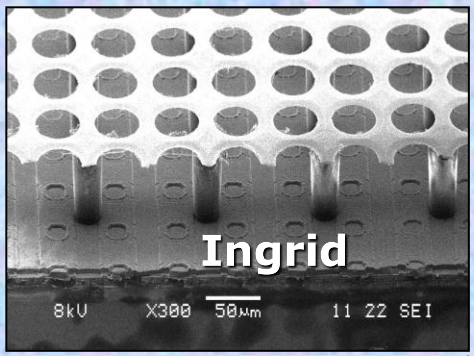
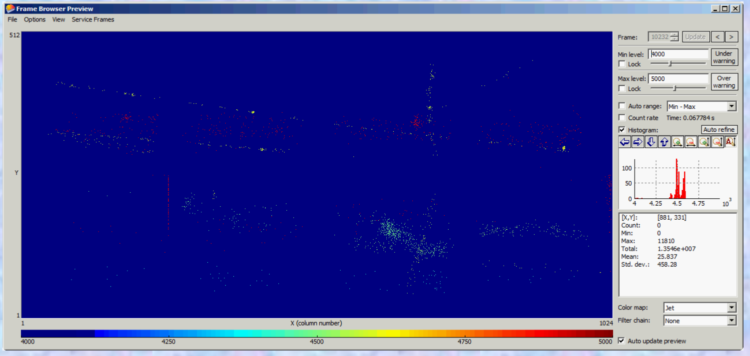
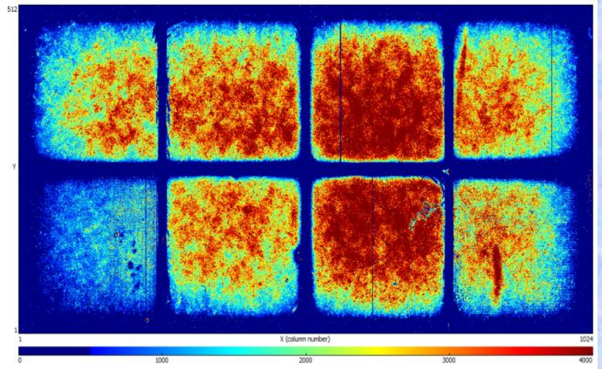
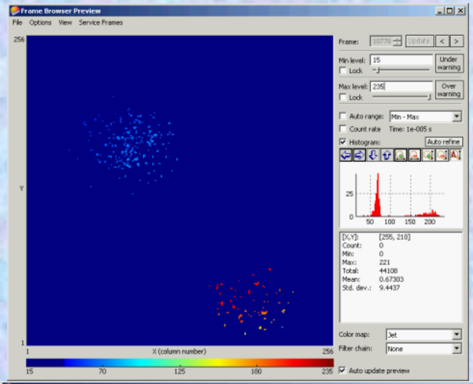
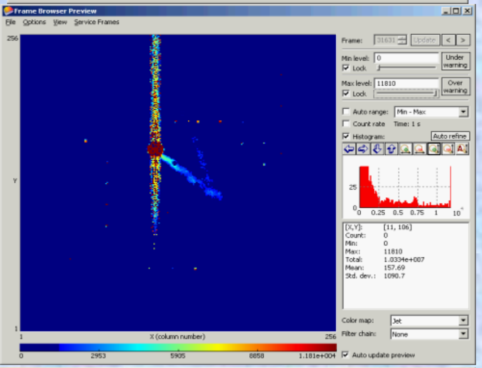










DESY Test-Beam Results with Octopuce

A. Chaus, D. Attie, P. Colas, M. Titov
CEA Saclay, Irfu/SPP, France

OUTLINE:

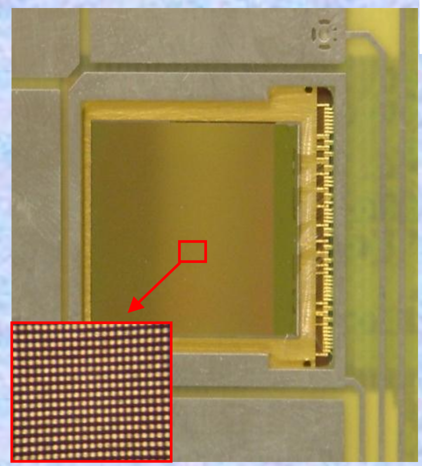
- “Octopuce” Uniformity Studies in the Laboratory
- DESY Test-Beam Track Reconstruction with Octopuce
- Tests of IZM-3 InGrids
- Future InGrid Tests using Low Energy Electrons from PHIL at LAL

LCTPC WP meeting #164
December 6, 2012

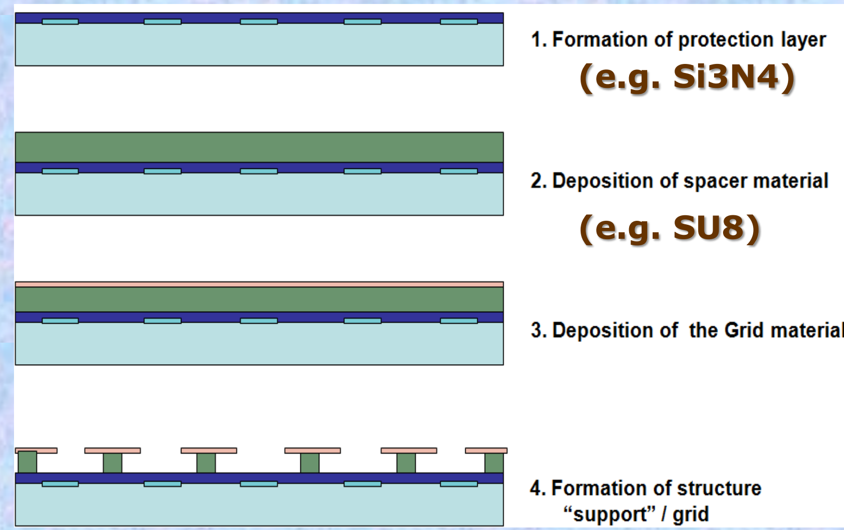
Integrated Electronics: Pixel Readout of Micro-Pattern Gas Detectors

3D Gaseous Pixel Detector → 2D (CMOS pixel chip readout) x 1D (drift time)

Bump bond pads for Si-pixel Detectors - Timepix or Medipix2 (256 × 256 pixels of size 55 × 55 μm2) serve as charge collection pads.

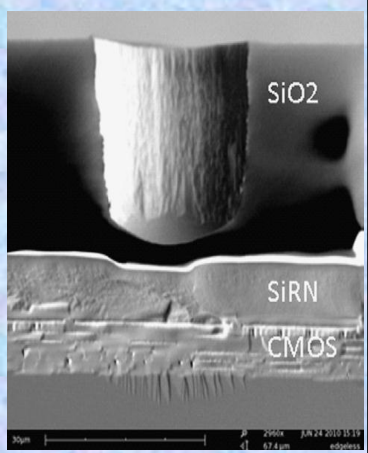


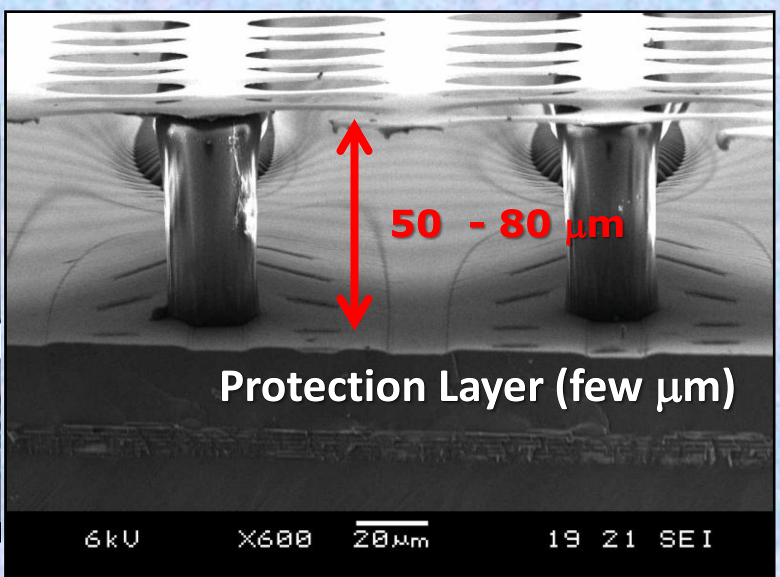
Through POST-PROCESSING INTEGRATE MICROMEGAS directly on top of CMOS chip

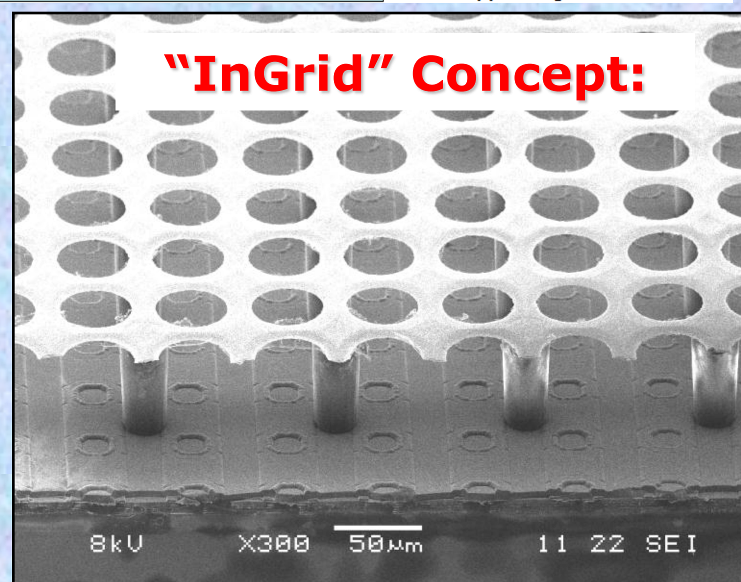


Each pixel can be set to:

- TOT ≈ integrated charge
- TIME = Time between hit and shutter end

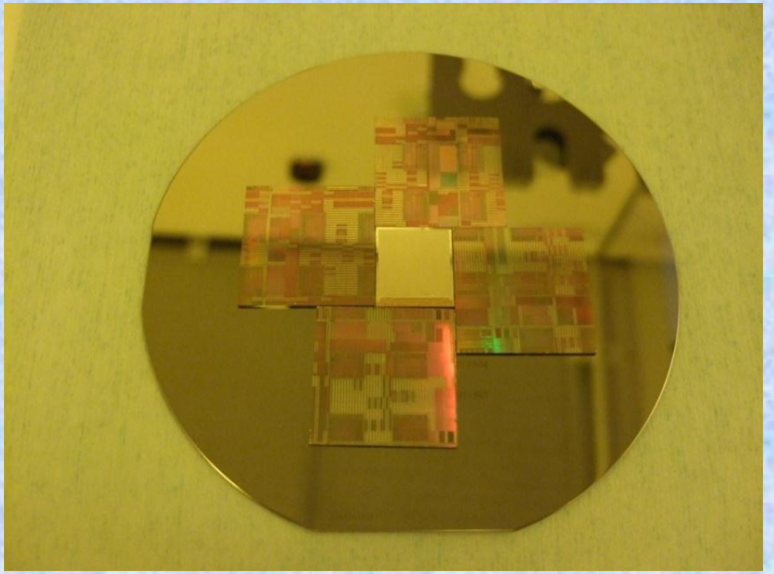




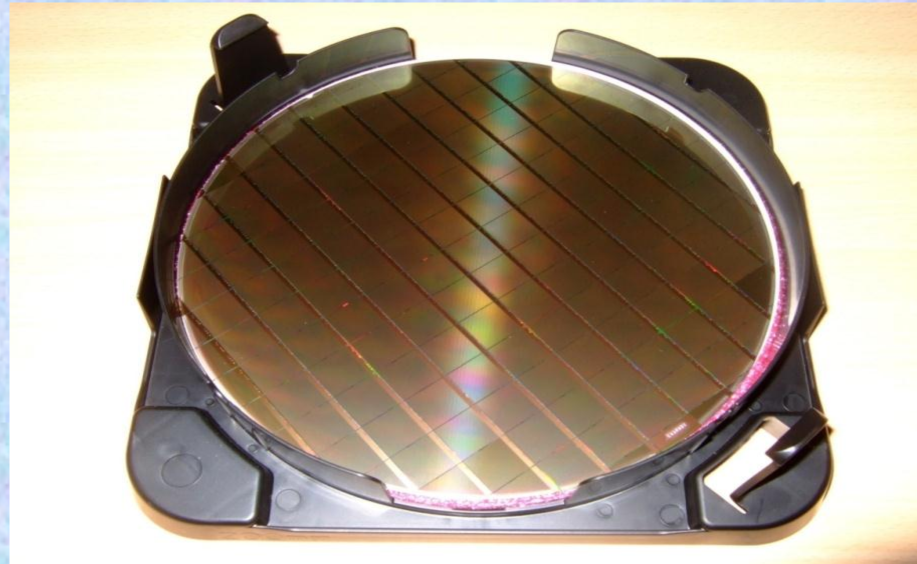


"InGrid" Technology and "Driving" Developments

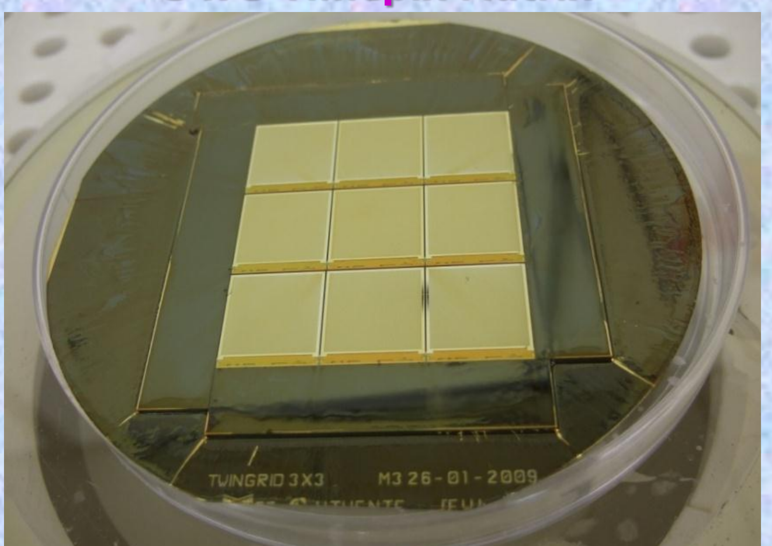
2005: Single "InGrid" Production

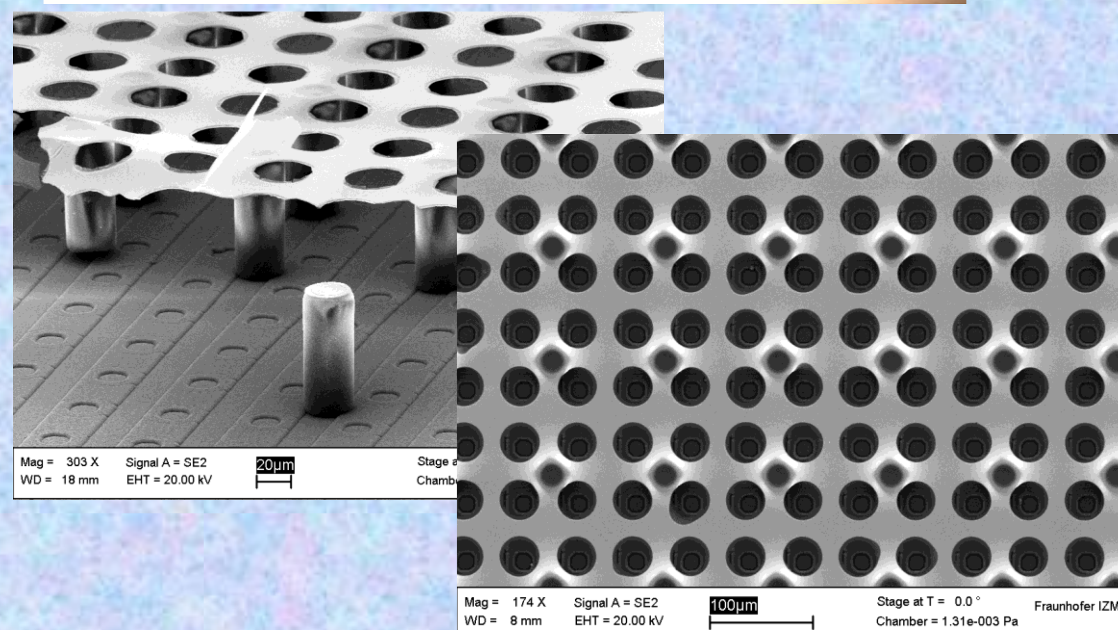


2011: Major Step Forward → InGrid Production on a wafer level (107 chips)

