HEC Noise Corrections

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Introduction

- In the last meeting I talked about finding corrections for the HEC oscillation noise observed in the 2004 CBT data. The idea was to find the parameters to use for the corrections, by minimizing the following:

$$\chi^2 = \sum_{i}^{\text{Events}} \sum_{j}^{\text{Channels}} \sum_{k}^{\text{Samples}} \frac{\left(s^{ij}_{k-meas} - p_j - r_j \sin\left(\omega t_k + \varphi_i + \varphi_k\right)\right)^2}{\sigma_j^2}$$

  Where:
  - s^{ij}_{k-meas} = measured signal
  - p_j = pedestal
  - r_j = relative channel amplitude
  - ω = frequency
  - φ_i = event phase
  - φ_k = channel phase
- This approach didn't work
- Data analyzed from RUN I: run $\#$829, 120 GeVμ beam, with 16 time samples
- Only connected channels are considered
- Number of events considered 1800

First step: determine offline corrections

- Instead of using the χ^2 formula given before the following quantities can be determined in a simpler manner:
  - Channel amplitudes: r_j
    Channel phases: φ_k
  - Frequency: ω
- Channel amplitudes determination:
  - Add the 16 time samples, average, and subtract the pedestal. Make a plot of this sum for all the events for 1 channel
  - To get the relative amplitude for the chosen channel, fit the plot previously obtained with a convolution function
- Channel phases determination
  - Pick one channel with a large amplitude and use this channel as reference channel to be able to calculate all the other channel phases
  - The reference channel has a phase, φ, set to zero
  - The the other channels have $\varphi \simeq 0$ or $\varphi \simeq \pi$

Channel amplitude determination

- Sum of 16 time samples:

$$sum_{exp} = \frac{1}{N_{samples}} \frac{1}{N_{channels}} \sum_{j}^{channels} \cos(\phi_j) \sum_{k}^{samples} (s_{jk} - ped_j)$$

- If oscillation is $y = A \sin \phi$
- Add noise

$$sum_{mod} = x = \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{y^2}{2\sigma^2}}$$

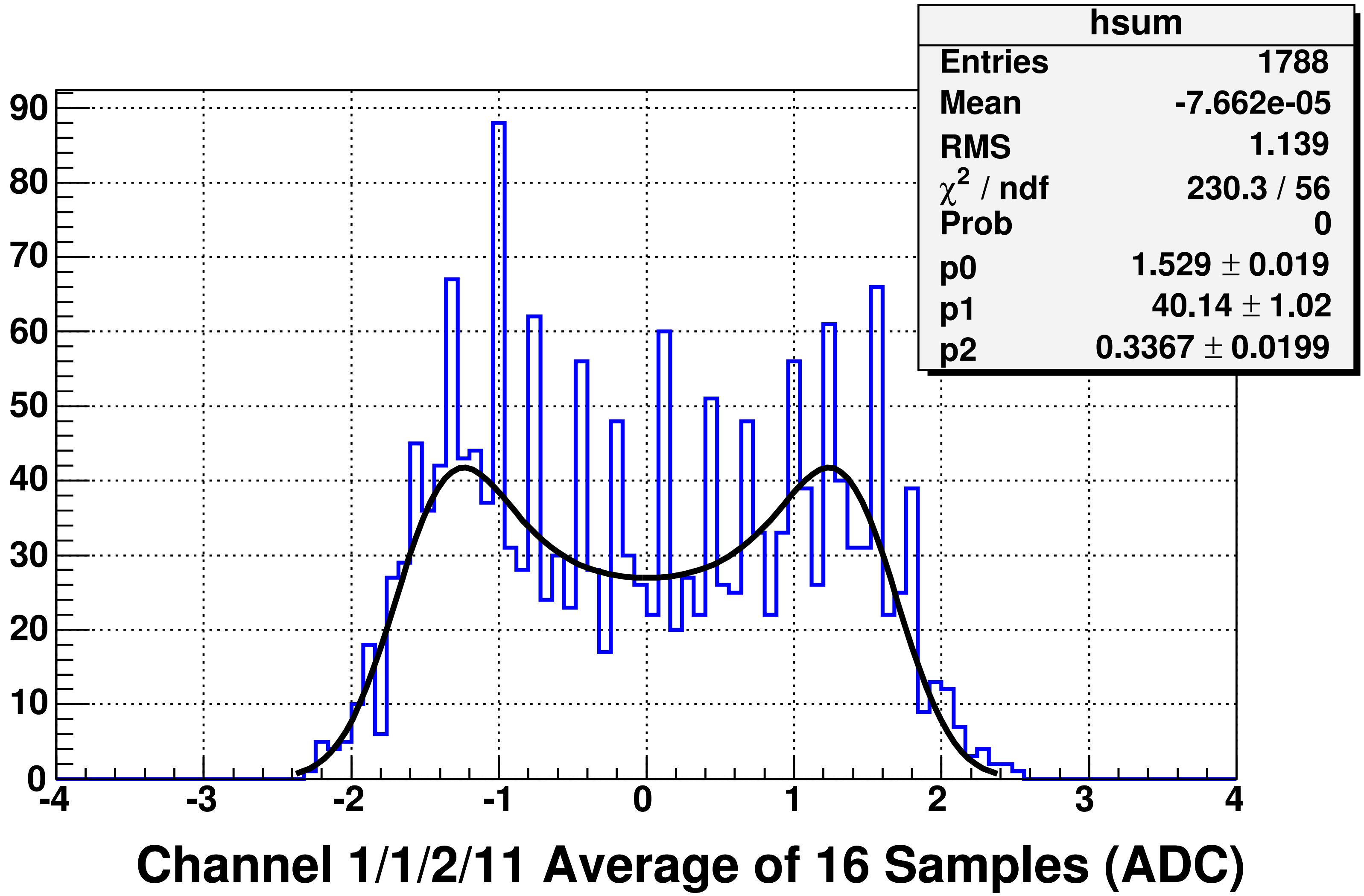
here σ is the thermal noise and the time smearing of oscillation

