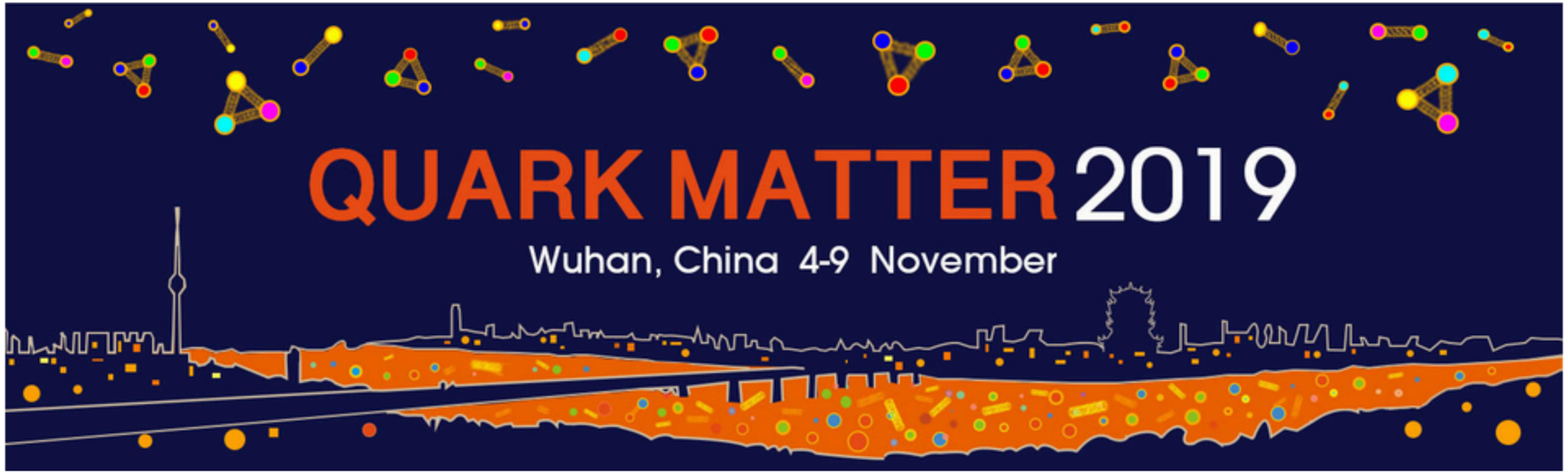
Highlights from the LHCb experiment

Benjamin Audurier* on the behalf of the LHCb collaboration



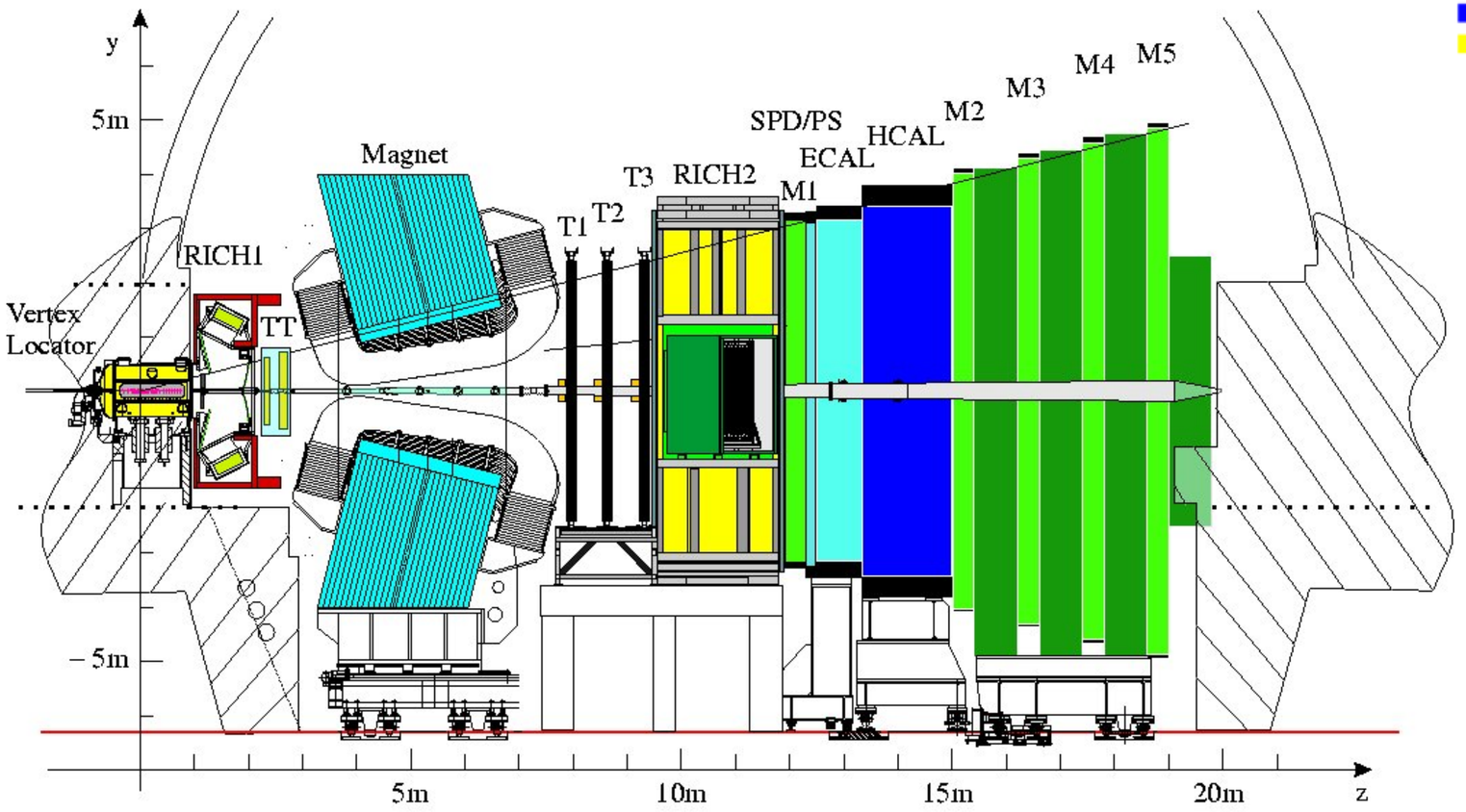
Thanks to all the collaboration !

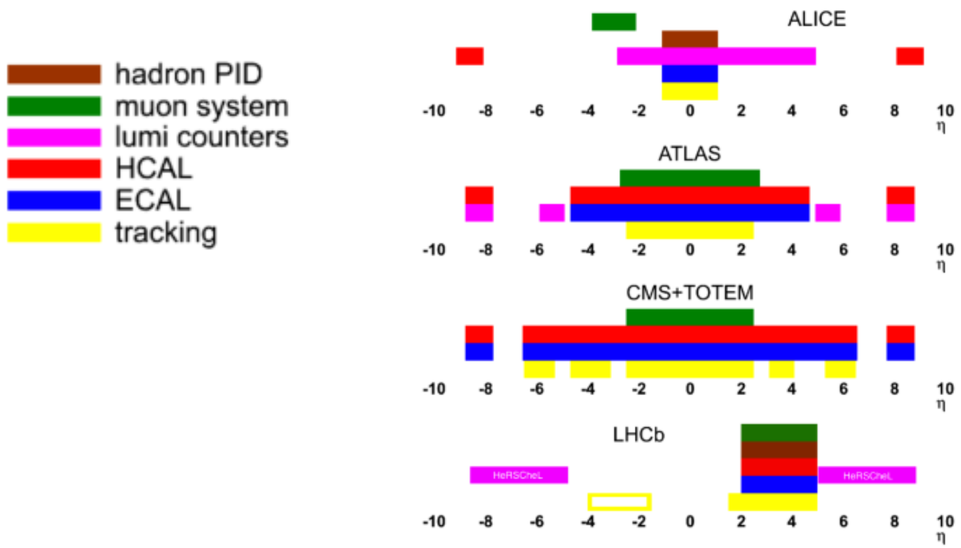
*benjamin.audurier@cern.ch

The LHCb detector

10.1142/S0217751X15300227

LHCb : **single arm spectrometer fully instrumented** in pseudo-rapidity range **2 < η < 5**



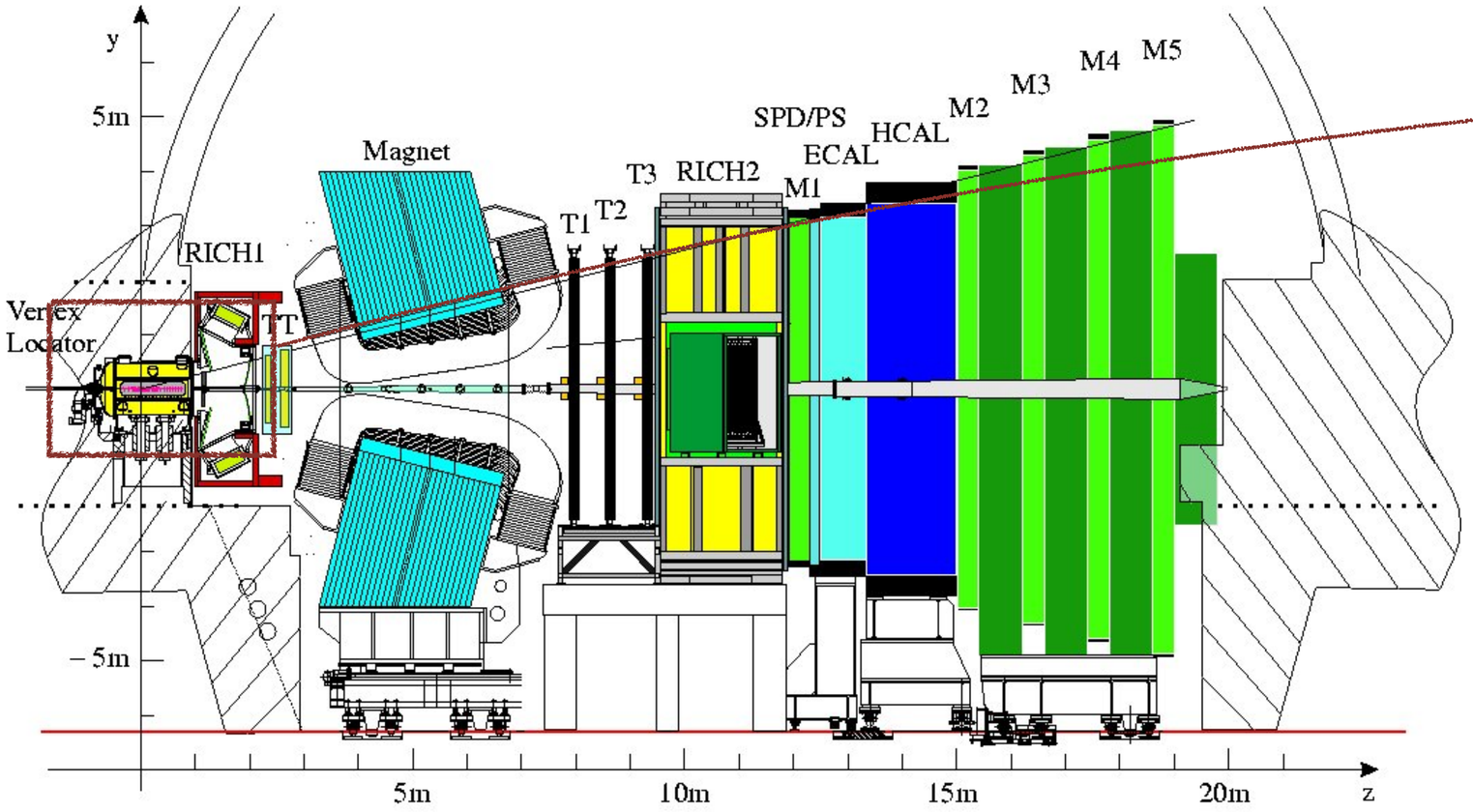


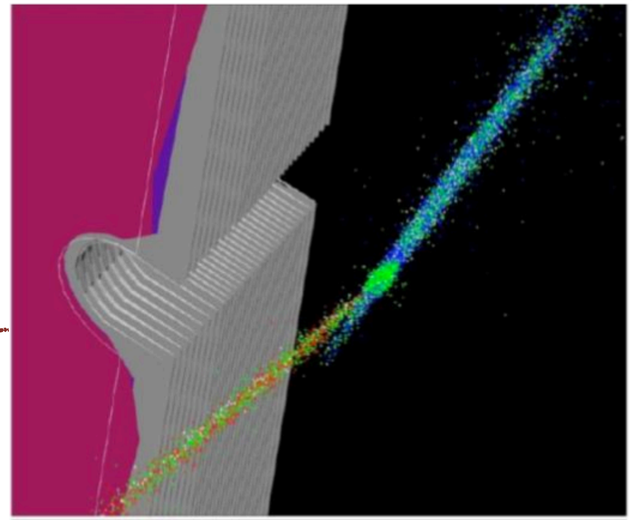
- Track reconstruction **down to $p_T = 0$.**
- Excellent **p_T and mass resolution.**
- Excellent **particle identification.**
- Precision **vertex reconstruction.**

The LHCb detector

10.1142/S0217751X15300227

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





Distribution of vertices overlaid on detector display. z-axis is scaled by 1:100 compared to transverse dimensions to see the beam angle.

