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New variable for studying H→γγ transverse momentum distributions at hadron colliders

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higgstools

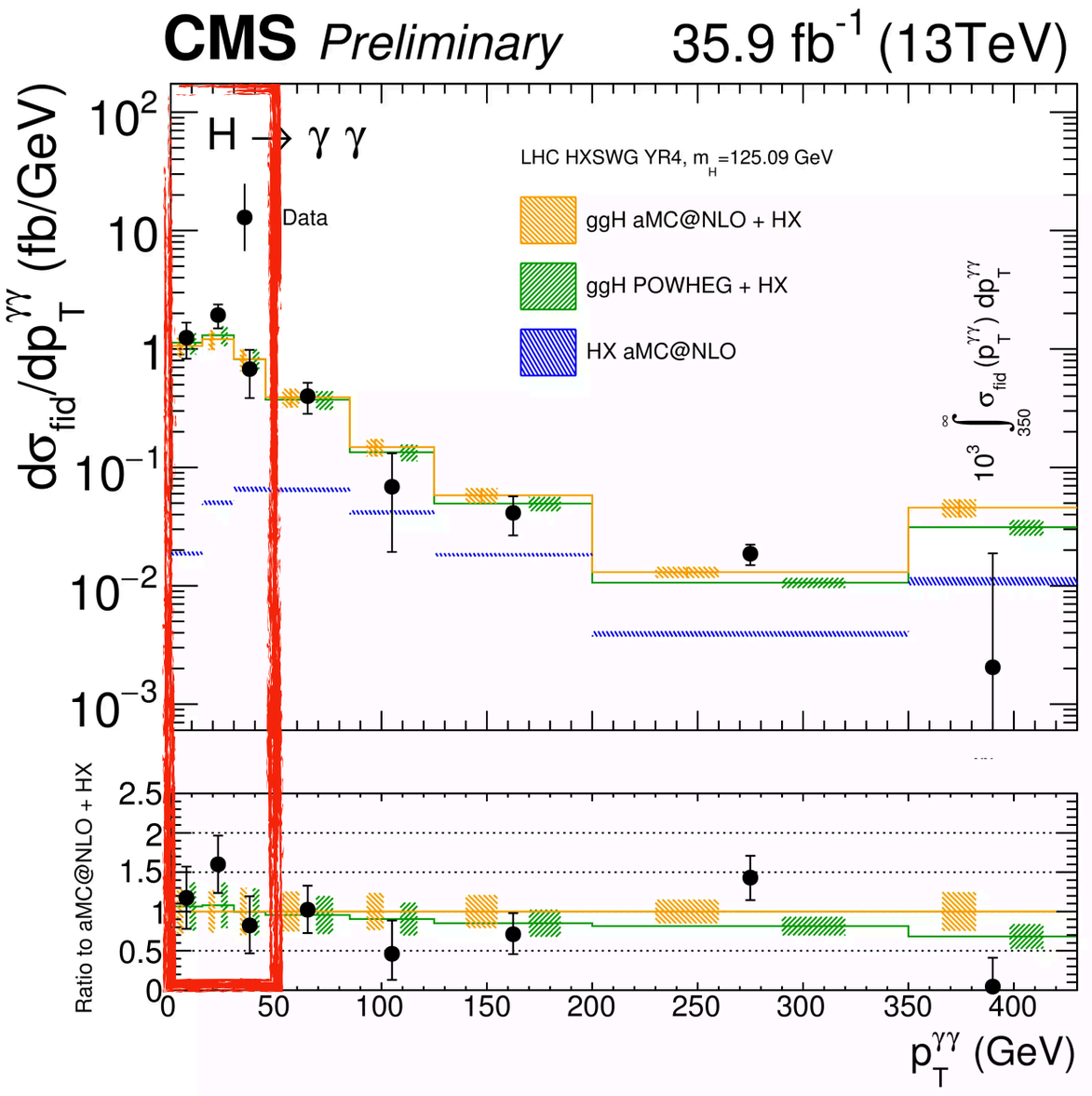
Motivation of Higgs p_T measurement

- Provide an ideal testing of pQCD
- Study the low $P_T(H)$ region where non-perturbative effects may play a role
- Improve the modelling of Higgs boson production with important implications for understanding it production.

Optimisation of new variables to study $P_T(H)$

Why a new variable ?

