TPC Analysis Jamboree – Orsay (May 2009)

Space charge: PART I

Analytical solution of the Laplace equ. for a coaxial cavity

Space charge: PART II

Space charge scenarios for the ALICE TPC

Space charge: PART III

Space point distortions due to space charges and more ...

Stefan Rossegger

Space charge: PART II

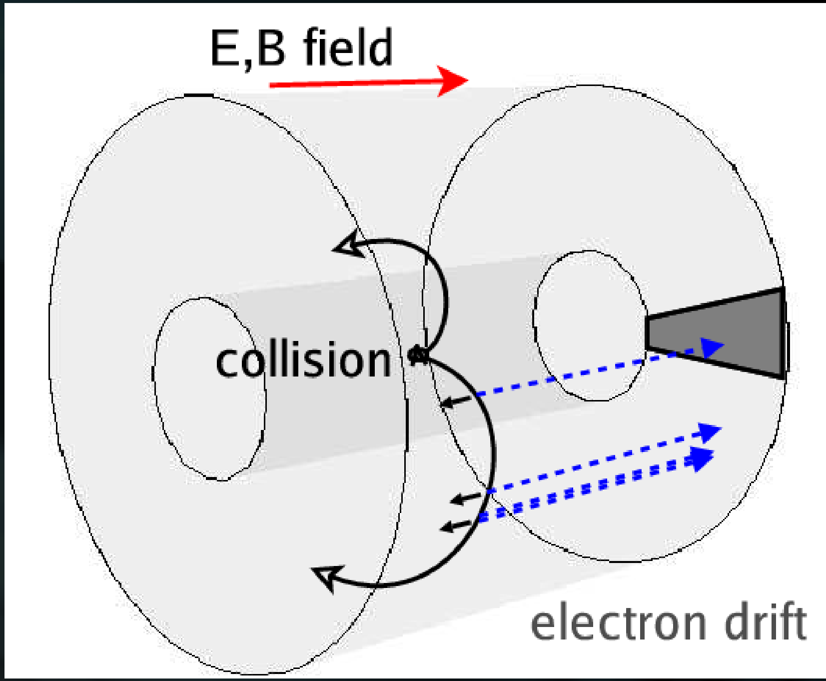
Space charge scenarios for the ALICE TPC

Stefan Rossegger

Ion sources

1. Primary (and secondary) Ionization due to tracks

2. Avalanche mechanism in the MWPC read-out (multiplication by the Gain!)



A few numbers (ALICE TPC)

Luminosity (PbPb): 4×10^{26} $cm^{-2}s^{-1}$ | Cross Section (PbPb) : 7.7 barn

Event rate: 3080 Hz (every 324 μs) | Ion drift velocity: ~ 4 cm^2/Vs

Ion clearing time (DRIFT VOLUME): ~ 0.156 s

 # min. bias events per clearing time: ~ 480 (Piled-Up events)

Out of Garfield simulations: (see next slide)

