

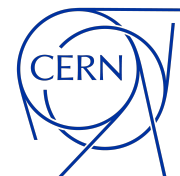
τ reconstruction at the Muon Collider

*Kevin Dewyspelaere, Giacomo Da Molin, Giovanni
Battista Marozzo*

Under the supervision of Michele Gallinaro

July 2nd, 2025

LIP - Laboratório de Instrumentação e Física Experimental
de Partículas



Introduction: Plan for the analysis



τ energy correction: $\Leftarrow$ (Current Phase)

- Fit on the distribution of MC τ energy in function of Rec τ energy done separately for different reconstructed τ decay modes

Physics Channel:

- Generate and reconstruct $Z \rightarrow \tau\tau$ and $H \rightarrow \tau\tau$ (**Giovanni generated them**)
- Correct τ energy
- Compare invariant mass distributions

Jets study:

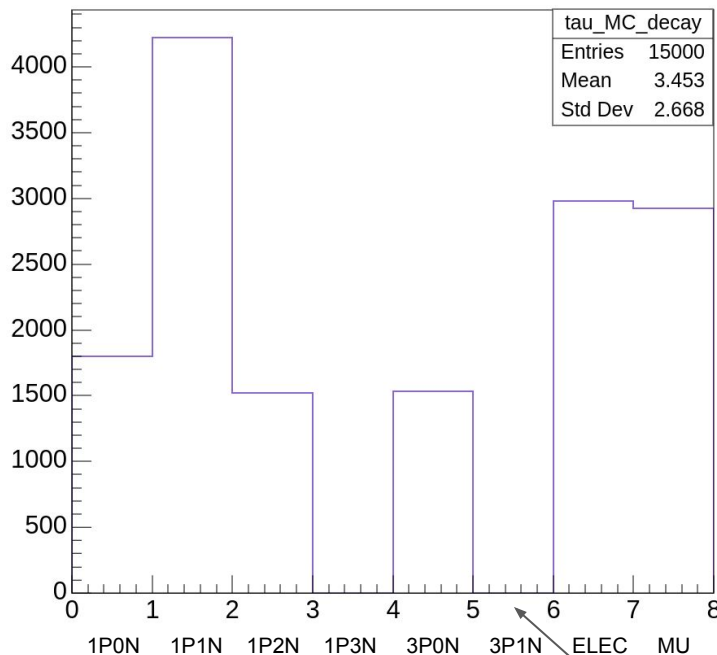
- For $Z \rightarrow jj$ and $H \rightarrow bb$
- See how many jets are seen as τ

MC Vs Reconstructed decay modes



15000 τ events generated: $0 \leq \varphi \leq 2\pi$ rad; $10^\circ \leq \theta \leq 170^\circ$; $20 \leq p_T \leq 320$ GeV/c

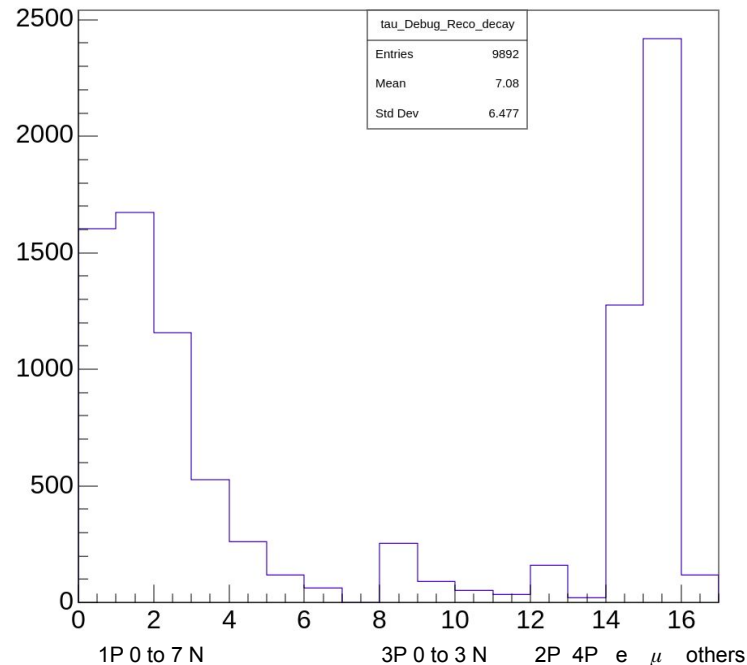
MC tau decay mode



with **N** = considered as **Neutral pions**

No events in 3P1N should see 300

Debug reco tau decay mode



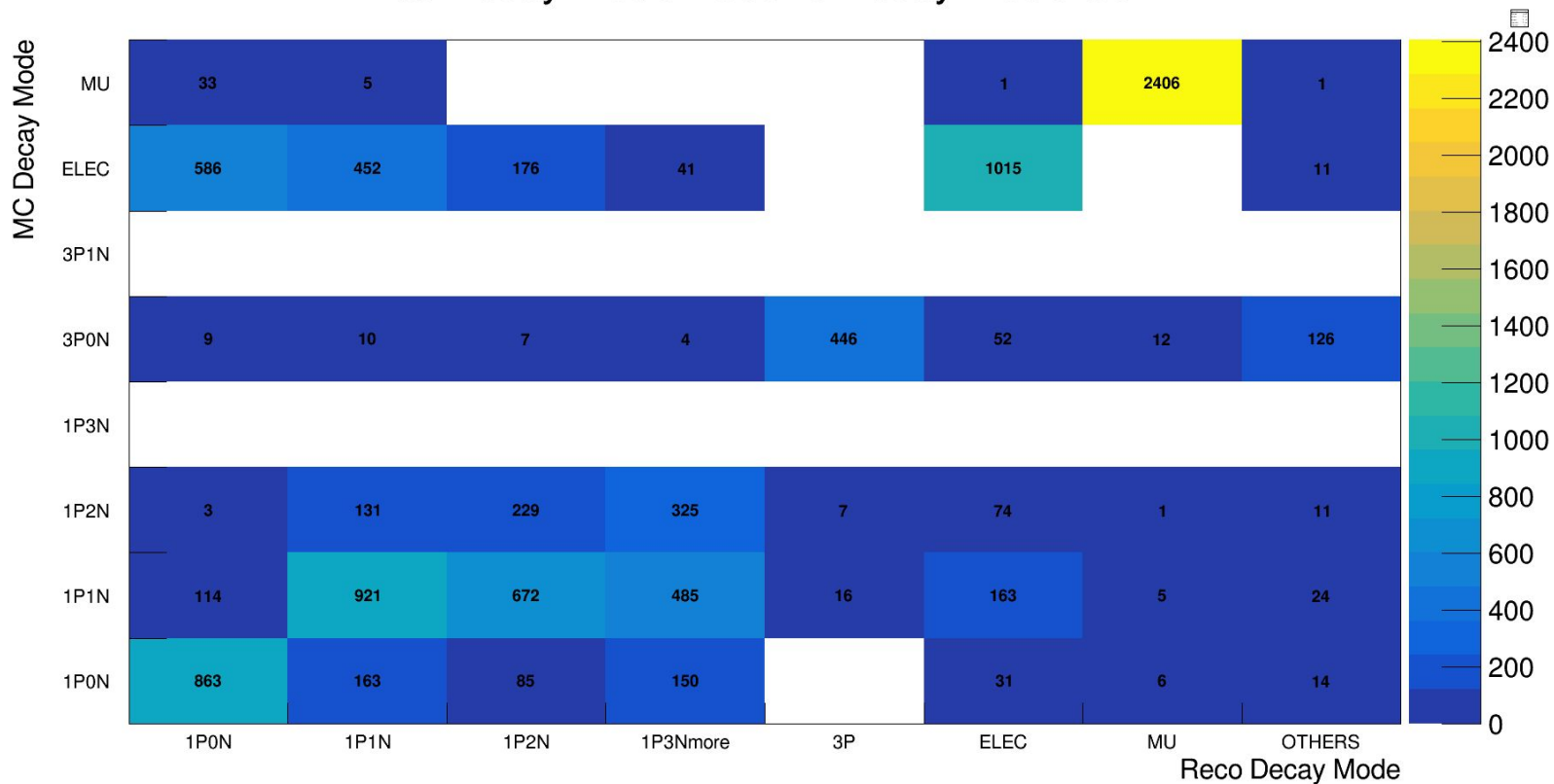
with **N** = considered as **Photons and Neutrons**