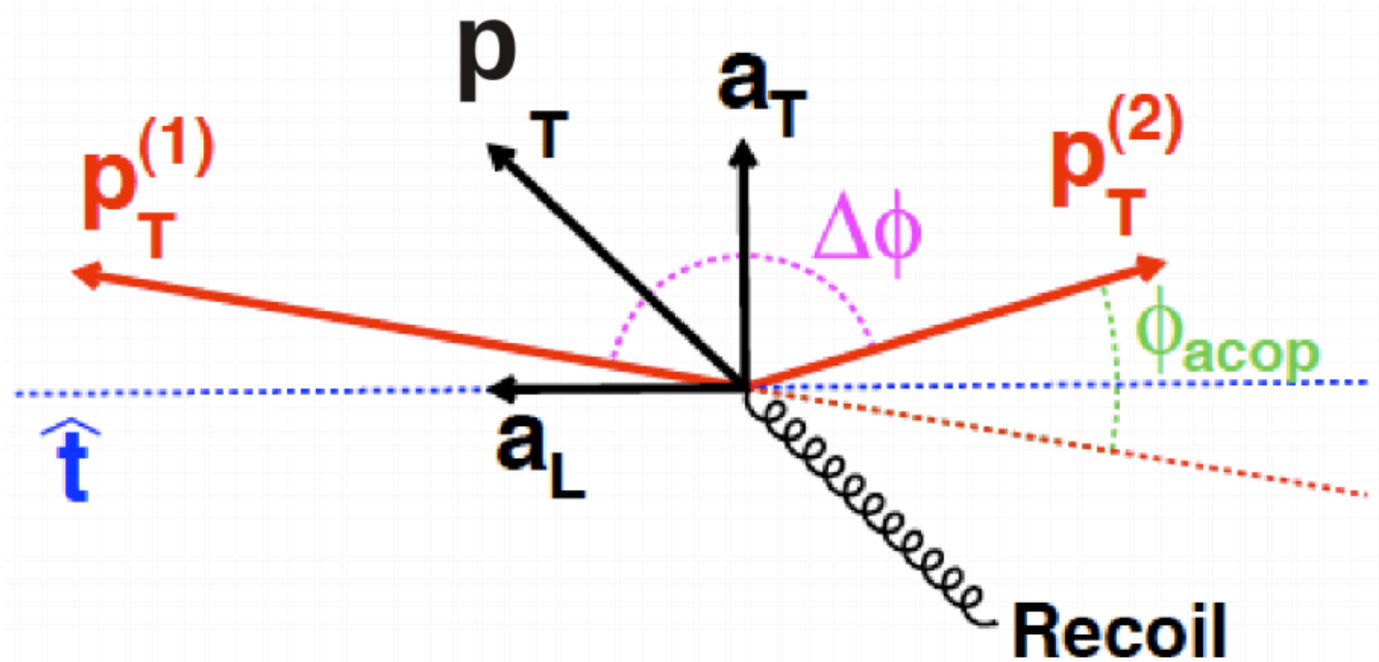
- With the increase of luminosity at the LHC, the measurement of at low $P_T(H)$ will be limited by the experimental resolution rather than the event statistics.
- Main systematic uncertainties of the latest $P_T(H)$ measurement :
  - photon resolution ~5%
  - vertex finding / pileup ~1.5 %



- Optimise a new variable :
  - less sensitive to the effects of experimental resolution
  - probe the same physical effects as $P_T(H)$

New variables to study $P_T(H)$

- Initial idea from measurement of $P_T(Z)$ from Phys J. C, 71:1600, 2011.



$$\hat{t} = (p_T^{(1)} - p_T^{(2)}) / |p_T^{(1)} - p_T^{(2)}|$$

$$p_T \rightarrow a_T \rightarrow a_T/m_H \overset{p_T^{(1)} \approx p_T^{(2)}}{\approx} \tan(\phi_{acop}/2)\sin(\theta^*)$$

