START AND TRIGGER DETECTOR T0 OF THE ALICE EXPERIMENT

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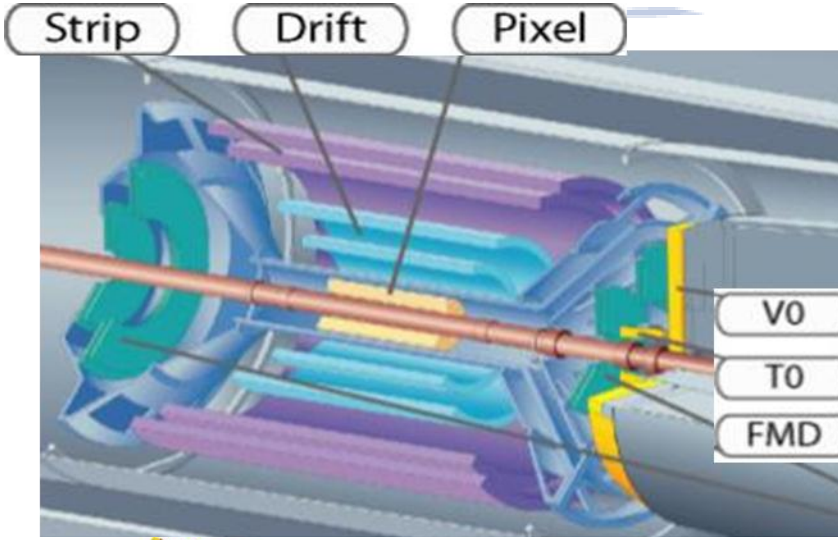
Dubna

ALICE experiment

ALICE experiment at LHC is aiming to study the physics of strongly interacting matter at extreme energy densities, where a new state of matter, quark-gluon plasma, is expected to be reached.
Due to its excellent track and vertex finding and particle identification capabilities, ALICE will be able to study the properties of QGP by means of a whole set of different and independent observables.

ALICE setup

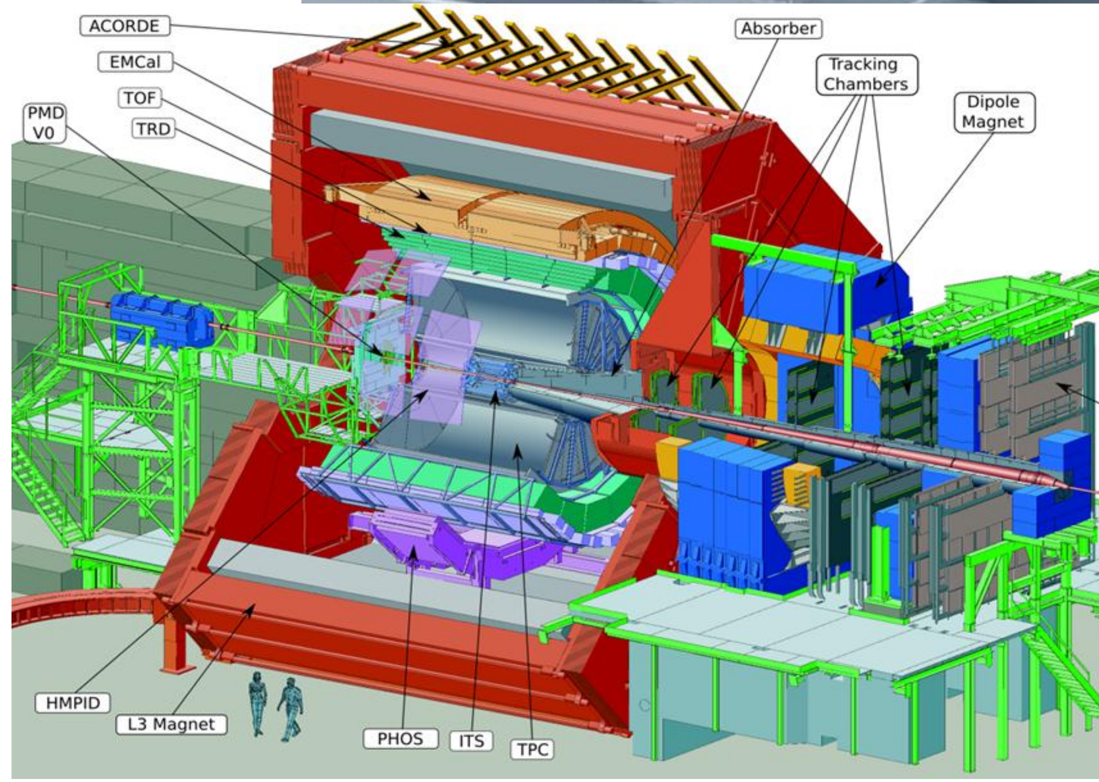


Central Detectors:
Inner Tracking System (ITS)
Time Projection Chamber (TPC)
Transition Radiation Detector (TRD)
Time-of-Flight (TOF)
High Momentum PID (HMPID)

Spectrometers:
Photon Multiplicity
Forward Multiplicity
Muon Spectrometer

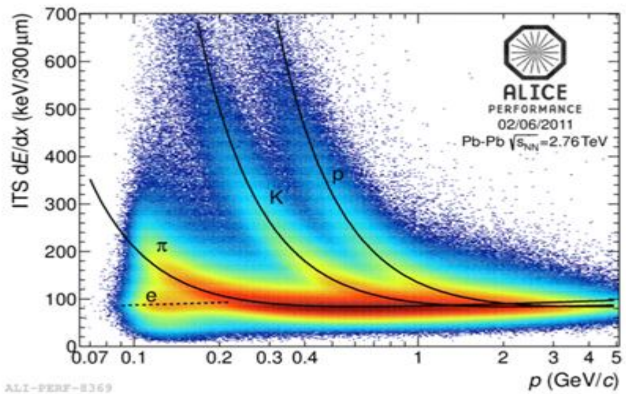
Calorimeters:
EM Calorimeter (EMCAL)
Photon Spectrometer (PHOS)
Zero Degree Calorimeter (ZDC)

Forward trigger detectors
T0
VZERO

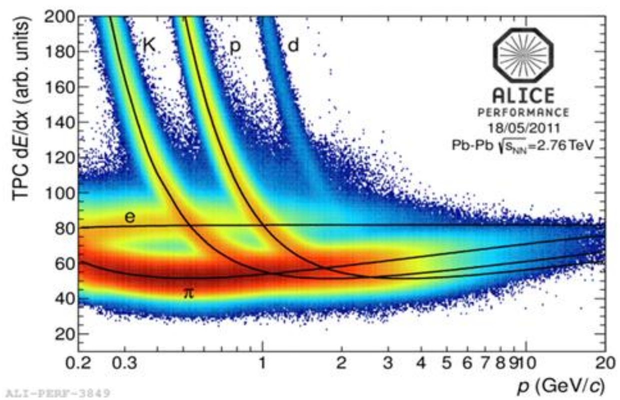


[ALICE Collaboration, JINST 3 (2008) S08002]

