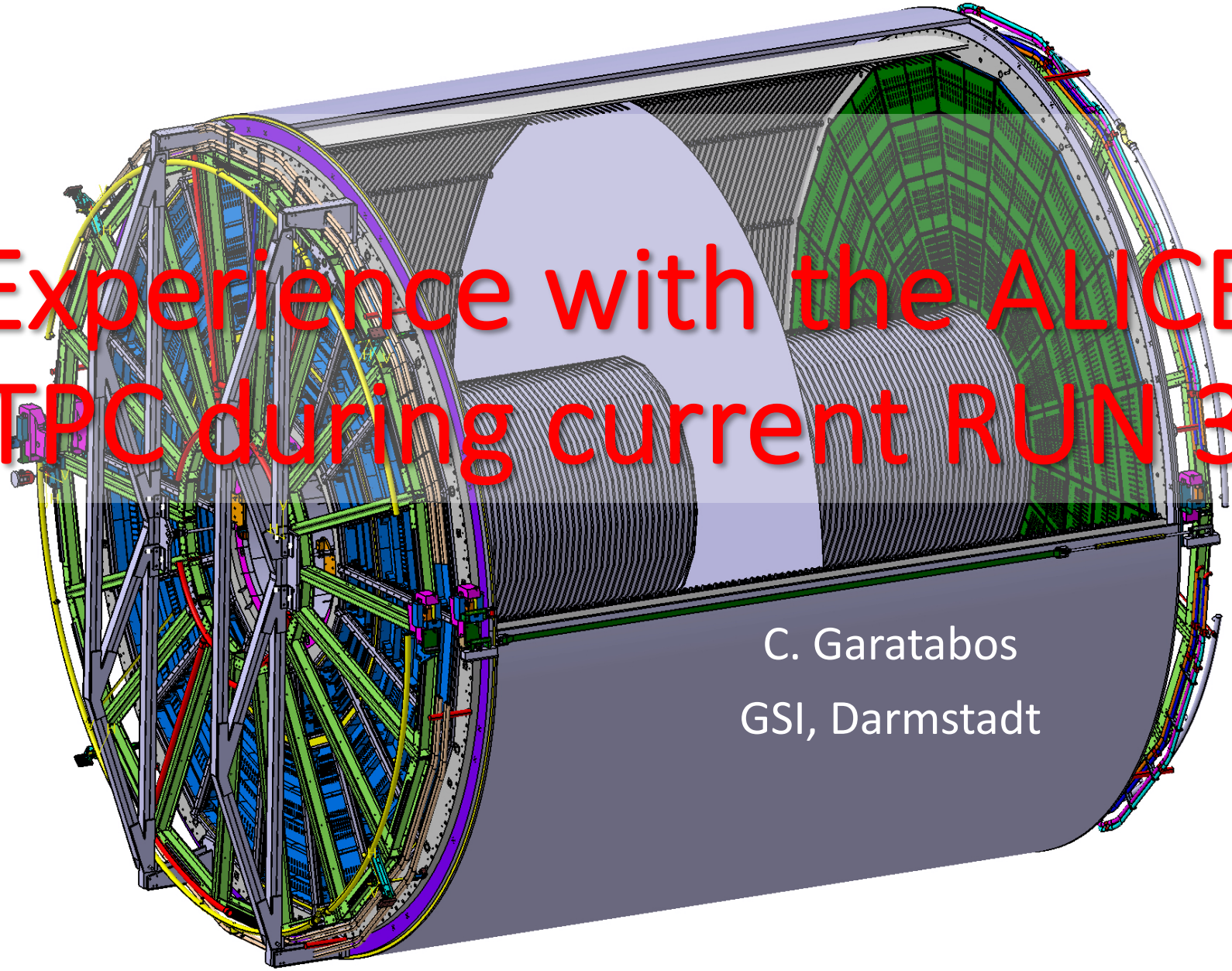
Experience with the ALICE TPC during current RUN 3



