Efficiency and purity simulations

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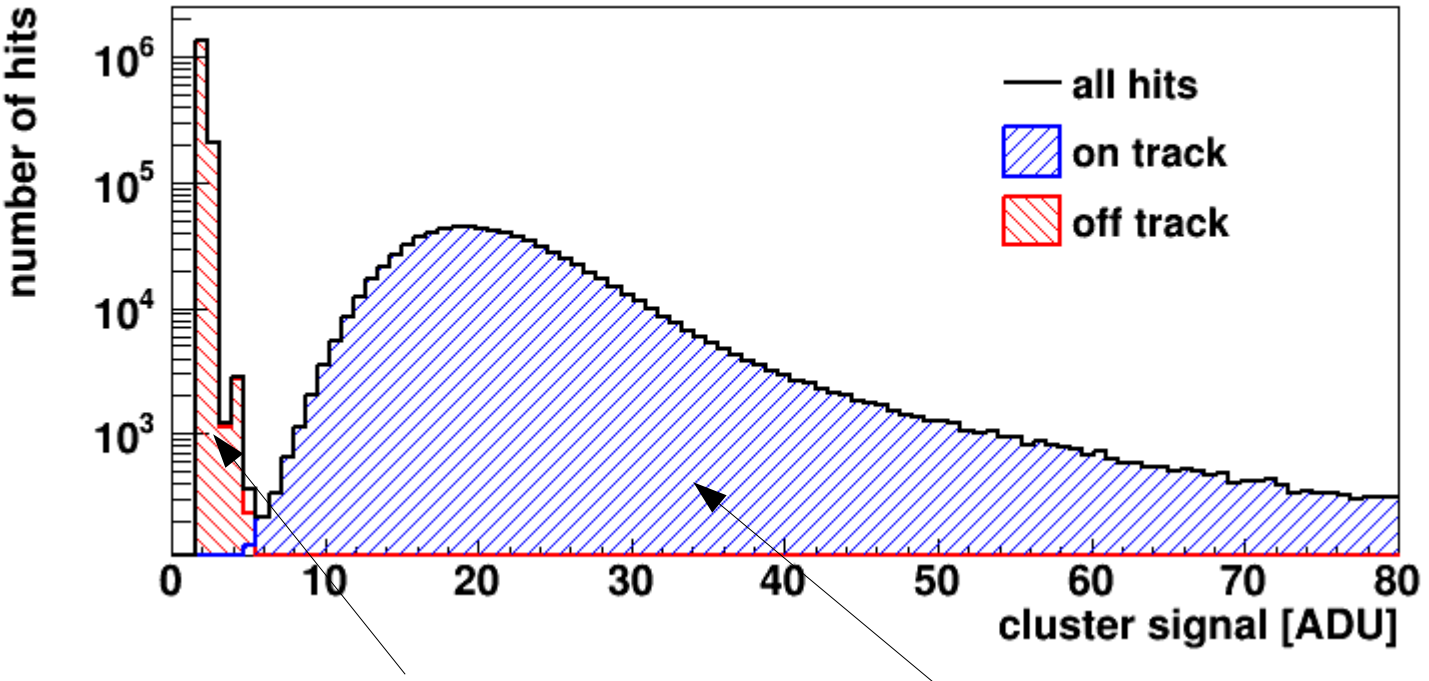
Overview / Questions

- Q: What is the largest useful zero suppression threshold?
  - High hit efficiency (> 99%)
  - Low rate of noise hits
- Q: What is a usefull ADC gain setting for the DCD?
  - High gain: small noise (~100e), small LSB (180e), **but:** small dynamic range (20uA)
  - Low gain: bigger range (30uA), **but** bigger LSB and more noise
- Q: How well can simulations (digitizer) model test beam data?
  - Summary of some relavant test beam measurements

