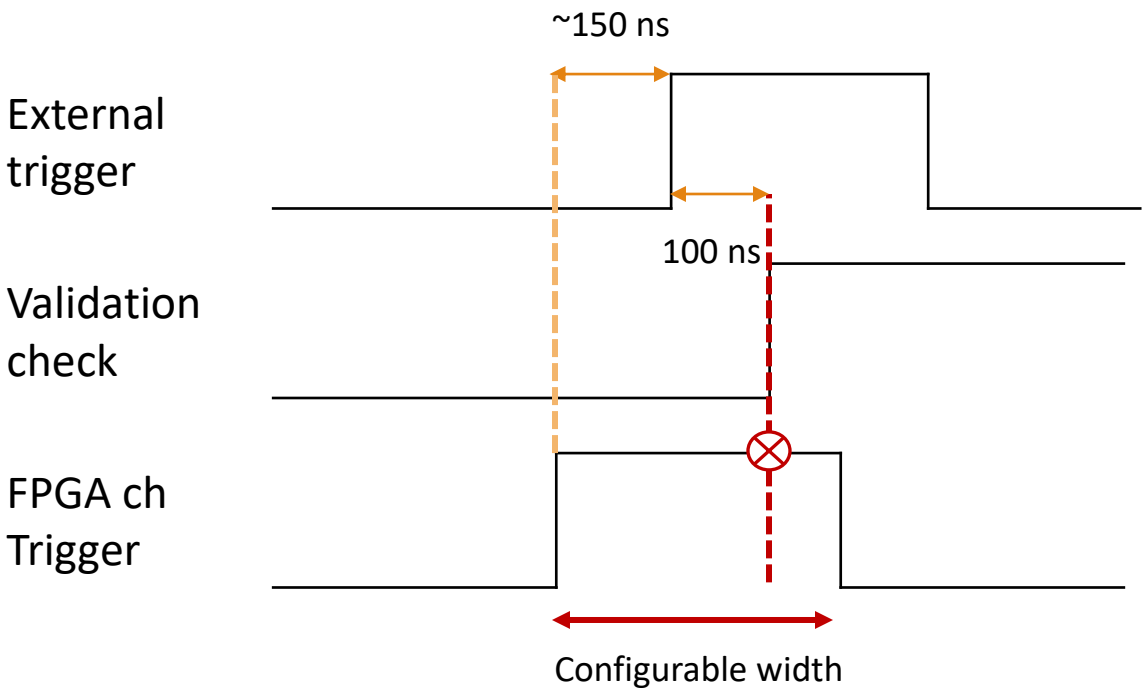




By
G. De Palma
A. Liguori

Triggers and validation

Trigger validation strategy (BETA FEB)



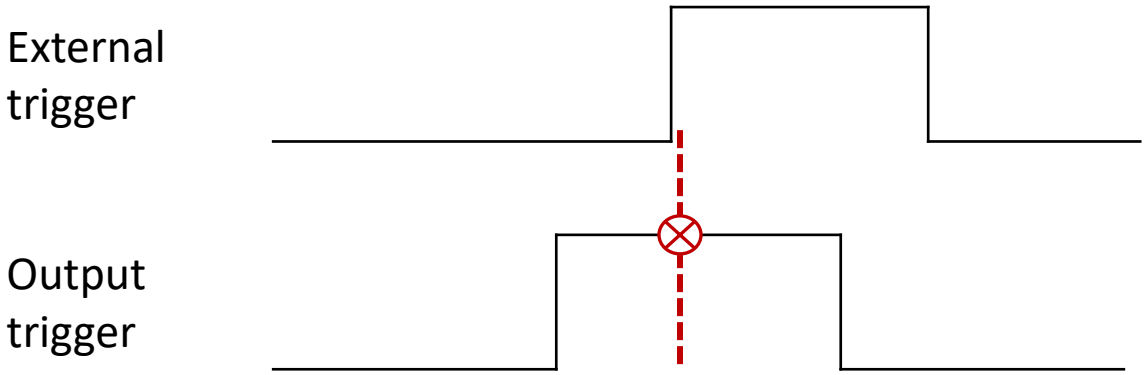
We can check internally the status of the triggers channel by channel

BETA ASIC internal triggers can be either reshaped in fixed-width (tunable) signals, or kept as a copy (TOT) of the original trigger by the FPGA

The external trigger is distributed by a CAEN board which was able to:

- Count incoming triggers from the subdetectors
- Check coincidences and provide the trigger when the condition is met

Trigger validation strategy (CAEN board)



We can check the status of the trigger produced by the BETA FEB FPGA (configurable between majority, map etc) with the CAEN module

BETA ASIC internal triggers can be either reshaped in fixed-width (tunable) signals, or kept as a copy (TOT) of the original trigger by the FPGA

The external trigger is distributed by a CAEN board which was able to:

- Count incoming triggers from the subdetectors
- Check coincidences and provide the trigger when the condition is met

Triggers and validation

Parameters to be optimized:

- Channels DAC thresholds
- Majority threshold
- Coincidence time window, i.e. the width of the triggers of single channels

Aspects which affected the efficiency during the TB:

- Pile ups
- Timing
- Both of these may change with the beam

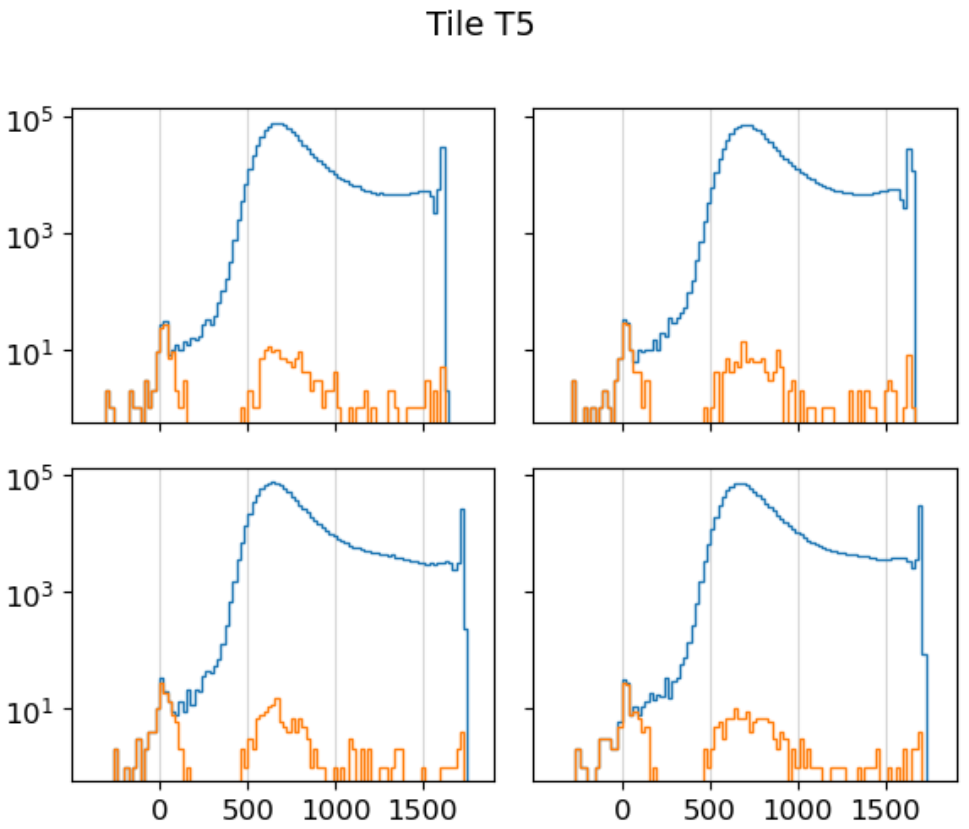
T5 center - BETA validation

Looking at the internal beta validation of the trigger. Time-Over-Threshold (copy) configuration

Fixed DAC thresholds for all channels.[~0.25 MIP]

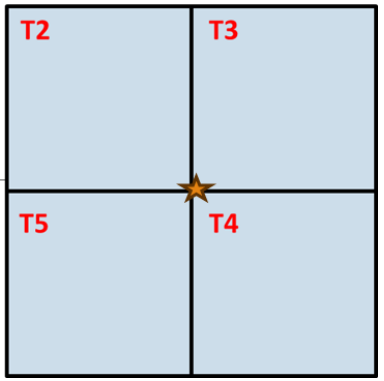
- Single channels validation ~ 99.977 %
  - Majorities

	T2	T3	T4	T5
Maj>1	2.410354	2.001010	2.318659	99.978348
Maj>2	2.343271	1.938184	2.247783	99.976775
Maj>3	2.256110	1.852781	2.154884	99.973815

