Measuring tau g-2 using ATLAS Pb+Pb collisions

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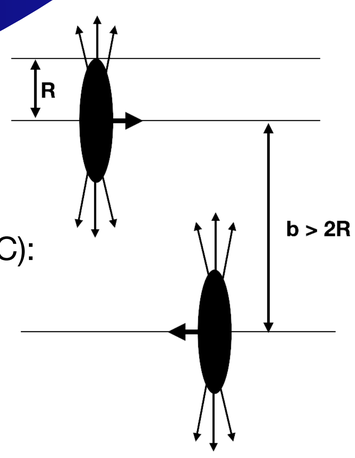
on behalf of the ATLAS Collaboration

Experimental realization

Measure a_τ using ultra-peripheral heavy ion collisions (UPC):

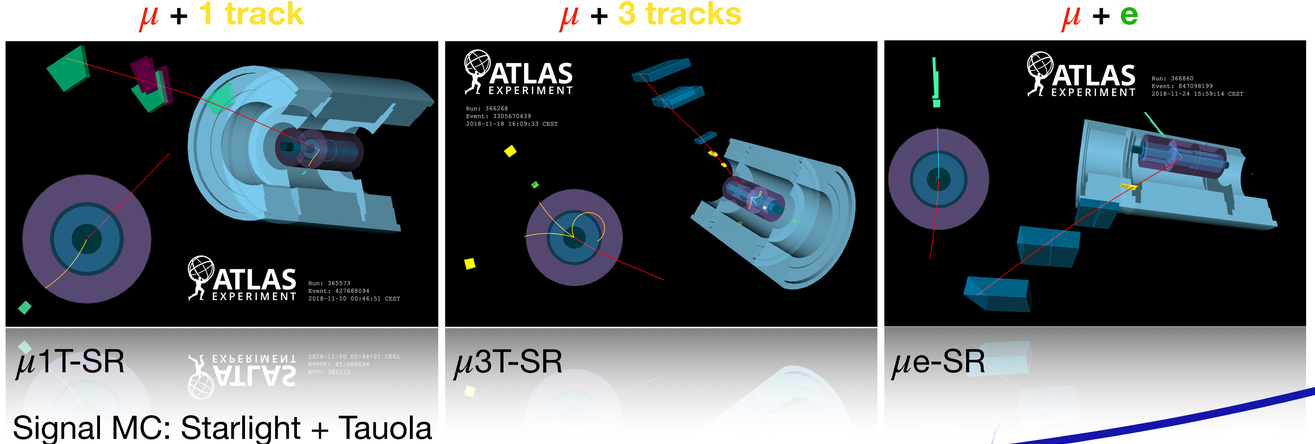


- Z^4 cross-section enhancement
- Very clean events with ~0 pileup
- Low trigger thresholds

Measurement uses 1.44 nb^{-1} of Pb+Pb data, $\sqrt{s_{NN}}$ = 5.02 TeV.

Signal candidates are selected using muonic τ decays and categorized using electrons or low p_T tracks:

μ + 1 track | μ + 3 tracks | μ + e



μ1T-SR | μ3T-SR | μe-SR

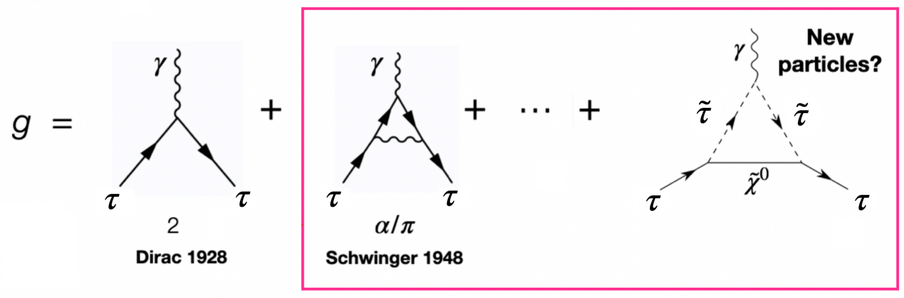
Signal MC: Starlight + Tauola

Anomalous magnetic moment of the τ - lepton

Charged particles with spin have an intrinsic magnetic moment:

