$H \to c\bar{c}$ AT MUON COLLIDER

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Samples

Goal: c-tagging, b-to-c discrimination

	Cross Section · BR (pb)
$\mu^+\mu^- \to H\nu\bar{\nu} \to c\bar{c}\nu\bar{\nu}$ (WW fusion)	$8.914 \cdot 10^{-3}$
$\mu^+\mu^- \to H\nu\bar{\nu} \to b\bar{b}\nu\bar{\nu}$ (WW fusion)	$1.801 \cdot 10^{-1}$

1000 events generated with Pythia at 1.5 TeV

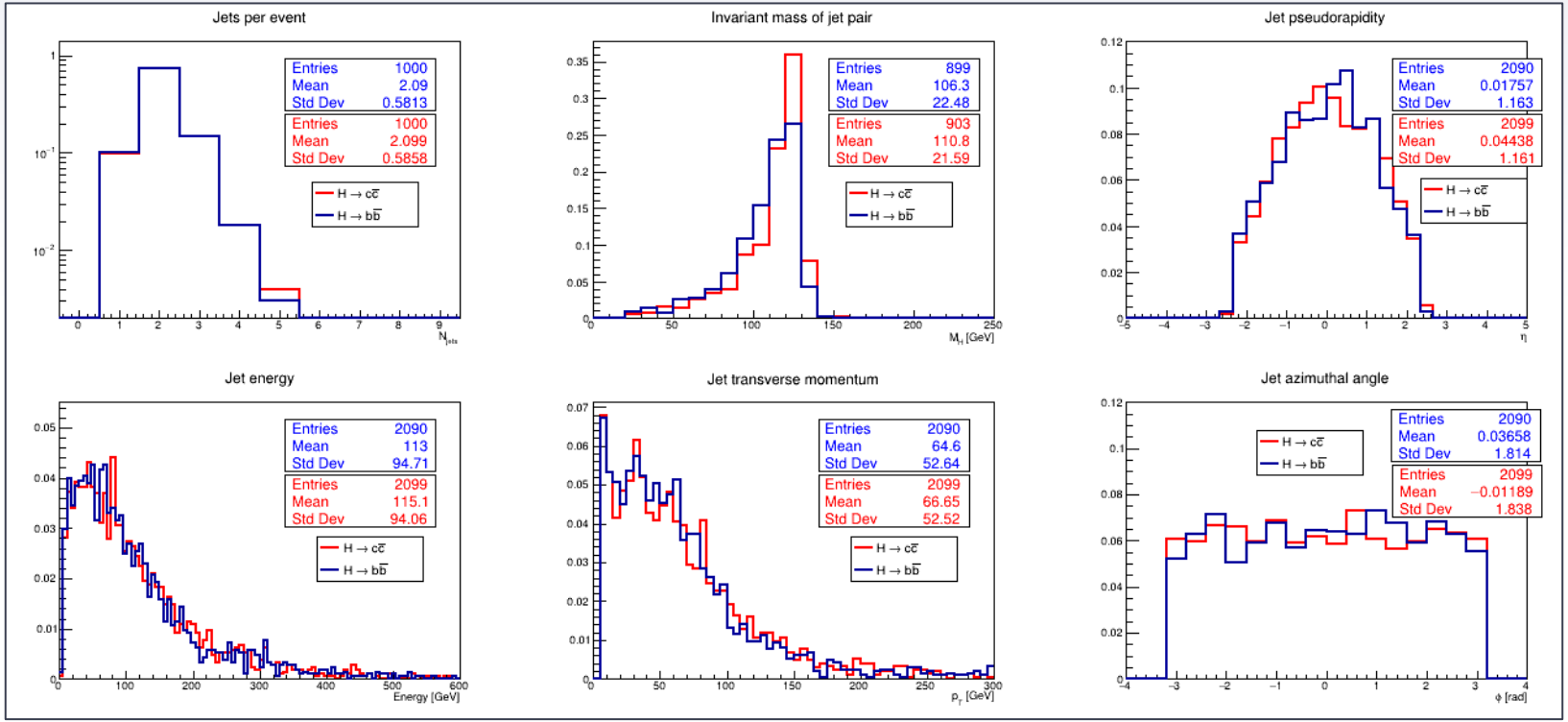
Simulated and reconstructed with the latest detector geometry and software release (v02-05-MC)

1

Jet reconstruction

FastJet Processor: k_T algorithm with R=1.0

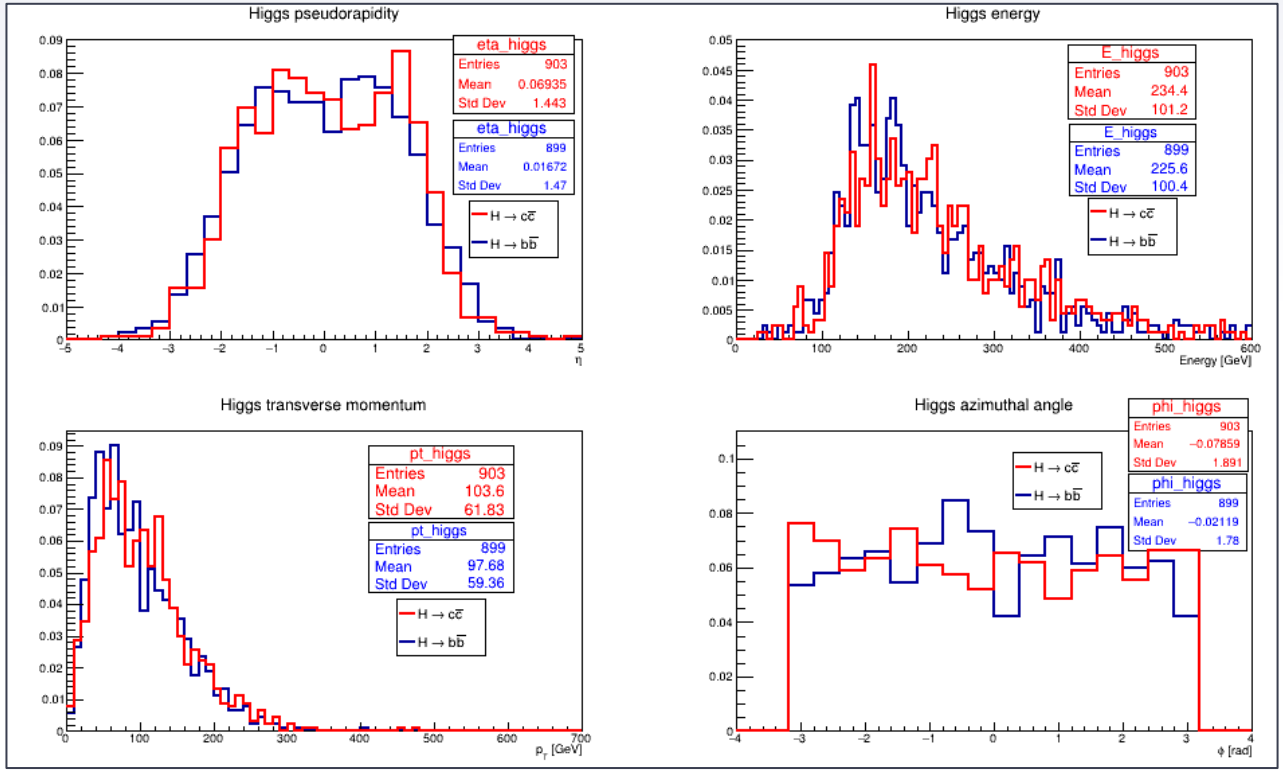
c-jet and b-jet kinematic variables are identical
Need for a tagging algorithm to identify c-jets



