DESY ATLAS Meeting

Identification and Rejection of $\gamma \rightarrow e^+e^-$ Conversion Tracks in τ Candidates

Philip Bechtle, David Côté
Michael Böhler

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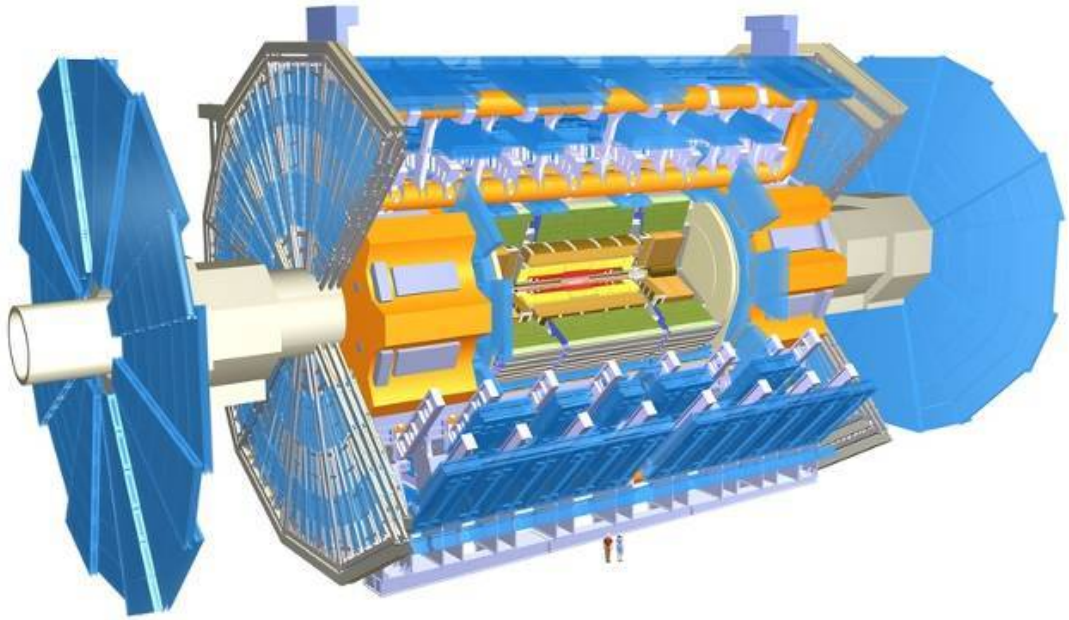
Outline

1. Short Reminder
2. Study on tertiary DPDs
   - TauDPDMaker & EV Tools
   - Photon Conversions
   - Tau Candidates
3. Summary and Outlook

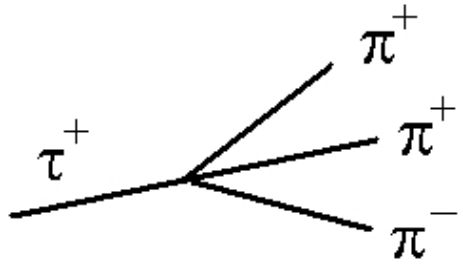


Short Reminder: τ-Decay and π^0-Decay

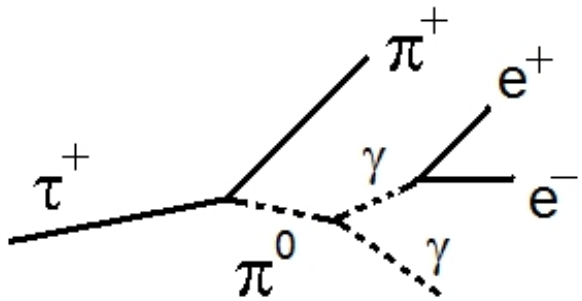
- τ-decay:

leptonic	**(35.2 %)**
$\tau \rightarrow e + \nu_e + \nu_\tau$	
$\tau \rightarrow \mu + \nu_\mu + \nu_\tau$	
hadronic	
1 Prong	**(46.8 %)**
$\tau \rightarrow \pi^\pm + \nu_\tau$	
$\tau \rightarrow \pi^\pm + n \cdot \pi^0 + \nu_\tau$	
3 Prong	**(13.9 %)**
$\tau \rightarrow \pi^\pm + \pi^\pm + \pi^\pm + \nu_\tau$	
$\tau \rightarrow \pi^\pm + \pi^\pm + \pi^\pm + n \cdot \pi^0 + \nu_\tau$	

- a π^0occurs in 40,58% of all τ-decays
- τ-decay with photon conversion:
  - $\tau^+ \rightarrow \pi^+\pi^0\nu_\tau \rightarrow \pi^+\gamma\gamma\nu_\tau \rightarrow \pi^+\gamma e^+e^-\nu_\tau$



τ decays into three charged π's (3 Prong)



τ decays into one π^+ (1 Prong) and one π^0, which decays into two γ's, one of them makes a e^+e^- pair creation

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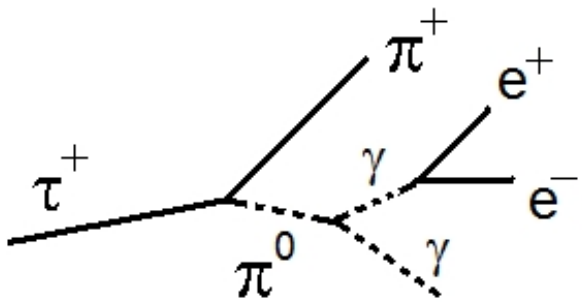
numerical example:

- process: $Z \rightarrow \tau\tau$

Events	100
τ	200
π^0	353
γ-conversions	185



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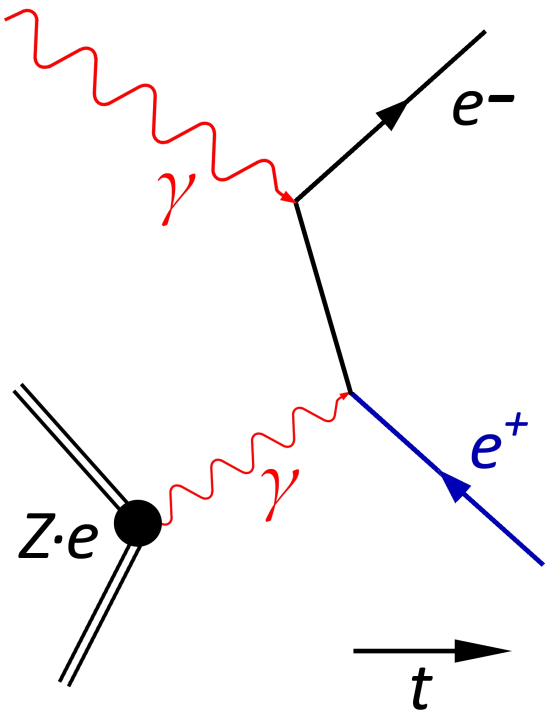
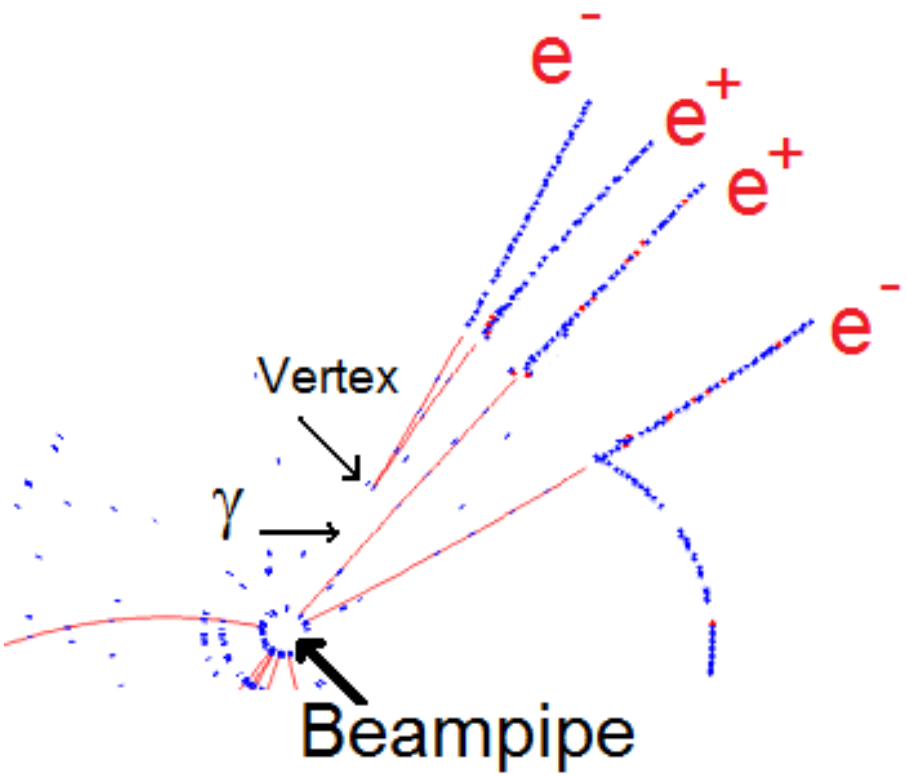
Photon conversion

- pair creation (e^+e^--pair)
- high energetic photon
- interaction with detector material

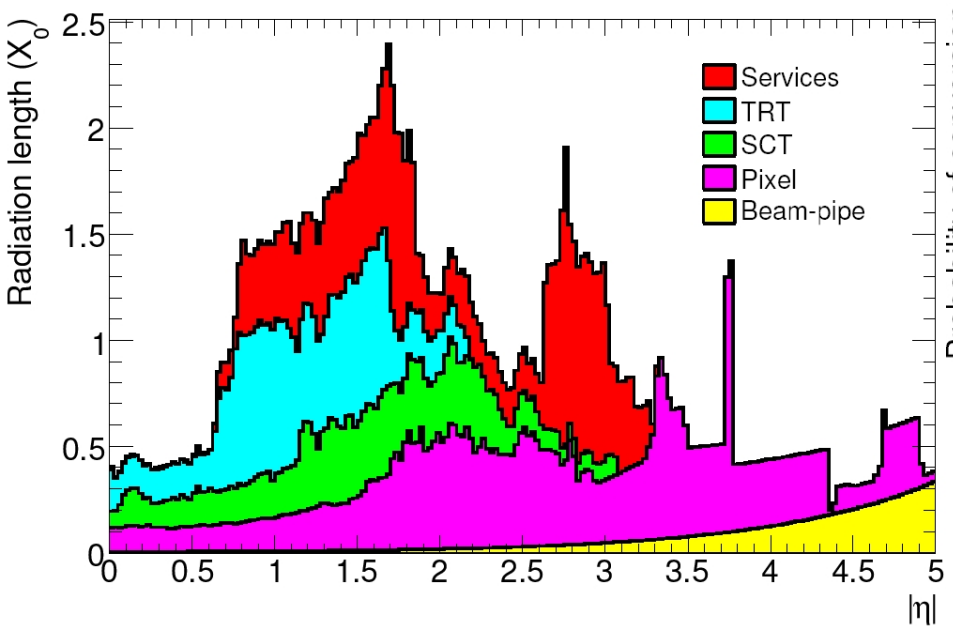


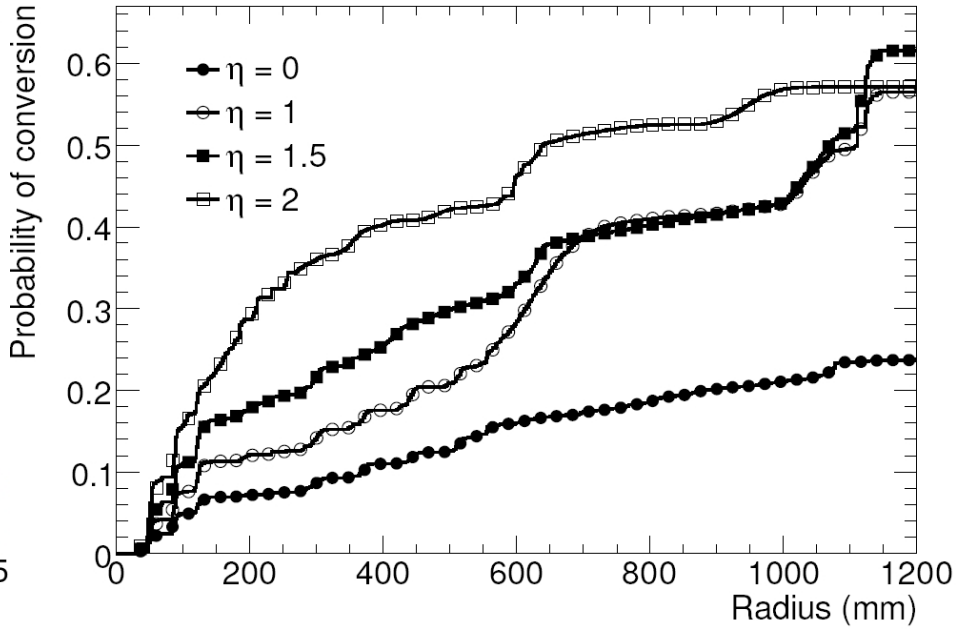
Feynman graph: pair creation via a photon-atom-interaction



example of tracks in the ATLAS detector

Material in the ATLAS Detector





- probability of a photon converting is proportional to the amount of material
- overall 60 % of all photons will be converted before reaching the face of the calorimeter

Study on tertiary DPDs

Produced tertiary DPD with TauDPDMaker

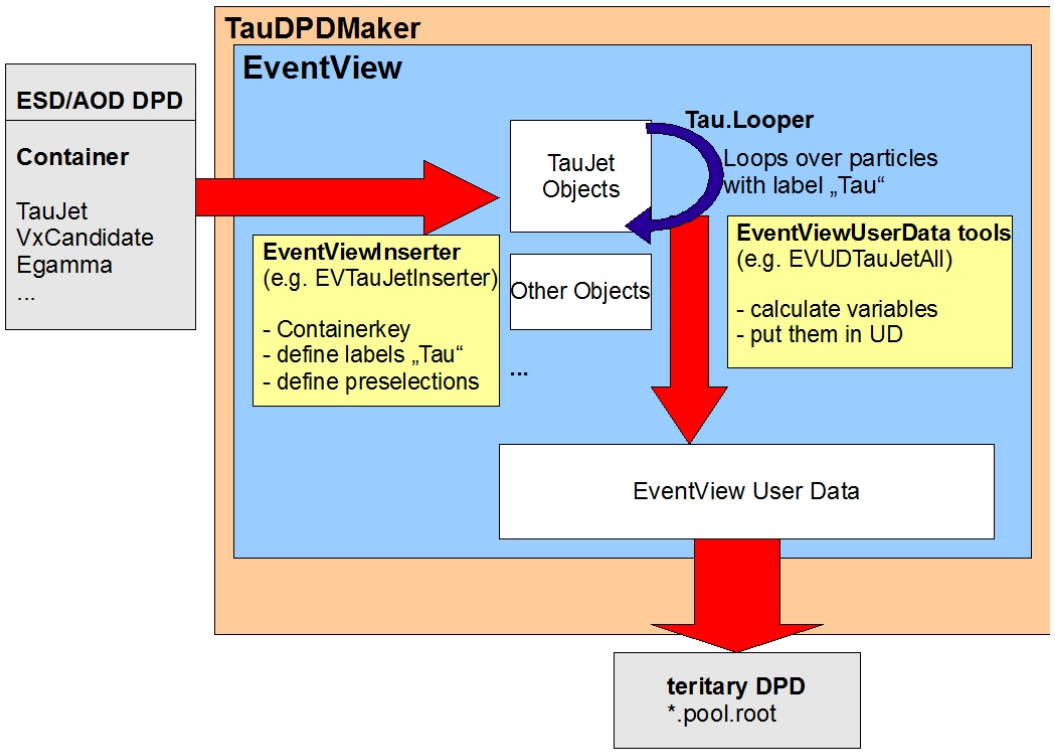
Process: $Z \rightarrow \tau\tau$
Statistics: 5000 Events
Input: ESD: valid1.005188.A3_Ztautau_filter.recon.e322_s412_r386
Release: 14.0.0.1