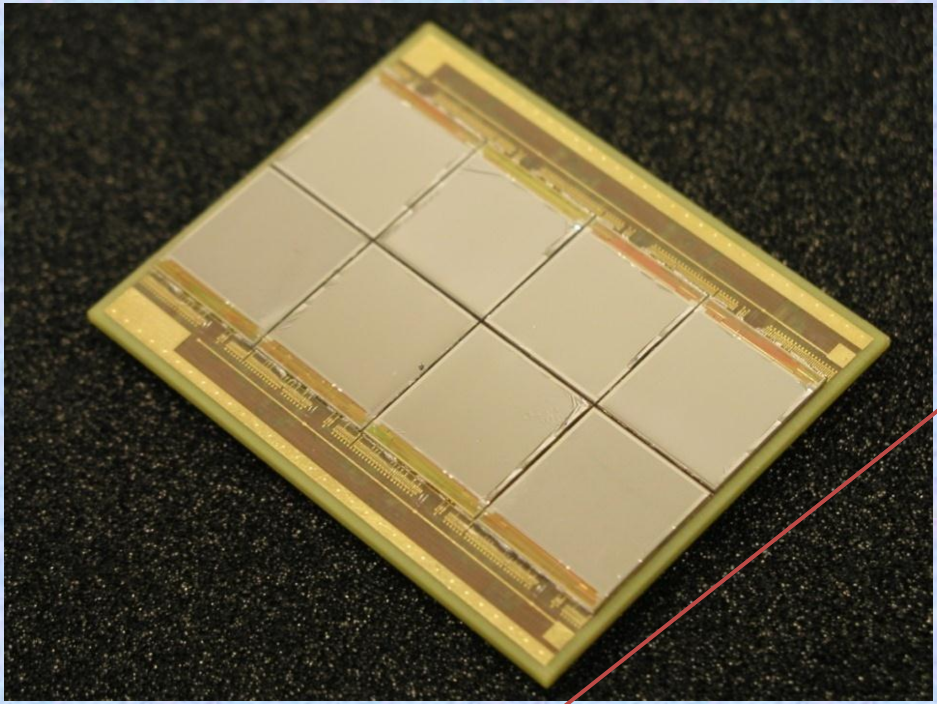


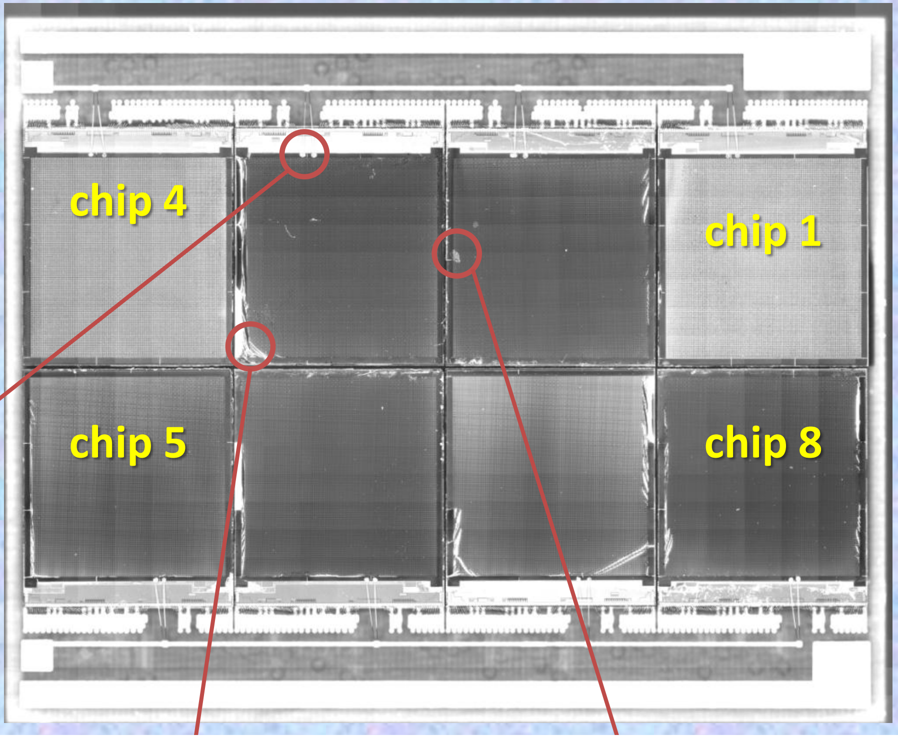
2009: "InGrid" Production on a 3 x 3 Timepix Matrix



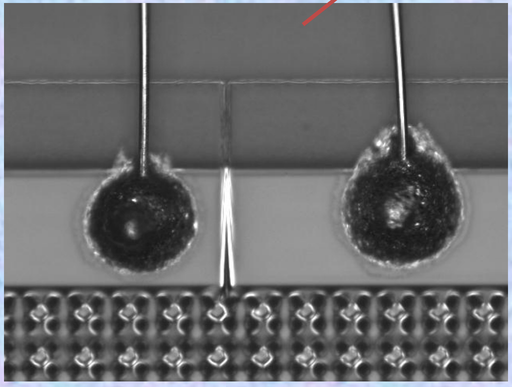


The "Octopuce" (2009)

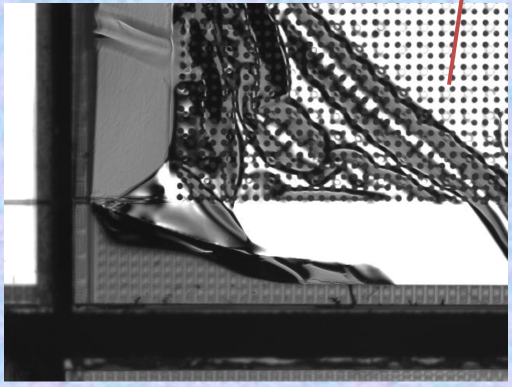


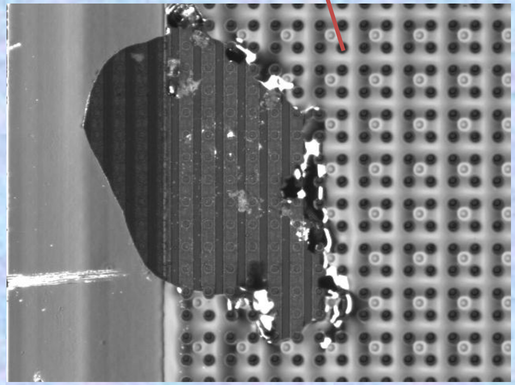


Non homogeneous area on the mesh of different chips



HV connections





"Grid irregularities"

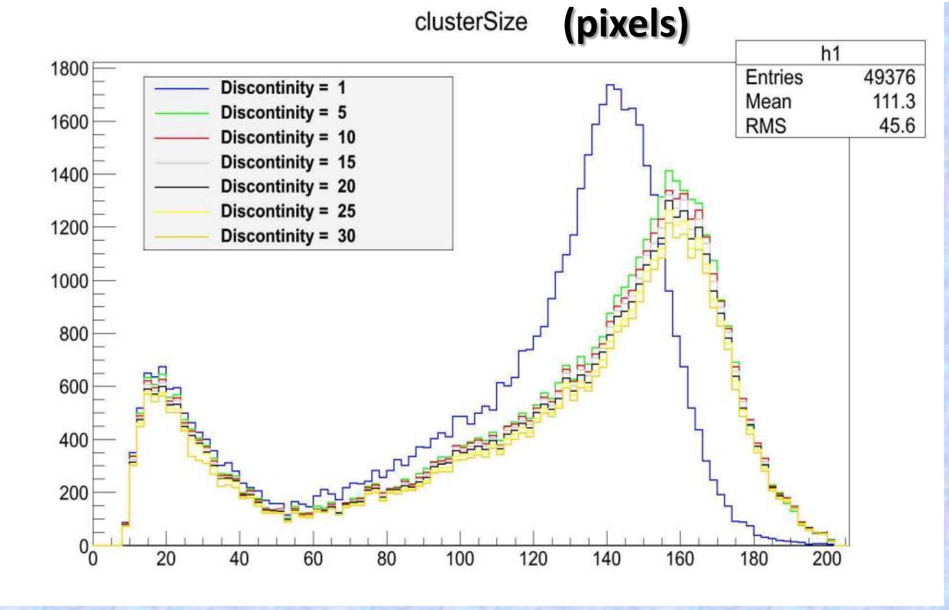
Octopuce Studies & Fe55: Homogeneous Irradiation

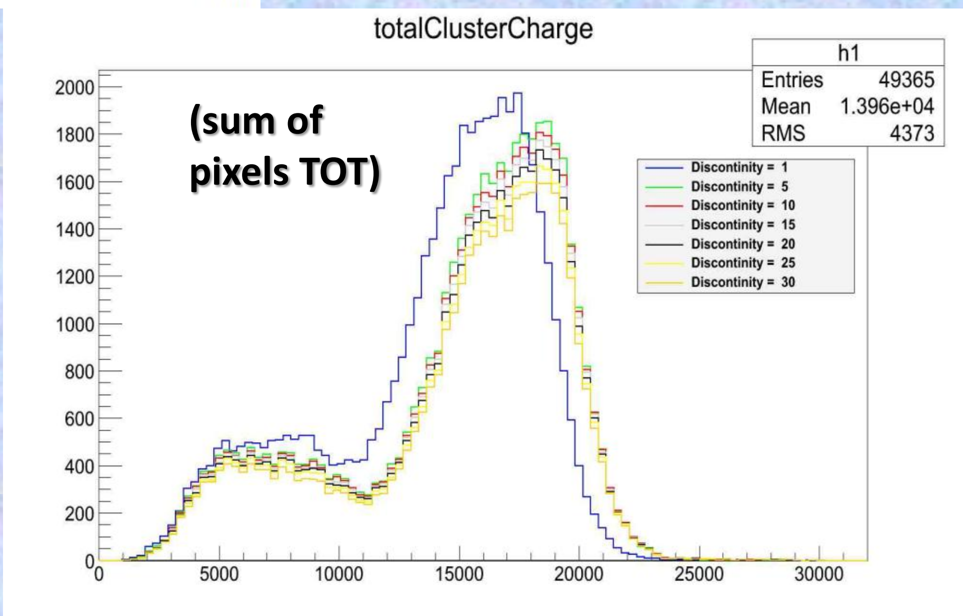
Fe^{55} Studies (26/07/2012):

He/Iso 80/20
Vmesh=390 V
Vdrift =3000 V

Integrated picture for all 8 chips:

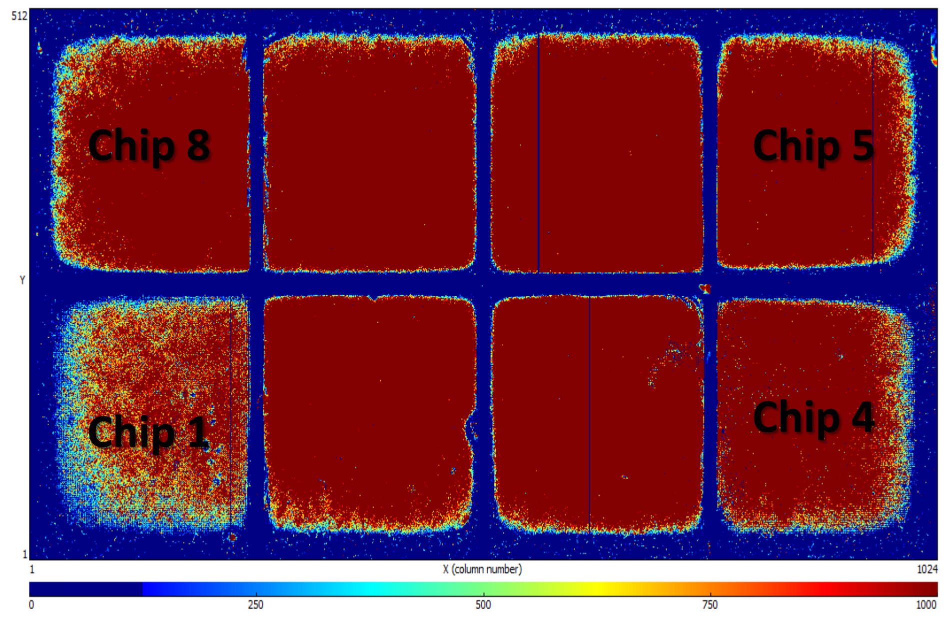
(discontinuity = distance between pixels in the cluster)



