B-tagging efficiency studies

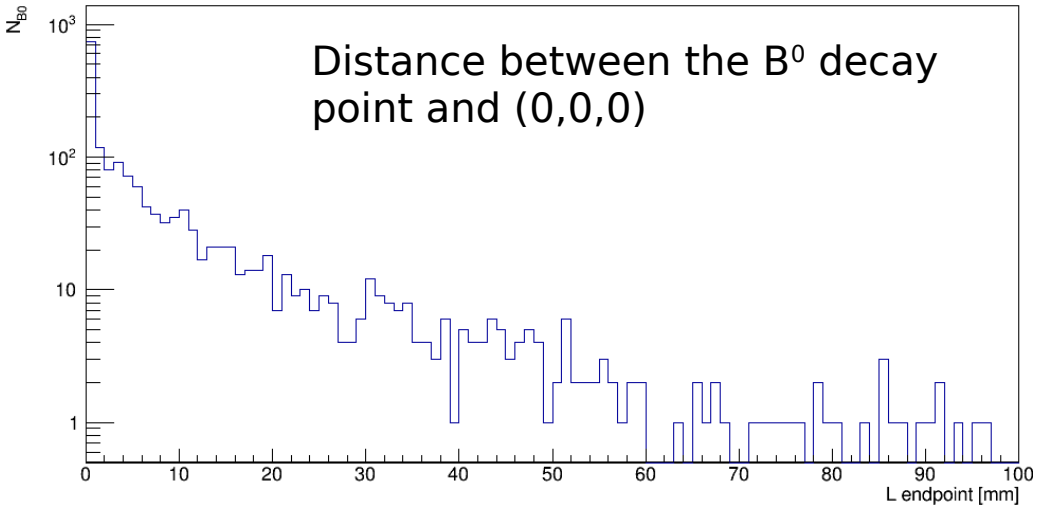
B tagging at Muon Collider
Laura Buonincontri 9/02/2021

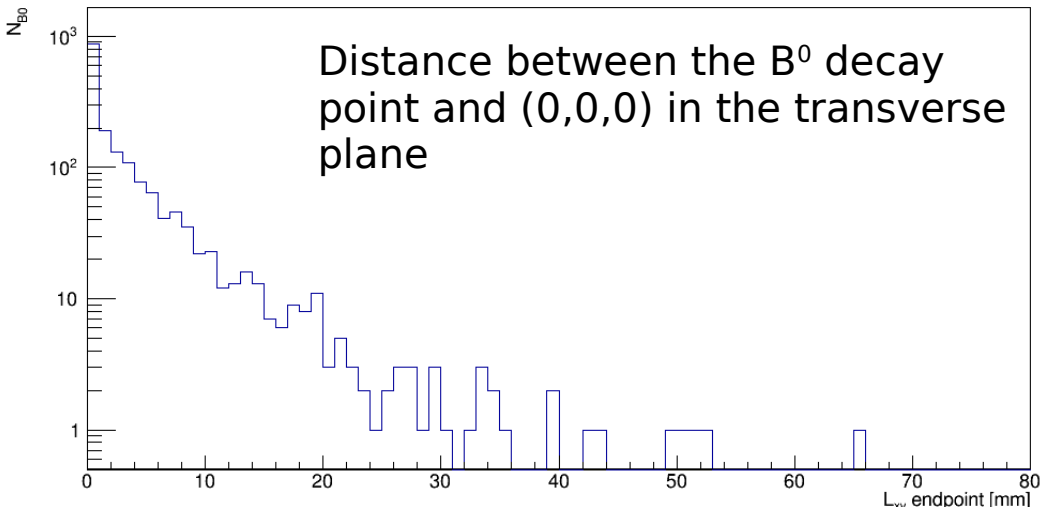
Double Higgs reconstruction

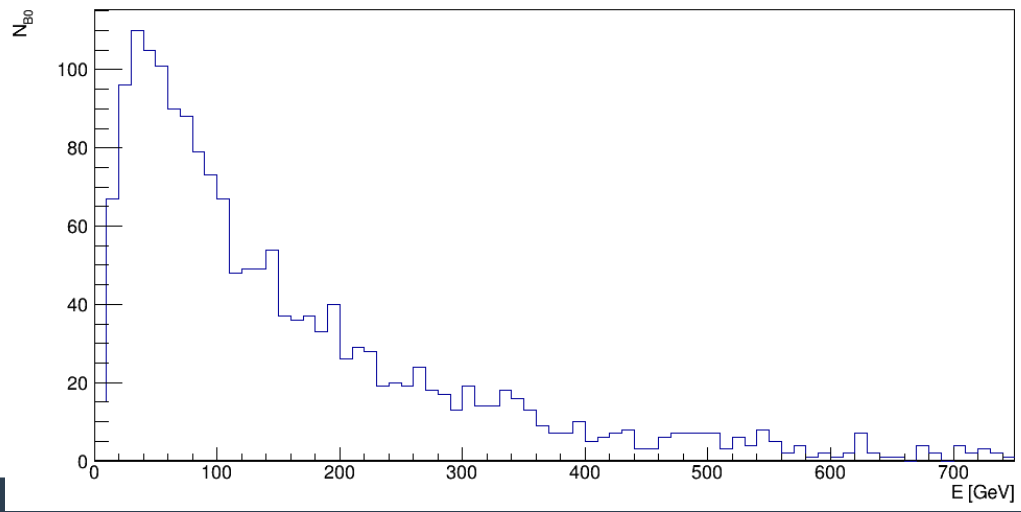
- First application of the LCFIPlusProcessor at the $\mu^+\mu^- \rightarrow HH\bar{\nu}\nu \rightarrow b\bar{b}b\bar{b}\nu\bar{\nu}$ process
- 1000 events generated with Whizard at 3 TeV center of mass energy
- No cuts (double layer filter,..) are applied, this studies are done with the original setup for the Conformal Tracking

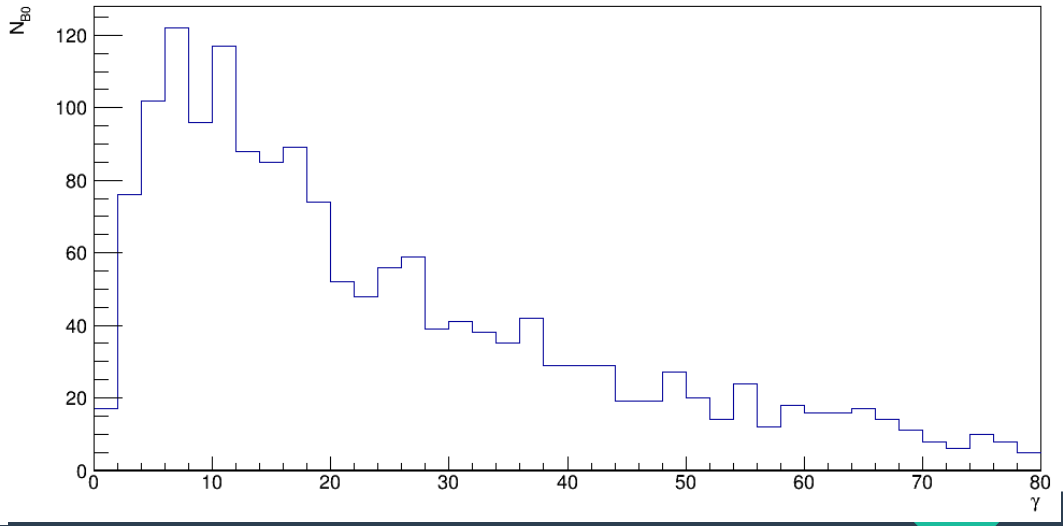
B mesons at Monte Carlo level

- B^0 mesons from Monte Carlo collection are considered

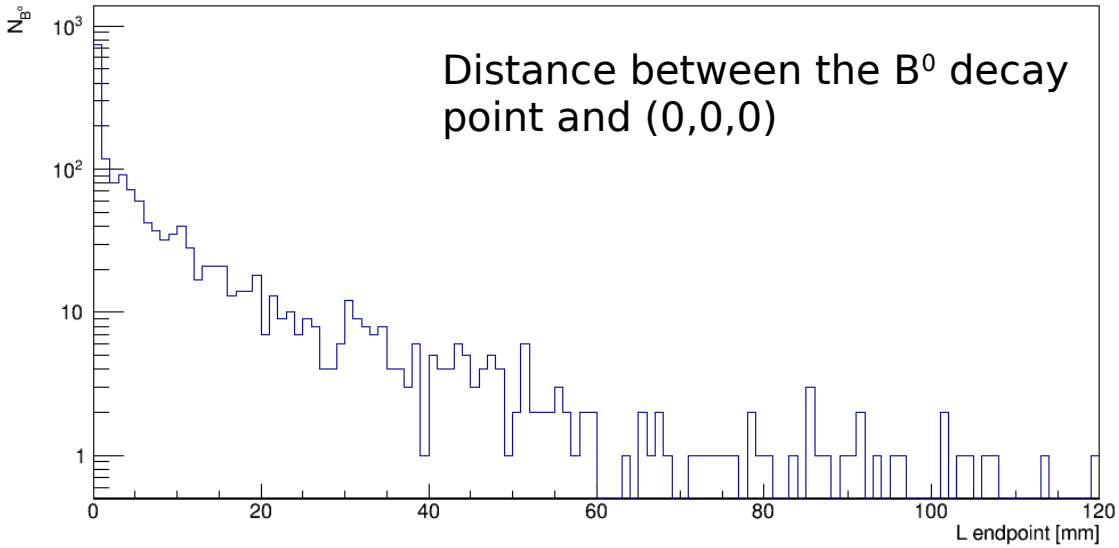


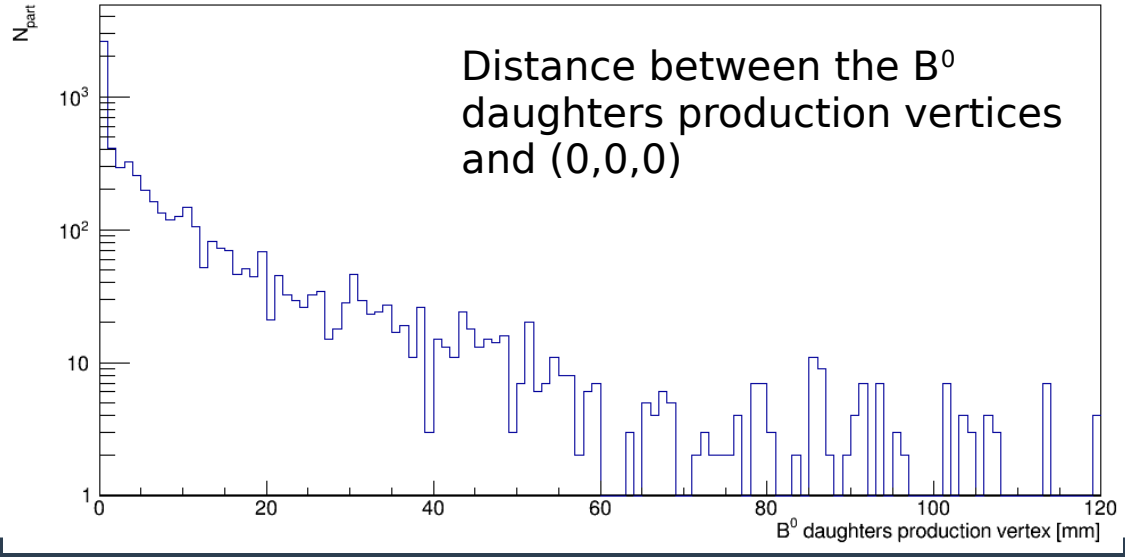




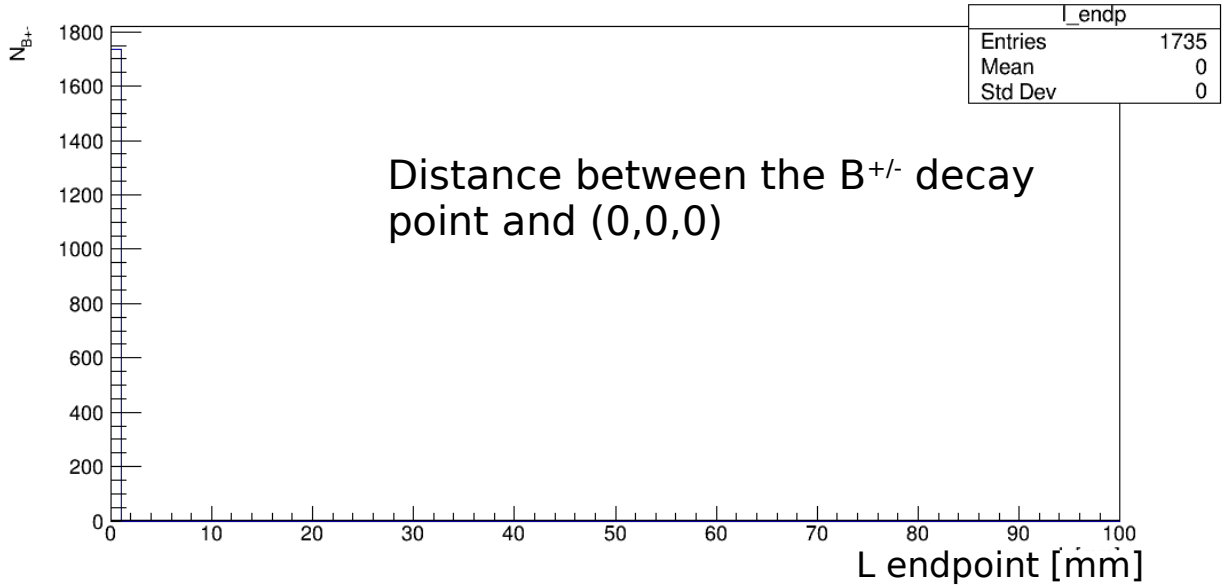


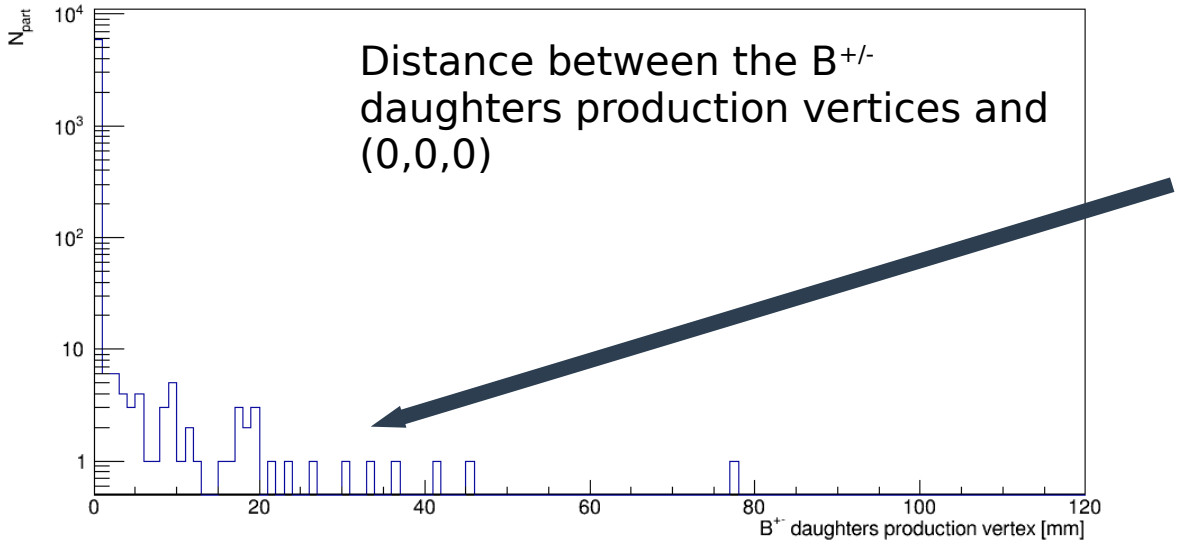
B^0 endpoint vs daughter vtx production





$B^{+/-}$ endpoint vs daughter vtx production

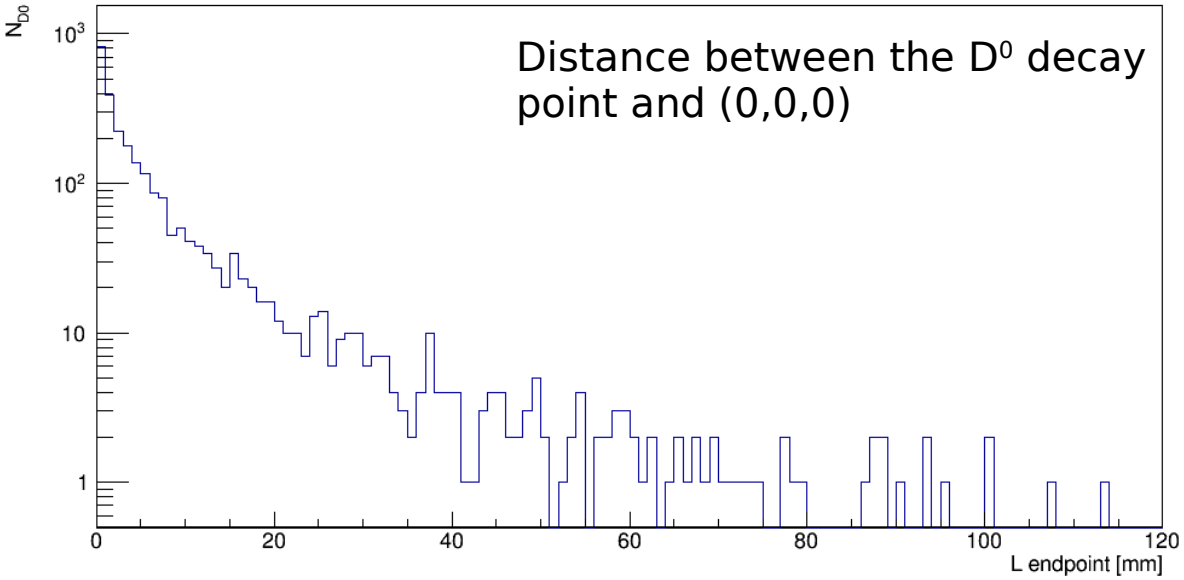


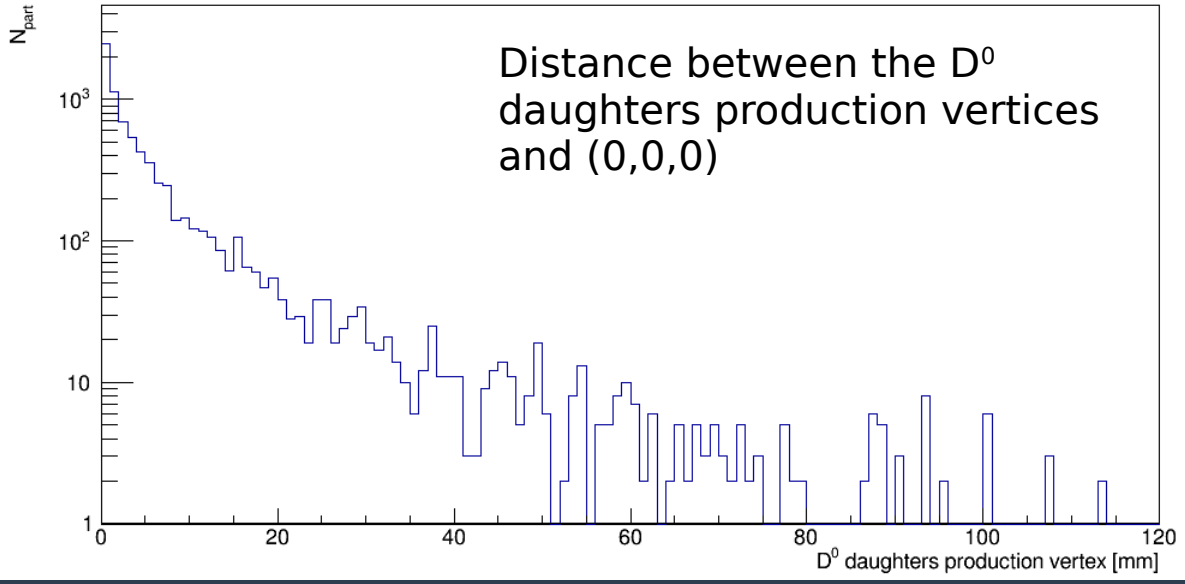


τ

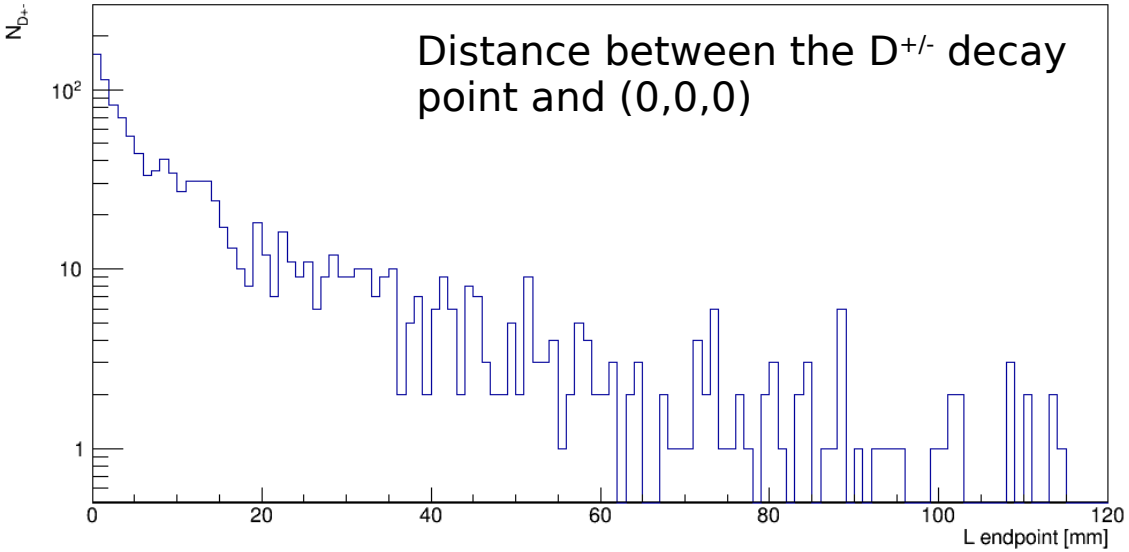
$c\bar{c}$ MESONS		
$\eta_c(1S)$	441	
$\chi_{c0}(1P)$	10441	Only 2
$\eta_c(2S)$	100441	
$J/\psi(1S)$	443	
$h_c(1P)$	10443	
$\chi_{c1}(1P)$	20443	
$\psi(2S)$	100443	
$\psi(3770)$	30443	Only 1
$\psi(4040)$	9000443	
$\psi(4160)$	9010443	
$\psi(4415)$	9020443	
$\chi_{c2}(1P)$	445	
$\boldsymbol{\chi_{c2}(2P)}$	$\mathbf{100445}^*$	

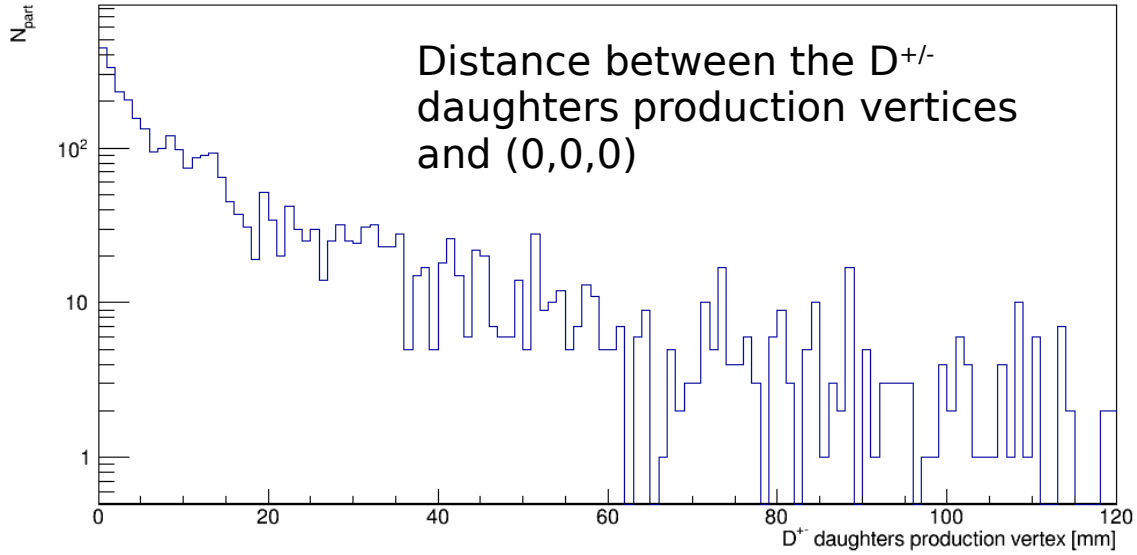
D^0 endpoint vs daughter vtx production



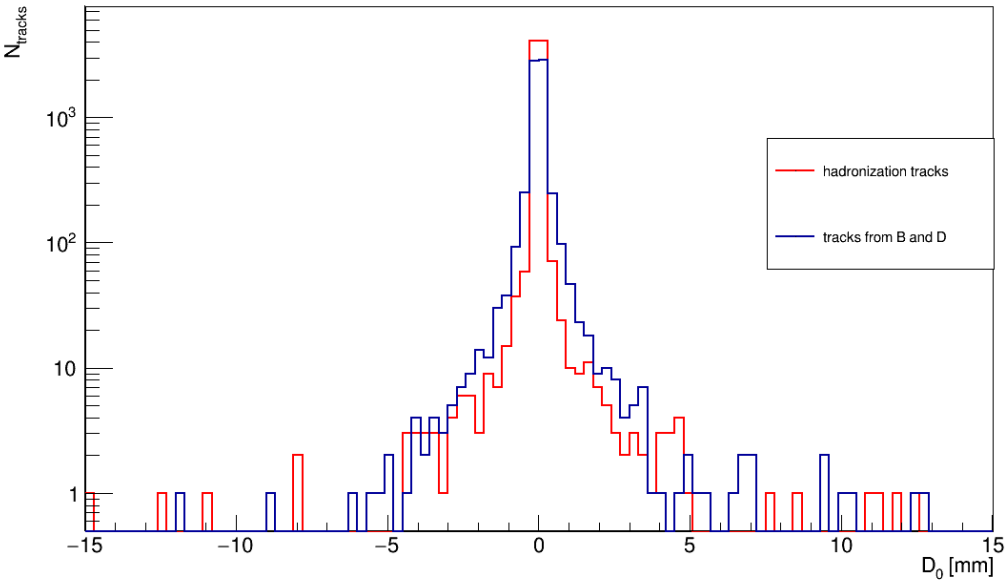


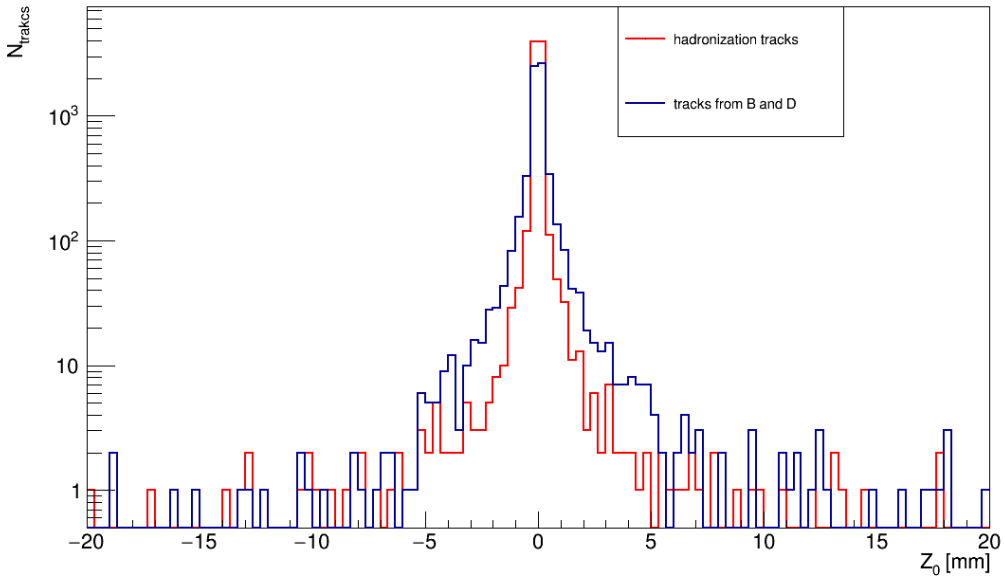
$D^{+/-}$ endpoint vs daughter vtx production

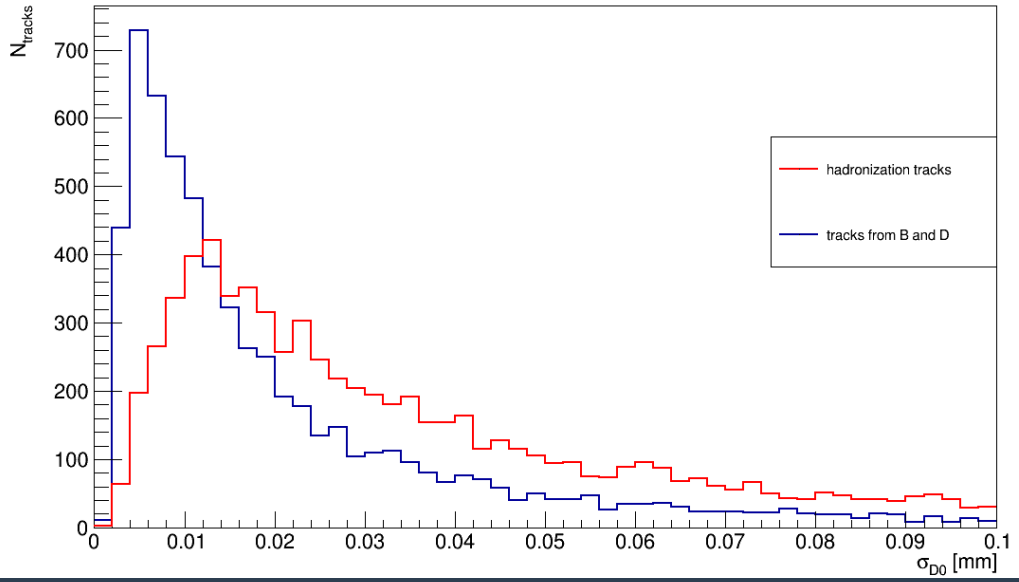


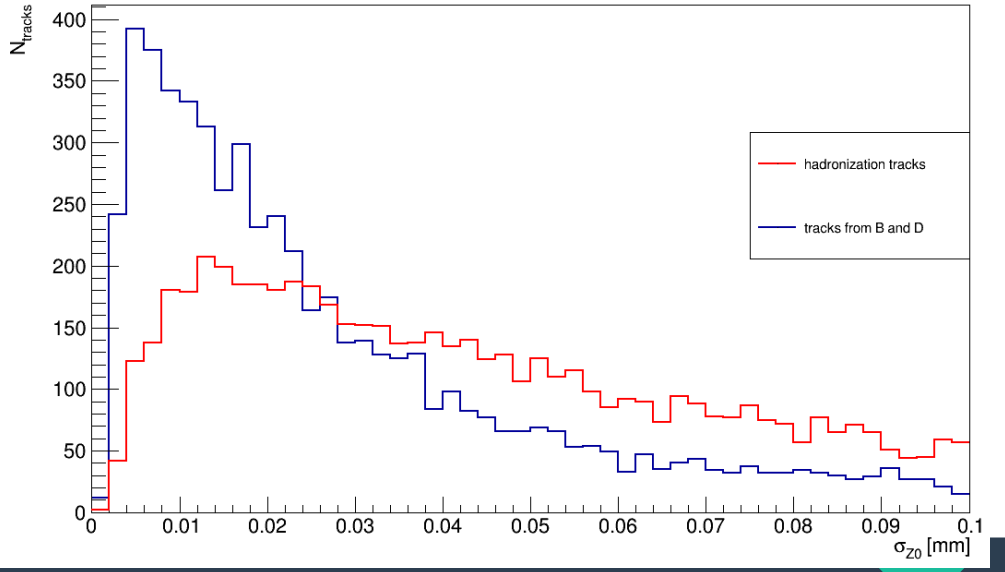


Track parameters (I)

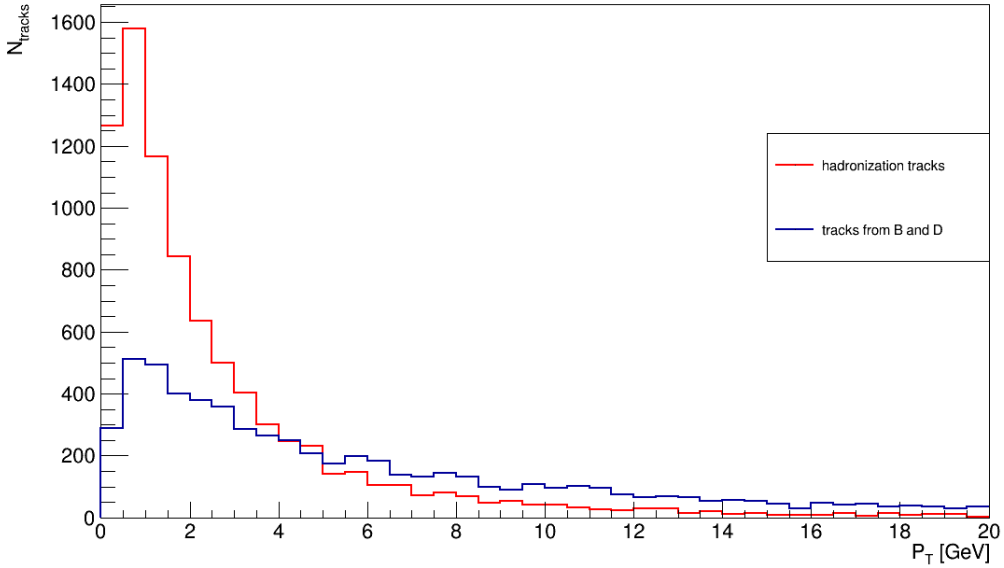


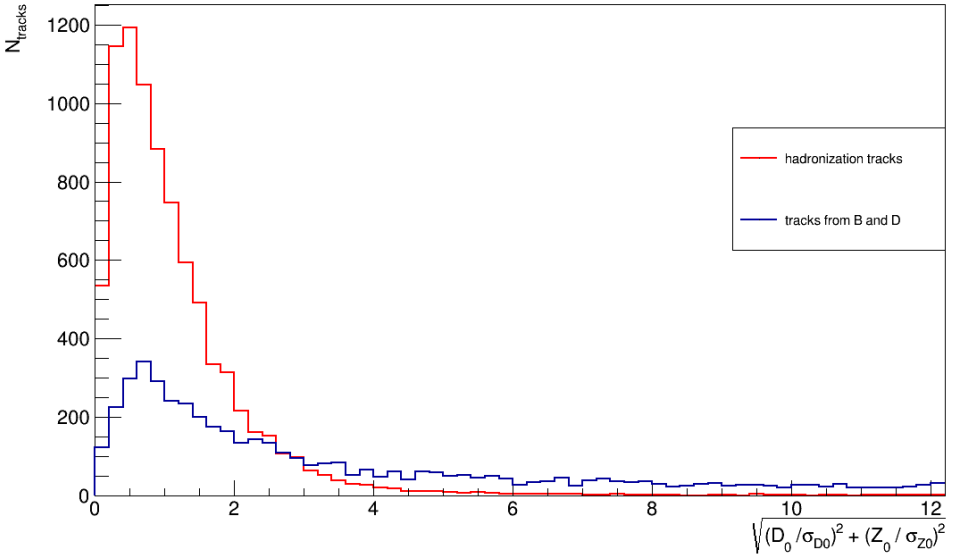


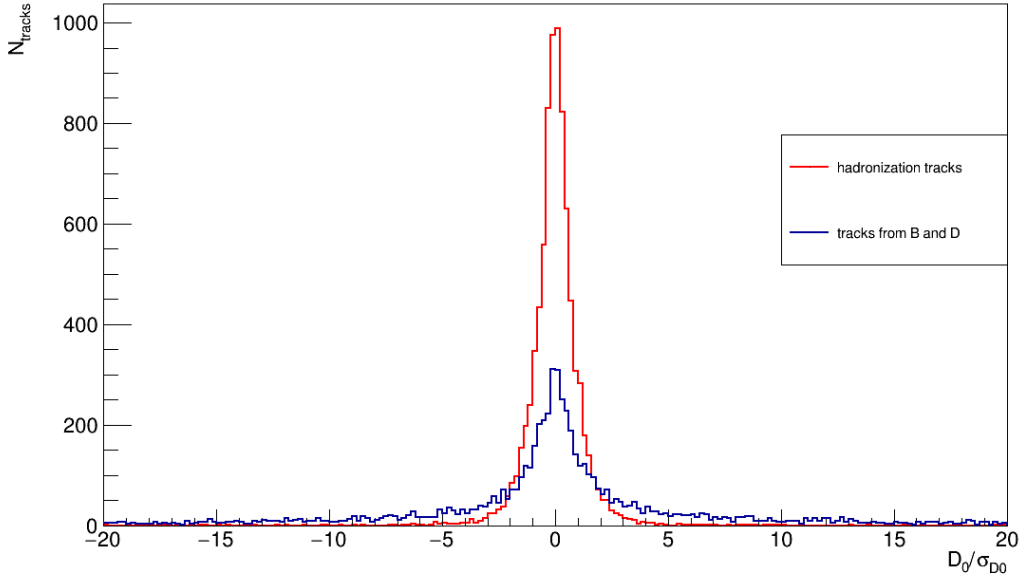


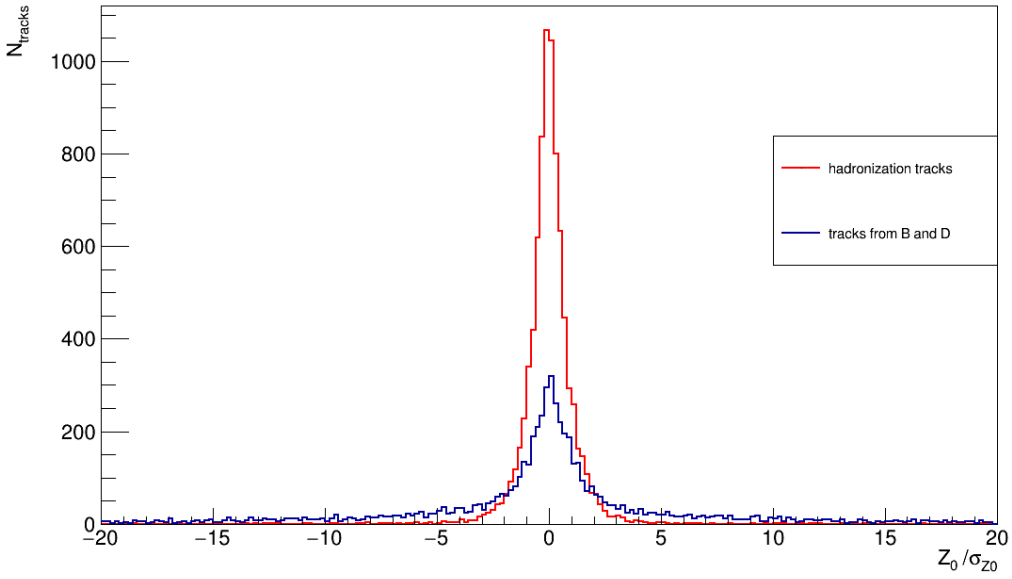


Track parameters (II)



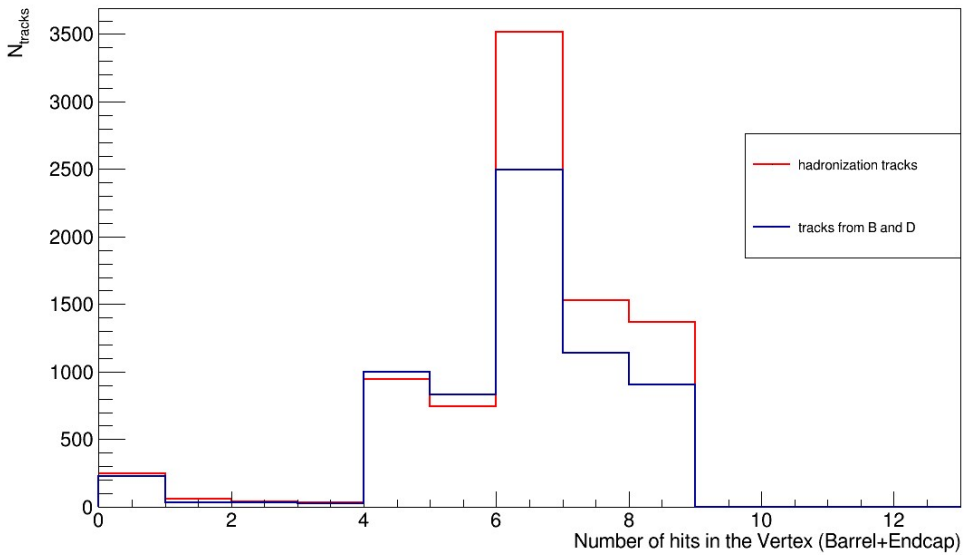


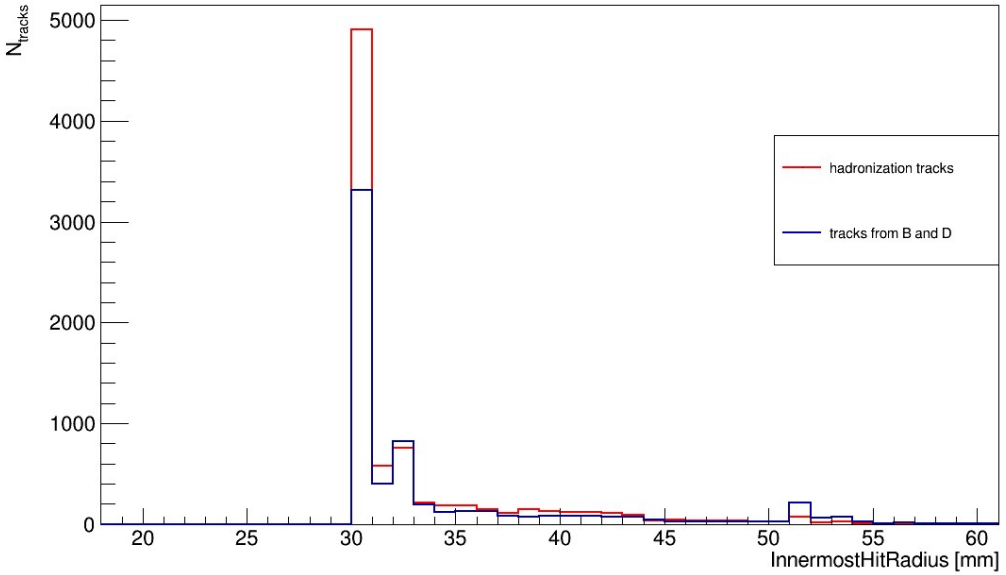




Track Hits

- Sum of hits in the barrel and endcap vertex





B tagging efficiency studies

- FastJetProcessor: kT algorithm with R=0.7 to reconstruct jets in HH events
- Reconstructed jets are matched with true jets from b quarks (b-recojets)
- LCFIPlusprocessor is run on the HH events with the following parameters (I started from Paola's studies and tried different configurations):

Parameters	PV	SV
Min D_0 [mm]	0.	0.
Max D_0 [mm]	0.2	5.
Max Z_0 [mm]	0.5	5.
TrackMinVdxFtdHits	2	4
Min P_T [GeV]	Default (0)	0.8

B tagging efficiency and mistag calculation

- b-recojets are matched with the secondary vertices (ΔR<0.7 in η-φ space)
- **The b tagging efficiency** is calculated as a function of the P_T of the reconstructed jet:

$$\epsilon = \frac{N_{b-recojets,SV}}{N_{b-recojets}}$$

Number of reco jets matched with true jets from b-quarks and with SV

Total number of reco jets matched with true jets from b-quarks

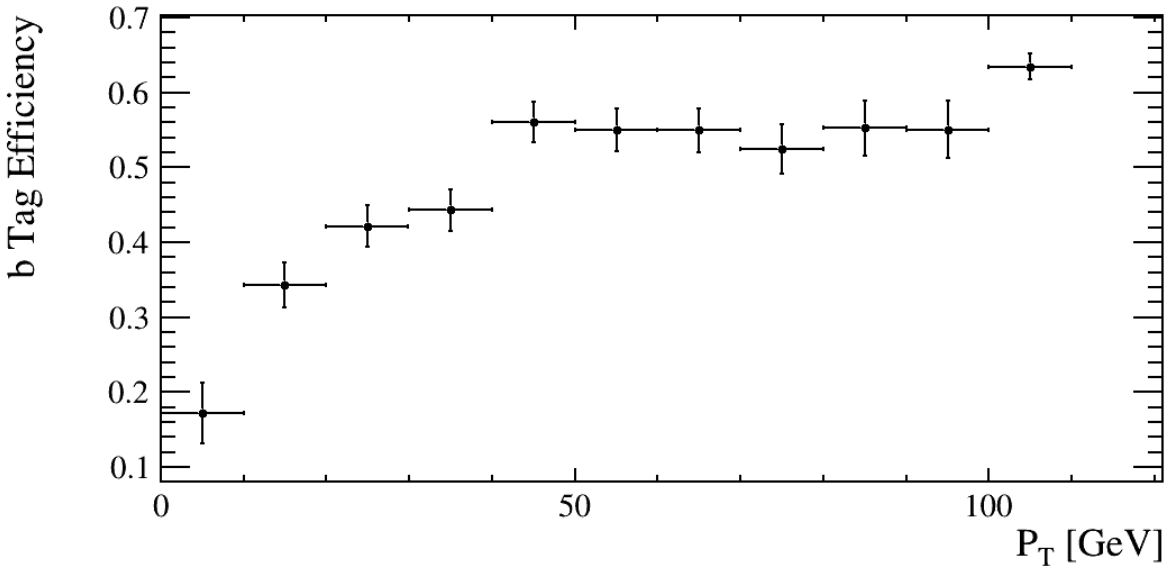
- **The mis-tag rate** calculated as a function of the P_T of the reconstructed jet as:

$$\omega = \frac{N_{not\,b-recojets,SV}}{N_{not\,b-recojets}}$$

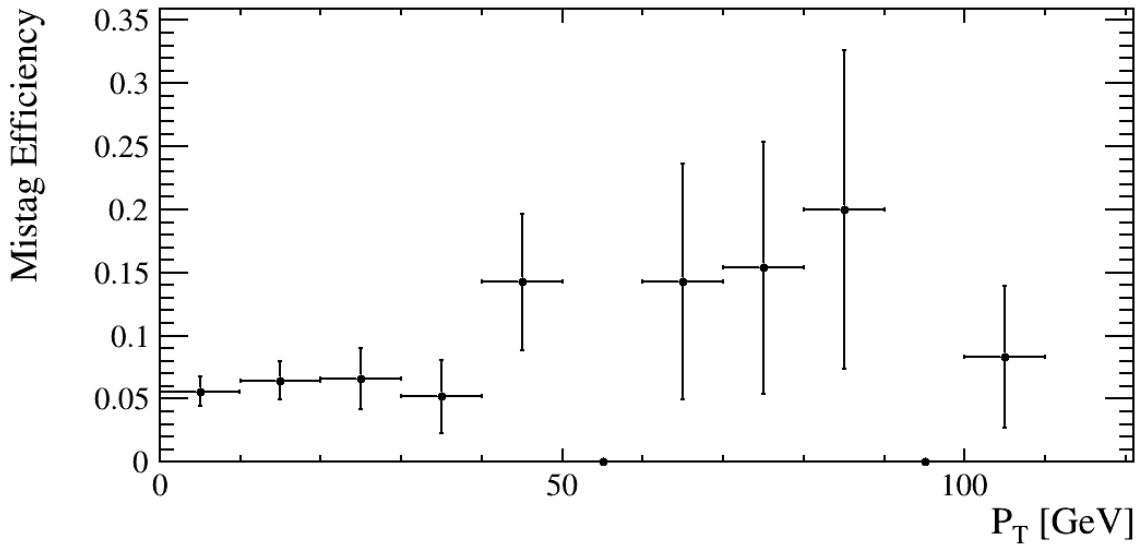
Number of reco jets **not** matched with true jets from b-quarks but **matched with SV**

Total number of reco jets **not** matched with true jets from b-quarks

B tagging efficiency and mistag plots



$$\epsilon = \frac{N_{b-recojets,SV}}{N_{b-recojets}}$$



$$\omega = \frac{N_{not\,b-recojets,SV}}{N_{not\,b-recojets}}$$

Conclusions

- The algorithm have to be studied in detail
- The processor provides a lot of possible combinations of cuts
- The fact that B meson travels a lot have to be kept in mind

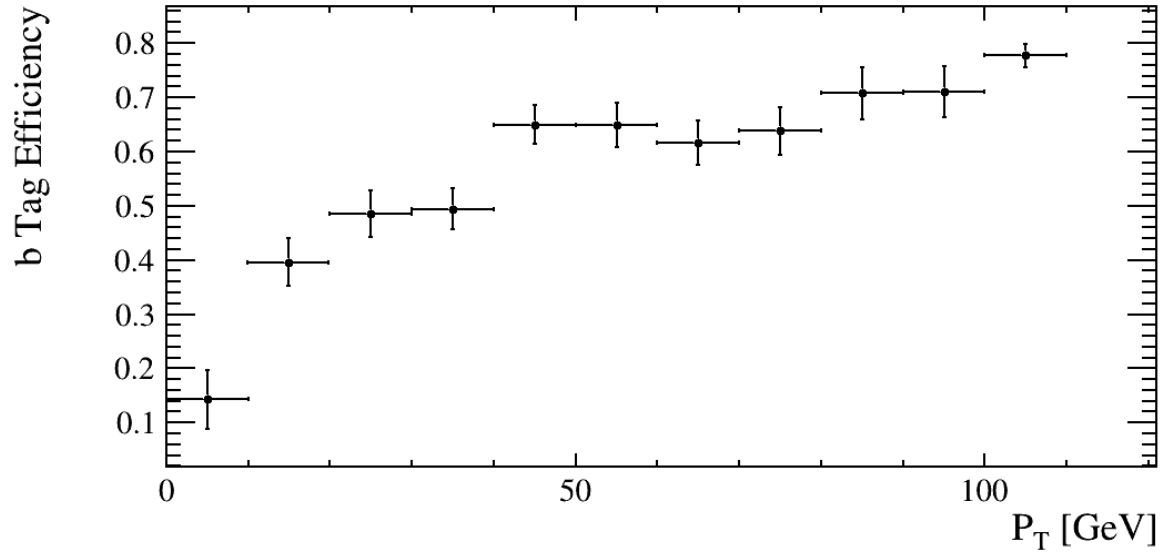
```
    <!-- parameters for primary vertex finder -->
    <parameter name="PrimaryVertexFinder.BeamspotSmearing" type="boolean" value="false" />
    <parameter name="PrimaryVertexFinder.TrackMaxD0" type="double" value="0.2" />
    <parameter name="PrimaryVertexFinder.TrackMaxZ0" type="double" value="0.5" />
<parameter name="PrimaryVertexFinder.TrackMinD0Err" type="double" value="0.01" /> <!--LAURA-->
    <!--parameter name="PrimaryVertexFinder.TrackMinZ0Err" type="double" value="" /-->
    <!--parameter name="PrimaryVertexFinder.TrackMaxInnermostHitRadius" type="double" value="31" /-->
    <parameter name="PrimaryVertexFinder.TrackMinVtxFtdHits" type="int" value="2" />
    <parameter name="PrimaryVertexFinder.Chi2Threshold" type="double" value="10." />


    <!-- parameters for secondary vertex finder -->
    <parameter name="BuildUpVertex.TrackMaxD0" type="double" value="5" />
    <parameter name="BuildUpVertex.TrackMaxZ0" type="double" value="5" />
    <parameter name="BuildUpVertex.TrackMinPt" type="double" value="0.8" />
    <parameter name="BuildUpVertex.TrackMaxD0Err" type="double" value="1" />
    <parameter name="BuildUpVertex.TrackMaxZ0Err" type="double" value="1" />
    <parameter name="BuildUpVertex.TrackMinVxdFtdHits" type="int" value="4" />
    <parameter name="BuildUpVertex.PrimaryChi2Threshold" type="double" value="10." />
    <parameter name="BuildUpVertex.SecondaryChi2Threshold" type="double" value="5." />
    <parameter name="BuildUpVertex.MassThreshold" type="double" value="10." />
    <parameter name="BuildUpVertex.MinDistFromIP" type="double" value="0.001" />
    <parameter name="BuildUpVertex.MaxChi2ForDistOrder" type="double" value="1.0" />
    <parameter name="BuildUpVertex.AssocIPTracks" type="int" value="1" />
    <parameter name="BuildUpVertex.AssocIPTracksMinDist" type="double" value="0." />
    <parameter name="BuildUpVertex.AssocIPTracksChi2RatioSecToPri" type="double" value="2.0" />
    <parameter name="BuildUpVertex.UseV0Selection" type="int" value="1" />
    <!-- Disable AVF -->
    <parameter name="BuildUpVertex.UseAVF" type="boolean" value="true" />
    <parameter name="BuildUpVertex.AVFTemperature" type="double" value="1.0" />
```

```
// cuts which are combined using the AND scheme
double minD0;
double maxD0;
double minD0Err;
double maxD0Err;
double minD0Sig;
double maxD0Sig;
double minZ0;
double maxZ0;
double minZ0Err;
double maxZ0Err;
double minZ0Sig;
double maxZ0Sig;
double minD0Z0Sig;
double maxD0Z0Sig;
double minPt;
double maxInnermostHitRadius;
// cuts which are combined using the OR scheme, th
int minTpcHits;
double minTpcHitsMinPt;
int minFtdHits;
```

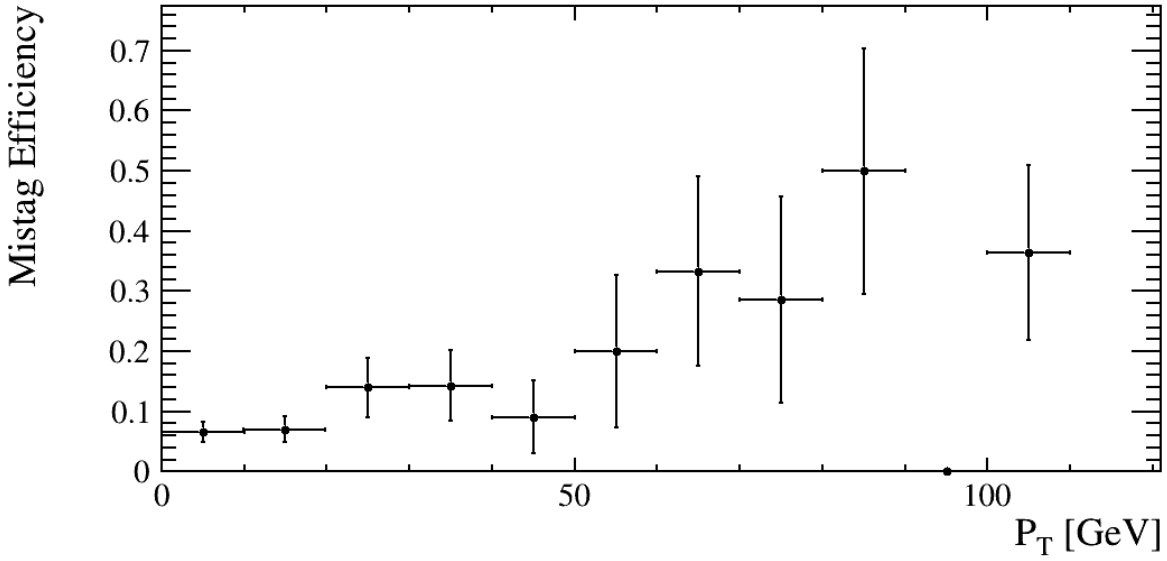
Test 2

Parameters	PV	SV
Min D_0 [mm]	0.	0.
Max D_0 [mm]	0.2	5.
Max Z_0 [mm]	0.5	5.
TrackMinVdxFtdHits	2	4
TrackMinD0Err	0.01	Default
Min P_T [GeV]	Default (0)	0.8

Test 2

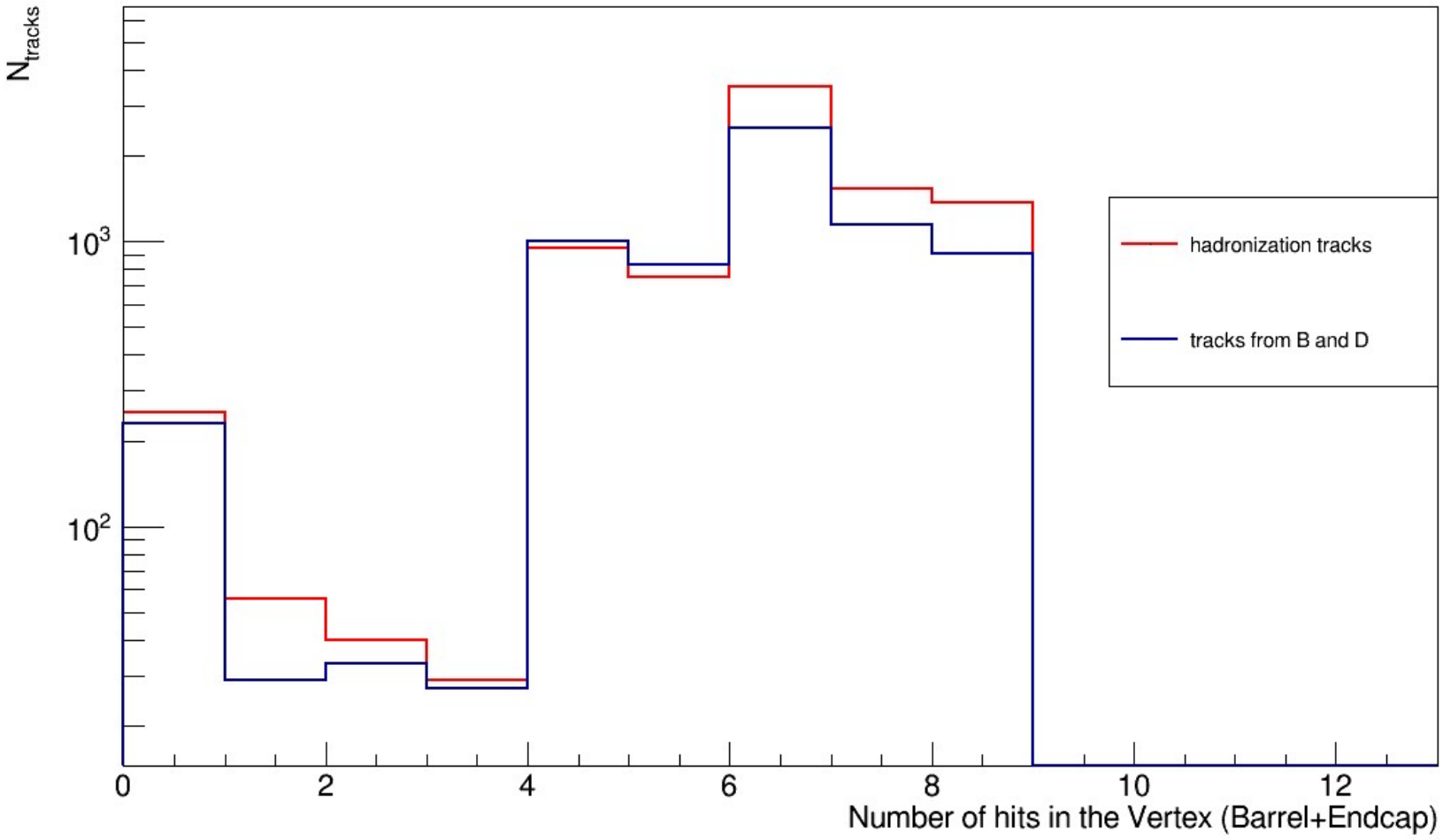


$$\epsilon = \frac{N_{b-recojets,SV}}{N_{b-recojets}}$$



$$\omega = \frac{N_{not\,b-recojets,SV}}{N_{not\,b-recojets}}$$

Track hits


N_{tracks}
10^3
10^2
0
2
4
6
8
10
12
Number of hits in the Vertex (Barrel+Endcap)
hadronization tracks
tracks from B and D