Source test for pixel single chip detectors - results

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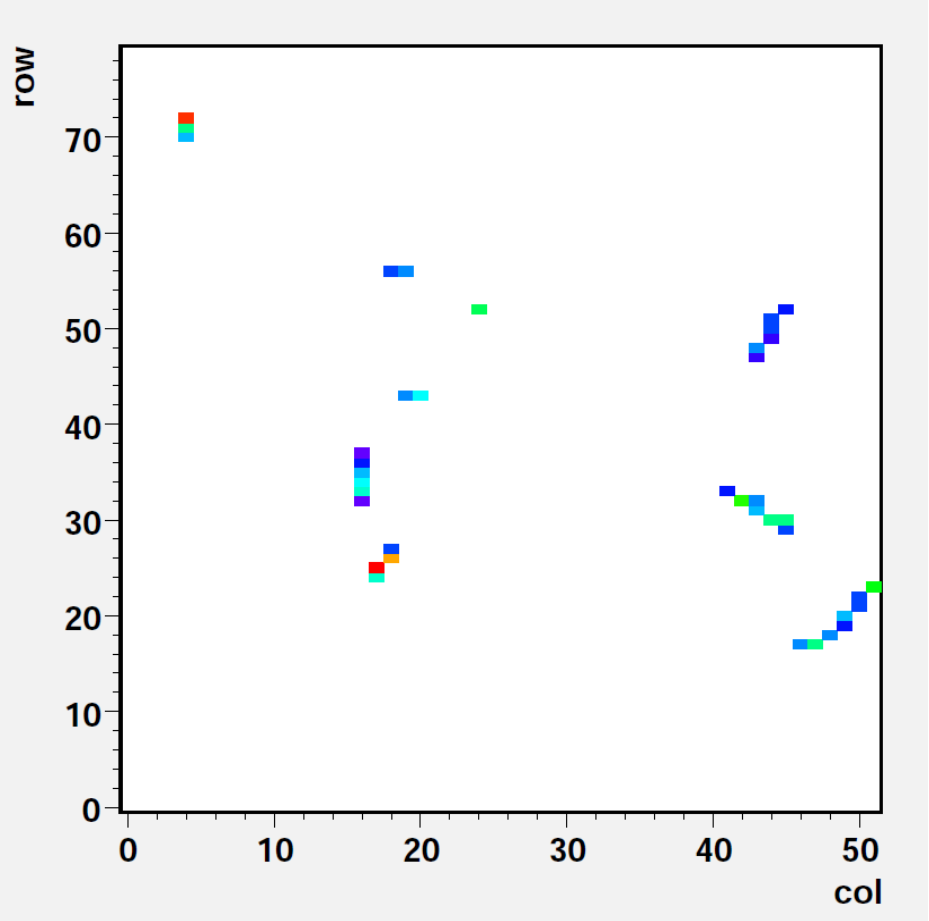
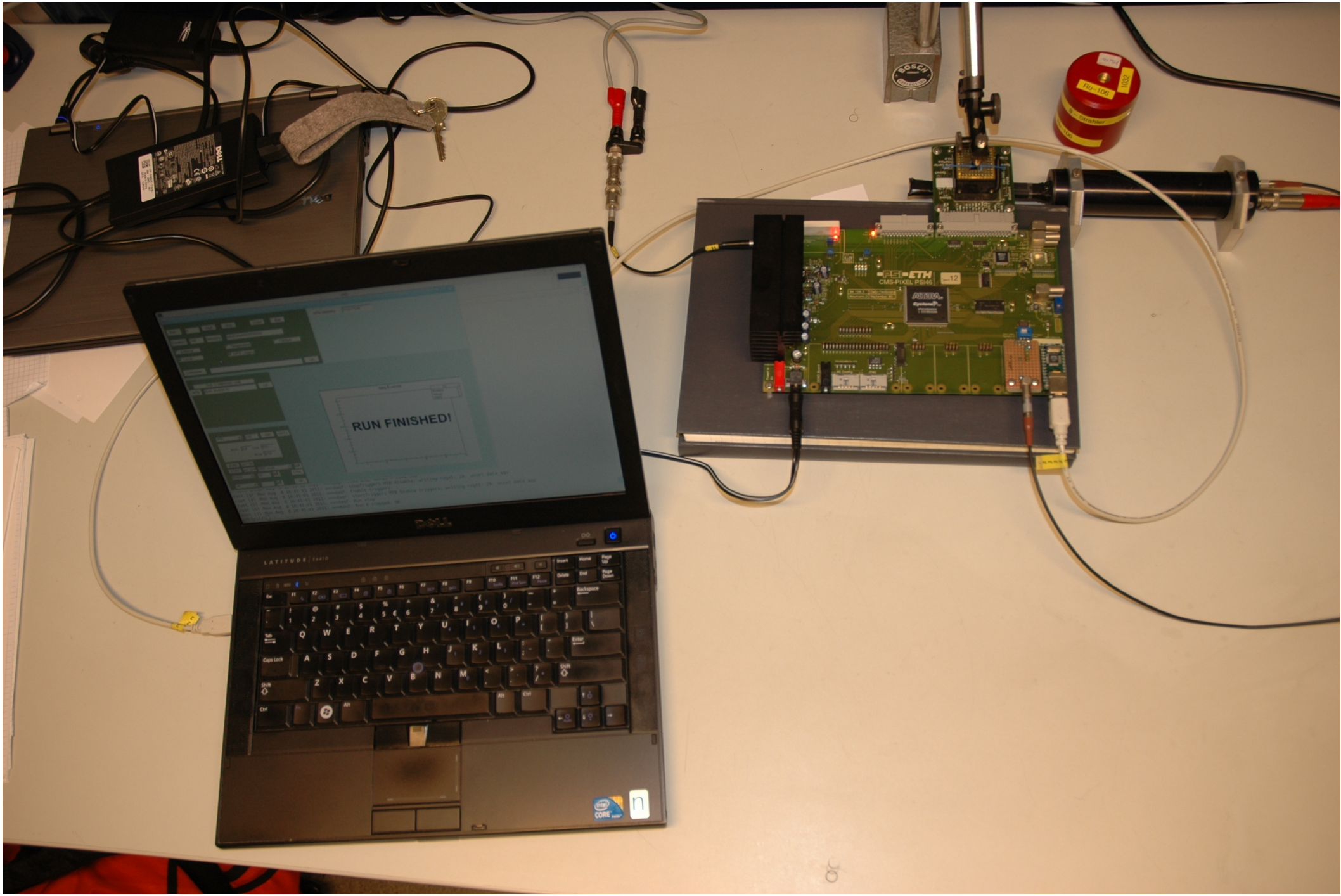
DESY CMS tracker upgrade meeting, 23.8.2011

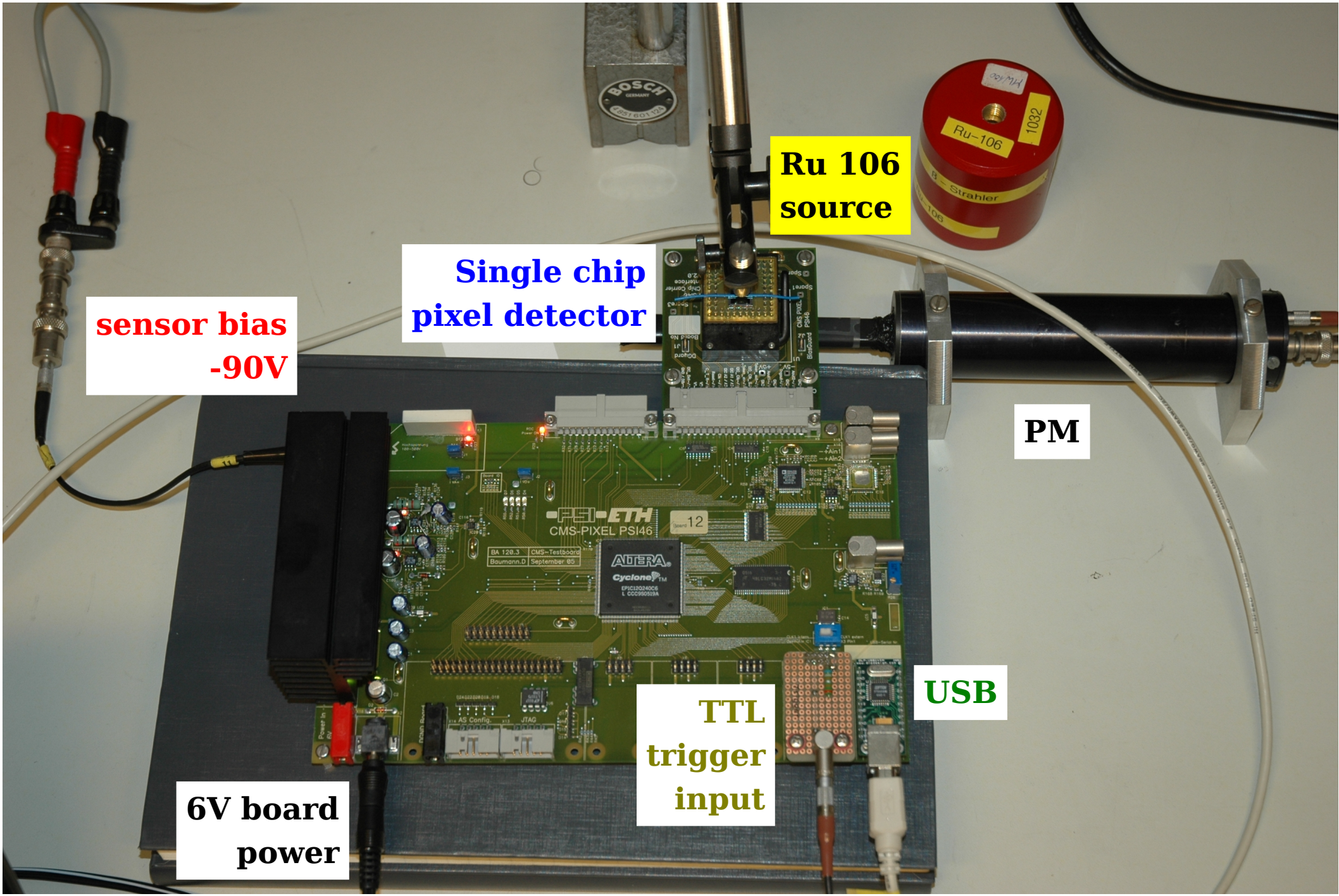


- pixel cluster analysis
- sensor bias voltage scans
- threshold scan
- plans for the DESY Testbeam

