Update on Silicon Pixel Readout for a TPC at NIKHEF

LCWS08 - Chicago

19 Nov 2008

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NIKHEF

Full post-processing of a TimePix

· Timepix chip + SiProt + Ingrid:

Timepix chip:

•256x256 pixels

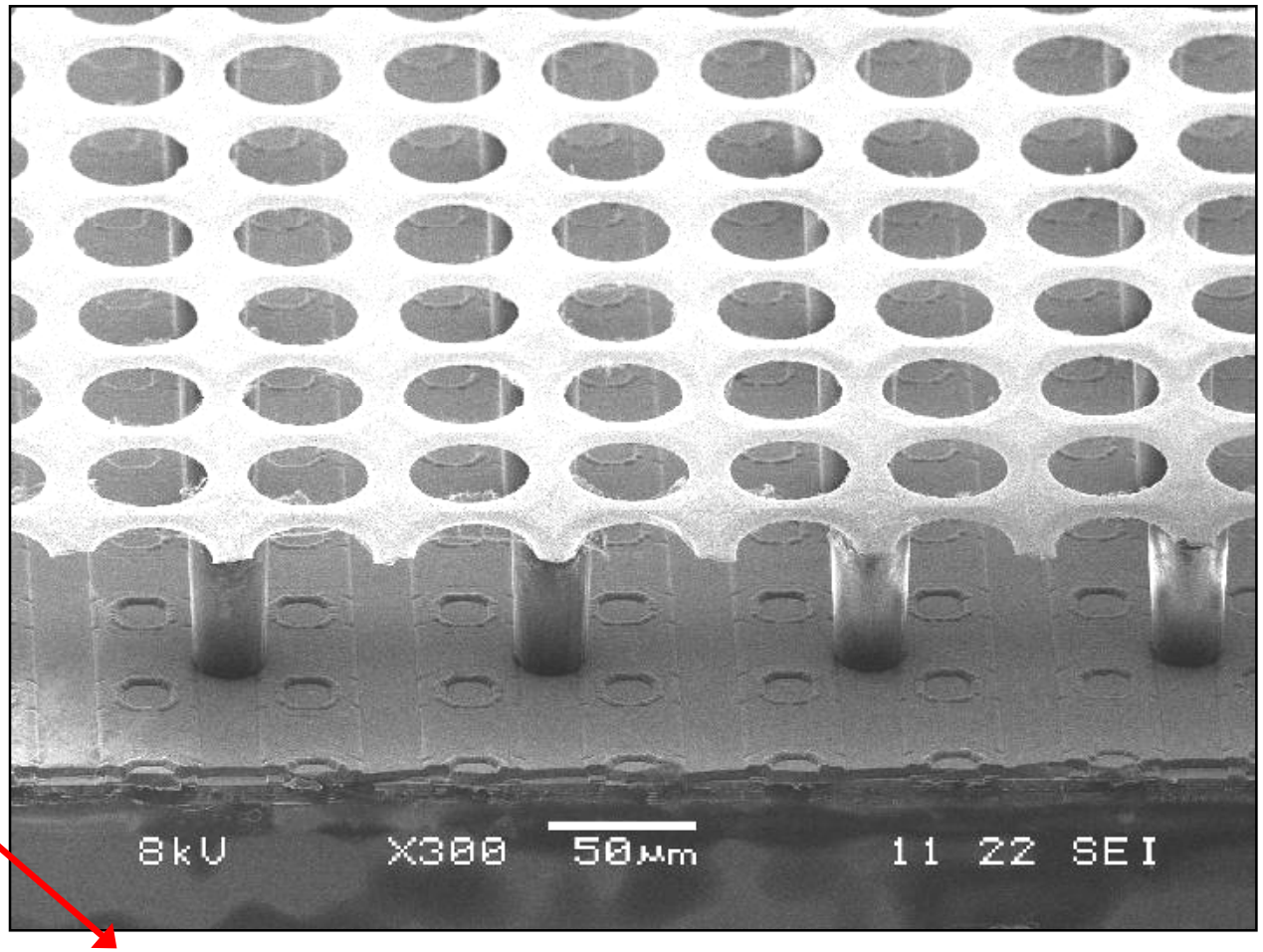
•pixel: 55x55 μm^2

•active surface: 14x14 mm^2

MESA+: Ingrid

IMT Neuchatel:

15 or 20 µm highly resistive aSi:H protection layer



Now also Si_3N_4 protection layers (7 µm)

“lifetime” of Medipix2/Timepix chips

- “naked” Medipix chips:

  up to few hours; sometimes very short!

  (both in He and in Ar mixtures)

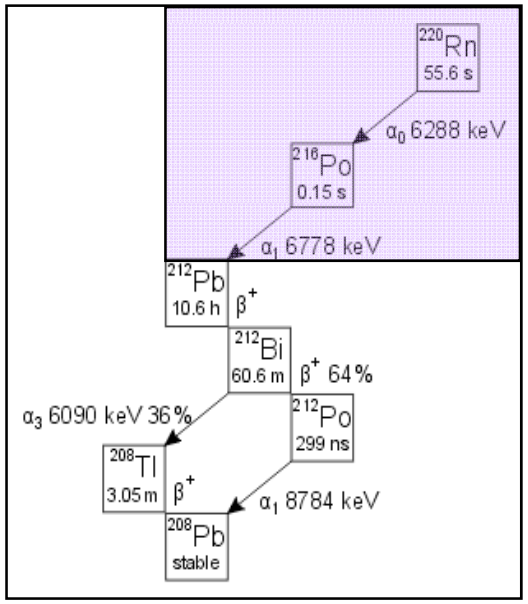
- With 4 μm amorphous Si:
  - in He/isobutane (80/20): > 3 months
  - In Ar/isobutane (80/20): ~ 1 day!