*Plots are not scaled to cross section · luminosity

*No selection is applied

Only events with at least a jet pair are considered
If more then two jets are found, the two with the invariant mass closer to the Higgs mass are chosen



*Plots are not scaled to cross section · luminosity

C-tagging algorithm

- Identify c-jets discriminating them against b-jets and light-flavour jets
- Several variables connected to the properties of heavy-flavour hadrons present in jets need to be combined into a single discriminator using MVA techniques

Track variables

3D/2D Impact Parameter (IP), 3D/2D IP significance, $\mathrm{pT_{rel}}$, η_{rel}, etc.

+

Secondary vertex variables

Number of SV per jet, 3D/2D flight distance (significance), corrected mass, etc.

+

Soft lepton variables

Muon and electron 3D/2D IP (significance), $\mathrm{pT_{rel}}$, η_{rel}, etc.

2

Vertex reconstruction

LCFIPlus Processor: PrimaryVertexFinder+BuildUpVertex algorithms

Track selection for vertexing

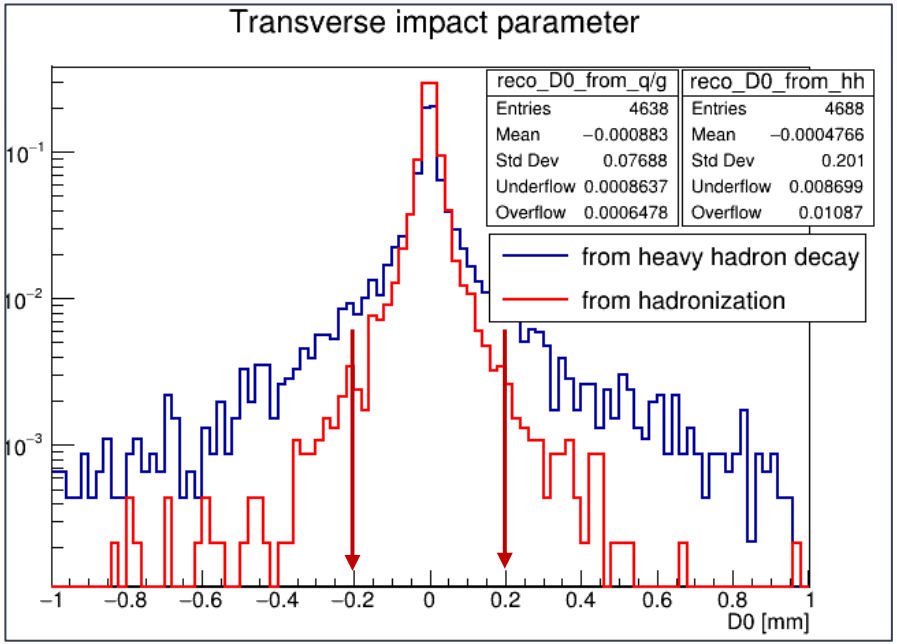
		PRE-SET	SET BY ME
PV	TrackMaxD0	20	0.2
	TrackMaxZ0	20	0.5
	TrackMinD0Err	0	0.02
	TrackMaxInnermostHitRadius	61	31
	TrackMinVtxFtdHits	1	2
SV	TrackMaxD0	10	5
	TrackMaxZ0	20	5
	TrackMinPt	0.1	0.8
	TrackMinVxdFtdHits	1	4

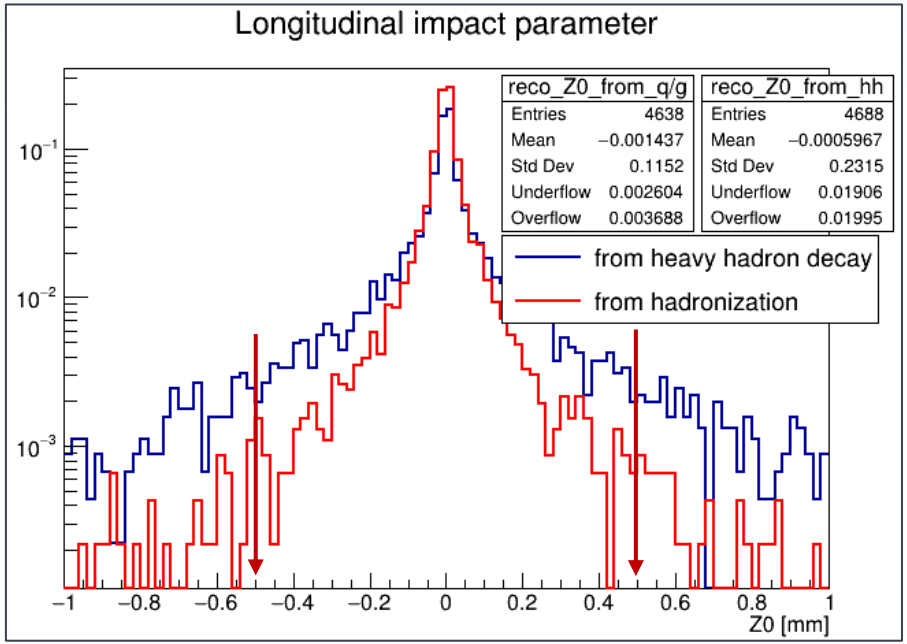
In order to choose these parameters two set of tracks (in bb sample) are selected according to their parent at gen-level:

- Tracks from hadronization have a quark /gluon parent at gen-level (should be used to fit PV)
- Tracks from heavy-hadron decay have B/C – hadron parent at gen level (should be used to fit SV)

