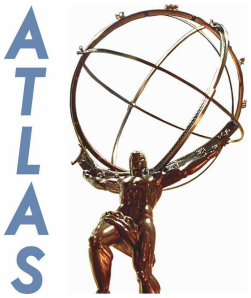
Optimal Filtering
Recent Updates



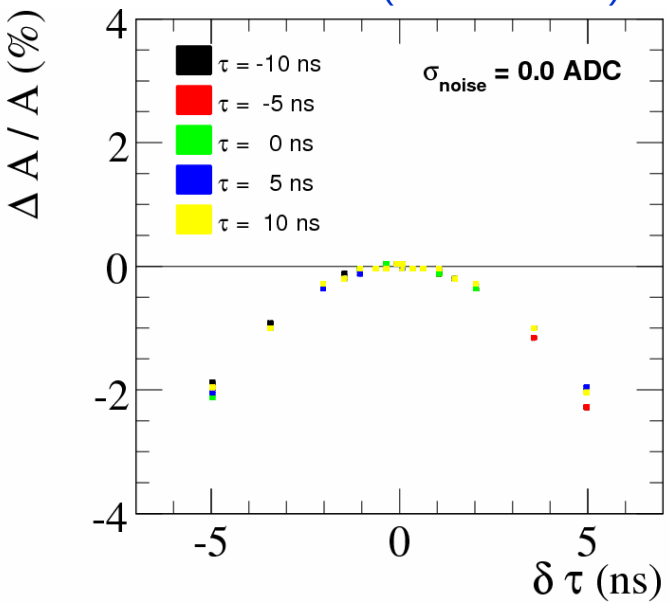
Ximo Poveda

TileCal Valencia Meeting
17-December-2007

Optimal Filtering news

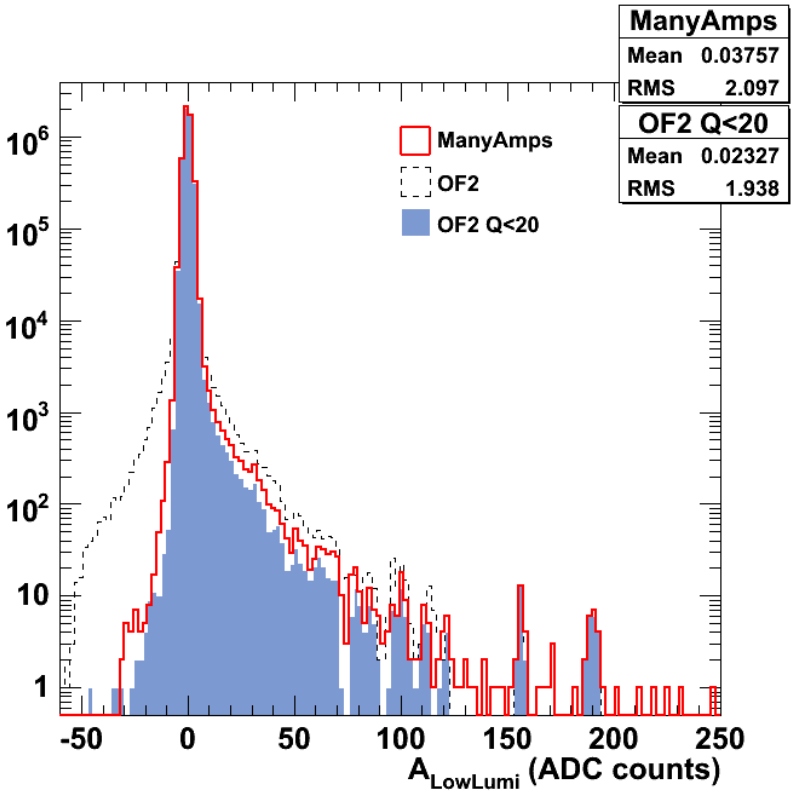
- Sasha asked to include latest version of optimal filtering in release 13.2.0 (January 2008) in order to be default for Full ATLAS reconstruction in release 14 (end February 2008)
- Lot of validation and updates done since release 13
- Latest things to be include:
  - Amplitude correction as a function of the phase (as shown by Belen with Toy MC in Tile Calibration Workshop)
  - New quality factor (still under validation, see next slides)

Belen's talk (13-Nov-2007)



Quality factor cut for MB Pileup rejection

- It was shown that by applying a cut on the OF quality factor, one can reject most of the out-of-time pileup (collisions in [±8, ±2] BXing) at Low Luminosity, obtaining even better performance than ManyAmps