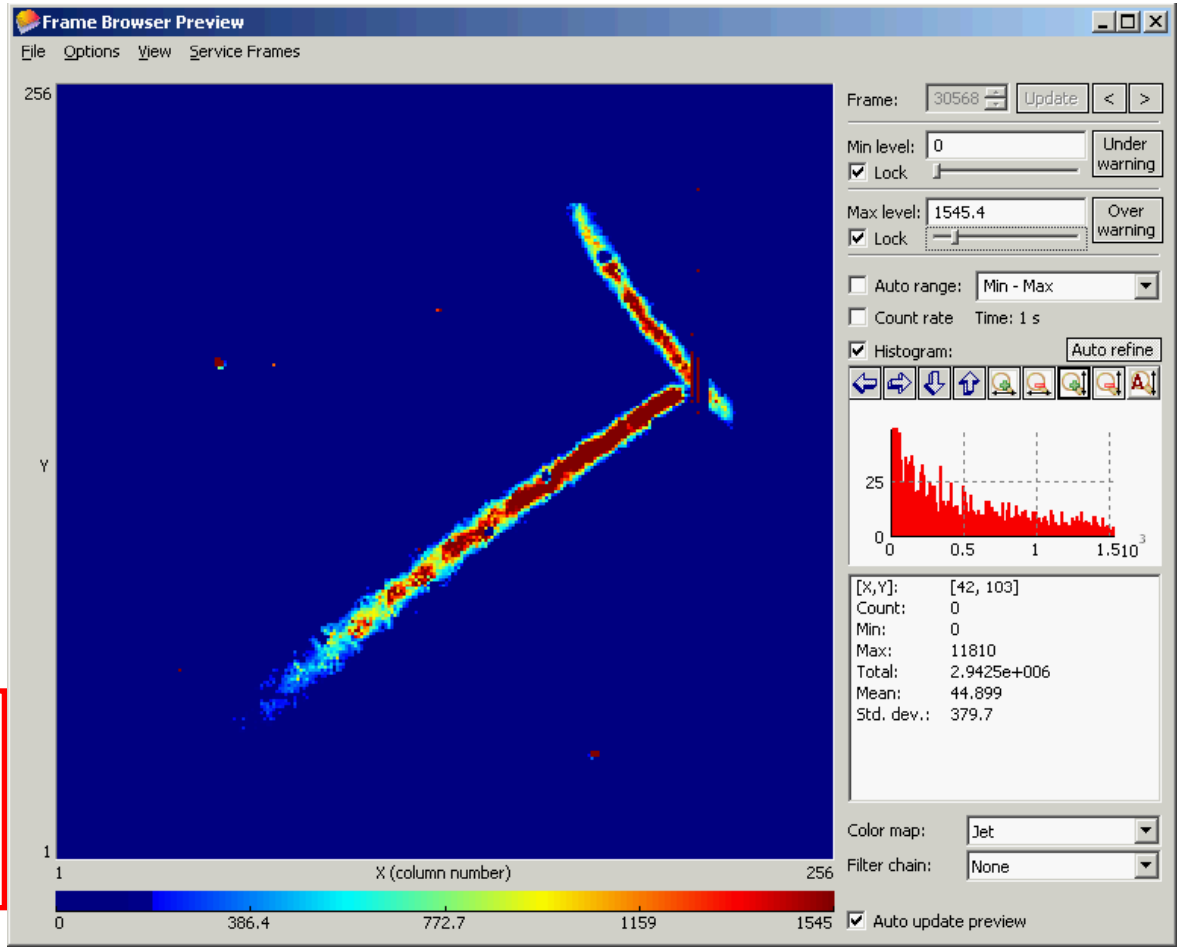
- With 15 or 20 μm protection layer ….. ???

Final assessment: spark-proofness

- Provoke discharges by introducing small amount of Thorium in the Ar gas
  - Thorium decays to Radon 222 which emits 2 alphas of 6.3 & 6.8 MeV
  - Depose on average $2.5.10^5$ & $2.7.10^5$ e- in Ar/iC_4H_{10} 80/20 at -420 V on the grid, likely to trigger discharges

Charge mode



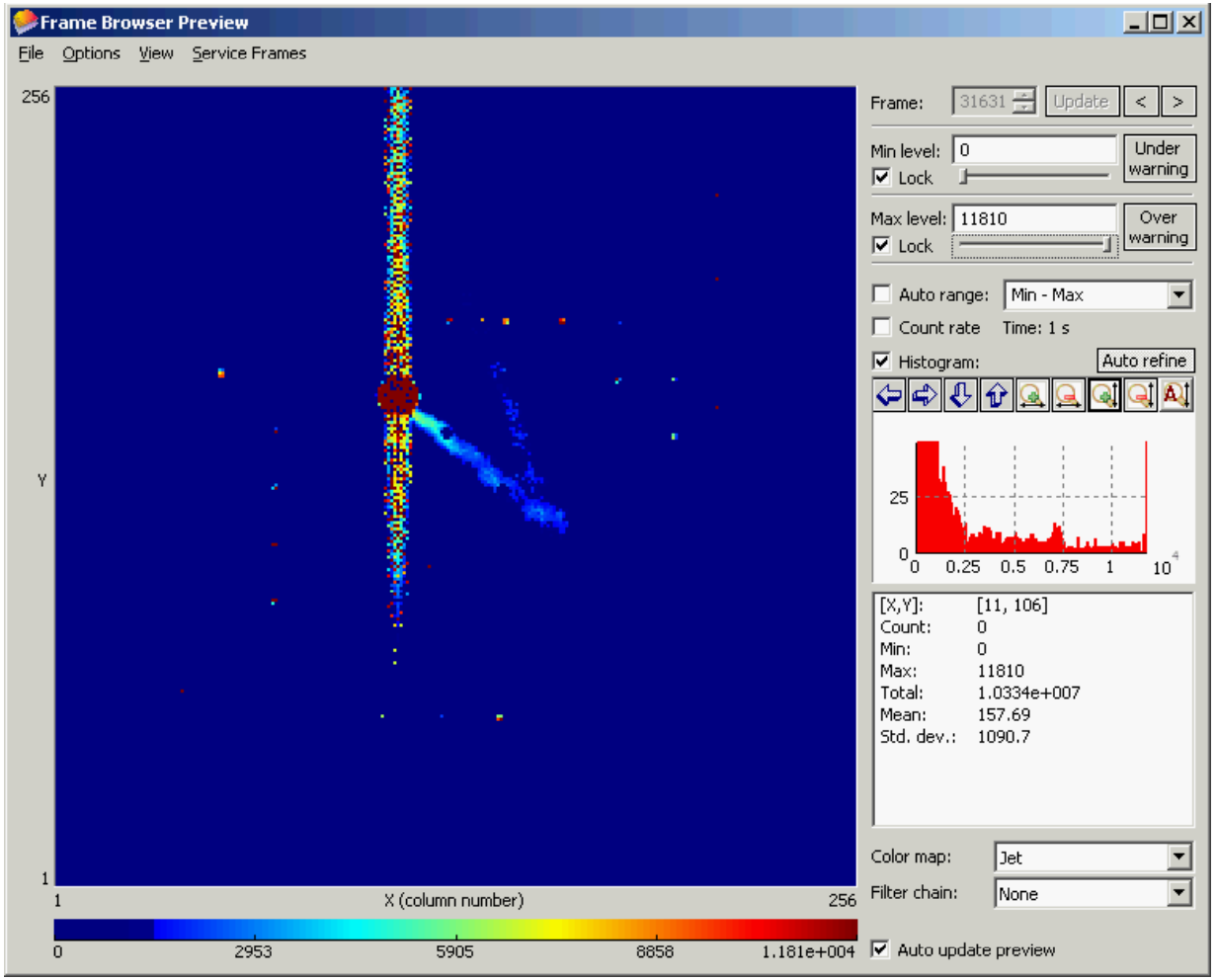


During ~3 days, some 5.10^4 alpha events recorded in 1% of which …

Oct. 2007
ALCPG@FNAL: … discharges are observed !