DEWYSPELAERE Kevin

MC Vs Reconstructed decay modes



Tau Decay Mode Reco vs Decay Mode Gen



with **N** = considered as **Neutral pions** for **MC** & considered as **photons and Neutrons** for **Reconstructed**

MC Vs Reconstructed decay modes



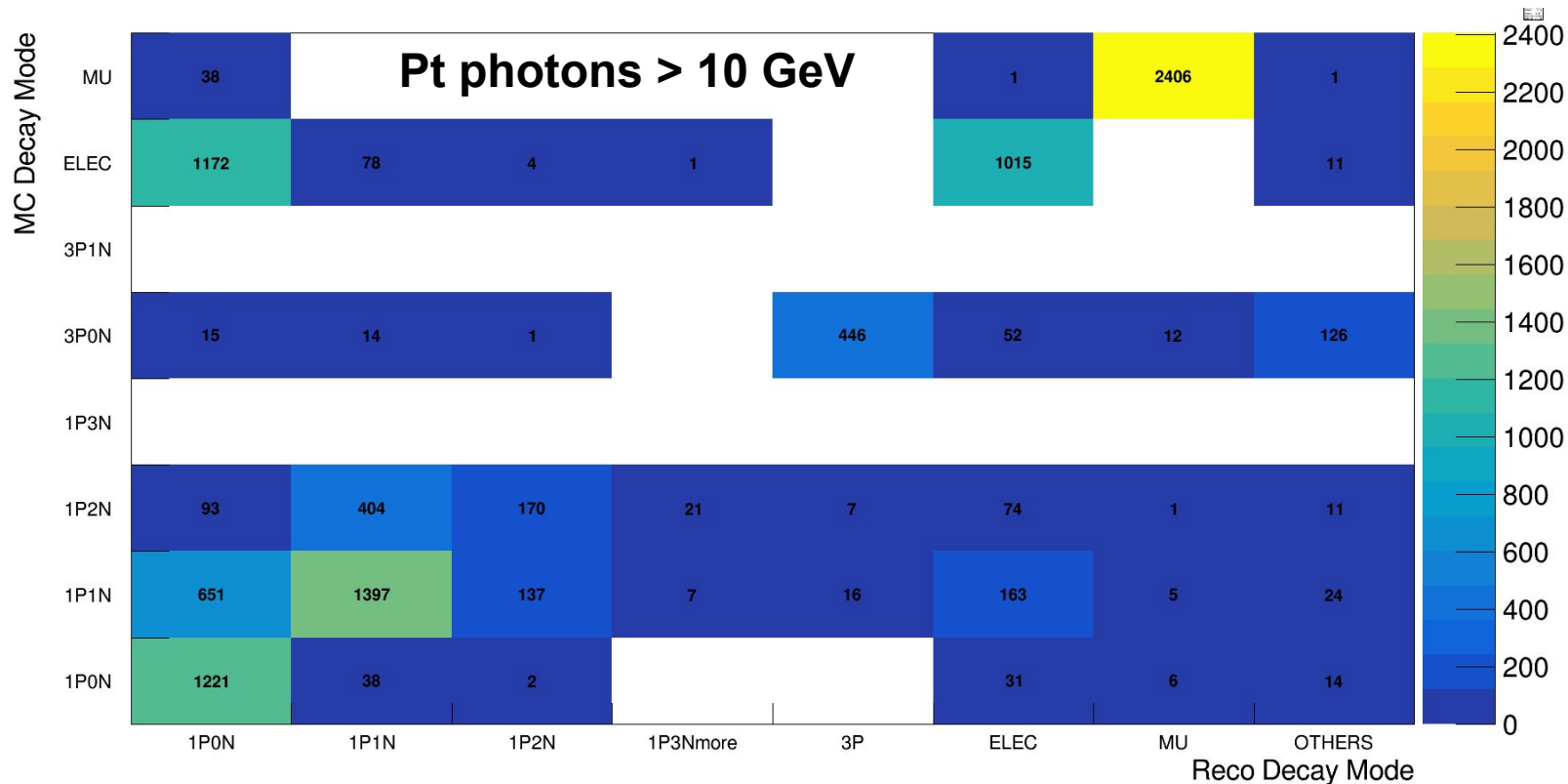
What we can observe:

- A lot of MC τ that decays into **electrons** events are reconstructed as **1 prong** events
- MC τ tagged as **1P1N** smeared into different **1P** categories same for MC **1P2N**
 $\Rightarrow$ In the next slides we are going to put a **minimum pT requirement** on the **photons** and observe how the previously shown decay mode matrix changes
- Good Match for τ that decays into **Muons**