Disentangle signal/noise in test beams

Simulated test beam setup: 3GeV electrons in pxd6 sensor

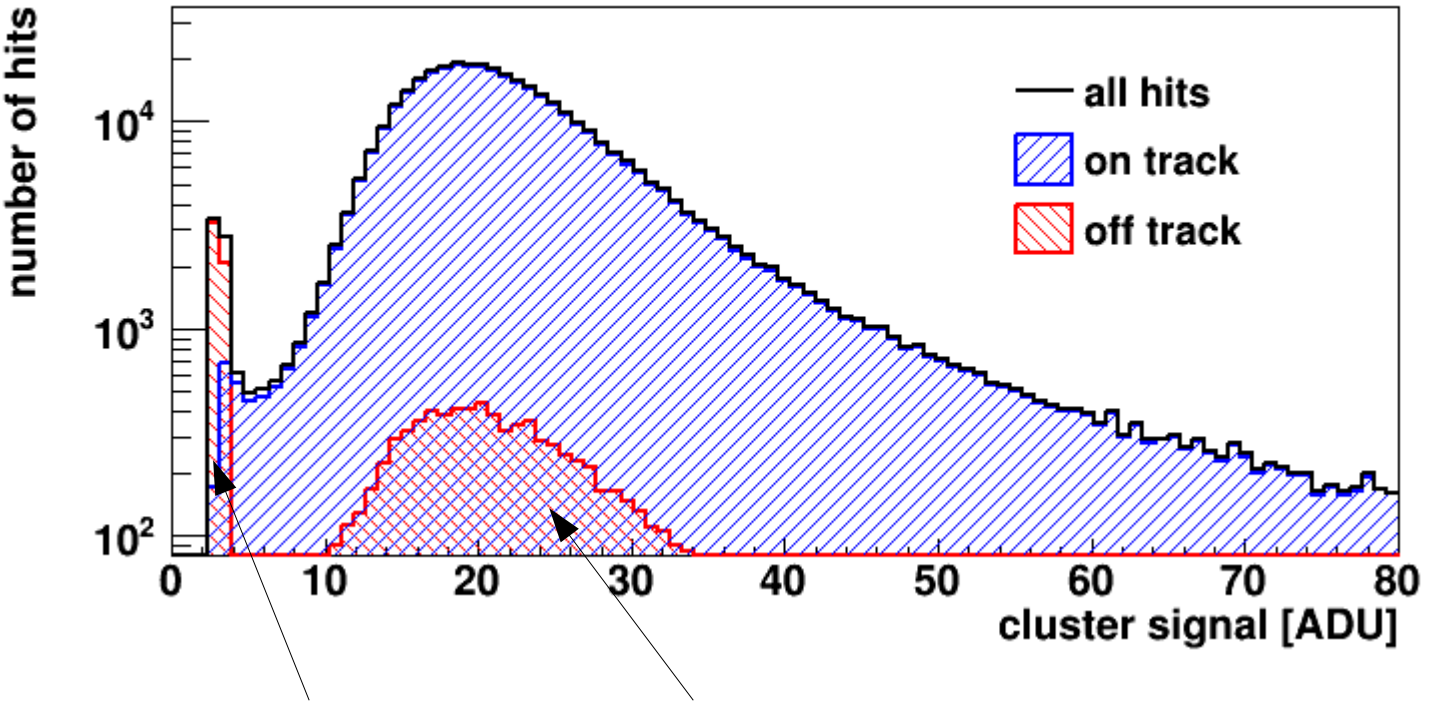


Hits (clusters) not matched to track (noise)

Hits matched to tel. track (true hits)

Disentangle signal/noise in test beams

Real test beam data from CERN 2012 (H4.1.15)



Off track hit
(noise clusters)

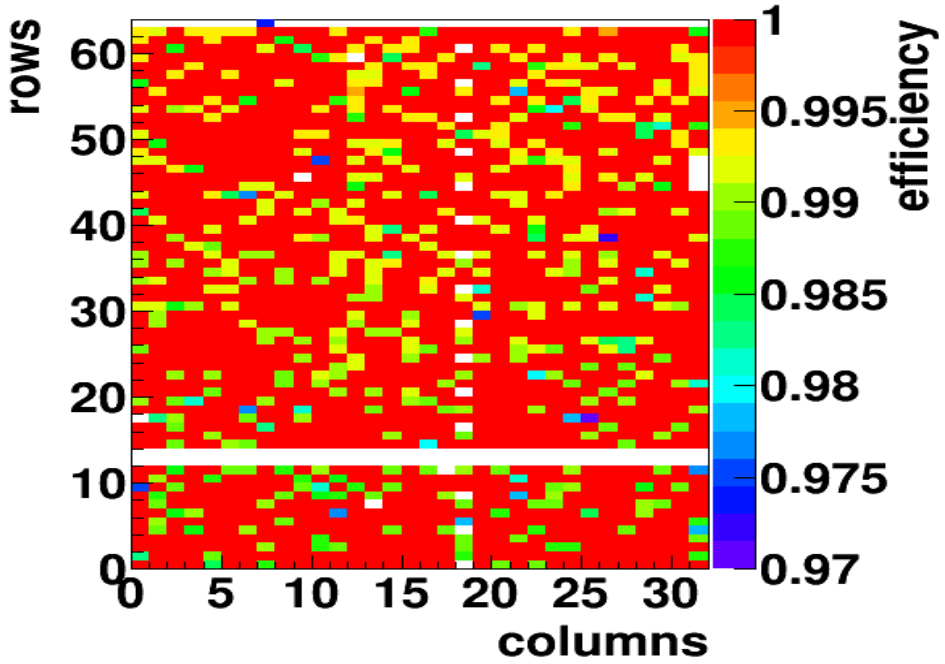
Off track hits
(probably signal but
tracking not fully efficient)