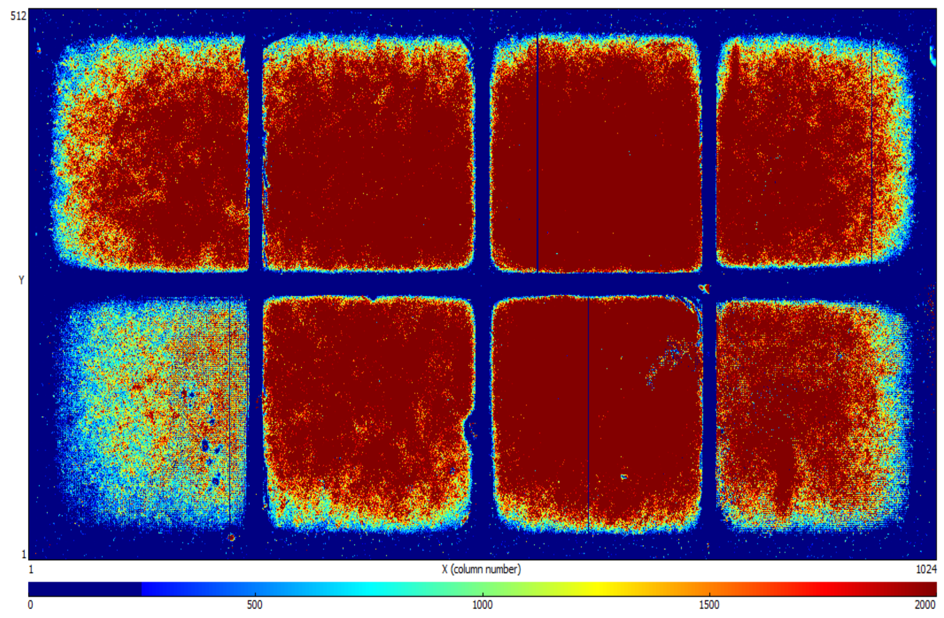


Octopuce: Uniformity of the Response (I)

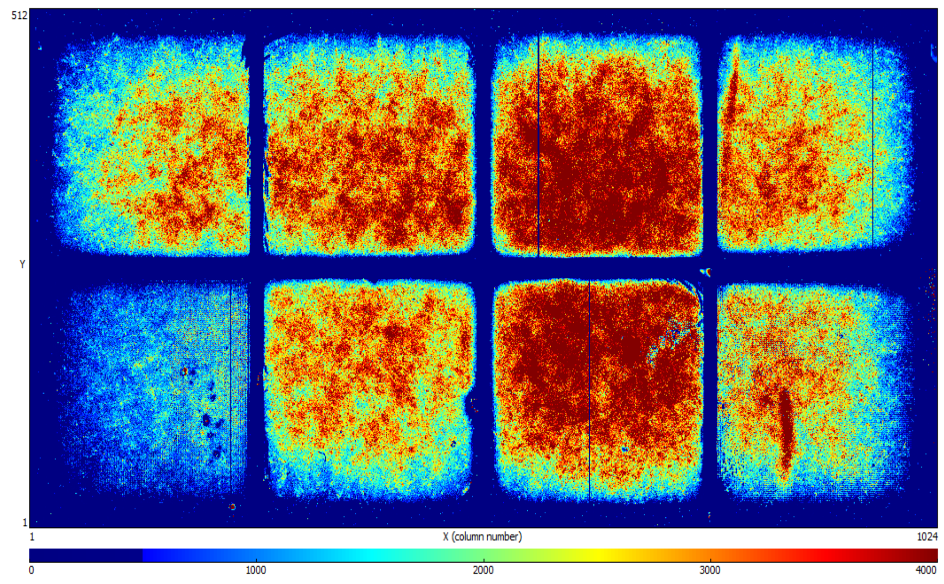
THRESHOLD = 1000 COUNTS



THRESHOLD = 2000 COUNTS



THRESHOLD = 4000 COUNTS



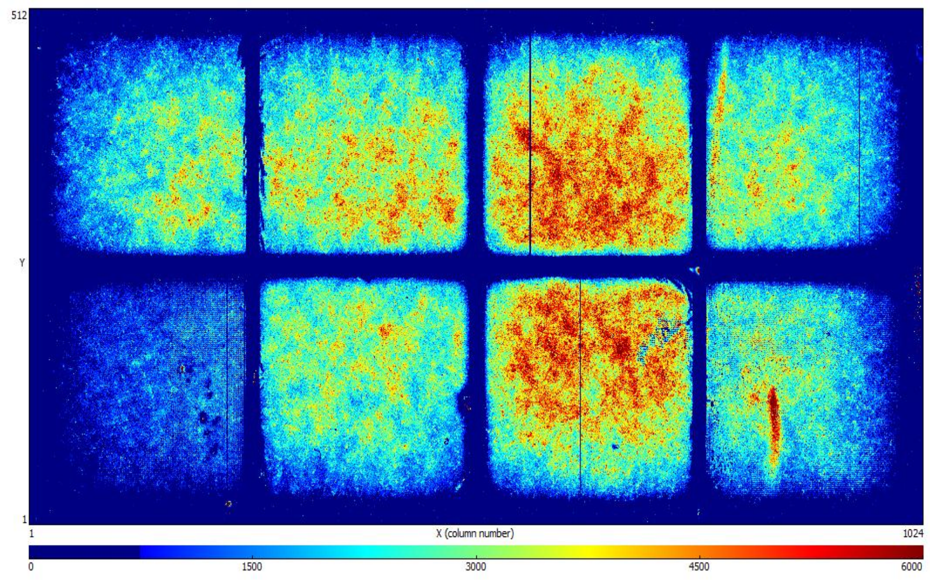
Non-sensitive (~ 1.5 mm) areas between chips

Fe^{55} Studies (26/07/2012):

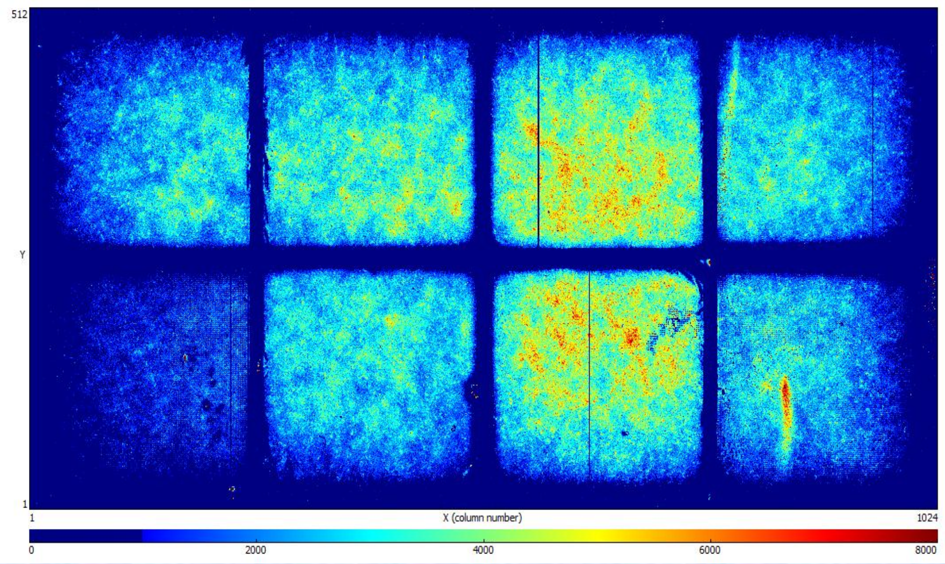
He/Iso 80/20
Vmesh=390 V
Vdrift =3000 V

Octopuce: Uniformity of the Response (II)

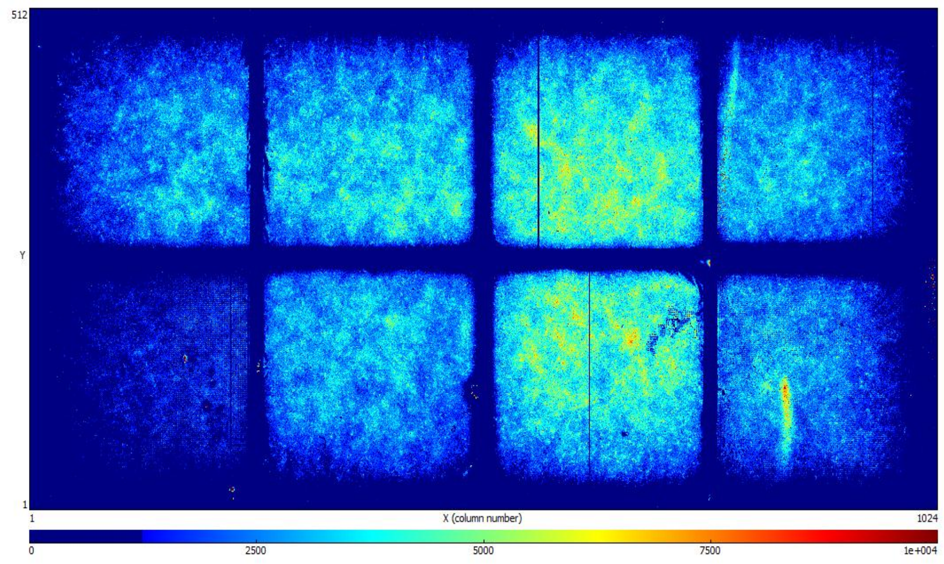
THRESHOLD = 6000 COUNTS



THRESHOLD = 8000 COUNTS



THRESHOLD = 10000 COUNTS



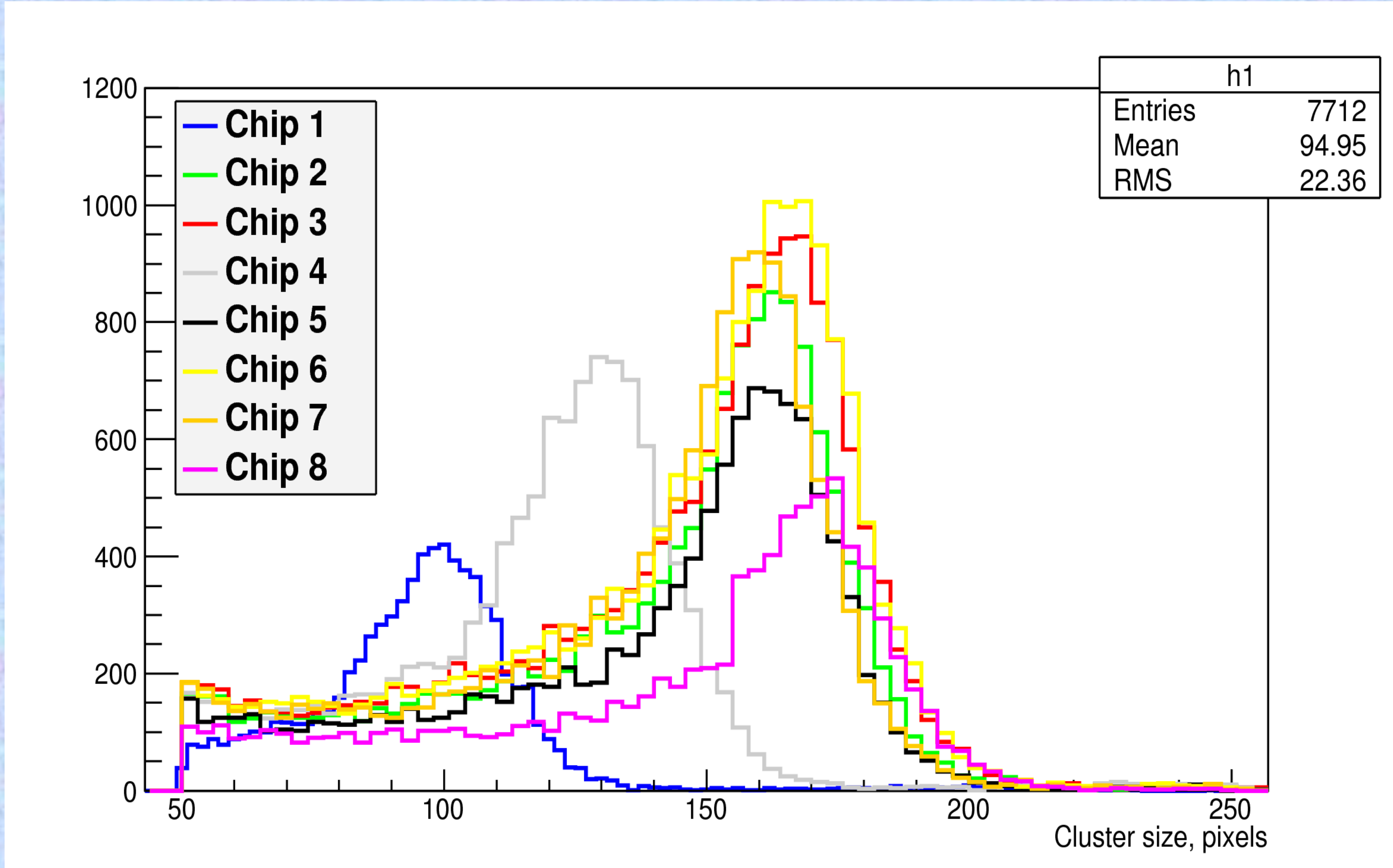
Non-sensitive (~ 1.5 mm) areas between chips:

More studies required to understand:

- **if "dead" areas between chips decrease with increased drift field;**
- **"dead" area on the outer edge as a function of the guard voltage**

Octopuce: Cluster Size Distribution

Single electron sensitivity is very high for all (but 1 and 4) chips

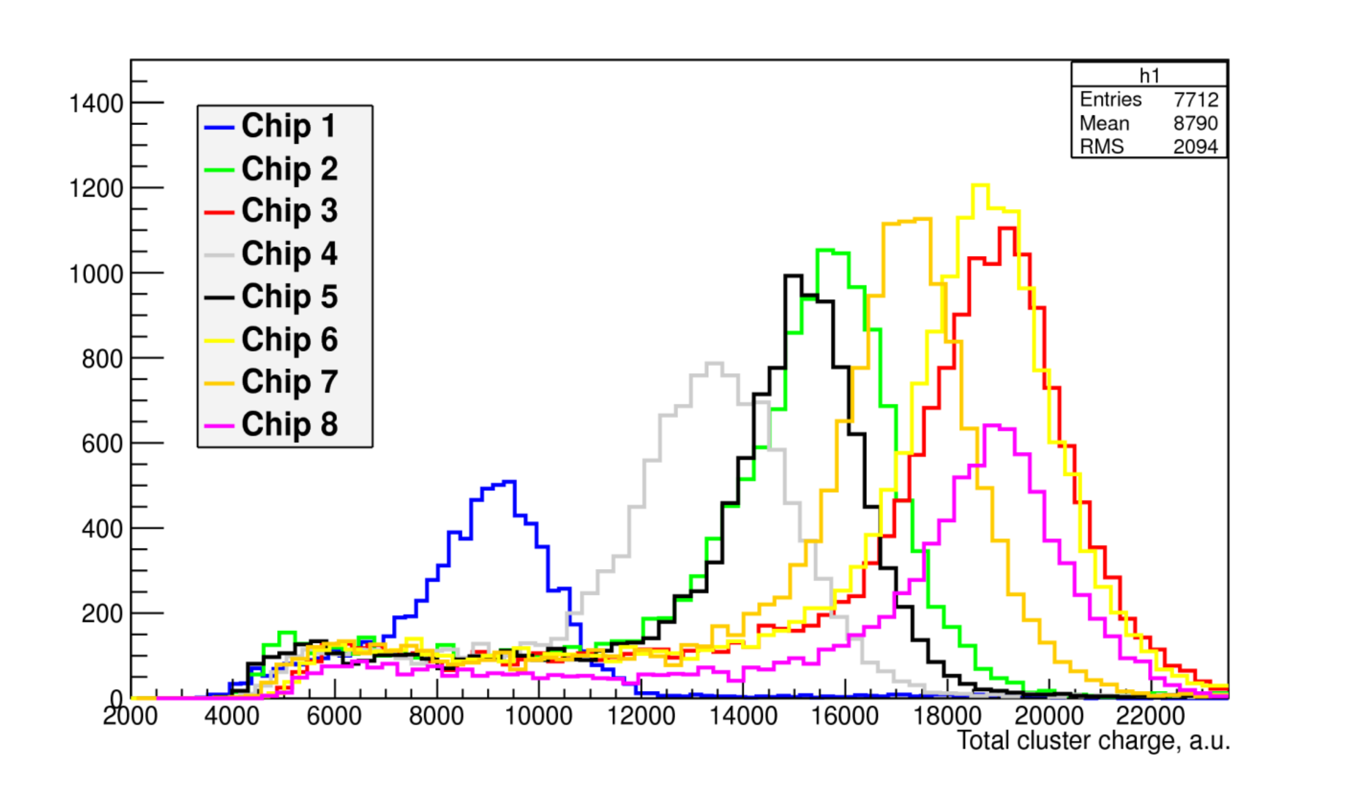


Expected number of primary electrons in He/Iso (80/20) ~ 165

Octopuce: Total Cluster Charge

Chips 1 and 4 have a lower response (same trend as for the cluster size distribution) →

