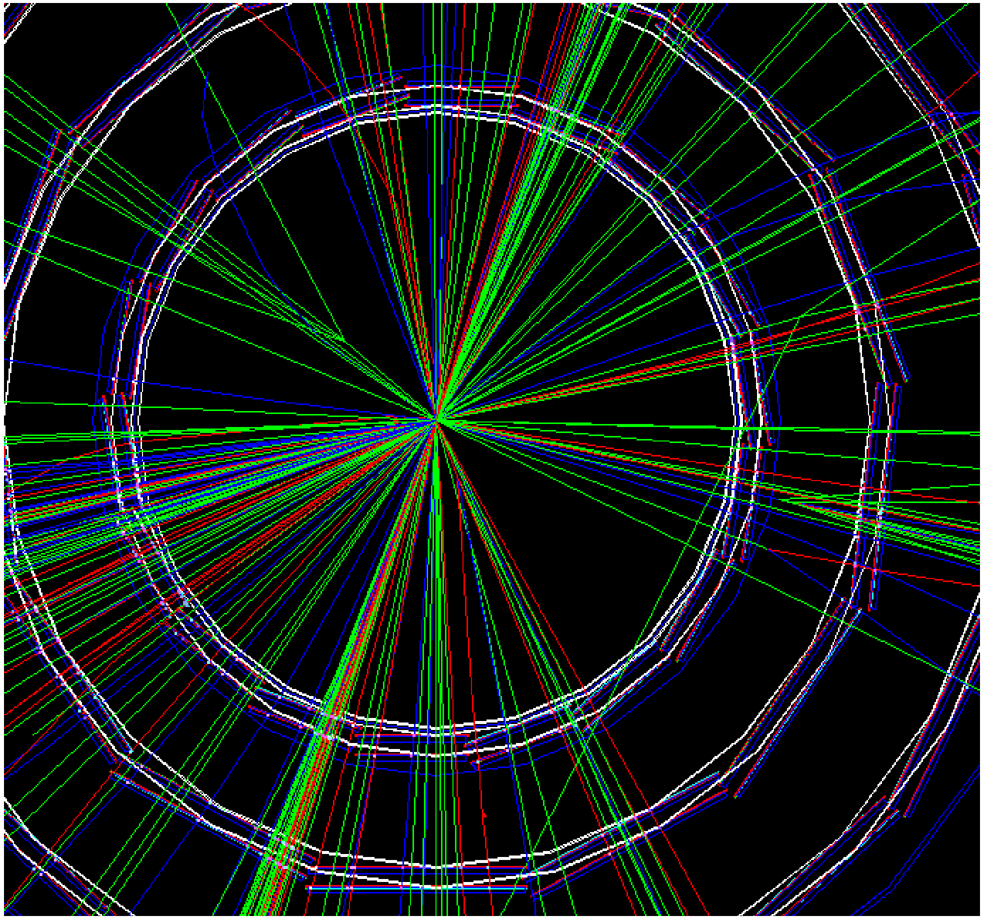
b-Tagging at multi-TeV:
Requirements and Issues



Marco Battaglia, Frederick Bogert

UCSC
Lawrence Berkeley National Laboratory
and CERN

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Peter Speckmayer)

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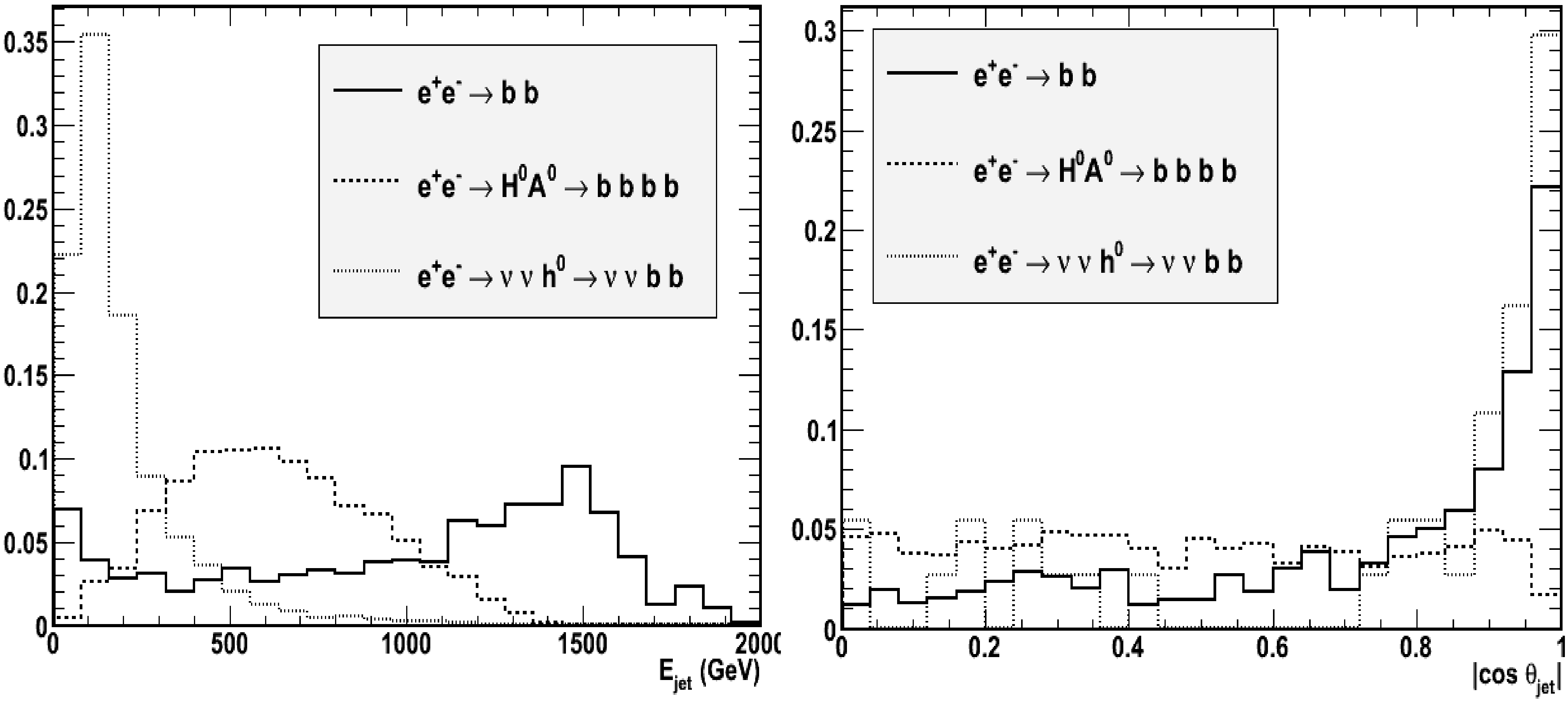
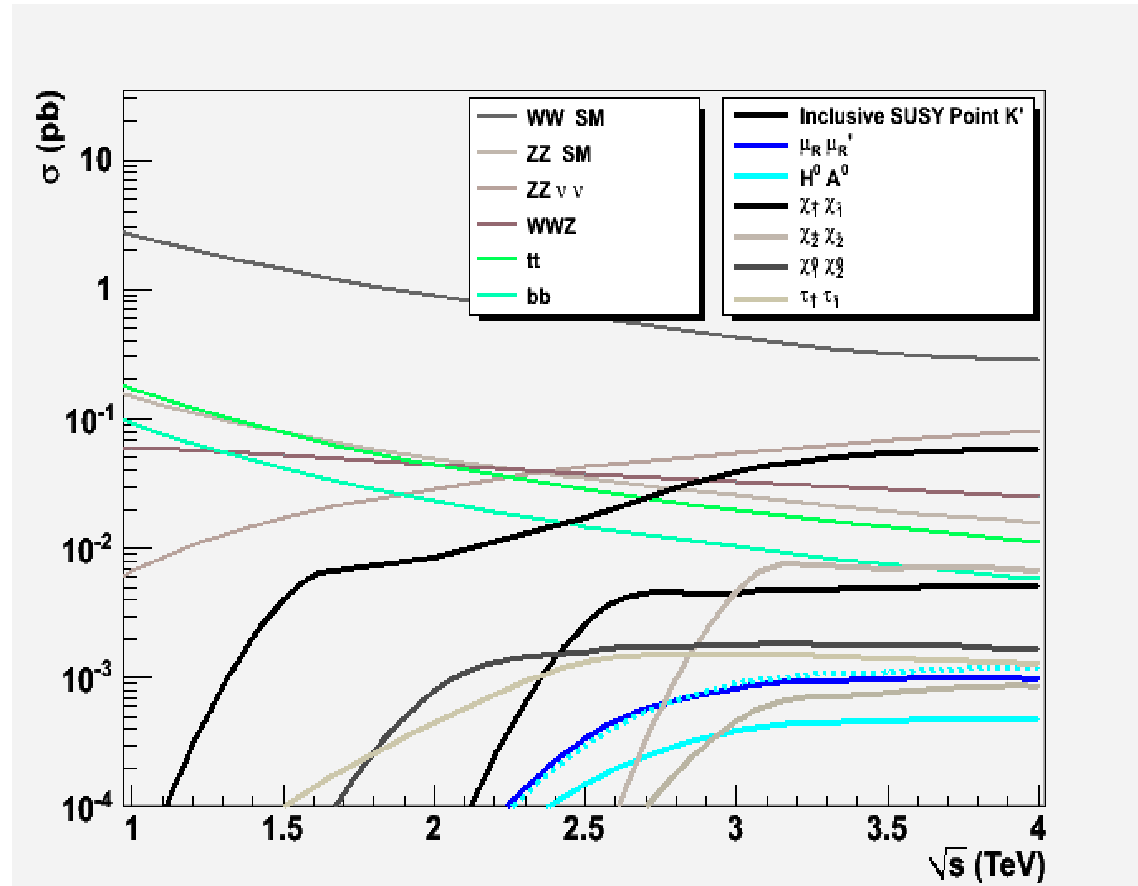
Tagging b-Jets in multi-TeV collisions



Combination of central new physics processes with fwd SM WBF reactions of interest in multi-TeV collisions make b jets to extend over a decade in energy and the full polar angle.

