Electrons Faking Photons

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Event Selection

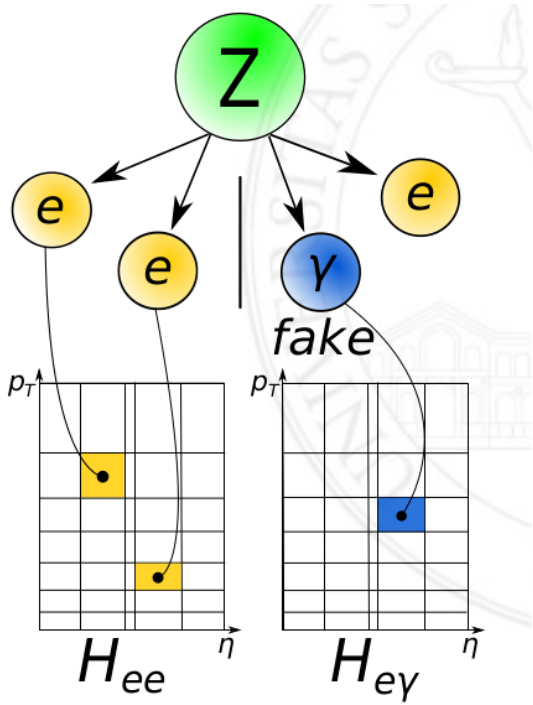
- The measurement is based on selection of candidate Z events
- Selection
  - At least 2 e/γ with p_T>25 GeV and $|\eta| < 2.37$, not in the crack region
  - Electrons:
    - ID: LLH Medium (as in the analysis)
    - ISO: GradientLoose (as in the analysis)
  - Photons:
    - ID: Tight (as in the analysis)
    - ISO: FixedCutTightCaloOnly (as in the analysis)
    - $\Delta R_{e,\gamma} > 0.4$ (as in the analysis)
  - It is important that the selected objects fulfil the same requests used for define objects in CR and SR in the analysis.

Method

- Consider the pairs with invariant mass inside a 75 -105 GeV window.
- For each event just the closest pair around the Z peak is considered.
- A re-weighting of the events is performed, fitting the invariant mass distribution and evaluating the Signal to Background ratio S/(S+B).

- If the best mass is given by two opposite sign electrons
  - fill a 2D histogram, H_{ee} (η^e, p_T^e)with the variables of both particles.
  - weighting each electron with the $\frac{S}{(S+B)}(m_{ee})$ weight of the pair
- If the best mass is given by electron-photon pair
  - fill a 2D histogram, $H_{e\gamma}$ (η^γ, p_T^γ)with the variables of the photon.
  - weighting the photon with the $\frac{S}{(S+B)}(m_{e\gamma})$ weight of the pair
- The "fake rate" is measured as:

$$F_{e\to\gamma}(\eta, p_T) = \frac{H_{e\gamma}(\eta, p_T)}{H_{ee}(\eta, p_T)}$$



Method

- Let f_{ij} be the fraction of Z boson events for which the leading (sub-leading) electron falls into the i^{th} (j^{th}) bin of the grid.
- The number of entries N_i^{ee} in the i^{th} bin of the electron-positron grid is

$$N_i^{ee} = \sum_j \epsilon_i \epsilon_j f_{ij} N + \sum_j \epsilon_j \epsilon_i f_{ji} N = \epsilon_i N \sum_j (\epsilon_j f_{ij} + \epsilon_j f_{ji}) \,.$$

- Similarly, the number of entries $N_i^{e\gamma}$ in the i^{th} bin of the electron-photon grid is

$$N_i^{e\gamma} = \sum_j p_i \epsilon_j f_{ij} N + \sum_j \epsilon_j p_i f_{ji} N = p_i N \sum_j (\epsilon_j f_{ij} + \epsilon_j f_{ji}) \,.$$