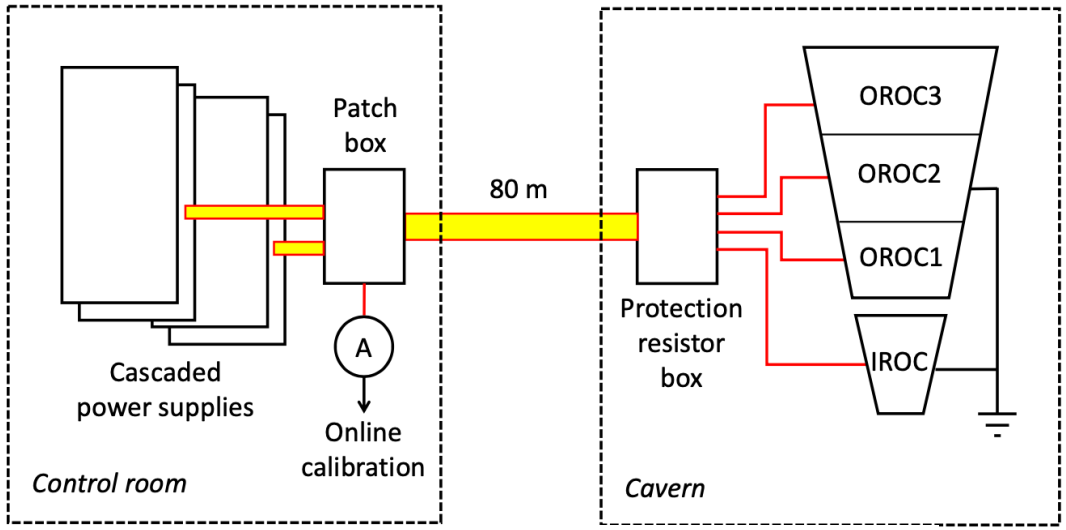
C. Garatabos

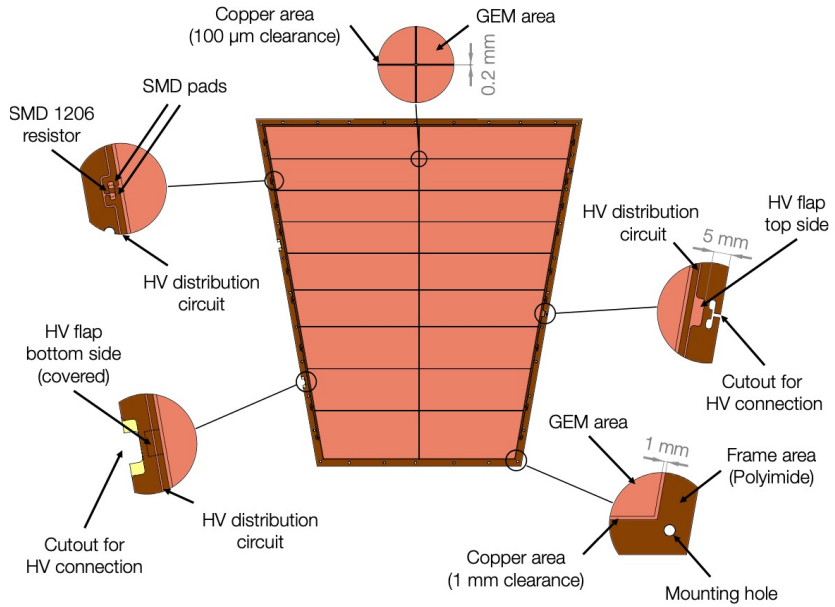
GSI, Darmstadt

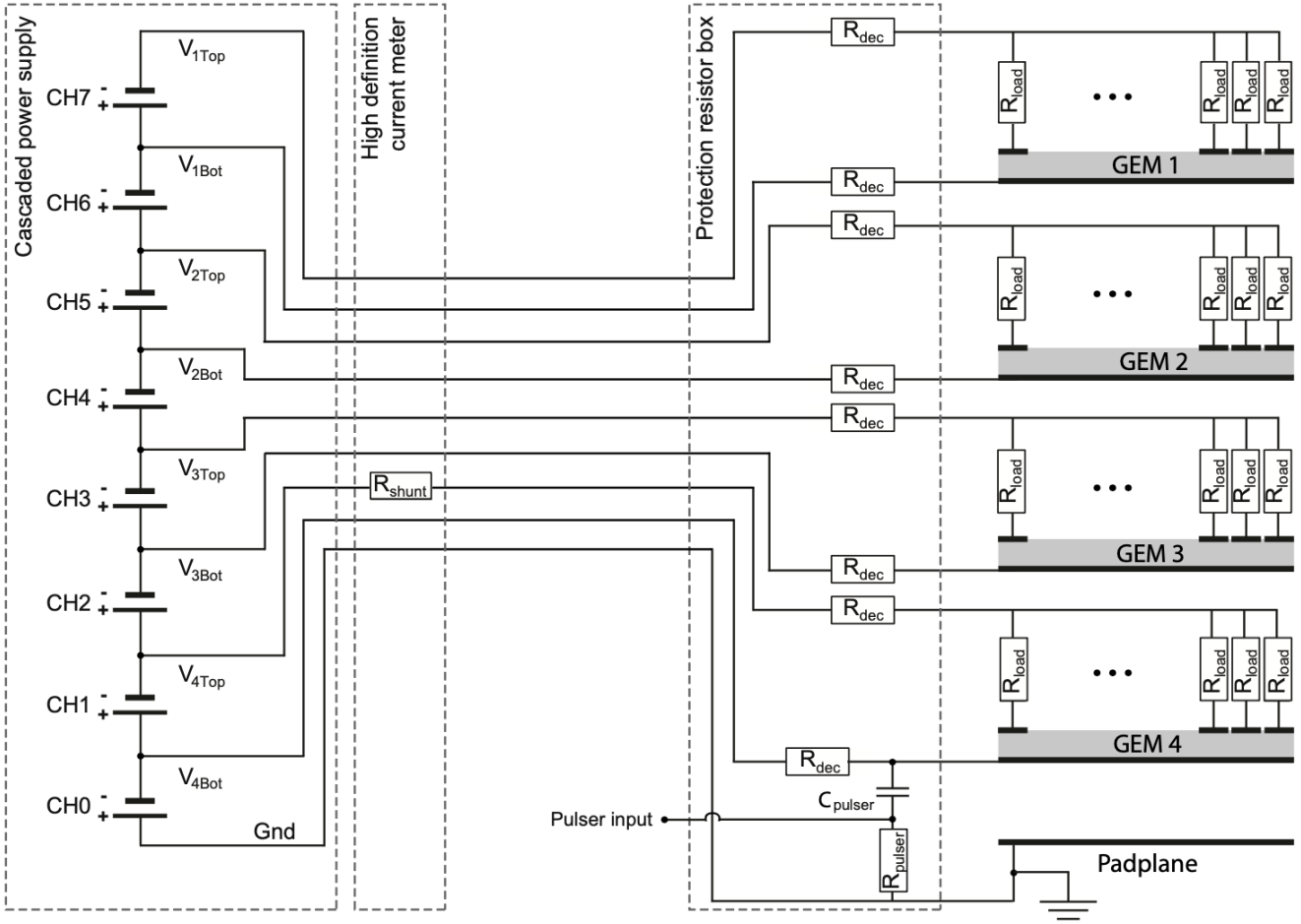
The upgraded ALICE TPC

- Aim at taking data with continuous readout at 50 kHz Pb-Pb collisions preserving the performance of the previous system
  - 👉 large distortions due to IBF and fluctuations to be corrected
- Take pp data at 500 kHz; planned tests at higher rates to test performance and develop tools for data processing, reconstruction, and calibration
- First ‘real’ HI run took place in October 2023
  - 50 kHz never really reached due to various issues with the machine and the injectors
  - Maximum rate ~47 kHz at the beginning of some fills; rapid luminosity burn out

