This project has been funded by the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 657751

CYGNUS-TPC gas meeting

NITEC
a Negative Ion Time Expansion Chamber for directional Dark Matter searches

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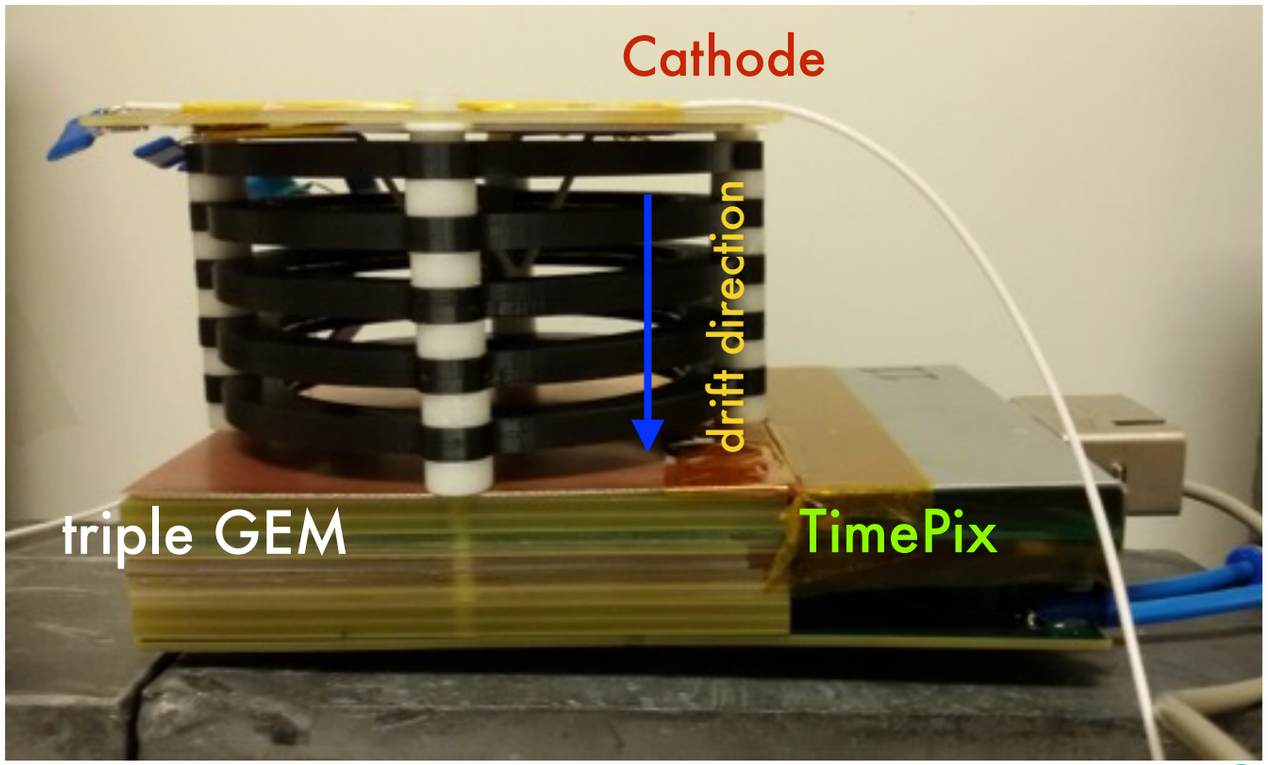
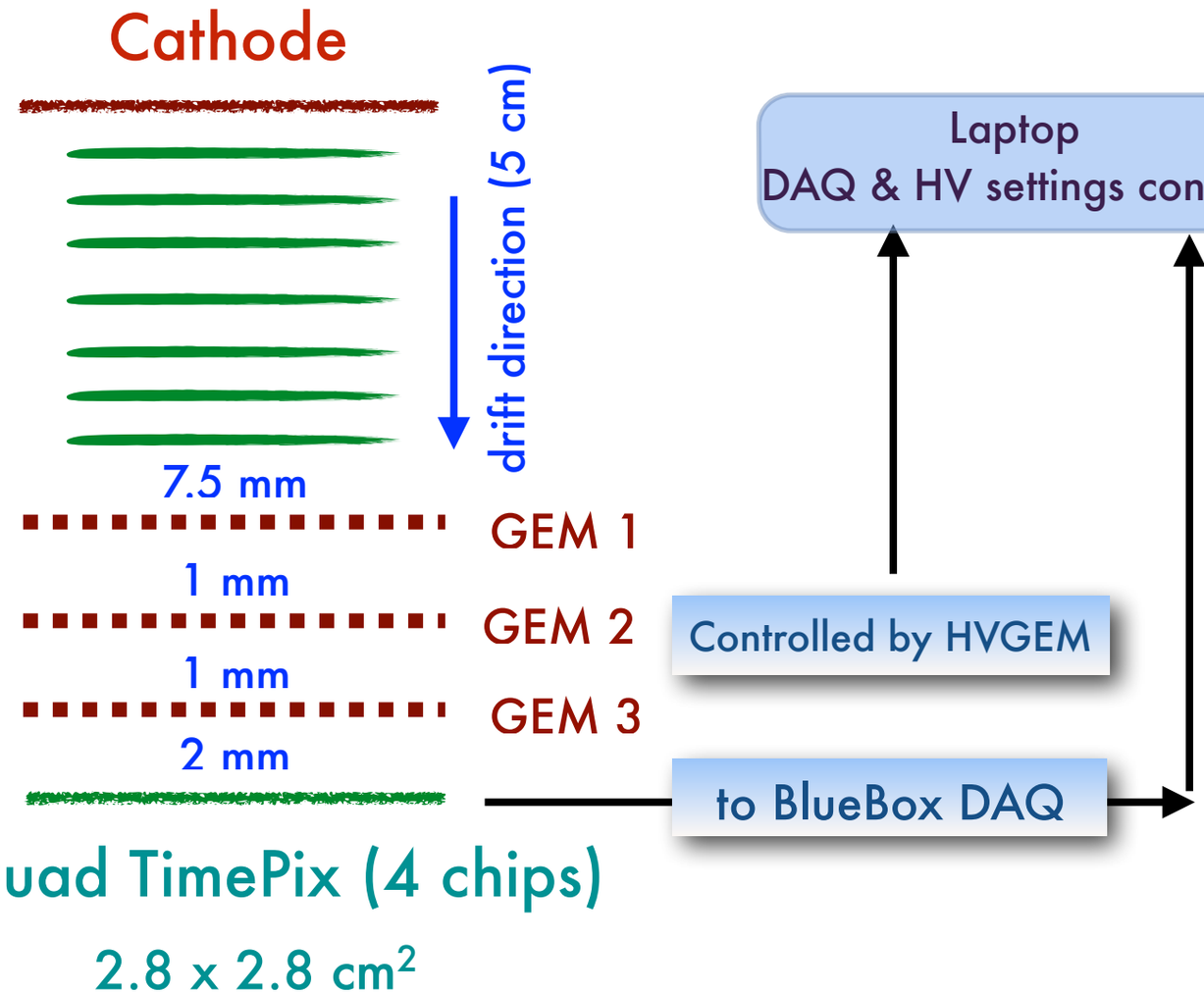
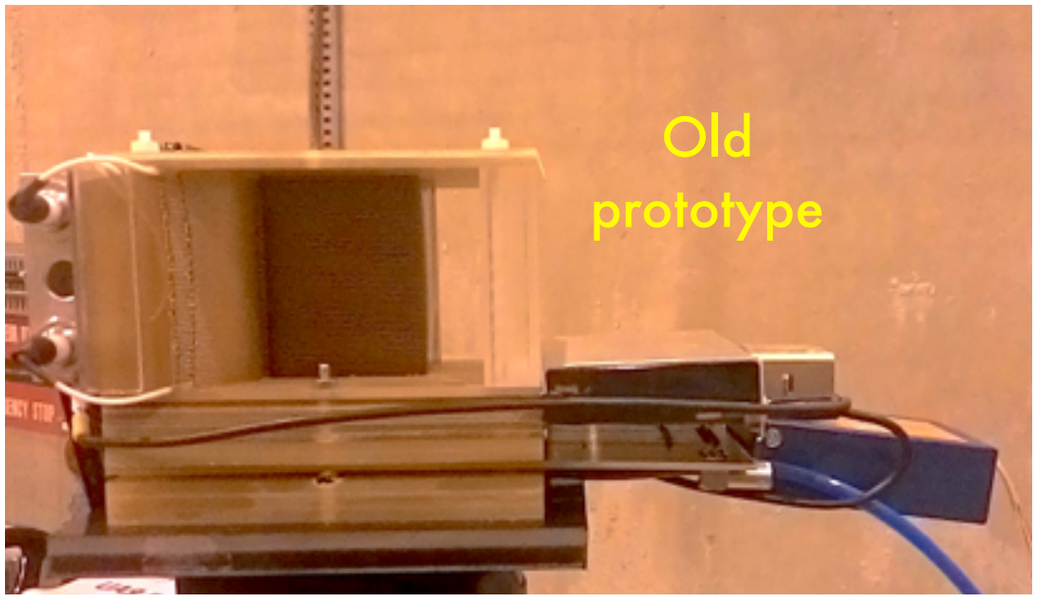
New NITEC prototype







