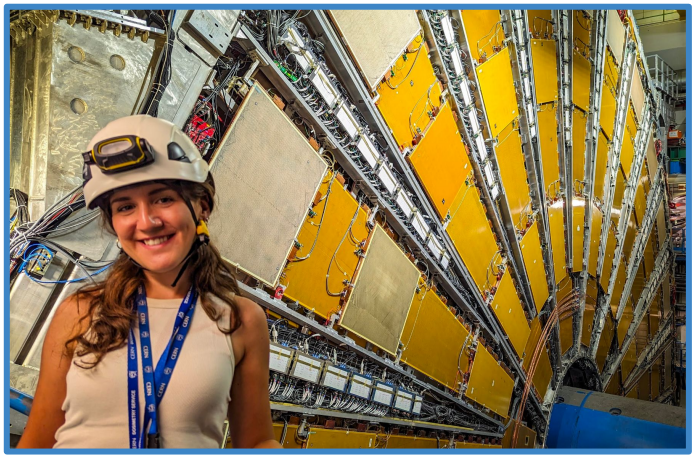
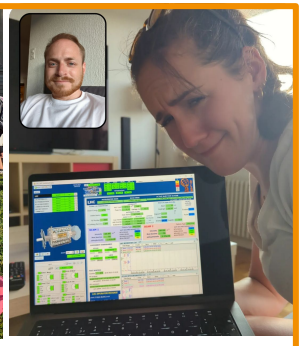
What am I working on?

- **Photon-induced WW**
  - Heavily involved in observation analysis
  - Unfolded dilepton kinematic distributions in follow-up differential analysis with low-p_T tracking and EFT fits
- **Photon-induced ττ**
  - Author of pheno study into prospects of constraining tau g-2 in LHC pp collisions
  - **NEW! Analysis contact for recently kicked-off ATLAS γγ→ττ in pp analysis**
  - Also involved in ATLAS heavy ion γγ→ττ analysis (mostly through supervision)
- **Forward proton CP**
  - Convener of AFP CP group (term March 2023–March 2025)
  - **Takes up most of my time!**
  - Also involved in ALPs+AFP analysis via CP
  - ATLAS Roman Pots General Meeting recently





Also lots of operations at CERN as AFP on-call expert

ATLAS Roman Pots General Meeting (ARP GM)

- The reason I missed the last DESY SM meeting!
  - → Had to get a flight at 06:30 on Monday morning

AFP CP overview

Savannah Clawson & Maciej Lewicki

ARP GM
4th June 2024

HELMHOLTZ DESY. ATLAS EXPERIMENT

Summary

- Several achievements since the last GM but lots still to do!
- **Group structure**
  - → Recently reevaluated the group's goals and priorities
  - → Also emphasizing importance of preservation and documentation of common tools
- **2022 and 2023 recommendations**
  - → Most 2022 recommendations are (almost) in place. Main outstanding items to deliver proton object are SiT efficiency, proton resolution and finalised systematics
  - → Issue with A-FAR synchronisation in 2023, high-μ analysis will be single-tag only
- **Preliminary 2024 performance**
  - → SiT looks good overall - working on quick offline analysis framework
  - → ToF has issues that are not fully understood but we now have the capability to spot these in real time and react accordingly

We look forward to a productive meeting :)

DESY. | Savannah Clawson & Maciej Lewicki | atlas-cp-proton-conveners@cern.ch | AFP CP overview @ ARP GM, 04/06/2024 19

indico.cern.ch/event/1418473/

Photon-induced tautau in pp collisions

- **Analysis plans**
  - New analysis STDM-2024-05 just kicked off 12 Apr.
  - Measure $\gamma\gamma \to \tau\tau$ in **Run 2+3** pp for $a_\tau = (g_\tau - 2)/2$ & d_τ.
  - Veto tracks near $\tau\tau$ vertex, SMEFT dipole analysis.

