DPG Conference

- Annual Conference of German Physics Society (DPG)
  - Section Particle Physics
  - 24. - 28. March in Mainz
  - Every member is allowed to give a talk
  - ~1000 contributions
  - Many parallel sessions
  - Also invited talks and plenar sessions
- This talk:
  - TPC 2 session
  - Abstract: http://www.dpg-verhandlungen.de/year/2014/conference/mainz/part/t/session/33
  - Group report: ~15-17 minutes talk + 3-5 minutes for questions
  - Idea: want to intoduce LCTPC-pixel collaboration
  - Present our work (with focuss on my/Bonn activities)
  - Hope: find some new members ;)

universitätbonn

A pixel TPC for the Linear Collider: Towards a demonstrator module

Michael Lupberger
University of Bonn
On behalf of the LCTPC-pixel Collaboration

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Pixel-TPC Meeting 13.03.2014

Outline

- LCTPC-pixel collaboration
- Timepix Chip
- 2013 Testbeam and data analysis
- Simulation
- Readout system
- Demonstrator module

universitätbonn

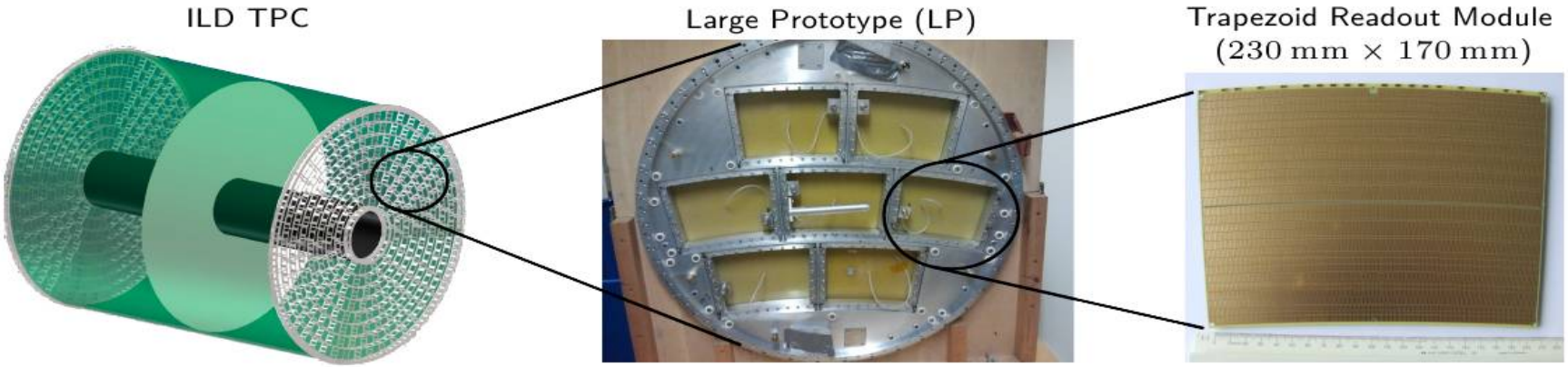
LCTPC-pixel collaboration

- LCTPC collaboration:
  - Develop a TPC for physics up to 1 TeV (at the ILC)
  - Groups from America, Europe and Asia
  - Several readout concepts using GEM/Micromegas
- LCTPC-pixel
  - R&D towards a pixel-TPC: MPGD + pixel readout
  - Groups:
    - NIKHEF: Module construction
    - University of Kiew: Simulation
    - CEA Saclay / DESY: Data analysis
    - Uni Bonn: Module construction, readout system, data analysis
    - Uni Siegen: Data analysis
  - Goal: build a demonstator module for a pixel-TPC

universitätbonn

LCTPC Prototype

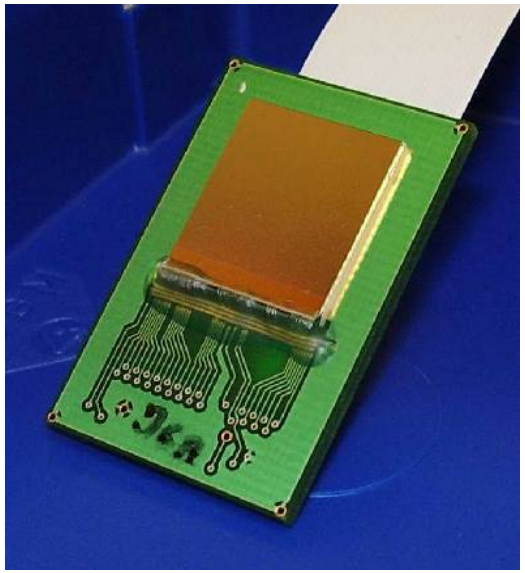
- Setup at DESY

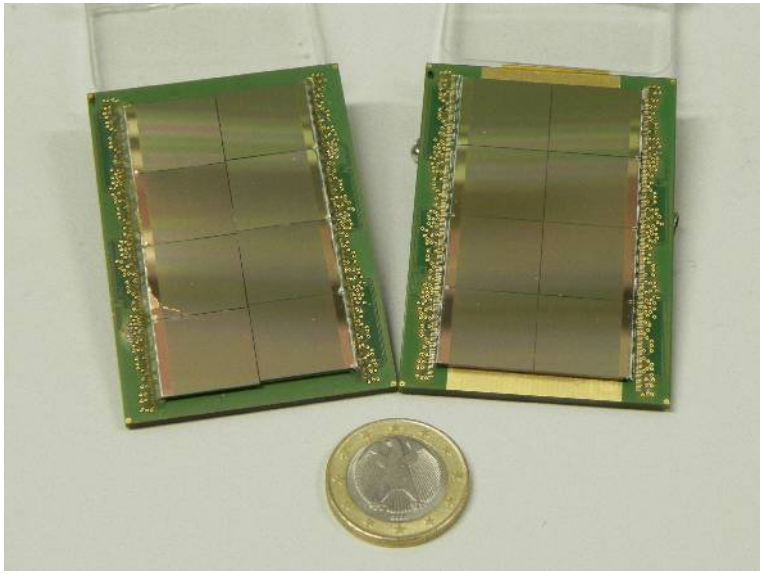


universitätbonn

Timepix chip

- Universal readout chip
- Properties:
  - active surface: 1.4 x 1.4 cm²
  - pixel size 55 x 55 µm²
  - 256 x 256 pixel array
  - 14 bit counter in each pixel (ToA or ToT)
  - Noise threshold ~500e^- (ENC ≈ 90e^-)

