NNLO predictions for Higgs production at LHC

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Outline

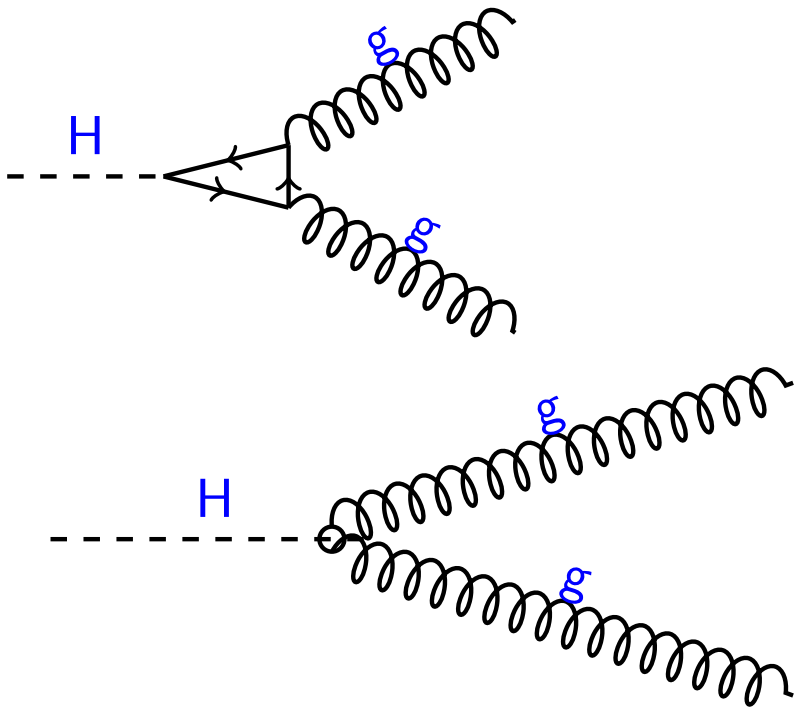
Motivation

- The Higgs was found three years ago at the LHC...
- ... or at least "a" Higgs was, is this the Standard Model Higgs?
- More precise predictions are required to either confirm or rule out this possibility

What do we need?

- A subtraction scheme
- (Mostly) automatic computer program
- A Large Hadron Collider running at 13 TeV ✓

Effective gg to H coupling

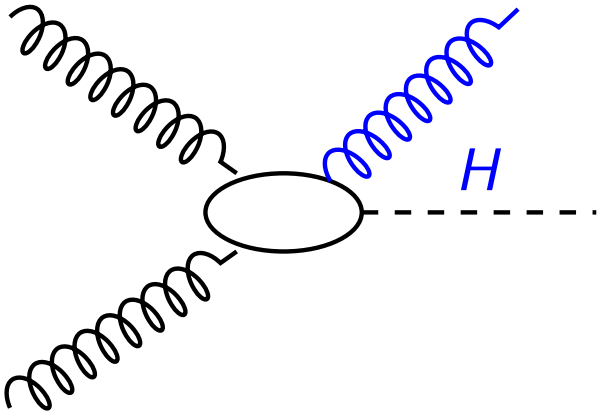


$$\lambda = \frac{\sqrt{G_F\sqrt{2}}}{6\pi}\alpha_s$$

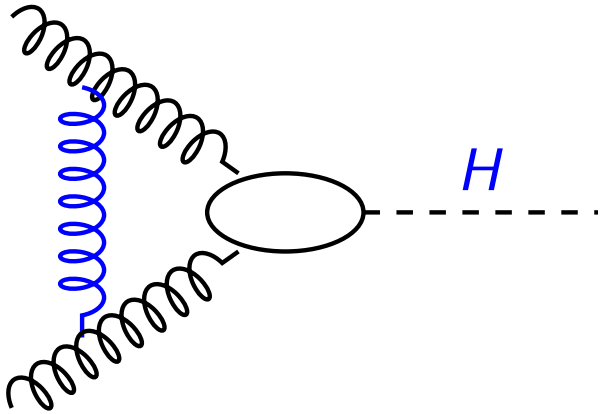
$$\mathcal{L} \propto \lambda H G^{\mu\nu} G_{\mu\nu}$$

Retaining top mass effect we find (at LO): $\mathcal{M}^2 \propto G_F \alpha_s m_H^4 \mid I(\frac{m_t^2}{m_H^2}) \mid^2$ where $I(x) \simeq 1 + \frac{1}{4x}$.