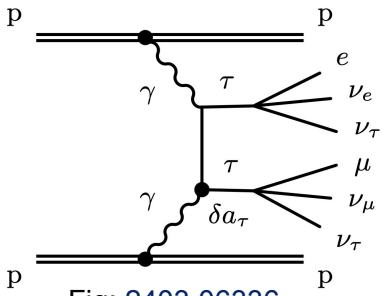
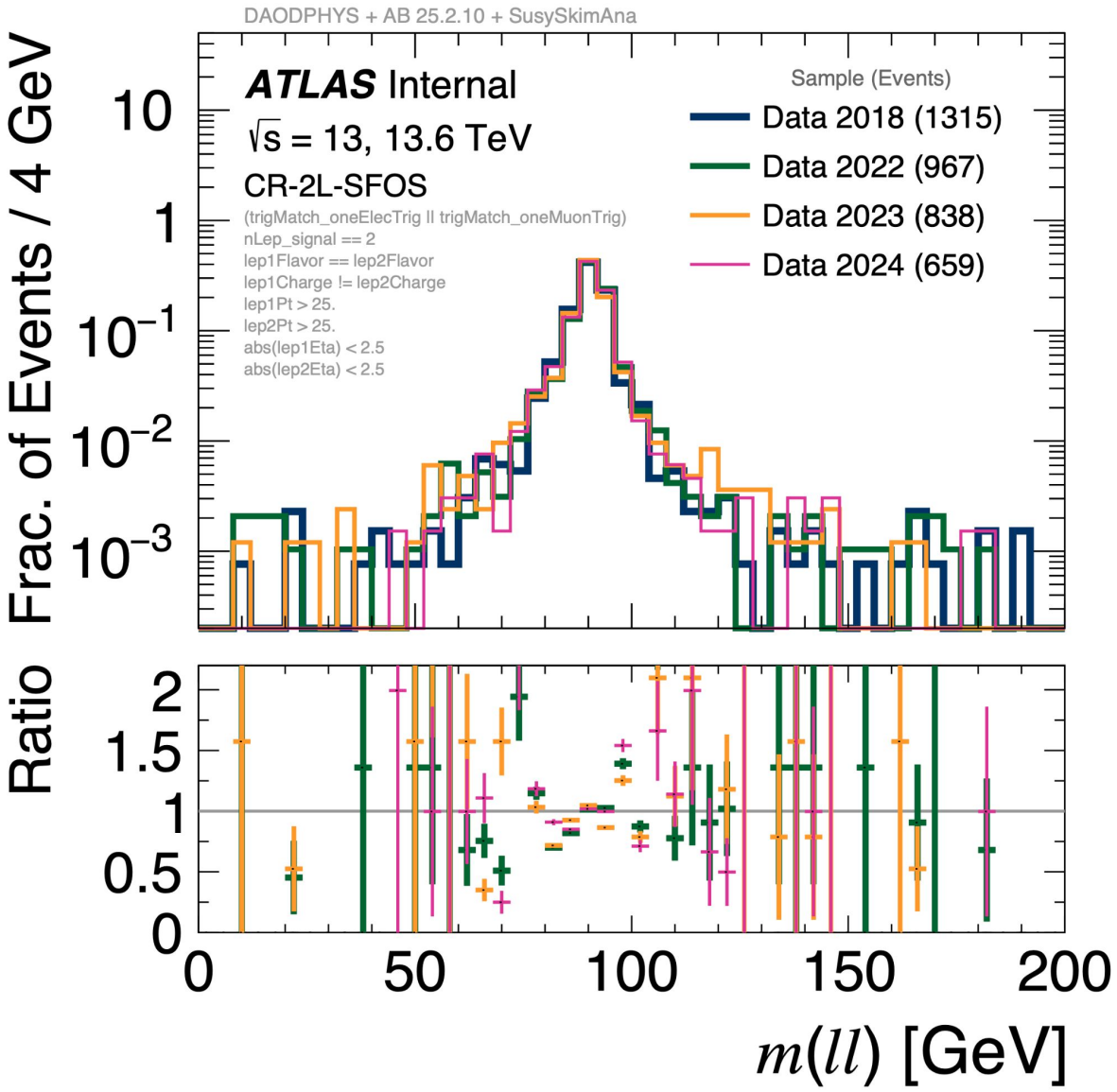


Fig: 2403.06336

- **Run 3 framework**
  - DESY+Cambridge group starting to explore SusySkimAna framework.
  - SUSYTools provides standard e/μ/τ_{had} CP object recommendations.

