The ALICE Transition Radiation Detector

Status and perspectives for Run II

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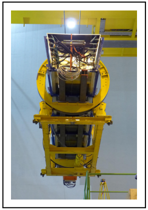
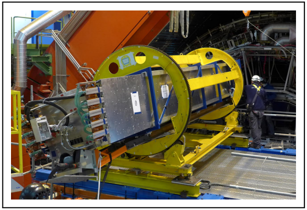
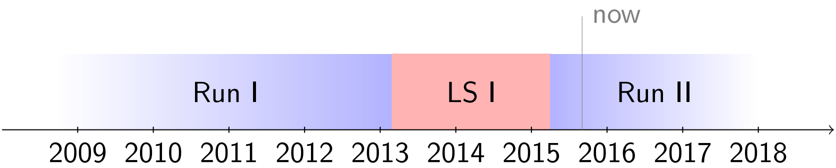
Outline





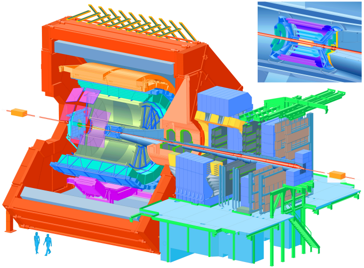
- setup in and results from Run I
- activities during Long Shutdown I
- plans for and first results from Run II

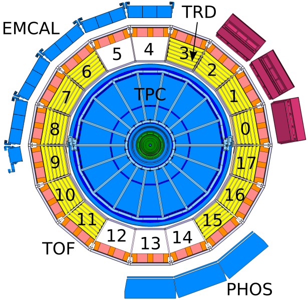


TRD in ALICE

- main detector concepts in ALICE
  - **tracking** in magnetic field
  - **particle identification**
  - electromagnetic calorimetry
- **jets** are interesting probes:
  - strongly affected by the medium
- **electrons** are interesting probes:
  - not affected by strong interaction
  - heavy-flavour decays
  - dileptons
- probes are rare
  $\rightsquigarrow$ **trigger**

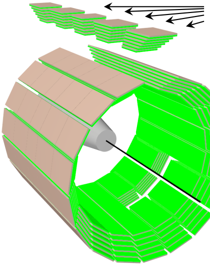
$\rightarrow$ **Transition Radiation Detector**

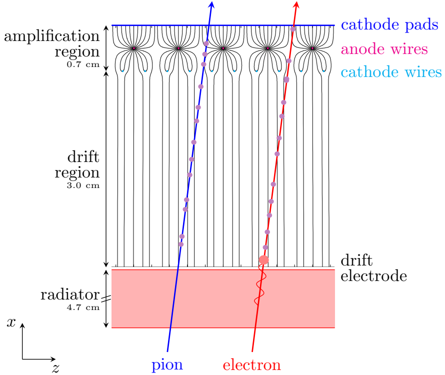




Run I status

TRD chamber





record time structure

radiator	produce transition radiation
drift volume Xe-CO_2 (85 % - 15 %)	primary ionization absorption of transition radiation
anode wires	gas amplification
cathode pad plane	read-out of induced signal

TRD in Run I

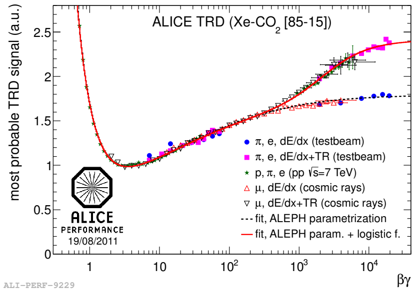
Overview

- stable data taking since beginning of Run I
- tracking and particle identification
  - integrated in global tracking
  - hadron identification using $\mathrm{d}E/\mathrm{d}x$
  - **electron identification** using Transition Radiation (TR)
- triggering
  - pretrigger
  - cosmics
  - **jets**
  - **electrons**
- physics
  - heavy-flavour electrons
  - J/Ψ
  - jets

bold items will be discussed further in following slides

Specific energy loss & transition radiation

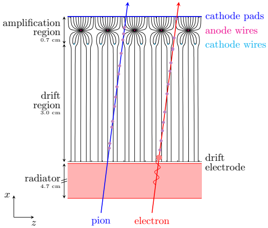
comparison of results from test beams, collisions, and cosmics:



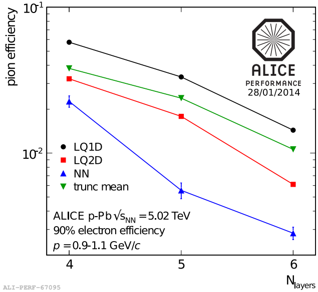
excellent agreement of results for different species

