What to learn from test beams for PXD simulation and clustering?

F2F Meeting Prague 2014

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For the test beam crew

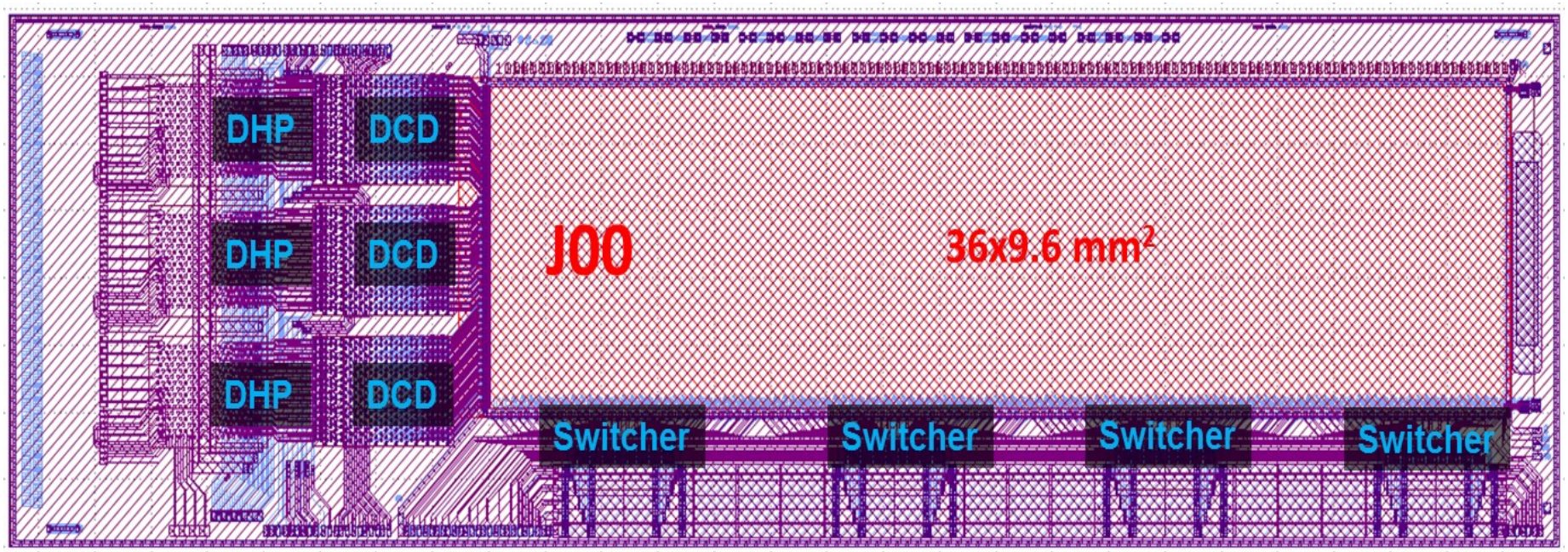
A first approach to answer ...

- Local PXD simulation relies on well working DEPFET and ASICS (DCD/DHP):
  - All pixel drain current Id in dynamic range
    - After dynamic 2bit current correction
    - Dynamic range of DCD: ~24µA
    - Signal current (~2µA) && baseline current (~60µA) && pedestals (??)
  - Global gain for all pixels: gq~500pA/e
  - El. noise (DCD/DHP): 100-200e
  - 8bit ADC channels in DCD
    - Linear transfer curve at full speed
    - Least significant bit ~ 200e

A first approach to answer ...

- November 2014 test beam at CERN tells us whether this can work:
  - Are all channels working for long sensor with ASICS?
  - What are the calibration constants to compare data with simulation?
    - El. Noise, Gq, LSB?
  - Does our signal match with simulation?
    - Landau, residuals, cluster size

The prototype detector



:- Pixel pitch: 50x75um²
:- Thickness: 50um thick sensor
:- 192 physical columns
:- 480 physical rows

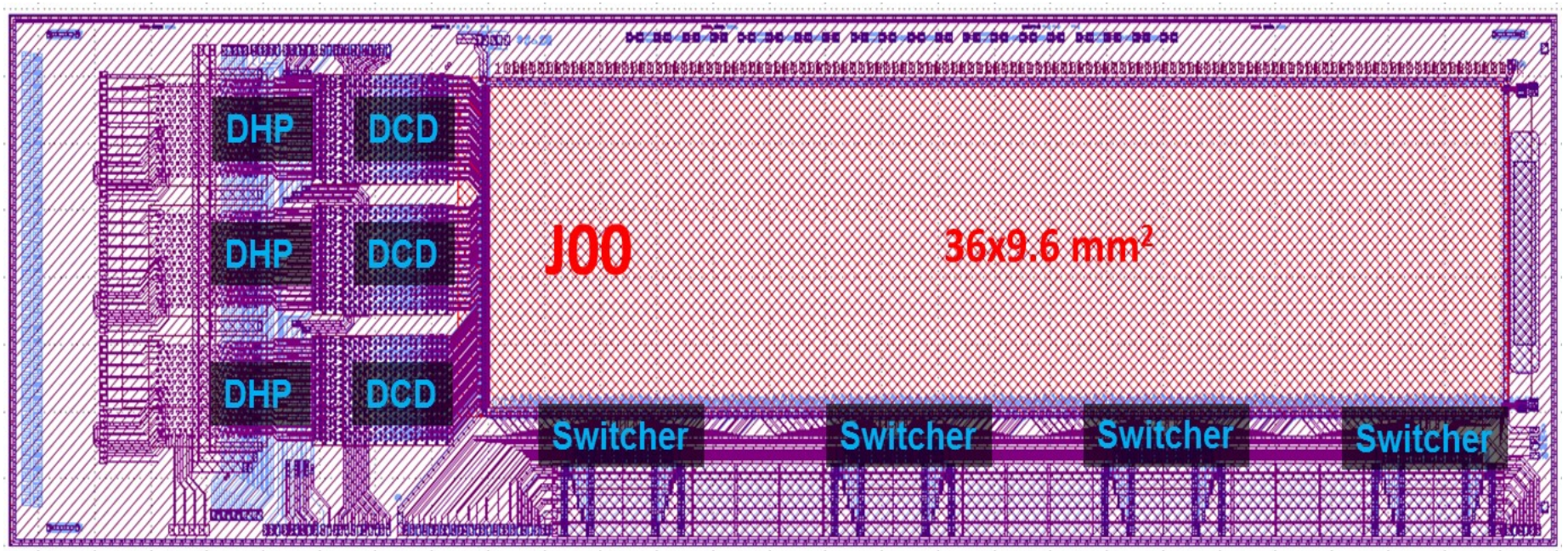
:- ASICS: DCDBv2, DHP02, SwitcherB1.8G
:- Speed: 250MHz (nominal 320MHz)

:- Same detector as in January 2014

:- 2um pointing error from telescope
→ in-pixel stat.