Tagging b-Jets in multi-TeV collisions

Process	σ (fb)
bb	10
HA → bbbb	~0.3
HA → tbtb	~1.0
ννHH(120) → bbbb	~0.7
ννH(185) → bb	~1.5
$\chi^0_2 \rightarrow \chi^0_1$ h(120) → bb	~2.0



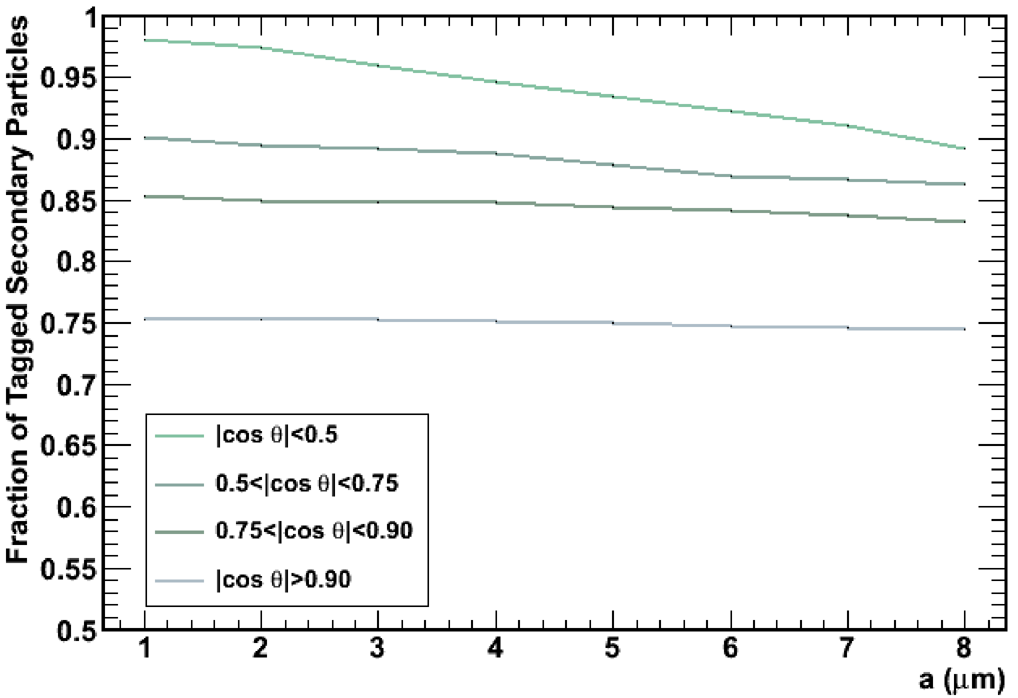
Processes of interest which can be identified through b-tagging have cross sections of ~few fb, charm background does not appear to be dominant is benchmark processes considered so far. High ε_b emerges as major requirement.

Track Extrapolation Accuracy

Study ability to identify secondary tracks from i.p. prob as function of track extrapolation accuracy: multiple scattering term emerges as more important than asymptotic resolution,especially in fwd region.

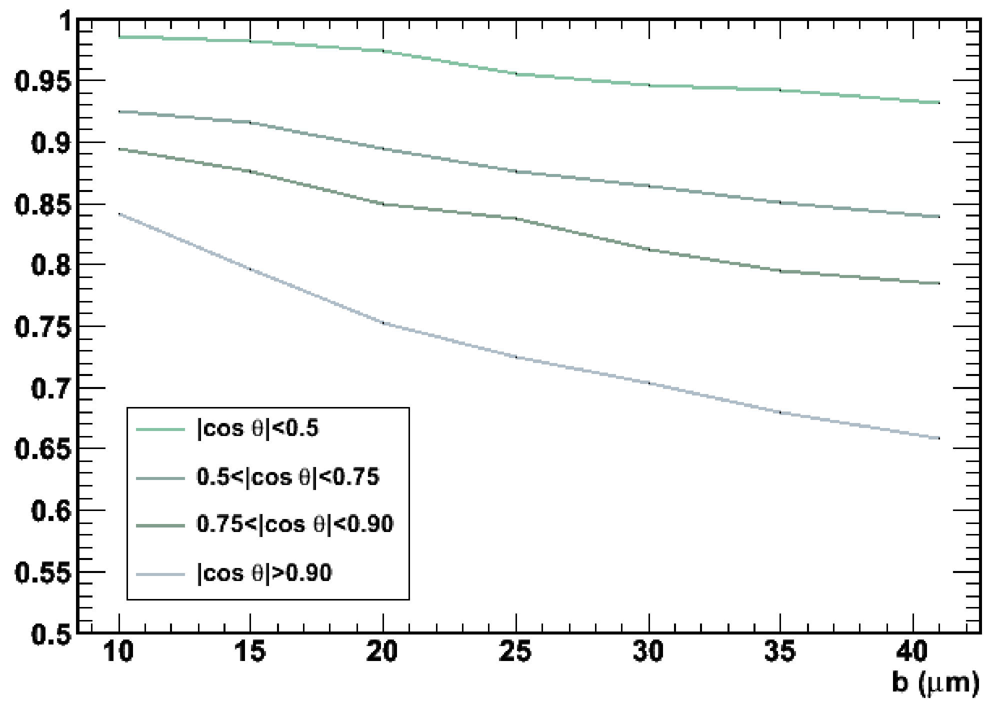
$$\sigma_{IP} = \underline{a} + b/p_t$$

(b = 20 μm/GeV)