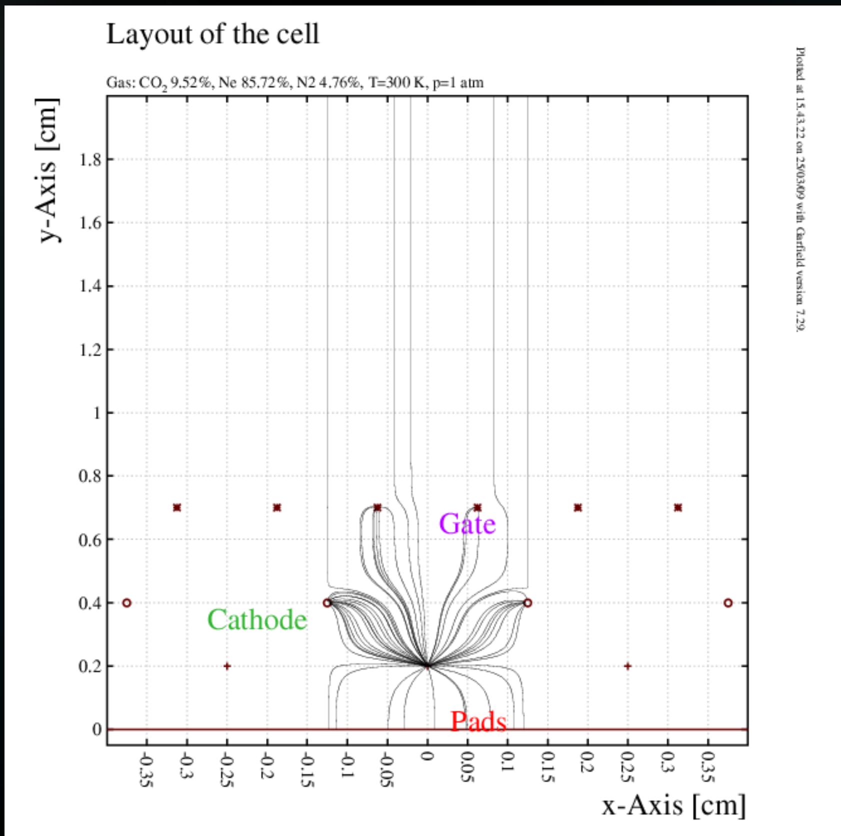
Ion clearing time (within ROC): ~ max 190 μs

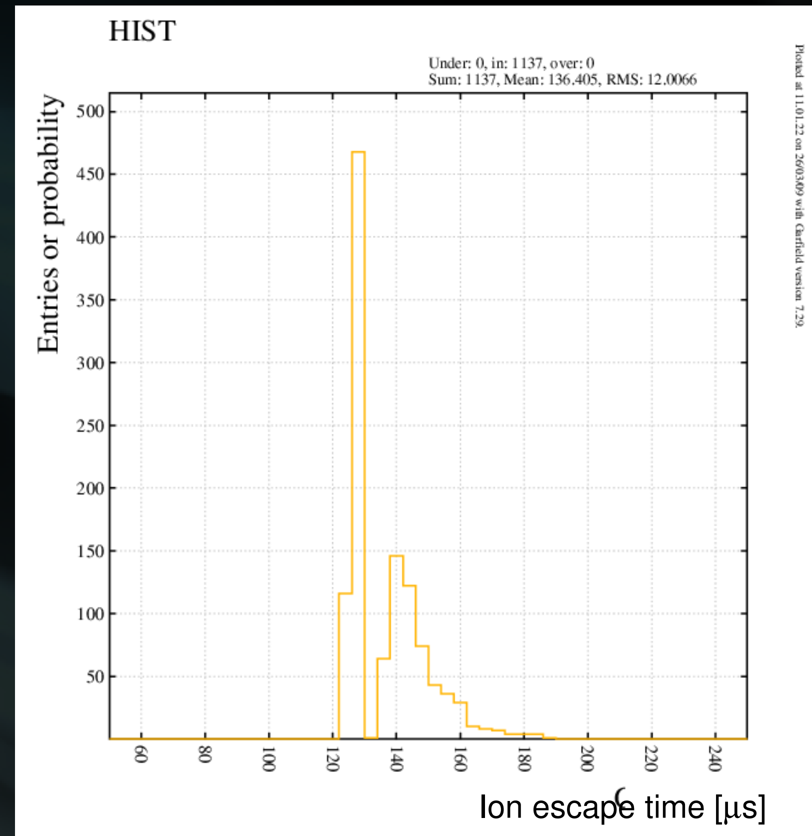
Gate Open leakage: ~ 20%

Gate Closed leakage: 0% if $V_{g\text{-}bias}$ > 66V (currently set to 80V)

Simulation of TPC Hits for PbPb collisions with the latest production cycle: LHC08d6 (5.5 TeV, Oct.2008)

Garfield simulation of ROC-ions (Gate Open)





