

# Analysis of PCB Exposure Tests

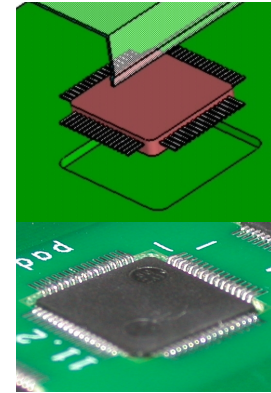
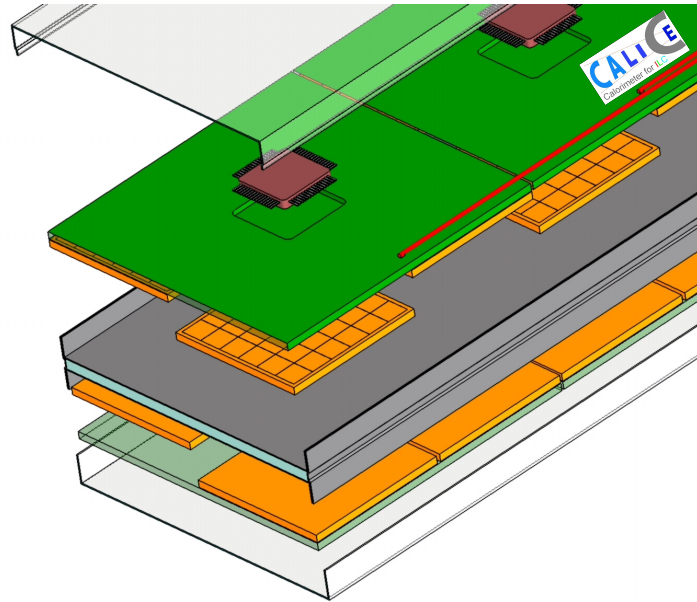
Roman Pöschl  
LAL Orsay

- Motivation
- Experimental Setup
- Data Samples
- Analysis and Results
- Summary, Conclusion and Outlook

Calice Collaboration Meeting Lyon Feb. 2009

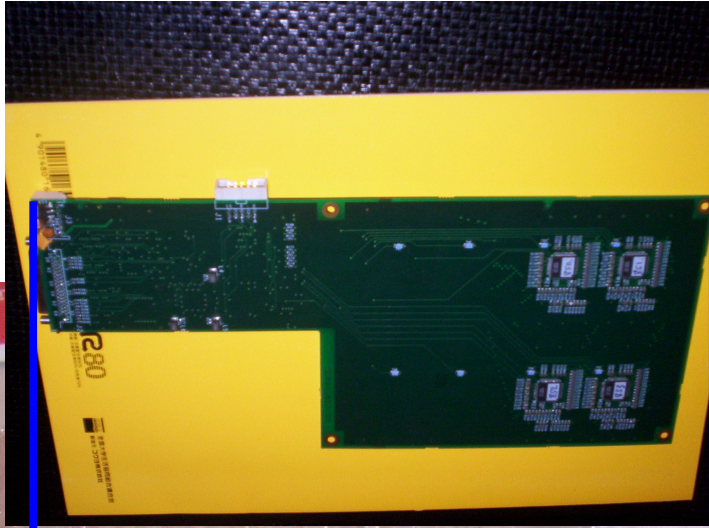
# Introduction

Calorimeter Electronics to be interleaved with layer structure

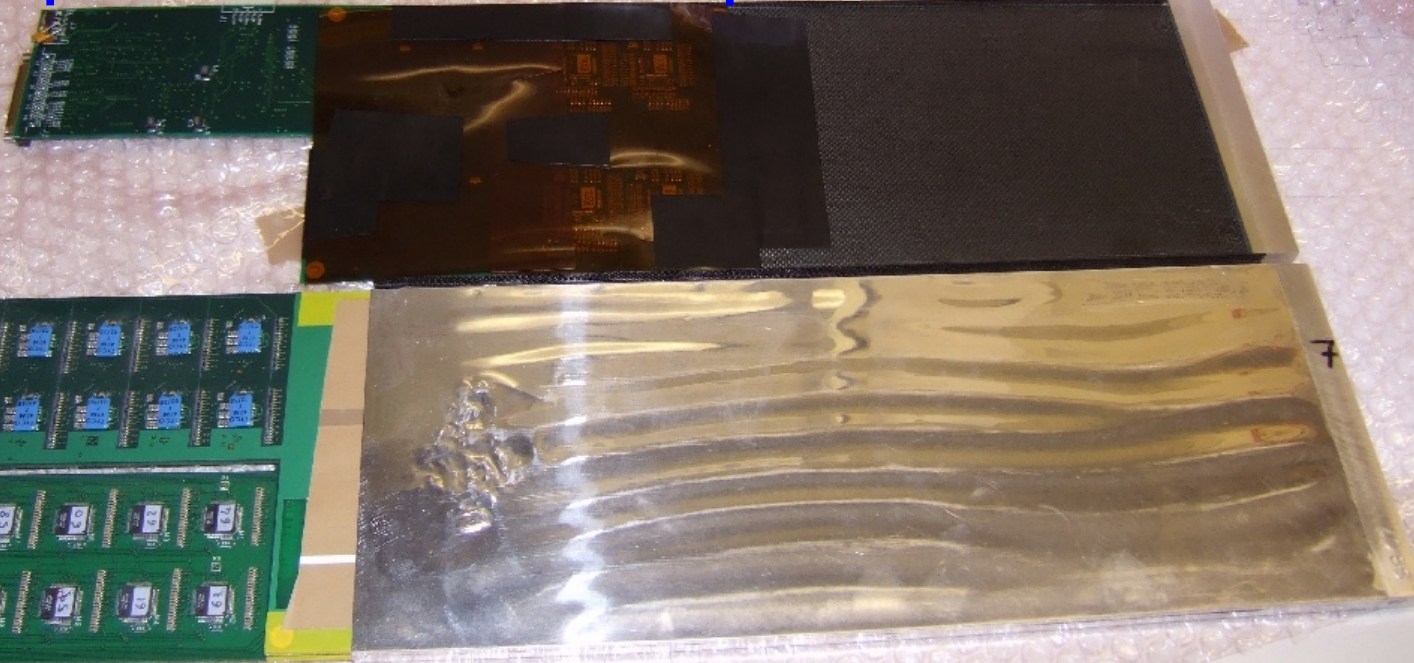


Do high energetic showers create signals directly in electronics ?  
If yes, Rate of faked signals ?

# Special PCB in Ecal Prototype during CERN 07 testbeam – Experimental Setup I



Test PCB  
- equipped with  
PHY3 Chip Set

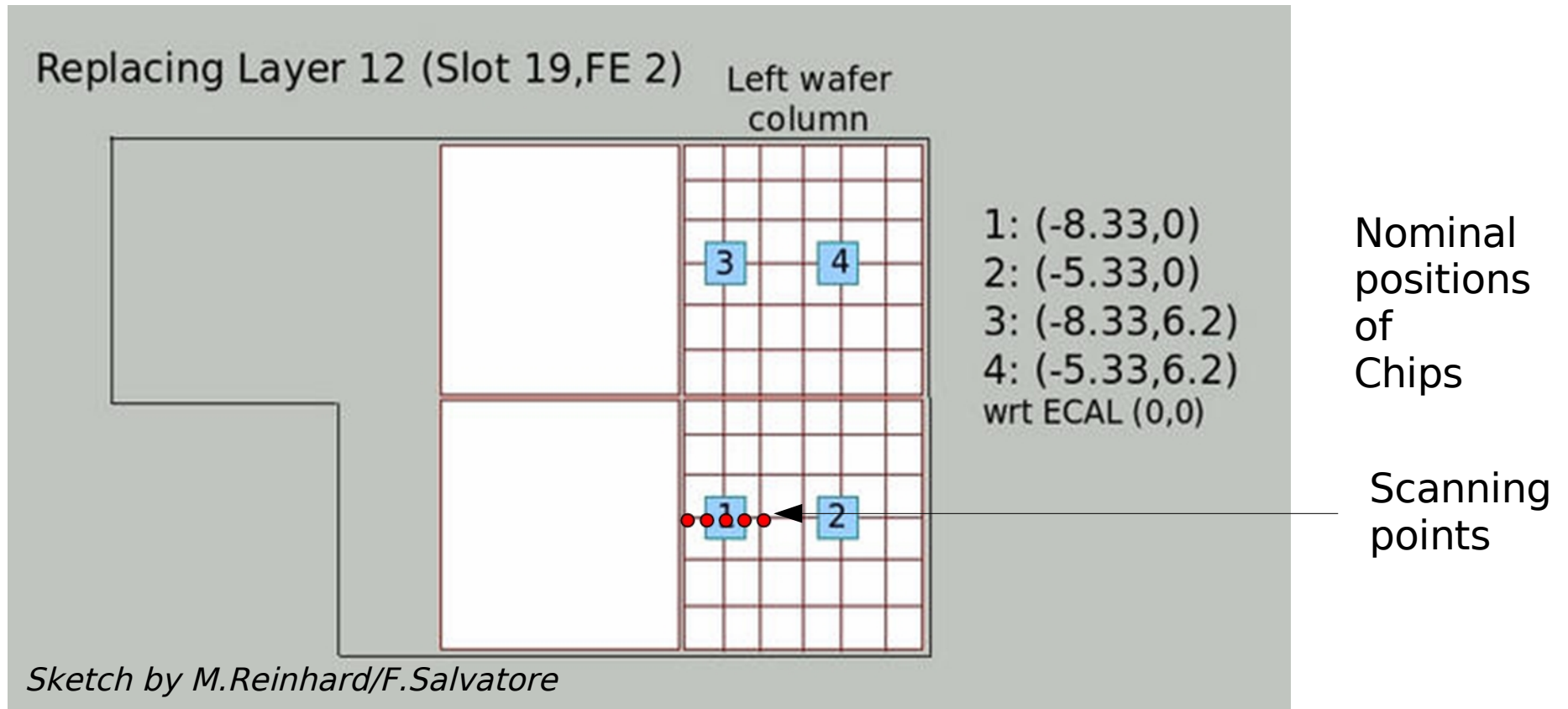


Prepared Slab  
- W dummy  
- capton and paper  
for electrical shielding

Usual Slab

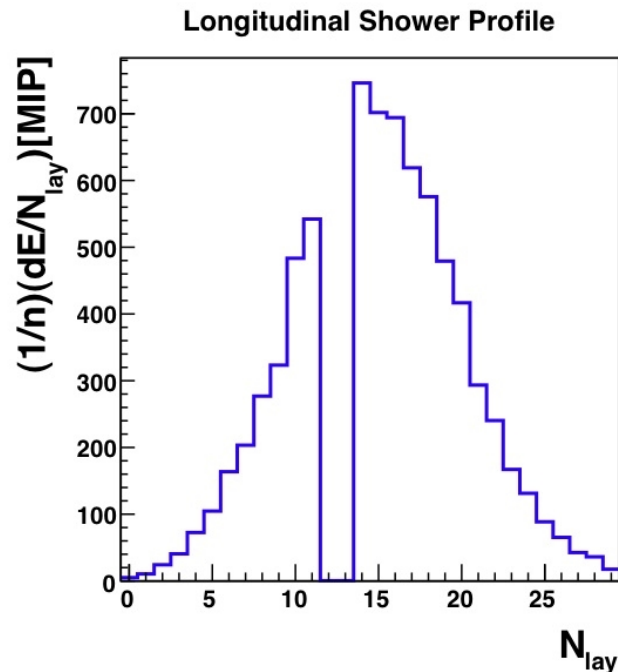
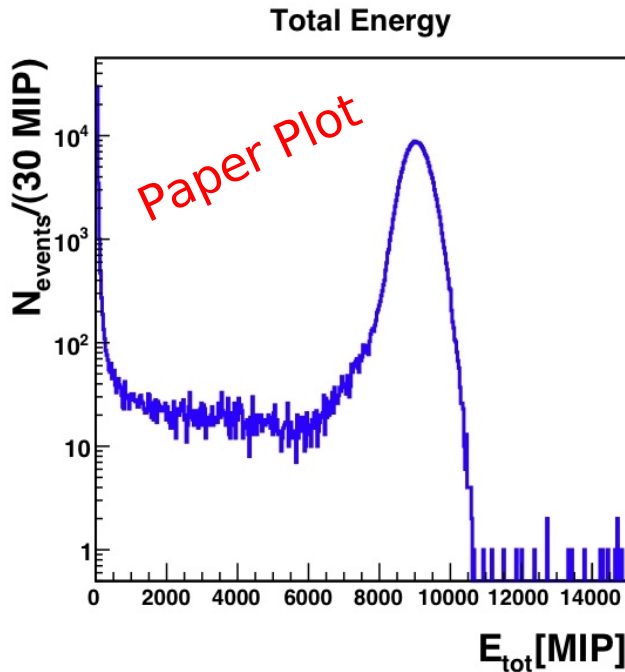
# Special PCB in Ecal Prototype during CERN 07 testbeam – Experimental Setup II

