Belle Starr Status Update and MANTS

Robert Bormuth
Leiden University and Nikhef
September 23, 2016

Belle Starr reco

Goal

Identify two shower signature “Double Bang” in our detector

Belle Starr reco so far, can be found at
http :// svn.km3net.de/reconstruction/Belle_Starr/trunk/ :

1. Single shower position, direction and energy fit (Belle Starr Prefit)
2. Scan two shower likelihood from rec position in $\pm 400\,\mathrm{m}$ along rec direction (Belle Starr Scan)
3. Analyze likelihood landscape using TSpectrum (Belle Starr Peak)

Scan results: Finding the minimum

Improved estimation of likelihood “bkg” estimation. Used now the output of TSpectrum for background fit (based on SNIP algorithm)

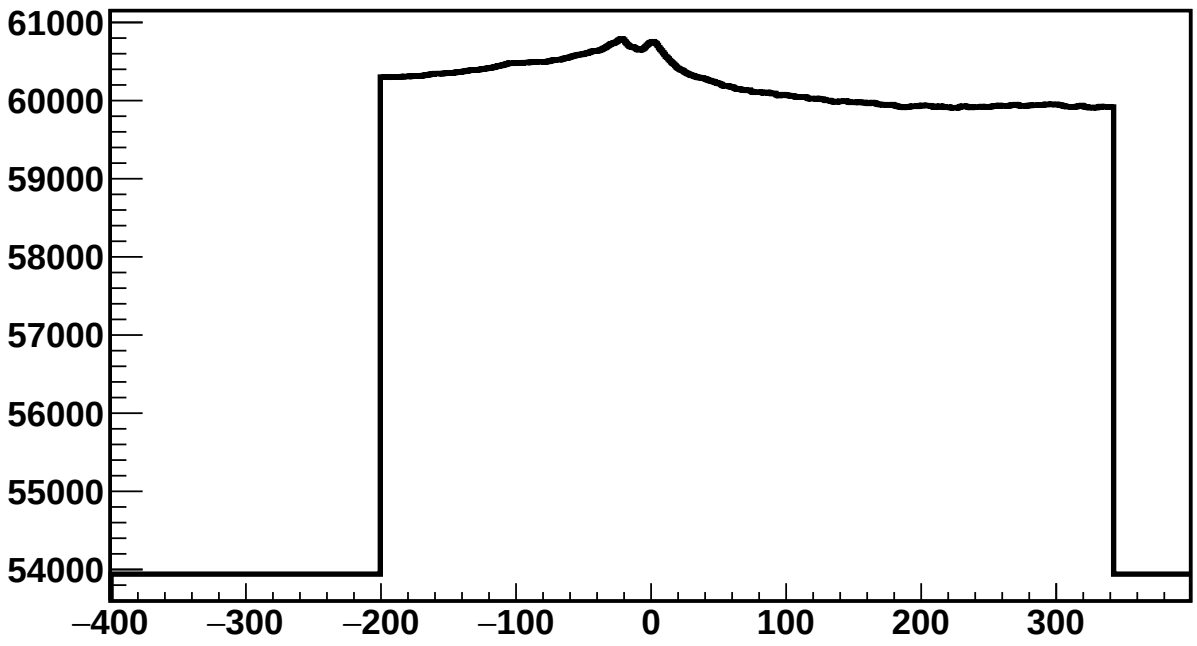


Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood

Scan results: Finding the minimum

Improved estimation of likelihood “bkg” estimation. Used now the output of TSpectrum for background fit (based on SNIP algorithm)

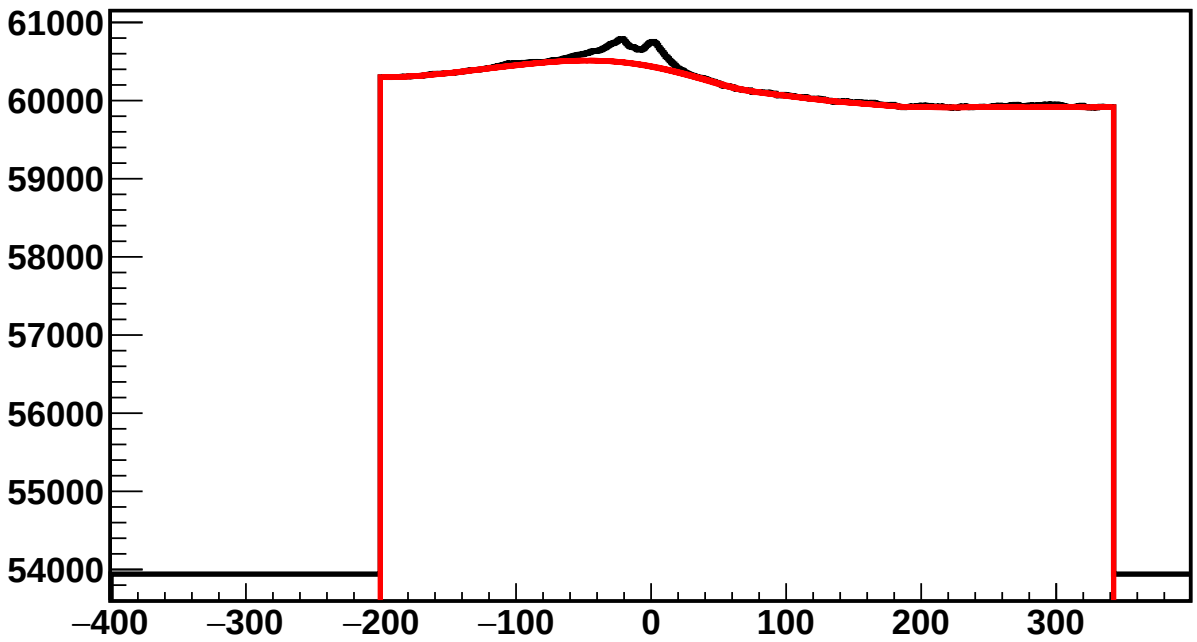


Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood

Scan results: Finding the minimum

Improved estimation of likelihood “bkg” estimation. Used now the output of TSpectrum for background fit (based on SNIP algorithm)

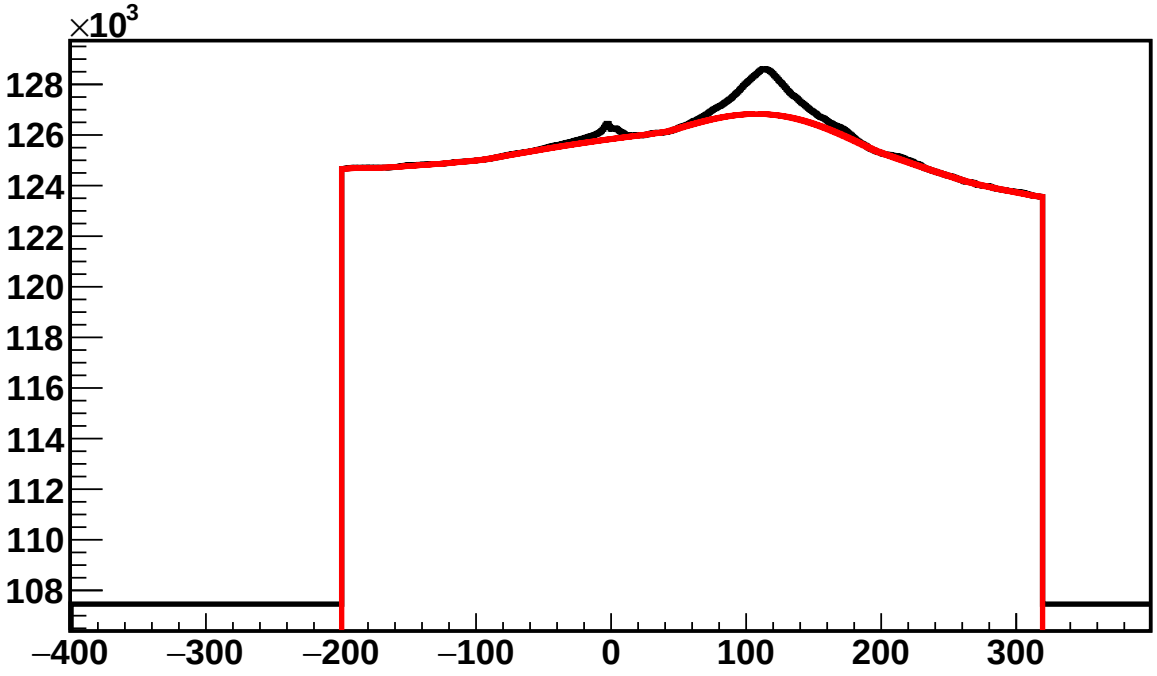


Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood

Scan treatment - TSpectrum routine

1. Flip original likelihood scan
2. Estimate continuous background and subtract background estimate
3. Enhance peak to background ratio using Markhov Chain approach
4. Find peaks by derivative change in enhanced spectra

