$Z \to \mu\mu\gamma$

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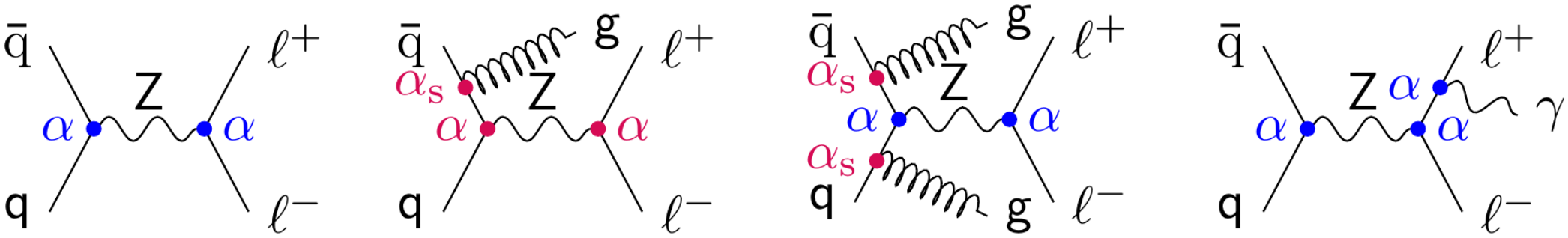
Introduction

Z DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1	$e^+ e^-$	[a]	(3.3632±0.0042) %	
Γ_2	$\mu^+ \mu^-$	[a]	(3.3662±0.0066) %	
Γ_3	$\tau^+ \tau^-$	[a]	(3.3696±0.0083) %	
Γ_4	$\ell^+ \ell^-$	[a,b]	(3.3658±0.0023) %	
Γ_5	$\ell^+ \ell^- \ell^+ \ell^-$	[c]	(3.5 ±0.4) $\times 10^{-6}$	S=1.7
Γ_6	invisible	[a]	(20.000 ±0.055) %	
Γ_7	hadrons	[a]	(69.911 ±0.056) %	
⋮				
Γ_{45}	$\Xi_c^0 X$		seen	
Γ_{46}	$\Xi_b X$		seen	
Γ_{47}	b-baryon X	[e]	(1.38 ±0.22) %	
Γ_{48}	anomalous γ + hadrons	[f]	$<$ 3.2 $\times 10^{-3}$	CL=95%
Γ_{49}	$e^+ e^- \gamma$	[f]	$<$ 5.2 $\times 10^{-4}$	CL=95%
Γ_{50}	$\mu^+ \mu^- \gamma$	[f]	$<$ 5.6 $\times 10^{-4}$	CL=95%
Γ_{51}	$\tau^+ \tau^- \gamma$	[f]	$<$ 7.3 $\times 10^{-4}$	CL=95%
Γ_{52}	$\ell^+ \ell^- \gamma\gamma$	[g]	$<$ 6.8 $\times 10^{-6}$	