- PCB positioned at place of layer 12 in Ecal ~ shower maximum  
x,y position identical to layer 2
- Schematic view of test PCB - 'Expect' signals from 72 pads, 4x18 = 2 Wafer



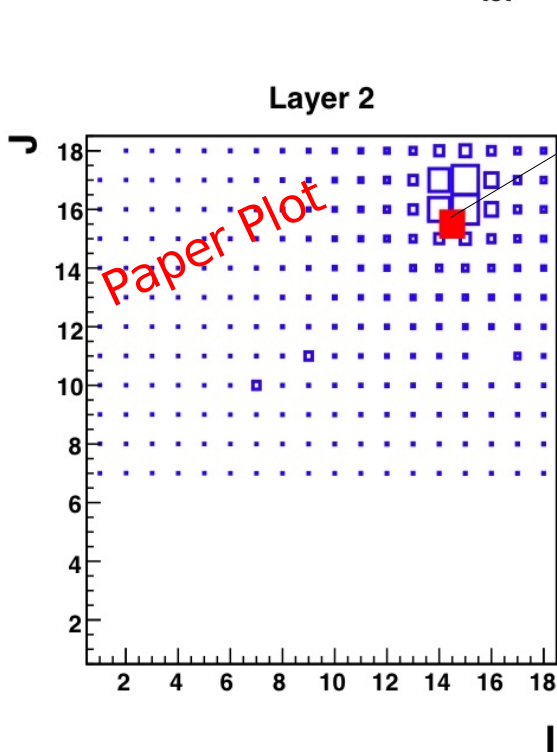
- $2.6 \cdot 10^6$  Events with 90 GeV Electrons (-  $5.8 \cdot 10^5$  with 70 GeV Electrons)  
At least 70 K at each scanning point (Details see later)  
Runs 331462 – 331518  
Today: **Full Statistics**
- First Step: Runs were subject to the same data processing chain as 'usual' runs  
*Calice Collaboration Meeting Sep. 2009*

# Basic Spectra and Alignment

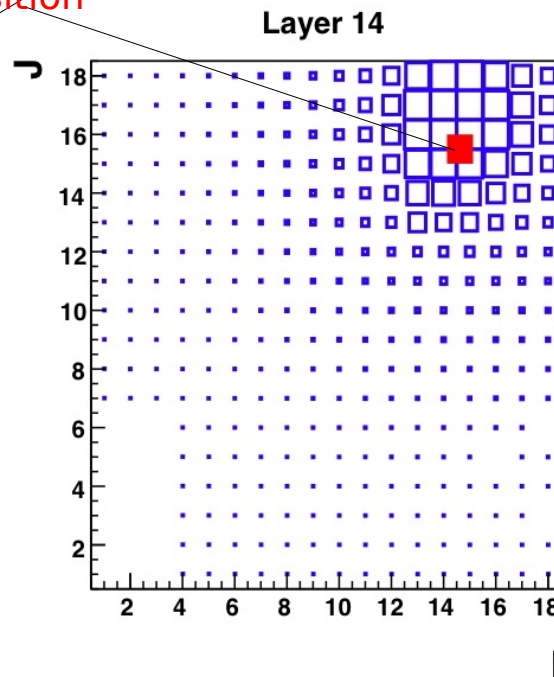


90 GeV run (331495)

- Clear Energy Peak
- Special Board place at  $\sim$  shower maximum



Projected Chip Position



## Hit Maps

- Layer 2  
Same xy-Position as Special Board
- Layer 14  
First instrumented Layer after Special board

Chip(s) well within lateral shower extension

So far all runs have been reconstruction using usual reco software

Now

Disabling of zero suppression in reco output

## - Three Scenarios:

- 1) No pedestal correction
- 2) Full pedestal Corrections
- 3) Pedestal Corrections restricted to signals from Chips

Remember that there are still 216 entries for the layer in the data files

## - General Methodology:

Subdivision of Runs into BeamTrigger and Pedestal Trigger Events (Oscillator Trigger) interleaved with beam events  
Corrections are applied (or not) to pedestal as well as to signal events

Note: The reconstruction s/w had to be tweaked a bit for that

### Three 'Standard Candles'

- 1) Development of MIP Peak in Energy Spectrum
- 2) Correlation between Chip Signals
- 3) 'Noise History' within run

# Statistics of Analysis

## Scan 3

Run331513: e- 90 GeV  
Signal: 216877 Evts.  
Pedestal: 9831 Evts.

Run331518: e-90 GeV  
Signal: 90395 Evts.  
Pedestal: 4347 Evts.

Run331511: e-?? GeV  
Signal: 86989 Evts.  
Pedestal: 3909 Evts.



Run331516: e- 90 GeV  
Signal: 228138 Evts.  
Pedestal: 10926 Evts.

Run331512: e- 90 GeV  
Signal: 218519 Evts.  
Pedestal: 9462 Evts.

## Scan 4

Run331495: e-90 GeV  
Signal: 314275 Evts.  
Pedestal: 15264 Evts.

Run331498: e- 90 GeV  
Signal: 66655 Evts.  
Pedestal: 4223 Evts.

Run331493: e- 90 GeV  
Signal: 85884 Evts.  
Pedestal: 4949 Evts.



Run331497: e- 90 GeV  
Signal: 214418 Evts.  
Pedestal: 13666 Evts.

Run331494: e- 90 GeV  
Signal: 217415 Evts.  
Pedestal: 11698 Evts.

## Scan 1

Run331473: e- 70 GeV  
Signal: 209312 Evts.  
Pedestal: 38361 Evts.

Run331470: e- 70 GeV  
331471  
Signal: 78293 Evts.  
Pedestal: 14624 Evts.

Run331479: e- 90 GeV  
Signal: 85543 Evts.  
Pedestal: 4306 Evts.



Run331472: e- 70 GeV  
Signal: 189966 Evts.  
Pedestal: 37137 Evts.

Run331478: 90 e- GeV  
Signal: 65249 Evts.  
Pedestal: 3602 Evts.

## Scan 2

Run331488: e- 90 GeV  
Signal: 213369 Evts.  
Pedestal: 13719 Evts.

Run331480: e- 90 GeV  
Signal: 85188 Evts.  
Pedestal: 4678 Evts.

Run331492: e- 90 GeV  
Signal: 89435 Evts.  
Pedestal: 4254 Evts.



Run331486: e- 90 GeV  
Signal: 129778 Evts.  
Pedestal: 6146 Evts.

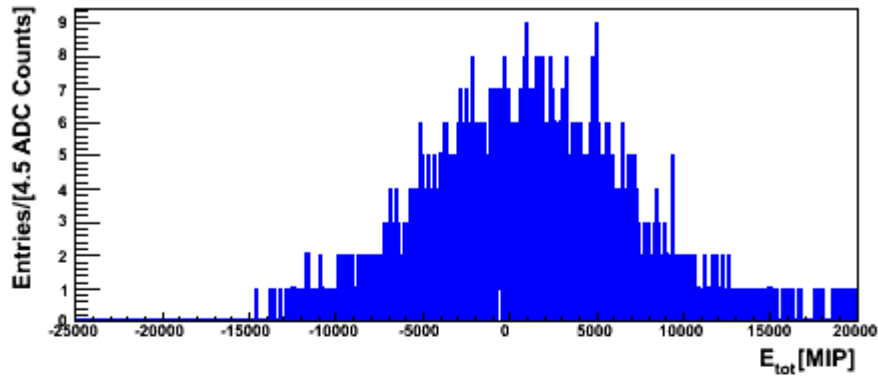
Run331491: e- 90 GeV  
Signal: 217711 Evts.  
Pedestal: 11053 Evts.

## On Run Selection and Observations

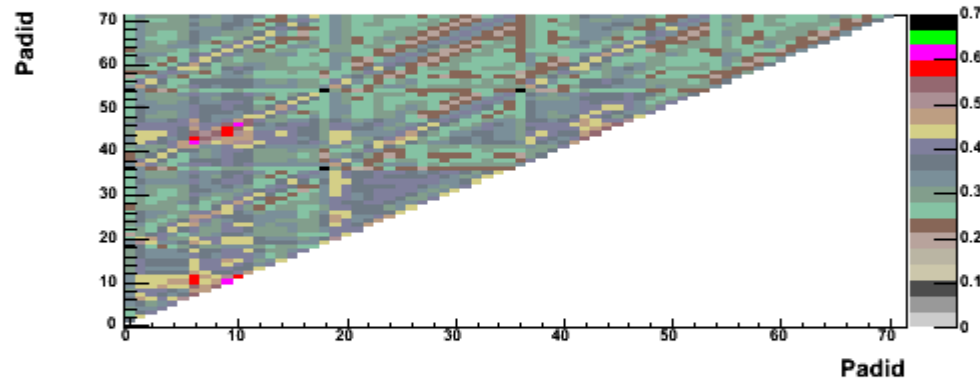
- Run Selected according to entries in the logbook  
No comments on bad quality by Shift Crew
- Switch of energy between Run 331473 and Run 331478
  - Change in Pedestal Rate  
20% of all events -> 5% of all events  
Still at least 3500 of (valuable) pedestal events
- at least 70k Events at each point
  - mostly 90 kEvents for off center runs
  - > 200k at (nominal) Chip Center