:- 2bit pedestal subtraction (DCDB)
→ Largest problem last time

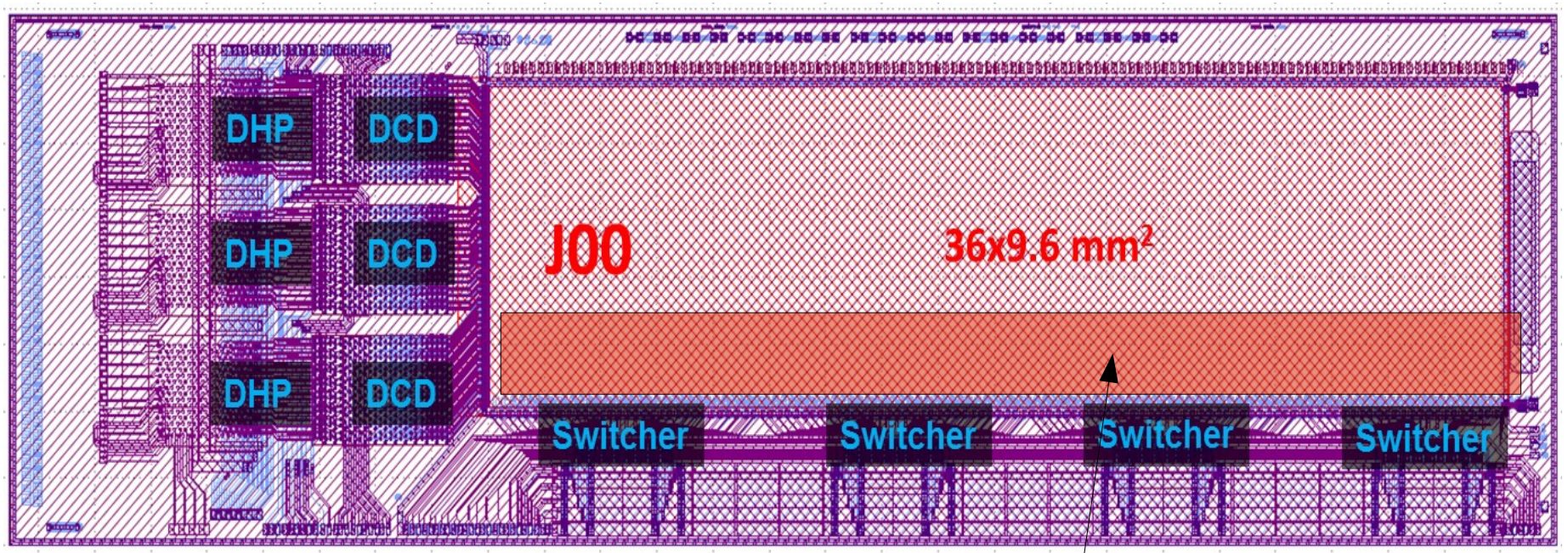
Local coordinate system



U; columns [0,192]

V, rows [0,480]

Only one DCD/DHP readout



U; columns [0,192]

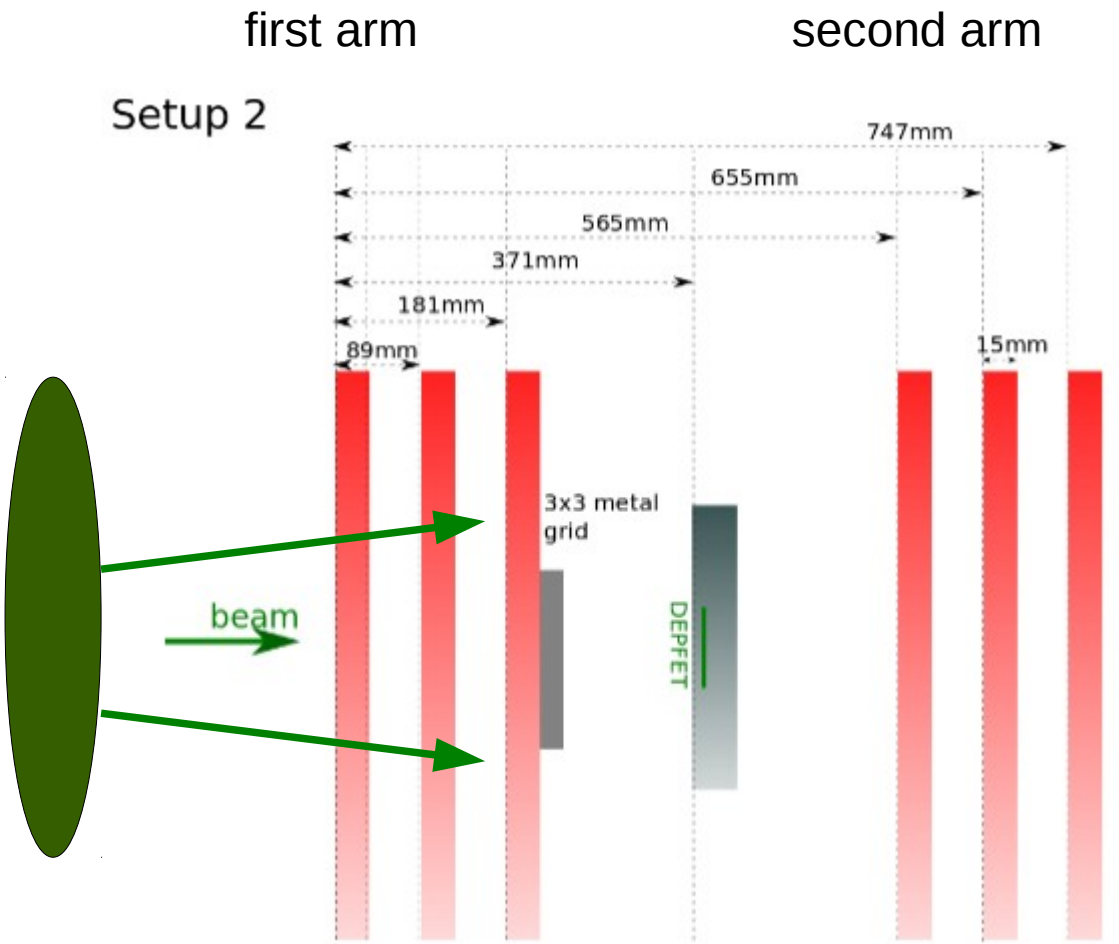
We see hits from here

V, rows [0,480]