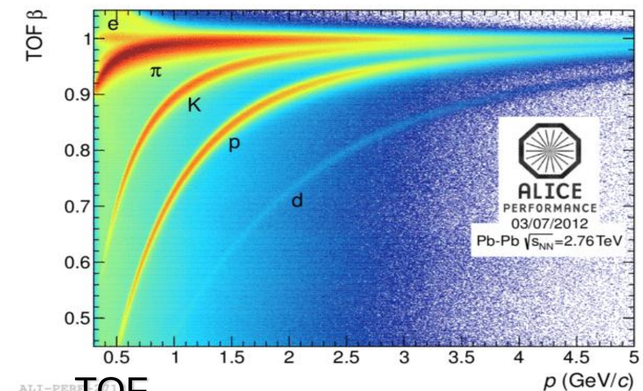
ALICE PID



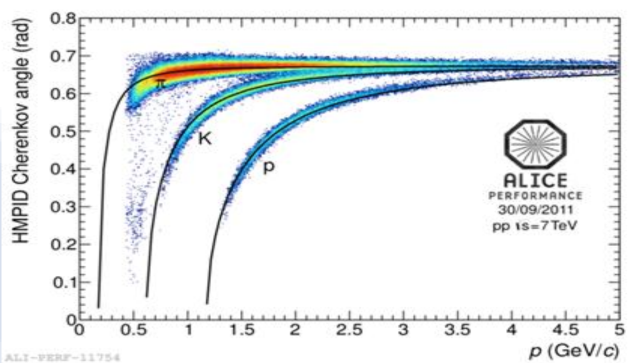
ITS standalone tracker,
PID (p_T <200MeV) – energy loss in the silicon;



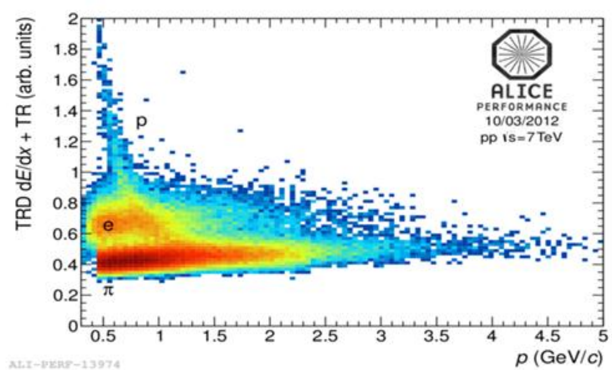
TPC main tracking system
PID - energy loss in the gas
p_T 0.1-50GeV/c



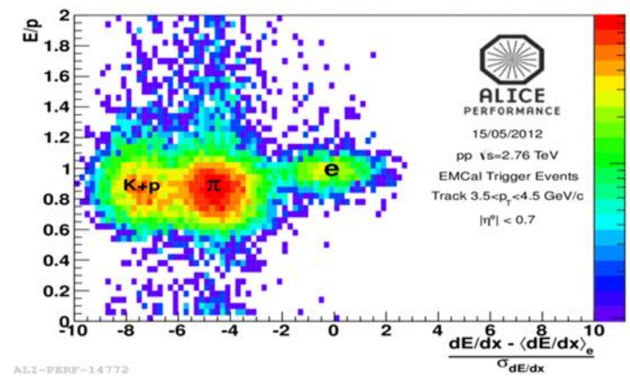
TOF
resolution ~85 ps (Pb-Pb);
π-k separation up to 2.5GeV/c;
protons-4GeV/c