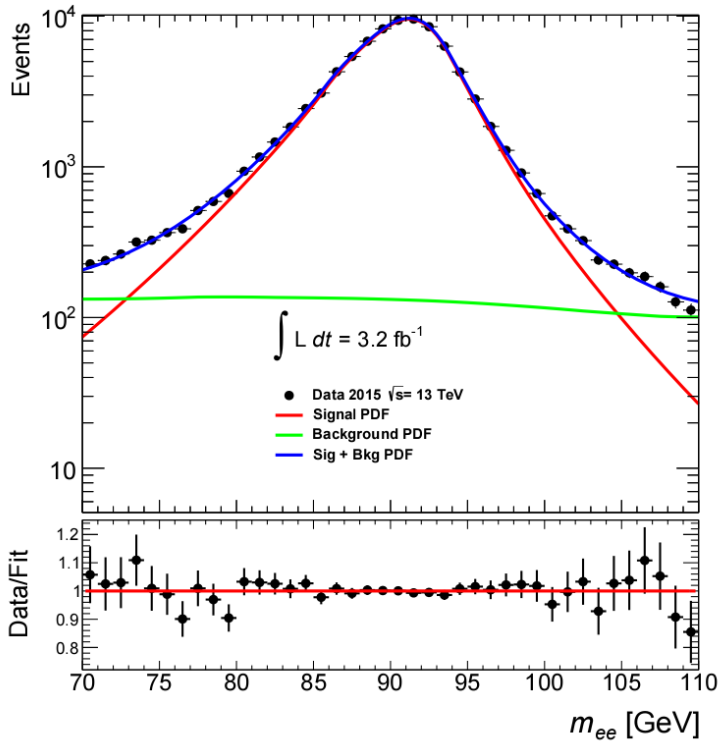
- The electron-to-photon *fake factor*, $F_{e\to\gamma}$, in bins of and η is defined as

$$F_{e\to\gamma}(p_{\mathrm{T}}, \eta) \equiv \frac{N_i^{e\gamma}}{N_i^{ee}} = \frac{p_i}{\epsilon_i}$$

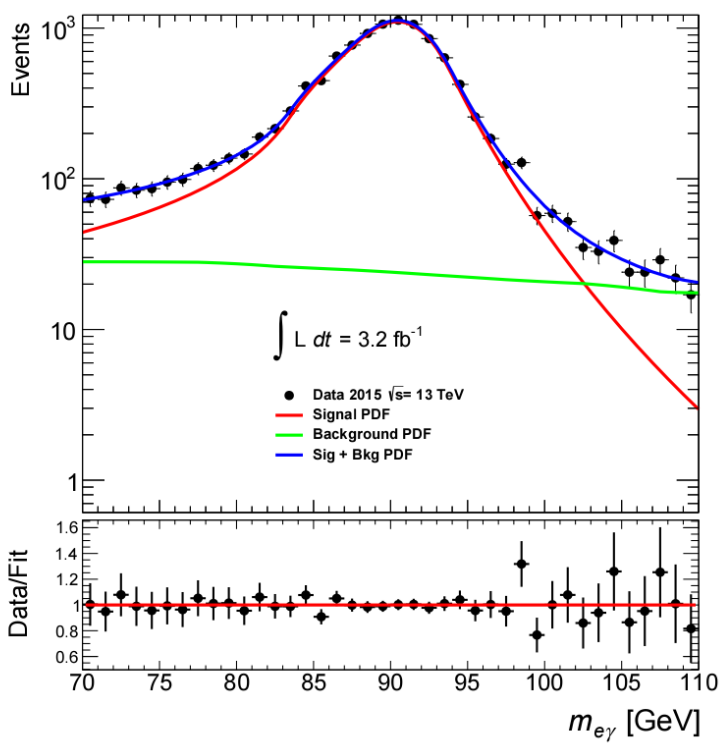
- Rather than the misidentification rate p itself, $F_{e\to\gamma}$ is instead the ratio of the misidentification rate and the electron reconstruction-identification efficiency.

Signal to Background ratio: Fit

- Signal: Double Crystal Ball
- Backgrund: template derived from a background only sample obtained reversing ISO and ID requirements
- The fit is performed for different η categories (barrel-barrel, barrel-endcap, endcap-endcap)