Gaussian avalanche with Sigma ~ 60deg

~19% of ions produced in the avalanche drift back into the drift volume

Mean escape time: ~ 140 µs

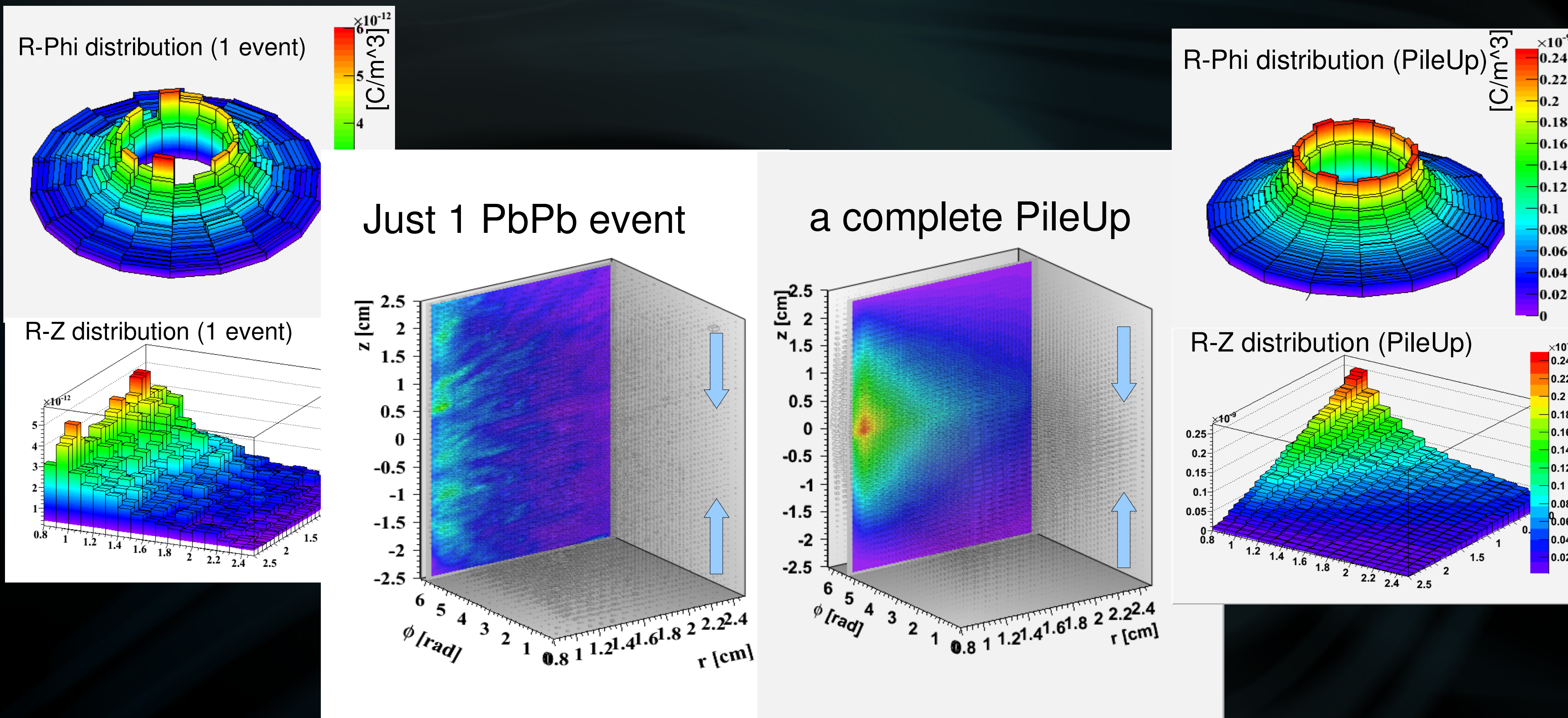
Max escape time: ~ 190 µs

Min escape time: ~ 120 µs

> 90 µs

1. **IONISATION** due to TRACKS

- in the TPC **drift volume**: Pile Up with clearing time of 0.156s (for 250cm) ➡ $\rho(r,z) = (2.2e^{-10} - 0.9e^{-10}\ z) / r^2$ [C/m³]



