Measurement of photon-induced processes with the CMS detector

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Outline

- Introduction
- $\gamma\gamma \to \tau\tau$ and τ anomalous electromagnetic moments constraints

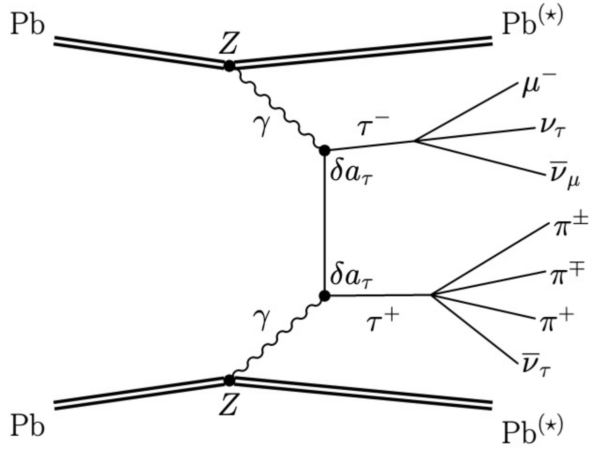
  based on CMS-PAS-HIN-24-011, Rep. Prog. Phys. 87 (2024) 107801
- $\gamma\gamma \to WW$ and quartic coupling constraints

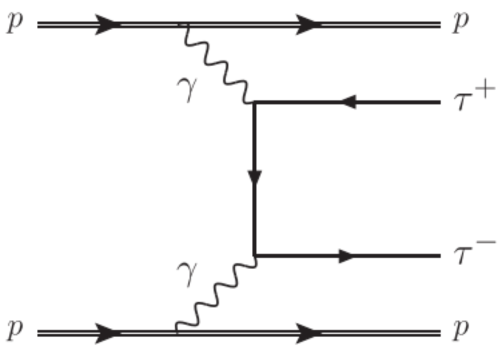
  based on CMS-PAS-SMP-24-019

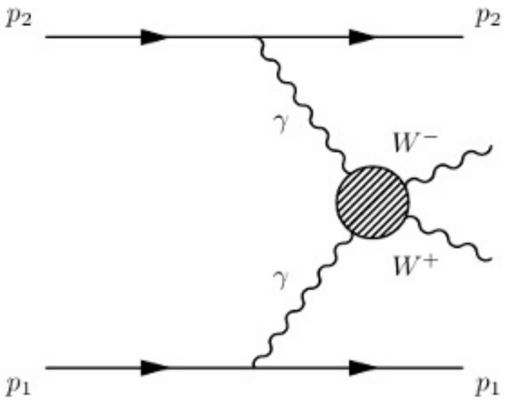
  New!
- Summary

Photon-induced Processes

- Provide a **pure electroweak** environment
- $\sigma(\gamma\gamma) \propto \log^3(\sqrt{S})$
- $\sigma(\gamma\gamma) \propto Z^4$
- **Quasi-real photon,** $q^2 \approx 0$
- $m_{\tau\tau}$O(10GeV) @ PbPb 5.02TeV
  $m_{\tau\tau}$O(100GeV) @ pp 13TeV
- Process signature:
  -Large impact parameter (b) →no Multi-Parton Interaction
  -opposite sign(OS) and back to back $W^{\pm}W^{\mp}/\tau^{\pm}\tau^{\mp}$

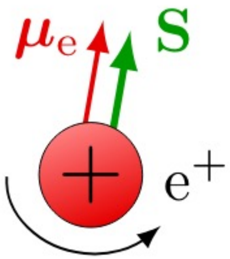






$\gamma\gamma \to \tau\tau$ and τ anomalous magnetic moments constraints

Anomalous Electromagnetic Moments of τ



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

$$a_l = \frac{g_l - 2}{2}$$

- Measurements of (g-2)$_e$ agreement with SM of 12 significant digits
- Many BSMs predict the enhancement of τ

  e.g. Yukawa-like coupling: $\frac{m_\tau^2}{m_\mu^2} \approx 280$

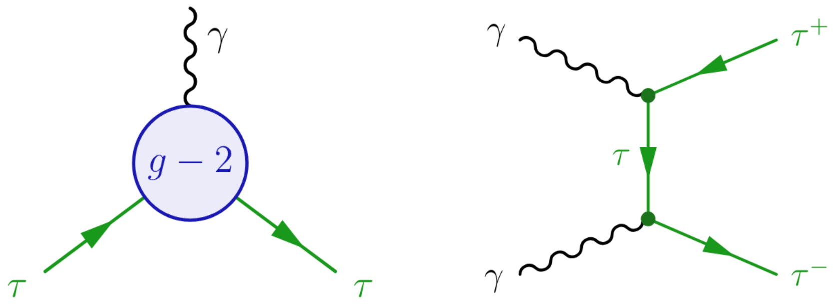
  ⟹probe for New Physics
- Constraints on (g-2)$_\tau$ in e^+e^- collisions:

  -DELPHI@LEP: $-0.052 < a_\tau < 0.013$ (95%CL)

d_τ: edm, electric dipole moment of τ

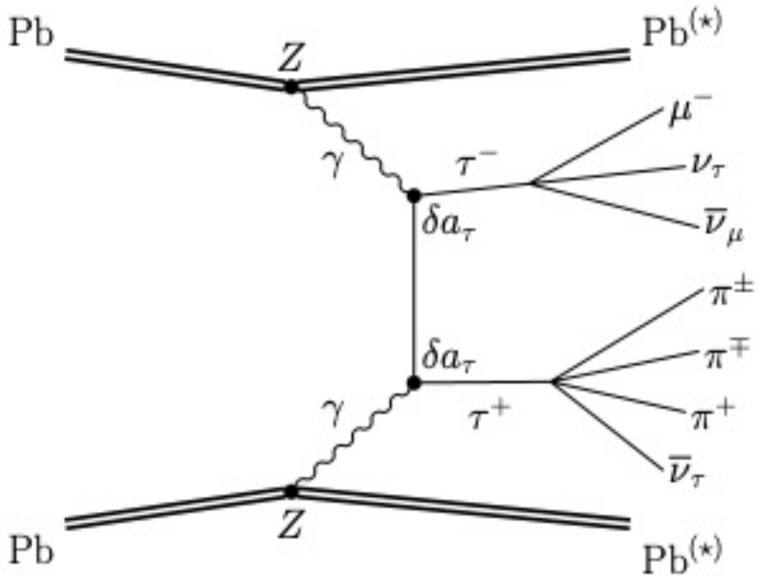
CP violation in CKM:
$d_\tau^{SM} \approx 10^{-37}$ ecm

some BSMs predict:
$d_\tau \approx 10^{-19}$ ecm



- a_τ and d_τ can be probed from γττ vertex
- $\gamma\gamma \to \tau\tau$ process contains 2 γττ vertices
- Constraints on electromagnetic moments a_τ & d_τ with SMEFT

$\gamma\gamma \to \tau\tau$ in Pb-Pb collisions at $\sqrt{s}$=5.02TeV with integrated luminosity = $1.7nb^{-1}$



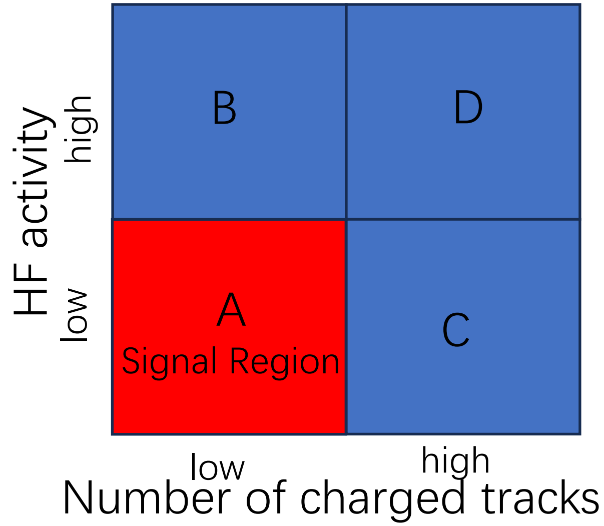
CMS-PAS-HIN-24-011

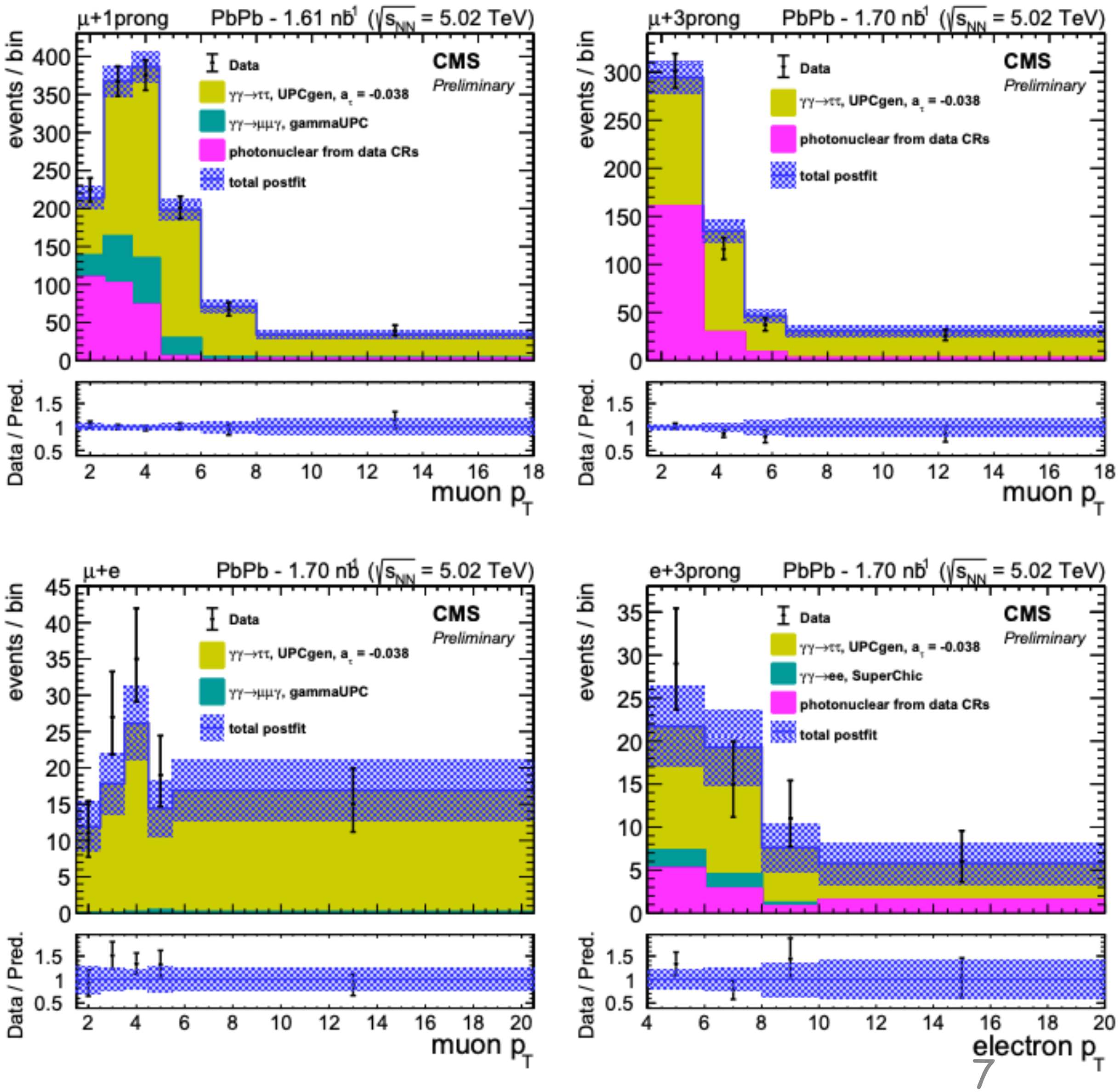
Analysis Overview

Phys. Rev. Lett. 131 (2023) 151803

- Final states: μ+3prong, μ+1prong, μ+e, e+3prong
- Integrated Luminosity: $1.7nb^{-1}$ ($404\ \mu b^{-1}$ in the previous study)
- **Gain from Z^4 enhancement, Low pileup, Low background**
- Estimate background with data-driven method