Source test setup



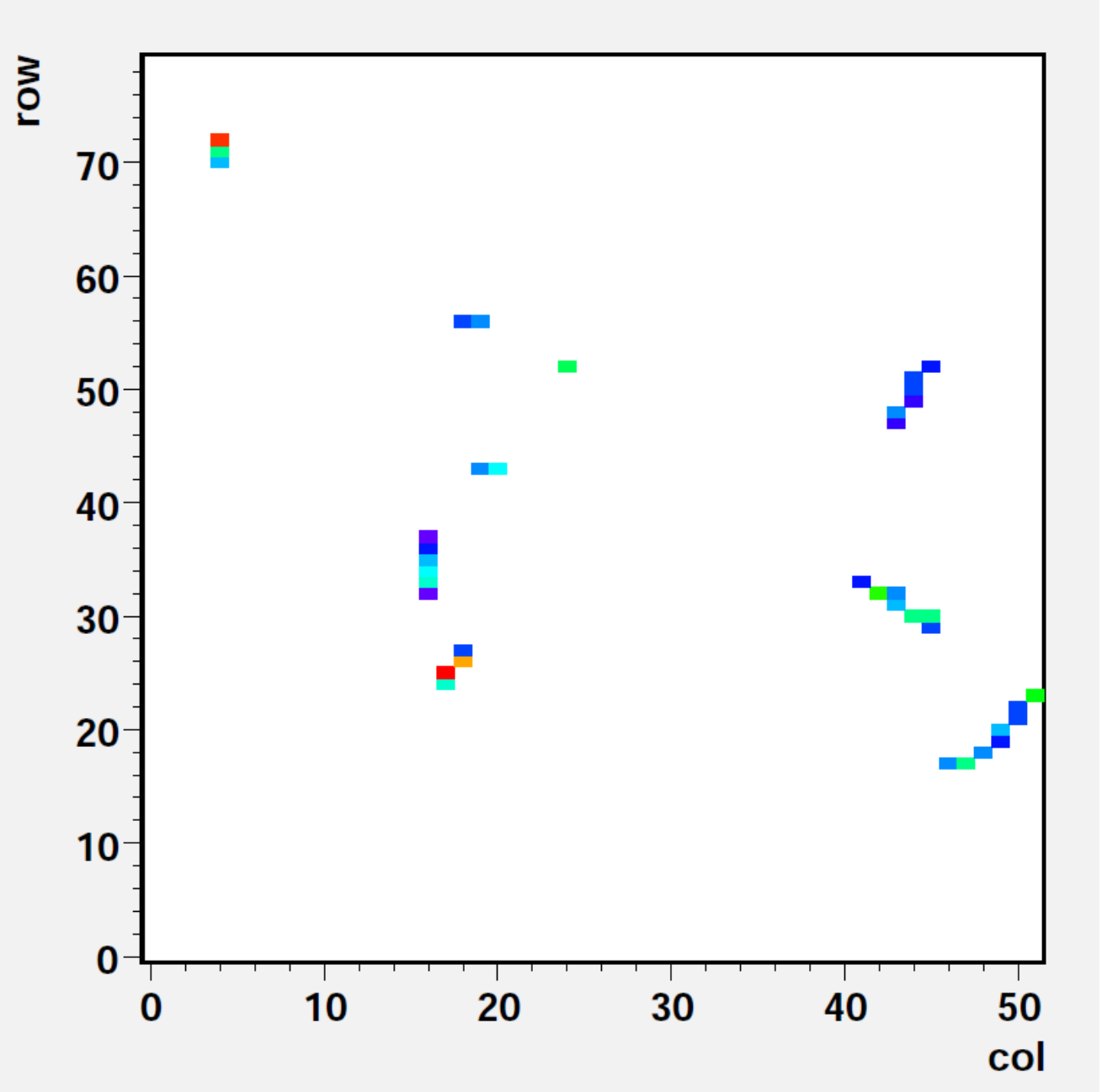
Source test setup



Cluster analysis code

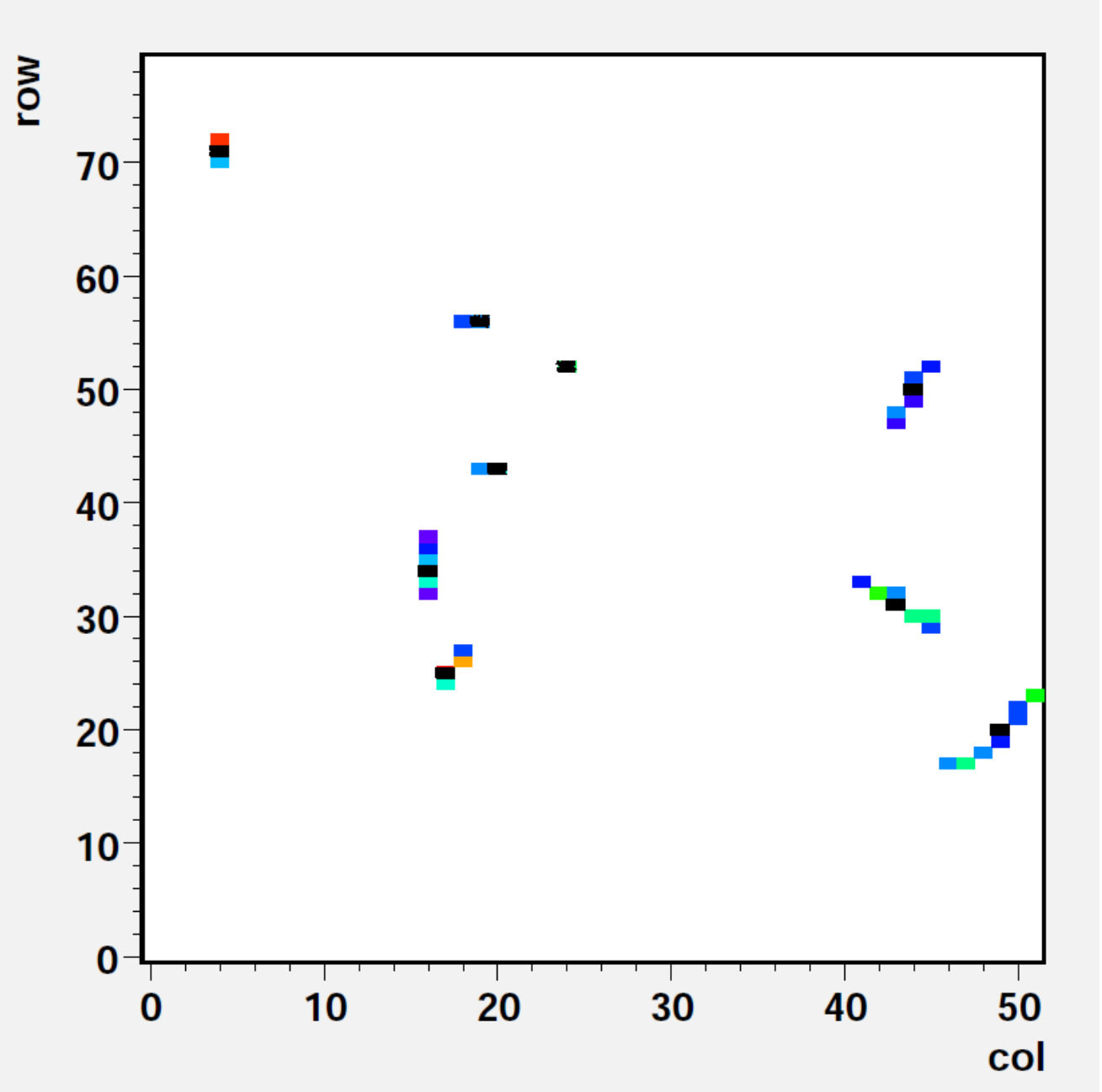
- Adapted clustering code from **`BinaryFileReader`** class (PSI code)
- For each event:
  - start from a hit pixel and adjoin neighboring hit pixels into a cluster
  - repeat for adjoined pixels, allow gap of one row/column
  - determine the weighted center pixel of a cluster
- Added analysis of mean:
  - cluster multiplicity
  - cluster size
  - cluster charge
- “Event display” for clusters

Single event display



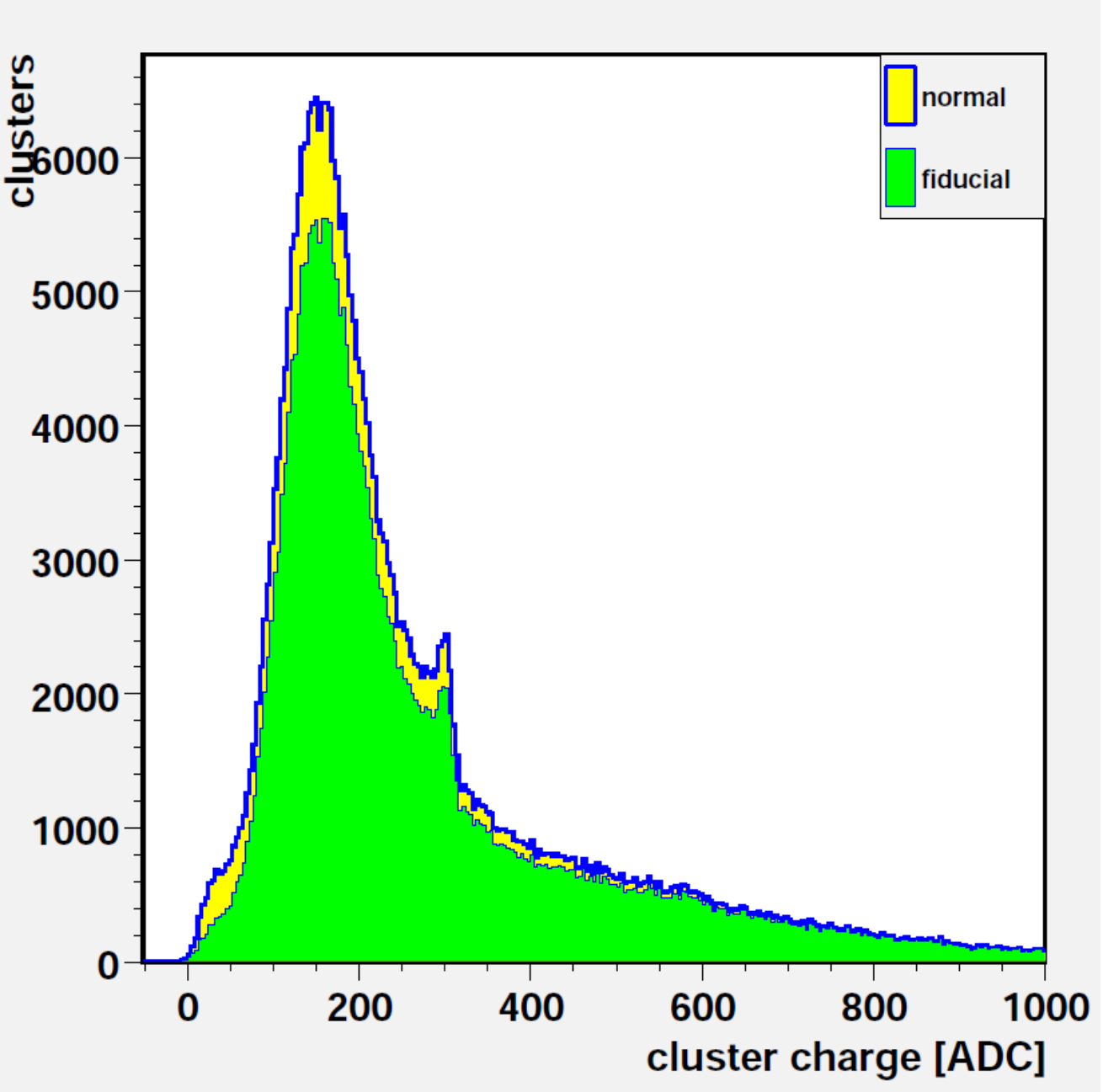
- Sample event
  - Ru 106 source
  - Chip 8
  - Clock stretch 1 ms
  - -100 V bias

