Analysis of PCB Exposure Tests

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LAL Orsay

- Motivation

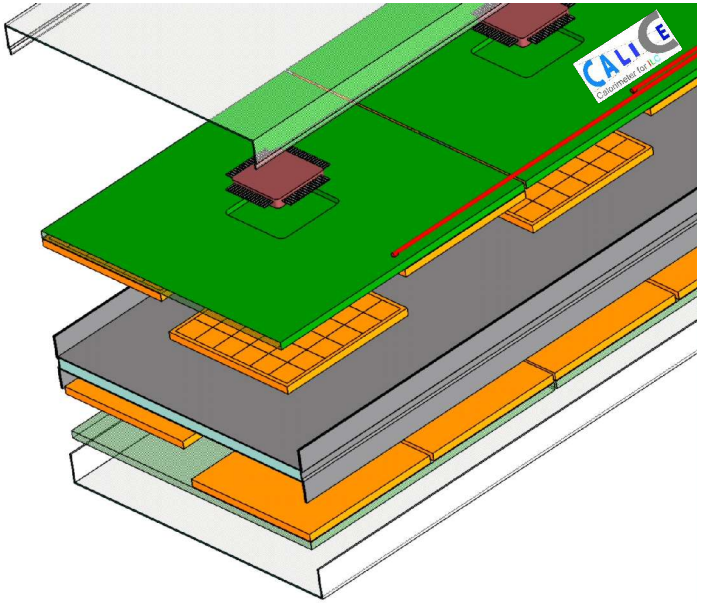
- Analysis and Results

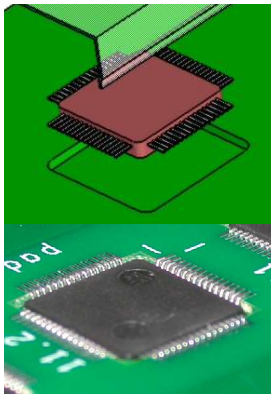
- Summary, Conclusion and Outlook

Calice Analysis Meeting 8/2/2010

Introduction

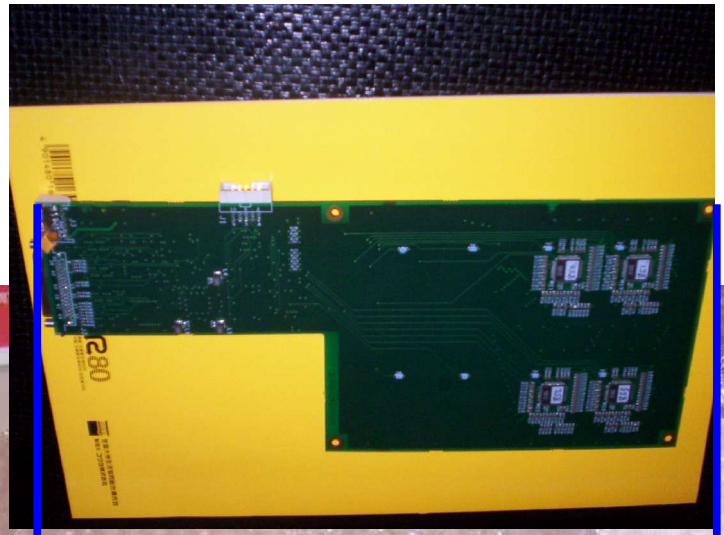
Calorimeter Electronics to be interleaved with layer structure





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

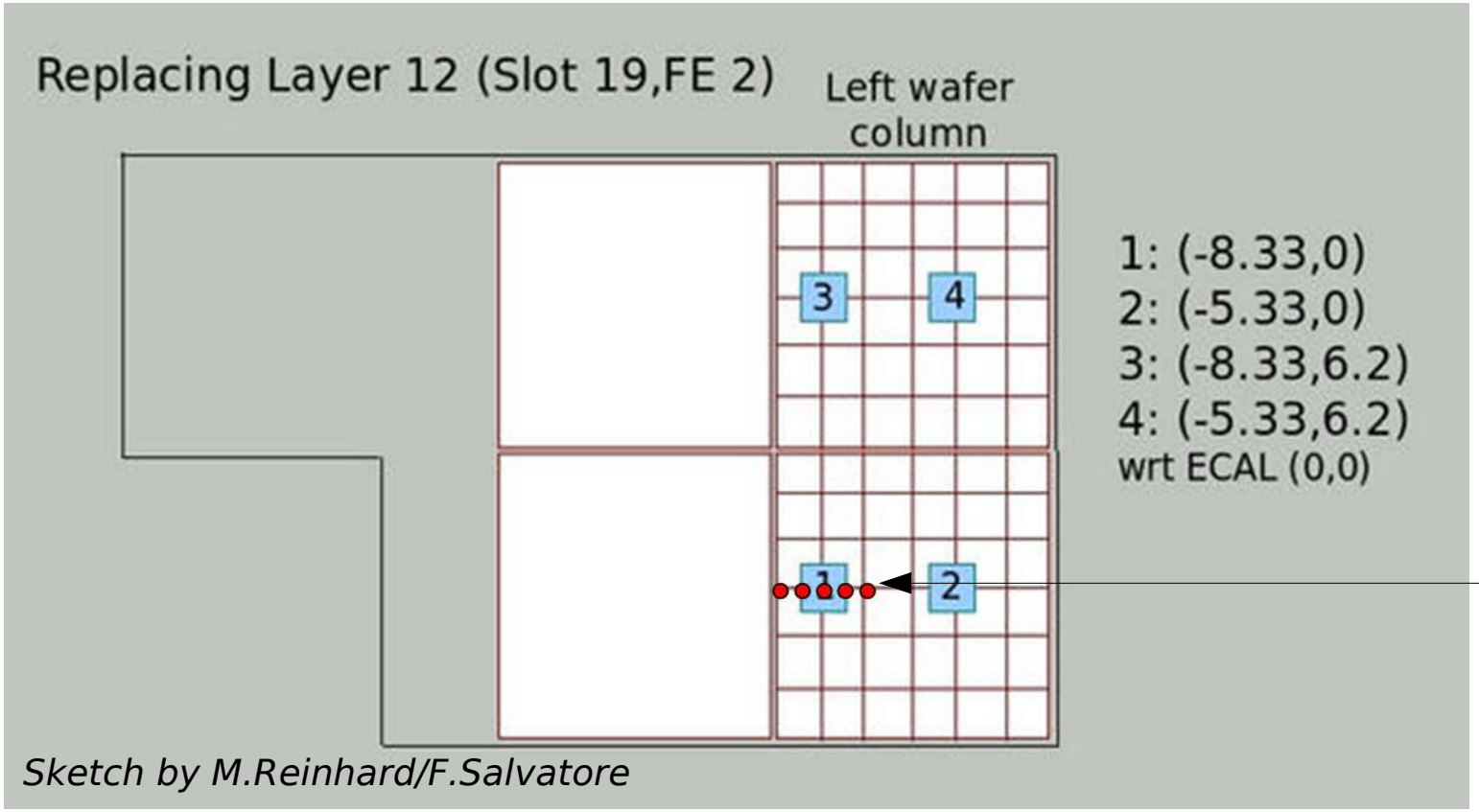
Usual Slab

Picture courtesy of B.Lutz

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



Nominal positions of Chips

Scanning points

- 2.6 10^6 Events with 90 GeV Electrons (- 5.8 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

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

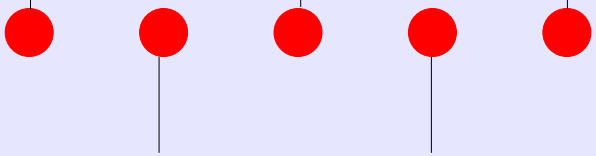
Statistics of Analysis

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.

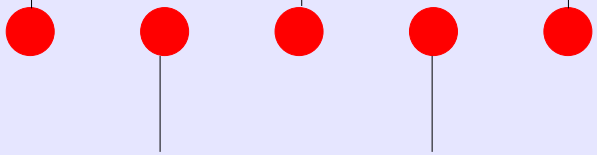
Run331512: e- 90 GeV
Signal: 218519 Evts.
Pedestal: 9462 Evts.

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.

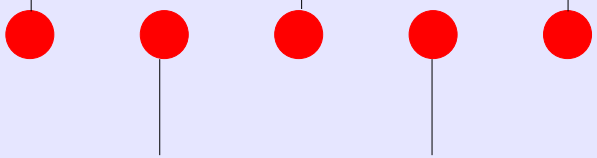
Run331494: e- 90 GeV
Signal: 217415 Evts.
Pedestal: 11698 Evts.

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.

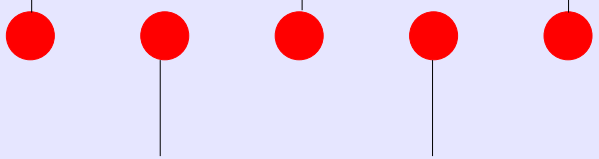
Run331478: 90 e- GeV
Signal: 65249 Evts.
Pedestal: 3602 Evts.

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: 89435Evts.
Pedestal: 4254 Evts.



