Simulation of thin DEPFET's
-
Validation using TB data

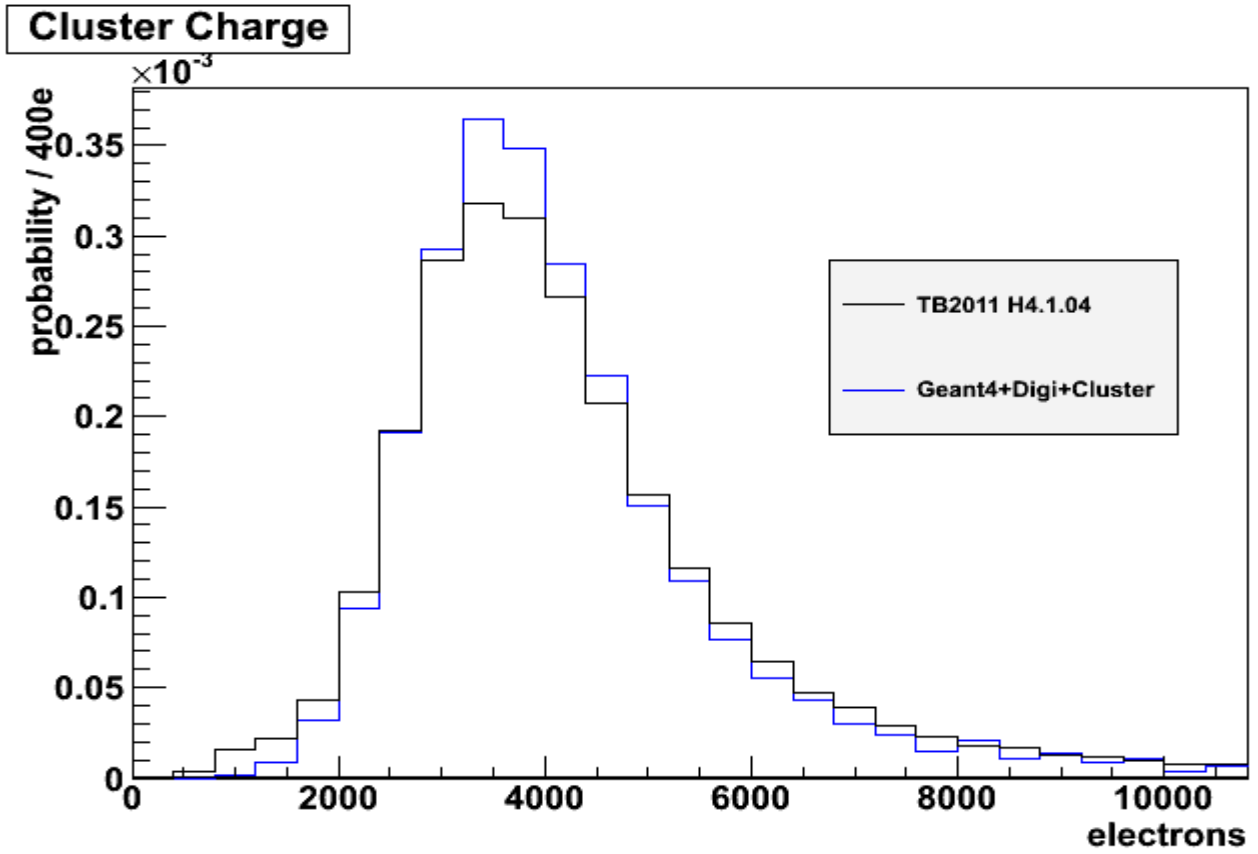
B. Schwenker
Universität Göttingen

Outline

- DEPFET simulation model:
  - Eloss inside active silicon (Geant4)
  - Collection of signal electrons
    - Drift and diffusion into internal gate
    - Taking into account Lorentz shift
    - Using inpixel potential (simplified!)
  - Electronic Noise & Simulation of 8bit ADC
- Test beam data helps to
  - Calibrate simulation: gq factor and noise in e-
  - Validate charge collection model
  - Answer question: Some effect missing? Biggest Uncertainty?

Signal Calibration Assumptions

- Charge collection:
  - We assume no losses in simulation
  - N electrons in bulk all collected in IG's
- Internal amplification:
  - Electrons (Q) to drain current (dI)
  - Need to know Gq [pA/e]
- ADC chip:
  - Drain current (Id) to ADC codes
  - Need to know LSB → ask Ivan
- We can estimate Gq fitting cluster charge spectrum of 120GeV pions to Geant4 spectrum.



