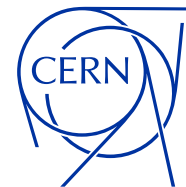


Some SiW-ECAL Test-Beam Results

Valeria Pérez Martínez



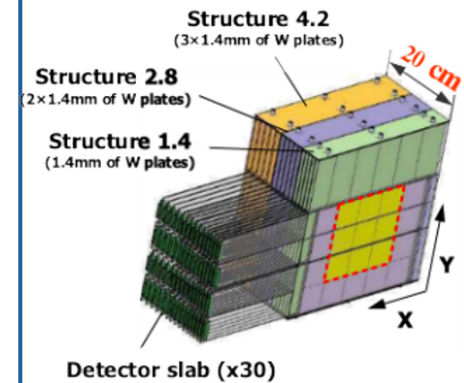
Institut Polytechnique de Paris



SiW-ECAL Timeline

Physical (2005-11)

- Proof of principle
- $1 \times 1 \text{ cm}^2$ on $500 \mu\text{m}$
 $6 \times 6 \text{ cm}^2$
Pad glued on PCB
Floating GR
- $\times 30$ layers (10k chan).
- External readout



2012-2023

- ‘ultimate’ design with SKIROC2 ASIC (2012) [LLR+IJCLab]
 - Many improvements: stability, noise, flexibility
 - $\rightarrow$ PCB + HV Kaptons
- DAQ and Readout [IJCLab]
- But serious issues stability of gluing of wafers on PCB
- Test of ASICs (Ω mega)

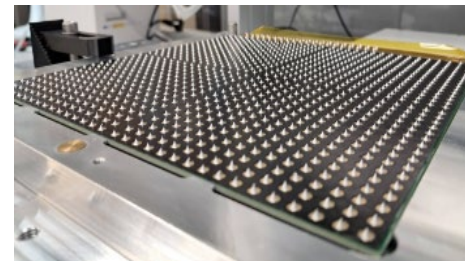
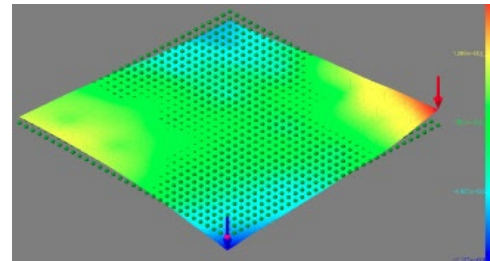


2024

Diagnostics and assembly
revisitation: **IJCLab**, **DMLab** +
IFIC Valencia

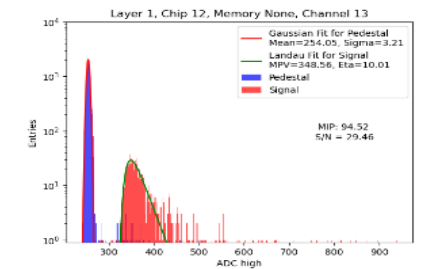
- Metrology, Thermal cycling, Gluing solutions

Puncturated
adhesive film (**DMLab**)
+
conductive glue dots (**IFIC**)

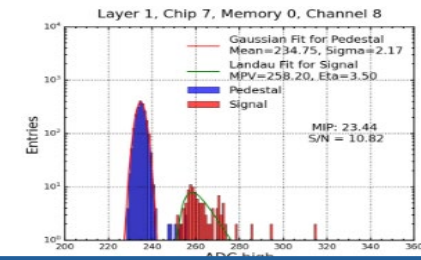


2025

- Test of 2 boards at DESY
 - Very good response at low- E (mips), noise compatible to run with full dynamics
- Production of 13 additional boards
- Tests & integration (**IJCLab**)



High Gain,
limited
dynamics
S/N ~ 29

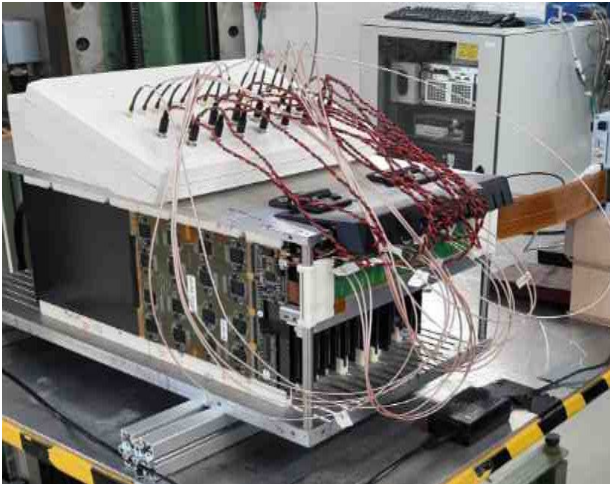


Low Gain,
Full dynamics
S/N ~ 11

SiW-ECAL Timeline

Technological (now)

- Embedded electronics
 - Power-Pulsed, Auto-Trig, delayed RO
 - $S/N = (MPV/\sigma_{\text{Noise}}) \geq \sim 12$ (trig)
- Compatible w/ 8+ modules-slab
- $5 \times 5 \text{ mm}^2$ on $500\text{--}650 \text{ }\mu\text{m}$ $9 \times 9 \text{ cm}^2$ $\times 15$ layers
 - 1,024 (slab) $\sim$ 15k (calo) channels



TestBeam CERN June 2026 (next slide)

On-going analysis

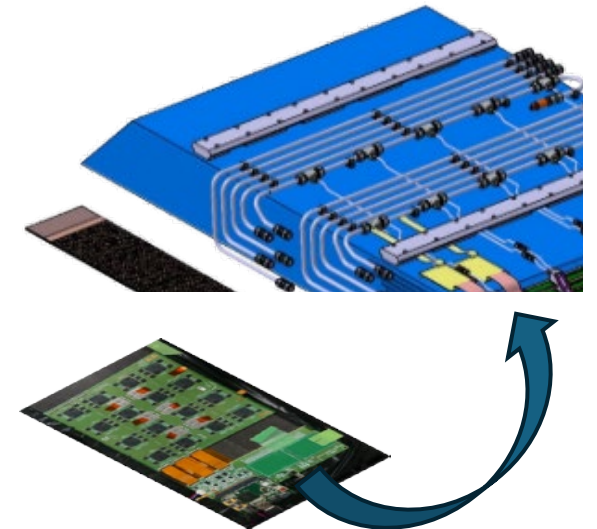
- J.P. Márquez: general software maintenance/development. Simulation.
- O. Arquero: Encoder for selecting high energy e- showers
- T. Kamiyama: Linearity & resolution studies (bottom-left area) using Gaussian filtering.
- T. Pule: Linearity & resolution studies (top-left area) using shower variable's cuts.
- V. Pérez: Uniformity scan analysis. Documentation
- B. Gautier: angle and position reconstruction

J.P. Márquez

Note: not a full list of contributors, just the ones involved with the code

FCC-ee Pilote $\rightarrow$ Full Detector

- 1M $\rightarrow$ 70M channels
 - on $725 \mu\text{m}$ $12 \times 12 \text{ cm}^2$ 8'' Wafers ?
 - Pre-industrial building
 - Full integration ($\supset$ cooling)
 - **Final ASIC** (GETROC)
- SHiP**
- 20 layers $\times$ $\sim$ 9k channels (next talk)

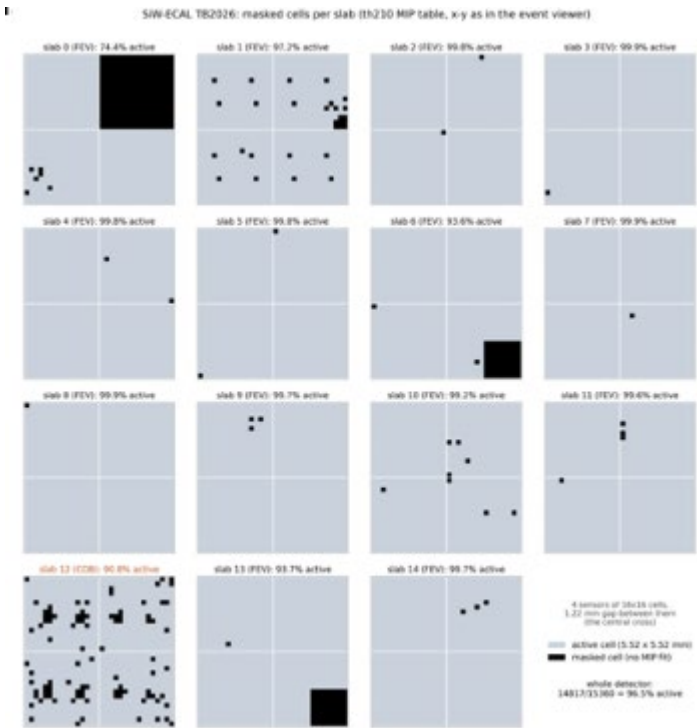


SiW-ECAL Uniform prototype

J.P. Márquez

A Stack of 15 uniform sensor layers, separated by W absorbers (non-uniform)

