

Secondary Vertex Algorithms in ATLAS Flavour Tagging

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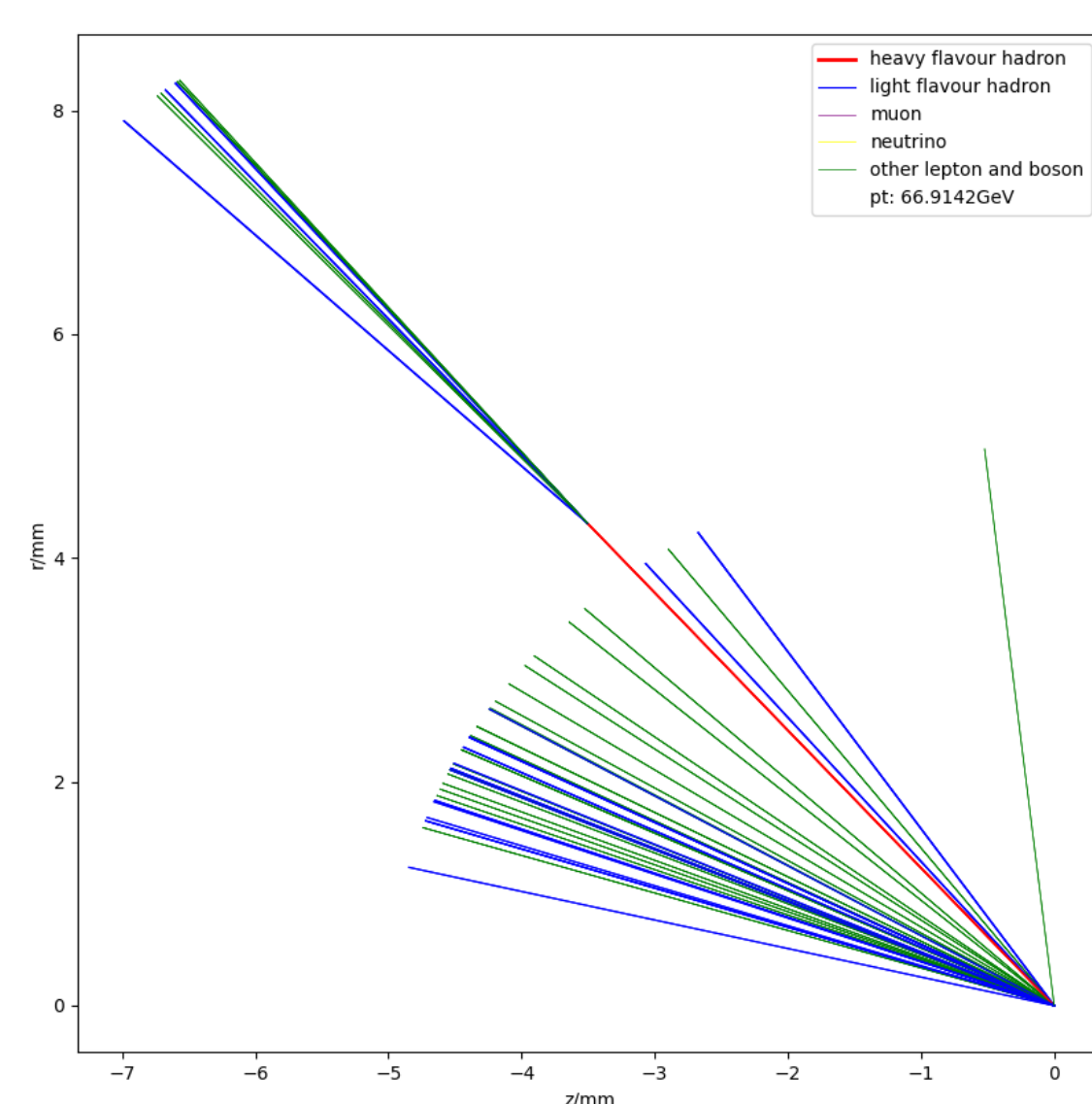
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Jet Flavour Tagging & Secondary Vertex:

Quarks and gluons from primary vertex produce jets after hadronization. For most analysis studies related to quarks with certain flavour, it is important to tag flavour of quarks through the jets they produce. Jets are usually labeled as B(ottom), C(harm) or L(ight) in flavour tagging and these labels are defined by the heaviest hadron in jet cone for jets in Monte Carlo samples.