This number is wrong

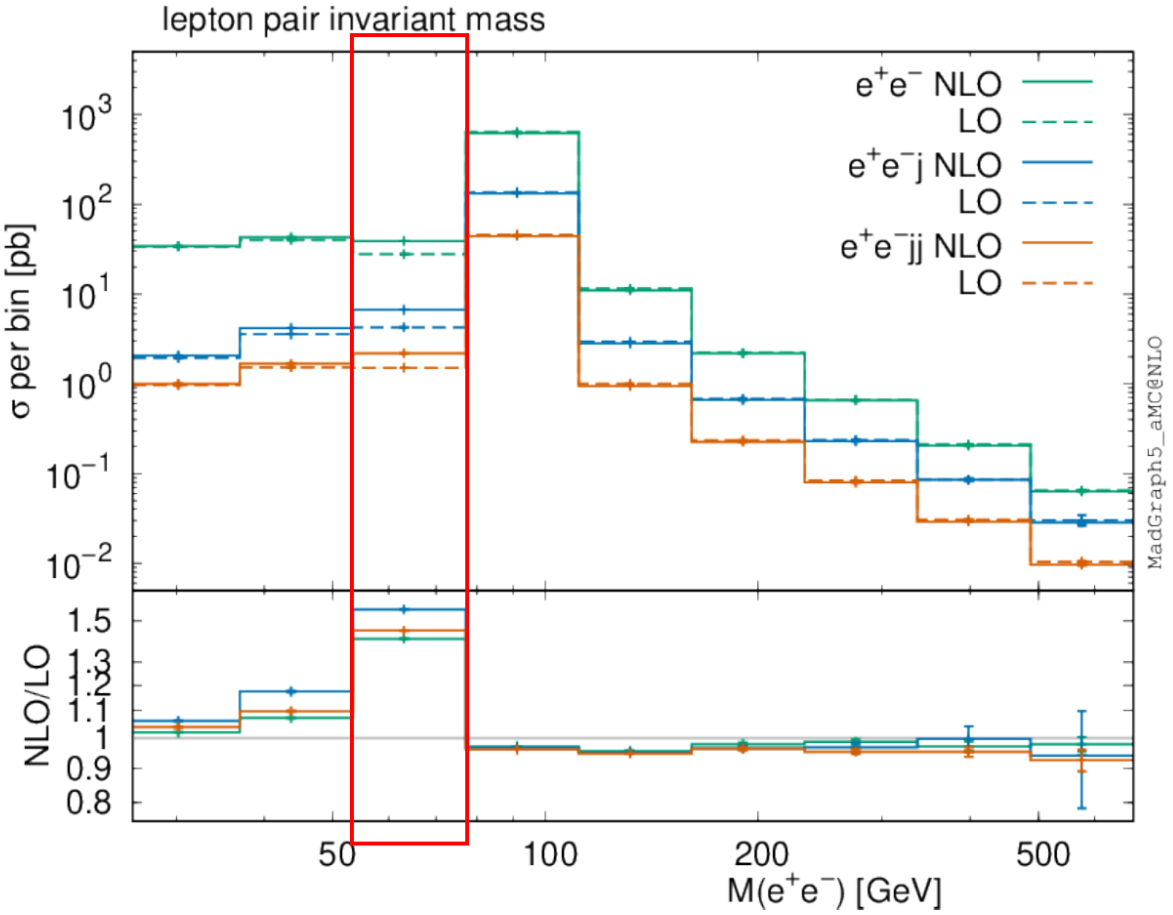
Counting couplings



LO	$\alpha^2\alpha_s^0$	100%
NLO QCD	$\alpha^2\alpha_s^1$	10%
NNLO QCD	$\alpha^2\alpha_s^2$	1%
NLO EW	$\alpha^3\alpha_s^0$	1%
Mixed NLO QCD×EW	$\alpha^{5/2}\alpha_s^{1/2}$	1%