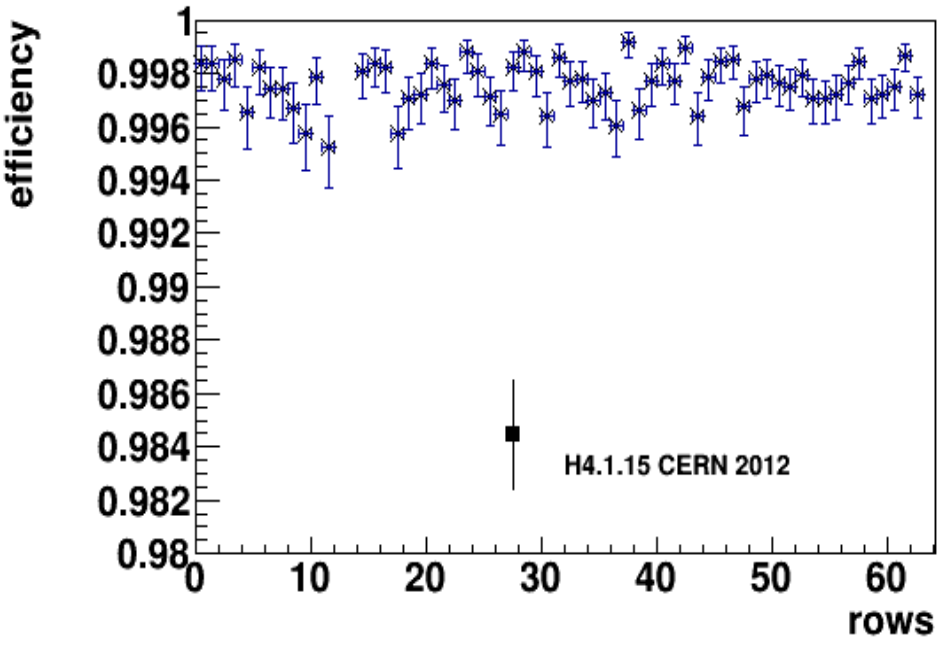
On track hits
(true hits)

Hit efficiency Hybrid 4

efficiency = #hits on track / # tracks

:- On track: ~100 microns around predicted tracks
:- Cluster Threshold > 3LSB
:- Consider only events with one track in telescope
:- Make sure track not on startgate

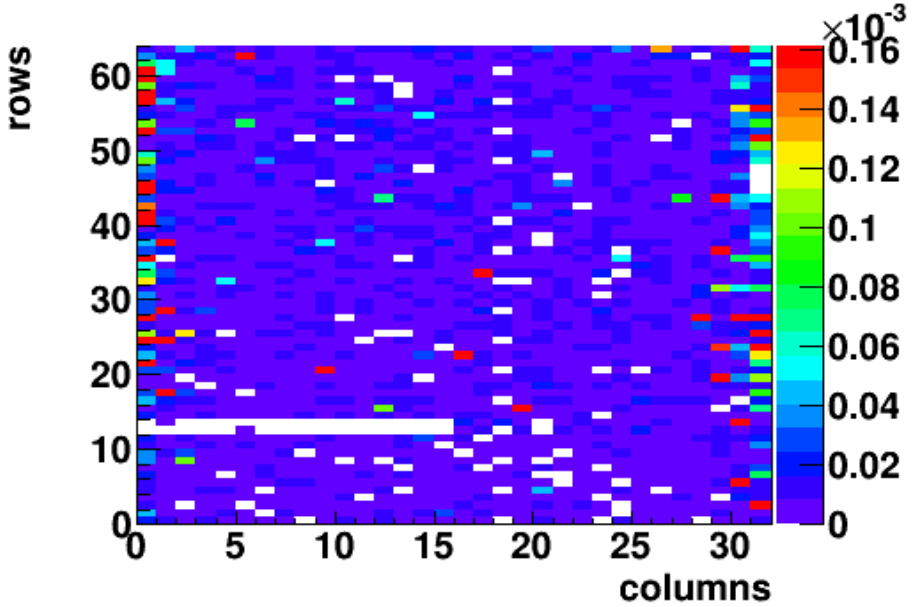


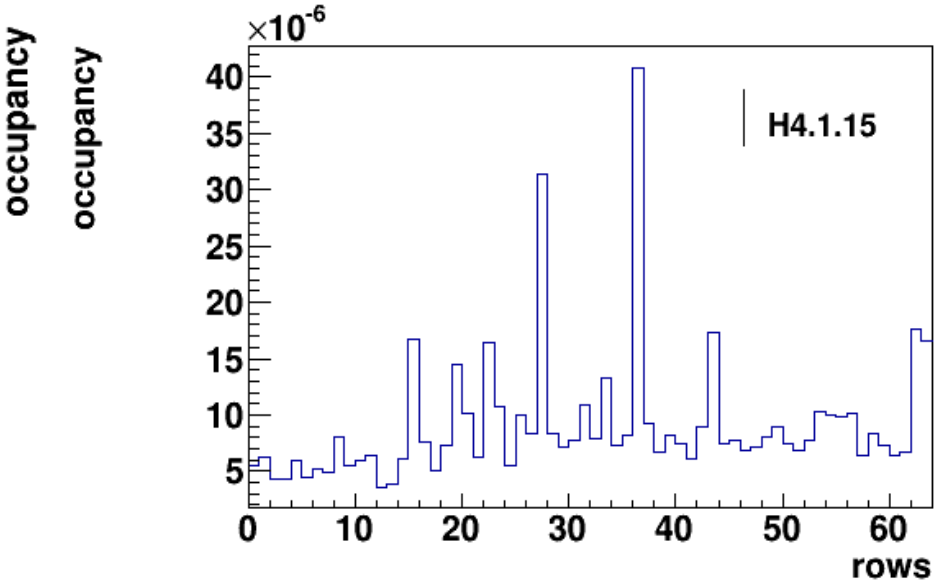


Occupancy Hybrid 4

Occupancy = #noise hits / # triggers

:- noise hits = cluster Threshold > 3LSB) far away from track
:- offline pedestal and common mode
:- mask noise channels (mostly columns 0,1,30,31)

