Dipoles, coherence and NLO

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Outline

- Overview on recent work
- Physics
  - A new dipole shower scheme
  - Analytical frameworks for shower(s) & matching
- Technicalities
  - Sampling Sudakov-type distributions
  - Automatizing matching
- Conclusions

Recent work

- Some enhancements to Herwig++, basically a merger from several things I've worked on
- Motivation: Provide a self-contained framework featuring
  - Tools and interfaces for NLO QCD
  - NLL correct shower with local recoils
  - An automatized way of matching NLO & shower(s)
  - Possibly opening the door to more accurate merging procedures or higher orders

Recent work

- Fixed-order features
  - Assume subtraction used for NLO (defaults to CS)
  - Helpers provided for CS subtraction
  - Helpers for loops & tensor reduction (Davydychev + IBP)
- NLO interface as minimal as possible
  - code or interface phasespace generator
  - code or interface matrix elements, dipoles & virtuals
  - run the fixed order or NLO+PS (no additional work required!)

Recent work

- Sampling and integration: the ExSample module
  - Adaptive sampling (i.e. unweighted events on the fly) and integration of differential cross sections
  - Motivated by Foam, ACDC. Properly deals with negative weights
  - Key feature: can also do adaptive sampling of Sudakov-type distributions
  - Working horse for both the shower and ME corrections

Recent work

- Shower
  - CS-type dipole shower (ISR and evolution different from existing ones)
  - ME corrections (aka POWHEG Sudakov) automatically built from NLO real-emission interface
  - Currently everything massless (interfaces general enough, though)
  - ‘Mass-reshuffler’ for using the Cluster hadronization

A new dipole shower scheme

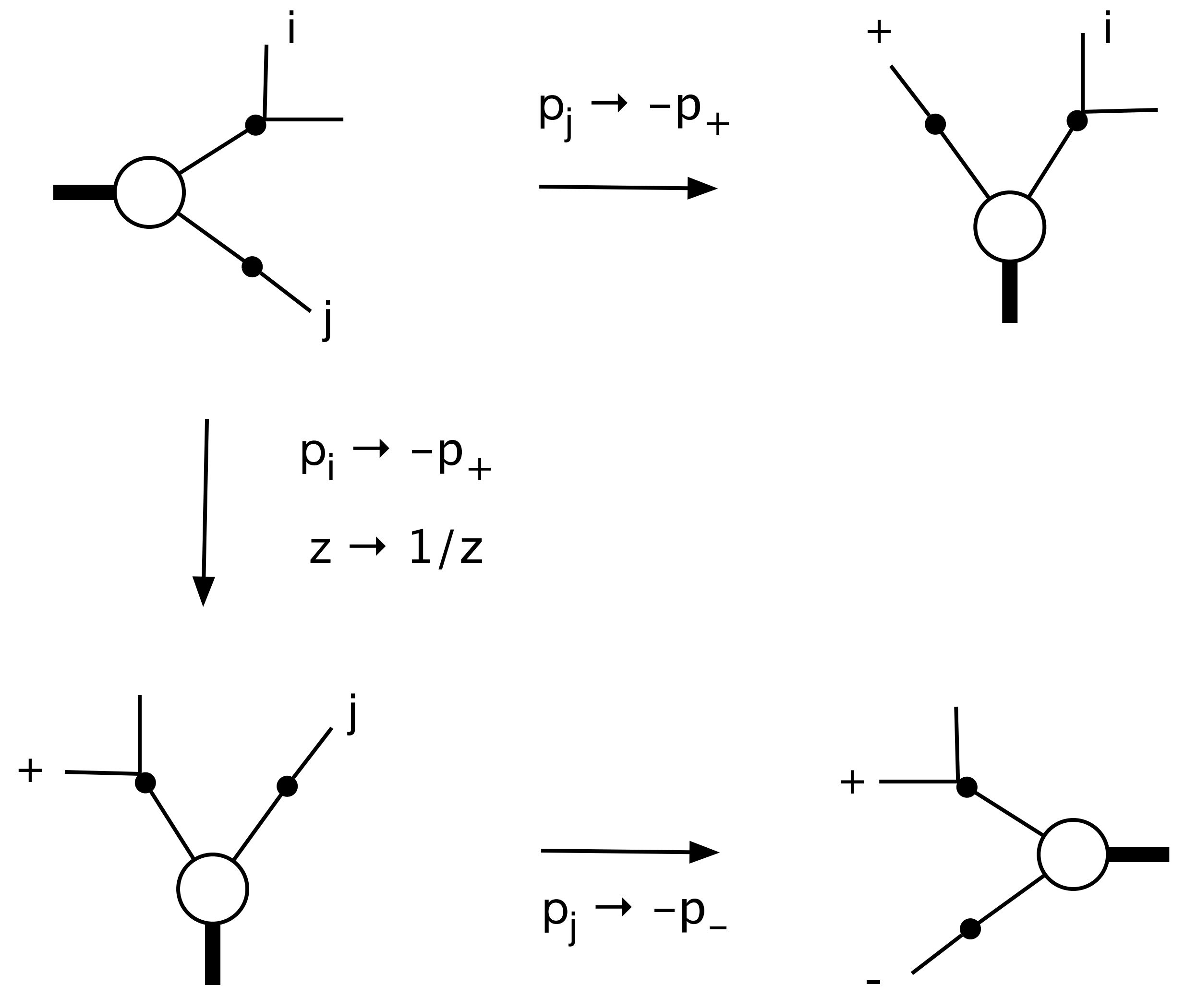
- Rethink the original CS shower proposal
  - Logarithmic accuracy, coherence?
  - Finite recoils truly subleading?
  - Generation of final state pt from ISR?
- In a nutshell
  - IR cutoff as used for pt ordering fine, evolution however not a strict pt ordering
  - ISR generates initial state pt, migrated to all final state partons by proper 'realignment' Lorentz transformation

