

GDR Neutrino 2014 LAL, Orsay

Measurement of the muon-induced fast neutrons at shallow depths

Adrien Hourlier – Jaime Dawson



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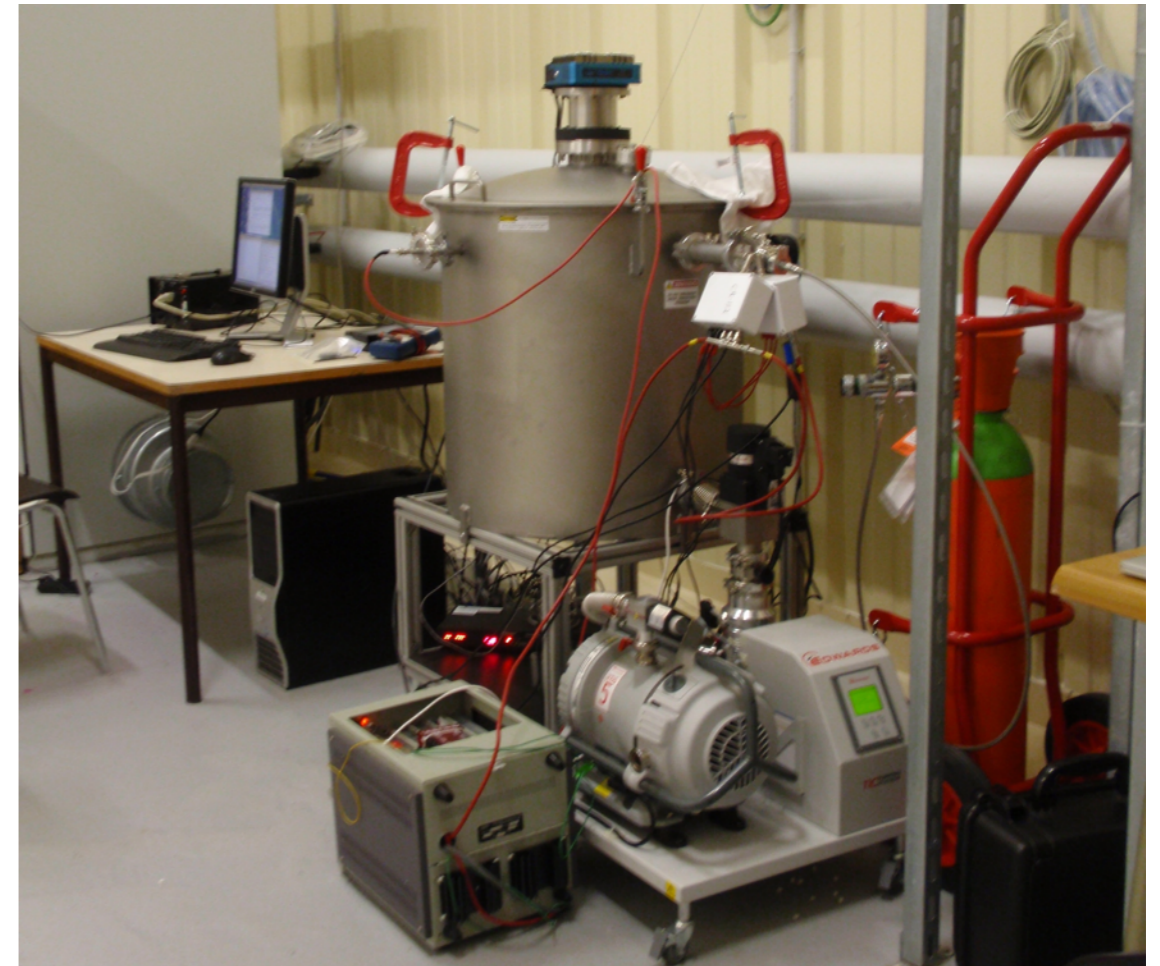
- Motivations for DCTPC
- Presentation, detection principle
- Background expectations
- Analysis beginning

What is DCTPC?

Double Chooz Time Projection Chamber



2L detection volume
0.1— 20 MeV nuclear recoil
4 months data taking at far hall



60L detection volume
0.2— 30 MeV nuclear recoil
3.5 months data taking at near hall

Two neutron TPC : one for each Double Chooz detector hall

Location of DCTPC



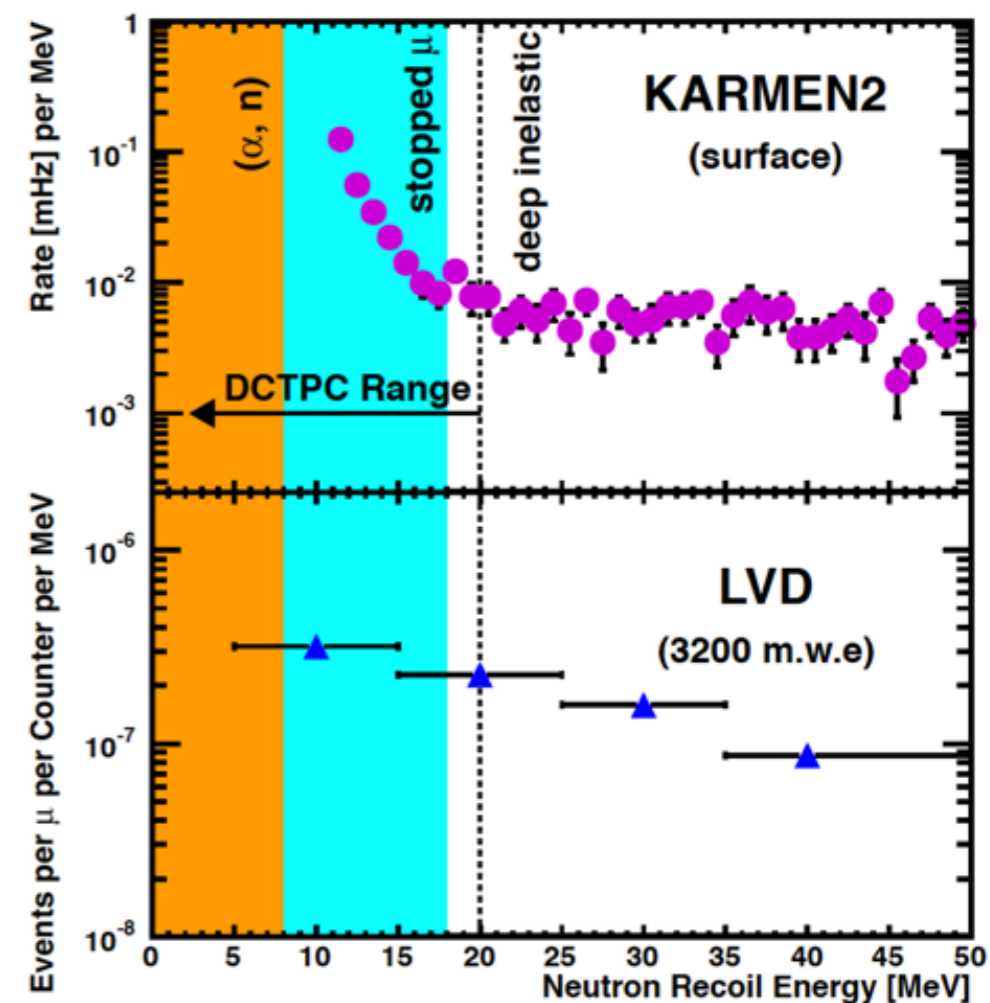
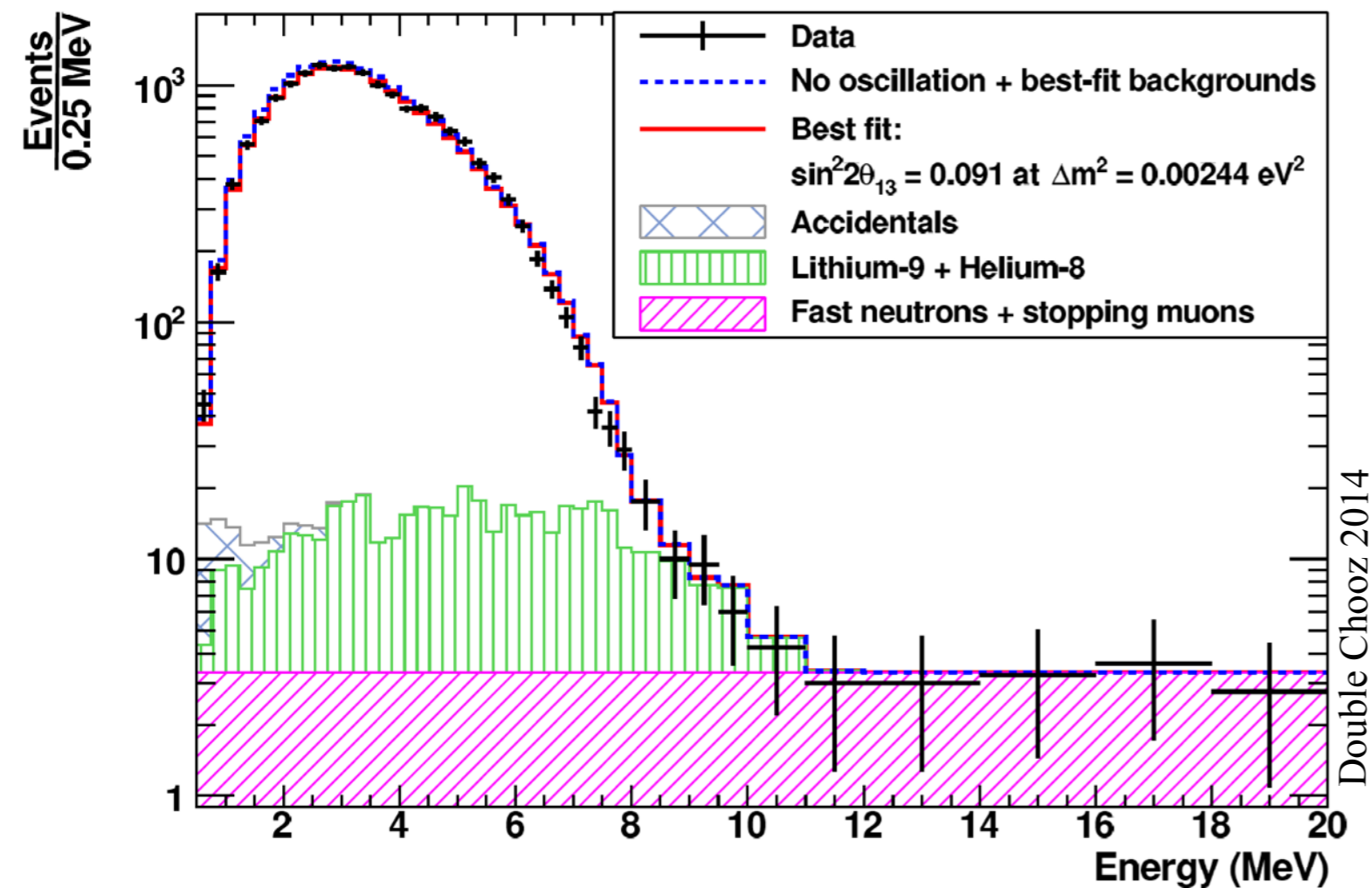
2 detectors :

- prototype DCTPC in the far hall (300 m.w.e)
- DCTPC in the near hall (120 m.w.e)

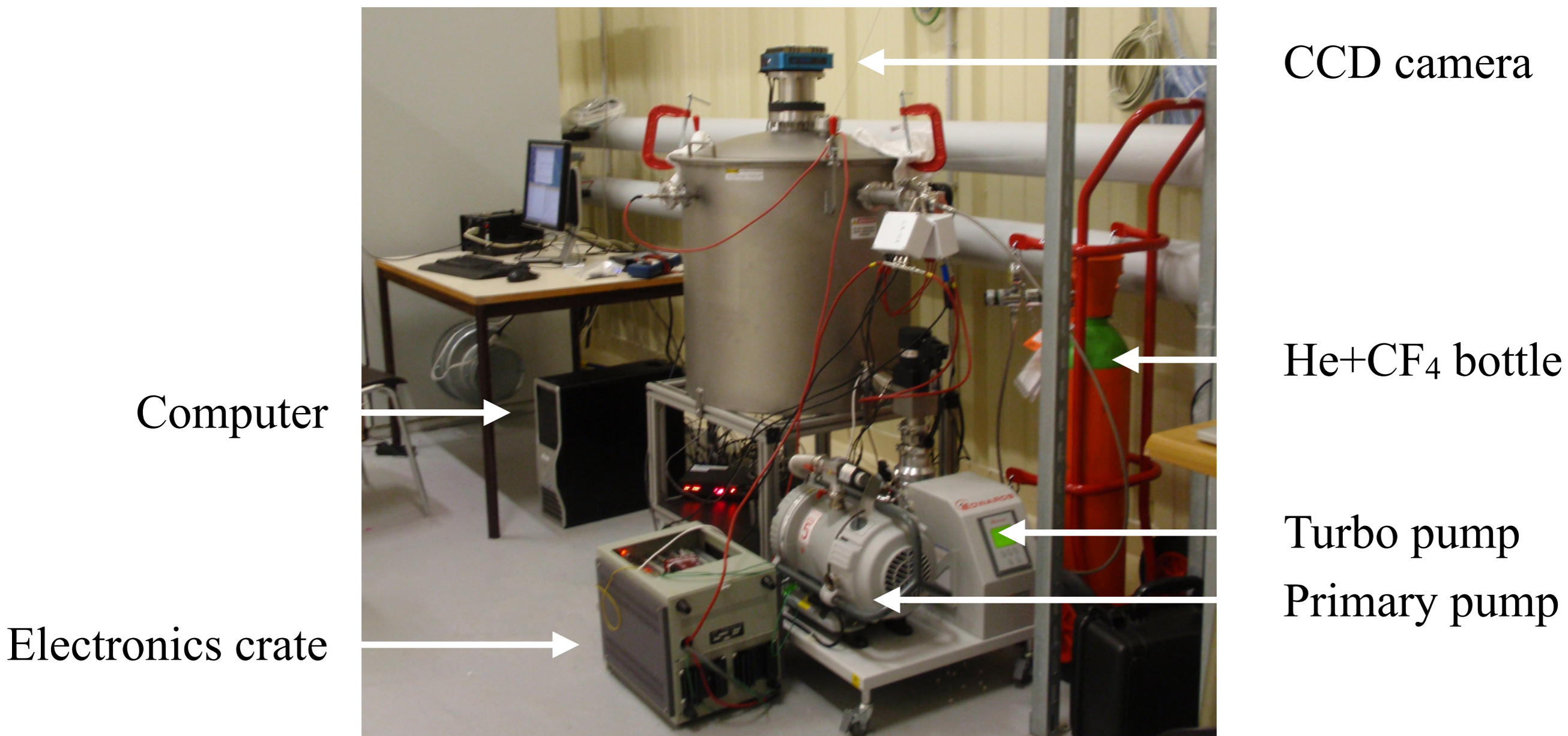
Swap the detectors after 6 months of data taking

Motivation for DCTPC

- Very few neutron measurements at shallow depths
- Important background for neutrino oscillation, double beta decay, or dark matter experiments
- Measurement in Double Chooz near and far hall will provide a crucial calibration point for the fast neutron background model in MC