- For the 1st time: image of discharges are being recorded
- Round-shaped pattern of some 100 overflow pixels
- Perturbations in the concerned column pixels
  - Threshold?
  - Power?

Chip keeps working !!



Since then (with 20 μm SiProt): no more Timepix chip damaged by discharges

- But: on 21st May in CERN T9 testbeam:

Chip (with 15 μm SiProt) no longer functioning after ¾ hour in Xe/CO_2 (70/30) mixture at V_{grid} = 490 V

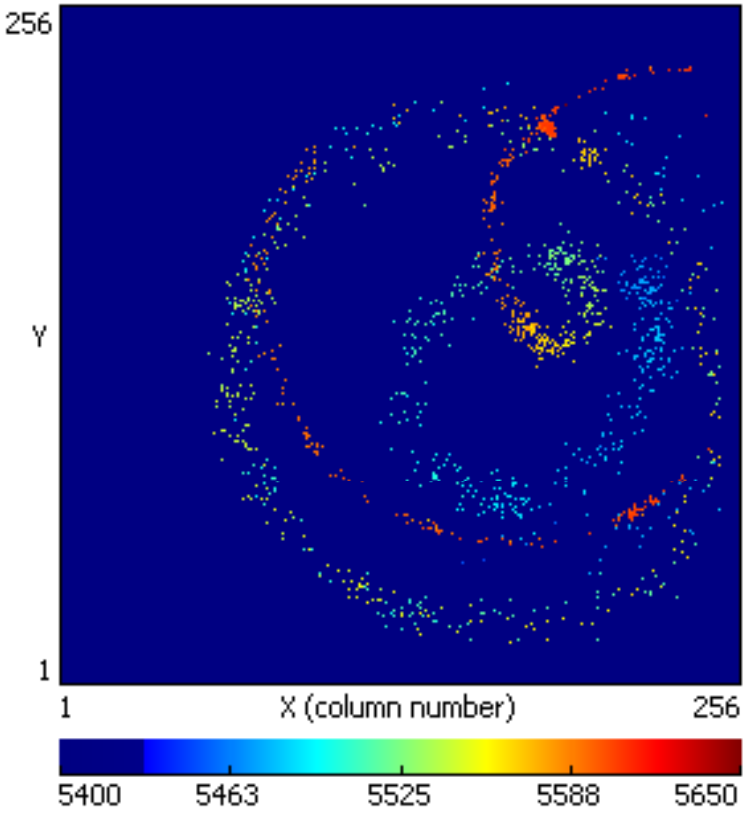
- Apart from that: lots of data collected, cosmics and beam. Analysis still ongoing

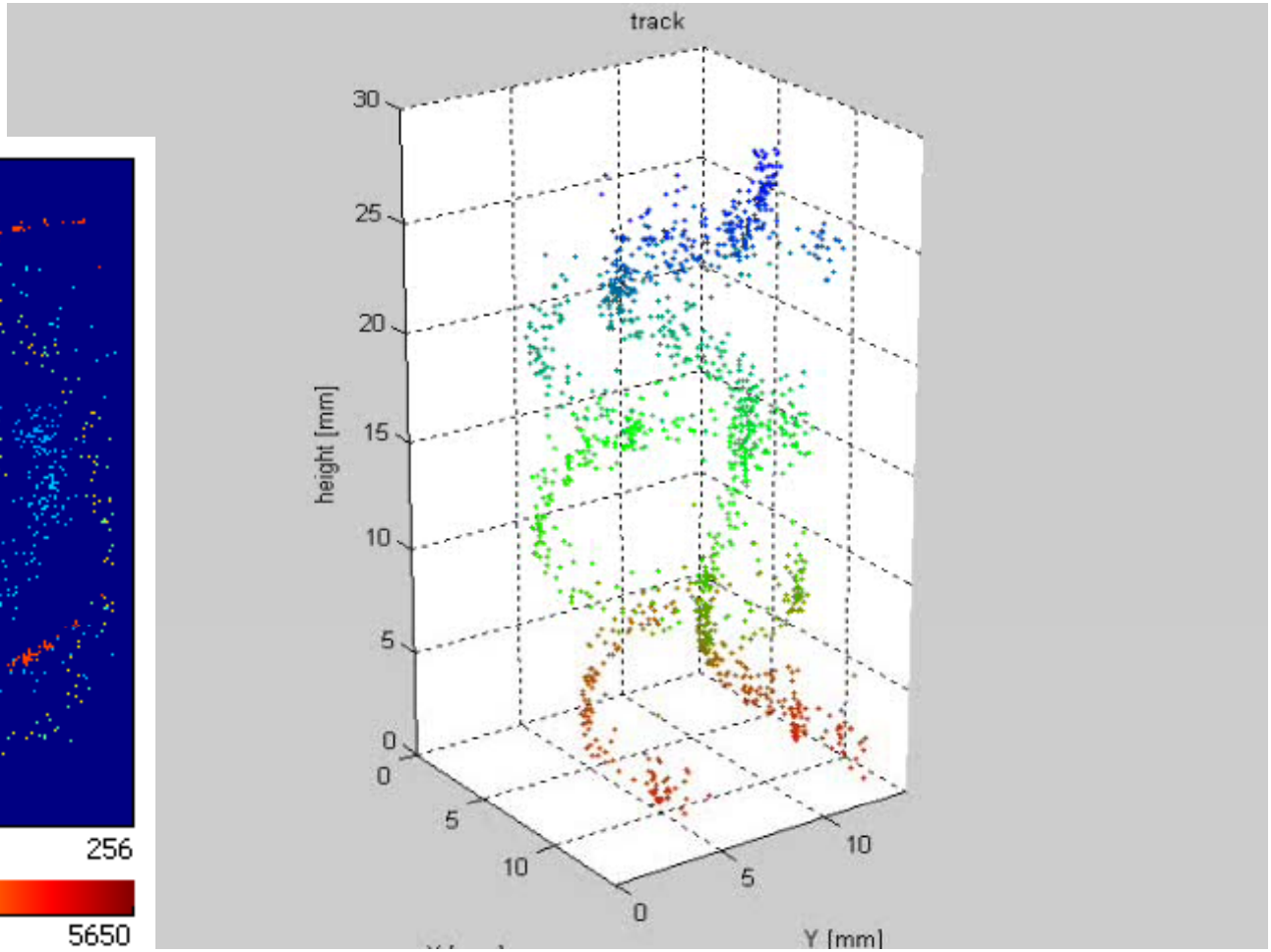
Some events

- From Nikhef in lab setup with magnet up to 1 T
- From CERN PS testbeam T9 (2 and 5 GeV pions and electrons)