Requirement on Pt of reconstructed photons



Tau Decay Mode Reco vs Decay Mode Gen Filtered neutrals

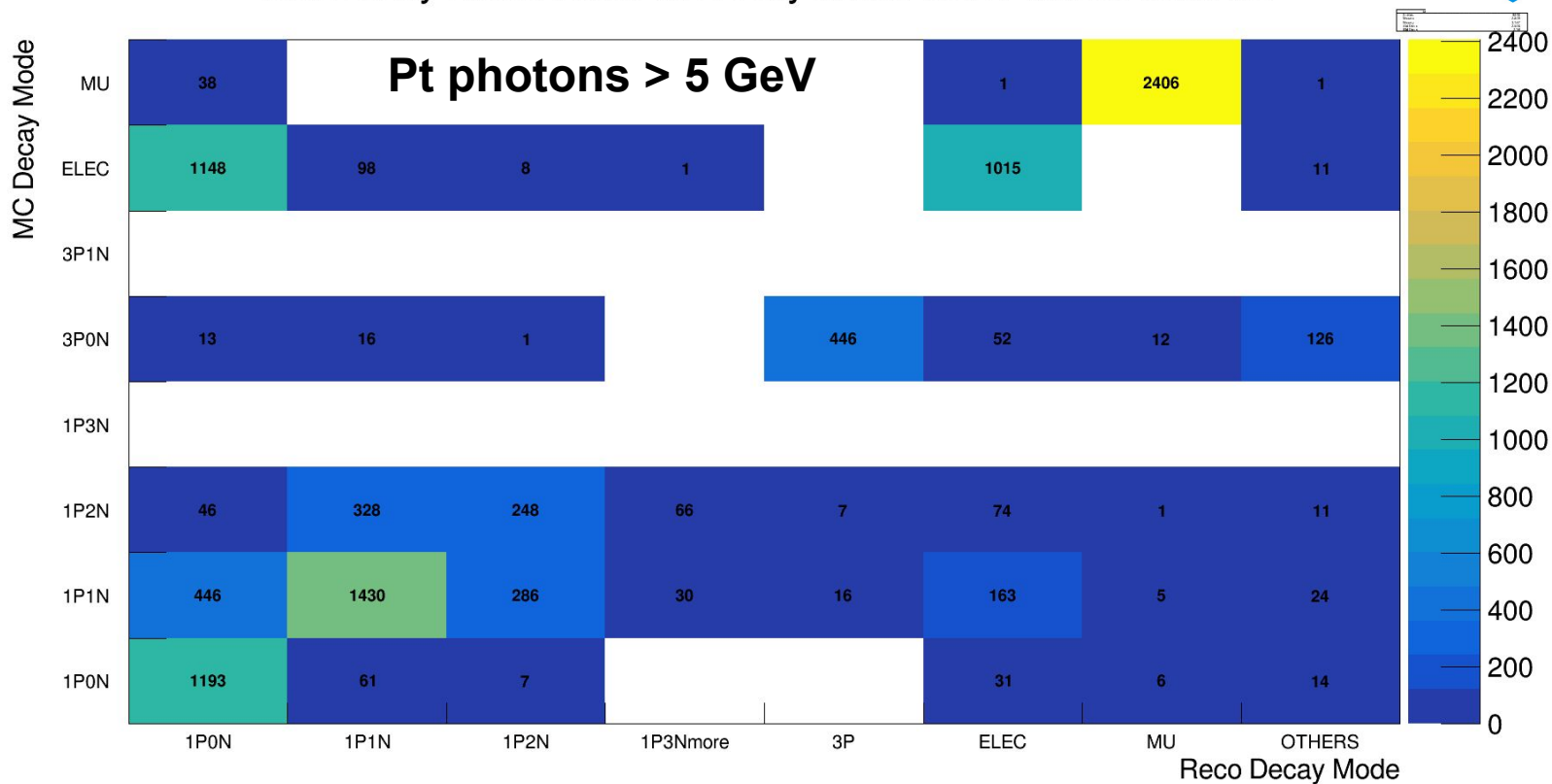


with **N** = considered as **Neutral pions** for **MC** & considered as **photons and Neutrons** for **Reconstructed**

Requirement on Pt of reconstructed photons



Tau Decay Mode Reco vs Decay Mode Gen Filtered neutrals

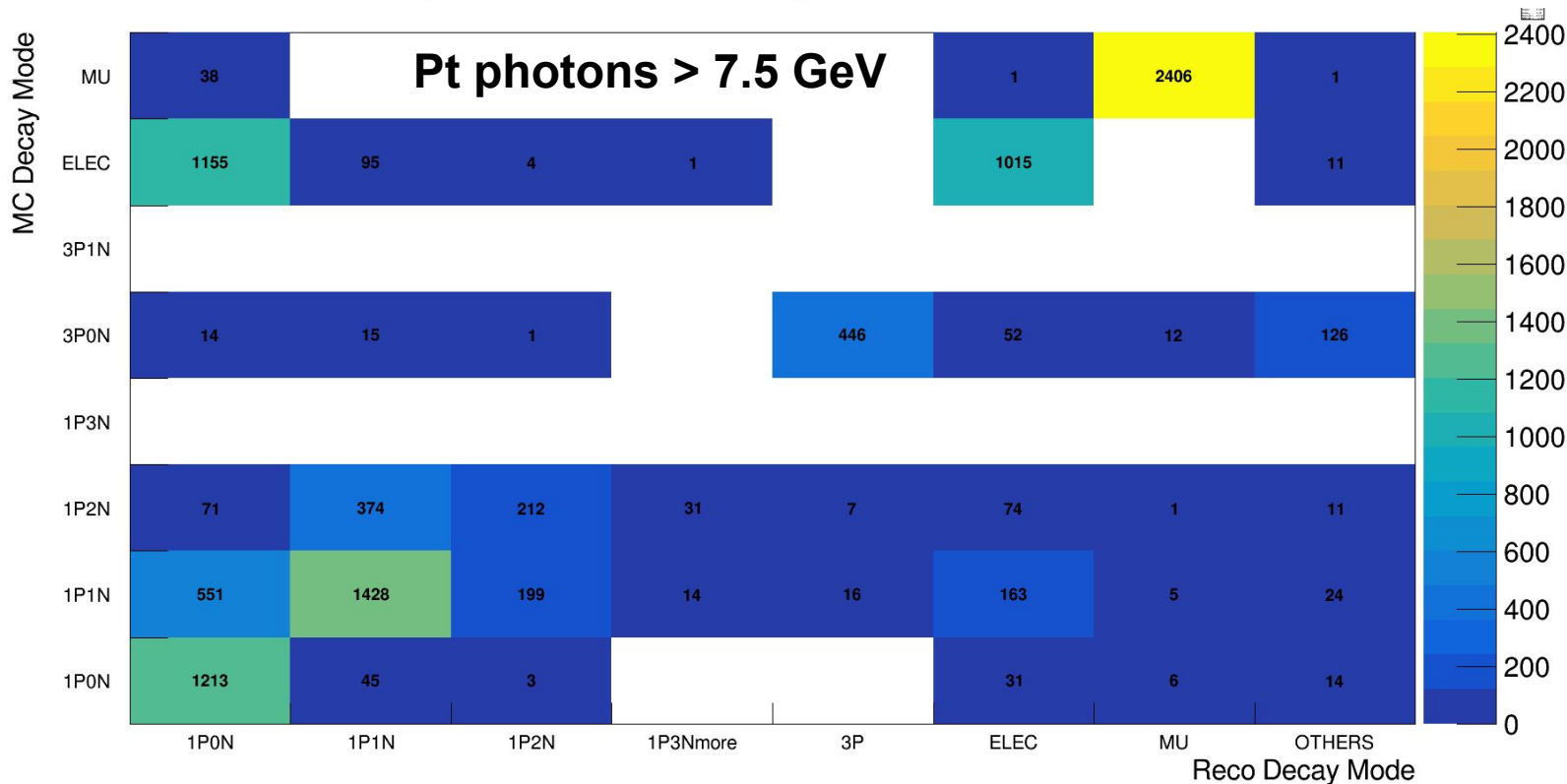


with **N** = considered as **Neutral pions** for **MC** & considered as **photons and Neutrons** for **Reconstructed**

