Study: Improve the Tau Reconstruction

By Rejecting e+/e- Tracks from Photon Conversions

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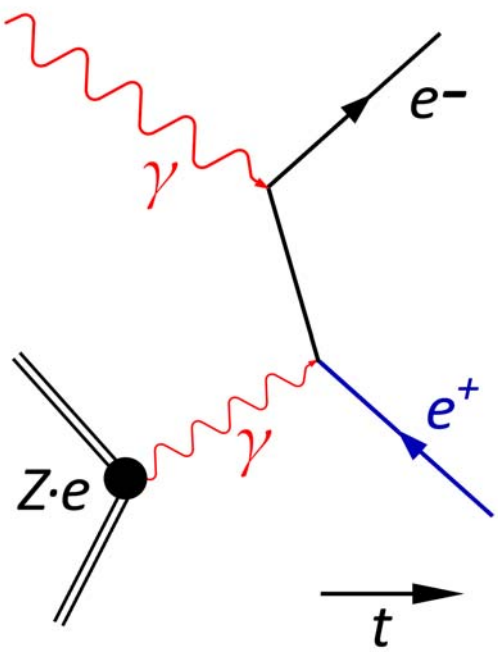
Outline

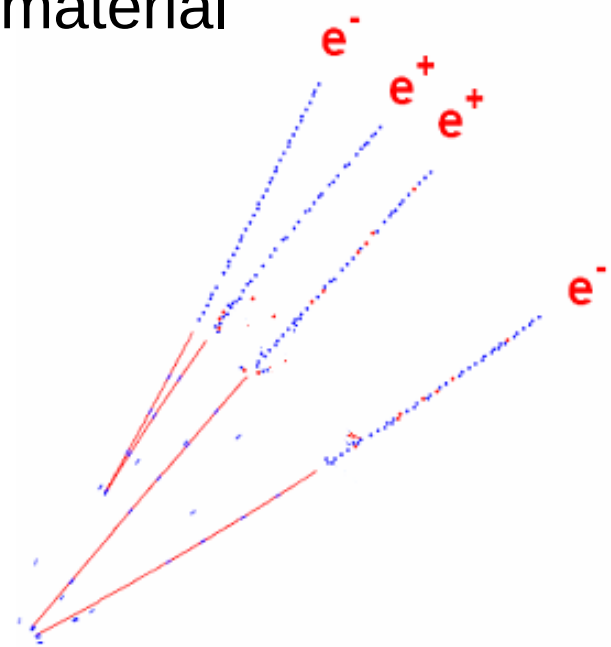
1. Photon Conversions
   - ConversionFinderTool
2. τ-decay and Reconstruction
   - TauRec algorithm
3. Rejection of τ-tracks
   - How we would like to implement a rejection algorithm

1. Photon Conversions

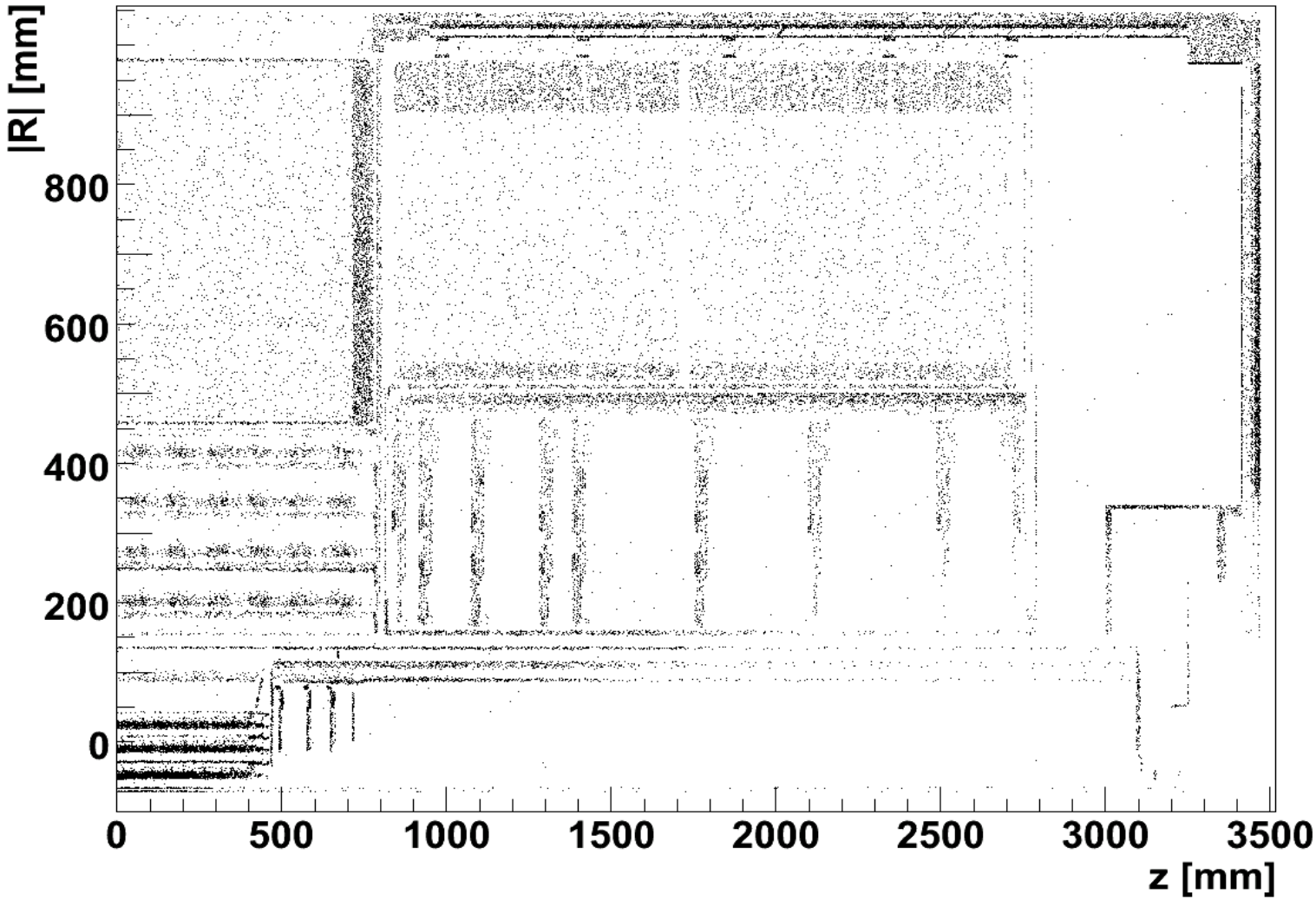
What is a Photon Conversion?



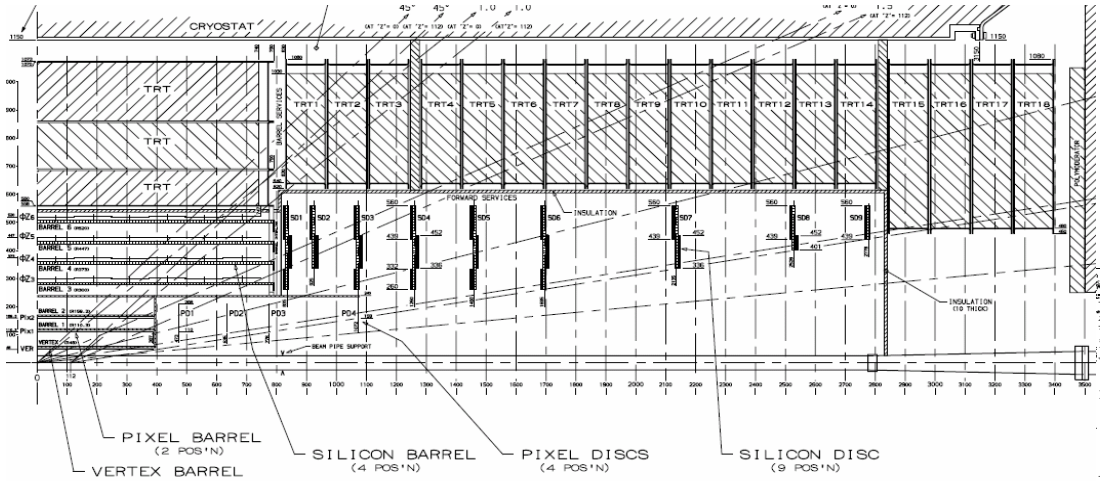
- pair creation
  - e+/e- pair
- high energetic photon
- material



