Slovak participation in ALICE

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RECFA Meeting Bratislava, Slovakia, 18 May 2018

Outline

- Slovak involvement in ALICE

- Experiment ALICE

- Hardware contributions

- Software contributions

- Physics analysis

- Summary

Slovak involvement in ALICE

Košice cluster

Institute of Experimental Physics, Slovak Academy of Sciences

Bratislava

Faculty of Science, P.J.Šafárik University

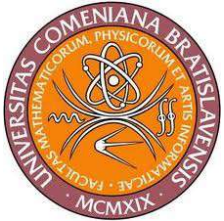Faculty of Mathematics, Physics and Informatics, Comenius University

Faculty of Electrical Engineering and Informatics, Technical University Košice
(ALICE full member since 2015)

Slovak involvement in ALICE

Bratislava

Kosice cluster

Team leader: B. Sitár

Team leader: I. Králik

Physicists, engineers:
M. Mereš, M. Pikna, P. Strmeň,
I. Szarka

PhD students:
A. Szabo

Technician:
E. Hanuska

Physicists and engineers:
M. Bombara, A. Kravčáková, J. Vrláková,
J. Jadlovský, A. Jadlovská, S. Jadlovská,
M. Vaľa, P. Kaliňák, M. Krivda, J. Mušinský,
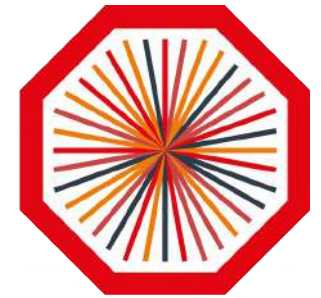R. Bílek, I. Kuľková, M. Straka, J. Špalek

PhD Students:
M. Šefčík, L. Tropp, Z. Jakubčinová, M. Kopčík,
M. Oravec, J. Čabala, D. Vošček, L. Koska,
J. Socháň

Students:
L.A. Husová, M. Tkáčik, A. Březina, M. Pánik, E. Hanc
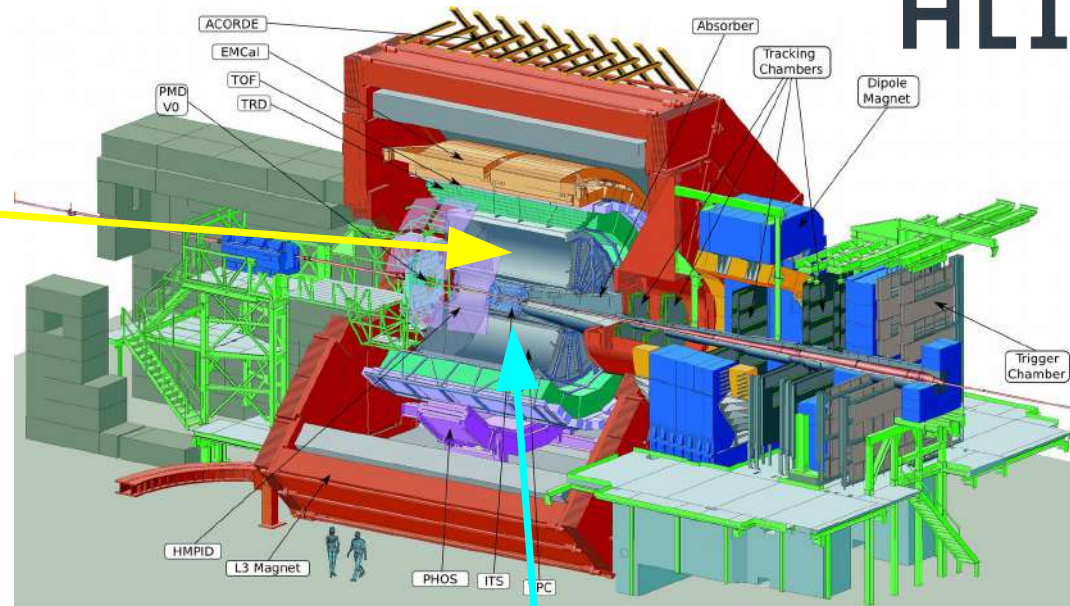
Experiment ALICE

ALICE (A Large Ion Collider Experiment) is a heavy-ion exeeperiment on the LHC designed to study the physics of strongly interacting matter at extreme conditions.

TPC

Time Projection Chamber
- main tracking device in ALICE.
Provides tracking and
PID via dE/dx

CTP

Central Trigger Processor
- the heart of the ALICE trigger.

SPD

Silicon Pixel Detector - the most inner tracking detector.
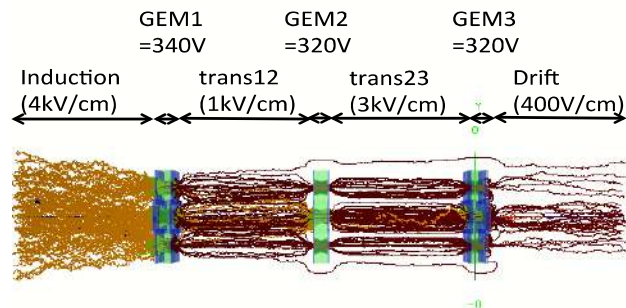Used for vertex finding, tracking, and triggering.

Hardware contributions

Work on the ALICE TPC upgrade

- **TPC continuous readout without gating grid**
  - minimize ion feedback from amplification region
  - change MWPC readout to GEM readout
  - preserving tracking and particle identification capabilities
  - online calibration and data reduction in HLT
  - at 50 kHz of Pb–Pb interaction: reduction factor of ~ 25, event rate tape 25 kHz, throughput to mass storage 20 GB/s
  - 3x faster gas mixture with CF_4 – research at Bratislava

- Event display

$Ar(70\%):CO_2(30\%)$

GEM1 =340V   GEM2 =320V   GEM3 =320V

Induction (4kV/cm)   trans12 (1kV/cm)   trans23 (3kV/cm)   Drift (400V/cm)

```
---- Event Summary 0 ----
*** ElectronsTotal = 238
***** ElectronsDrift = 0
***** ElectronsGEM3UpperMetal = 0
***** ElectronsGEM3Plastic = 1
***** ElectronsGEM3LowerMetal = 15
***** ElectronsTransfer23 = 0
***** ElectronsGEM2UpperMetal = 0
***** ElectronsGEM2Plastic = 2
***** ElectronsGEM2LowerMetal = 17
***** ElectronsTransfer12 = 0
***** ElectronsGEM1UpperMetal = 0
***** ElectronsGEM1Plastic = 14
***** ElectronsGEM1LowerMetal = 87
***** ElectronsInduction = 102
*** IonsTotal = 238
***** IonsDrift = 33
***** IonsGEM3UpperMetal = 85
***** IonsGEM3Plastic = 9
***** IonsGEM3LowerMetal = 2
***** IonsTransfer23 = 0
***** IonsGEM2UpperMetal = 1
***** IonsGEM2Plastic = 3
***** IonsGEM2LowerMetal = 0
***** IonsTransfer12 = 0
***** IonsGEM1UpperMetal = 76
***** IonsGEM1LowerMetal = 0
***** IonsInduction = 0
```

- 7 holes/layer are drawn for display (TGeoManager).

7
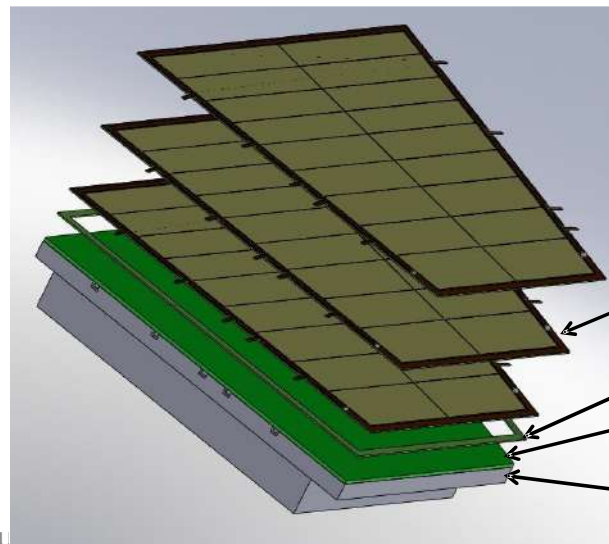
Ion mobility and drift measurement in a special TPC chamber

❑ Ion drift length can be set in the range 5 – 50 mm.