A new dipole shower scheme

- Coherence proven for CS final state kernels, provided:
  - evolution in transverse momentum
  - IR cutoff is a simple pt cutoff
  - emission otherwise constrained by kinematic limits only (allows for unordered emissions)
- Generates the correct LL and NLL coefficients
- Finite recoil effects beyond NLL

A new dipole shower scheme

- Initial state?
  - Use symmetric splitting kinematics from appropriate 'crossings'
  - Phasespace still exact
  - Express CS kernels in new variables (not cross the final state kernels)
  - Conjecture that ISR is coherent



Analytical frameworks

- New showers and matching require analytic understanding prior to any implementation
- Start from description of stochastic (Markov) process: calculate what MC does
- Analyze evolution structure, evolution equations, ...
- Detailed (not toy model) analysis of matching to fixed-order calculations
  - MC@NLO evident
  - POWHEG emergent from matching shower with ME correction
  - NNLO matching foreseen

Sampling Sudakov-type distributions

- ME corrections and POWHEG matching require a handle on probability densities of the type

$$F(x,\vec{z}|y) = \theta(y-x) f(x,\vec{z}) \exp\left(-\int_x^y \int_{V_{d-1}} f(t,\vec{\xi}) \mathrm{d}^{d-1}\xi \mathrm{d}t \right)$$