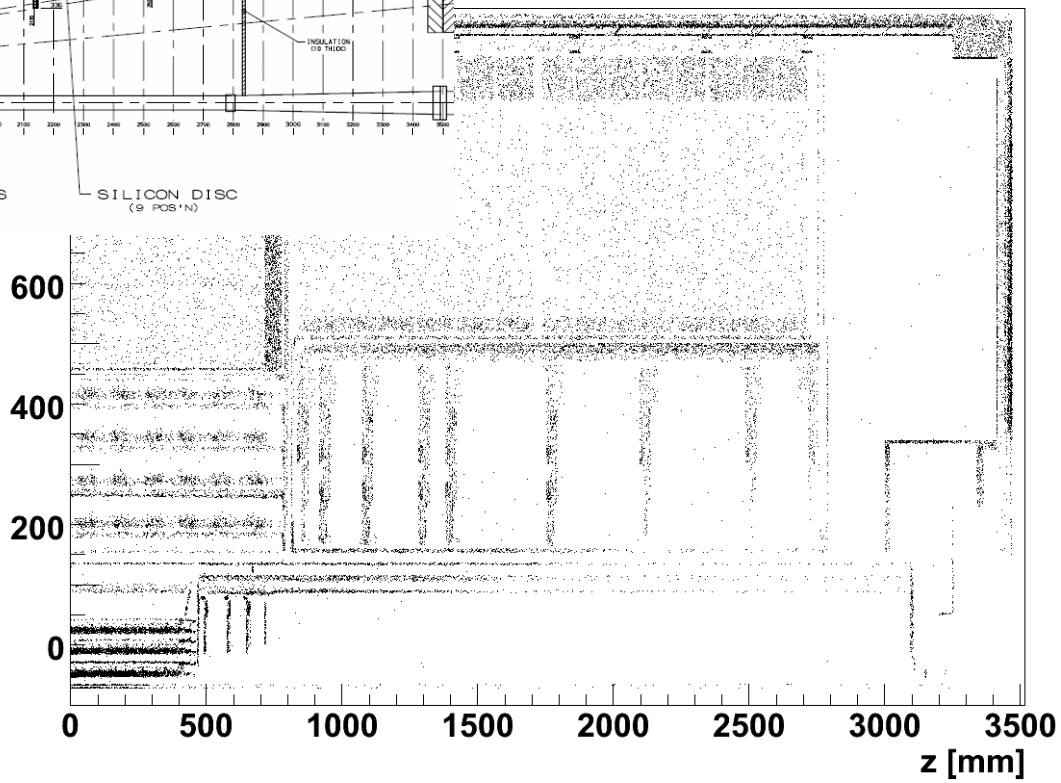
Vertices of all true Conversions (MC)



What we see…



ATLAS Inner Detector
Technical Design Report



How does the Conversion Finder tool work?

- InDetConversionFinderTools (Version in Rel. 12 & 13)
- Collection of tracks
  - rejects all tracks coming from primary vertex
  - uses all possible positive - negative track pairs
  - symmetric photon conversions
    - **distance** and **momentum cuts**
  - very asymmetric conversions
    - Have to be implemented !!
- Improvements are under construction (release 14)
  - Mauro Donega, Thomas Koffas, Hongbo Zhu

Sample/Tool we have used

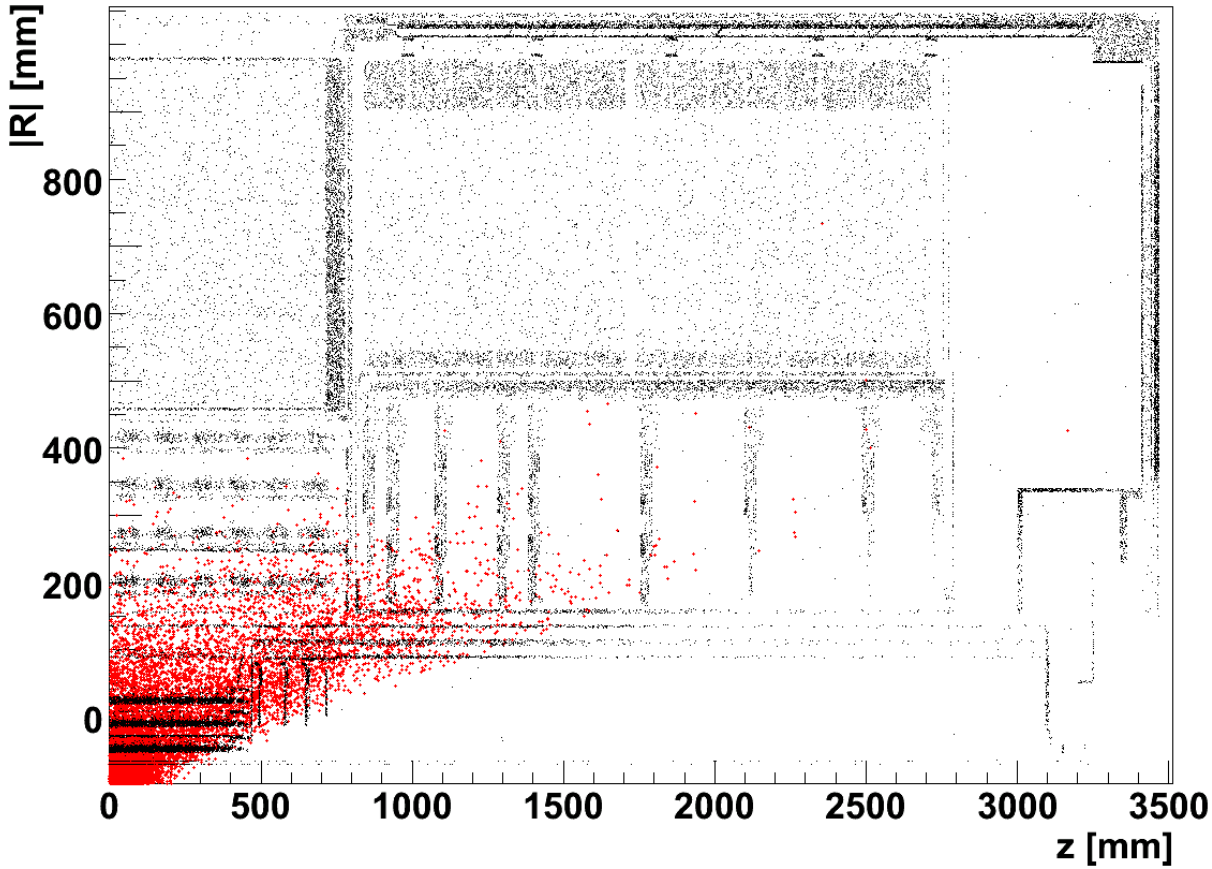
- CBNT ntuple:

005188.A3_Ztautau_filter.CBNT.RDO.