❑ The chamber can handle also mixtures of aggressive gasses like CF-4.

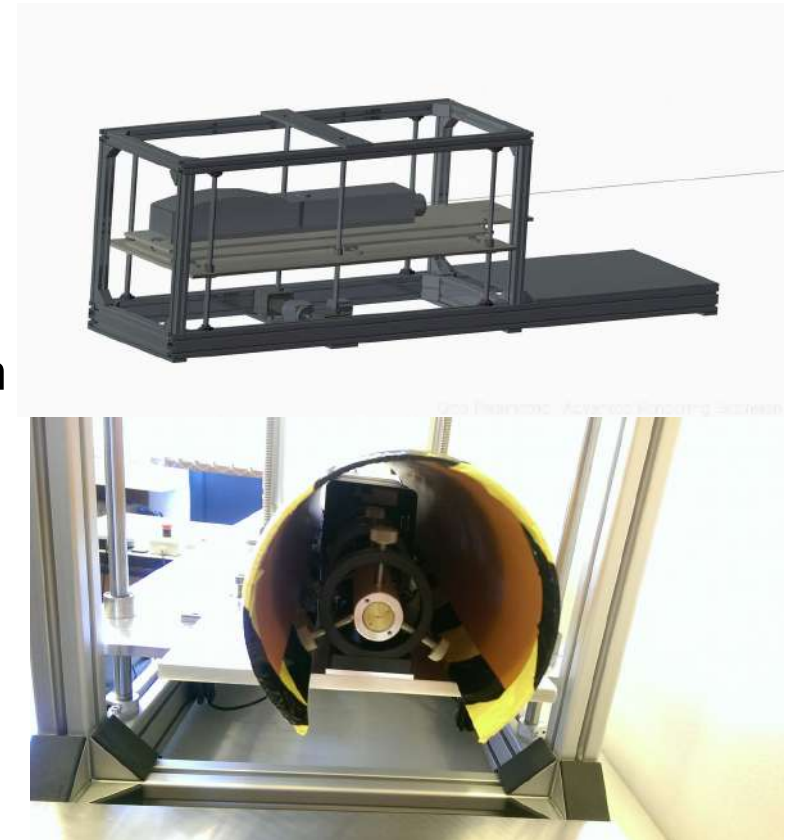❑ The aim of the ion drift measurement is to minimize the backward ion flux in the ALICE TPC.

Laser detector laboratory

Collimated beam φ < 1 mm of photons with 213 nm wavelength for detector testing is provided by a powerfull UV Nd: YAG laser

Optical bench allows to set the beam position w.r.t.with the precision ≤ 0.1 mm

Research and development of the GEM TPC for ALICE experiment

- ➢ The study of the discharge behavior in a gas mixture (Ar+CO$_2$ 90:10) in the configuration GEM + anode

- ➢ The mechanism of the pro pagation of discharges from GEM to the anode is not understood.

- ➢ For comparative measurements a GDT (Gas Discharge Tube) is used.
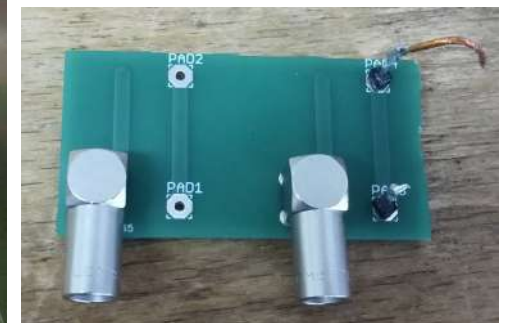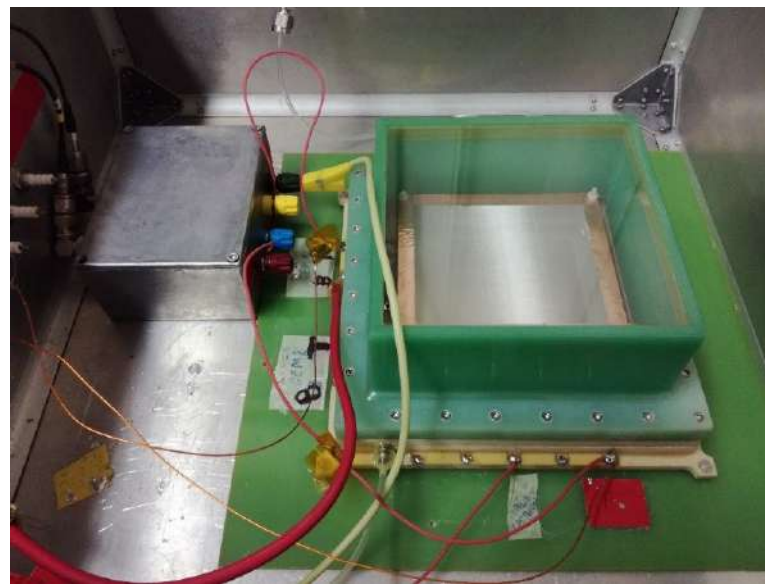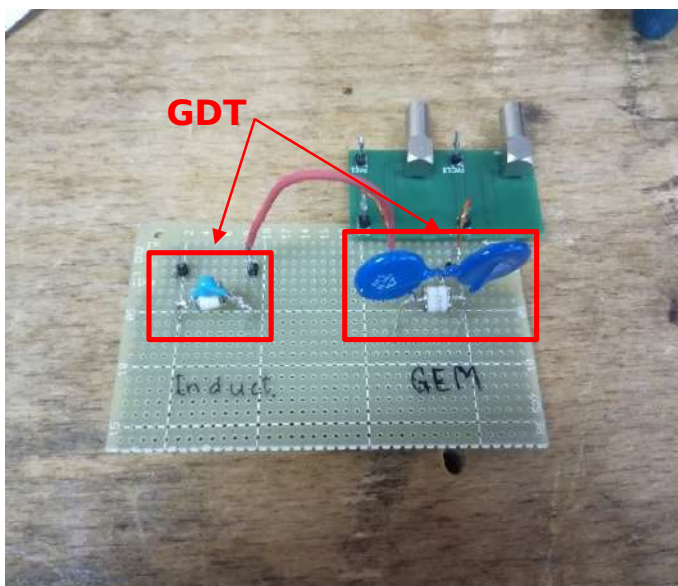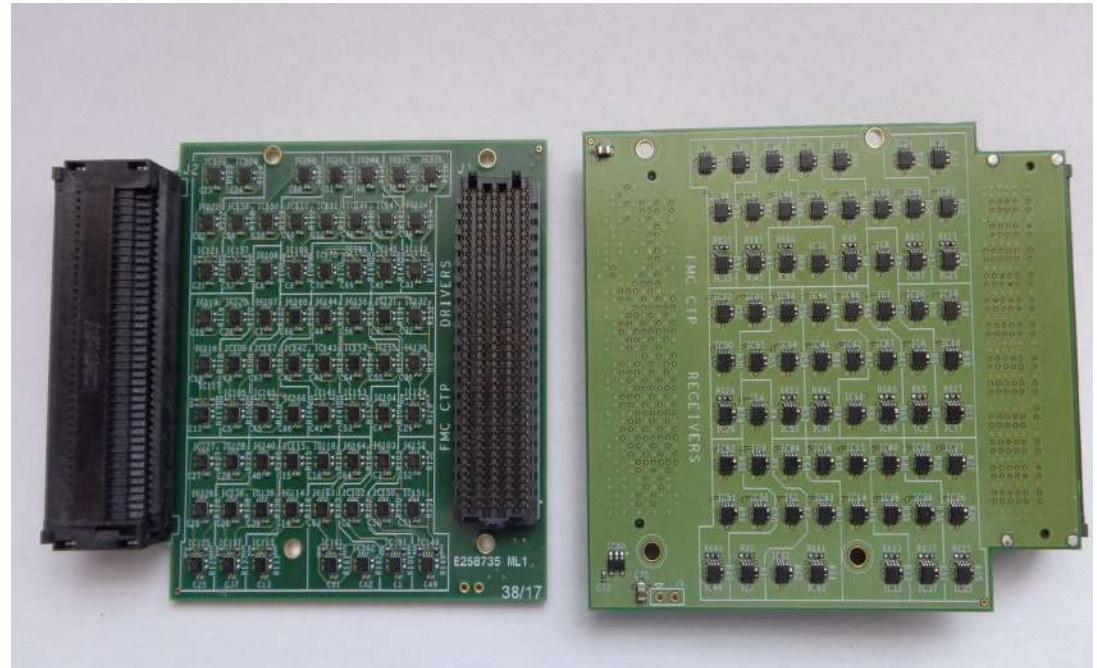