Data sample from CERN

- Many short runs needed for debugging and not usable for validation.
- Runs at perpendicular incidence; 120GeV
  - Runs: 209, 210, 211, 212
  - First DCD/DHP pair used
  - Total of 350k tel. tracks with DEPFET hit
- Runs at 30° tilted sensor
  - Only one long run: Run325
  - Tilt around local horizontal (x) axis
  - Only few tracks (<10k matched tracks)

EUDET Tracking



:- 6 eudet layer, ~2um error

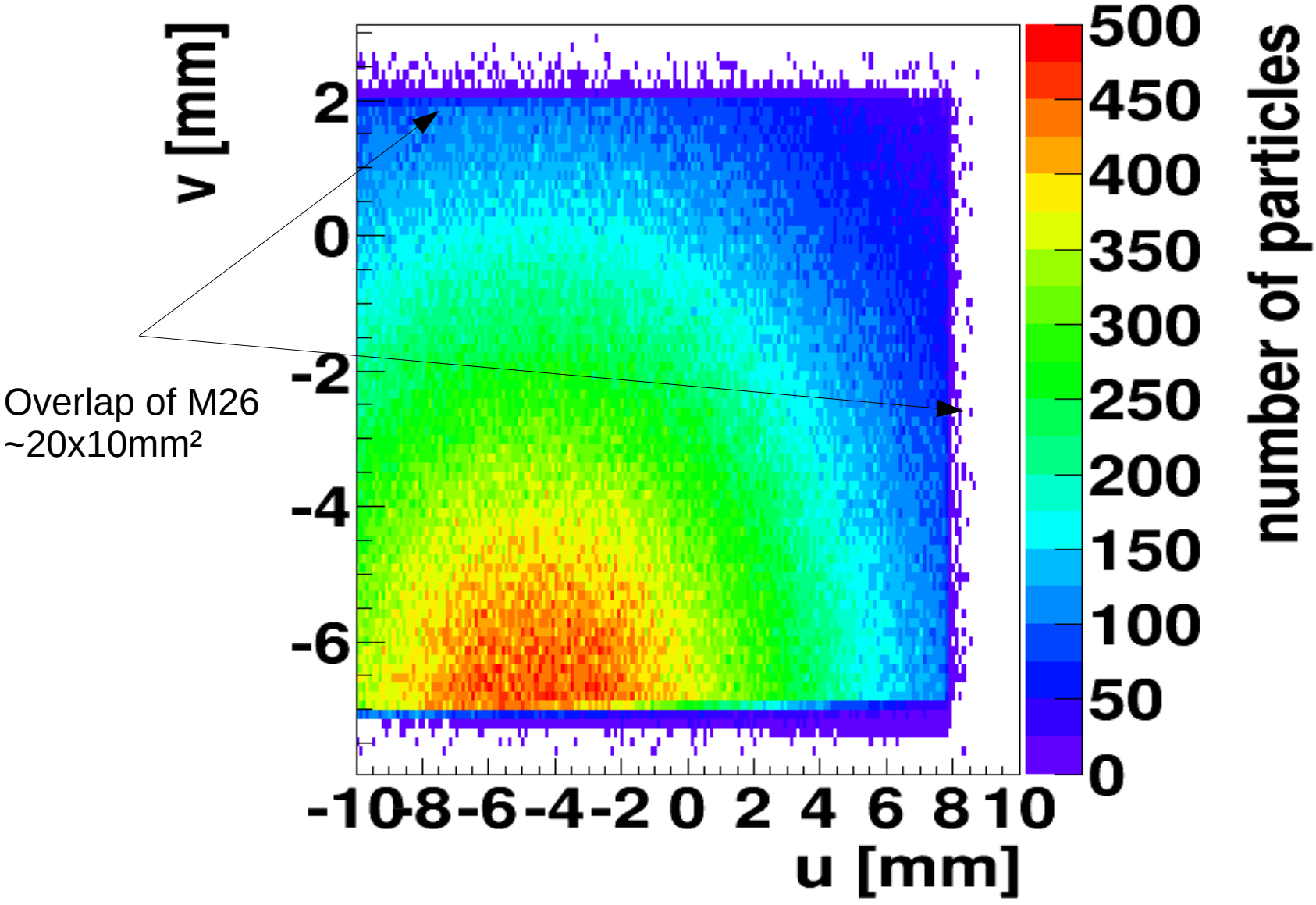
:- trigger PMT's before and after eudets

:- triggered track: 6hit eudet hit(!)

:- z axis is aligned to beam axis

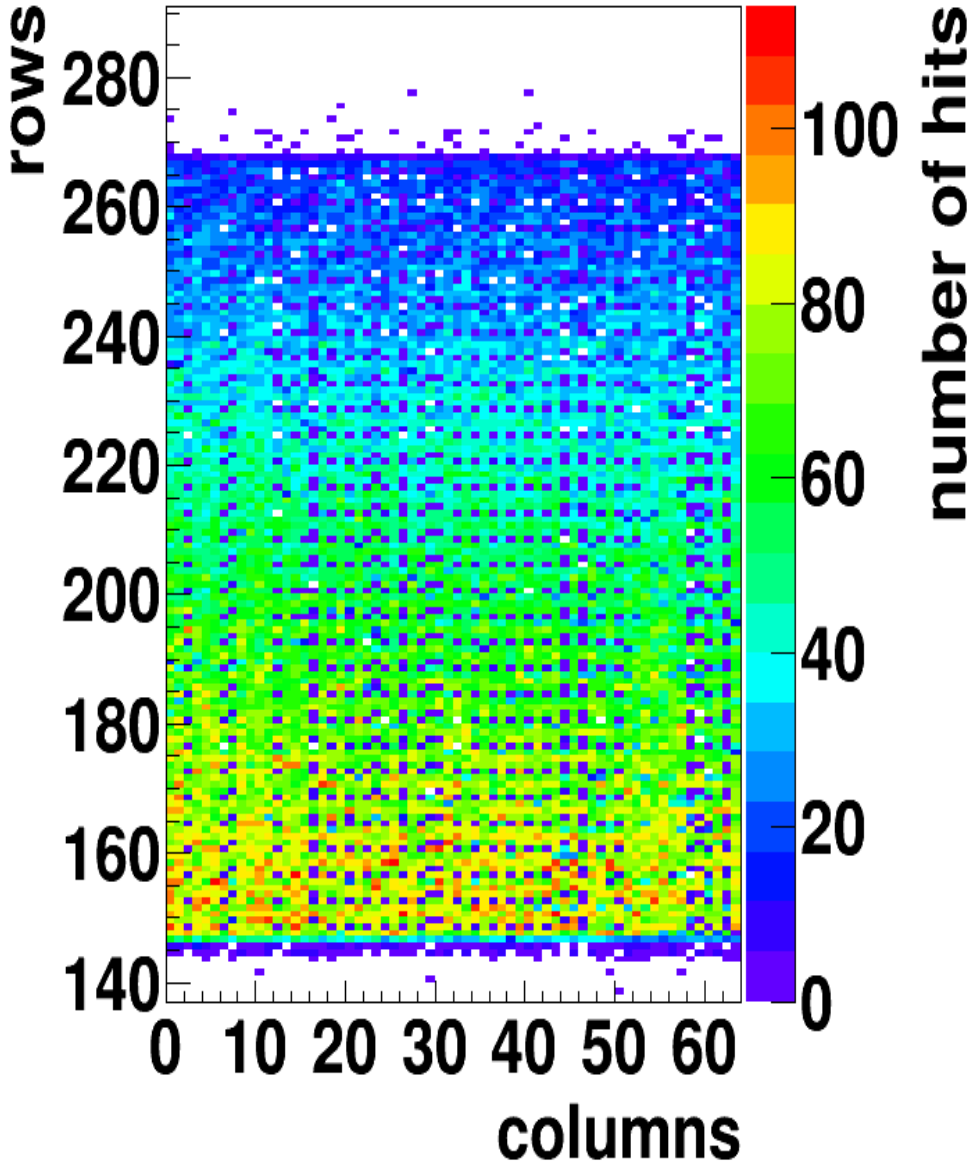
:- finding/alignment/tracking in in ILCSsoft.