Singularities



A_3^0(g,g,g)



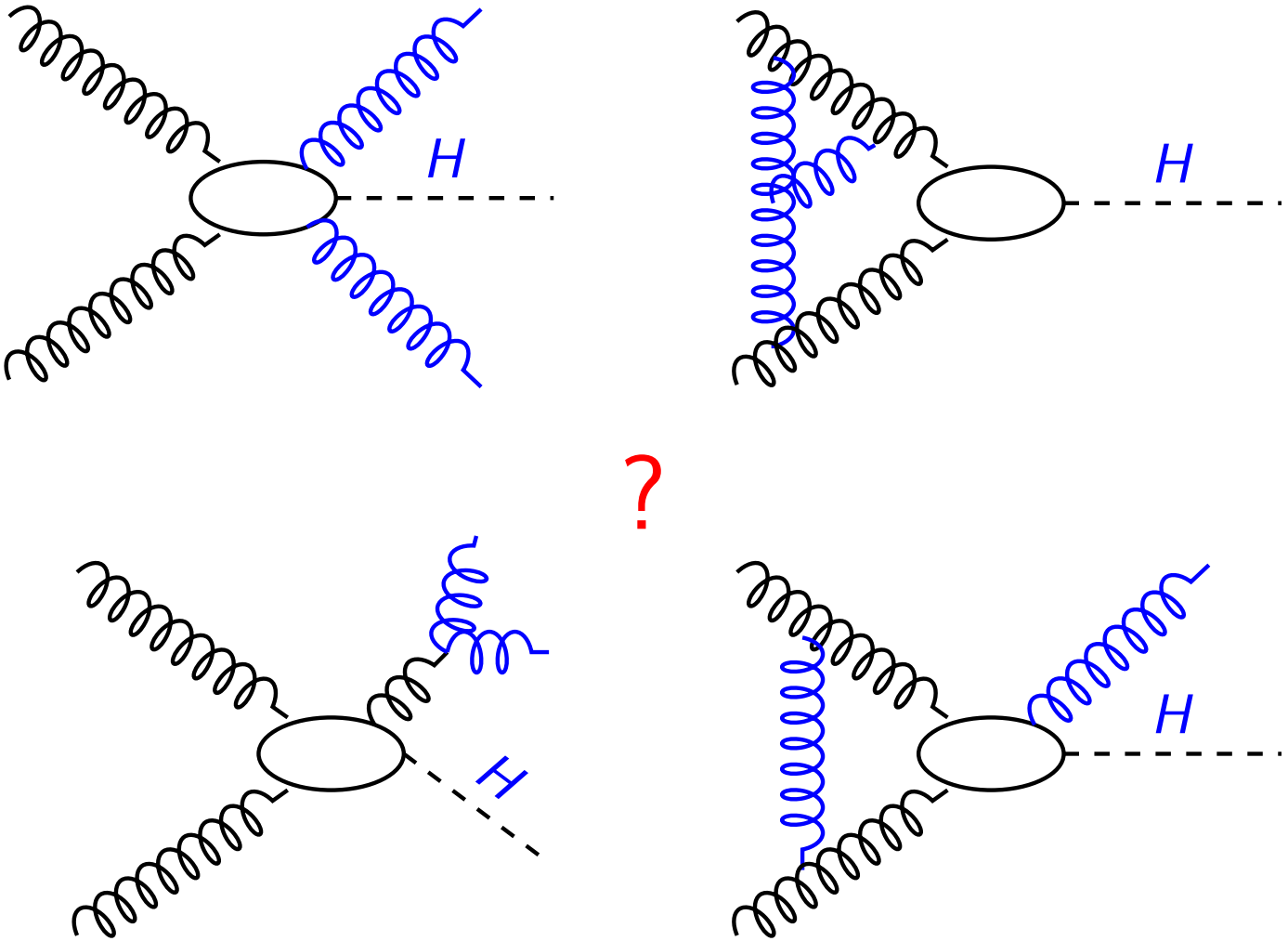
A_2^1(g,g)

$$d\sigma^R_{NLO} = d\Phi_3 \left(A_3^0 - F_3^0 A_2^0\right) \qquad d\sigma^V_{NLO} = d\Phi_2 \left(A_2^1 + \mathcal{F}_3^0 A_2^0\right)$$

where $\mathcal{F}_3^0 = \int d\Phi_3' \left(F_3^0 d\Phi_2\right)$.

