ALICE status report

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Outline

- Detector and data-taking status
- Physics results:
  - Papers and conferences
  - New results from pp collisions
  - Highlights from the latest p-Pb run
  - Highlights from Pb-Pb collisions
- Upgrade status
- Conclusions
Data-taking status
ALICE timeline in 2017

- Intense commissioning phase
- ~150 M minimum bias events collected with reduced magnetic field → study of di-electron continuum and resonances in the low-mass region
- Standard data-taking at a luminosity of ~2.6 Hz/μb (μ ~ 1%)
- ~80 M minimum bias events collected with isolated bunches for inelastic cross section and diffractive measurements
pp data-taking at $\sqrt{s} = 13$ TeV in 2017

Running a **rich trigger menu:**

- minimum bias
- high-multiplicity (V0-based)
- single and di-muon
- jet and $\gamma$ from EM calorimeters
- electron, jet and (anti-)nuclei from the TRD
- double diffractive gap
- muon-calorimeter coincidences

**Work in progress:**

- high-multiplicity (SPD-based)
- forward $J/\psi$ from EM interactions
### Run II data-taking summary

<table>
<thead>
<tr>
<th></th>
<th>pp 5 TeV</th>
<th>pp 13 TeV</th>
<th>p-Pb 5.02 TeV</th>
<th>p-Pb 8.16 TeV</th>
<th>Pb-Pb 5.02 TeV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Luminosity for rare triggers (goal)</strong></td>
<td>112 nb⁻¹ (600 nb⁻¹)</td>
<td>19 pb⁻¹ (40 pb⁻¹)</td>
<td>3.4 nb⁻¹</td>
<td>21 nb⁻¹</td>
<td>250 μb⁻¹ (1 nb⁻¹)</td>
</tr>
<tr>
<td><strong>Number of minimum bias events (goal)</strong></td>
<td>128 M (1000 M)</td>
<td>2 G (200 M low-B) (3.5 G)</td>
<td>764 M</td>
<td>70 M</td>
<td>157 M (250 M)</td>
</tr>
<tr>
<td><strong>Number of high multiplicity / central events (goal)</strong></td>
<td>- (-)</td>
<td>900 M (2.5 G)</td>
<td>- (-)</td>
<td>47 M</td>
<td>- (250 M)</td>
</tr>
</tbody>
</table>

*pp reference run at 5 TeV is a major goal for 2017 data-taking*

→ several p-Pb and Pb-Pb require these data
Physics results
10 Papers submitted since the last LHCC meeting

http://aliceinfo.cern.ch/ArtSubmission/submitted
ALICE at the main summer conferences

15 talks

18 talks

22 talks

22 talks

One of the three main heavy-ion conferences
New results from pp collisions
Multiplicity distributions over a wide pseudorapidity range

- Multiplicity distributions measured over 8.4 pseudorapidity units at 3 different energies

*arXiv:1708.01435*
Multiplicity distributions over a wide pseudorapidity range

- Multiplicity distributions measured over 8.4 pseudorapidity units at 3 different energies

One of the key observables to describe the global properties of pp interactions

Input for event generators

\[ P(N_{\text{charged}}) \]

\[ N_{\text{charged}} \]

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\( \pi^0 \) and \( \eta \) meson production in pp collisions at \( \sqrt{s} = 8 \) TeV

- Four different reconstruction methods

- Test of gluon fragmentation functions \( \rightarrow \) \( \eta/\pi^0 \) ratio reproduced by pQCD + FF

- Constrain event generators

arXiv:1708.08745
**$\Xi_c$ and $\Lambda_c$ production in pp (and p-Pb) collisions**

- First cross section measurement for $\Xi_c \rightarrow e^+ \Xi^- \nu_e$

  in pp collisions at the LHC (note: unknown BR)
**Ξ_c and Λ_c production in pp (and p-Pb) collisions**

- First cross section measurement for $\Xi_c \rightarrow e^+ \Xi^- \nu_e$ in pp collisions at the LHC (note: unknown BR)

- Ratio to $D^0$ is **sensitive to hadronisation models** (e.g. color reconnection vs ropes)

- Results compared to generators with different hadronisation mechanisms
- Ratio underestimated by models for both particles
- $\Lambda_c / D^0$ ratio in p-Pb compatible with pp
J/ψ and open HF production vs multiplicity in pp collisions

- Correlate «soft» and «hard» components of particle production
- Sensitive to Multiple-Parton Interactions
- Increase of the yields with multiplicity observed for D-mesons and J/ψ

![Graph showing yield vs multiplicity for J/ψ and D mesons at 7 TeV and 13 TeV](image)
J/ψ and open HF production vs multiplicity in pp collisions