- 15 Sensor layer made of :
 - 4 wafers $[500\text{ }\mu\text{m} \times (16 \times 5.5\text{mm})^2 \text{ Si PIN Diodes}] \Rightarrow 18 \times 18\text{ cm}^2$
 - 1 PCB (FEV2.1)
 - 16 ASICs (SKIROC2a)
 - Tungsten absorbers:
 - $8 \times 4.2\text{ mm } [1.2\text{ }X_0] + 7 \times 5.6\text{ mm } [1.6\text{ }X_0]$
- Total= 20.8 Radiation length**
- Missing channels: bad connexion, ASIC, noise: ~4%



Layer	Active cells (%)
0	74.4
1	97.2
2	99.8
3	99.9
4	99.8
5	99.8
6	93.6
7	99.9
8	99.9
9	99.7
10	99.2
11	99.6
12 (COB)	90.8
13	93.7
14	99.7
All	96.5

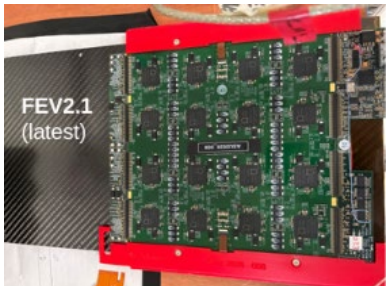
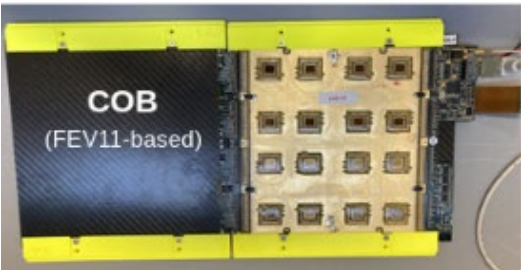
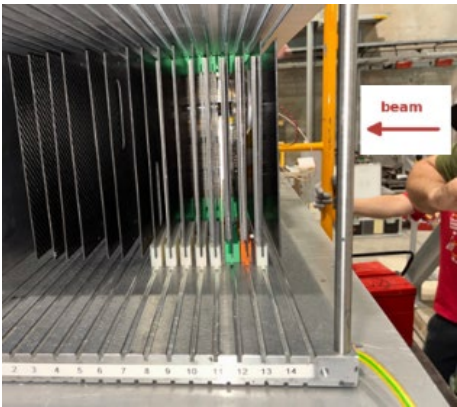
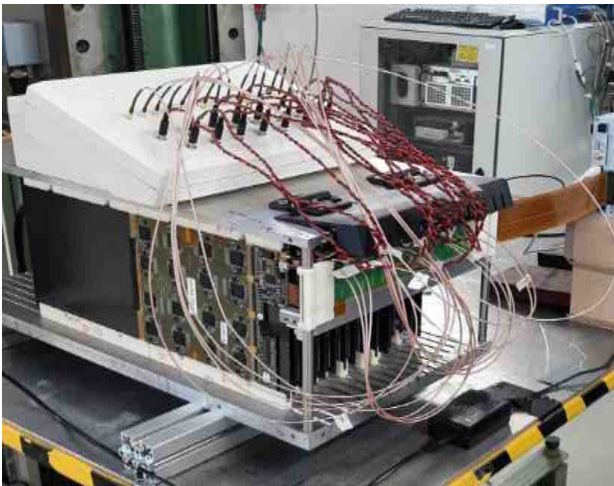
Dead sensor

Old design

Chip 9 dead

COB

Chip 9 dead

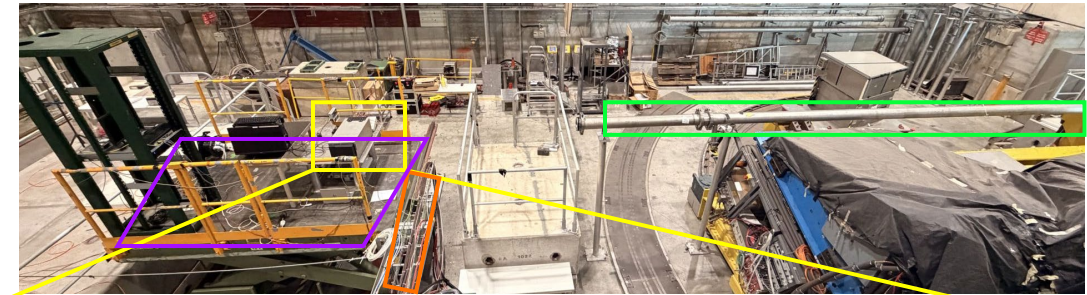
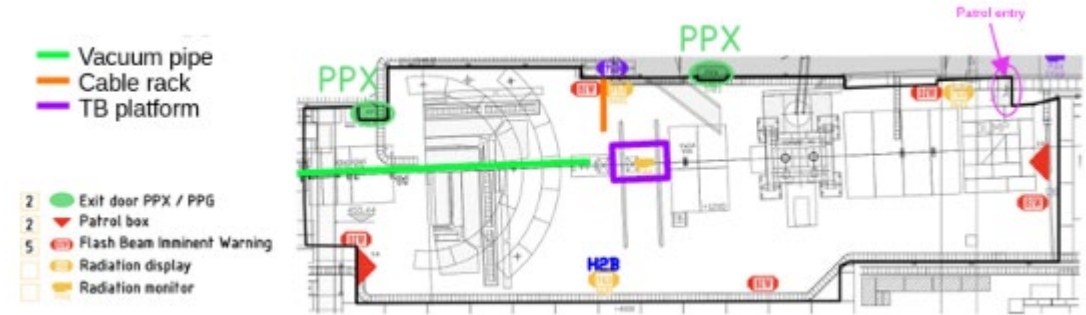


New boards are way better than the previous ones!

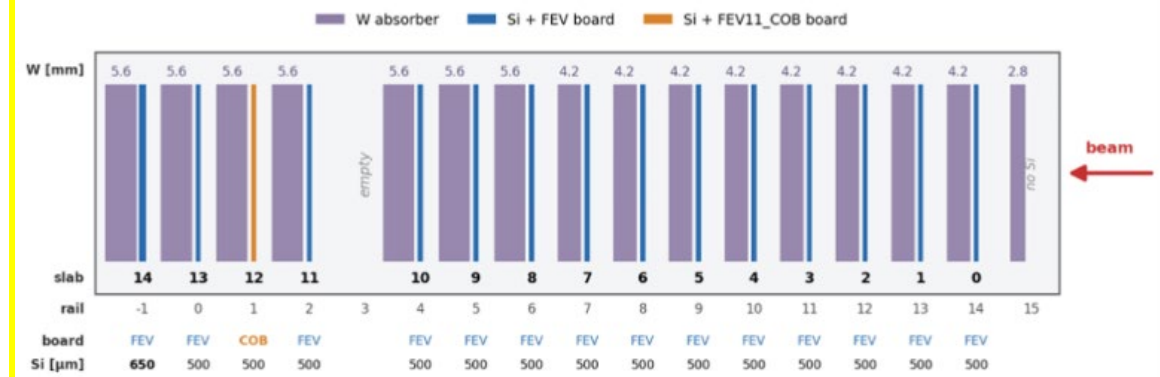
Test-beam at CERN June 2026

Test Beam in SPS line H2 June 17th to 25th

- 8 days of around 22h/day data-taking
- Mounting the first day without major complications
- Almost no beam shutdowns
- Very successful TB!