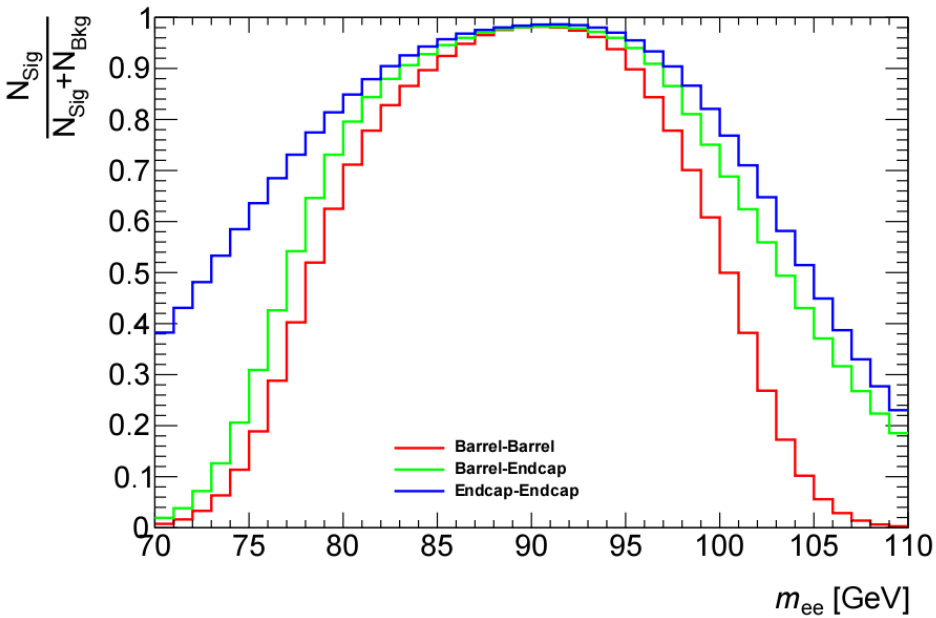
ee pair Endcap-Endcap

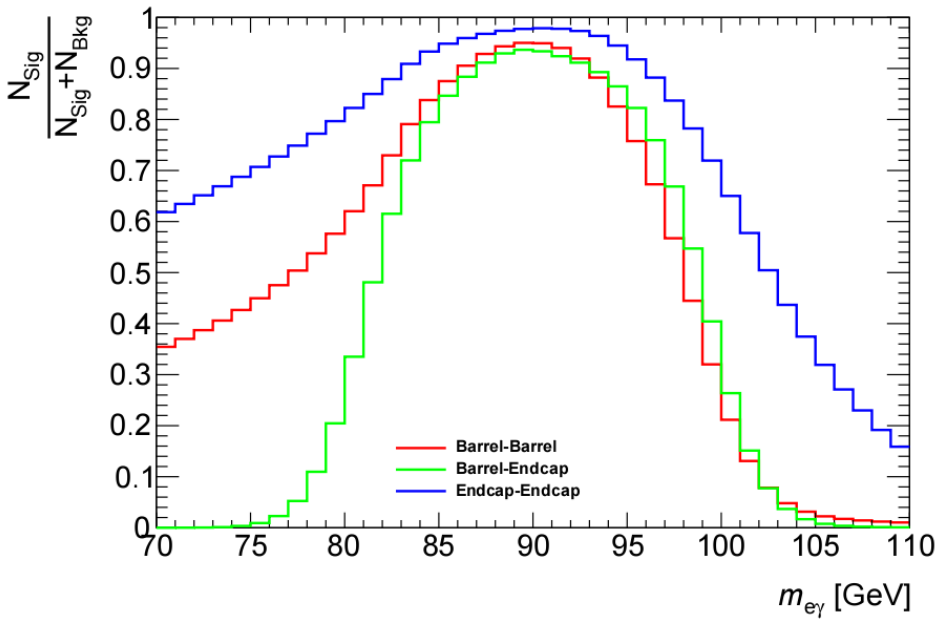


$e\gamma$ pair Endcap-Endcap

Signal to Background ratio: Weight

- The fit on the different categories leads to different weights distributions
- The reweighting is then performed picking the correct category for each pair.

