LUXE ECAL TB2022 noise study

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***AITANA group at IFIC – CSIC/UV**

AGENCIA ESTATAL DE INVESTIGACIÓN
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Financiado por la Unión Europea NextGenerationEU
Plan de Recuperación, Transformación y Resiliencia
GENERALITAT VALENCIANA
GVANEXT Fondos Next Generation en la Comunitat Valenciana
Gen—T
AITANA

Outline

- ECAL-e CALICE activities (snapshot)
- ECAL-p activities
  - Carbon Frames
  - Metrologis
  - Glue thickness studies
- Plans 2024

Noise study: intro

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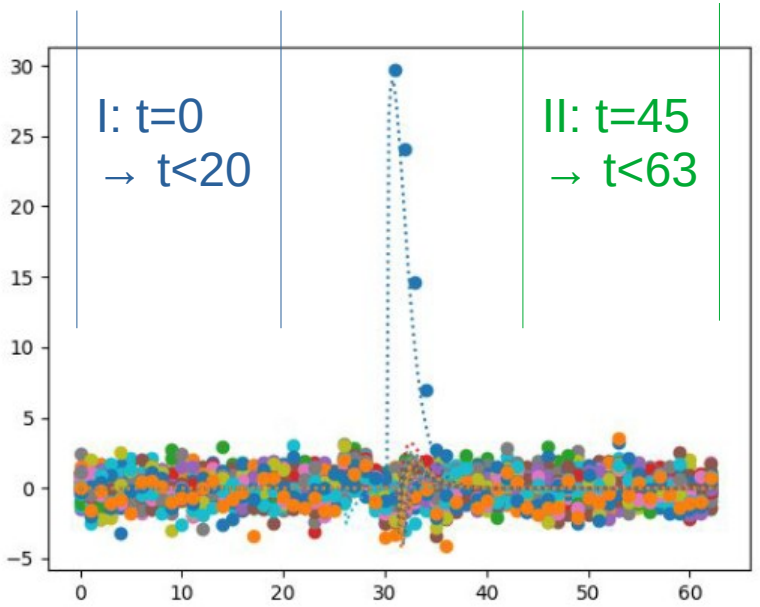
Input info

- I use 10000 ROC (ReadOut Cycles) with no telescope coincidence required
- Run: 4533
- Calice 74
- Raw data in root file provided by Melissa (with help/support of Dawid and Shan)
- Pedestal subtracted by Dawid
- In every ROC, every channel provides 63 ADC samples (63 time samples).
- I divide the 63 in 3 sectors: I, II, III



Pre-study

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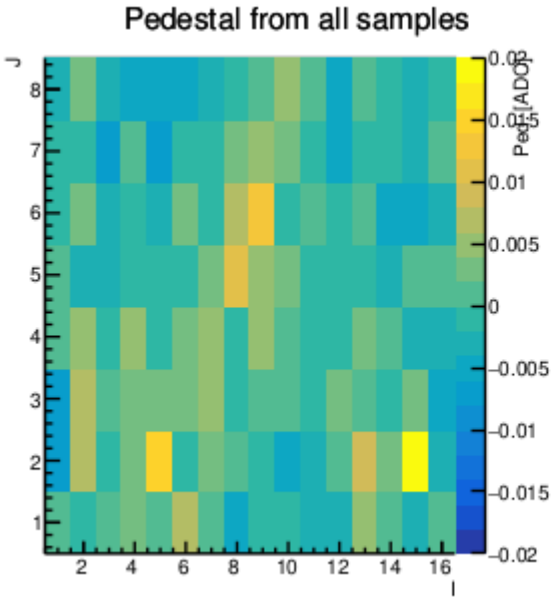
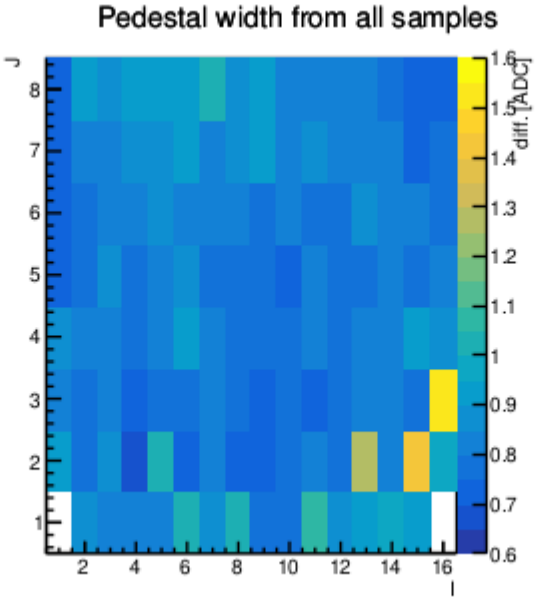
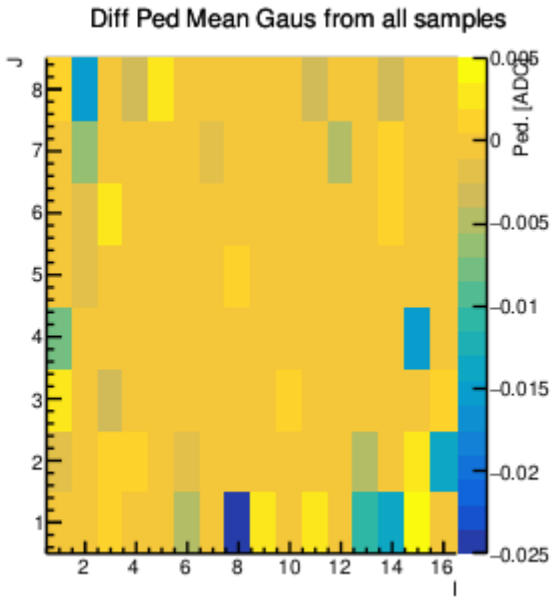
- Are the pedestals correctly calculated?
- For region **III**
  - I calculate the pedestals with two methods: simple average (Mean Histogram) and gaussian fit







  - The results are in good agreement with Dawid calculations within ~0.02ADC

Pre-Study

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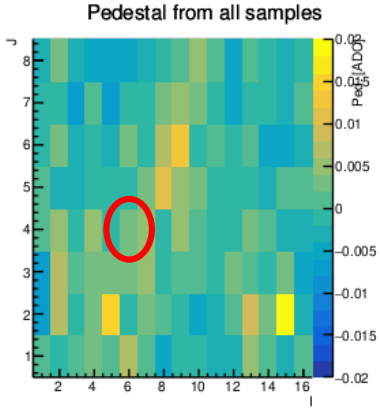
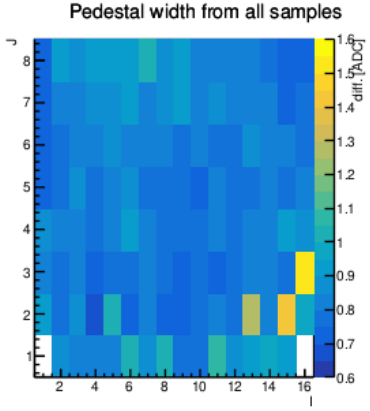
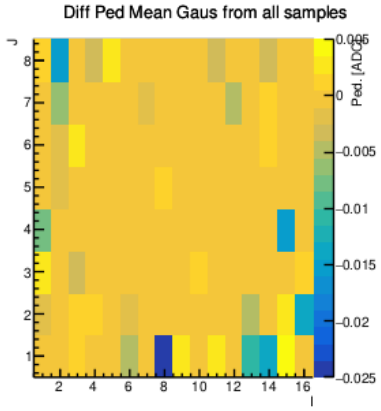
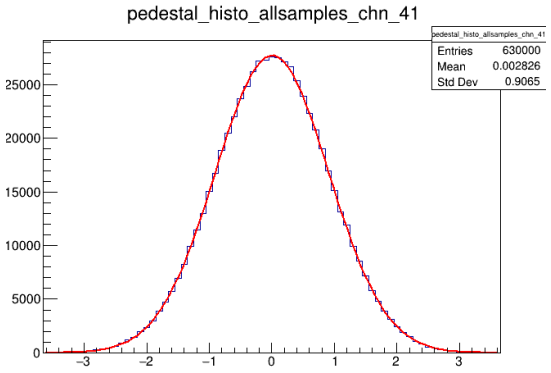
- Few Examples









