Production of a pair of τ leptons via photon-photon fusion and probing tau g-2

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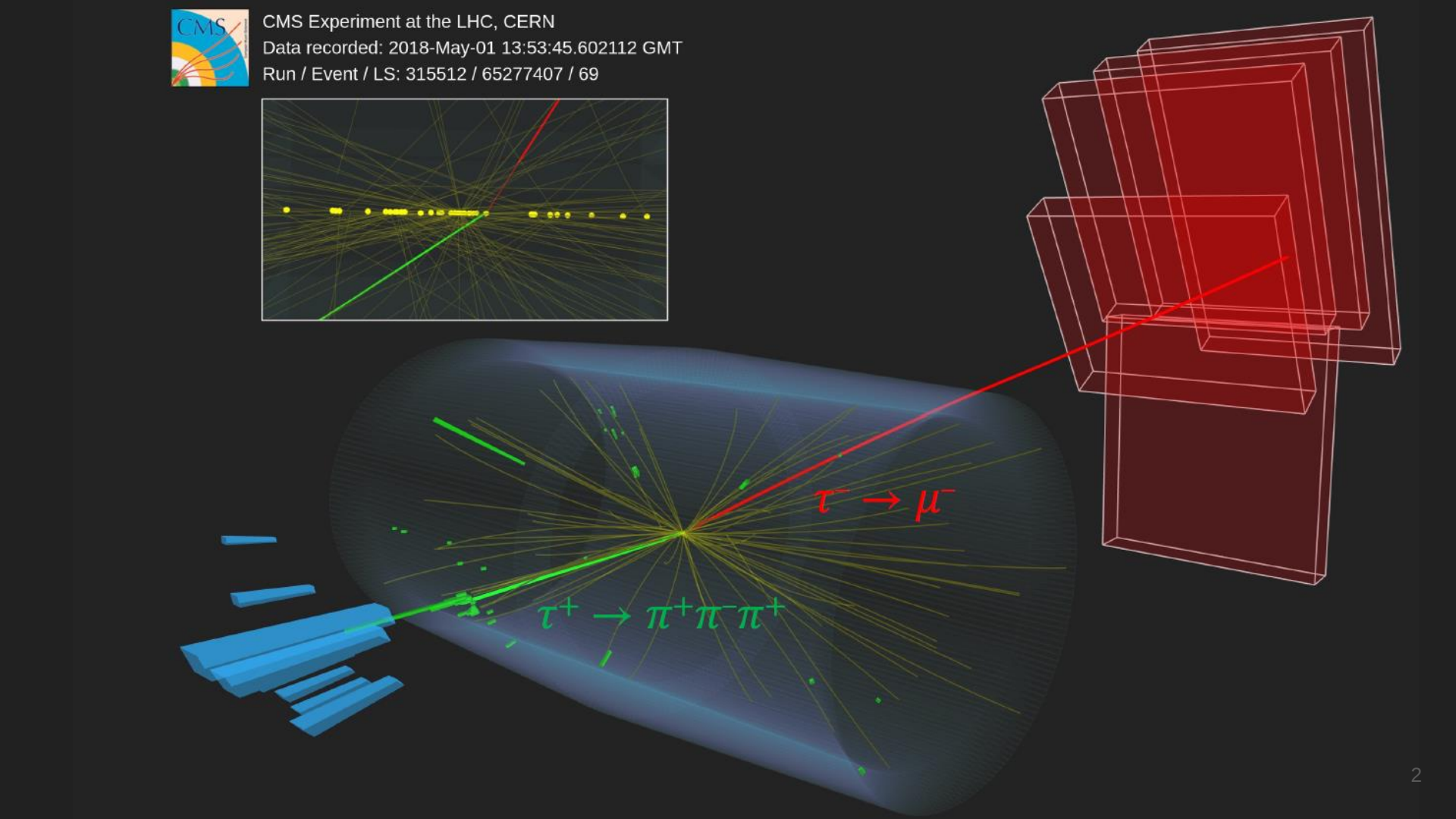
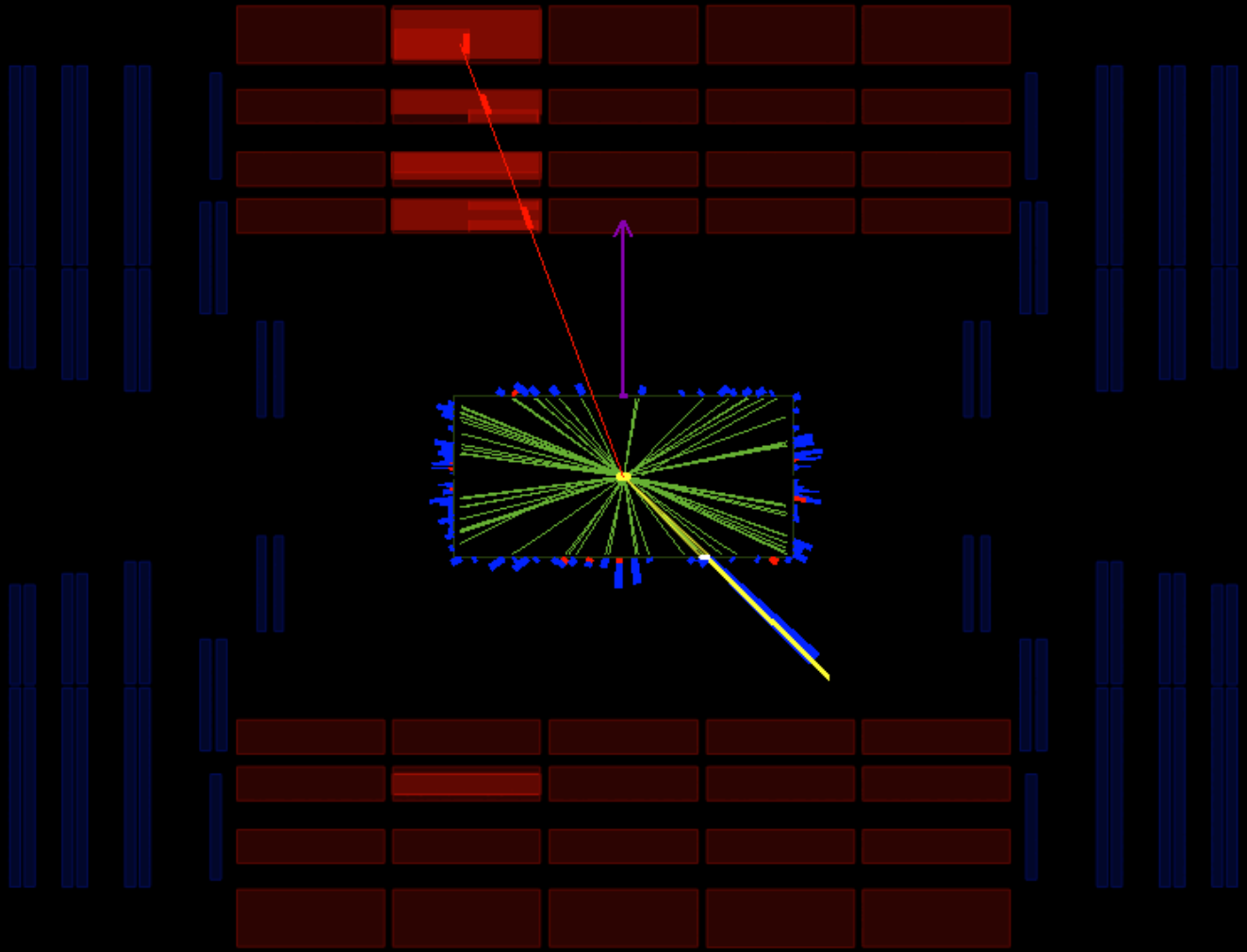
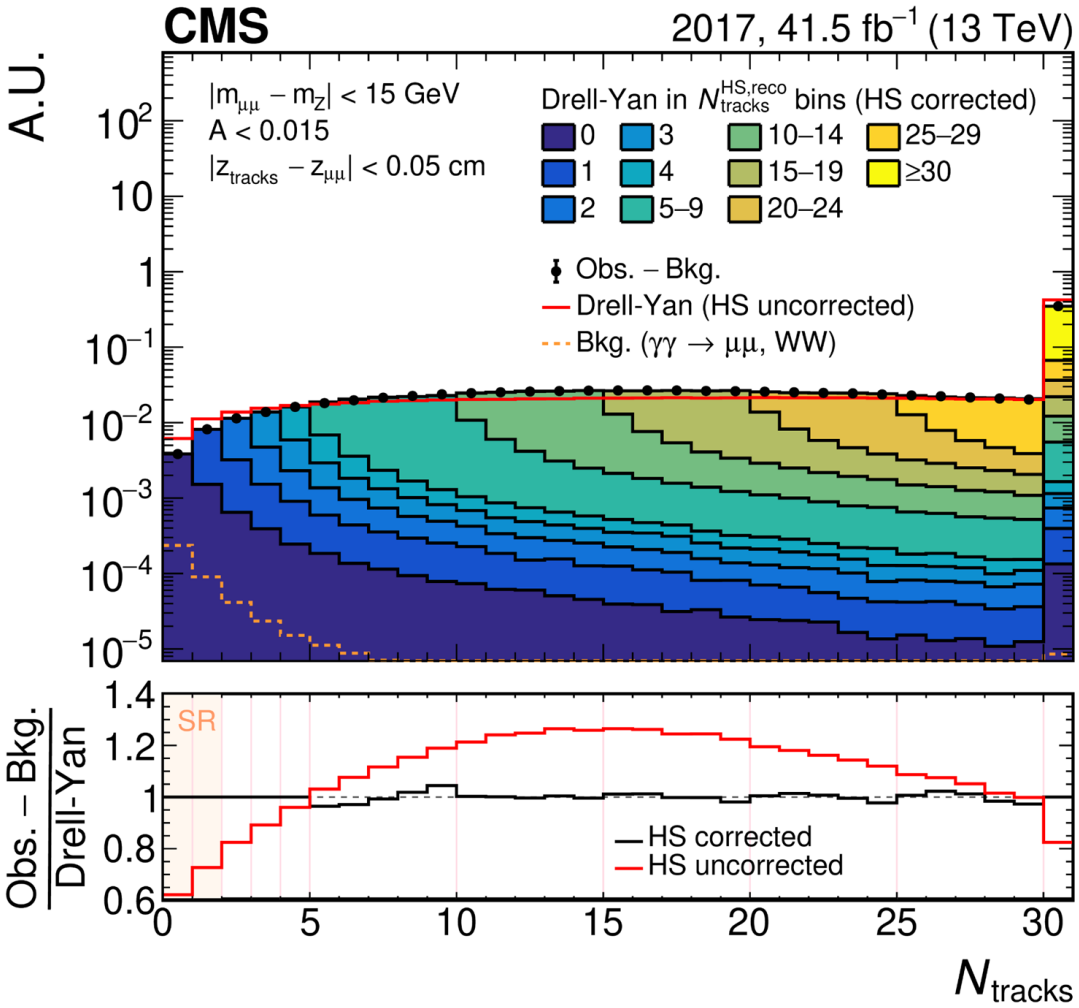
