Plans for Pythia 8

Simulation of Final States Relevant to LHCb

Current Plans for Joint Monash-Warwick Projects

(Not intended to be exhaustive or exclusive; open to further suggestions from others at both institutions.)

Broader Pythia 8 Activities at Monash

Peter Skands (Monash University)
Monash-Warwick Alliance on Particle Physics, May 2021

Simulation of Final States Relevant to LHCb

Feb 2021: joint ARC grant proposal on "beautiful strings" (Kreps+PS)

ARC "Discovery Project" - basically funds for one post doc.

Assessments expected in June, announcements in Oct/Nov; no reason to wait.

1. Efficient Pythia MC for producing B_c (and relatives)

Preparatory steps started at Monash, with **T. Hadavizadeh** + will involve new Monash-Warwick post doc **M. Singla** (started today!)

Idea: enhance $g \to Q\bar{Q}$ shower branchings [Mrenna+PS, arXiv:1605.08352]

+ enhance probability "close" in phase space to other heavy quarks

Expect joint publication this year.

2. Final states with specific B hadron(s) on request

3. Uncertainties in B→partons decays

Lead: M. Kreps.

4. Collective Effects on B Spectra (in pp)

Rare Final States

Type(s) of B hadron:	$B_0,\ B^+$	$B_s,\ \Lambda_b$	$\Upsilon(1S),\ \Xi_b$	$\Sigma_b\ ,\ B_c$	$\Omega_b,\ \Xi_{bc}$
Rate in inclusive sample:	$\mathcal{O}(10^{-2})$	$\mathcal{O}(10^{-3})$	$\mathcal{O}(10^{-4})$	$\mathcal{O}(10^{-5})$	one-in-a-million or less

Probability to produce double-heavy hadrons in Pythia is prohibitively low for high-stats runs

Currently only possible to "bias" event generation by requiring at least one heavy quark present in hard interaction, eg $gg \to b\bar{b}$, $gb \to gb$, …

Then run parton shower and "hope" for a $g \to c\bar{c}$ branching (or vice versa) that just happens to end up producing a colour-singlet ($b\bar{c}$) system with sufficiently low invariant mass → B_c meson.

    Not bloody likely.

    + "fragmentation contribution" even harder ($gg \to gg$ with **two** accidents)

Dedicated packages (eg GenXicc) to force these states used by LHCb/Warwick

Not easy to maintain, extend, thread (!), and documentation not always exhaustive/extensive

    + also miss fragmentation contribution?

MWA Project(s): enhance $g \to Q\bar{Q}$ shower branchings, in the "right" phase-space regions

$\implies$ generate **weighted** events with O(1) probabilities for requested states

Follow-ups: validation of quality of modelling + extend to hadronisation algorithms ($\to$ enhance B baryons)

Since May, Pythia now has "triumvirate" leadership:

Spokesperson: PS

Code Master: Phil Ilten (now at Cincinnati)

Web Master: Christian Bierlich

→ **new home: pythia.org**

should be opening within the coming month or so

New email address for issues etc already open

authors@pythia.org

With nice issue-tracking functionality + future searchability

E.g., use it to report HME issue?

Weak Boson Fusion (coherence & ME corrections with Vincia antenna-shower vs Pythia's DGLAP-based shower)

Pythia lacks accurate initial-final coherence (and cannot do CKKW-L merging for VBF)

Vincia antenna-shower model (partonShowers:model = 2) can do both.

Paper out very soon.

Interleaved Resonance Decays (new treatment of **finite-width** effects) **+ Electroweak Showers**

With R. Verheyen (UCL);

Paper out very soon.

Top Production and Decay

Recoil effects and precision top mass; much interaction with ATLAS top group

Vincia Antenna-Shower Model (lead node: Monash)

Showers with 2nd-order kernels, joint with C. Preuss (HDR student), S. Hoeche & J. Campbell (Fermilab) & H. T. Li (Northwestern)

First paper out soon + another DP grant proposal for longer-term development.

Longer-Term Projects

Strangeness Enhancements in PP

(currently project with honours student)

Strangeness enhancement effects in B sector?

Opportunities for LHCb? Consequences for LHCb?

QCD @ Future EE Colliders

FCC-ee, CEPC, ILC

Defining ideal set of maximally constraining QCD measurements

Tuning for Pythia 8.3

Last tuning (Monash) was done in 2013

Opportunity for major overhaul, new constraints, new **techniques**.

E.g., treatment of statistics (& neglect of correlations) so far unimpressive in tuning contexts

Input / Desires / Constraints from LHCb?

New extensive dedicated manual for Pythia 8.3

Plan is to finally rival the detail of Pythia 6.4 manual (~600 pages)

Already several hundred pages; likely to still take a few months to finish