PCB antenna
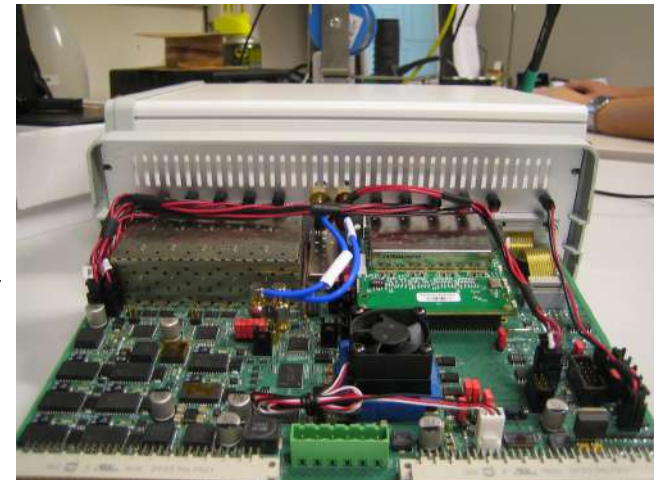
CTP electronics for the ALICE upgrade

Development, production
and testing of the FMC-CTP board
(FPGA Mezzanine Card)
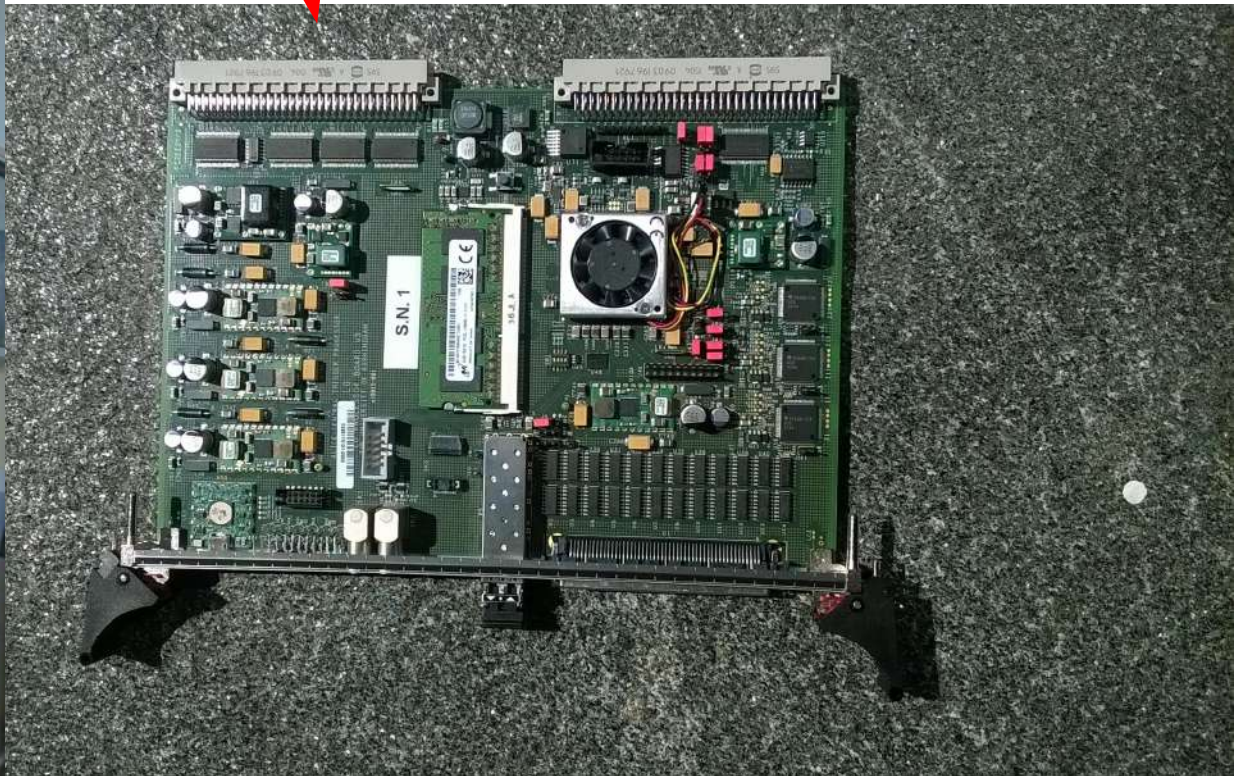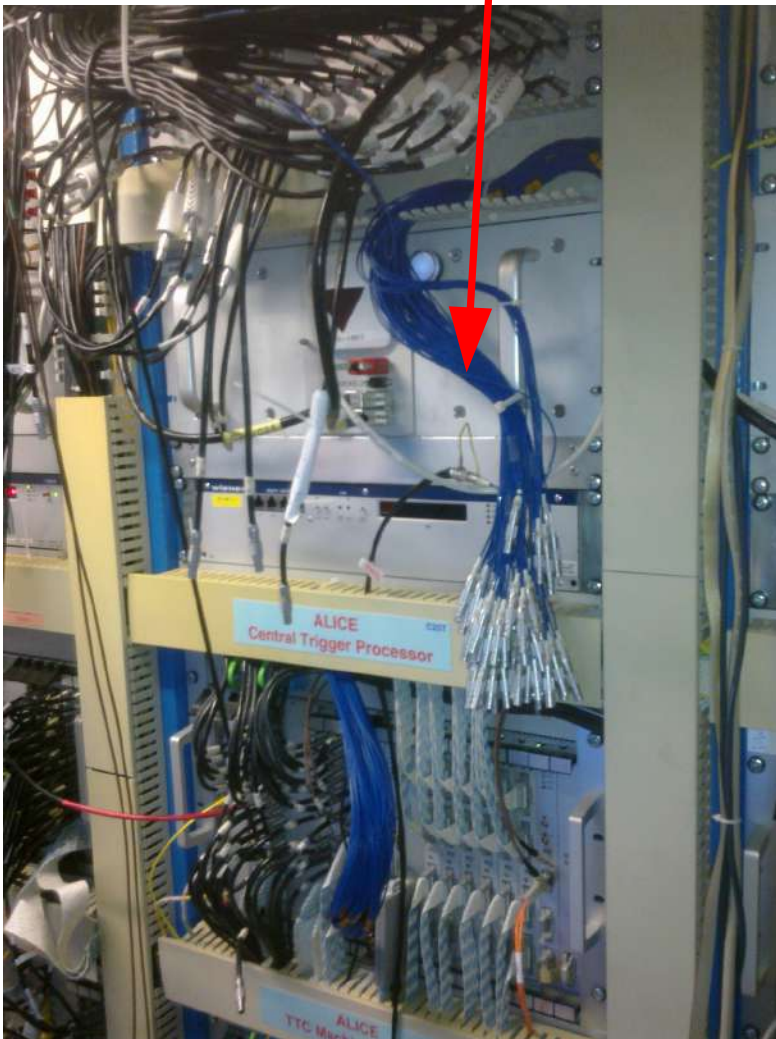

Octopus cable
production

Connection of the Trigger
board and the front panel
for the VME Elma box

CTP electronics

- Production of a new patch-cable for the CTP

- Debugging of a new L0 board for the CTP

Testing cables for the ALICE ITS upgrade

Proposal and production of an adaptor for measurent of the HF properties of various ITS readout bus prototypes.

