The Silicon TPC System

EUDET Extended SC meeting

1 September 2008

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NIKHEF

JRA2 activity/task

- Silicon TPC readout ("SITPC")

    - development MediPix $\rightarrow$ TimePix chip
    - development diagnostic endplate module incl. DAQ

Purpose: a SiTPC based monitoring system

Partners:

ALU Freiburg, Bonn, CEA Saclay, CERN, NIKHEF

SITPC Tasks:

- ✓ Develop the Timepix chip that allows to measure the 3rd coordinate (drift time)
- ✓ Implementation of Timepix together with GEM and Micromegas/Ingrid into diagnostic endplate system (in progress)
- ✓ Performance measurements in test infrastructure at DESY (in preparation)
- ✓ Develop simulation framework (in progress)
- ✓ Develop DAQ system and integrate in overall DAQ of EUDET infrastructure (in progress)

Timepix

- 1st run 2006: 6 (Eudet) wafers

  +14 ("private" + Medipix coll.)

  All wafers probed; avg. yield ~73%

- 2nd run 2008: 38 (Eudet) wafers

  +34 ("private" + Medipix coll.)

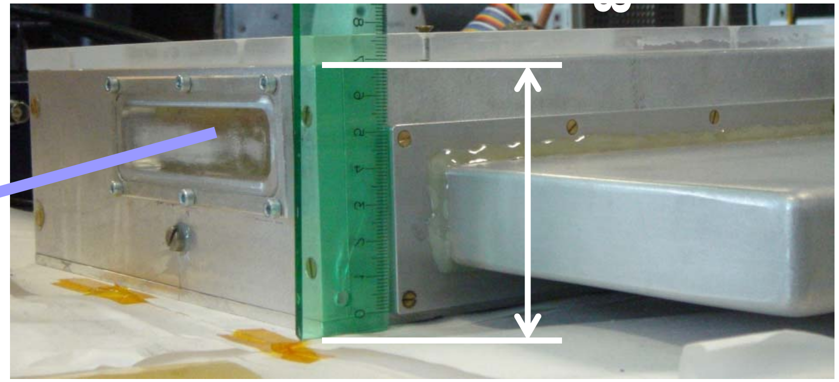
  Sofar 2 wafers probed; similar yield

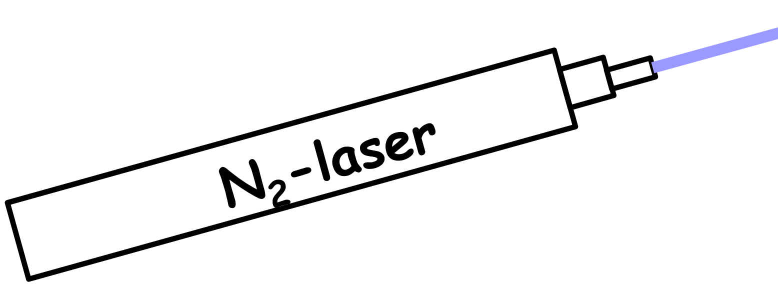
Freiburg activities

Measurements with laser @ Freiburg

Installation of a laser test bench for measurements with single (primary) electrons.

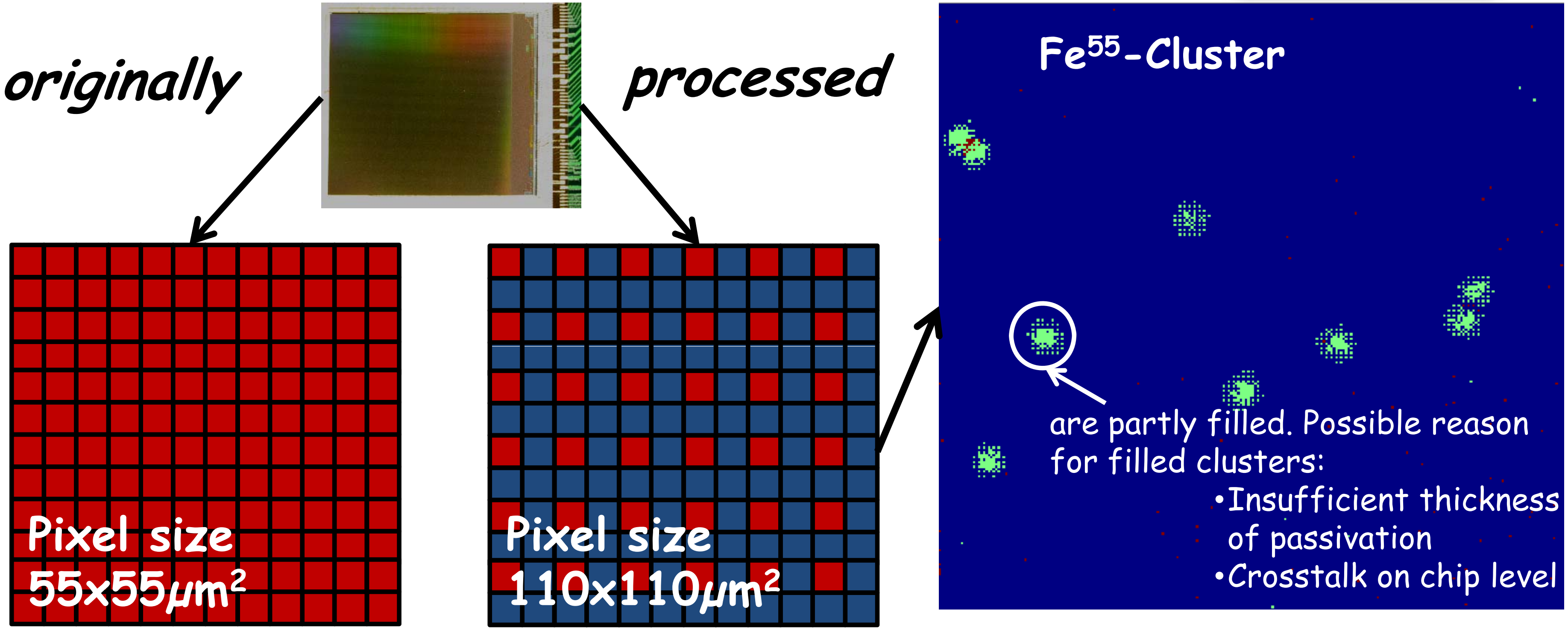
Detector with metallized drift cathode. From this laser releases single photo-electrons ⇒ creation of well defined and seperated clusters





- Measure detection effieciency for single electron clsuters
- Investigate influence from number of primary electrons on single point resolution.
- Possibly study ion backdrift proberties