KLN Theorem: $d\sigma^R_{NLO} + d\sigma^V_{NLO} = \text{finite}$

NNLO: a world of possibilities



Antenna subtraction: NNLO

Life gets complicated once we open an extra slot for soft and collinear particle to play with.

$$d\sigma = d\sigma^{B}_{LO} + \left(d\sigma^{R}_{NLO}\right) + \left(d\sigma^{V}_{NLO}\right) + \left(d\sigma^{RR}_{NNLO}\right) + \left(d\sigma^{RV}_{NNLO}\right) + \left(d\sigma^{VV}_{NNLO}\right)$$

- We know that each bracketed term is, sadly, infinite by itself.
- Computers have trouble dealing with singular objects

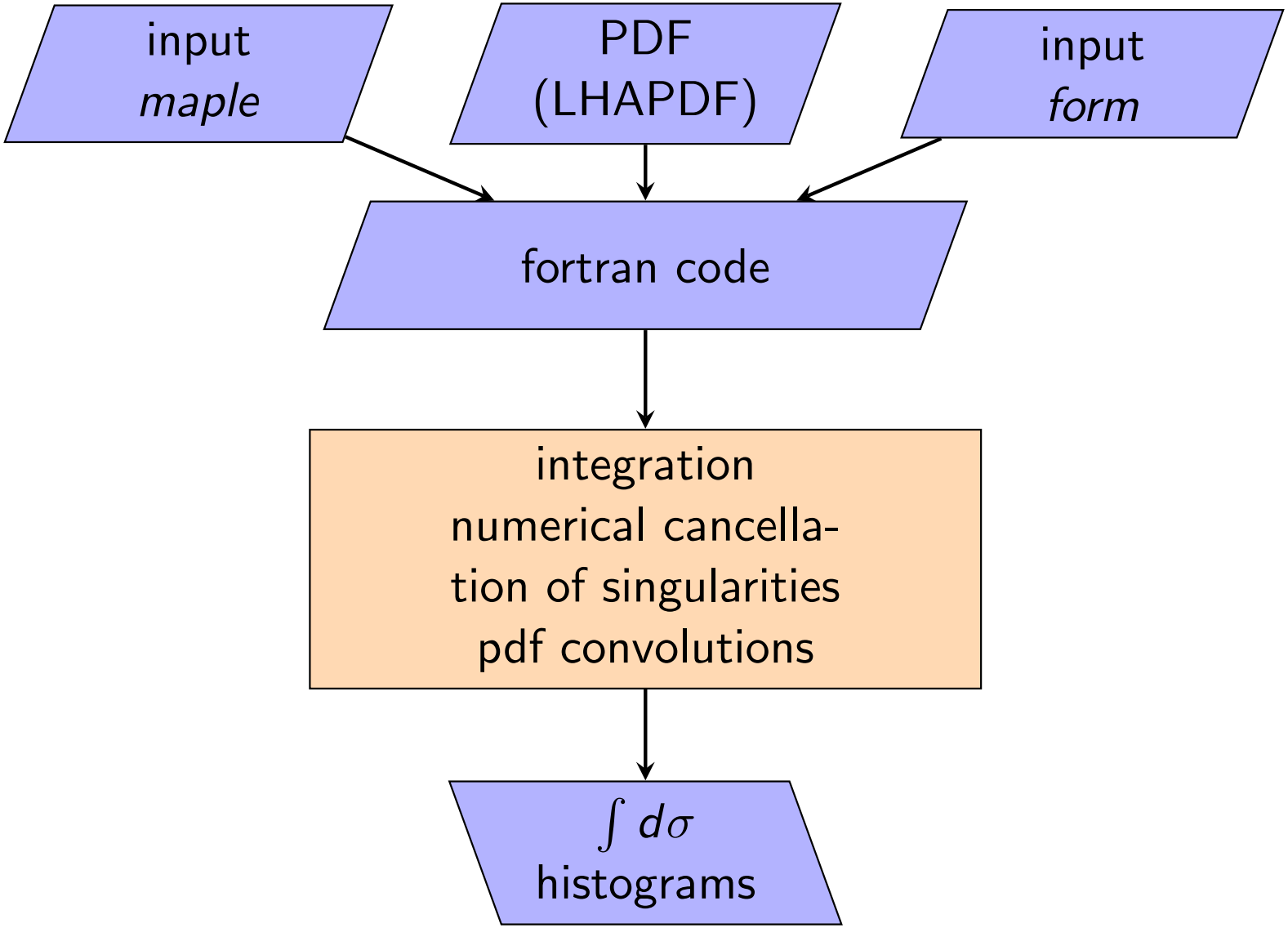
Antenna subtraction: NNLO

Life gets complicated once we open an extra slot for soft and collinear particle to play with.