- If N = number of events the convolution function is defined as:

$$\frac{dN}{dx} \sim \int_{-A}^{A} exp \frac{(x-y)^2}{2\sigma^2} \frac{1}{\sqrt{A^2-y^2}} dy$$

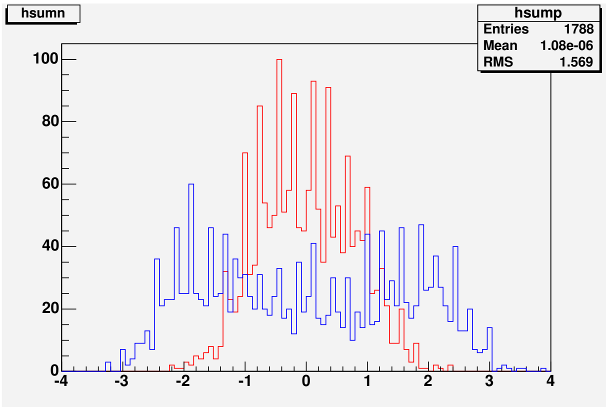
Reference channel

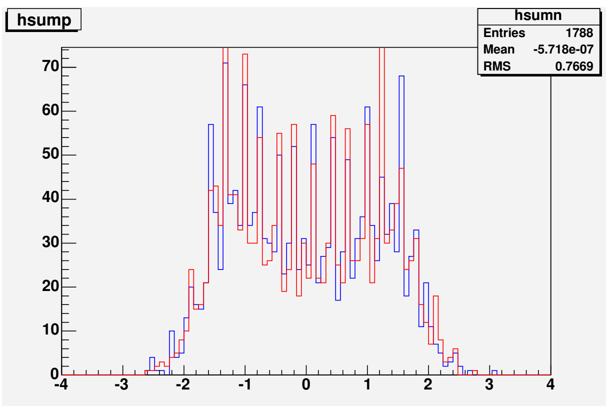
Channel phase and amplitude distributions for the the reference channel located in sampling 1, region 1, $\eta = 2$, and $\phi = 11$