120GeV pions in 50mu Si

H4.1.04 in TB2011:
LSB is 103nA

- Most probable signal 10 +/- 0.5 ADU (H4.1.04)
- Pixel noise is 0.5ADU
- **Gq is 0.29 +/ 0.01 nA/e**
- **Equivalent noise charge 180e-**

Parameter Overview H4.1.04 @ 100MHz

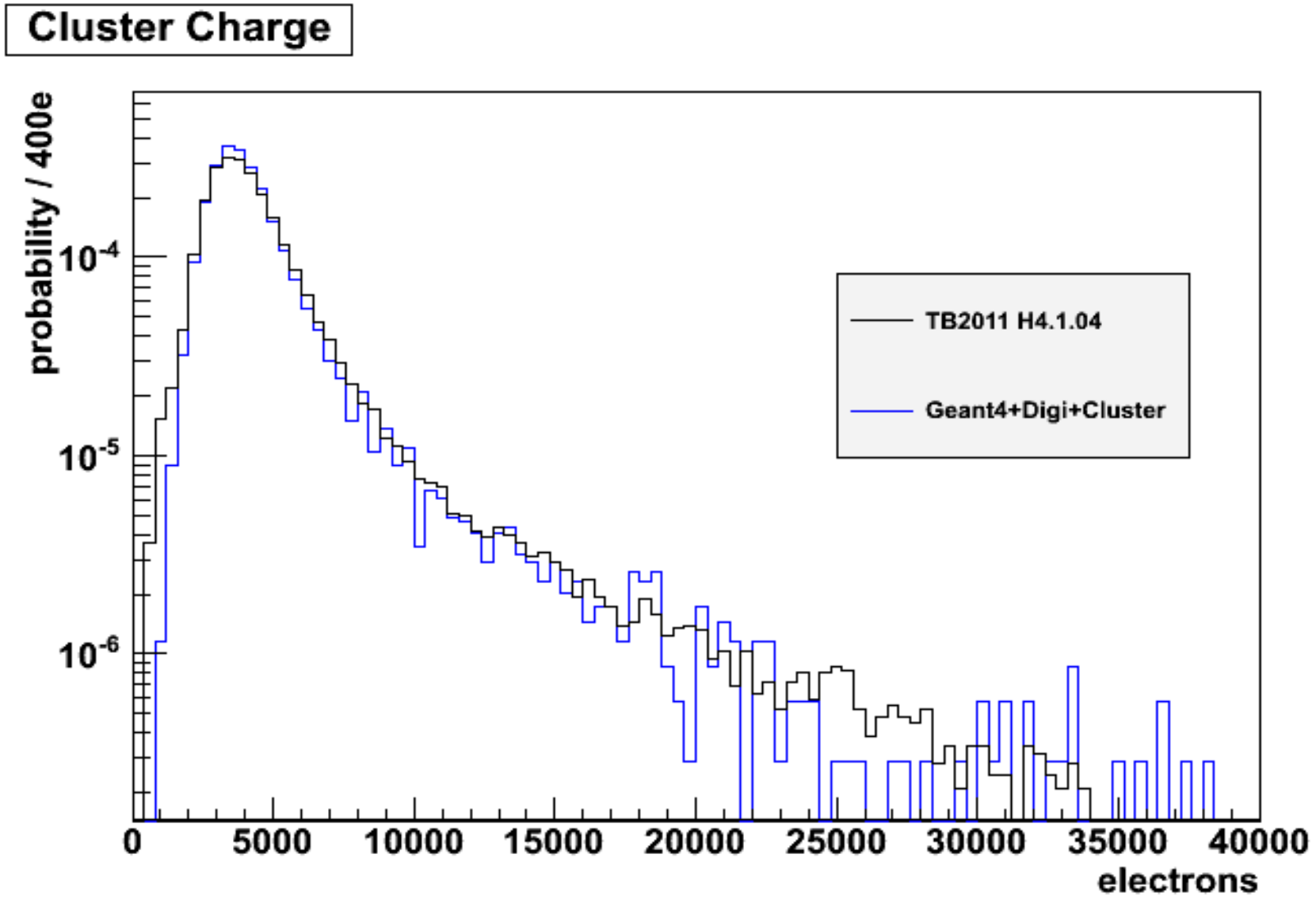
- 8bit ADC: LSB is 103nA
- Noise: 0.5ADU or 50nA
- Pedestals: 10ADU (Mean) and 20ADU (RMS)
  - ADC range is [-127,128]
  - Overflow: pixel signal > 117ADU
- Gq is 0.29nA/e-
  - Noise charge is 180e-
  - LSB is 360e-
  - Signal headroom without pedestals: [0e,92000e]
  - Signal headroom with pedestals: [0e,...,42000e]

Parameter Overview
Belle II scenario

- Some number well known:
  - DCD noise: 60,...,100nA [Ivan: DCDBv2 @ 300MHz]
  - Gq: 0.5nA [Rainer: Standard design, 5um gate length]
    - Equivalent noise 120,..,200e-
- Pedestal distribution is badly known
  - TB case can serve as a optimistic starting point
  - Dependence on matrix size, irradiations, etc.
- LSB can probably be optimized
  - For spatial resolution: LSB < 2xNoise
  - Other criteria (pattern recognition) ??