Beam 1 - Beam 2, Beam 1 - Gas, Beam 2 - Gas.

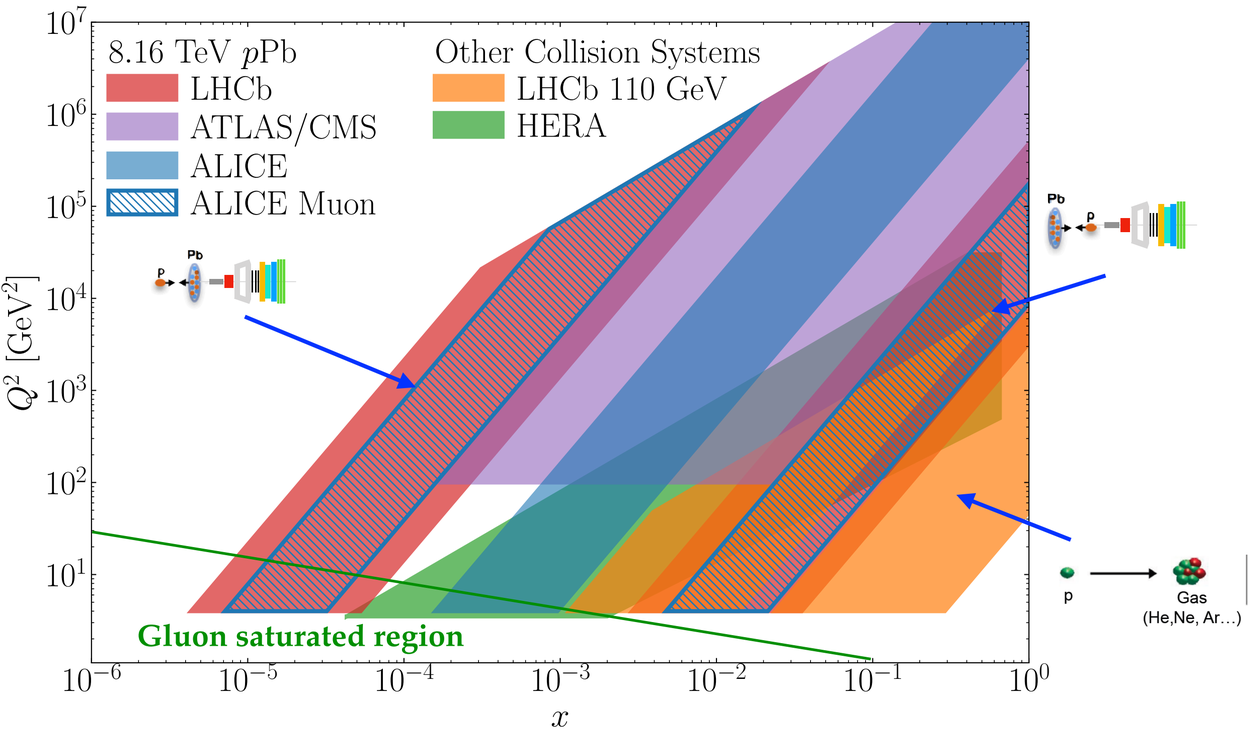
Fixed-target mode: **unique at LHC !**

- 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

LHCb : general purpose detector for heavy-ions

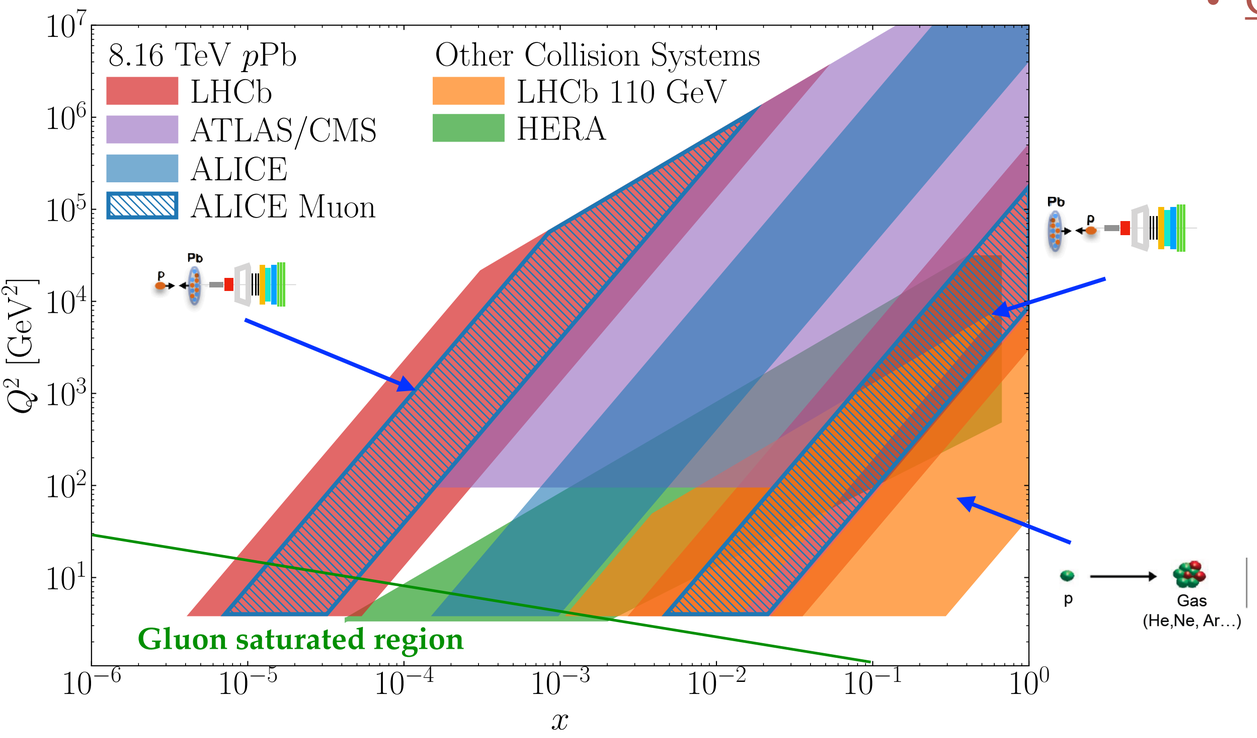
Hadronic and QGP physics



Large phase space coverage

LHCb : general purpose detector for heavy-ions

Hadronic and QGP physics

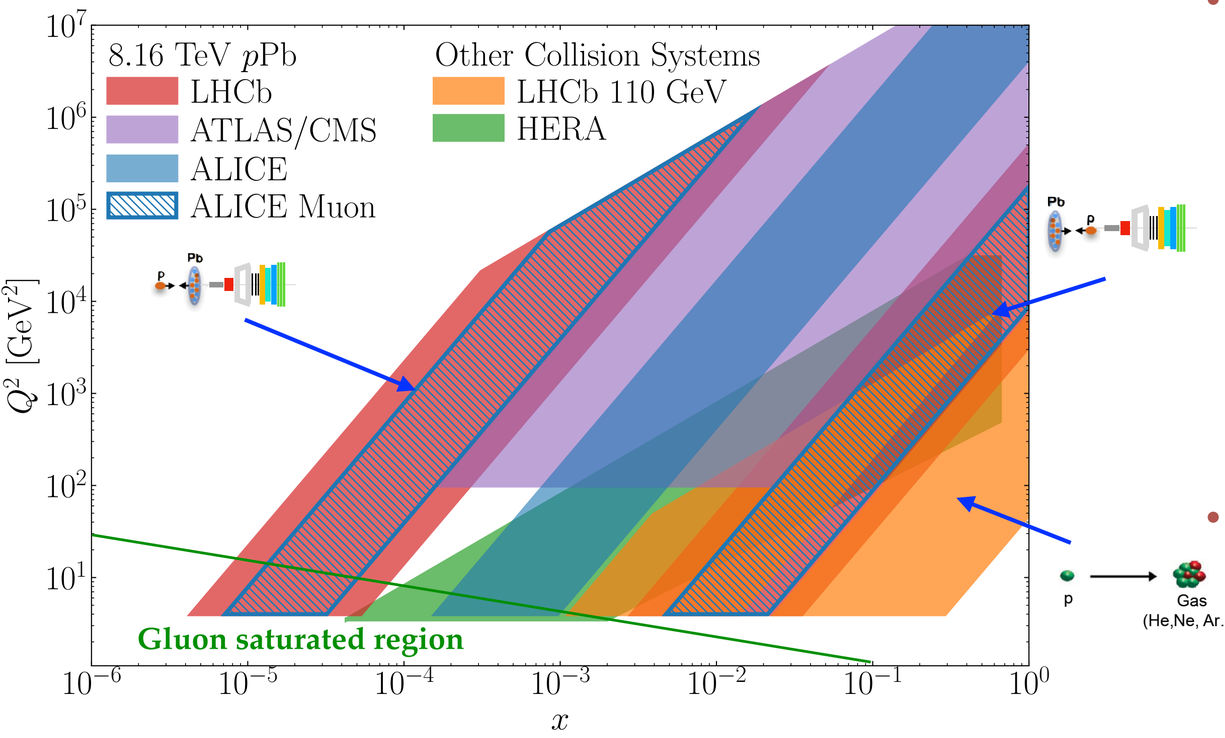


Large phase space coverage

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

LHCb : general purpose detector for heavy-ions

Hadronic and QGP physics



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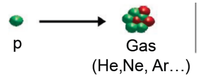
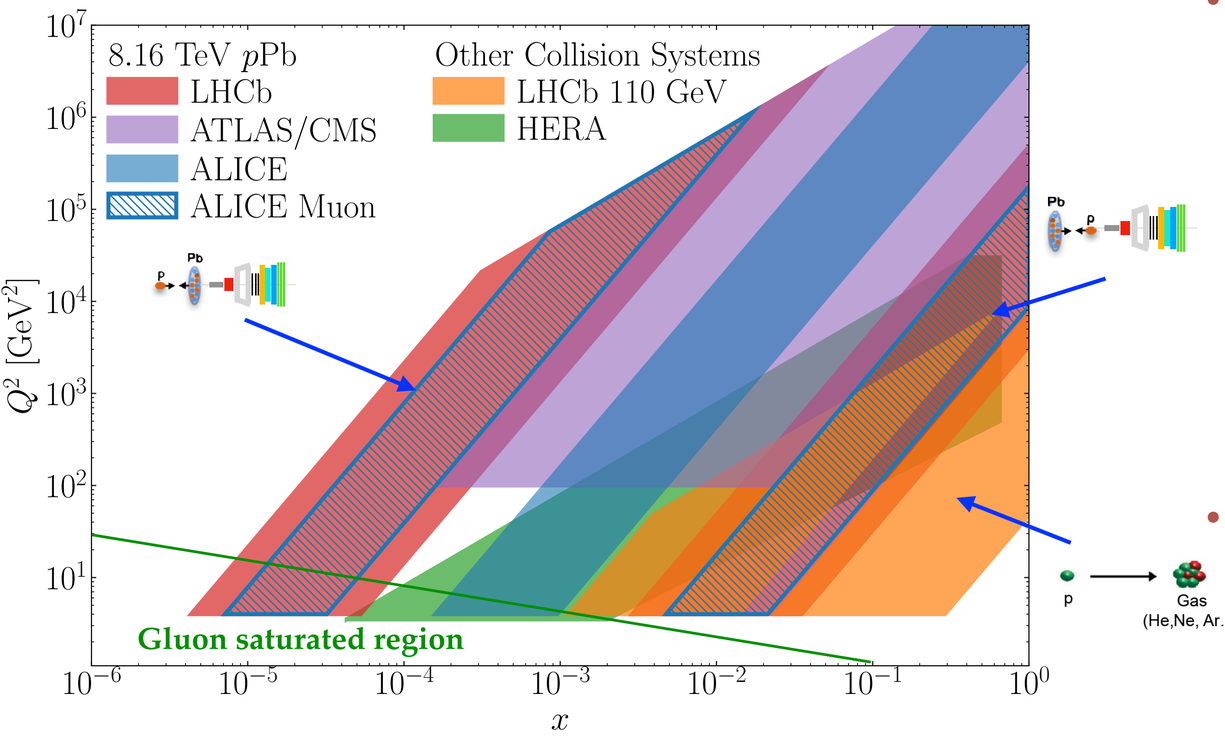


- Fixed-target program :
  - (n)PDFs studies.
  - Test cosmic physics in laboratory.