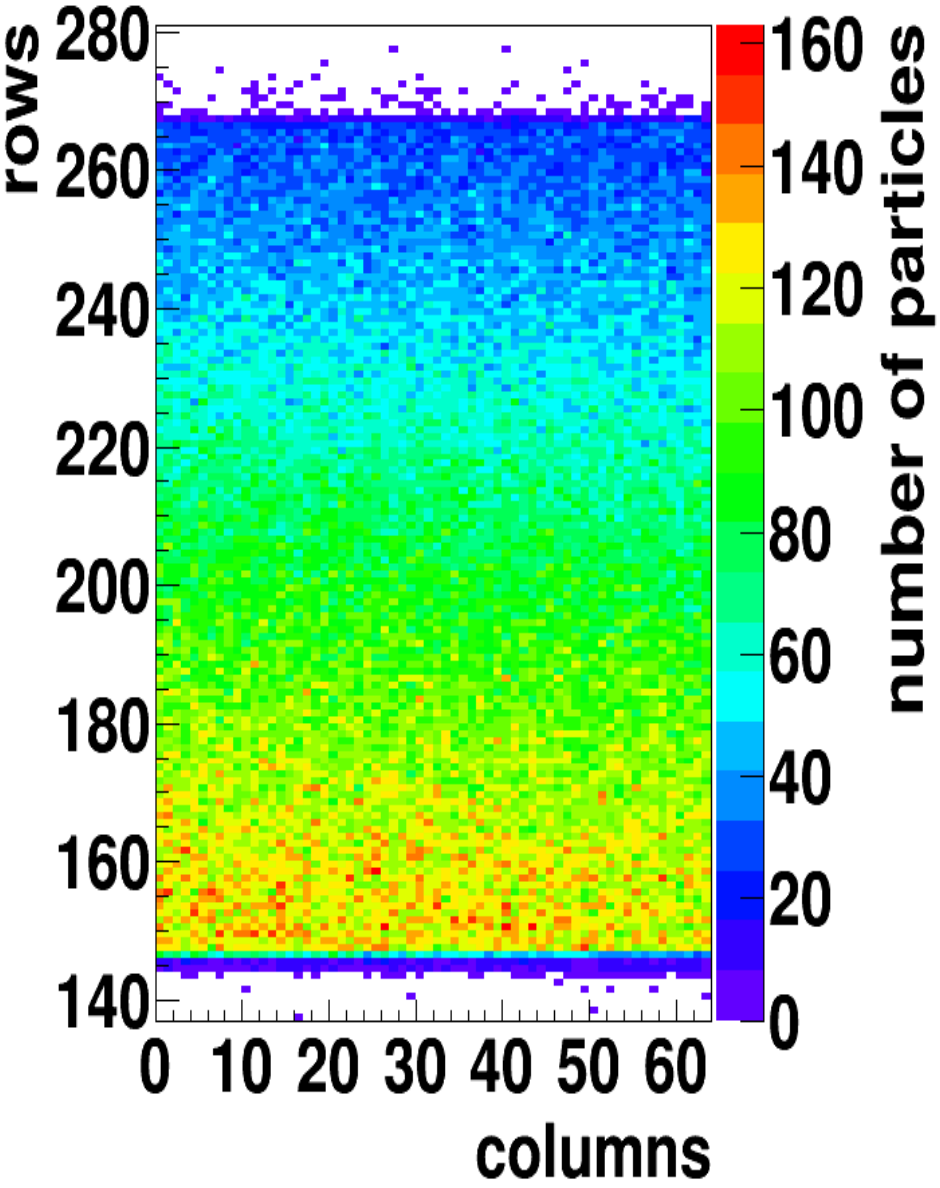
Beam Spot: Tel. Acceptance



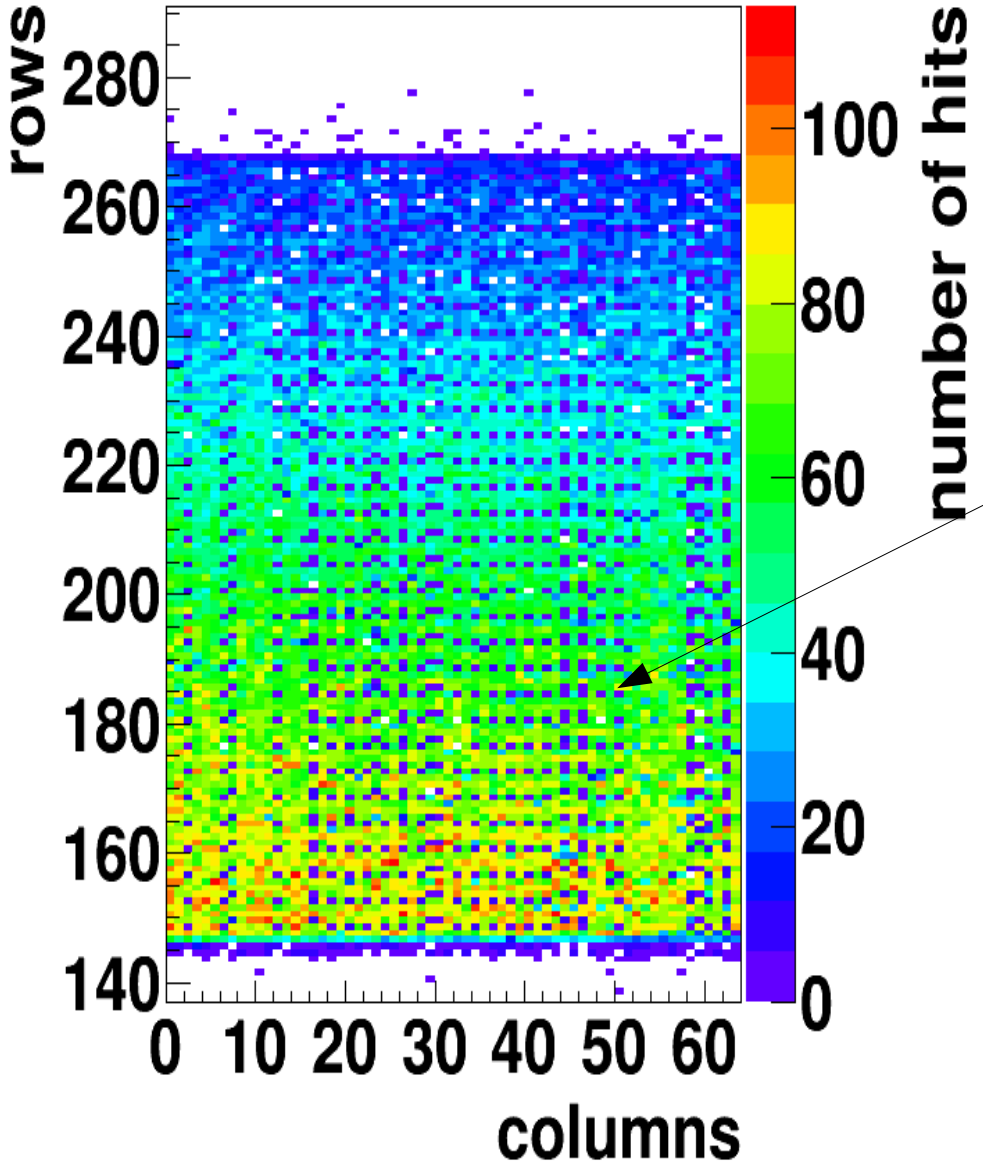
v [mm]
2
0
-2
-4
-6
-1
36x9.6 mm²
J00
Switcher
Switcher
Switcher
Switcher
DCD
DCD
DCD
HP
HP
HP
2 4 6 8 10
u [mm]
500
450
400
350
300
250
200
150
100
50
0
number of particles