Used Tools:

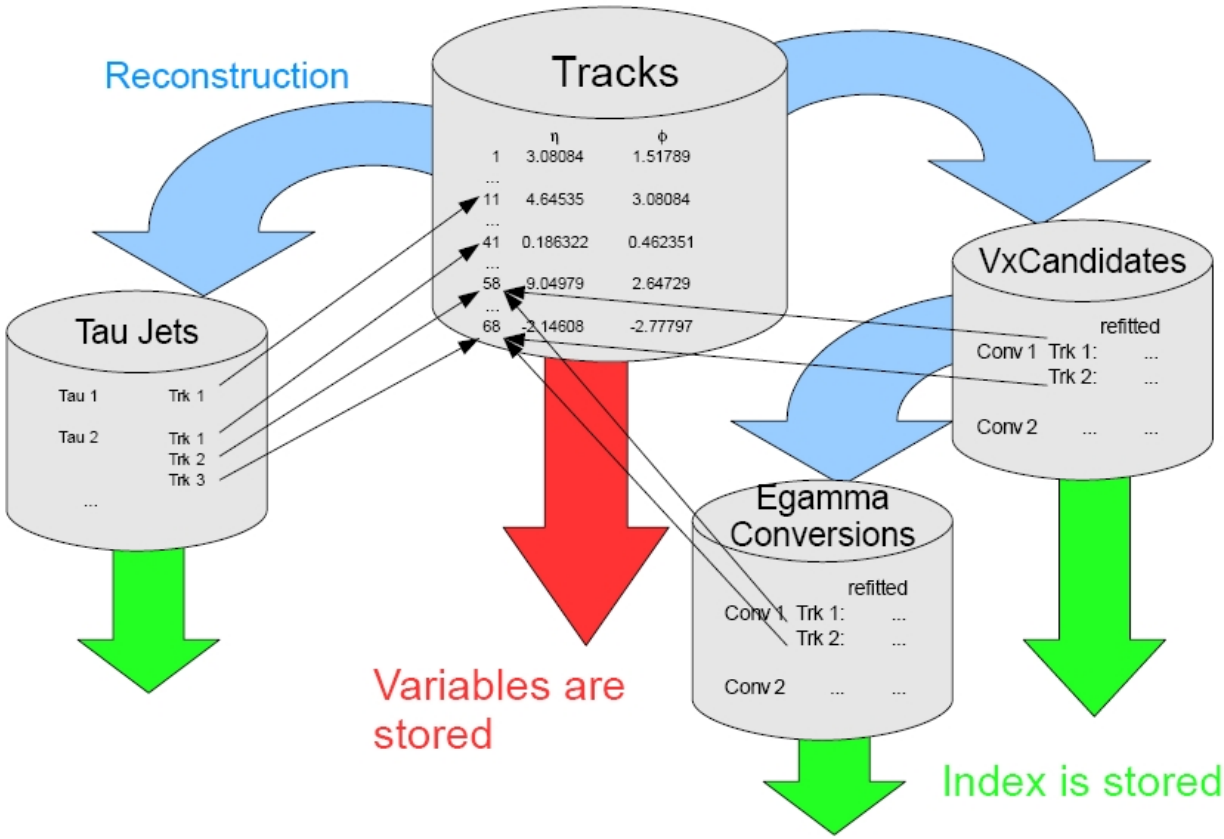
- TauDPDMaker-00-02-08
- EventViewUserData-00-01-25
- EventViewInserter-00-01-08
- RootUtils-00-00-31

needed EventView Tools:

- EVUDTauJetAll
- EVUDVertex
- EVUDIndex
- EVUDTruthEgammaConv
- EVUDEgammaConv

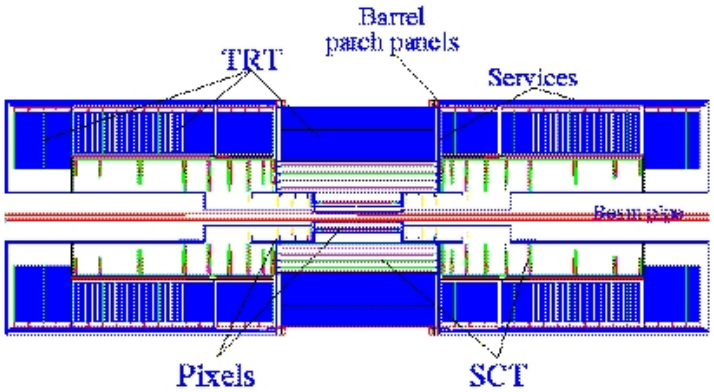


Summary of the Index tool

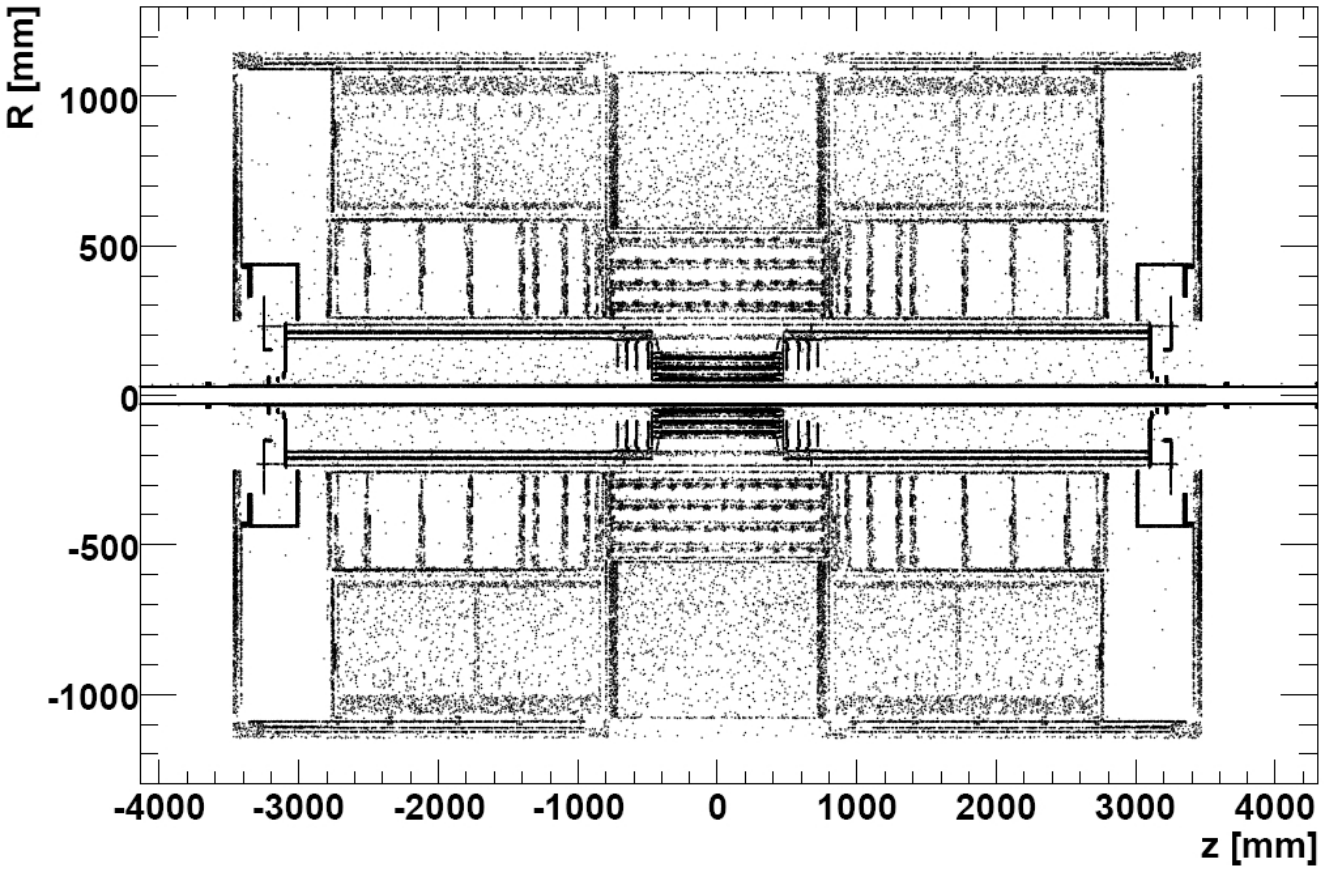


- detail informations stored once for all tracks
- other objects use these informations by the index
- smaller tertiary DPDs $\rightarrow$ faster analysis
- rejection of photon conversion tracks in τ-cone without ΔR match

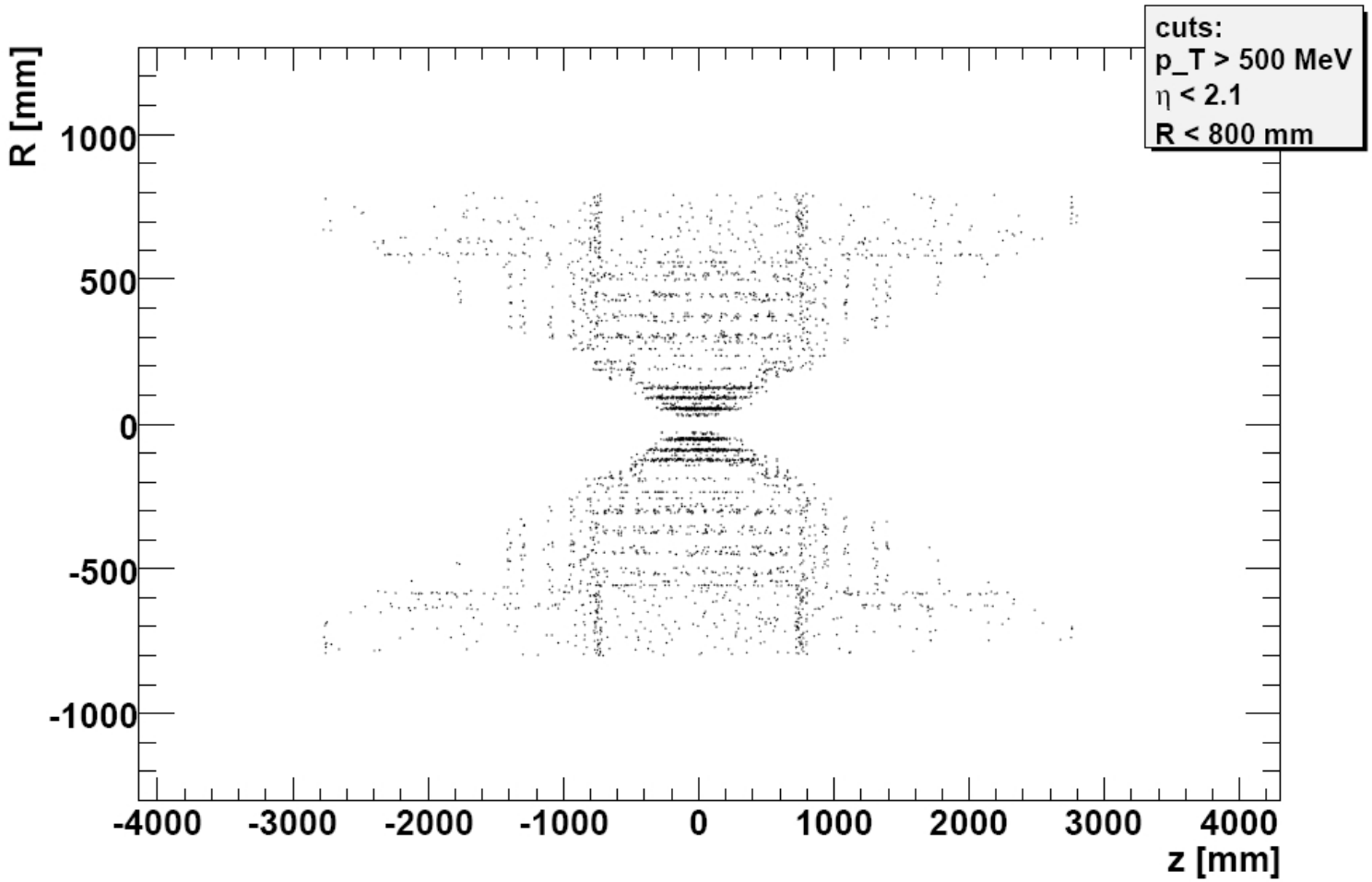
Vertices of true Photon Conversions



- consider the detector geometry for the γ-conversion simulation
- each dot is a simulated (MC truth) vertex of a γ-conversion

