

2026 SPS TB - HGCROC Readout

September 15, 2026

Friederike Bock



- 1 SPS 2026 Set C - 44V
 - Overview
 - Pedestals
 - TOA offset calibration
 - Muon Calibrations
- 2 Calibrations Summary
- 3 Additional material

2026 SPS TB - HGCROC Readout Full Set C - analysis status



Overview - Set C

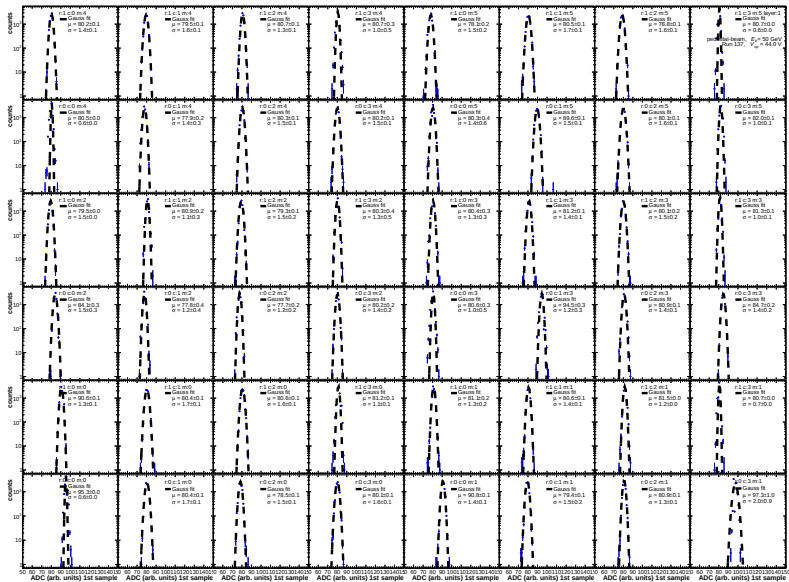
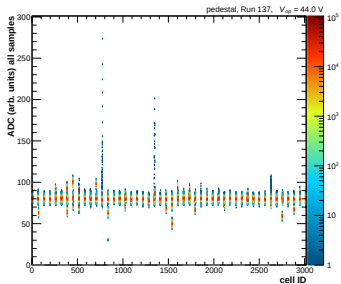
Full Set C

Summing Board V2, $V_{op} = 44$ V, gain settings: RF = 9, CF = 7, CC= 5, CFcomp=1

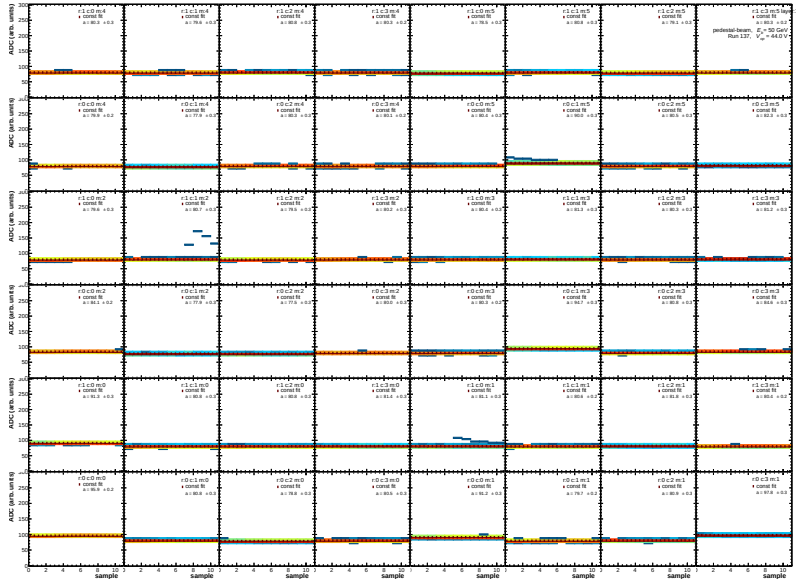
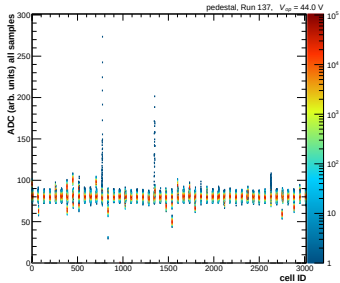
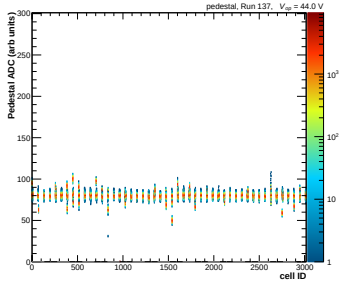
May 16, 2:34 - May 16, 14:54, additional May 17, 14:37 - May 17, 17:37

Calibration sets:															
μ table position	ped	(-15,10)	(15,0)	(-15, -10)	(-5,10)	(-5,0)	(-5,-10)	(5,10)	(5,0)	(5,-10)	(-15,10)	(15,0)	(-15, -10)		
1 st	runs	137	147	148	149	146	145	144	141	142	143	140	139	138	
	tot events	10K	152K	153K	155K	158K	163K	152K	156K	151K	151K	155K	159K	153K	
μ table position	ped	(10,-5)	(10,5)	(-10, -5)	(-10,5)	(0,0)									
2 nd	runs	188	190	191	193	192	194								
	tot events	10K	155K	150K	152K	155K	150K								
μ table position	ped	(10,-5)	(10,5)	(-10, -5)	(-10,5)	(0,0)									
3 rd	runs	278	289	292	291	290	289								
	tot events	10K	164K	157K	160K	154K	155K								
Electron set:															
E (GeV)	20	30	40	50	80	100									
e ⁻	runs	150	151	152	153	154	155								
	tot events	257K	280K	260K	288K	264K	270K								
e ⁺	runs	156	157	158	159	160	161								
	tot events	254K	255K	234K	254K	250K	254K								
	runs	279	280												
	tot events	254K	255K												
Hadron set:															
E (GeV)	20	30	40	50	60	70	80	90	100	150	200	250	300	325	350
h ⁻	runs	162	163	164	165	166	167	168	169	170	171	172	173		
	tot events	258K	256K	255K	253K	258K	255K	255K	257K	254K	256K	255K	255K		
	runs														
	tot events														
h ⁺	runs	175	176	177	178	179	180	181	182	183	186	174, 187			
	tot events	258K	253K	254K	253K	251K	251K	257K	255K	251K	260K	506K			
	runs														
	tot events														
						282	285	286	286	286	283	284	287	288	
						268K	252K	316K	253K	253K	256K	263K			

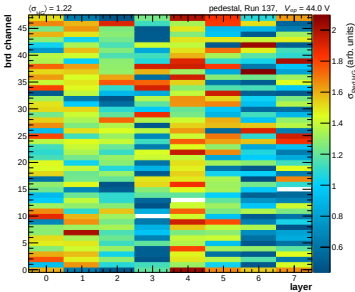
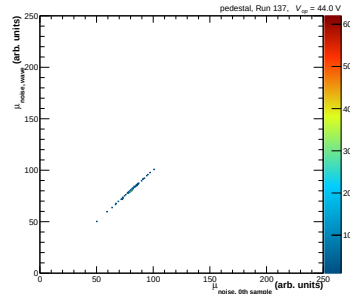
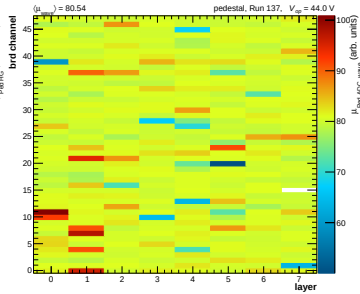
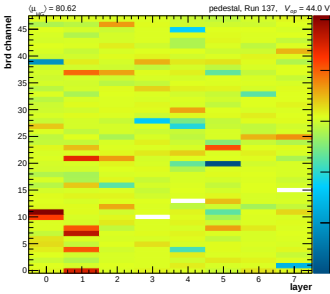
- time:
 - 16.5.2026 2:34 - 14:54 & 17.5.2026 14:37 -17:37
- $V_{op} = 44$ V, $V_{br} = 38.3$ V
- Gain settings:
 - RF = 9, CF = 7, CC= 5, CFcomp=1
- e^- and $h^\pm$ with small scintillators
- μ with large scintillator triggers:
 - 12 positions Scan “_1”
 - 5 positions Scan “_2”
 - 5 positions Scan “_3”



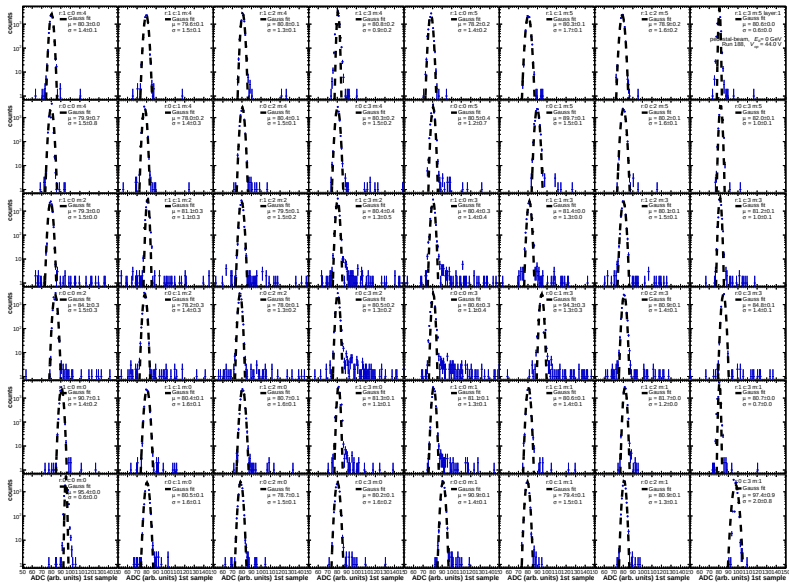
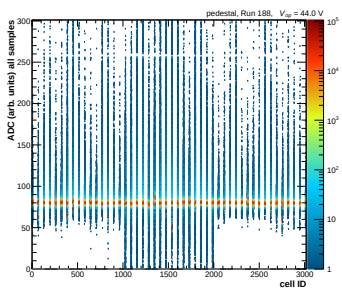
Muon calibration - Set 1: Pedestals



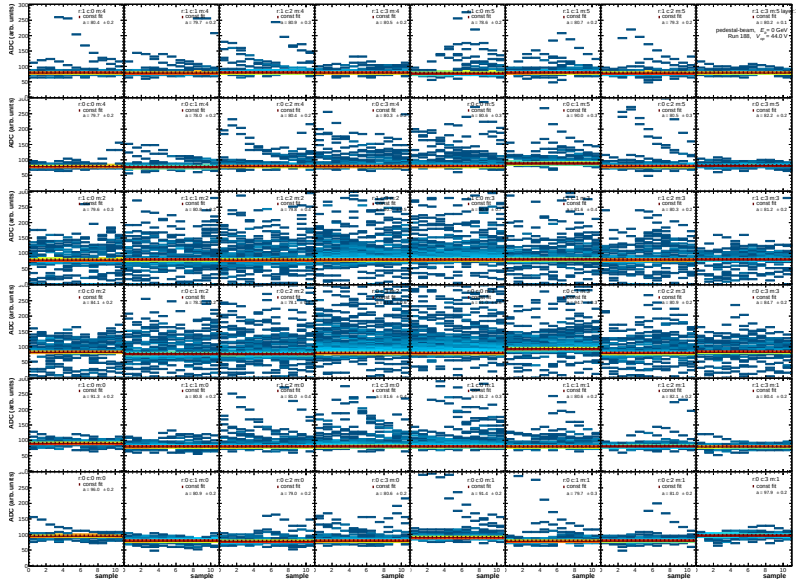
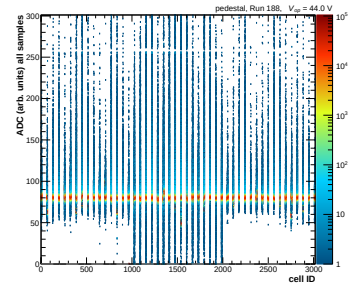
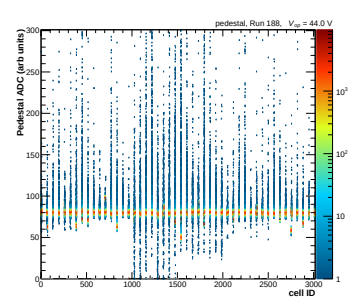
Muon calibration - Set 1: Pedestals