Forward Hadron Calorimeter



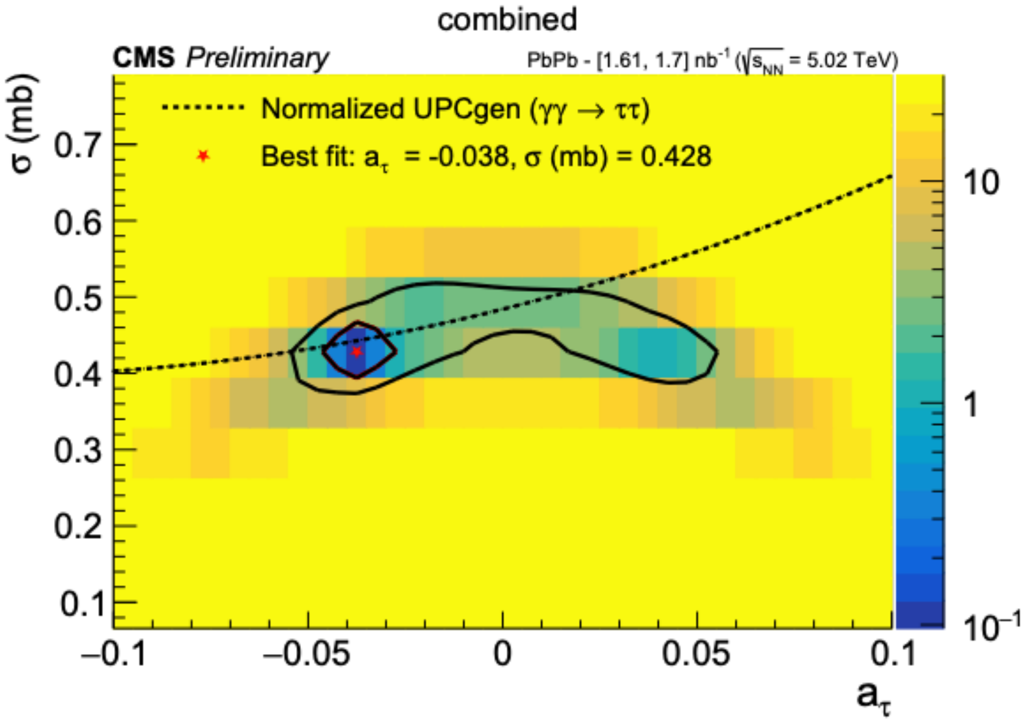


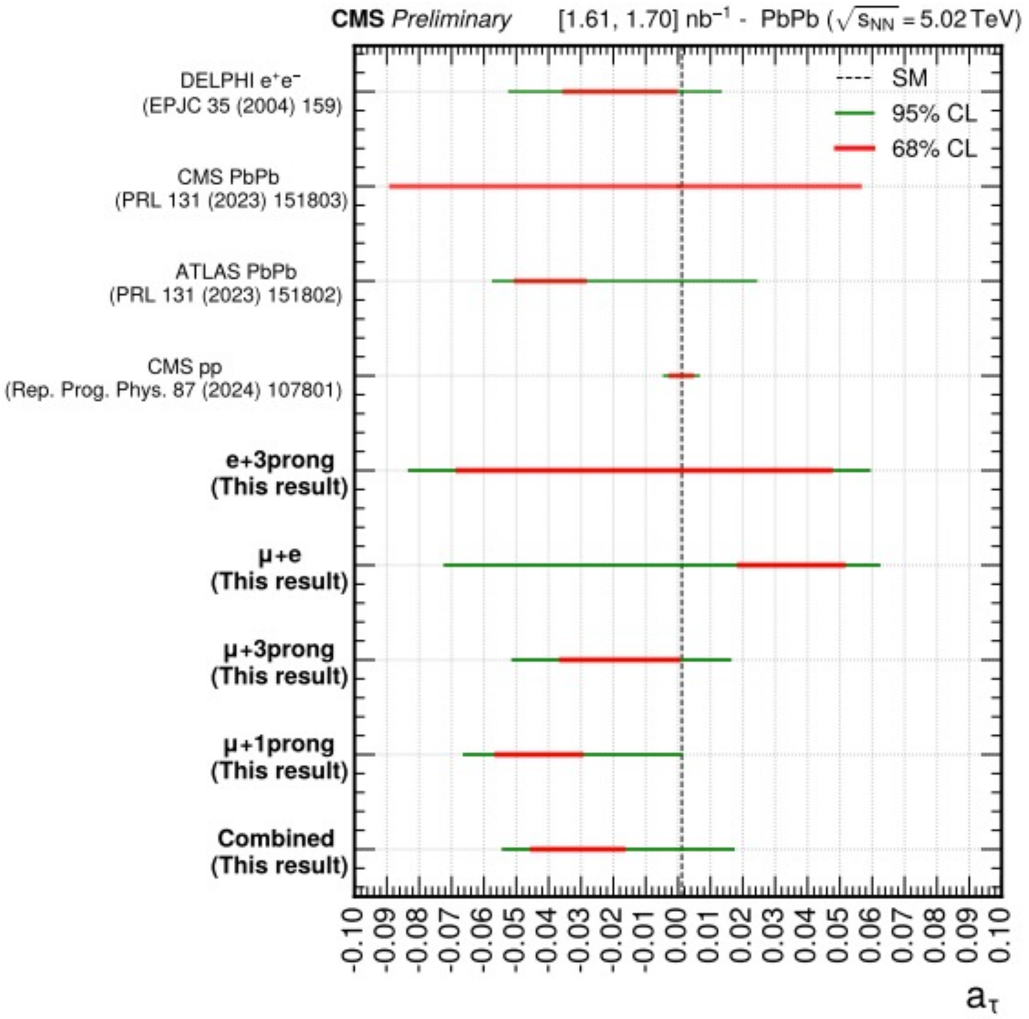
Fiducial selections:

- $\tau\ p_T$>1GeV
- $\tau\ |\eta|$<3

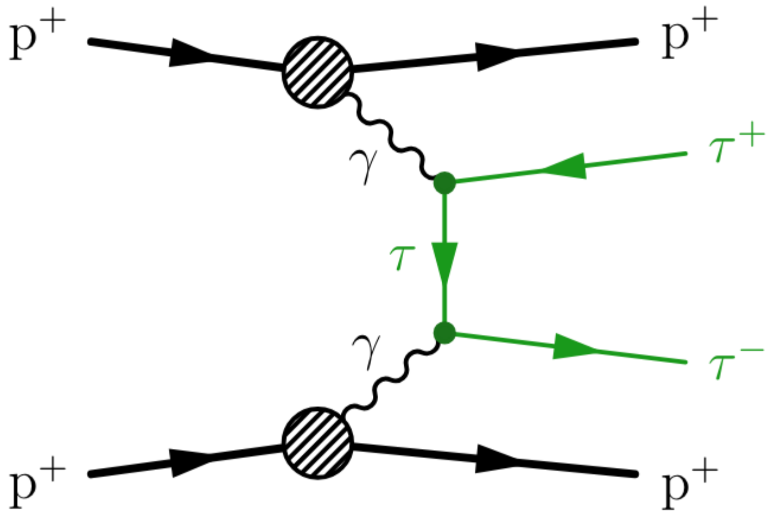
$\sigma^{fiducial} = 447^{+16}_{-11}\mu b$

$a_\tau = -35^{+18}_{-10} \times 10^{-3}$





$\gamma\gamma \rightarrow \tau\tau$ in pp collisions at $\sqrt{s}$=13TeV with integrated luminosity = 138 fb^{-1}



Rep. Prog. Phys. 87 (2024) 107801

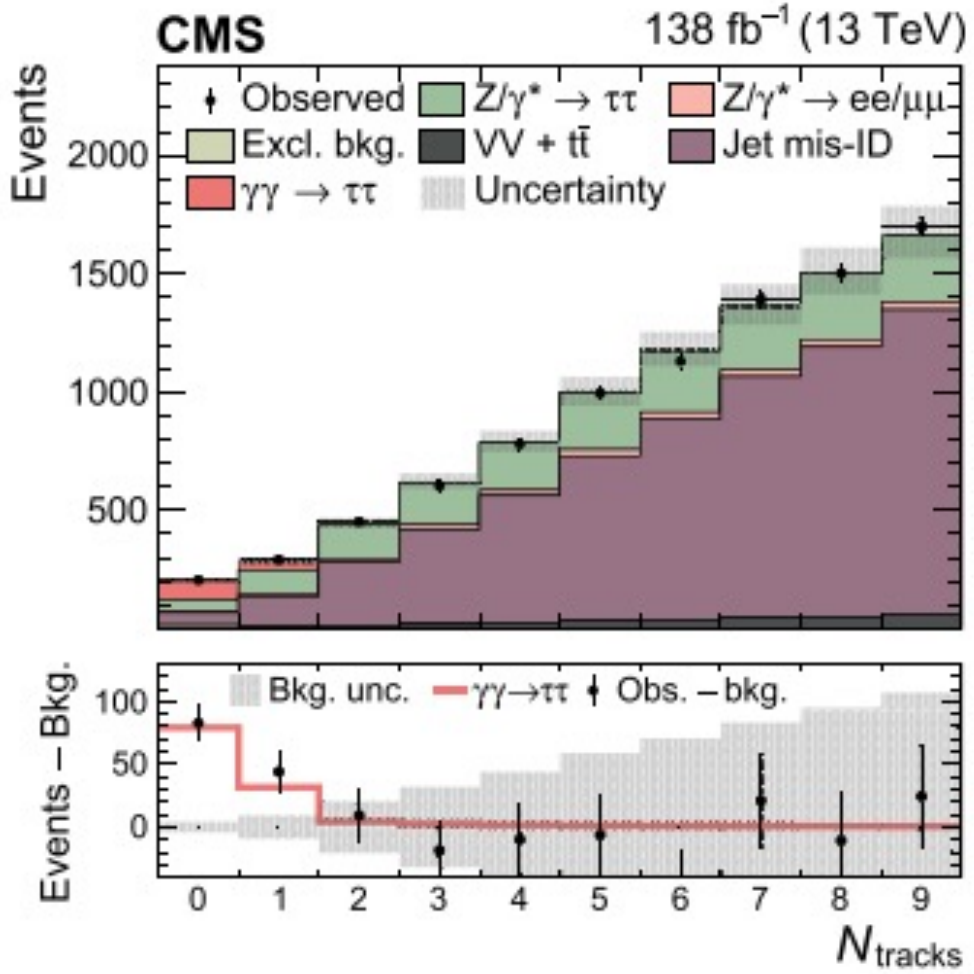
Analysis Overview

Combine 4 ττ final states: $e\mu, e\tau_h, \mu\tau_h, \tau_h\tau_h$

Hadronic decay

- **Acoplanarity** $\mathbf{A = 1 - \frac{|\Delta\Phi|}{\pi} \approx 0}$
- Exclusive selection of SR:
  - opposite sign $\tau^+\tau^-$
  - A<0.015
  - $N_{tracks} = 0{,}1$ in the 0.1 cm width window of the di-τ vertex

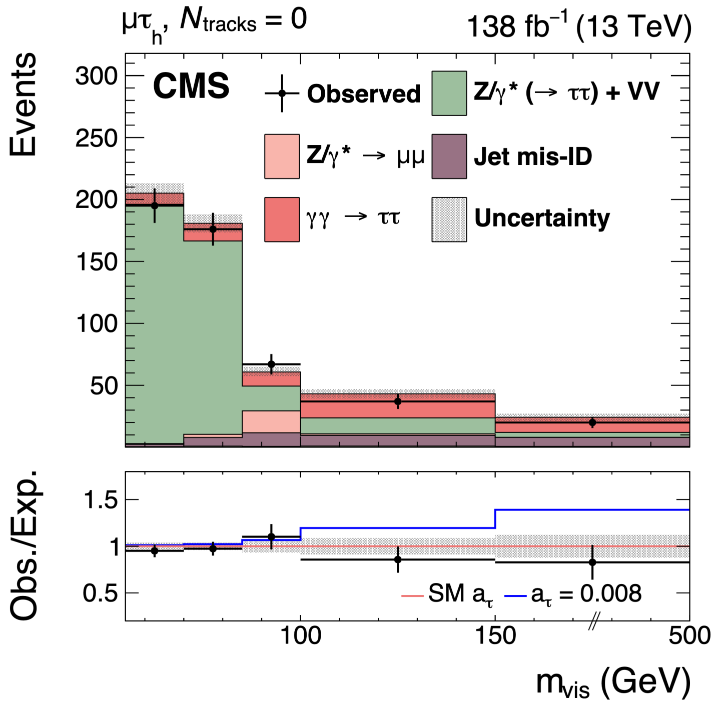
  (N_{tracks}: number of extra charged tracks)



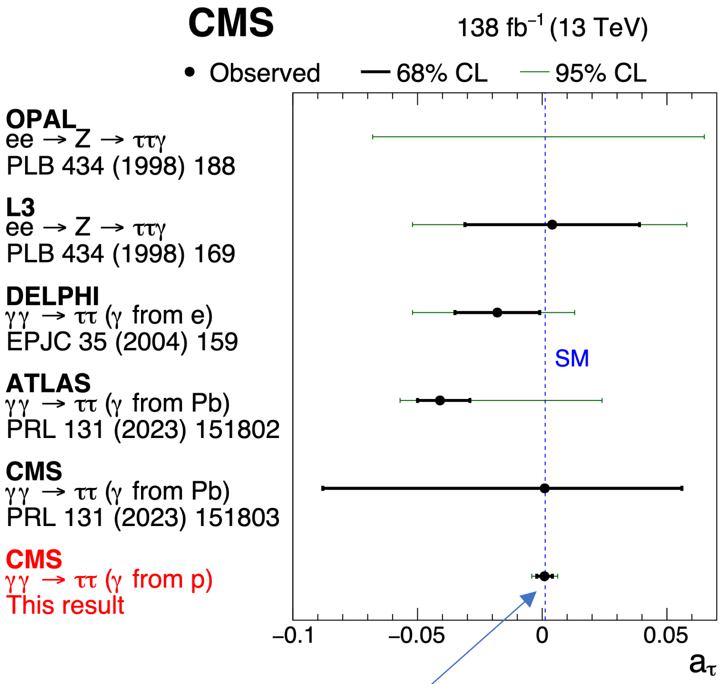
First Observation of $\gamma\gamma \to \tau\tau$ in pp collisions

