2024 TB - CAEN Readout

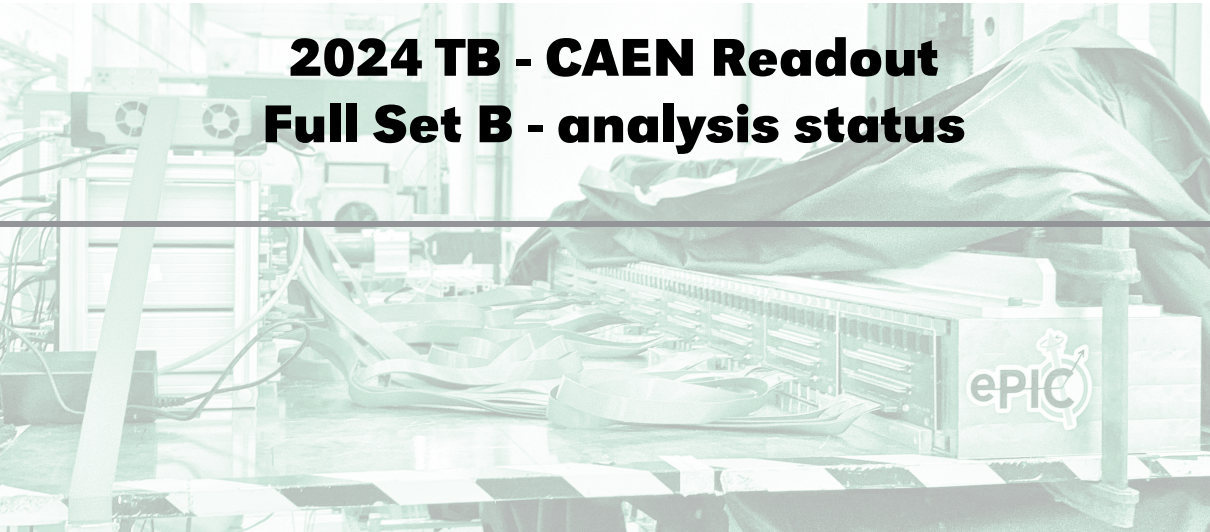
June 16, 2026

Friederike Bock

Overview

1. CAEN Set B - 42V
   - Overview
   - Pedestals
   - Gain Correlations
   - Muon Calibrations
   - LG-HG correlation - physics runs
   - QA data - e^- runs
2. Next steps

2024 TB - CAEN Readout
Full Set B - analysis status



Overview - Set B

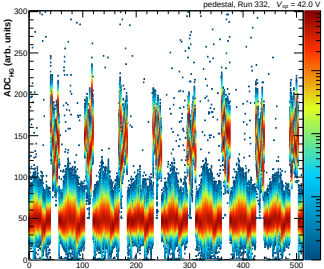
- time:
  8.9.2024 2:50 -
  8.9.2024 17:30
- $V_{op} = 42$ V,
  $V_{br} = 38.3$ V
- $t_{shape} = 87.5$ ns
- CAEN gain settings:
  $a_{HG} = 50, a_{LG} = 50$
- μ with large scintillator triggers
- e^- and $h^{\pm}$ with small scintillators

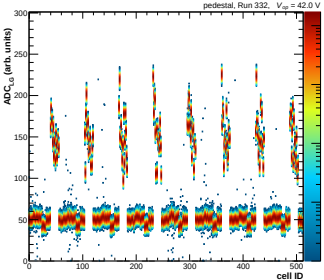
CAEN Full set B: $V_{op} = 42$ V

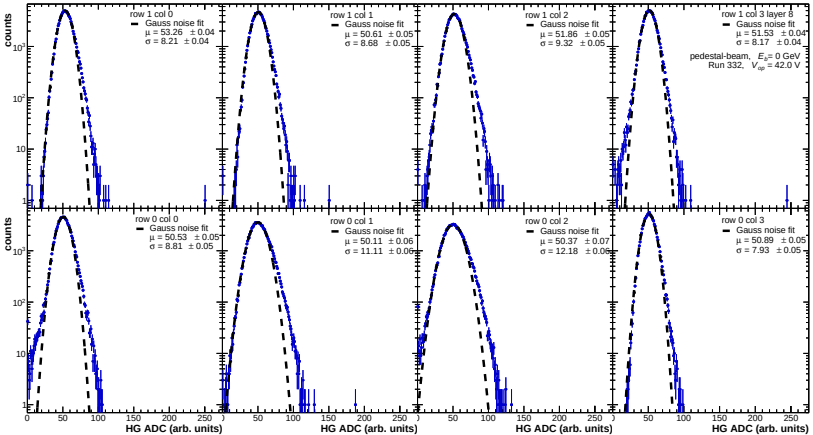
$t_{shape} = 87.5$ ns, hold-delay = 0, $a_{HG} = 50$, $a_{LG} = 50$, Sept 8, 2:50 - 17:30 ,

Calibration sets:						
	μ table position	(0,0)	(-5,0)	(5,0)	ped	
1^{st}	runs	309	331	322	332, 308	
	tot events		100K	102K	106K	
2^{nd}	runs		370(371)	374	369	
	tot events		63+50K	101K	259k	
Electron set (0,0):						
	E	1 GeV	2 GeV	3 GeV	4 GeV	5 GeV
e^-	runs	333	334	336	337	338
	tot events	25.4K	36.6K	25.5K	25.0K	26.1K
Hadron set (0,0):						
	E	3 GeV	5 GeV	8 GeV	10 GeV	
h^-	runs	340, 349	346	350	357	
	tot events	55+50.2K	50.2K	52K	50K	
	E	5 GeV	8 GeV	10 GeV	15 GeV	
h^+	runs	360	362	367	368	
	tot events	50.5K	50.2K	50.5K	50K	

Muon calibration - Set 1: Pedestals







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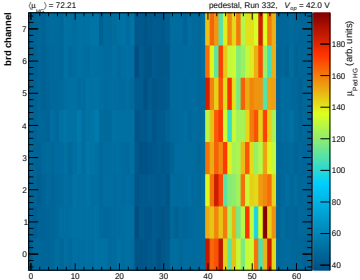
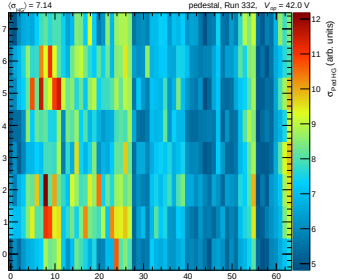
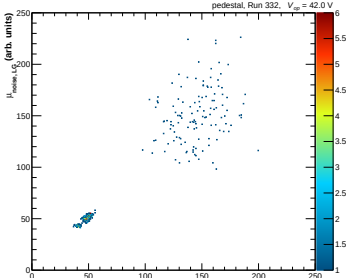
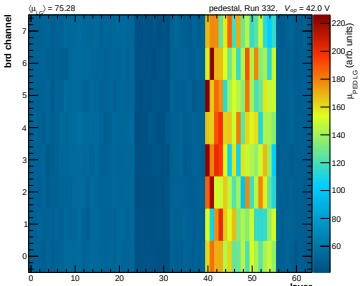
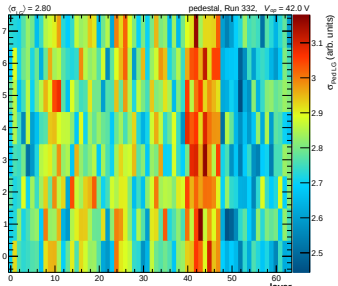




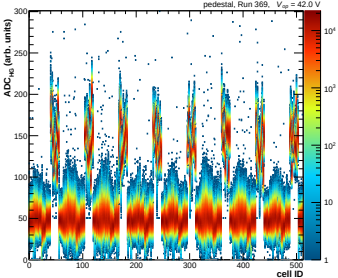


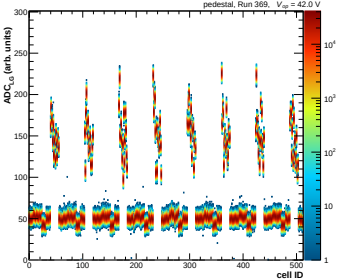


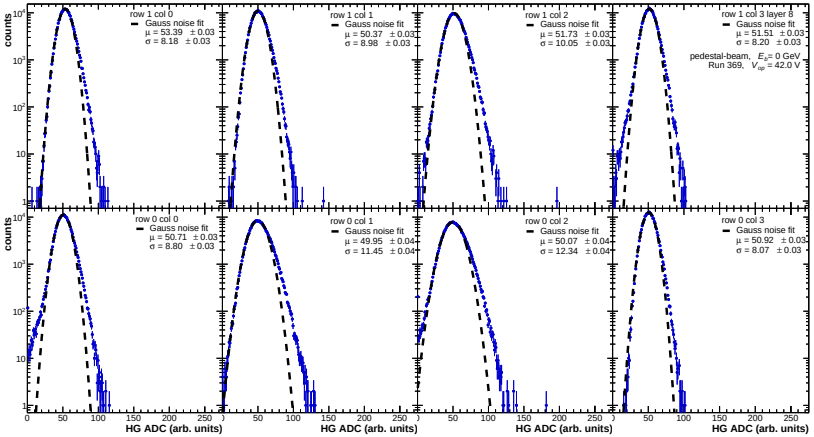


- Pedestal for all readout units set to 50 ADC
- Readout units 6 & 7 behaving significantly differently for all runs, pedestal around 150 ADC
- No loose cables found or and cables were even swapped
- Fitting converges for most cells
- HG & LG pedestal strongly correlated for RO 1-5 & 8

Muon calibration - Set 2: Pedestals







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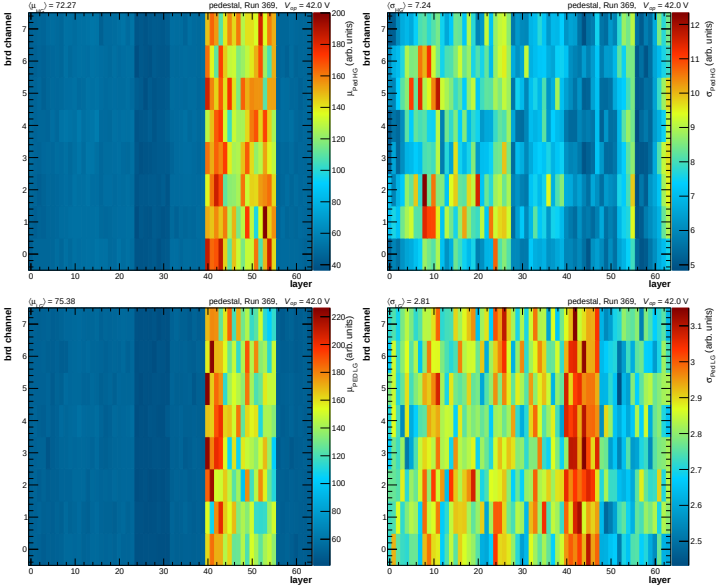

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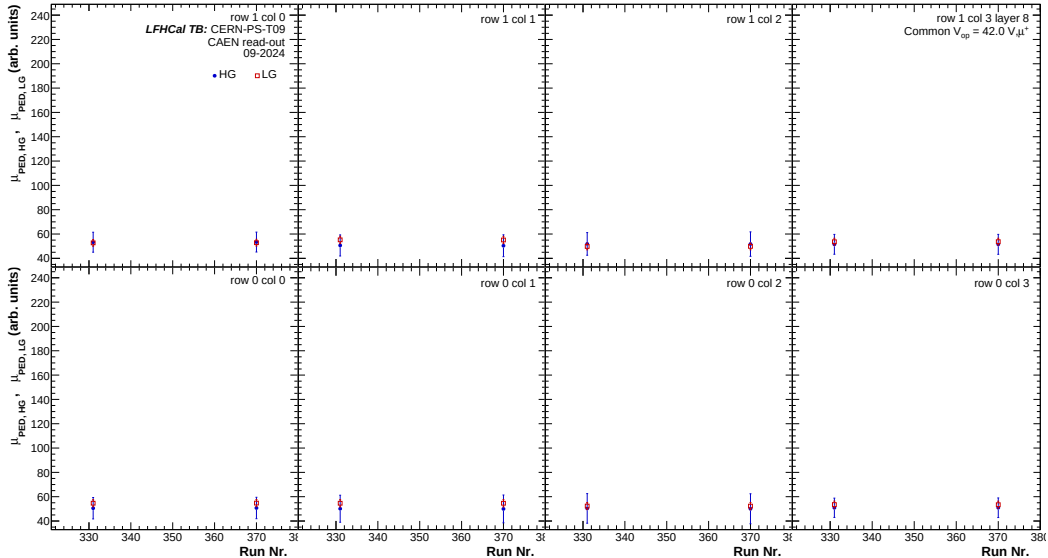
Muon calibration - Pedestal Comparison



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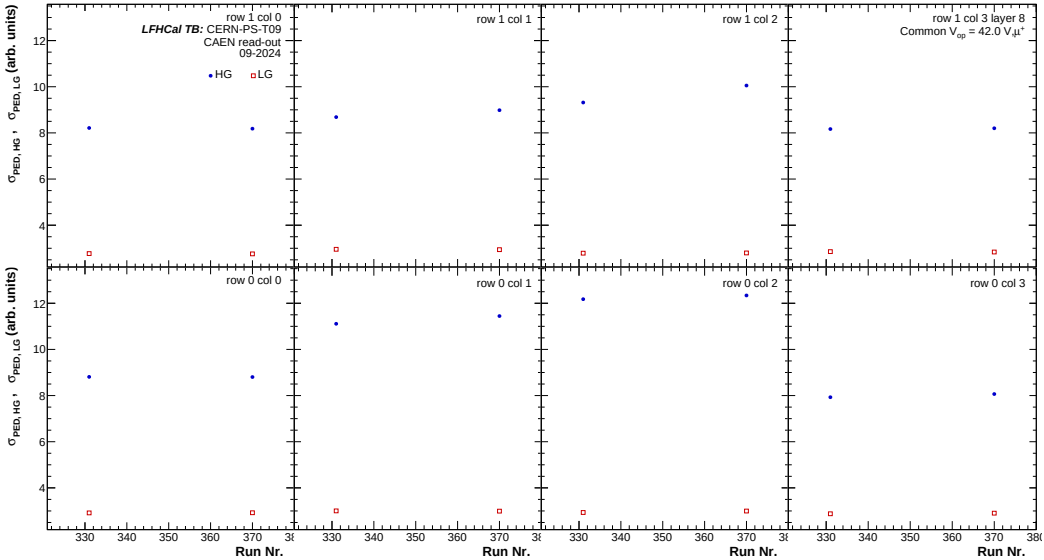