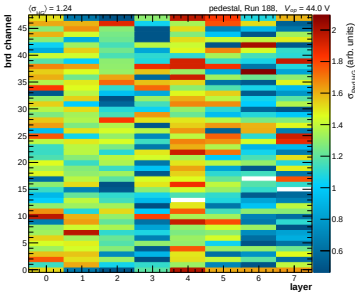
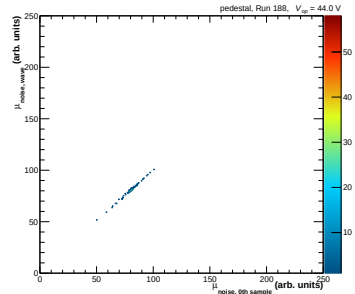
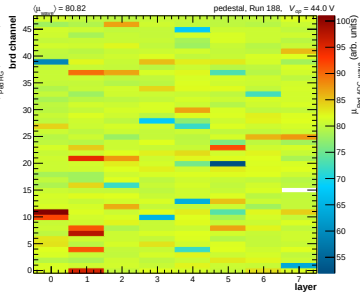
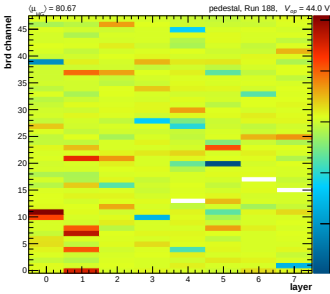
- Pedestal for all readout units set to 80 ADC
- Online calibration verified
- Fitting converges for most cells (3 missing)
- Good correlation between alternative fitting methods for pedestal



Muon calibration - Set 2: Pedestals

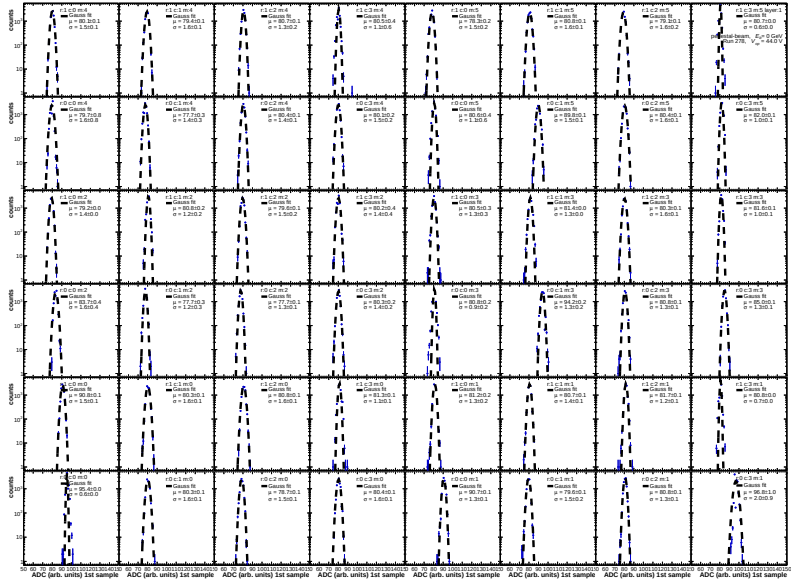
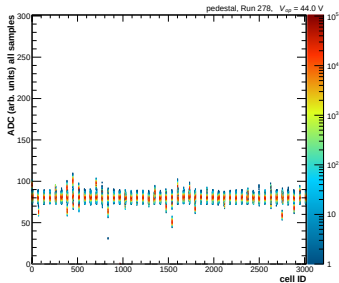
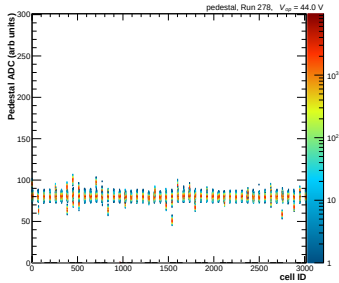


Muon calibration - Set 2: Pedestals

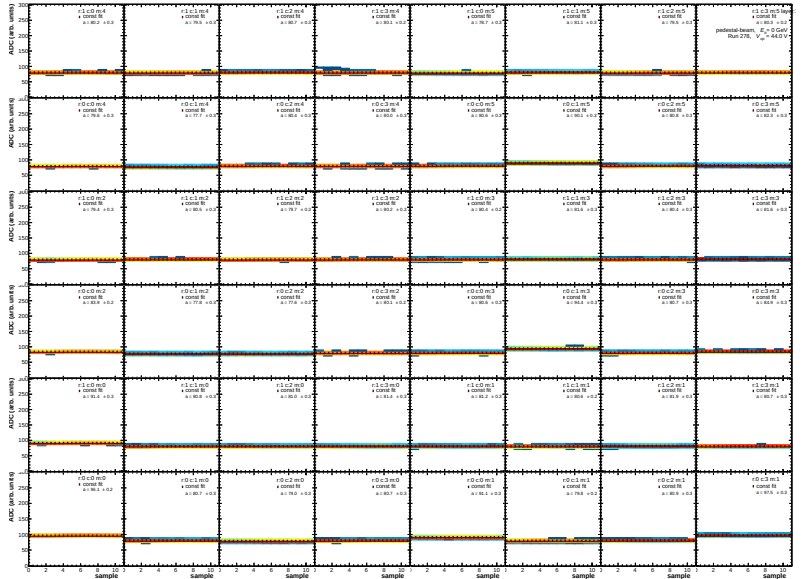
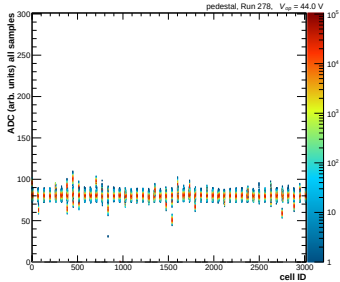
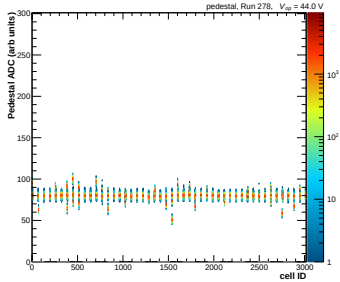


- Pedestal for all readout units set to 80 ADC
- Online calibration verified
- Contamination with random beam particles (shutter not fully closed & high intensity beam) - no big influence on pedestal
- Fitting converges for most cells (3 missing)
- Good correlation between alternative fitting methods for pedestal

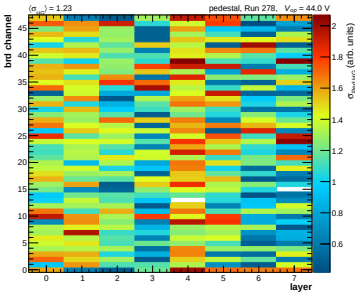
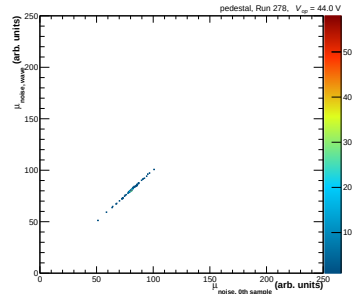
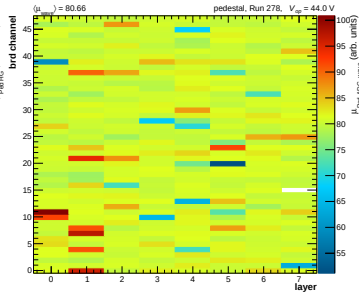
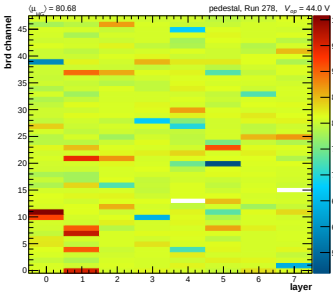
Muon calibration - Set 3: Pedestals



Muon calibration - Set 3: Pedestals

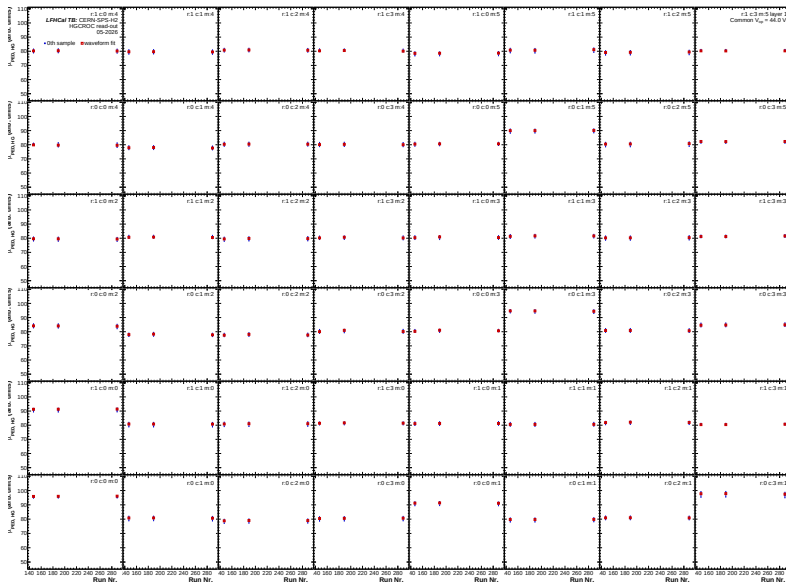
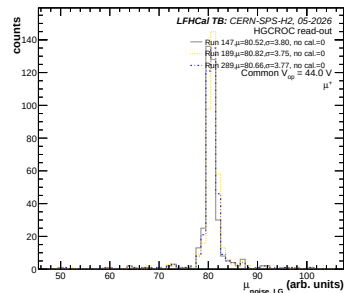
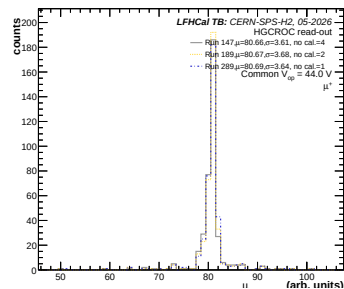


Muon calibration - Set 3: Pedestals

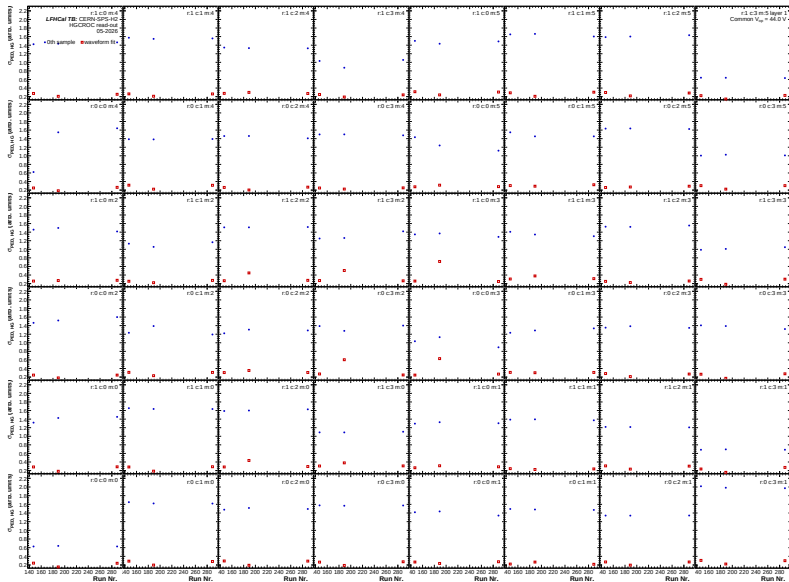
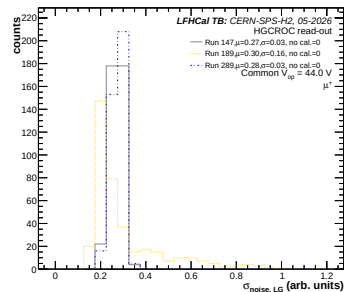
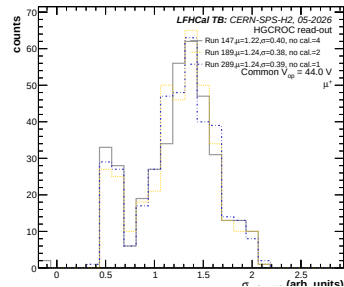


- Pedestal for all readout units set to 80 ADC
- Online calibration verified
- Fitting converges for most cells (2 missing)
- Good correlation between alternative fitting methods for pedestal

