Shower modelling with TB data and Commissioning data from the SiW ECAL prototype

Fabricio Jiménez, on behalf of the SiW ECAL groups

Calice Collaboration Meeting
September 29th, 2020

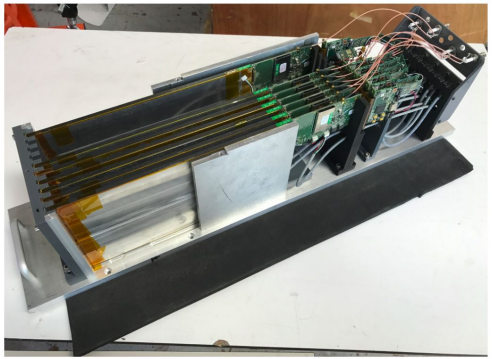
Outline

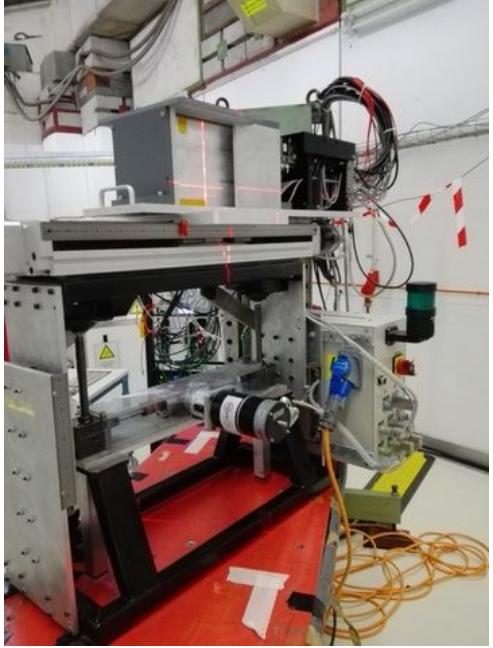
1. **Modelling showers - Test Beam data from the 2017 SiW-ECAL prototype**
- Data set from the 2017 Test Beam
- Selection of events and cell hits for modelling electromagnetic showers
- Shower modelling

2. **A look on “cosmics” data for the new prototype**
- The prototype
- Pedestals and MIP data

Modelling showers - Test Beam data from the 2017 SiW-ECAL prototype

Data used*





- Scans of various energies: 1, 2, 3, 4, 5, 5.8 GeV.
- Different W configurations with varying amounts of W in front of each slab:
  - W-configuration 1: 0.6, 1.2, 1.8, 2.4, 3.6, 4.8 and 6.6 X_0
  - W-configuration 2: 1.2, 1.8, 2.4, 3.6, 4.8, 6.6 and 8.4 X_0
  - W-configuration 3: 1.8, 2.4, 3.6, 4.8, 6.6, 8.4 and 10.2 X_0
- Energy calibrated to mips

→ **The goal is to use the data collected from positron beams to model EM shower profiles**

* Located in TB2017-06/DESY/ConvertedData/pass3/Tungsten/**conf{1,2,3}**/grid20/**{1, 2, 3, 4, 5, 5.8}**GeV_build.root

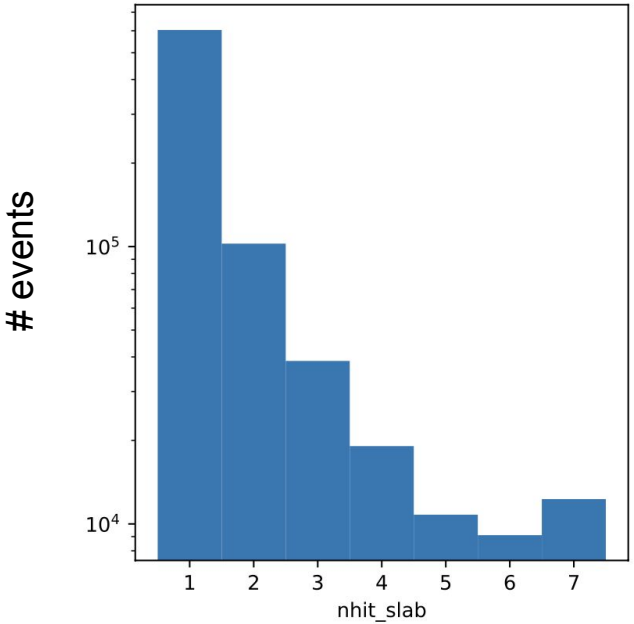
Global selection of events

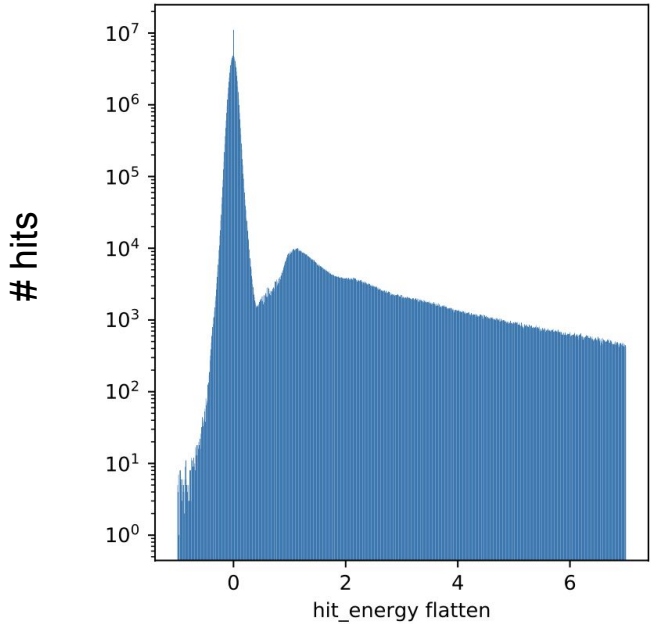
Use two criteria: **1. Slabs hit by the shower** **and** **2. Energy of hits in cells**

Example:
Configuration 2 @ 2 GeV

Require:

- **At least 5 slabs hit**
- **μ+6σ on ped gaussian fit**
- **“Central” slabs hit**





Shower model

Model the longitudinal and transversal energy profiles of showers

Transversal (per-layer) model

Double gaussian (6 parameters)
shared mean, no correlation (ρ1 = ρ2 = 0)
σ1 < σ2

$$A(f\mathcal{N}(\boldsymbol{\mu}, \mathbb{1}\sigma_1) + (1-f)\mathcal{N}(\boldsymbol{\mu}, \mathbb{1}\sigma_2))$$

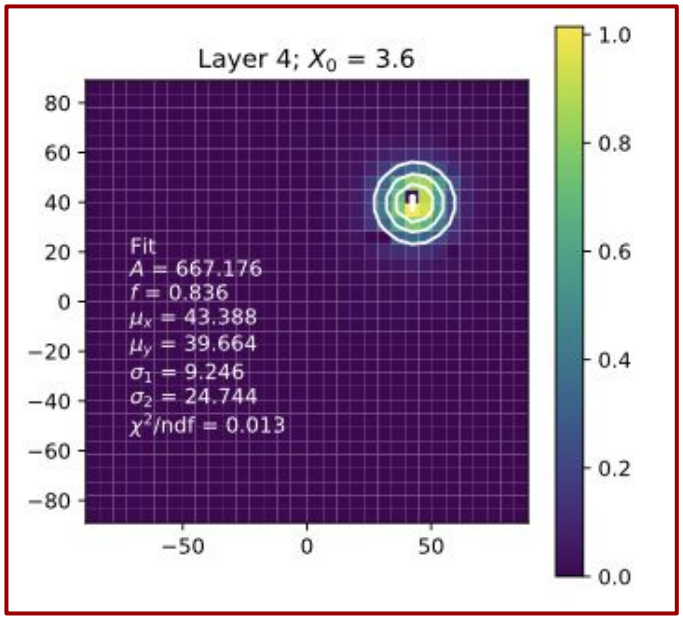
Longitudinal

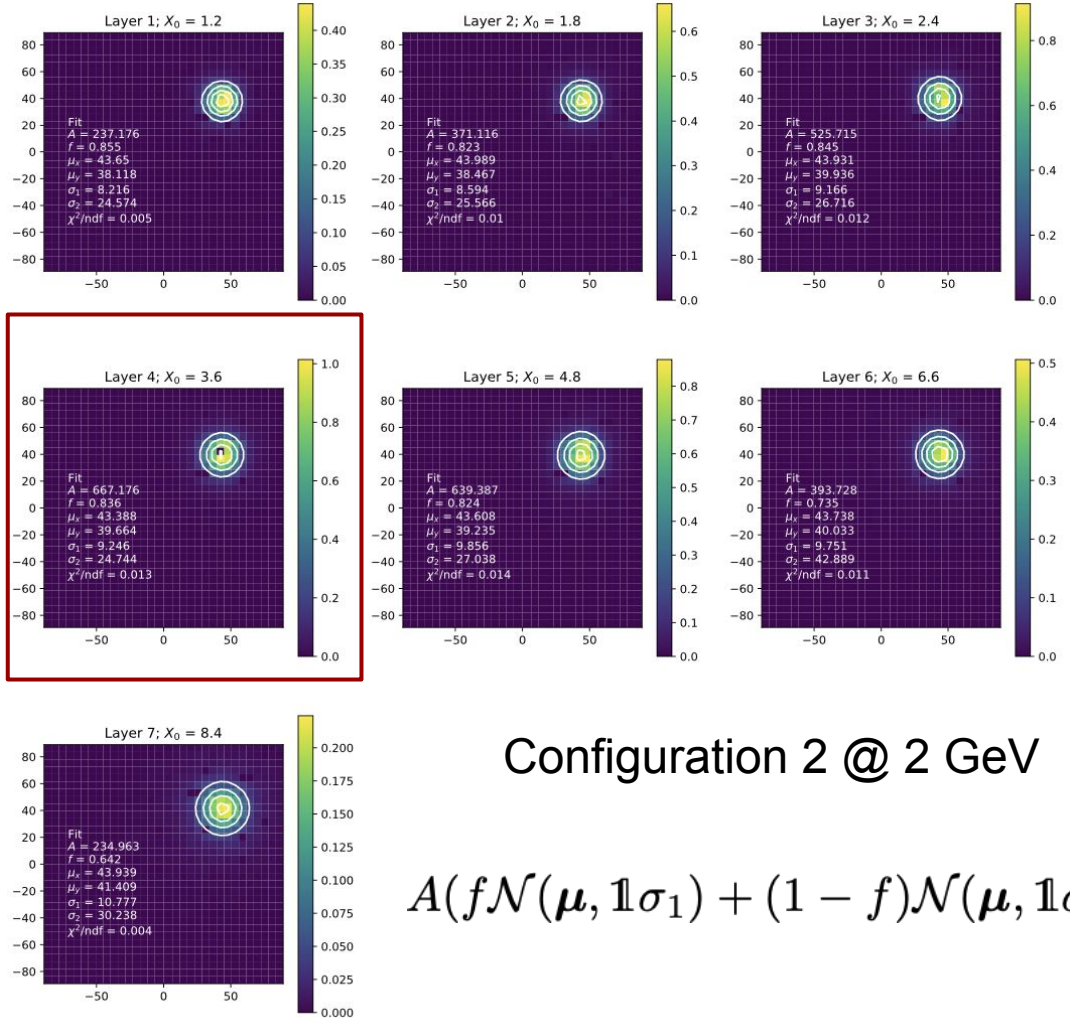
$$\frac{dE}{dt} = E_0\, b\, \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$

