Alice TPC Review

Short Summary

The ALICE Review of TPC Distortions

17-November-2016

Attending: Gigi Rolandi, Leszek Ropelewski, Fabio Sauli, Ron Settles, Jim Thomas, Rob Veenhof, Howard Wieman, with Jamie Dunlop attending on behalf of LHCC;

Harald Appelshauser, Chilo Garabatos, Jens Wiechula, Robert Munzer, Peter Braun-Munzinger, Ruben Shahoyan, Werner Riegler, Marian Ivanov, Luciano Musa, Kai Schweda on behalf of ALICE.

(Harald -> Alice Spokesman , Werner -> Alice Technical Coordinater)

Alice TPC Review

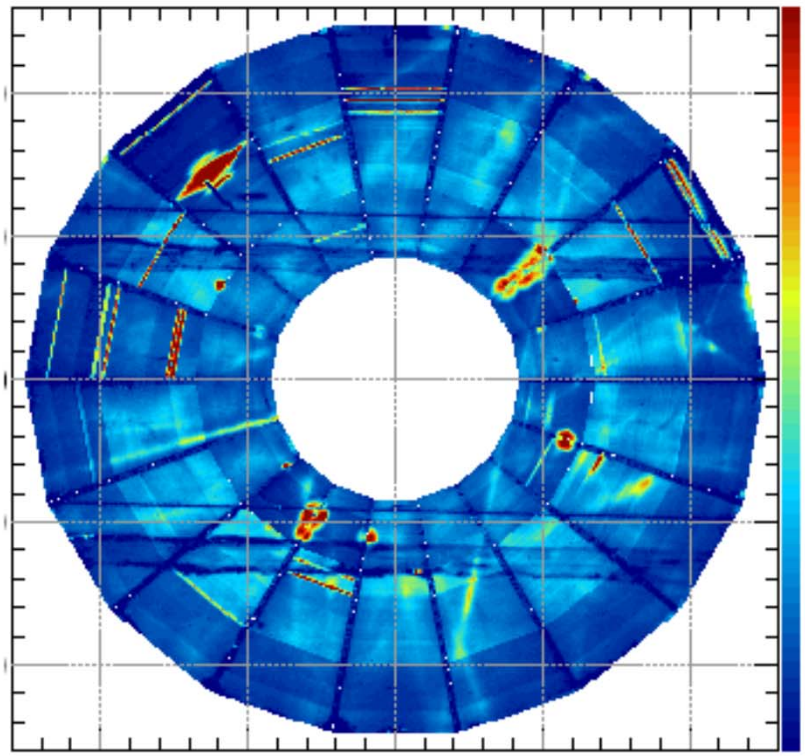
Talks → Discussion

Chilo Garabatos -- TPC construdtion and operation

Jens Wiechula -- Space charge distortion

Ruben Shahoyan -- Calibration

A Large Ion Collider Experiment



Distortions in the ALICE TPC

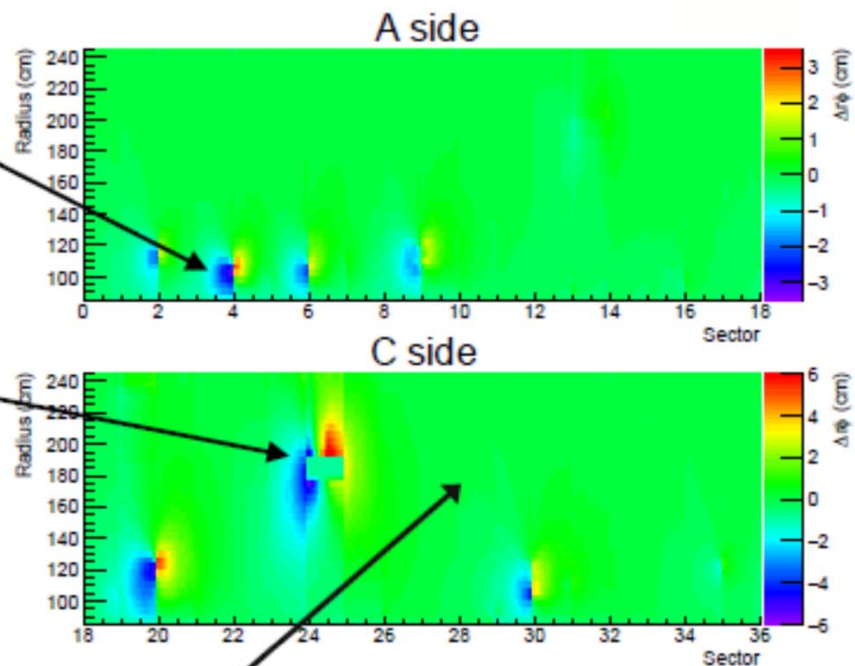
ALICE TPC review
CERN, Nov 17, 2016

Harald Appelshäuser
Goethe University Frankfurt

Distortions in RUN2 at high IR

Large local distortions up to 5cm localized at chamber edges of IROCs: Origin not understood