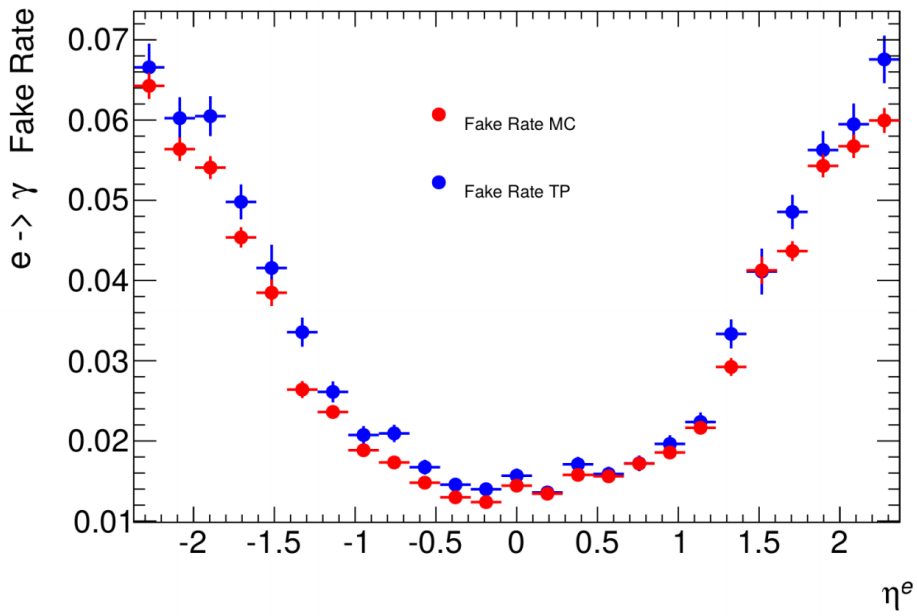




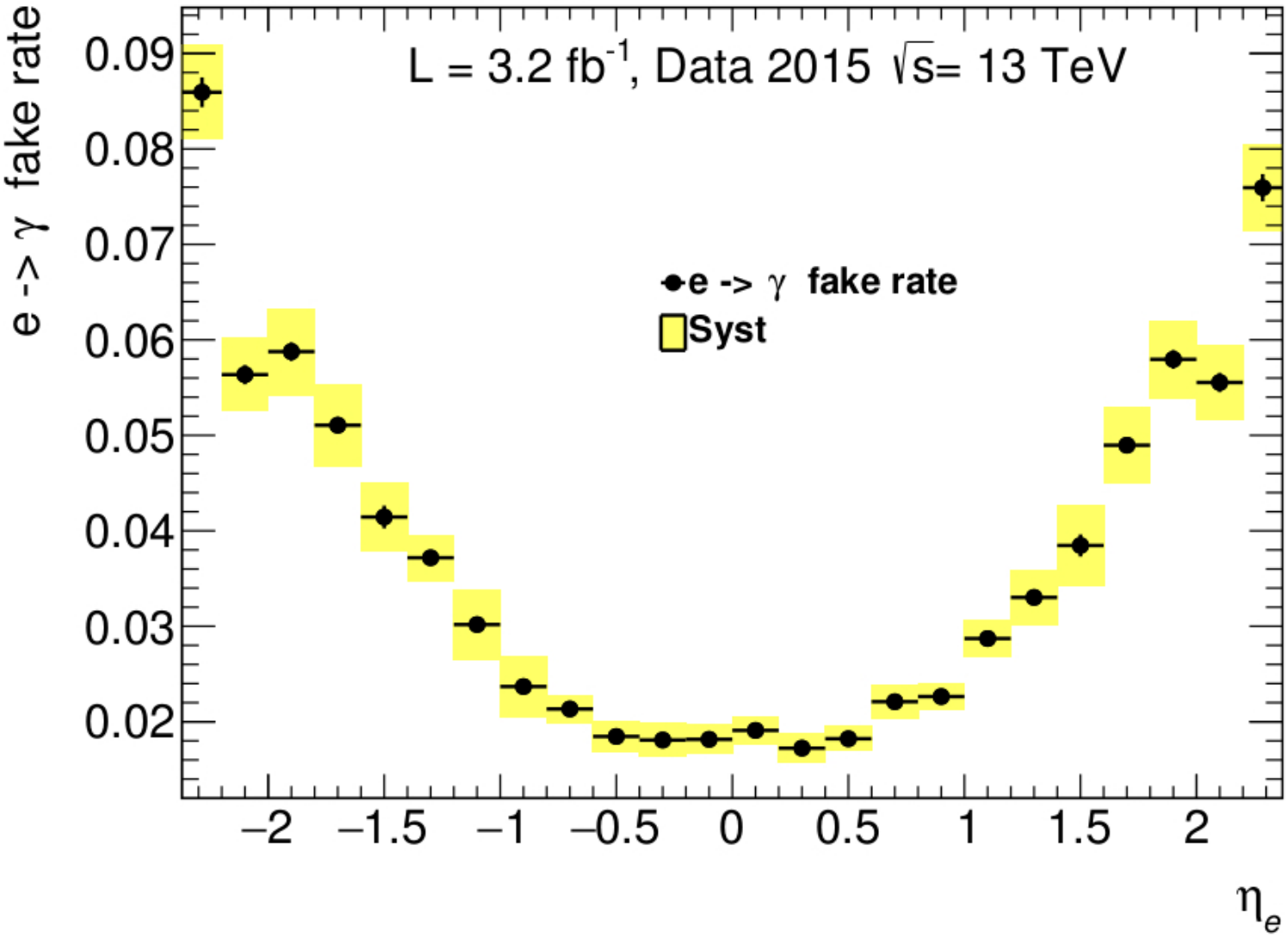
Systematic Uncertainties

- The systematic uncertainties are estimated considering different sources.
- Changing the size of the mass selection window in which the pairs are selected from [75-105] GeV to [70-110] GeV and to [80-100] GeV