Measurements and analysis of HF properties of several flexible buses for the ITS readout before and after their irradiation in the cyclotrone at UJV Rez, Czech republic.

Measurements and analysis of HF properties of several high speed cables.
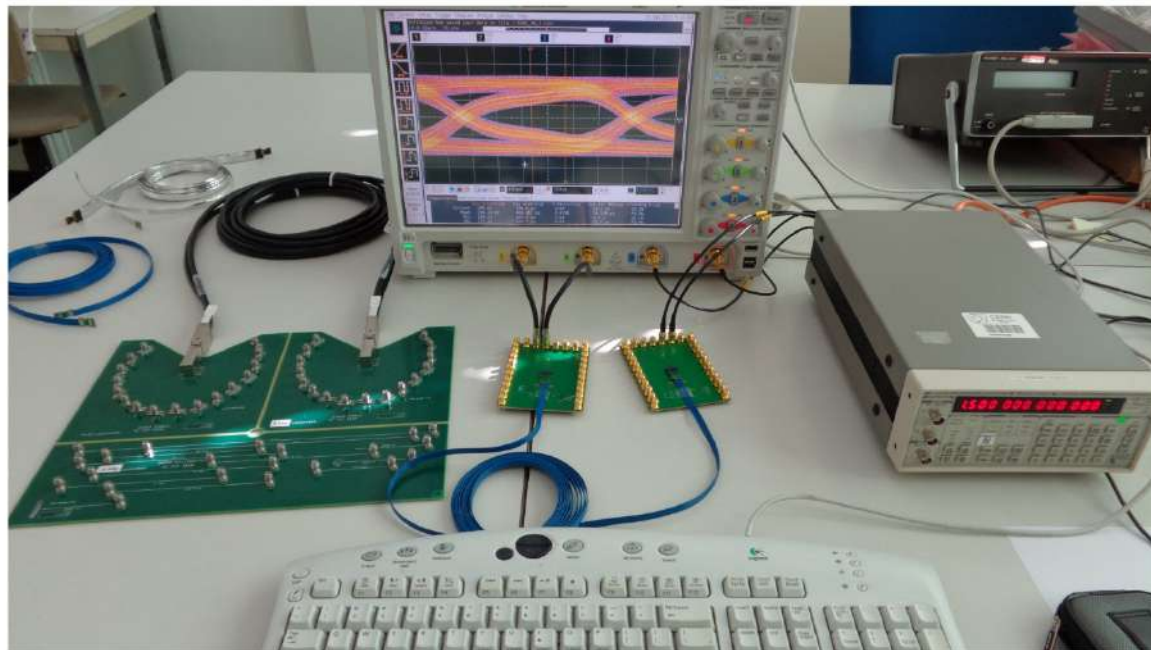
Setup at CERN

Software contributions

External access to ALICE control conditions data - AMANDA 3

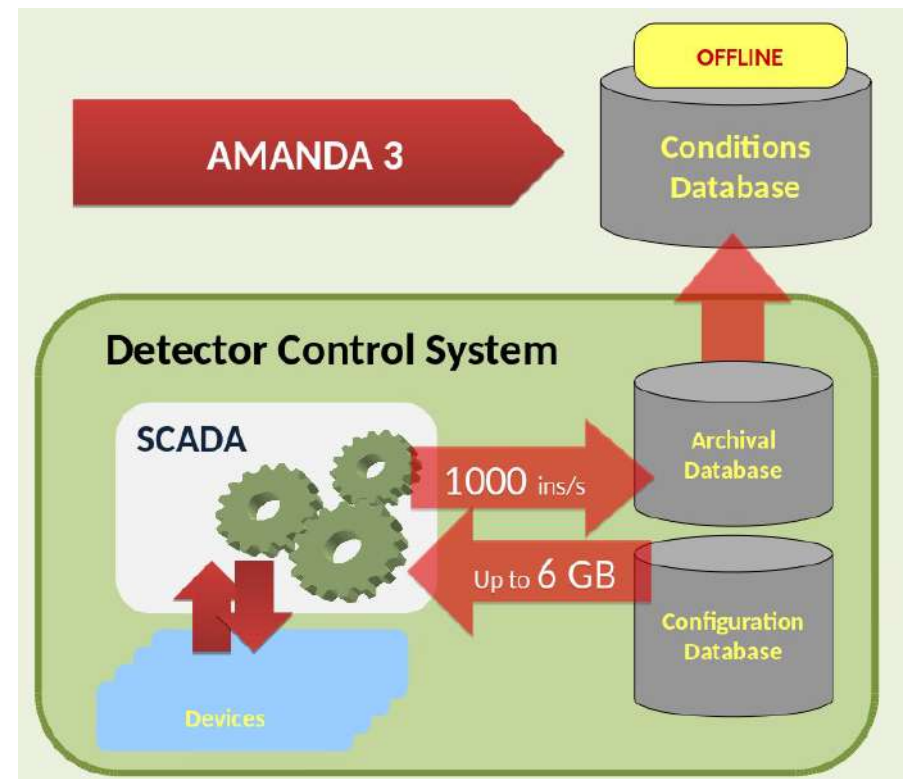**A**lice **MAN**ager for **D**cs **A**rchives

The conditions data exchange between the DCS and ALICE offline.

Specific tasks are scatteres among multiple computers, which allows for load balancing and system jam prevention.

The web client removes the dependency on the operating system.

The system is used by ALICE Offline to extract operational conditions after a run is completed.

AMANDA 3 was introduced into CERN infrastructure in 2014

Dcs ARchive MAnager for ALICE conditions data (DARMA)
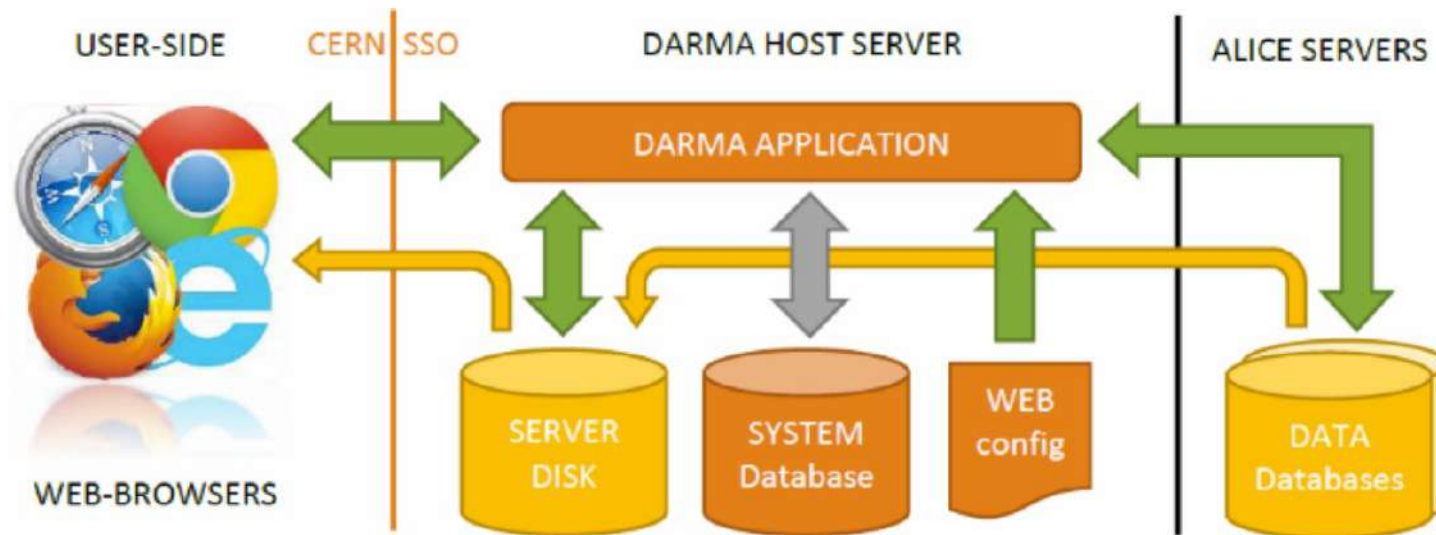
Updated version of AMANDA 3