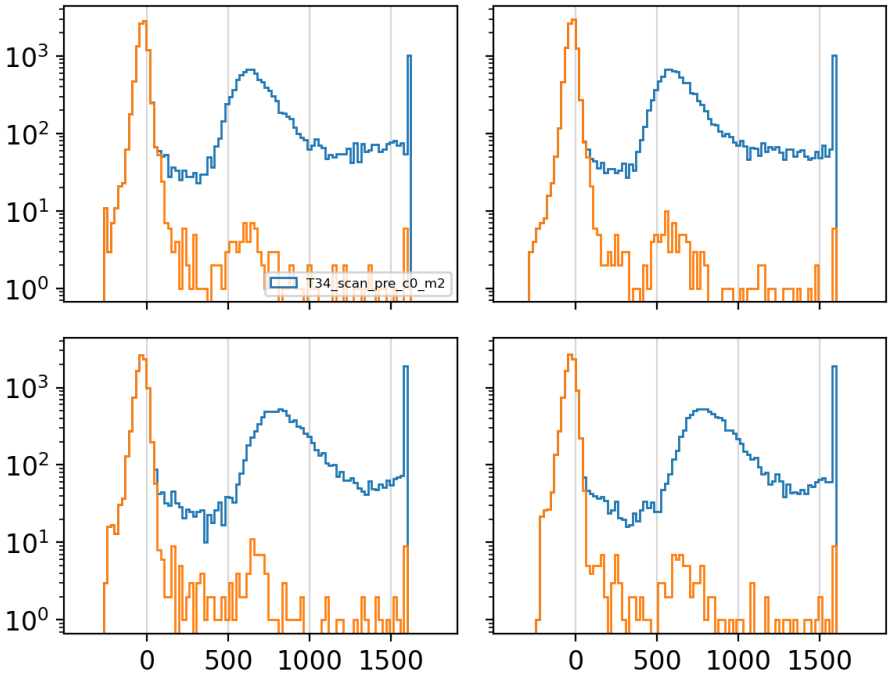


ORANGE NOT validated

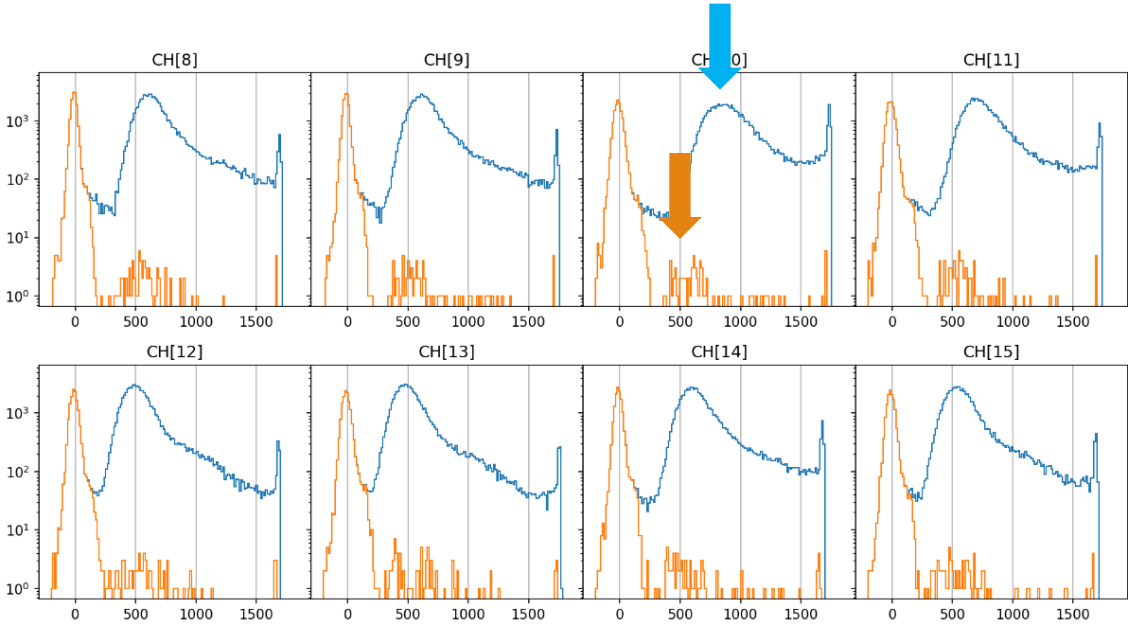
No correlation with beam position



Tile T3 center of quadrant position

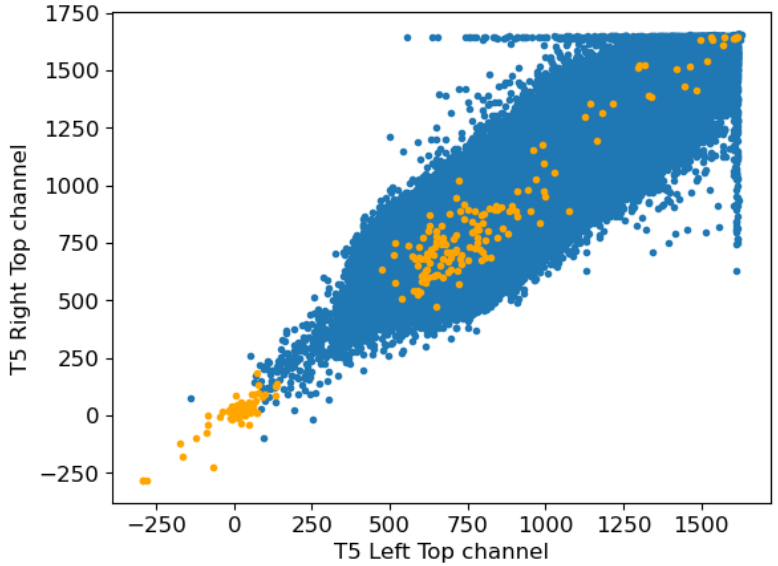


Single SiPM interface – Tile T4 - Center of quadrant position

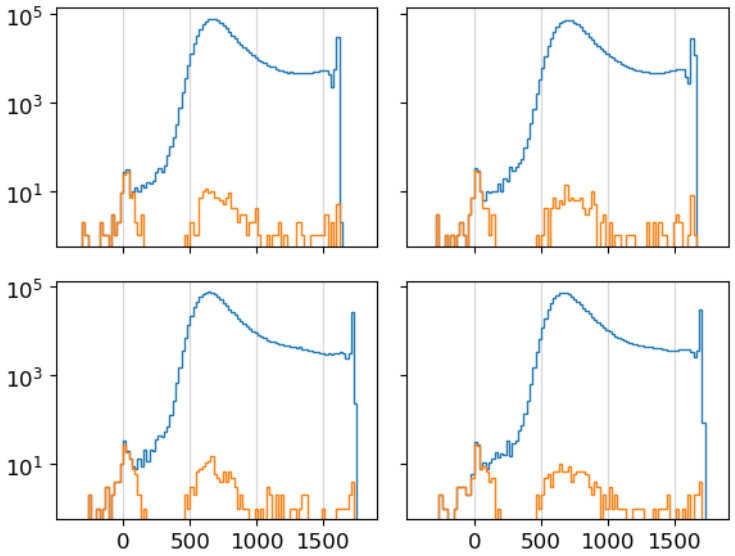


T5 center - BETA validation

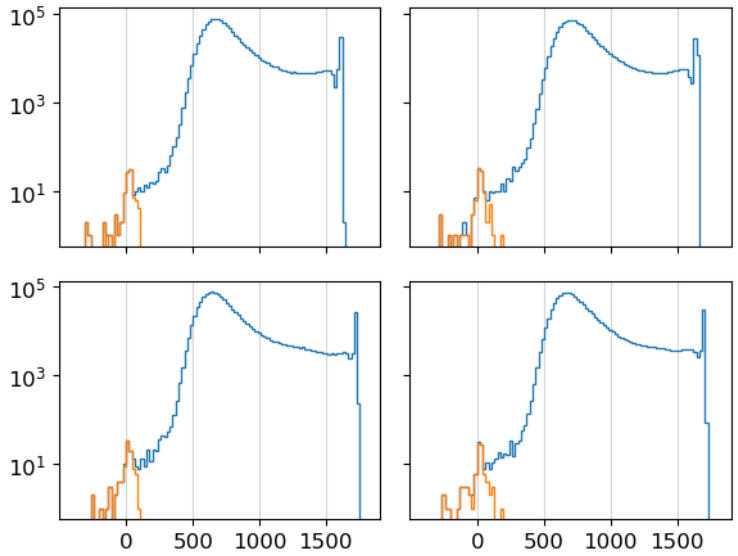
Being T.O.T. the individual triggers should be high above threshold. So why these non validated evts? FW issues? Trigger inefficiency/timing?



