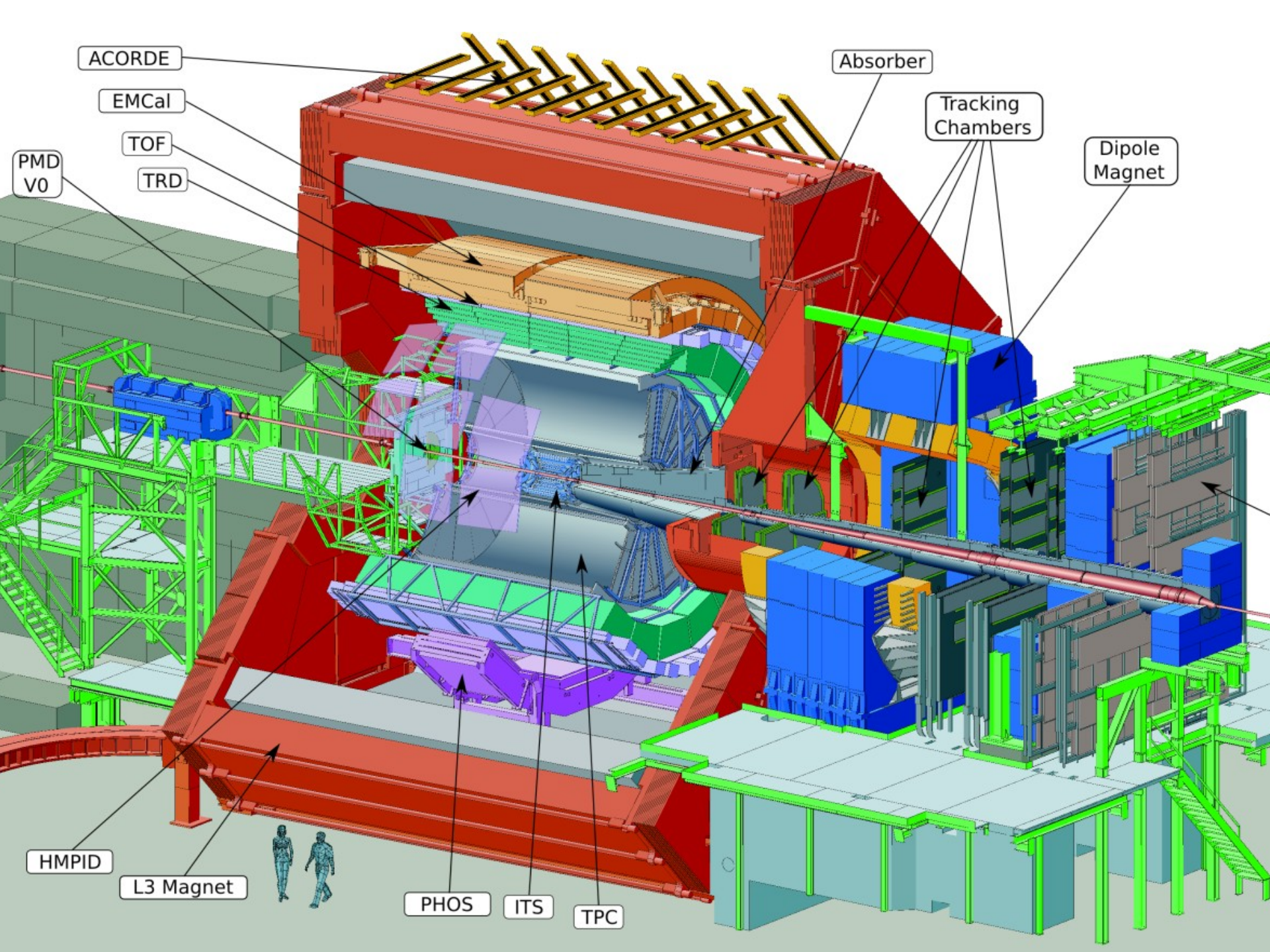
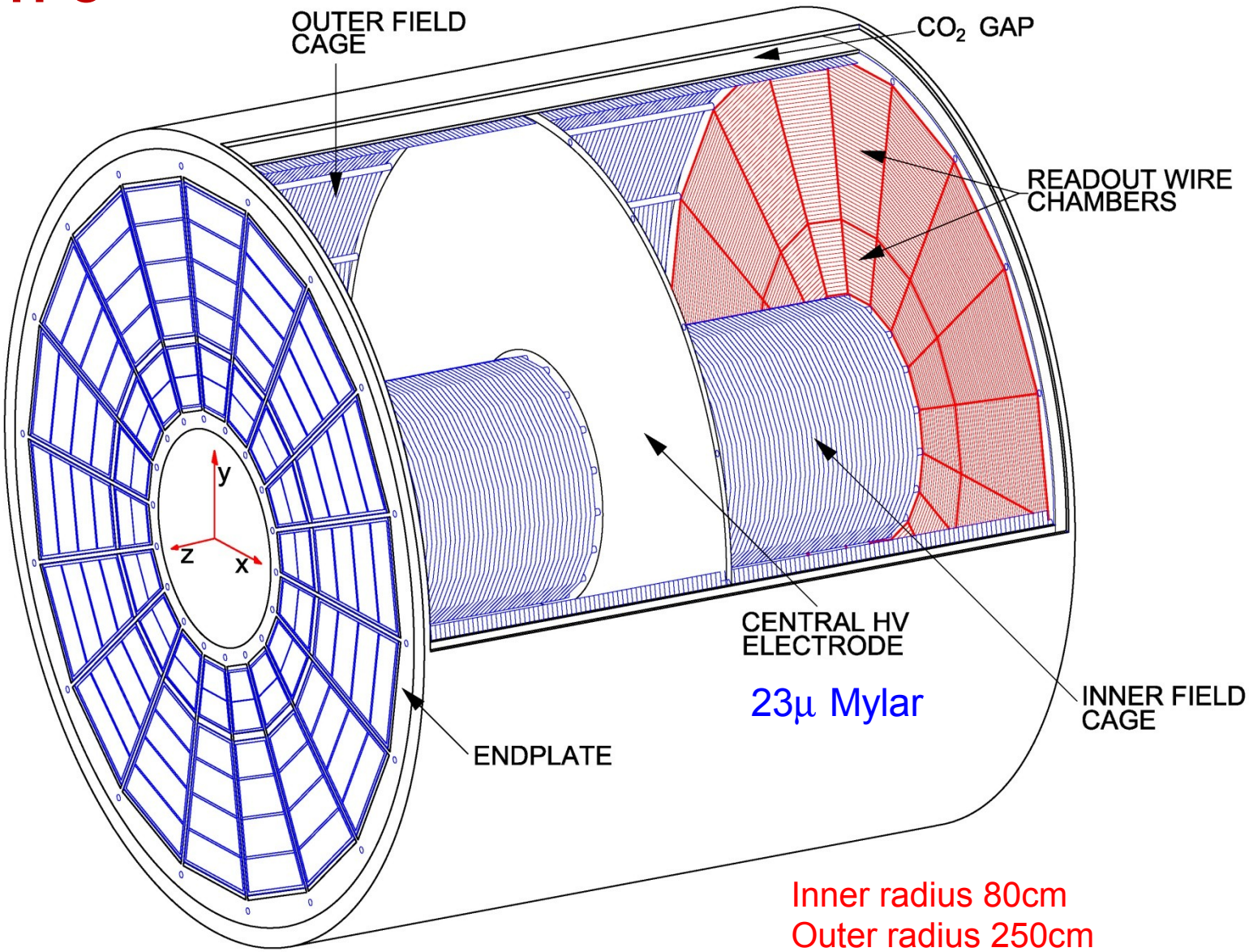
ALICE TPC

Danilo Vranic
on behalf of the ALICE TPC Collaboration
20th of October, 2010


ACORDE
EMCal
TOF
TRD
PMD
V0
Absorber
Tracking
Chambers
Dipole
Magnet
HMPID
L3 Magnet
PHOS
ITS
TPC

ALICE TPC



Inner radius 80cm
Outer radius 250cm
Length 2x250cm

ALICE TPC is a large volume Time Projection Chamber with overall 'conventional' lay-out but designed for extreme high track density expected in Pb-Pb collisions at LHC energy.

GAS CHOICE

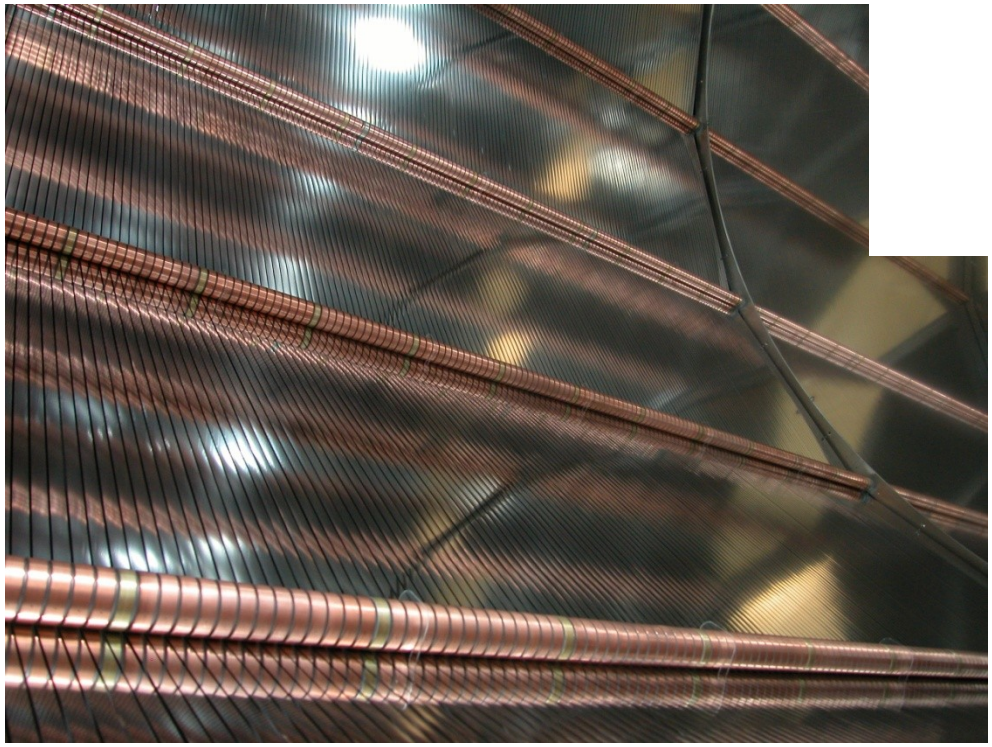
Ne because:
less material, faster ion mobility (less space charge effect), low diffusion
Quencher: **CO_2** (minimized ageing)+ N_2.

