The Silicon TPC System

EUDET Extended SC meeting

31 August 2010

Jan Timmermans

NIKHEF/DESY

SITPC Tasks:

- ✓ Develop the Timepix chip that allows to measure the 3rd coordinate (drift time)
- ✓ Implementation of Timepix together with GEM and Ingrid into diagnostic endplate system (with GEM working; with Ingrid in progress)
- ✓ Performance measurements in test infrastructure at DESY (analysis GEM+Timepix data in progress)
- ✓ Develop simulation framework (continues)
- ✓ Develop DAQ system and integrate in overall DAQ of EUDET infrastructure (first used in June'09; now also under test with EUDET and ZEUS telescope)

Partners:

ALU Freiburg, Bonn, CEA Saclay, CERN, NIKHEF

Milestone/deliverable has 3 ‘legs’:

- one LP endplate module with triple-GEM (Bonn/Freiburg) read out by system of 2x4 Timepix chips; operational June’09 in T24; further test on LP later this year
- one LP endplate module with 8 Ingrids, a Micromegas-like integrated grid (Saclay/Nikhef), on 8 Timepix chips; operational in gas test box, some HV instabilities; a new set of 8 Ingrids being prepared; test on LP-TPC later this year
- One (or more) small detector(s) with ‘Quad’ Ingrids = “traveling infrastructure”; detector with 4 Ingrids ready, RO problems being investigated

All groups have established contacts with outside institutions for 8” wafer scale post-processing:

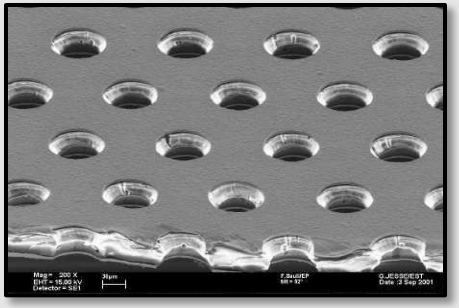
- Freiburg Metallforschungszentrum (pixel enlargement)
- IZM Berlin: Ingrid/GEMGrid technology
- SMC (Scottish Microelectronics Centre) Edinburgh: Ingrid technology
- LAAS (CNRS) Toulouse (max. 6” wafers)

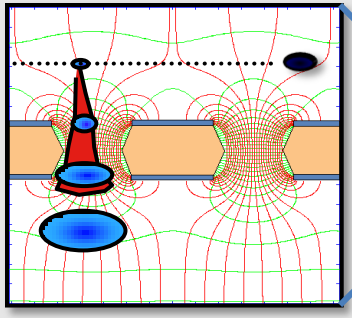
SITPC TA plans and future

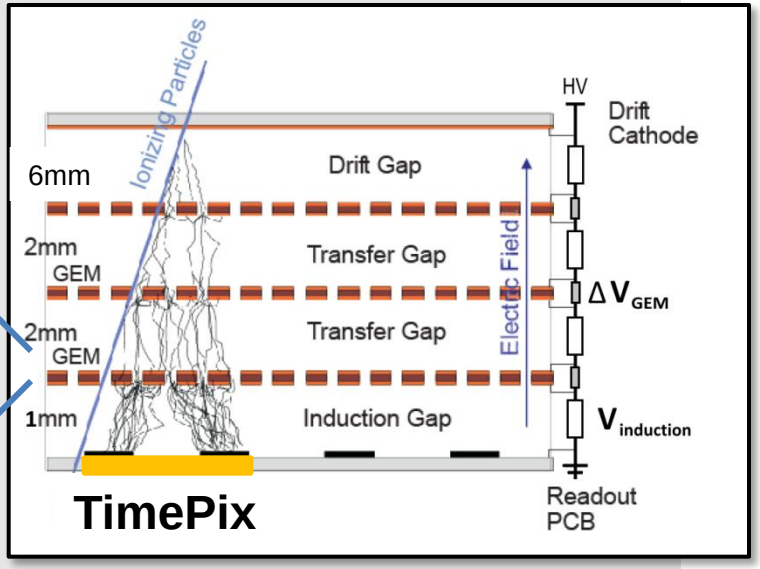
- GEM + (2 x 4) Timepix in LP endplate module (Bonn) under test in June 2009 @ DESY. Can be made available also with standalone gas testbox. Full LP module with >100 Timepix under study
- 8 x (Ingrid + Timepix) in LP endplate module (Saclay + Nikhef) under test; (expected) fall 2010 @ DESY. Can be made available also with standalone gas testbox.
- 4 x (Ingrid + Timepix) in small standalone detector(s) @Nikhef (possible in 1T magnet) and elsewhere. Worked for 3 days in DESY T21 beam in March 2010; RO problems. Will become available again (?)
- 64 x (Ingrid + Timepix) system with “Relaxed readout” planned @Nikhef

Test Setup

GEM Setup





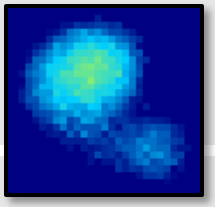


GEM+TimePix

charge is spread over *several pixels* *(>50)*

Consequences

- few e^- per channel (strong diffusion effects within the GEM-stack)
  high gas gain necessary for detection of *MIPs*



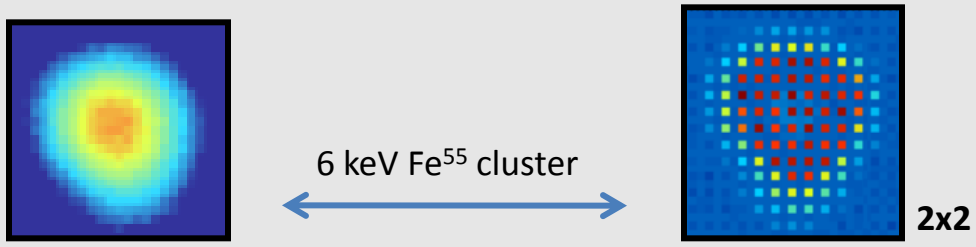
Post Processed chips

Postprocessed chips (IZM)

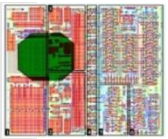
- **1x1:** metallization extended from ≈20x20 µm² to ≈50x50 µm²
- **2x2:** 3 of 4 pixels passivated, then metalized pixel size 105x105 µm²

Motivation: enlarged pixels

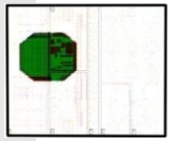
- more charge per pixel
  → higher probability of detection
- less gas amplification needed → fewer positive Ions
- optimization of spatial resolution vs. pixel size



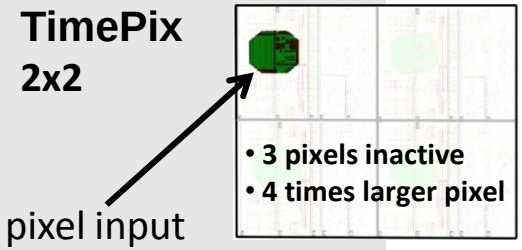
TimePix (original)

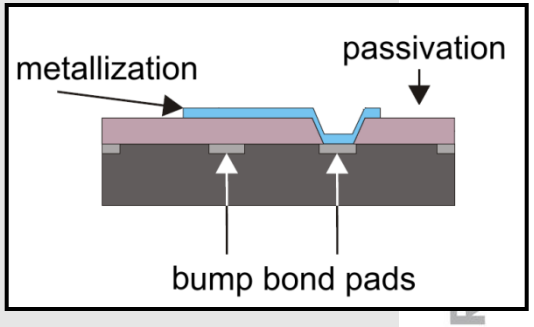


TimePix 1x1



TimePix 2x2





profile of postprocessed pixels

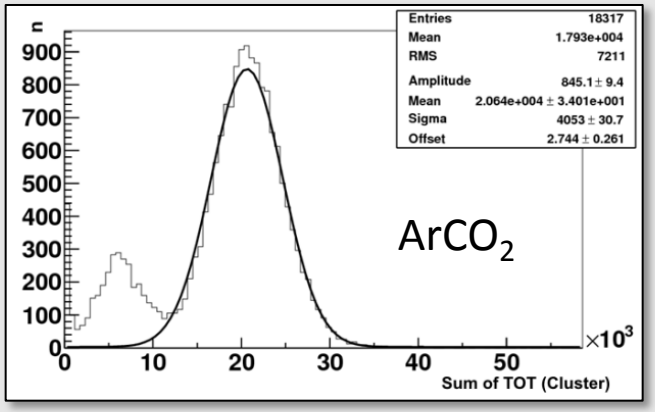
universitätbonn

UNI FREIBURG

Gain studies and Crosstalk

Setup

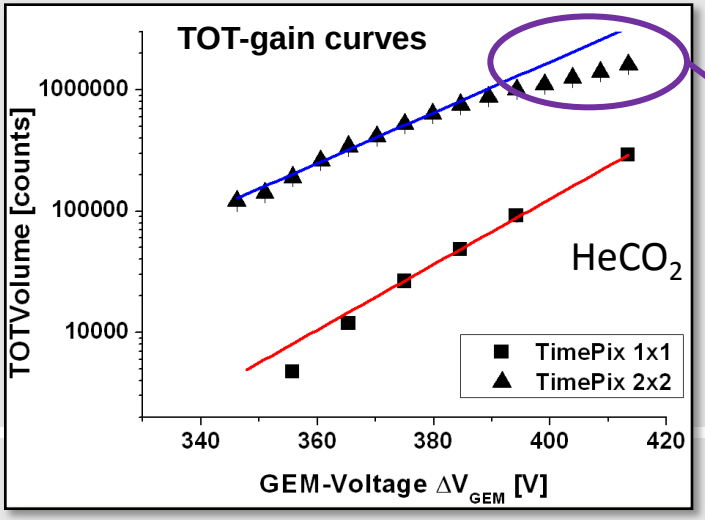
- gas: $HeCO_2$/ Fe55 (6 keV photons)
- 1x1 and 2x2 with similar thresholds