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

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

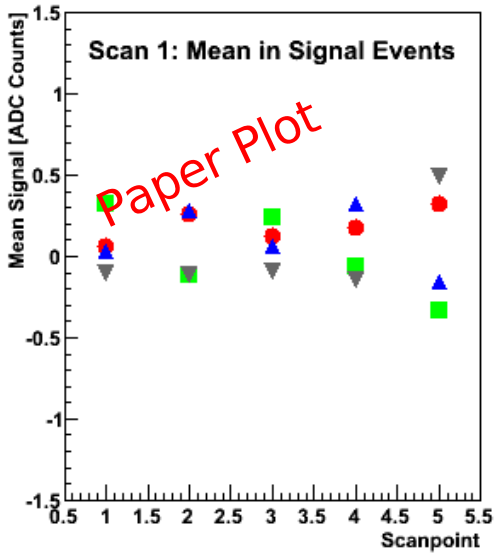
On Run Selection and Observations

- Run Selected according to entries in the logbook
  No comments on bad quality by Shift Crew

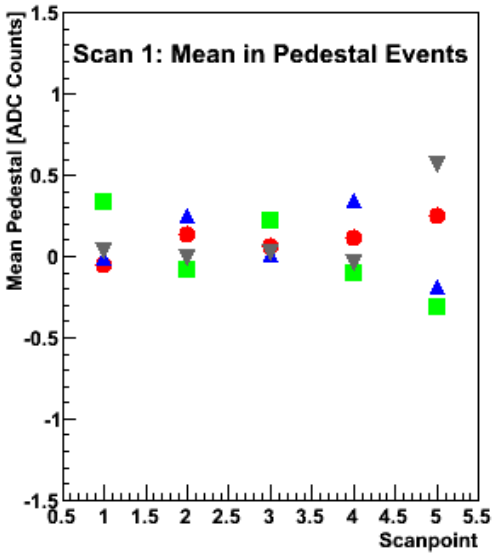
- Switch of energy between Run 331473 and Run 331478
  - Change in Pedestal Rate
    20% of all events -> 5% of all events
    Still at least 3500 of (valuable) pedestal events

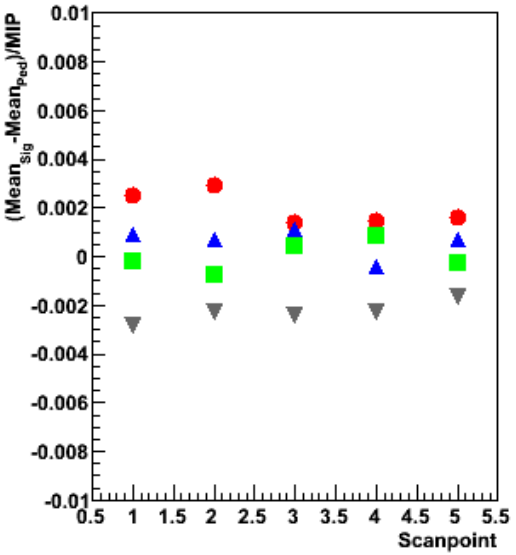
- at least 70k Events at each point
  - mostly 90 kEvents for off center runs
  - > 200k at (nomincal) Chip Center