- **Open issues** (common to photon fusion)
  - **Derivations**. DAOD_PHYS good start but skims p_T(trk) > 10 GeV.
    $\gamma\gamma \to XX$ needs p_T(trk) > 0.1/0.5 GeV. Philip Sommer migrated STDM7 to R22 then Lydia Beresford requested data in 24.0.20 (thanks both!!).
    Todo: request MC, add taus for N(e/μ/τ) ≥ 2, R22 low-p_T tracks migration.
  - **Huge ntuples**. Tracks inflate ntuples 100 GB++: how to manage? Grid jobs speed? Central SM (grid) space? Typical Run 2+3 ntuple size?
  - **MC**. Todo: request $\gamma\gamma \to$ ee/μμ/$\tau\tau$/WW EL+SD+DD in mc20+mc23.

Hands on: our first plot with AB 25.2.10



210/fb data available

data15-18: 140/fb GRL.

data22: 29.0/fb (muon trigger GRL).

data23: 27.2/fb (eEM or eTAU trigger GRL).

data24: 18.9/fb recorded so far (GRL in progress).

Test DAODPHYS 24.0.21

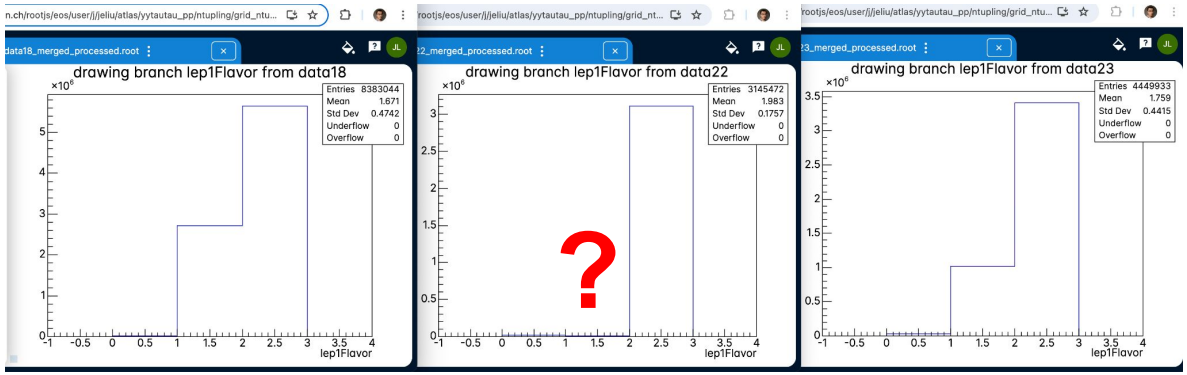
100k events per dataset:

```
data18_13TeV.periodAllYear.physics_Main.PhysCont.DAOD_PHYS.grp18_v01_p6026
data22_13p6TeV.periodAllYear.physics_Main.PhysCont.DAOD_PHYS.grp22_v01_p6029
data23_13p6TeV.periodAllYear.physics_Main.PhysCont.DAOD_PHYS.grp23_v01_p6029
data24_13p6TeV.00474991.physics_Main.deriv.DAOD_PHYS.f1462_m2248_p6142
```

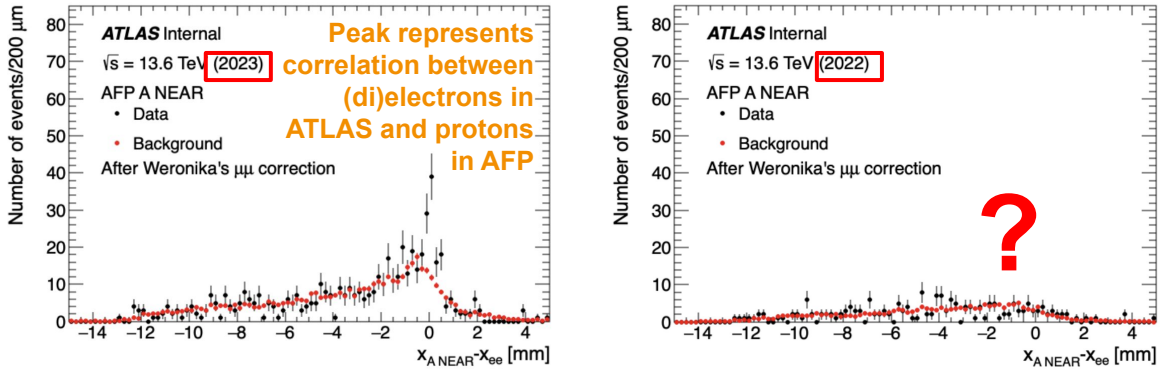
(also testing on mc20 & mc23)

What's going on with electrons..?