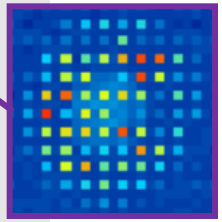


Procedure

- find clusters
- sum up the *TOT* values of the pixels (TOT - counts clock cycles above a chosen threshold)
- fit gauss (peak)
- take mean = *TOTVolume*

drop caused by crosstalk of pixels





Fe55-source
Volt./GEM: 385V
2x2 all pixels

Conclusion

with pixel enlargement:

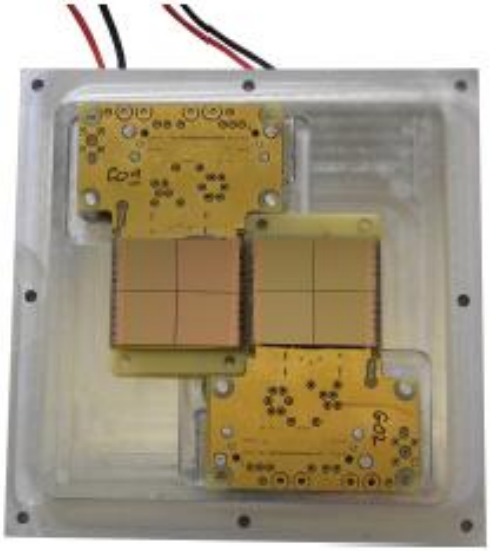
→ less gas gain needed

Detector Module

Bonn + Freiburg

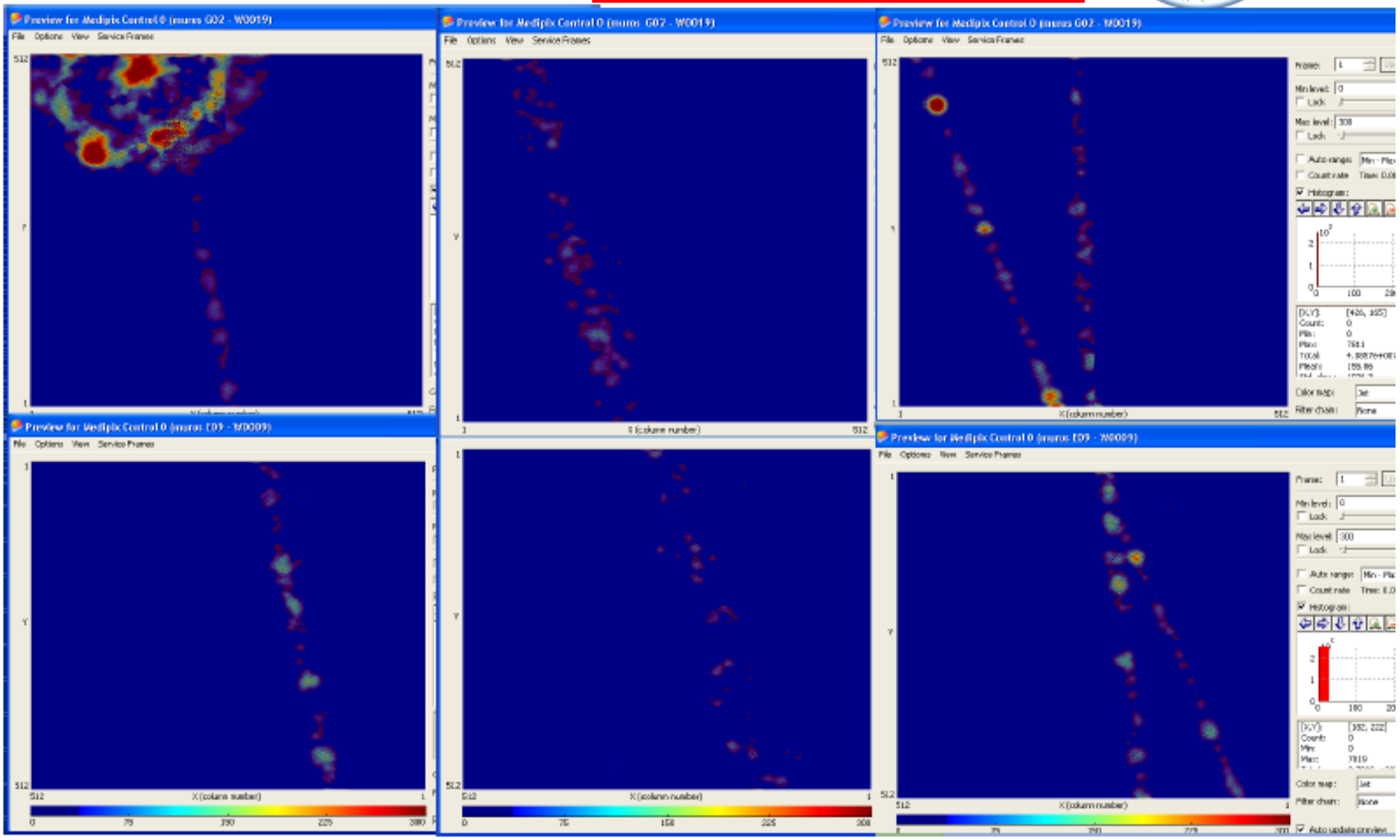
Gas Amplification Stage: stack of 3 GEMs
Readout: 8 Timepix chips + 2 MUROS
Gas Mixture: He:CO_2 70:30 and Ar:CF_4:iButan 95:3:2

A large set of data was taking varying the track inclination, particle momentum, drift distance, gas gain and magnetic field.



