Photon flux modelling in tau g-2 analysis in Pb+Pb

SM Group Meeting

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13 May 2025

HELMHOLTZ

ATLAS EXPERIMENT

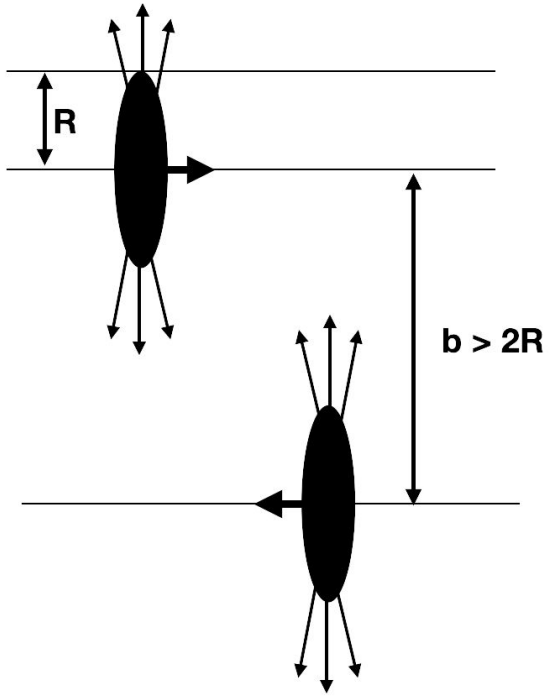
DESY.

Introduction

Photon flux in ultra-peripheral heavy ion collisions

Ultra-peripheral heavy-ion collisions (UPC):

- UPC occurs when the impact parameter is larger than twice the radius of the ions (b>2R)
- Strong EM fields interact
- Initial state photons come from ion's EM field



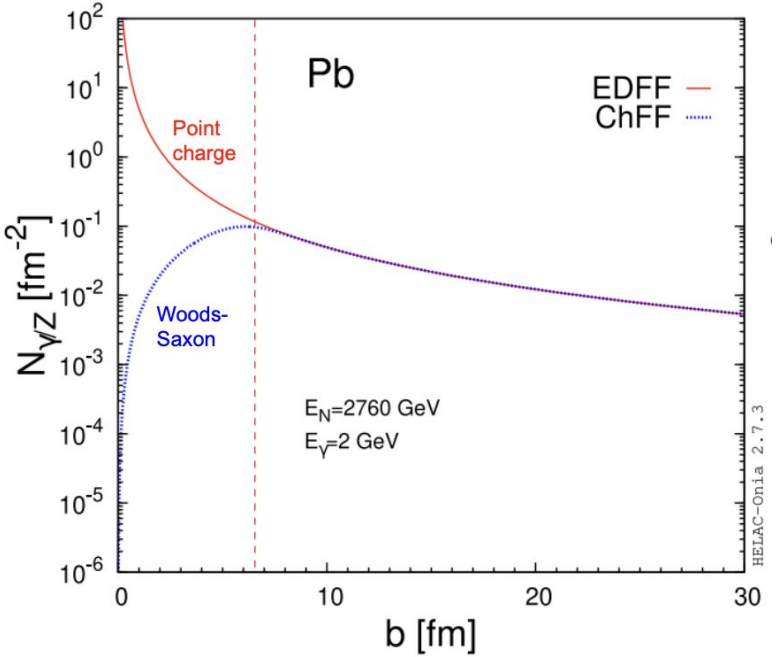
Introduction

Modelling of the photon flux

Photon flux depends on choice of nuclear charge distribution:

- **STARlight**: point-like charge (not physical)
- **SuperChic**: Wood-Saxon distribution

SuperChic is expected to provide more accurate description of the photon flux:



- Nominal MC generated by STARlight → reweight the photon flux to SuperChic
- Reweighting on\off taken as systematic uncertainty