Cluster analysis



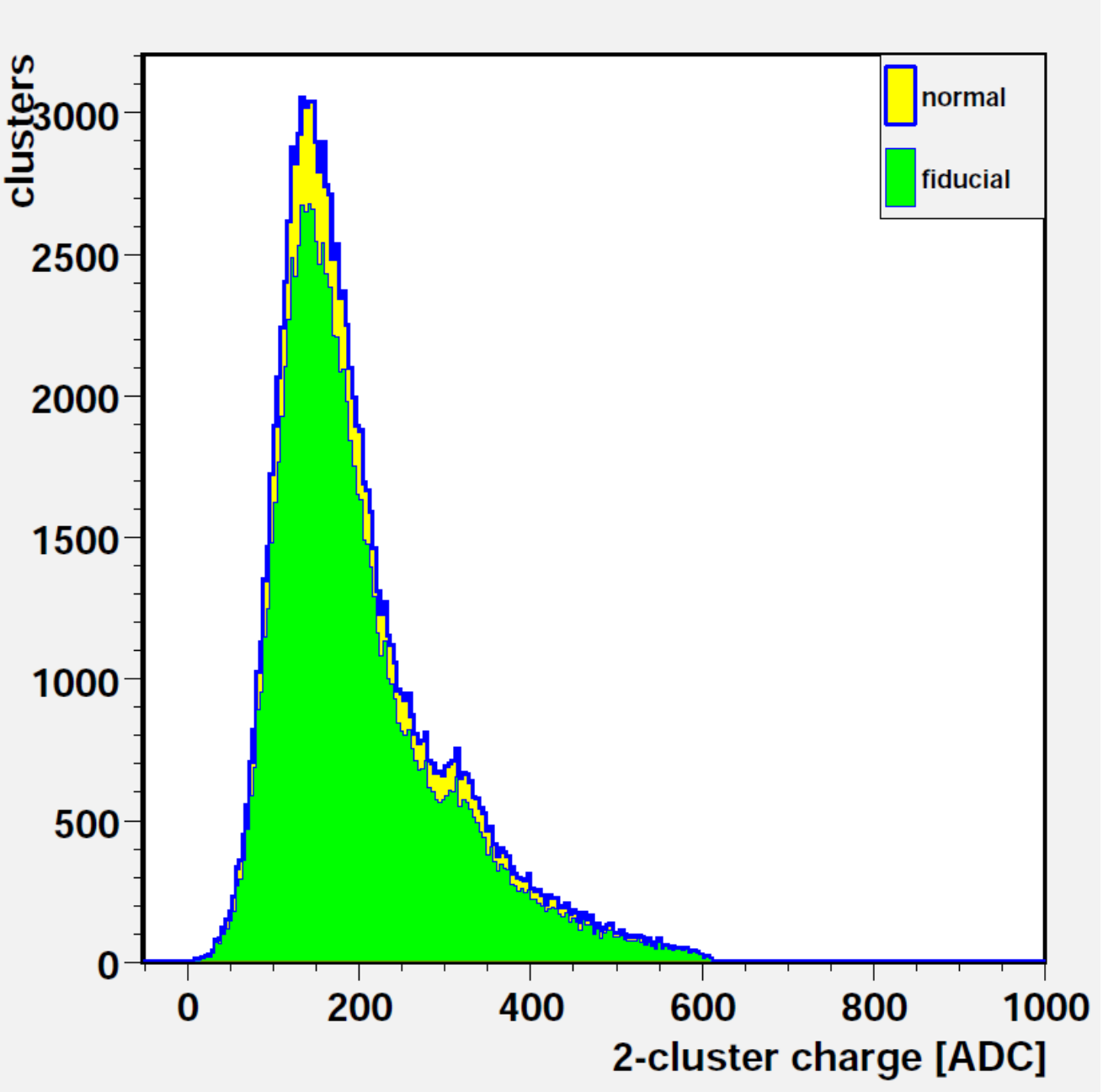
- Sample event
  - Ru 106 source
  - Chip 8
  - Clock stretch 1 ms
  - -100 V bias
- 9 clusters identified
- Black pixels indicate centers of clusters

Cluster charge distribution



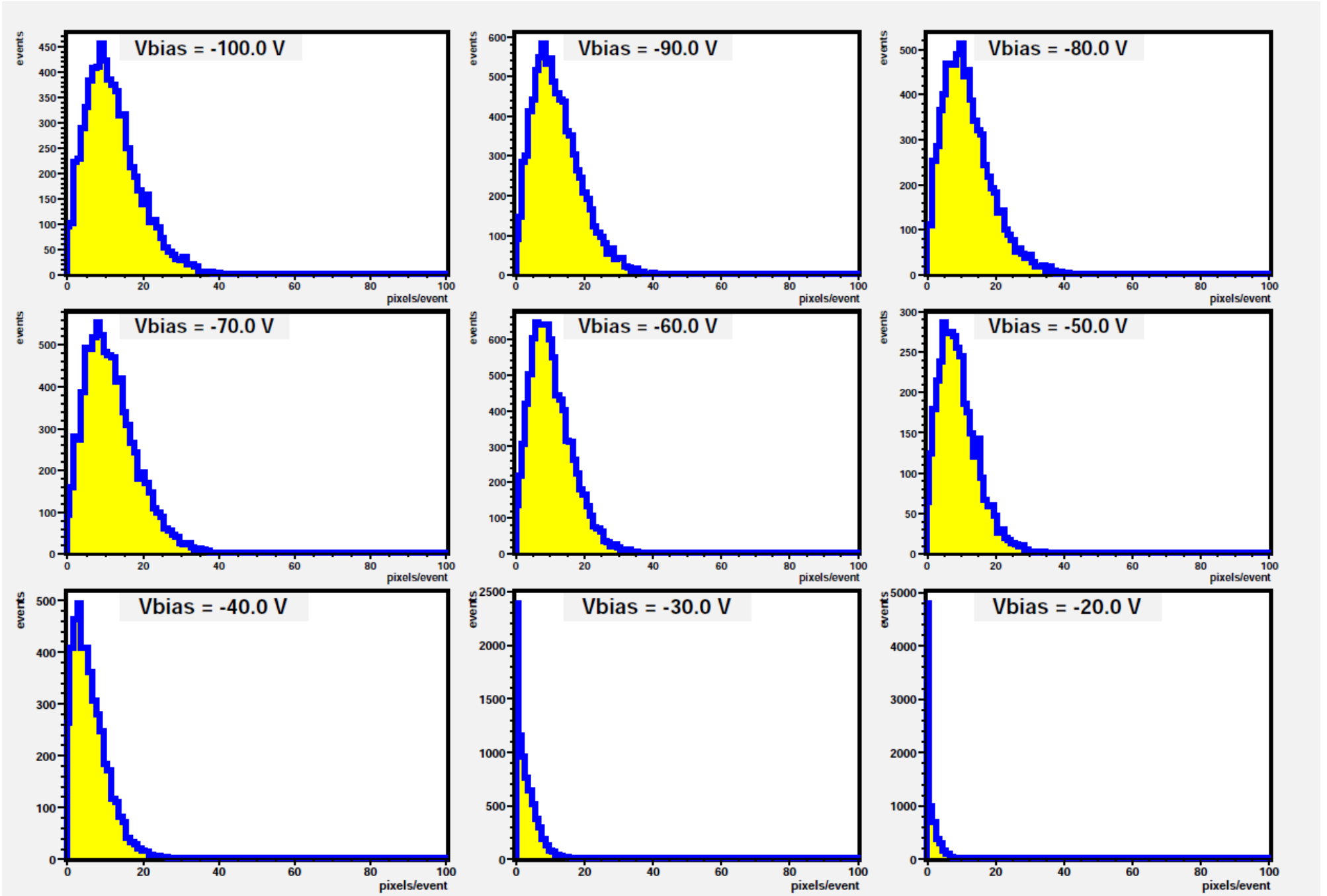
- Ru 106 source
- All Clusters
- Peak at 300: saturated pixel
- Cluster charge distribution affected by hits at the edges
- Fiducial: cluster center 2 pixels from the edge

