Precision physics at colliders:

Higgs, top & vector bosons

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Les Houches, CERN Theory Retreat, 2015

Fulbright student at Fermilab, with J. Campbell and K. Ellis

- NLO techniques
- Wb studies (4/5FNS…)

Visiting fellow at KIT

- vector boson studies

Ph.D. in Milano with S. Forte

- BFKL resummation, factorization theorems
- Beyond pure DGLAP in PDF evolution

Post-doc at Johns Hopkins with Kirill Melnikov

- NNLO computations
- Higgs studies, the off-shell Higgs and the Higgs width

NNLO theory and phenomenology

My goal: precise and realistic predictions for collider pheno

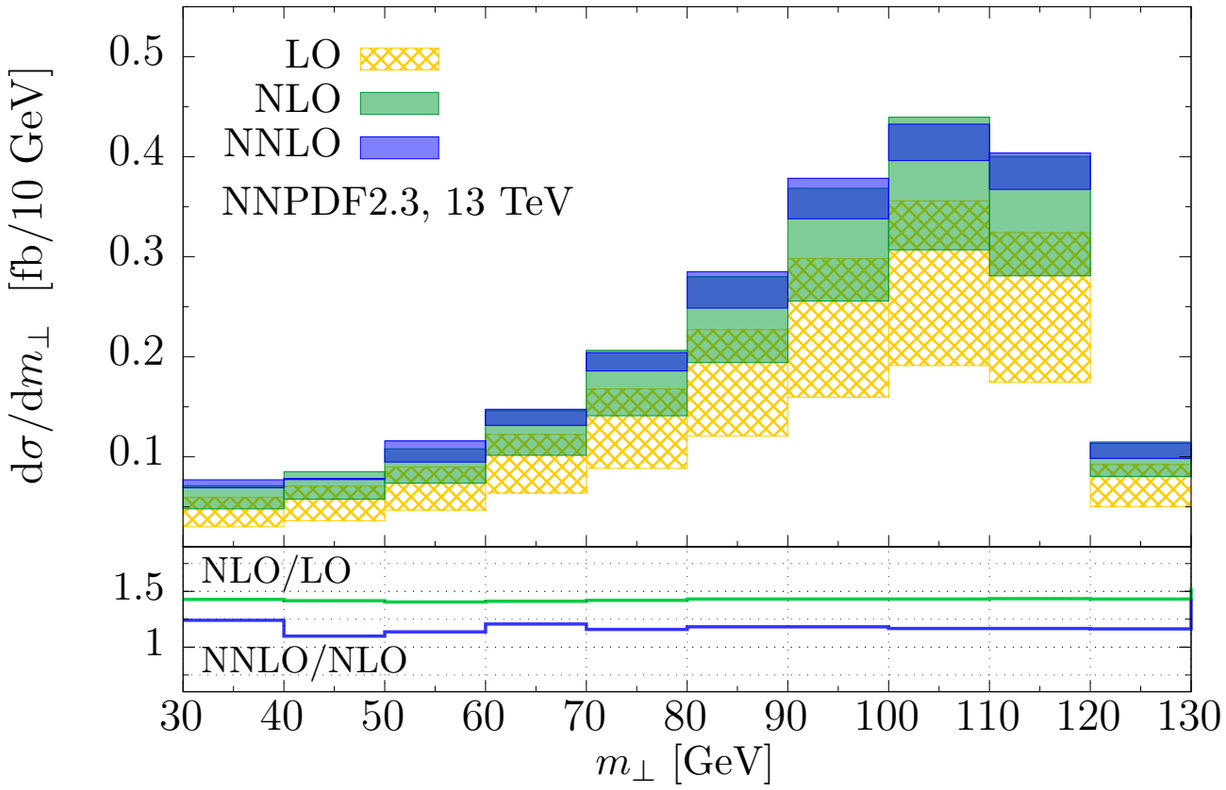
i.e.: higher order predictions for

- arbitrary processes (non trivial color flow, final state jets…)
- arbitrary observables
- fiducial cuts on final state particles

The main challenges

- interplay of soft/collinear and hard physics
  -> subtraction schemes, efficient computational frameworks…
- two loop amplitudes
  -> two-loop integrals, symbols, Goncharov and beyond
  -> integrand reduction
- one loop in soft/collinear regions