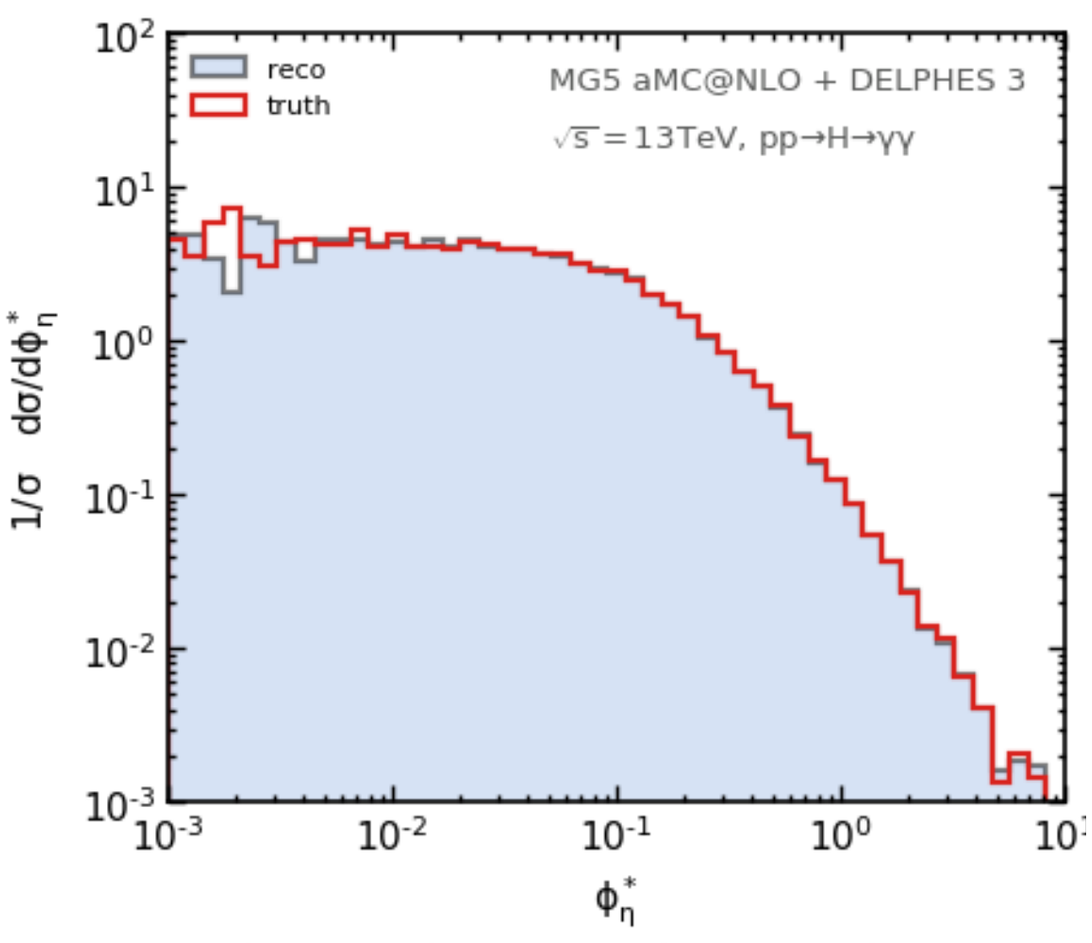
θ* is the scattering angle of the photons relative to the beam direction in the diphoton rest frame