Large local distortions („hot spots“) in the center of OROC C06: Likely due to floating GG wire(s)

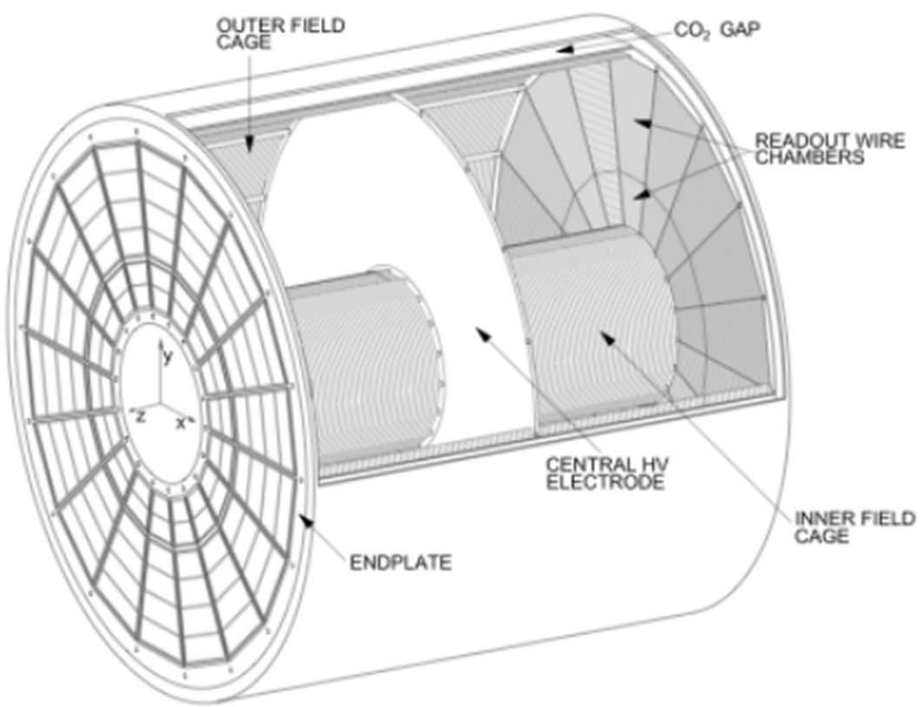


„Bulk distortions“consistent with expectation from gas properties

→ Comprehensive study of physics and test data to characterize the distortions

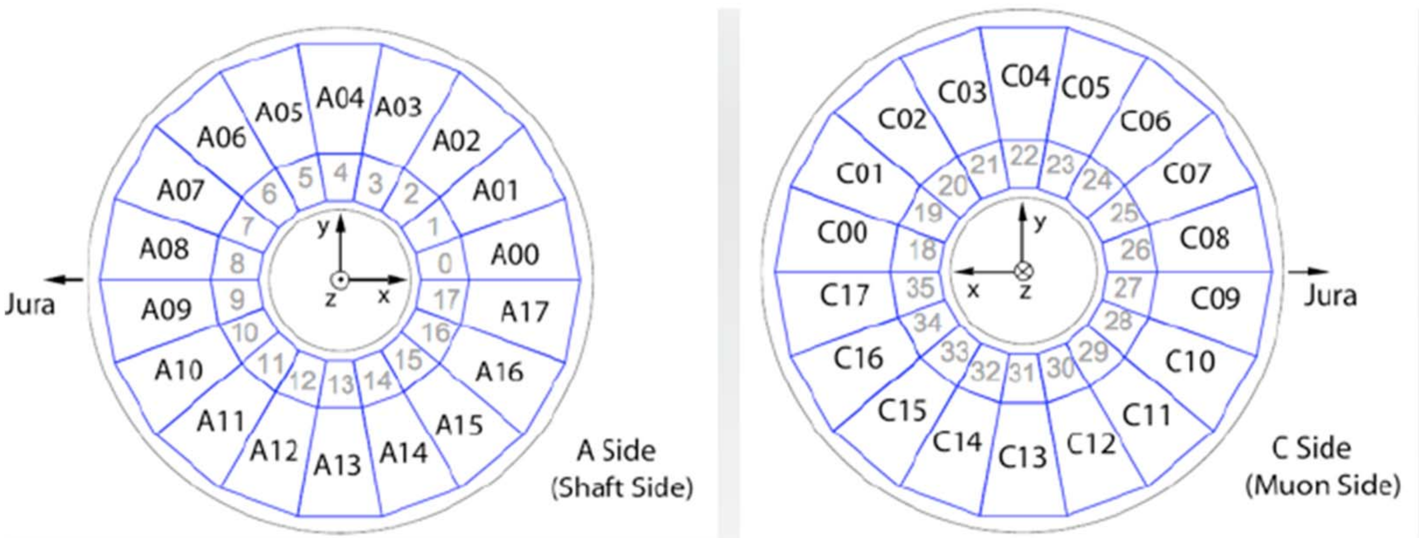
Chilo Garabatos -- From Chilo's Talk

The ALICE TPC



- 5 m x 5 m
- ≈90 m^3
- 100 kV in CE
  - 400 V/cm
  - ≈100 μs
- 2x2x18 chambers: IROC and OROC
- Gain 3000-6000
- 557568 readout pads

