



Charmonia photo-production in ultra-
peripheral and peripheral PbPb collisions
with LHCb

Roman Litvinov
on behalf of the LHCb collaboration.

OUTLINE

Ultra-peripheral PbPb collisions

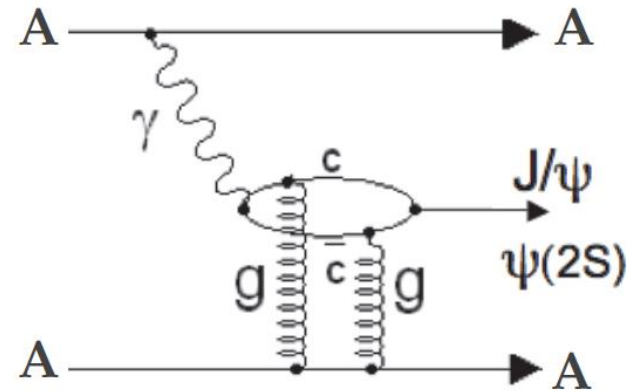
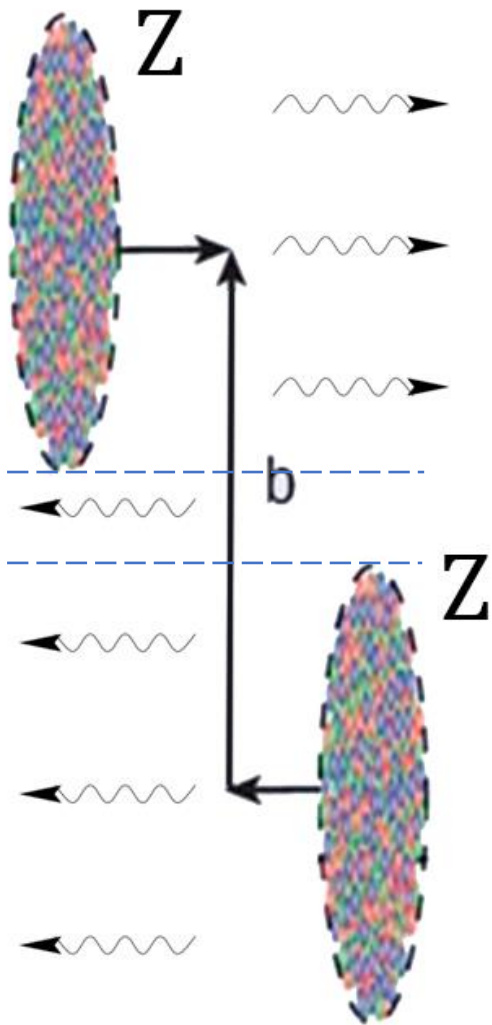
The LHCb detector at CERN

Coherent J/ψ production in ultra-peripheral collisions

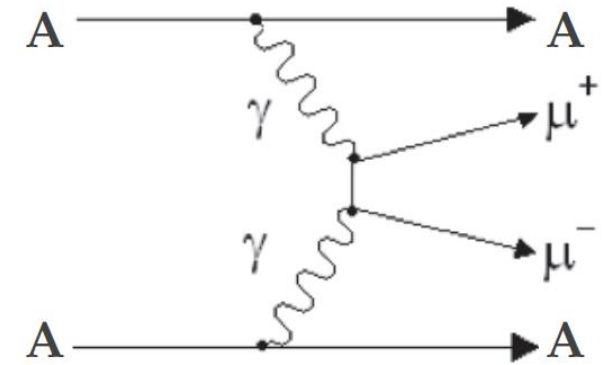
Ongoing analyses

Conclusion

Ultra-peripheral PbPb collisions



Photon-induced quarkonium production:
 • A $q\bar{q}$ loop created by the photon interactions with a pair of gluon exchange (pomeron)