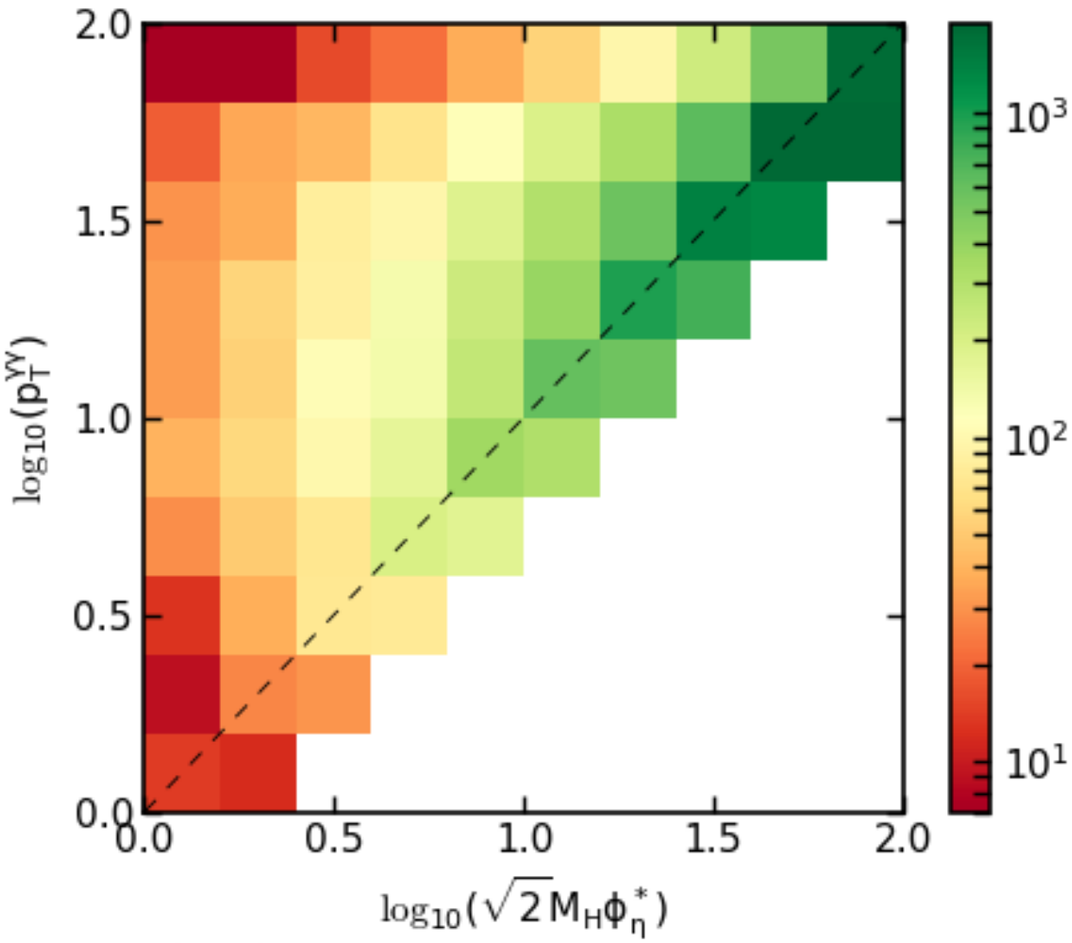
The ϕ^*_η variable

- θ^* is still sensitive to the effects of photon momentum resolution.
- θ^*_η is an alternative way to estimate the scattering angle:

$$\cos(\theta^*_\eta) = \tanh\left(\frac{\eta_1 - \eta_2}{2}\right)$$

$$a_T/m_H \approx \tan(\phi_{acop}/2)\sin(\theta^*) \rightarrow \phi^*_\eta \equiv \tan(\phi_{acop}/2)\sin(\theta^*_\eta)$$