Requirement on Pt of reconstructed photons



Tau Decay Mode Reco vs Decay Mode Gen Filtered neutrals



with **N** = considered as **Neutral pions** for **MC** & considered as **photons and Neutrons** for **Reconstructed**



What we can observe:

- Events with multiple neutrals are transferred toward categories with less neutrals
- Putting a high requirement slides to much categories, so it seems that a cut between 5 and 10 GeV on the pt of photons seems good

τ energy correction



When the visible products of the τ leptons interact with the detector, they are reconstructed with an energy that can differ from their true energy.

⇒ We apply corrections by fitting the distribution of the reconstructed pt against generated pt

⇒ Without cut on the pt of photons

τ energy correction

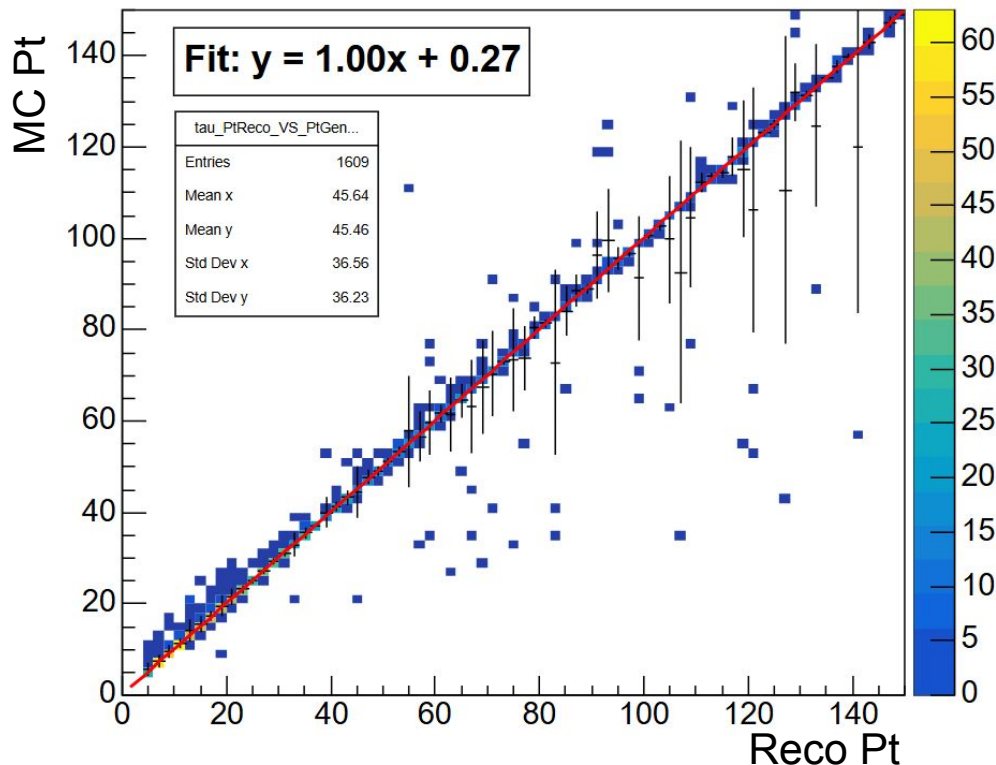


With the slope (a) we calculate:
 $E_{\text{corr}} = a * E_{\text{reco}}$

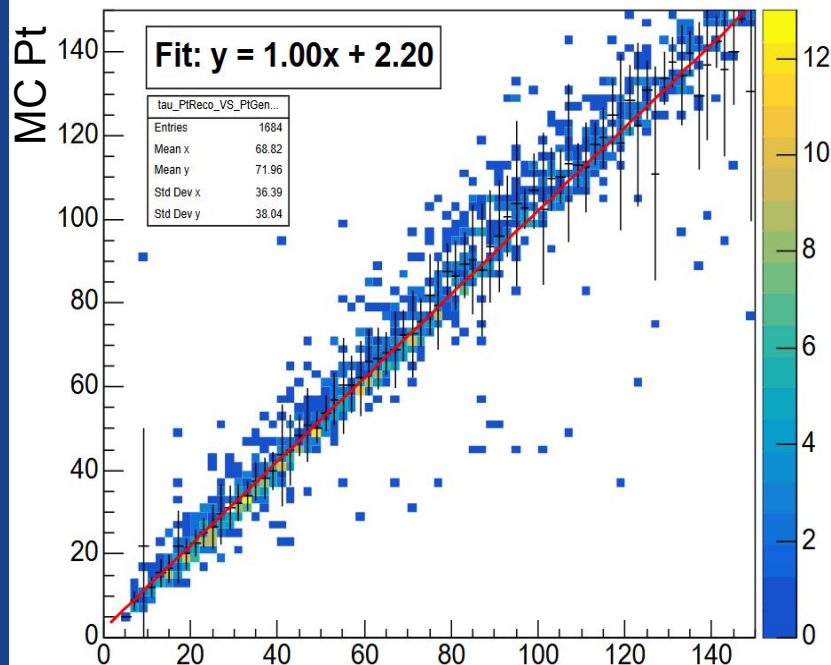
Intercept is useful to see the general bias for the whole distribution
 $\Rightarrow$ Higher with Neutrals