Pre-study

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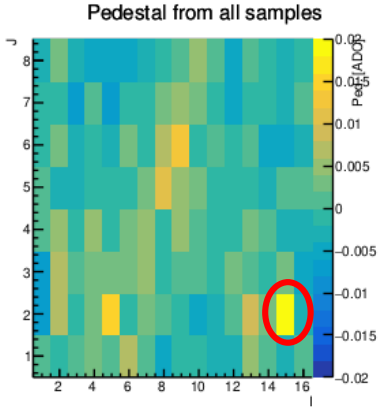
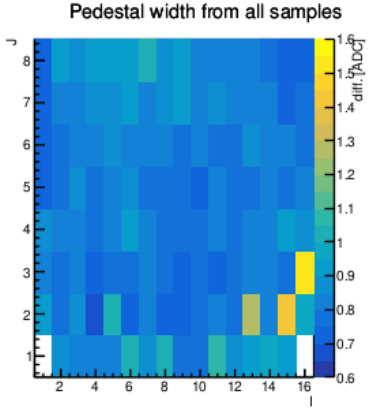
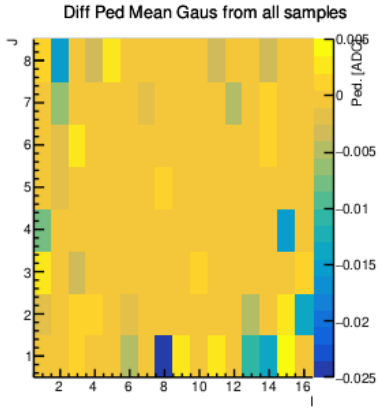
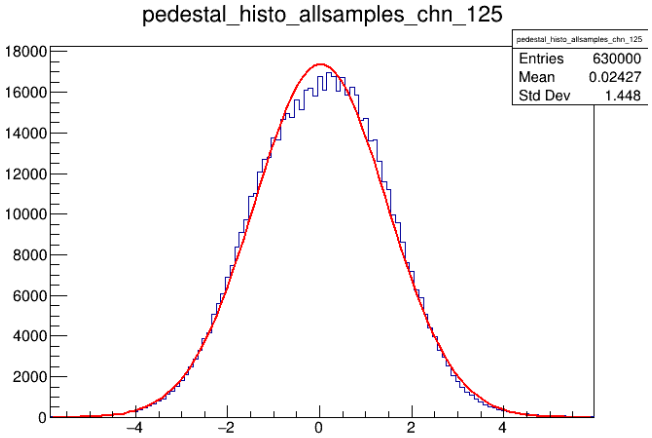
- Few Examples









Pre-Study

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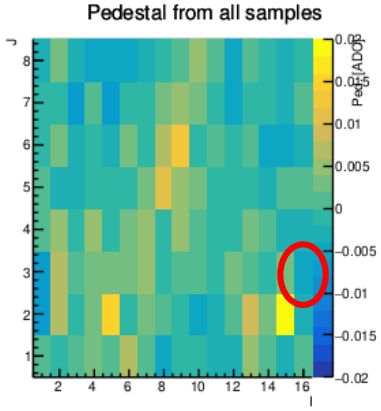

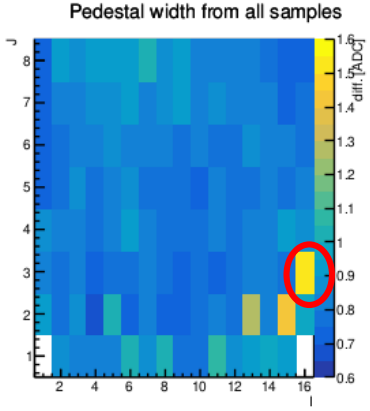

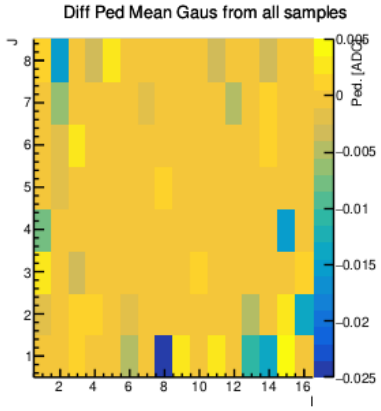

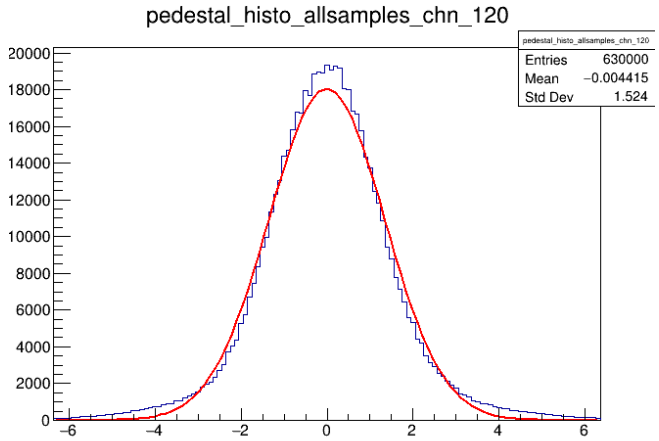

Pre-study

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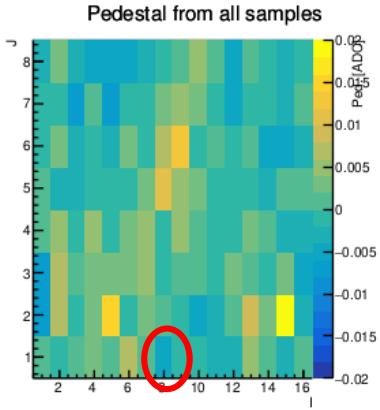
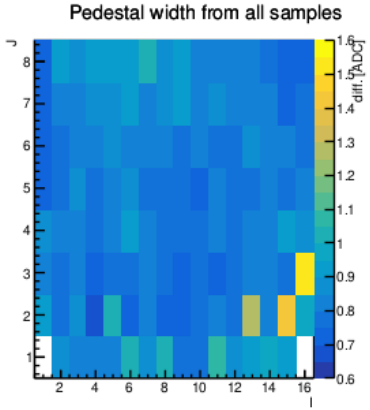
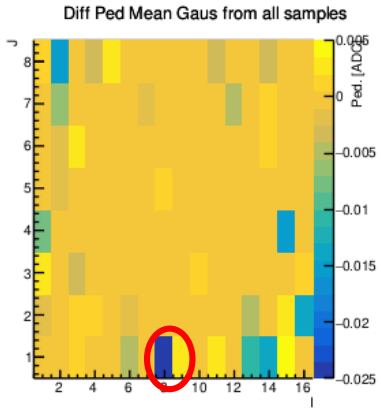
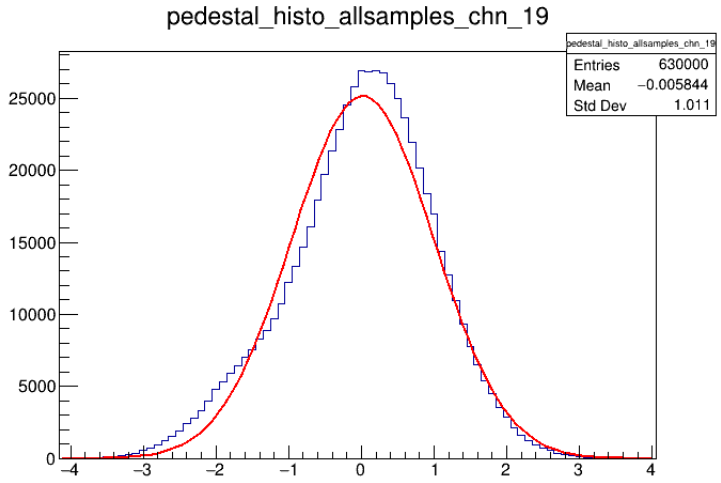
- Few Examples