5.3σ observed, 6.5σ expected

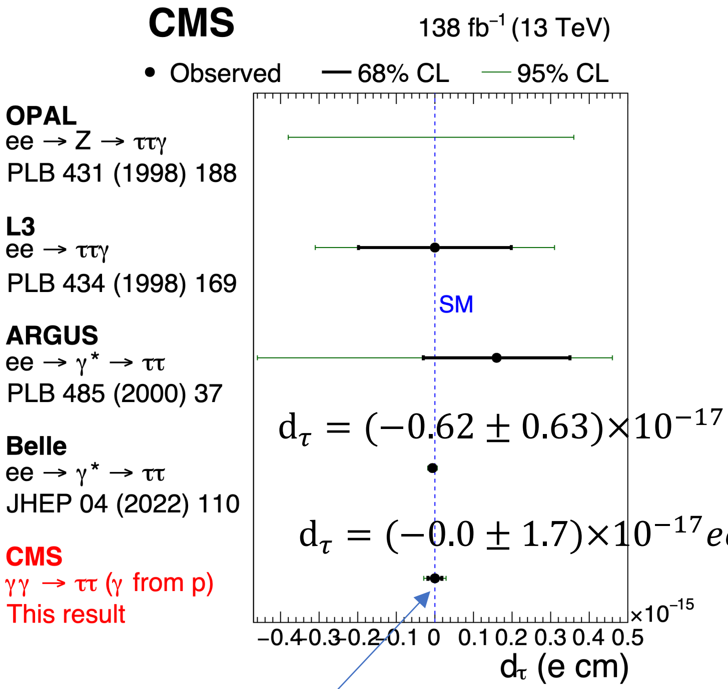
Based on m_{vis} distribution for 4 final states with nTrk=0,1



much larger BSM effect on larger $m_{\tau\tau}$



Large improvement over LEP and LHC PbPb

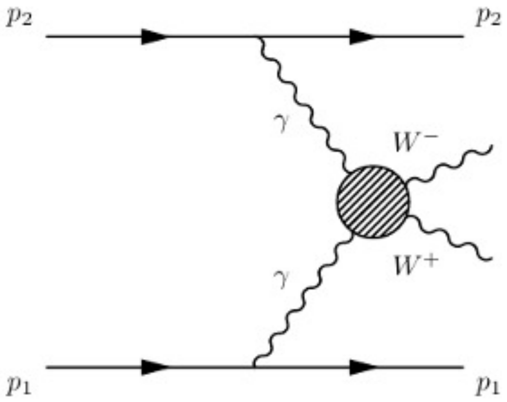


$d_\tau = (-0.62 \pm 0.63) \times 10^{-17} ecm$

$d_\tau = (-0.0 \pm 1.7) \times 10^{-17} ecm$

Approaching Belle precision

$\gamma\gamma \rightarrow WW$ in pp collisions at $\sqrt{s}$=13TeV with integrated luminosity = 138 fb^{-1}



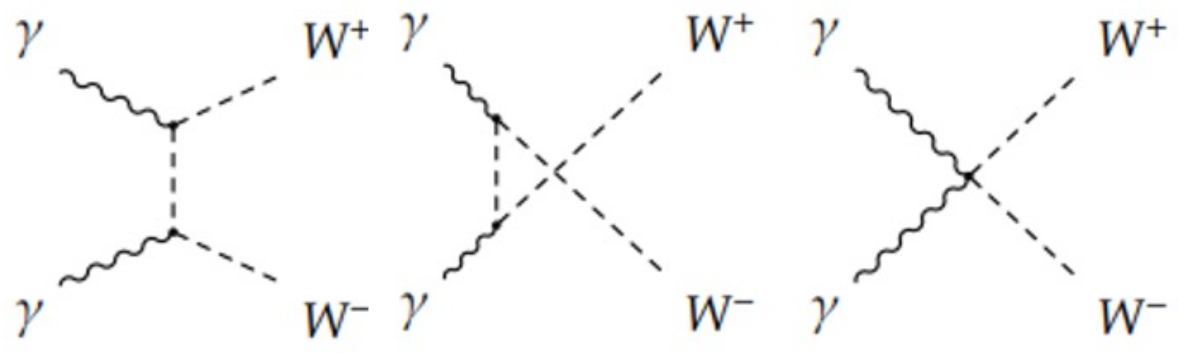
New!

CMS-SMP-24-019

Photon-induced W Pair Production and EFT Description

New!

In standard model photon-induced WW produced via trilinear and quartic gauge couplings.



$$\mathcal{L}_{WW\gamma} = -ie\{(\partial^\mu W^\nu - \partial^\nu W^\mu)W_\mu^\dagger A_\nu - (\partial^\mu W^{\nu\dagger} - \partial^\nu W^{\mu\dagger})W_\mu A_\nu + W_\mu W_\nu^\dagger(\partial^\mu A^\nu - \partial^\nu A^\mu)\}$$

$$\mathcal{L}_{WW\gamma\gamma} = -e^2(W_\mu^\dagger W^\mu A_\nu A^\nu - W_\mu^\dagger A^\mu W_\nu A^\nu)$$

- Run1 results used an effective Lagrangian with dim-6 operators:

$$\mathcal{L}_{eff} = -\frac{\alpha_{em}\pi}{2}\frac{a_0^W}{\Lambda^2}\mathcal{Q}_{\gamma W,1}^{\partial=2} - \frac{\alpha_{em}\pi}{2}\frac{a_c^W}{\Lambda^2}\mathcal{Q}_{\gamma W,2}^{\partial=2}$$

- We use the latest recommendation on dim-8 operators from LHC EFT WG Note
- The LEP like dim-6 operators can be related to linear dim-8 operators

$$a_0^W = -\frac{M_W^2}{\pi\alpha_{em}}\left[s_w^2\frac{f_{M,0}}{\Lambda^2} + 2c_w^2\frac{f_{M,2}}{\Lambda^2} + s_w c_w\frac{f_{M,4}}{\Lambda^2}\right],$$

$$a_c^W = -\frac{M_W^2}{\pi\alpha_{em}}\left[-s_w^2\frac{f_{M,1}}{\Lambda^2} - c_w^2\frac{f_{M,3}}{\Lambda^2} + 2s_w c_w\frac{f_{M,5}}{\Lambda^2} + \frac{s_w^2}{2}\frac{f_{M,7}}{\Lambda^2}\right],$$

Analysis Overview

New!

- Final State: eμ (based on the eμ channel of $\gamma\gamma \rightarrow \tau\tau$ study)
  - ➢ opposite sign $e^{\pm}\mu^{\mp}$
  - ➢ low activity (low $\boldsymbol{N_{tracks}}$) around eμ vertex
  - ➢ Acoplanarity = 1-$\frac{|\Delta\Phi|}{\pi}$
- Use μμ final state as control channel to derive following corrections

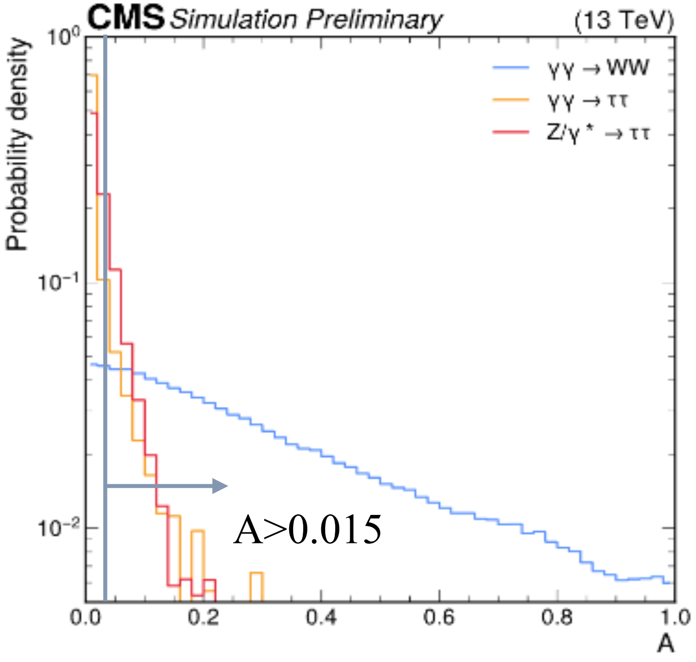
  Taken from τ g-2 study
  - ➢ Acoplanarity correction
  - ➢ Beam spot
  - ➢ Pileup N_{tracks}^{PU} correction

  Derived for this analysis
  - ➢ Hard scattering N_{tracks}^{HS} correction
- Measure $\gamma\gamma \rightarrow WW$ from observed $p_{Te\mu}$ shape & yield

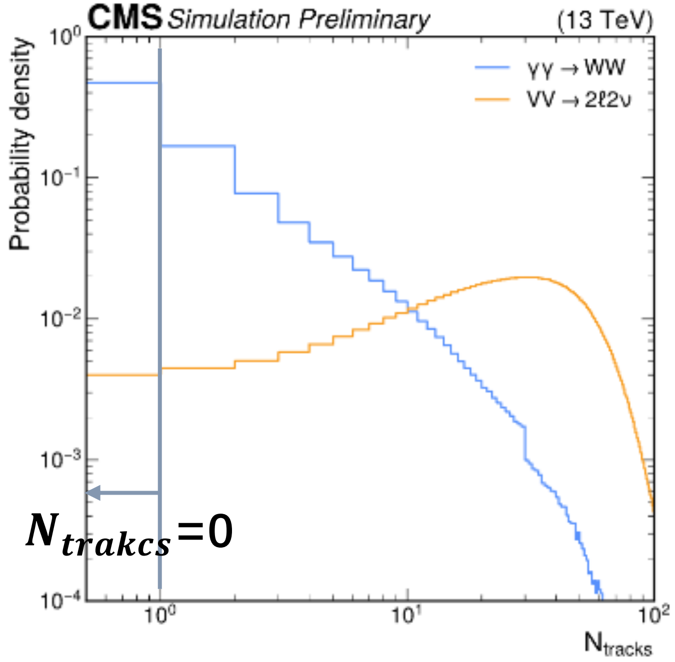
Event Selections

New!

	$e\mu$ SR (CR)	$\mu\mu$
p_T^e (GeV)	$> 15/24$	—
$\lvert\eta^e\rvert$	< 2.5	—
$\lvert d_{xy}^e\rvert$ (cm)	< 0.05 (barrel)	—
	< 0.1 (endcap)	
p_T^μ (GeV)	$> 24/15$	$> 26-29/10$
$\lvert\eta^\mu\rvert$	< 2.4	< 2.4
$\lvert d_{xy}^\mu\rvert$ (cm)	< 0.02	< 0.05
$m_{\ell\ell}$ (GeV)	> 20	> 50
OS	Yes	Yes
$\lvert dz(\ell,\ell)\rvert$ (cm)	< 0.04	< 0.1
ΔR	> 0.5	> 0.5
A	> 0.015	—
N_{tracks}	0 ([1, 5])	—

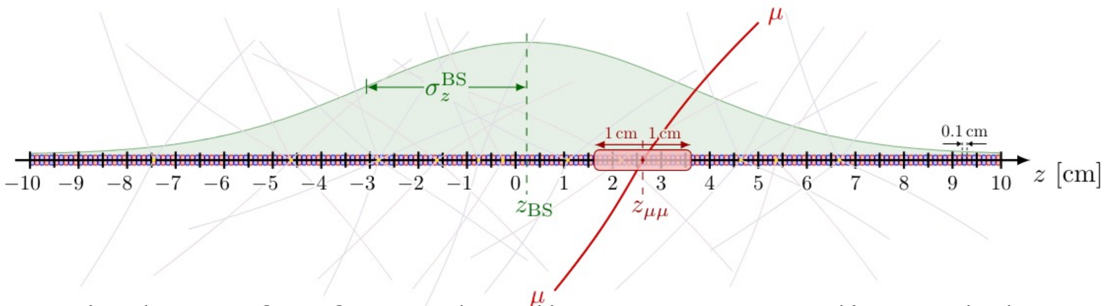


Heavier mass of W than τ

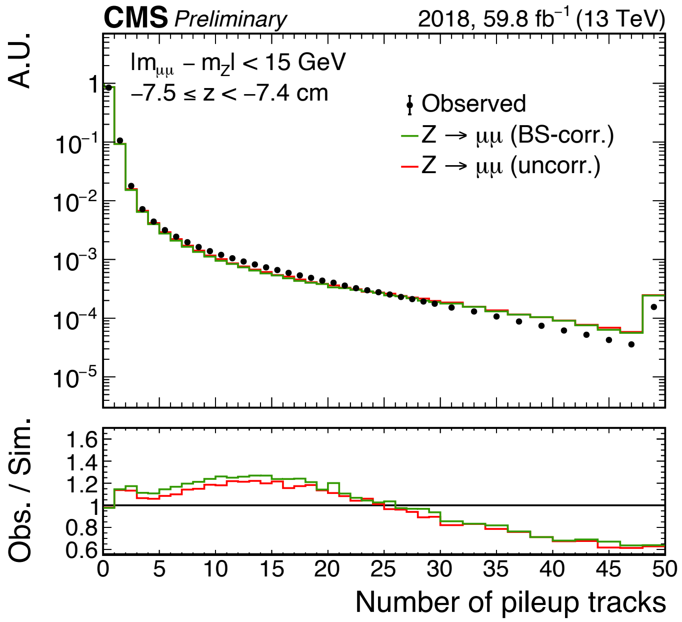


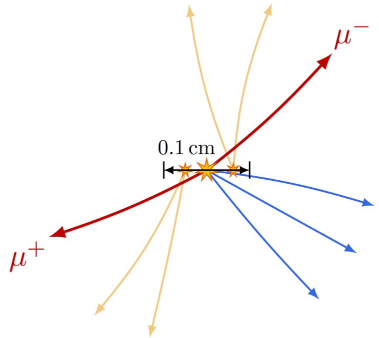
N_{tracks}: number of tracks with |dz|<0.05cm to the di-W vertex, reconstructed as (z(e)+z(μ))/2, removing tracks used to build lepton candidates.