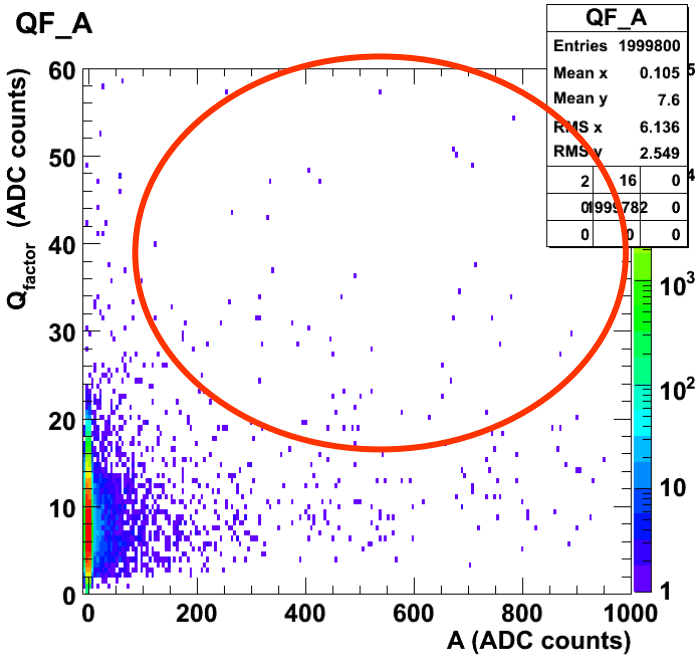
Amplitude obtained with pileup for empty events when there is no pileup

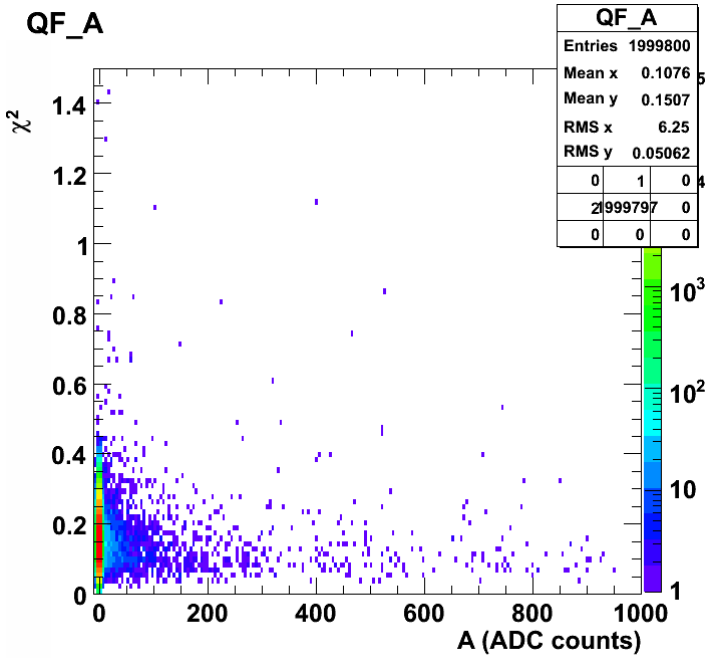
$$Q = \sum_{i=1}^{n} \left| S_i - \left(Ag_i + p \right) \right|$$

- Several issues about it (thanks to Belen for her feedback):
  - What about the reconstruction of signal events? Do they have also Q<20? Is it amplitude dependent?
  - In real data, the beahaviour is not the same….
- Optimization of the cut to apply to reject MB pileup and/or redefinition of the Q factor.

SIMULATED DATA: Q factor

- Sample of SinglePi9 (E=500 GeV) → wide range of amplitudes





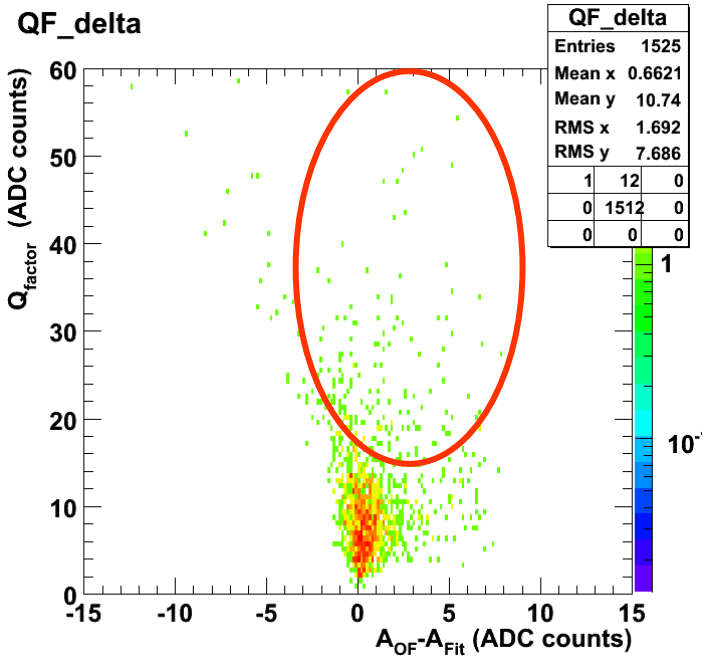
$$Q = \sum_{i=1}^{N} \left| S_i - \left(A g_i + p \right) \right|$$

$$\chi^2 = \sum_{i=1}^{N} \frac{\left| S_i - \left(A g_i + p \right) \right|}{S_i}$$

