Photon energy smearing in the simulation

RGA Fall 2018, outbending — $e\gamma\pi^+ n$ final state

Elouan Ferrand

CEA Saclay

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Photon energy smearing: method

Observable

Width of the missing neutron mass

$$M_{\text{miss}} = \left| p_{\text{beam}} + p_{\text{target}} - p_e - p'_\pi - p_\gamma \right|$$

separately for photons in the **FT** and in the **FD**.

Sample

- RGA Fall 2018, **outbending**.
- Data and simulation with **all the cuts** of my analysis.
- Simulation weighted with the full model of my analysis (Sullivan, Δ^+, $N^\star$, interference).
- Applied **after** the momentum corrections and the electron smearing.

Smearing

$$E_\gamma^{\text{smear}} = E_\gamma^{\text{reco}} + z\,\sigma_{\text{smear}}(p_\gamma)$$

- Direction kept (massless photon).
- $z \sim \mathcal{N}(0,1)$: random shift of width σ_{smear}.
- z drawn **once per event** and kept fixed while σ_{smear} is varied: only σ_{smear} changes between trials $\Rightarrow$ $\sigma_{\text{MC}}(\sigma_{\text{smear}})$ smooth and increasing, no statistical noise between trials.

Photon energy smearing: determination

In each p_γ bin

- Bins of equal data statistics: **9** in the FT (3.0–8.5 GeV), **3** in the FD (3.0–8.1 GeV).
- Width σ of the M_{miss} peak: Gaussian fit.
- σ_{smear} found by **bisection**: $\sigma_{\mathrm{MC}}(\sigma_{\mathrm{smear}}) = \sigma_{\mathrm{data}}$.