- Something funny going on with electrons in STDM7 derivations for 2022 data (not seen in DAOD_PHYS)



- Also issues in AFP global alignment analysis when using electrons (also using STDM7)

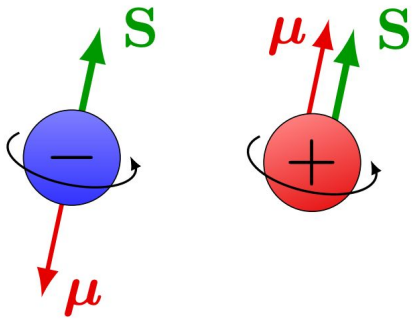


- Bug for electrons in these derivations [ATLASDPD-2055] but shouldn't have much impact here if appropriate electron ID and p_T cuts are applied
- Different electron triggers for 22 and 23, maybe wrongly configured in derivation..?

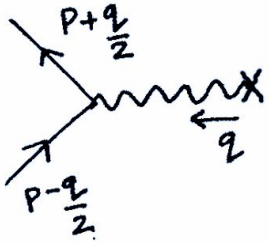
Backup

Lepton magnetic moments

- Lepton spin, **S**, and magnetic moment, **μ**, linked through gyromagnetic factor, **g**
  - → Dirac equation predicts $g = 2$



$$\boldsymbol{\mu} = g\frac{e}{2m}\mathbf{S}$$



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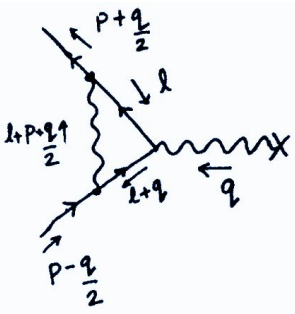
- Quantum corrections give rise to anomalous magnetic moments:

$$a_l = (g - 2) / 2$$



- Leading SM loop correction is the Schwinger term:

$$a_l = \alpha_{\mathrm{EM}} / 2\pi \cong 0.0012$$

+

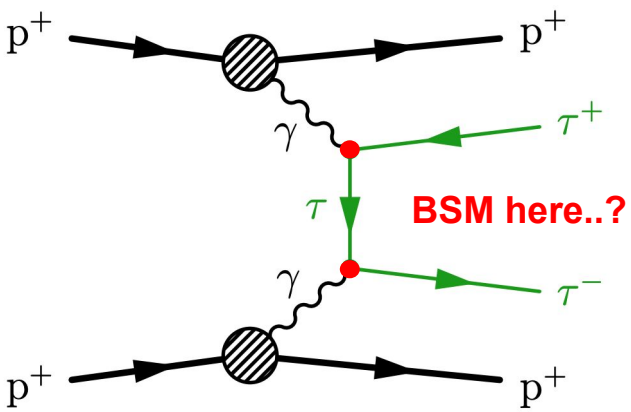
- Electron and muon g-2 among some of the most precisely measured quantities in physics
  - → Interesting tension between experiment and theory in muon g-2

. . .

- Tau g-2 evades precise measurement due to short tau lifetime

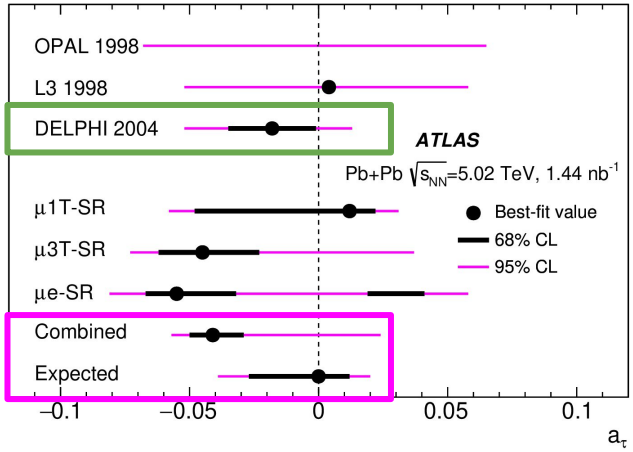
$$a_\tau^{\mathrm{SM}} \cong 0.0018$$

Motivation for yy->tautau in pp analysis



- Precise measurements of EM dipoles are fundamental tests of the SM
- Can probe EM dipoles through $\gamma\gamma \rightarrow \tau\tau$ process
- Existence of tau loop interactions with photons remains strikingly untested
  - ➡ Experimental precision is still far below the Schwinger term!

