Budapest QA center in the ALICE TPC Upgrade

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On behalf of the ALICE collaboration

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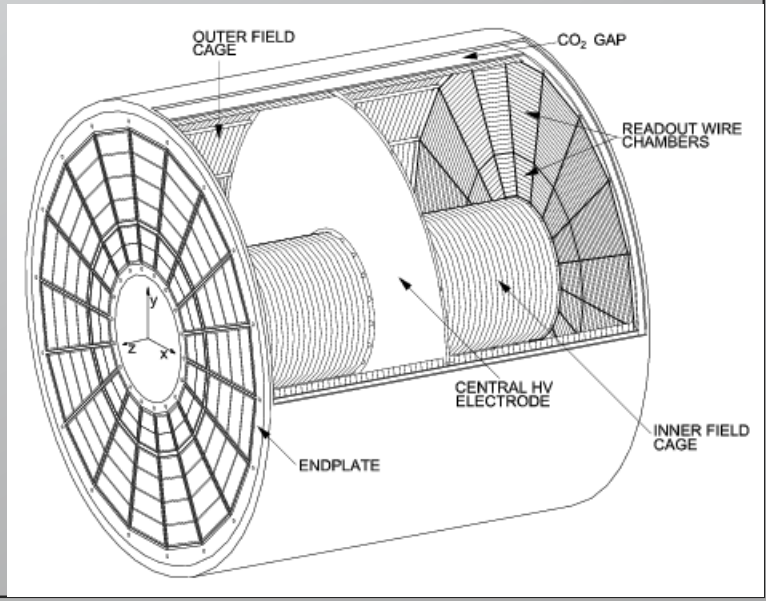
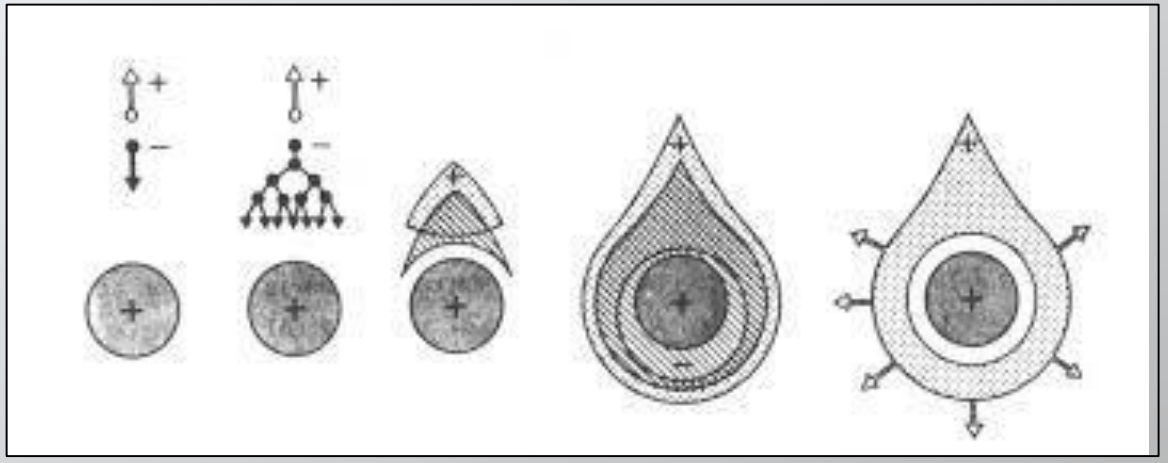
TPC upgrade in ALICE

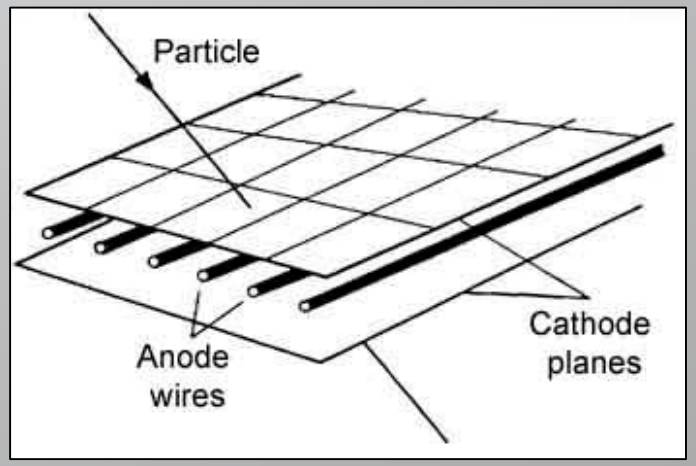
- Acces to rare events and previously inaccessible physics observables
- High precision and high statistics is needed
- In 2019-2020 LS2 general upgrade at LHC
- At ALICE the increased Pb-Pb rate: 50kHz(now ~1kHz)
- Requires higher TPC operation rate
  - Continuous readout of events
  - No gating grid can be used
  - Space charge from ions became an issue
  - Spatial and energy resolution shall remain the same



MWPC – Multi Wire Proportional Chamber

- Curently used technology in ALICE and other experiments
- Charged particle ionizes the gas ~ 100e- /cm
- High electric field around wires → electron avalanche
- Gain: 10^3-10^6 (electron amplification)