- Improved stability:
  - Improved resistors
  - Circular shape
  - Improved transport to first GEM

Measurement @ Beam Test Facility

450 MeV
electron beam down
to single particle
(< 1 mm^2 beam spot)

micrometric table
(~100 um position
uncertainty)

Measurements performed

We measured the Time Of Arrival @ 250, 530, 640, 750 and 860 V/cm for each configuration below

also TOT data

- Pure SF_6 at 75 Torr, 100 Torr, 150 Torr

GEM gain 1140 V 1240 V 1440 V

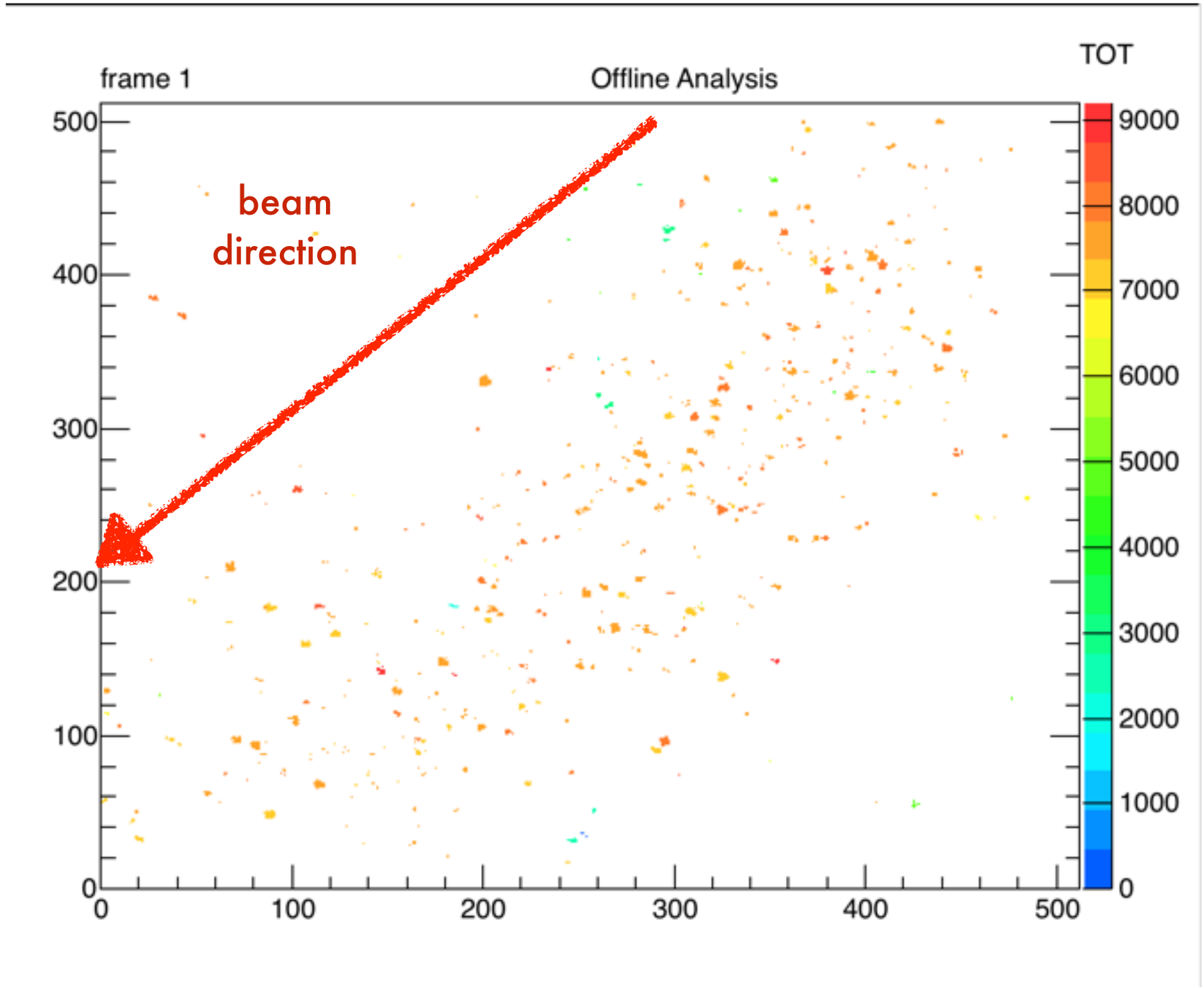
also TOT data

- $He:CF_4:SF_6$ 60:40:120 Torr, 360:240:10 Torr

GEM gain 1460 V 1640 V

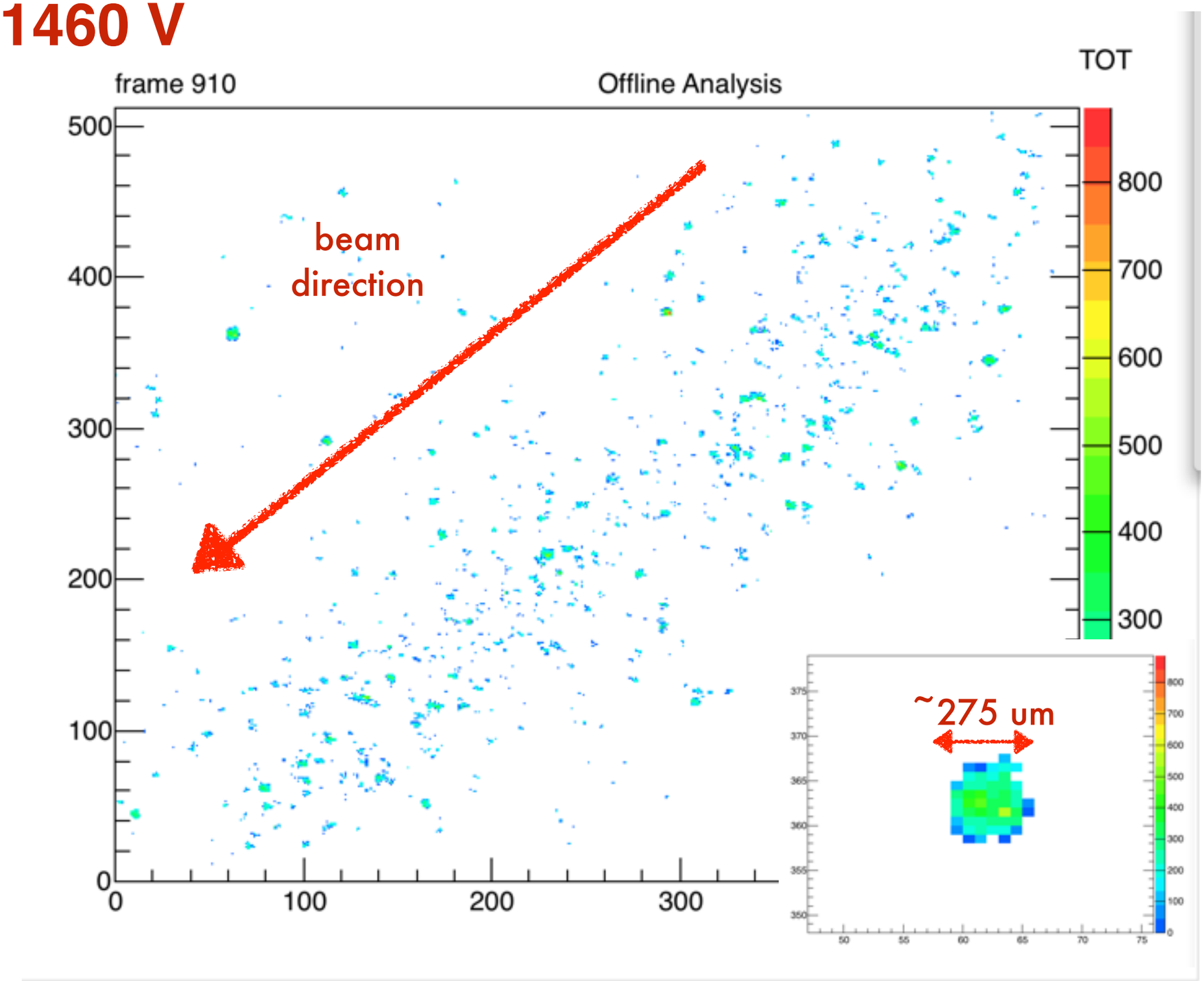
SF_6 @ 150 Torr TOA

gain 1440 V

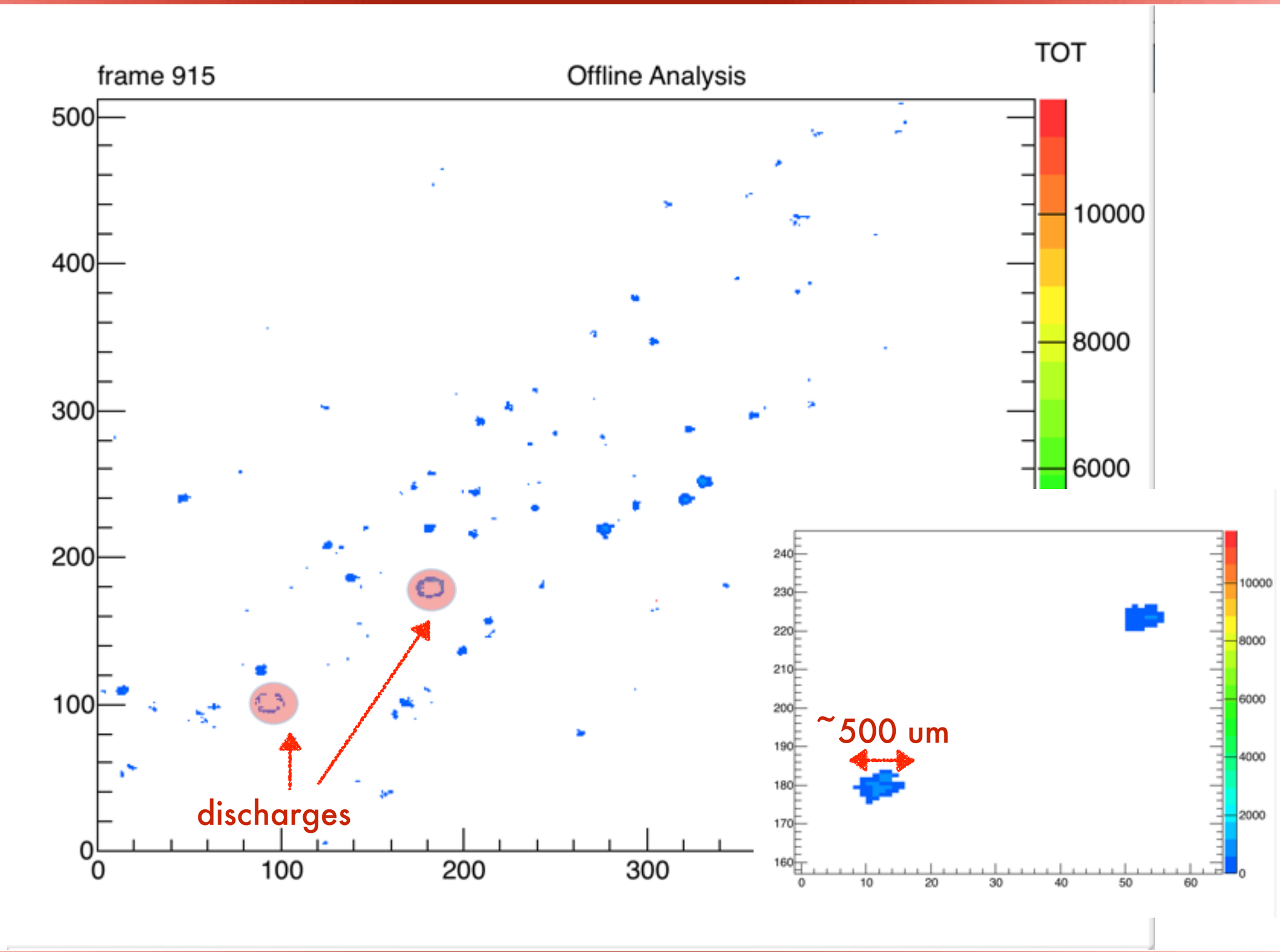


SF_6 @ 150 Torr TOT

