

# **2026 SPS TB - HGCROC Readout**

**September 15, 2026**

**Friederike Bock**



- 1 SPS 2026 Set E - 44V
  - Overview
  - Pedestals
  - TOA offset calibration
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- 2 Calibrations Summary
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# **2026 SPS TB - HGCROC Readout Full Set E - analysis status**



# Overview - Set E

## Full Set E

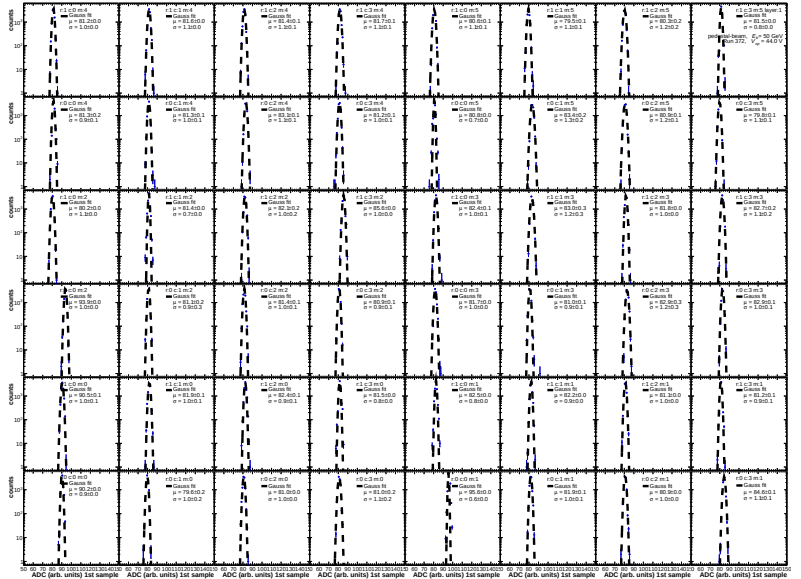
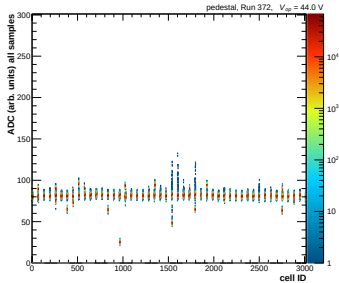
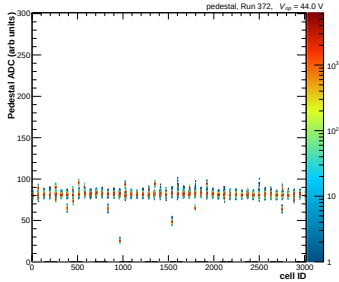
Summing Board V2,  $V_{op} = 44$  V, gain settings: RF = 12, CF = 7, CC= 3, CFcomp=1  
May 18, 17:05 - May 19, 2:36, additional May 19, 17:35 - May 19, 19:01

| Calibration sets:    |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
|----------------------|------------|----------|--------|-----------|------------|---------|----------|------|------|------|------|------|------|------|------|------|
| $\mu$ table position | ped        | (10,-5)  | (10,5) | (-10, -5) | (-10,5)    | (0,0)   |          |      |      |      |      |      |      |      |      |      |
| 1 <sup>st</sup>      | runs       | 372      | 375    | 376       | 377        | 378     | 374      |      |      |      |      |      |      |      |      |      |
|                      | tot events | 10K      | 155K   | 161K      | 154K       | 154K    | 156K     |      |      |      |      |      |      |      |      |      |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| $\mu$ table position | ped        | (10,-5)  | (10,5) | (-10, -5) | (-10,5)    | (0,0)   |          |      |      |      |      |      |      |      |      |      |
| 2 <sup>nd</sup>      | runs       | 420      | 422    | 423       | 425        | 424     | 421      |      |      |      |      |      |      |      |      |      |
|                      | tot events | 10K      | 151K   | 158K      | 152K       | 164K    | 151K     |      |      |      |      |      |      |      |      |      |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| $\mu$ table position | ped        | (10,-10) | (10,0) | (10,10)   | (-10, -10) | (-10,0) | (-10,10) |      |      |      |      |      |      |      |      |      |
| 3 <sup>rd</sup>      | runs       | 471      | 473    | 474       | 477        | 482     | 481      | 478  |      |      |      |      |      |      |      |      |
|                      | tot events | 10K      | 152K   | 156K      | 151K       | 150K    | 156K     | 151K |      |      |      |      |      |      |      |      |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| Electron set:        |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| E (GeV)              | 20         | 30       | 40     | 50        | 80         | 100     |          |      |      |      |      |      |      |      |      |      |
| e <sup>-</sup>       | runs       | 391      | 392    | 381       | 382        | 383     | 384      |      |      |      |      |      |      |      |      |      |
|                      | tot events | 254K     | 256K   | 259K      | 255K       | 253K    | 254K     |      |      |      |      |      |      |      |      |      |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| e <sup>+</sup>       | runs       | 385      | 386    | 387       | 388        | 389     | 390      |      |      |      |      |      |      |      |      |      |
|                      | tot events | 253K     | 256K   | 253K      | 258K       | 253K    | 252K     |      |      |      |      |      |      |      |      |      |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| Hadron set:          |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| E (GeV)              | 20         | 30       | 40     | 50        | 60         | 70      | 80       | 90   | 100  | 150  | 200  | 250  | 300  | 325  | 350  |      |
| h <sup>-</sup>       | runs       | 393      | 394    | 395       | 396        | 397     | 398      | 399  | 400  | 401  | 402  | 403  | 404  |      |      |      |
|                      | tot events | 281K     | 259K   | 265K      | 256K       | 260K    | 258K     | 252K | 263K | 262K | 254K | 255K | 256K |      |      |      |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |
| h <sup>+</sup>       | runs       | 405      | 406    | 407       | 408        | 409     | 410      | 411  | 412  | 413  | 414  | 415  | 416  | 417  | 418  | 419  |
|                      | tot events | 288K     | 255K   | 266K      | 263K       | 255K    | 253K     | 253K | 259K | 257K | 259K | 258K | 258K | 260K | 251K | 263K |
|                      |            |          |        |           |            |         |          |      |      |      |      |      |      |      |      |      |

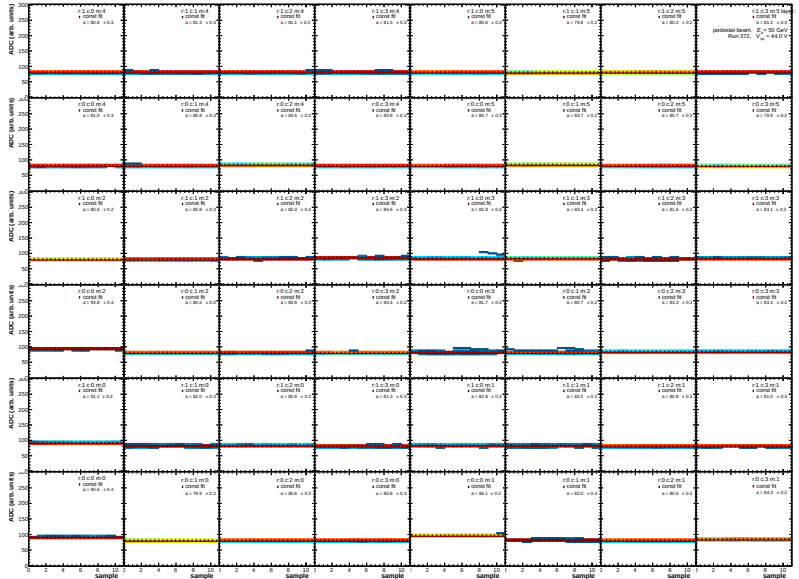
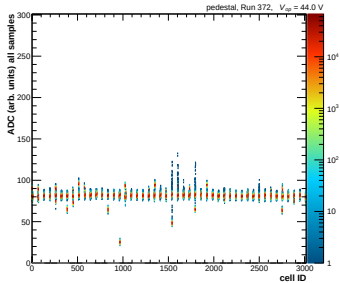
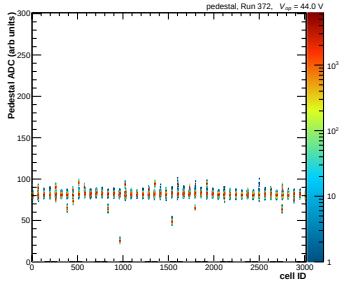
- time:
  - 18.5.2026 17:05 - 19.5.2026 2:36 &
  - 19.5.2026 17:35 -19:01
- $V_{op} = 44$  V,  $V_{br} = 38.3$  V
- Gain settings:
  - RF = 12, CF = 7, CC= 3, CFcomp=1
- e<sup>-</sup> and h<sup>±</sup> with small scintillators
- $\mu$  with large scintillator triggers:
  - 5 positions Scan “\_1”
  - 5 positions Scan “\_2”
  - 6 positions Scan “\_3”



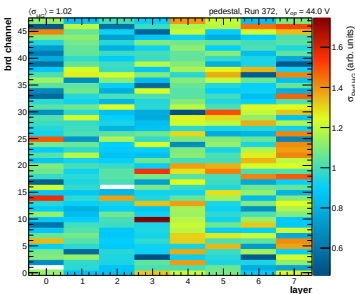
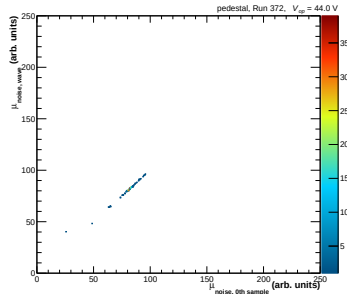
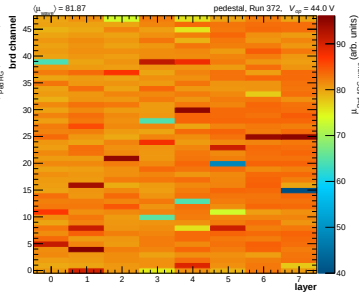
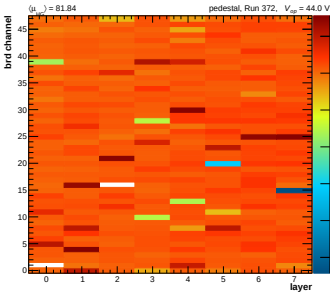
# Muon calibration - Set 1: Pedestals



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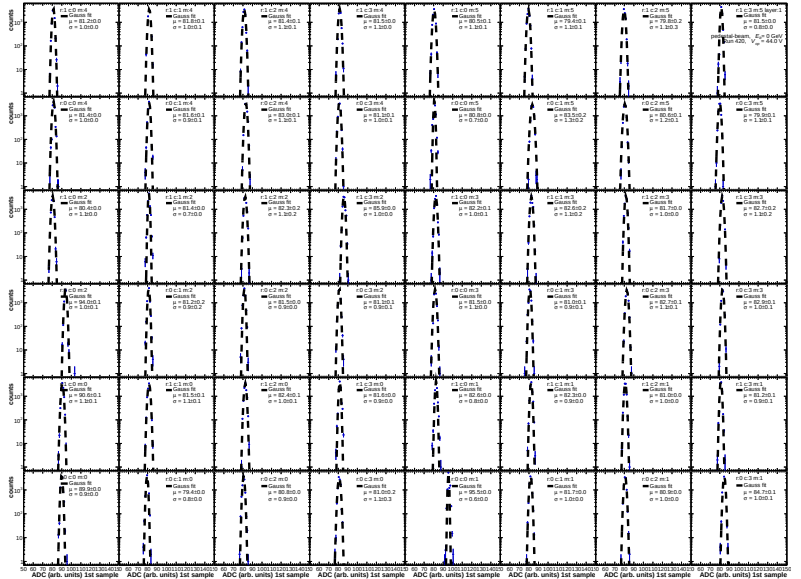
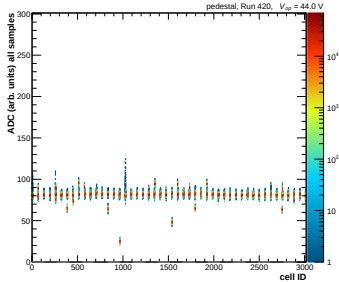
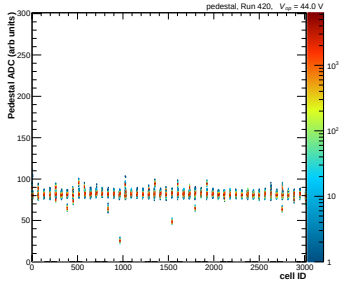


