Ultra-peripheral collisions at the HL/HE-LHC with ALICE

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on behalf of the ALICE collaboration

HL/HE-LHC WG1 Meeting – QCD physics

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Possible contributions from ALICE / 1

Estimates for expected number of events for:

- Multi-differential studies for J/ψ and Ψ(2S) production
  - b-slope dependence → transverse gluon distributions (1611.05471)
  - ZDC → disentangle low-x and high-x contributions
- High-mass vector mesons
  - Ψ(3S) → DDbar (*not measured at HERA*)
  - ϒ production
- Inclusive photonuclear charm production
  - σ (γ gluon → c cbar) ≈ 1b
  - Pb+Pb → Pb+c+cbar+X
- coherent UPC Φ production

Expected integrated luminosities:

PbPb: 10/nb @0.5T, 3/nb @0.2T

pPb: 50/nb (ALICE LoI baseline)

Possible contributions from ALICE / 2

Estimates for expected number of events for:

- γγ processes
  - η_C (χ_{C0}, χ_{C2}) production
  - γγ → 4μ: double-VM production, *e.g.* γγ → J/ψ J/ψ , ρ^0 J/Ψ
  - γγ → ppbar (η_C → ppbar), γγ → γγ
- Jet photoproduction (ALICE is probably not competitive)
  - direct access to the gluon distribution (ATLAS-CONF-2017-011)

Besides in UPC, signs of coherent photo-production have been found in peripheral collisions

Summary

- We need to understand how the UPC part is shared between WG1 and WG5
- There is an active physics analysis group for UPC in ALICE
  - several members are interested in contributing to the Yellow Report

Appendix

Expected number of events for L^{int} = 10/nb in Pb-Pb

process	central barrel	muon arm	Comments
J/ψ → l+l-	4.1M	620k	STARLIGHT
Ψ(2S)	109k	15k	STARLIGHT
ϒ	5,260	430	STARLIGHT
Ψ(3S)→DDbar	(acc×eff) × 5,900	---	Ψ(3S) → DDbar → $K^+\pi^-$ $K^-\pi^+$ https://indico.cern.ch/event/347071/
η_C → 2π 2K	(acc×eff) × 49k	---	σ = 490 μb (STARLIGHT), BR(η_C → 2π2K) ≈ 0.01
γγ → 4μ (VV)	(acc×eff) × 310	---	p_T > 0.5 GeV, |y| < 0.9: σ ≈ 31 nb (Sczcurek et al. 1708.07742)
γγ → ppbar	(acc×eff) × 350k	---	p_T > 1 GeV, |y| < 0.9: σ ≈ 35 μb (Szczurek et al. 1708.09836)
γγ → γγ	240 (E_T>3 GeV, |η| <2.4)	---	ATLAS: 0.45/nb 13 ev → 10/nb 240 ev (DOI: 10.1038/NPHYS4208); ALICE/ATLAS acc ≈ 7%
UPC jets	(acc×eff) × O(4M)	----	ATLAS-CONF-2017-011: 110k events with 0.3/nb in|η|<3.2 → 3.7M events with 10/nb

Quarkonia in PbPb at 5.5 TeV

J/Ψ, Ψ(2S), Upsilon:

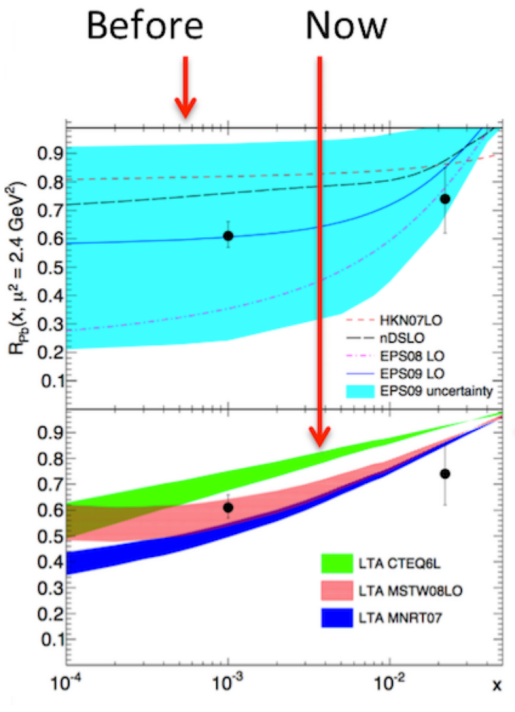
- Efficiency = tracking efficiency using current AliRoot (no trigger)
- MUON arm: acc(-4.0 < y < -2.5) × eff for $\mu^+\mu^-$: 22%
- Central barrel: acc(|y|<1) × eff for e^+e^-: 25%, $\mu^+\mu^-$: 27%

