

# The Higgs $p_T$ Spectrum and Total Cross Section with Fiducial Cuts at $N^3LL' + N^3LO$

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Higgs 2021

Stony Brook, October 21



# The Higgs $p_T$ Spectrum and Total Cross Section with Fiducial Cuts at $N^3LL' + N^3LO$

based on

[PRL 127 (2021) 7, 072001, 2102.08039]

in collaboration with

G. Billis, B. Dehnadi, M. Ebert, F. Tackmann



# Overview of results

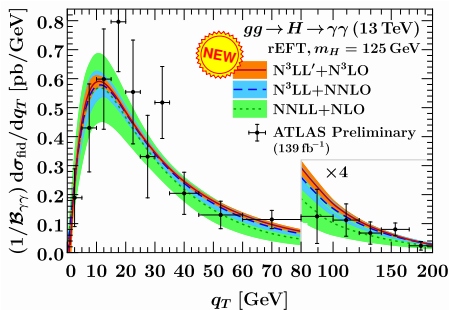
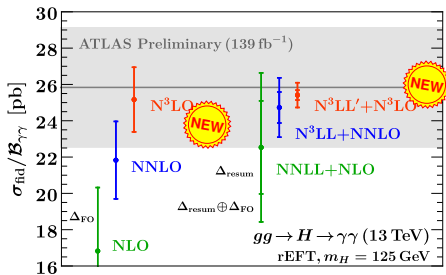
Consider  $gg \rightarrow H \rightarrow \gamma\gamma$  with ATLAS fiducial cuts:

$$p_T^{\gamma 1} \geq 0.35 m_H, \quad p_T^{\gamma 2} \geq 0.25 m_H, \quad |\eta^\gamma| \leq 2.37, \quad |\eta^\gamma| \notin [1.37, 1.52]$$

## New results

[Billis, Dehnadi, Ebert, JM, Tackmann, PRL 127 (2021) 7, 072001, 2102.08039]

- First total fiducial cross section at N<sup>3</sup>LO (and optionally improved by resummation)
- First differential cross section for  $q_T \equiv p_T^H = p_T^{\gamma\gamma}$  at N<sup>3</sup>LL'+N<sup>3</sup>LO



# Total fiducial cross section at N<sup>3</sup>LO

Differential  $q_T$  subtractions:

$$\sigma = \int_0^{q_T^{\text{off}}} dq_T \frac{d\sigma_{\text{FO}}^{\text{sing}}}{dq_T} + \int_0^{q_T^{\text{off}}} dq_T \frac{d\sigma_{\text{FO}}^{\text{nons}}}{dq_T} + \int_{q_T^{\text{off}}} dq_T \frac{d\sigma_{\text{FO}1}}{dq_T}$$

- $d\sigma^{\text{sing}}$  contains all singular (+ virtual) terms  $\sim \frac{1}{q_T} \left[ \ln^n \frac{q_T}{m_H} + \frac{q_T}{m_H} \ln^n \frac{q_T}{m_H} \right]$
- Predicted by factorization  $\Rightarrow$  integrate analytically
- Last missing piece: three-loop gluon beam function  
[Ebert, Mistlberger, Vita '20; Luo, Yang, Zhu, Zhu '20]
- $d\sigma_{\text{FO}1}$  from existing fiducial NNLO<sub>1</sub>  $H + j$  data from NNLOjet  
[Chen, Cruz-Martinez, Gehrmann, Glover, Jaquier '15-16; as used in Chen et al. '18; Bizoń et al. '18]
- Extract  $d\sigma_{\text{FO}}^{\text{nons}} = d\sigma_{\text{FO}1} - d\sigma_{\text{FO}}^{\text{sing}}$  by fit to known subleading-power form

$$\sigma_{\text{fid}}^{\text{N}^3\text{LO}} / \mathcal{B}_{\gamma\gamma} = (25.16 \pm 1.78_{\text{FO}} \pm 0.11_{\text{nons}}) \text{pb}$$

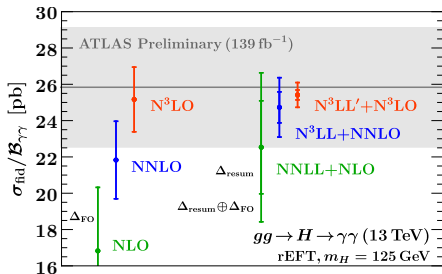
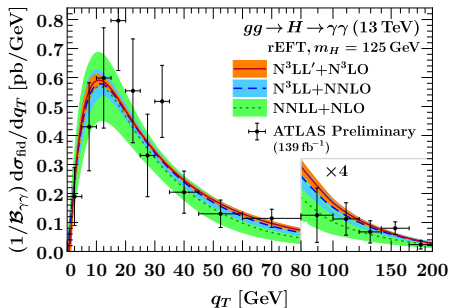
Differential  $q_T$  subtractions:

$$\sigma = \int_0^{q_T^{\text{off}}} dq_T \frac{d\sigma_{\text{FO}}^{\text{sing}}}{dq_T} + \int_0^{q_T^{\text{off}}} dq_T \frac{d\sigma_{\text{FO}}^{\text{nons}}}{dq_T} + \int_{q_T^{\text{off}}} dq_T \frac{d\sigma_{\text{FO}1}}{dq_T}$$

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    - Predicted by factorization  $\Rightarrow$  integrate analytically
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[Chen, Cruz-Martinez, Gehrmann, Glover, Jaquier '15-16; as used in Chen et al. '18; Bizoń et al. '18]
  - Extract  $d\sigma_{\text{FO}}^{\text{nons}} = d\sigma_{\text{FO}1} - d\sigma_{\text{FO}}^{\text{sing}}$  by fit to known subleading-power form
- First complete application of  $q_T$  subtractions at N<sup>3</sup>LO
- Would be valuable to compare to  $\int$  of N<sup>3</sup>LO fiducial spectra from other method  
[Chen, Gehrmann, Glover, Huss, Mistlberger, Pelloni, 2102.07607; see talk by B. Mistlberger]

# Higgs $p_T$ spectrum (and the total fiducial cross section) at $N^3LL'+N^3LO$

- Doing the resummed spectrum now easy:  $d\sigma_{FO}^{sing} \rightarrow d\sigma_{res}^{sing}$  and don't integrate
- Identical ingredients for  $N^3LL'$  resummation as for  $N^3LO$  fixed-order subtraction
- Qualitative improvement in uncertainties from previous  $N^3LL$  to  $N^3LL'$ 
  - Similar improvement also found in [Re, Rottoli, Torrielli, 2104.07509; see talk by L. Rottoli]



- Fiducial acceptance  $A(q_T)$  induces residual resummation effect in *total*  $\sigma_{fid}$ 
  - Effect is fully quantified in resummed perturbation theory
  - ▶ Best prediction for  $\sigma_{fid}$  from integrating resummed + matched  $d\sigma_{fid}/dq_T$