# Muon calibration - Set 1: Pedestals

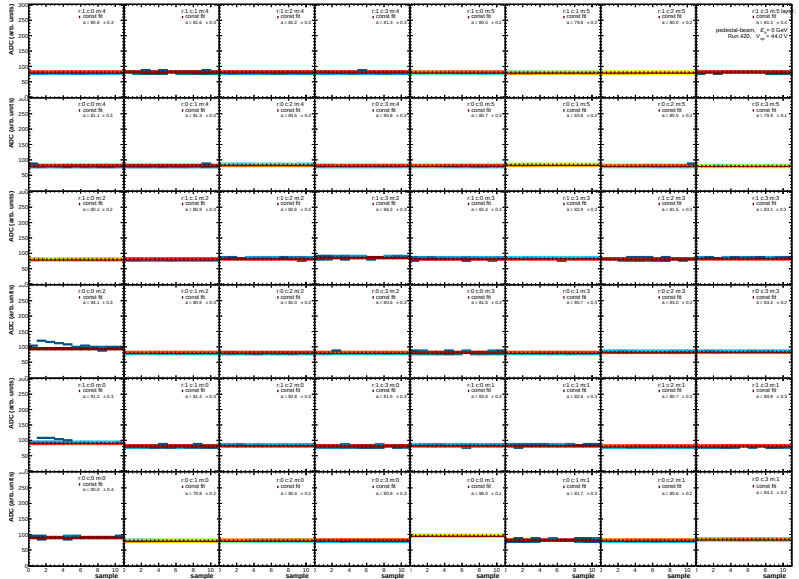
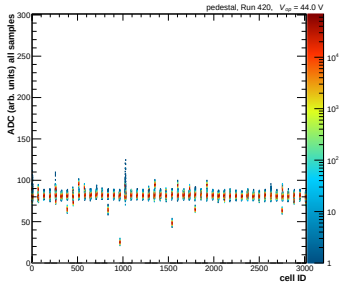
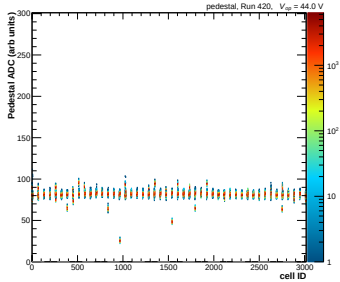


- Pedestal for all readout units set to 80 ADC
- Online calibration verified
- Fitting converges for most cells (4 missing)
- Good correlation between alternative fitting methods for pedestal

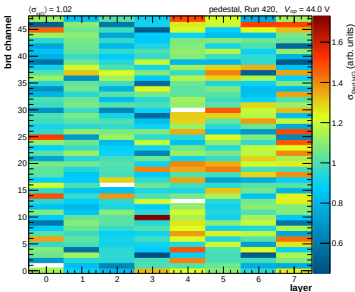
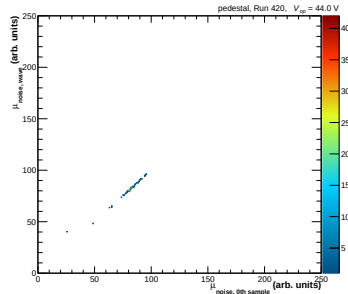
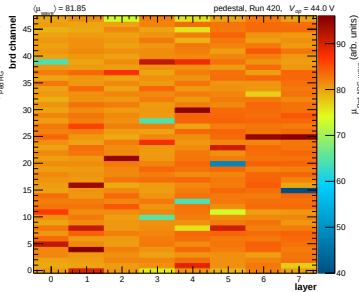
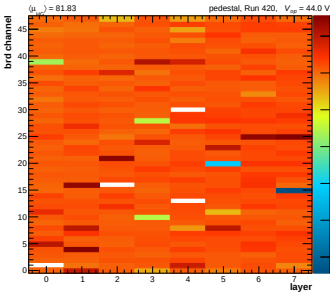
# Muon calibration - Set 2: Pedestals



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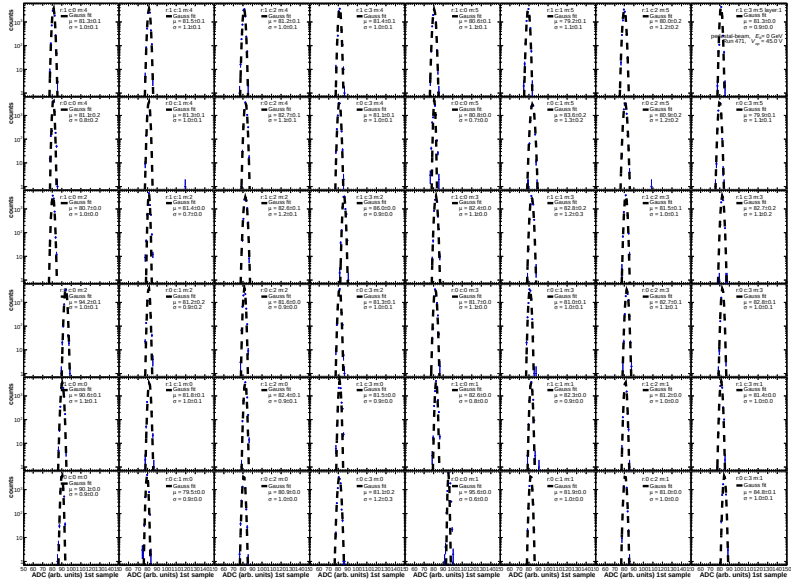
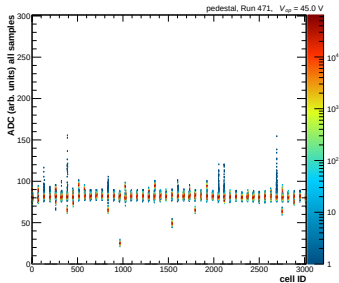
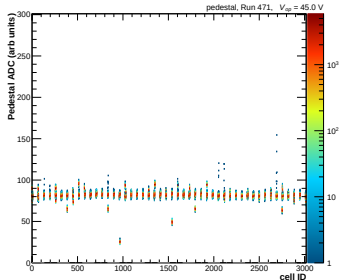


# Muon calibration - Set 2: Pedestals

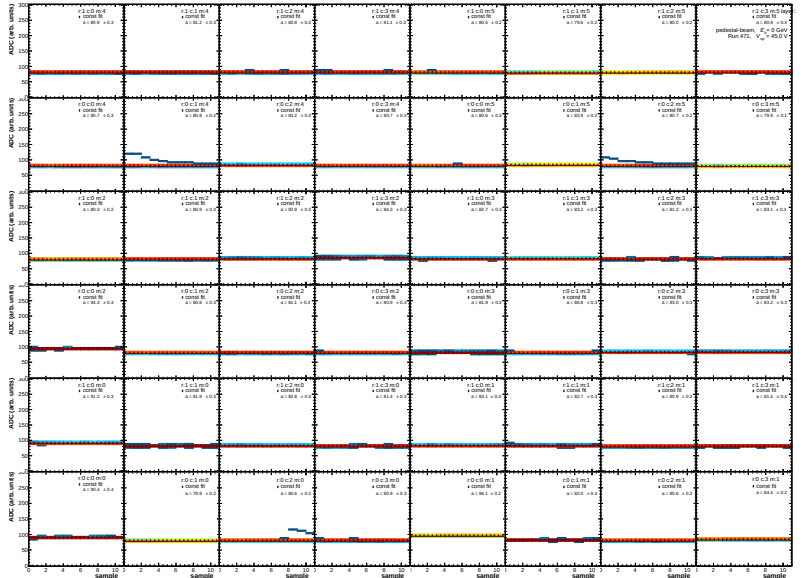
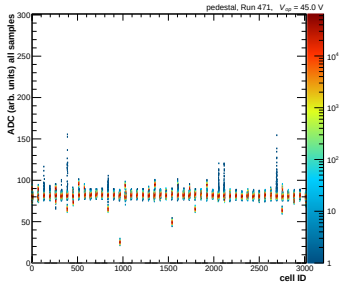
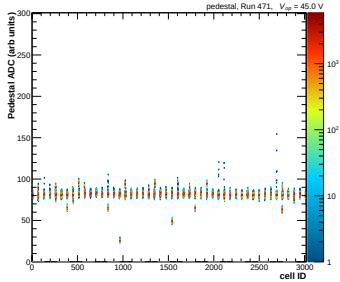


- Pedestal for all readout units set to 80 ADC
- Online calibration verified
- Fitting converges for most cells (3 missing)
- Good correlation between alternative fitting methods for pedestal

# Muon calibration - Set 3: Pedestals

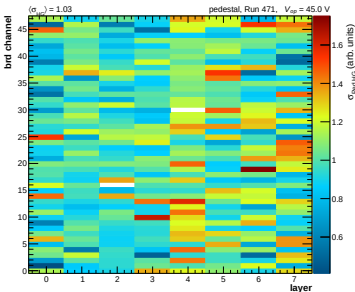
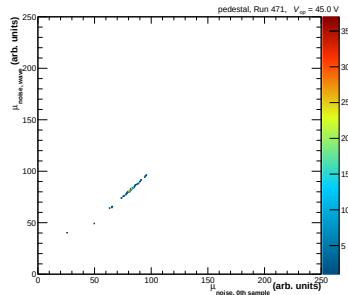
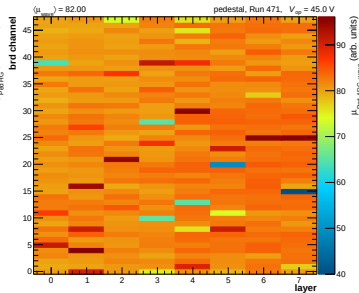
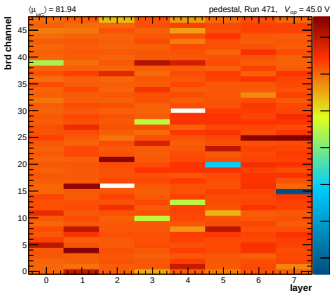


# Muon calibration - Set 3: Pedestals



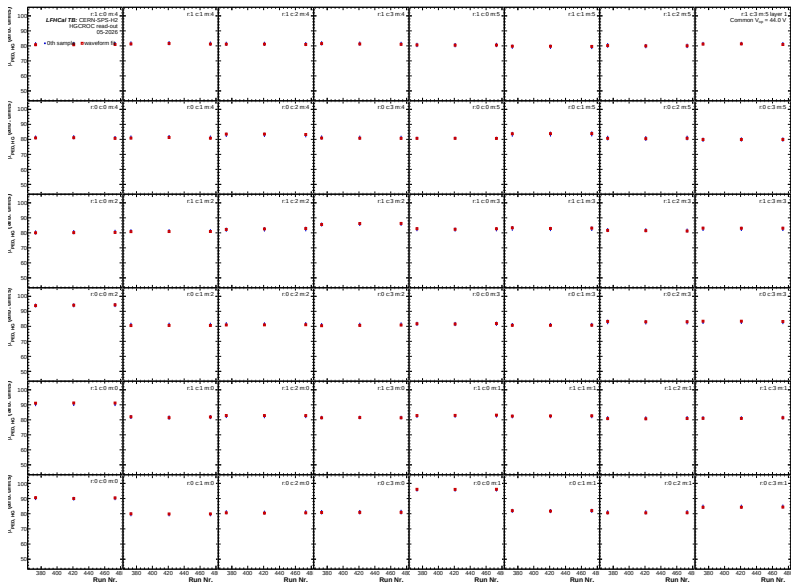
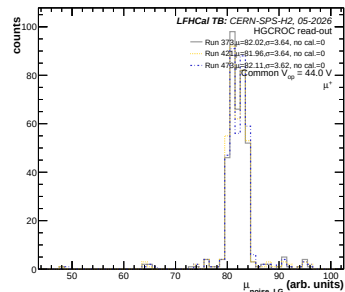
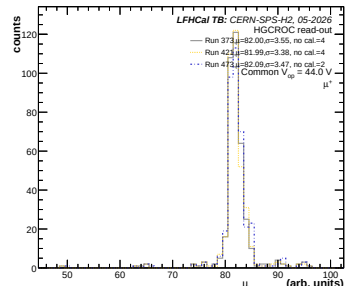


# Muon calibration - Set 3: Pedestals

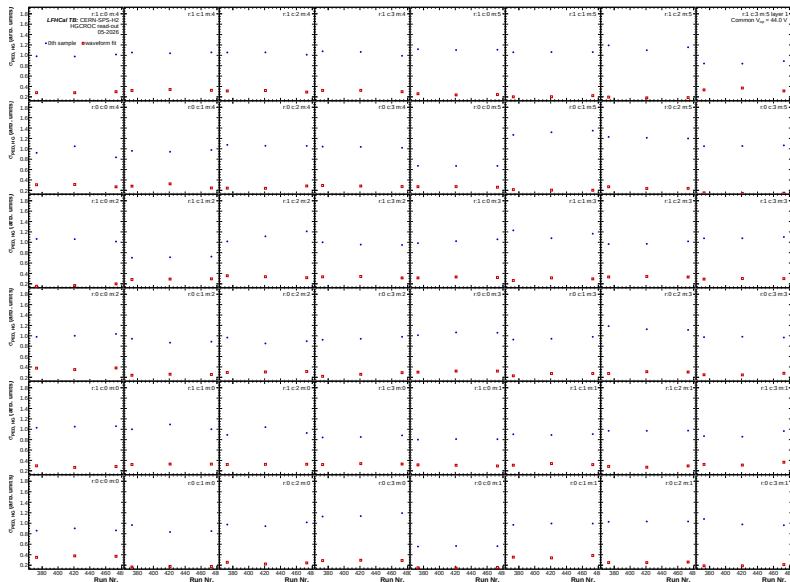
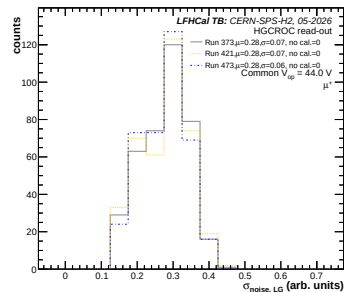
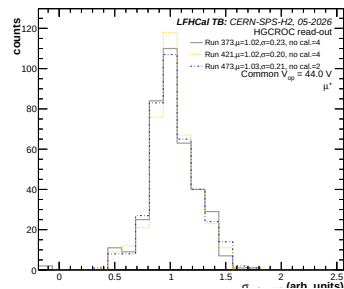