Flip original likelihood scan

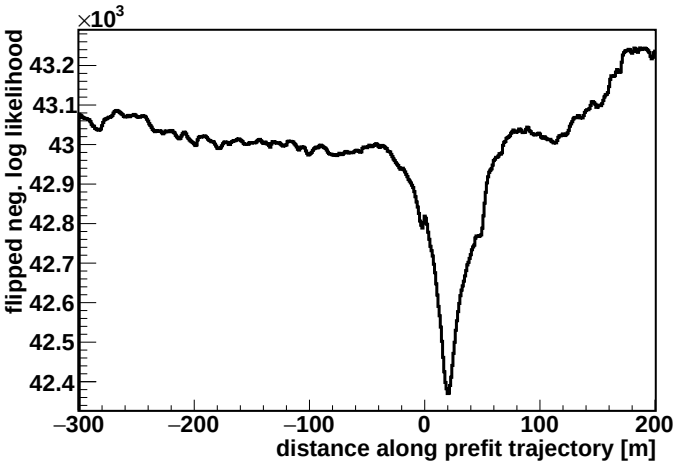


Figure : Original likelihood scan

→

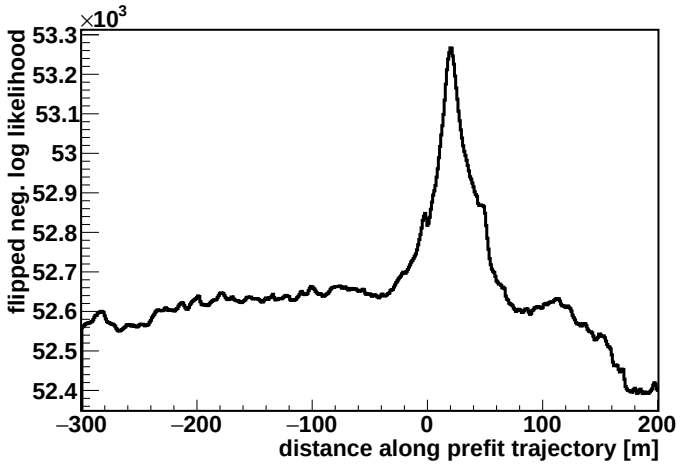


Figure : Flipped likelihood scan

Estimate continuous background and subtract background estimate

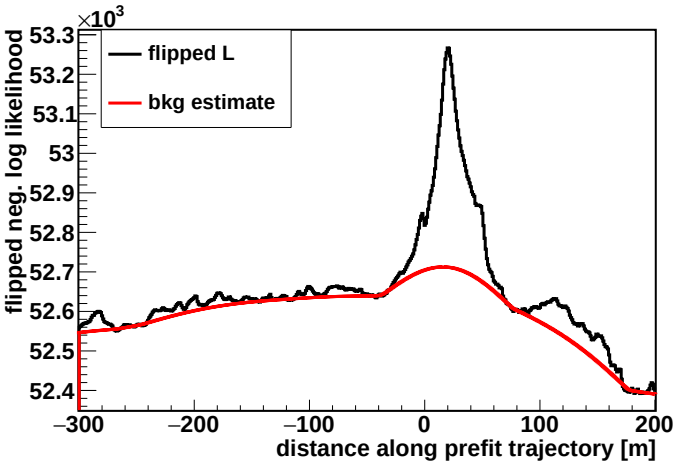


Figure : Flipped and est. bkg

→

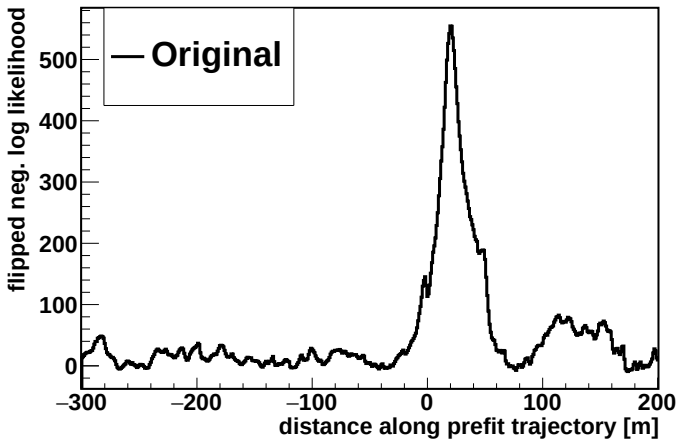


Figure : bkg subtracted

Enhance peak to background ratio using Markhov Chain approach

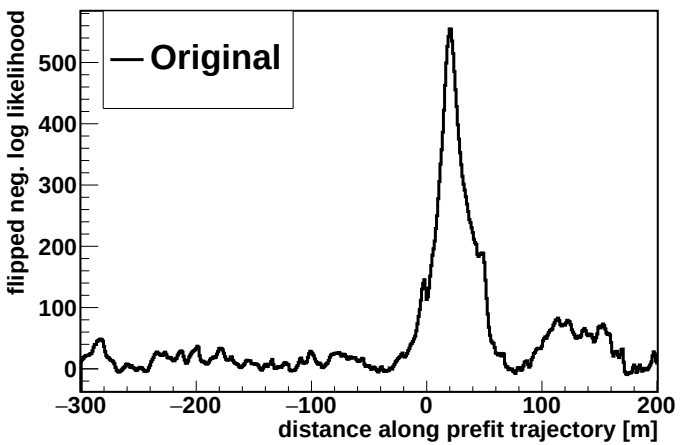


Figure : flipped + bkg subtracted

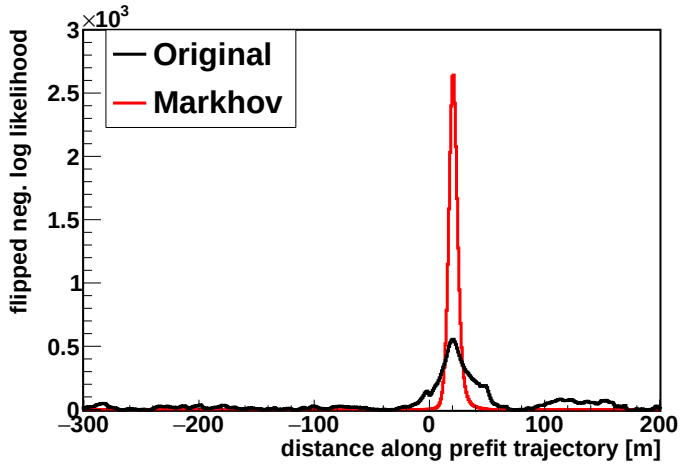


Figure : Enhancement of peaks

Scan results - peak estimation

Peak significance

TSpectrum finds peaks based on width with previous enhancement, need to establish if these peaks are significant, found good discriminator

$$\text{peak}_L \geq \text{bkg}_L + 300 \tag{1}$$

Scan results - peak estimation

Peak significance

TSpectrum finds peaks based on width with previous enhancement, need to establish if these peaks are significant, found good discriminator