Average Mean and RMS for Scan 1



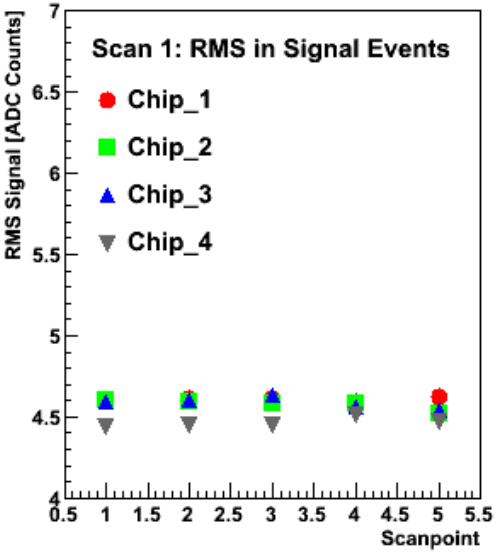
Paper Plot

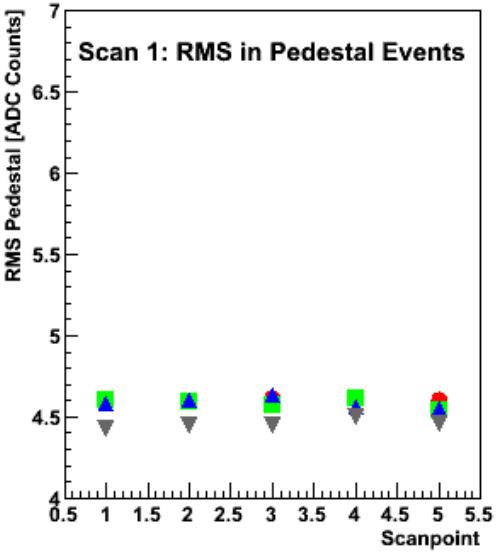


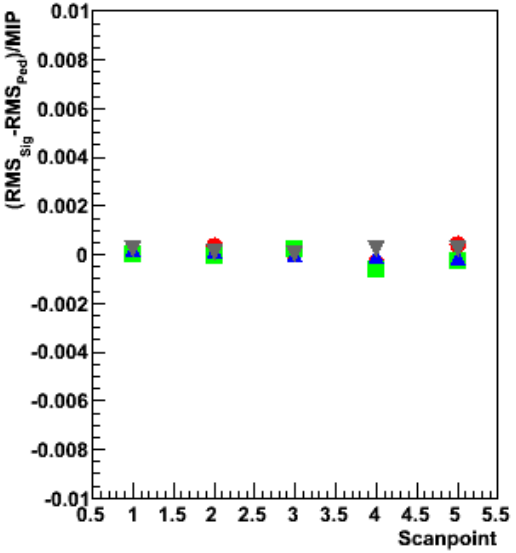


Difference normalized to MIP

<< 1% of MIP





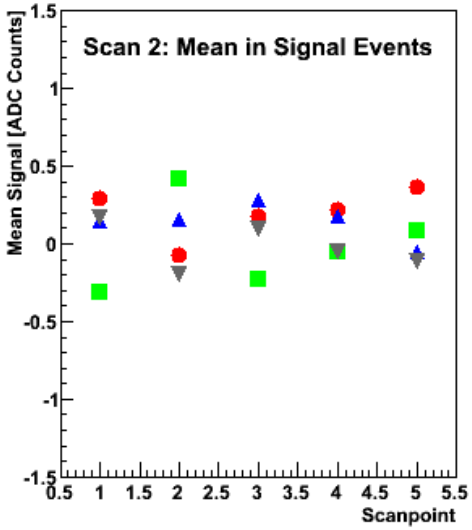


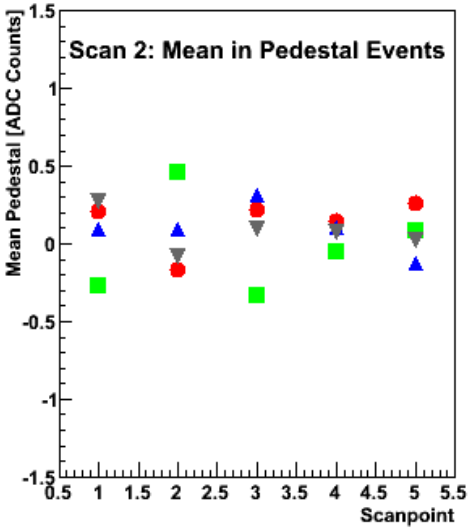
Difference normalized to MIP

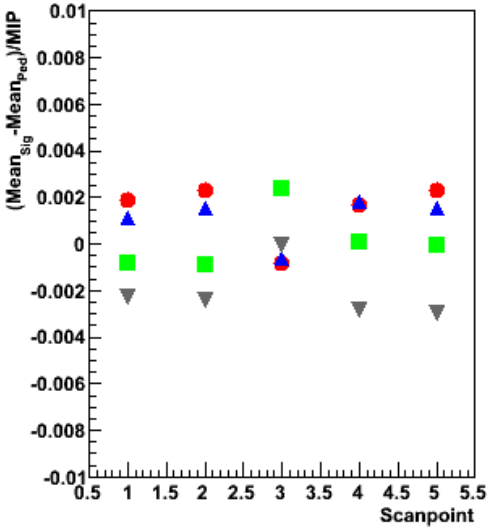
<<0.5% of MIP

No dependency on scan position visible

Average Mean and RMS for Scan 2

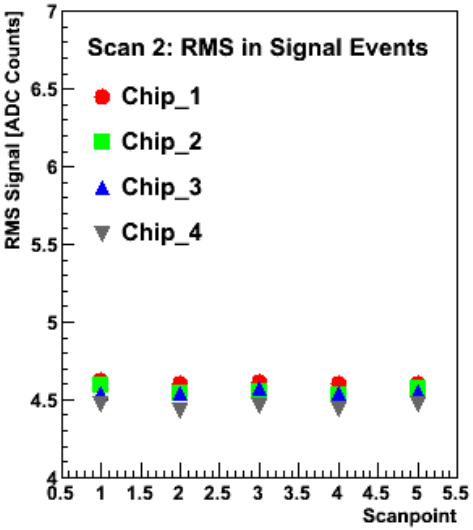


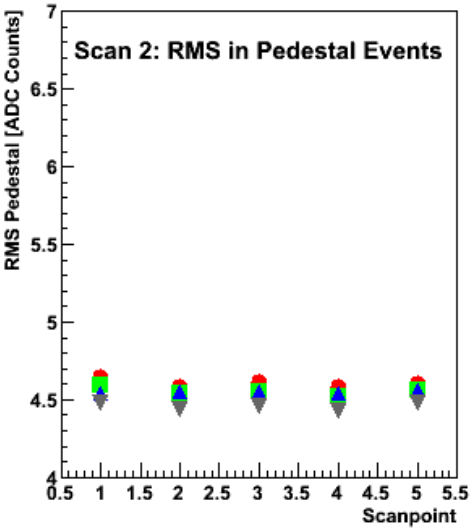


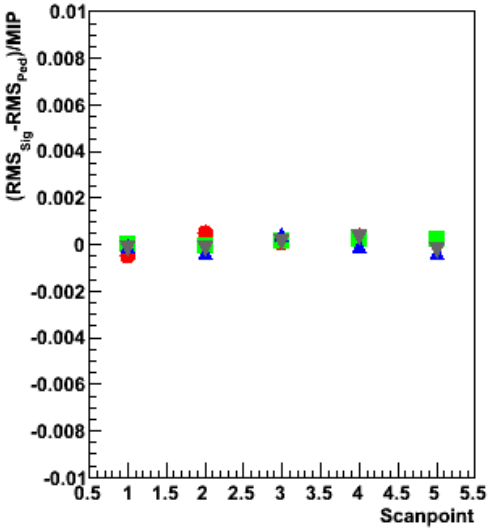


Difference normalized to MIP

<< 1% of MIP





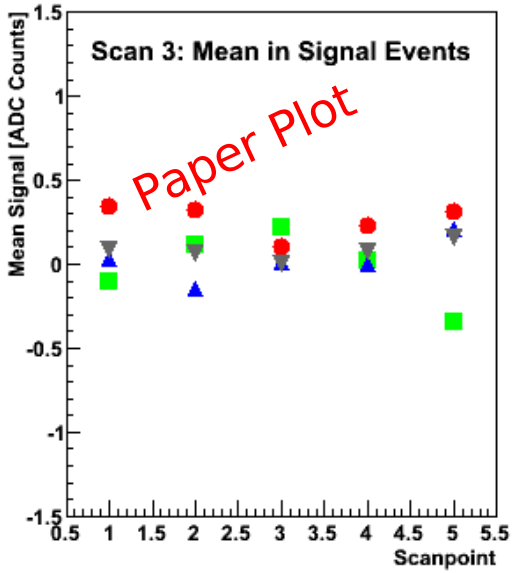


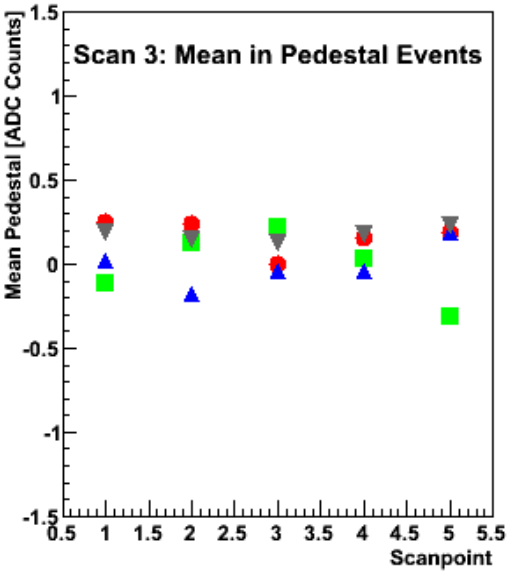
Difference normalized to MIP

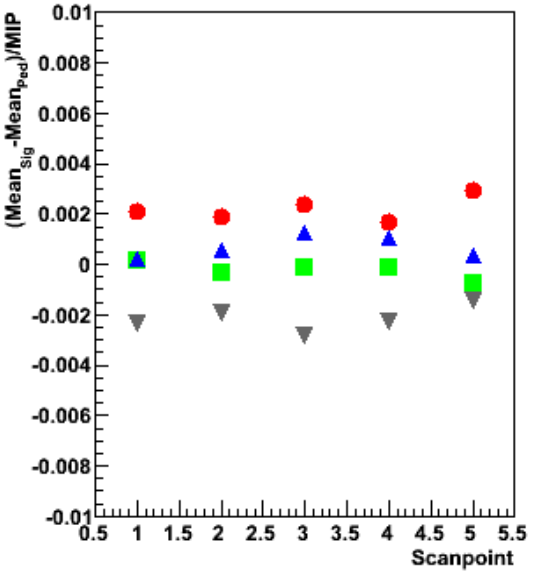
<<0.5% of MIP

No dependency on scan position visible

Average Mean and RMS for Scan 3

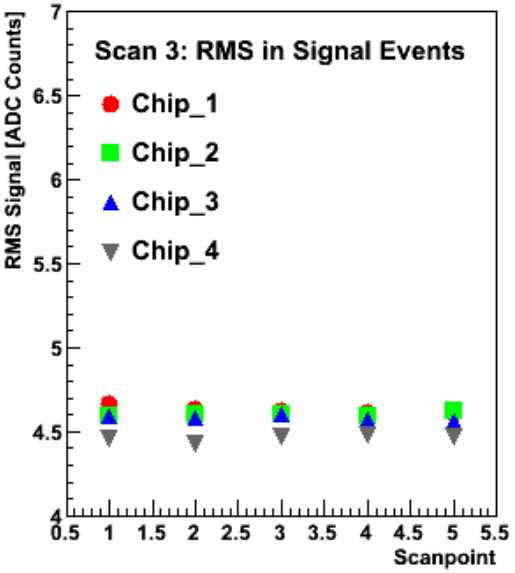


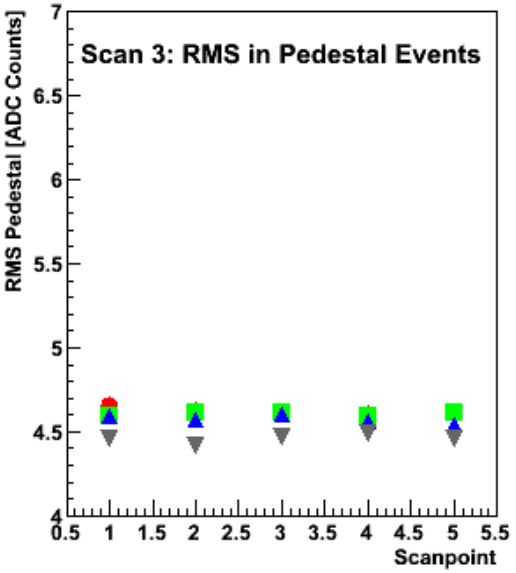


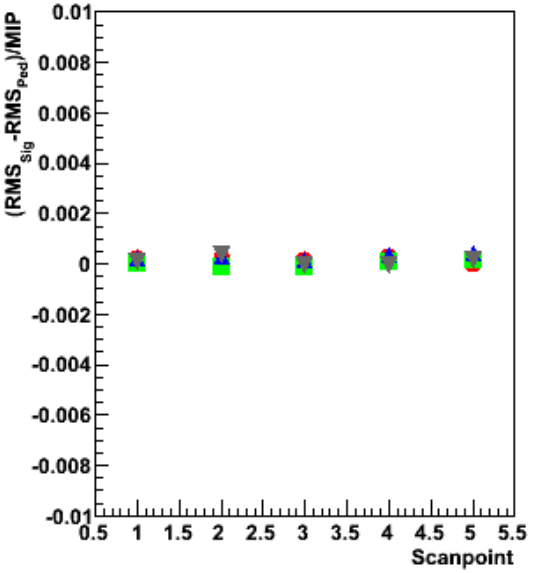


Difference normalized to MIP

<< 1% of MIP





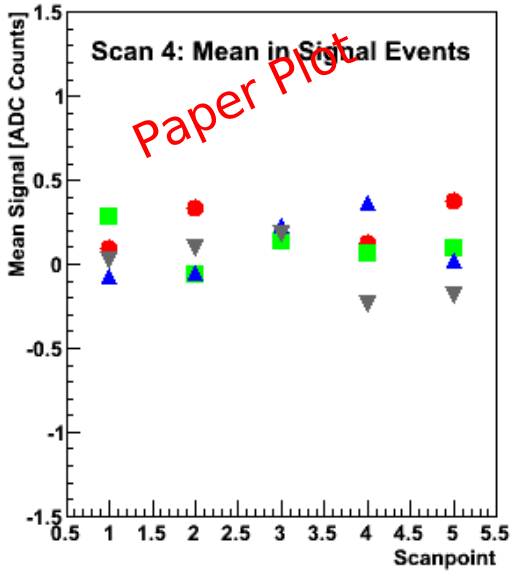


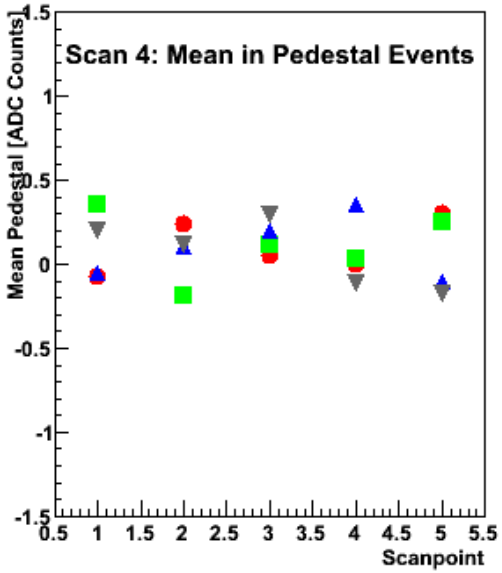
Difference normalized to MIP

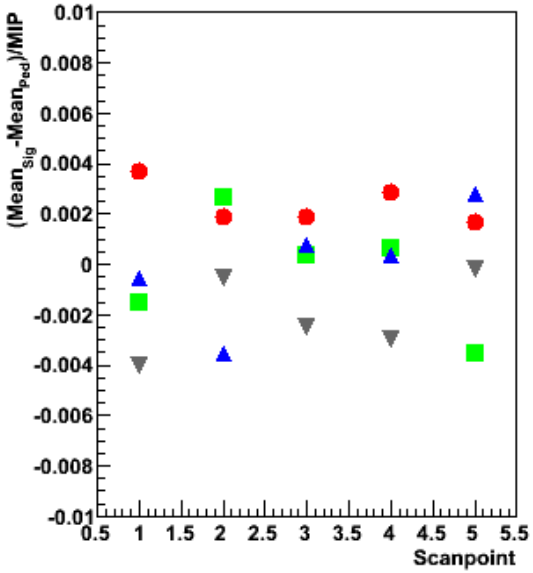
<<0.5% of MIP

No dependency on scan position visible

Average Mean and RMS for Scan 4

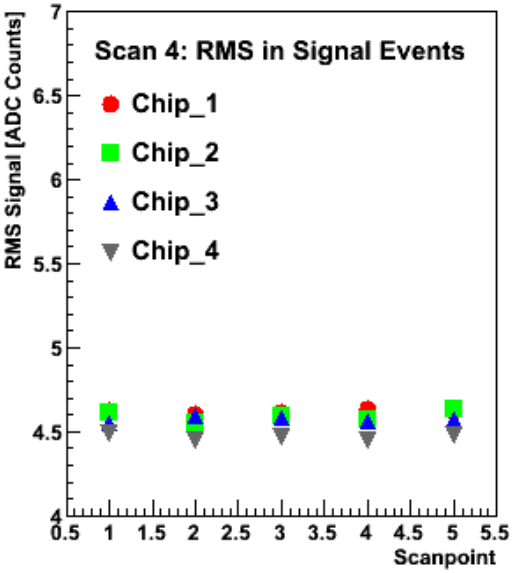


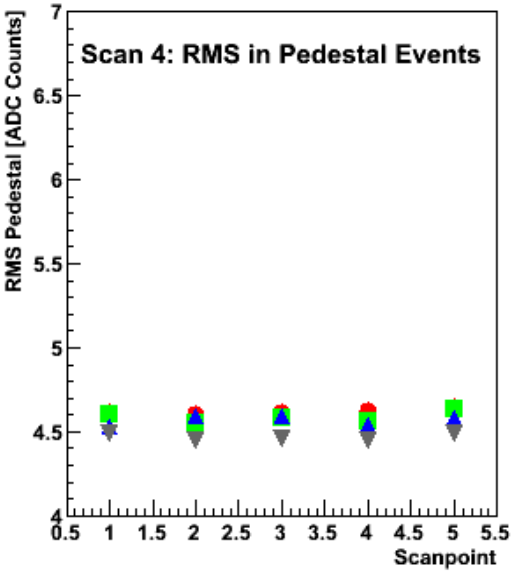