- Pedestal for all readout units set to 80 ADC
- Online calibration verified
- Fitting converges for most cells (2 missing)
- Good correlation between alternative fitting methods for pedestal

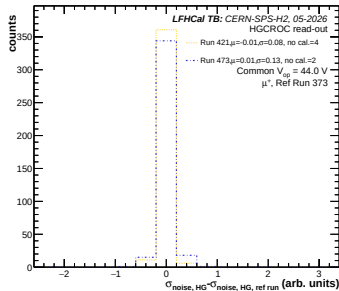
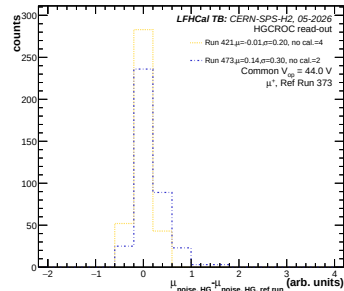
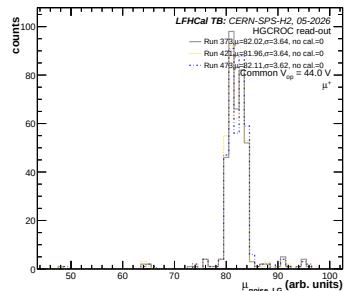
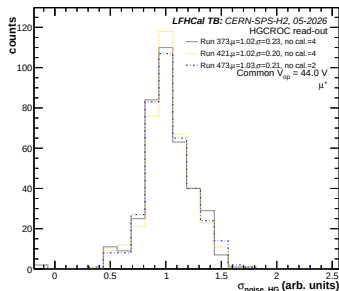
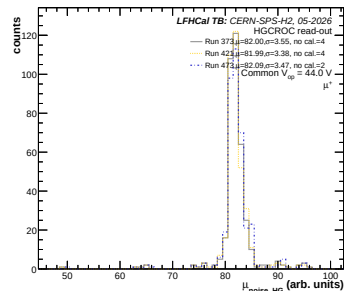
# Muon calibration - Pedestal Comparison



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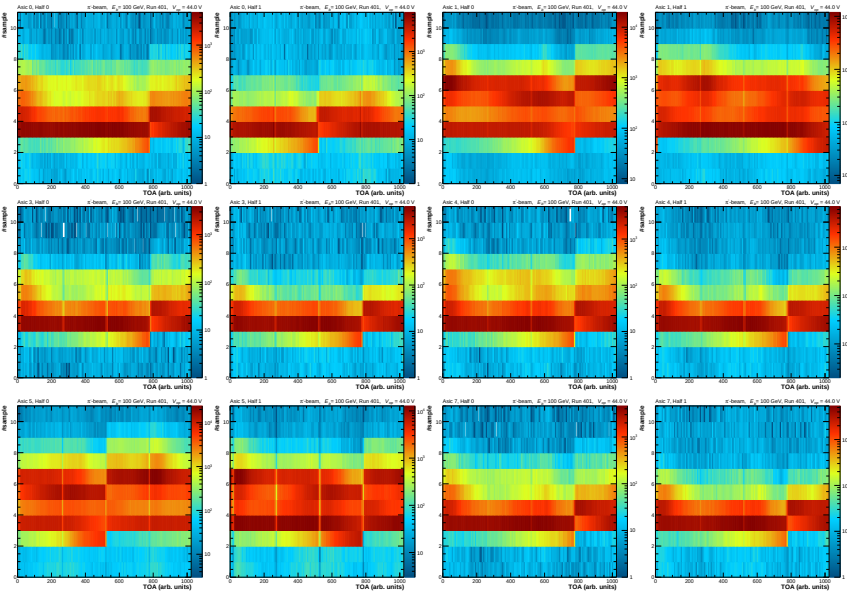


# Muon calibration - Pedestal Comparison



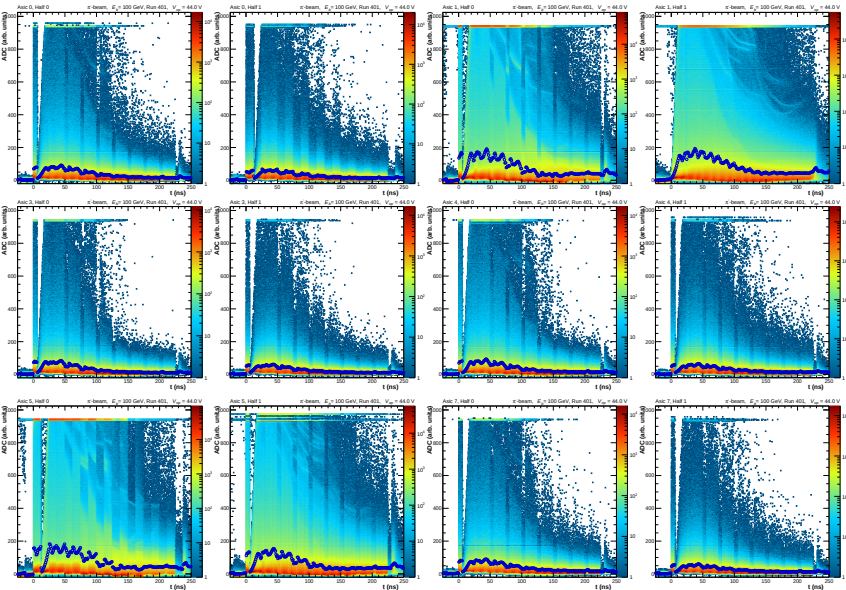
- Very similar pedestal position for all pedestal runs
- Width varies slightly between runs, but within fitting uncertainties
- Either run could be used for corrections

# TOA offset calibration



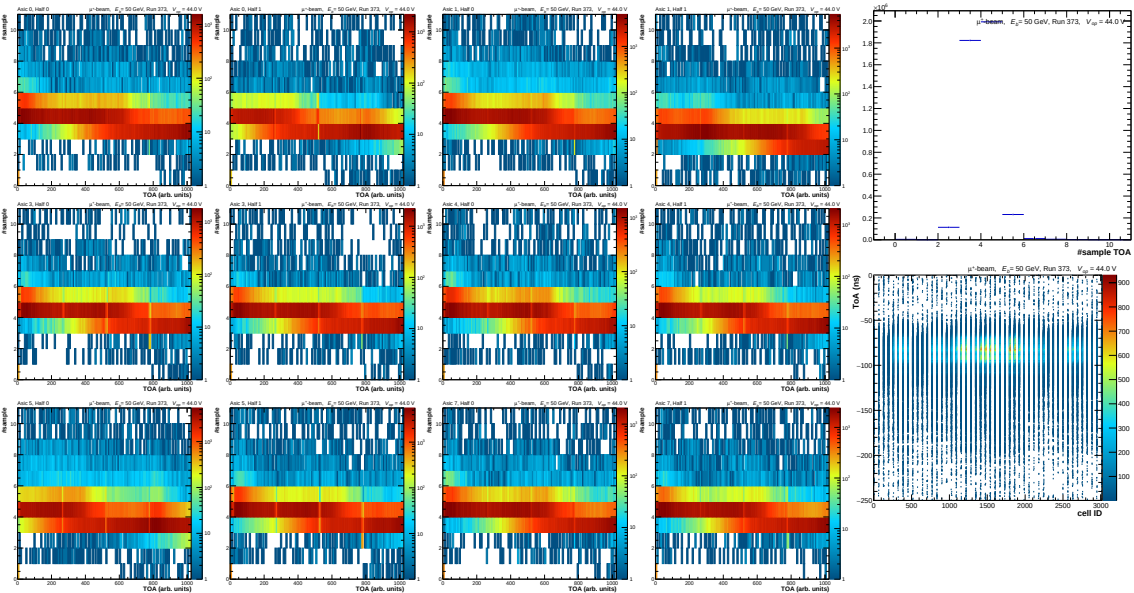
- Estimated using 100 GeV pion run (401)
- Based on ToA vs nSample plot
- Applied consistently to subsets 1-2
- [TOA calib offset file (1 & 2)]
- Using ToA offsets from run 452 (FullSet F) for 3rd subset
- [TOA calib offset file (3)]

# TOA offset calibration

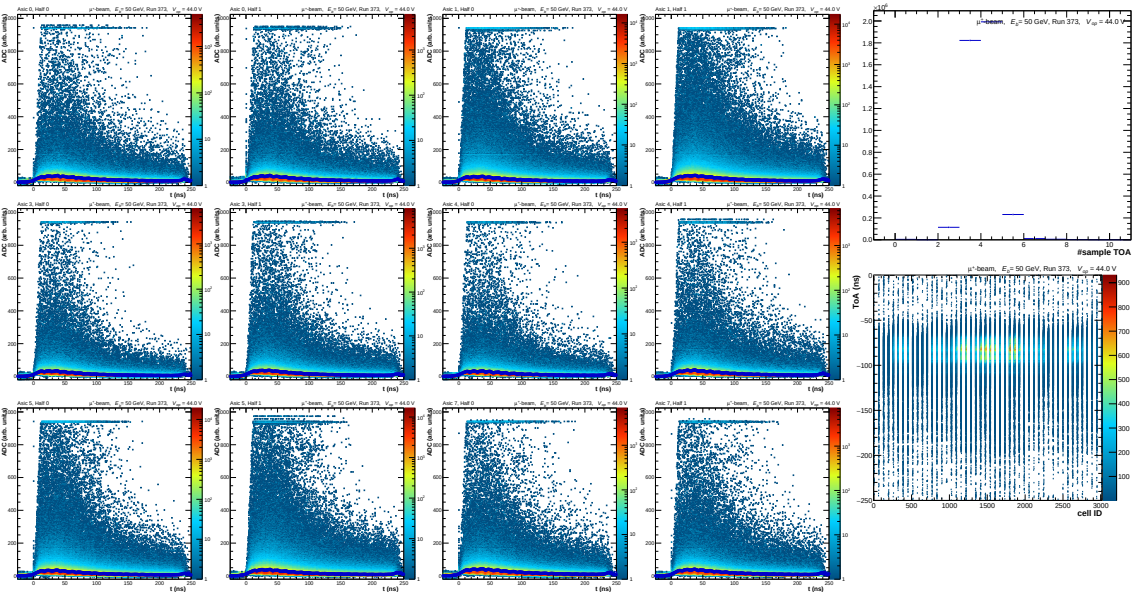


- Estimated using 100 GeV pion run (401)
- Based on ToA vs nSample plot
- Applied consistently to subsets 1-2
- [TOA calib offset file (1 & 2)]
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- [TOA calib offset file (3)]