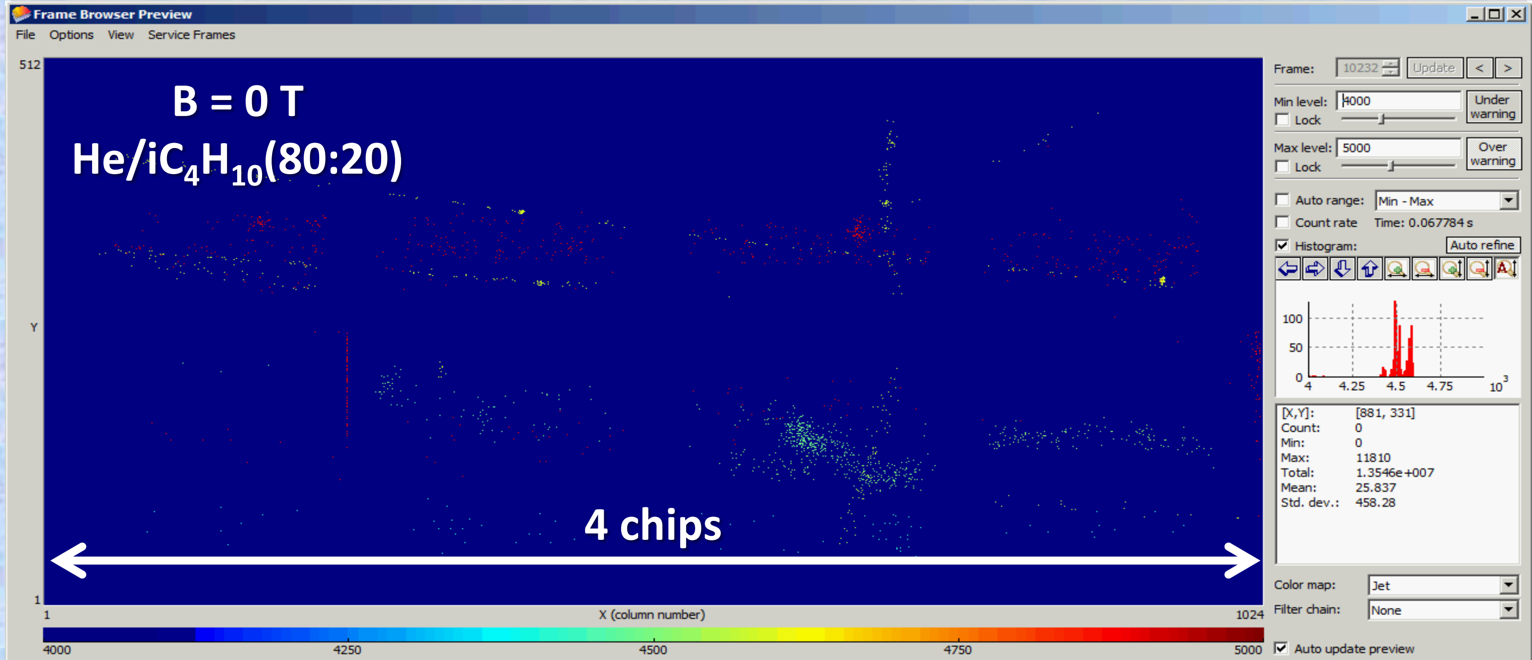
- **Difference in amplification gap**
- **Difference in threshold (too big to explain differences between 1 &4 and others)**



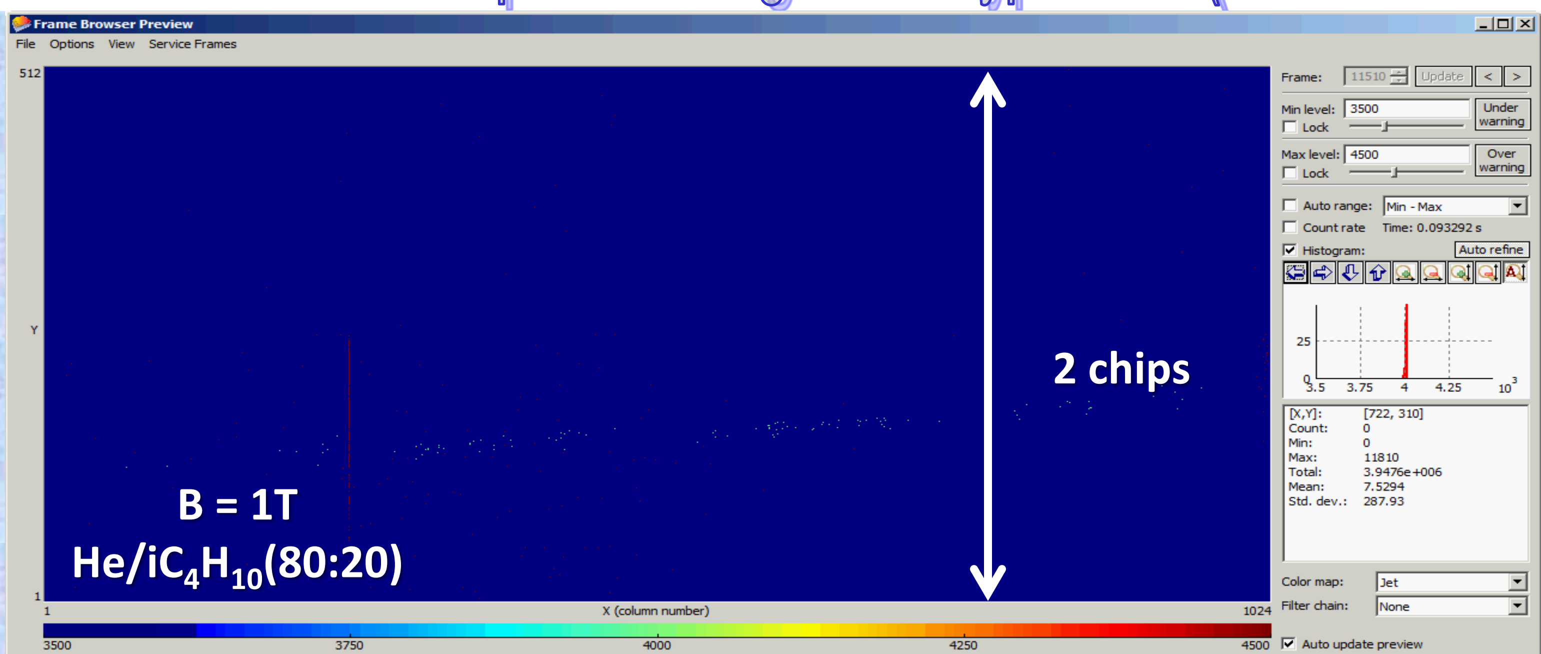
After equalization:

Chip number	Threshold level
1	337
2	335
3	340
4	335
5	330
6	327
7	330
8	320

Some differences in amplification gaps between different chips are seen by microscope (studies are not conclusive, might come from different thickness of the glue under the chips)

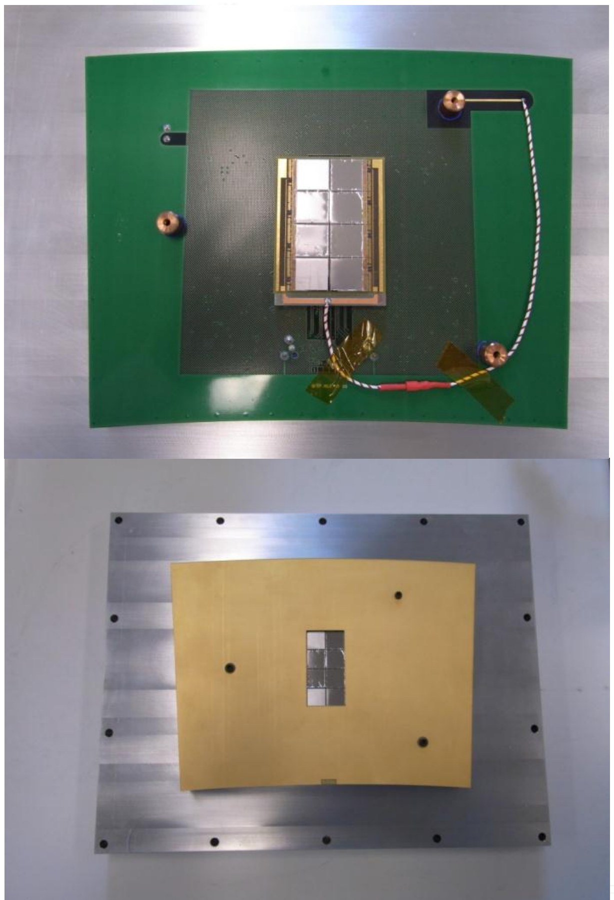


DESY Test-Beam with Octopuce & Large Prototype TPC (December 2010)

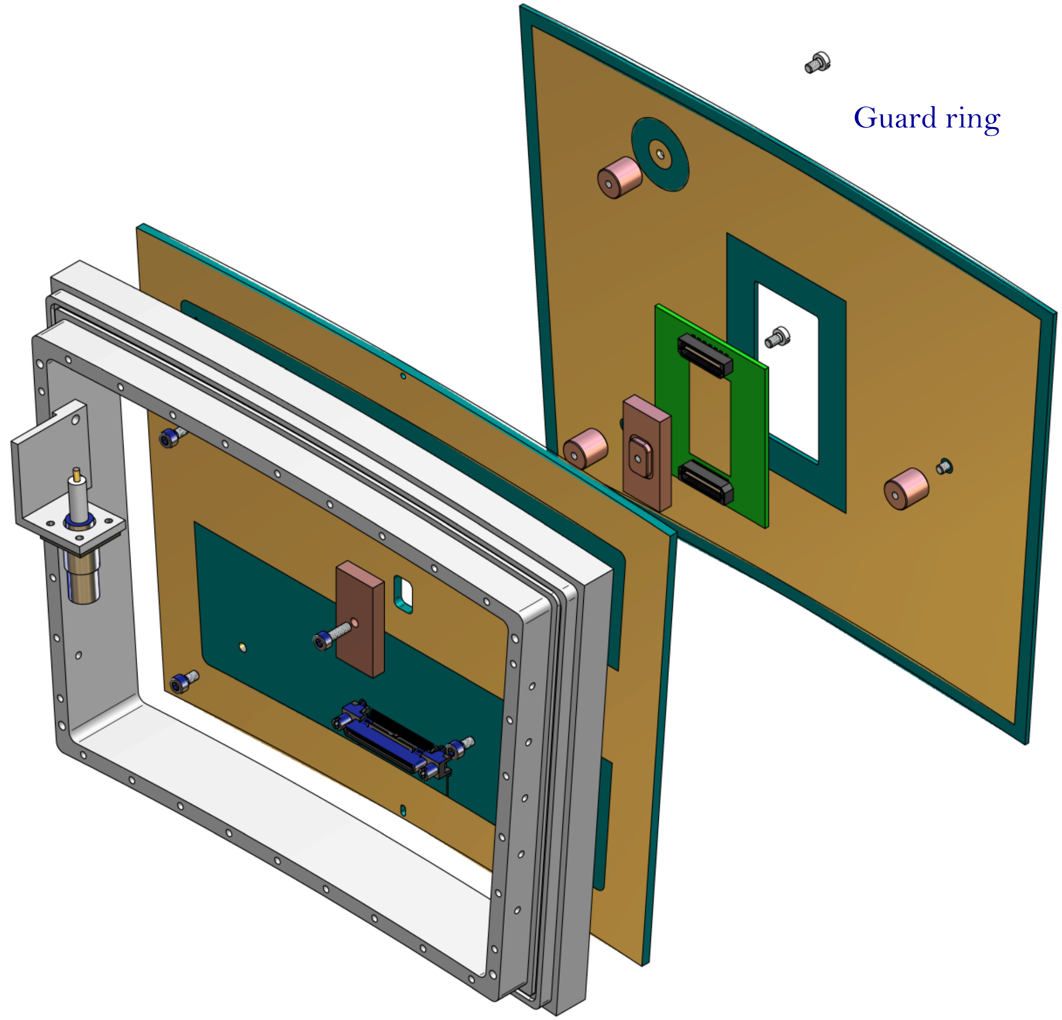


"The Octopuce" in the Large Prototype TPC

- Chips on a mezzanine board making wire bonding easier
- Large Prototype compatible
- Heat dissipator