Example Tracks

Bonn + Freiburg



Drift Distance 10 cm

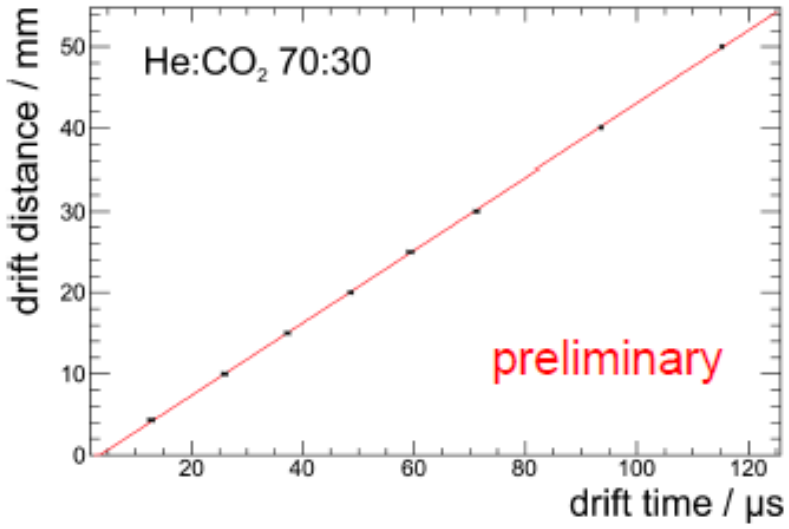
Drift Distance 50 cm

Drift Distance 4 cm

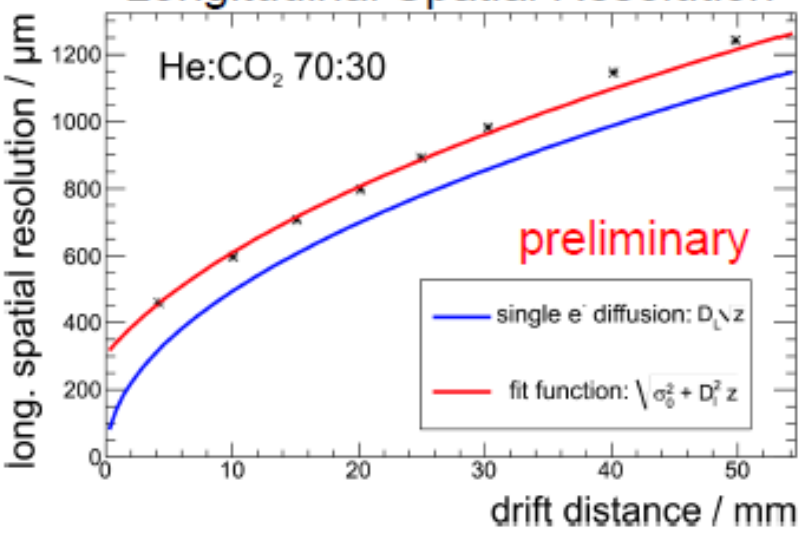
Results

Bonn + Freiburg

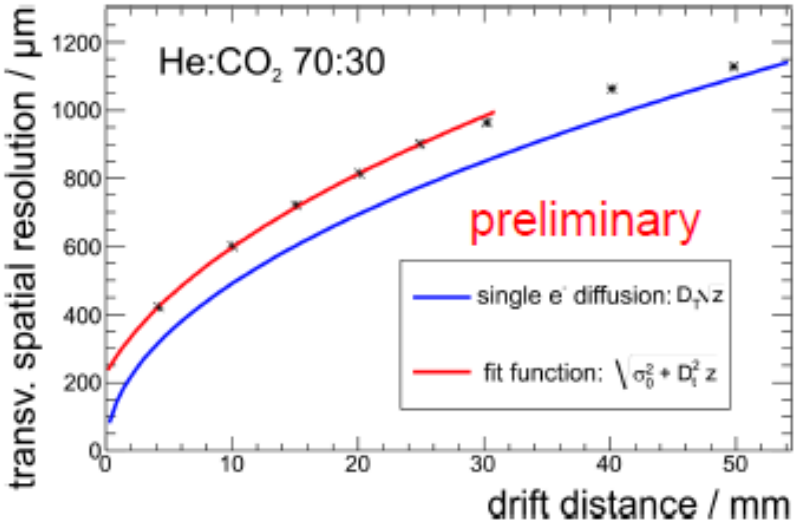
Determination of Drift Velocity

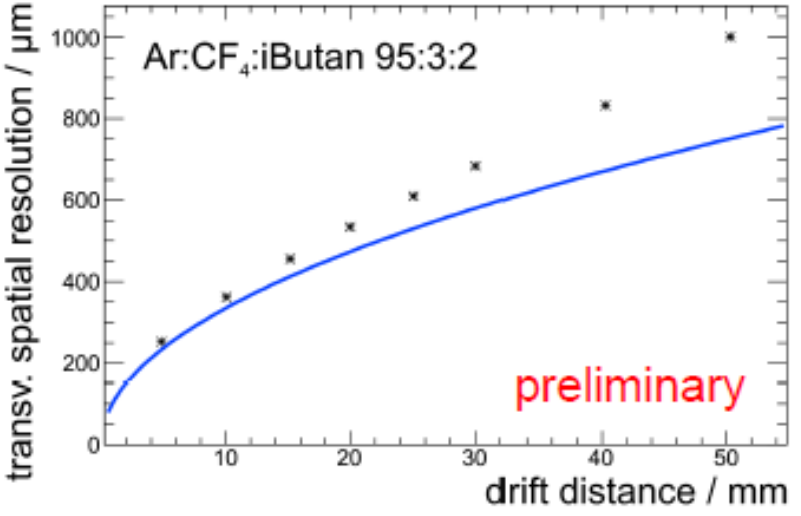


Longitudinal Spatial Resolution



Transverse Spatial Resolution





Outlook

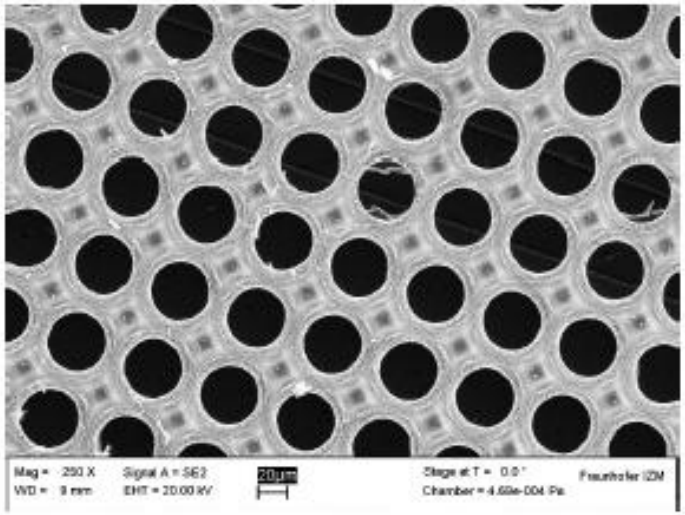
Bonn + Freiburg

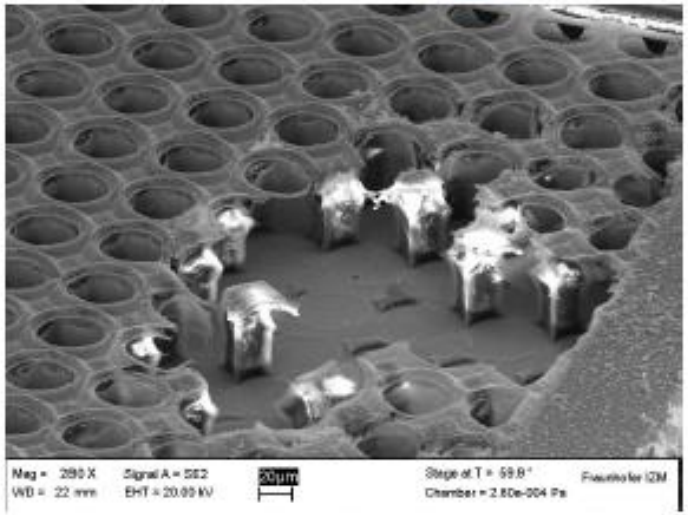
Detector was damaged after last run.
Repair work has been finished,
the chips are now being calibrated,
the detector will be reassembled soon and then shipped to DESY.

Another test beam campaign is under consideration to benefit from the improved LP setup.
(i.e. get rid of magnetic field inhomogeneities)

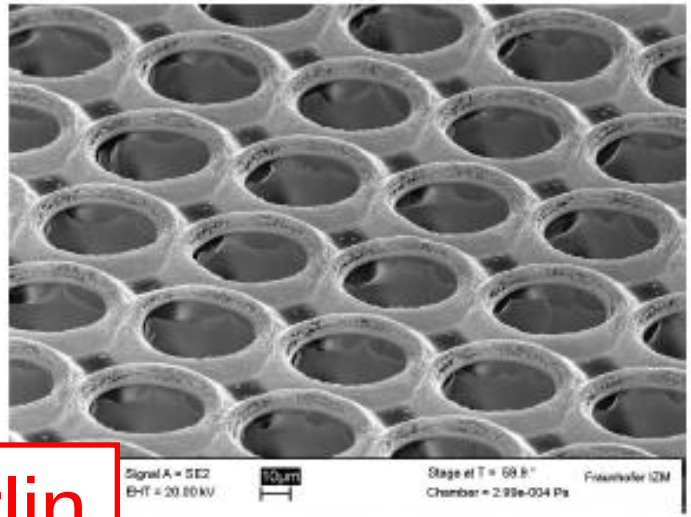
SEM-Pictures of First Dummies

GEMGrid





Pitch of the holes is 55 µm.

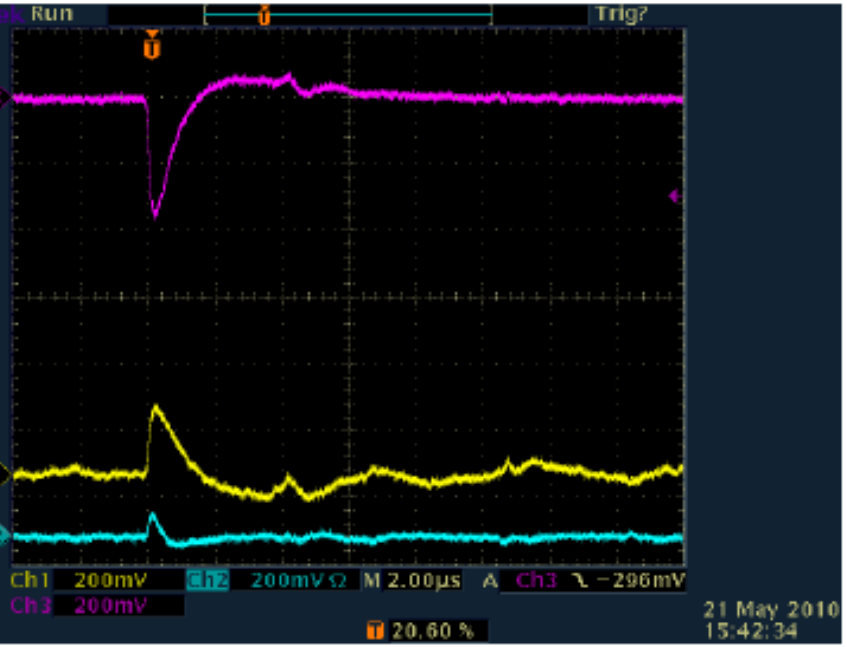


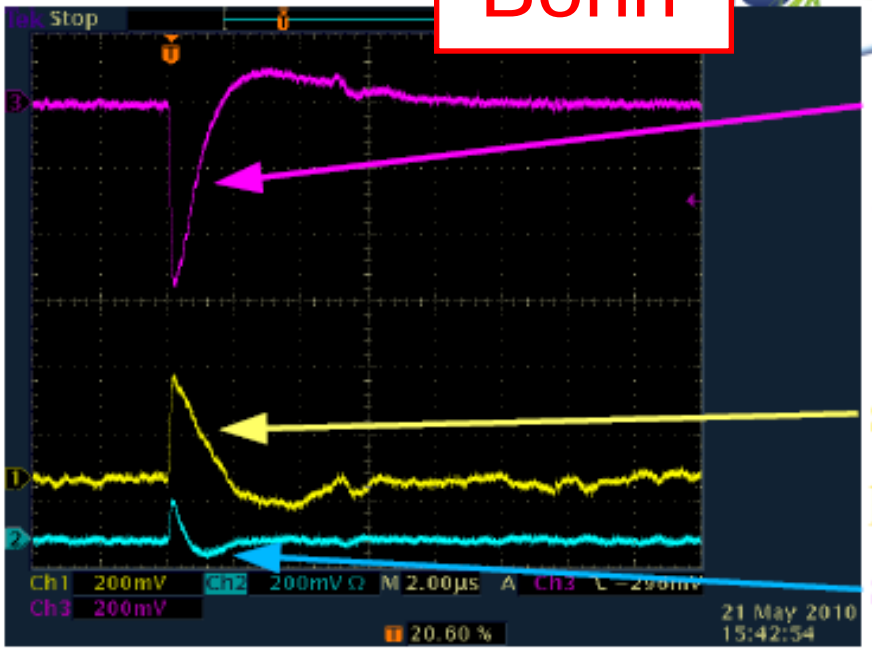
Small walls (2-3 µm) around the holes.