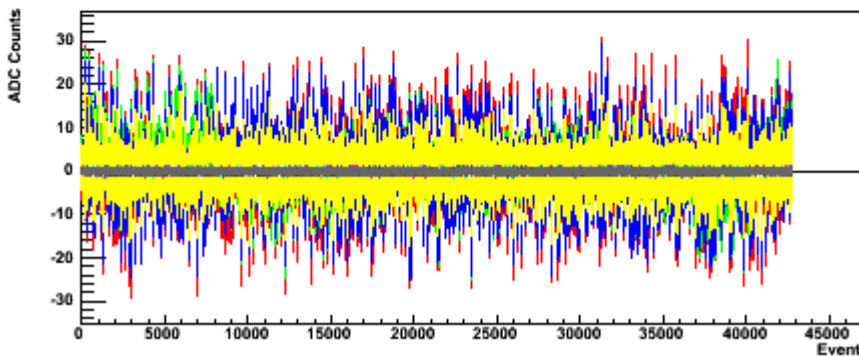
# Pedestal Correction Disabled



MIP Peak vanishes entirely



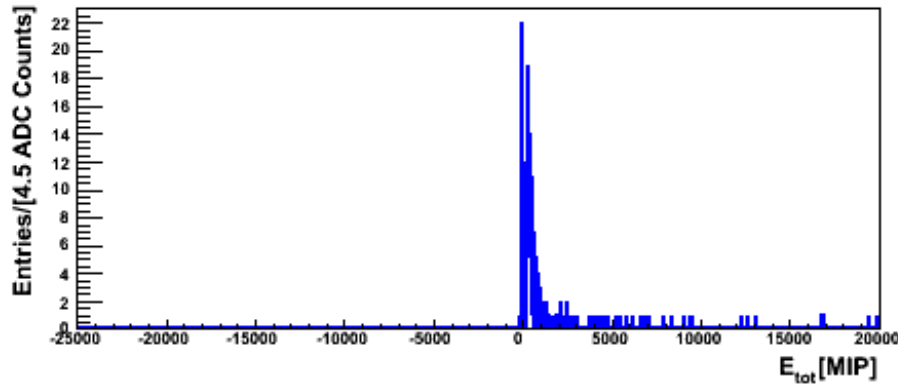
Large Correlation between Signals  $O(35\%)$



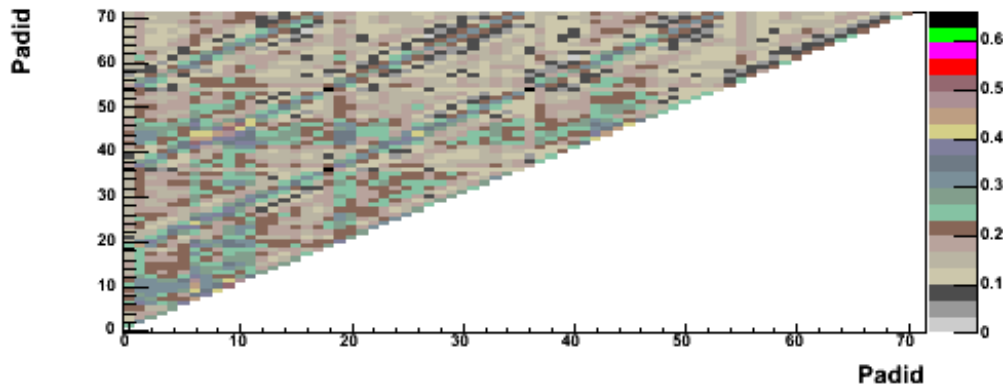
## Noise History

- 'Grey' Band "Other signals"
- Colored Lines  
Signals from Chips  
Large Fluctuations  
[-30,30] ADC Counts

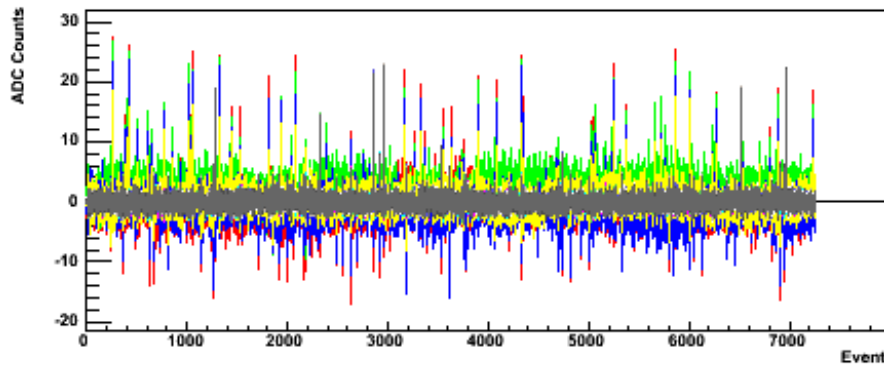
# Pedestal Correction Fully Enabled



MIP Peak restored



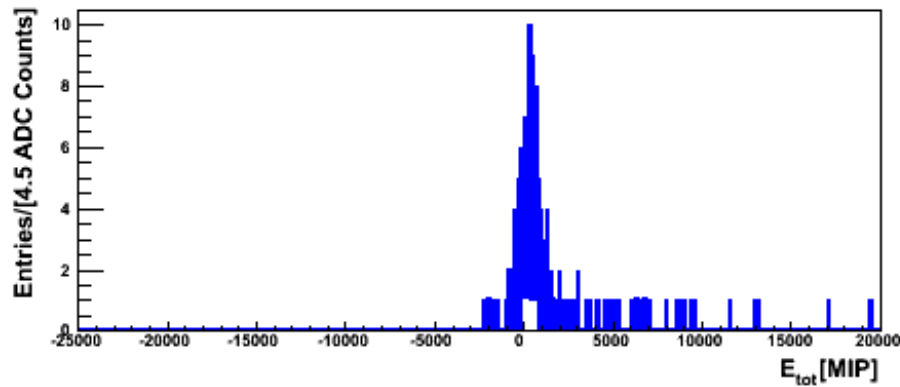
Correlation between Signals slightly reduced O(25%)



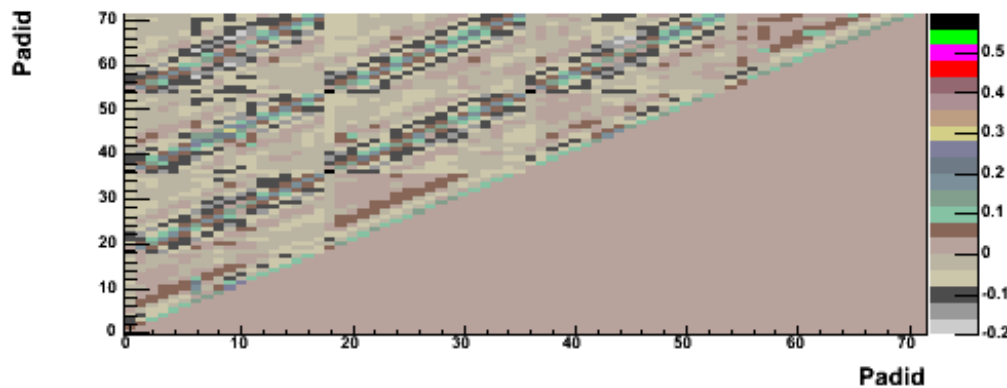
## Noise History

- 'Grey' Band "Other signals"
- Colored Lines  
Signals from Chips  
Fluctuations largely tamed  
[-6,6] ADC Counts  
with occasional correlated spikes

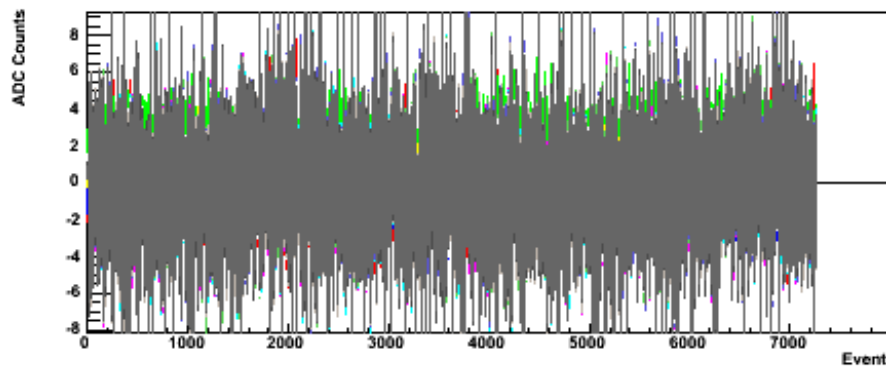
# Pedestal Correction Restricted to four Chips



MIP Peak slightly washed out  
- Reason: Pedestal Correction calculated for Chips applied to all 216 signals  
less important for this study



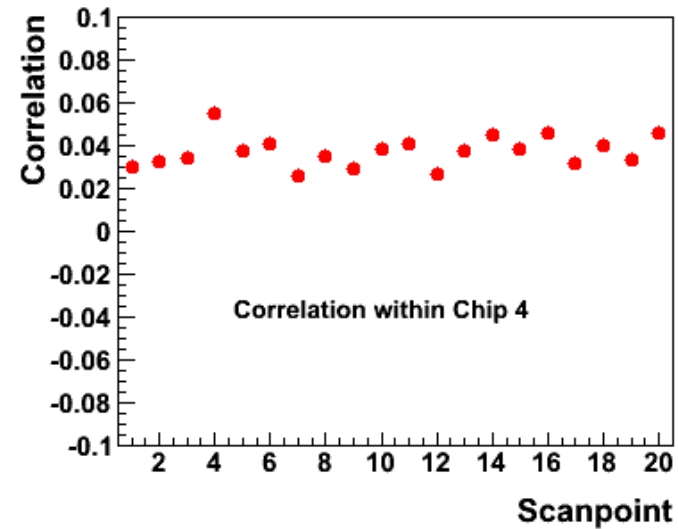
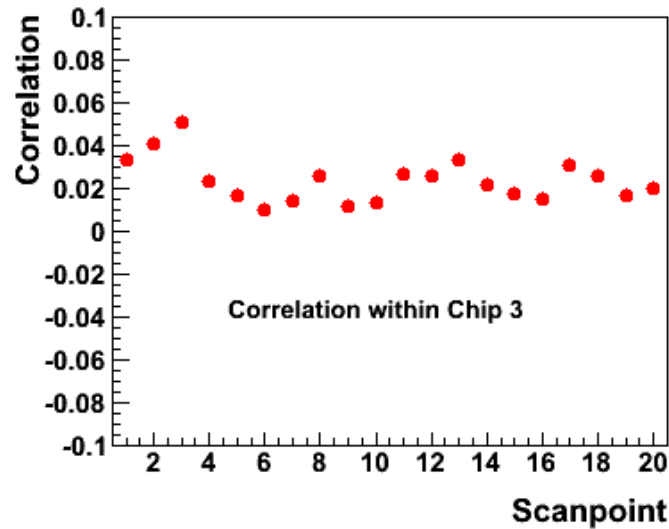
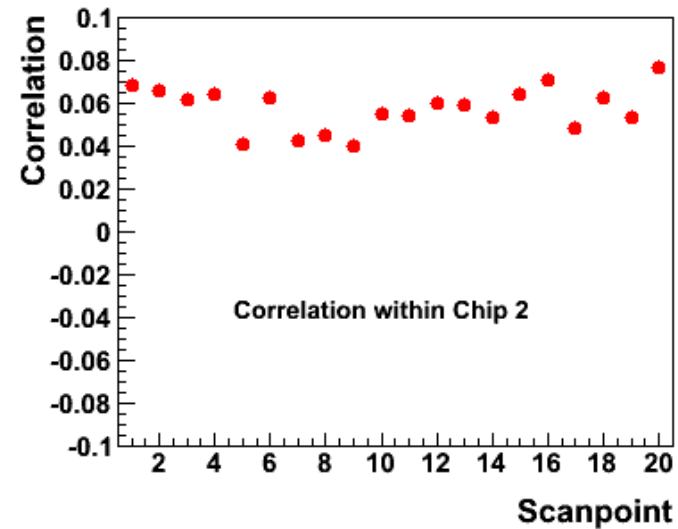
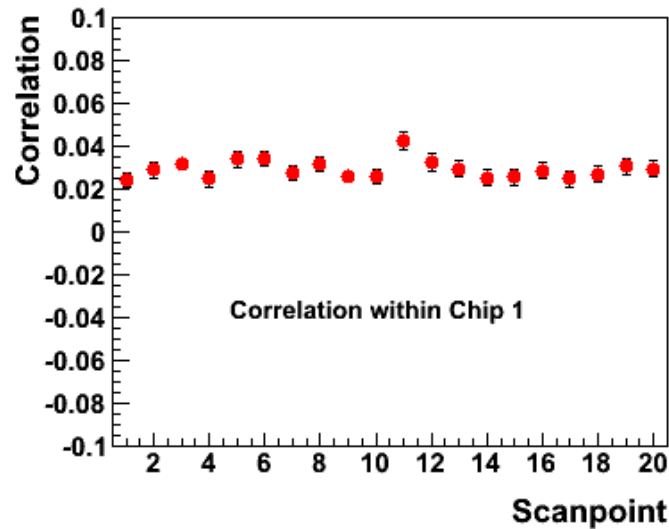
Correlation between Signals strongly reduced  
O(5%) on average  
More details -> see later