Untriggered Validation for Maj>1

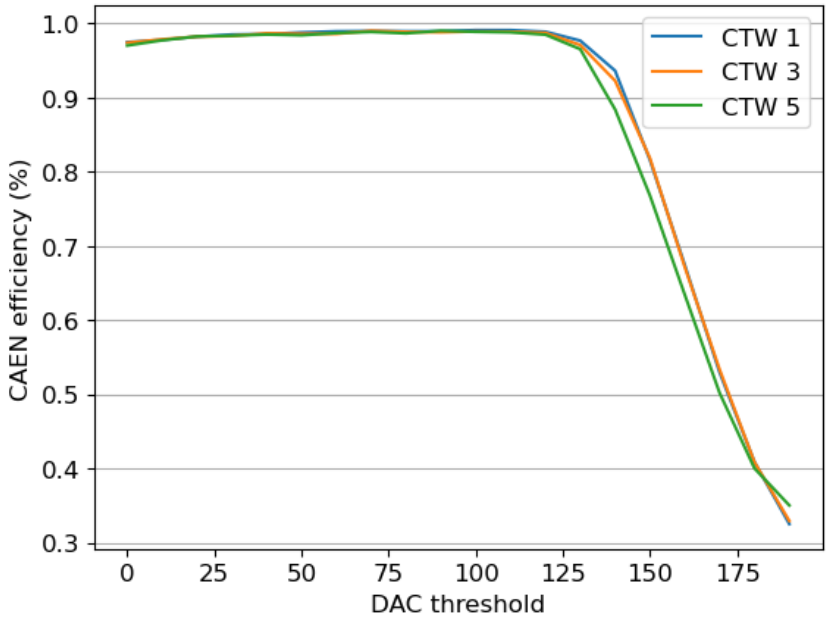


Untriggered ADC for Maj>1



Coincidence time window

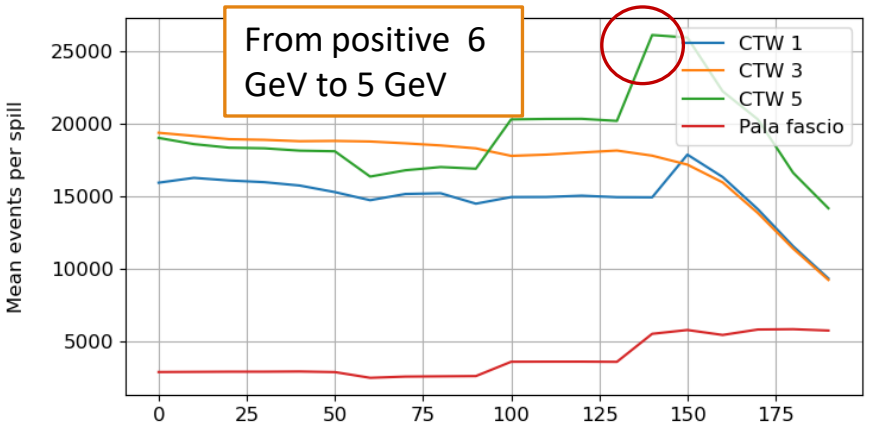
Majority >1 of the T4 tile monitored with the CAEN

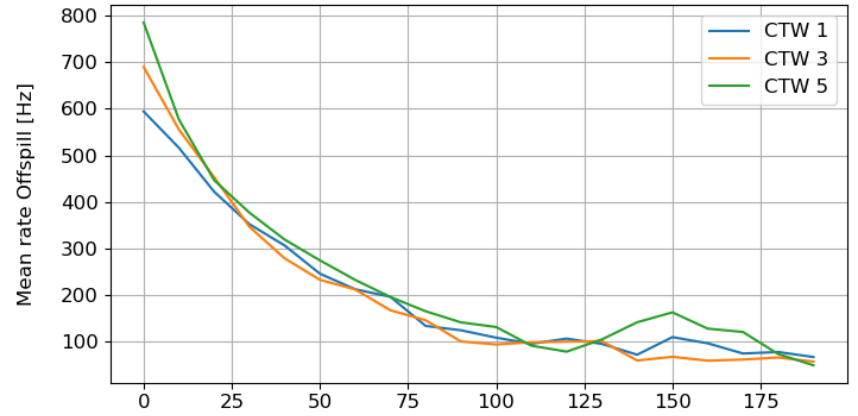


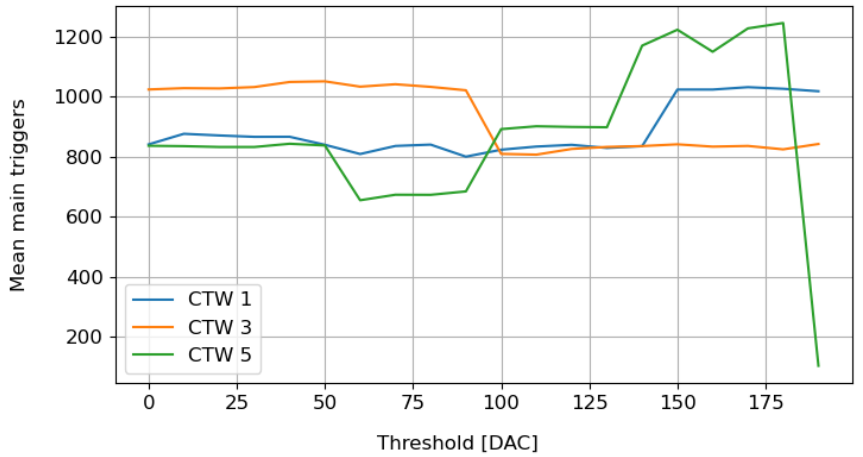
In terms of efficiency it seems there is no difference in the CTW (with gate)

CTW 1 = 75 ns
CTW 3 = 175 ns
CTW 5 = 275 ns

Same rate off spill





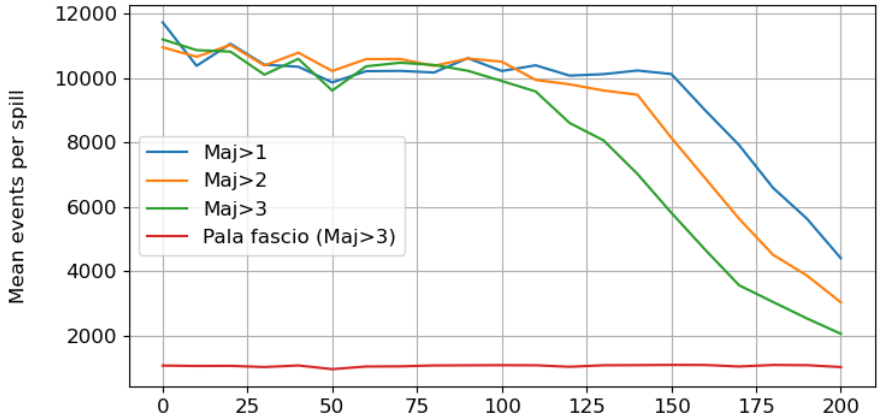


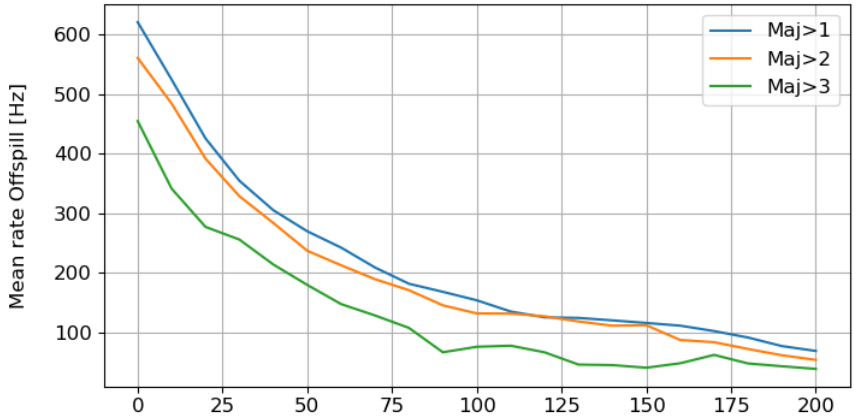
Majority threshold (CTW 1)

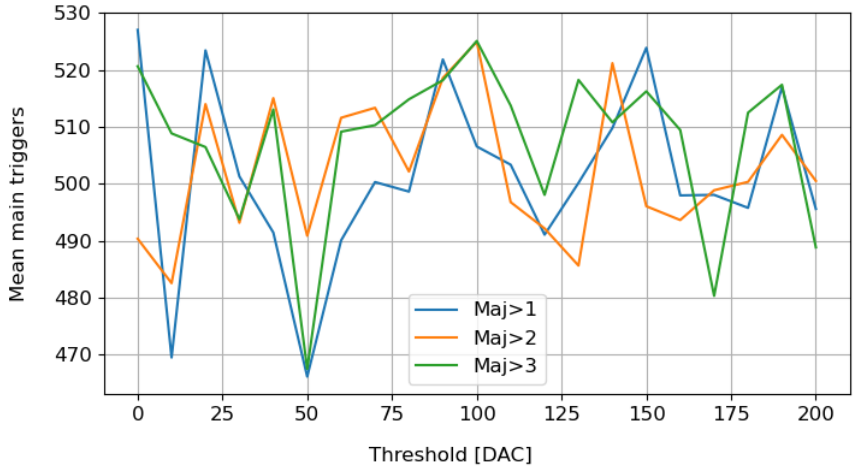
CTW1=75 ns , Monitor majority sent to the CAEN