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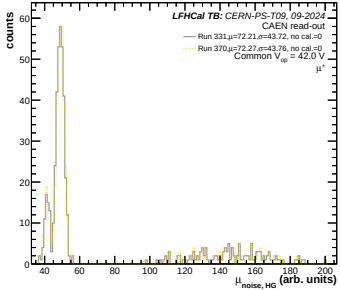
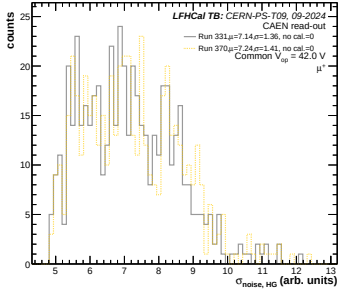
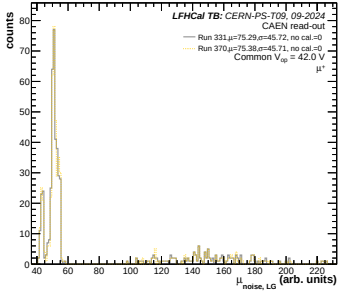
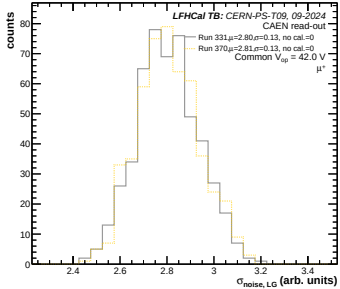


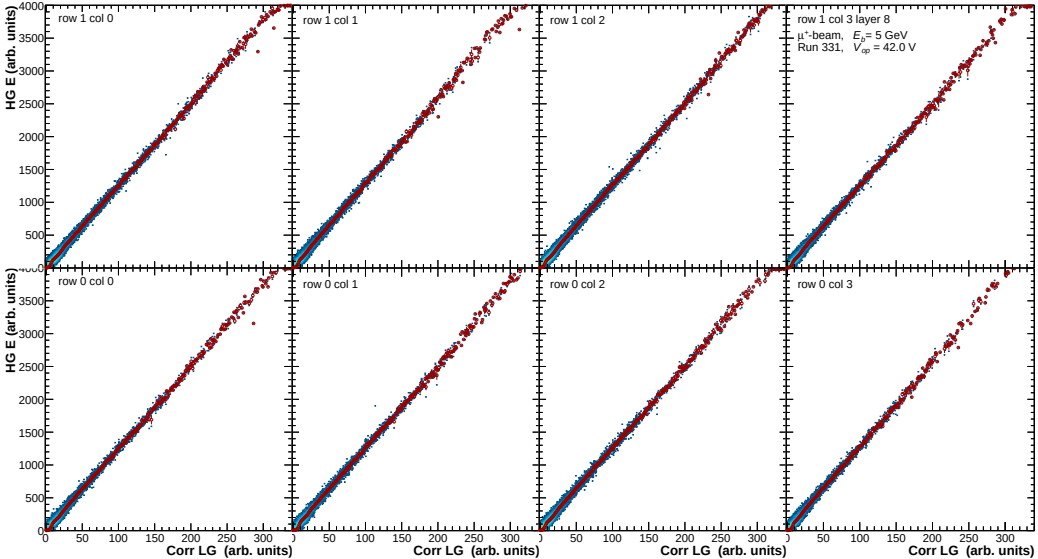






- Very similar pedestal position for both pedestal runs
- Width varies slightly between runs
- Later run with larger pedestal width
  Outside temperature: 18.9C (Run 332) vs 17.8C (Run 369)

Muon calibration - LG-HG Correlation -Set 1



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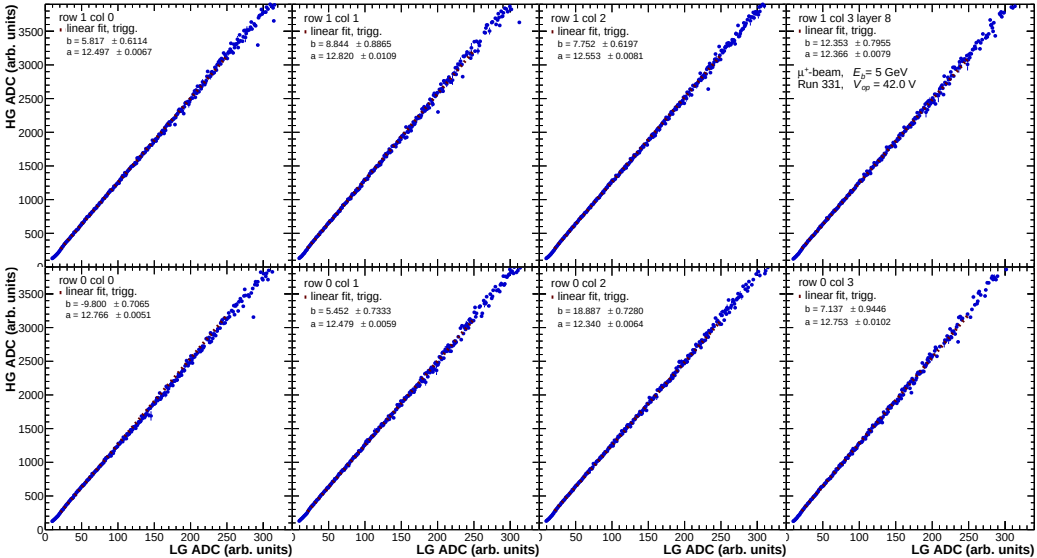
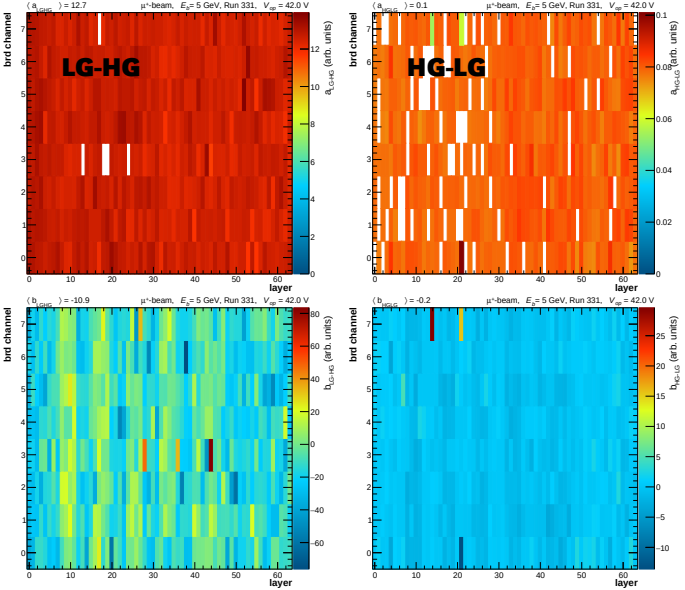
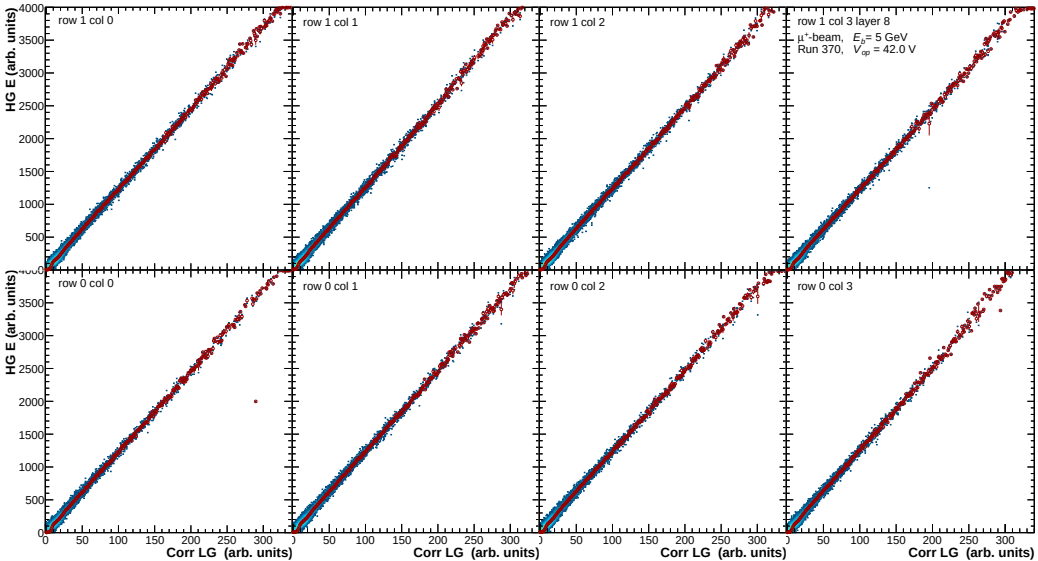


Muon calibration - LG-HG Correlation -Set 1



- LG-HG correlation much more stable to fit than HG-LG
- Average Slope for $\langle a_{LG-HG} \rangle = 12.7$ and $\langle a_{HG-LG} \rangle = 0.1$
- Intercept fluctuates a lot, $\langle b_{LG-HG} \rangle = -10.9$ and $\langle b_{HG-LG} \rangle = -0.2$

Muon calibration - LG-HG Correlation -Set 2



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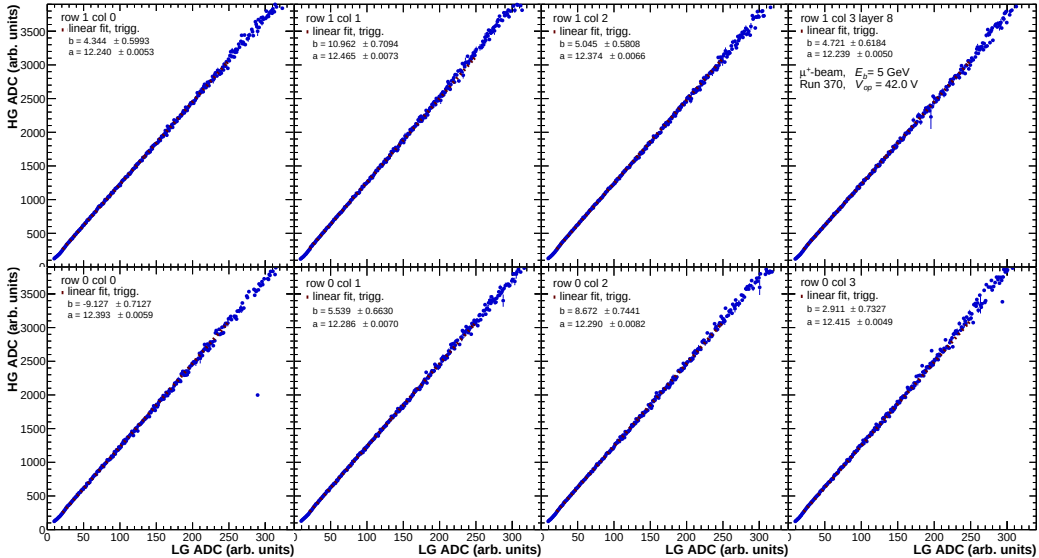

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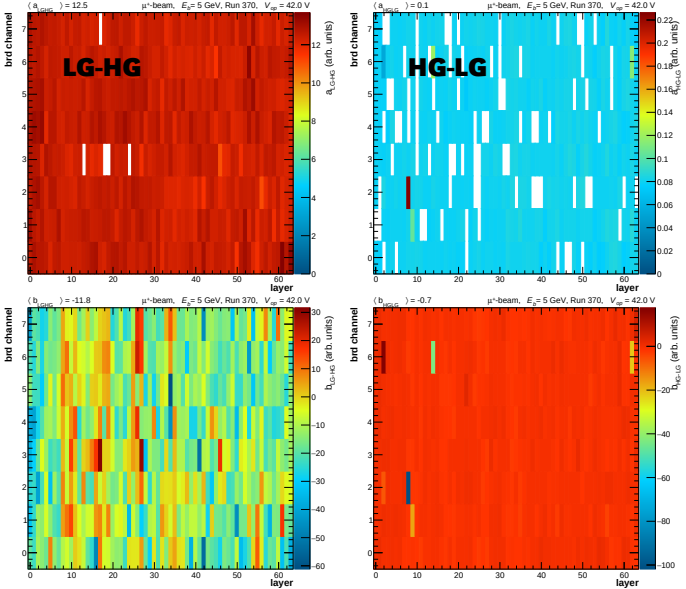
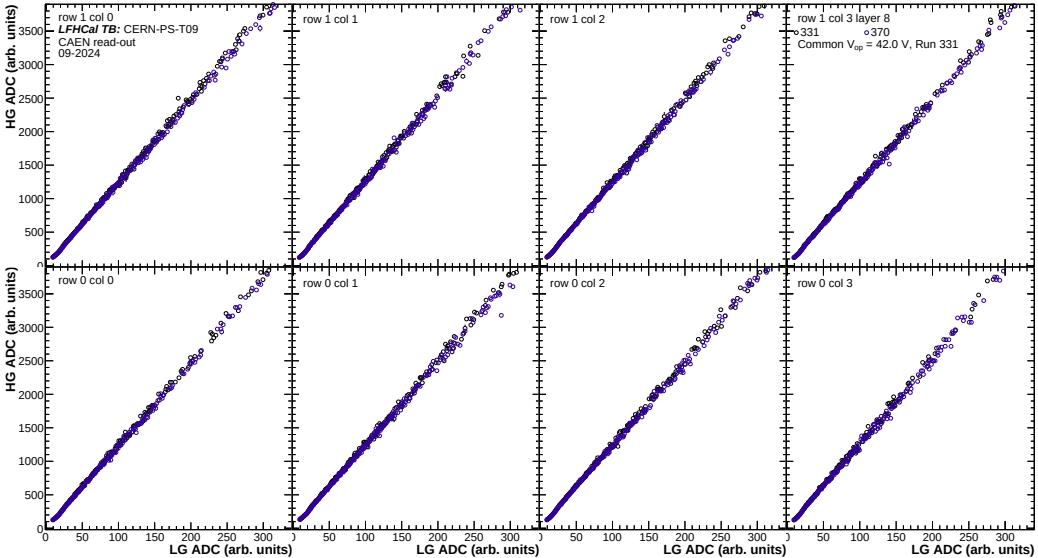