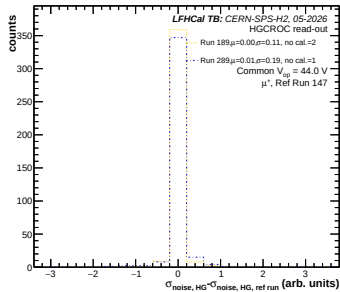
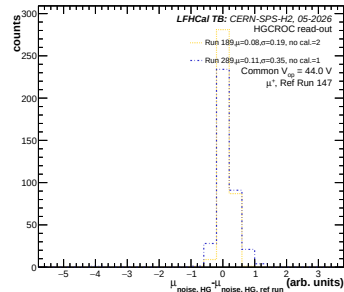
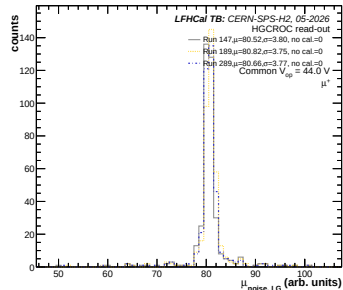
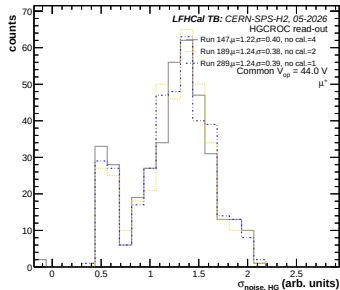
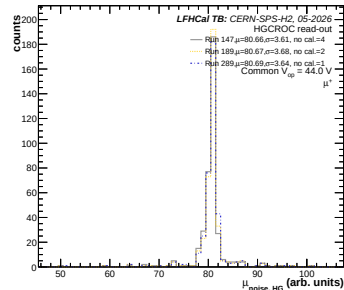
Muon calibration - Pedestal Comparison



Muon calibration - Pedestal Comparison

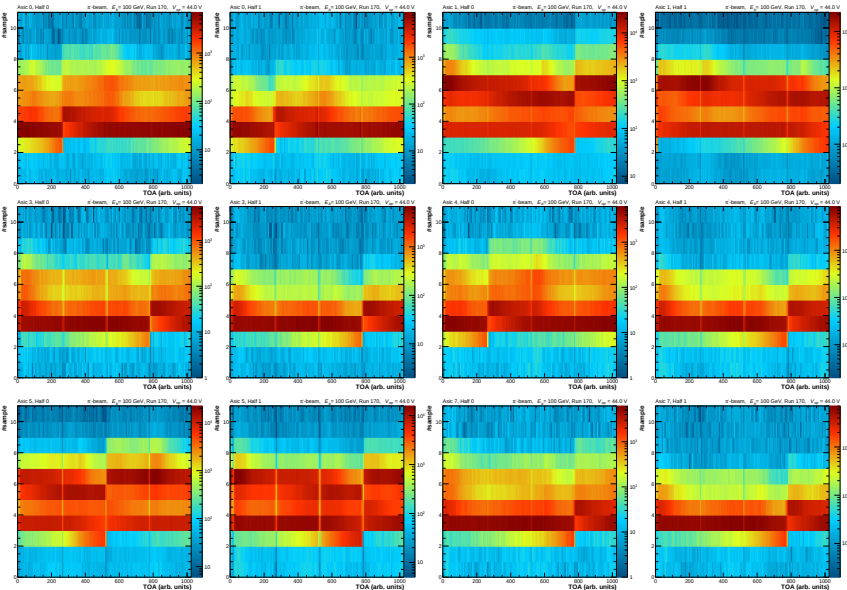


Muon calibration - Pedestal Comparison



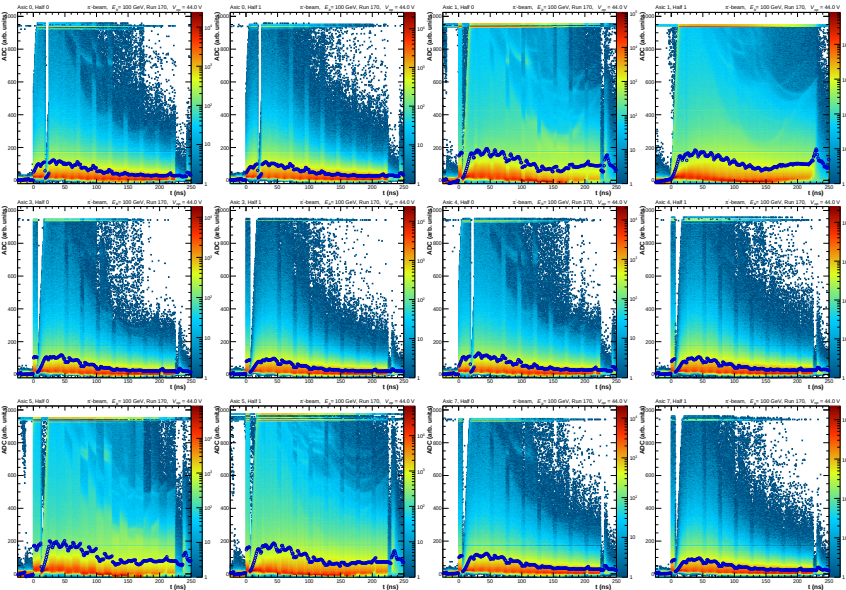
- Very similar pedestal position for all pedestal runs
- Width varies slightly between runs, but within fitting uncertainties
- Either run could be used for corrections

TOA offset calibration



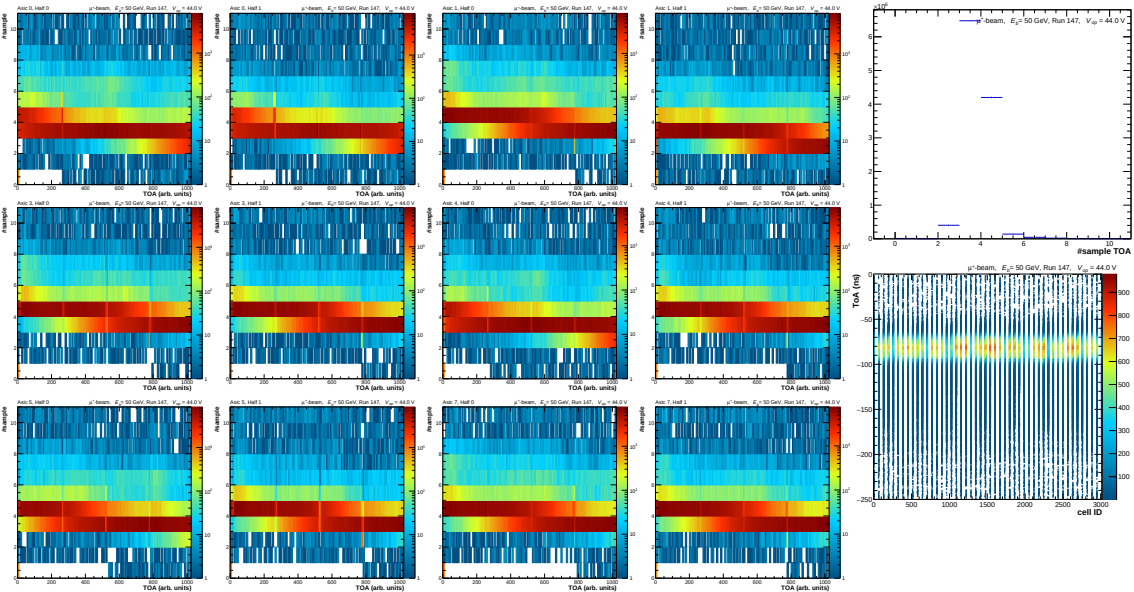
- Estimated using 100 GeV pion run (170)
- Based on ToA vs nSample plot
- Applied consistently to subsets 1 & 2
- [TOA calib offset file (1 & 2)]
- Using ToA offsets from run 281 (additional stat) for 3rd subset
- [TOA calib offset file (3)]

TOA offset calibration

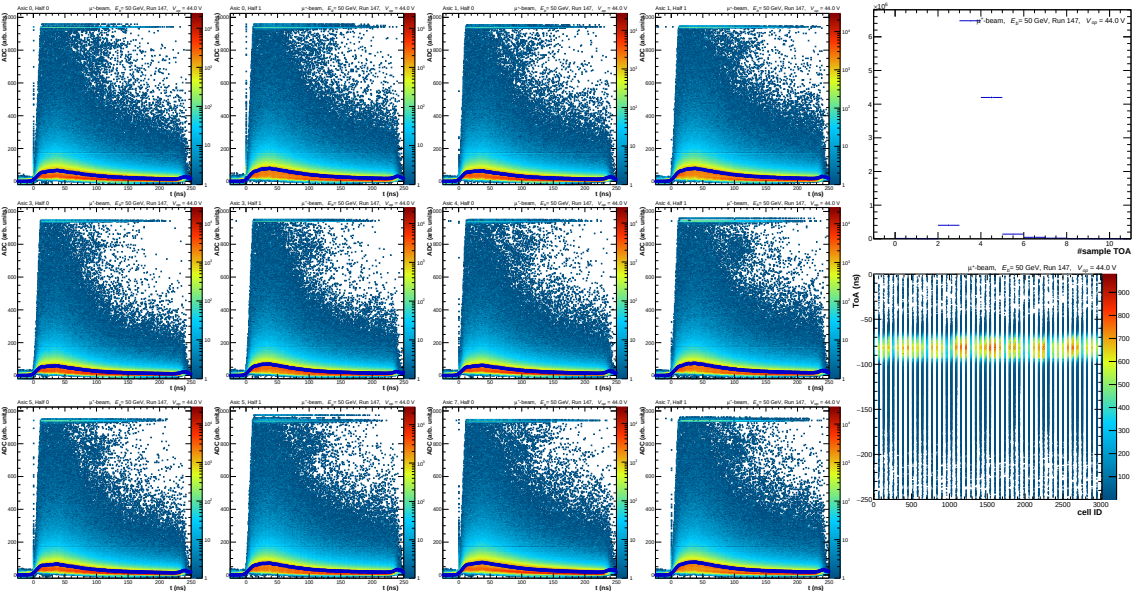


- Estimated using 100 GeV pion run (170)
- Based on ToA vs nSample plot
- Applied consistently to subsets 1 & 2
- [TOA calib offset file (1 & 2)]
- Using ToA offsets from run 281 (additional stat) for 3rd subset
- [TOA calib offset file (3)]