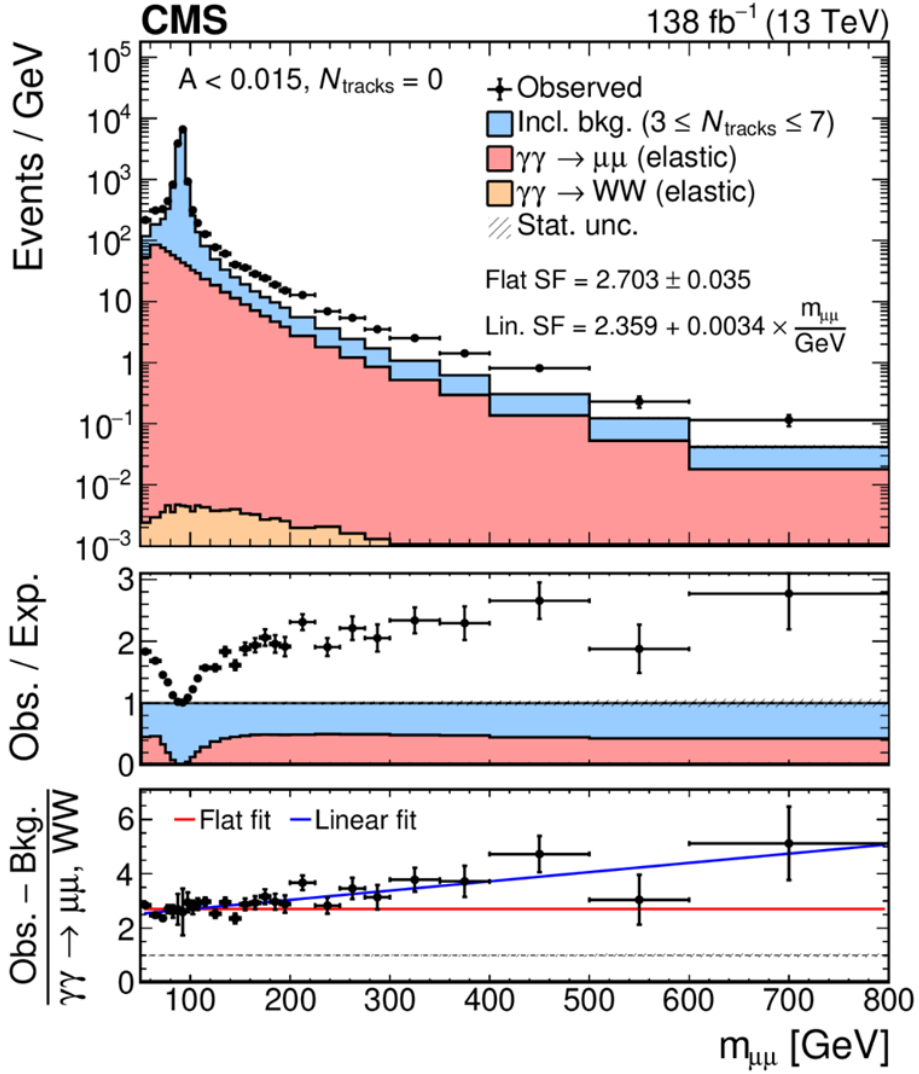
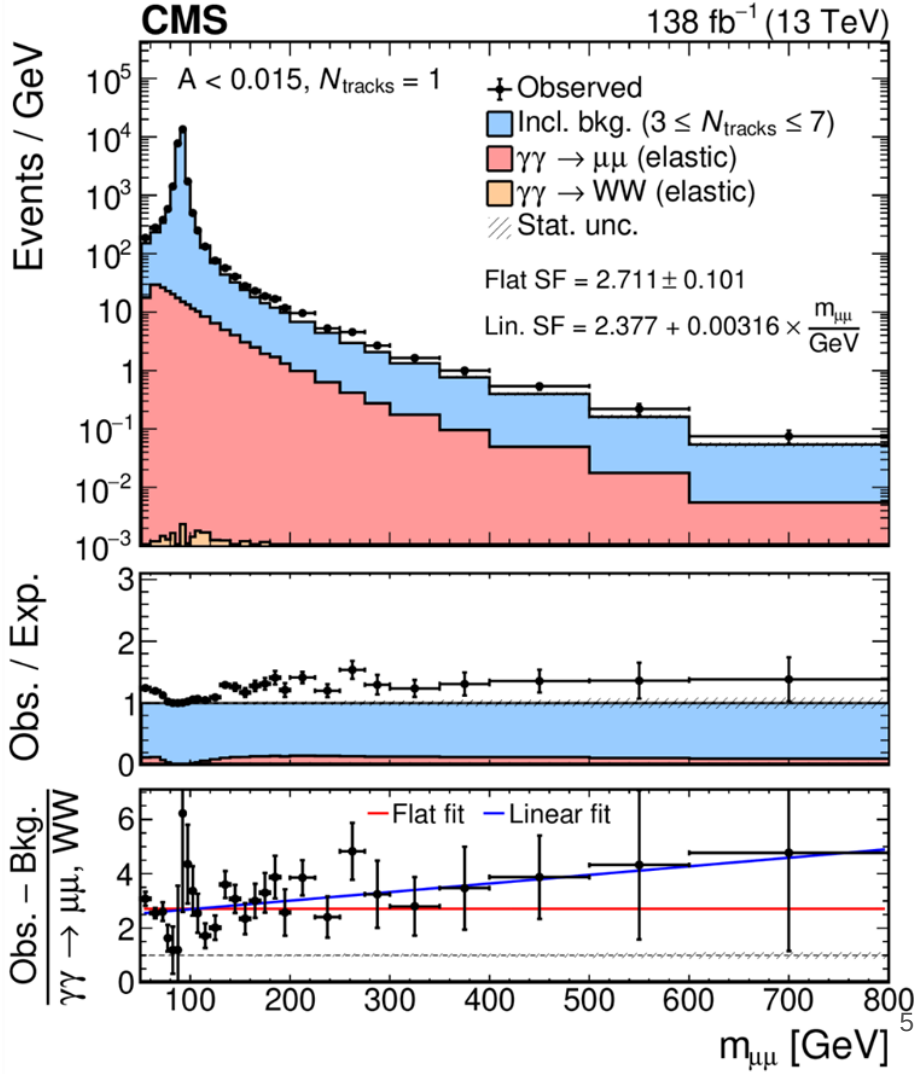
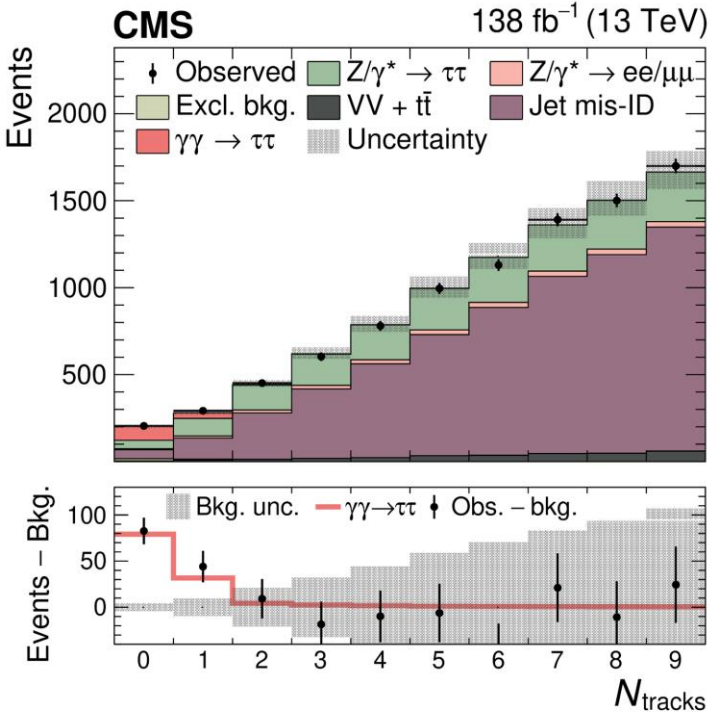