- LG-HG correlation much more stable to fit than HG-LG
- Average Slope for $\langle a_{LG-HG} \rangle = 12.5$ and $\langle a_{HG-LG} \rangle = 0.1$
- Intercept fluctuates a lot, $\langle b_{LG-HG} \rangle = -11.8$ and $\langle b_{HG-LG} \rangle = -0.7$

Muon calibration - LG-HG Correlation - Comparison



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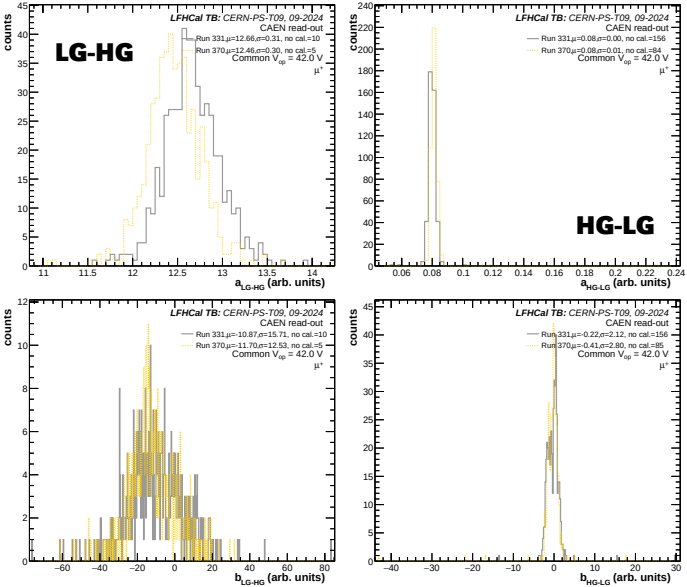
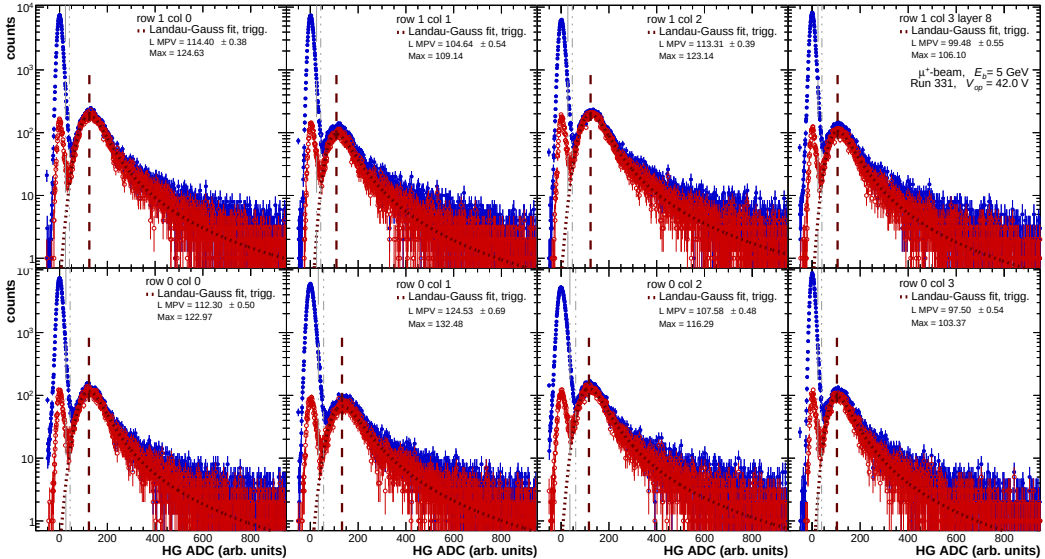


- LG-HG correlation slope average shifted in 2nd set ($\Delta\langle a\rangle = -0.2$), less spread in intercept parameter
- HG-LG follows inverse but much harder to fit $\Rightarrow$ more fits fail

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



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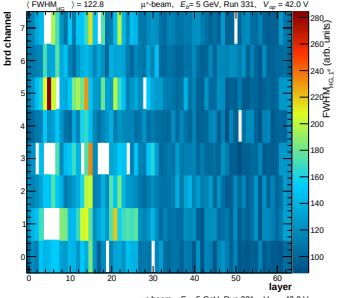
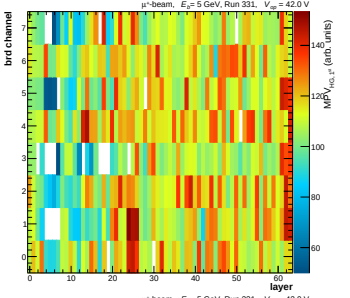
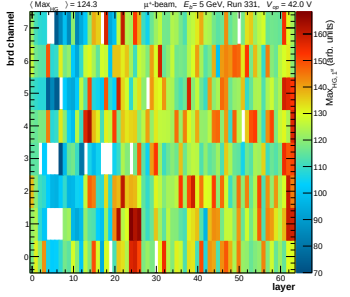
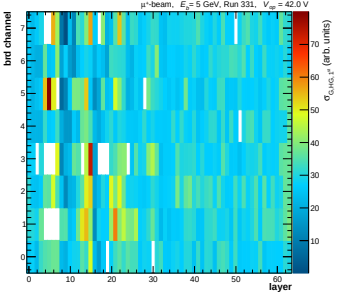
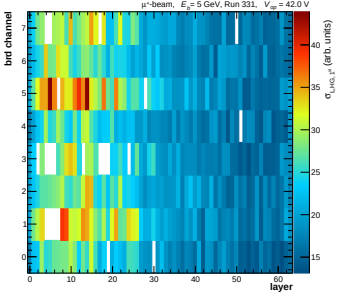




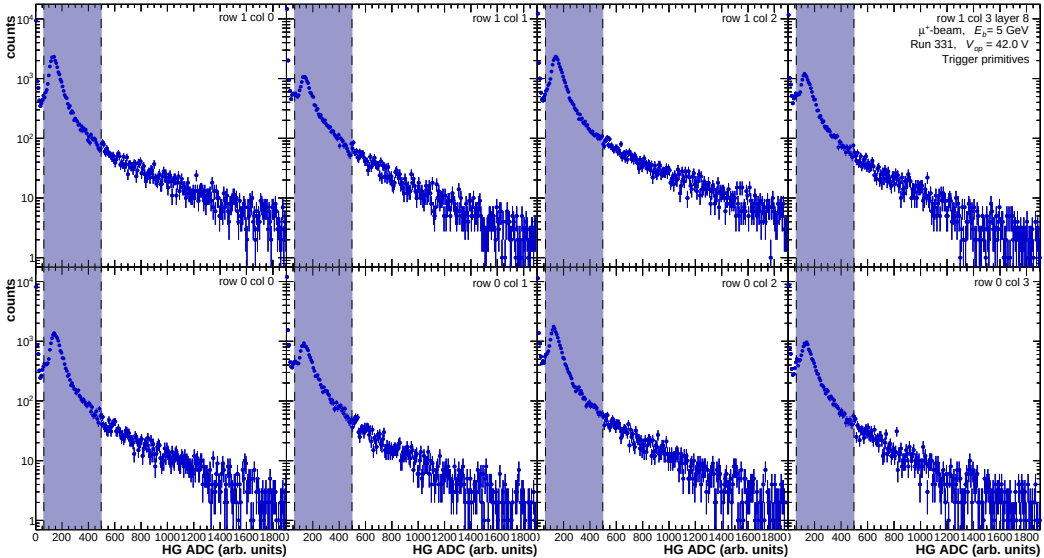






- Initial fit for 42 V still quite stable < 30 channels fail in initial fit (blue distribtion previous slide)
- $\langle Max_{HG,mip} \rangle = 124.3$
- A bit biased towards lower values due to very pronounced pedestal peak
- No strong ch-by-ch variations in indivial parameters, outlier in layer 6 drives z-scale for FWHM &, Gaussian & Landau width

Muon calibration - Set 1: Muons HG - Trigger



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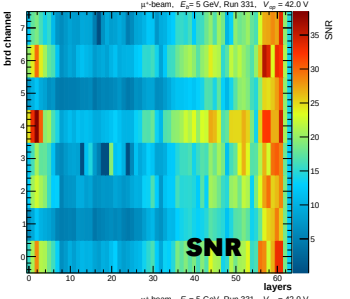
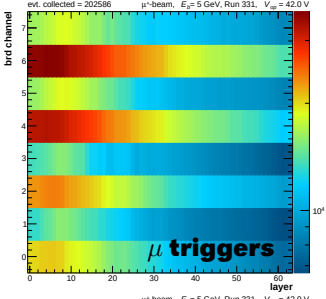
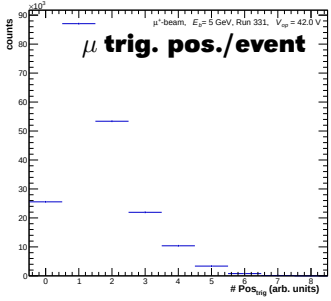
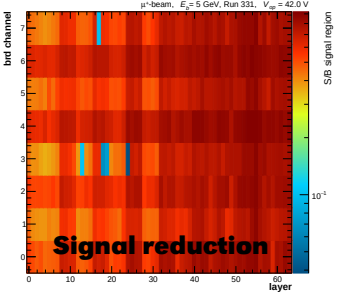
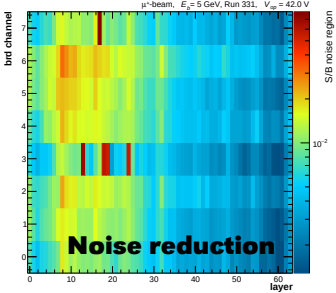




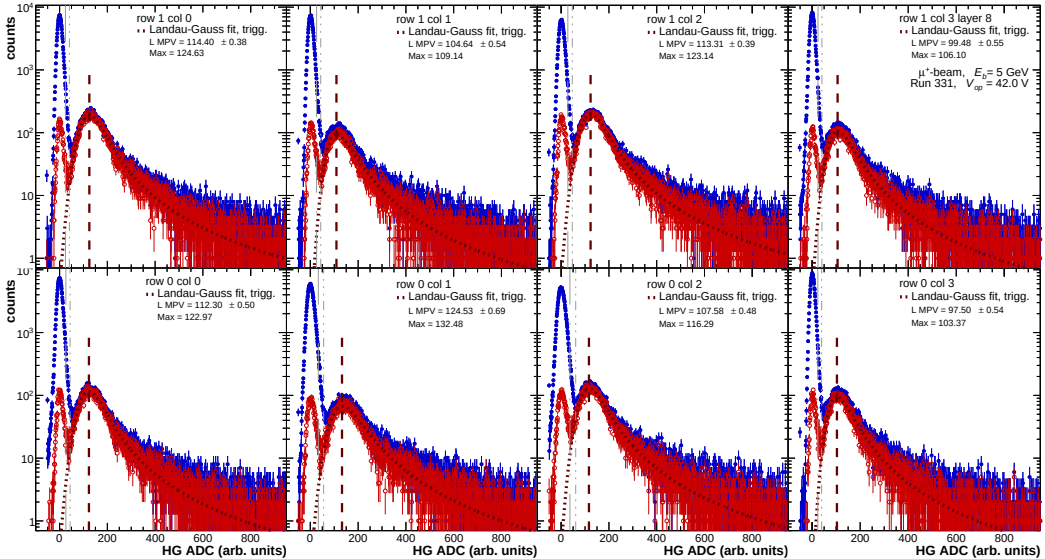






- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in $z > 3\sigma_{ped,HG}$
- Clear enhancement in trigger primitives, 0th level muon selection within $0.5\langle Max_{HG,mip}\rangle < trigg_{prim} < 4\langle Max_{HG,mip}\rangle$
- Same range used for skimming
- Significant reduction of noise peak (red vs. blue on next page)

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



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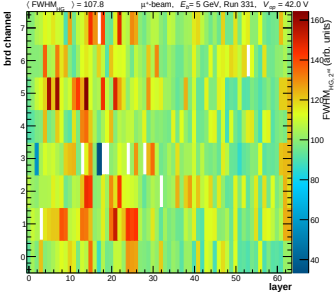
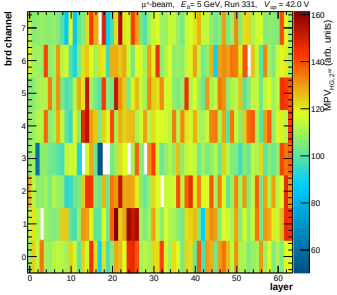
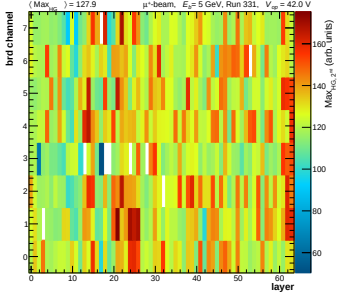
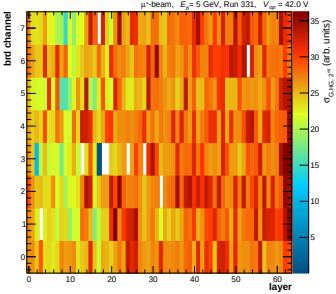
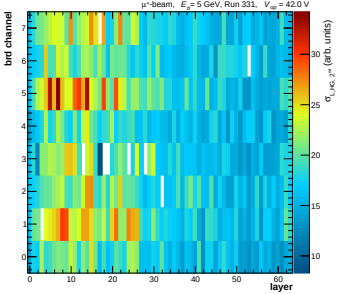