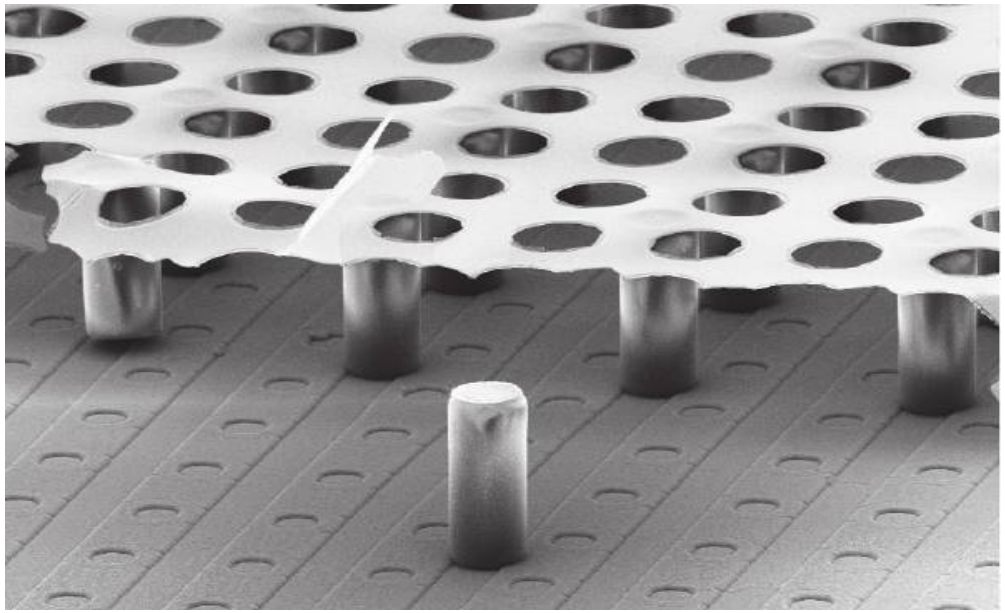


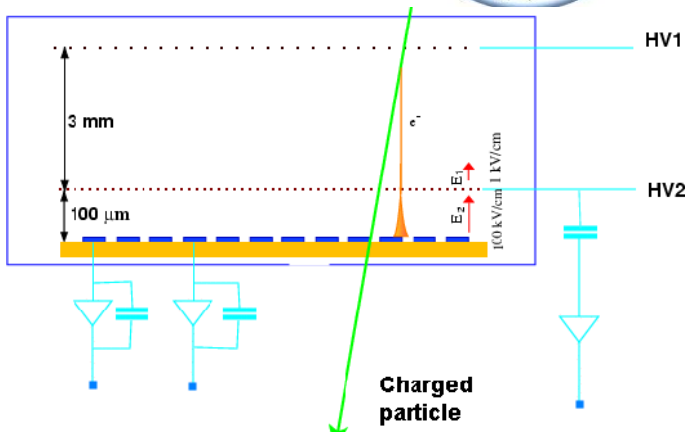


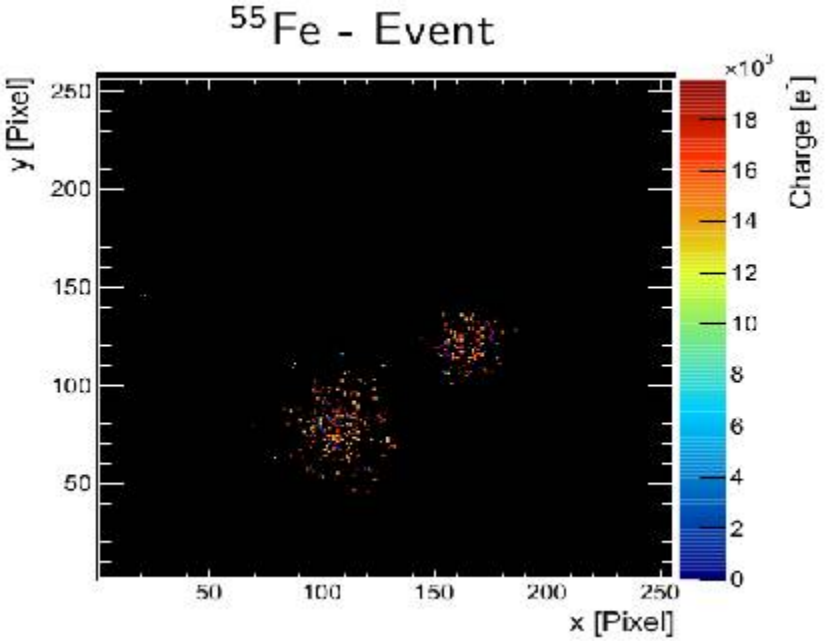
universitätbonn

Timepix+Micromegas=InGrid

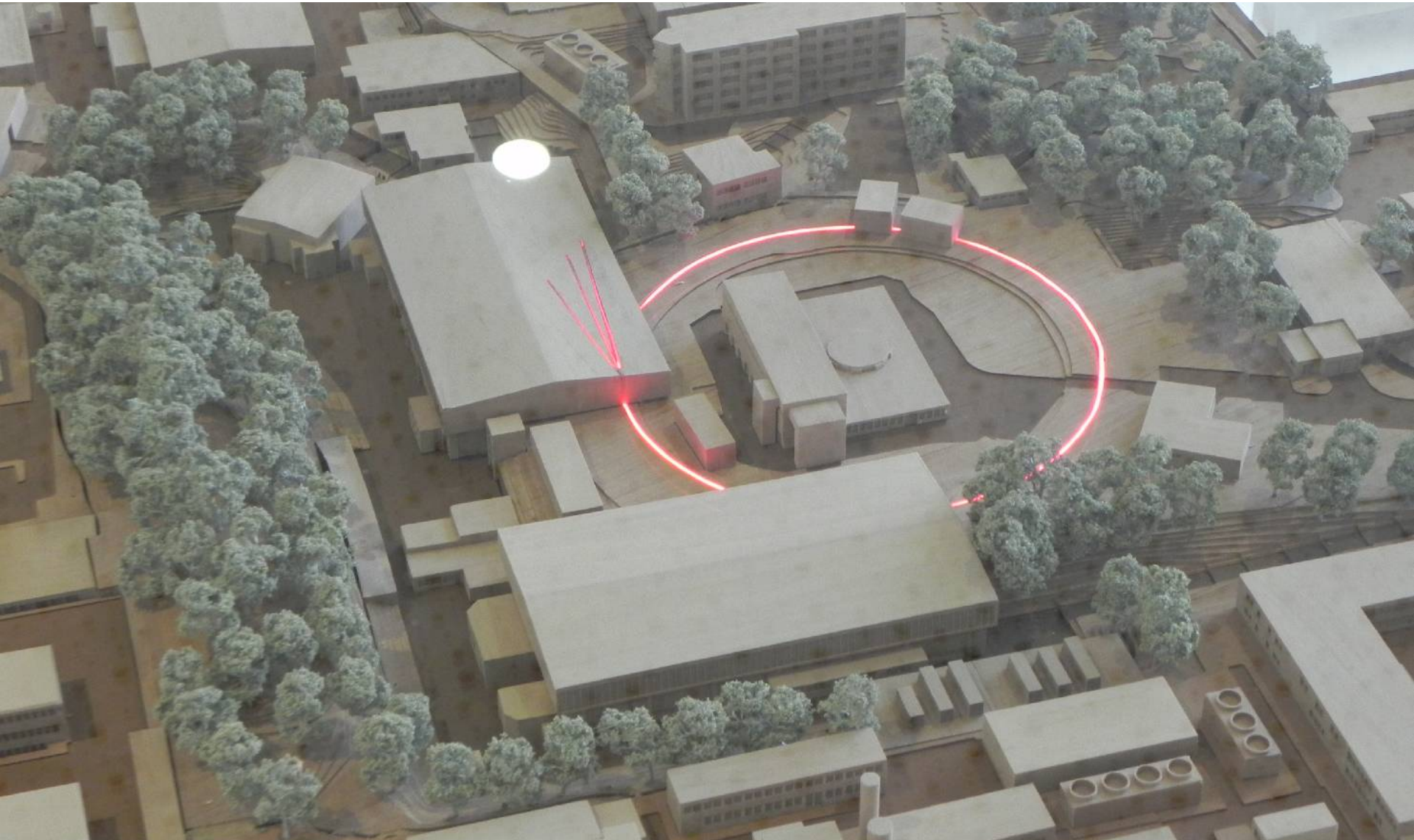
- Aluminium mesh on chip
- Use photolithographic process
  - Hole to pixel alignment
  - Pillar height uniformity





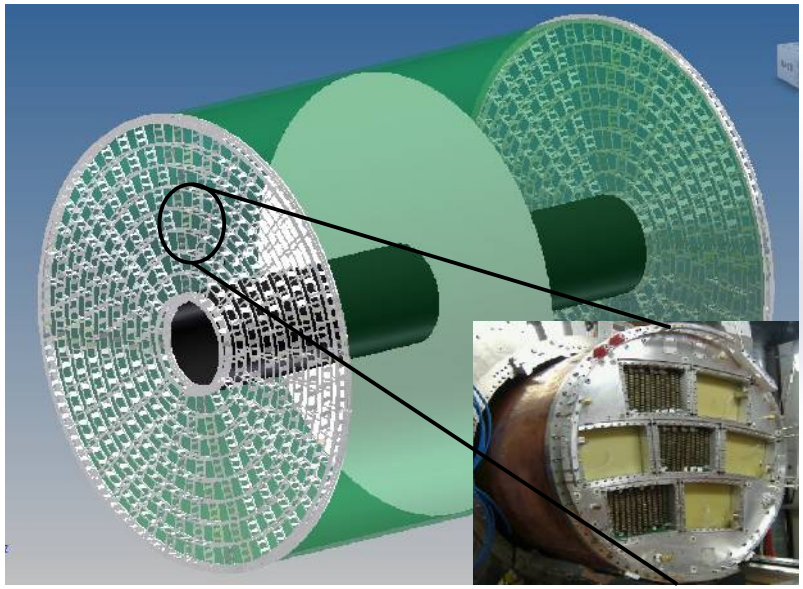


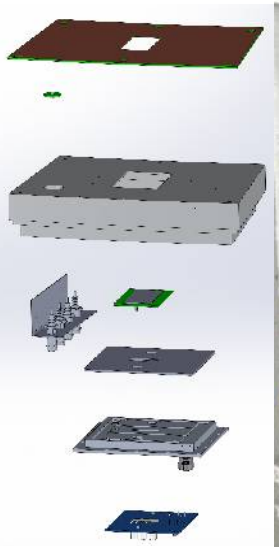
2013 test beam

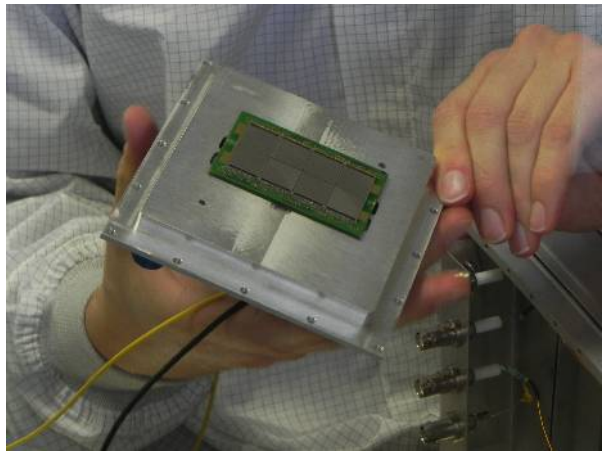


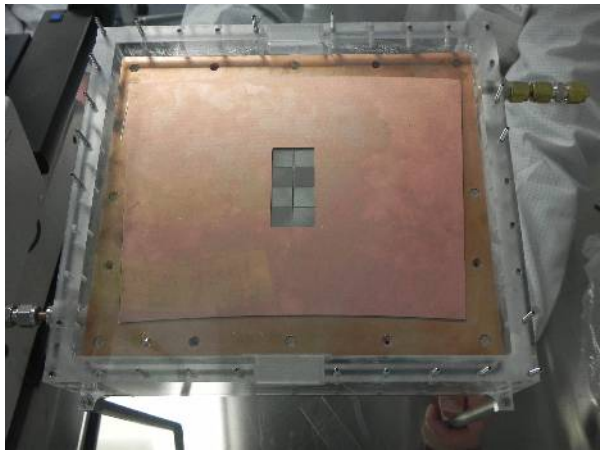
2013 test beam

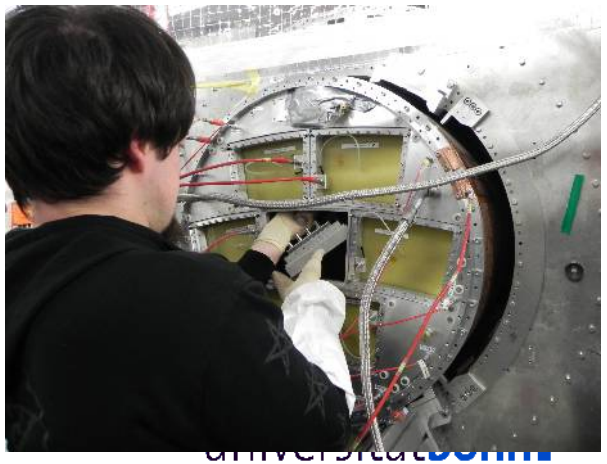
Setup at DESY











2013 test beam

March/April 2013: 2 LCTPC octoboard modules

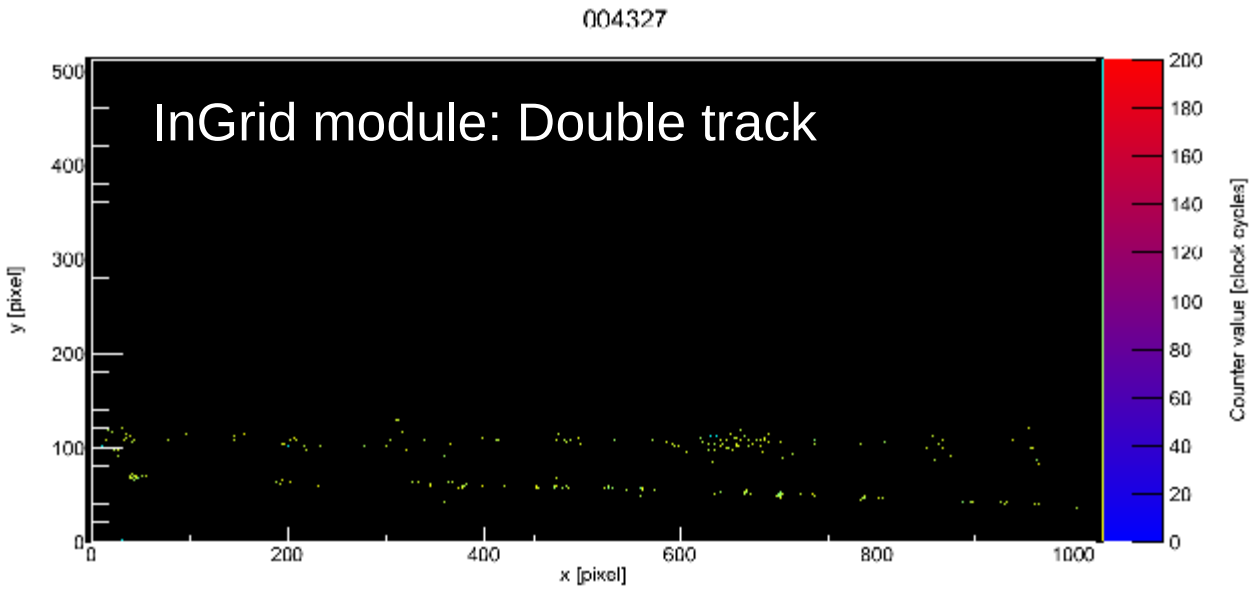
- Different amplification structures: GEM / InGrid
- Test of readout system

- Readout rate: 2.5 Hz; 40MHz clock
- Electron beam of up to 6 GeV
- Gas: Ar:CF4:iC4H10 (95:3:2) = T2K gas
- ~ 2 Mio. frames recorded, including B = 1 T
- Extensive testbeam program

