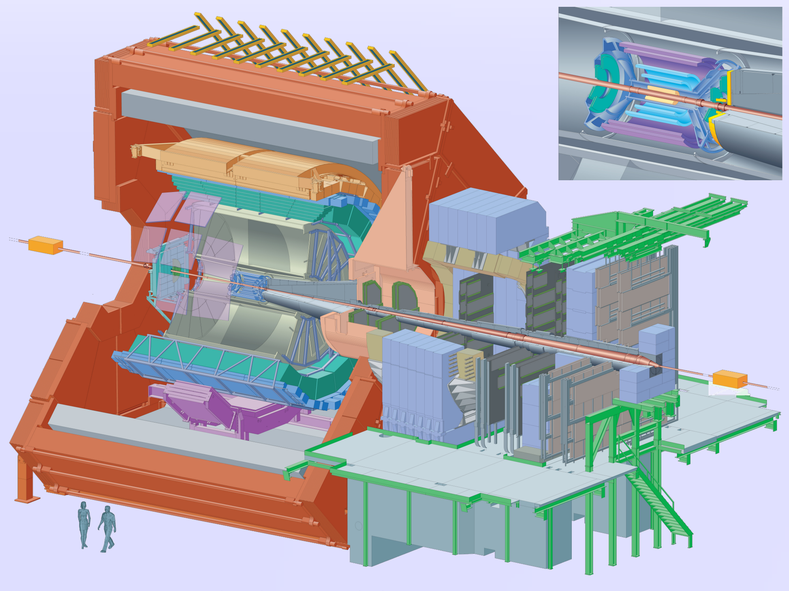
ALICE TPC control and read-out system

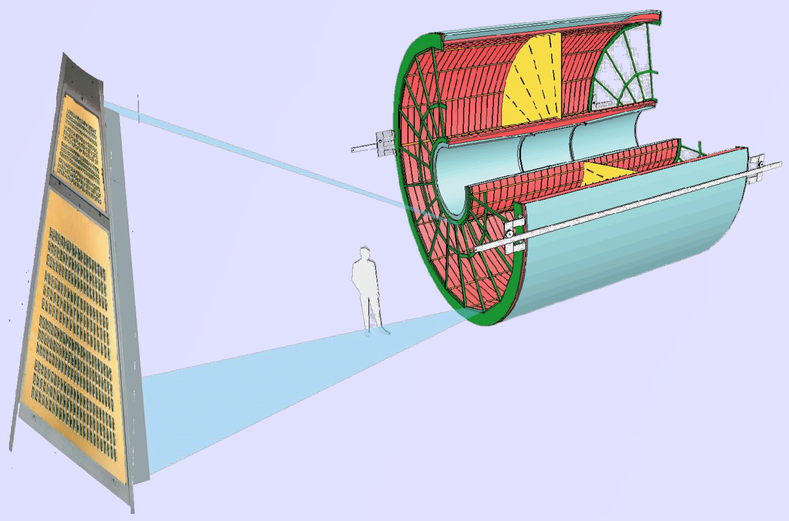
Dag Toppe Larsen[(a)] for the ALICE TPC collaboration
(a) Department of Physics and Technology, University of Bergen
Email: (a) *dagtl@ift.uib.no*