Cluster charge distribution

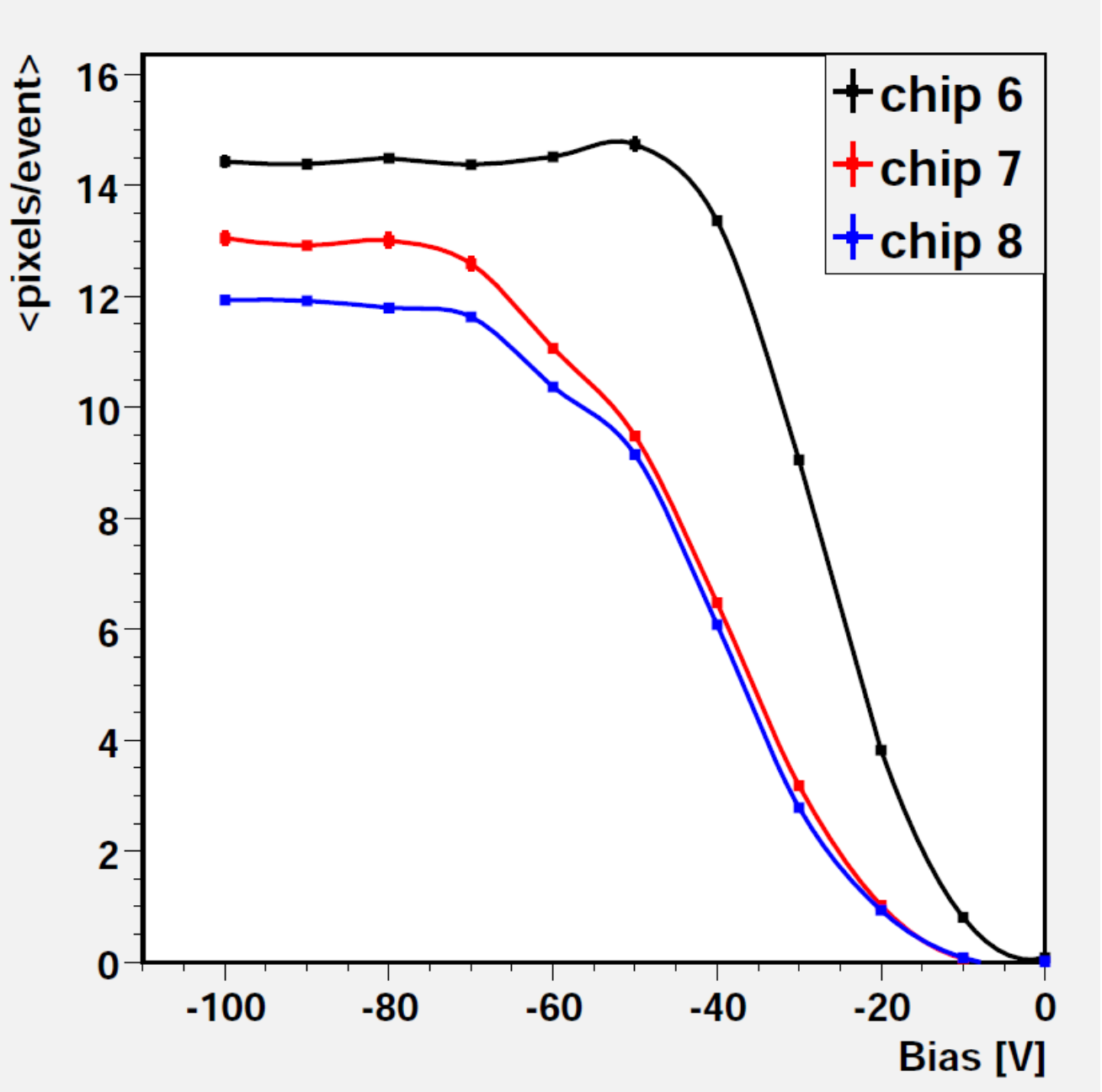


- Ru 106 source
- 2-pixel clusters
- Reduced peak at 300: saturated pixel
- Cluster charge distribution less affected by hits at the edges

Pixel multiplicity vs bias voltage

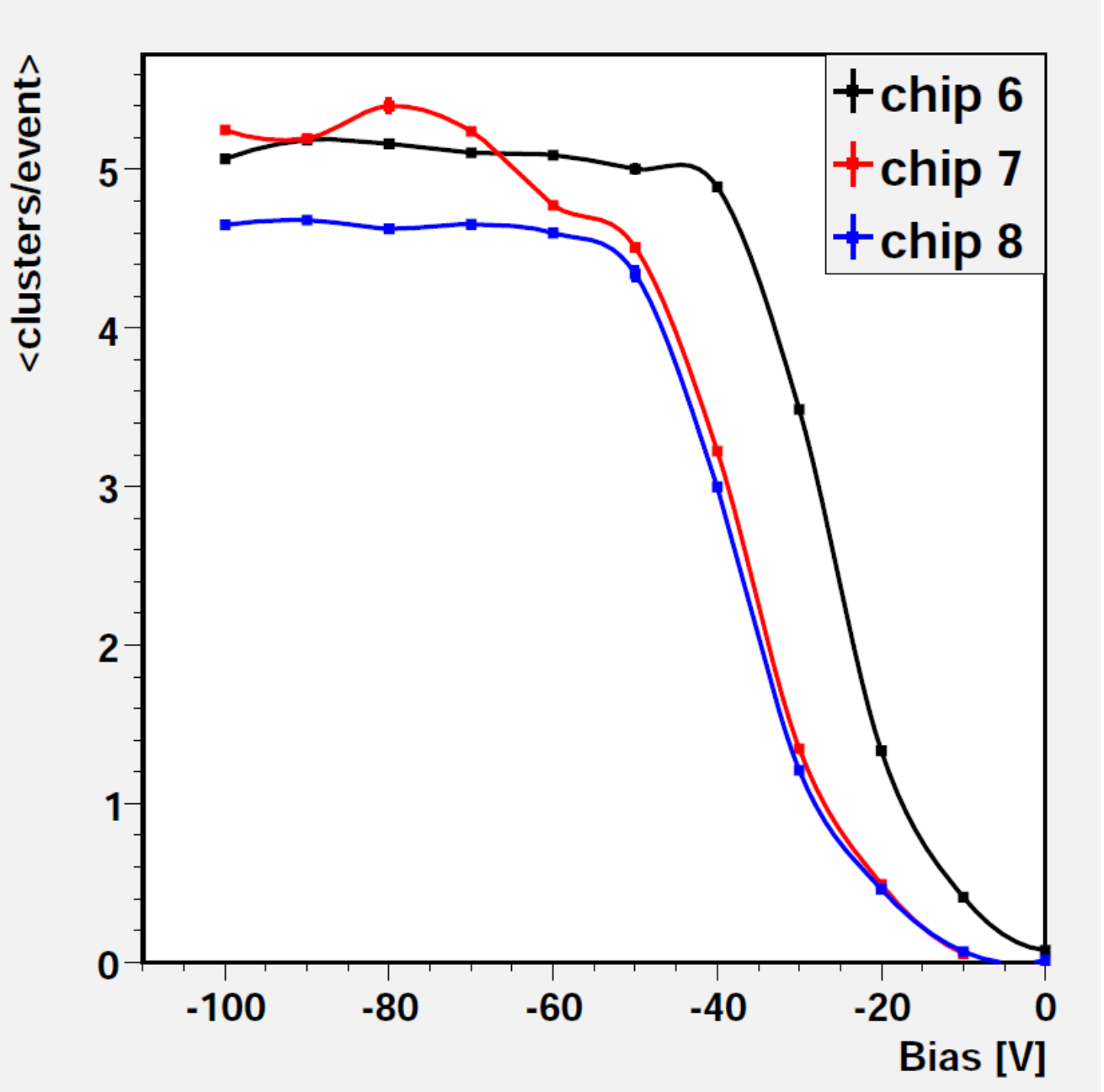


Pixel multiplicity vs. bias voltage



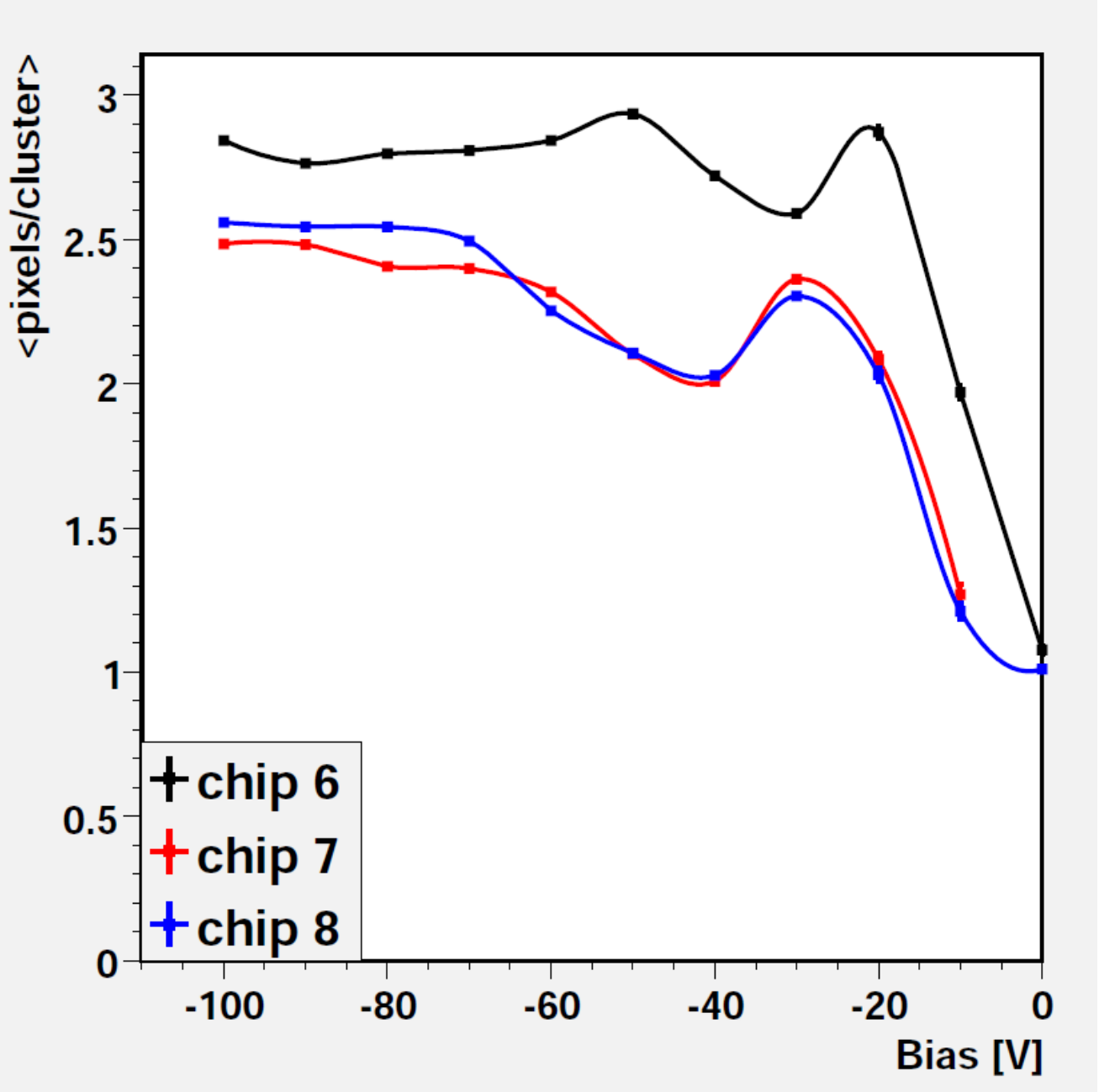
- All scans with:
  - Internal trigger
  - Clock stretch 1 ms
  - 10s run for one Vbias value
- Scans for chips 6, 7, 8
  - Thresholds from Alexey Petrukhin
- Full depletion below -70 V