CMS Experiment at the LHC, CERN
Data recorded: 2018-May-01 13:53:45.602112 GMT
Run / Event / LS: 315512 / 65277407 / 69
$\tau^- \to \mu^-$
$\tau^+ \to \pi^+\pi^-\pi^+$

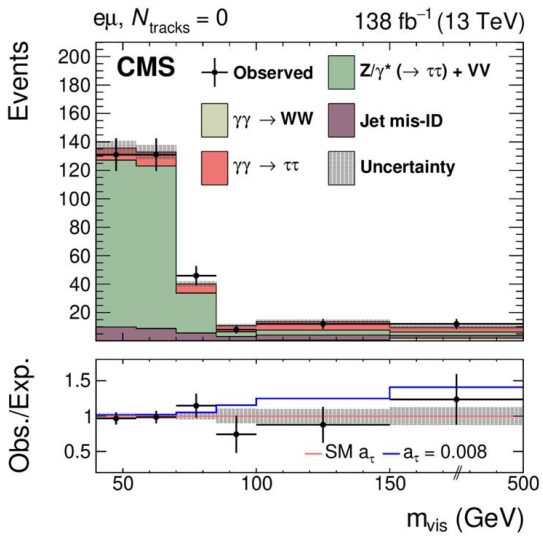


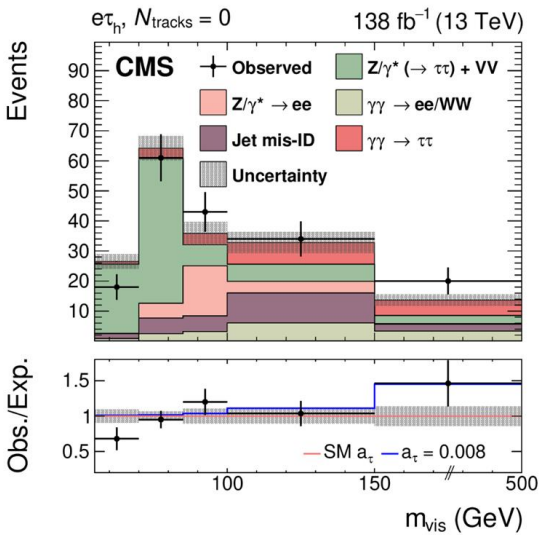

CMS
2017, 41.5 fb^{-1} (13 TeV)
A.U.
$|m_{\mu\mu} - m_Z| < 15$ GeV
A < 0.015
$|z_{tracks} - z_{\mu\mu}| < 0.05$ cm
Drell-Yan in $N_{tracks}^{HS,reco}$ bins (HS corrected)
0
1
2
3
4
5–9
10–14
15–19
20–24
25–29
≥30
Obs. – Bkg.
Drell-Yan (HS uncorrected)
Bkg. ($\gamma\gamma \rightarrow \mu\mu$, WW)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
SR
Obs. – Bkg. / Drell-Yan
1.4
1.2
1
0.8
0.6
HS corrected
HS uncorrected
0
5
10
15
20
25
30
N_{tracks}

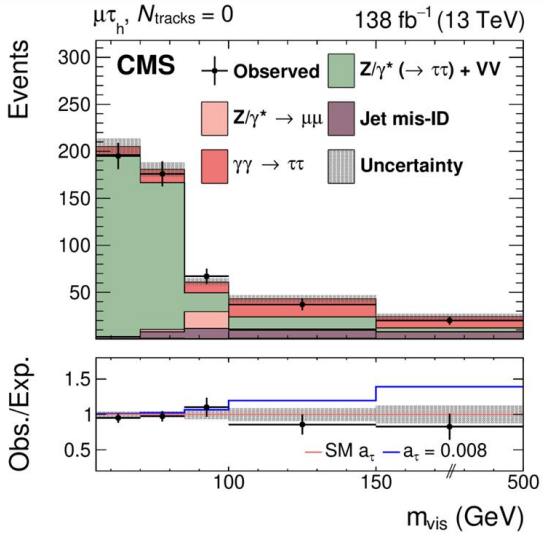

CMS
138 fb^{-1} (13 TeV)
A < 0.015, N_{tracks} = 0
Observed
Incl. bkg. (3 ≤ N_{tracks} ≤ 7)
γγ → μμ (elastic)
γγ → WW (elastic)
Stat. unc.
Flat SF = 2.703 ± 0.035
Lin. SF = 2.359 + 0.0034 × $m_{\mu\mu}$/GeV
Events / GeV
Obs. / Exp.
Obs. − Bkg. / γγ → μμ, WW
Flat fit
Linear fit
$m_{\mu\mu}$ [GeV]