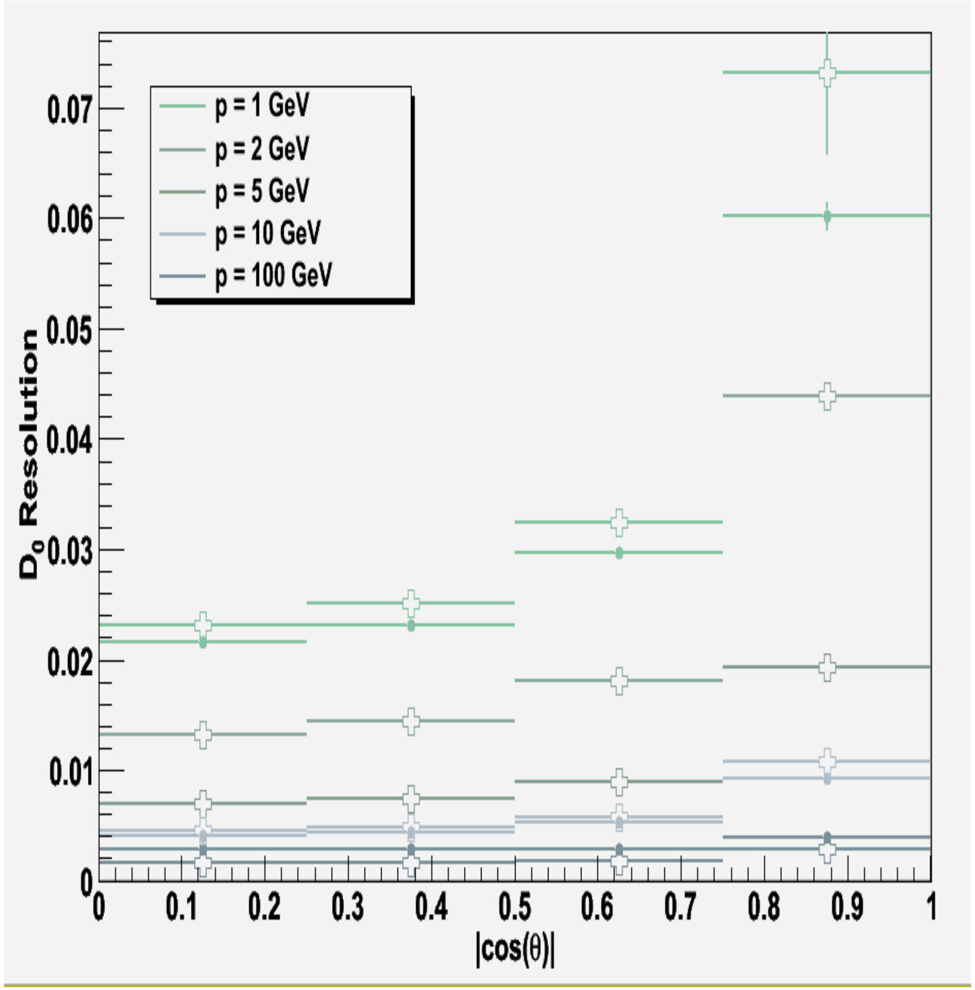
$$\sigma_{IP} = a + \underline{b}/p_t$$

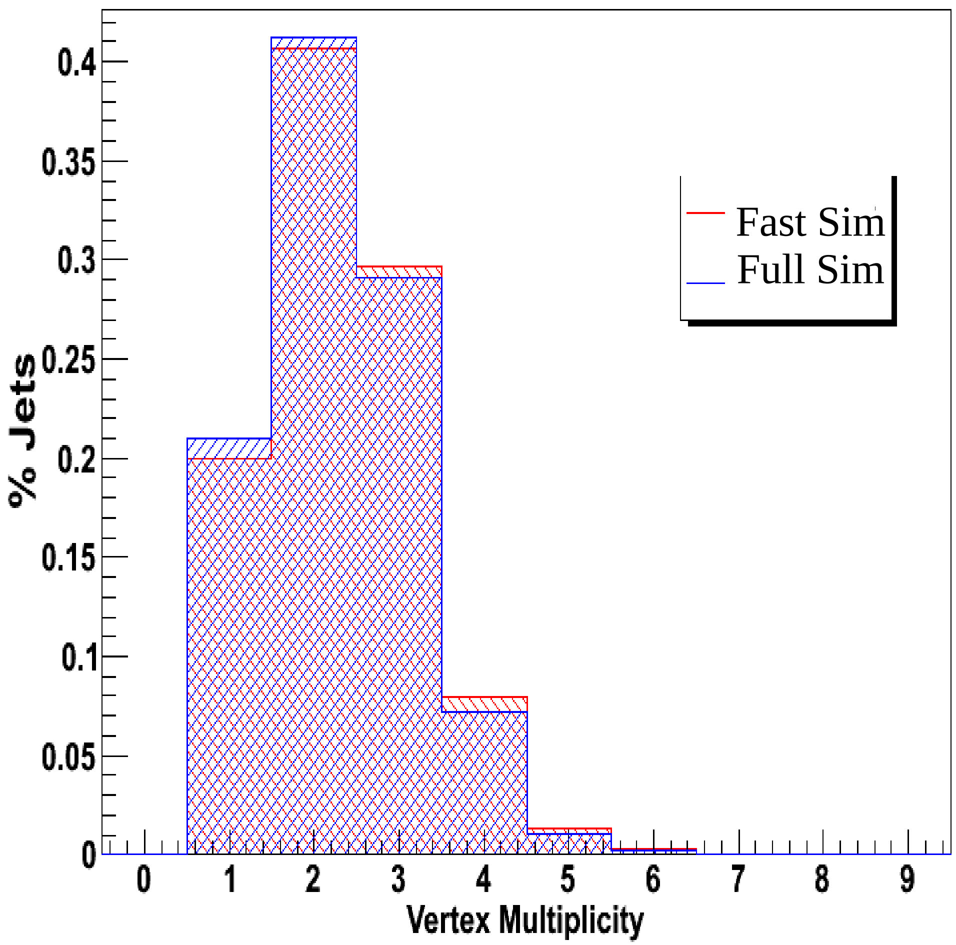
(a = 2 μm)



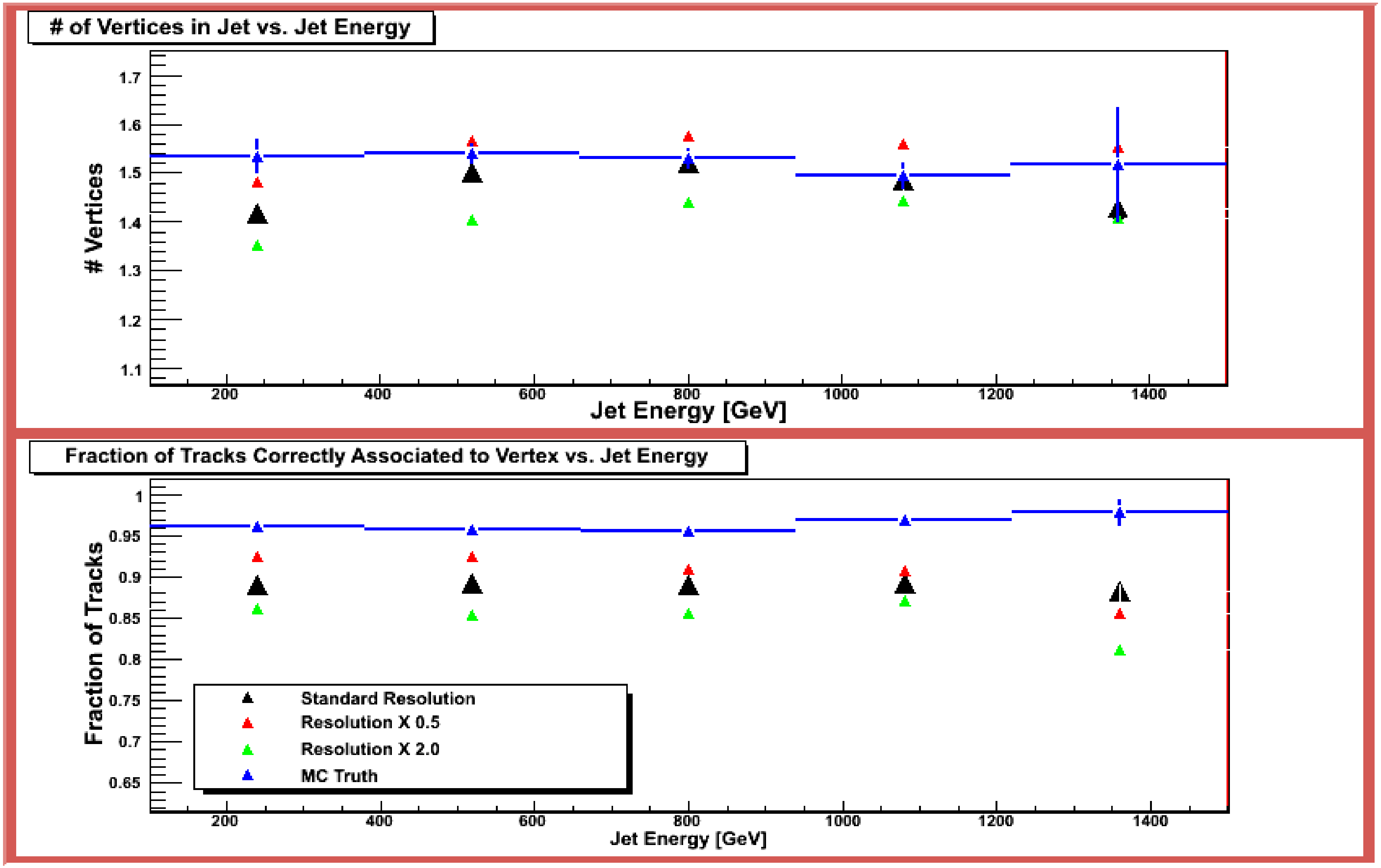
Fast vs Full Simulation

Use parametrisation of track covariance matrix for fast simulation of events. Convert particle tracks smeared based on LCDTRK into lcio Track and ReconstructedParticle collection to be analysed with same Marlin processors as Mokka+MarlinReco events. Validated on ful sim+reco events. Useful for studying effects of variation in resolution and systematic studies.