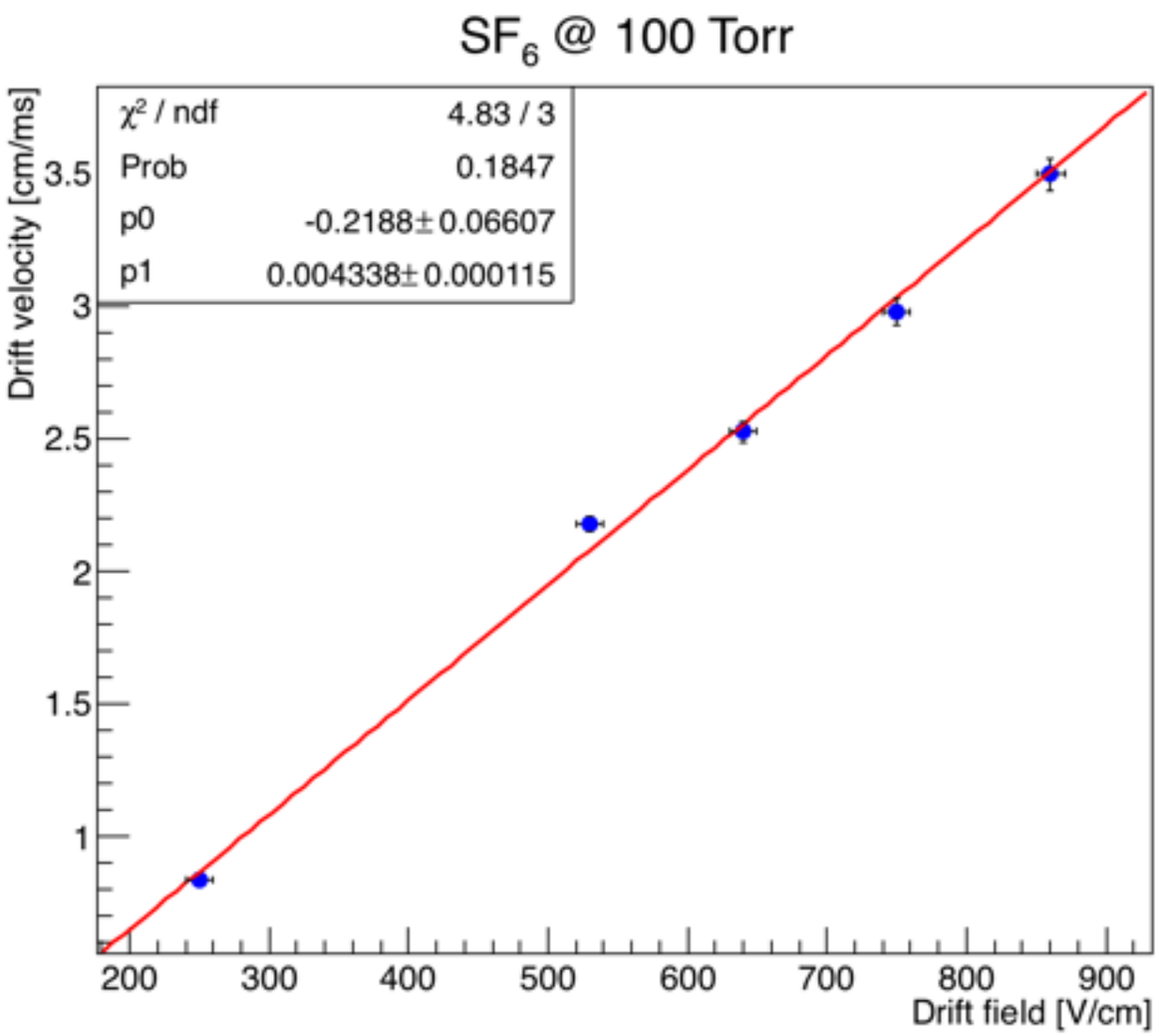
gain 1460 V



He:CF_4:SF_6 360:240:10 Torr TOT



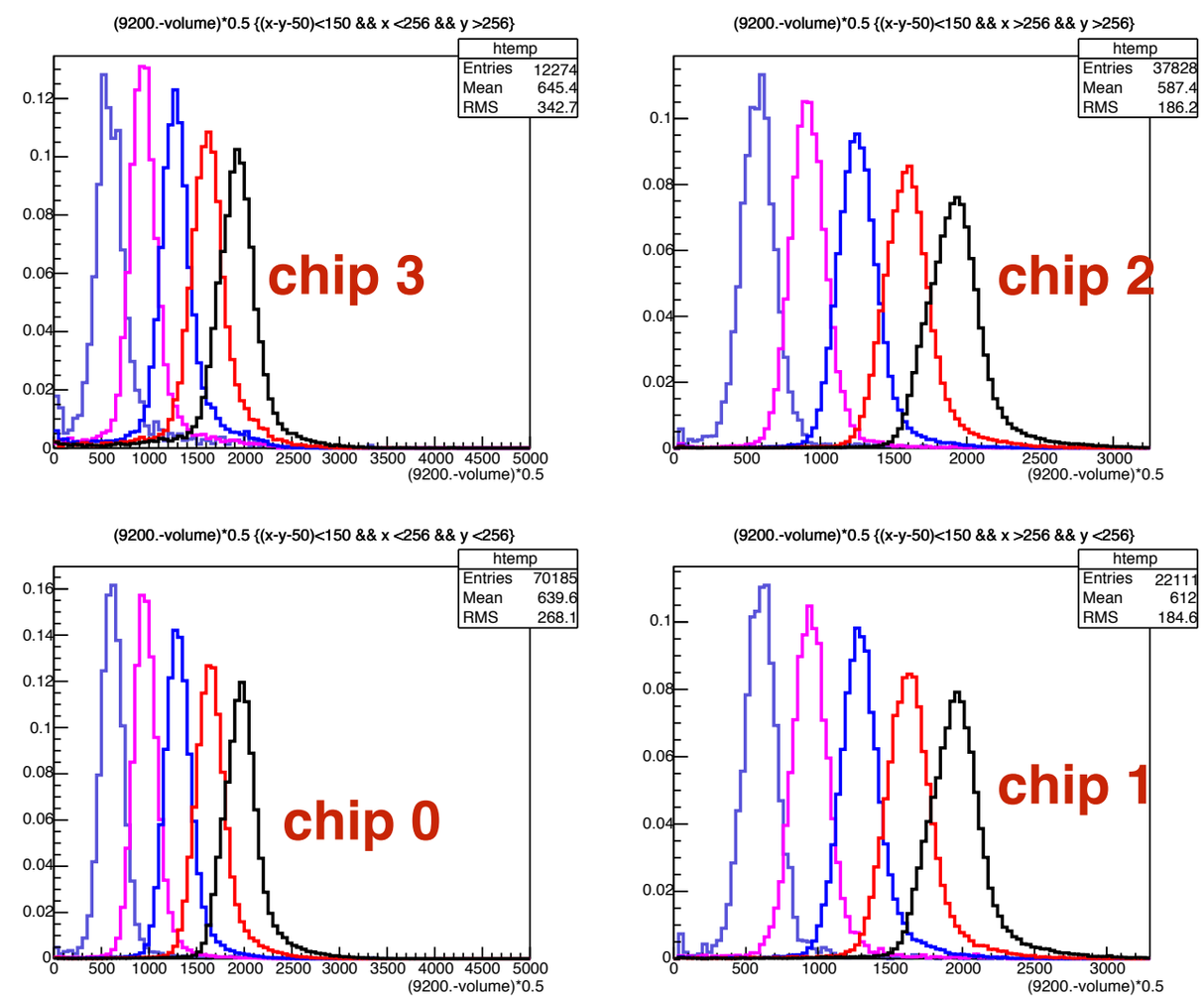
SF_6 @ 100 Torr TOA



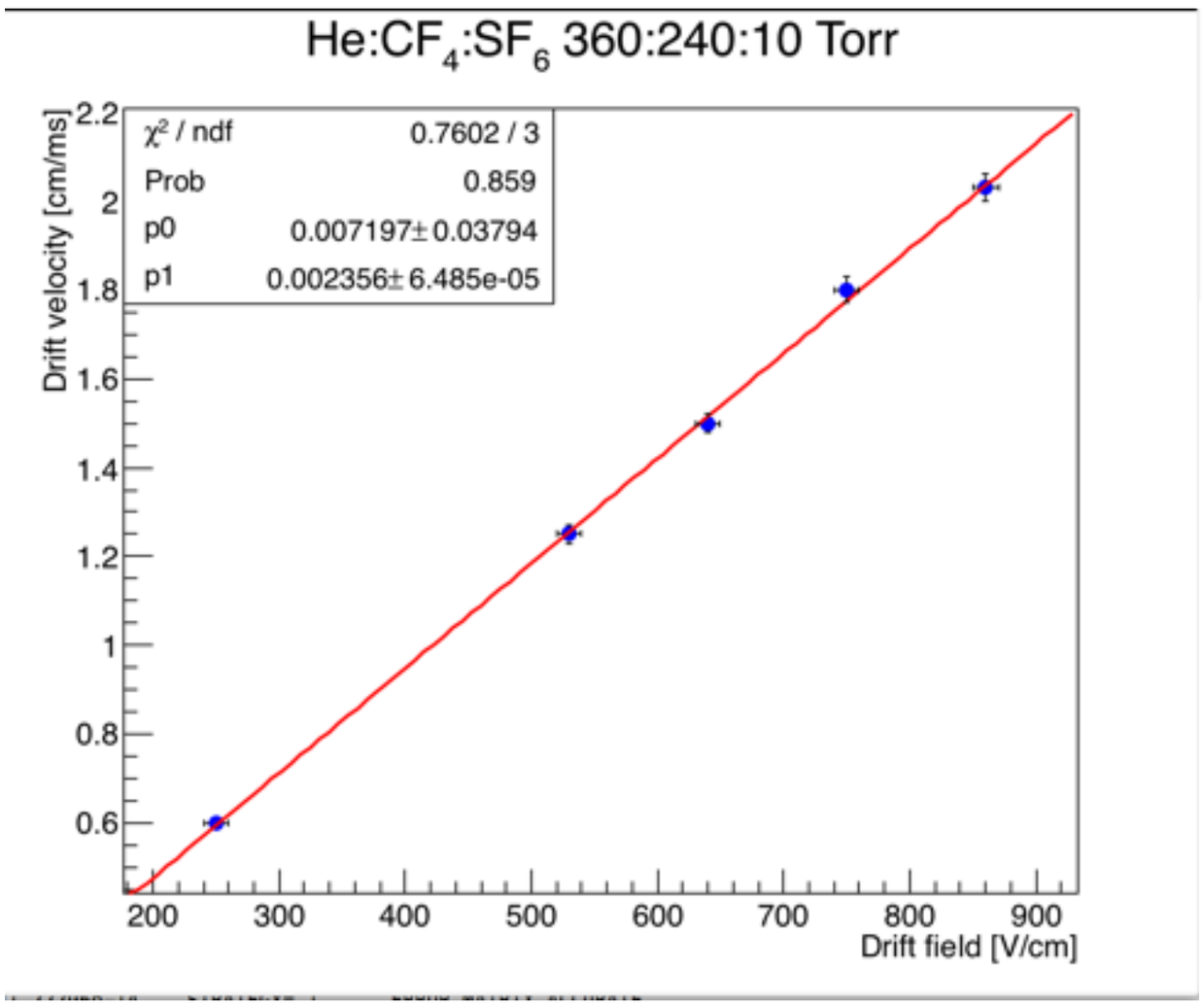
750 V/cm

```
vdrift chip 0 is 0.00295763 +/- 9.35414e-05
vdrift chip 1 is 0.00296488 +/- 9.37884e-05
vdrift chip 2 is 0.00299155 +/- 9.46174e-05
vdrift chip 3 is 0.00299736 +/- 9.48585e-05
```