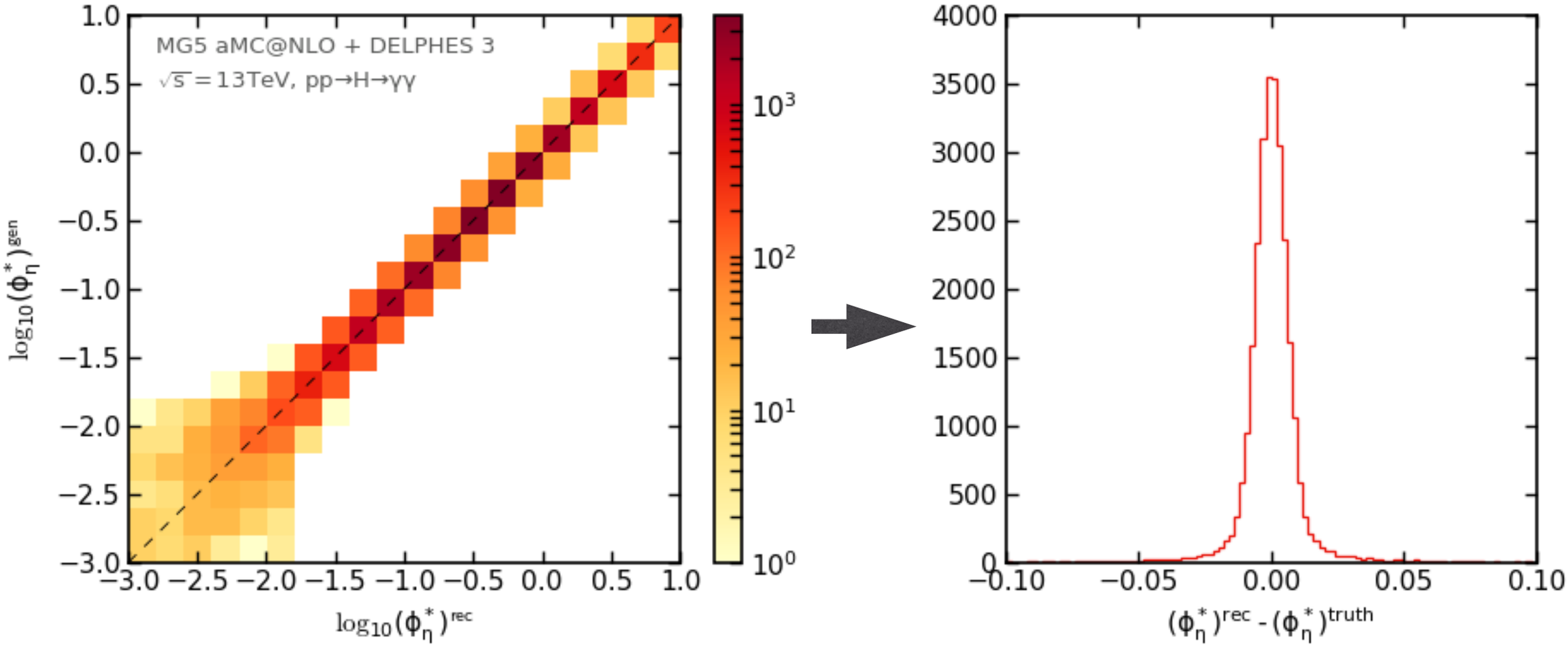




- ϕ^*_η is based entirely on the measured photon directions

Comparison of few variables to study $P_T(H)$

- Dependence on the CMS detector resolution effect mimicked by DELPHES 3 (arXiv:1307.6346)
- The Higgs signal is simulated by Madgraph5 at the NLO accuracy
- Same fiducial volume as used for the differential cross section measurements (CMS-PAS-HIG-17-015) :
- $P_T^{\gamma}(1,2)/m_{\gamma\gamma} > 1/3\ (1/4)$, Isolation < 10 GeV, $|m_{\gamma\gamma} - 125| < 10$ GeV



- The performance of each variable is defined by the RMS of the deviation from the truth value
- This method was proposed and used in Phys J. C, 71:1600, 2011.

