Test Beam Results and DEPFET Simulations

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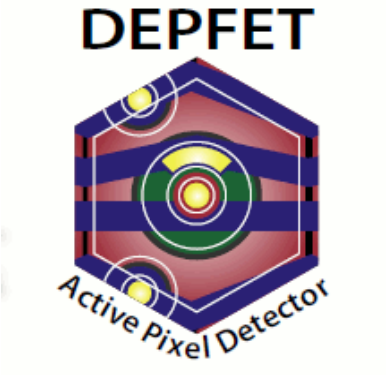
On behalf of the test beam crew



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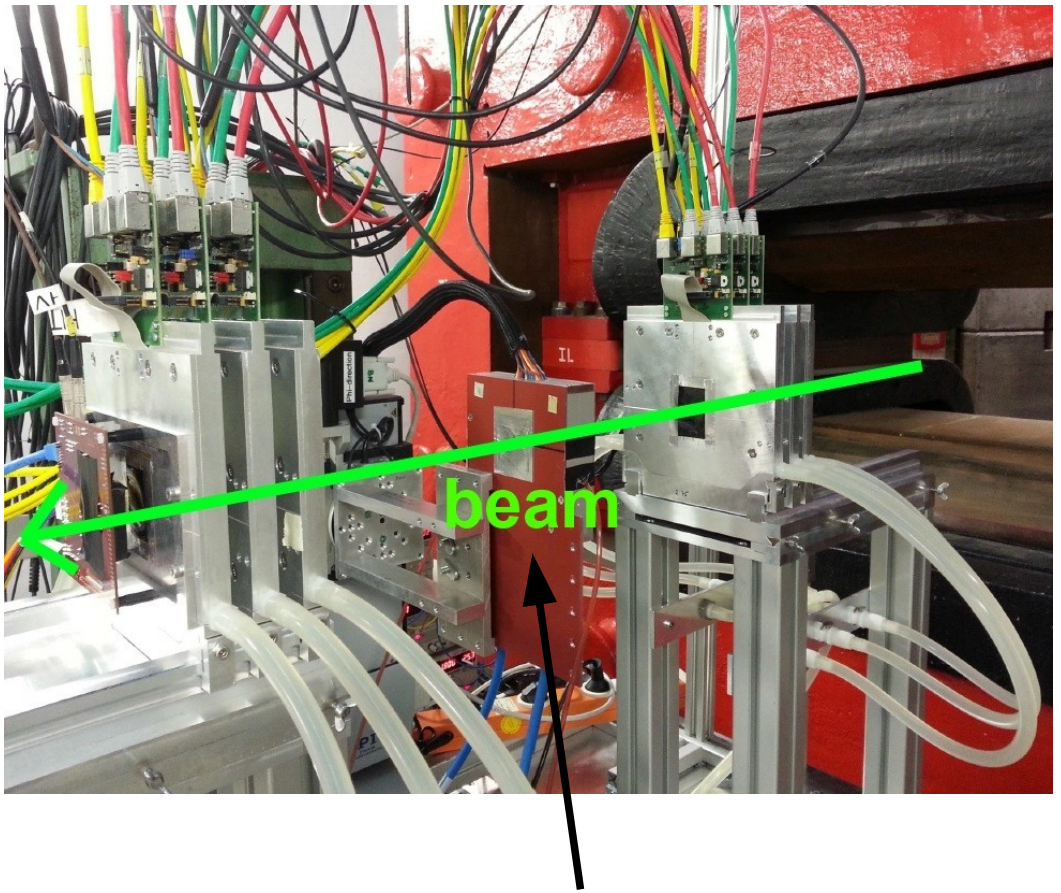
Outline

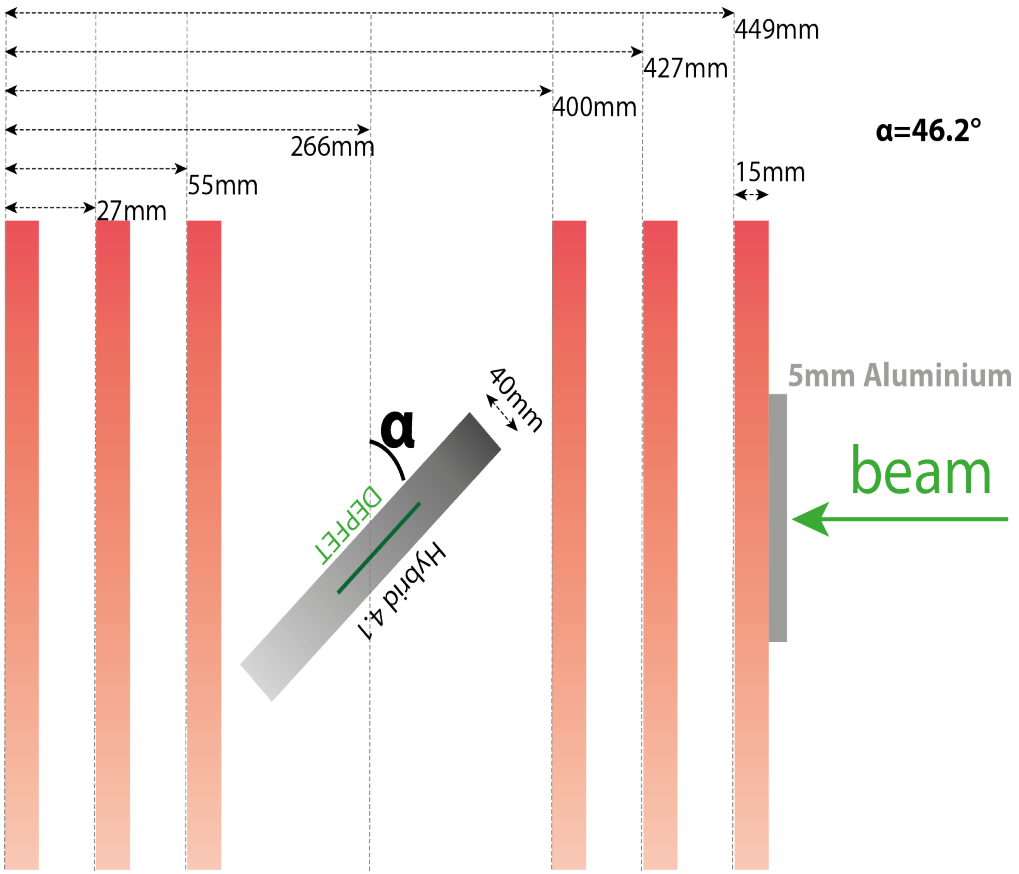
- Results from TB2013 at DESY
  - Focus on runs with Hybrid 4 STD sensors
  - Tilt scans at 100MHz (75um direction): 0, 46deg
  - First prelim. results from runs at 320MHz
- DEPFET resolution study using TB data
  - Spatial resultion vs. detector noise
  - 8bit analog signals vs. binary hits
- Simulation of spatial resolution @ ILC VTX