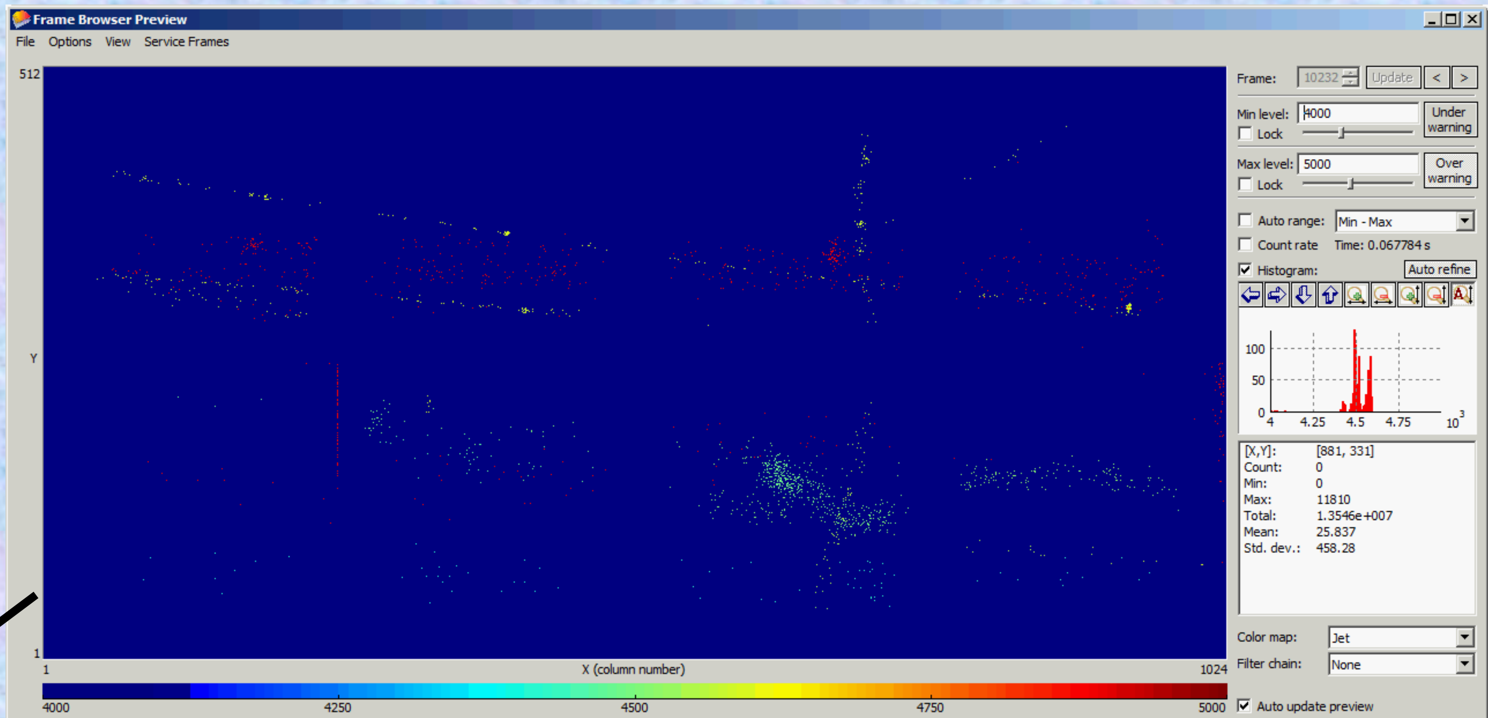
Timepix pane for Large Prototype TPC

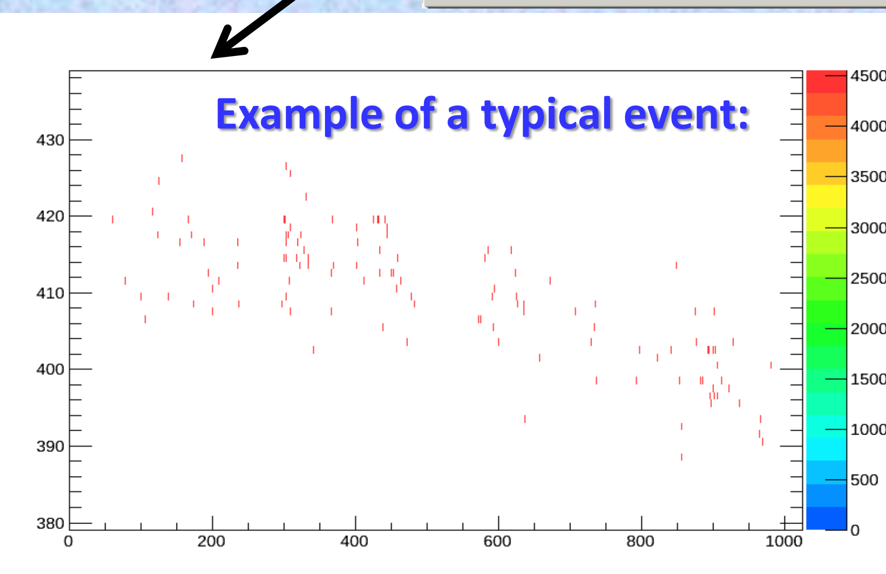


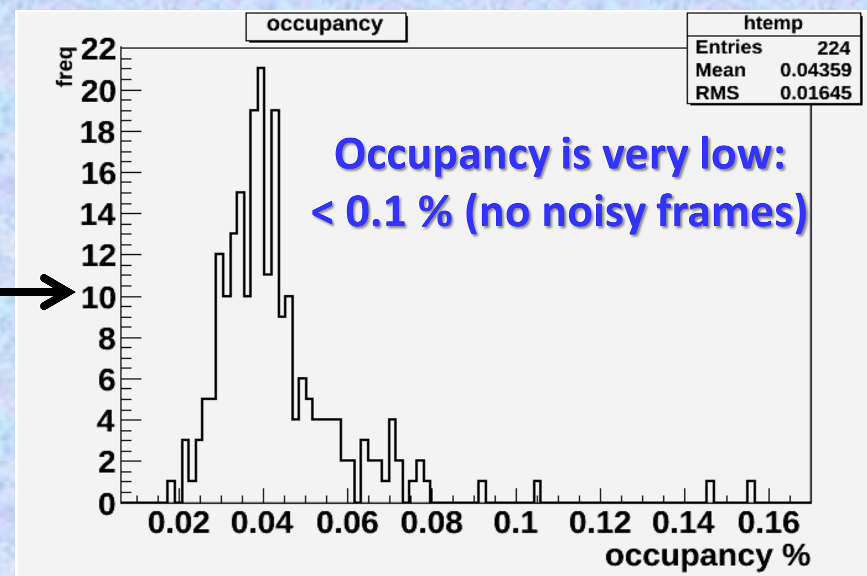
Octopuce in the Large Prototype TPC at 0 T

- **He/Iso 80/20**
- **V_{mesh} = 380V**

- **Time mode**
- **Shutter Time: 100 μs, start given by beam trigger**



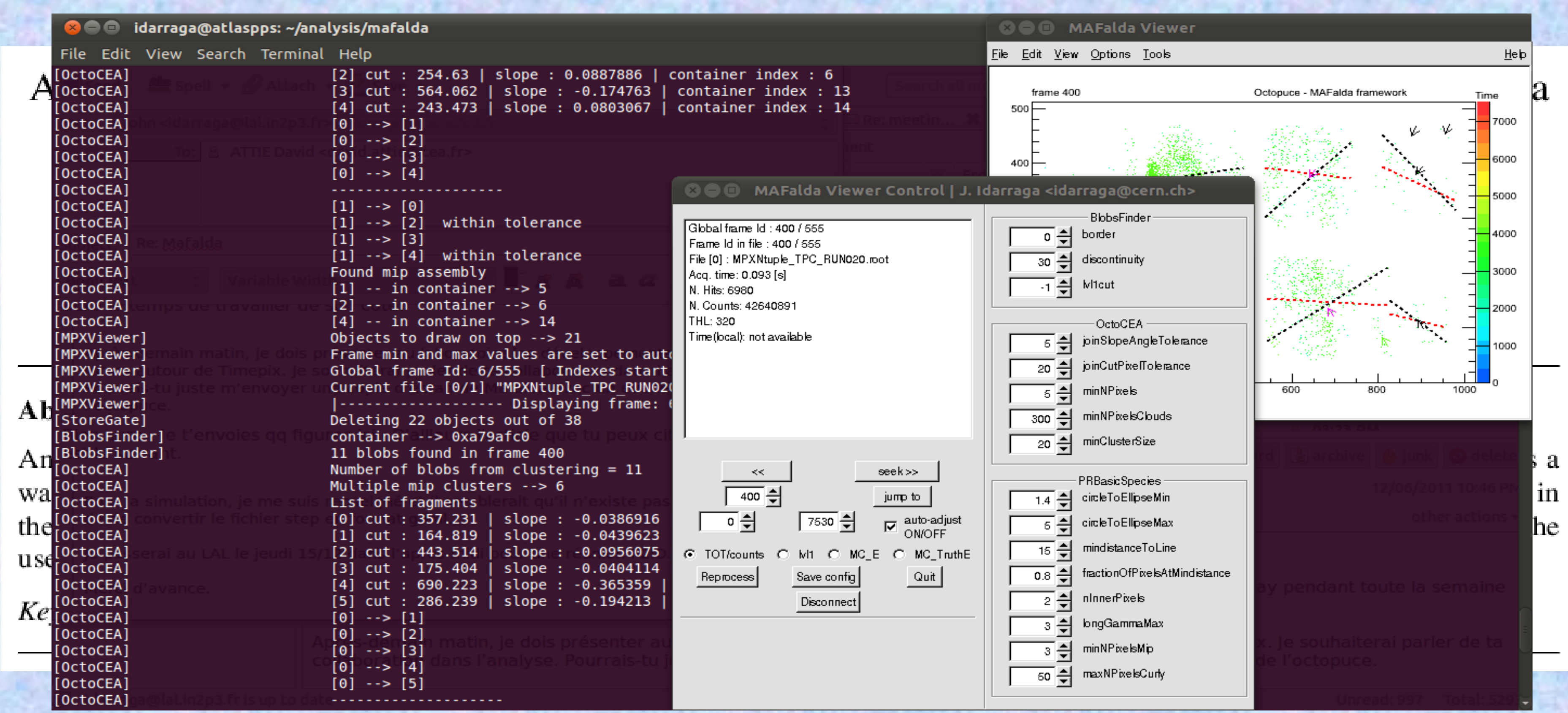




MAFalda: Medipix Analysis Framework

ROOT based analysis package developed by John Idarraga (LAL)

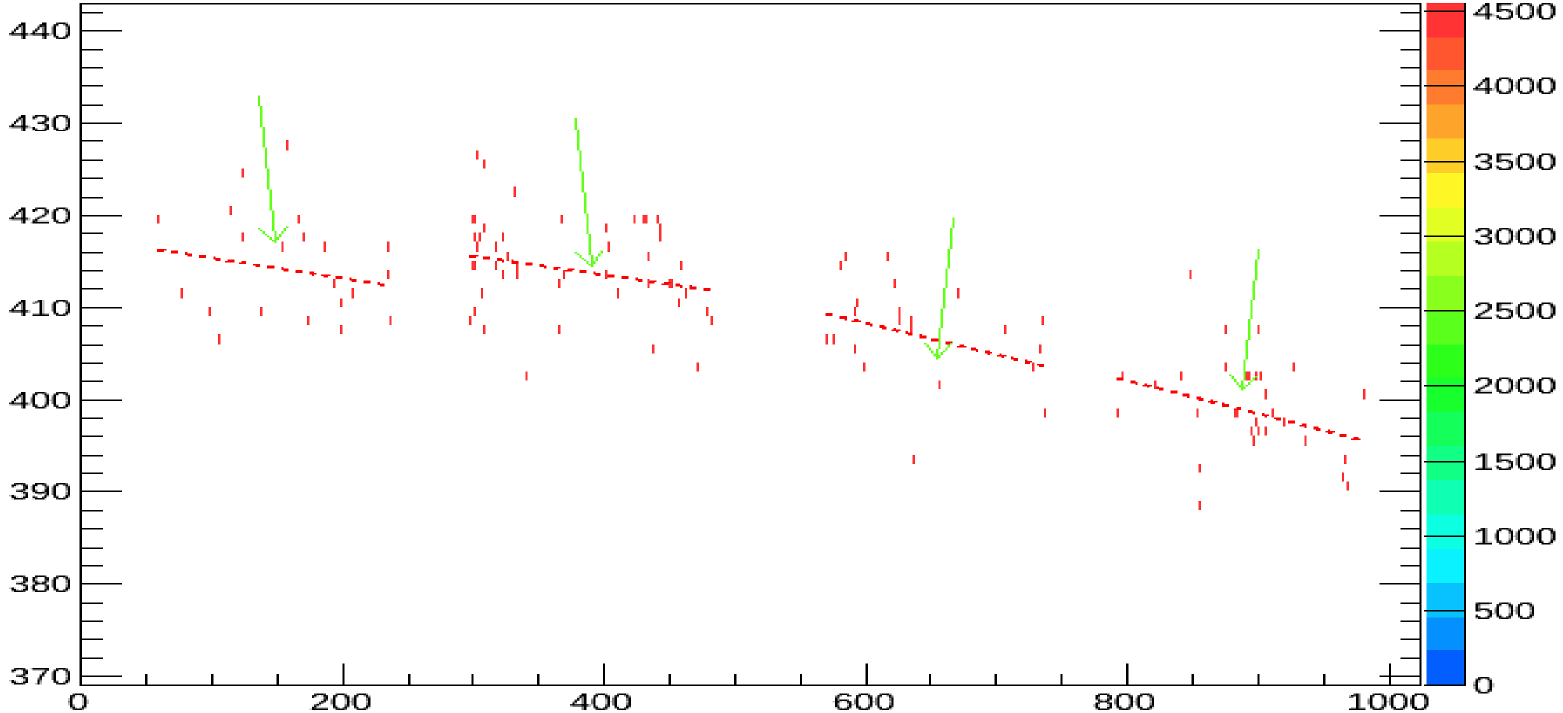
- C++ classes including processors:
  - OctoCEA (define in a few minutes)
  - Pattern recognition of tracks for low threshold