Drift times



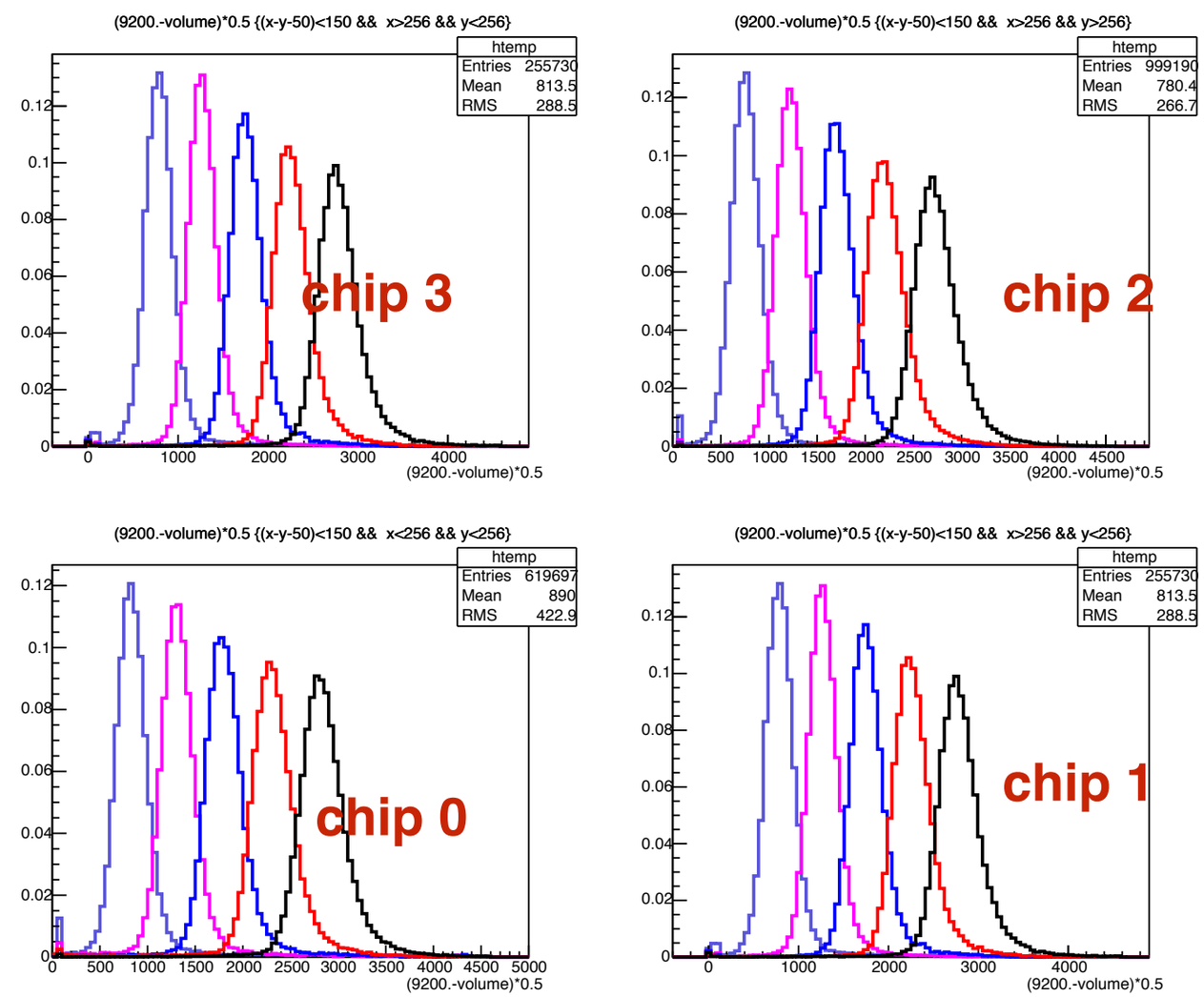
He:CF_4:SF_6 360:240:10 Torr TOA



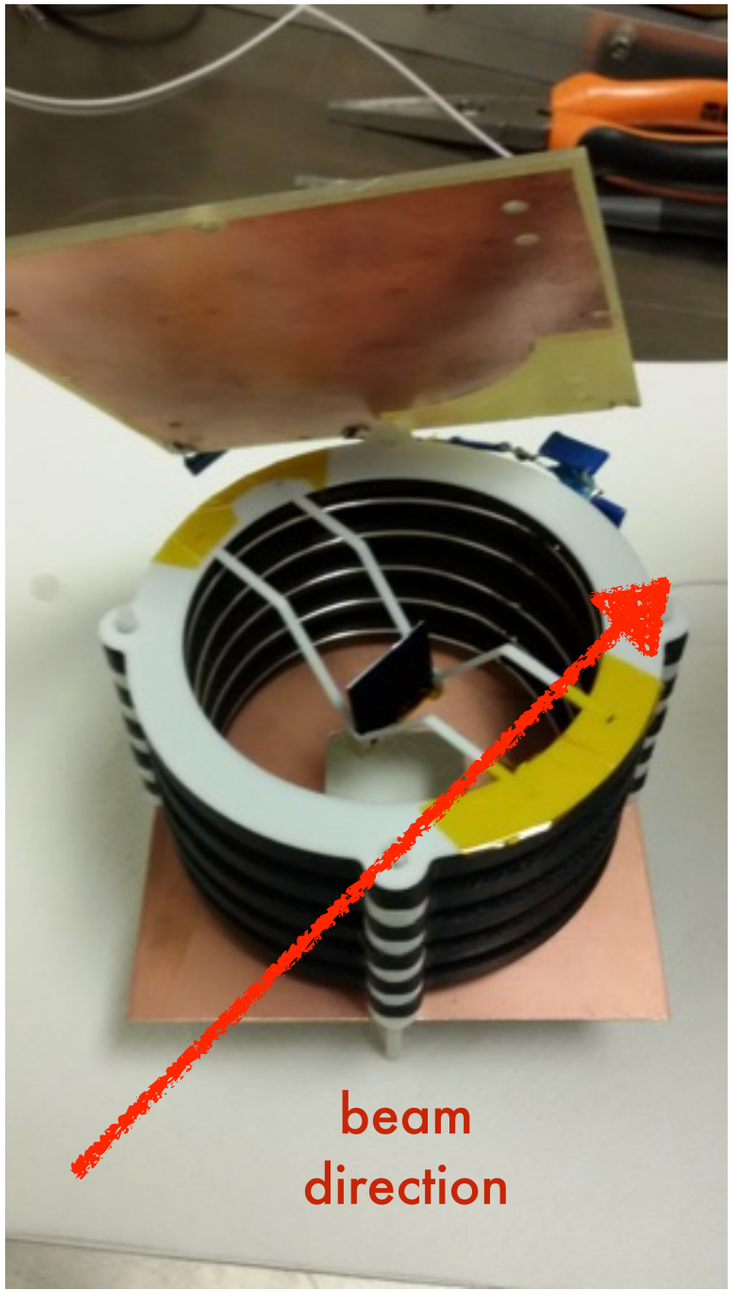
860 V/cm

```
vdrift chip 0 is 0.0020193 +/- 6.38648e-05
vdrift chip 1 is 0.00203158 +/- 6.42549e-05
vdrift chip 2 is 0.00205442 +/- 6.49827e-05
vdrift chip 3 is 0.00203158 +/- 6.42549e-05
```