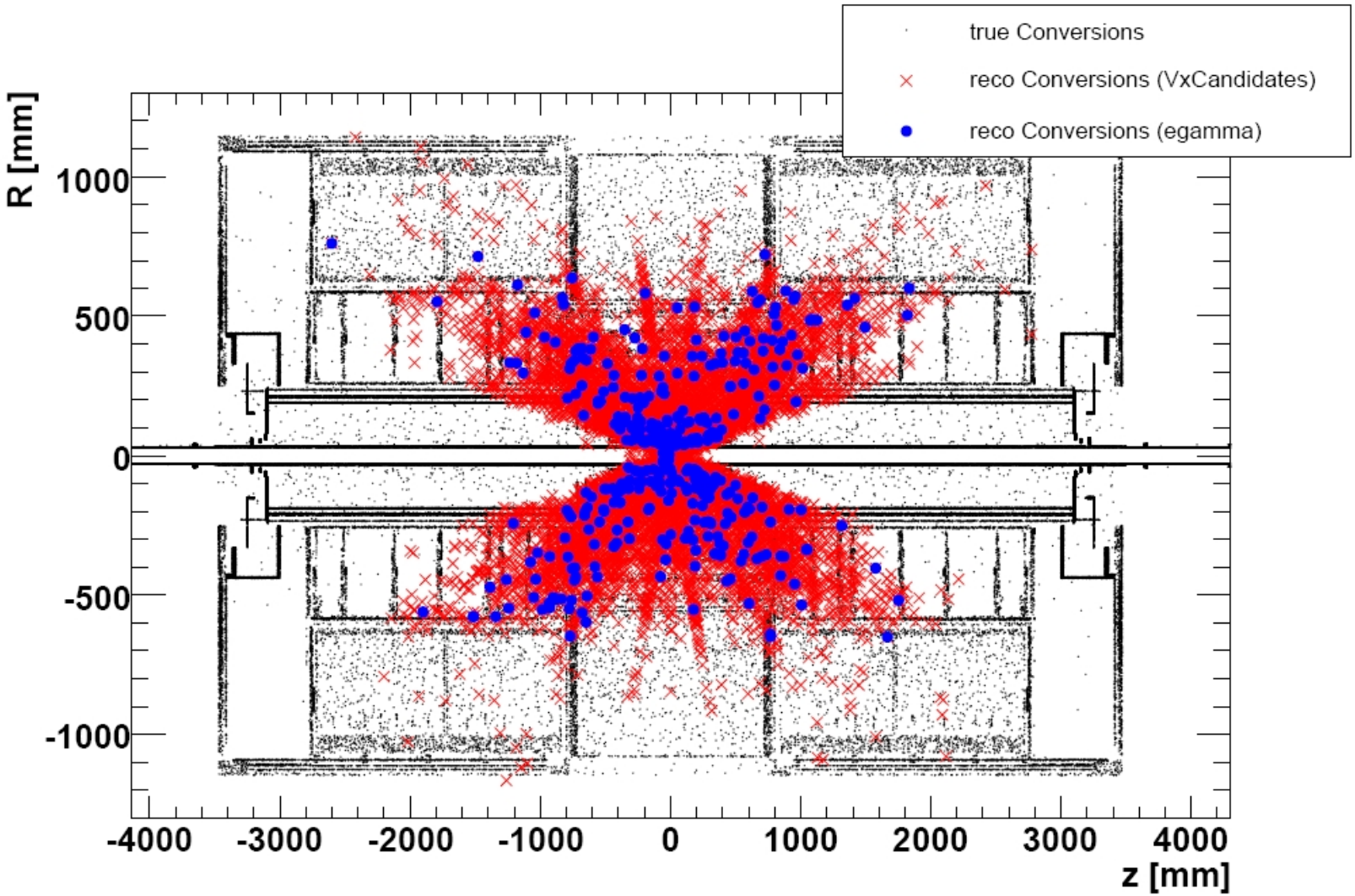


Vertices of 'reconstructable' true Photon Conversions



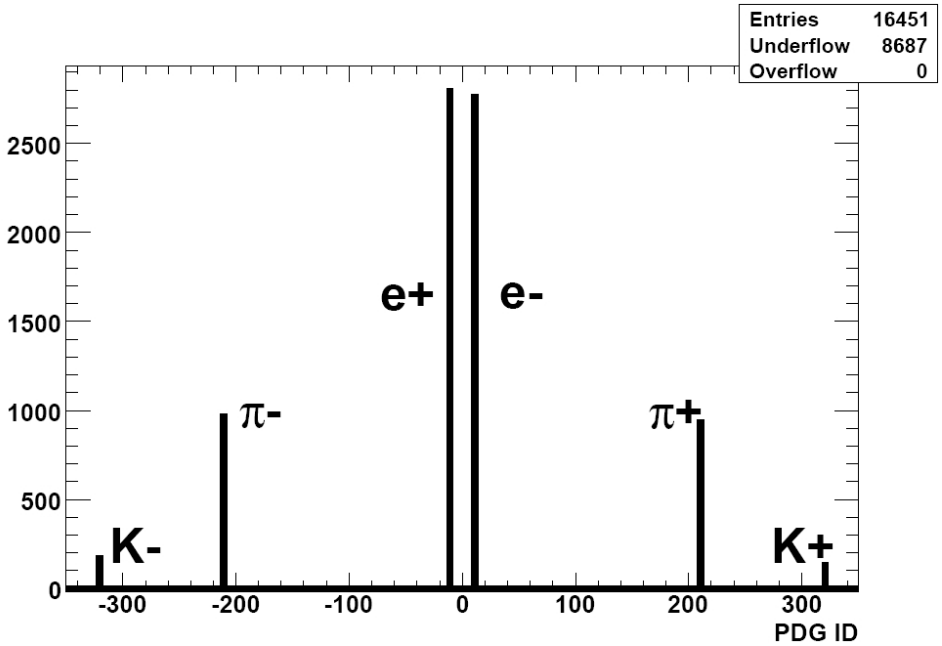
- tracks of γ-conversions can only be reconstructed in this region
- after all cuts 2.15% of γ-conversions are reconstructable
- BUT: comparable track selections on τ tracks

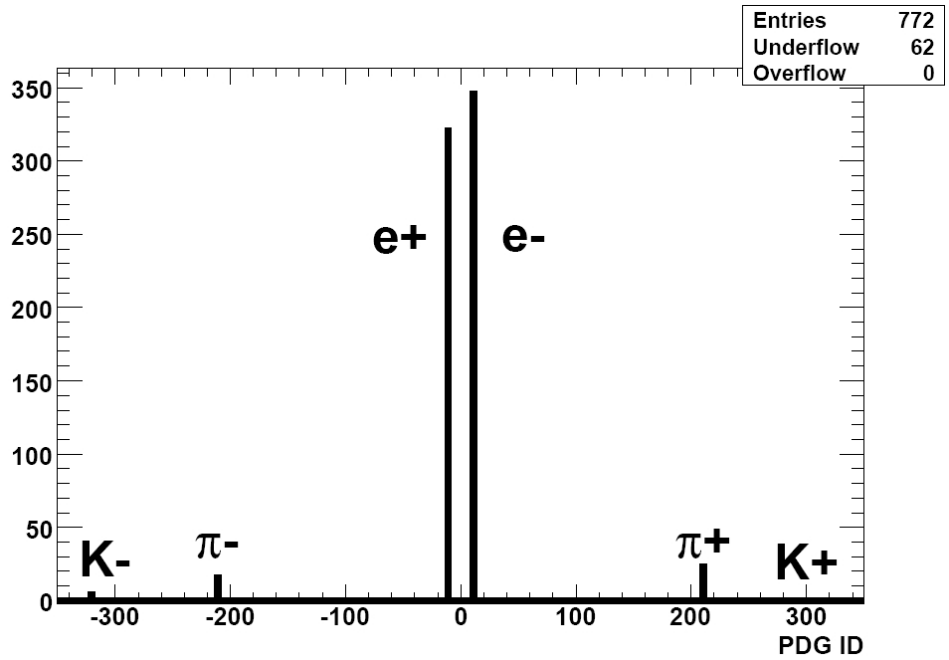
Vertices of Photon Conversions



- *VxCandidates* are the seeds for *Egamma* conversions

VxCandidates and Egamma Conversions





VxCandidates

- input: collection of tracks
- rejection of all Tracks from IP
- pos/ neg Track Pairs are built
- secondary vertex is refitted
- refitted track variables are stored

EGamma Conversions

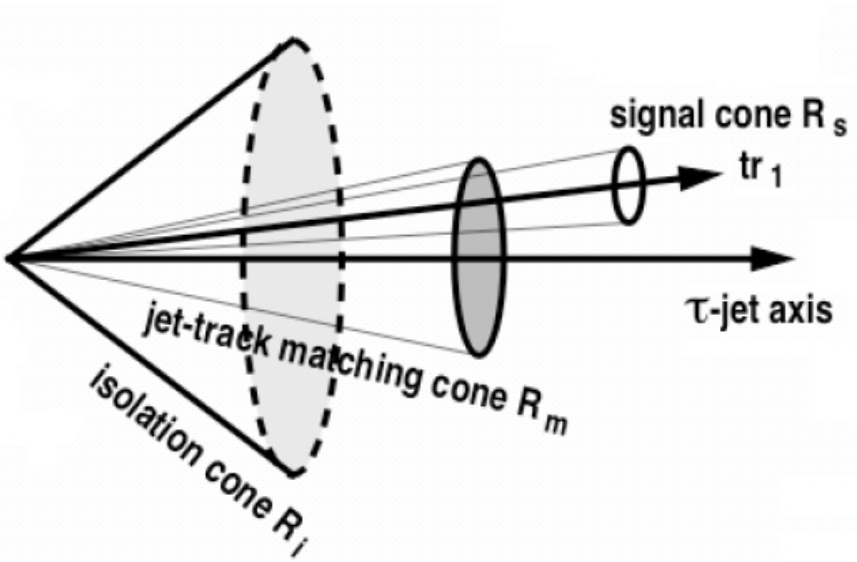
- Seeds are VxCandidates
- search a calorimeter Cluster for each track with:
  - $\Delta\eta < 0.05$
  - $\Delta\phi$ <0.10
  - $\frac{E}{p} < 10$

- VxCandidates have to be optimized for τ-environment

Reconstruction of τ-Candidates

TauRec algorithm

- Based on TopoClusters, every TopoJet found is considered a τ-candidate
- tracks within a cone of $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2} < 0.3$ to the TopoCenter are accepted
  - tracks of a τ-candidate (cp. tr_1)
- analyse jets of τ-candidates **before** likelihood cut

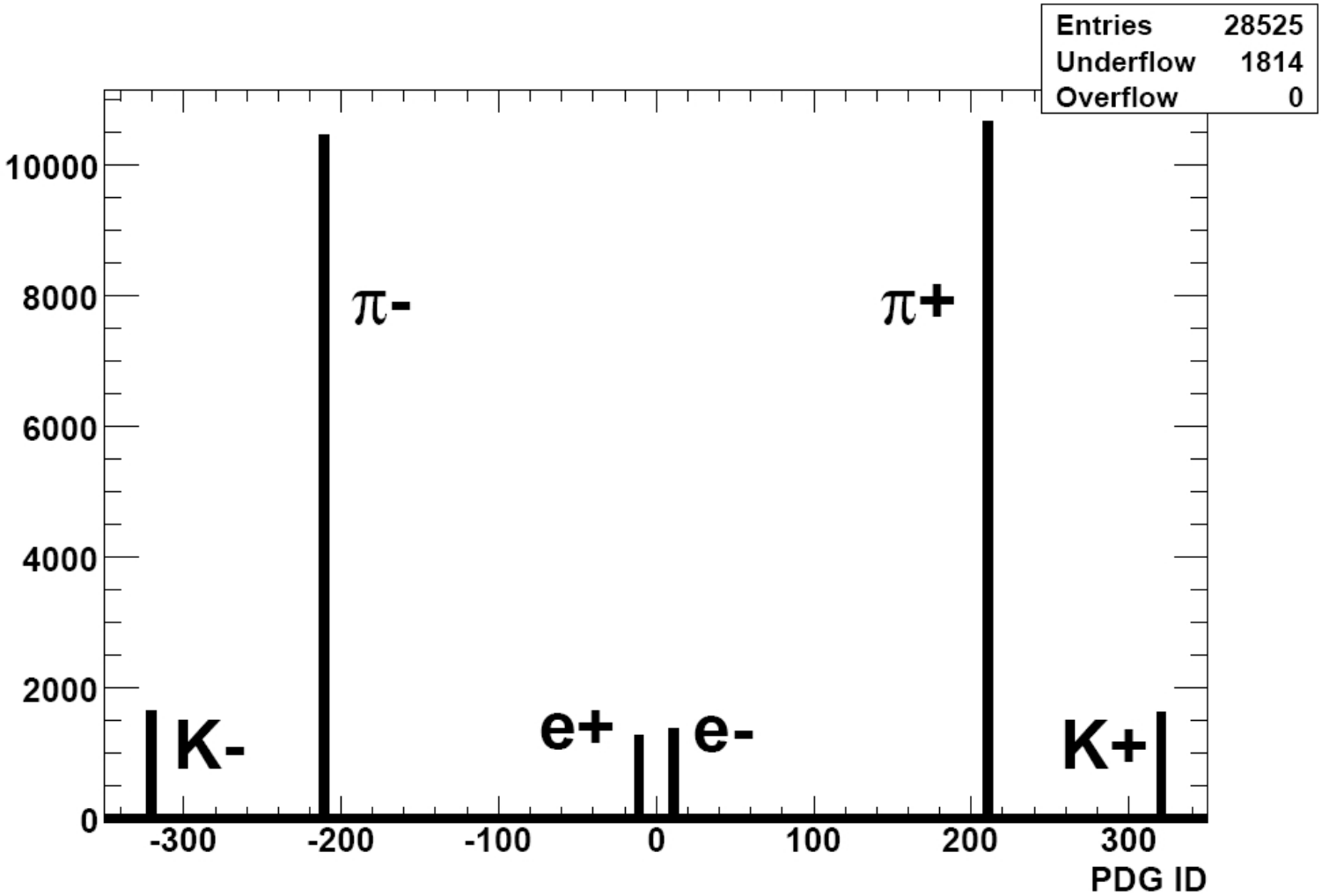


Track Selection Criteria

- $\Delta R < 0.3$
- $p_T > 1.0$ GeV
- $d0 < 1.5$ mm
- $\frac{\chi^2}{ndf} < 3.5$
- # Si Hits (Pixel + SCT) ≥ 6
- # Pixel + B-Layer Hits ≥ 1

Aim of this study: Indentify tracks from photon conversions which lie in the ΔR cone of a τ-candidate

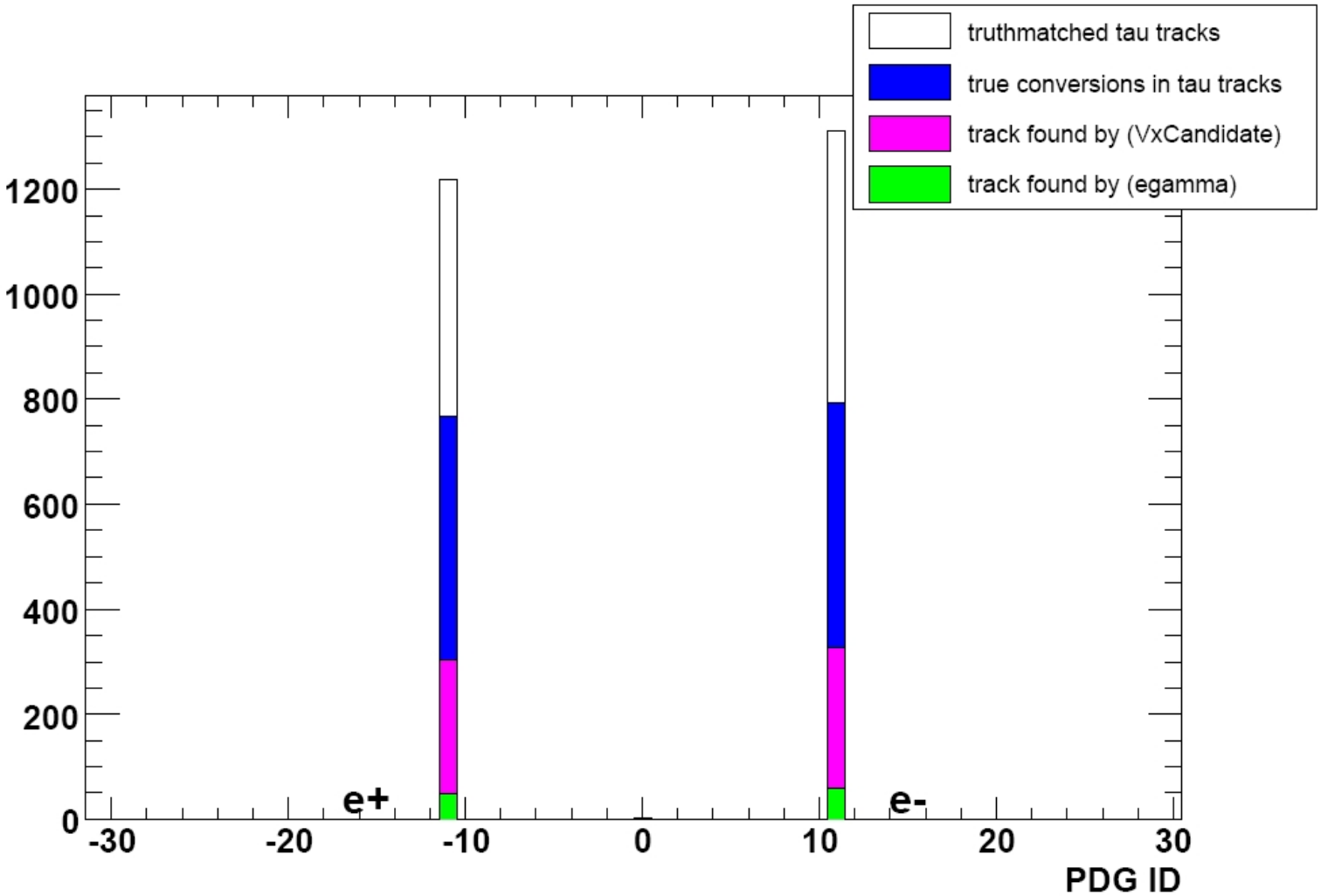
τ-Candidate ID



$\pi^+\pi^-$	74 %
e^+e^-	9 %
K^+K^-	11 %
not matched	6%

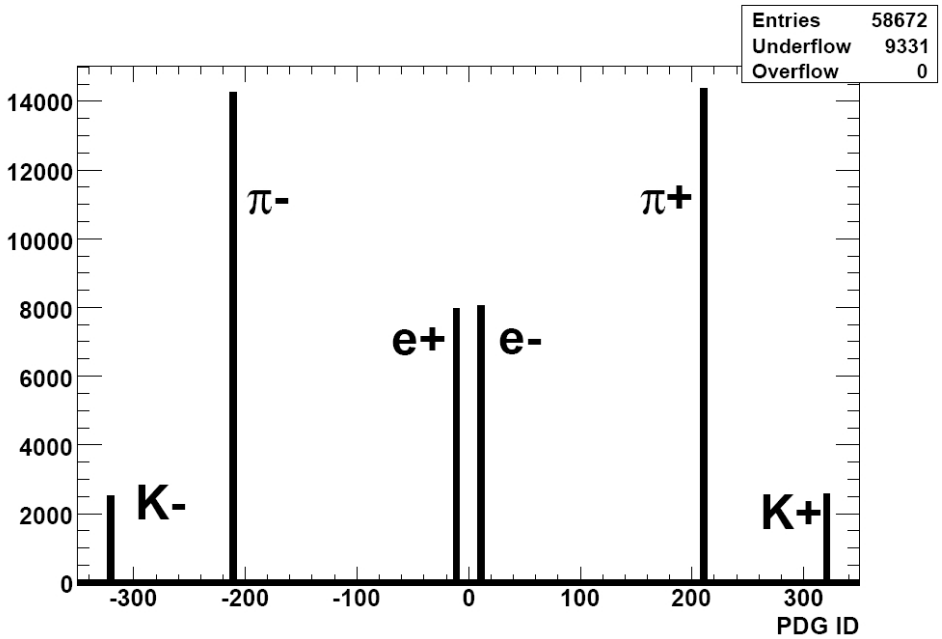
- truthmatched track ID of τ-jets
- after Quality Selection Cuts