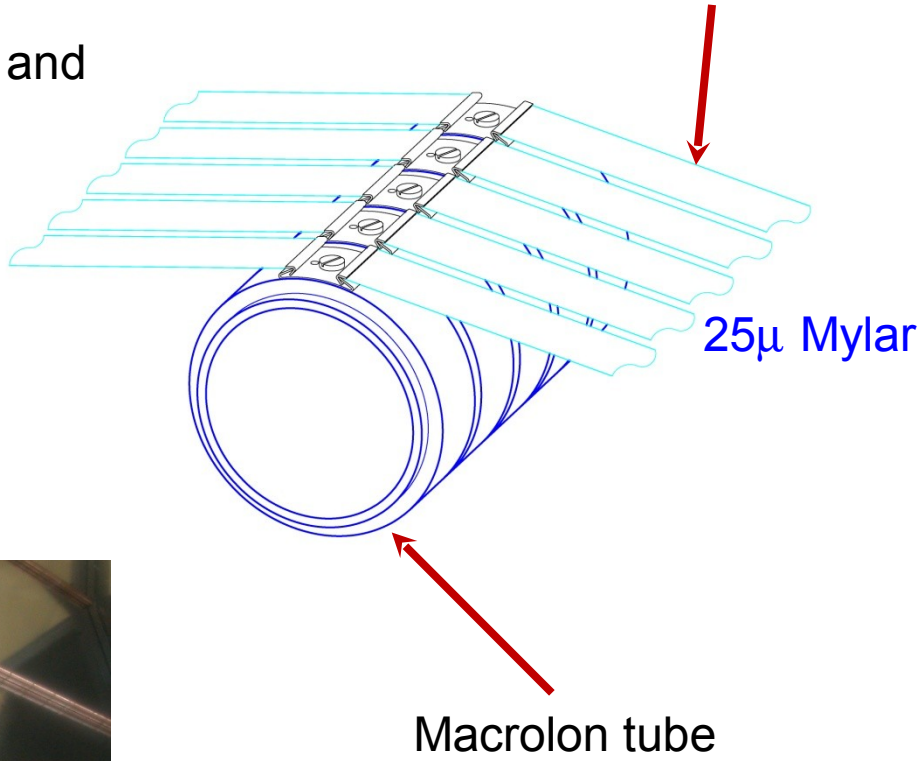
Active volume: 90 m^3
Final gas mixture: Ne-CO_2-N_2: 85.7% - 9.5% - 4.8%
(N_2 added to improve quenching at high gain)
Cool gas - low diffusion
Non-saturated drift velocity u temperature stability and homogeneity $\leq$ 0.1 K
Gain ~ 10^4

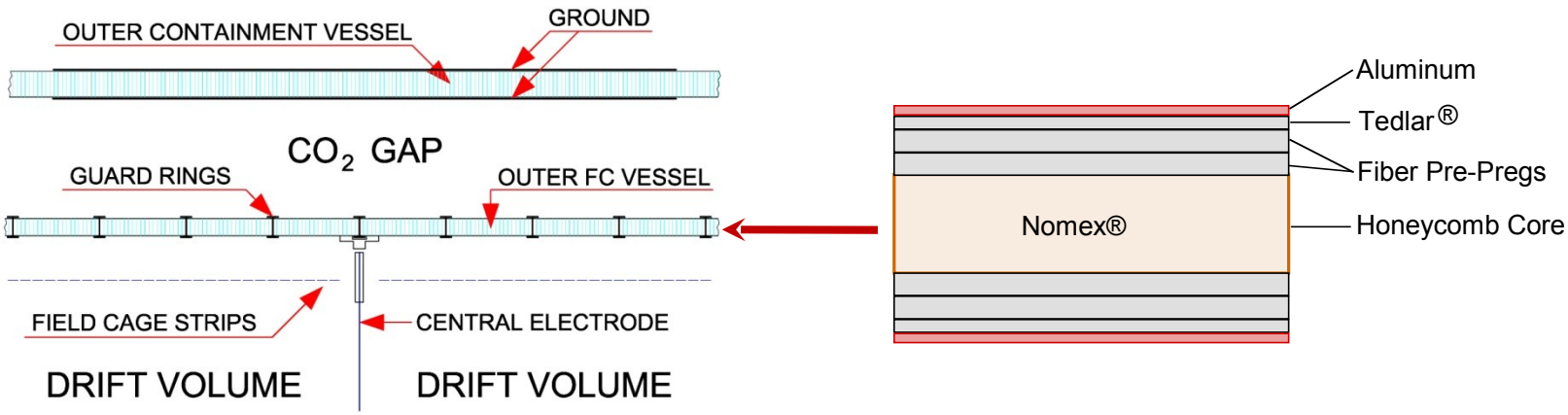
With this gas mixture we need 400V/cm in the field cage!

ALICE TPC Field cage is made of free standing aluminized Mylar strips

More complicate system but very stable and reliable for high drift voltages.



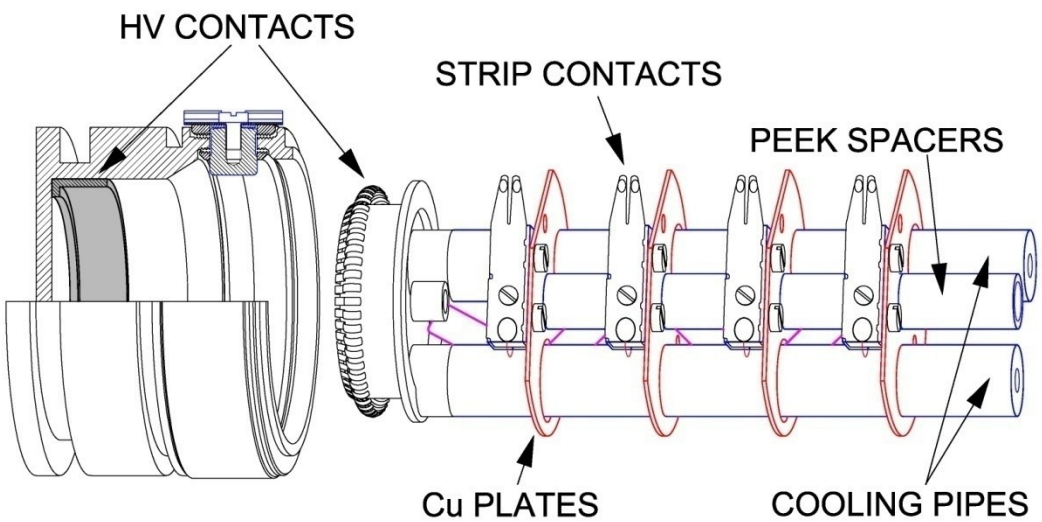




The ALICE field cage consists of two parts; a field cage vessel with a set of coarsely segmented guard rings and finely segmented field cage which is located inside the field cage vessel.

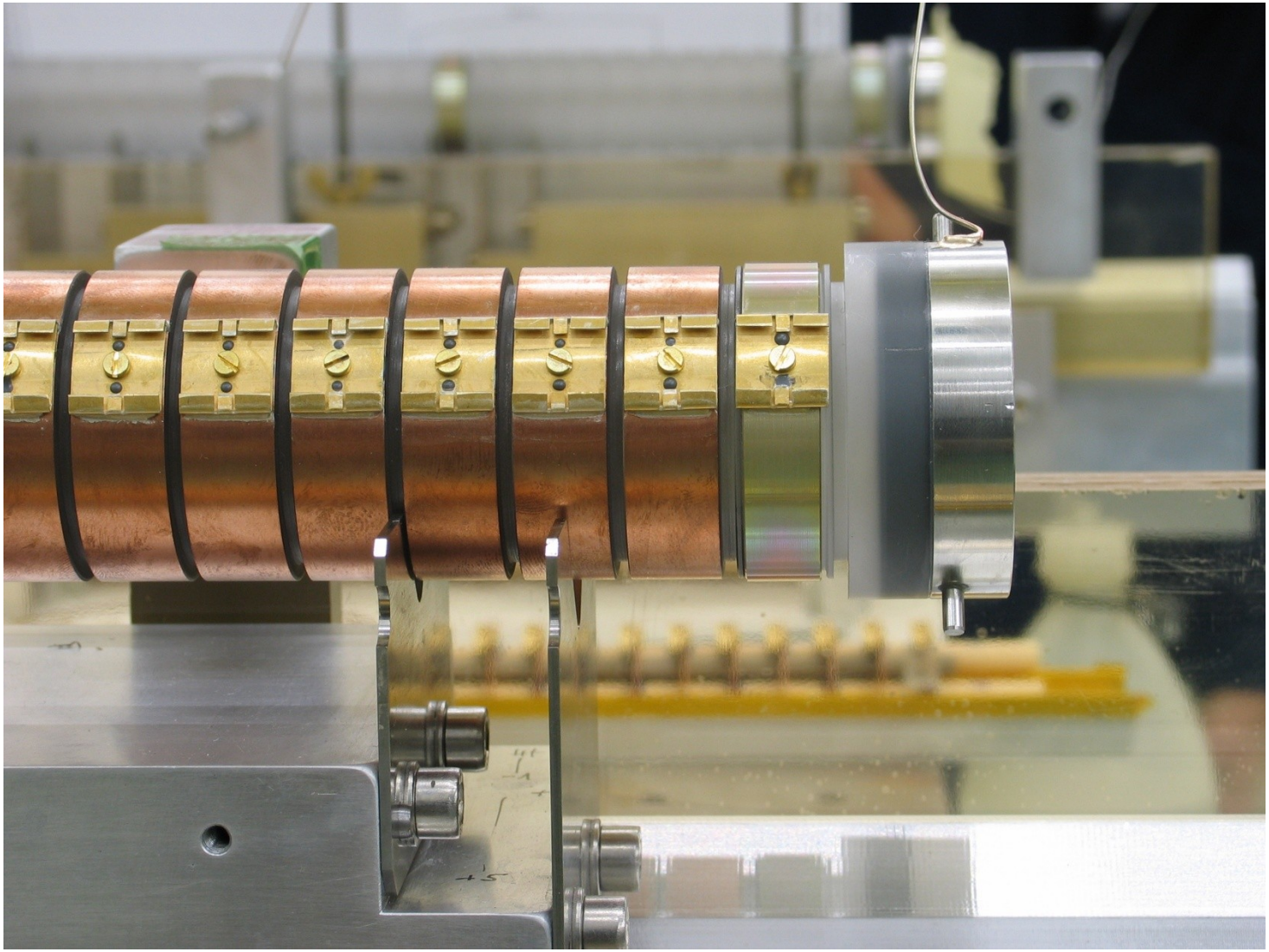
For temperature stability and homogeneity ≤ 0.1 K