$N^{PU}_{tracks}/N^{HS}_{tracks}$ Correction



windows far from the di-μ vertex to discard the tracks from the hard scattering interactions





Correct events with N^{HS}_{tracks}=0 at N_{tracks} =0

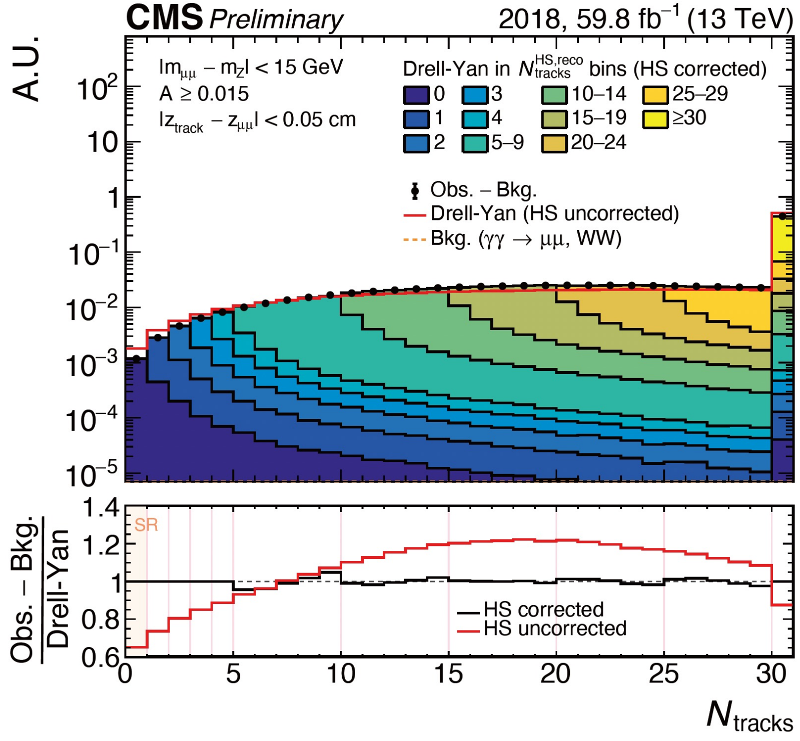
Correct events with N^{HS}_{tracks}=1 at N_{tracks} =1

⋮

Final corrections

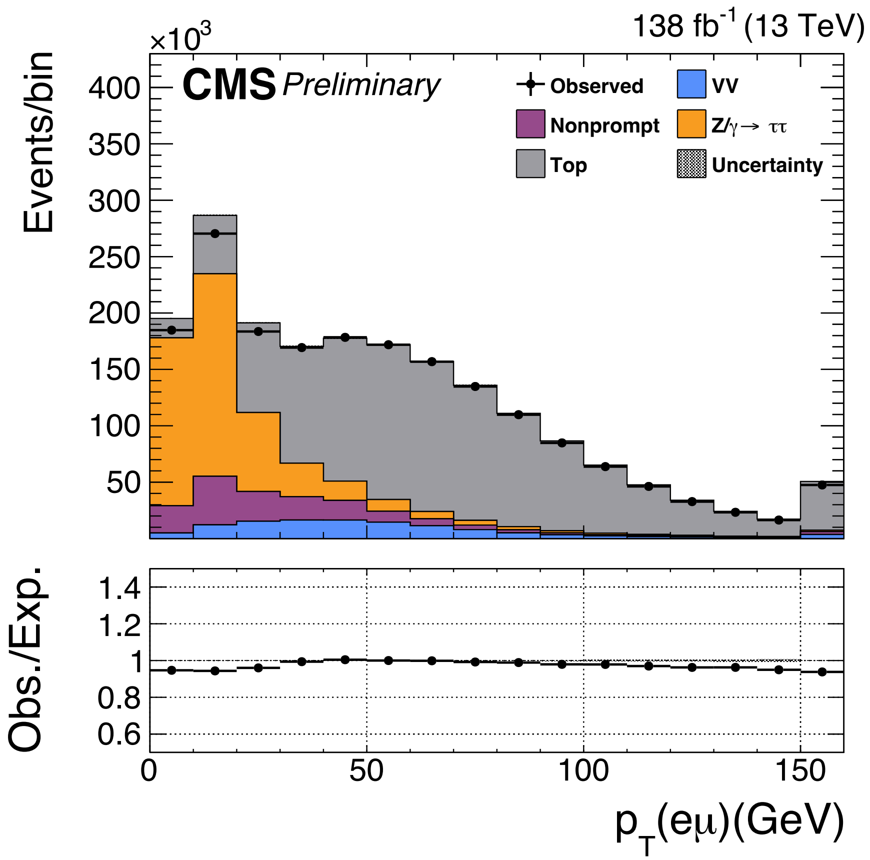
New!

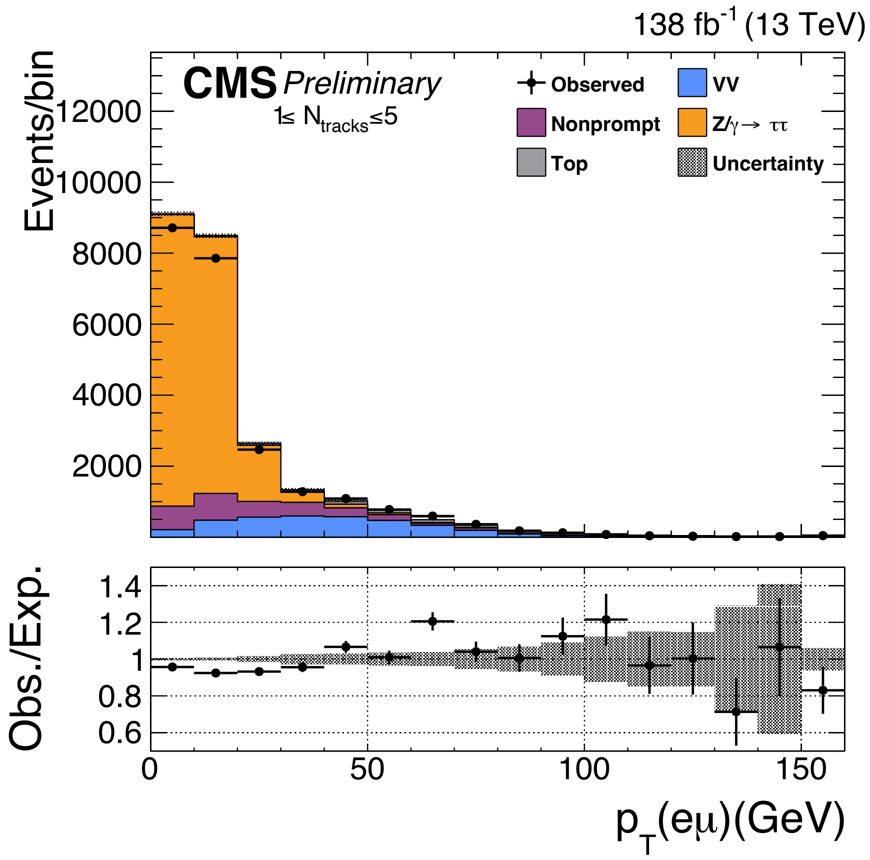
$$N_{tracks} = N^{PU}_{tracks} + N^{HS}_{tracks}$$



$p_{Te\mu}$ Distribution in CR

New!





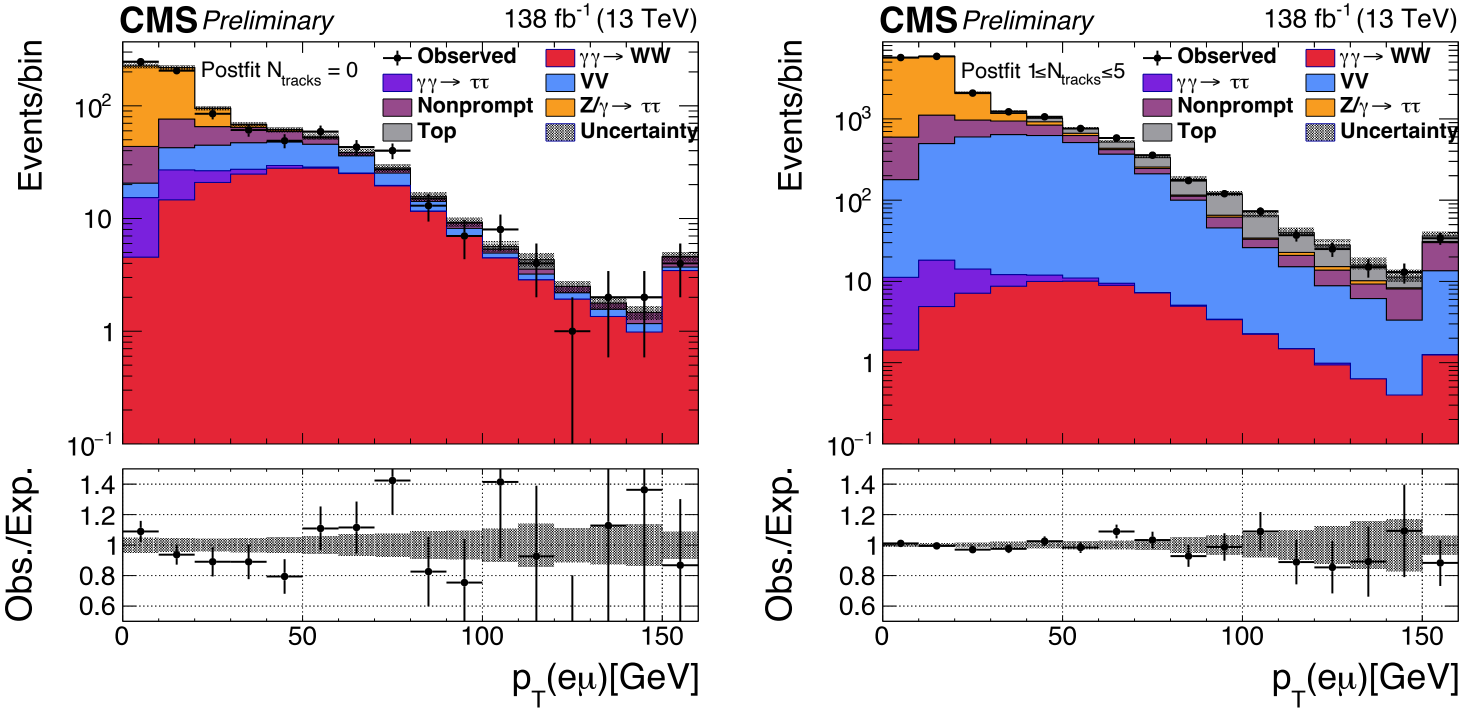
Only statistical uncertainty shown, prefit

Systematic Uncertainties

New!

Uncertainty	Process	Magnitude
Luminosity	All simulations	$< 3\%$
L1 prefiring	All simulations	negligible
Pileup reweighting	All simulations	Event-dependent
Drell-Yan normalization	Drell-Yan simulation	Rate Parameter
Top cross section	Top simulation	3%
$\gamma\gamma \to$ WW and $\gamma\gamma \to \tau\tau$ normalization	$\gamma\gamma \to$ WW $\gamma\gamma \to \tau\tau$	2%
μ_R, μ_f	Drell-Yan simulation	Shape
PDF	Drell-Yan simulation	Shape
ISR, FSR	Drell-Yan simulation	Shape
Inclusive VV normalization	Inclusive VV simulation	Rate Parameter
e ID, iso, trigger	All simulations	up to 2%
e ID multiplicity correction	All simulation	1%
μ ID, iso, trigger	All simulation	up to 1%
N^{PU}_{tracks} reweighting	All simulations	2%
N^{HS}_{tracks} reweighting	Drell-Yan and inclusive VV	Rate Parameter
OS-to-SS SFs Stat. Unc.	$jet \to e/\mu$ fake background	Shape
Background composition	$jet \to e/\mu$ fake background	10%
Limited statistics	All simulation, fake background	Barlow-Beeston-lite approacl

Inclusive Cross Section Measurement



New!

Inclusive cross section of $\gamma\gamma \to WW$ with all W decay modes

$\sigma^{inclusive} = 658.8^{+81.7}_{-77.7}$ fb

- Statistical and systematic uncertainties are shown
- Last bin contains overflows
- The observed significance is over **7σ**, first observation of $\gamma\gamma \to WW$ at CMS

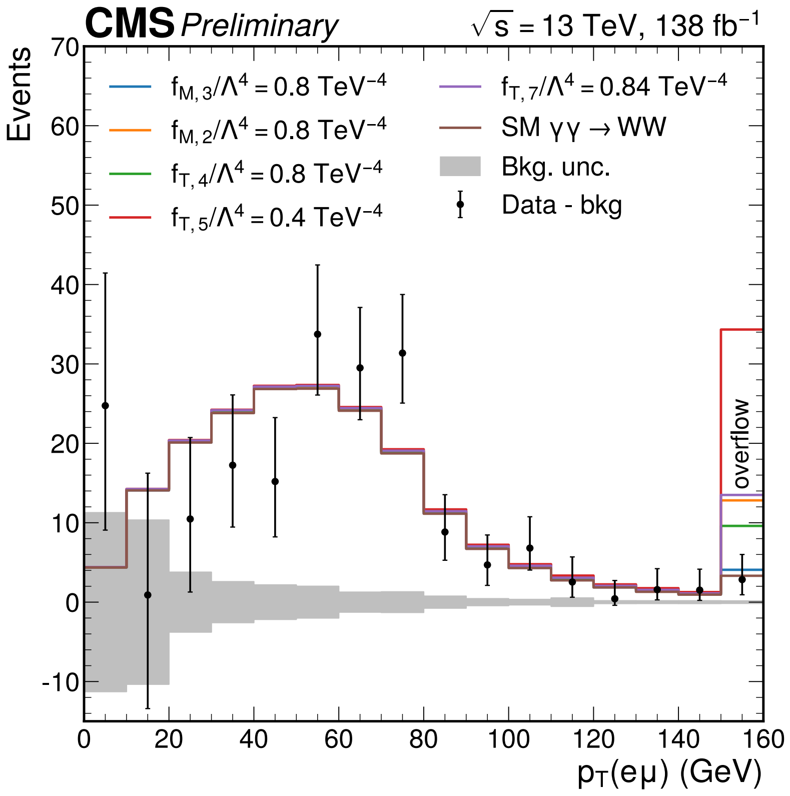
Fiducial Cross Section Measurement

New!