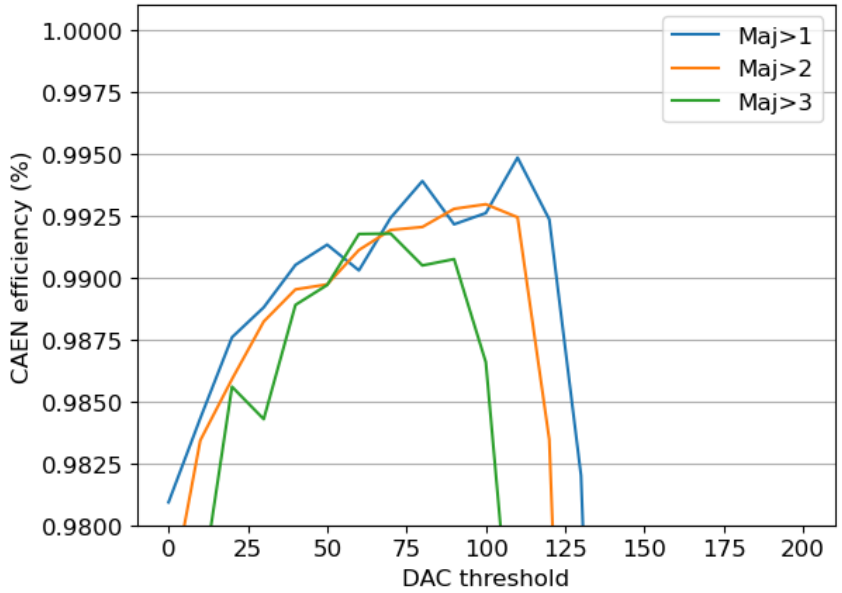
5 GeV positive beam

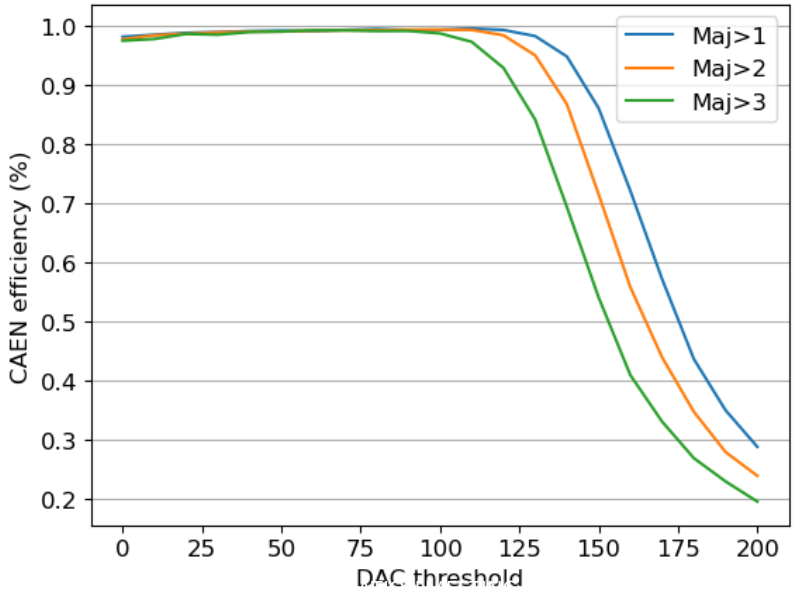
Below a certain threshold the efficiency and the number of trigger counts are the same





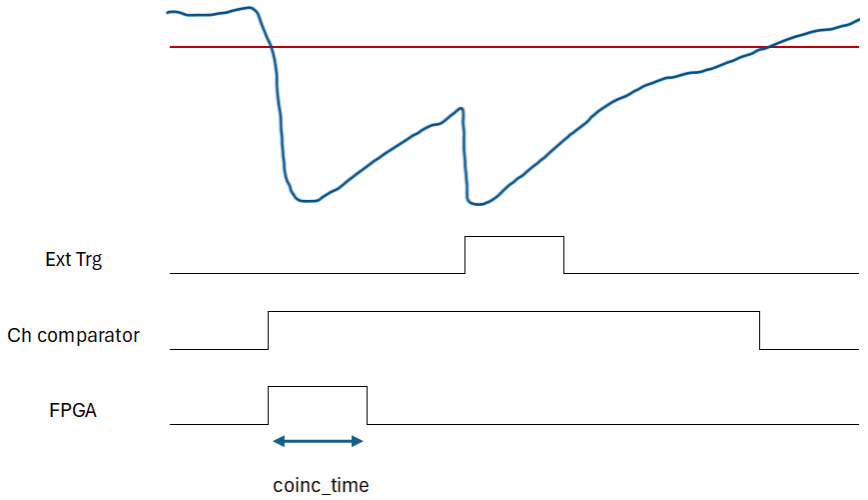


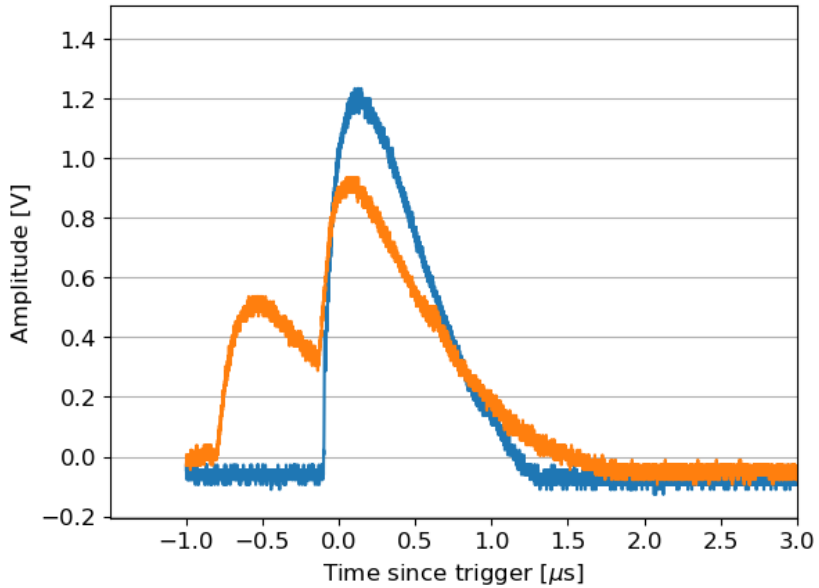




The pile-up

- Each event induces a dead-time needed for charge/discharge of the preamp analog signal, therefore on the discriminator (trigger signal τ)
- If another event occurs while the signal is already over-threshold, the two signal sum leading to a longer trigger
- The information of WHEN the second particle arrived is lost (no leading edge)
- This poses a limit for the efficiency calculated wrt external system