HMPID
Cherenkov angle measurement
PID p_T 1 -5 GeV/c

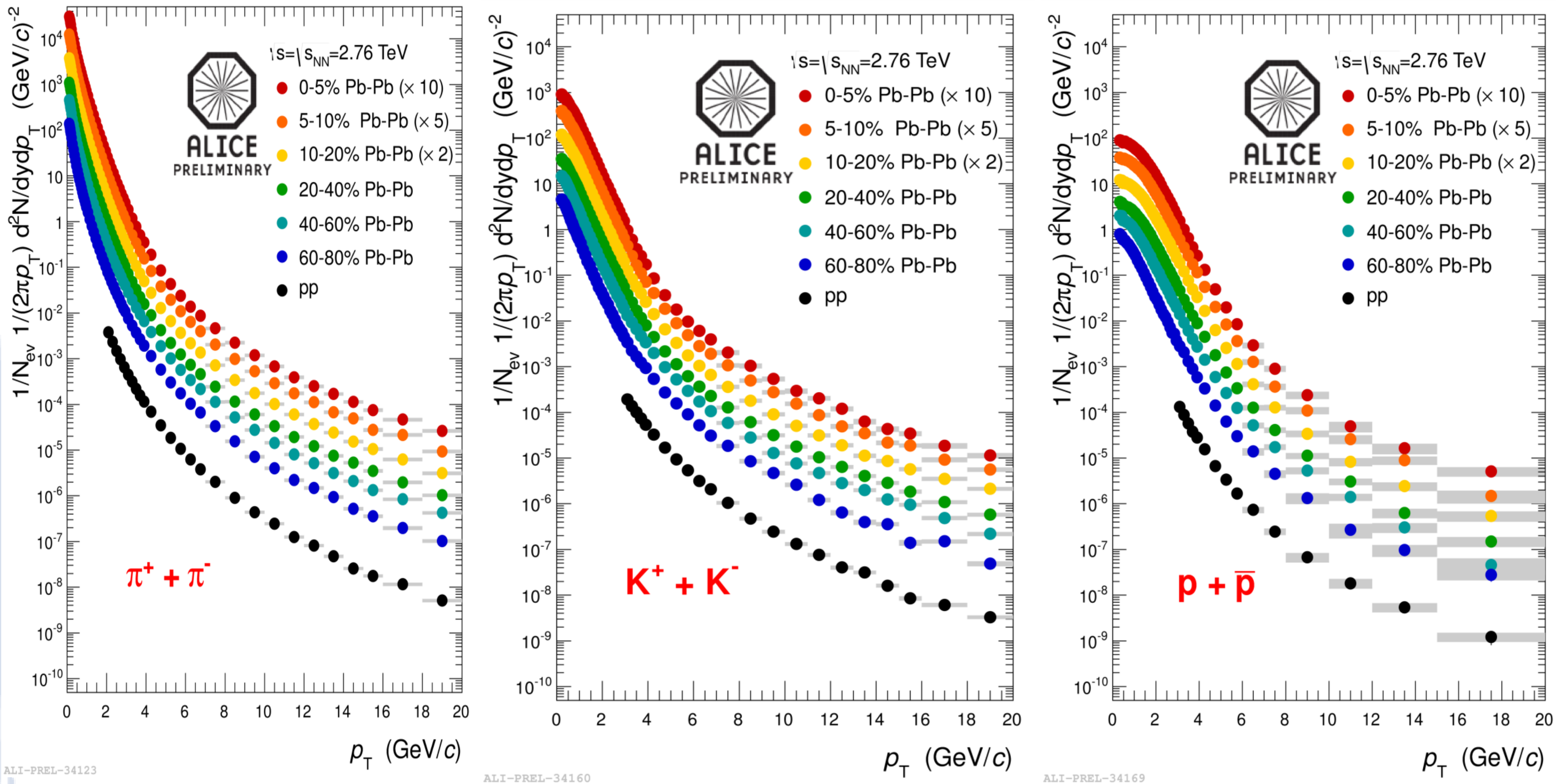


TRD
Electron and hadron identification via TR + energy loss in the gas ; p_T >1GeV/c



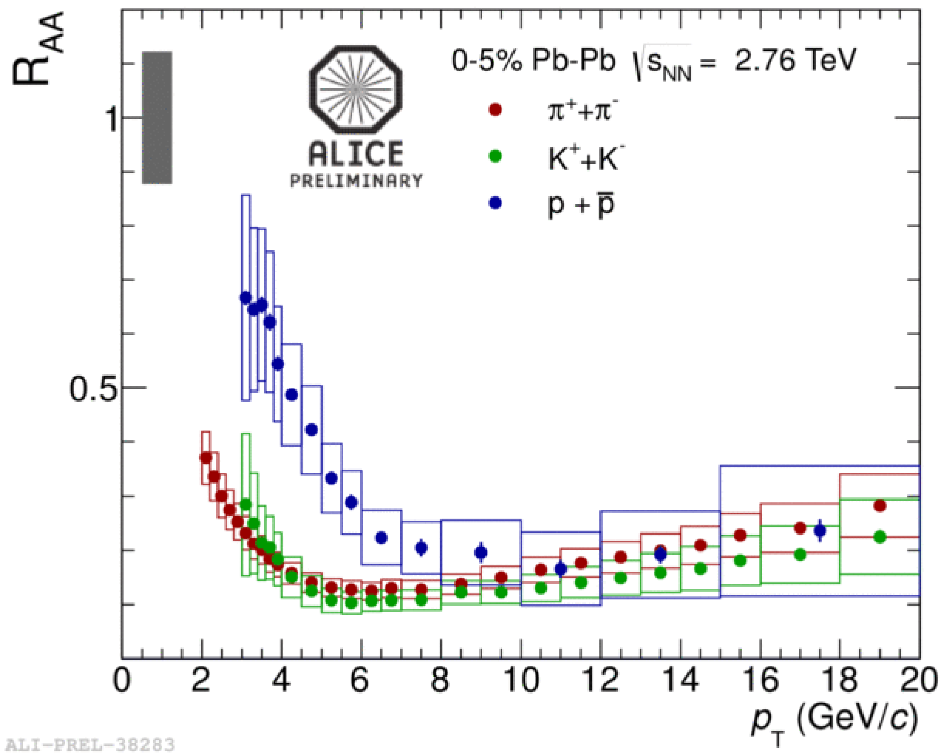
E/p from calorimeters (EMCAL, PHOS)
Electron identification

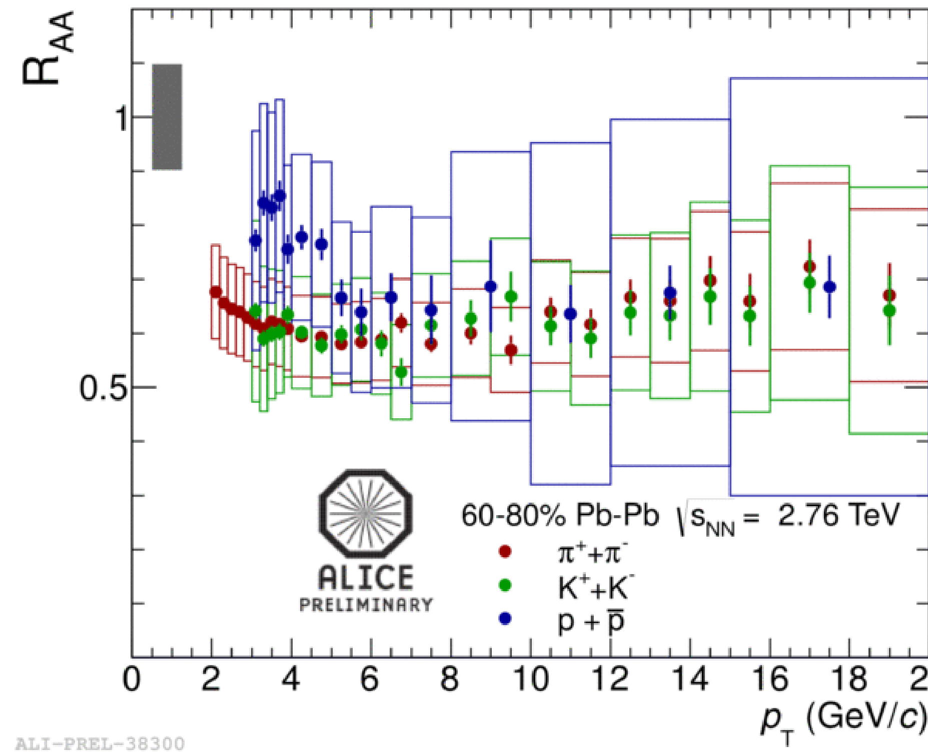
Identified particle spectra



High p_T results - first time PID up to 20 GeV/*c* :
Pions: p_T >2 GeV/*c* Protons and Kaons: p_T> 3GeV/*c*.