1. **IONISATION** due to TRACKS

- within the **Read-Out Chambers** (even if gate is closed) dynamic Pile Up with clearing time of ~190µs (for 3mm)

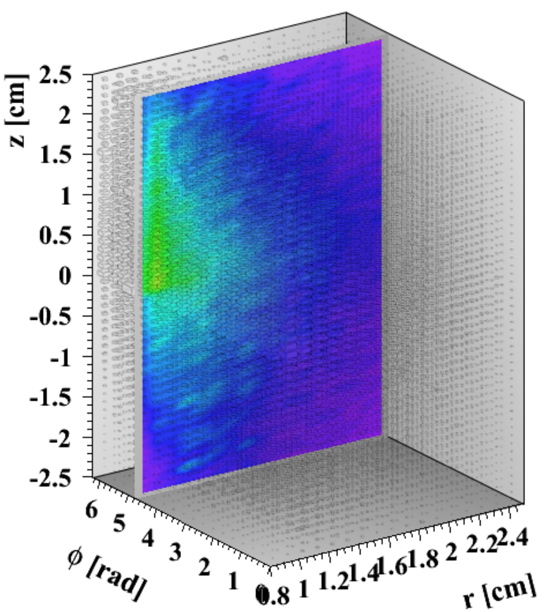
50% x 20% = 10% | gain = 5000 |

➡ ~500 ions per electron can leave if gate is opened (depends heavily on trigger structure)

BUT not a lot of “Hits” within the ROC (for 9mm)!

➡ Consequence on ρ(r,z): ~ factor 2

After a complete PileUp



2. AVALANCHE PROCESS within the ROCs

... while the Gate is open (and electrons are allowed to enter)

All electrons from the drift volume reaching the ROC (early or later) are multiplied by the GAIN, which gives a factor of ~1000 ions (20% gate-open-leakage) for every incoming electron.

If the GATE stayed OPEN?

- factor ~1000 of Space Charges drifting back into the volume

GATE CLOSES (after 90µs)?

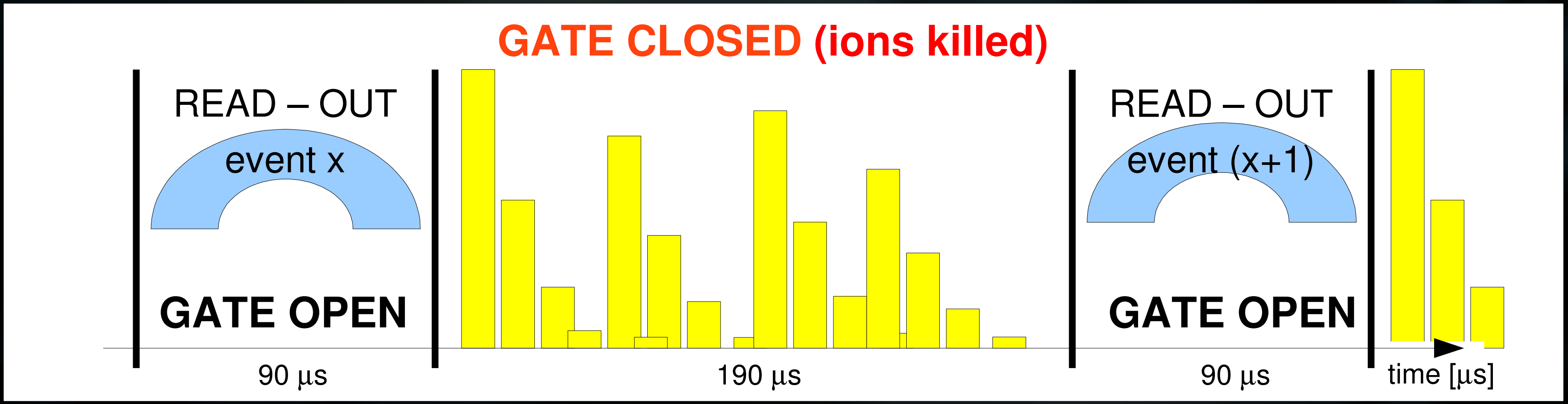
- Essentially all ions are captured (see slide 5)

WHAT IF THERE IS ANOTHER Central event (to be read out)?