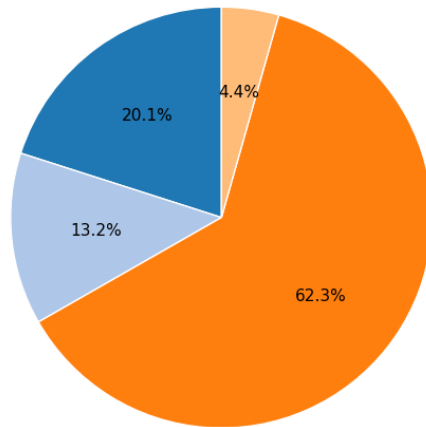
SiW-ECAL, CERN SPS test beam 2026: 15 slabs, $21.6 X_0$ of W (75.6 mm), rail pitch 15 mm



Test-beam at CERN June 2026

General Test-beam summary

Analyses performed
27,830,409 reported events

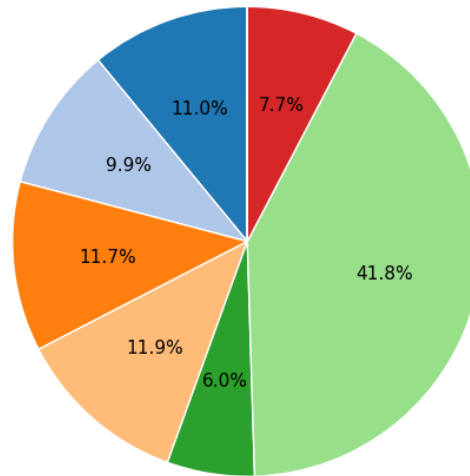


- Energy calibration: 5,582,510 (20.06%)
- Uniformity with positrons: 3,675,893 (13.21%)
- Muons: 17,350,987 (62.35%)
- Other analyses / unassigned: 1,221,019 (4.39%)

Muons – 150 GeV – For calibration
(about 3 night runs)

Pions – 10, 20 and 30 GeV – For future
analysis

Positrons — beam energies
10,378,503 reported events

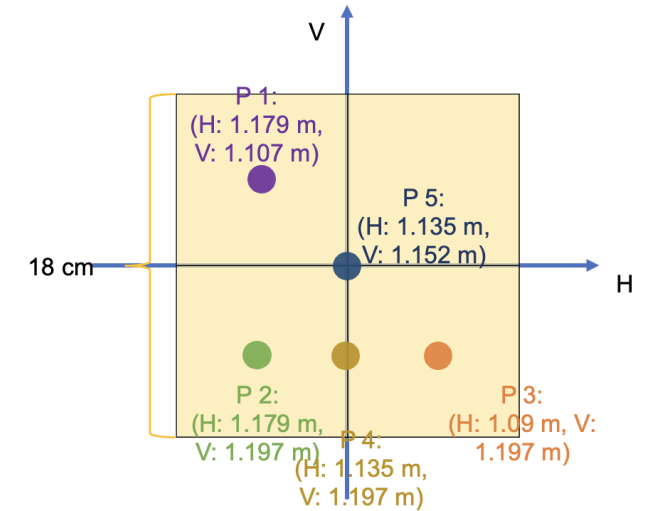


Energy scan

- 7.5 GeV: 1,137,821 (10.96%)
- 10 GeV: 1,031,279 (9.94%)
- 20 GeV: 1,212,870 (11.69%)
- 34 GeV: 1,233,868 (11.89%)
- 52 GeV: 624,947 (6.02%)
- 74 GeV: 4,340,721 (41.82%)
- 99 GeV: 796,591 (7.68%)

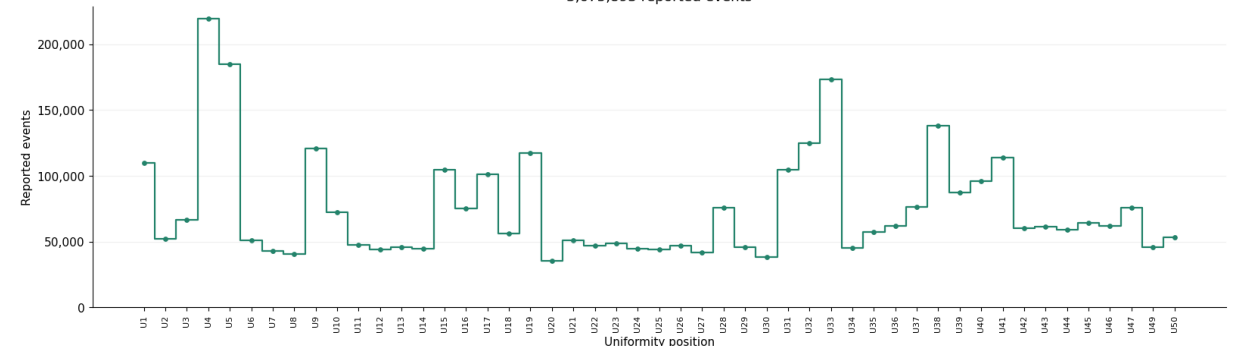
Also: 5, 10, 30 and 45° angle with 7.5, 10, 20, 34, 52 and 74 GeV

Positions used for the energy scan



Uniformity scan 50 positions, 74 GeV

Uniformity with positrons — events by position
3,675,893 reported events



Preliminary results on shower & energy

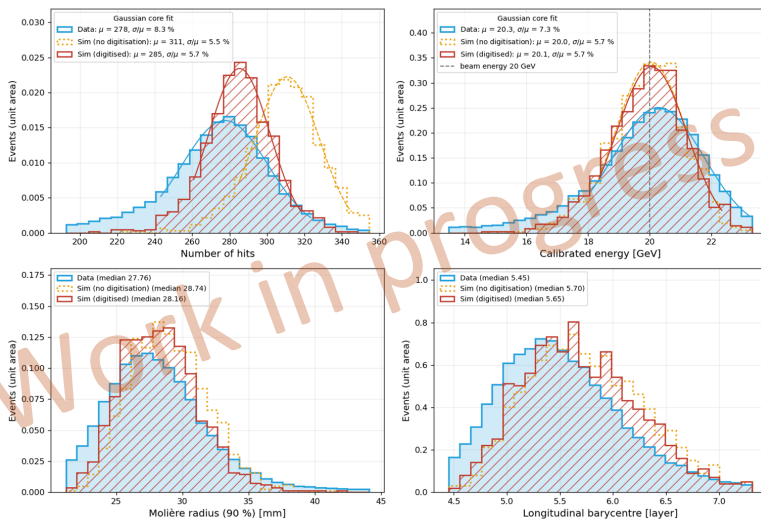
— data
- - - Sim (no digi)
— Sim (digi)

20 GeV

Sim vs data (unfiltered) comparison

74 GeV

20 GeV e^+ , th210, beam at (26, -52) mm — data: eudaq 291; shower-like events, N data / no-digi / digi = 36293 / 1000 / 1000



Almost all variables look very accurate.

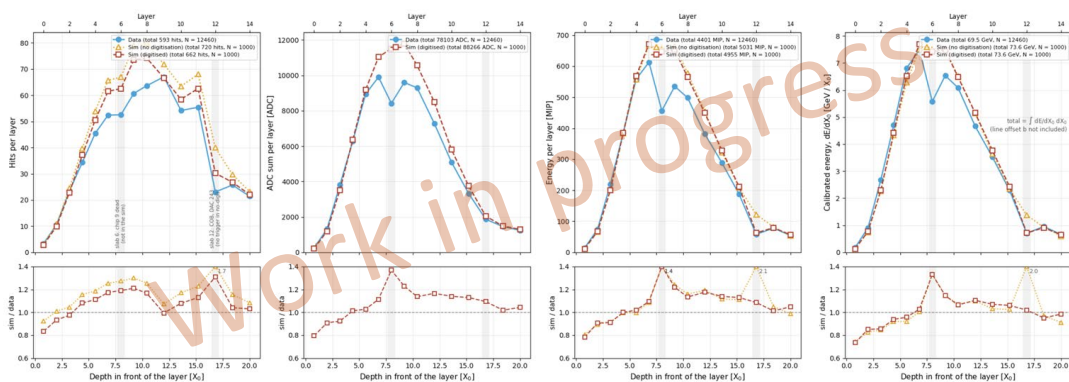
Real shower peaks a bit early and the beam size is bigger than in the simulation.

Saturation and leakage.