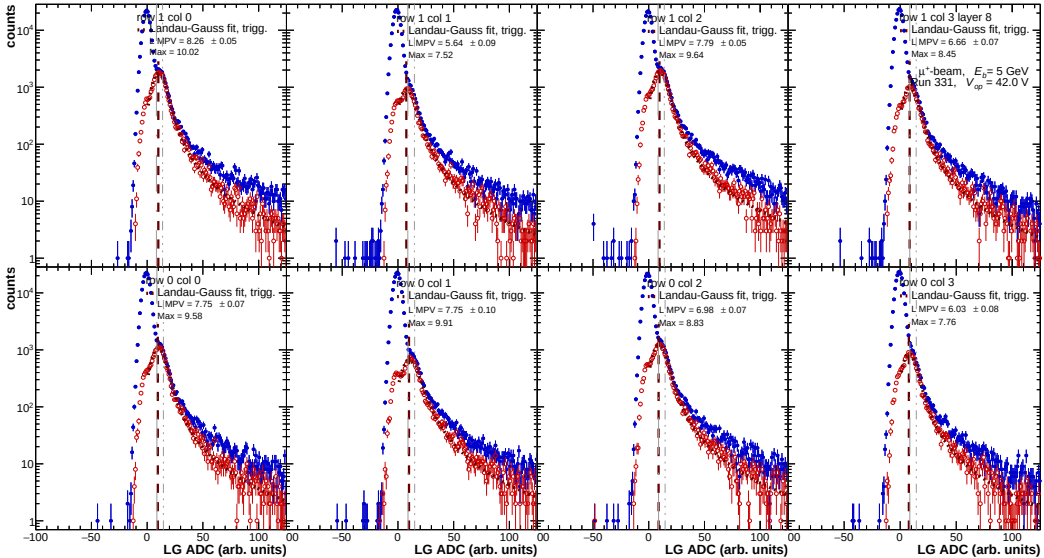






- Nearly all channels "fitable"
- 5 channels identified as bad
- Poor χ^2/ndf for some
- Constrained fit much more in width
- $\langle Max_{HG,mip} \rangle = 127.9$

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



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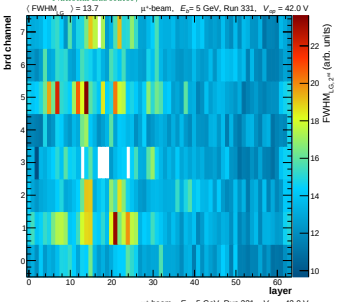
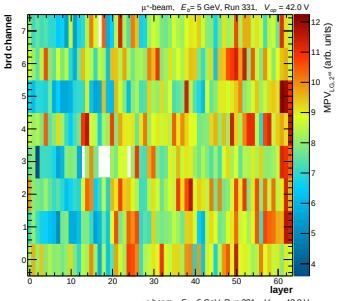
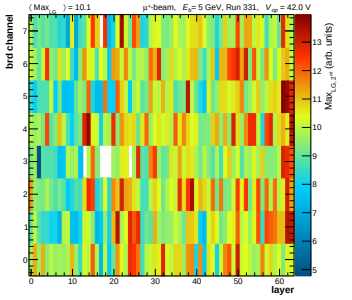
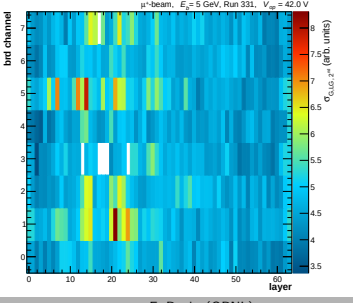
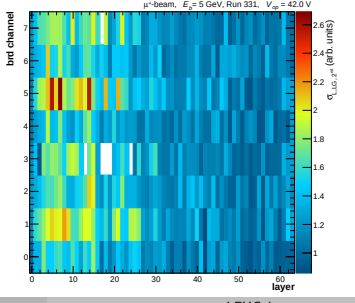




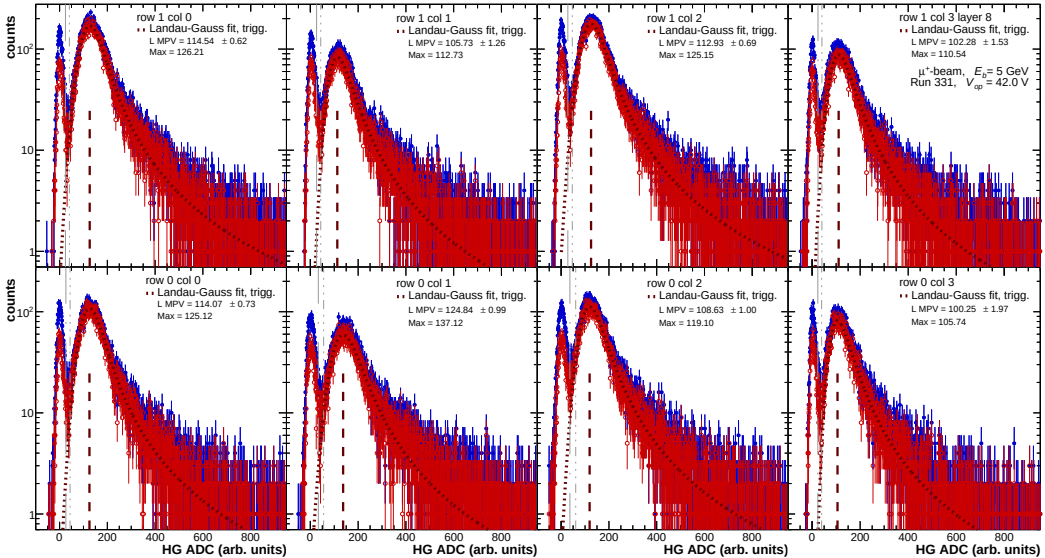




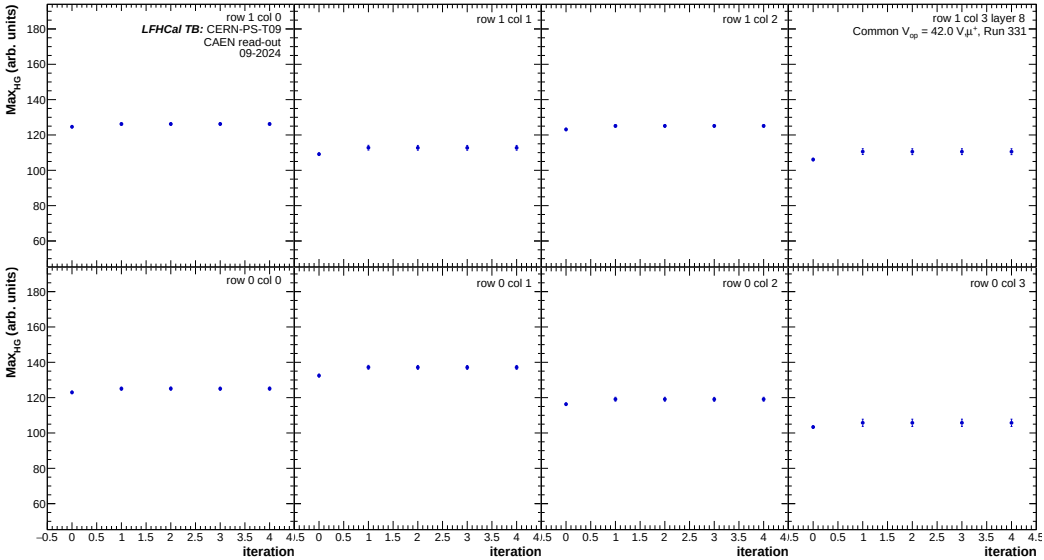


- First iteration fitting LG peaks, nearly all channels "fitable"
- 5 channels identified as bad
- Poor χ^2/ndf for some, signal and pedestal peak merge ($\sigma_{ped,LG} \approx 2.8$ ADC)
- $\langle Max_{LG,mip} \rangle = 10.1$

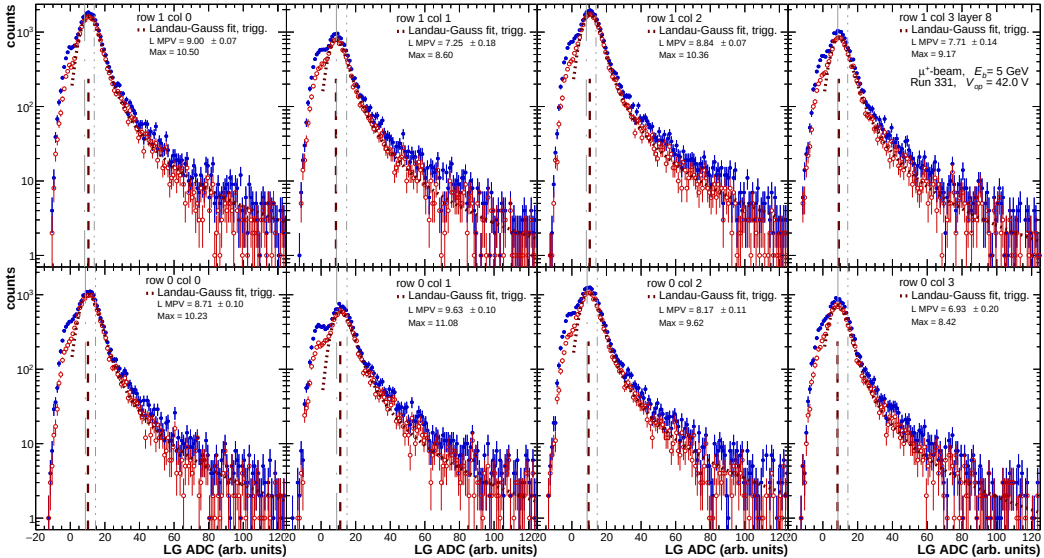
Muon calibration - Set 1: Muons - Iterations



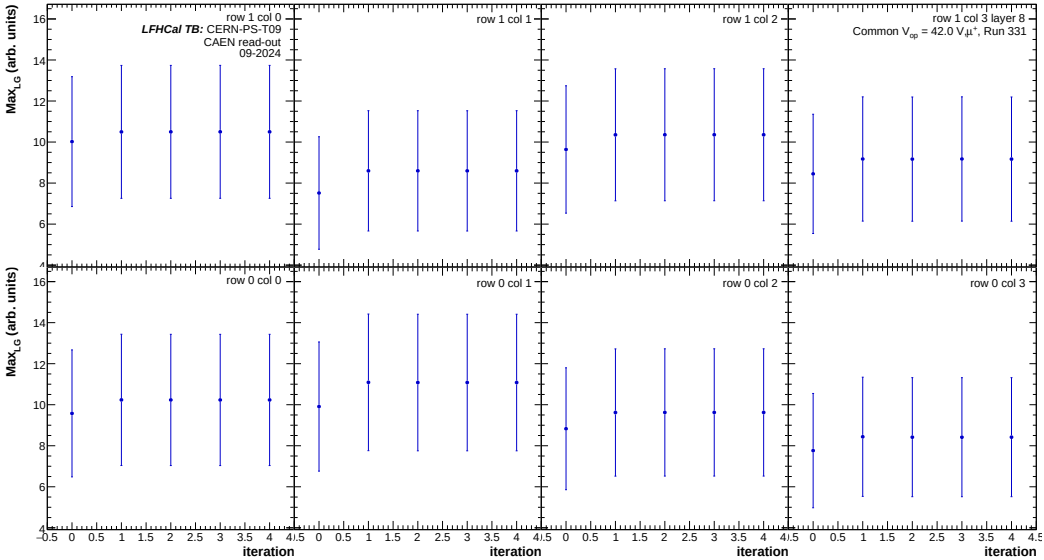
Muon calibration - Set 1: Muons - Iterations



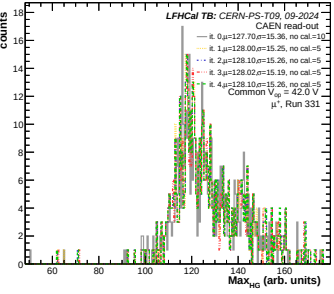
Muon calibration - Set 1: Muons - Iterations

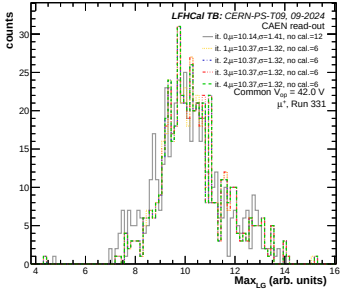


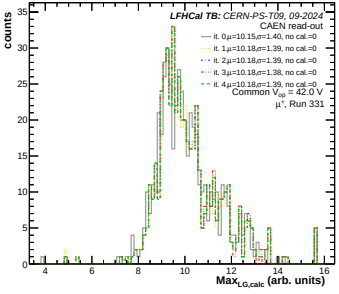
Muon calibration - Set 1: Muons - Iterations

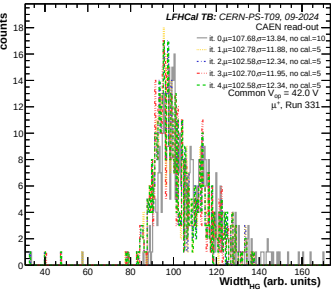


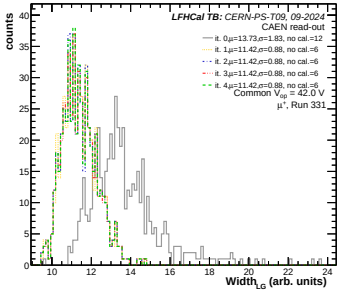
Muon calibration - Set 1: Muons - Iterations









