Decay Modes Distributions against the signal

entsprechend den Gestaltungsrichtlinien von Februar 2025

Ánuar Sifuentes Name | 5. February 2026

ETP – Institut für experimentelle Teilchenphysik

Content

1. How were the different decay modes chosen?
2. Chosen decay modes and how were they saved separately
3. Examples of distributions

Institut für Experimentelle Teilchenphysik

1. How were the different decay modes chosen

Objective and Overview:
Further reducing bkg with cuts for different modes

IDEA: Define cuts for every decay mode in order to further reduce bkg

1. Find which decay modes are most present in the background ($Z \rightarrow b\bar{b}$)
2. Build/create a separate file for each decay mode
3. Plot signal* vs each decay mode to look for differences and:

Either :

- apply **a general cut** if distributions look very similar

Or

- apply **a different cut for each decay mode** if their distributions seem way different

*100k signal events were selected randomly for plotting

Which decay modes to look at?

Presentation on the construction of decay modes dictionary made in November 2025 (examples shown later):

- Signal full decay modes
- Background full decay modes

The goal was to **compare signal and background decay modes** to determine their similarities and differences.

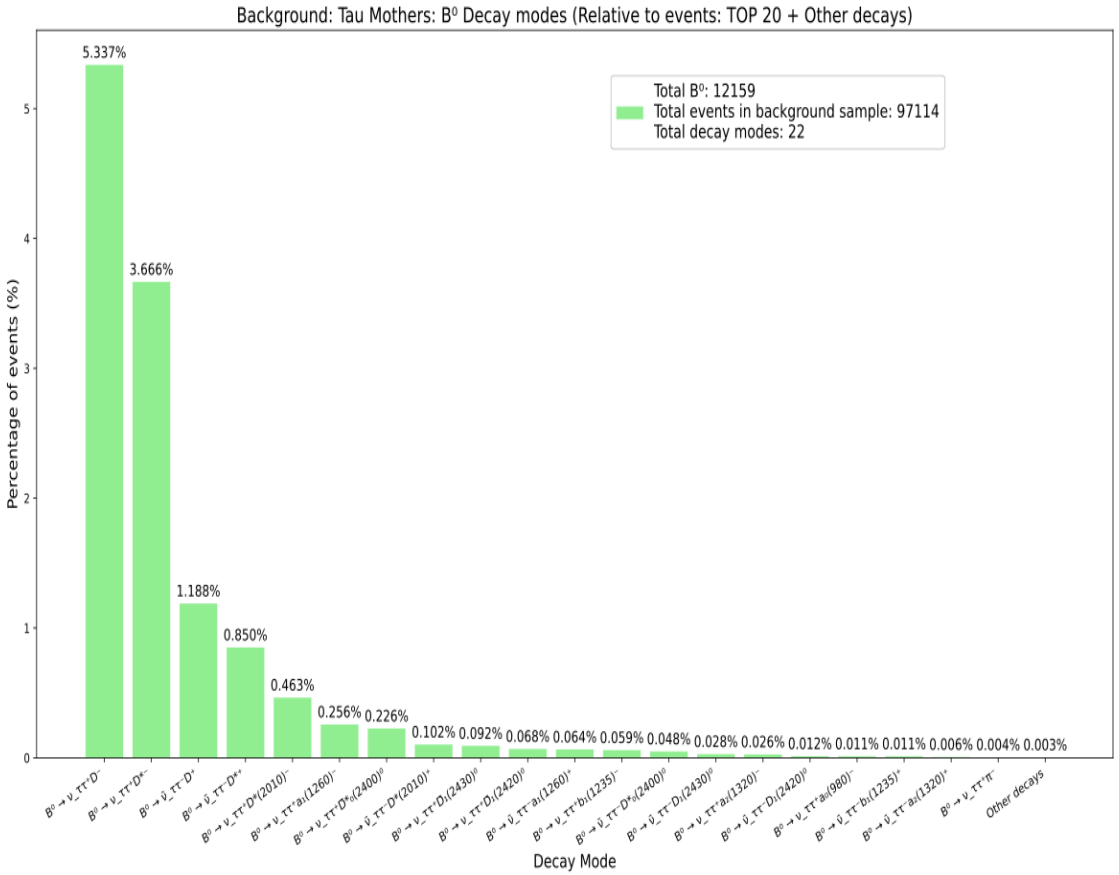
- **Focus:** Select decay modes with a **high frequency relative to background events**.
- **Selection:** Retain **5–10 decay modes** that occur most frequently for further analysis.

2. Chosen decay modes and how were they saved separately

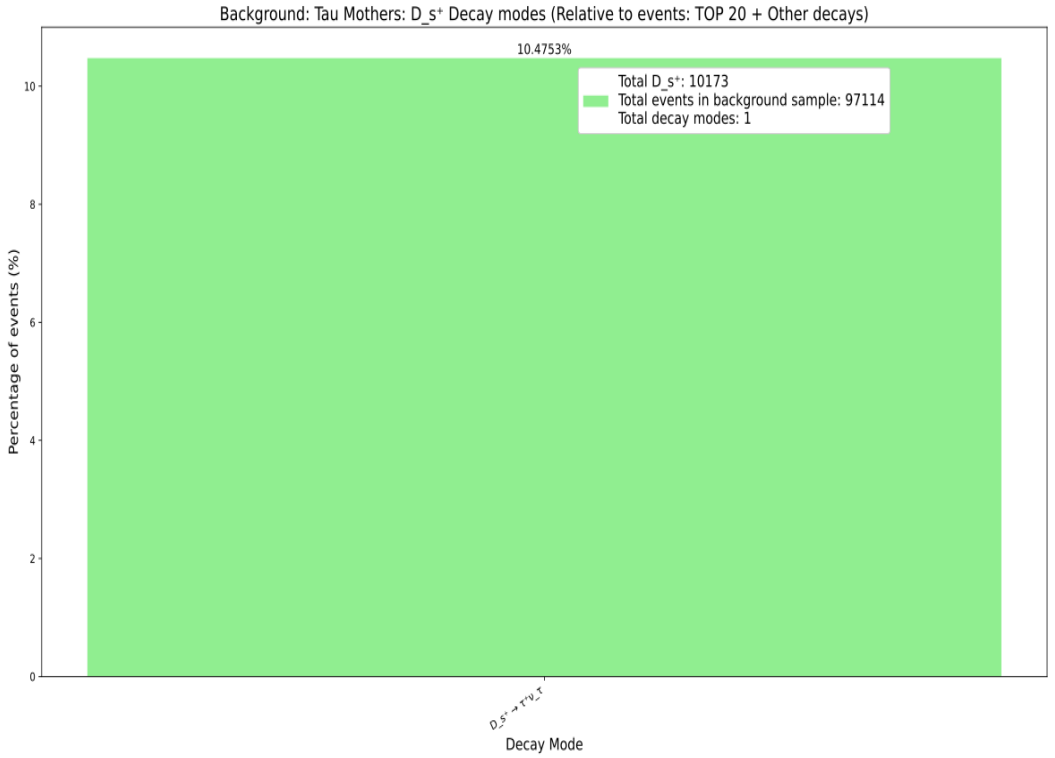
Examples of decay modes built in Nov. 2025

We have to look at the frequency of the decay modes **relative to the total number of events**

B_0 meson



D_S^+ meson



Decay modes chosen

1. $B \to \tau\, D^{(*)}\, \nu_\tau$
2. $B \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$
3. $D_s \to \tau\, \nu_\tau$
4. $B_0 \to \tau\, D^{(*)}\, \nu_\tau$
5. $B_s \to \tau\, \nu_\tau\, D_s^{(*)}$

Additional note:
$D^{(*)}$ includes both D and D^*states.

These were chosen because they occur **frequently compared to background events**, but they **do not necessarily resemble or mimic the signal** itself.

Steps for creating a file per decay mode

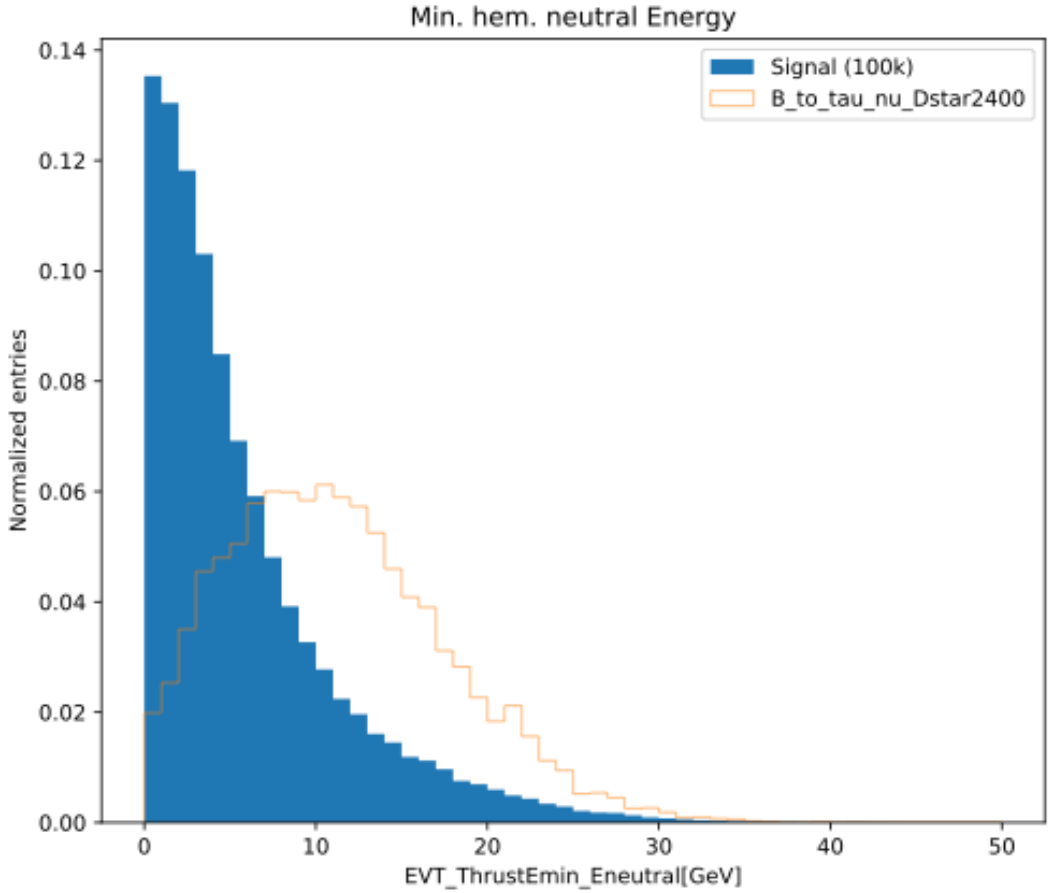
1. Define all interesting decay modes to be searched for using the Monte Carlo ID for each particle
   - Example "B0_to_tau_D_nu": (511, [15, 411, 16])
2. Find all tau particles in one event
   - Look for abs(MC_PDG) = 15
3. Find the mothers of the tau particles (e.g. B_0 meson)
   - Using MC_M1 and MC_M2
   - The MC_PDG of the tau-mother should coincide with the MC_PDG of the decay mode we are interested in
4. If the IDs coincide, check what are the daughters of each mother using MC_D1 and MC_D2
   - If the decay mode was found in the event, **the whole event is saved**
5. Do steps 2-4 for each event on the bkg file
6. Save the events that have such decay mode as a Parquet file

*They are saved separately for a quick plotting and to analyze them separately

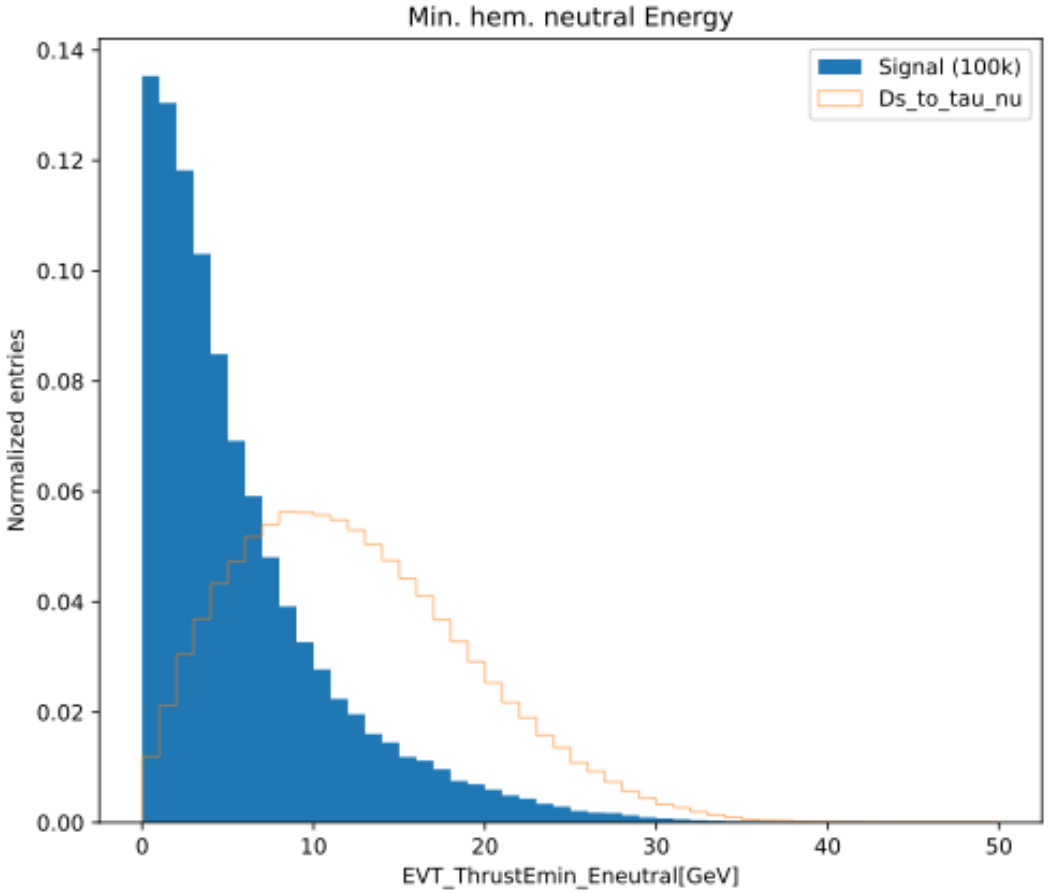
3. Examples of distributions

“EVT_ThrustEmin_Eneutral”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

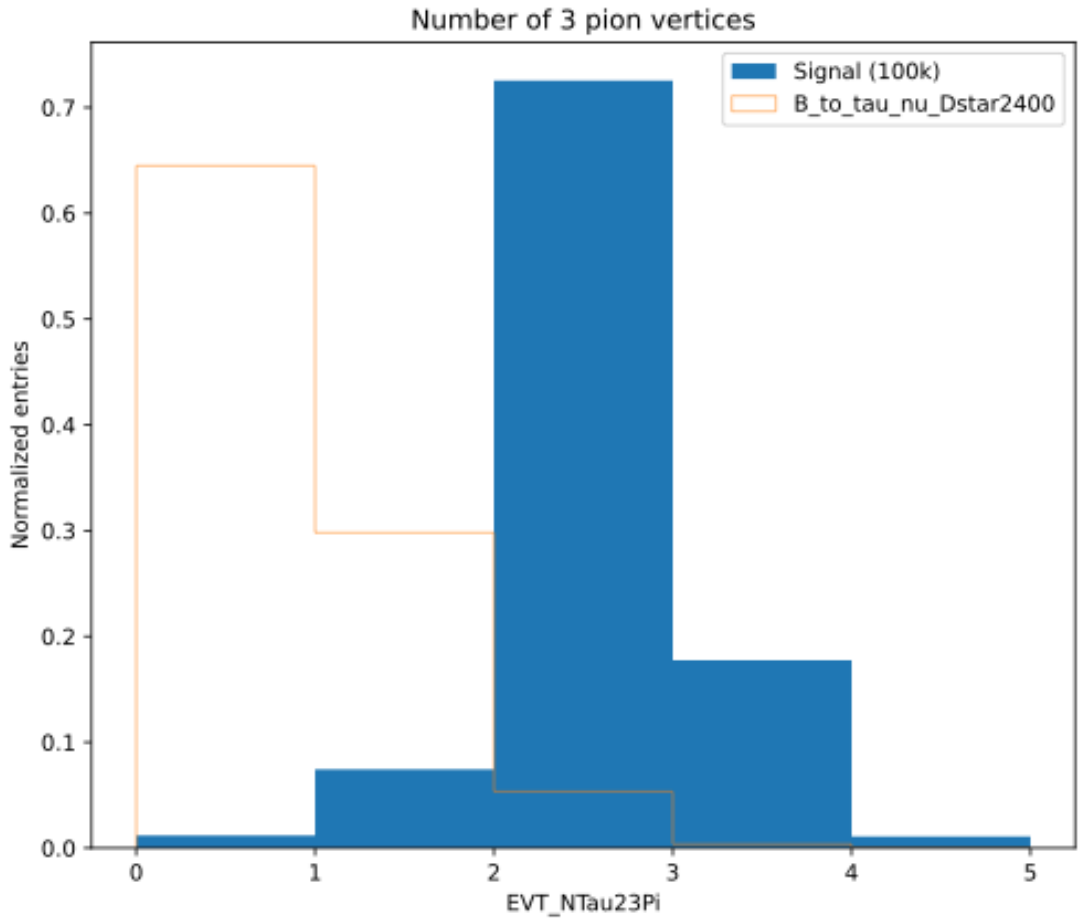


$D_s \to \tau\, \nu_\tau$

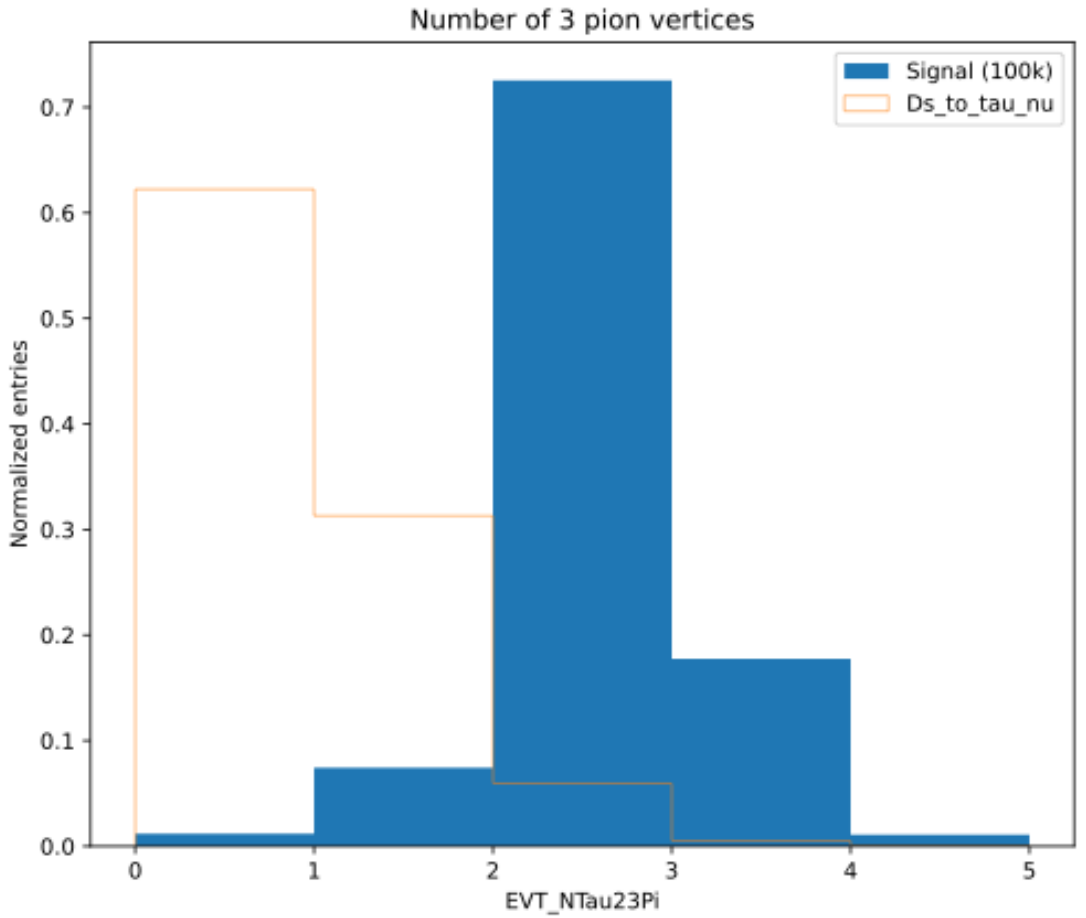


“EVT_ThrustEmin _NTau23Pi”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

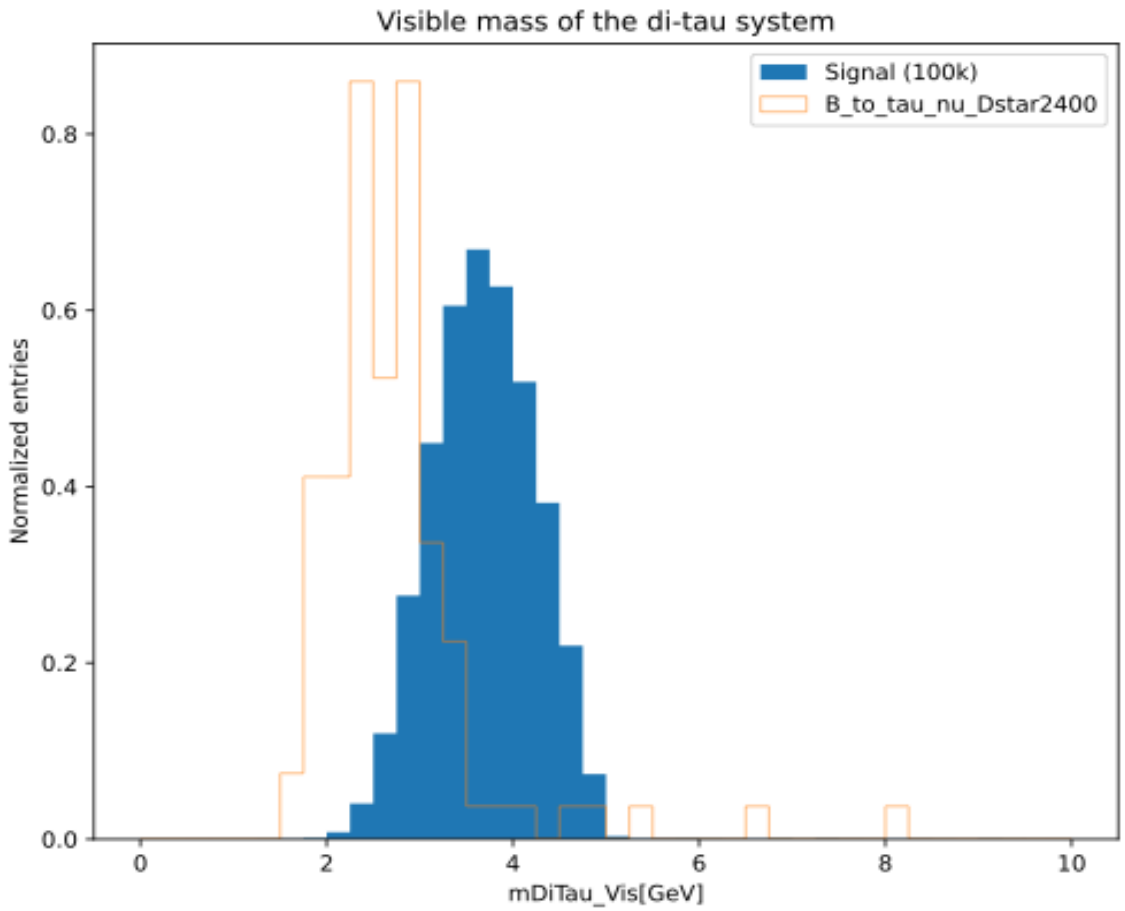


$D_s \to \tau\, \nu_\tau$

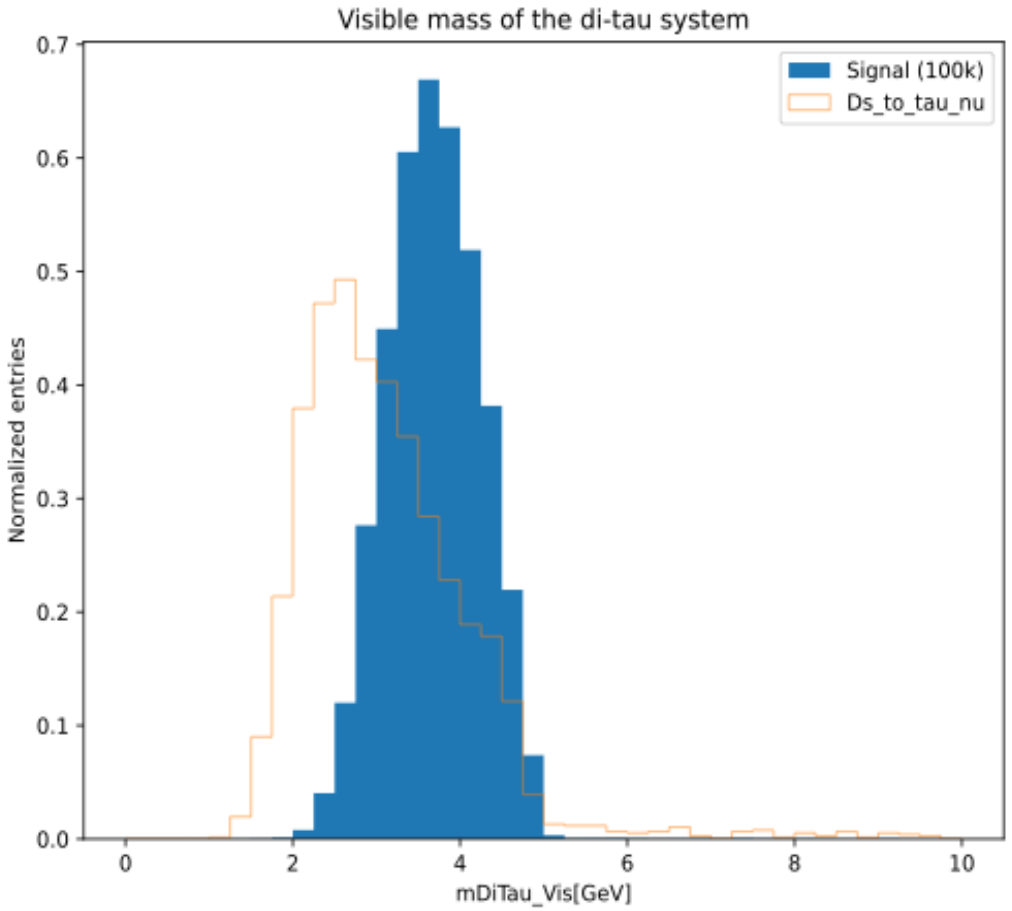


“mDiTau_Vis”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

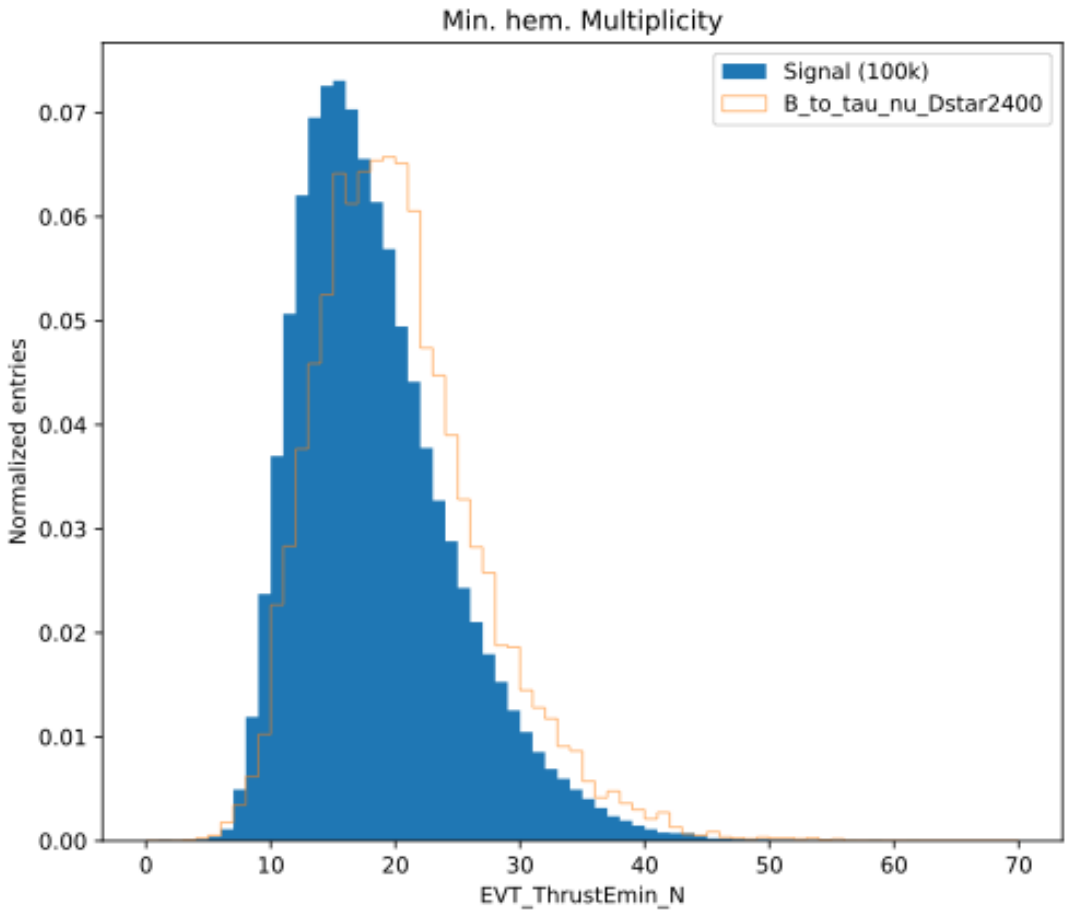


$D_s \to \tau\, \nu_\tau$

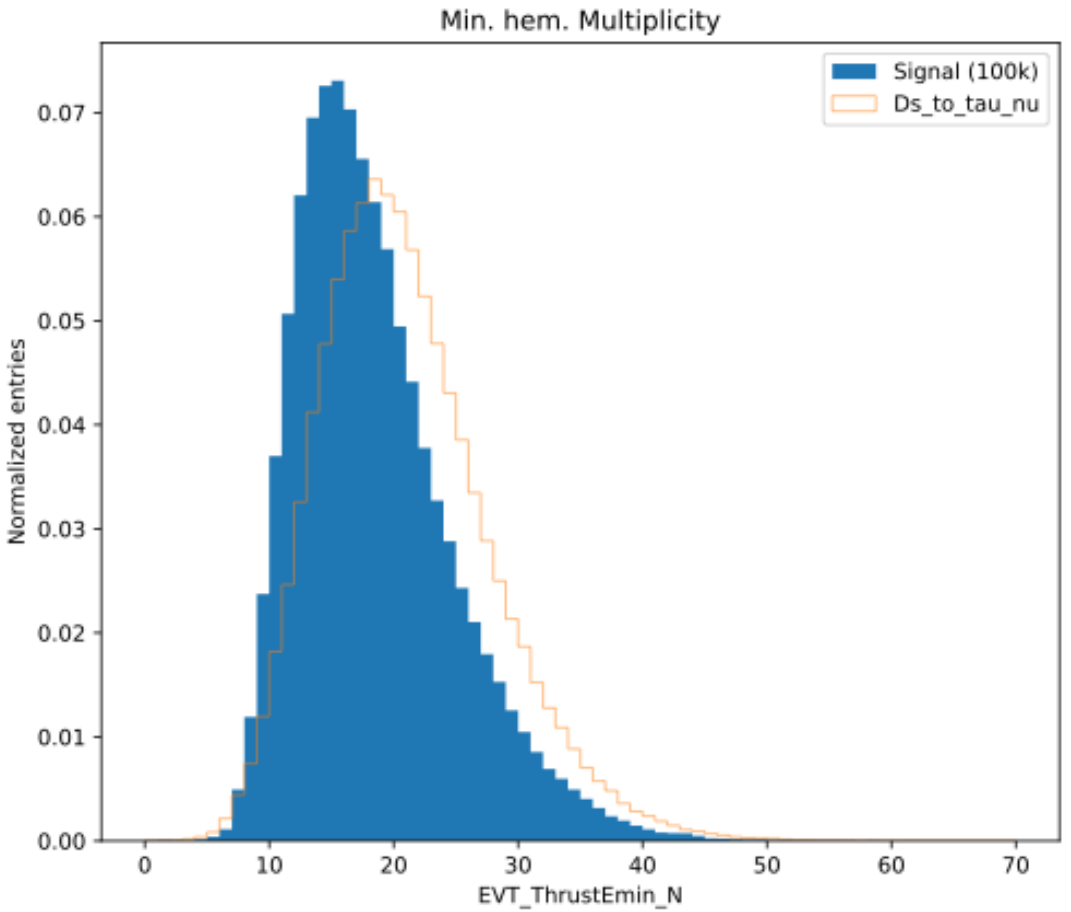


“EVT_ThrustEmin_N” (hard to distinguish example)

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$



$D_s \to \tau\, \nu_\tau$



Summary + Practical Next Steps

Status:

- Parquet files per decay mode available for analysis.
- Dictionary building was challenging; initially considered charge-aware dictionaries.
- Exploring cut regions (work in progress).

Next Steps:

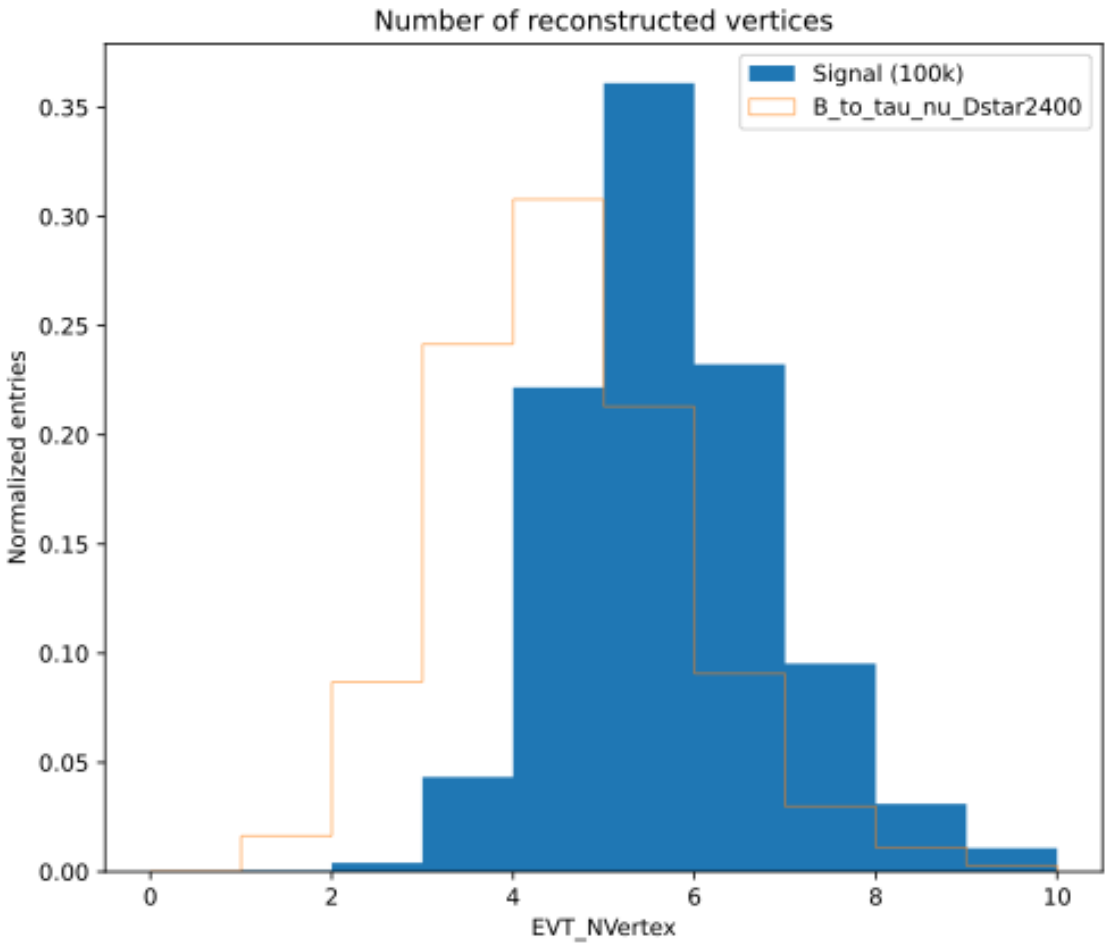
- Decide: **general cuts** vs. **decay-mode-specific cuts**.
- Identify background modes matching the **6-pion + neutrino final state**.
- Optimize cuts using **S/√B** (signal significance).
- Update and present efficiencies post-cuts.

- **Another topic:** Compare **LGATr vs. vanilla Transformer**.

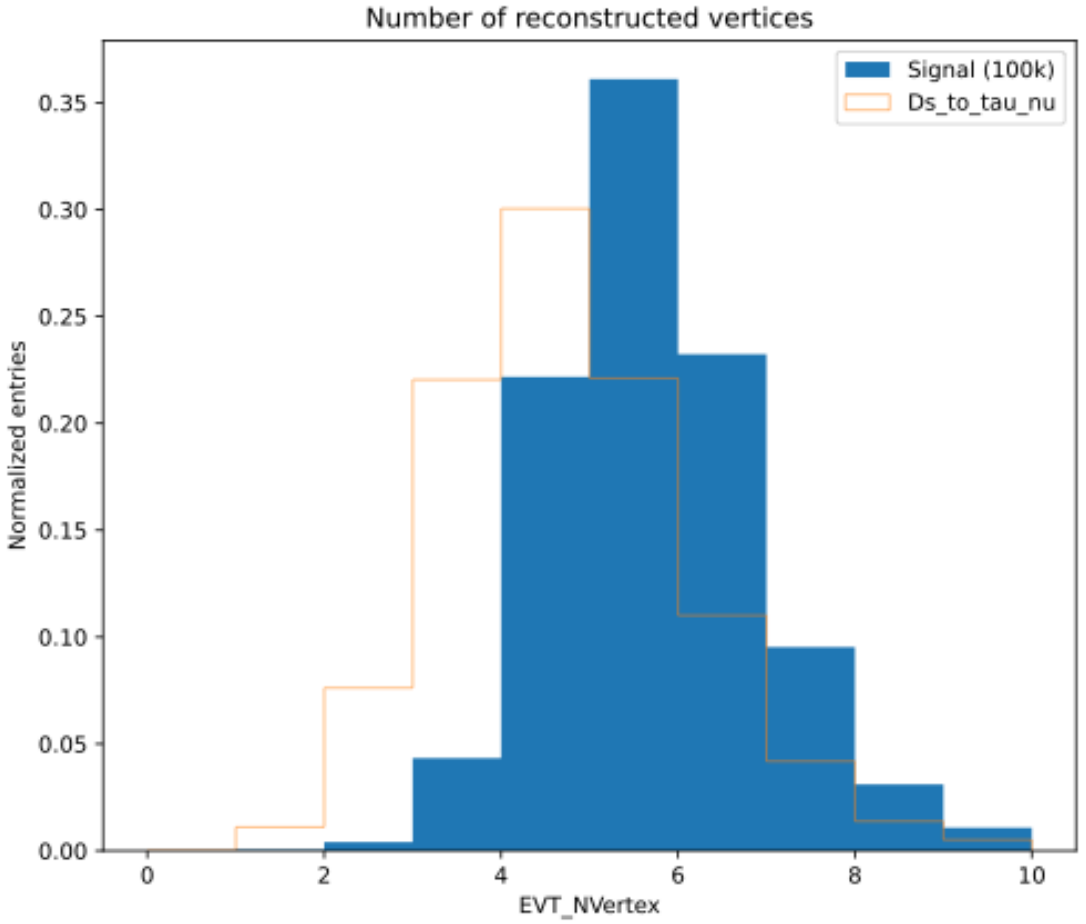
Thank you for your attention!

“EVT_NVertex”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

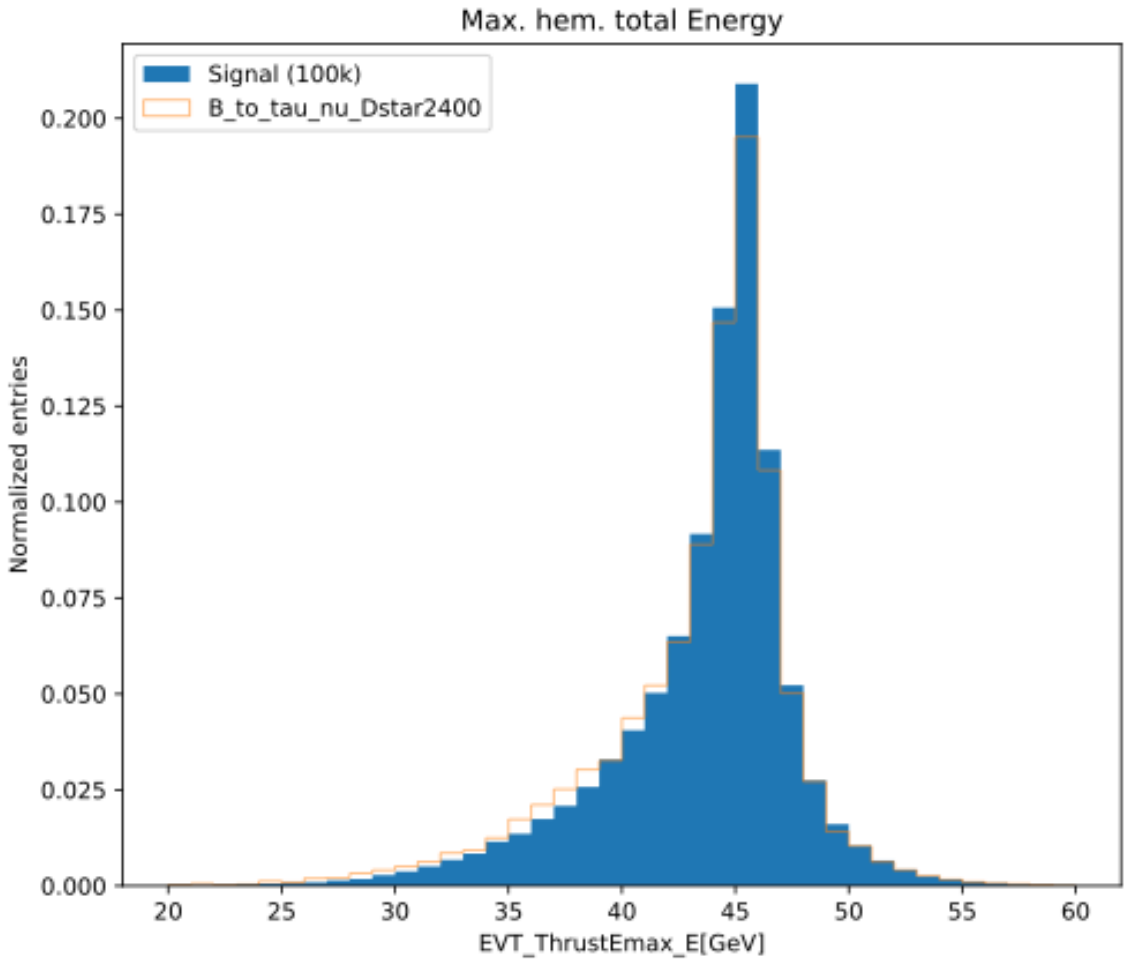


$D_s \to \tau\, \nu_\tau$

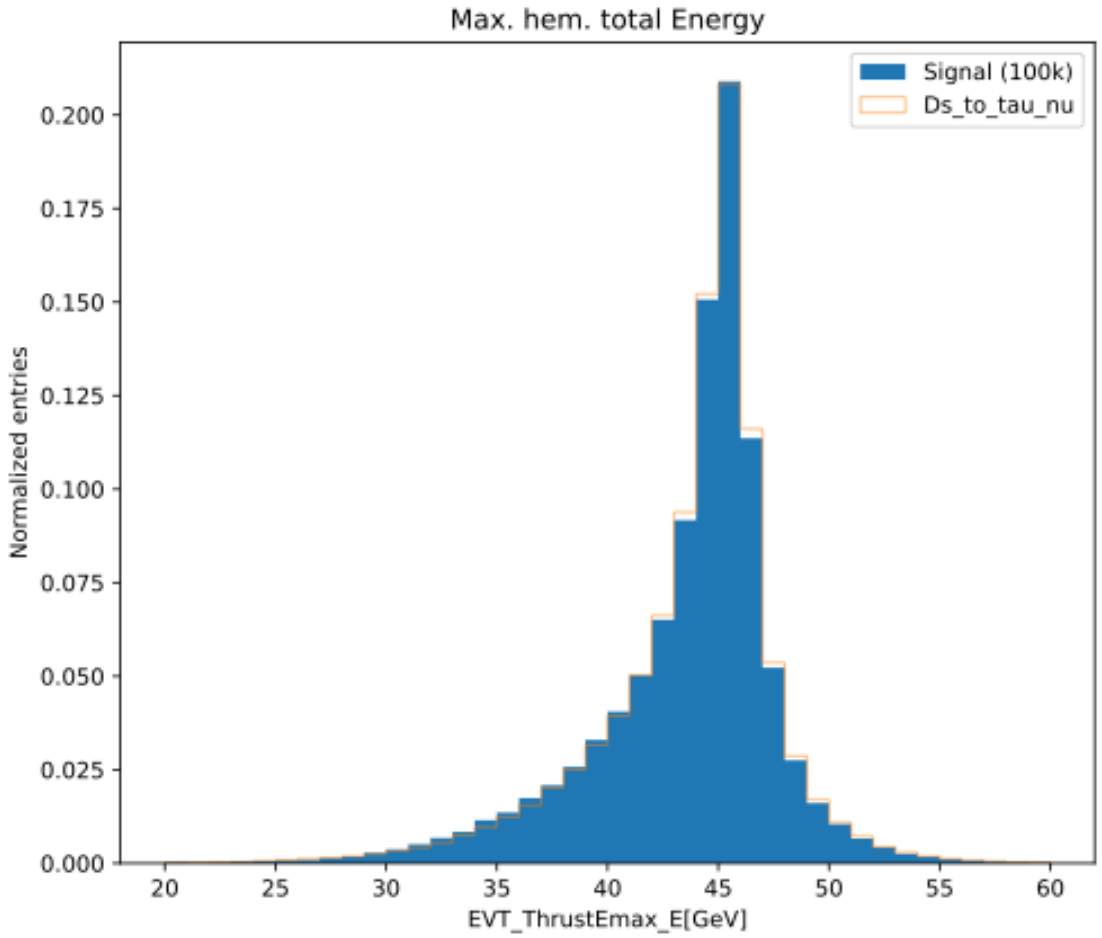


“EVT_ThrustEmax_E”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

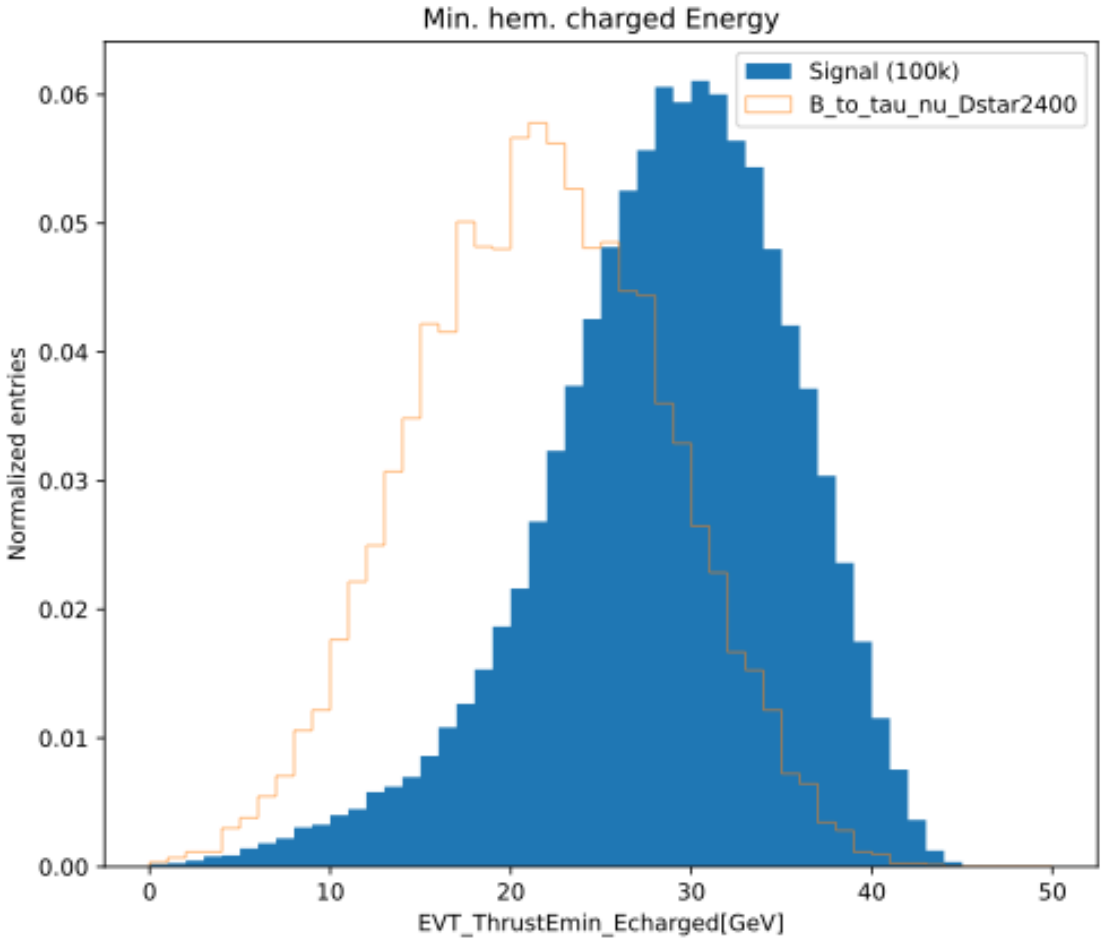


$D_s \to \tau\, \nu_\tau$

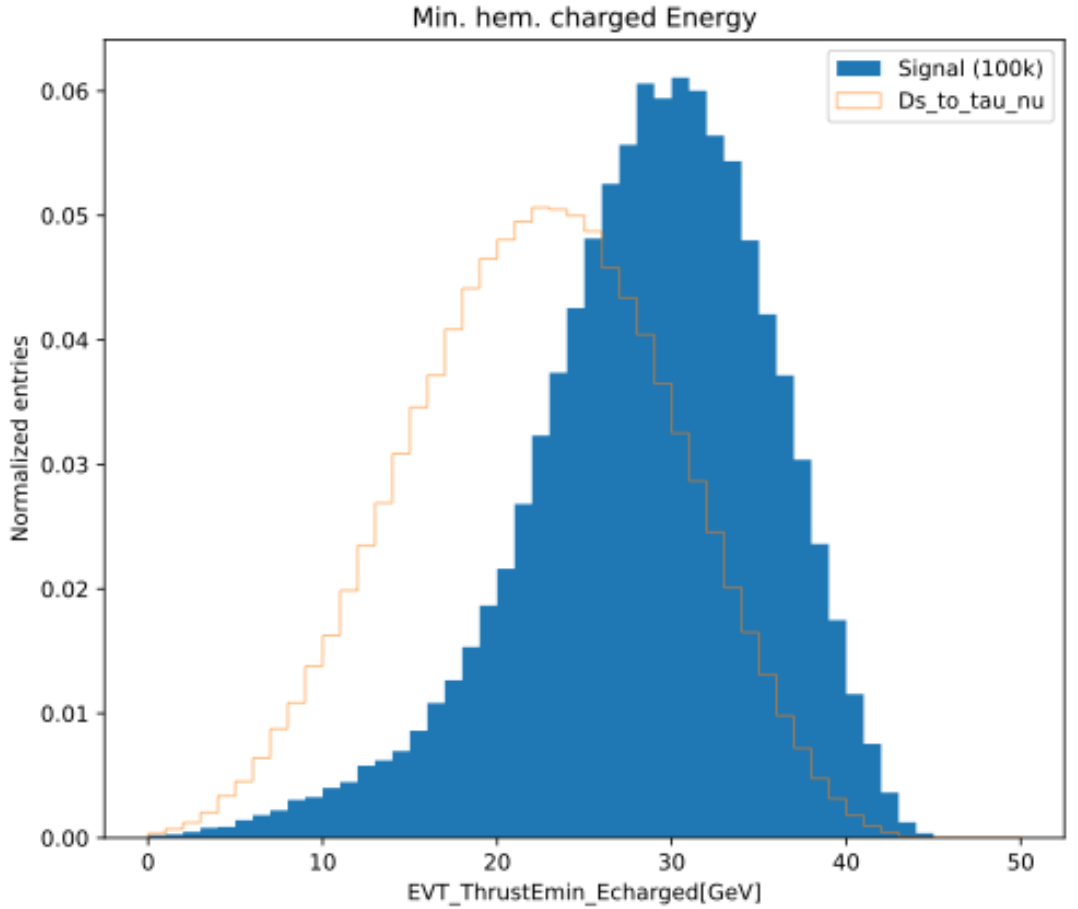


“EVT_ThrustEmin_Echarged”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

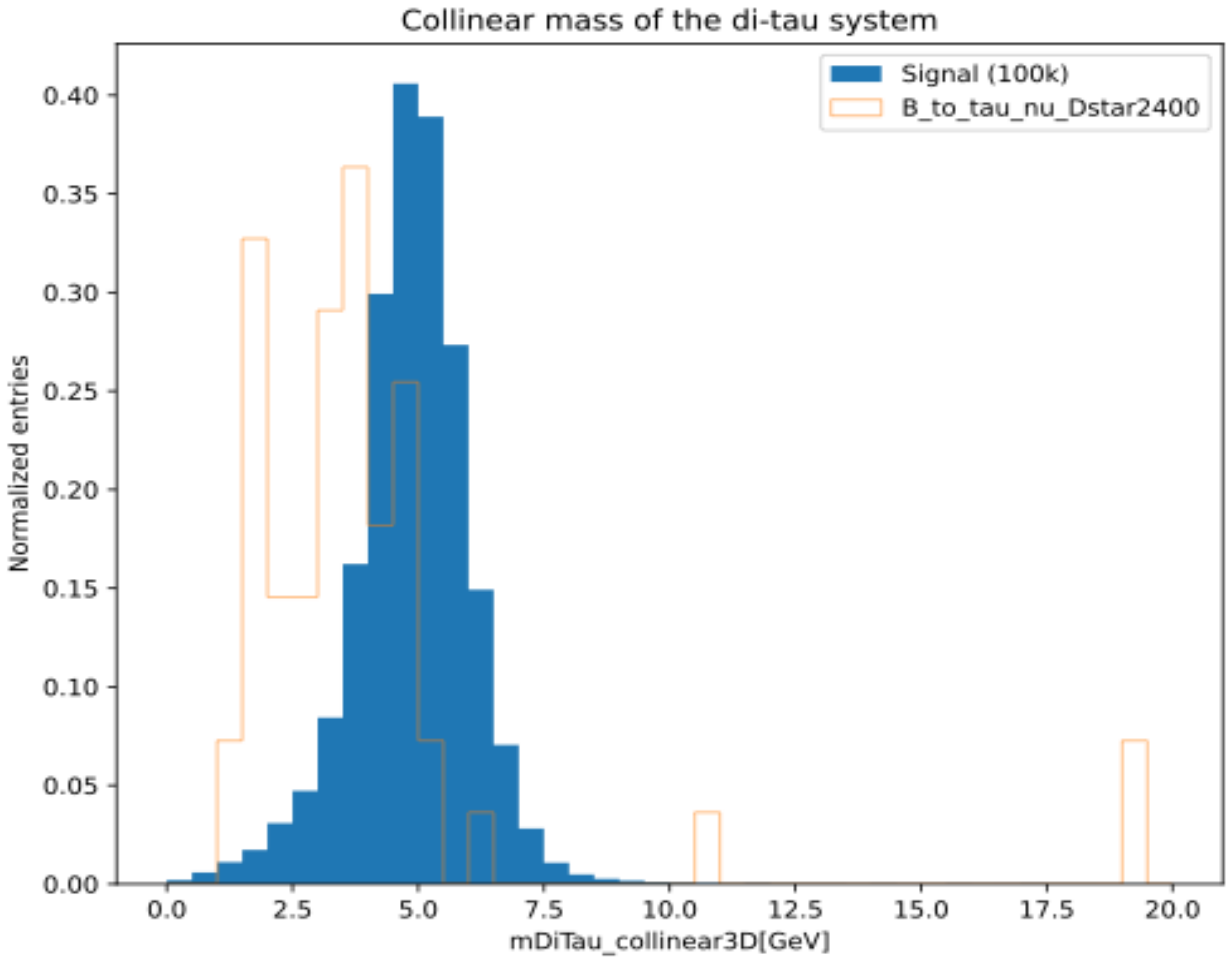


$D_s \to \tau\, \nu_\tau$

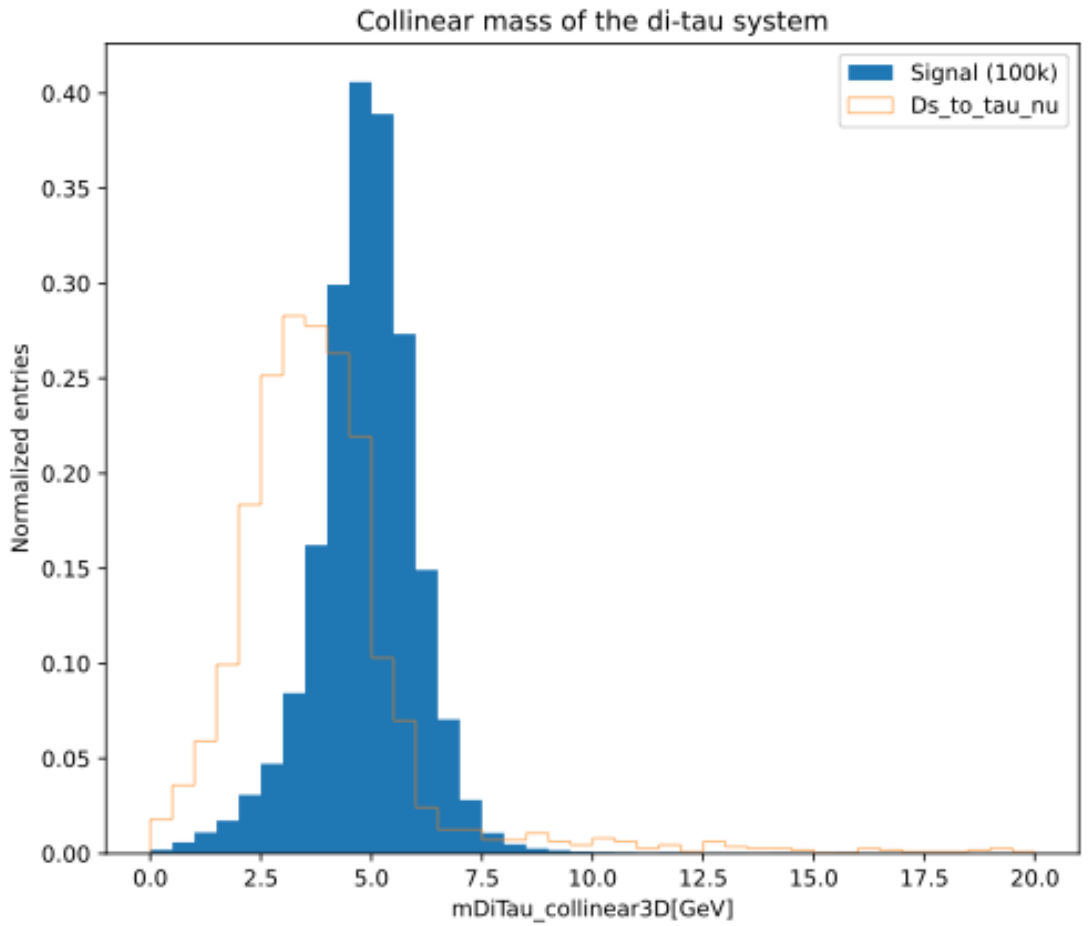


“mDiTau_Collinear3D”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$

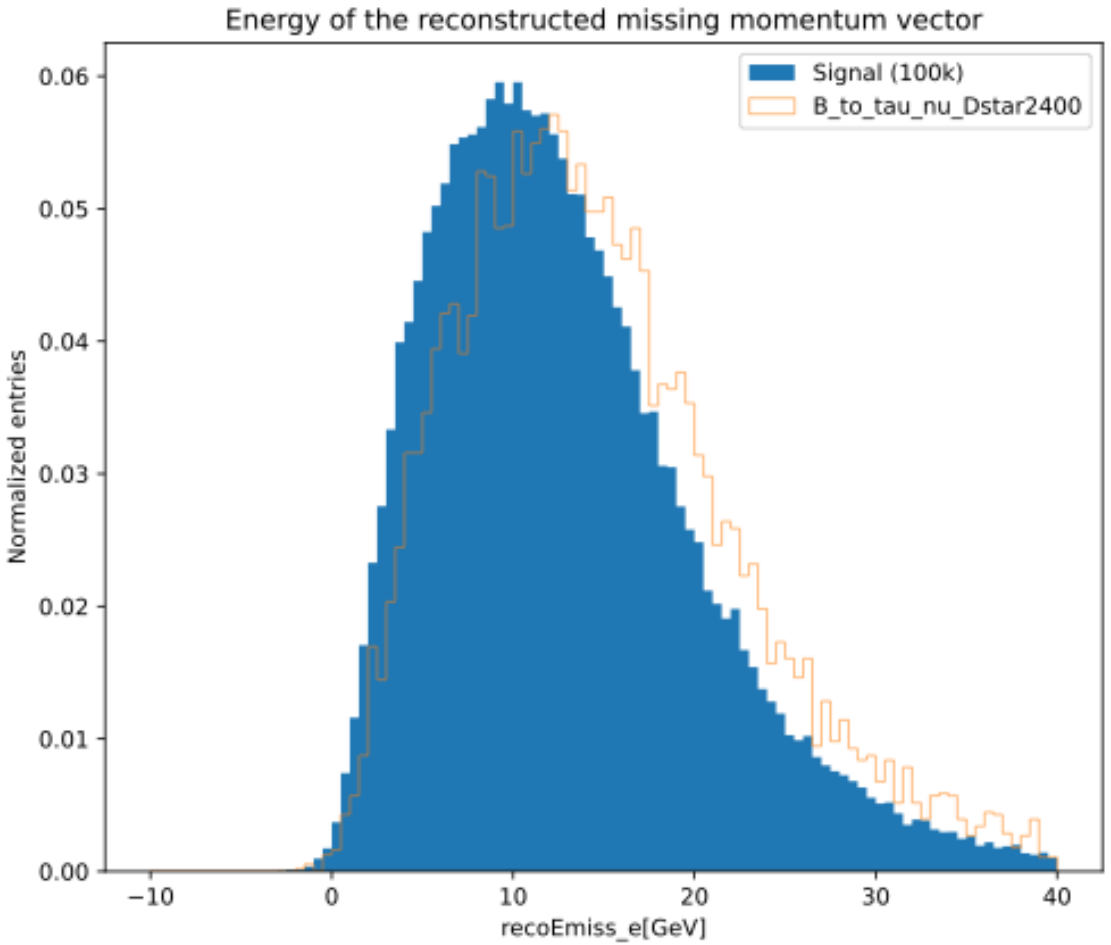


$D_s \to \tau\, \nu_\tau$



“recoEmiss_e”

$B_0 \to \tau\, \nu_\tau\, \mathrm{D}_2(2400)$



$D_s \to \tau\, \nu_\tau$