Slab 6 needs further look

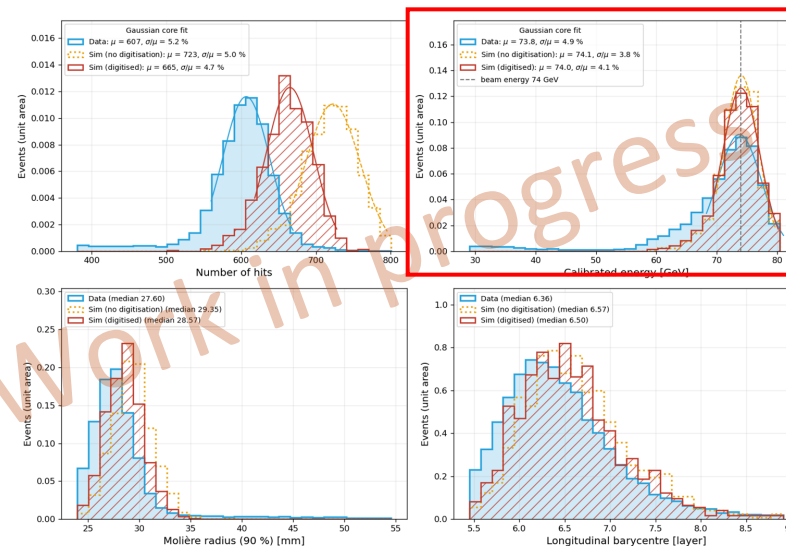
$E_{\text{hit}} \geq 0.5 \text{ MIP}$

Longitudinal profiles, 74 GeV e^+ , th210, beam at (22, -49) mm — data: eudaq 286; shower-like events, hits > 0.5 MIP



J.P. Márquez

74 GeV e^+ , th210, beam at (22, -49) mm — data: eudaq 286; shower-like events, N data / no-digi / digi = 12460 / 1000 / 1000



At $\uparrow$ energies, leakage and π/μ contamination appear.

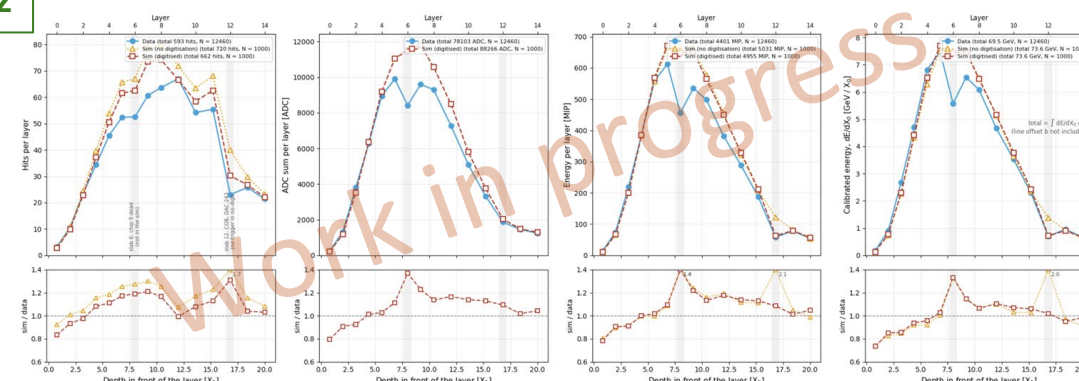
Saturation causes $\downarrow$ hit count (to be corrected).

Saturation and leakage.

Slab 6 $\rightarrow$ further look.

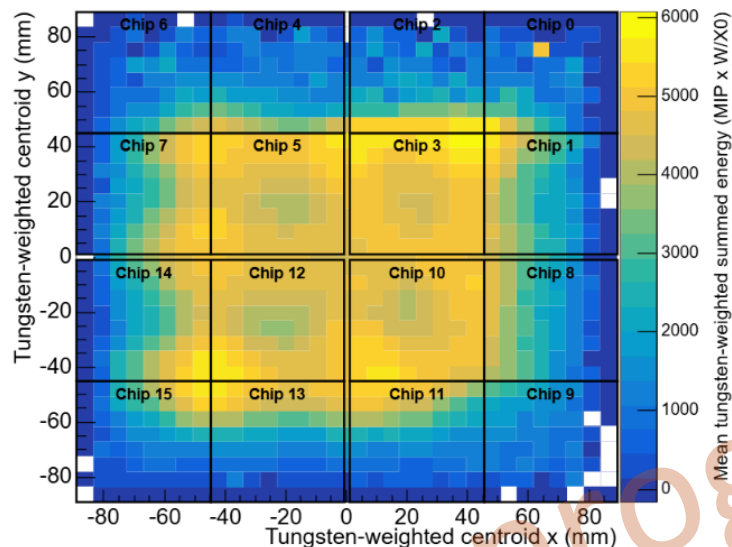
$E_{\text{hit}} \geq 0.5 \text{ MIP}$

Longitudinal profiles, 74 GeV e^+ , th210, beam at (22, -49) mm — data: eudaq 286; shower-like events, hits > 0.5 MIP

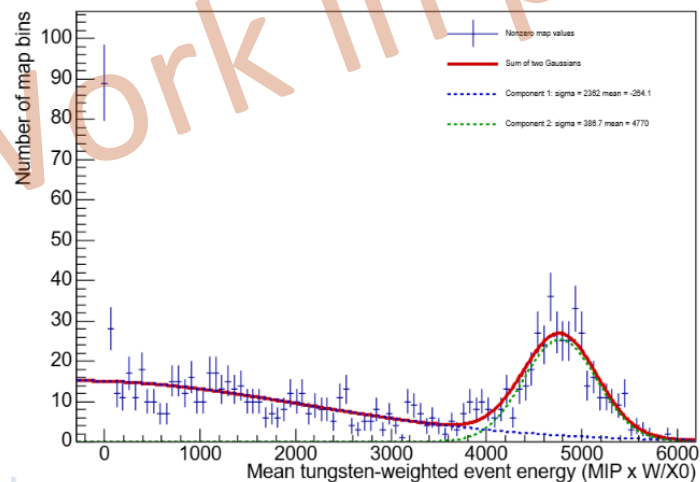


Preliminar uniformity analysis scan

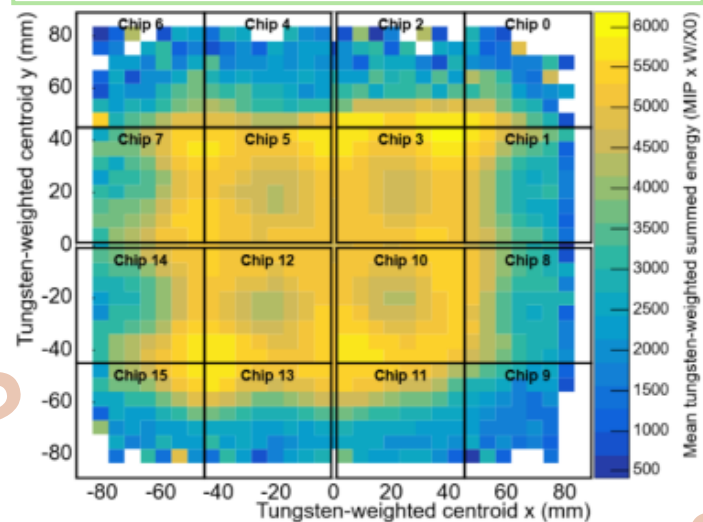
All 55 runs, slabs 0 and 2-13, All events



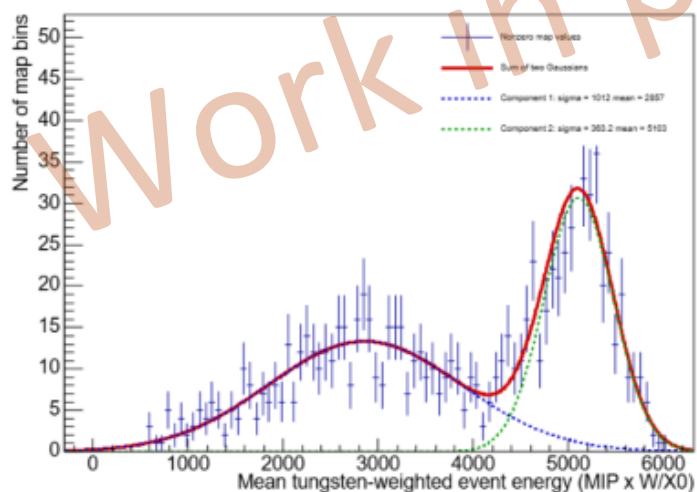
Tungsten-weighted energy, All events, tungsten centroid: two Gaussians, zeros excluded