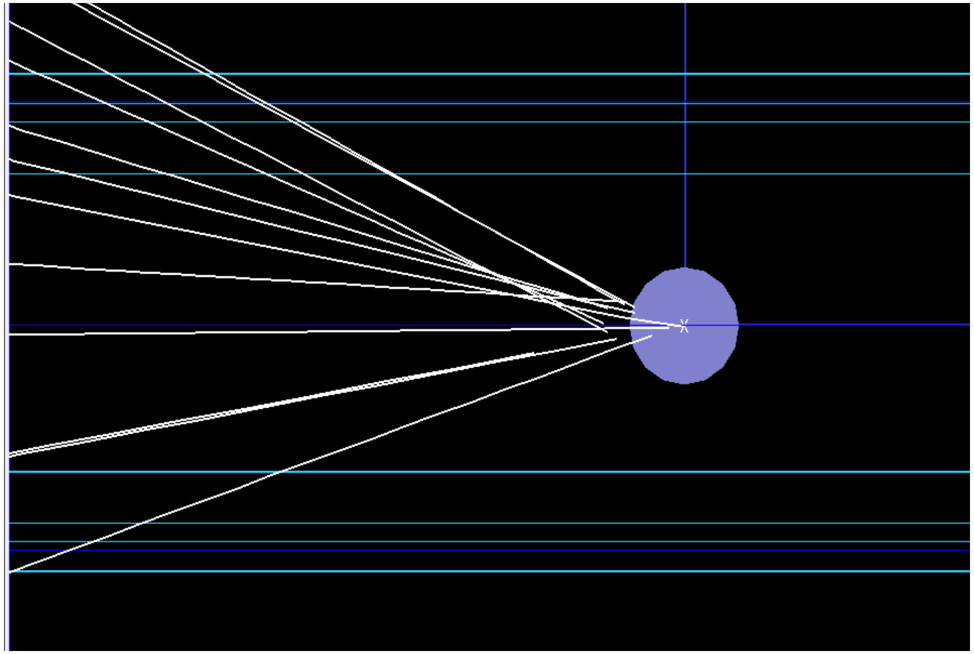


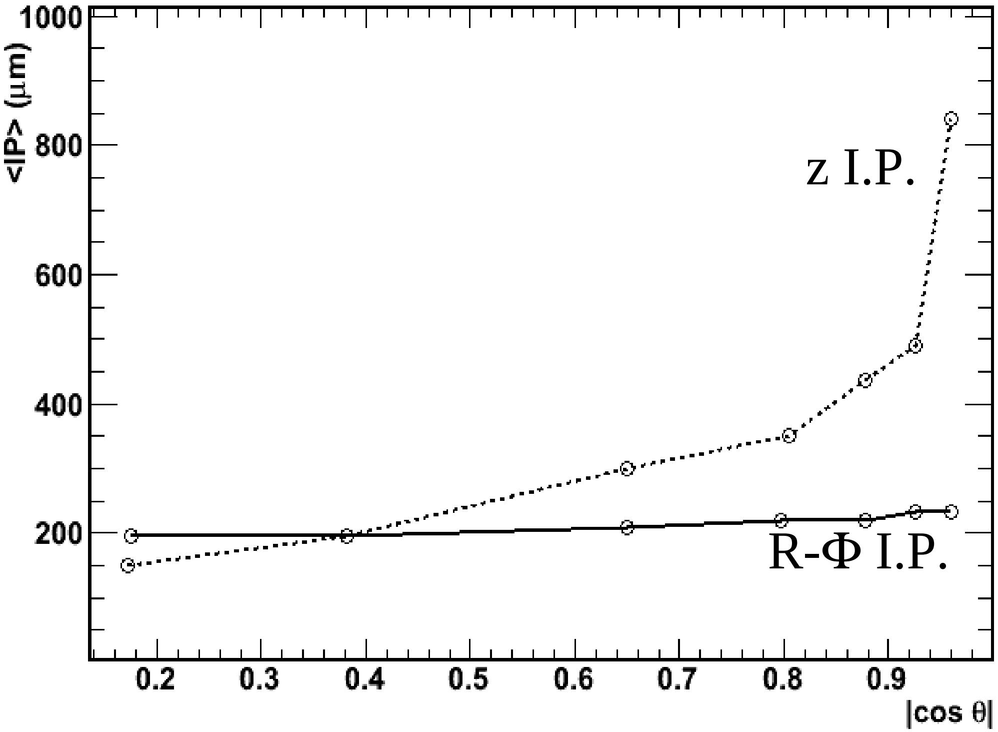


Track Extrapolation Accuracy

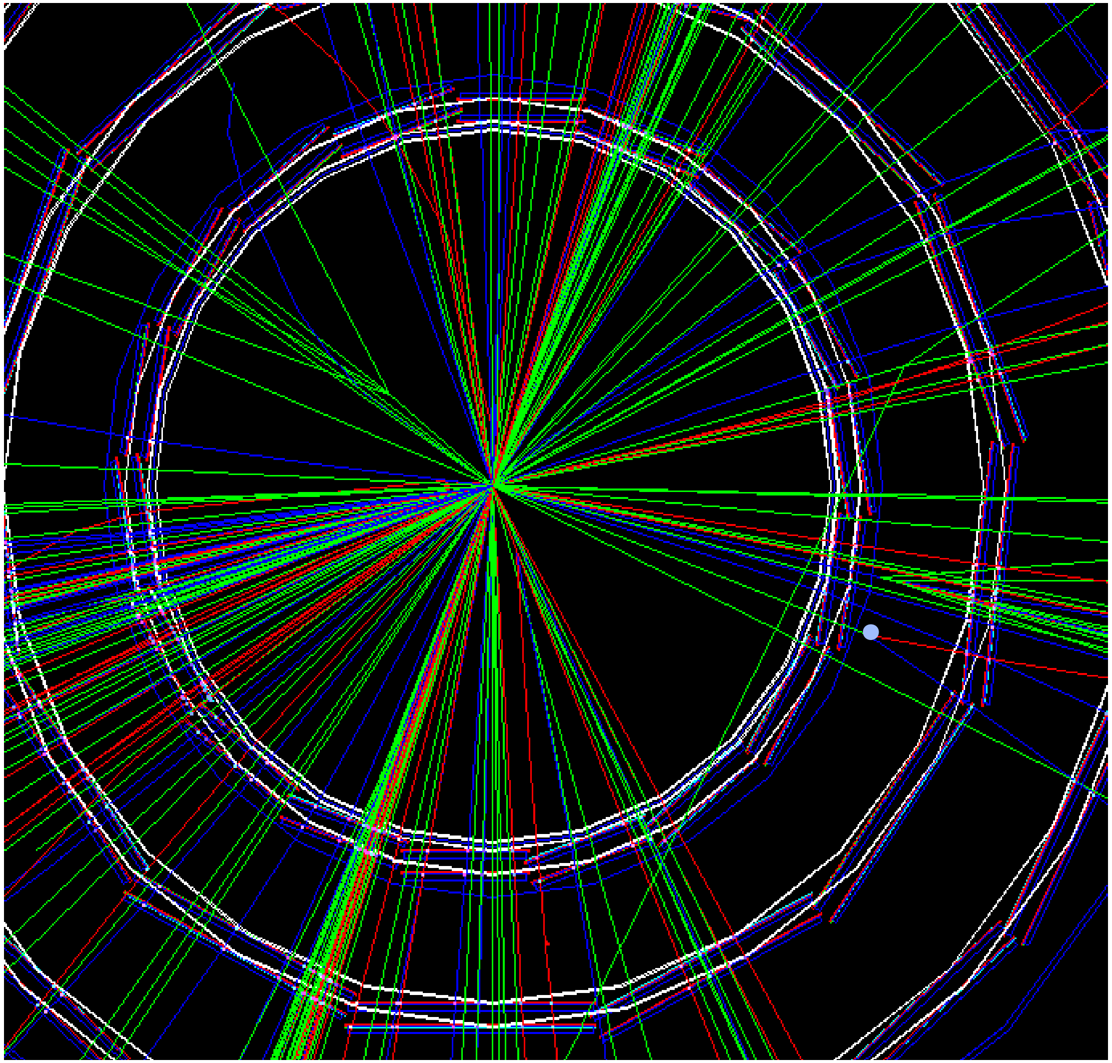


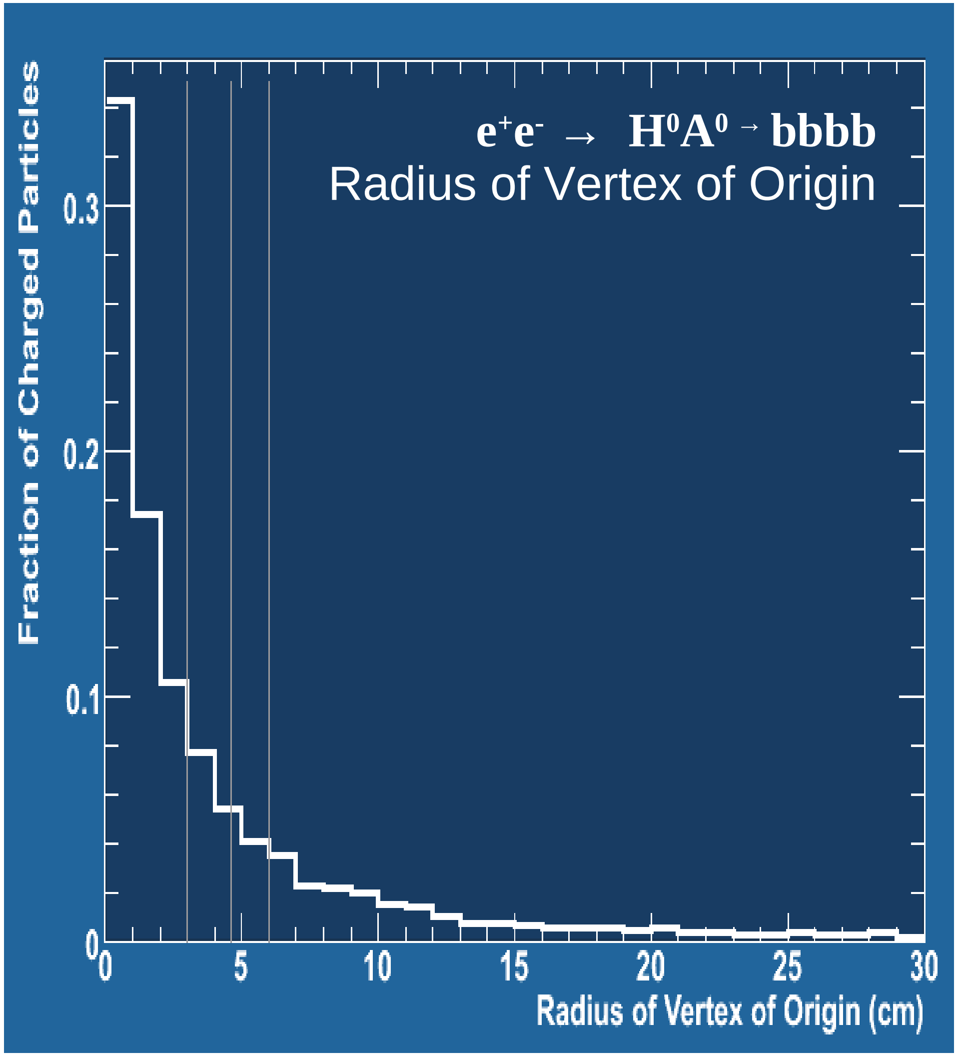
Track Extrapolation Accuracy





B Decay Length



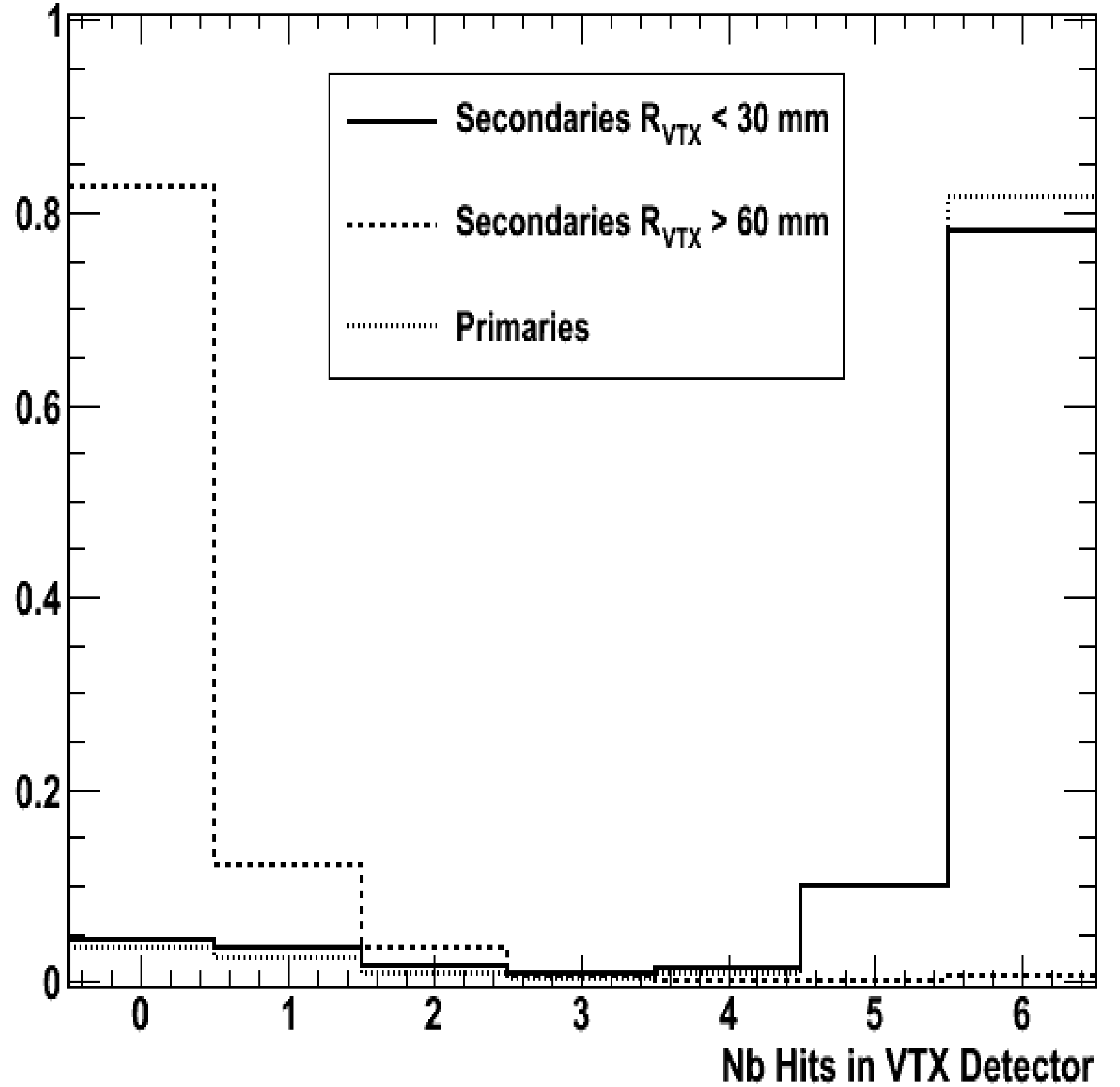


B Decay Length

Because of large displacement of decay vertices in b decay chain ~15% of tracks in TeV jets have < 5 VXD hits;