DEPFET hits vs. tel. tracks





DEPFET hits vs. tel. tracks



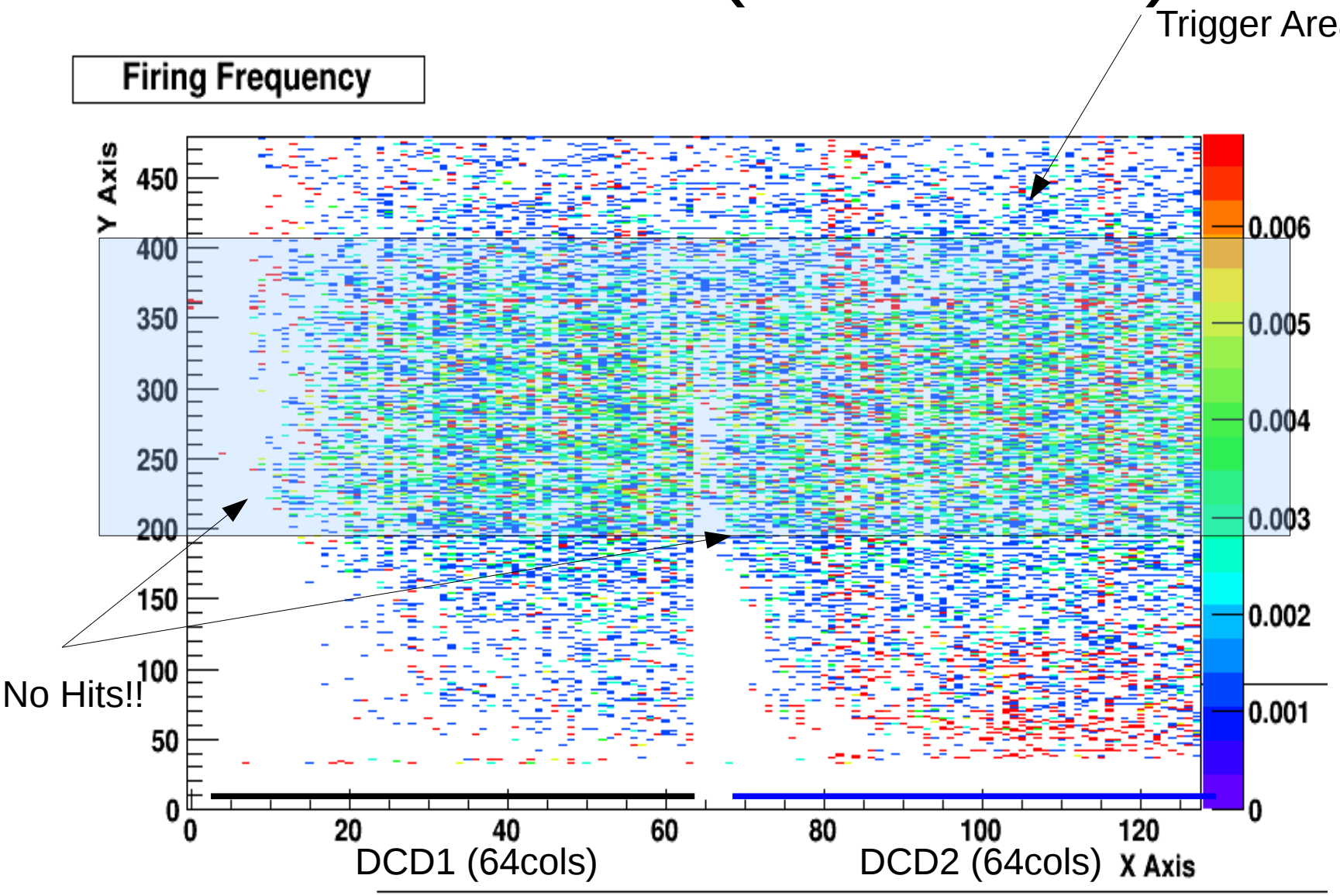
:- Tracks cross only rows 140-270

:- sizeable fraction of pixel which record no hits

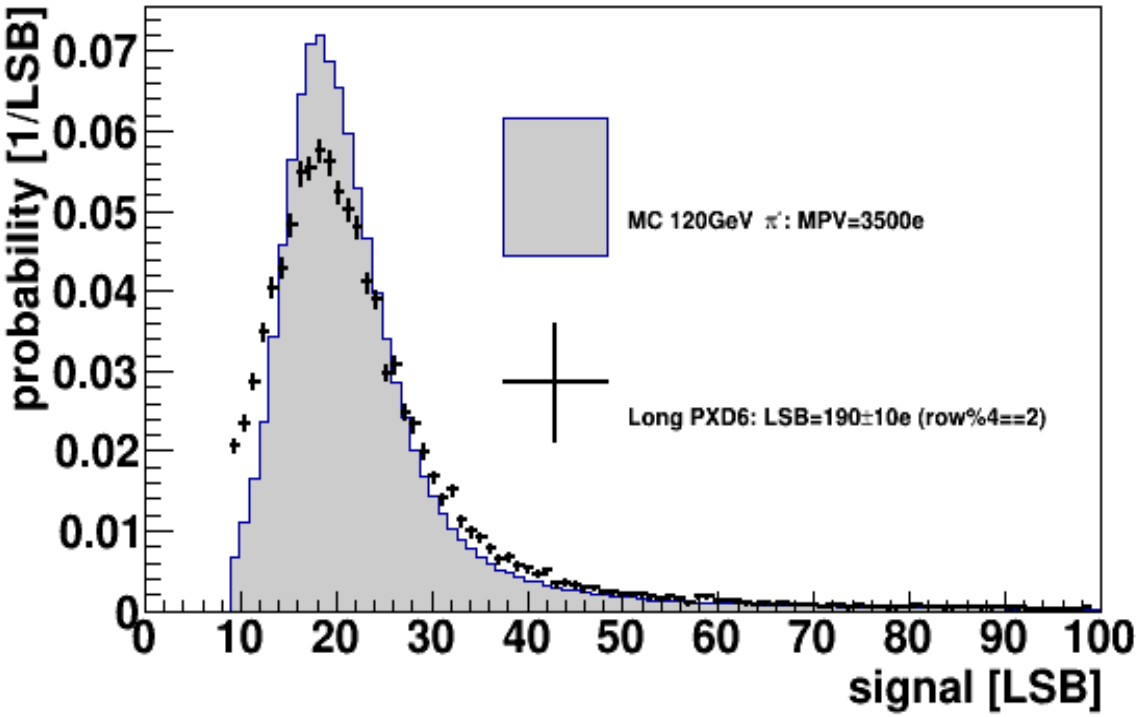
:- drain current out of dynamic range at DCD input (most likely explanation)

:- Variation of pedestals currents larger than expected from small sensor.

Improvement from 2bit pedestal correction (Jan. 2014)



