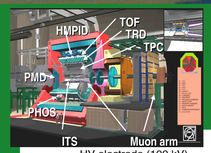
Results from the ALICE test TPC

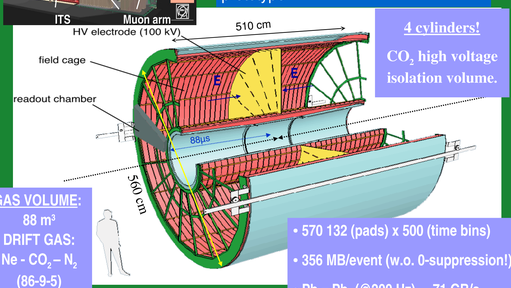
P. Christiansen (Lund University) for the ALICE TPC Collaboration

The ALICE TPC collaboration: Bergen, Bratislava, CERN- PH- AIT- DT1, CERN- PH- ED, Copenhagen, Darmstadt TU, Frankfurt, GSI Darmstadt, Heidelberg KIP, Heidelberg PI, Krakow, Lund

THE ALICE TPC



The ALICE TPC is the main tracking detector of the ALICE experiment, and is currently being commisioned at CERN.
Here we present results with a test prototype.

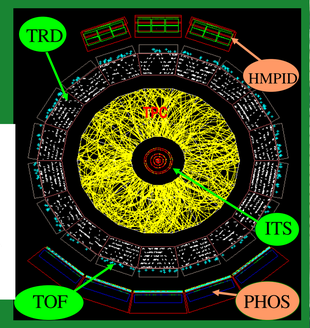


4 cylinders!
CO_2 high voltage isolation volume.

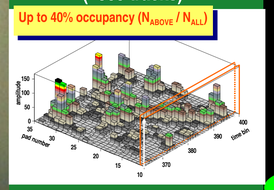
GAS VOLUME:
88 m³
DRIFT GAS:
Ne - CO_2 – N_2
(86-9-5)

- 570 132 (pads) x 500 (time bins)
- 356 MB/event (w.o. 0-suppression!)
- Pb – Pb (@200 Hz) 71 GB/s
- p-p (@1KHz) 356 GB/s

Pb+Pb event
(dN/dy = 8000)
Δθ = 2° slice only!
(~500 tracks)



Up to 40% occupancy (N_{ABOVE} / N_{ALL})



Clusters at the innermost pad row of the TPC

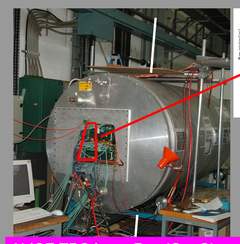
TPC DESIGN PARAMETERS

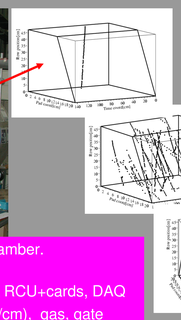
- Minimize multiple scattering
  - Composite materials for field cage
- High occupancy
  - High readout segmentation (3D)
  - Neon gas (fast ion drift velocity)
  - CO_2 quencher (small diffusion and good aging properties)
- Small signal (Small pads, low density gas)
  - Low noise electronics (<1000e)
  - High gain (~10^4) + Non-transparent gate (<10^{-4})
- Good space point resolution
  - Small field distortions (field cage precision)
  - Temperature stability<0.1K gradient

TPC PERFORMANCE REQUIREMENTS

- Noise < 1000 e^-
- S/N > 30 (S=Most likely Qmax for a MIP)
- Large dynamic range 30*MIP (for low momentum)
- Signal online correction and filtering by electronics
- Space point resolution ~ 800-1200µm
  - Momentum resolution p_T/p_T ~ 1-2% (0.1 < p_T<3GeV/c)
- PID energy loss resolution
  - < 10% for p_T<3GeV/c (e/pi separation)
  - < 7 % (5.5%) for p_T>3GeV/c (PID on relativistic rise)

COSMIC RAY TEST SETUP



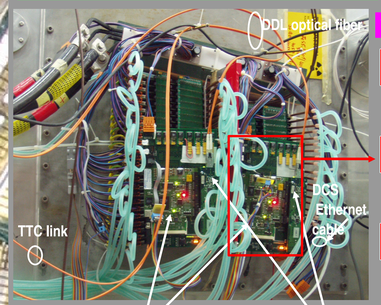


Cosmic events with varying occupancy in the TPC.