## Noise History

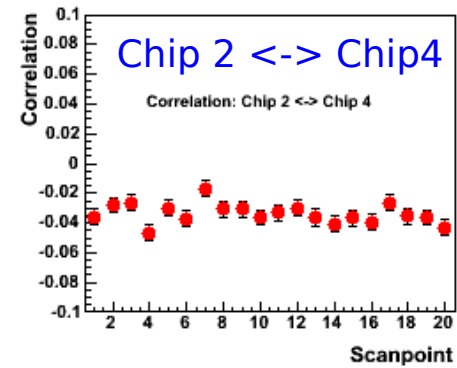
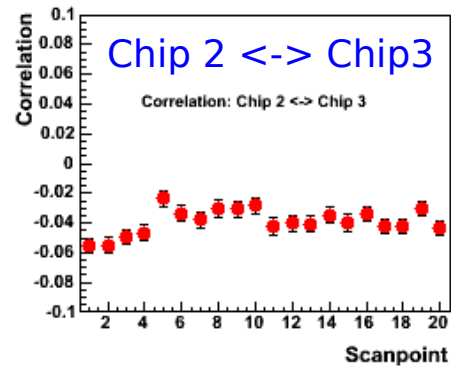
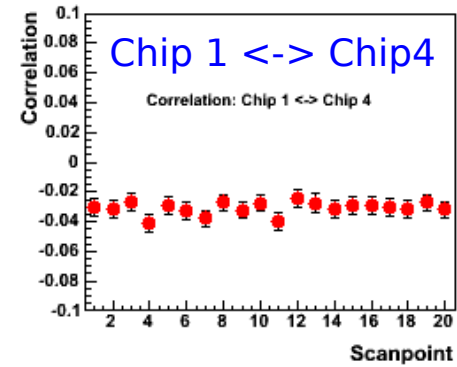
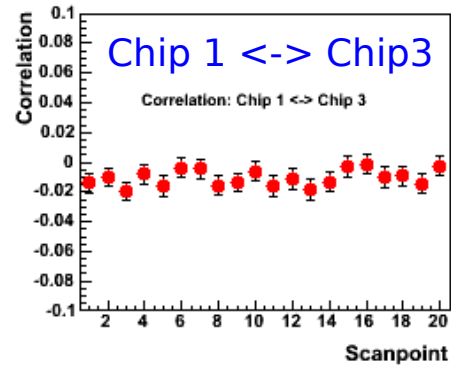
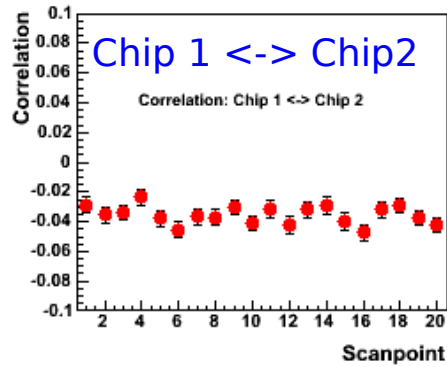
- 'Grey' Band "Other signals"
- Colored Lines  
Signals from Chips  
Fluctuations tamed  
[-4,4] ADC Counts  
no spikes

# Average Correlation within Chips

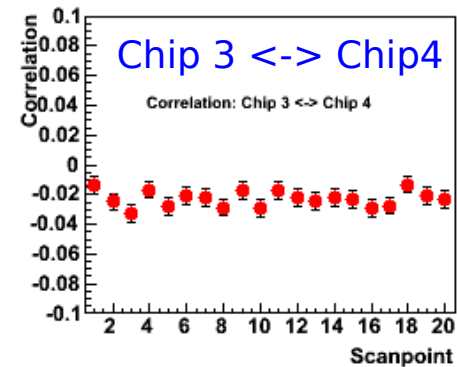


Slightly positive correlation within a Chip  $O(4\%)$

# Average Correlation among different Chips

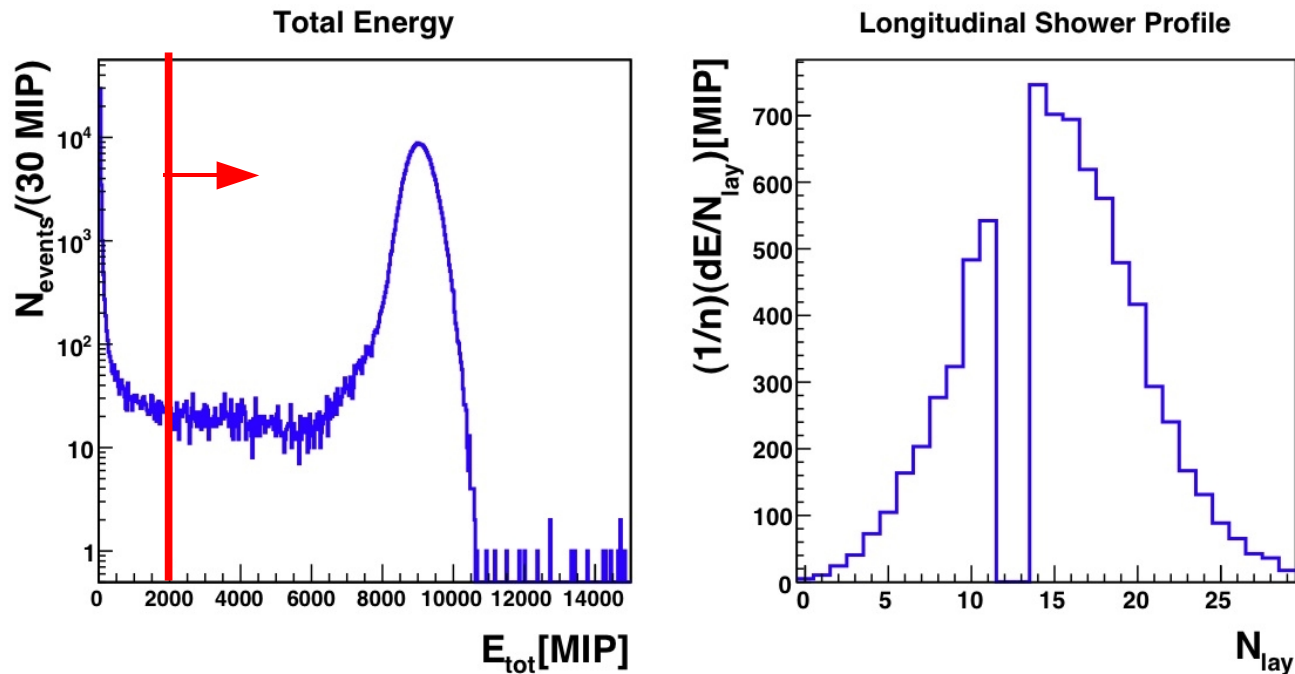


Slight negative correlation  
between Chips  
 $O(4\%)$



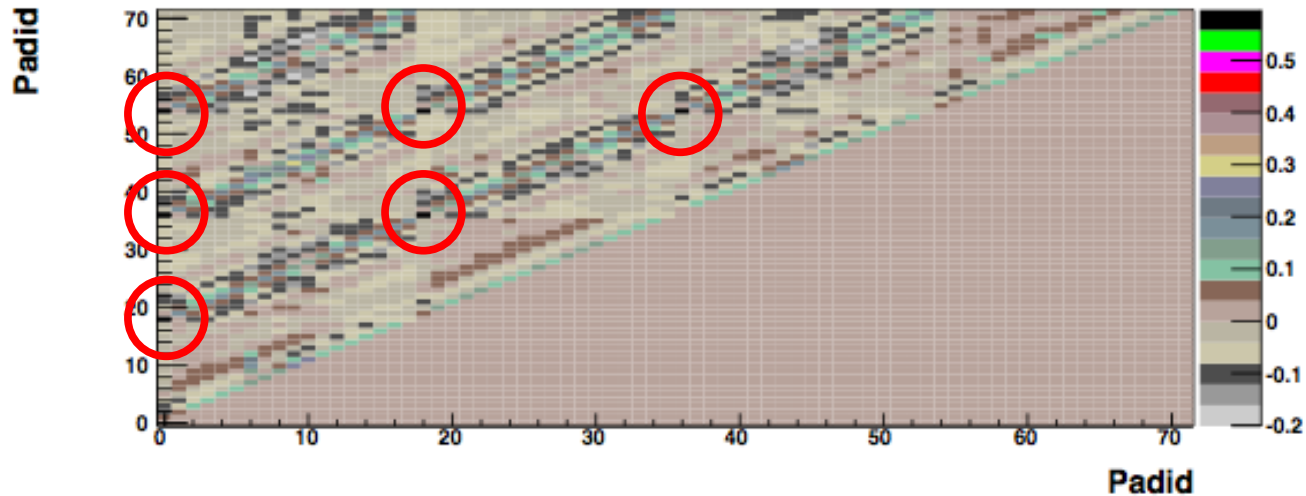
## Scenario for extraction of results I

- No zero suppression
- Pedestal Correction applied to Chips only  
Major Change w.r.t. to results shown at Daegu  
Not a sensation but now well investigated
- Only 'electron' events/entries  
Low energetic entries may bias the results



## Scenario for extraction of results II

### Discarding of Signals



- Closer Look reveals strong correlation between first signals of each chip  
These signals arrive together in the multiplex series of the data acquisition  
(Remember all 216 cells of a board are transmitted in 12x18 chunks to the CRC boards)  
Reason is unknown but it rings a bell ...