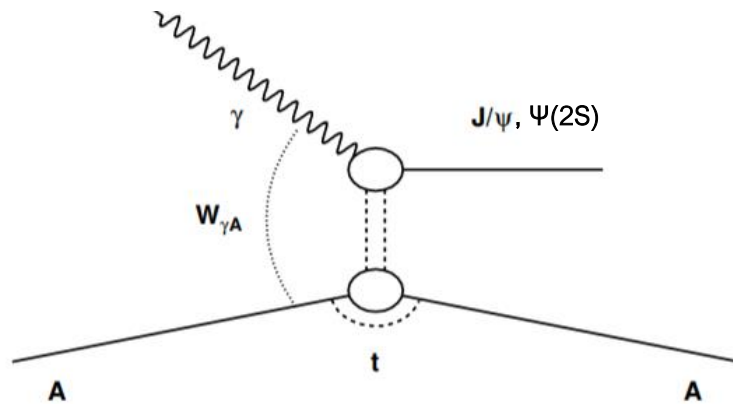


Photon-Photon interactions (non-resonant) Precisely known at p-QED

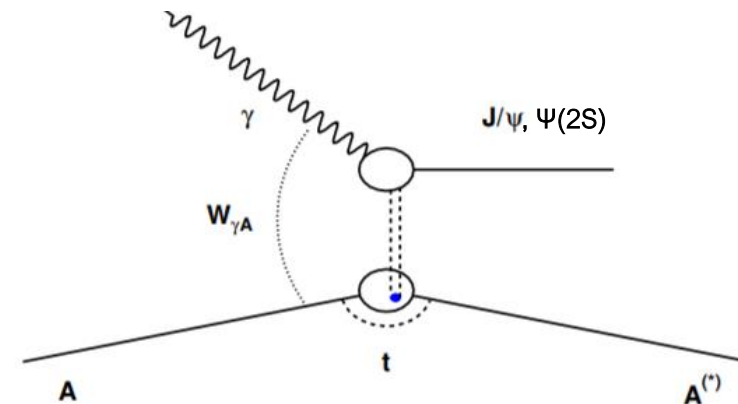
- o Ultra-peripheral collisions: Two nuclei bypass each other with an impact parameter larger than the sum of their radii;
- o Photon-induced interactions are enhanced by the strong electromagnetic field of the nucleus.

Ultra-peripheral PbPb collisions

Coherent J/ψ production:
photon interacts with the
whole nucleus coherently.