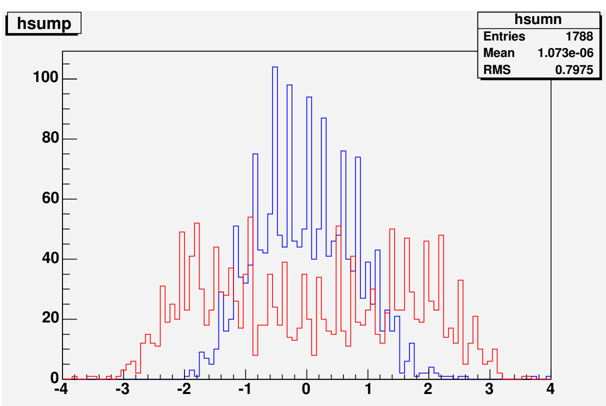


Channel phases

Some channel phase distributions



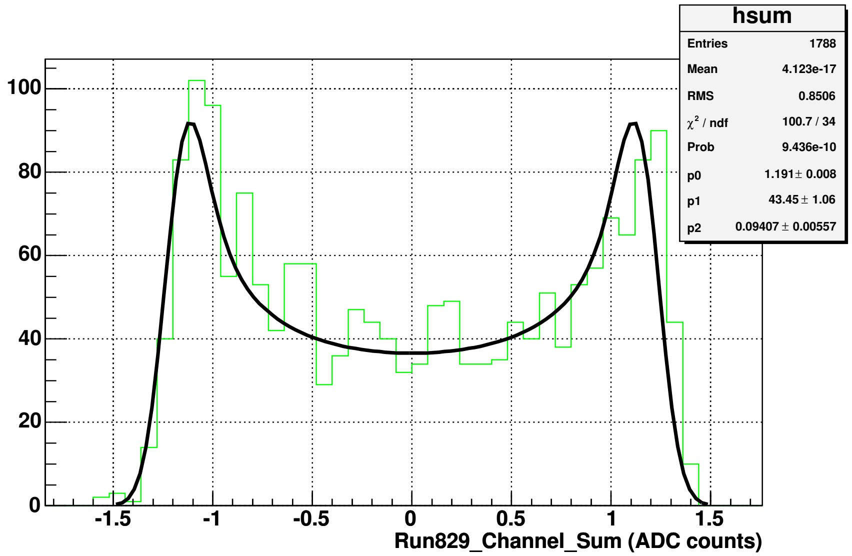


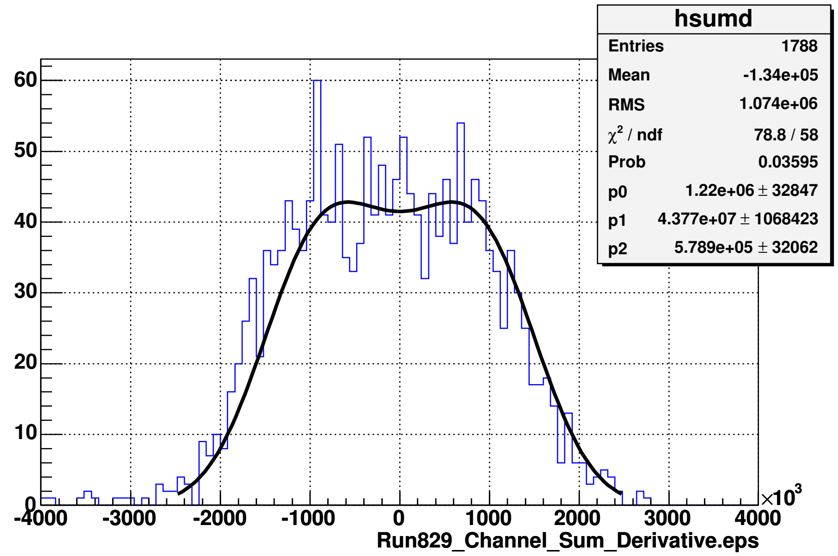


- Distribution in red shows the difference between the reference channel sum and the other channel sum
- Distribution in blue shows the sum of both
- Three cases are to consider:
  - RMS $>$ RMS $\rightarrow$ phase is 0
  - RMS $<$ RMS $\rightarrow$ phase is π
  - RMS $=$ RMS $\rightarrow$ amplitude is 0

New amplitude and frequency determination

- Left plot shows the channel sum distribution: the fit yields the oscillation amplitude A
- Right plot shows first derivative: the fit yields $A\omega$





- $A\,\omega = 1.22e^6 \pm 3.3e^4$
- $A = 1.191 \pm 0.008$
- $\omega = 1.024e^6 \pm 2.85e^4$
- $f = 163\,kHz \pm 4.5\,kHz$