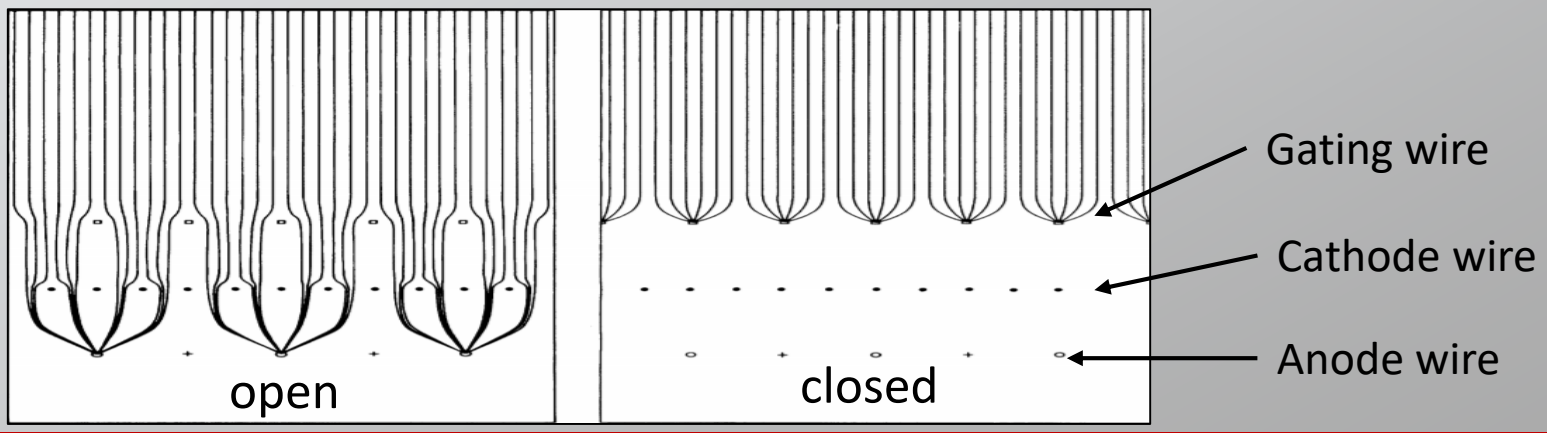




ALICE TPC with MWPCs

- 3D tracking with a few mm precision in 90 m^3
- 72 MWPC-based readout chambers → 32 m^2 area
- Gating Grid is limited: low mobility of ions → 3.5 kHz
- MWPC-based readout chambers will be replaced by a GEM system

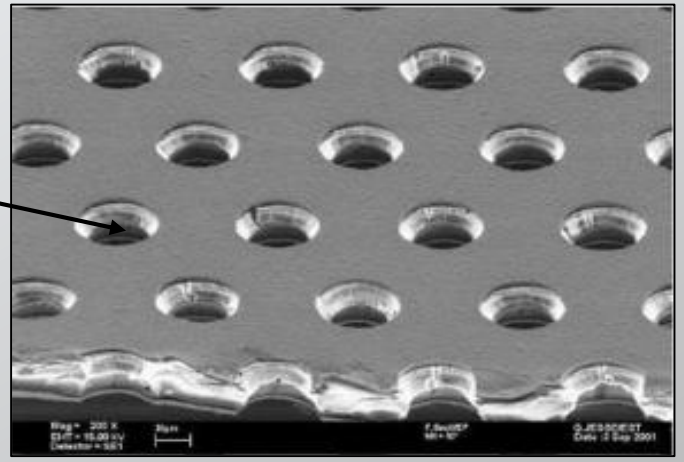
Example: operation of the gating grid

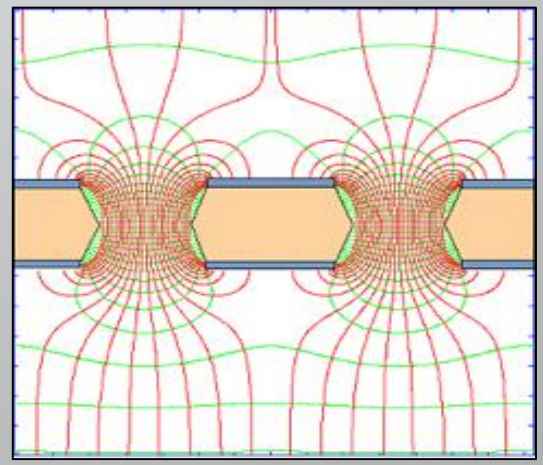


GEM operation

- Novel Micro Pattern Gaseous Detectors (MPGD) – RD51
- Gas Electron Multiplier(GEM)
- A thin, metal-clad polymer foil, chemically pierced by a high density of holes(single mask technique)
- Difference of potential between top and bottom side, high electric field inside the holes
- Electrons drift into the holes and multiply (avalanche), the GEMs can be cascaded