Landau (50um Si)



MPV~20 LSB

:- DEPFET hits matched to track.

→ clean hit sample

:- LSB ~ 190 electrons

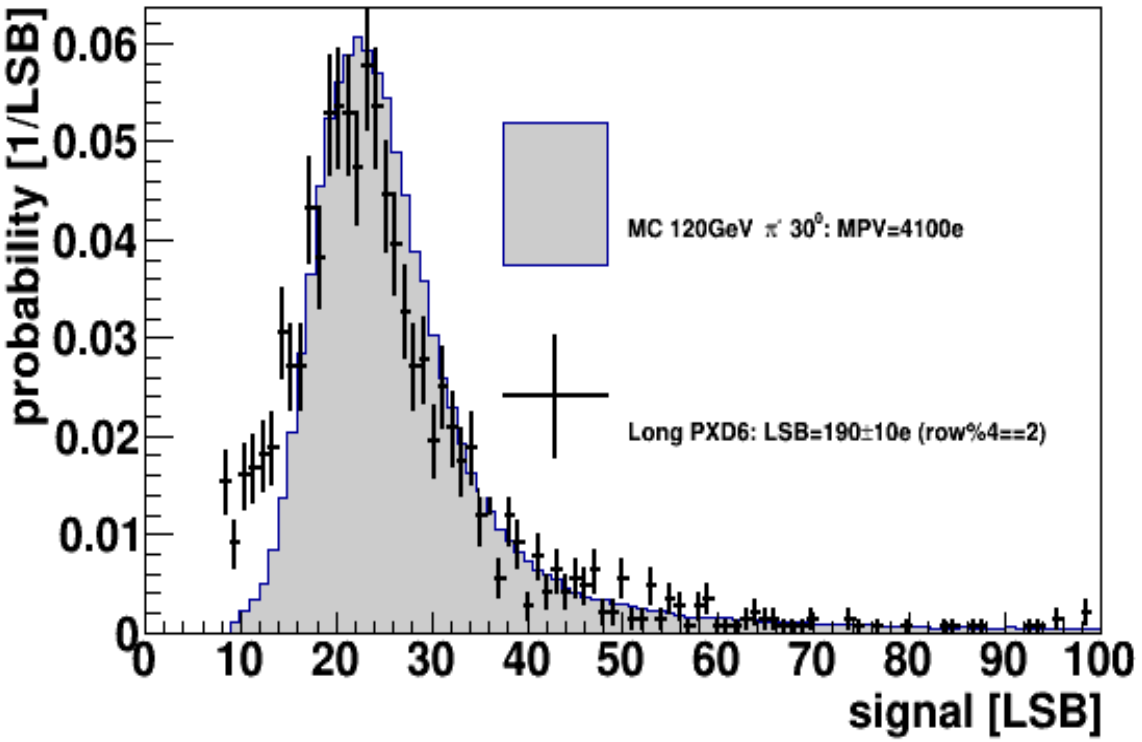
→ scaled to MC data (PXD digitizer)

:- FWHM ~ 2000 electrons (Landau fluctuations)

→ fine spaced sampling of noise.

:- Only use 4th row to avoid dead channels.

Landau (50um Si; 30° tilt)



MPV~21 LSB

:- DEPFET hits matched to track.