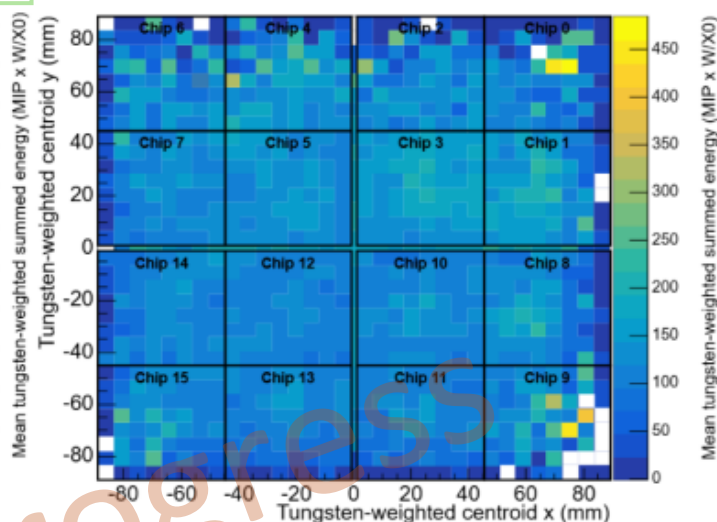
All 55 runs, slabs 0 and 2-13, NHit > 100



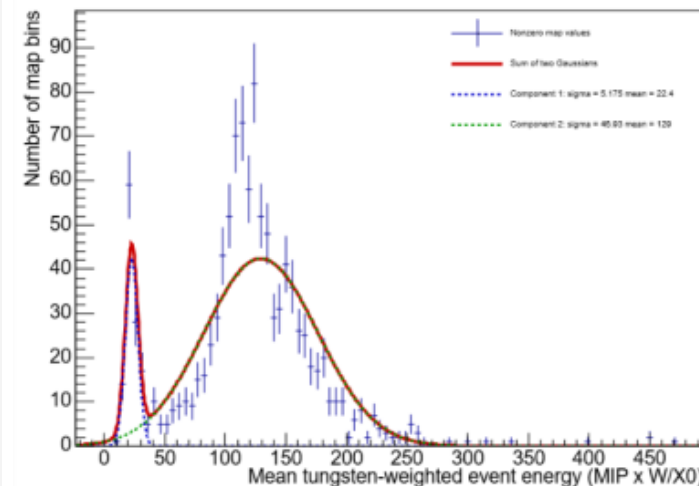
Tungsten-weighted energy, NHit > 100, tungsten centroid: two Gaussians, zeros excluded



All 55 runs, slabs 0 and 2-13, NHit < 100

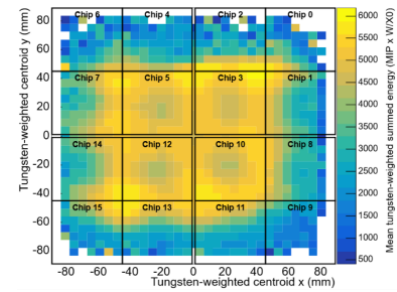


Tungsten-weighted energy, NHit < 100, tungsten centroid: two Gaussians, zeros excluded