v12000605_tid00916.root

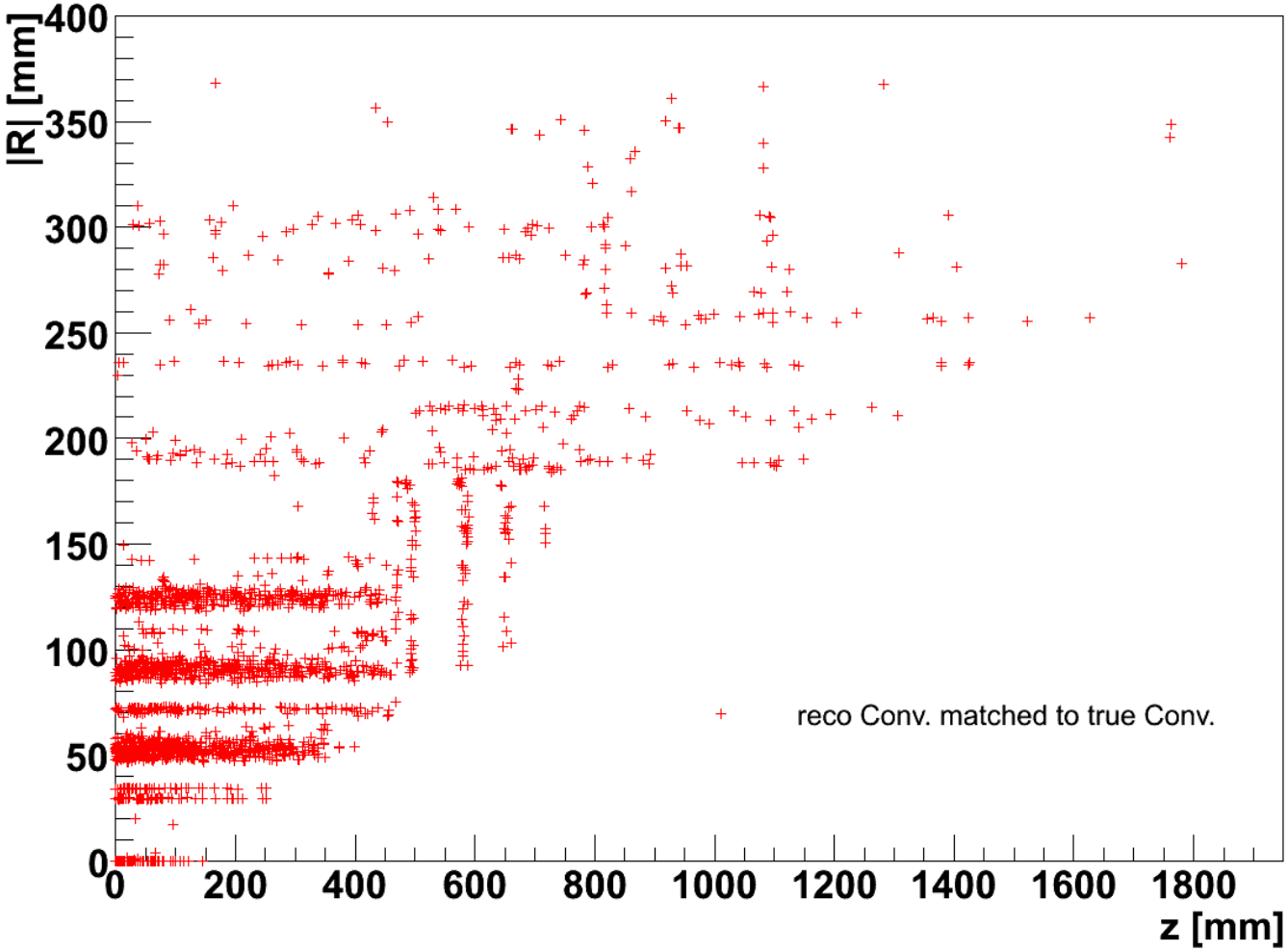
- Process: $Z \rightarrow \tau\tau$
- Statistic: 9950 Events
- Algorithm:
  - TauRec
  - InDetConversionFinderTool

Reconstructed Conversions



Purity: (correct reco)	10.11 %
Efficiency: (frac. to total)	4.74 %

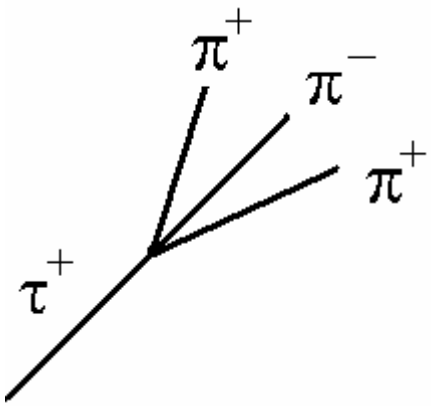
Reconstructed Conversions matched to true Conversions



2. τ-Decay and Reconstruction

τ-Decay

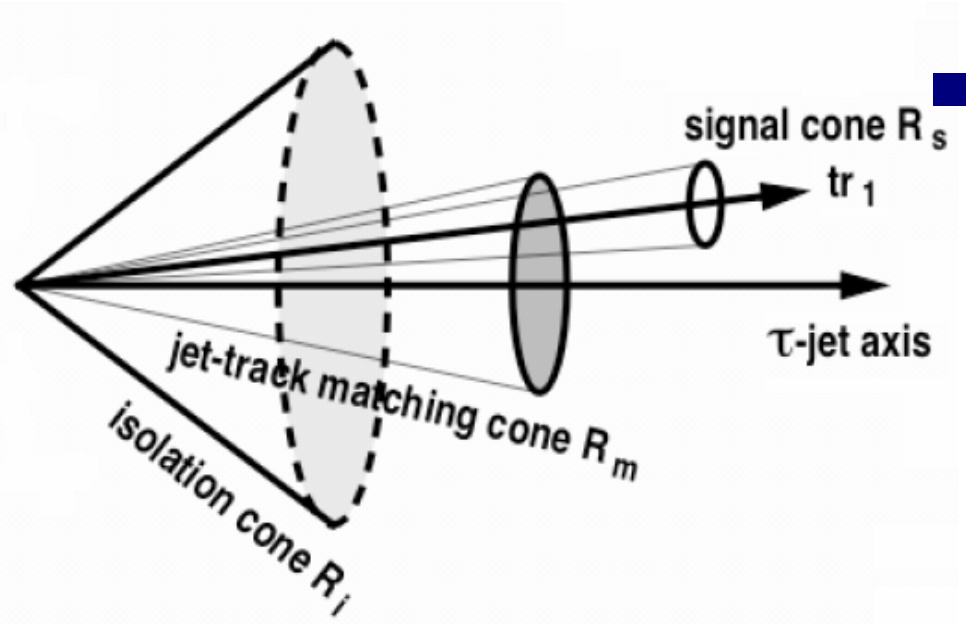
- Leptonic
- Hadronic
  - 1 Prong
  - 3 Prong
  - other



$\tau \to e\nu_e\ \nu_\tau,$ $\tau \to \mu\nu_\mu\ \nu_\tau$	17.8 % 17.4 %	35.2 %
$\tau \to \pi^\pm\nu_\tau$	11.1 %	46.8 %
$\tau \to \pi^0\pi^\pm\nu_\tau$	25.4 %	
$\tau \to \pi^0\pi^0\pi^\pm\nu_\tau$	9.19 %	
$\tau \to \pi^0\pi^0\pi^0\pi^\pm\nu_\tau$	1.08 %	
$\tau \to \pi^\pm\pi^\pm\pi^\pm\nu_\tau$	8.98 %	13.9 %
$\tau \to \pi^0\pi^\pm\pi^\pm\pi^\pm\nu_\tau$	4.30 %	
$\tau \to \pi^0\pi^0\pi^\pm\pi^\pm\pi^\pm\nu_\tau$	0.50 %	
$\tau \to \pi^0\pi^0\pi^0\pi^\pm\pi^\pm\pi^\pm\nu_\tau$	0.11 %	
$\tau \to K^\pm X\nu_\tau$	3.74 %	
$\tau \to (\pi^0)\pi^\pm\pi^\pm\pi^\pm\pi^\pm\pi^\pm\nu_\tau$	0.10 %	
others	0.03 %	

- We intend to reconstruct 1 and 3 Prong decays

τ-Reconstruction



- TauRec algorithm
  - reconstructs hadronic τ–leptons
  - starts from reconstructed TopoClusters (clusters of Calorimeter Cells)
  - associates tracks within ΔR <0.3 of the TopoJet centre
    - tracks of τ-candidate (e.g. tr_1)