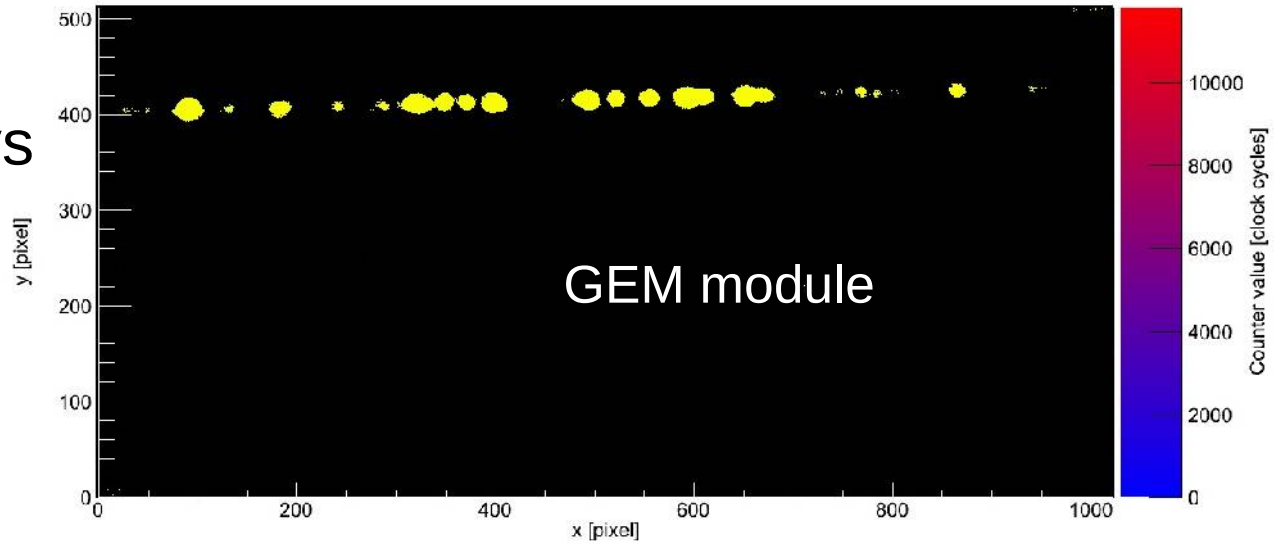
- Preliminary data analysis in MarlinTPC Robert Menzen