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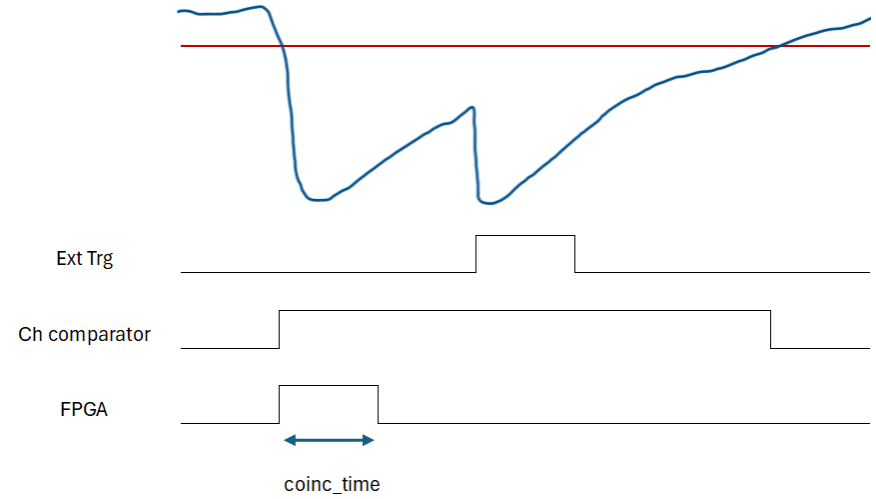
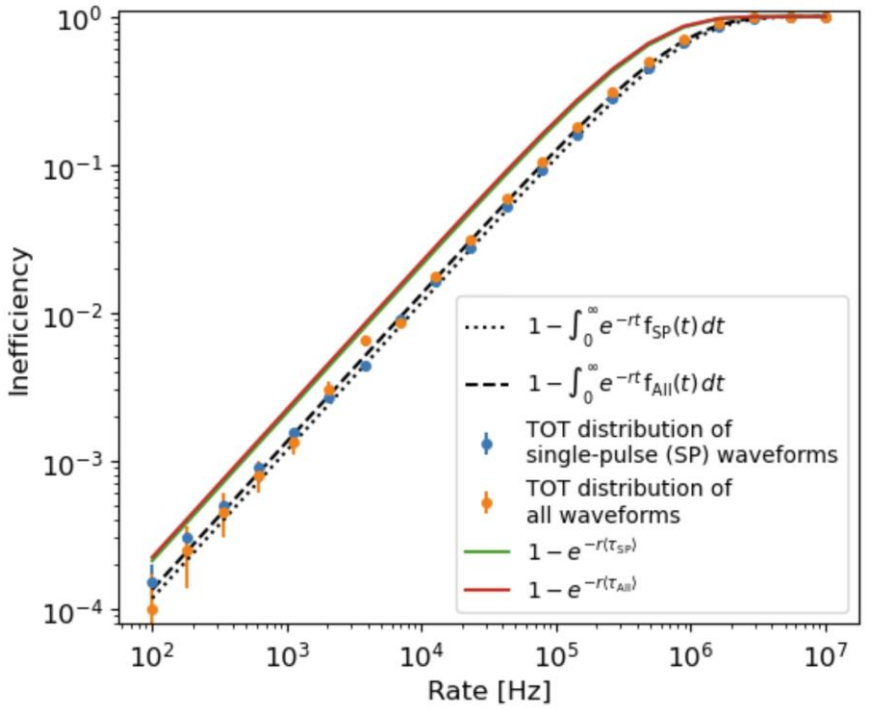
- This poses a limit for the efficiency calculated wrt external system

At low rates (wrt tau) a good approximation is $\varepsilon \approx 1 - m\tau$





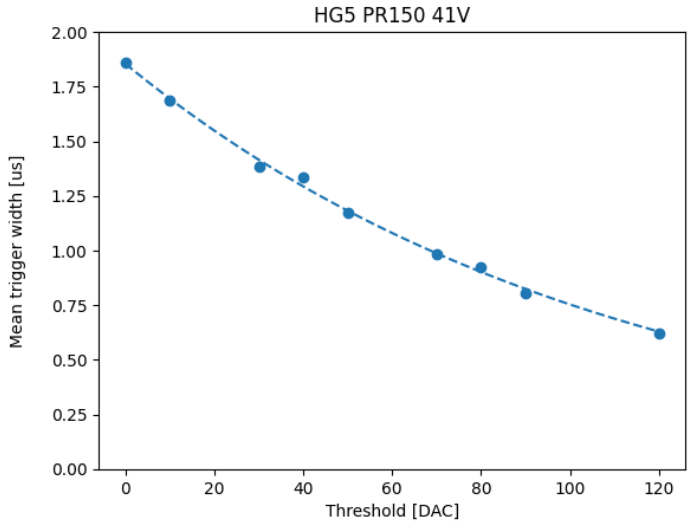
By
D. Cerasole
A. Liguori

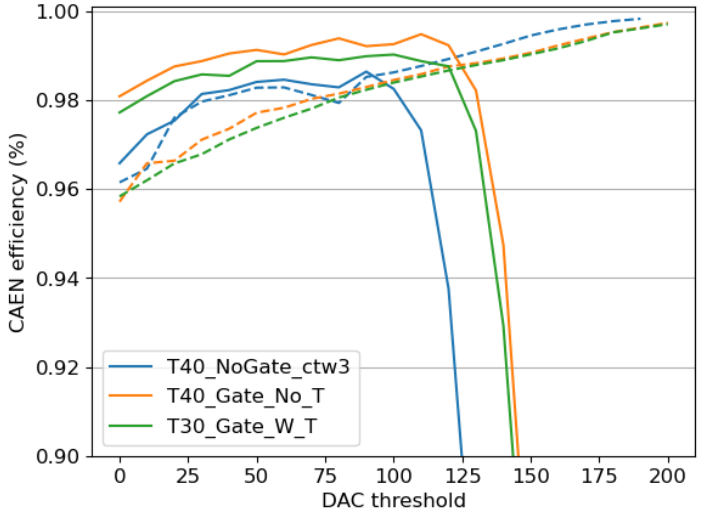
Pile-up limit (preliminary)

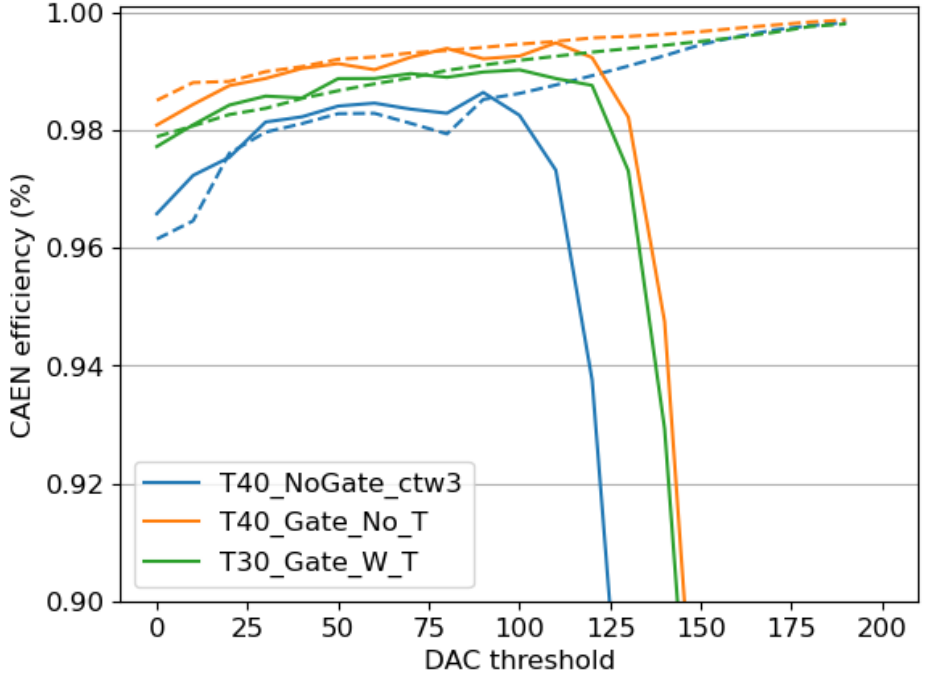
- Correction with the term $m_{\text{rate detection}} \times \tau$
- It ‘‘works’’ until we had to send the beta trigger to a gate generator. Then i have to apply some corrections on the observed rate
- Need to investigate extensively on all the data (where possible)

From T.O.T. acquisitions with the oscilloscope…

τ changes with the trigger. Lower thresholds means more dead time







Conclusions

- PS beam test revealed pile-ups effects
- Absolute efficiency (in charge or trigger) measurements are not feasible with the rate at PS