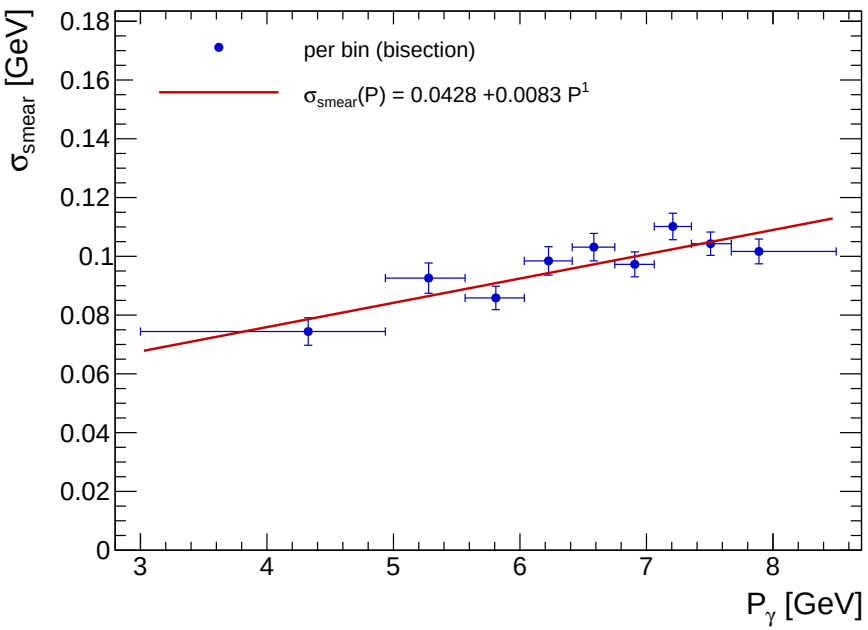
Straight-line fit in p_γ

FT: $\sigma_{\mathrm{smear}} = 0.0428 + 0.00827\, p_\gamma$

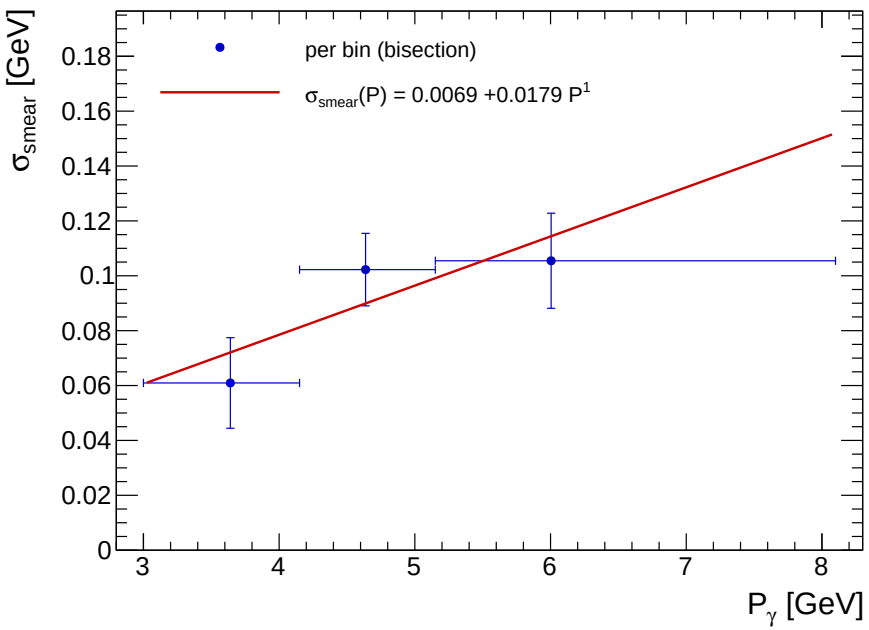
FD: $\sigma_{\mathrm{smear}} = 0.0069 + 0.0179\, p_\gamma$

GeV, clamped to the calibrated range.

FT photons: photon energy smearing



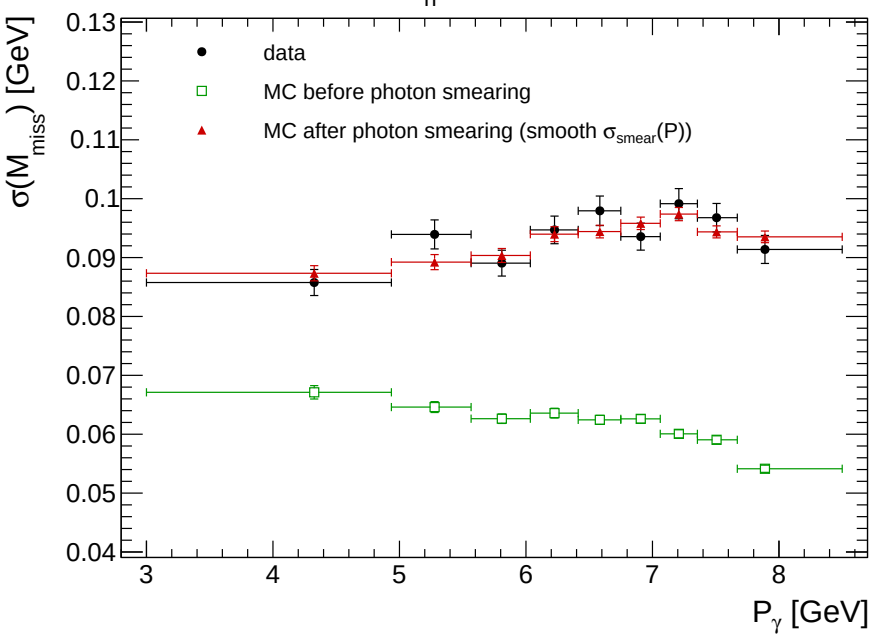
FD photons: photon energy smearing



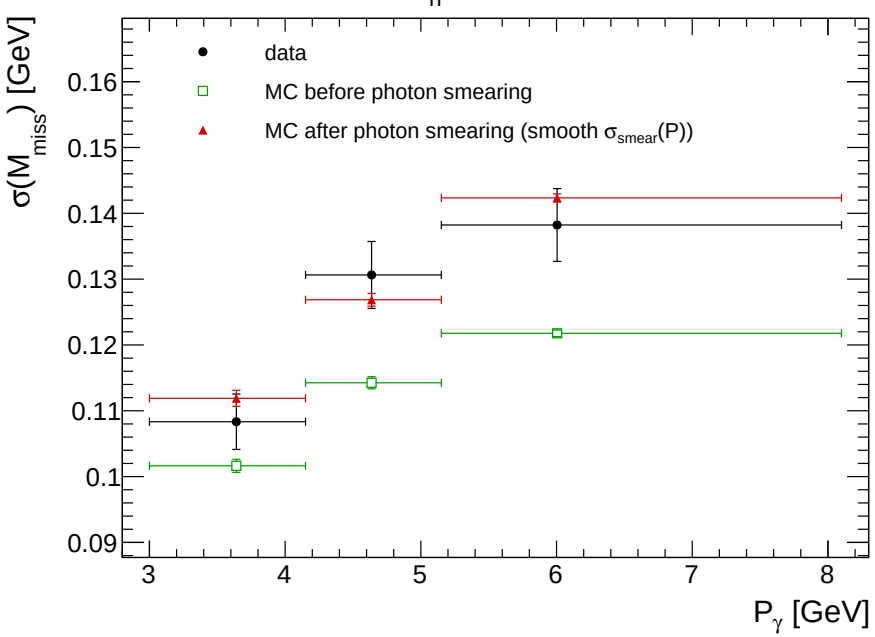
σ_{smear} per bin and fitted line: FT (left), FD (right).