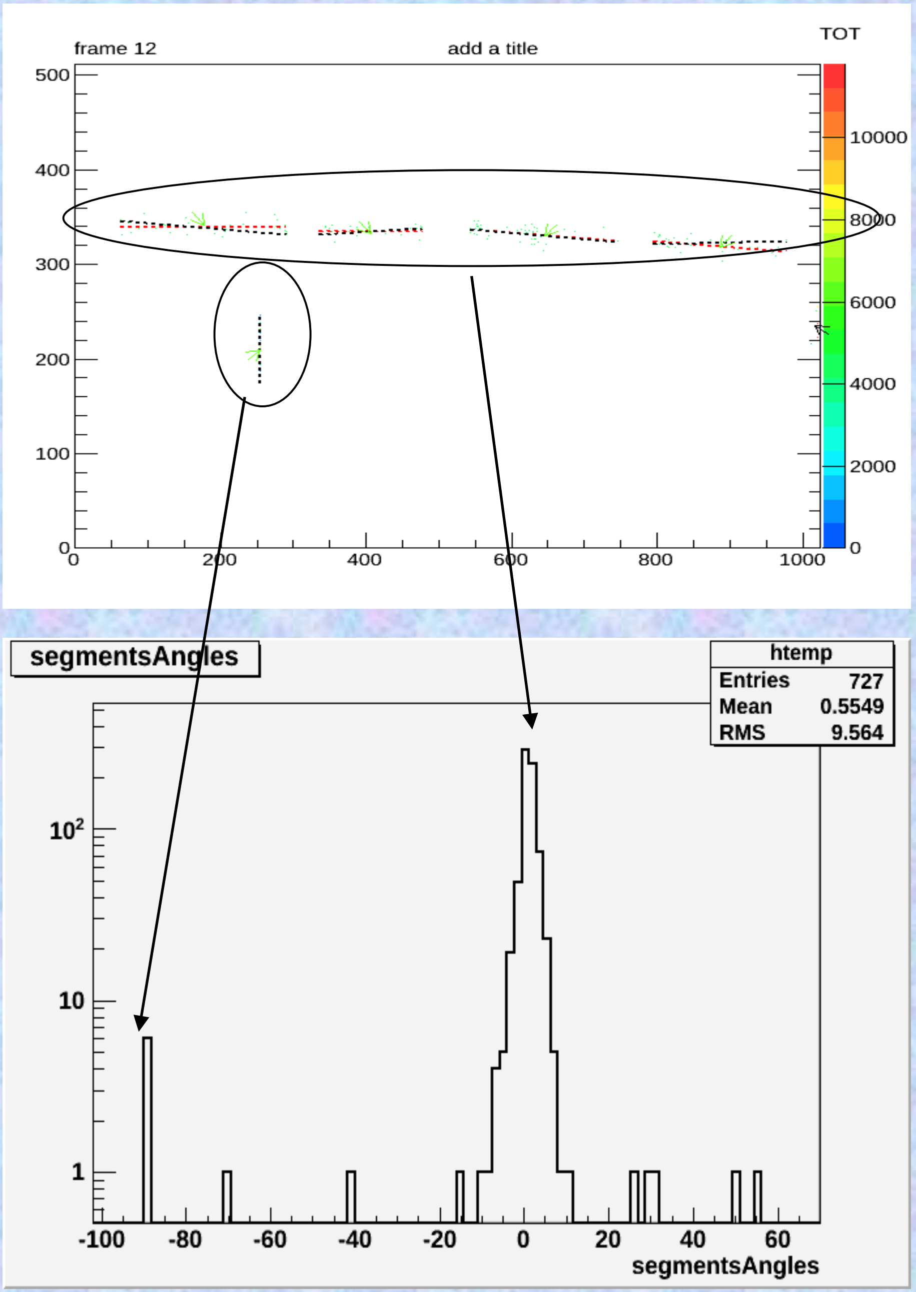
Use MAFalda as the first step → implement reconstruction algorithm in Marlin TPC

MAFalda: Cluster Finding and Track Segments (I)

- Form cluster from the pixels with “discontinuity” < 40 pixels (each cluster should contain > 12 pixels)
- Calculate the linear regression with all points in the cluster (red dotted line)
- Calculate residuals from the red line to each point (if > 80 % the points are within 20 pixels – this is the “track segment” !



MAFalda: Cluster Finding and Track Segments (II)

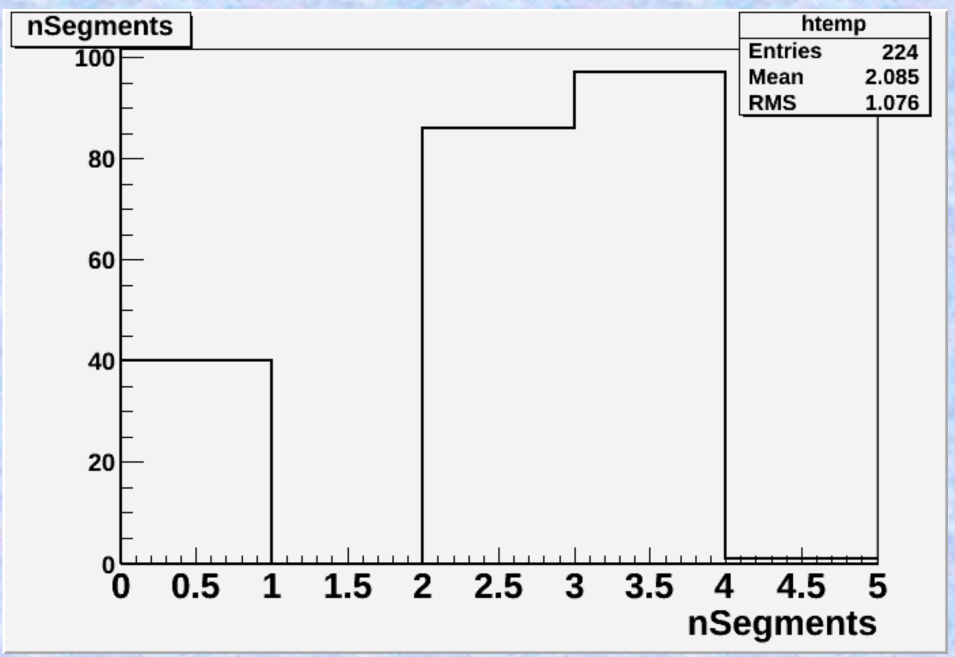


Check incident angles of track segments

→ **Take segments within +/-10 degrees (electron beam is in the horizontal direction)**

Number of segments per reconstructed track

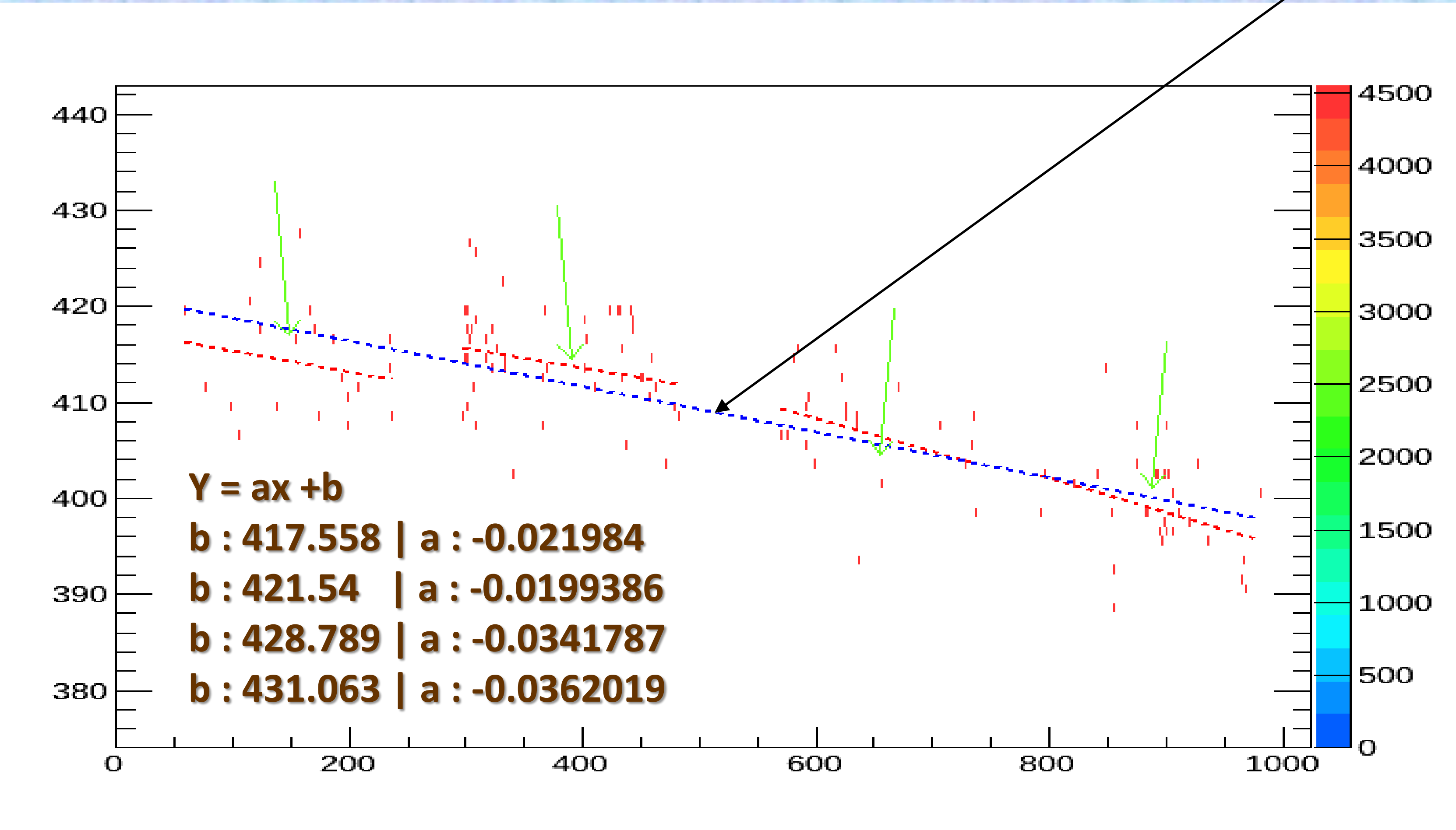
(most tracks consist of 2-3 segments):



Track Reconstruction

Reconstruct track from track segments (if more than 2 segments):

- **Apply data quality cuts to make sure all segments correspond to a given track**
- **Perform a linear regression for all pixels on a track → reconstructed track (blue dotted line)**



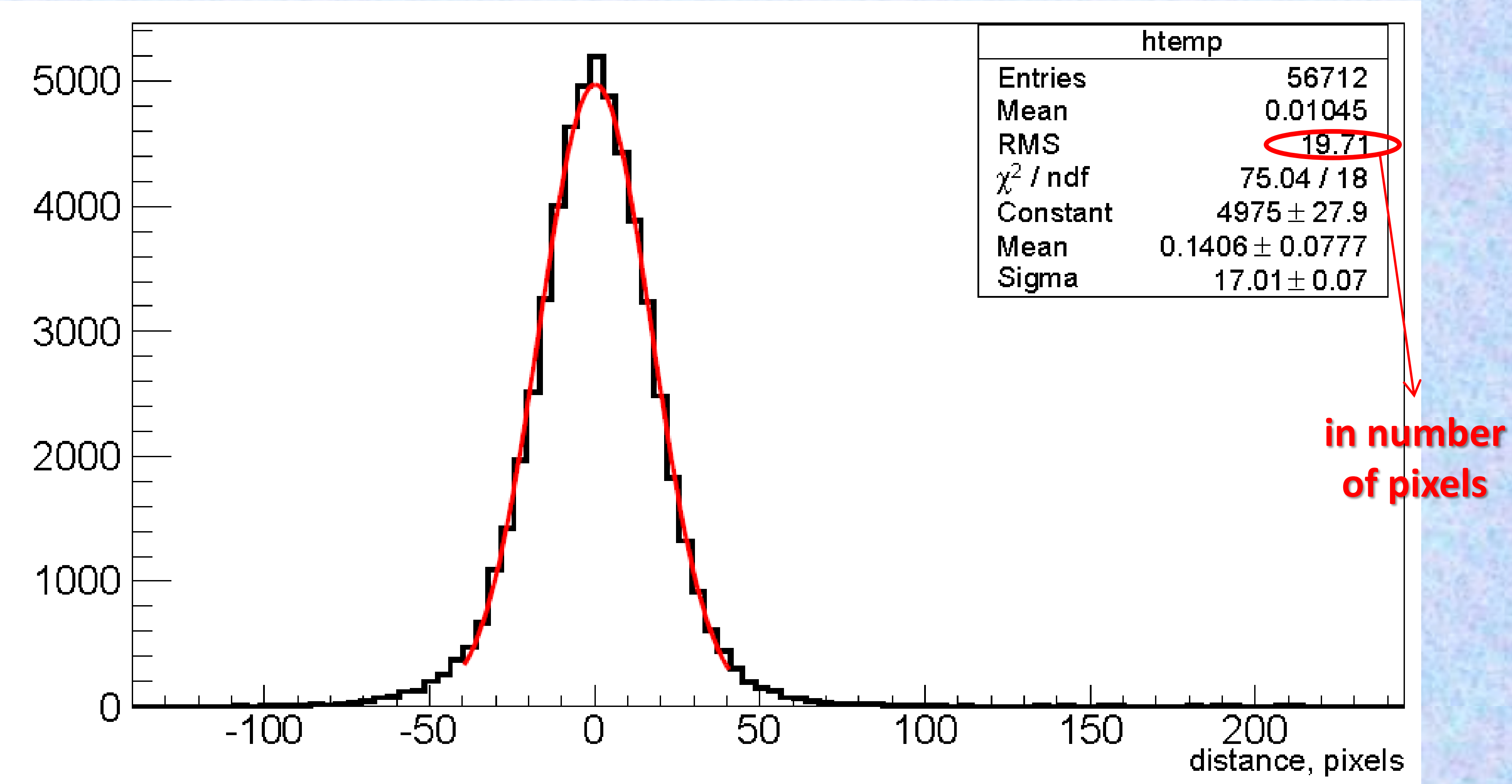
Track Reconstruction: Residuals

An unbiased estimate of the single point resolution: σ = Sqrt(σ1 * σ2):

Perform fit to all pixels and calculate the distance between each pixel and the position of the point of closest approach along the fitted track:

σ1 = Gaussian fit, when all pixels are included in the track fit

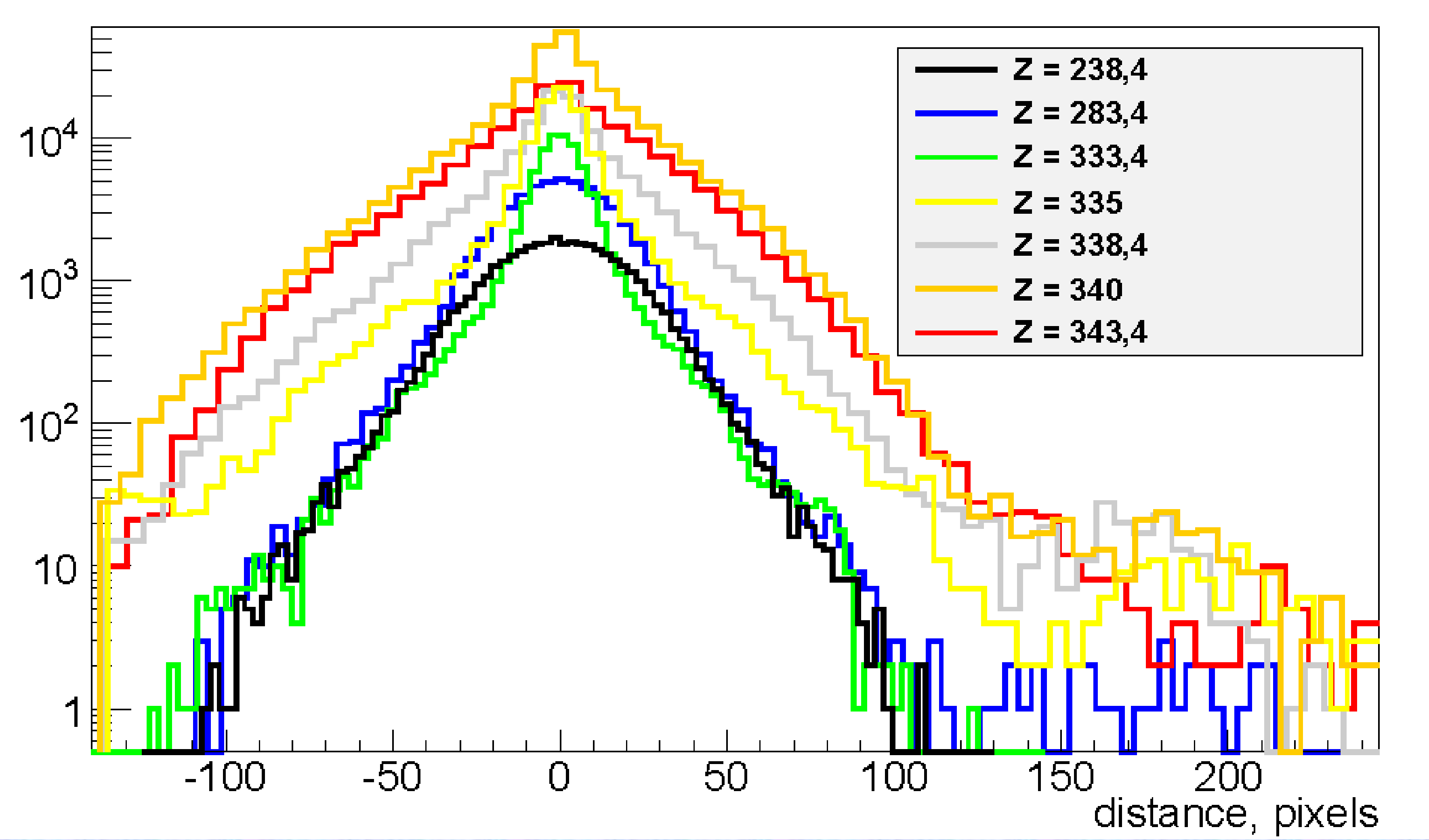
σ2 = Gaussian fit, omitting pixel under consideration from the track fit