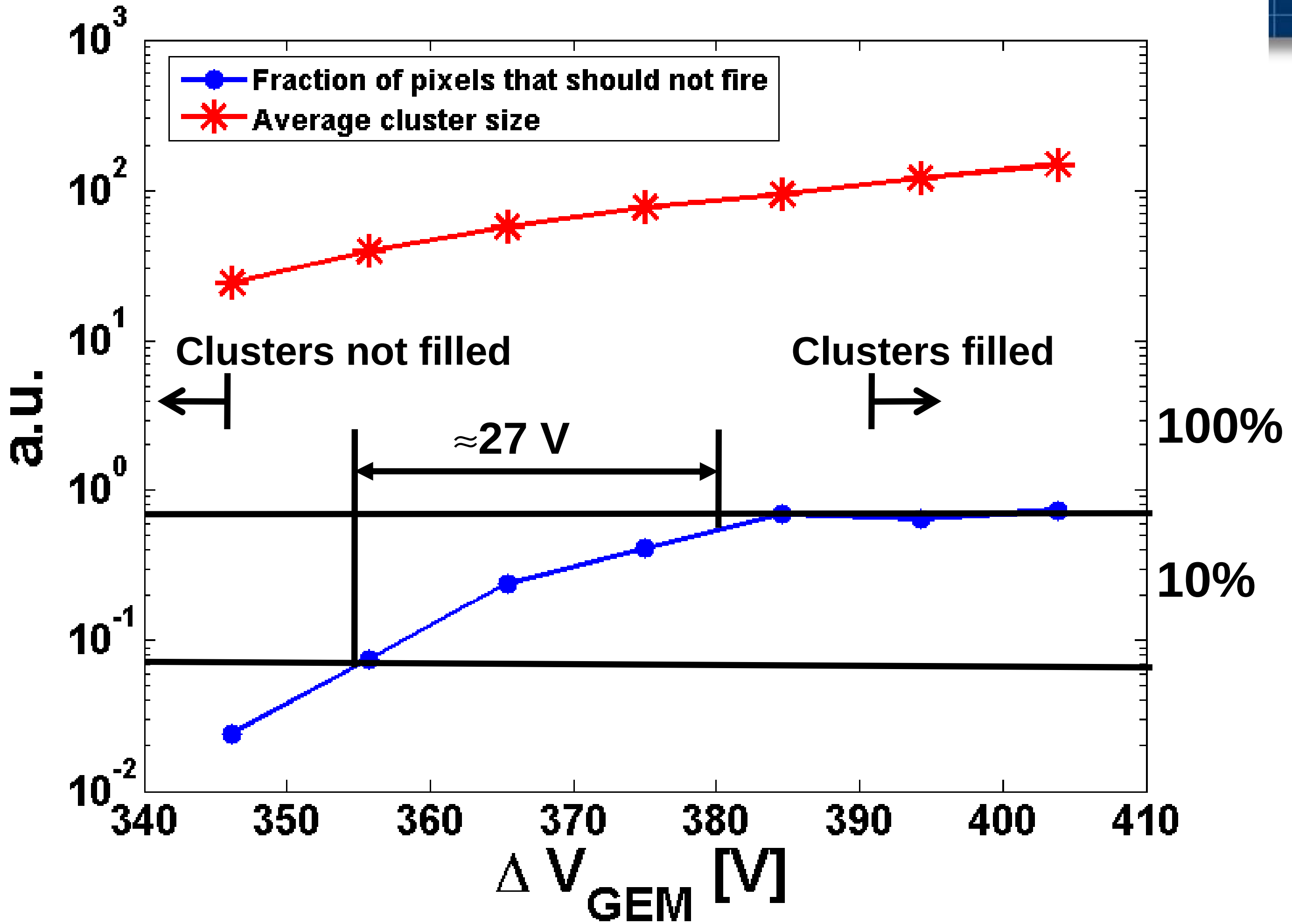
Chip Post-Processing



■ Pixel acitve
■ Pixel passivated

- Work on technologies for post processing chips
- Optimization of readout granularity

First results with pro-cessed chip

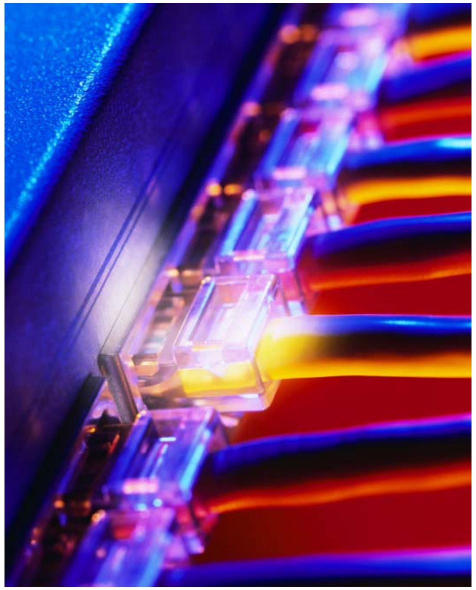


≈27V correspond to a factor 5 in gain.
Ongoing investigation of the cross talk behavior

Next steps...

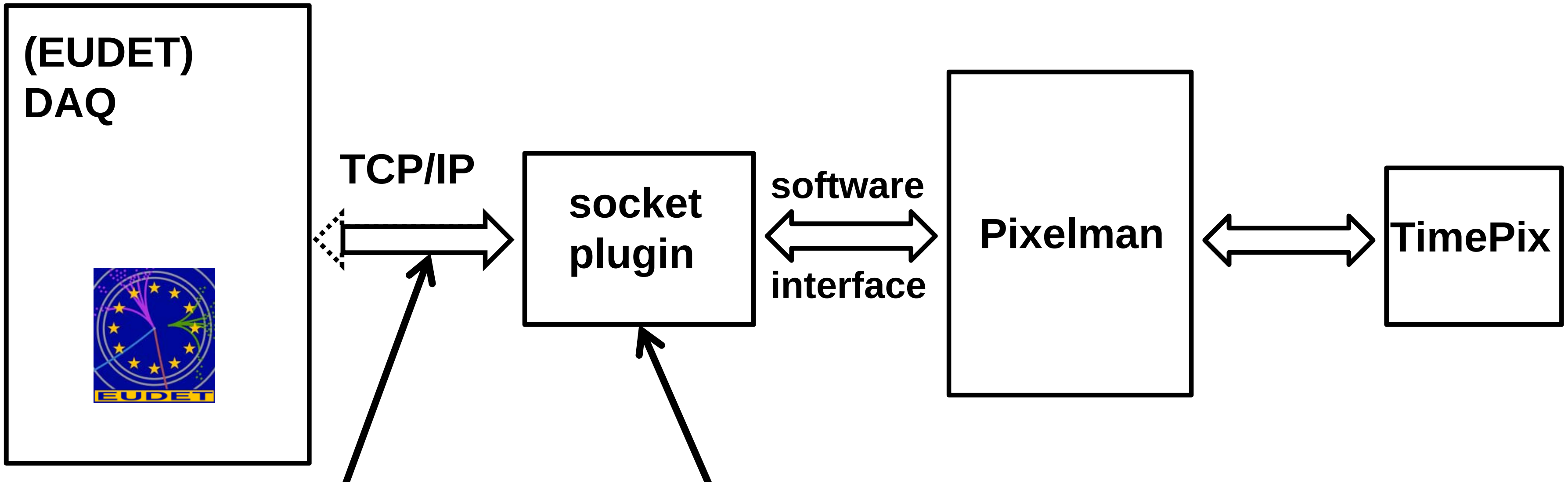
Produce Linux based DAQ steering (basic) Pixelman functions

Solution → use network tools



Program a plug-in that uses standard network connections and TCP/IP, so that Pixelman software can be operated by a Linux DAQ-system, e.g. EUDAQ

Next steps...



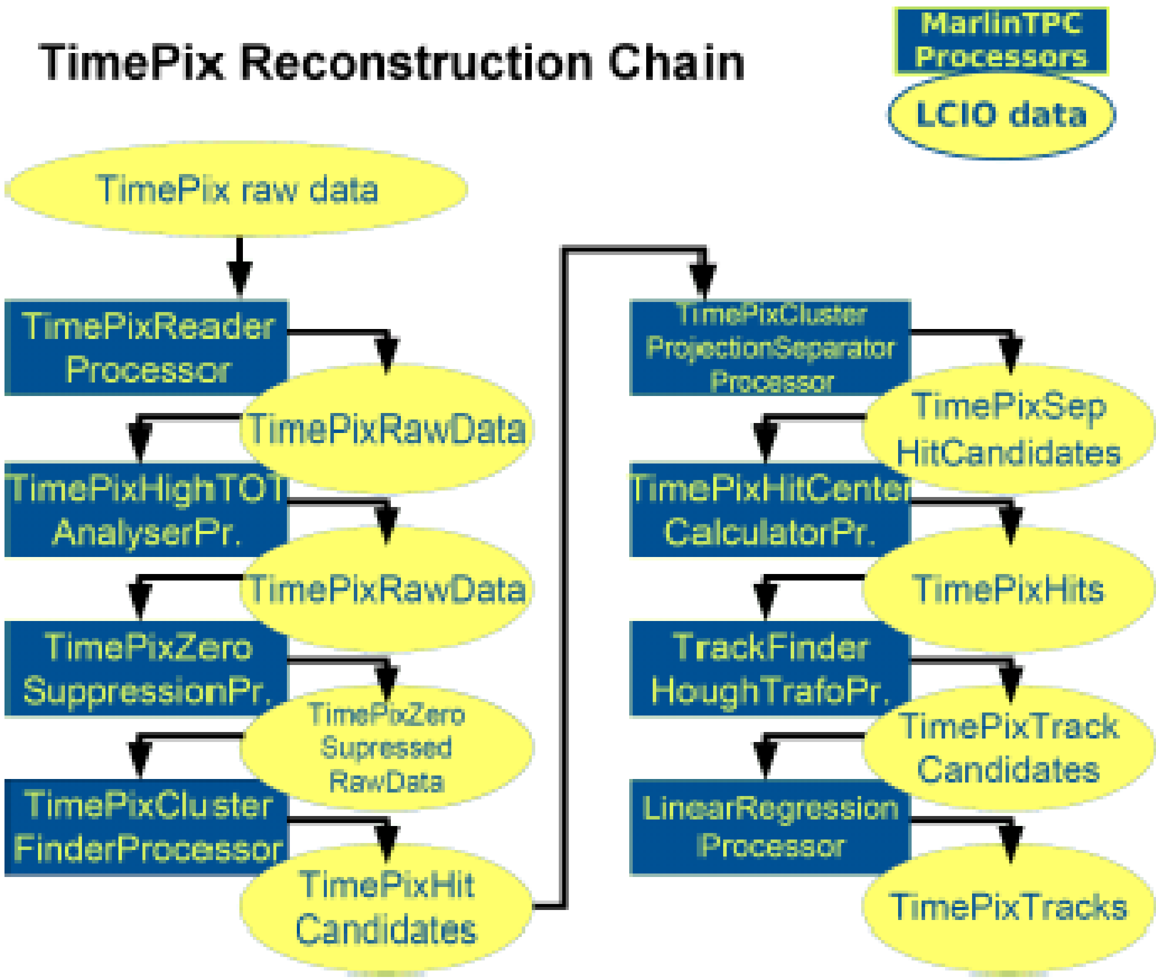
As an option Pixelman can send commands to the DAQ via the socket plug-in

A socket is a software interface between two programs for interprocess communication. The programs can be running on the same machine or on different machines connected via network.