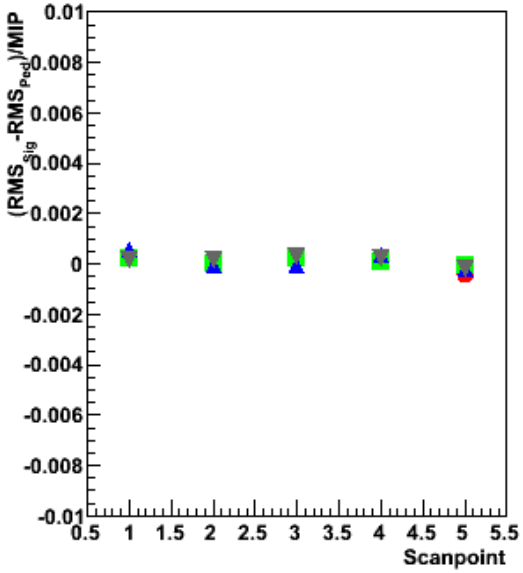


Difference normalized to MIP

<< 1% of MIP







Difference normalized to MIP

<<0.5% of MIP

No dependency on scan position visible

Probability of fake hits - Estimation

Binomial Distribution

$P = N_{sig}/N_{tot}$, N_{tot} = Nevents x 17 (17 independent signals/Chip)

N_{sig} = #Signals > |n| ADC Counts

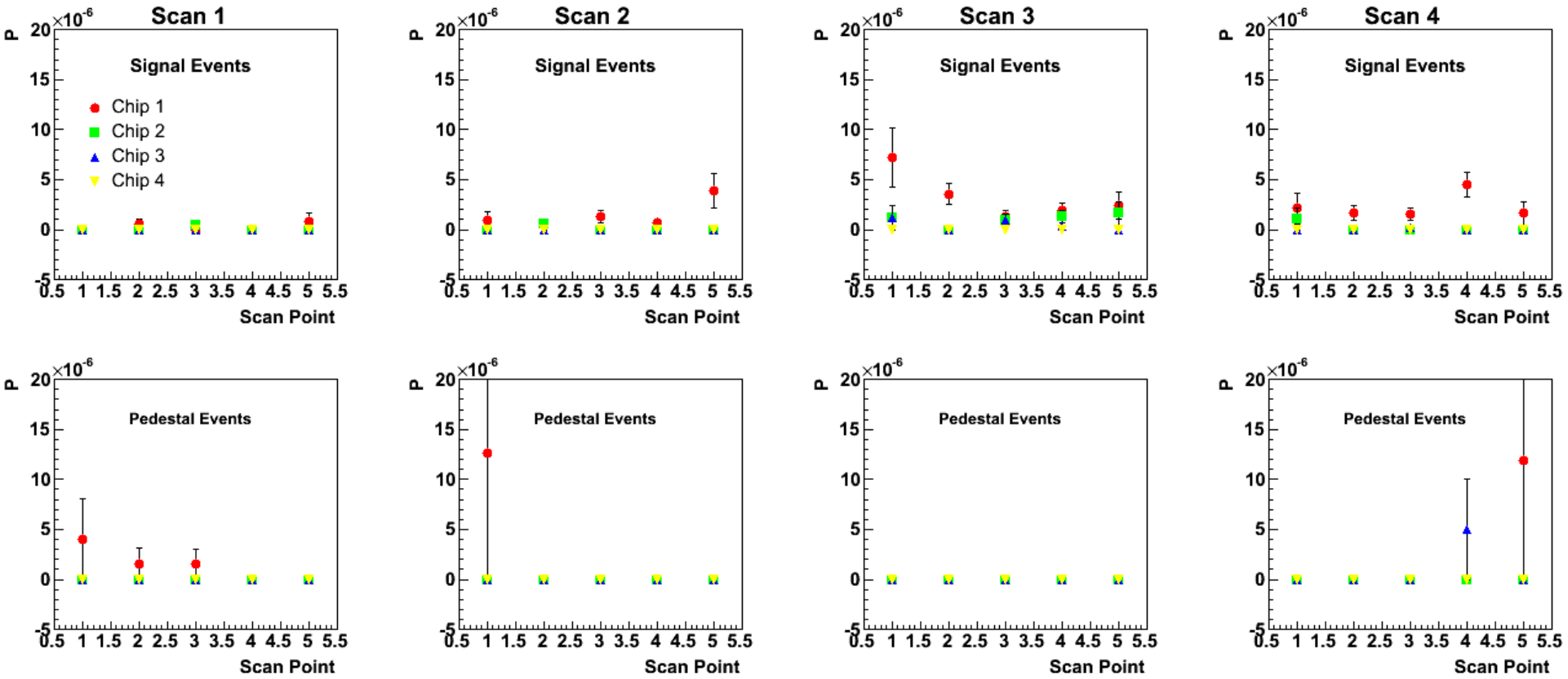
$\Delta_P = [P(1-P)/N_{tot}]^{1/2}$

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

First signals seen for n=30 <=> 2/3 MIP

Today's starting Point – Figure Shown on CALICE Collab. Meeting at Lyon

Probability for #Hits > |2/3| MIP



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

Calculation of upper Limits

- Probabilities shown on slide 13 not adequate for 0 counts

- Upper Limits/Probabilities as a function of the Threshold

  - Requires calculation of limits with underlying background

  Probability Density Function (Frequentist Approach):

$$f'(n;\lambda_S+\lambda_B) = f(n;\lambda_S+\lambda_B) / \sum_{n_B=0}^{k} f(n_B;\lambda_B) \quad \text{f, f' are Poissonnian Densities}$$

  Presence of Background via numerator (Approach a la Zech NIM A277)

  Using this pdf the Confidence Limits/Upper Limits
  can be calculated using regular statistics techniques

  Here: S. Brandt, Datenanalyse, pp.183

  Developed ("c++ fied") program to calculate upper limits in the presence of known background.