$\alpha \sim 0.01$, $\alpha_s \sim 0.1$

MadGraph NLO EW prediction



Madgraph5_aMC@NLO: JHEP 07 (2018) 185

CMS analysis

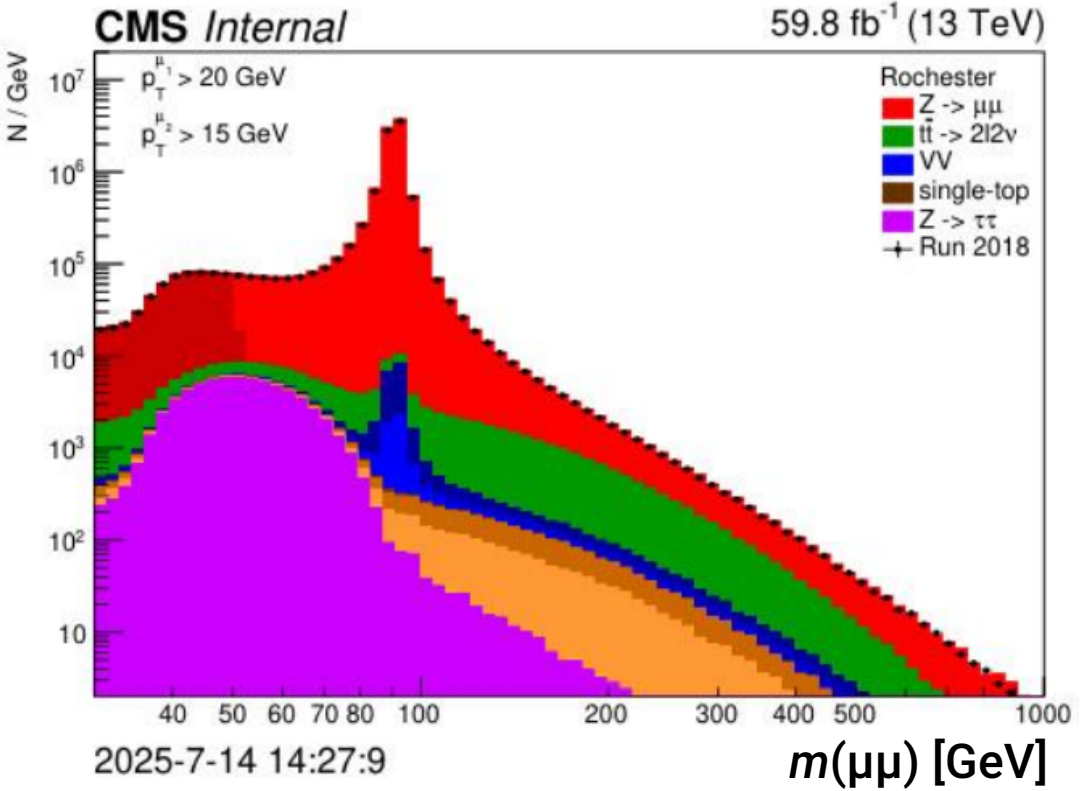
Ojars Martins Eberlins, Ying An, Patrick Connor, Ankita Mehta, Louis Moureaux, Markus Seidel

Measure Z → μμɣ

- Branching fraction
- Differential distributions

Preliminary selection (2018 only)

- Two tight muons, p_T > 15, 20 GeV
- One tight photon, p_T > 20 GeV
- **40 < *m*(μμ) < 76 GeV**
- 76 < *m*(μμɣ) < 106 GeV
- ~13% efficient