Example: Higgs and Jets

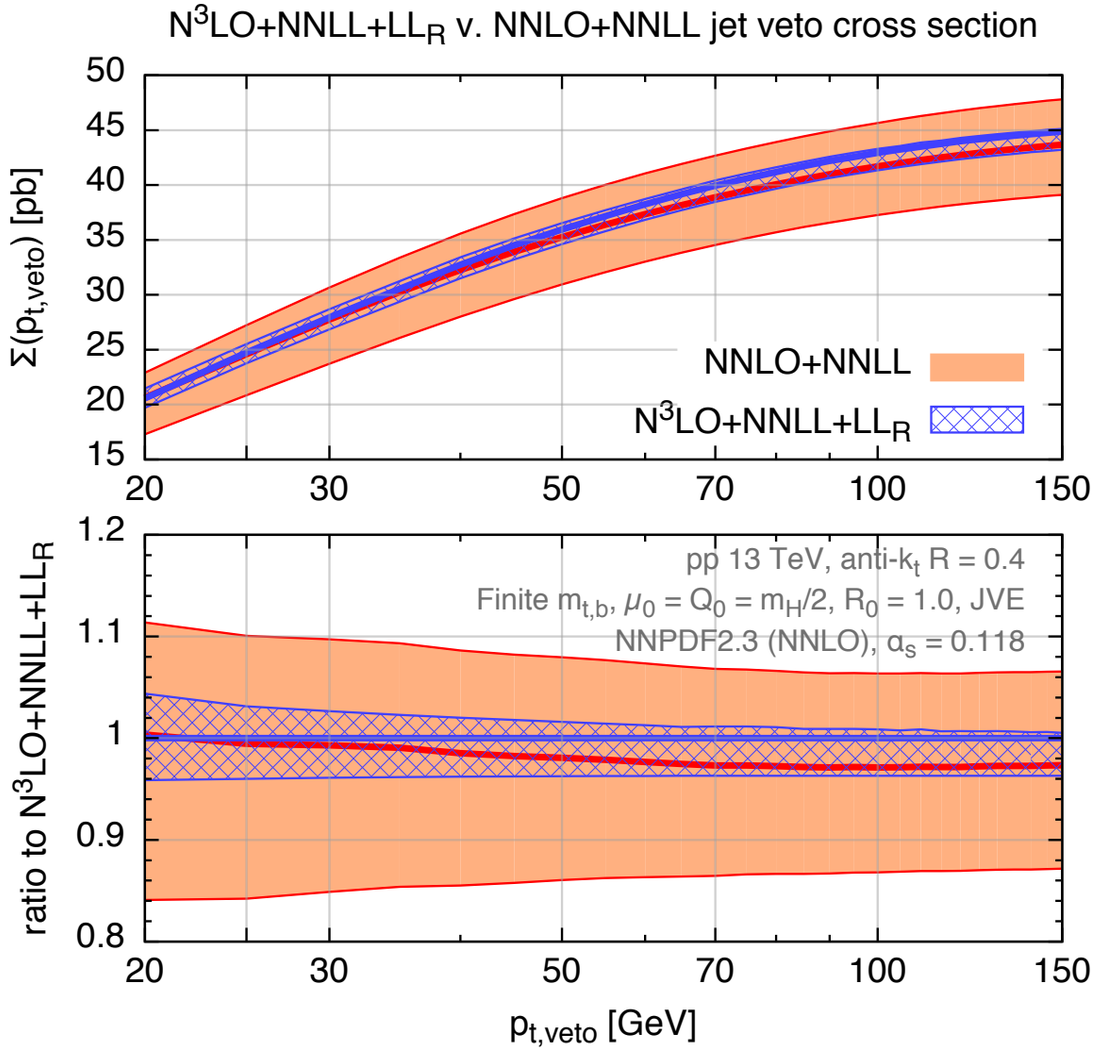


Higgs plus Jet@NNLO

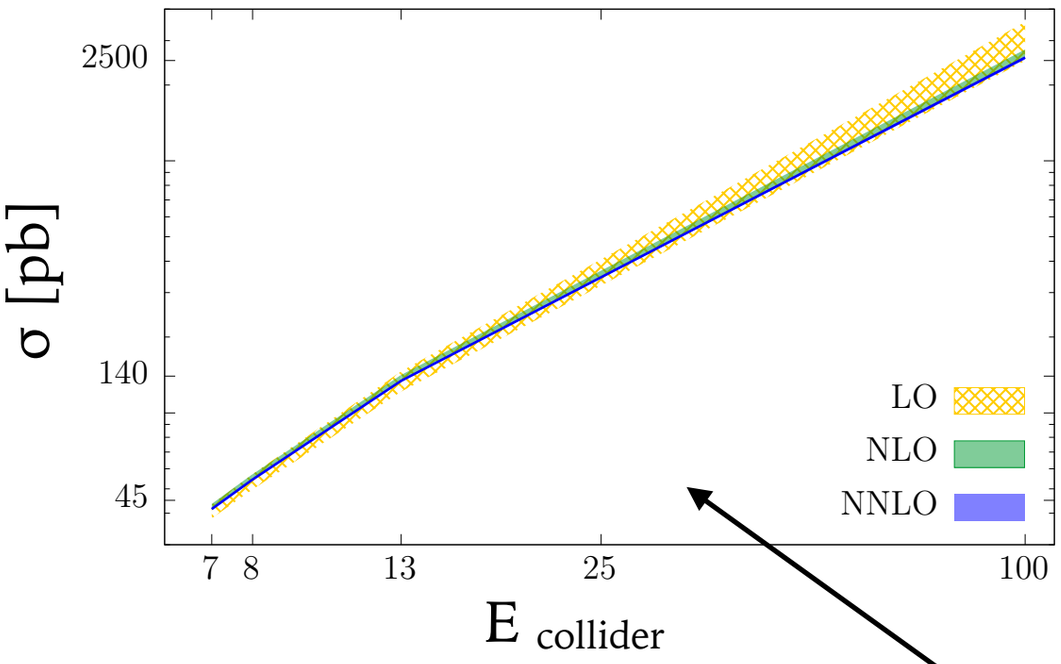
- fully differential
- Higgs decays fully accounted for
- can directly compare against data