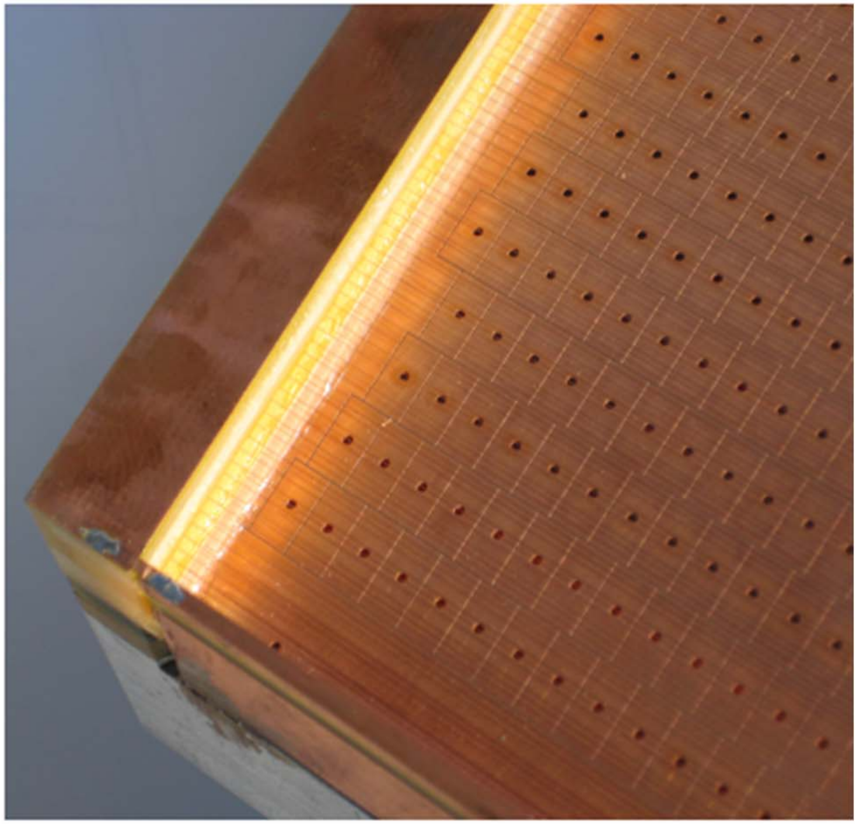
Chamber naming convention



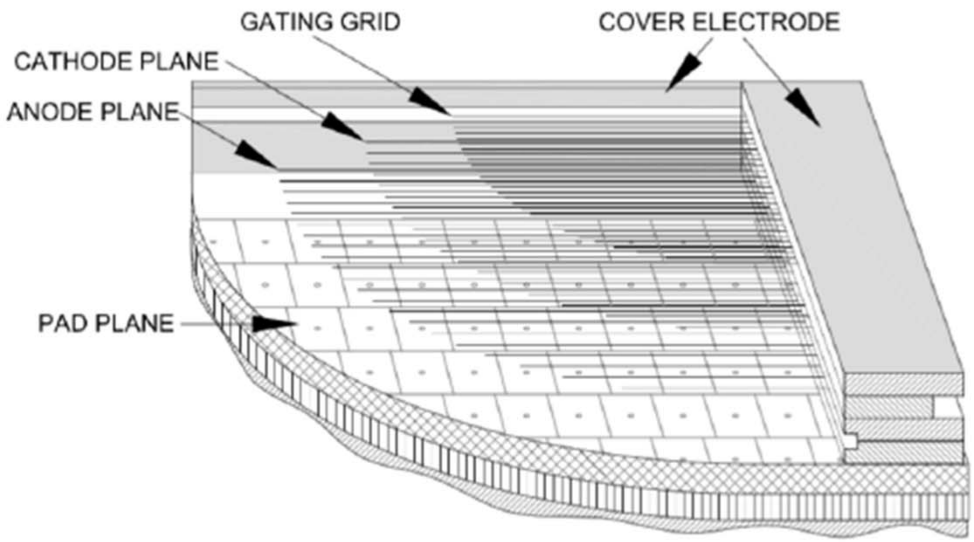
- Sector numbering starting at φ=0
  - 0-17 [A00-A17] on the A-Side (positive z)
  - 18-35 [C00-C17] on the C-Side (negative z)

Readout chambers

- Adopt a tight geometry as NA49
  - relatively small pads: 4x7.5, 6X10, 6X15 mm^2
- No field wires
- Surround chambers with a 'cover' electrode to avoid field distortions and avoid leakage of ions