~700 clusters

~2500 clusters

ALICE TPC Inner ReadOut Chamber.
5504 channels = 1% of ALICE
Final components: IROC, FEC, RCU+cards, DAQ
Settings: Voltages, field (400 V/cm), gas, gate

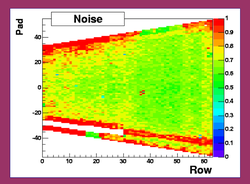


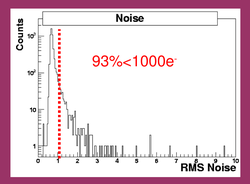
Trigger and data flow

Trigger Crate
L1 & L2 (accept)
RCU
FEE
DATA
DAQ

Black (full) event 3.6MB.
~ 10 MB/s bandwidth limited.

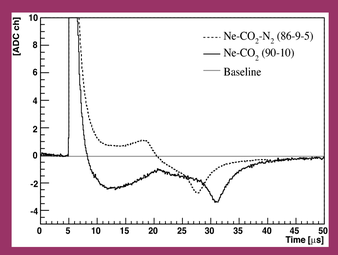
NOISE PROFILE ON THE IROC

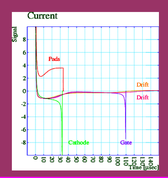




- <Noise> = 700 e^- [TDR: 1000 e^-]
- The limiting factor is S/N for being able to reduce the data online without losing information
- Increased noise close to edges is specific to test setup

SIGNAL SHAPE OF THE ION TAIL



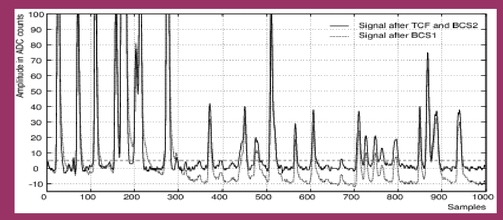


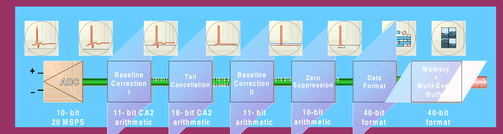
GARFIELD smulation of the ion tail for different ion drift trajectories.

The ion tail was measured for clusters with large signals.
It was slightly different for the two gas mixtures:
- Ne-CO_2 (90-10) – Anode voltage: +1250V
- Ne-CO_2-N_2 (90-10-5) – Anode voltage: +1480V

The tail is used to tune the ALTRO correction and filter parameters.

ALTRO ACTION WITH COSIMC SHOWERS



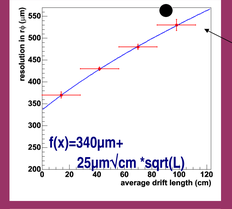


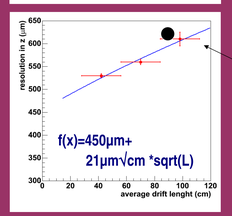
By triggering on cosmic ray showers it is possible to obtain local track densities similar to those expected in central collisions at LHC and study the performance of the ALTRO algorithm.