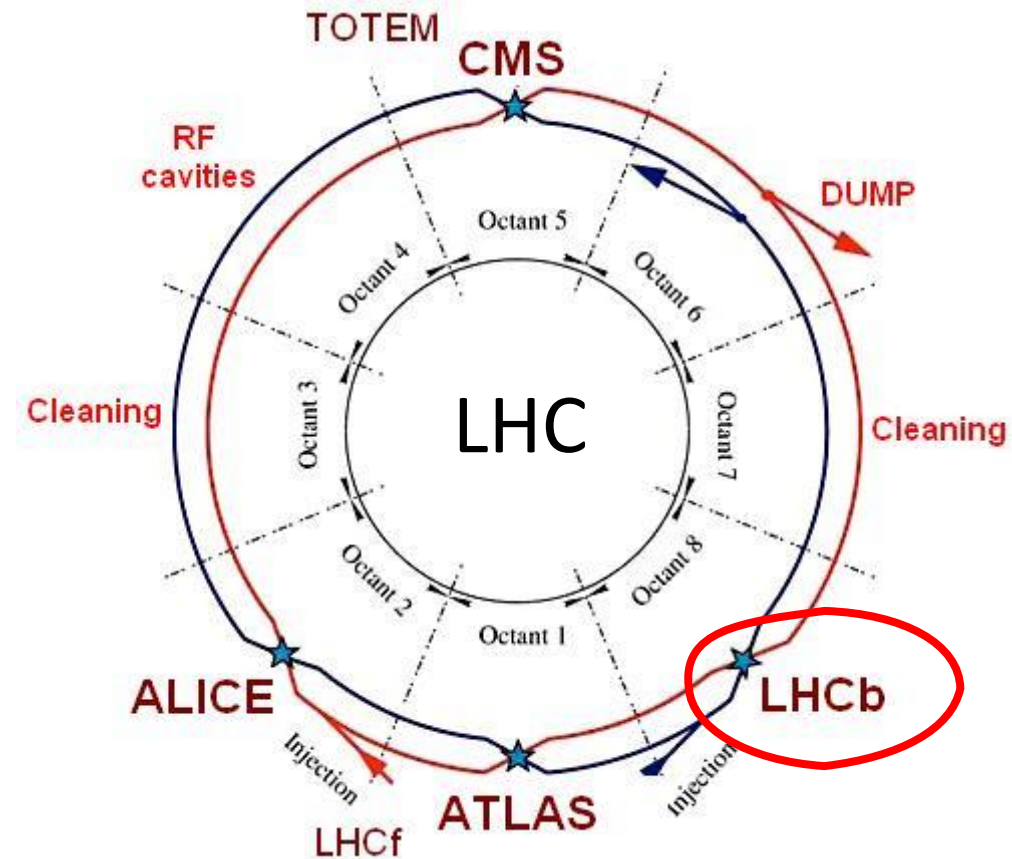
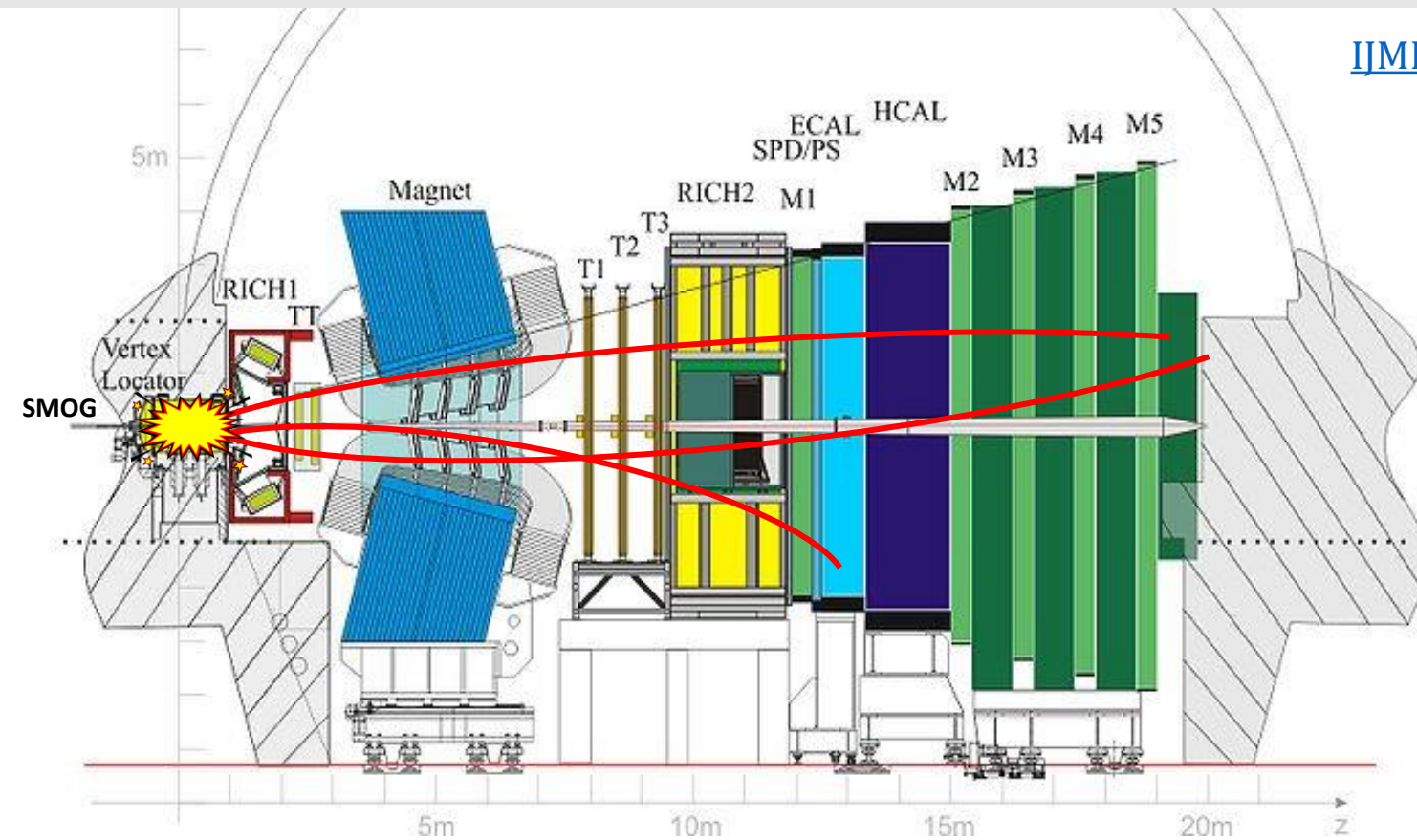
Incoherent J/ψ production:
photon interacts with particular
nucleons in the nucleus.



- o Important probe to nuclear PDFs and how it may be affected by partonic energy loss, shadowing and gluon saturation;
- o The $\psi(2S) / (J/\psi)$ ratio measurement is helpful to constrain the choice of the vector meson wave function in dipole scattering models [e.g. PLB 772 (2017) 832, PRC (2011) 011902].

The LHCb detector at CERN

[IJMP A, Vol. 30, No. 07, 1530022 \(2015\)](#)

