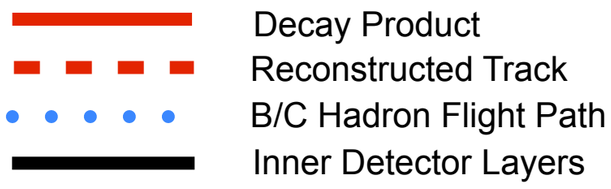
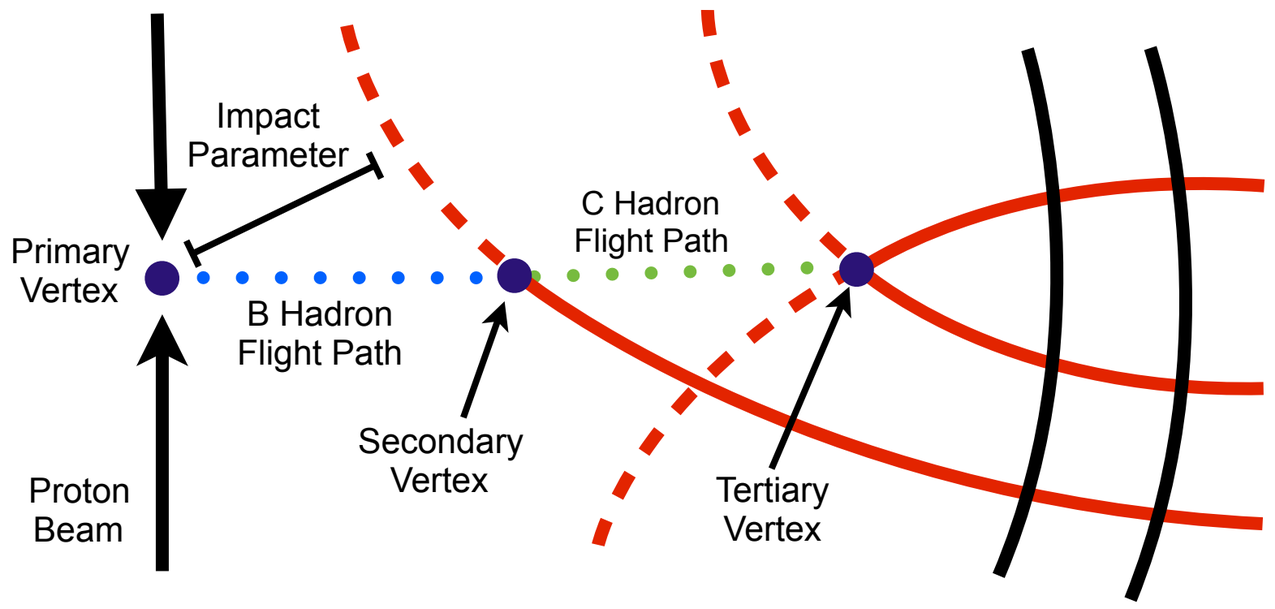
RAL Summer School - Lancaster University, September 2015

Data Commissioning of Flavour Tagging in Run 2 Data with ATLAS





Flavour Tagging Algorithms

- Jets can be tagged in 3 flavours; b, c or light. The flavour of the jet denotes the flavour of the quark from which the jet was initiated.
- The heavy hadron contained within b and c jets will, due to its long lifetime, decay a measurable distance from the primary vertex, the point where the two proton beams collide.
- The pattern of tracks is used to look for this secondary vertex and discriminate between the different jet flavours.
- The tracks are reconstructed by looking at hits caused by charged particles interacting with silicon layers in the inner detector.

The three most commonly used base flavour tagging algorithms are:

Impact Parameter (IPxD)

- For all tracks calculate the impact parameter (I.P.), the distance of closest approach to the primary vertex.

Secondary Vertex (SV)

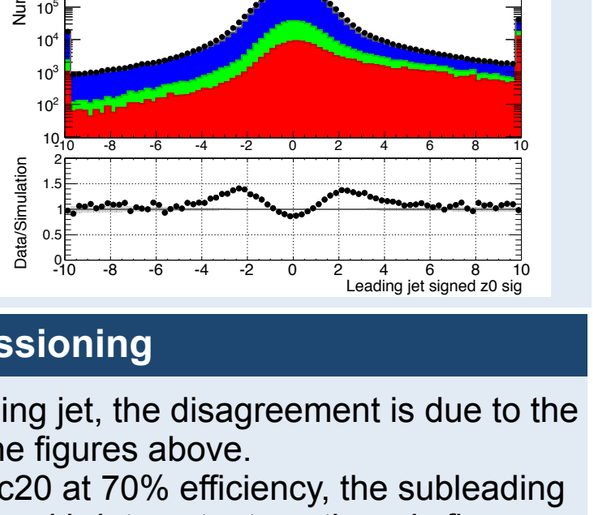
- Reconstruct a secondary vertex from the intersection of two or more tracks.