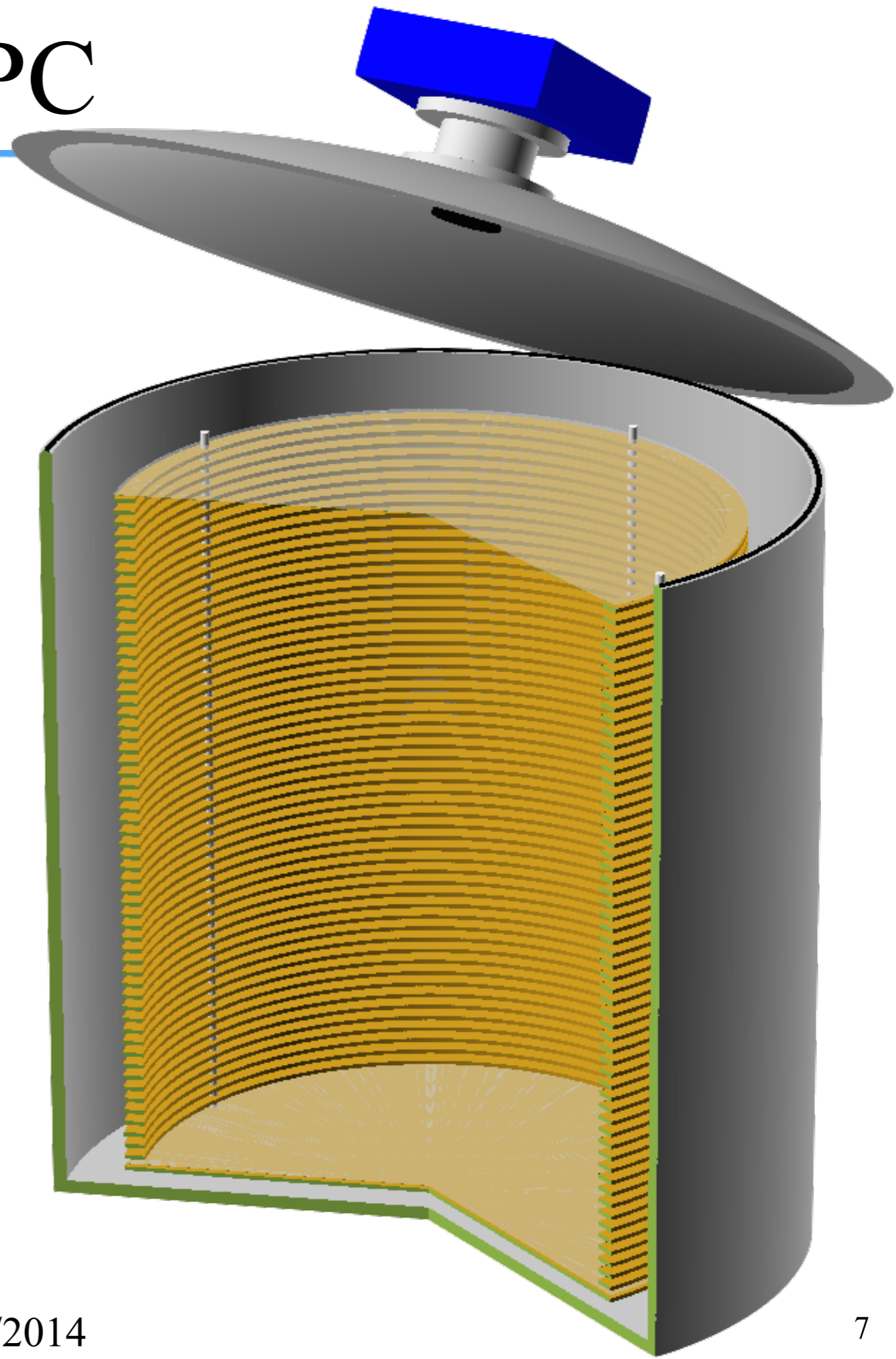


Presentation of DCTPC



Presentation of DCTPC

0.8 bar
CF₄ (12.5%)
He (87.5%)



Presentation of DCTPC

CCD camera

0.8 bar
CF4 (12.5%)
He (87.5%)

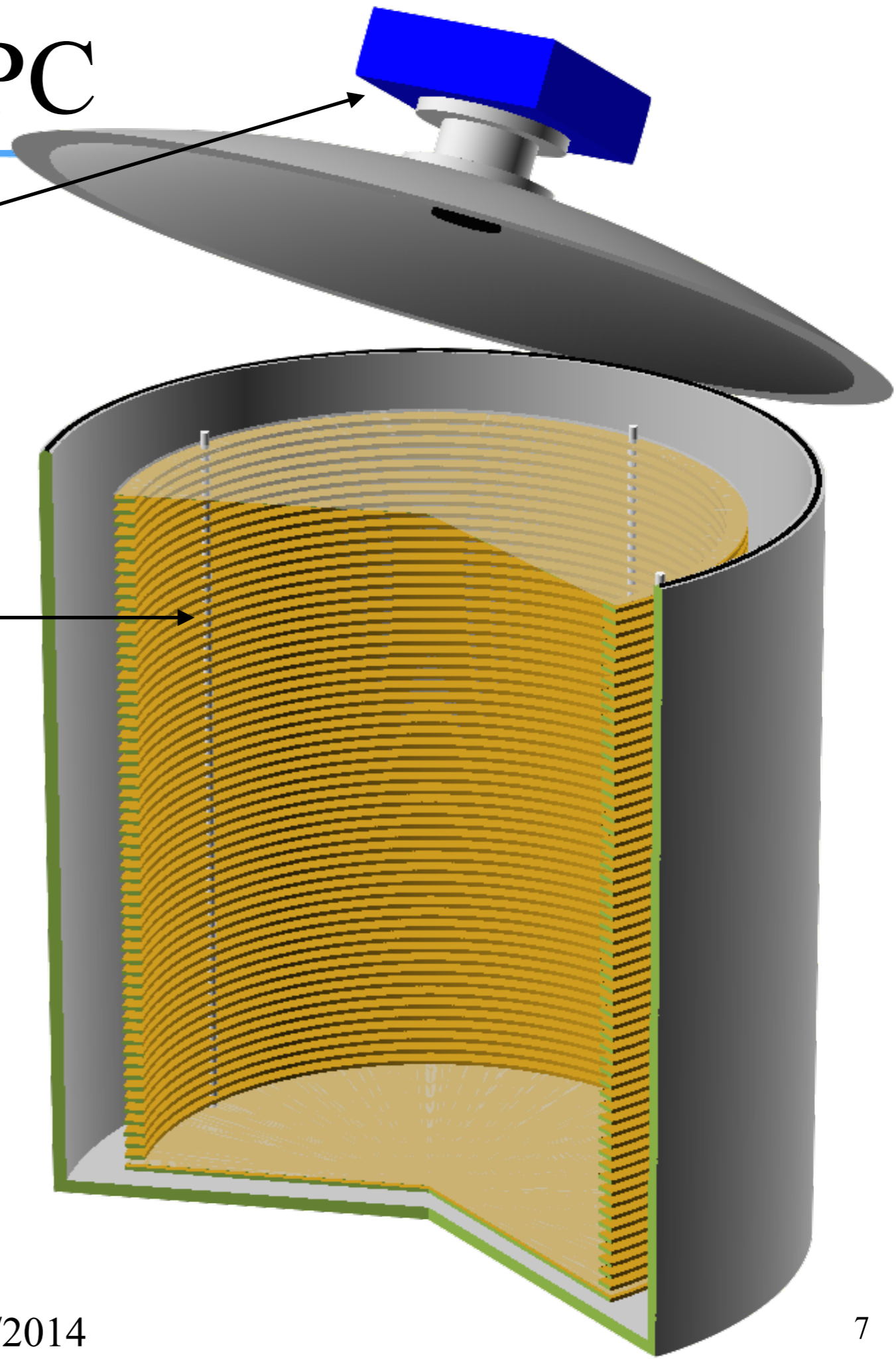


Presentation of DCTPC

CCD camera

0.8 bar
CF4 (12.5%)
He (87.5%)

Drift cage
(detection volume)



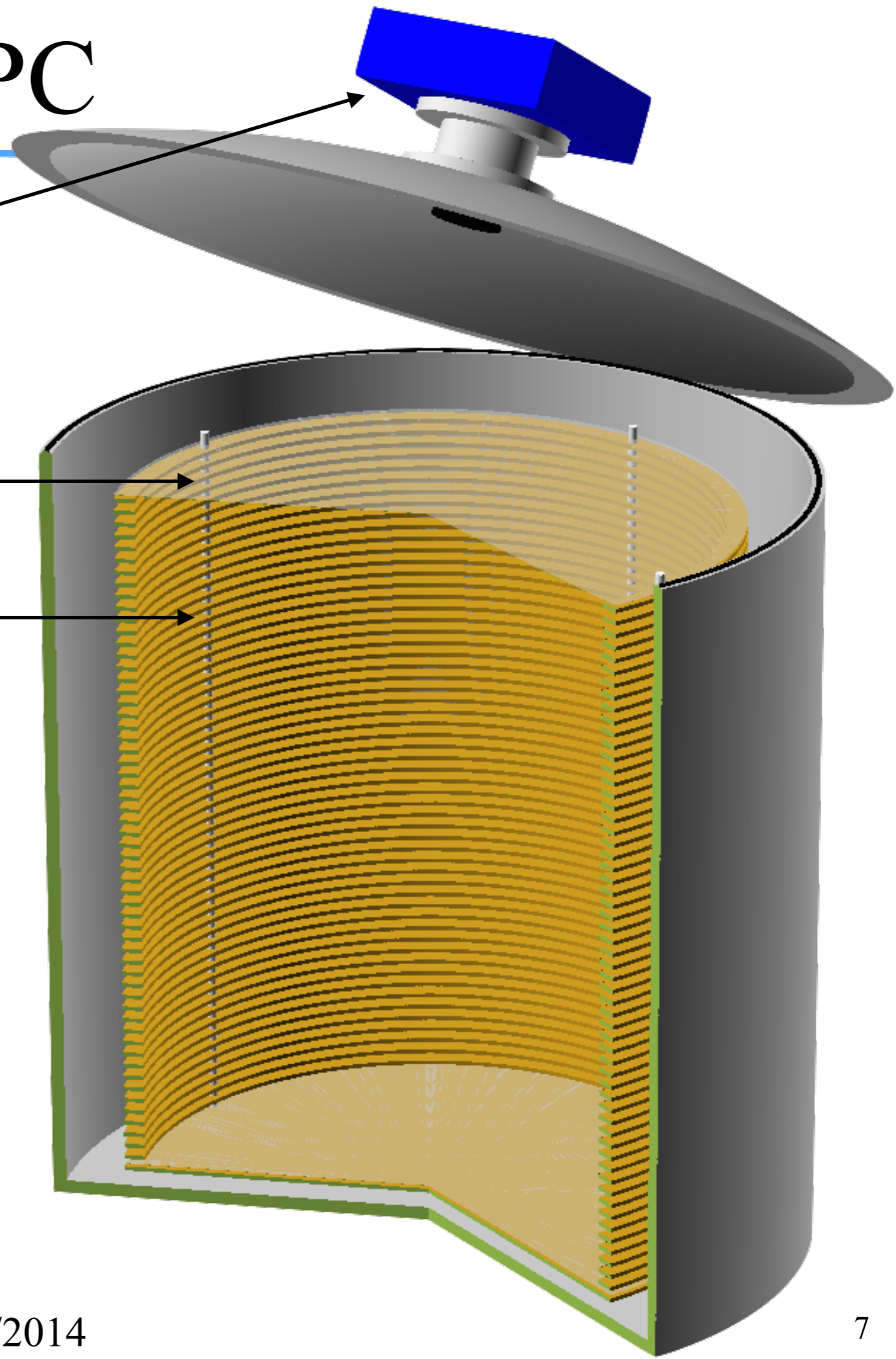
Presentation of DCTPC

CCD camera

0.8 bar
CF4 (12.5%)
He (87.5%)

Cathode mesh
(-7.5 kV)

Drift cage
(detection volume)



Presentation of DCTPC

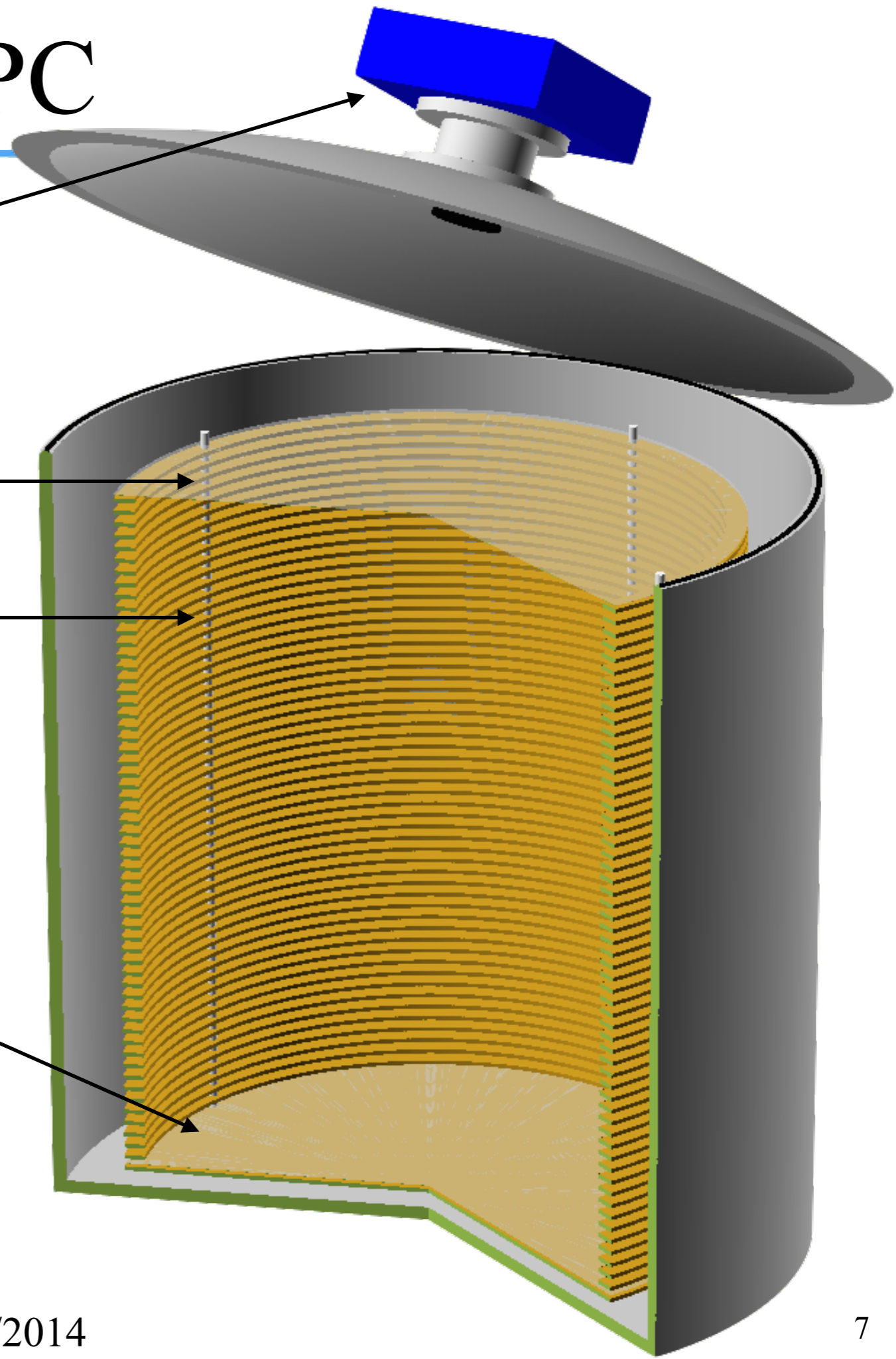
0.8 bar
CF4 (12.5%)
He (87.5%)

CCD camera

Cathode mesh
(-7.5 kV)

Drift cage
(detection volume)

Ground mesh



Presentation of DCTPC

0.8 bar
CF4 (12.5%)
He (87.5%)