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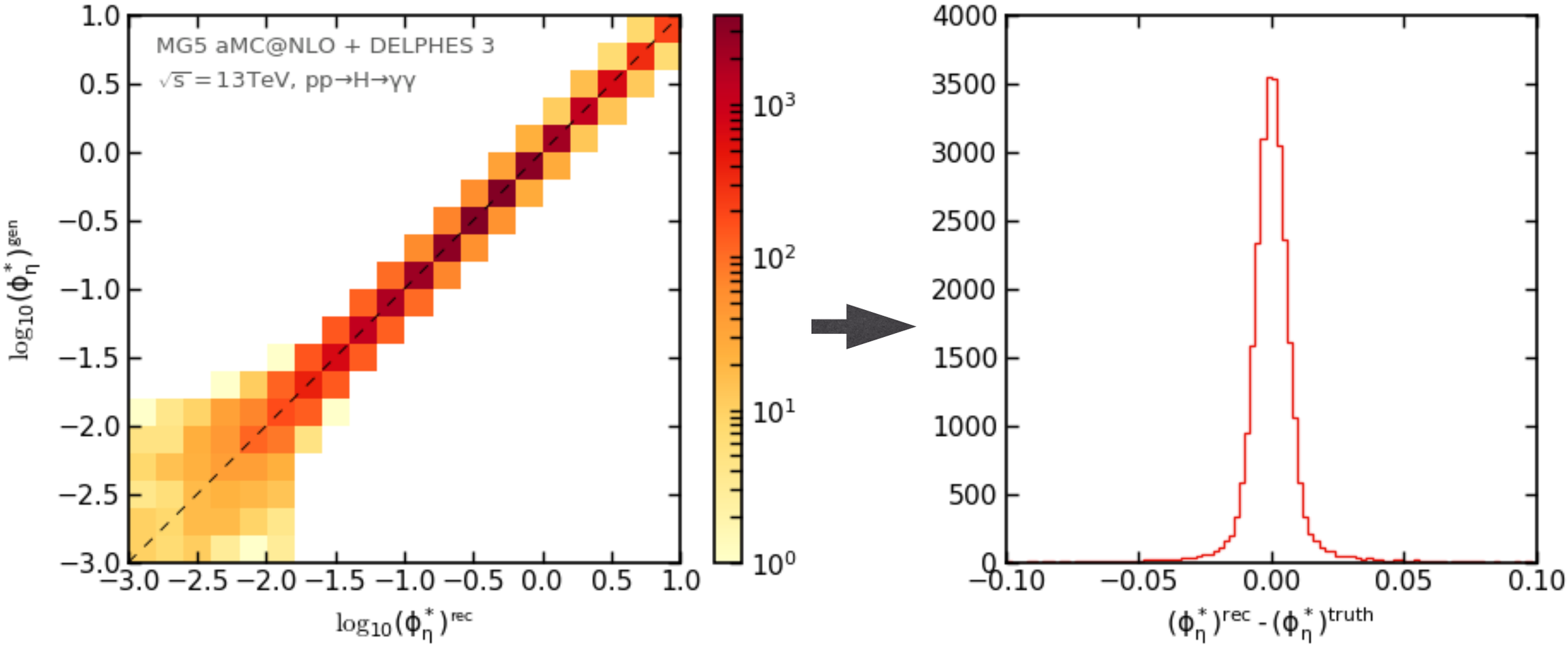
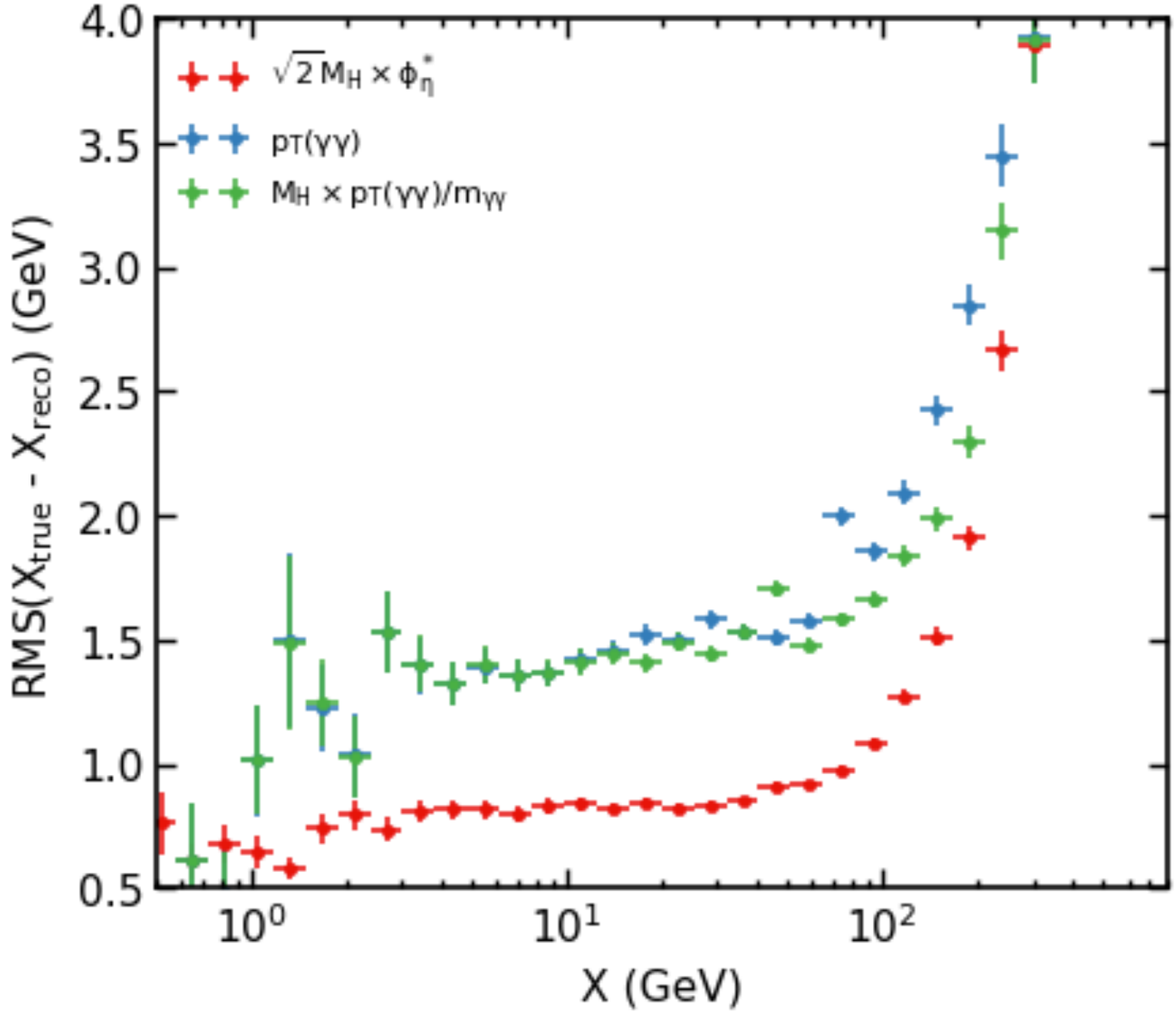