LHCb : general purpose detector for heavy-ions

Hadronic and QGP physics



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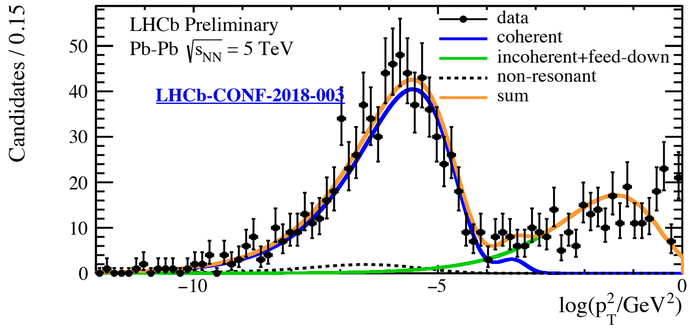
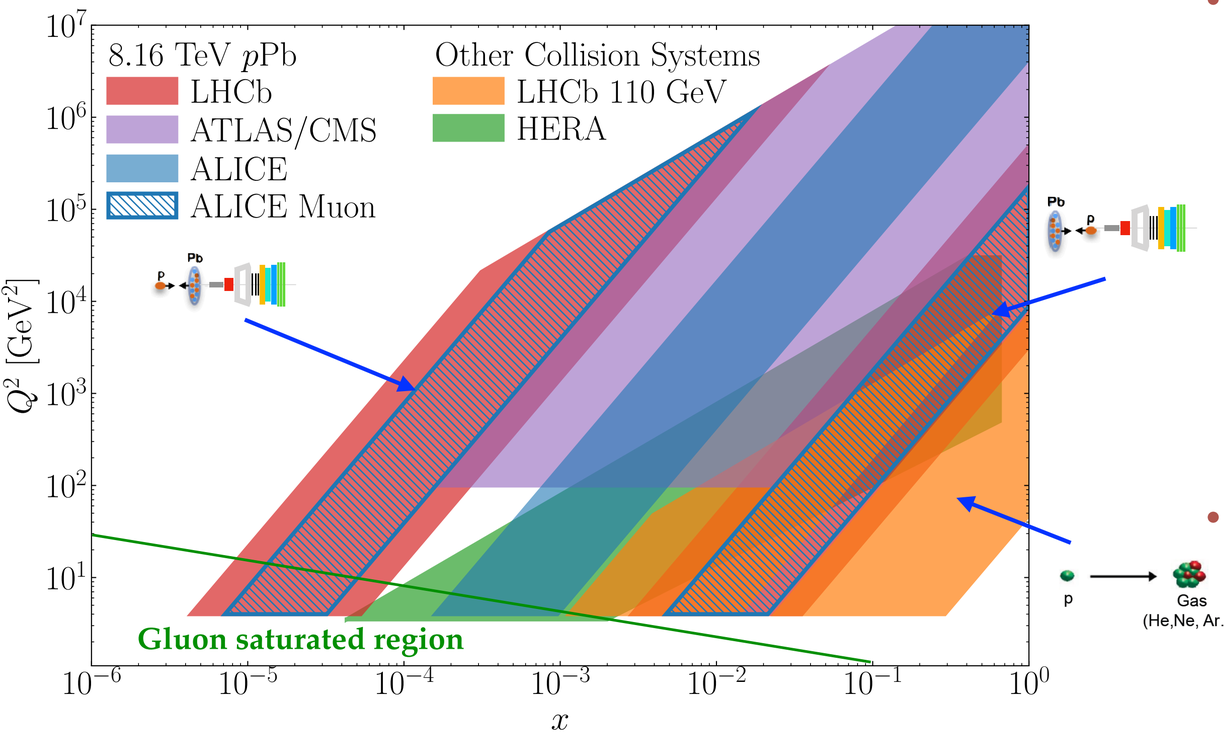
UPC physics



- 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

Hadronic and QGP physics



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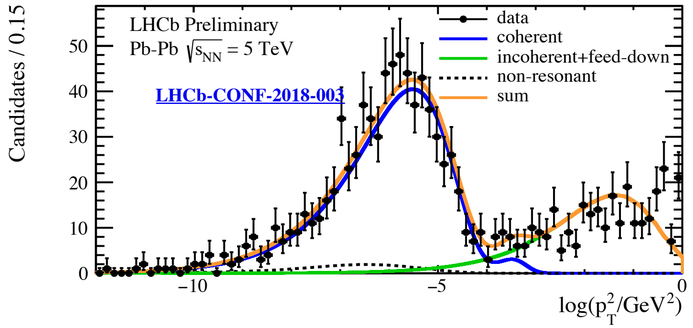
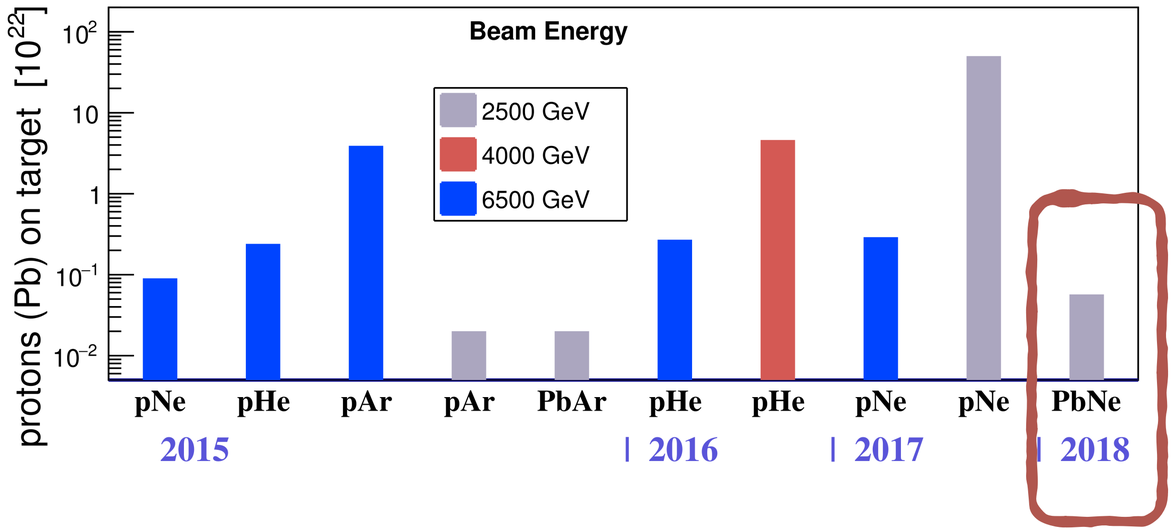


- p_T resolution : key to ultra-peripheral PbPb collisions.
- UPC physics can be extended to pA and fixed-target.

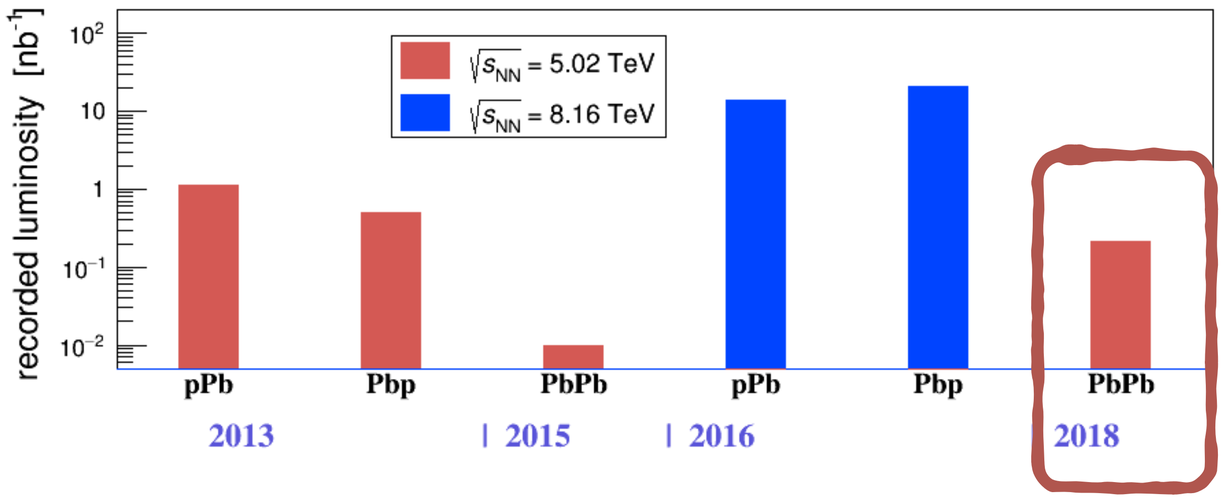
Large and expanding physics program !

LHCb physics program

Fixed-target mode samples



Collider mode samples



~ 20 times 2015 luminosity

- 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

LHCb program this week

*benjamin.audurier@cern.ch

List of contributions

Speaker	Parallel talk
Hengne Li	Charmonium production in Pb-Pb ultra-peripheral collisions (UPC) and Z production in pPb collisions at LHCb
John Matthew Durham	LHCb measurements of the exotic tetraquark candidate X(3872) in high multiplicity pp and pPb collisions
Shanzhen Chen	Open and hidden beauty production in pPb collisions at LHCb
Pasquale Di Nezza	LHC Run 3 and Run 4 prospects for heavy-ion physics with LHCb

4 talks

Speaker	Posters
Jianqiao Wang	open charm production at LHCb in pPb
Felipe Andres Garcia Rosales	Fixed-target collisions at LHCb
Jana Crkovska	Charmonia production in pPb collisions at LHCb
Samuel Belin	Open Heavy-Flavour and J/psi production in peripheral PbPb collisions at LHCb
Maitreyee Mukherjee	Probing small-x gluons with gamma+hadron correlations in the forward rapidity with the LHCb detector.

5 posters

- Many new results for QM19, talk with our speakers for more insights !

X(3872)/ψ(2S) in pp and pPb collisions at 8 TeV

Matt Durham - Wed. at 5:20 pm

X(3872)/ψ(2S) in pp and pPb collisions at 8 TeV

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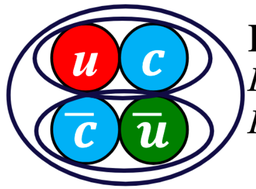
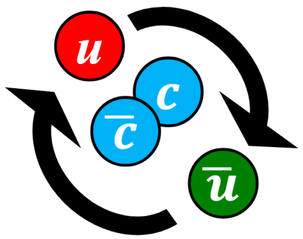
  - Tetraquark / hadronic molecule / something else ?