Estimation of Background

Several Approaches:

- "Gaussian Background"

  Assume gaussian distribution of noise spectra
  mean and sigma from measured noise spectra

- "Detailed Background"

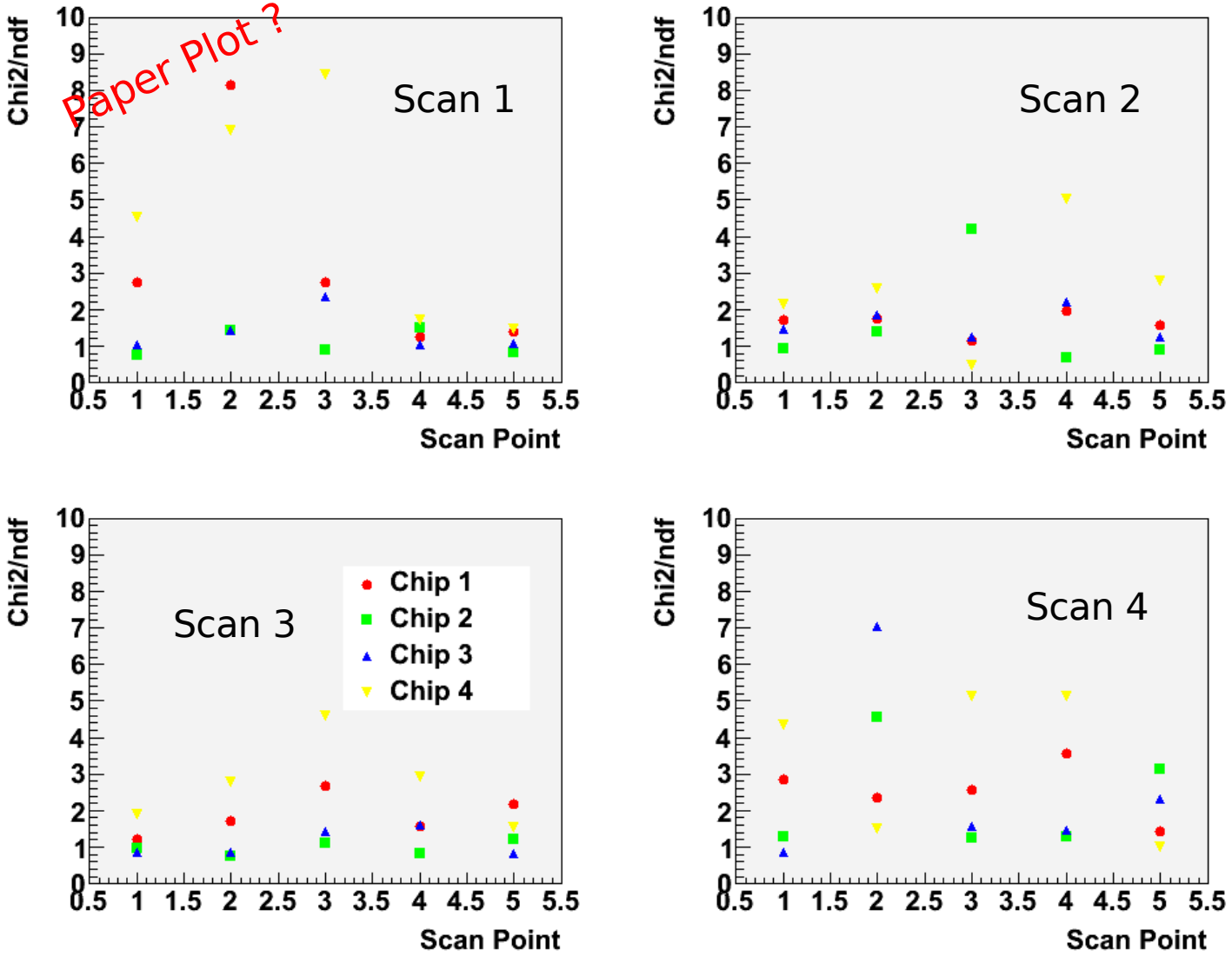
  Create pdf from measured noise spectra and generate noise background from these pdfs

- "Cross Modelled Background"

  Create pdf of a Chip x from measured Signal spectra when scanned over a Chip opposite to Chip x
  E.g. spectra for Chip 1 from Scan over Chip 4

Gaussian Background

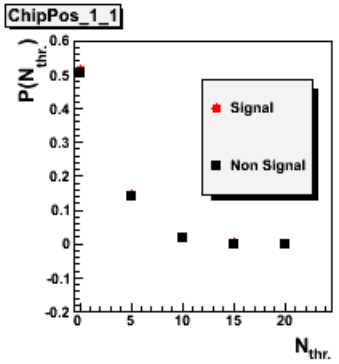
Comparison between Signal and Pedestal Distributions – χ^2 Test (root 5.22/00)

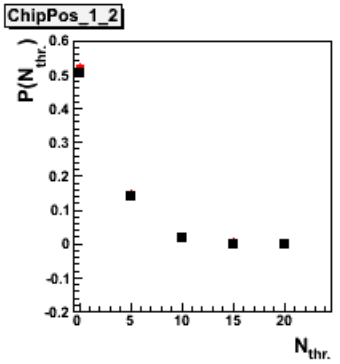


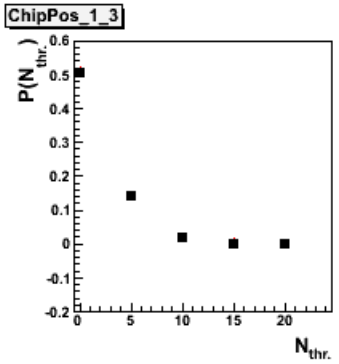
In general good agreement χ^2/ndf ≈ 1.5, however some serious outliers

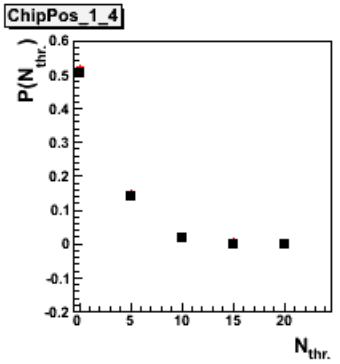
Gaussian Background
Hit Probability as a Function of Threshold – Chip 1 – “Positive” Hits