universitätbonn

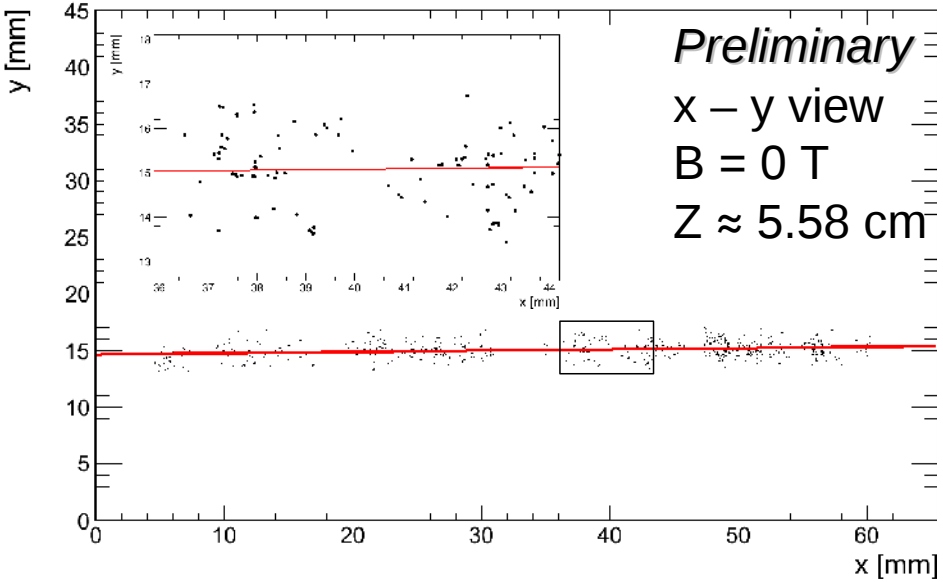
2013 test beam

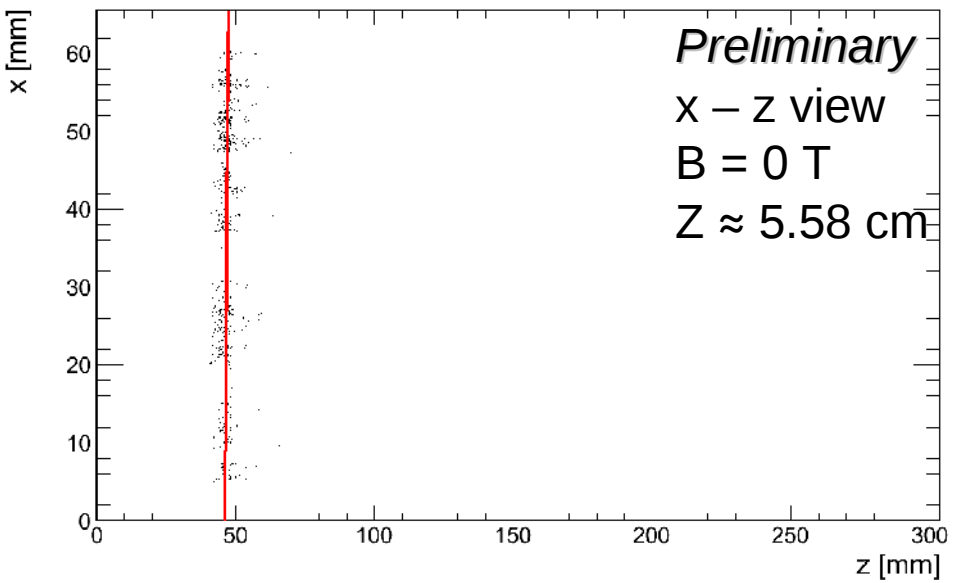


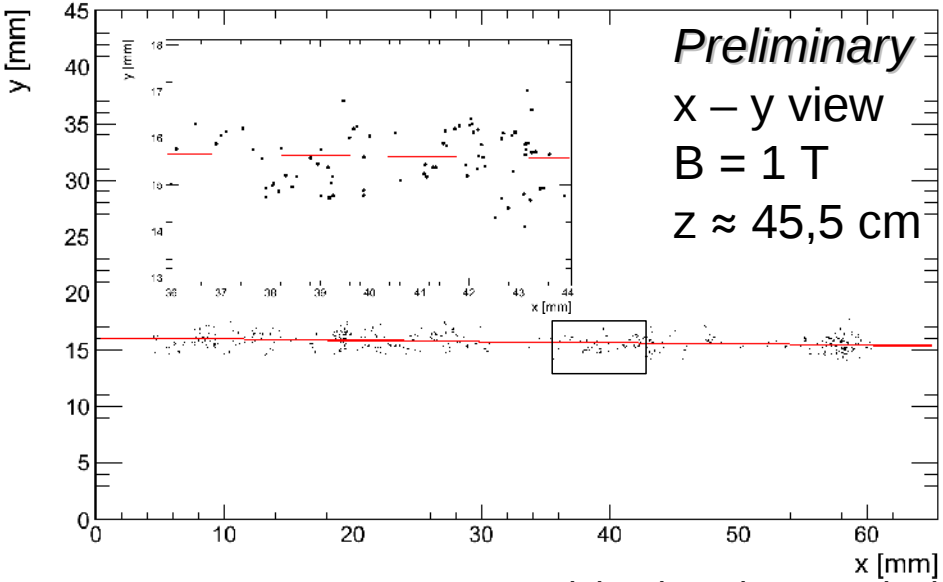
Online event displays



Reconstructed tracks



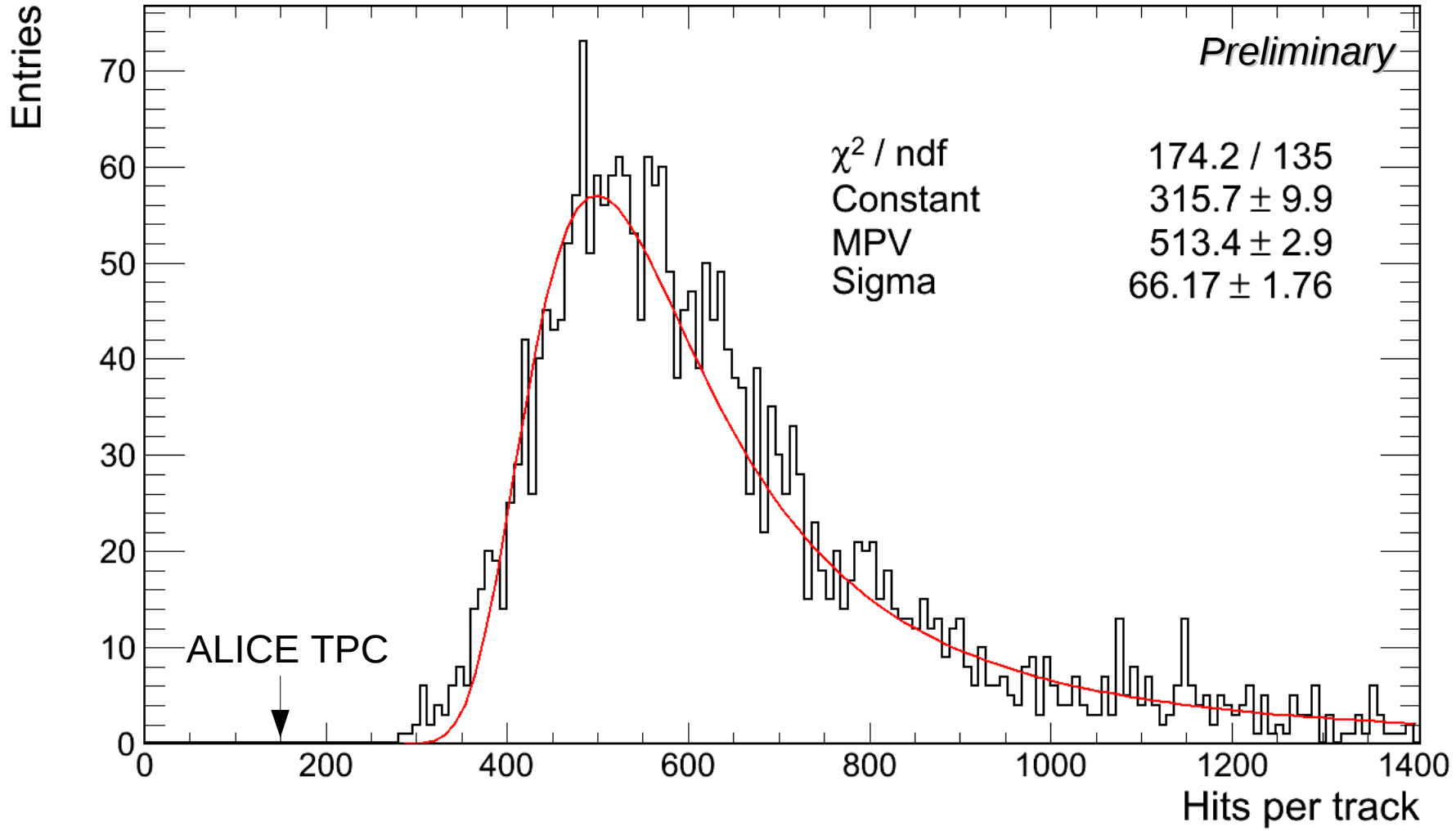




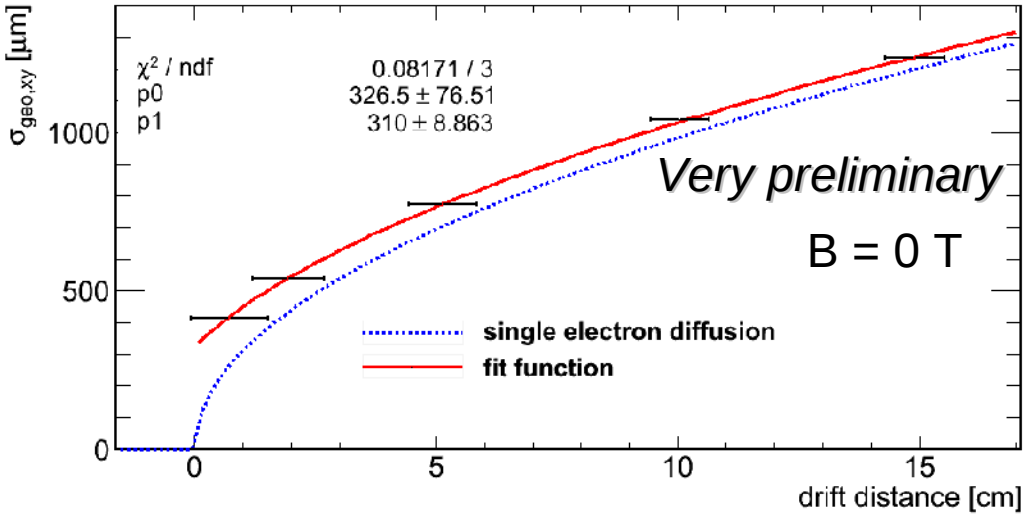
universitätbonn

Hits per tracks

B = 0 T, z = 5,58 cm, track length ≈ 5,6 cm

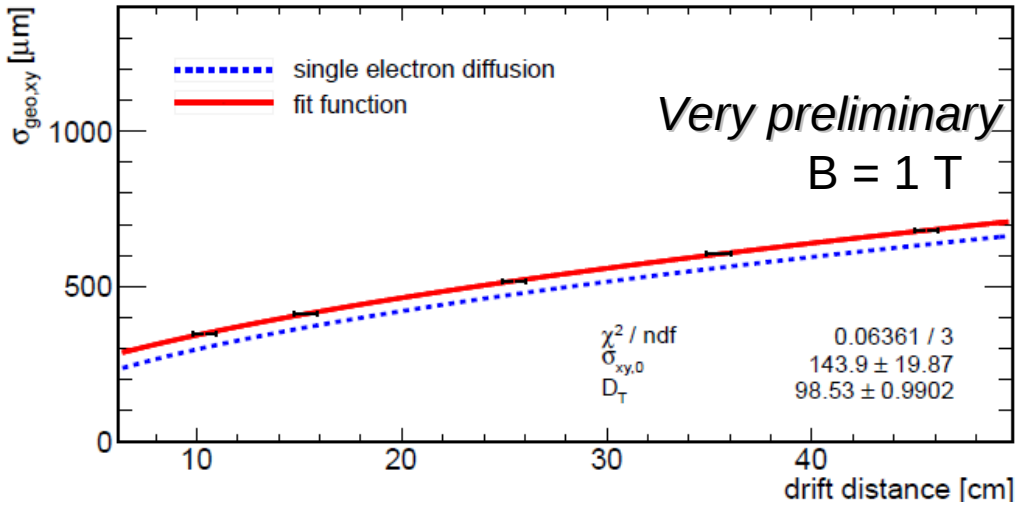


Transverse spatial resolution



Fit function $f(x) = \sqrt{P0^2 + P1^2 \cdot z}$

P0: intrinsic x-y resolution 327 µm
dominated by field distortions
P1 = 310 µm/√cm:
diffusion in T2K for E = 230 V



universitätbonn

Data analysis

Andrii Chaus (DESY/CEA Saclay):

Processing Octoboard test beam data

- MAFalda analysis framework ok for fast analysis at testbeam
  - Track reco based on raw data, no GEAR info
  - Field distortions, drift velocity, residuals, diffusion
- MarlinTPC for real analysis (using GEAR information)
  - Processors for octoboard analysis
  - Analysis chain setup ongoing

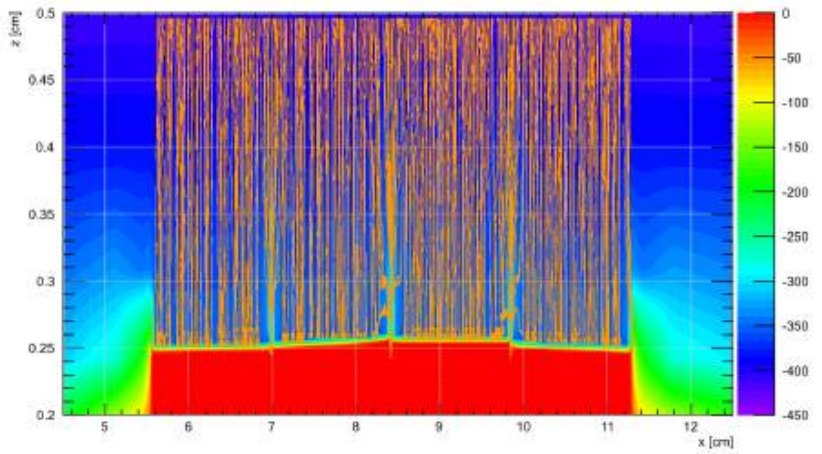
Amir Shirazi (Uni Siegen):

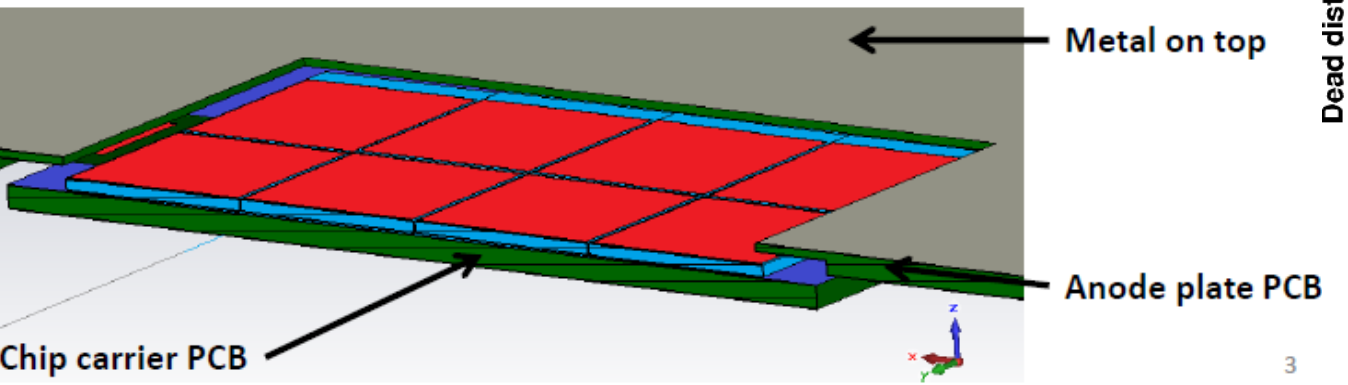
Just started to set up and learn MarlinTPC

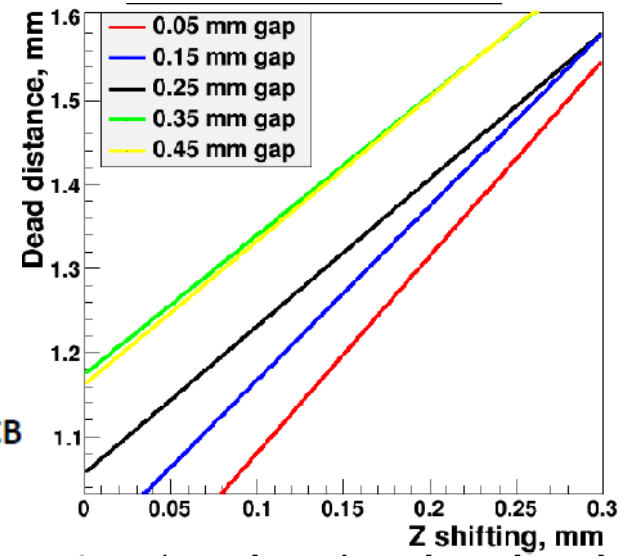
Simulation

Oleksiy Fedorchuk (Uni Kiew) : Octoboard simulation

- Single octoboard simulation
  - Successfully modelled
  - Field distortions
  - Simulated occupancy similar to data
  - Impact of shifted chips
- Next step:
  - Include B field
  - 100 chip module