- The performance of each variable is defined by the RMS of the deviation from the truth value
- This method was proposed and used in Phys J. C, 71:1600, 2011.
- we compared 3 different variable: $P_T(\gamma\gamma)$, $P_T(\gamma\gamma)/m_{\gamma\gamma}$, ϕ^*_η

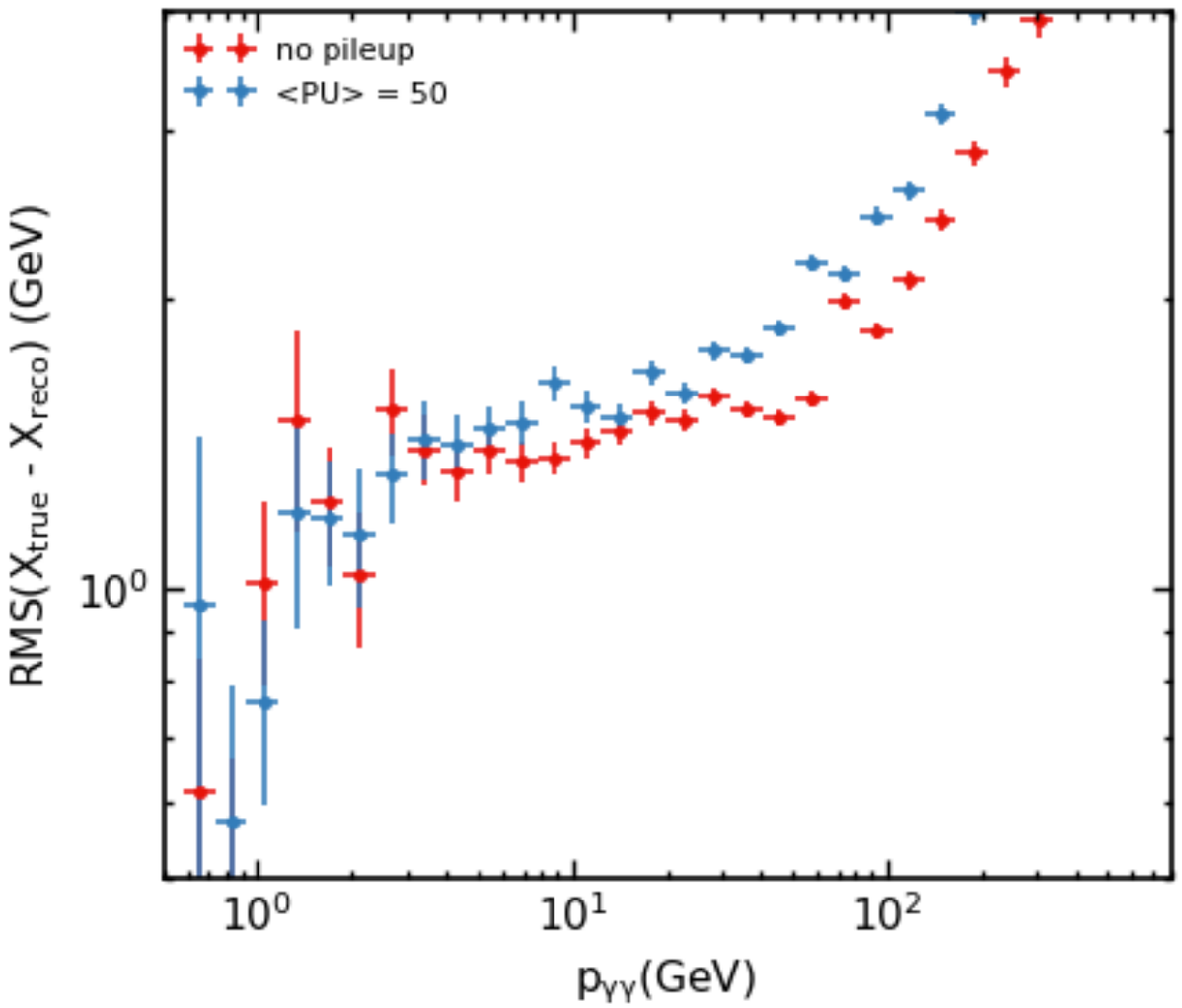
Comparison of few variables to study $P_T(H)$