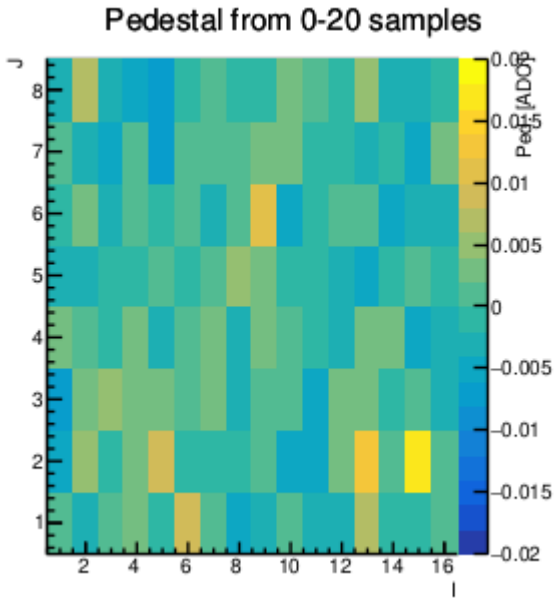




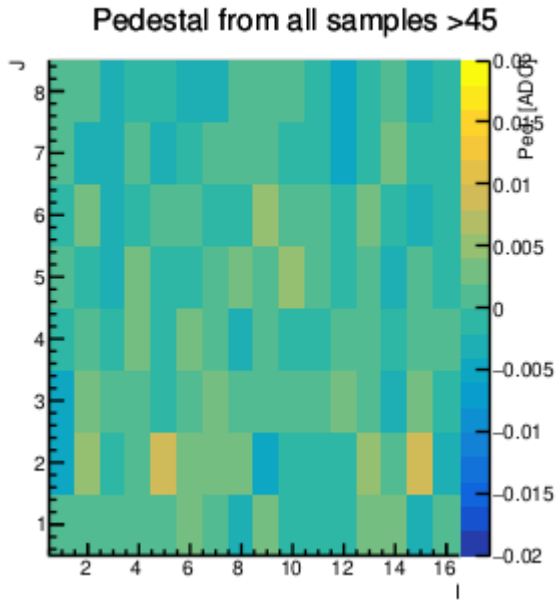




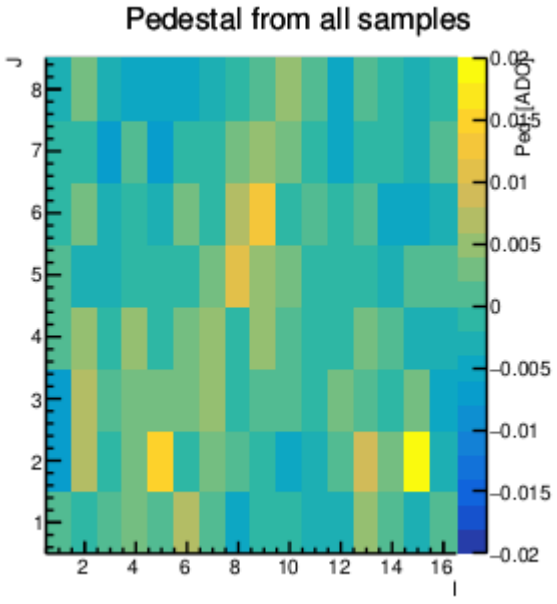
PRe-study: comparison regions



I: t=0
→ t<20



II: t=45
→ t<63



III: t=0 →
t<63

Conclusion pre-study

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- **Pedestals are correctly calculated within few 0.01ADC**
- **Width/noise** is ~0.8ADC for most channels but there are **some outliers and channels behaving funny**
  - I am pretty sure that this is not new (channels that are not connected to the electronics, or known to be noisier, or wrongly glued) → I still need to cross check all this with Melissa's notes.
- **However, I propose a method to study these features systematically**
  - The goal is to study in deep the differences between Si and GaAs

Noise study: intro 2

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Coherent noise source identification in multi channel analysis

T. Frisson*[1] and R. Poeschl[1]

[1]Laboratoire de L'accélerateur Linéaire (LAL), CNRS/IN2P3, Orsay, France

May 4, 2021

https://arxiv.org/pdf/1401.7095.pdf

- "The goal is to identify and characterize dissociable noise sources in a multi channel systems. This method cannot separated noise sources which affect exactly the same set of channels. In this case, the noises sources are processed as a single source. We consider a system with N channels. "
- "Each channel **k** is affected by an incoherent noise source **I_k** and Nc coherent noise sources (**C1_k, C2_k,... CN_k**). We assume that all noise source distributions are Gaussian and independant."

Noise study: intro 2

$$\sigma_i^2 = \sigma_{I_i}^2 + \sum_{j=1}^{N_c} \sigma_{C_i^j}^2 \quad (1)$$

The covariance matrix element from the two channels i and k is expressed by:

$$cov(i,k) = \delta_{ik}\sigma_{I_i}\sigma_{I_k} + \sum_{j=1}^{N_c} \sigma_{C_i^j}\sigma_{C_k^j} \quad (2)$$

where:

$$\delta_{ik} = \begin{cases} 1 & \text{if } i = k \\ 0 & \text{if } i \neq k \end{cases} \quad (3)$$

The covariance matrix element can also be determined from the data:

$$cov_{Data}(i,k) = \frac{\sum_{n=1}^{N_{event}} (A_i(n) - \mu_{A_i})(A_k(n) - \mu_{A_k})}{N_{event}} \quad (4)$$