$$d\sigma = d\sigma^{B}_{LO} + \left(d\sigma^{R}_{NLO} - d\sigma^{S}_{NLO}\right) + \left(d\sigma^{V}_{NLO} - d\sigma^{T}_{NLO}\right) + \left(d\sigma^{RR}_{NNLO} - d\sigma^{S}_{NNLO}\right) + \left(d\sigma^{RV}_{NNLO} - d\sigma^{T}_{NNLO}\right) + \left(d\sigma^{VV}_{NNLO} - d\sigma^{U}_{NNLO}\right)$$

- We know now that each bracketed term has to be finite by itself.
- Now we can integrate!

We like automation



Inclusive cross sections

Using the cteq6 set of PDFs with LHAPDF 6:

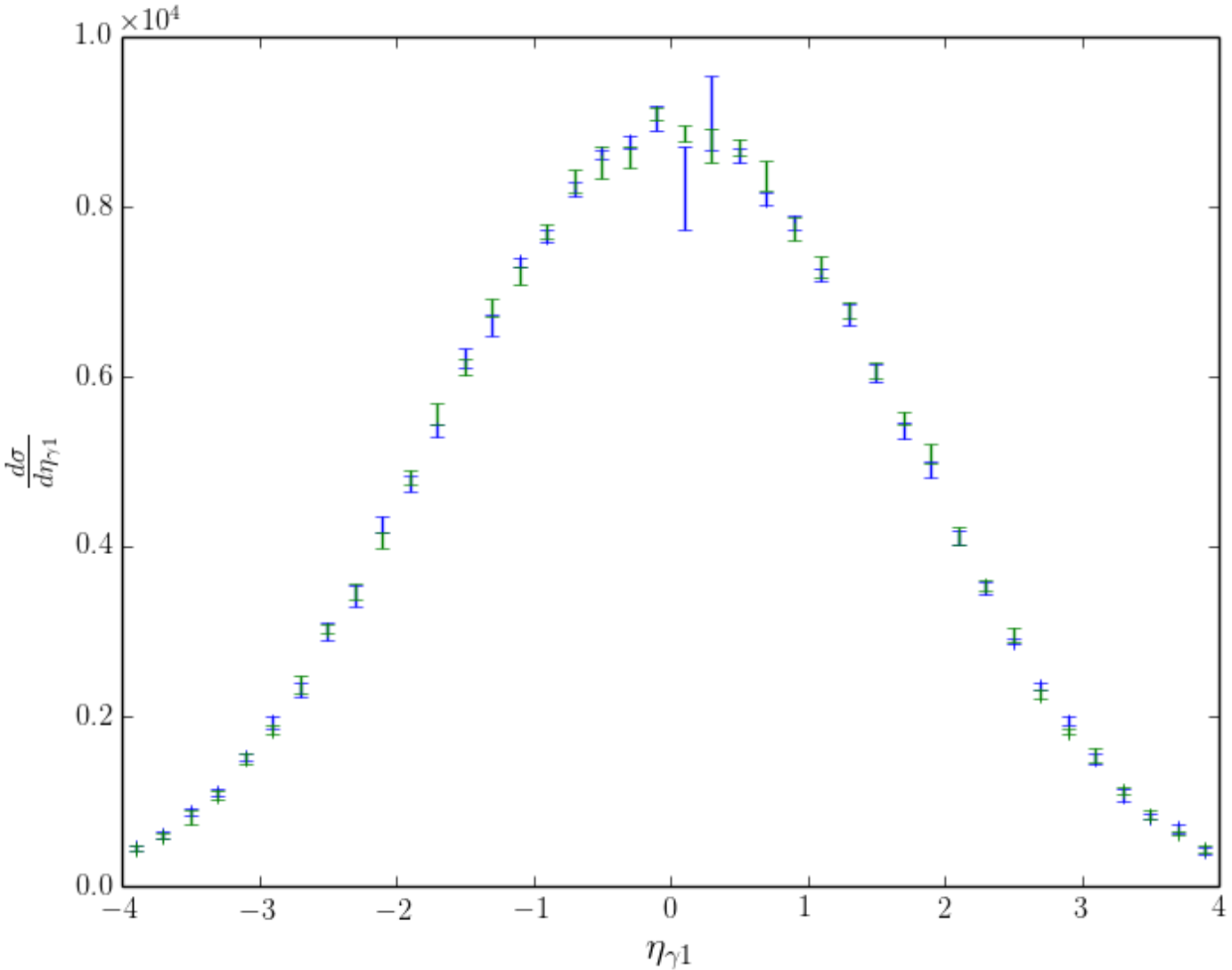
$$d\sigma^{NNLO} = 18.698 \pm 0.079 \text{ pb} \quad (1)$$