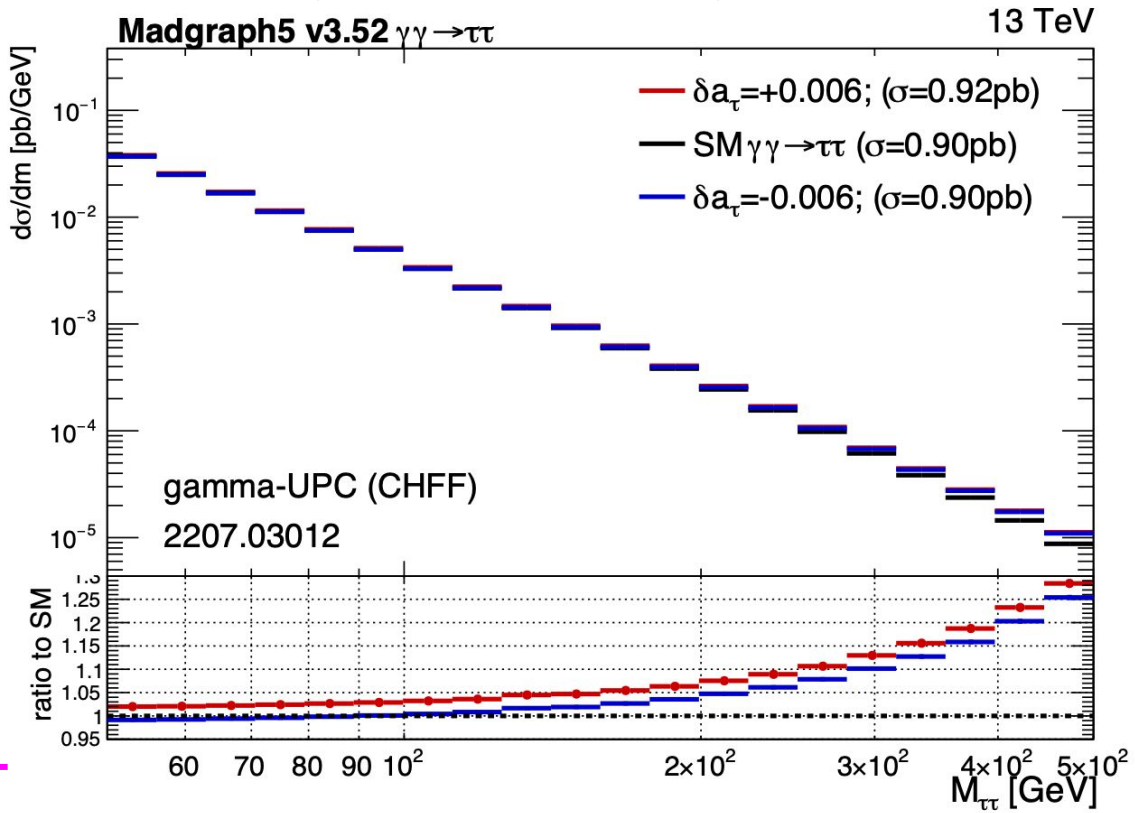
- **Analysis never done before by ATLAS in pp collisions**
  - ➡ Expect SM process to be low-mass, observation of $\gamma\gamma \rightarrow \tau\tau$ already performed in Heavy Ion (HI) collisions by both **ATLAS** [PRL 131 (2023) 151802] and CMS [PRL 131 (2023) 151803]
  - ➡ HI analyses only just approaching same sensitivity to tau g-2 as 20 year old limit set by **DELPHI** [EPJC 35, 159–170 (2004)]
  - ➡ However, **better constraining power on anomalous tau g-2 in pp collisions** due to higher mass reach



Power of pp vs PbPb

- BSM effects are more pronounced at high tau p_T and ditau mass
- Can access much higher mass scales in pp collisions = better constraining power on anomalous g-2

