Belle Starr Status Update

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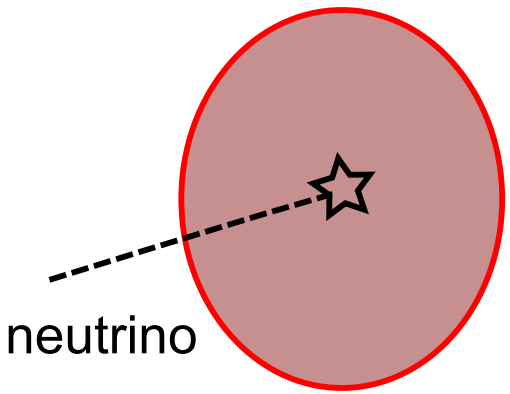
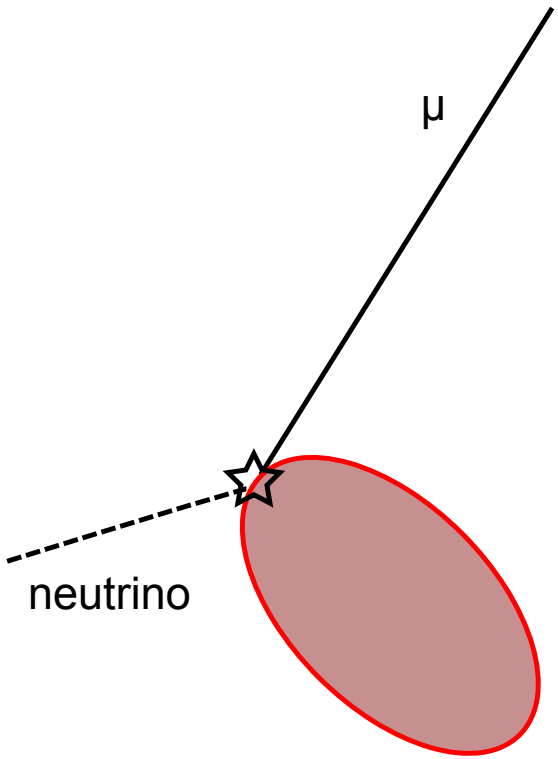
Motivation

So far our detector distinguishes two event types: tracks and single showers



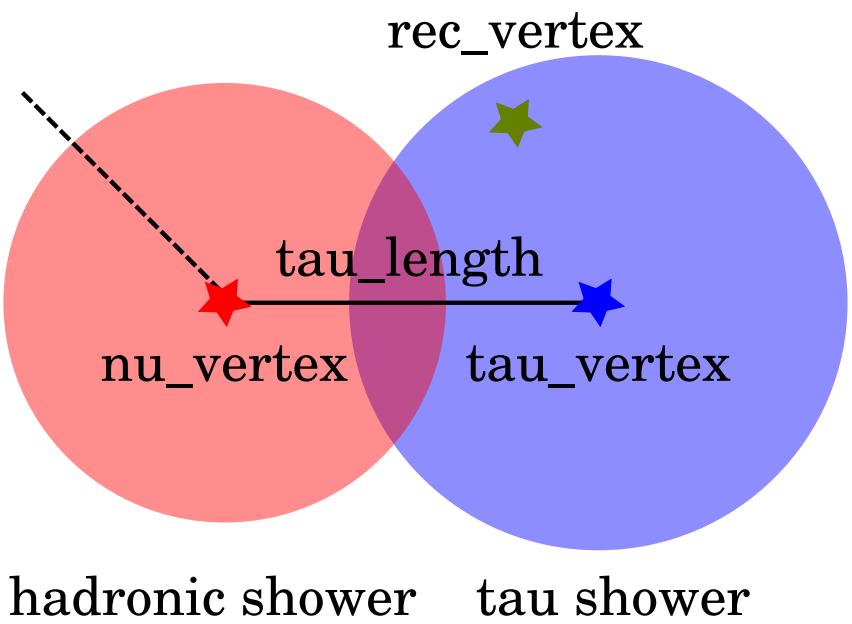
(a) Single Shower



(b) Track event

New event type

A tau neutrino produces a tau lepton, which decays into muon (track event) or hadrons/electron (shower event)



↪ If tau flight length increases (relativistic boost, high energies) we can distinguish these events from single shower or normal track events

Belle Starr reco

Goal

Identify two shower signature “Double Bang” in our detector

Procedure:

Prefit: Reconstruct one vertex position and direction (also total energy)

Scan: Evaluate two shower likelihood starting from prefit position along $\pm 400\,\mathrm{m}$ in prefit direction