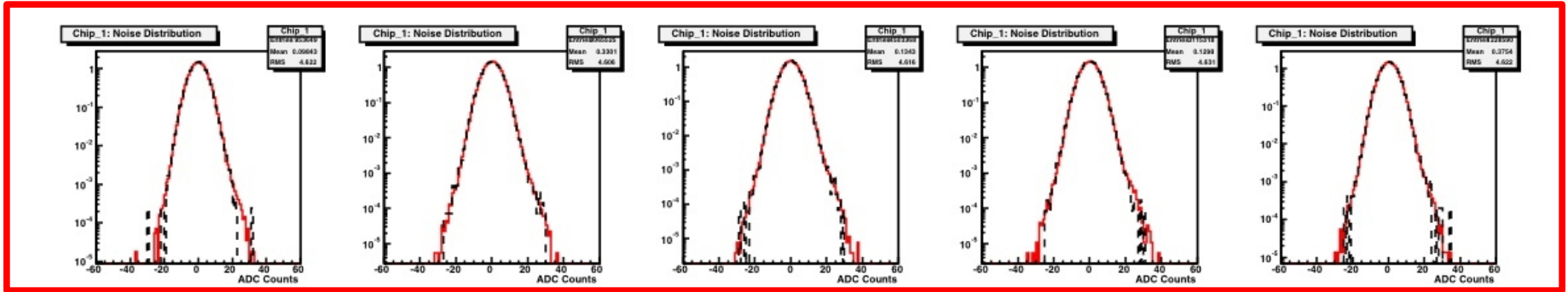
**=> First signal of each chip discarded in analysis**

# Noise Spectra Scan 4

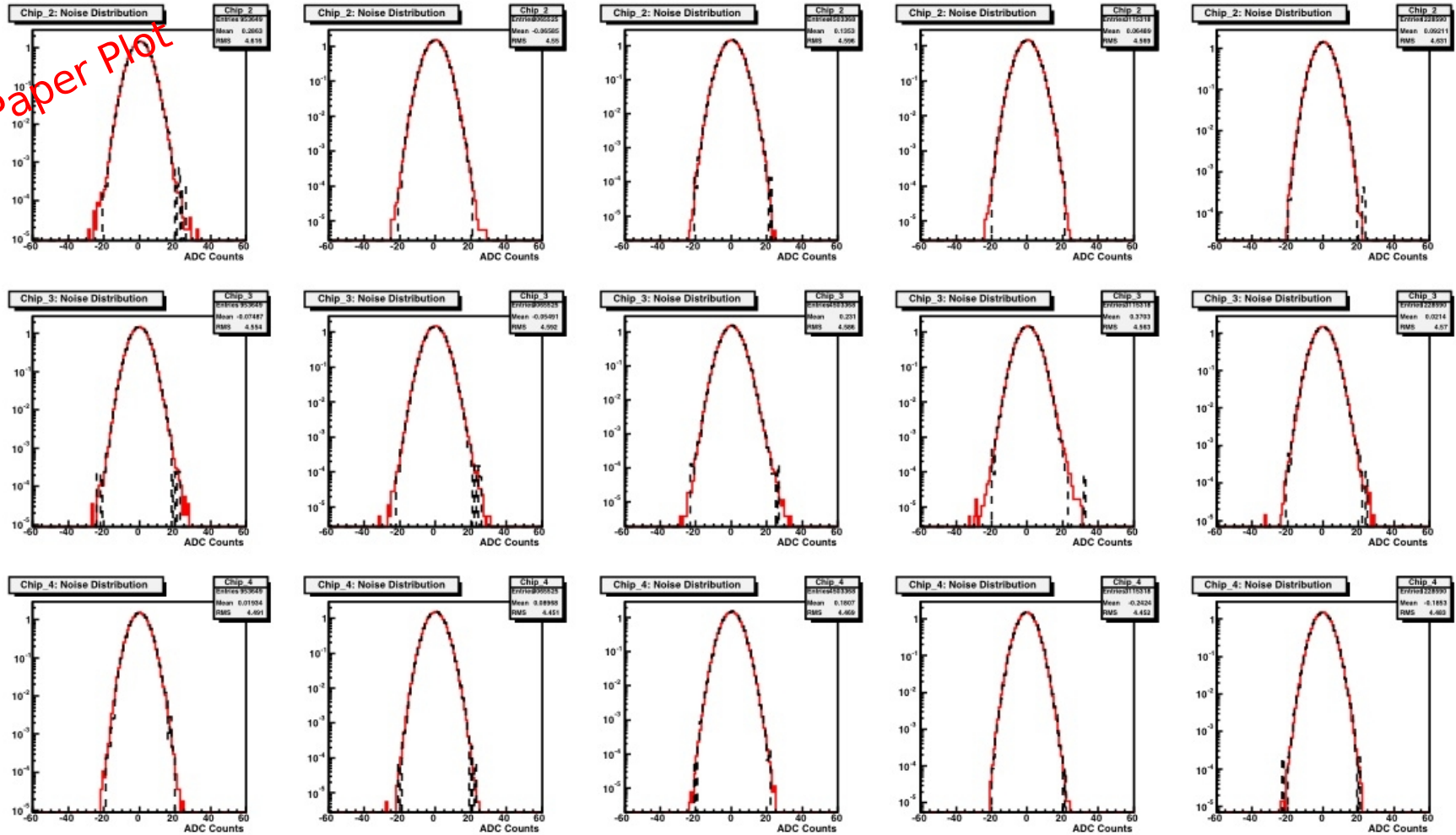
**Signal Events**  
**Pedestal Events**

Scan ID

C  
h  
i  
p  
I  
D



Paper Plot





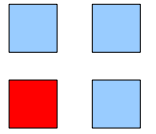
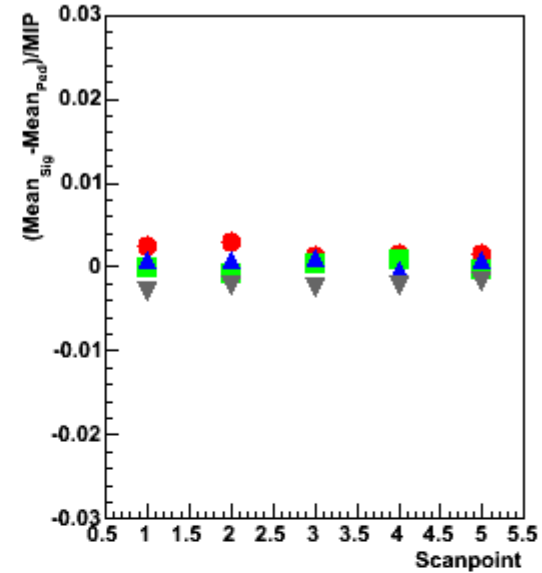
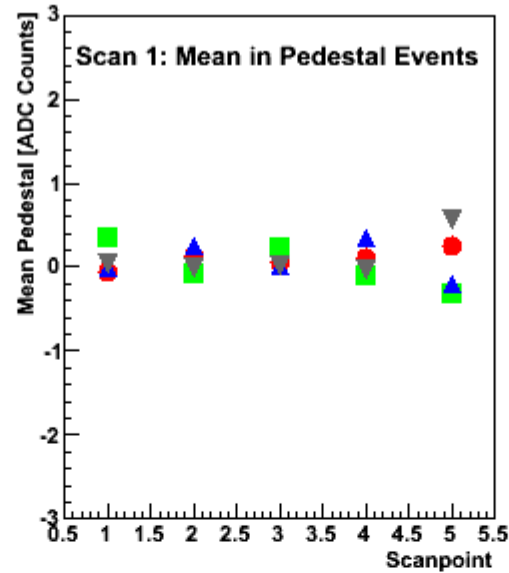
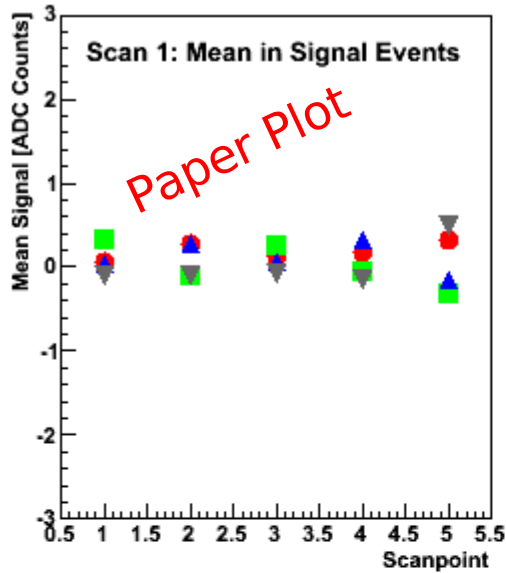
## Discussion of Noise Spectra

Did show only a selection of spectra

- Full set of scan plots in Annex to talk
- First Order: No difference between signal and pedestal events visible
- No obvious dependency on scan position
- No Hits above MIP threshold

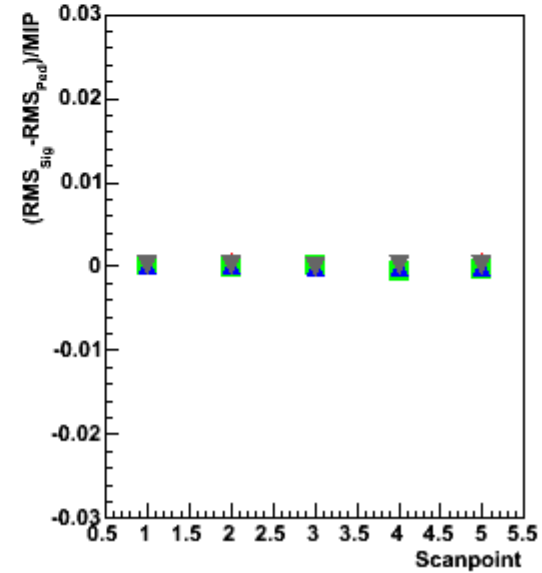
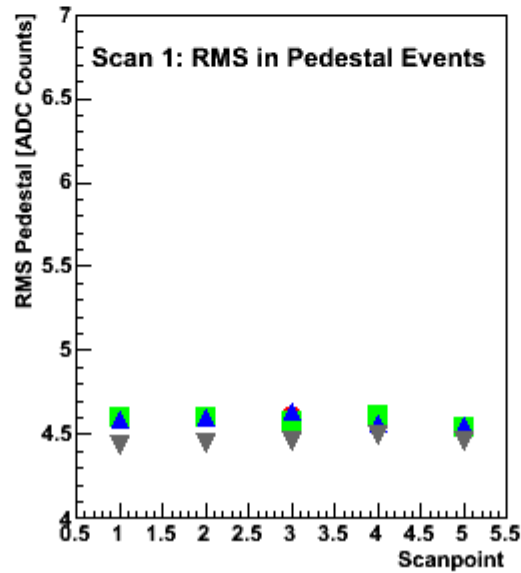
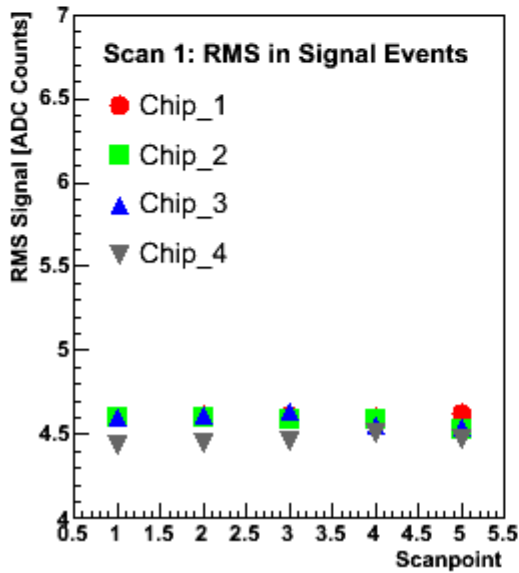
Assume 45 ADC counts for a MIP  
Quantitative results -> Next Slides

