Simone Alioli

- 2006-2009, PhD, Milano-Bicocca University, Milan, Italy
- 2009-2011, PostDoc, DESY, Zeuthen, Germany
- 2011-2014, PostDoc, LBNL, Berkeley, USA
- Since Nov. 2014, Fellow, CERN, Switzerland

Research interests and activities:

- Precision QCD calculations
- Monte Carlo event generators (POWHEG, GENEVA)
- Resummation
- LHC phenomenology (SM and beyond)

Improving theoretical predictions for event generators

There are 3 approaches to predictions for collider processes with strongly-interacting particles:

1. Fixed-order
   systematically improvable α_s^n, good for inclusive quantities, but bad near IR-sensitive regions and when large ratio of scales appear
2. Resummation
   systematically improvable $\alpha_s^n L^{2n}, \alpha_s^n L^{2n-1}, \ldots$, good for large scale ratio and IR-sensitive regions, but requires observable definition beforehand
3. Parton showers
   not so improvable, work in strongly-ordered limit only, but allows every observable to be predicted at LL (including NLL effects)

In the past years great progress has been made towards a unified description :

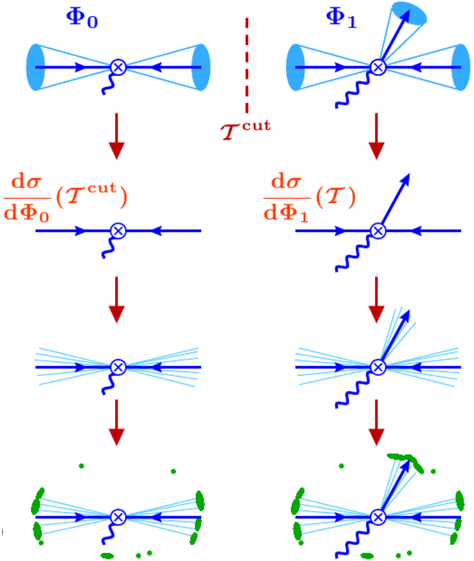
1+2 is the standard matching of resummation to fixed-order, e.g. NNLO+NNLL

1+3 has seen ME+PS (CKKW-MLM), NLO+PS (POWHEG-MC@NLO), now being pushed to NNLO+PS (MINLO-UNNLOPS)

Our framewok called GENEVA (GENerate EVents Analytically) does 1+2+3

GENEVA: recipe

1. Start from an IR-finite NLO definition of events, based on resolution parameters $\mathcal{T}_N^{\rm cut}$.
2. Associate differential cross-sections to events such that inclusive jet bins are (N)NLO accurate and jet resolution is resummed at NNLL'$_\mathcal{T}$
3. Shower events imposing conditions to avoid spoiling higher order logarithmic accuracy reached at step 2
4. Hadronize, add MPI and decay without restrictions



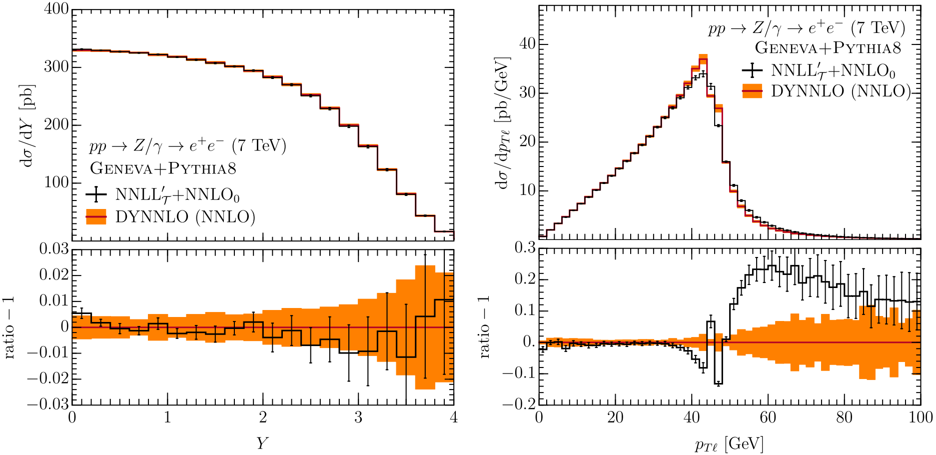
GENEVA: Drell-Yan production at NNLO$_0$+NNLL'$_{\mathcal{T}_0}$

- For Drell-Yan at NNLO need to provide partonic formulae for up to 2 extra partons.
- We separate jet bins according to $\mathcal{T}_0^{\rm cut}$ and $\mathcal{T}_1^{\rm cut}$ values.
  - 0-jet excl. bin integrates NNLL' $\mathcal{T}_0$ spectrum from SCET, nonsingular from NNLO$_0$ matching

$$\frac{d\sigma^{\rm NNLL'}}{d\Phi_0}(\mathcal{T}_0^{\rm cut}) = \int_0^{\mathcal{T}_0^{\rm cut}} d\mathcal{T}_0 \sum_{ij} \frac{d\sigma_{ij}^B}{d\Phi_0} H_{ij}(Q^2, \mu_H)\, U_H(\mu_H, \mu) \\ \times \left[B_i(x_a, \mu_B) \otimes U_B(\mu_B, \mu)\right] \times \left[B_j(x_b, \mu_B) \otimes U_B(\mu_B, \mu)\right] \\ \otimes \left[S(\mu_S) \otimes U_S(\mu_S, \mu)\right],$$