Measured amplitude if no hit

Pedestal position → calculated as simple histogram Mean

Noise study: intro 2

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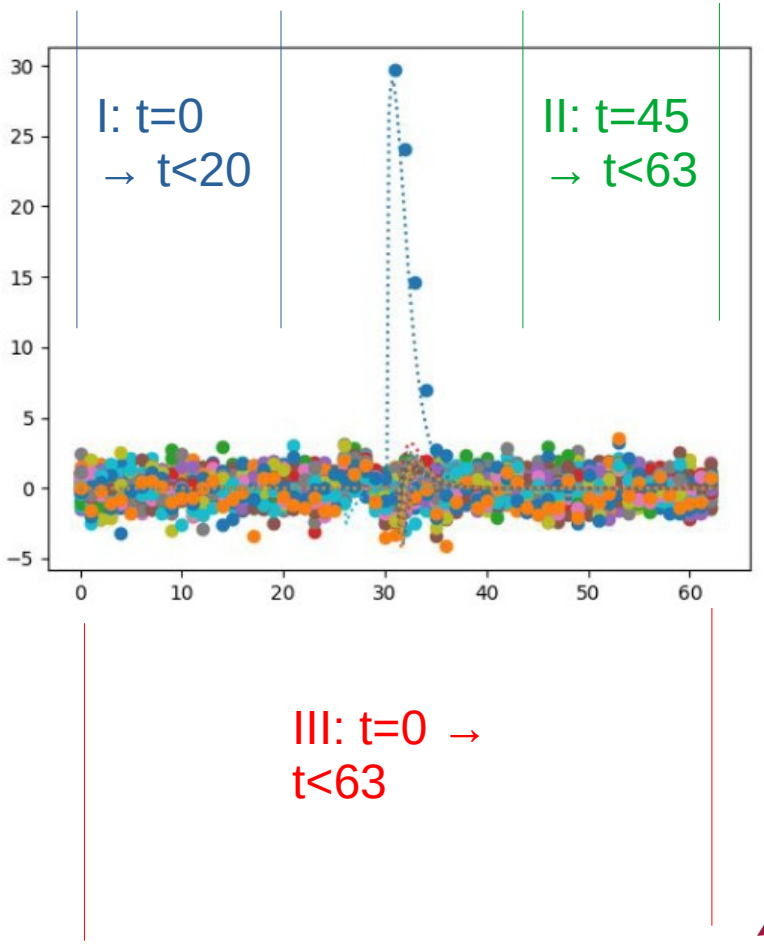
Input info (same as before)

- I recalculate the pedestal on the fly to correct for the minor differences observed



Inocoherent noise

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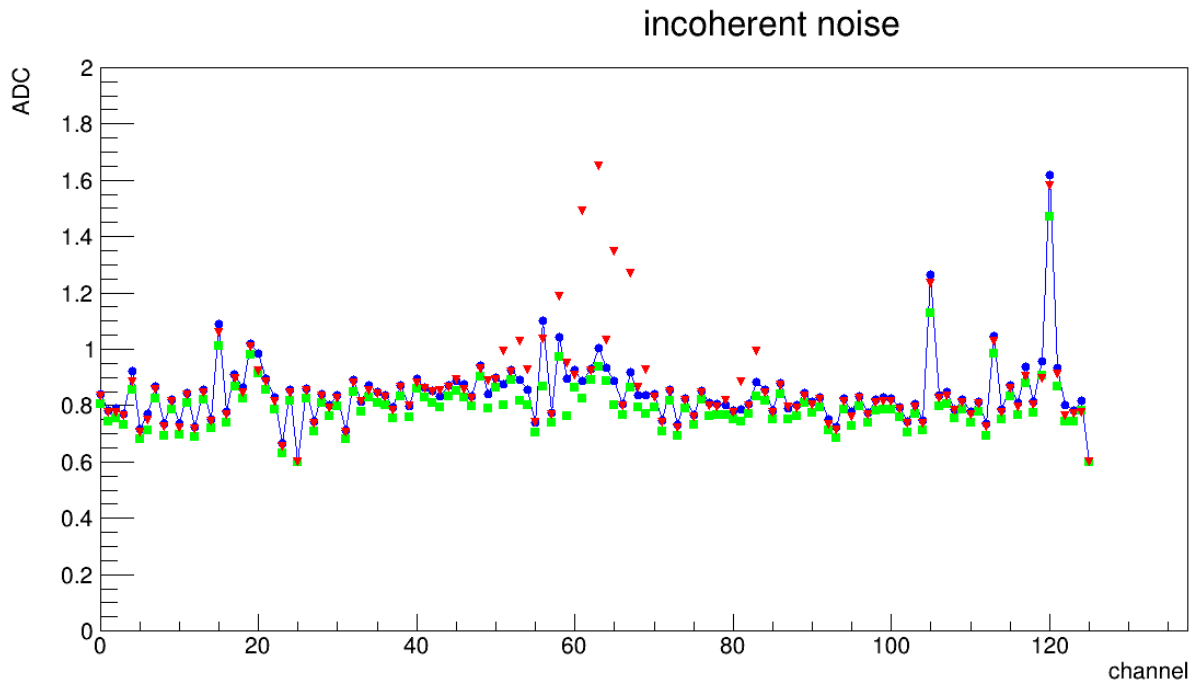
- **Compatible results for all channels**
  - Region II shows systematically lower values ~0.02ADC
  - 60, 61, … = beam spot (wider because of signal treated as noise)

$$\sigma_i^2 = \sigma_{I_i}^2 + \sum_{j=1}^{N_c} \sigma_{C_i^j}^2$$



I: t=0 → t<20	II: t=45 → t<63	III: t=0 → t<63
Nc=2	**Nc=2**	**Nc=4**

Inocoherent noise

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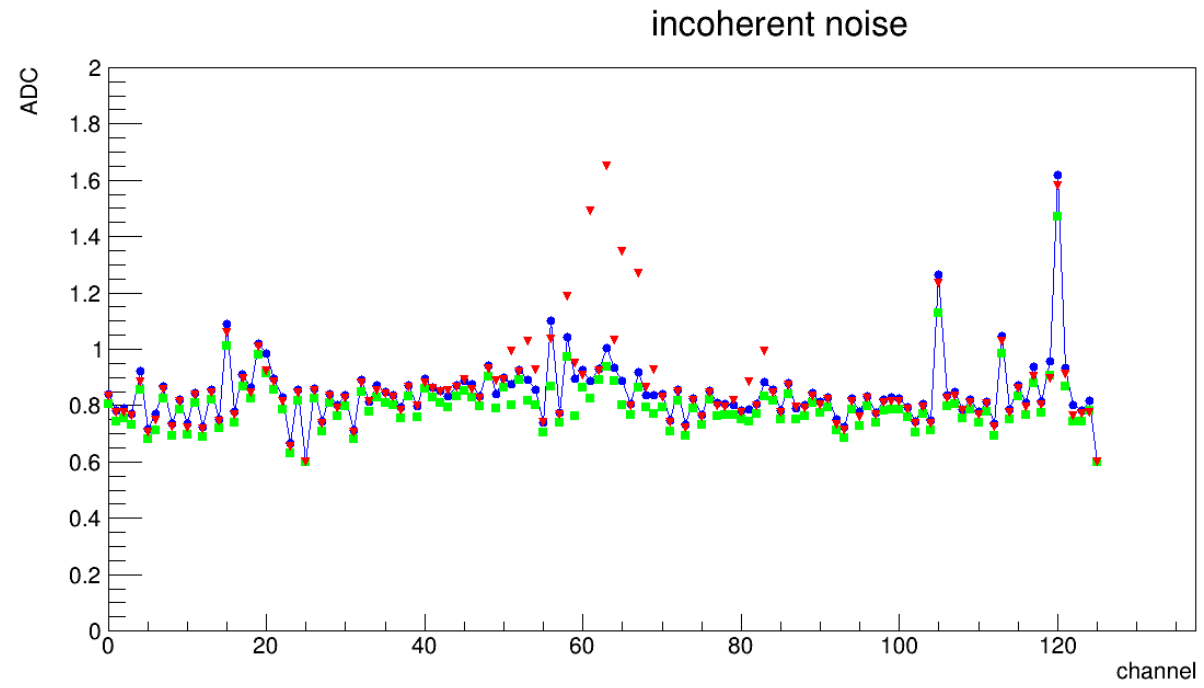