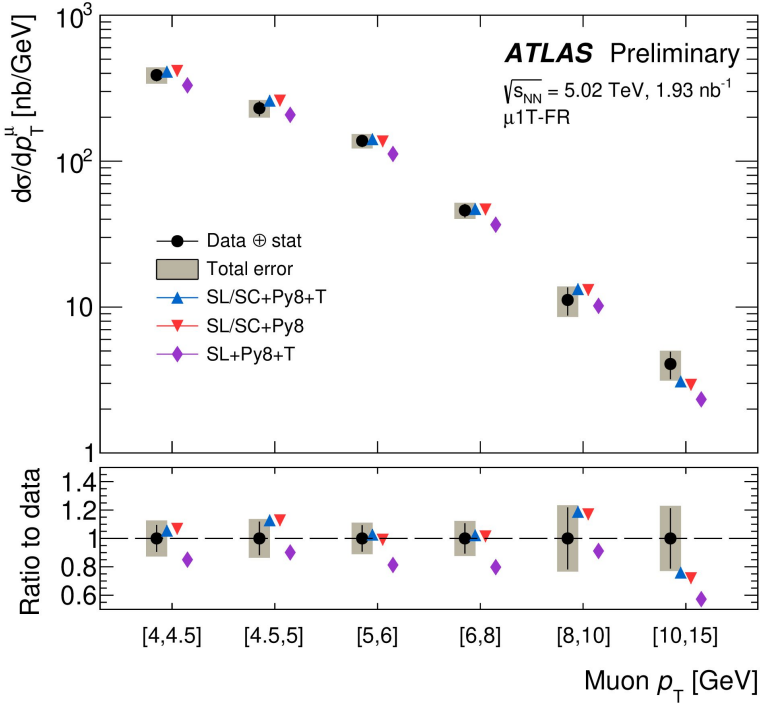
Introduction

Modelling of the photon flux

Modelling of yy→tautau process:

- Nominal signal: STARlight with photon flux reweighted to SuperChic
- Varied photon flux: without the reweighting

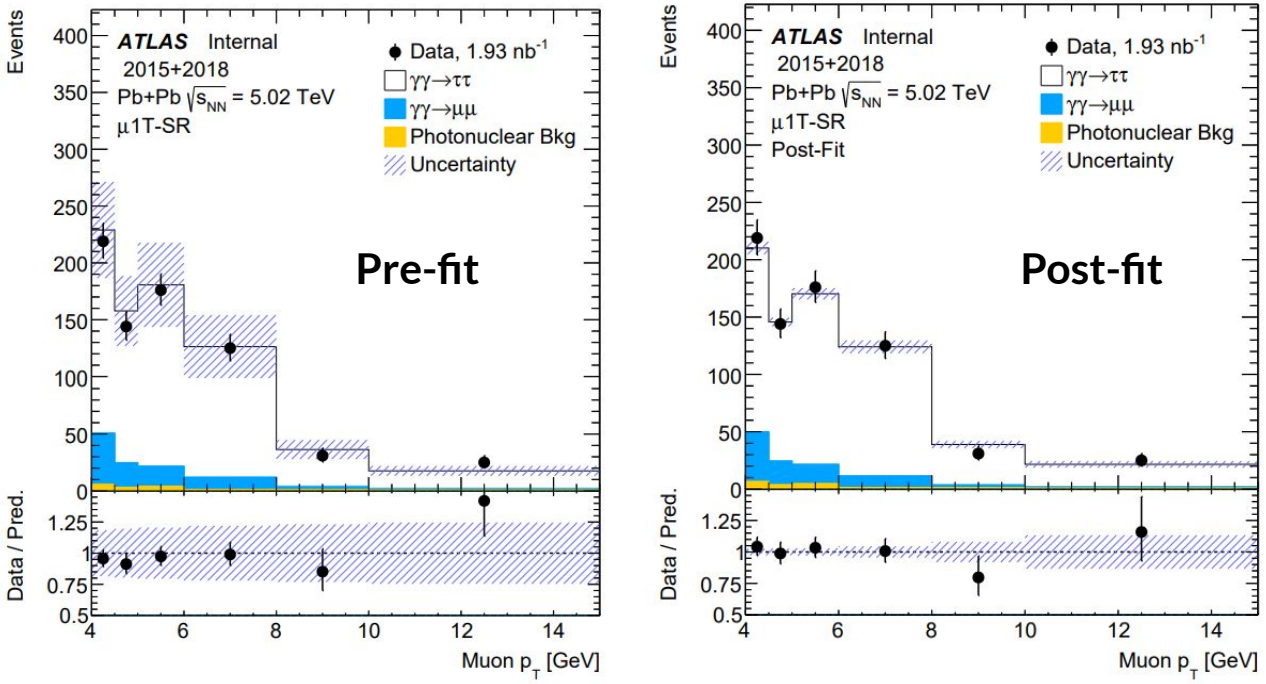
Significant difference!