Aim is to simplify the overall
complexity of the AMANDA 3
- simpler implementation
- simpler administration
- portability
without sacrificing the functionality
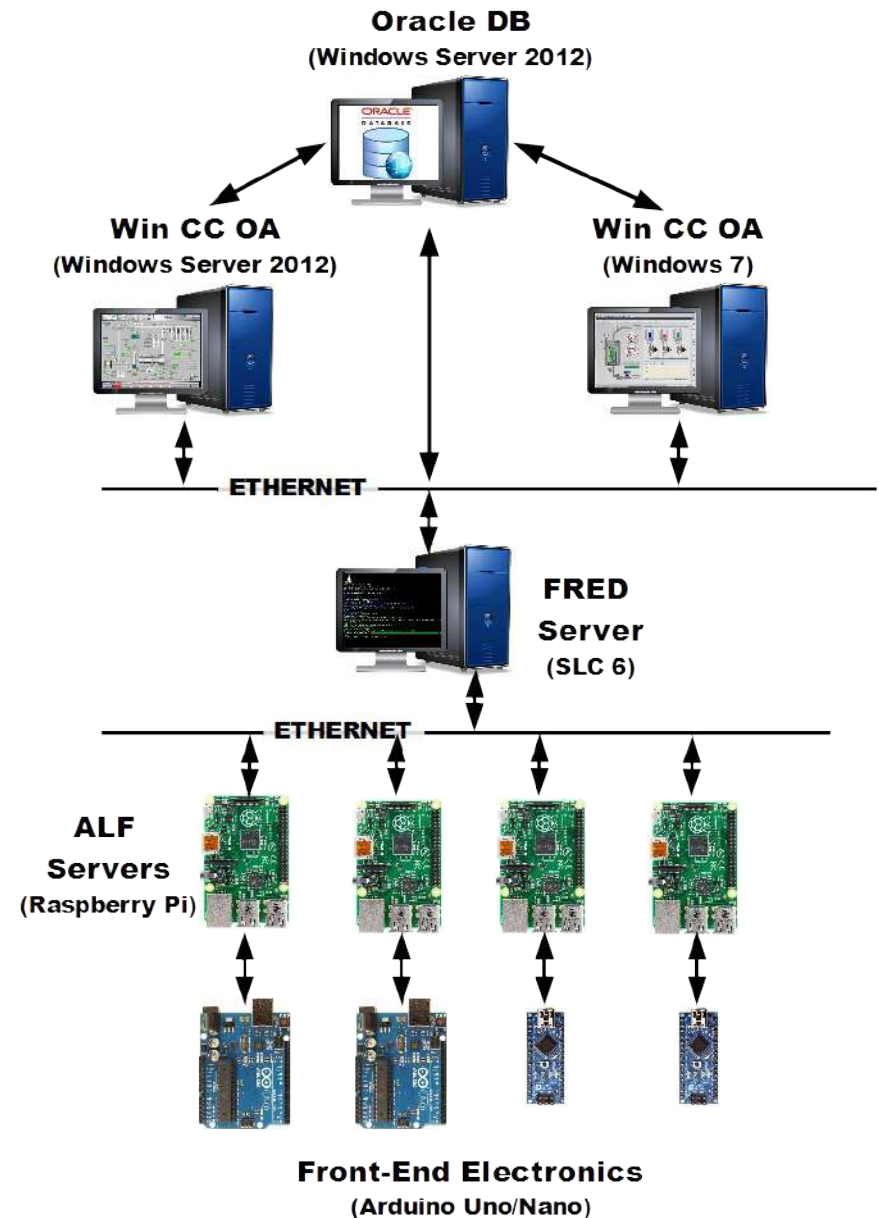
User side:
- classic PC
- mobile phone
- tablet

Detector Control System for the Internal Tracking System (RUN 3)

New ITS being built for the RUN 3 needs completly new Detector Control System

Development and building of a new control system is

Oracle DB
(Windows Server 2012)

Win CC OA
(Windows Server 2012)

Win CC OA
(Windows 7)

ETHERNET

FRED
Server
(SLC 6)

ETHERNET

ALF
Servers
(Raspberry Pi)

Front-End Electronics
(Arduino Uno/Nano)

Detector Control System
for the Internal Tracking System (RUN 3)

Simulator of sensors and
actuators and their integration
into the DCS infrastructure

It is a part of the functional
copy of the CERN DCS infrastructure
used for developing and debugging
of individual system components
at Technical University Kosice.

With tools like this all development
can be done at TUKE and
only debugged and tested components
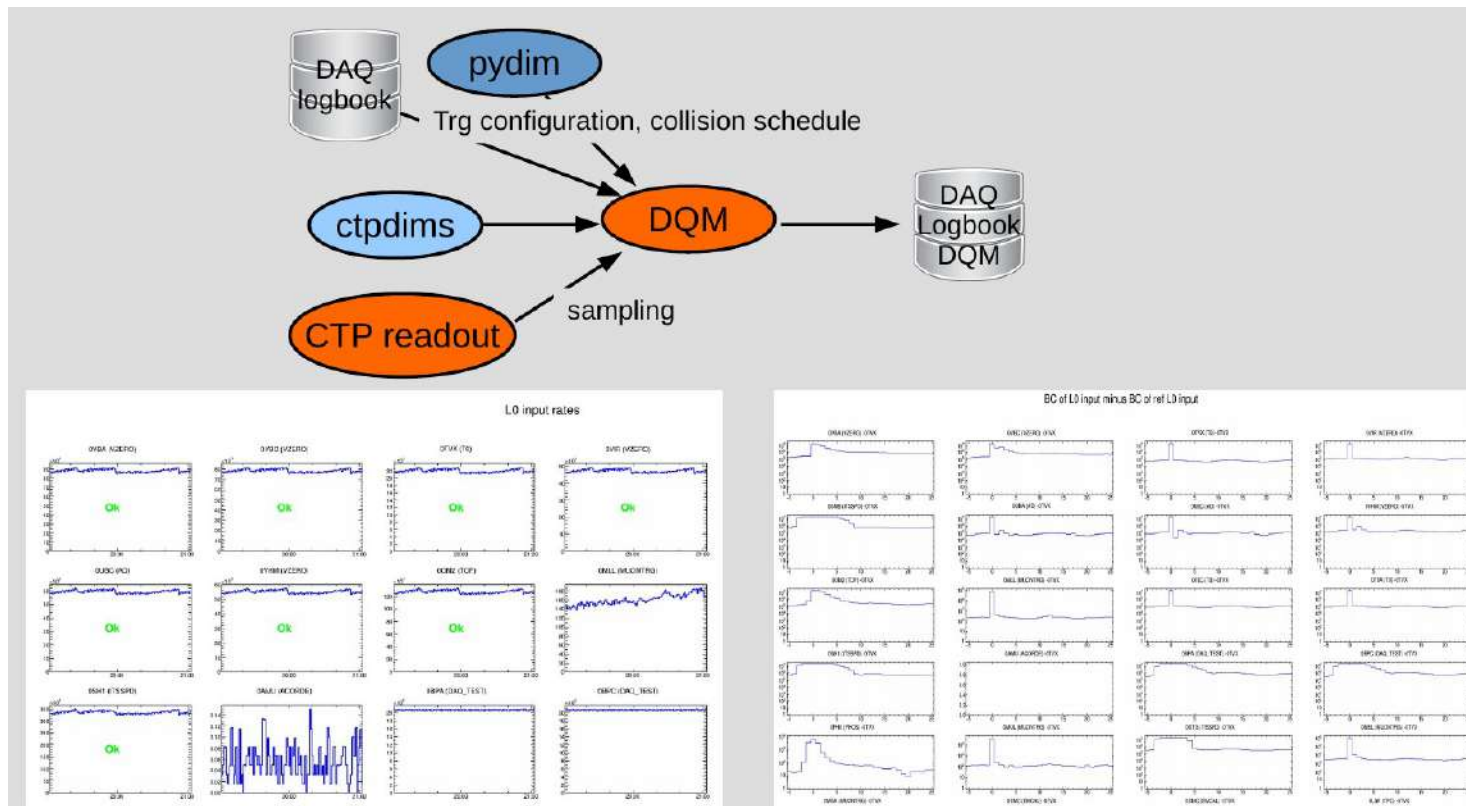of the ITS DCS are installed at CERN.