Remark: Two Outer and two “next to central” impact points are joined

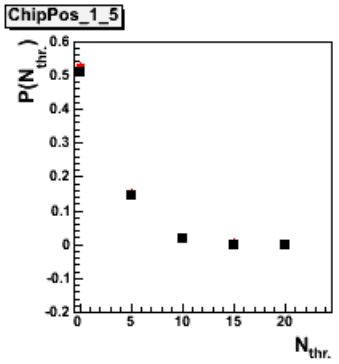


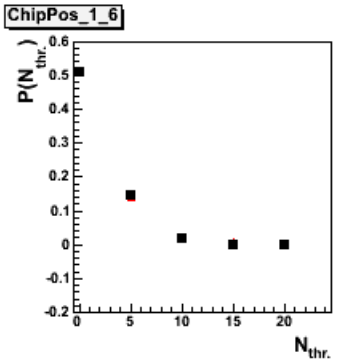


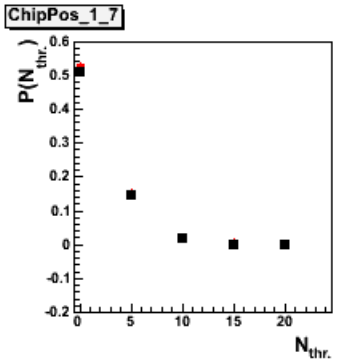


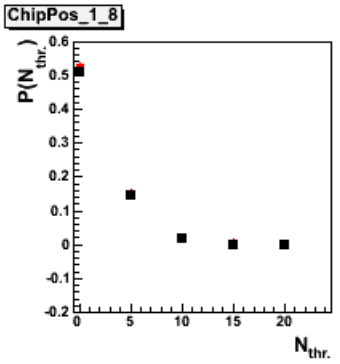


Central

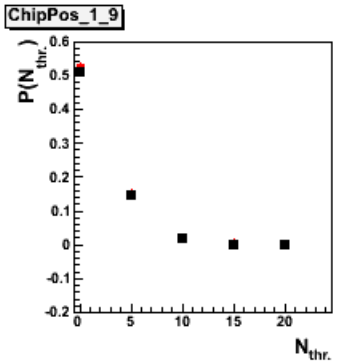


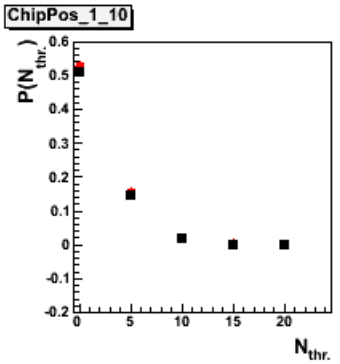


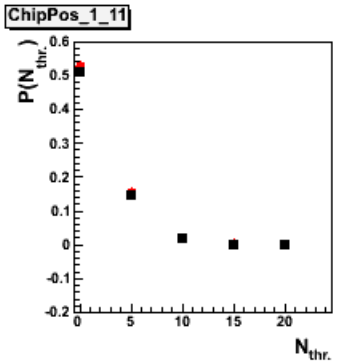


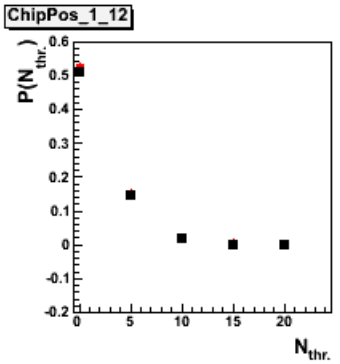


Next-to-Central







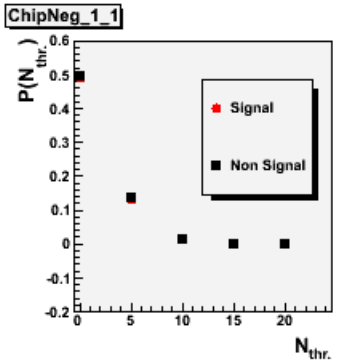


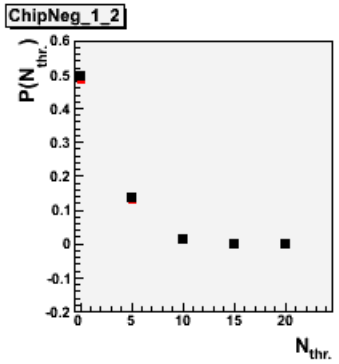
Outer

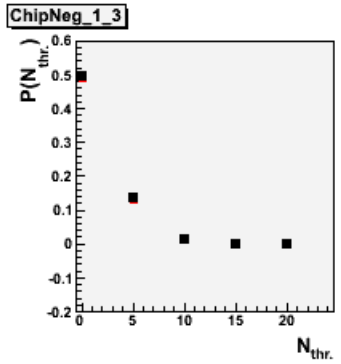
Shape of Signal and Background nearly identical

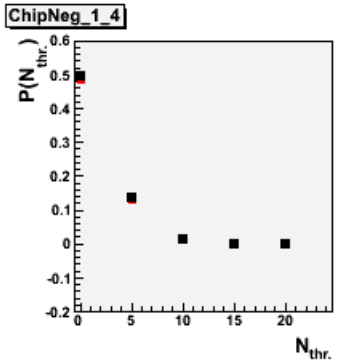
Gaussian Background
Hit Probability as a Function of Threshold – Chip 1 – “Negative” Hits