$\Rightarrow$ As planned leptons barely don't need any corrections

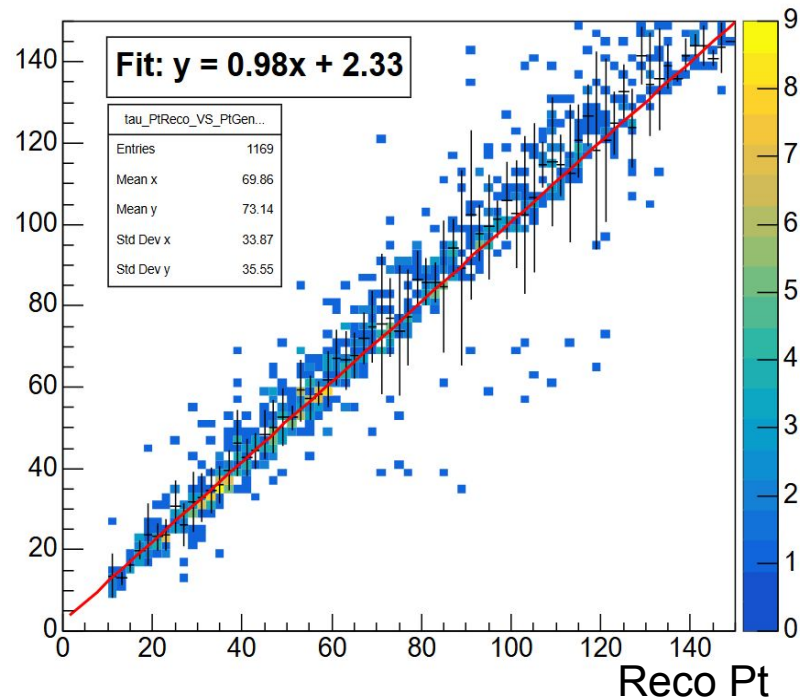
Tau reco pt vs Visible gen pt 1P0N



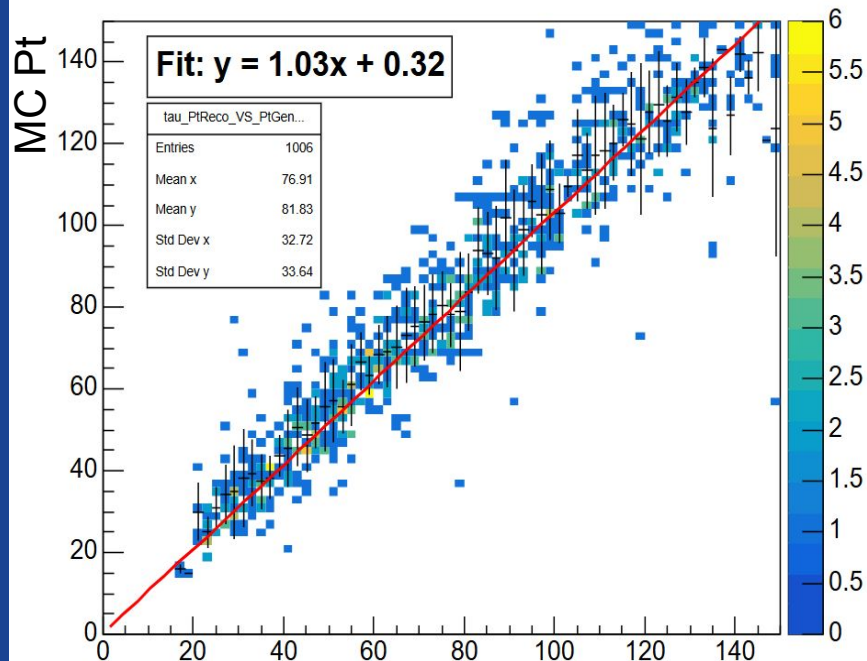
Tau reco pt vs Visible gen pt 1P1N



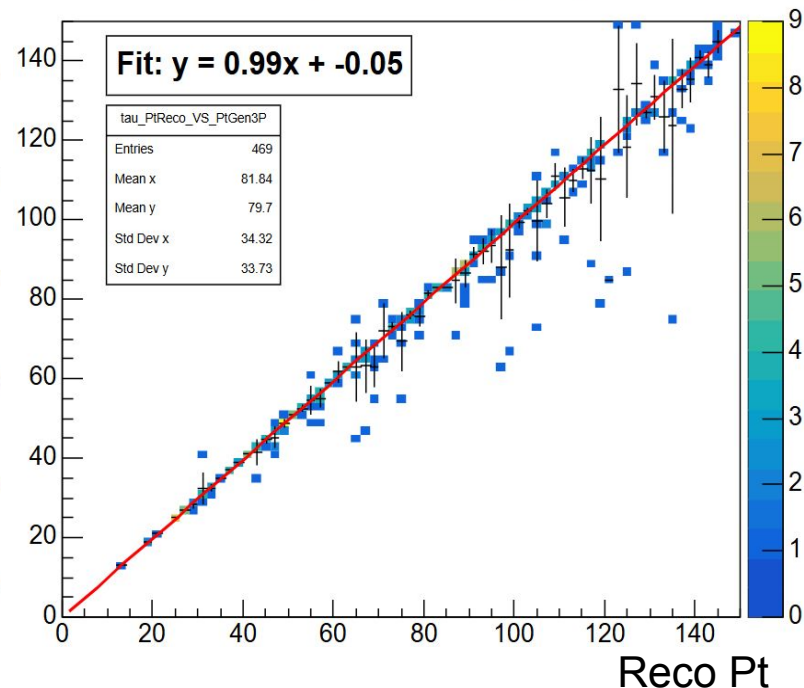
Tau reco pt vs Visible gen pt 1P2N



Tau reco pt vs Visible gen pt 1P3Nmore



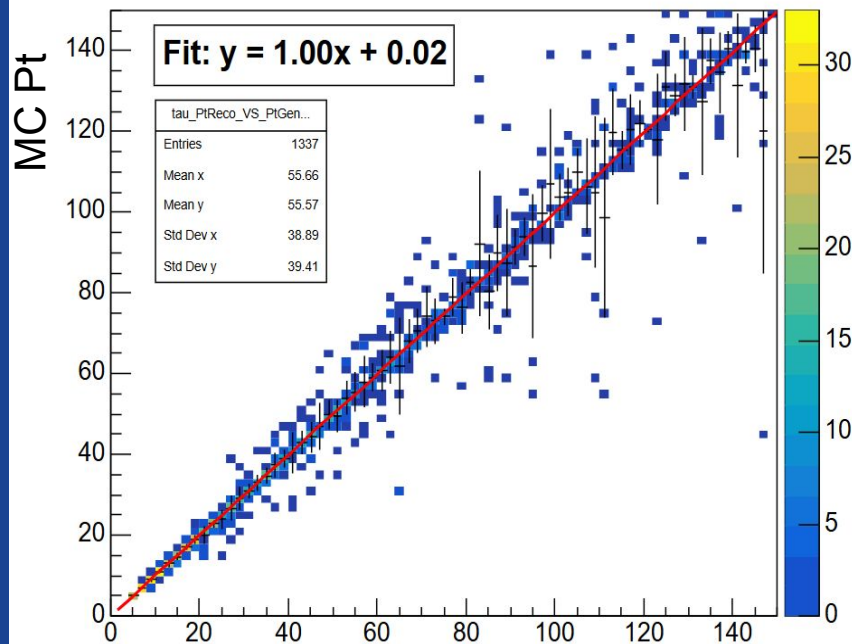
Tau reco pt vs Visible gen pt 3P



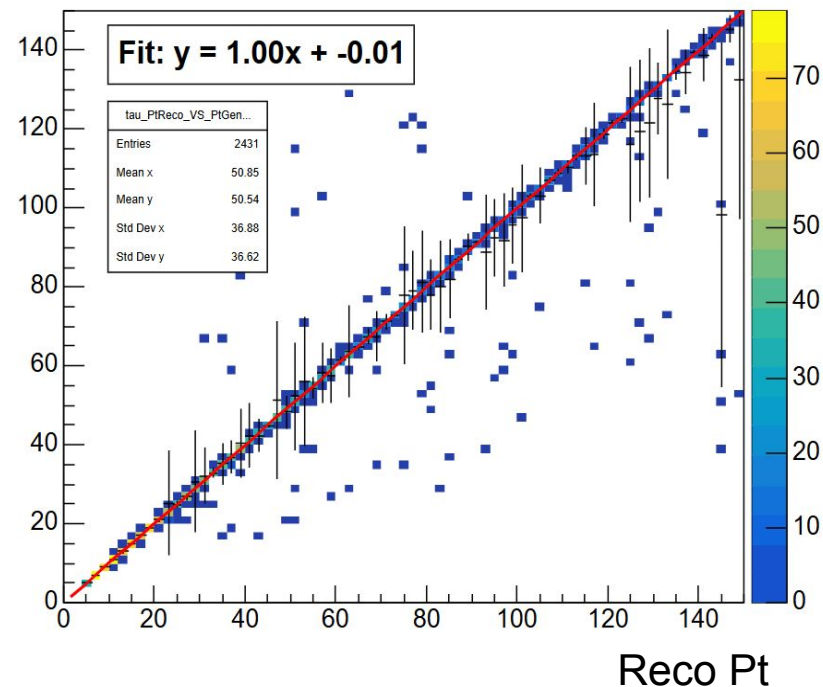
τ energy correction



Tau reco pt vs Visible gen pt Elec