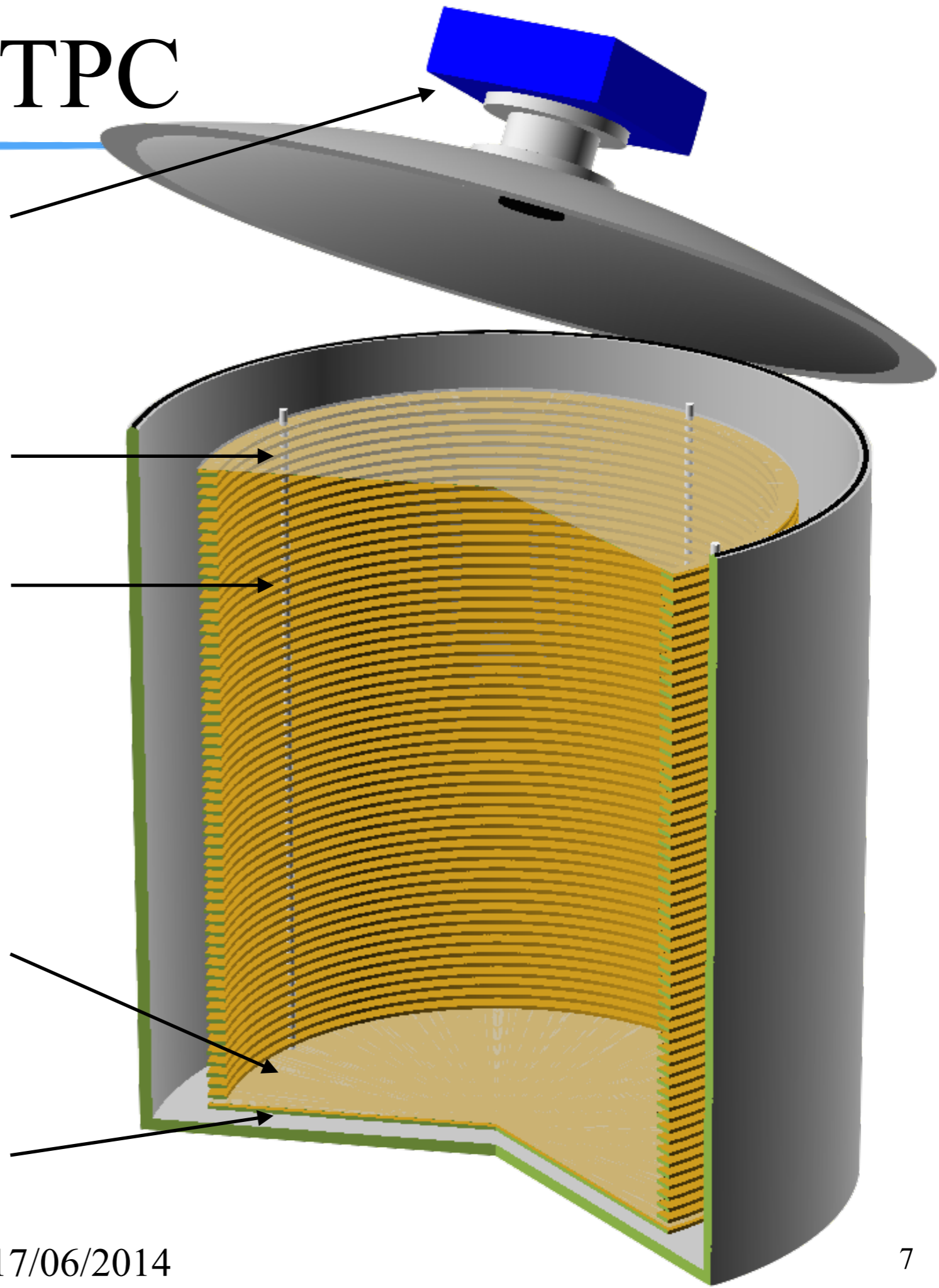
CCD camera

Cathode mesh
(-7.5 kV)

Drift cage
(detection volume)

Ground mesh

Anode plate
(715 V)



Presentation of DCTPC

0.8 bar
CF4 (12.5%)
He (87.5%)

CCD camera

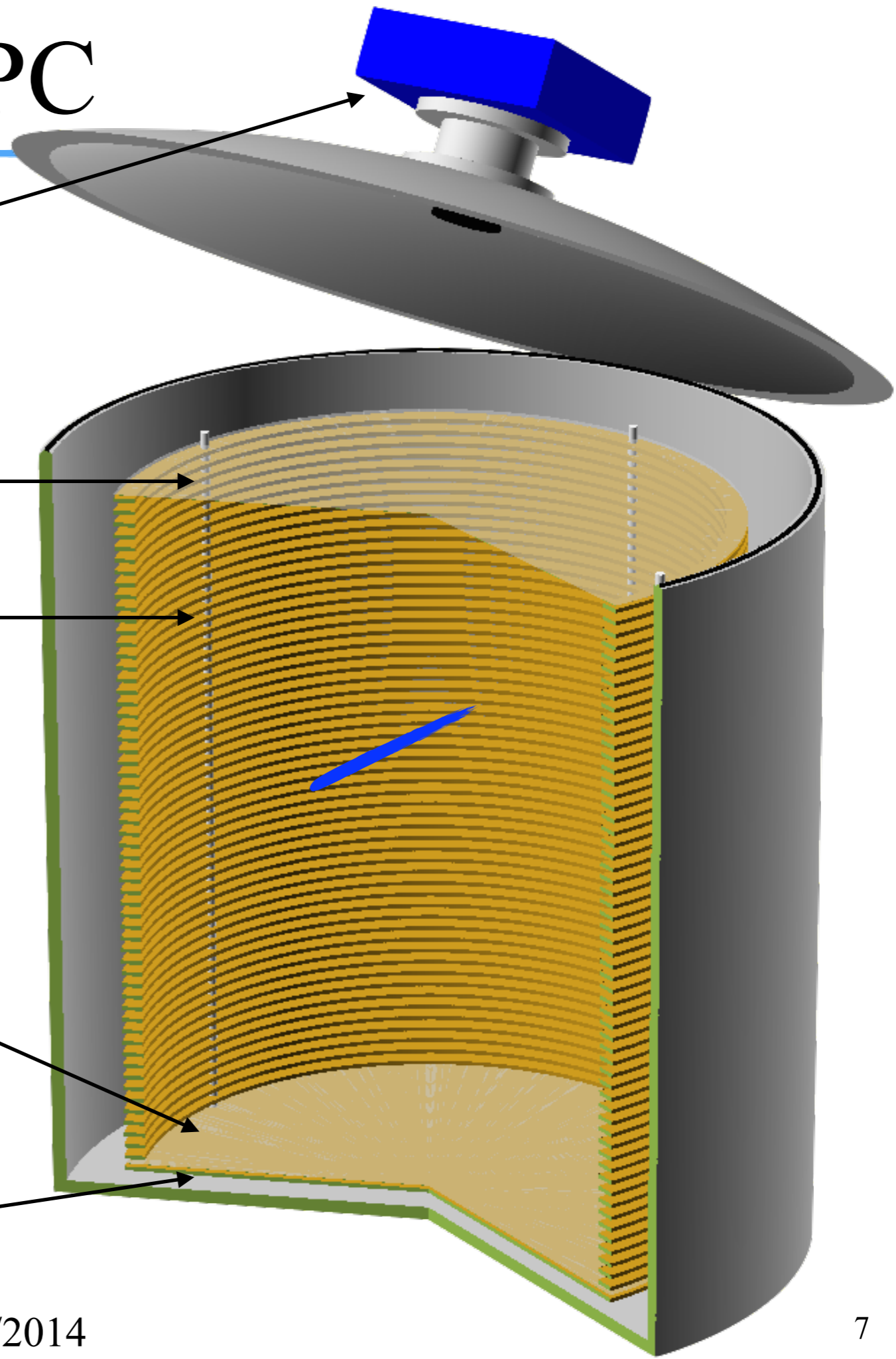
Cathode mesh
(-7.5 kV)

Drift cage
(detection volume)

Primary ionization track

Ground mesh

Anode plate
(715 V)



Presentation of DCTPC

0.8 bar
CF4 (12.5%)
He (87.5%)

CCD camera

Cathode mesh
(-7.5 kV)

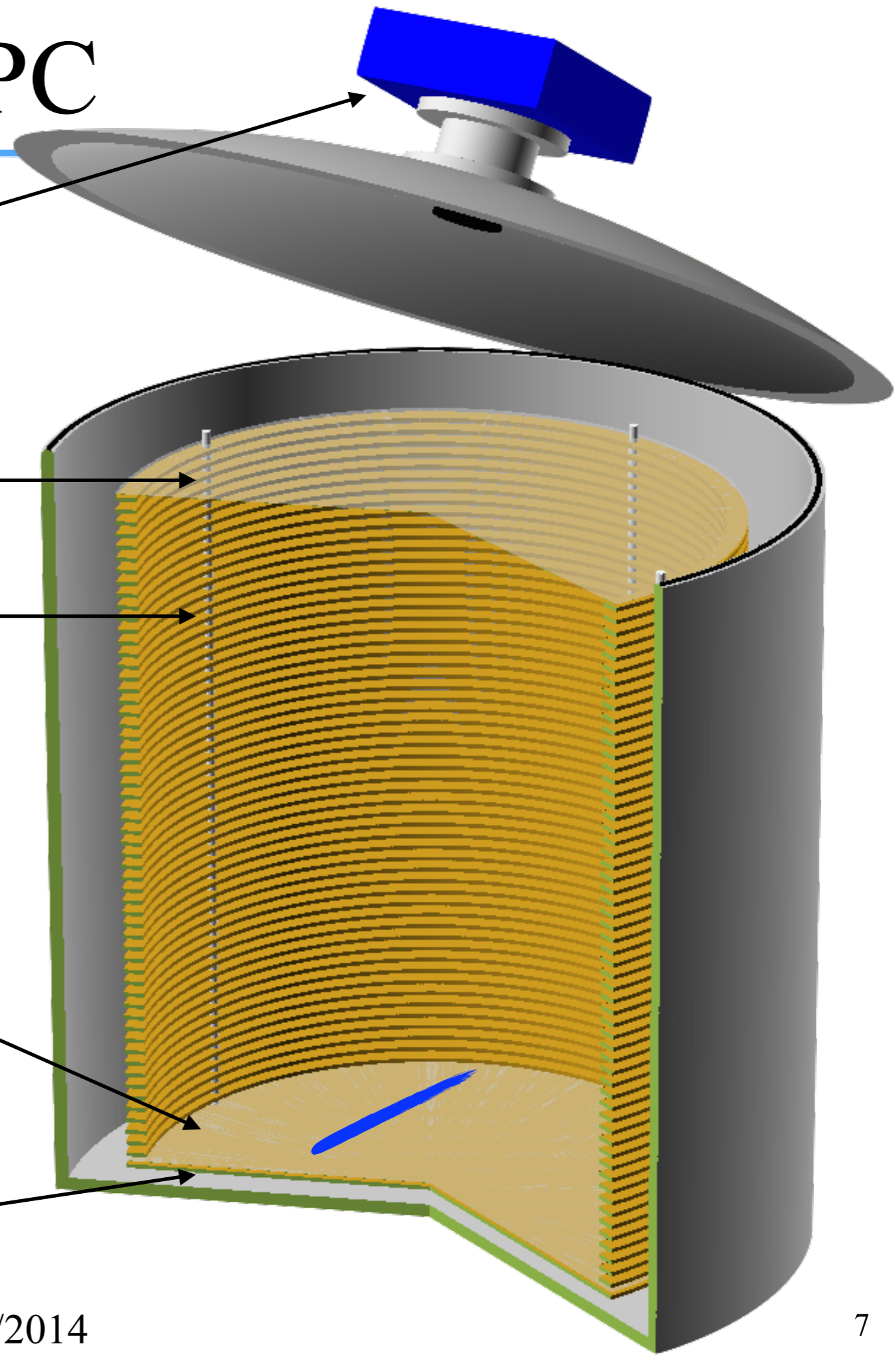
Drift cage
(detection volume)

Primary ionization track

Drift

Ground mesh

Anode plate
(715 V)



Presentation of DCTPC

0.8 bar
CF4 (12.5%)
He (87.5%)

CCD camera

Cathode mesh
(-7.5 kV)

Drift cage
(detection volume)

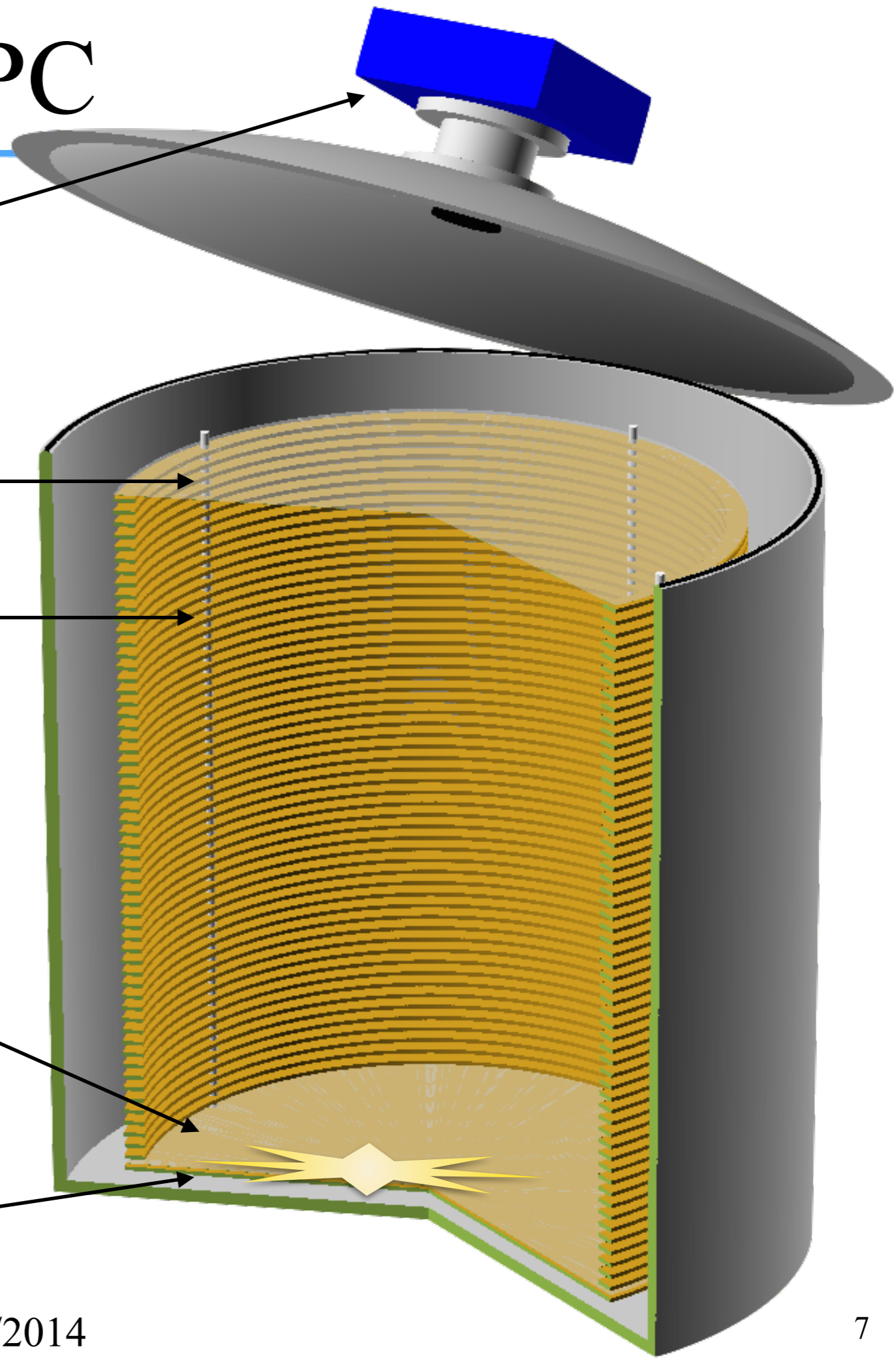
Primary ionization track

Drift

Ground mesh

Amplification

Anode plate
(715 V)