Photon energy smearing: results

FT photons: width of the M_n peak



FD photons: width of the M_n peak



Width of the M_{miss} peak vs p_γ: data, simulation before and after smearing.

FT

Before: MC much narrower.
After: data reproduced in all 9 bins.

FD

Before: MC already closer.
After: data reproduced within the data uncertainties.

Photon energy smearing: limits

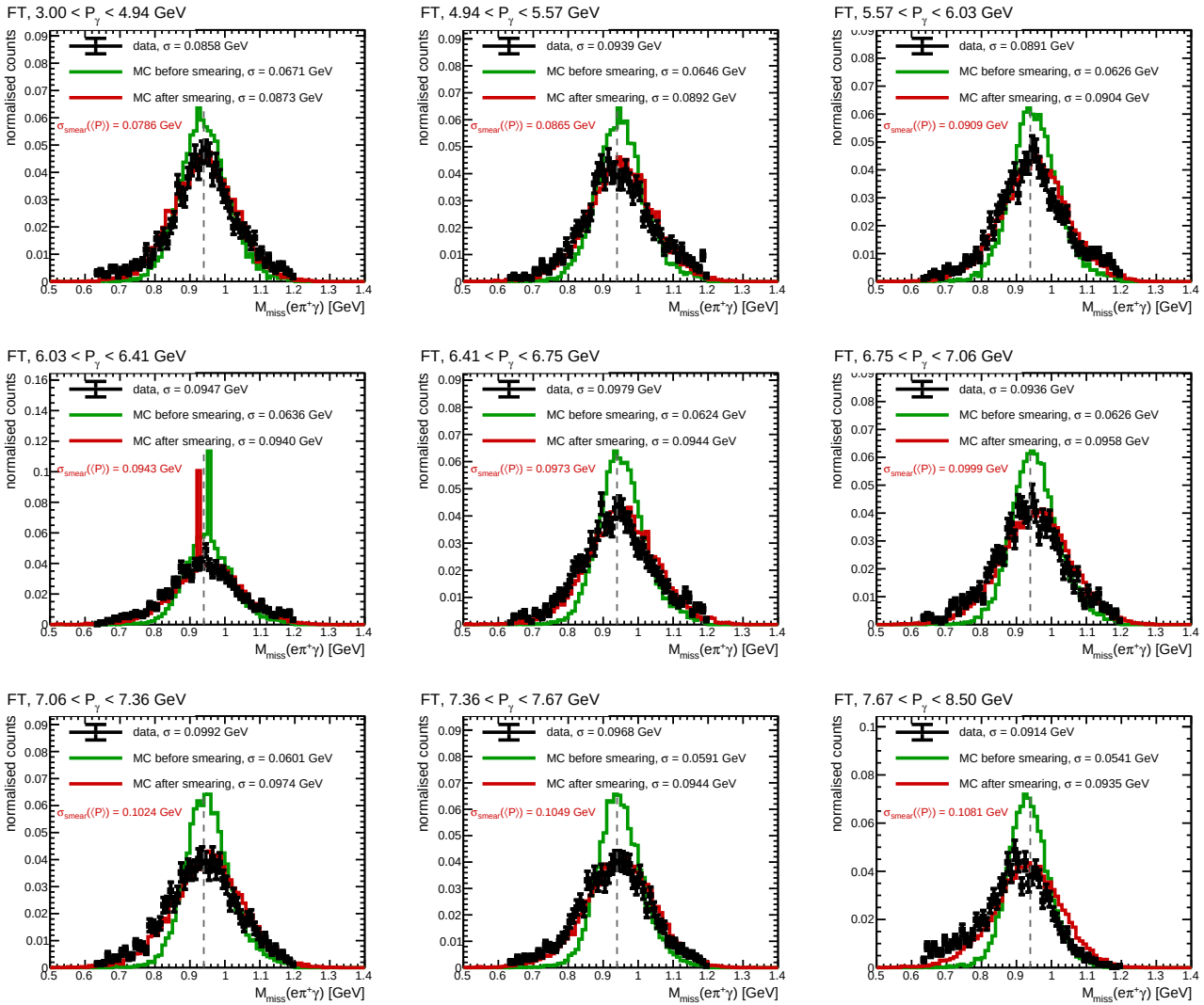
Specific to this analysis

- Tuned on **one final state**, $e\gamma\pi^+ n$, with its cuts and its kinematics: the p_γ, θ_γ range and the FT/FD share are those of this sample.
- Depends on the **momentum corrections** applied before, some of them developed for this analysis on the data, and on the **electron smearing**: any change of these requires redoing the photon smearing.