Peak: Analyze likelihood scans to discriminate “Double Bang” events

Scan results: Finding the minimum

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

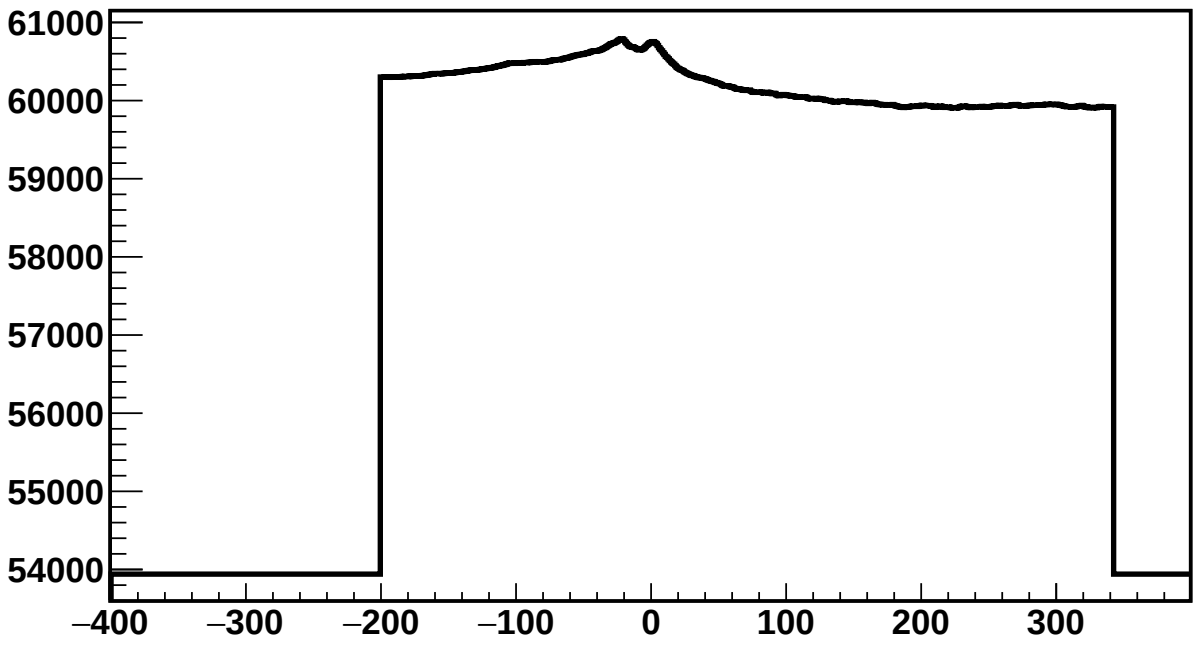


Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood

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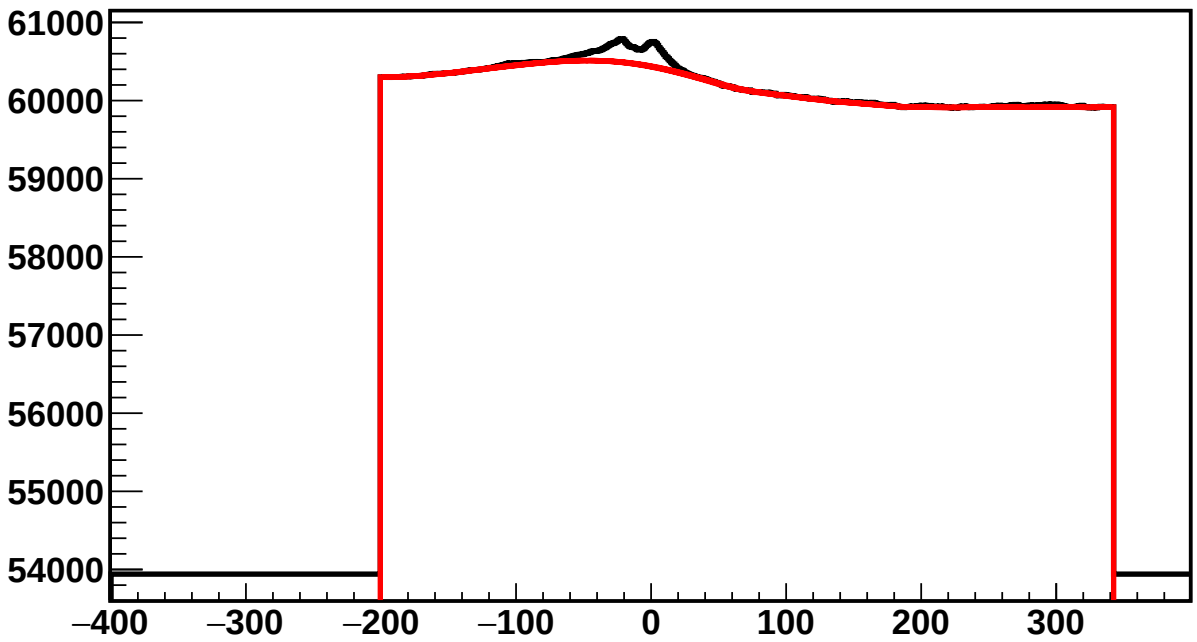