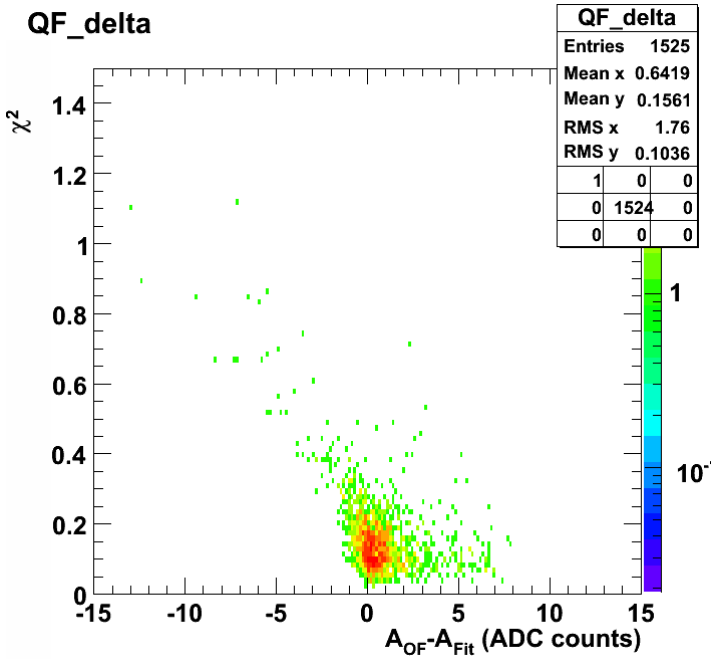
- With the current definition, Q varies a lot with no trend with A
- The residuals are equally weighted, no matter the value of S_i
- Redefine quality similar to χ^2 but simpler (feasible implementation in DSP)