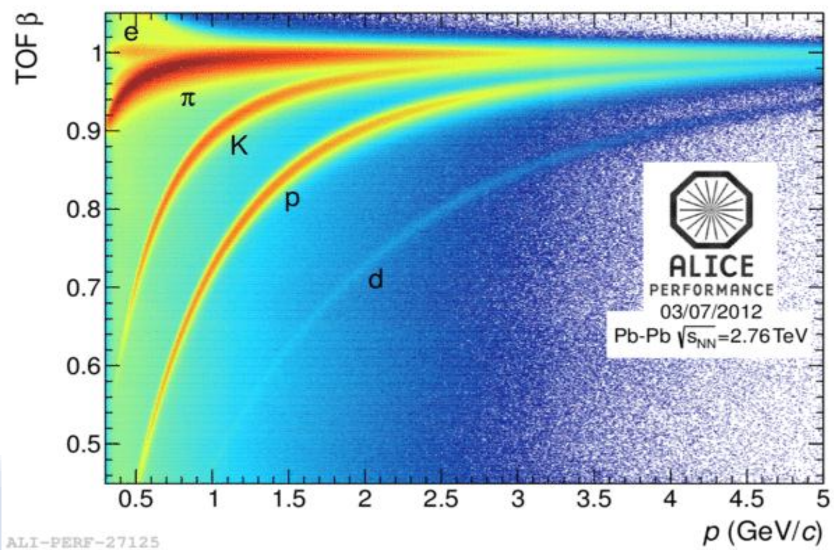
R_{AA} of identified hadrons

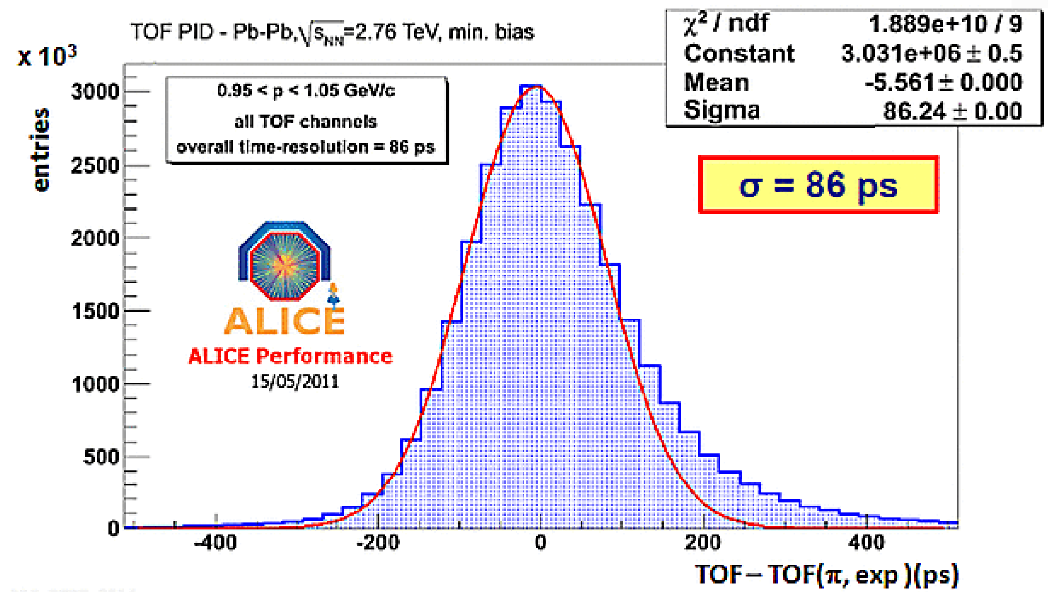


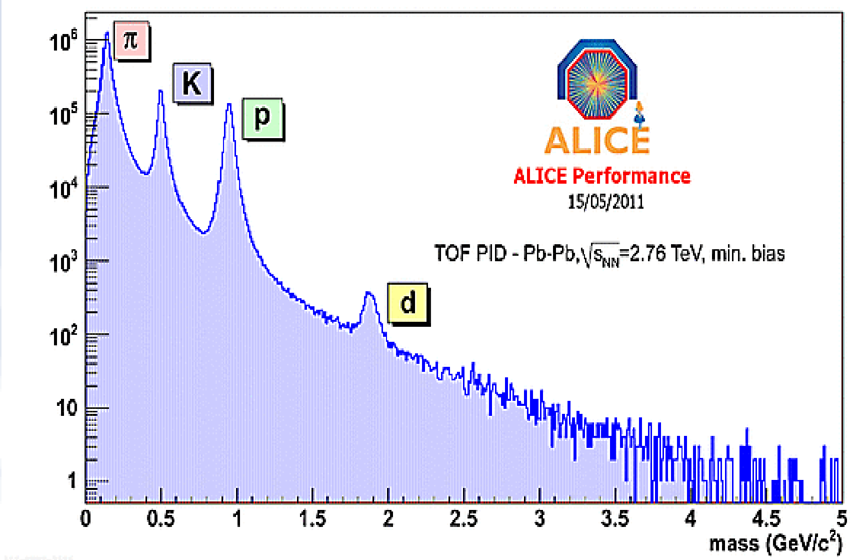


- **For p_T < 8 GeV/c: R_{AA} for π and K are compatible and smaller than R_{AA} for protons - "baryon anomaly".**
- **At high p_T above 10 GeV/c the R_{AA} for π, K and proton are compatible within systematic errors.**

PID by TOF







PID in the TOF is based on the arrival time of the particles ('time of flight') at the TOF detector. TimeZero is the time of the interaction, measured in ALICE by means of T0 detector OR TOF detector itself.

$$\widehat{PID}_{TOF} = \frac{(time_{hit} - timeZero) - time_{expected}(p, m, L)}{\sigma_{PID(TOF)}}$$

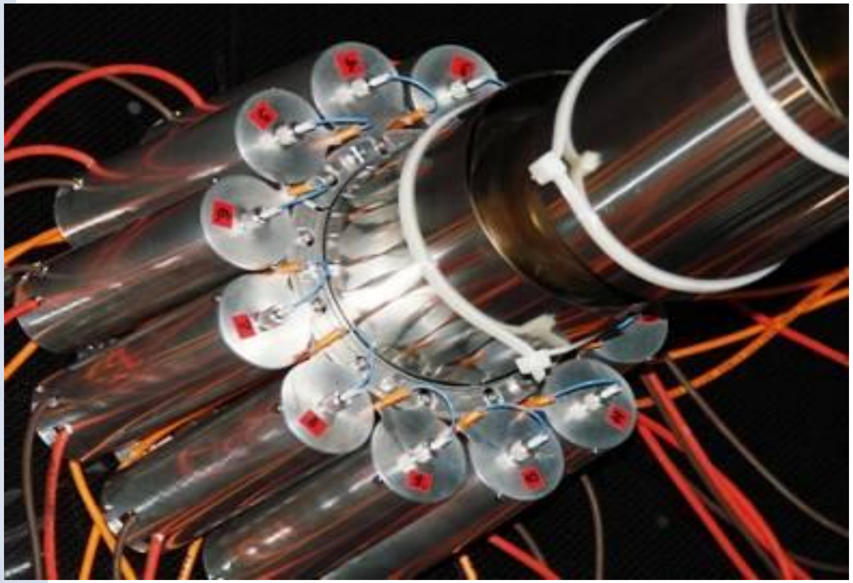
the timeZero for the event (measured/estimated in different ways)

