Junctions and Baryons

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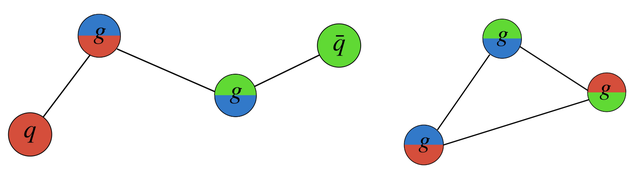
The Lund String Model

- Quantum Chromodynamics is represented by the **SU(3) gauge group** with three colours (and anticolours): **red**, **green** and **blue**
- **Confinement** in QCD dictates that quarks and gluons are found in colour-singlet states:
  - **Colour-anticolour** combination
  - **(anti)red** + **(anti)green** + **(anti)blue** combination

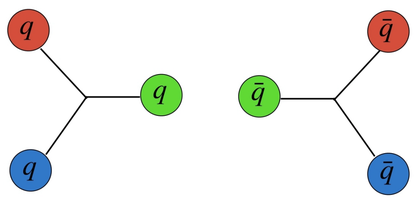
What is a string?

- The colour confinement field modeled as a 1+1 dimensional flux tube with a constant tension (*i.e.* ***a string***) as modelled in PYTHIA
- There are **three different string topologies:** dipole strings, gluon loops and junctions
  - Colour-neutral **colour-anticolour** strings:



The left topology is referred to as a dipole string, and the right is a gluon-loop configuration.

  - Colour-neutral **red**-**green**-**blue** string called a (anti)junction:



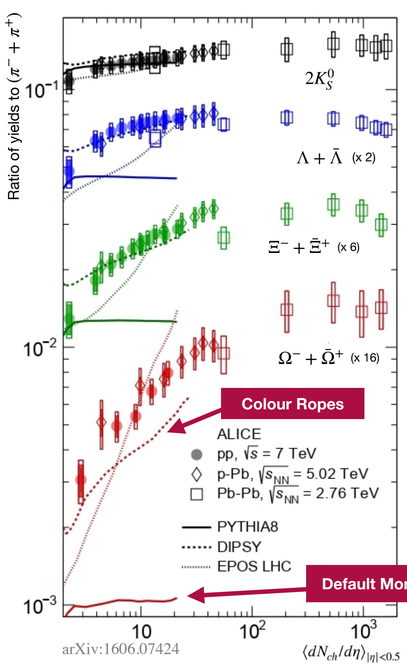
Junctions only included in Colour Reconnection (CR) model

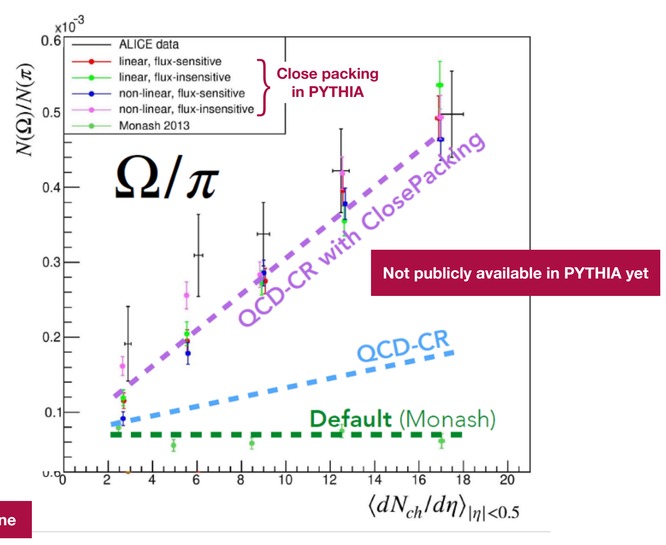
Strangeness enhancement

- Recent data from ALICE shows an increase in strange hadrons with respect to charged multiplicity, in particular a **rise in strange baryons**.

Collective Effects

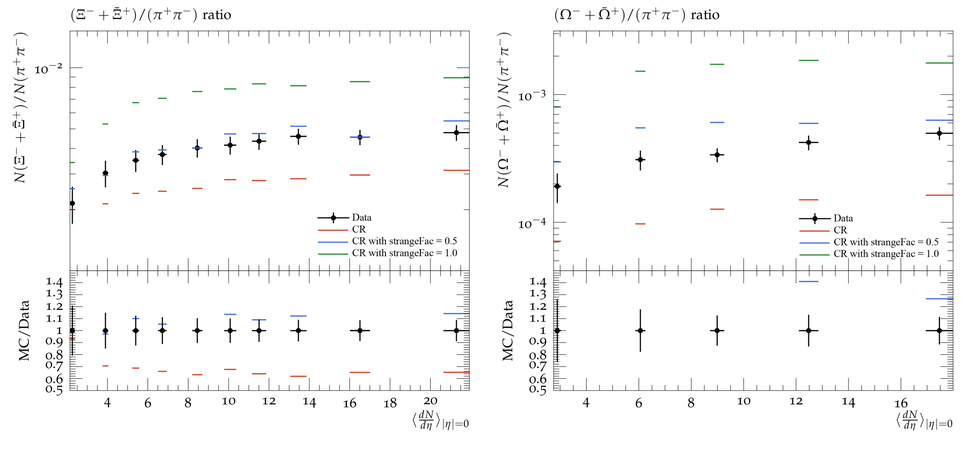
- **Close-packing** and **rope hadronisation** increases the string tension in more densely packed string environments → more likely to create **heavier partons** from string breaks → **more strange!**