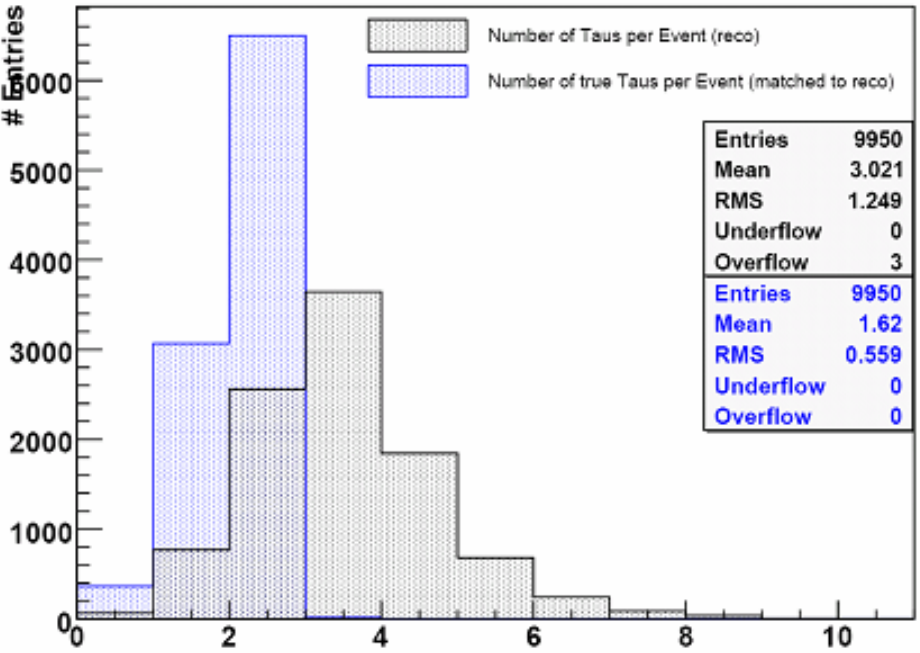
e.g.:

$$\tau^+ \to \pi^+\pi^0\upsilon_\tau \to \pi^+\gamma\gamma\upsilon_\tau \to \pi^+\gamma e^+e^-\upsilon_\tau$$

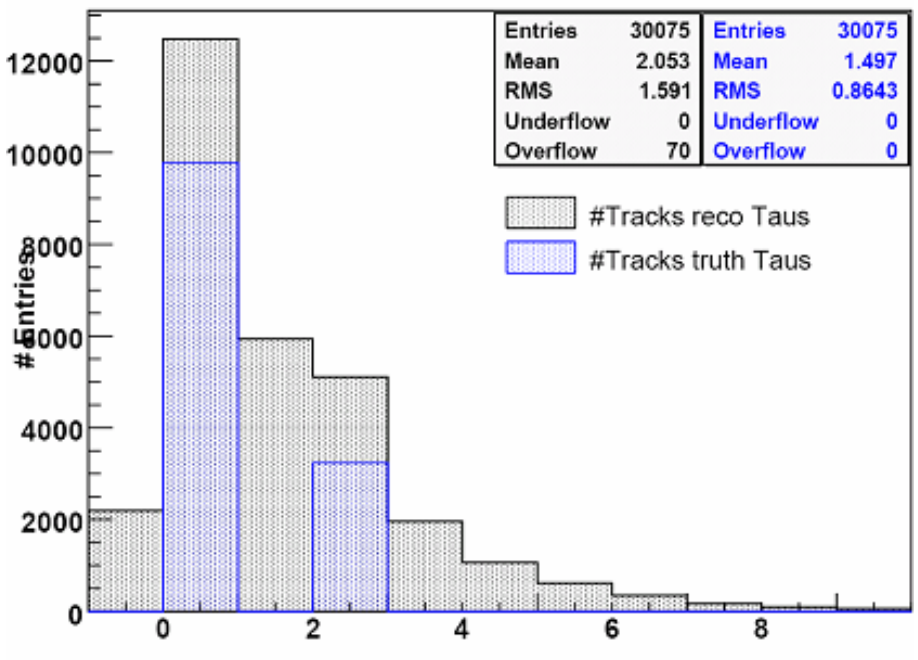
- Search for tracks in τ-candidates which come from a photon conversion

Some figures from τ-Reconstruction (with TauRec)