Overview of DESY TB

- Runs with Hybrid4.1.11 (PXD6 STD)
  - Normal incidence runs at 100MHz: ~1Mio hits total
  - Tilt scans at 100MHz in range 0...46°: 50k per angle
  - Normal incidence at 320MHz: ~1Mio hits total
  - Long pedestal run at 320Mhz without beam
- Runs with Hybrid5 system (PXD6 STD)
  - Threshold scans (DHH emulator && DHH/Onsen)
  - Beam energy scan (1-6GeV)
  - High rate (~4kHz) runs of ONSEN/DHH

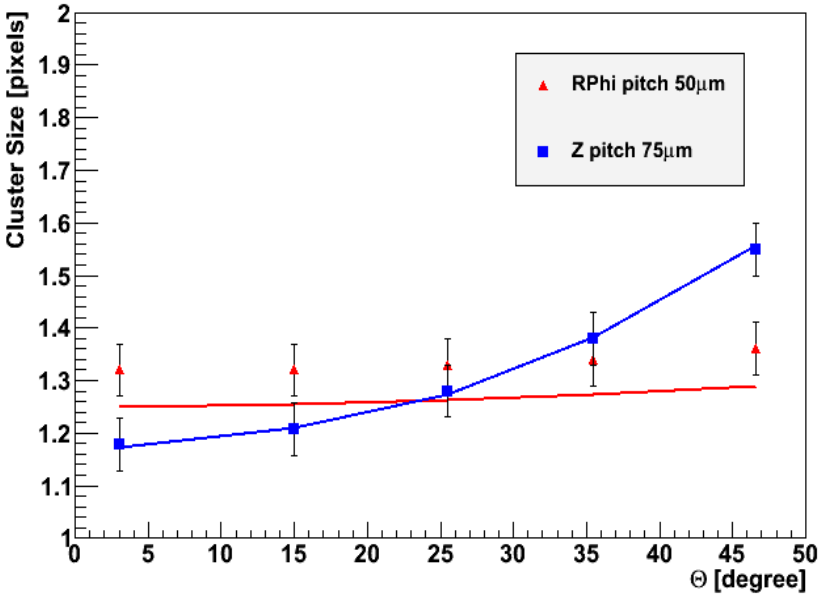


Tilt scan results at DESY

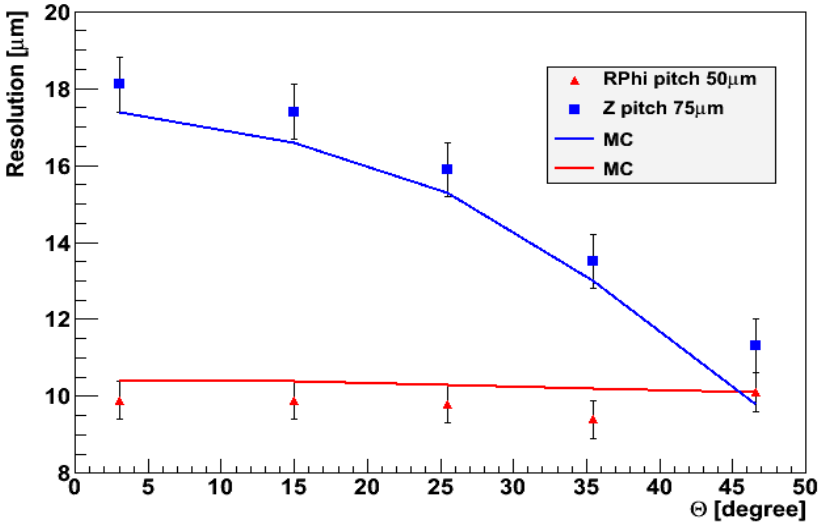