HV powering scheme





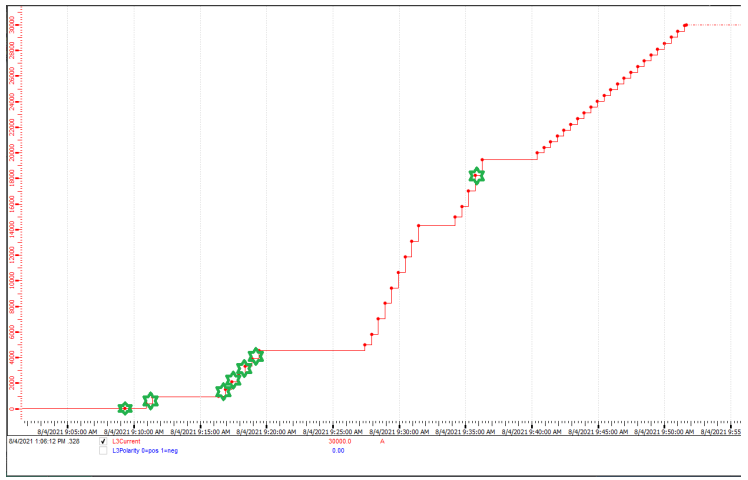


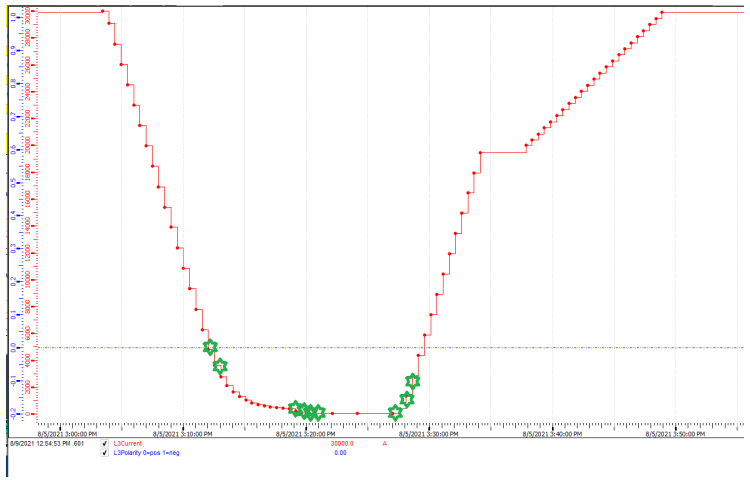
Gas: Ne-CO_2-N_2 (90-10-5)

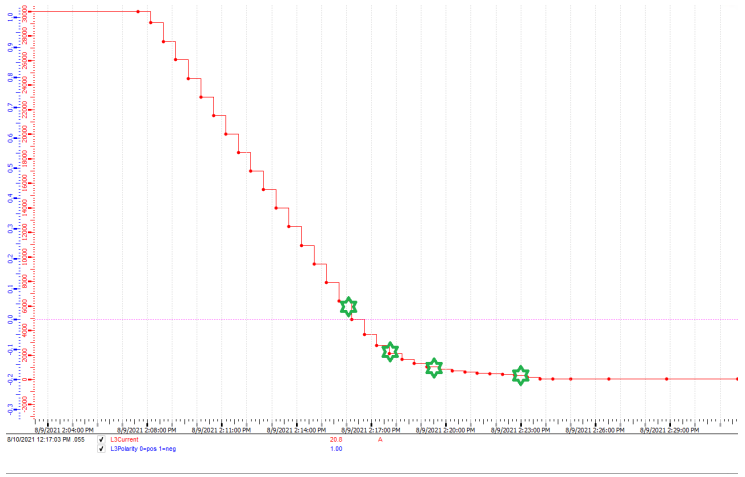
Trips and shorts

- The TPC was installed in the experiment with 2-3 shorted segments (~100 cm^2 each) from commissioning at the surface, in 2020
- During first ramps of the ALICE solenoid, several trips occurred and 3 more segments got shorted –clear correlation with changing B field
  - decide to ramp the magnet only with GEMs at full voltage: occasional trips but no more shorts
- A few shorts appeared during operation in 2022 and 2023, all disappeared after a few days