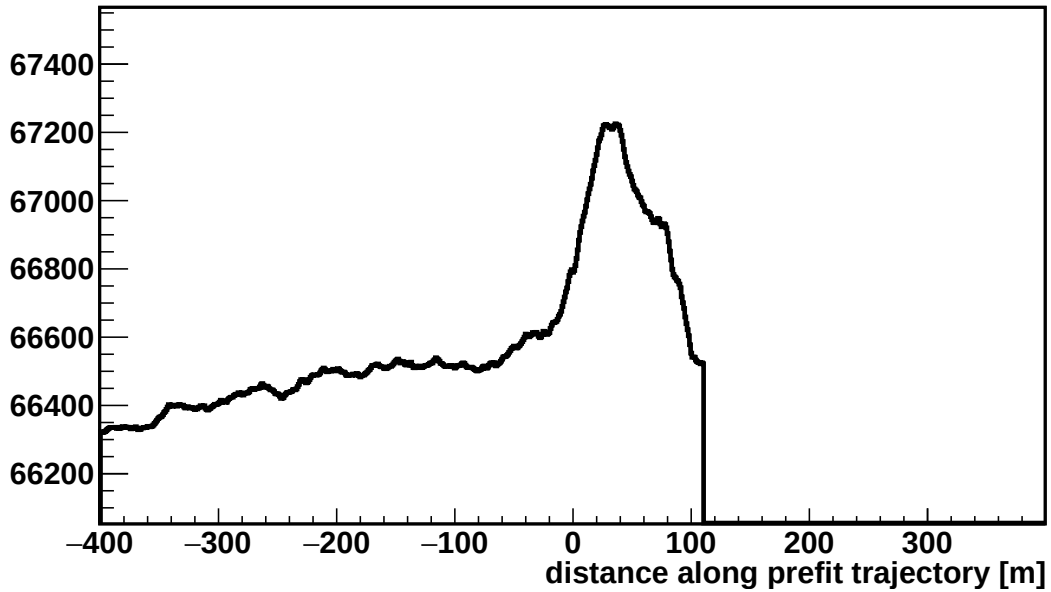


Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood

Scan results - peak estimation

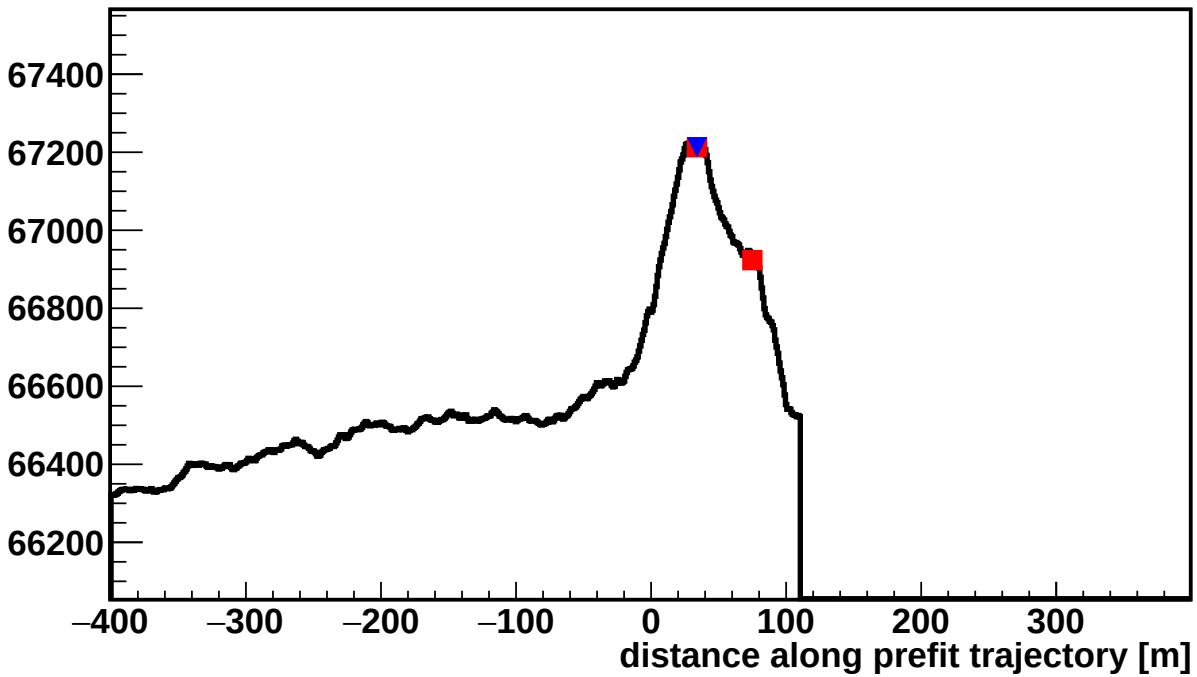


Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood, red square: all peaks found, blue triangle: significant peaks

Further improving shower position reco

Belle Starr reco so far, can be found at
http :// svn.km3net.de/reconstruction/Belle_Starr/trunk/:

1. Single shower position, direction and energy fit (Belle Starr Prefit)
2. Scan two shower likelihood from rec position in ± 400 m along rec direction (Belle Starr Scan)
3. Analyze likelihood landscape using TSpectrum (Belle Starr Peak)

$\hookrightarrow$ further improve reco by running full two shower position fit on good output (apply selection as Slide 18 except length cut on scan quantities) of Belle Starr Peak

Refitting the output

Since we only refit the two positions, expect improvement in vertex reco and direction reco [for direction only change for events with length 5 m or larger based on position]:

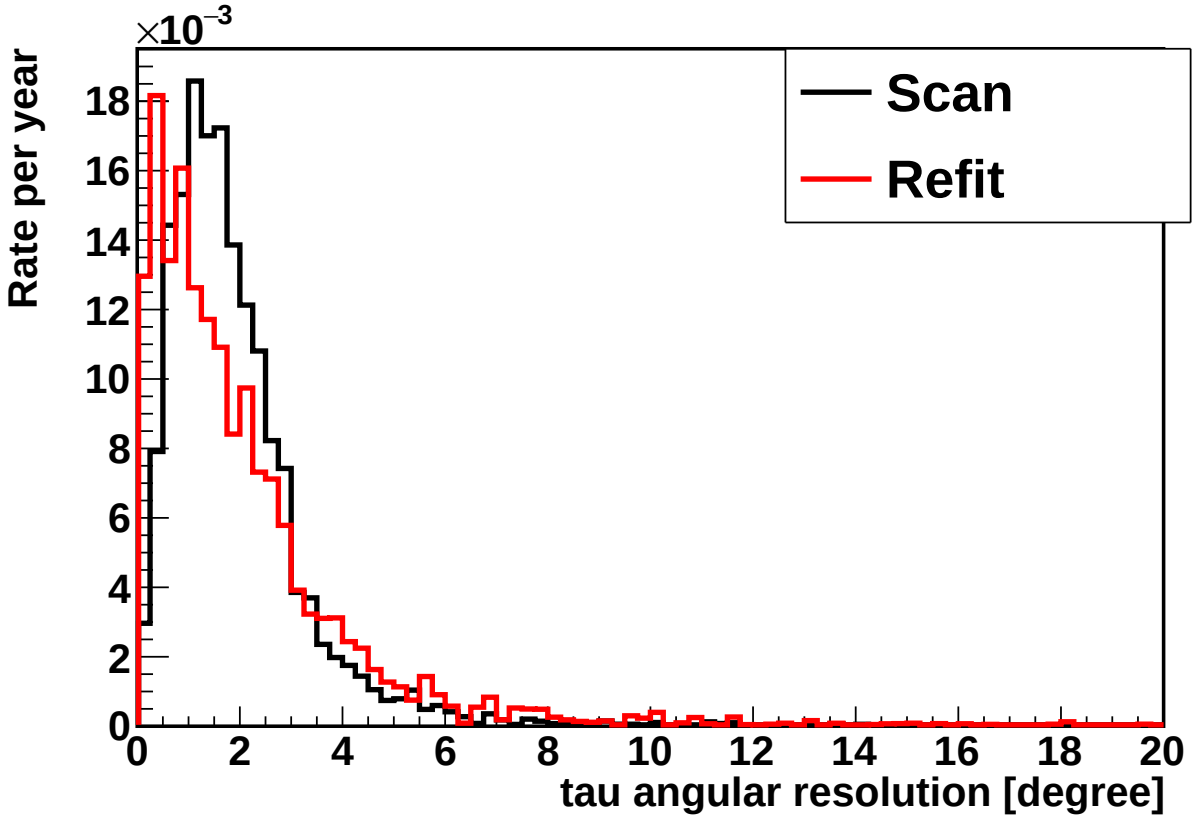
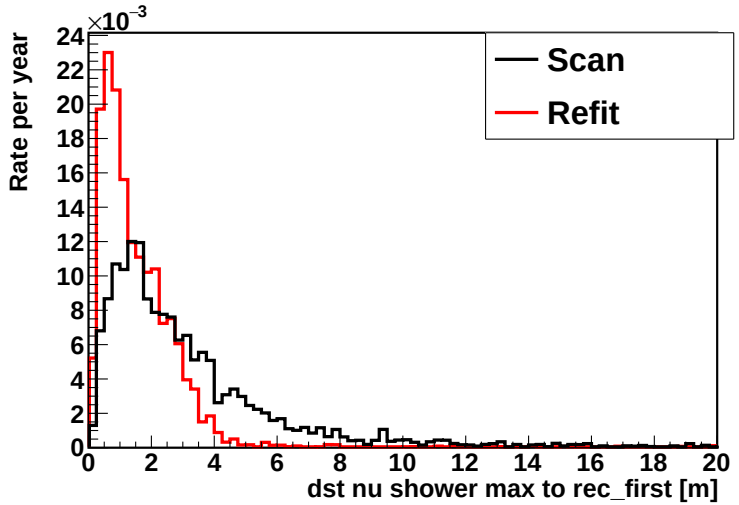