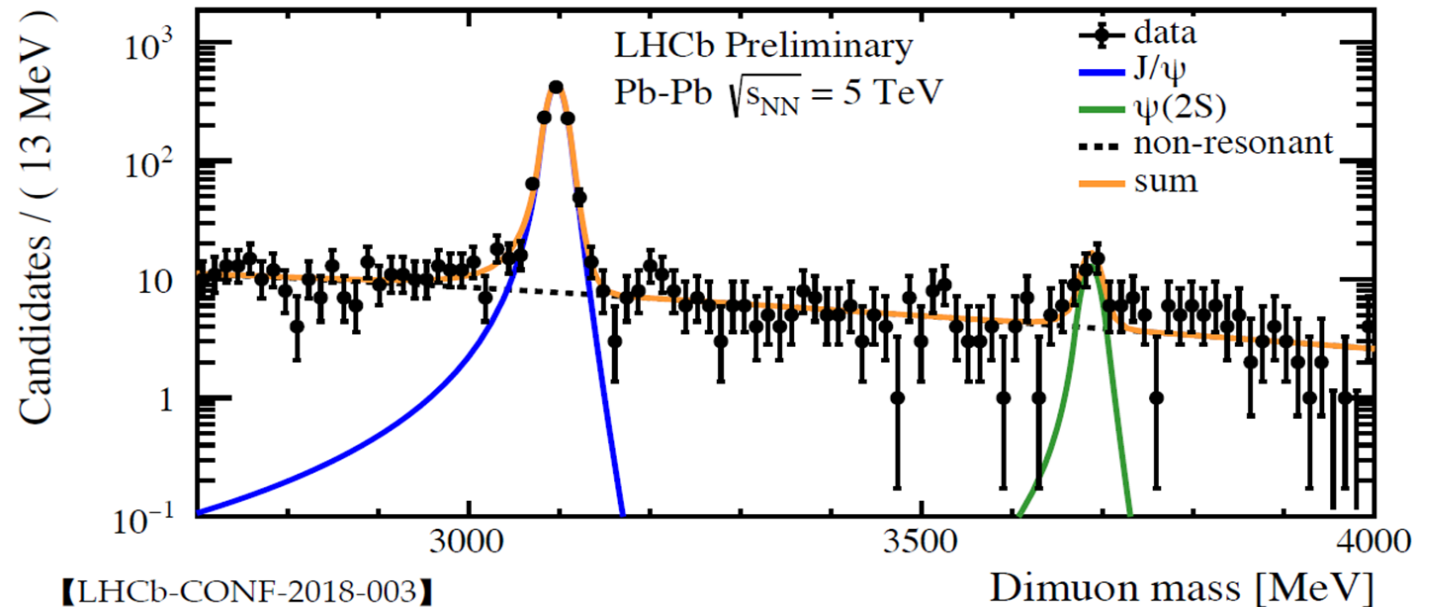
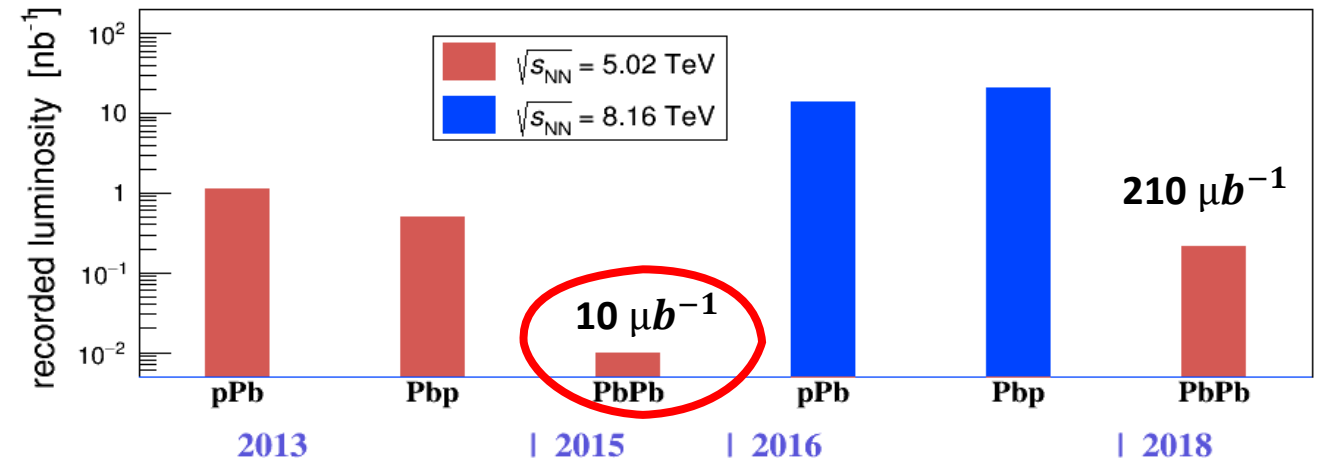


- $2 < \eta < 5$ pseudo-rapidity range;
- pp/PbPb and fixed target mode;
- Interaction point resolution $< 10 \mu\text{m}$;
- Momentum resolution 0.5–1.0% (5–200 GeV/c);
- Excellent $e, \mu, \pi, K, p, \gamma$ identification.

Signal extraction (2015 data)

- Event selection requires a nearly empty detector with only two long tracks reconstructed;
- HeRSChEL detector is used to detect any activity in high pseudorapidity range;
[JINST 13 (2018) 04 P04017]
- Acceptance is defined as:
 $2.0 < \eta_\mu < 4.5;$
 $p_{T\mu} > 800 \text{ MeV};$
 $p_{T\mu^+\mu^-} < 1 \text{ GeV};$
 $|\Delta\phi_{\mu^+\mu^-}| > 0.9\pi;$
- The signal yields are extracted from the dimuon mass fits.