Bonn activities

Reconstruction and Analysis: MarlinTPC

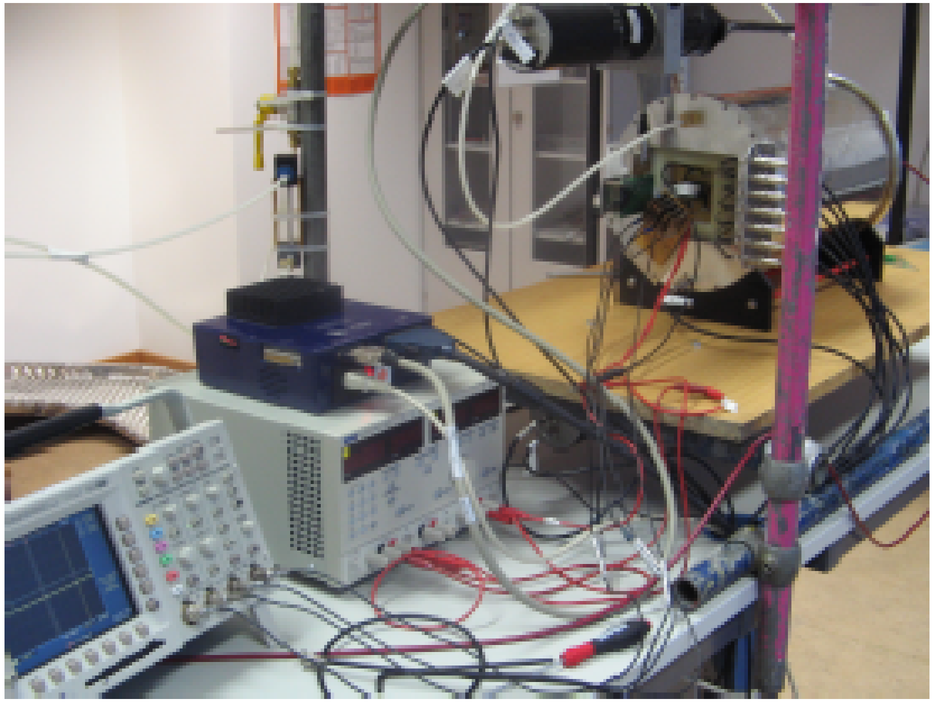
MarlinTPC is the TPC simulation, digitisation, reconstruction and analysis package for the Marlin framework



Very modular with more than 50 processors, suited for all kinds of TPC readout (GEMs/Micromegas, ADCs, TDCs, TimePix)

- Reader for TimePix data from PixelMan
- Complete TimePix reconstruction chain
- Analysis processors (e. g. to determine spatial resolution)
- TimePix digitisation

TPC Test Setup



- Field cage designed and produced in Aachen
  - 26 cm diameter
  - 26 cm drift distance
  - Low material budget: 1 % X_0
  - Drift field up to 1 kV/cm
  - Fits into 5 T magnet at DESY
- Trigger for cosmic muons: Scintillators above and below the chamber
  - Veto circuit: Only one shutter window per recorded frame
- TimePix readout with Muros and PixelMan

universitätbonn

Post-Processing of TimePix

Freiburg group is testing MediPix chips with enlarged pixels (110×110 μm^2), post-processed on per chip level by FMF (Freiburger Metallforschungszentrum)

Bonn has established first contact with IZM:
Institut für Zuverlässigkeit und Mikrointegration, Berlin

Institut
Zuverlässigkeit und
Mikrointegration

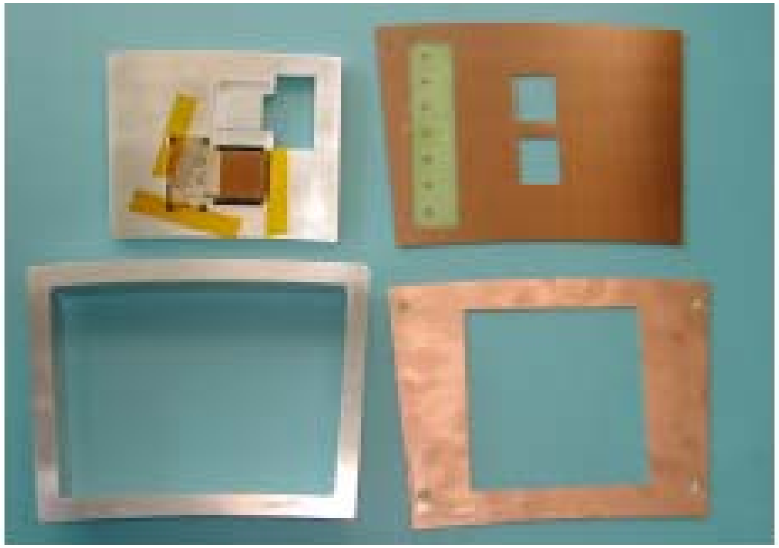
Post-Processing of TimePix chips — on wafer level:

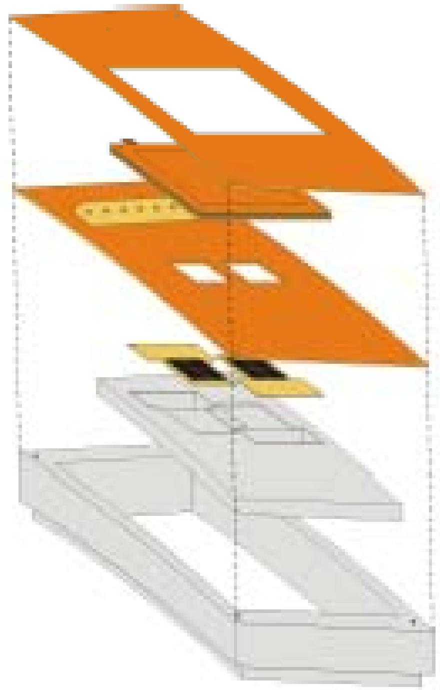
- **Enlarging pixel size**
  by adding metal pads on a passivation
- **Silicon through vias**:
  replacing wire bonds by bump bonds
- **InGrid** — plans to learn technology from Twente University

Contributions to the development of a TimePix successor chip.

LP Module with 3GEM + TimePix

- 3 standard GEMs 10 × 10 cm^2
- 1 mm transfer gaps and induction gap
- Two quad-boards (NIKHEF) with 4 TimePix chips each





- GEMs and QuadBoards have to be assembled

Status

GEMs

- GEMs are in house
- G10 frames have been delivered

QuadBoards

- One QuadBoard is fully equiped and bonded
- QuadBoard worked fine except for a broken bond
(could not read DAC values from second chip)
- After fixing the bond the board does not answer any more

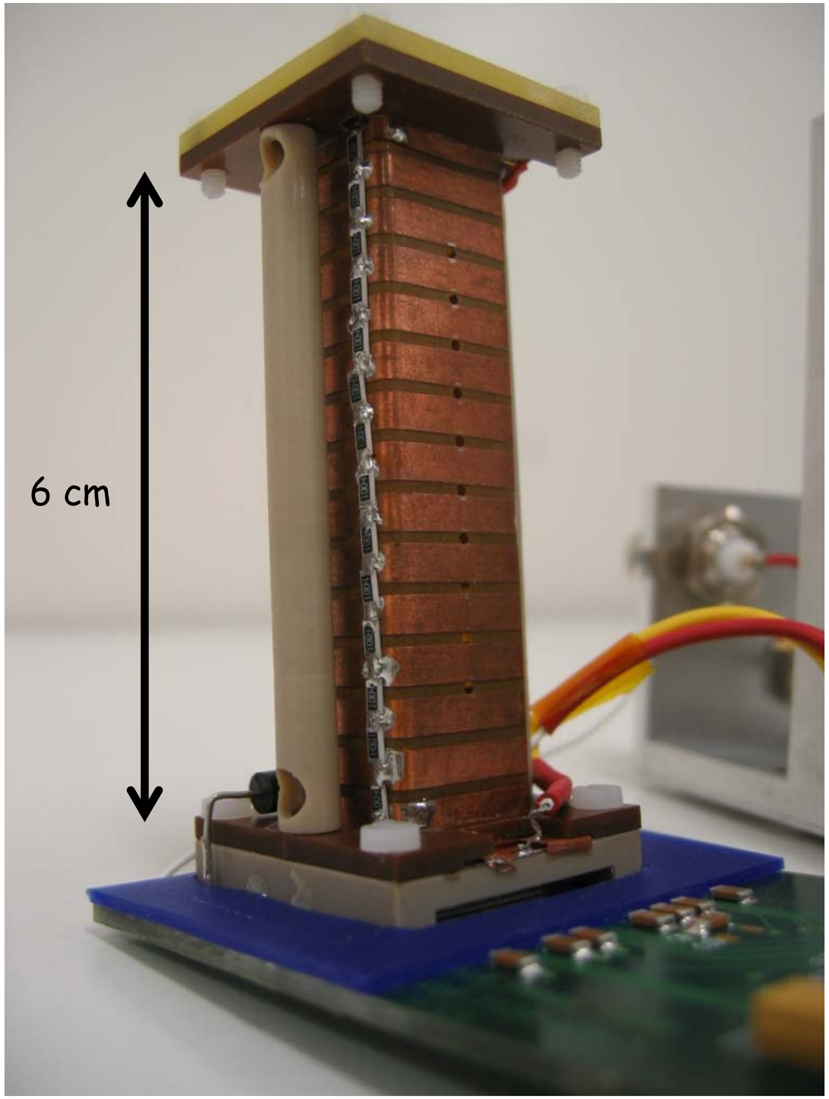
Problem not understood!

