Combination of ATLAS+CMS measurements on $\gamma\gamma \to \tau^+\tau^-$ production in Pb+Pb UPC

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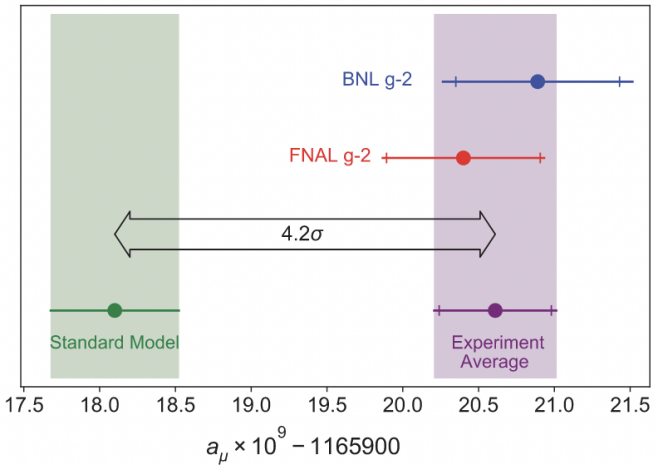
Outline

Motivation

- Measurements of anomalous magnetic moments of leptons $a_l = \frac{(g-2)l}{2}$ are sensitive to new physics
  - Dirac equation predicts $g = 2$, but higher-order corrections (QED, weak, hadronic loops, ...) lead to $\neq 2$
- a_τ is poorly constrained experimentally:
  $-0.52 < a_\tau < 0.013$ (95% CL)
  DELPHI, EPJC 35 35 (2004) 159
  Due to it can be sensitive to BSM effects
- For example, measurements of a_e and a_μ are the most accurate.
  Difference with SM predictions observed for a_e (2.5σ) and a_μ (up to 4.2σ)

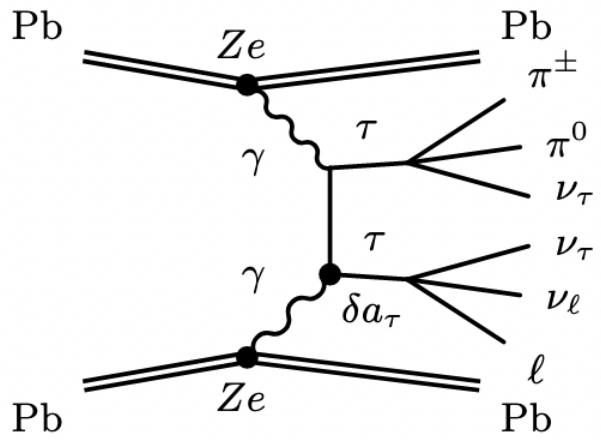


Muon g-2 Collaboration,
PRL 126 (2021) 141801

$\gamma\gamma \to \tau^+\tau^-$ production in Pb+Pb UPC

Pb+Pb UPC studies have some advantages over pp collisions:

- $\sim Z^4$ ($Z = 82, Z \approx 4.5 \cdot 10^7$) enhancement of cross sections
- Due to **Zero Degree Calorimeter** (ZDC) (ATLAS) and **Forward Hadron** (HF) calorimeter allows to control event activity above the noise threshold
- $\approx$ no hadronic pileup $\to$ exclusivity selections
- Low p_T thresholds in trigger and offline reconstruction
- Exploit $\gamma\gamma \to \tau\tau$ cross section to set limits on a_τ
- $\gamma\gamma \to \tau\tau$ production observed for the first time in hadron collisions at the LHC in 2022



PRD 102 (2020) 113008

ATLAS measurement overview

- Measurement uses 1.44 nb^{-1} of 2018 UPC data at $\sqrt{s_{\text{NN}}} = 5.02$ TeV
- Monte Carlo simulations:
  - signal modeled with: `Starlight+Tauola` (`Pythia8+Photos` for QED FSR) samples reweighted to photon flux from `SuperChic`
- Event selection categorised with semileptonic decay modes:

μ**1T-SR** muon + 1 track (e/μ/hadron ("prong"))	$p_T^{\mu} > 4$ GeV, $p_T^{e} > 4$ GeV, $p_T^{\text{trk}} > 100$ MeV
μ**3T-SR**: muon + 3 tracks (3 hadrons (3 prongs))	
μe-**SR**: muon + 1 track (muon + electron)	$p_T^{\text{clus}} > 1$ GeV ($\lvert\eta\rvert < 2.5$), $p_T^{\text{trk}} > 100$ MeV ($2.5 < \lvert\eta\rvert < 4.5$)