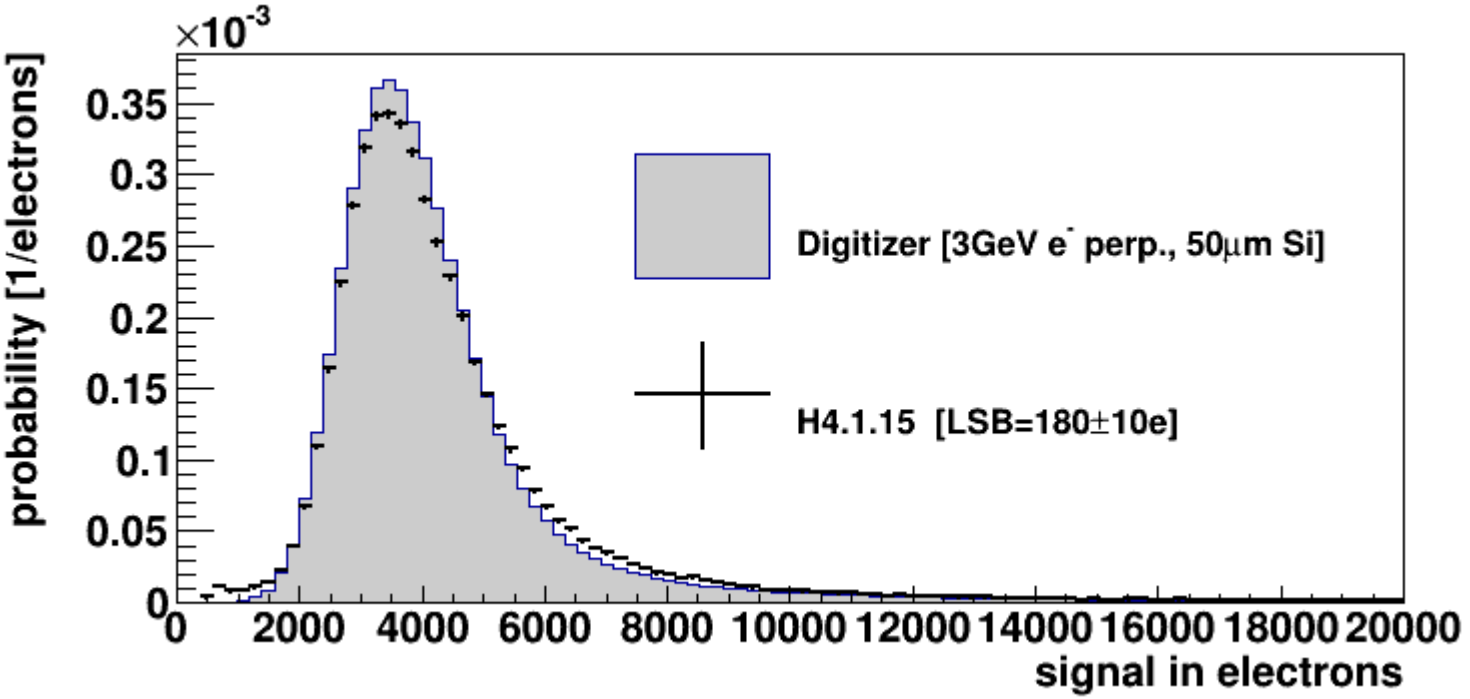




Signal Calibration Hybrid 4

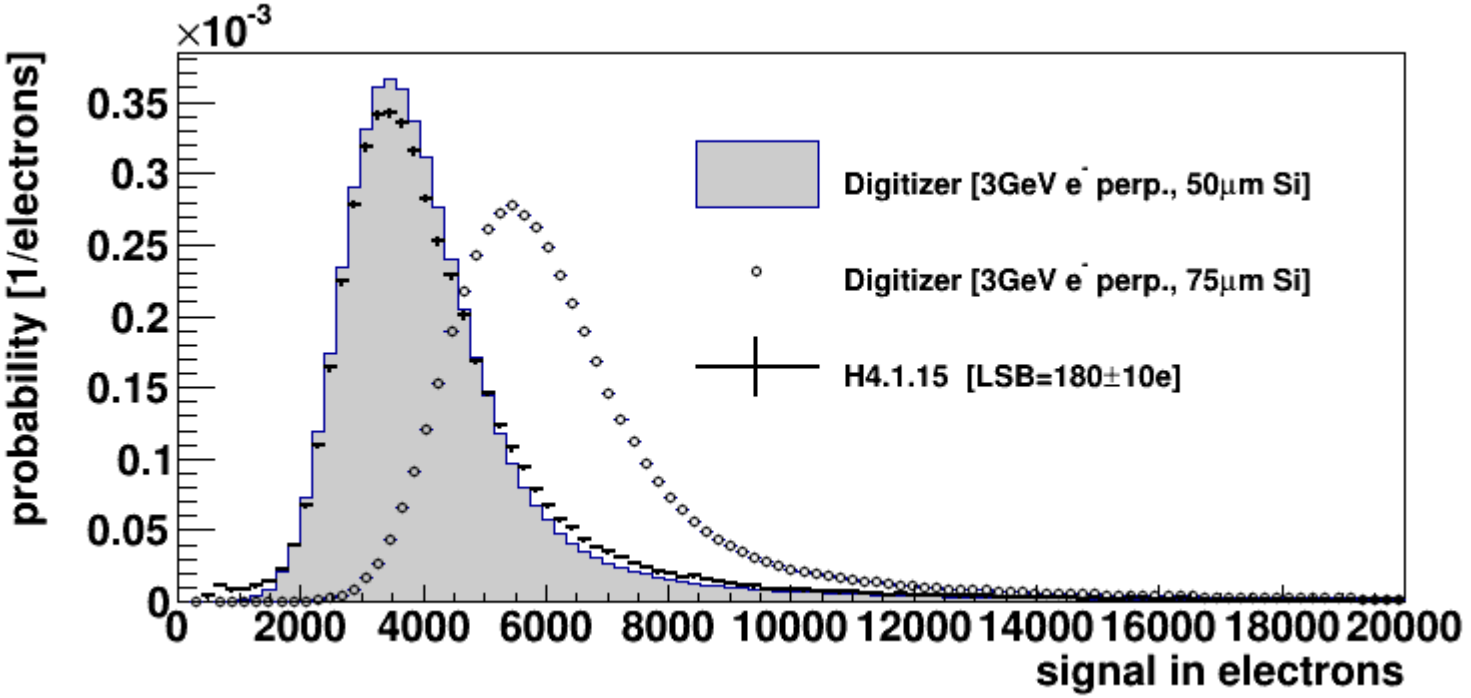
:- Using hits near a telescope track (signal cluster)
:- Compare with MIP charge deposit (Geant4 + charge sharing + …)