Transverse and longitudinal IP

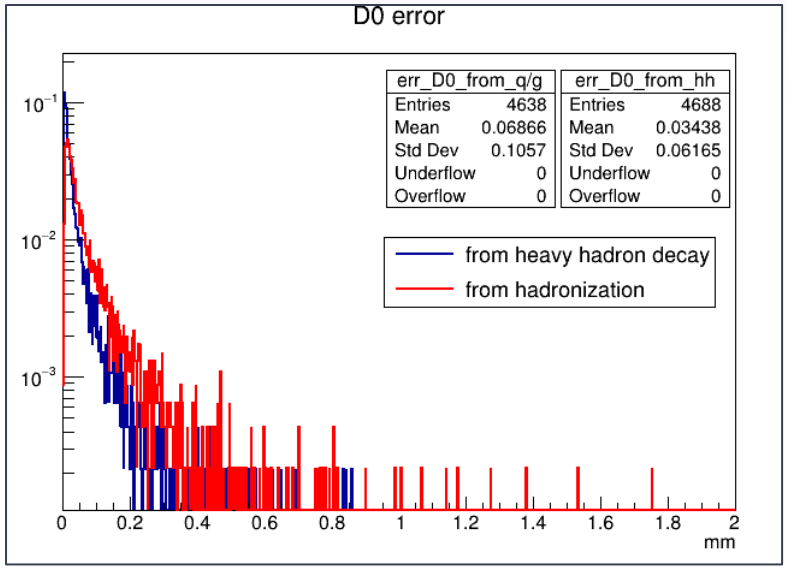
D0 and Z0 cuts for PV are shown
Cuts for SV are at 5 mm

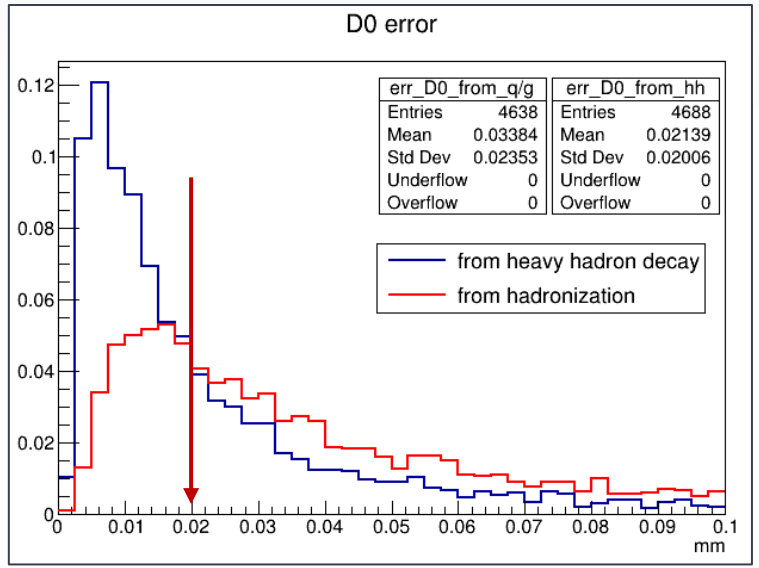




Min D_0 error for PV

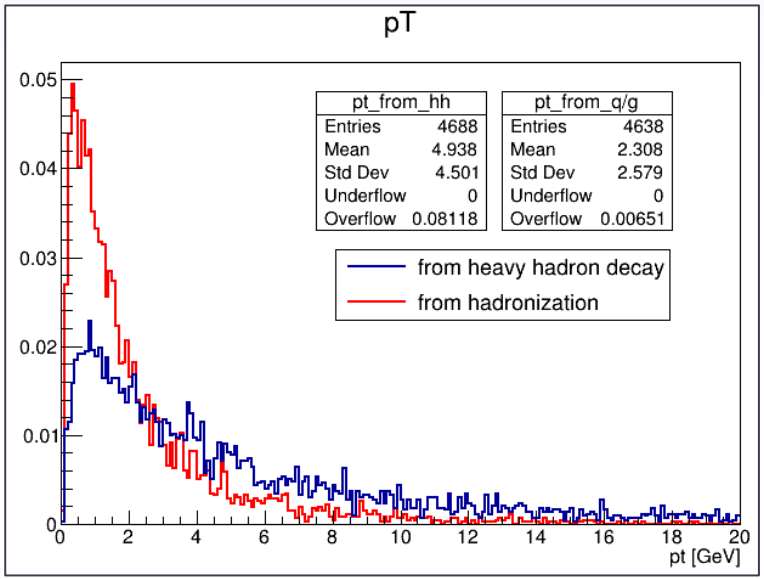
Introduced in the processor to increase SV efficiency

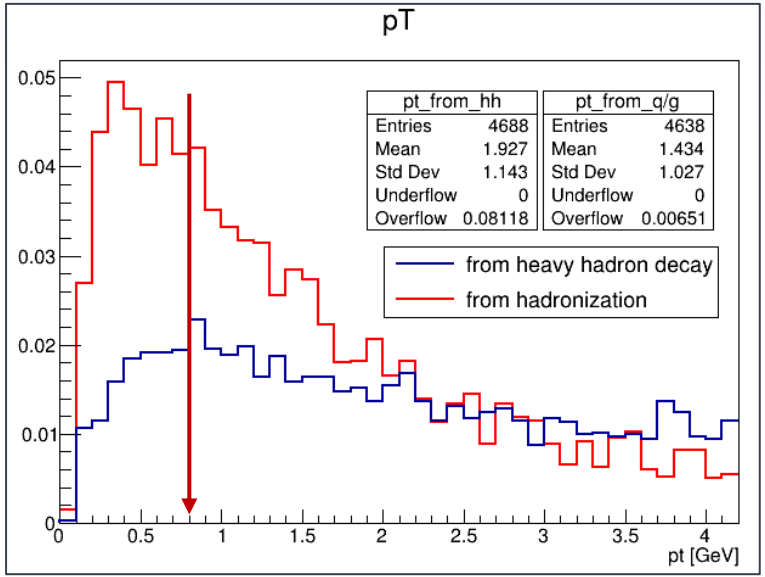




p_T cut for SV

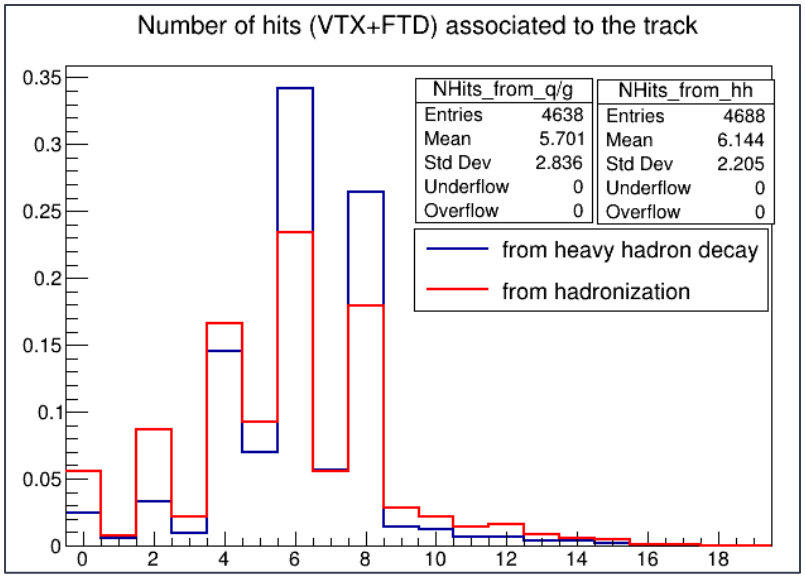
Increased from 0.1 to 0.8 GeV to reduce SV fake rate

