

The taus, what about the taus?

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Belle Starr: Recap

- Coincidence hit selection
- Clusterize hits
- Perform first single shower M-estimator prefit
- Residual based hit selection $-40 \text{ ns} > h.t > 40 \text{ ns}$
- Clusterize hits
- Perform second single shower M-estimator prefit
- Perform a two shower PDF based likelihood fit on all hits in event, with likelihood:

$$\mathcal{L} = \sum_i P(\text{hit}_i | \text{vertex}_1) + P(\text{hit}_i | \text{vertex}_2) + P(\text{hit}_i | \text{bkg})$$

Belle Starr performance on the tau MC

Event selection: tau CC shower events with tau.len ≥ 10 m and both showers contained in the detector

Rate: For all the versions of IceCube flux and one block ARCA this corresponds to roughly 0.2 events per year

Belle Starr performance on the tau MC

Event selection: tau CC shower events with tau.len ≥ 10 m and both showers contained in the detector

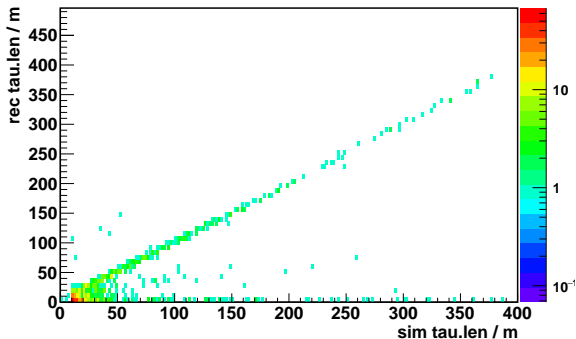


Figure : Reconstructed length vs simulated tau length for full Belle Starr with length and containment cut

Belle Starr: An ideal case

Event selection: same

Prefit: Skip refit and give **MC truth** vertices as input to two shower position fit

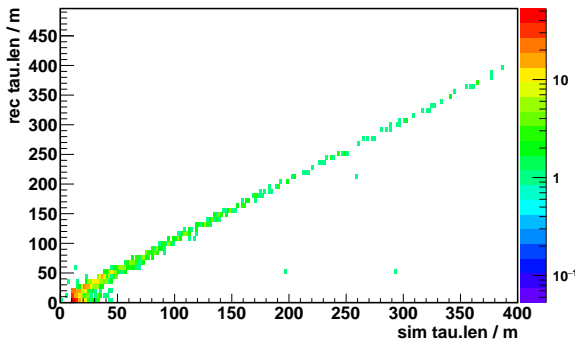


Figure : Reconstructed length vs simulated tau length for Belle Starr with prefit replaced by MC truth information with length and containment cut

Visibility of the showers

Are all events with $\text{tau.len} \geq 10$ m and both showers contained in the detector reconstructable?

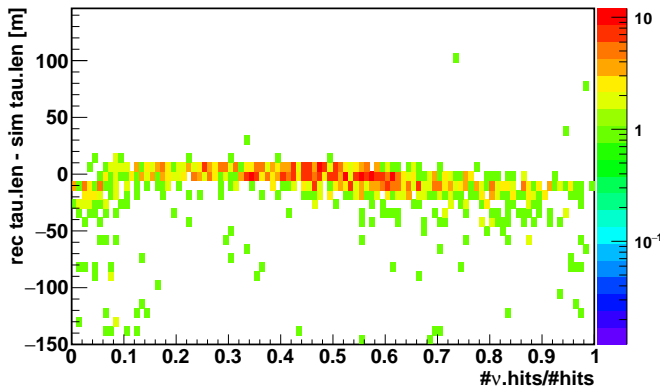


Figure : Length resolution vs the number of hits produced by the neutrino shower relative to all signal hits