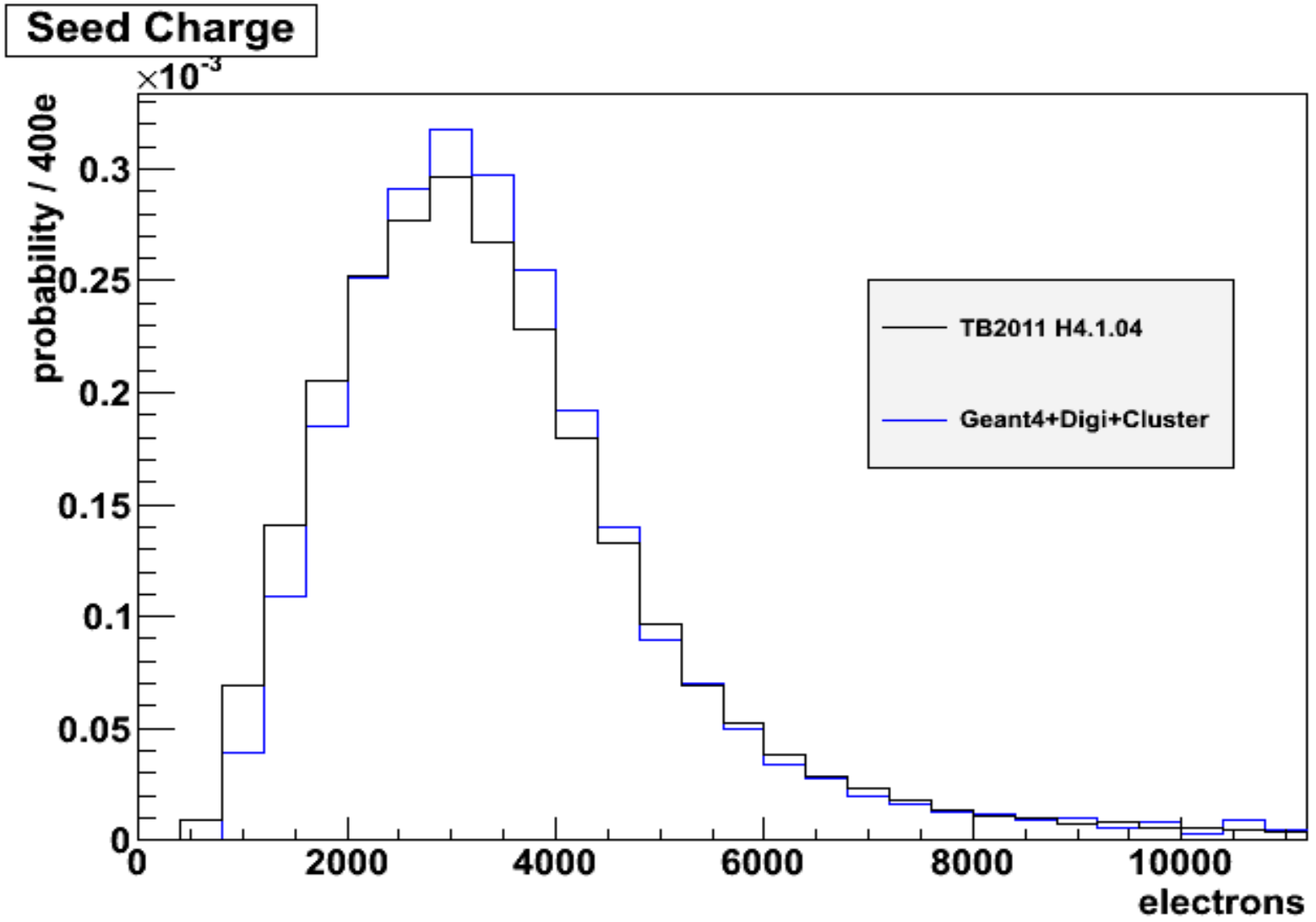
Simulation Setup

- 5 telescope modules
  - 20x20um^2 DEPFET's
  - Thickness is 50um
  - Z spacing is 10mm
- DUT module
  - Simulation of DEPFET H4.1.04
- Particle gun
  - 120GeV pions
  - vertex spread
  - normal incidence with angular spread as TB
- Reconstruction parallel to TB data
  - 3x3 clustering: Seed cut 4xNoise; Neighbor cut 2xNoise
  - Match DUT hits to tracks for analysis