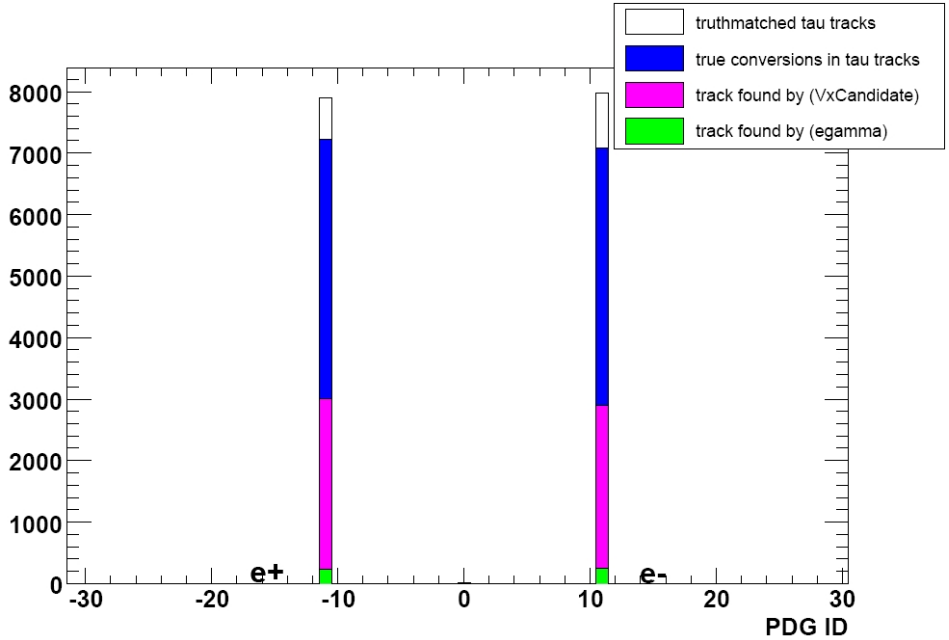
Origin of the Electrons

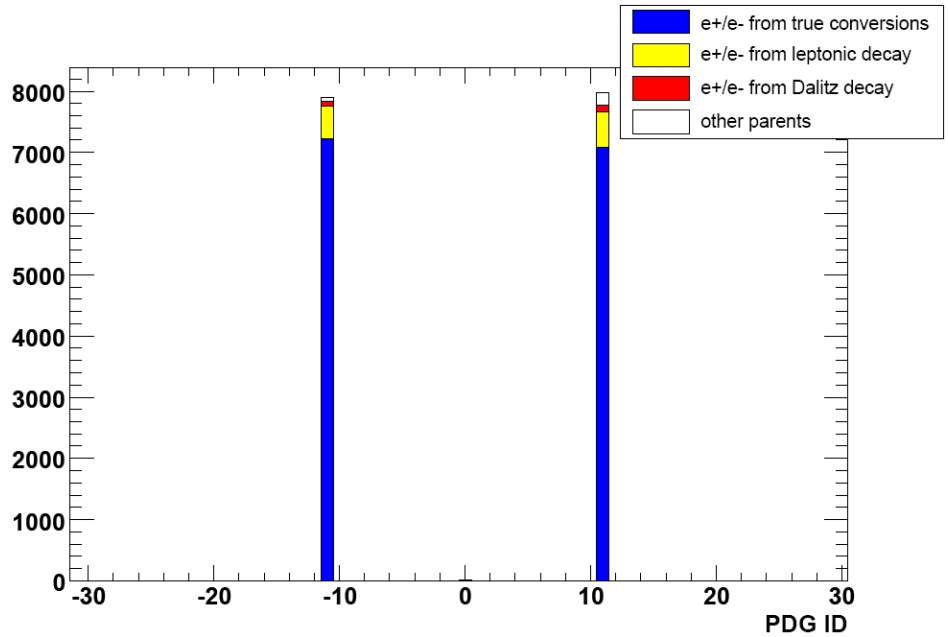


- 61 % of the truthmatched e^+e^- come from a true γ-Conversion
- 40 % of these true γ-Conversion have been found by *ConversionFinder*

Alternative: Loosen the τ Track Quality Cuts

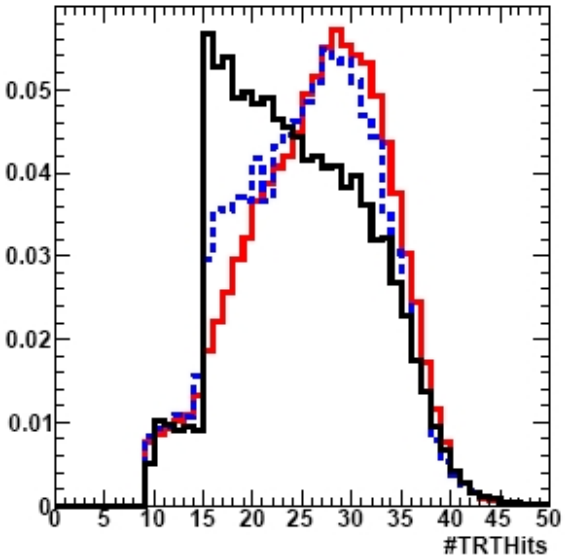


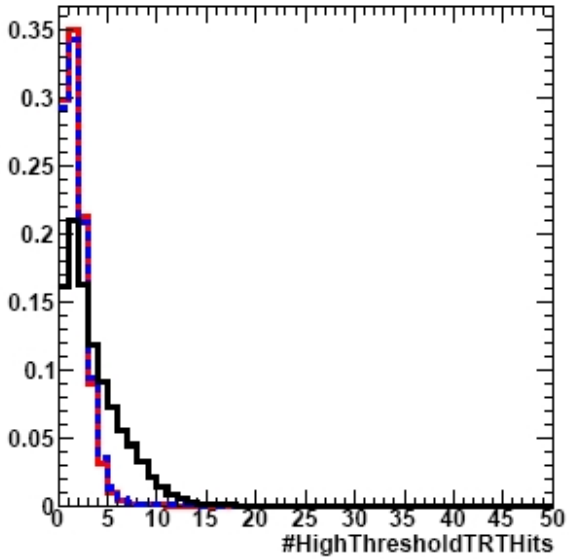


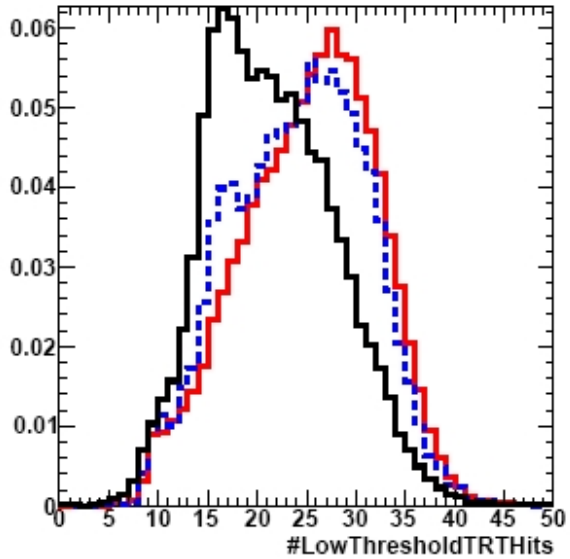


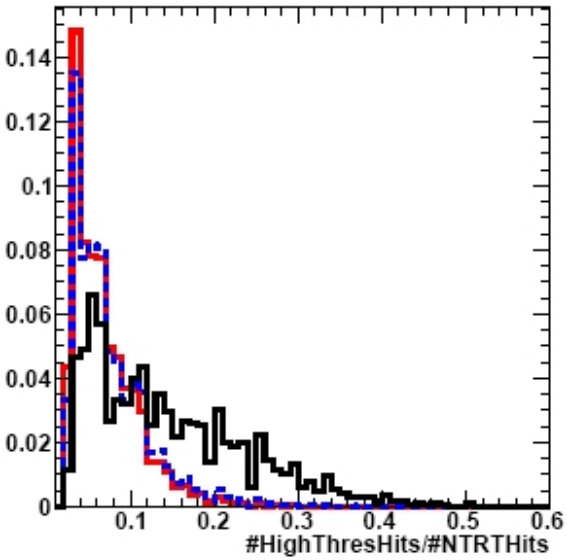
- all Tracks within $\Delta R < 0.3$
- only cut: $p_T > 500$ MeV
- Optimization is planned

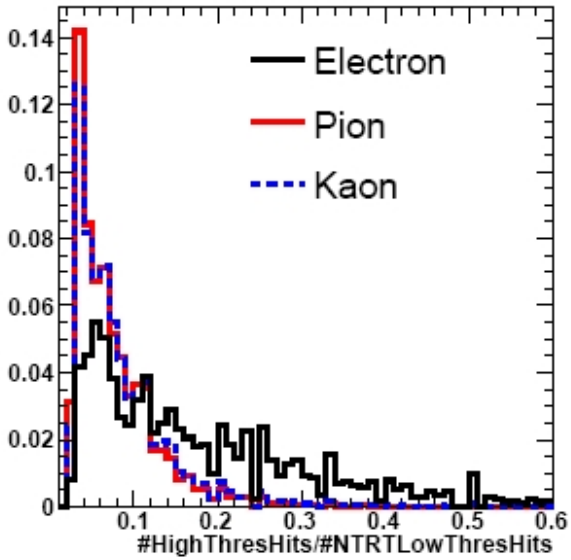
TRT cuts for VxCandidates









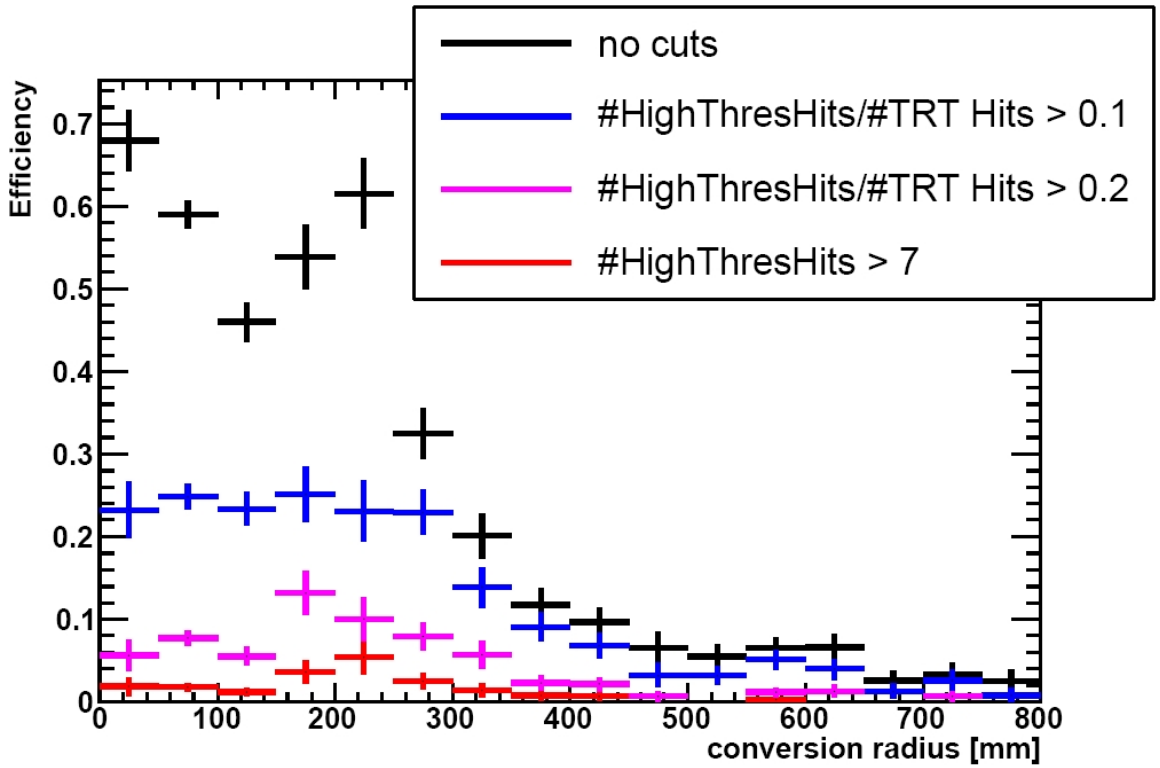


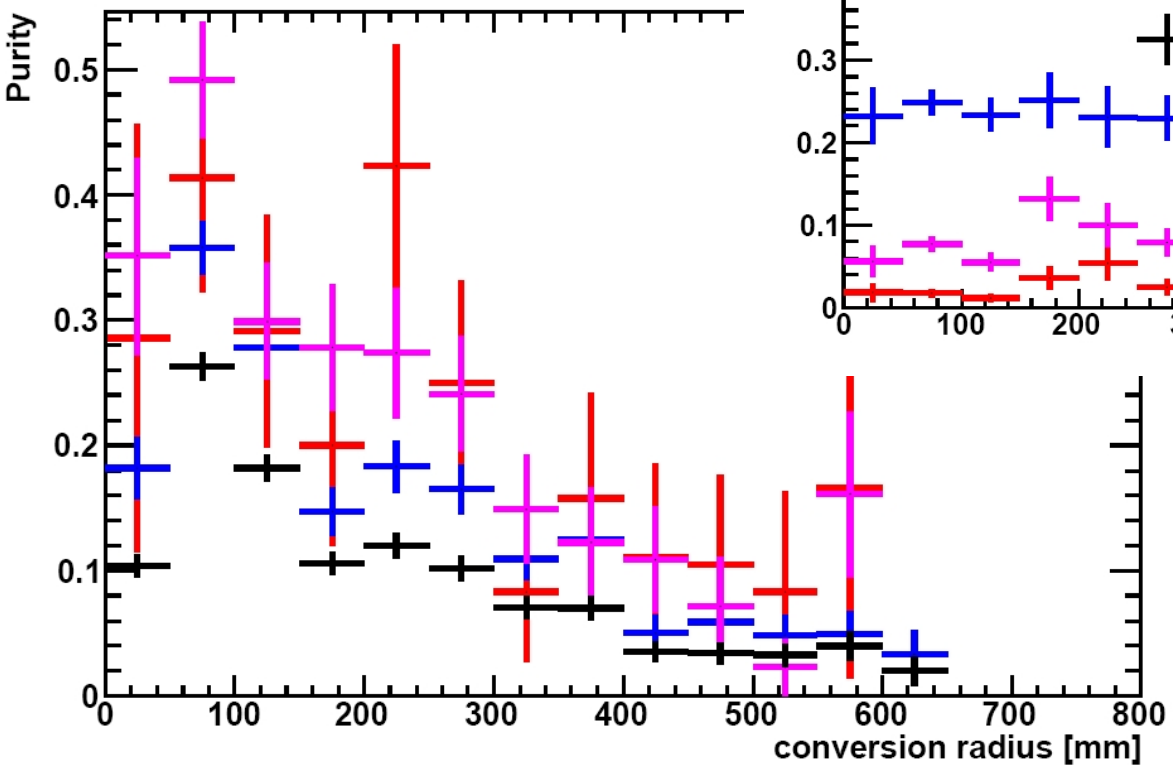
- Cleaning the VxCandidates by TRT cuts
- several cuts have been tested
- Optimization has to be done