SIMULATED DATA: Q factor

- Sample of SinglePi9 (E=500 GeV) → wide range of amplitudes



$$Q = \sum_{i=1}^{N} \left| S_i - \left(Ag_i + p \right) \right|$$

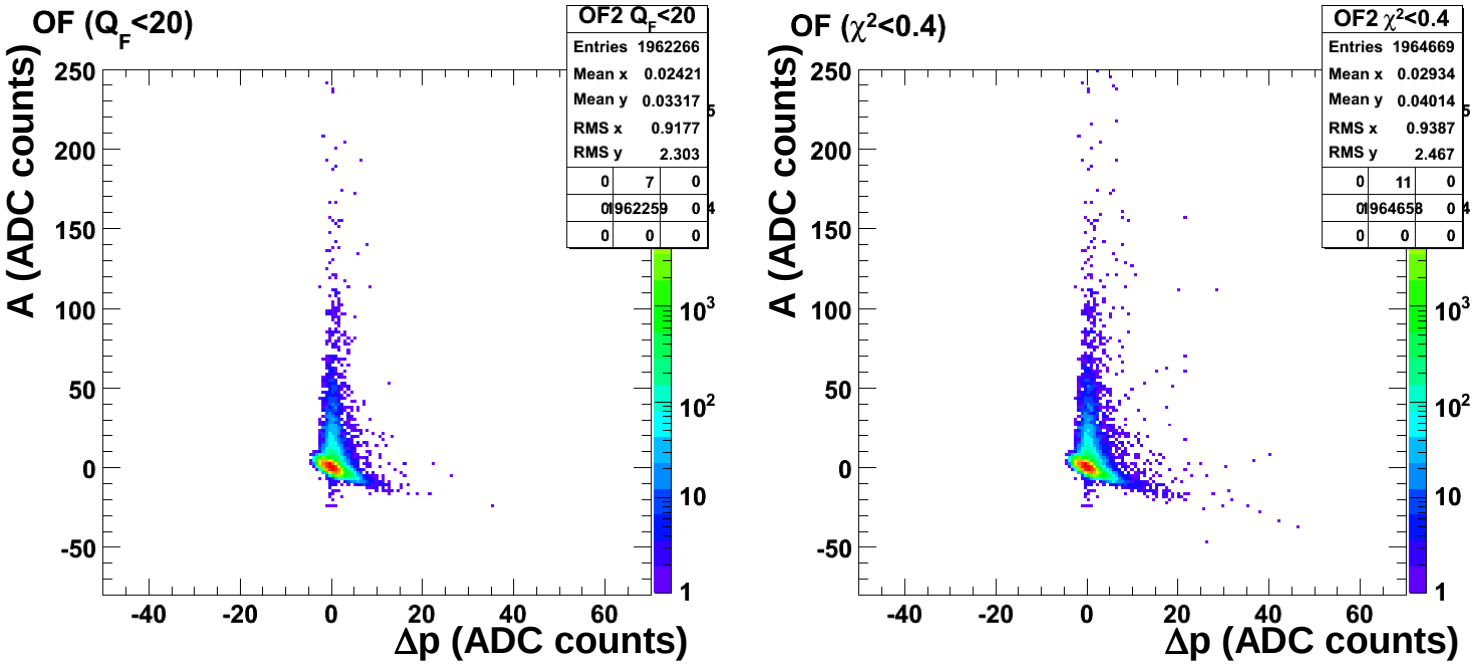


$$\chi^2 = \sum_{i=1}^{N} \frac{\left| S_i - \left(Ag_i + p \right) \right|}{S_i}$$

- Big Q in cases with $A_{OF} \approx A_{FIT}$

SIMULATED DATA: Q factor

- Noise events at Low Luminosity MB pileup:



$$Q = \sum_{i=1}^{N} \left| S_i - \left(A g_i + p \right) \right|$$

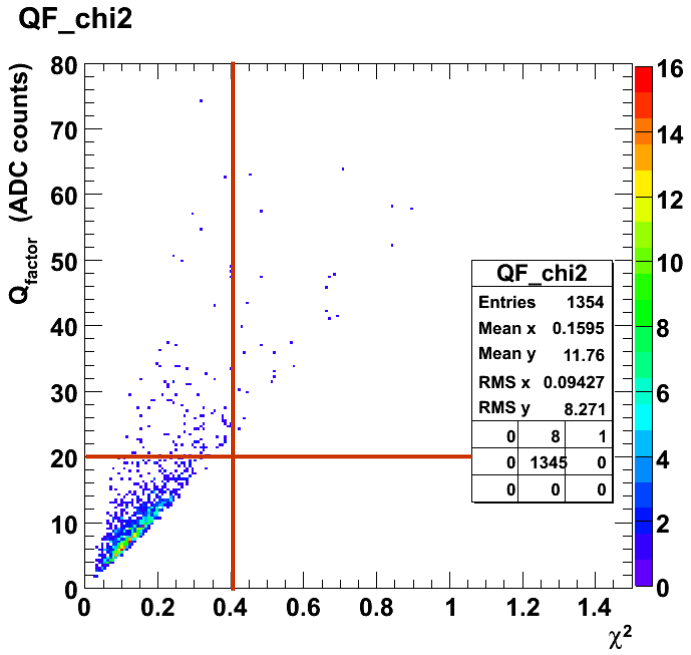
$$\chi^2 = \sum_{i=1}^{N} \frac{\left| S_i - \left(A g_i + p \right) \right|}{S_i}$$

- Cut can also be set on χ^2 with similar behaviour with both definitions

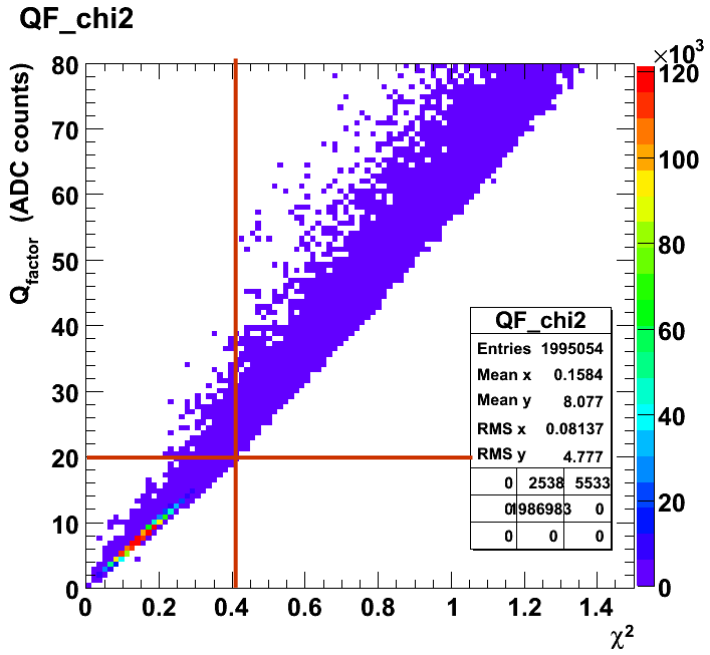
SIMULATED DATA: Comparison Q-χ^2

$$Q = \sum_{i=1}^{N} \left| S_i - \left(Ag_i + p \right) \right|$$

$$\chi^2 = \sum_{i=1}^{N} \frac{\left| S_i - \left(Ag_i + p \right) \right|}{S_i}$$