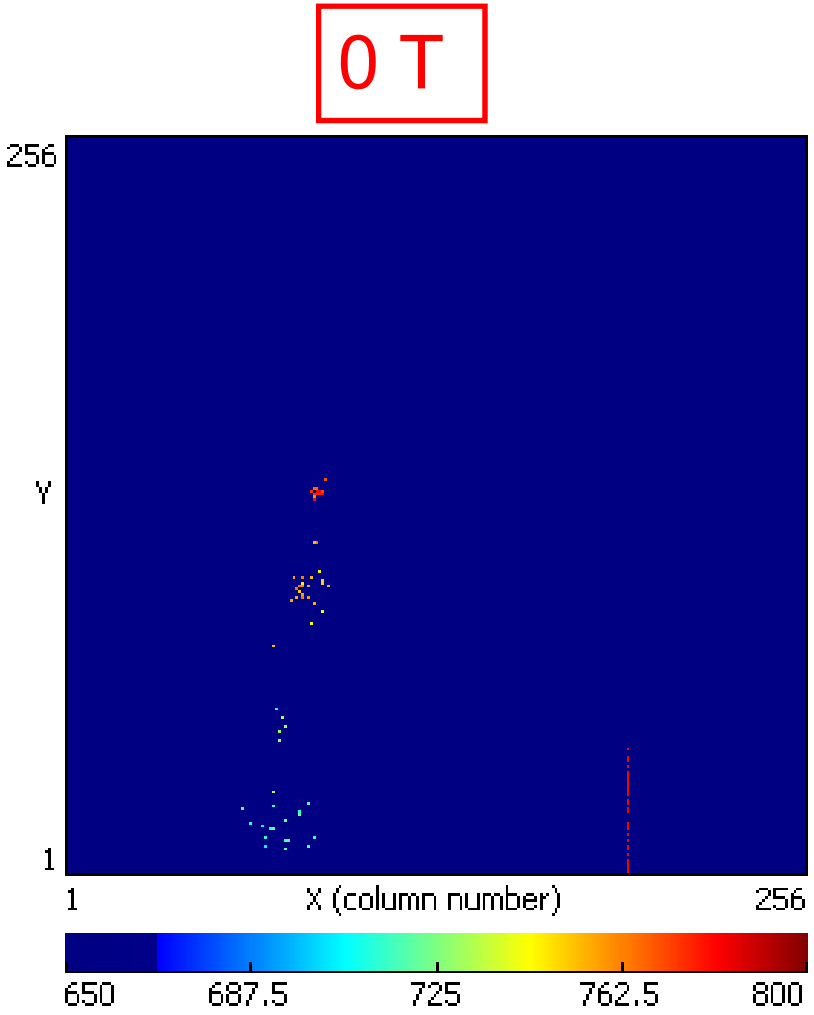
A 5 cm^3 TPC (two electron tracks from ^{90}Sr source)