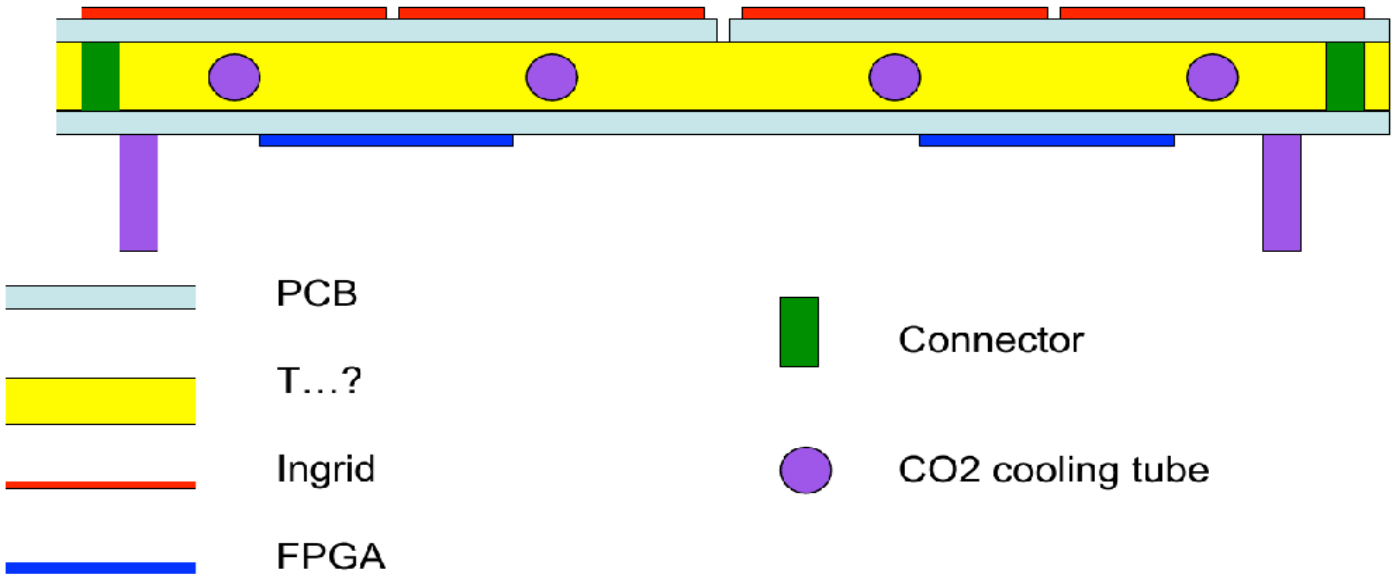




Detector construction

Jan Timmermans (NIKHEF) : 2 Octopuce testbeam

- Testbeam with 2 Octoboards @ LP
  -
  -
  -
- Plan for module layout + readout

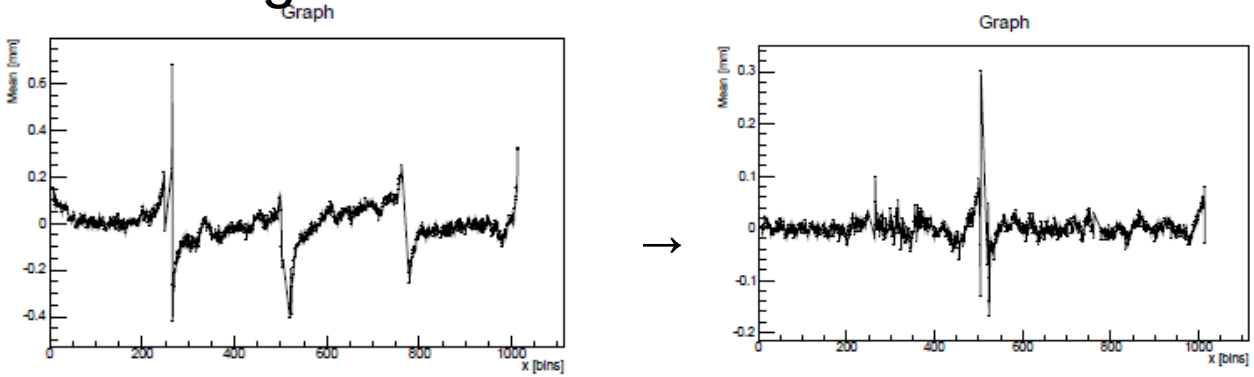


Bonn group activities

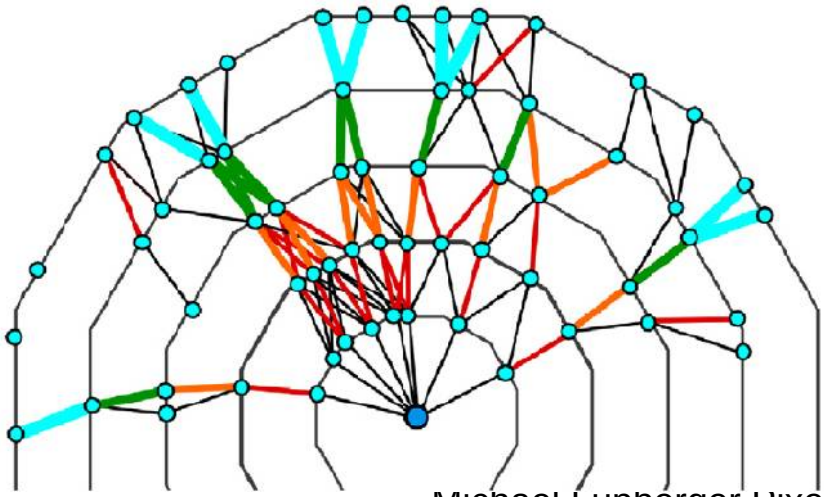
Data analysis

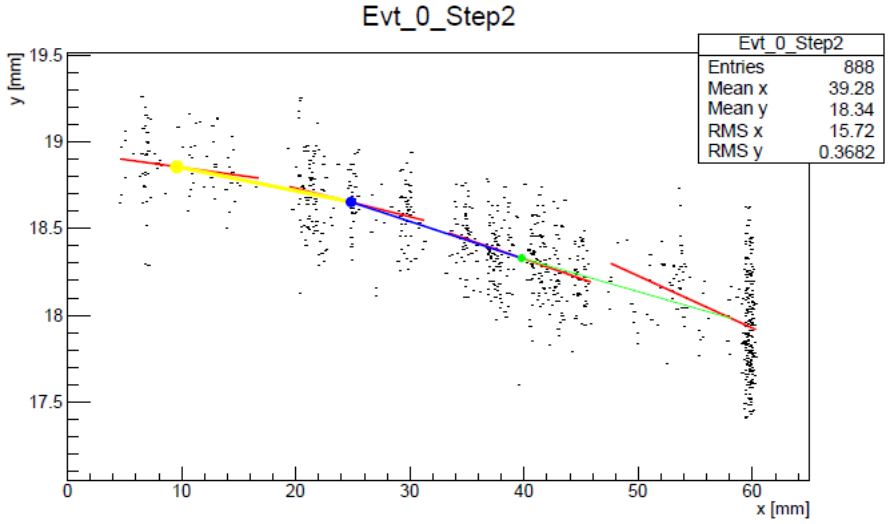
Martin Rogowski: A new tracking algorithm

- Reinvestigate field distortions of Roberts analysis



- Algorithm from Forward Tracking Detector for ILD





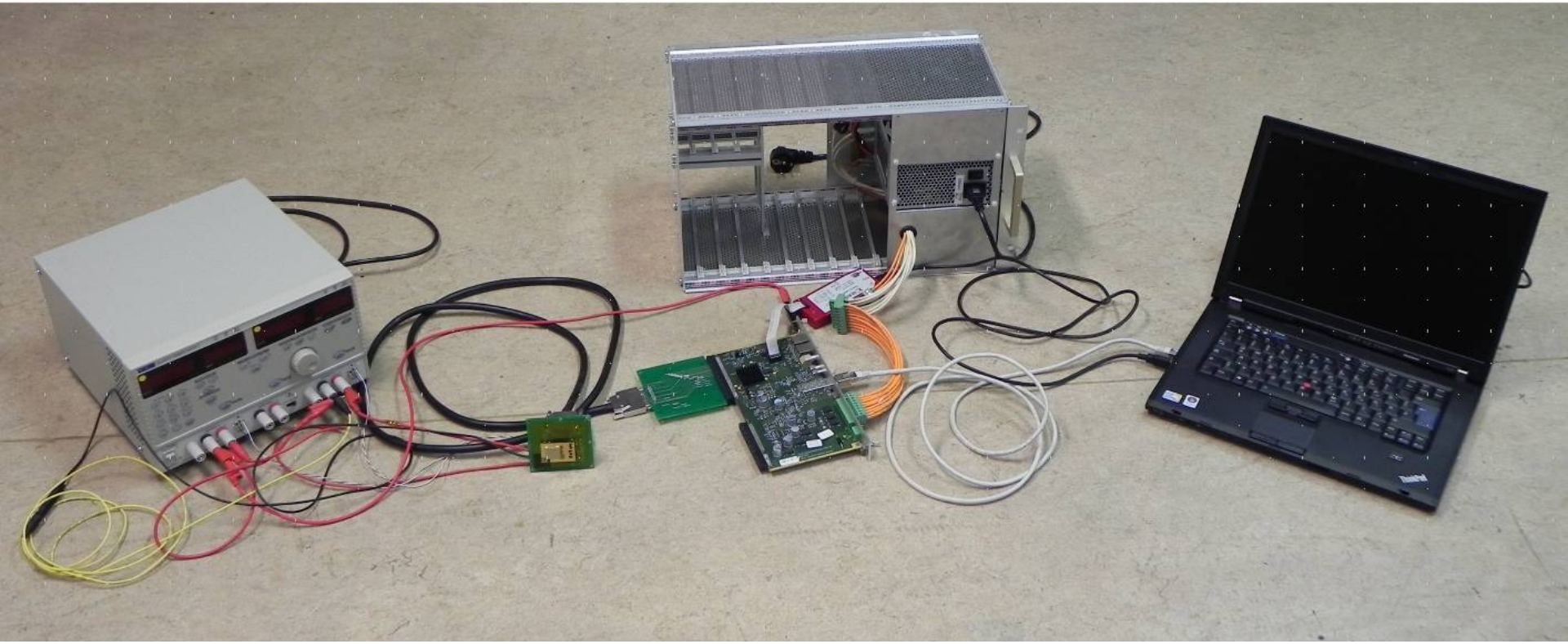
Data analysis and simulation

Martin Rogowski: A new tracking algorithm

Listen to his talk !

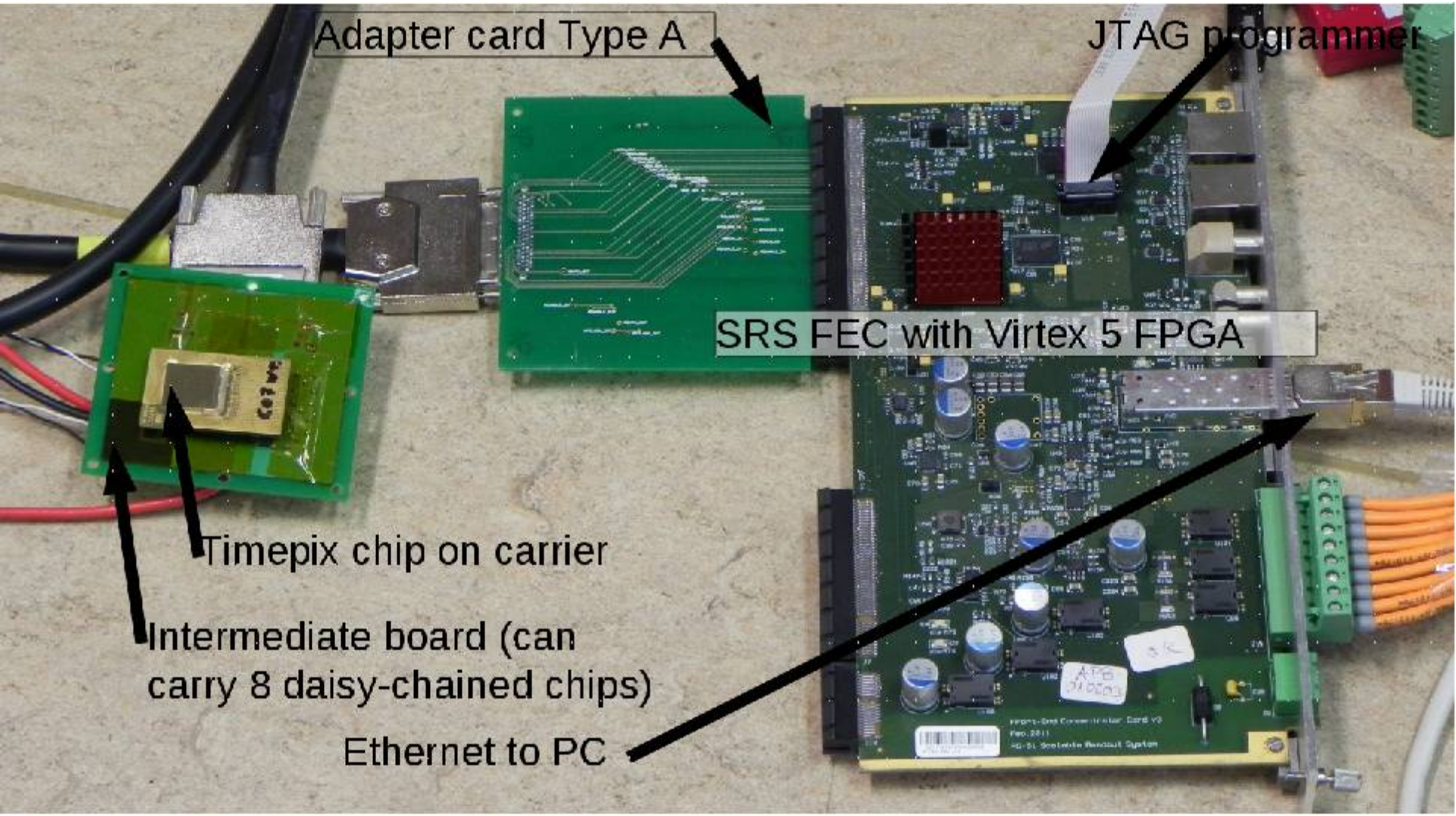
Readout system

Scalable Readout System (RD51, CERN)