- Only data in `0n0n` ZDC category used to suppress photonuclear/hadronic backgrounds
- Simulation `Starlight+Tauola` reweighted to `0n0n` with data-driven weights

CMS measurement overview

- Measurement uses 0.4 nb^{-1} of 2015 UPC data at $\sqrt{s_{\text{NN}}} = 5.02$ TeV
- Monte Carlo simulations:
  - signal modeled with: `MADGRAPH5 aMC@NLO(v2.6.5)` (`PYTHIA8 (v2.1.2)`) samples reweighted to photon flux from `SuperChic`
- Event selection categorised with semileptonic decay mode:

μ**3T-SR**: muon+3 prongs	$p_T^{\text{vis}} > 0.2$ GeV $0.2 < m_{\pi\pi\pi}^{\text{vis}} < 1.5$ GeV $\lvert\eta\rvert < 2.5$

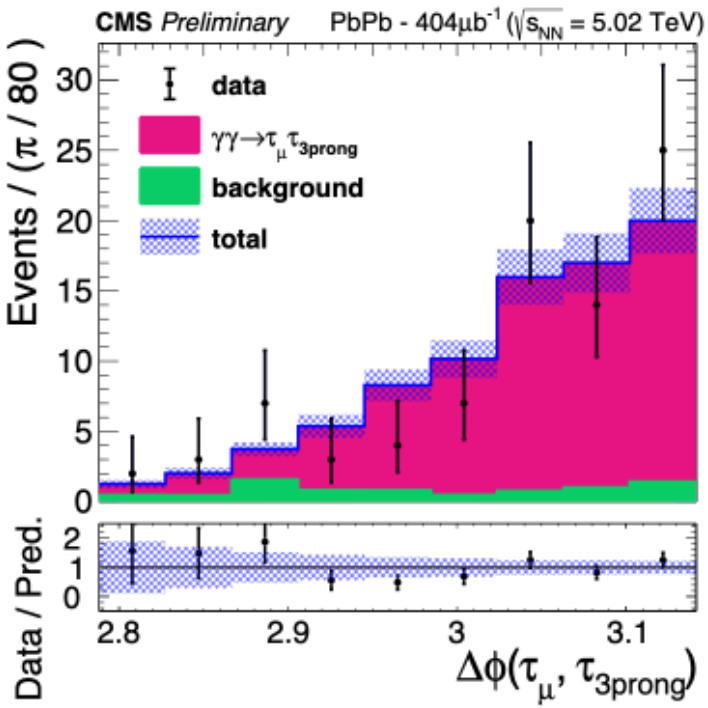
Constraints on a_τ anomalous magnetic moment

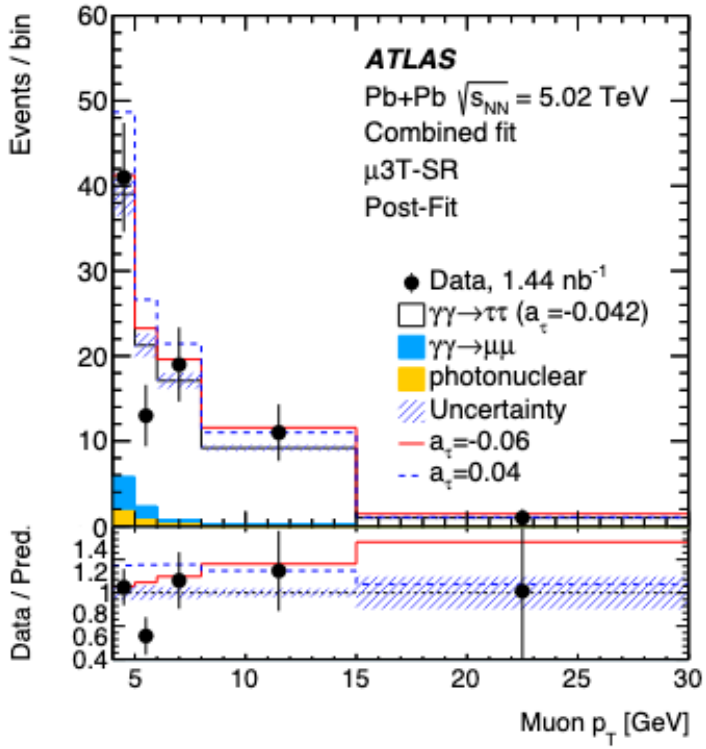
Interest in measuring a_τ at the LHC revisited recently

