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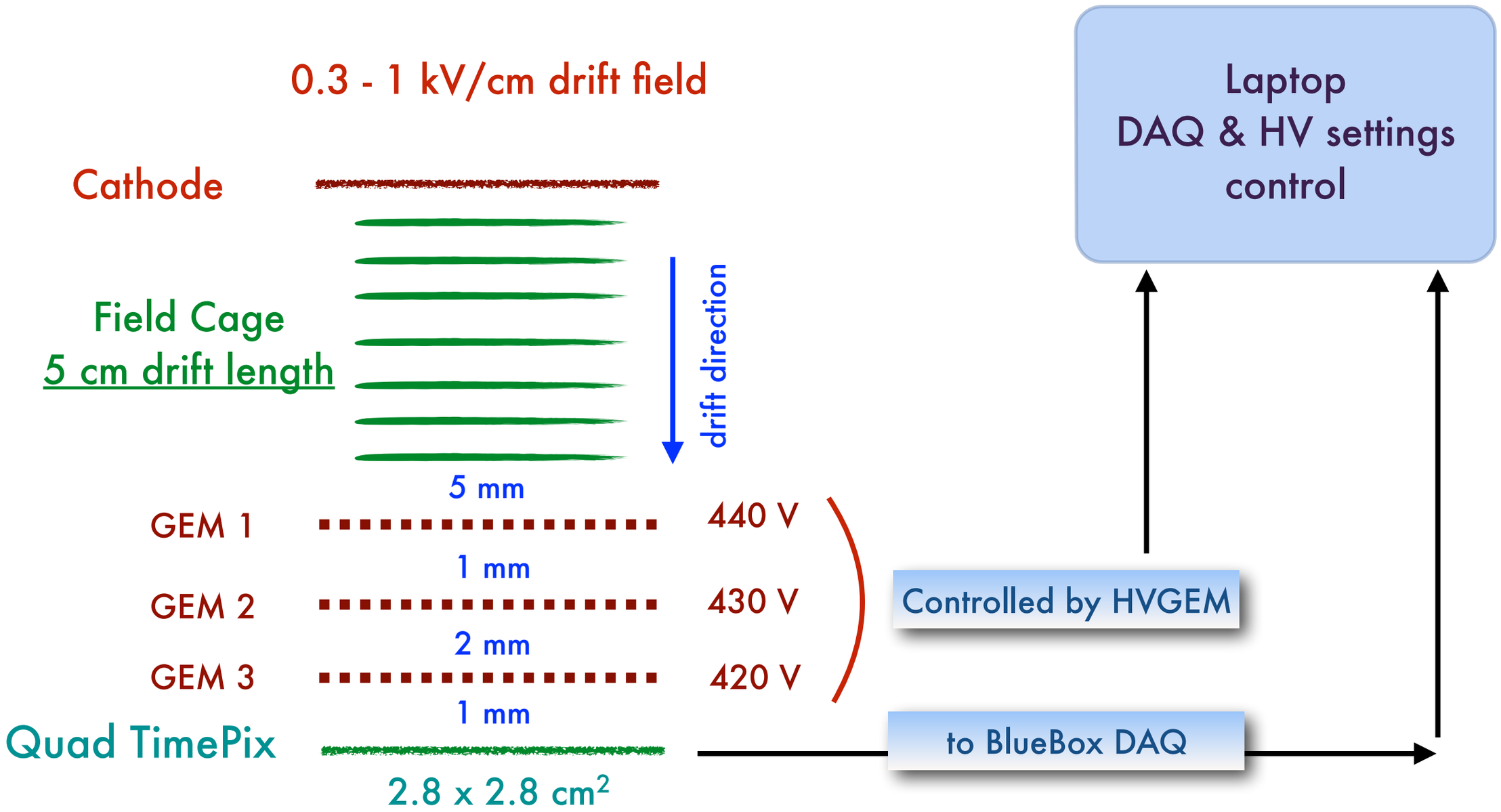
Preliminary results from NITEC

a Negative Ion Time Expansion Chamber for directional Dark Matter searches

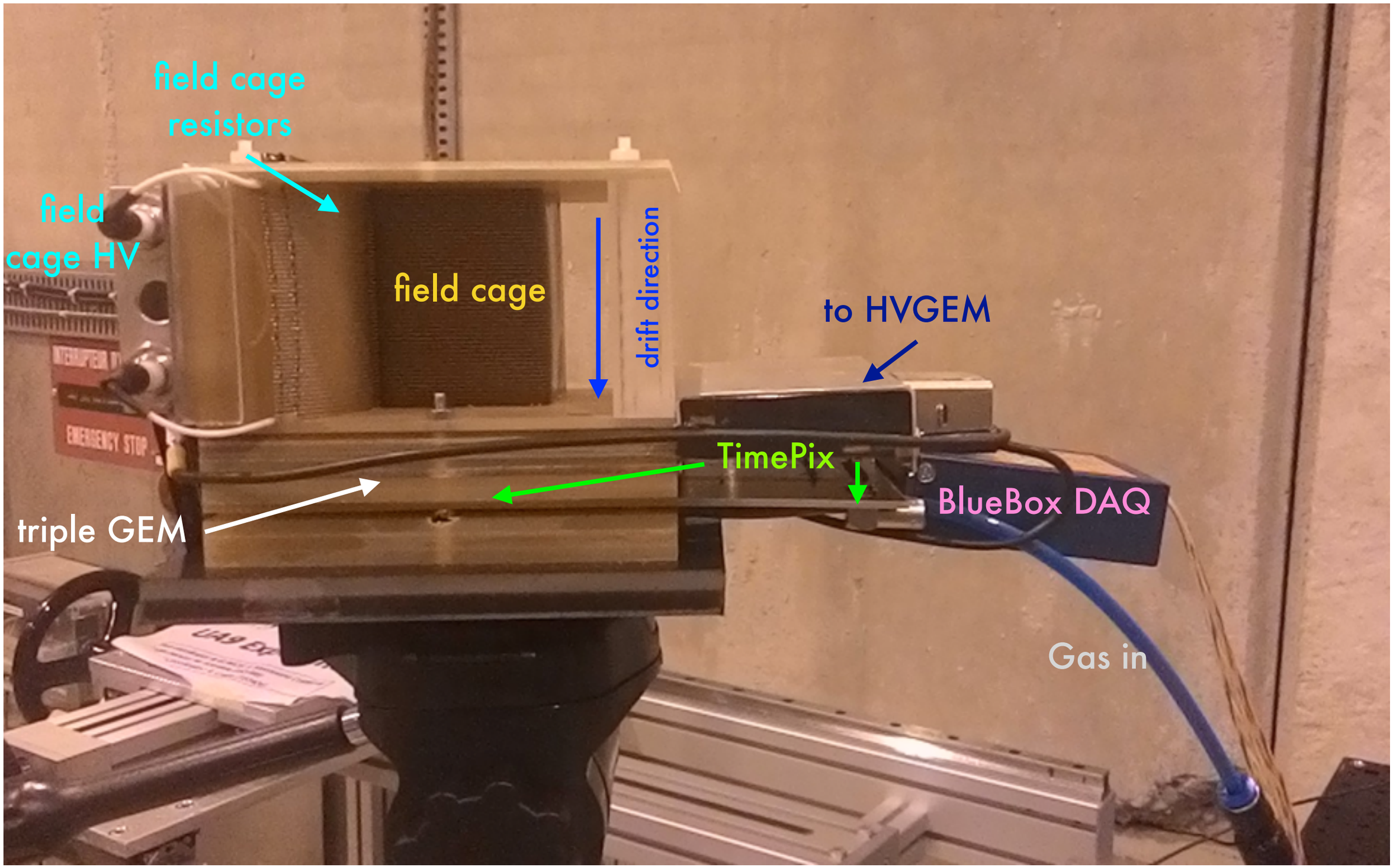
First CYGNUS collaboration meeting 2016
Boulby - United Kingdom