# Average Mean and RMS for Scan 1



Difference normalized to MIP

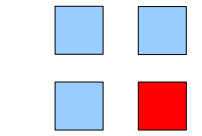
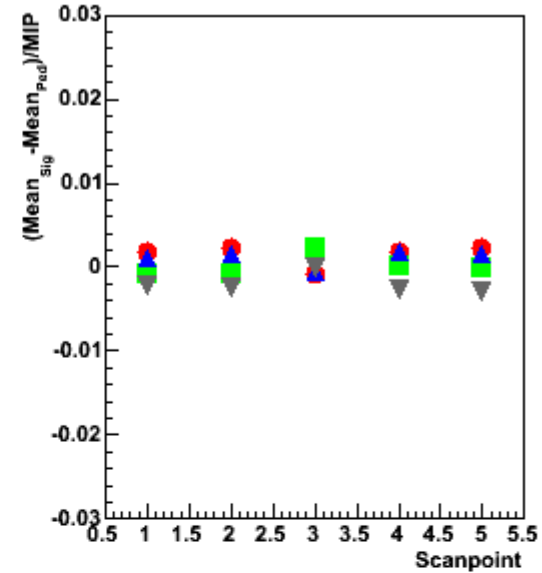
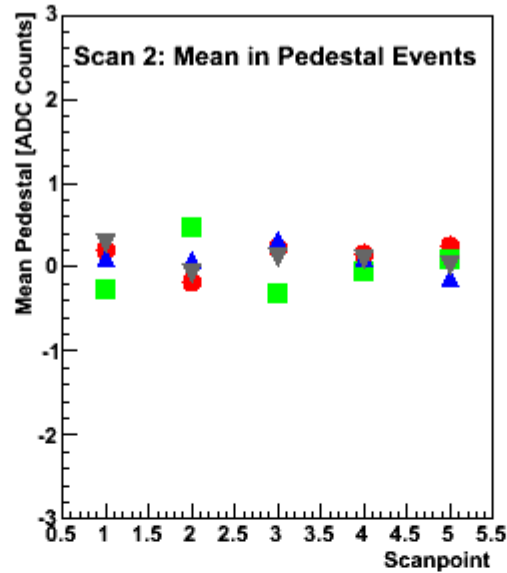
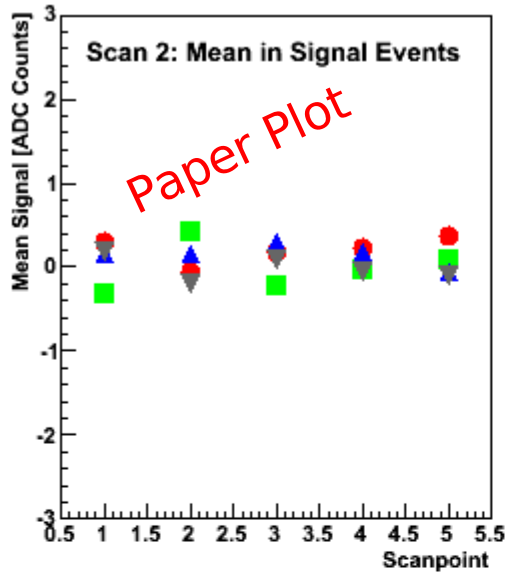
<< 1% of MIP



Difference normalized to MIP

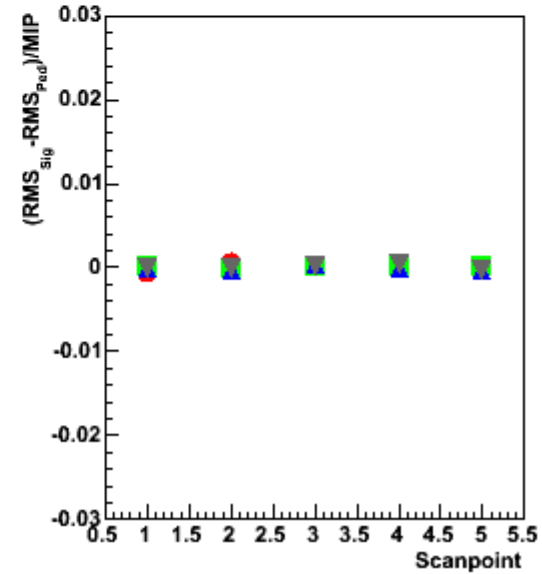
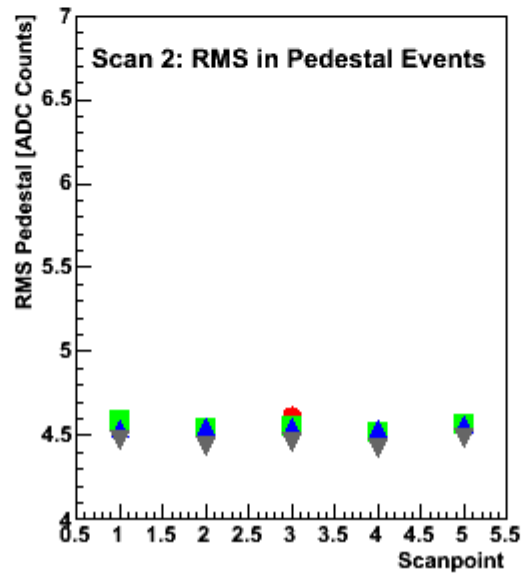
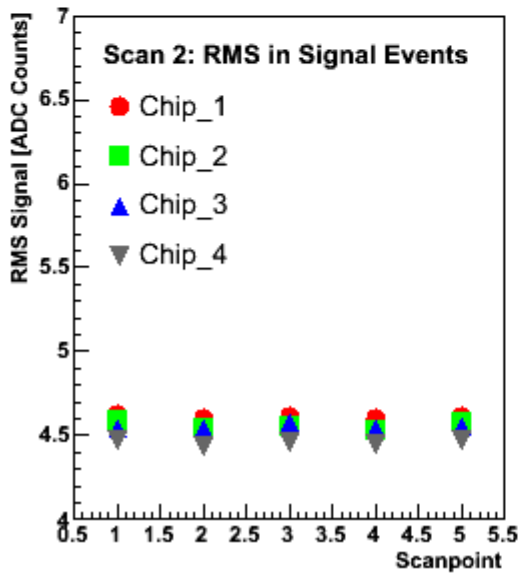
<< 0.5% of MIP

# Average Mean and RMS for Scan 2



Difference normalized to MIP

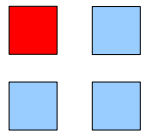
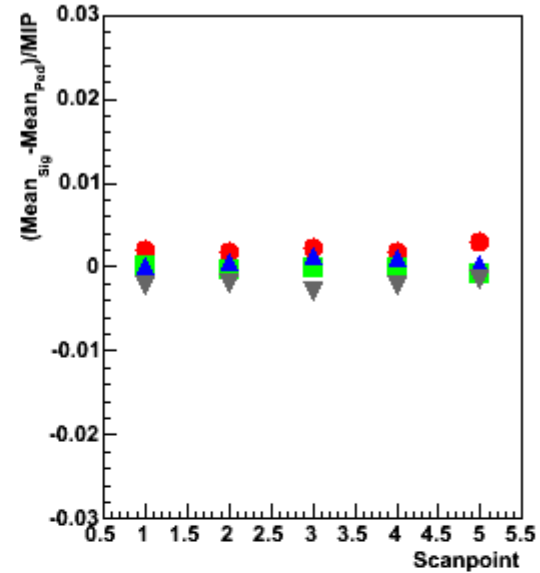
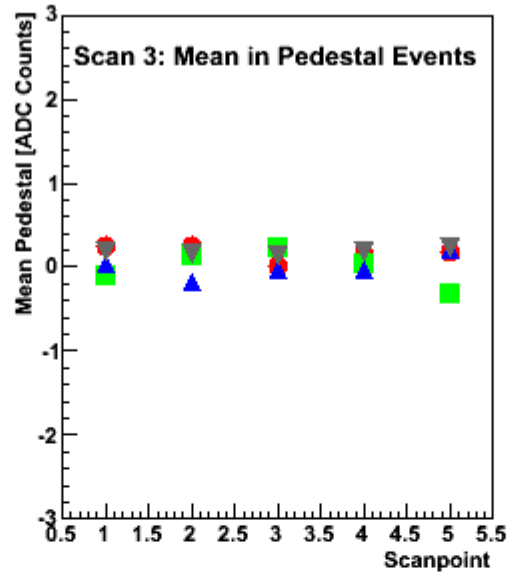
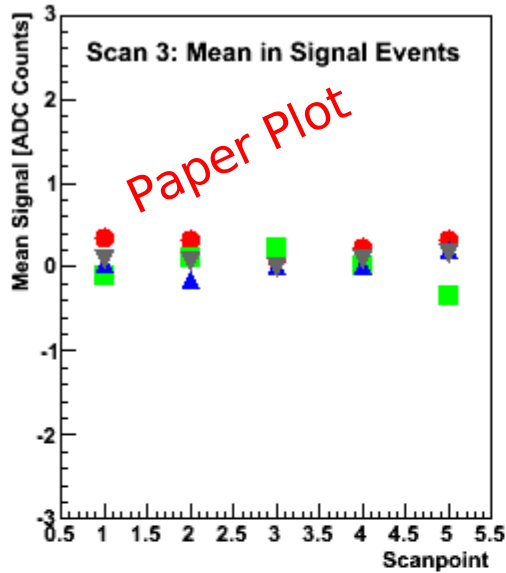
<< 1% of MIP



Difference normalized to MIP

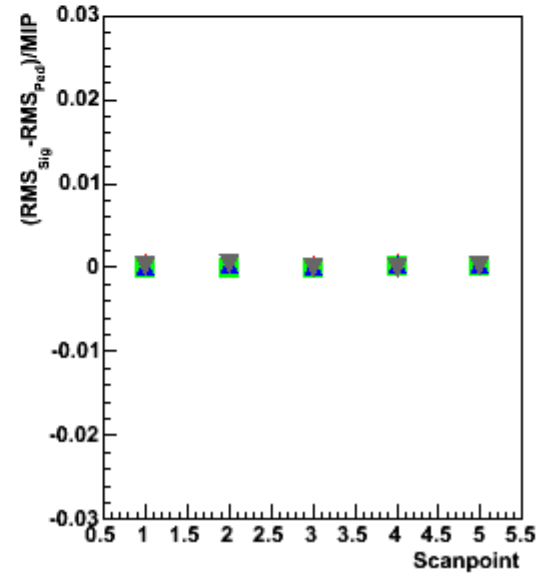
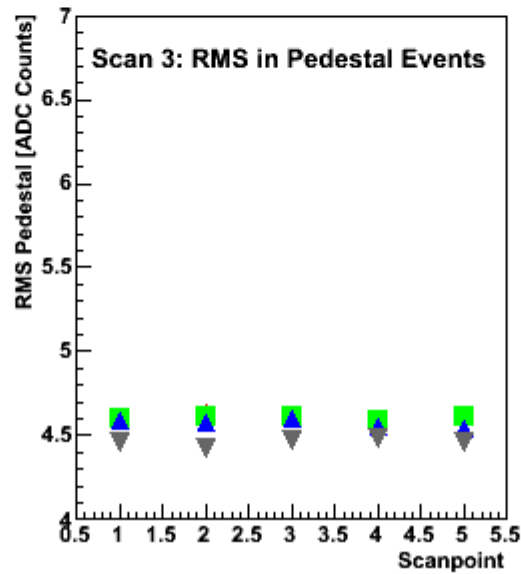
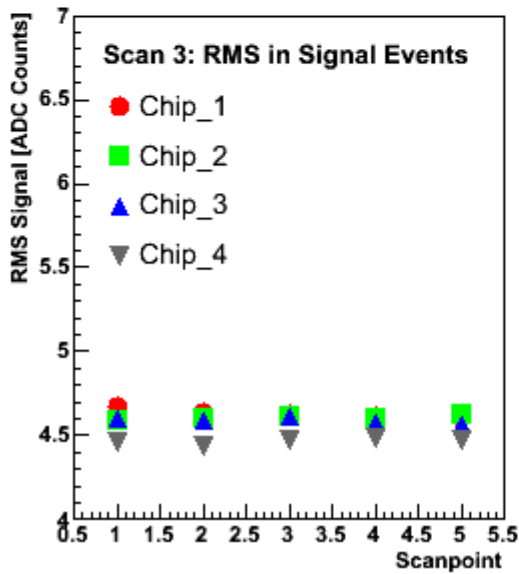
<< 0.5% of MIP