A Large Ion Collider Experiment

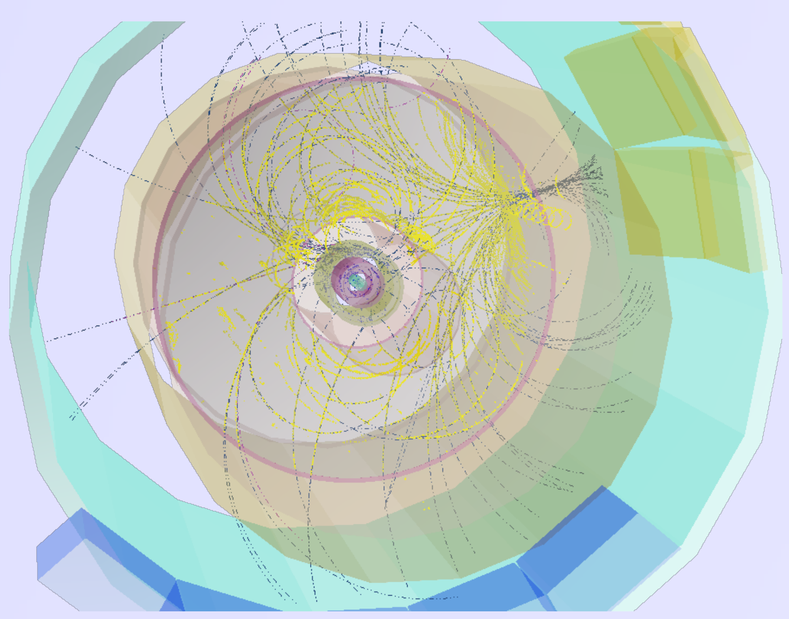


ALICE is a dedicated heavy-ion experiment at the CERN LHC. One of the main goals is to reproduce the physics conditions shortly after the big bang to study the quark–gluon plasma. A number of sub-detectors are installed to measure the properties of particles produced in the collisions. A Time Projection Chamber (TPC) is used as the main tracker.

Time Projection Chamber (TPC)



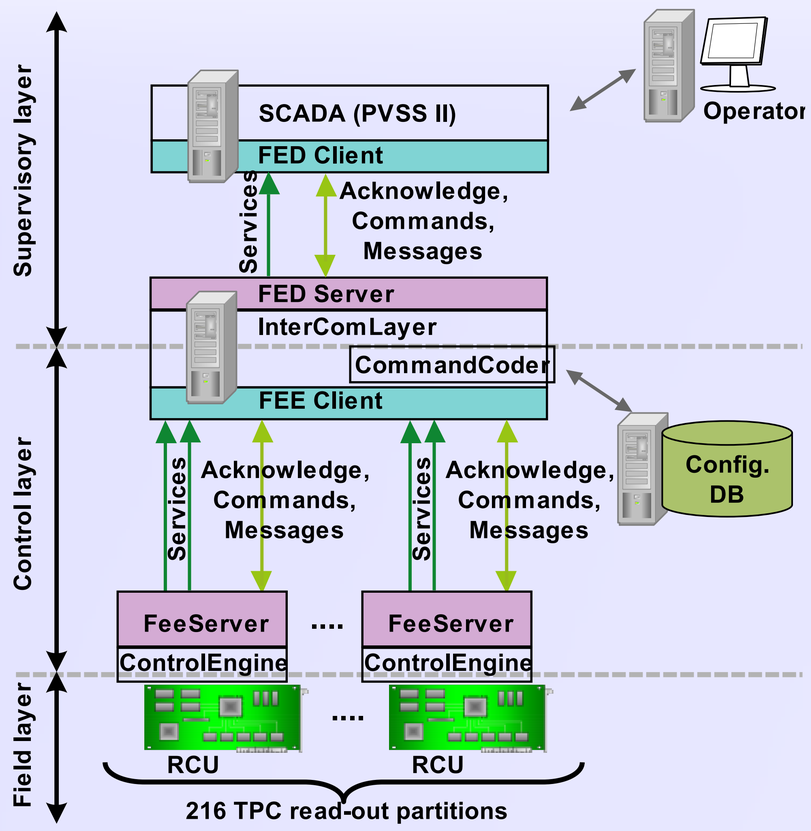
The ALICE TPC is a gaseous barrel tracking detector, filled with a counting gas composed of 85.7 % Ne, 9.5 % CO_2 and 4.8 % N_2. It is the largest built so far; both diameter and length are 500 cm. Collisions will take place in the beam pipe passing through the centre of the TPC, allowing the particles to traverse the TPC and leave tracks of ionised gas along their paths. A strong electric field from a 100 kV Central Electrode (CE) will make the electrons drift towards the end planes. Each end plane is divided into 18 azimuthal sectors, which again are divided into two Multi-Wire Proportional Chambers (MWPC). The charges are induced on a total of 557568 read-out pads. The TPC is designed to perform well for multiplicities as high as $dN_{ch}/d\eta$=8000 in the particle momentum range [0.1, 100] GeV/c and $|\eta|$ <0.9.