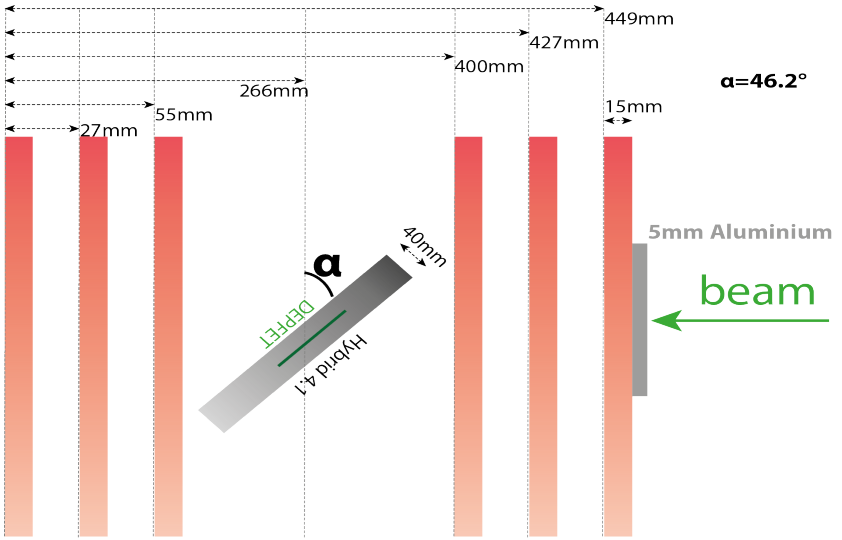
- Hybrid H4.1.11 has pitch of 50x75.
- Long clusters are in 75um direction.
- Range of tilt scan is 0...46° limited by mechanics.
- Telescope resolution varies from 5um up to 16um.
  - Z spacing adjusted for each angle.
- Full analog data available for all angles.
- Standard data processing uses
  - 3LSB zero suppression (~5xNoise)
  - CoG hit estimator

Resolution vs. Track Incidence

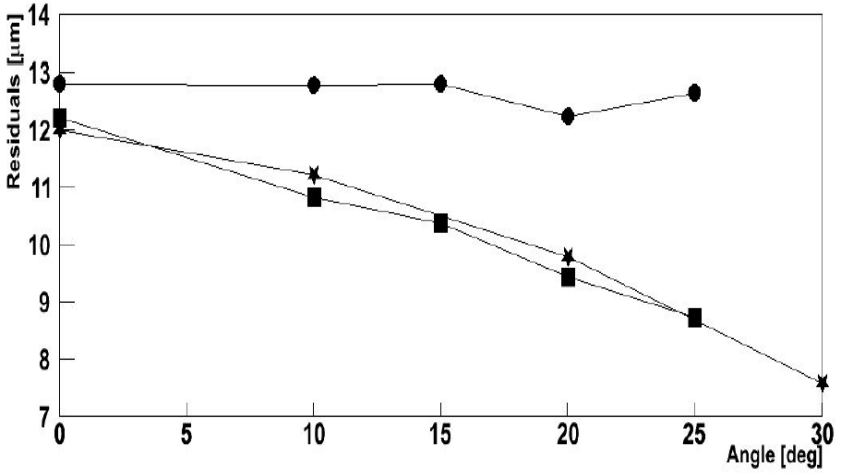


Z pitch 75µm (H4.1.11)





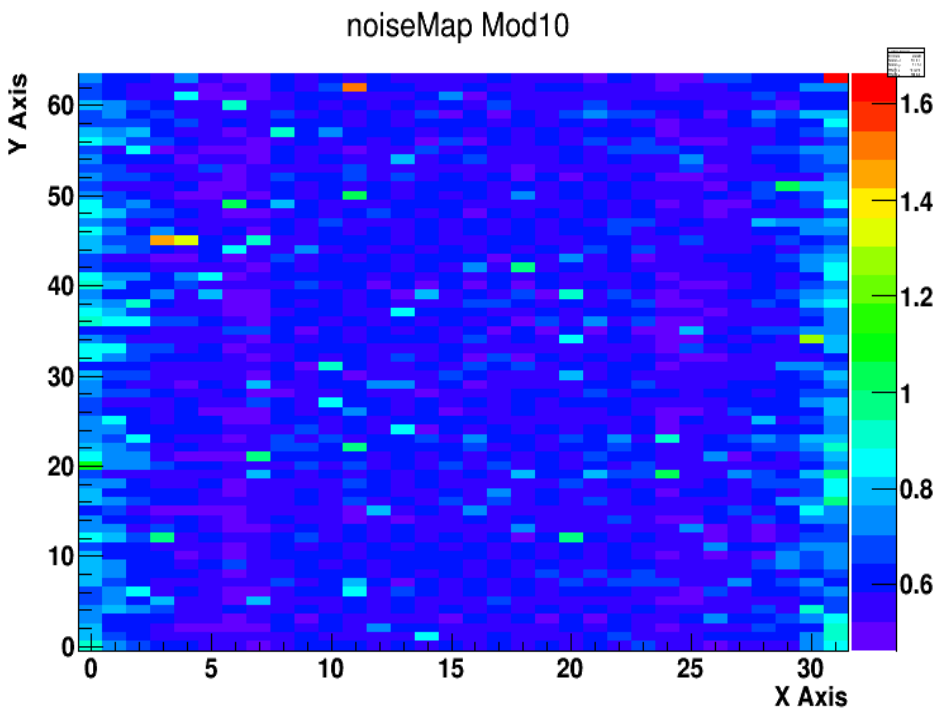
Z pitch 50µm (old H4.1.04)