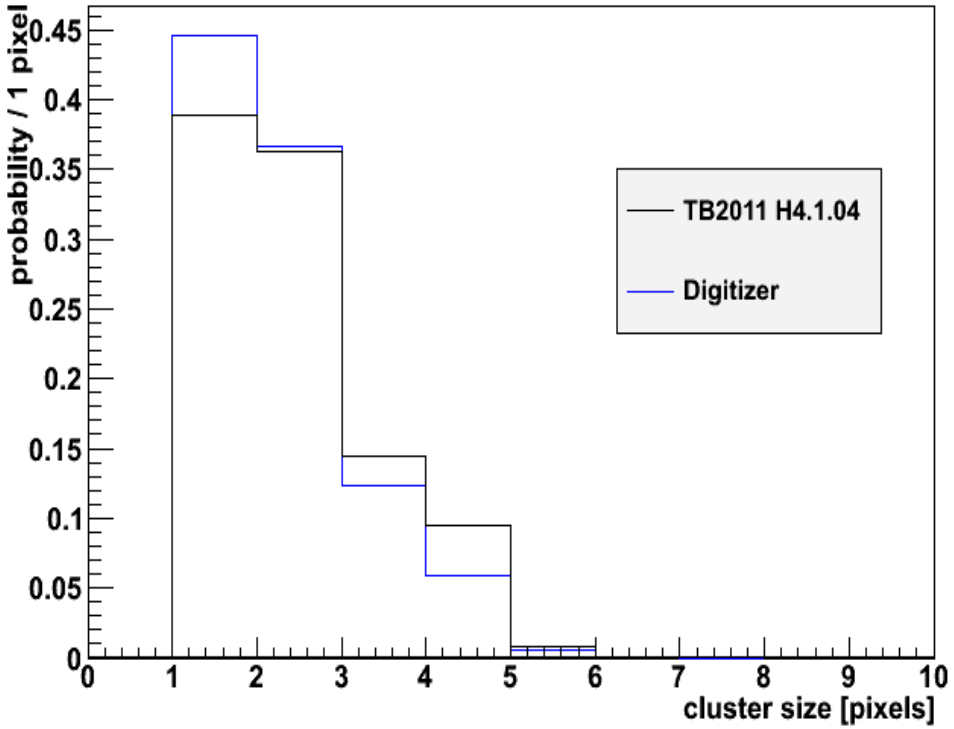
:- Nice Landau distributions

:- No overflow in TB data seen (as expected)