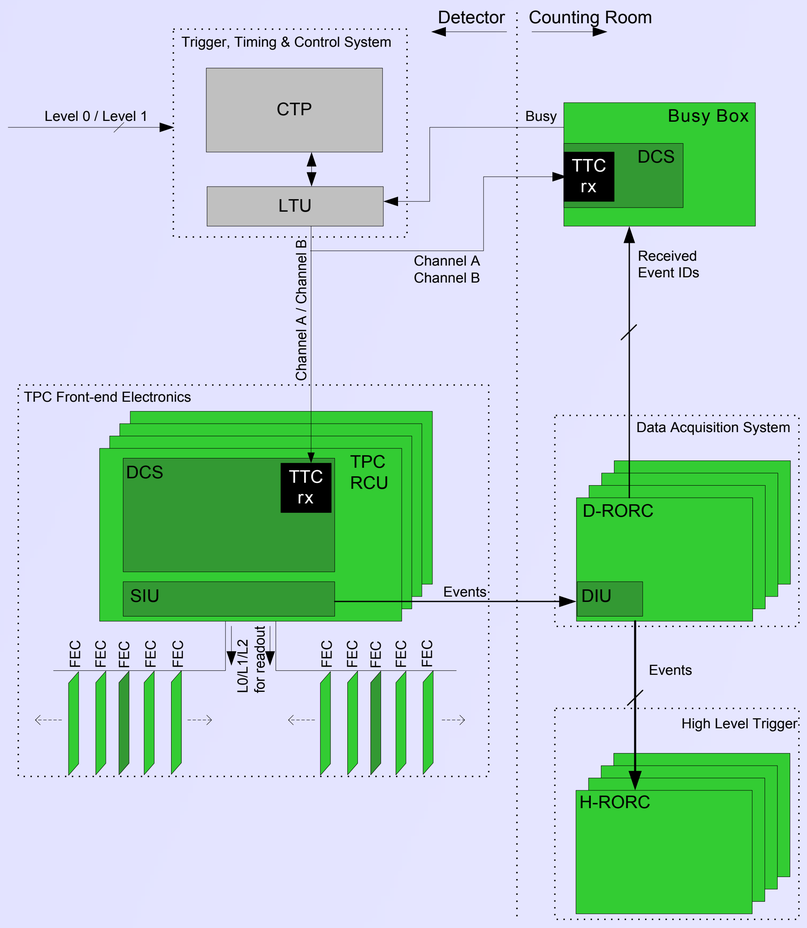
Example of cosmic shower as seen by the TPC and other detectors.

Detector control system (DCS)

The DCS is based on a tree-layer hierarchy: "field layer" is the FEE itself; "control layer" is the software, FeeServer (FS), running on the FEE of each RP, as well as the lower part of the InterCom-Layer (ICL); "supervisory layer" is the upper part of the ICL and the GUI the shifter is operating. Configuration of the FEE is accomplished by sending binary configuration data blocks to the FS. Values of registers of special importance, such as FEC temperatures, voltages and currents, as well as states of the state machine, are being published. Upon receiving a high-level configuration command from the GUI, ICL assembles configuration blocks for the FS by retrieving configuration parameters from the DB. ICL also collects data points published by FS, and forward them to the GUI. Full Experiment Control System (ECS) integration enables remote operation by the ALICE shifter.