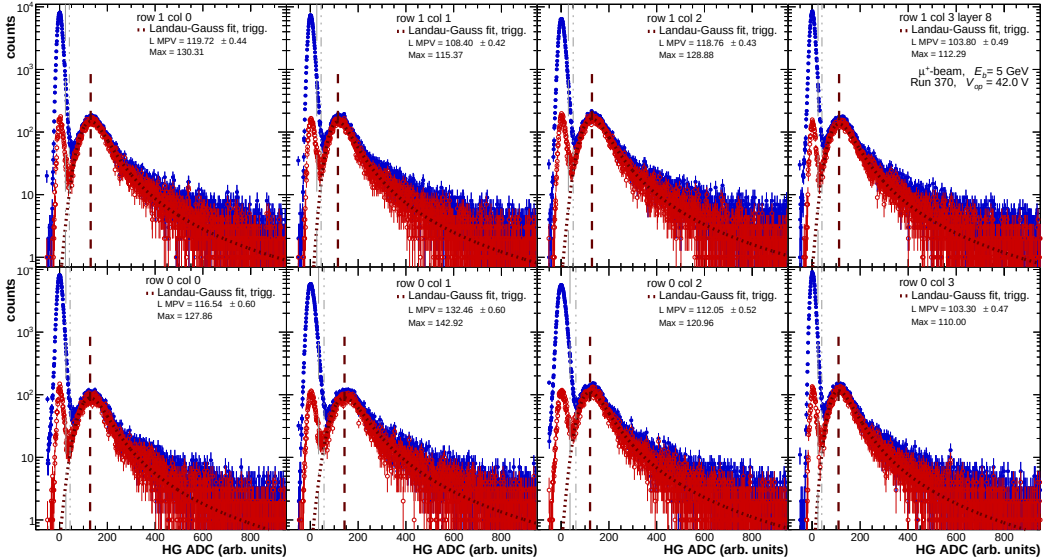


- Reduced mip selection range for trigger primitives
  $0.8\langle Max_{HG,mip}\rangle < trigg_{prim} < 2\langle Max_{HG,mip}\rangle$

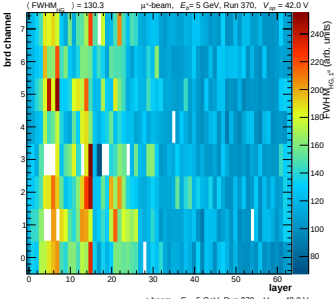
$\Rightarrow$ Further reduction of noise peak

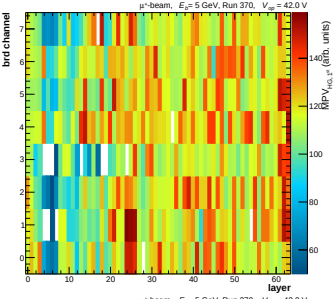
- Refined fitting during improved iterations using average mip from previous iteration as basis for constraints
- Convergence of most cells within 2-3 iterations

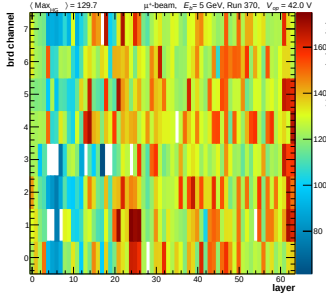
Muon calibration - Set 2: Muons HG - init (blue)

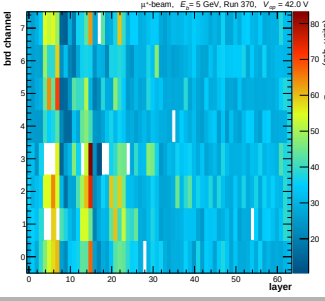


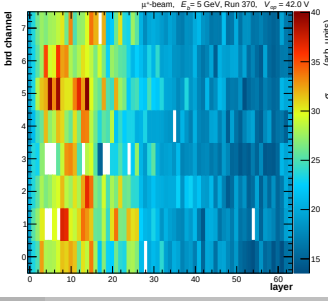
Muon calibration - Set 2: Muons HG - init (blue)





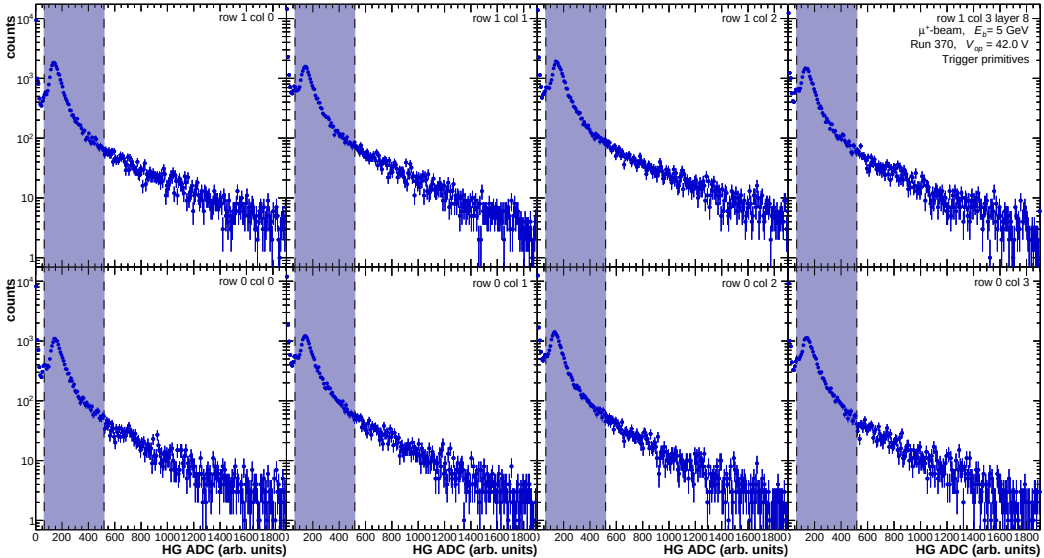




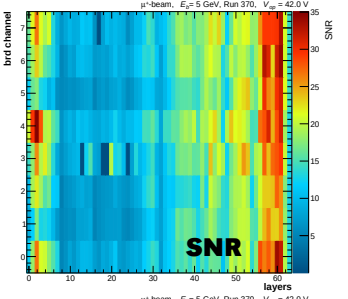


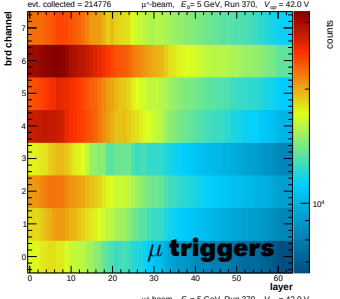
- Initial fit for 42 V still quite stable < 20 channels fail in initial fit (blue distribtion previous slide)
- $\langle Max_{HG,mip} \rangle = 129.7$
- A bit biased towards lower values due to very pronounced pedestal peak
- No strong ch-by-ch variations in indivial parameters, outliers in widths drive z-range of plots

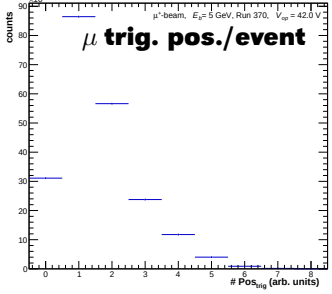
Muon calibration - Set 2: Muons HG - Trigger

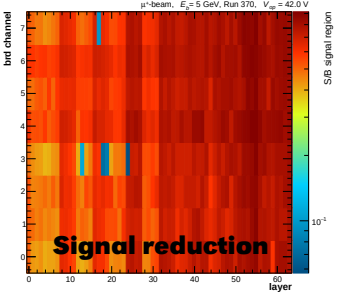


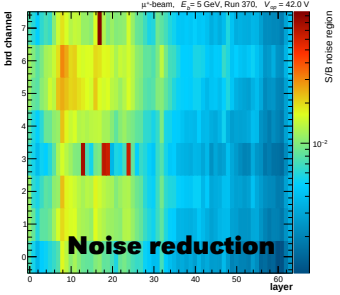
Muon calibration - Set 2: Muons HG - Trigger





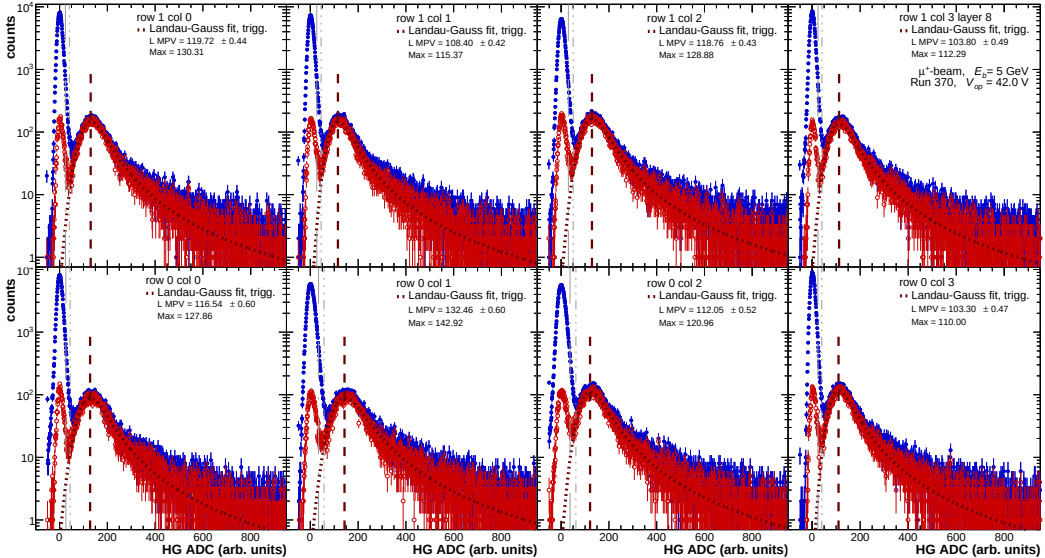




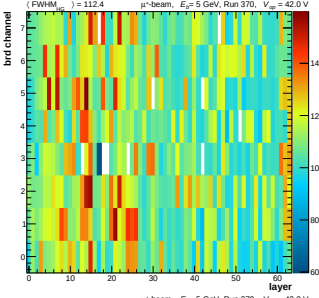


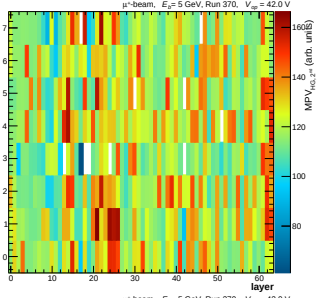
- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in $z > 3\sigma_{ped,HG}$
- Clear enhancement in trigger primitives, 0th level muon selection within $0.5\langle Max_{HG,mip}\rangle < trigg_{prim} < 4\langle Max_{HG,mip}\rangle$
- Same range used for skimming
- Significant reduction of noise peak (red vs. blue on next page)

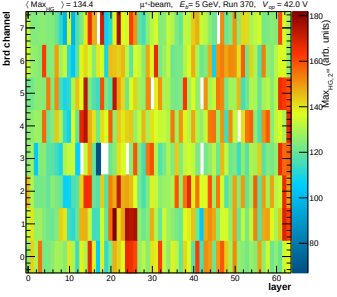
Muon calibration - Set 2: Muons HG - 0th ite

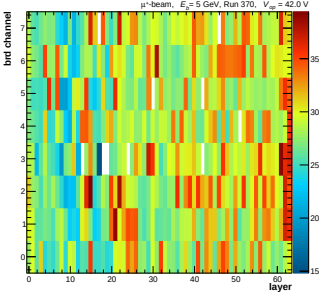


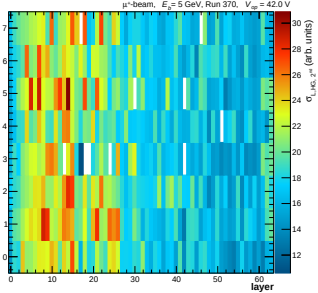
Muon calibration - Set 2: Muons HG - 0th ite





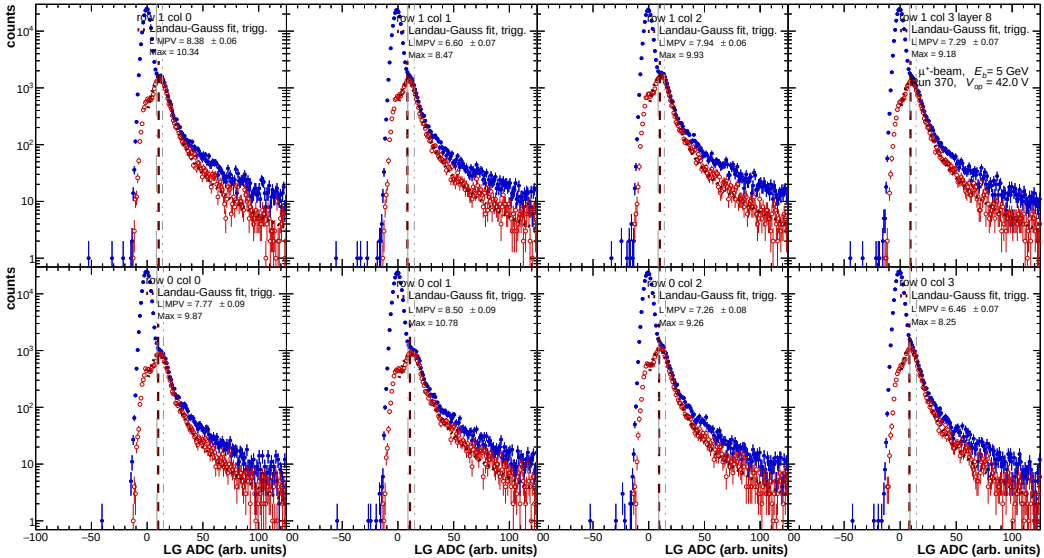




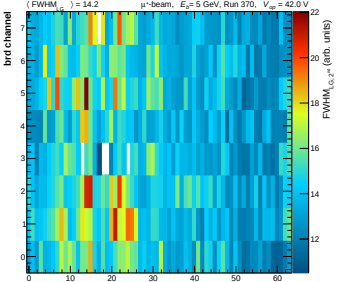


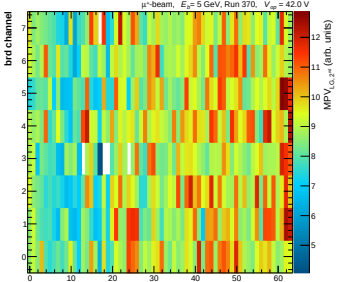
- Nearly all channels "fitable"
- 5 channels identified as bad
- Poor χ^2/ndf for some
- Constrained fit much more in width
- $\langle Max_{HG,mip} \rangle = 134.4$