- Fit the longitudinal and transversal parts separately
- Fit the longitudinal part using integral of double gaussian as prompt for E per layer

Transversal fits

Fit on each layer the double gaussian model





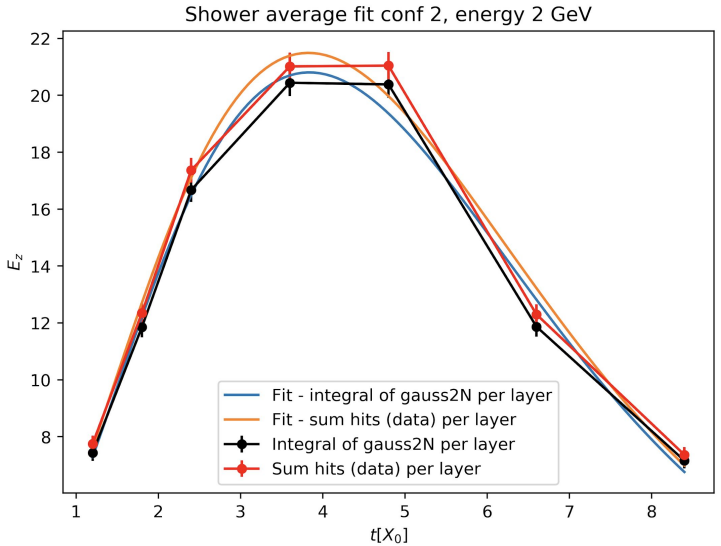
Configuration 2 @ 2 GeV

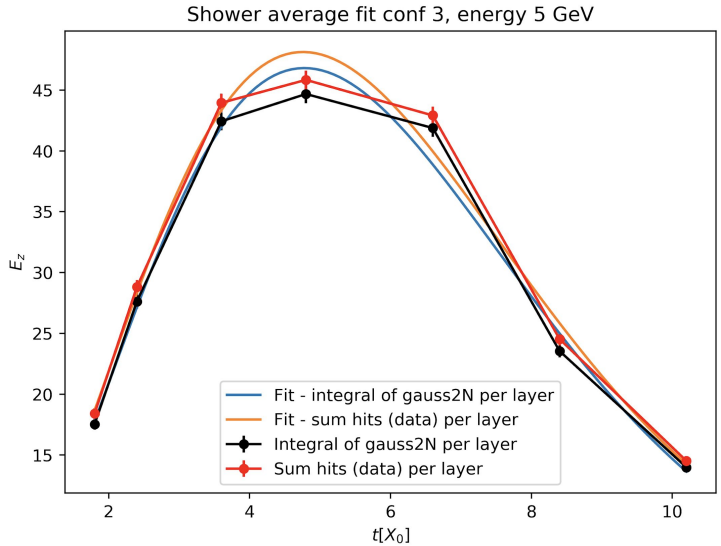
$$A(f\mathcal{N}(\boldsymbol{\mu}, \mathbb{1}\sigma_1) + (1-f)\mathcal{N}(\boldsymbol{\mu}, \mathbb{1}\sigma_2))$$

Deficit in longitudinal profile

Require “central” slabs hit by shower

$$\frac{dE}{dt} = E_0\, b\, \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$





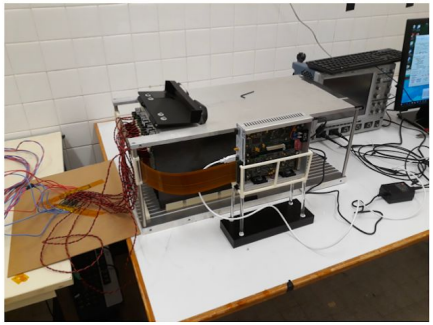
Overview on shower modelling on 2017 TB data

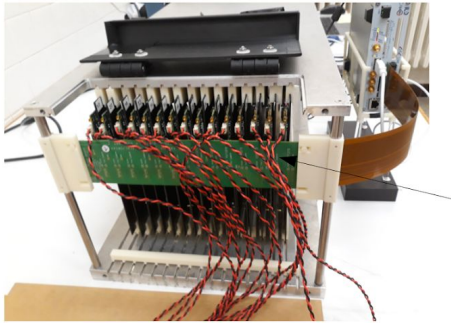
- First attempt at fitting shower shapes on SiW-ECAL data (7 layers)
  - Might help handle masked cells
  - Still some issues with calibration mip→shower ?
    - To be x-checked
  - Software being developed
- To Do’s
  - Robustness against noise cuts
  - Robustness of method to be assessed on simulation data
  - Adapt to individual showers
    - Check beam profile
  - Use integrated (over cell surface) functions
    - Try various lateral shower profiles
  - Complete with full 3D profiles

A look on commissioning data for the new prototype

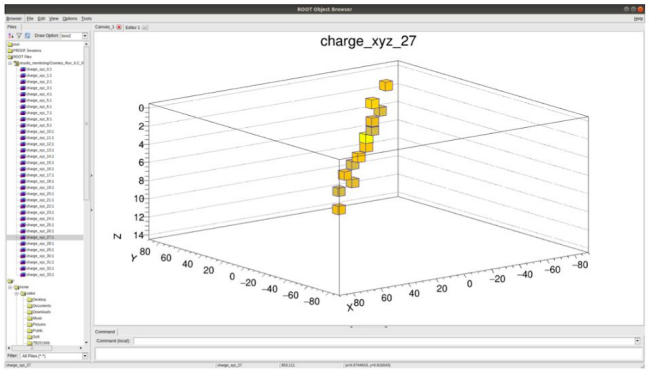
Beginning of June ...

Running with 15 layers with 15360 channels (of which 13824 equipped with wafers !!!!)





First cosmic (Adrian Irles)



- Already now a major breakthrough for the project
  - (Towards) the culmination of 10 years of work on Technological prototype
- Real size digital readout gives realistic impression of density at extremities of Ecal layers
- Revision and scrutinisation of setup
  - This talk

Slide from Roman's talk yesterday

Taking data with the prototype

A commissioning procedure has been put in place by Adrián (see Roman's talk yesterday)

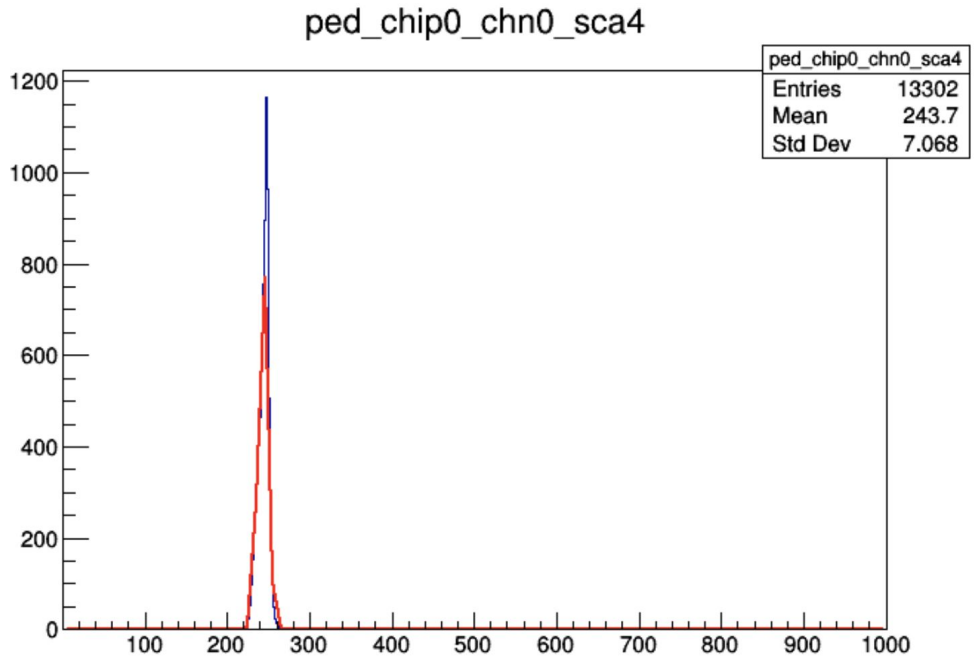
Preliminary data taken to put in place a system for pedestal and MIP studies

I will show below some aspects of the data taken:

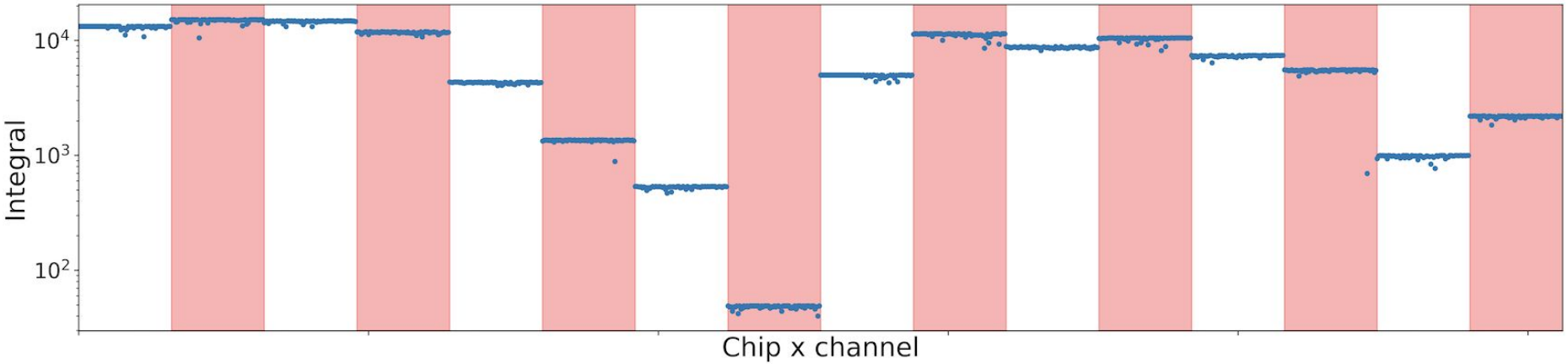
- Acquisition time: 48h
- Configuration for cosmics
- 14 boards connected

Example pedestal

We have that for each SCA (15), channel (64), chip (16) and board (15) → 230k

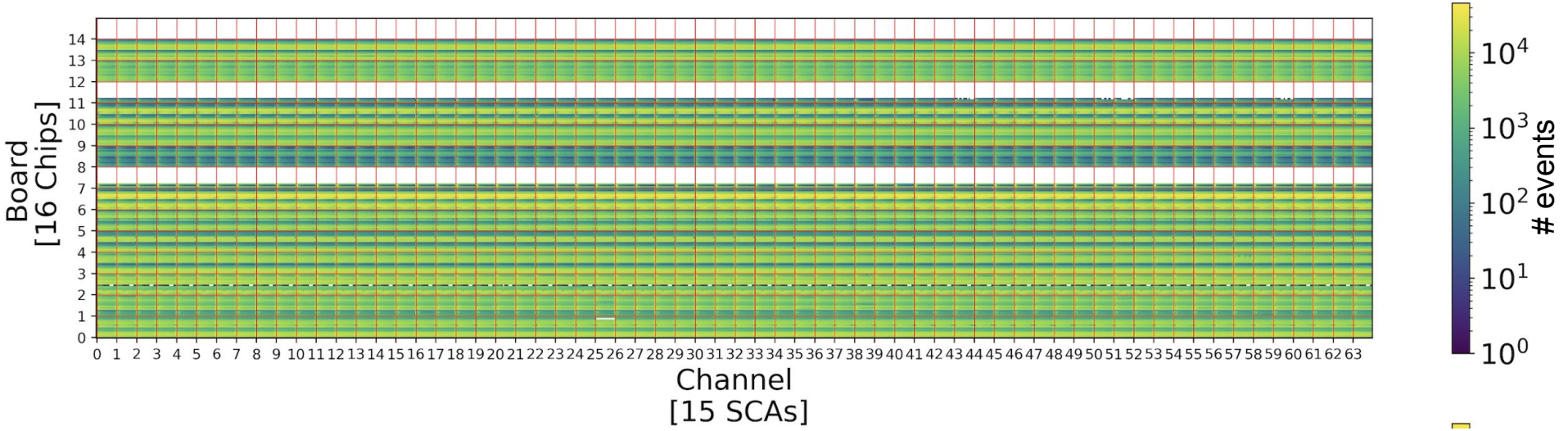


Summarize pedestal (board 4, SCA 5)

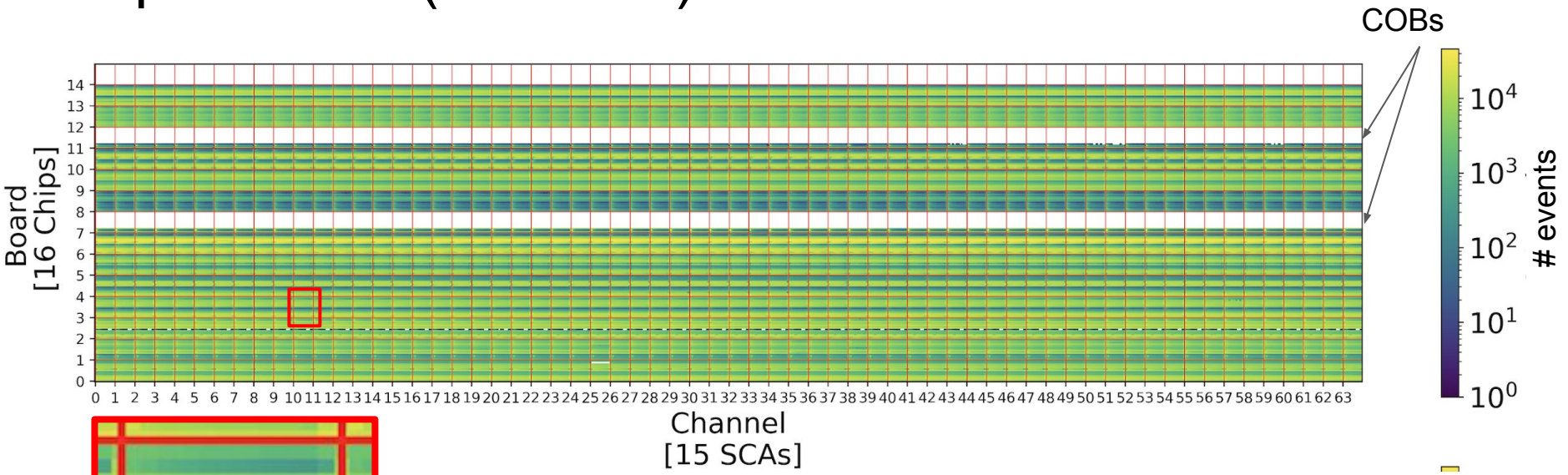


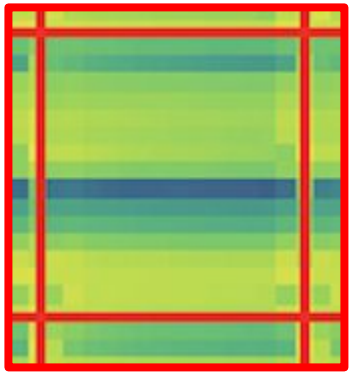
→ Same can be done for mean, RMS of pedestal histogram (backup)

All pedestals (number of events)



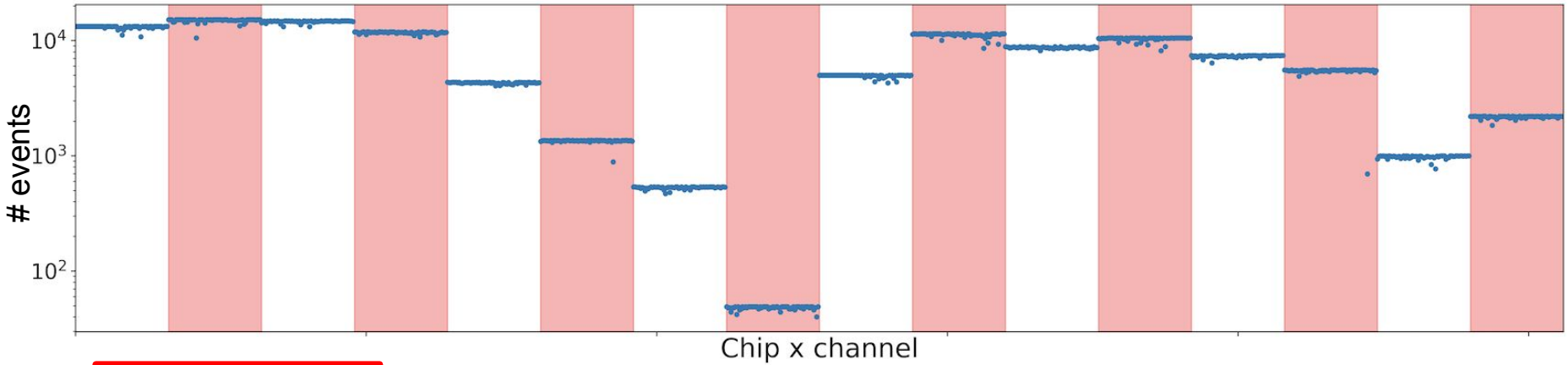
All pedestals (# events)