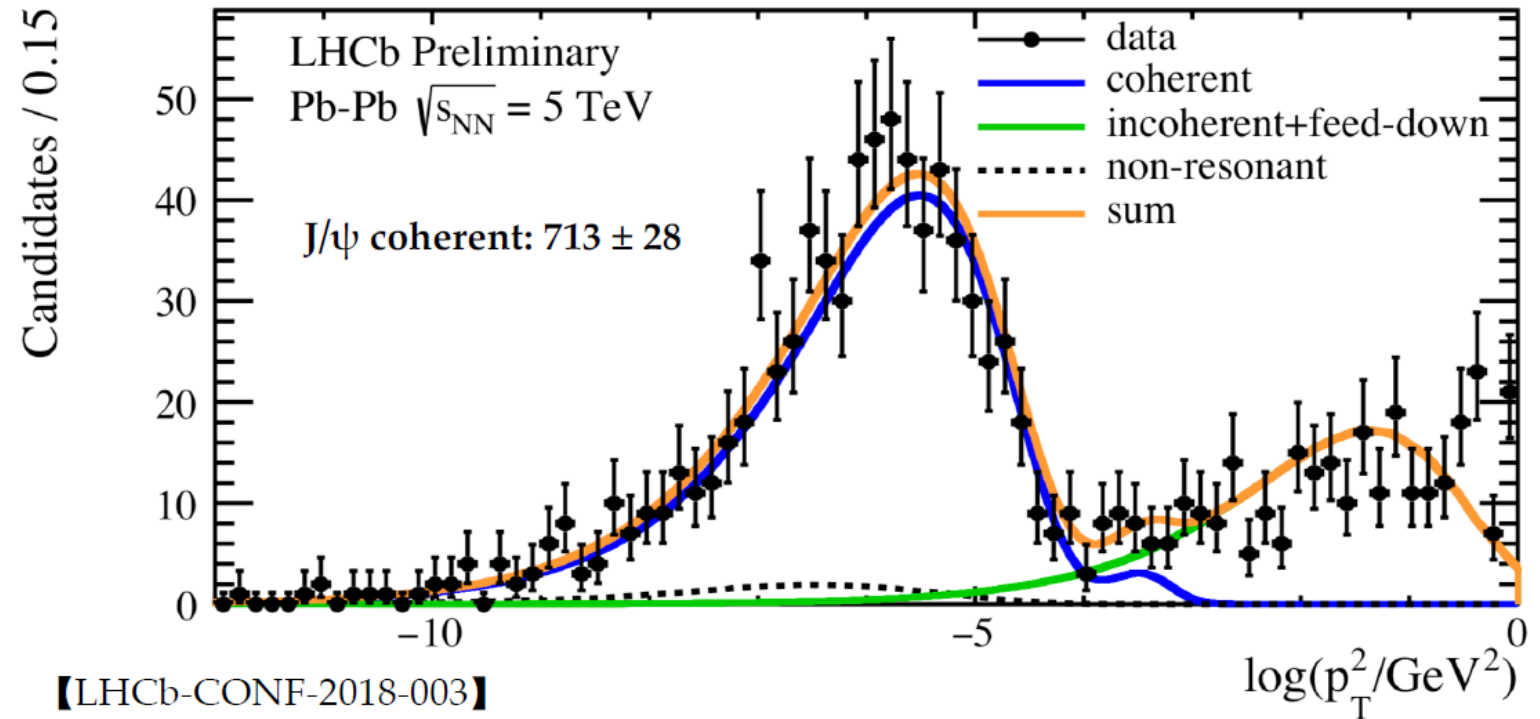
Collider mode samples:



Signal extraction (2015 data)

StarLight is used to generate the J/ψ events [\[arXiv:1607.03838\]](https://arxiv.org/abs/1607.03838)

- coherent J/ψ production:
full simulation StarLight template;
- incoherent J/ψ production:
full simulation StarLight template;
- feed-down $\psi(2S)$:
particle gun with shape from StarLight used to estimate the feed-down from $\psi(2S) \rightarrow J/\psi \pi^+\pi^-$, normalisation from reconstructed $\psi(2S) \rightarrow \pi^+\pi^-$;
- non-resonant full:
simulation StarLight template.