Bonn + IZM Berlin

First Signals with ^{90}Sr-source

Bonn

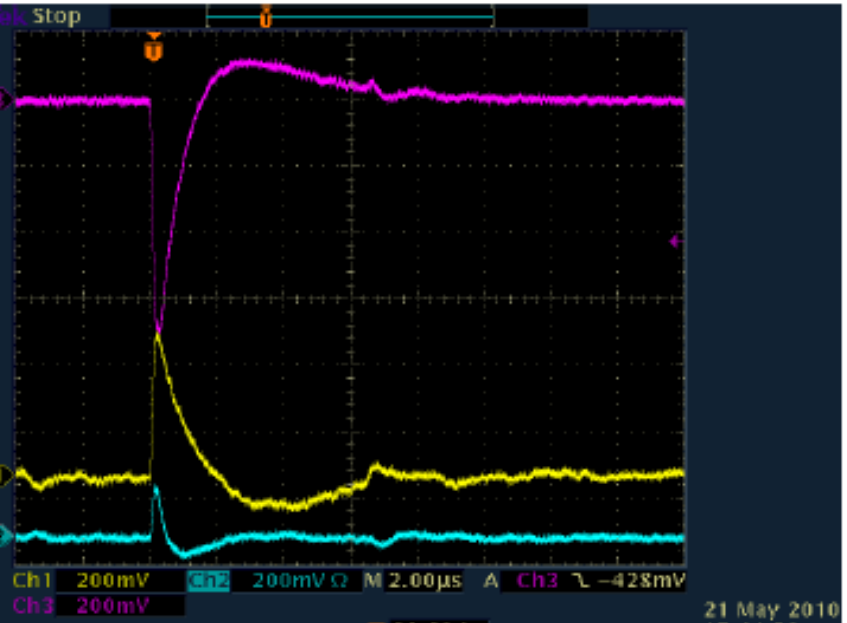


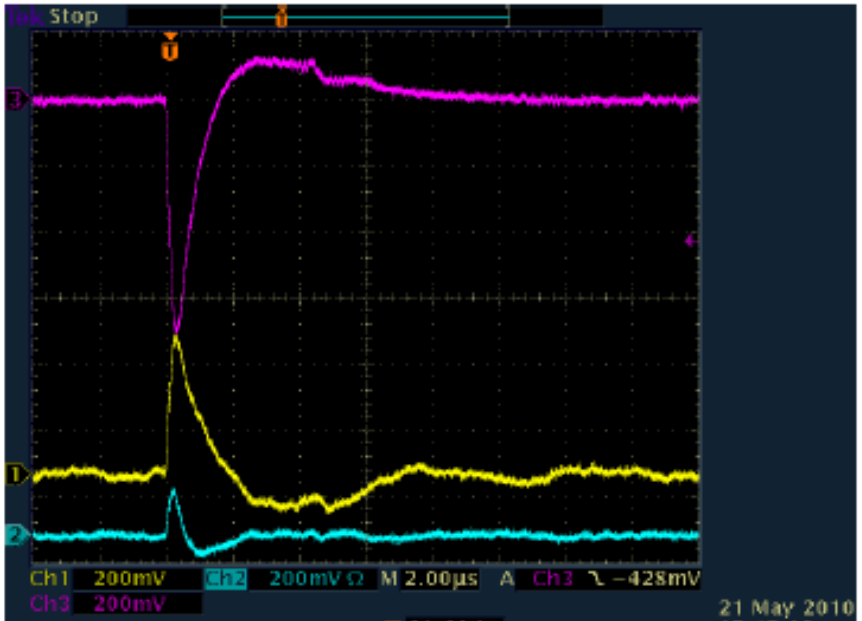


signal o
grid

signal o
pad

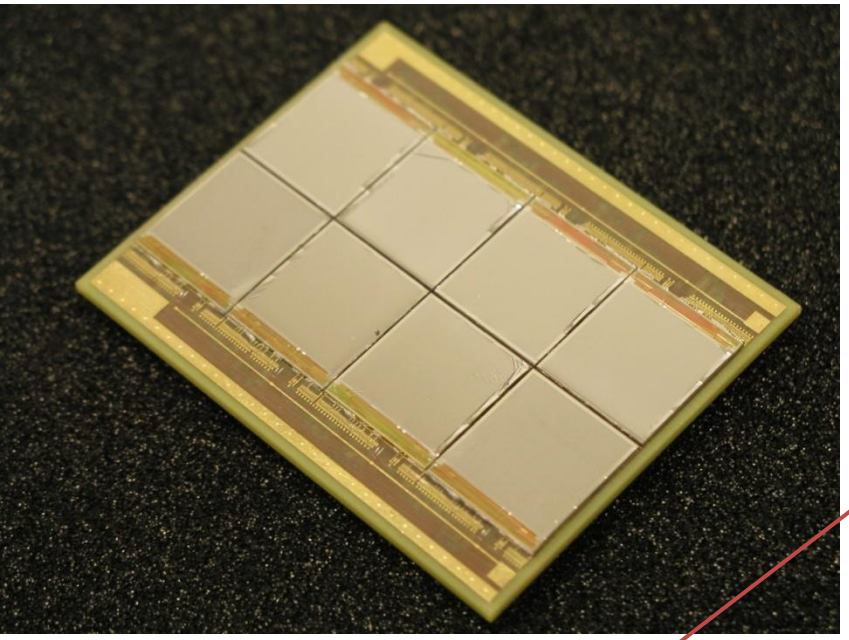
signal o
ring



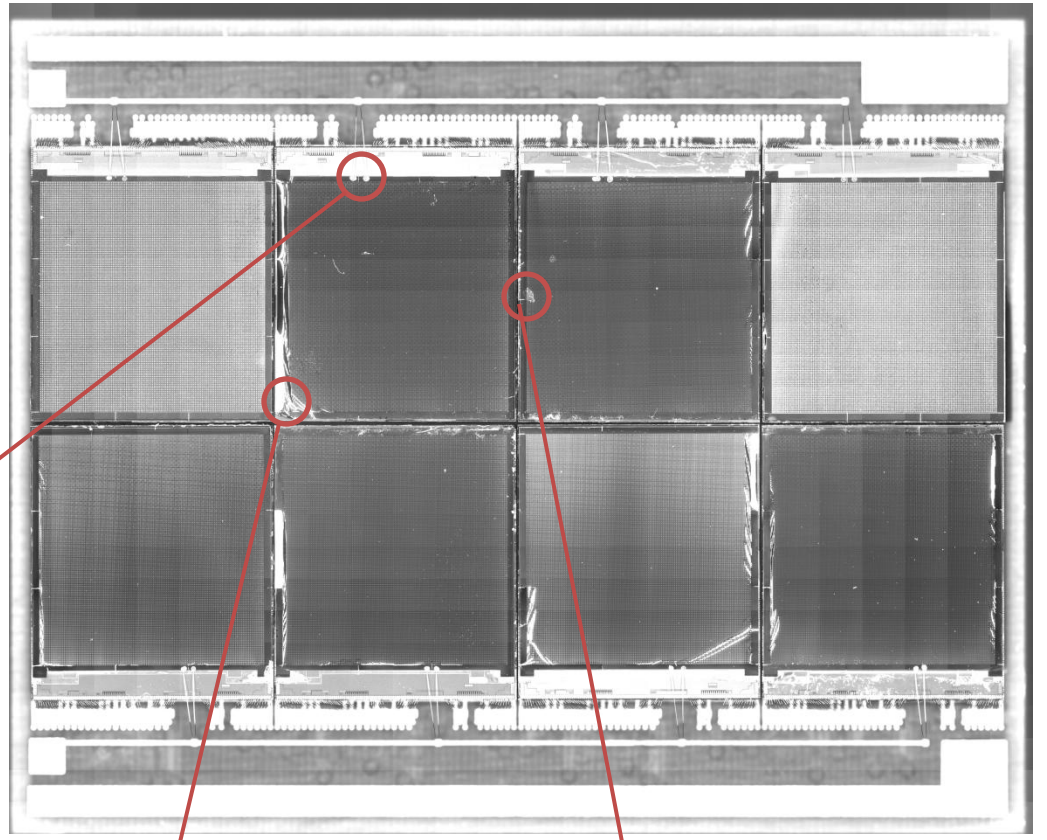


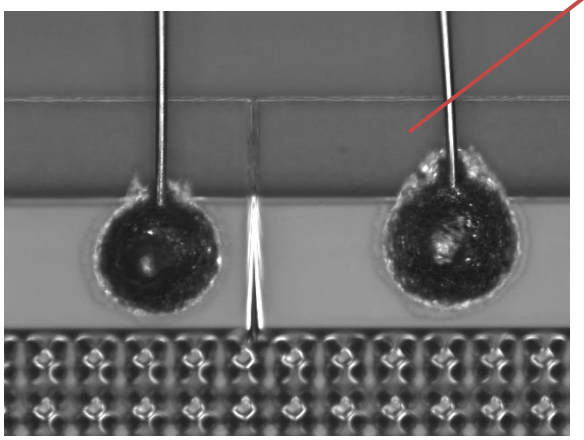
Rate
highly
correlate
with rad
source!