- Theoretical investigations outlined in:
  - L. Beresford, J. Liu,
    PRD 102 (2020) 113008
  - M. Dyndal, M. Schott, M. Klusek-Gawenda, A. Szczurek,
    PLB 809 (2020) 135682
    This paper suggested to use datasets from ATLAS experiment to improve the sensitivity on a_τ
    Mateusz had a presentation in the past HonexComb meeting
- Final results from 5.02 TeV Pb+Pb UPC from ATLAS
  - ATLAS Collaboration submitted to PRL, arXiv:2204.13478
- Preliminary results from 5.02 TeV Pb+Pb UPC from CMS
  available at the link
  - CMS PAS HIN-21-009

Comparison both measurements

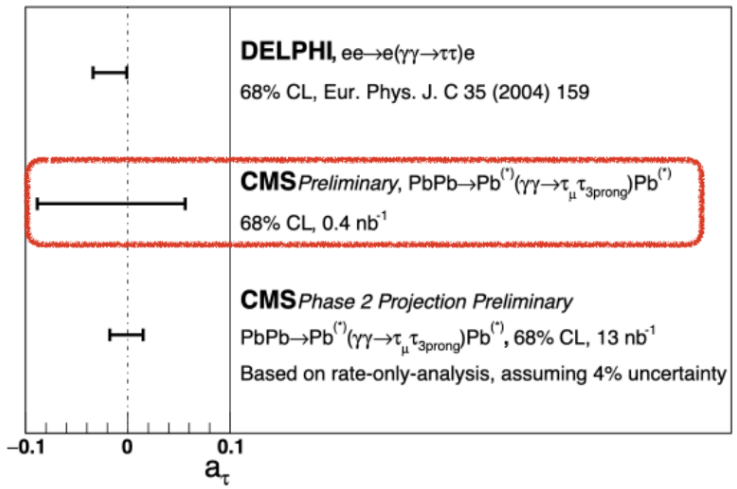
- **CMS**: fiducial cross section measured with 16% relative precision (stat.-dominated) (2015 data)
- **ATLAS**: signal strength measured with 5% relative precision (stat.-dominated) (2018 data)

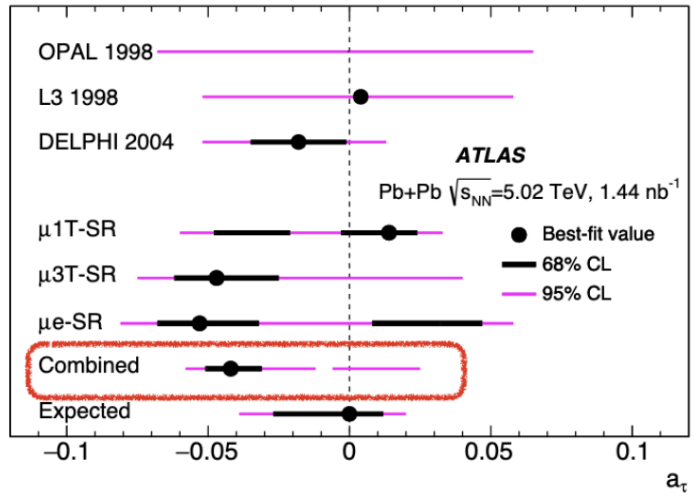




Constraints on a_τ anomalous magnetic moment

- Both experiments provide their first constraints on a_τ
- ATLAS precision is comparable to the DELPHI@LEP (PDG) results
- Statistical uncertainties are dominated in both experiments





Summary & Outlook

- HI UPCs are high-quality probes to QED and BSM physics
  - UPC data is used to constrain a_τ at LHC
  - ATLAS and CMS provide a measurement of exclusive $\tau^+\tau^-$ production in Pb+Pb collisions with above 5σ at the LHC
  - Found precision is compatible with LEP (PDG)
- Following the steps made in the combination of ATLAS+CMS data on $\gamma\gamma$ measurement expecting to combine results on $\tau^+\tau^-$ production

Thank you for your kind attention!