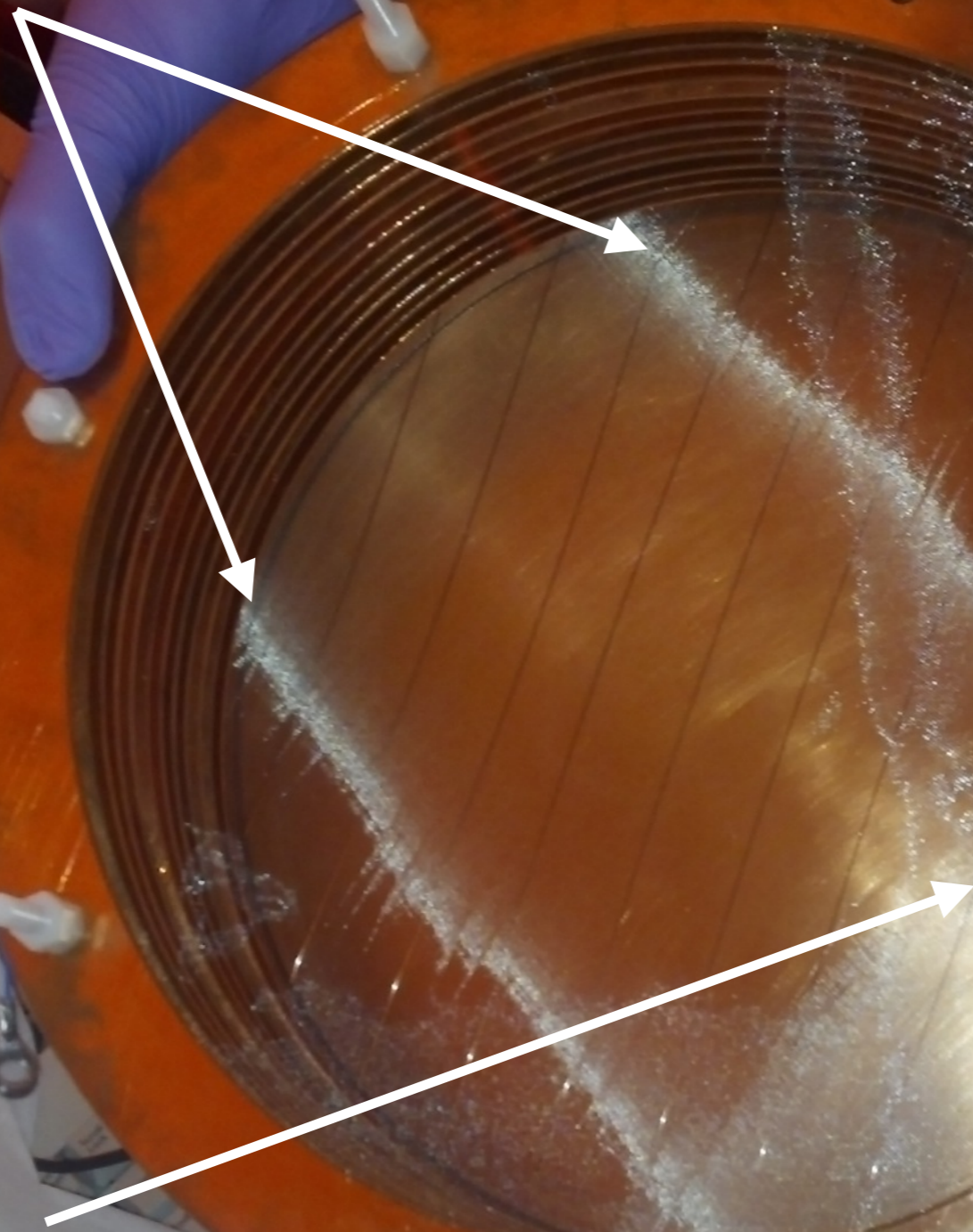


Drift Chamber



Prototype Drift Chamber

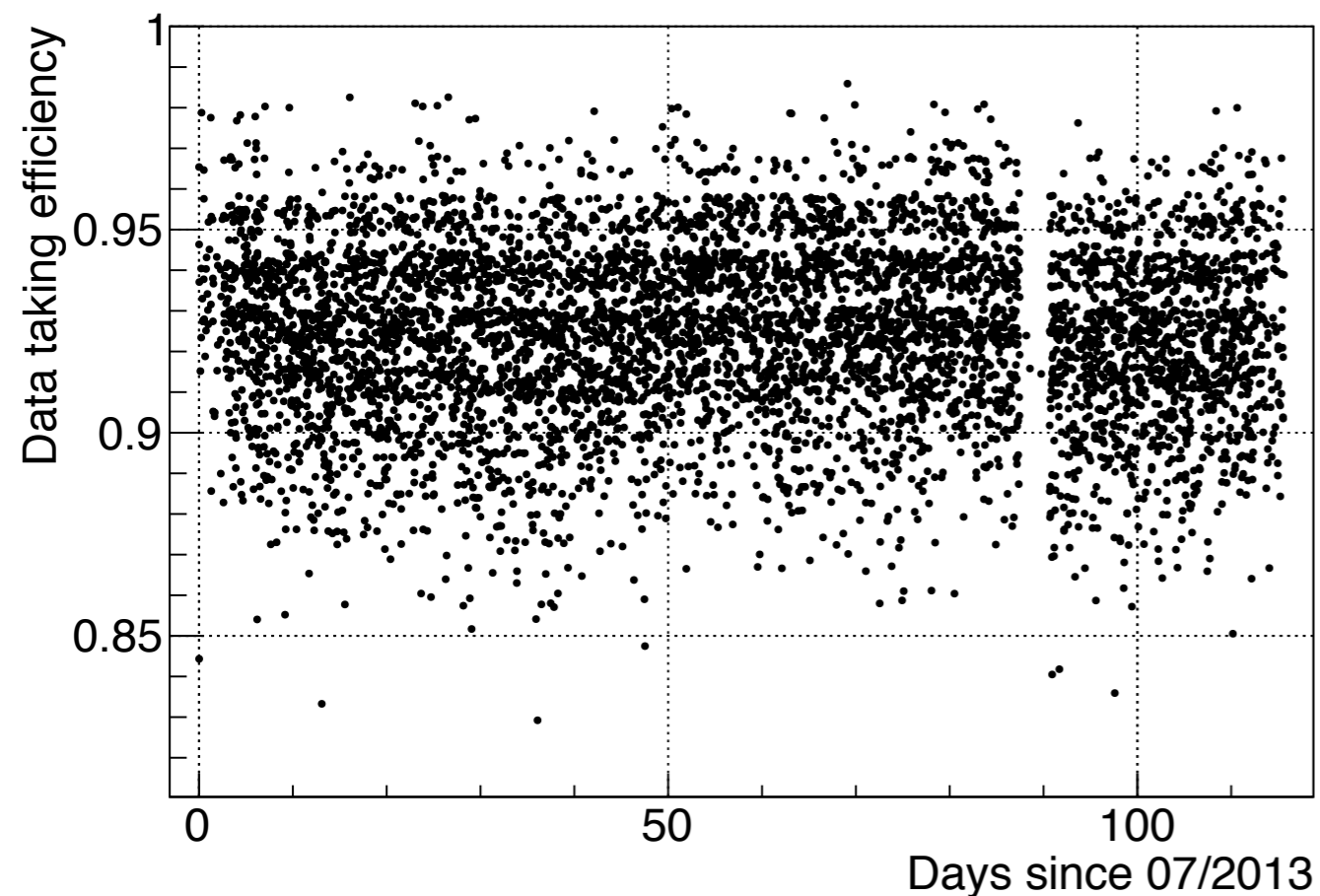
Reflection on the ground mesh



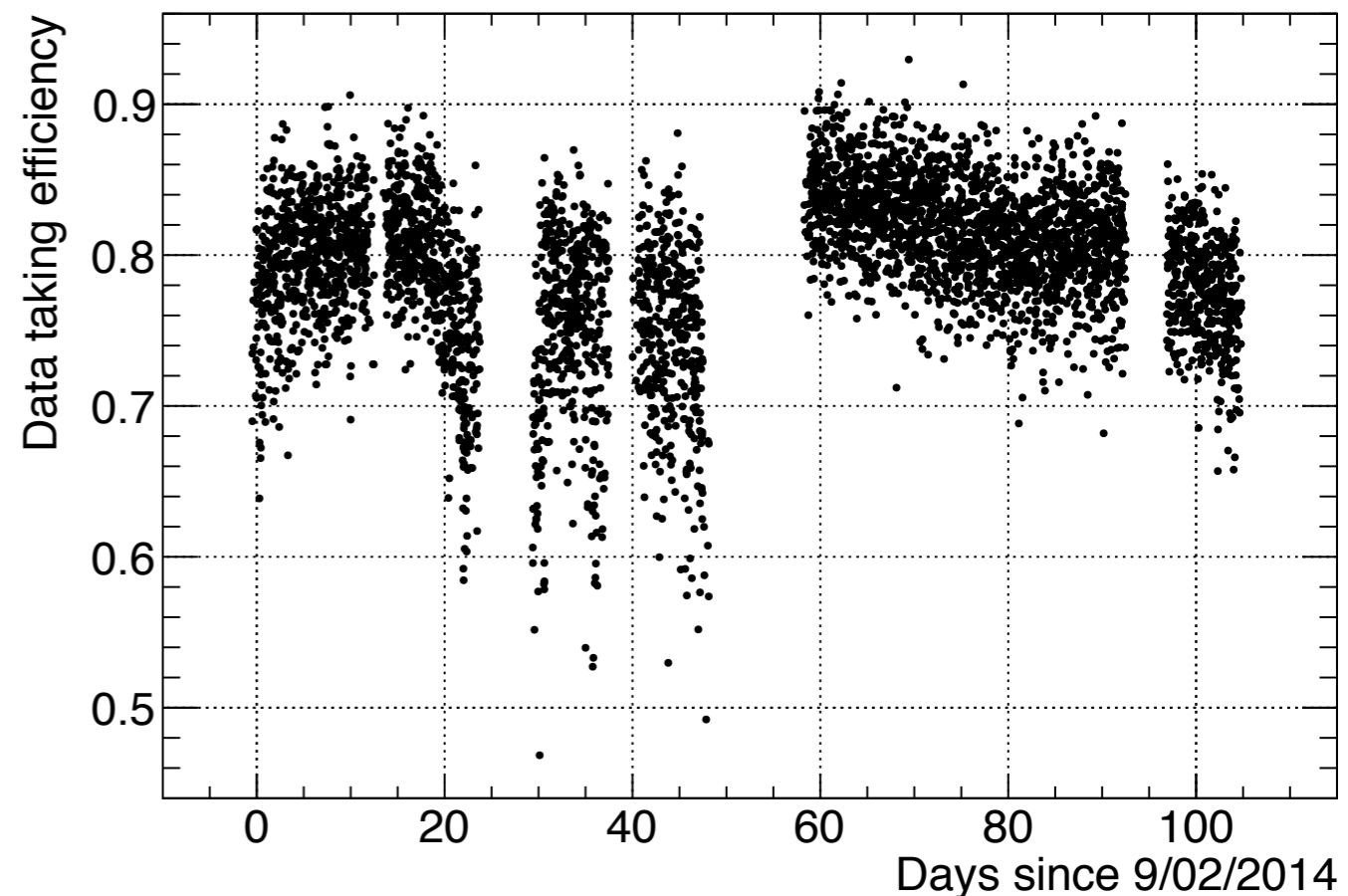
Reflection on the cathode mesh

2.5 L

Data Taking Efficiency



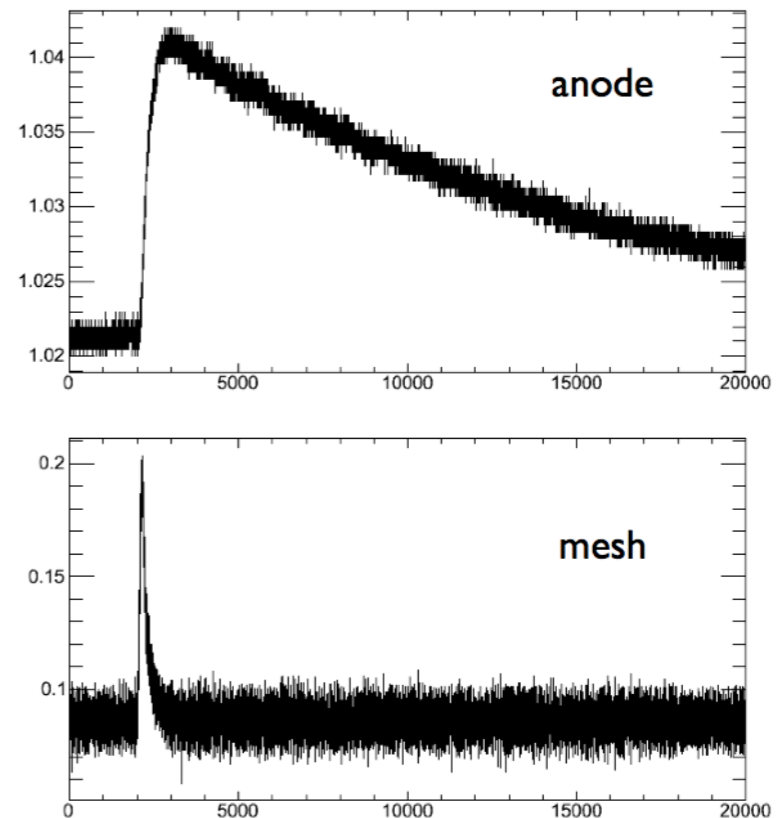
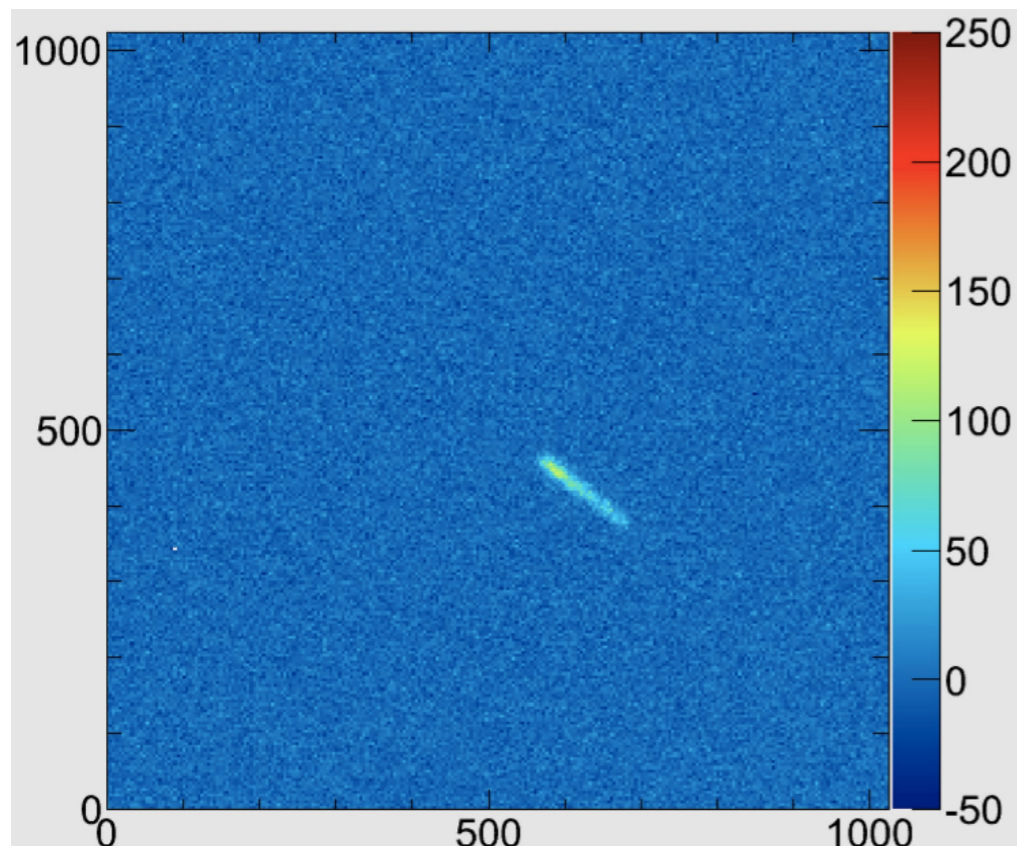
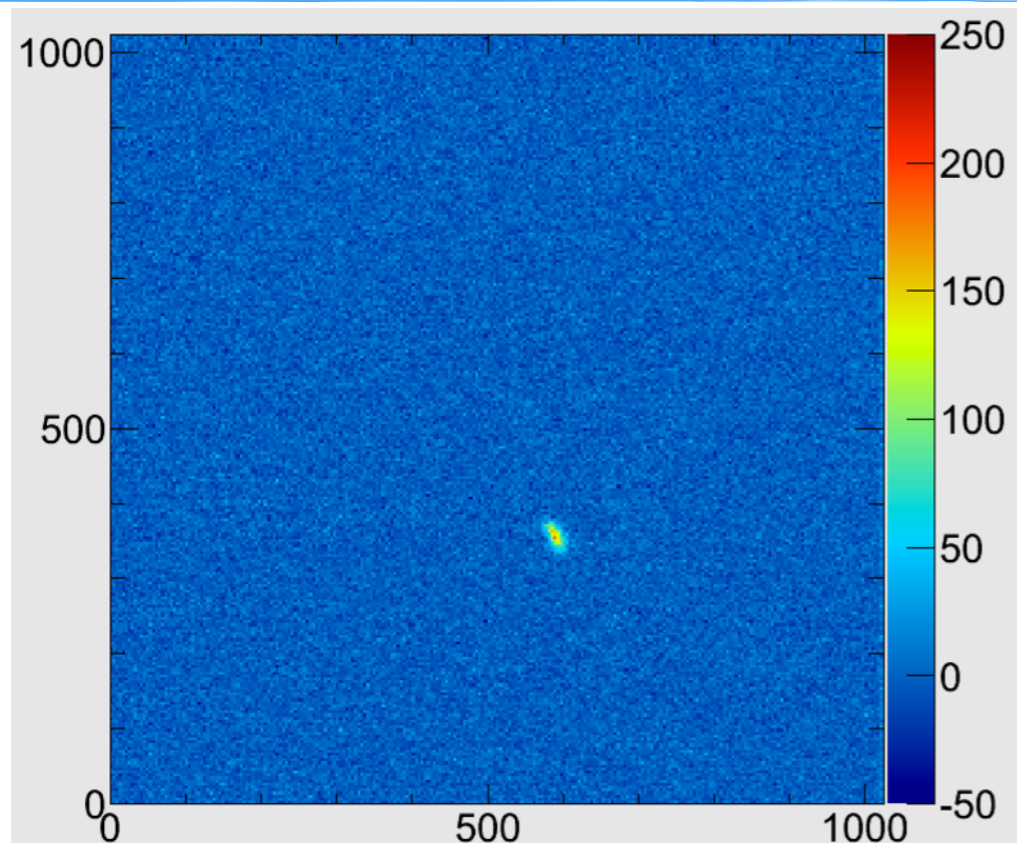
Prototype DCTPC:
Total integrated live time 64 days