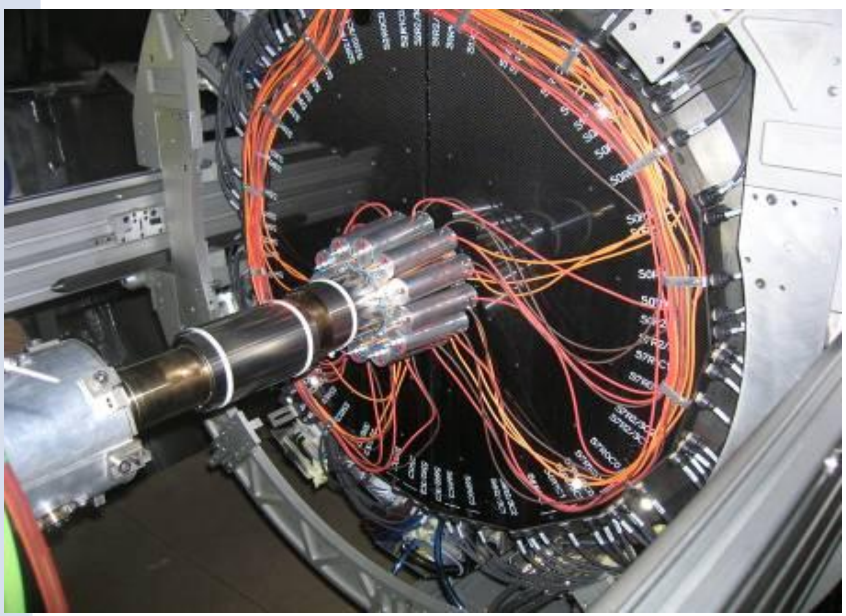
the time measurement made by the TOF detector

This is computed, during reconstruction by ALICE core central tracking ('integrated times')

$$\sigma_{PID(TOF)} = \sqrt{\sigma^2_{TOF} + \sigma^2_{timeZero} + \sigma^2_{tracking}}$$

T0 detector overview





2 arrays of Cherenkov counters located at +370 cm (T0A) and −70 cm (T0C) along the beam-line.

Each counter: quartz radiator/PMT/readout

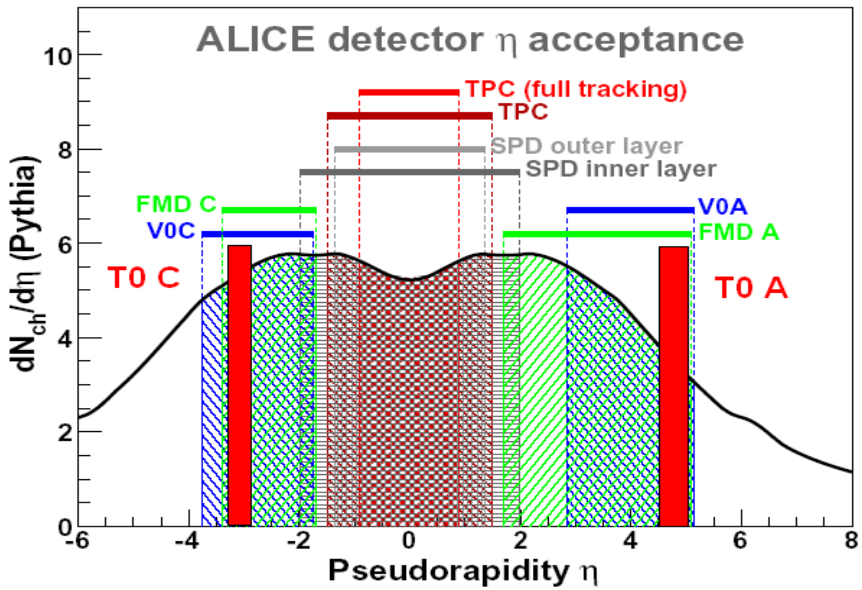
- **Precise start signal for TOF**

  (time resolution of below 40 ps)

- **Trigger functions (on-line):**
  - **Coarse vertex position**

    position resolution (along the beam direction) 1 cm;
  - **Coarse multiplicity**
- **“wake-up” signal to TRD**
- **Luminosity using T0**

T0 performance



Pseudorapidity coverage

T0-C -3.28 < η < -2.97

T0-A 4.61 < η < 4.92

+370 cm (T0A) and −70 cm (T0C) along the beam-line

Interaction time signal independent on vertex position (T0A+T0C)/2

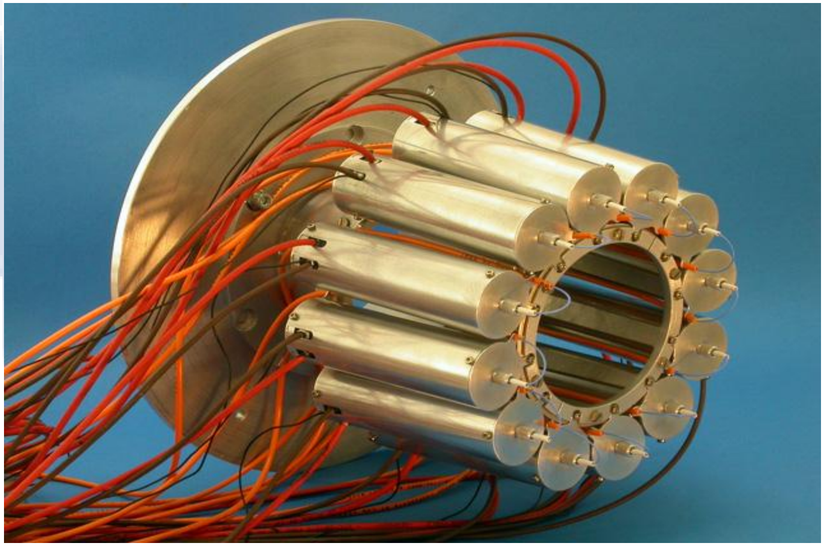
For events with low multiplicity when only one signal exits T0A or T0C could be used after correction by z-position of vertex measured with SPD with accuracy ~50mKm.