Efficiency and Purity VxCandidates

Efficiency:

- higher with smaller R
- reduced by truthmatching





Purity:

- even strong cuts do not lead to more than 50 % purity

→ Truthmatching

Truthmatching

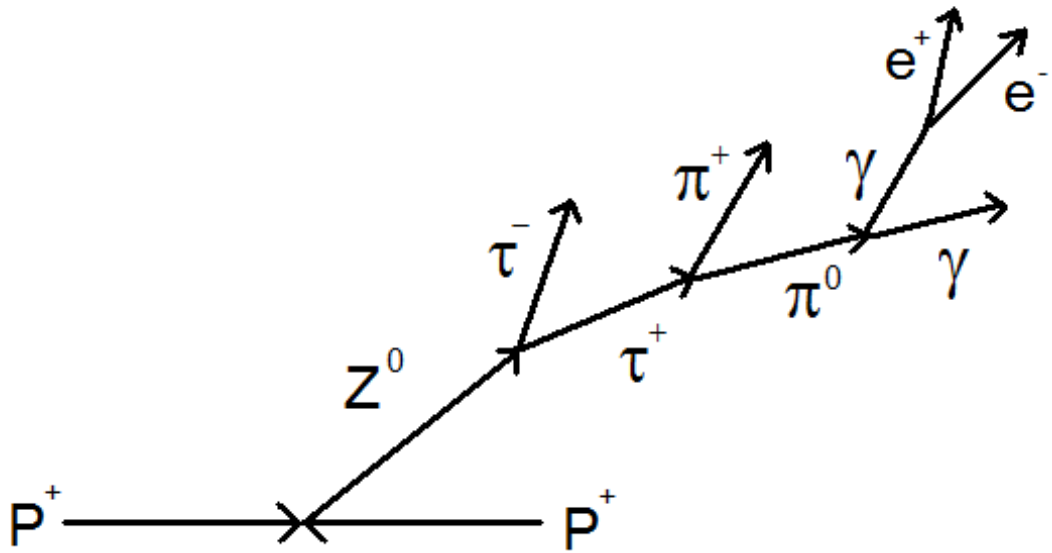
Problems:

- only ≈ 50 % of the *VxCandidate* tracks have been truthmatched
- this does not yield a good purity and efficiency
- purity and efficiency are strongly dependent on the truthmatching definition

Truthmatching Criteria:

- $\Delta R < 0.1$
- $\frac{\Delta p_T}{p_T} < 10\%$
- same charge

for refitted tracks

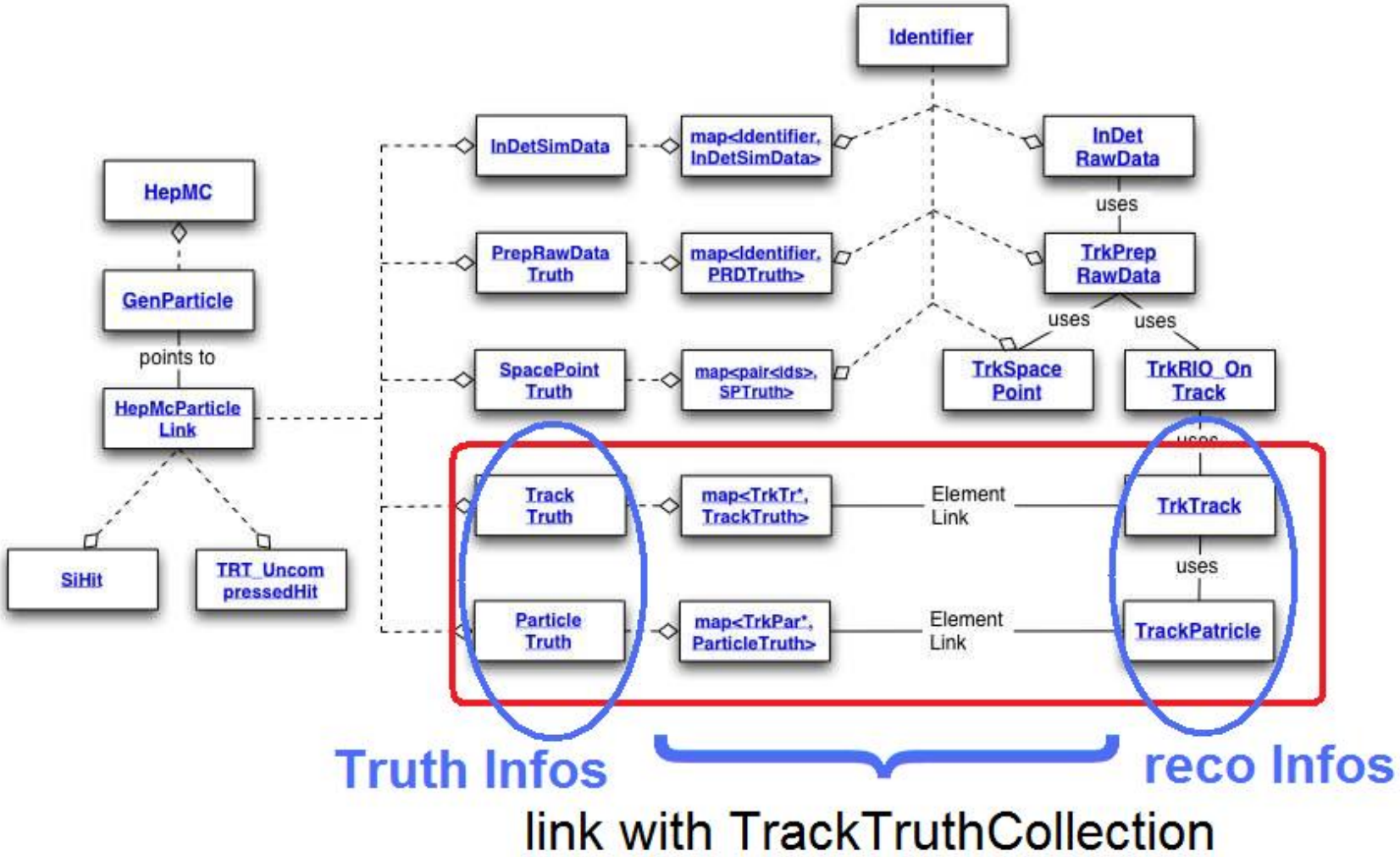


to solve this problem we will:

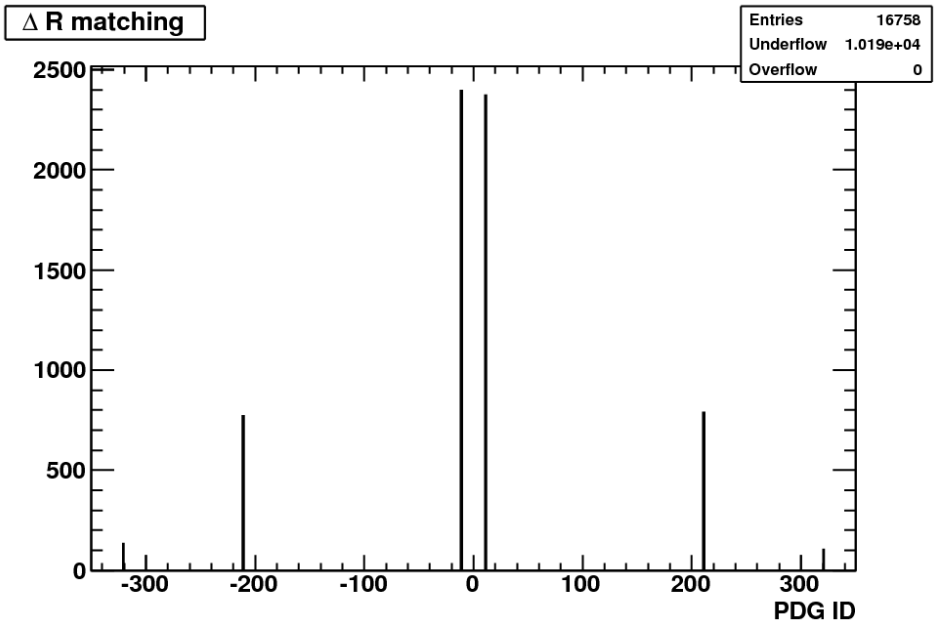
- use the so-called *TrackTruthCollection*, which directly associates a reco track to the corresponding truth track

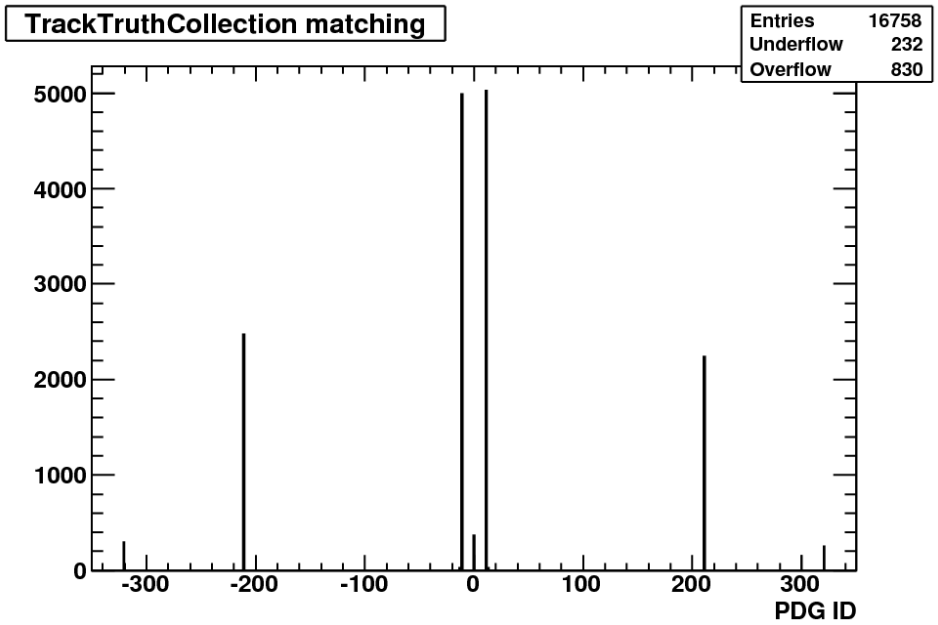
Mapping with *TruthTrackCollection*

- during the digitization process the truth association is created
- informations about number of shared hits between the track and the truth trajectory are used



First Results with *TrackTruthCollection* Matching





ΔR Matching

- underflow NOT to $\pi^{\pm}$, $K^{\pm}$ $e^{\pm}$ and $\mu^{\pm}$ matched tracks

TrackTruthCollection Matching

- 0 bin: NOT matched tracks
- under- and overflow p rest

- first results are very promising
- **next step:** use this truthmatching definiton for efficiency and purity

Summary and Outlook

Summary:

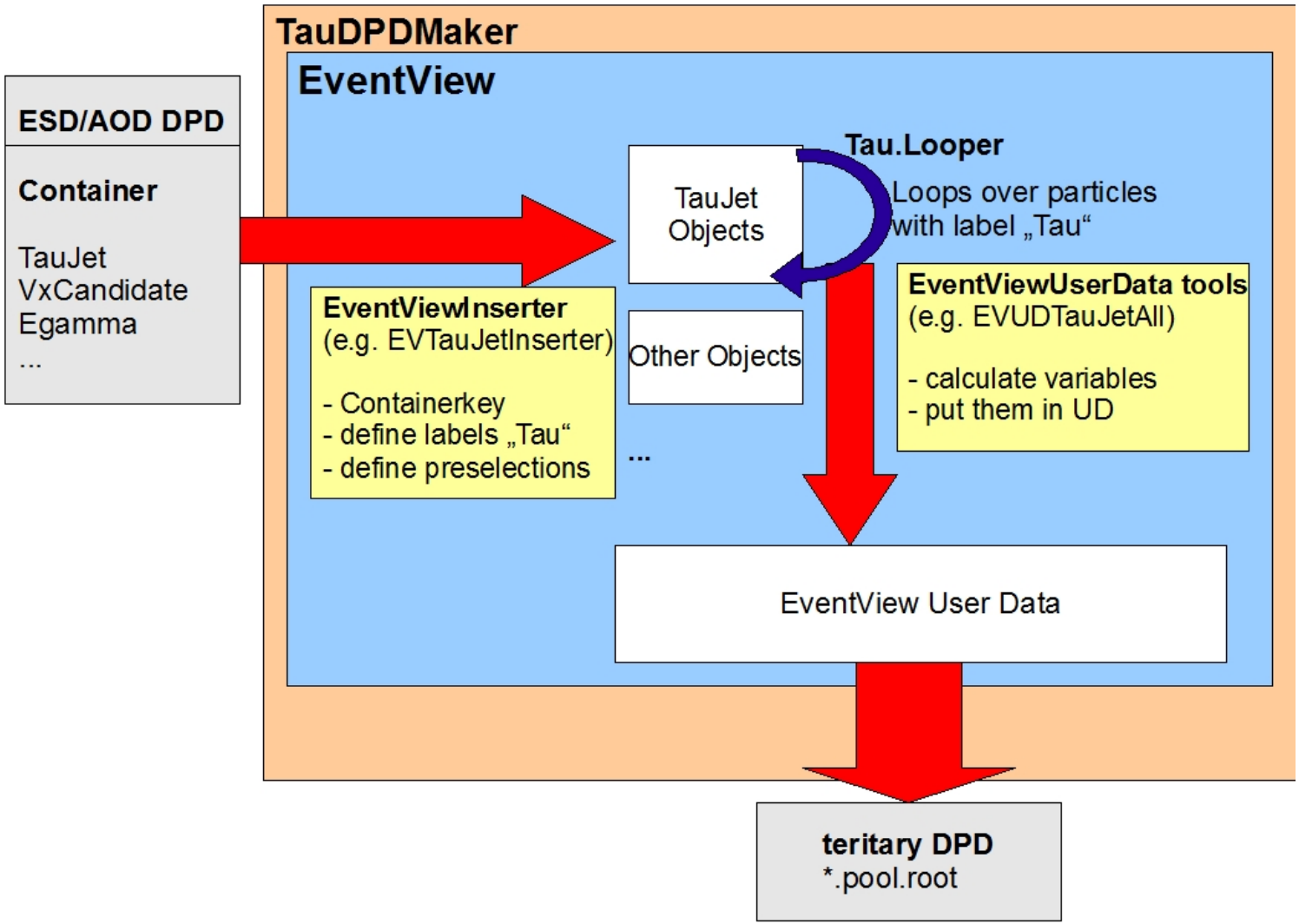
- specific EV tools have been written and are ready for rel. 14
- first tertiary DPD is produced with about 5000 Events
- comparison between *Egamma* and *VxCandidate* conversions is possible
- first tests for TRT cleaning are done

Outlook:

- redo the efficiency with *new* truthmatching
- optimization of TRT cuts
- rejection of tracks from $\gamma \rightarrow e^+e^-$ conversion in the τ-candidates
- re-implement the *TauRec* likelihood variables after rejection

Back-up Slides

How TauDPDMaker produces tertiary DPDs



- EventViewInserter selects objects from AOD/ESD
- EventViewUserData calculates the variables for the inserted objects