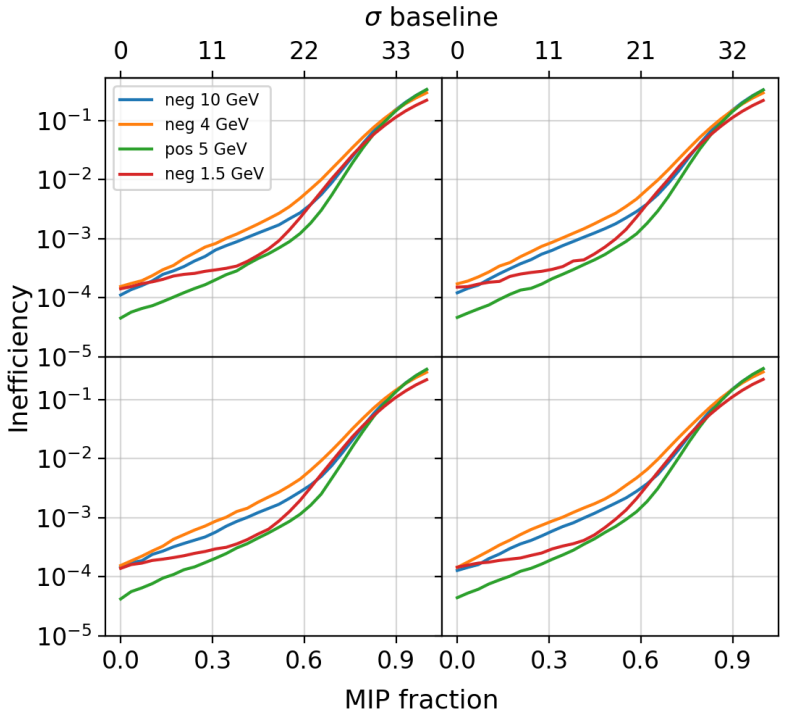
Nevertheless…

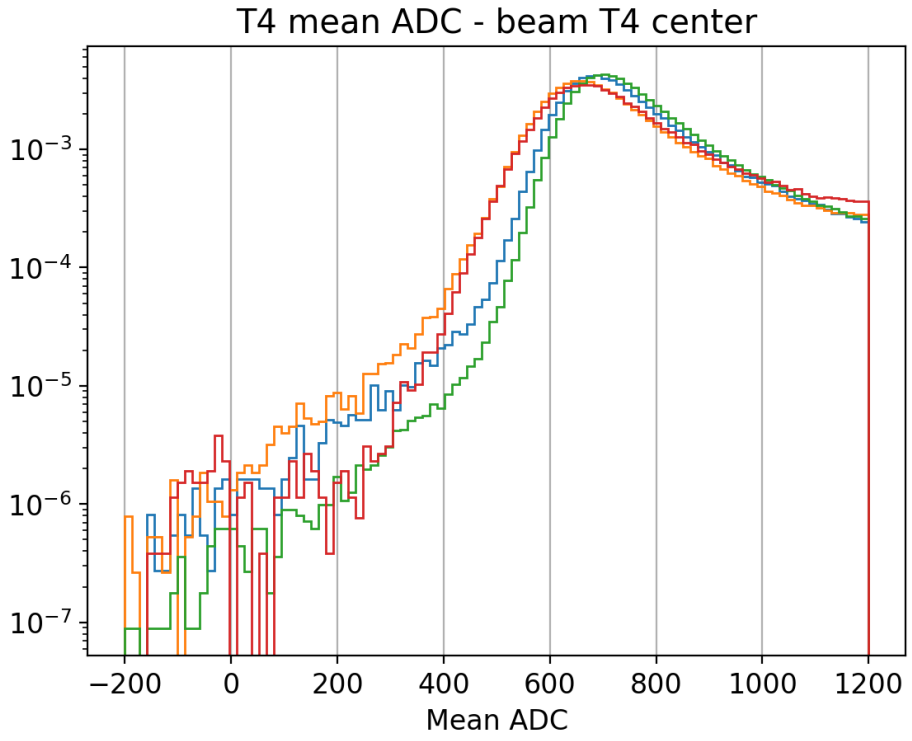
- We can study tile uniformity response with OR-ed and Single concentrator data
- We can study pile-up effects, check how much they limit performances with an ADAPT/APT realistic particle environment. And how to compensate (?)
- Many things need to be verified… there's work to do!

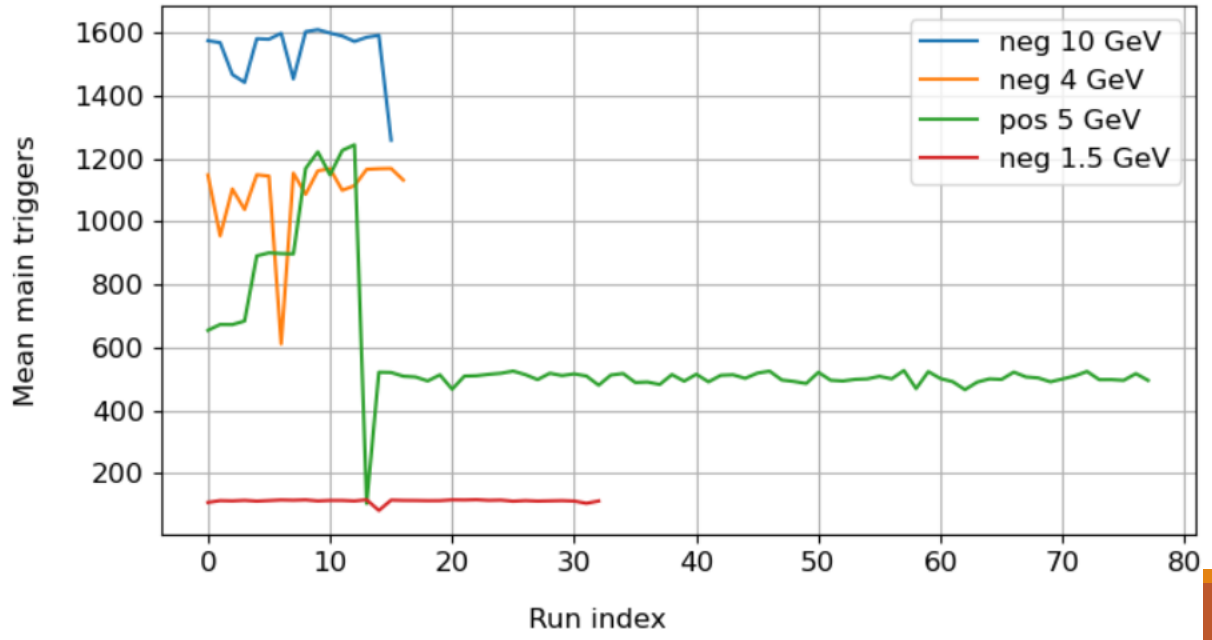
Thanks you for your attention!