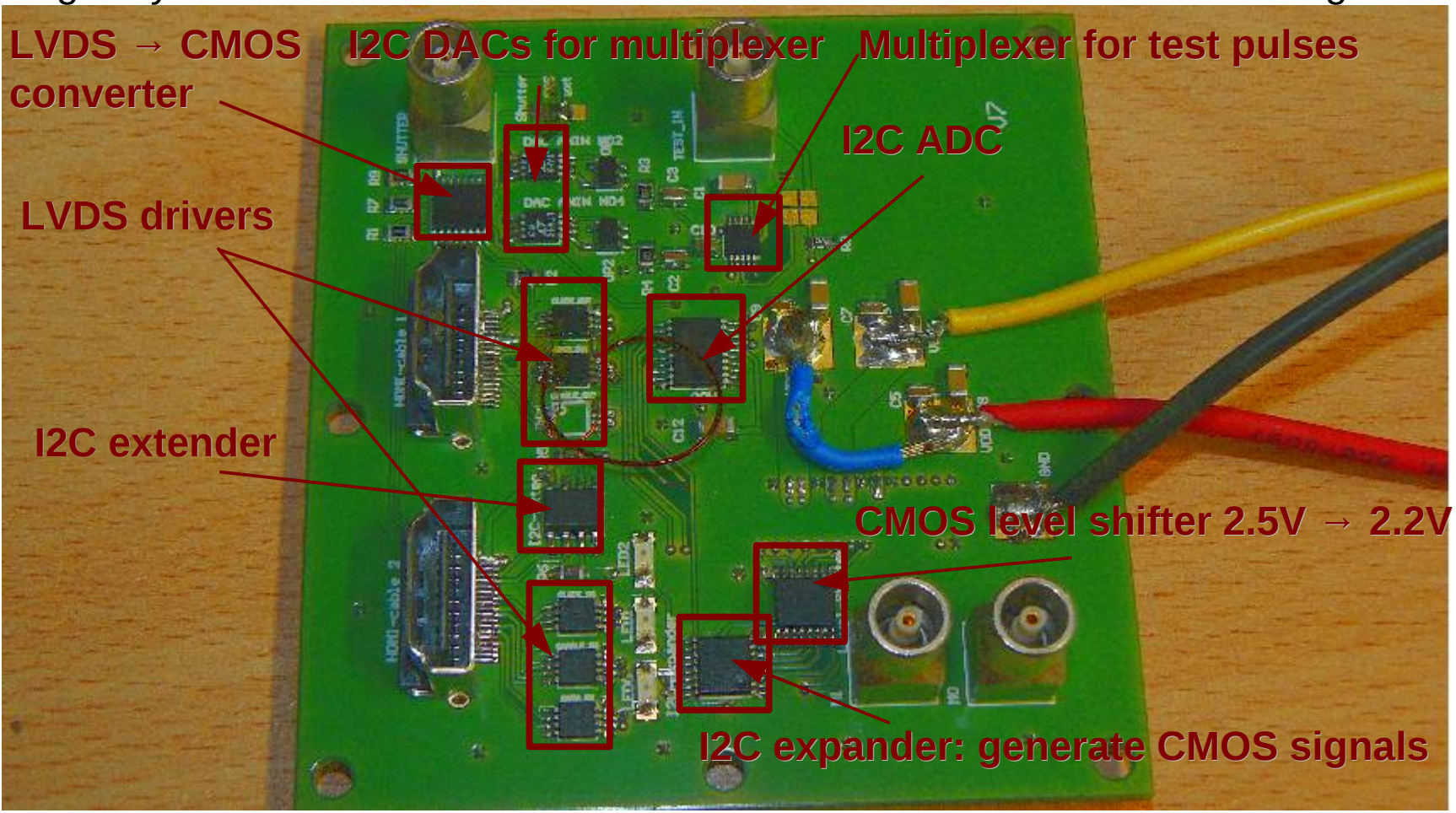
Chain: Chip – Adapter card+FEC – Computer

SRS with Timepix chip



New Intermediate board

I2C: standard for small network. Signals: scl (clock), sda (data)
Originally between PCBs next to each other. Several meters distance using extenders.



universitätbonn

Status Timepix+SRS Readout

- Test of FPGA Firmware:
  - I2C interface ready

- Test of new components finished
  - I2C network ok (DACs, ADC, expander work)
  - DDR2 Ram ok
  - LVDS driver work

    => chip can be operated, data taking ok, even for 8 chips
- Software implementation finished (ADC readout for DAC scan, automatic calibration with test pulses from multiplexer)

- Redesign of intermediate board and A Card for scale-up

universitätbonn

LP module: next steps

~100 chip module

- Progress depends on many factors
  - InGrids
  - Man power
  - DESY testbeam schedule
- Project: test a 32 InGrid board in September/October
  - Similar design as 8 InGrid module
  - Expandable to 96 InGrids

- Mechanical construction (Bachelor student: Johann Tomtschak)
  - CAD drawings in SolidWorks
  - Construction of light LP frame in workshop
  - Construction of chip support structure in workshop
  - Use water cooling

LP module: next steps

~100 chip module

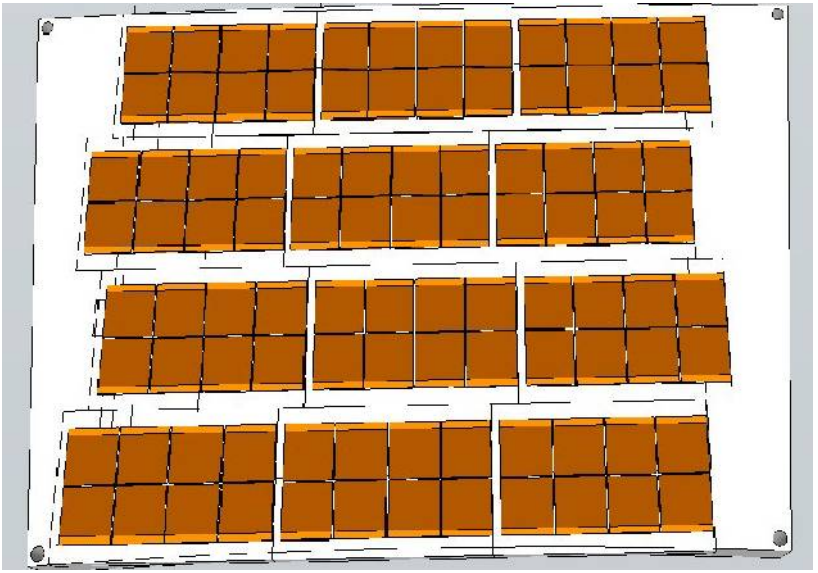
- Powering (Bachelor student: Kathrin Kohl)
  - Was already critical for a single octoboard
  - Low voltage supply for 4/12 octoboards?
  - High voltage supply

- PCB layout (Jochen Kaminski)
  - Depends on powering
  - Space is limited
  - Need many HDMI cables
- InGrid bonding, testing, quality control, calibration

Summary and Outlook

LCTPC-pixel collaboration is very active:

- Analysis of 2013 testbeam data
- Simulation of field distortions
- Development of readout system
- Design of a 32 / 96 chip module

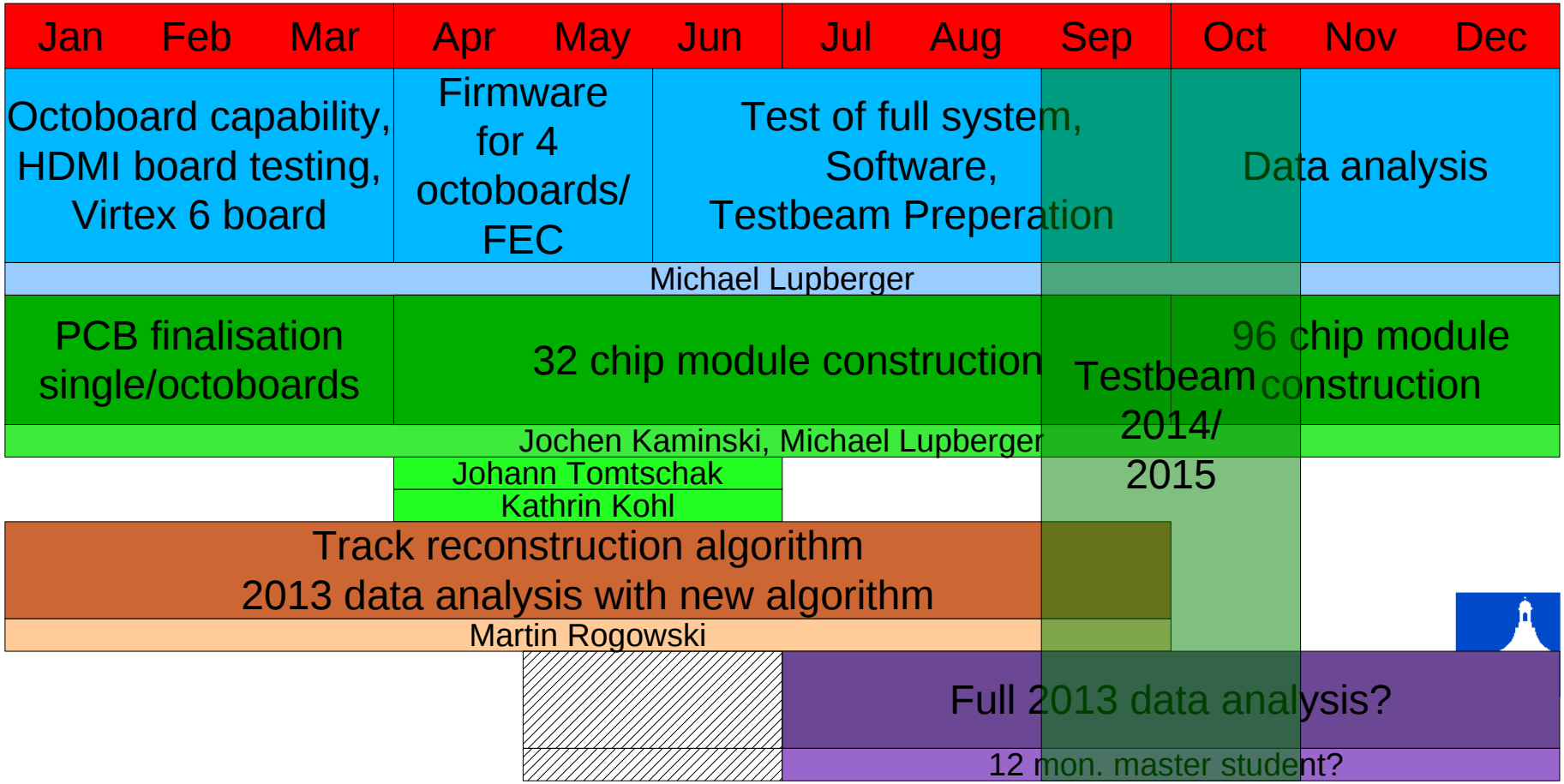


=> Demonstrator for a pixel TPC (for ILD @ ILC)