List of the new (EventView) Tools

All these modifications are available in EventViewUserData-00-01-23

EVUDIndex

- EVUDTauTrkIndex
- EVUDegammaTrkIndex
- EVUDegammaConvTrkIndex

- Tools read EventViewUserData and store the index (e.g. of tau track) into UD

EVUDVertex

- Stores all vertex and tracks at vertex informations into UD (e.g. Conversions)
- Stores indices of original (unfitted) tracks at the vertex into UD

EVUDegammaConv

- Stores all vertex and tracks at vertex informations from EGamma object into UD

EVUDTruthEgammaConv

- writes all informations from true photon conversions into UD

EVUDTauJetAll

- updated for release 14 (after τ algorithm merging)

Overview of the Index tool

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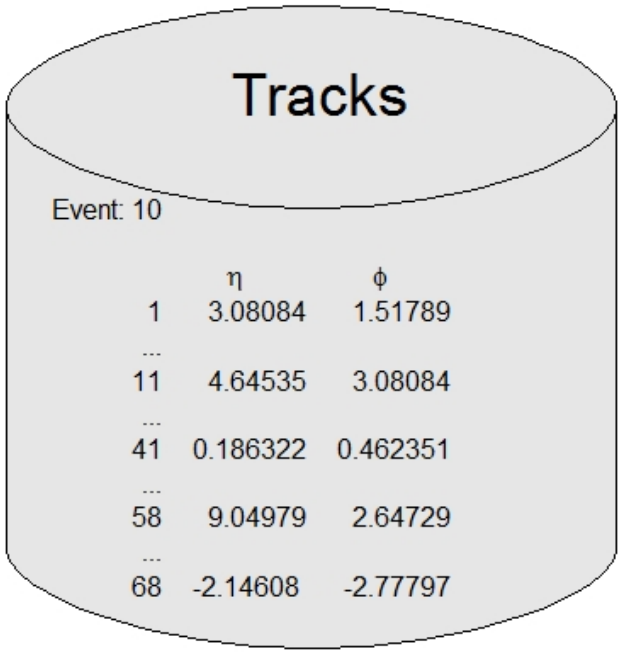

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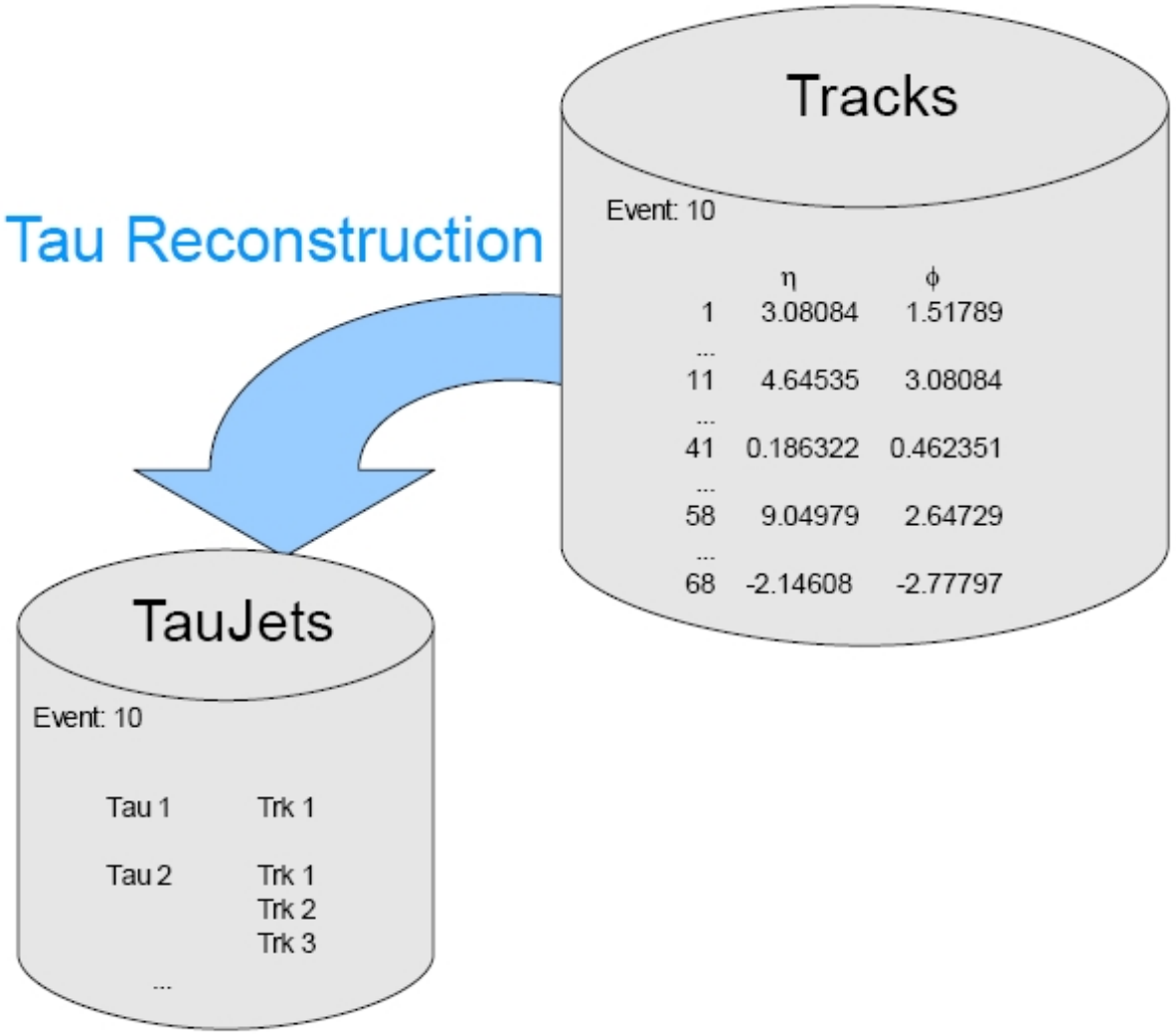

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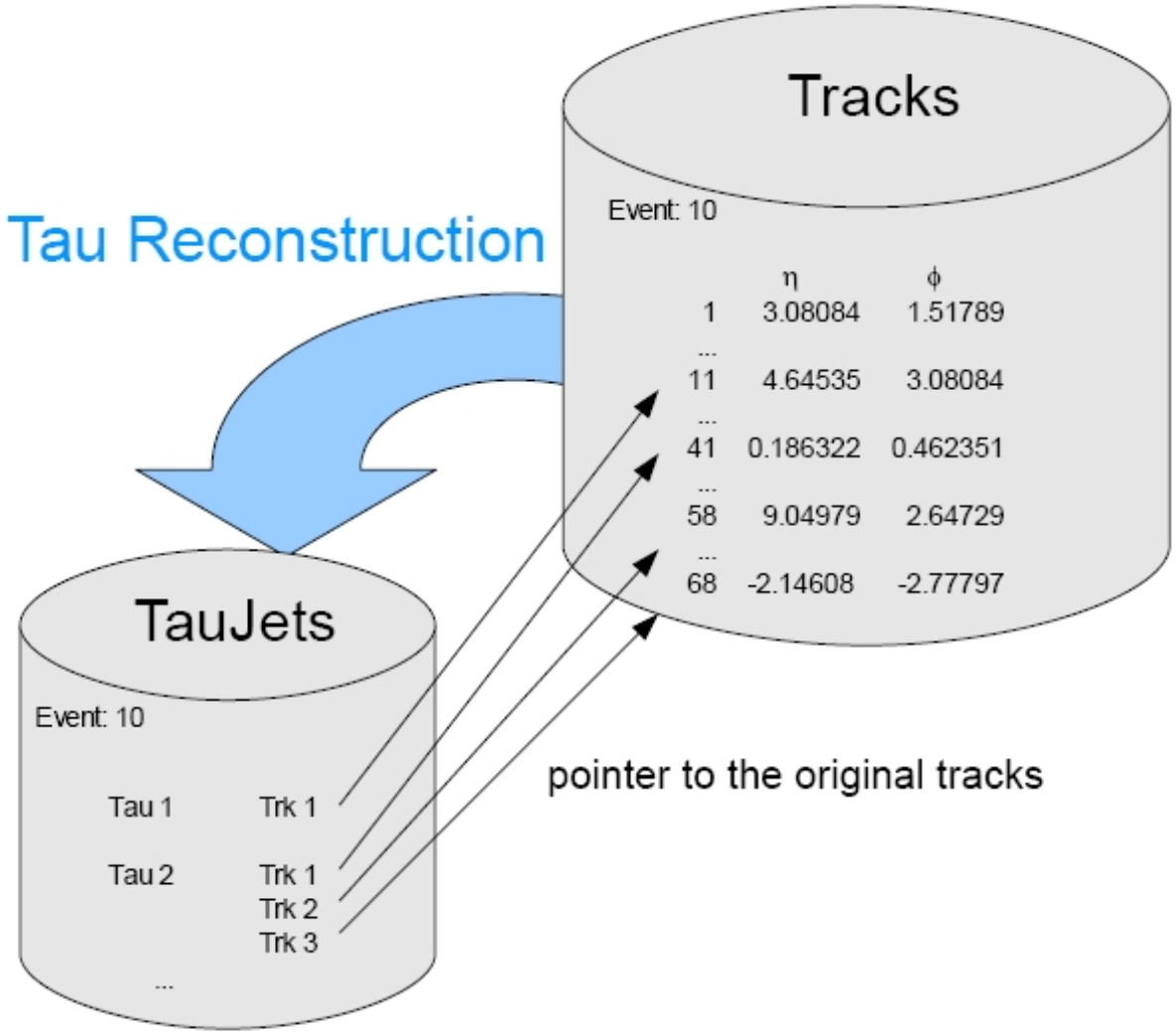

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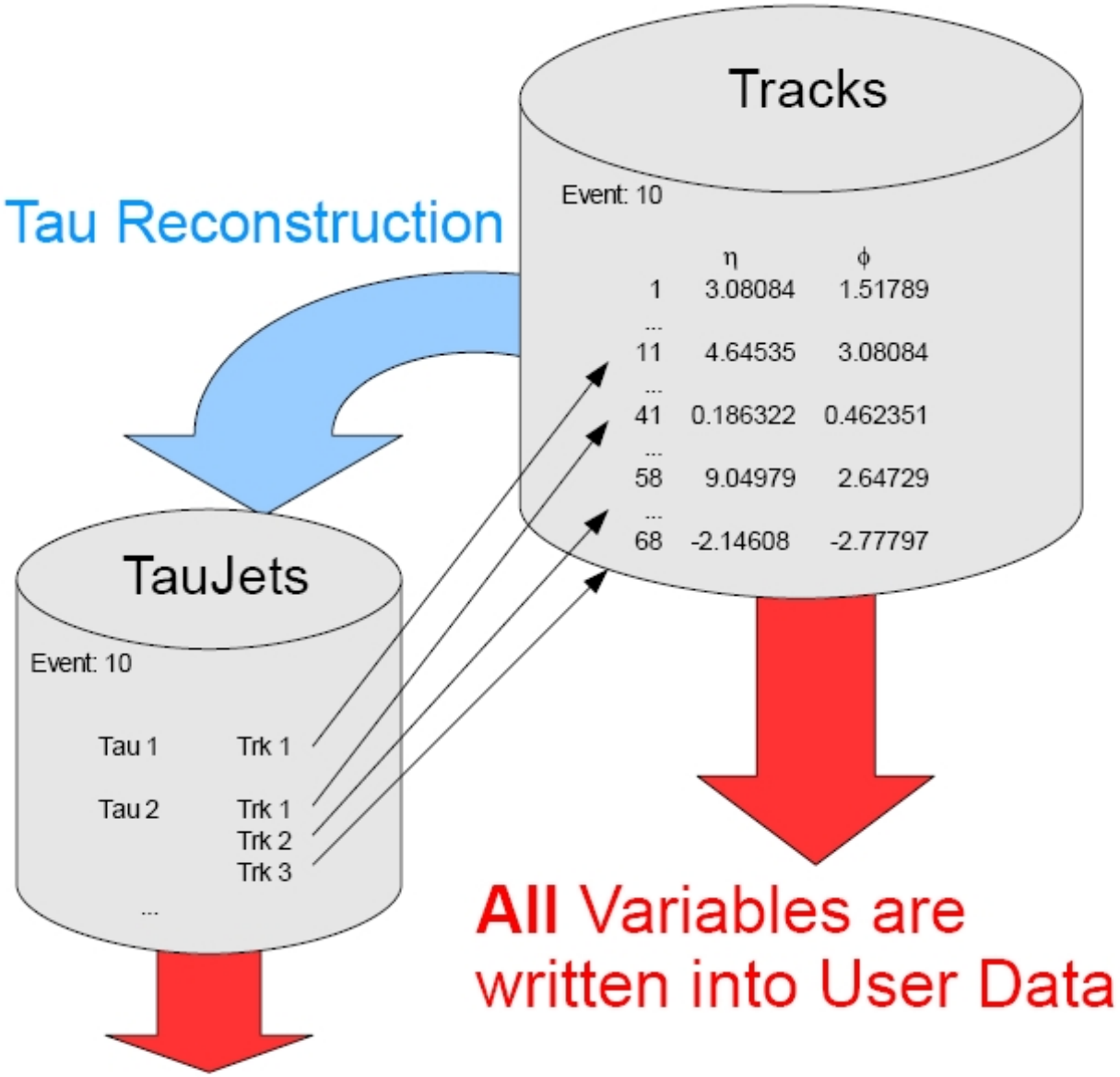

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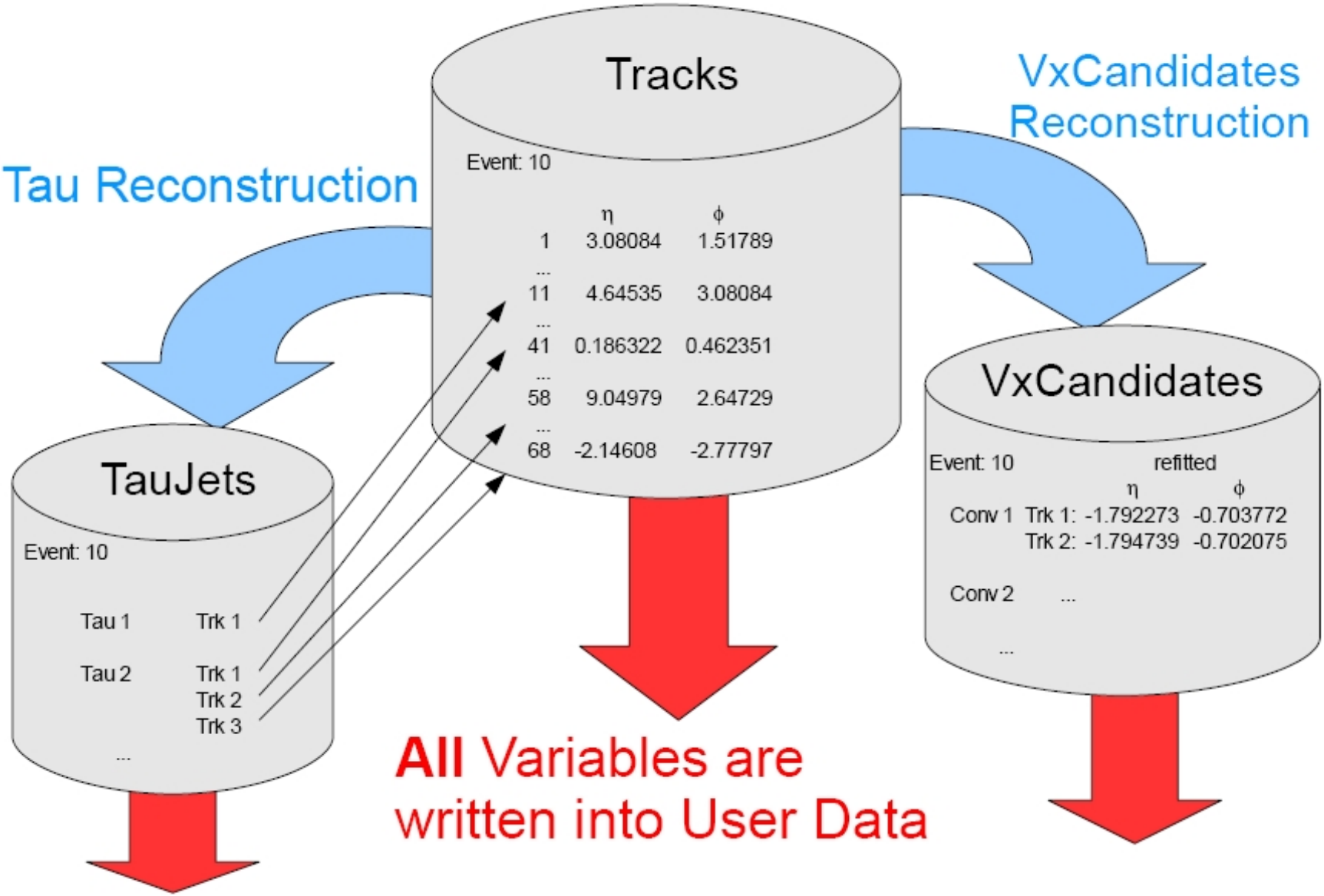