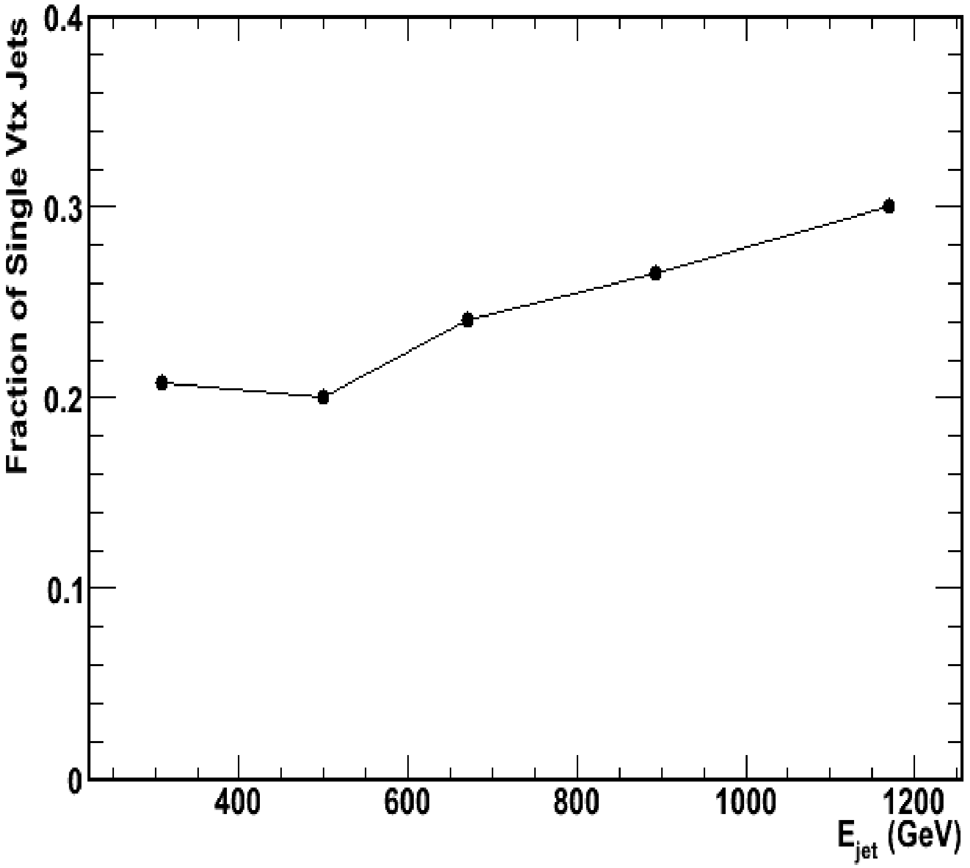
Quality cuts based on VXD hits bias reconstructed sample towards shorter decay distances, lower b energies;

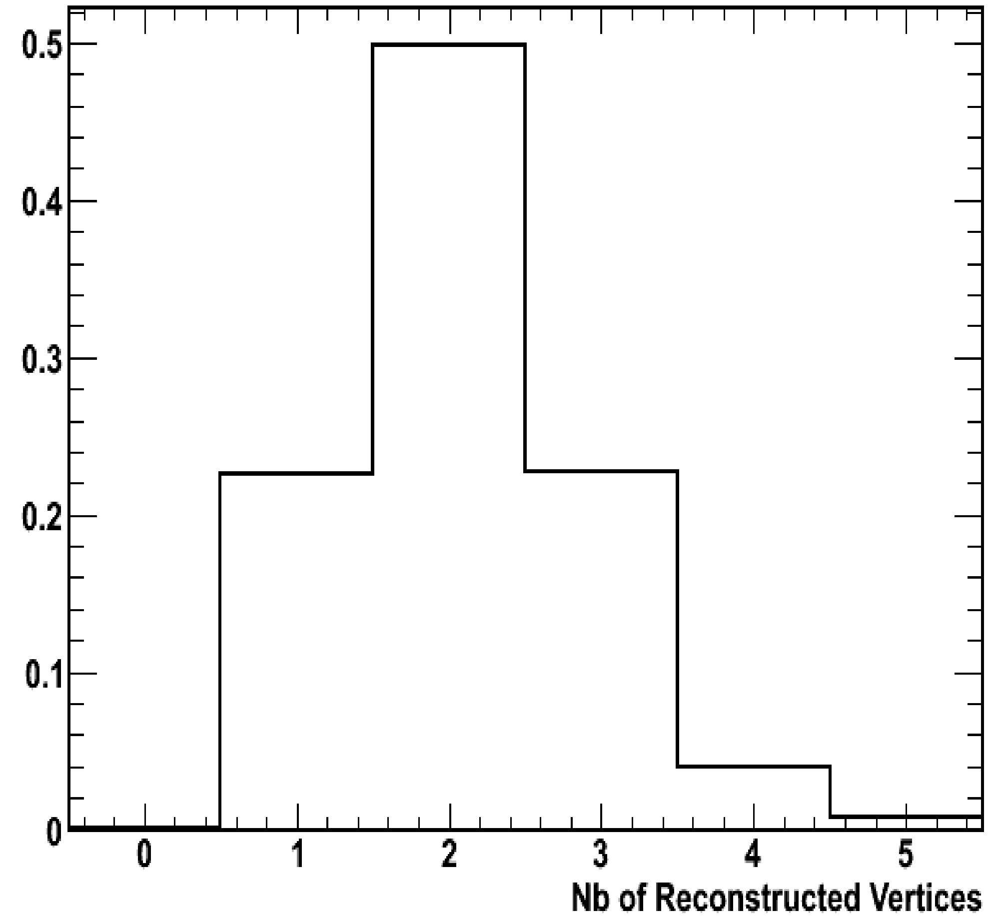
Can use nb of tracks with few or no VXD hits to tag these cases but bkg from interactions/ badly reco tracks is large.