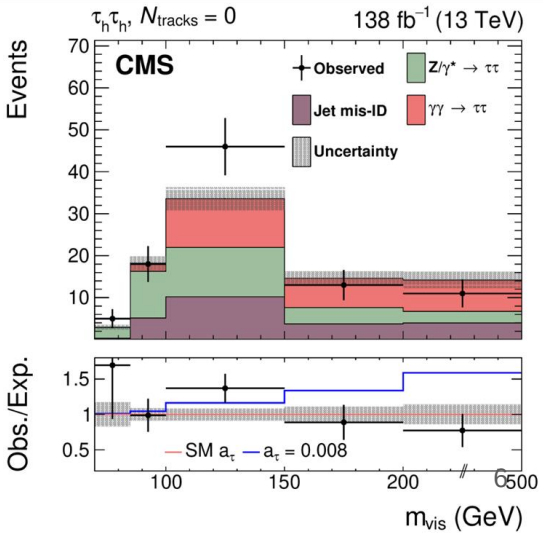

CMS
138 fb^{-1} (13 TeV)
A < 0.015, N_{tracks} = 1
Observed
Incl. bkg. (3 ≤ N_{tracks} ≤ 7)
γγ → μμ (elastic)
γγ → WW (elastic)
Stat. unc.
Flat SF = 2.711 ± 0.101
Lin. SF = 2.377 + 0.00316 × $m_{\mu\mu}$/GeV
Events / GeV
Obs. / Exp.
Obs. − Bkg. / γγ → μμ, WW
Flat fit
Linear fit
$m_{\mu\mu}$ [GeV]

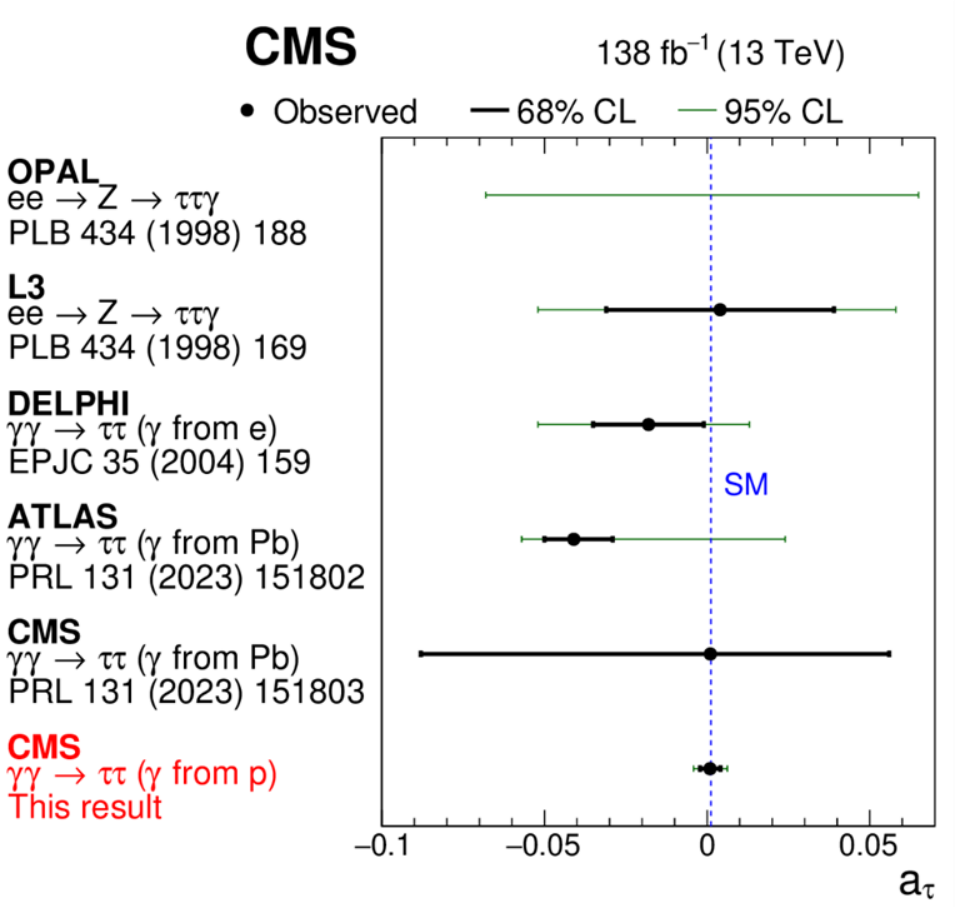

CMS
138 fb^{-1} (13 TeV)
Observed
Excl. bkg.
γγ → ττ
Z/γ* → ττ
VV + tt̄
Z/γ* → ee/μμ
Jet mis-ID
Uncertainty
Events
Bkg. unc.
γγ→ττ
Obs. − bkg.
Events − Bkg.
N_{tracks}