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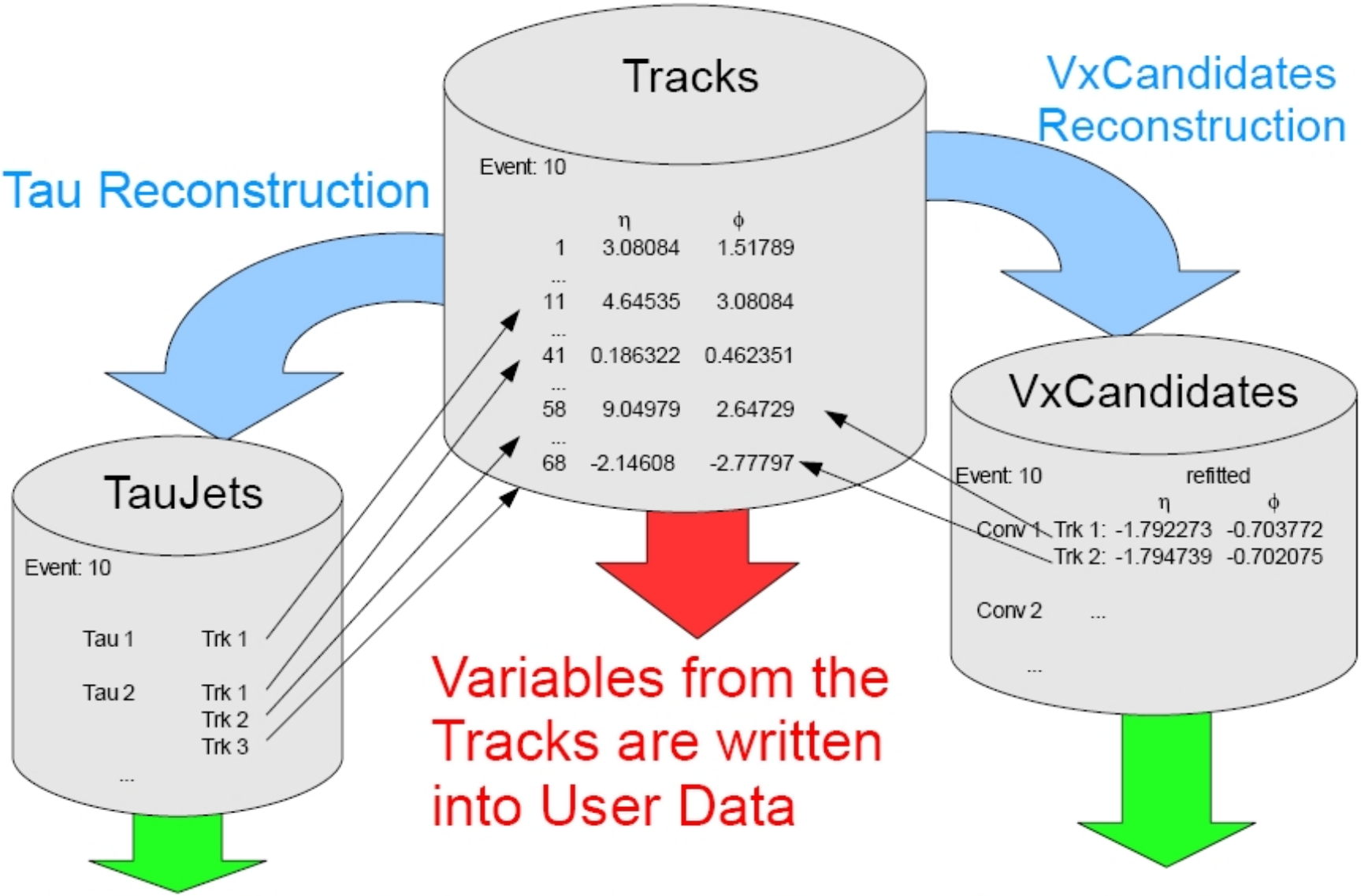

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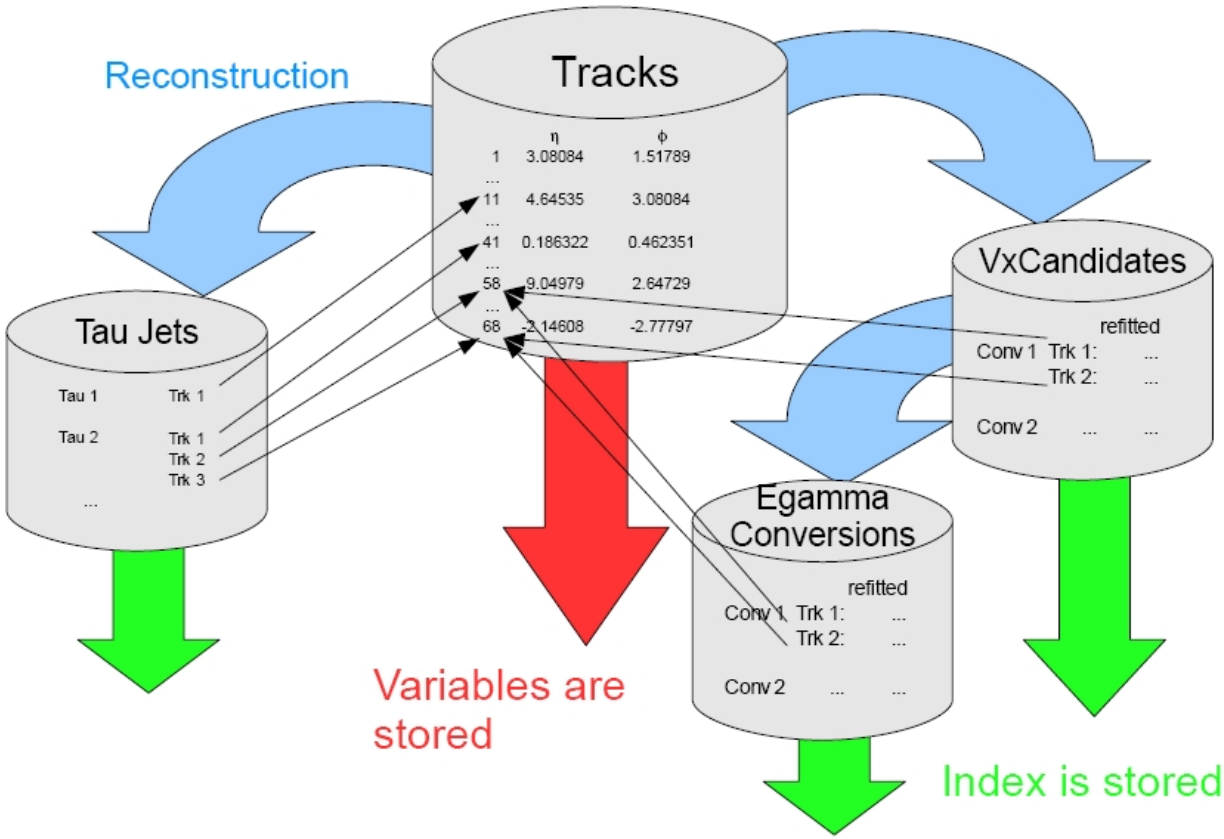


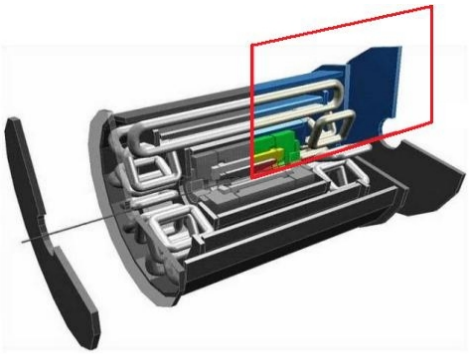
- detail informations stored once for all tracks
- other objects use these informations by the index
- smaller tertiary DPDs $\rightarrow$ faster analysis
- rejection of photon conversion tracks in τ-cone without ΔR match

Pilot Study with CBNT ntuple

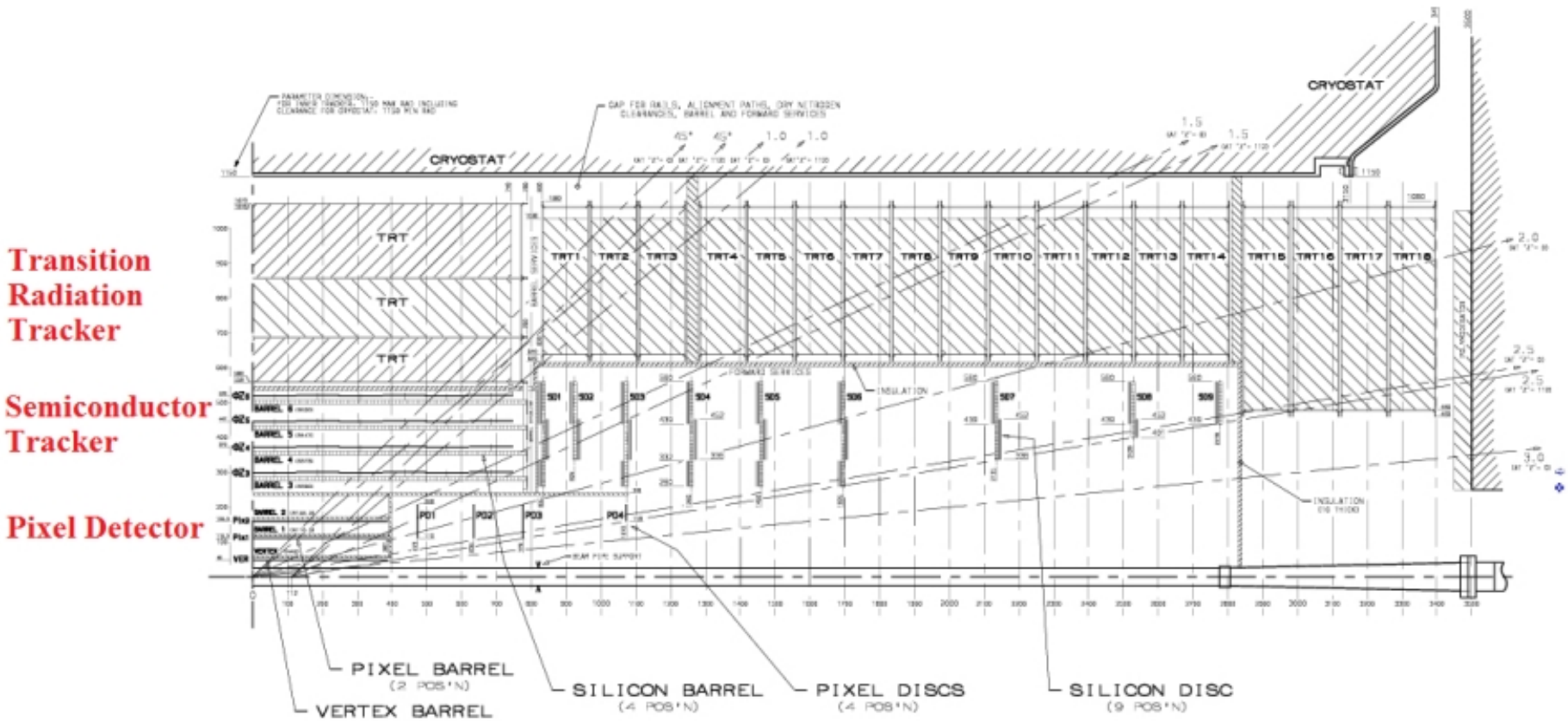
Used Sample

- CBNT ntuple:
  - release 13 with TopoCluster TauRec
  - 005188.A3_Ztautau_filter.CBNT.RDO.v12000605_tid00916.root
- process: $Z \rightarrow \tau\tau$
- statistics: 9950 events
- algorithms
  - TauRec
  - InDetConversionFinderTool

Material in the Detector

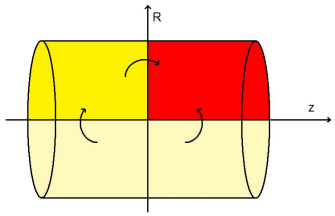


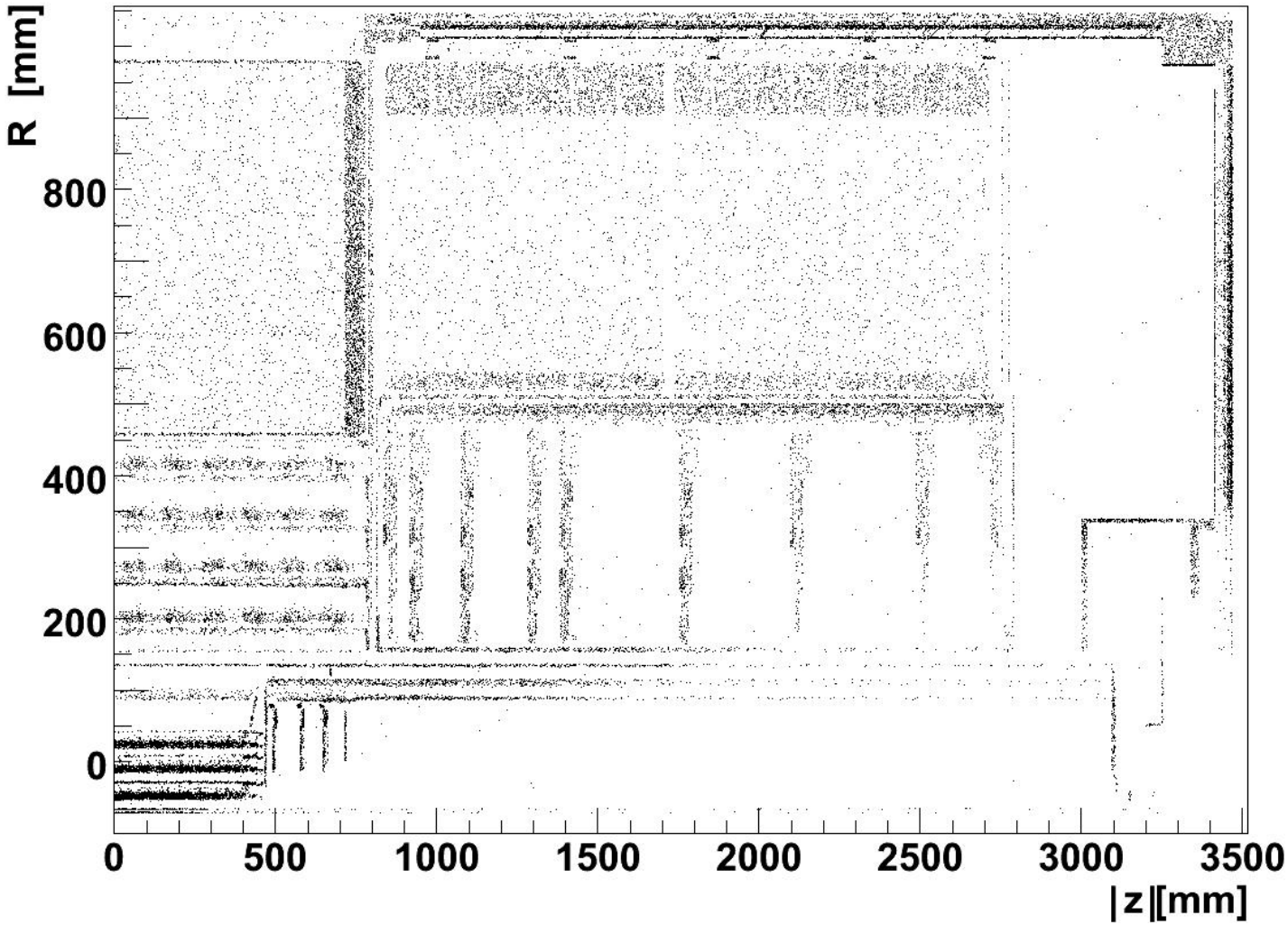
- right upper corner of the ATLAS detector
- consider the detector geometry for the γ-conversion simulation