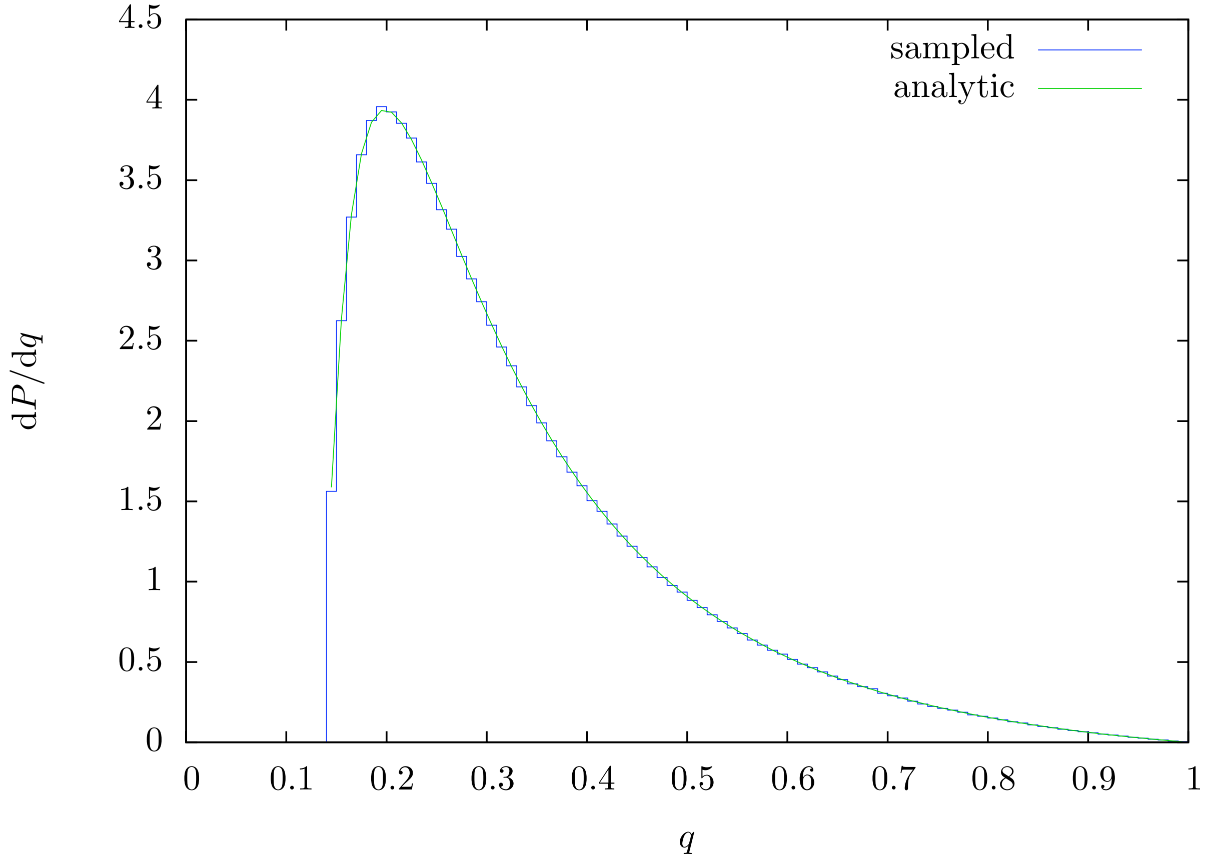
- Veto algorithm well known
  - Requires analytically known and sufficiently simple overestimate to the kernel f
  - Impossible for complicated processes
  - Goal: find a way to sample F knowing f only numerically