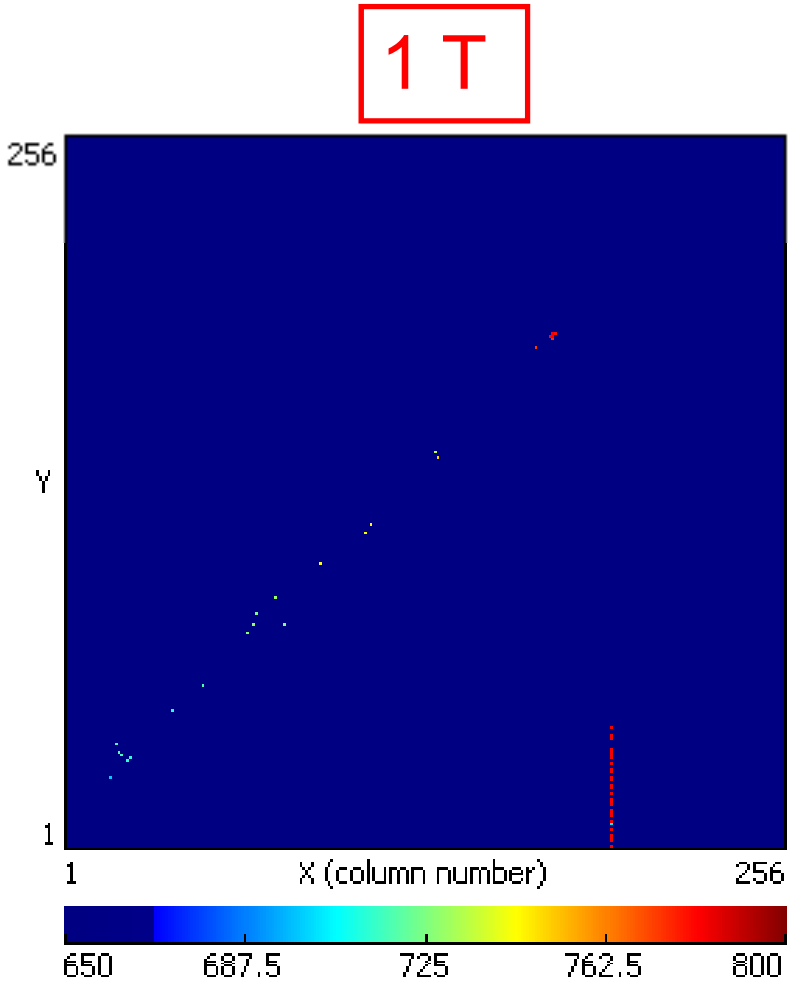
B = 0.2 T





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





"large" diffusion

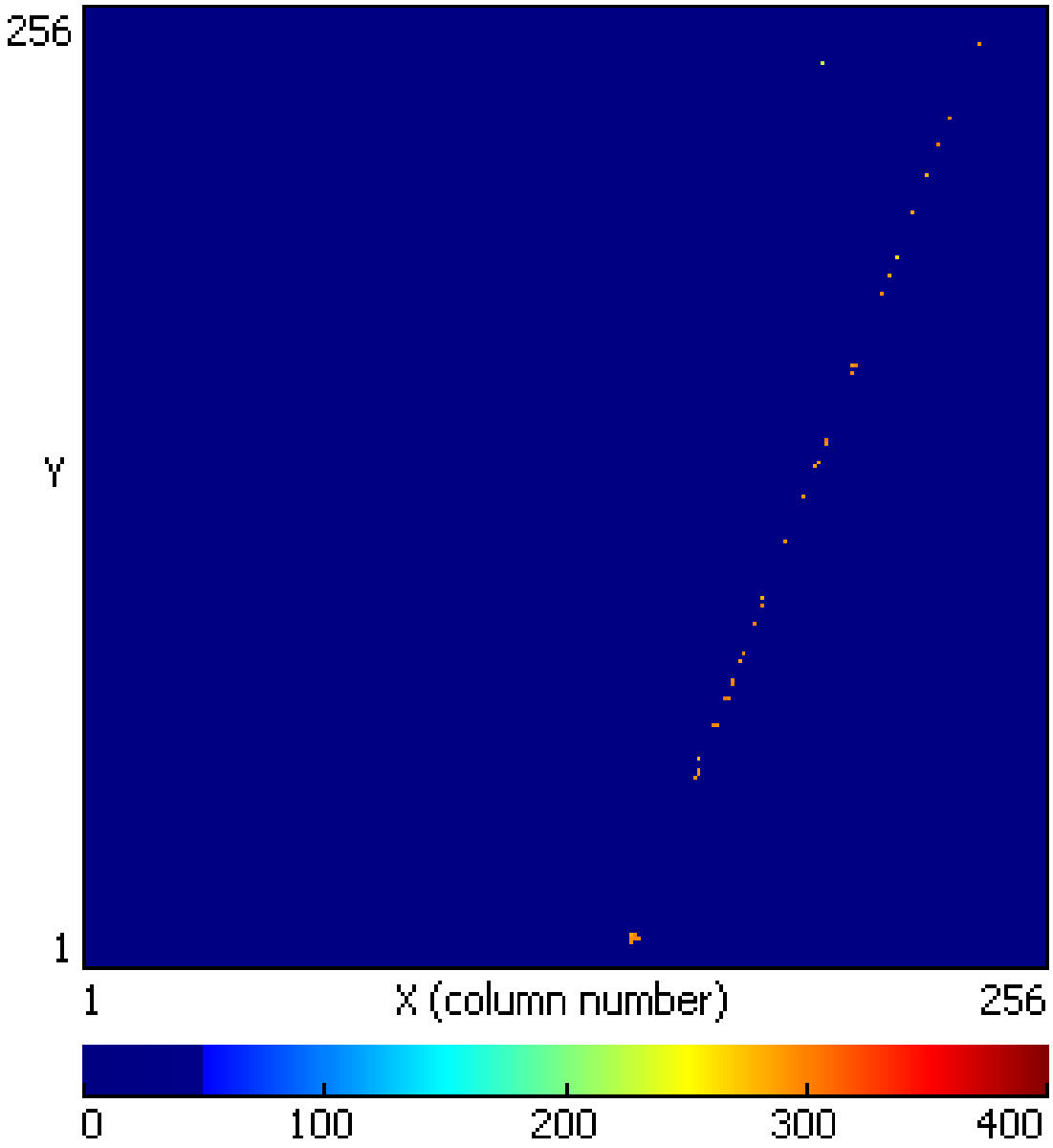
"little" diffusion

19 May 2008

5 GeV neg. beam

$ArCO_2$ (70/30)

Colour code = drifttime



20 May 2008

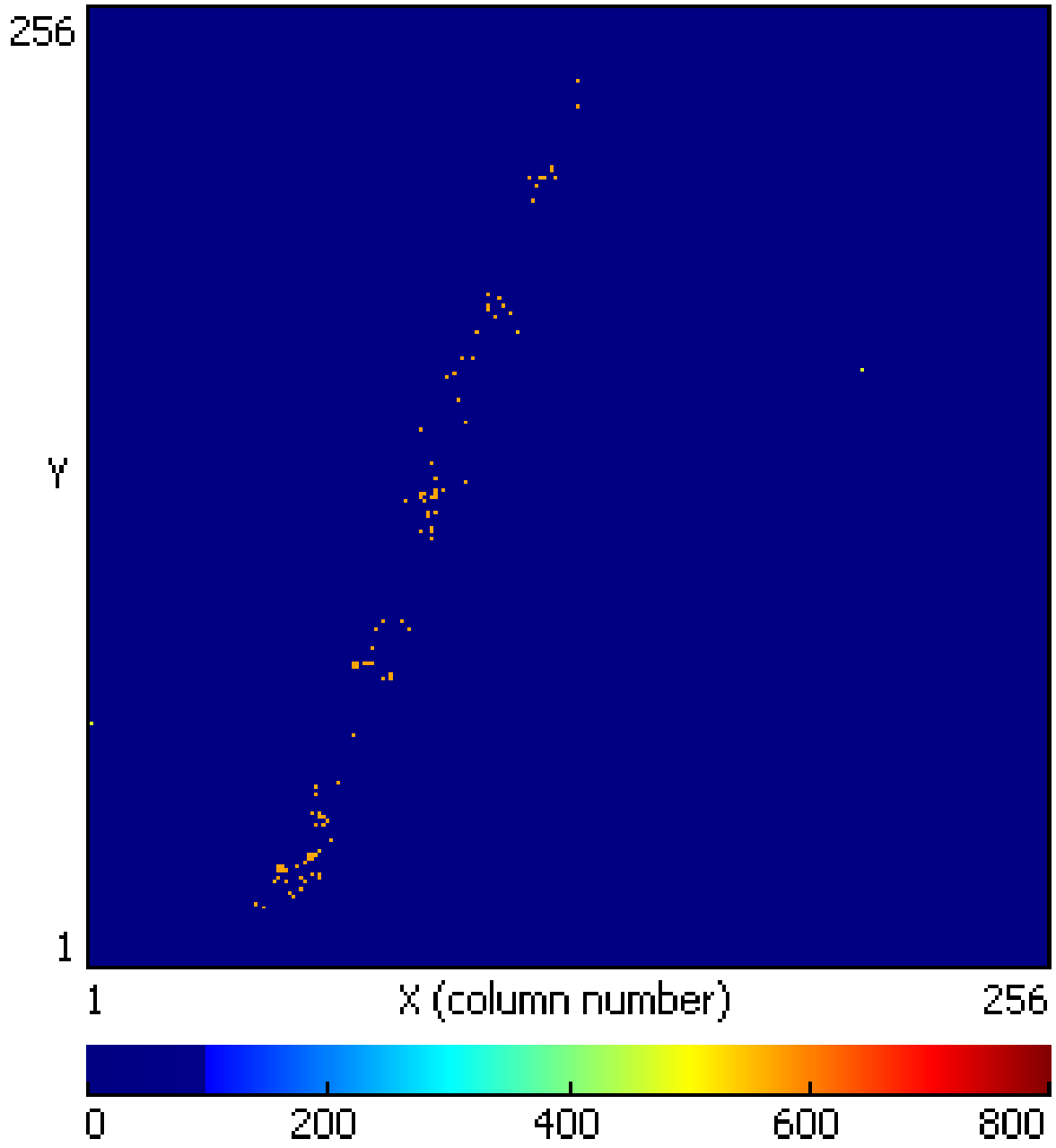
(early morning)

2 GeV neg. beam

“electron” trigger

$ArCF_4$isoB
(90/3/2)