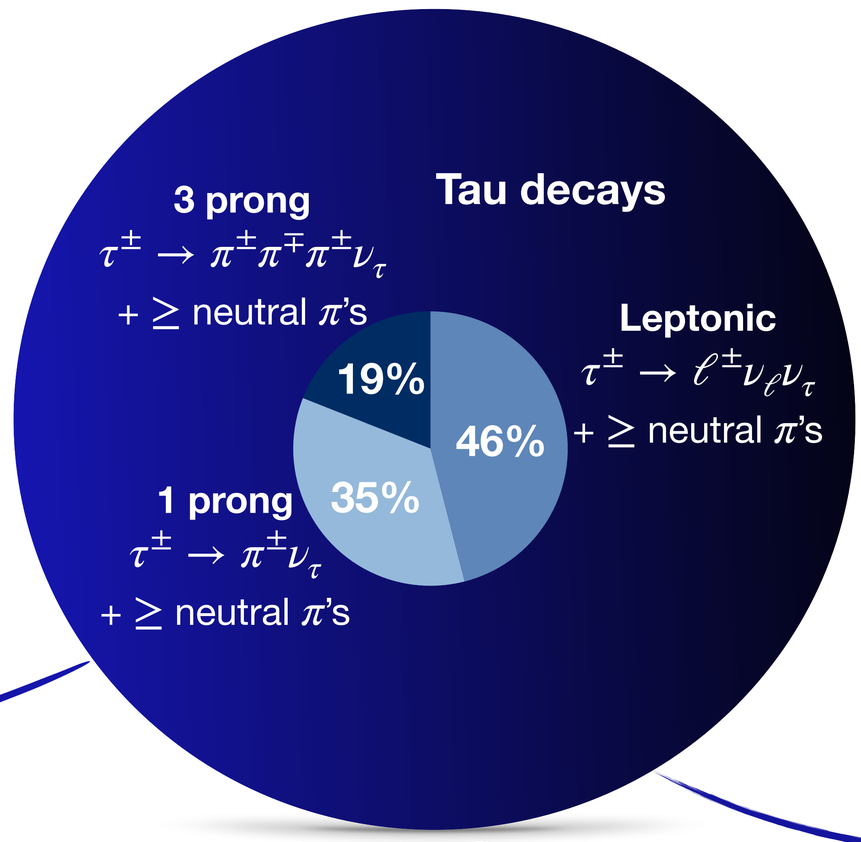
$$\vec{\mu} = g\frac{q}{2m}\vec{S}$$

Where:



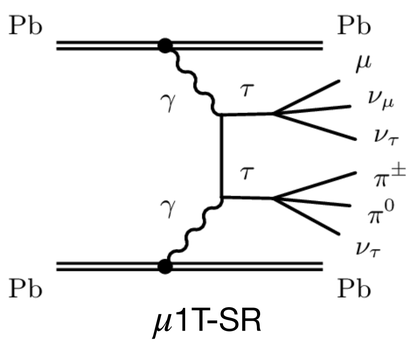
Anomalous magnetic moment: $a = \frac{g-2}{2}$

- a_μ and a_e - very precisely measured
- a_τ is still poorly constrained: $-0.052 < a_\tau < 0.013$ (95% CL) DELPHI (2004)
- τ is extremely hard to measure!
- a_τ is more sensitive to some BSM phenomena

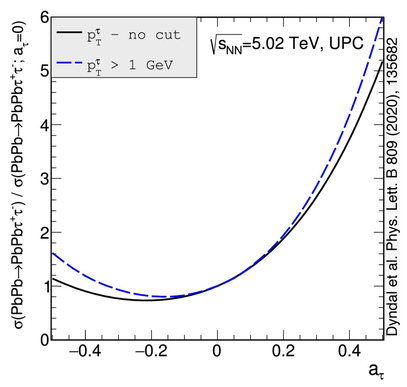


Analysis strategy

- Exploit $\gamma\gamma \to \tau\tau$ cross-section to set limits on a_τ:



μ1T-SR

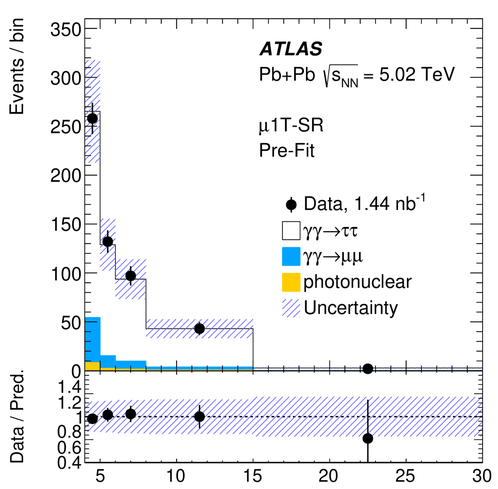


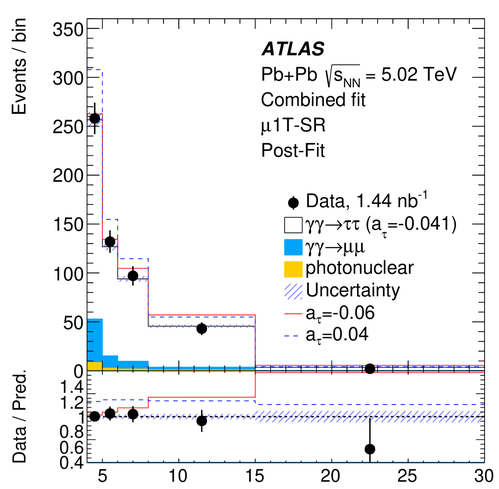
- Reduce uncertainties using $\gamma\gamma \to \mu\mu$ control region (2μCR)
- Fit muon p_T in signal regions + di-muon control region to extract a_τ

Fit setup

Extract signal strength and a_τ using profile likelihood fit:

- Build templates for different a_τ values: a_τ = [0, ± 0.01, ± 0.02, …, ± 0.1]
- Pre- and post-fit distributions of p_T^μ in μ1T-SR:





- Uncertainties decrease
- Differences between SM and BSM values of a_τ change with p_T^μ

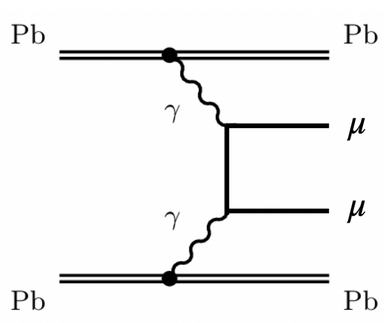
Main backgrounds

Di-muon

Estimated with MC:

$\gamma\gamma \to \mu\mu$: Starlight + Pythia8

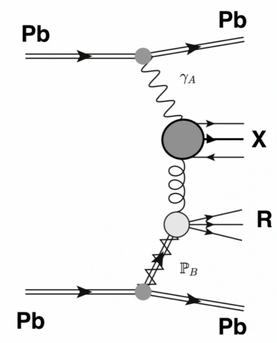
$\gamma\gamma \to \mu\mu\gamma$: Madgraph5



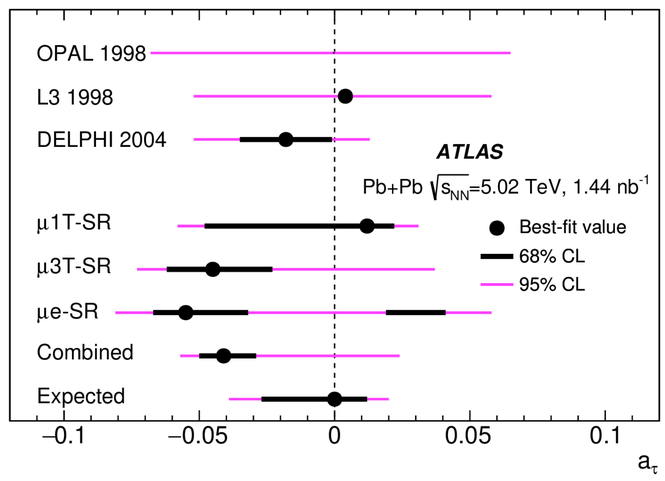
Photonuclear

Data-driven estimation:

Build CR requiring an additional low- p_T track



New limits on a_τ



- Expected 95% CL limits from combined fit: **$-0.039 < a_\tau < 0.020$**
- Observed 95% CL limits: **$-0.057 < a_\tau < 0.024$**

Conclusions

- $\gamma\gamma \to \tau\tau$ observed in Pb+Pb with a significance exceeding 5 σ
- Hadron-collider result is used to measure electromagnetic τ properties
- Competitive with electron-collider result

Ref.

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