29.04.2010: 8 Timepix + InGrid Chips glued and bonded daughterboard by Joop

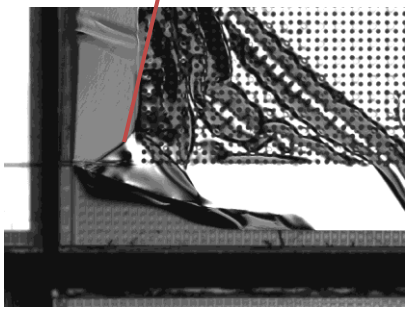


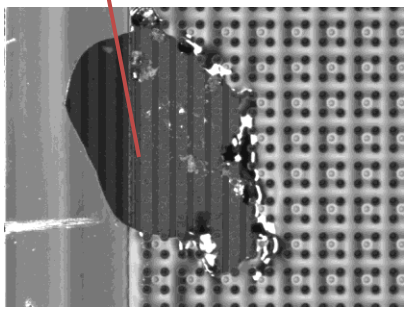
Microscope: Grids not perfect, but very good





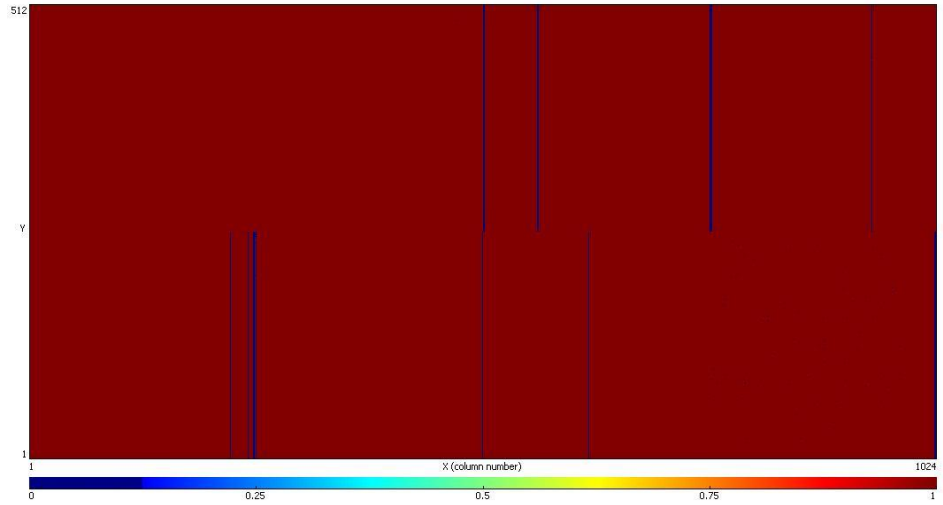
Grid HV bonds fixed with silver glue



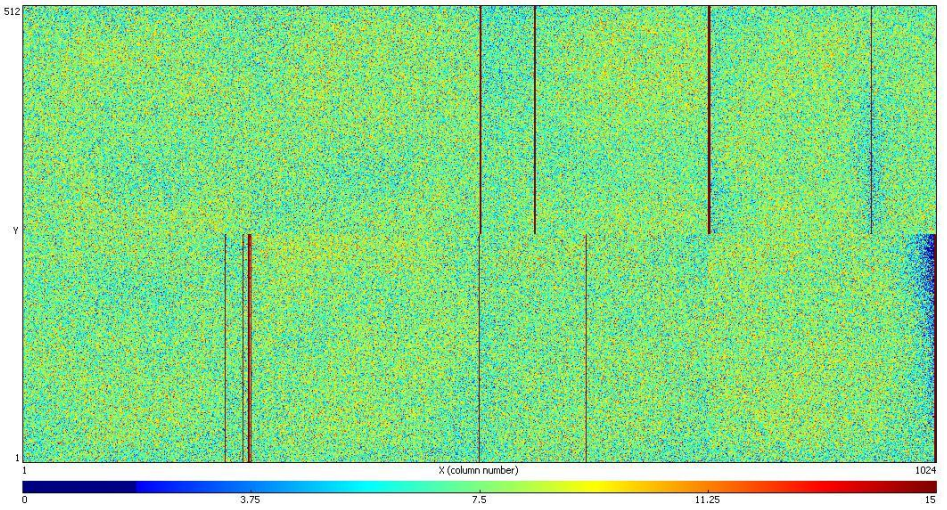


Saclay + NIKHEF

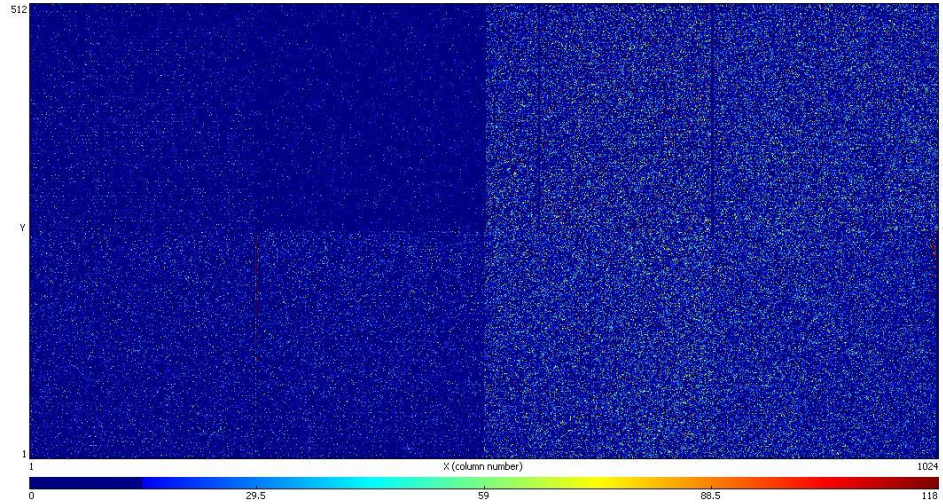
18.05.2010: all 8 chips detected on board and electronically tested
Images from Pixelman



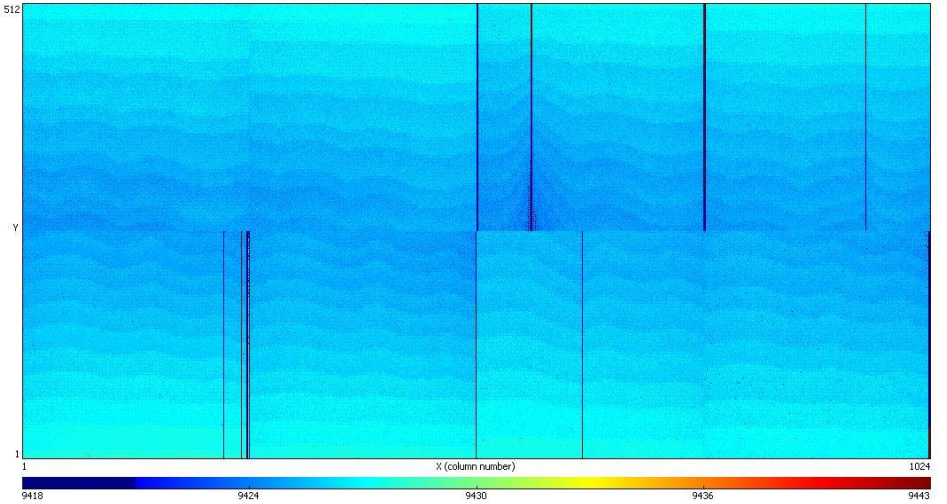
Mask map:4352 pad pixels⇒519937 channels