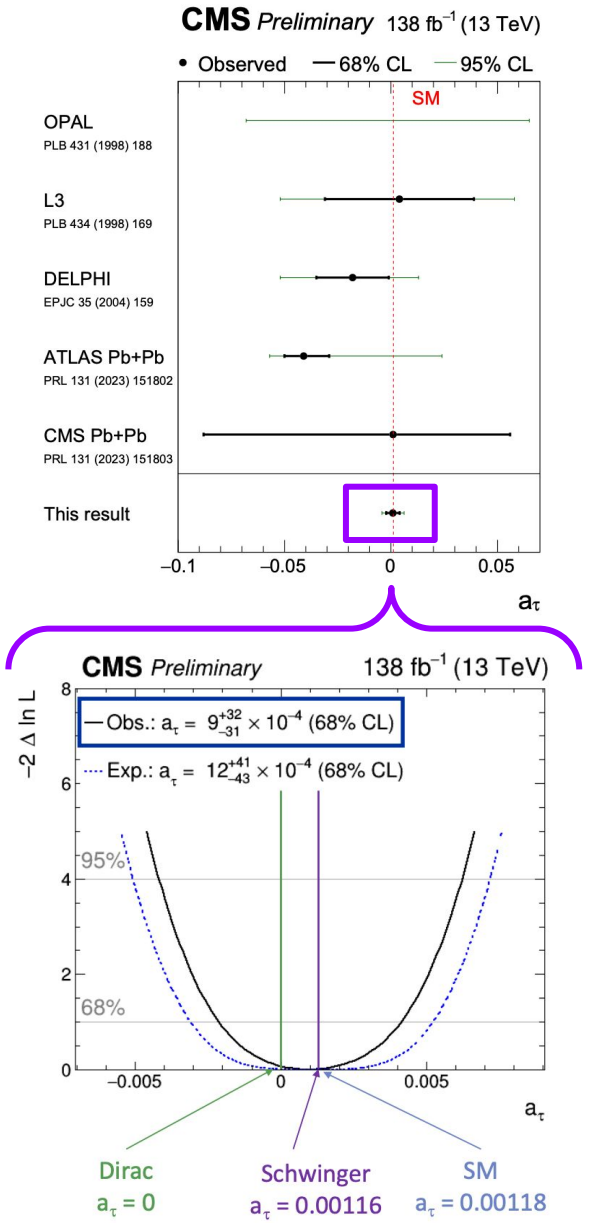
C. Caillol, CERN - LPCC seminar, March 12th 2024



HI analyses can access $m(\tau\tau) \gtrsim 25$ GeV

Motivation: CMS did it already

- Recent Run 2 CMS analysis [CMS-PAS-SMP-23-005], improving 20 year old DELPHI limits on tau g-2 by a **factor of five!!**
  - ➞ Observed the $\gamma\gamma \to \tau\tau$ process in pp collisions with an observed (expected) significance of 5.3σ (6.5 σ)
  - ➞ Analysis uses many **methods from ATLAS $\gamma\gamma \to WW$ observation** [PLB 816 (2021) 136190] related to charged particle multiplicity (Nch) corrections and signal modelling
  - ➞ Precision on tau g-2 still 3x Schwinger term
- **Need an ATLAS pp analysis** to compete with (and hopefully improve on) the CMS tau g-2 limits
- Complementary high-mass measurement of the $\gamma\gamma \to \tau\tau$ process, in addition to ATLAS HI results