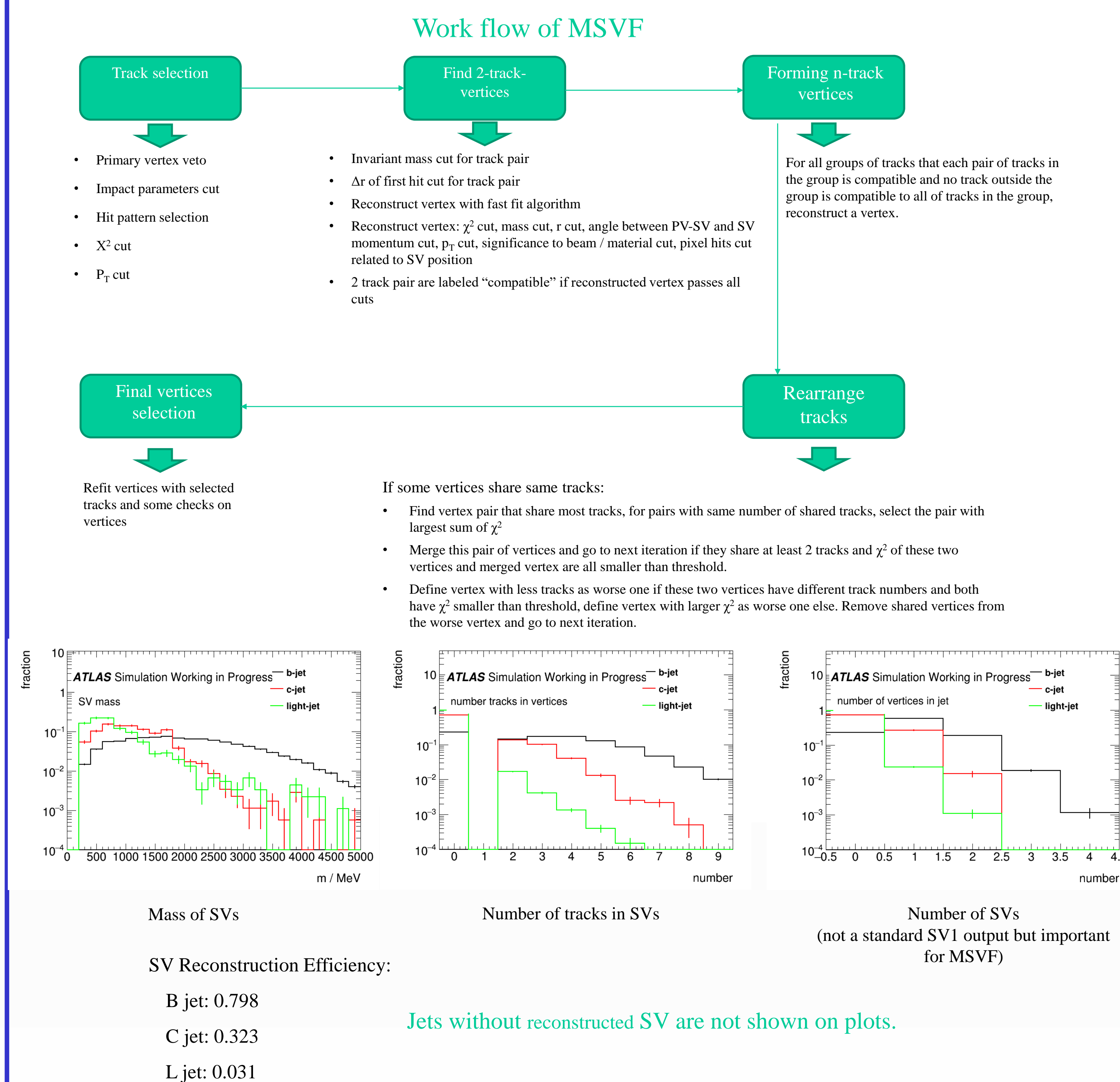
- Except many final state particles and short-lived particles which decay immediately after produced, most Bottom jets contain a B meson and most Charm jets contain a D meson after hadronization.
- B and D mesons have lifetime of $O(10^{-12}s)$ and most of them can fly $O(10mm)$ before decay, producing a secondary vertex (SV) away from primary vertex which is useful in flavour tagging.
- Usually, only B and C jets have SVs and SVs of B jets are further away from primary vertex because B mesons have longer lifetime and produce D meson in hadronic decay, which will decay later.