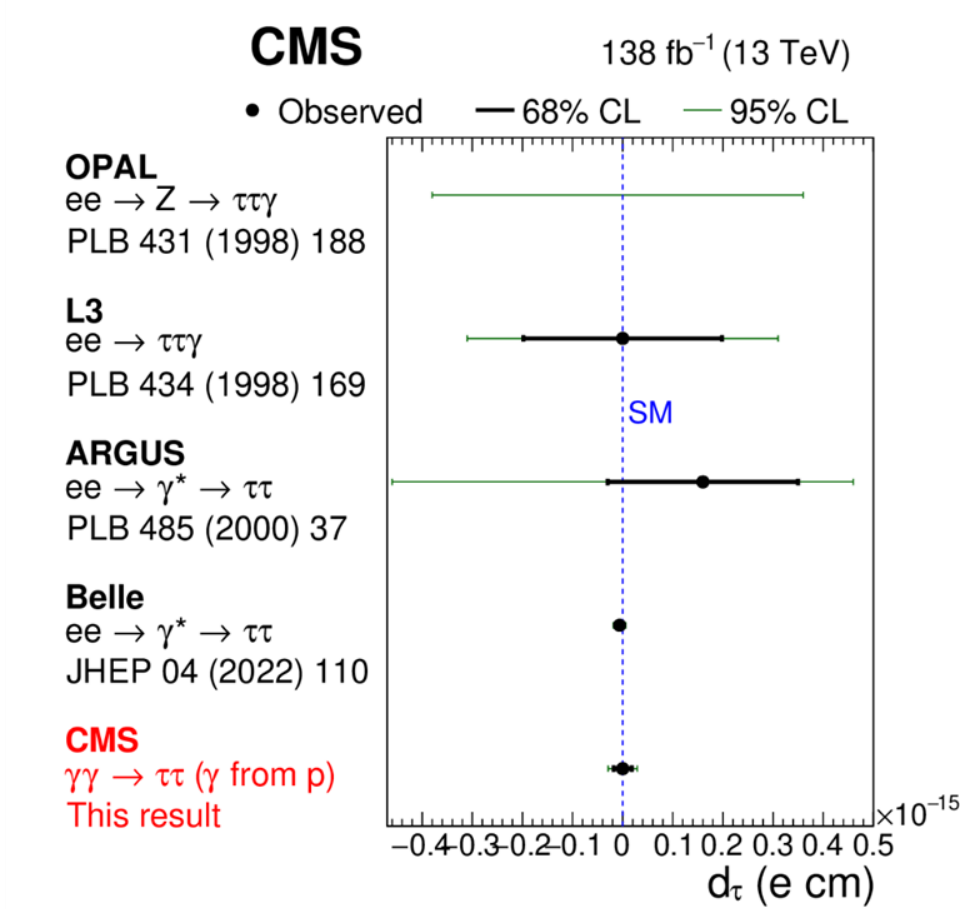

eμ, N_{tracks} = 0
138 fb^{-1} (13 TeV)
CMS
Observed
Z/γ* (→ ττ) + VV
γγ → WW
Jet mis-ID
γγ → ττ
Uncertainty
Events
Obs./Exp.
SM a_τ
a_τ = 0.008
m_{vis} (GeV)


eτ$_h$, N_{tracks} = 0
138 fb^{-1} (13 TeV)
CMS
Observed
Z/γ* (→ ττ) + VV
Z/γ* → ee
γγ → ee/WW
Jet mis-ID
γγ → ττ
Uncertainty
Events
Obs./Exp.
SM a_τ
a_τ = 0.008
m_{vis} (GeV)


μτ$_h$, N_{tracks} = 0
138 fb^{-1} (13 TeV)
CMS
Observed
Z/γ* (→ ττ) + VV
Z/γ* → μμ
Jet mis-ID
γγ → ττ
Uncertainty
Events
Obs./Exp.
SM a_τ
a_τ = 0.008
m_{vis} (GeV)

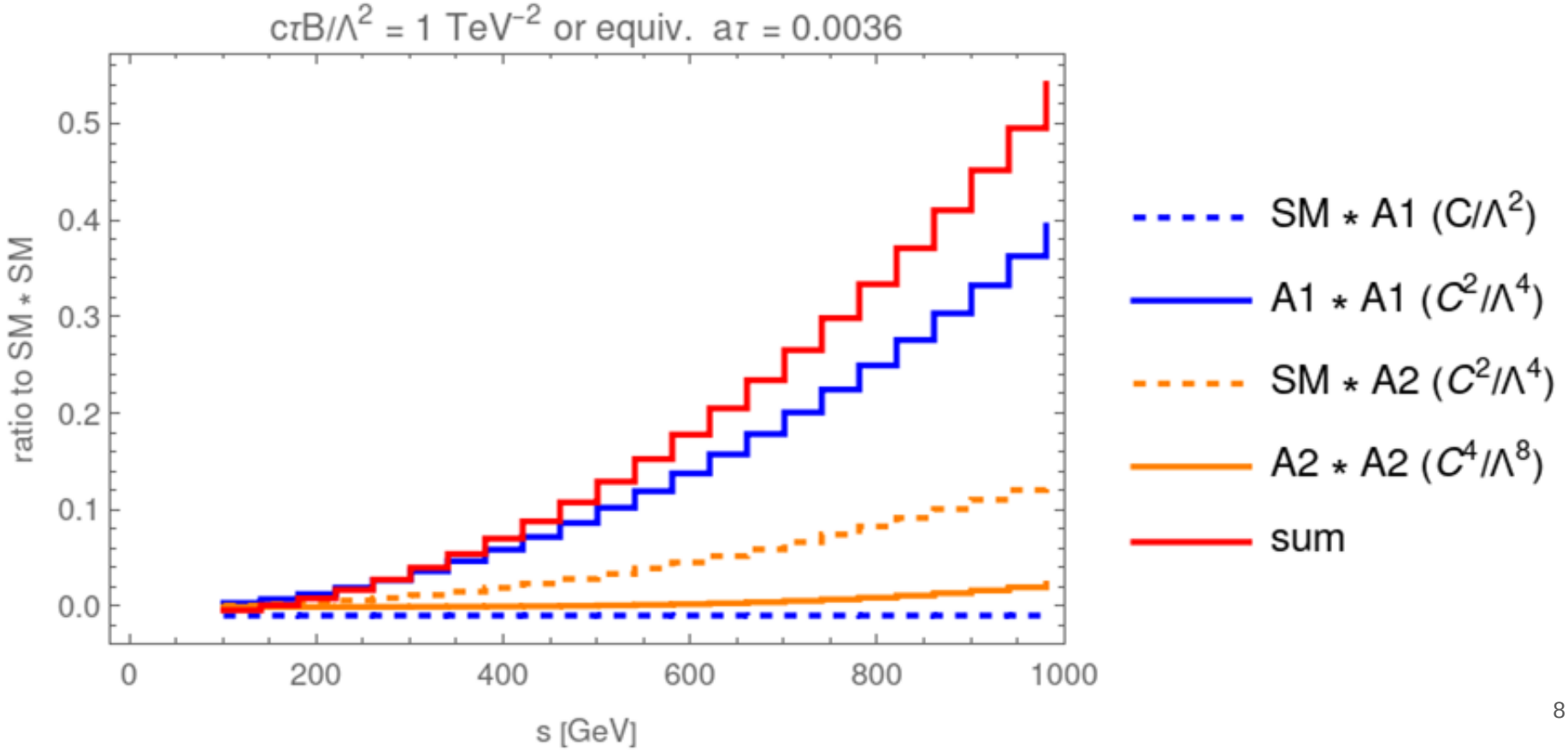

τ$_h$τ$_h$, N_{tracks} = 0
138 fb^{-1} (13 TeV)
CMS
Observed
Z/γ* → ττ
Jet mis-ID
γγ → ττ
Uncertainty
Events
Obs./Exp.
SM a_τ
a_τ = 0.008
m_{vis} (GeV)