Cluster multiplicity vs. bias voltage



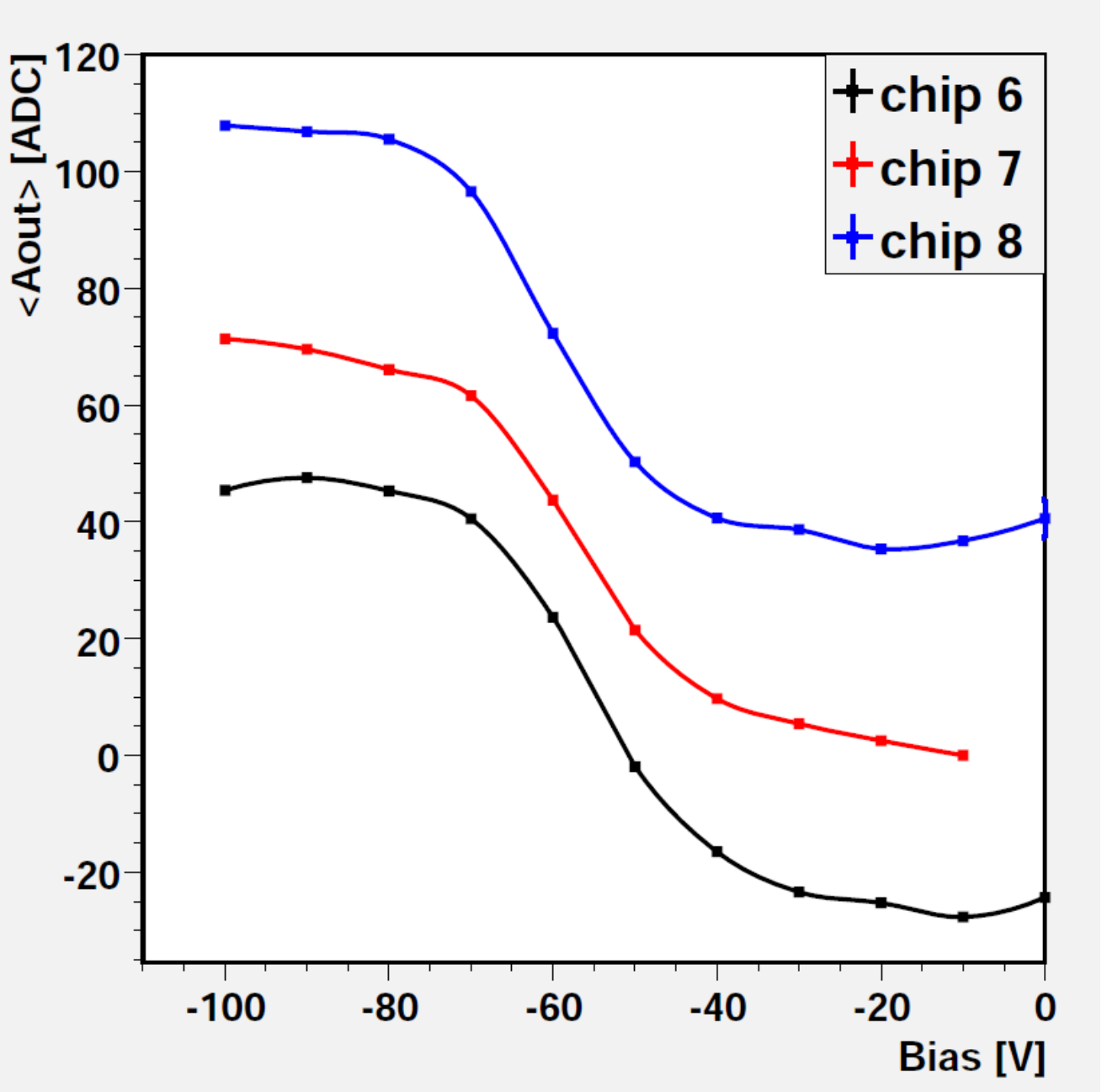
- All scans with:
  - Internal trigger
  - Clock stretch 1 ms
  - 10s run for one Vbias value
- Scans for chips 6, 7, 8
  - Thresholds from Alexey Petrukhin
- Cluster efficiency saturates below -50 V

Cluster size vs. bias voltage



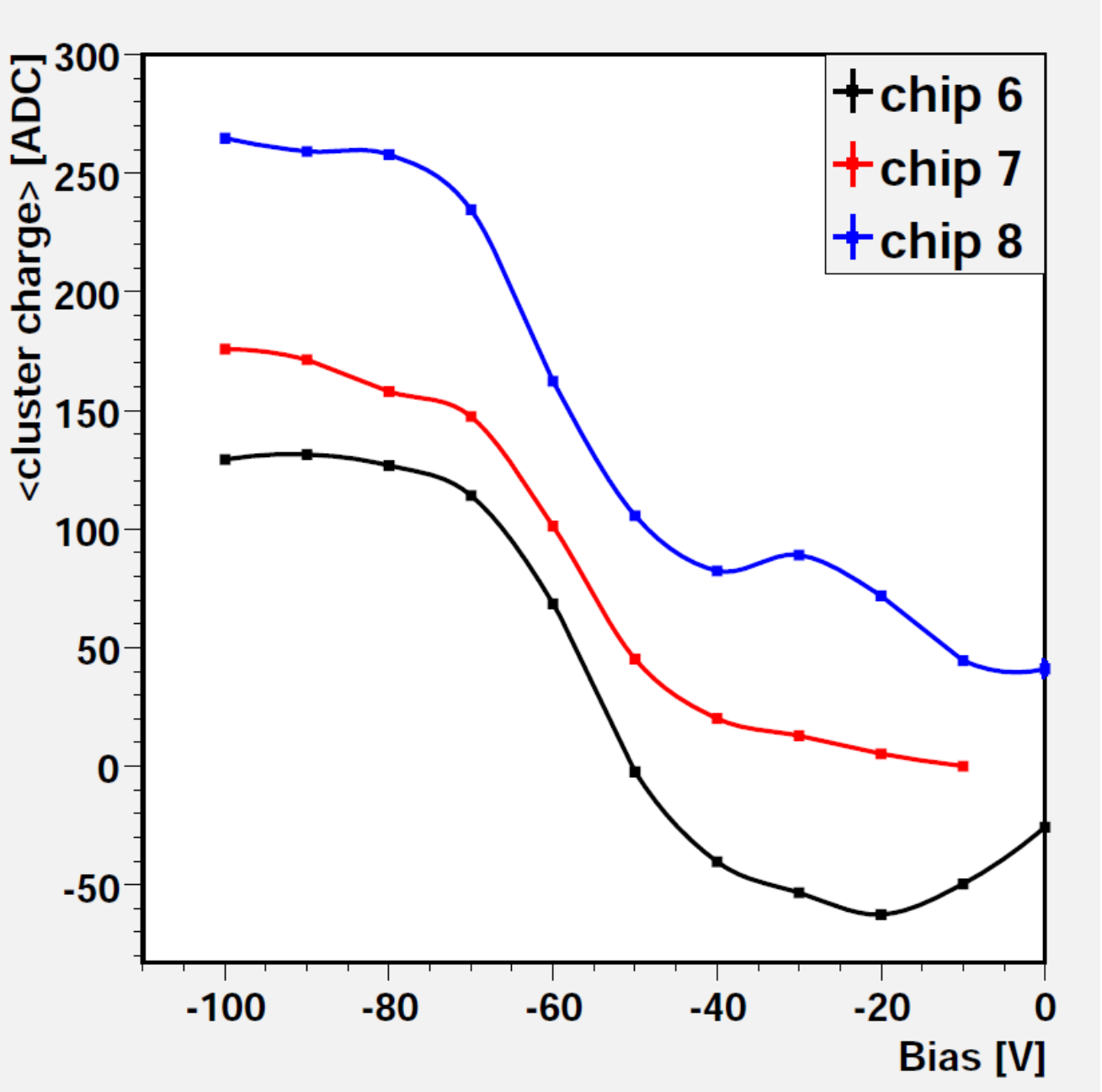
- All scans with:
  - Internal trigger
  - Clock stretch 1 ms
  - 10s run for one Vbias value
- Scans for chips 6, 7, 8
  - Thresholds from Alexey Petrukhin

Pixel charge vs. bias voltage



- All scans with:
  - Internal trigger
  - Clock stretch 1 ms
  - 10s run for one Vbias value
- Scans for chips 6, 7, 8
  - Thresholds from Alexey Petrukhin
- Analog gain and offset not equalized

Cluster charge vs. bias voltage

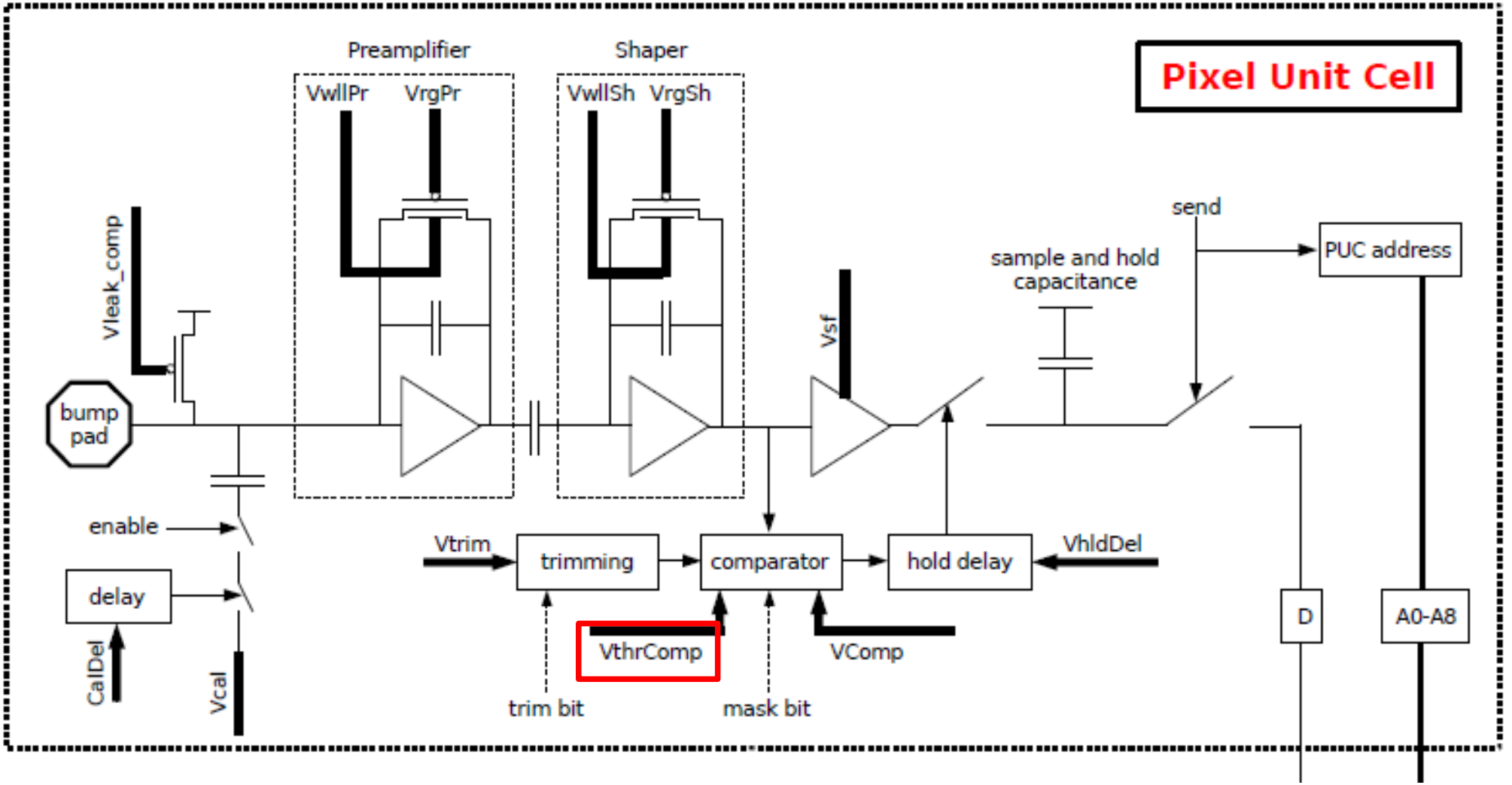


- All scans with:
  - Internal trigger
  - Clock stretch 1 ms
  - 10s run for one Vbias value
- Scans for chips 6, 7, 8
  - Thresholds from Alexey Petrukhin
- Analog gain and offset not equalized