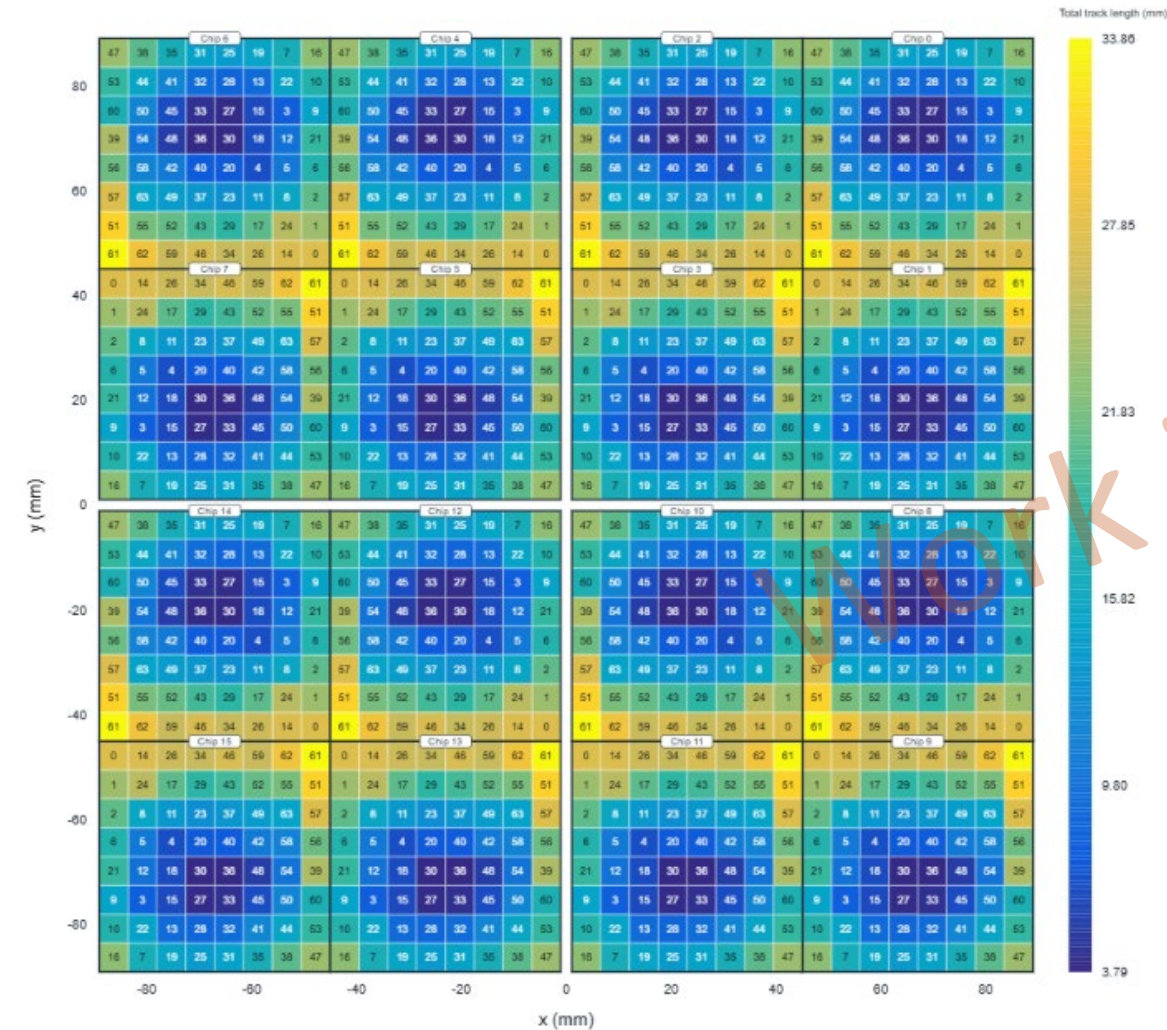


Preliminary uniformity analysis scan

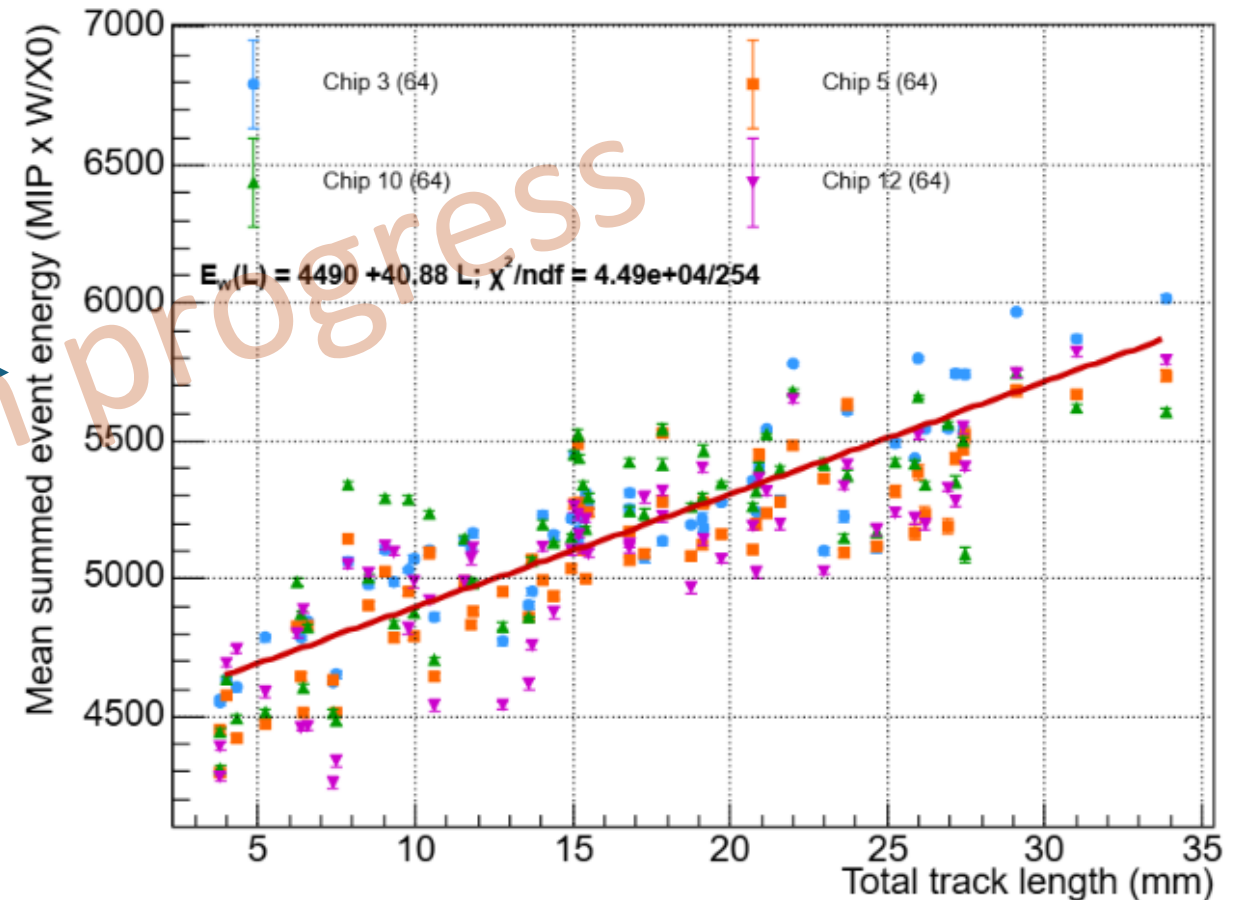
Maybe the track length affects the response??



Total track length at physical channel positions
Labels: channel numbers · Outlines: chips · Shared colour scale: Total track length (mm)



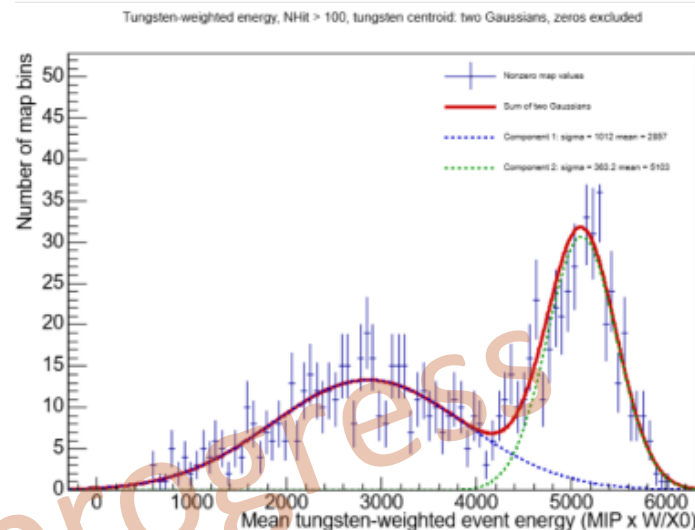
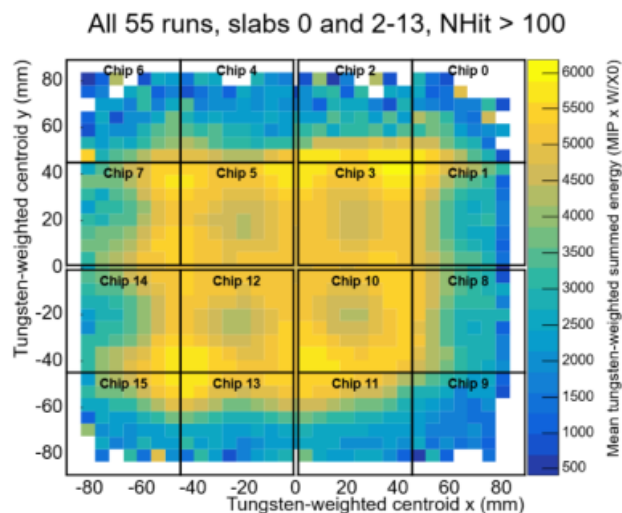
Middle chips 3, 5, 10, 12, 55 runs, NHit > 100



Preliminar uniformity analysis scan

Total track length correction

Before

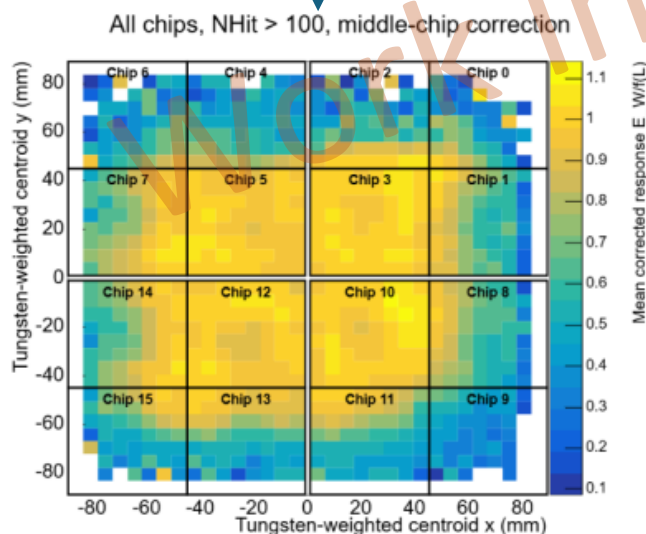


$$E_{\text{corrected}} = \frac{E_u}{a + bL}$$

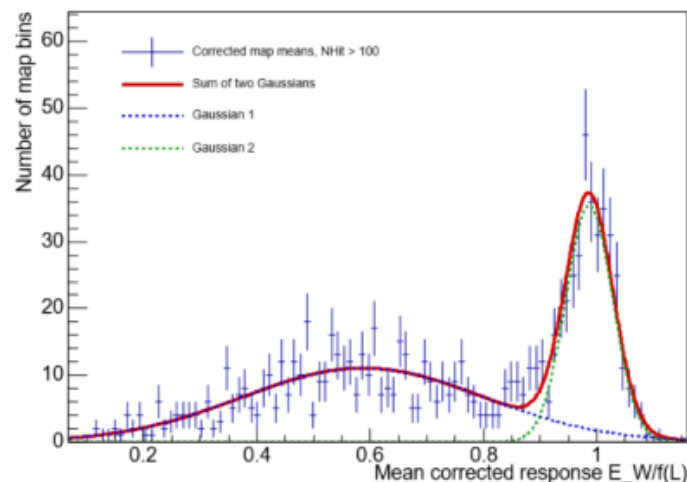
$$\text{Relative width} = \frac{\left(\frac{\sigma_u}{\mu_u}\right) - \left(\frac{\sigma_c}{\mu_c}\right)}{\sigma_u/\mu_u} \times 100$$

33.16% relative width reduction

After



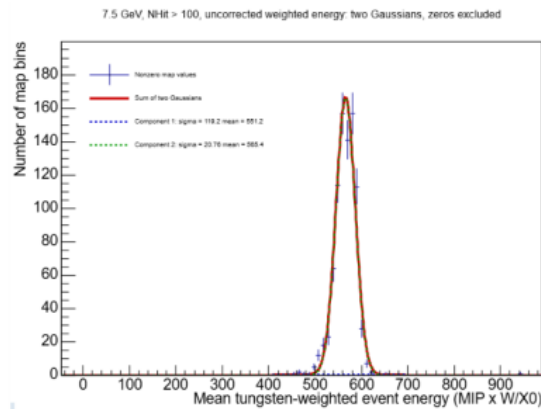
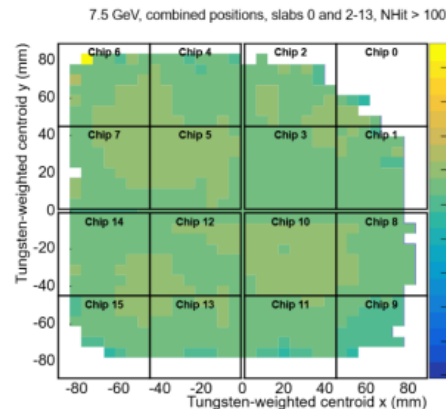
Corrected map response, NHit > 100