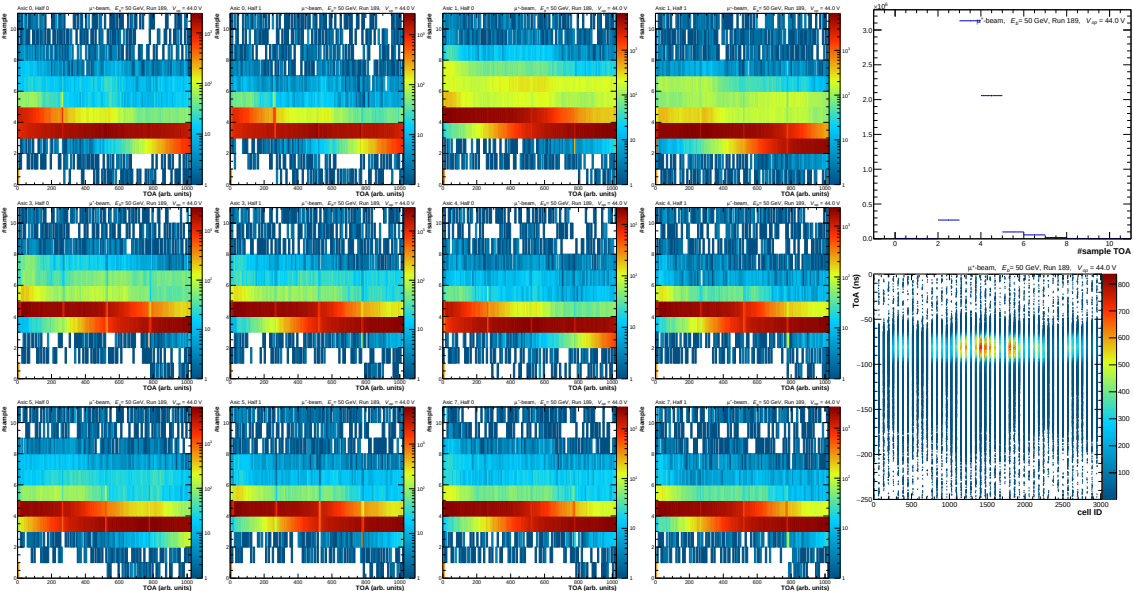
TOA offset calibration - Applied Set 1



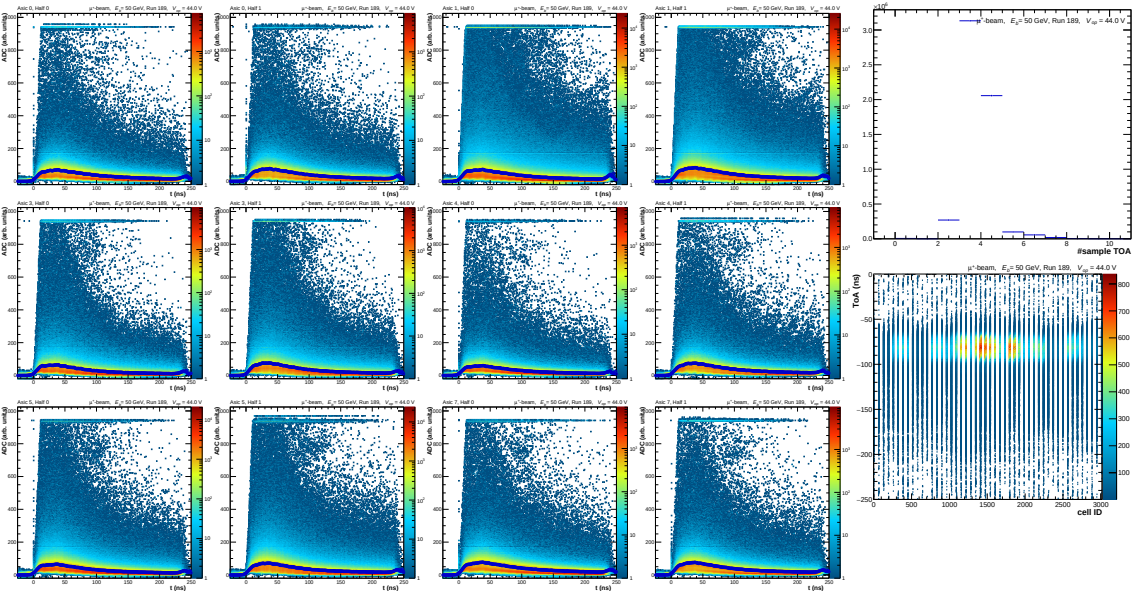
TOA offset calibration - Applied Set 1



TOA offset calibration - Applied Set 2

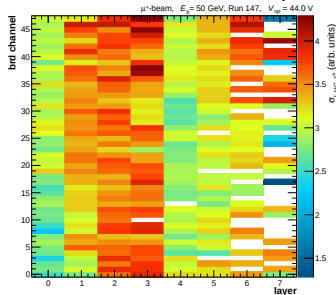
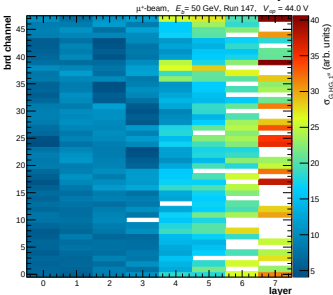
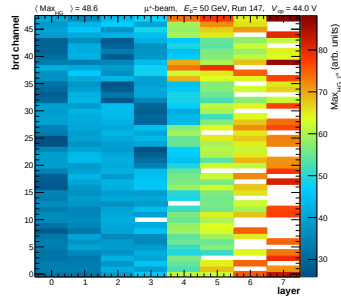
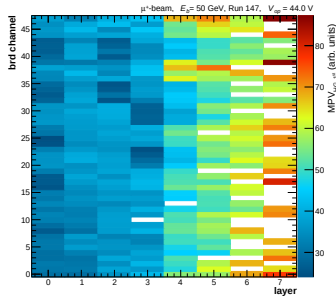
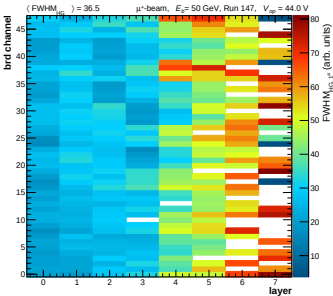


TOA offset calibration - Applied Set 2



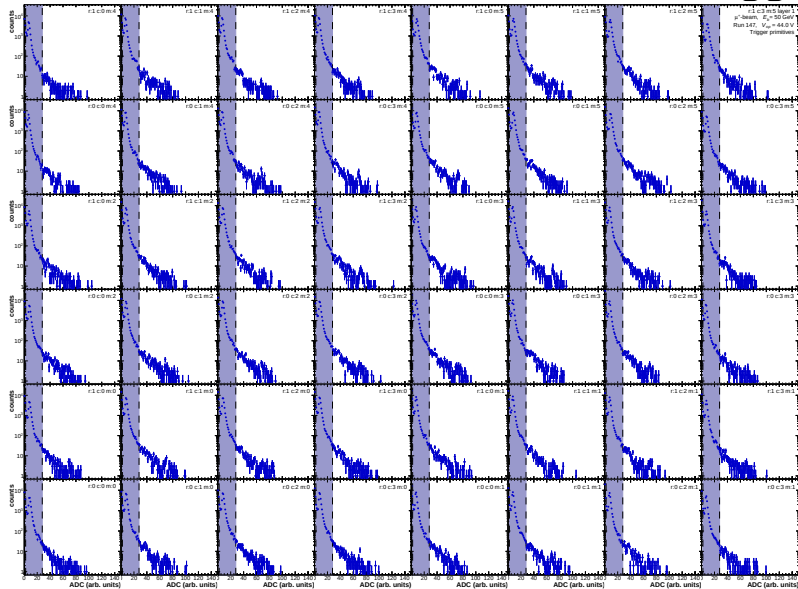


Muon calibration - Set 1: Muons - init (blue)

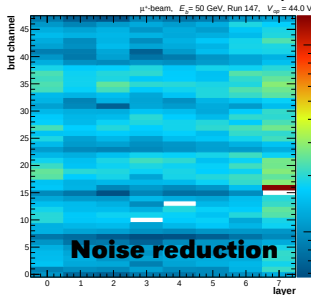
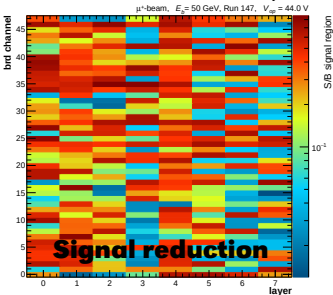
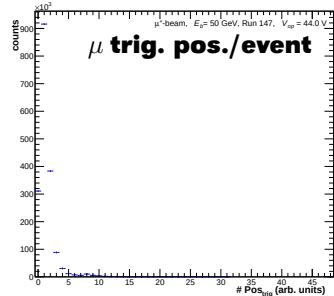
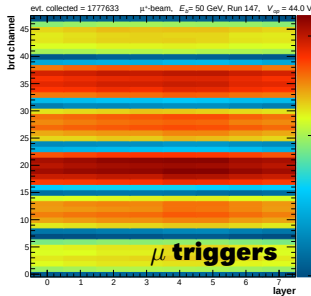
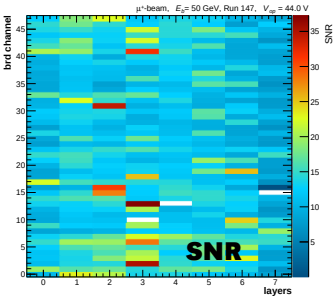


- Initial fit for 44 V & RF=9 with lots of no converging cells, primarily layers in the back fail in initial fit (blue distribution previous slide)
- $\langle \text{Max}_{mip} \rangle = 48.6$
- channels with lower statistics not well fitted

Muon calibration - Set 1: Muons - Trigger

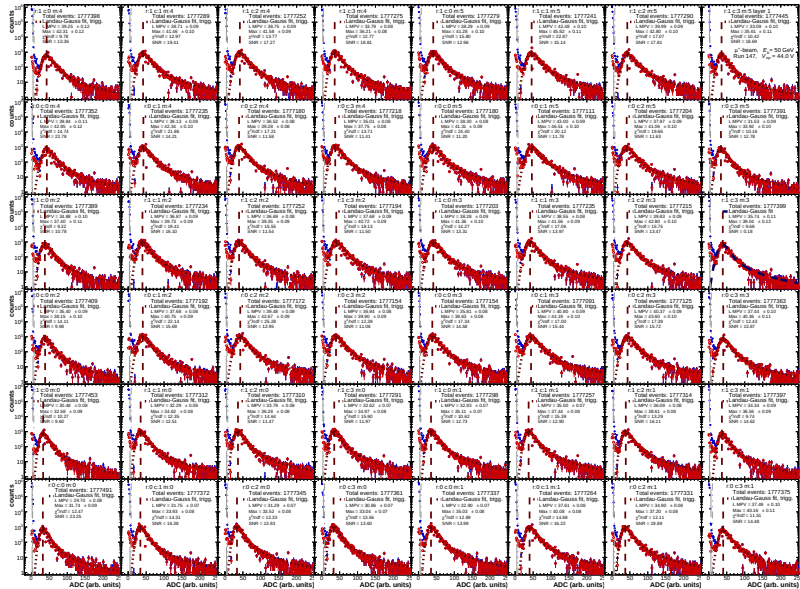


Muon calibration - Set 1: Muons - Trigger

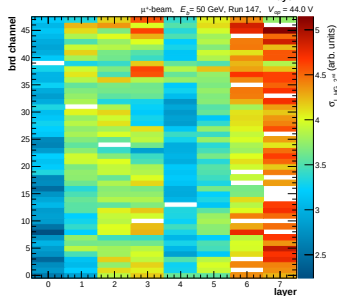
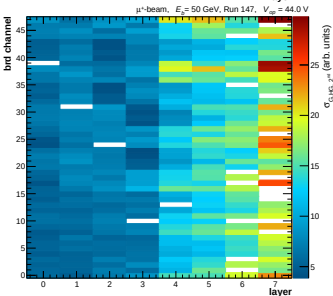
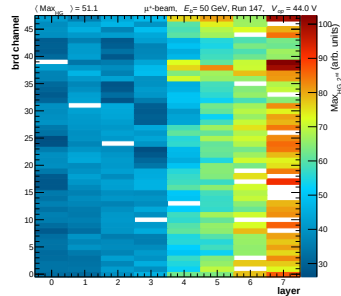
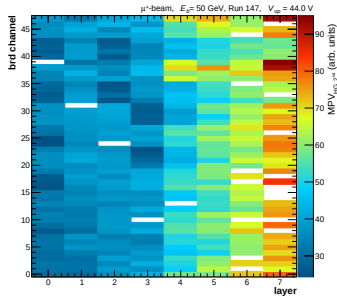
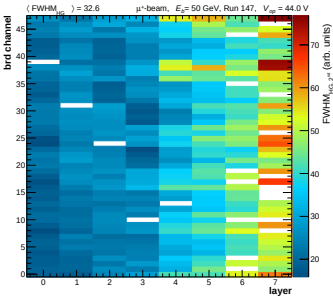


- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in $z > 3\sigma_{ped}$
- ⇒ Noise suppression could be improved by increasing $n\sigma_{ped}$
- Clear enhancement in trigger primitives, 0th level muon selection within $0.3\langle Max_{mip} \rangle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