Trips upon magnet ramp up/down







Red line: magnet current

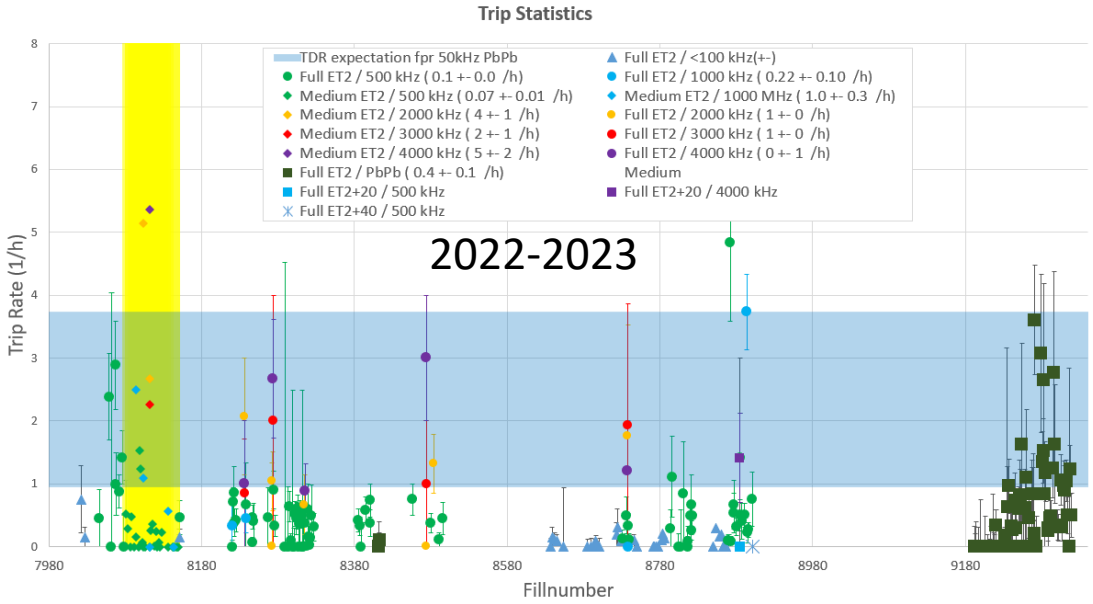
Green points: HV trips

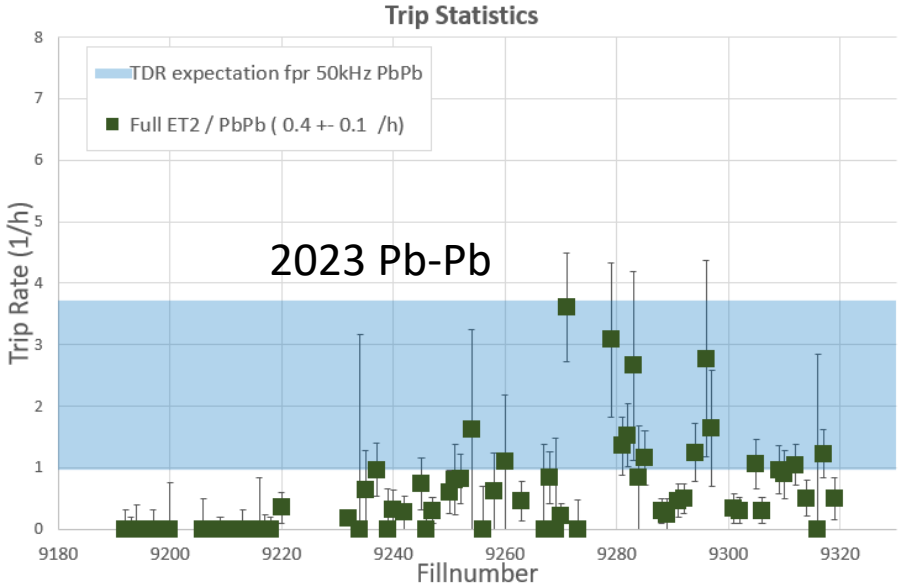
- Trips usually happened at beginning of ramp
- Figured that small dust particles at **any** GEM surface move to a hole and create HV path
- If discharge energy not high enough, dust melts and produces short
- If discharge energy high enough, dust evaporates

Short of full stack

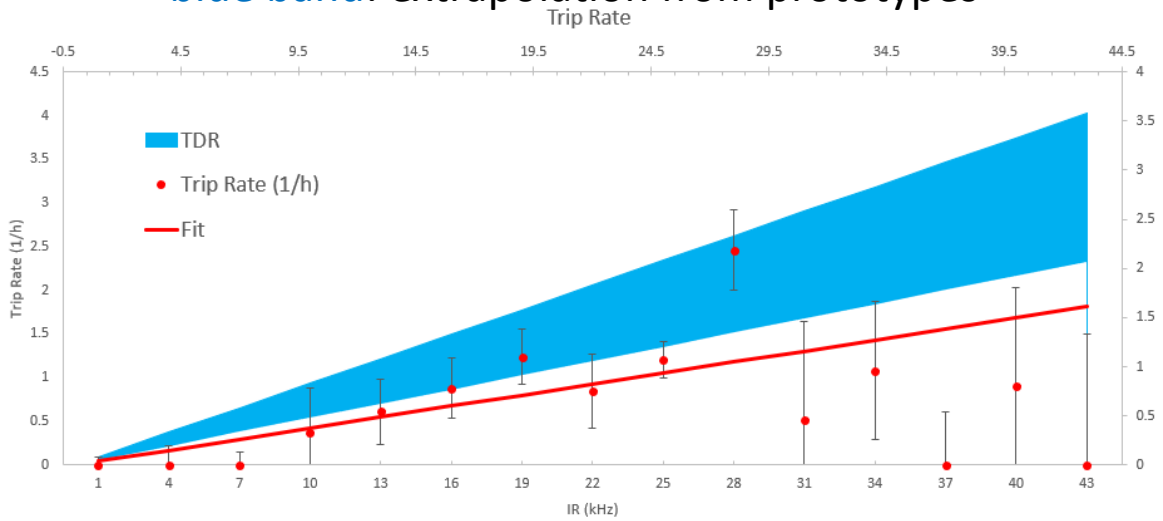
- IROC A11 suddenly tripped and showed ~10 kOhm short in GEM1
  - can apply ~10 V across GEM1 with current limit 1 mA
- Happened well into the 2023 heavy-ion run at a moderate particle load (well into a fill)
- Probably a direct short across the foil before any loading resistor
- Studies carried out in the lab to find HV setting that produce signal and back-drifting ions
  - clusters in IROCs needed for good track matching to the inner tracking system
  - being tested in the TPC these days
  - try also to apply some ‘treatment’