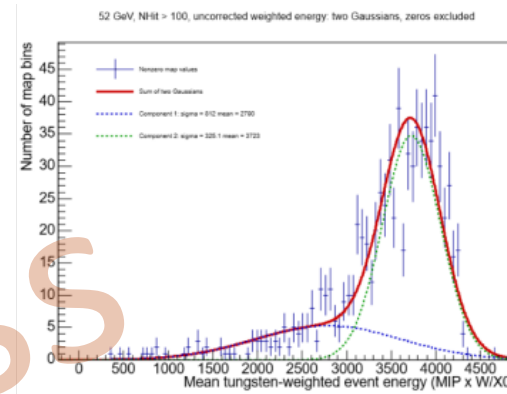
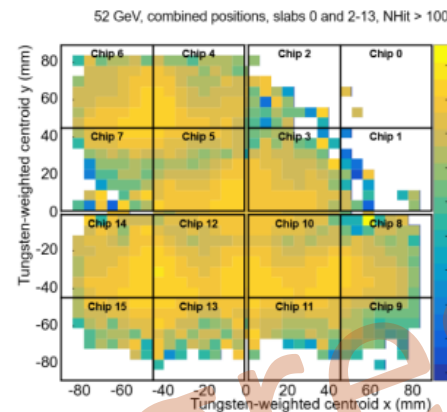
Next: do the same with the energy scan runs

Preliminar uniformity analysis scan

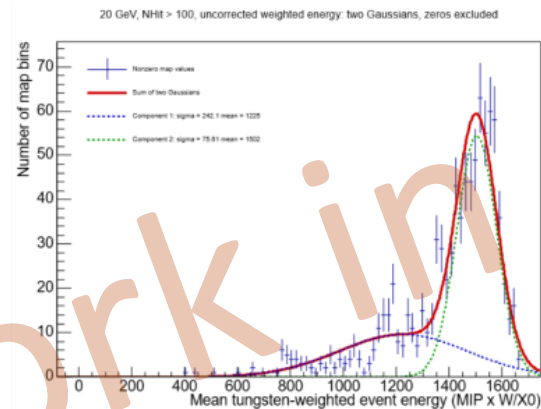
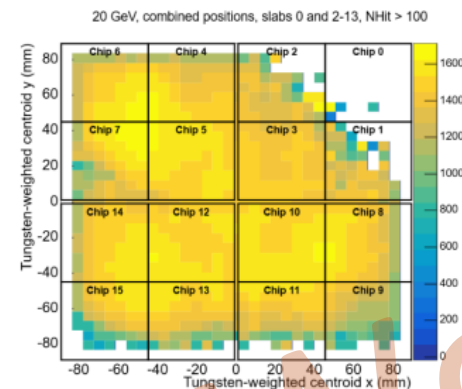
7.5 GeV



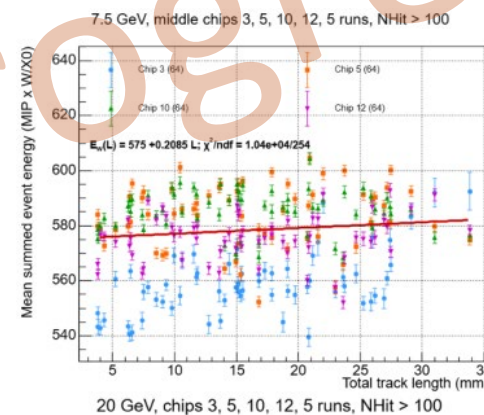
52 GeV



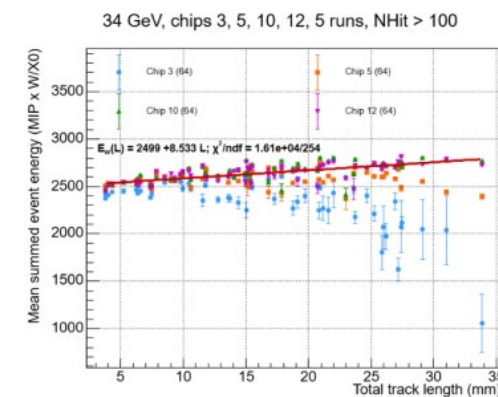
20 GeV



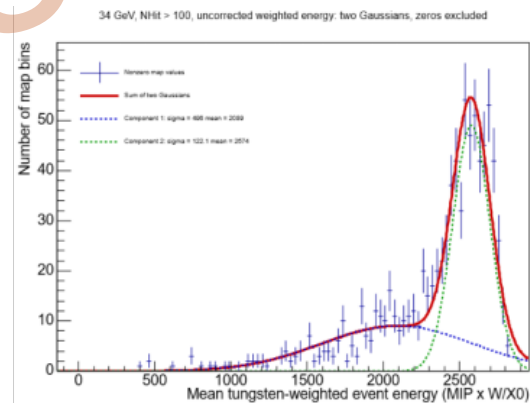
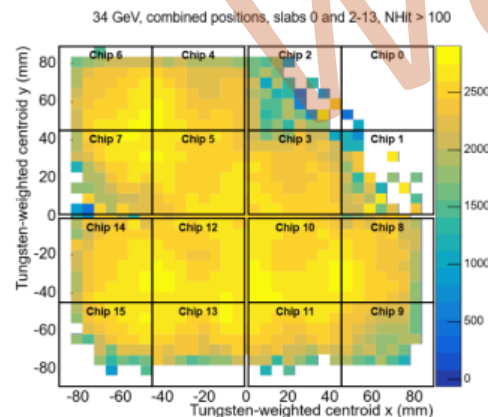
7.5 GeV