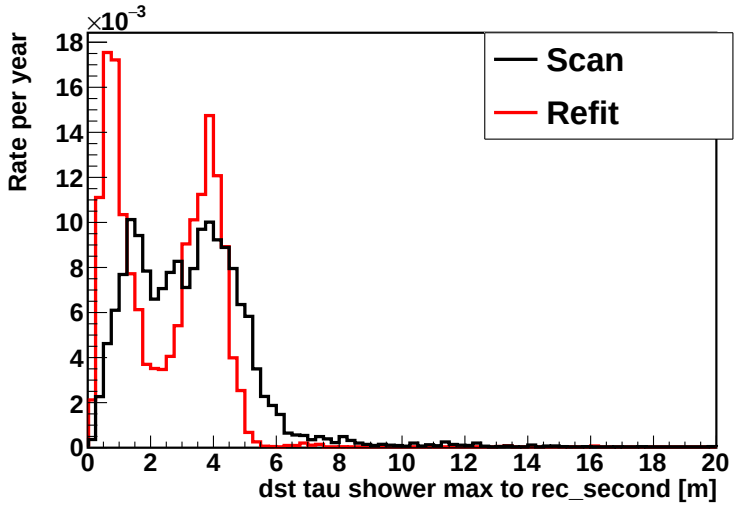
Figure : Angular resolution of tau events before and after refitting

Refitting the output

Since we only refit the two positions, expect improvement in vertex reco and direction reco [for direction only change for events with length 5 m or larger based on position]:



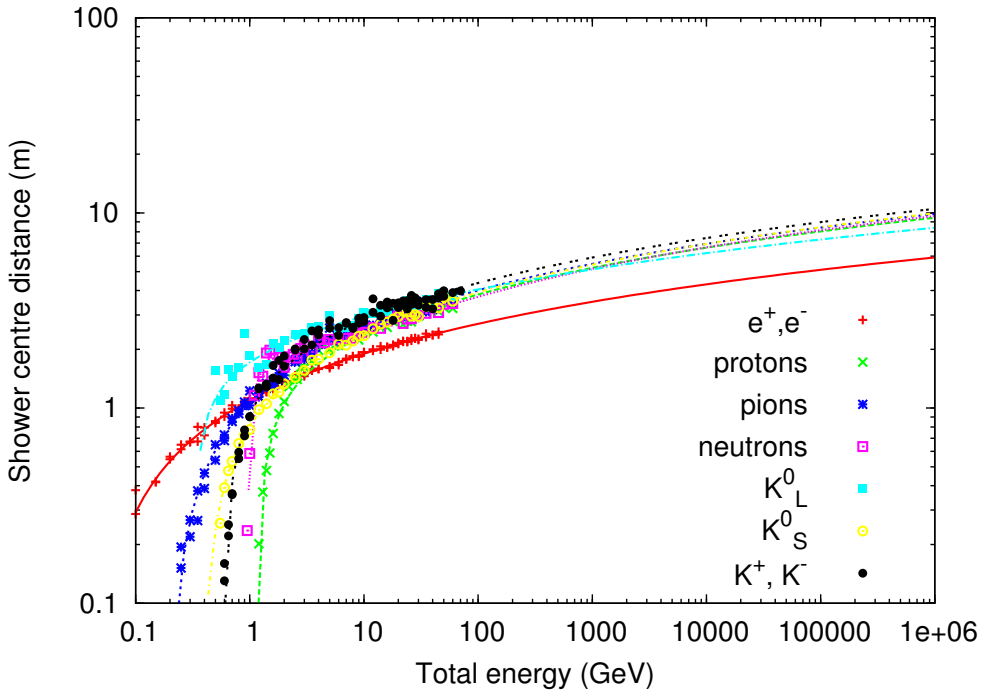
(a) Distance between neutrino shower maximum and first (in time) rec position before and after refitting



(b) Distance between tau shower maximum and second (in time) rec position before and after refitting

2nd vertex position resolution

Double peak structure for tau decay shower resolution is caused by the uniqueness of the tau decay (only 2 or 3 pions most of the time). A charged pions has a much greater simulated shower length in the order of 3.5 m therefore the energy distribution among the neutral and charged pions changes the tau decay shower length