Tau reco pt vs Visible gen pt Muon





⇒ Investigated on the different decay mode of MC and reconstructed taus

⇒ Tau decay mode reco vs gen shows that there is a lot of tau decaying into electrons in MC that are mismatched as 1P0N

⇒ Requirement on photons reconstructed pt gives a better match for 1 prong categories

⇒ Tau energy corrections are giving good results

Thank you for your attention

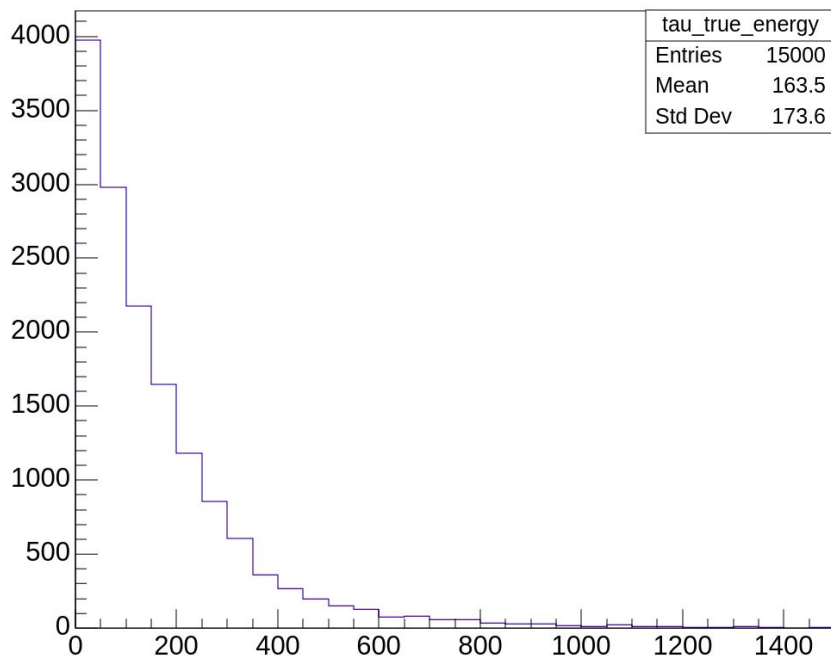
Current state analysis



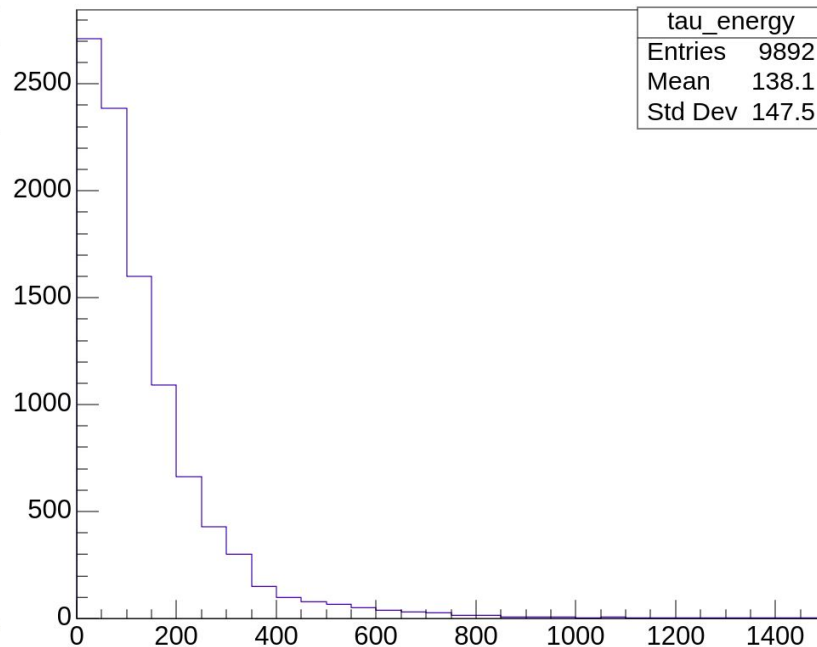
τ energy comparison between MC & Reco:

- ~ Efficiency of ~66% in total

True Tau Visible Energy



Reconstructed Tau Energy



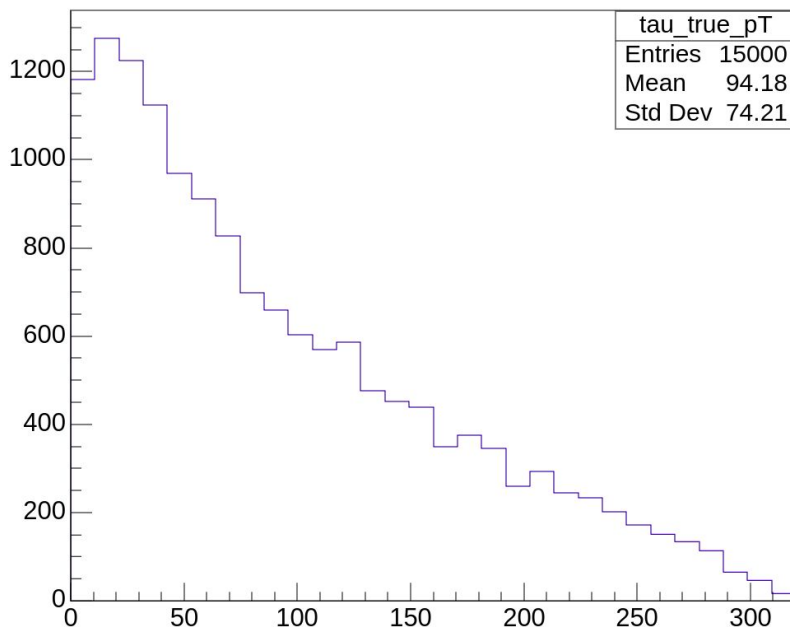
Current state analysis



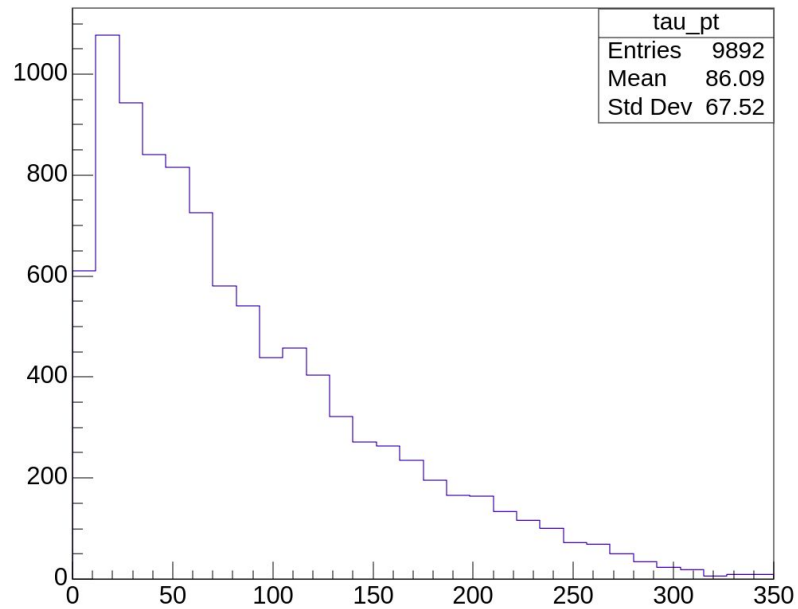
τ pt comparison between MC & Reco:

- ~ Efficiency of ~66% in total

True Tau Visible Pt



Reconstructed Tau Pt

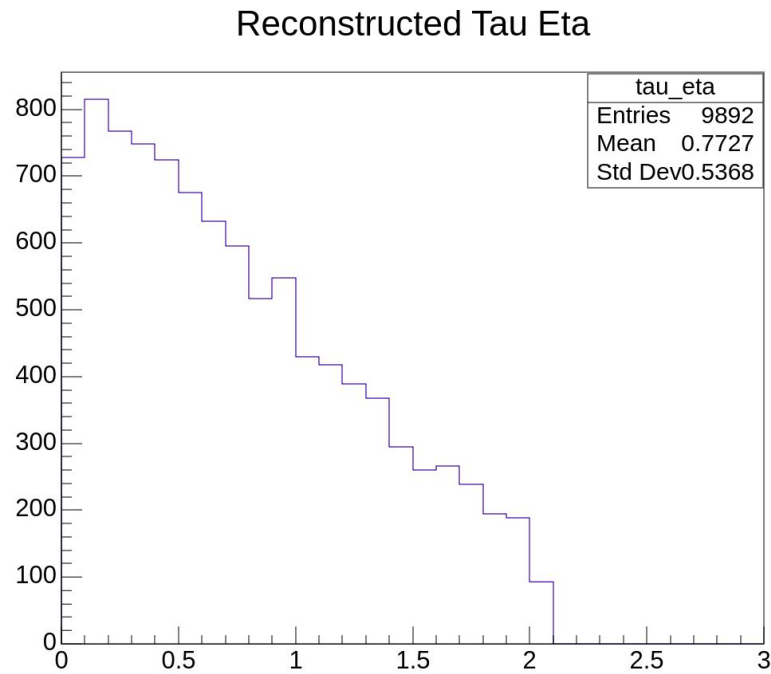
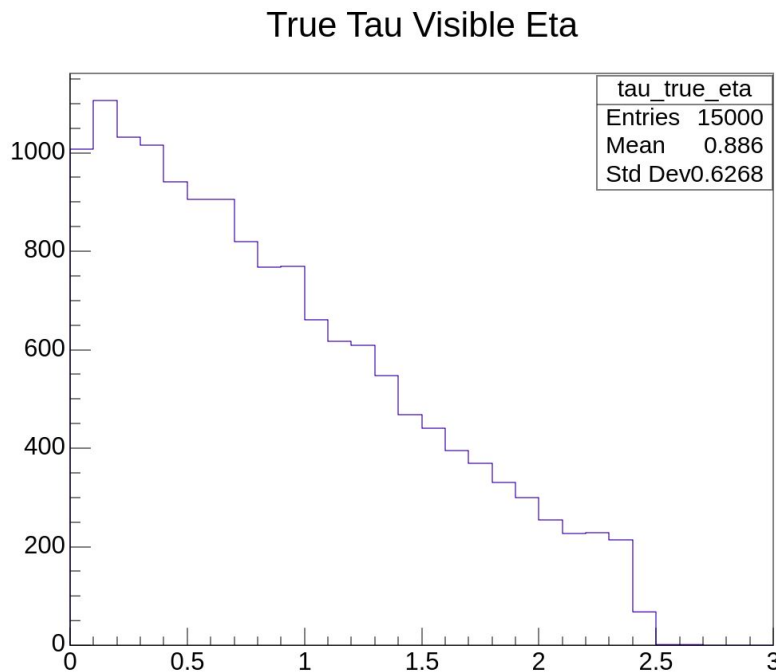


Current state analysis



τ eta comparison between MC & Reco:

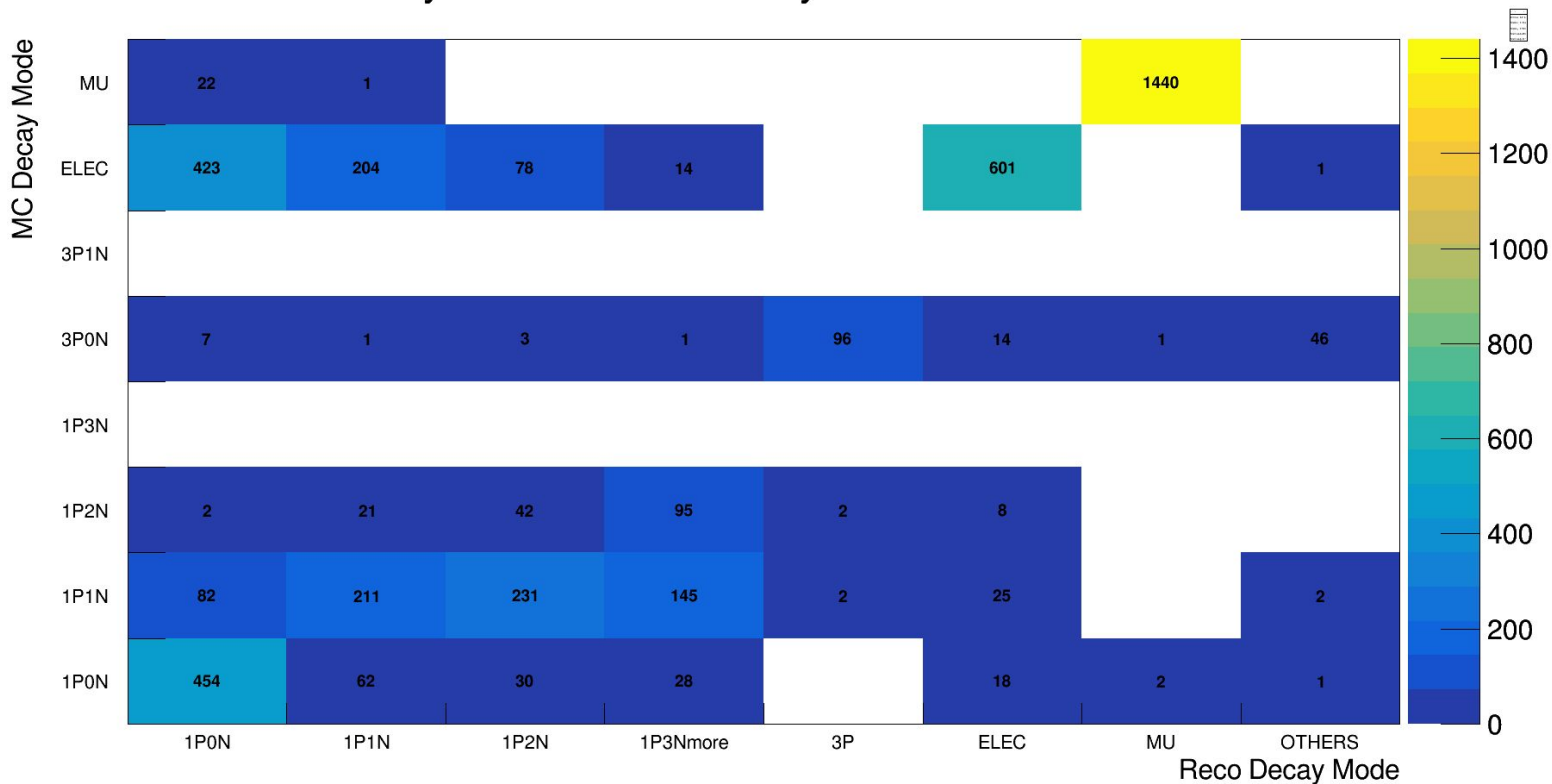
- ~ Efficiency of ~66% in total



MC Vs Reconstructed decay modes



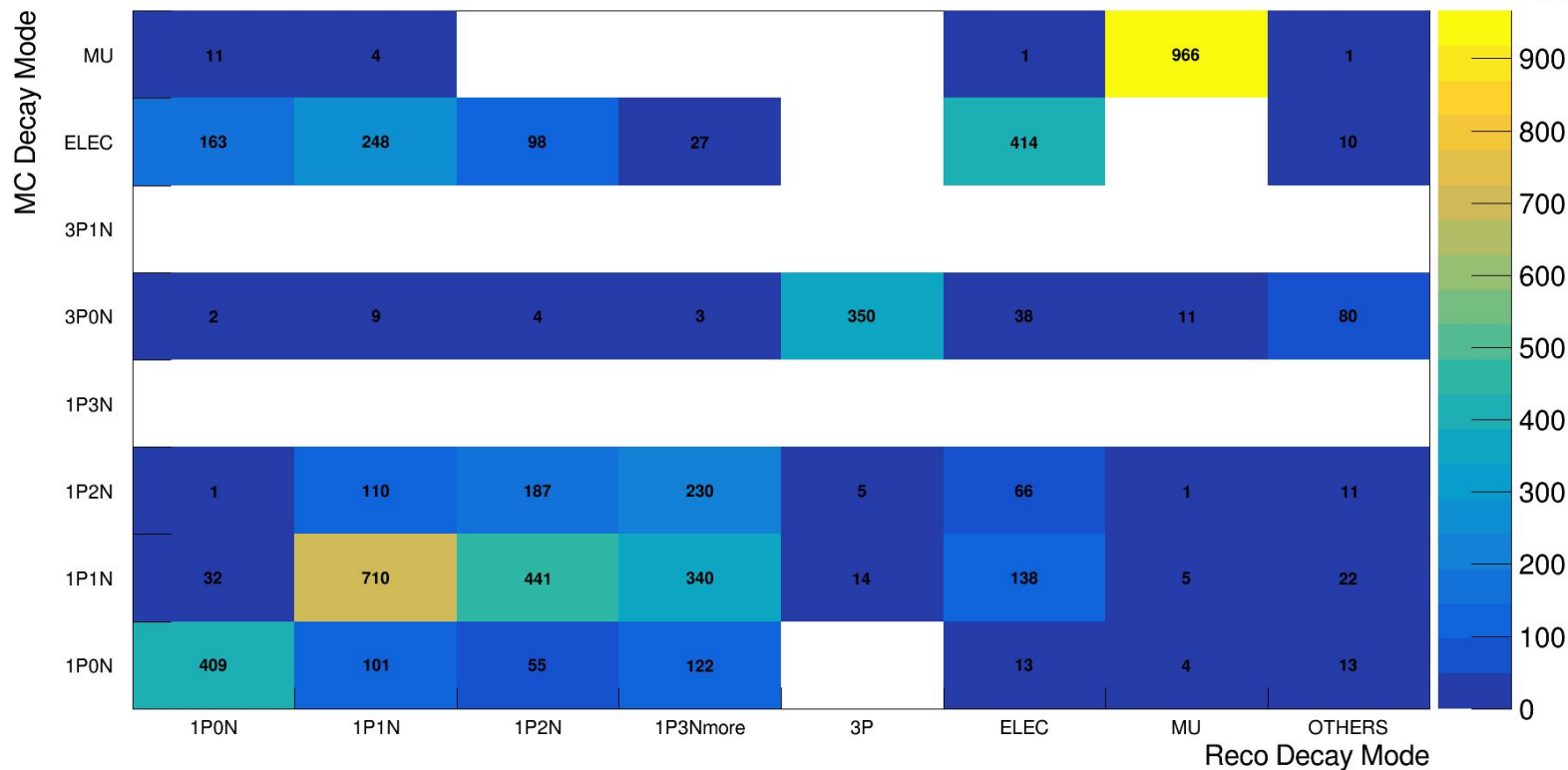
Tau Decay Mode Reco vs Decay Mode Gen Pt 0 to 60 GeV



with **N** = considered as **Neutral pions** for **MC** & considered as **photons and Neutrons** for **Reconstructed**

MC Vs Reconstructed decay modes

Tau Decay Mode Reco vs Decay Mode Gen Pt >60 GeV



with **N** = considered as **Neutral pions** for **MC** & considered as **photons and Neutrons** for **Reconstructed**