ALICE Status Report

A. Andronic (GSI Darmstadt) on behalf of ALICE Collaboration

- Data taking and reconstruction
- Recent physics results
- ALICE Upgrade
Data taking - pp $\sqrt{s} = 13$ TeV

IR: 100-550 kHz, triggered and min-bias data

ALICE Performance 2016, pp $\sqrt{s} = 13$ TeV

Minimum bias: 822M
High multiplicity: 514M

ALICE Performance 2016, pp $\sqrt{s} = 13$ TeV

Dimuon and single muon high-$p_T$: 9.7 pb$^{-1}$
Single muon low-$p_T$: 0.56 pb$^{-1}$
High multiplicity: 4.2 pb$^{-1}$ (514M)
CALO high threshold: 4.4 pb$^{-1}$
CALO low threshold: 0.44 pb$^{-1}$
PHOS $\gamma$: 3.2 pb$^{-1}$
Double gap: 0.47 pb$^{-1}$
Minimum bias: 0.012 pb$^{-1}$ (822M)
p–Pb $\sqrt{s_{NN}} = 5.02$ TeV
Data taking - p–Pb $\sqrt{s_{NN}} = 5.02$ TeV

focus: min-bias data; optimized 17 kHz IR, 1.6 kHz readout

95% efficiency with full suite of sub-detectors
Data taking - p–Pb $\sqrt{s_{NN}} = 8.16$ TeV

focus: triggered data; IR: $\sim 300$ kHz beginning of fill

**p–Pb**

ALICE Performance 2016, p-Pb $\sqrt{s} = 8$ TeV

- Muon + UPC forward: 8.68 nb$^{-1}$
- PHOS $\gamma$: 4.51 nb$^{-1}$
- EMCAL jet and $\gamma$: 3.74 nb$^{-1}$
- UPC central: 2.00 nb$^{-1}$
- TRD quarkonia and nuclei: 0.45 nb$^{-1}$
- V0 high multiplicity: 1.29 nb$^{-1}$ (20M)
- Minimum bias: 0.03 nb$^{-1}$ (62M)

**Pb–p**

ALICE Performance 2016, Pb-p $\sqrt{s} = 8$ TeV

- Muon + UPC forward: 6.82 nb$^{-1}$
- PHOS $\gamma$: 4.21 nb$^{-1}$
- EMCAL jet and $\gamma$: 3.88 nb$^{-1}$
- UPC central: 0.10 nb$^{-1}$
- TRD quarkonia and nuclei: 0.08 nb$^{-1}$
- V0 high multiplicity: 0.74 nb$^{-1}$ (16M)
- Minimum bias: 0.02 nb$^{-1}$ (33M)
Reconstruction and MC production

• Pb–Pb 5 TeV: fully calibrated and reconstructed
• pp 13 TeV: ongoing
• fast track reconstruction (muon spectrometer and calorimeters) running synchronously with data taking
• p–Pb: calibrated (no backlog), reconstruction planned after p–Pb data taking
• massive Monte Carlo productions running
Muon Spectrometer performance

**p–Pb, 5.02 TeV**

- **Counts per 50 MeV/c^2**
  - ALICE Performance, 27/11/2016
  - p–Pb, $\sqrt{s_{NN}} = 5.02$ TeV (2016)
  - $2.03 < y_{cms} < 3.53$

**p–Pb, 8.16 TeV**

- **Counts per 50 MeV/c^2**
  - ALICE Performance, 27/11/2016
  - p–Pb, $\sqrt{s_{NN}} = 8.16$ TeV
  - $2.03 < y_{cms} < 3.53$

**Pb–p, 8.16 TeV**

- **Counts per 50 MeV/c^2**
  - ALICE Performance, 28/11/2016
  - Pb–p, $\sqrt{s_{NN}} = 8.16$ TeV
  - $-4.46 < y_{cms} < -2.96$

**Counts per 100 MeV/c^2**

- ALICE Performance, 25/11/2016
  - p–Pb, $\sqrt{s_{NN}} = 5.02$ TeV (2016)
  - $2.03 < y_{cms} < 3.53$