I: t=0 → t<20	II: t=45 → t<63	III: t=0 → t<63
Nc=2	**Nc=2**	**Nc=4**

Coherent noise

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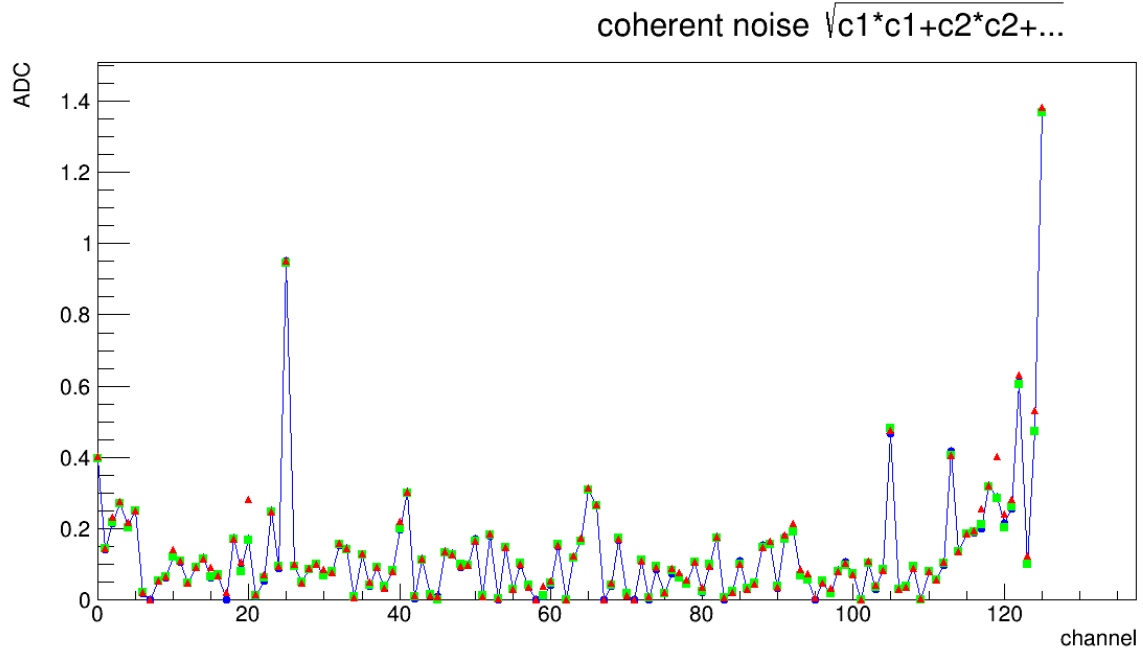
- **Compatible results for all channels**
  - Region II shows systematically lower values ~0.02ADC
  - Beam spot is not “understood” as coherent noise.
  -

$$\sigma_i^2 = \sigma_{I_i}^2 + \sum_{j=1}^{N_c} \sigma_{C_i^j}^2$$



I: t=0 → t<20	II: t=45 → t<63	III: t=0 → t<63
Nc=2	Nc=2	Nc=4

Comparison of two methods

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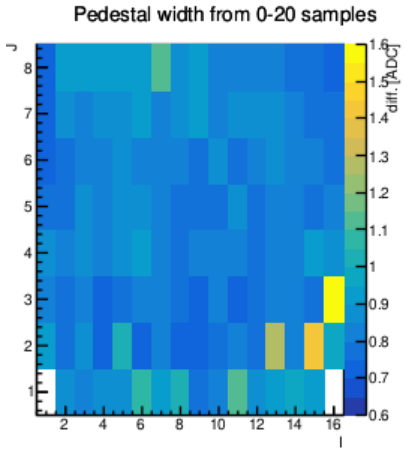
- Simple approach



I: t=0
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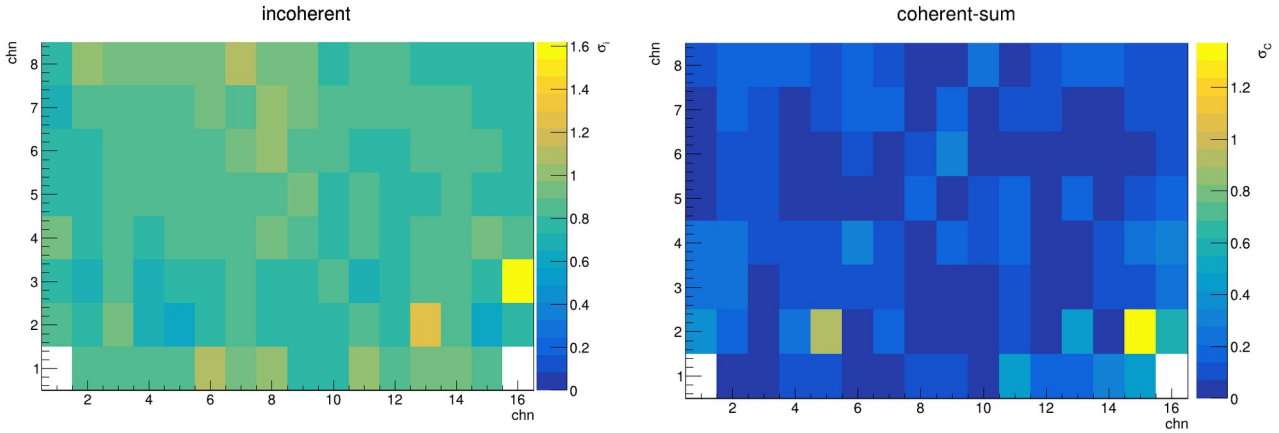
- Cov. matrix



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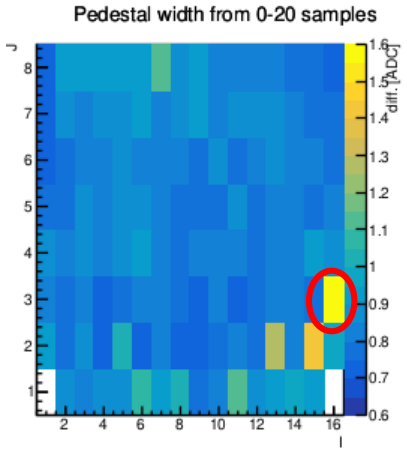

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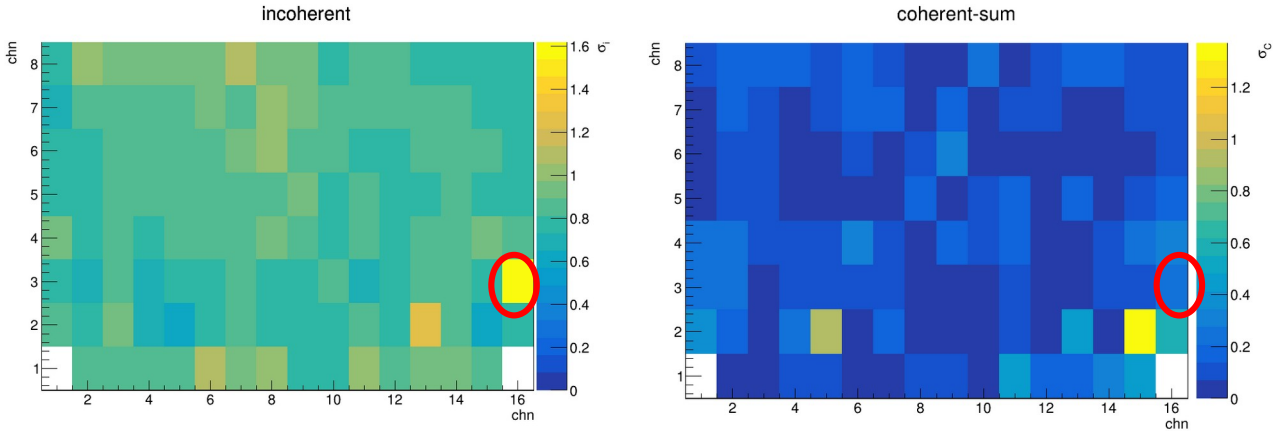
- Cov. matrix