- Varying (independently) the invariant mass range of the fit from [70-110] GeV to [65-115] GeV and to [75-105] GeV (new sets of weights and different fake rates are evaluated)
- Considering the non-closure between the measured fake rate and the truth MC fake rate

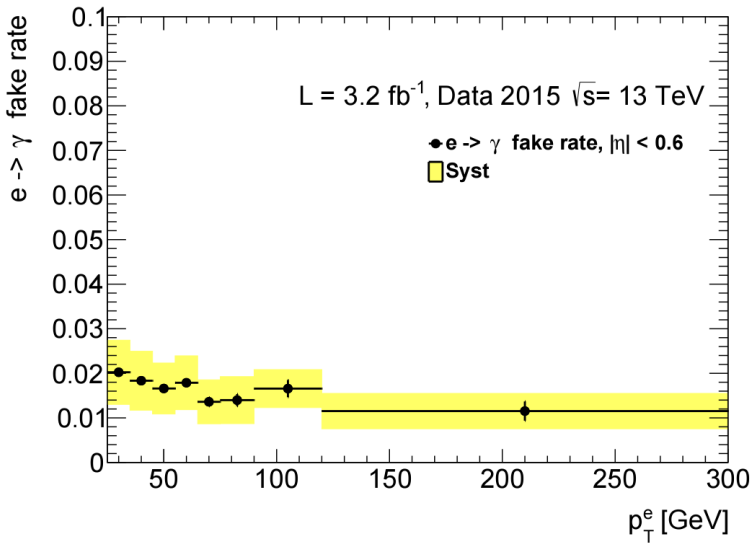
$$F^{MC}_{e\to\gamma} = \frac{N_{\gamma(ISO,ID|e_{truth})}}{N_{e(ISO,ID|e_{truth})}}$$