- ALICE Performance, 29/11/2016
  - Pb–p, $\sqrt{s_{NN}} = 8.16$ TeV
  - $-4.46 < y_{cms} < -2.96$
Recent papers

Published

• Jet-like correlations with neutral pion triggers in pp and central Pb-Pb collisions at 2.76 TeV

• D-meson production in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV and pp collisions at $\sqrt{s} = 7$ TeV

Submitted

• $W$ and $Z$ boson production in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, arXiv:1611.03002

• Determination of the event collision time with the ALICE detector at the LHC, arXiv:1610.03055

• Measurement of the production of high-$p_T$ electrons from heavy-flavour hadron decays in Pb–Pb collisions at
  $\sqrt{s_{NN}} = 2.76$ TeV, arXiv:1609.07104

• Evolution of the longitudinal and azimuthal structure of the near-side jet peak in Pb–Pb collisions at
  $\sqrt{s_{NN}} = 2.76$ TeV, arXiv:1609.06667

• Anomalous evolution of the near-side jet peak shape in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, arXiv:1609.06643
Event collision time

\[ \sigma_{t_{Best}}: \text{weighted mean of } t_{ev}^{T0} \text{ and } t_{ev}^{TOF} \]

\textit{TOF track multiplicity} 15 \sim 50\% \text{ V0A multiplicity class in } p-Pb \text{ and } 80\% \text{ centrality class in } Pb-Pb \text{ collisions}
W and Z boson production (p–Pb collisions)

pQCD and shadowing calculations describe the data
(another) proof of binary collision scaling
Heavy-quark energy loss

...via the measurement of decay electrons (from charm and beauty hadrons)

(continued with $D$-meson data; $R_{AA}$ & elliptic flow) constrain theoretical models...towards extraction of HQ transport coefficients
Particle correlations

hadrons “associated” with a “trigger” (all charged particles)

ALICE, Pb-Pb
\sqrt{s_{NN}} = 2.76 TeV
0-10%

\frac{1}{N_{\text{trig}}} \frac{d^2N_{\text{assoc}}}{d\Delta \eta d\Delta \phi}

combinatorial background and long-range correlations (collective flow) subtracted

conspicuous “depletion” around \( \Delta \eta = 0 \) (excluded from fits)

arXiv:1609.06643
Data indicative of a prominent jet-medium interaction

Armesto, Salgado, Wiedeman, PRL 93 (2004) 242301

Main features of data described by transport model AMPT, which incorporates jet-medium interactions
Particle correlations

hadrons “associated” with a $\pi^0$ “trigger”; $I_{AA} = \frac{\text{yield in Pb-Pb}}{\text{yield in pp}}$

near side ($\Delta \phi \sim 0$)

away side ($\Delta \phi \sim \pi$)

arXiv:1608.07201

High $p_T$: parton energy loss (away side: $I_{AA} < 1$)
Low $p_T$: jet-medium interaction and in-medium fragmentation
Models describe data, not in all details though (at low $p_T$)
Hadron production in jets

PYTHIA events smeared with background fluctuations

$K^-_S$: data consistent with PYTHIA within uncert.

$\Lambda$: data significantly above PYTHIA at low $p_T$

hadronization different in presence of medium?
Hyperon production

(big geometric) fireball in Pb–Pb reached with violent pp and p–Pb collisions
(Grand canonical) statistical description works well in Pb–Pb (with $T$ of QCD phase boundary)
is the same mechanism at work in small systems (at large multiplicities)?