Strange Junctions

- Confinement field around a junction is not necessarily the same as near endpoints or for dipole strings
- What if we allow for **strangeness enhancement around junctions?** → strangeness increase to be mostly for baryons
- May help reduce overprediction of proton-to-pion ratio
  - Below shows early-stage preliminary results:



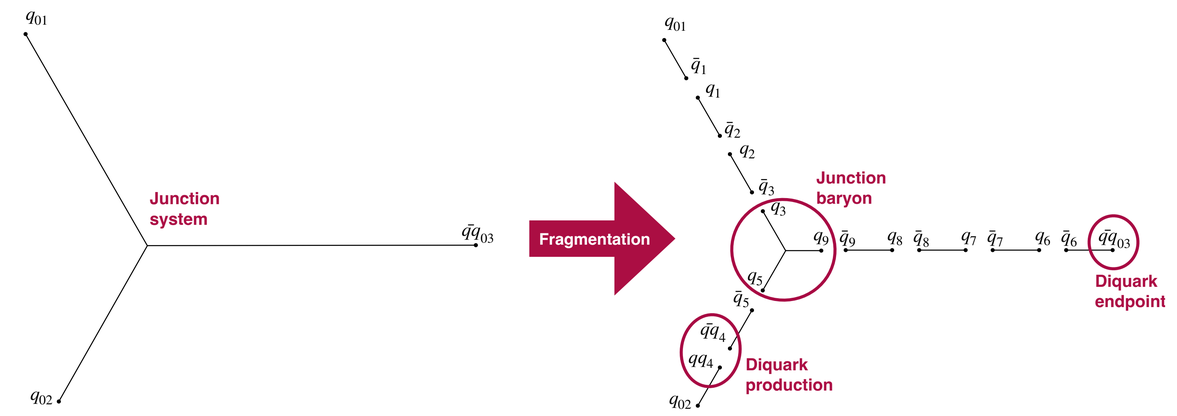
Hadronisation

- In high energy collisions like at the LHC, partons move apart from one another at high energies, stretching the string
- The **strings break** and create new quark-antiquark (or diquark-antidiquark) pairs → **final state hadrons!**
- Can only make **light flavour quarks** (up, down and strange). Heavy flavours must come from hard processes

note that the colours here are illustrative to keep track of the initial $q\bar{q}$ pair, and not meant to represent SU(3) colours

Baryon Production

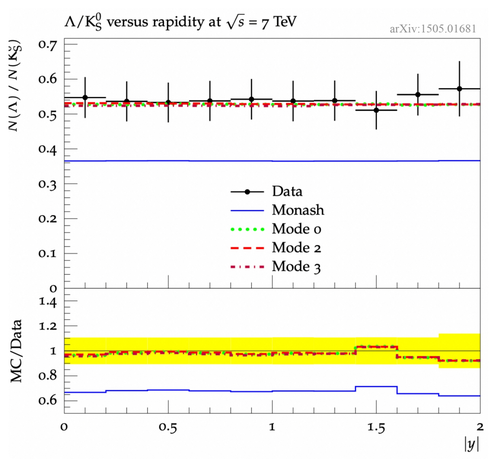
- There are three ways to make baryons in the Lund String Model: diquark production, beam remnant diquarks (diquark endpoints), or junctions

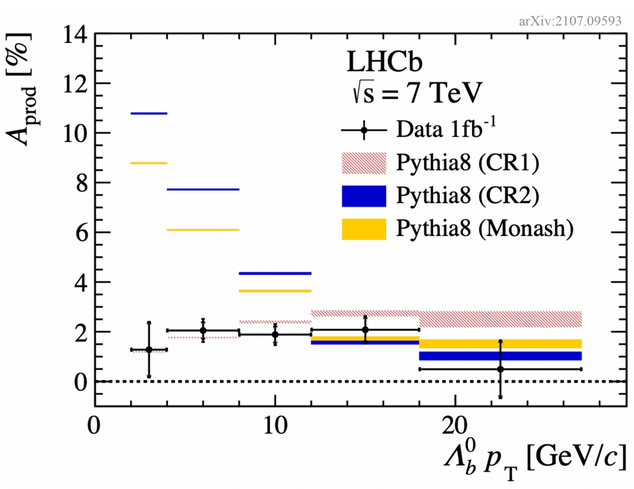


Effect of Junctions

Baryon-to-meson ratios

- LEP-tuned diquark production rates underpredicts the **baryon-to-meson ratio** in pp collisions without junctions (Monash tune)
- Junctions increase total baryon-to-meson rate (CR Modes 0-3)





Left plot demonstrates increased baryon-to-meson ratio and right plot shows low $p_\perp$ effects.

Low $p_\perp$ heavy-flavour baryons

- Default PYTHIA predicts high Λ_b **asymmetry at low** $p_\perp$ due to heavy quarks (but not antiquarks) connecting with beam remnants
- Junctions are more likely to form in denser string environments → **low** $p_\perp$
- Junctions and antijunctions formed in equal quantities → diluting the asymmetry

Outlook

- Improving junction modelling, including special treatment of **soft endpoint junction systems** (*i.e.* usually low $p_\perp$ heavy-flavour junctions)
- Combine effects of **close-packing and strange junctions**
- Reduce current pp collision **overprediction of proton production**. Model diquarks as **successive colour fluctuations** (popcorn mechanism), allowing fluctuations to connect with nearby strings → reduce probability of forming diquarks → reduce proton production