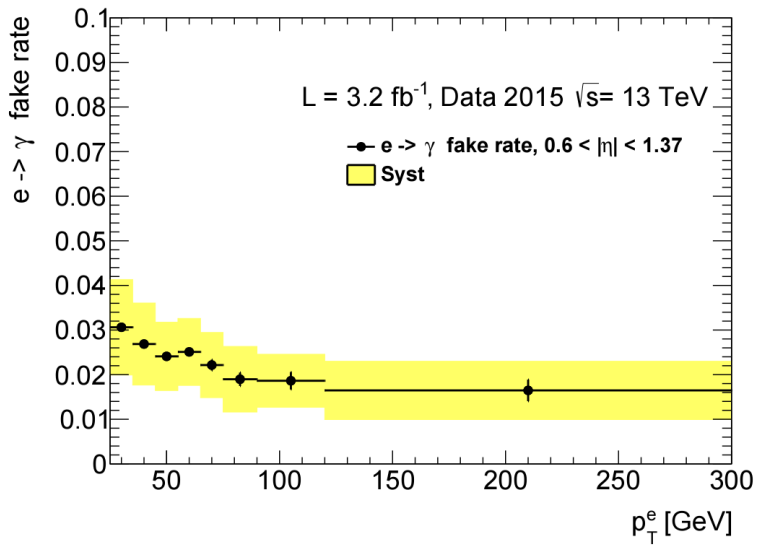


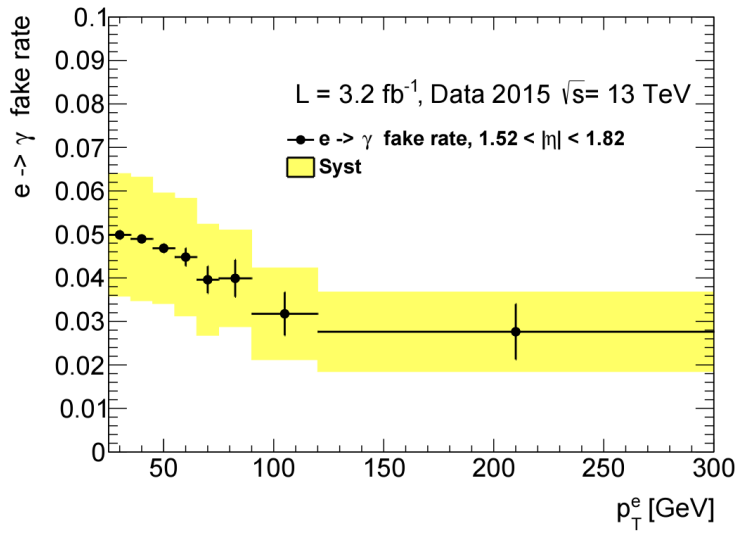
Result

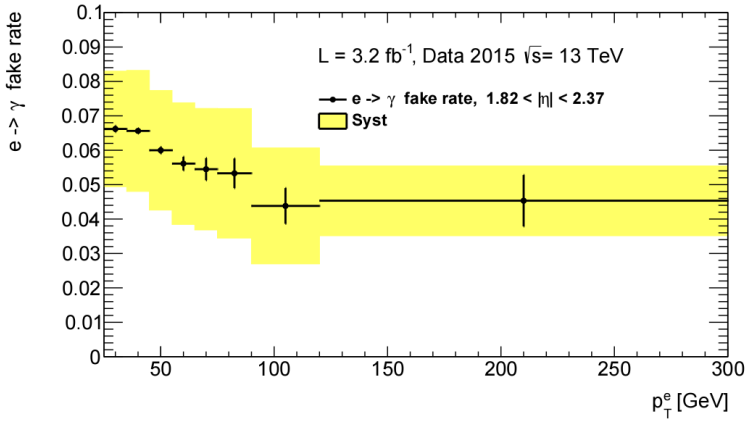

L = 3.2 fb^{-1}, Data 2015 $\sqrt{s}$= 13 TeV
e -> γ fake rate
Syst
e -> γ fake rate
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
η_e

Result


L = 3.2 fb^{-1}, Data 2015 $\sqrt{s}$= 13 TeV
e -> γ fake rate, |η| < 0.6
Syst
e -> γ fake rate
p_T^e [GeV]


L = 3.2 fb^{-1}, Data 2015 $\sqrt{s}$= 13 TeV
e -> γ fake rate, 0.6 < |η| < 1.37
Syst
e -> γ fake rate
p_T^e [GeV]


L = 3.2 fb^{-1}, Data 2015 $\sqrt{s}$= 13 TeV
e -> γ fake rate, 1.52 < |η| < 1.82
Syst
e -> γ fake rate
p_T^e [GeV]


L = 3.2 fb^{-1}, Data 2015 $\sqrt{s}$= 13 TeV
e -> γ fake rate, 1.82 < |η| < 2.37
Syst
e -> γ fake rate
p_T^e [GeV]

Example: electroweak background in di-photon+E_T^{miss}

- EW background accounts for SM contributions mainly from W(W$\rightarrow$eν)γ, $t\bar{t}\gamma$, Z(W$\rightarrow$ee/$\tau\tau$)γ.
- Evaluated rescaling the number of events in a control region defined as SR but which requests to have exactly one photon and at least one electron with $p_T^{\gamma} > 75$ GeV

$$N_{e\rightarrow\gamma}(p_{\mathrm{T}}, \eta) = F_{e\rightarrow\gamma}(p_{\mathrm{T}}, \eta) \times N_{e\gamma}(p_{\mathrm{T}}, \eta)$$

  where $F_{e\rightarrow\gamma}(p_{\mathrm{T}}, \eta)$ is measured starting from a Z$\rightarrow$ee data sample as the ratio of the number of the selected ee and eγ couples.
- The contribution to SR is 0.03 ± 0.02

$p_T(e)$	$\eta(e)$	$p_T(\gamma)$	$\eta(\gamma)$	H_T	E_T^{miss}	$F_{e\rightarrow\gamma}$
113	-0.606	88	-1.849	1606	186	0.019
166	0.581	105	-1.273	1033	586	0.012

Conclusion

- An electron fakes photon rate measurement has been performed using 3.2 fb^{-1} at $\sqrt{s} = 13$ TeV
- Next steps:
  - Repeat the measurement using 2016 data
  - Improving the fit procedure
  - Better understanding of the non closure systematic
- The Photon ID group is now working to provide a measurement and eventually a tool/database using both 2015 and 2016 data.