Case 1. **After 300 µs** (> 90+190) of previous read-out?

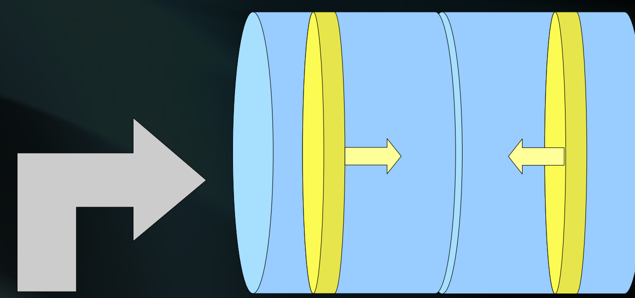
➡ **NO problem** since even the last ions produced from late incoming electrons are destroyed at the closed gate!

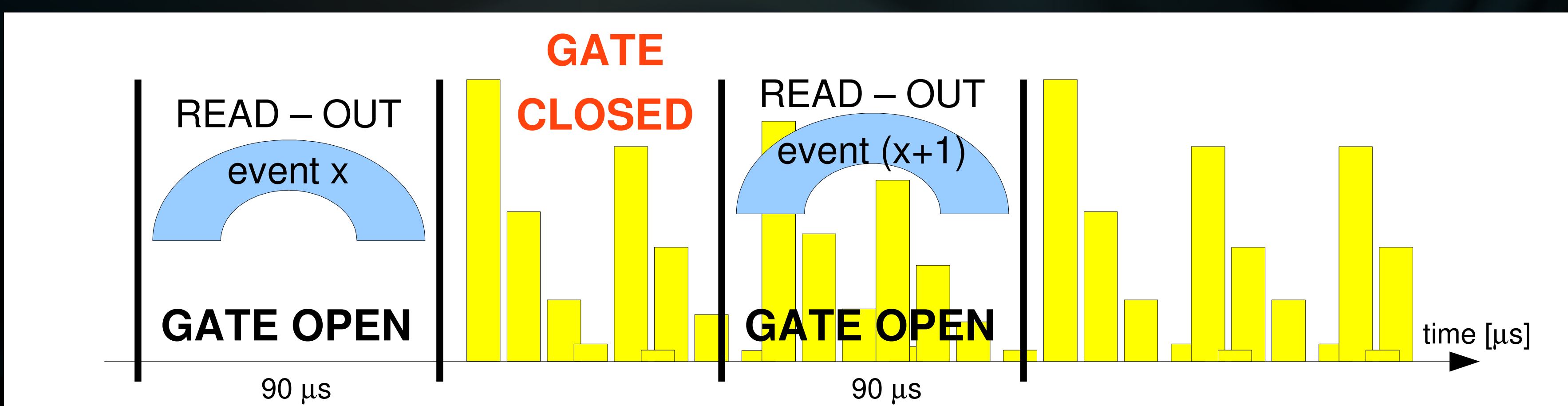
We just have Space Charges from Primary Ionization and 'small' Ion Feedback (from prev. tracks within the ROC)