:- Gives a total gain: Gq x G_dcd → LSB == 180e



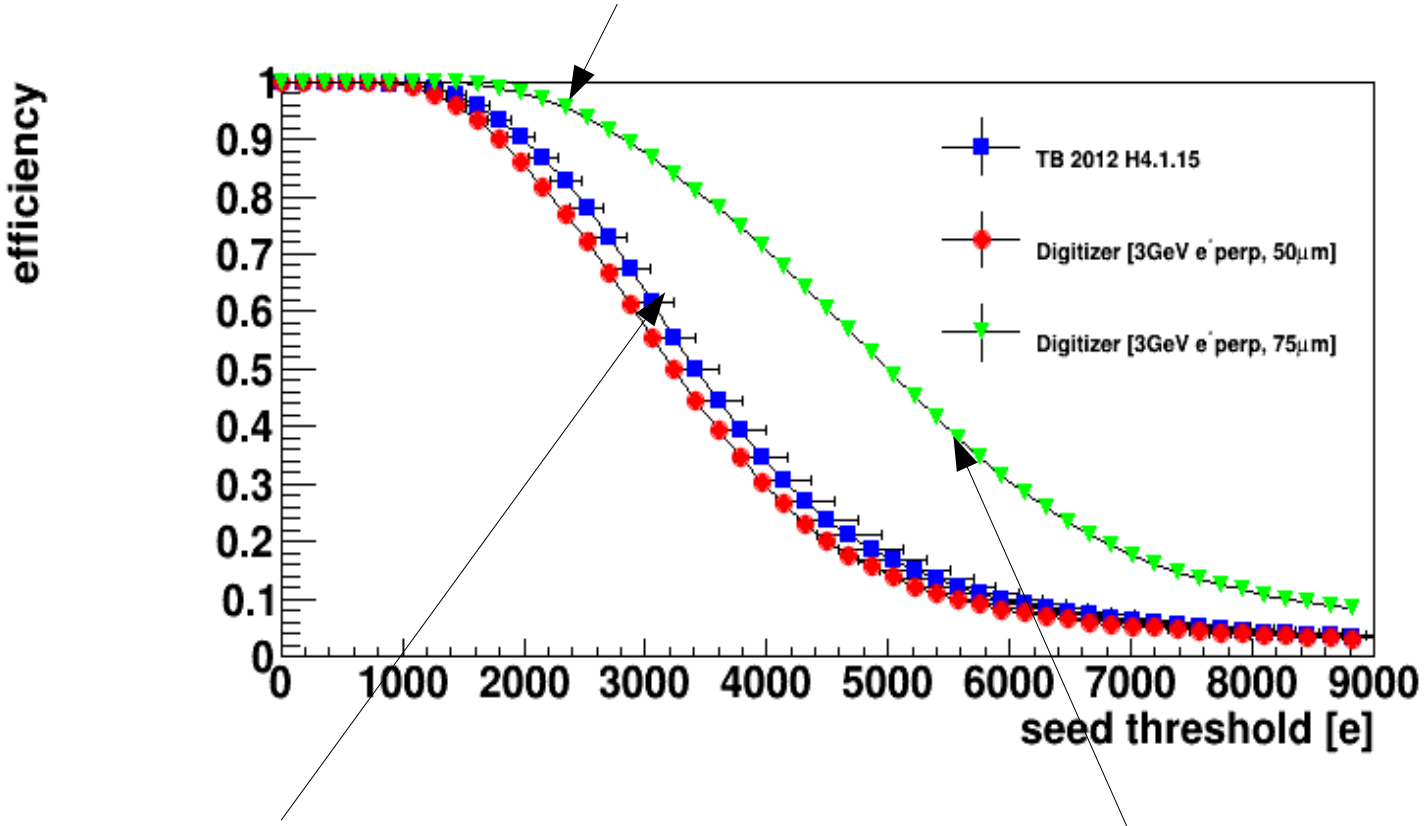
Extrapolate to PXD 9

:- 75x50 micron pixels on 75 micron thick silicon
:- perp. incidence of particles → worst case for efficiency
(MIP signal may be split between 2-3 pixels)



Efficiency vs seed charge threshold

PXD9: threshold of 2000e still ok.