- Only **RGA Fall 2018 outbending**: not validated for inbending or other run periods.

Method

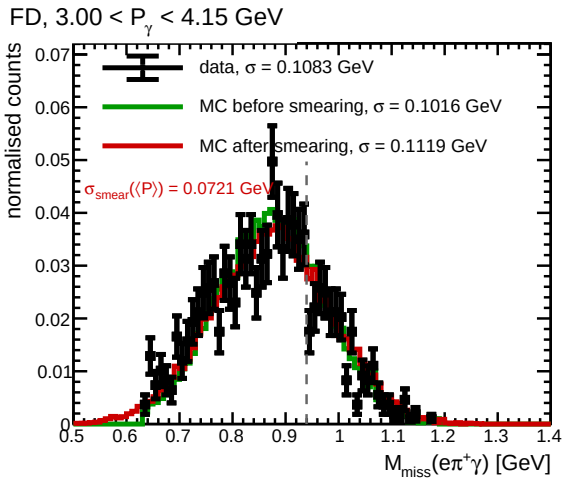
- M_{miss} also depends on the e and π^+ resolutions: the photon smearing absorbs any residual mismatch of the other particles (effective smearing, not a pure photon resolution).
- Only the **energy** is smeared, not the angles.
- **FD**: 3 bins, large uncertainties; linear form assumed, clamped outside the calibrated range.

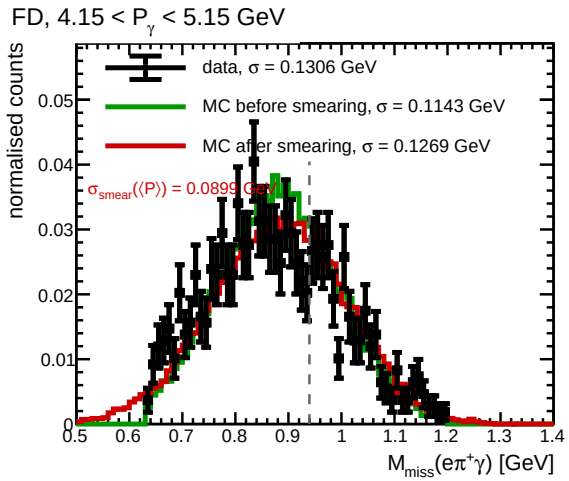
Backup: M_{miss} peak in each photon momentum bin (FT)

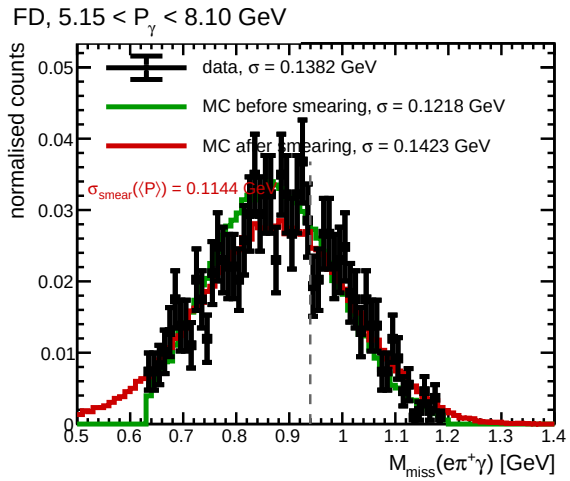


FT, 9 bins

Backup: M_{miss} peak in each photon momentum bin (FD)







FD, 3 bins