

Update of photon energy scale from $Z \rightarrow ll\gamma$

Y. Fang

IHEP

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Introduction

- ▶ Extract photon energy scale (PES) from $Z \rightarrow ll\gamma$ events
 - ▶ Release: 21.2.5
 - ▶ Data sets: $\sim 80/\text{fb}$ pp collision data taken at 13 TeV during 2015, 2016 and 2017
- ▶ Use the template fit method
Perform a split of dataset into converted photons (1+2 tracks) and unconverted photons for the determination of the residual PES w.r.t. photon η , pile-up $\langle \mu \rangle$

Variable name and type	Bin boundaries
Photon η	$[0, \pm 0.6, \pm 1, \pm 1.37, \pm 1.82, \pm 2.37]$
Pile-up ($\langle \mu \rangle$)	$\langle 18, 18-27, > 27$

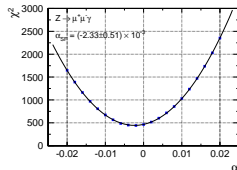
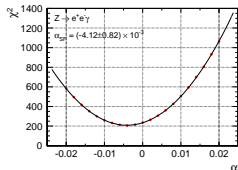
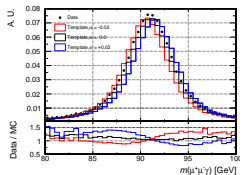
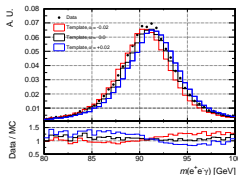
Template fit method

Use MC samples to construct $m(\ell\ell\gamma)$ templates for α between -0.02 and 0.02 , in steps of 0.002

- ▶ Scale photon p_T by a factor of $(1 + \alpha)$
- ▶ Re-compute invariant mass of $\ell\ell\gamma$

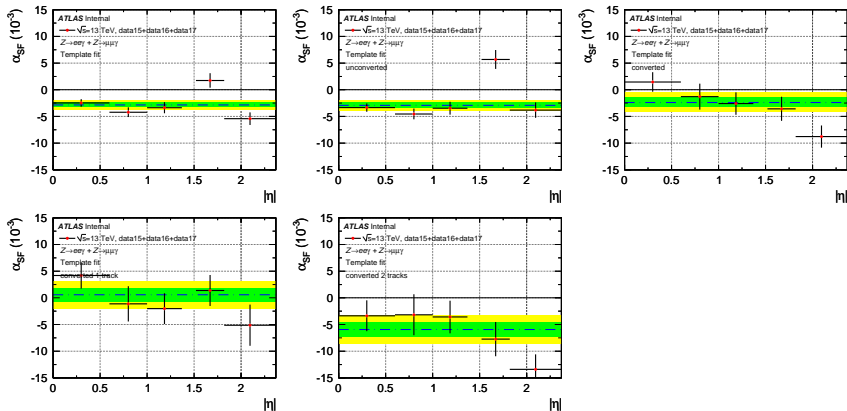
Compute $\chi^2 = f(\alpha)$ between data and each MC template:

$$\chi^2 = \sum_{\text{bin}} \frac{(\text{data}_{\text{bin}} - \text{MC}_{\text{bin}})^2}{(\delta\text{data}_{\text{bin}})^2 + (\delta\text{MC}_{\text{bin}})^2}$$



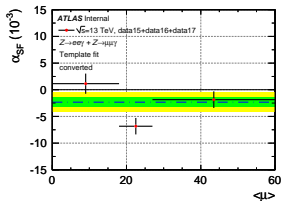
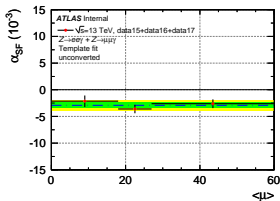
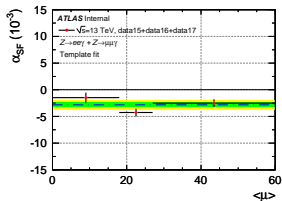
- ▶ Fit $\chi^2\alpha$ with parabola $\chi^2 = a + \frac{(x-m)^2}{s^2}$, the best estimate of PES is the parameter m while its uncertainty will be s
- ▶ Combine results of electron and muon channels

Differential results - $|\eta|$



$\alpha_{SF} (10^{-3})$	All	Bin 1	Bin 2	Bin 3	Bin 4	Bin 5
Incl	-2.84 ± 0.43	-2.47 ± 0.71	-4.21 ± 0.91	-3.36 ± 1.04	1.74 ± 1.36	-5.41 ± 1.18
unconv	-2.93 ± 0.49	-3.34 ± 0.77	-4.54 ± 1.00	-3.45 ± 1.20	5.68 ± 1.77	-3.81 ± 1.44
conv	-2.39 ± 0.93	1.46 ± 1.83	-1.29 ± 2.42	-2.59 ± 2.11	-3.57 ± 2.26	-8.76 ± 2.07
conv 1 trk	0.58 ± 1.27	4.19 ± 2.47	-1.11 ± 3.31	-2.03 ± 2.90	1.38 ± 2.90	-5.12 ± 3.87
conv 2 trks	-5.94 ± 1.35	-3.36 ± 2.89	-3.17 ± 3.84	-3.58 ± 3.06	-7.73 ± 3.21	-13.40 ± 2.80

Differential results - $\langle \mu \rangle$



$\alpha_{SF} (10^{-3})$	All	Bin 1	Bin 2	Bin 3
Incl	-2.82 ± 0.43	-1.47 ± 0.94	-4.27 ± 0.69	-2.50 ± 0.72
unconv	-2.92 ± 0.49	-2.15 ± 1.08	-3.61 ± 0.78	-2.62 ± 0.81
conv	-2.33 ± 0.93	1.14 ± 1.89	-6.83 ± 1.54	-1.85 ± 1.56