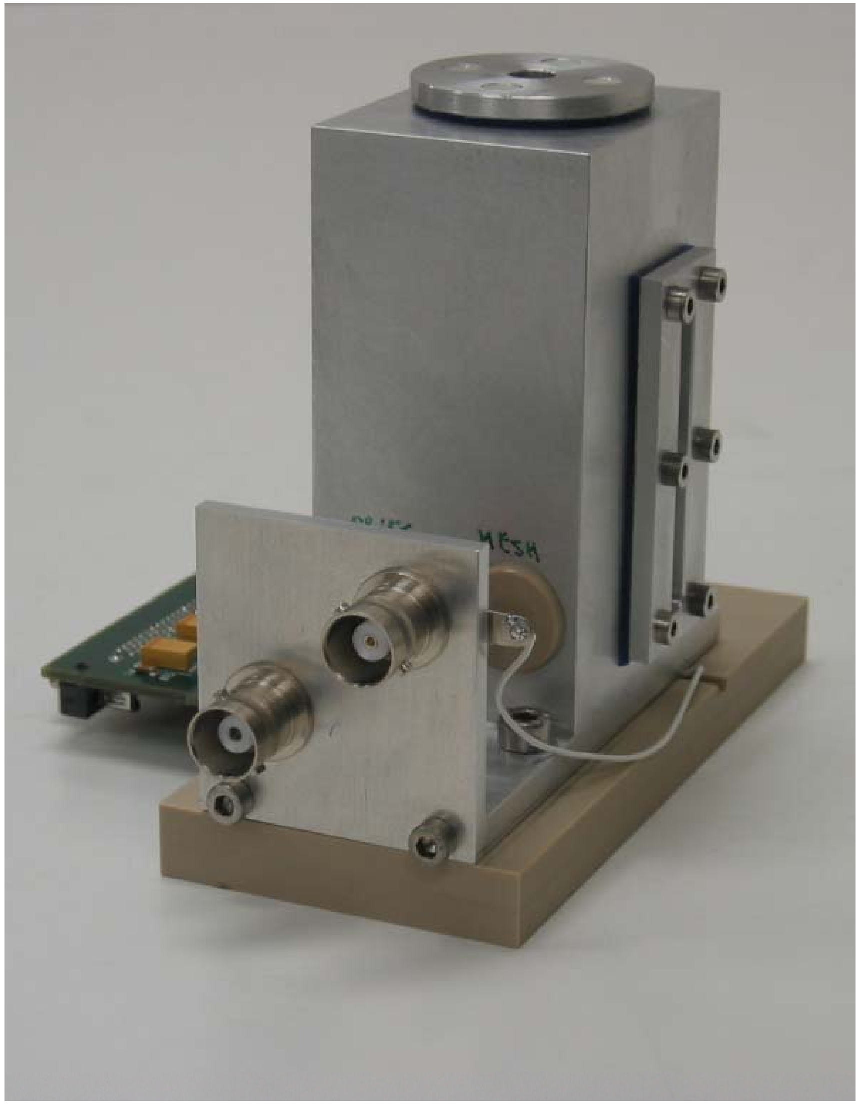
Saclay activities

Deliverable 1: single-chip diagnostic tool

- Must include a field cage
- Micromegas mesh with 55 micron pitch, to avoid Moiré effect
- Special frame to handle the mesh (in pick)
- 2 windows (beta on the side, gamma on the top). Also possible to shoot a photon beam for polarimetry applications.
- No magnetic component.