# TOA offset calibration - Applied Set 1

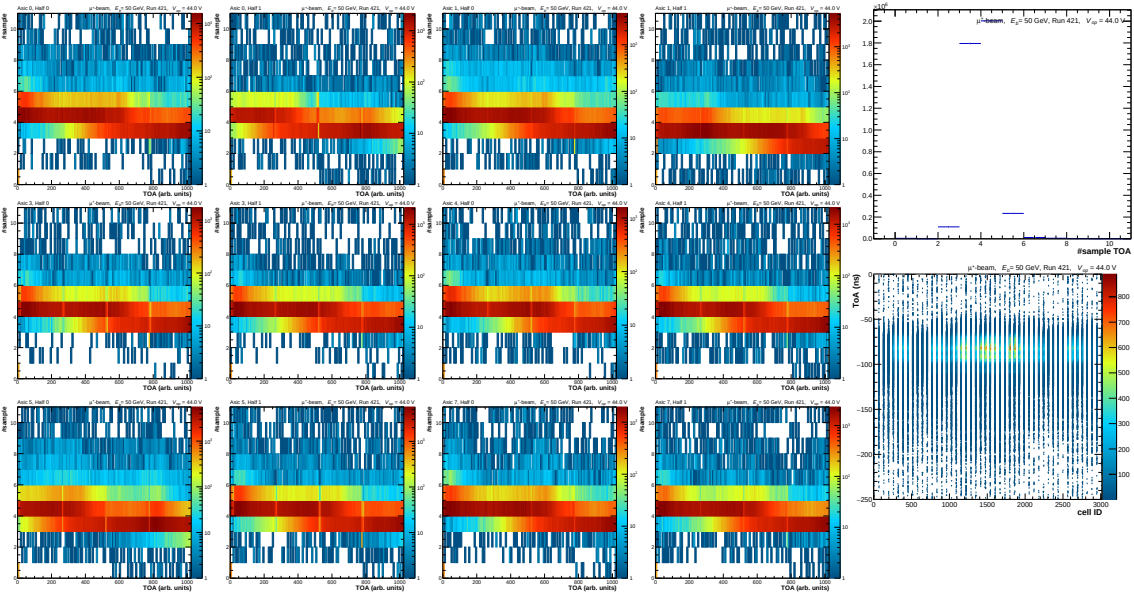


# TOA offset calibration - Applied Set 1

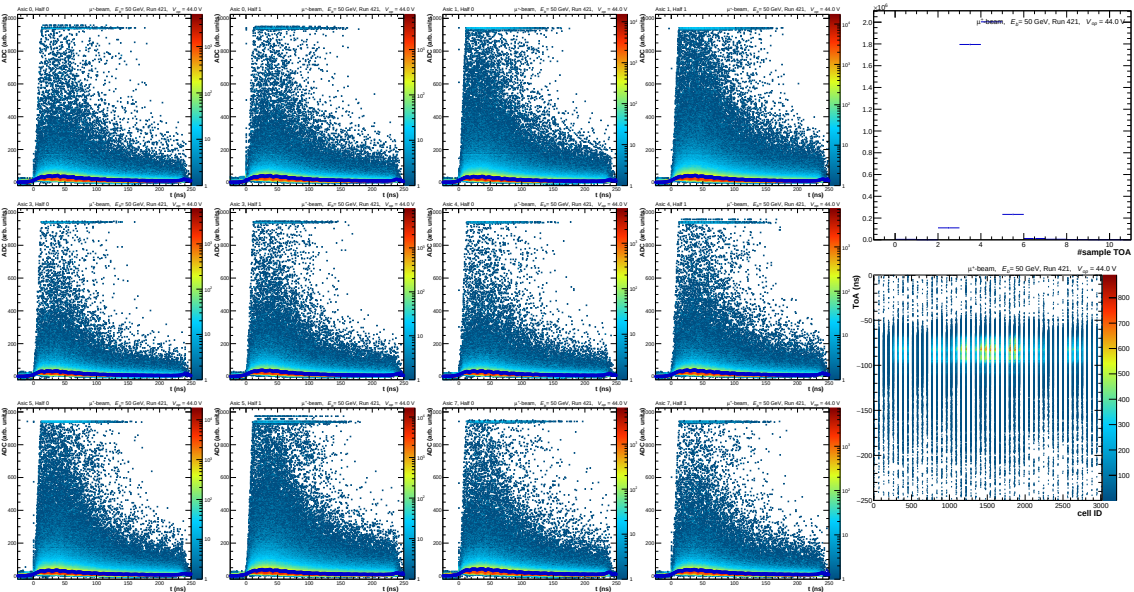




# TOA offset calibration - Applied Set 2

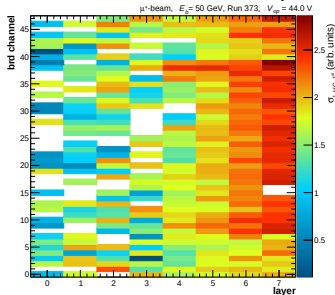
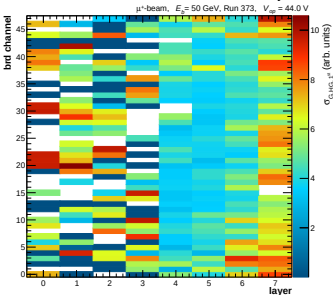
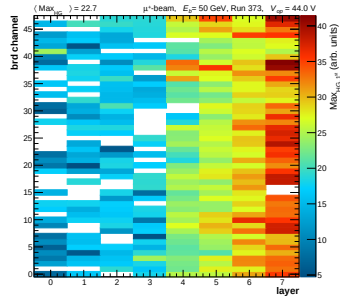
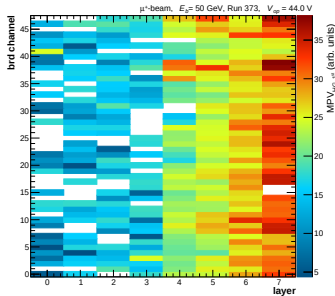
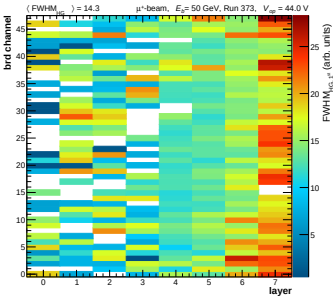


# TOA offset calibration - Applied Set 2



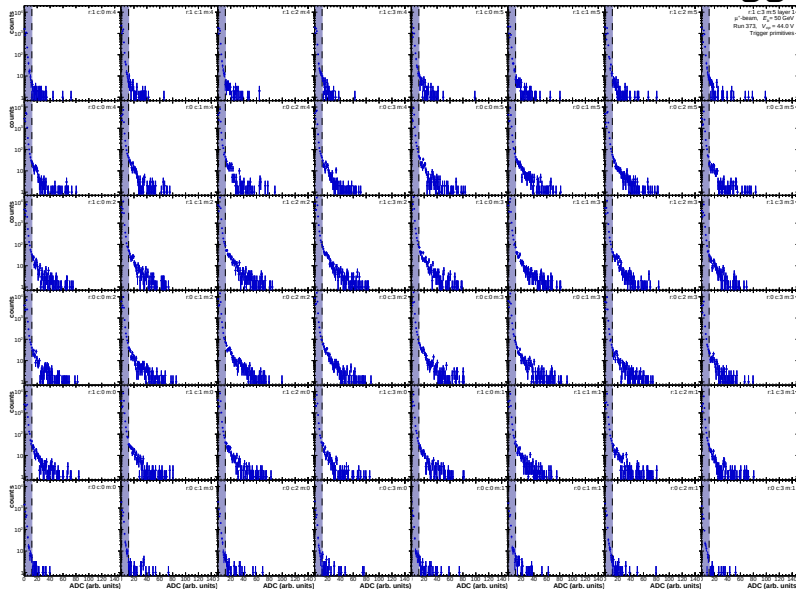


# Muon calibration - Set 1: Muons - init (blue)

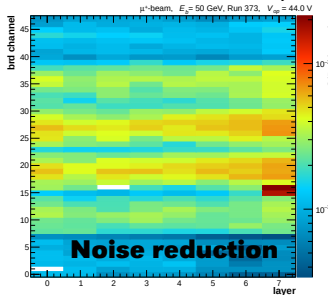
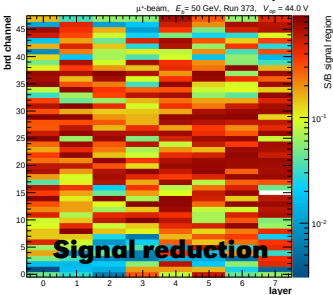
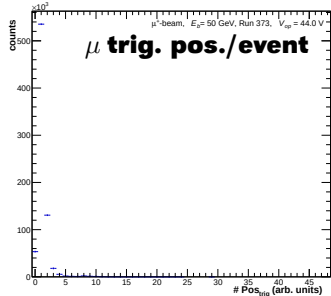
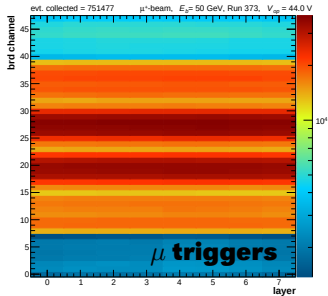
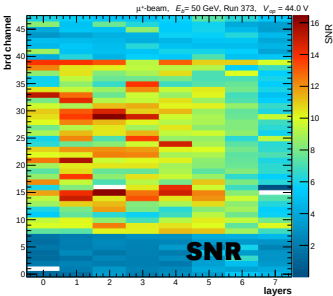


- Initial fit for 44 V & RF=12 with lots of non converging cells, most of front layers fail initial fit (too bad separation between pedestal & mip )
- $\langle \text{Max}_{\text{mip}} \rangle = 22.7$

# Muon calibration - Set 1: Muons - Trigger



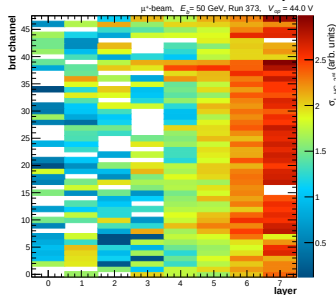
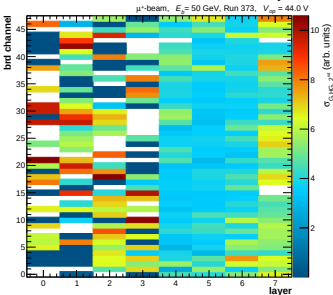
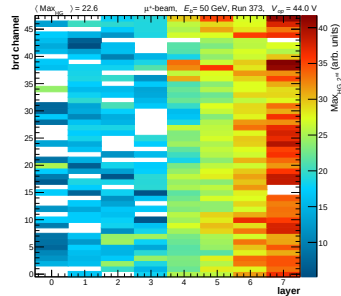
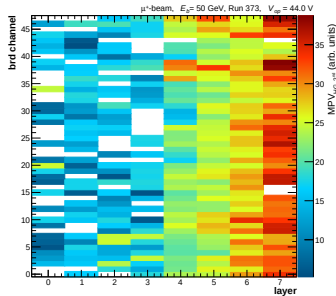
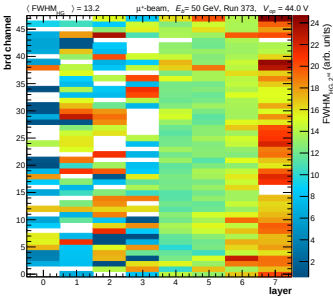
# Muon calibration - Set 1: Muons - Trigger



- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in  $z > 3\sigma_{ped}$
- ⇒ Noise suppression could be improved by increasing  $n\sigma_{ped}$
- Clear enhancement in trigger primitives, 0th level muon selection within  $0.3\langle Max_{mip} \rangle < trigg_{prim} < 4\langle Max_{mip} \rangle$
- Same range used for skimming
- Significant reduction of noise peak (red vs. blue on next page)



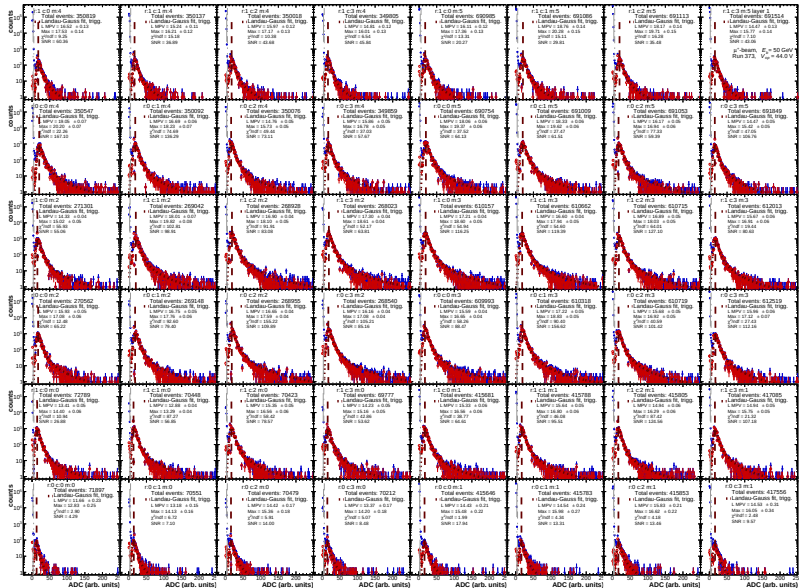
# Muon calibration - Set 1: Muons - 0th ite



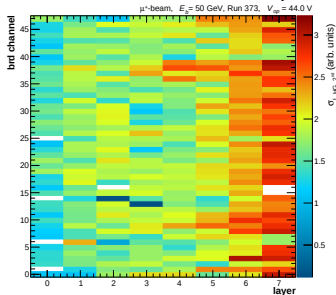
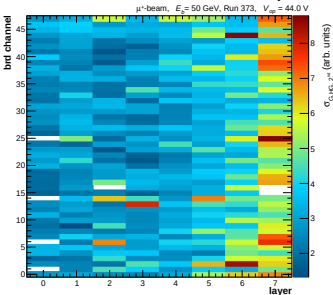
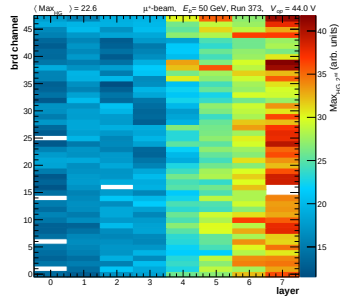
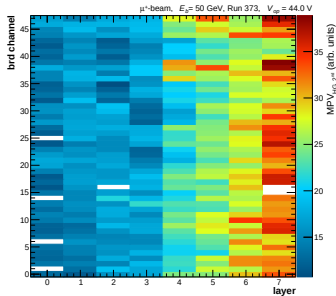
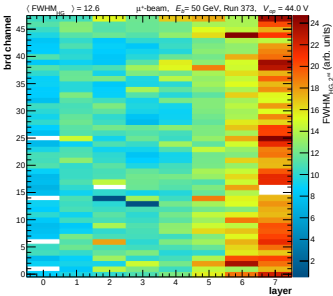
- Increased successrate, but still lots of failures in lower layers
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 22.6$