First GEMPix TPC: schematically



This is the first ever realized 5 cm drift TPC equipped with GEMPix

First GEMPix TPC for real

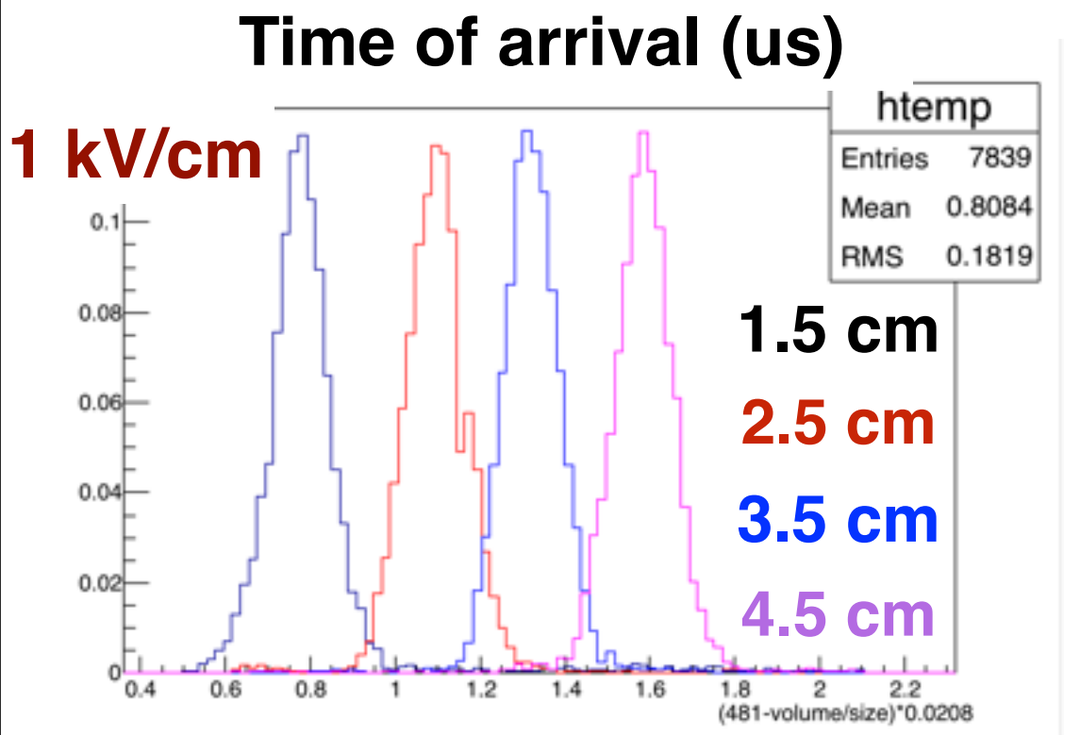


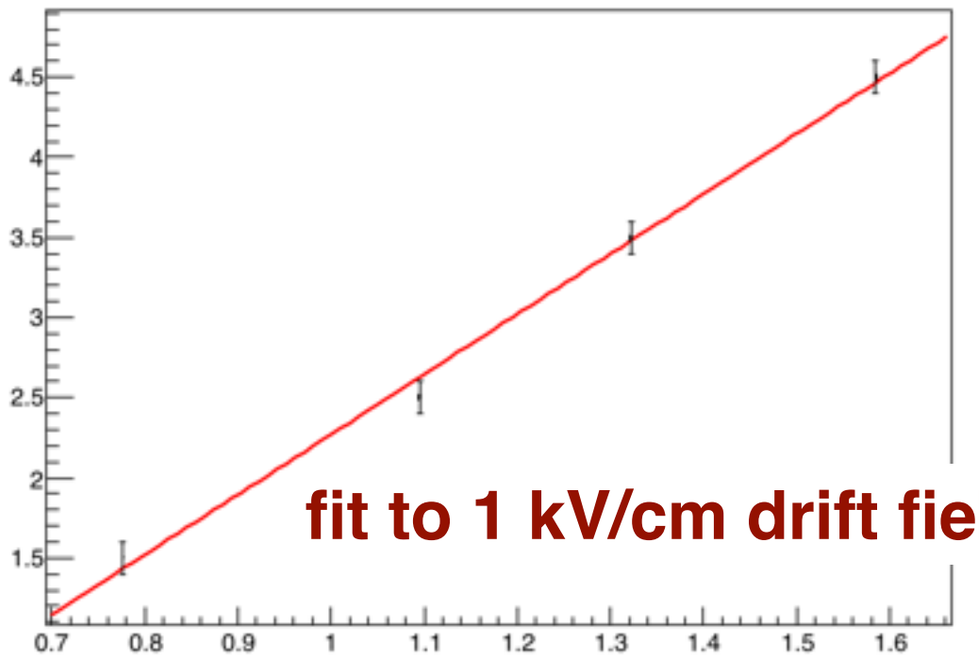
First tests and preliminary results

Some caveats:

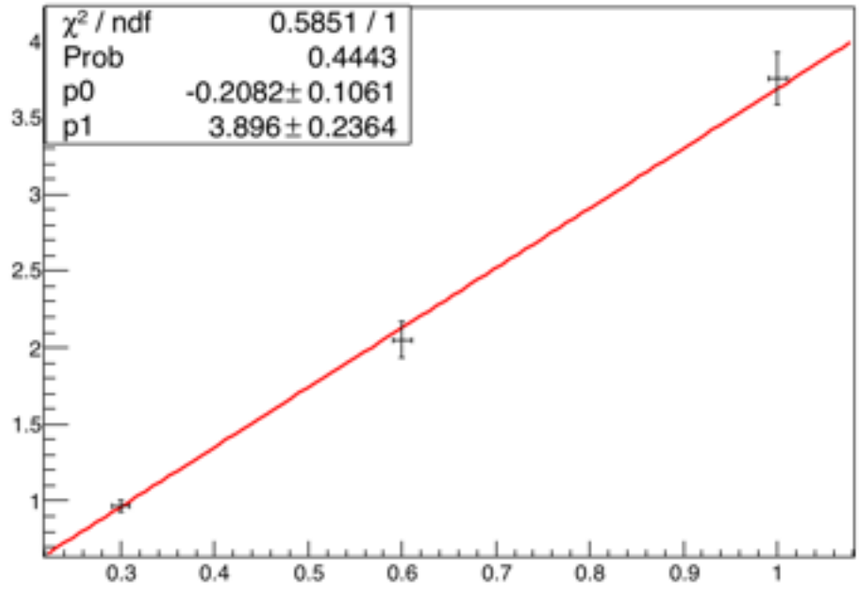
- Ar:CO_2 for cosmic rays and ^{55}Fe data, Ar:CO_2:CF_4 for beam data (400 MeV electrons) at atmospheric pressure
- Not optimized field cage HV and GEM HV settings
- 48 MHz DAQ acquisition with external trigger
  - Scintillator coincidence for cosmic ray
  - From BTF RF system in coincidence with particle bunches
- TOA for cosmic rays and beam data, TOA and TOT for ^{55}Fe data
- FITPix system and Pixelman software to readout TimePix data, MAfalda ROOT-based framework to interface with them, very preliminary and non-optimal data analysis (improvements on-going)