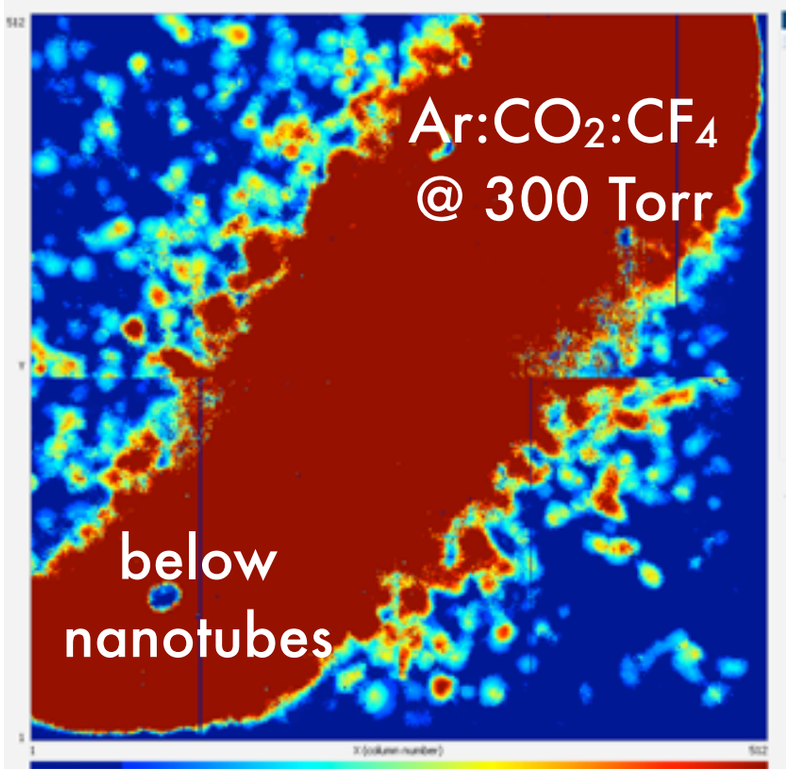
Drift times

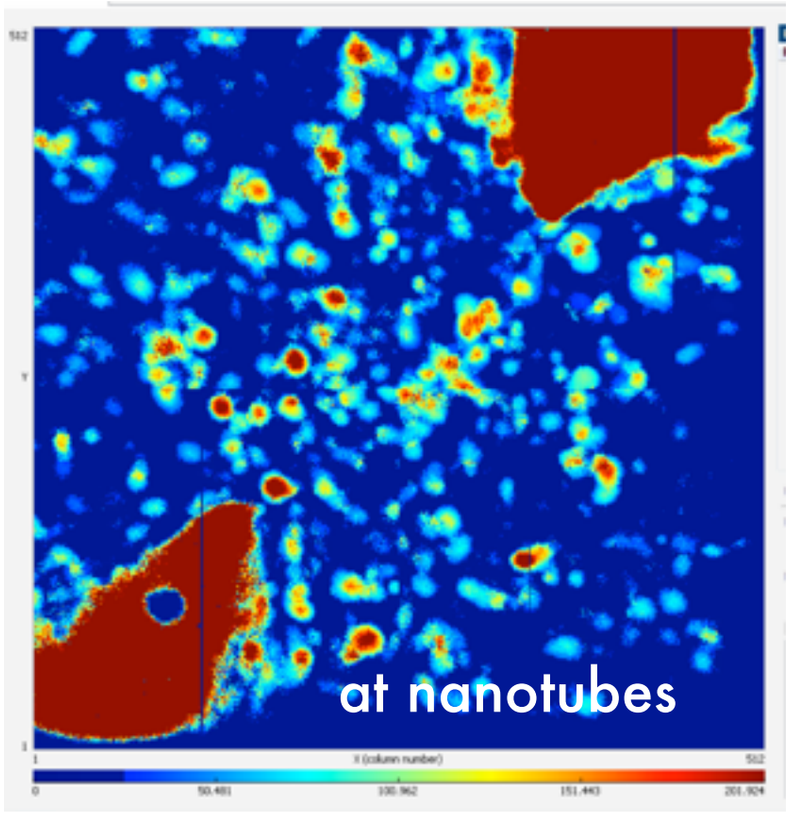


NITEC with carbon nanotubes

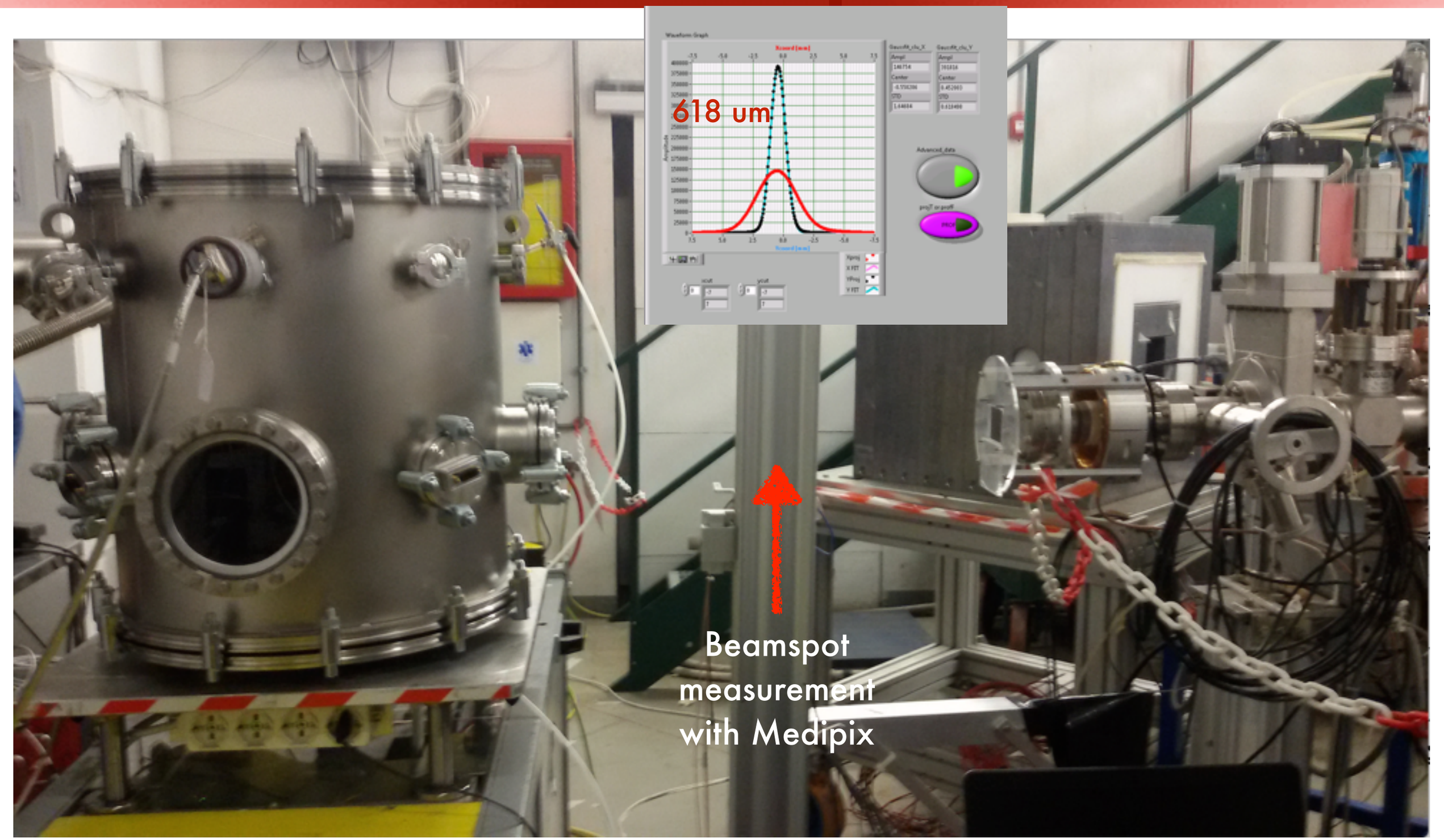


- We observe a consistent modification of the drift field due to the introduction of nanotubes structure AND support
  - Support and kapton scotch used very likely to polarize
  - On going work on ANSYS simulation, nearly ready (tomorrow?)