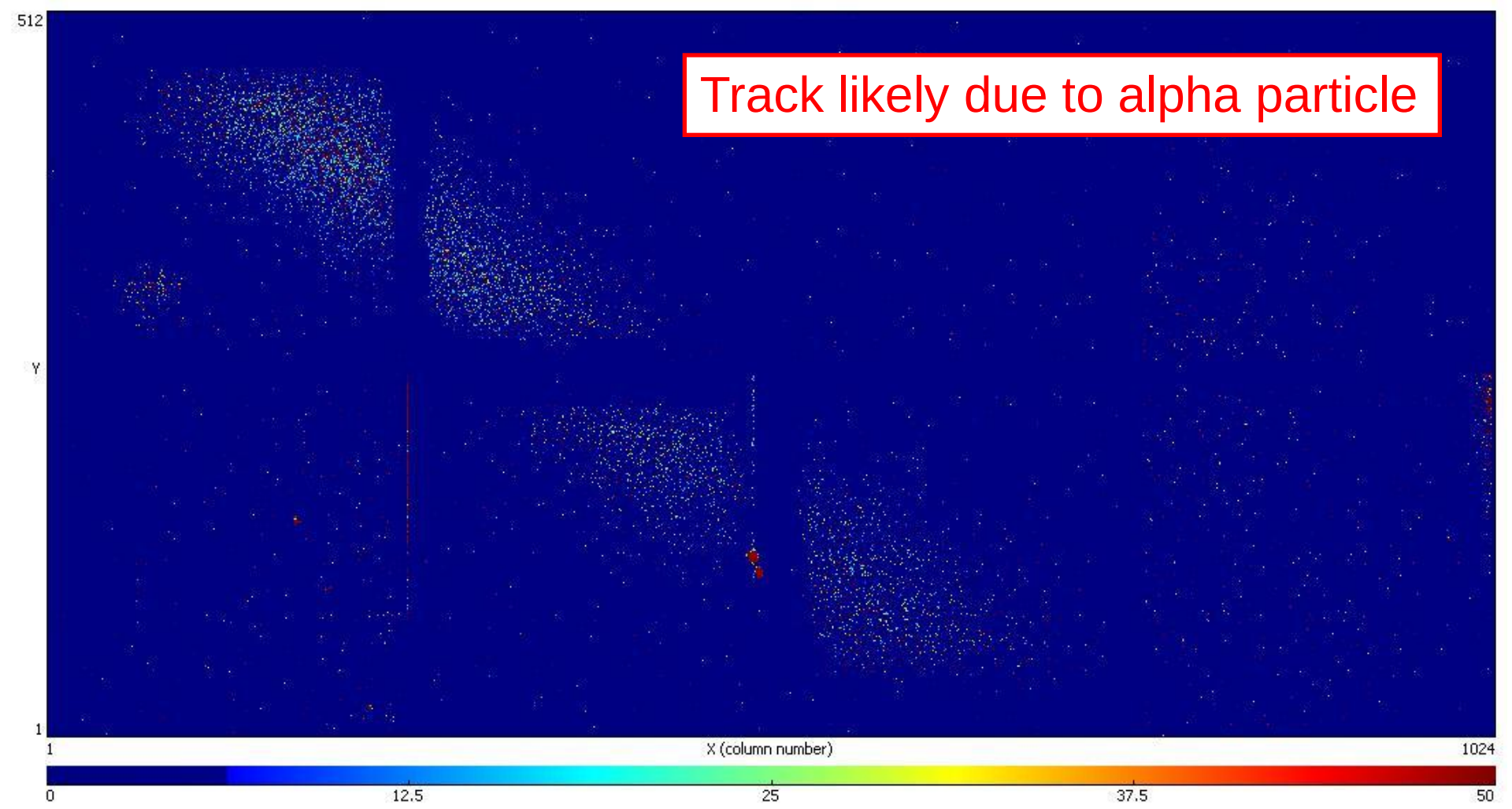
Threshold adjustment map



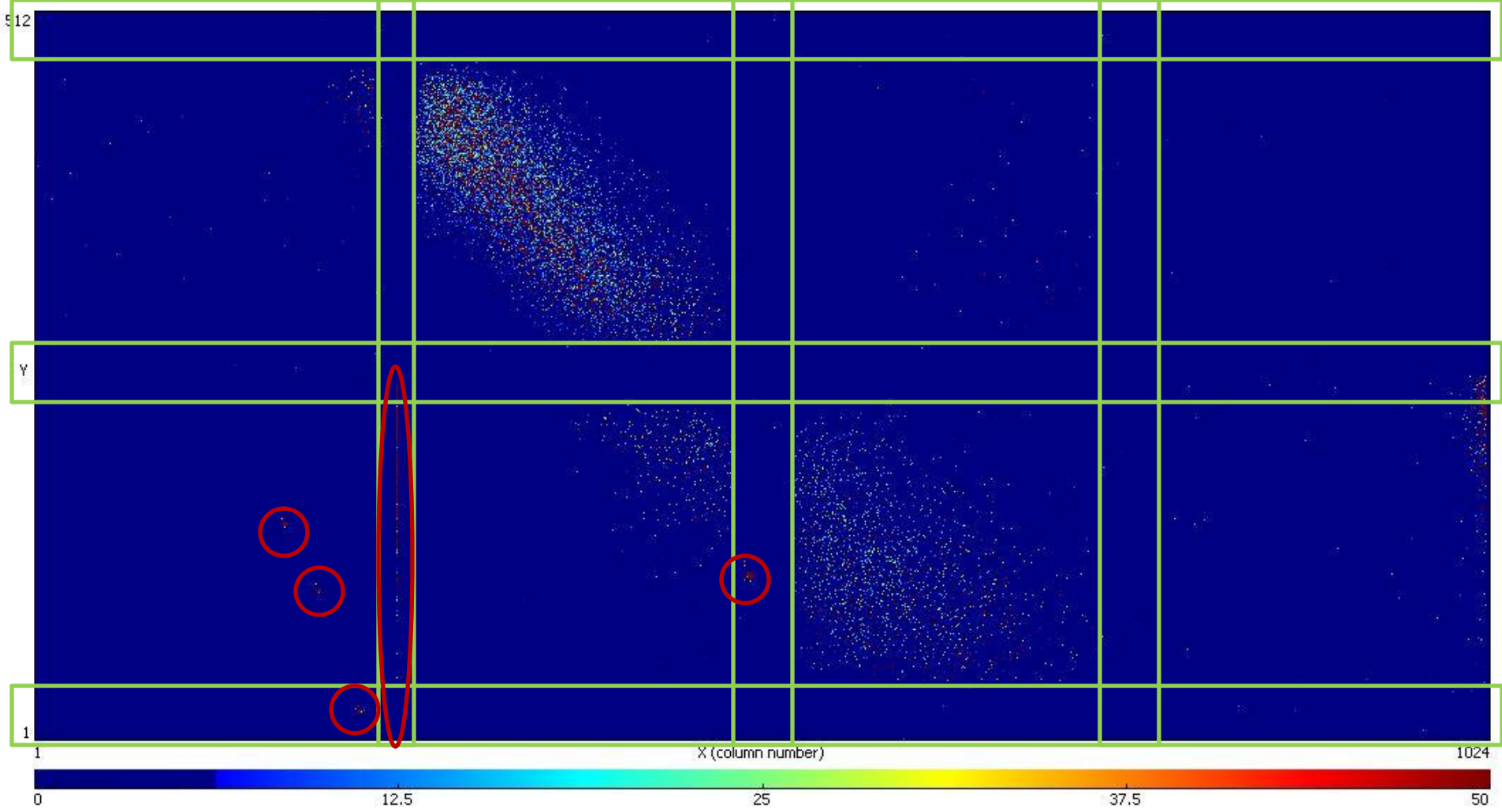
Noise (different threshold for chips to see them)