universitätbonn

Schedule for 2014

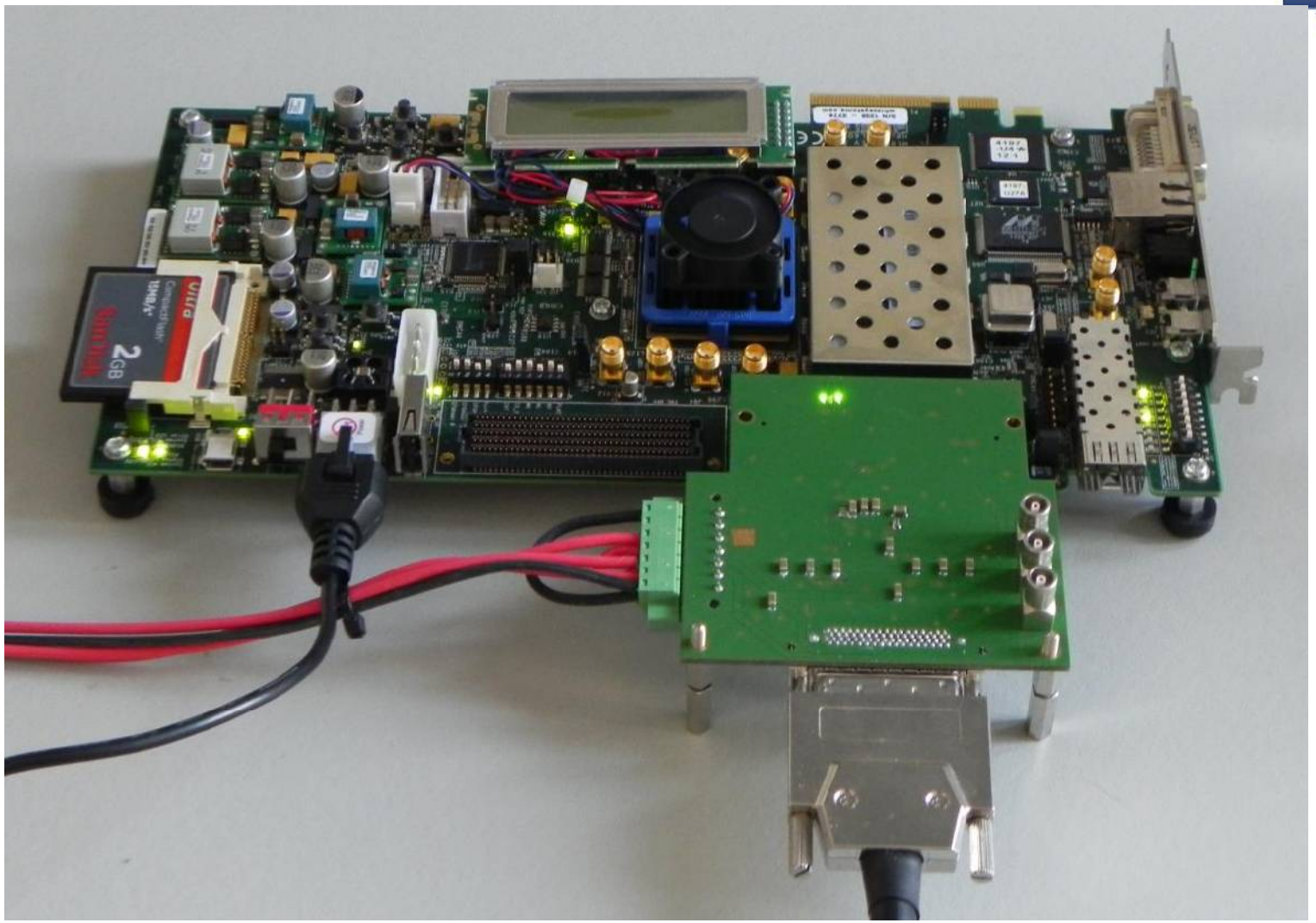
- Additionally:
  - Need/would like to have a master student for full analysis
  - Data analysis of new testbeam data
  - 96 chip module test in 2015 ?



We can provide soon:

- SRS (A card) with full functionality (for MUROS compatible intermediate board)
  - Users with SRS can plug and play Timepix
  - Users can use MUROS or SRS for same detector
  - Comparability study, documentation
- V6 evaluation board (VHDCI cables MUROS compatible):
  - Updated adapter board, I2c network tested
  - ADC, DAC control and readout with i2c (firmware, software)
  - Users with V6 board can plug and play Timepix
    - Users can use MUROS or SRS for same detector
    - Comparability study, documentation:
  - Use in CAST

Xilinx Evaluation board



Virtex 6 FPGA

Preliminary Analysis: Cuts

Dataset for first analysis:

z-scan, B=0 T, E_{Drift} = 230 V/cm (D_T = 311 µm/√cm)

⇒ tracks parallel to x-axis

Cuts:

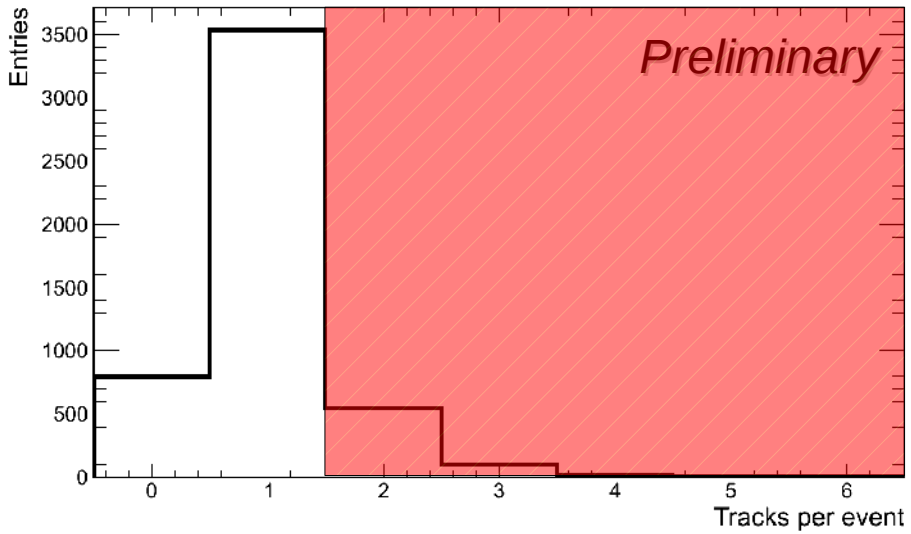
- Only hits within shutter window
- More than 200 hits per track

Preliminary Analysis: Cuts

Dataset for first analysis:

z-scan, B=0 T, E_{Drift} = 230 V/cm (D_T = 311 µm/√cm)

⇒ tracks parallel to x-axis



Cuts:

- Only hits within shutter window
- More than 200 hits per track

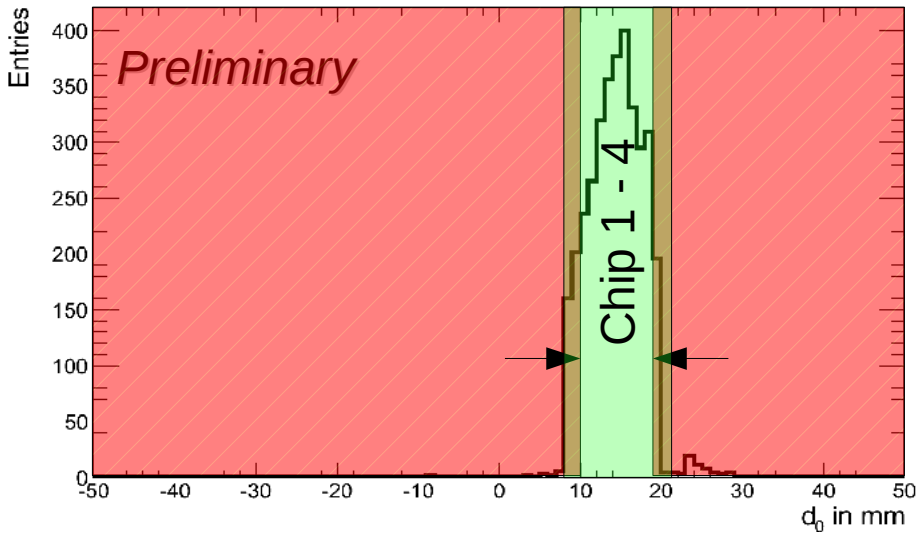
- Only single track events

Preliminary Analysis: Cuts

Dataset for first analysis:

z-scan, B=0 T, E_{Drift} = 230 V/cm (D_T = 311 µm/√cm)

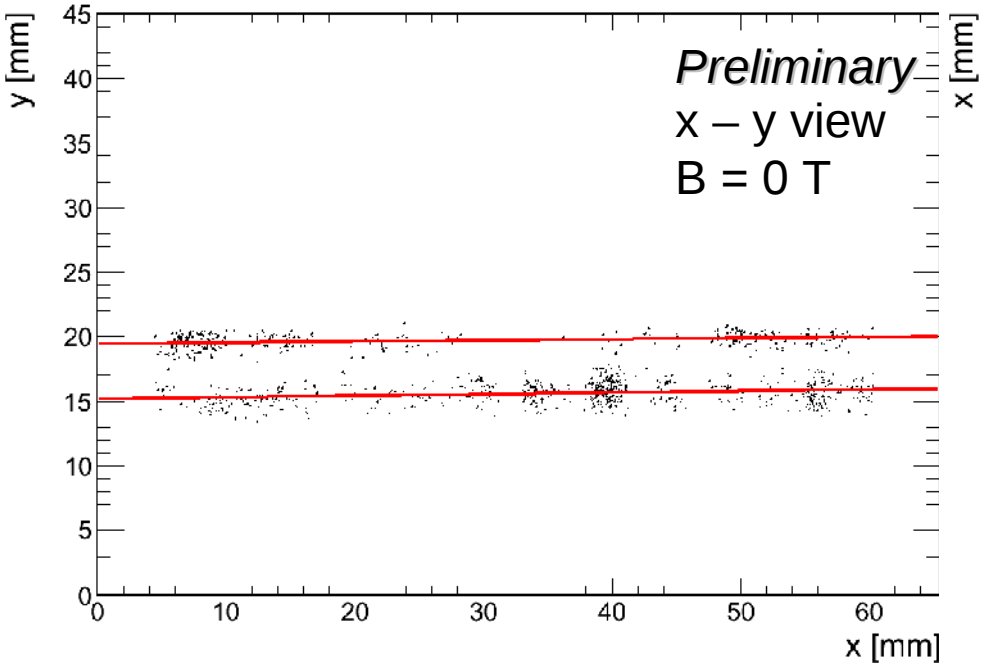
⇒ tracks parallel to x-axis

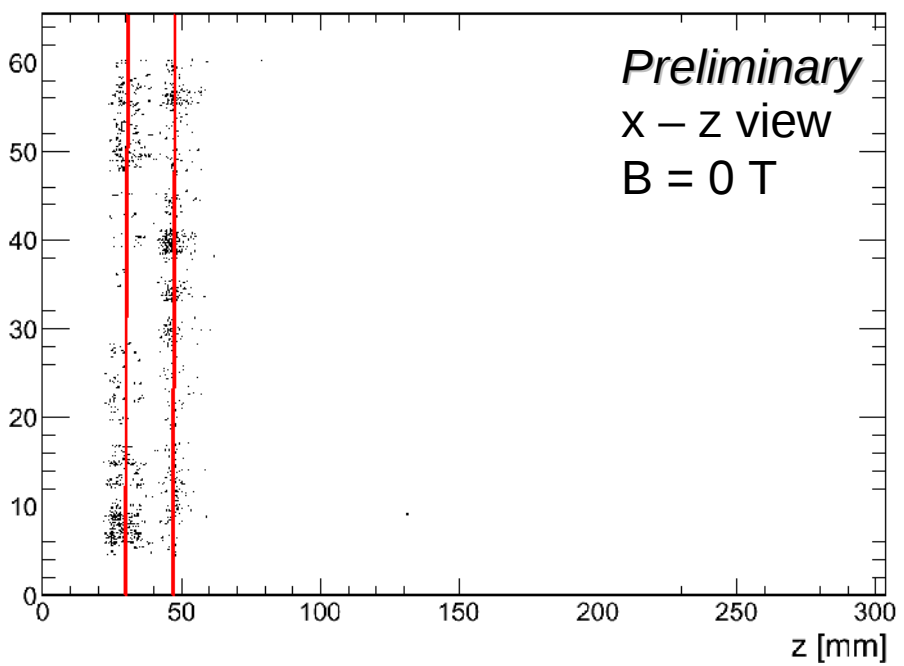


Cuts:

- Only hits within shutter window
- More than 200 hits per track
- Only single track events
- Tracks centred on lower chip row (z dependent)