Trigger Data Quality Monitoring for RUN 2

DQM:

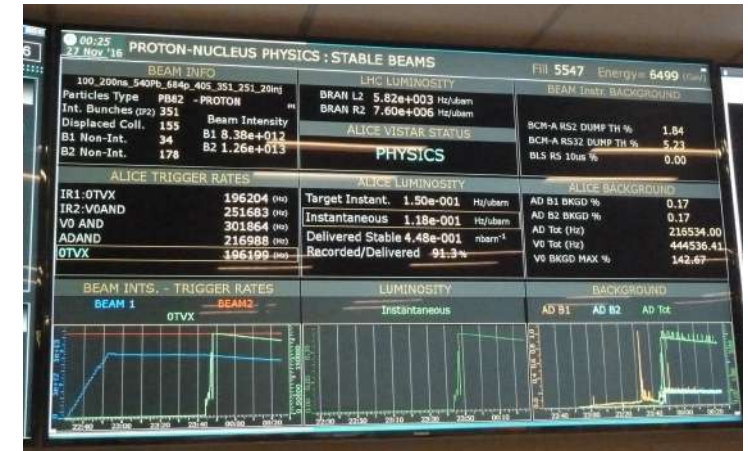ROOT application supplying many histograms from data acquired by:

   - reading CTP counters (1/min, DIM)

   - subset of events from the DAQ stream

   - histograms, available only during data taking, are stored in DAQ logbook
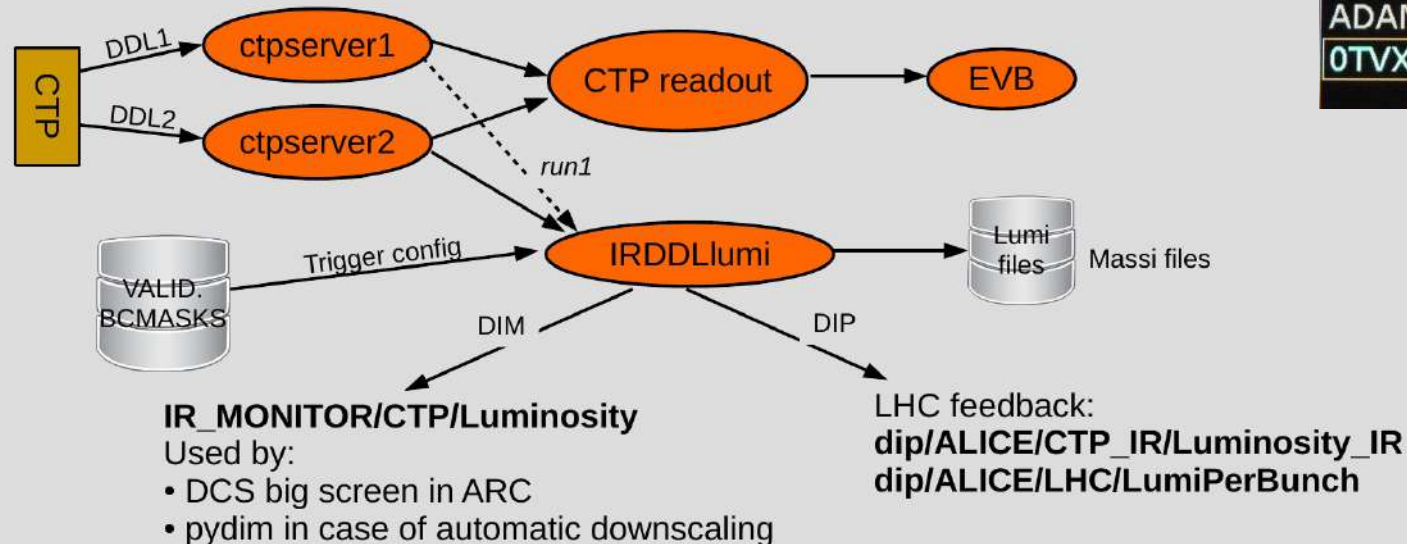
LHC IF : On-line luminosity monitoring

Provides on-line beam luminosity for each
colliding pair of bunches, DIM and DIP
publications, simple archivation for off-line processing
- on-line feedback for LHC
- off-line files for each colliding pair of bunches (LHC)
- display in ACR
- data for the VdM scans

IR_MONITOR/CTP/Luminosity
Used by:
• DCS big screen in ARC
• pydim in case of automatic downscaling