Process	$N_{\text{tracks}} = 0$	$1 \leq N_{\text{tracks}} \leq 5$
$Z/\gamma^* \to \tau\tau$	359.9 ± 22.4	11262.3 ± 166.4
Jet mis-ID	120.4 ± 10.2	2176.1 ± 186.1
Inclusive VV	115.2 ± 10.0	3733.7 ± 184.4
$\gamma\gamma \to \tau\tau$	34.2 ± 1.4	37.3 ± 1.5
Top	7.0 ± 1.5	718.6 ± 114.9
Nonfiducial $\gamma\gamma \to$ WW	11.5 ± 0.5	70.5 ± 2.4
Total bkg.	648.1 ± 28.3	17998.5 ± 174.3
Fiducial $\gamma\gamma \to$ WW	183.7 ± 22.2	124.0 ± 15.8
Total	835.4 ± 28.8	18122.5 ± 159.6
Observed	829	18112

- Fiducial region definition:
  - eμ final state from W
  - leading lepton p_T>24GeV
  - subleading lepton p_T>15GeV
  - $|\eta_e|$<2.5
  - $|\eta_\mu|$<2.4
  - 0 extra track
  - A>0.015
  - $\Delta R(e,\mu)$>0.5
  - $m_{e\mu}$>20GeV
- Signal events in the fiducial region: 94%
- Treat signal events outside the fiducial region as background
- $\sigma^{fid} = 4.1 \pm 0.5$ fb

Constraints on Quartic Coupling



$p_{Te\mu}$ distribution of $\gamma\gamma \to WW$ with nonzero EFT parameters

Maximum likelihood fit

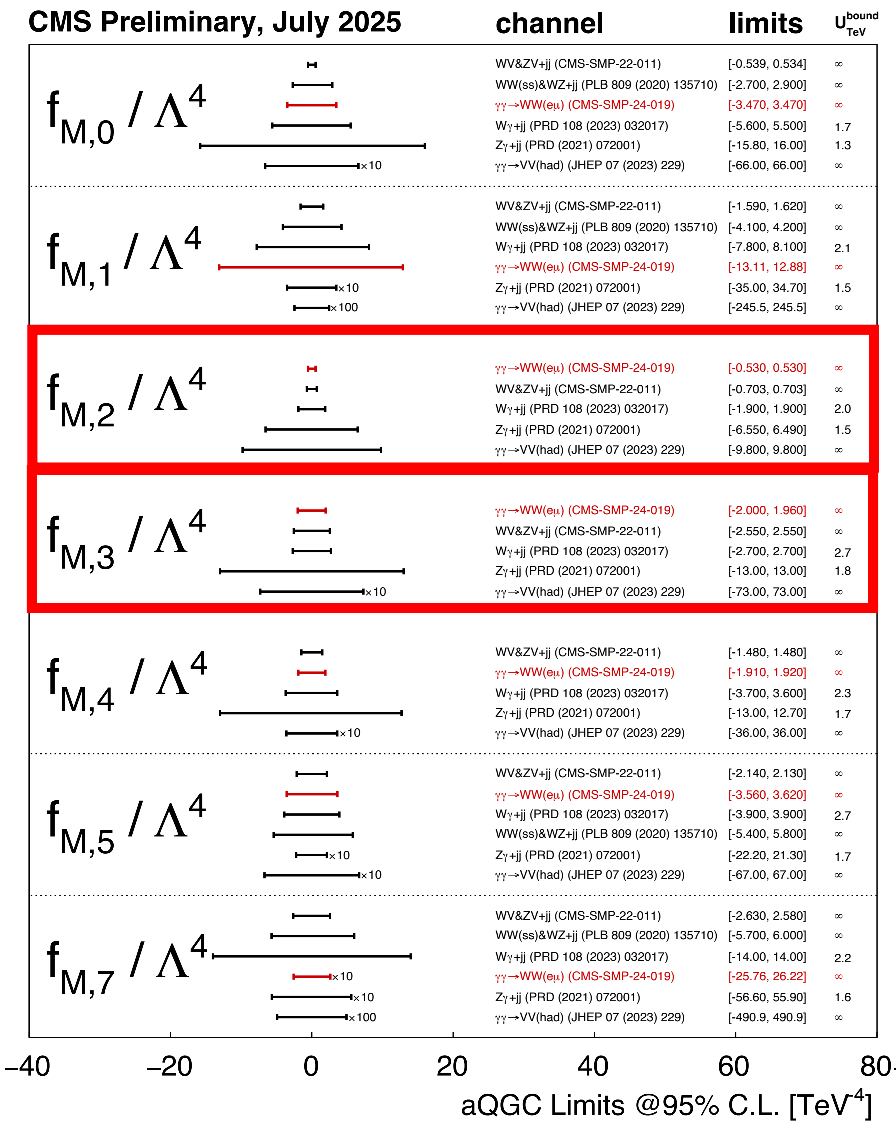
First constraints on f-odd parameters, indicated by tilde

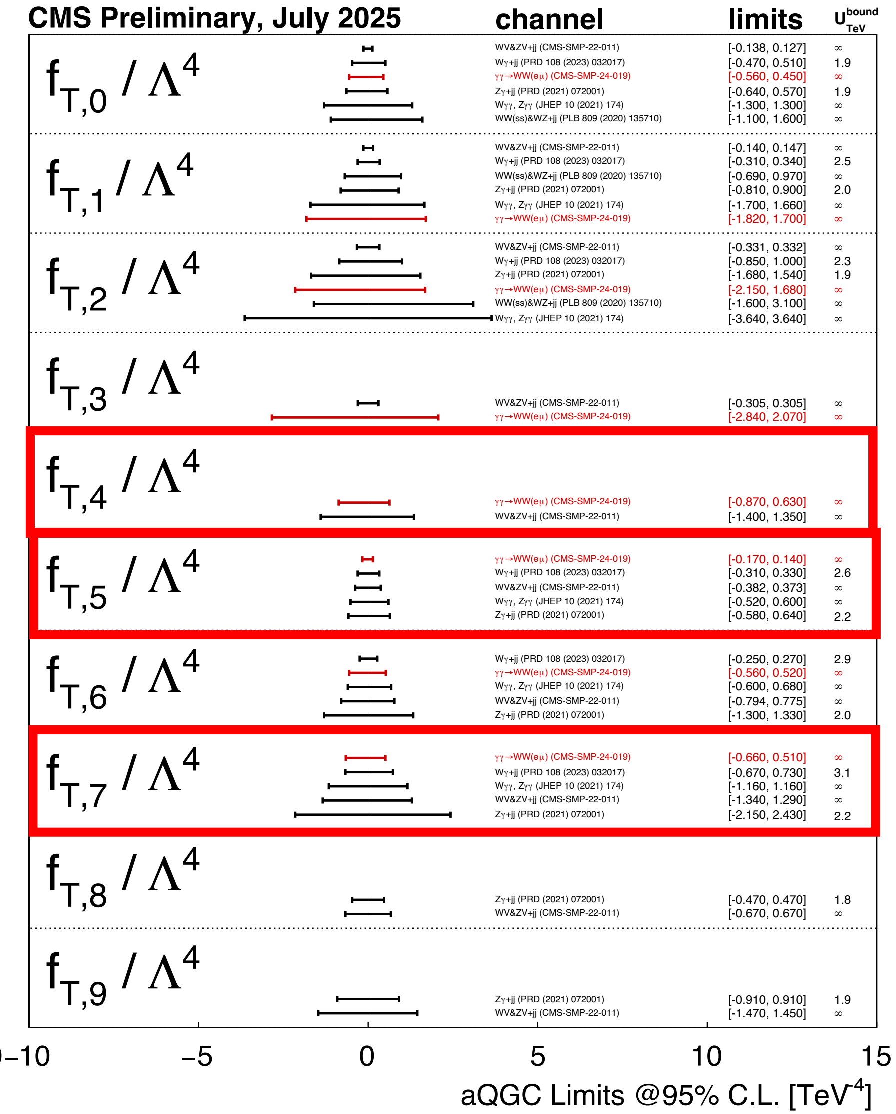
New!

	Expected 95% CL (TeV^{-4})	Observed 95% CL (TeV^{-4})
f_{M0}/Λ^4	[-3.95, 4.02]	[-3.47, 3.47]
f_{M1}/Λ^4	[-15.19, 14.66]	[-13.11, 12.88]
$f_{\widetilde{M1}}/\Lambda^4$	[-0.61, 0.61]	[-0.53, 0.53]
f_{M2}/Λ^4	[-0.60, 0.61]	[-0.53, 0.53]
$f_{\widetilde{M2}}/\Lambda^4$	[-2.20, 2.20]	[-1.92, 1.91]
f_{M3}/Λ^4	[-2.32, 2.24]	[-2.00, 1.96]
f_{M4}/Λ^4	[-2.18, 2.22]	[-1.91, 1.92]
$f_{\widetilde{M4}}/\Lambda^4$	[-4.41, 4.41]	[-3.84, 3.82]
f_{M5}/Λ^4	[-4.05, 4.20]	[-3.56, 3.62]
$f_{\widetilde{M5}}/\Lambda^4$	[-1.99, 1.99]	[-1.74, 1.73]
f_{M7}/Λ^4	[-29.31, 30.38]	[-25.76, 26.22]
f_{T0}/Λ^4	[-0.64, 0.52]	[-0.56, 0.45]
f_{T1}/Λ^4	[-2.09, 1.97]	[-1.82, 1.70]
f_{T2}/Λ^4	[-2.46, 1.97]	[-2.15, 1.68]
$f_{\widetilde{T2}}/\Lambda^4$	[-0.088, 0.088]	[-0.076, 0.076]
f_{T3}/Λ^4	[-3.23, 2.44]	[-2.84, 2.07]
$f_{\widetilde{T3}}/\Lambda^4$	[-0.088, 0.088]	[-0.076, 0.076]
f_{T4}/Λ^4	[-0.99, 0.74]	[-0.87, 0.63]
$f_{\widetilde{T4}}/\Lambda^4$	[-0.37, 0.37]	[-0.32, 0.32]
f_{T5}/Λ^4	[-0.20, 0.16]	[-0.17, 0.14]
$f_{\widetilde{T5}}/\Lambda^4$	[-0.21, 0.21]	[-0.18, 0.18]
f_{T6}/Λ^4	[-0.64, 0.60]	[-0.56, 0.52]
$f_{\widetilde{T6}}/\Lambda^4$	[-0.61, 0.61]	[-0.53, 0.53]
f_{T7}/Λ^4	[-0.75, 0.60]	[-0.66, 0.51]

Comparison of Constraints on Quartic Coupling

New!





The constraints are ranked with respect to the sensitivity, on top are the most sensitive constraints.

Tight constraints on f_{m2}, f_{m3}, f_{t4}, f_{t5}, f_{t7}

Summary

- The CMS Collaboration has used the $\gamma\gamma \rightarrow \tau\tau$ events in heavy ion collisions to constrain the τ electromagnetic moments: $a_\tau = -35^{+18}_{-10} \times 10^{-3}$ at 68% CL

- **The CMS Collaboration has first observed $\boldsymbol{\gamma\gamma \rightarrow \tau\tau}$ process in pp collisions with over 5σ**

$$a_\tau = 0.9^{+3.2}_{-3.1} \times 10^{-3} \text{ at 68\% CL}$$
$$-0.0042 < a_\tau < 0.0062 \text{ at 95\% CL}$$
$$-1.7 \times 10^{-17}\,\text{ecm} < d_\tau < 1.7 \times 10^{-17}\,\text{ecm}$$

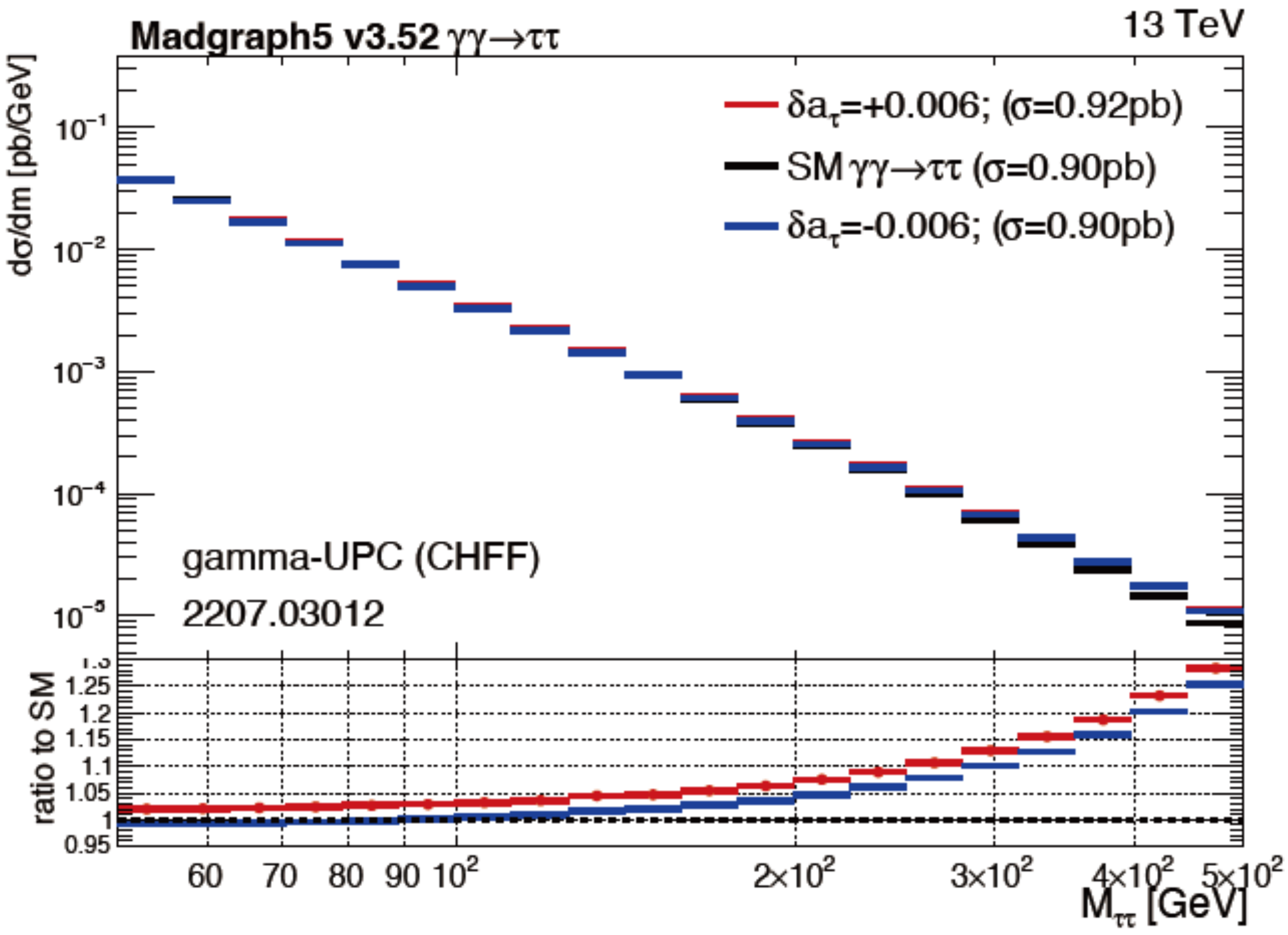
- **First observation of $\boldsymbol{\gamma\gamma \rightarrow WW}$ at CMS with over 7σ**
  - Observed inclusive cross section is $658.8^{+81.7}_{-77.7}$ fb
  - First constraints on f-odd parameters
  - Tight constraints on f_{m2}[-0.53, 0.53], f_{m3}[-2.00, 1.96], f_{t4}[-0.87, 0.63], f_{t5}[-0.17, 0.14], f_{t7}[-0.66, 0.51] TeV^{-4}