Compact tetraquark/pentaquark

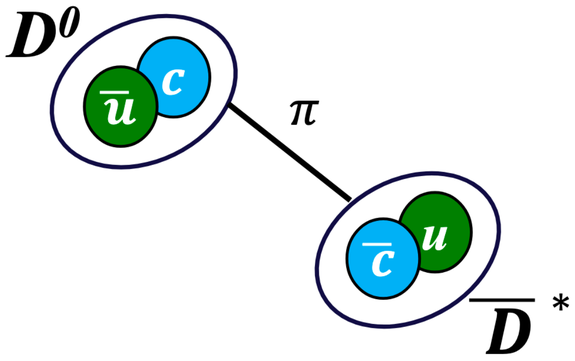


Diquark-diquark
PRD 71, 014028 (2005)
PLB 662 424 (2008)



Hadrocharmonium/ adjoint charmonium
PLB 666 344 (2008)
PLB 671 82 (2009)

Hadronic Molecules
PLB 590 209 (2004)
PRD 77 014029 (2008)
PRD 100 0115029(R) (2019)



X(3872)/ψ(2S) in pp and pPb collisions at 8 TeV

Matt Durham - Wed. at 5:20 pm

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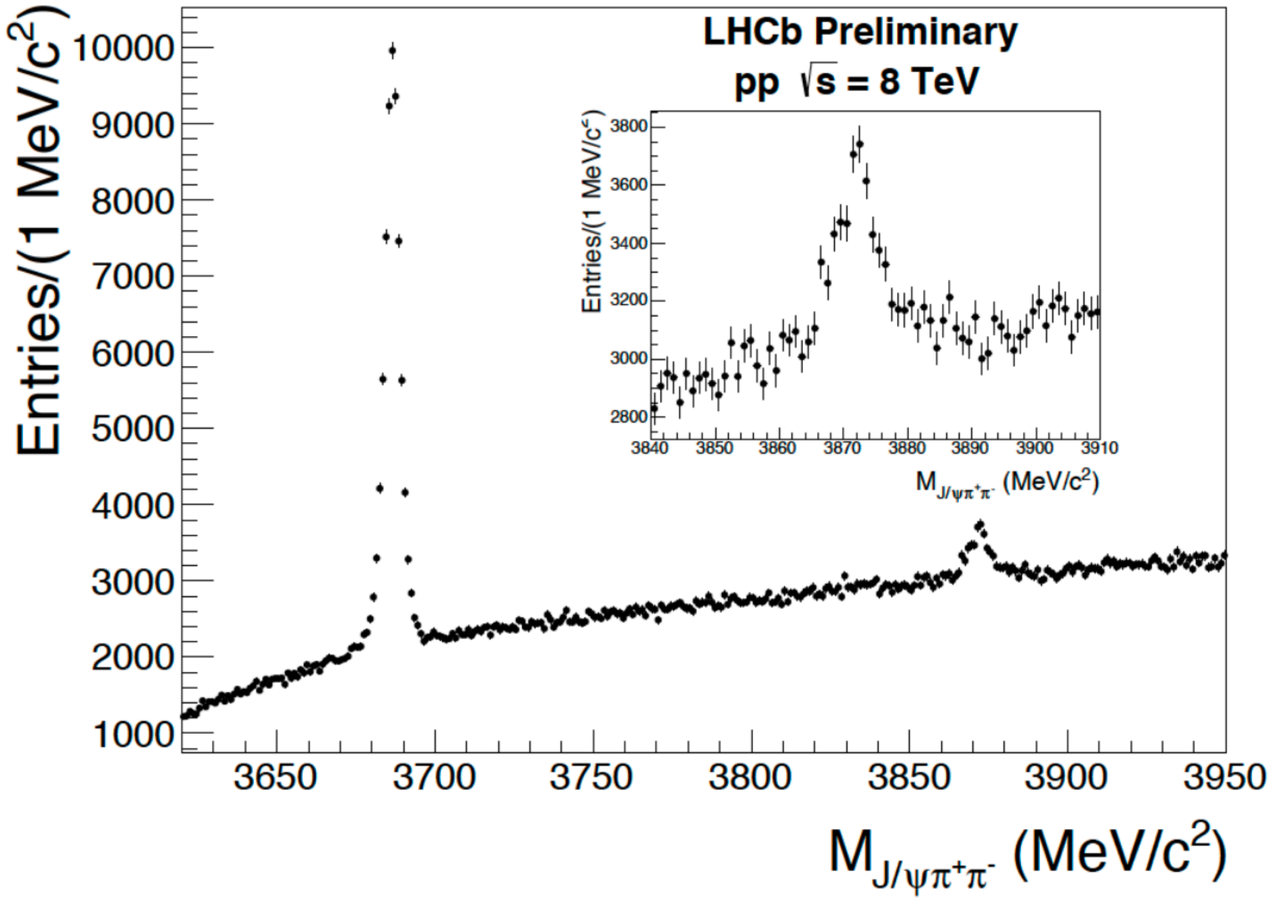
- **X(3872)/ψ(2S) ratio versus N_{tracks} measured in pp collisions at √s = 8 TeV.**



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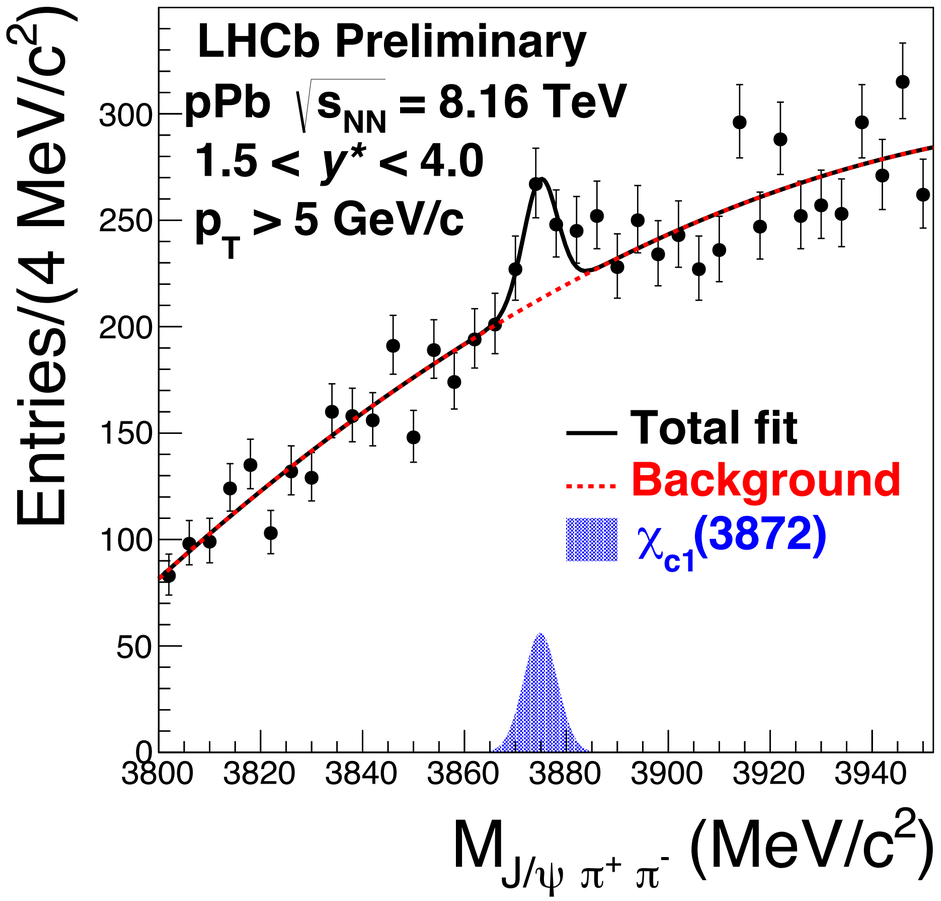
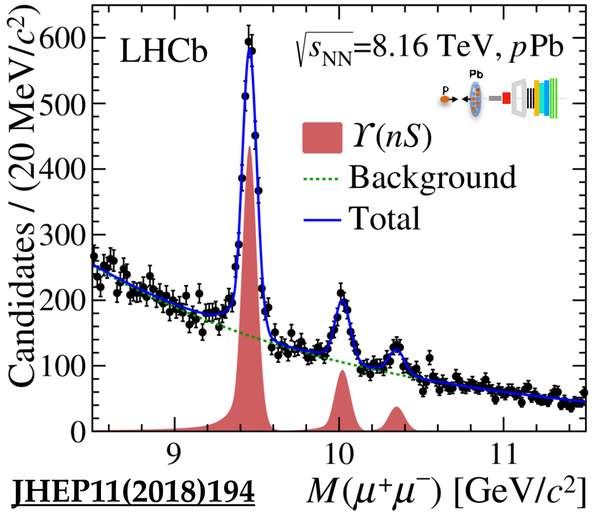
- X(3872) : exotic state still not understood.
  - ➡ Tetraquark / hadronic molecule / something else ?
- **X(3872)/ψ(2S) ratio versus N_{tracks} measured in pp collisions at $\sqrt{s}$ = 8 TeV.**
- **Baseline for a future pPb analysis !**



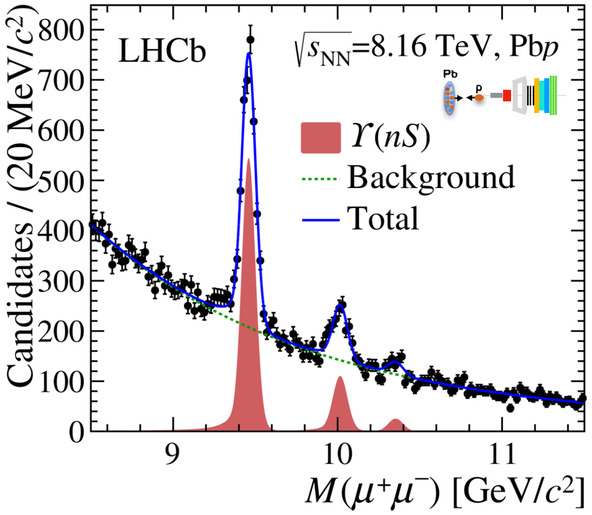
Open and hidden beauty production in pPb collisions

Shanzhen Chen - Wed. at 4:40 pm

Open and hidden beauty production in pPb collisions



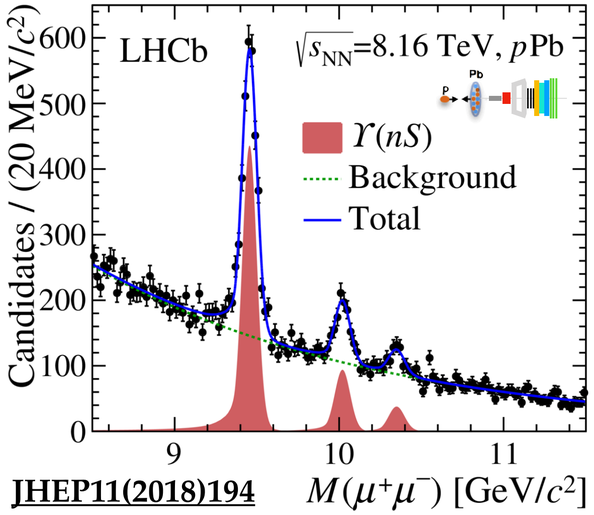
JHEP11(2018)194

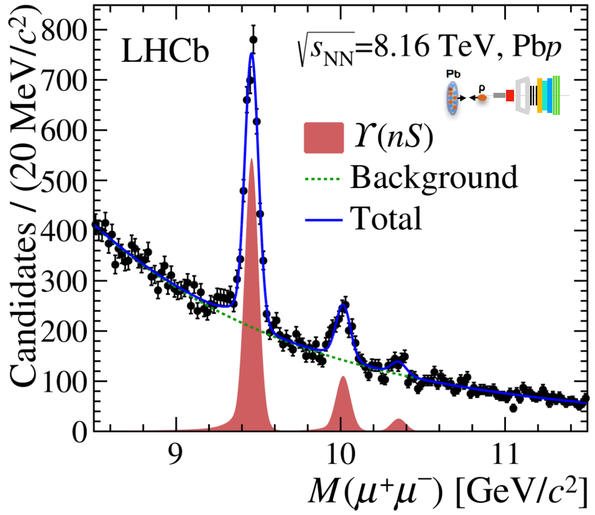


Shanzhen Chen - Wed. at 4:40 pm

- Relative production of upsilon states to test cold (hot ?) nuclear matter effects in pPb collisions.
- **Relative Υ(2S)/Υ(1S) and Υ(3S)/Υ(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.