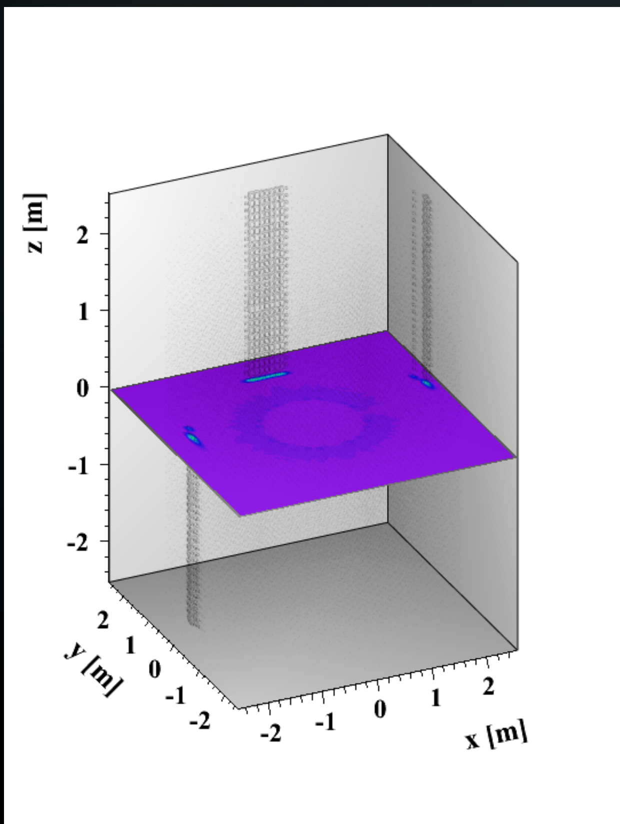
Case 2. Next central event after 200 μs? (< 90+190) of previous read out?

- ➡ AVALANCHE ions (from previous read-out) are allowed to leave (factor 10^3)
- ➡ “Thin slice” (with lots of ions) will drift towards the CE
- ➡ All following events (within the next 0.156 s) are affected



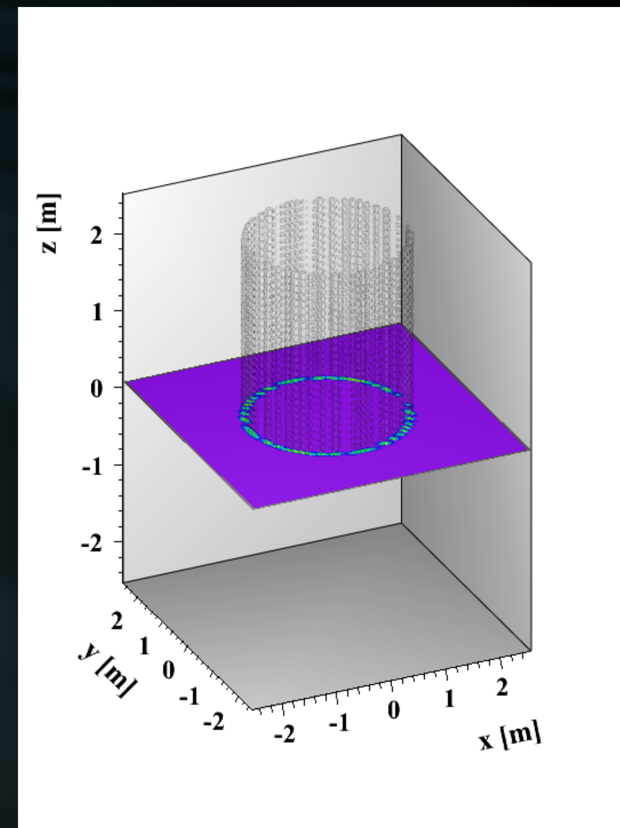


Case 2 (Ion slices drifting towards the CE) is prevented by the past-future protection within the Alice experiment



What happens in the unlikely case of **floating wires** or/and **other leaks** ??

When identified, we can handle them with the "Analytic solution"



CONCLUSION

Besides the Track-Ionization within the drift volume, essentially two different sources of expected **Ion Feedback (IFB)**

- **ROC-IFB** from all min. bias events (tracks within the ROC)
  - additional factor of ~1 compared to Prim. Ionization
- **Prev-ReadOut-IFB** if the next trigger comes within 300μs
  - additional factor ~1000 (thin slice drifting to the CE, visible for the next ~500 events)

(Their magnitudes heavily depend on the event-trigger structure!)

WHEN MAGNITUDE IS IDENTIFIED (Quantitatively),

we can handle them !!