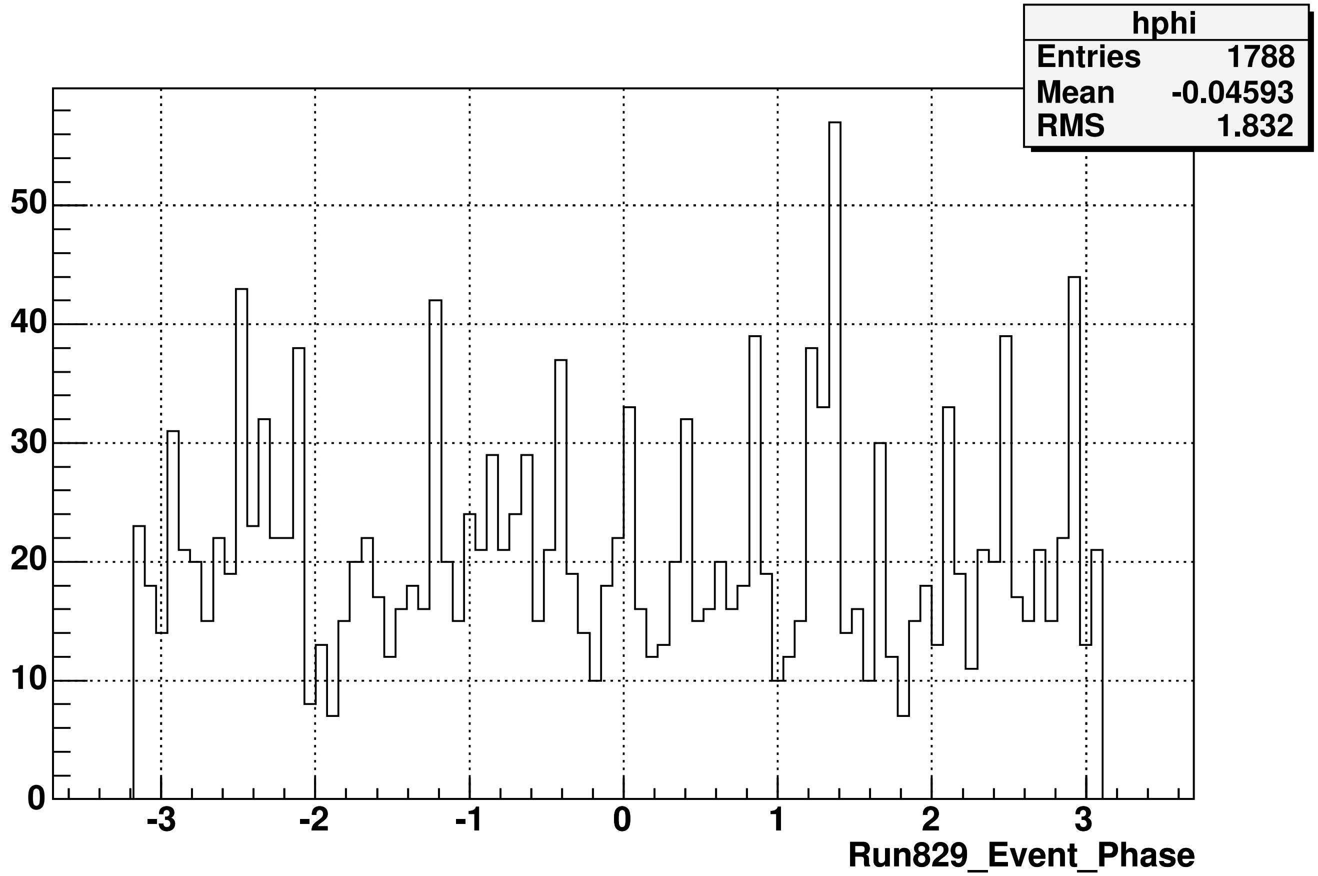
Second step: determine online corrections

- Obtain the event phase by considering the channel phases, the amplitude, and the frequency previously measured
- Once this event phase is determined one can go ahead and apply the correction to the data

Event phase determination

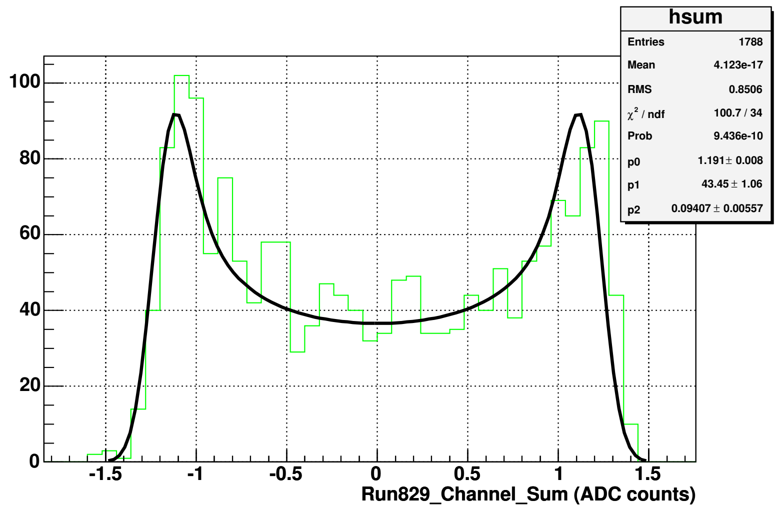
- Find event phase for which the following χ^2 is minimal