Open and hidden beauty production in pPb collisions





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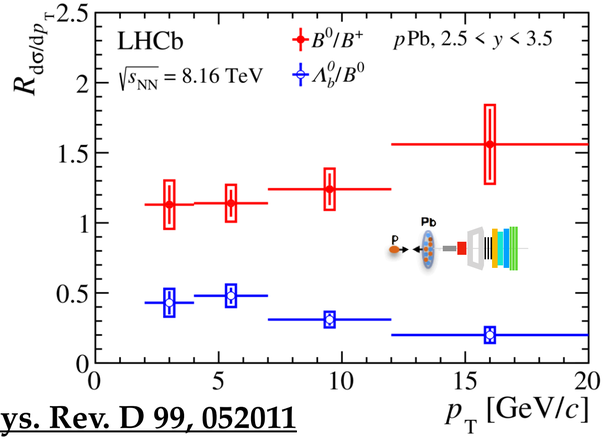
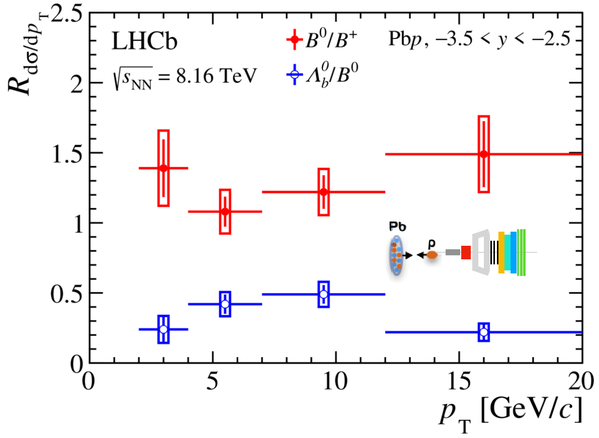




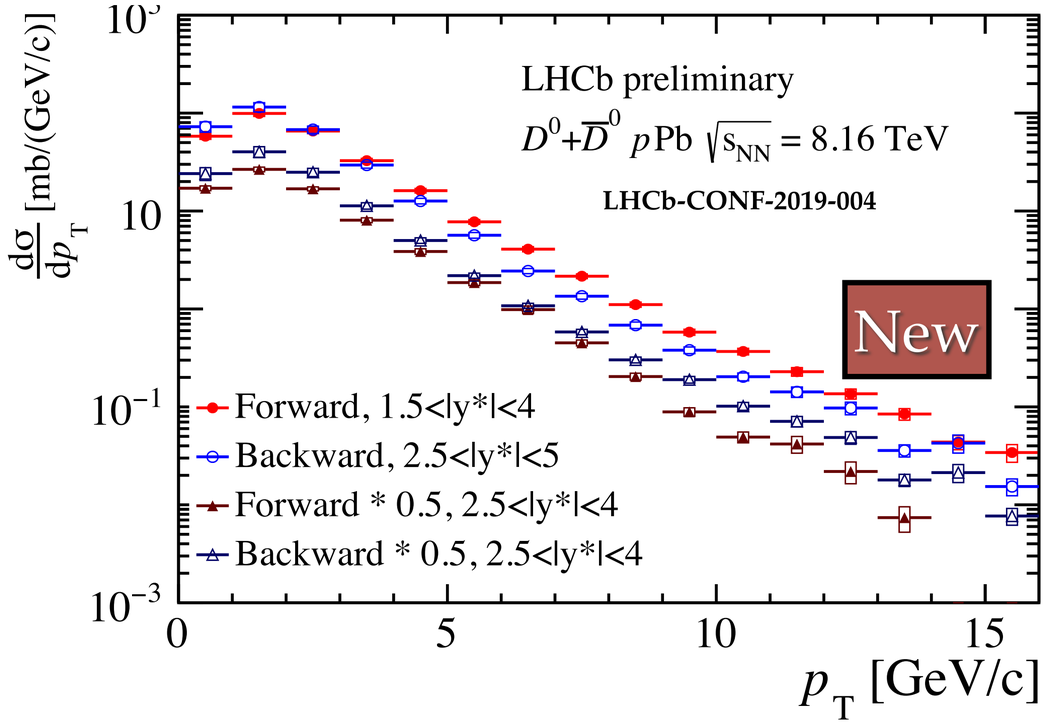
Phys. Rev. D 99, 052011

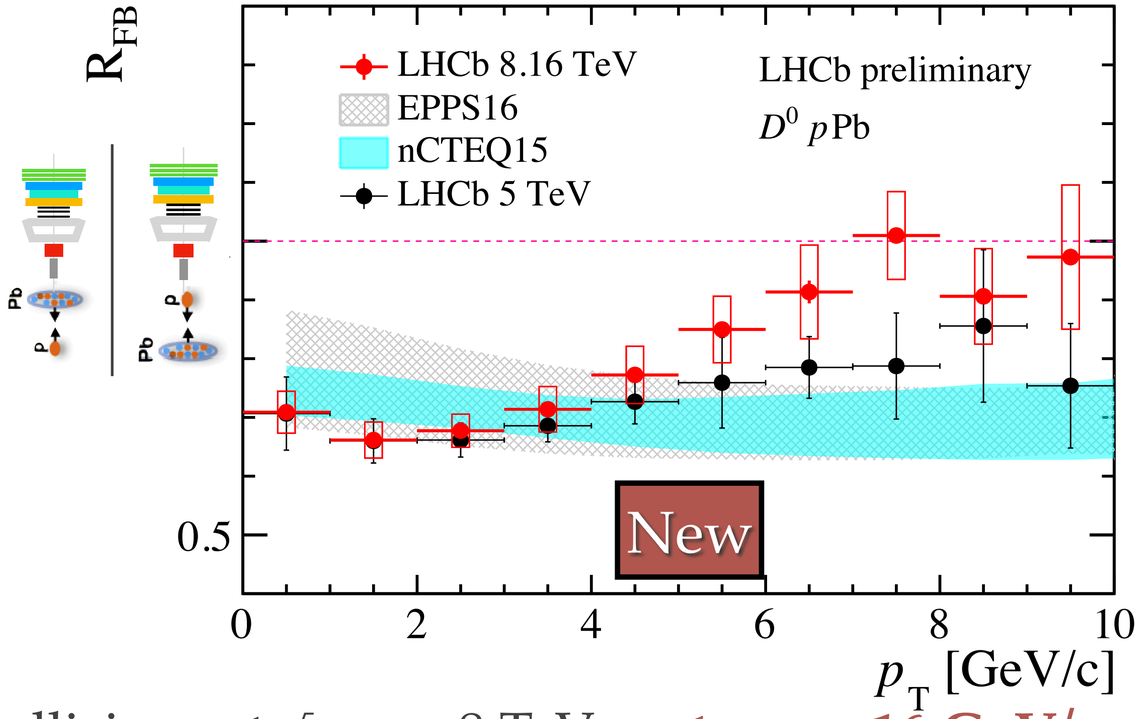
Shanzhen Chen - Wed. at 4:40 pm

- Relative production of upsilon states to test cold (hot ?) nuclear matter effects in pPb collisions.
- **Relative Υ(2S)/Υ(1S) and Υ(3S)/Υ(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.
- **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

Open and hidden charm production in pPb collisions

Jianqiao Wang - poster

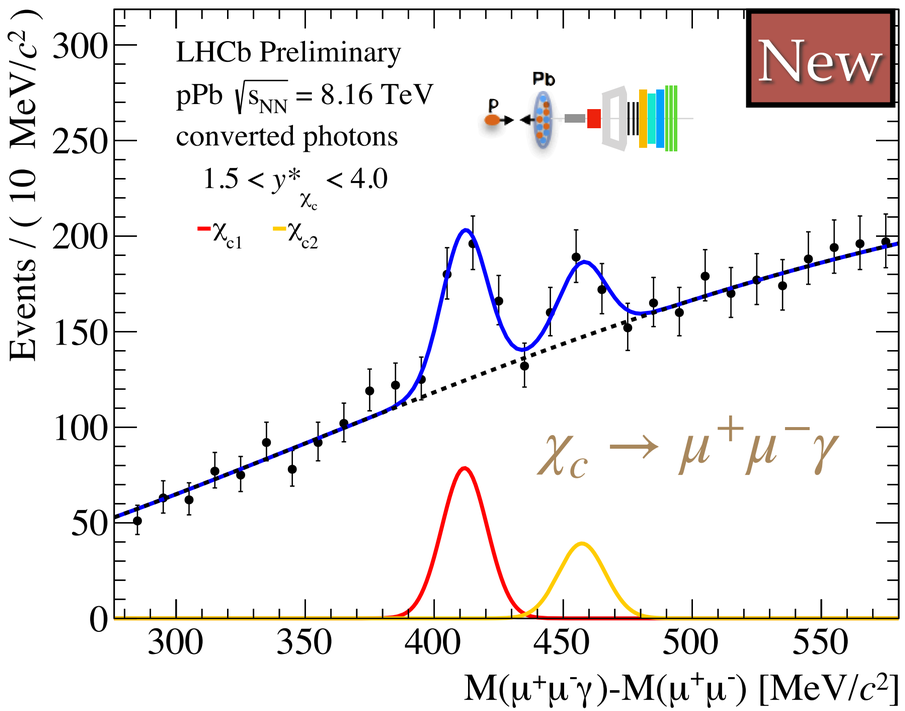


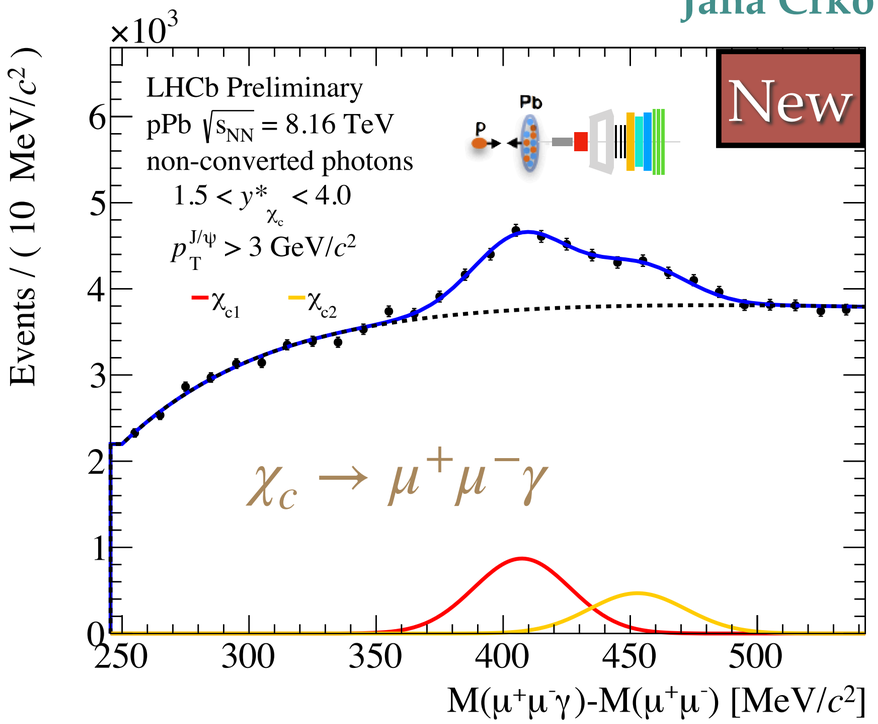


- **Preliminary results for D^0 cross-section** in pPb / Pbp collisions at $\sqrt{s_{NN}}$ = 8 TeV **up to p_T = 16 GeV/*c***.
- **Improved statistics** by factor 20 compared to previous LHCb results.
- **Tension between data and nPDFs predictions. Additional effects required.**