Drift velocity measurements

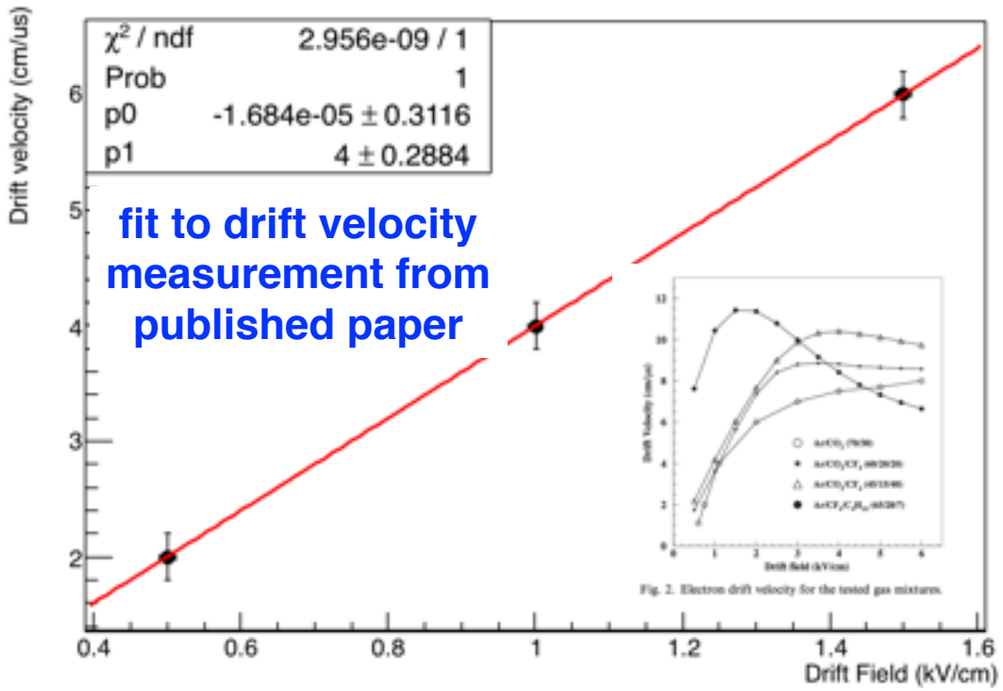




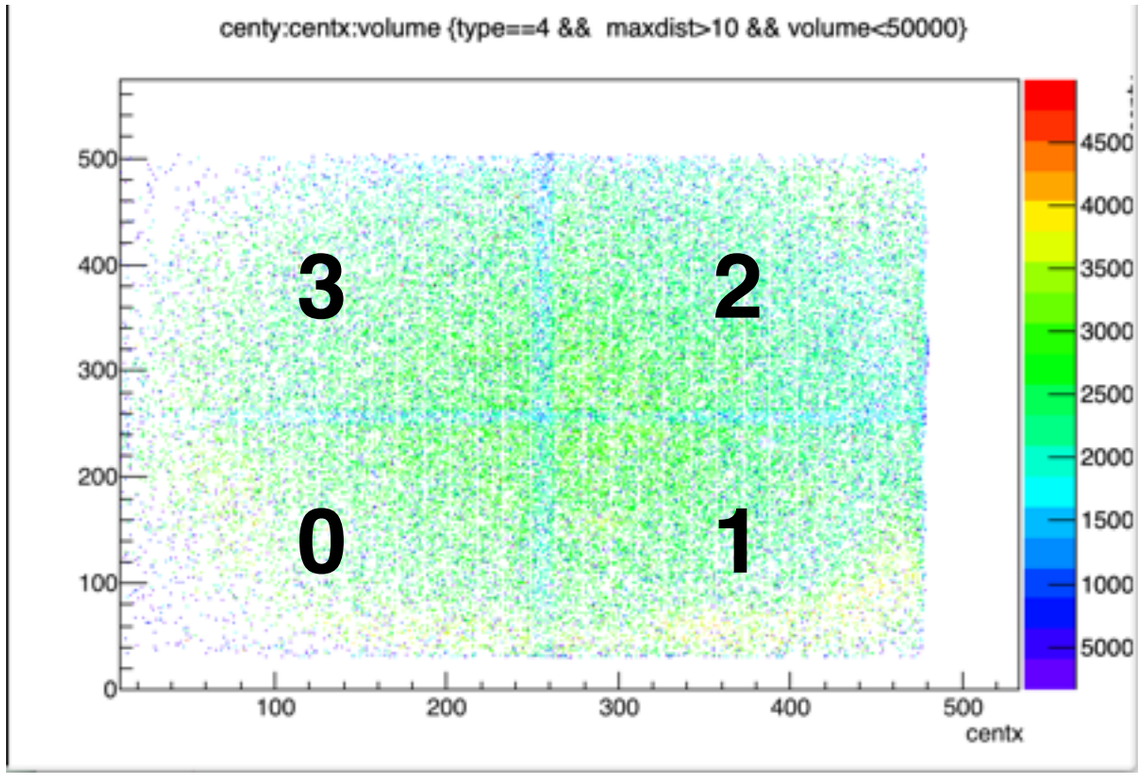
fit to drift velocity measurement

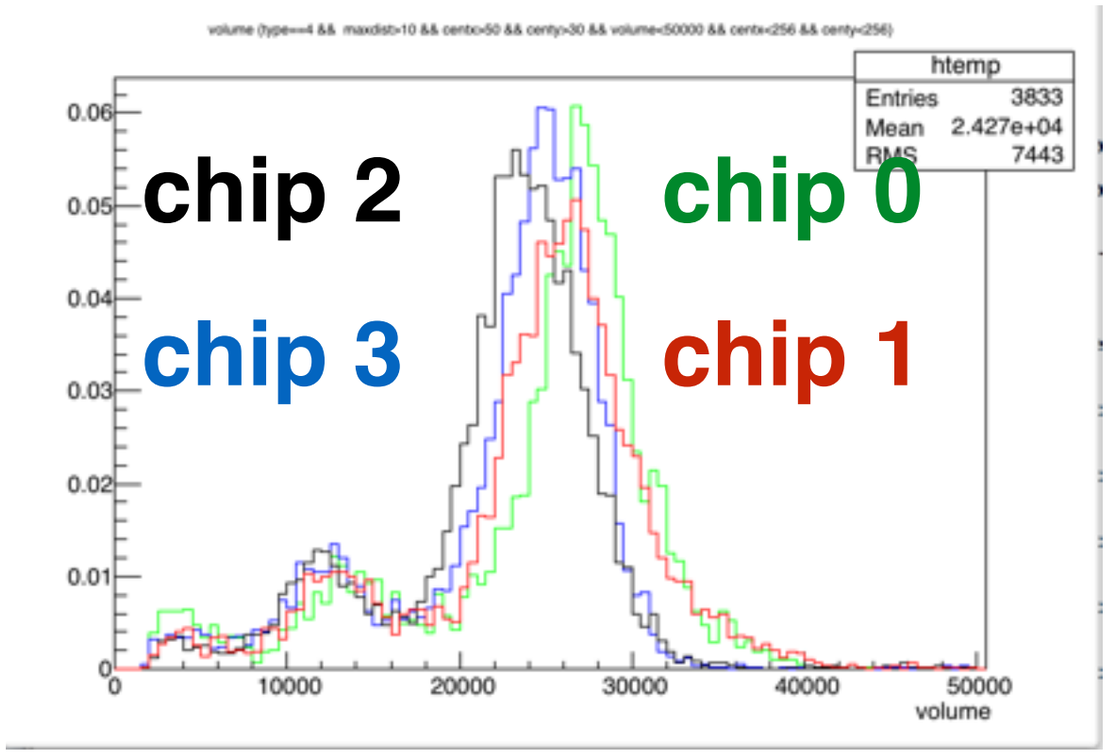


confirms we are understanding the detector

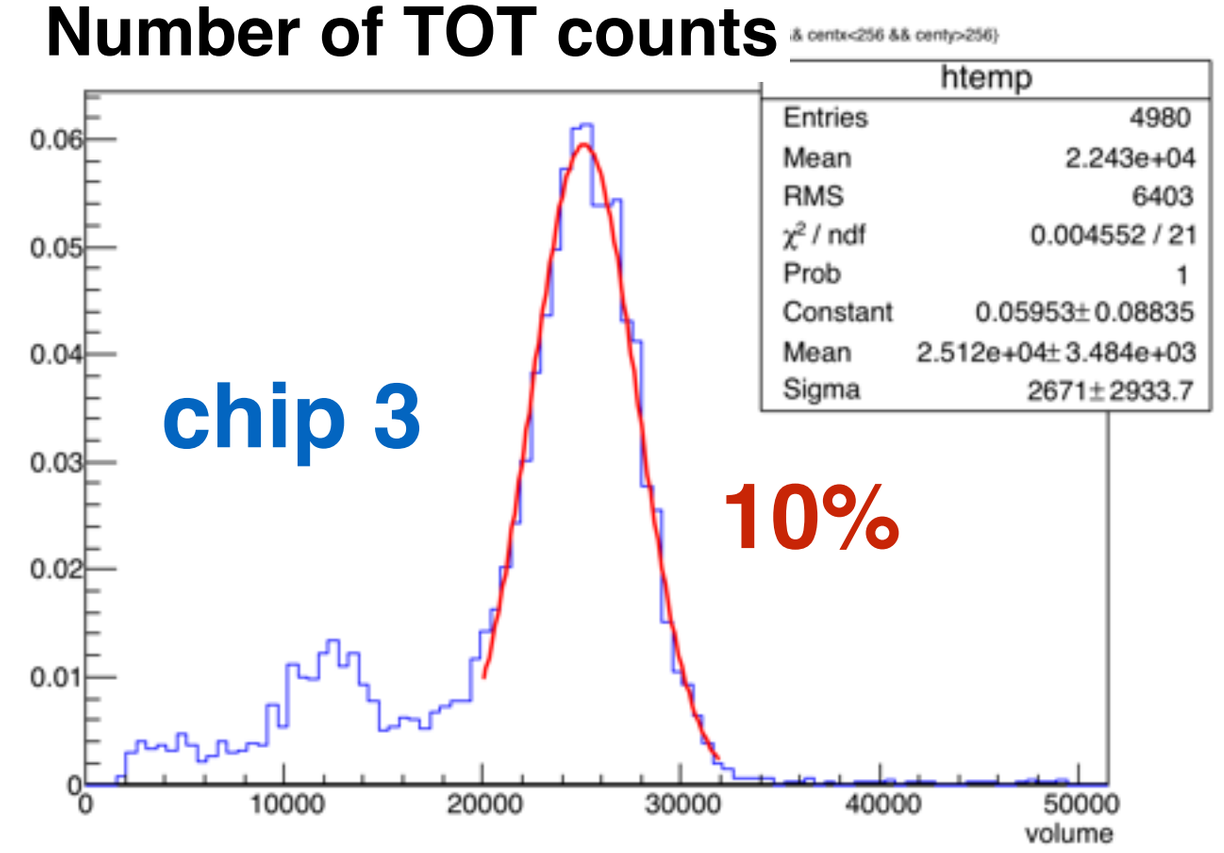


Energy resolution with ^{55}Fe