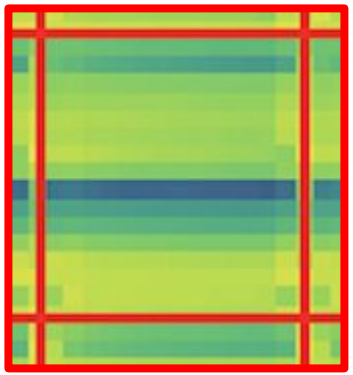




Typically channels present this two-partition pattern

Example for board 4, SCA 5

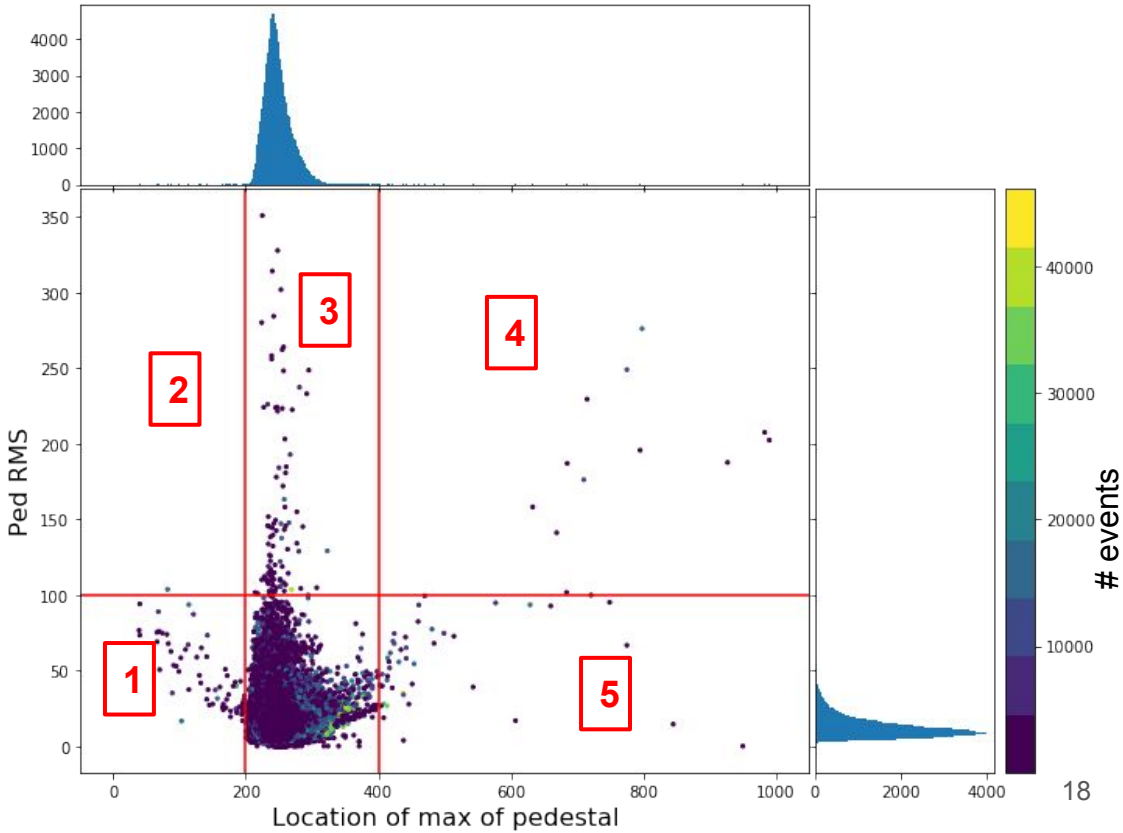




Usually chips 6-7-8 and 14-15-16 present a dip

Pedestal RMS and max location

Ped extreme “outliers” in 1+2+3+4+5
→ 230 peds (0.12%)



Pedestal RMS and max location

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In a stricter sense, ped gone wrong has:

- **RMS > 10**
- **Max location ∉ (200, 300)**
- **Noisy → #counts > 1000?**

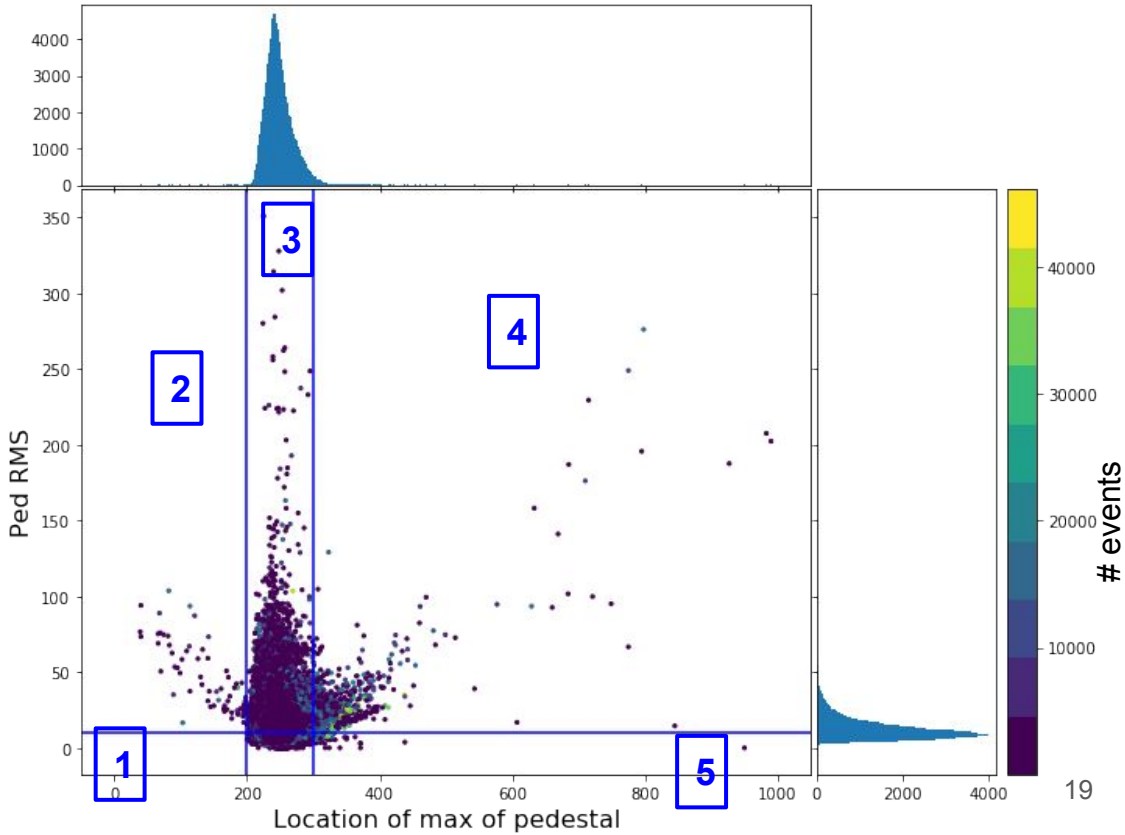
In 1+2+3+4+5: 83119 peds (~44%)

Most of what we see so far is noise

→ Retake data:

Patch pannel

Longer acquisition



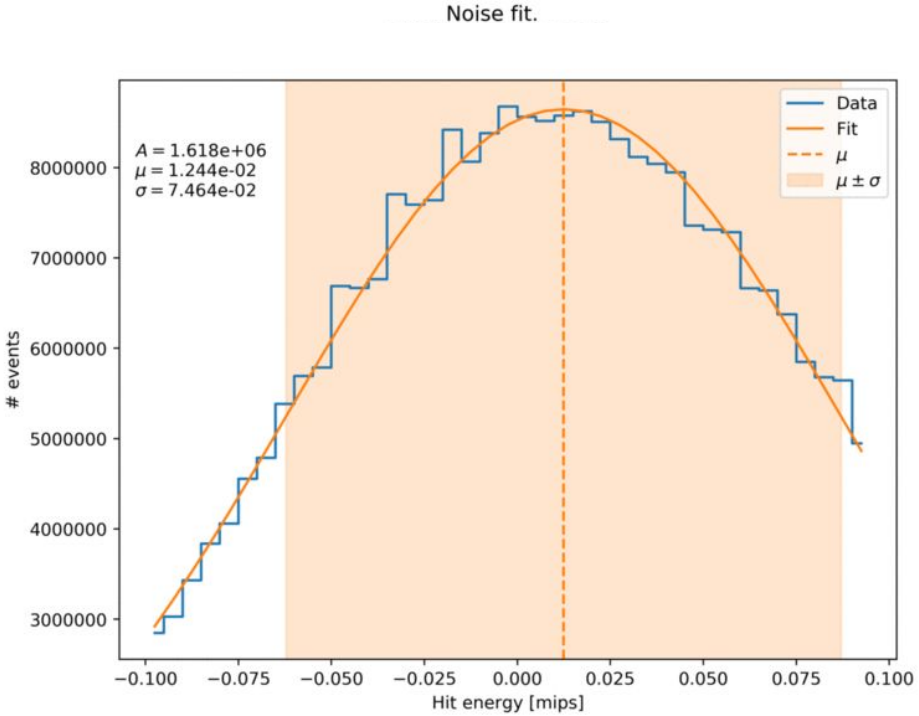
To be done

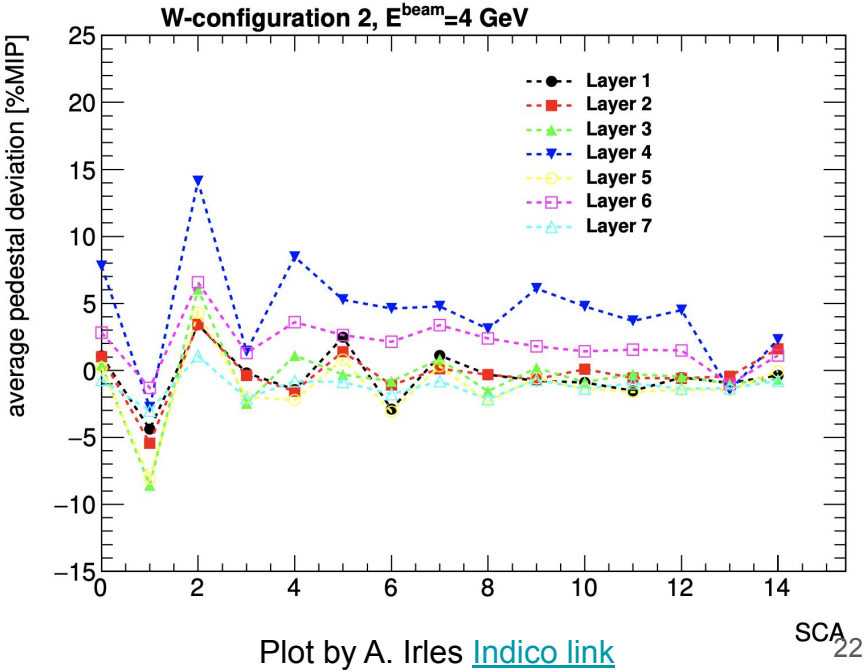
- Data shown mostly noise at the moment
  - Building events / check timing
  - Fit Pedestals and MIPs
- Longer data taking
- Do similar checks on testbench data taken at LLR
- Cosmics trace reconstruction