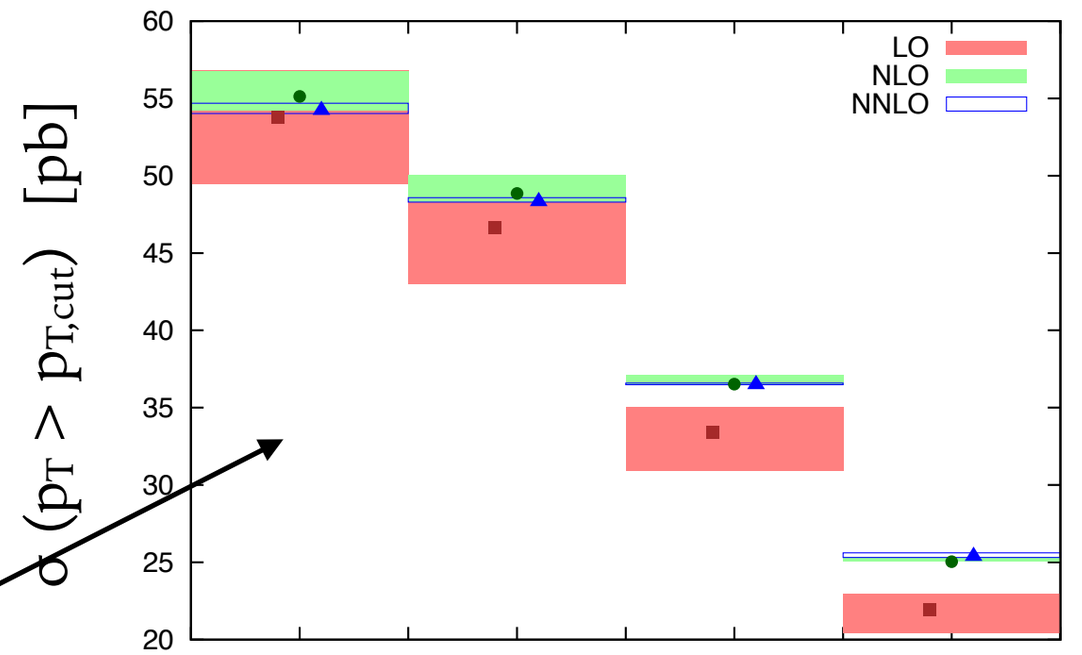
Higgs with a jet-veto@N³LO

- combine with the N³LO total cross section (Claude and Bernhard)
- combine with NNLL small jet-R resummation (Frédéric, Gavin and Giulia)