Colour code =
drifttime



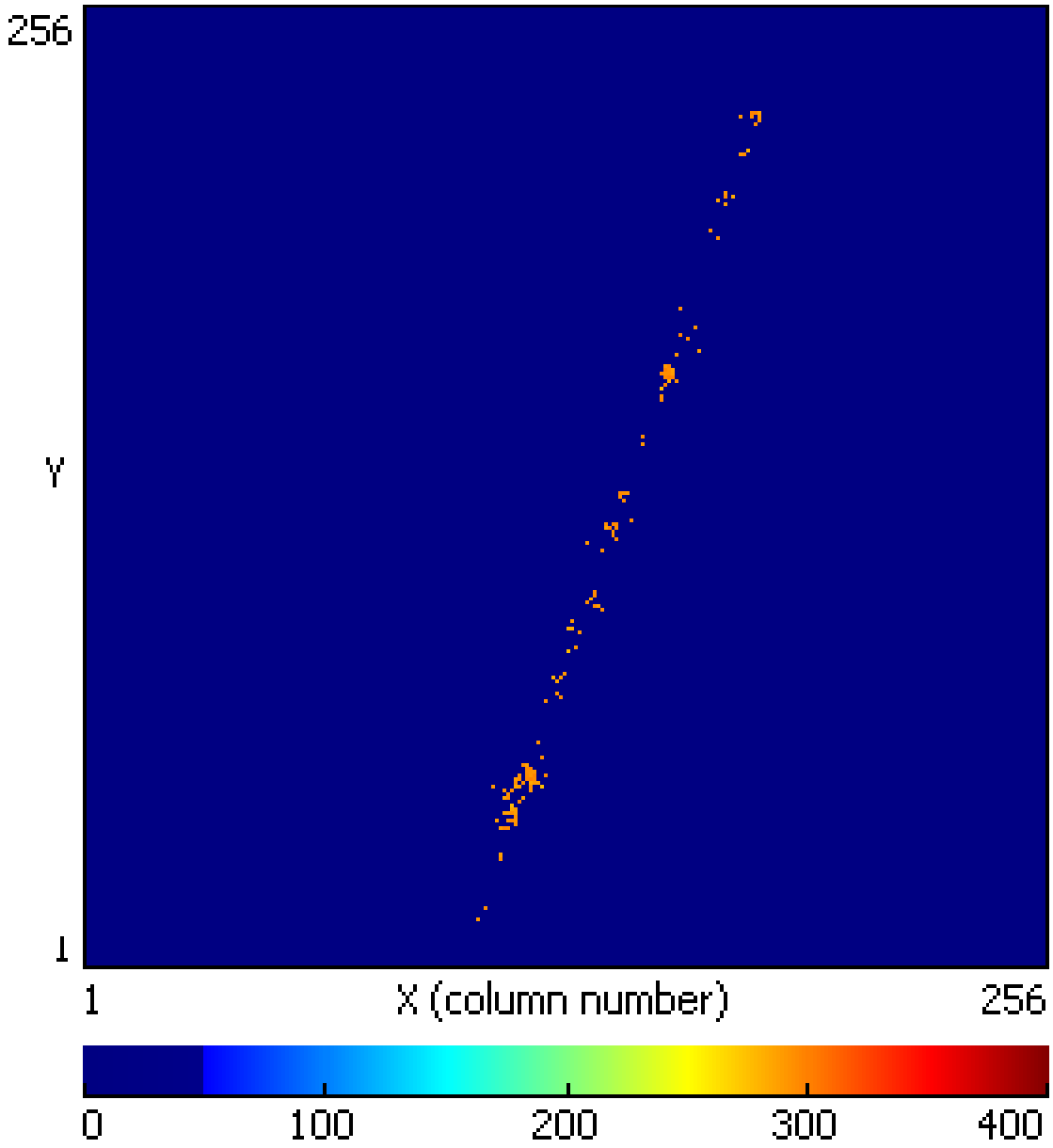
20 May 2008

(early morning)

2 GeV neg. beam

$ArCF_4$isoB
(90/3/2)