Trip rate summary





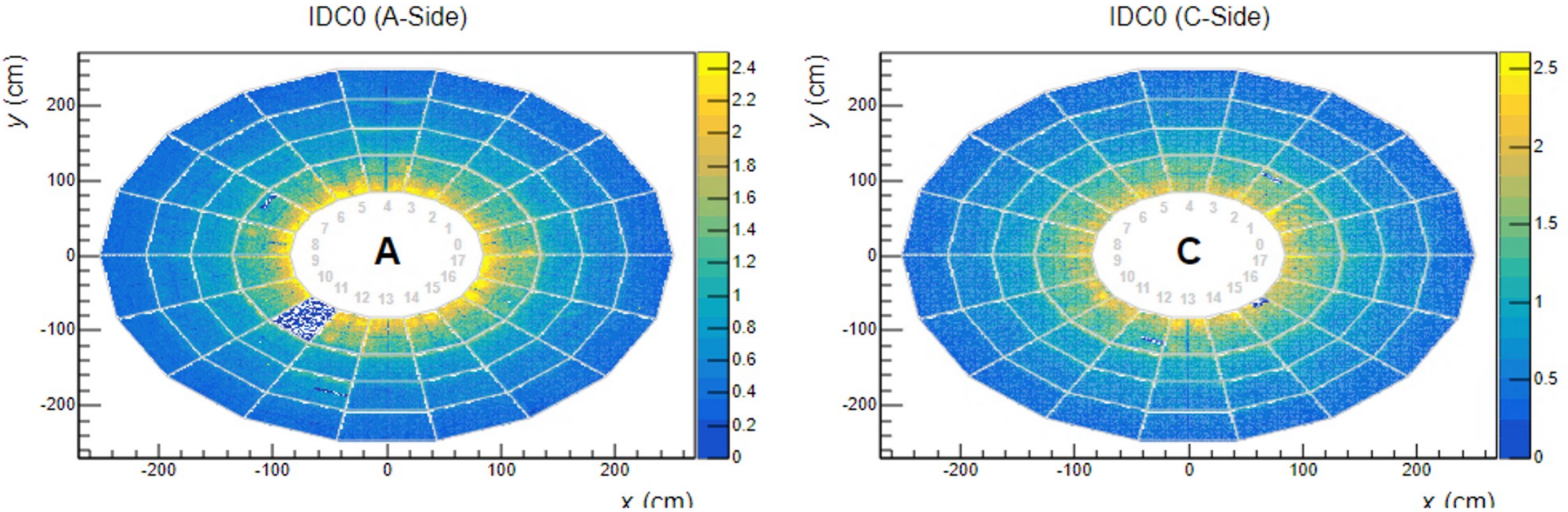
blue band: extrapolation from prototypes



Plans for 2024:

- Apply alternative voltage setting (already tested during 2023)
  - ➢ lower trip rate
  - ➢ slightly reduced IBF

TPC acceptance at the end of 2023 operation

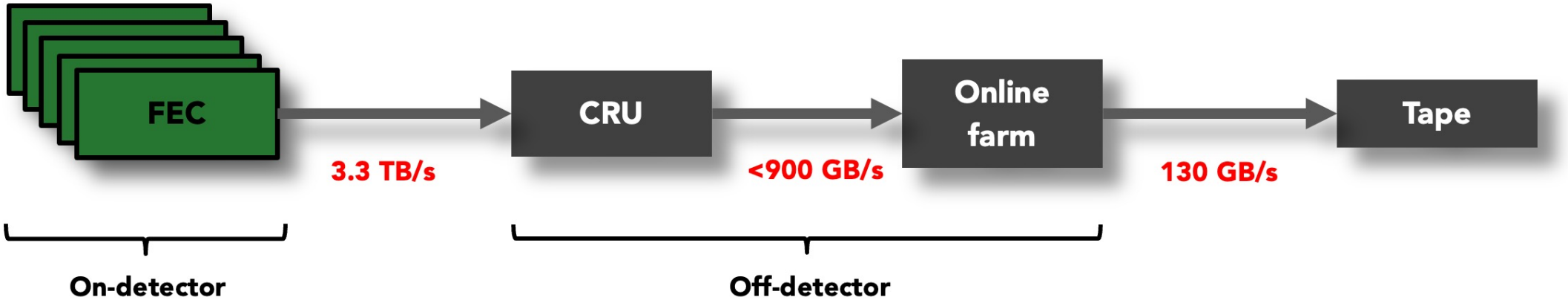


- ...and then maintenance activities start: AUG tests, electrical maintenance, cooling water maintenance...