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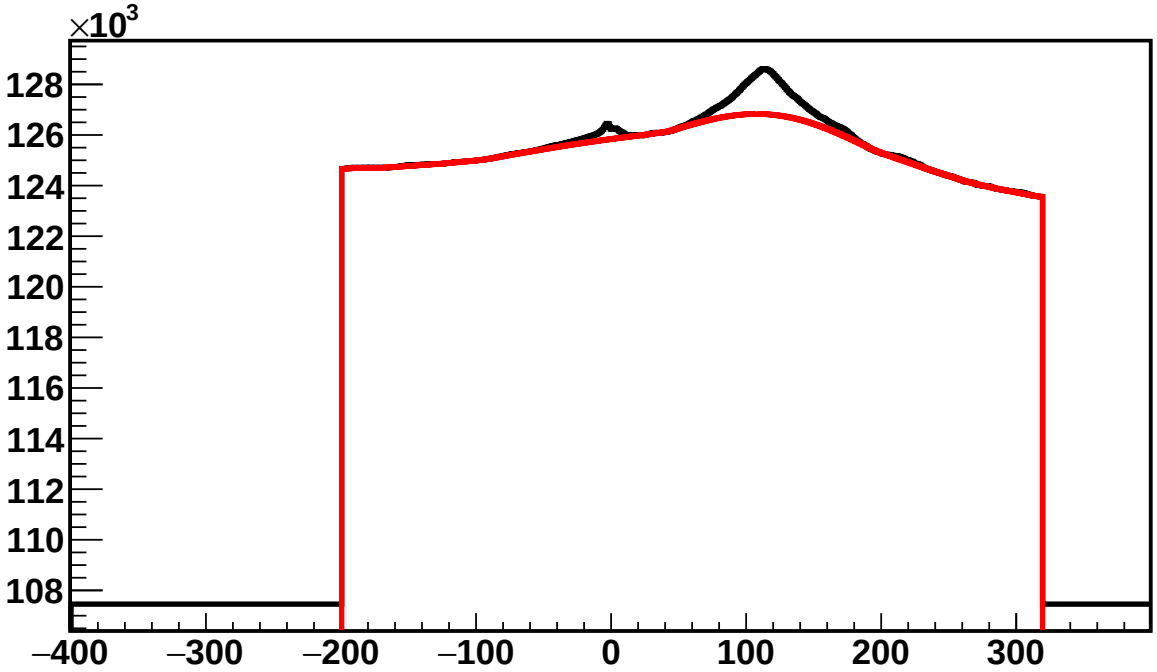

Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood

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

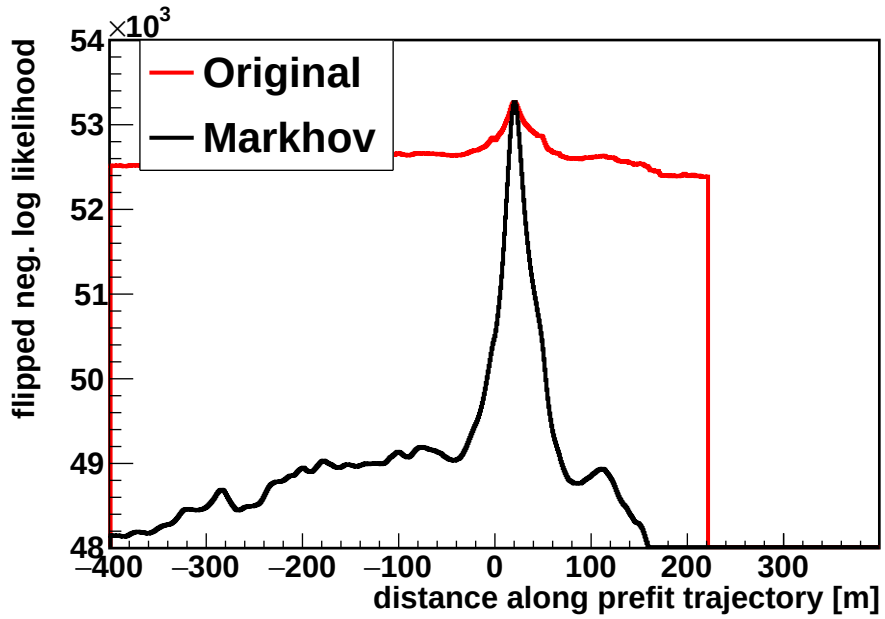

Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood; black original scan, red histogram with enhanced peaks

Scan results - peak estimation

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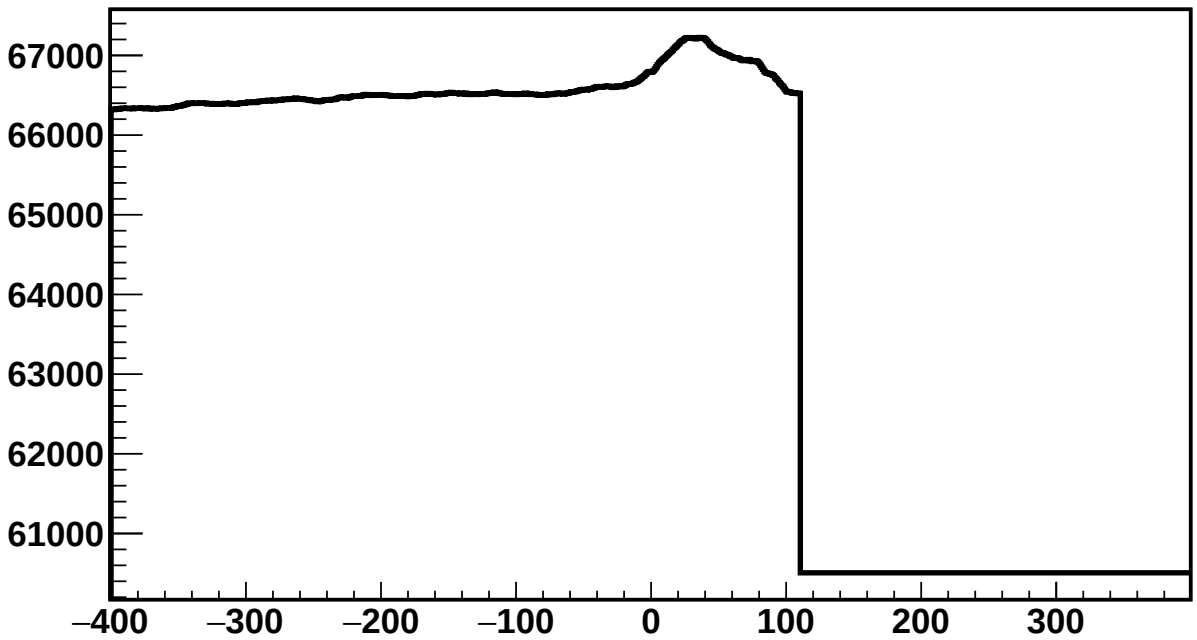
$$\text{peak}_L \geq \text{bkg}_L + 300 \tag{1}$$