SinglePi9

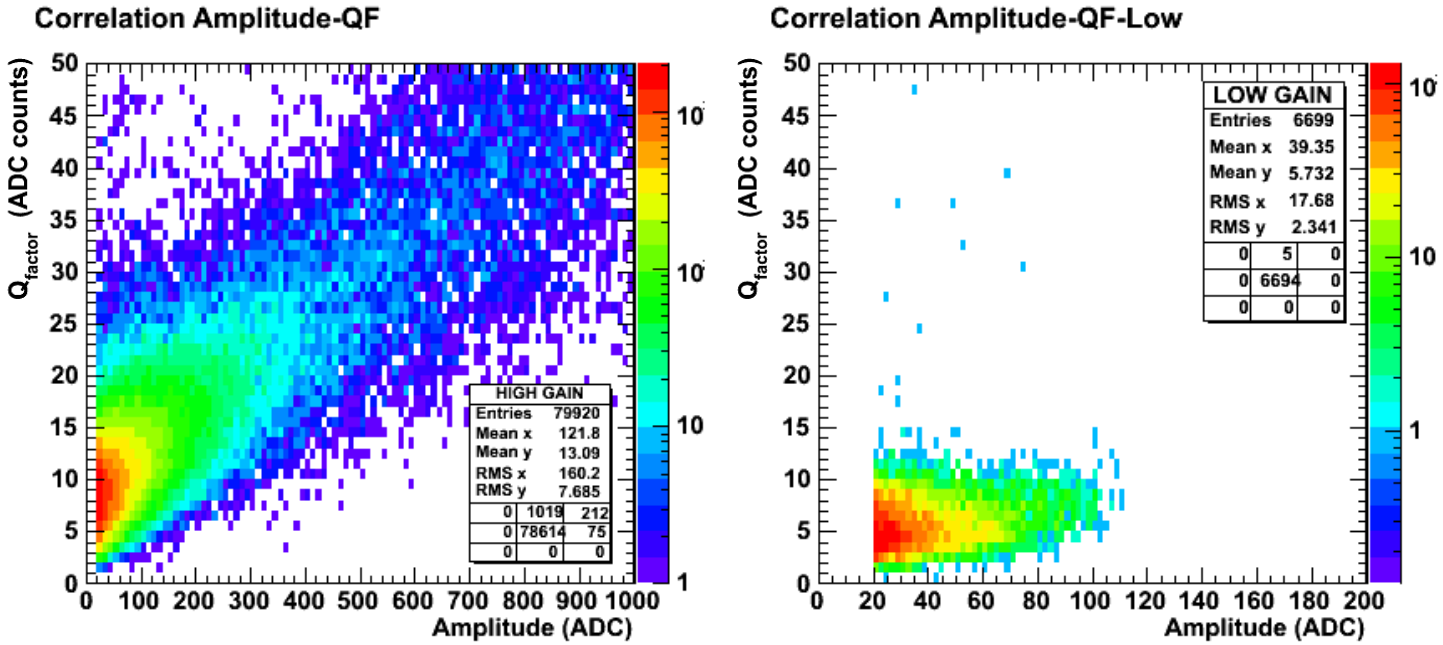


Pedestal under MB

- All events with high χ^2 also have high Q_F.
- "Bad" events with old definiton may not be bad according to χ^2.
- As far as we can go with simulated data