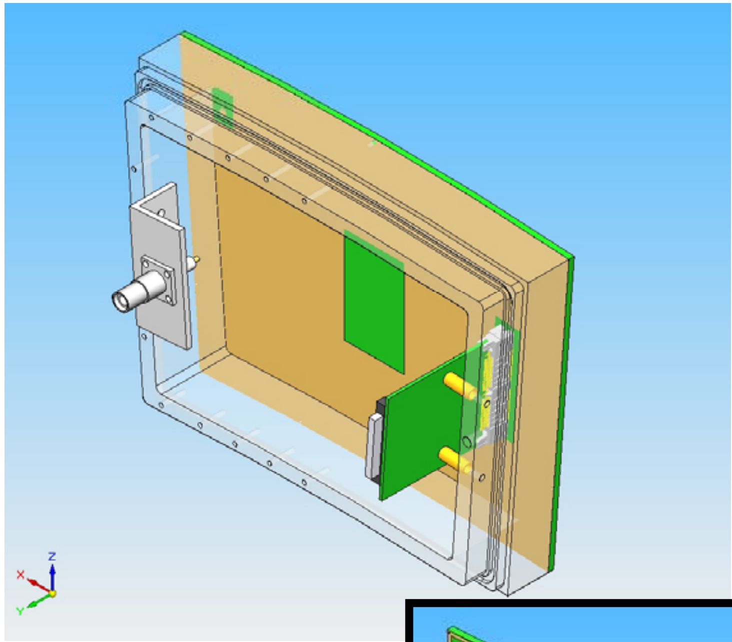
TimePix+Micromegas detector

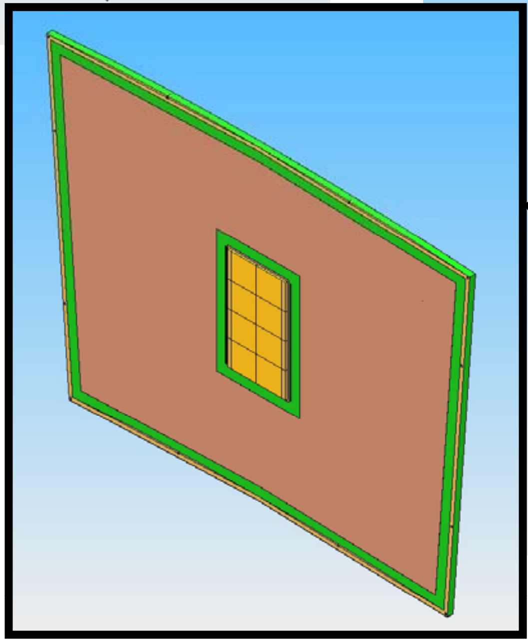


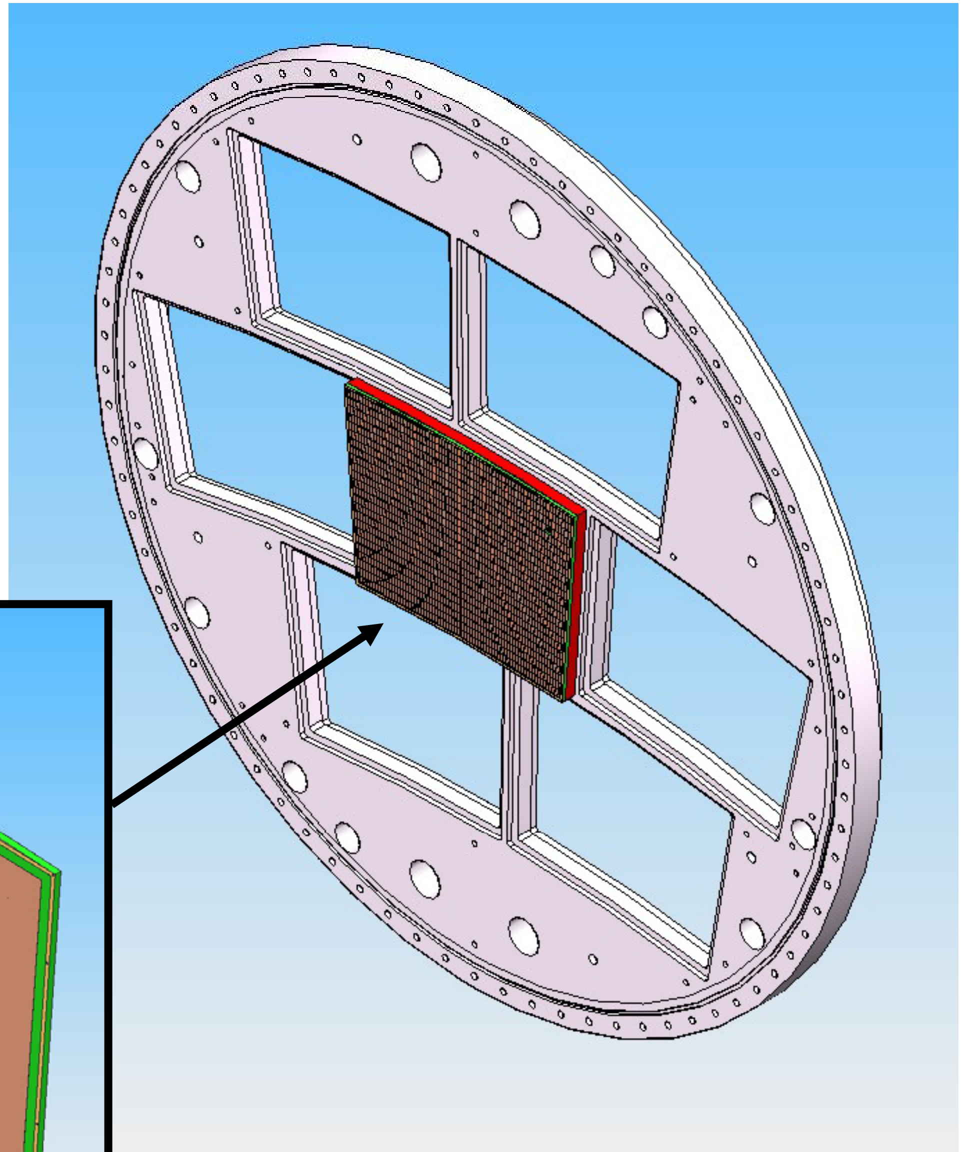


Next Deliverable:
8-chip endplate panel infrastructure

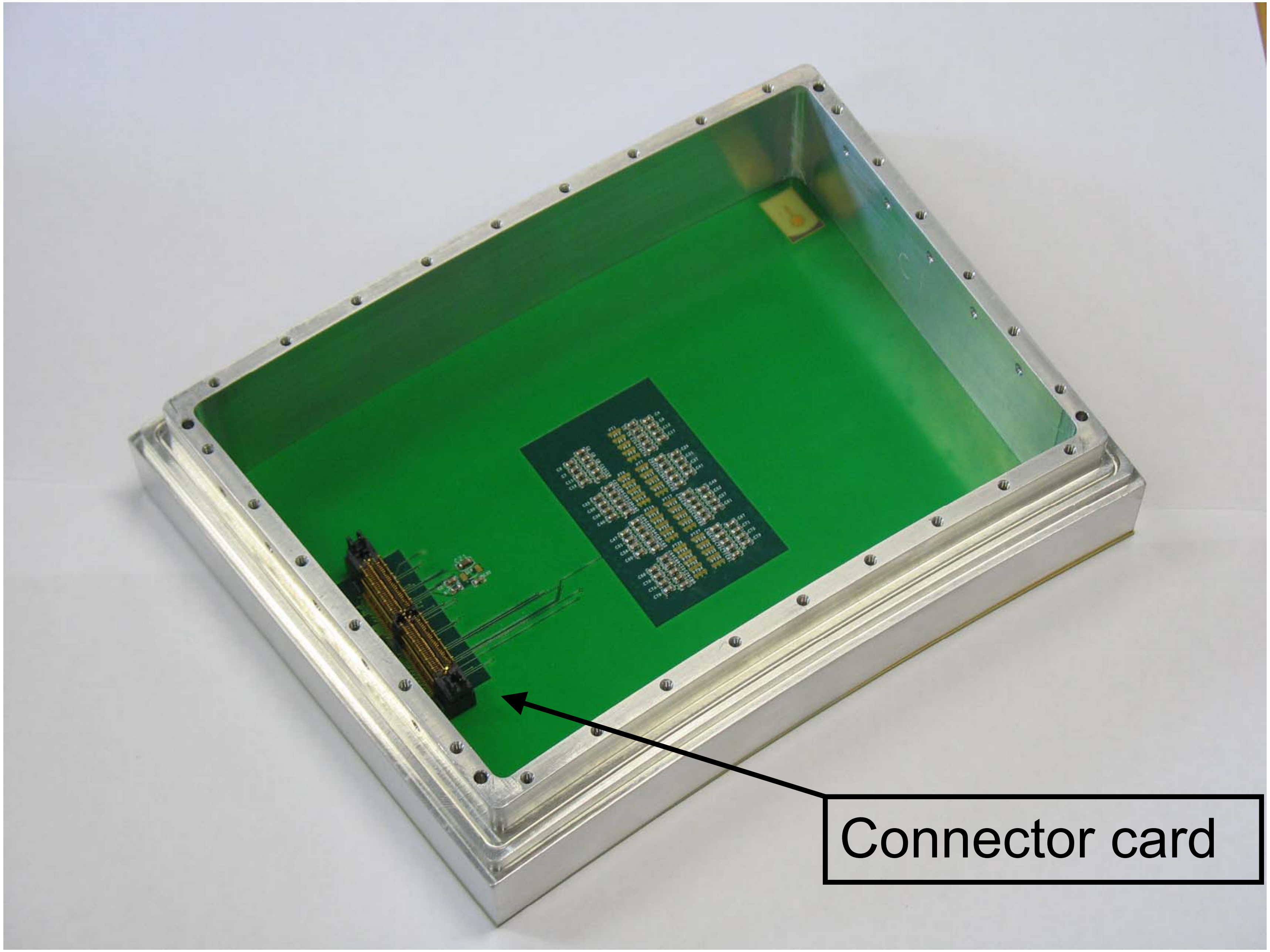
- 8 chips is the maximum that can be handled by a MUROS readout card.
- The 8 chips must be power-supplied and the readout must be daisy-chained
- There must be a possibility to bypass any broken chip (but only one at a time)
- Chips must be equipped with an InGrid