Scan results - peak estimation



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Scan results - peak estimation

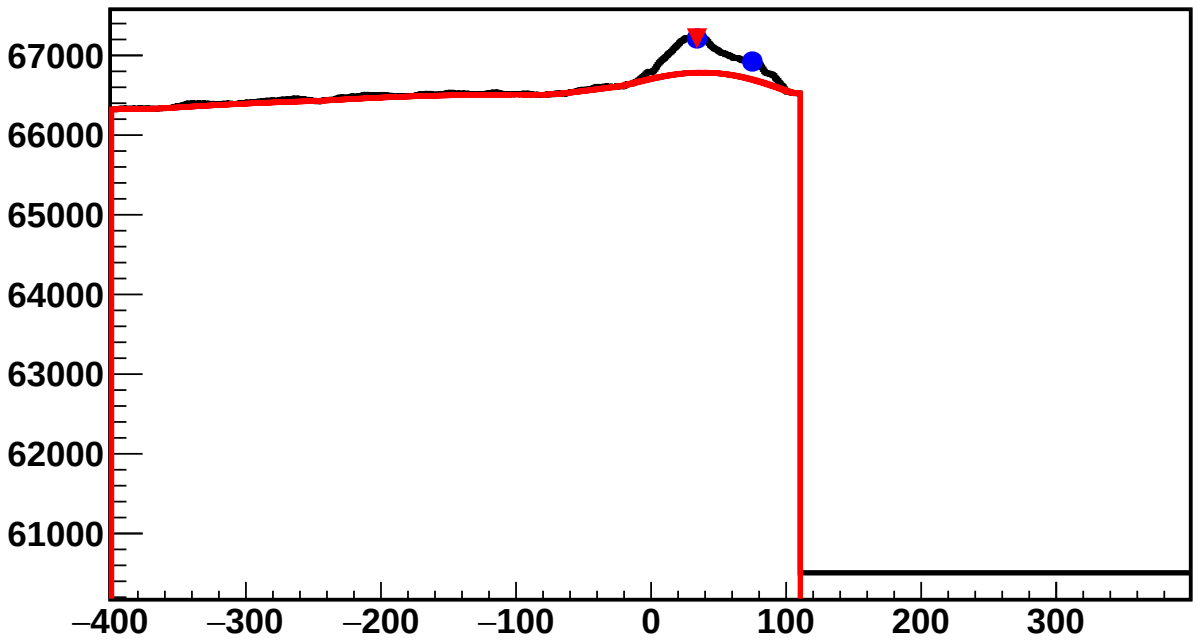

Figure : X: distance along scan direction in meter; Y: flipped neg. log likelihood, blue all peaks found, red significant peaks

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 $\pm 400\,\mathrm{m}$ 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 of Belle Starr Peak

Refitting the output

Since we only refit the two positions, expect improvement in vertex reco and direction reco:

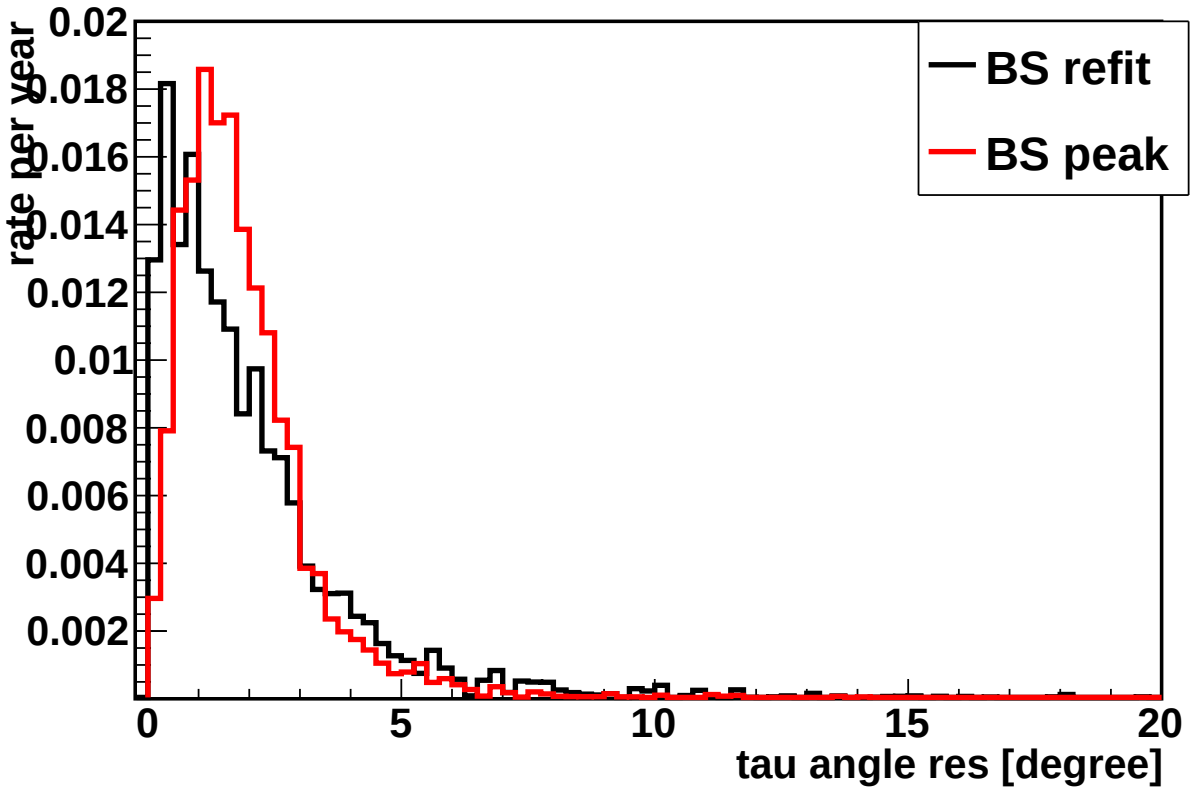

Figure : Angular resolution of tau events before and after refitting

Refitting the output

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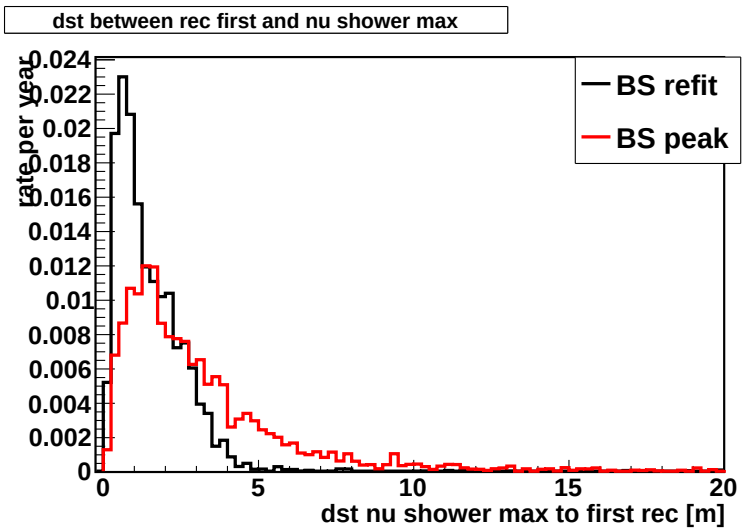
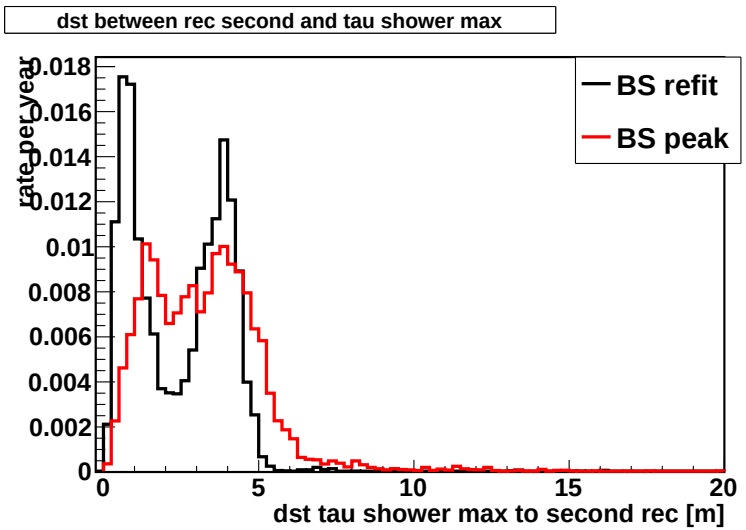


(a) Distance between neutrino shower maximum and first (in time) rec position before and after refitting



(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

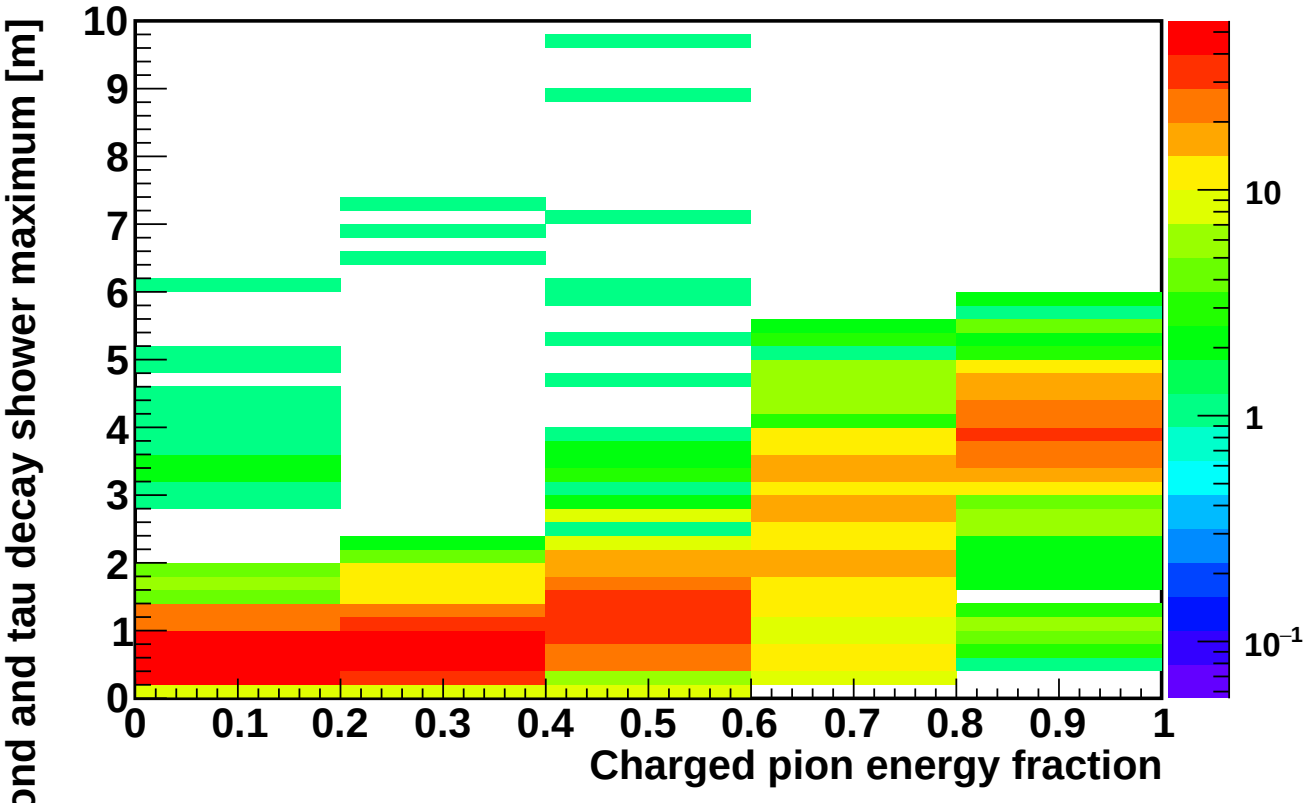


Figure : Distance 2nd rec vertex to calculated tau shower maximum vs energy fraction of charged pion of visible tau shower energy

Atmospheric Muons

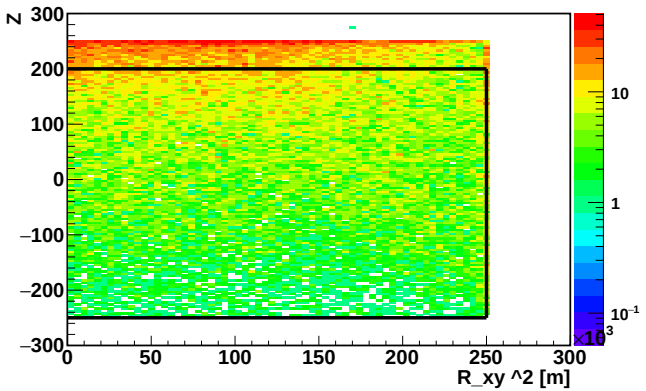
Started looking at atmospheric muon rejection, for diffuse HE IceCube the LoI quotes 6 μ_{atm} surviving the BDT

Used MC

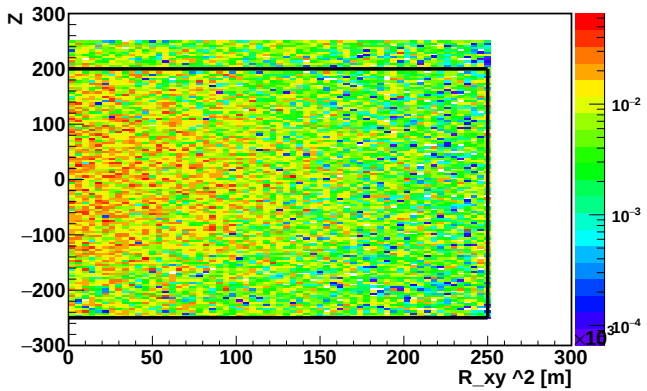
Used the atmospheric muon production with threshold 50 TeV

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

Cut on likelihood value

To further reduce the atmospheric muon background the reduced two shower position likelihood (of the scan) is used:

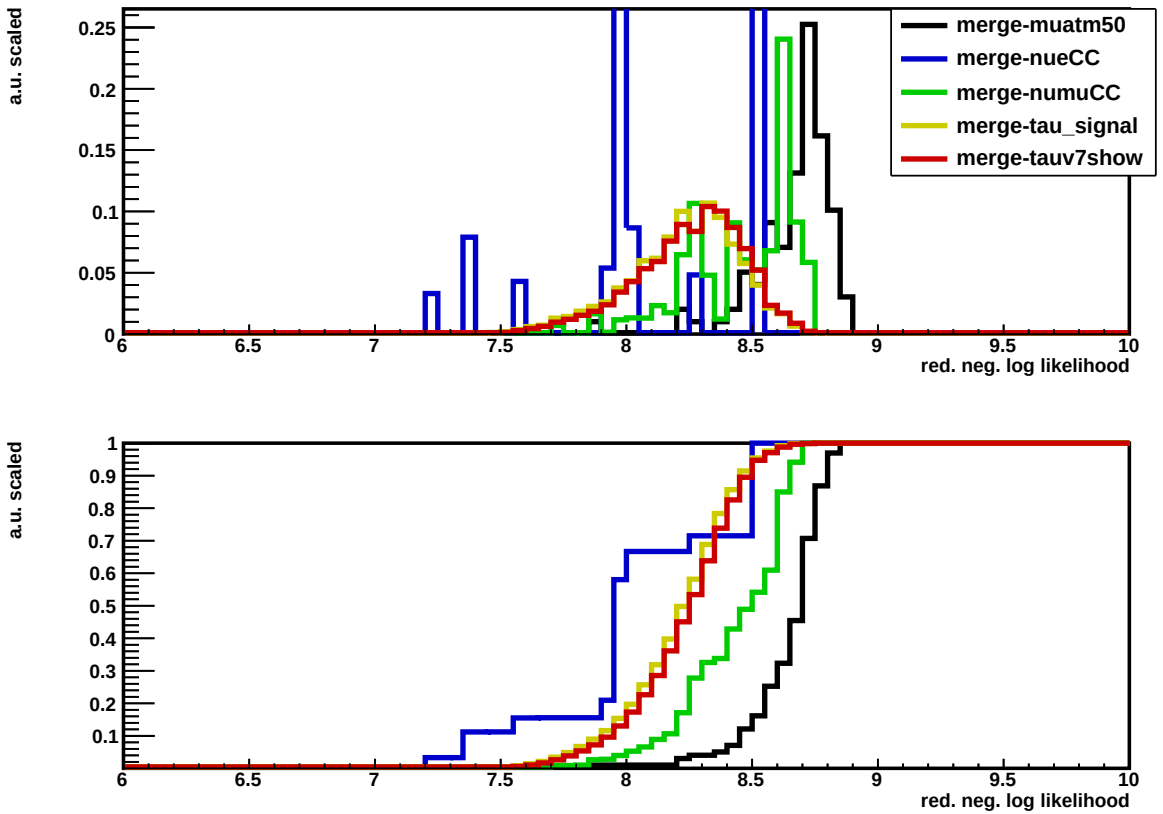


Figure : Likelihood of selected events top, bottom cumulative distribution

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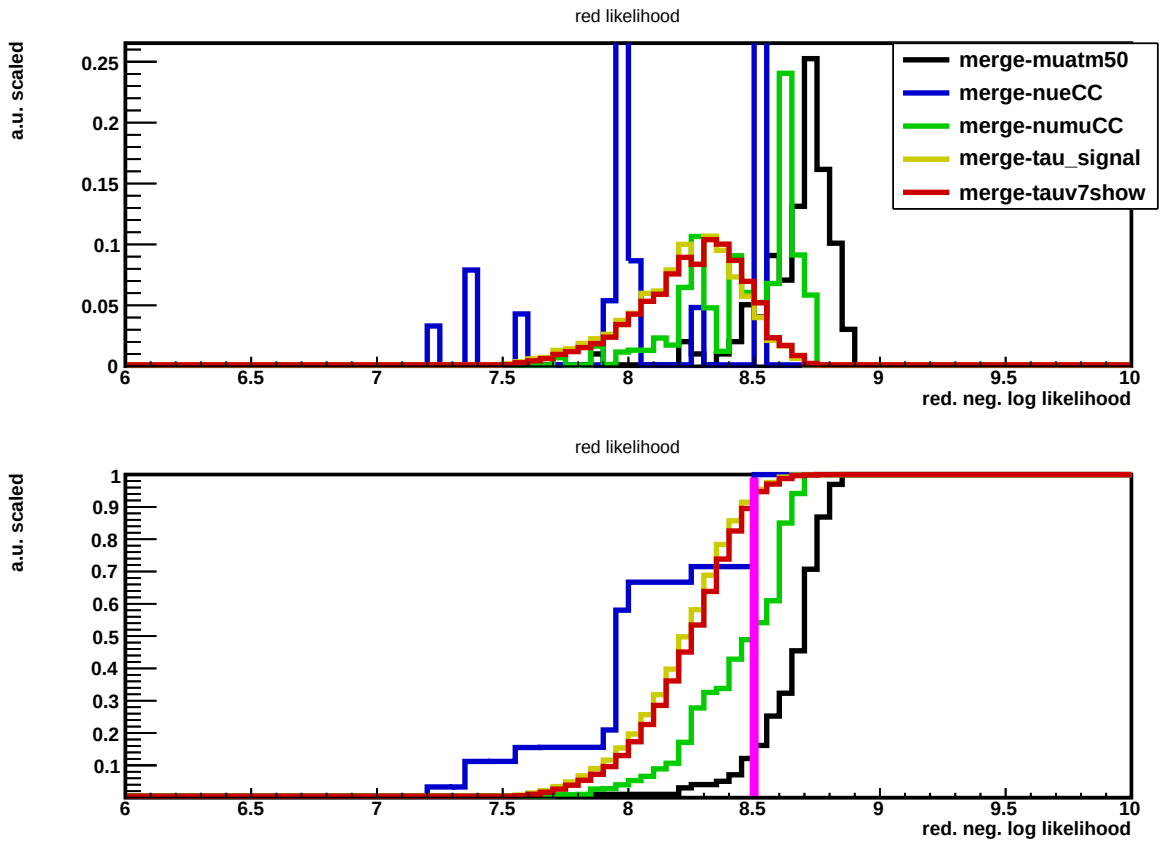