$$d\sigma^{NNLO}_{hnnlo} = 18.624 \pm 0.058 \text{ pb} \quad (2)$$

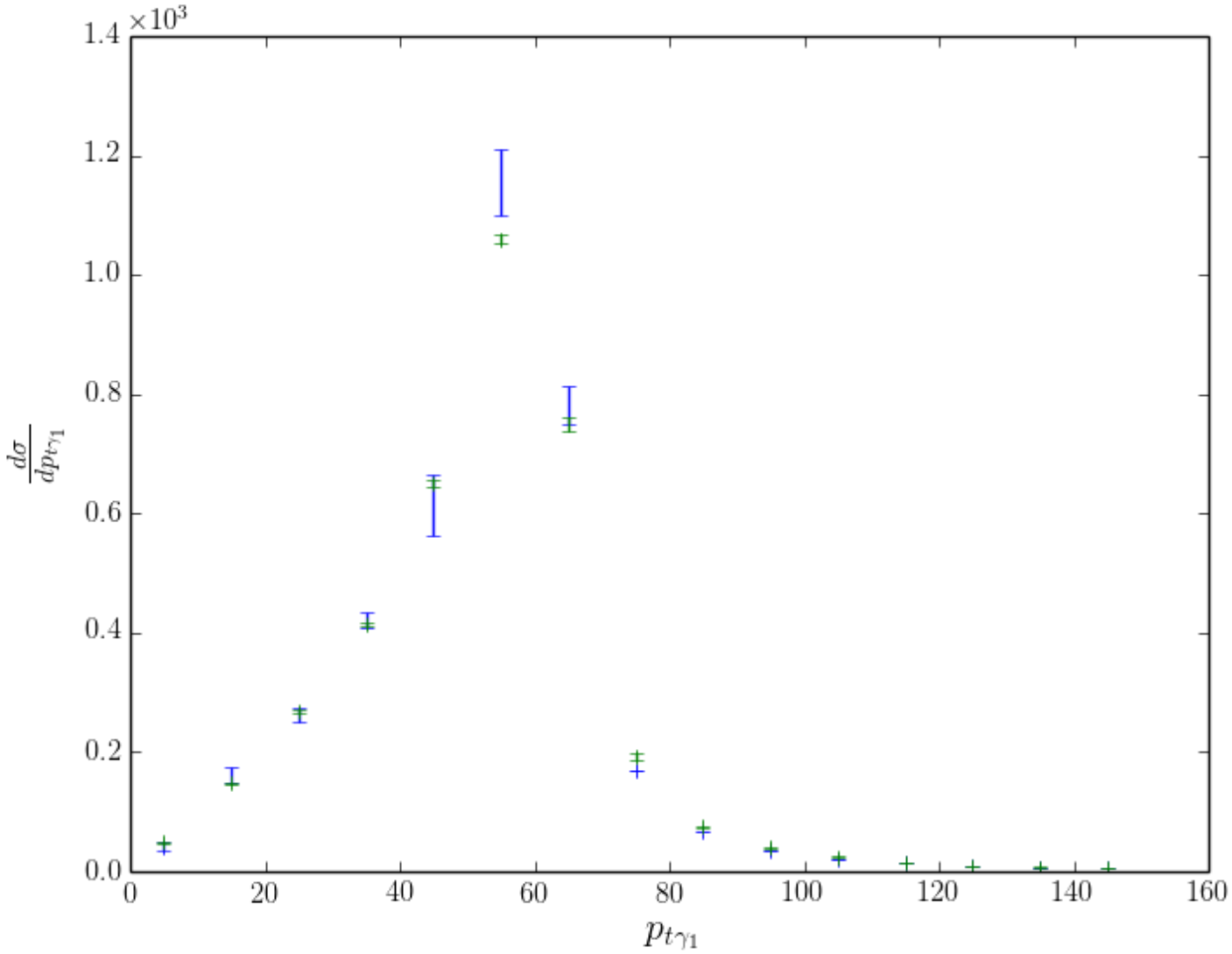
with an arbitrarily fixed scale, just for comparison!
Does it work? Yes! We can move on!