- Number of τ–candidates per Event

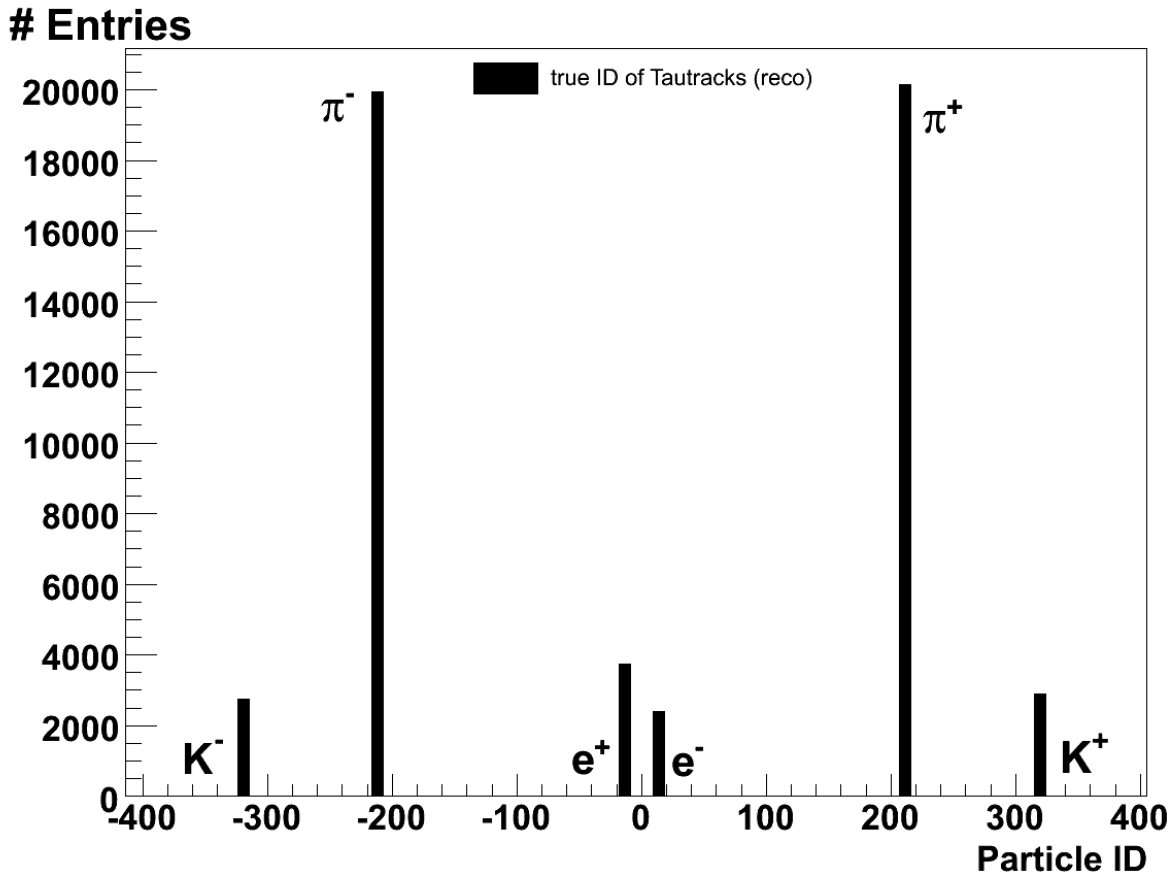


- Number of tracks per τ–candidate



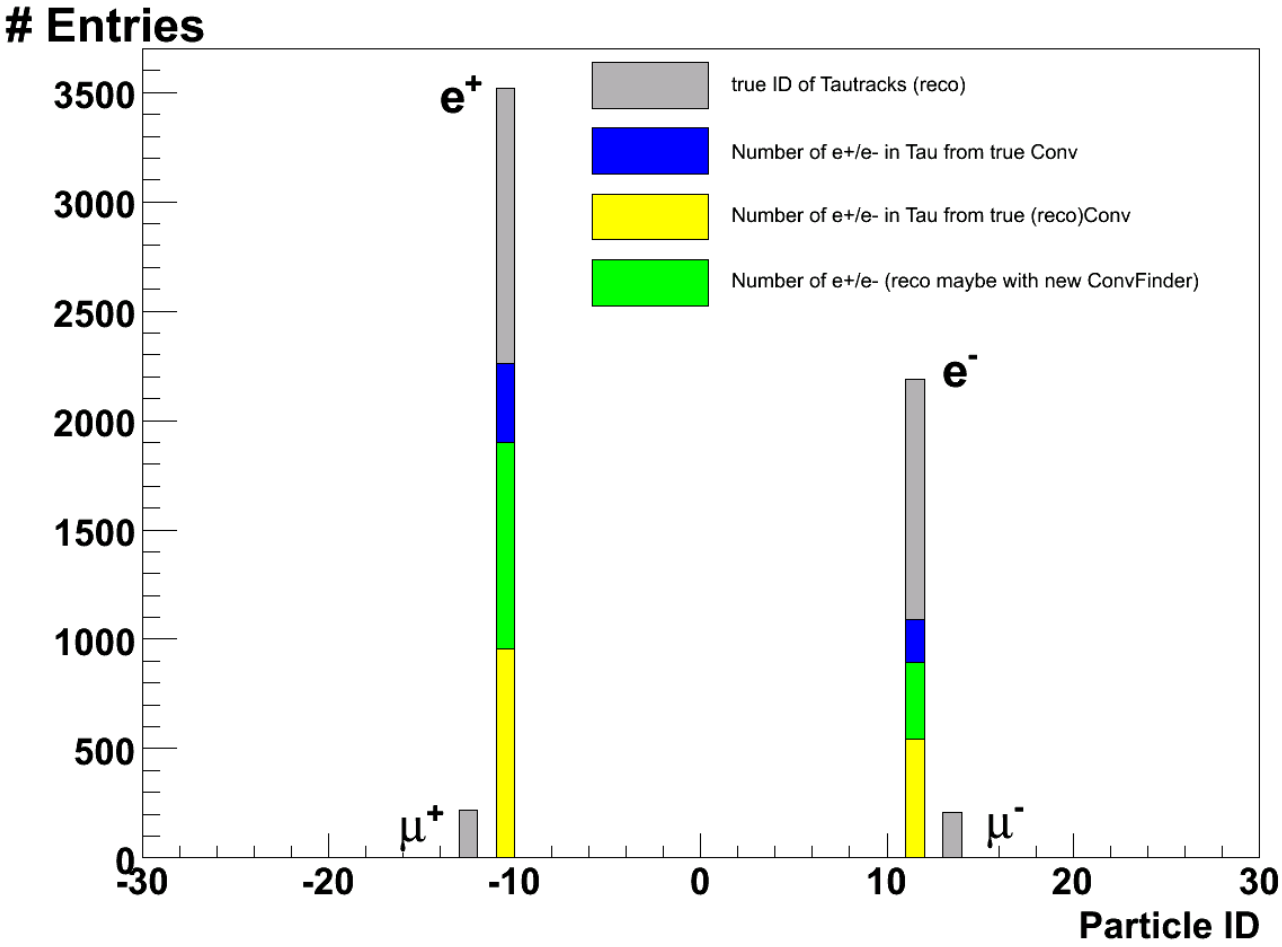
These τ-candidates have **no** Likelihood-cut!!

Particle ID of all τ-Tracks



- As we expect the hadronic τ-decay

Leptonic Particles in τ-tracks



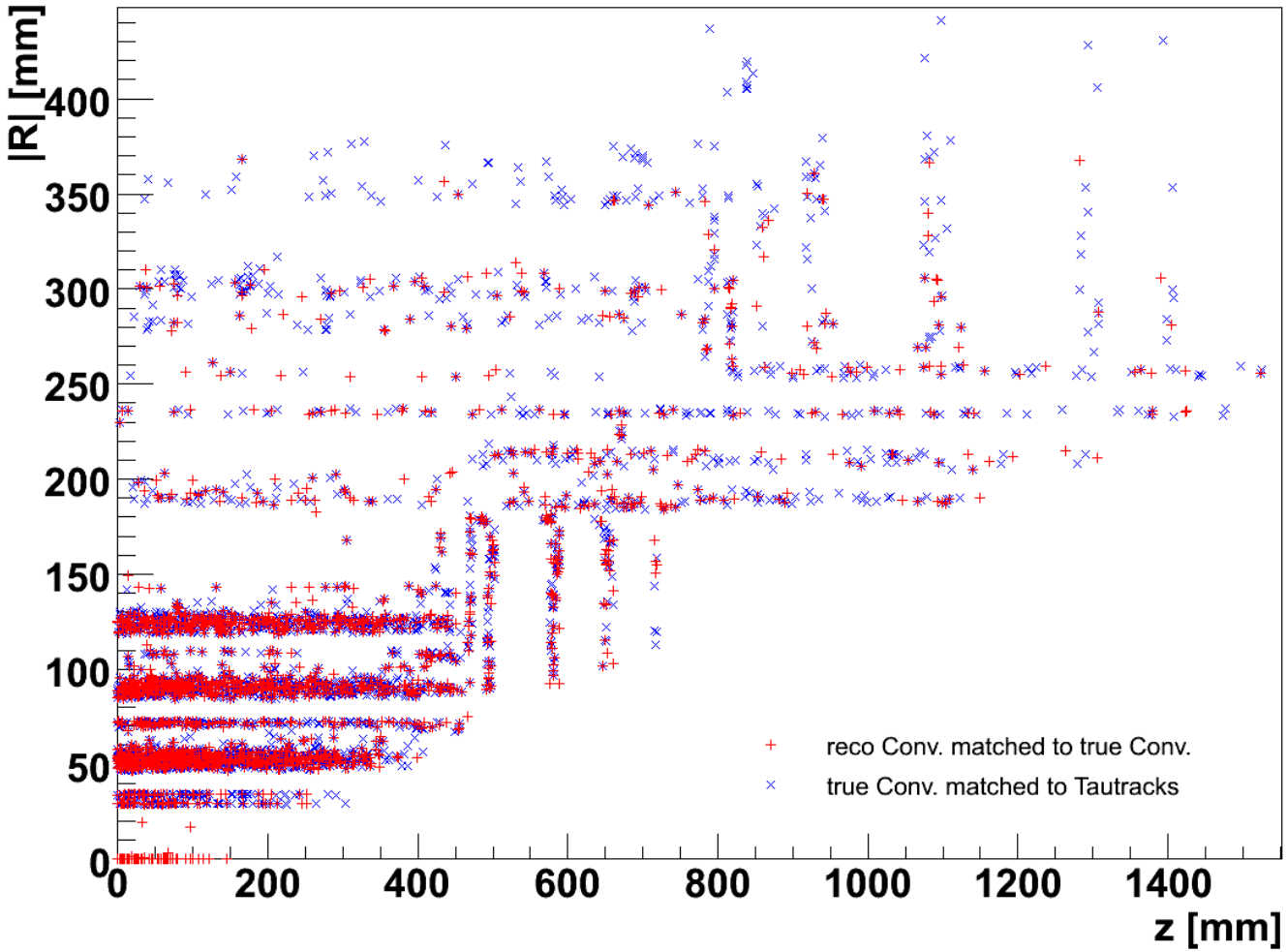
- in % to total tracks

True e+/e- in Tau	10.4 %
From true conv	6.08 %
From reco conv	2.73 %
(New Conv.Finder	5.08 %)

- in % to e+/e- in τ

Reco conv	44.8 %
(New Conv.Finder	83.5 %)

In spite of the low Efficiency



3. Rejection of τ-Tracks

This part shows more or less what we would like to do as a next step!

