

Recent results and prospects on ultra-peripheral heavy ion collisions at LHCb

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Central exclusive production (CEP) and Ultraperipheral collisions (UPC) in ion collisions

- Two nuclei bypass each other with impact parameter larger than the sum of their radii
- Collisions are 'elastic'
- Characteristic properties
 - low momentum transfer
 - low transverse momentum
 - no additional particle production

Inelastic collisions





elastic collisions



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Central exclusive production (CEP) and Ultraperipheral collisions (UPC) in ion collisions

- $Pb + Pb \longrightarrow Pb + X + Pb$
- Heavy ions carry a strong electromagnetic field
- EM fields of the ions can interact with each other or the nuclei via photon or 'pomeron'



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LHCb detector

- LHCb single armed forward spectrometer, located at LHC
- Acceptance 2 < η < 5
- Proton-proton interaction at up to √s = 13 TeV
- Physics goals:
 - Designed for: *CP* violation in *b* and *c* sectors
 - Today: also general purpose physics in forward region



[IJMPA 30, 1530022 (2015)] [2008 JINST 3 S08005]

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LHCb recorded data

- *pp* collider: 2010-2018, $\sqrt{s_{NN}} = 2.76, 5, 7, 8, 13$ TeV, L ≈ 9 fb⁻¹
- *p*Pb collider: 2013 and 2016, $\sqrt{s_{NN}} = 5.02 \& 8.16$ TeV, L $\approx 2 \& 34$ nb⁻¹
- PbPb collider: 2015 and 2018, $\sqrt{s_{NN}} = 5$ TeV, L $\approx 10 \ \mu b^{-1} \& 210 \ \mu b^{-1}$



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- First preliminary result by LHCb on PbPb collisions
- Goal is to study coherent J/ψ production in PbPb collisions at $\sqrt{s(NN)} = 5 \text{ TeV}$
- Data set: PbPb 2015, integrated luminosity ~ 10 μb⁻¹
- Muons in acceptance. $Pt(J/\psi) < 1$ GeV. Rapidity 2.0 < y < 4.5
- Photon-induced J/ψ production cross-section is enhanced by the strong electromagnetic field of the nucleus
- The collisions are either
 - coherent, where the photon couples coherently to all nucleons
 - or incoherent, where the photon couples to a single nucleon



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- Invariant mass fit
 - non-resonant: Exponential times straight line (\propto (a + bm_{µ+µ}-e^{τm}_{µ+µ}-))
 - J/ψ : Double sided Crystal Ball function
 - $\psi(2S)$: Double sided Crystal Ball function with all parameters apart from normalisation and mean constrained to be identical to J/ψ



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- Transverse momentum fit
 - non-resonant: STARlight template, normalisation is fixed by Gaussian constraint to the result of the mass fit
 - incoherent J/ψ production: STARlight template, this also accounts for feeddown $\psi(2S) \rightarrow J/\psi X$
 - coherent J/# production: STARlight template



The STARlight templates are from the generated events smeared with a resolution model

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- Cross section for coherent J/ψ production at 5 TeV:
 - $\sigma = 5.3 \pm 0.2$ (stat) ± 0.5 (syst) ± 0.7 (lumi) mb,
- Coherent (photon couples to all nucleons)
 J/ψ production gives constraints to nPDF
- Uncertainty smaller than models spread
- Phenomenological models:
 - PRC 97 024901 (2018), PRD 96 094027 (2017), PRC 93 055206 (2016), PLB 772 (2017) 832



Hershel detector

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Rapidity coverage



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High Rapidity Shower Counters for LHCb (HeRSCheL)





Different processes compared with the acceptance of the LHCb detector



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Separation of coherent and incoherent

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- If the nucleus breaks up it will leave debris in $5.0 < \eta < 7.5$
- HeRSCheL extended LHCb to observe this debris
- A reduction of the incoherent background is expected after vetoing significant energy detected in HeRSCheL



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Conclusions

- LHCb has measured the cross section for coherent J/ψ production in lead-lead ultra-peripheral collisions using 2015 data
- We have potential to improve the precision of this measurement by using HeRSCheL
- We have prospects for many future analyses with 2018 data
- Stay tuned!

Backups

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