Last shorted segment –after the run

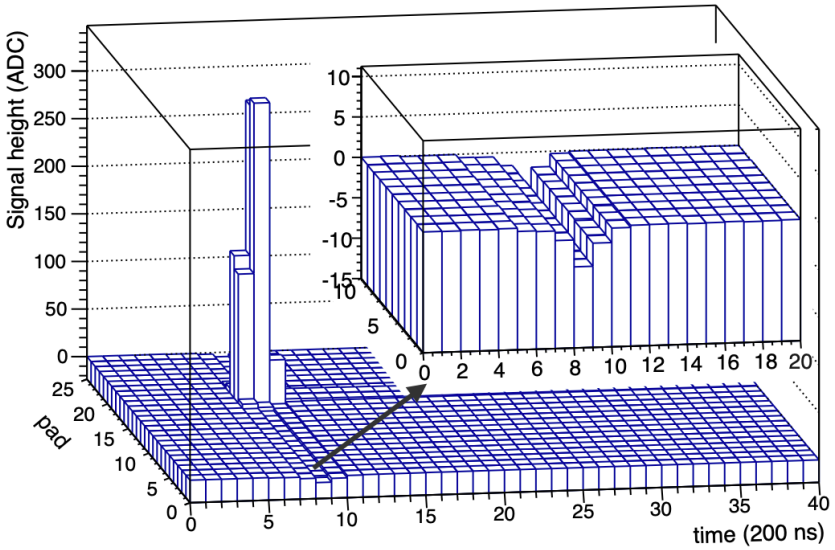
- One more segment shorted when the GEMs were under ... 18 Volts!
- Few degrees temperature excursions in the cavern due to various maintenance activities

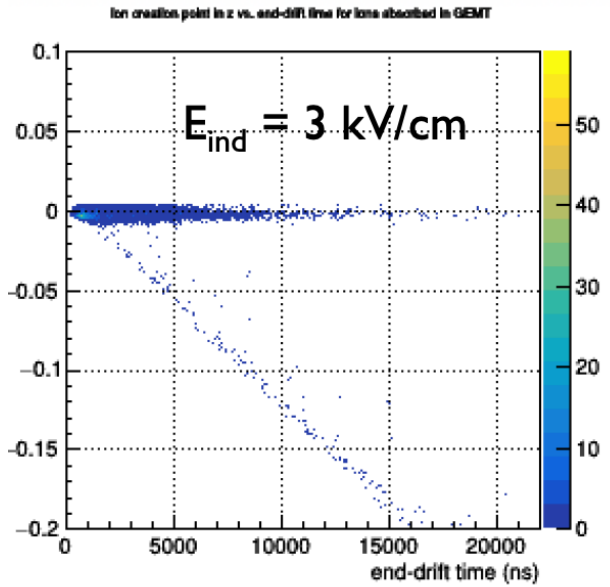
The TPC readout chain

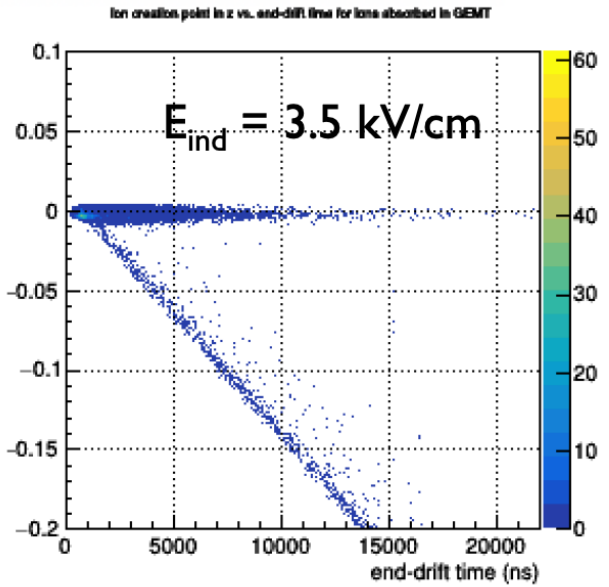


- 3276 SAMPA-based FECs
- 360 FPGA-based readout cards (CRU) receive all data (continuous readout)
- In the FPGA User Logic area, data are processed: synchronised, signals are corrected for **common-mode** and **ion-tail**, **zero-suppressed**, and **densely packed** for further processing in the EPN online farm