Vertices MC simulation of photon conversions

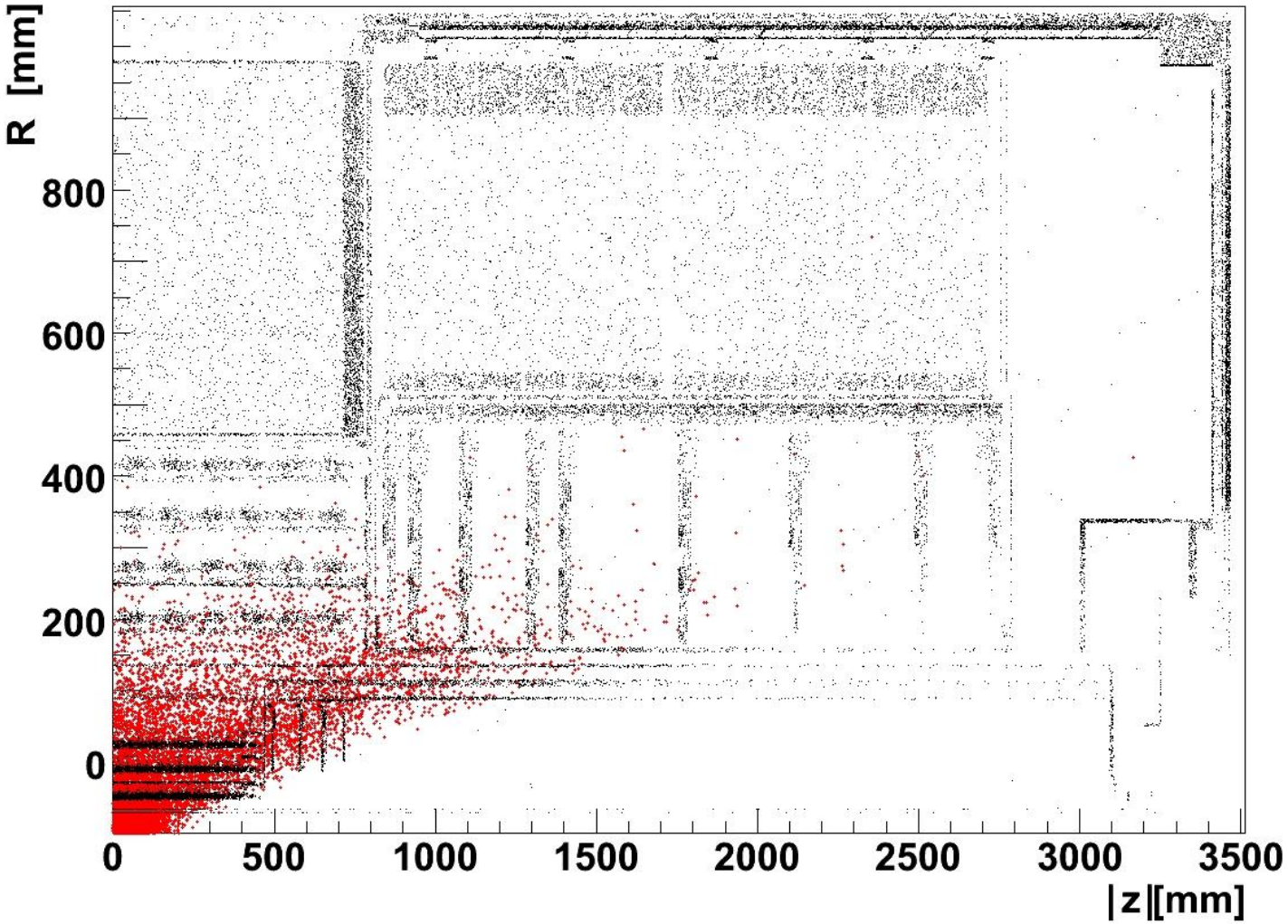
- projection onto the upper right quarter



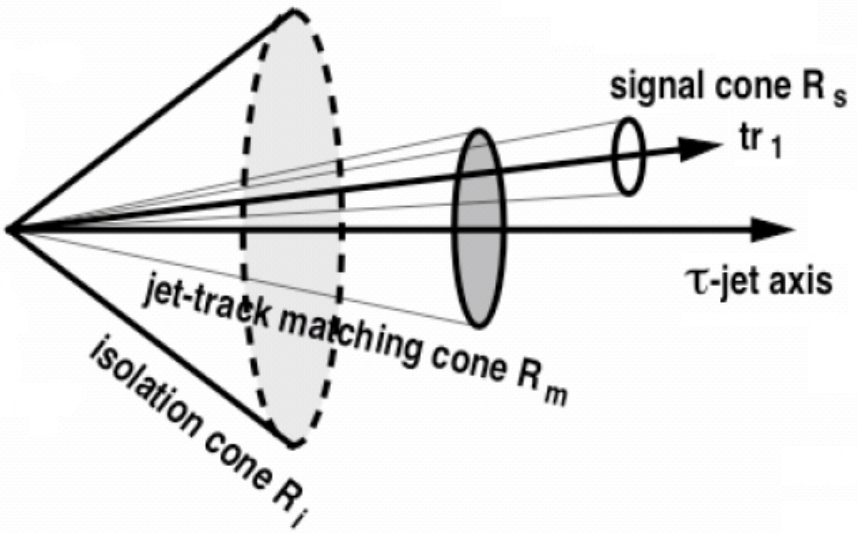


Reconstructed Vertices

- : true γ-conversions
- : reconstructed γ-conversions



Reconstruction of τ-candidates

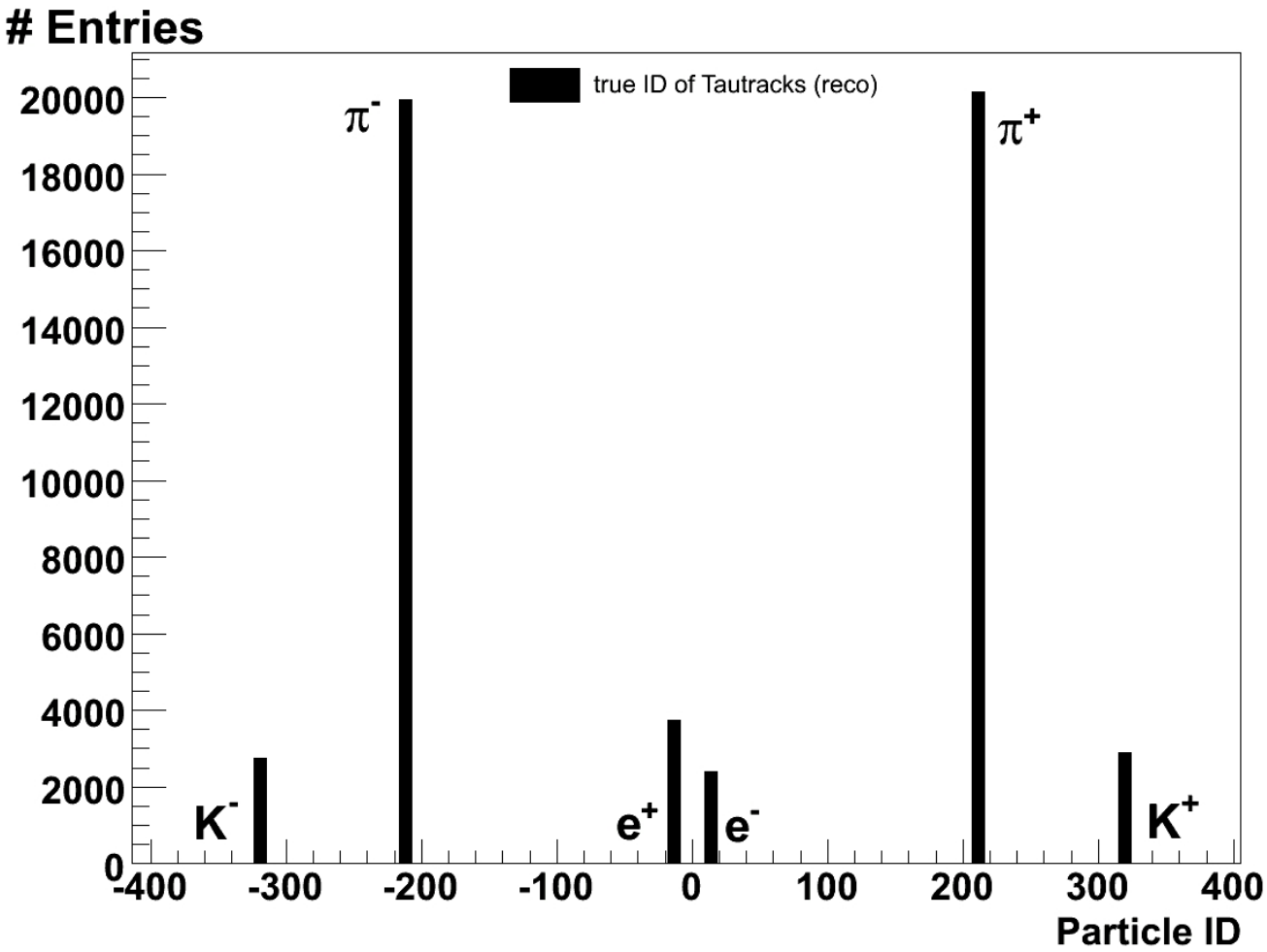


TauRec algorithm

- analyse jets of τ-candidates
- tracks of a τ-jet in a cone of $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2} < 0.3$ are accepted
  - tracks of a τ-candidate (cp. tr_1)
- up to 3 tracks are available for this study
- these are sorted by their transversal momentum

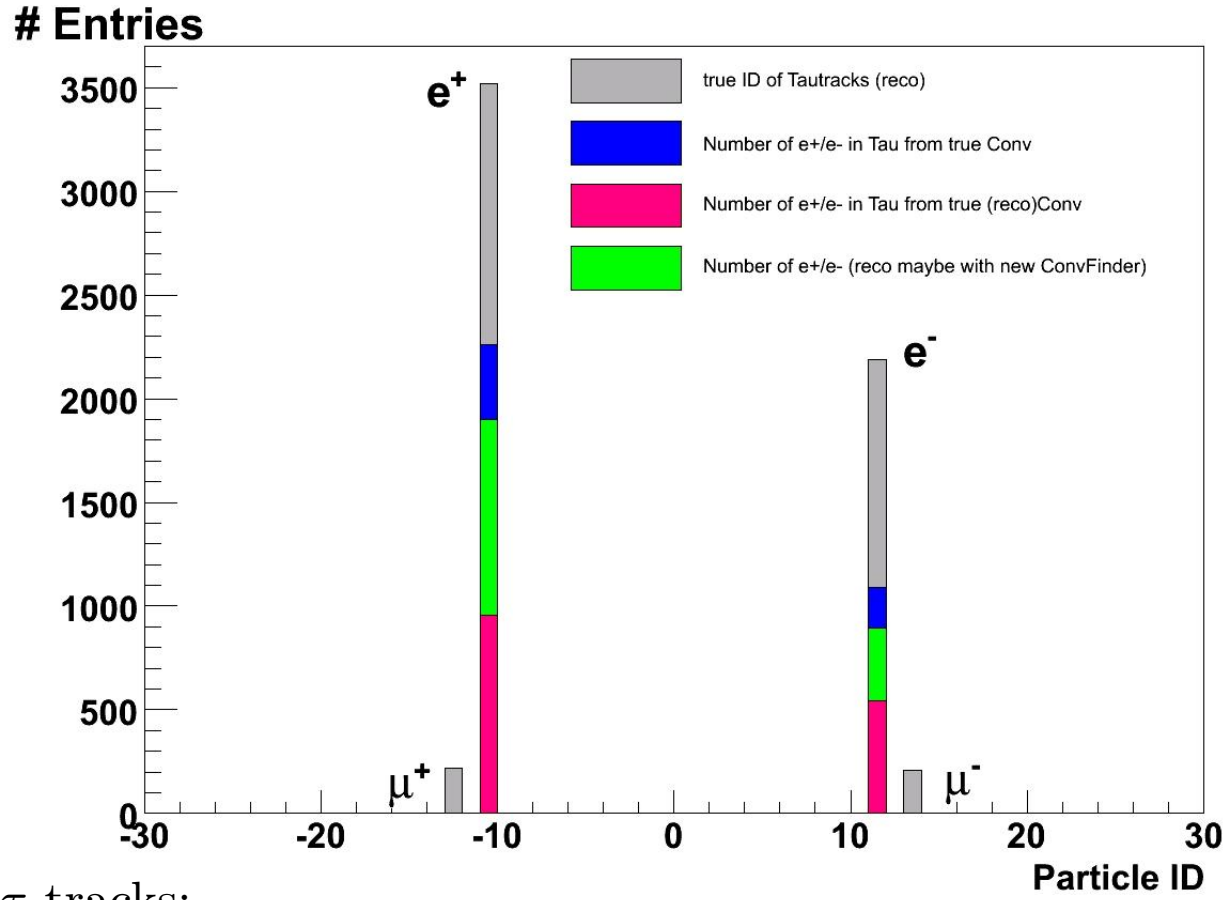
Aim of this study: Indentify tracks from photon conversions which lie in the ΔR cone of a τ-candidate

Identity of all τ-tracks



- as we have expected: most of the tracks come pions

Leptonic Fraction



Fraction to all τ-tracks:

true e^+e^-	10.4 %
true γ-conv.	6.08 %
reco. γ-conv.	2.73 %
New γ-conv. reco.	5.08% ?

Fraction to e^+e^- tracks of the τ-candidates:

reco. γ-conv.	44.8 %
New Conv.Finder	83.5 % ?

Summary and Wishlist

results of this pilot study:

- 6.1 % of the reconstructed τ-tracks are e^+ or e^--tracks from true photon-conversions
- purity of the *ConversionFinder* tool very poor
  (there is no electron identification)

Summary and Wishlist

results of this pilot study:

- 6.1 % of the reconstructed τ-tracks are e^+ or e^--tracks from true photon-conversions
- purity of the *ConversionFinder* tool very poor (there is no electron identification)

wishlist:

- using the modified *ConversionFinder* tools available in rel. 14.0.0 (modified by Thomas Koffas, Mauro Donega et al.):
  - enhanced track selection
  - enhanced vertex fitting
  - reconstruction of single track conversions
  - pointer to the unfitted conversion tracks
- optimisation of the *ConversionFinder* tool for the τ-environment
  - enhance the purity by cleaning the sample with an electron identification, perhaps invariant mass cut, ...
- enhance the correlation between conversion- and τ-tracks by using the *Trk-Indices*
- consider all tracks of a τ-candidate