	σ (μb) STARLIGHT	Acceptance		BR→$\mu^+\mu^-$	BR→e^+e^-	Yield per 1/nb		
		|y|<1	-4.0<y<-2.5			central barrel		muon arm
						$\mu^+\mu^-$	e^+e^-	$\mu^+\mu^-$
Υ(1S)	103.74	40.2%	7.67%	2.48%	2.38%	279	247	43
Ψ(2S)	8110	32.7%	10.9%	7.9×10^{-3}	7.9×10^{-3}	5660	5240	1536
J/Ψ	41620	31.5%	11.3%	5.96%	5.97%	211k	196k	62k

Ψ(3S):

- Cross section ≈ 0.0179 × σ(J/Ψ) = 745 μb (https://indico.cern.ch/event/347071/)
- BR Ψ(2S) → DDbar → $\pi^+K^-\pi^-K^+$ = 52.4% × $(3.89\%)^2$ = 7.93×10^{-4}
- Yield per 1/nb: 590 events (without acc × eff)

UPC measurements in Run1 and in Run2

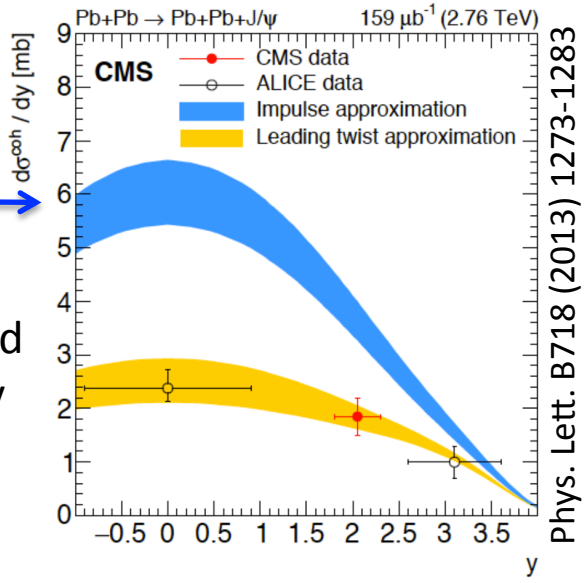


V. Guzey, *et al.* Phys. Lett. B726 (2013) 290-295

UPC J/Ψ in Pb-Pb

Impulse approximation (no nuclear effects)

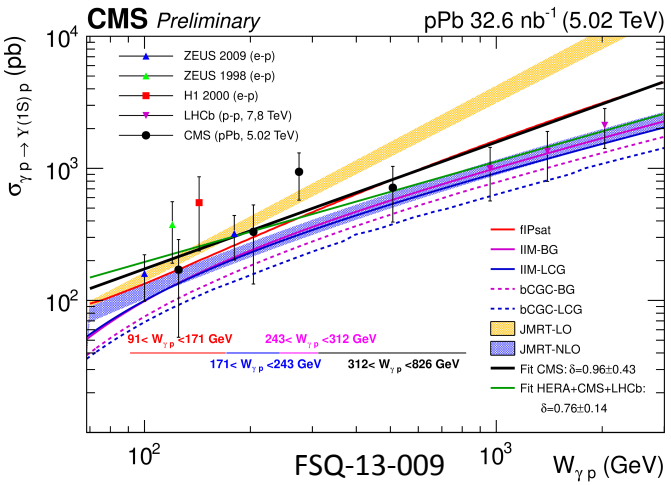
UPC measurements are being used to constrain nuclear gluon density functions