Ideas of some Cuts for Rejecting Tracks

- For rejecting the tracks we plan to use:
  - Trk-number of the conversion track
  - Trk-number of the τ-track
    - Then it is easy to find the “same” track

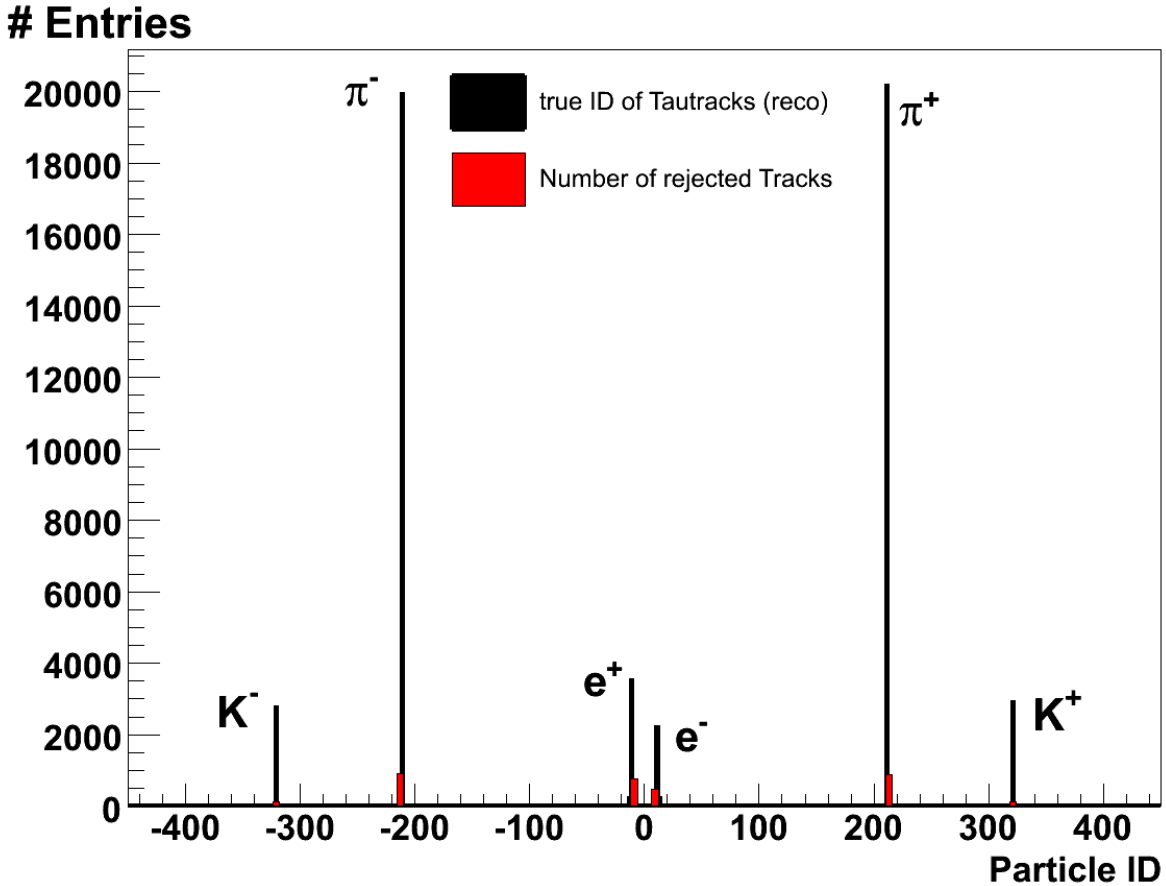
- For this study we made some cuts to get some “nice” plots
  - $|R| > 25$ mm (conversion radius)
  - $\Delta R < 0.1$

$$\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

$$\Delta p_T = \left| p_{T(\tau-track)} - p_{T(conv.-track)} \right|$$

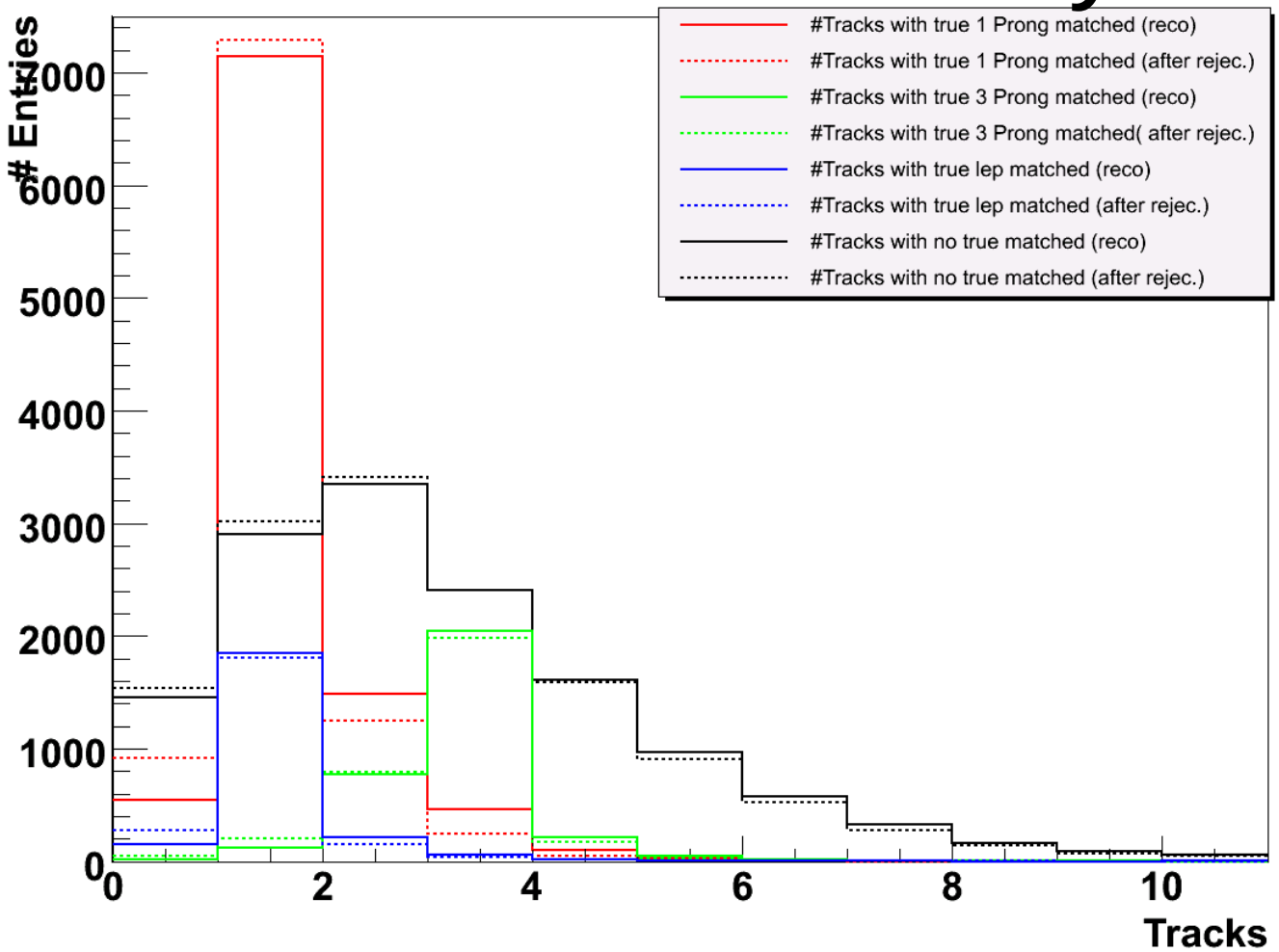
  - $\dfrac{\Delta p_T}{p_{T(\tau\text{-track})}} < 0.01$
  - same charge
  - first 3 tracks with most p_T

Which Particles do we reject?