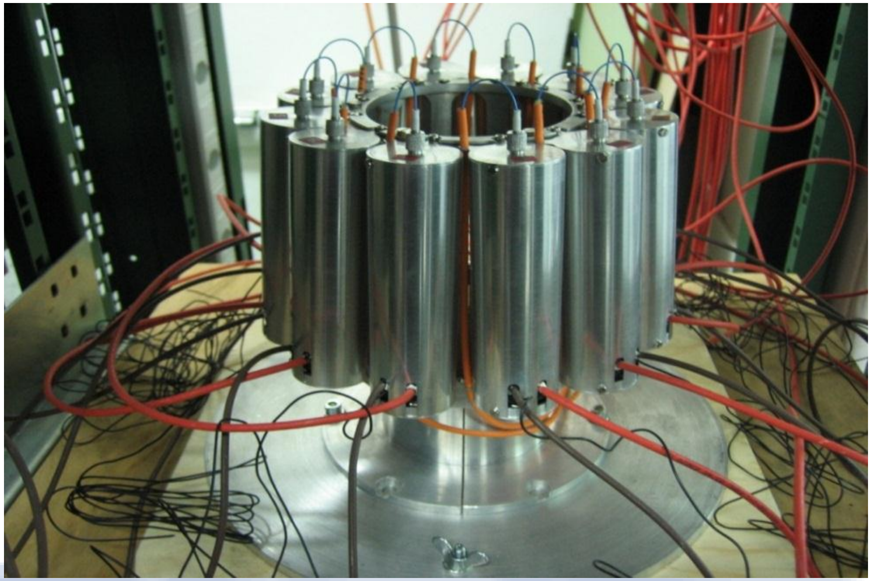
Time resolution of ~ 40ps for protons and ~20ps for PbPb collisions

Efficiency: depends on event multiplicity. For PbPb collisions it is around 100% for events with centrality below 70% and drops to 65% T0A and T0C and 35% (T0A+T0C)/2 for events with centrality 90% .

For proton collisions 7TeV T0A or T0C signals were provided with efficiency ~70% and (T0A+T0C)/2 with efficiency 50%

T0-C & T0-A production





T0 calibration

Online calibration is based on raw data:

Before start of period, a set of laser runs (1 run per laser amplitude) are taken. Results are written in OCDB :

- **amplitude in channel vs amplitude in MIPs;**
- **time – amplitude dependence (slewing correction).**

During data taking: collects time value for each of 24 channels with slewing correction from "online" OCDB; writes in OCDB mean time value for each channel ;

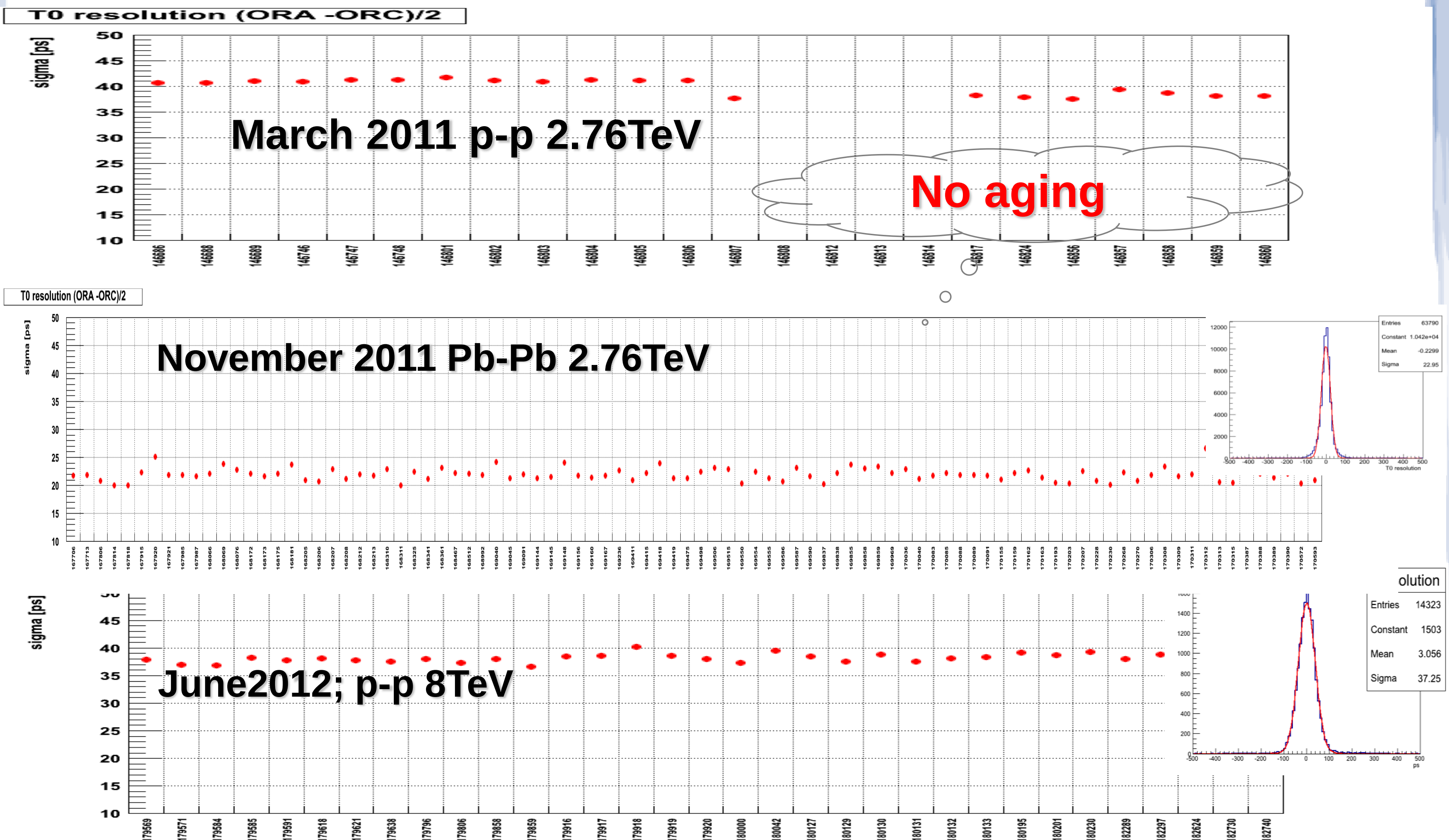
Offline calibration is based on reconstructed ESD(Event Summary Data)

Mean time value for each PMT with slewing correction optimized for MB trigger. Replace OCDB entry with mean time value for each channel