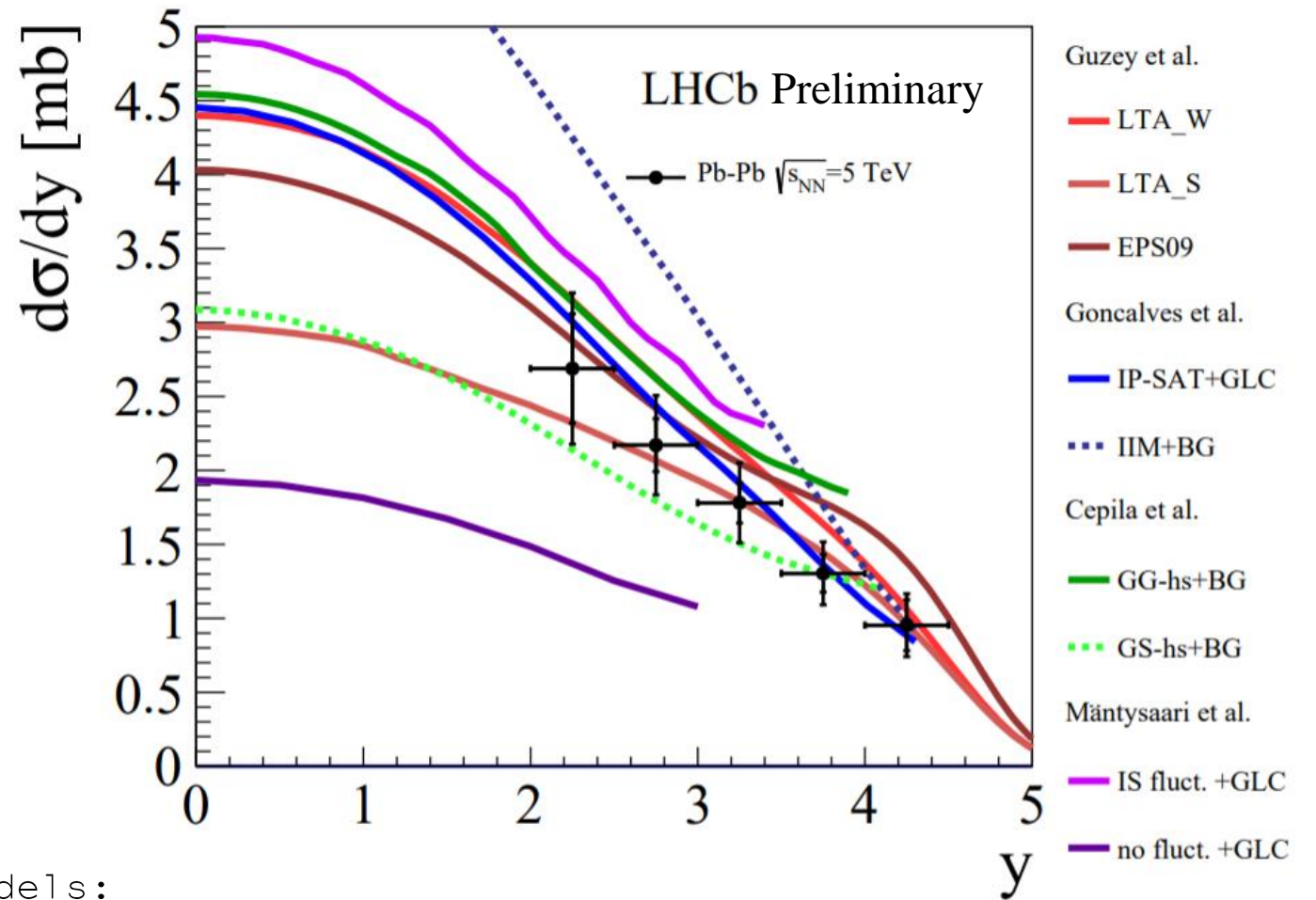
Result

$$\frac{d\sigma_{coh.,J/\psi}}{dy} = \frac{N_{coh.,J/\psi}}{\epsilon_{tot.} \cdot B(J/\psi \rightarrow \mu^+\mu^-) \cdot L \cdot \Delta y}$$

Differential cross-section for coherent J/ψ production compared to different phenomenological predictions. The LHCb measurements are shown as points, where inner and outer uncertainties represent the statistical and the total errors, respectively.

p-QCD calculations:
[PRC 93 (2016) 055206]