Big DCTPC:
Total integrated live time 40 days

data taking efficiency loss dominated by sparks in the amplification volume

Event Read-out



- 1s CCD integration time
- The CCD image allows a 2D imaging of the track and an energy measurement
- The mesh and anode read-out allows a vertical length reconstruction and energy measurement
- 3 energy measurements
- full 3D reconstruction of the track

Expected Background

Low pressure detector :

- no MIP
- no γ
- no β



Expected Background

Low pressure detector :

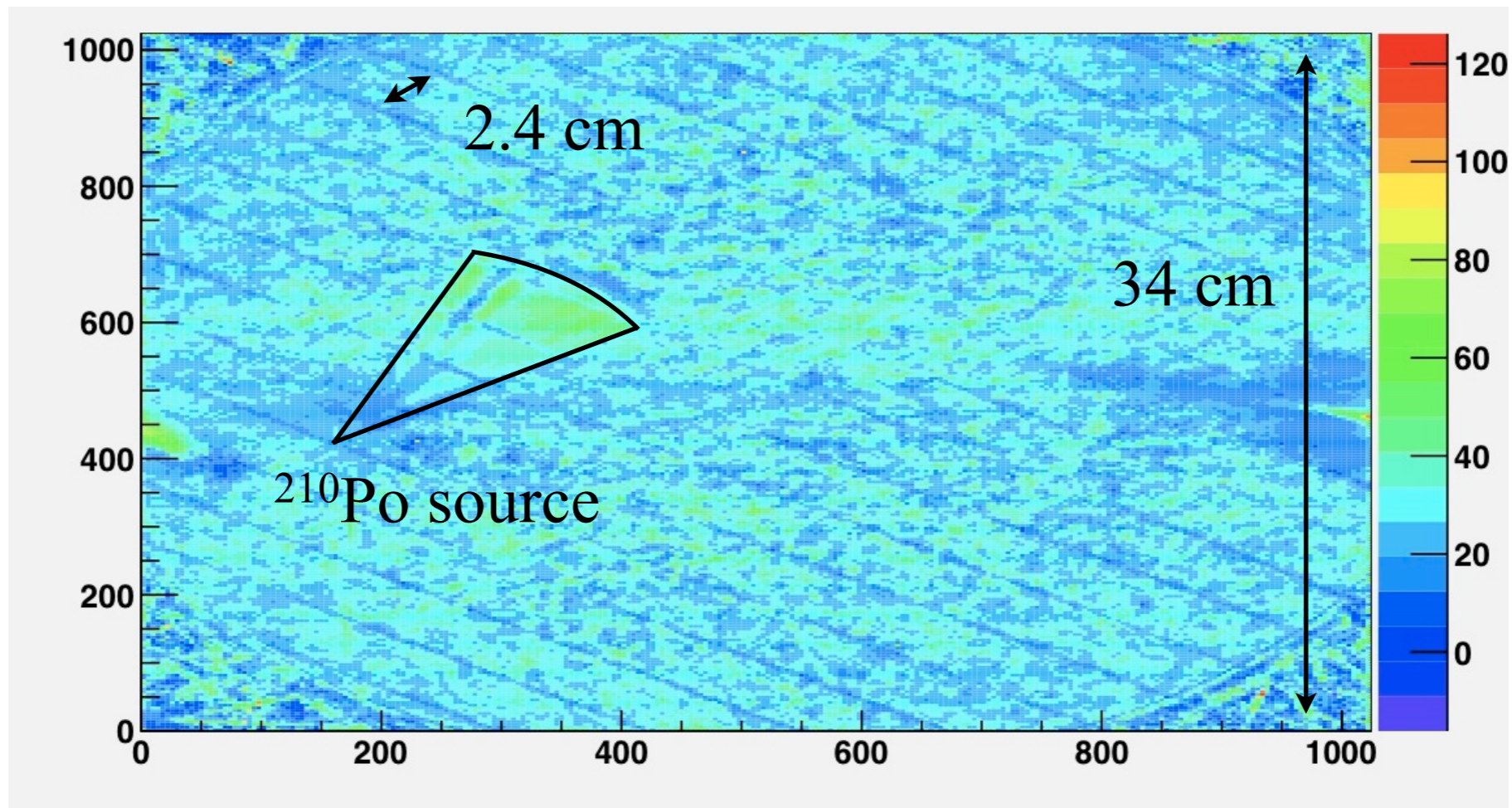
- no MIP
- no γ
- no β



Only one background : α particles

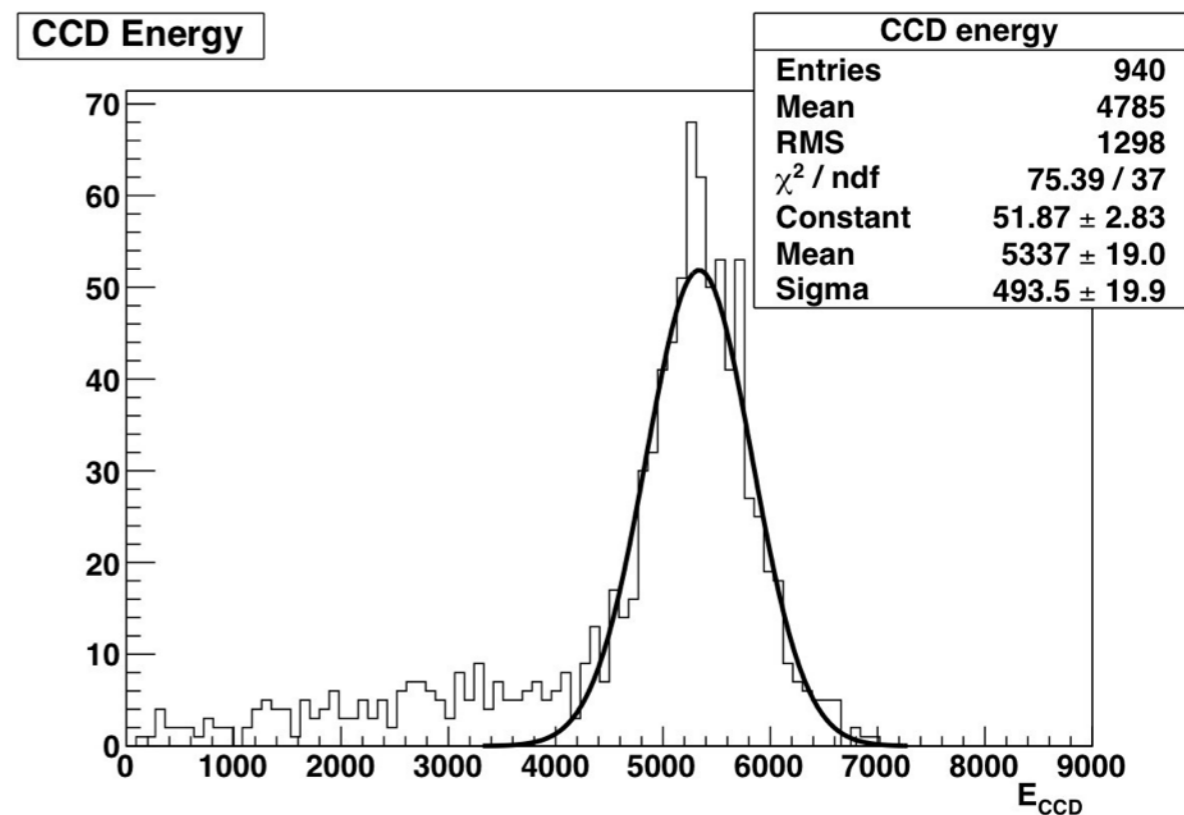
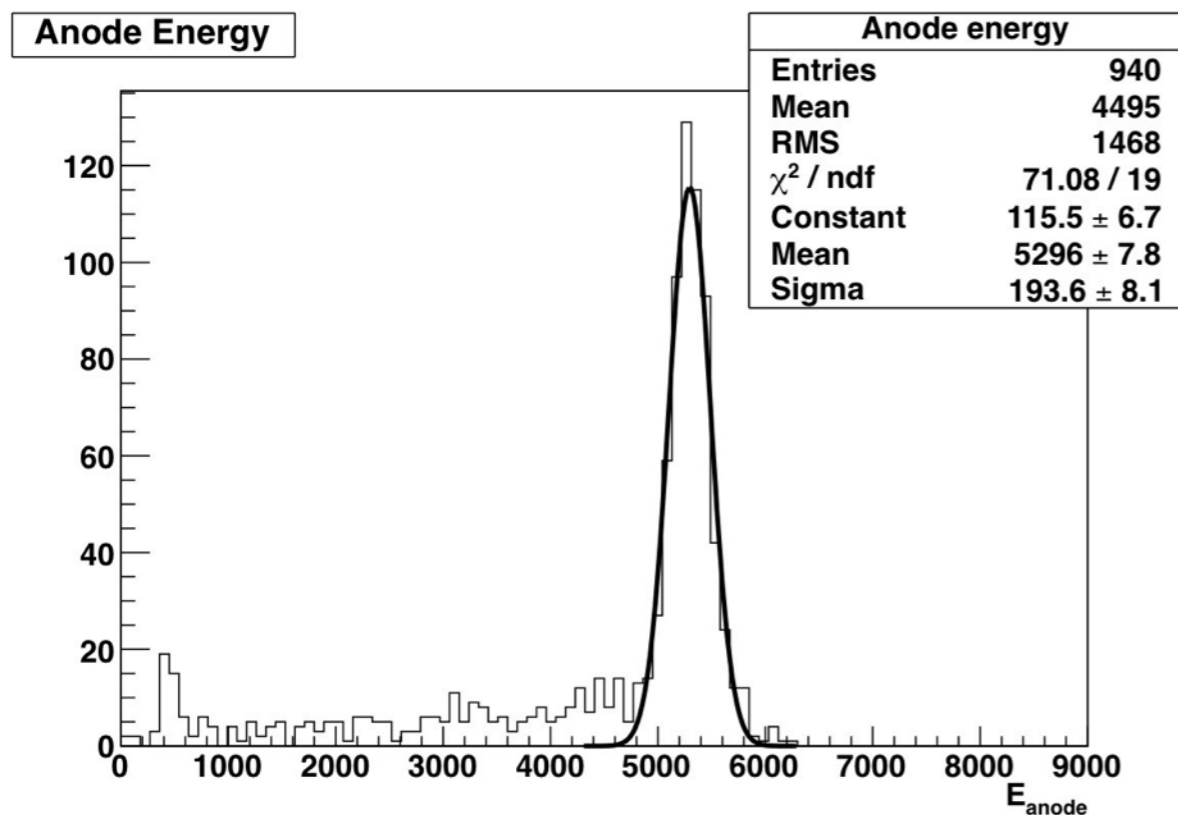
- from the copper rings
- created within the volume (Rn decay chain)

Spatial calibration



- Use spacers to calibrate the size of the CCD image
- Needs to be done every time we open the TPC

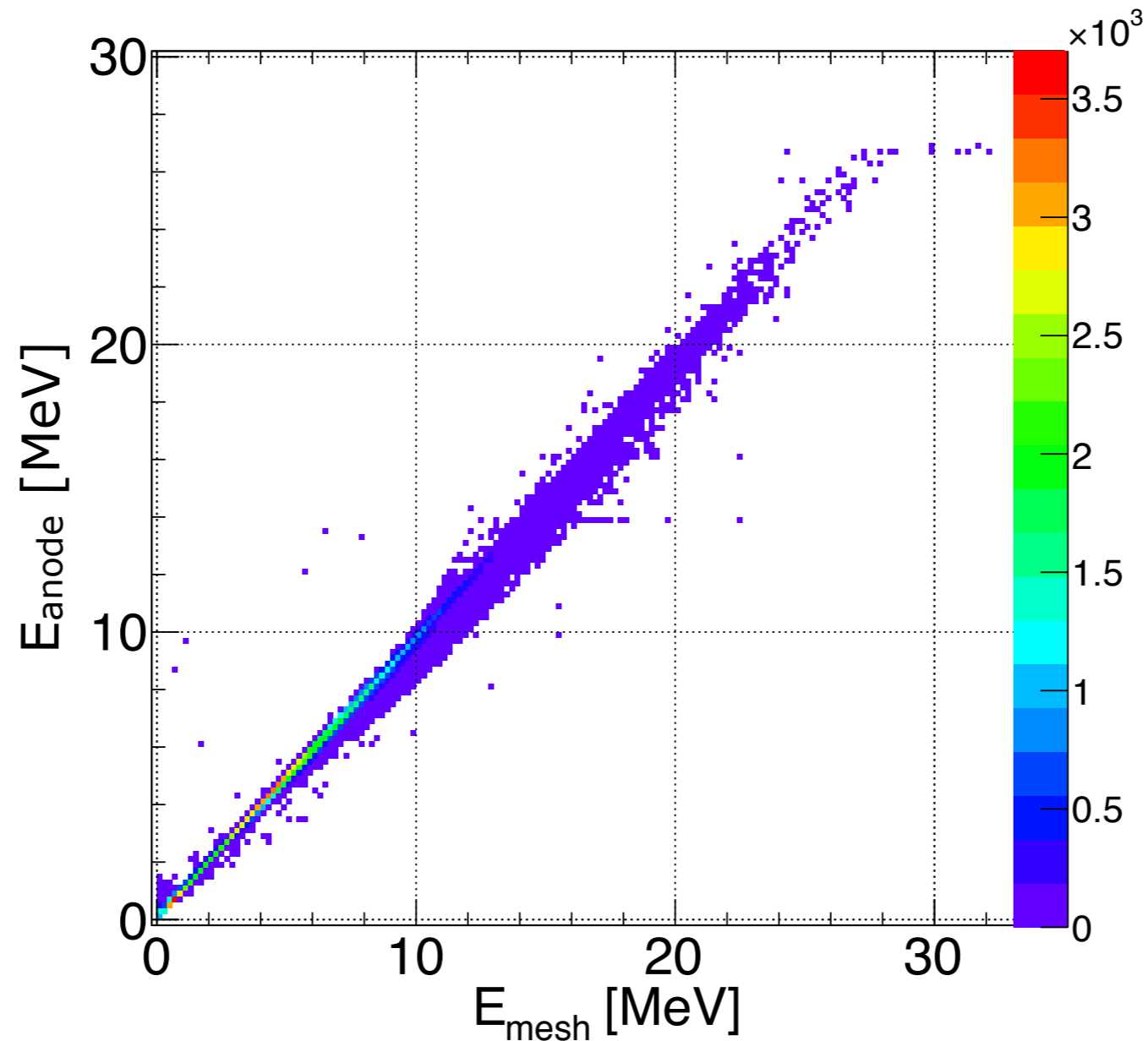
Energy calibration



Calibration with a ^{210}Po source (5.3 MeV α):
3% energy resolution with the anode signal
9% energy resolution with the CCD signal