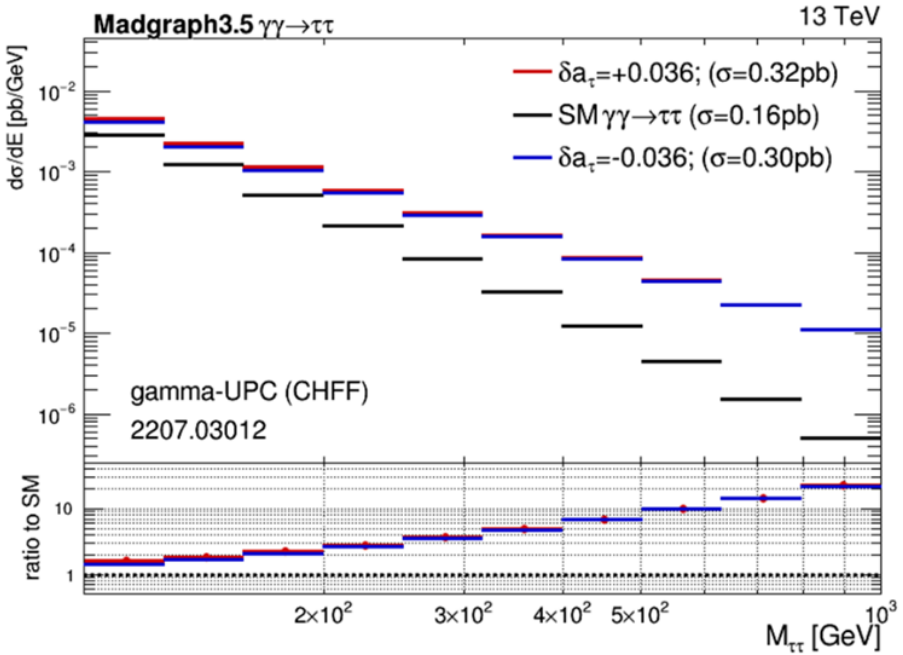


"It would be very nice to measure μ_τ with enough precision to check this [Schwinger term], as it was checked for the e and the μ years ago. At present such precision is a dream. The best that has been done so far is to use the decay $Z^0 \to \tau\tau\gamma$." (M. L. Perl, WEIN symposium, June 1998)

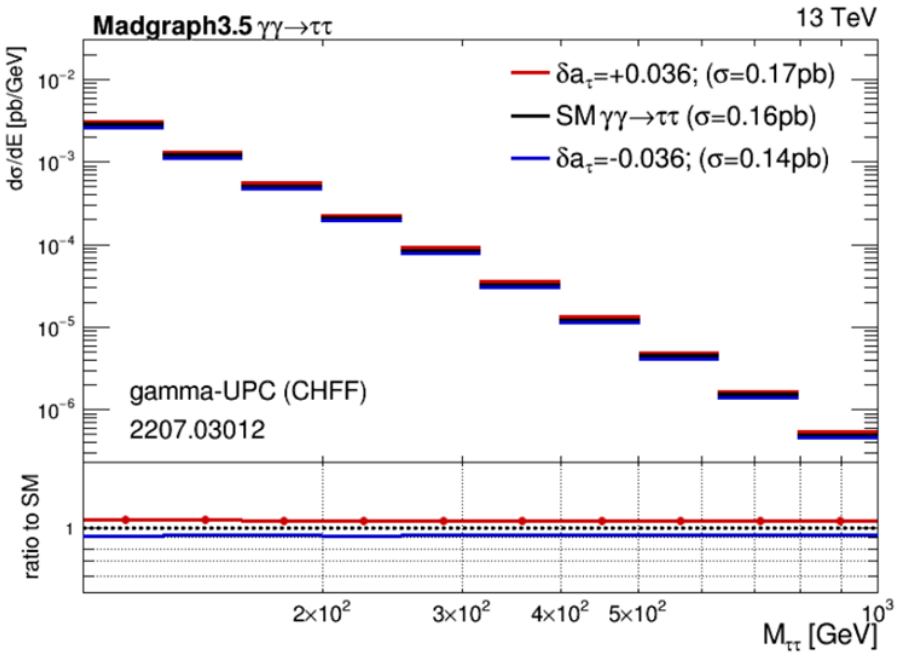
$\gamma\gamma \to \tau^+\tau^-$ tree-level, truth-level, no cuts or acceptances



$\gamma\gamma \to \tau^+\tau^-$ tree-level, truth-level, MadGraph simulation
1 insertion only: dominated by $|A_1|^2$