A D meson (red line) and its decay vertex in all particles from a charm quark hadronization

Multi secondary vertex finder:

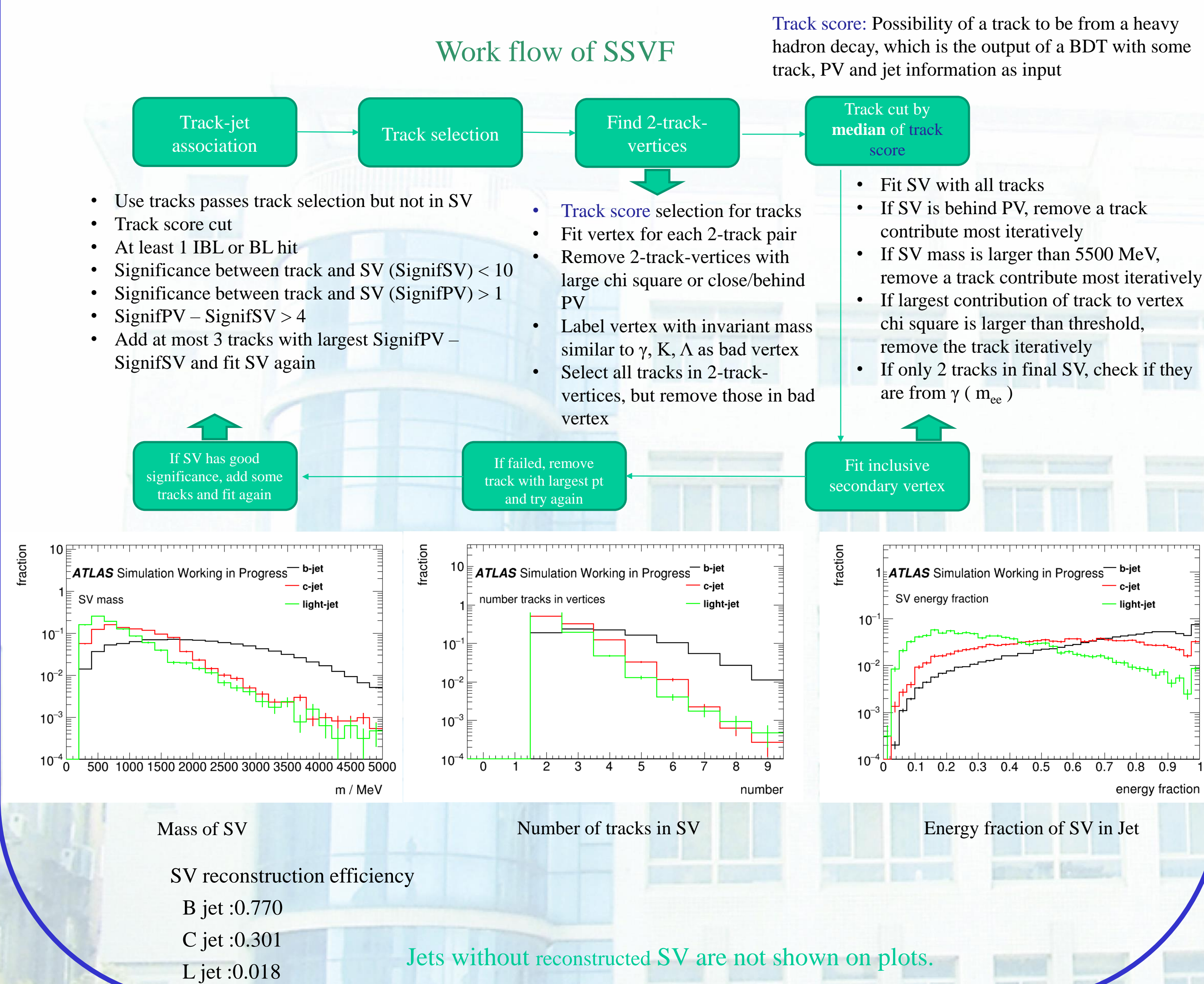
Multi secondary vertex finder (MSVF) is an alternative SV finder which can be used in SV1 to replace the default SSVF. MSVF tries to produce multiple SVs in jet. MSVF is not currently used in standard ATLAS flavour tagging algorithms.