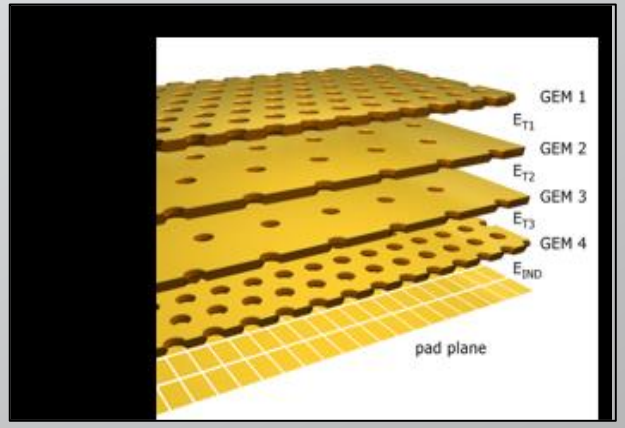
50μm

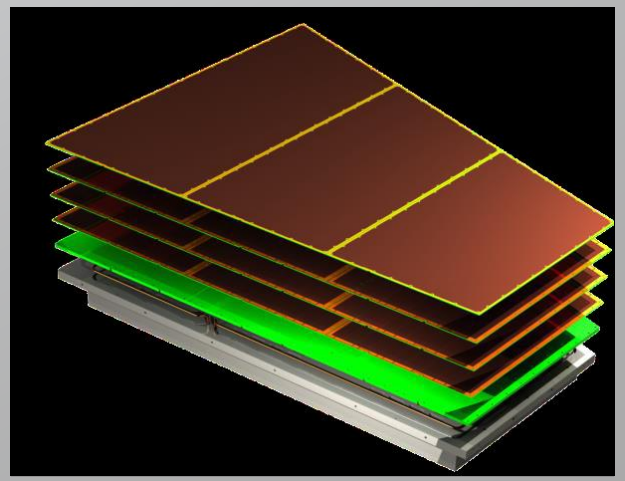




The ALICE TPC upgrade

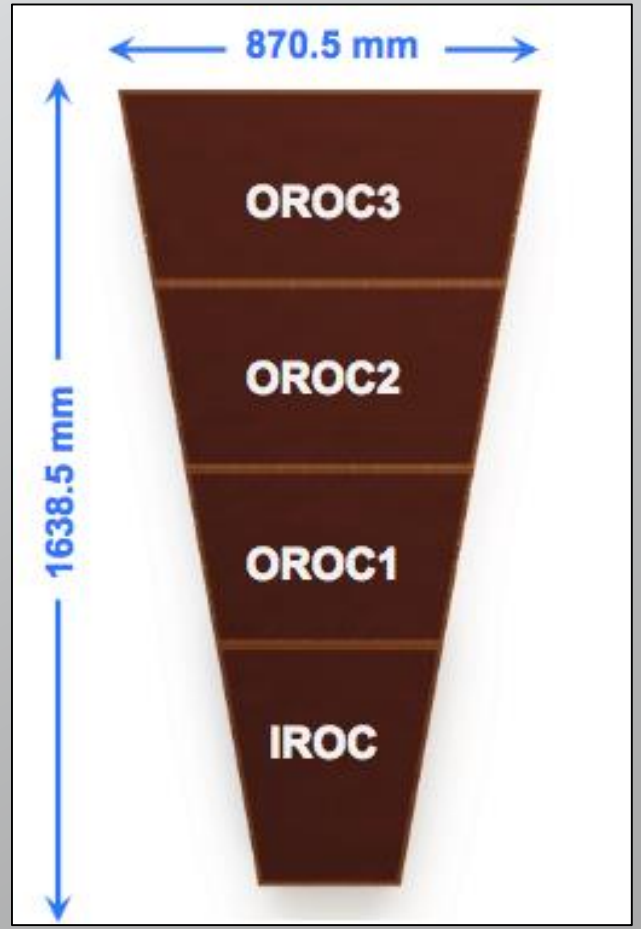
- Inner and Outer Readout Chambers (IROCs and OROCs)
- Continuous readout
- Quadruple GEM stacks have proven to provide sufficient ion blocking capabilities
- Upper limit of 1% for the fractional ion backflow(IBF)
- That preserve the intrinsic dE/dx resolution and keep the space-charge distortions at a tolerable level.
- Total effective gain ~ 2000