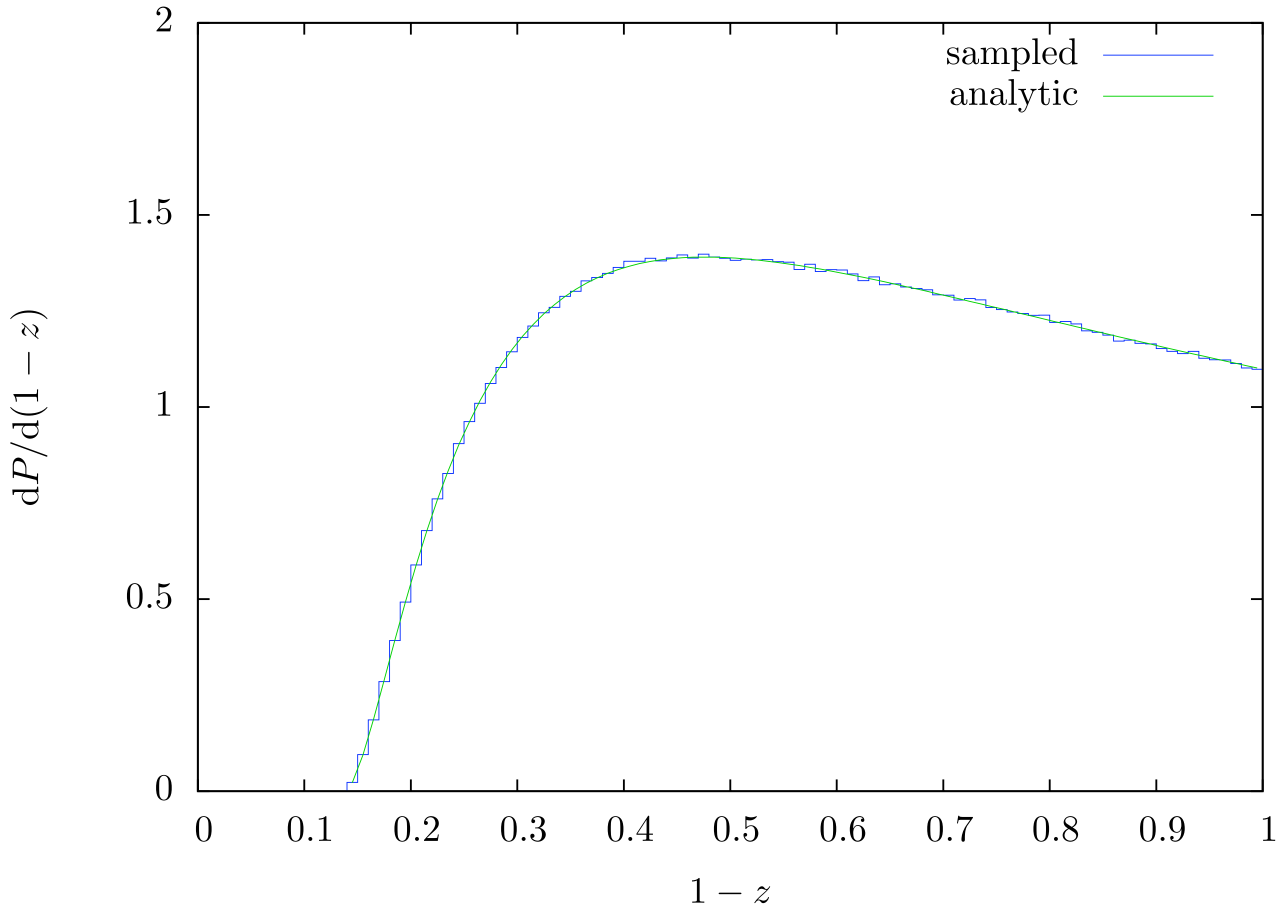
Sampling Sudakov-type distributions

- ExSample uses an approximate overestimate from a presampling to sample a function
  - Successively refined through binary splits to optimize unweighting efficiency
  - Compensates for newly encountered maximum weights
- For sampling Sudakov-type distributions, we use this overestimate as an input to the veto algorithm, optimizing on acceptance
  - Compensation for new overestimates is possible