Backup

Pedestal instability

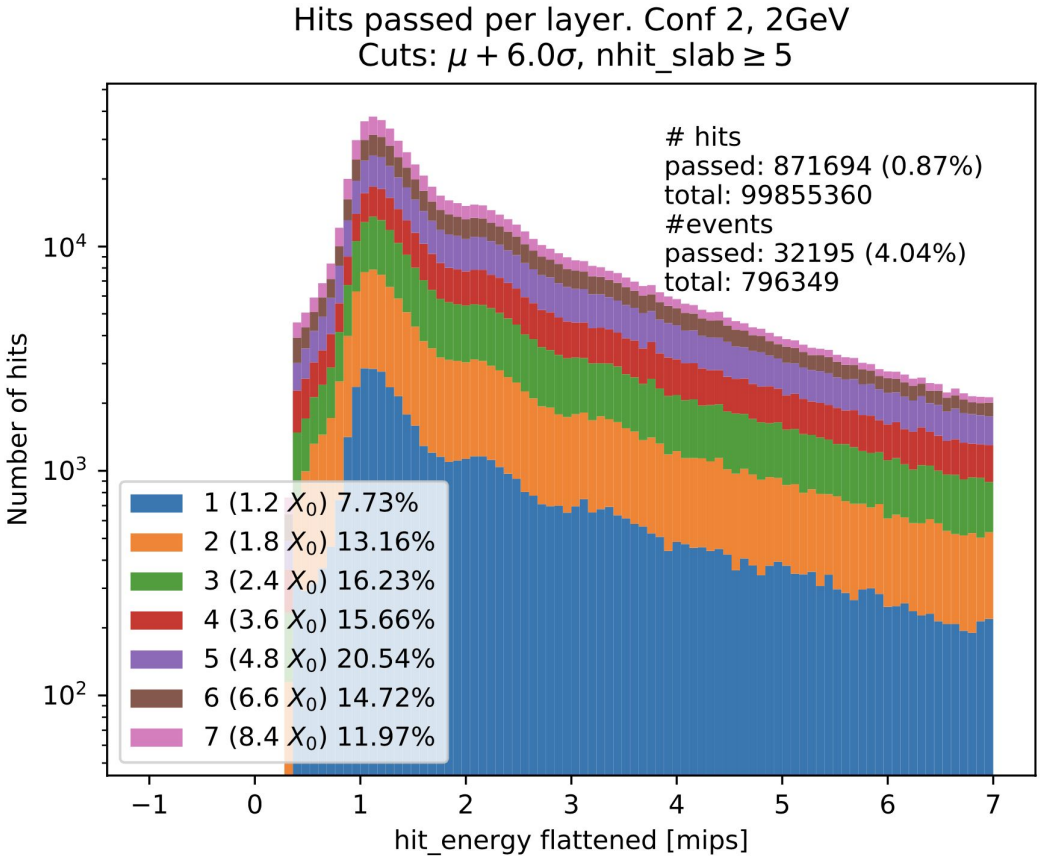
Pedestal is different for each conf/energy (left) and across SCAs (right)



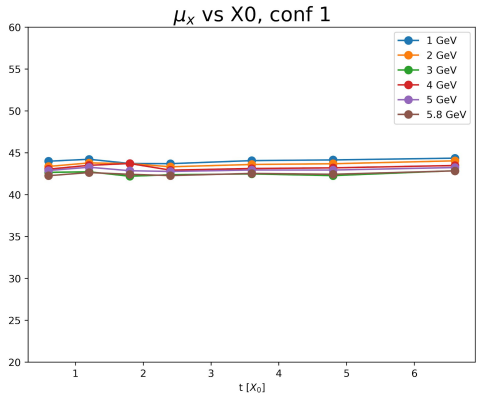


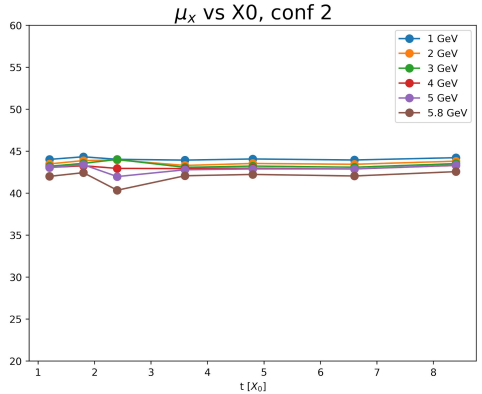
Plot by A. Irles [Indico link]

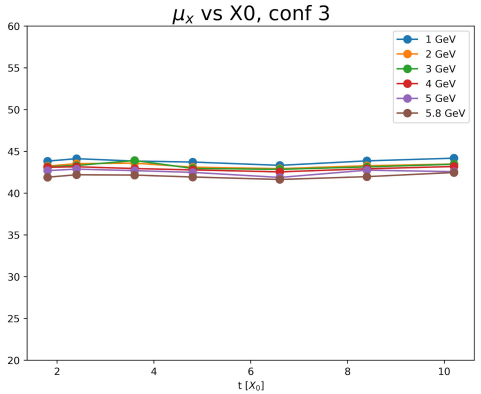
After selection

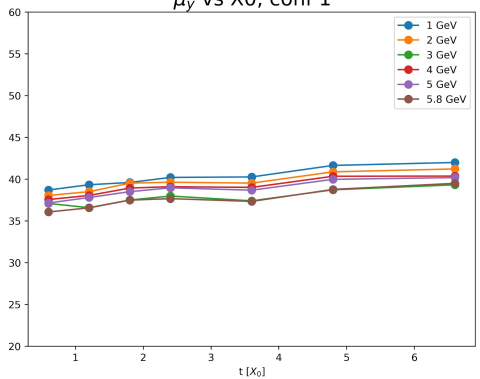


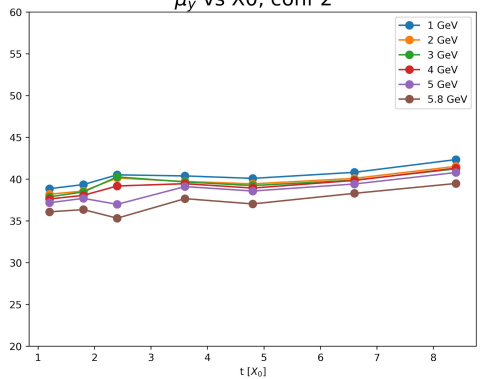
Evolution of mean x (top) and mean y (bottom)

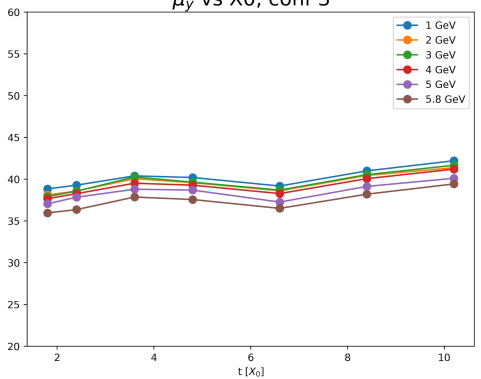




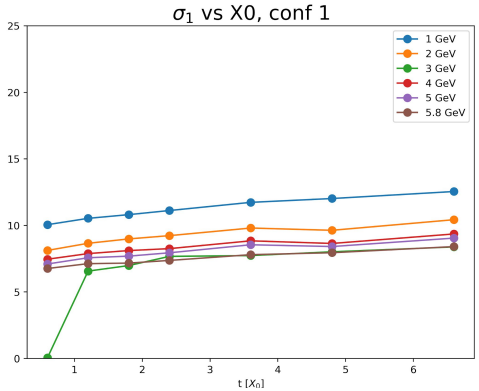


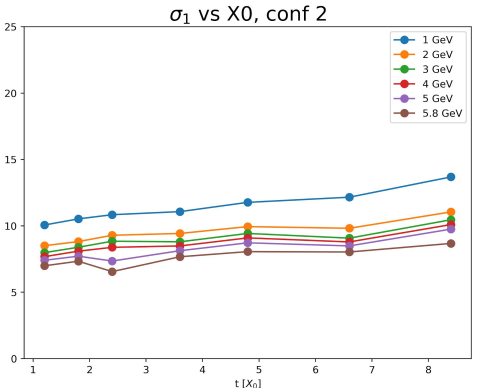


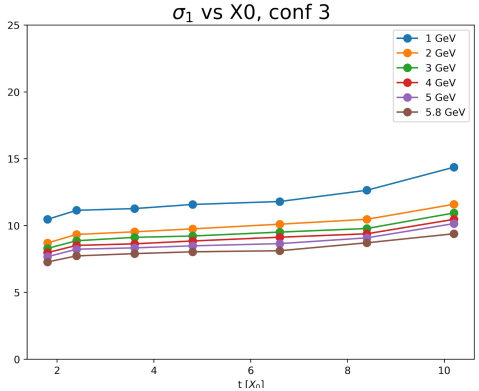


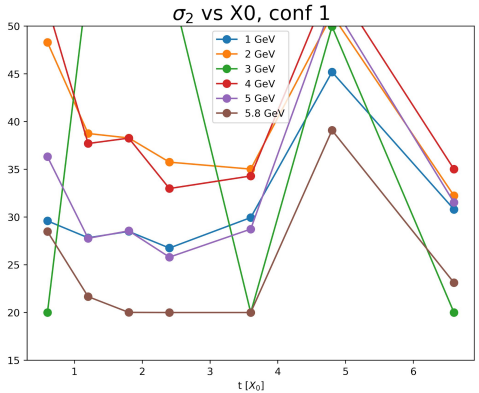


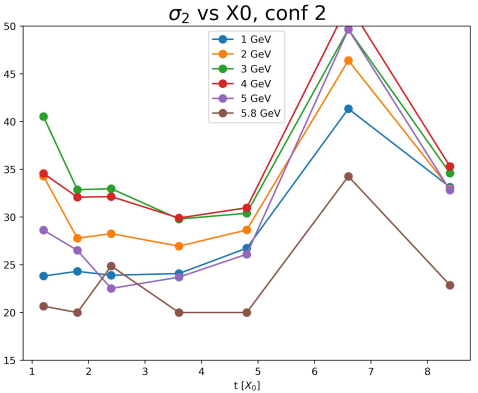
Evolution of sigma 1 (top) and sigma 2 (bottom)