2nd vertex position resolution

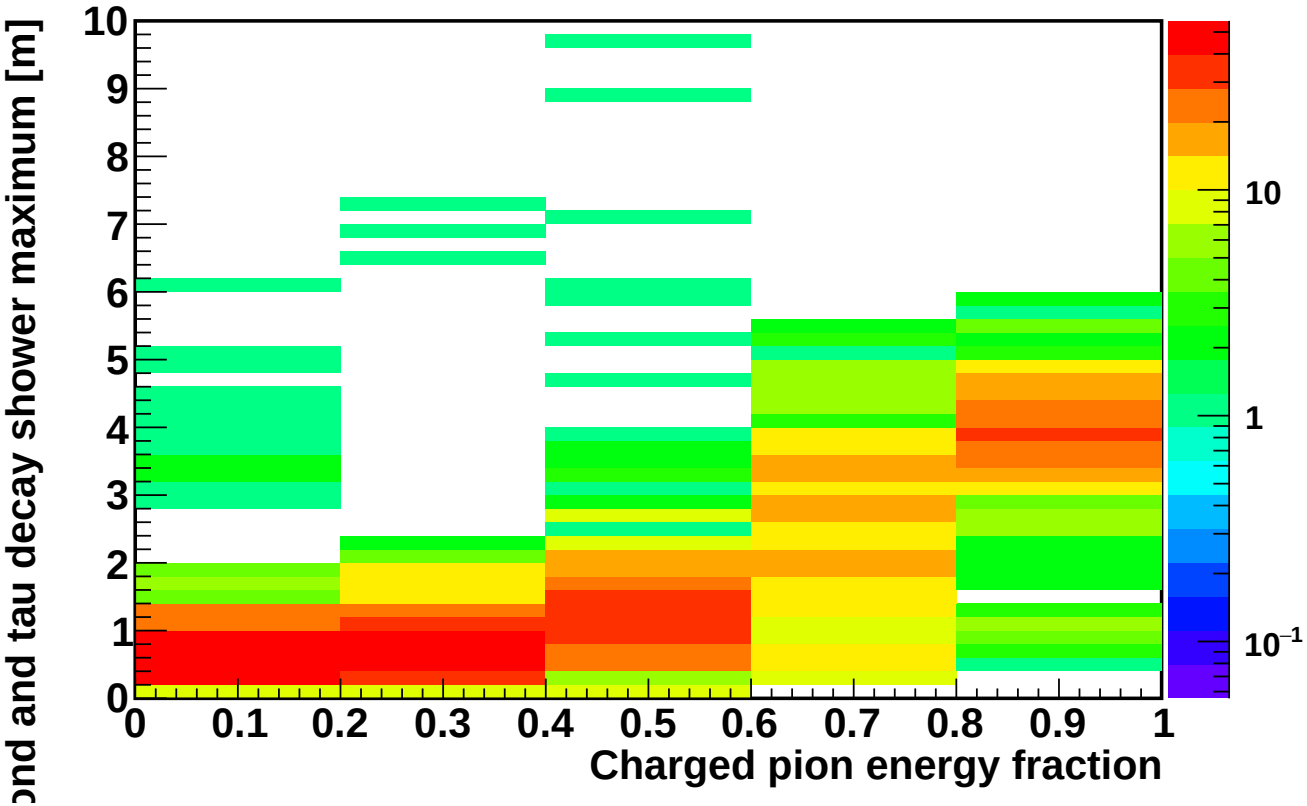


Figure : Distance 2nd rec vertex to calculated tau shower maximum vs energy fraction of charged pion of visible tau shower energy

Atmospheric Muons

Started looking at atmospheric muon rejection, for diffuse HE IceCube the LoI quotes 6 μ_{atm} surviving the BDT

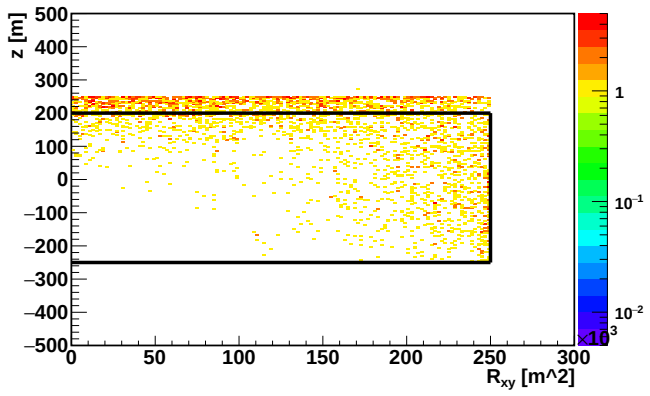
Used MC

Used the atmospheric muon production with threshold 50 TeV

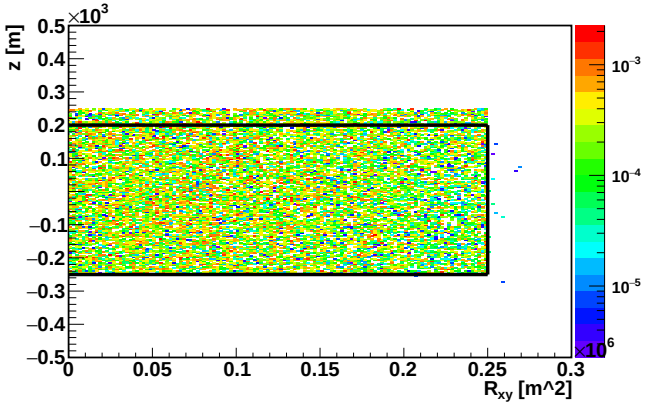
All cut variables are shown with the previous cuts as defined in Slide 18 defined and applied on refitted quantities

Containment Cut

Since atmospheric muons come from “above” we expect the first rec vertex to be in the top of the detector



(a) Position of first rec vertex in detector, black lines indicate containment cut, atmospheric muon events



(b) Position of first rec vertex in detector, black lines indicate containment cut, “Double Bang” events

Number of peaks $= 1, 2$

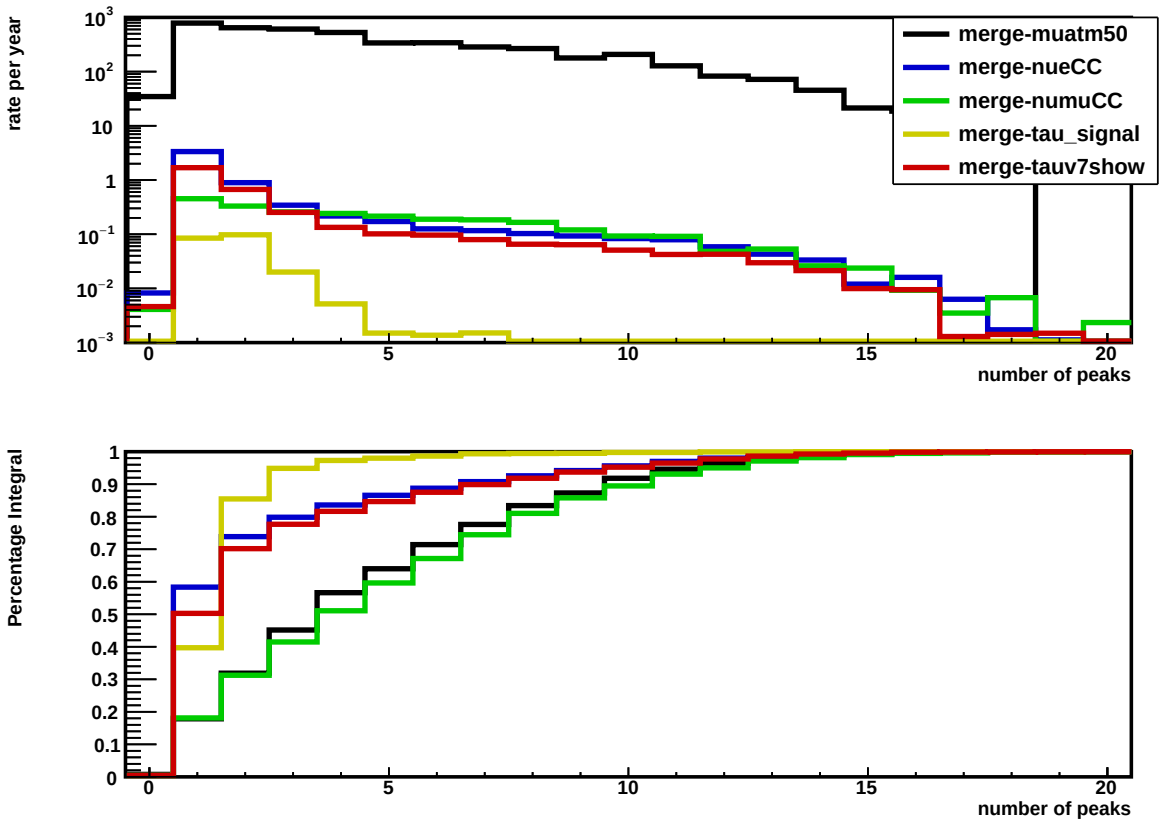


Figure : Number of found peaks of selected events top, bottom cumulative distribution