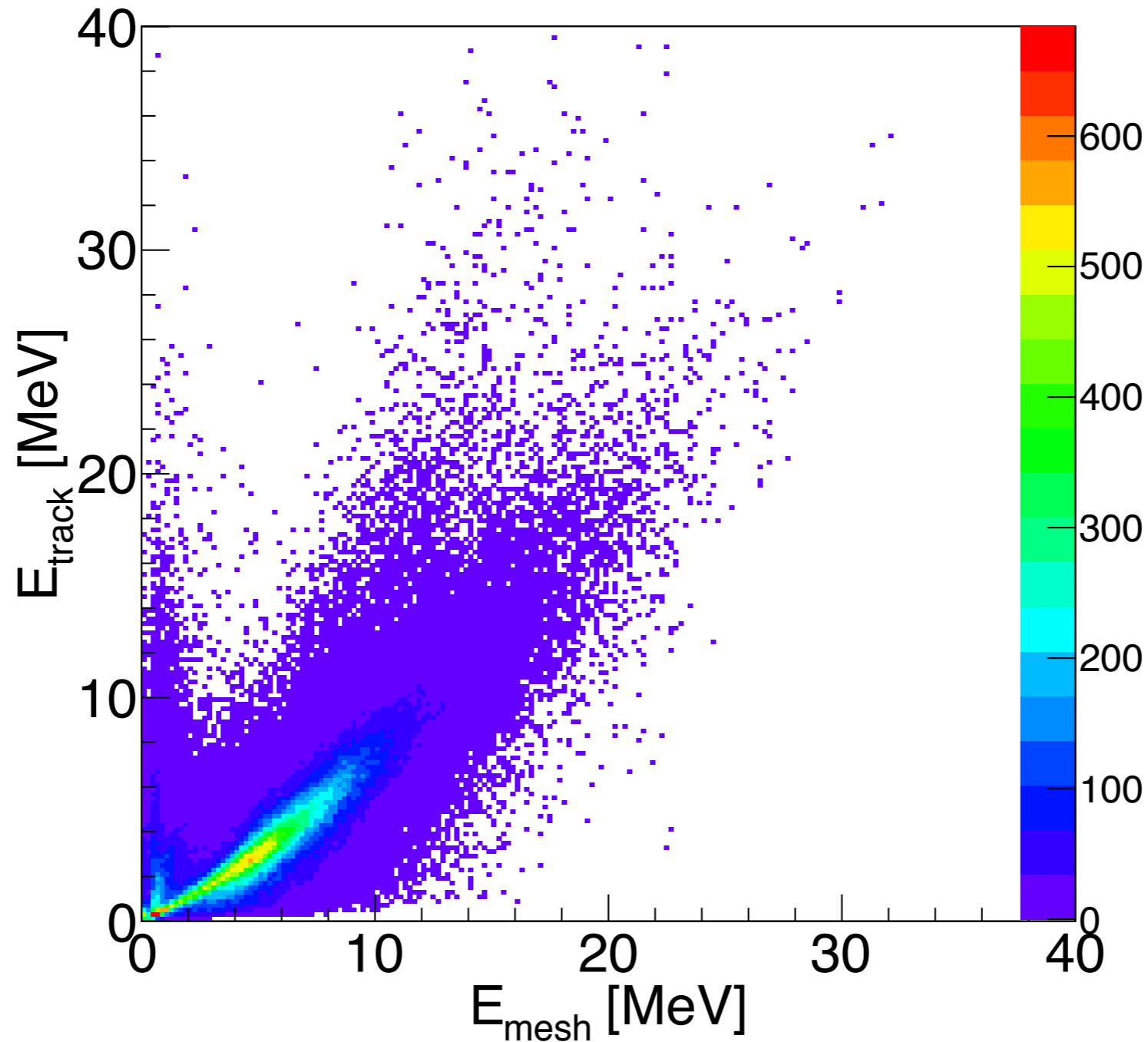
E_{CCD} : cross check

Consistency of Energy Measurement



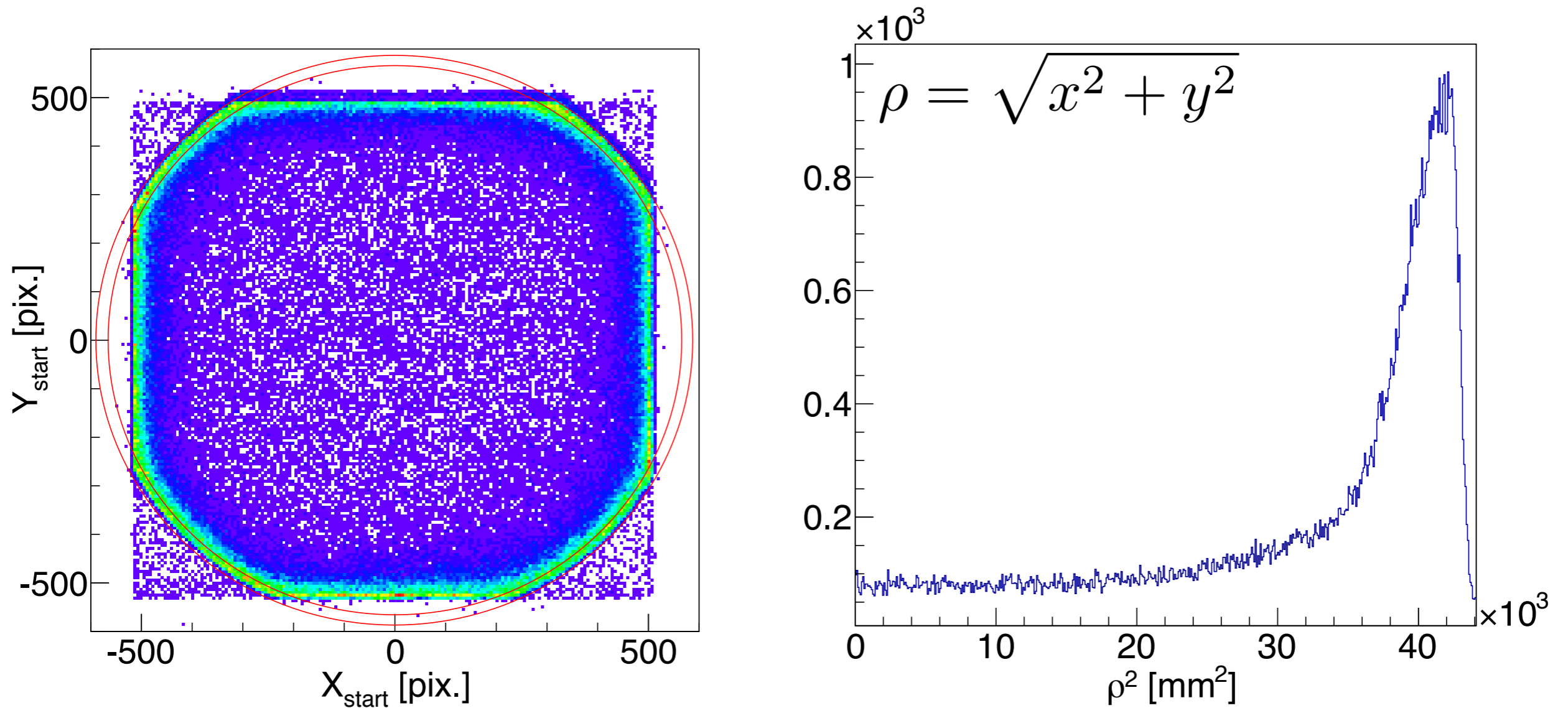
Beautiful linearity between energy measurements from mesh and anode

Consistency of Energy Measurement



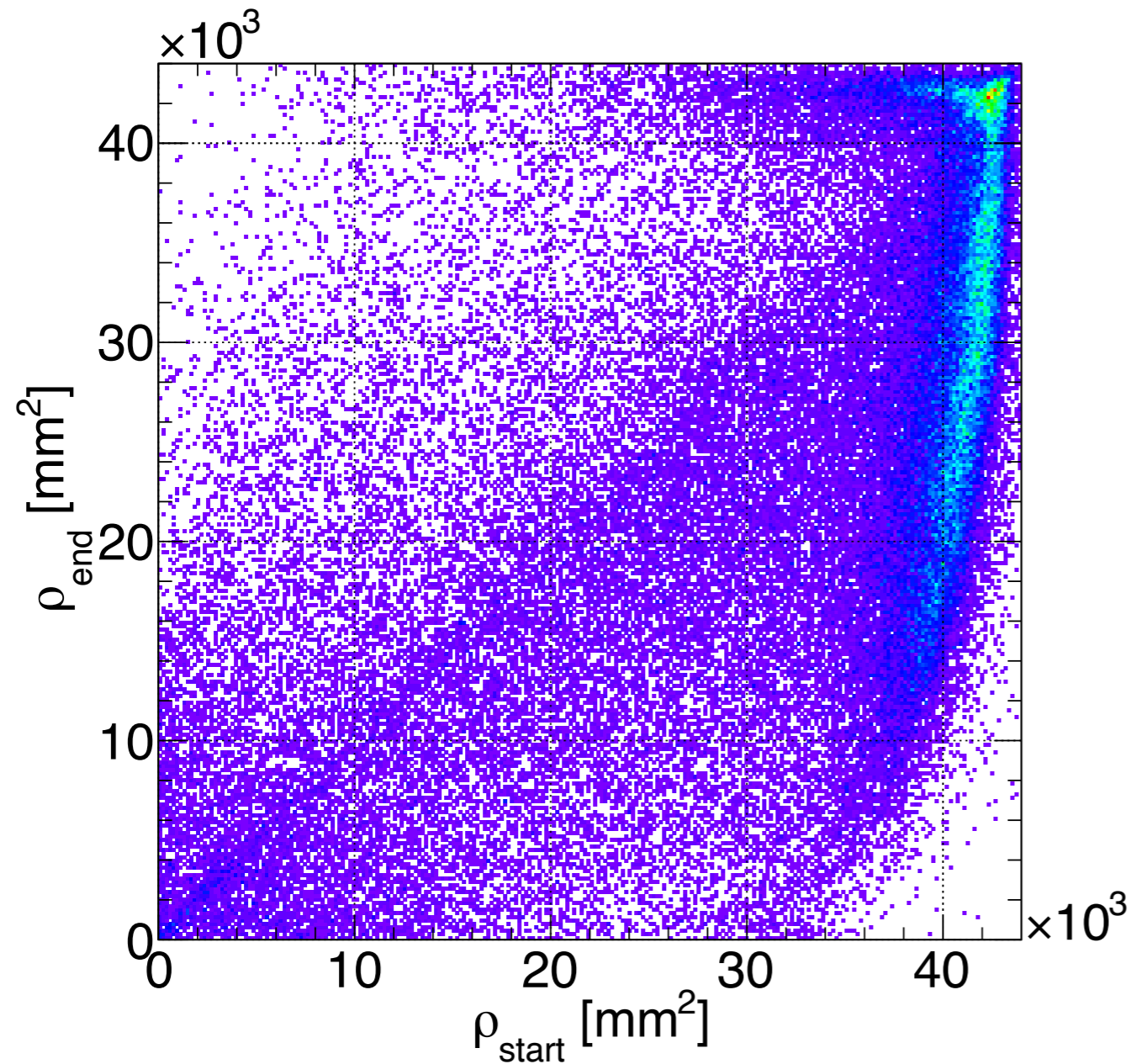
The CCD energy reconstruction introduces a polynomial correlation with the WF-based measurement

Background Reduction : Ring α



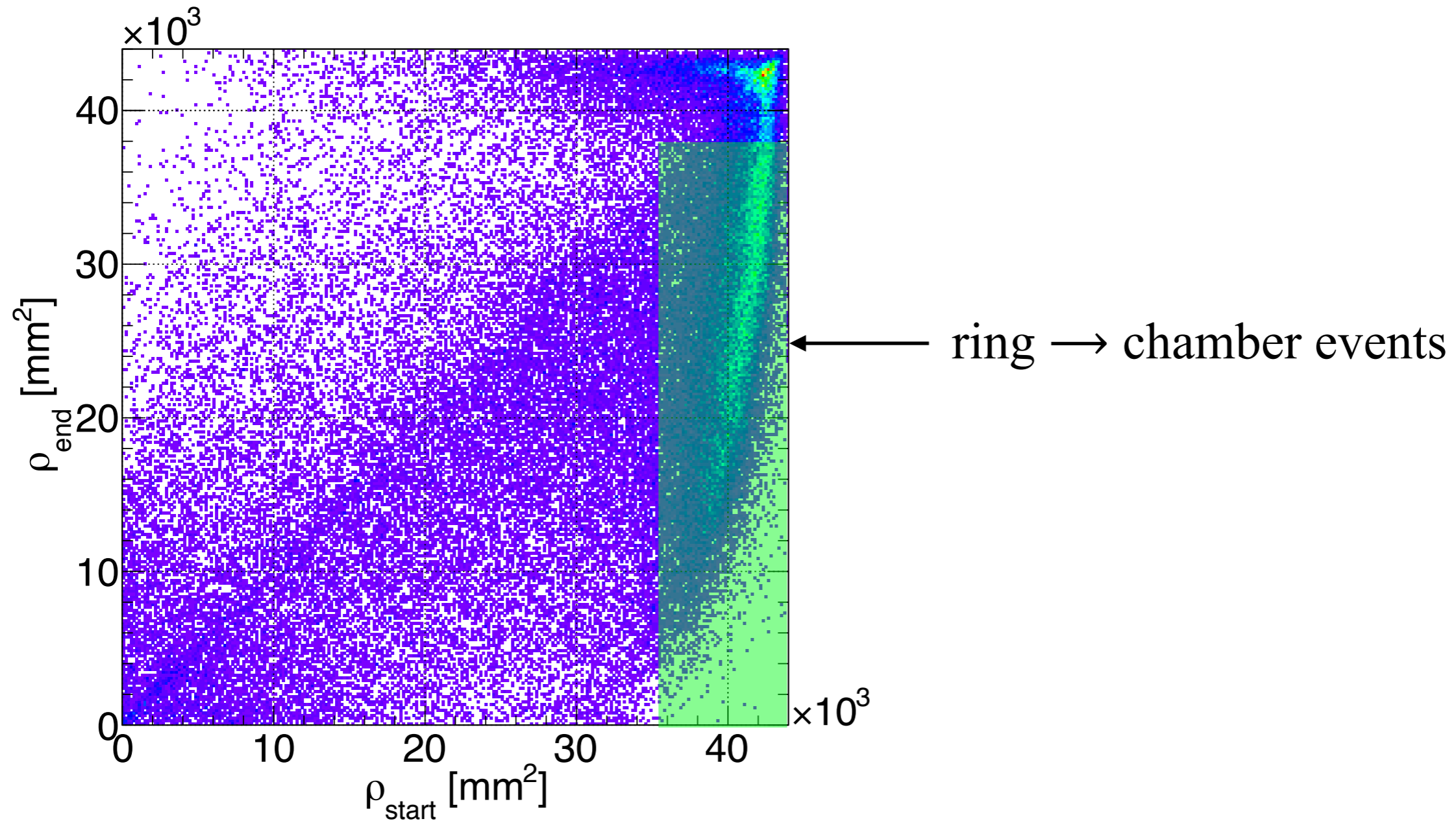
The positions of the beginning of the tracks allow a very good definition of the rings \rightarrow cut on ρ_{start} should reduce the alphas from the ring