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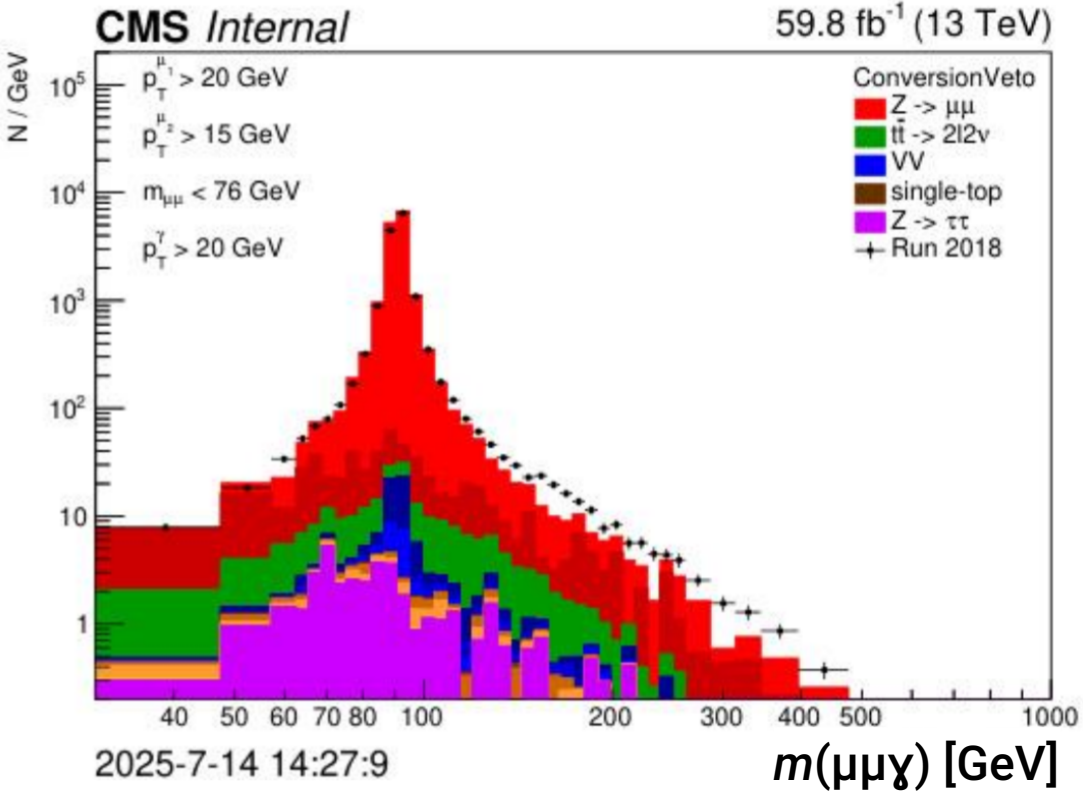
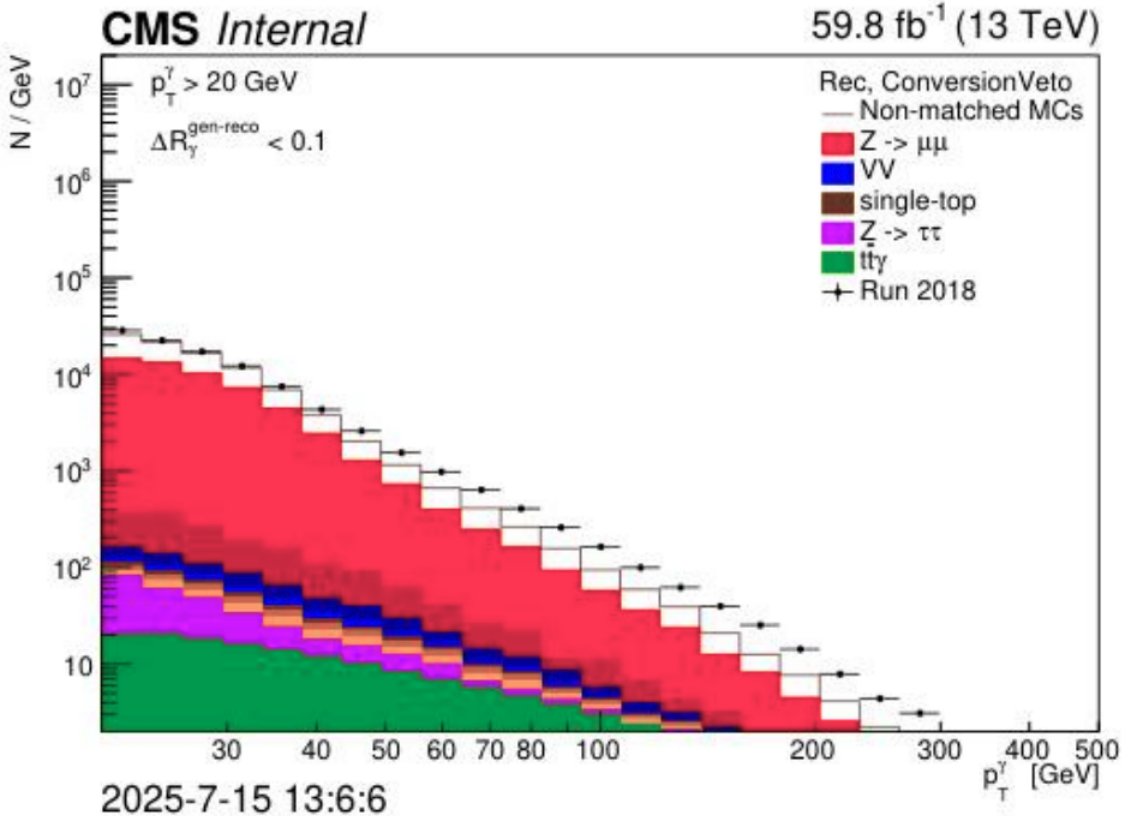