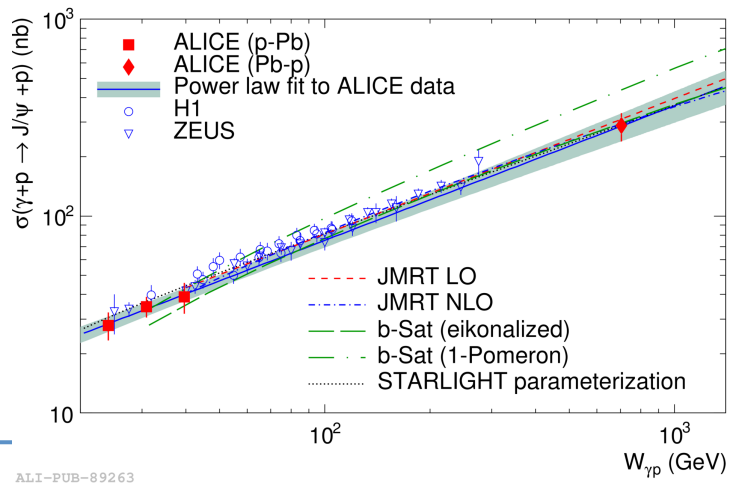


Phys. Lett. B718 (2013) 1273-1283
Eur. J. Phys. C73, 2617 (2013)
Phys. Lett. B772 (2017) 489-511

UPC J/Ψ, Υ in p-Pb

- Cross section is proportional to the square of the nuclear gluon distribution
- Higher $W_{\gamma p}$ energies than at HERA can be probed at the LHC



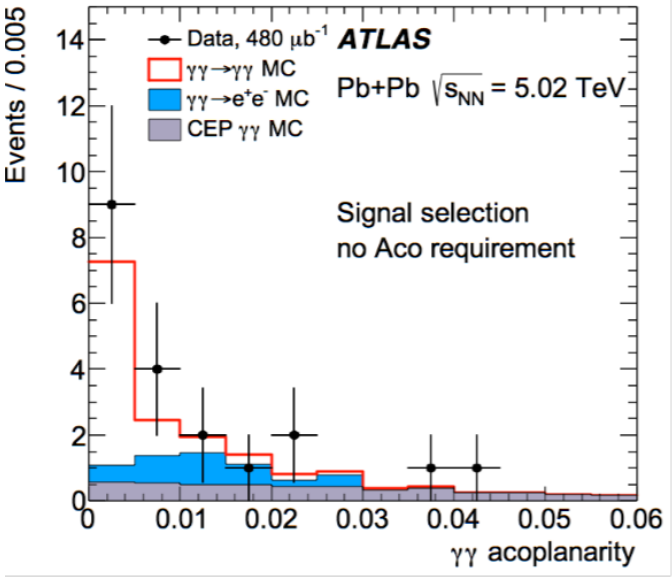


Light-by-light scattering

Pb+Pb collisions

- softer EPA spectrum (ω_{max}≈80 GeV for $\sqrt{s_{NN}}$=5 TeV) → $M(\gamma\gamma)_{max}$≈160 GeV
- AA (γγ) cross-sections scale as Z^4
- gluonic cross-sections scale with A^2 (lower QCD background w.r.t. pp)
- low pile-up (< 1%)*
- Short LHC Pb-Pb campaigns (cf. pp)
- Proposed as a good channel to study *e.g.*
  - Anomalous gauge couplings
  - Contributions from BSM particles in the loops

Nature Phys. 13, 852 (2017)



pp collisions

- harder EPA spectrum (ω_{max}≈2 TeV for $\sqrt{s}$=13TeV) → $M(\gamma\gamma)_{max}$≈4 TeV
- large pile-up (multiple interactions per bunch crossing)
- large datasets available, O(10 fb^{-1})
- hard to trigger on low-p_T objects

* O(10%) for EM dissociation will be important effect @ HL-LHC

γγ collisions (QCD)

- The process γγ → $q\bar{q}$ is an elementary QCD process
  - Rates can be calibrated with γγ→$\mu^+\mu^-$
- Can do very clean QCD measurements a la e^+e^-
  - α_S, fragmentation functions, etc.

ATLAS-CONF-2016-025