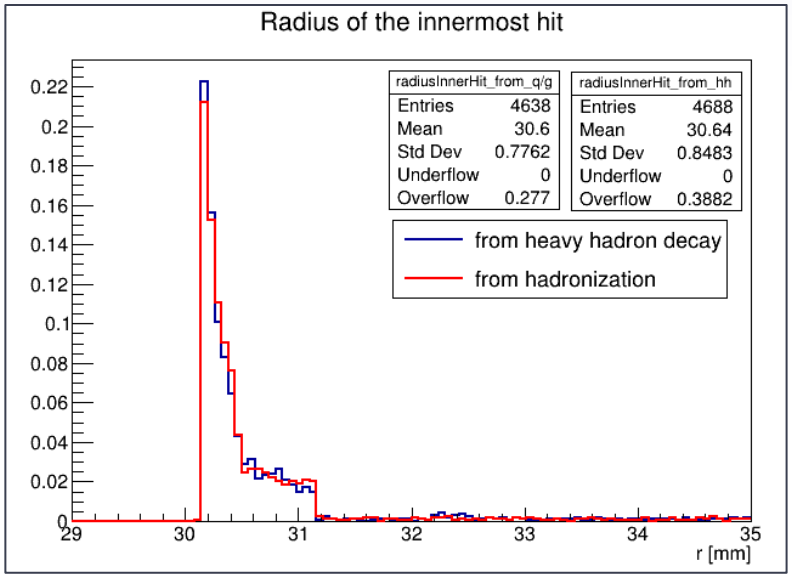




Track Hits

Minimum number of track hits for PV is set to 2
Minimum number of track hits for SV is set to 4
Maximum radius of the innermost track hit for PV is set to 31



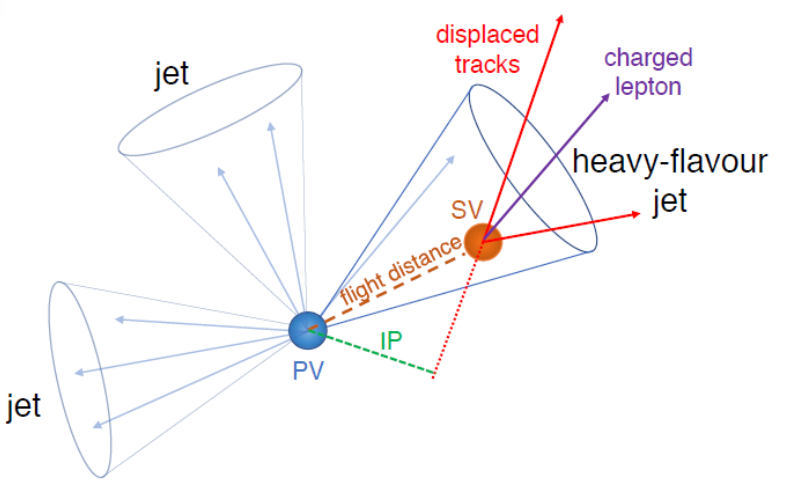


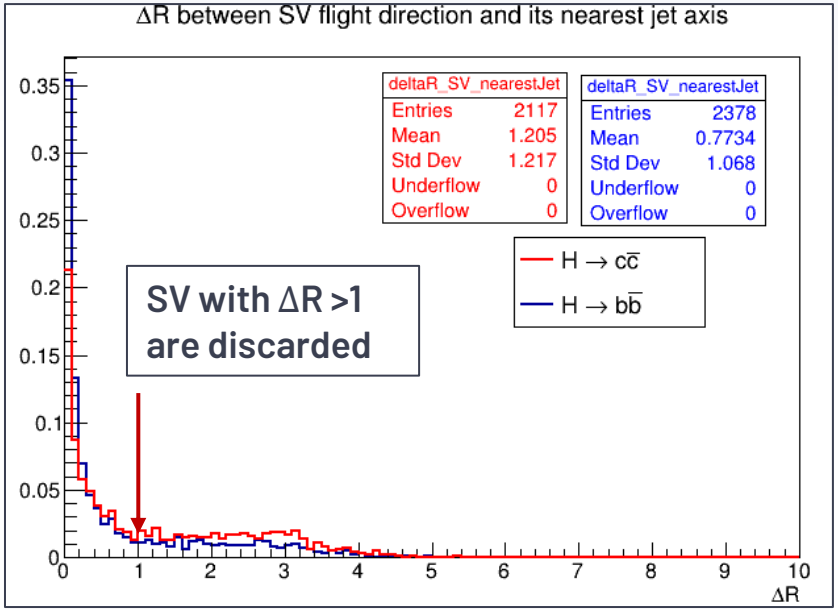
3

Secondary Vertex variables

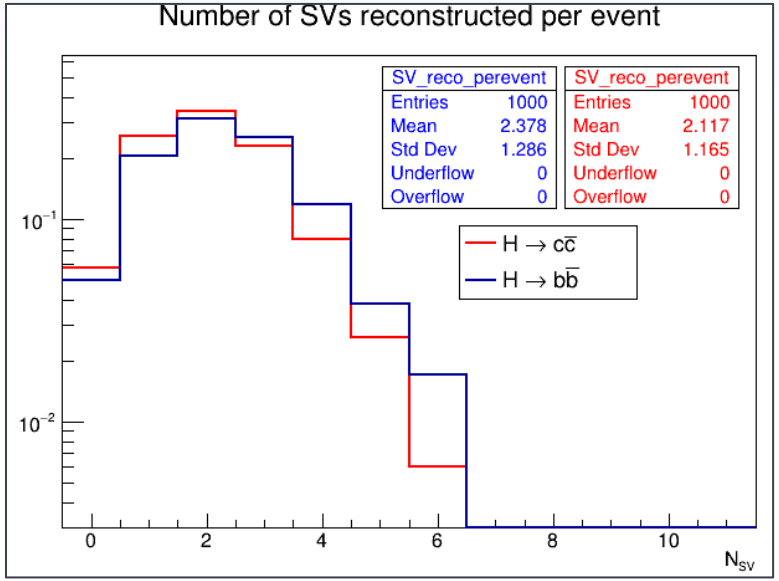
SV-to-jet association

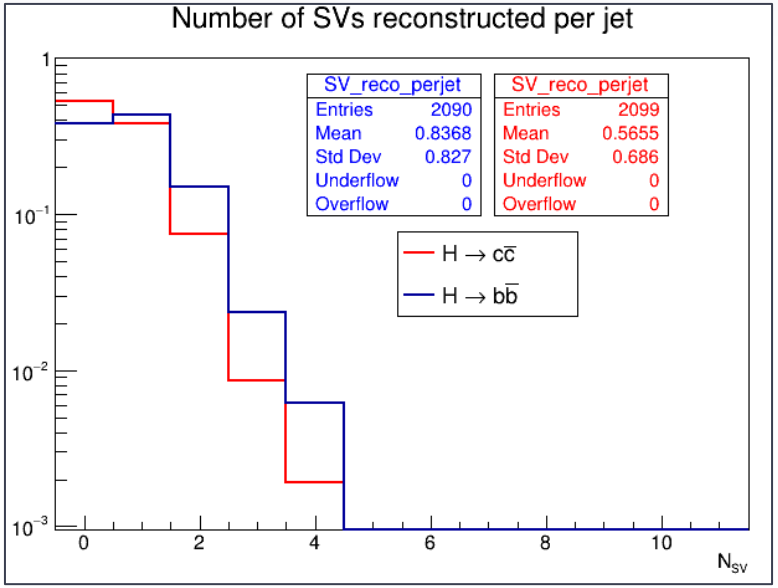
ΔR between the SV flight direction and the jet axis is required to be < 1.0