Reconstructed double tracks

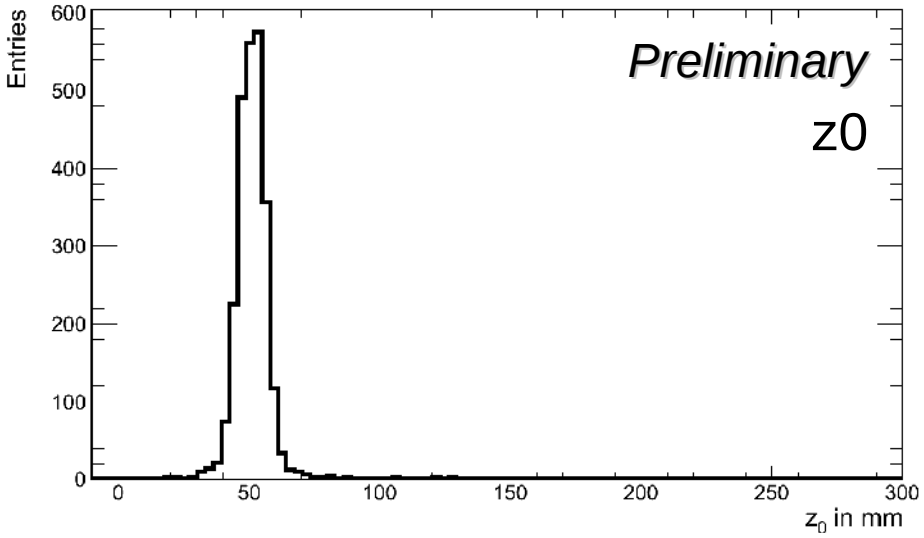


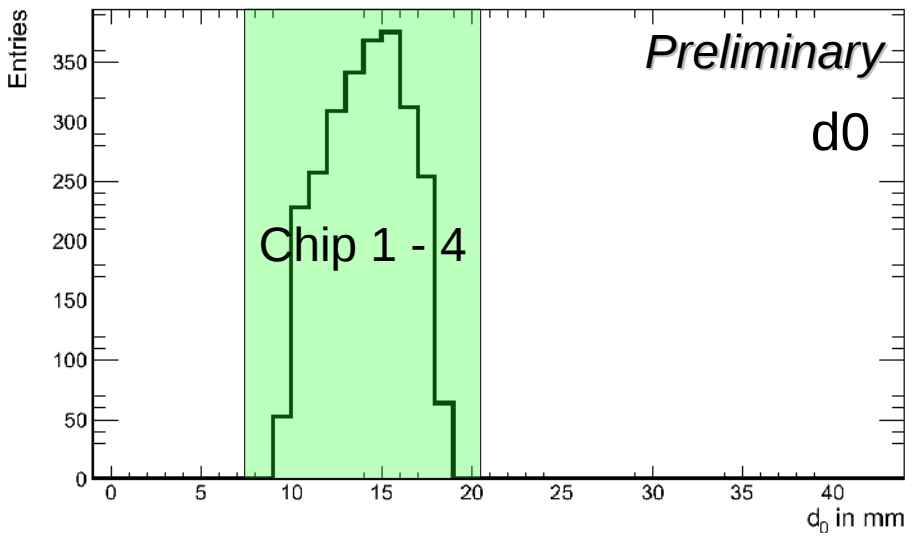


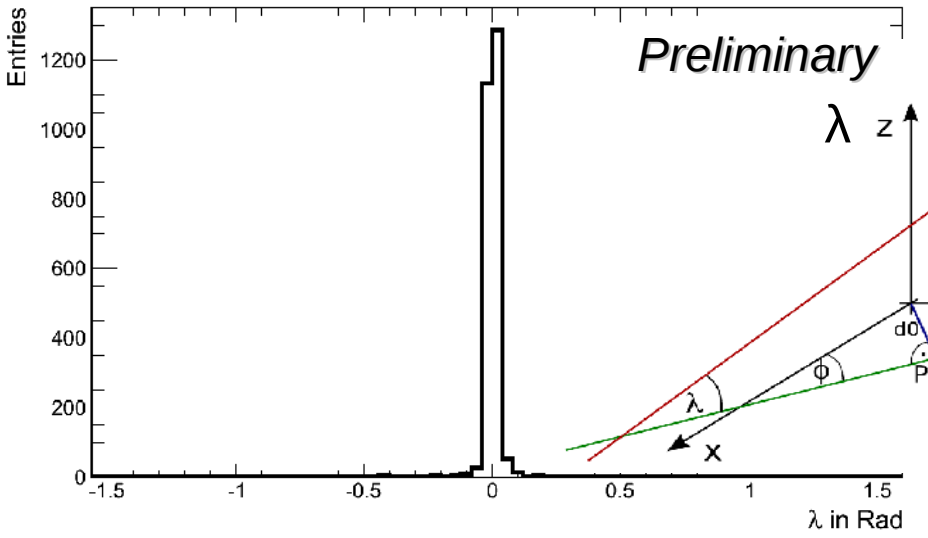
universitätbonn

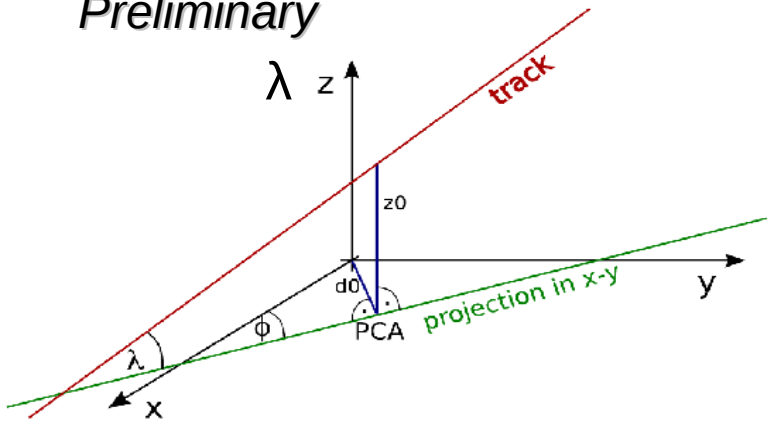
Track parameters

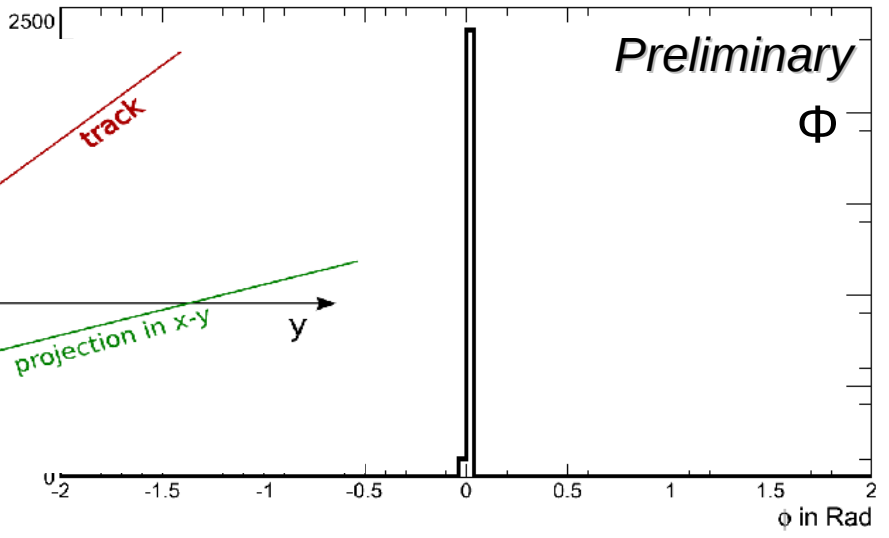
Run: z = 5,58 cm, B = 0 T



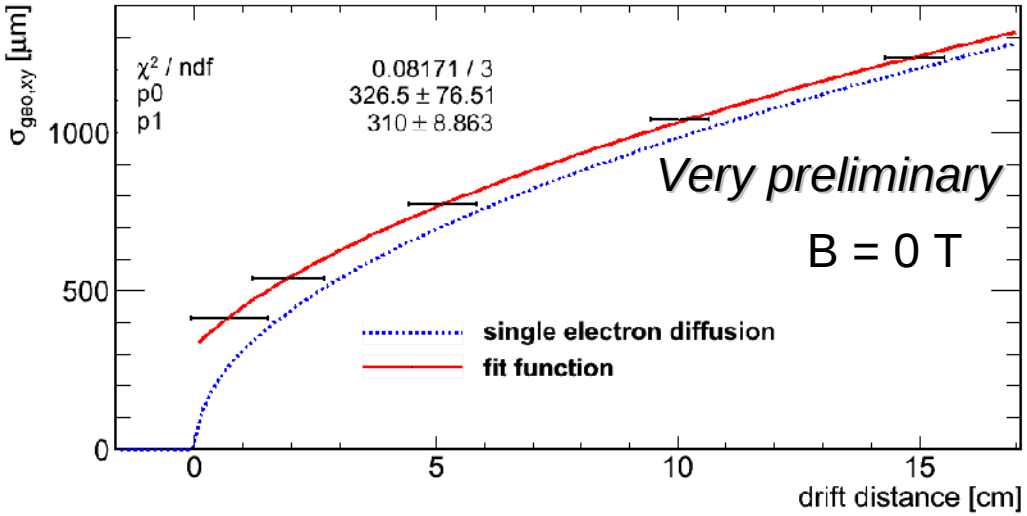






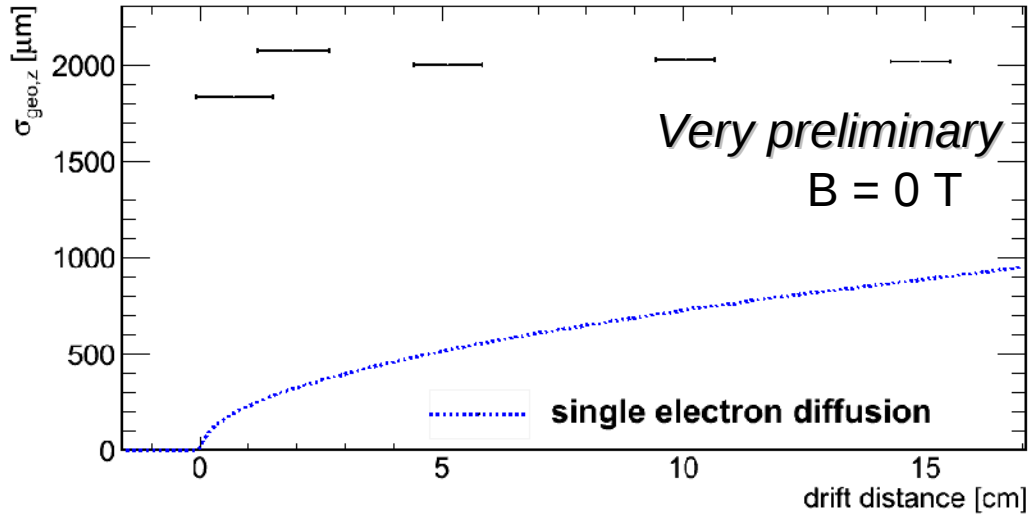


Preliminary z-scan results



Fit function $f(x) = \sqrt{P0^2 + P1^2 \cdot z}$

P0: intrinsic x-y resolution 327 µm
dominated by field distortions
P1 = 310 µm/√cm:
diffusion in T2K for E = 230 V



z resolution dominated by
- Clock frequency (25 ns time bins)
- Fast T2K gas (v_{Drift} ≈ 73 mm / µs)
- Timewalk effect

universitätbonn