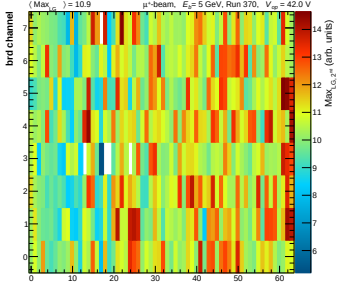
Muon calibration - Set 2: Muons LG - 0th ite

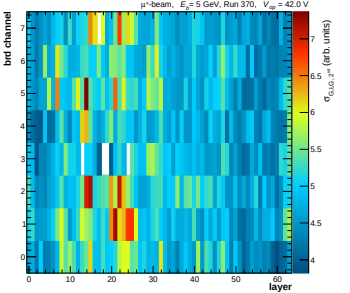


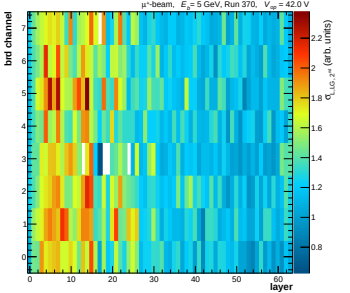
Muon calibration - Set 2: Muons LG - 0th ite





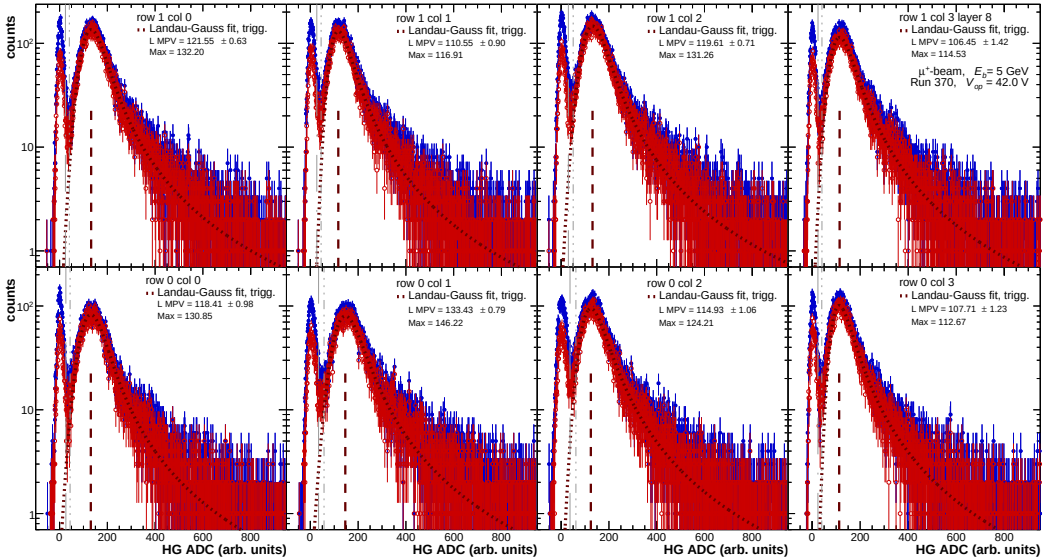




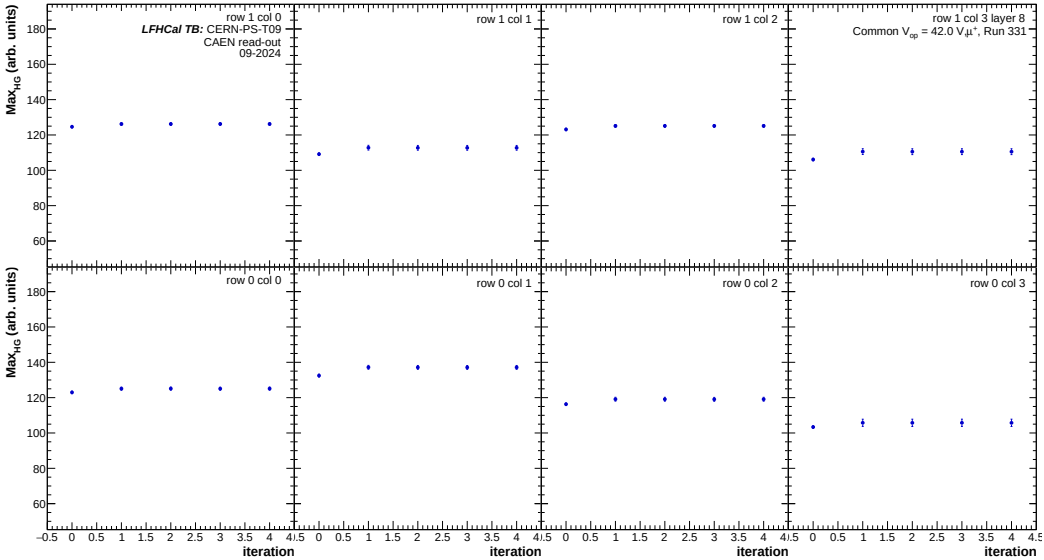


- First iteration fitting LG peaks, nearly all channels "fitable"
- 5 channels identified as bad
- Poor χ^2/ndf for some, signal and pedestal peak merge ($\sigma_{ped,LG} \approx 2.8$ ADC)
- $\langle Max_{LG,mip} \rangle = 10.1$

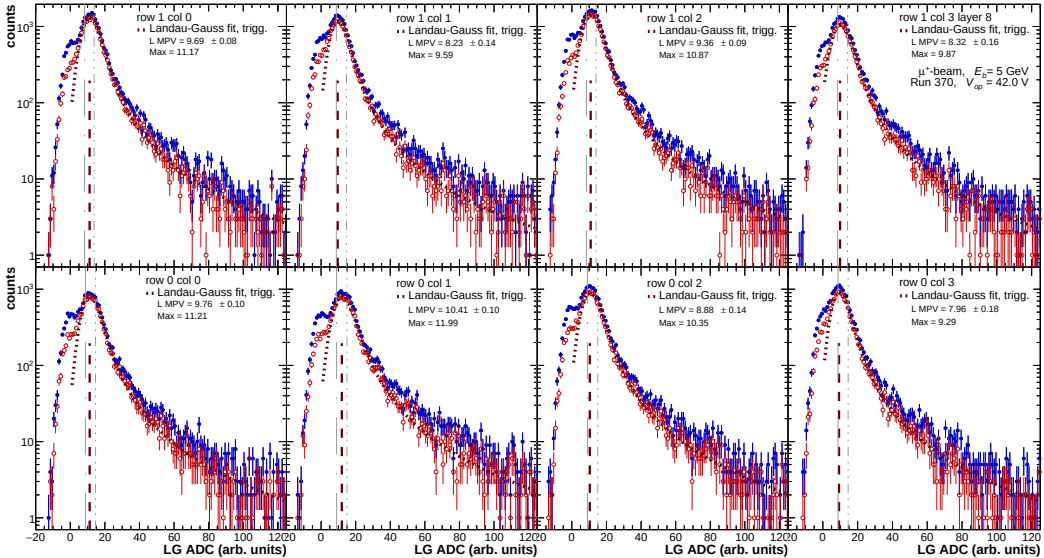
Muon calibration - Set 2: Muons - Iterations



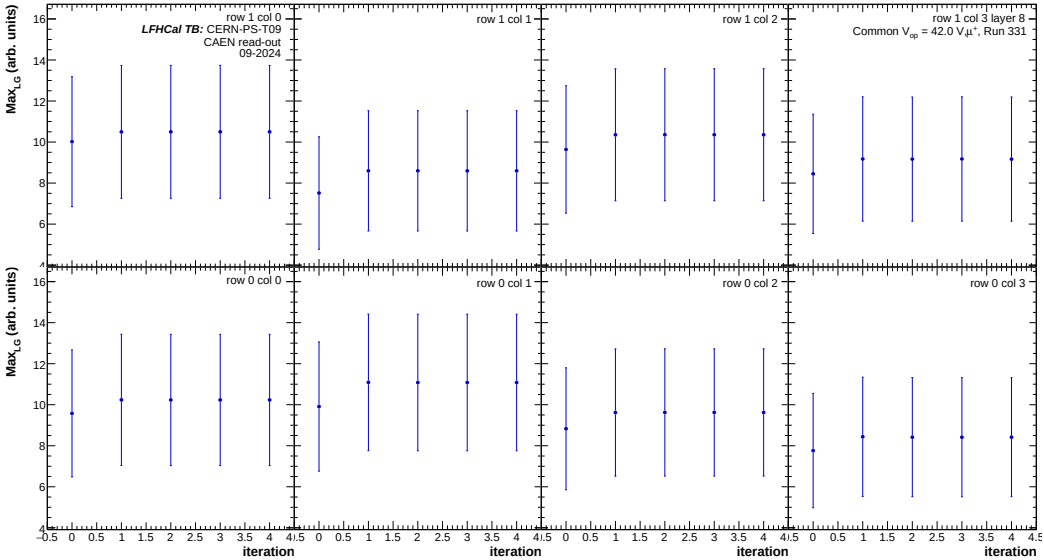
Muon calibration - Set 2: Muons - Iterations



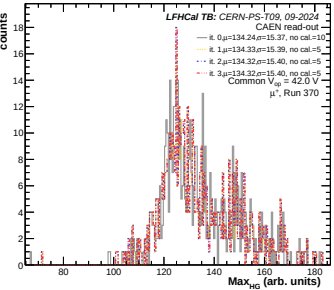
Muon calibration - Set 2: Muons - Iterations

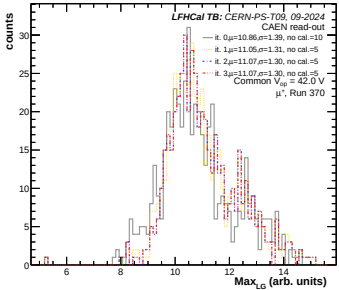


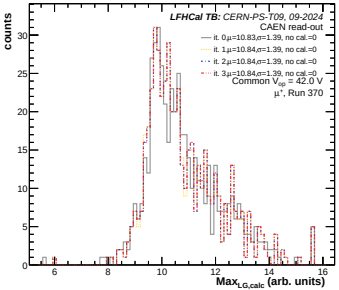
Muon calibration - Set 2: Muons - Iterations

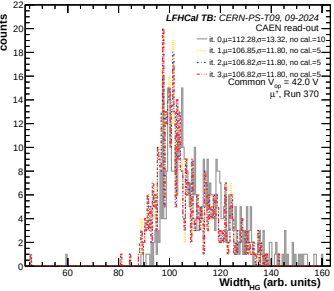


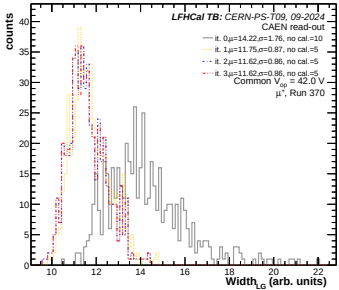
Muon calibration - Set 2: Muons - Iterations









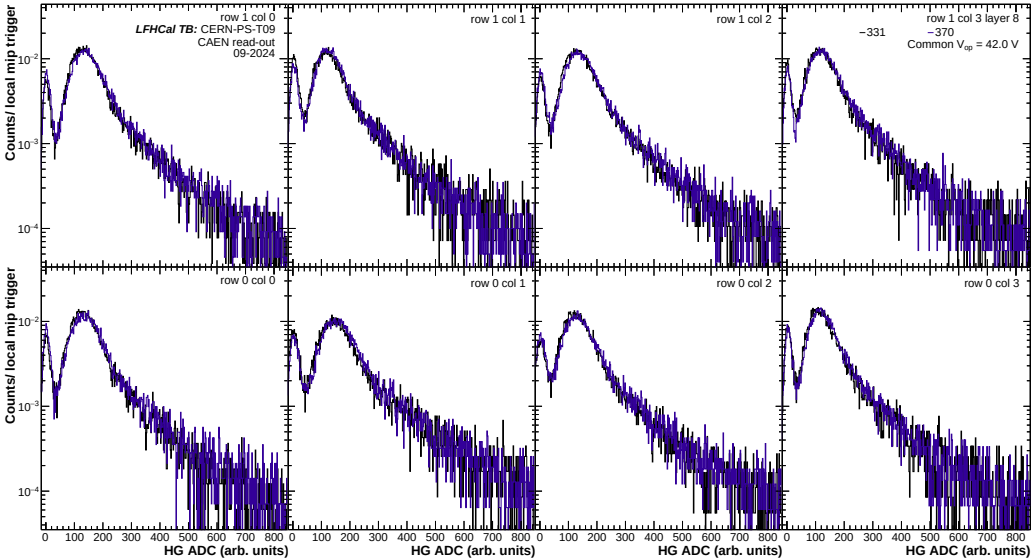


- Reduced mip selection range for trigger primitives
  $0.8\langle Max_{HG,mip}\rangle < trigg_{prim} < 2\langle Max_{HG,mip}\rangle$