Comparison between $b\bar{b}$ and $c\bar{c}$ samples

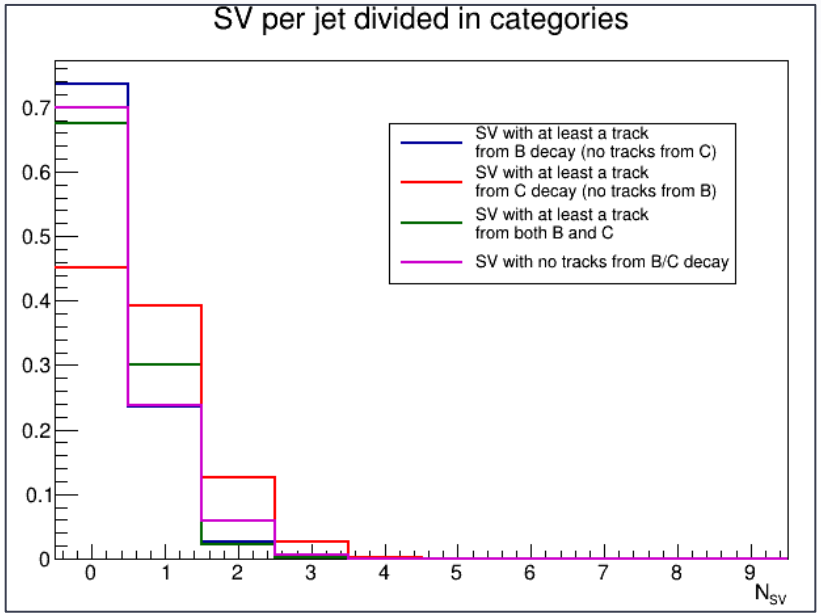




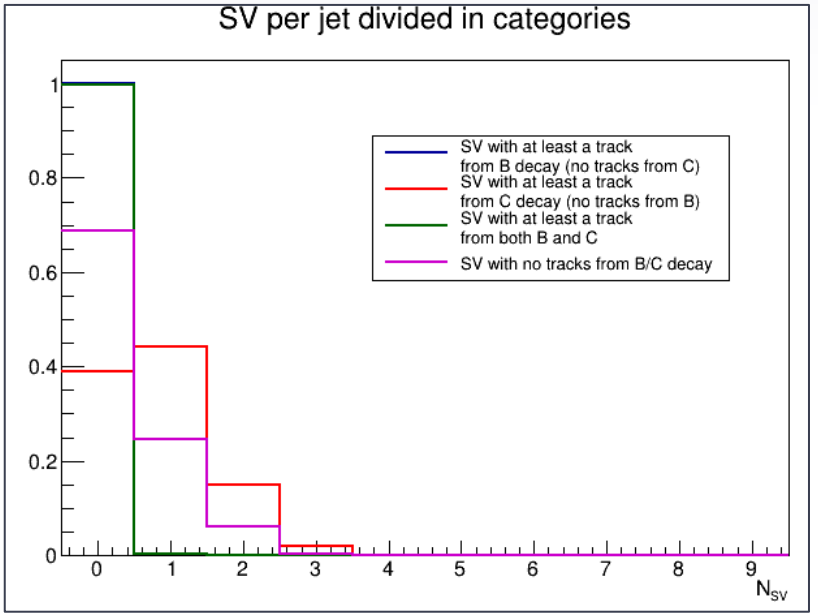
Variables per vertex category

ONGOING STUDIES

bb sample



cc sample



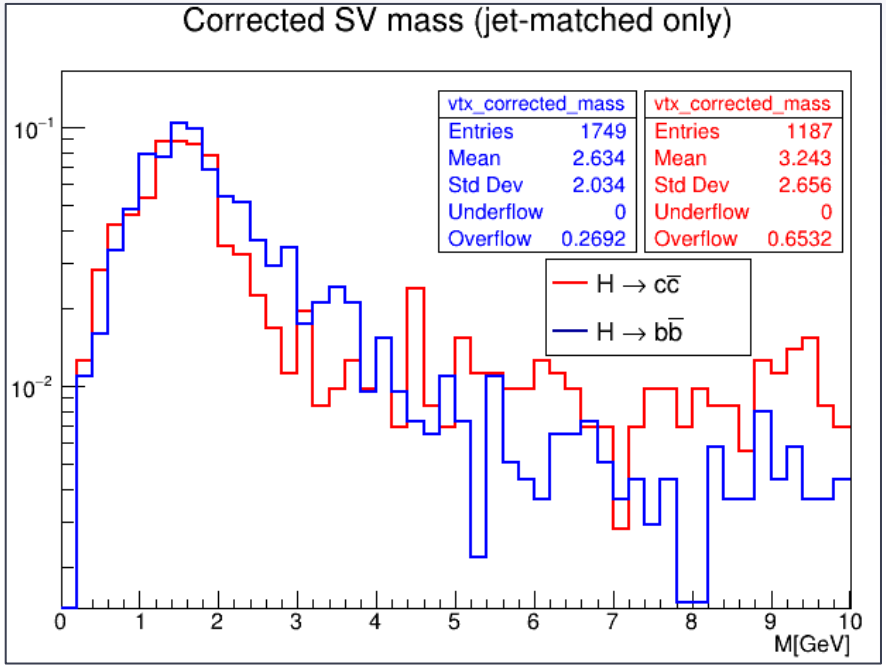
Corrected mass

Directly related to the mass of the heavy-flavour hadron

Defined as:

$$\sqrt{M_{SV} + p^2 sen^2\theta} + psen\theta$$

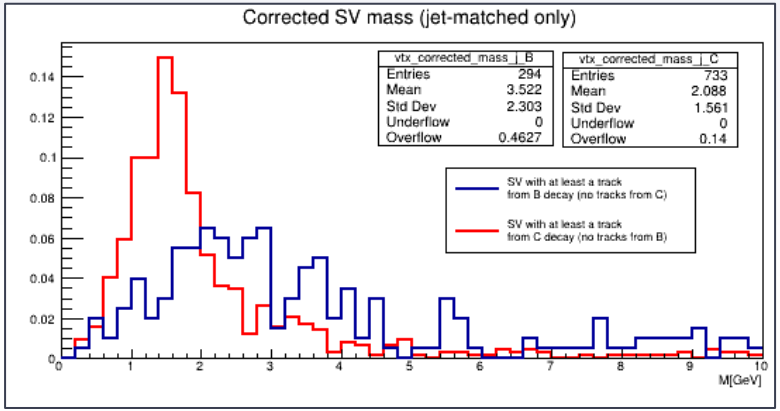
SV mass is corrected for the observed difference between the SV flight direction and SV momentum