Test pulses in TIME mode

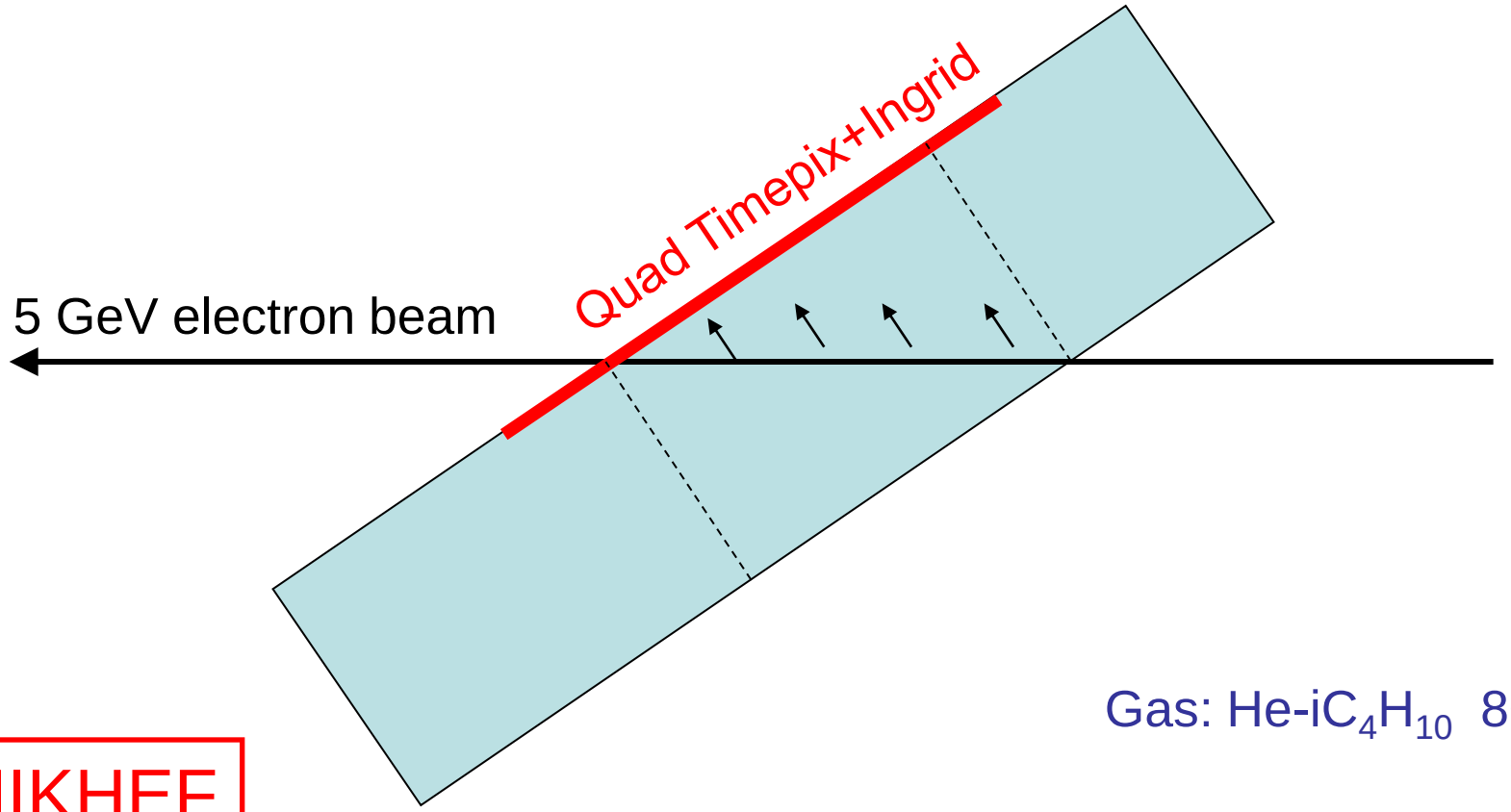


Pixelman image of one of the first tracks:
ArIso 95/5, 275V Grid voltage (gain < 1000), Acq.time 0,5 s



Pixelman image of one of the first tracks:
ArIso 95/5, 275V Grid voltage (gain < 1000), Acq.time 0,5 s

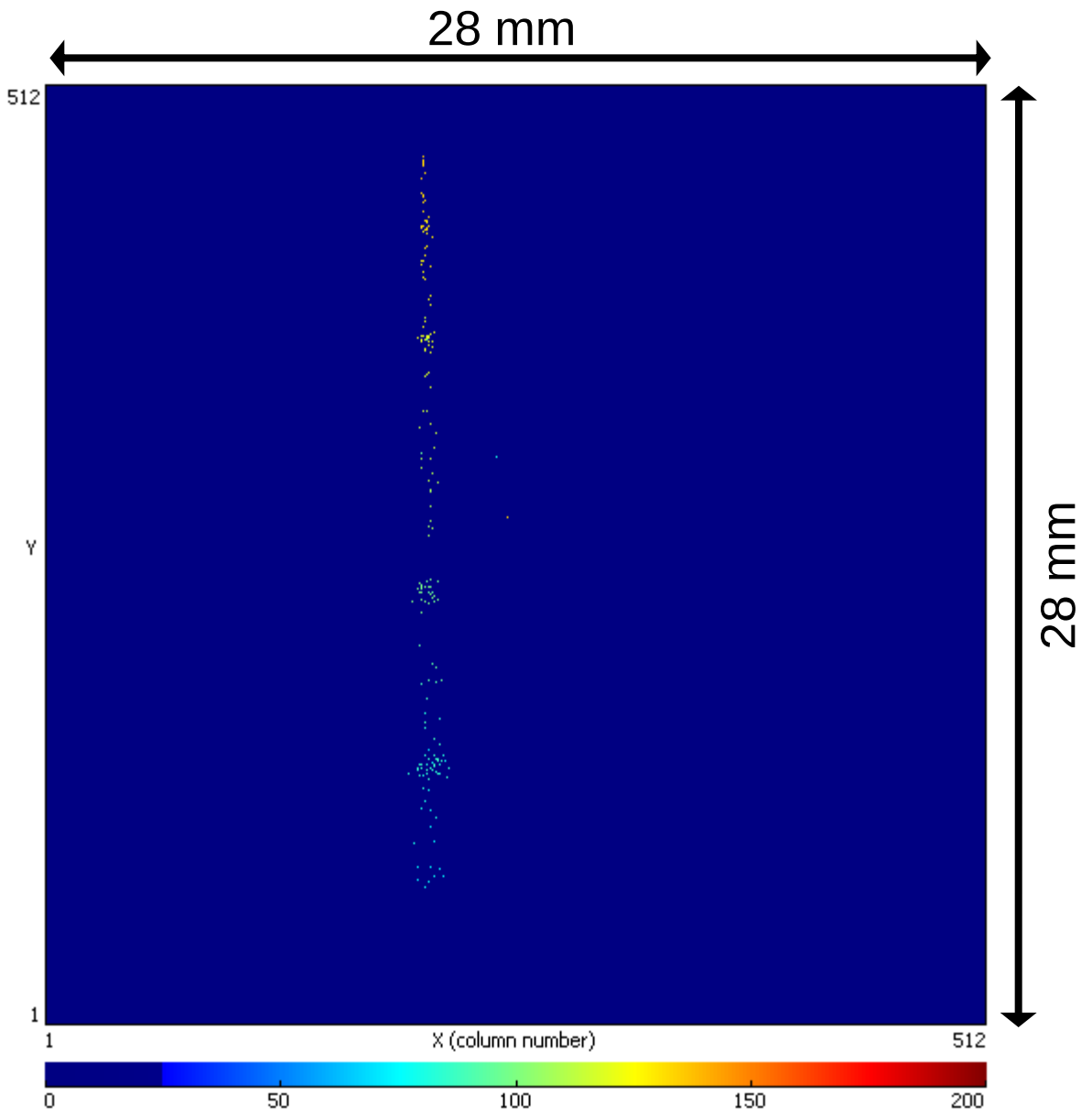
Few tracks from ~3-day test at DESY with quad-Ingrid detector