# Muon calibration - Set 1: Muons - 5th ite

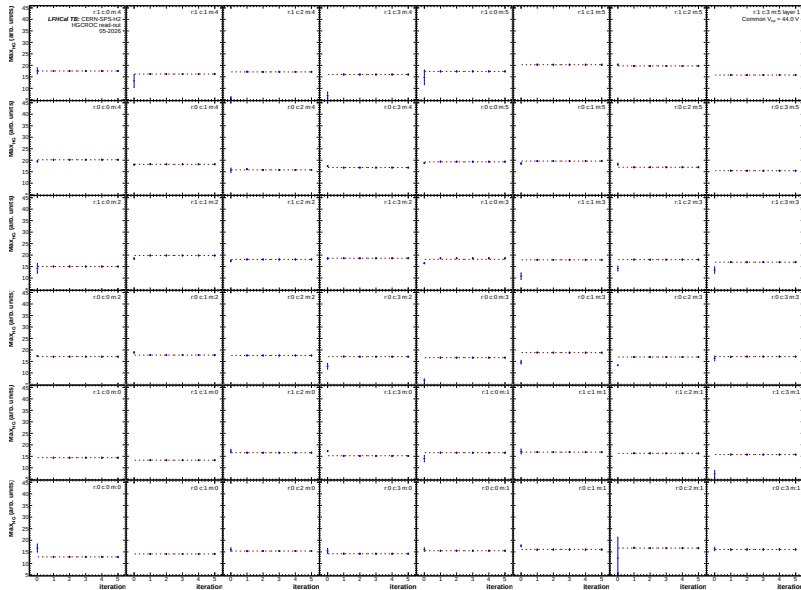


# Muon calibration - Set 1: Muons - 5th ite

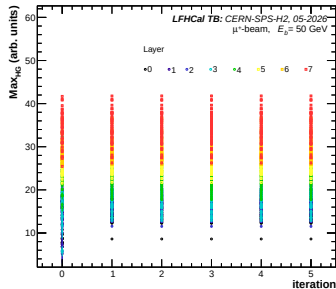
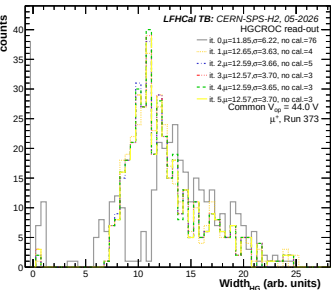
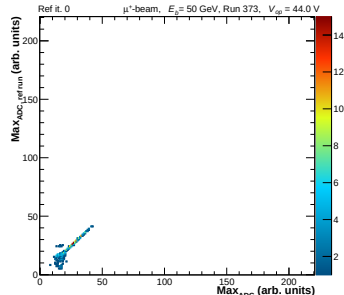
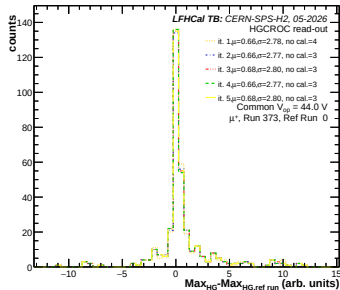
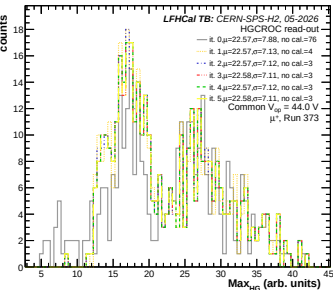


- Nearly all channels "fitable"
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 22.6$

# Muon calibration - Set 1: Muons - Iterations



# Muon calibration - Set 1: Muons - Iterations

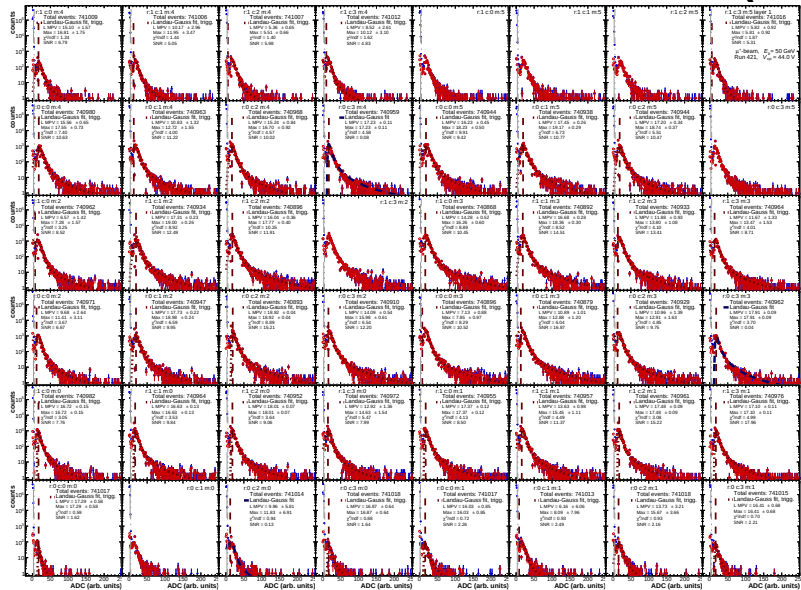


- Reduced mip selection range for trigger primitives  
 $0.8 \langle Max_{mip} \rangle < trigg_{prim} < 2.5 \langle Max_{mip} \rangle$

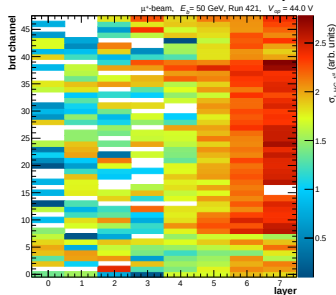
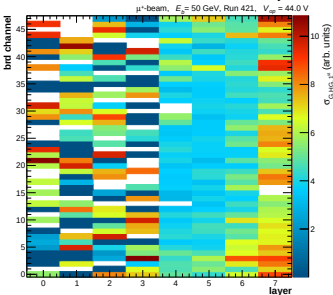
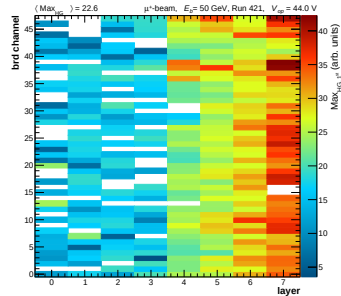
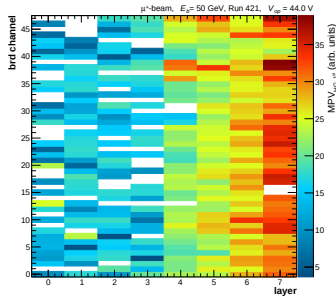
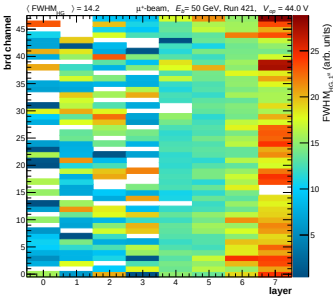
⇒ Further reduction of noise peak

- Refined fitting during improved iterations using average mip from previous iteration as basis for constraints
- Convergence of most cells within 3-4 iterations, very few cells still fail after 5 iterations

# Muon calibration - Set 2: Muons - init (blue)

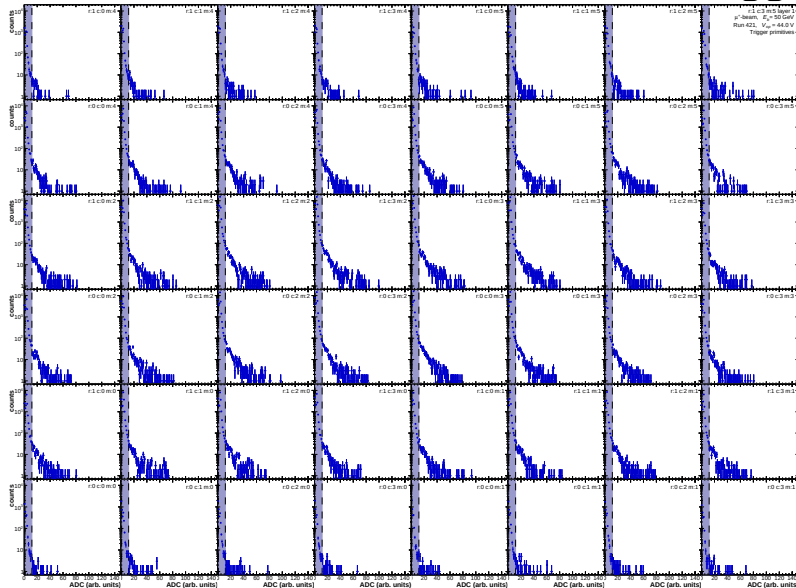


# Muon calibration - Set 2: Muons - init (blue)

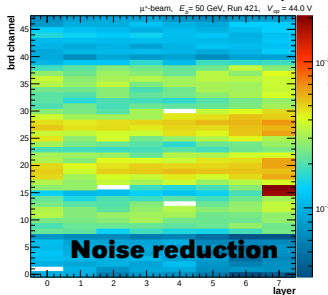
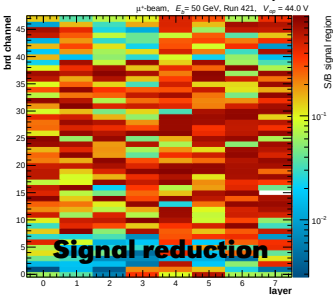
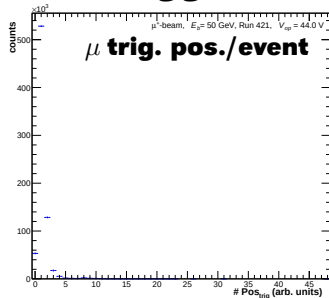
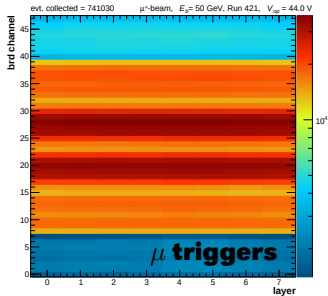
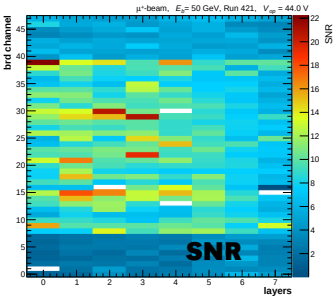


- Initial fit for 44 V & RF=12, with lots of non converging cells, most of front layers fail initial fit (too bad separation between pedestal & mip)
- $\langle \text{Max}_{\text{mip}} \rangle = 22.6$
- No strong ch-by-ch variations in individual parameters per layer

# Muon calibration - Set 2: Muons - Trigger



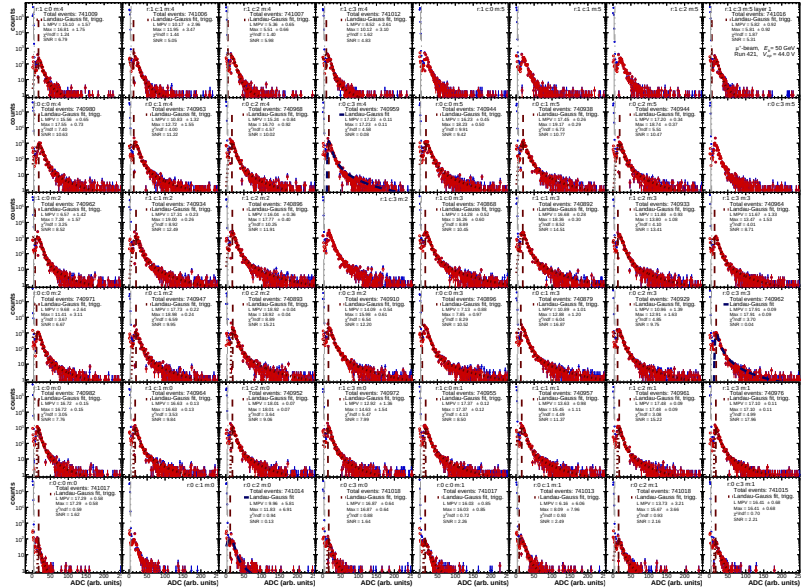
# Muon calibration - Set 2: Muons - Trigger



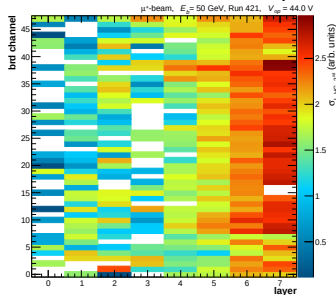
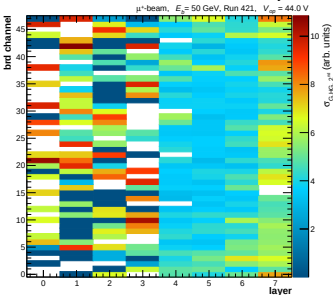
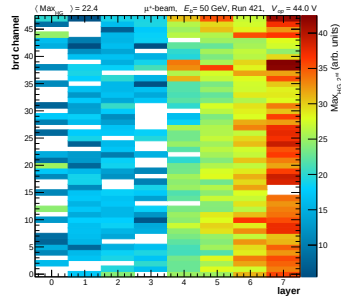
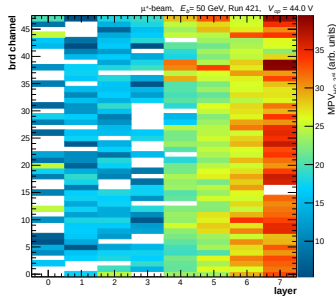
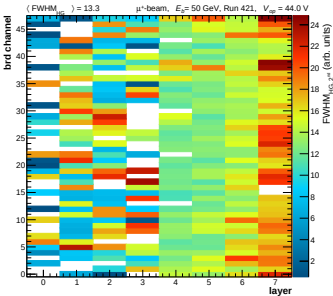
- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in  $z > 3\sigma_{ped}$
- ⇒ Noise suppression could be improved by increasing  $n\sigma_{ped}$
- Clear enhancement in trigger primitives, 0th level muon selection within  $0.3\langle Max_{mip} \rangle < trigg_{prim} < 4\langle Max_{mip} \rangle$
- Same range used for skimming
- Significant reduction of noise peak (red vs. blue on next page)