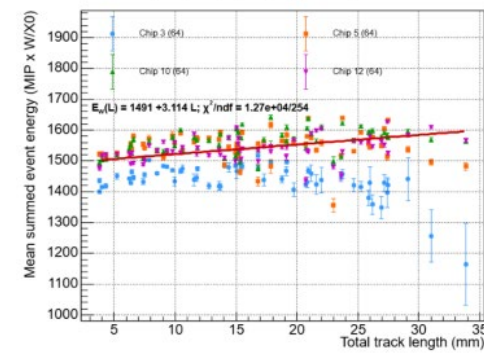
34 GeV



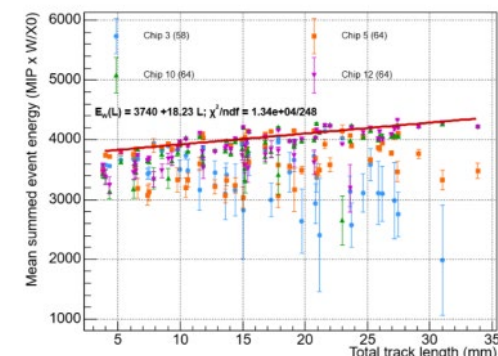
34 GeV



20 GeV



52 GeV

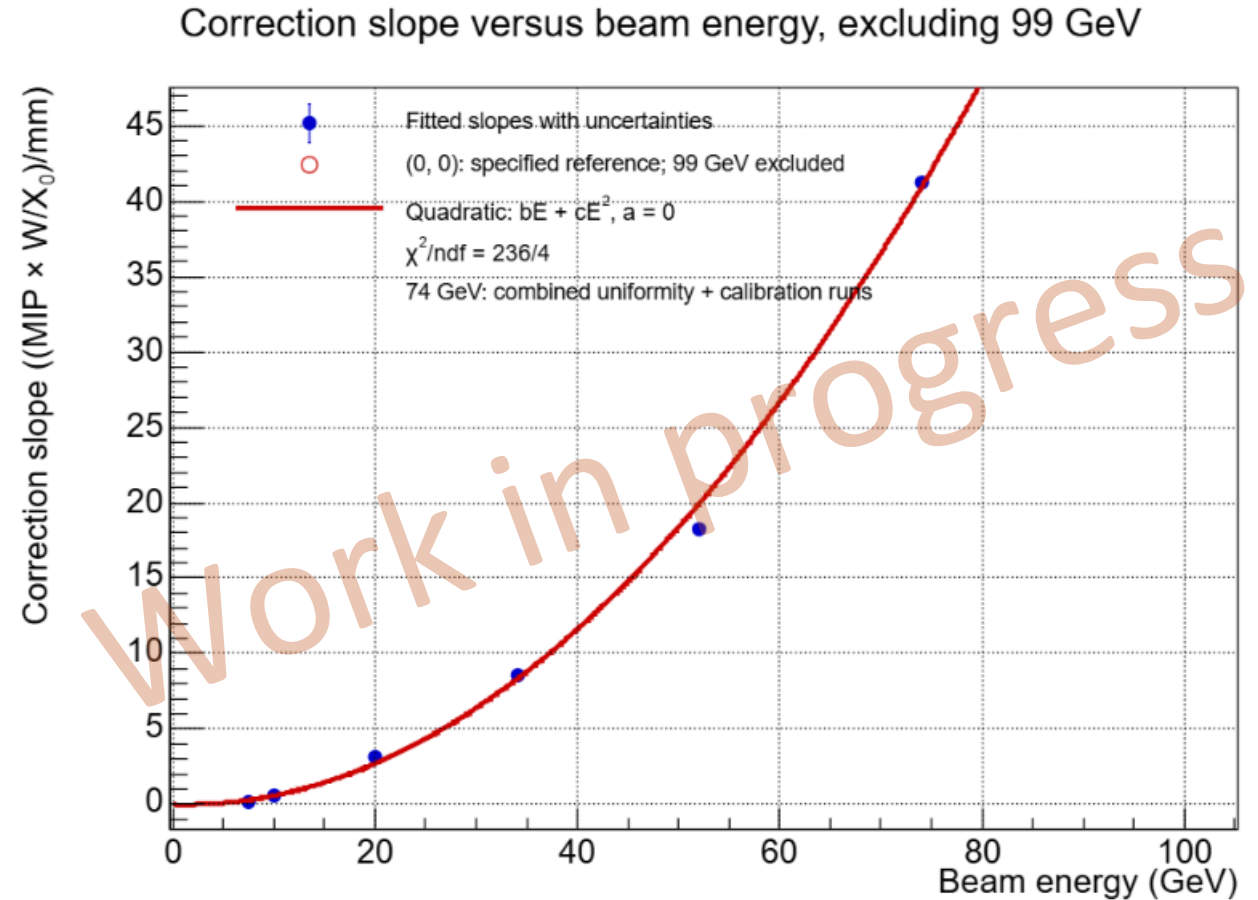


Preliminar uniformity analysis scan

Energy (GeV)	Relative width reduction (%)
7.5	4.17
10	8.34
20	14.77
34	34.96
52	17.83
74	33.16

Considering the fits done to all the energies

Idea: plot the slope as a function of the energy



Now? Why does it behave like that?

TBD: Do we get cross-talk from shield planes connected to V_{PA} ?

The total charge in the ASIC:

$$Q_A = \sum Q_i$$

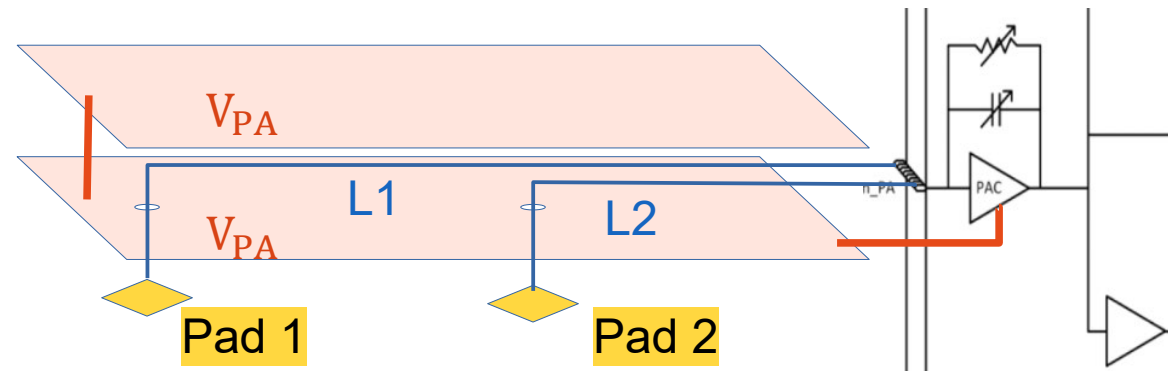
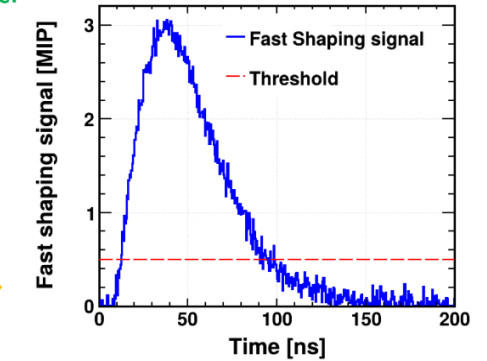
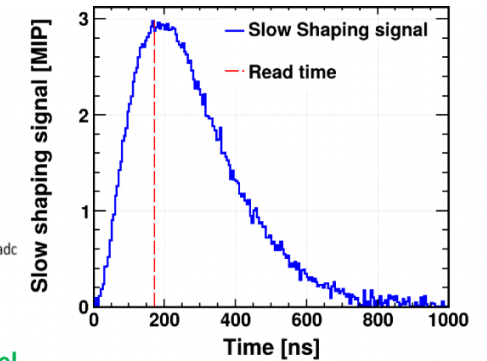
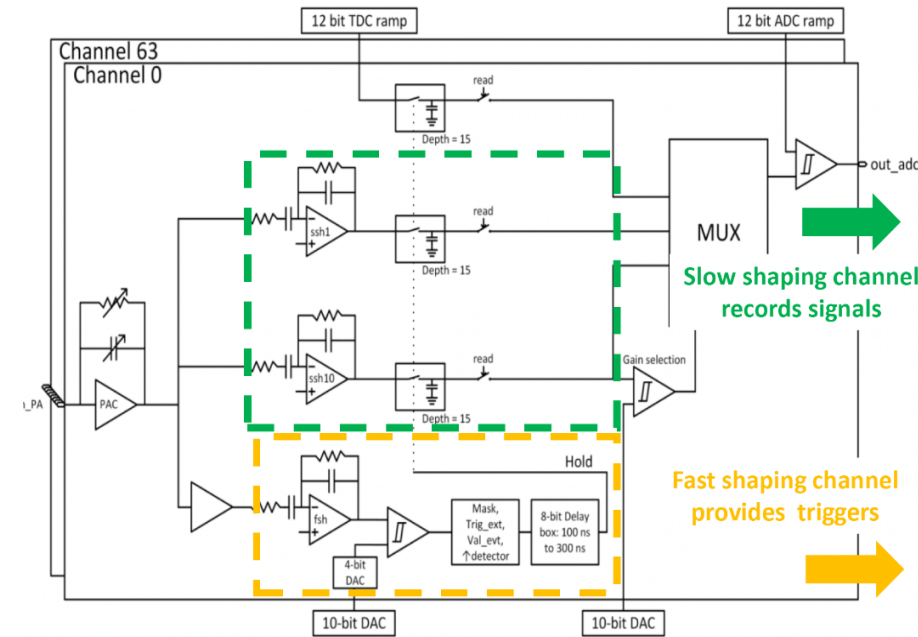
might induce a linear voltage variation ΔV_{PA} in the shield planes, generating cross-talk $\propto$ to the channels length (L_i)

$$\Rightarrow \Delta Q_i = \alpha(\sum Q_i \times L_i)$$

+ second order if α is sizable

V. Boudry

SKIROC chips



Conclusions

- Very successful Beam-Test taken at CERN, June 2026
- No definitive results yet, but work in progress looks good!
- Uniformity scan in progress, electronic components seem to affect the response
- Many people working on getting definitive results

To be done on the uniformity analysis:

- Check for the cross talk effect
- Include an event filtering

Thank you for listening! :D