Open and hidden charm production in pPb collisions

Jana Crkovska - poster



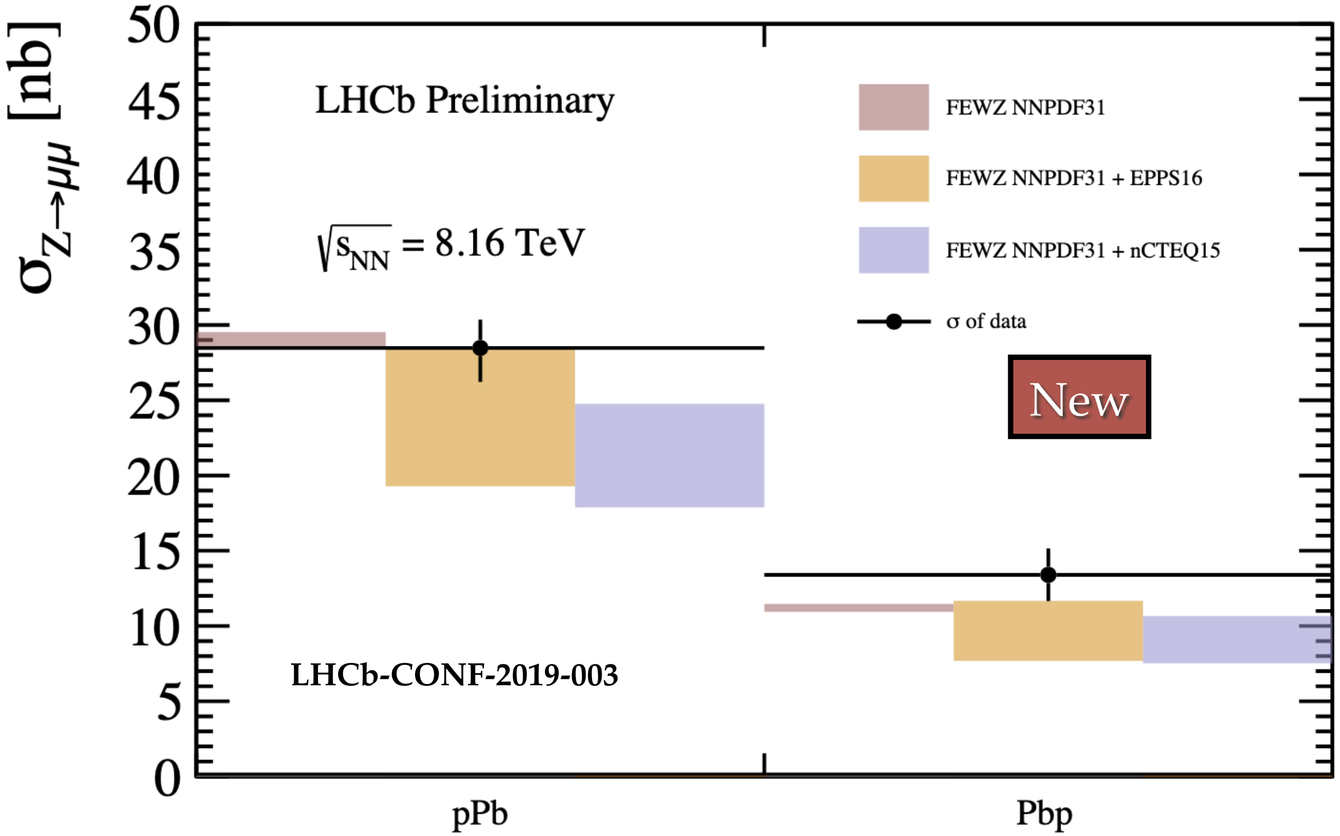


- χ_{c1} and χ_{c2} peaks **observed** in pPb / Pbp collisions with converted and non-converted photons.

Analysis ongoing, stay tuned !

Electroweak : Z in pPb collisions

Hengne Li - Tue. at 9:40 am

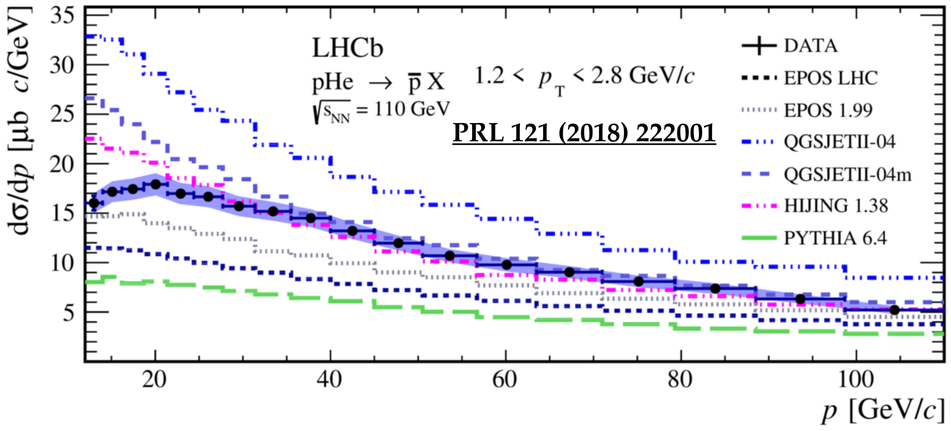


- **Preliminary measurements of Z cross-section** in pPb/Pbp collisions at $\sqrt{s_{NN}} = 8$ TeV
- **Factor 20 increase in statistics** compared to previous LHCb measurements.
- **Data are precise enough to strongly constrain predictions.**

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.

Fixed-target results

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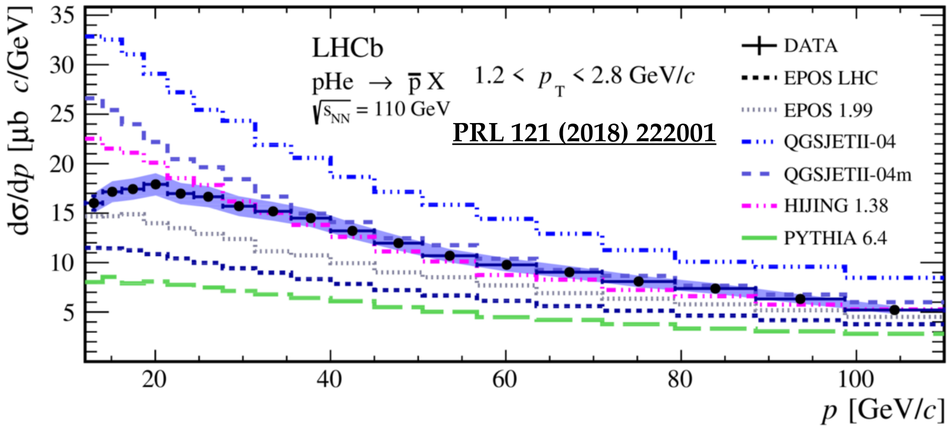

- Antiproton cross-sections in pHe : key to constrain dark matter search in cosmic flux.
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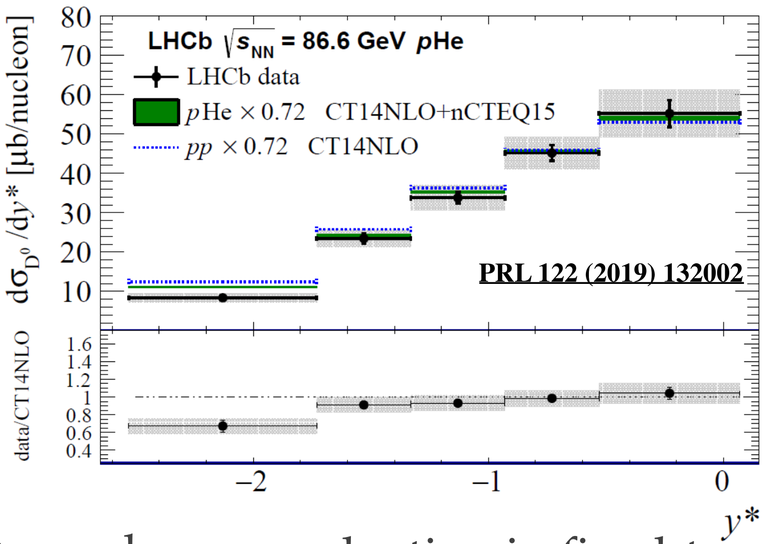
Charm in pHe at $\sqrt{s_{NN}}$ = 86.6 GeV