Single-differential

Planning to repeat [EWK-11-016]

- Photon p_T
- $\Delta R_{\gamma\mu}$
- $m_{\mu\mu}$, $m_{\mu\mu\gamma}$

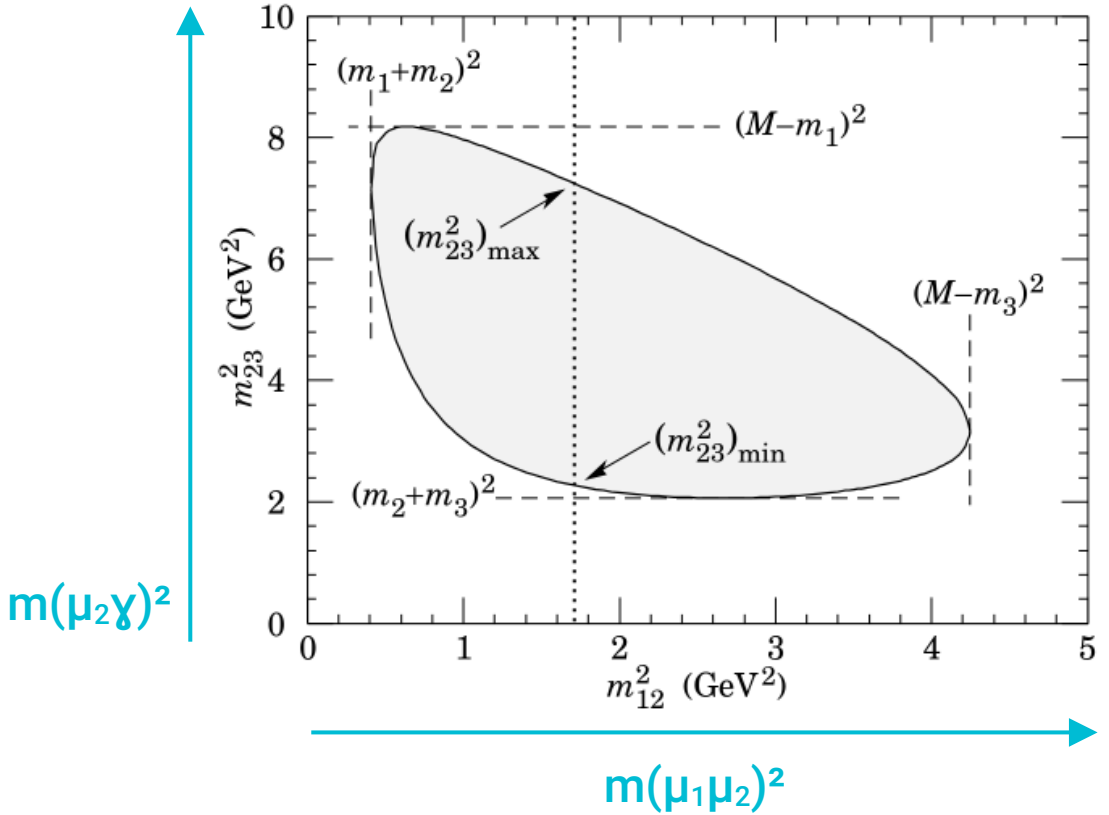


Double-differential

Parametrization of 3-body decays: Dalitz plots

- Invariant masses of object pairs
- Complete description of the decay (ignoring spin effects)

PDG on kinematics



Double-differential

First 2D plot

- All muon & photon corrections applied
- General description is OK
- 10–20% too much simulation?
  Affecting wide-angle radiation more
- We do not know yet if this is real