Muon calibration - Set 1: Muons - 0th ite

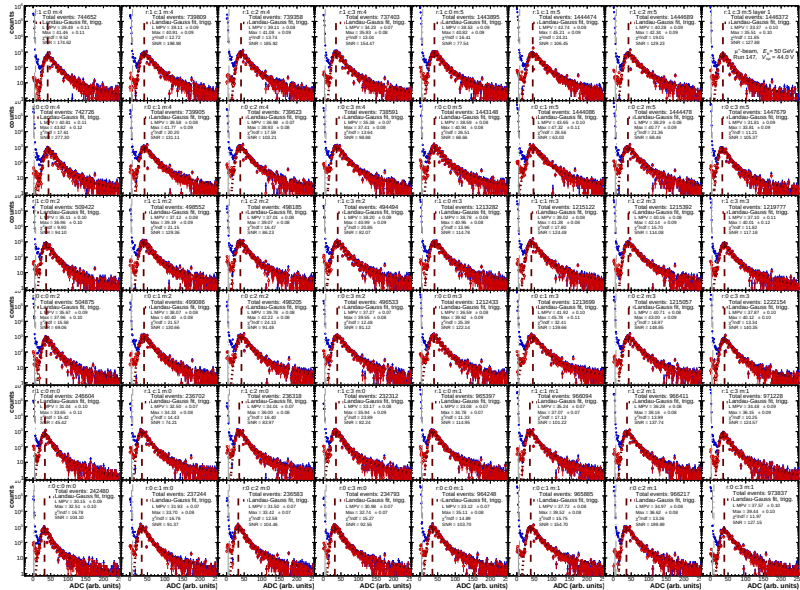


Muon calibration - Set 1: Muons - 0th ite

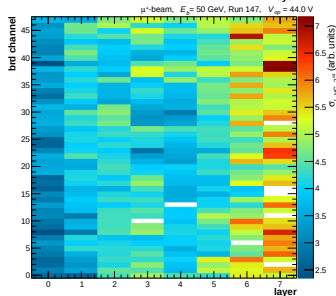
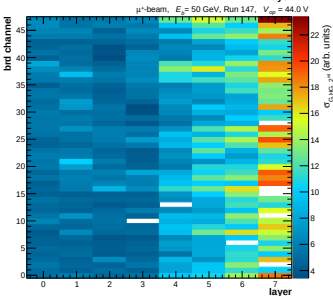
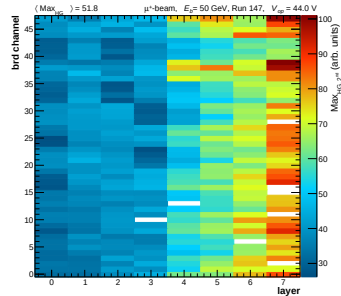
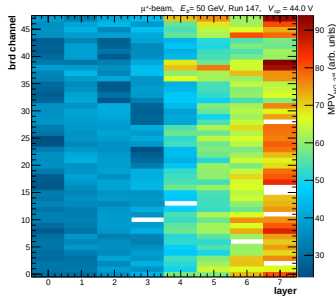
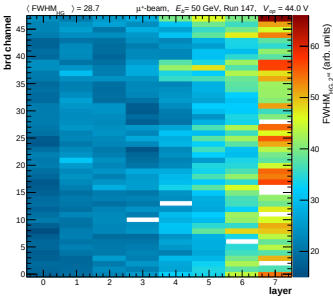


- Most channels "fitable"
- 2 channels identified as bad
- Constrained fit much more in width
- $\langle \text{Max}_{mip} \rangle = 51.1$

Muon calibration - Set 1: Muons - 5th ite

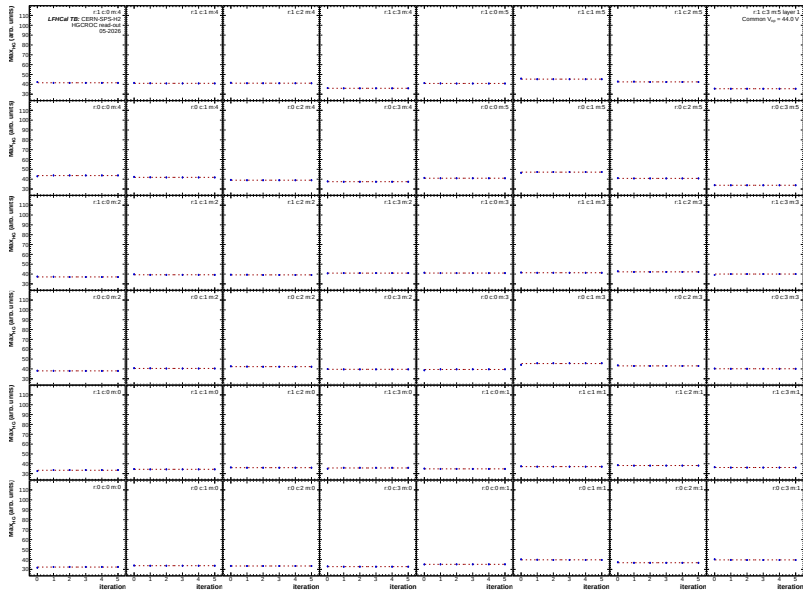


Muon calibration - Set 1: Muons - 5th ite

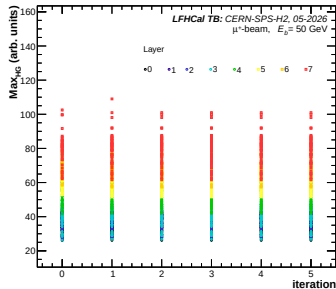
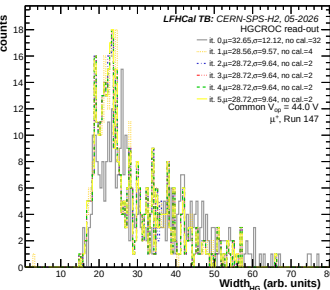
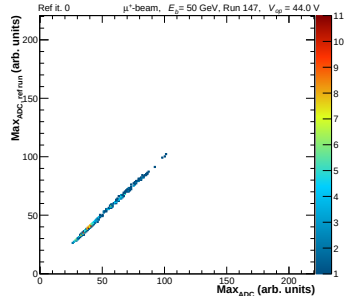
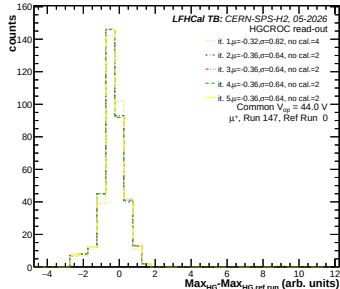
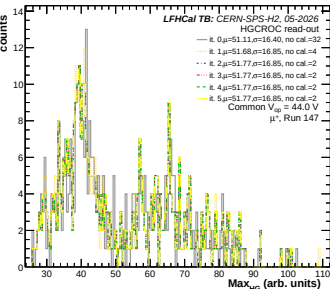


- Nearly all channels "fitable"
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 51.8$

Muon calibration - Set 1: Muons - Iterations



Muon calibration - Set 1: Muons - Iterations



- Reduced mip selection range for trigger primitives

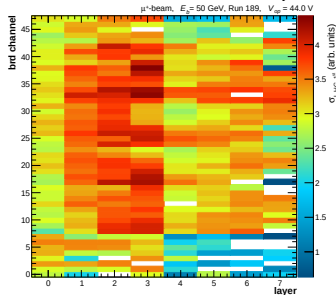
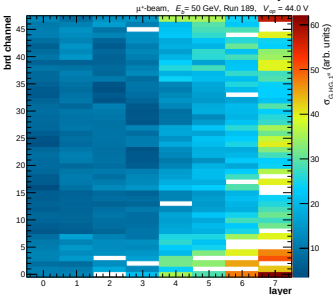
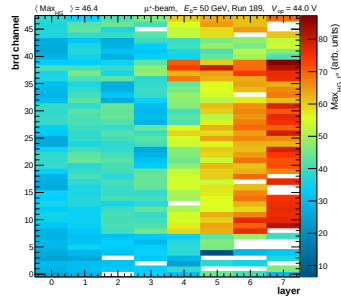
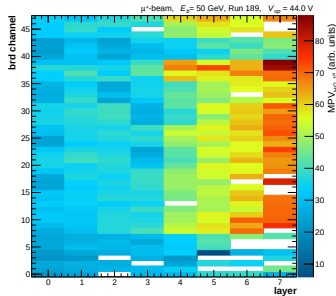
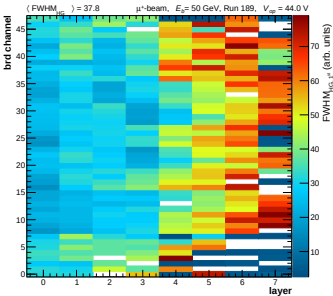
$$0.8 \langle Max_{mip} \rangle < trigg_{prim} < 2.5 \langle Max_{mip} \rangle$$

⇒ 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 2-3 iterations

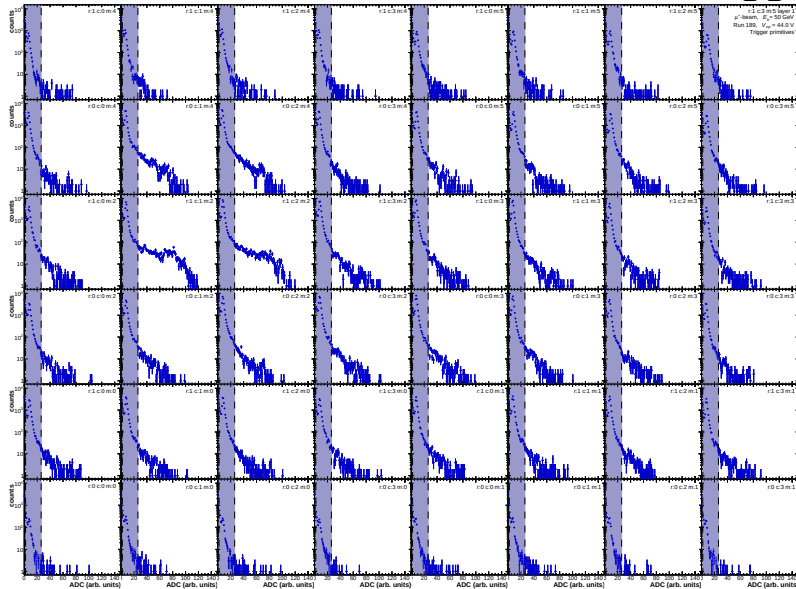


Muon calibration - Set 2: Muons - init (blue)

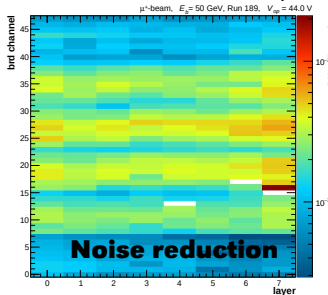
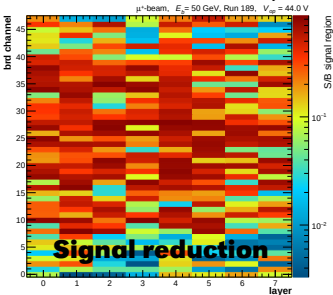
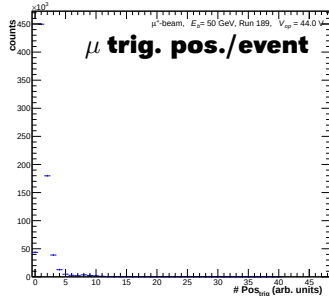
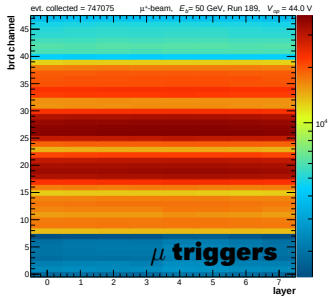
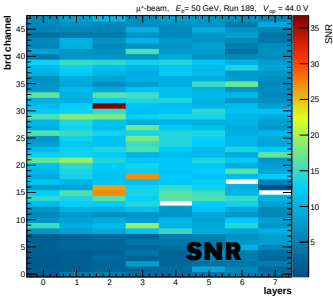


- Initial fit for 44 V & RF=9, statistics driven in particular at edges of detector
- $\langle \text{Max}_{\text{mip}} \rangle = 46.4$
- No strong ch-by-ch variations in individual parameters per layer