Pixel Noise H4.1.11

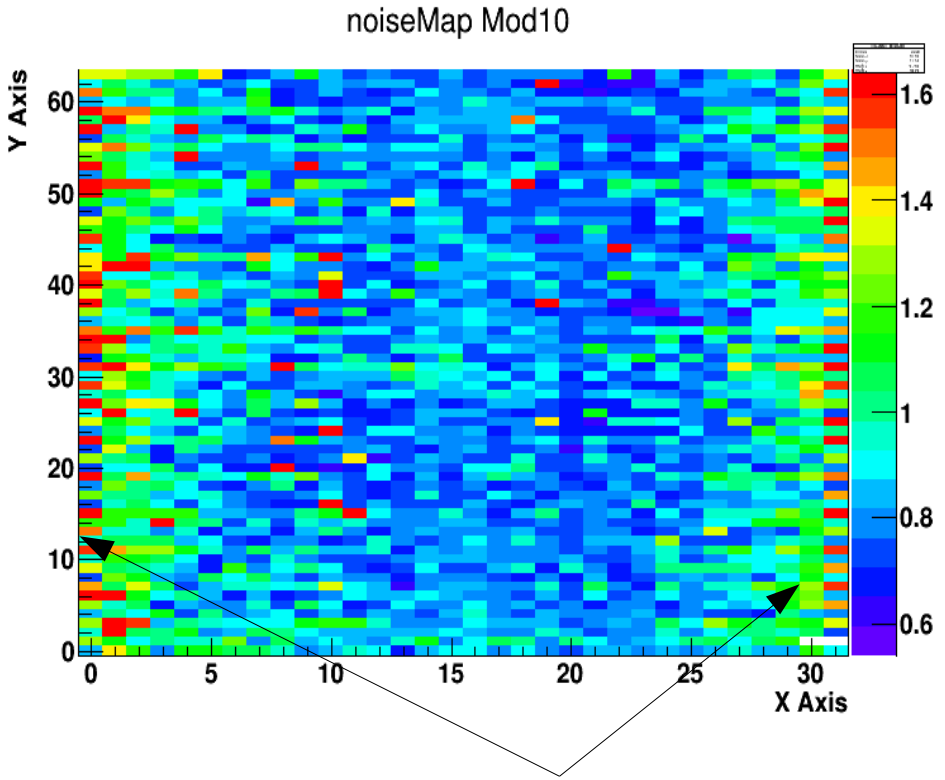
Plots drawn with same color scale, optimization of voltages as found given by Christian (HLL)

100MHz



MPV noise at 0.6LSB, rather homogeneous.

320MHz

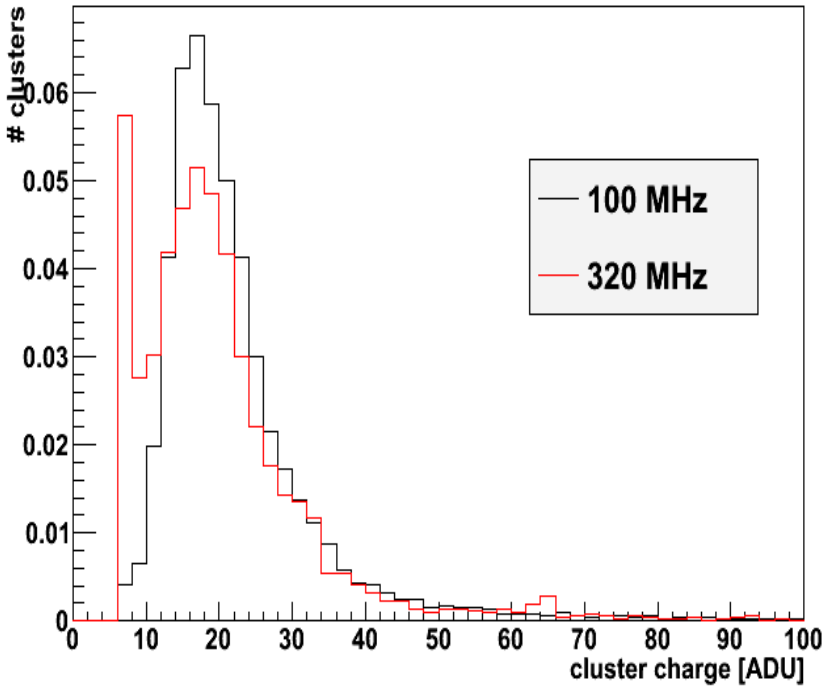


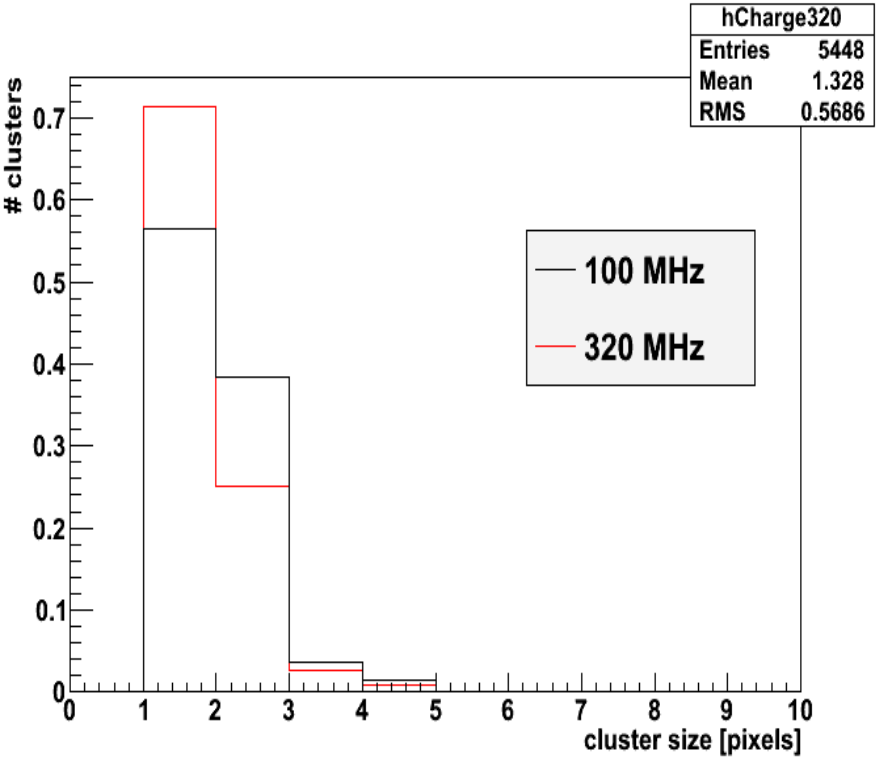
Noise seems to spread from edges

320 MHz runs (Prelim.)

:- No signal loss visible at full speed
:- but DCD(?) much more noisy
(>10% channels have noise>1LSB)