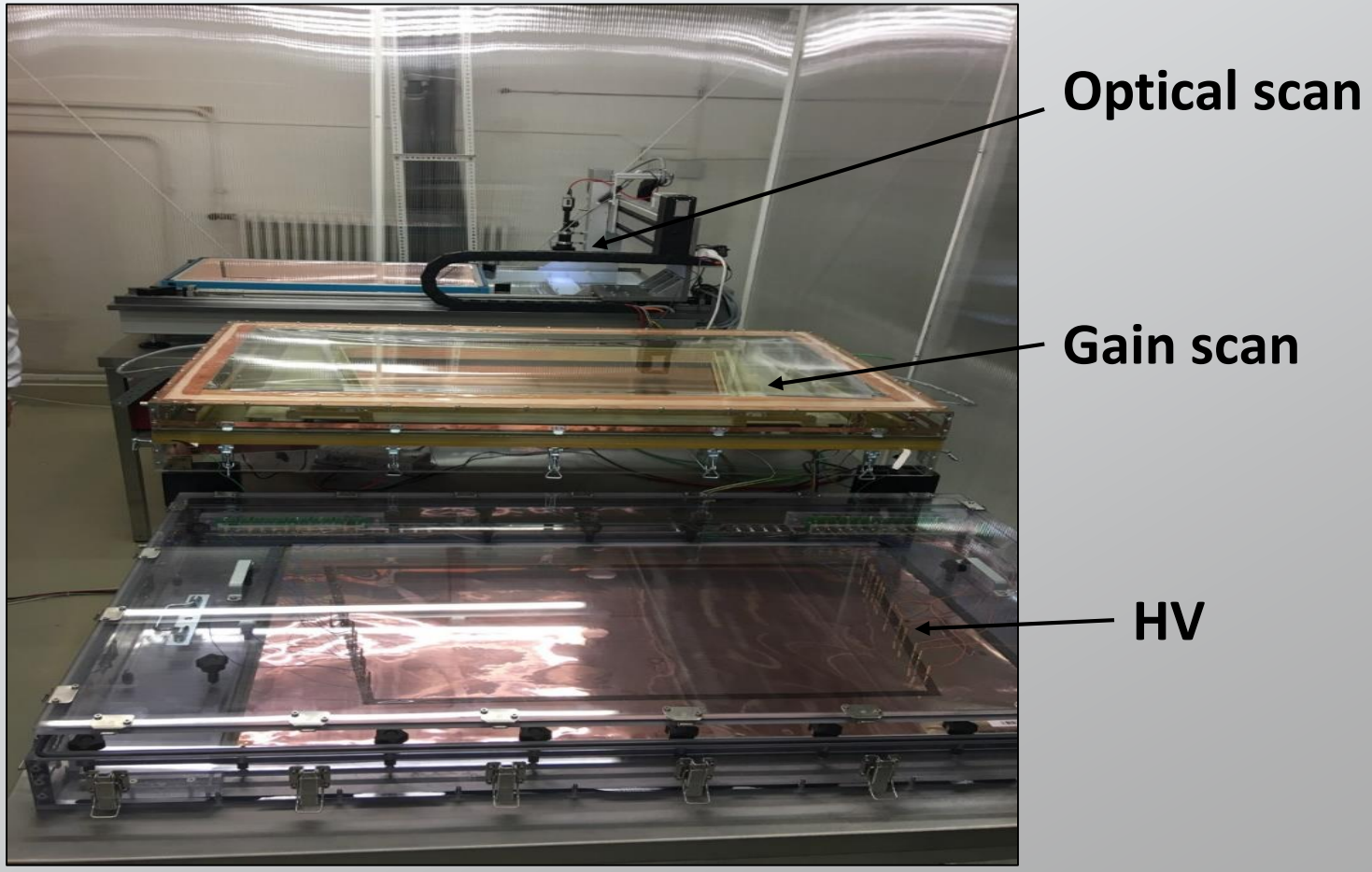
GEM Quality Assurance

- Cannot be repaired during operation
- Cutting edge technology
- Production issues (chemical etching)
- Quality selection
  - Imperfections
  - Hole size uniformity
  - Gain uniformity
  - Long term stability
- Feedback for production
- Four types of GEMS:
  - Budapest QA center: IROC,OROC2
  - Helsinki QA center: OROC1,OROC3
- 720 Foils → 1,5 years (2017-2018)



Budapest GEM QA center

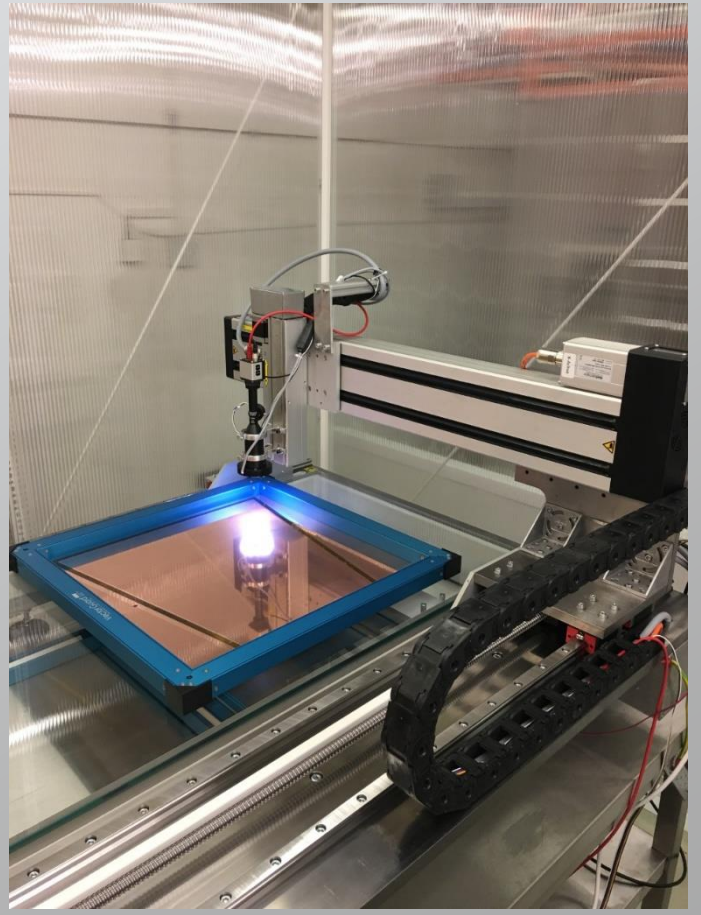
- Requires clean room operation
- Photo taken in Budapest at Wigner RCP
- Observation of defects
- Find the exact connection between hole diameter and gain



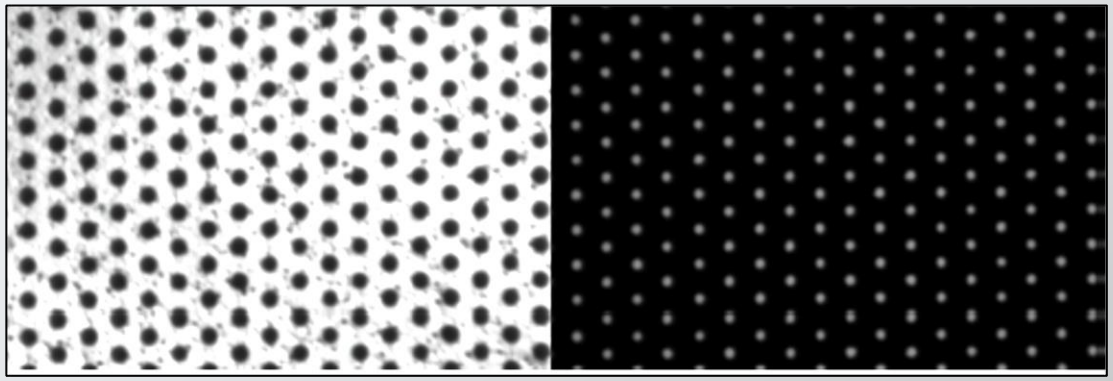
Optical scan

- To measure hole size uniformity, detect defects

- X-y-z table with robot
- CMOS 5 Mpx camera
- Making 1cm^2 size pictures covering the whole surface of GEM
- Convolutional Network algorithm(part of surface or not)
- Neural network(automatized hole recognition and analysis)