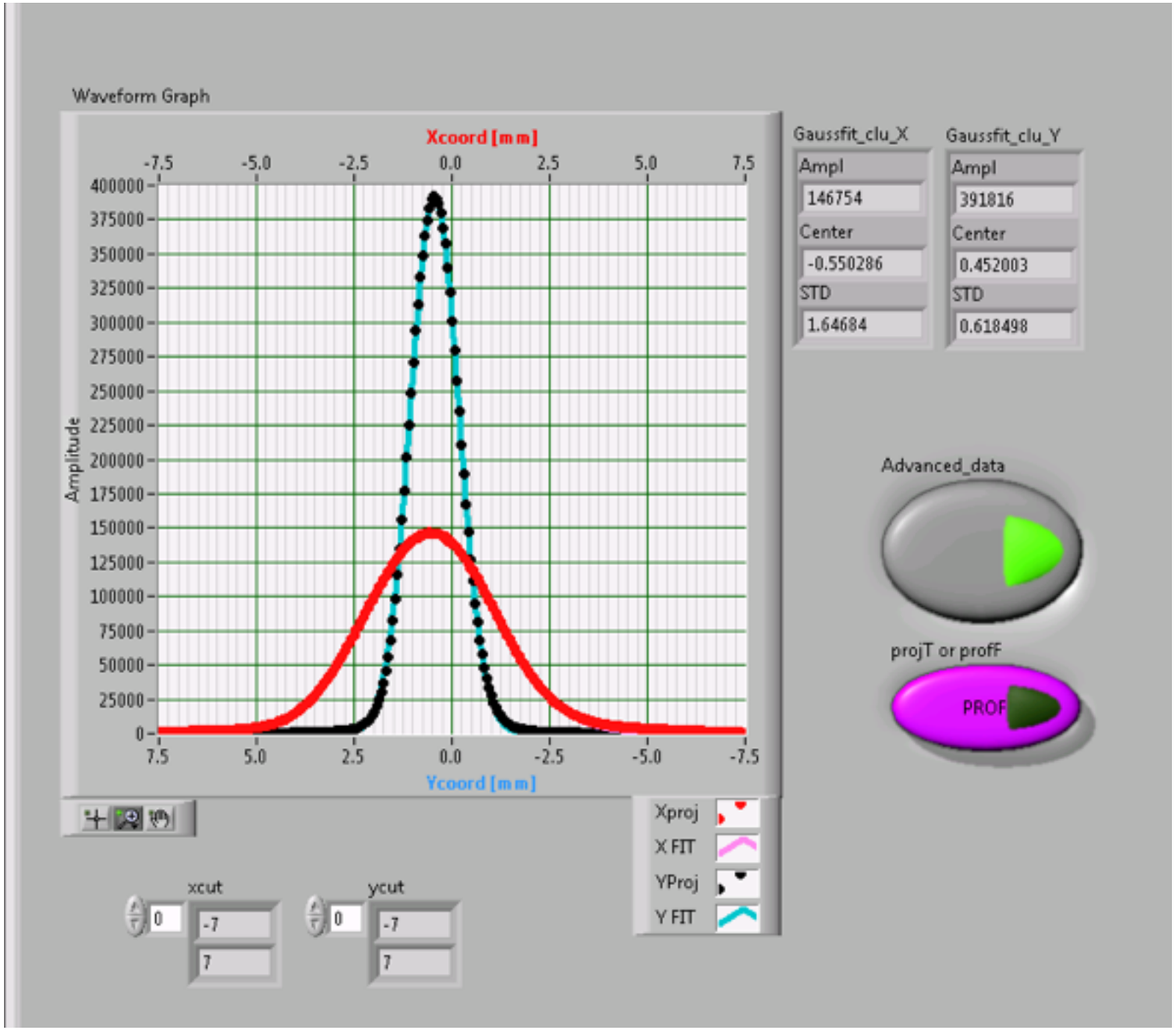




Beam spot



Beamspot @ Medipix



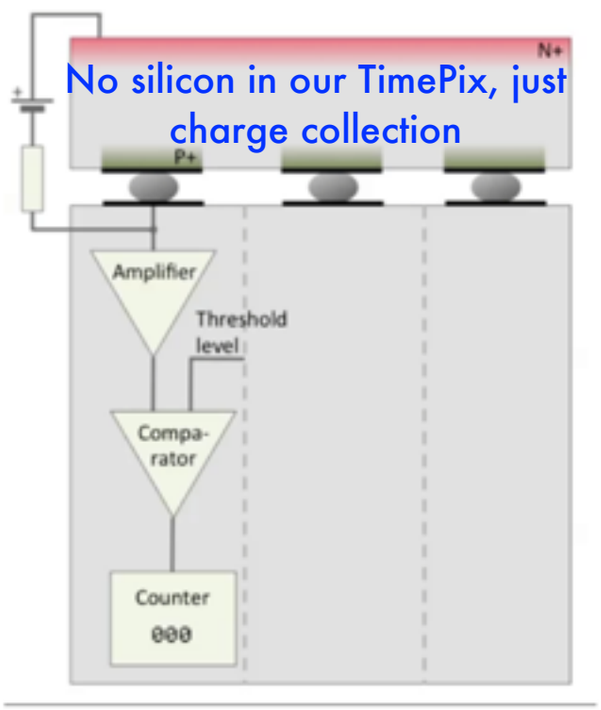
On going/to do

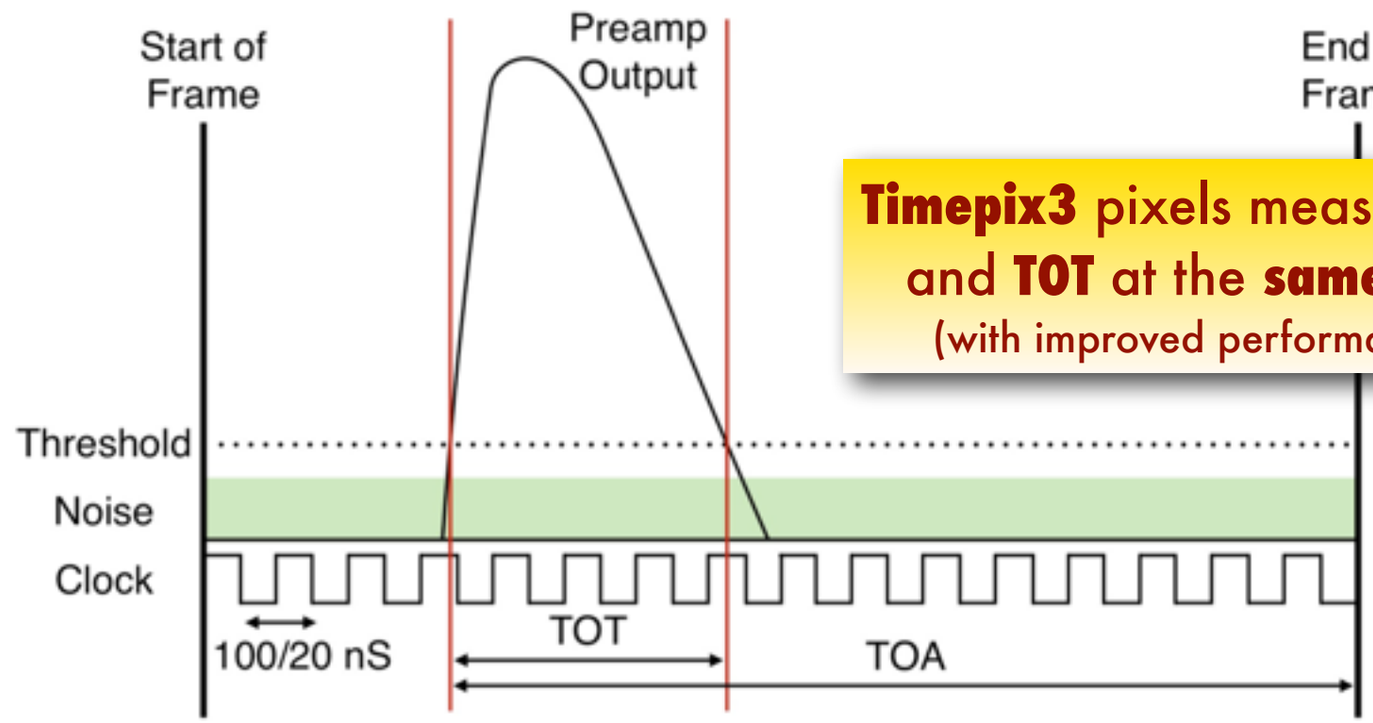
- Finalize drift time analysis
- Diffusion analysis: need to precisely know expected beam sigma inside NITEC
  - sigma_beam ~ 600 um
  - sigma_MS ~ 2 mm
  - beam divergence ~ 2 mm (need to be precisely known, work on going)
- Minority carriers: unlikely to be seen in cumulative plots with the numbers above, need to reconstruct single tracks, work on going

Backup

TimePix

- TimePix is a pixelated silicon detector developed by MediPix2 collaboration
- We use a 2x2 array for a total of 512x512 pixel of 55 um side WITHOUT silicon sensors
- Processing electronics, including preamplifiers, discriminator threshold and pseudo-random counter fit inside the footprint of the overlying semiconductor pixel.
- Can be operated in counting TOA, TOA and TOT mode but also *TOA/TOT MIXED mode*



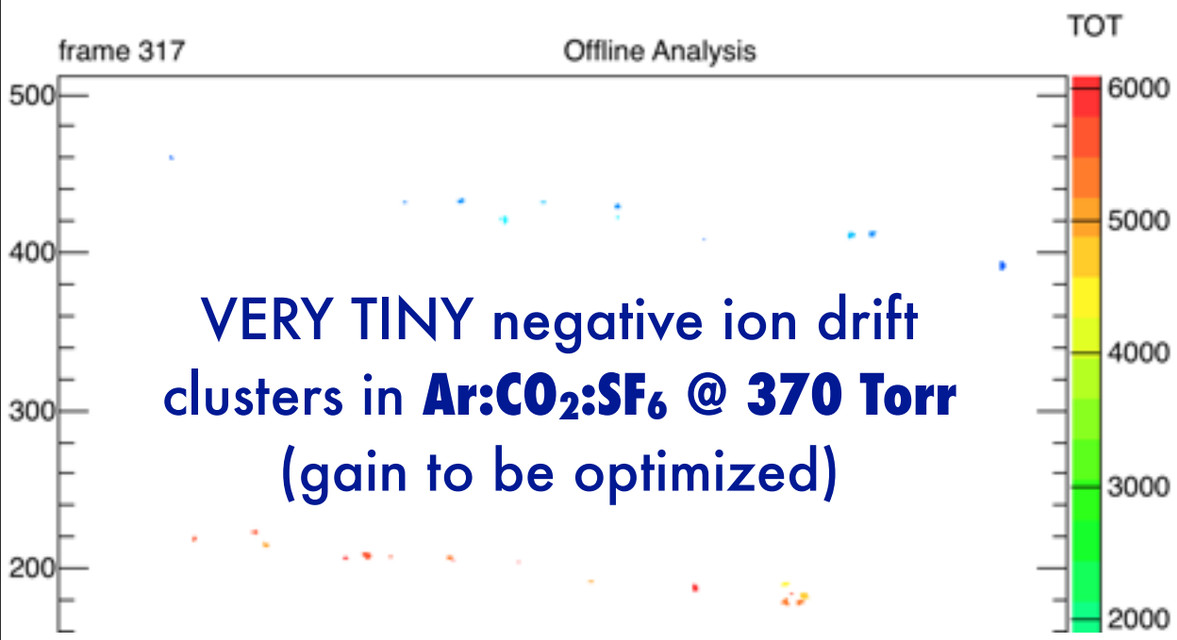


Timepix3 pixels measure **TOA** and **TOT** at the **same time** (with improved performances)

- Timepix clock can run from <1 MHz up to 100 MHz
- Timepix counter depth is 11810 —> limits total acquisition time —> ok for negative ion slow drift as well

NITEC negative ion operation $Ar:CO_2:SF_6$

Negative ion operation with $Ar:CO_2:SF_6$ mixture 52:23:25 @ 370 Torr



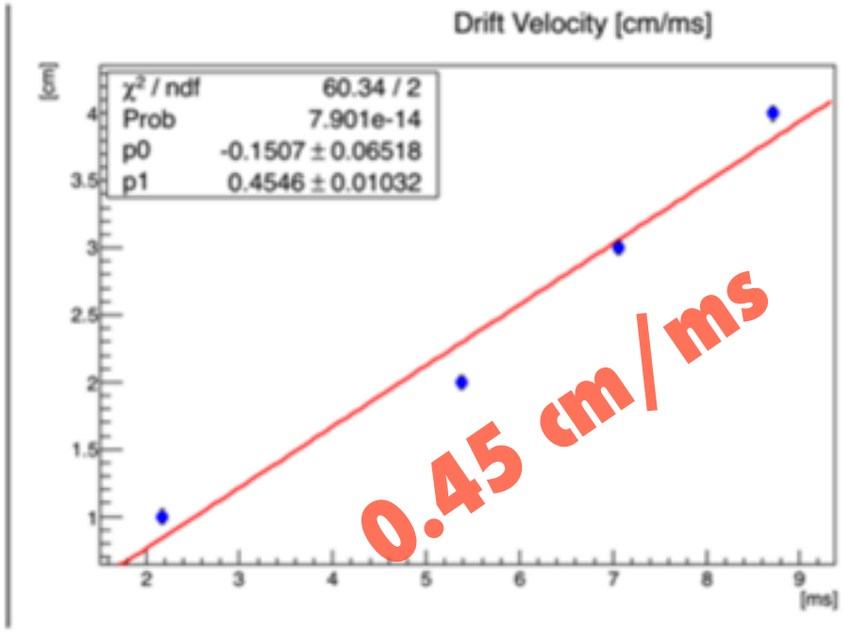
electron drift clusters in **$Ar:CO_2$ @ 740 Torr**

- Encountered several operating issues for the TPC due to the low pressure regime
  - Field cage built by Nikhef before the NITEC start for proton tomography and to be operated at atmospheric pressure
- Pressure and drift field strongly limited by this
  - Data taken at 370 Torr with ~0.3-0.6 kV/cm drift field
- Thanks to this experience, we are carefully designing the large prototype and performing preliminary tests on each component in order to solve all these issues