Colour code =
drifttime

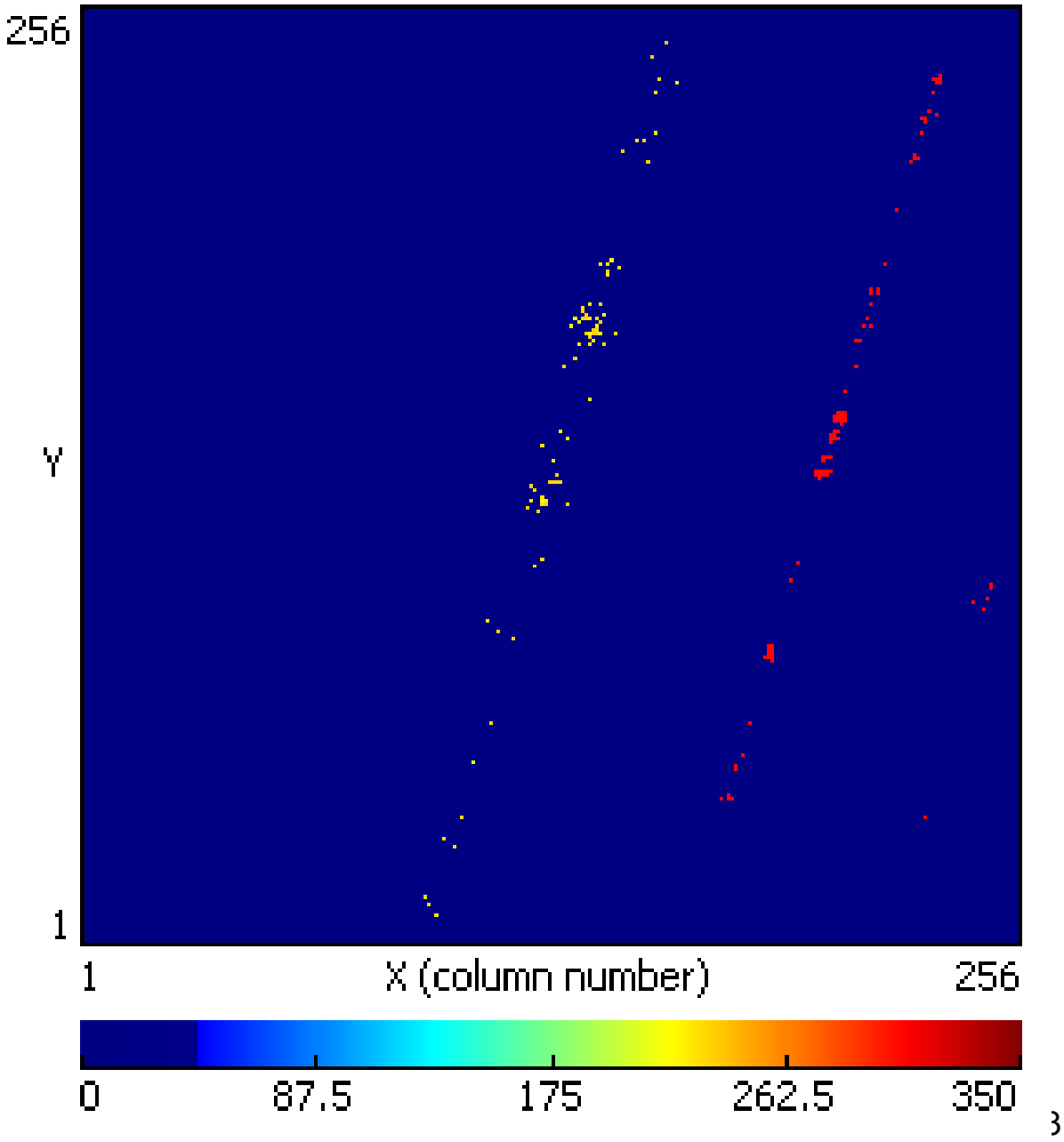


21 May 2008

5 GeV neg. beam

$XeCO_2$ (70/30)

Colour code = drifttime



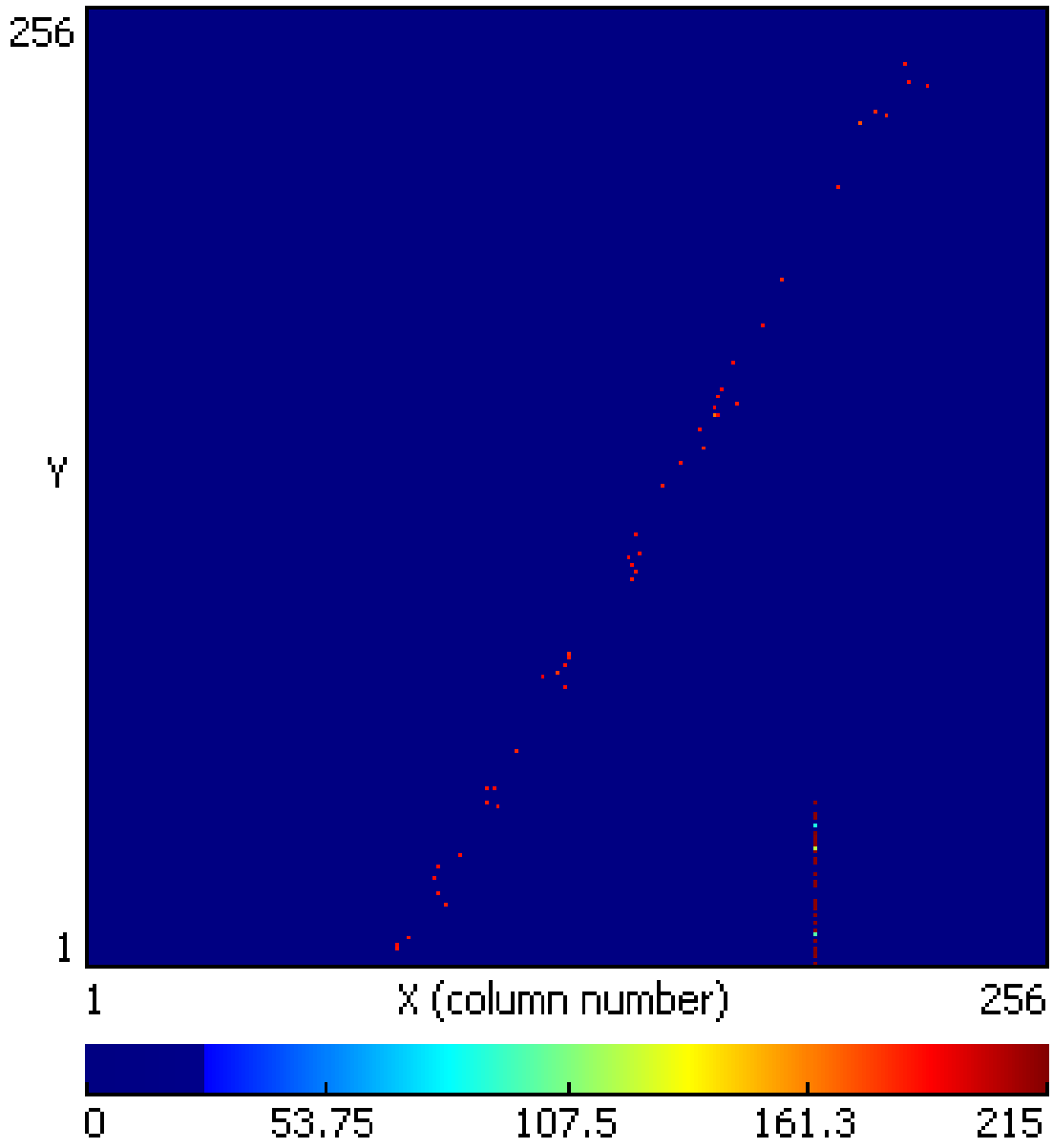
23 May 2008

5 GeV neg. beam

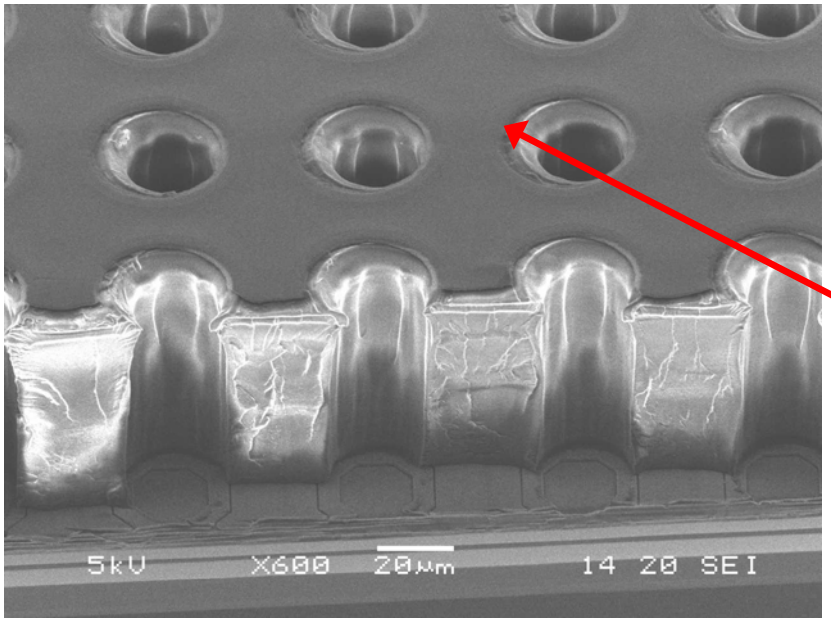
He-isoB (80/20)