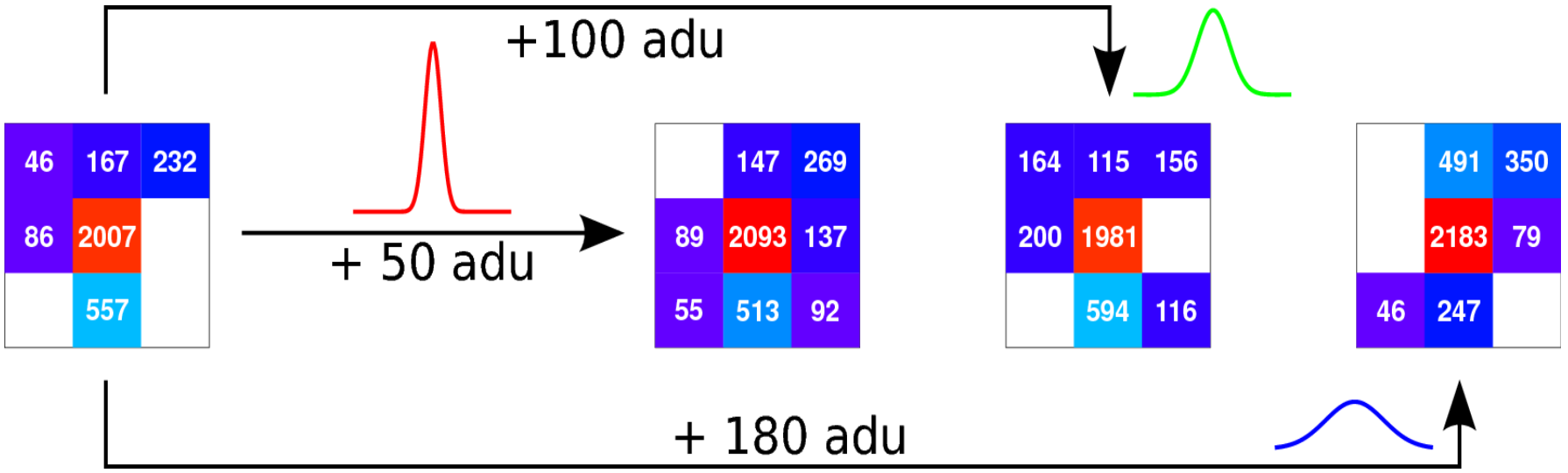
:- Cluster sizes similar
:- Differenz at 3LSB Thr due to noisy Pixels
:- Track level analysis will be cleaner