Number of significant peaks $= 1, 2$

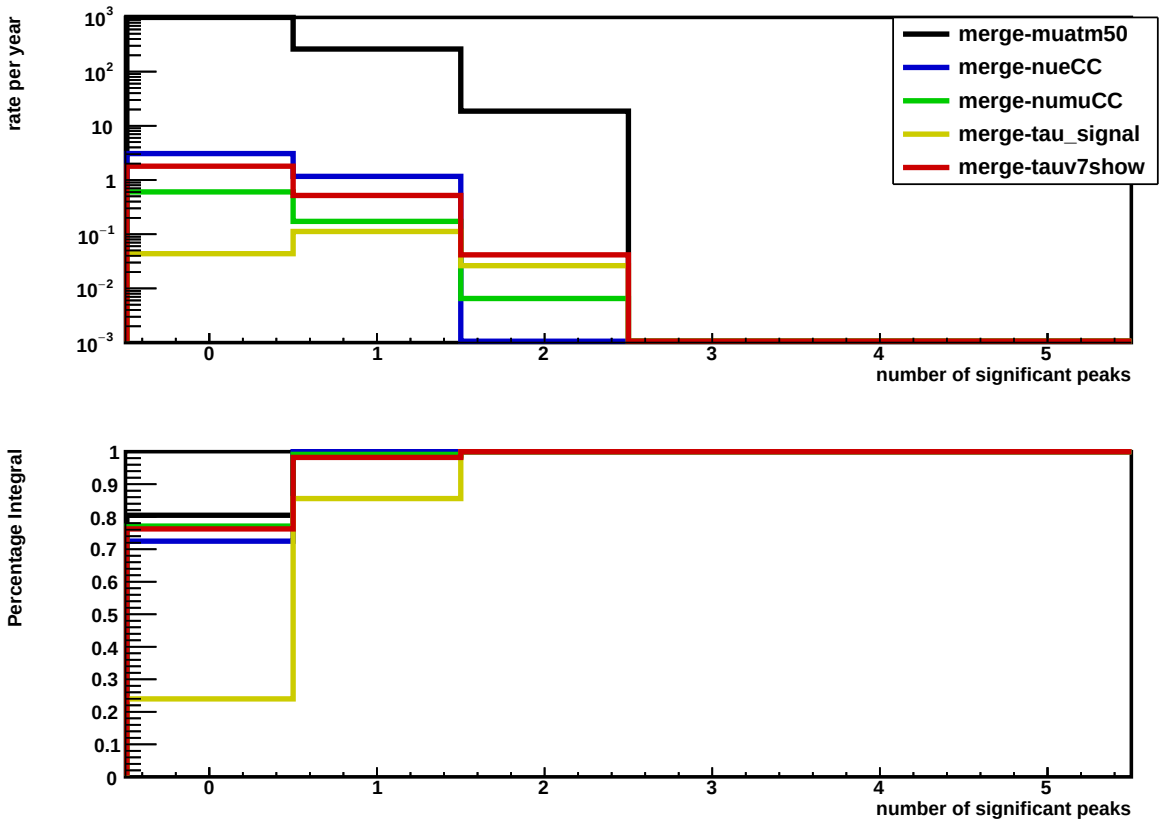


Figure : Number of found significant peaks of selected events top, bottom cumulative distribution

Cut on likelihood value red L ≤ 8.5

To further reduce the atmospheric muon background the reduced two shower position likelihood (of the scan, currently checking full posfit likelihood) is used:

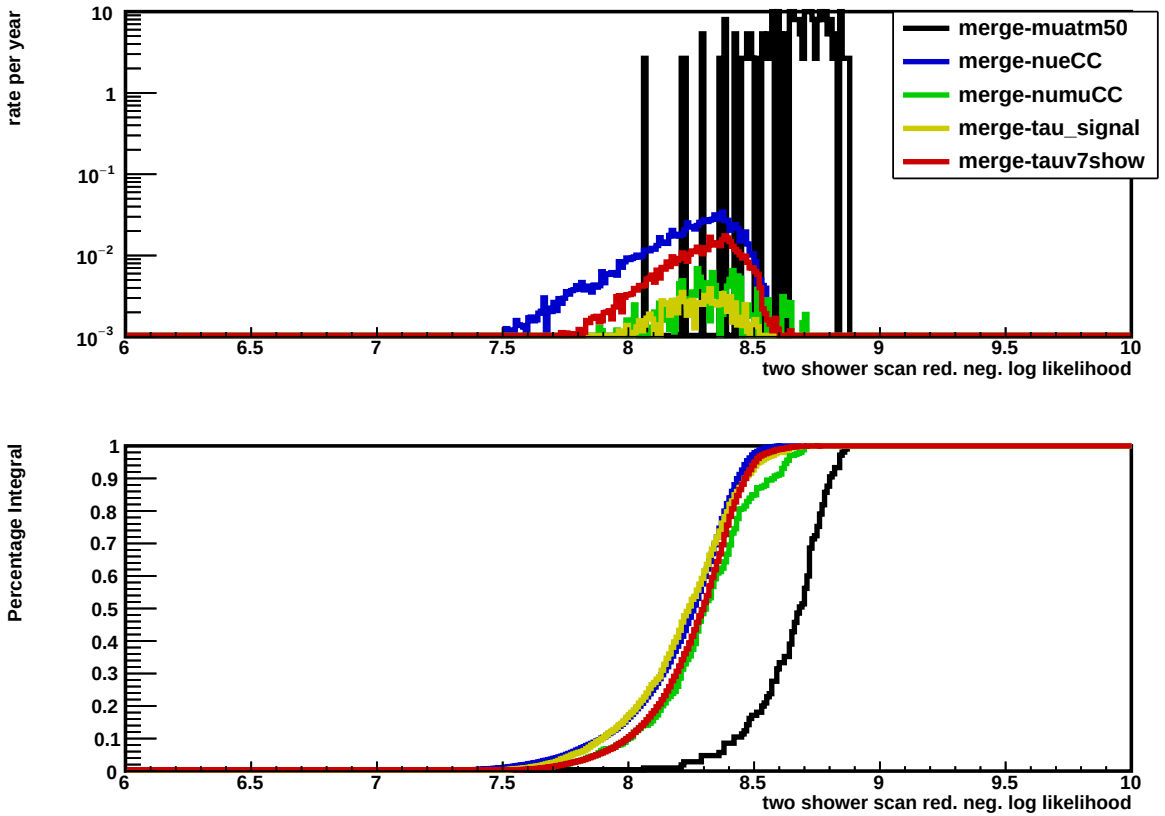


Figure : Likelihood of selected events top, bottom cumulative distribution

Adjust length cut?

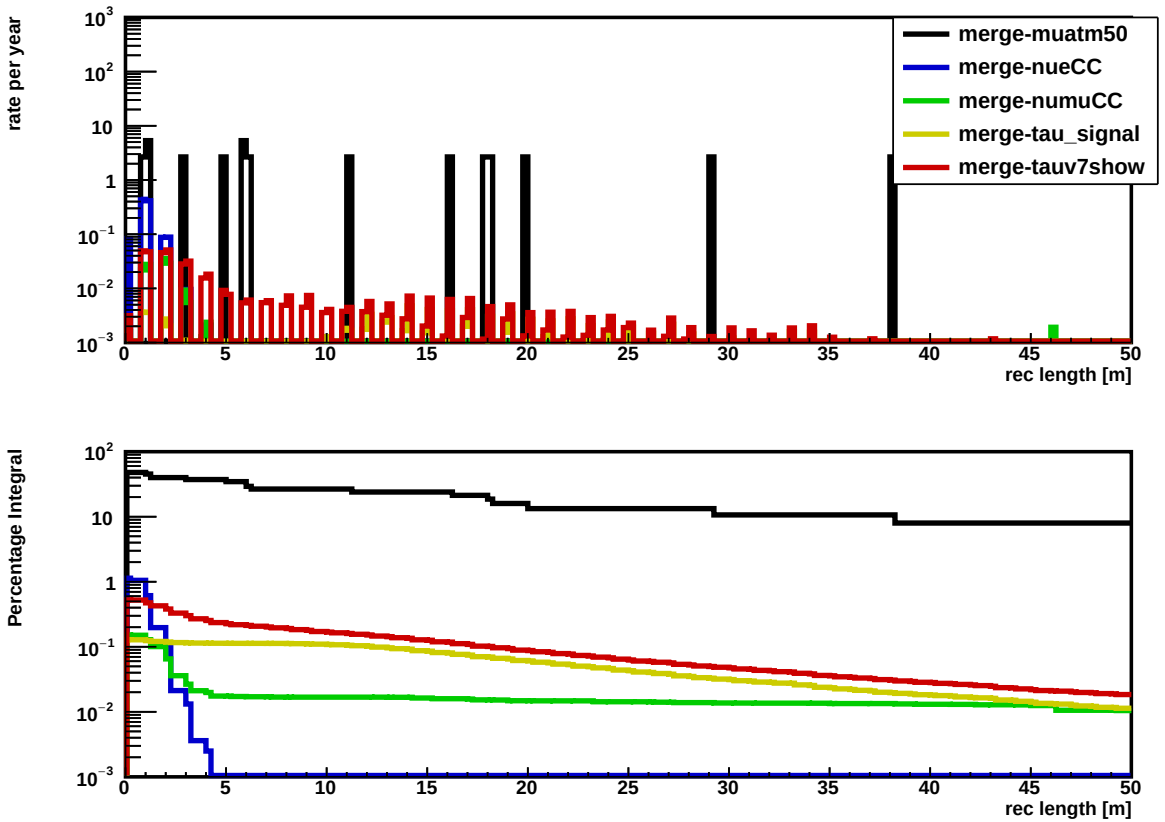


Figure : Reconstructed length after OTHER cuts, top: histogram of rec length, bottom cumulative distribution; maybe reduce below 10 m?