REAL DATA: Q factor

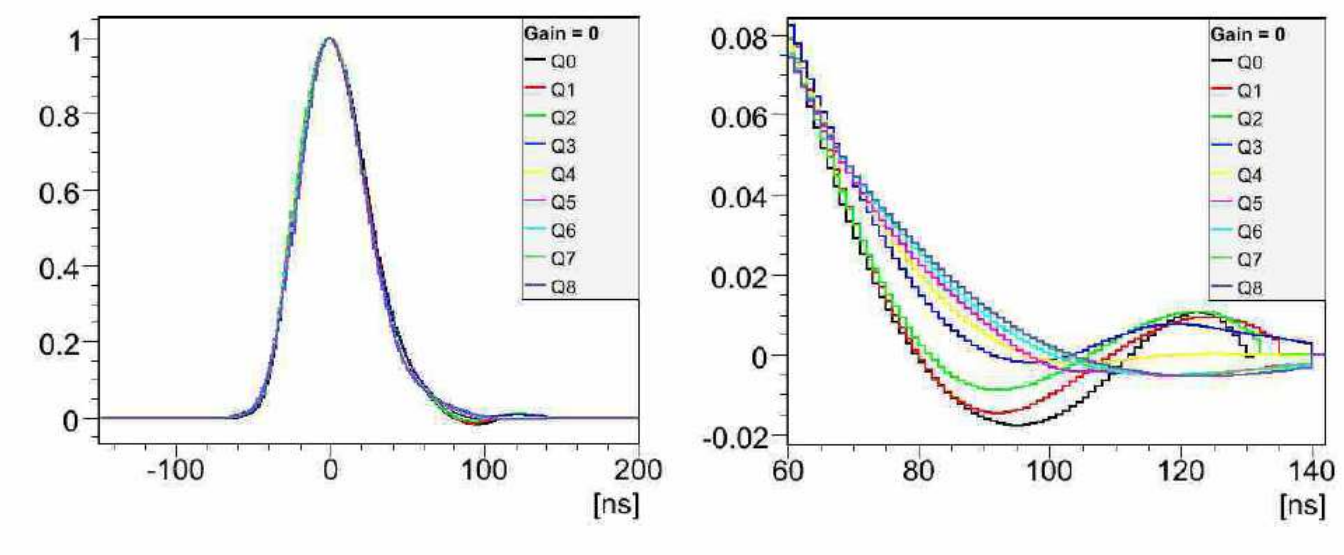
- CTB run #2102202: pions, 180 GeV, η=0.55 (Warning: 9 samples!)



$$Q = \sum_{i=1}^{N} \left| S_i - \left(Ag_i + p \right) \right|$$

- With real data Q grows with Amplitude!!! (is that why original definition had an extra 1/A factor?)
- Like that no cut for MB handling can be made…

Why such a big difference?