- Due to the purity of the conversion finder we also “reject” pions and kaons

Tracks matched to Decay Mode



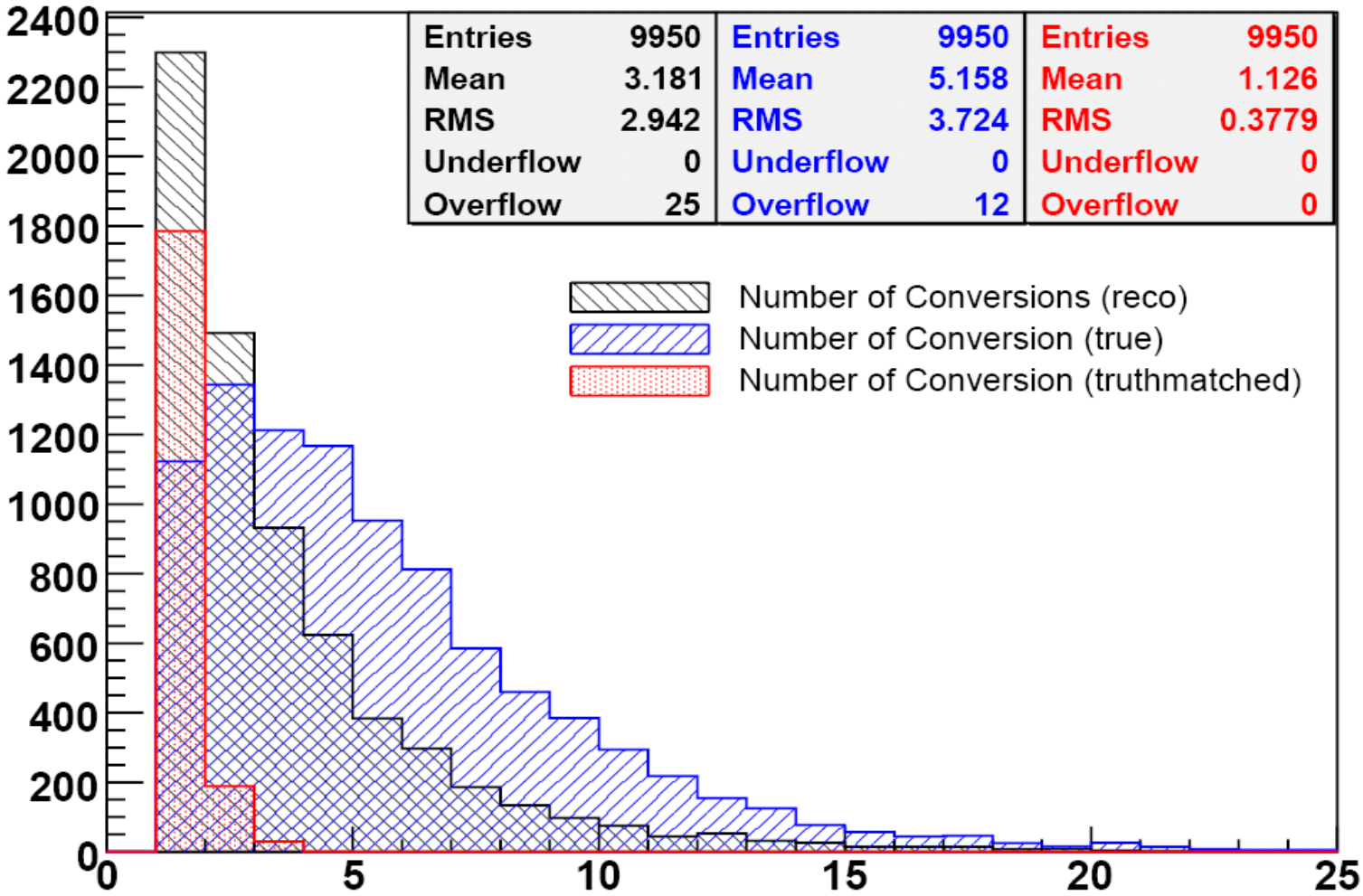
- Don’t forget: Just a first study with a poorly working conversion finder tool!!

Conclusion

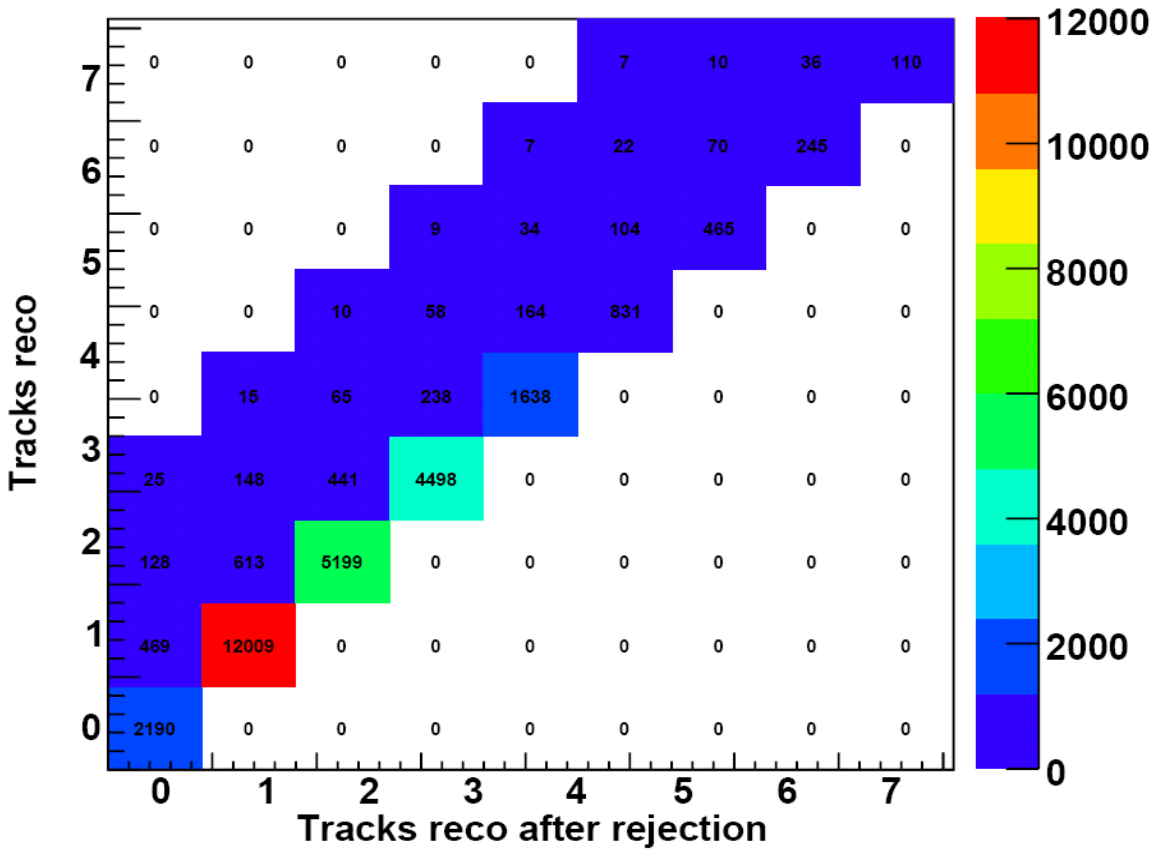
- "first results:"
  - 10.4 % of τ-tracks are e+ or e-
    - This number will rise if we reconstruct additionally the tracks with lower p_T
  - Purity of the "old" ConversionFinderTool is 10.11 %
    - This tool will be modified by the EGamma-Group
- there are many things to do…
  - using new ConversionFinderTool when available
  - implement Trk-no. from Conv. Finder to TauRec
  - implement code for using additional τ-tracks
- Maybe we can apply this method to k_s decays

