$B_c^+ \to \tau^+ \nu_\tau, \tau^+ \to e^+ \nu_e \overline{\nu_\tau}$ Analysis

Taifan

B_c^+ Multiplicity

- 10^{12} Z bosons, 10^8 B_c^+. B_c^+s are mostly in $Z \to bb$, but some are in $Z \to cc$(don't consider this one for now).
- $BR(B_c^+ \to \tau^+ \nu_\tau) = 1.6\%$ (Pythia), $\rightarrow 10^6$.
- $BR(\tau^+ \to e^+ \nu\nu) \approx BR(\tau^+ \to \mu^+ \nu\nu) \approx 17\%$, $\rightarrow 10^5 \sim 10^6$
- $BR(\tau^+ \to \pi^+ \nu) = 10\% \rightarrow 10^5$
- $BR(\tau^+ \to \pi^- \pi^+ \pi^+) = 9\ \%$, $\rightarrow 10^5$

Work progress

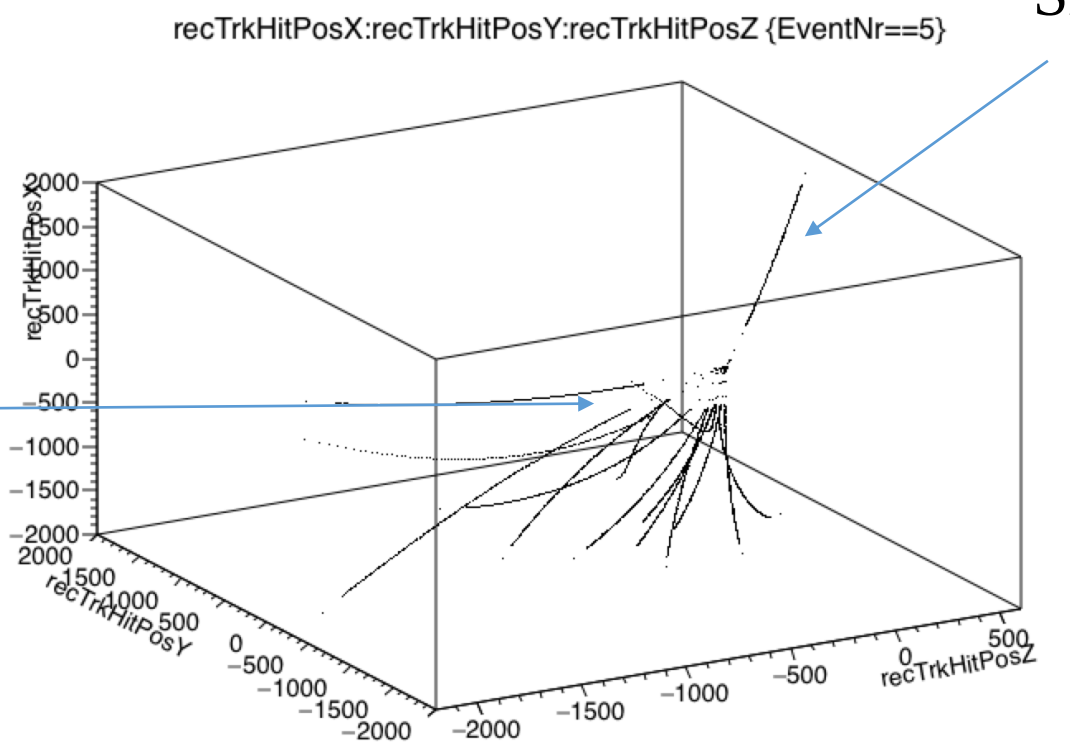
- Generate 1×10^6 $B_c^+ \to \tau^+ \nu_\tau$ and $B^+ \to \tau^+ \nu_\tau (Z$ pole) samples using Pythia8.
- Convert the .hepevt format of sample file to .slcio (making the conversion tool). Because otherwise Mokka sets all of the unstable particle's creation and decay points as (0, 0, 0).
- Work environment setup & checking and comparing with Fenfen's results.
- Preliminary cut chain

What we want to find

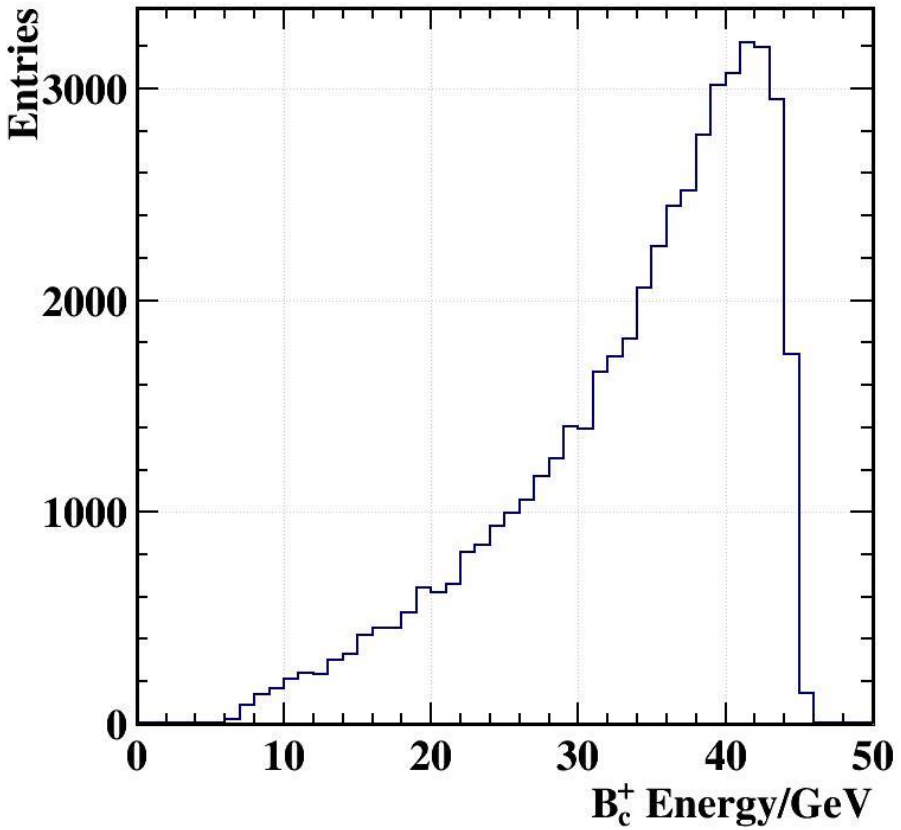
$B_c^+ \to \tau^+\nu_\tau, \tau^+ \to e^+\nu_e\overline{\nu}_\tau$ at Z pole.

Signal side

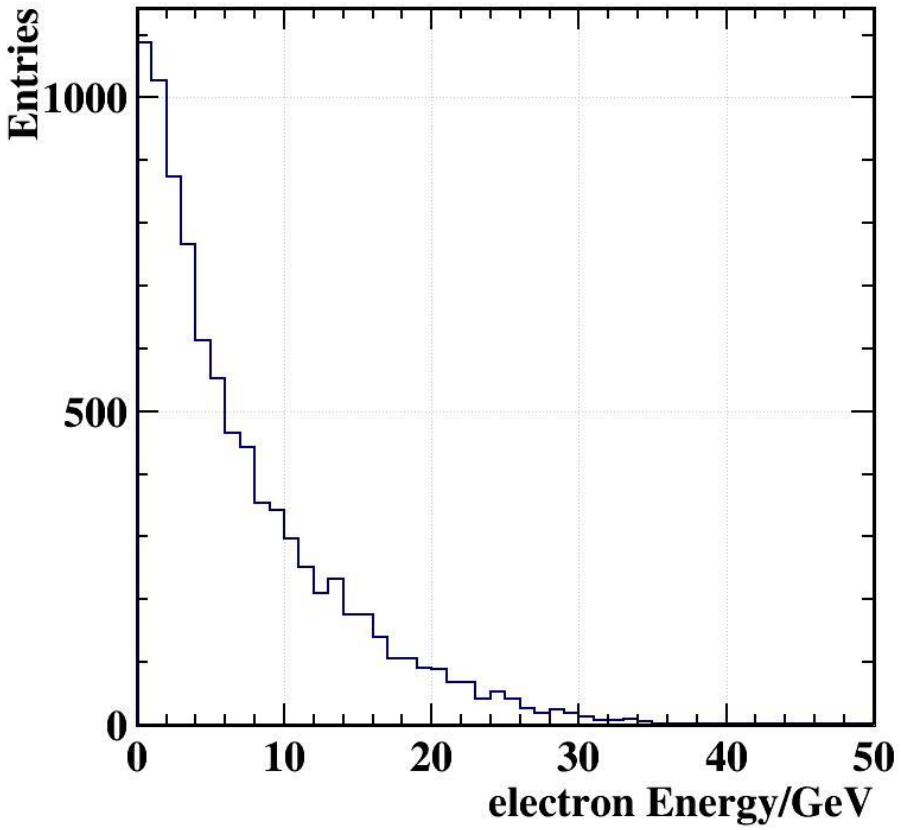
Recoil side



Energy spectrum

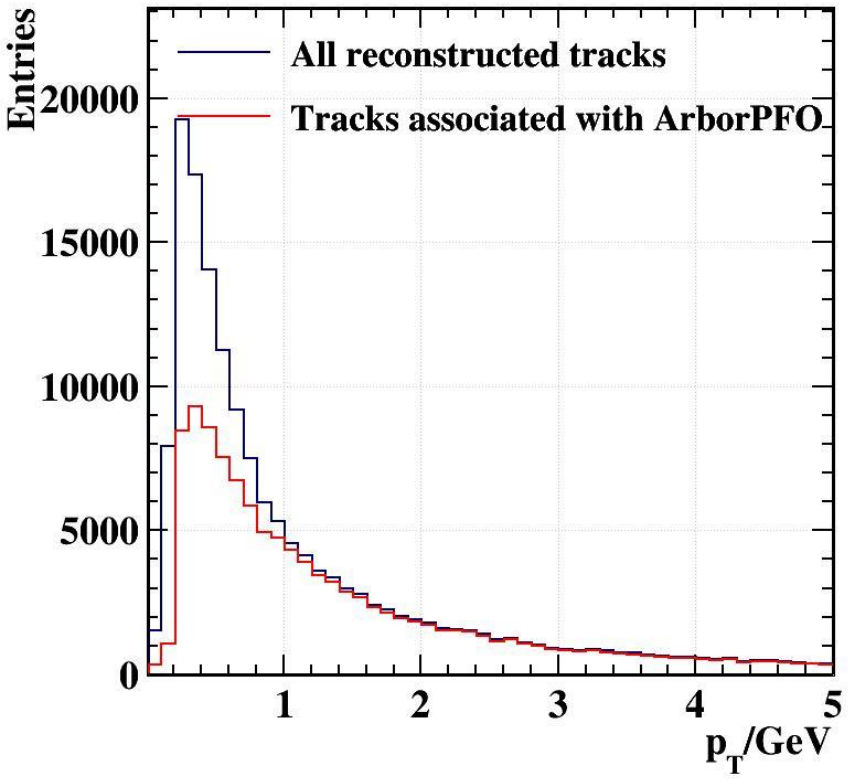


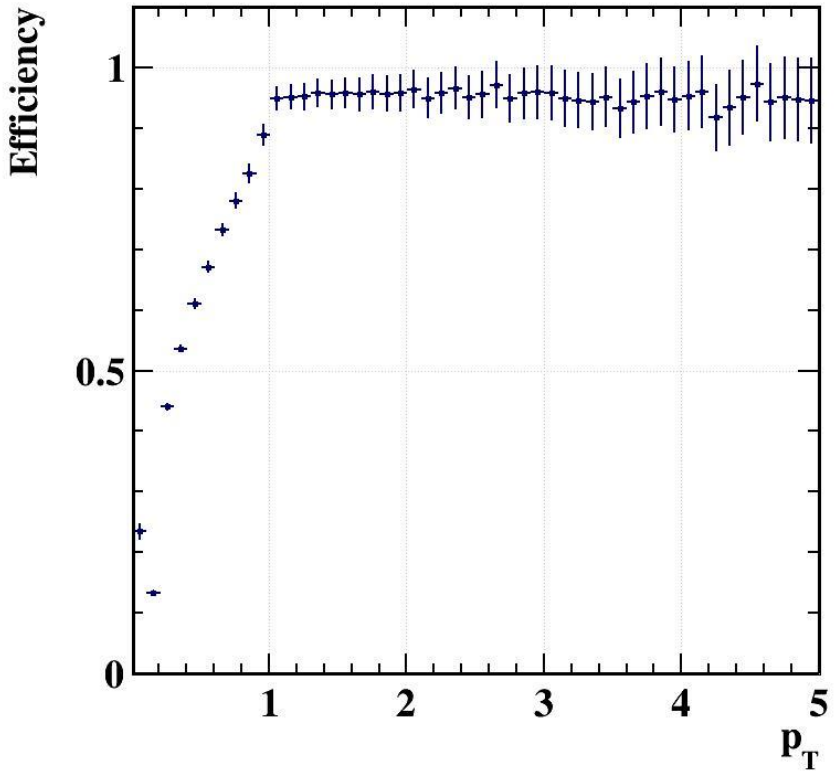
B_c^+



Electron from B_c^+

Linkage between track and PFO (reconstructed particle)

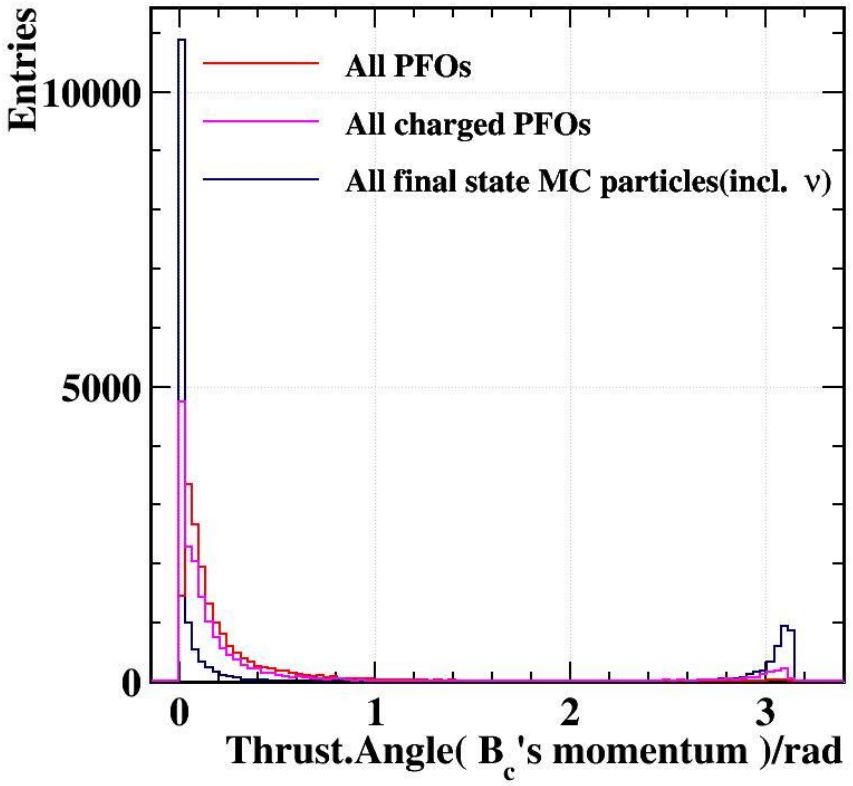




Thrust axis

Define thrust axis n using all of the charged and neutral particles to maximize *T*. The direction is set towards the hemisphere with less energy.

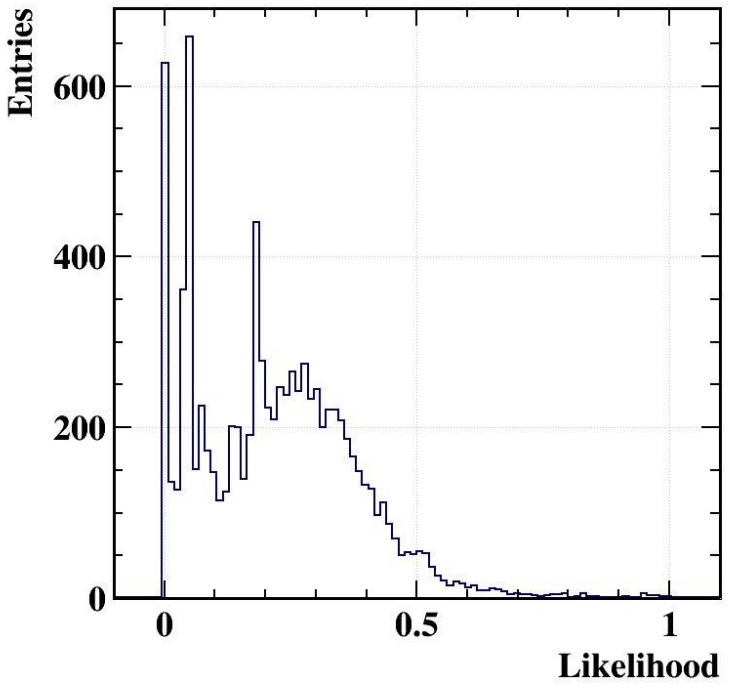
$$T = \max_{|\boldsymbol{n}|=1} \frac{\Sigma_i |p_i \cdot n|}{\Sigma_i |p_i|}$$



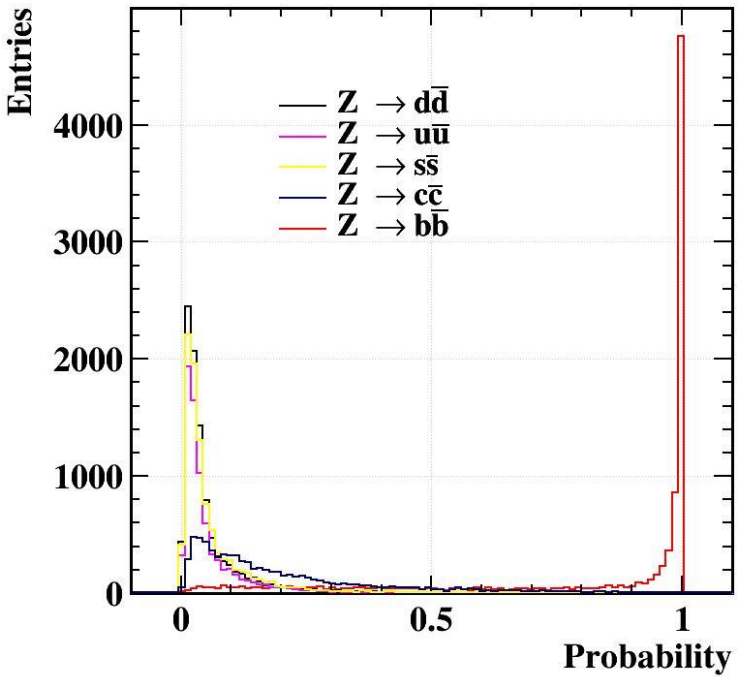
Using Fenfen's code to show the angle between the thrust axis and the B_c's momentum in $B_c \to \tau\nu, \tau \to e\nu\nu$.

b-jet tagging

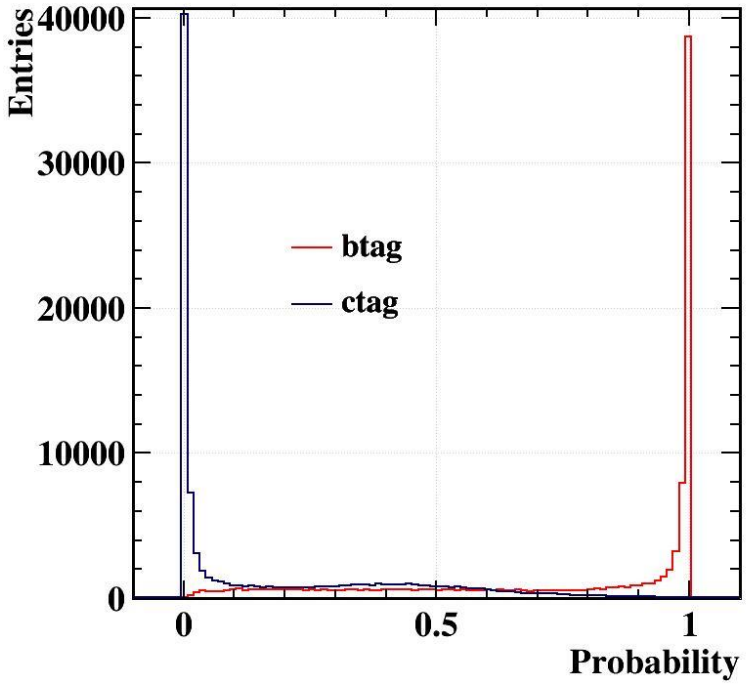
Cluster the events into two jets, then tag on the leading jet



$Z \to \tau\tau$

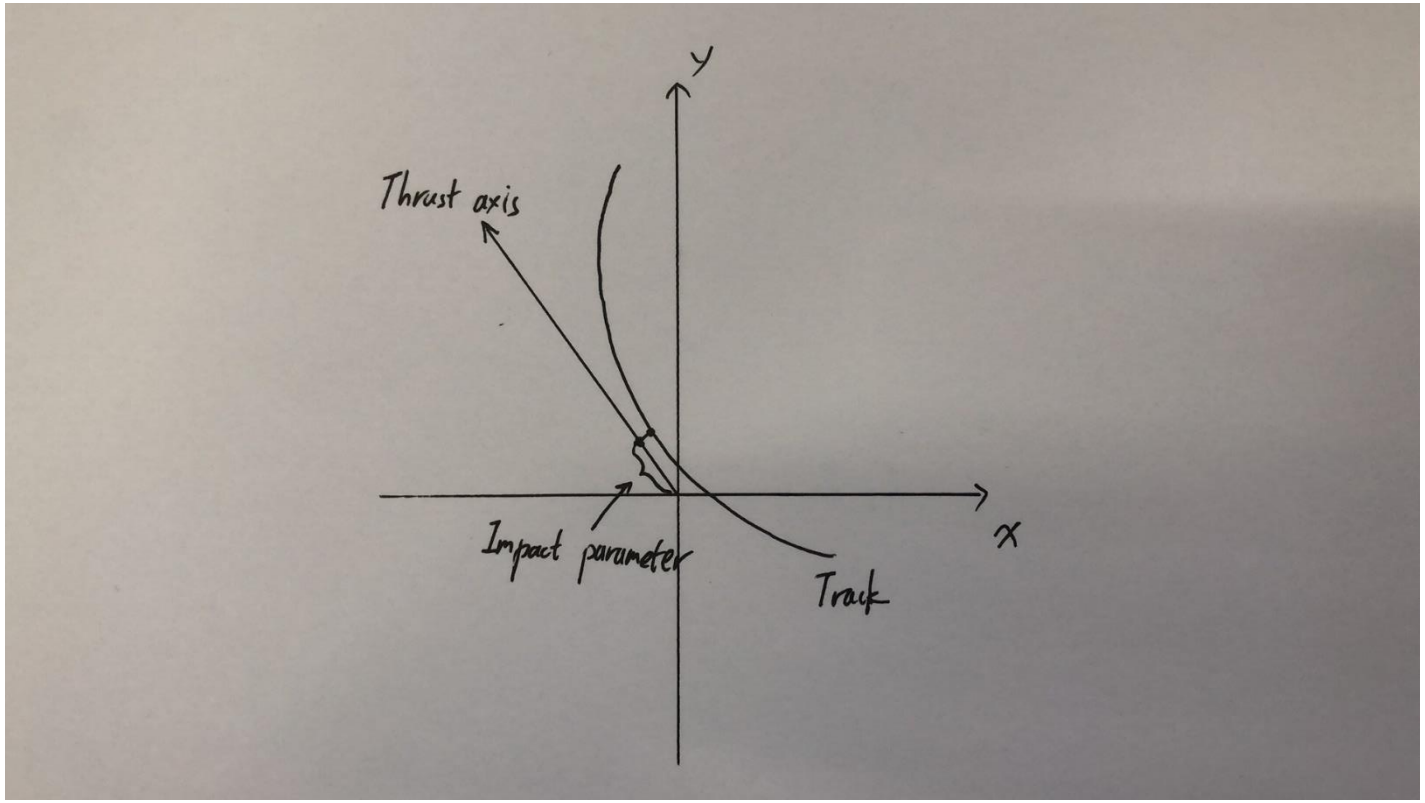


$Z \to q\,\overline{q}$



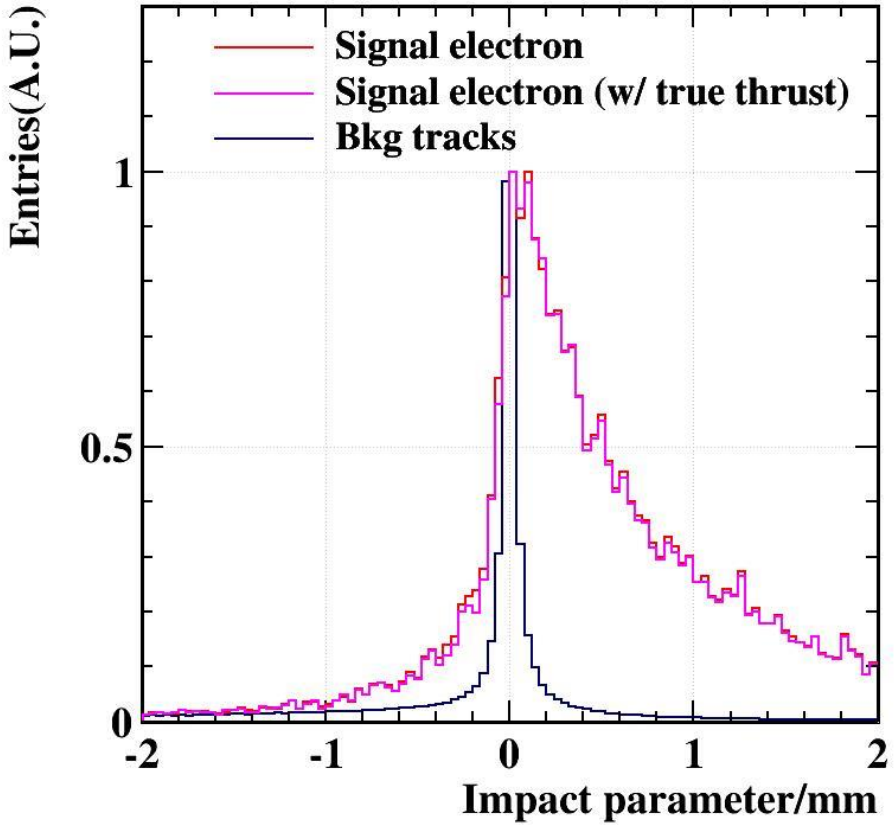
$B_c^+ \to \tau^+\nu_\tau$

Impact parameter w.r.t the thrust axis in 3D

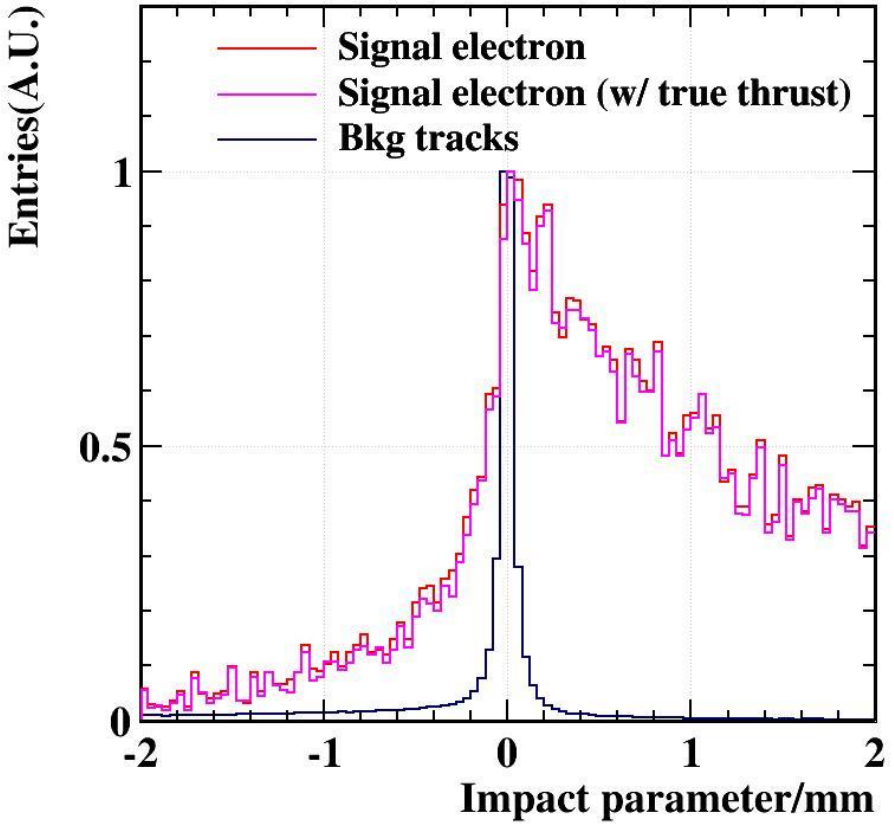


Find the point on the thrust axis closest to the track. The impact parameter is the distance between that point to the IP (I drew in 2D space but calculated in 3D space).

Impact parameter w.r.t the thrust axis in 3D

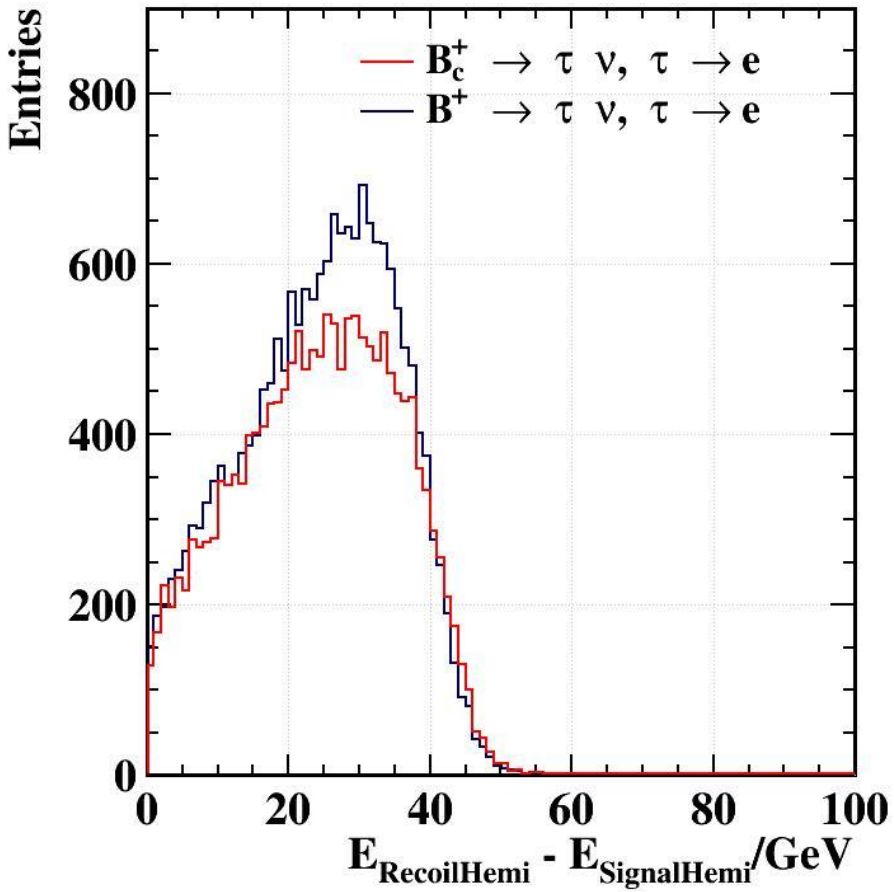


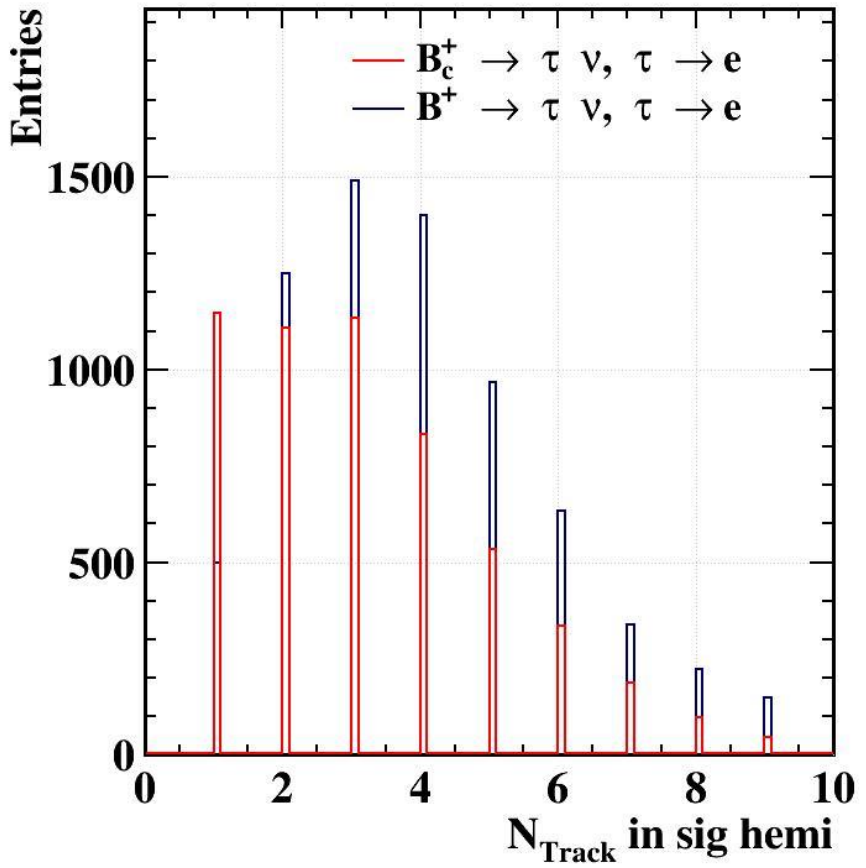
B_c^+



B^+

B_c^+ and B^+ are hard to separate

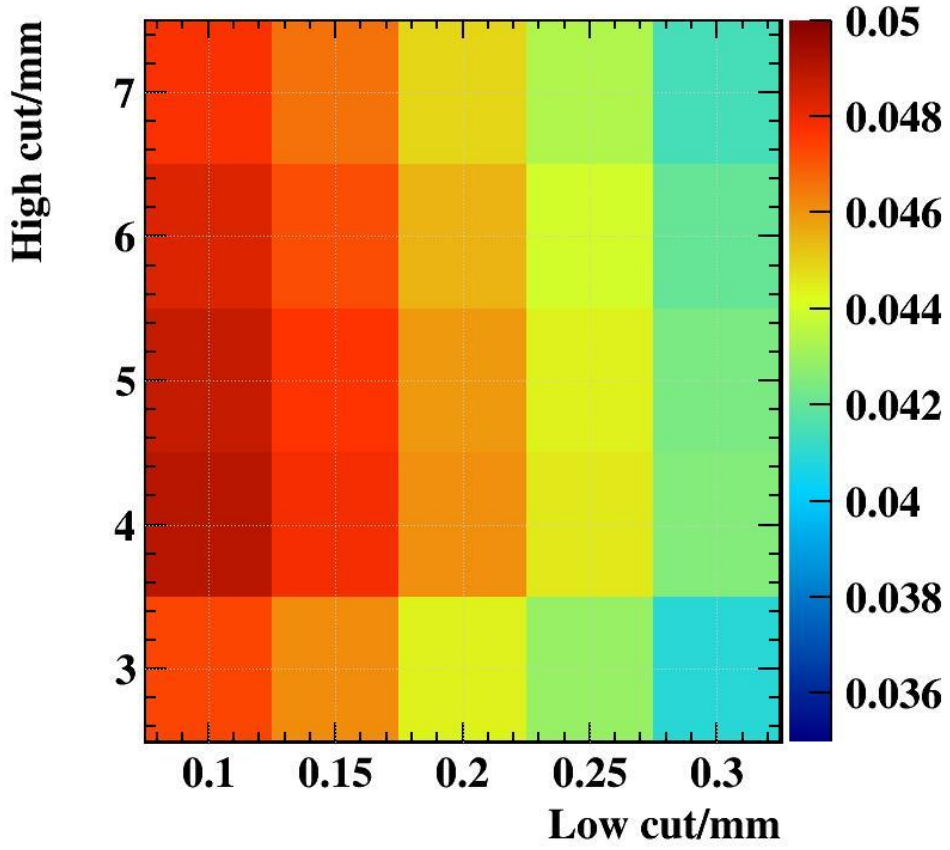




Cut chain

	$B_c^+ \to \tau^+\nu_\tau/\tau^+ \to e$	$B^+ \to \tau^+\nu_\tau/\tau^+ \to e$	$Z \to q\bar{q}$	$D_s^+ \to \tau^+\nu_\tau/\tau^+ \to e$
All	99858/17542	100000/19685	1219756	99600/19616
b-tag > 0.6	72180/12759	67368/13378	227786	53079/10175
N_{Lepton} in sig hemi == 1	27218/6546	25209/6616	72173	16274/3039
The lepton is e & its E is maximum in the hemi	3250/2997	3600/3371	1616	579/311
Electron $E > 1$ GeV	3189/2949	3570/3347	1610	577/310
Max other momenta in the hemi < 2 GeV	2669/2508	2469/2335	318	185/105
Max E of neutral cluster inside cone (angle w/ thrust < 0.5) < 0.5	1292/1280	770/762	1	2/0
B_c^+ energy > 30 GeV	1288/1276	769/761	1	2/0
Max impact para except e $(-\infty, 0.25]$ mm	1133/1123	667/662	1	2/0
Electron impact para [0.25, 4] mm	847/840	328/320	1	1/0

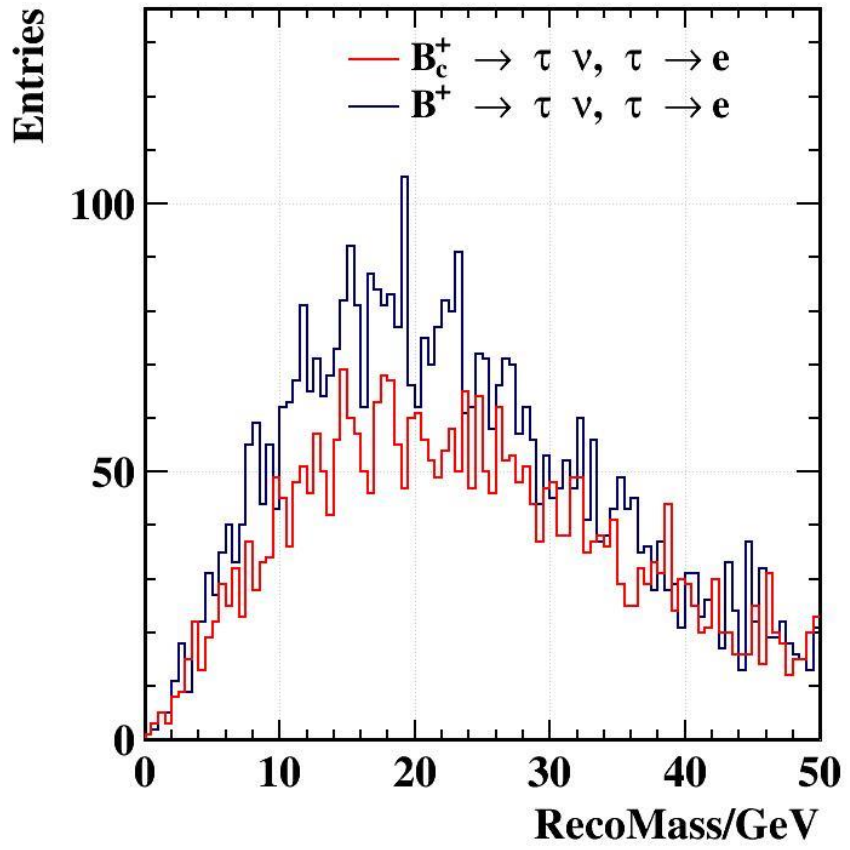
Cut on the electron impact parameter



Distribution of efficiency * purity

Assume there are only $B_c^+ \to \tau^+\nu_\tau$ and $B^+ \to \tau^+\nu_\tau$.

Kinematic fit on B_c^+ mass to exclude potential backgrounds from $Z \to q\bar{q}$?



This one is not fitted. It's calculated using:
E = 91.2 – all visible energy + electron energy
P = All visible momentum – electron momentum.