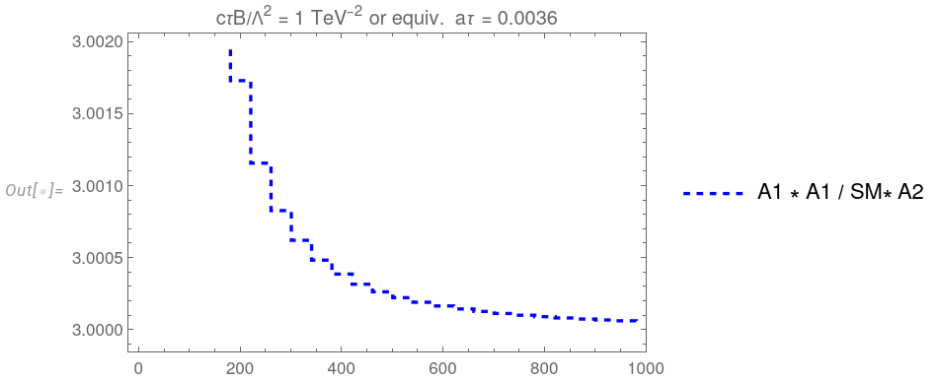
$$A^2 = (A_{SM} + A_1)^2$$



$$A^2 = (A_{SM} + A_1)^2 - |A_1|^2$$

$\gamma\gamma \to \tau^+\tau^-$ tree-level, truth-level, no cuts or acceptances

$m\tau \neq 0$



$m\tau = 0$ limit

$$|A_{SM}|^2 = 8e^4 \frac{5(t^2+u^2)+8tu}{tu}$$

$$|A_1|^2 = 96s \frac{v^2 |C_{\tau\gamma}|^2}{\Lambda^4}$$

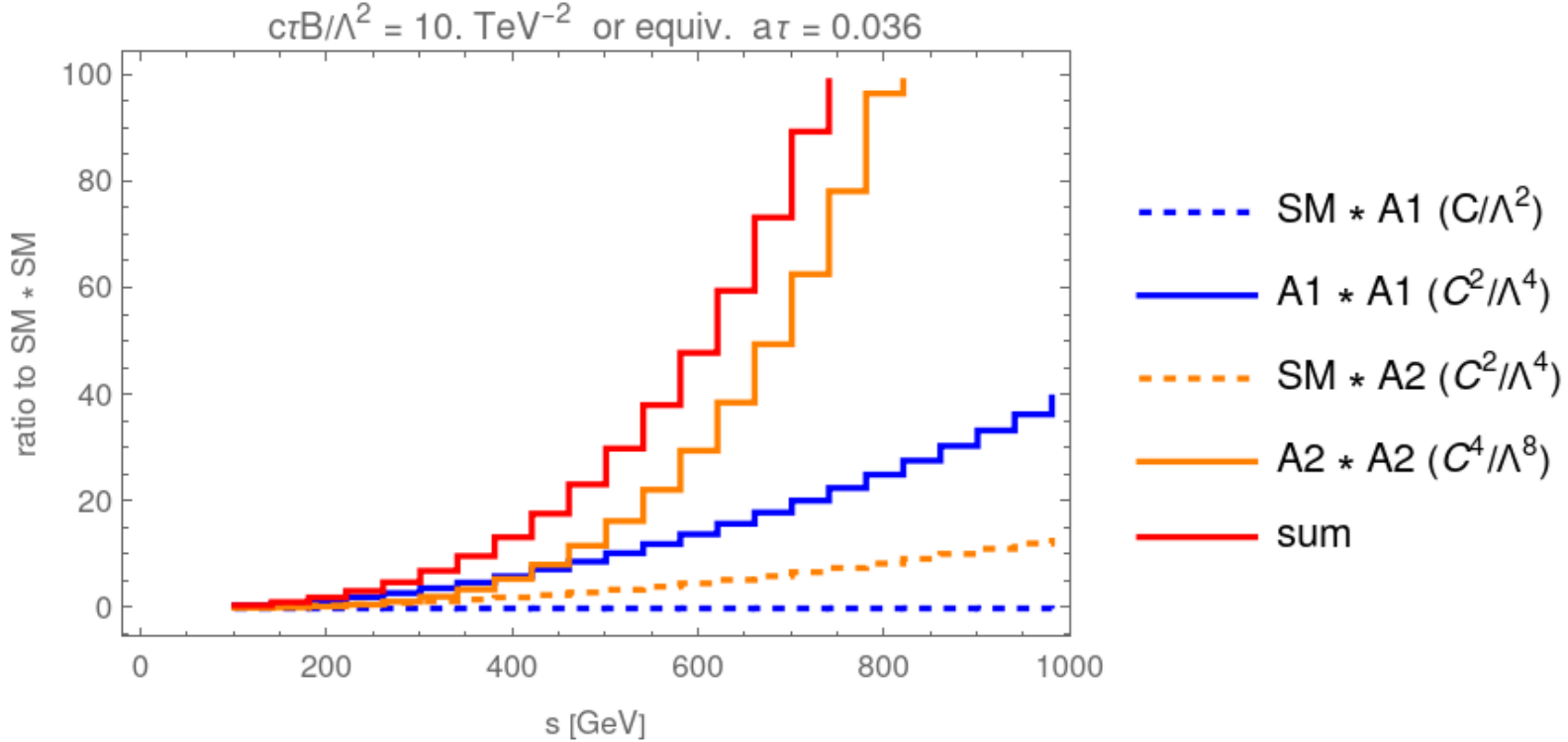
$$2\Re(A_{SM} A_2^\dagger) = 32s \frac{v^2 |C_{\tau\gamma}|^2}{\Lambda^4}$$

$$|A_2|^2 = 64tu \frac{v^4 |C_{\tau\gamma}|^4}{\Lambda^8}$$

$$2\Re(A_{SM} A_1^\dagger) = 0 \qquad 2\Re(A_1 A_2^\dagger) = 0$$

$\gamma\gamma \to \tau^+\tau^-$ tree-level, truth-level, no cuts or acceptances

Out[•]=



Further reading:

- CEP di-tau in and g-2 pp with proton tag:
  - S. Atag, A.A. Billur (1005.2841)
- CEP di-tau and g-2 in pp w/o proton tag:
  - L. Beresford, S. Clawson, J. Liu (2403.06336)
- CEP di-tau and g-2 in PbPb:
  - L. Beresford, J. Liu (1908.05180),
  - M. Dyndal, M. Klusek-Gawenda, M. Schott A. Szczurek (2002.05503),
  - N. Burmasov, E. Kryshen, P. Buehler, R. Lavicka (2203.00990)
- Inclusive di-tau and g-2 in pp:
  - U. Haisch, L. Schnell, J. Weiss (2307.14133)
- Inclusive di-tau and g-2 in ee:
  - R. Escribano, E. Massó (PLB 301 (1993), 419)
- SMEFTsim package: I. Brivio, Y. Jiang, M. Trott (1709.06492)
- CMS result: SMP-23-005