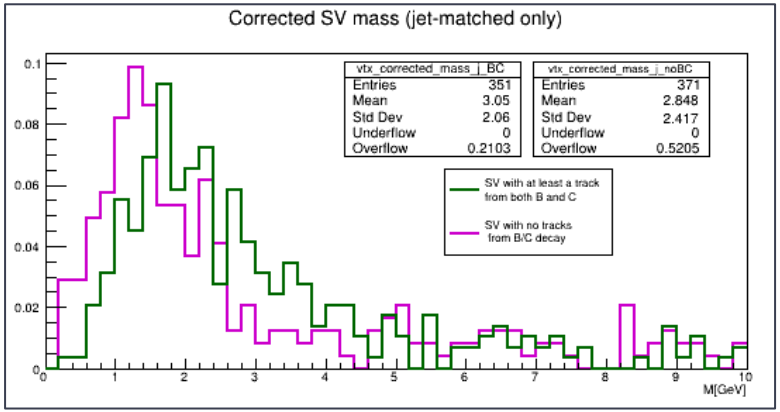


Variables per vertex category

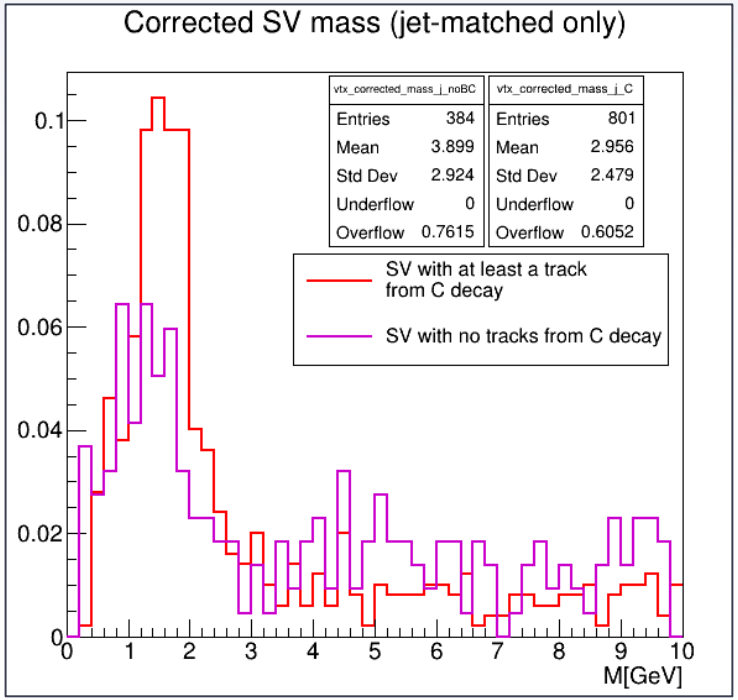
bb sample

ONGOING STUDIES

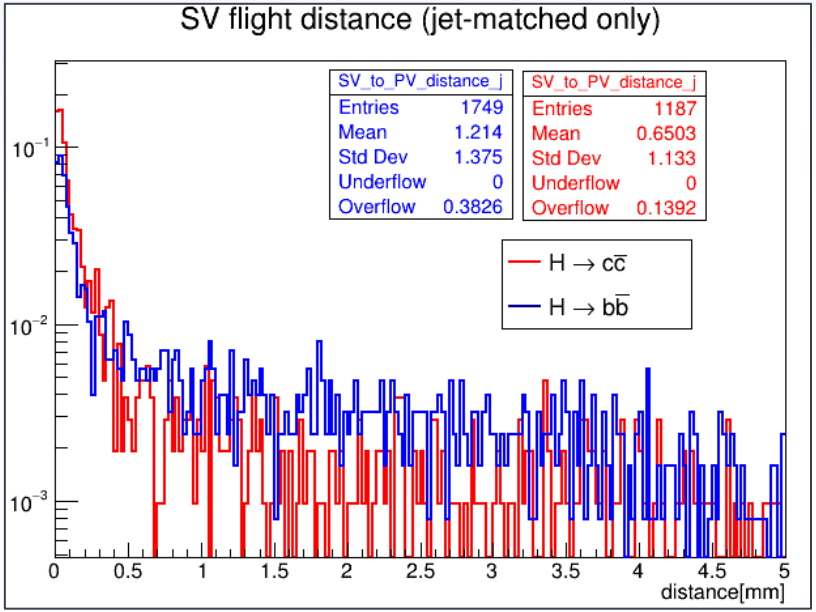


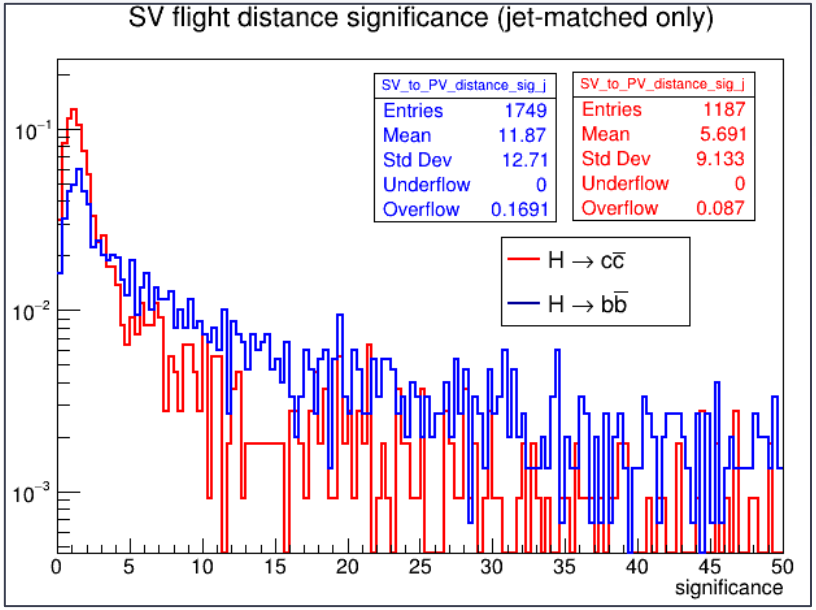


cc sample



Flight distance





Next steps

- Optimize vertexing parameters
- Run simulation + reconstruction with 10000 events
- Extract from the sample the variables needed for tagging
- Performe MVA to discriminate between b and c jets
- Prove the discrimination power of the tagging algorithm also against uds jets

Many thanks to Laura, Massimo and Lorenzo for their precious help!

THANKS!

Any questions?