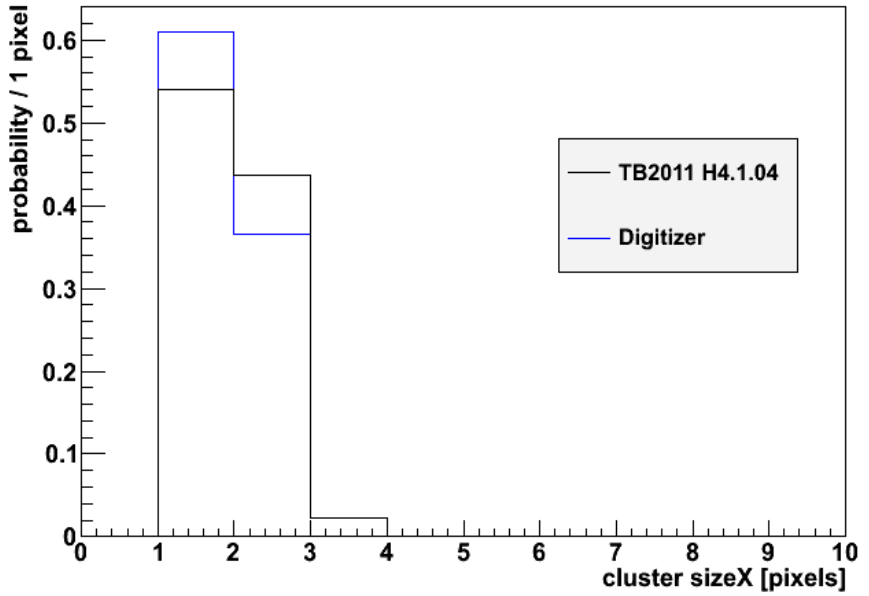


:- Good modeling of seed charge in Digitizer

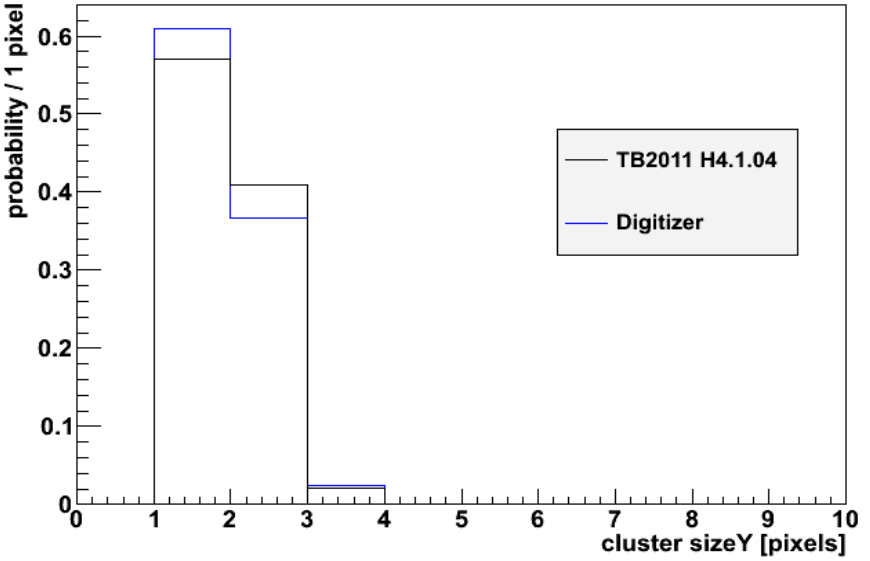
Cluster Size



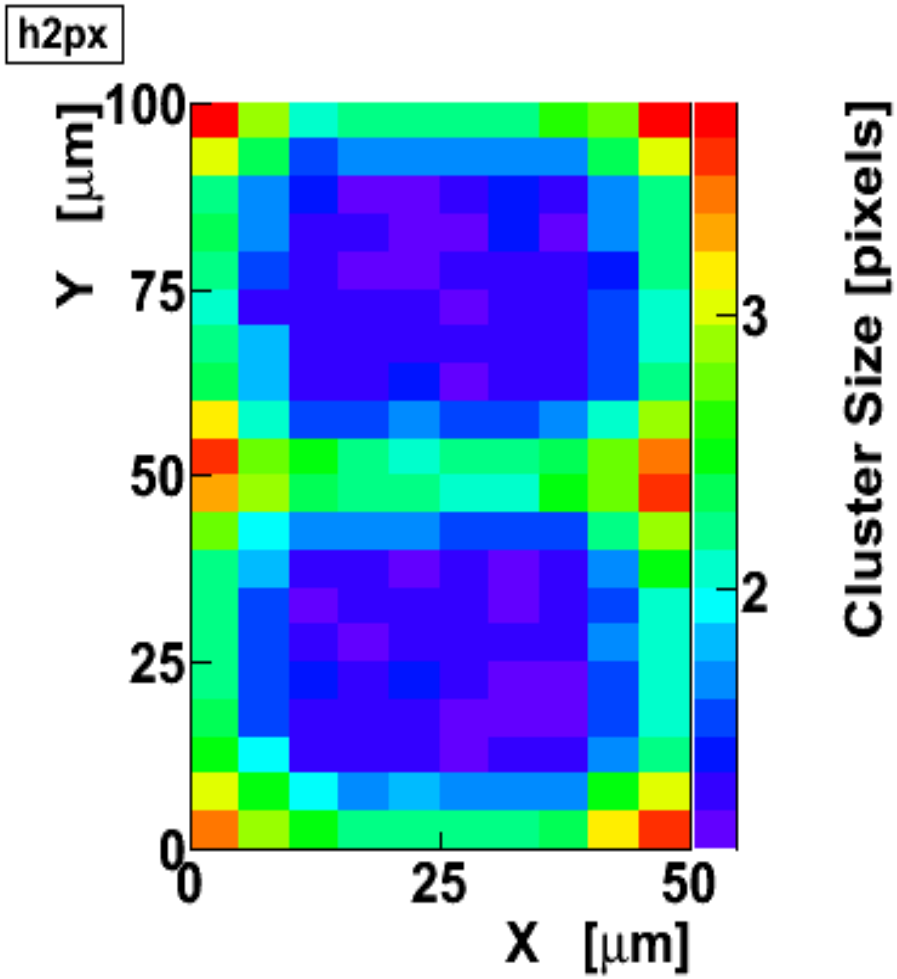
Cluster SizeX



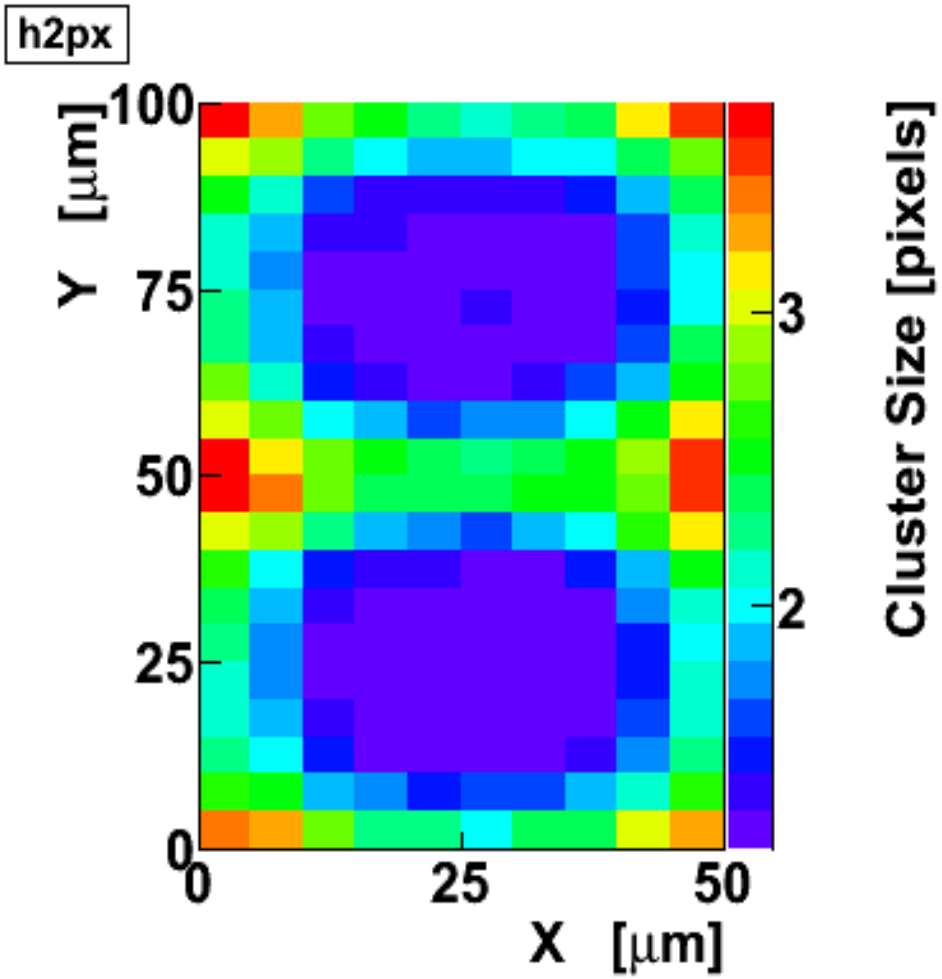
Cluster SizeY