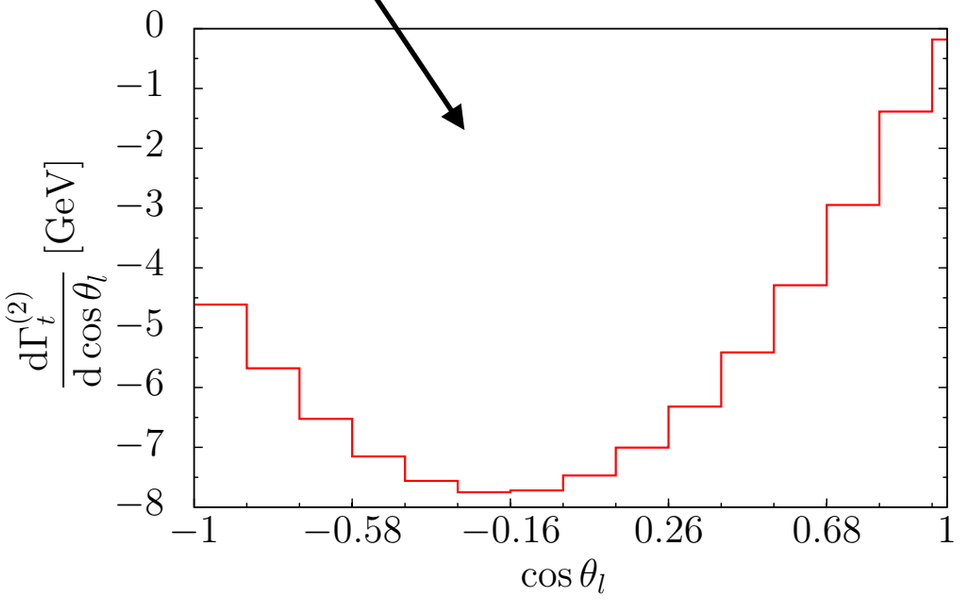
Example: t-channel Single Top@NNLO





Production

Decay

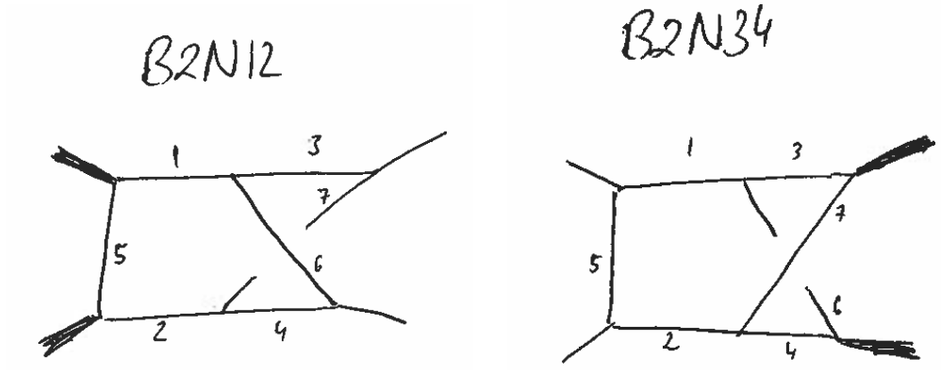


For the future

- Higgs -> pheno studies
- top -> merge production and decay, pheno
- better techniques (new physics insight), new processes…