# Muon calibration - Set 2: Muons - 0th ite

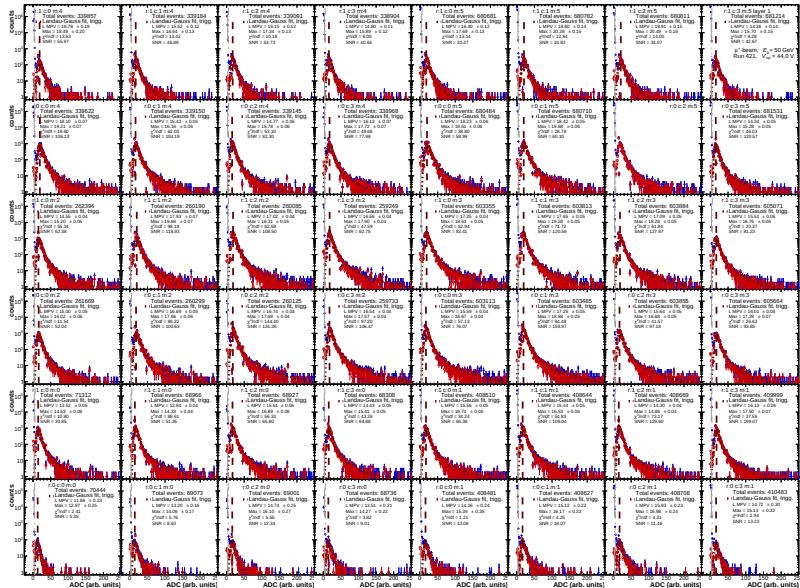


# Muon calibration - Set 2: Muons - 0th ite

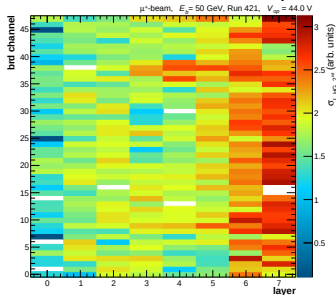
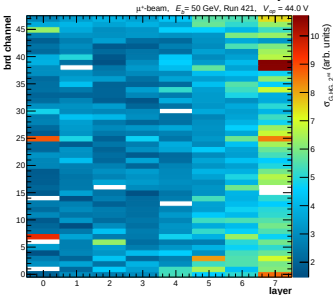
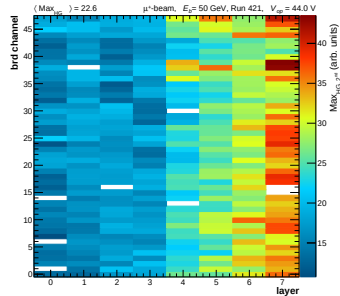
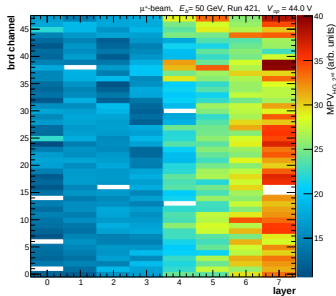
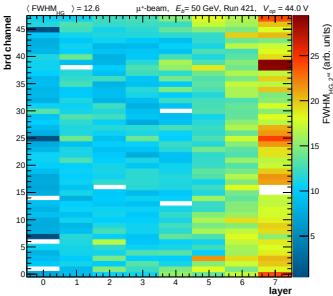


- Increased successrate, but still lots of failures in lower layers
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 22.4$

# Muon calibration - Set 2: Muons - 5th ite

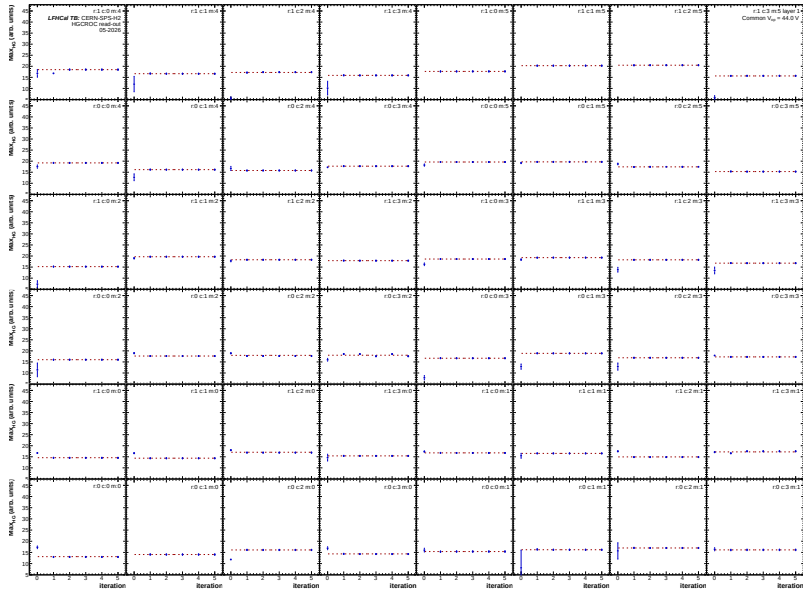


# Muon calibration - Set 2: Muons - 5th ite

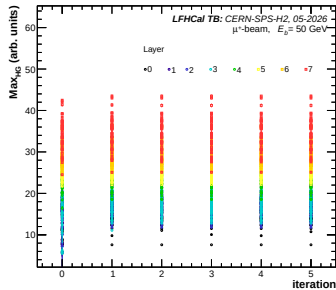
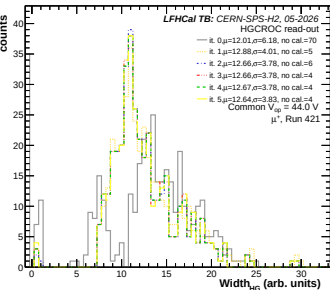
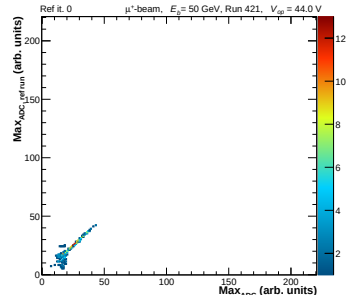
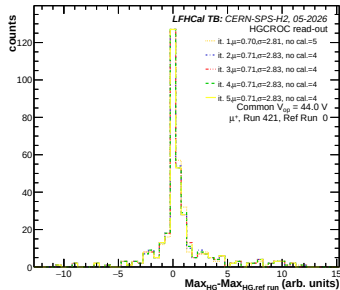
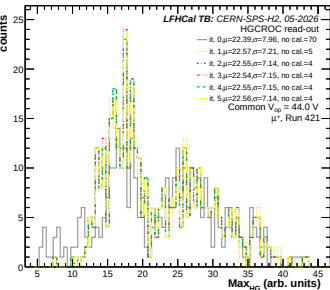


- Nearly all channels "fitable"
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 22.6$

# Muon calibration - Set 2: Muons - Iterations



# Muon calibration - Set 2: Muons - Iterations

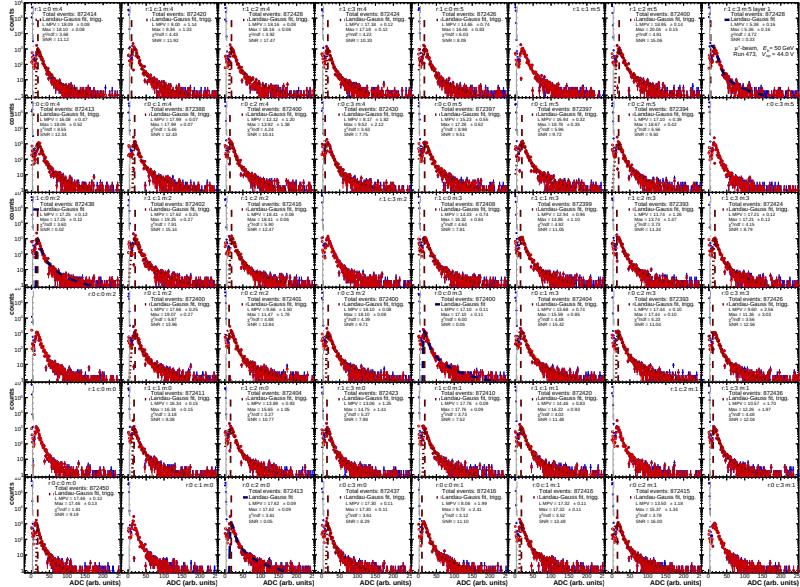


- Reduced mip selection range for trigger primitives  
 $0.8 \langle Max_{mip} \rangle < trigg_{prim} < 2.5 \langle Max_{mip} \rangle$

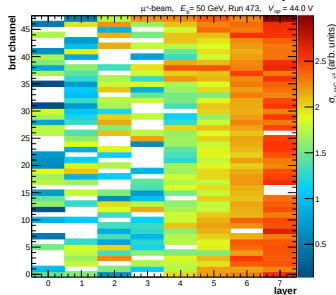
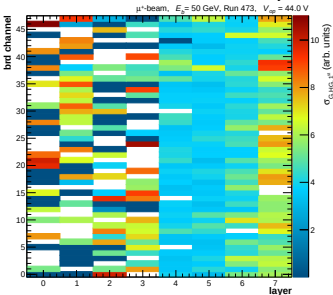
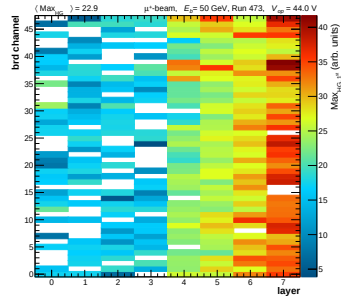
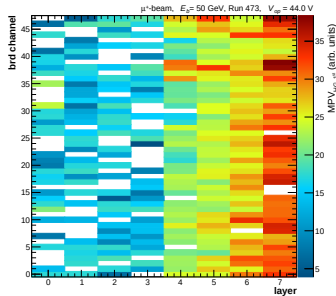
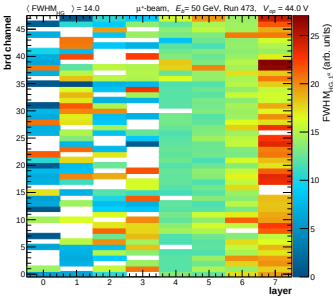
⇒ Further reduction of noise peak

- Refined fitting during improved iterations using average mip from previous iteration as basis for constraints
- Convergence of most cells within 3-4 iterations, very few cells still fail after 5 iterations

# Muon calibration - Set 3: Muons - init (blue)



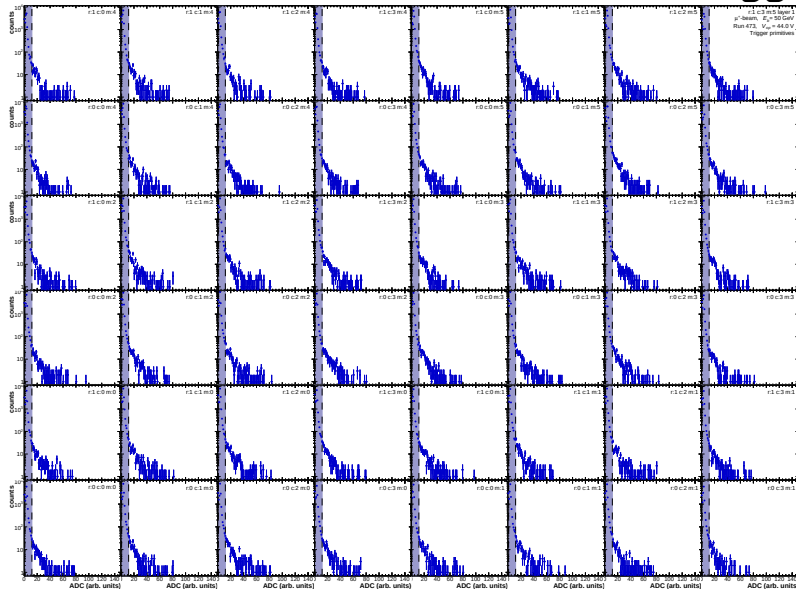
# Muon calibration - Set 3: Muons - init (blue)