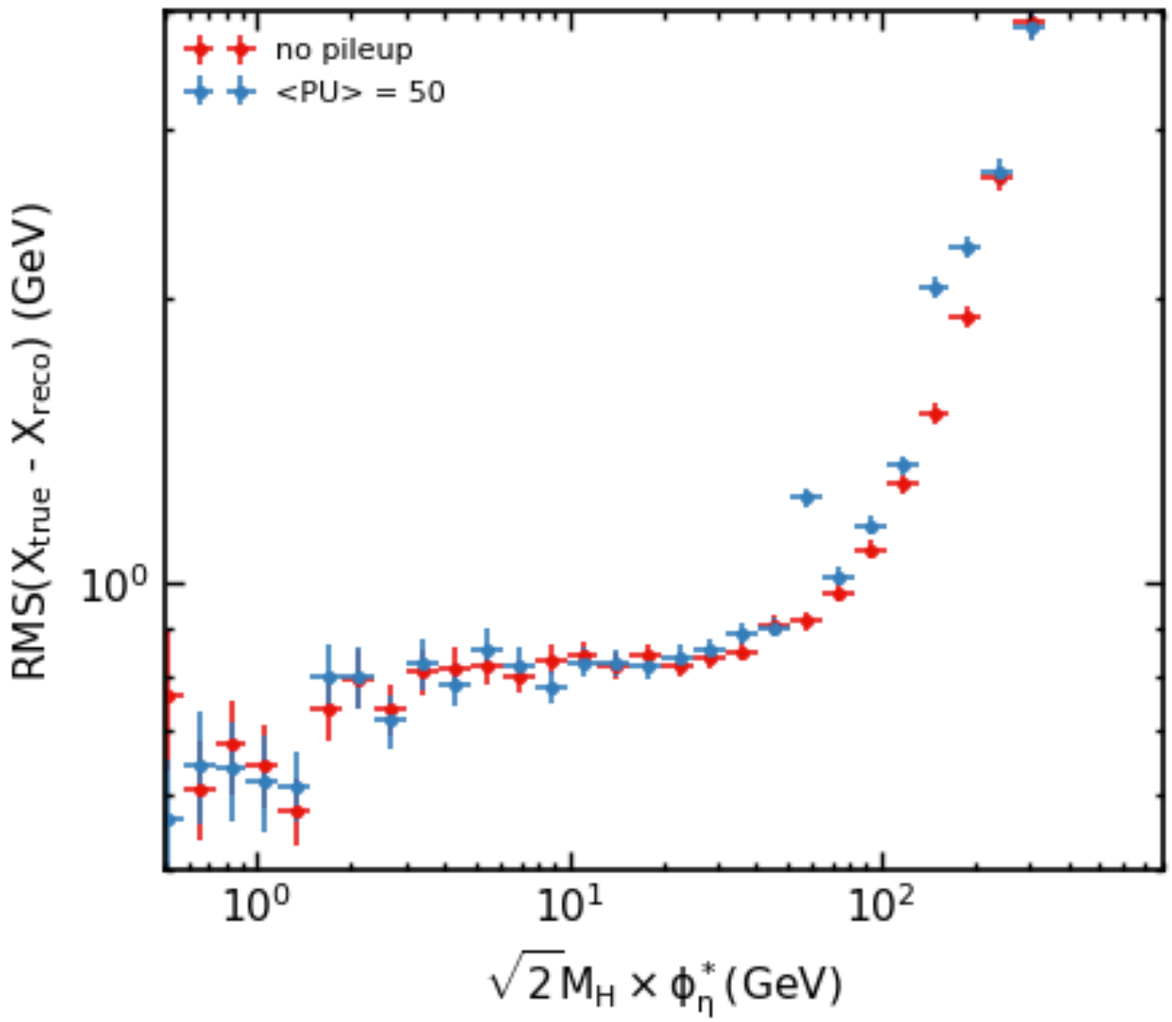


- ϕ^*_η has the best resolution in comparison with other variables to study $P_T(H)$, more than 50% improvement the region < 100 GeV

The case of pileup

- To take into account the effect of pileup that introduce additional vertices
- Wrong vertex choice lead to an impact to the θ^*_η introducing additional systematic on the ϕ^*_η
- We compared two scenarios, with a pileup of μ = 50 and without pileup





- Pileup has a little impact on this variable comparing the $P_T(\gamma\gamma)$

Conclusion

- Measurement of of diphoton transverse momentum distributions are crucial for improving Higgs models at hadron colliders
- We explored the use of the ϕ^*_η variable, introduced to study the Z p_T in the case of of Higgs decaying into photons
- ϕ^*_η variable showed very promising results, improving the precision on low pT region by a factor of 2.5
- The pile is shown to have little impact