Remark: Two Outer and two “next to central” impact points are joined

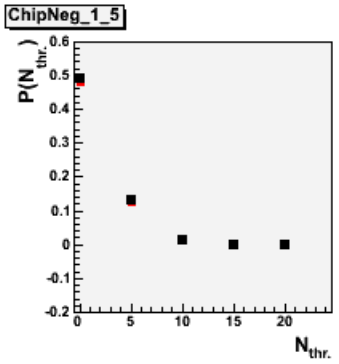


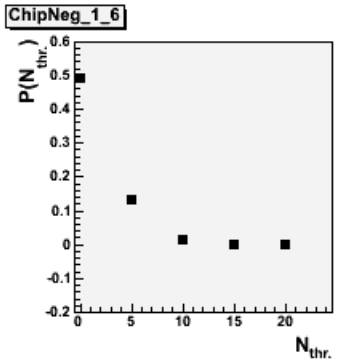


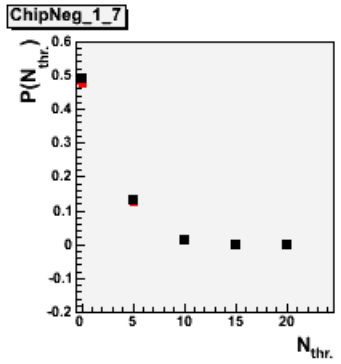


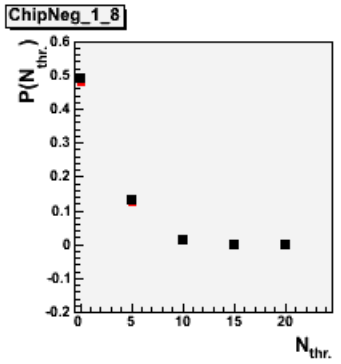


Central

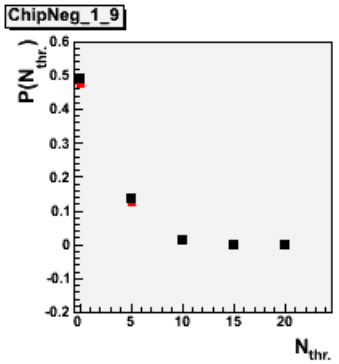


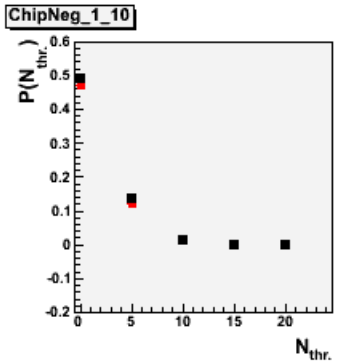


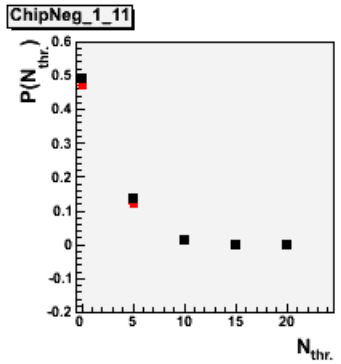


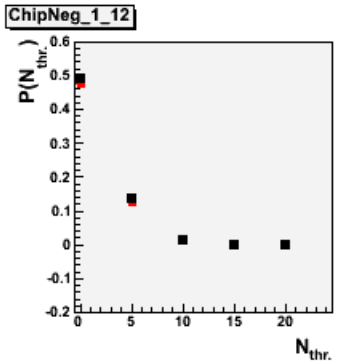


Next-to-Central





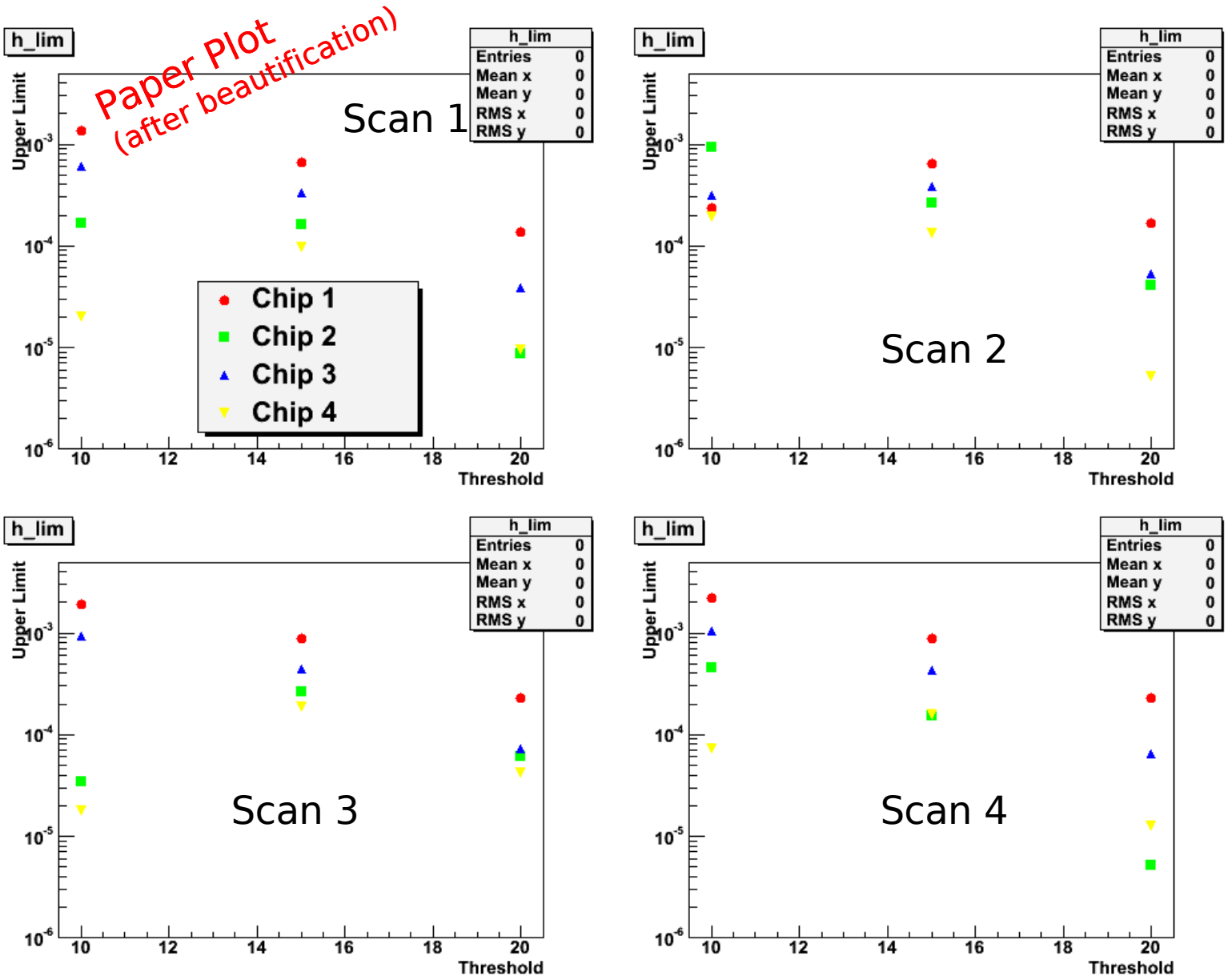




Outer

Shape of Signal and Background nearly identical

Gaussian Background
Upper Limits from Central Impacts – "Positive" Hits



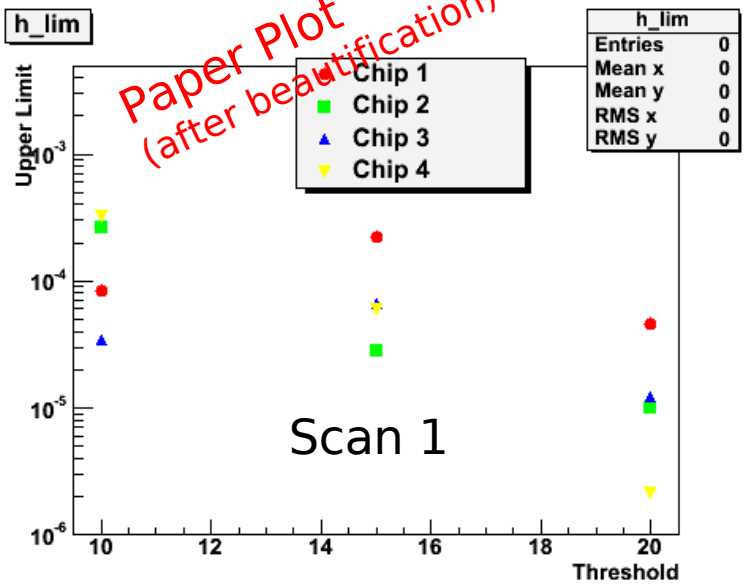
- 95% Confidence Limits
  Upper Limit < 1.5×10^{-3}
  for threshold ≈ ¼ MIP
  Upper Limit < 2×10^{-4}
  for threshold ≈ 0.4 MIP

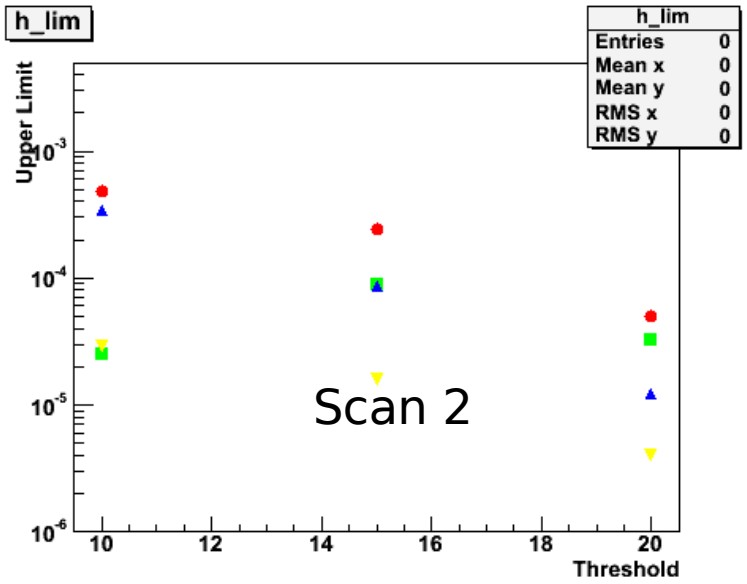
- Limits depend on thresholds

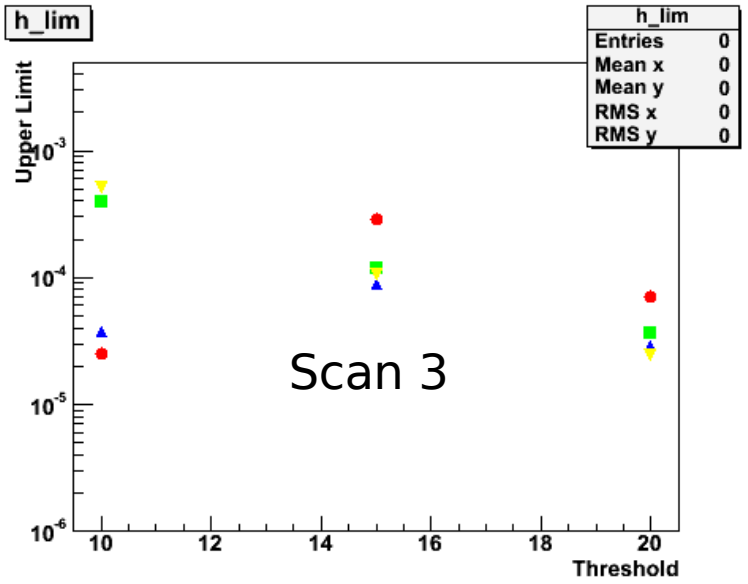
- Convolution of Detector effects and Parasitic Hits
  Currents from imperfect grounding
  of special PCB and entire detector
  => residual baseline shifts

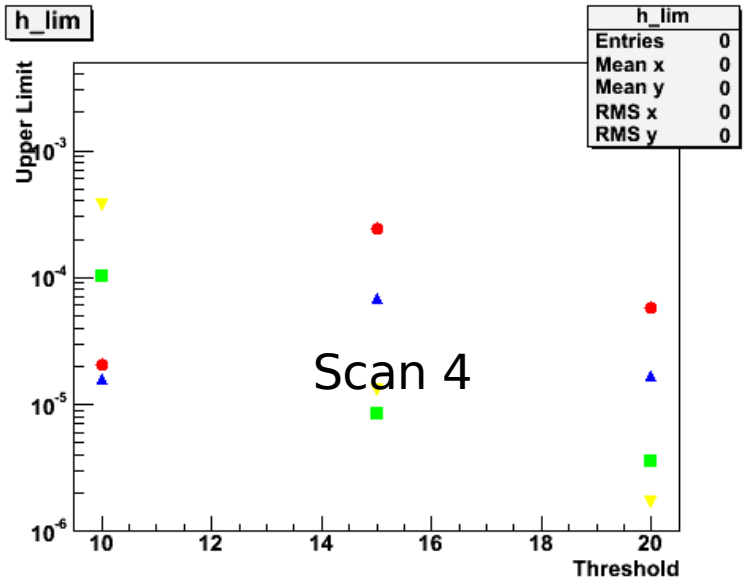
- Very slight tendency that
  Chips reach maximum upper limit when scanned over

Gaussian Background
Upper Limits from Central Impacts – “Negative” Hits









- 95% Confidence Limits
  Upper Limit < 10^{-3}
  for threshold ≈ -¼ MIP
  Upper Limit < 10^{-4}
  for threshold ≈ 0.4 MIP