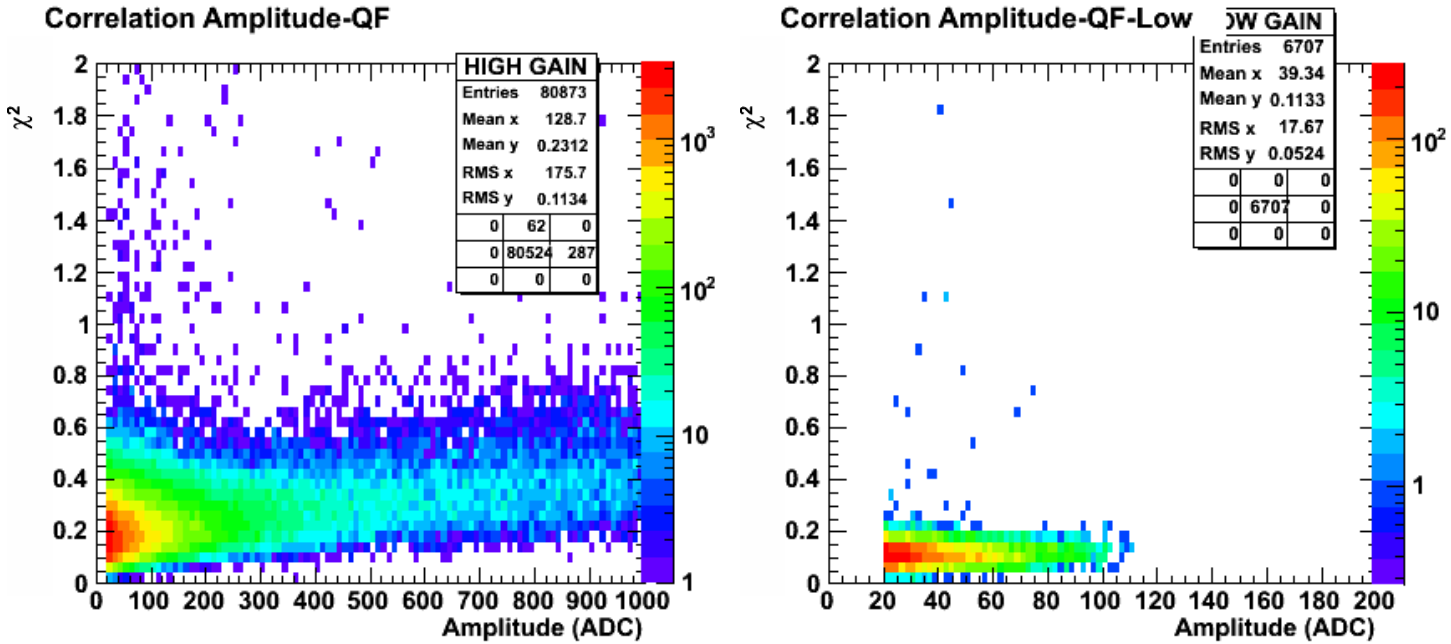


High Gain	
Q-bin	Amplitude
Q0	$0 < A < 4$
Q1	$4 < A < 22$
Q2	$22 < A < 44$
Q3	$44 < A < 87$
Q4	$87 < A < 174$
Q5	$174 < A < 348$
Q6	$348 < A < 522$
Q7	$522 < A < 696$
Q8	$696 < A < 870$

- A possible reason: Pulse shape actually changes with amplitude
- Plot's by Nils' summer student
- Differences in the pulse width and the undershoot region
- In athena constant pulse shape is assumed $\rightarrow$ different behaviour with real data
- No plan to use changing pulse shape for simulation in release 14.

REAL DATA: Q factor

- CTB run #2102202: pions, 180 GeV, η=0.55 (Warning: 9 samples!)



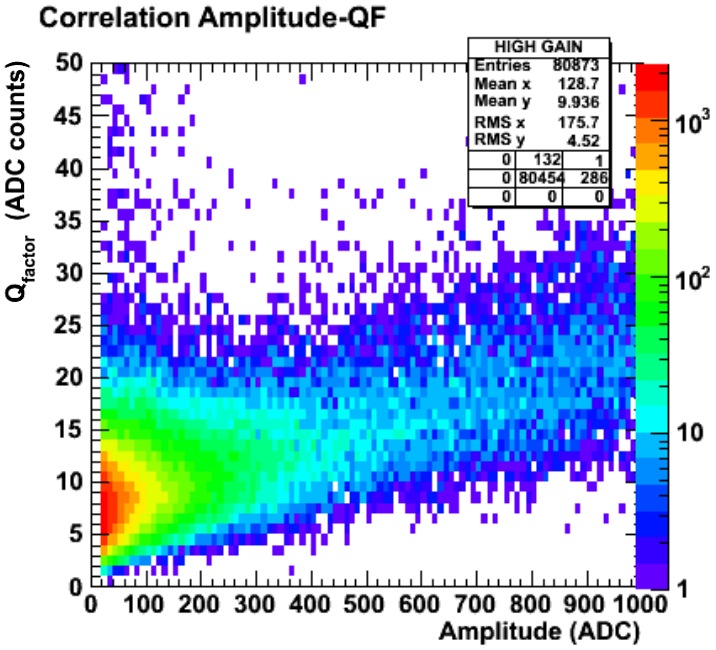
$$\chi^2 = \sum_{i=1}^{N} \frac{\left|S_i - \left(Ag_i + p\right)\right|}{S_i}$$

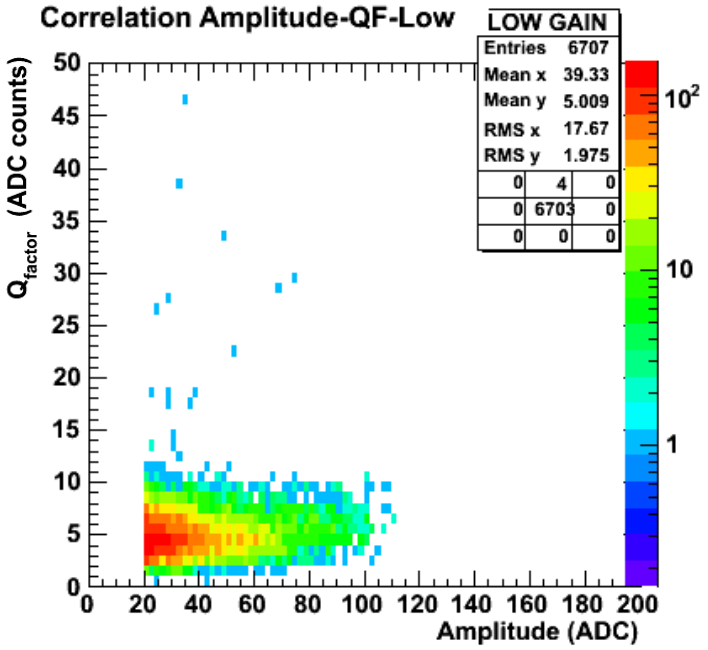
- Much better behaved with this definition…
- Cut for MB could be set for A below 300-400 ADC counts