Extracting atau

Pre- and post fit distributions

Detector-level fits to muon pT: pre-fit largely dominated by photon flux uncertainty



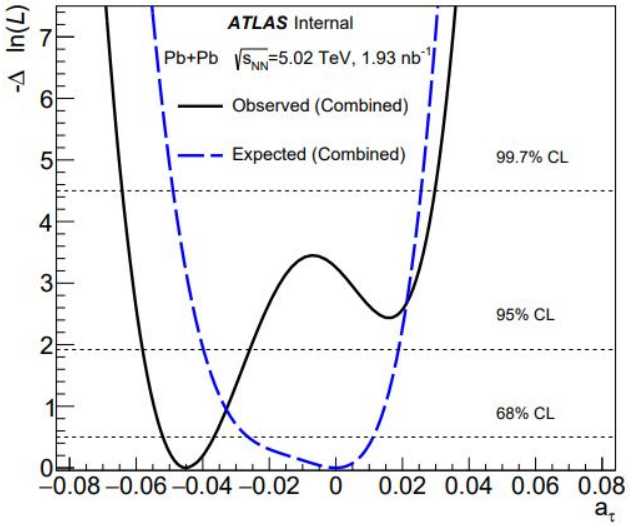
Extracting atau

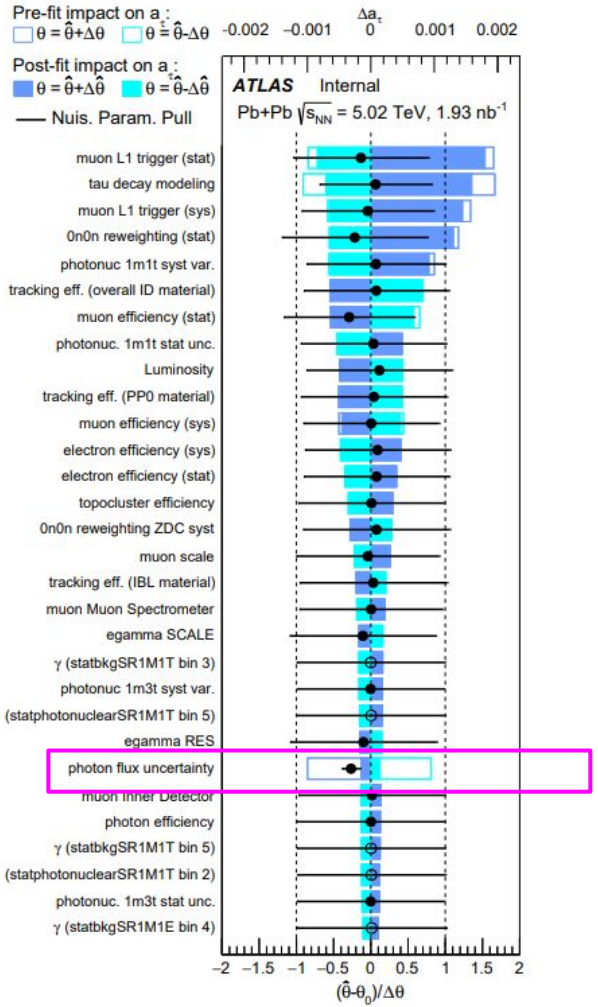
Systematics ranking plots and fitting results

Photon flux nuisance parameter:

- **leading systematics (at ~20%, compared to others ~<2%)**
- significantly constrained and pulled
- problematic, since it is a **two point systematic**

- Similar shape observed in previous round of the analysis
- Is it physical?

