Highlights from the LHCb experiment

Benjamin Audurier* on the behalf of the LHCb collaboration

Thanks to all the collaboration!

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The LHCb detector

LHCb: single arm spectrometer fully instrumented in pseudo-rapidity range $2 < \eta < 5$

- Track reconstruction **down to** $p_T = 0$.
- Excellent $p_T$ and mass resolution.
- Excellent particle identification.
- Precision vertex reconstruction.

10.1142/S0217751X15300227
The LHCb detector

Can operate both in pp/pPb/PbPb and fixed-target!

Fixed-target mode: unique at LHC!
• Injecting gas in the LHCb VErtex LOcator (VELO) tank.
• Noble gas only: He, Ne, Ar
• Gas pressure: $10^{-7}$ to $10^{-6}$ mbar
LHCb : general purpose detector for heavy-ions
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Hadronic and QGP physics

Gluon saturated region

Large phase space coverage
LHCb: general purpose detector for heavy-ions

Hadronic and QGP physics

- **Collider mode:**
  - Detector is well suited to constrain (n)PDFs.
  - New PbPb dataset reaching 60% in centrality.

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LHCb : general purpose detector for heavy-ions

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- **Fixed-target program:**
  - (n)PDFs studies.
  - Test cosmic physics in laboratory.

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LHCb: general purpose detector for heavy-ions

Hadronic and QGP physics

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UPC physics

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- **p_T resolution:** key to ultra-peripheral PbPb collisions.
- UPC physics can be extended to pA and fixed-target.

LHCb - general purpose detector for heavy-ions

- **8.16 TeV pPb**
  - LHCb
  - ATLAS/CMS
  - ALICE
  - ALICE Muon

- **Other Collision Systems**
  - LHCb 110 GeV
  - HERA

- **Q^2 (GeV^2)**

- **x**

- **Gluon saturated region**

- **Large phase space coverage**

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LHCb : general purpose detector for heavy-ions

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**Large phase space coverage**

**UPC physics**

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LHCb physics program

Large variety of samples to study!

Two new samples: PbNe at $\sqrt{s_{NN}} = 68.6$ GeV and PbPb at $\sqrt{s_{NN}} = 5.02$ TeV

Fixed-target mode samples

Collider mode samples

~ 20 times 2015 luminosity
LHCb program this week
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**4 talks**  

**5 posters**

- Many new results for QM19, talk with our speakers for more insights!
$X(3872)/\psi(2S)$ in pp and pPb collisions at 8 TeV
X(3872) : exotic state still not understood.

- Tetraquark / hadronic molecule / something else ?
X(3872)/ψ(2S) in pp and pPb collisions at 8 TeV

- X(3872): exotic state still not understood.
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- X(3872)/ψ(2S) ratio versus N_{tracks} measured in pp collisions at √s = 8 TeV.
X(3872)/ψ(2S) in pp and pPb collisions at 8 TeV

❖ X(3872) : exotic state still not understood.
   ▷ Tetraquark / hadronic molecule / something else ?

❖ X(3872)/ψ(2S) ratio versus N_{tracks} measured in pp collisions at $\sqrt{s} = 8$ TeV.

❖ Baseline for a future pPb analysis !
Open and hidden beauty production in pPb collisions
Open and hidden beauty production in pPb collisions

- Relative production of upsilon states to test cold (hot ?) nuclear matter effects in pPb collisions.
- Relative $\Upsilon(2S)/\Upsilon(1S)$ and $\Upsilon(3S)/\Upsilon(1S)$ suppression measured in pPb and PbP at $\sqrt{s_{NN}} = 8$ TeV down to zero $p_T$.
- **Good agreement** between data and predictions when including co-movers effects.

Shanzhen Chen - Wed. at 4:40 pm

**JHEP11(2018)194**
Open and hidden beauty production in pPb collisions

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- Good agreement between data and predictions when including co-movers effects.
- Beauty mesons and baryon measured in pPb/PbP collisions at $\sqrt{s_{NN}} = 8$ TeV
- Extensive studies show good agreement between data and model predictions.

Shanzhen Chen - Wed. at 4:40 pm

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Open and hidden charm production in pPb collisions

❖ Preliminary results for D⁰ cross-section in pPb/Pbp collisions at \( \sqrt{s_{\text{NN}}} = 8 \text{ TeV} \) up to \( p_T = 16 \text{ GeV/c} \).

❖ Improved statistics by factor 20 compared to previous LHCb results.