Jet Fitter (JF)

- Use the full decay chain by constructing a flight-path axis with many vertices along it.

Multi-Variate Tagger (MV2)

- The three basic taggers are combined, using a boosted decision tree, to optimise flavour tagging performance.
- In Run 2, the recommended tagger is MV2c20.

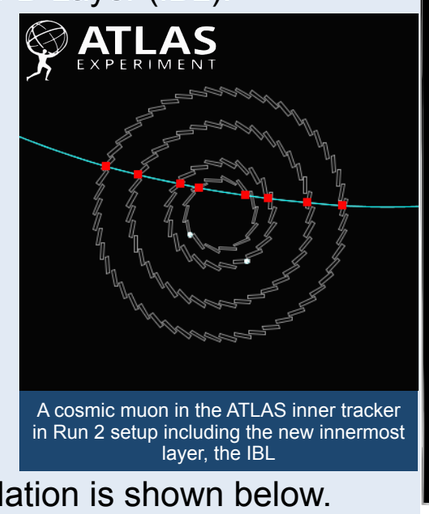


Data Commissioning for Run 2

- Since the LHC's first data taking run in 2010-12, there has been a long shutdown in preparation for Run 2.
- In the long shutdown there have been many changes at ATLAS that will affect flavour tagging performance in Run 2; increased collision energy, updated algorithms and a new innermost silicon layer, the Insertable B-Layer (IBL).
- Flavour tagging performance after these changes has been tested and optimised in simulation.
- In addition flavour tagging performance must be validated in data before use in analyses.
- This is done by comparing data to simulation.

- Here we consider 56 pb^{-1} of early Run 2 data collected at ATLAS between May-July 2015.
- The simulation is a QCD dijet sample produced using a Monte Carlo generator, Pythia 8.
- Event selection - Trigger on one high-p_T jet, the leading jet, with p_T > 70 GeV.
  - Plot subleading jet separately if it has p_T > 35 GeV.

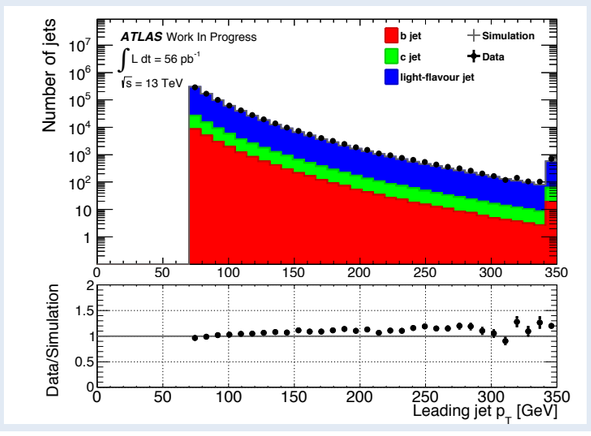
- In the commissioning plots shown below, the number of simulated events has been normalised to the number of events observed in the data sample.
- The simulation is shown as a stack of its flavour composition with data points overlaid (red for b-jets, green for c-jets, blue for light-flavoured jets and black for data). The ratio of data to simulation is shown below.

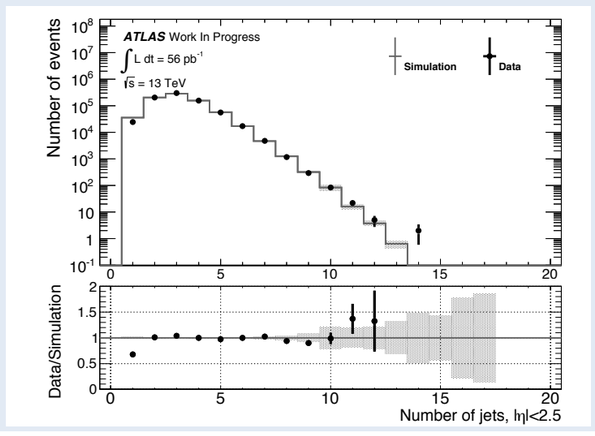


A cosmic muon in the ATLAS inner tracker in Run 2 setup including the new innermost layer, the IBL

Jet Kinematics

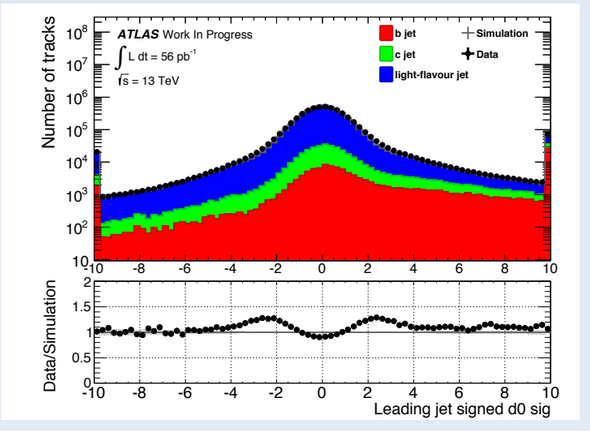
- Before considering flavour tagging, it must be shown that the jet kinematics are well modelled in the simulation.
- Below, the leading jet p_T and jet multiplicity show reasonable agreement.