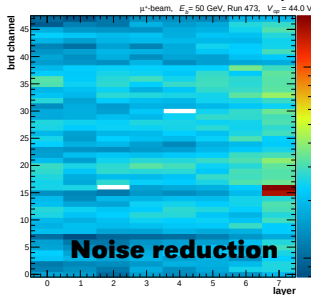
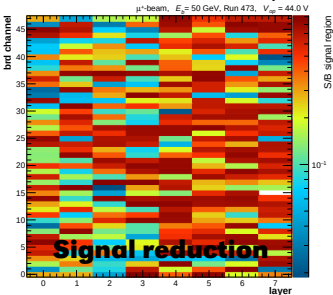
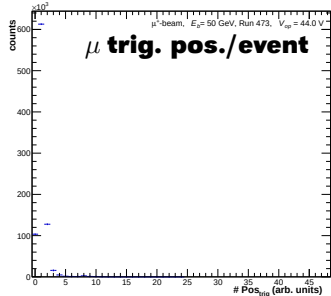
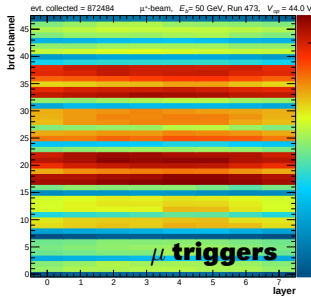
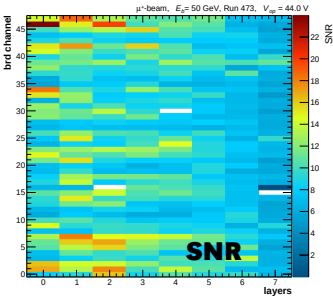
- Initial fit for 44 V & RF=12, with lots of non converging cells, most of front layers fail initial fit (too bad separation between pedestal & mip)
- $\langle Max_{mip} \rangle = 22.9$
- No strong ch-by-ch variations in individual parameters per layer



# Muon calibration - Set 3: Muons - Trigger

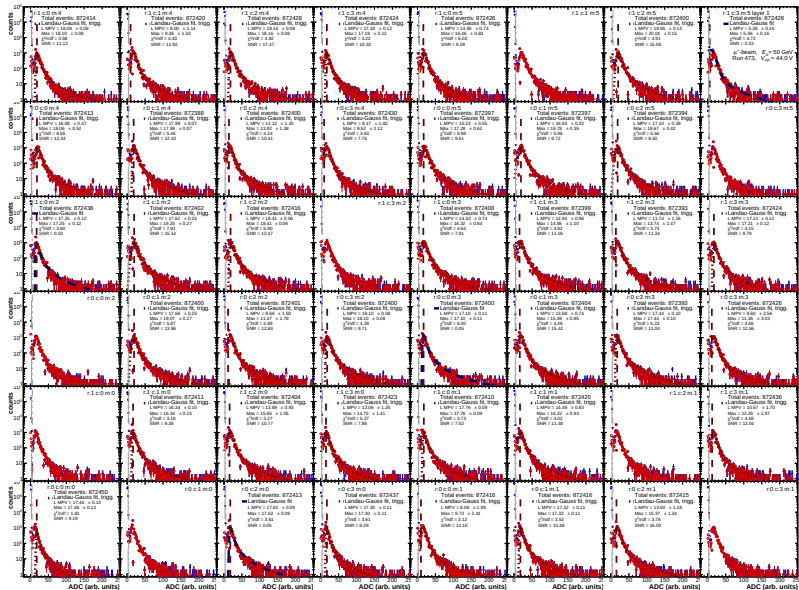


# Muon calibration - Set 3: Muons - Trigger

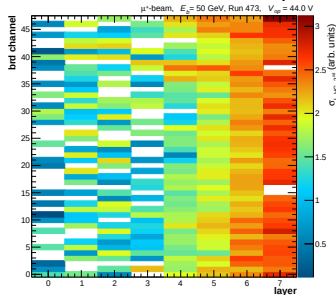
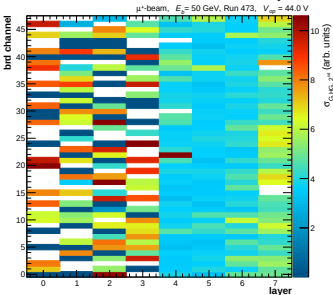
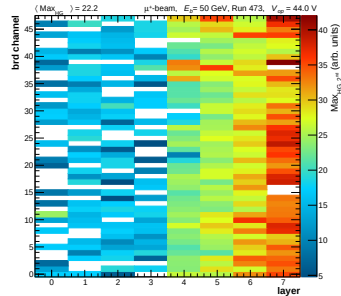
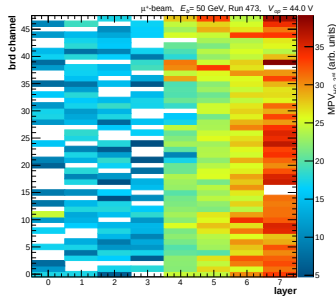
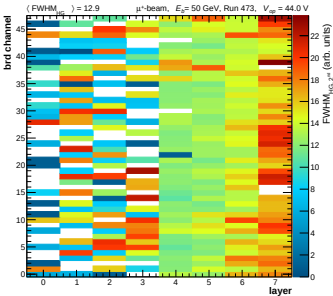


- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in  $z > 3\sigma_{ped}$
- ⇒ Noise suppression could be improved by increasing  $n\sigma_{ped}$
- Clear enhancement in trigger primitives, 0th level muon selection within  $0.3\langle Max_{mip} \rangle < trigg_{prim} < 4\langle Max_{mip} \rangle$
- Same range used for skimming
- Significant reduction of noise peak (red vs. blue on next page)

# Muon calibration - Set 3: Muons - 0th ite

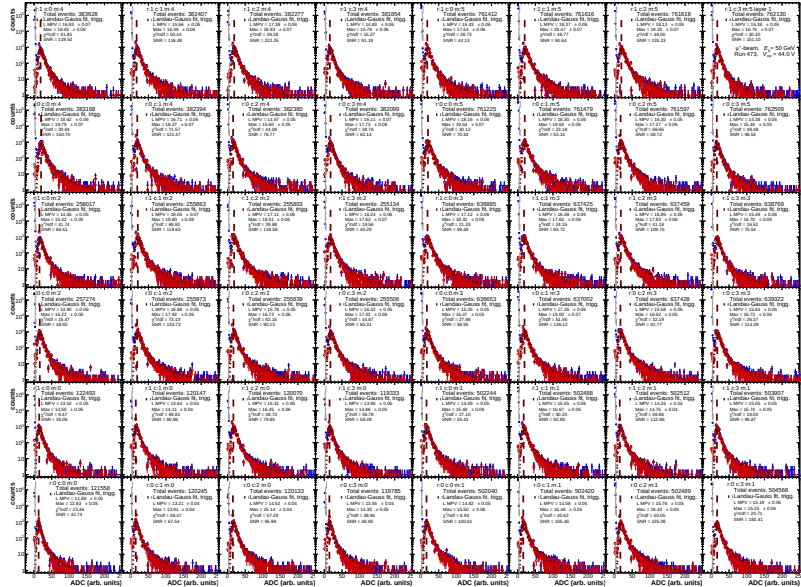


# Muon calibration - Set 3: Muons - 0th ite

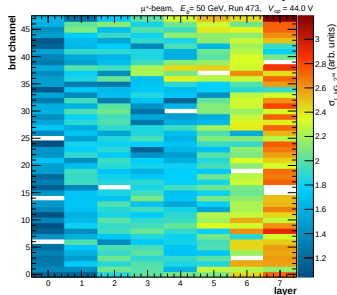
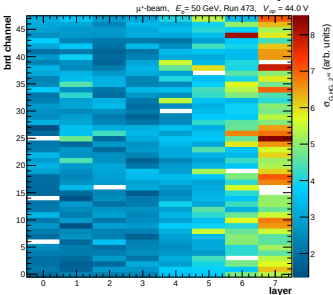
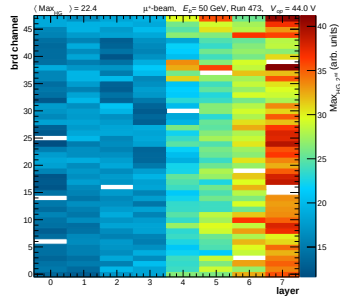
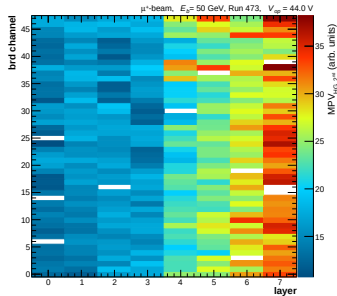
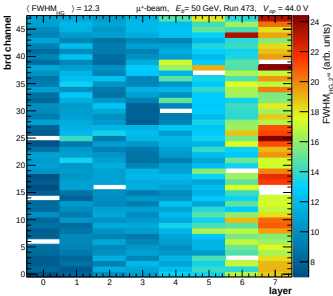


- Increased successrate, but still lots of failures in lower layers
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 22.2$

# Muon calibration - Set 3: Muons - 5th ite

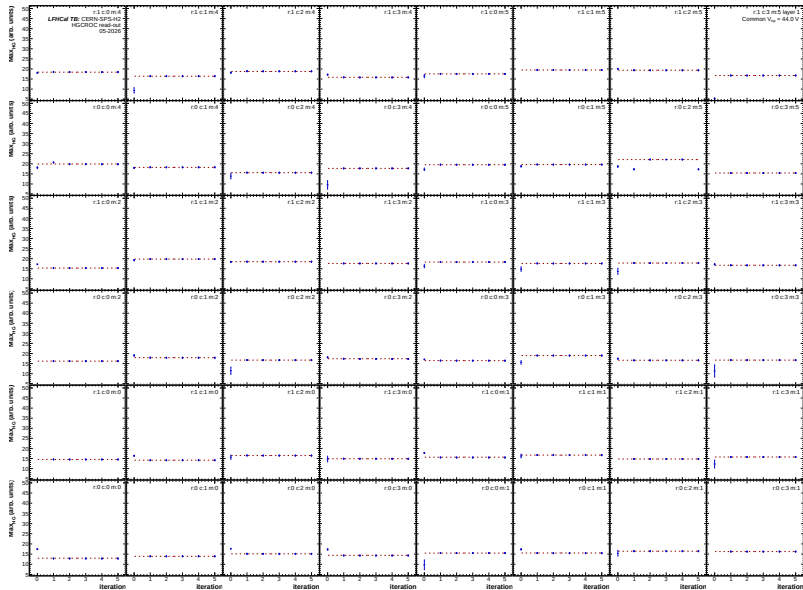


# Muon calibration - Set 3: Muons - 5th ite

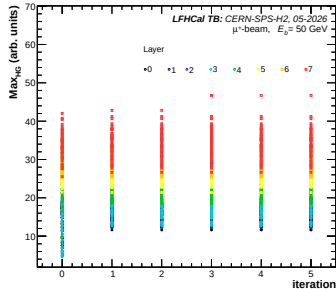
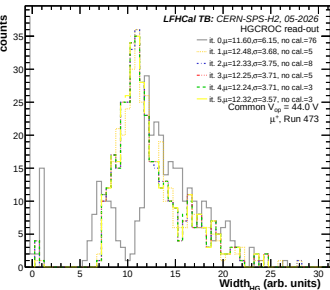
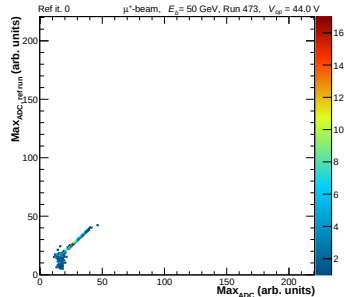
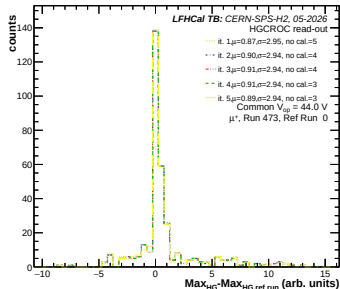
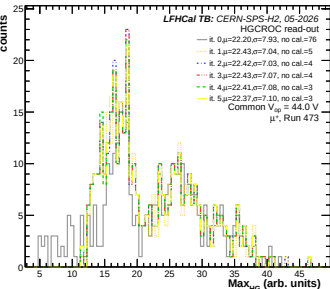


- Nearly all channels "fitable"
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 22.4$