Leakless cooling system including FC Resistor rod

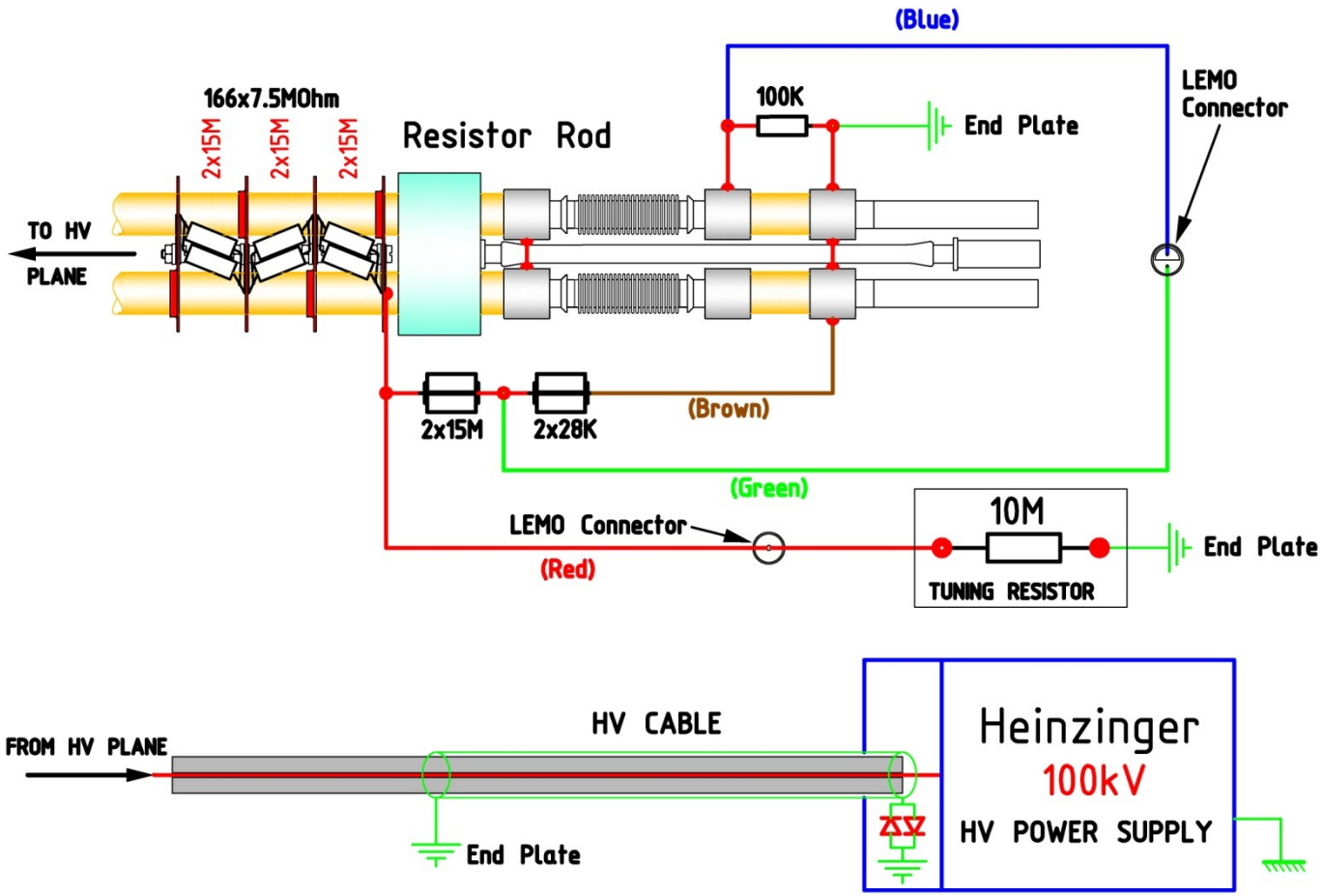


To monitor the temperature distribution
~500 PT1000 sensors are mounted both inside and outside of the gas volume

RESISTOR ROD WITH WATER COOLING – OUTER PART



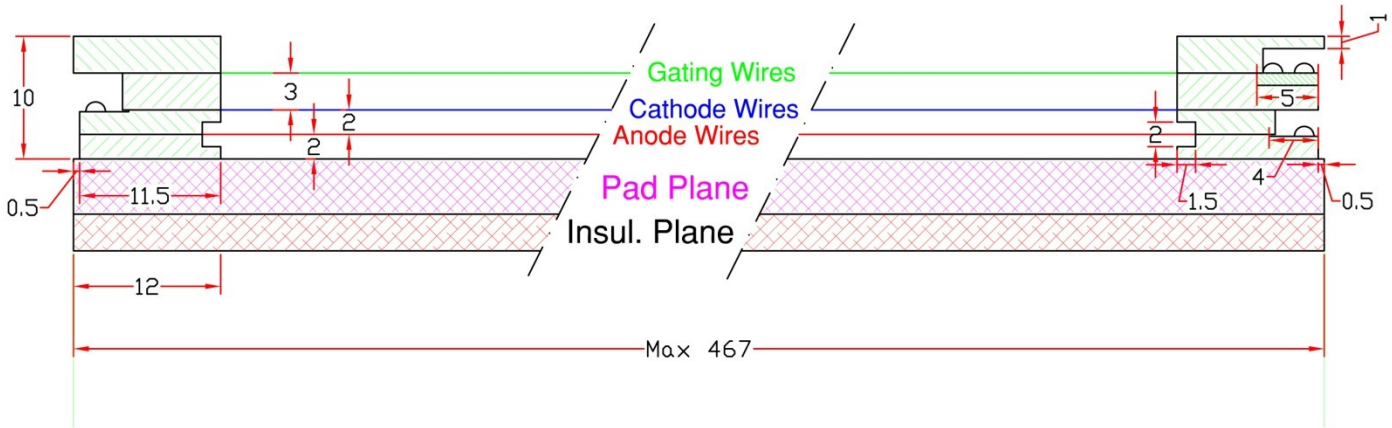
RESISTOR ROD - MECHANICAL AND ELECTRICAL ARRANGEMENT



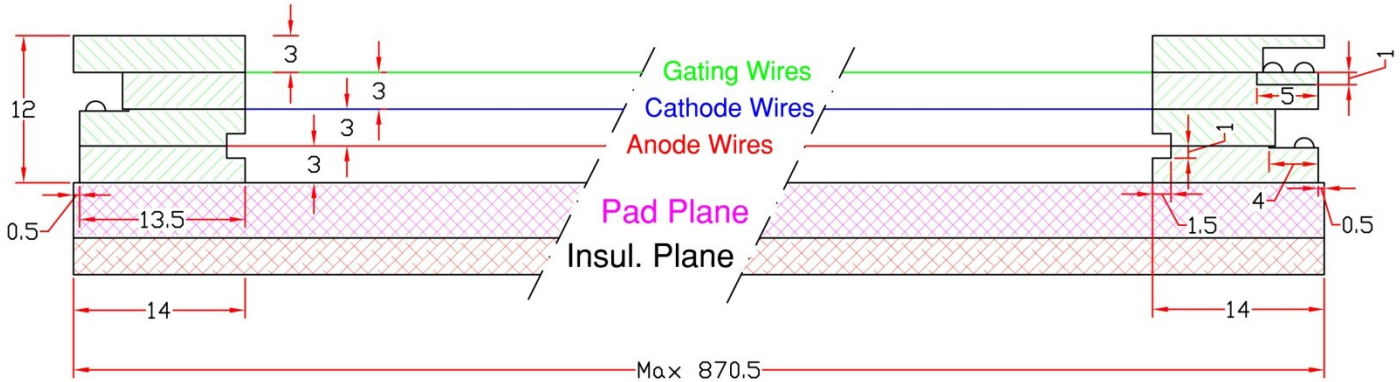
READ-OUT CHAMBERS DESIGN

MWPCs with pad-readout with extra optimization for high rate and high track density.