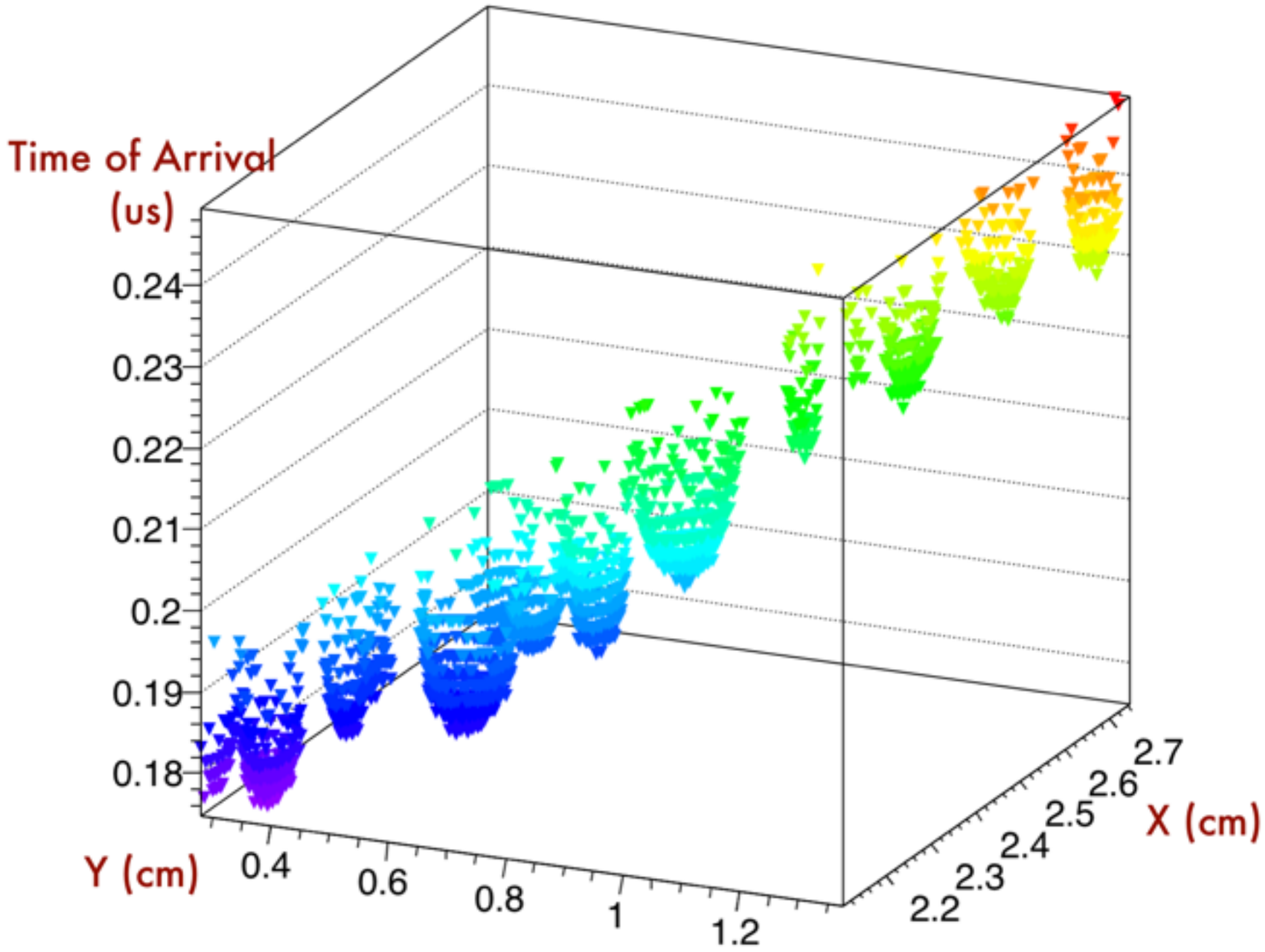


Number of TOT counts



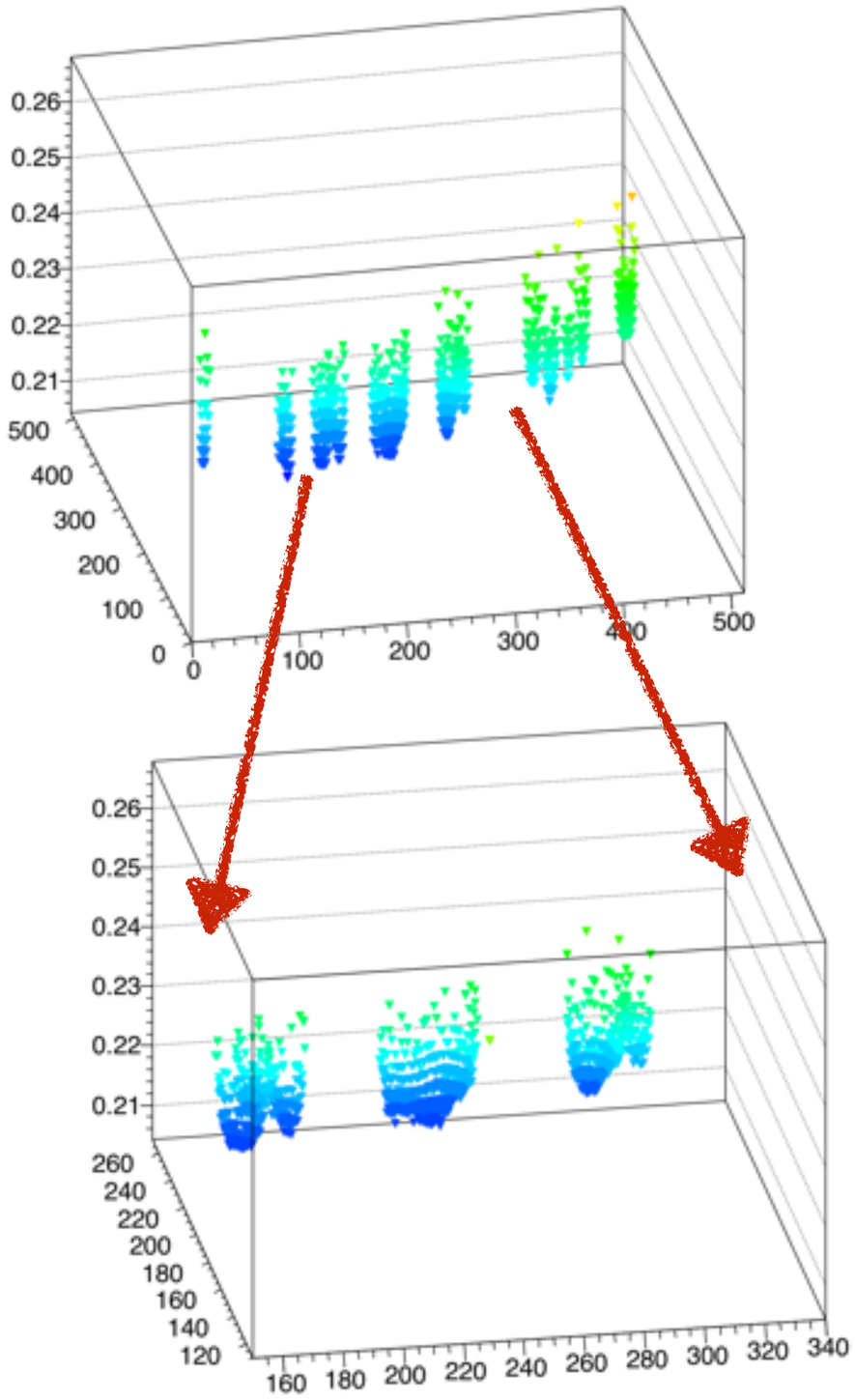
10% - 12% energy resolution with non-optimized calibrations

A recorded track

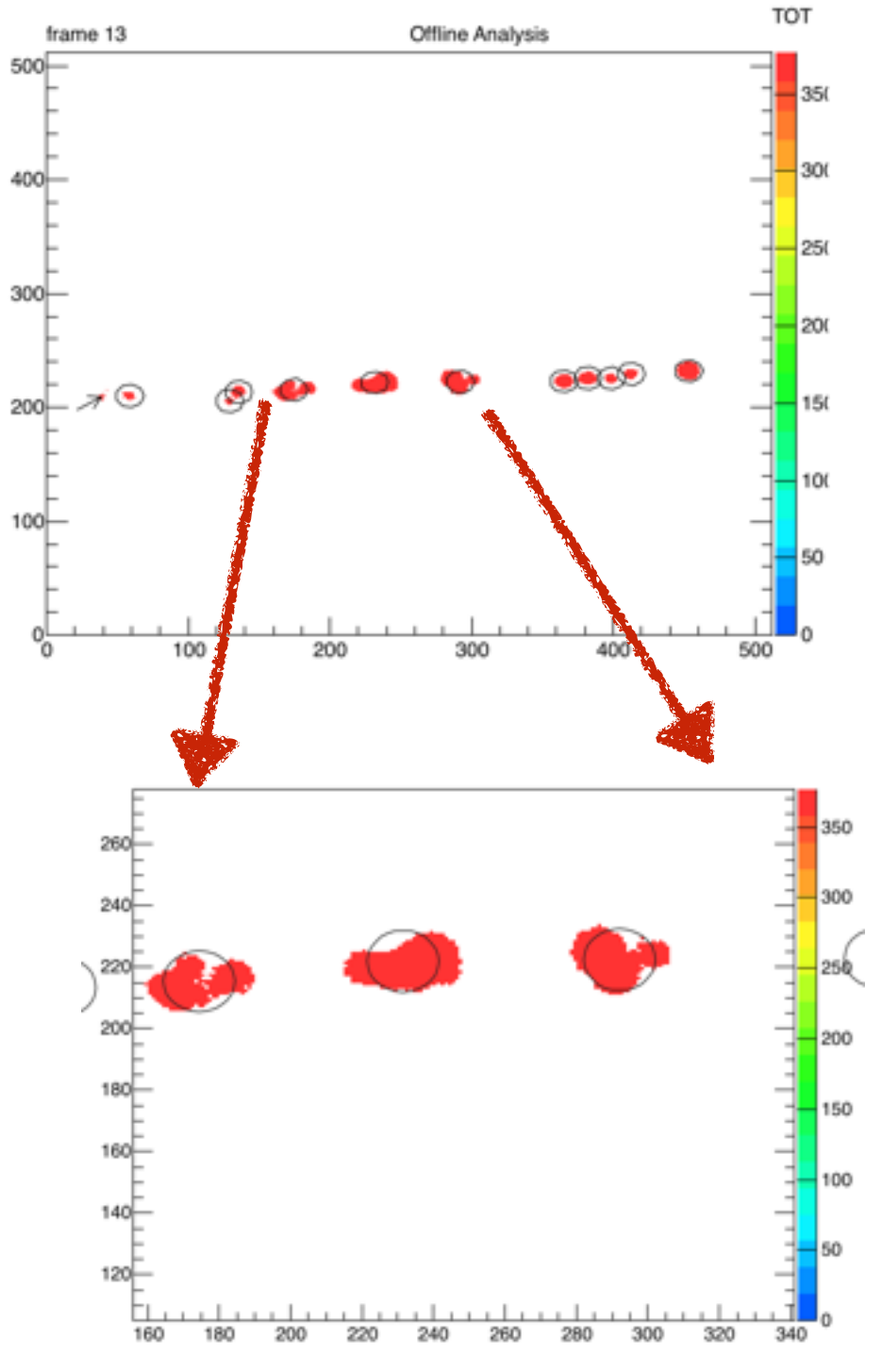


Cluster counting

All pixels information (private code)