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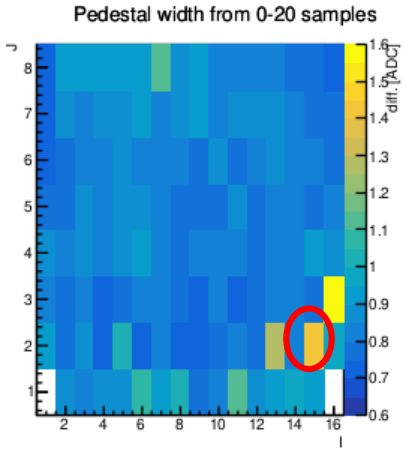

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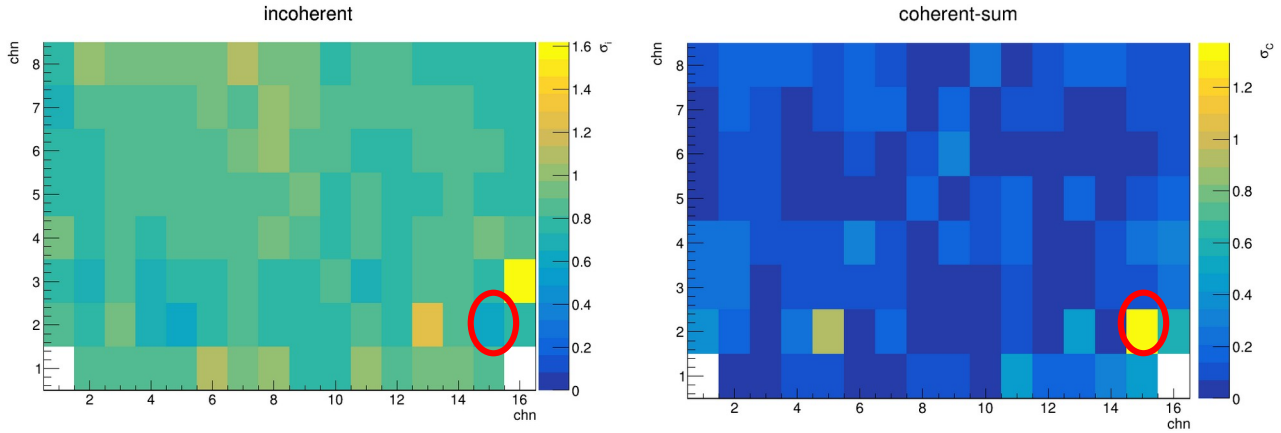
- Cov. matrix



Comparison of two methods

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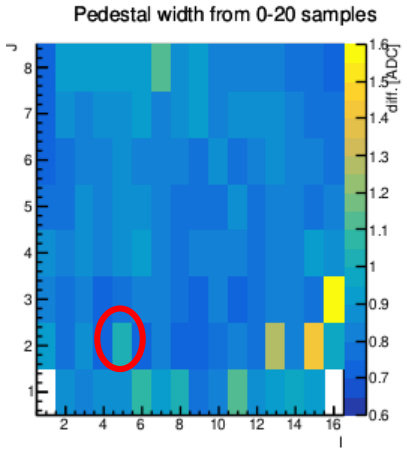

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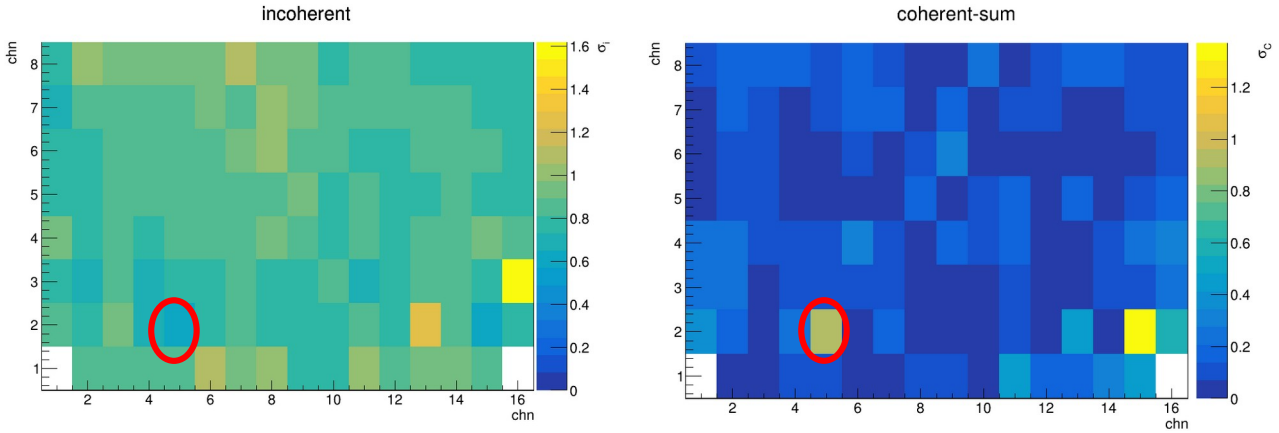
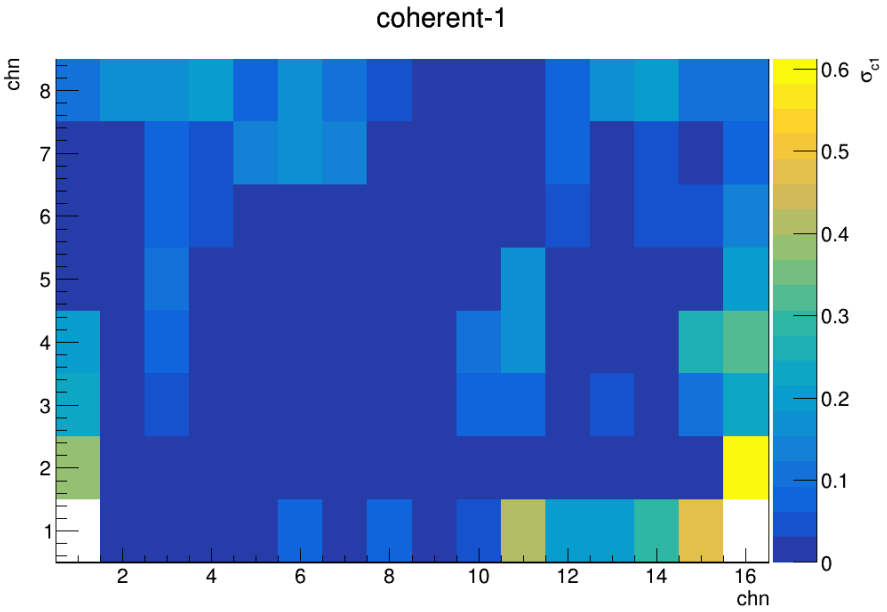
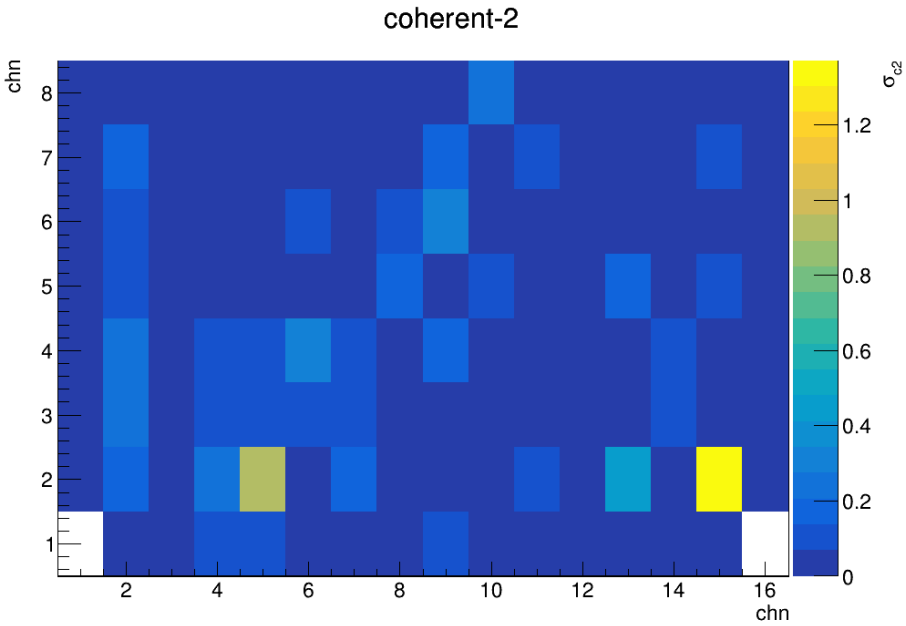