Common mode and Ion tail



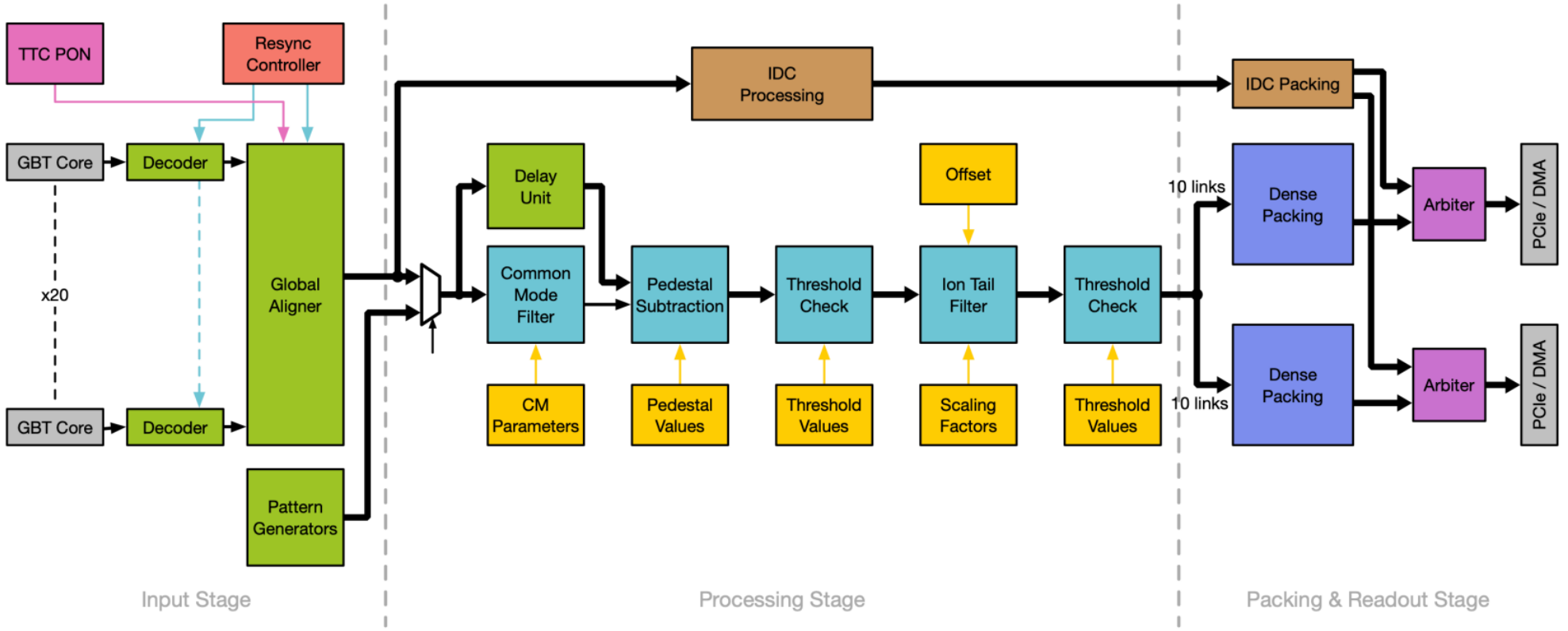




- Common-mode fraction into the pads is ~45 %
- Ion tail due to
  - ions produced at (the bottom of) the holes in GEM4
  - ions produced in the induction gap (gas and field dependent)

👉 These corrections are needed to preserve dE/dx resolution at high occupancies

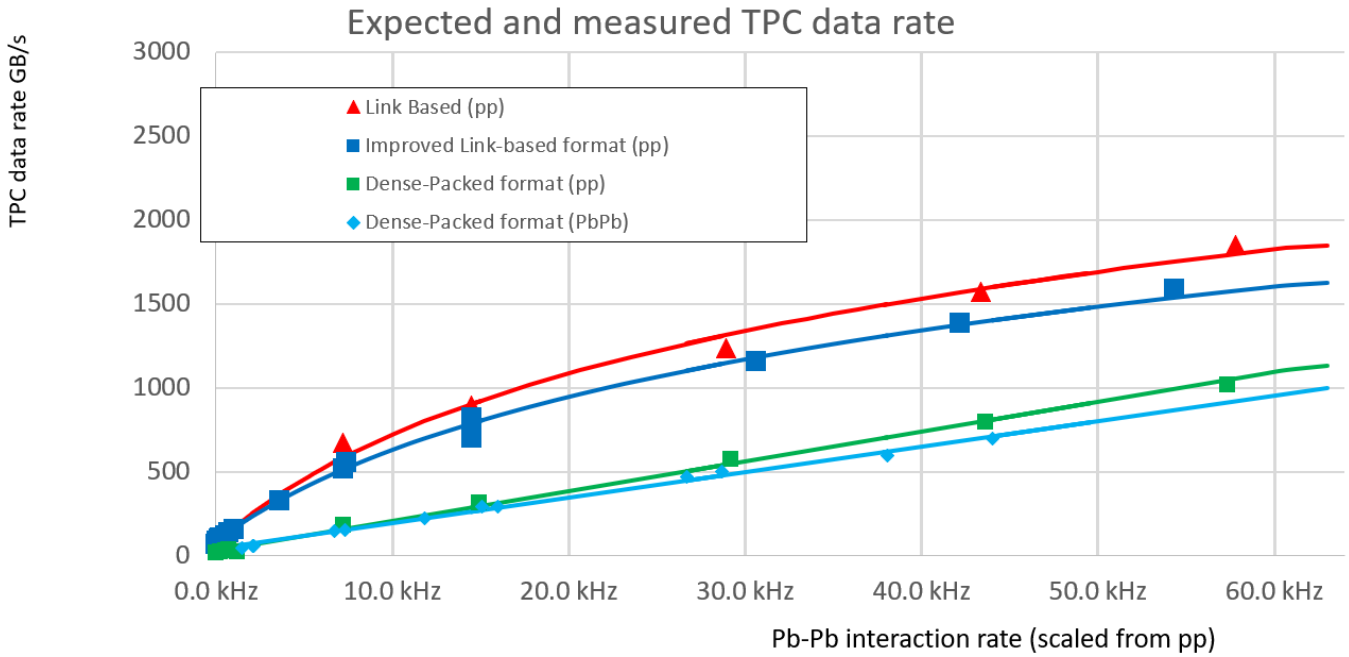
The Firmware



Plenty of development during the last two years: all functionality implemented (large design)
FW finalised and consolidated by mid 2023
Further improvements being implemented (focus on monitoring and debugging)