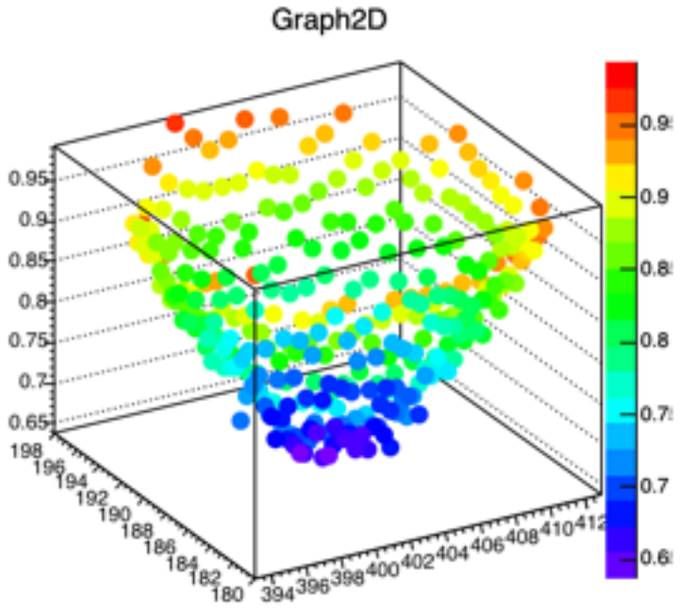


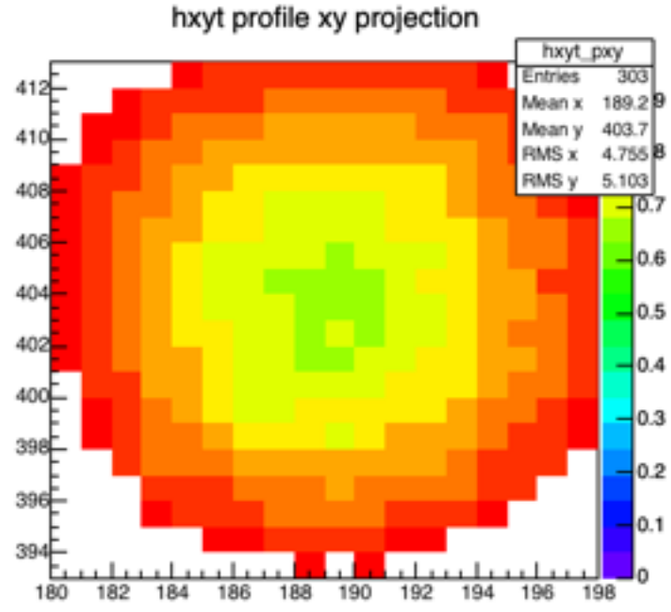
BlobsFinder MAfalda framework output

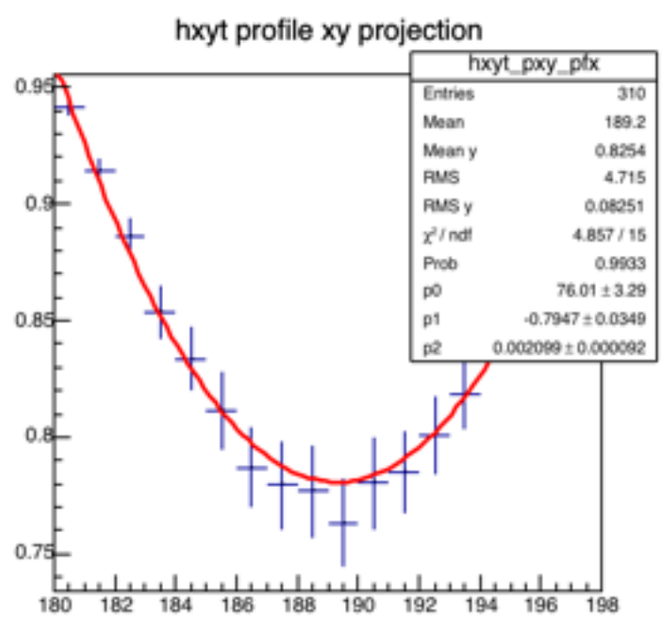


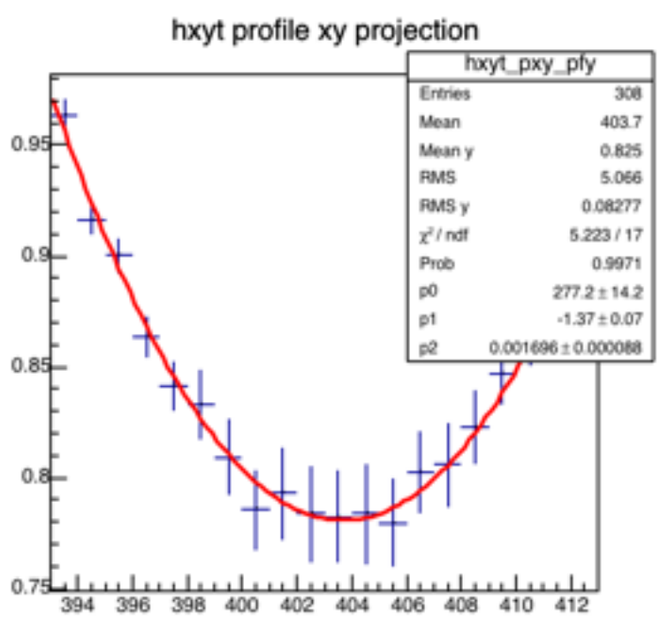
Cluster counting

- Start from BlobsFinder output and see if found blobs represent more than one cluster
- Tune the logic on ^{55}Fe data where only single clusters are present
- Extremely simple strategy for the moment
  - Look at xy, xt and yt projection
  - if single cluster, xt and yt projection can be fitted by pol2
- More complex strategy to be developed