❖ Tension between data and nPDFs predictions. Additional effects required.

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Open and hidden charm production in pPb collisions

- $\chi_{c1}$ and $\chi_{c2}$ peaks observed in pPb/Pbp collisions with converted and non-converted photons.

Analysis ongoing, stay tuned!
Preliminary measurements of $Z$ cross-section in pPb/Pbp collisions at $\sqrt{s_{NN}} = 8$ TeV

- Factor 20 increase in statistics compared to previous LHCb measurements.
- Data are precise enough to strongly constrain predictions.
Fixed-target results
Fixed-target results

**Antiproton in pHe at $\sqrt{s_{NN}} = 110$ GeV**

- Antiproton cross-sections in pHe: key to constrain dark matter search in cosmic flux.
  - Data constrain extrapolations from pp to pHe cross-sections.
  - Data constrain empirical parameterization for scaling violation of cross-sections.

*Benjamin Audurier - benjamin.audurier@cern.ch*
Fixed-target results

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Charm in pHe at $\sqrt{s_{\text{NN}}} = 86.6$ GeV

- Open-charm production in fixed-target LHCb acceptance: access to anti-shadowing and intrinsic charm content in the nucleons.
  - Precise $J/\psi$ and $D^0$ measurements in pHe.
  - Good agreement between data and theory with no strong intrinsic charm contribution observed.

Felipe Garcia - poster
Sneak peek at UPC PbPb collisions

- Coherent charmonium production analysis ongoing in ultra-peripheral PbPb collisions at $\sqrt{s_{NN}} = 5$ TeV.
- Factor 20 increase in statistics compared to previous UPC results.

Analysis ongoing, stay tuned!
Sneak peek at hadronic PbPb-PbNe collisions

Samuel Belin - poster

- New PbPb dataset at $\sqrt{s_{NN}} = 5$ TeV:
  - up to 60% centrality reached in hadronic collisions!

- New PbNe dataset at $\sqrt{s_{NN}} = 68.6$ GeV:
  - No limitation in centrality!

Analysis ongoing, stay tuned!

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LHCb in the future
LHCb detector: season 3 (2021)

ียว Upgrade based on pp collision requirements:
- Collision rate at 40 MHz.
- Pile-up factor $\mu \approx 5$

 Girlfriend Replace the entire tracking system.
 Girlfriend Full software trigger.
- Remove L0 triggers.
- Read out the full detector at 40 MHz.

New Tracking system:
- Silicon upstream detector (UT)
- Scintillating tracking fibre (SciFi)

New electronics for muon and calorimeter systems

New pixel VELO

New RICH optics and photodetectors

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LHCb fixed-target program evolution

- **SMOG 2 (TDR)**: Standalone gas storage cell covering \( z \in [-500; -300] \) mm:
  - **Up to x100 higher gas density** with same gas flow of current SMOG.
  - Gas feed system measures the **gas density with few % accuracy**.

- Installation due in December 2019, to be operational from the start of LHC Run 3.
Run 3 and Run 4 prospects for heavy-ion physics with LHCb

Pasquale Di Nezza - Tue. at 5:20 pm
Run 3 and Run 4 prospects for heavy-ion physics with LHCb

PbPb collisions at LHCb
Run 3 and Run 4 prospects for heavy-ion physics with LHCb

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**PbPb collisions at LHCb**

*❖* No significant saturation of the new LHCb detectors up to 30%!

*❖* Two proposals for a new tracker:
- in 2024 → reach event more central collisions!
- In 2030 → no more limitations!
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Fixed-target program

- Rapidity scan at 72 GeV with FT@LHCb can complement the RHIC beam energy scan.
Conclusions
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- **LHCb results contribute to enlarged nuclear physics program**
  - Many precise results from large pPb/Pbp datasets at $\sqrt{s_{NN}} = 8$ TeV.
  - Unique results with the fixed-target program at LHC.
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❖ LHCb physics program is expanding
  - Two new datasets to explore: PbPb at $\sqrt{s_{NN}} = 5$ TeV and PbNe at $\sqrt{s_{NN}} = 86$ GeV.
  - A full UPC physics program to look at with high precision.
Conclusions

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❖ **LHCb’s future is bright**
  - New detector with new tracking/PID system driven by pp physics.
  - Improved fixed-target program with SMOG 2.
  - Better performances expected for Run 3 in high-multiplicity collisions.
  - Extended capabilities of the detector = expansion of the physics program!