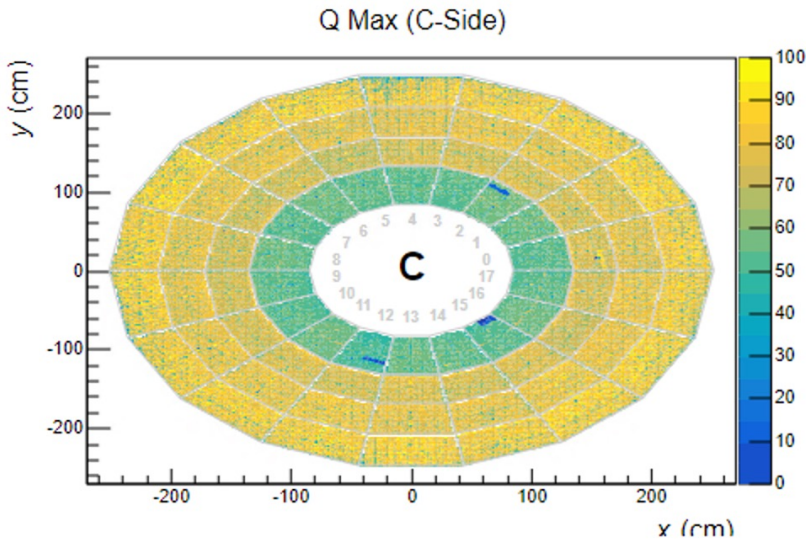
Data rate between FLPs and EPN farm

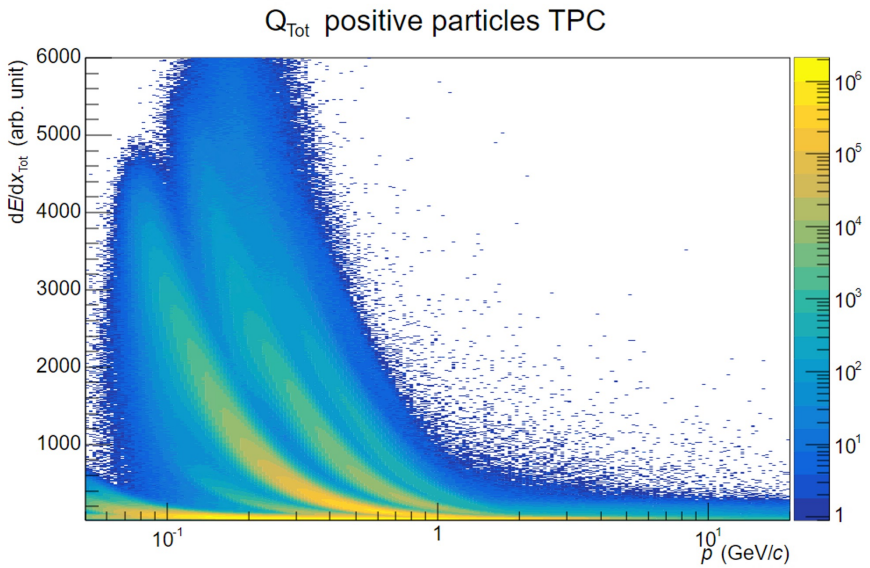
- TPC rate higher than anticipated (contribution from material and from neutrons)
- FW redesigned to pack the data minimising padding and shortening headers
- Performance at 50 kHz Pb-Pb well below the 1.25 TB/s bandwidth limit

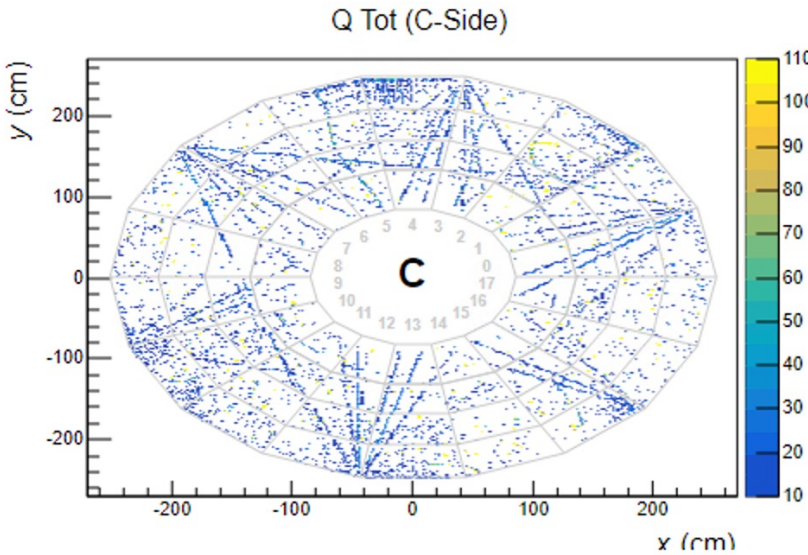


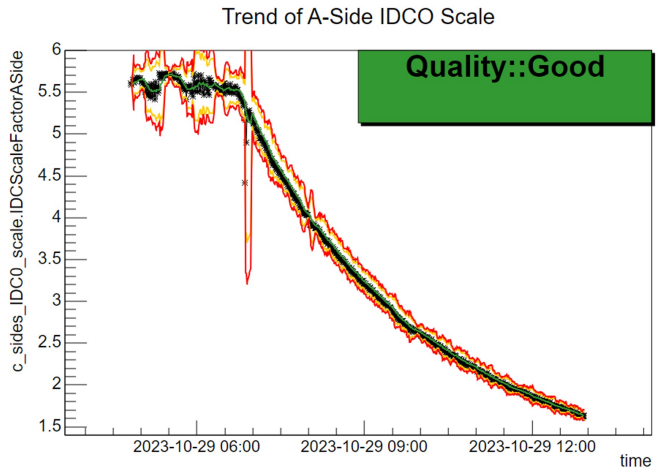
Dense data packing:
Green: extrapolated rate from pp to Pb-Pb
Blue: measured rate in Pb-Pb

Online workflows and QC









- Various observables with trending and automatic checkers
- Periodic Pulser, Pedestal, and (embedded) Laser runs
- For asynchronous reconstruction:
- IDCs: Integrated Digital Currents (SAMPA data processed through a separate stream)
- SACs: Sampled Analog Currents (per-stack high precision currents from GEM4T)
- SICs: Sampled Ion Currents (FC currents for ion drift velocity measurement)

Conclusions

- The upgraded ALICE TPC, along with the experiment, has successfully taken continuous data during 2022 and 2023, including the first heavy-ion run in October 2023
- HV trip rate as expected
- A couple of surprises with shorts, being addressed
- Effective data processing and online/offline calibration and monitoring in place
- RD51 contributions