Precise di-boson predictions: gg->4l

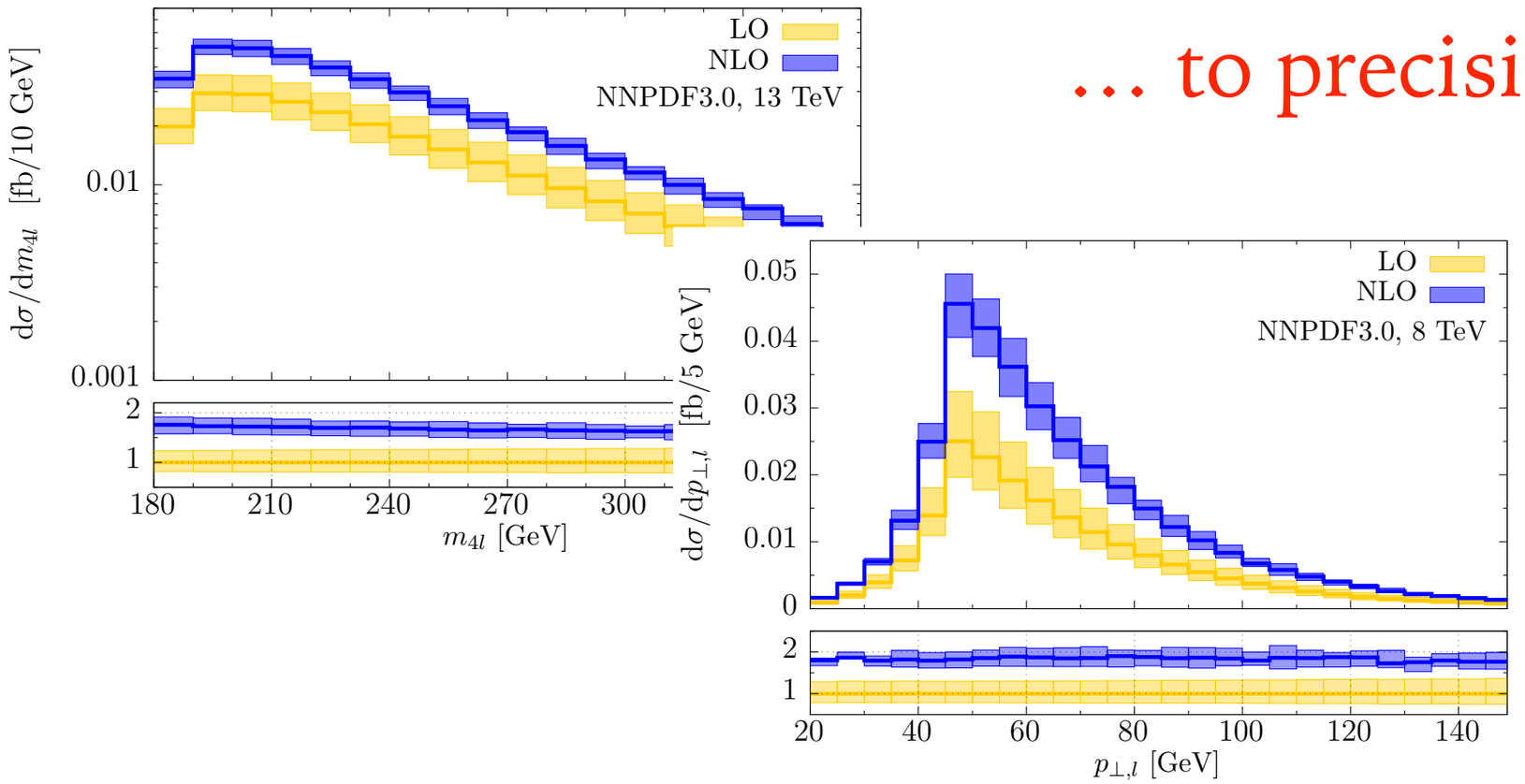
From scattering amplitudes…



$$\partial_x \vec{f} = \epsilon \hat{A}_x(x, y, z \dots) \vec{f}$$

$$G(a_n, a_{n-1}, \dots, a_1, t) = \int_0^t \frac{\mathrm{d}t_n}{t_n - a_n} G(a_{n-1}, \dots a_1, t_n)$$

- Differential equations, canonical form
- Long alphabets (symbol, co-products…)
- One loop: semi analytical 4d reduction, fast and stable num. eval.