# Average Mean and RMS for Scan 3



Difference normalized to MIP

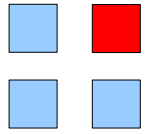
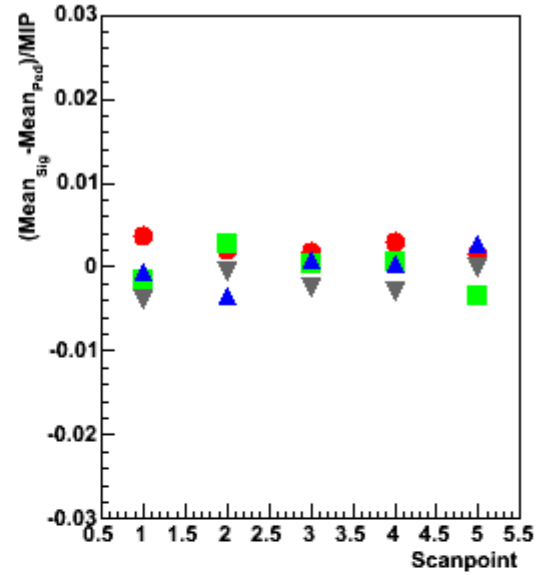
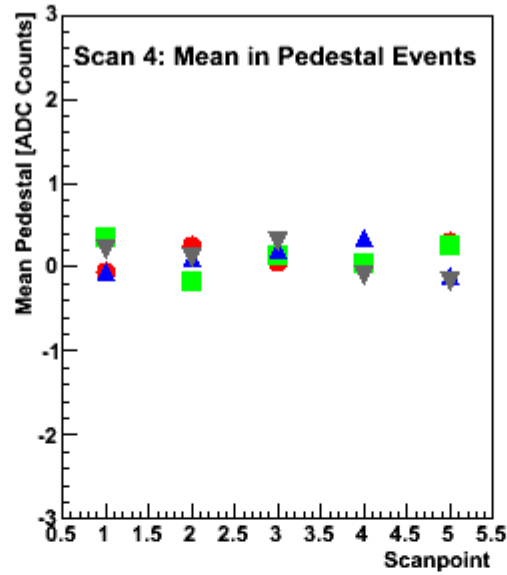
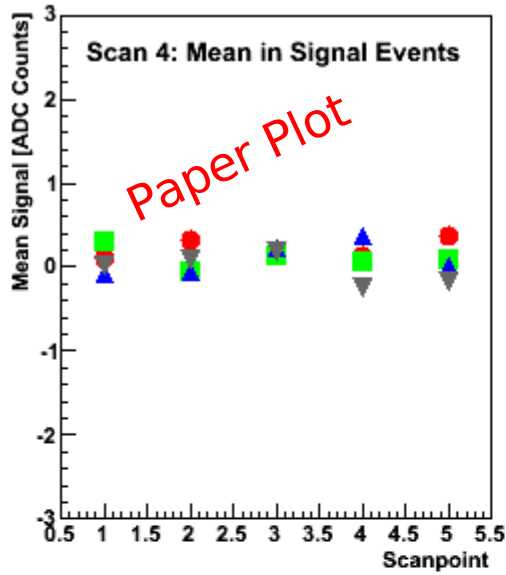
$\ll 1\%$  of MIP



Difference normalized to MIP

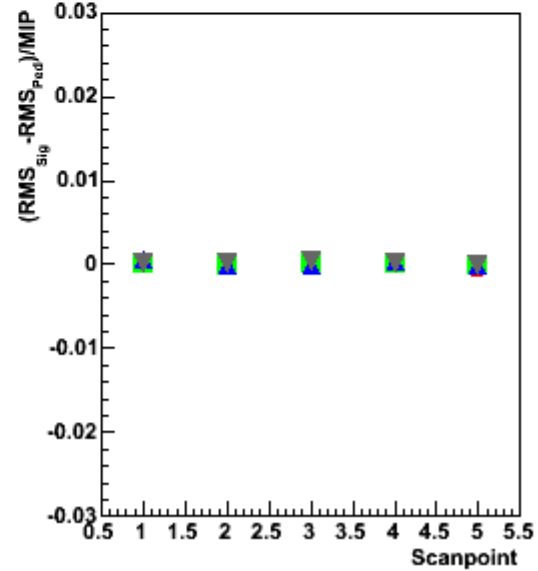
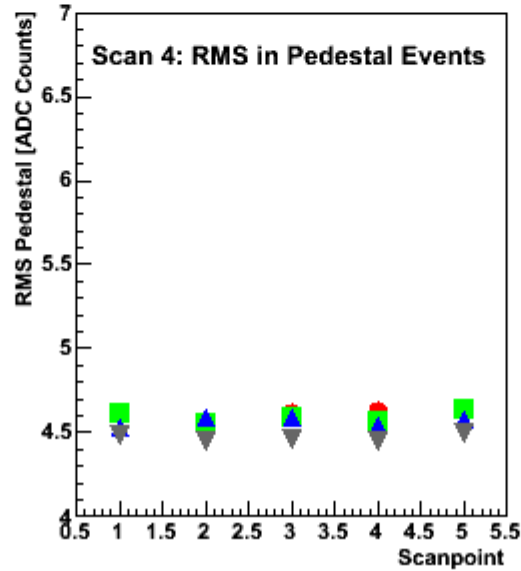
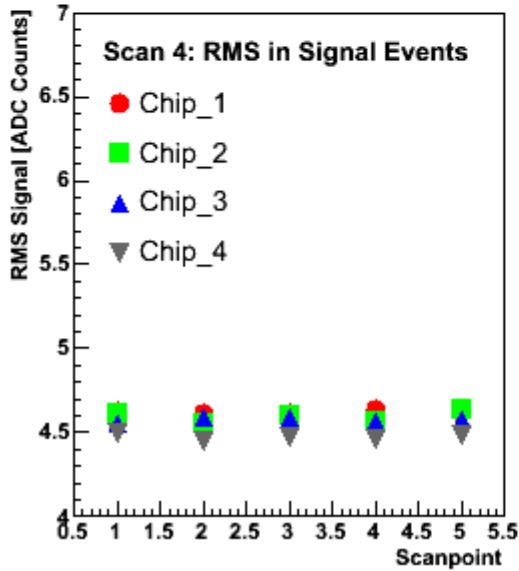
$\ll 0.5\%$  of MIP

# Average Mean and RMS for Scan 4



Difference normalized to MIP

$\ll 1\%$  of MIP



Difference normalized to MIP

$\ll 0.5\%$  of MIP

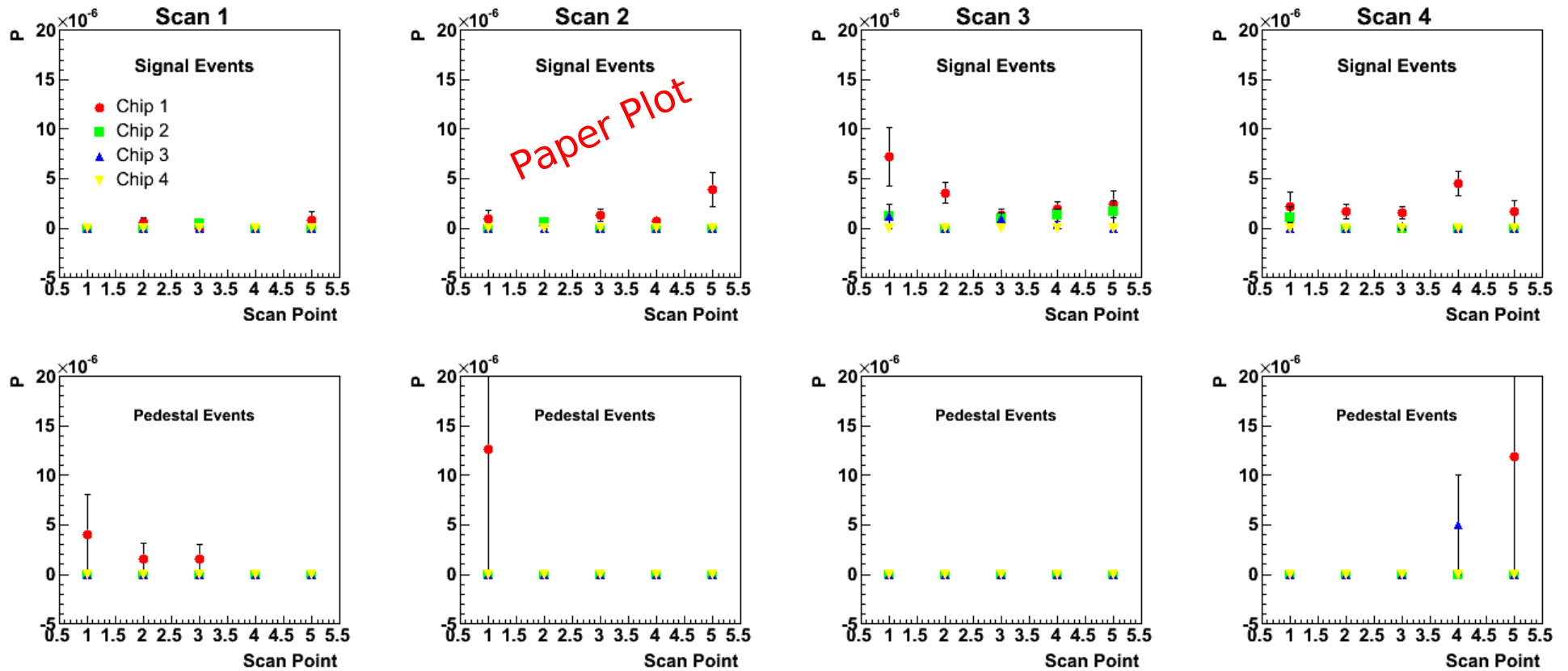
## Binomial Distribution

$$P = N_{\text{sig}} / N_{\text{tot}}, \quad N_{\text{tot}} = \text{Nevents} \times 17 \text{ (17 independent signals/Chip)}$$
$$N_{\text{sig}} = \text{\#Signals} > |n| \text{ ADC Counts}$$
$$\sigma_p = [P(1-P)/N_{\text{tot}}]^{1/2}$$