String hadronization models do not describe data well
Hyperon production

studies are being extended with pp data at $\sqrt{s} = 13$ TeV (as well as in p–Pb collisions)

$\frac{\Xi}{\pi}$

$\frac{\Omega}{\pi}$ (×5)

$\frac{2K^0}{s}$

$\Lambda+\bar{\Lambda}$ (×2)

$\Xi^-+\bar{\Xi}^+$(×6)

$\Omega^-+\bar{\Omega}^+$(×16)

ALICE

$\langle dN_{\text{ch}} / d\eta \rangle_{|\eta|<0.5}$

$|s_{NN}| = 2.76$ TeV

$|s_{NN}| = 5.02$ TeV

$|s_{NN}| = 7$ TeV

$|s_{NN}| = 0.9$ TeV

$|s_{NN}| = 13$ TeV (Preliminary)

ARXIV:1606.07424
an intriguing result ...even if, considering uncertainties, not a large effect
expectation from the sequential “melting” (Debye screening): \( R_{AA}^{5.02} \leq R_{AA}^{2.76} \)
do we see (re)generation? (in QGP/at phase boundary?)
Pb–Pb $\sqrt{s_{\text{NN}}} = 5.02$ TeV full data set reconstructed

Hypertriton production
about half of all Pb–Pb statistics
ALPIDE sensor ready for production

- Size: $3.0 \times 1.5 \text{ cm}^2$
  50/100 $\mu\text{m}$ thickness
  $1.3 \times 10^5$ pixels/cm$^2$
- Spatial resolution: 5 $\mu\text{m}$
- Max particle rate: 100 MHz/cm$^2$
- Fake-hit rate: $< 10^{-10}$ /pixel/event
- Power: $\sim 300$ nW/pixel
- Continuous or external trigger

Detection Efficiency (%)

Threshold ($e^-$)

512 rows

1024 pixel columns

Bias, Data Buffering, Interface
ALICE Upgrade: TPC

First final-design OROC assembly at NIPNE Bucharest

- Pre-production campaign almost completed
  (2 IROC + 2 OROC)
- Comprehensive test campaign in lab and beam ongoing
- Start of mass production in 2017
ALICE Upgrade: TPC

- SAMPA MPW2 chips available
  ...tests ongoing to confirm TPC specifications by Dec. 2016
- First FEC Rev0 prototype cards available, tests ongoing
Summary

- efficient data taking over whole 2016
- reconstruction in good shape
- interesting physics results (and some puzzling too)
  - detailed investigations of jet-medium (QGP) interaction
  - hyperon production in jets “enhanced” at low $p_T$ (medium-modified fragmentation)
  - hint of (re)generation of $\Upsilon$ mesons? (QGP/phase boundary?)
  ...more to come, in particular with Run 2 data, our largest data set
- significant improvements not only in statistics, but also on systematic uncertainties
  ...a significant set of results expected for Quark Matter 2017 (Feb.) conference
- upgrade projects on track
Jets in Pb–Pb collisions at 5.02 TeV

\[ R_{AA} \]

\[ \text{ALICE Pb-Pb } |s_{NN}| = 5.02 \text{ TeV} \]

- shape uncertainty
- correlated uncertainty

Anti-\( k_T \) \( R=0.2 \) \( |\eta| < 0.7 \) \( p_T^{\text{lead}} > 5 \text{ GeV/c} \)

- \( |s_{NN}| = 5.02 \text{ TeV} \) ALICE 0-10 % (Ch Jet, \( R=0.2 \) pp:Data)
- \( |s_{NN}| = 5.02 \text{ TeV} \) ALICE 0-10 % (Ch Jet, \( R=0.2 \) pp:POWHEG)
- \( |s_{NN}| = 2.76 \text{ TeV} \) ALICE 0-10 % (Full Jet, \( R=0.2 \))
- \( |s_{NN}| = 2.76 \text{ TeV} \) ATLAS 0-10 % (Full Jet, \( R=0.4 \))

PLB 746 (2015) 1
PRL 114 (2015) 072302

ALICE Preliminary
Heavy-quark energy loss

...via the measurement of decay muons (from charm and beauty hadrons)

same values at the 2 energies ...not trivial, since parton spectra harder at 5.02 TeV
Hadron yields and the statistical model

A. Andronic - ALICE collab.

all species in fit

$\pi$, $K^\pm$, $K^0$ from charm included (0.7%, 2.9%, 3.1% for the best fit)

$T = 156.5 \pm 1.5 \text{ MeV}$, $\mu_B = 0.7 \pm 3.8 \text{ MeV}$, $V_{\Delta y=1} = 5280 \pm 410 \text{ fm}^3$