Primary particle definitions
(in Rivet)

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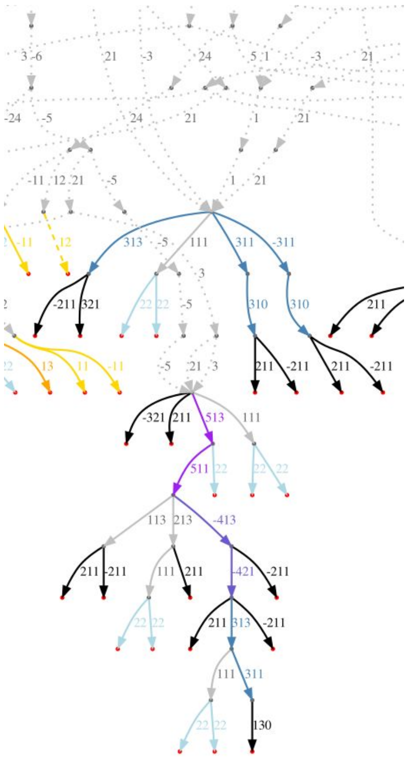
Primary particle definition(s)

- **Primary particles define the “truth” final state**
  - But **the definition of “primary particle” is pretty ambiguous!**
  - For-sure post-hadronisation, including all radiative modelling …
  - But **which stage in the hadron decay chain?**
    - A note: the nomenclature is very poor but we are stuck with it
    - We mean “primary” from the detector point of view, as contrasted with material-interaction secondaries. But *not* the first hadrons to be produced! ⇒ those stable enough to propagate and interact with a detector at ~10’s mm
  - **Historically left to the generator configuration.** “Classic” setup is **$c\tau_0$ > 10 mm** — note the “0”, meaning *species average* lifetime rather than *per-particle* lifetime — could be better?
  - Generator sets status=1 for these particles; Rivet and others ~obey

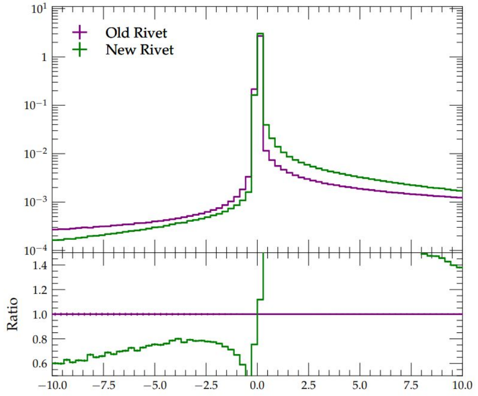


- **Experimental variations**
  - In practice driven by precise “fiducial mapping” reco → primary p’s
  - Experiments may also exclude e.g. strange baryons with poor reco

STATUS=1 is not enough!

Rivet, PPDs, and LLPs

- **Can't trust the generator: *we need to do what the analysis did***
  - This is *already* the general Rivet philosophy: PPDs were a historic gap. Probably because MB/UE were first LHC measurements.
  - Quite a relief to finally fix it…

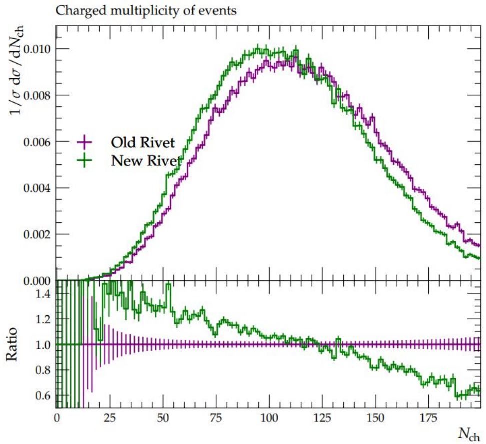


While we're at it, fix the signed-IP calculator…

- **Other motivation: BSM LLPs**
  - General handling of (decay-)displaced particles needed for SM
    - Esp LHCb, ALICE, etc. identified-hadron studies
  - **But BSM long-lived particles (LLPs) also an increasing focus**
    - Natural in several models, evade classic reco techniques
  - **Need to handle both SM and BSM, and identify short- and long-lived equally**
    - The interest can both be in displacement of production and displacement of decay — often re. whether parent is charged
    - Intimately linked to detector geometry and response: use-case will often be model-independently identifying particles whose properties (mass, kinematics, decay class, …) are to be fed to an ML → reco efficiency for reinterpretation

Rivet FinalState PPD algorithm

- **Work last summer by Sophie McNeill & AB to better define PPDs**
  - Work in Rivet, using FinalState projection model on event graph
  - **Walk backward from status=1 gen-stable particles:**
    - For each, recurse up ancestor links to find *real* primary hadron (i.e. the hadron for which the parent is partonic/MC-specific)
    - Condition is simply status != {1, 2}
    - Shortcut true direct leptons and photons →final state
  - **For each primary hadron, walk *forward* through decays:**
    - if a particle meets the user-defined stability definition, add it to the FS list and exit current recursion branch
  - **Note: two passes = not cheap, but optimisable & cacheable**



Nch distribution from mean-lifetime stability definition vs default Pythia status=1. Truncates decay chains →lower FS mult. Clustered/jet observables unaffected

- **User-defined stability definition?**
  - Oh yes, that. Since there's no universal PPD, we **need tools to easily define cases on a per-analysis basis**
  - **std::function<bool(const Particle&)> or Rivet::Cut**
    e.g. FinalState(Cuts::pT > 1*GeV, Cuts::zProd > 10*cm && Cuts::rhoDec > 1*metre)?
  - Implementation soon, promise. **Important to minimise compatibility breaking**