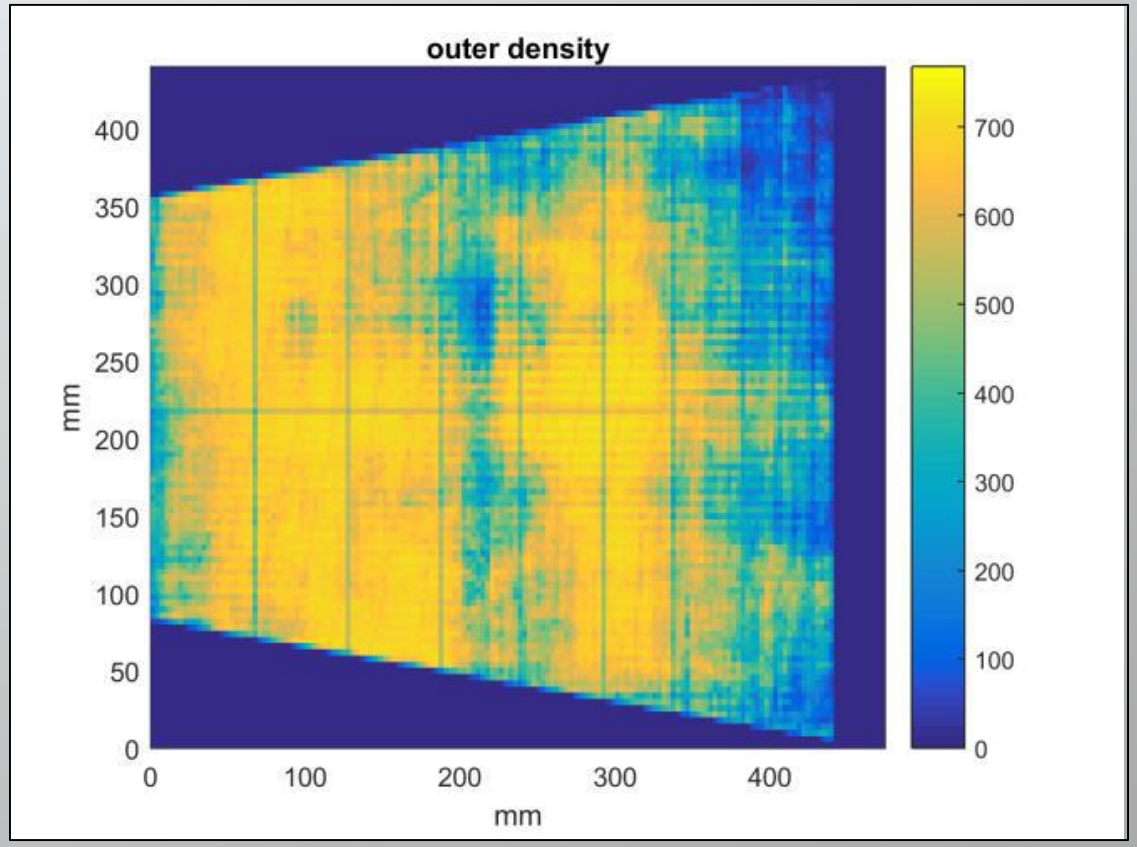
Optical scan example



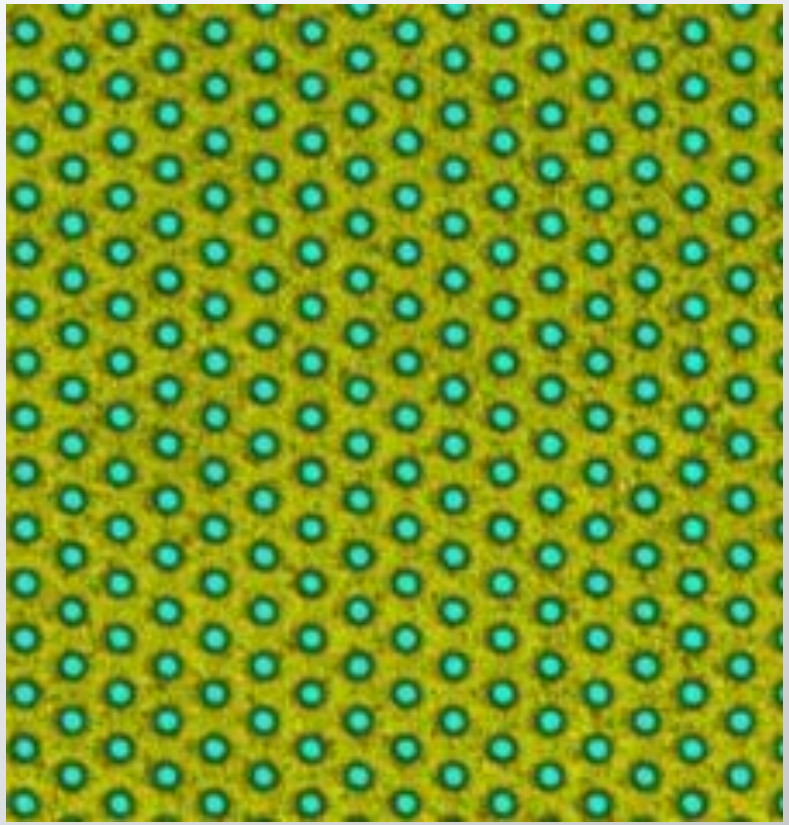
Outer hole

Inner hole

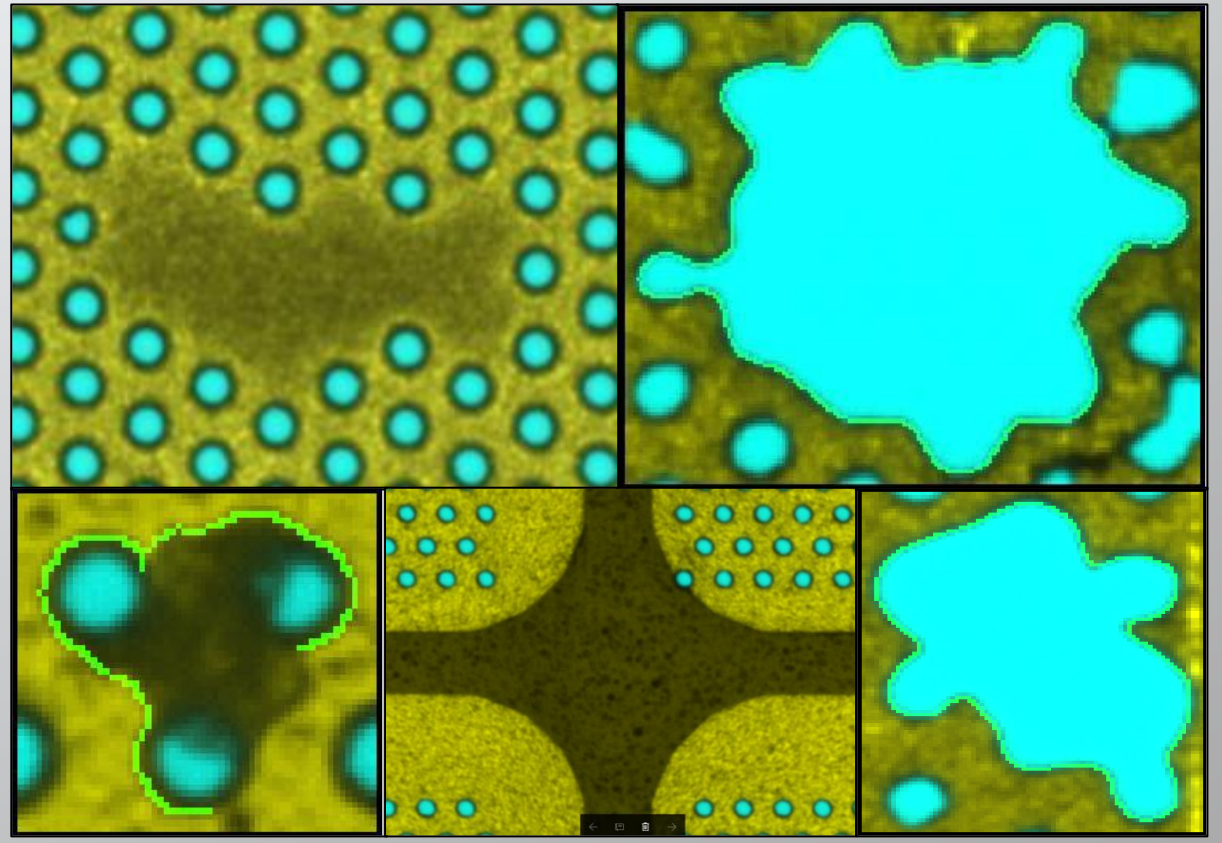
Outer diameter map



Optical scan: Imperfections