Background Reduction : Ring α



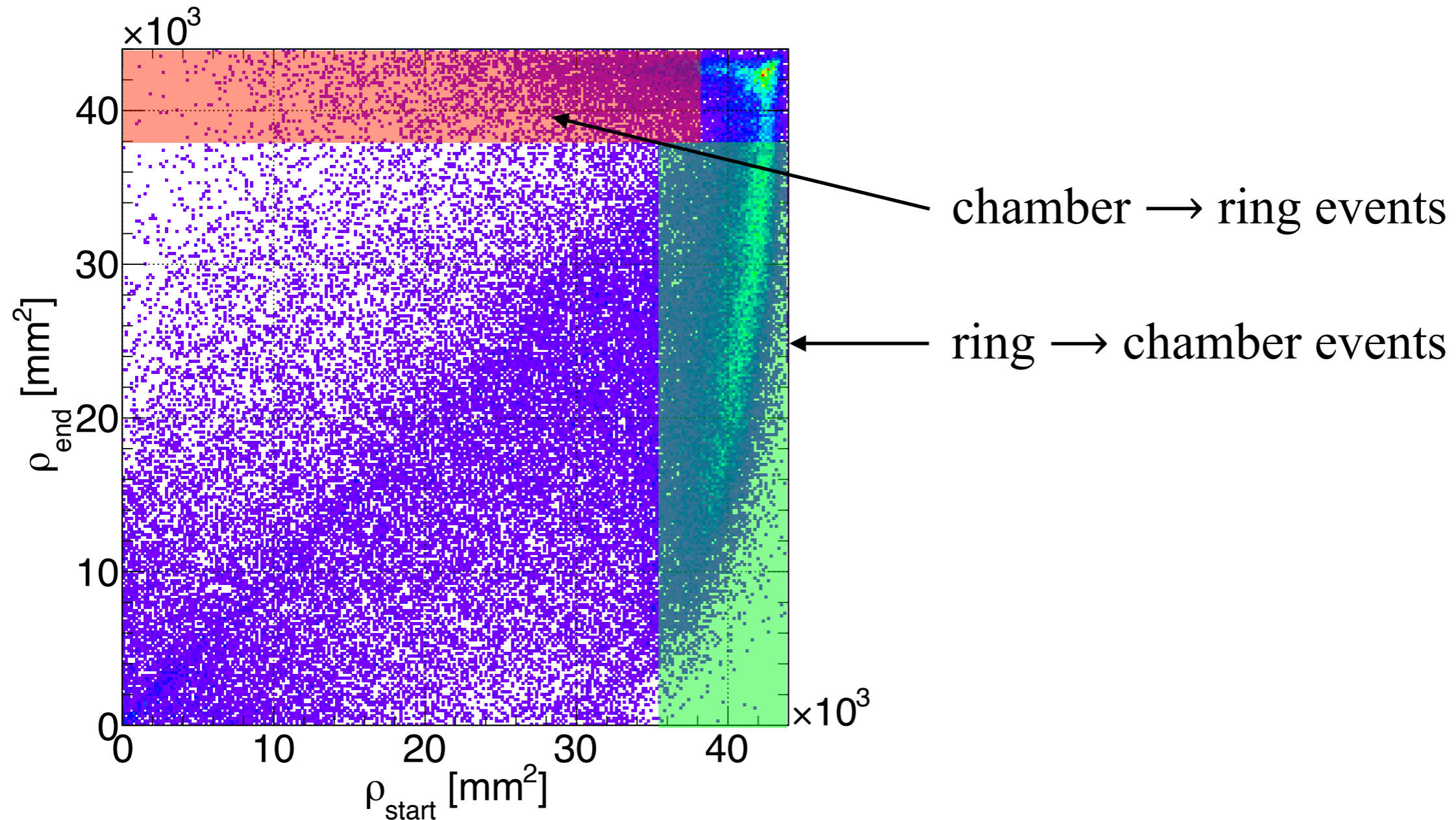
Some mis-reconstructed tracks : we have to apply a cut in ρ_{start} AND ρ_{end}

Background Reduction : Ring α



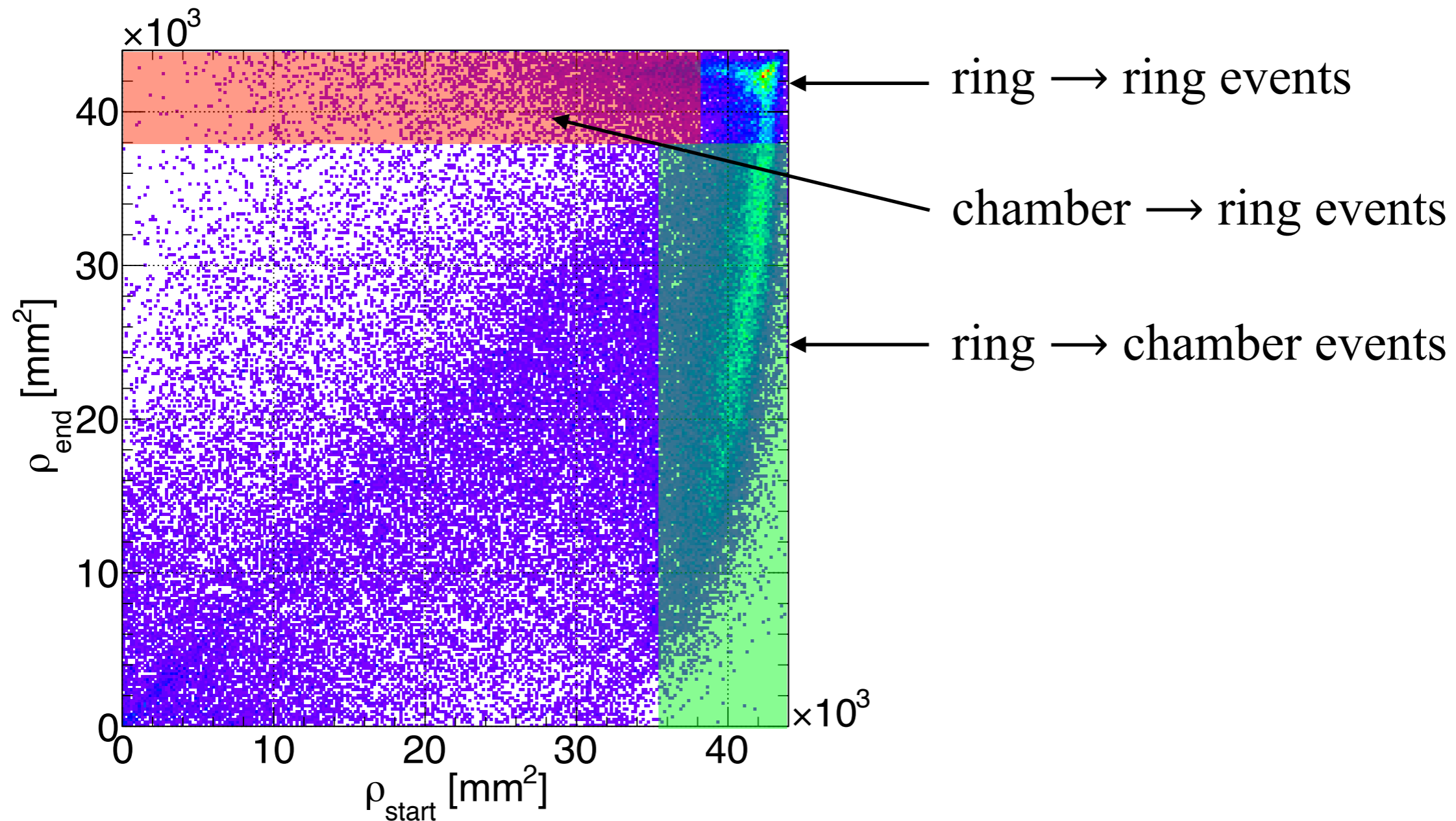
Some mis-reconstructed tracks : we have to apply a cut in ρ_{start} AND ρ_{end}

Background Reduction : Ring α



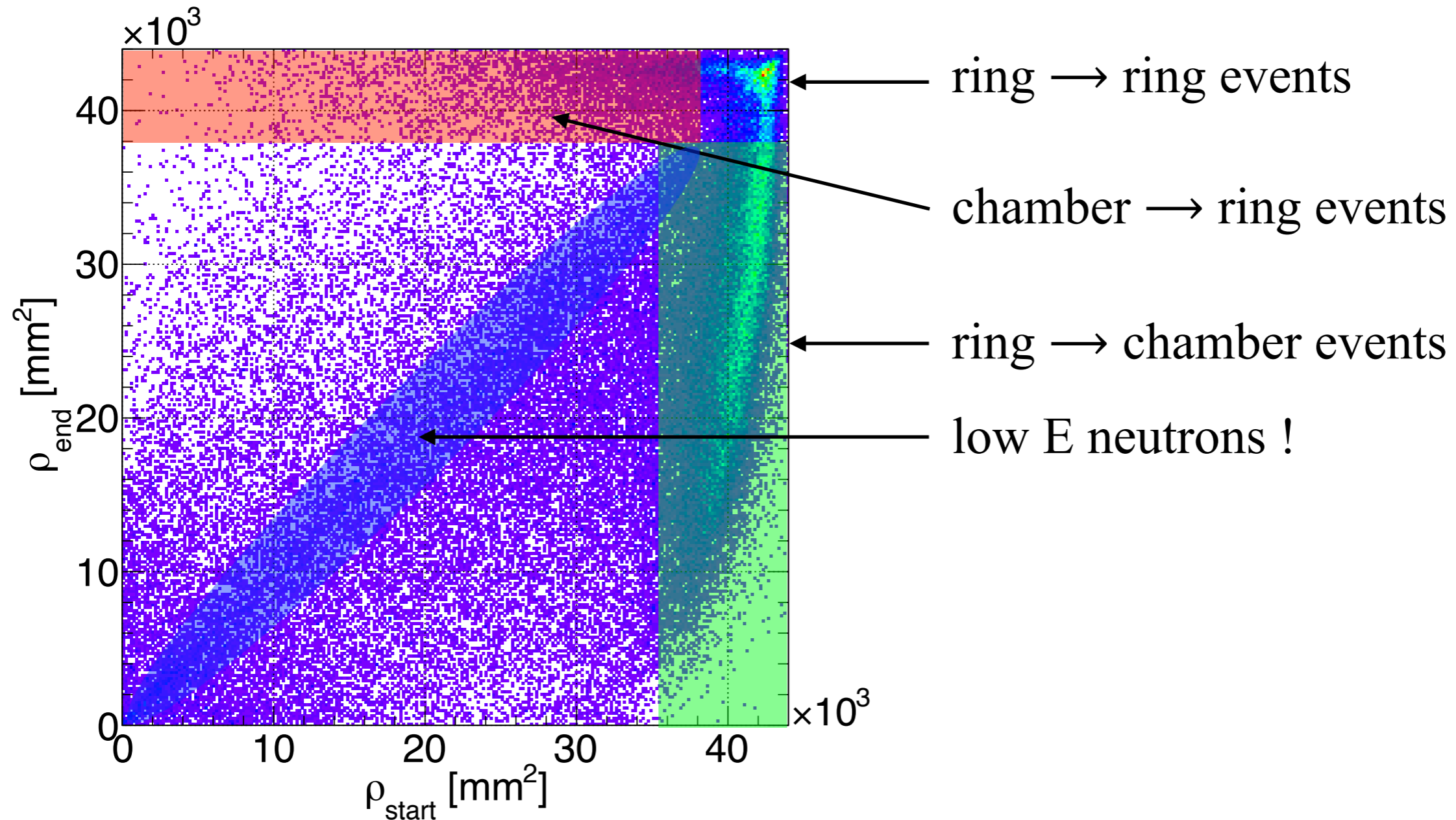
Some mis-reconstructed tracks : we have to apply a cut in ρ_{start} AND ρ_{end}

Background Reduction : Ring α



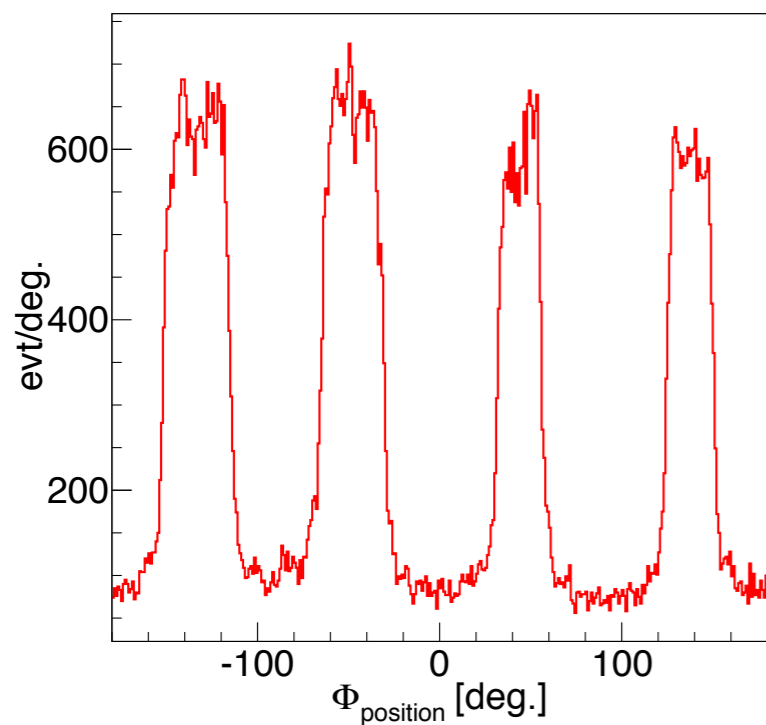
Some mis-reconstructed tracks : we have to apply a cut in ρ_{start} AND ρ_{end}