Thanks for listening

&

Welcome all comments

BSM effect



Madgraph5 v3.52 γγ→ττ
13 TeV
δa_τ=+0.006; (σ=0.92pb)
SM γγ→ττ (σ=0.90pb)
δa_τ=-0.006; (σ=0.90pb)
gamma-UPC (CHFF)
2207.03012
dσ/dm [pb/GeV]
ratio to SM
M_ττ [GeV]

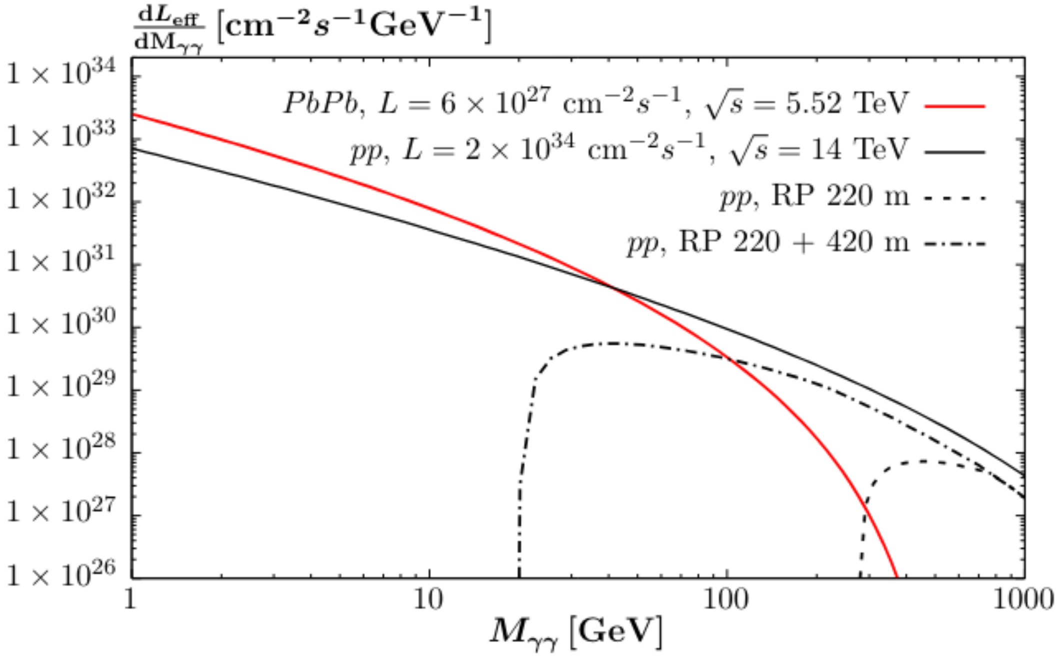
Electromagnetic ultra-peripheral collisions(UPC)

- provide a pure QED(electrodynamics) environment
- $\sigma(\gamma\gamma) \propto Z^4, \sigma(\gamma\gamma) \propto \log^3(\sqrt{S})$, much larger luminosities of pp collisions than PbPb collisions
- quasi-real photon, $q^2 \approx 0$
- max(longitudinal) γ energies $E_\gamma \approx$80GeV(PbPb),2.5TeV(pp)
- much larger BSM effect on larger $m_{\tau\tau}$
- process signature:

  -opposite sign(OS) $\tau^\pm\tau^\mp$

  -back-to-back in azimuthal plane: $|\Delta\Phi| \approx \pi$

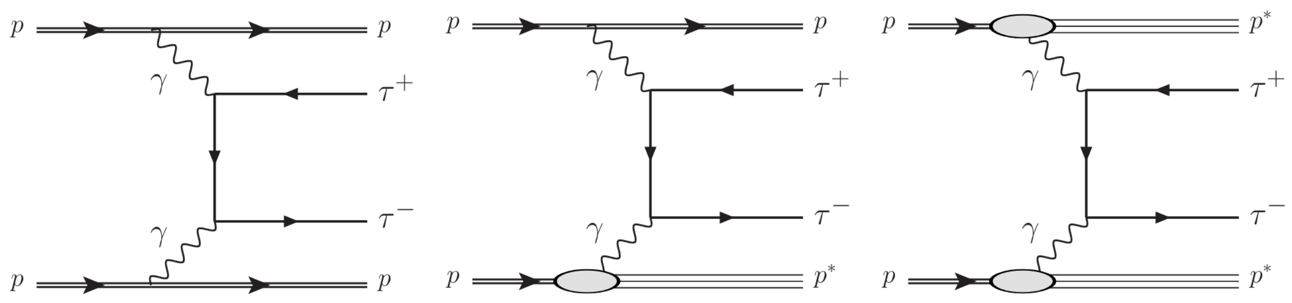
  -low activity around ττ vertex



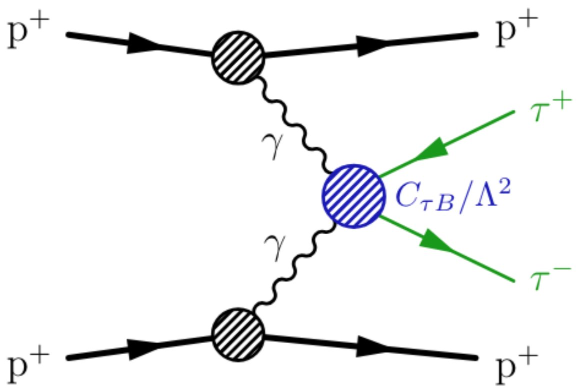
Signal Simulation pp

- **Only** **elastic events** are generated using gammaUPC, data-driven method to include the dissociative component and SUPERCHIC for cross-check
- a_τ & d_τ interpretation using the **EFT approach** with the SMEFTsim package, simplifying with $C_{\tau W}$=0 since the linear combination of $C_{\tau B}$ and $C_{\tau W}$:

$$\delta a_\tau \propto \frac{Re[C_{\tau B}]}{\Lambda^2}, \delta d_\tau \propto \frac{Im[C_{\tau B}]}{\Lambda^2}$$



elastic semi-dissociative fully-dissociative



Basic Selections pp

	$e\mu$	$e\tau_h$	$\mu\tau_h$	$\tau_h\tau_h$	$\mu\mu$
p_T^e (GeV)	$> 15/24$	> 25–33	—	—	—
$\lvert\eta^e\rvert$	< 2.5	< 2.1–2.5	—	—	—
p_T^μ (GeV)	$> 24/15$	—	> 21–29	—	> 26–$29/10$
$\lvert\eta^\mu\rvert$	< 2.4	—	< 2.1–2.4	—	< 2.4
$p_T^{\tau_h}$ (GeV)	—	> 30–35	> 30–32	> 40	—
$\lvert\eta^{\tau_h}\rvert$	—	< 2.1–2.3	< 2.1–2.3	< 2.1	—
$m_{\mu\mu}$ (GeV)	—	—	—	—	> 50
OS	yes	yes	yes	yes	yes
$\lvert d_z(\ell,\ell')\rvert$ (cm)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
$\Delta R(\ell,\ell')$	> 0.5	> 0.5	> 0.5	> 0.5	> 0.5
$m_T(e/\mu\, p_T, \vec{p}_T^{\,miss})$ (GeV)	—	< 75	< 75	—	—

Acoplanarity Correction

$$A = 1 - \left|\frac{\phi}{\pi}\right|$$

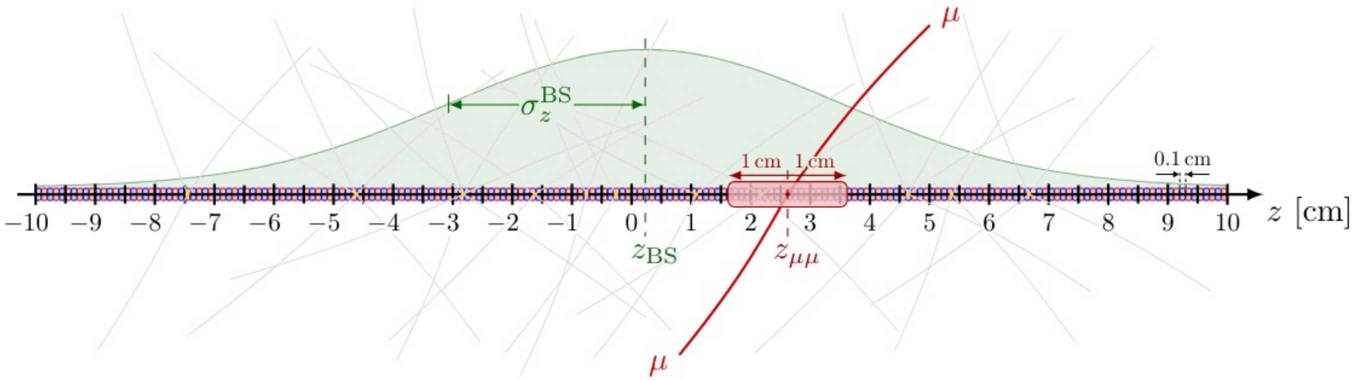
The correction is derived as a function of acoplanarity by fitting the data/MC ratio.
It is kept constant above 0.35.
It modifies the Drell-Yan normalizations in various p_T ranges (the corrections are different in different p_T ranges), but keeps the overall Drell-Yan normalization constant.

Beam Spot Correction

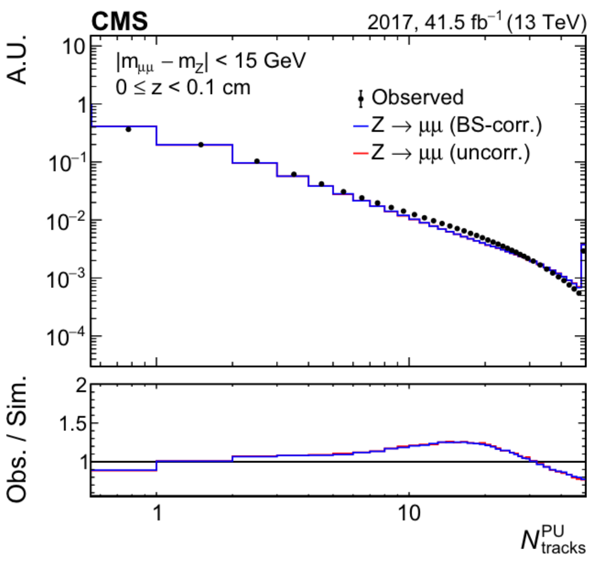
$$z^{\mathrm{corr}} = z_{\mathrm{MC}}^{\mathrm{BS}} + \frac{\sigma_{\mathrm{Data}}^{\mathrm{BS}}}{\sigma_{\mathrm{MC}}^{\mathrm{BS}}}(z - z_{\mathrm{MC}}^{\mathrm{BS}})$$

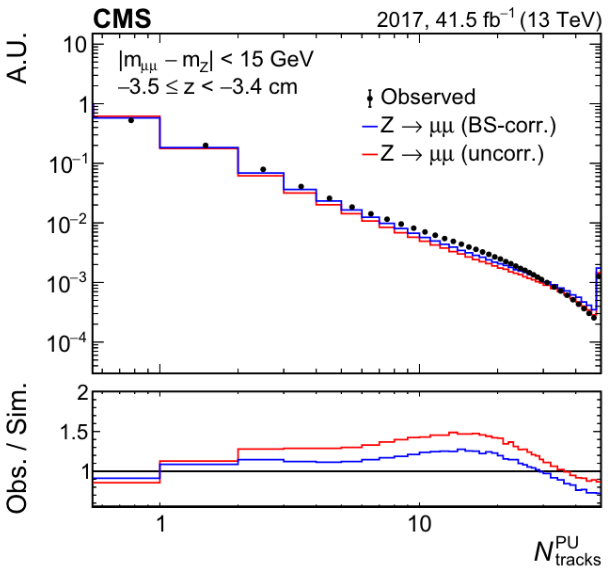
$$z^{\mathrm{corr}} = z + z_{\mathrm{Data}}^{\mathrm{BS}} - z_{\mathrm{MC}}^{\mathrm{BS}}$$