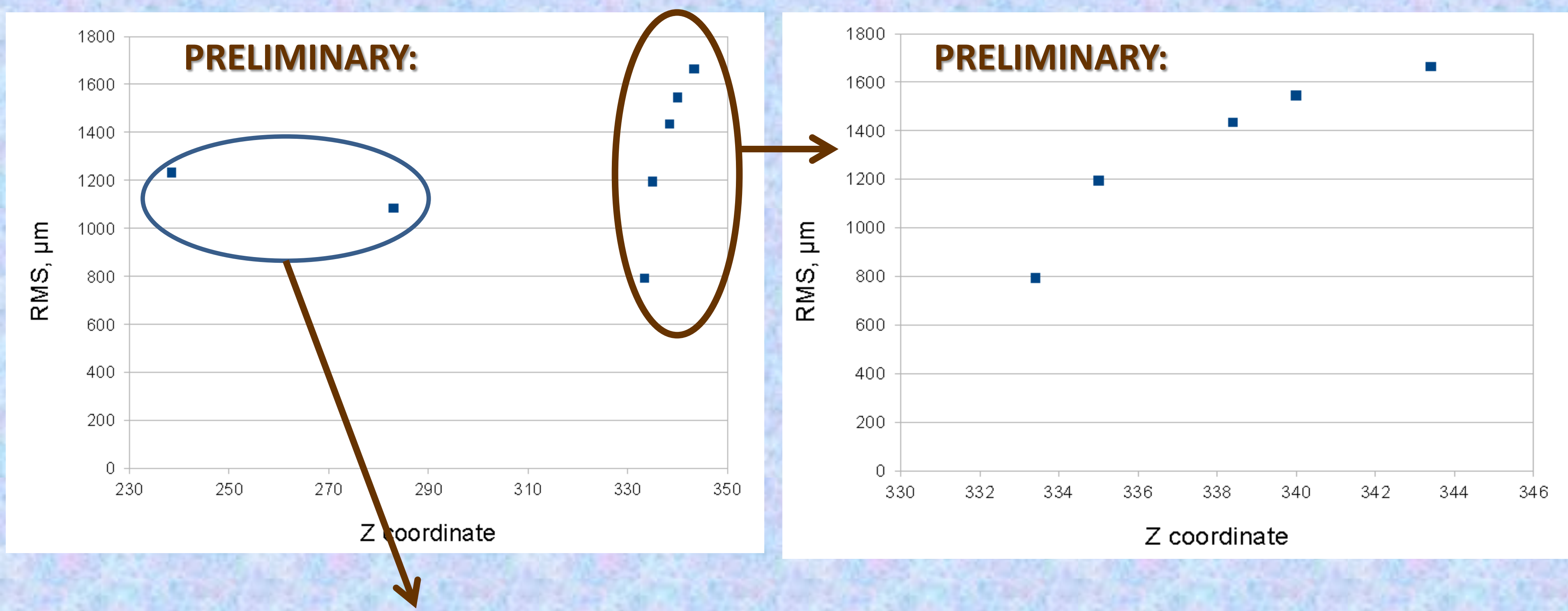
DESY Test-Beam: Track Residuals

Summary of residuals (σ = sqrt(σ1*σ2)) for different Z-coordinates:

(corresponds to the different positions of electron beam passing through the Large Prototype TPC)

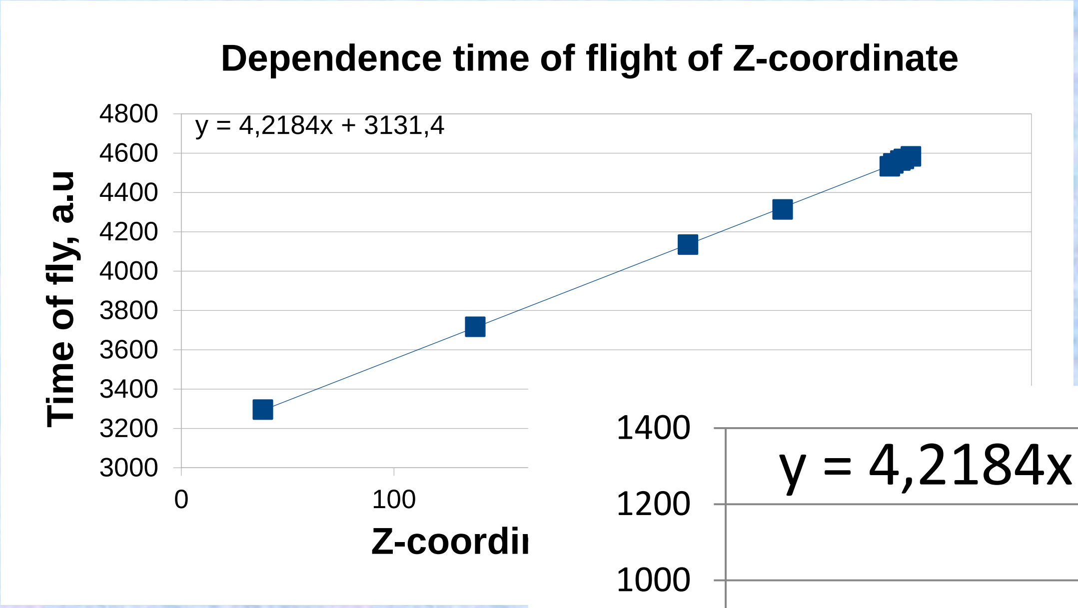


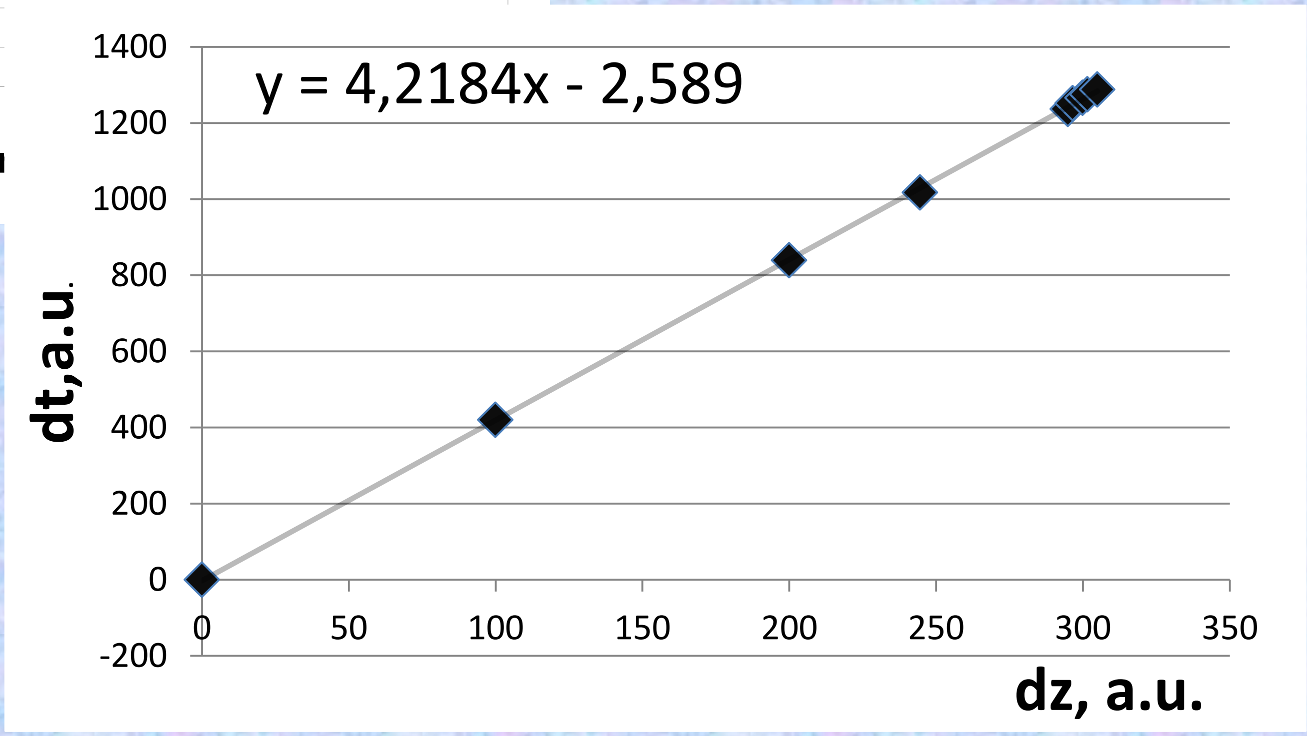
DESY Test-Beam: Track Residuals as a function of Z (Large Prototype TPC)



Very low statistics, behavior needs to be understood

DESY Test-Beam: Time vs Z-coordinate correlation (Large Prototype TPC)



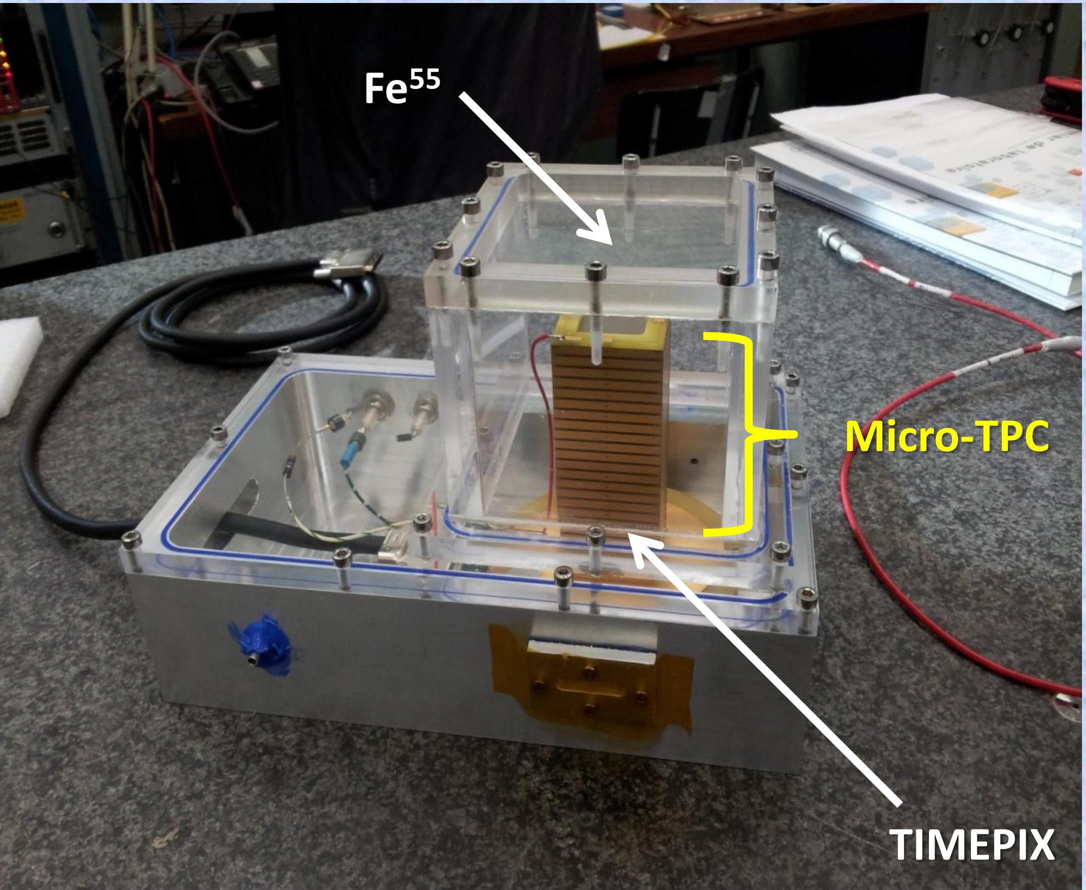


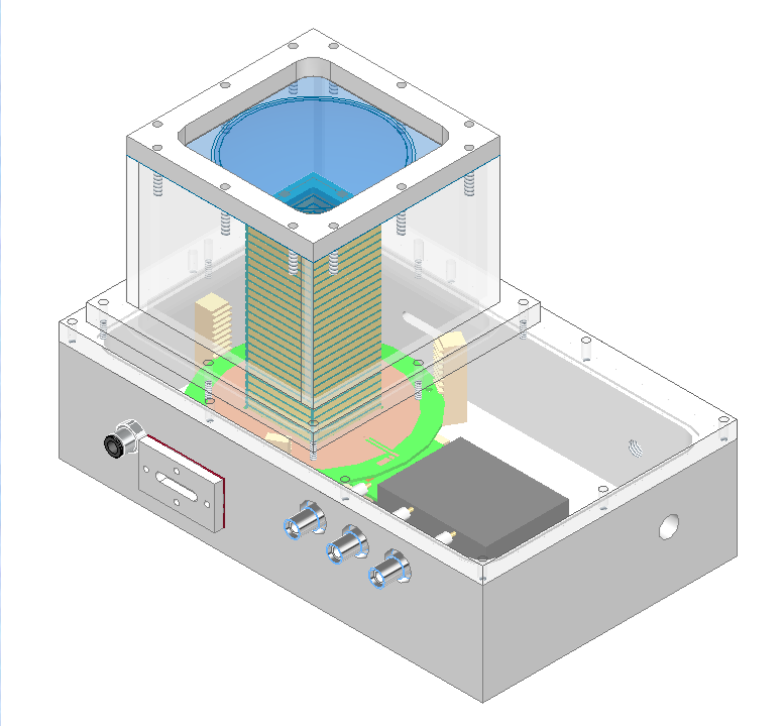
We calculate dZ= Zn- Z0;