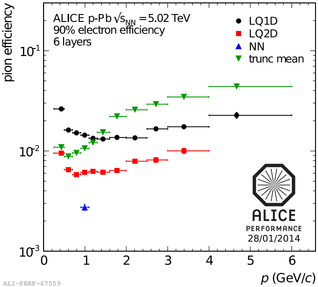
for cosmics:

- cosmic muons extend to very high momenta
- excellent momentum resolution
- passing through radiator in front or behind active volume



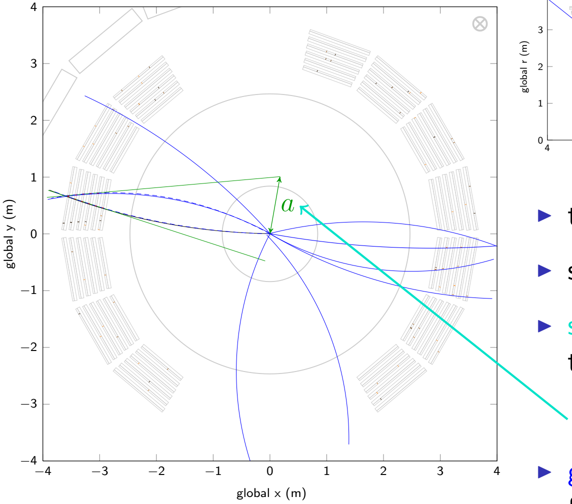
Electron identification

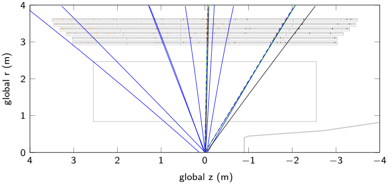




- sampling of signal allows to use multiple time slices for PID
- different methods:
  - 1-dimensional likelihood
  - 2-dimensional likelihood
  - neural network
  - truncated mean
- can be further improved by higher dimensional likelihoods

Online tracking



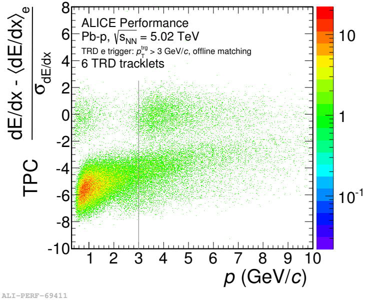


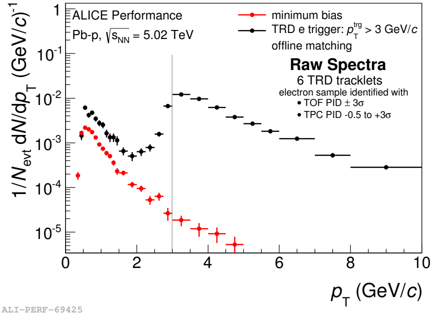
- tracklets in chambers
- stack-wise matching to tracks
- straight line fit through contributing tracklets

  $a \propto \frac{1}{p_{\mathrm{T}}}$, PID from charge
- global tracks for comparison

Run I status

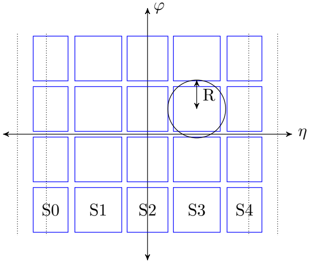
TRD-triggered electrons

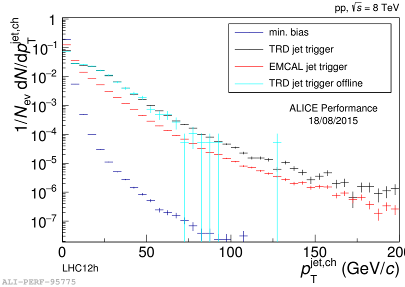




- significant enhancement above threshold of 3 GeV/c
- significant improvement by offline clean-up (track matching)
  $\Rightarrow$ trigger suffers from late conversions
- similar trigger for enhancement of quarkonia (J/ψ)