- Correlate «soft» and «hard» components of particle production
- Sensitive to Multiple-Parton Interactions
- Increase of the yields with multiplicity observed for D-mesons and J/ψ
- New results:
  - J/ψ vs mult. vs p_T at mid-rapidity (13 TeV)
    → steeper slope with multiplicity at high p_T
  - Muons from HF at forward rapidity (8 TeV)
    → Slower increase wrt D mesons at mid-rapidity?
Highlights from the latest p-Pb run
J/ψ production at forward rapidity in p-Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

- p-Pb collisions as a **benchmark experiment**
- ideal ground to test cold nuclear matter effects

Nuclear modification factor:

$$R_{pPb} = \frac{\text{Yield per event in p-Pb}}{(\text{Yield per event in pp}) \times \langle N_{\text{collisions}} \rangle}$$

![Diagram showing J/ψ production at forward rapidity in p-Pb collisions.](ALICE-PUBLIC-2017-001)
J/ψ production at forward rapidity in p-Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

- p-Pb collisions as a benchmark experiment
- Ideal ground to test cold nuclear matter effects

New result:
$Q_{pPb}$: nuclear modification factor of J/ψ as a function of the collision centrality

- Compatible with Run I results at 5.02 TeV
- Finer binning
- Opposite centrality dependence for Pb-going and p-going
  → Waiting for theoretical input at 8.16 TeV
D-meson production at mid-rapidity in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

**D-meson nuclear modification factor** compatible with unity up to $p_T \sim 35$ GeV/c

Also compatible between strange and non-strange D mesons

Measurement precision mostly **limited by the pp reference** $\to$ looking forward to new pp data at 5 TeV!

Ratio of central to peripheral $Q_{pPb}$:

$Q_{cp} > 1$ with **1.7$σ$ significance** in 3-7 GeV/c $\to$ room for **final state effects and, possibly, collectivity**?
Highlights from Pb-Pb collisions
New results on (multi-)strange baryon / pion ratios from Pb-Pb collisions at $\sqrt{s} = 5.02$ TeV

Run II statistics allows for **fine binning in event multiplicity**

$\rightarrow$ for $\Xi$, peripheral Pb-Pb overlaps with high-mult. pp and p-Pb

Smooth behaviour across energies and colliding systems (also seen for $K_0^*$ and $\Lambda$): a **common underlying mechanism**?
Strangeness production: from pp to Pb-Pb

New results on (multi-)strange baryon / pion ratios from Pb-Pb collisions at √s = 5.02 TeV

Run II statistics allows for fine binning in event multiplicity

→ for Ξ, peripheral Pb-Pb overlaps with high-mult. pp and p-Pb

Thermal model: hadrons emitted by a source in thermal and chemical equilibrium, dN/dy \(\sim e^{-m/T}\)

Predictions (T fitted to 2.76 TeV data) are within 2.1σ (<1σ) of data for Ξ (Ω)
Light (anti-)nuclei production in Pb-Pb (and pp) collisions

High-resolution measurement of deuteron spectra in 10 centrality classes (+pp) from Run II data

Sensitive probe of the hadronic scattering stage

Rising trend of d/p ratio with multiplicity until intermediate multiplicities, then saturation: interplay between coalescence and thermal production?
Measurement of the (anti-)hypertriton lifetime in Pb-Pb collisions

\[ ^3\Lambda H \text{ reconstructed in the } ^3\text{He}-\pi \text{ decay channel (} ^3\text{He identification via E-loss in TPC)} \]

Result fully compatible with the world-average and with the free \( \Lambda \) lifetime

Significantly improved uncertainties wrt Run I

(and one of the most precise available measurements)
Charge-dependent directed flow in Pb-Pb collisions

- Search for **magnetic-induced charged currents** from moving nuclei

- **Goal:** constrain the early-time magnetic field in the medium
  → pre-requisite for studying its interactions with the quantum properties of the system (e.g. Chiral Magnetic Effect)

- Directed flow ($v_1$): quantifies **collective particle motion under pressure gradients** in the expanding system

\[
\frac{dN}{d\varphi} \propto 1 + v_1 \cos[\varphi - \Psi_1] + 2v_2 \cos[2(\varphi - \Psi_2)] + 2v_3 \cos[3(\varphi - \Psi_3)] + \ldots
\]

- Magnetic field expected to induce a charge-dependent directed flow on particles in the medium

- Rapidity slope of ($v_1^+ - v_1^-)$ expected to vary with $p_T$

Charge-dependent directed flow in Pb-Pb collisions

- Search for **magnetic-induced charged currents** from moving nuclei

- **Goal:** **constrain the early-time magnetic field in the medium**
  - pre-requisite for studying its interactions with the quantum properties of the system (e.g. Chiral Magnetic Effect)