LHC feedback:
dip/ALICE/CTP_IR/Luminosity_IR
dip/ALICE/LHC/LumiPerBunch

Physics analysis

Pentaquark search on the ALICE experiment

- For the background estimation, the sideband method was used.
- Since mass of the P_s^+ is a priori unknown - tests for the presence of a signal carried out at a numerous mass hypotheses.
- Investigated spectrum from 2.2 GeV/c^2 to 3.0 GeV/c^2 - scanning of each 40 MeV/c^2 wide window in the sideband-subtracted invariant mass spectrum.
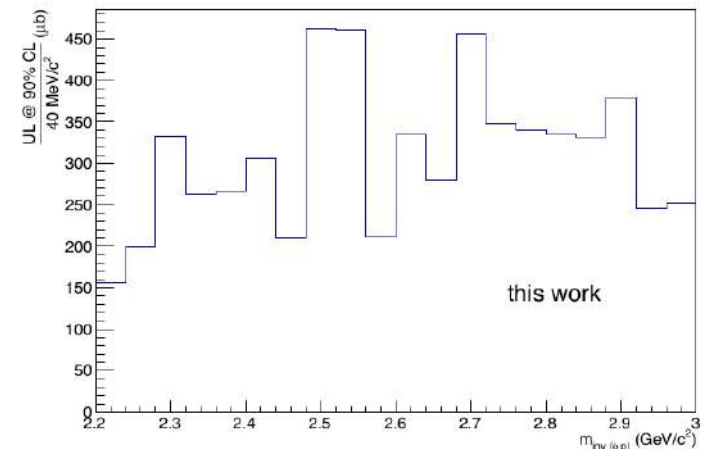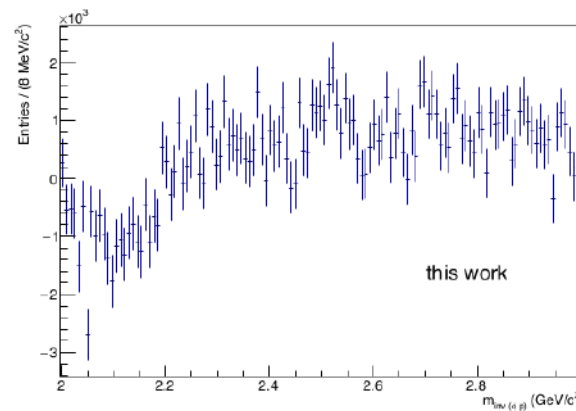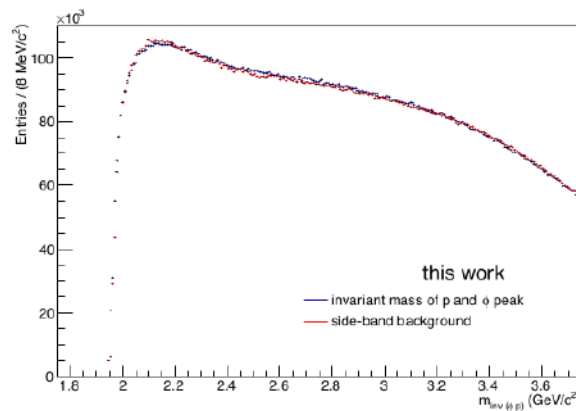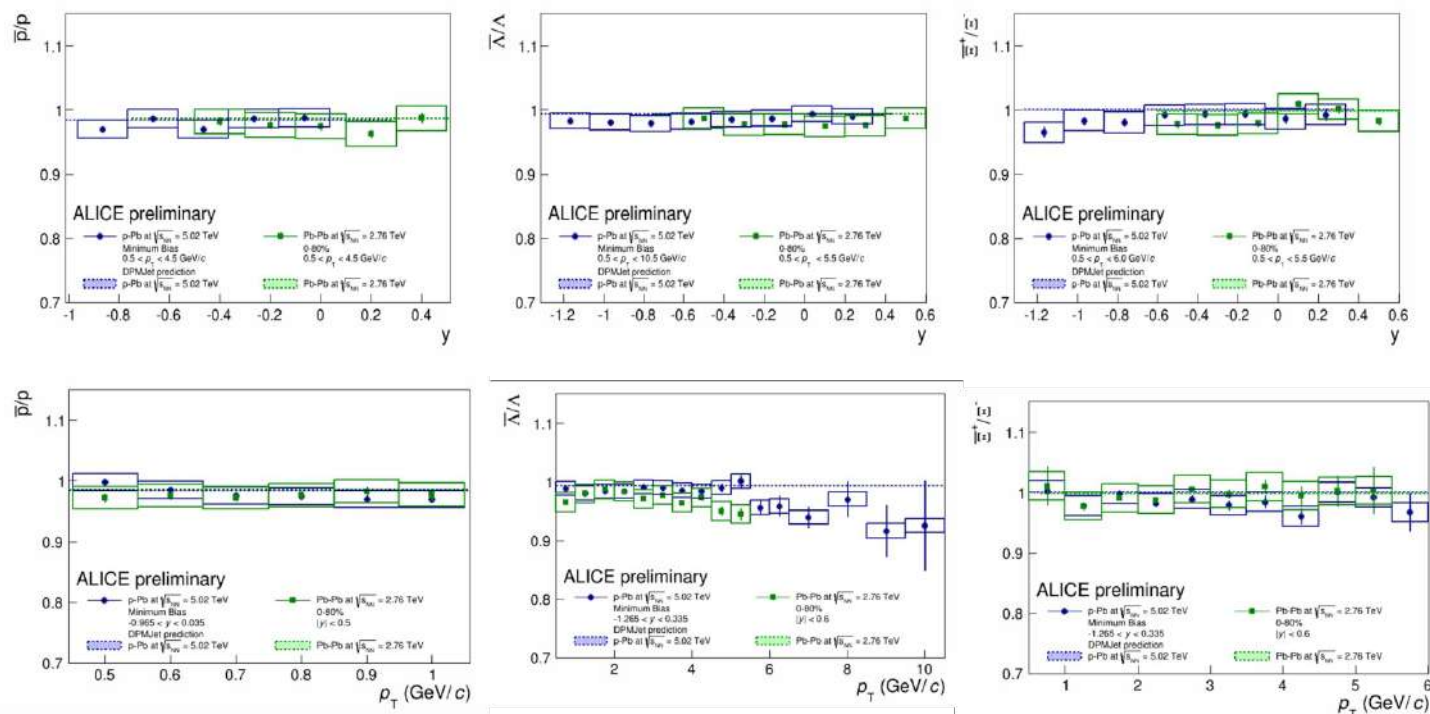

The average value for the upper limit of the P_s^+ production over all tested masses was found to be **284.4 ± 3.8 µb**
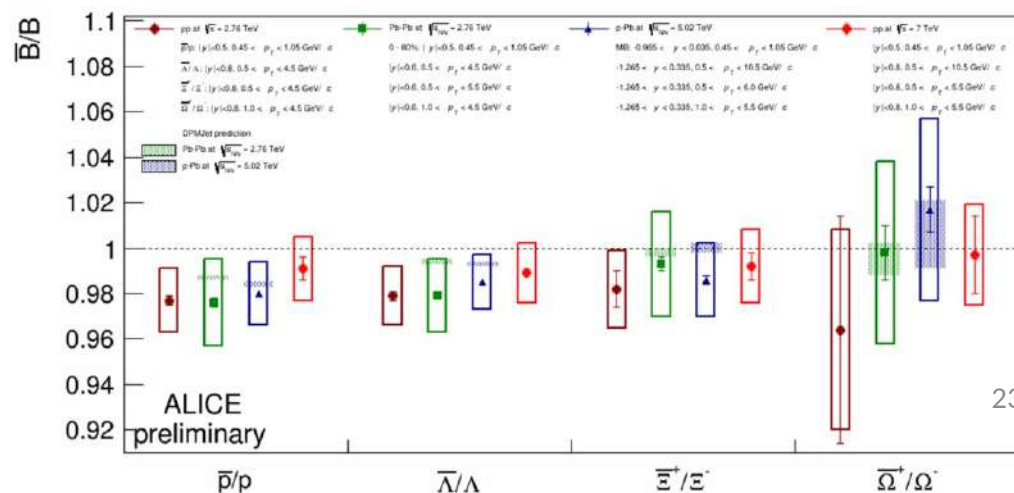
Midrapidity antibaryon-to-baryon ratios in Pb-Pb and p-Pb collisions measured by the ALICE experiment

Rapidity dependence
p-Pb @ 5.02 TeV
Pb-Pb @ 2.76 TeV

Transverse momentum dependence

System dependence:
pp @ 2.76 TeV
Pb-Pb @ 2.86 TeV
p-Pb @ 5.02 TeV
pp @ 7 TeV

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Strange and multi-strange particle production in p-p and Pb-Pb collisions

Study of the K^0_S and Λ in p-p and Pb-Pb collisions at various LHC energies

- physics analysis (selection of signals, systematic errors, ...)
- systematic studies, method improvement
- testing robustness of analysis methods