# Muon calibration - Set 3: Muons - Iterations



# Muon calibration - Set 3: Muons - Iterations



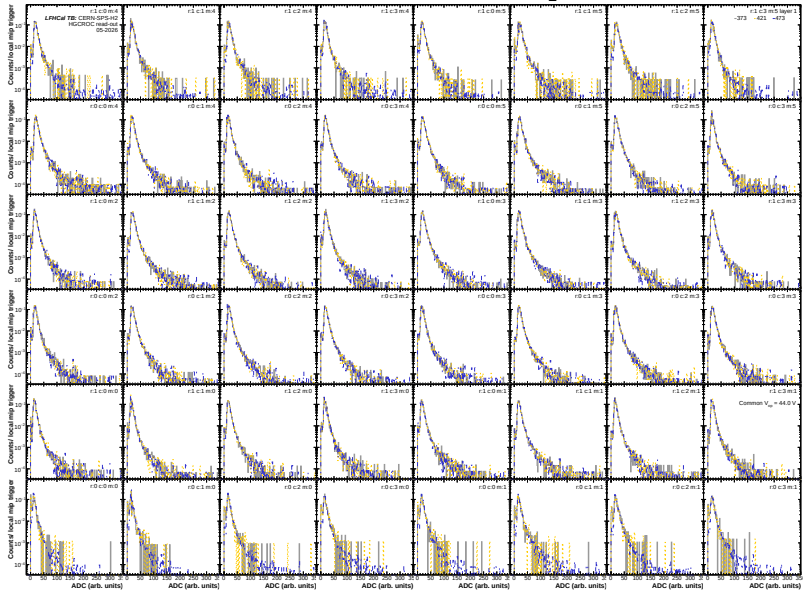
- Reduced mip selection range for trigger primitives  
 $0.8 \langle Max_{mip} \rangle < trigg_{prim} < 2.5 \langle Max_{mip} \rangle$

⇒ Further reduction of noise peak

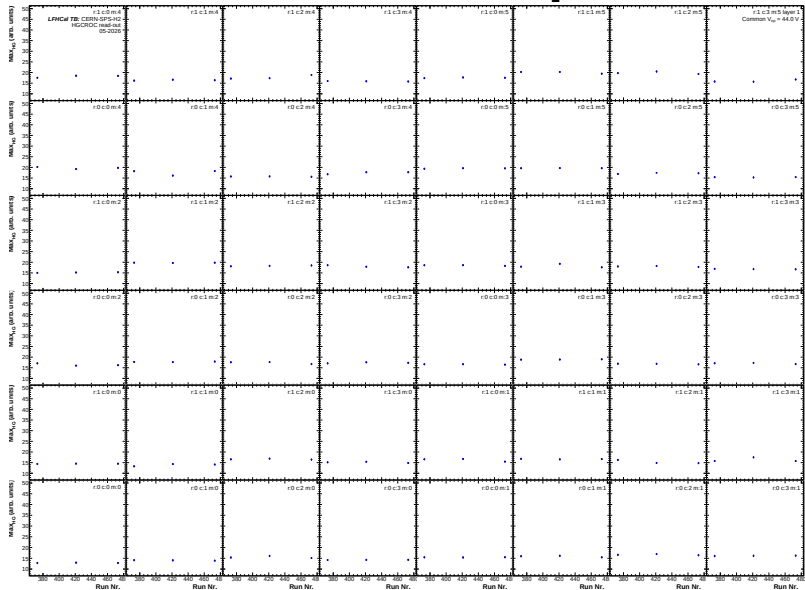
- Refined fitting during improved iterations using average mip from previous iteration as basis for constraints
- Convergence of most cells within 3-4 iterations, very few cells still fail after 5 iterations



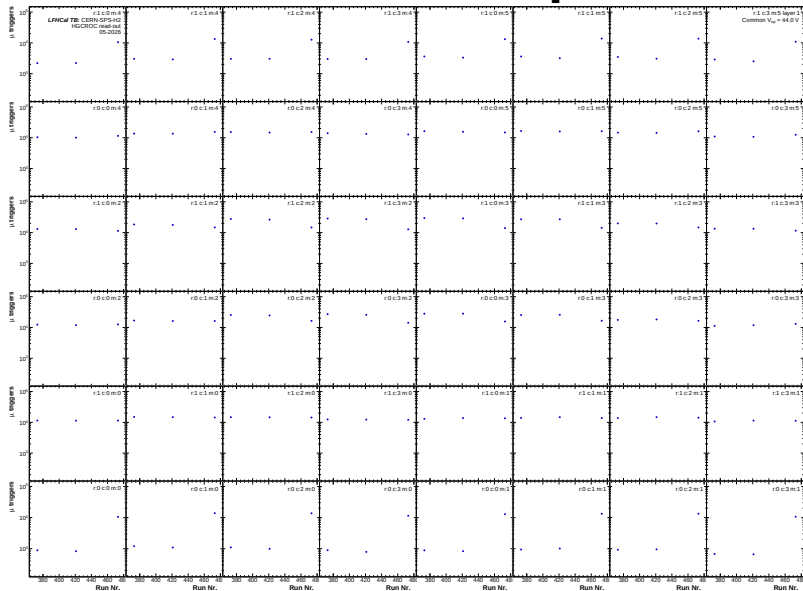
# Muon calibration - Comparison Sets



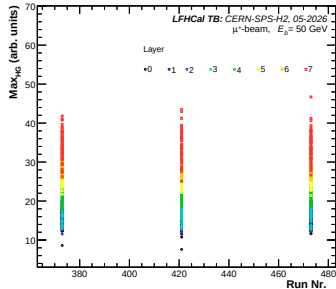
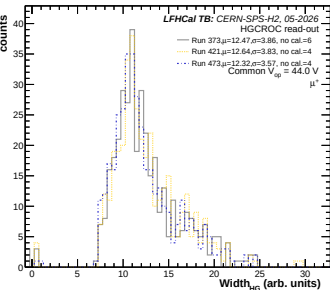
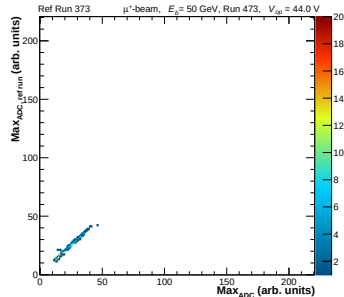
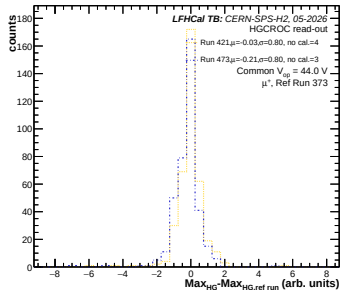
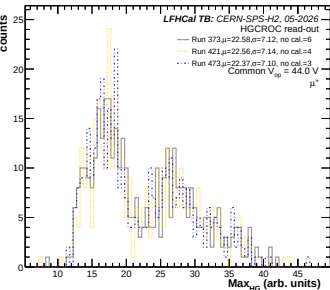
# Muon calibration - Comparison Sets



# Muon calibration - Comparison Sets



# Muon calibration - Comparison Sets



- 3rd set significantly higher statistics at edges
- mip deviations within estimated fitting uncertainties
- very good correlation for same channel
- will use 3rd set for final calibration (1st or 2nd for possible error estimates)

# Calibration summary - Set E



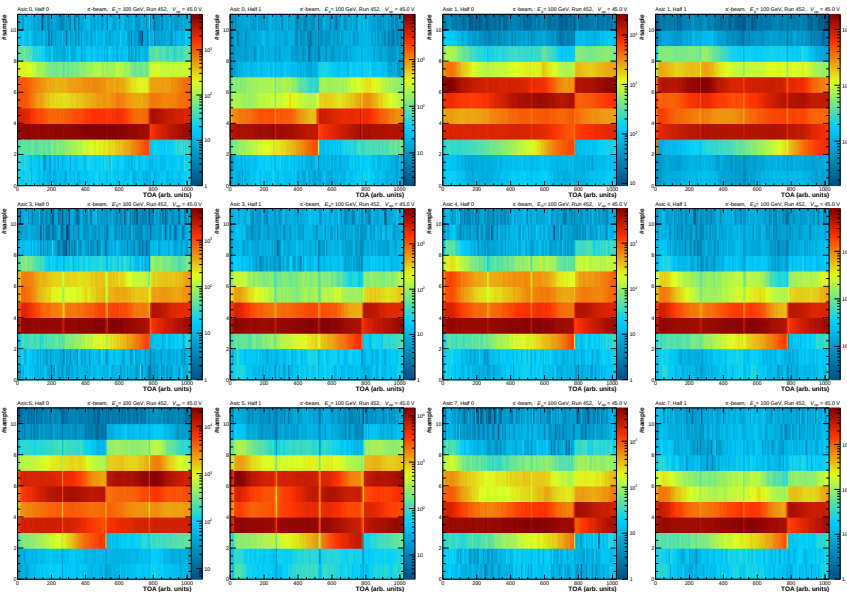
# Calibration summary

- Besides 2 bad channels identified in this data set no further channels found problematic
- ToA offset calibration estimated on 100 GeV  $h^-$  run (pion) run valid for all runs of set E, 3rd muon set calibrated with offset from FullSet F
- Final calibration based off 'Set\_3' (6 beam positions) due to higher statistics & better coverage
  - ▶ Calib file FullSet E 1<sup>st</sup> [txt-file]
  - ▶ Calib file FullSet E 2<sup>nd</sup> [txt-file]
  - ▶ Calib file FullSet E 3<sup>rd</sup> [txt-file]

# Additional material



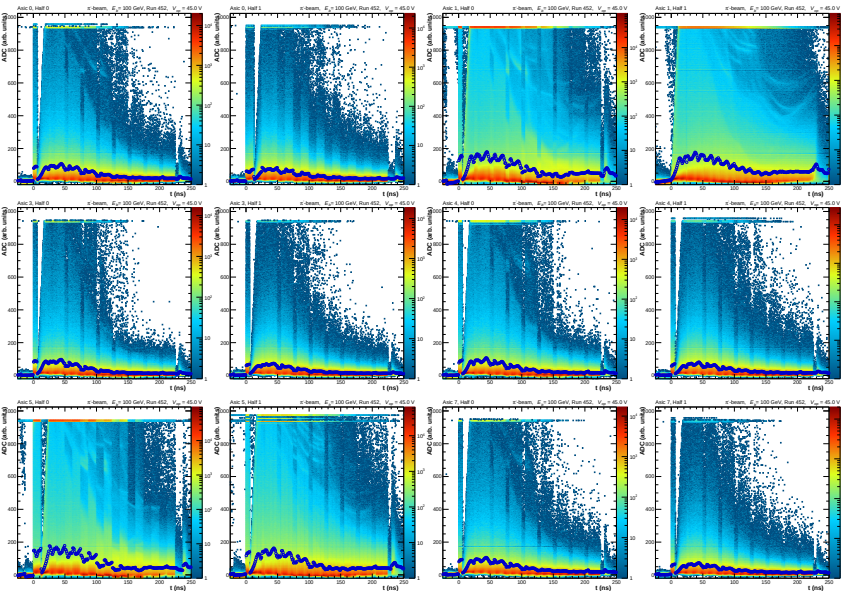
# TOA offset calibration 3rd set



- Estimated using 100 GeV pion run (452)
- Based on ToA vs nSample plot
- Using ToA offsets from run 452 (Full Set F) for 3rd subset
- [TOA calib offset file (3)]

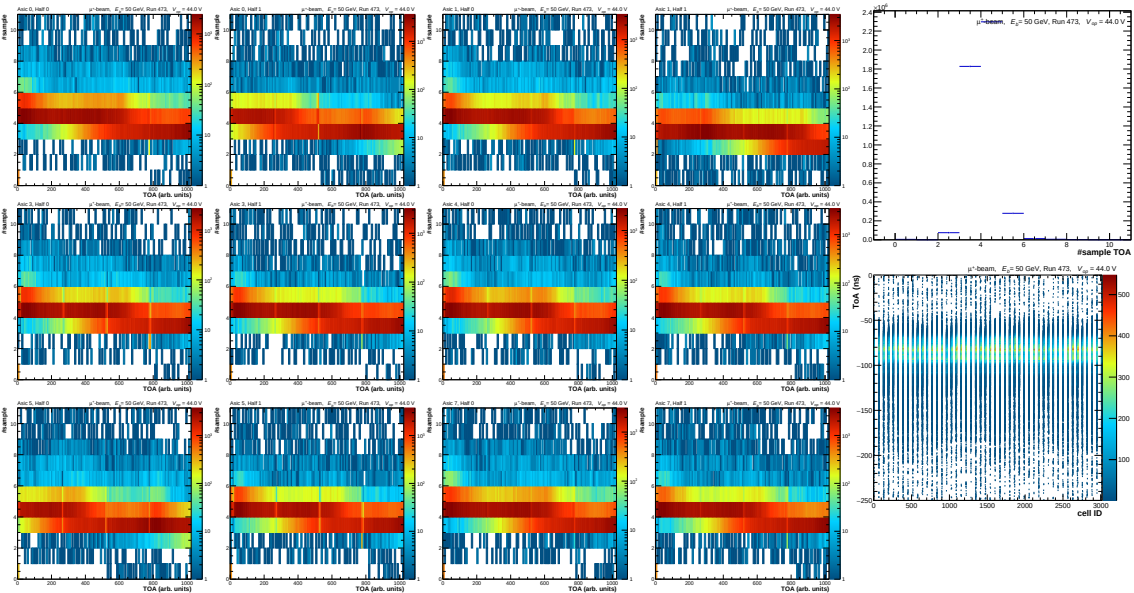


# TOA offset calibration 3rd set



- Estimated using 100 GeV pion run (452)
- Based on ToA vs nSample plot
- Using ToA offsets from run 452 (Full Set F) for 3rd subset
- [TOA calib offset file (3)]

# TOA offset calibration - Applied Set 3



# TOA offset calibration - Applied Set 3