Muon calibration - Set 2: Muons - Trigger

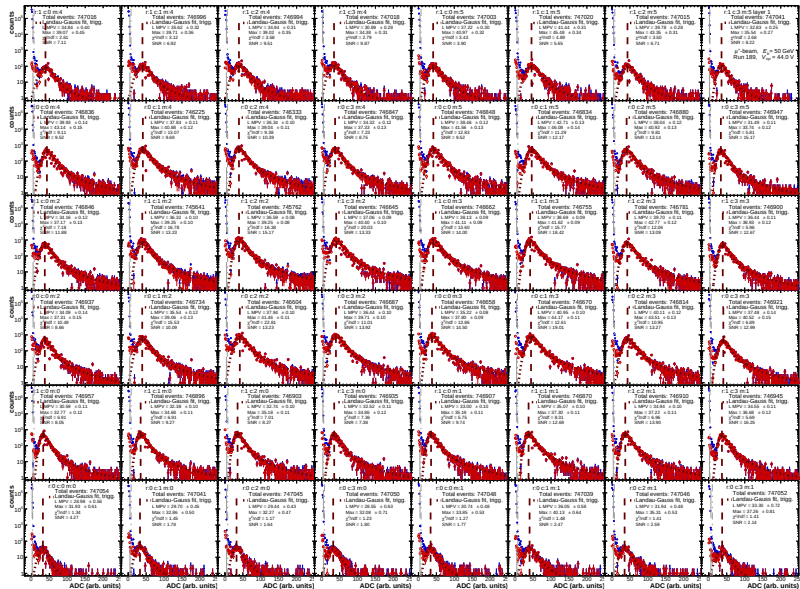


Muon calibration - Set 2: Muons - Trigger

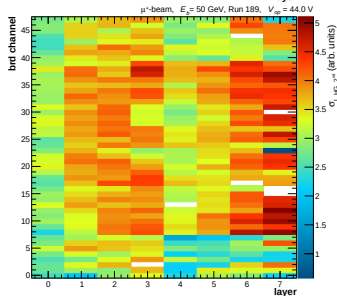
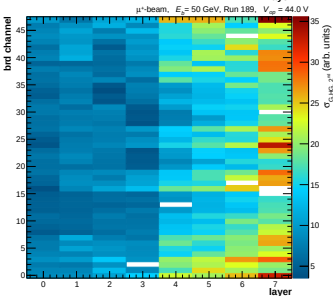
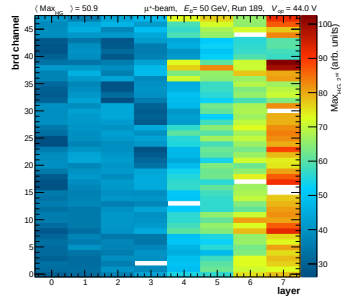
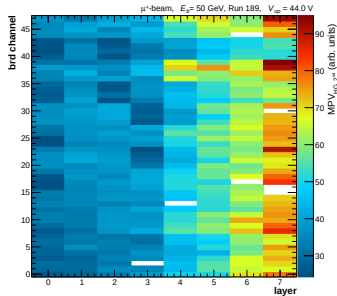
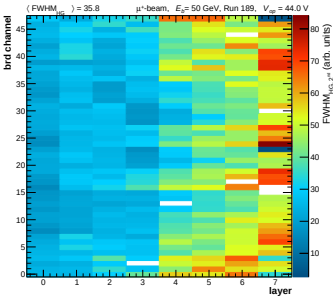


- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in $z > 3\sigma_{ped}$
- ⇒ Noise suppression could be improved by increasing $n\sigma_{ped}$
- Clear enhancement in trigger primitives, 0th level muon selection within $0.3\langle Max_{mip} \rangle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

Muon calibration - Set 2: Muons - 0th ite



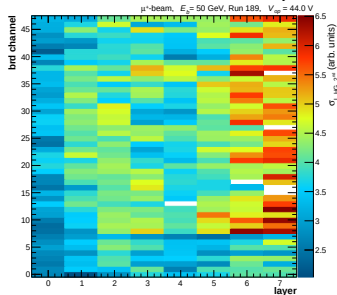
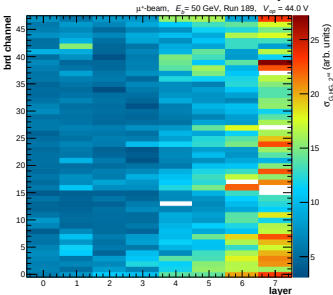
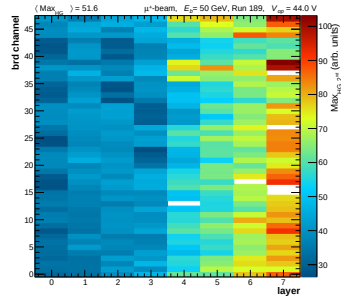
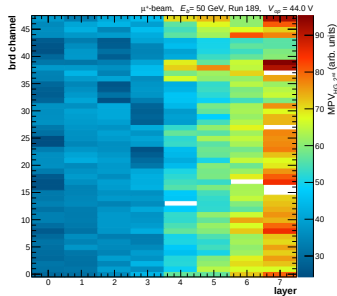
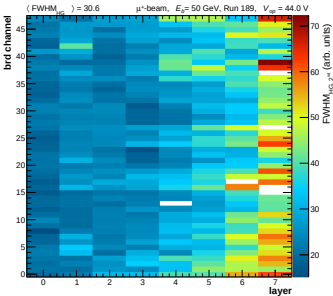
Muon calibration - Set 2: Muons - 0th ite



- Nearly all channels "fitable"
- 2 channels identified as bad
- Poor χ^2/ndf for some
- Constrained fit much more in width
- $\langle \text{Max}_{mip} \rangle = 50.9$

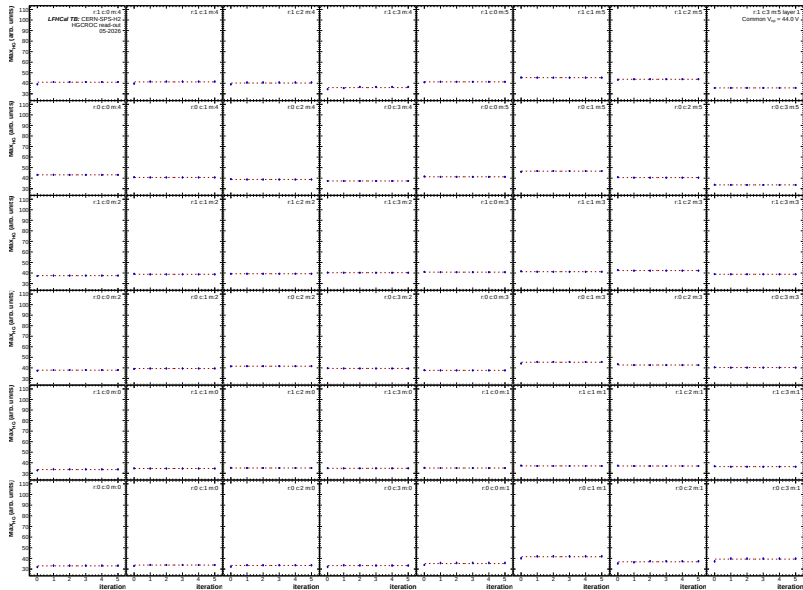


Muon calibration - Set 2: Muons - 5th ite

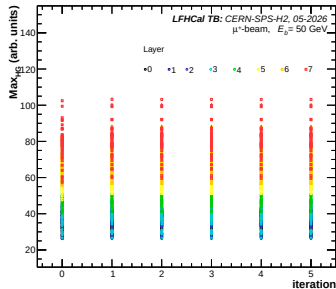
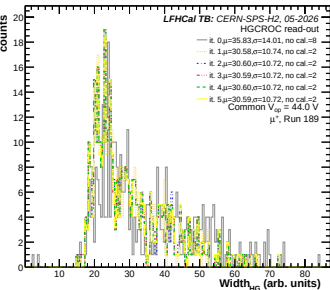
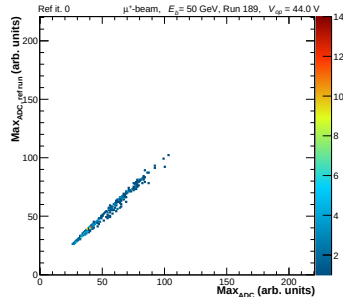
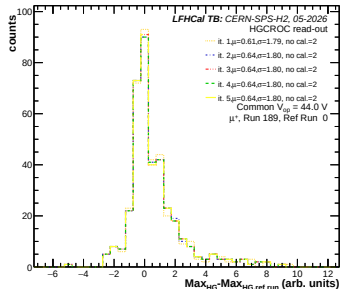
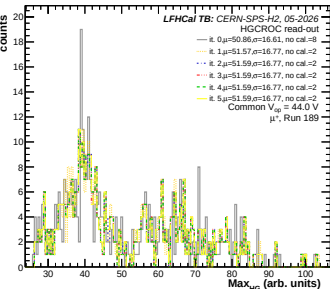


- Nearly all channels "fitable"
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 51.6$

Muon calibration - Set 2: Muons - Iterations



Muon calibration - Set 2: Muons - Iterations



- Reduced mip selection range for trigger primitives

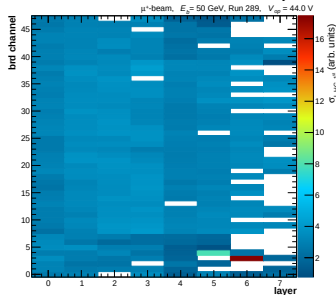
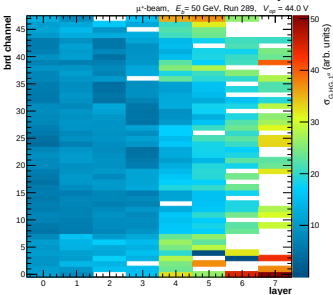
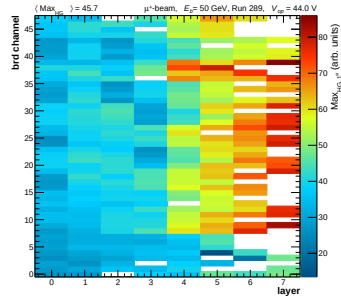
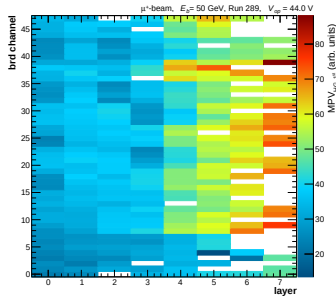
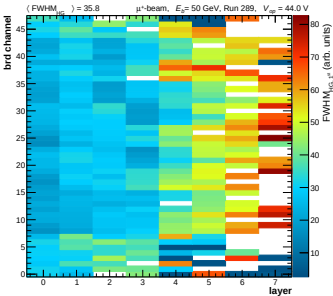
$$0.8 \langle Max_{mip} \rangle < trigg_{prim} < 2.5 \langle Max_{mip} \rangle$$

⇒ 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 2-3 iterations

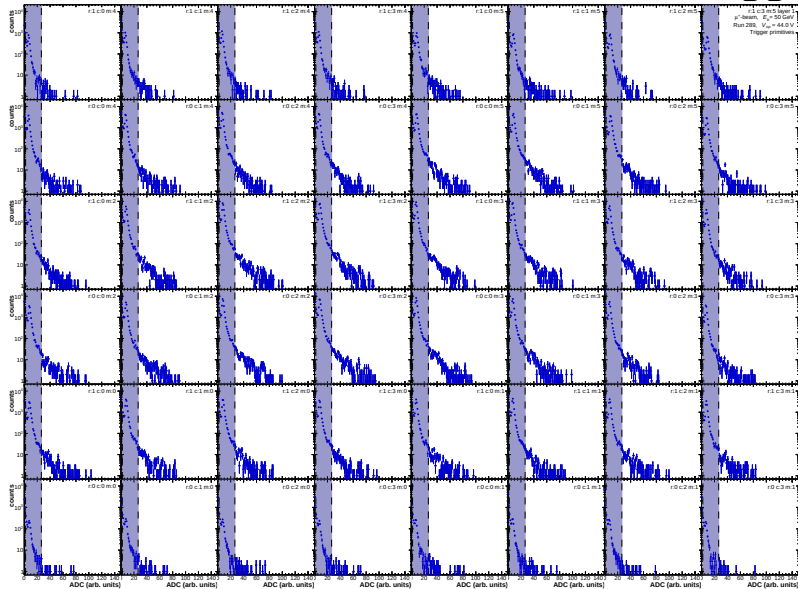


Muon calibration - Set 3: Muons - init (blue)

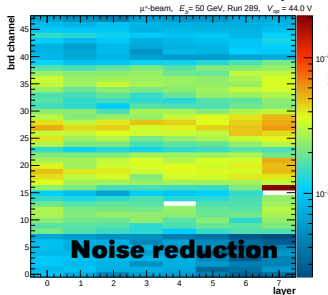
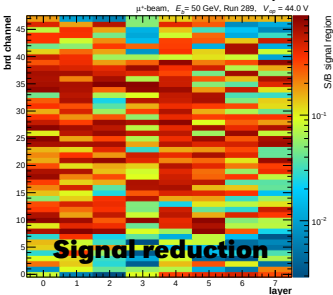
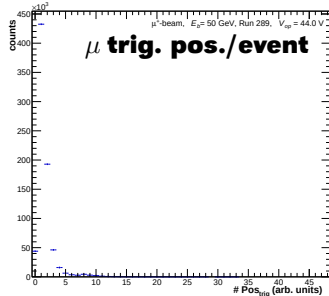
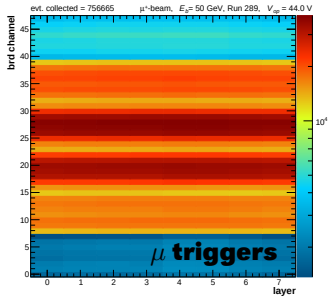
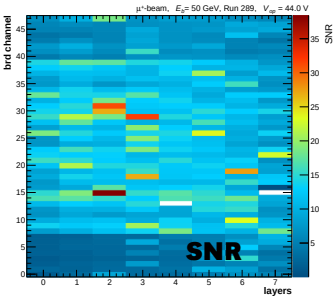