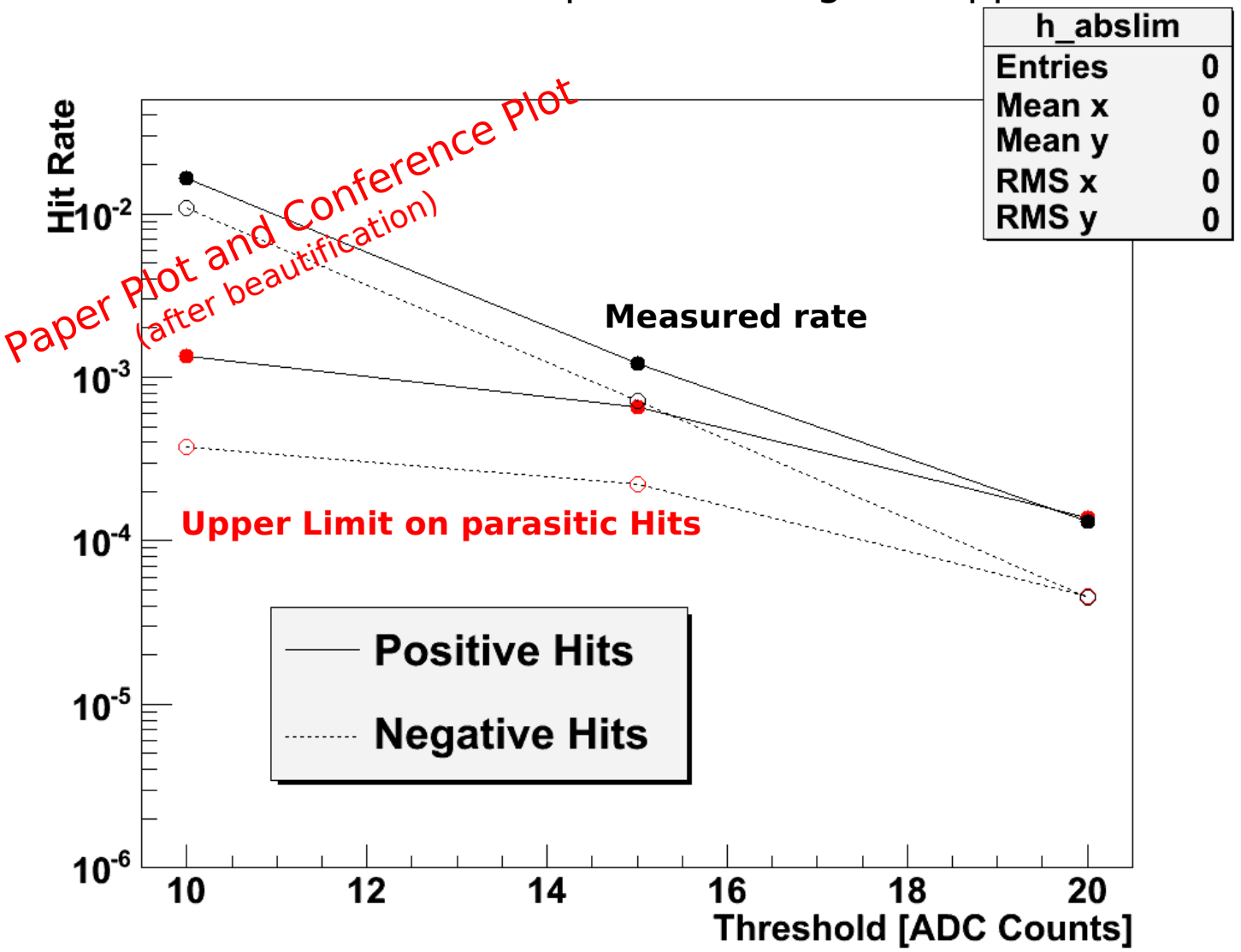
- Limits dependent on thresholds

- Convolution of Detector effects and Parasitic Hits
  Currents from imperfect grounding of special PCB and entire detector <=> residual baseline shifts

- Upper Limits on average smaller than for positive Hits
  Signal Events lead preferrably to positive ADC Counts

“Absolute Upper Limits”

At each threshold the scanned chip with the highest upper limit delivers entry



Compare with MIP ≈ 45 ADC Counts
Effect cannot be excluded but order of magnitude smaller than noise rate
One cell out of thousand might carry additional 10-15 ADC Counts

Summary, Conclusion and Outlook

- No signals above 1 MIP observed

- Upper limit on finding signals with > 0.4 MIPS < 2×10^{-4}

- Influence of shower on noise distributions cannot entirely be excluded

Noise distribution is shifted towards positive values

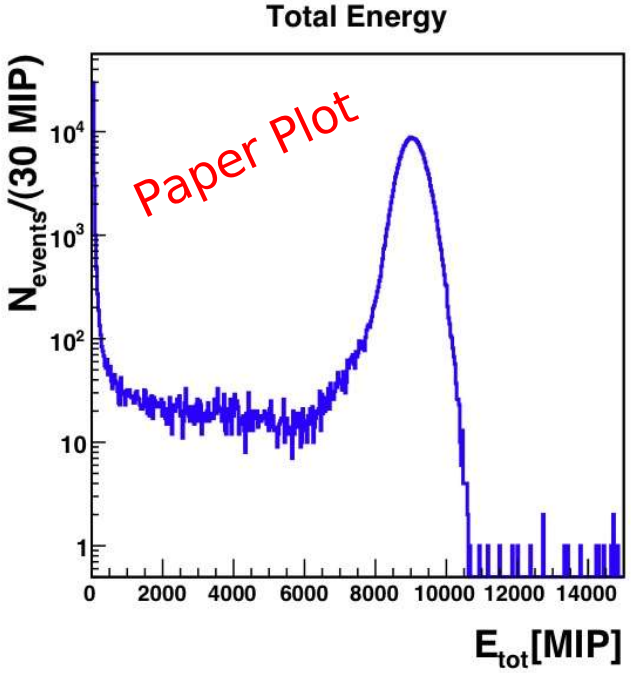
Whatever it is, the influence can be neglected for all practical purposes!!!!

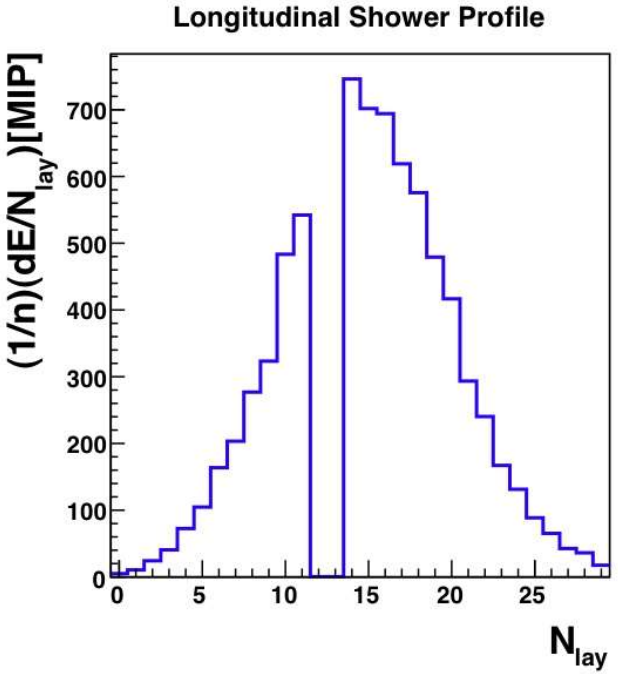
- Observed 'effects' however influenced by details of detector behaviour

Further insight could only be gained by detailed modelling of detector effects on noise distributions (at least very challenging!!!)

Backup Slides

Basic Spectra and Alignment

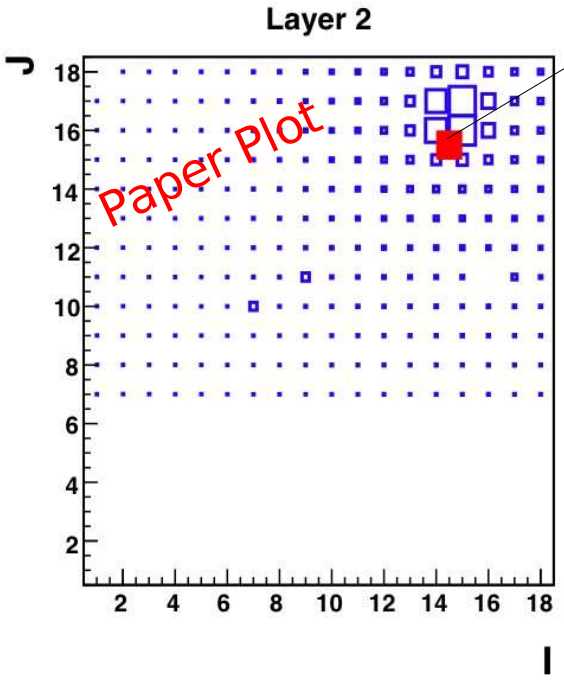


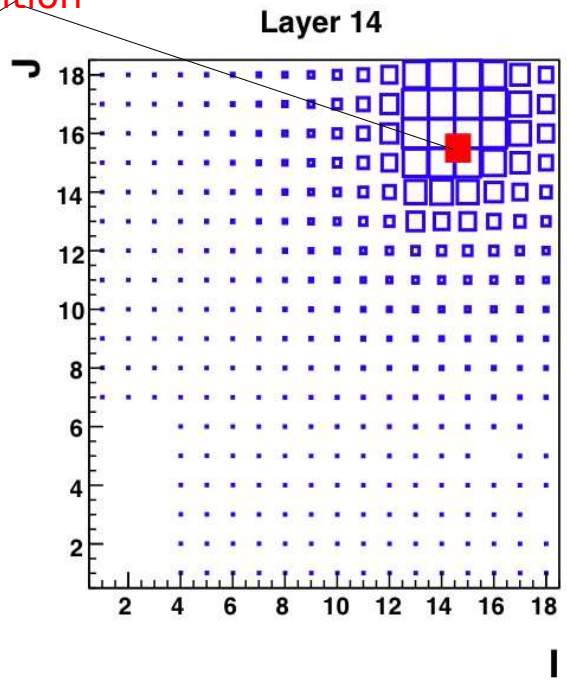


90 GeV run (331495)

- Clear Energy Peak
- Special Board place at ~ 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