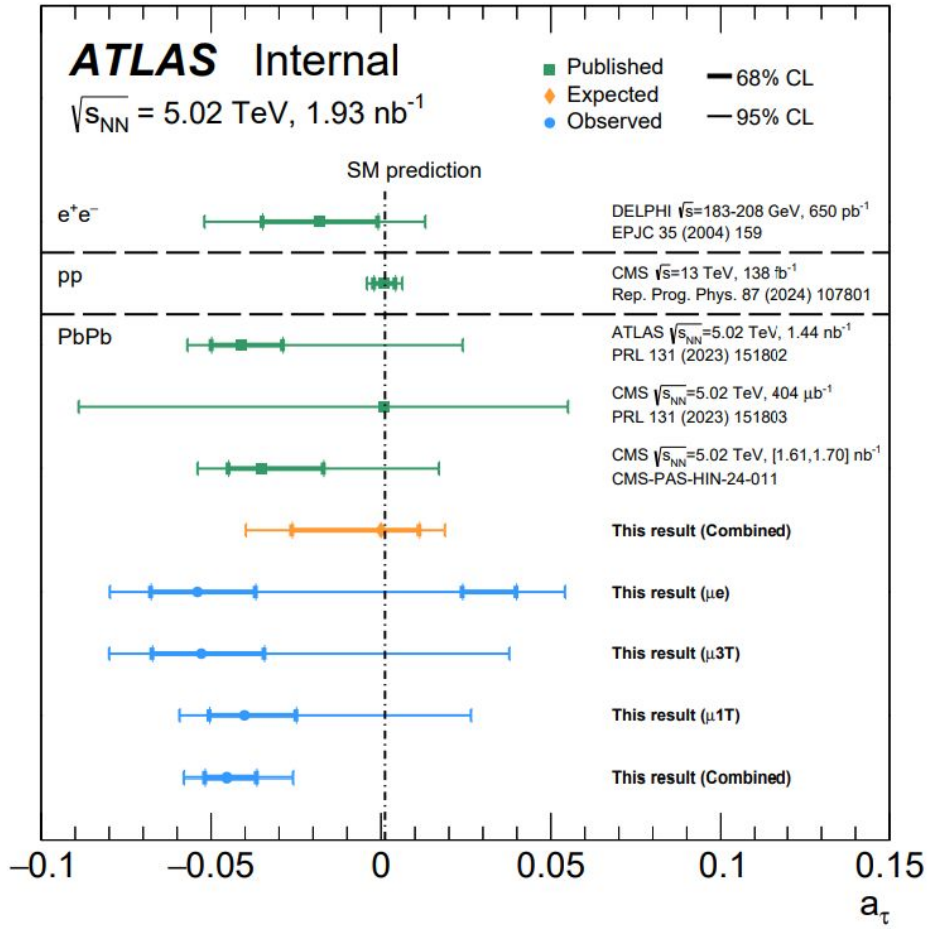




Extracting atau

Comparison of the results

- improved precision → tension with SM at 95% CL
- tension to CMS pp result
- consistent with results of the previous ATLAS Pb+Pb analysis



Proposed solution for future paper

Make sure that the fitted atau value is physical and not from interplay of **photon flux modelling**, **2-point systematics treatment** and **non-zero atau cross section minimum**:

Reweighting on/off for definition of the photon flux systematic uncertainty

Vary relevant Woods-Saxon density parameters in SuperChic

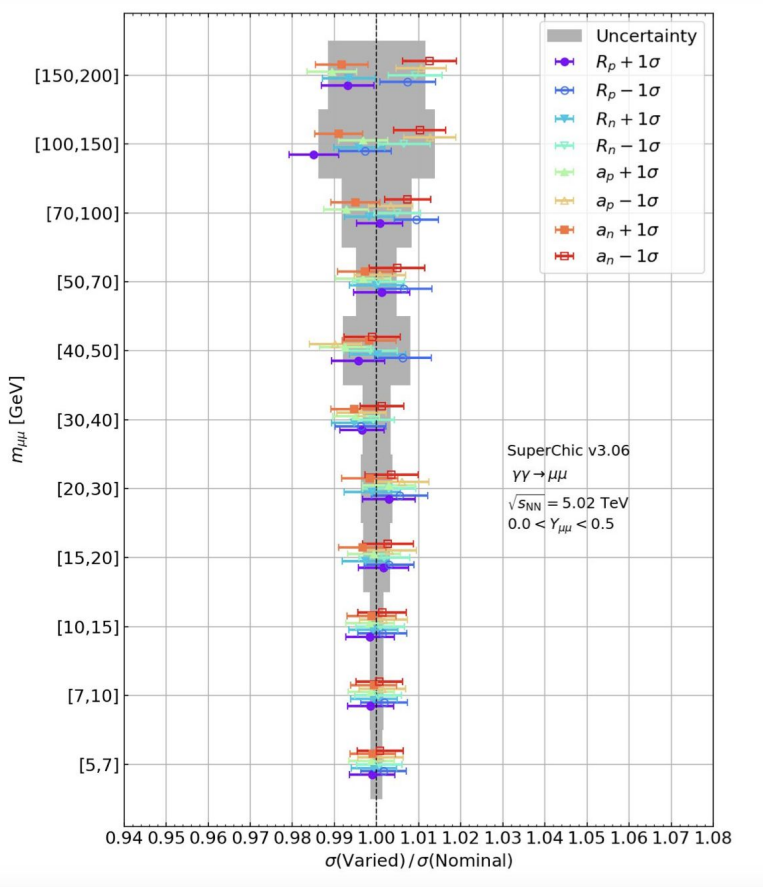
Defining new photon flux uncertainty

SuperChic uses a weighted sum of proton and neutron densities ⟶ 4 free parameters (R_p,R_n,a_p,a_n):

$$\rho(r) = \frac{Z}{A}\rho_p(r) + \frac{(A-Z)}{A}\rho_n(r)$$
$$\rho_p(r) = \frac{1}{1+\exp\left((r-R_p)/a_p\right)}$$
$$\rho_n(r) = \frac{1}{1+\exp\left((r-R_n)/a_n\right)}$$

Look at change in yy⟶dimuon cross section as a function of invariant mass in bins of rapidity.

And a separate **flat 2.5%** on the total cross section for dimuon, dielectron & ditau due to survival factor modelling.



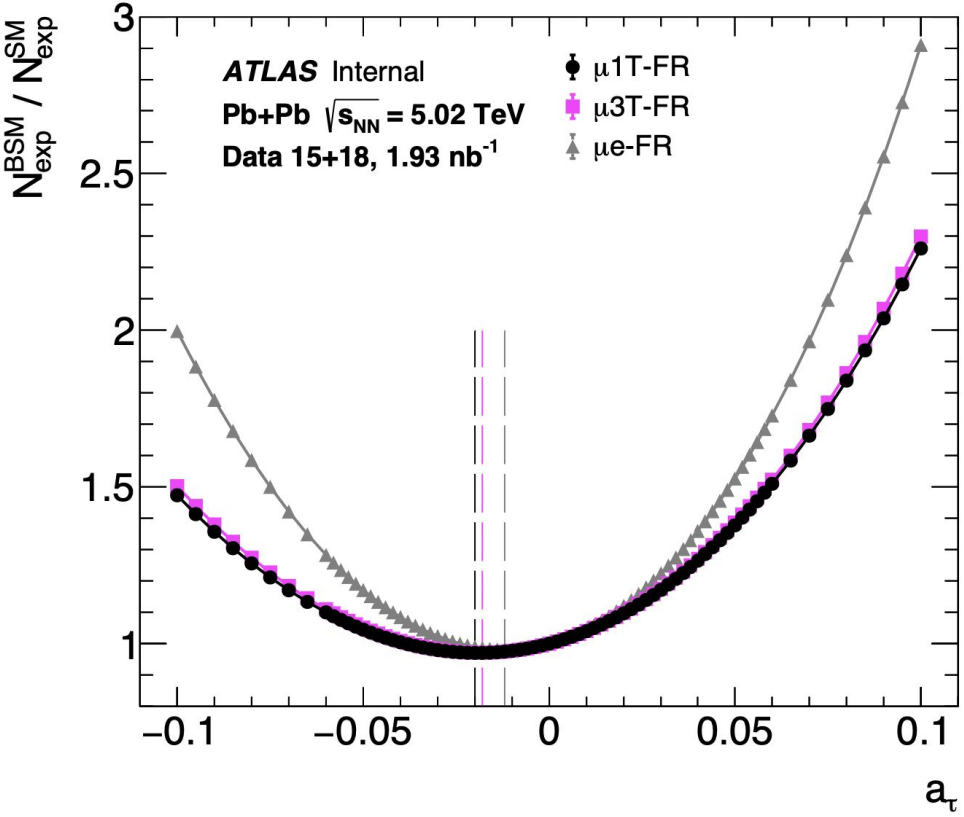
Summary

- Poor photon flux modelling with potential consequences on results for atau
- Pull and constraint on related nuisance parameter → Problematic since it is a 2-point systematic
- For paper: Need to ensure that the fitted atau value is physical
- Vary relevant Woods-Saxon density parameters in SuperChic to define modelling uncertainty, instead of using reweighting on/off for definition
- And a separate **flat 2.5%** on the total cross section
- Any thoughts?

Thank you!

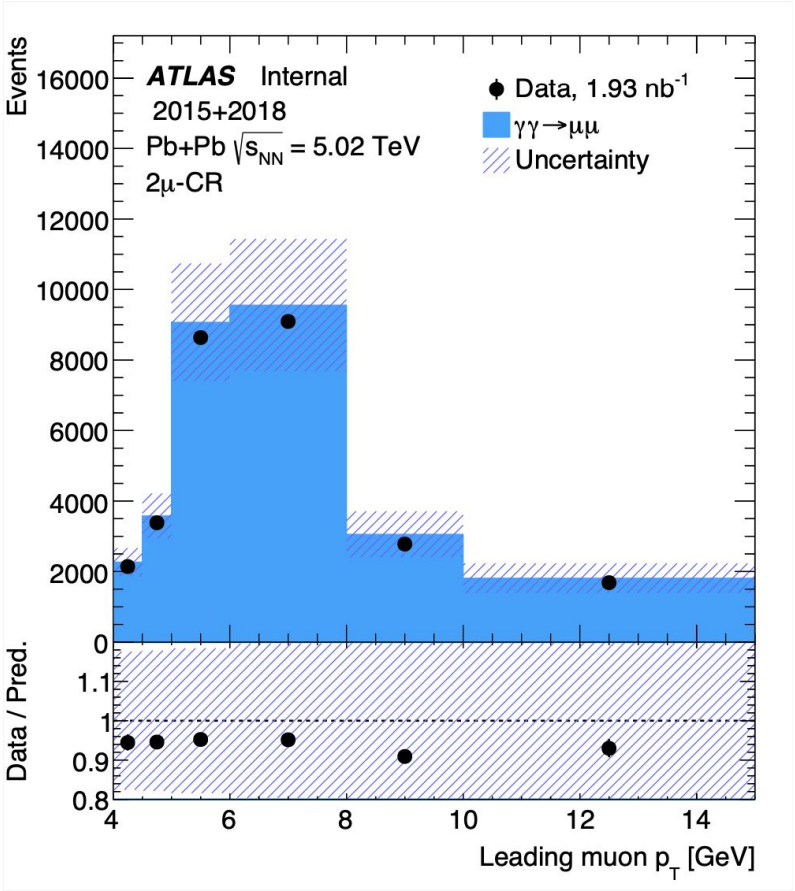
Backup slides

Number of events vs atau



Photon flux in dimuon Control Region

- Dimuon CR can be used to measure flat photon flux factor
- Pre-fit: ~ 5% offset between MC and data



Parameters in SuperChic

- a_p and a_n are the "thickness" parameters in the Woods saxon function
- control the smoothness of the transition from max to zero density

$$V(r) = -\frac{V_0}{1 + \exp(\frac{r-R}{a})}$$