Recent observation:
The production of strange and multi-strange particles in the hight multiplicity p-p collisions exhibits behaviour observed in Pb-Pb collisions
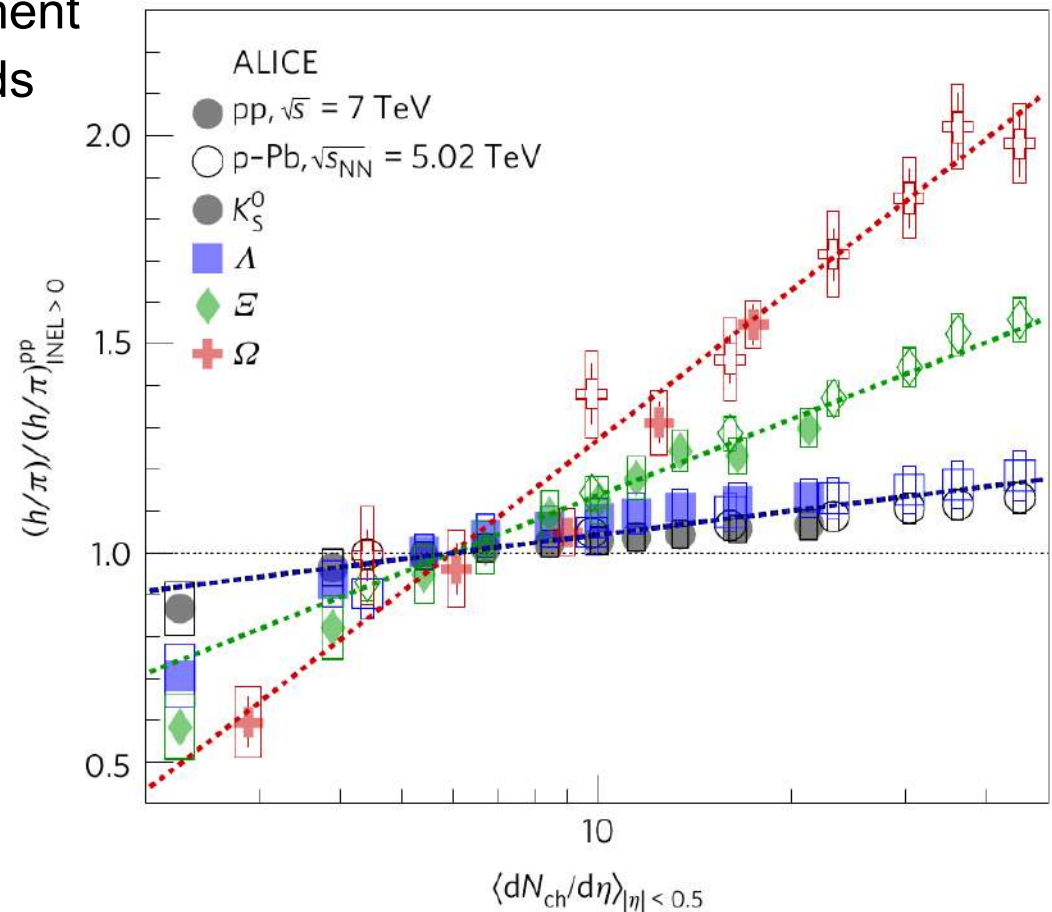
Main analysis topic in Kosice

Nature Physics 13 (2017) 535-539

Angular correlations between strange and non-strange particles in p-p @ 13 TeV
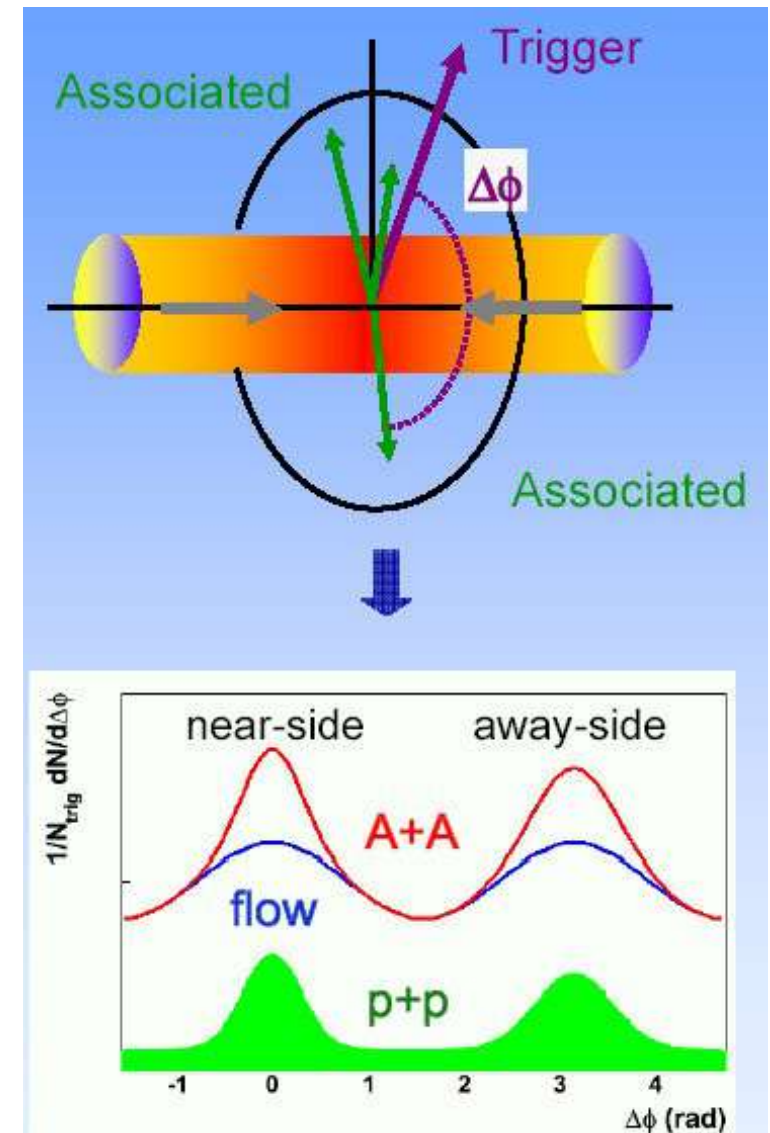
Trigger particle: Λ or K^0_S with $p_T > 4$ GeV/c

Associated particles: any charged hadrons

Motivation:
- gluon jets produce more baryons than quark ones
- p-Pb or high-multiplicity p-p events may lead
  to some phenomena observed in much larger
  systems

Status:
- one diploma work completed
- the subject may be studied in PhD thesis
 (not in Kosice)

φ meson polarization
in p-p and Pb-Pb collisions

- New functions needed for the φ polarization studies were implemented
  into the official analysis code AliROOT
- Work in progress ...

Normalization cross section measurement
using Van der Meer scans

- Data acquision from the CTP using LHC IF soft.
  with extra input channels used only for VdM
- Production of data sets for the analysis
- Calculation of the corrections due to
  electromagnetic interactions between two beams
  and corresponding systematic errors

T0-rate-VdM (BLUE) TVX-rate-DDL2 (RED)
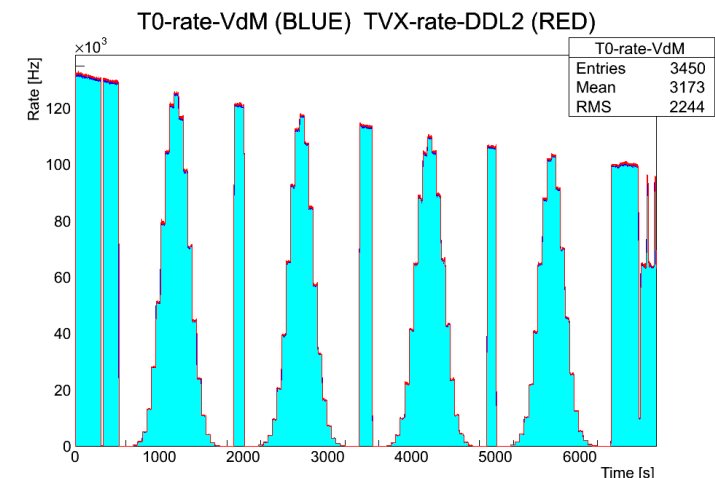
Summary

- Slovak hardware activities and main software contributions are aimed at the ALICE upgrade during LS2. Considerable involvement of PhD students.

- New infrastructure is being built for work on ALICE upgrade in Bratislava as well as in Kosice.

- Physics analysis is driven mainly by the PhD students and postdocs.

- Gaps in age structure in HEP physics.

- One generation of very experienced electronic engineers is retiring with almost zero chance to replace them - we are shifting our main focus from electronics design to detector control sytems.

- The ALICE experiment will give us at least another decade of exciting physics and challenging working environment.