Backup

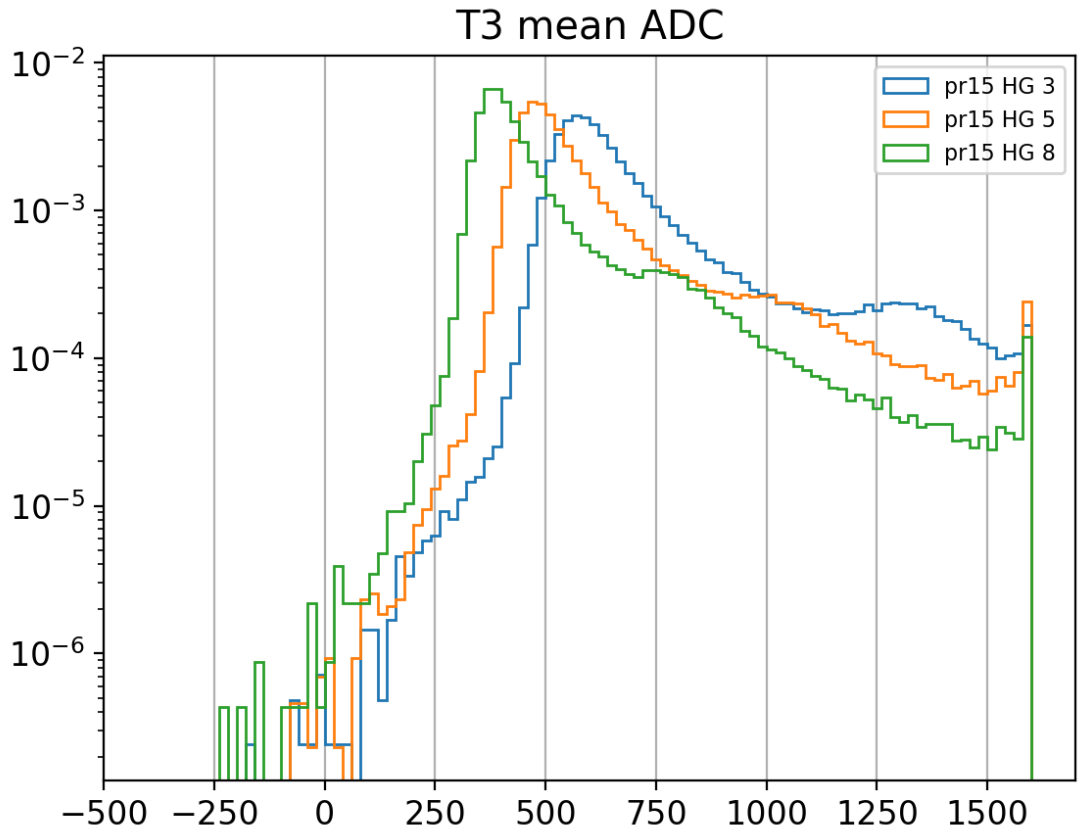
Tile centers –T4

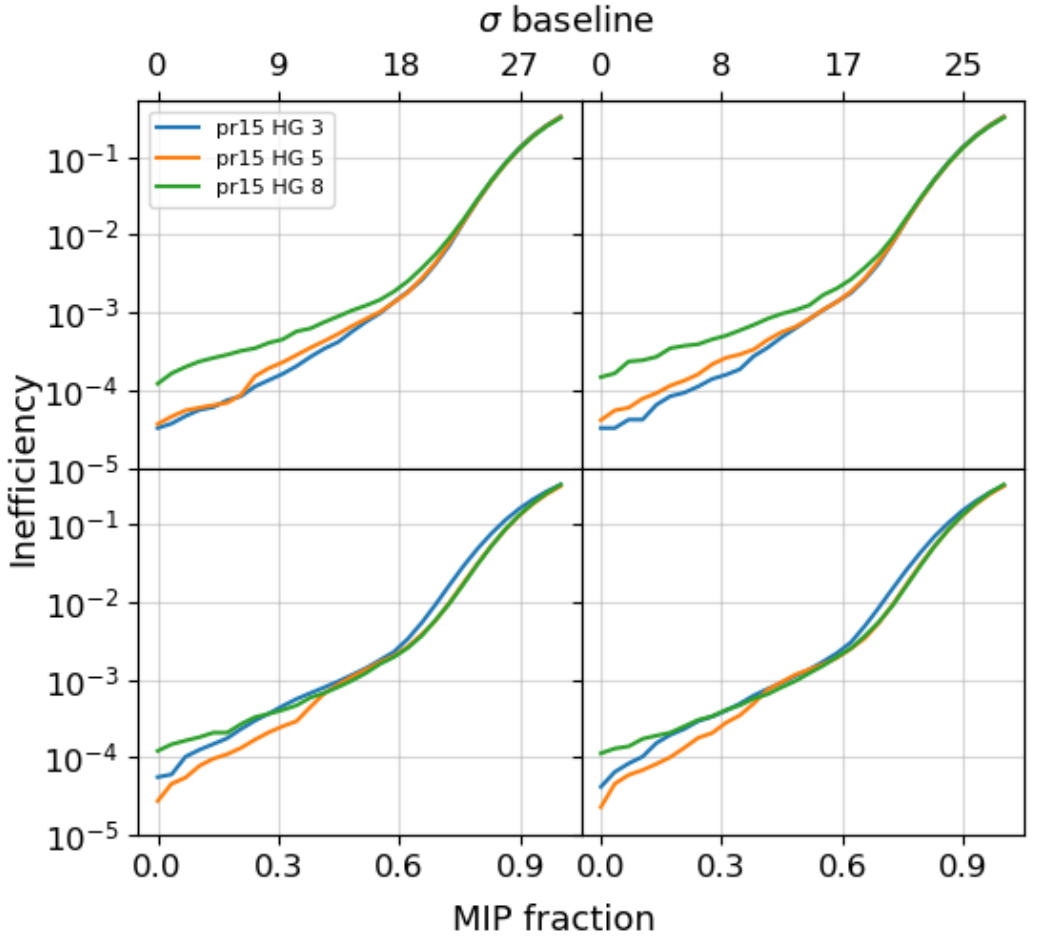






Playing with shaping



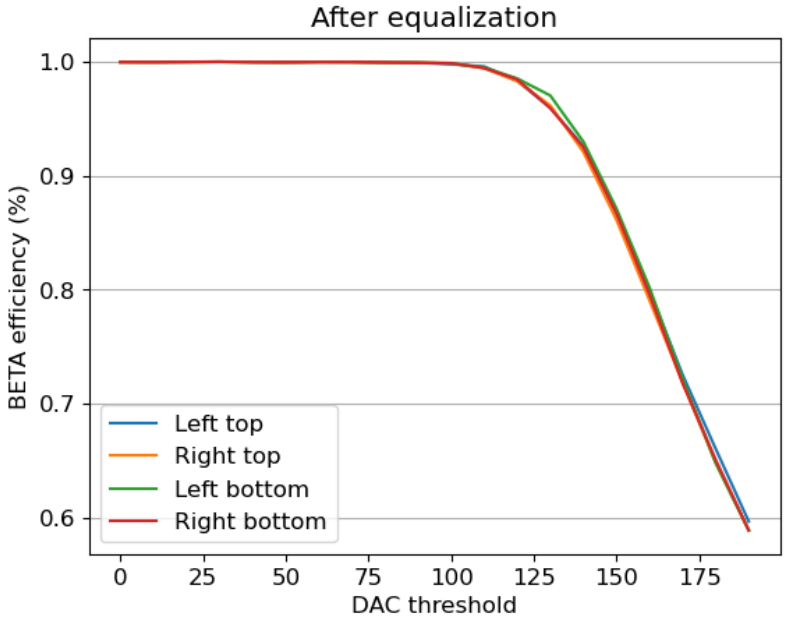


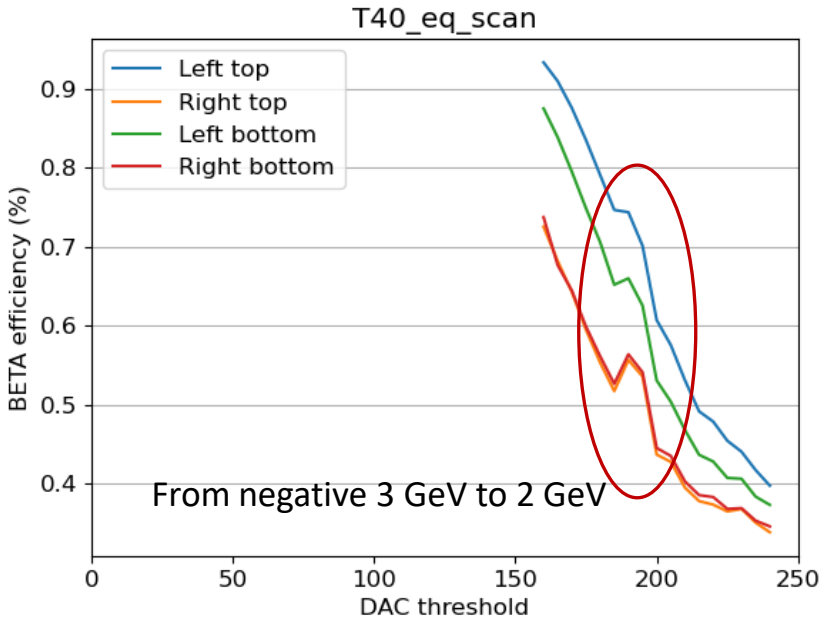
Threshold equalization

Acquisition in external trigger but internal threshold scan.

Checking the validation efficiencies the curves were shifted.