- Initial fit for 44 V & RF=9, statistics driven in particular at edges of detector
- $\langle Max_{mip} \rangle = 45.7$
- No strong ch-by-ch variations in individual parameters per layer

Muon calibration - Set 3: Muons - Trigger

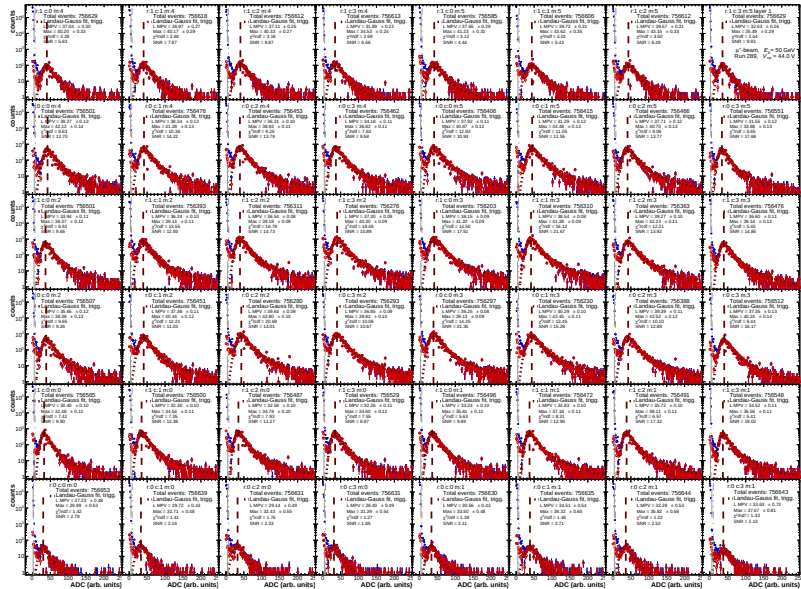


Muon calibration - Set 3: Muons - Trigger

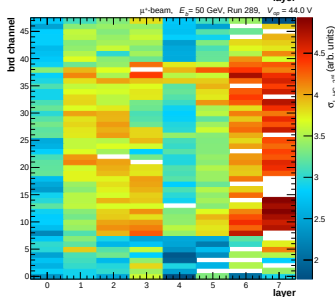
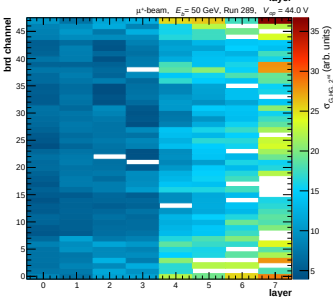
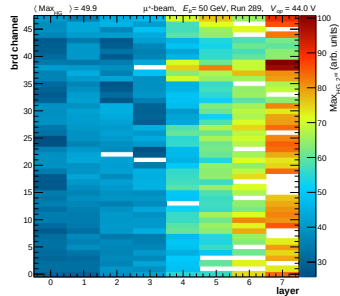
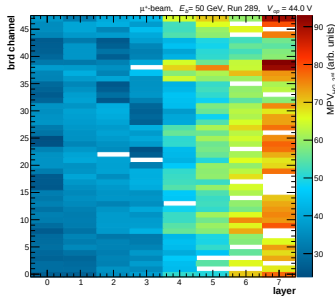
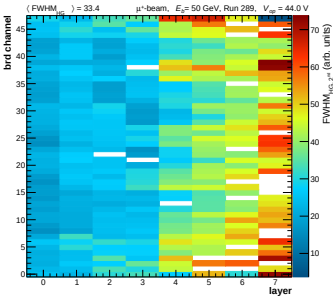


- Trigger evaluation for fixed column and row (all z-segments) if average signal summed over all active cells in $z > 3\sigma_{ped}$
- ⇒ Noise suppression could be improved by increasing $n\sigma_{ped}$
- Clear enhancement in trigger primitives, 0th level muon selection within $0.3\langle Max_{mip} \rangle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

Muon calibration - Set 3: Muons - 0th ite

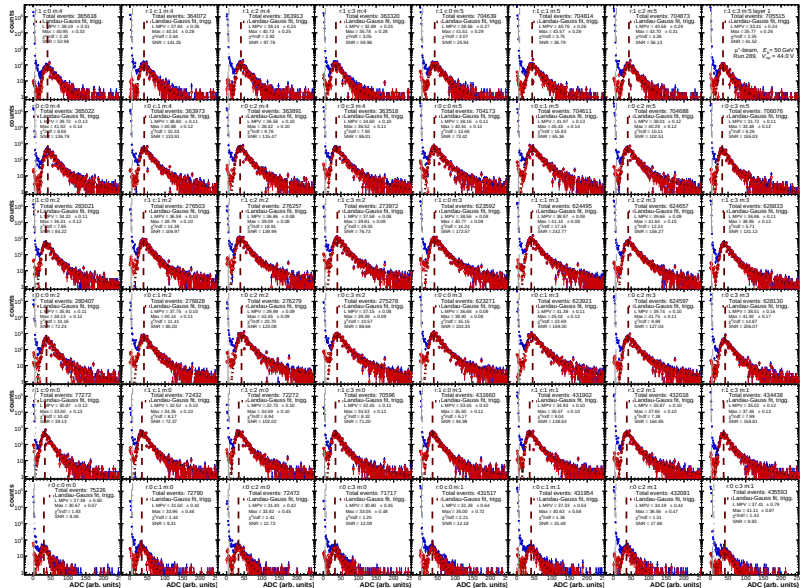


Muon calibration - Set 3: Muons - 0th ite

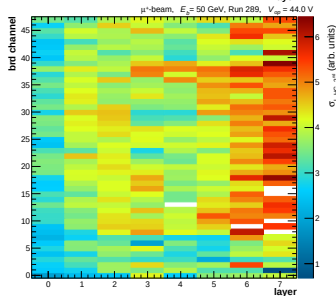
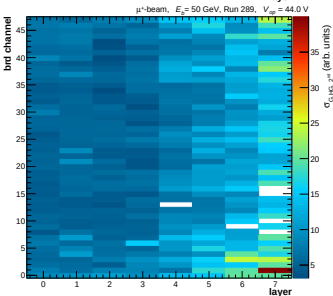
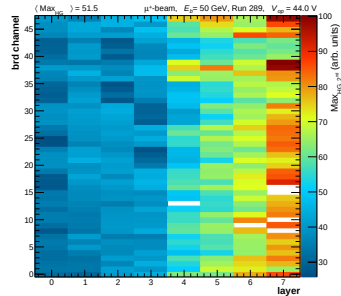
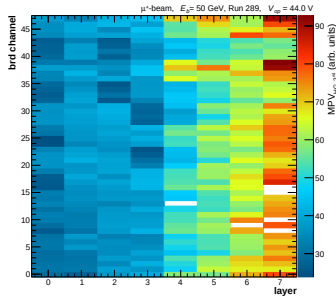
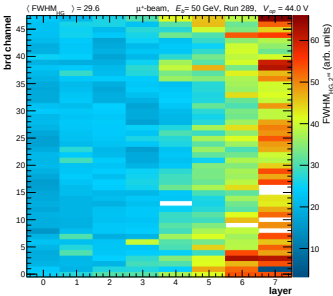


- Nearly all channels "fitable"
- 2 channels identified as bad
- Poor χ^2/ndf for some
- Constrained fit much more in width
- $\langle \text{Max}_{mip} \rangle = 49.9$

Muon calibration - Set 3: Muons - 5th ite

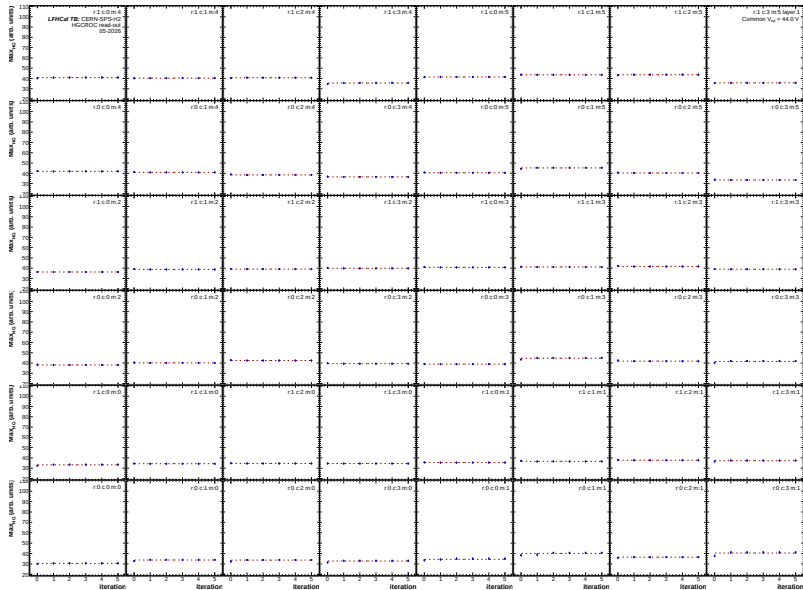


Muon calibration - Set 3: Muons - 5th ite

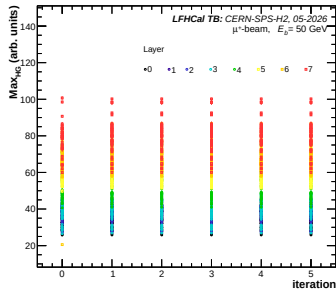
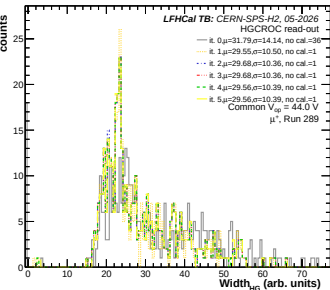
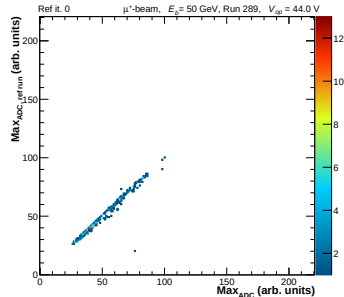
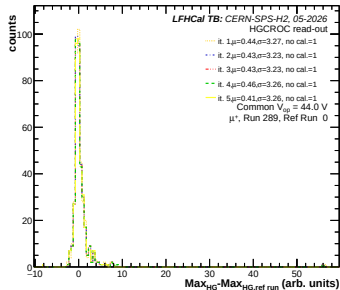
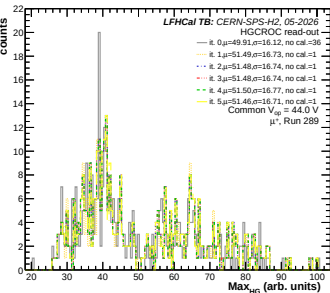


- Nearly all channels "fitable"
- 2 channels identified as bad
- $\langle \text{Max}_{mip} \rangle = 51.5$