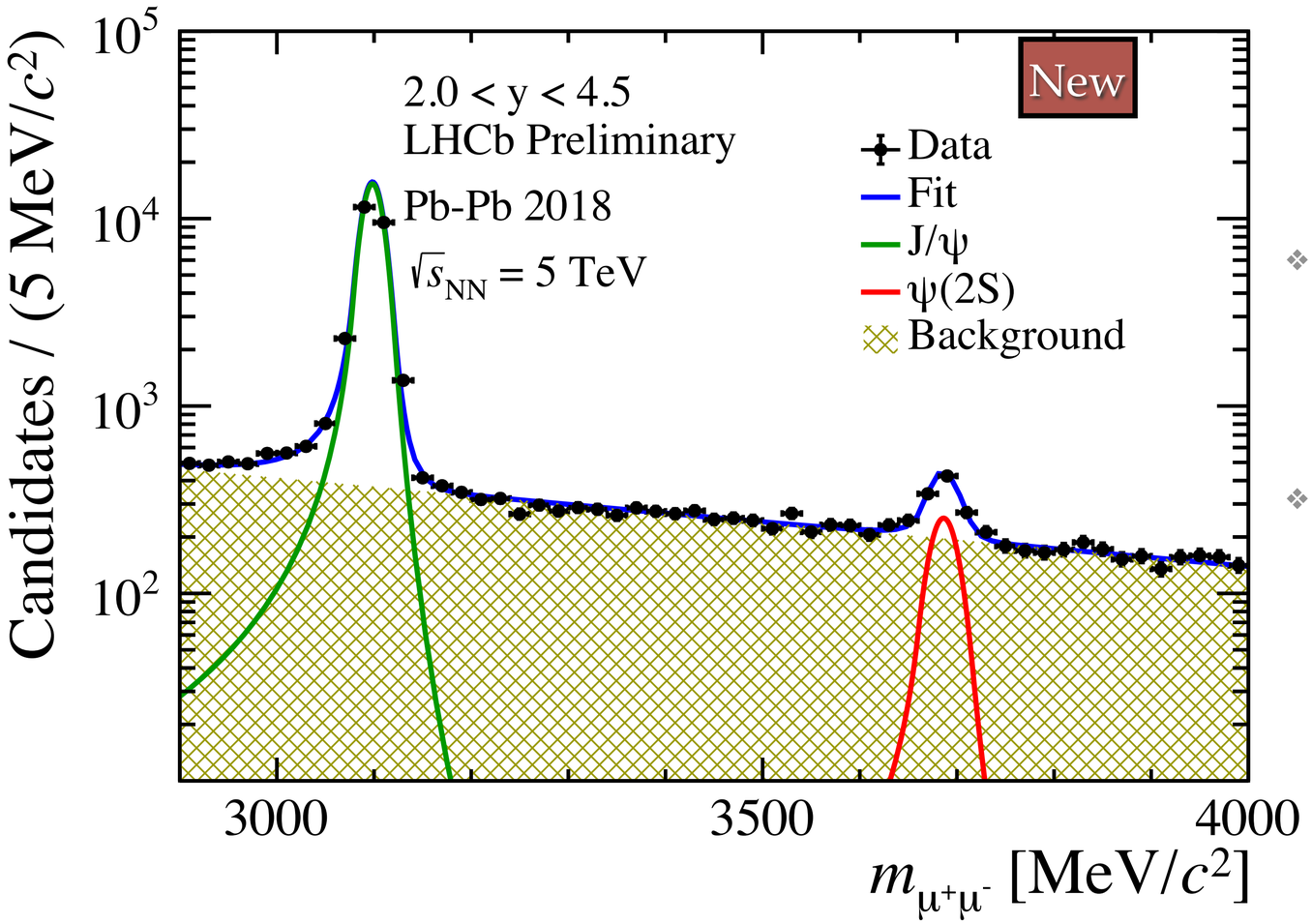


Felipe Garcia - poster

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

Sneak peek at UPC PbPb collisions

Hengne Li - Tue. at 9:40 am

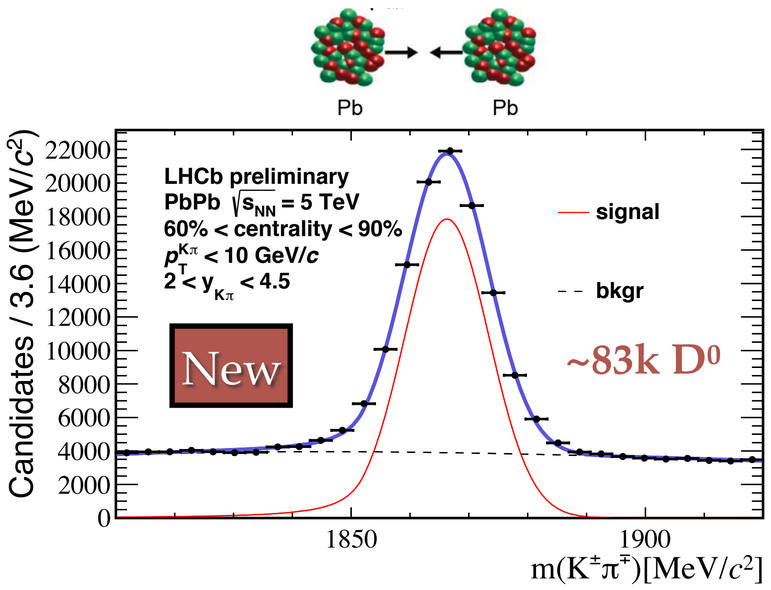


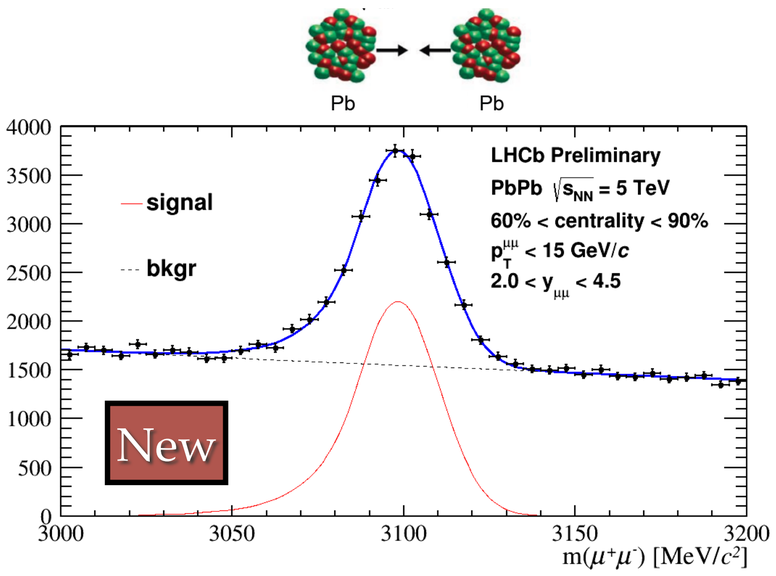
- **Coherent charmonium production analysis ongoing in ultra-peripheral PbPb collisions at $\sqrt{s_{NN}}$ = 5 TeV.**
- **Factor 20 increase in statistics** compared to previous UPC results.

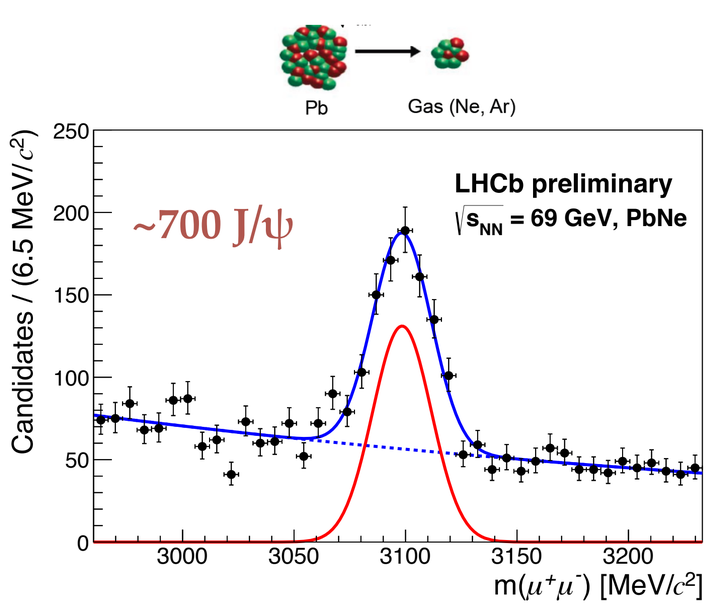
Analysis ongoing, stay tuned !

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 !**

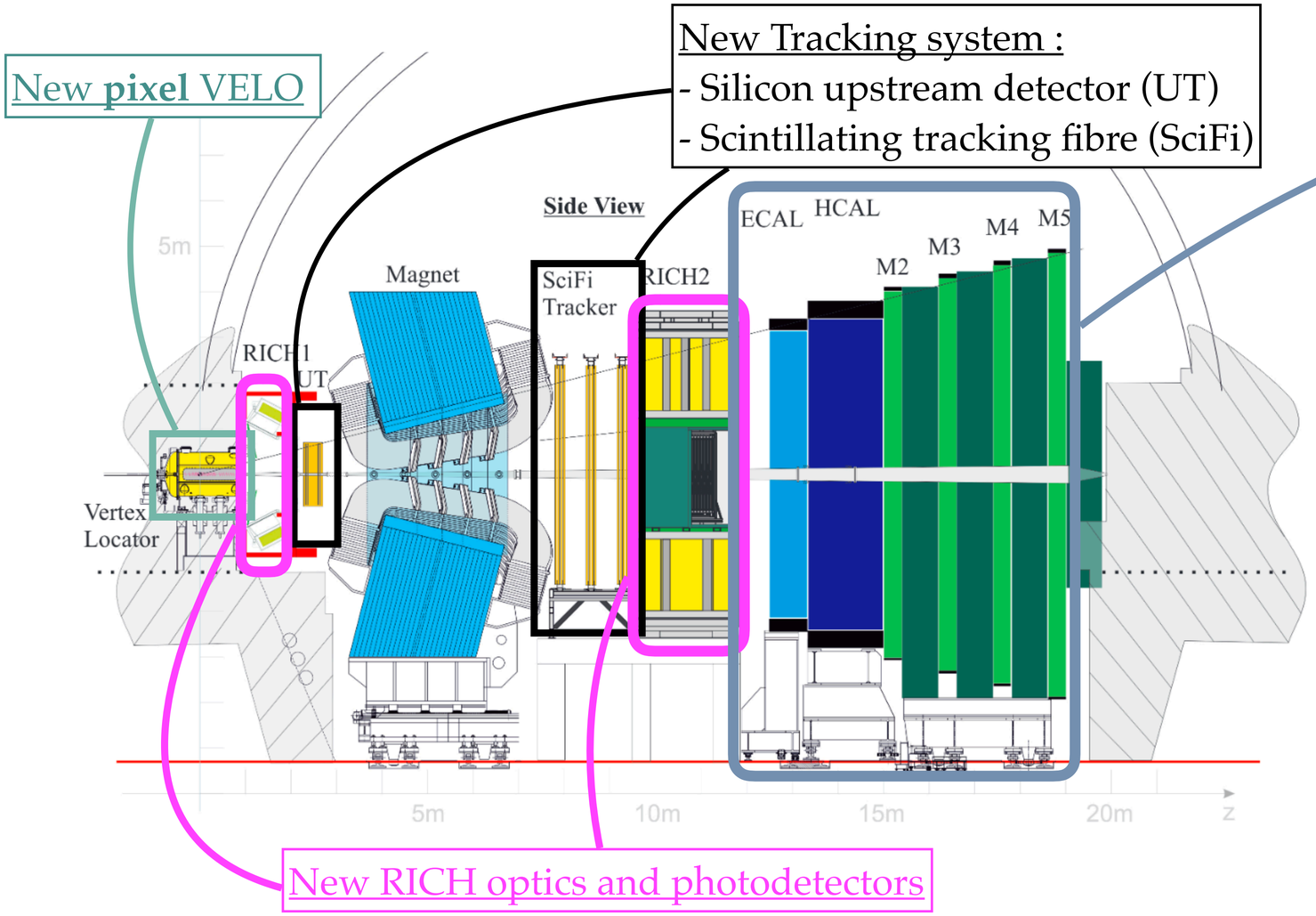
Analysis ongoing, stay tuned !

LHCb in the future

*benjamin.audurier@cern.ch

LHCb detector : season 3 (2021)

[CERN-LHCC-2012-007]

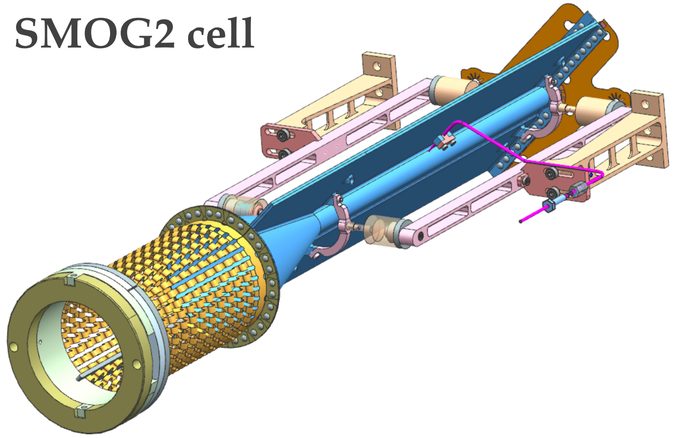


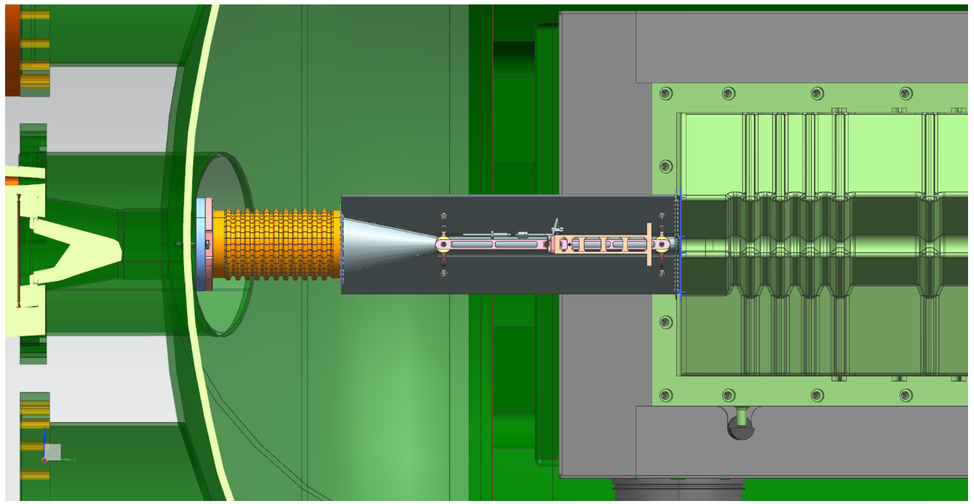
- Upgrade based on pp collision requirements :
  - Collision rate at 40 MHz.
  - Pile-up factor $\mu \approx 5$
- **Replace the entire tracking system.**
- Full **software trigger.**
  - Remove L0 triggers.
  - Read out the full detector at 40 MHz.