B Decay Length

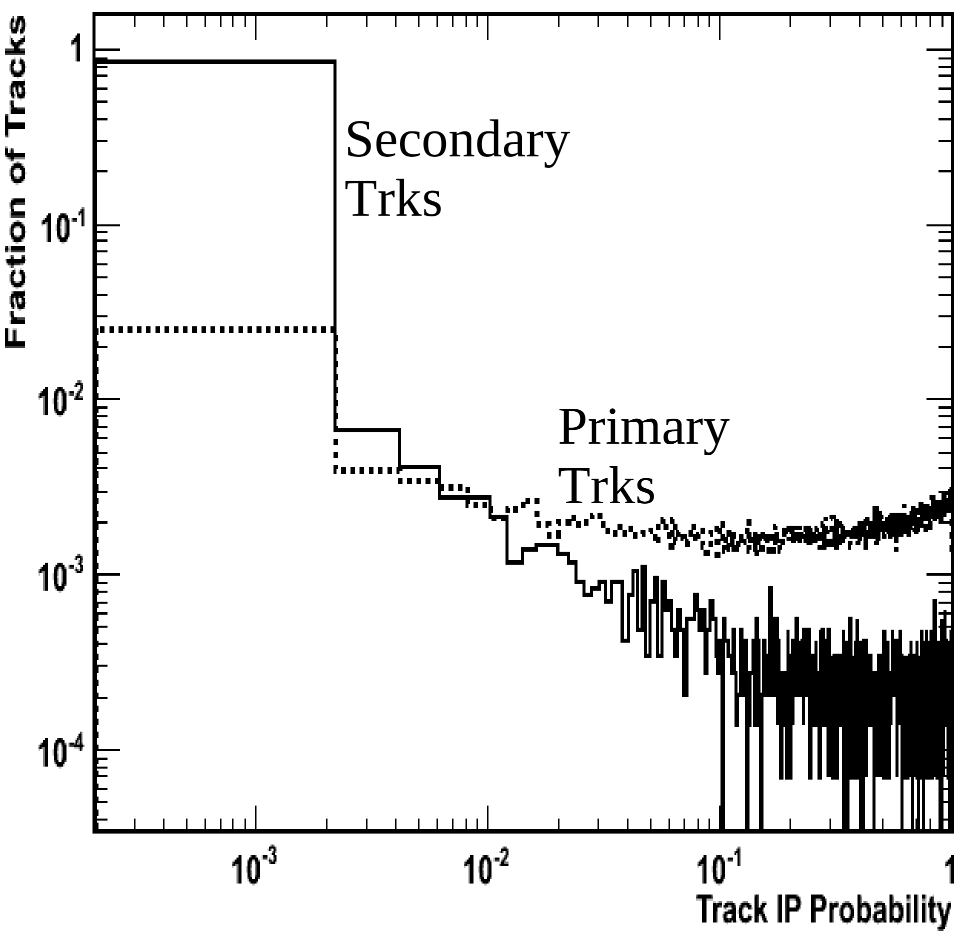
Jets with no secondary vertex represent most problematic class: account for 20-30% of b-jets and ~90% of light jets : need to be recovered in part to ensure efficient b-tagging;

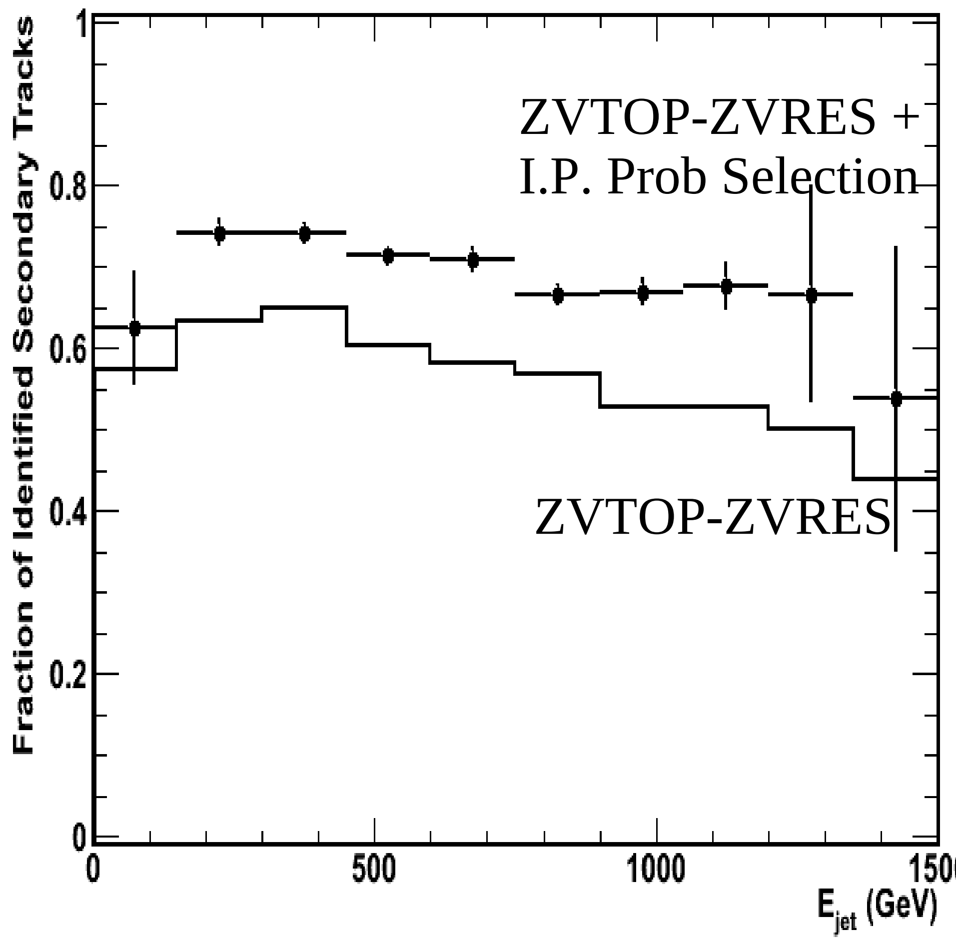




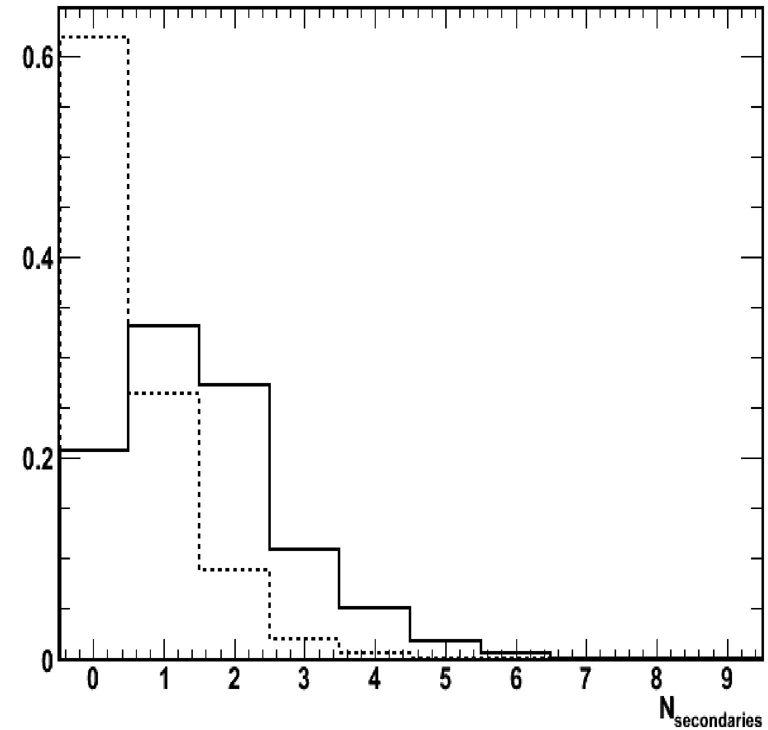
Category for no sec vtx jets	Fraction
< 2 Charged Decay products	0.19
R decay > 30 mm	0.35

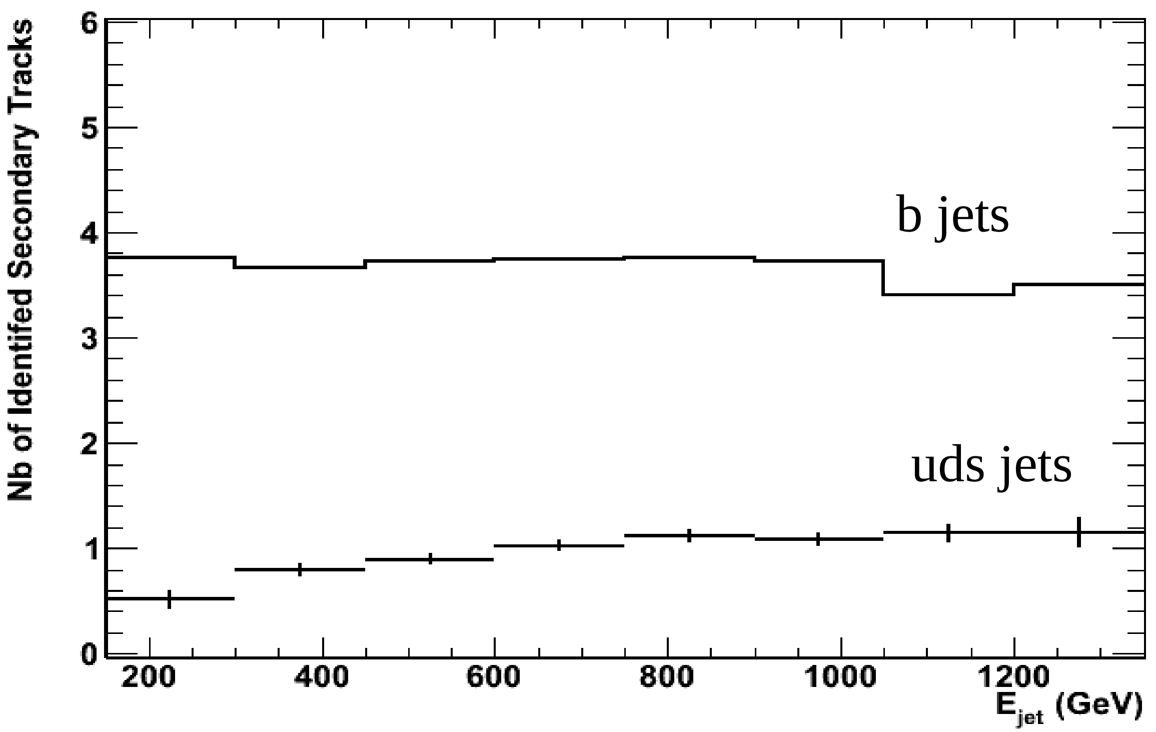
Recover jets w/o reconstructed secondary vtx by identifying candidate secondary particles based on their (R-Φ,z) impact parameter probability:

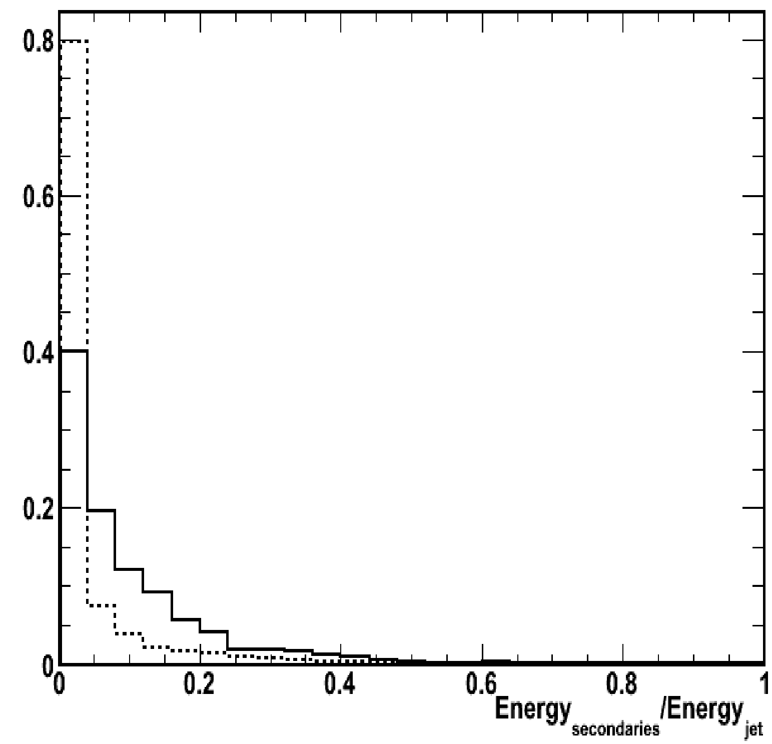




Use candidate secondary particles tagged based on impact parameter probability rather than vertex topology to build variables equivalent to those from ZVTOP (nb of sec., sec. mass, sec. energy / jet energy)

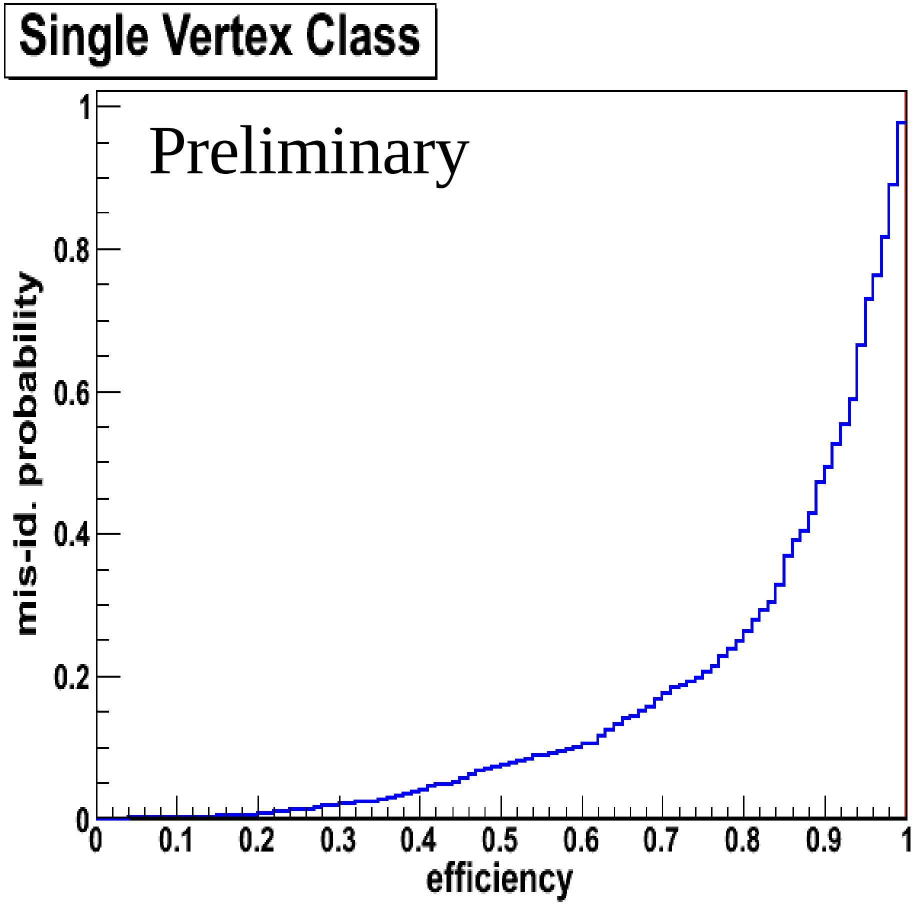


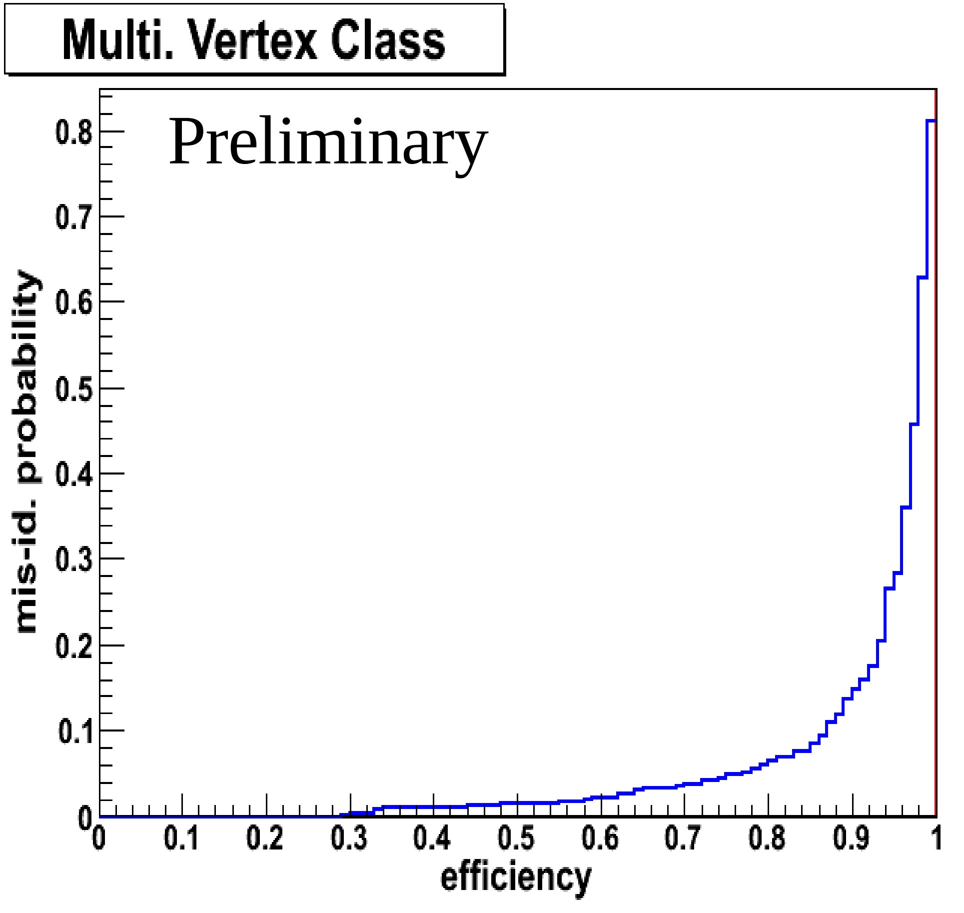




Combining b Tagging variables

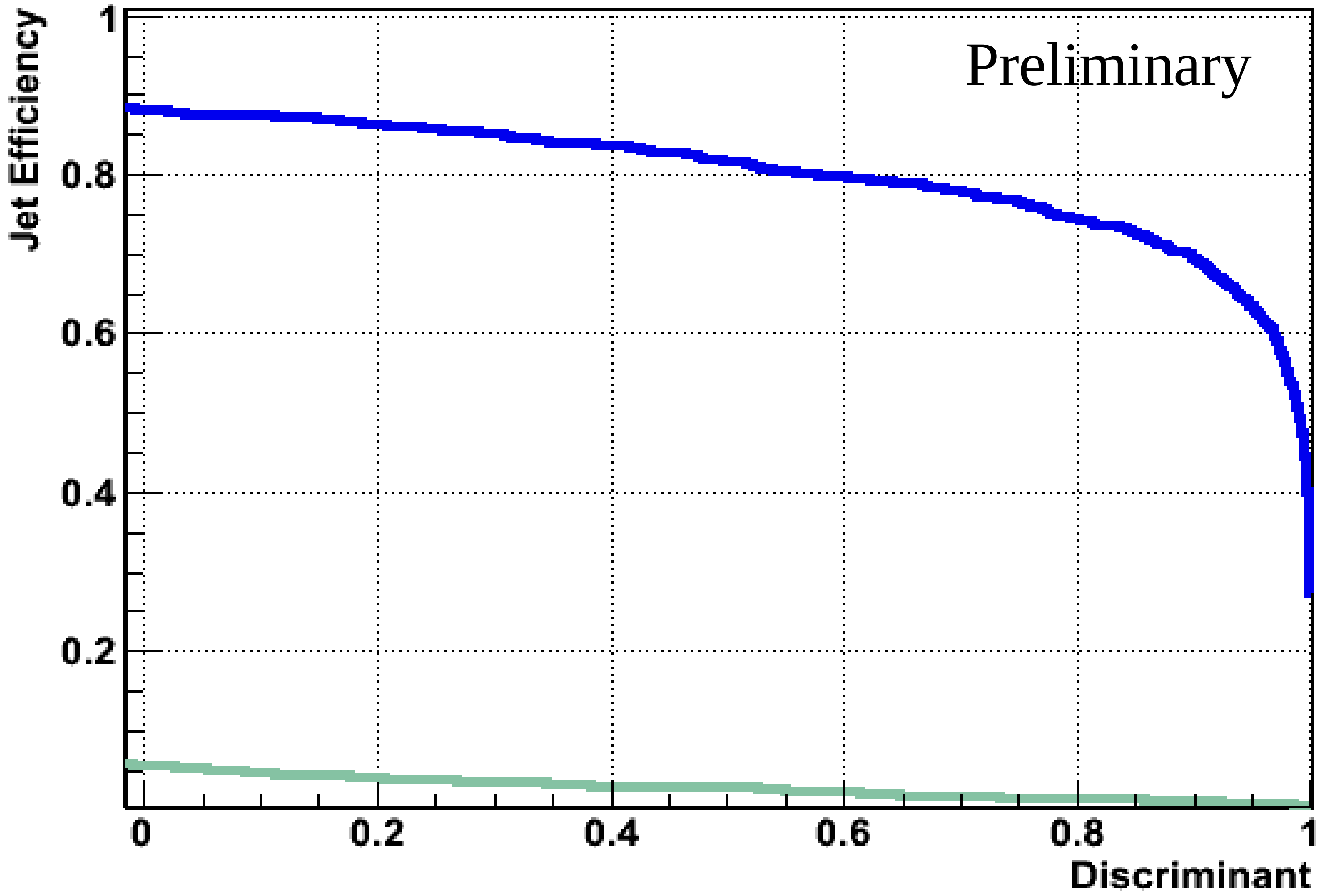
Feed tagging variables for single-vertex and multi-vertex jets separately to TMVA, train the classes of events independently with the boosted decision tree method on HA → bbbb and HA → qqqq fully simulated and reconstructed events;





