NNLO QCD
&
Higgs Phenomenology

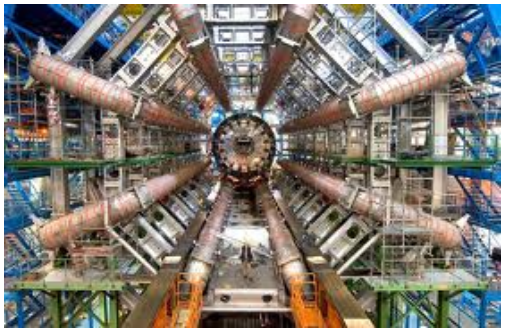
Franz Herzog

PhD from ETH Zurich with **Babis Anastasiou.** Also worked with **Stephan Bühler, Achilleas Lazopoulos, Romain Müller**

Challenges at NNLO

- Finite observables are sums of infrared divergent quantities:

$$\mathrm{FiniteObservable} = \sum_j \int_{\mathrm{boundaries}} \prod_i dp_i \mathrm{DivergentAmplitude}_j(\{p_k\})$$

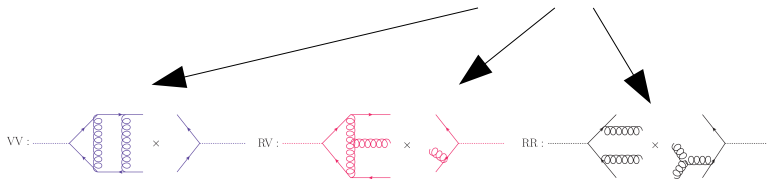


- Integration boundaries must be kept arbitrary in order to simulate the experimental set-up realistically.

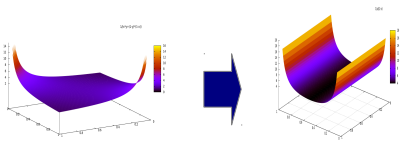
Overview

NNLO QCD

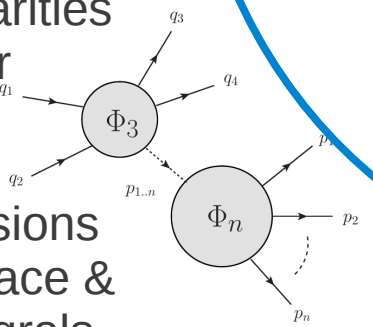
$$\sigma = \sigma_{LO} + \alpha_s \sigma_{NLO} + \alpha_s^2 \sigma_{NNLO} + \mathcal{O}(\alpha_s^3)$$



$$x \mapsto \frac{xA}{xA + (1-x)B}$$



- Interested in methods for computing higher order corrections:
- IR Singularities
- Non-linear mappings
- Double real-emissions
- Phase-space & Loop Integrals



Reasonable predictions for Higgs cross-sections

IHixs (a public program for inclusive Higgs production includes all fixed order corrections)

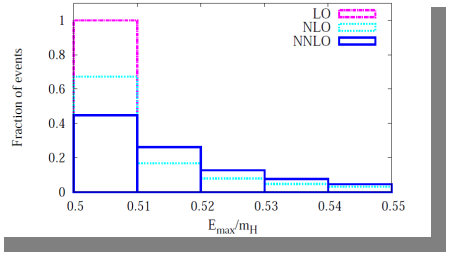
Fully differential NNLO event generators**:**

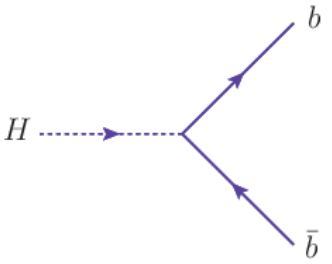
bb → H &
H → bb

Higgs Pheno-menology

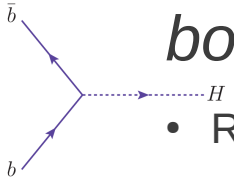
NNLO Applications

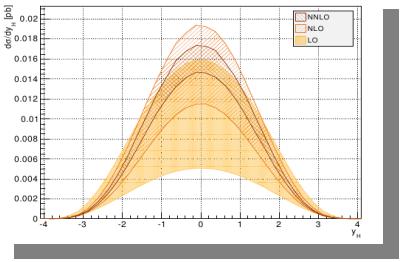
- *On the factorisation of overlapping singularities* (11/2010)
  - Established systematic method via non-linear mapping
  - Studied singularities in two loop and double real integrals
  - Double real radiation for massive colored or massless color singlet systems in hadron collider processes (Higgs, top-pair,...)
- *The fully differential H to b bbar width at NNLO* (10/2011)
  - Real-virtual for 1 → 2 decays
  - Double real-radiation for 1 → 2 decays

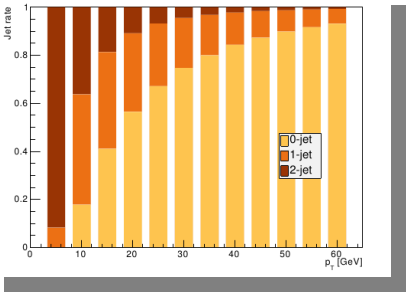




- *The Fully differential hadronic production of a Higgs boson via bottom quark fusion at NNLO* (03/2012)
  - Real-Virtual for 2 → 1
  - Applied method for Double real-radiation of







Outlook

- NNLO project with Stefano Frixione:

  Wish to find a way to cancel singularities without the need of subtraction
  → *No integration of counter terms..*

- For now this is just a collection of ideas:

- IR Singularities cancel on the cuts of real and virtual contributions (KLN theorem)
- Loop integrals can be written as phase space integrals..
  ..Feynman Tree theorem?.. dual propagators?

$$A_{1-\text{loop}} = \sum_{\text{Cuts}} A_{1-\text{loop}}$$

- Four Dimensional Regularization/Renormalization (Pittau 2012) .. via the introduction of a single (gauge-invariant) mass parameter in the propagator.. interesting, but may need more formal understanding.
- Off-shell regularisation?
- ...