Threshold scan

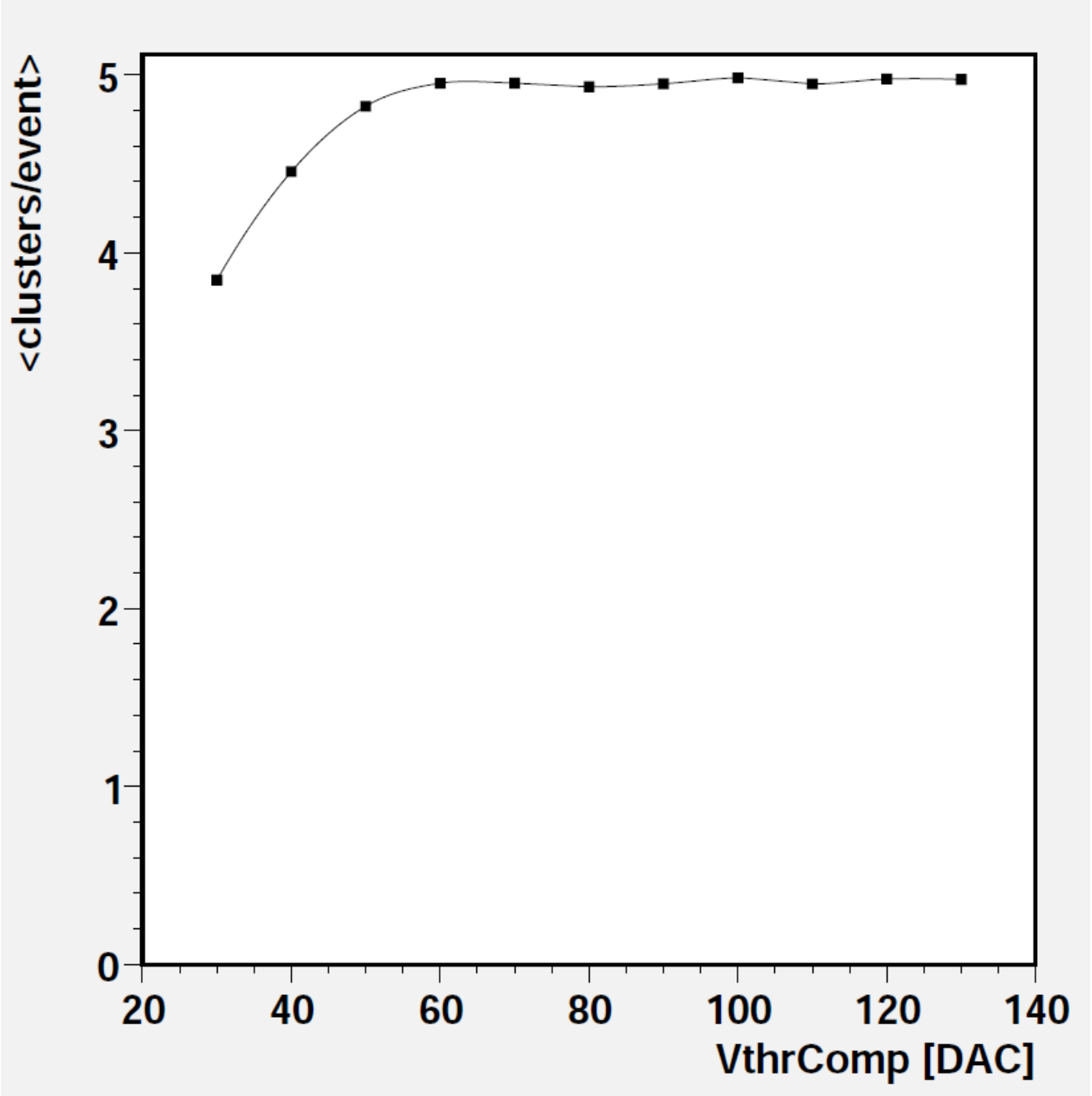
- Varied DAC parameter: VthrComp: common threshold
- Values [DAC] range:
  - From 30 – highest threshold
    - No hits recorded for higher thresholds
  - To 130 – lowest threshold
    - Empty readouts for lower thresholds → buffer overflows, internal reset
- Bias voltage fixed at -90 V
- Lowered source position
  - ~2x rate increase
- Internal trigger
  - Clock stretch 0.5 ms to keep same multiplicity. 1.8 kHz trigger