Normal foil



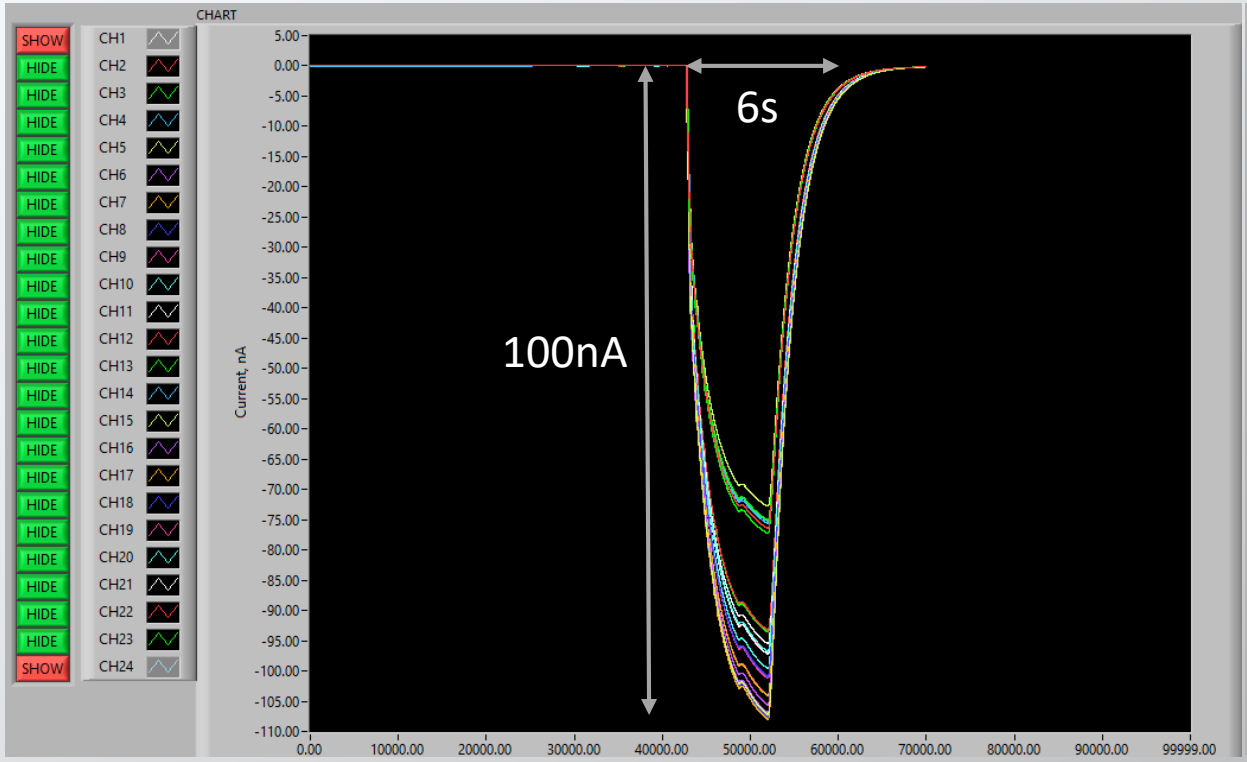
Defects example

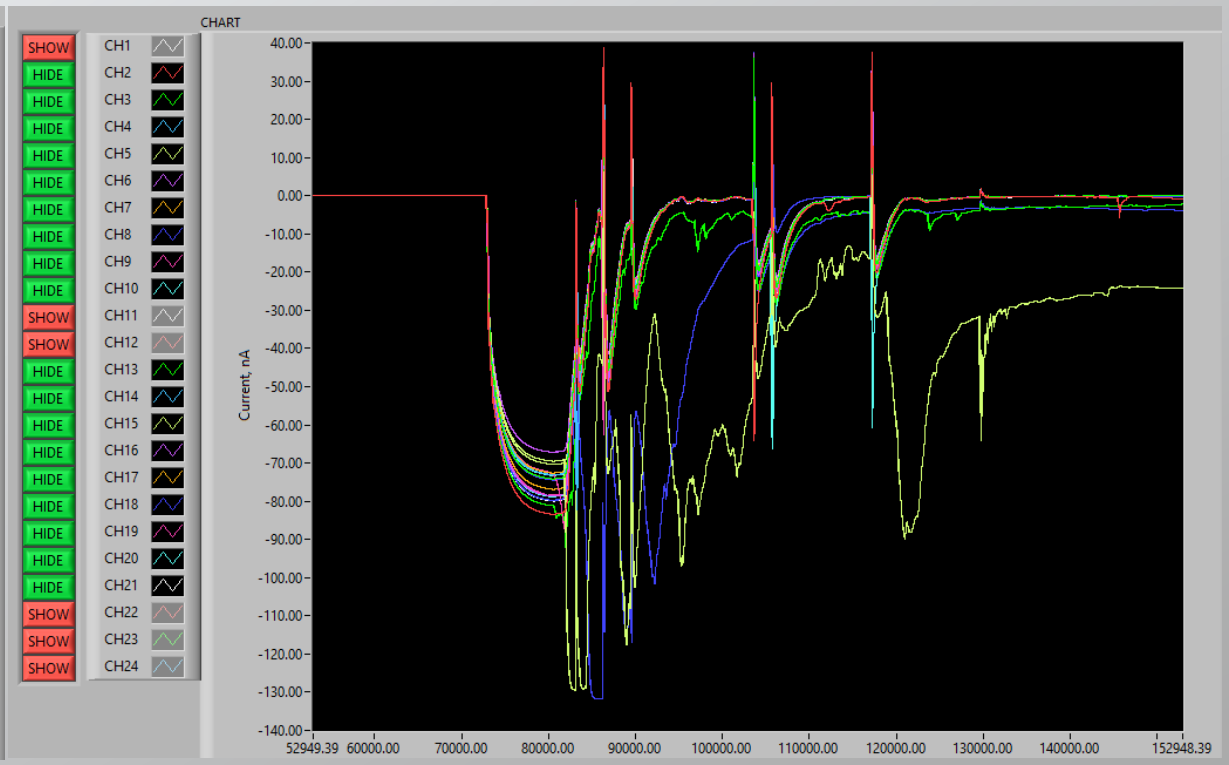
Long term HV test

- Check electrical stability

- The HV box is flushed with $N_2$for 2 hours at 60 $\frac{l}{h}$
- 500 V on every sector for at least 6 hours
- Multi channel PicoAmper meter
- Leakage current criteria is 0.5 nA/segment
- Identify sparks
- Analysis (currents, spark numbers)