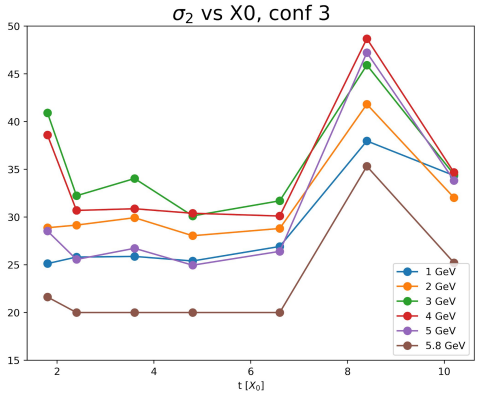






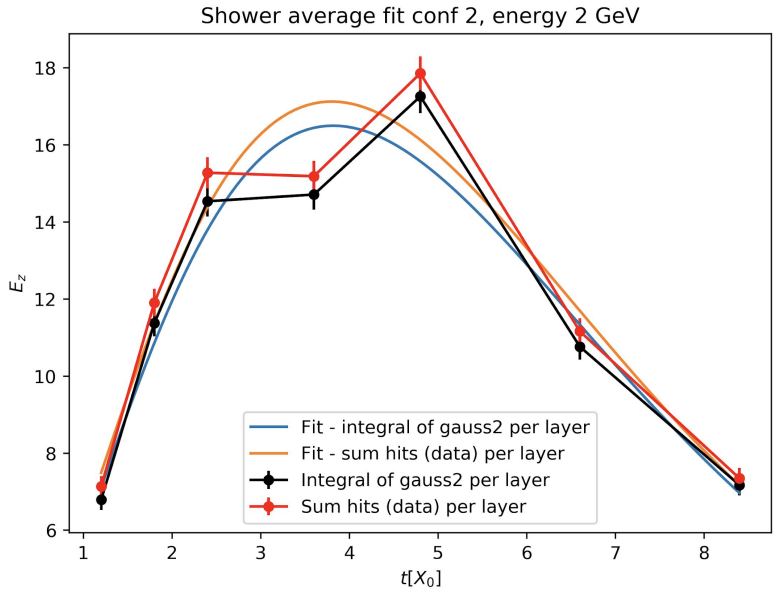






Longitudinal fits

$$\frac{dE}{dt} = E_0\, b\, \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$



- Black dots come from integrating the model on each layer (prev. slide)
- Red dots are the sum of hit energies
- Solid lines are respective fits

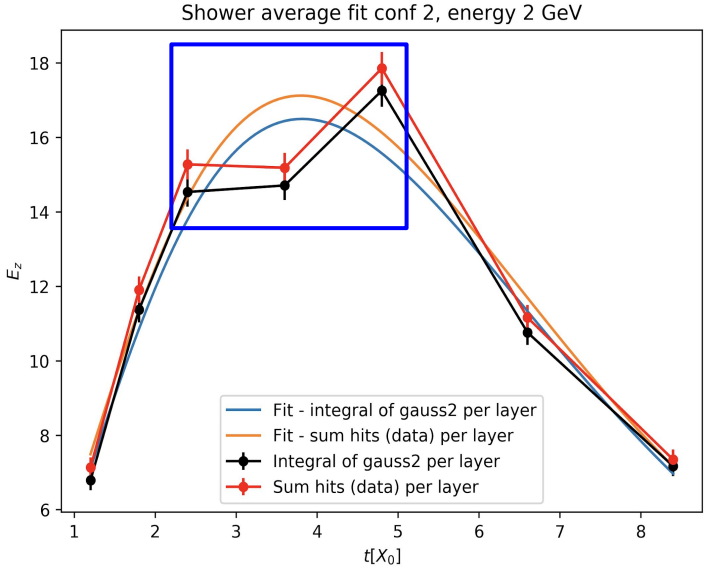
→ The integral of the model slightly underestimates the integral of hit energies

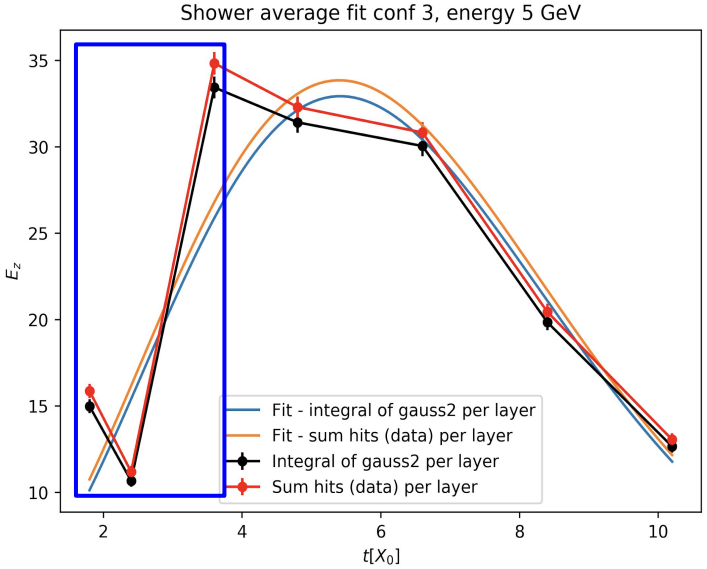
→ Function fit better than 4th layer deficit?

Deficit in longitudinal profile

Deficit may be due to overload

- **Before:**
  - **nhit_slab >= 5**
  - **hit_E > μ+6σ of pedestal gauss fit**
- Improve by selecting “central” slabs (next slide)





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- Before:
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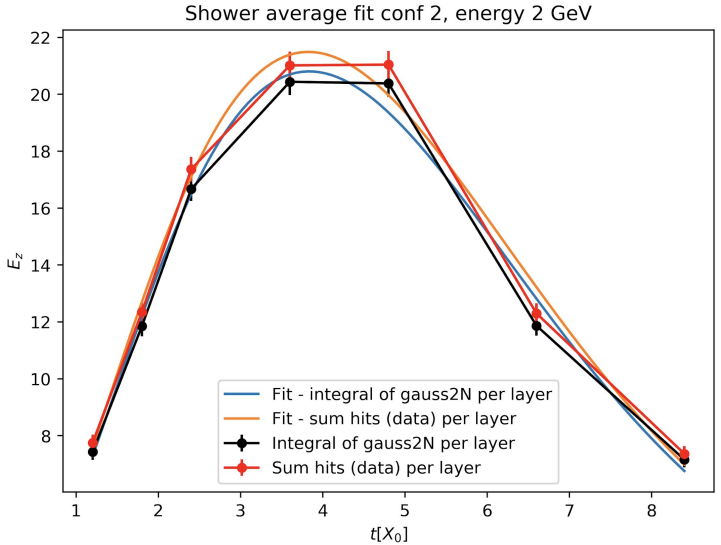
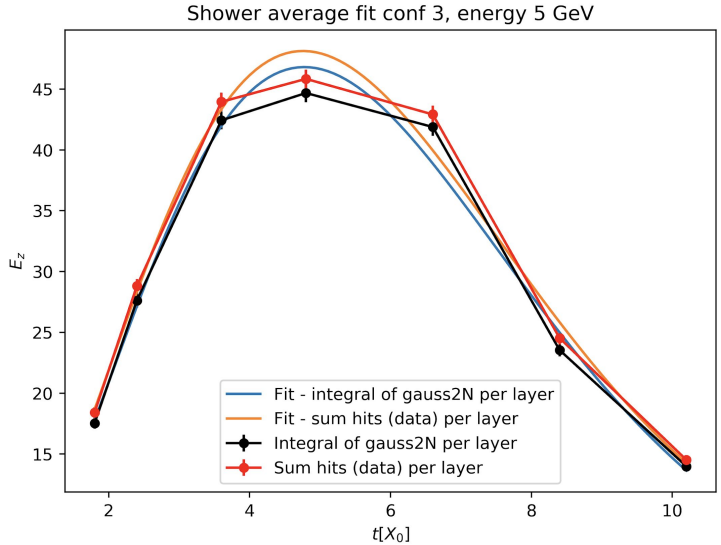
- **Improve by selecting “central” slabs**