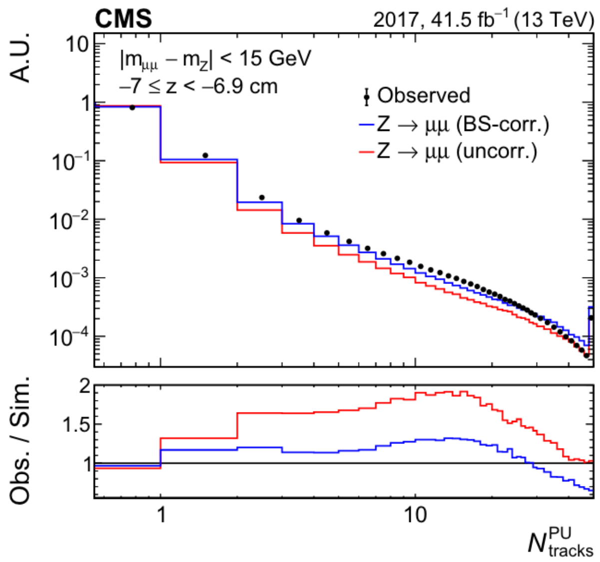
Pileup Track Multiplicity Correction



windows far from the di-μ vertex to discard the tracks from the hard scattering interactions in $|m_{\mu\mu} - m_Z|$<15GeV







Photon-induced Process Correction pp

- scan a_τ & d_τ values through matrix element reweightging in two independent 1D grids of 100 points for $C_{\tau B}$:

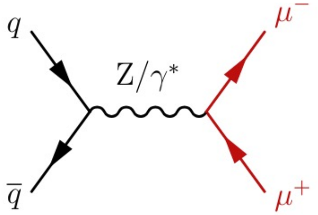
  $$Re[C_{\tau B}] \in [-40,40], Im[C_{\tau B}] \in [-40,40]$$

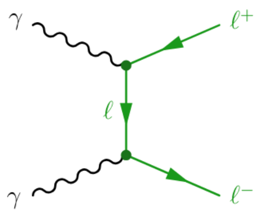
- result independent from of choice of Λ, $C_{\tau B}$ & $C_{\tau W}$ scale with Λ^2, but we fix Λ=2TeV in event generation

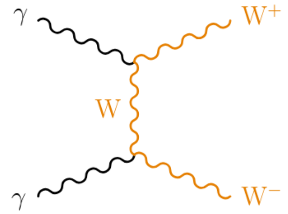
Backgrounds pp

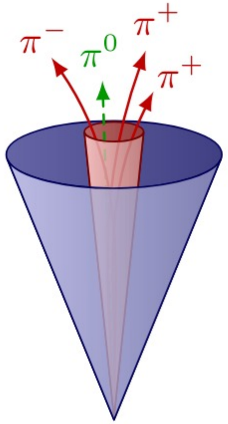
- MC simulation
  - -Drell-Yan($Z/\gamma^* \to ll$):dominant at low mass
  - -exclusive $\gamma\gamma \to ee, \mu\mu, WW$ production
  - -inclusive WW production(small)

- data-driven: misidentified hadronic jets
  - -$j \to \tau_h$:$e\tau_h$,$\mu\tau_h$,$\tau_h\tau_h$ channels
  - -$j \to e/\mu$:$e\mu$ channels

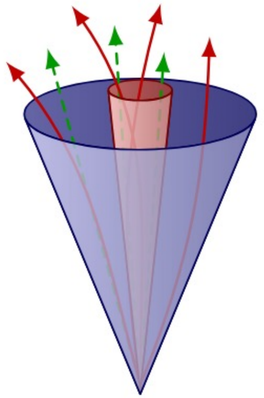






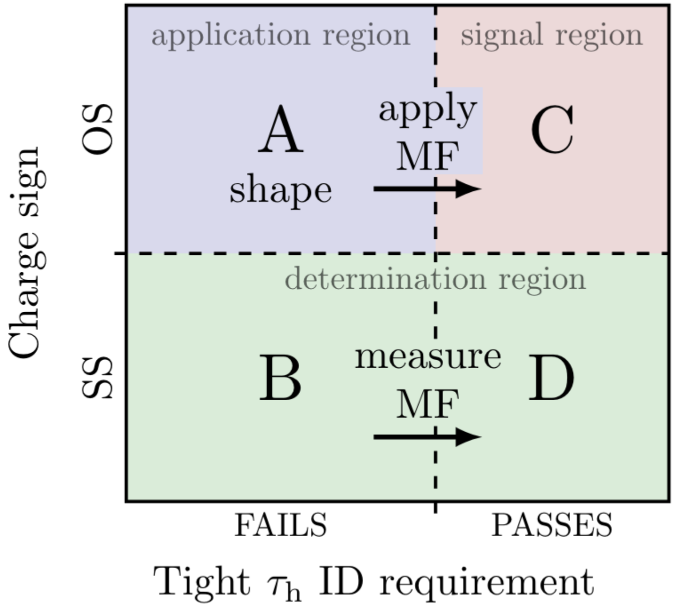


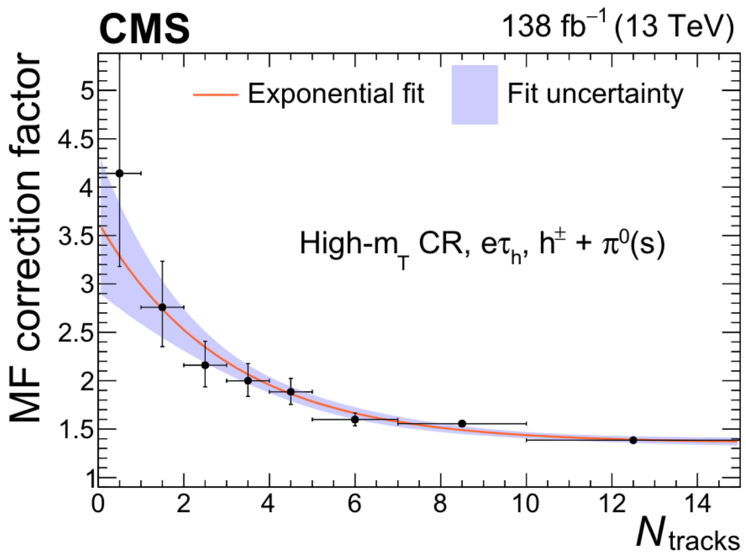
hadronic τ_h jet

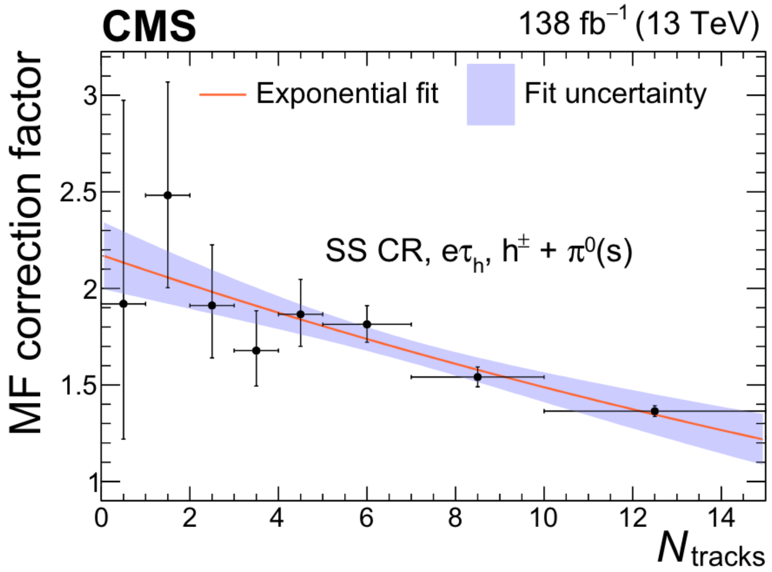


hadronic quark/gluon jet

Misidentified τ_h Background



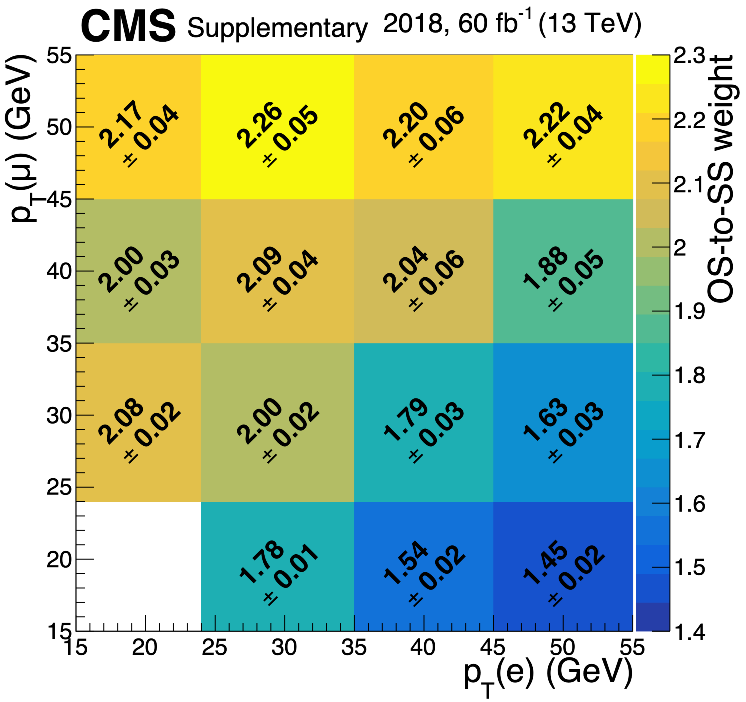




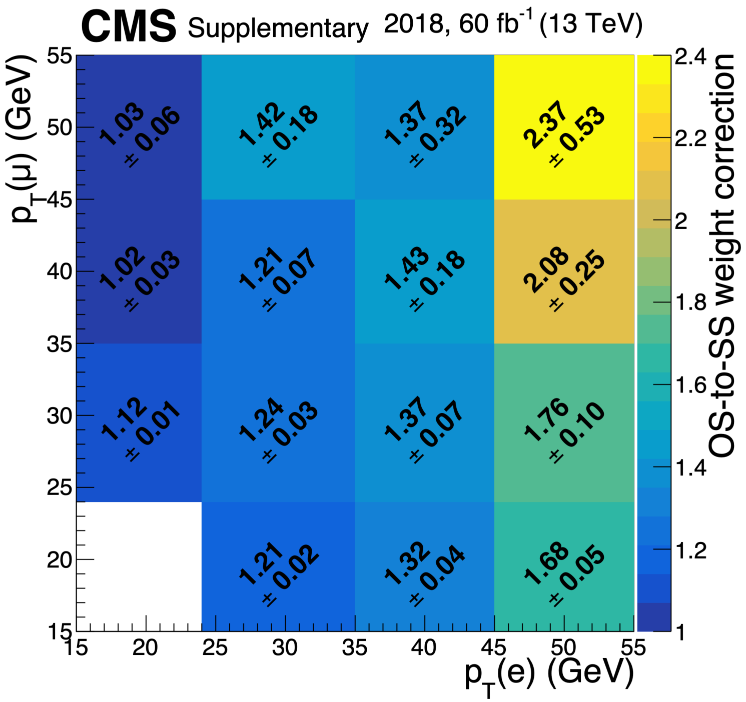
- MFs measured in separate CRs
  - -W+jets:m_T>75GeV
  - -QCD:SS, m_T<75GeV

Jet-fake eμ background pp

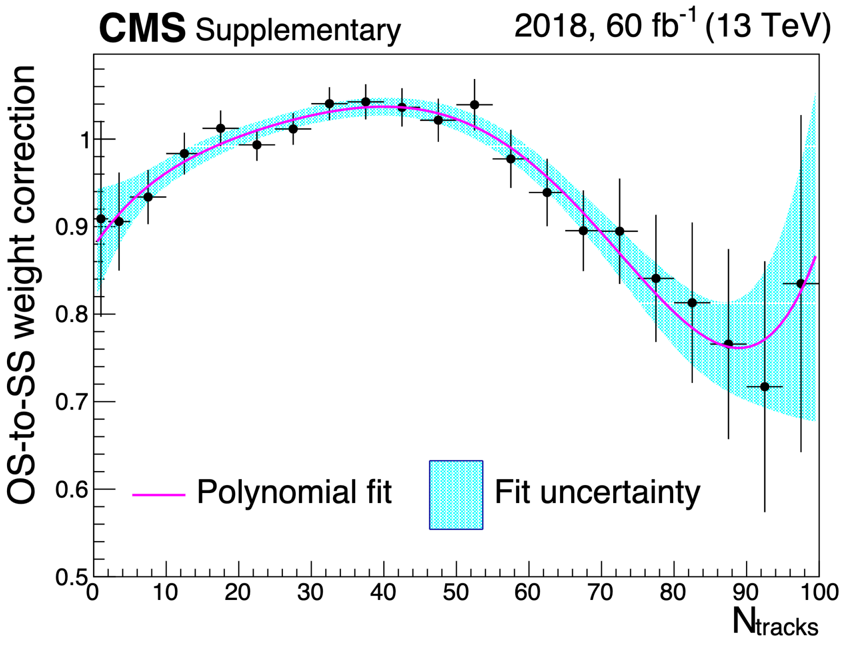
- reweigh SS events with SF made of 3 multiplicative terms
- OS/SS SF measured in events with anti-isolated μ
- correction for μ inverted isolation
- N_{tracks} corretions