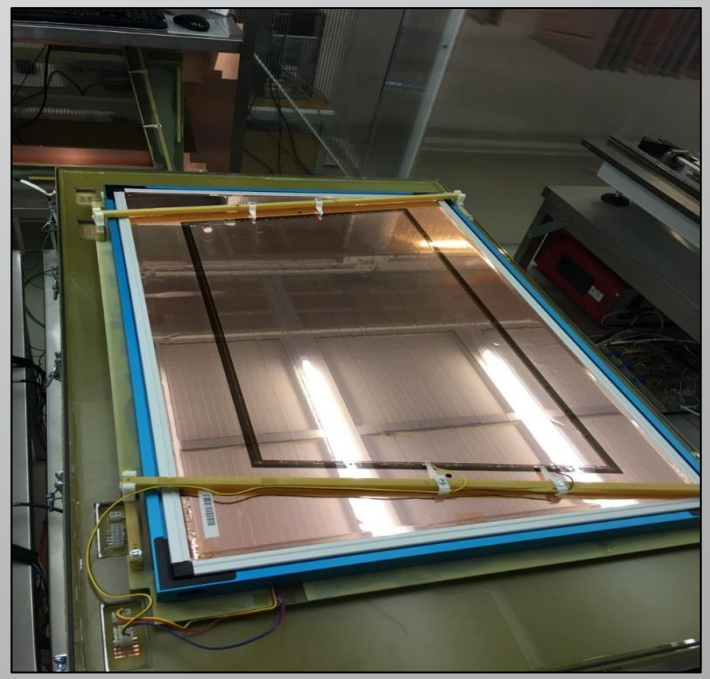
Long term HV test examples



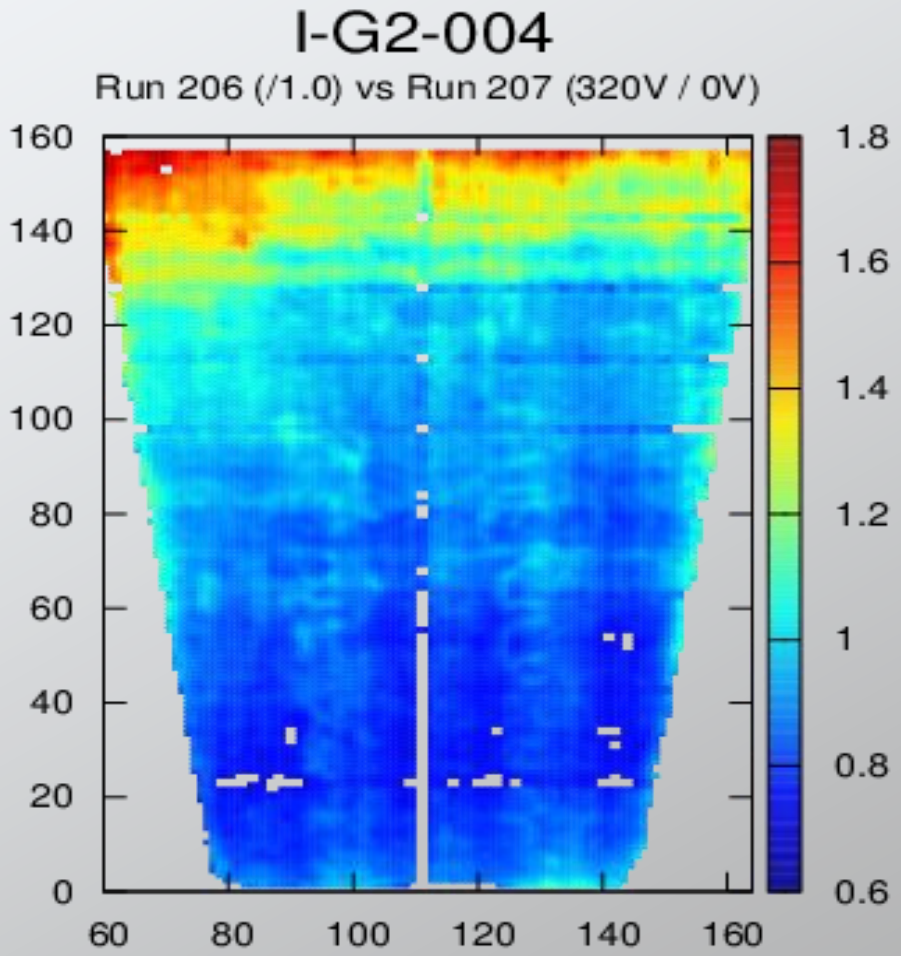


Gain uniformity scan

- Measure the gain uniformity of a few GEM
- GEM gain ~ 10 → postamplification with a multi wire structure developed at Wigner RCP
- $G = N_0 \cdot G_{GEM} \cdot G_W$
- Fe^{55} source, Ar-CO_2 Gas mixture,
- Spatial resolution 2x2 mm^2
- Study the correlation between the optical scan and the gain

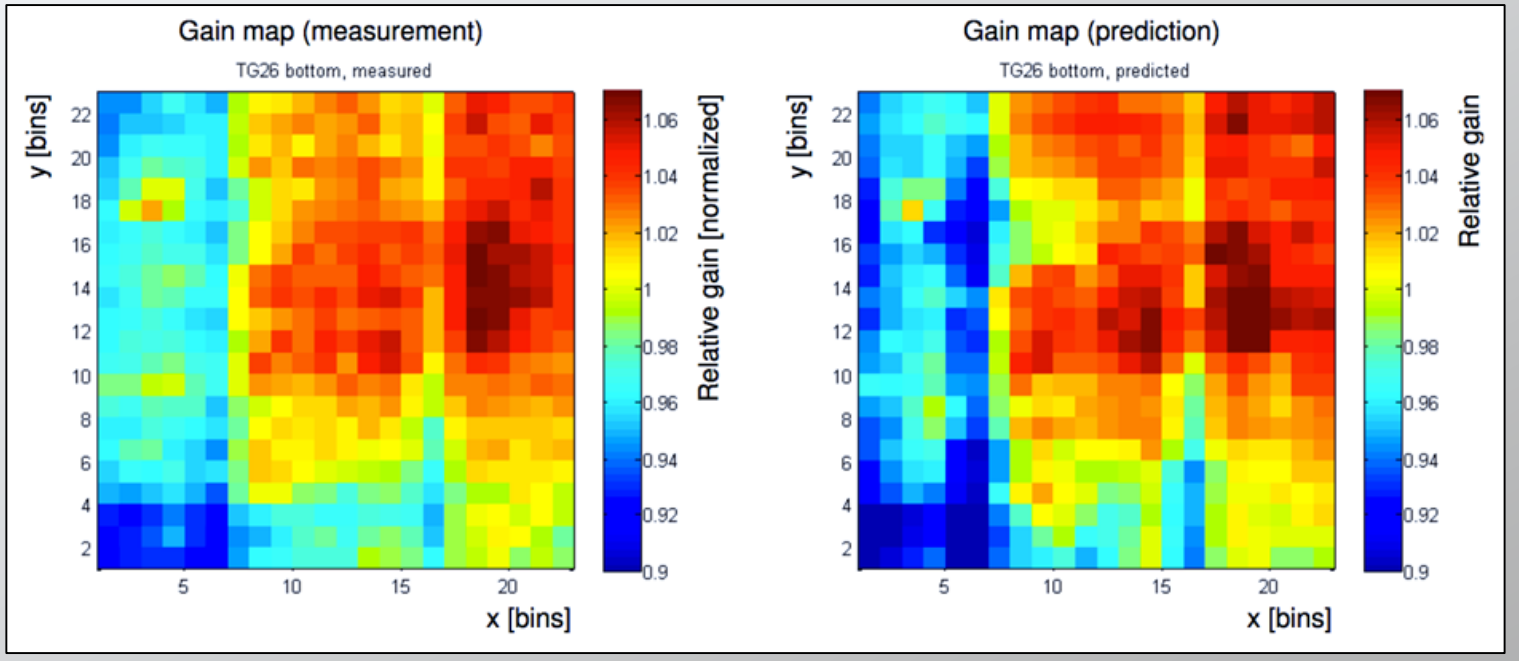


Gain uniformity scan example



Gain uniformity correlation

Correlation tests with small sample



Summary

- ALICE upgrade during LS2
- TPC with continuous readout at 50 kHz in Pb-Pb
  - No gating grid, Low ion backflow, good resolution
- GEM TPC
  - Quadruple GEM, optimized for low IBF < 1%
- Quality Assurance
  - Optical scan
    - Ongoing detailed analysis
  - Long term HV test
  - Gain uniformity

Thank you for Your attention!

Acknowledgements:

ALICE TPC Upgrade group

REGARD group

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Budapest QA center members: Ádám Gera, Dezső Varga, Márton Vargyas, László Boldizsár, Gergő Hamar