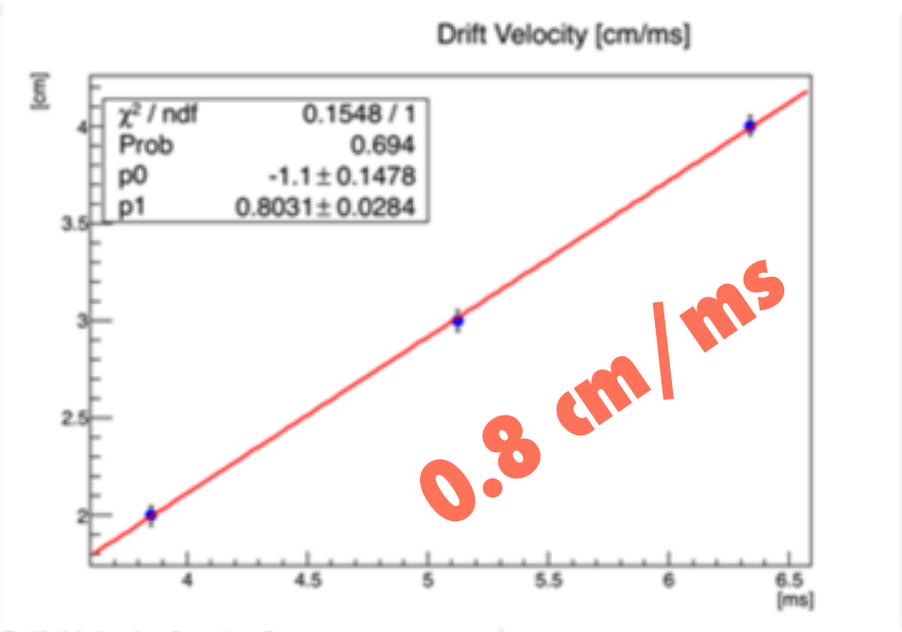
450 MeV electron beam data @ BTF

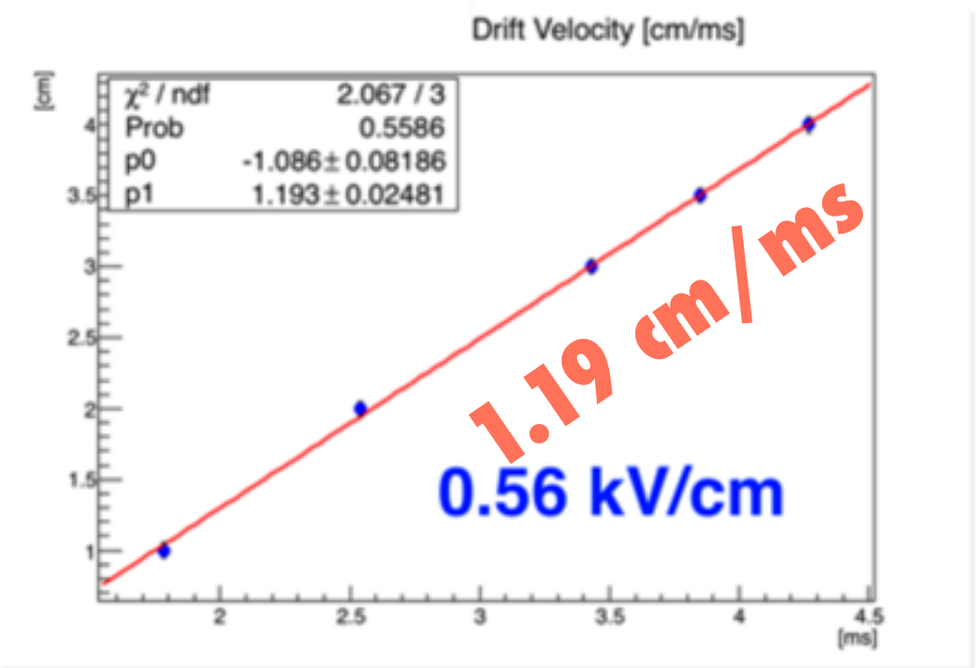
Negative ion drift velocity measurement in $Ar:CO_2:SF_6$

0.3 kV/cm



0.4 kV/cm



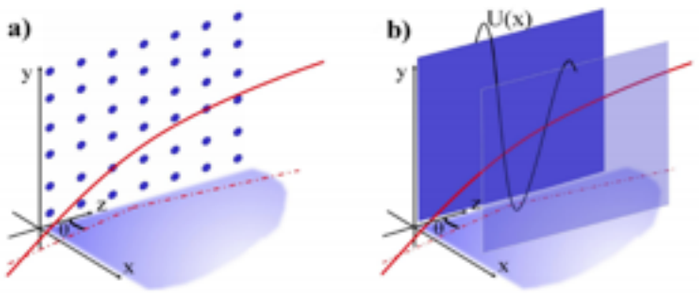


PRELIMINARY

450 MeV electron beam data @ BTF

NITEC synergy: DCANT

Channelling concept



Critical (Lindhard's) angle

$$\theta_C = \sqrt{\frac{2U_0}{E}}$$

U_0: Potential well depth

E: Particle energy

~ 8 deg for ^6C at 10 KeV

Detector concept

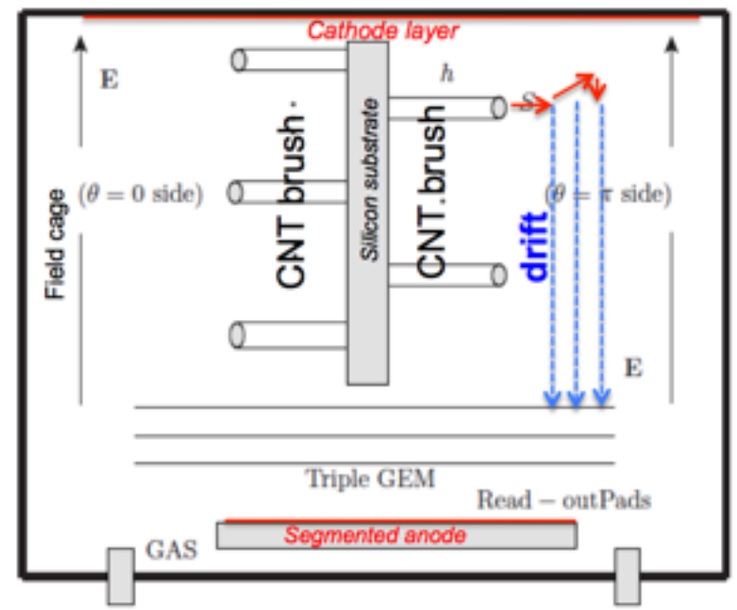
Low pressure gas (0.1 bar)

Range of 10 KeV ^6C in 0.1 bar Ar ~ 1mm (TRIM)

Not to scale!

h ~100 μm
S ~ π(5)² nm²

Drift distance can be 10 cm

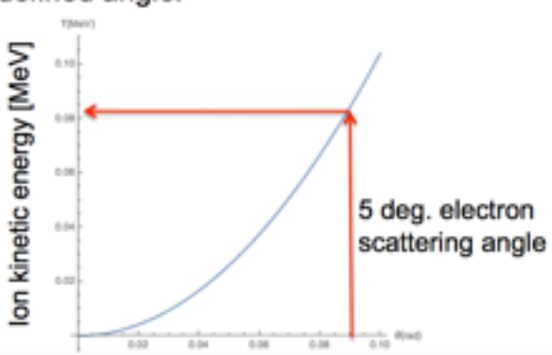


Carbon ions **ranging out** In the gas

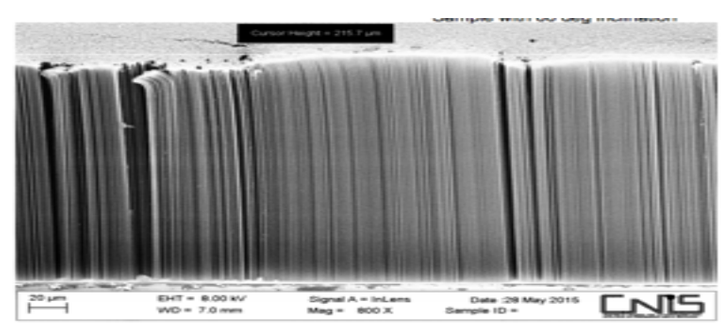
Electrons from ionized gas atom **drift** towards anode

Need to be tested:

- Use electron beam at LNF BTF to "extract" carbon ions from CNT
  - One carbon ion elastically scattered by a 500 MeV electron
    - PRO: trigger on scattered electron at well defined angle: beam clearly visible
    - CON: electron beam can induce a sizeable background into TPC



Could allow an integrated gas + solid DM target experiment WITH DIRECTIONAL SENSITIVITY



- About 10^{16} 1nm diameter SWCNT can fit on a 10x10 cm² substrate
- Surface density of a graphene layer: 1/1315 g/m²
- About 2 g CNT on 100cm²
  - ***CNT ropes?***

Developed an active and fruitful collaboration with DCANT group @ Roma1