MSVF has similar performance with SSVF, but provides additional variables such as number of vertices which can further benefit high level flavor tagging.

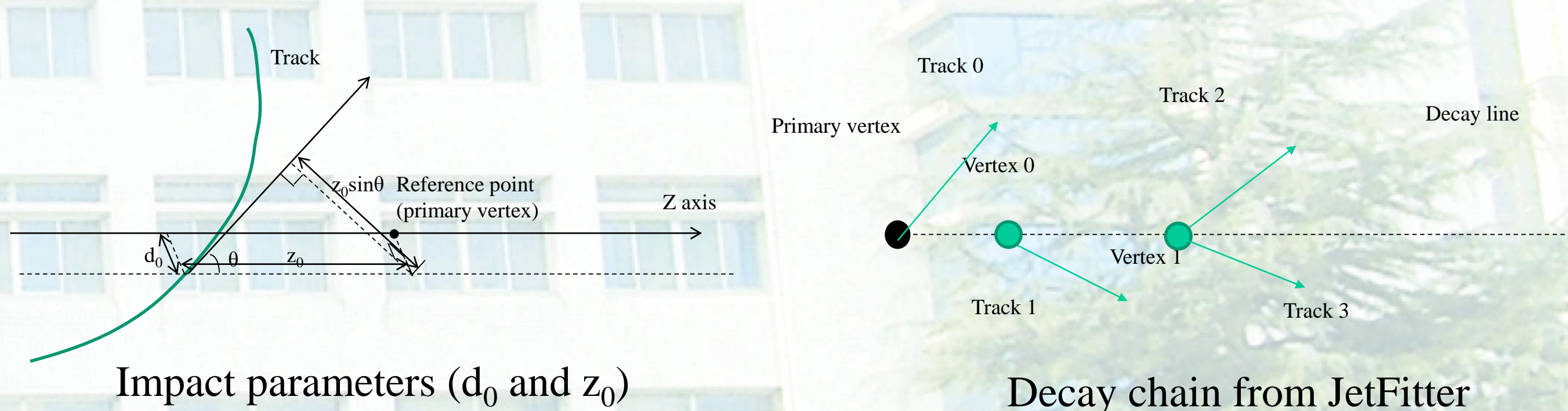
SV1 Algorithm:

SV1 is a low level jet flavour tagger based on reconstruction of SV from heavy hadron decay in jet. It use the single secondary vertex finder (SSVF) to reconstruct an inclusive SV in jet and produce output variables both from the final SV and during the reconstruction.



Flavour Taggers in ATLAS:

ATLAS flavour taggers consist of low level taggers and multi-variable taggers. Low level taggers use tracks information associated to jets and produce inputs for multi-variable taggers. Low level taggers usually means IP2D, IP3D, SV1 and JetFitter, as well as optional ones such as soft muon tagger. IP2D and IP3D directly use impact parameters of tracks associated to jets. JetFitter reconstruct a decay line from primary vertex and some vertices on the decay line.



Multi-variable taggers usually use boosted decision trees and neural networks, and their outputs are probabilities of flavours. Currently, most ATLAS analysis studies in need of flavour tagger use BDT based MV2 sets and/or neural network based DL1 sets.