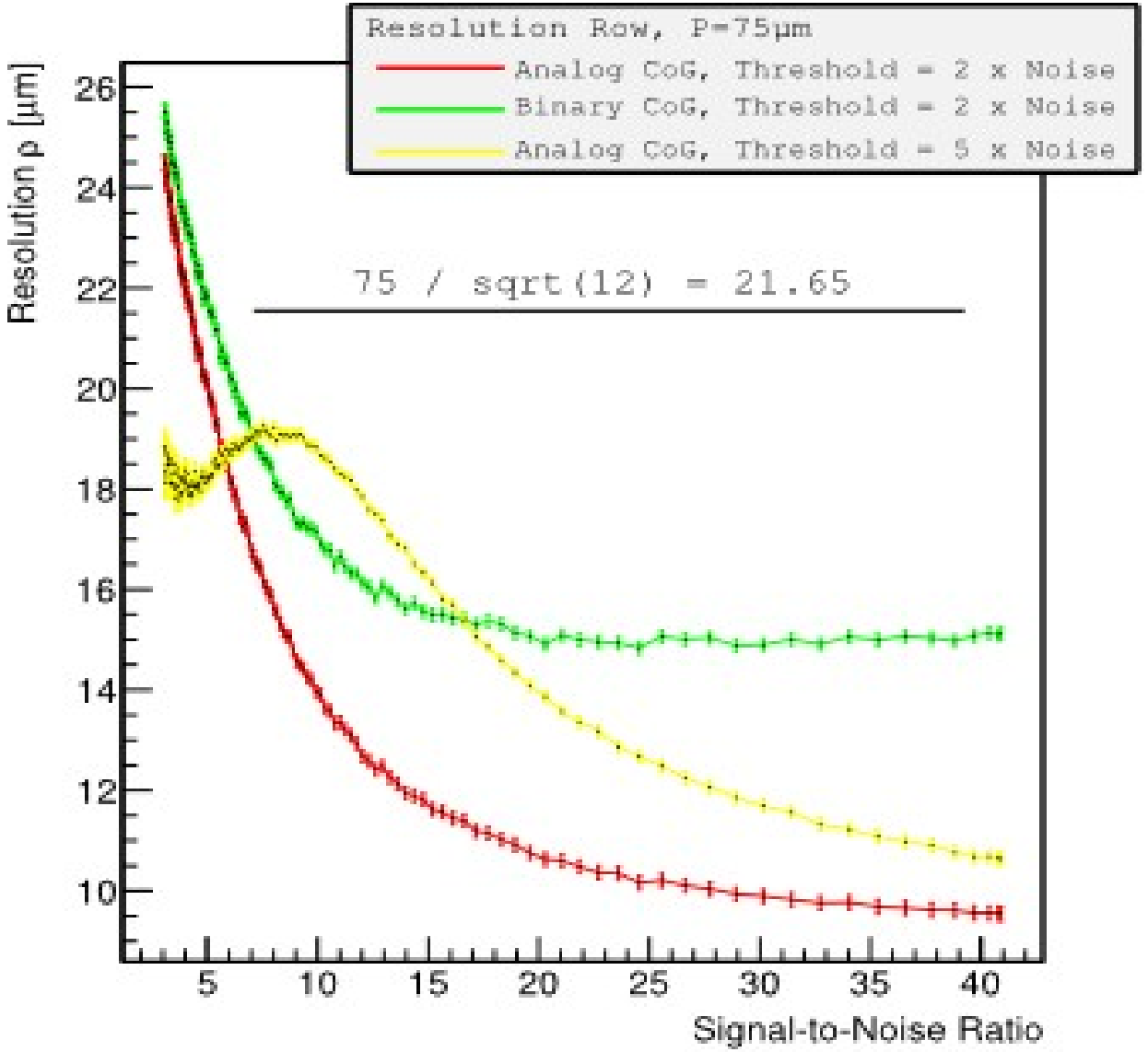


Detector Resolution Study

- Emulate sensor with more noise by adding noise on level of raw clusters.
- Hit_Threshold = Cut_Multiplier x Noise
- Binary COG = Hit pixel signal replaced by '1'

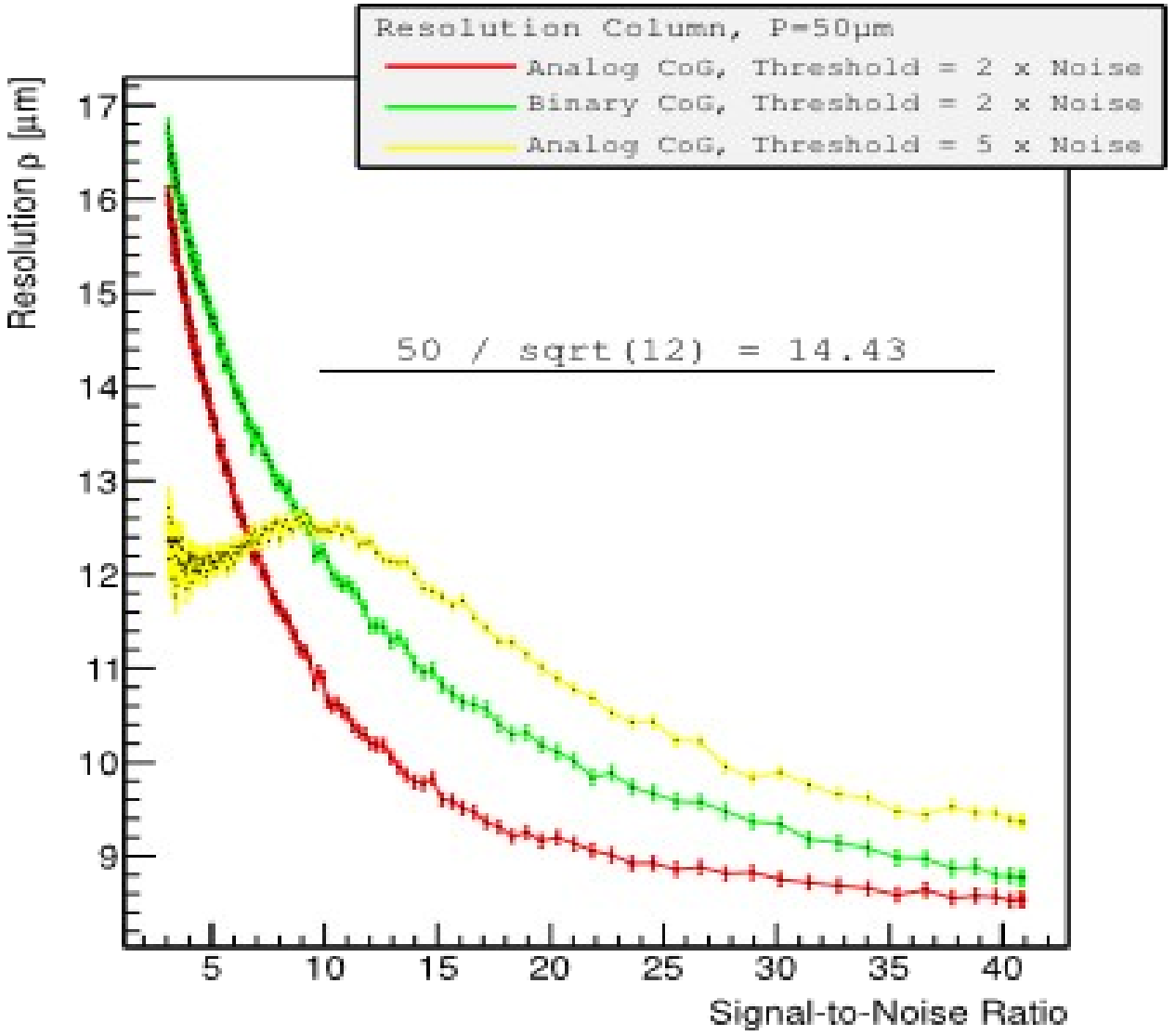


Tracks tilted by 46° in row direction with 75um pitch



- **Noise varies from 0.6,...,9 LSB.**
- **1 LSB ~ 100nA ~ 200e**
- **Binary and analog CoG profit from multi pixel clusters.**
- **Analog CoG is best, but depends on hit threshold**
  - **Red (2xNoise) best but not realistic.**
  - **Yellow (5xNoise) more realistic, but worse resolution.**
- **Binary CoG not so much worse than 'realistic' CoG**
  - **Assuming comparator noise <100e.**