Calculate exact (T0A+T0C)/2, T0A and T0C position. This should be done to have interaction time centered around zero. Write OCDB entry

All steps of T0 calibration run automatically

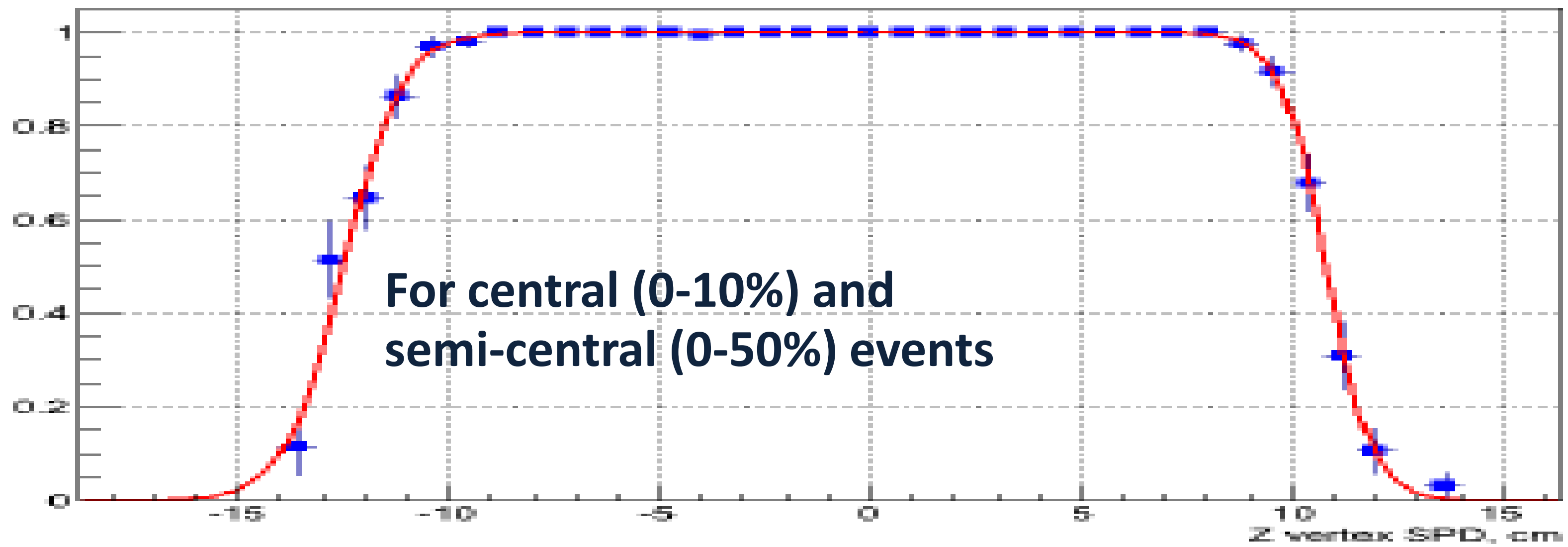
T0 detector performance: timeZero resolution



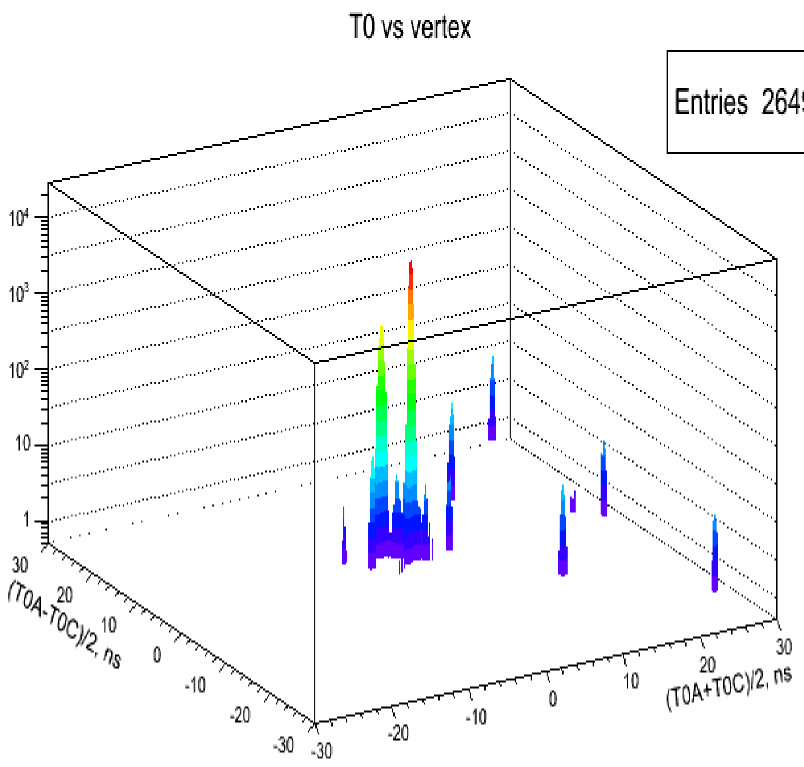
T0 trigger

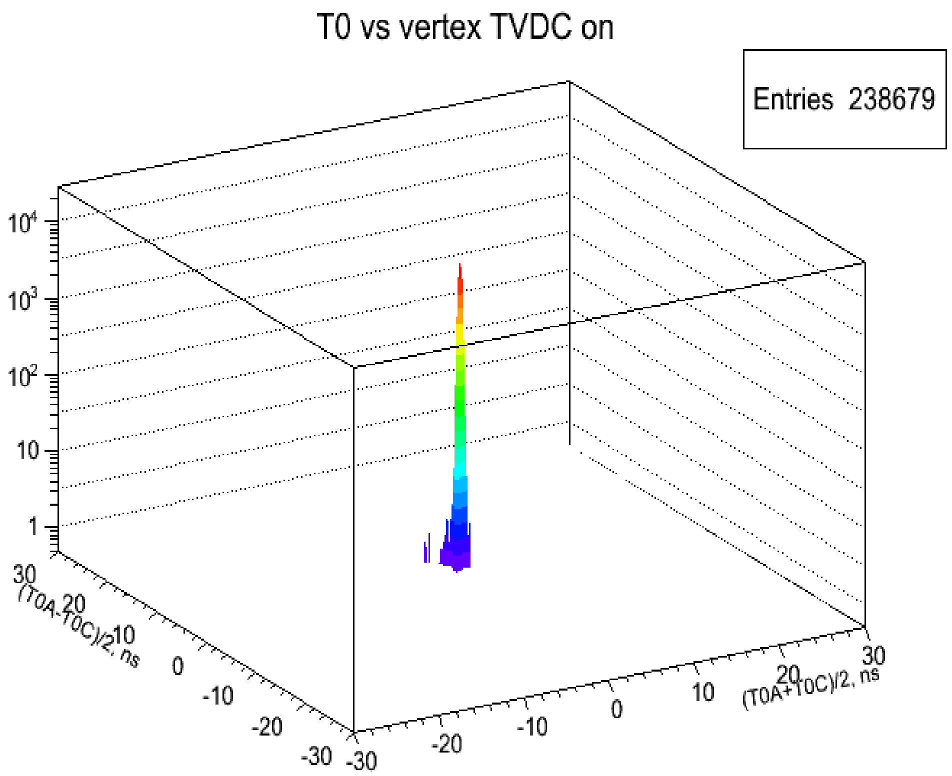
- T0 vertex trigger with timing cut on T0A-T0C difference rejects background and satellite collisions.
- Used as interaction trigger for high interaction rate – 400 kHz in 2012 proton runs
- Used in PbPb runs 2011 for online event selection for central and semi-central events