Two sources of coherent noise





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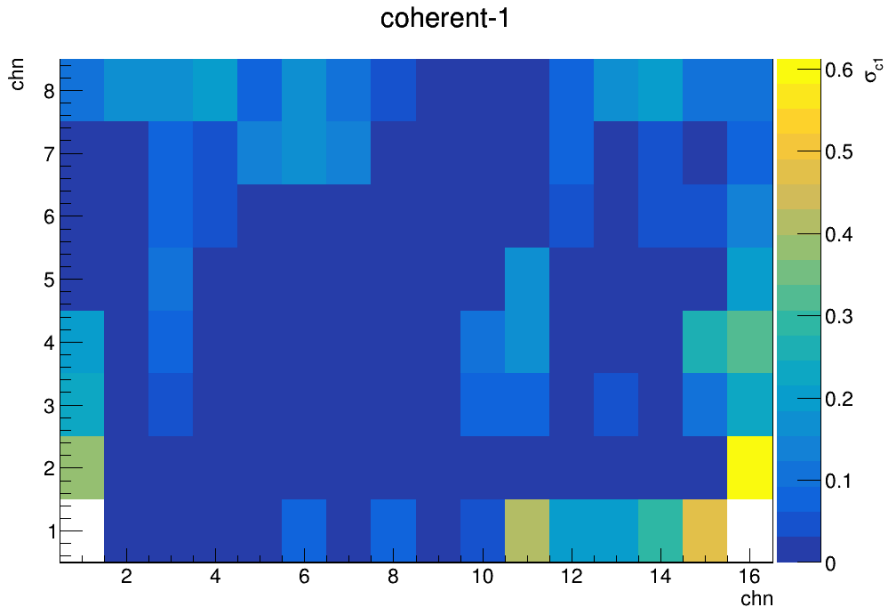
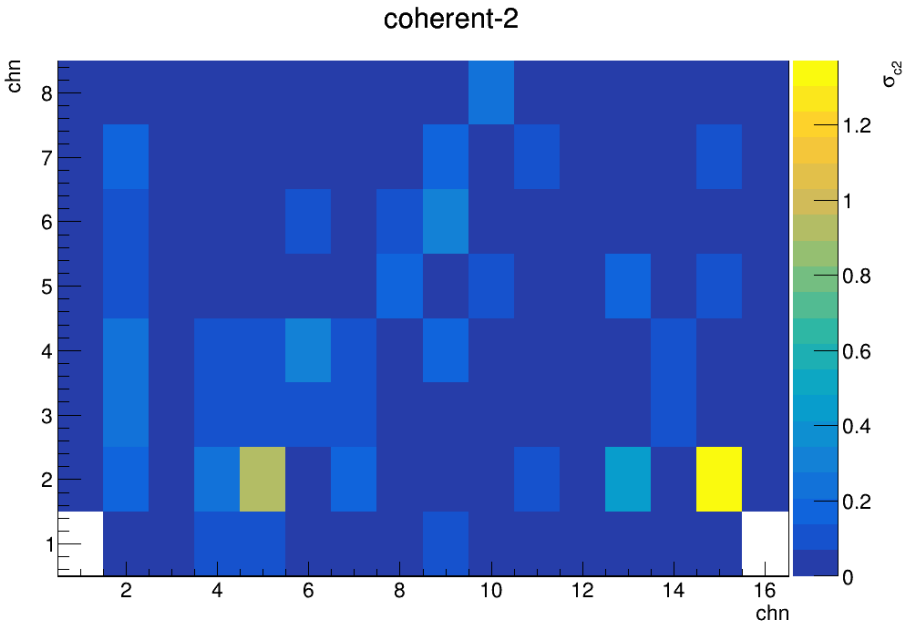
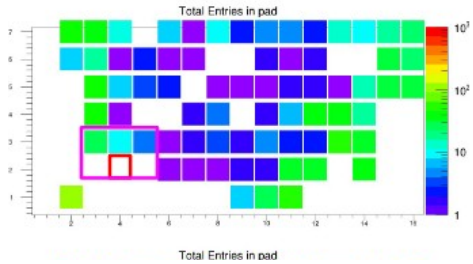
Two sources of coherent noise