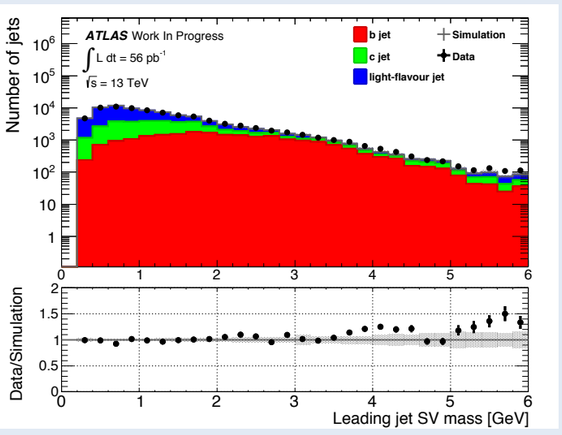
Impact Parameter Significance

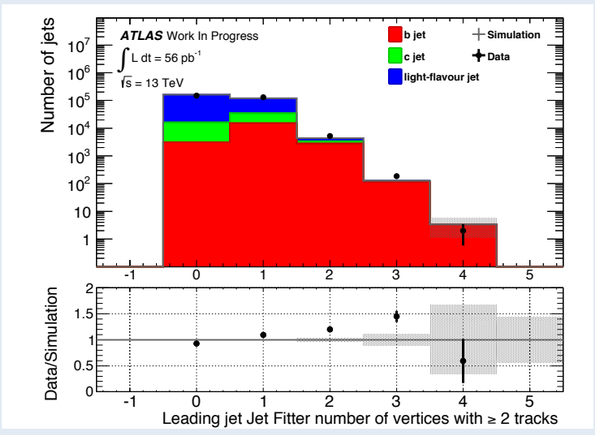
- Transverse and longitudinal impact parameter (d0 and z0) significance are inputs to IP2D and IP3D, where Significance = (I.P. / Uncertainty)
- The discrepancies are likely due to residual material mismodeling in simulation.



Secondary Vertex and Jet Fitter

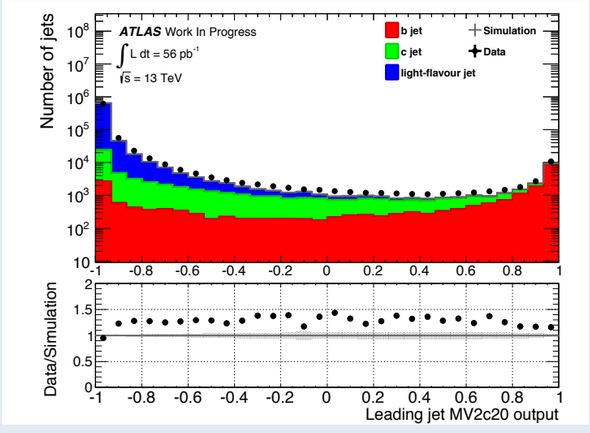
- The inputs to MV2 from SV are secondary vertex properties that discriminate between jet flavours, such as the vertex invariant mass (shown bottom left), which discriminates as B, charmed and light-hadrons have different masses.
- The inputs of Jet Fitter to MV2 are properties of constructed vertices that can discriminate jet flavour, such as the number of vertices with at least 2 tracks, shown on the right.
- SV and JF inputs exhibit reasonable agreement between data and simulation.

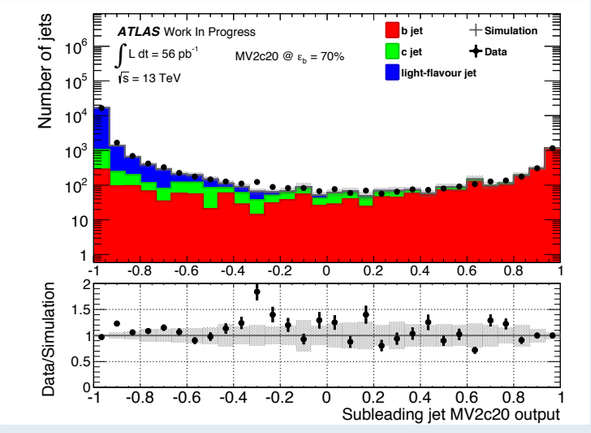




MV2 Commissioning

- MV2c20, is shown on the left for the leading jet, the disagreement is due to the difference in I.P. significance, shown in the figures above.
- Then by tagging the leading jet with MV2c20 at 70% efficiency, the subleading jet forms an unbiased sample with enhanced b-jet content, as there is flavour correlation between leading and subleading jet, but no tag is applied to that jet.
- MV2c20 for this b-enhanced subleading jet sample is shown on the right.





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