Backup - Slides

Conversions per Event

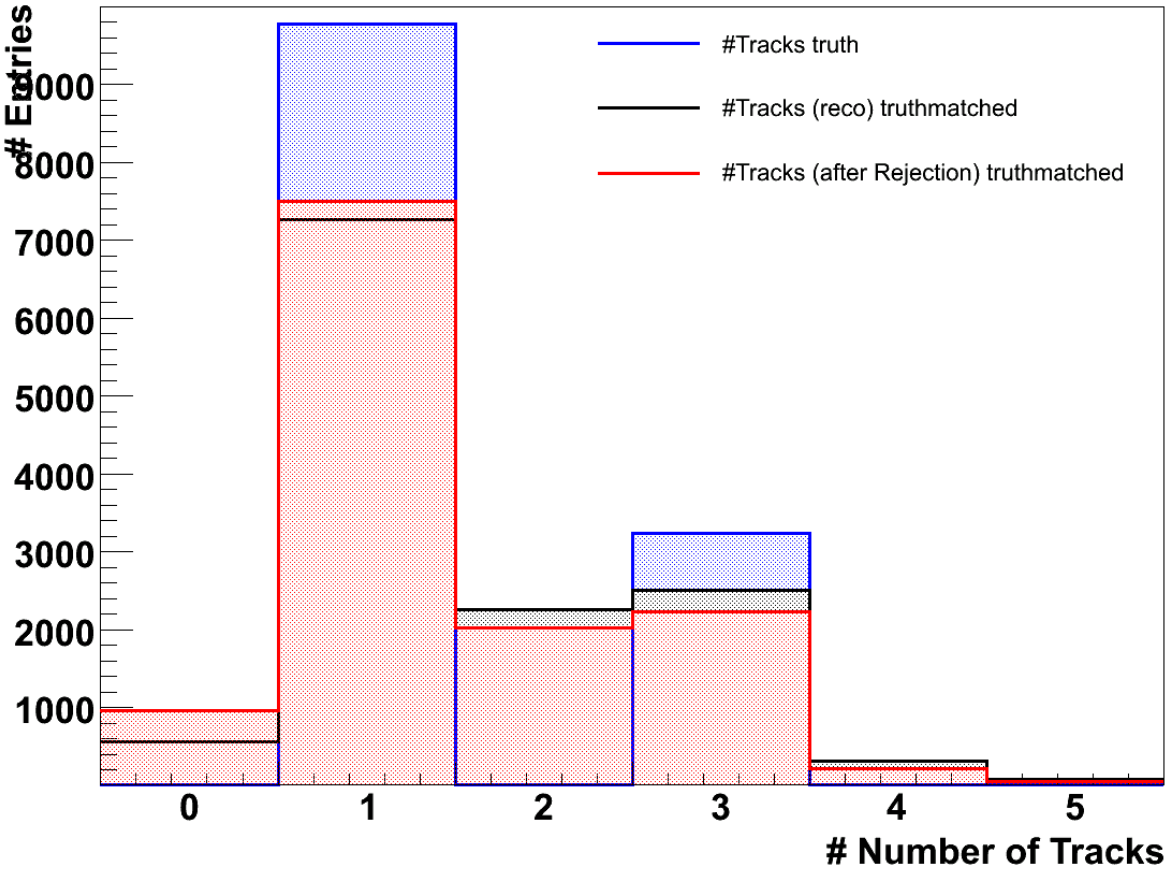


Fluctuation from… to…



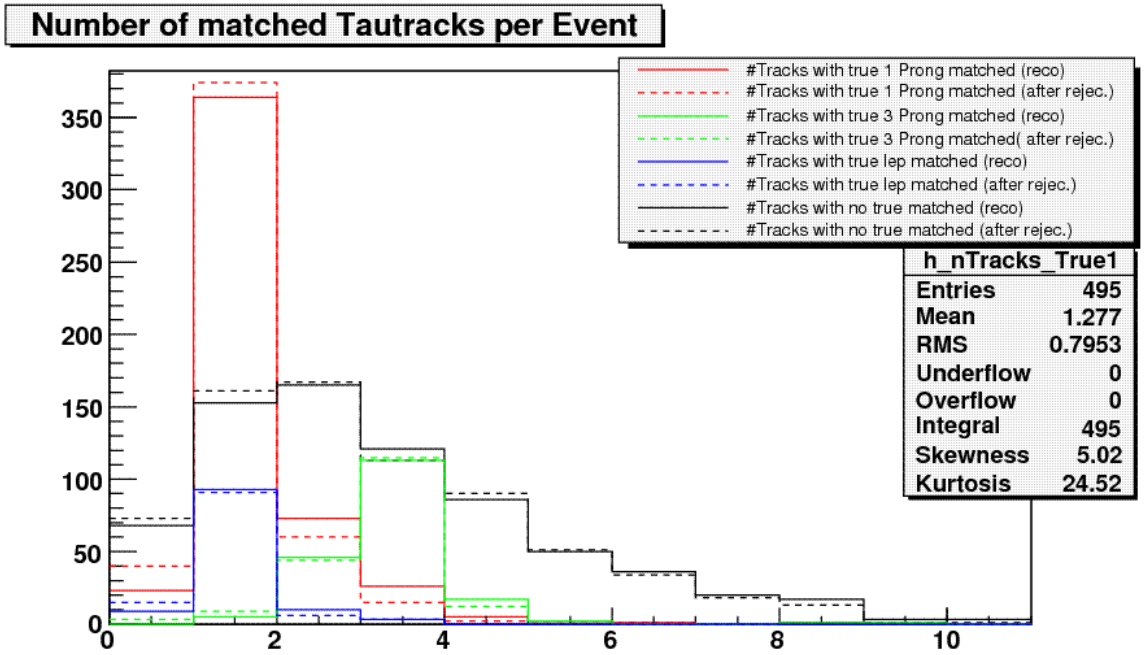
- Only 3 tracks are used!!

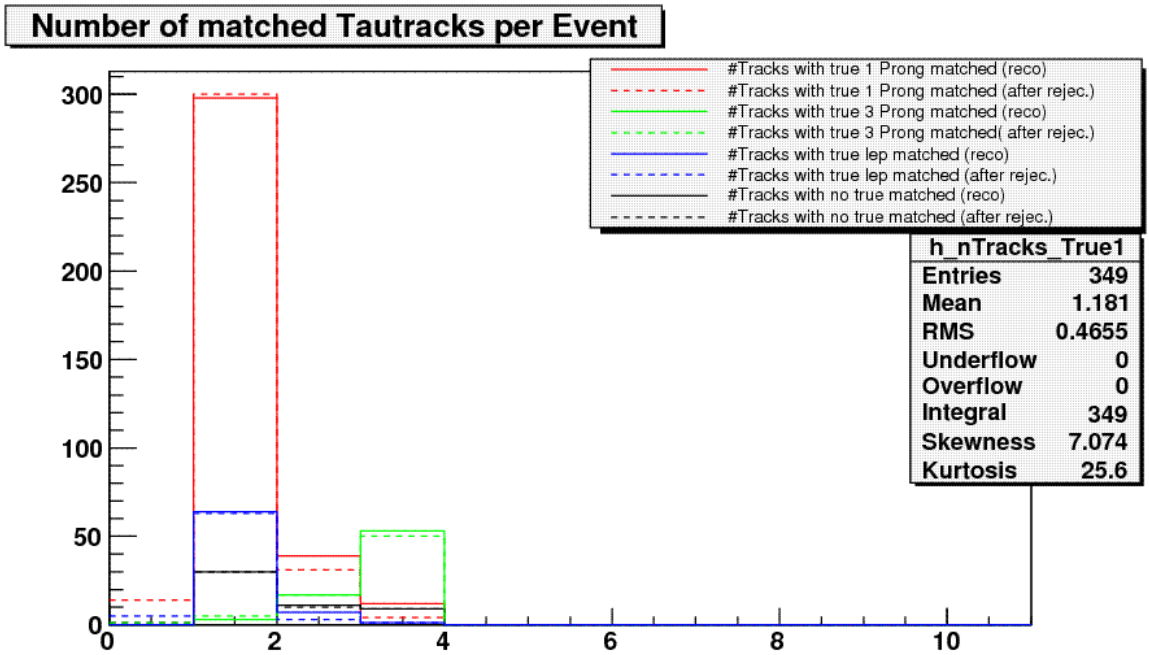
Number of Tracks after “Rejection”



- No improvement (at the moment)
- But we will see what we can achieve with a better Conv.finder tool

Comparison of Number of tracks matched to decay mode without and with Likelihood-cut





ΔR as an Example