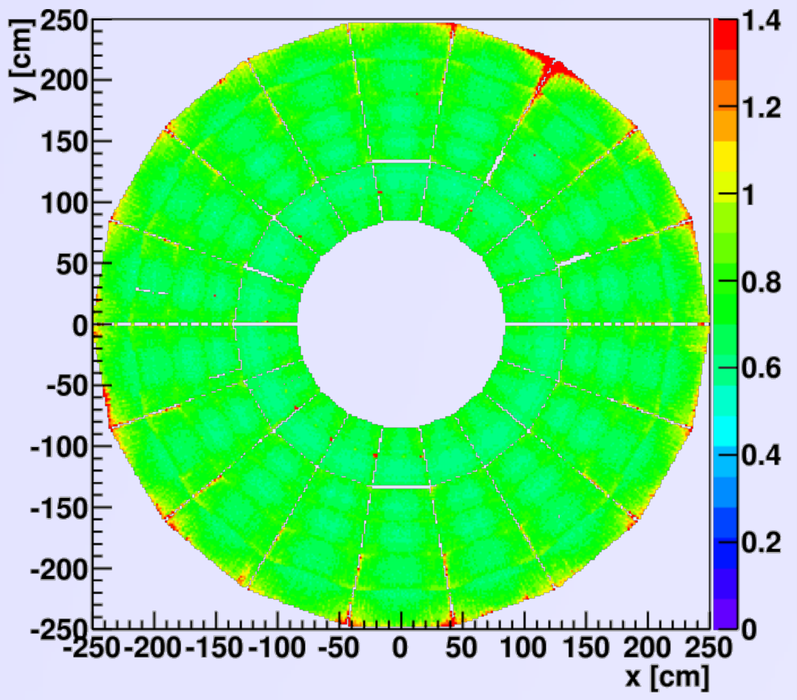


Data read-out design



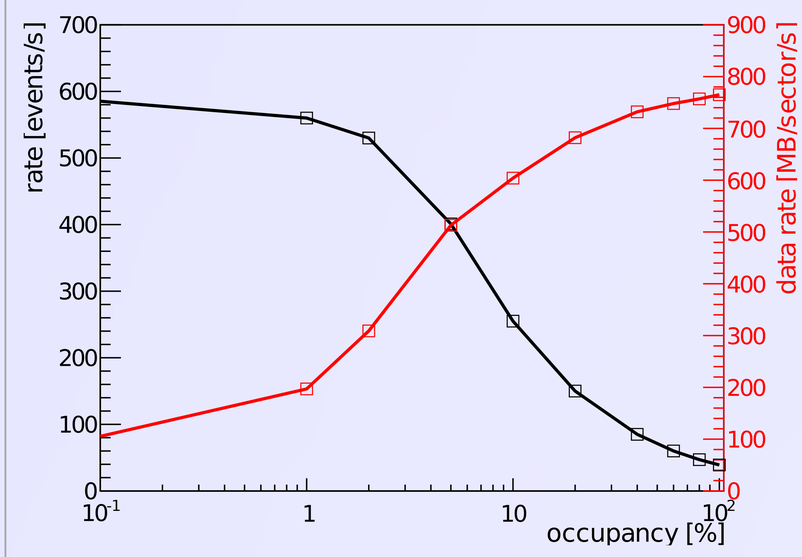
Each sector has six Read-out Partitions (RP), which consists of a Read-out Control Unit (RCU) with 18-25 Front-End Cards (FEC). Eight ALICE TPC Read-Out (ALTRO) chips are mounted on a FEC, each capable of reading out 16 read-out pads. Data is forwarded from the RCU via a 1.25 Gb/s optical fibre. A Detector Control System (DCS) board equipped with an embedded ARM processor running Linux is attached to the RCU for control and monitoring. On the FECs, the pad signal passes through a shaping amplifier before it is forwarded to the ALTRO, which will digitise and digitally filter it. The ALTRO is using a 10-bit Analogue-Digital-Converter (ADC) capable of 10 million samples per second. The digital filtering is performed in several stages: removal of systematic effects and low frequency perturbations; tail cancellation using fully programmable filter coefficients; removal of non-systematic perturbations of the base-line superimposed on the signal.

Noise level



The noise figure is required to be less than 1000 e^- RMS of base-line, corresponding to 1 ADC count. Levels obtained from pedestal runs show the noise figure is ≈0.7 ADC count (700 e^-), and does not change much with time. This is close to the natural limit, and allows for zero-suppressed empty events less than 70 kB (noise); without zero-suppression 10 000 times larger.

Data read-out performance



Only PRs with 25 FECs can utilise the full bandwidth of the optical fibre, hence effective read-out rate per six-RP sector is limited to 770 MB/s. Benchmark tests show this is achievable for high-occupancy, zero-suppressed events. For low-occupancy events, read-out is possible at an event rate of 595 Hz (0 % occupancy) using full readout. Using sparse read-out — empty channels, including headers, are entirely stripped — the rate increases to 1386 Hz. Respective data rates are 70 MB/s and 927 kB/s.