**N=45, 38:  $N_{\text{sig}} = 0$  for all runs and all chips !!!!**

**First signals seen for  $n=30 \iff 2/3 \text{ MIP}$**

# Probability for #Hits > |2/3| MIP



**Probability <  $10^{-5}$**

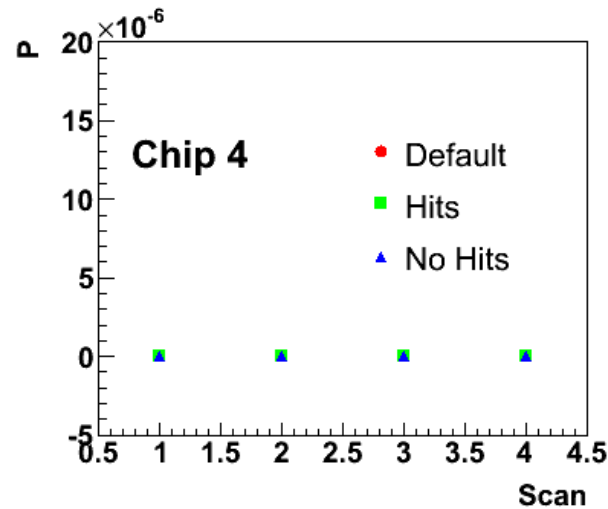
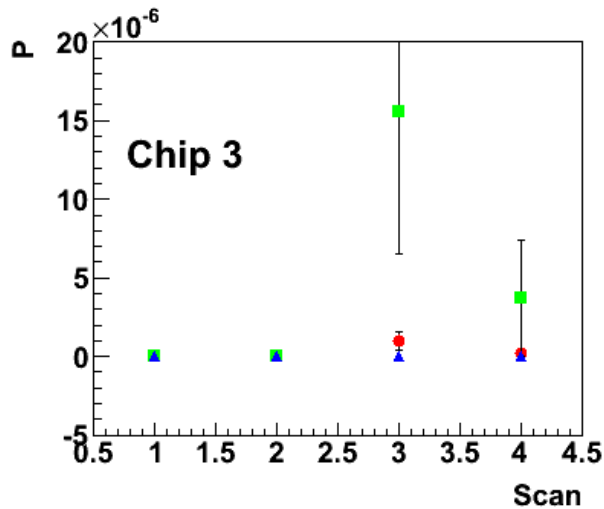
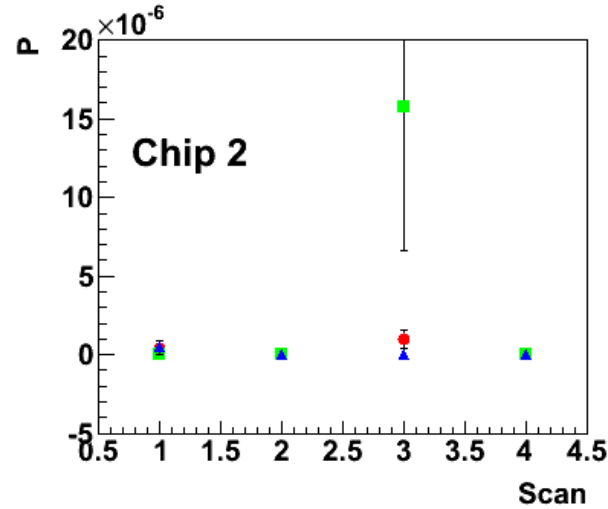
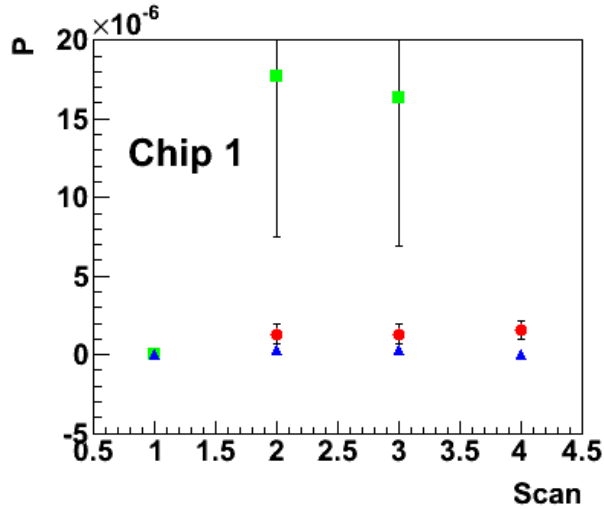
No evidence for beam induced signals  
 Same level of 'outliers' in Signal and Pedestal Events  
 Chip 1 looks like being a bit noisier than the others  
 Largest 'Hit Probability' when beam was targeted on other Chips  
 Given number is **upper limit**

# Influence of other Chips

Probability of finding a Signal  $> 2/3$  MIP if

a) There was a signal  $> 15$  ADC Counts in another Chip (“Hits”)

b) There was no signal  $> 15$  ADC Counts in another Chip (“No Hits”)



Tendency that Signal in one Chip induce Signals in the other Chips

- Consistent with residual Correlation (see above)

- Allows for conclusion that 'real' probability is yet smaller than given here!

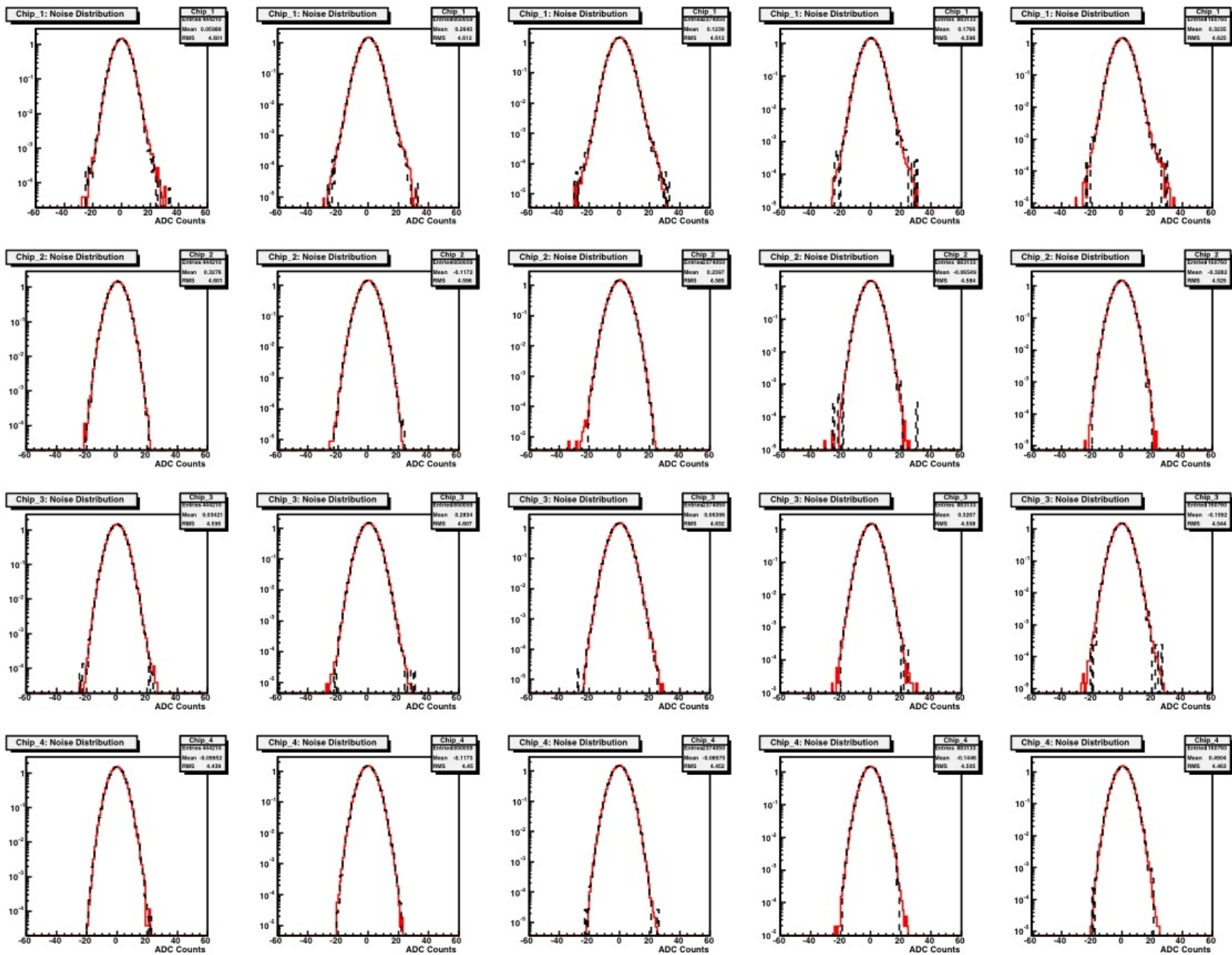


## Summary, Conclusion and Outlook

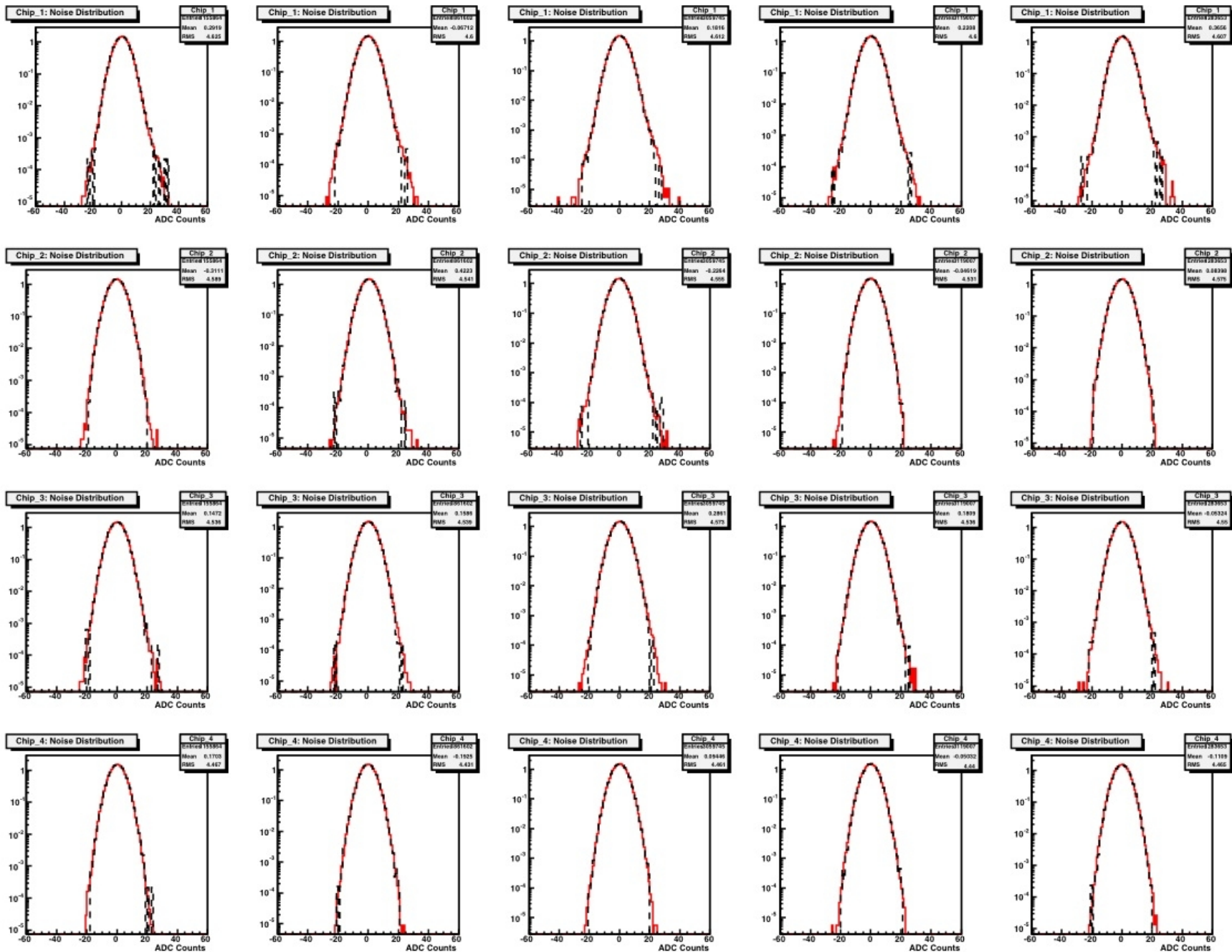
- Analysis of PCB exposure test with full statistics  
Study is finished
- Pedestal Correction necessary for analysis
- No signals above 1 MIP observed
- **Probability to find signals with  $> |2/3|$  MIPS  $< 10^{-5}$**   
**'Real' probability looks like being much smaller**
- **No evidence that shower particles create fake hits in detector or even influence noise distribution at smaller level**
- **All observed 'effects' seem to be independent of scan position**
- Presented results summarised in note for CALICE  
(waiting for approval by referees)
- Can be “immediately” sent to NIM

## Annex: Noise Spectra in other scans

# Scan 1



# Scan 2



# Scan 3