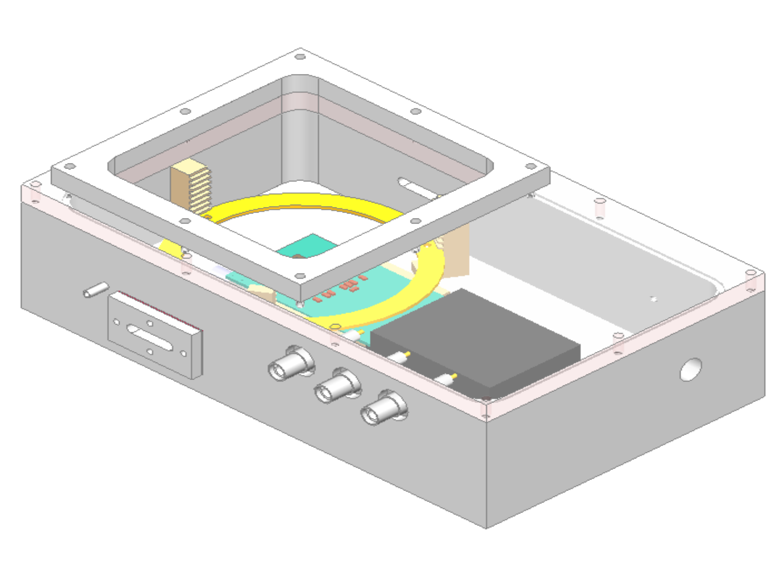
We calculate dt= tn- t0;

Saclay Micro-TPC with Timepix

- Two micro-TPC boxes have been built
- Drift distance in micro-TPC (~ 10 cm) is large enough to allow study of single electron response from Fe^{55} source

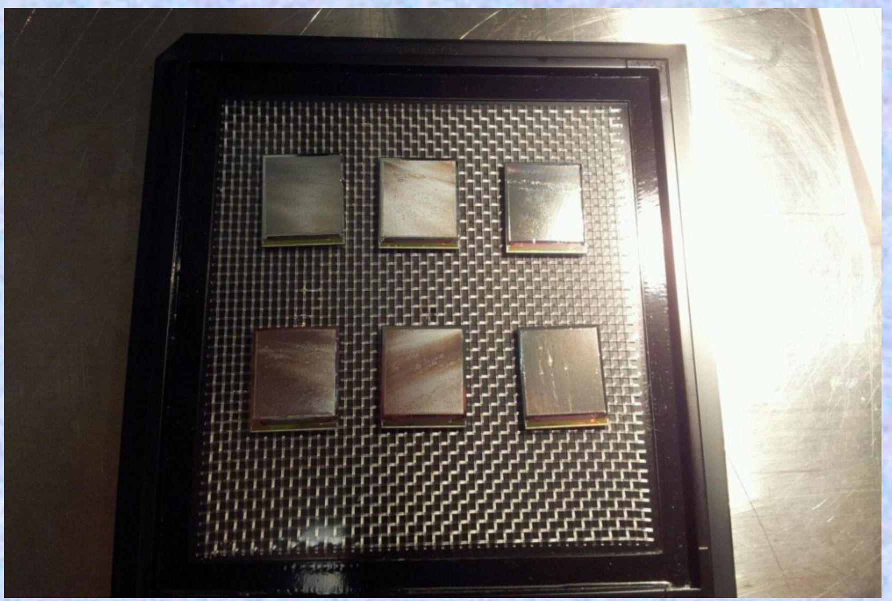






Studies of new IZM-3 InGrids in the Saclay micro-TPC

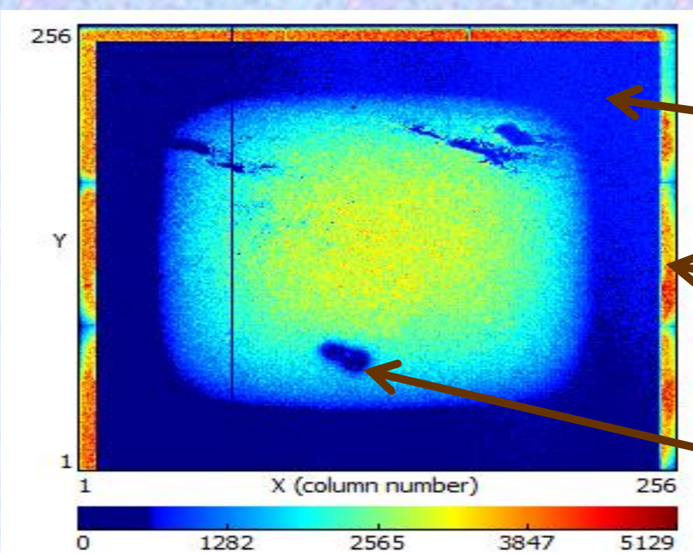
2011: Major Step Forward → InGrid Production on a wafer level
2013: 3rd IZM production run to post-process Timepix chips on a wafer level



- Received 6 IZM-3 InGrids in Saclay (earlier studies with IZM-3 InGrids have been performed in Bonn, NIKHEF)
- Four chips are mounted on PCB (one does not work)

One InGrid is tested →
in general, good behavior

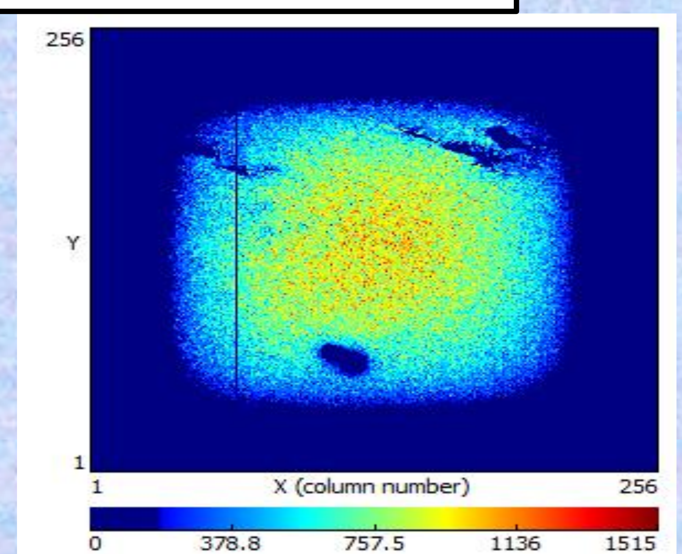
WE use it two weeks!! Ar/Iso – 95/5



Guard ring problem in micro-TPC

Some noise and/or discharges

Some local grid issues



Proposal of a Flexible Detector Setup using Low Energy Electrons from PHIL at LAL

PHIL provides electrons with momentum 5 MeV/c and 10^9 particles per bunch

Goal: **obtain samples of "monochromatic" electrons**

- **with energy between 1 and 5 MeV and energy spread of better than 10%**
- **with adjustable intensity down to 10^4 electrons per bunch**

Study dE/dx by cluster counting using InGrid detectors the electron range 1-5 MeV

(earlier simulation results by M. Hauschild & NIKHEF experimental studies)

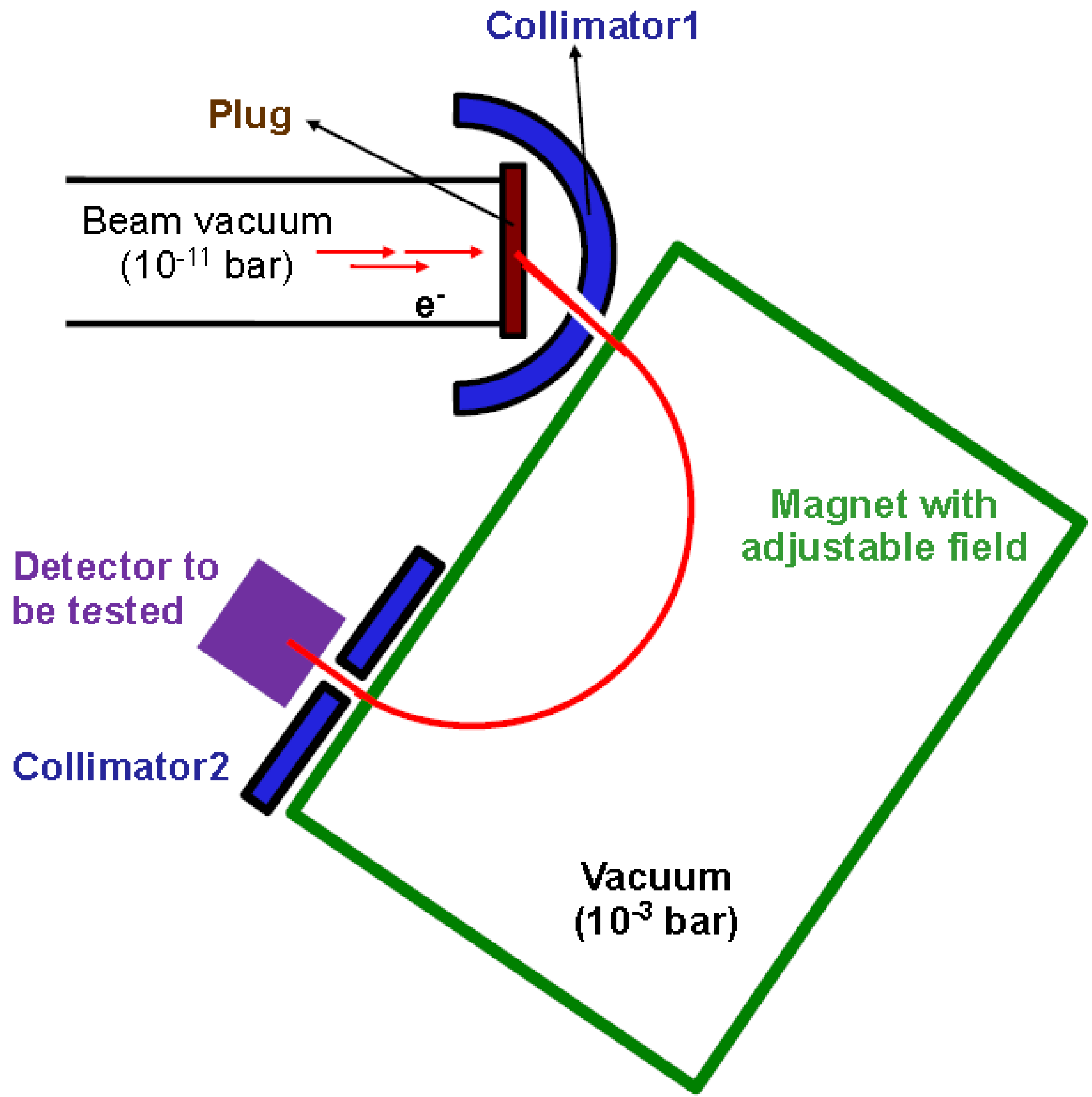
Joint proposal LAL & IRFU

LAL contribution from S. Barsuk, L. Burmistrov, H. Monard, A. Variola

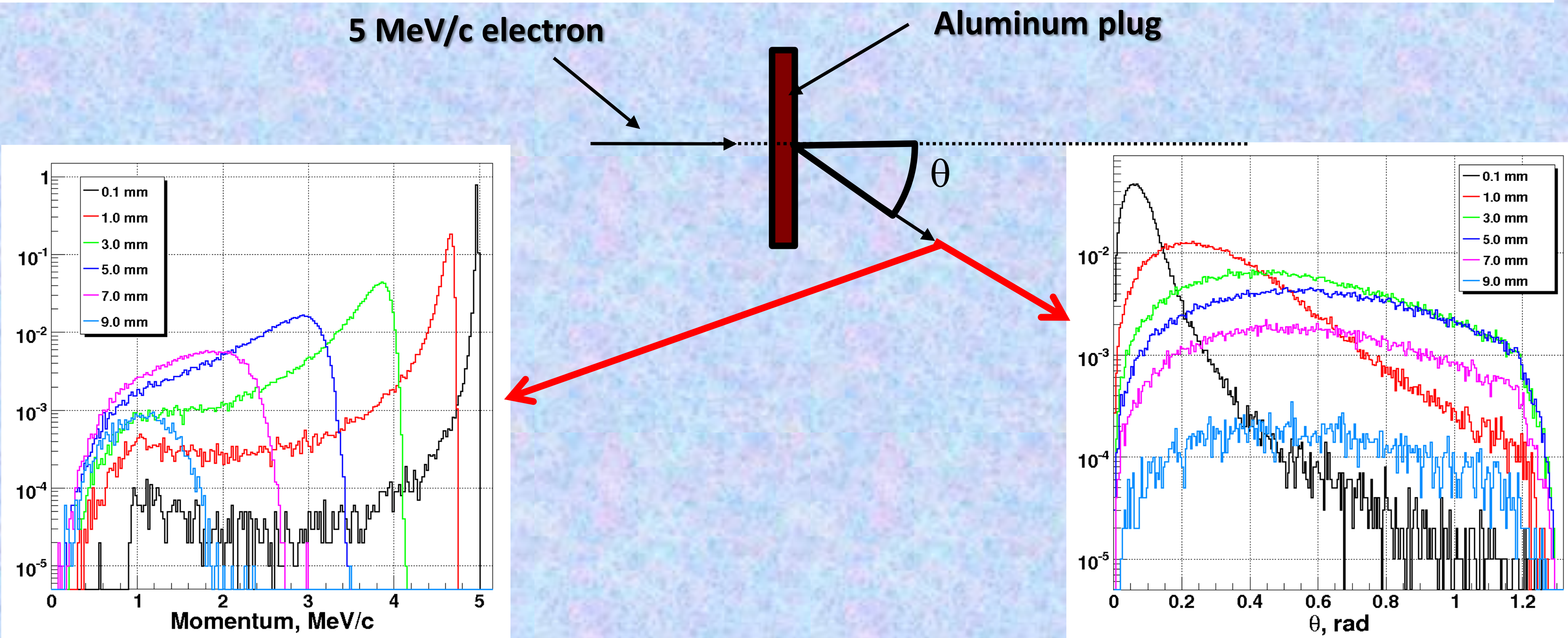
Spectrometer to sample "monochromatic" low energy electrons

Setup idea:

- ❑ Use electrons from PHIL
- ❑ Reduce energy/intensity using Al plug
- ❑ Select unique direction for electrons passing the plug with collimator 1
- ❑ Select required energy by half-turn of electron in the magnetic field (position of collimator 2)
- ❑ Adjust intensity/energy spread using collimator 2, positioned in front of tested detector



Momentum and angular spectra of electrons passing through the Al plug, depending on the plug thickness : Geant4 simulation



Example of sampling 1 MeV electrons from 5 MeV beam: from simulated 10^8 electrons a sample of ~10^3 electrons and momentum spread of ~10 % are obtained with collimator opening of 6 mm.