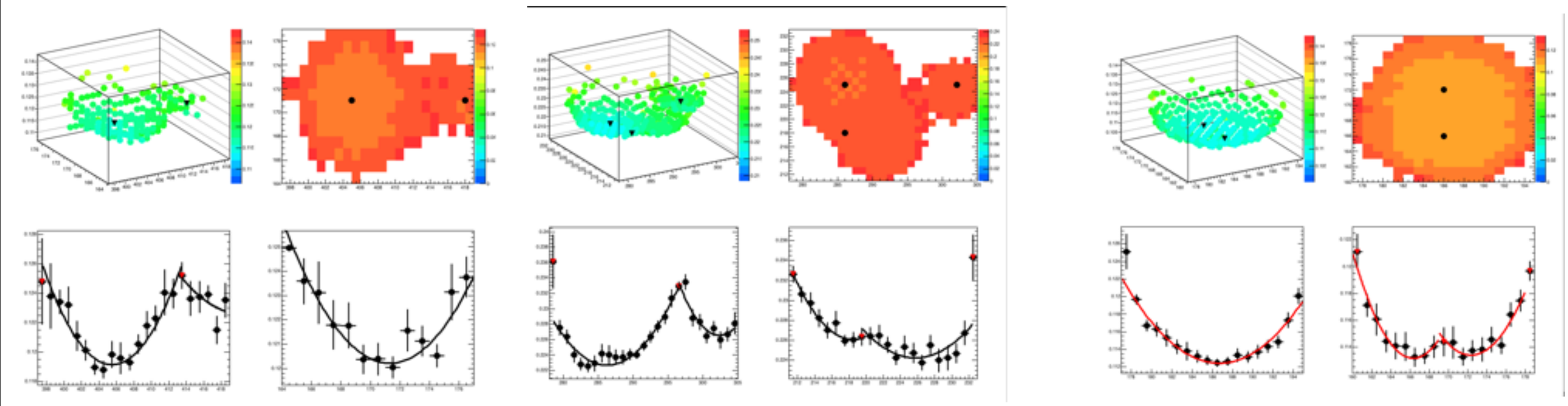


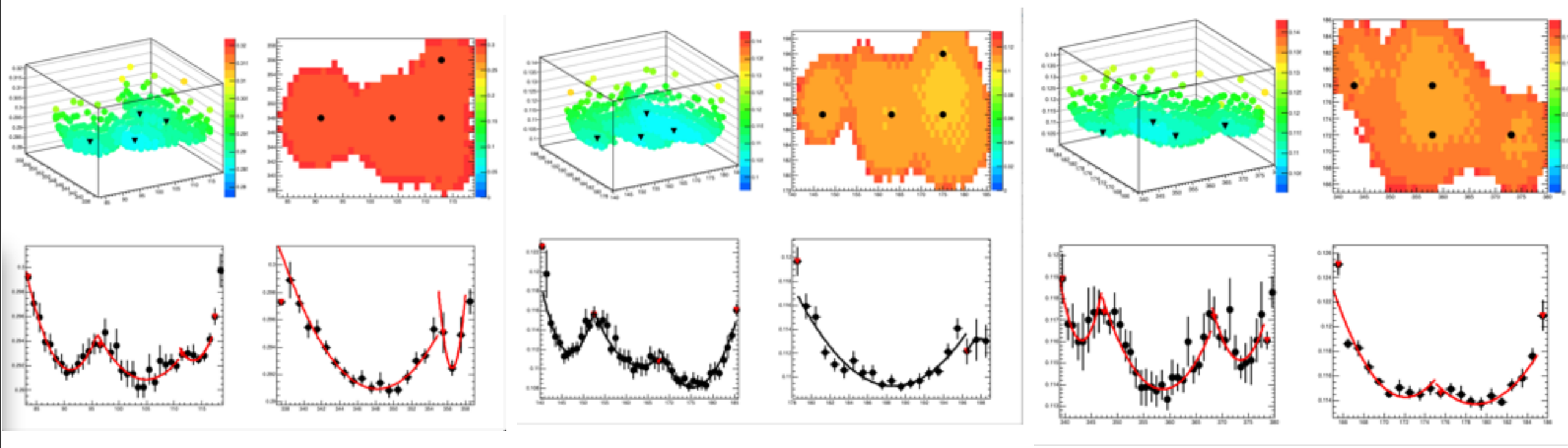






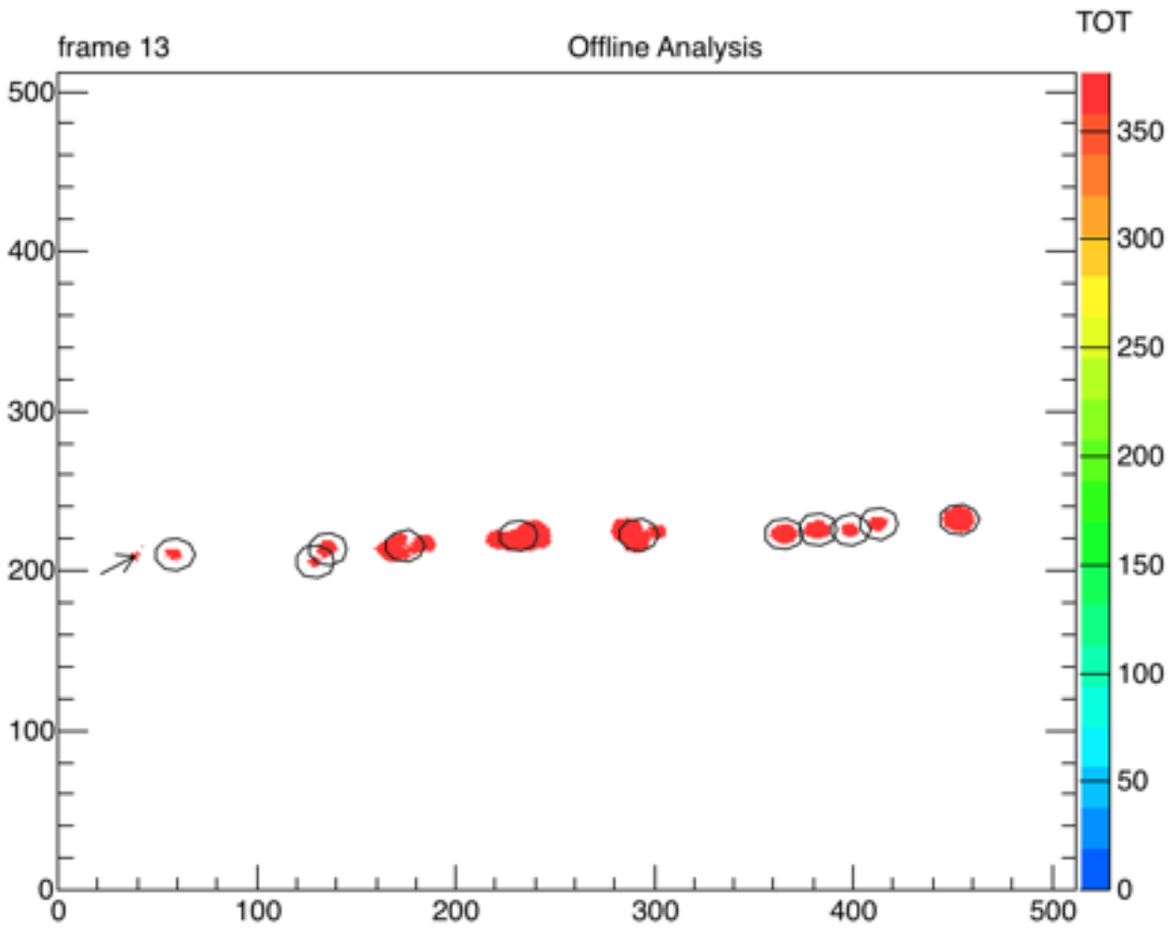
Cluster counting