REAL DATA: Q factor

- CTB run #2102202: pions, 180 GeV, η=0.55 (Warning: 9 samples!)
- Intermediate proposal: residuals weighted by a simple function emulating the $1/S_i$ behaviour.

$$Q' = \sum_{i=1}^{N} w(S_i)\left|S_i - (Ag_i + p)\right| \qquad \begin{cases} w(S_i) < 60 : w = 1 \\ 60 < w(S_i) < 150 : w = 0.5 \\ w(S_i) > 150 : w = 0.25 \end{cases}$$





Some bad events (SinglePi9)

Samples	**51**	**66**	**496**	**894**	**486**	**169**	**74**
Residuals	-1.22	5.73	73.82	-6.55	-44.22	-17.68	-7.04
A=846.6 p=54.2 t=-2.5		χ^2=0.55		Q=156.25		Q'=42.20	

Samples	**48**	**53**	**255**	**537**	**330**	**134**	**68**
Residuals	-2.55	-2.16	-7.8	-0.26	5.21	6.31	0.92
A=485.6 p=51.7 t=0.55		χ^2=0.20		Q=25.22		Q'=11.64	

Summary

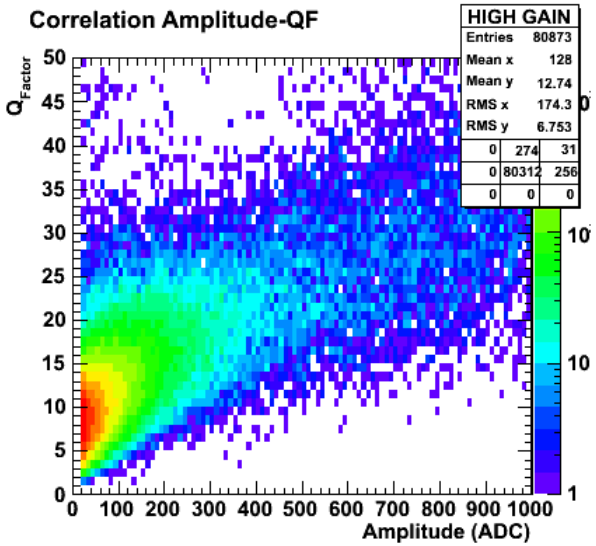
- Different definition for the Optimal Filtering reconstruction quality being studied
  - Keep the possibility of flagging events affected by MB pileup
  - Well behaved with real data (as far as we know about real data now: CTB, Commissioning…)
  - Proposal:
    - Offline reconstruction: best definition available $\chi^2 = \sum_{i=1}^{N} \frac{|S_i - (Ag_i + p)|}{S_i}$
    - DSP reconstruction:
      - Decision to be taken by people responsible of the DSP development.
      - But must flag all bad quality channels so that raw data are sent for offline reconstruction and eventual rejection.
      - Flag as bad quality as less unneeded channels as possible (waste of bandwidth)
- To be implemented in OF coding in athena for rel 14 (i.e.: ATLAS first data taking)

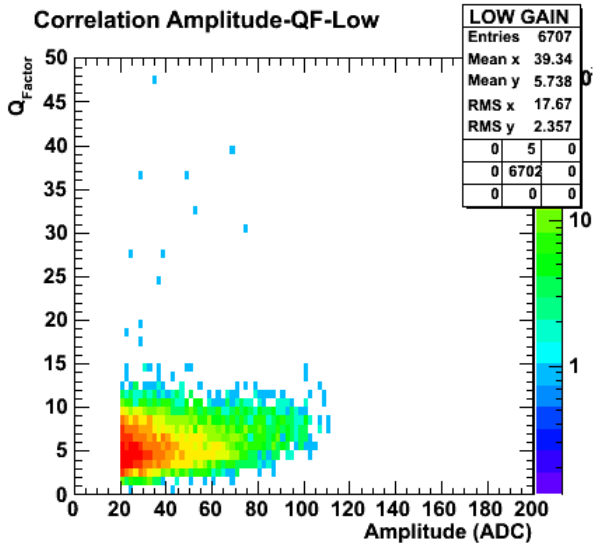
Last minute…

- Belen's proposal for easy DSP implementation:

$$Q' = \sum_{i=1}^{N} w(S_i)\left|S_i - (Ag_i + p)\right|$$

$$\begin{cases} w(S_i) < 255 : w = 1 \\ 255 < w(S_i) < 511 : w = 0.5 \\ w(S_i) > 511 : w = 0.25 \end{cases}$$





- May it be:

$$\begin{cases} w(S_i) < 64 : w = 1 \\ 64 < w(S_i) < 511 : w = 0.5 \\ w(S_i) > 511 : w = 0.25 \end{cases}$$