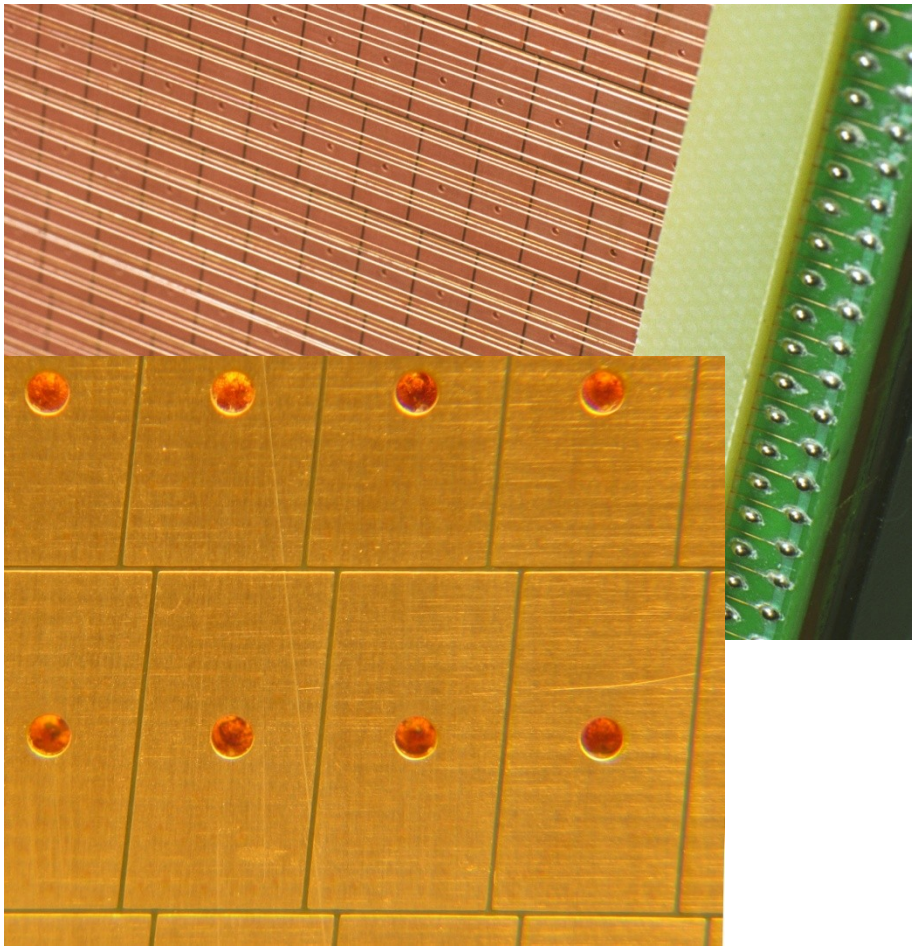
Inner Chamber



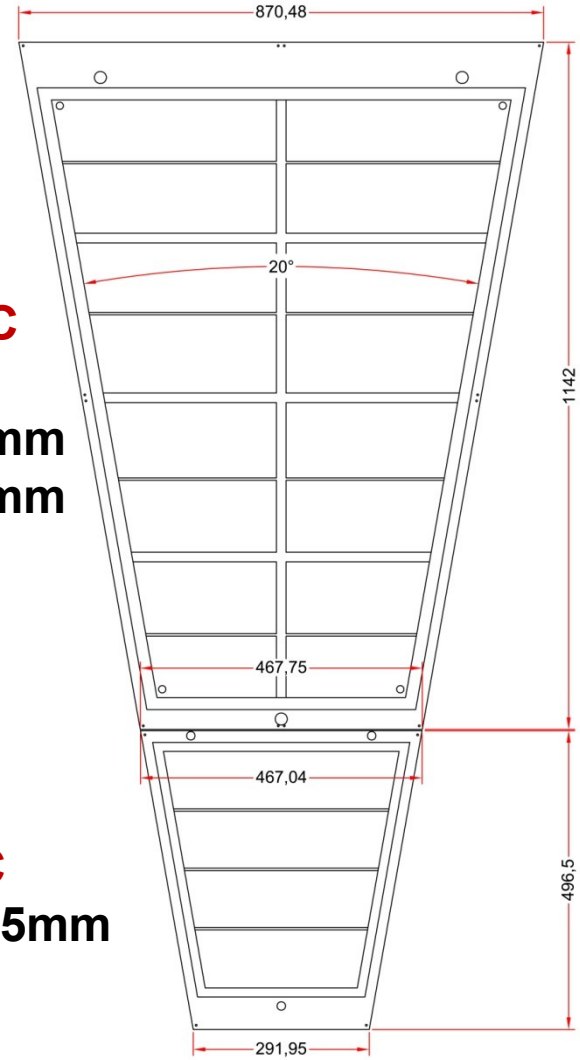
Outer Chamber



READOUT CHAMBERS



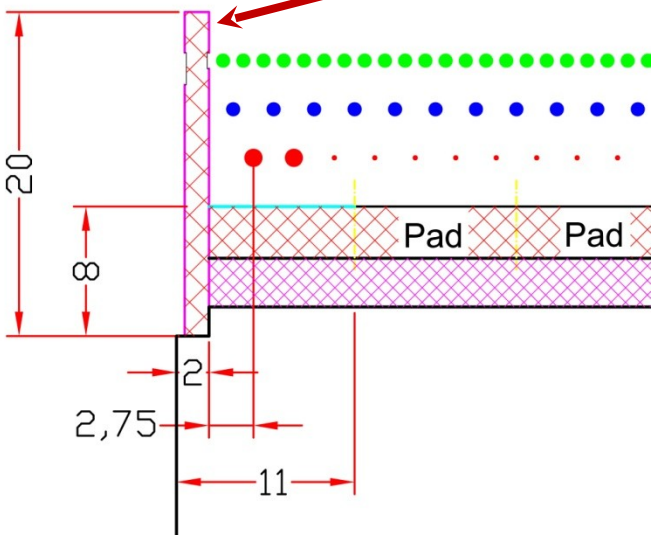
ONE OF THE 36 SECTORS



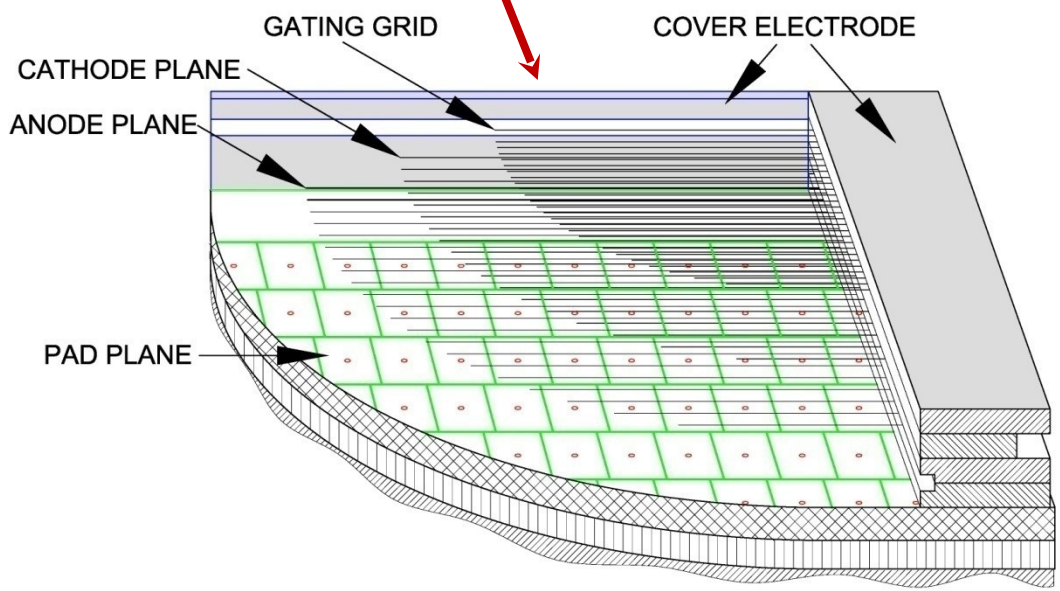
OROC
pads
6x10mm
6x15mm

IROC
pads 4x7.5mm

Positive ion leakage protection ('cover electrode')



Gating-wire grid
Cathode-wire grid
Anode-wire grid

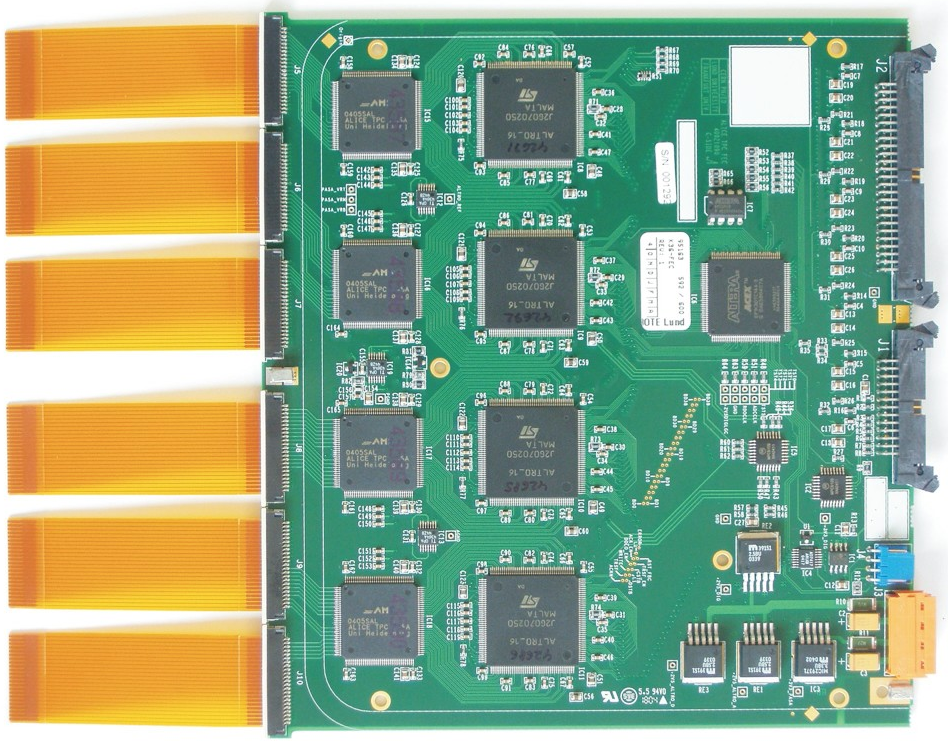


Very important to minimize ion leakage into drift volume

FRONT END ELECTRONICS AND READOUT

The signals from 557 568 pads are passed to Front-End Cards (FEC) via 7cm long flexible Kapton cables.
FEE is designed to cope with a signal occupancy as high as 50%. Furthermore the extremely large raw data volume (750MB/event) requires the zero suppression already in the FEE in order to fit events at the foreseen event rate into the DAQ bandwidth (216 links at 160 MB/s)

FEC with Kapton cables for 128 inputs.