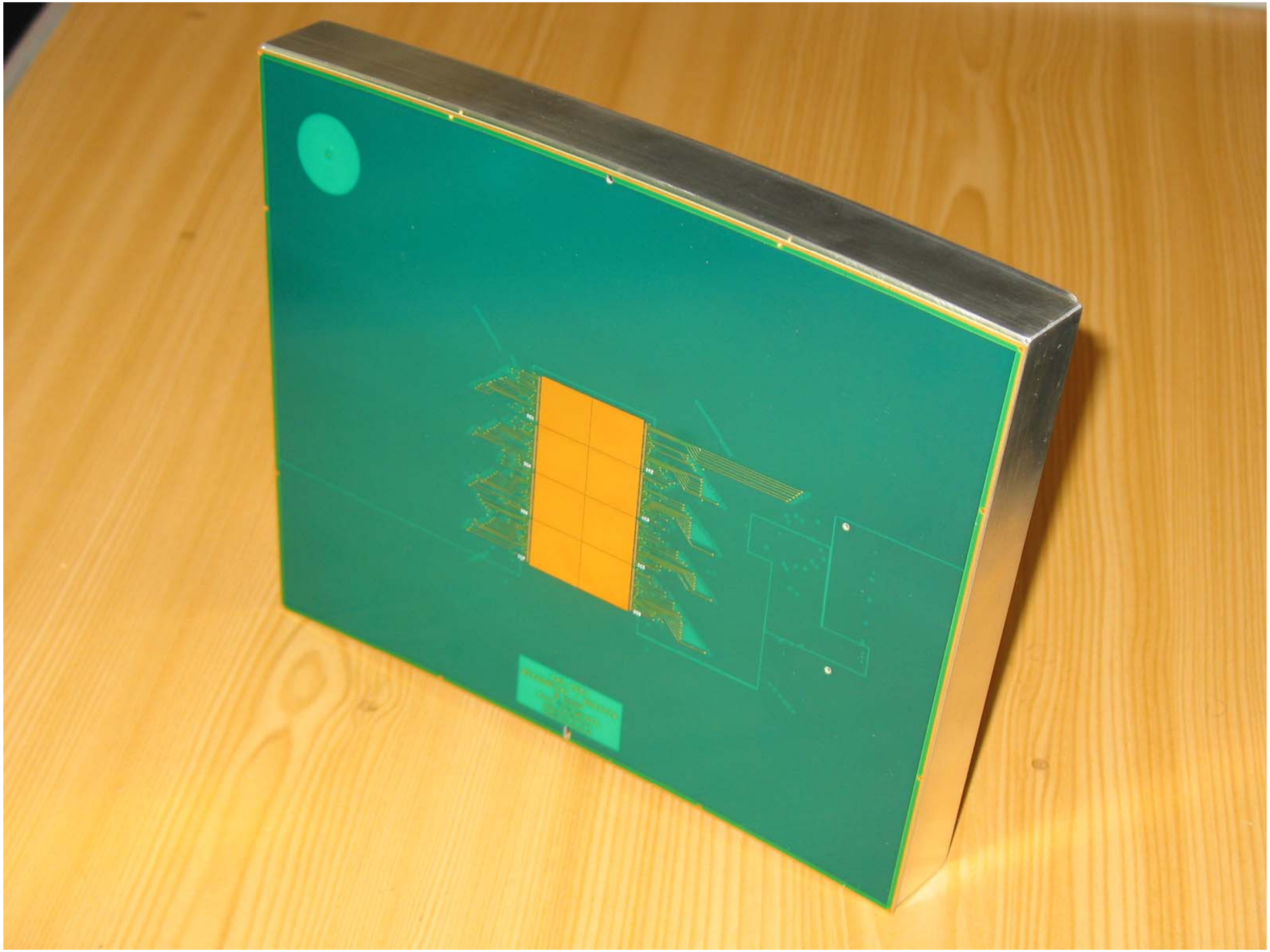






To be inserted in place of a standard panel in the LC-TPC Large Prototype


Connector card



Recent developments and plans

- This infrastructure has been delivered in March 2008.
- Since then, it was equipped with 8 TimePix chips (600 wire bondings)
- Not enough power from MUROS: use external supply
- Mistake in the design found; solved by cutting some tracks on the PCB. Now a pure serial readout is used.
- Still not possible to read all 8 chips: wiring mistake will be corrected. This should solve the problem.
- After test with this PCB, will consider making a new PCB with 12 layers instead of 6; should contain all connections in a 30x60 mm rectangle.

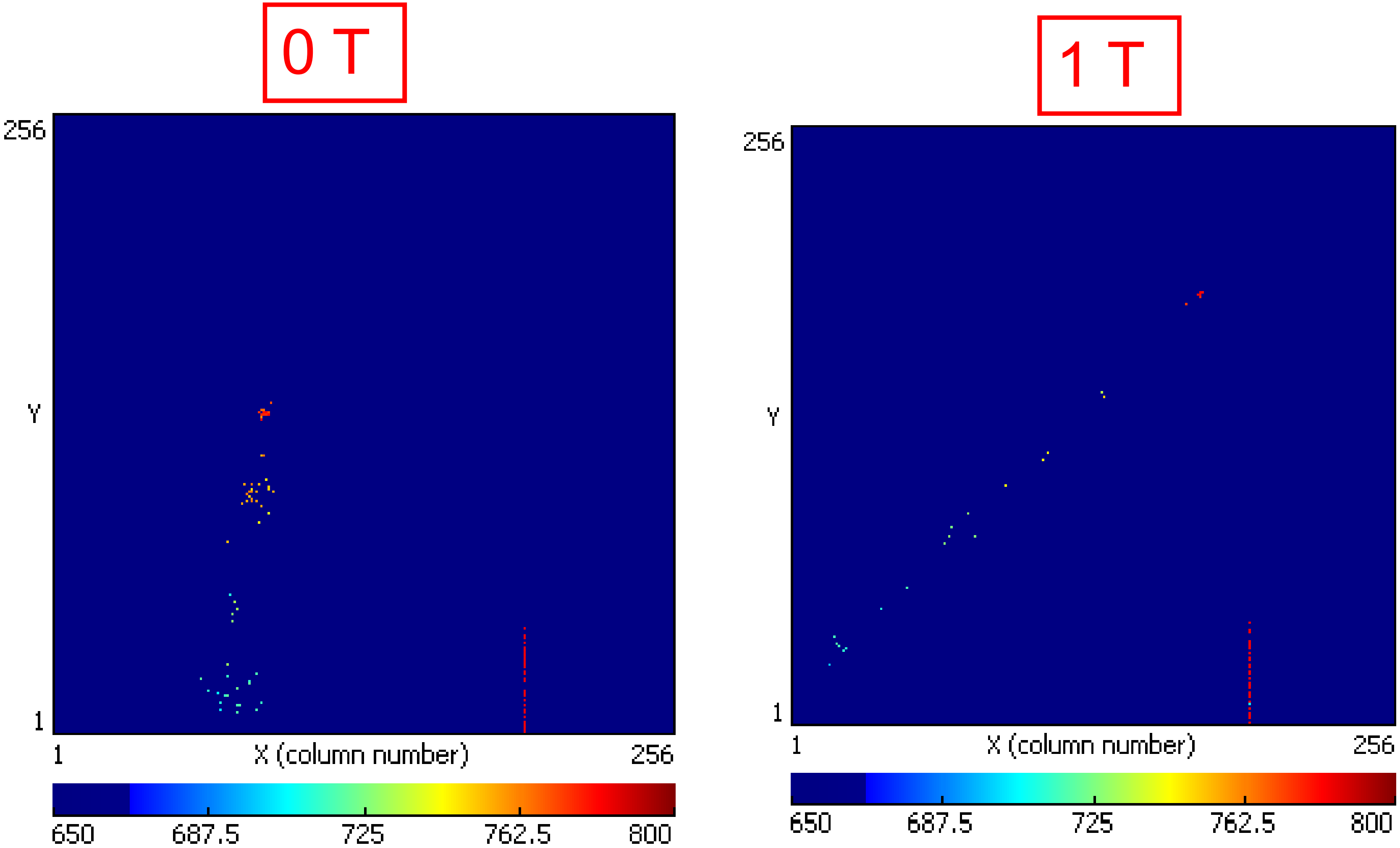
  At the same time we can correct the present version for known mistakes.

NIKHEF activities

- 1T magnet data and CERN PS data analysis
- Technology development:

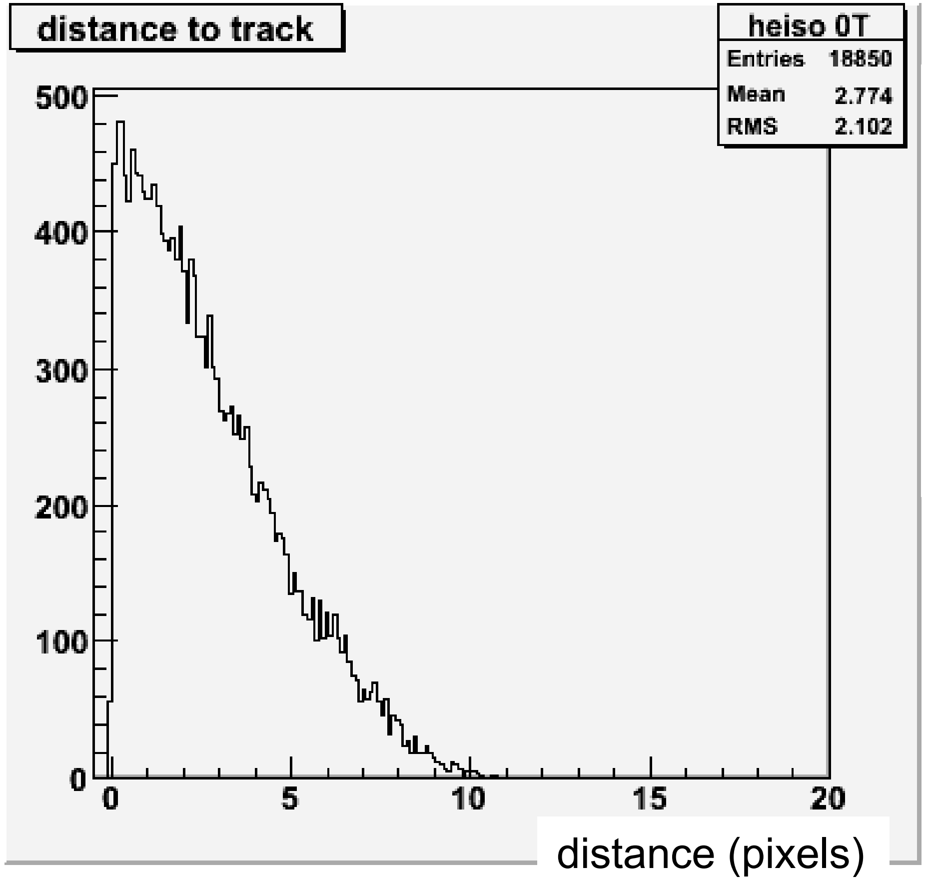
  (together with Univ. Twente)
  - Ingrid, “GEM”grid, Twingrid
  - Protection layers: aSi:H, Si_3N_4
  - Design larger chip-arrays