Tracks tilted by 0° in column direction with 50um pitch

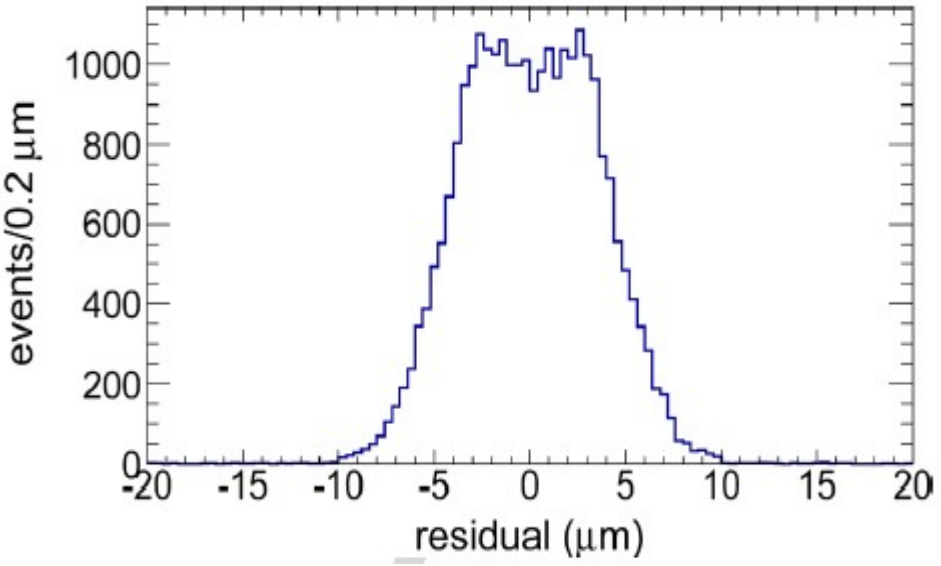


- **Binary CoG (green) very similar to analog CoG!!**
- **Binary CoG profits from multi pixel clusters.**
- **Resolution depends on hit threshold**
  - **Yellow (analog, 5xnoise) already worse than binary**
- **Large S/N (>20) only mildly improve resolution**
  - **No ~1/(S/N) dependence observed.**
  - **Landau fluctuations dominate pixel noise.**

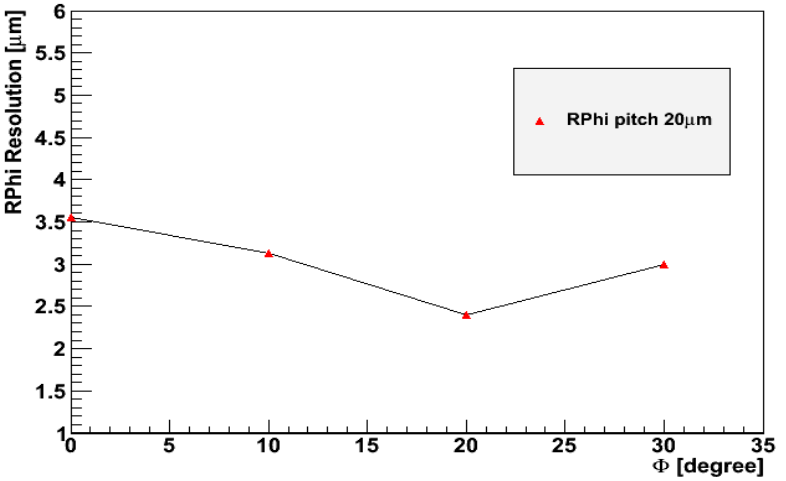
ILC type DEPFET designs

- 50µm thick, rphi pitch 20µm, z pitch 20-75µm
- Pixel noise 100e-, 8bit ADC, Hit threshold 500e-
- Resolution defined as RMS95 of position measurement errors
  - Measurement errors typically non Gaussian