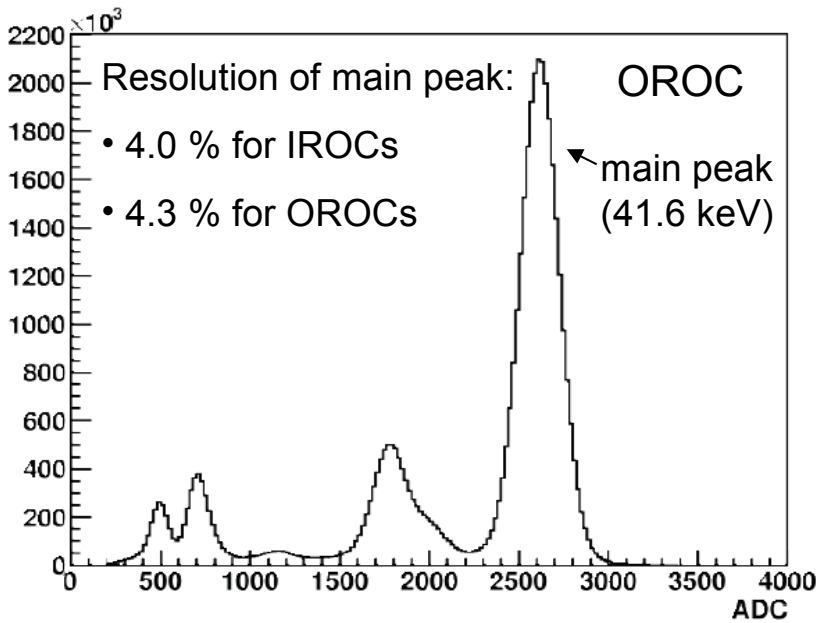


Commissioning

- Mean noise level:
  - 0.7 ADC count (700 e)
  - Designed - 1 ADC count (1000 e)
- Data volume of empty event:
  - ZS event: ~ 30kB
  - non-zero suppressed (ZS): ~ 700MB
- Typical size of the event with data:
  - 0.1 - 1 MB (p - p)
    - 360 kB TPC @ 7 TeV
  - ~ 30 MB (Pb - Pb, dN/dy = 2000 -> expected)

Commissioning

Gain calibration using Kr



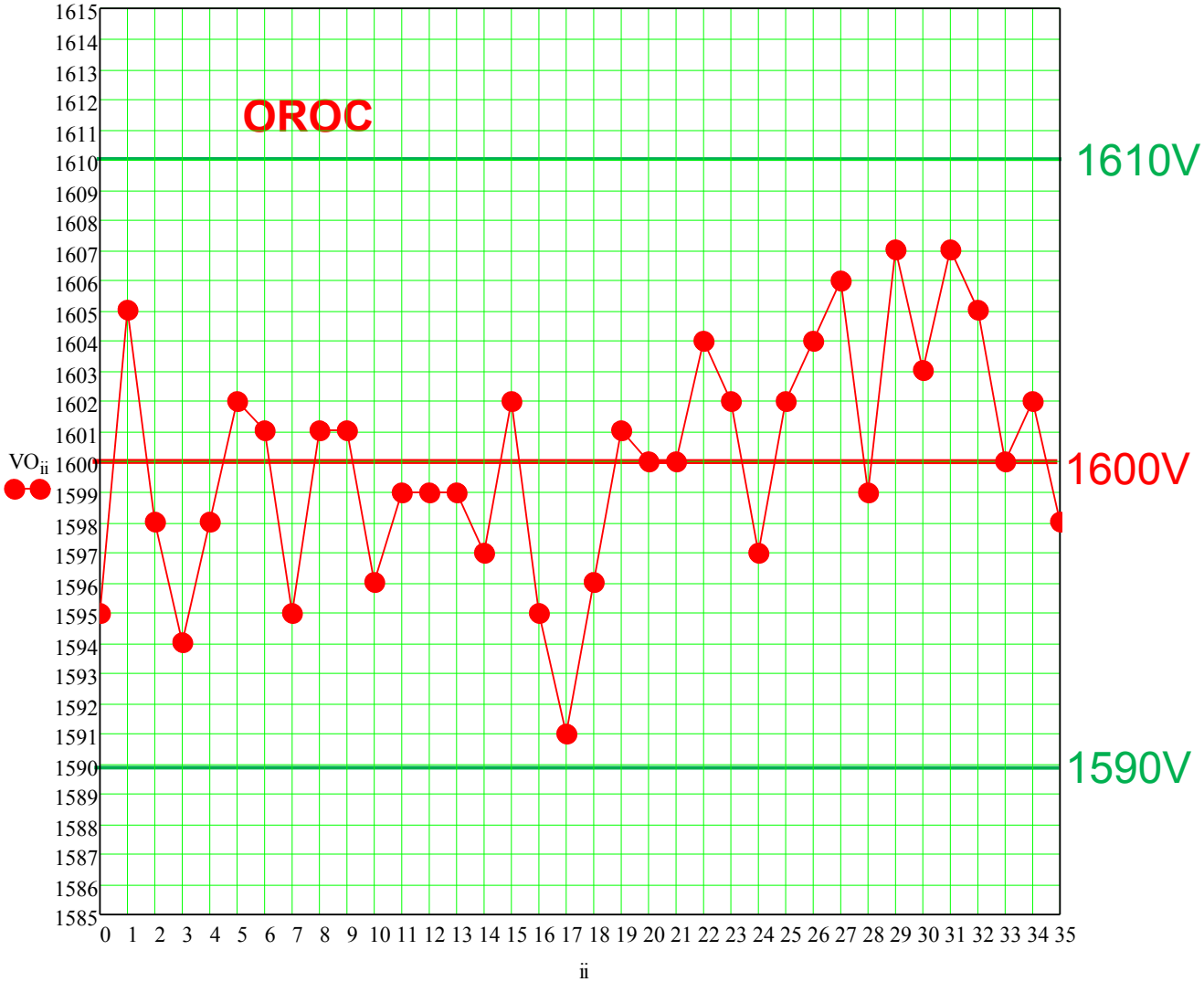
Determine gain for each pad

- 3 different HV settings (gains)
- High statistics: several 10^8 Kr events
- Accuracy of peak position: << 1% (design: 1.5%)

-> recent development:

Equalization on the sector-voltage level

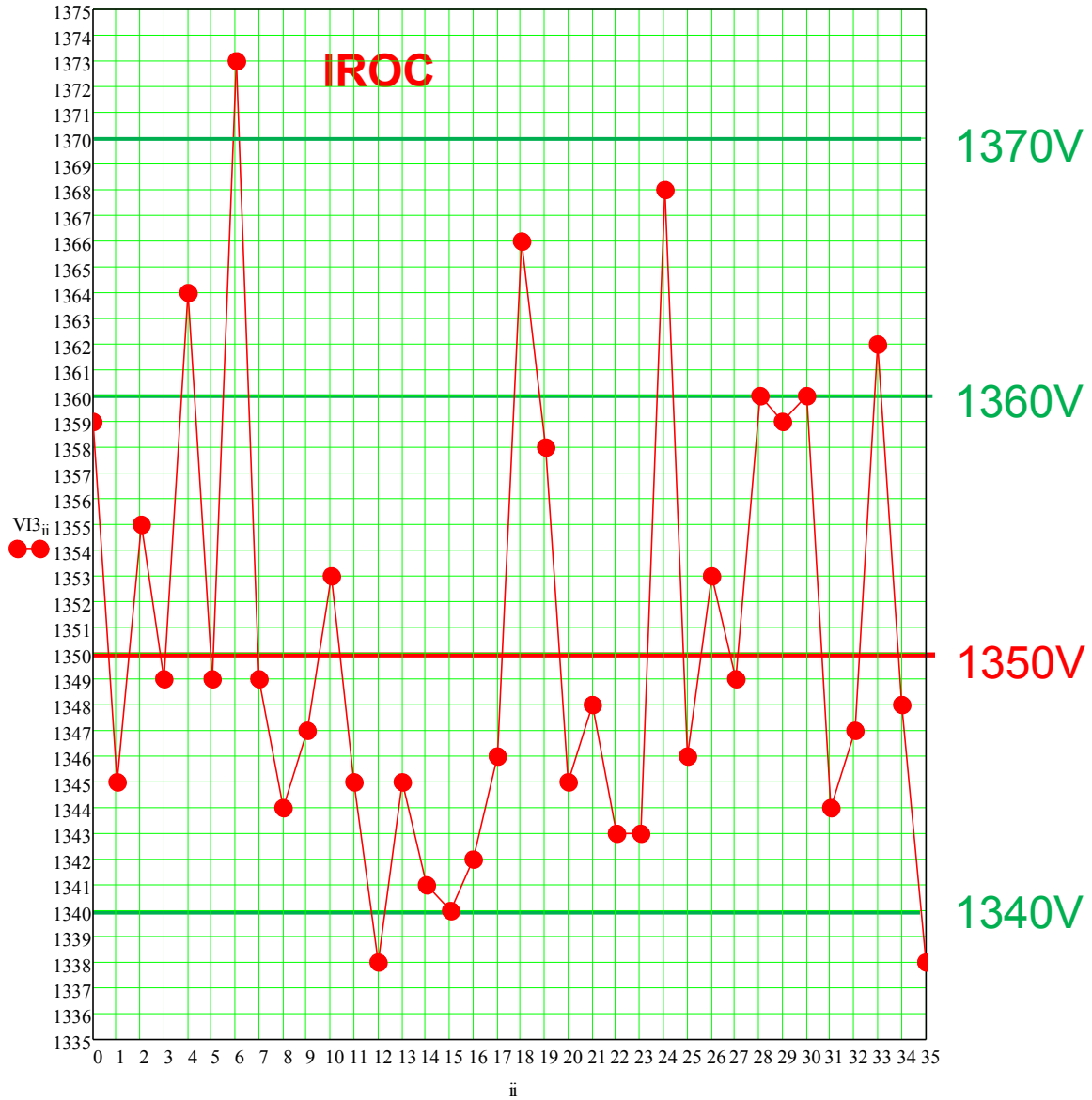
OROC GAIN EQUALIZATION



V_{max}=1607V

V_{min}=1591V

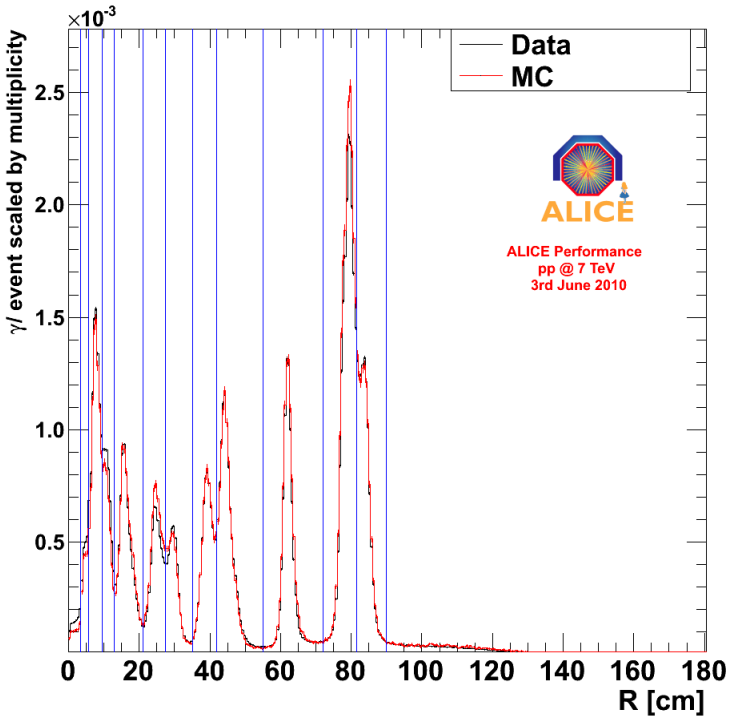
IROC GAIN EQUALIZATION



Material budget

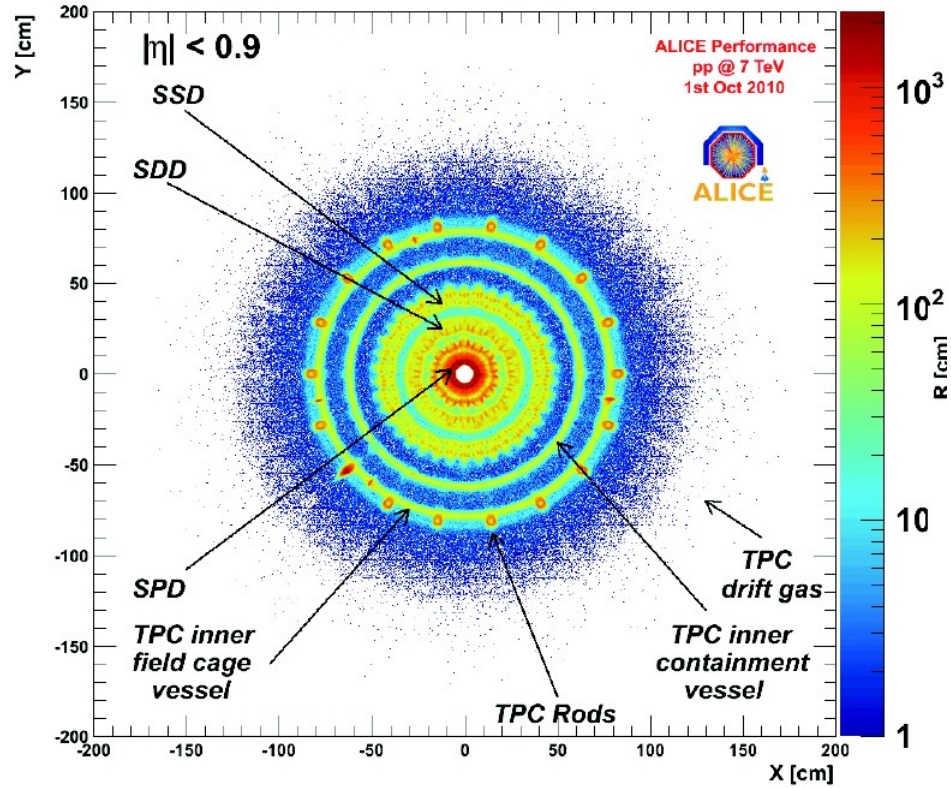
Inner FC 1.367% X/Xo

Radial distribution



TPC begins here

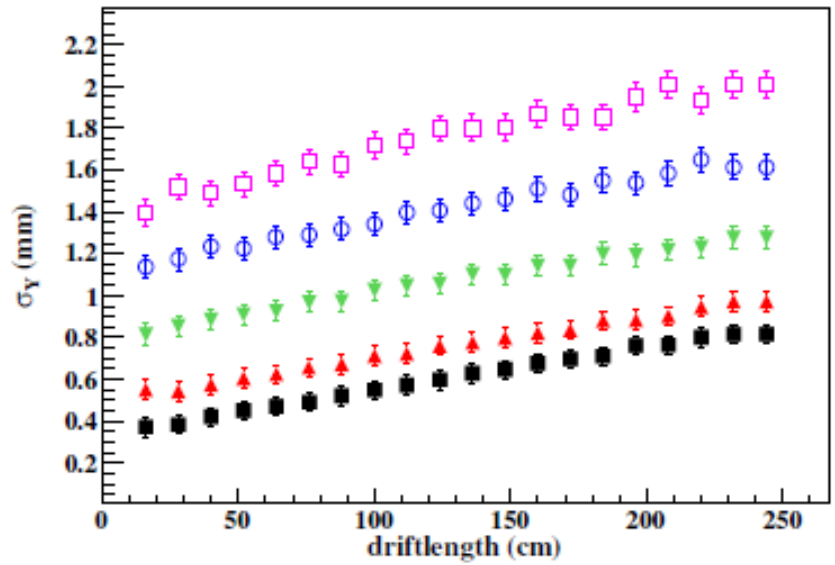
Outer FC 2.153% X/Xo

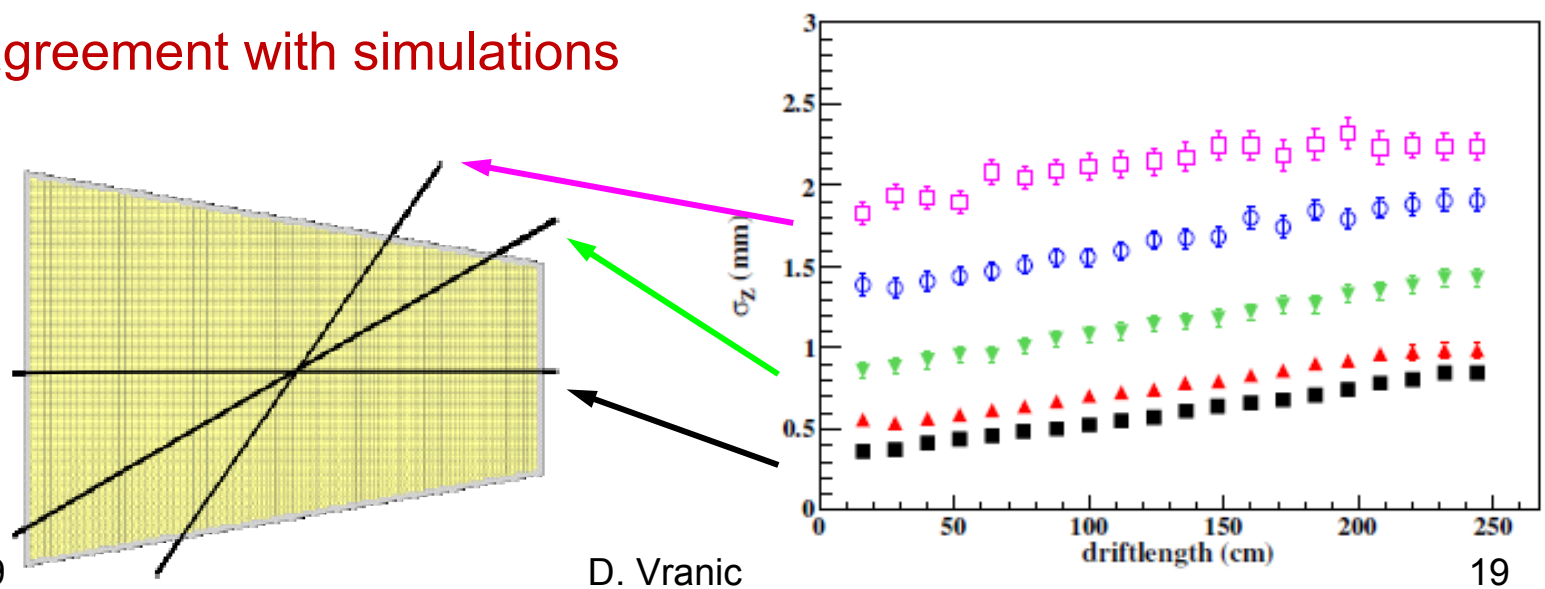


Agreement between MC and DATA: 5.5% in |η|<0.9

Space point resolution

- Depends on:
  - Drift length
  - Inclination angle
  - Charge deposited on the anode wire
- In rφ direction: σ_Y = 300 - 800 μm
  - for small inclination angles (high momentum tracks)
- In drift direction: σ_Z = 300 - 800 μm
- Good agreement with simulations