Background Reduction : Ring α

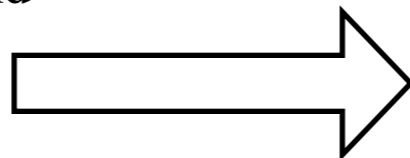


Some mis-reconstructed tracks : we have to apply a cut in ρ_{start} AND ρ_{end}

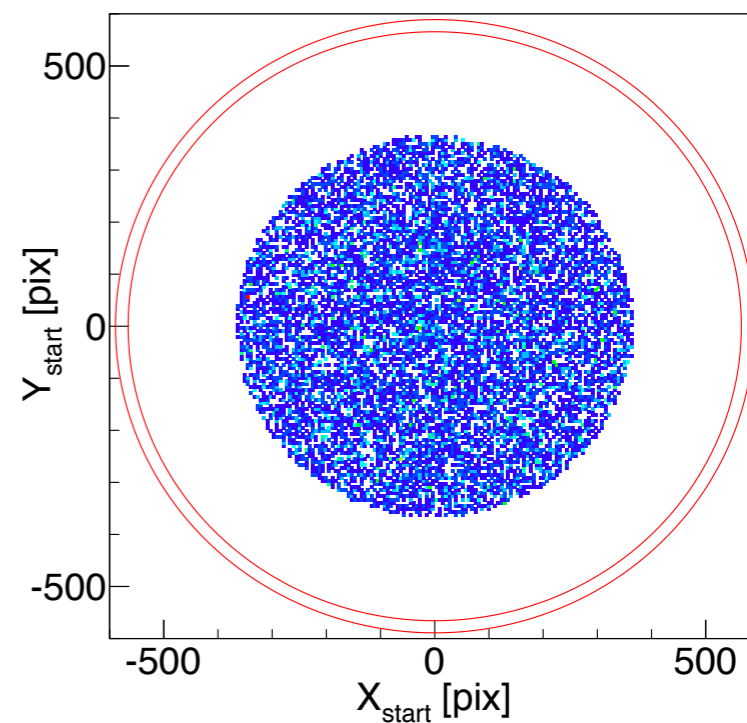
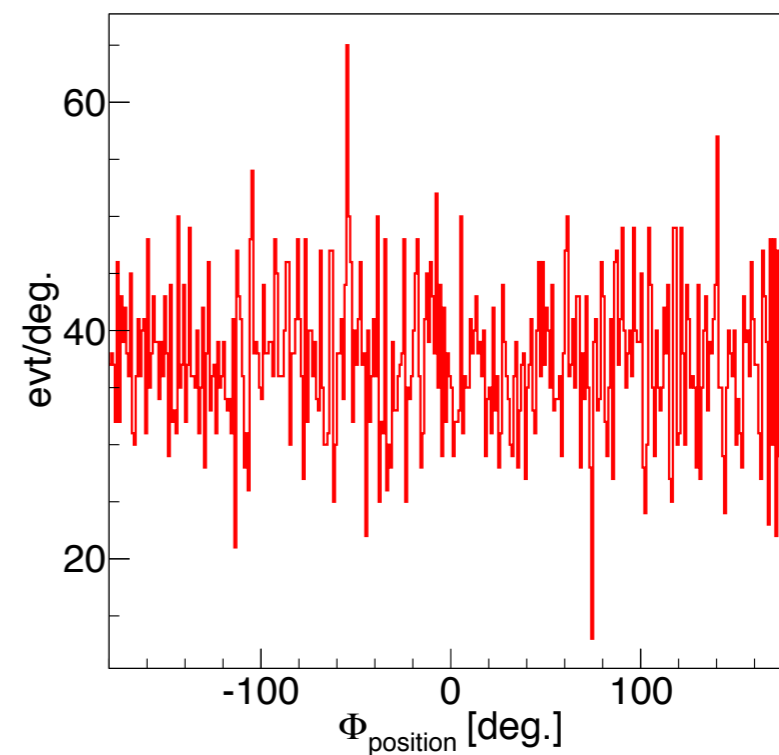
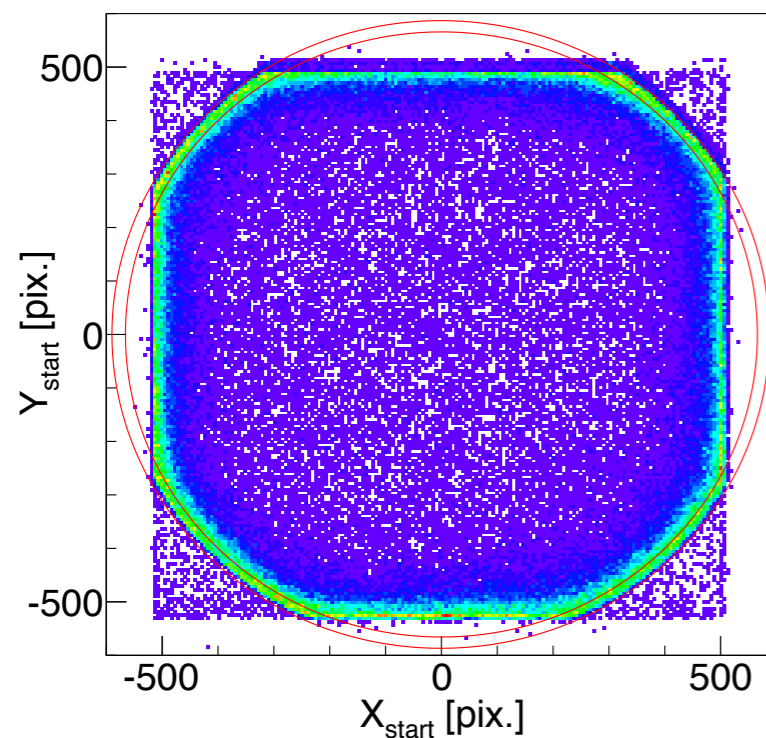
Background Reduction : Ring α



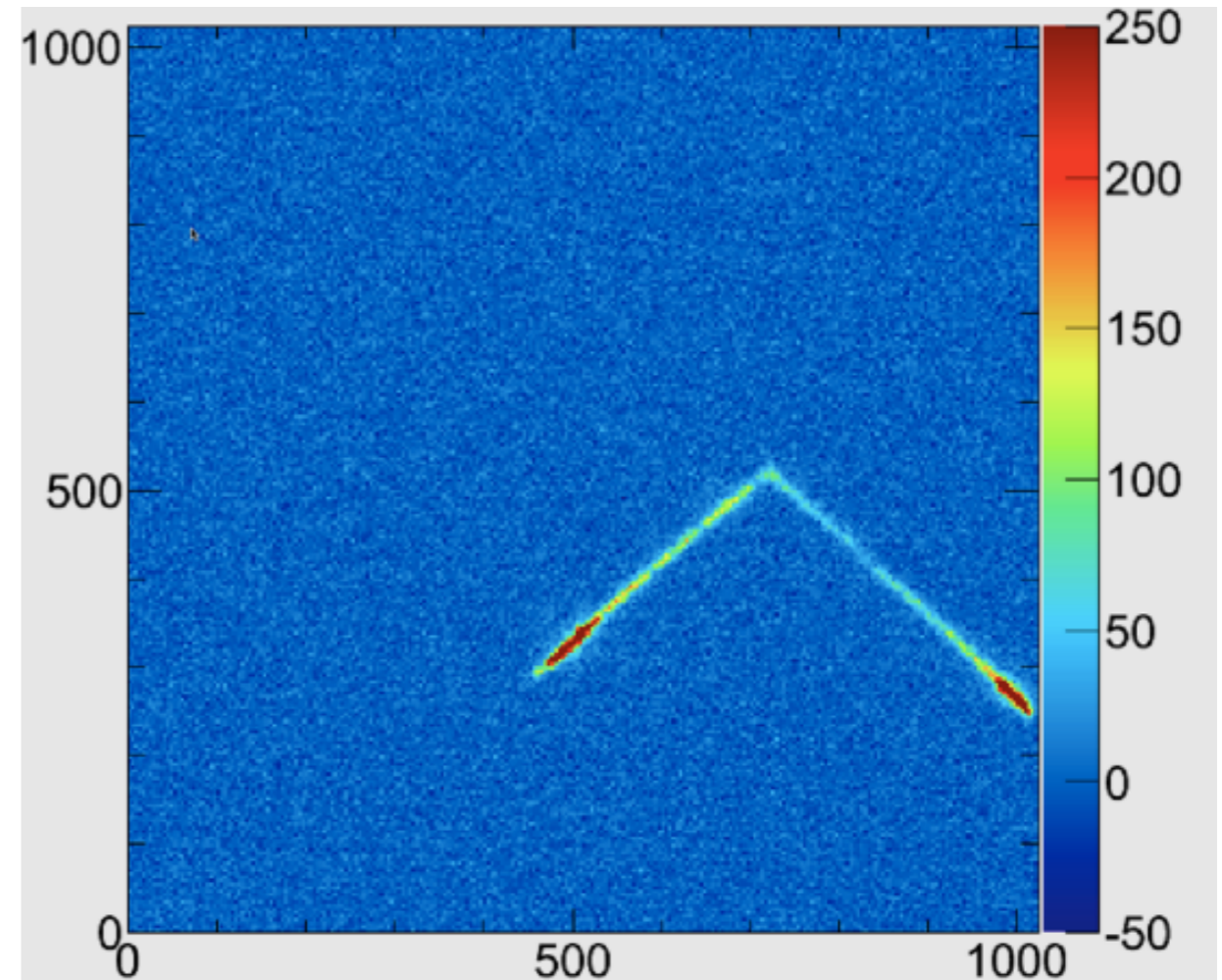
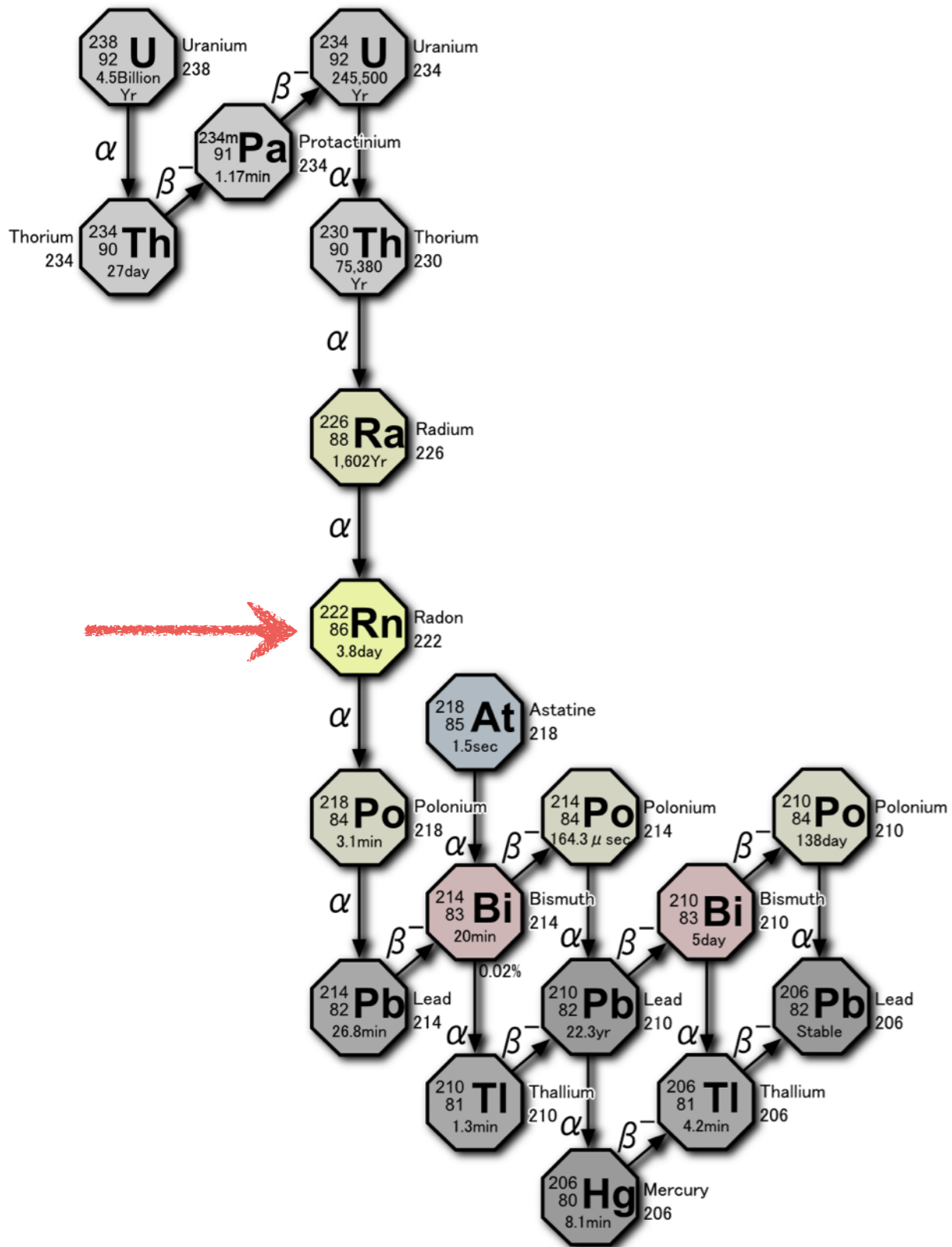
$\rho_{\text{start}} < 130 \text{ mm}$
 $\rho_{\text{end}} < 160 \text{ mm}$



no more edge
effect,
homogeneous
distribution in Φ



Alpha events



double α event

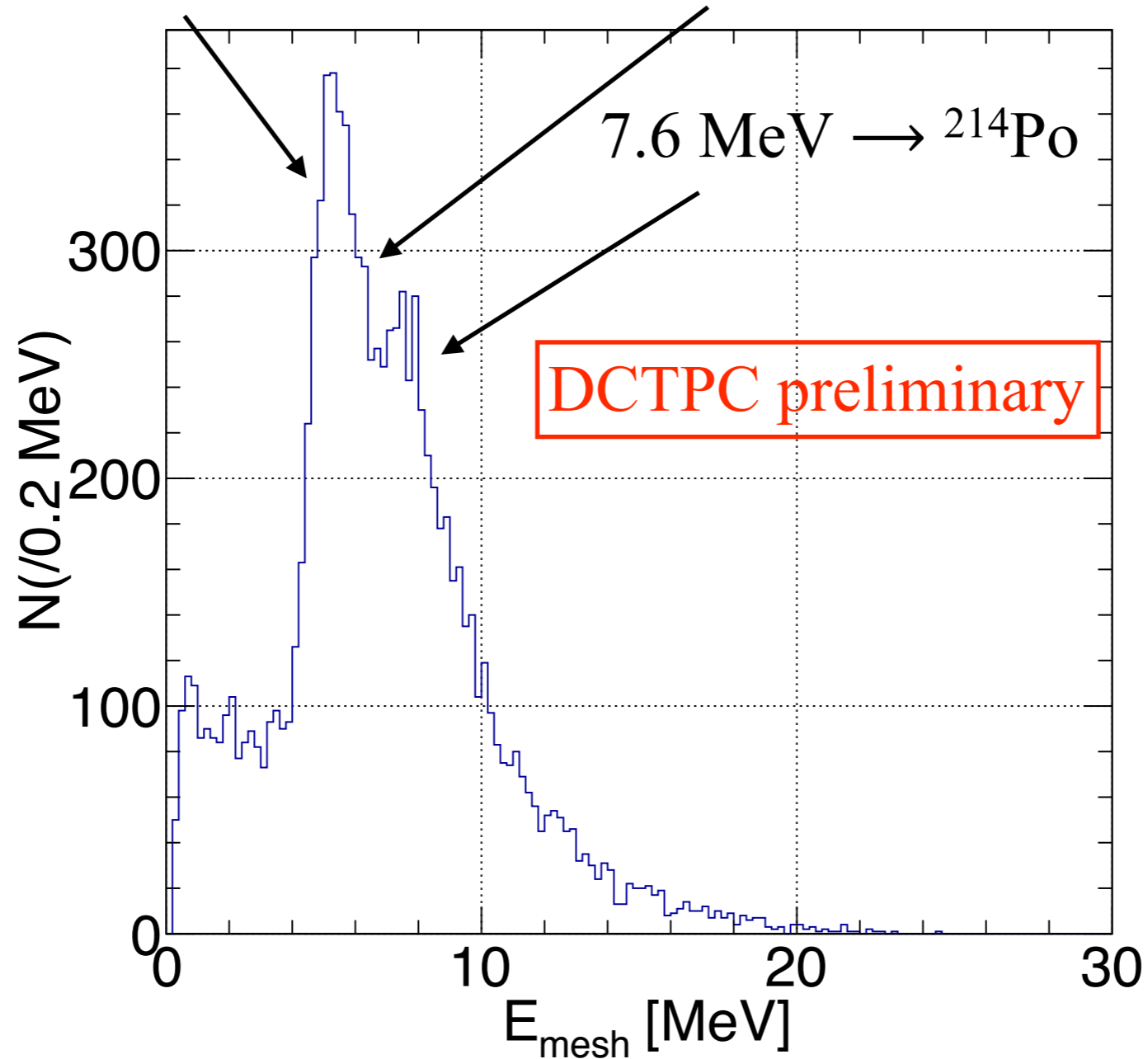
Observed spectrum

5.3 MeV \rightarrow ^{210}Po

5.4 MeV \rightarrow ^{222}Rn

6.0 MeV \rightarrow ^{218}Po

7.6 MeV \rightarrow ^{214}Po



high contamination of Po in our sample, we are still working on reducing it

Conclusion




- DCTPC has been taking data since February 2014
- The analysis is only beginning
- We start having a good understanding the detector's behavior
- We are now working on reducing the α background



More results to come very soon!

Stay tuned!

A circular opening in a copper mesh, possibly a skylight or a decorative element. The mesh is made of concentric rings of copper wire. In the center of the opening, there is a shadow of a person, likely the photographer, cast onto a light-colored, possibly wooden or stone, surface. The lighting is warm and directional, creating strong highlights and shadows.

Thank you for you attention!