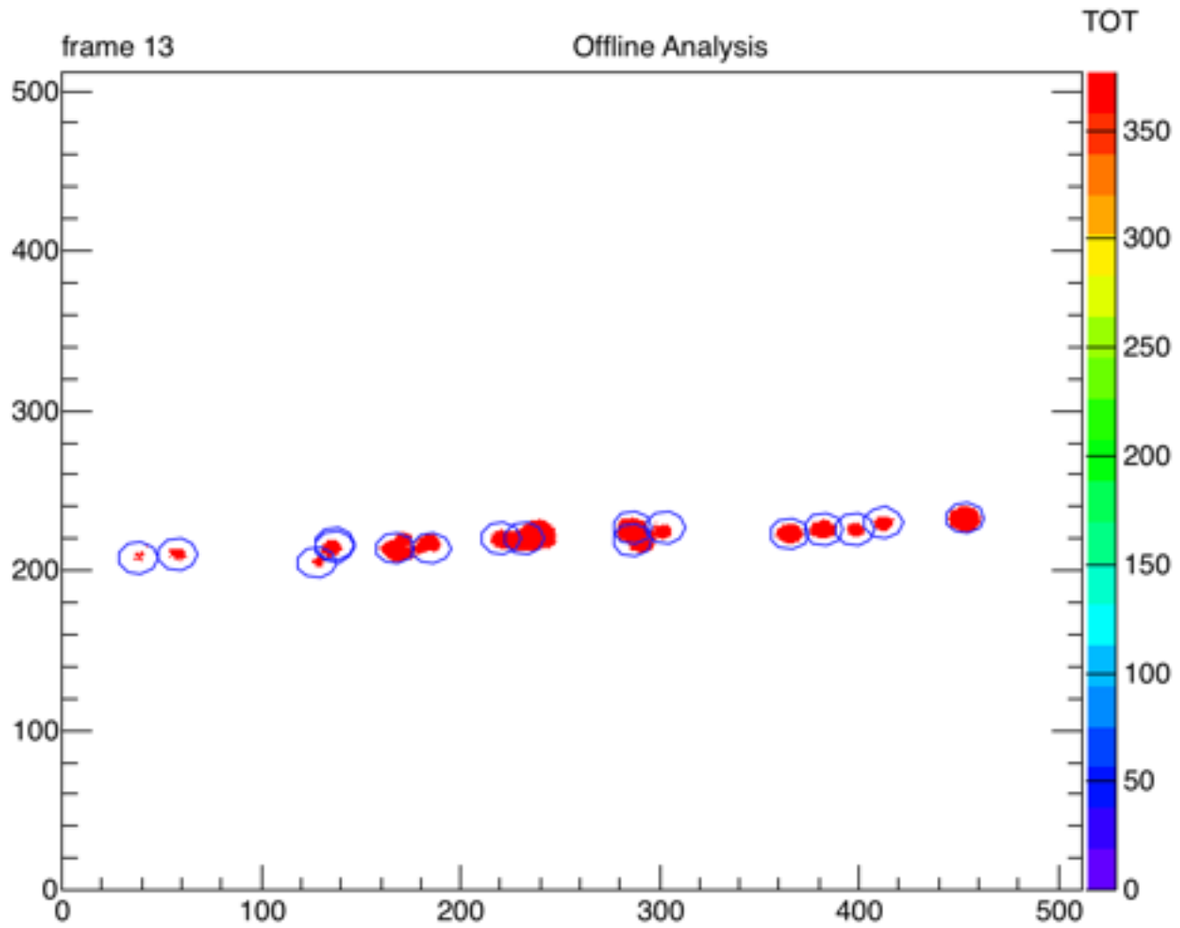


Cluster counting on tracks

BlobsFinder MAfalda framework output

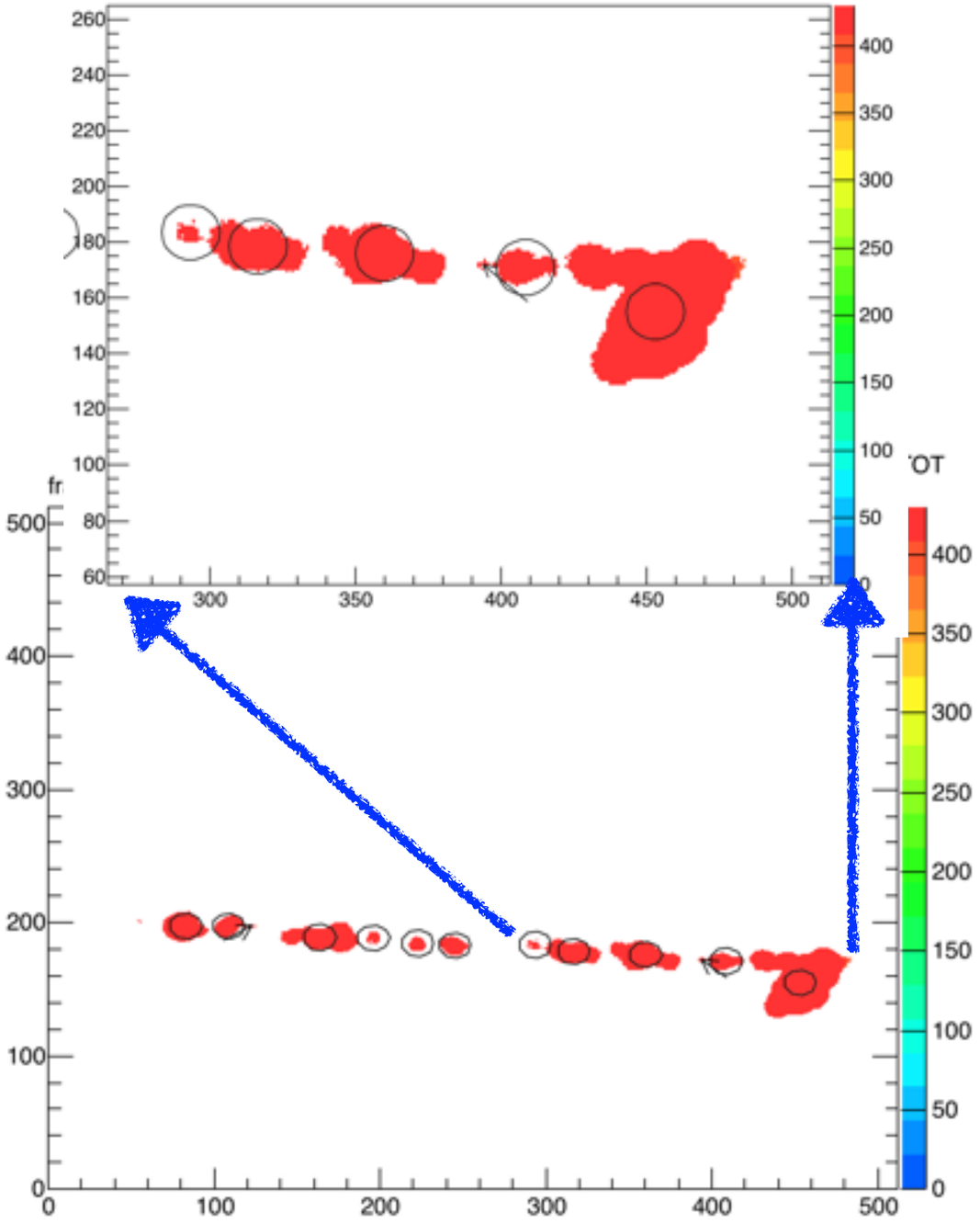


All pixels information (private code)