NLO results validated for every channel (and higher multiplicities) against MCFM (thanks!).

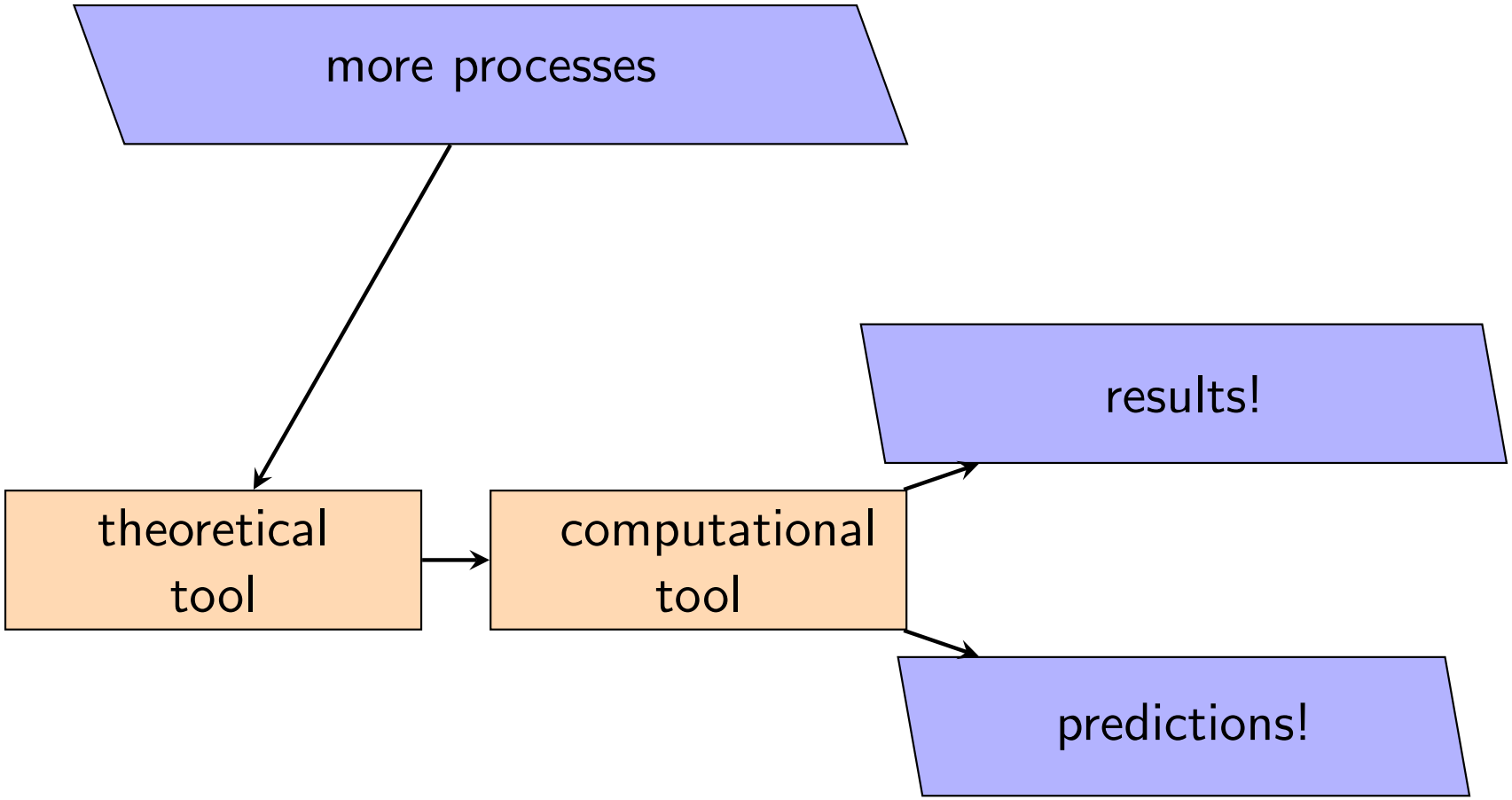
Differential distributions: pseudorapidty



Differential distributions: transverse momentum



So we are ready!



Conclusions

- Once we have a working structure including new processes is trivial-ish
  - H + jet
  - H + Z + jet
- Improvement of the subtraction scheme:
  - for numerical performance
  - for simplicity and ease of use

Thanks!