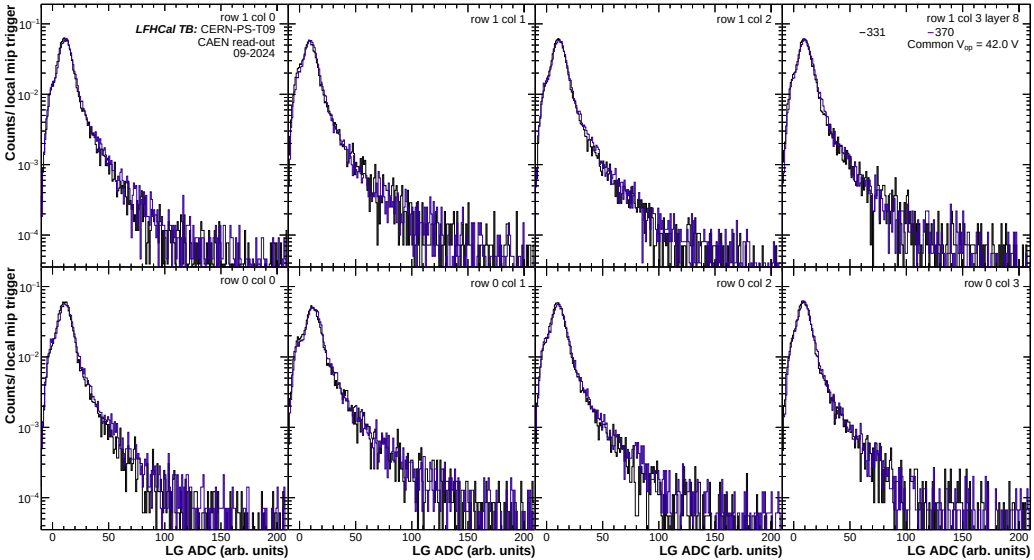
$\Rightarrow$ Further reduction of noise peak

- Refined fitting during improved iterations using average mip from previous iteration as basis for constraints
- Convergence of most cells within 2-3 iterations

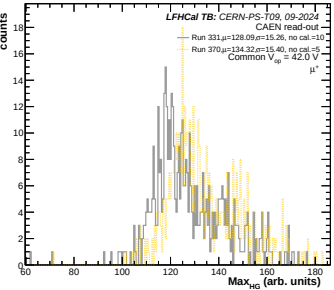
Muon calibration - Comparison Sets

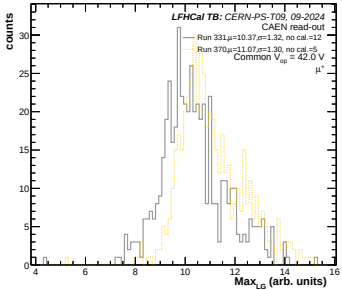


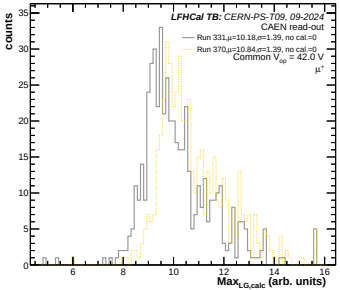
Muon calibration - Comparison Sets

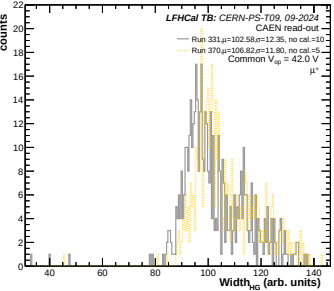


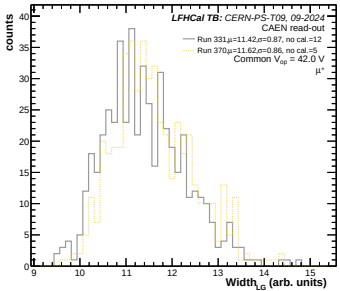
Muon calibration - Comparison Sets





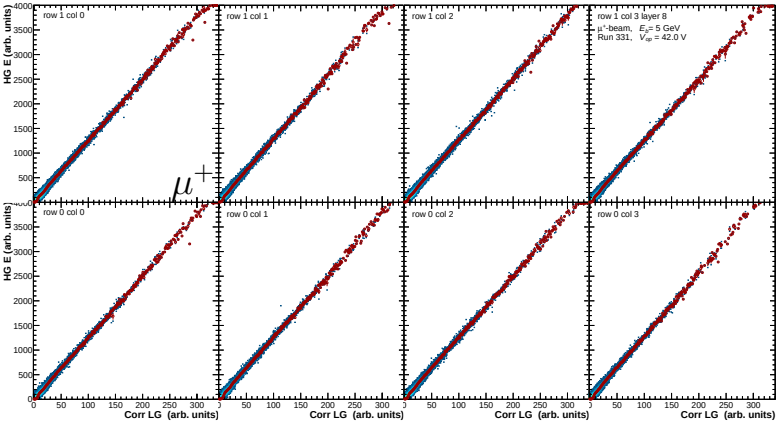






- 1st set significantly lower average mip max
- 1st set smaller spread in nearly all quantities

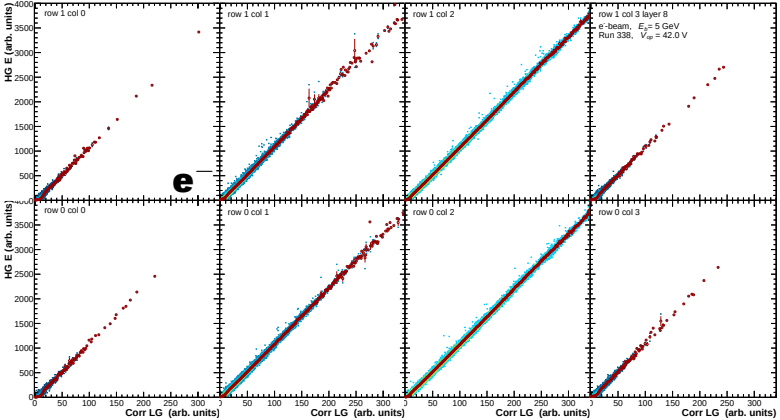
LG-HG correlation - Comparison Sets



μ^+ - Runs 331 & 370

- Slope $\approx$ 12.5
- Little spread, no additional bands

LG-HG correlation - Comparison Sets



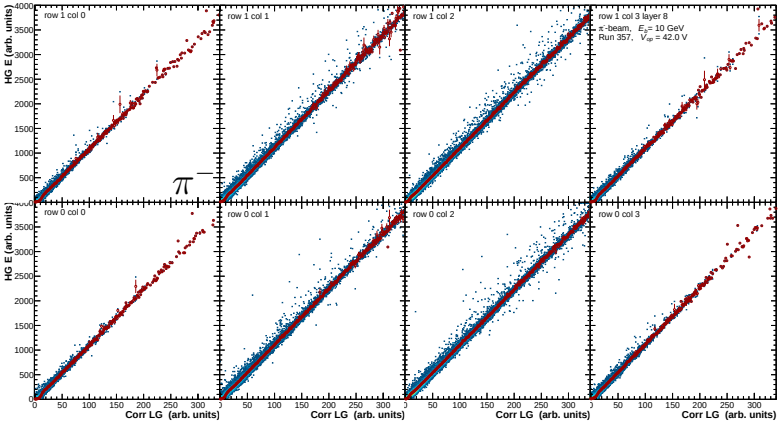
μ^+ - Runs 331 & 370

- Slope $\approx$ 12.5
- Little spread, no additional bands

e^- - Runs 333-388

- Significantly lower slope than μ^+
- Little spread, no additional bands
- Not enough ADC reach to calibrate all ch. $\rightarrow$ outer in each layer & later layers

LG-HG correlation - Comparison Sets



π^- - Runs 340,349,346,350,357

- Significantly lower slope than μ^+
- Common slope with e^-
- Little spread, no additional bands

μ^+ - Runs 331 & 370

- Slope $\approx$ 12.5
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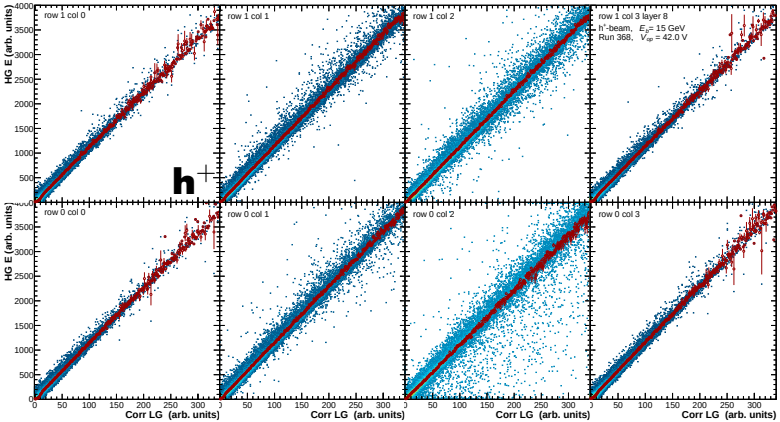
LG-HG correlation - Comparison Sets



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- Significantly lower slope than μ^+
- Common slope with e^-
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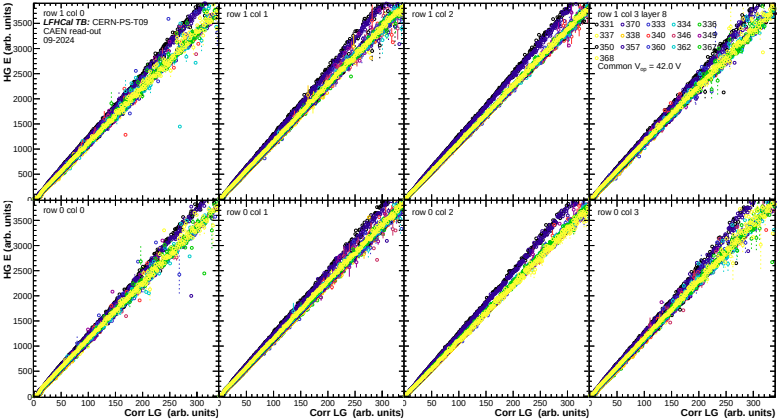
h^+ - Runs 360-368

- Significantly lower slope than μ^+
- Mostly common slope with e^-
- Higher energy runs with add. band at HG=0, significantly larger number of off-diagonal elements
- Incident particle rate related?

LG-HG correlation - Comparison Sets



μ^+ - Runs 331 & 370

- Slope ≈ 12.5
- Little spread, no additional bands

e^- - Runs 333-388

- Significantly lower slope than μ^+
- Little spread, no additional bands
- Not enough ADC reach to calibrate all ch. $\rightarrow$ outer in each layer & later layers

π^- - Runs 340,349,346,350,357

- Significantly lower slope than μ^+
- Common slope with e^-
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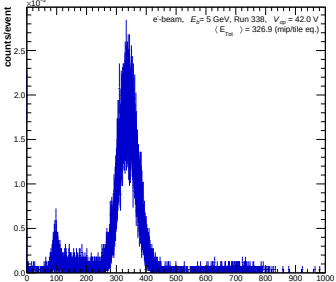
h^+ - Runs 360-368

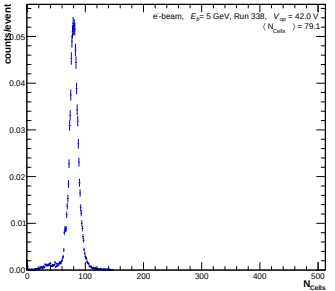
- Significantly lower slope than μ^+
- Mostly common slope with e^-
- Higher energy runs with add. band at HG=0, significantly larger number of off-diagonal elements
- Incident particle rate related?

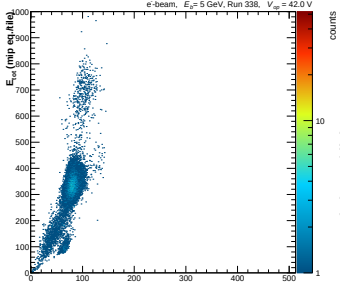
Direct comparison

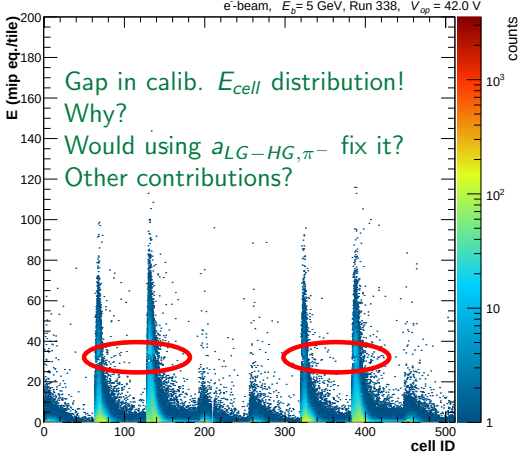
- Common slope for all $h^\pm$ & e^- in all layers
- Profile not significantly influenced by off diagonal elements
- Use a_{LG-HG} from π^- runs for calib of $h^\pm$ & e^-?

QA: e$^-$, $E = 5$ GeV (1)

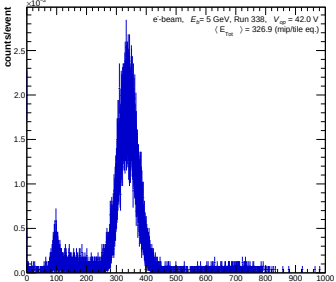

e⁻beam, E_b= 5 GeV, Run 338, V_{op} = 42.0 V
⟨ E_{Tot} ⟩ = 326.9 (mip/tile eq.)
counts/event
E_{tot} (mip eq./tile)

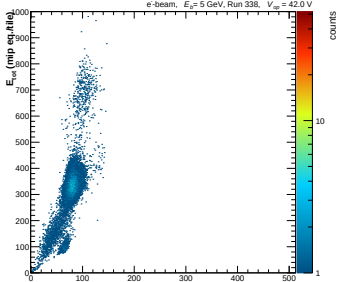

e⁻beam, E_b= 5 GeV, Run 338, V_{op} = 42.0 V
⟨ N_{Cells} ⟩ = 79.1
counts/event
N_{Cells}

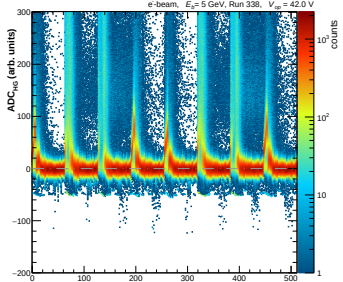

e⁻beam, E_b= 5 GeV, Run 338, V_{op} = 42.0 V
E_{Tot} (mip eq./tile)
N_{Cells}
counts

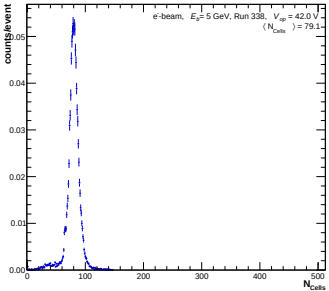

e⁻beam, E_b= 5 GeV, Run 338, V_{op} = 42.0 V
E (mip eq./tile)
cell ID
counts
Gap in calib. E_{cell} distribution!
Why?
Would using a_{LG-HG,π^-} fix it?
Other contributions?