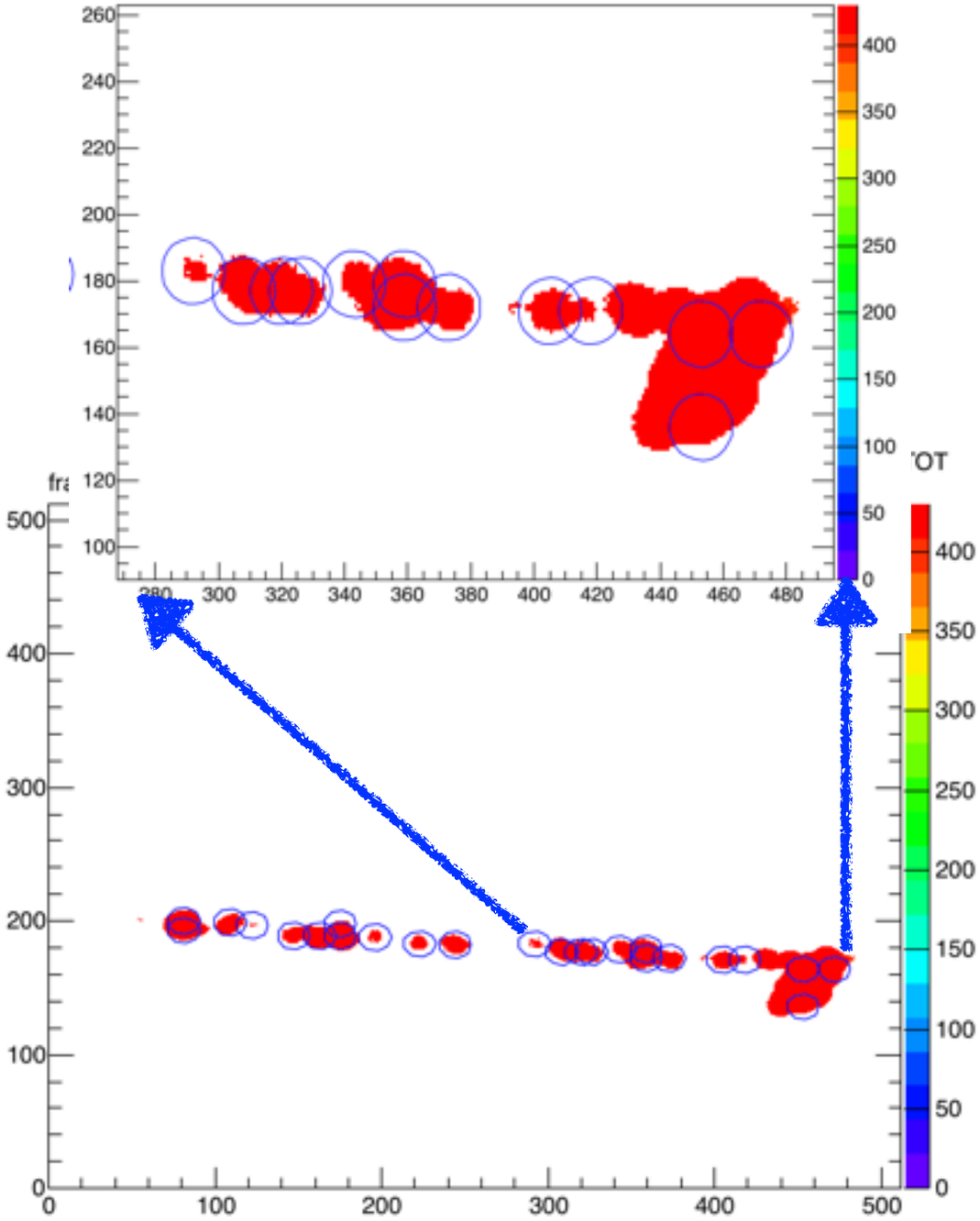


Cluster counting on tracks

BlobsFinder MAfalda framework output



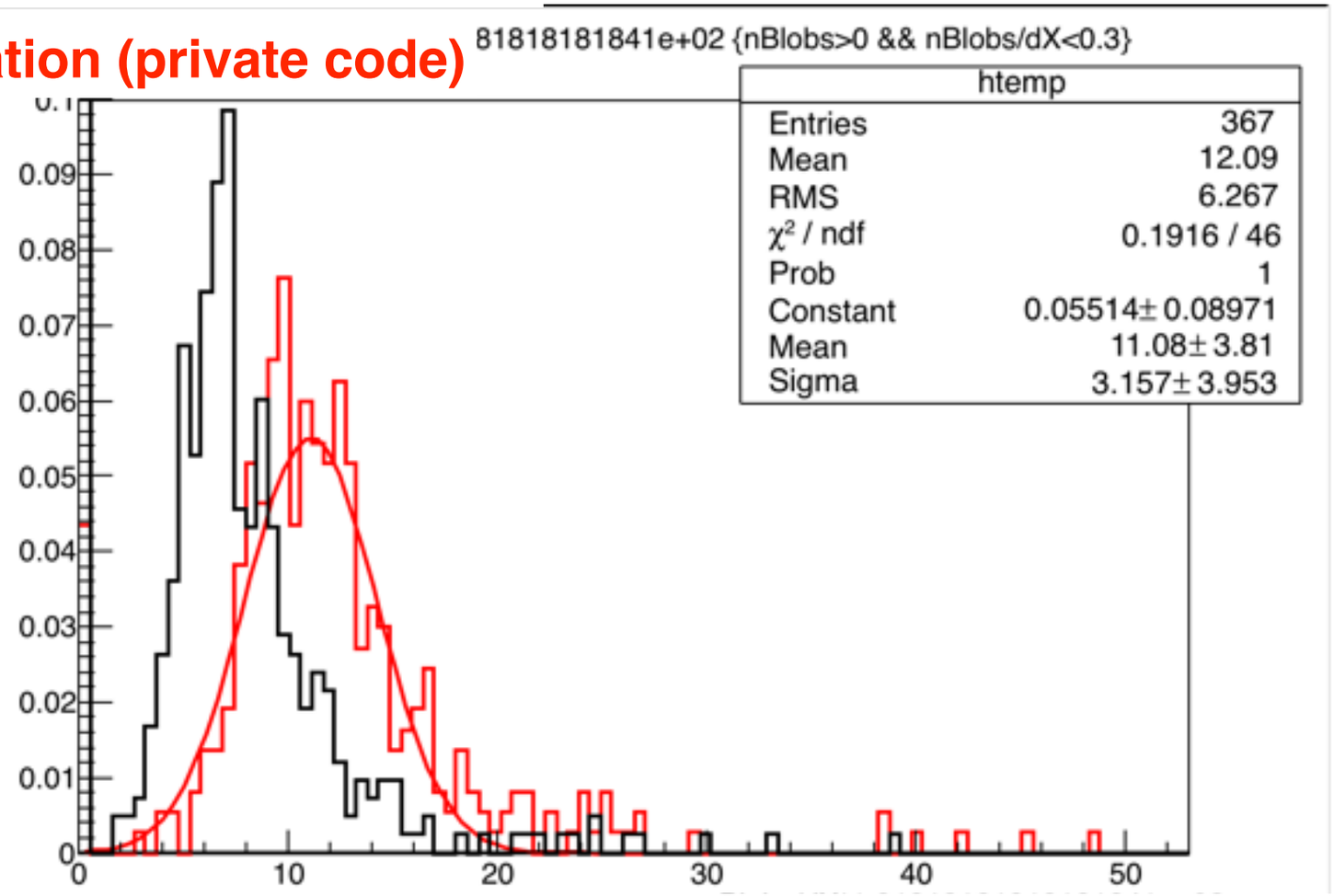
All pixels information (private code)



of clusters/cm

BlobsFinder MAfalda framework output

All pixels information (private code)



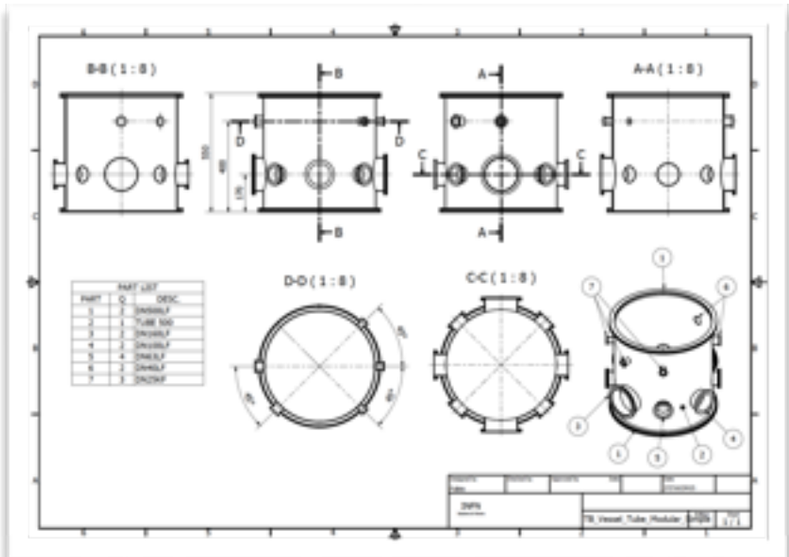
#of clusters/cm expected ~ 25

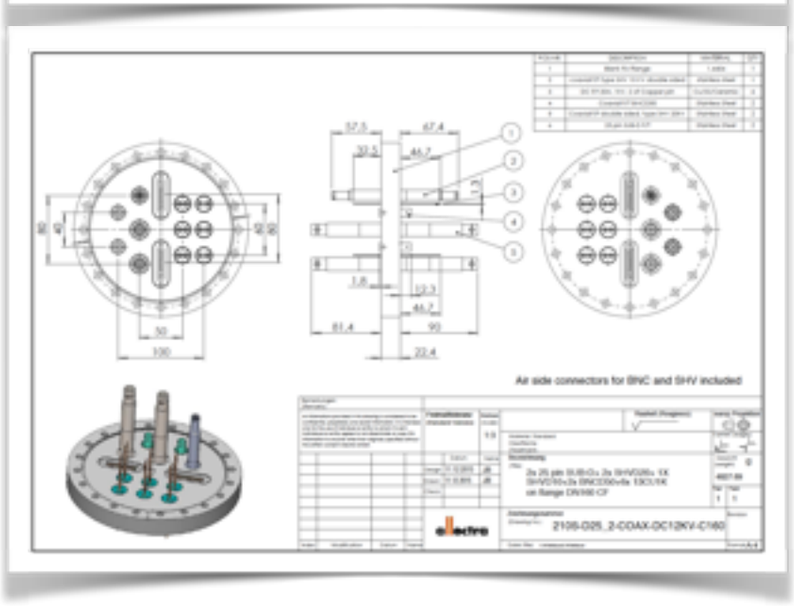
more work needed but already very encouraging (~50% efficiency)

From Nygren's paper it appears that, even if the counting efficiency is significantly less than 100%, the energy resolution can still remain close to the intrinsic resolution. The reason for this is that if the fraction of counts lost is not large, the level of fluctuations in the lost counts is small relative to the intrinsic fluctuations in the number of electron/ion pairs in the total track. This assertion implicitly assumes

Future plans & Funds

- Vacuum vessel to operate below atm pressure to be delivered mid February
- With vacuum vessel + 20 cm drift distance (field cage being built):
  - Ar + CO_2 + CF_4
  - CF_4 + SF_6
  - CS_2 at Occidental College lab (thanks Dan!!)
- Take data with cosmic rays + ^{55}Fe + neutron source?
- Two weeks beam time at BTF in April with 400 MeV electron & positrons
- MSCA funds (nearly) all already used + my position ending May 2017
  - ERC Starting grant application 2015: not funded

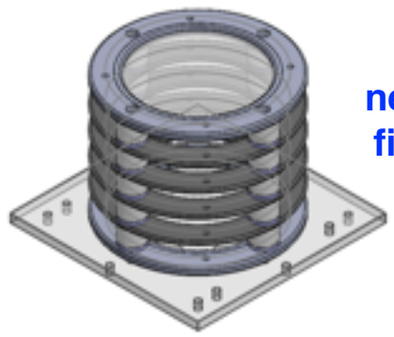




Final panel score : A (fully meets the ERC's excellence criterion and is recommended for funding if sufficient funds are available)

European Research Council
Executive Agency
Established by the European Commission

- ERC Starting grant application 2016 for columnar recombination studies
  - 1.5 MEUROS budget
  - 2 researcher positions for 5 years + me
  - 300k EUROs material + equipment
  - Results before summer



new 20 cm field cage

A personal view (to convince other people)

- We need to aim at 10^{-45} but I don't think we can state we are going to do it with low pressure gas
- We need to have a short term meaningful goal with known technologies (low pressure gas + readout)
  - Develop tens of m^3 size TPCs, build and strengthen international directional DM community around CYGNUS (first stage)
  - Keep on R&D for innovative technologies (possibly TPC-based) and for this keep the detector modular to test new ideas
  - Aim at ton-size with infrastructure + TPCs built at first stage and improved technology developed in R&D (second stage)
  - Think about unconventional approach like merging multiple techniques (and target materials!!) such as :
    - low pressure gas TPC + CNTs
    - high pressure gas TPC with columnar recombination + CNTs

Backup

TimePix vs Timepix3

	Timepix (2006)	Timepix3 (2013)
Pixel arrangement	256 x 256	
Pixel size	55 x 55 µm²	
Technology	250nm CMOS - 6Metals	130nm CMOS - 8Metals
Acquisition modes	1) Charge (iTOT) 2) Time (TOA) 3) Event counting (PC)	1) Time (TOA) AND Charge (TOT) 2) Time (TOA) 3) Event counting (PC) AND integral charge (iTOT)
Readout Type	1) Full-Frame	1) Data driven (DD) 2) Frame (FB)
Zero suppressed readout	NO	YES
Dead time per pixel	> 300µs readout time of one frame	> 475ns **~600x** Pulse measurement time + packet transfer time
Minimum timing resolution	10ns	1.562ns **6.4x**
On-chip Power pulsing (PP)	NO	YES
Minimum detectable charge	~750e-	>500e- **1.5x**
Output bandwidth	1 LVDS ≤200Mbps 32 CMOS ≤3.2Gbps	1 to 8 SLVS @640Mbps DDR ≤5.2Gbps **1.6x**

Timepix Timing

The Timepix - Timing Information

- Clock can run at 1, 10 or 50 Mhz (100 as well, but is unstable) -> 1us, 100ns, 20ns time resolution

- Counter depth is 11810 - places limits on total acq time.

- Readout ~10 mS (**slow**)