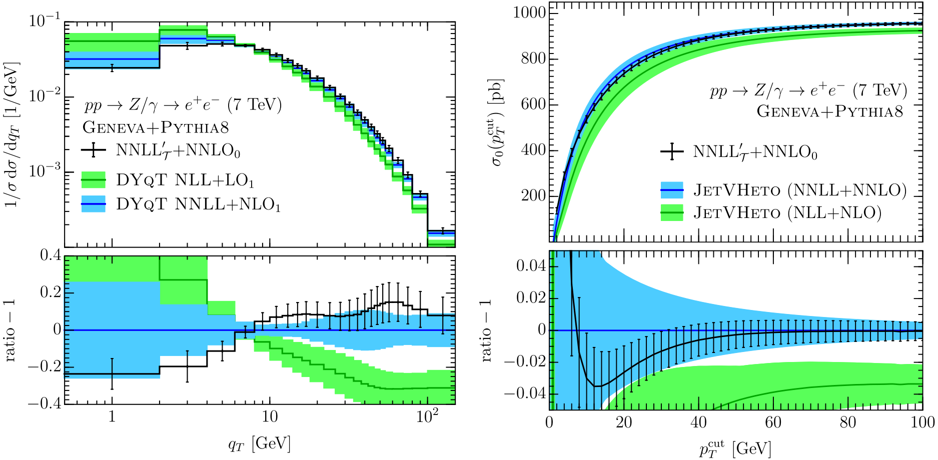
  - 1-jet excl. bin from NNLL' $\mathcal{T}_0$ spectrum times ${\rm sp}(z, \phi)$. Includes LL $\mathcal{T}_1$ resummation.
  - 2-jet incl. bin follows from unitarity.
- Interface to PS need to respect $\mathcal{T}_k^{\rm cut}$ boundaries. Easy if shower ordered in $\mathcal{T}_k$, not so easy for any existing shower.
- Solution is to do first emissions using a LL $\mathcal{T}_k^{\rm cut}$-Sudakov
  - Φ_0 events only constrained by normalization, shape given by PYTHIA
  - Φ_1 events vanish lowering $\mathcal{T}_k^{\rm cut}$-Sudakov cutoff.
  - Φ_2 events: PYTHIA showering start affecting $\alpha_s^3/\mathcal{T}_0$, beyond NNLL

GENEVA: NNLO validation



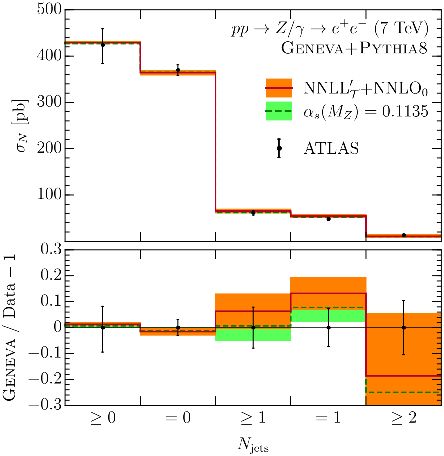
- Everything as expected, both central and scale var. agrees with NNLO
- GENEVA better than NNLO around jacobian peak of $p_{\mathrm{T}\ell}$

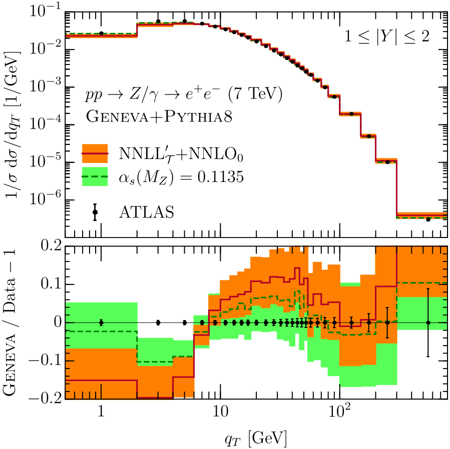
GENEVA: predictions for other quantities



- For observables other than $\mathcal{T}_0$ GENEVA is not formally NNLL
- But it agrees much better with NNLL than with NLL

GENEVA: comparison with 7 TEV LHC data





- Good agreemen with data for both inclusive and resummation-sensitive quantities
- Lower $\alpha_s(M_Z)$ value yelds better agreement for resummation-sensitive quantities

Other ongoing works:

- $V + j$@NNLO , with F. Caola, M. Schulze, S. Carrazza (CERN)
  - Important process for SM and BSM. Precision available in data (cfr $p_{\mathrm{T}\,Z}$), improvement in theory required.
  - Use local NNLO subtraction scheme employed for $H + j$.
  - Early stage, gathering relevant matrix elements and rewriting them to be fast and stable.
  - Interesting longer term spin-off: compare with $\mathcal{T}_1$-subtraction and assess stability and convergence.
- FONLL predictions for $W^{\pm}$ + $D^{\mp}$, with E. Mereghetti(LANL), M. Girard, C. Bauer (LBNL)
  - Important process to access strange pdf at $x \sim 0.01$. Currently limited by theoretical uncertainty.
  - Fixed-order (MCFM) provides large scale uncertainties.
  - (NLO) Monte Carlo resum only a subset of all contributions enhanced by large $\log(m_c/p_T)$. Flavor excitation and gluon-splitting only included at LO.
  - NLL resummation in the fragmentation function approach helps reducing the theoretical error, especially at high p_T.
  - FONLL combines NLO calculation with full mass effects with NLL resummation of $\log(m_c/p_T)$

Thank you for your attention!