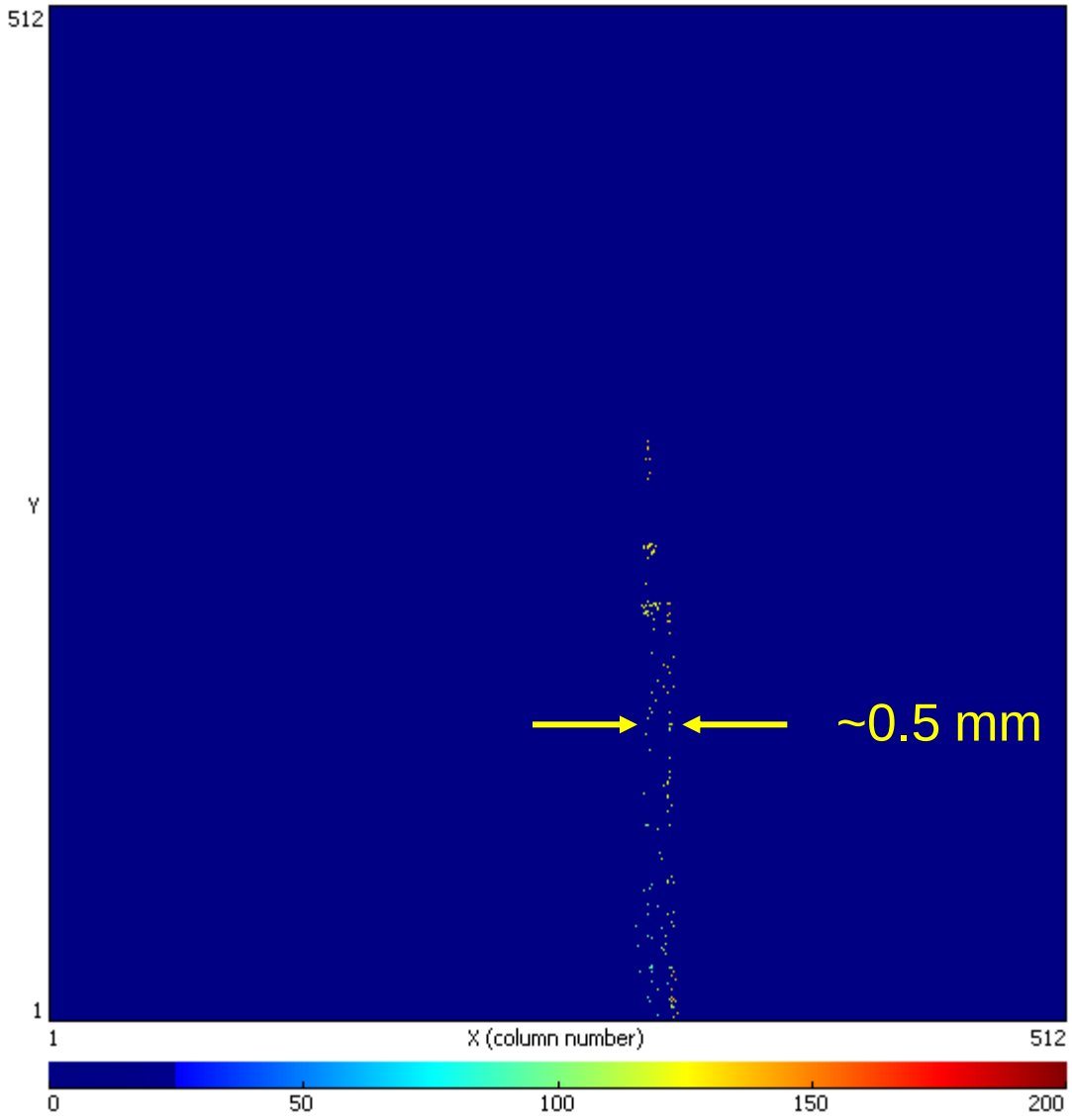
Gas: He-iC_4H_{10} 80/20

NIKHEF

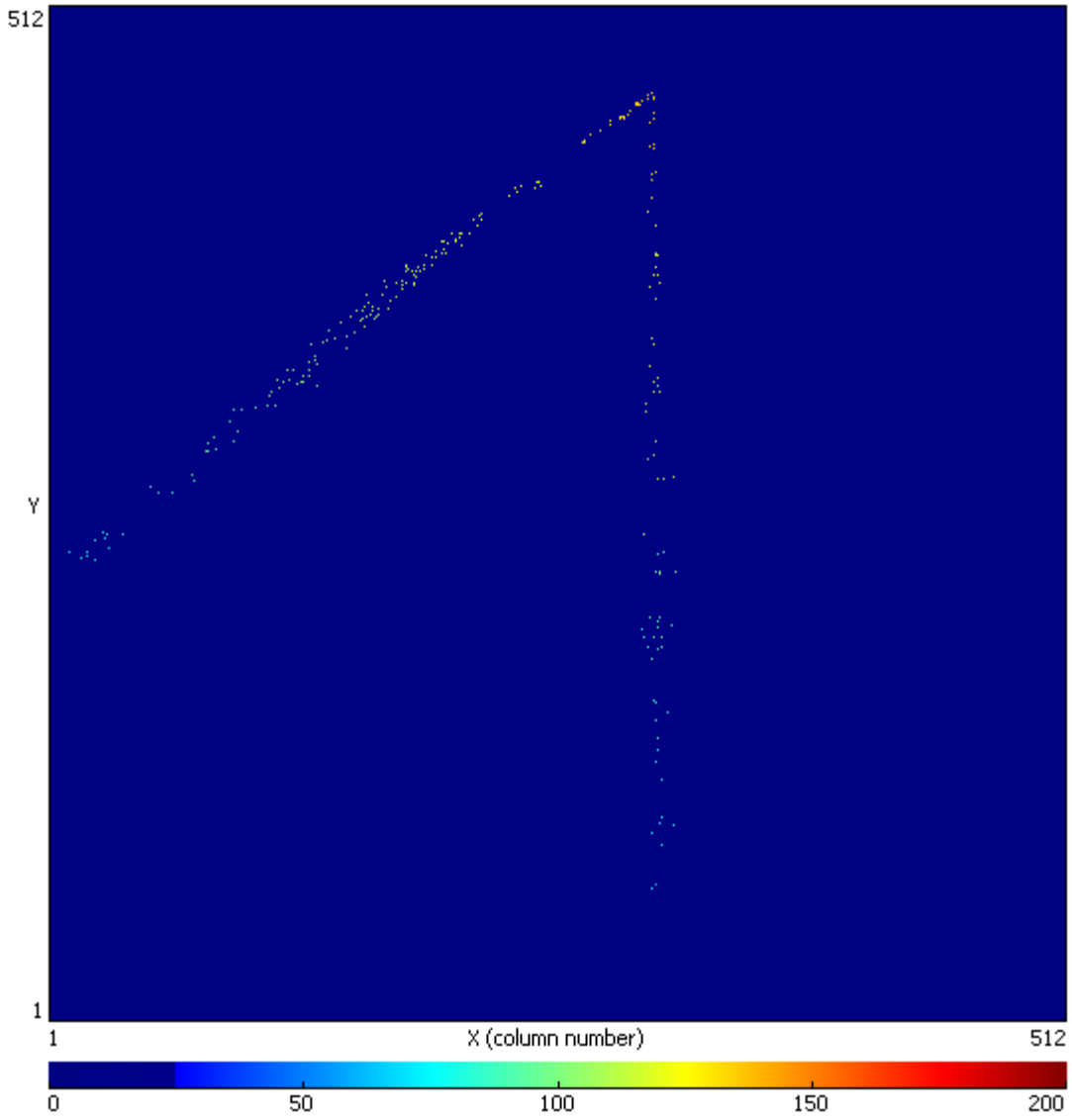
A normal track



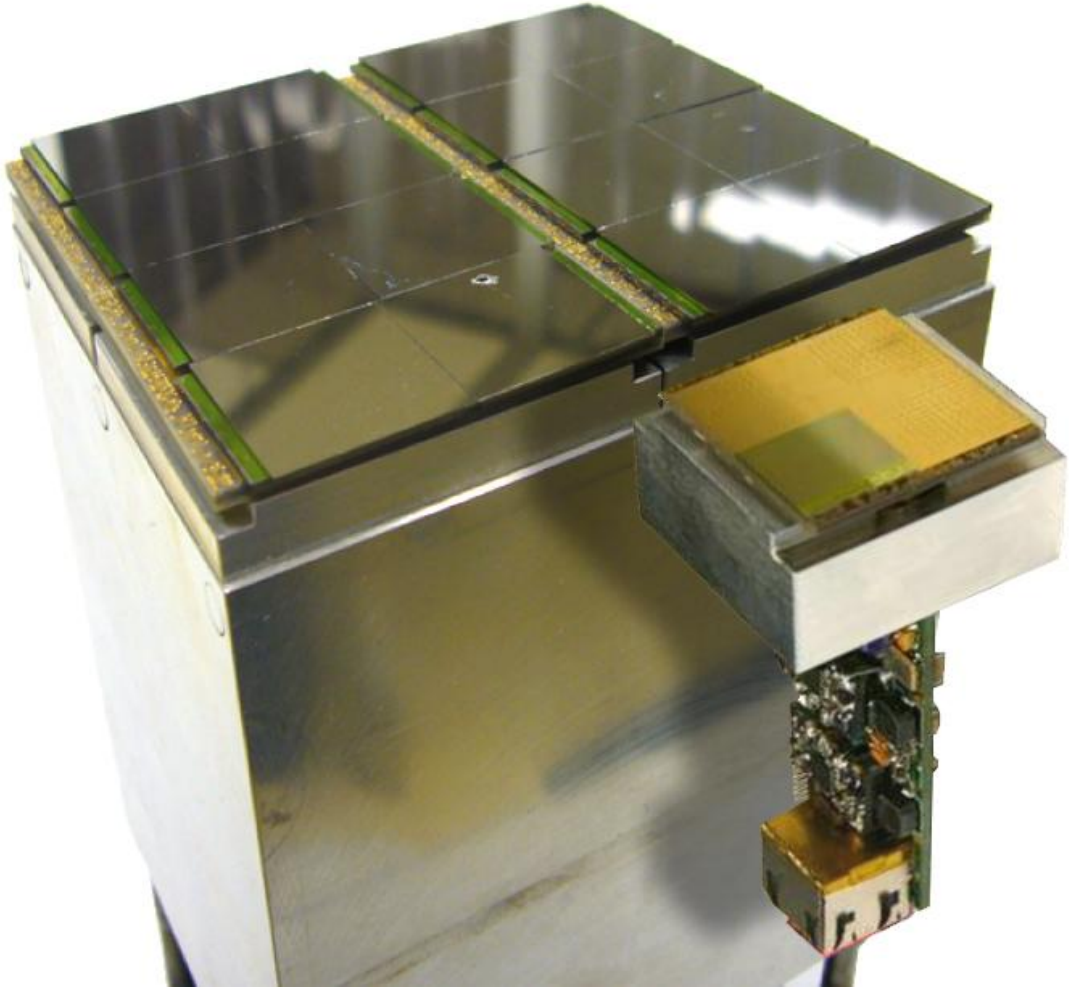
Two tracks about 0.5 mm apart in x



Track backscattering from chip (=anode)



NIKHEF



- within Relaxed project: 4x4 Medipix chips in compact mounting

- Will evolve in 8x8 Timepix chips for EUDET

Conclusions

- EUDET-SITPC final infrastructure available for 3-GEM + 8 Timepix chips. New test at LP foreseen in fall 2010.
- LP module with 8 Timepix+Ingrid chips produced. Readout working! Some HV problems. Production of 2nd module approved and being prepared. Test at LP late(?) 2010.
- Quad-Ingrid detector for standalone tests having readout problems; being investigated
- All (or most) EUDET money is spent; some groups 'overspent' own contribution.
- Longer term: working on larger systems of 64 and 119 chips for Ingrids and GEMs or GEMGrids.
- Despite some problems, consider JRA2/SITPC very successful.