SPACE POINT RESOLUTION FROM TRACKS

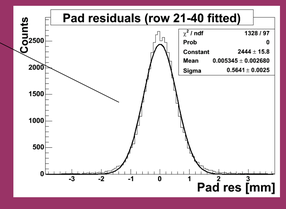
The space point resolution was studied using track residuals

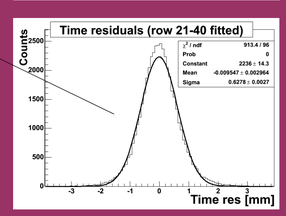
Cosmic data Ne-CO_2 (90-10)





Test beam data Ne-CO_2-N_2 (90-10-5)

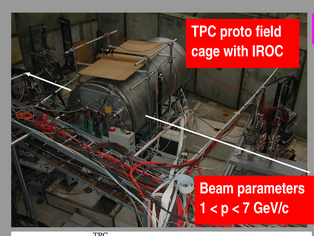




Extrapolation:	-r	-z
• to 0:	450µm	450µm
• to 250 cm:	740µm	785µm

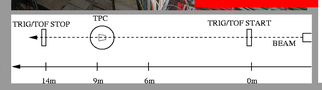
NB! Tracks parallel to endplate

TEST BEAM SETUP

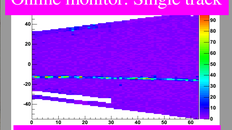


TPC proto field cage with IROC

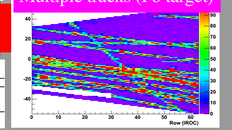
Beam parameters
1 < p < 7 GeV/c



Online monitor: Single track

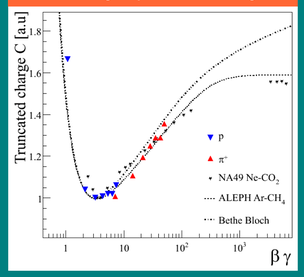


Multiple tracks (Pb target)



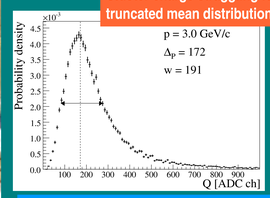
ENERGY LOSS RESOLUTION

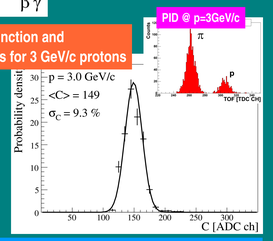
Truncated charge dependence on beta-gamma



- Truncated mean was taken of the 60% lowest cluster charges in a track.
- The truncated mean dependence on beta-gamma is similar to what was observed by Aleph and NA49.
- The Aleph curve is used for the simulations/TDR

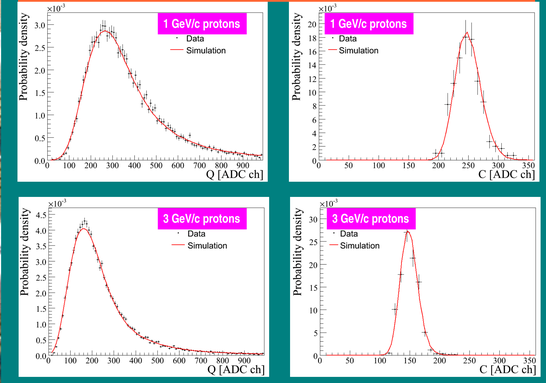
Cluster charge straggling function and truncated mean distributions for 3 GeV/c protons





Energy loss resolution for the truncated charge C is ~9% (~ 63 rows~47cm out of 160cm)
⇒ Estimated final energy loss resolution (160 cm track):
9.0%/√3.3 ~ **5.2%**

Comparsion to calculations by H. Bichsel with diffusion and amplification variations.



By comparing to calculations by Hans Bichsel we realized that the diffusion introduces correlations between clusters in neighboring rows which reduces the information of the track – making the resolution worse! Using his calculations and a simple simulation of the TPC taking diffusion and exponential amplifications into account we get an excellent description of our data (the truncated mean is described better than by a Gauss fit!).

CONCLUSIONS

- Integration and tests of the final components was successful
- The measurements with the ALICE test TPC has demonstrated that the expected performance is achieved.
  - Noise < 1000e-
  - Signal and noise well separated (“S/N”>30)
  - Extrapolated space point res. ~0.8mm (after 2.5 m drift)
  - Extrapolated energy res. ~ 5.0% for full TPC (ideal tracks)

The results were published as:
D. Antonczyk *et al.* [for the ALICE TPC Collaboration], Nucl. Instrum. Meth. A **565** (2006) 551.