→ clean hit sample

:- LSB ~ 190 electrons

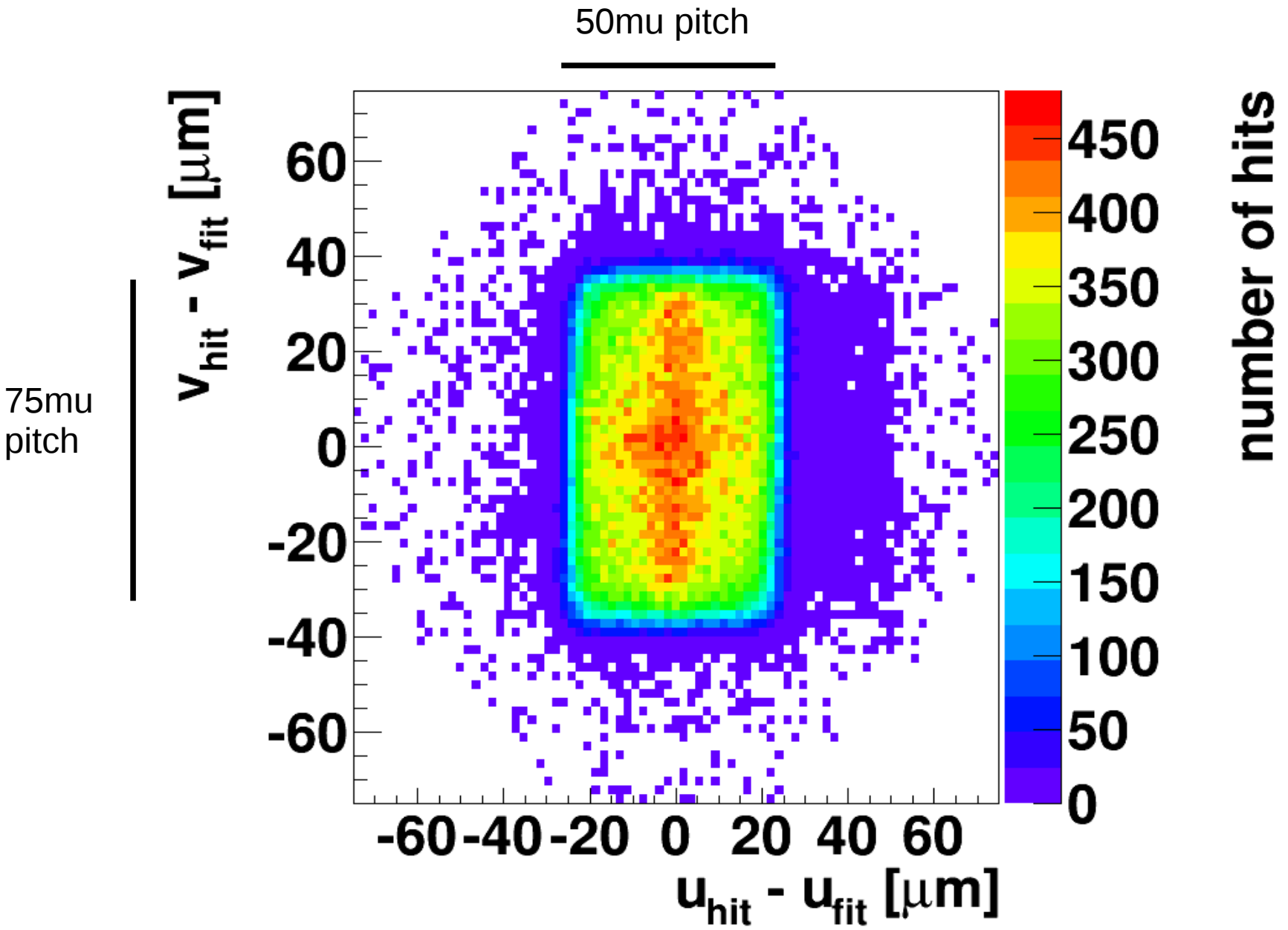
→ scaled to MC data (PXD digitizer)

:- FWHM ~ 2000 electrons (Landau fluctuations)

→ fine spaced sampling of noise.

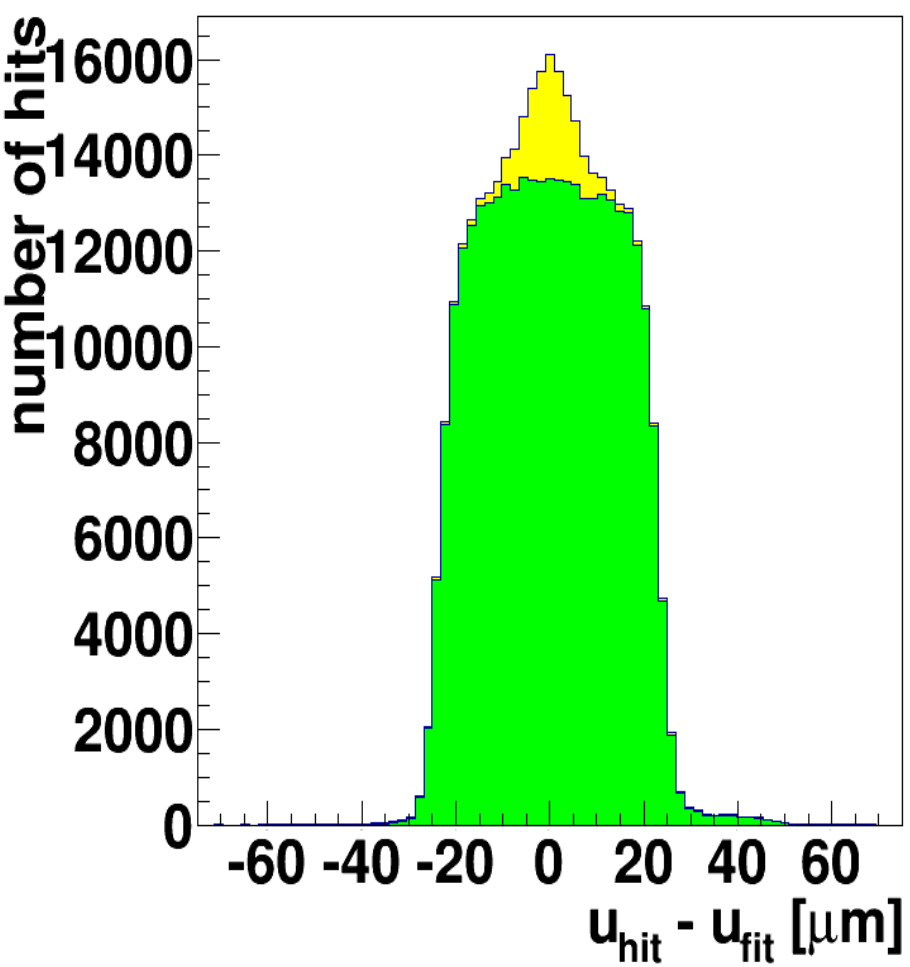
:- Only use 4th row to avoid dead channels.