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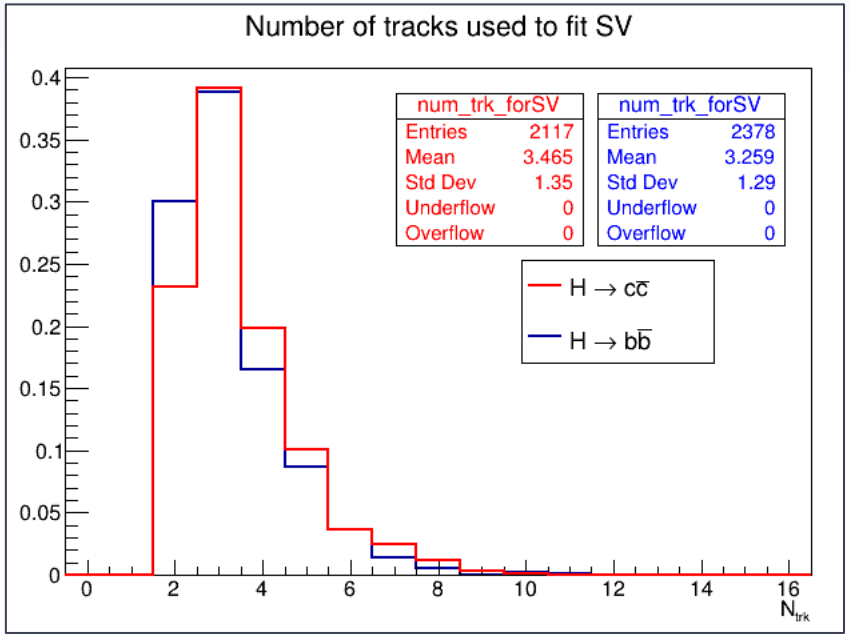
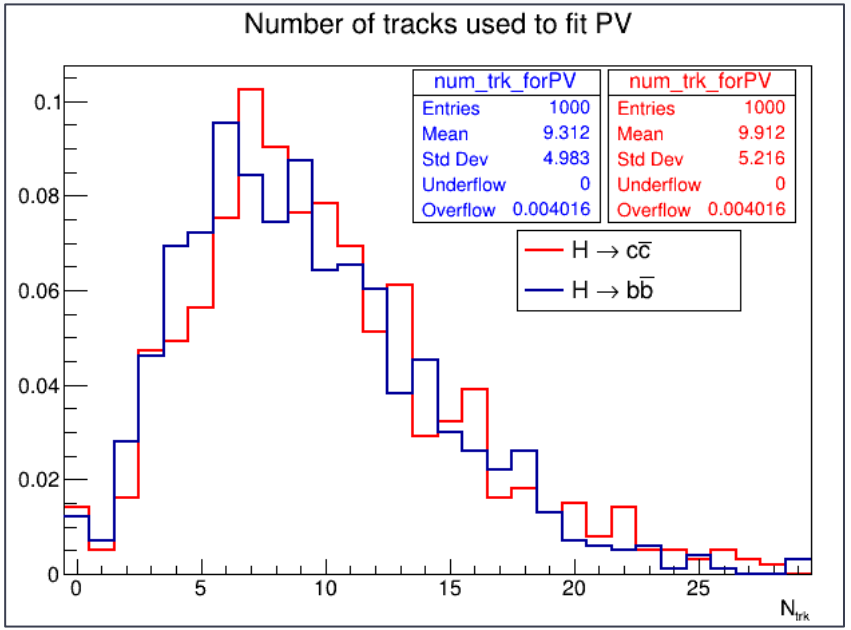
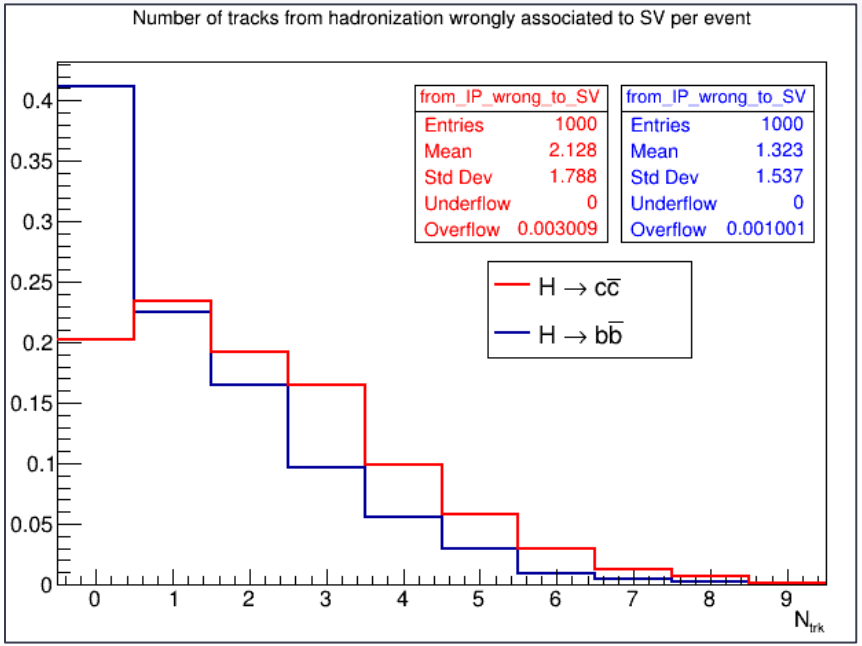
BACKUP