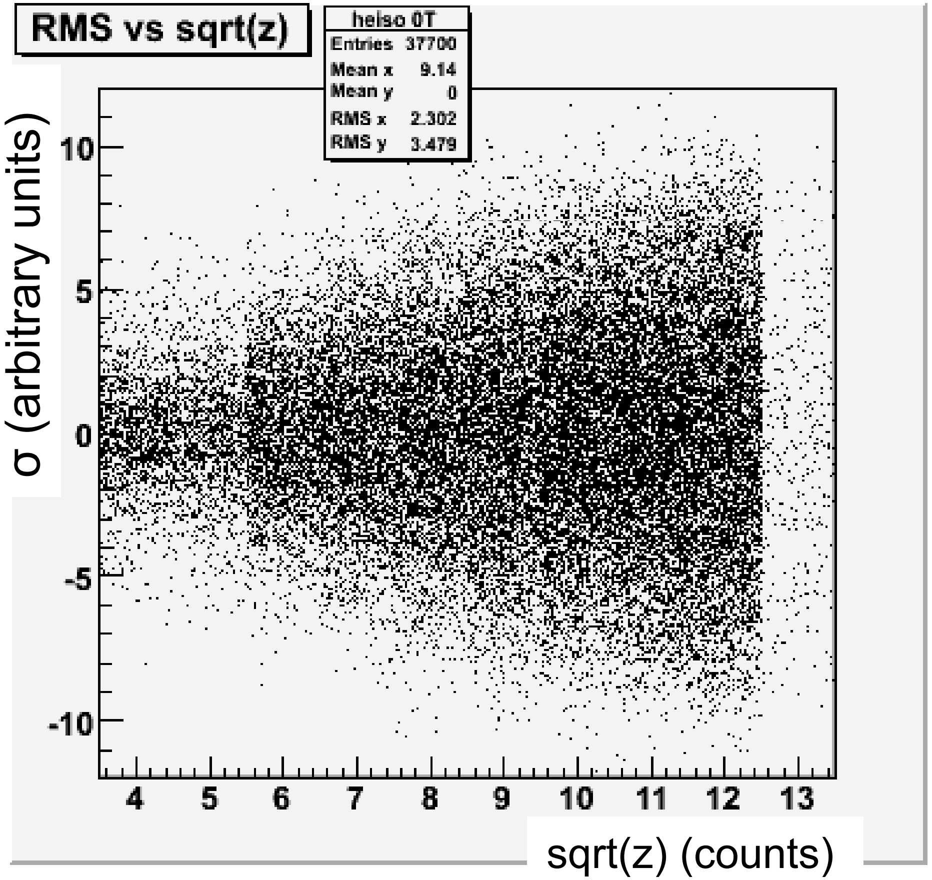
Cosmic tracks traversing ~ 30 mm drift space in Ar-CF4-iC4H10 (95/3/2%)



"large" diffusion "little" diffusion

distance to track





CERN PS testbeam data (B=0)

Full post-processing of a TimePix

· Timepix chip + SiProt + Ingrid:

Timepix chip:

•256x256 pixels

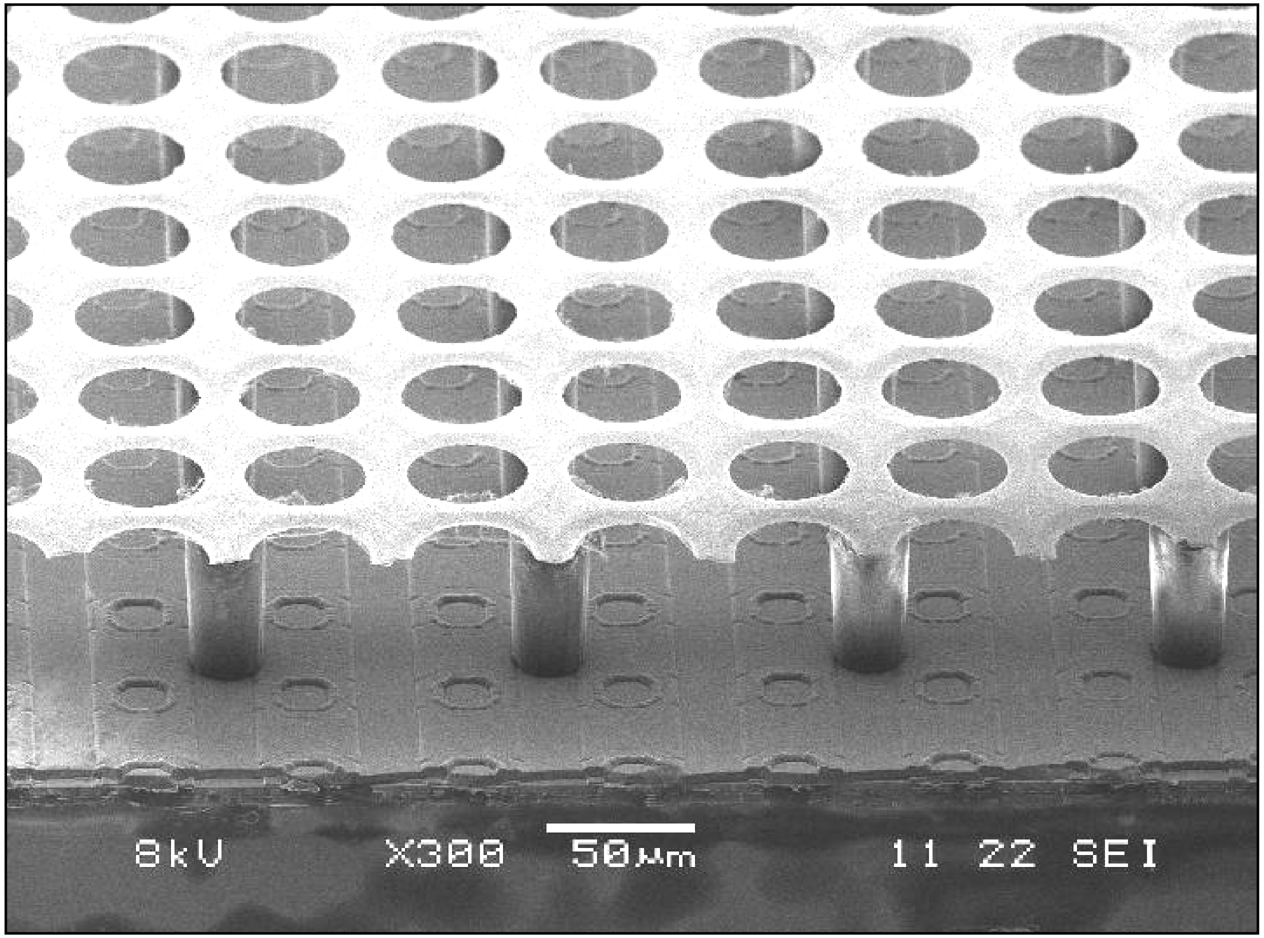
•pixel: 55x55 μm^2

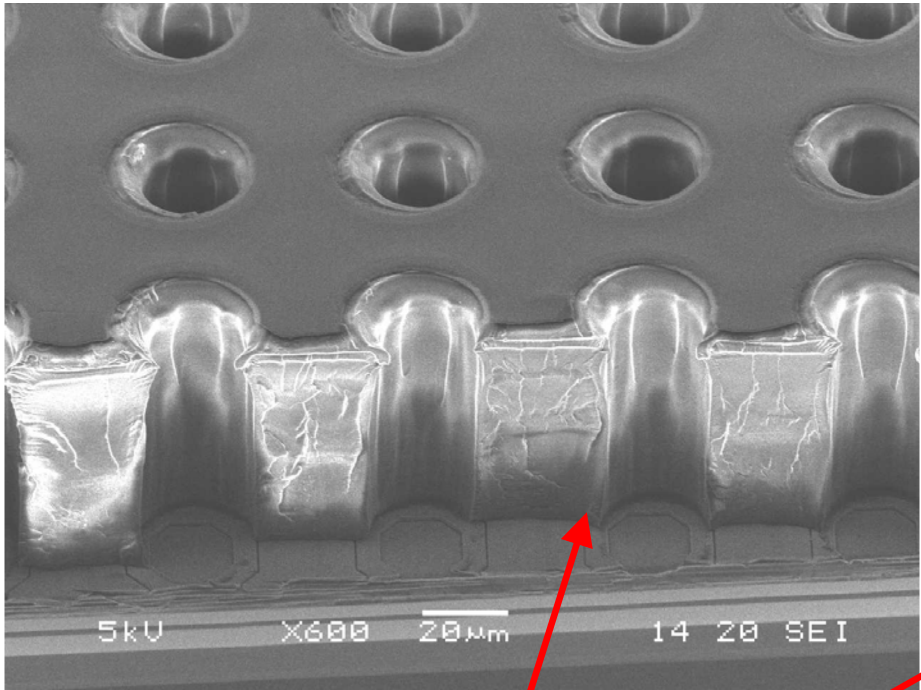
•active surface: 14x14 mm^2

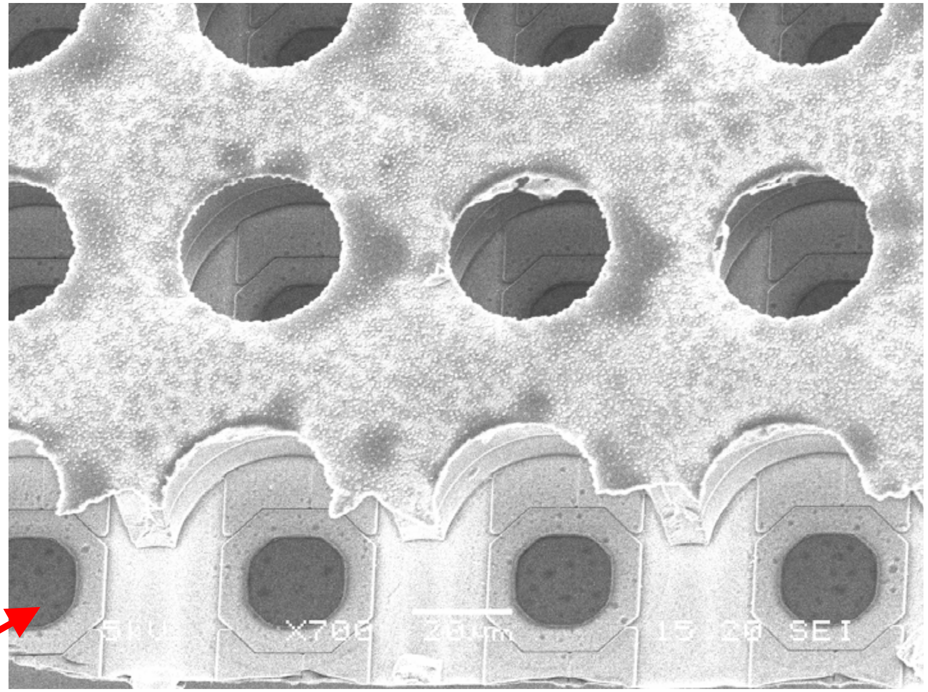
MESA+: Ingrid

IMT Neuchatel:

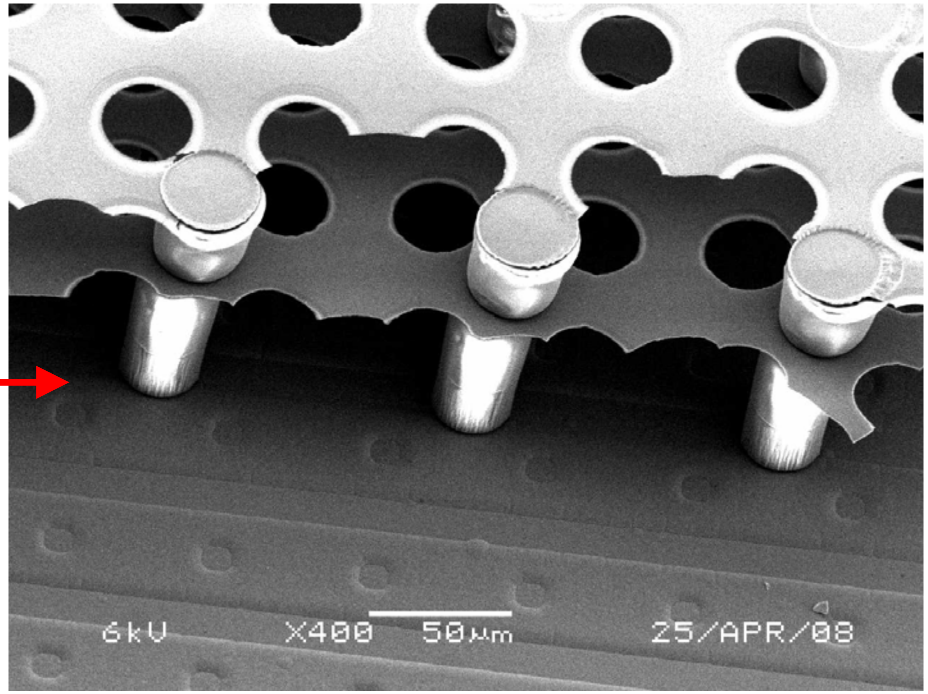
15 or 20 μm highly resistive aSi:H protection layer







“GEM”grids

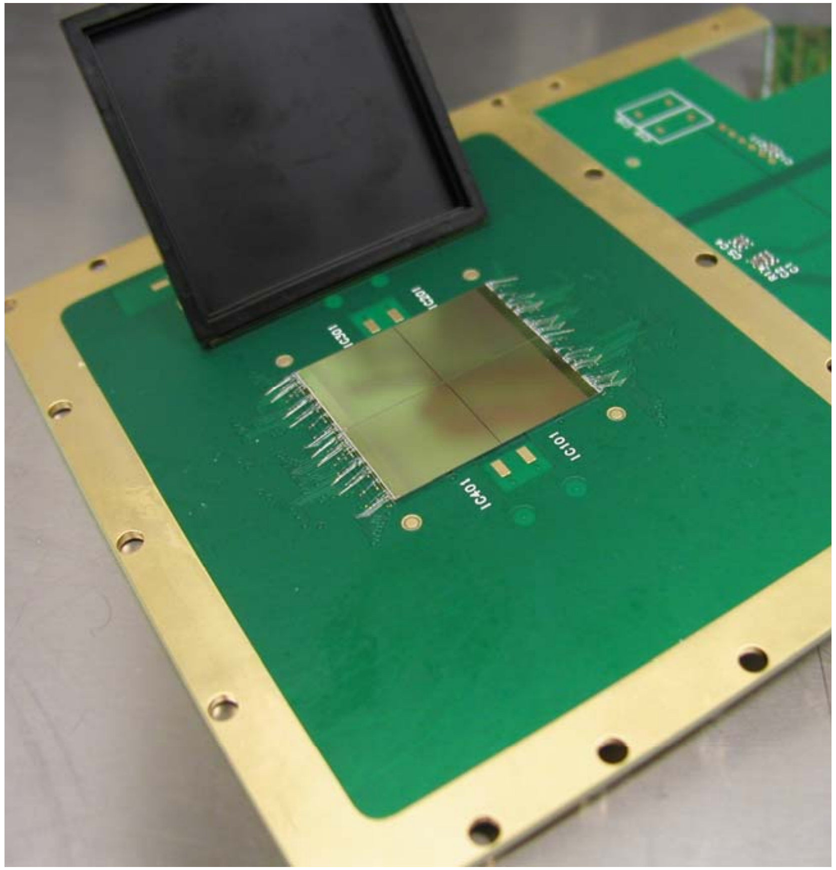


Twingrid

(under test)

Quad boards

- A square of 4 Timepix chips on a pcb.
- Solved some power problems.
- Set up works.
- Awaiting chips with Si(N)Prot and InGrid from Twente
- Potential deliverable for EUDET.



Work in progress

- (Post) processing in Twente.
  - Both SiNProt and InGrid can be applied.
  - Chip squares of 3X3 Timepix chips instead of individual chips.
  - Search for high res InGrids. (Si_3N_4)
  - Ageing test chips.
  - Discharge test chips.

- Quad in testbeams.

- Design of an 8X8 array.
  - Input from the RELAXED project.
  - Composed of quads.
  - Mechanics are being made right now.
  - Readout electronics in prototype stage.

SiTPC Summary-1

- Sofar mostly single-chip systems used
- Soon (Eudet deliverable) small multi-chip systems operational:
  - Bonn: two 4-chip boards $\rightarrow$ on endplate module
  - Saclay: one 8-chip board $\rightarrow$ on endplate module
  - NIKHEF: 4-chip board, fitting single-chip detector mechanics and drifter (could become endplate module)
- Later (~3/2009): aim for a 64-chip system (bottleneck could be production of sufficient # Ingrids; IZM Berlin interested)

SiTPC Summary-2

- A lot of progress made in last ‘year’; not mentioned many details on track resolution studies and on signal development
- Part of the technology is ready:
  - Very good energy resolution for Ingrid devices
  - Ion backflow at the few per-mil level at high field ratio
- Discharge protection seems working for Ingrid (and Micromegas) devices under “normal” conditions
- Robust operation with GEM devices (without protection)

Next:

- Build larger multi-chip detector systems with fast readout