Anti-isolated the μ to get the OS-to-SS as fake factors

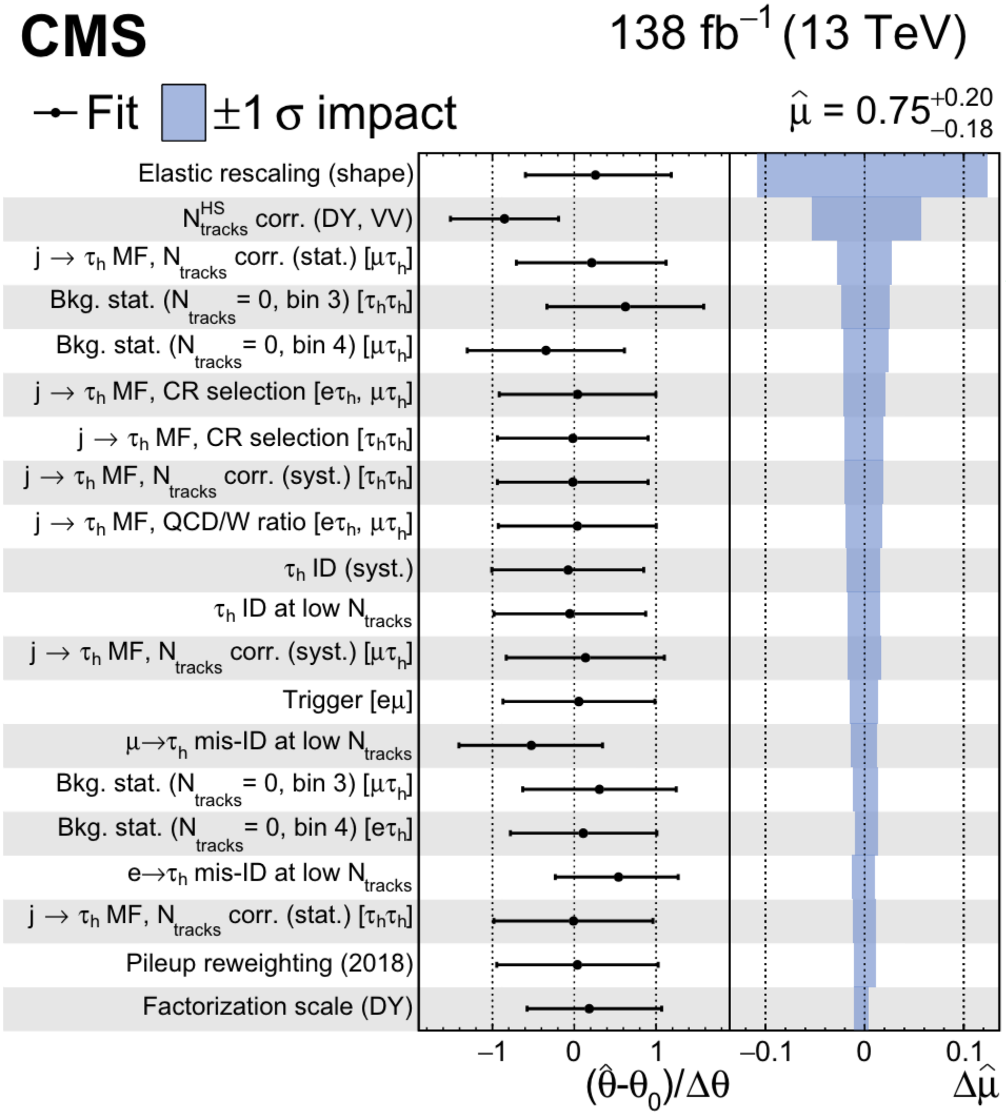


Anti-isolated the e with isolated μ and anti-isolated μ to correct the effect of the shift of the μ isolation

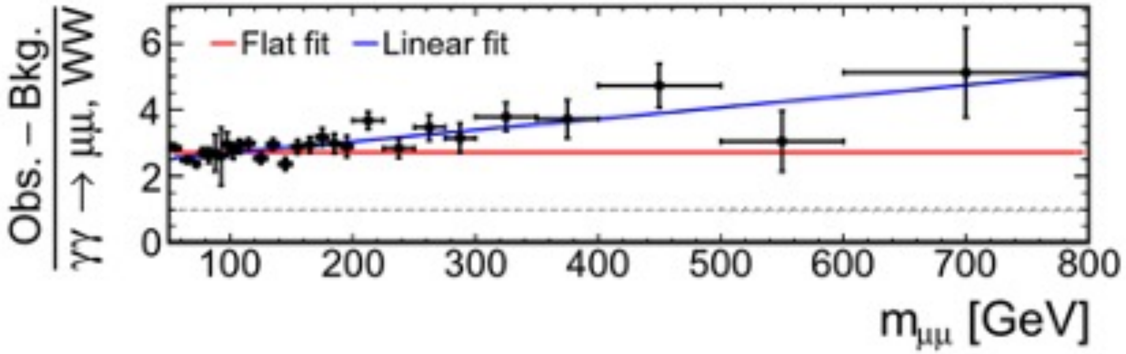


Derive the N_{tracks} dependence of the OS-to-SS

Leading Systematics on the signal significance pp



shape uncertainty of the elastic rescaling: the difference between the flat factor and the linear factor

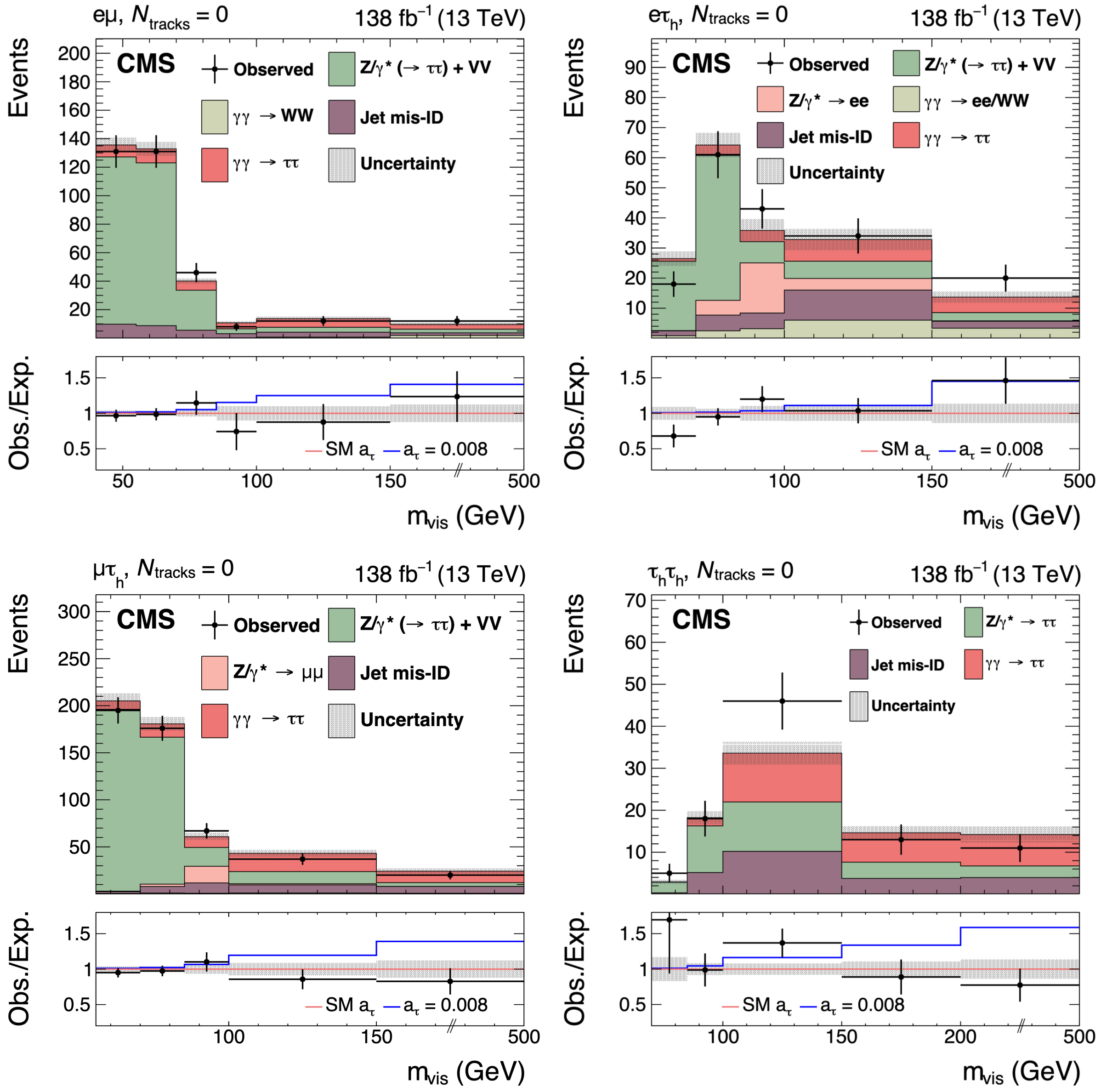


uncertainty of the N^{HS}_{tracks} correction is taken to have the same magnitude as the relative fraction of $\gamma\gamma \to \mu\mu/WW$ in the correction derived region.

N_{tracks} extrapolation of the jet$\to \tau_h$ MF estimate jet mis-ID background(up to ~20%)

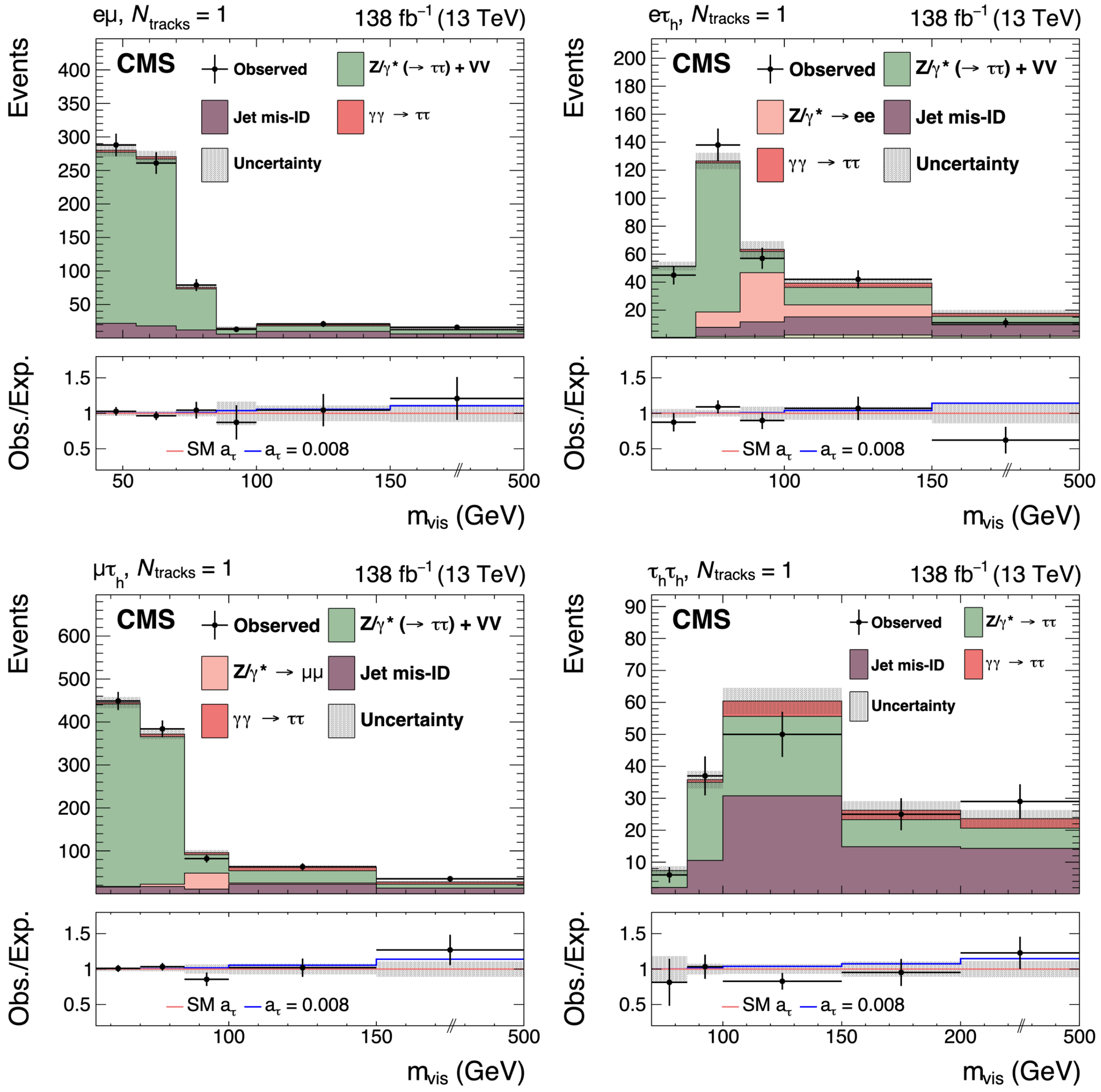
Real and fake τ_h identification (at low N_{tracks})

nTrk=0 pp



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

nTrk=1 pp



eμ, N_tracks = 1
138 fb⁻¹ (13 TeV)
CMS
Observed
Z/γ* (→ ττ) + VV
Jet mis-ID
γγ → ττ
Uncertainty
eτ_h, N_tracks = 1
Z/γ* → ee
μτ_h, N_tracks = 1
Z/γ* → μμ
τ_hτ_h, N_tracks = 1
Z/γ* → ττ
Events
Obs./Exp.
SM a_τ
a_τ = 0.008
m_vis (GeV)