Pinning down tau g-2

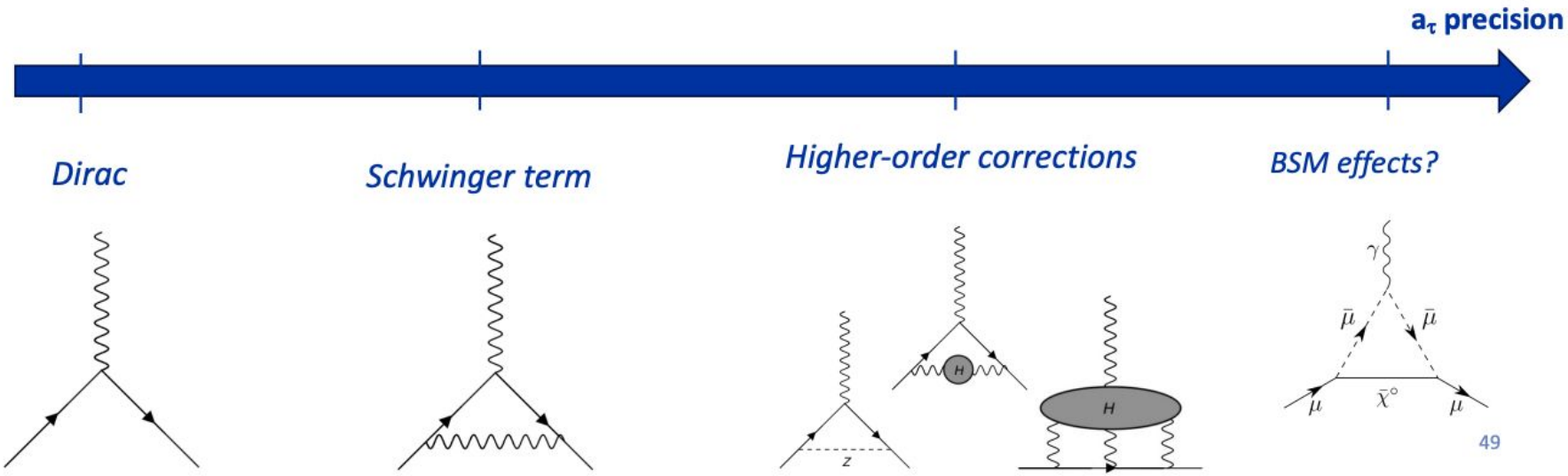
C. Caillol, CERN - LPCC seminar, March 12th 2024

The precision journey has just started...

DELPHI
OPAL
Pb-Pb LHC

CMS pp
Approaching the
Schwinger term!

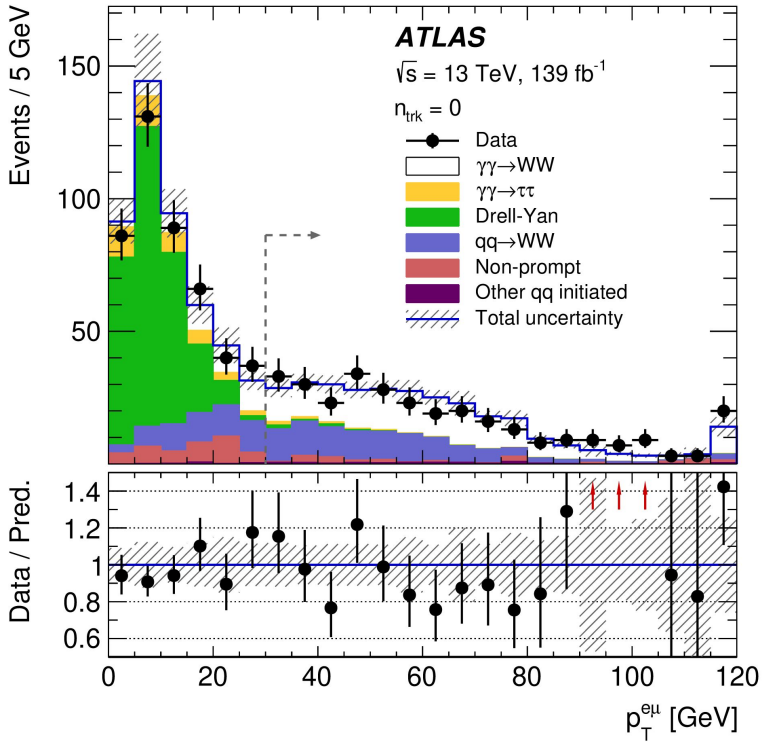
More precision needed to probe BSM effects scaling with m_ℓ^2...