TRD-triggered jets





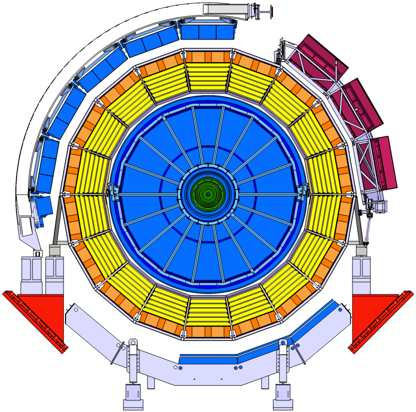
- at least 3 tracks with $p_\mathrm{T} > 3\ \mathrm{GeV}/c$ in any stack ($\simeq$ jet cone $R \simeq 0.2$)
- covers target region: $p_\mathrm{T}^\mathrm{jet,ch}$ up to $200\ \mathrm{GeV}/c$
- in agreement with EMCAL-triggered sample
- bias becomes negligible for $p_\mathrm{T}^\mathrm{jet,ch} \geq 80\ \mathrm{GeV}/c$

MB, TRD,
EMCAL, MB + TRD

Long Shutdown I activities

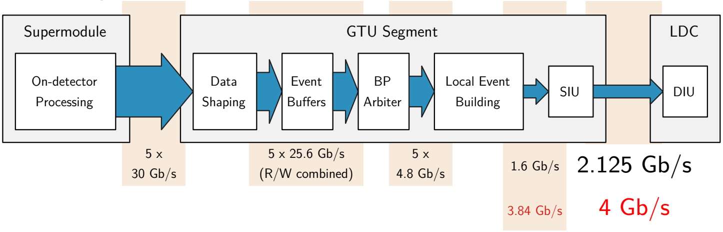
many activities for consolidation and upgrade, most importantly:

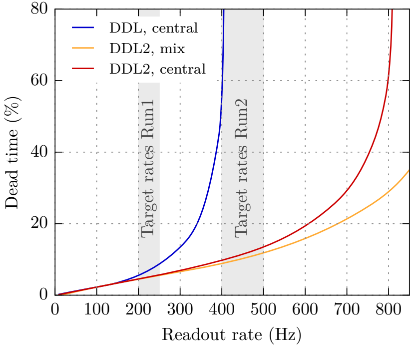
- electronics production completed
- **construction and installation of full TRD completed**
  $\rightsquigarrow$ full central barrel acceptance
- **read-out upgrade**
- **trigger upgrade**
- rework of low-voltage connections
- redundant Ethernet installation for slow control and monitoring



Run II status

Read-out upgrade

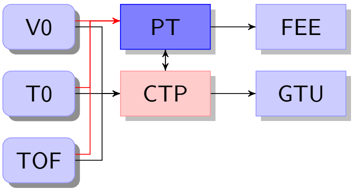




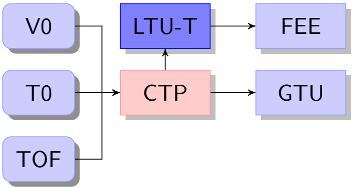
- Run I bandwidth to DAQ would be saturated in Run II
- Detector Data Link (DDL) integrated into FPGA
- DDL → DDL2, 2.125 Gbit/s → 4 Gbit/s
- dead time ∼ 15 % for target read-out rates

Trigger upgrade

Run I setup



Run II setup



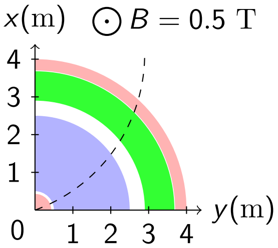
- front-end electronics (FEE) requires wake-up before level-0 trigger
- in Run I:
  provided by dedicated pretrigger system (PT)
- now integrated with Central Trigger Processor (CTP)
- protocol converter (LTU-T) to adapt to FEE requirements
- improved performance:
  - more flexible conditions
  - consistent downscaling

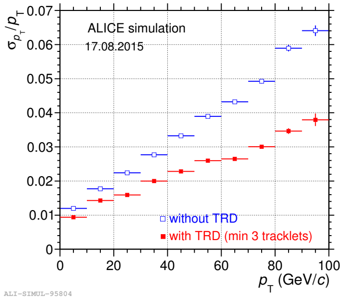
Run II

with completed TRD:

- in full central barrel acceptance:
  - improved p_{T} resolution for global tracks
  - uniform electron and hadron identification
  - level-1 triggers
- faster read-out and more efficient wake-up trigger
- improved stability
- physics
  better resolution and statistics for:
  - heavy-flavour electrons
  - J/Ψ
  - jets