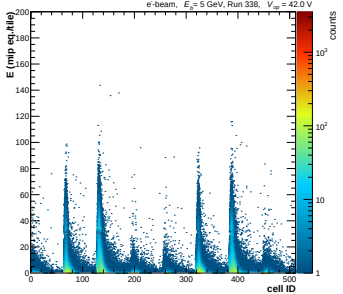
QA: e^-, $E = 5$ GeV (1)

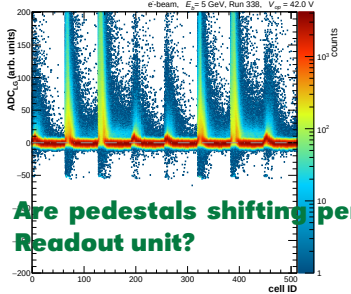






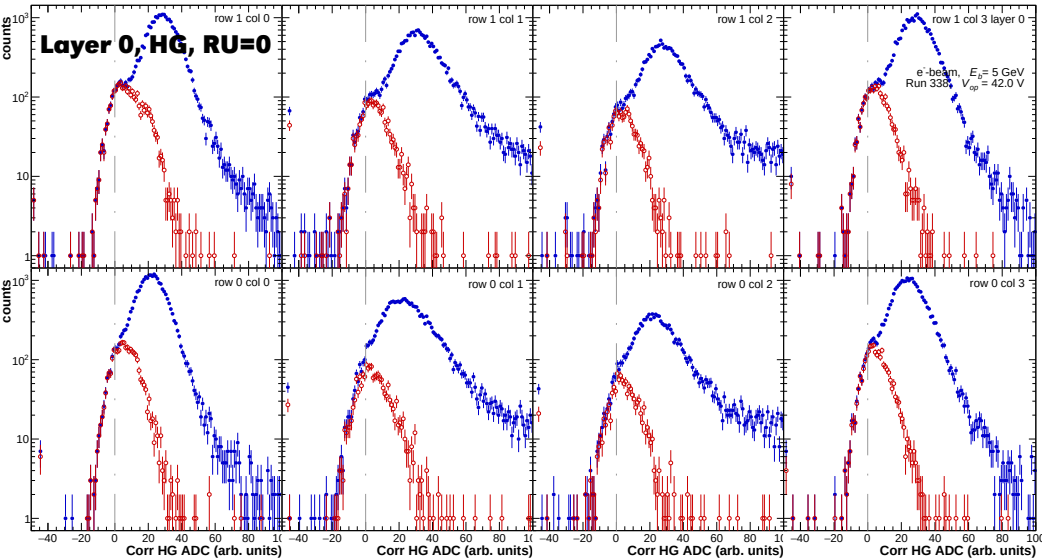






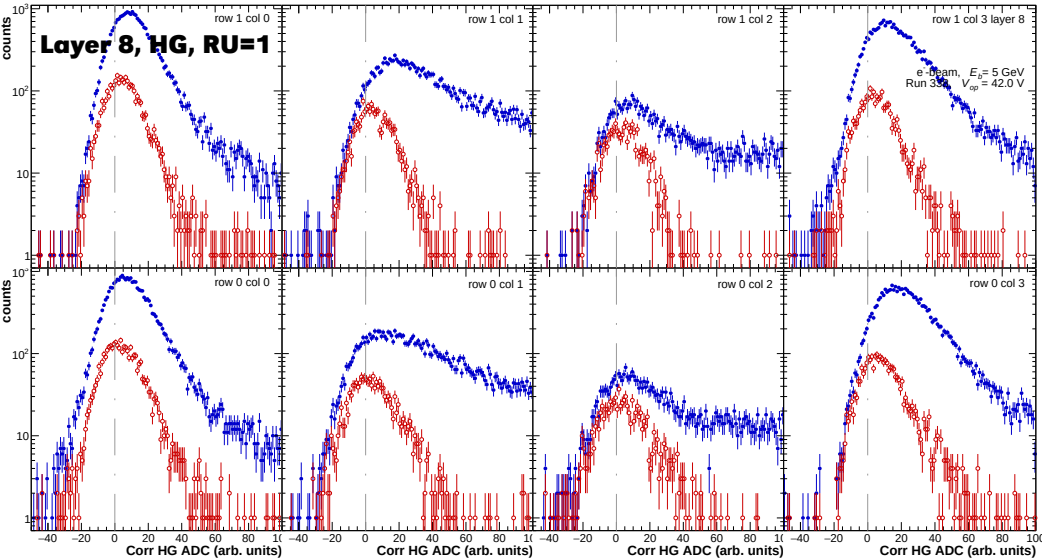
Are pedestals shifting per Readout unit?

QA: e^-, $E = 5$ GeV (2)



- Attempt to isolate noise triggers
- Pedestal shifts seem to correlate with total charge in RU
- LG shifted less than HG
- Offset consistent per layer

QA: e^-, $E = 5$ GeV (2)



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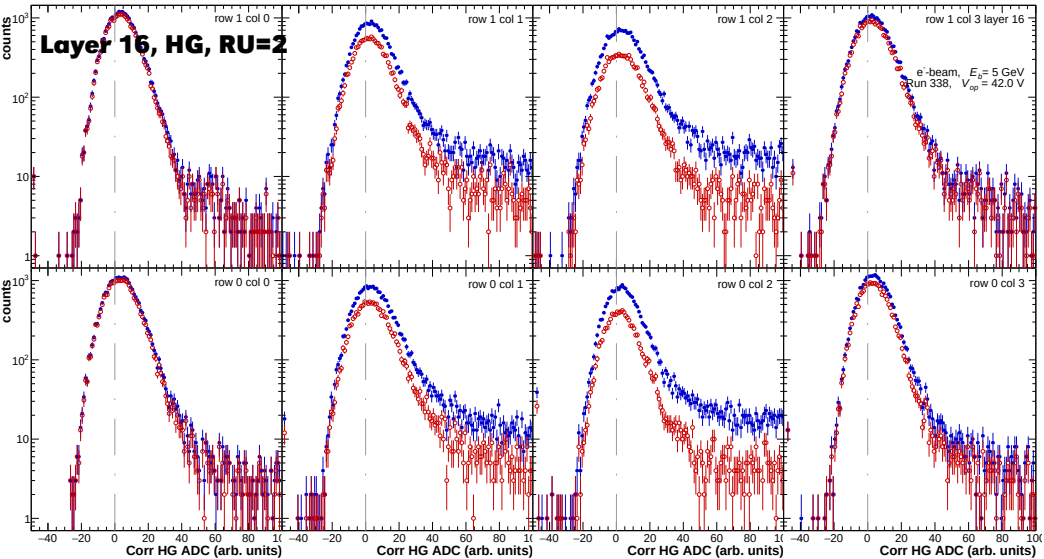

- Attempt to isolate noise triggers
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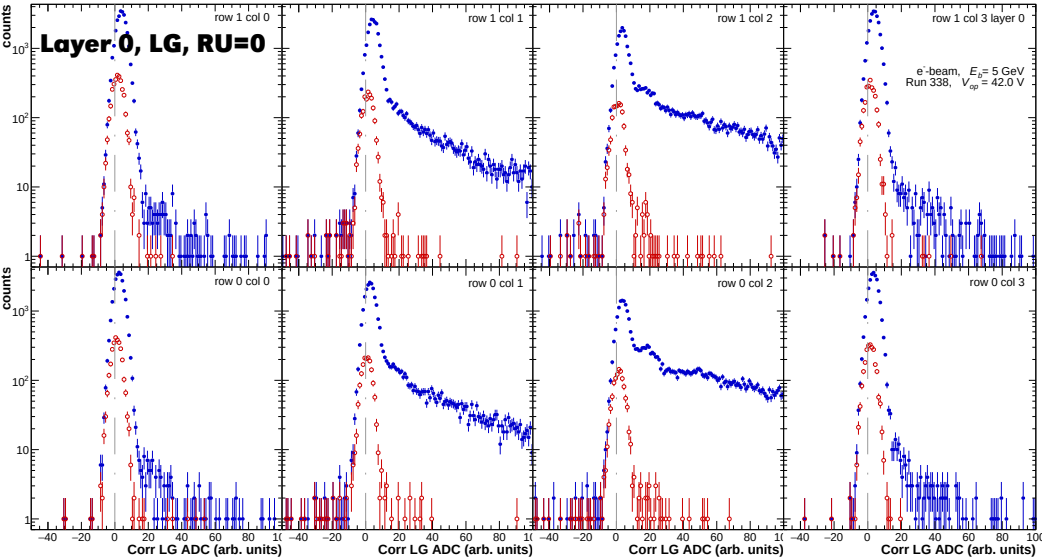

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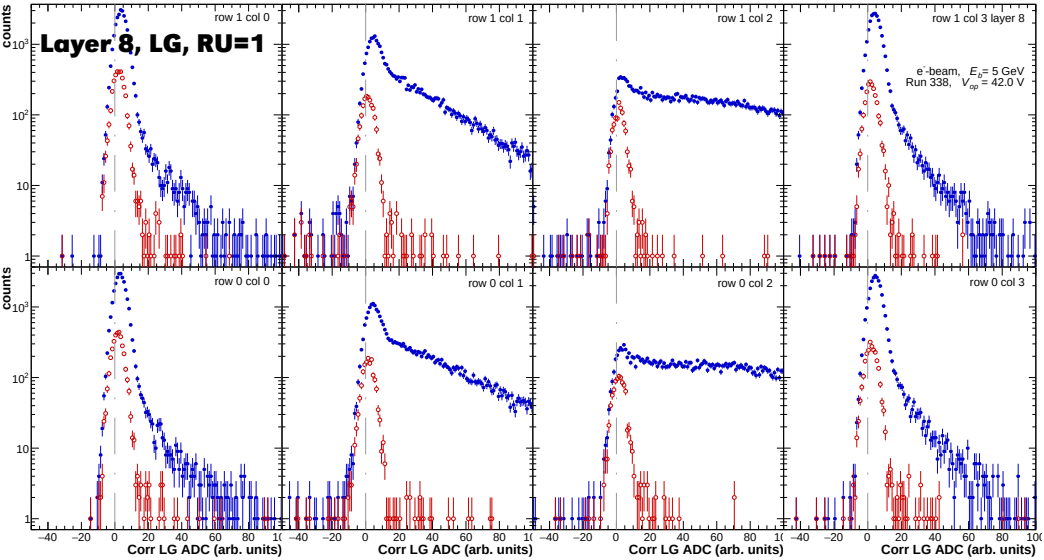

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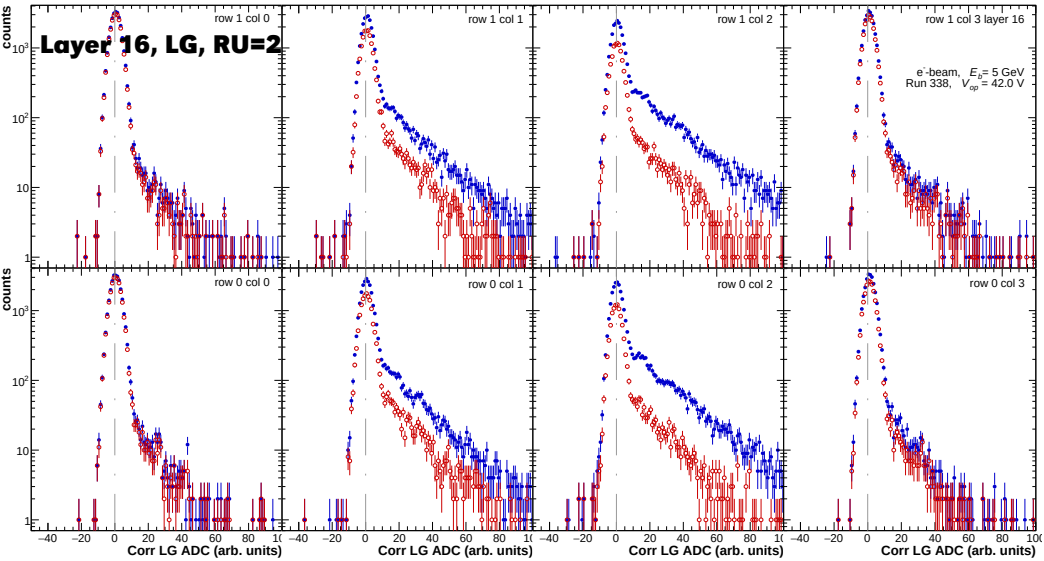

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- Offset consistent per layer

2024 TB - CAEN Readout
Next steps

Next steps

- Redo event time difference evaluation
  - → Can we find a time difference cut restoring same conditions for LG-HG corr as for muons
  - → Can we get rid of these weird $HG = 0$ events like that?
- Attempt to remove events where a channel had $HG = 0$ but $LG > XX$ after pedestal subtraction
- Evaluate LG-HG corr values based off π^- runs & patch calib objects
- Reevaluate pedestal per layer for physics runs?