Efficiency of vertex cuts by T0



Online background rejection by T0 vertex trigger





T0 time vs T0 vertex

Online event selection with trigger 0TVX

In addition by offline selection:
T0 pile-up flag -> more then one interactions were in interval -70ns +1130ns from triggering event
T0 backgroud flag -> if we have both signal from T0-A and T0_C, but with bad vertex (OTVX signal -off)

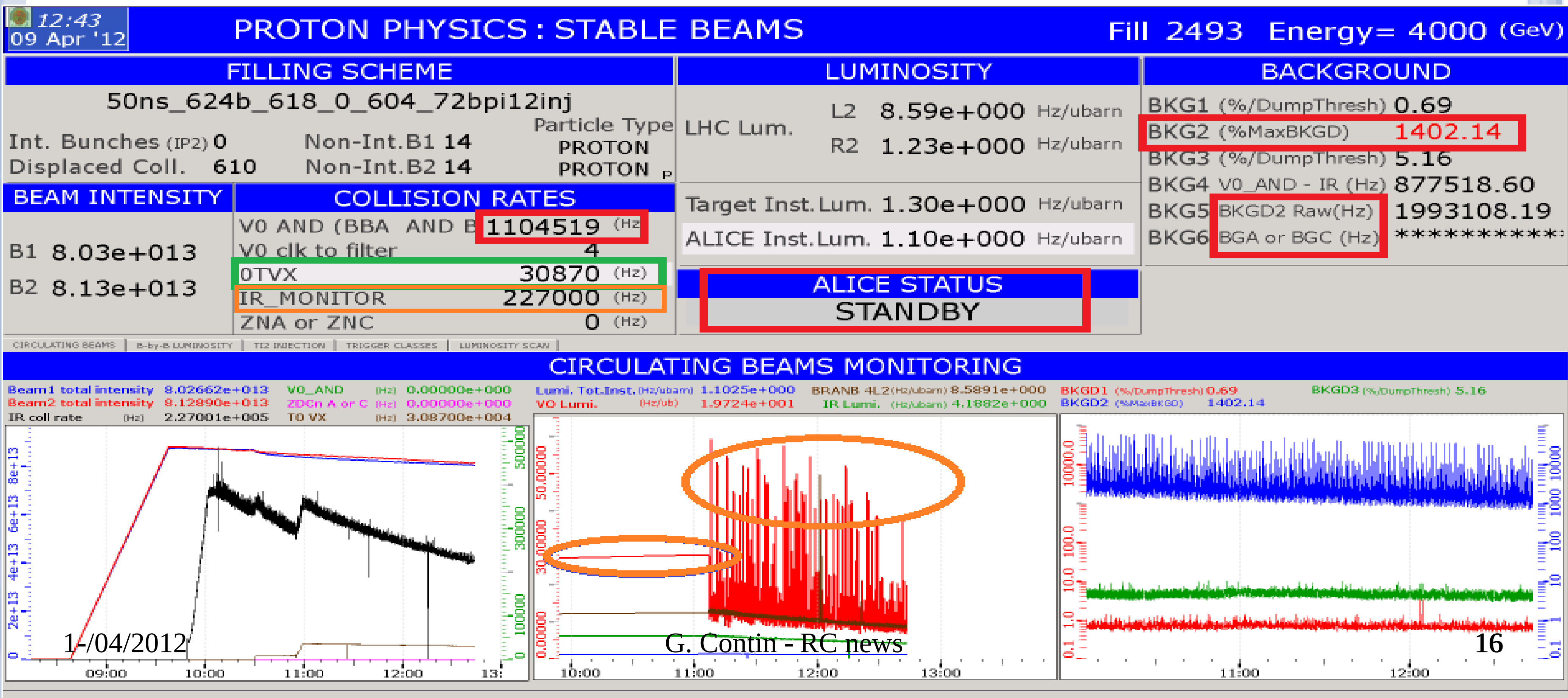
ALICE LHC Interface

ONLINE monitoring of luminosity:

Luminosity estimated from measured rates

Online display, monitoring and archiving

Feedback to LHC: needed for beam tuning, optimizing beam conditions and establishing proper running conditions.



Summary

One of the most important part of the ALICE is the T0 detector, based on quartz Cherenkov technology, which is a key component of the trigger system and provides the collision time zero to be used in the time of flight (TOF) measurement.

The detector is routinely used for online luminosity monitoring and to provide fast feedback to the accelerator team.

The T0 detector provides up to five different trigger signals for physics selections, based on the online determination of the centrality and of vertex position of the collision, and for background rejection.

During the first years of the LHC run the detector has shown excellent performance and stable operations both in pp and Pb-Pb collisions and it has fully confirmed its central role for the ALICE data taking.

Excellent time resolution was obtained both in pp (~40 ps) and Pb-Pb (~20ps)

some anxious minutes waiting for 1st collisions..

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T0 reconstruction

Event reconstruction

- read raw: time and amplitude for all channels ;
- correct time measurement according amplitude with slewing correction from OCDB channel by channel;
- subtract mean time from OCDB (calculated online or during CPass0) to have time centered around zero (channel by channel)
- choose min (1^{st}) time for A and C side (T0A and T0C);
- calculate interaction time (T0A+T0C)/2 which is not depend on vertex;
- correct T0A and T0C with primary vertex position;
- shift T0A, T0C and (T0A+T0C)/2 with value from OCDB calculated in CPass1 to have them centered around zero.

(T0A+T0C)/2, T0A, T0C are ready to be used by TOF as timeZero