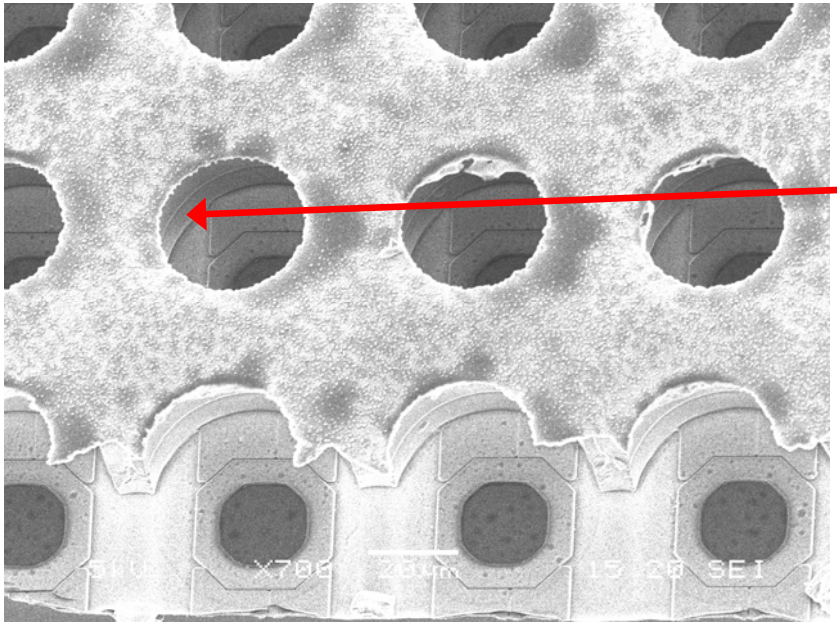
V_{grid} = 420 V

Colour code = drifttime



Alternative Grid structures





GemGrids

(mechanically more robust than Ingrids)

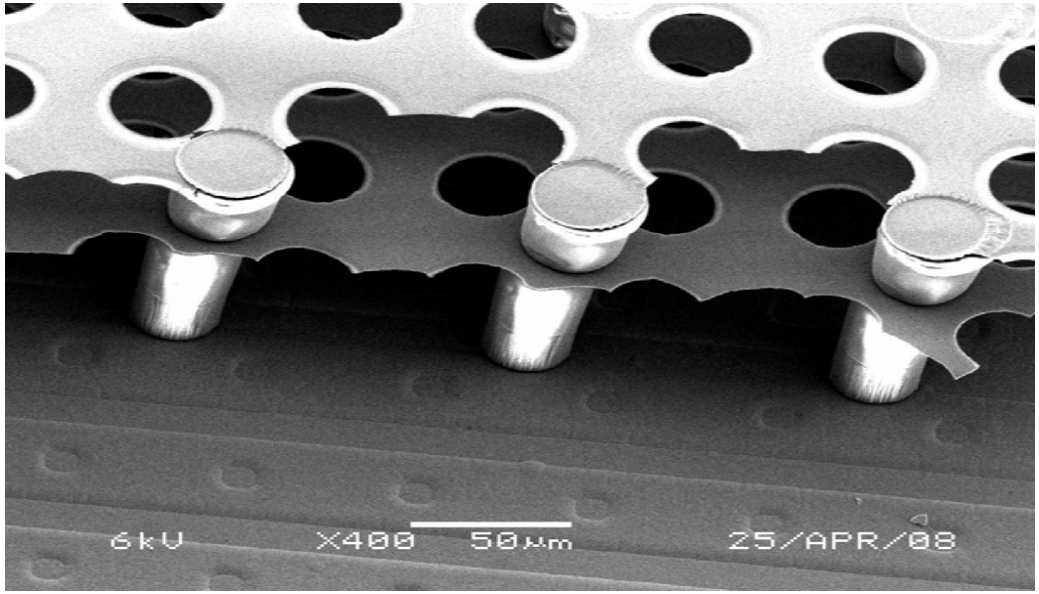
- recessed metal:

Much less gain than with pillars (micromegas-like)

- recessed insulator:

Somewhat less gain, but OK

TwinGrid



Possible advantages:

- Separate high-gain region from anode
- Or share total gain over the two regions;

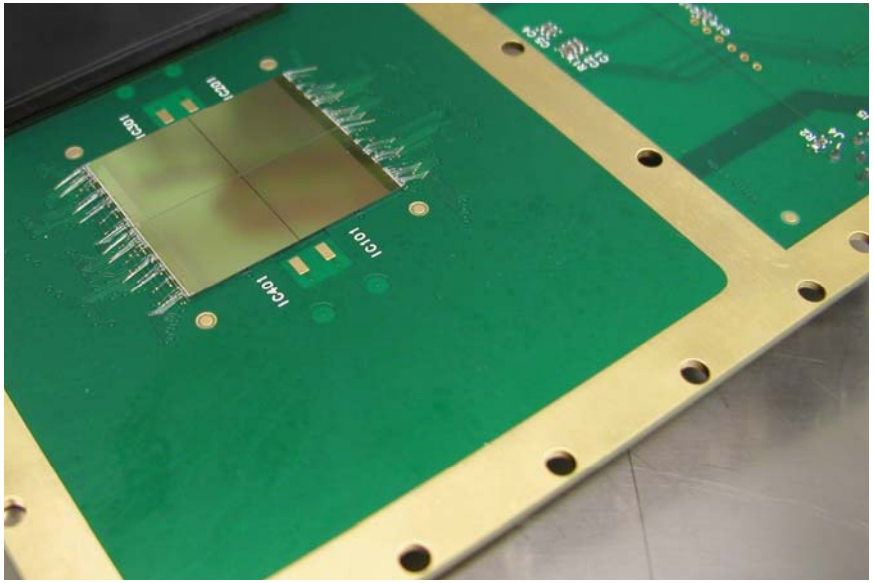
→ Both give reduction of discharge probability

- Lower ion backflow: not yet measured

It works!

Work in progress

- (Post) processing in Twente.
  - Both Si_3N_4 and InGrid can be applied.
  - Treating chip squares of 3X3 timepix chips instead of individual chips.
  - Search for high res InGrids. (Si_3N_4)
- Optimize protection and signal integrity.
  - Discharge test structures.
- Scaling up.
  - 4 chip detectors (3X3 cm): soon
  - 64 chip detector (12X12 cm): later in 2009/10
- Timepix2 development



Summary

- A lot of progress made in last ‘year’; not mentioned many details on energy and point resolution studies and on signal development (see thesis Max Chefdeville, Jan.2009)
- 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

Next:

- Build larger multi-chip detector systems with fast readout