Selection Cuts

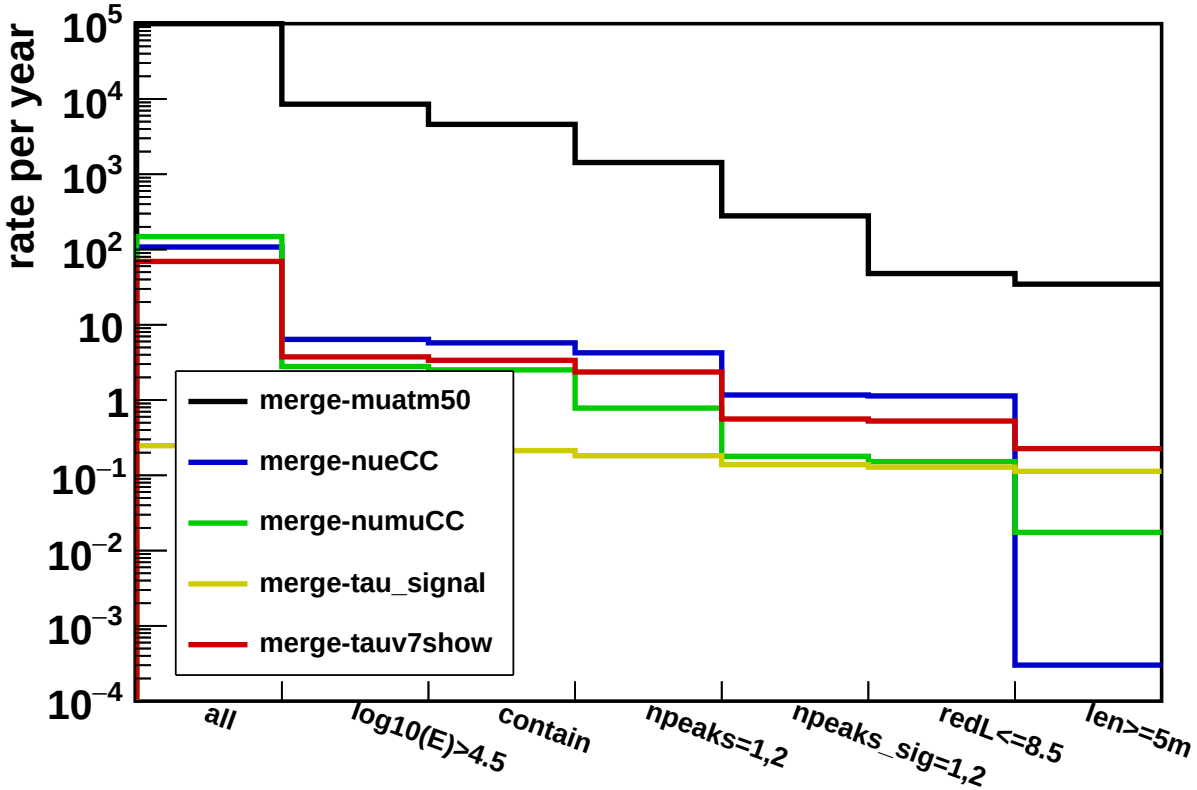
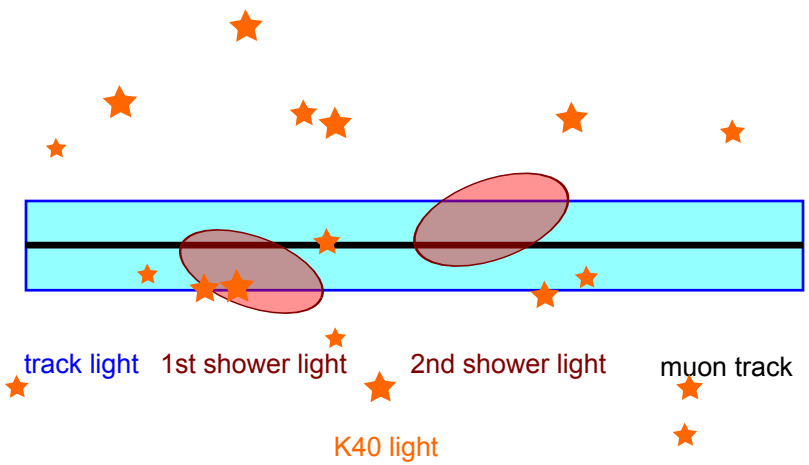


Figure : Selected events for cut flow

Further Muon suppression

Method

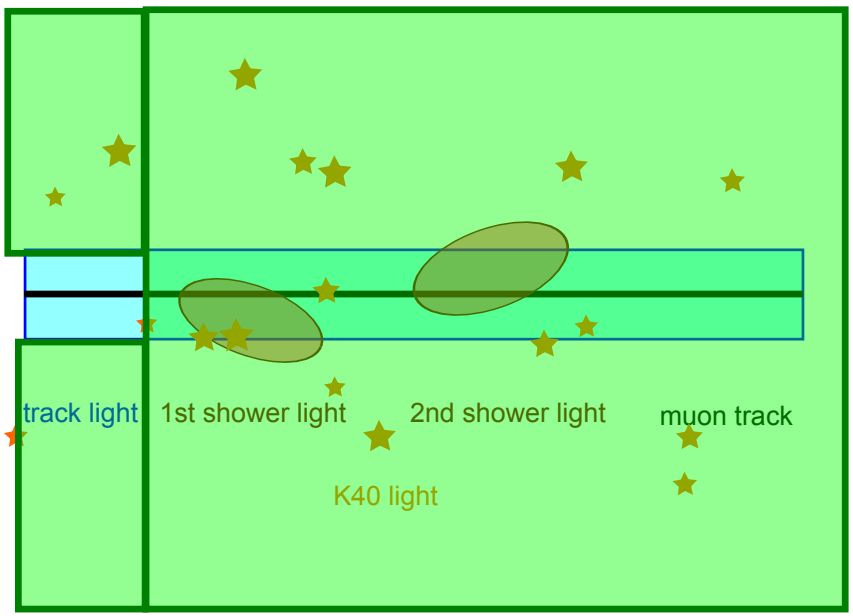
Use the fact that the muon track produces light before and after the two reconstructed showers!