Prefit performance

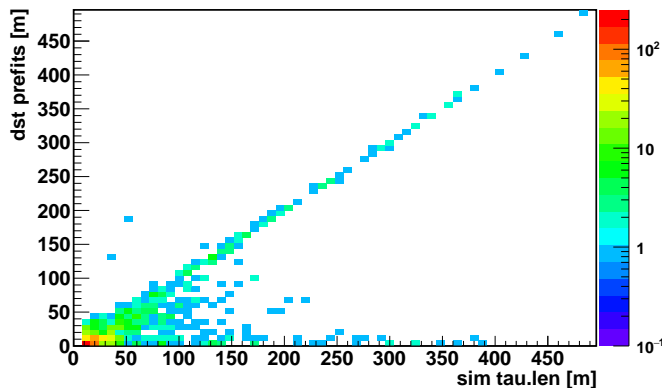


Figure : Distance between the prefits vs the simulated tau.len

Prefits in detail

- Coincidence hit selection: Merge all hits on DOM with at least a second in 20 ns (ignore single hits)
- Clusterize hits
- Take DOM with most hits as starting point
- Perform first single shower M-estimator prefit, score function:

$$m = \sum_i \text{hit}_i.a \times \sqrt{(0.5 + \text{hit}_{i,\text{residual}}^2)}$$

- Residual based hit selection $-40 \text{ ns} > h.t > 40 \text{ ns}$
- Clusterize hits
- Take DOM with most hits as starting point
- Perform second single shower M-estimator prefit

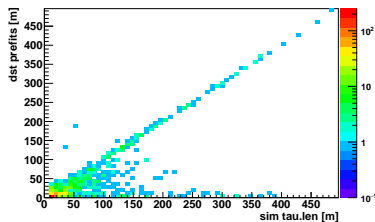
Idea to improve the profits for two shower scenario

Change the score function of the minimizer to pull more towards one of the two showers:

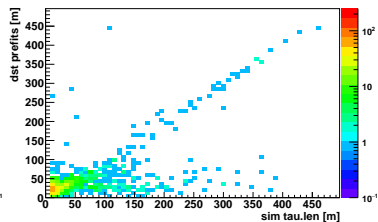
$$m = \sum_i \text{hit}_{i,a} \times \left(\sqrt{(0.5 + \text{hit}_{i,\text{residual}}^2)} \pm \text{scale} \times \text{hit}_{i,\text{residual}} \right)$$

Currently using scale factor 0.8, use + to punish late hits and use - to punish early hits

Performance prefits



(a) Distance between prefits
standard score function



(b) Distance between prefits
weighted score function

Belle Starr performance with weighted prefits

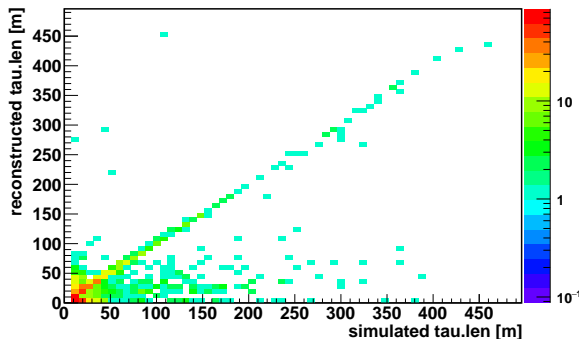
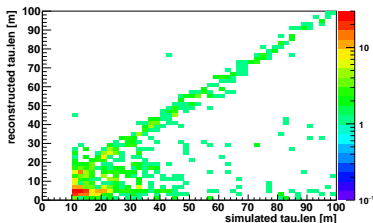
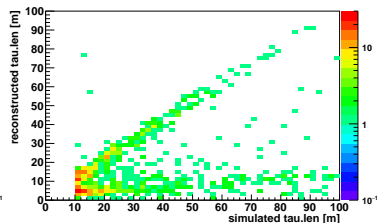


Figure : Reconstructed length vs simulated tau length for full Belle Starr with length and containment cut

Belle Starr performance with weighted prefits



(a) Reconstructed length vs simulated tau length for full Belle Starr with length and containment cut, **normal**



(b) Reconstructed length vs simulated tau length for full Belle Starr with length and containment cut, **weighted**