psi46 pixel readout chip



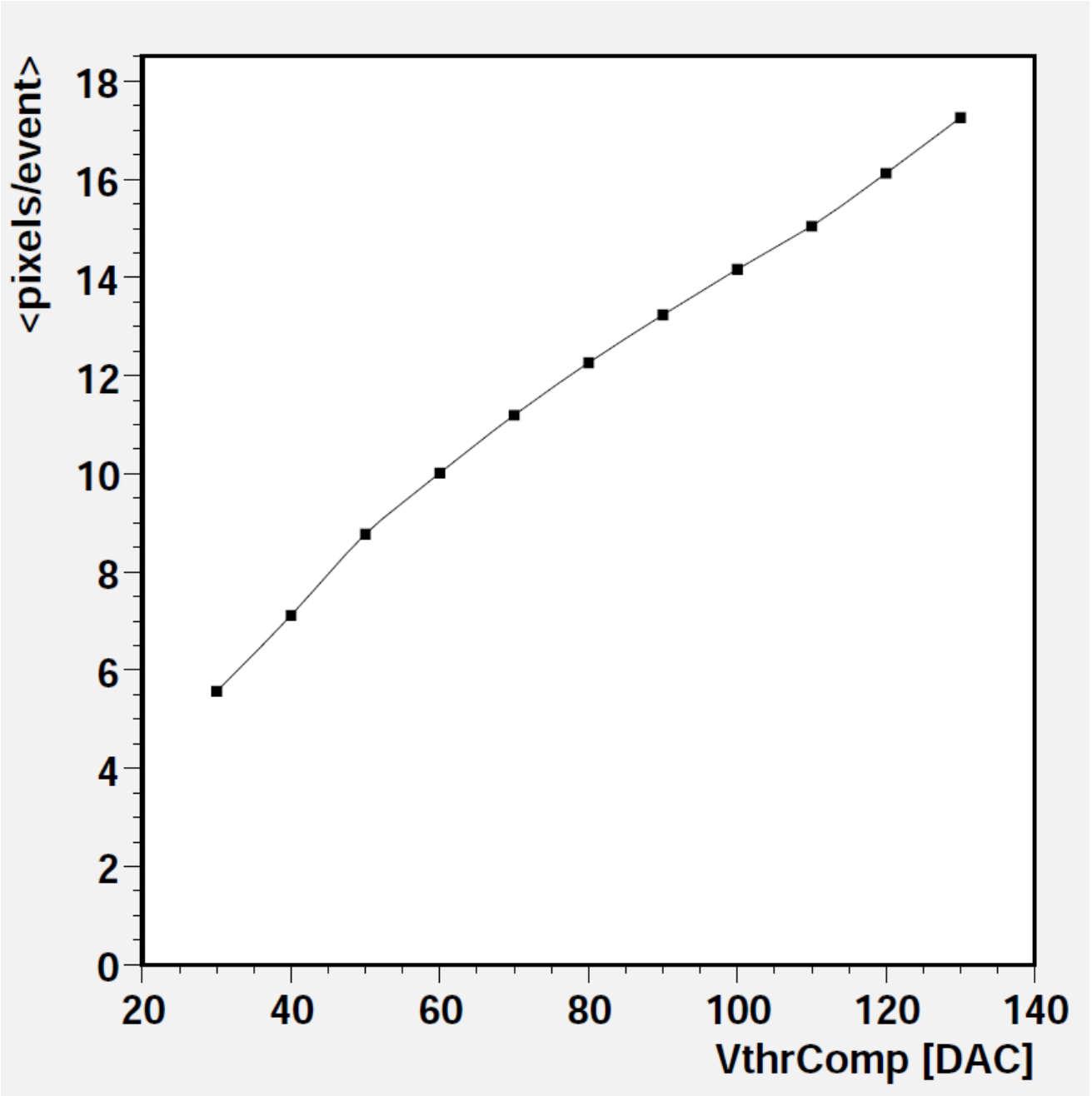
adjustable by programmable DAC, per ROC

Cluster multiplicity vs. threshold



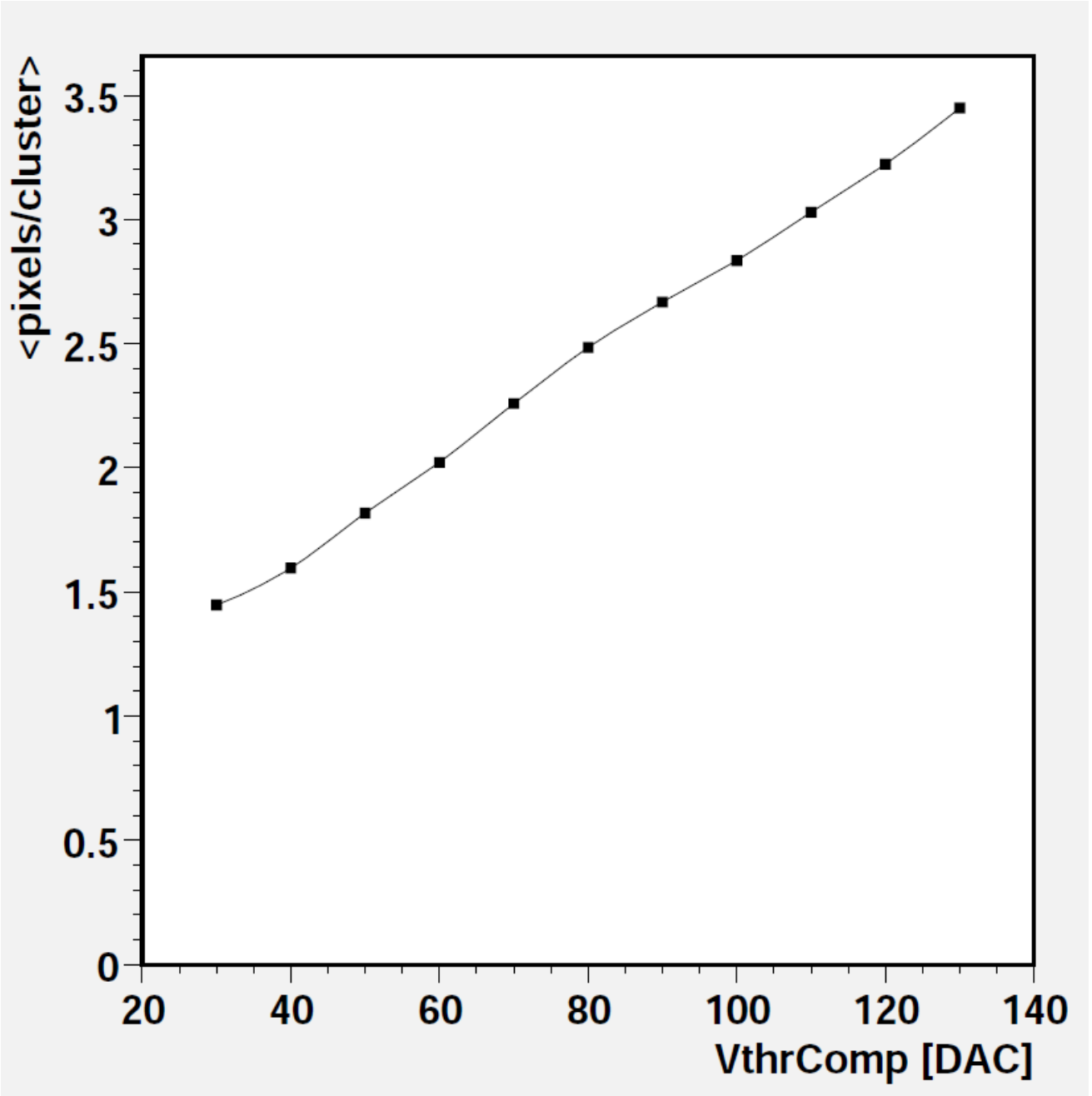
- scan with:
  - Chip 8
  - Ru 106 source
  - Internal trigger
  - Clock stretch 0.5 ms
  - 10s runs
  - Vbias -90 V
- Mean number of clusters stable for thresholds above 60 DAC

Pixel multiplicity vs. threshold



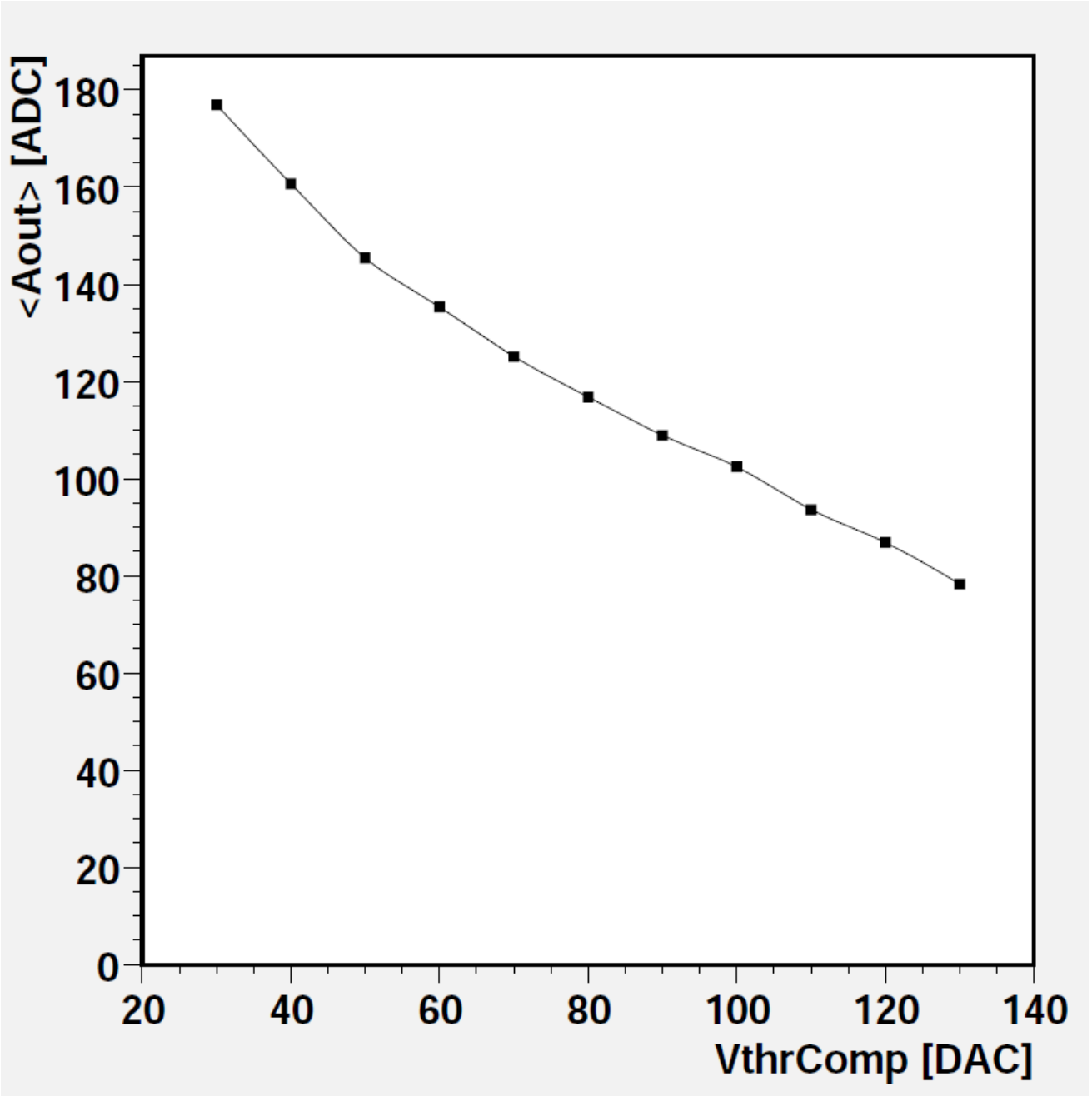
- scan with:
  - Chip 8
  - Ru 106 source
  - Internal trigger
  - Clock stretch 0.5 ms
  - 10s runs
  - Vbias -90 V
- Pixels in the halo of clusters continue to grow

Cluster size vs. threshold



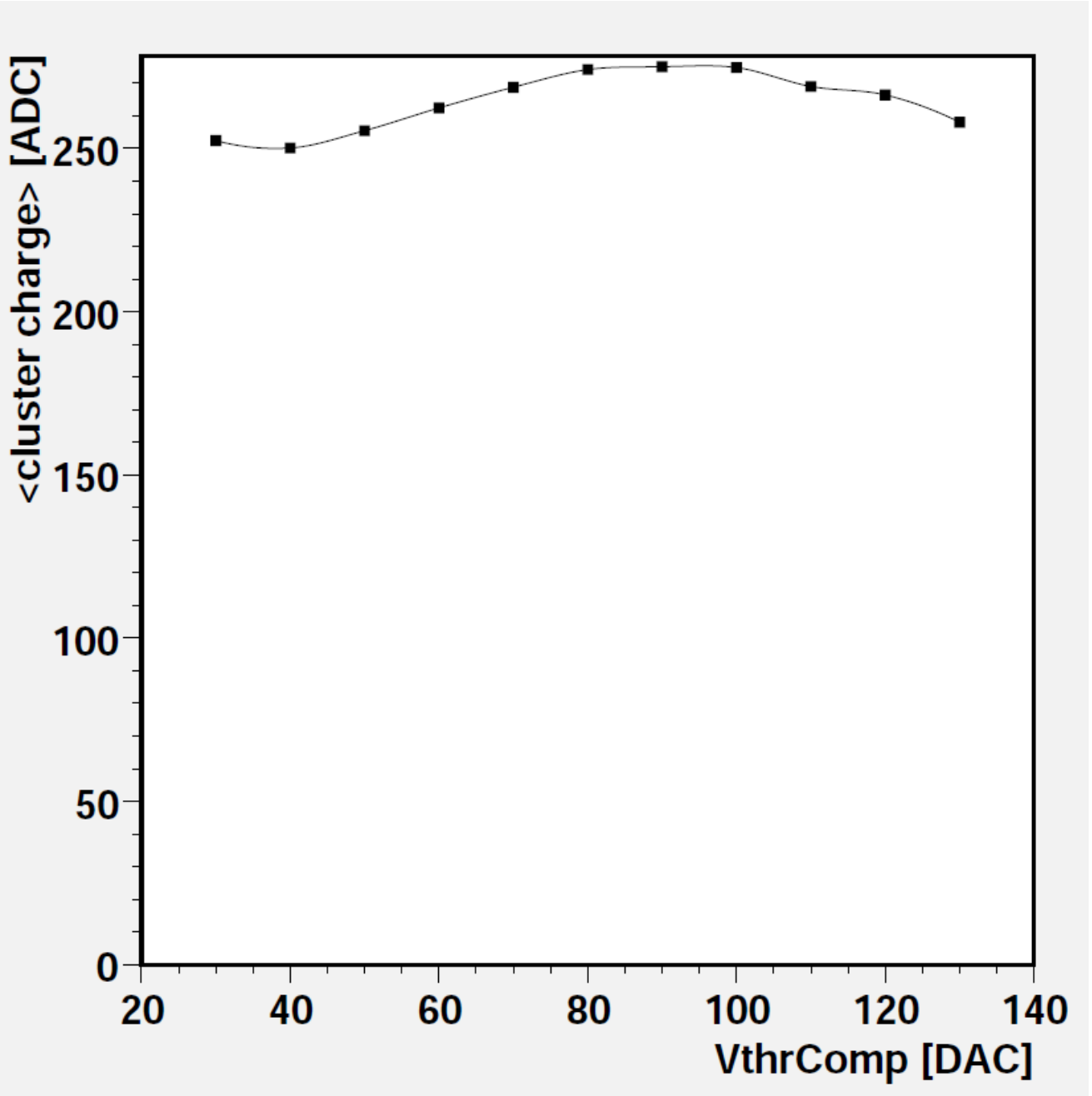
- Linear growth of clusters with softer threshold

Pixel charge vs. threshold



- Low amplitude pixels appear with softer threshold

Cluster charge vs. threshold



- Stronger threshold → clusters lose some pixels
- A small drop at weak threshold?