Good agreement with simulation
for Hybrid 4 (50 micron thick)

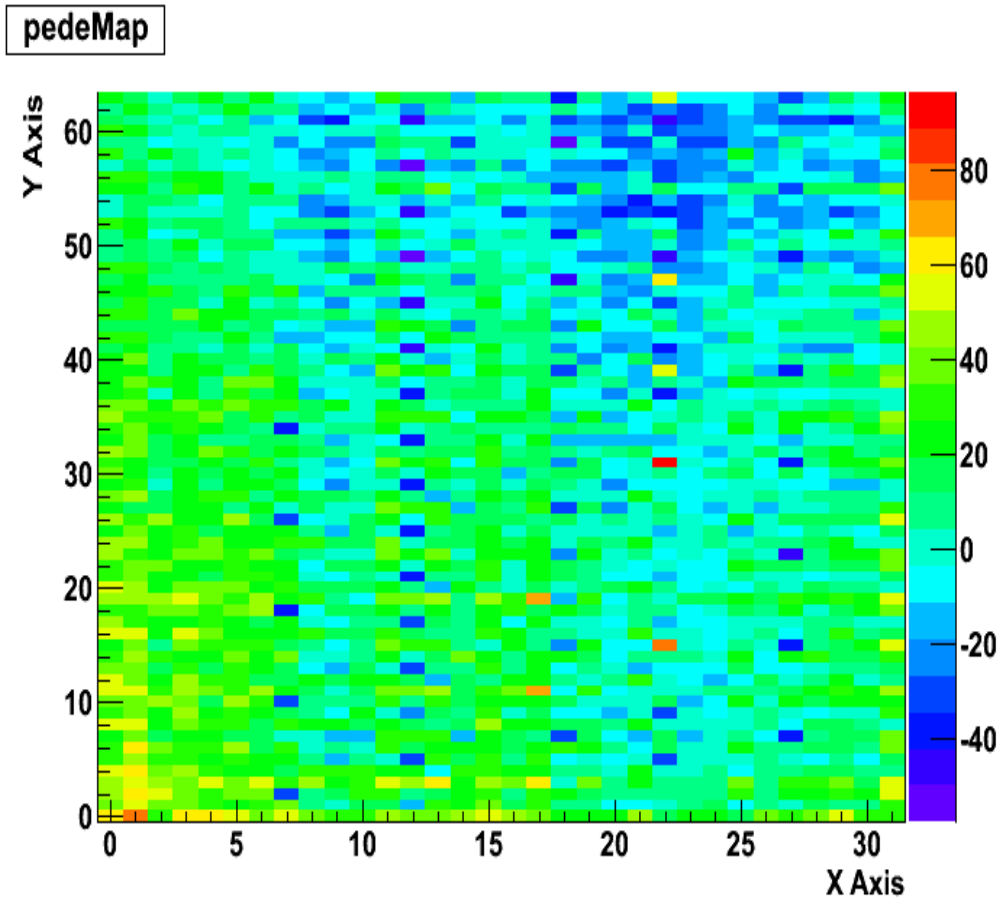
Extrapolation for PXD9
(75 micron thick)