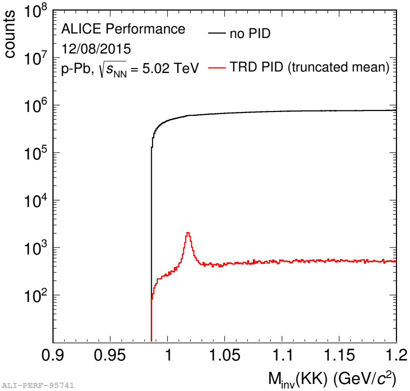
Tracking





- combined tracking in central barrel
- start with cluster seeds at the outer radius of the TPC
- Kalman propagation inwards, include information from ITS
- Kalman propagation outwards, include information from TRD and TOF
- refit inwards for ultimate parametrization
- TRD improves p_T resolution by adding clusters at large radii

Hadron identification

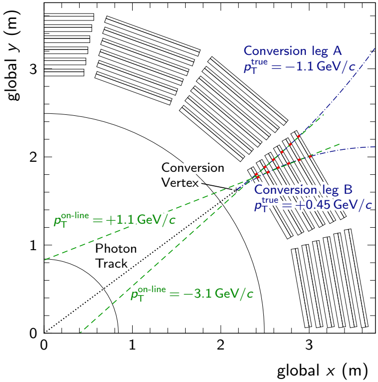


- beyond electron identification: improve on top of TPC $\mathrm{d}E/\mathrm{d}x$ in full acceptance
- $\mathrm{d}E/\mathrm{d}x$ resolution in p–Pb:
  TPC $\sim$ 6 %,
  TRD $\sim$ 10 %
- better S/B for resonances, e.g. $\phi \rightarrow K^+K^-$

general PID ALICE: talk by Francesco Noferini

Late conversions

- conversions at large radii:
  $\gamma + X \to e^+e^- + X^*$
- online tracks point
  closer to primary vertex $\rightsquigarrow$ high p_T
- fake high-p_T primary electrons

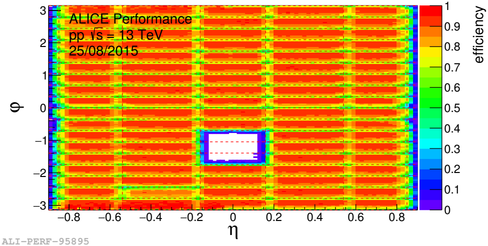


- exploit discrepancy of local curvature and reconstructed p_T to suppress late conversions
- online calculation of sagitta and cut on:

$$\Delta p_\mathrm{T}^{-1} := p_\mathrm{T,GTU}^{-1} - p_\mathrm{T,sag}^{-1}$$

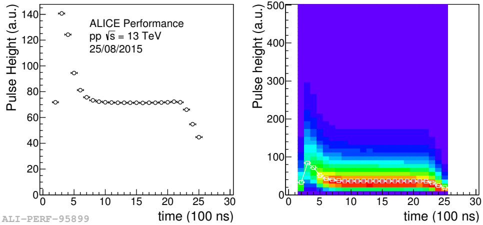
additional latency $< 500\ \mu\mathrm{s}$

Performance in Run II



ALI-PERF-95895

- TPC–TRD matching:
  ⇝ covering full acceptance
- hole in front of PHOS
  by design



ALI-PERF-95899

- pulse height vs time:
  ⇝ timing requirement met
  with new trigger setup

Physics objectives with the TRD

- enhance statistics of heavy-flavour electrons in pp and p–Pb, in particular from beauty-hadron decays
- R_{AA} and v_2 of heavy-flavour electrons, in particular from beauty-hadron decays
- extend p_{T} reach for high-p_{T} physics, both jets and single tracks

interesting analyses ahead of us

Summary & Outlook

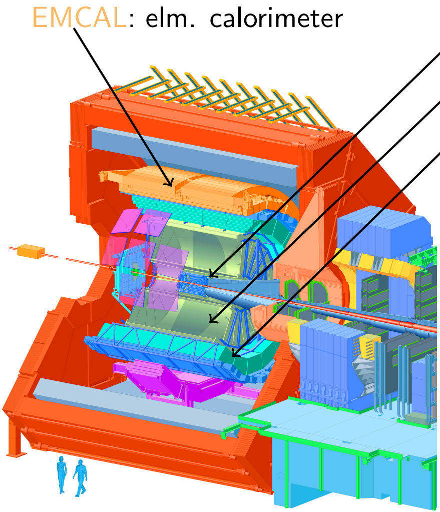
ALICE Transition Radiation Detector:

- provides:
  - tracking
  - electron and hadron identification
  - level-1 triggers
- contributes to:
  - heavy-flavour electron analysis
  - J/Ψ analysis
- installation completed end of 2014
- fully commissioned with
  - read-out upgrade
  - trigger upgrade
- taking data in LHC Run 2
  with full azimuthal acceptance

Thank you for your attention!