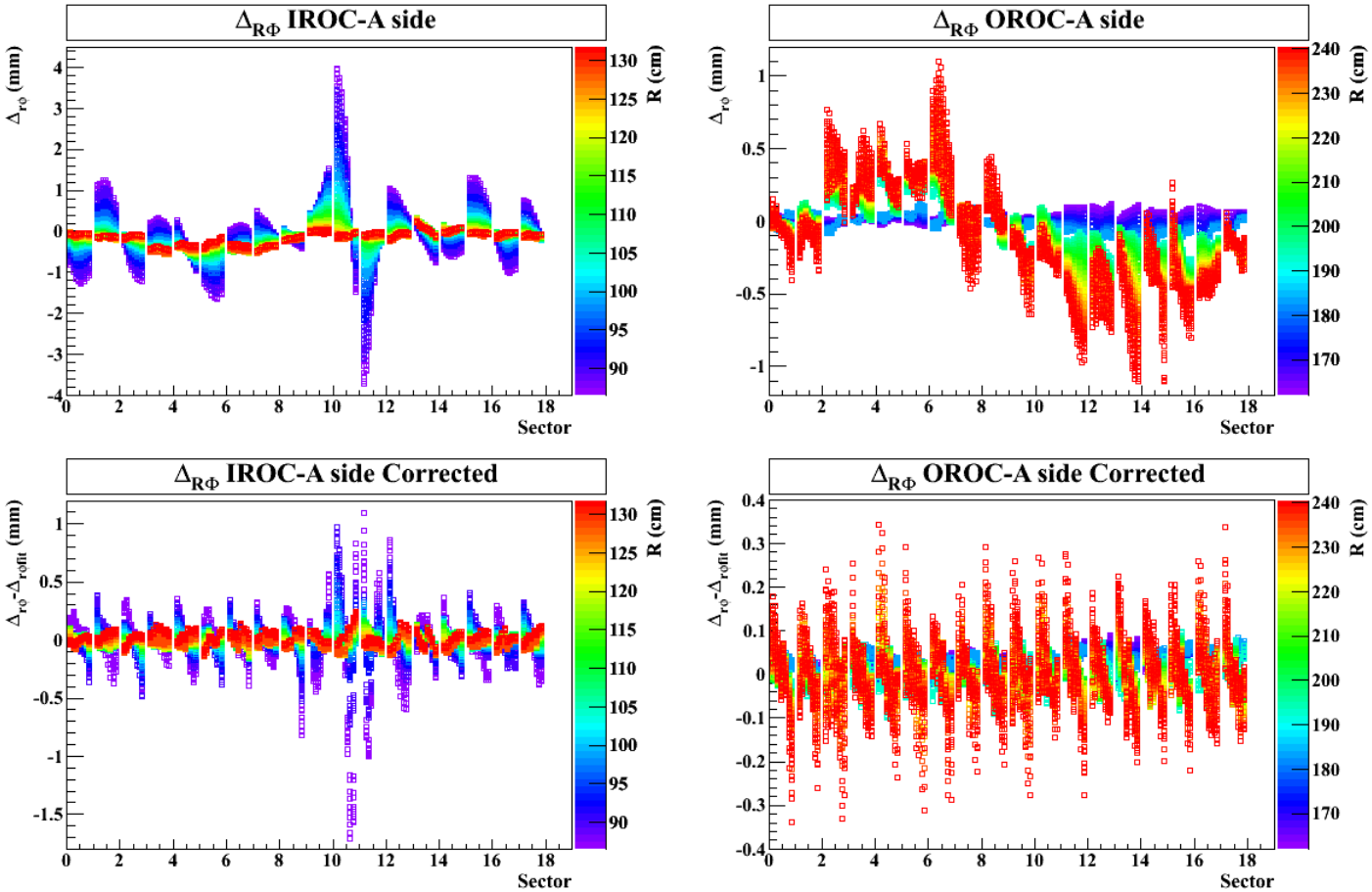




- gain & drift velocity calibration very good
  - now working on local, static field distortions (mechanical tolerances/deformations)
    - track distortions reduced by factor 4-5 (< 500 μm close to Field Cage)
    - required to go to higher momenta

Track Distortions Before Corrections

After Corrections



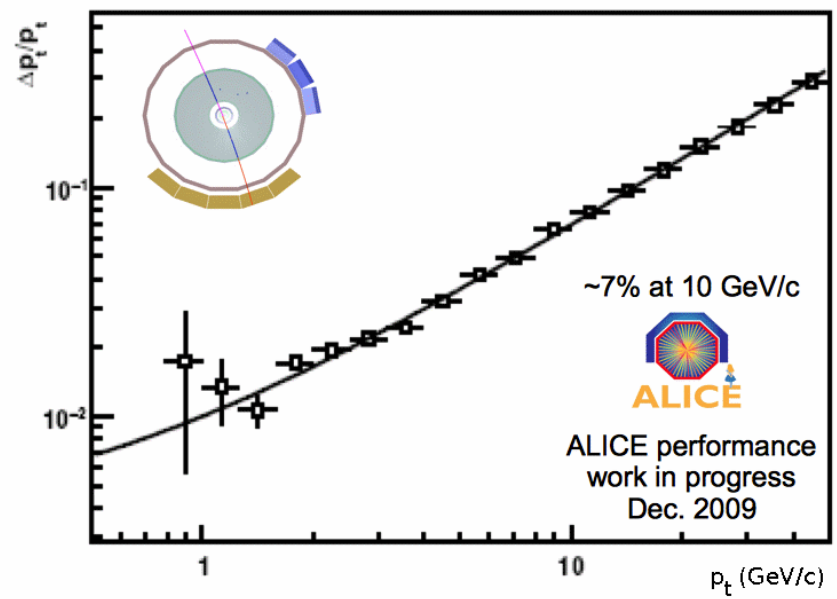
Momentum resolution

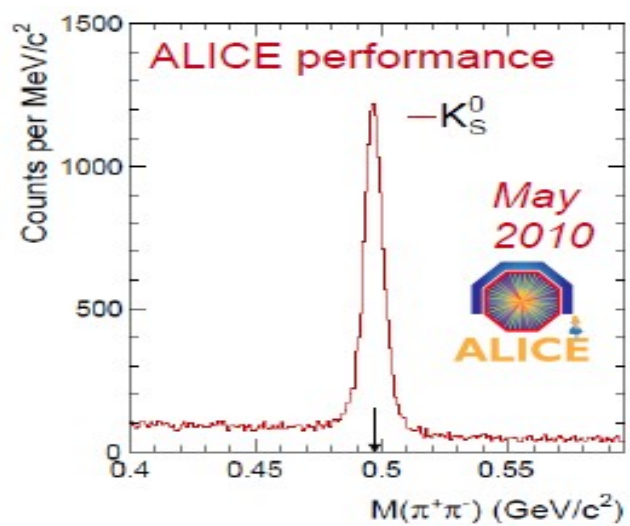
- High momentum tracks
  - Cosmic muon tracks treated independently in two halves of TPC
  - Comparison of p_T at vertex gives resolution
  - Statistics: ~ 5 × 10^6 events
- Low momentum tracks
  - Deduced from the width of K^0_S mass peak
- **Status (end of 2009) :**

  $(\sigma_{pT}/p_T)^2 = (0.01)^2 + (0.007p_T)^2$
- Achieved: ~ 7 % @ 10 GeV/c

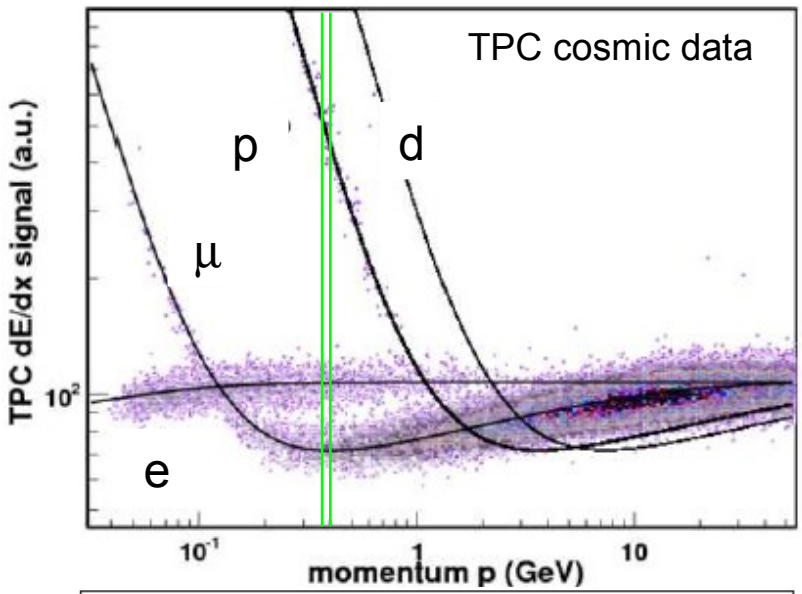
  ~ 1 % below 1 GeV/c
- **Current pass2 resolution:**

