PRECISION ➩ SHOWER UNCERTAINTIES

Resummations (incl showers) are all-orders calculations

What is the possible size of terms beyond the precision of the algorithm/ calculation?

The answer computed by a shower algorithm depends on:

Radiation functions (e.g., $P(z)$; beyond universal terms)

Scale Choices for each branching (μ_R, μ_F)

Choice of resolution measure / evolution variable

Kinematics Maps / Recoil Strategies

Starting and Ending Scales

Treatment of coherence, subleading colour, spin correlations, PDFs, …

Can we impose constraints?

If not, *vary* …

Framework for automated variations developed & tested for some years in VINCIA   Giele, Kosower, Skands PRD84 (2011) 054003

2016: All-orders proof & **Pythia 8 implementation**   Mrenna, Skands Phys.Rev. D94 (2016) 074005

Can vary μ_R [~ subleading logs] and **P(z)** [~ process dependence]

Mrenna, Skands Phys.Rev. D94 (2016) 074005

Idea: perform a shower with nominal settings

Ask: what would the probability of obtaining this event have been with **different choices** of μ_R, radiation kernels, … ?

Easy to calculate **reweighting factors**

In MC accept/reject algorithm:

for **all** branchings

$\forall$ *Accepted Branchings:*
$$R'_{\mathrm{acc}}(t) = \frac{P'_{\mathrm{acc}}(t)}{P_{\mathrm{acc}}(t)}$$

$\forall$ *Rejected Branchings:*
$$R'_{\mathrm{rej}}(t) = \frac{1 - P'_{\mathrm{acc}}(t)}{1 - P_{\mathrm{acc}}(t)}$$

Giele, Kosower, Skands PRD84 (2011) 054003

ee→hadrons   91.2 GeV

1-Thrust (udsc)

- ■ L3
- ● Pythia
- ⊕ Pythia μ=0.5p_T
- □ Pythia μ=2.0p_T

$\chi^2_{5\%}/N_{\mathrm{bins}}$ 0.4 ±0.1

Data from Phys.Rept. 399 (2004) 71
Pythia 8.215

VINCIAROOT

Output: **vector of weights** for each event

One for the nominal settings (unity)

+ Alternative weight for each variation

→ **bands**

(Note: similar functionality also recently implemented in Herwig++ and Sherpa)