Position Error at normal incidence



Rphi resolution vs. incidence angle



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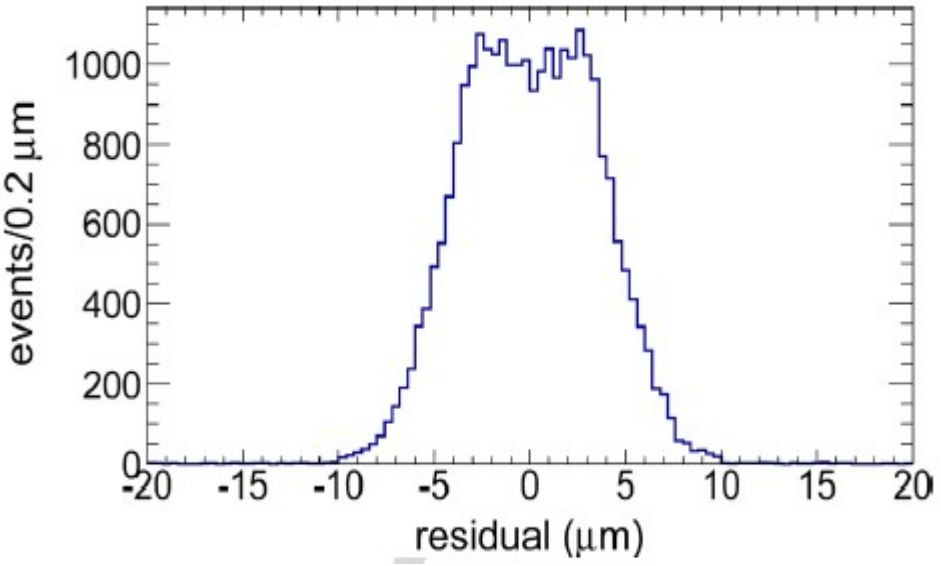
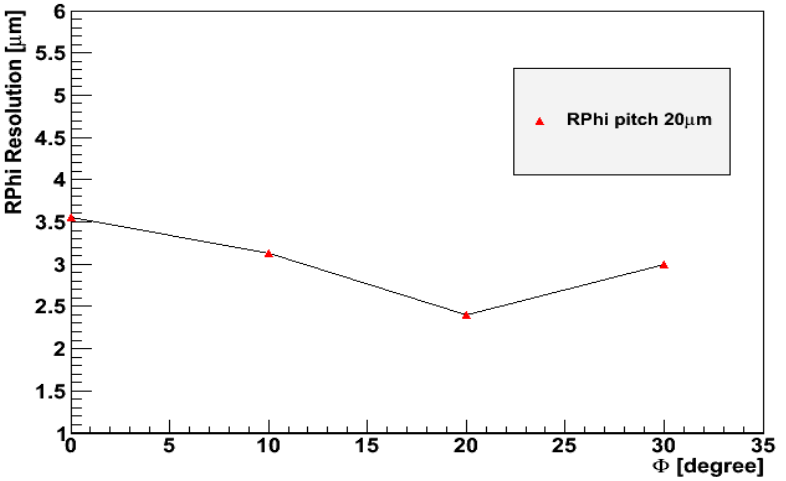
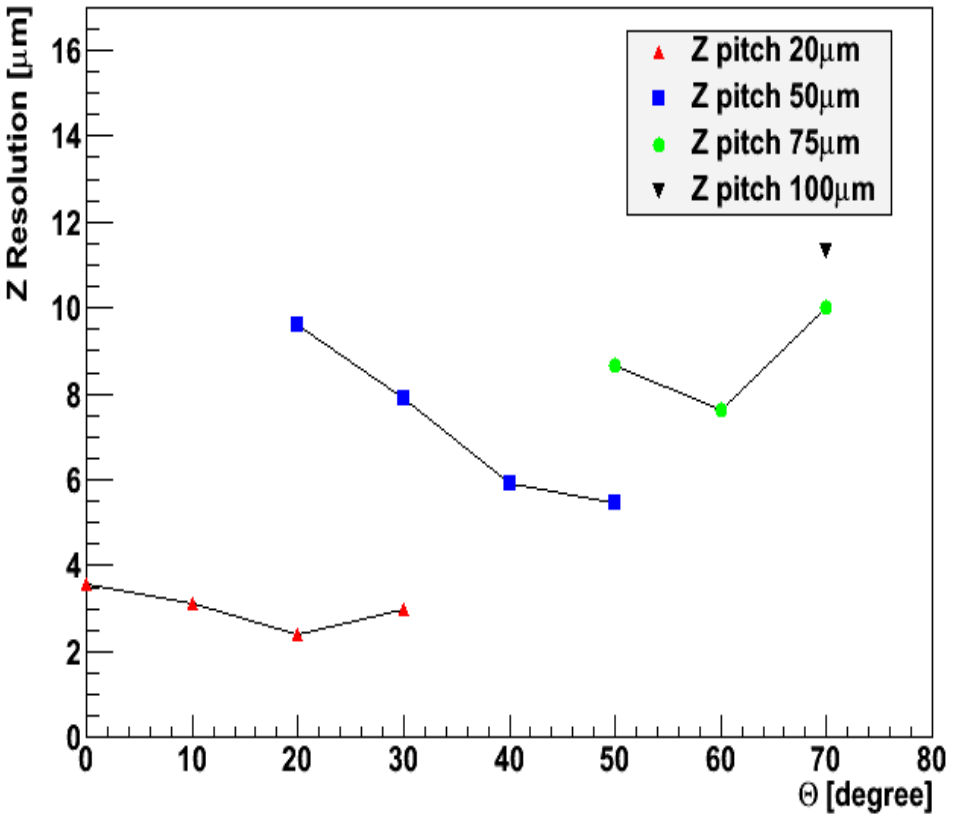


Rphi resolution vs. incidence angle

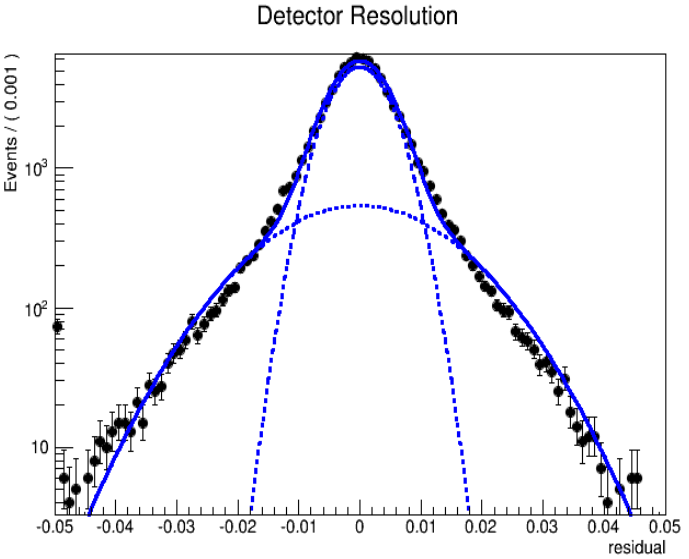


Position Resolution vs. Track Incidence in rz-view



:- Hard to maintain 3.5um at outer barrel of VTX.
:- Double Gaussian resolution functions at large tilts

Theta = 60°



Summary

- Analysis of tilt scan data completed
  - Simulation model works well
  - Tilt scan data relevant for ILC outer barrel
- Readout noise at 320MHz is still a severe problem.
- Analog CoG improves resolution for tilted tracks if hit threshold small (<5xNoise).
- In case of normal incidence, binary CoG gives better resolution.

THANK YOU