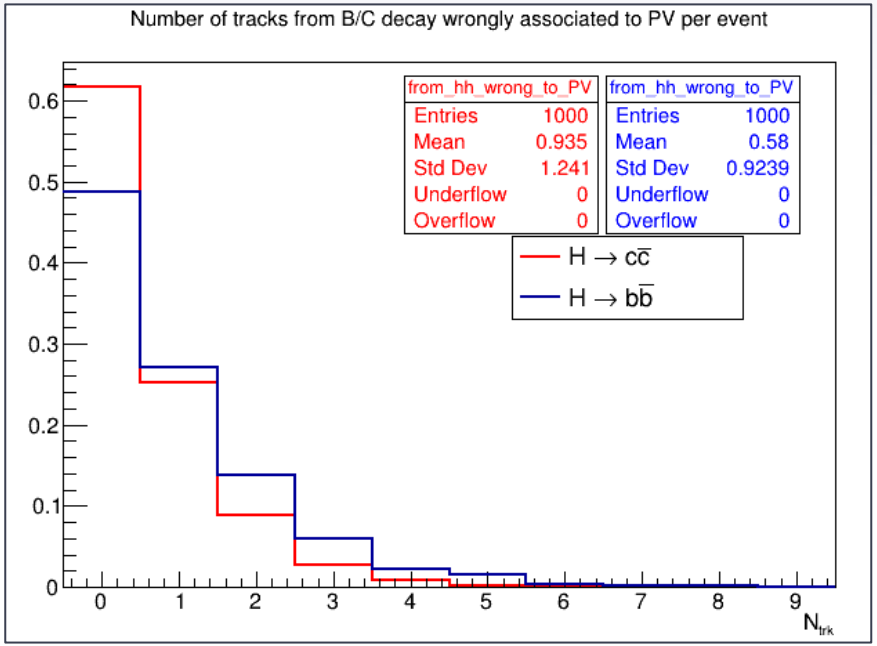
Number of tracks to fit PV and SV





Wrong association

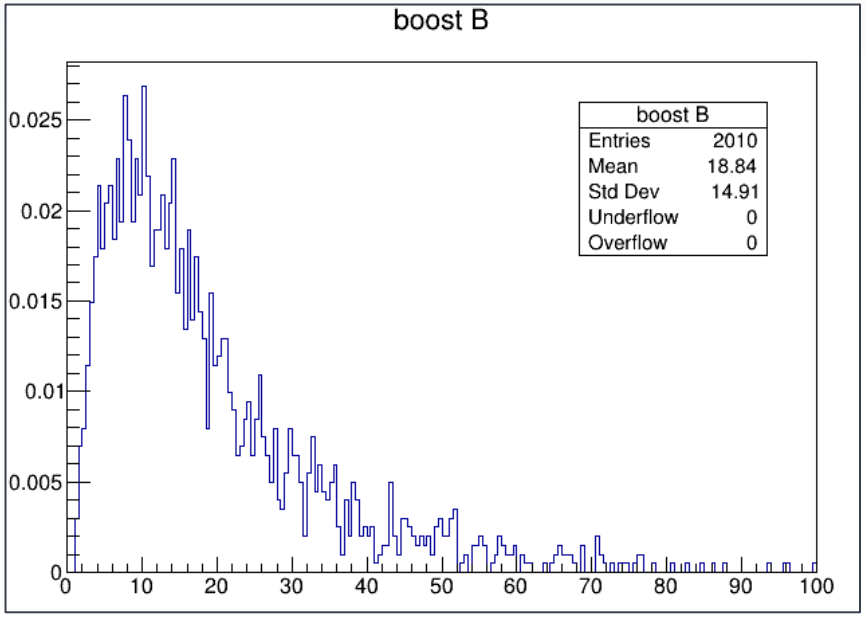


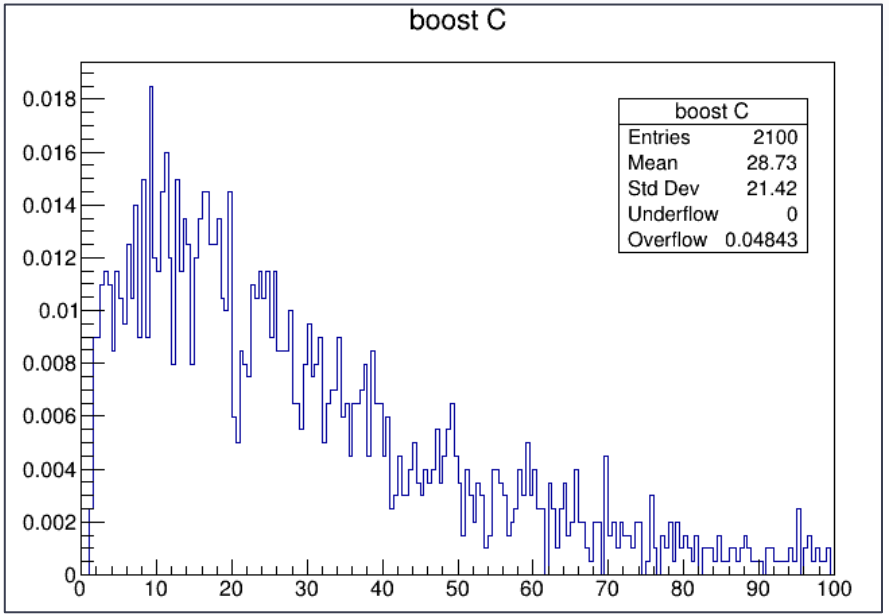


Efficiency and fake-rate

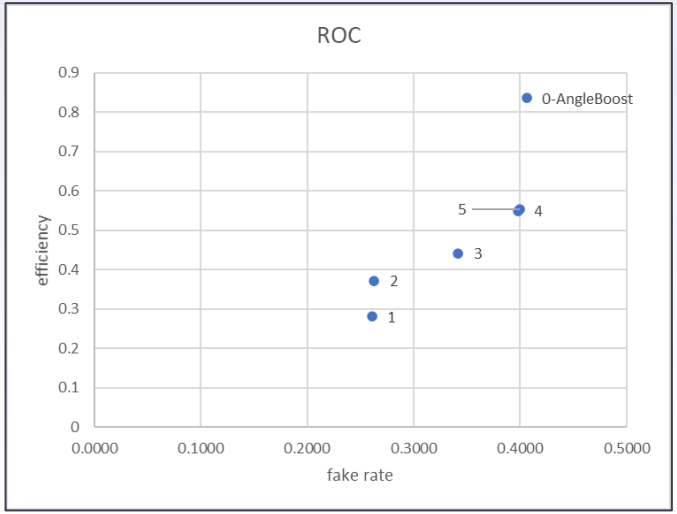
	bb	cc
FAKE RATE SV (wrong/tot)	0.405952746	0.61414141
EFFICIENCY (SV per jet)	0.8368	0.5655
SIGNAL EFFICENCY (% of jets with a SV)	0.615789	0.467365
BKG EFFICIENCY	0.405952746	0.61414141
SIG EFF/$\sqrt{}$BKG EFF	0.966482923	0.59637852

Lorentz factor for B/C hadrons





Attempts with different parameters



	1	2	3	4	5	Zero-Angle Boost
FAKE RATE SV (wrong/tot)	0.2607	0.2631	0.3419	0.3984	0.3998	0.4060
EFFICIENCY (SV per jet)	0.2808	0.3725	0.4422	0.5497	0.5540	0.8368
SIGNAL EFFICIENCY (% of recovertex)	0.2646	0.3281	0.3940	0.4532	0.4551	0.6158
BKG EFFICIENCY (=fake rate SV)	0.2607	0.2631	0.3419	0.3984	0.3998	0.4060
SIG_EFF/SQRT(BKG_EFF)	0.518125648	0.639673509	0.673748101	0.718009576	0.71973706	0.96648292

Parameters

Pink highlights the parameters changed from one attempt to the next one

		1	2	3	4	5	Zero_Angle Boost
PV	TrackMaxD0	0.02	20	20	20	0.2	0.2
	TrackMaxZ0	0.05	20	20	20	0.5	0.5
	TrackMinD0Err	0	0.015	0.02	0.02	0.02	0.02
	TrackMinVtxFtdHits	3	3	2	2	2	2
SV	TrackMaxD0	5	5	5	5	5	5
	TrackMaxZ0	5	5	5	5	5	5
	TrackMinPt	0.8	0.8	0.8	0.8	0.8	0.8
	TrackMinVtxFtdHits	1	1	4	4	4	4
	MassThreshold	100	100	100	10	10	10