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Selection Cuts

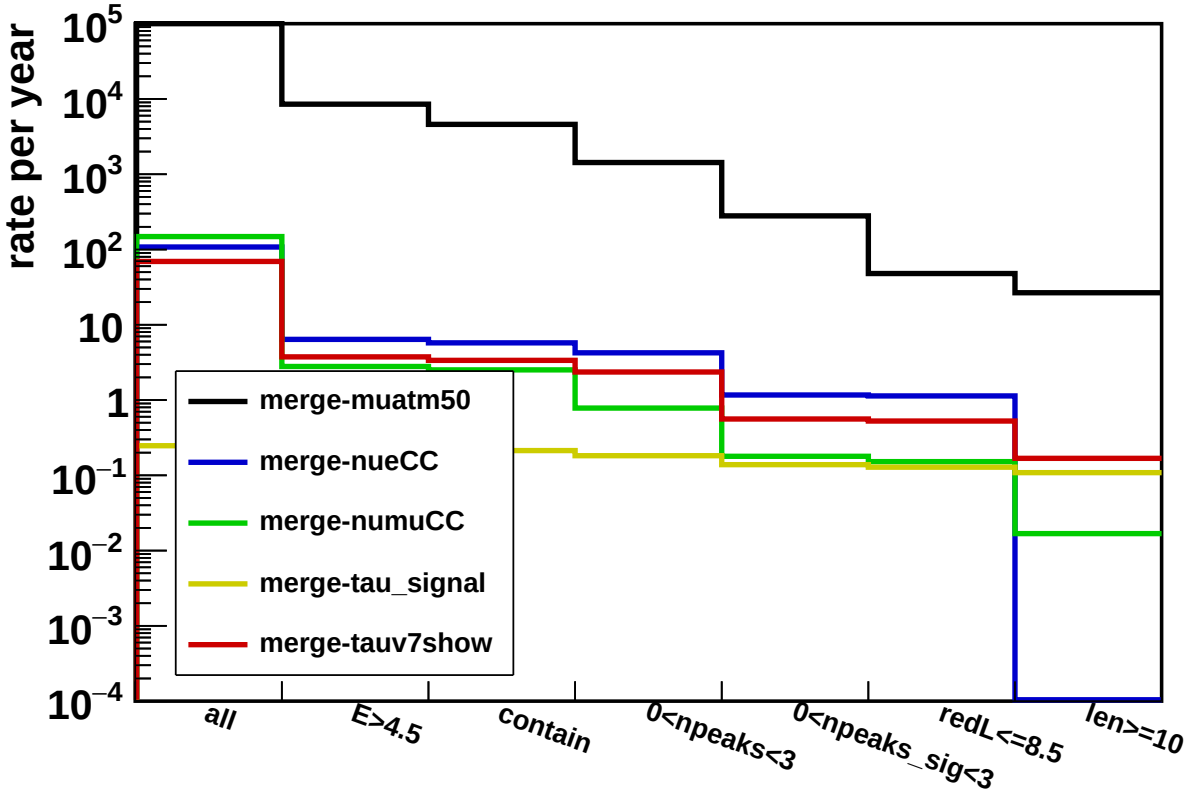

Figure : Selected events for cut flow

Adjust length cut?

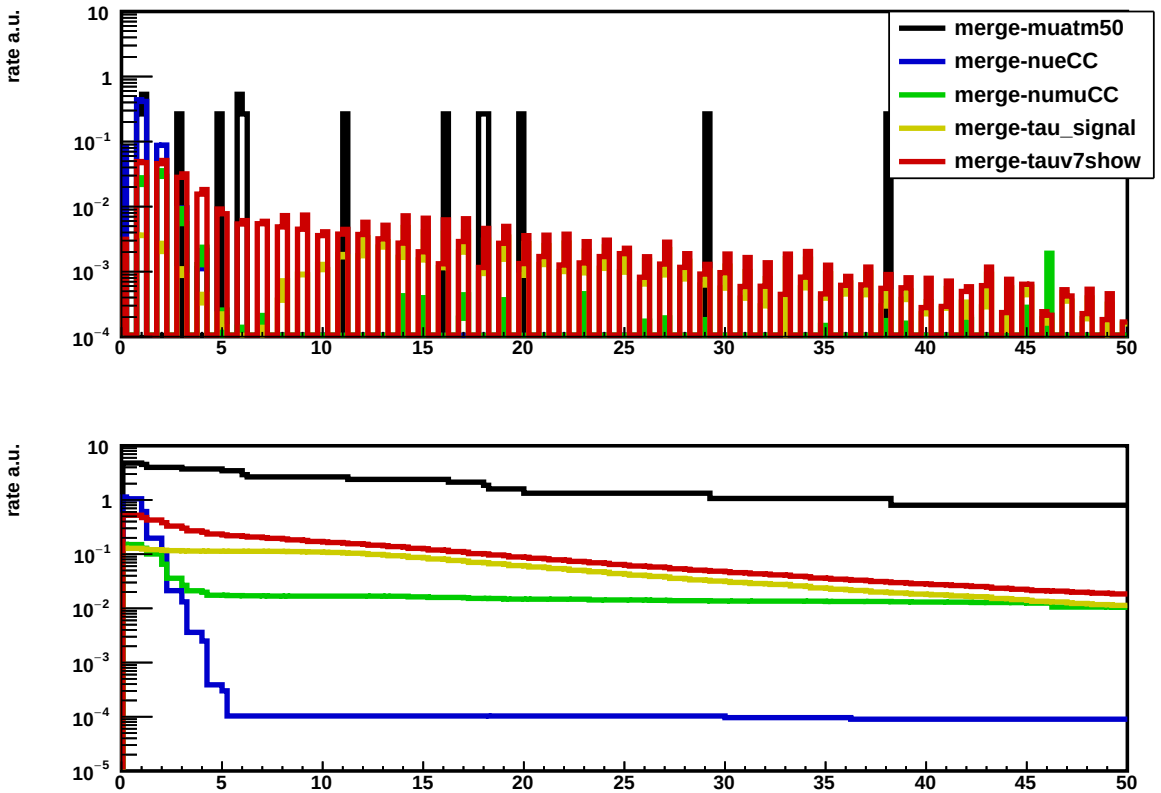

Figure : Reconstructed length [on x axis in meter] after OTHER cuts, top: histogram of rec length, bottom cumulative distribution; maybe reduce below 10 m?