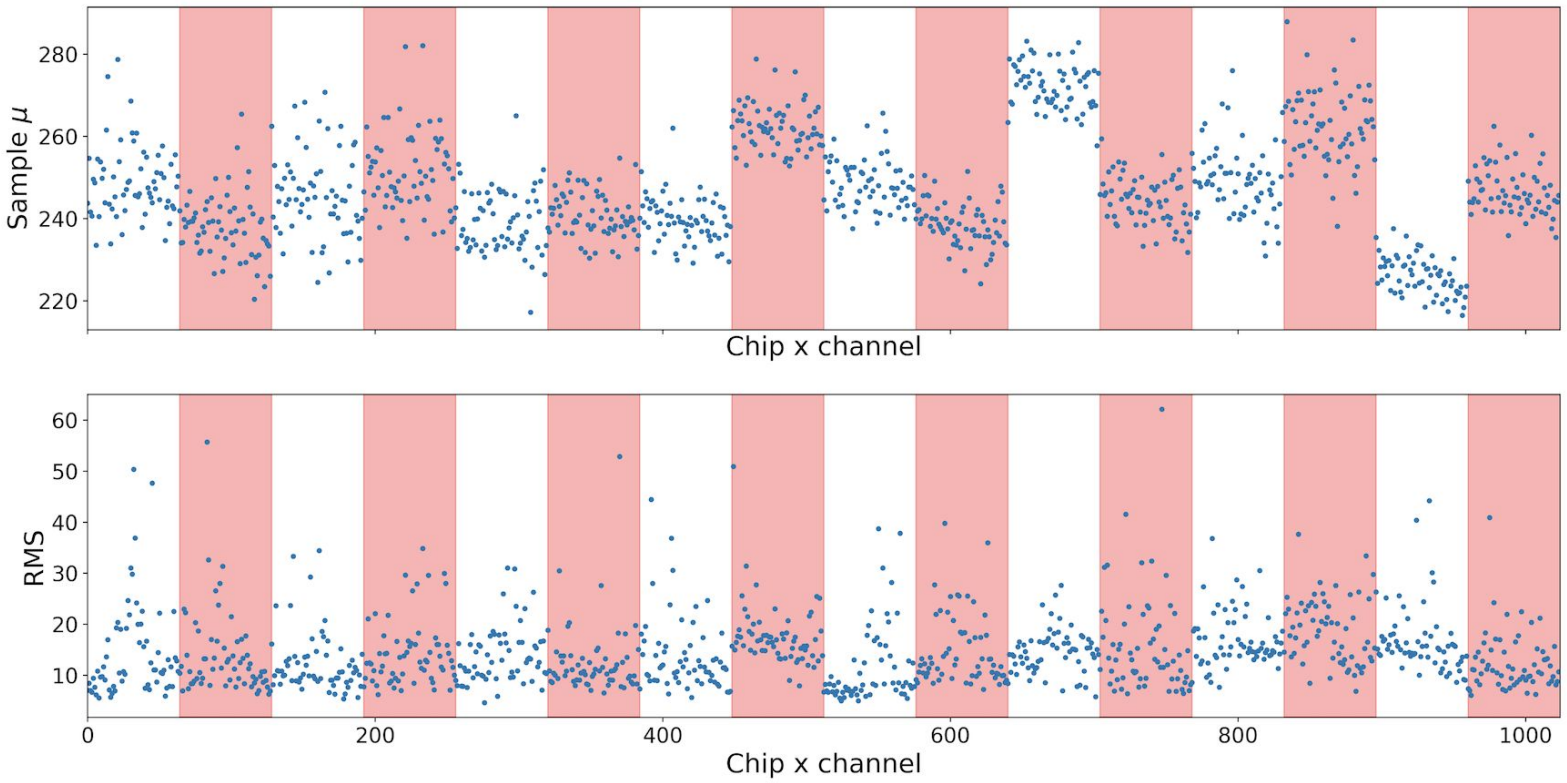
Also require hits in those layers

Require layers 2-3-4 in all cases.
Except conf 3, 5 GeV: 1-2-3-4

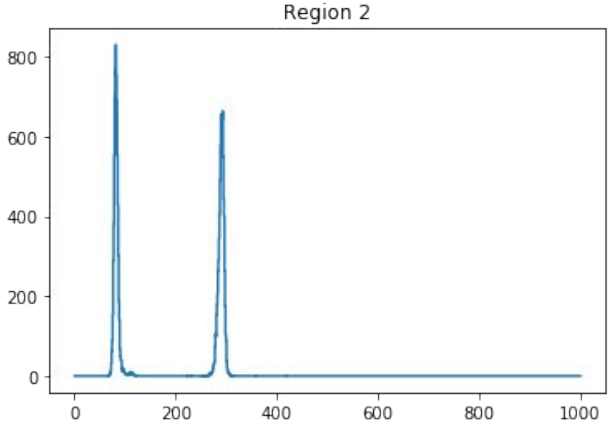


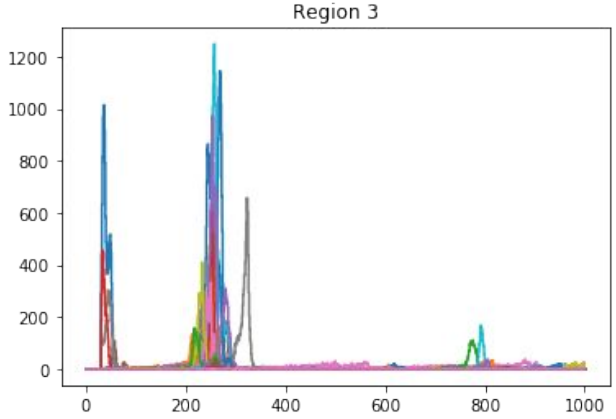


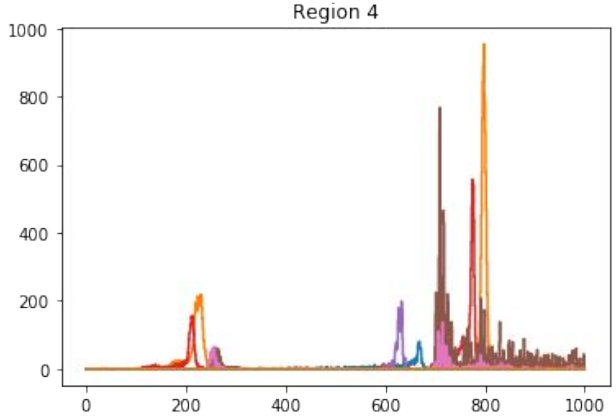
Summarize pedestal (board 4, SCA 5)

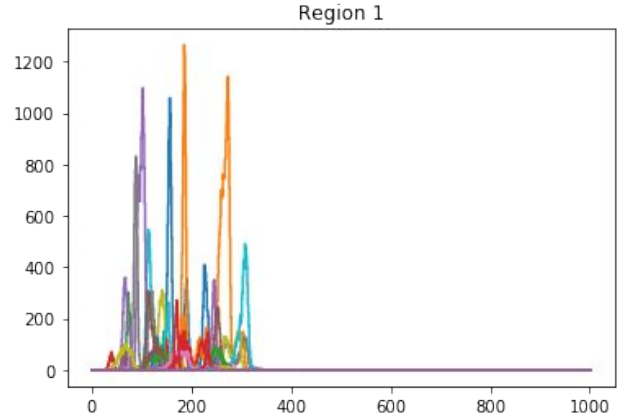


Pedestal RMS and max location, per ‘region’







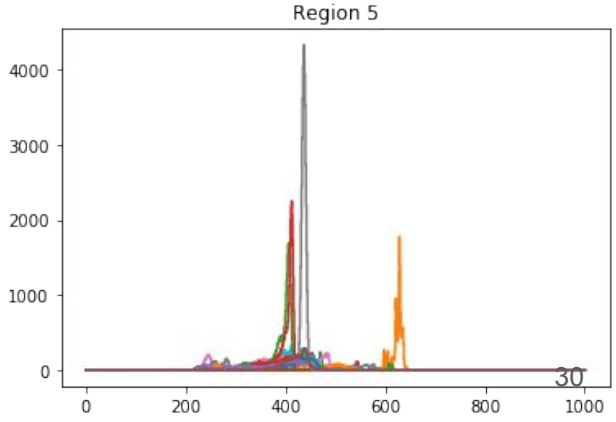


High RMS (Regions 2, 3, 4)

- 2+ peaks
- Wide distributions

Low RMS (1, 5)

- Low max location
  Concentrated



Pedestal RMS and max location

Ped extreme “outliers”

→ 230 peds (0.12%)

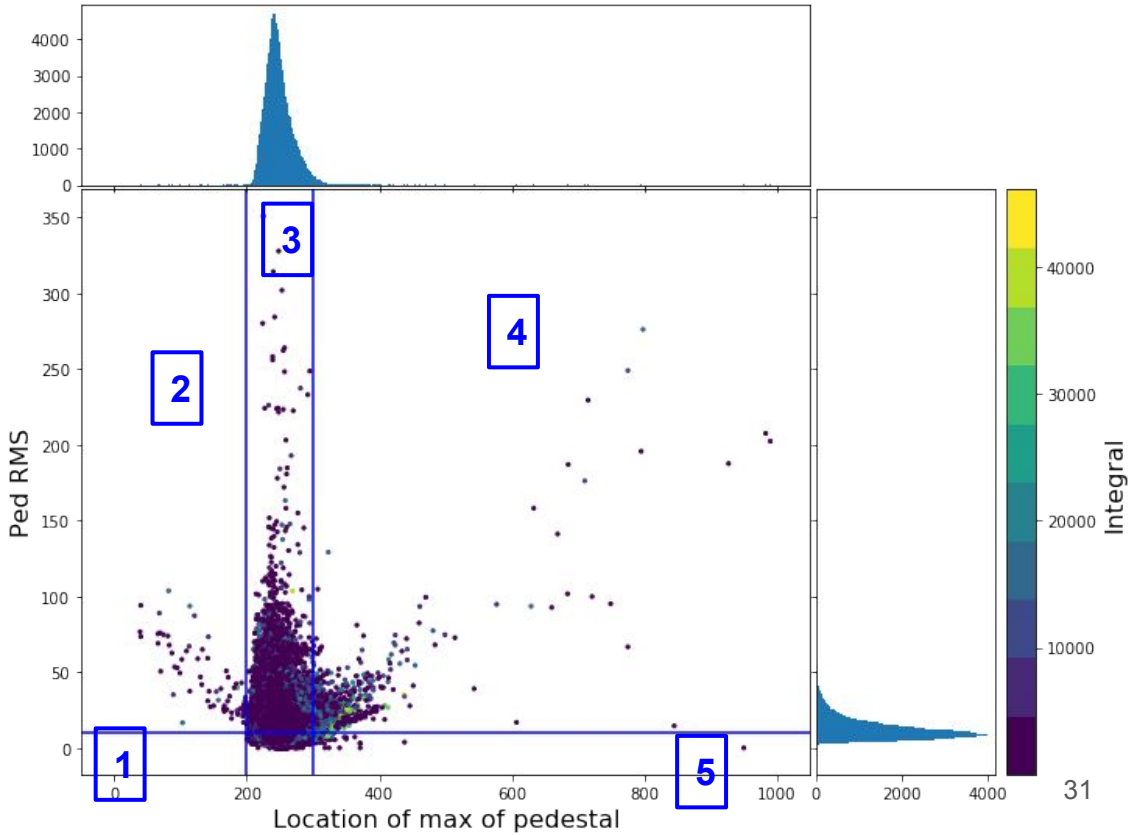
In a stricter sense, ped gone wrong has:

- **RMS > 10**
- **Max location ∉ (200, 300)**
- **Noisy → #counts > 1000?**

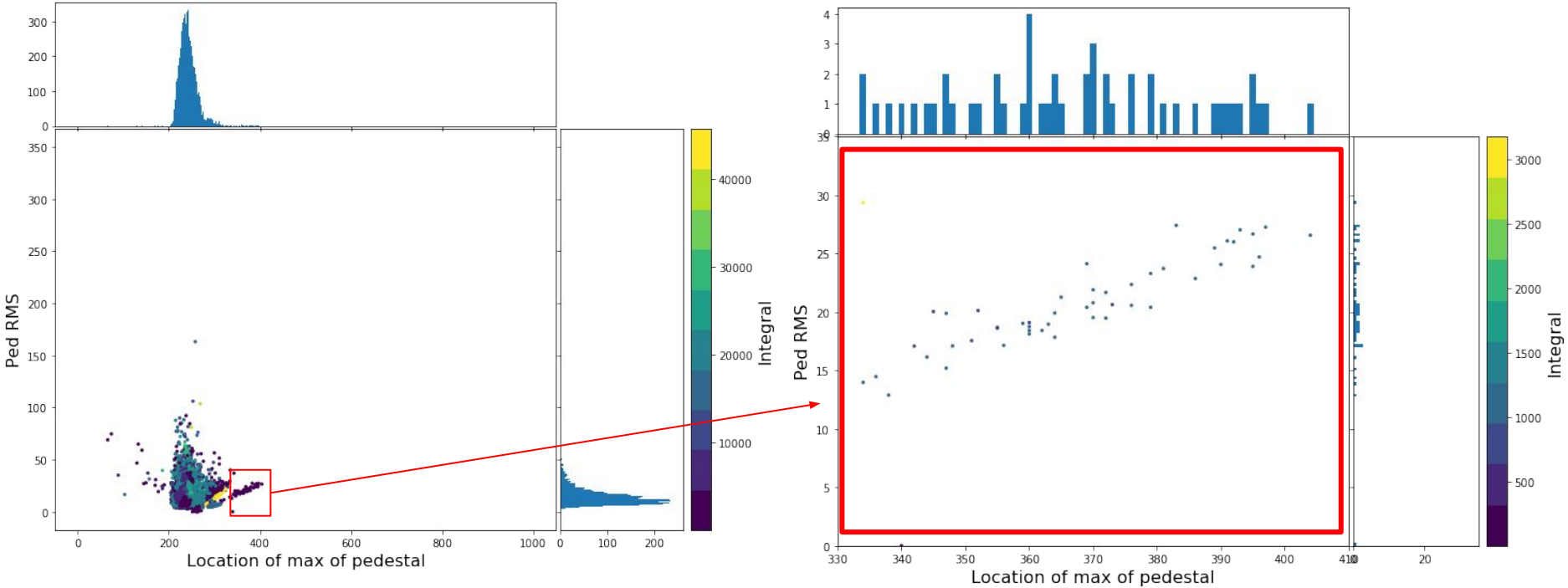
In which case, many went wrong?

→ check if e.g. already masked

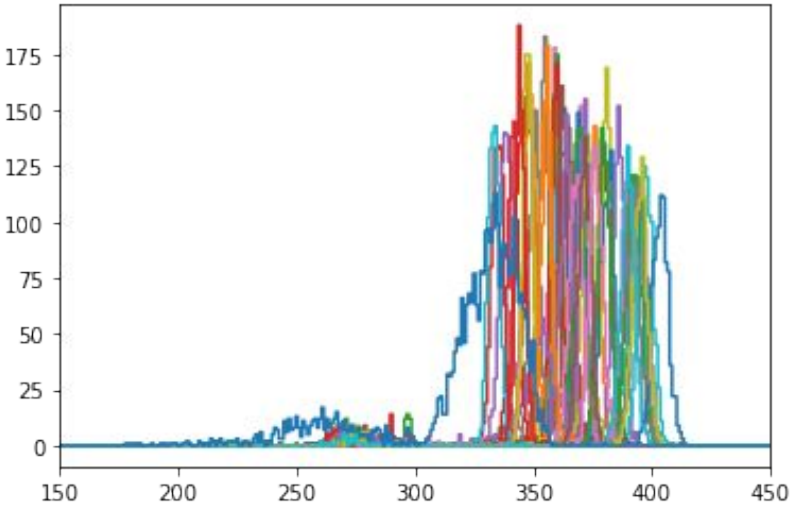
In 1+2+3+4+5: 83119 peds (~44%)

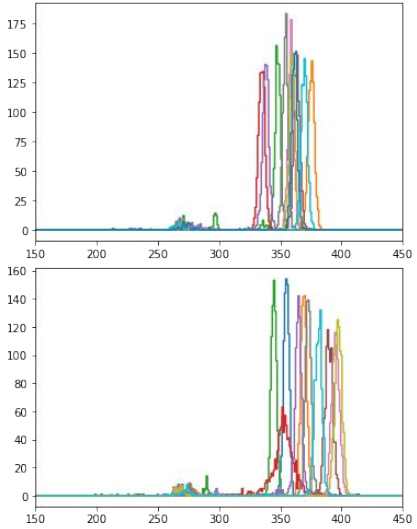


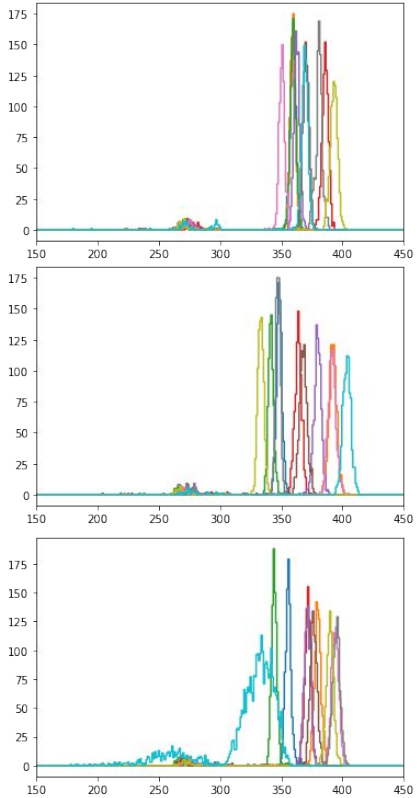
Pedestal RMS and max location (SCA 0)



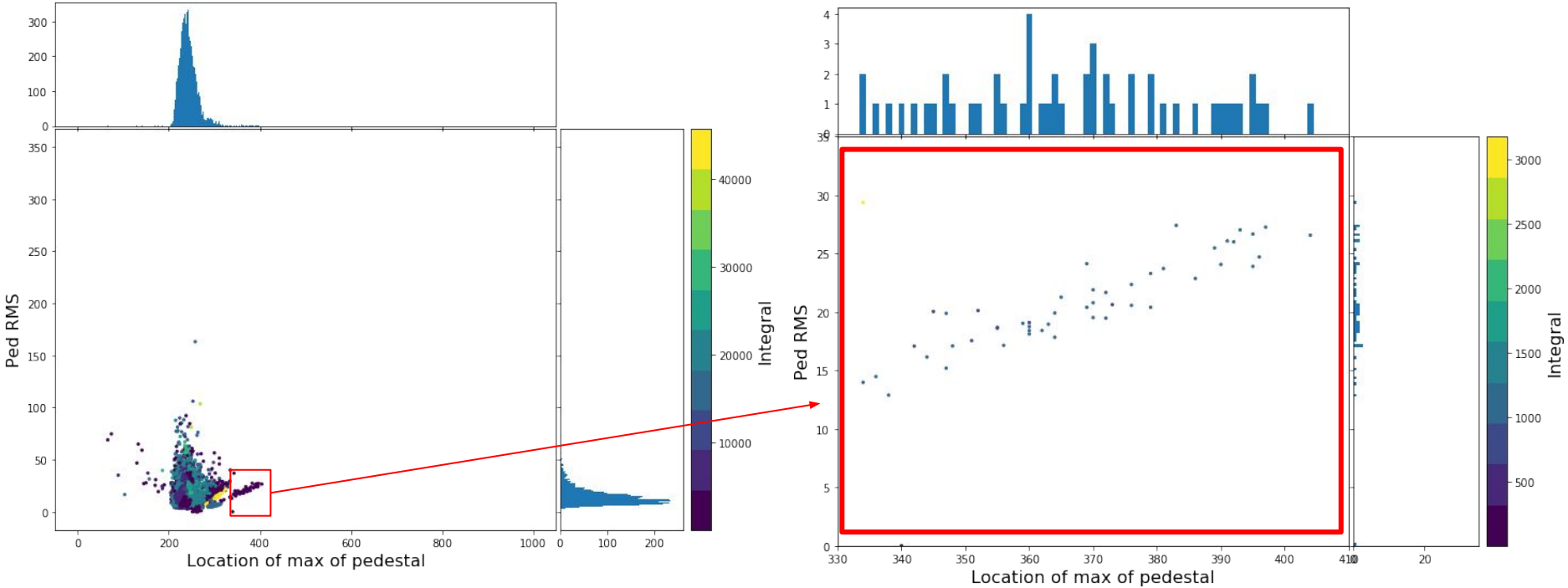
Pedestal RMS and max location in SCA 0 - trend







Pedestal RMS and max location (SCA 0)



Board setup

https://docs.google.com/spreadsheets/d/1ecl0UY6vKw6d_gQ8TMOZYOZw8osKKzpL_1ia69nTXqQ/edit#gid=0

coreKapton slot	Layer position	Slab ID	ASU type	wafer	front end (slboard ID)	Glissiere neded for the W	*W in front (mm)*	*X0*	*X0 (acc)*	Comments/Issues
0	1	26	COB	500	12	whatever (no W will be added)		*0*	*0*	
1	2	27	COB	500	8	2.1mm		*0*	*0*	
2	3	16	FEV11	320	9	2.1mm	*2.1*	*0.6*	*0.6*	**wafer delaminated -> @LPNHE since 9/9/20**
3	4	13	FEV11	320	10	2.1mm	*2.1*	*0.6*	*1.2*	
4	5	14	FEV11	320	5	2.1mm	*2.1*	*0.6*	*1.8*	
5	6	15	FEV10	320	1	2.1mm	*2.1*	*0.6*	*2.4*	
6	7	19	FEV11	320	13	2.1mm	*2.1*	*0.6*	*3*	
7	8	20	FEV11	320	11	2.1mm	*2.1*	*0.6*	*3.6*	
8	9	24	FEV12	500	7	2.1mm	*2.1*	*0.6*	*4.2*	Stable AVDD ??
9	10	21	FEV11	320	14	2.1mm	*2.1*	*0.6*	*4.8*	
10	11	25	FEV12	500	3	2.1mm	*2.1*	*0.6*	*5.4*	problems communicating the ID of the SLboard ?? (SOLVED)
11	12	22	FEV11	320	4	4.2mm	*2.1*	*0.6*	*6*	
12	13	23	FEV10	320	6	4.2mm	*4.2*	*1.2*	*7.2*	
13	14	18	FEV11	320	2	4.2mm	*4.2*	*1.2*	*8.4*	problems communicating the ID of the SLboard ?? (SOLVED) Stable consumption ?? --> SOLVED shorcut in DVDD (capacitance in skiroc 14)
14	15	17	FEV11	320	0	whatever (no W will be added)	*4.2*	*1.2*	*9.6*	**Wafer delaminated -> @LPNHE since 4/8/20**