Muon calibration - Set 3: Muons - Iterations



Muon calibration - Set 3: Muons - Iterations



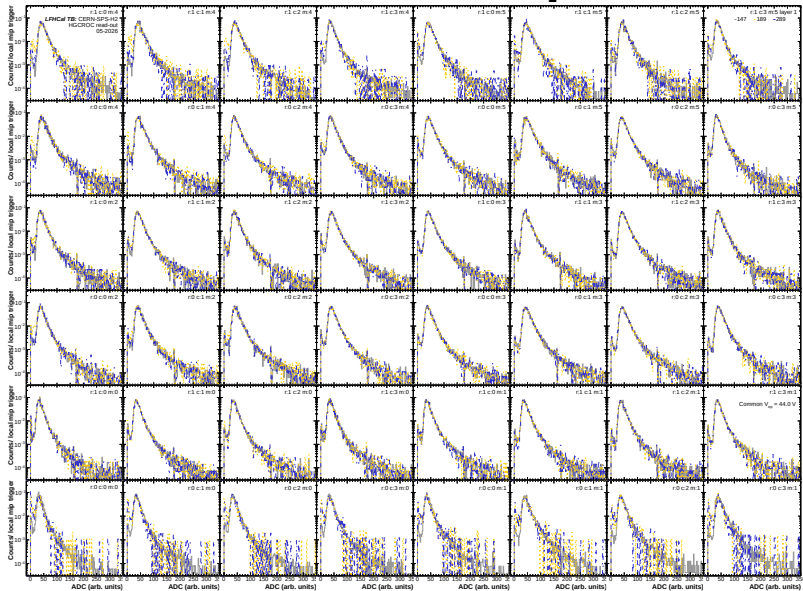
- Reduced mip selection range for trigger primitives

$$0.8 \langle Max_{mip} \rangle < trigg_{prim} < 2.5 \langle Max_{mip} \rangle$$

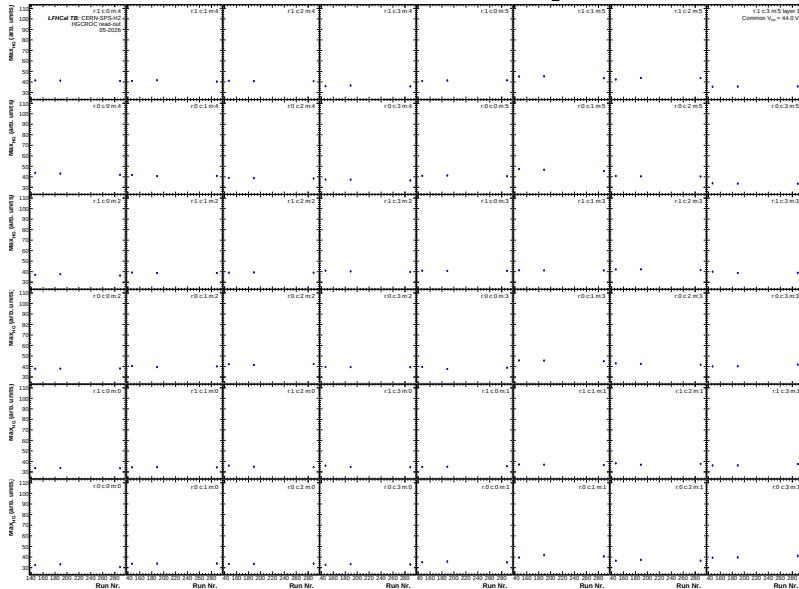
⇒ Further reduction of noise peak

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

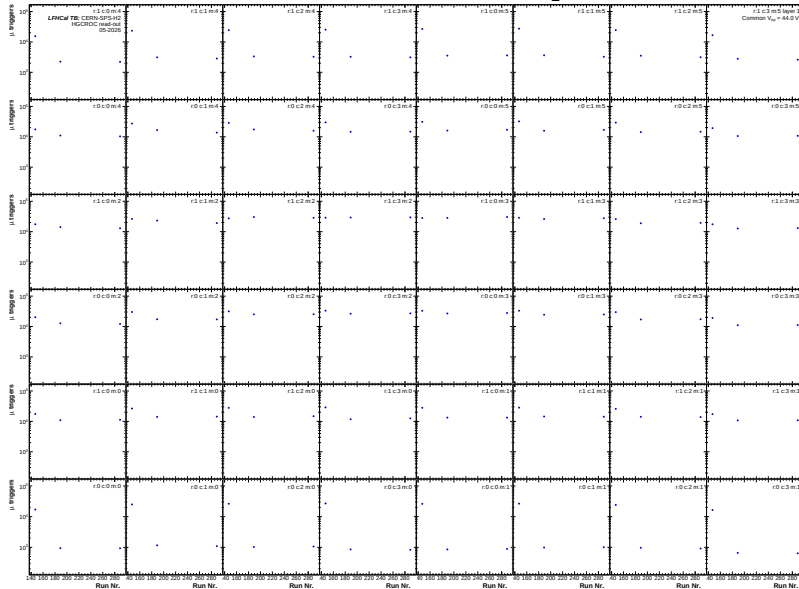
Muon calibration - Comparison Sets



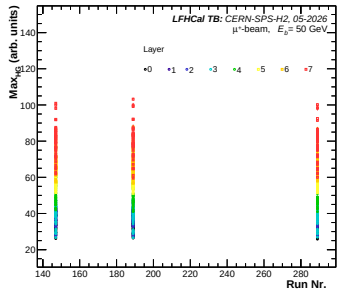
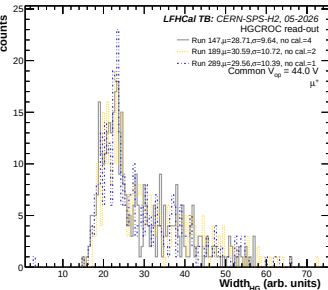
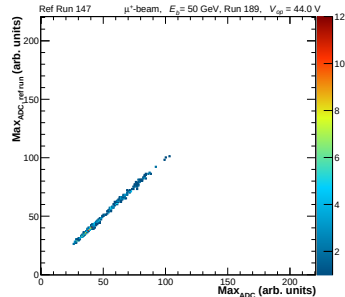
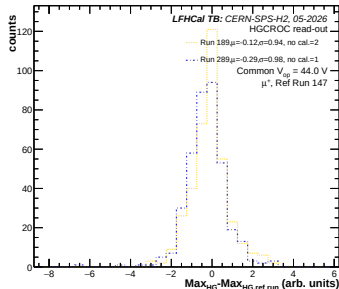
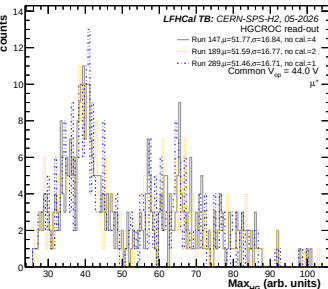
Muon calibration - Comparison Sets



Muon calibration - Comparison Sets



Muon calibration - Comparison Sets



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

Calibration summary - Set C



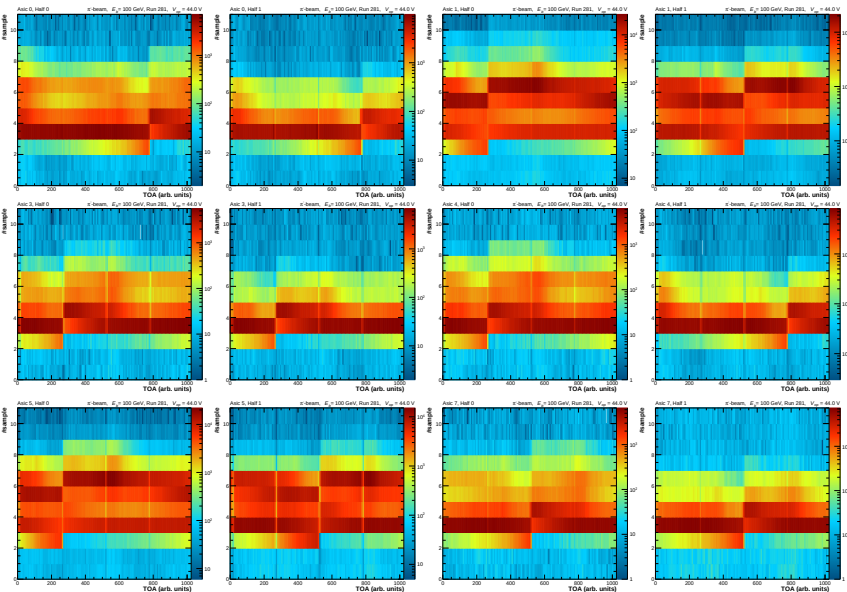
Calibration summary

- 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 main set of C run, additional runs use their own 100 GeV h^- run (pion) run
- Final calibration based off 'Set_1' (12 beam positions) due to higher statistics & better coverage
 - ▶ Calib file FullSet C 1st [txt-file]
 - ▶ Calib file FullSet C 2nd [txt-file]
 - ▶ Calib file FullSet C 3rd [txt-file]

Additional material

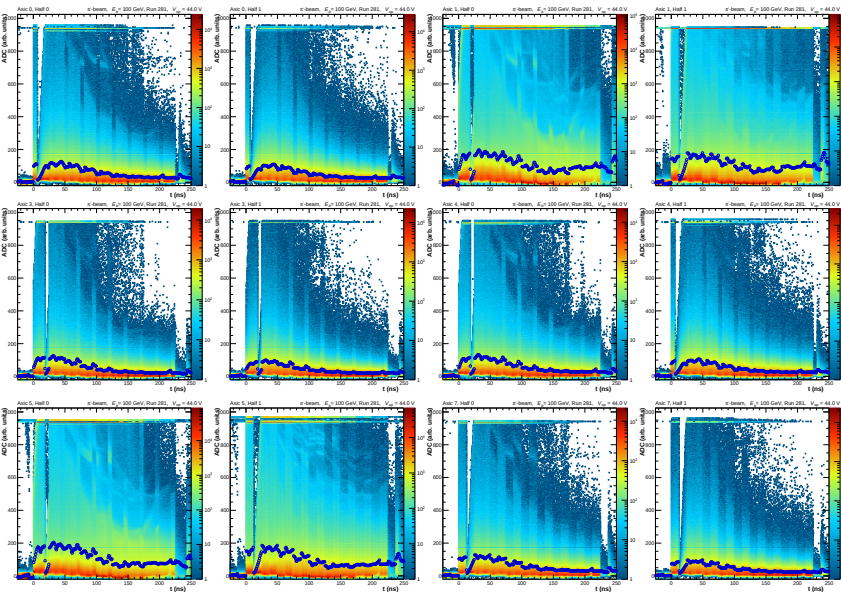


TOA offset calibration 3rd set



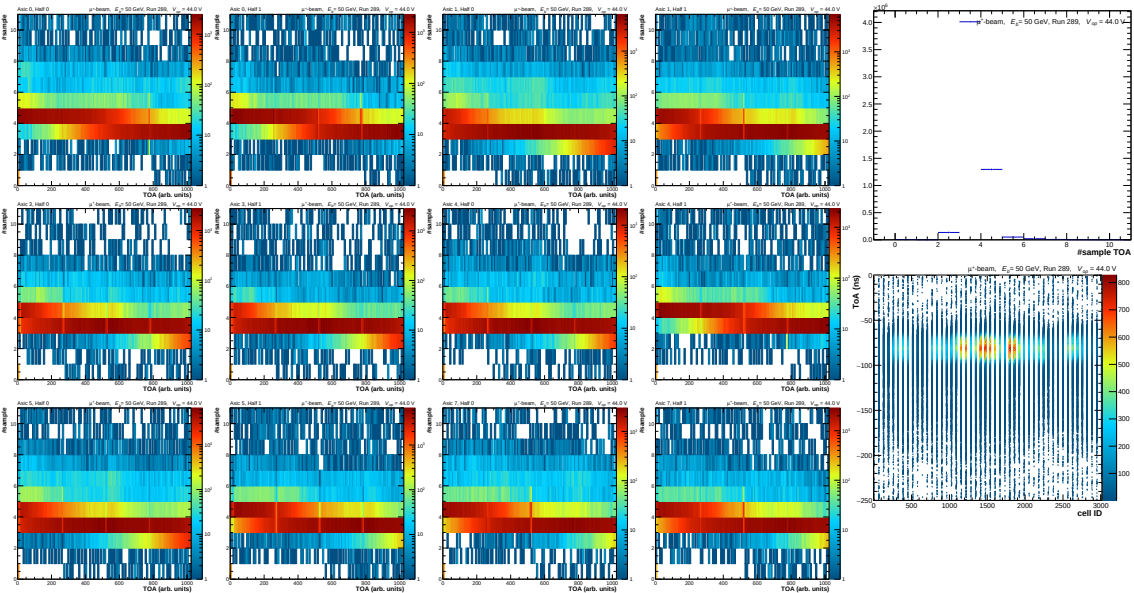
- Estimated using 100 GeV pion run (281)
- Based on ToA vs nSample plot
- Using ToA offsets from run 281 (additional stat) for 3rd subset
- [TOA calib offset file (3)]

TOA offset calibration 3rd set



- Estimated using 100 GeV pion run (281)
- Based on ToA vs nSample plot
- Using ToA offsets from run 281 (additional stat) for 3rd subset
- [TOA calib offset file (3)]

TOA offset calibration - Applied Set 3



TOA offset calibration - Applied Set 3