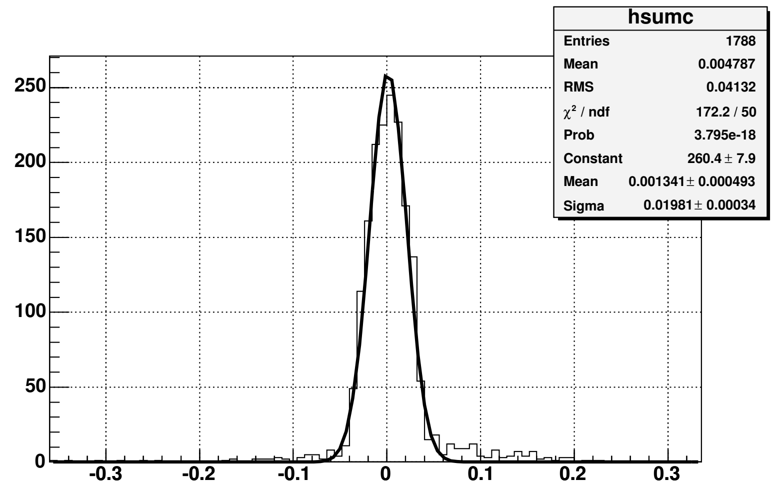
$$\chi^2 = \sum_{k}^{\text{Samples}} \left(\left(\sum_{j}^{\text{Channels}} \cos(\varphi_j)(s_{jk} - p_j) \right) - A \sin(\omega\, k\, 25e^{-9} + \varphi_{evt}) \right)^2$$



Results I

- Left plot shows the channel sum distribution before correction
- Right plot shows the same plot but after correction

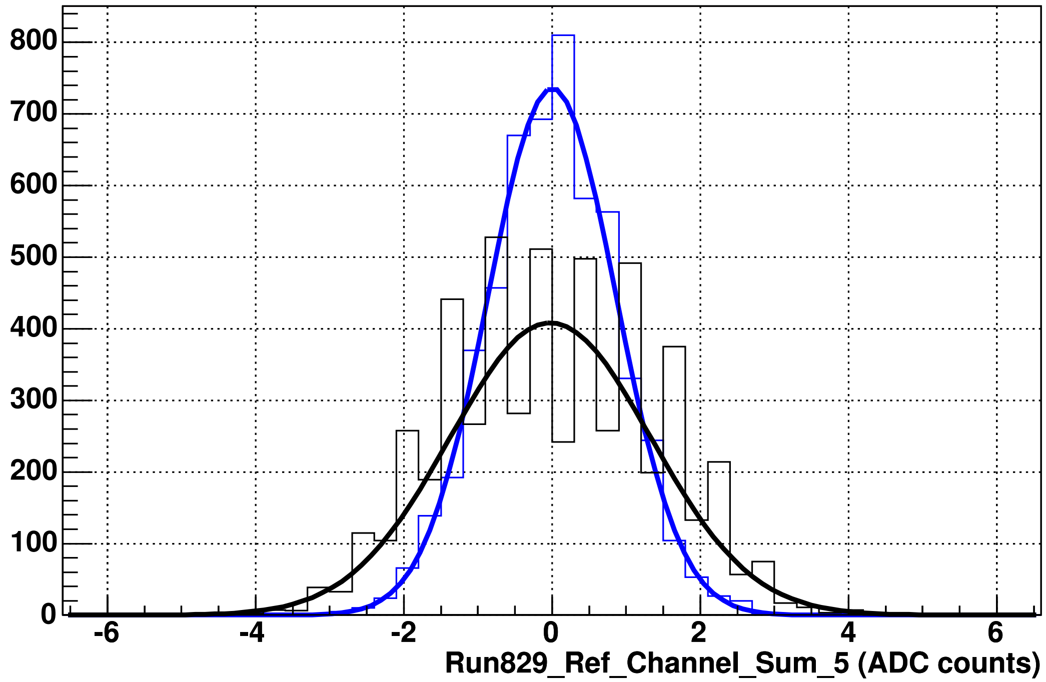




- No oscillation any more after correction
- Note: scale after correction is a factor 10 smaller

Results II

- Plot shows the channel sum distribution for one channel (sum of 5 samples) before correction in black, after correction in blue



- Improvement : Noise is reduced by $\sim$ 40%
- Important note: Since this is correlated noise the effect is even bigger on clusters (eg many cells)