DAC differences evaluated and set for the next scan



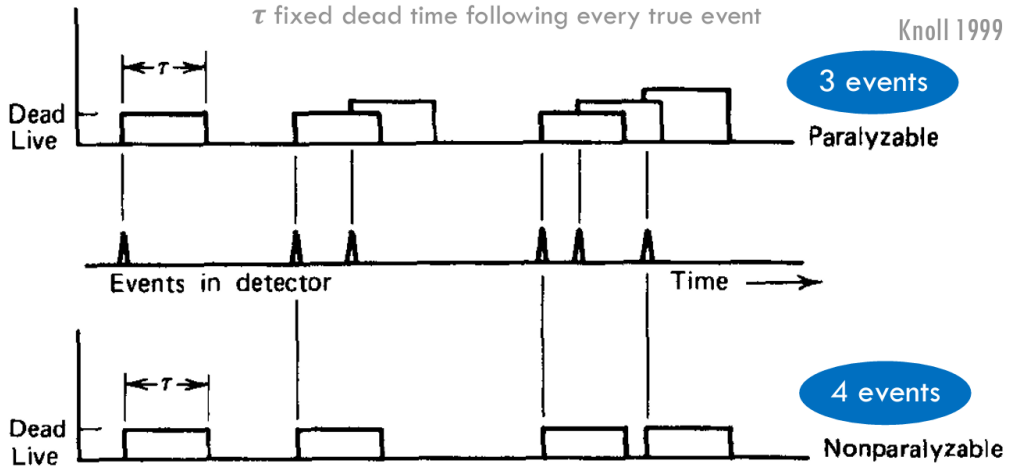


Paralyzable model

True rate: n Dead time: τ

Observed rate: $m = ne^{-n\tau}$

Efficiency: $\varepsilon = \frac{M}{N} = e^{-n\tau}$

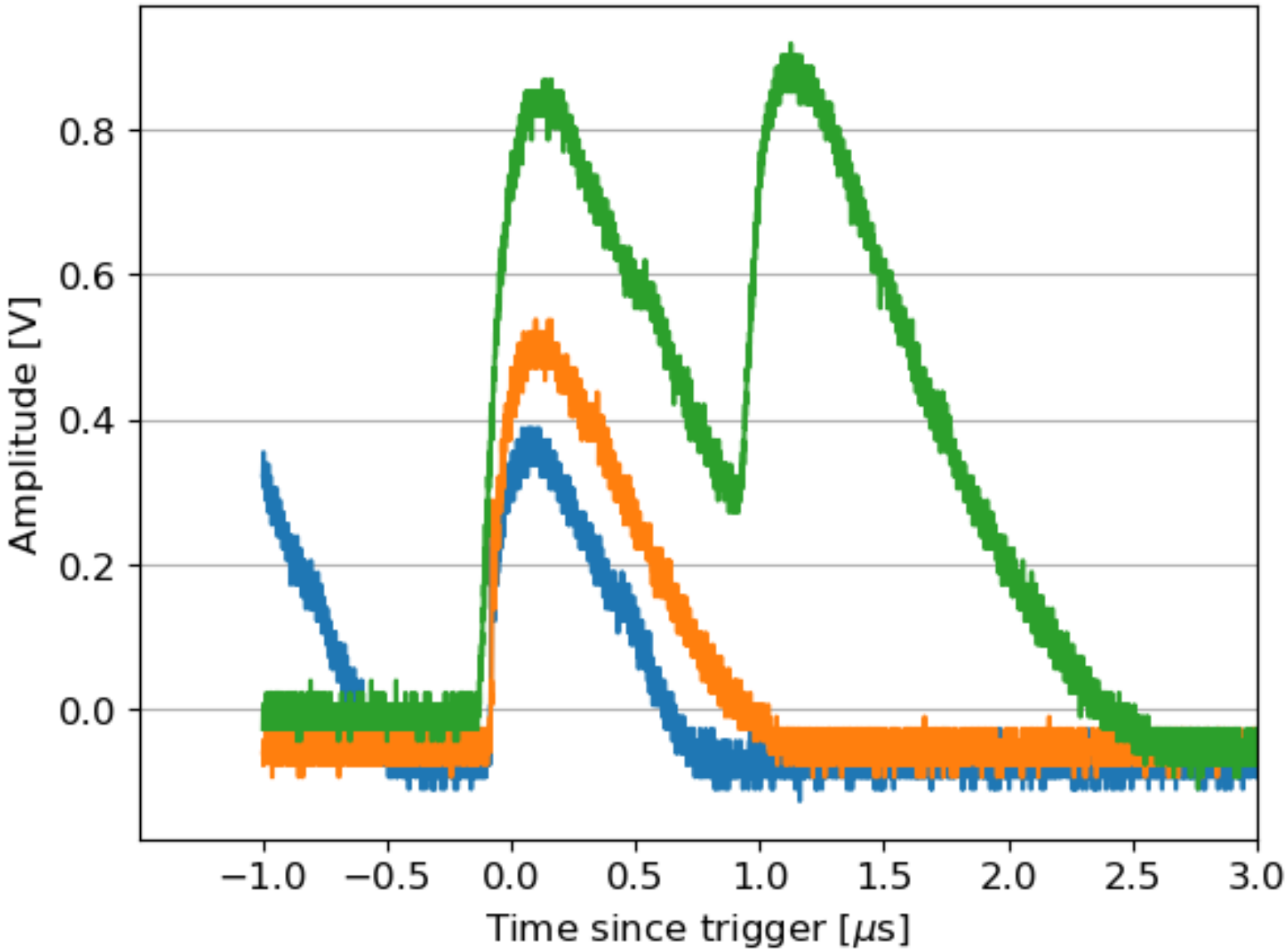


We only know the observed rate m, but at low rates (wrt tau) a good approximation is
$\varepsilon \approx 1 - m\tau$

Full correct formula here:

https://doi.org/10.1016/0168-9002(91)90021-H

$$\rho = \frac{R}{1 - R\tau - \frac{1}{2}(R\tau)^2 - \frac{2}{3}(R\tau)^3 - \frac{9}{8}(R\tau)^4 - \cdots}$$

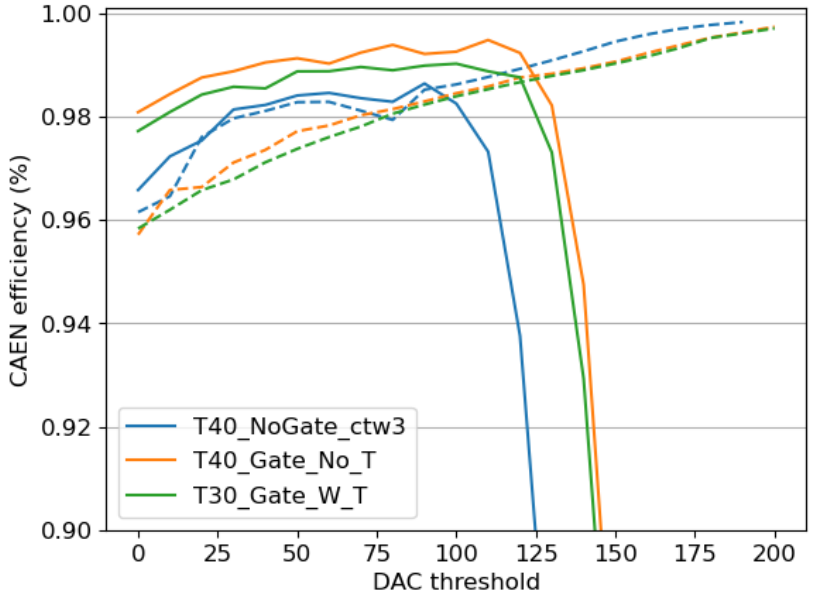

0.8
0.6
0.4
0.2
0.0
Amplitude [V]
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Time since trigger [μs]

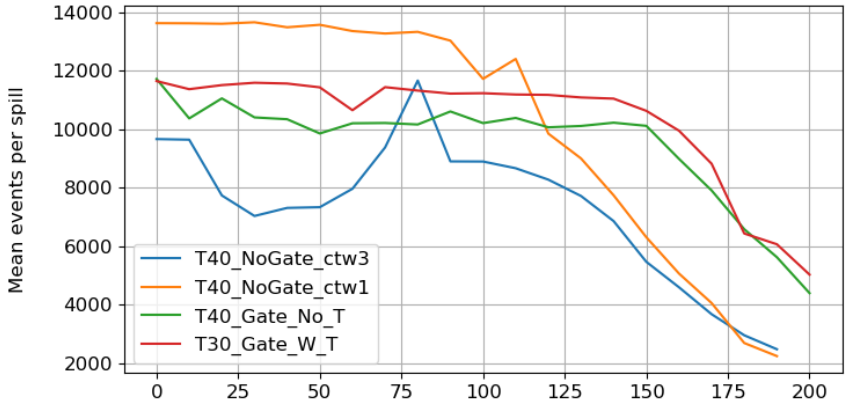
Pile-up probability

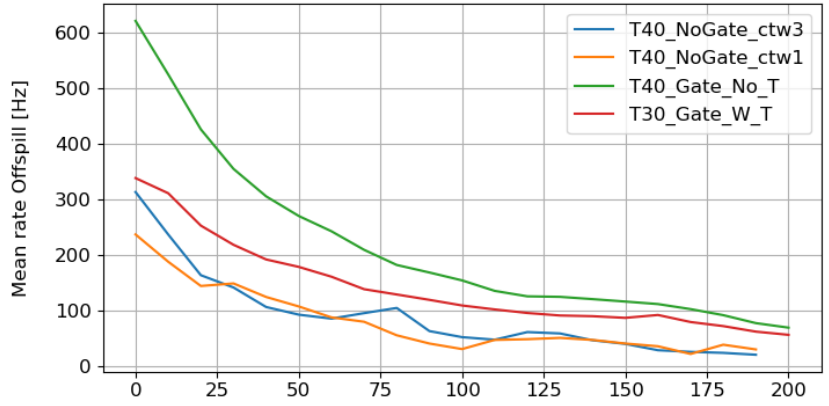
Correction with the term, $\mathrm{m}_{\mathrm{rate\ detection}} \times \tau_{MPV}$

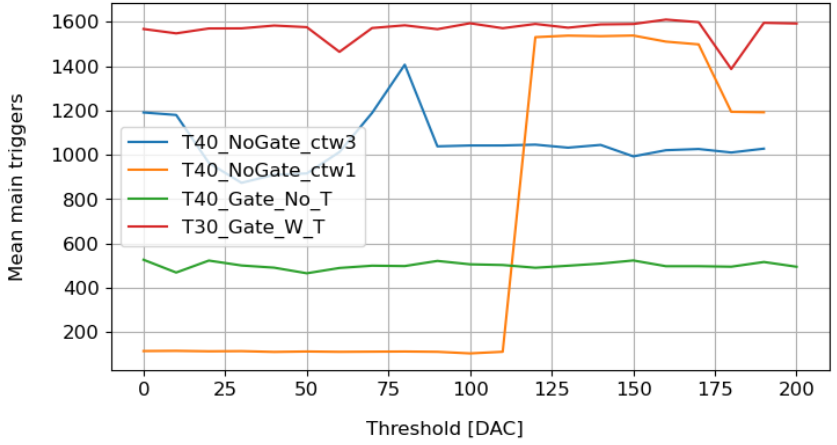
It works until we had to send the beta trigger to a gate generator.

Here the comparison with three central positions taken in different moments.
Before gate,
After gate (No T),
After terminating gate signal









Pile-up probability

Correction with the term, $\mathrm{m}_{\mathrm{rate\ detection}} \times \tau_{MPV}$

It works until we had to send the beta trigger to a gate generator.

Using the offspill counts to normalize the detection rate to the «no gate» condition, is it possible to recover the efficiency limit

Correzione di un fattore:

~ 0.35 No T

~ 0.5 With T