Status

- Software for source tests ready
  - Chips 6,7 and 8 tested
- Problems with corrupt readouts still present
  - They are masked out for analysis

Plans for the Testbeam

- Use external scintillator trigger (E. Garutti)
- 3 GeV positrons, ~ 4 kHz trigger rate measured in TB 21 (I. Gregor)
- H. Maser prepared support frame for the testboard
- Measure pulse height for each pixel
  - Uniformity test
- Threshold scan
- Delay scan

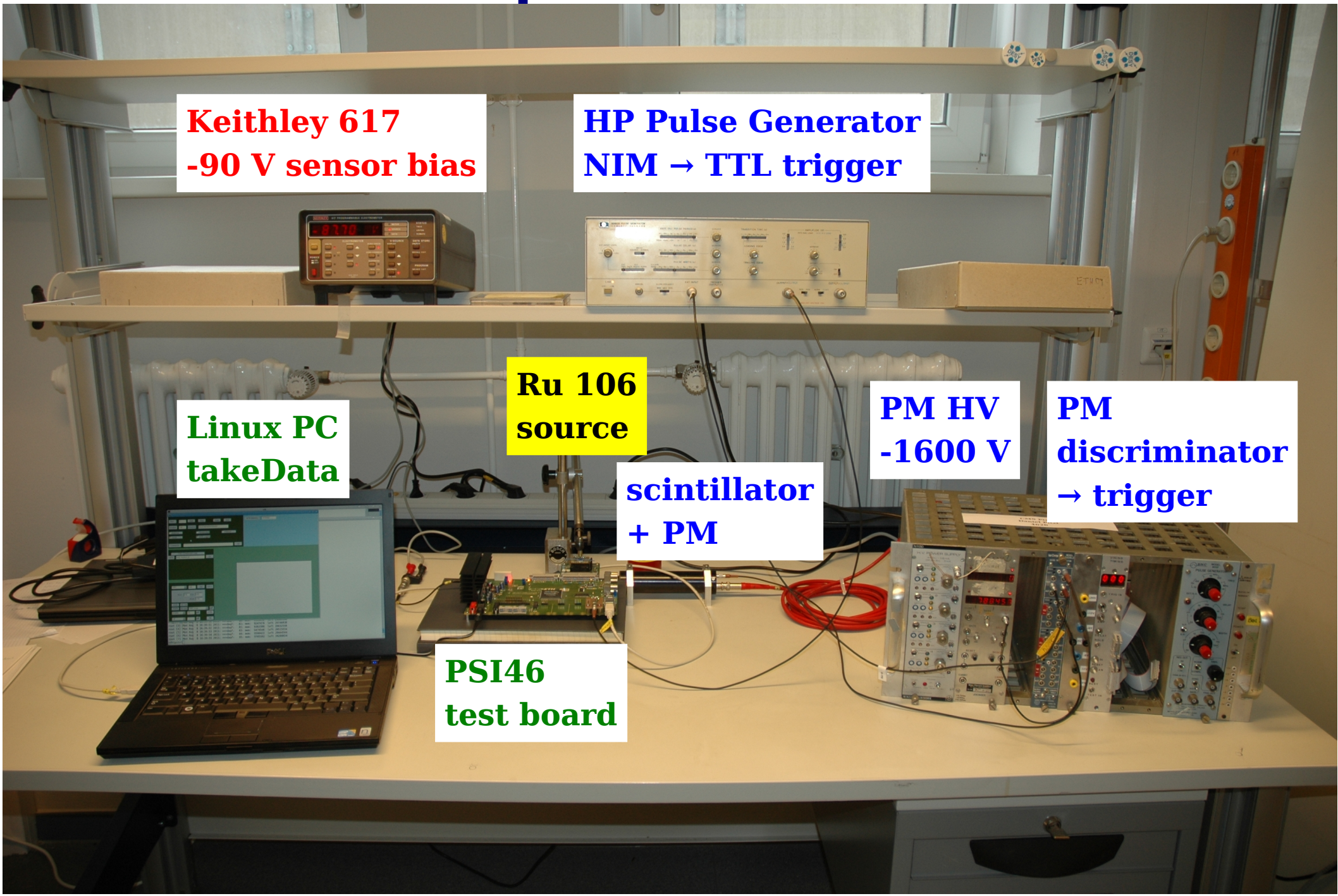
Acknowledgements

- Uli Koetz (DESY):
  - lab space, NIM crate and modules, scope
- Erika Garutti (DESY and Uni HH):
  - finger scintillator and PM.
- Torsten Külper:
  - TTL trigger adapter.
- Beat Meier (PSI), Thomas Weiler (KIT), Tilman Rohe (PSI):
  - code and advice.
- Carsten Niebuhr (DESY):
  - Strahlenschutzunterweisung
- Wladimir Hain (DESY):
  - source
- Carsten Muhl (DESY):
  - source holder

Source and detector

- $Ru^{106} \rightarrow Rh^{106} \rightarrow Pd^{106}$:
  - pure beta emitter,
  - E_{max} 3.54 MeV,
  - half life 1.02 y,
  - DESY Ru source #1032 has ~15 kHz activity today (scintillator).
- PSI46 ROC (v 2.4) from 2005 (chip 6)
  - bump bonded at PSI to a baby pixel sensor.

Setup in 1d EG 408



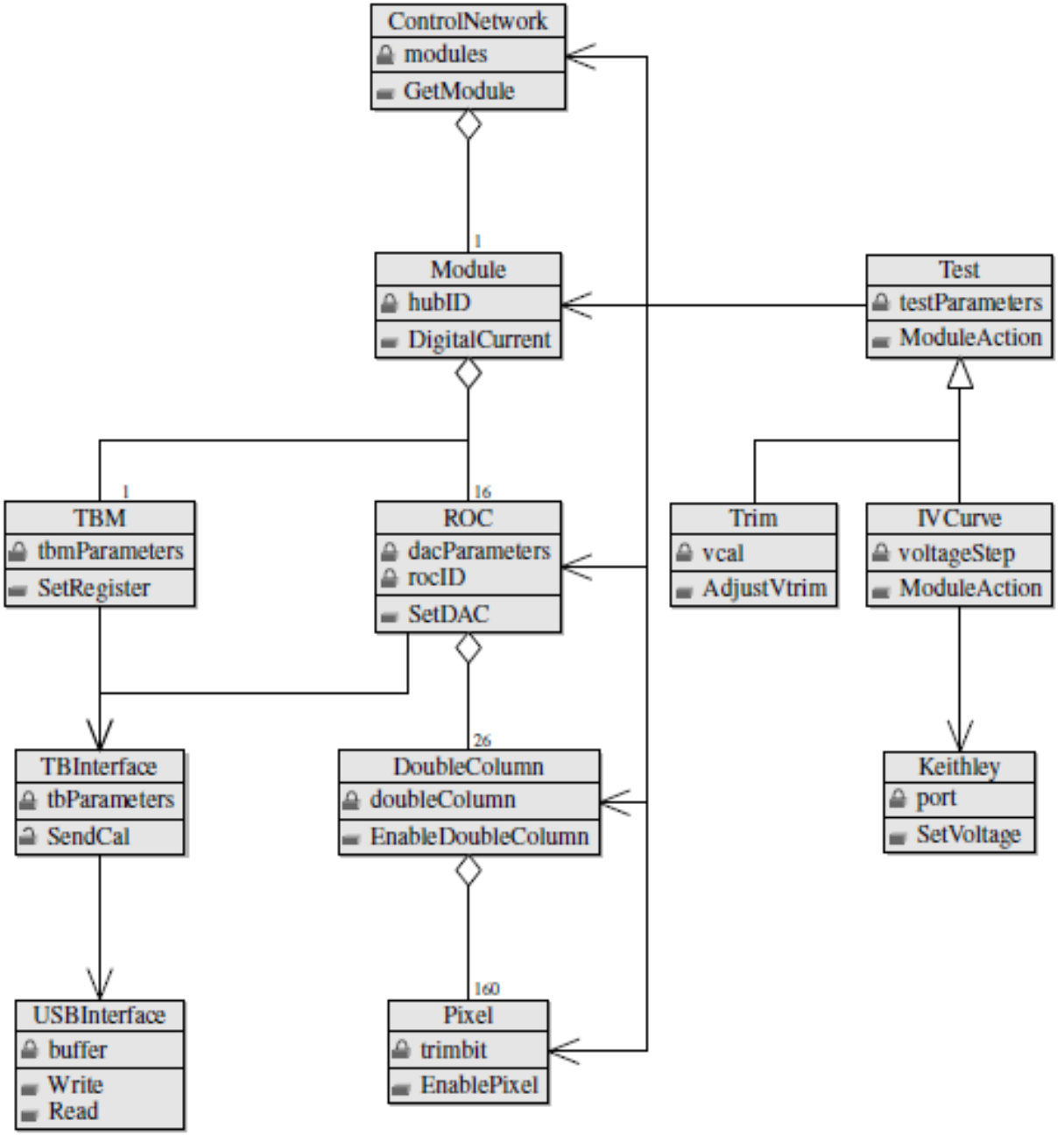
Software

- PSI test board with Aug 2010 FPGA firmware (v 6.1)
- Single ROC (no TBM emulator)
  - settings for the 28 ROC DACs determined by A. Petrukhin.
- takeData code from PSI under 64 bit Linux:
  - Run for up to 300 seconds (memory limit).
  - FPGA generates reset – clock stretch – trigger – token sequence at up to 1 kHz.
  - Raw data from ROC are stored in 64 MB memory.
  - transfer memory via USB (0.44 MB/s), store as binary file.
- Process binary file:
  - decode raw data: header, pixel address, pulse height.
  - (cluster finding code to be written…).
  - fill ROOT histograms.

PSI46 test board trigger modes

- External trigger:
  - used in CMS
  - needed for test beam
  - source test with penetrating beta rays
- Internal trigger:
  - generated on the test board
  - needed for X-ray source test
  - allows stretching of the clock by up to $2^{16} \times 25$ ns =1.64 ms for increased efficiency
  - reached up to 89% duty cycle: 890 Hz with 1 ms clock stretch.
- Timing:
  - board trigger delay tct = 103 BC after stretched clock cycle.
  - ROC bunch crossing pointer WBC = 100.

psi46expert software



- C++ class library.
- Written by Peter Trüb (ETH, 2005-2007) for Scientific Linux (32 bit).
- Now compiled with g++ 4.4.5 under Ubuntu 10.10 (64 bit).
- USB interface required some changes (long → int).
- Lot's of code – only a small portion explored so far...