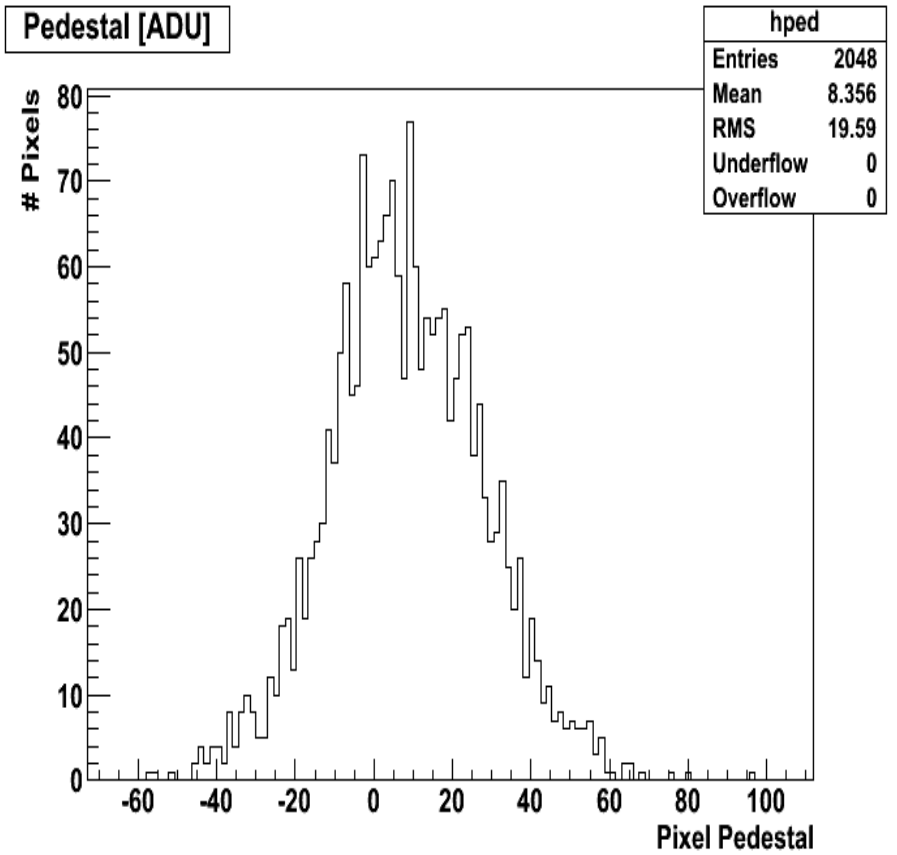
Summary

- So far: simulations do not account for ADC effects
  - Effects from integer pedestal and CM correction
  - Effects form integer setting of hit threshold
  - To be done for Seeon
  - But: So far no effect seen in DCD high gain operation
- Extend study to test beams with DHP
  - Consider occupancy vs. threshold
  - Consider efficiency vs. threshold

Backup Slides

Pedestals

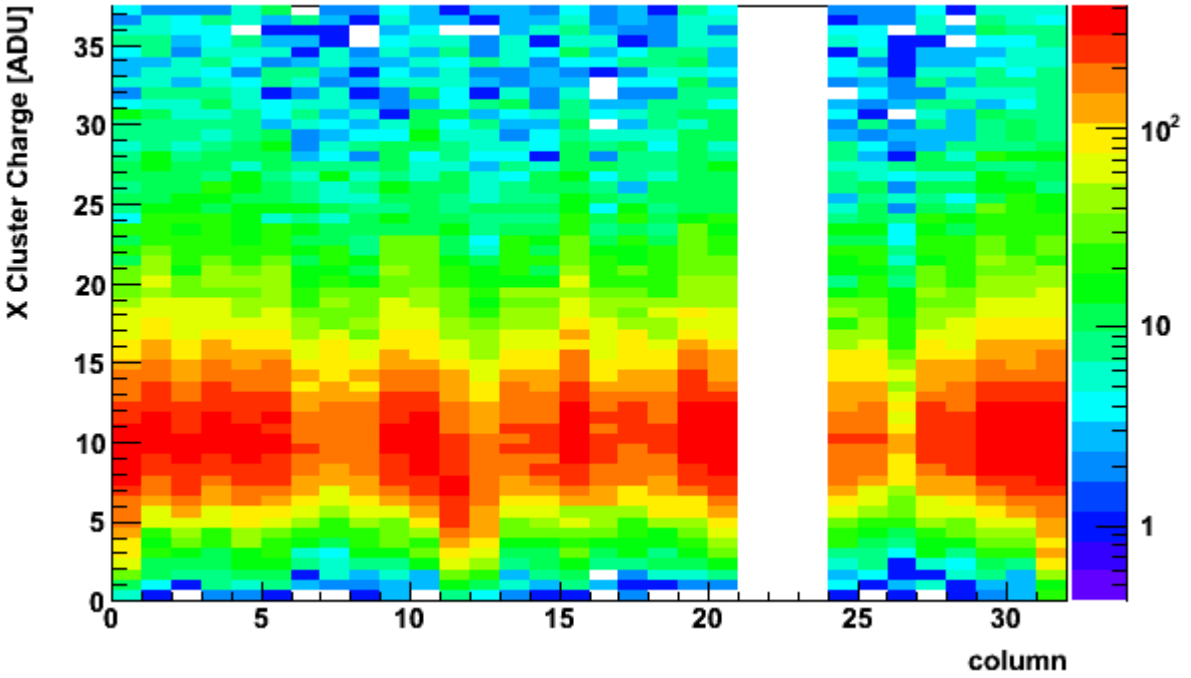


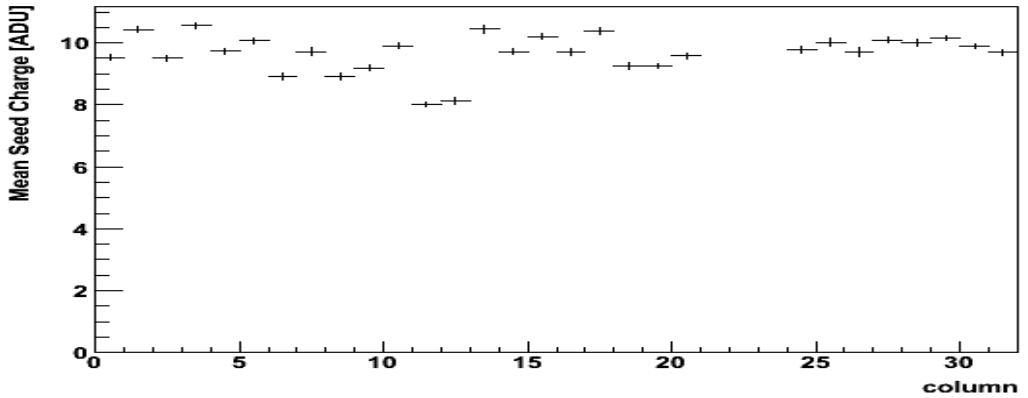


:- Variation der Pedestals nicht zufällig (Unbekannte Systematik)
:- Gradienten über die Sensor Fläche erkennbar.