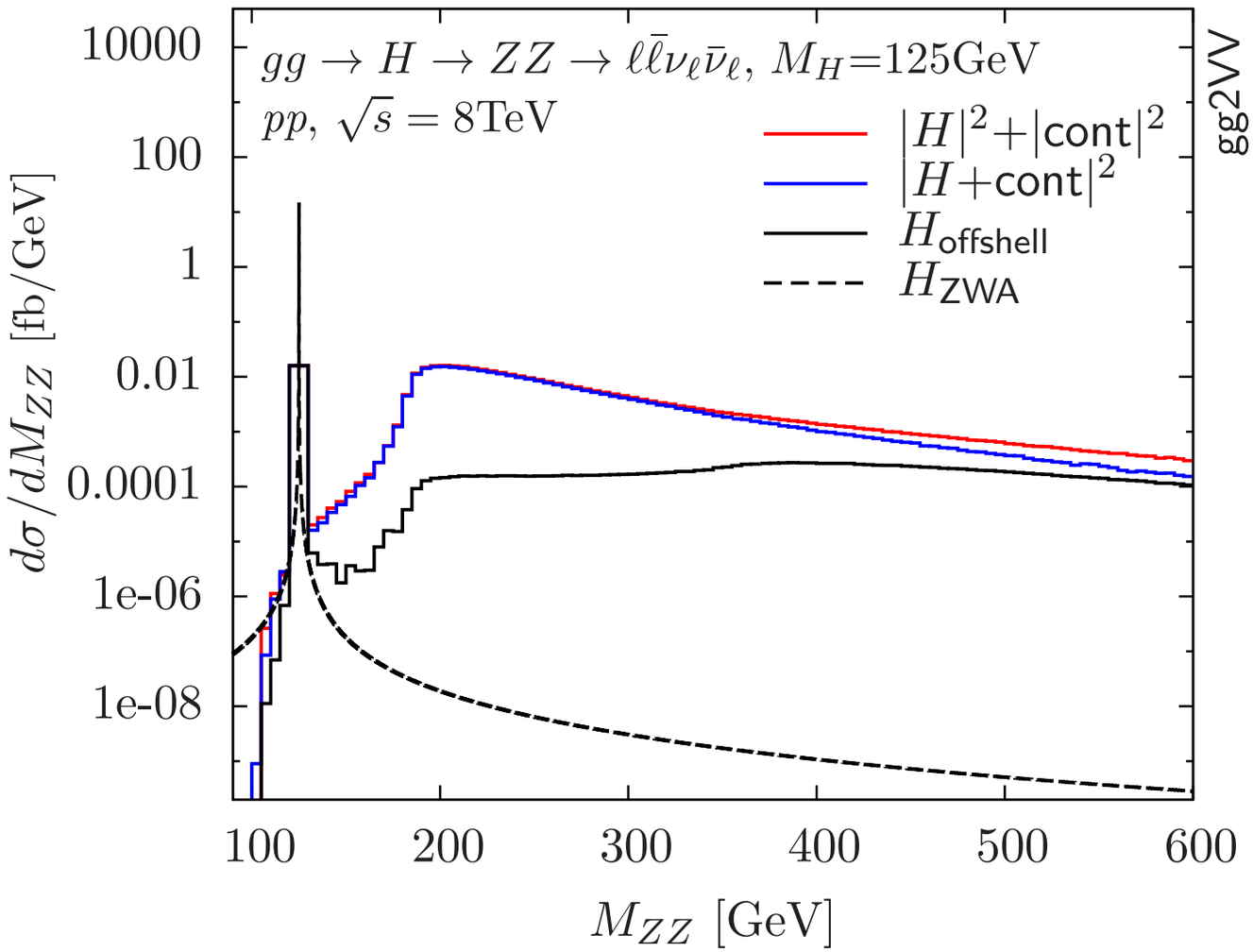
… to precision phenomenology

- Large K-factor
- not accounted for in NNLO scale variation
- formally N^{3}LO, but +5% correction

Precise di-boson predictions: gg->4l

Future plans:

- gg->WW, fiducial measurements, jet veto
- thorough phenomenological studies



gg->VV and the Higgs off-shell region

- Signal/background interferences
- The high mass region: multi-scale integrals with internal masses
- Reliable predictions for off-shell tail (coupling and width constraints…)