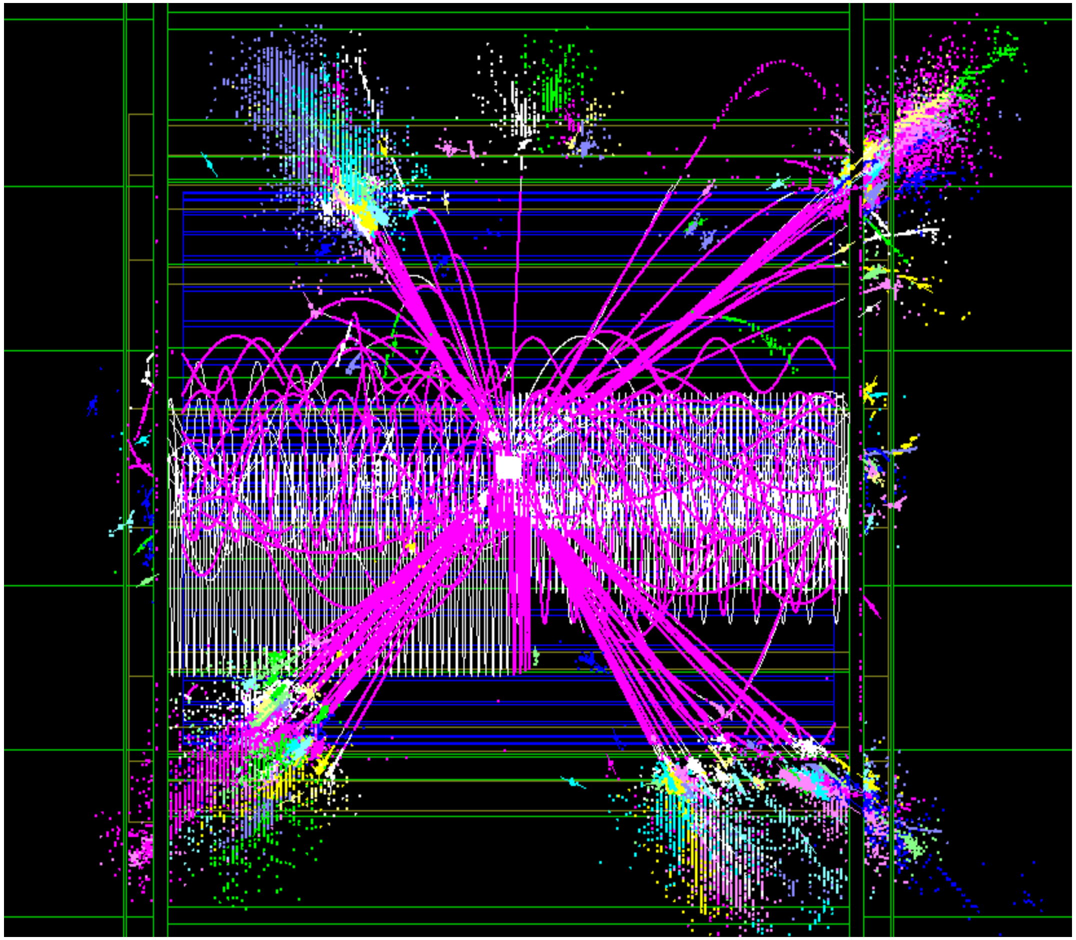
Combining b Tagging variables

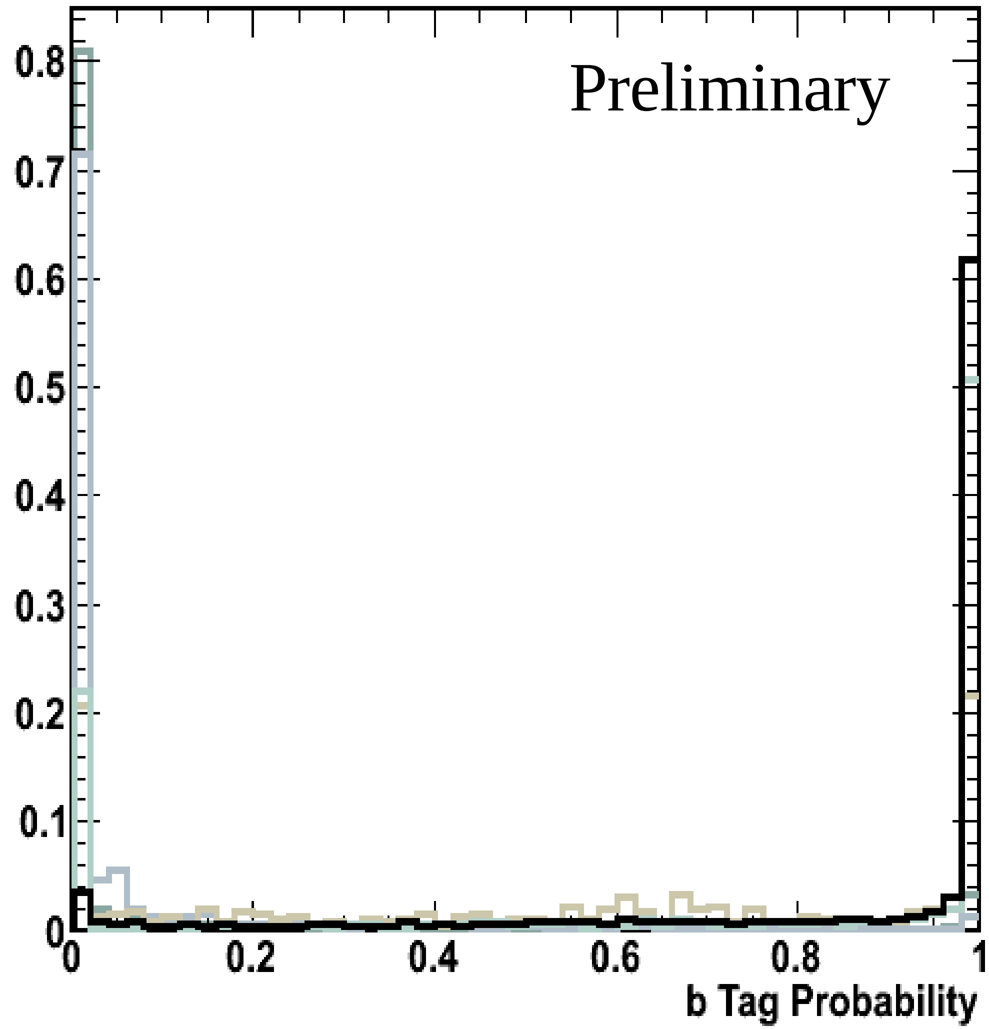
Jet Probability for uds and b jets from HA decays (200 GeV < E < 1400 GeV) obtained from TMVA BDT using single and multi-vertex classes;



Example: b Tagging in $e^+e^- \rightarrow H^0A^0 \rightarrow bbbb$

Test b-tagging on a benchmark physics process: b tag probability computed for each jet of events passing pre-selection; use boosted decision tree strategy in TMVA package and combine into di-jets and event probabilities:





Conclusions

Multi-TeV physics puts special emphasis on b-tagging, in particular for high efficiency, and b decay properties need to be properly taken int account.

TeV b-jets requires some special care due to long decay length of B hadrons (30% flying past first VXD layer), optimise for high efficiency by performing secondary particle search in jets with no reco secondary vertices;

Use of i.p. probability to classify secondary tracks in absence of reco sec vtx allows recover fraction of jets with no reconstructed secondary vertex and ensure flatter response vs jet energy;

First (and preliminary) results on b-tagging at jet, di-jet and event level are being tested on benchmark processes (HA $\rightarrow$ bbbb, $\chi^0_2 \rightarrow \chi^0_1$ h $\rightarrow$ bb, …) to validate method and optimise response.

Several improvements still necessary/possible (use of leptons with significant i.p., apply tighter discriminant cuts to single vertex jets, understand sec. vtx reconstruction failures at high momenta, optimise for fwd b-jets, ...)