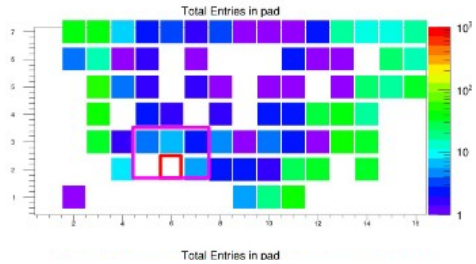




Low amplitude signals in pads: C75

Shown by Melissa in VLC meeting





I: t=0
→ t<20

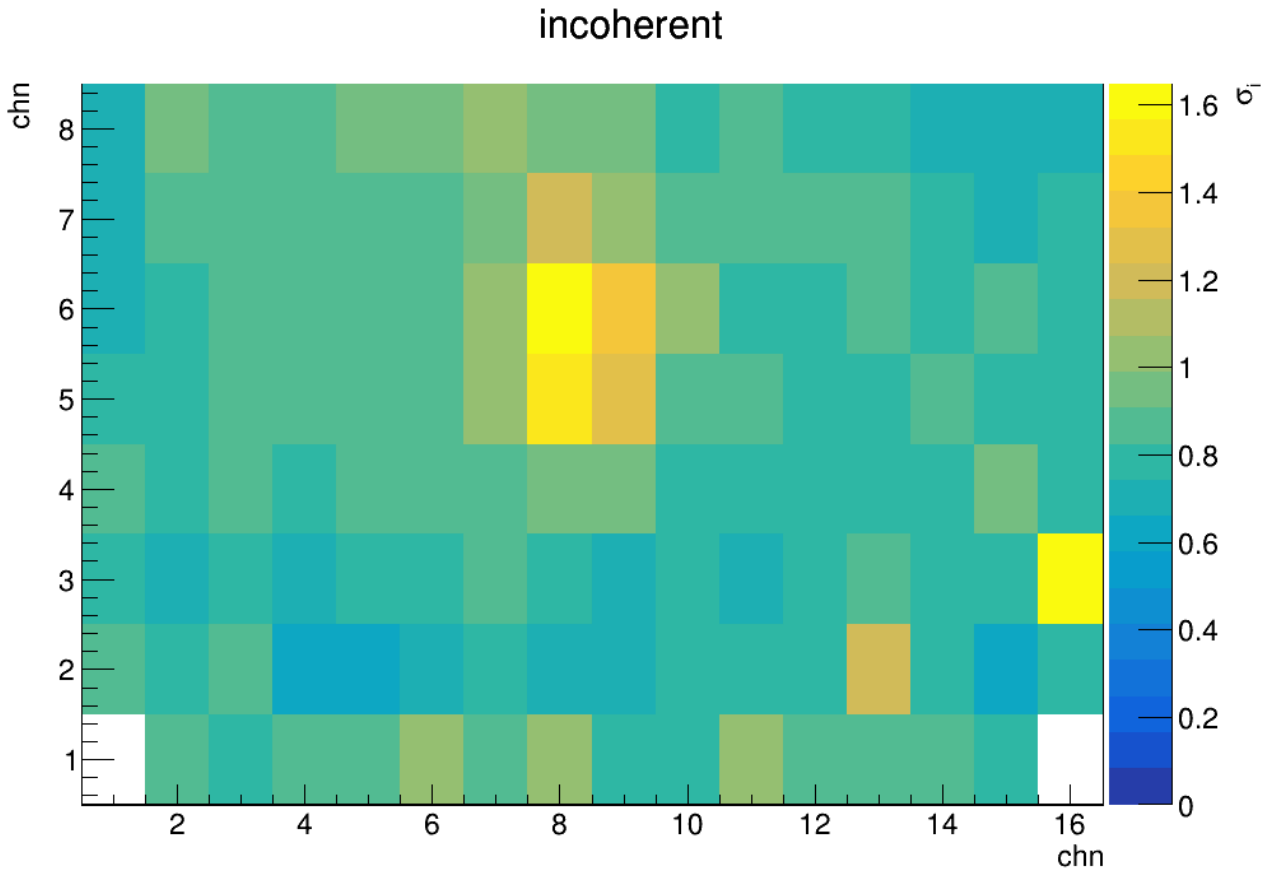
Summary

- Work-in-progress but it seems that the covariance matrix seems a very useful characterization tool for the noise of the modules in TB2022
- I did not have time to cross-check with existing info of the sensor and electronics (noisy channels, dead channels, etc...)

- So far only a small data sample used with only one sensor
  - Please, provide me with files for all sensors → will this tool be able to tell something about the traces of the GaAs ??
- Once that we have all sensors analyzed → would it be worthy to include this study in the paper?

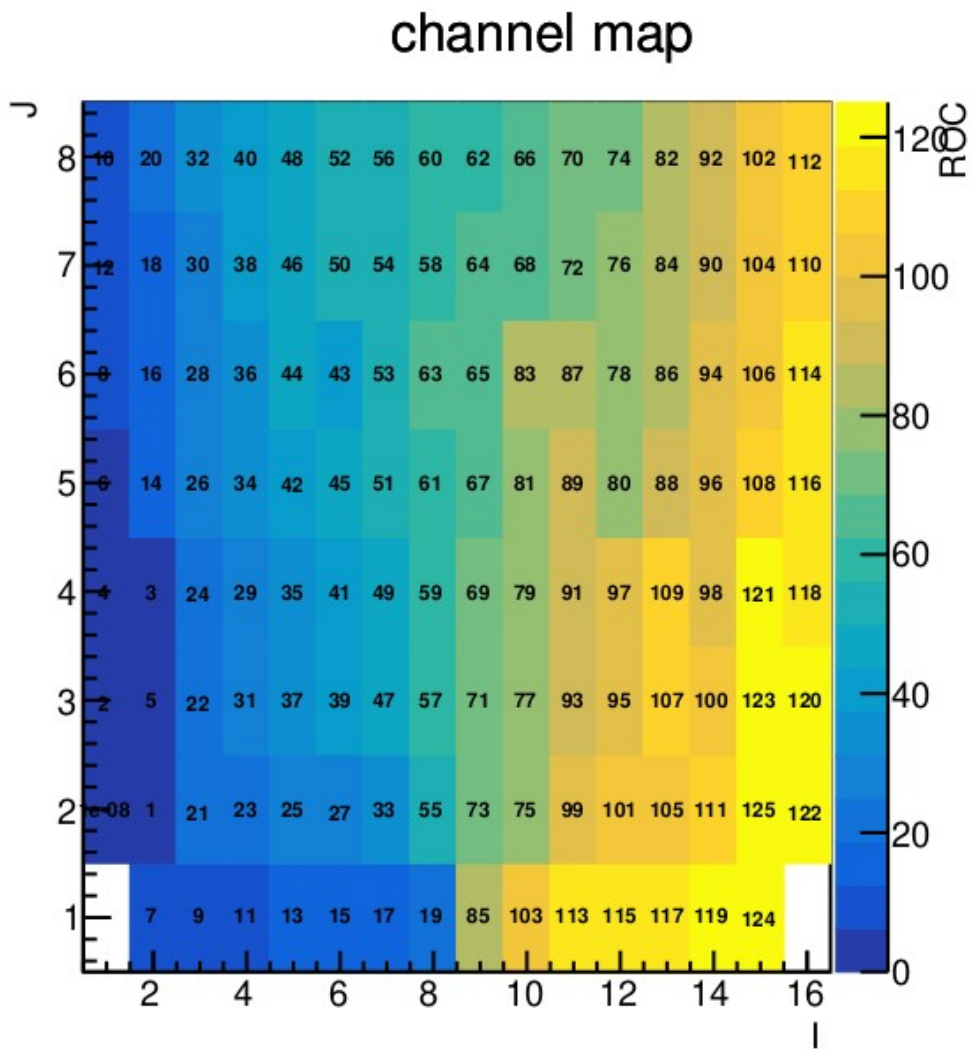
- Code will be submitted to gitlab
- LUXE syle plots can be provided if requested.

back-up



III: t=0 → t<63

Nc=4


channel map
J
I
ROC
8 10 20 32 40 48 52 56 60 62 66 70 74 82 92 102 112
7 12 18 30 38 46 50 54 58 64 68 72 76 84 90 104 110
6 8 16 28 36 44 43 53 63 65 83 87 78 86 94 106 114
5 6 14 26 34 42 45 51 61 67 81 89 80 88 96 108 116
4 4 3 24 29 35 41 49 59 69 79 91 97 109 98 121 118
3 2 5 22 31 37 39 47 57 71 77 93 95 107 100 123 120
2 08 1 21 23 25 27 33 55 73 75 99 101 105 111 125 122
1 7 9 11 13 15 17 19 85 103 113 115 117 119 124
2 4 6 8 10 12 14 16
120 100 80 60 40 20 0