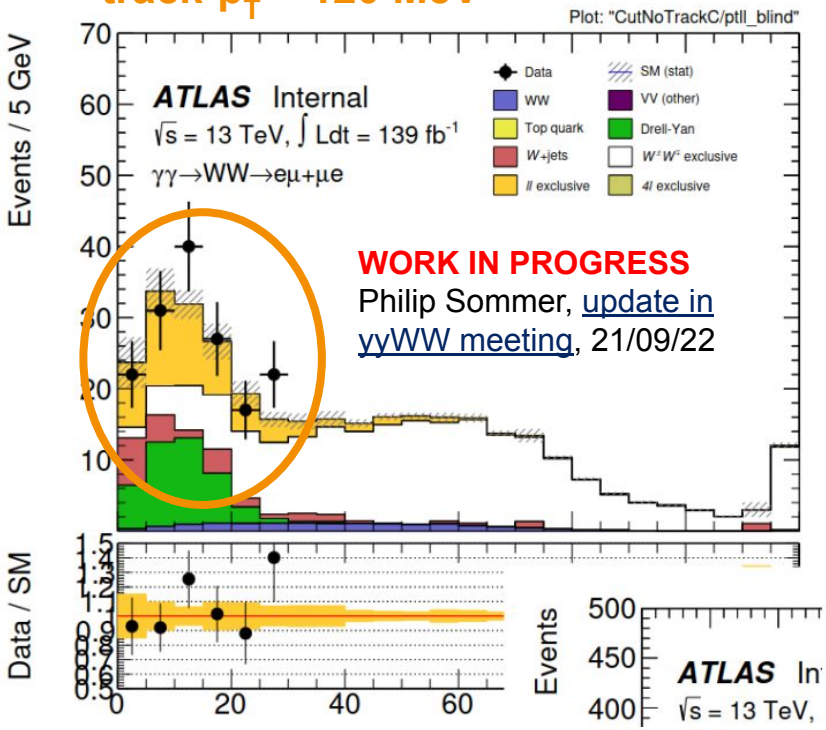
Impact of low-p_T tracking in $\gamma\gamma \rightarrow WW$

- Can already see $\gamma\gamma \rightarrow \tau\tau$ in the $\gamma\gamma \rightarrow WW$ analysis control region!
- Would be nice to add in low-pT tracking but currently only validated in rel21 Run 2 data
- Already interest from other analyses in migrating low-pt tracking framework to rel22+ Run 3

$\gamma\gamma \rightarrow WW$ observation,
track-p_T > 500 MeV



$\gamma\gamma \rightarrow WW$ differential measurement,
track-p_T > 120 MeV

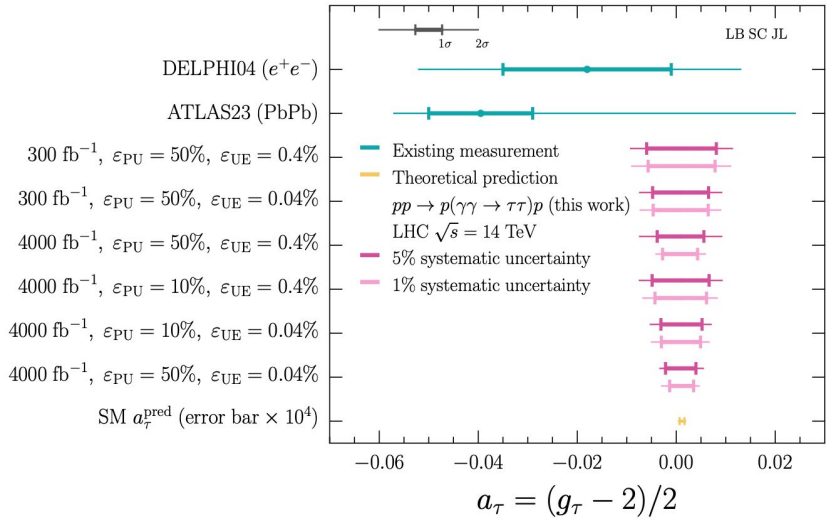


Mostly $\gamma\gamma \rightarrow \tau\tau$ events

Beresford, Clawson, Liu - pheno study

- Studying prospects of measuring $\gamma\gamma \to \tau\tau$ in pp collisions, combined Run 2+3 and HL-LHC
  - Fully-leptonic only, eμ
  - Only considering elastic signal for tau *g-2* limits, to enforce $q^2 \approx 0$
  - Interfacing SMEFTsim with MadGraph3.5 for cross-section calculation and MC event simulation
  - Comparing different efficiencies of pileup and underlying event tracks passing track veto

arXiv:2403.06336



Kinematic distributions after basic dilepton selection and track veto, motivating selections: