Probing colour reconnection using hadronically decaying top quarks

Deepak Kar
University of Witwatersrand

MPI@LHC at Perugia, December 2018
A large radius jet of $R = 2m/p_T$ can contain all decay products

Hadronically decaying top quark, Higgs/W/Z bosons, new heavy particles ...

Exploit the internal structure of the large radius jet coming from signal to distinguish them from large radius jet coming from background (light quark, gluon, lepton)

Preferred jet algorithms are $k_t$ or CA, as they preserve clustering order
Outline

Measure colour reconnection

Utilise the Lund plane
Colour Reconnection in ttbar

- One of the largest modelling uncertainty in precision measurements
- Not really any measurements to constraint it in models
Pull Plots

Definition of jet pull

$\Delta \phi = \phi - \phi_{j_1}$

$\Delta y = y - y_{j_1}$

Legend:
- Jet-pull vector $\vec{P}(j_1)$
- Jet-connection vector $\theta_P$
- Jet-pull angle ($j_1$ w.r.t. $j_2$)
- Constituent of $j_1$ (size weighted by $p_T$)

Little or no sensitivity to CR :-(
(Too coarse binnings?)
We are trying to construct observables sensitive to CR using boosted hadronic tops (very preliminary, work in progress)

Generator level studies with Pythia8
Dissecting the large-R jet

The idea is: if we pick 3 subjet events, we should get a qqb triplet. We can b-tag the subjet (blue), so then measuring charged particle activity between qq and qb should be sensitive to CR
Plots

We see noticeable difference. May get washed up in real data!
Jet displays

Staring at many of those, can you learn something?
Interpreting jet displays

• Without being told anything about QCD, the student realised for signal the (sub)jets are closer together in signal than in background (collinear emission vs wide angle radiation).

• The student realised signal have on average more (sub)jets (three-prong decay from top quark as opposed to one-prong from light quark or gluons).

• Given an unlabeled set of figures, the student identified 70% of them correctly!
Lund Plane

Useful way of representing emissions inside a jet

Made using C-A declustering

Soft collinear radiations are emitted uniformly in the whole plane.

Whereas ...
Lund Plane

Novel way to characterise radiation patterns inside a jet

Different regions sensitive to different aspects

Find part of the plane sensitive to MPI/CR?

Large angle radiation
We plotted...
Nominal

Ungroomed

Soft-dropped

Softer

More collinear

Softer

More collinear
MPI Off

Ungroomed

Soft-dropped

Softer

More collinear

Softer

More collinear
MPI Enhanced

Ungroomed

Soft-dropped

Softer

More collinear

Softer

More collinear
CR Off

Ungroomed vs Soft-dropped

- Softener
- More collinear

Ungroomed

Soft-dropped
CR Enhanced

Ungroomed

Soft-dropped

Softer

More collinear

Softer

More collinear
FSR Off

Ungroomed

Soft-dropped

Softer

More collinear

Softer

More collinear
FSR Enhanced

Ungroomed

Soft-dropped

Softer

More collinear
Looking Forward

- Jet substructure is well integrated at MPI-LHC: ATLAS results and Ramandeep’s talk
- Expecting more measurements!

From my ICHEP talk
WHERE IS THE HERWIG LINE?

IT IS MPI@LHC