:- Dynamischer Bereich -127,...,+128
:- Pedestals verbrauchen viel Messbreich
:- Small (32x64 pixels), nicht bestrahlt!!

Seed Signal Homogeneity



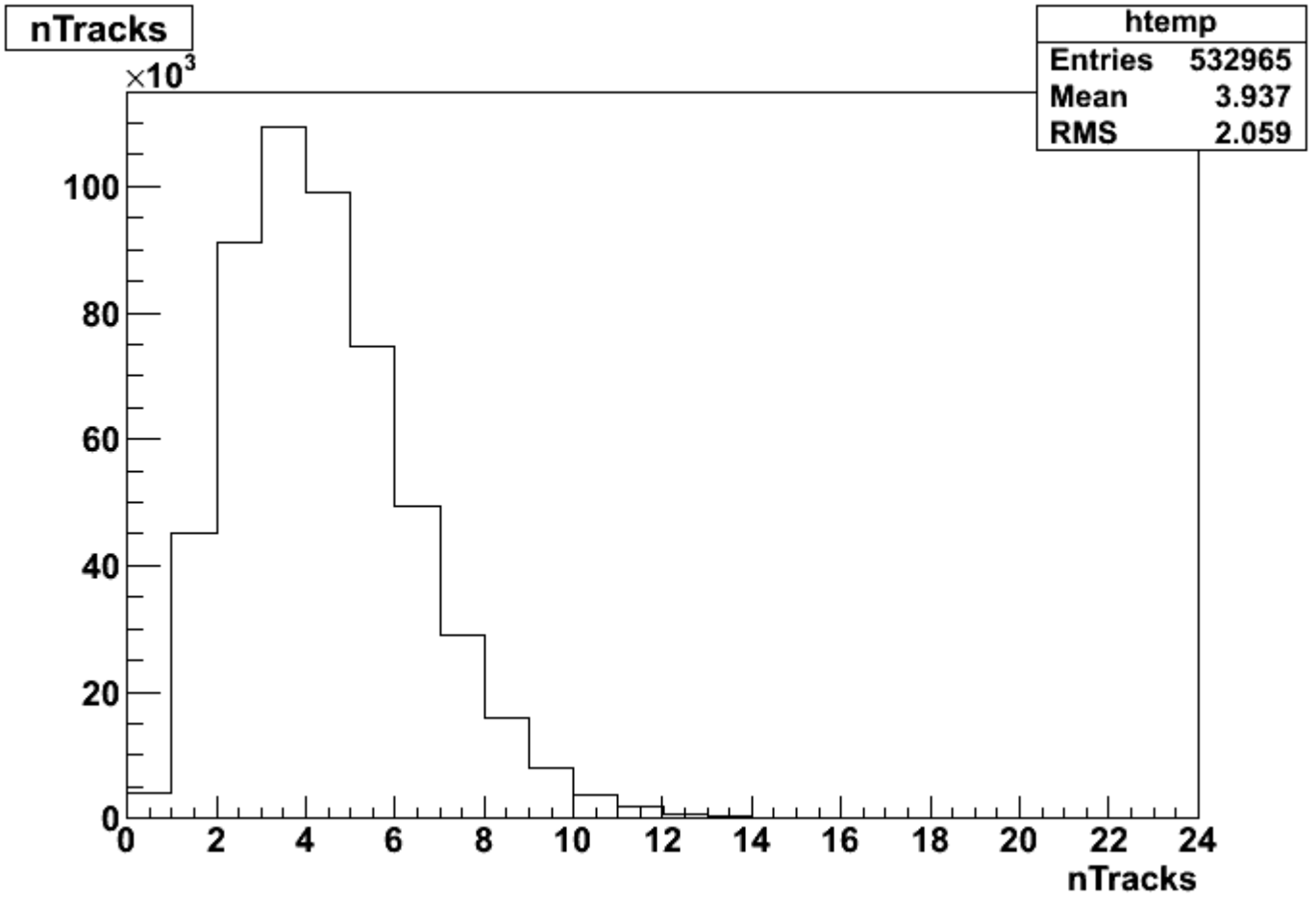


- Columns give more statistics.
- Rel. variations at level of ~ 10%.
- Pixel wise variations maybe larger.
- Little signal loss at border columns?

M26 Hit Efficiency

- M26 hit efficiency is eff > 92%. But lets assume eff = 92% for the moment.
- Naïve track efficiency for 6 hits
  - eff_trk = eff^6 = 60%
- Naïve track efficiency for min. 4 hits
  - eff_trk = eff^6+6*eff^5*(1-eff)+15*eff^4*(1-eff)^2
  - eff_trk = 99.1%
- That is good enough for us DEPFET hit effi measurment on 1% level.

Track Multiplicity Run1249



We have only 45k events with a single telescope track.
Deep cut in statistics :(