LHCb fixed-target program evolution

Pasquale Di Nezza - Tue. at 5:20 pm

SMOG2 cell





- **SMOG 2** (TDR) : Standalone gas storage cell covering z ϵ [-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.

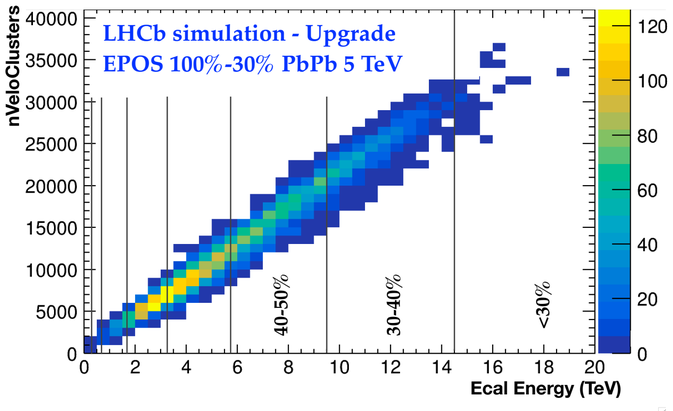
Run 3 and Run 4 prospects for heavy-ion physics with LHCb

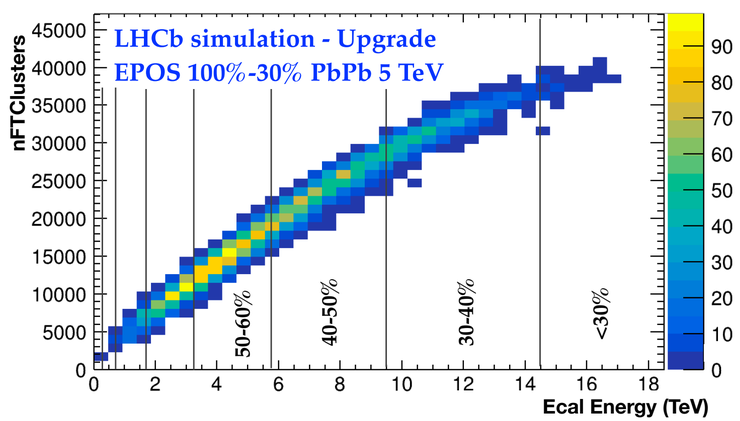
Pasquale Di Nezza - Tue. at 5:20 pm

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

Pasquale Di Nezza - Tue. at 5:20 pm

PbPb collisions at LHCb





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

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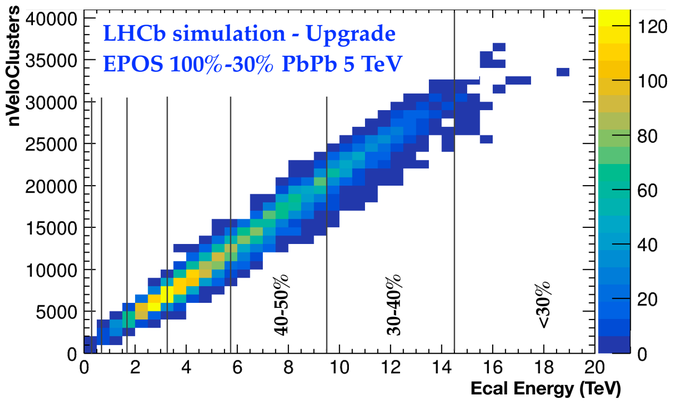

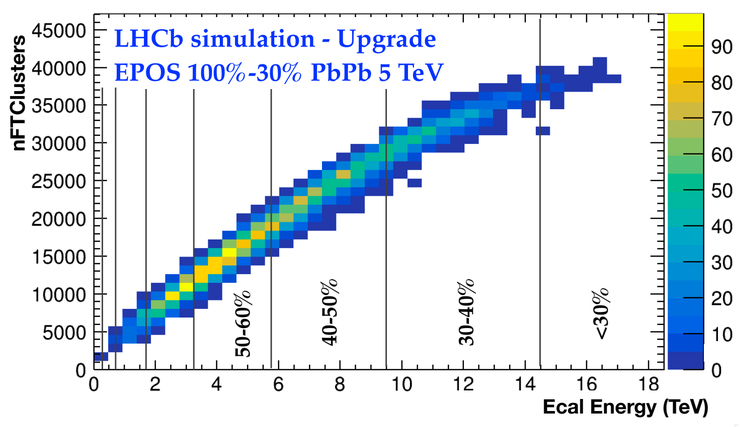

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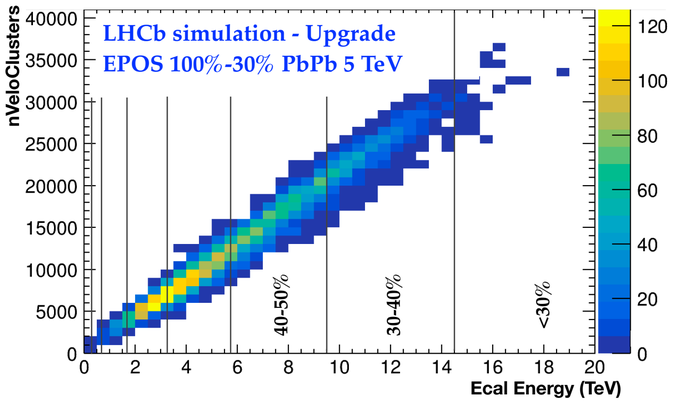

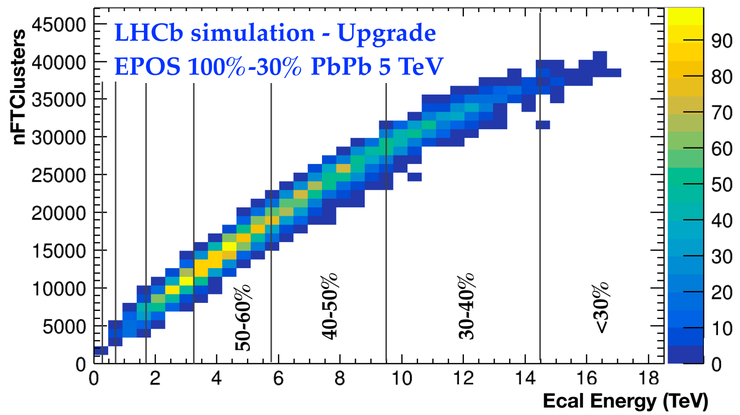

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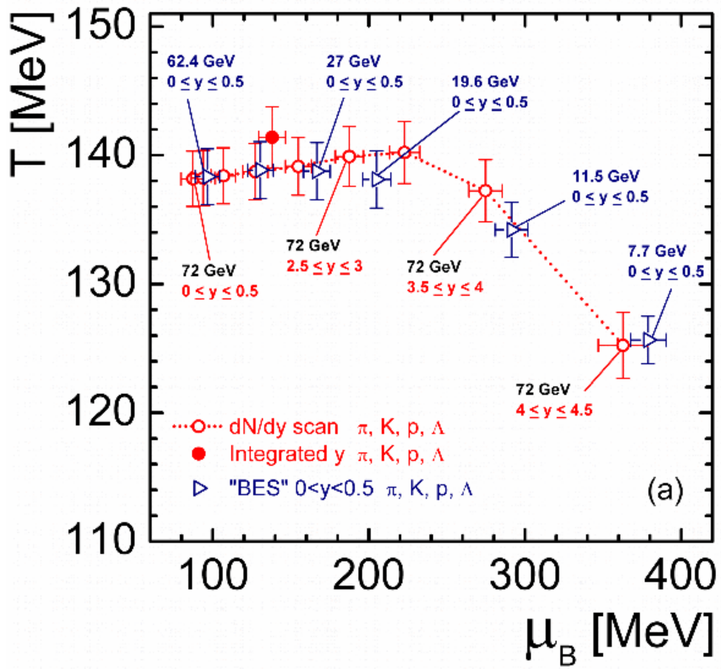
Fixed-target program

Phys. Rev. C98 (2018) 034905



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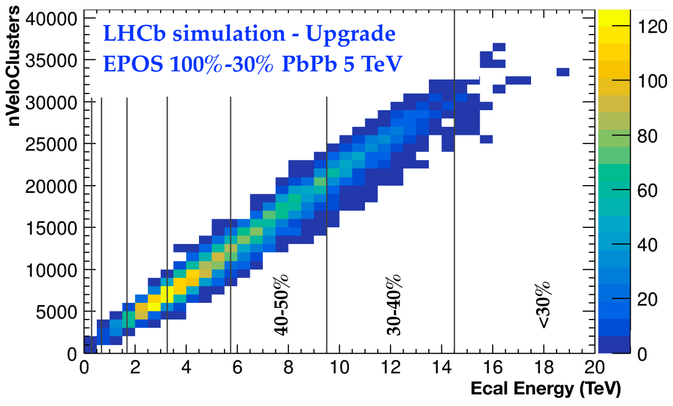

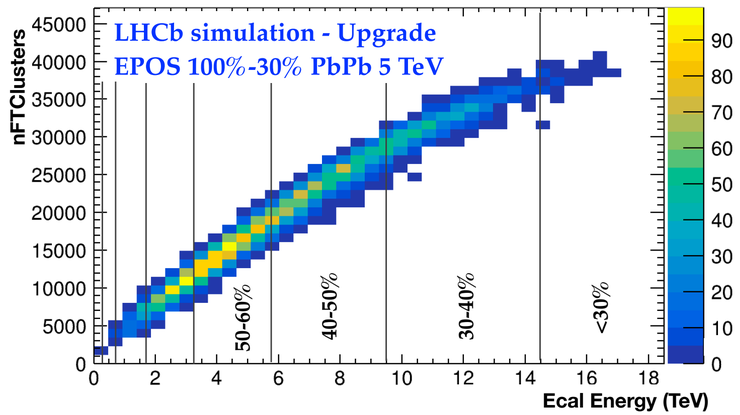

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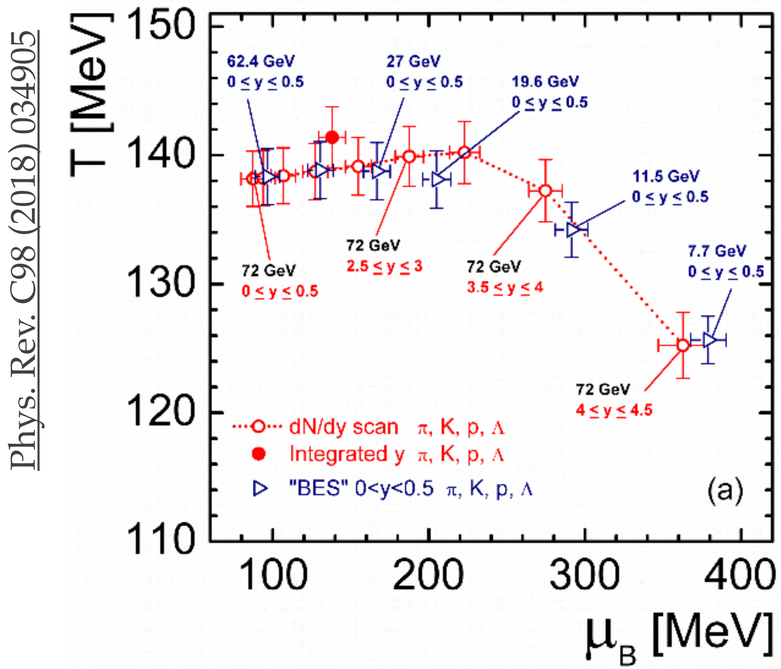

- **Rapidity scan** at 72 GeV with FT@LHCb **can complement the RHIC beam energy scan.**

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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 !**