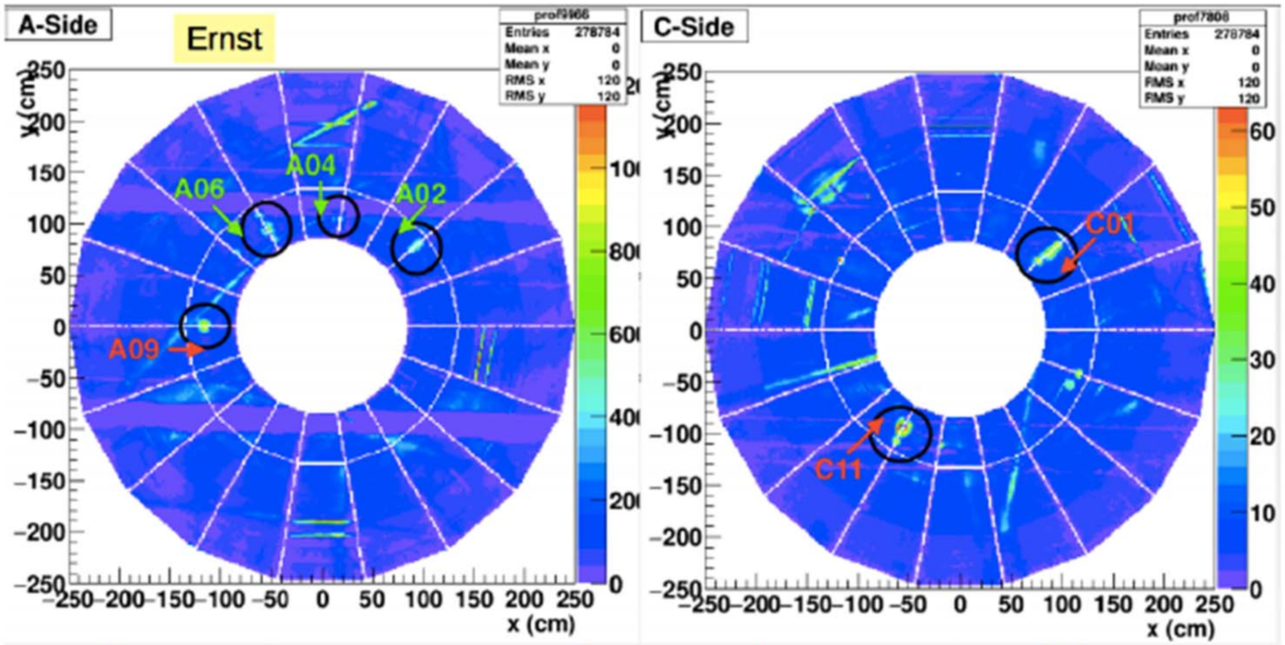
Wire ledges



Potential on GG, cover and skirt match the drift field. Fine tuning done with data

- Wires are soldered on a ~3 mm Cu tape stripe on alternating sides of the ledges
- Wires are glued on their ledges as the next ledge is laid
- Both sides are passivated with a 0.5 mm layer of epoxy
- Anode wire grid ‘terminated’ by two thick wires
- A cover electrode matches the drift field and prevents ion leakage

Central Electrode



- Distortion hot spots occur always at the same side of the ROC (C-Side is mirrored)
- Individual chambers could be associated to a specific batch during chamber production

- The CE is composed of 3 Al-mylar foils glued together and stretched
- Stray laser light extracts photoelectrons to provide an image of the CE onto the ROCs, for drift velocity calibration

Harald‘s executive summary of findings

- Magnitude of distortions scales with driftlength
  → space charge of ions is origin
- Distortions scale with interaction rate and multiplicity
  → proportional to primary ionization
- Distortions disappear when anode HV is switched off
  → ions are produced at anode wires
- Distortions do not scale with anode gain
  → ions not produced in standard gas-gain process
- Distortions do not scale with GG trigger rate
  → GG has finite transparency in closed mode, or ions come from \`outside´.
- No obvious dependence on GG voltage or cover voltage settings

→ No obvious mitigation strategy found

Harald‘s executive summary of findings

- Ion-producing IROCs come from the same production site
  → no obvious difference in manufacturing procedure
- The ions emerge from the same side of the chamber
  → so far, no conclusive relation to the distortions found
- Reanalysis of Run1 data revealed similar distortion pattern, but faction 10 - 20 times smaller than Run2
  → not explained by know gas properties

Some causes discussed:

- The sharp edge of the cover electrode may be producing ions above and beyond the volume of space that is governed by the action of the GG. A principal objection to this explanation is that the distortions are not observed to come from the full length of the chamber … and also, why only the right edge?
- Epoxy may have dripped onto the GG during the procedure to glue the cover electrode into place. Epoxy is an insulator and charge can build up on the epoxy and thus nullify the action of the GG. Thus, a localized failure of the GG would allow ions from the anode wires to drift into the tracking volume of the TPC. This idea was proposed by several members of the collaboration and it is a leading candidate to explain the distortion.

- Fabio Sauli proposed another mechanism that could lead to a local failure of the GG. The presence of dielectric material at the chamber wall may disrupt the fields associated with the GG near the wall. In addition, he proposed that local sources of contamination on the chamber walls could lead to an excess of ions that could overwhelm the weak action of the GG near the walls. But "why only the right hand wall?".
- It may also be true that the fixed boundary condition imposed by the Cover Electrode (a Cu plane at a fixed potential above the GG) may disrupt the electric fields near the wall and interfere with the action of the GG. This, combined with local sources of contamination, could give rise to hot spots. The left-right asymmetry is not explained.

- The anode wires are terminated in a solder ball on one side of the chamber. However, the other end of the wires was simply cut off with a razor blade at the outside wall of the chamber. It is the “cut wire” side of the chamber that generates ions. Normally these exposed wires are covered in epoxy to prevent gas amplification near the exposed tips; however a failure to cover all of the wire tips could lead to ion formation in the gap between the chambers. The essential elements of this idea were proposed by several members of the collaboration and it is another leading candidate to explain the source of the ions.

The chamber drawings show a clear difference between left (cathode solders) and right (anode solders) sides. Also, a crucial detail seems to be missing, i.e. the copper electrode on top of the “cover”. As this is capital for understanding the asymmetry in the distortions, it should be clarified.

The exposed-anode-wire model -can easily explain the left-right asymmetry. (One end of the anode wire terminates in a solder ball while the other end terminates in a sharp point; and the point may be exposed to the TPC gas

Nothing can be done to repair the problem. It is not practical to remove the chambers before Run 3 and then they are scheduled for replacement, anyway, and the problem will go away.

Conclusions:

It is not possible at this time to locate, precisely, the source of distortions. However, this does not affect the collaborations ability to properly calibrate and analyze Run 2 data. The calibrations procedures are very good and very well done. The distortions can be removed from the data with high precision.

The local sources of spacecharge which distort the tracks in the TPC are most likely due to the construction of the wire chamber readout modules. A similar problem is not expected for the upgraded GEM modules because the GEM foil readout chambers will utilize entirely different construction techniques and will have their own problems.

In brief, the problems reported here are being expertly addressed by the collaboration and they will not affect Run 3.

I have an addditional conclusion:

A problem is that they cannot open the Alice detector orTPC to easily (by ´´easily´´, I mean -> a couple of days to do the job of opening and closing) to inspect the affected region or make repairs. We should design ILD and the LCTPC so that this is possbile. Several times, we made use of this feature that was included in the design of Aleph and the TPC.