Digitizer

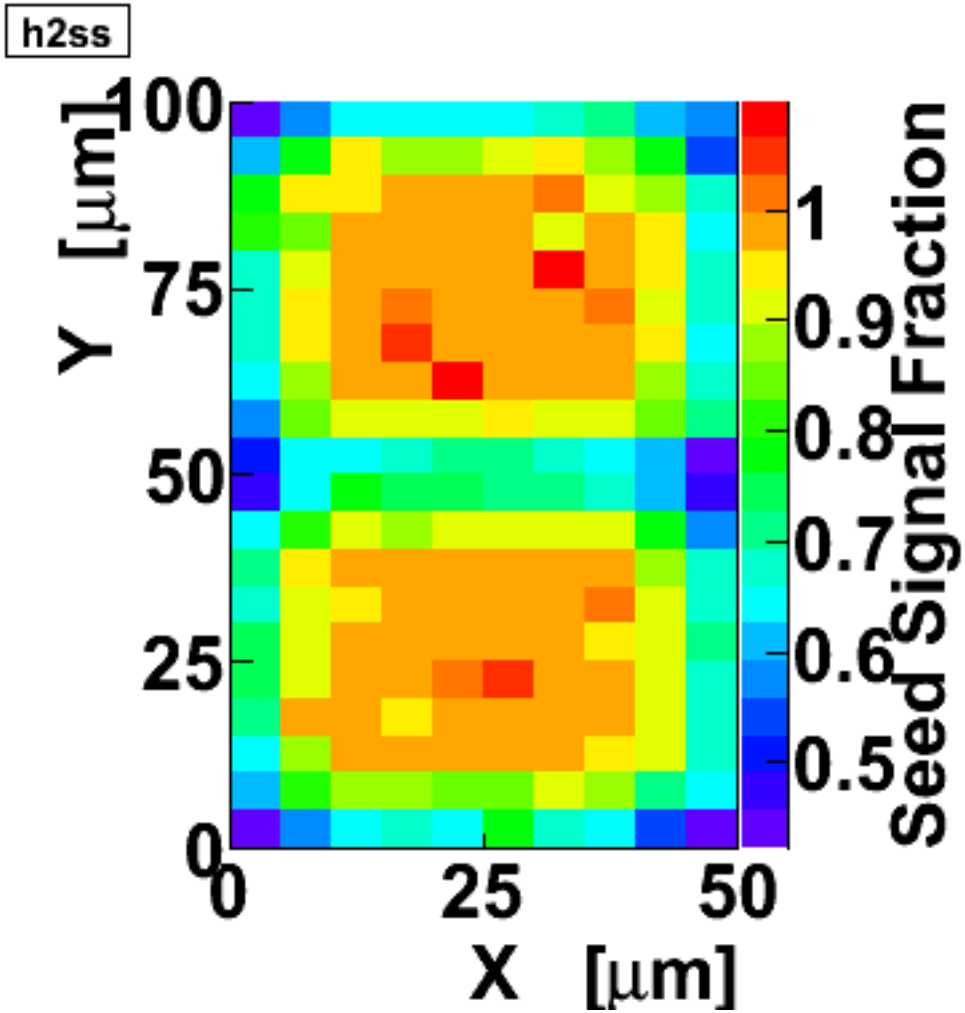


TB

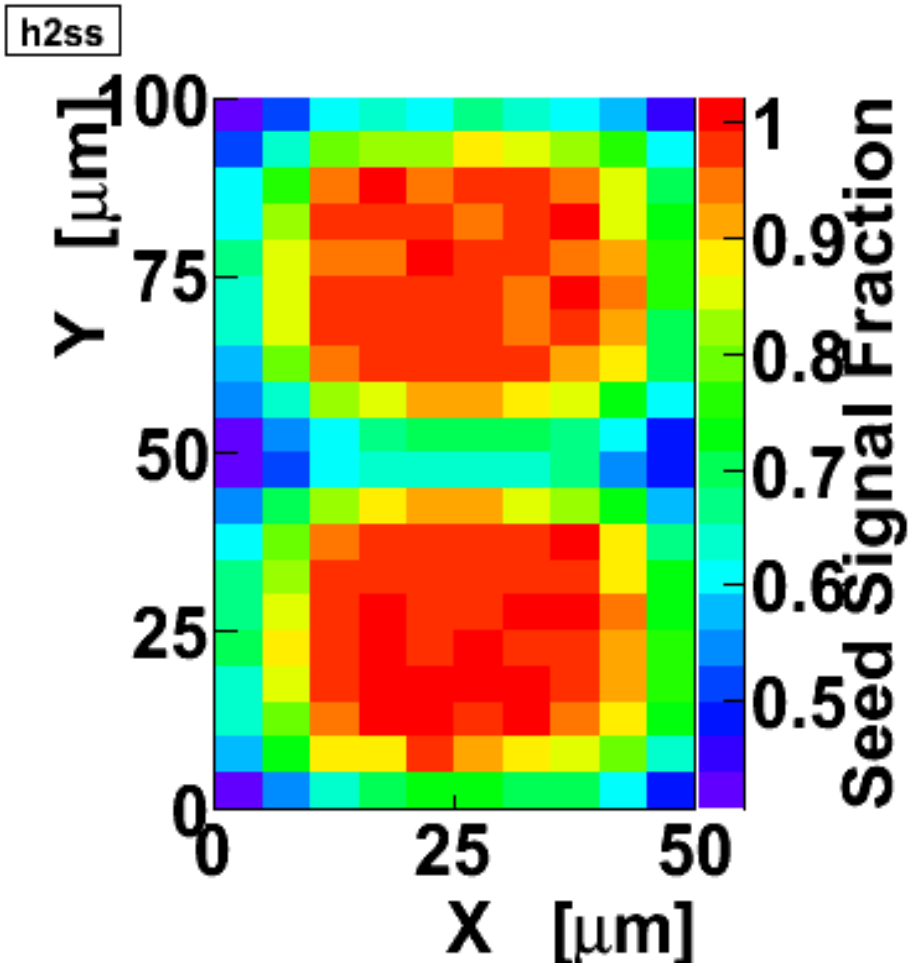


Seed Fraction = Seed Signal / Cluster Signal

Digitizer

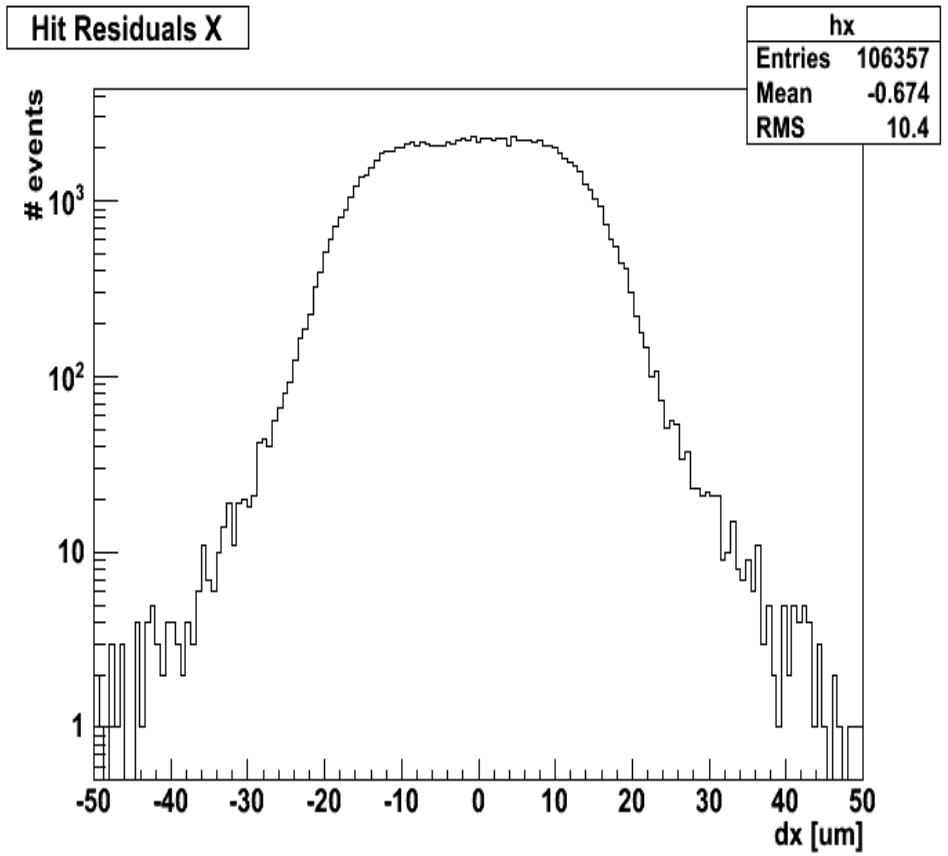


TB

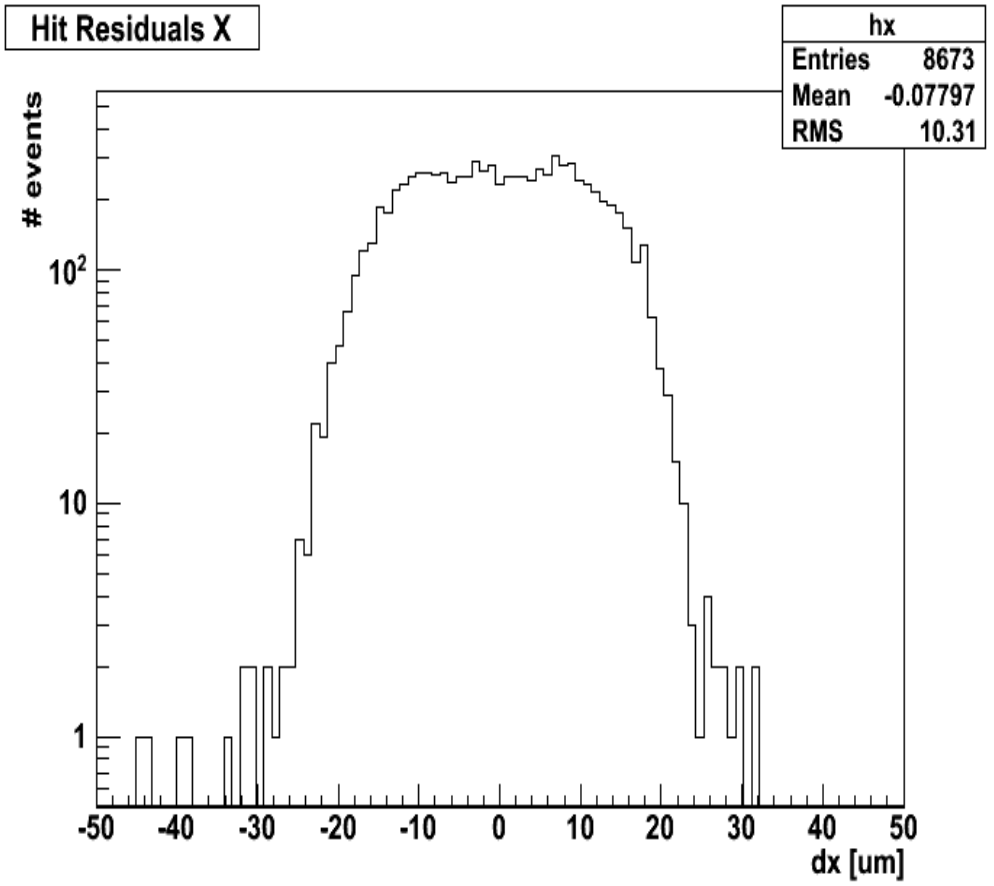


CoG Residuals

TB Data



Digitizer



Summary

- Charge collection model in Digitizer works well
  - This was known for thick DEPFET's
  - Now checked for thin devices
- Digitizer should always simulate 8bit ADC
  - Add simulation of Gaussian pedestals to Digitizer
  - Each pixel gets a specific signal headroom
- Least well known parameters
  - Shape of pedestals
  - Optimization of LSB
- ToDo: processing of angular scan data from test beam [0°,..,60°]
- Plan to integrate 3D potentials into digitizer simulation (Prag, Goettingen)