Further Muon suppression

Hit Selection

- hit.t≤vertex1.t
- −10 ns≥hit.residual(track)≤10 ns

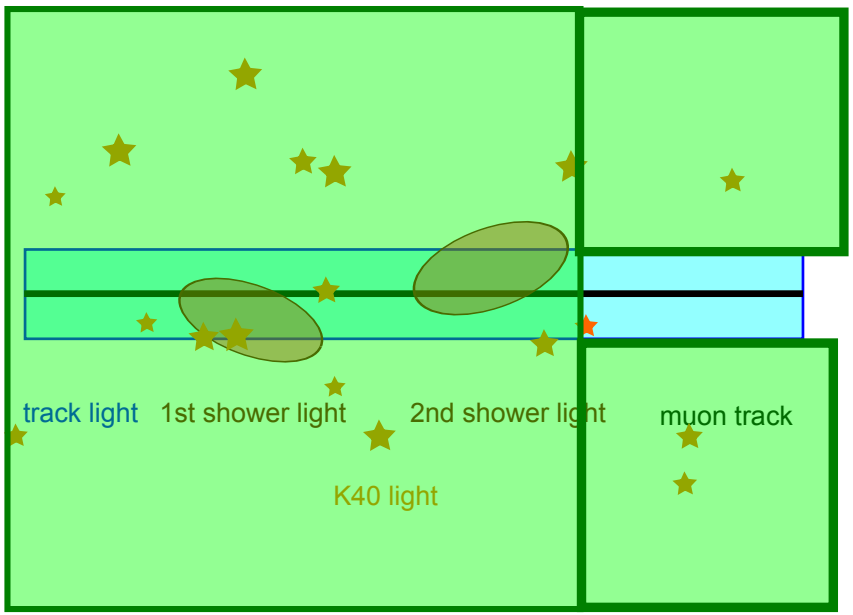


rejected hits early

Further Muon suppression

Hit Selection

- hit.t≥vertex2.t
- hit.residual(shower—vertex12)≤−10 ns
- −10 ns≥hit.residual(track)≤10 ns



rejected hits late

Further Muon suppression

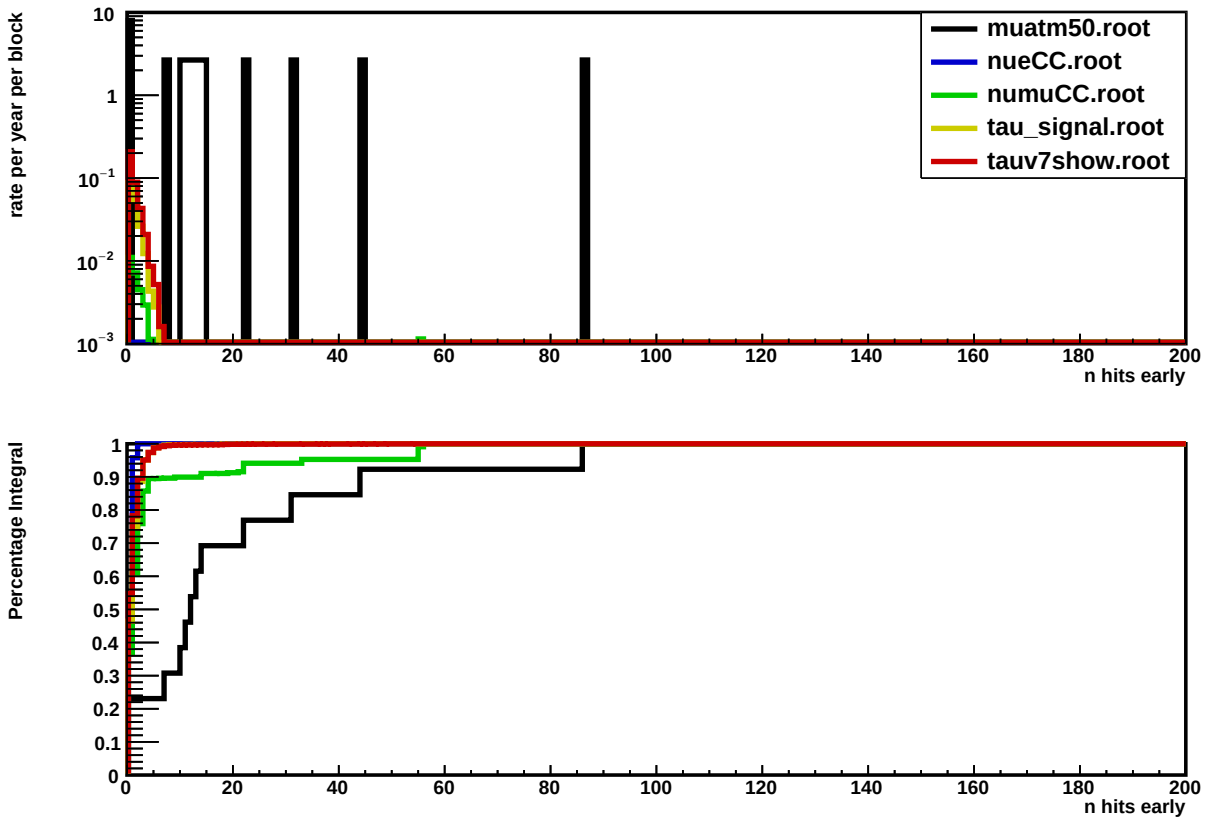


Figure : top: Number of early hits for different channels; bottom: cumulative distribution

Further Muon suppression

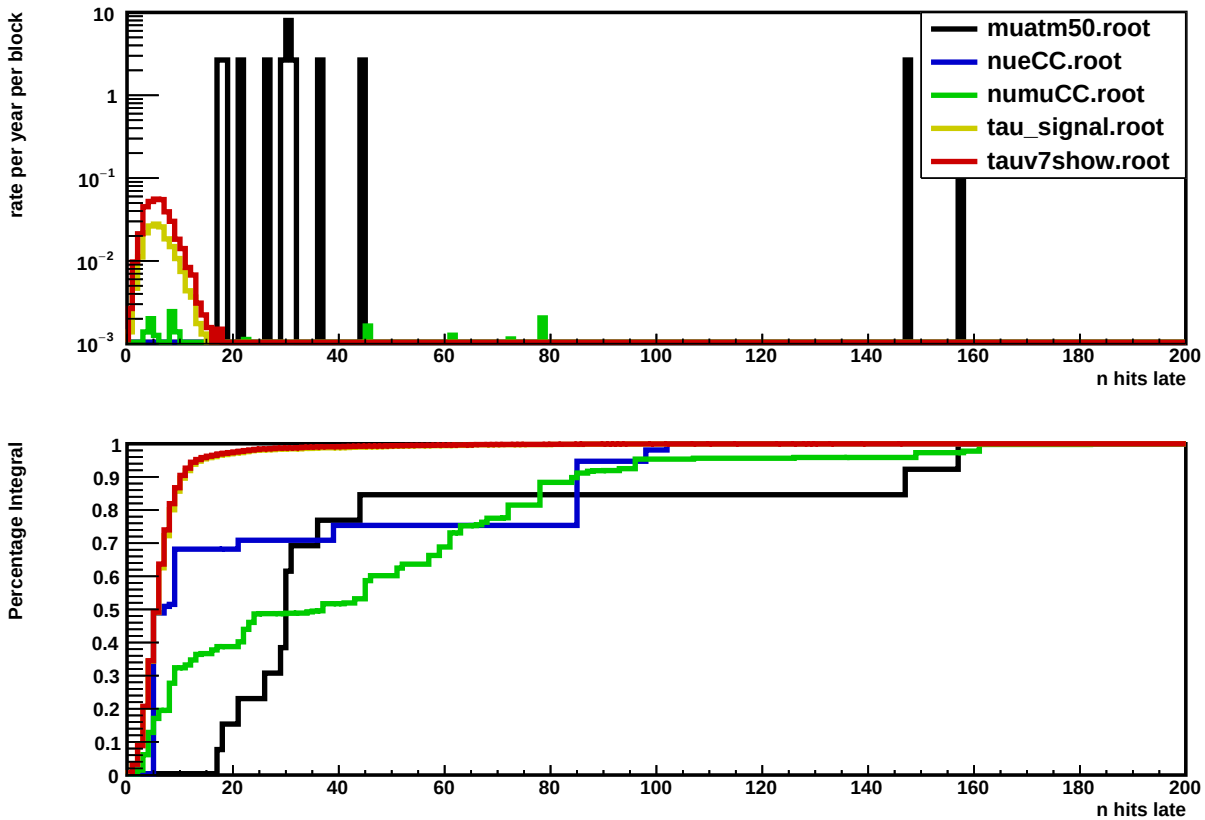


Figure : top: Number of late hits for different channels; bottom: cumulative distribution