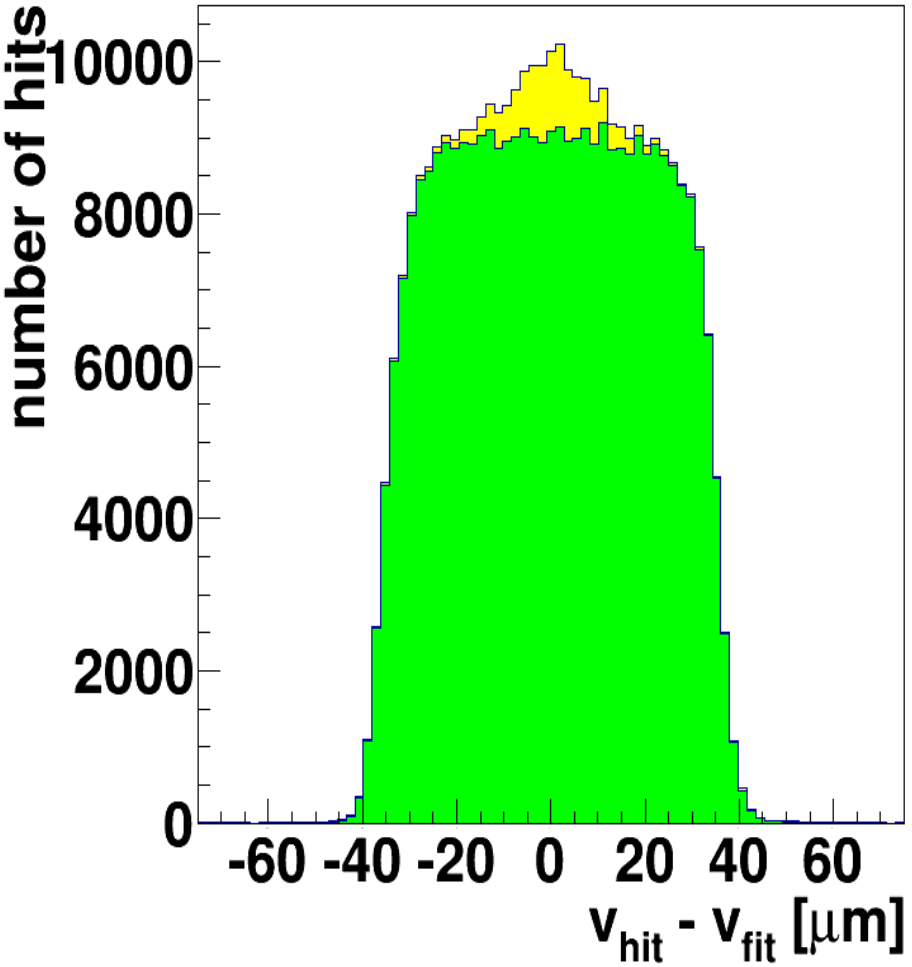
2D Residuals (perp. incidence)



1D residuals (perp. incidence)

Mostly 1px clusters, few two pixels when track hits pixel edge
(having much better resolution)



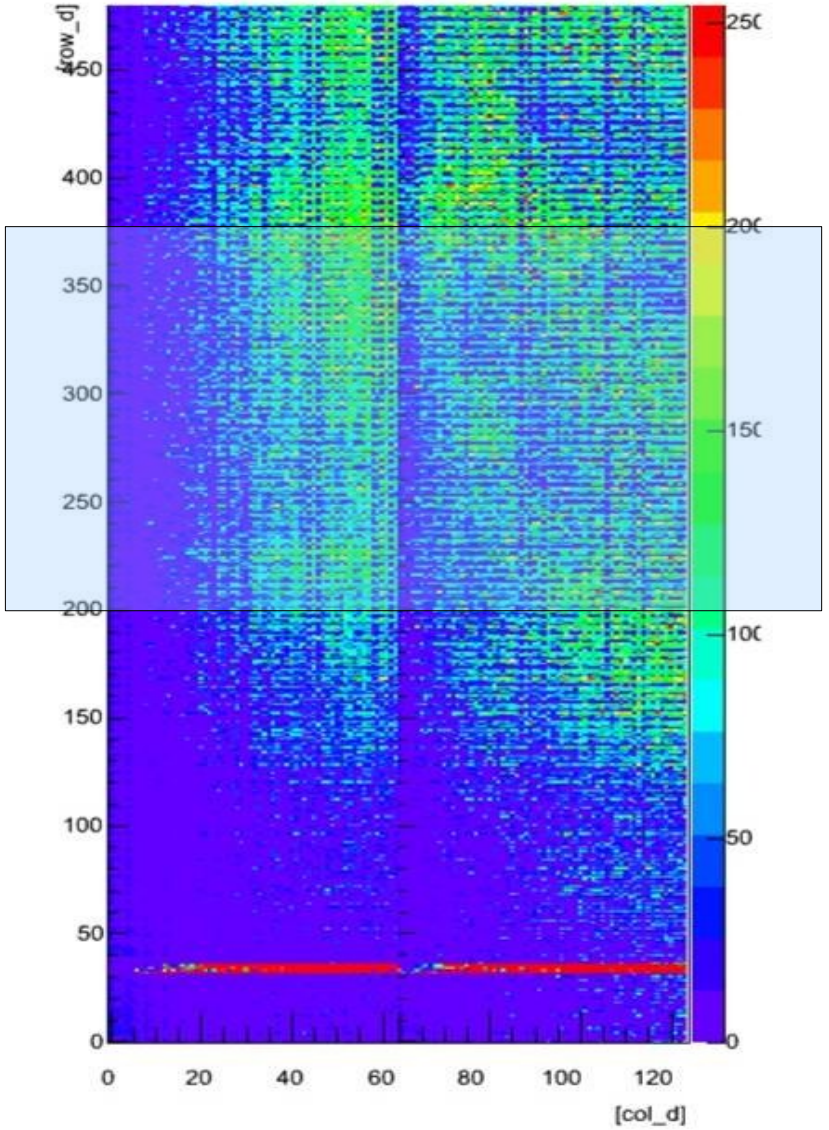


Summary

- 2bit pedestal subtraction is clear improvement compared to Jan. 2014
  - however not enough; still many dead pixels
  - Clear hardware topic
- We measure landaus, clusters and residuals as expected for high threshold operation.
  - Thresholds are 8xLSB ~ 1500e
  - Spatial resolution (to lesser extent: pxd hit effi) degrades significantly for such high thresholds.

Thanks

Pedestals and Dynamic Range



:- Same coordinates as before

:- Zero pedestal: out of DCD range!!

:- Pedestal variation too strong to operate all sensor

:- There is also a row wise patter in Pedestals.

:- Questions:

A) How much can 2bit pedestal dac help (not used in tb)?

B) How much of pedestal is due to Mechanic stress/ bad optimization?