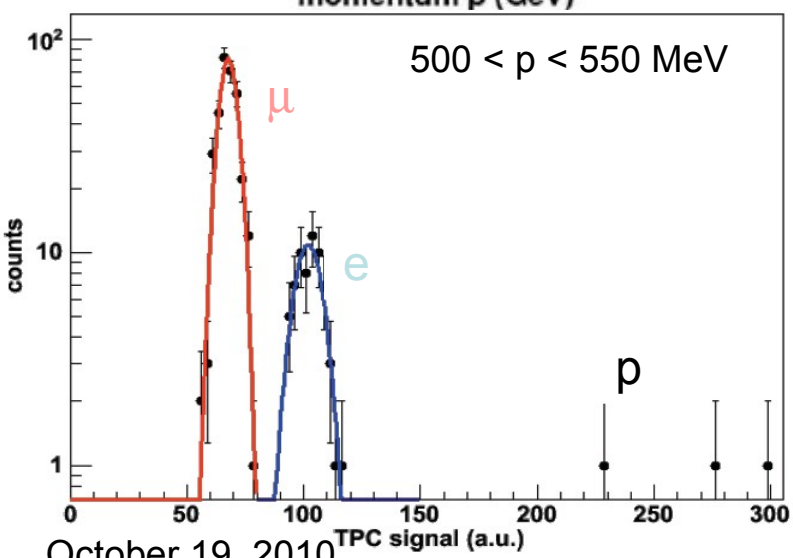
  4% at 10 GeV





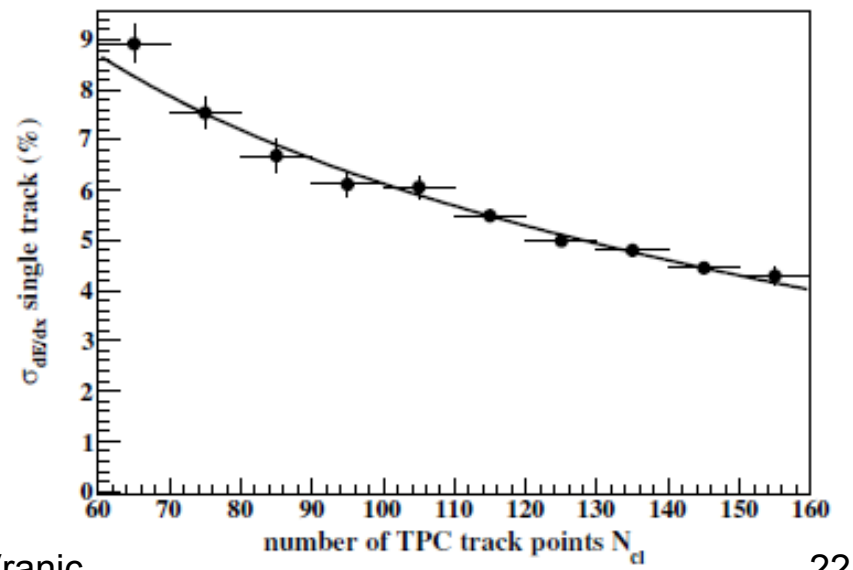
dE/dx resolution - cosmics



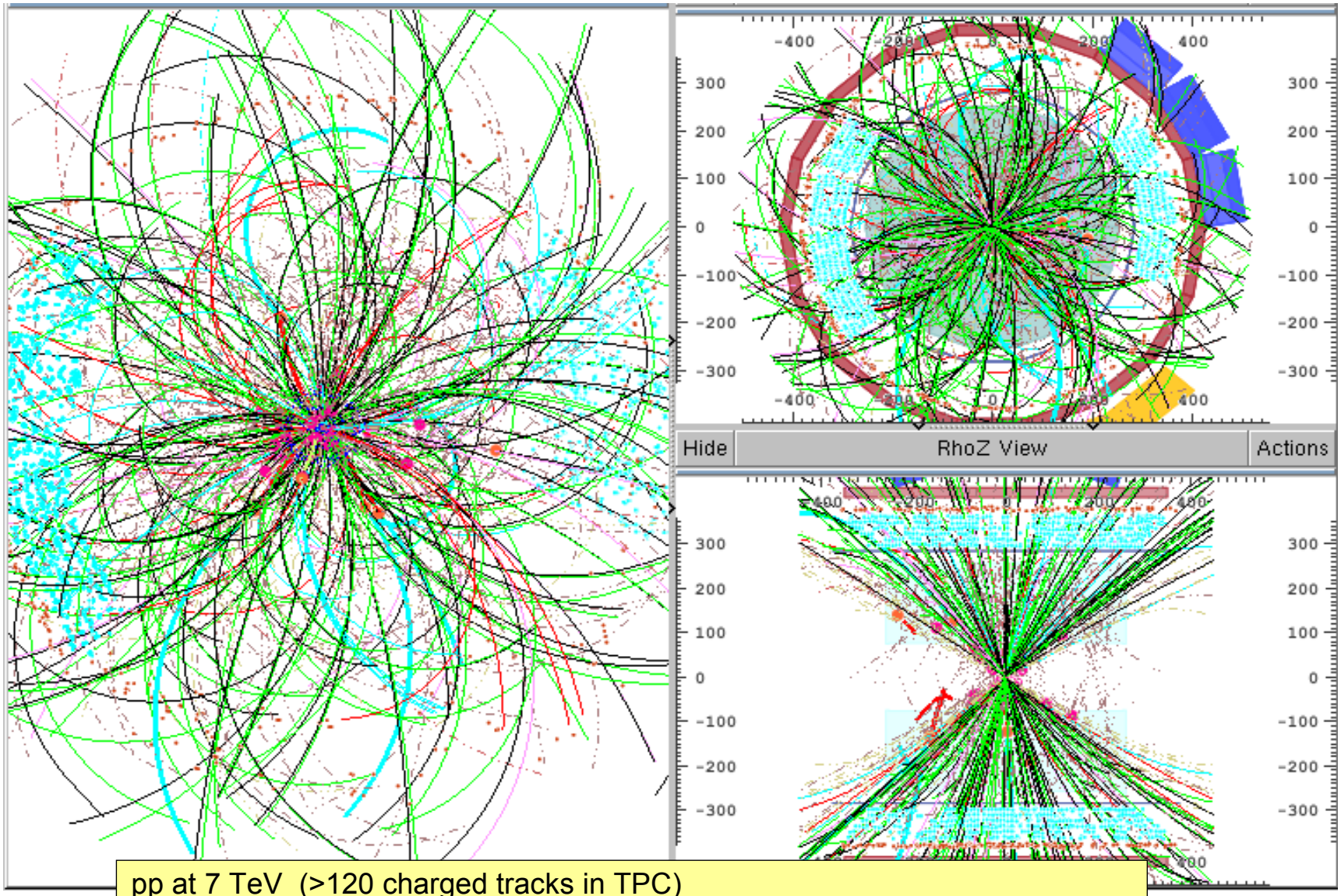


Allows particle identification up to 50 GeV/c

- Statistics: 8.3× 10^6 cosmic tracks in 2008
- Design goal: 5.5 %
- Measured: < 5 %

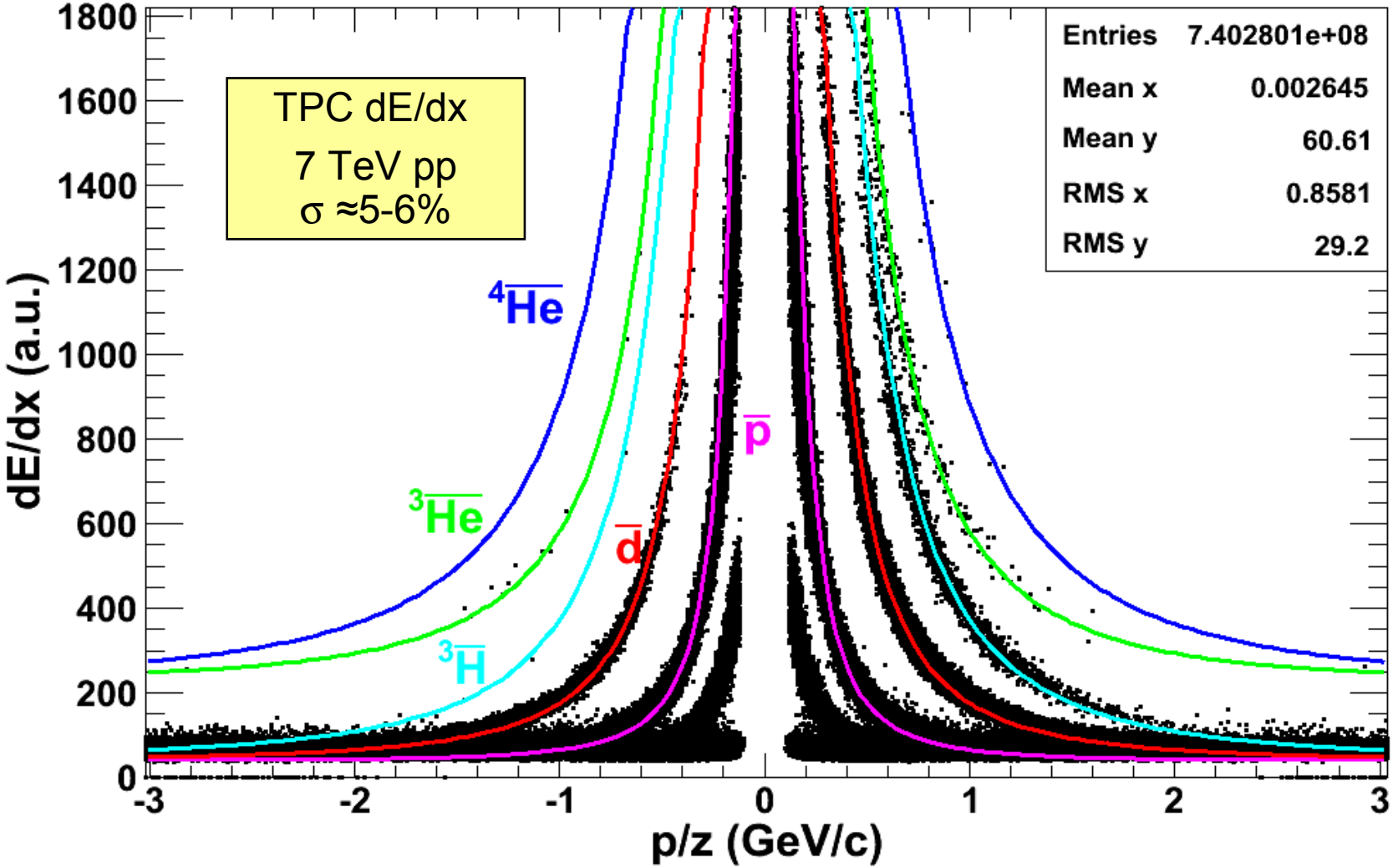


High-multiplicity event



pp at 7 TeV (>120 charged tracks in TPC)

dE/dx resolution - pp



STABILITY

For 10 kHz pp interaction rate very stable operation

For 100 kHz pp investigation presently ongoing

note: comparing number of tracks/s

100 Hz PbPb collisions equals 15 kHz pp collisions

for dN/dy = 2000

CONCLUSION

- ALICE TPC works stably during p-p data taking
- Main calibration was done already in 2009
- Fine tuning calibration techniques bring us to the performance at the design specifications

THE TPC IS READY FOR Pb-Pb collisions

J. Alme et al.
The ALICE TPC, a large 3-dimensional tracking device with fast readout for ultra-high multiplicity events, **NIM A 622** (2010) 316-367