- Measurement performed so far for the pseudorapity-odd component of $v_1$
Charge-dependent directed flow in Pb-Pb collisions

- Search for magnetic-induced charged currents from moving nuclei

- Goal: constrain the early-time magnetic field in the medium
  → pre-requisite for studying its interactions with the quantum properties of the system
    (e.g. Chiral Magnetic Effect)

- Measurement performed so far for the pseudorapidity-odd component of $v_1$

- Non-zero slope measured with a significance of $2\sigma$

- Interpretation requires more data and further theoretical effort:
  - slope is 1-2 order of magnitude bigger than expectations, and of opposite sign
  - $p_T$-dependence
  - competing Faraday and Hall effects
$J/\psi$ nuclear modification factor at mid-rapidity

- **Measurement of the $J/\psi$ nuclear modification factor vs $p_T$ at mid-rapidity**
- Data indicate a **smaller suppression than at forward rapidity** in central collisions and low $p_T$
- Compatible with regeneration/recombination scenarios

![Graph showing $R_{AA}$ vs $p_T$ for $J/\psi$ production in Pb-Pb collisions at $s_{NN} = 5.02$ TeV, 0-20% centrality, with data points for $J/\psi \rightarrow \mu^+\mu^-$ and $J/\psi \rightarrow e^+e^-$ at $|y| < 0.9$ and $2.5 < y < 4$.](image)
• **Measurement of the $J/\psi$ nuclear modification factor at mid-rapidity** with Run II data

• Data indicate a **smaller suppression than at forward rapidity** in central collisions and low $p_T$

• Compatible with regeneration/recombination scenarios

• Data sit on the upper side of the theory band from a transport model (with regeneration)
D-meson production

- Measurement of the nuclear modification factor
- Strong suppression of D mesons in central (0-10%) Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV
- Hint for a smaller suppression of $D_s^+$ wrt non-strange D mesons → coalescence + strangeness enhancement?
**D-meson production**

- **Elliptic flow** is quantified by the $v_2$ coefficient
  
  $\frac{dN}{d\phi} \propto 1 + 2v_1\cos(\phi - \Psi_1) + 2v_2\cos(2(\phi - \Psi_2)) + 2v_3\cos(3(\phi - \Psi_3)) + \ldots$

- Address collectivity in Pb-Pb collisions
  
  → study how the **initial system asymmetry affects final-state kinematical distribution**

- $v_2$ of D mesons measured in semi-central collisions compatible with that of charged particles
  
  → points to a strong **participation of charm quarks in the collective motion**

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- arXiv:1707.01005

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The measurements of $v_2$ and $R_{AA}$ provide together important constraints for the medium transport coefficients.
Upgrade status
## Long Shutdown 2 schedule

<table>
<thead>
<tr>
<th>Year</th>
<th>Period</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>2015</td>
<td>Oct-Feb (20 wks)</td>
<td>Recommissioning</td>
</tr>
<tr>
<td>2016</td>
<td>Mar-Dec (44 wks)</td>
<td>TPC upgrade, Services installation</td>
</tr>
<tr>
<td>2017</td>
<td>Jan-Sep (37 wks)</td>
<td>Reinstall TPC/ITS/MFT/FIT/beampipe, close Experiment</td>
</tr>
<tr>
<td>2018</td>
<td>Dec-Feb (10 wks)</td>
<td>Open Experiment, TPC/ITS/beampipe removal</td>
</tr>
</tbody>
</table>

**Timeframe**
- Oct - Feb (20 weeks)
- Mar - Dec (44 weeks)
- Jan - Sep (37 weeks)

**Activities**
- Electronics engineering
- R&D
- Beamline commissioning
- TPC upgrade
- Services installation
- Reinstall TPC/ITS/MFT/FIT/beampipe
- Close Experiment
Pixel Sensor Chip (ALPIDE) – Production

<table>
<thead>
<tr>
<th>Production Status</th>
<th>Nr. wafers</th>
<th>Nr. chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>delivered</td>
<td>560</td>
<td>24840</td>
</tr>
</tbody>
</table>

Full production order: 1200 wafers
2 wafers of each lot are shipped to CERN (monitor yield)
Remaining wafers are sent to Korea for thinning and dicing

Production proceeds smoothly
Throughput ⇒ 100 wafers/month
⇒ Production will continue till Feb 2018

Detector Layout

- 7 layers: 3 (IL), 2 (ML), 2 (OL)
- 192 Staves: 48 (IL), 54 (ML), 90 (OL)
Inner Tracking System upgrade