Sampling Sudakov-type distributions

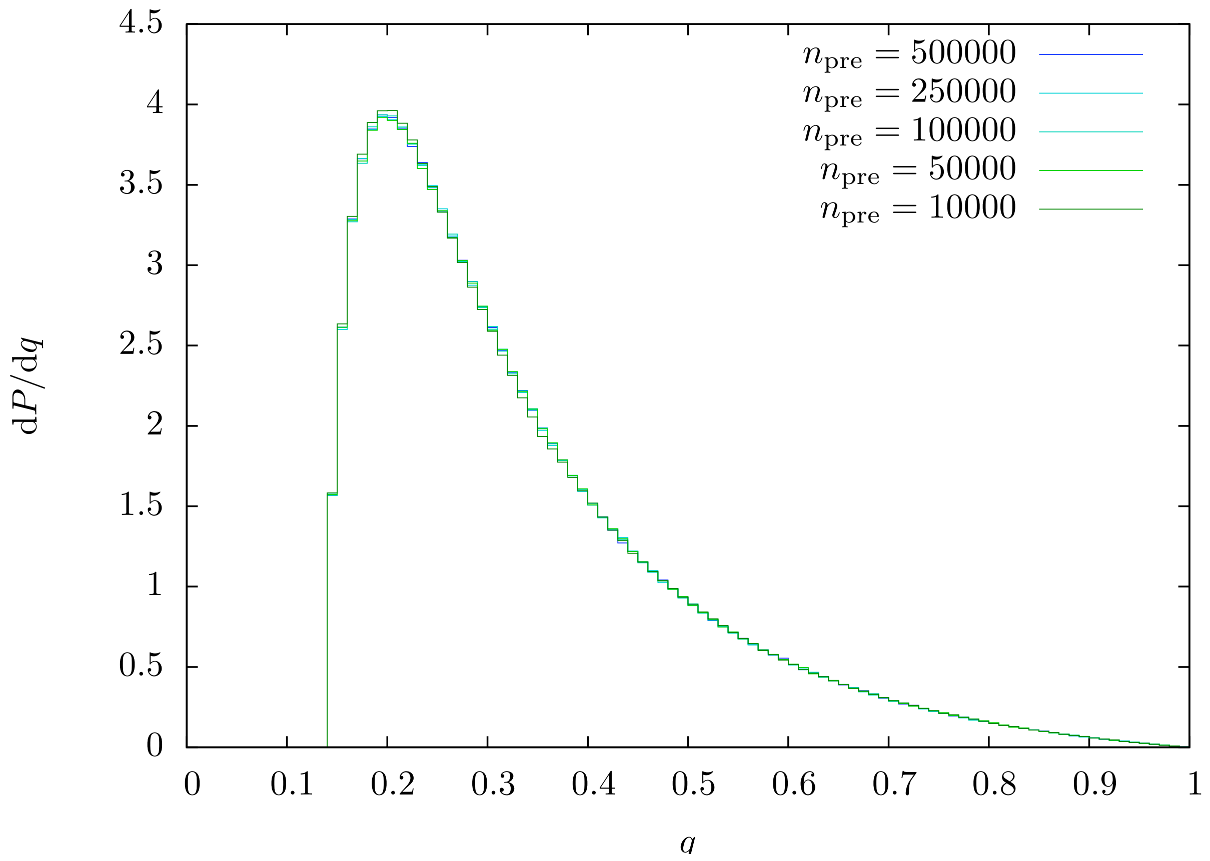
- Typical splitting function

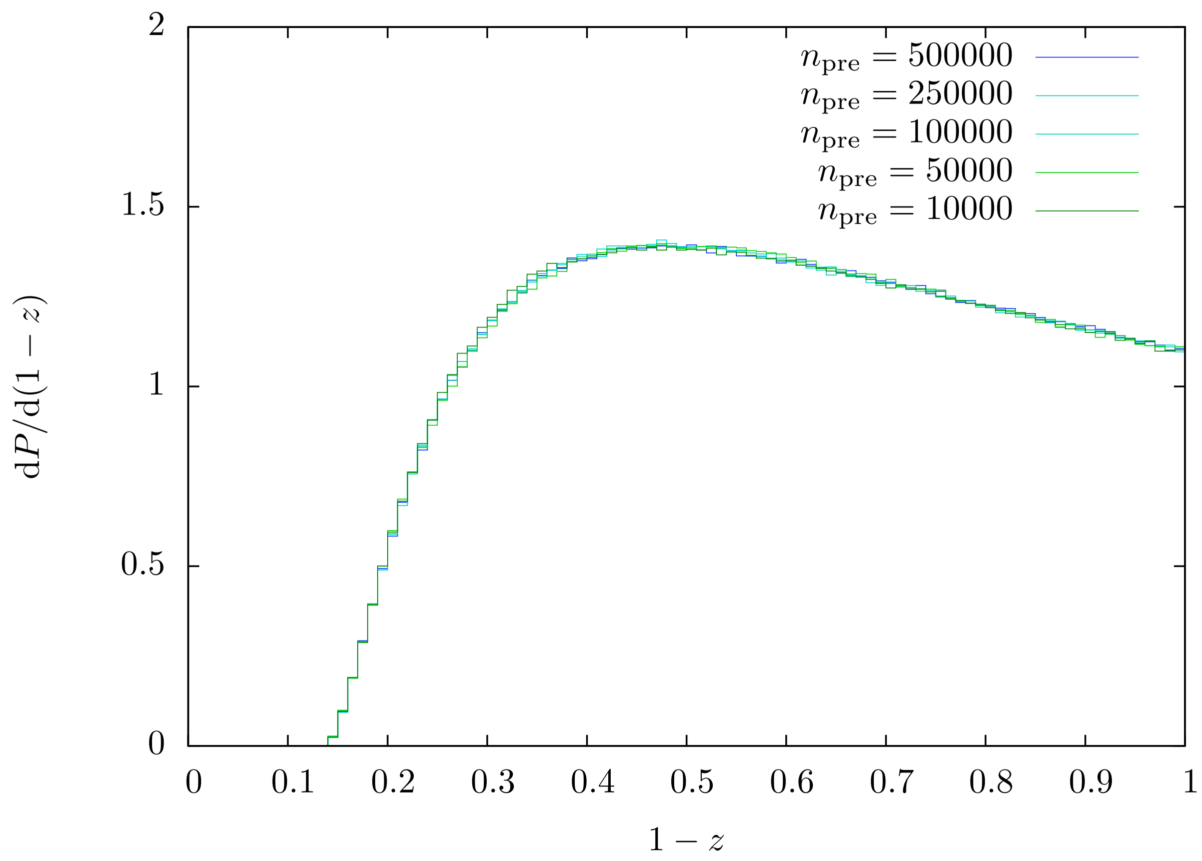




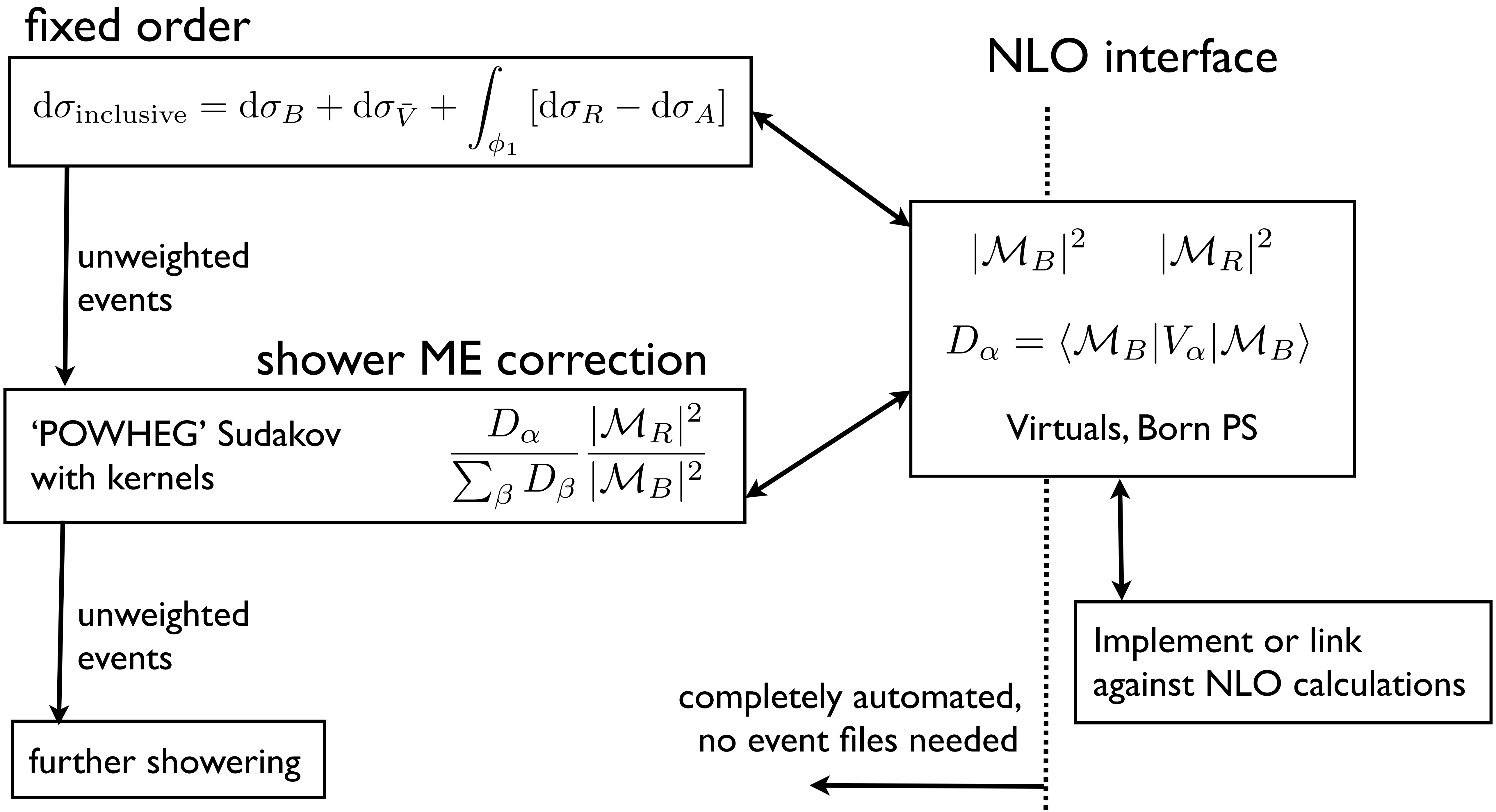
Sampling Sudakov-type distributions

- Test compensation: independent of the number of presampling points





Automatizing matching



Status

- Everything implemented, currently testing & debugging
- Simple processes at NLO on the way, more complicated ones to come
  - focus on VBF when done with simple ones (VBFNLO in shape)

Conclusions

- Dipole-type showers are appealing, but need confidence in accuracy
  - Especially important for matching
  - NLL dipole-type showers are possible
- Matching itself requires more general (technical) concepts to deal with state-of-the-art NLO calculations
  - Quest for easy interfacing and usage of existing work
- Assembled pieces should be convenient to use
  - On the way to automatizing NLO matching