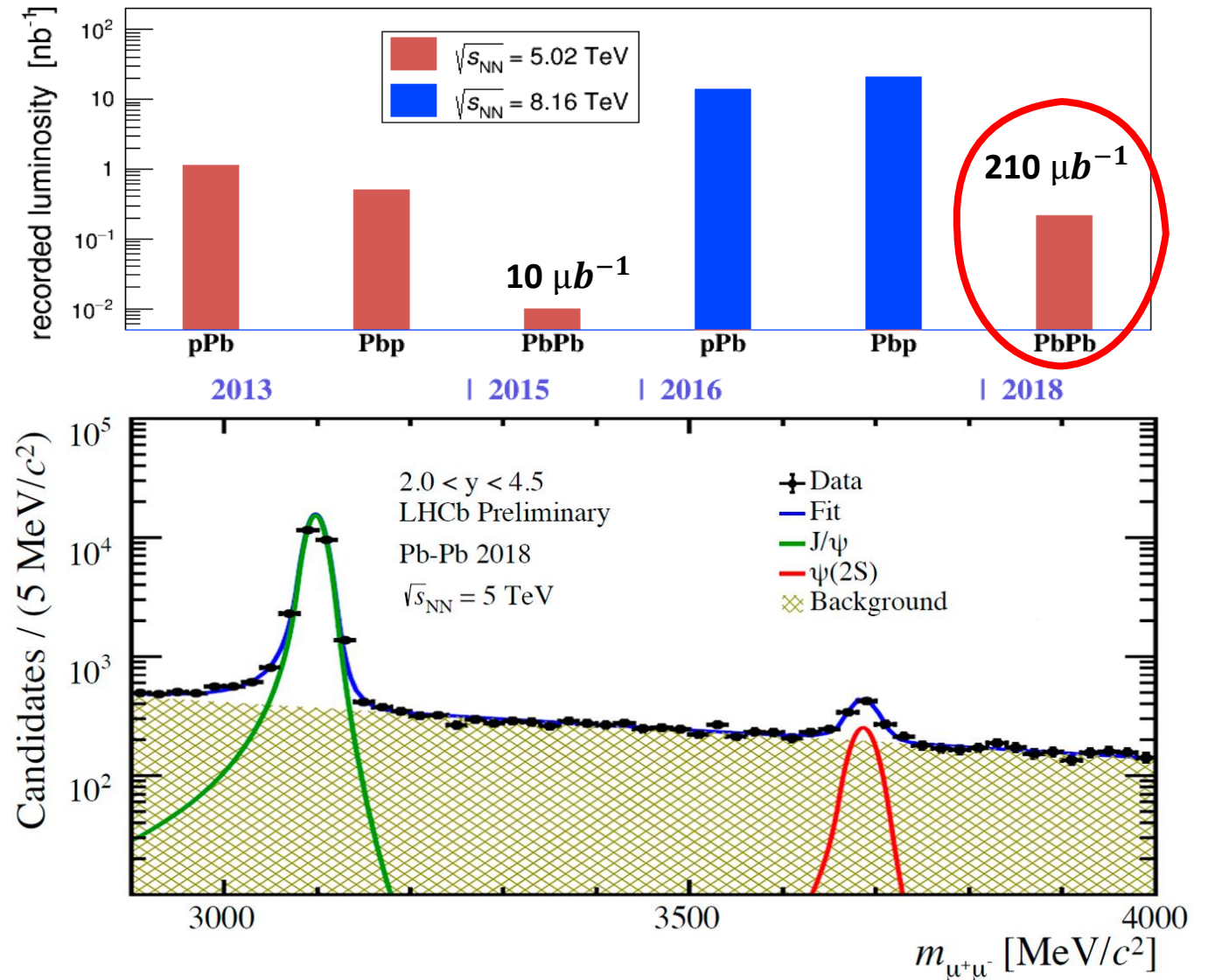
Color dipole models:
[PRD 96 (2017) 094027]
[PRC 97 (2018) 024901]
[PLB 772 (2017) 832]



ONGOING ANALYSIS

- o The 20 times higher statistics make it possible to determine the cross-sections of both J/ψ and $\psi(2S)$;
- o Measurement of the cross-section ratio $\psi(2S) / (J/\psi)$ possible.

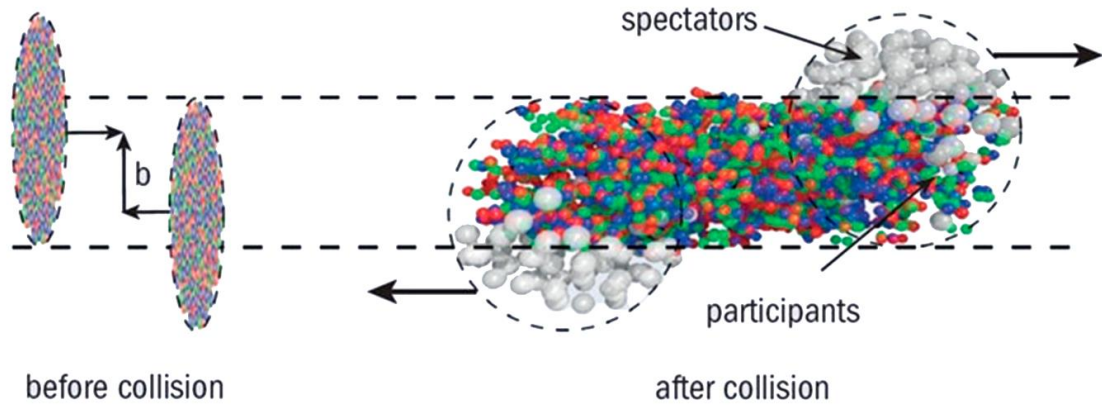
Collider mode samples:



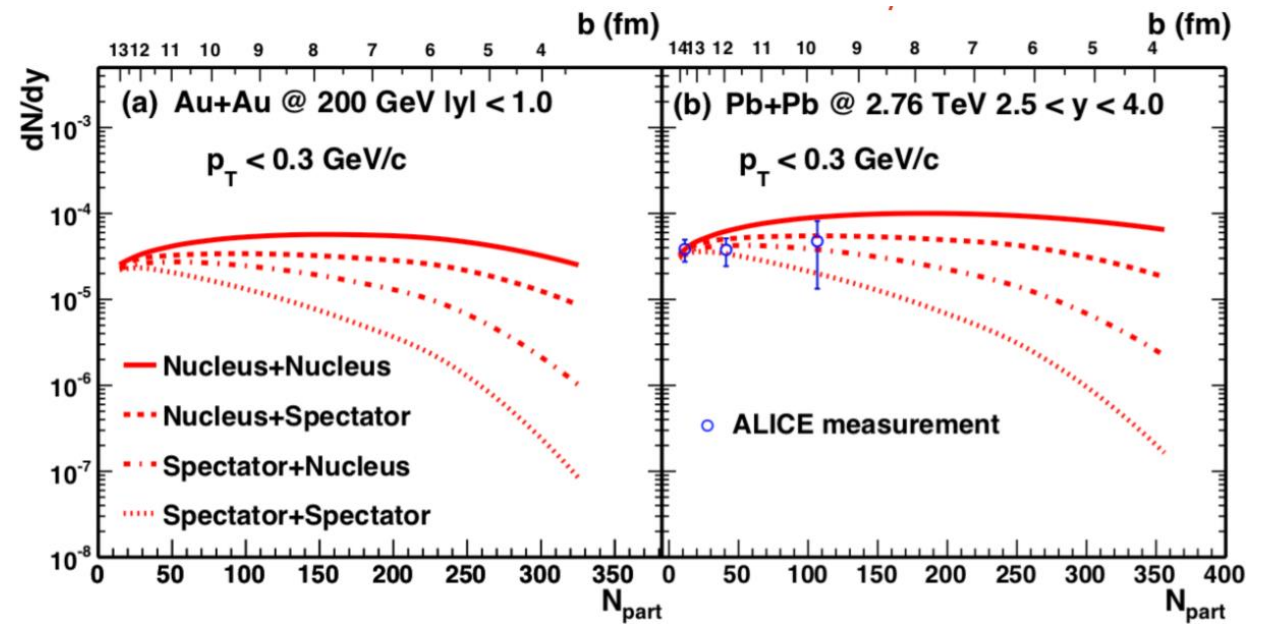
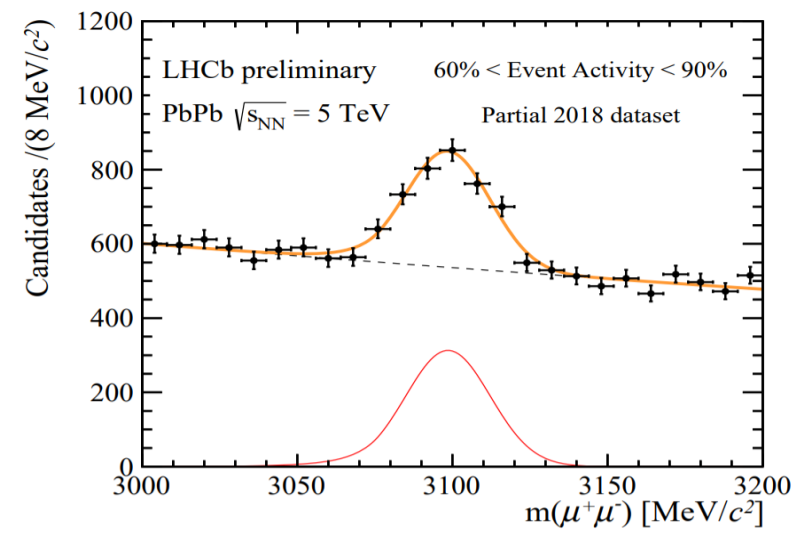
Peripheral J/ ψ production in PbPb collisions

ONGOING ANALYSIS

Same interaction as in UPC,
but with a hadronic collision



- o Does the overlapping region have an effect on the yield ?
- o Which part of the projectile is interacting ?
- o A possible new probe for QGP physics ?



Conclusion

- o Charmonium production in ultra-peripheral and peripheral Pb-Pb collisions are of particular interest to probe gluon Parton Density Functions;
- o Results based on 2015 PbPb dataset at 5 TeV are presented;
- o Higher precision results using 2018 data set with 20 times higher statistics for both the J/ψ and $\psi(2S)$ cross-sections are coming soon;
- o Result with peripheral PbPb collisions using 2018 data set is coming soon.