Stave Prototypes

- First half-stave of stave 1 tested in Torino; all 98 chips fully functional
- Plot shown here:
  - Noise distribution measured in threshold scan on all 98 chips operated concurrently
  - Threshold scan tests both readout and analogue performance
  - Noise value comparable to single chips

Detector Layout

- ITS structure:
  - 7 layers: 3 (IL), 2 (ML), 2 (OL)
  - 192 Staves: 48 (IL), 54 (ML), 90 (OL)

Noise distribution

Preliminary

51 M pixels!
Time Projection Chamber upgrade

- Main detector upgrade: build **new GEM-based read-out chambers**
- 45% of all required GEM foils produced
- **Production completed by Apr 2018**
- First 5+5 full **Inner + Outer Read-Out Chambers (IROC+OROC)** being produced

**IROC:**
- 4 IROCs are ready and qualified — all acceptance criteria met
- 1 shipped to CERN for test at P2

**OROC:**
- All GEMs framed
- All chamber bodies assembled
- 1 OROC assembled at GSI
- 2 more OROC bodies at GSI for assembly in Sept.
- 2 more OROC bodies at Bucharest for assembly in Sept./Oct.
### Electronics upgrade status

<table>
<thead>
<tr>
<th></th>
<th>Engineering Design Review</th>
<th>Production Readiness Review</th>
<th>Installation ready</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRU</td>
<td></td>
<td>Q4 2017</td>
<td></td>
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<tr>
<td>CTP</td>
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<td>FIT read-out</td>
<td>26 Sept 2017</td>
<td>Dec 2018</td>
<td></td>
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<tr>
<td>ITS ALPIDE</td>
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<tr>
<td>ITS read-out</td>
<td></td>
<td>Jan 2018</td>
<td></td>
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<tr>
<td>MCH system &amp; FEC</td>
<td></td>
<td>Q2 2018</td>
<td></td>
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<tr>
<td>MCH SOLAR</td>
<td></td>
<td>Oct 2017</td>
<td></td>
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<tr>
<td>MFT</td>
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<td>Q2 2018</td>
<td></td>
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<tr>
<td>MID front-end</td>
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<td>MID read-out</td>
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<td>Oct 2017</td>
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<tr>
<td>SAMPA</td>
<td></td>
<td>Feb 2018</td>
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<tr>
<td>TPC</td>
<td>4 &amp; 5 Oct 2017</td>
<td>Jul 2018</td>
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<tr>
<td>TOF</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>ZDC</td>
<td>Dec 2017</td>
<td>Q4 2018</td>
<td></td>
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</tbody>
</table>

- Moved from R&D into the pre-series and production phase
Full electronics chain system test
Conclusions

• A wealth of results from both Run II and Run I data
  - study the properties of particle production in pp collisions
  - constrain cold nuclear matter effects in p-Pb collisions (+ onset of collectivity?)
  - study the hot and dense medium produced in Pb-Pb collisions in both the soft and hard sector

• Analysis of Run II data still in full swing ➔ many more results to come up soon

• Promising 13 TeV pp data-set being collected with a rich trigger menu

• Looking forward to the pp run at 5 TeV

• Upgrade projects for Run III well on track
Event statistics 2017 (pp 13 TeV)

~150 M events collected at reduced magnetic field in 2017 (+50 M in 2016)
→ study of di-electron continuum and resonances in the low-mass region

~80 M events collected with isolated bunches
→ inelastic cross section and diffractive measurements.
→ Exploit dedicated optics during vdM scans, allowing us to run our ZDCs in pp
Elliptic flow of identified particles in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

- **Elliptic flow** is quantified by the $v_2$ coefficient

\[
\frac{dN}{d\varphi} \propto 1 + 2v_1\cos[\varphi - \Psi] + 2v_2\cos[2(\varphi - \Psi)] + 2v_3\cos[3(\varphi - \Psi)] + \ldots
\]

- Typically used to address «collectivity» in Pb-Pb collisions

  - study how the initial system asymmetry affects final-state kinematical distribution
  - mass-ordering
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\]

- Typically used to address «collectivity» in Pb-Pb collisions
  - study how the initial system asymmetry affects final-state kinematical distribution
  - mass-ordering

$v_2$ for identified particles measured in p-Pb collisions

Mass-ordering observed up to $p_T \sim 2.5$ GeV/c

More effort needed to understand the role of non-flow contributions to $v_2$
$J/\psi$ $Q_{pPb}$ at 5.02 TeV from Run I
D-meson and charged particles $R_{pPb}$ and $Q_{pPb}$

ALICE Preliminary
NSD, p-Pb $\sqrt{s_{NN}} = 5.02$ TeV

Uncertainties: stat. (bars), sys. (boxes)