Backup

ALICE: detector overview



ITS: Inner Tracking System

TPC: Time Projection Chamber

TRD:
Transition Radiation Detector

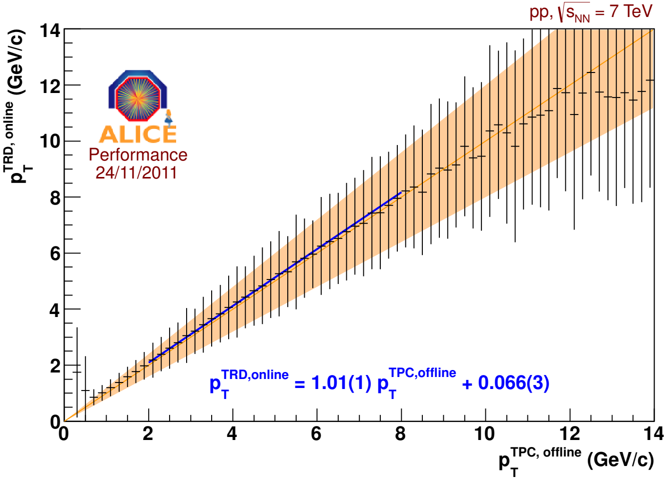
- full coverage in central barrel ($|\eta| < 0.9$, $\varphi \in [0, 2\pi]$)
- e/π-separation by transition radiation
- short drift time $\sim 2\ \mu s$
- track reconstruction in front-end electronics

V0: scintillator wheels

T0: Cerenkov counters

muon spectrometer (forward)

Online tracking



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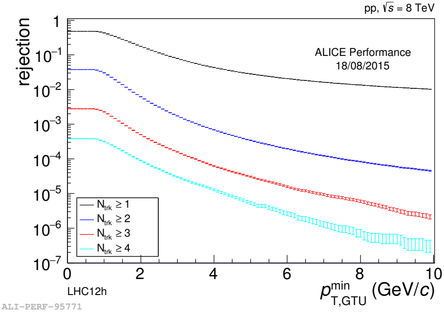
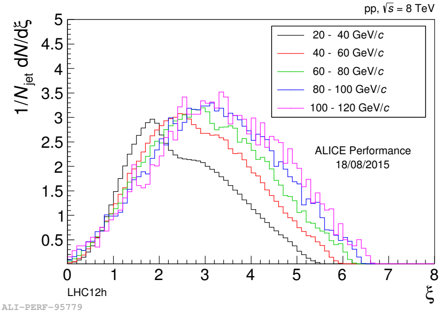
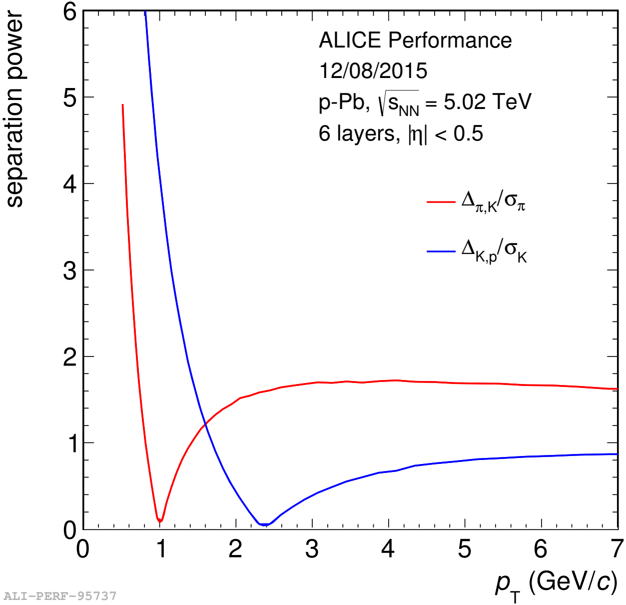
TRD jet trigger

- jet fragmentation biased by trigger requirement
- look at fragmentation function: $\xi = -\ln \frac{p_{\mathrm{T}}^{\mathrm{trk}}}{p_{\mathrm{T}}^{\mathrm{jet}}}$
- bias becomes negligible for high jet $p_{\mathrm{T}} \geq 80\ \mathrm{GeV}/c$
- ask for N tracks in one stack with p_{T} above threshold, we use: **at least 3 tracks above 3 GeV/c**





Separation power truncated mean



Read-out upgrade