



UNIVERSITY OF
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Track Merge Refinement Algorithm in MicroBooNE

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HEP @ CAVENDISH LABORATORY

TrackMergeRefinementAlgorithm

- Written and implemented for DUNE by Isobel M (Wawrick) the algorithm stitches together tracks with EM showers belonging to cosmic rays.

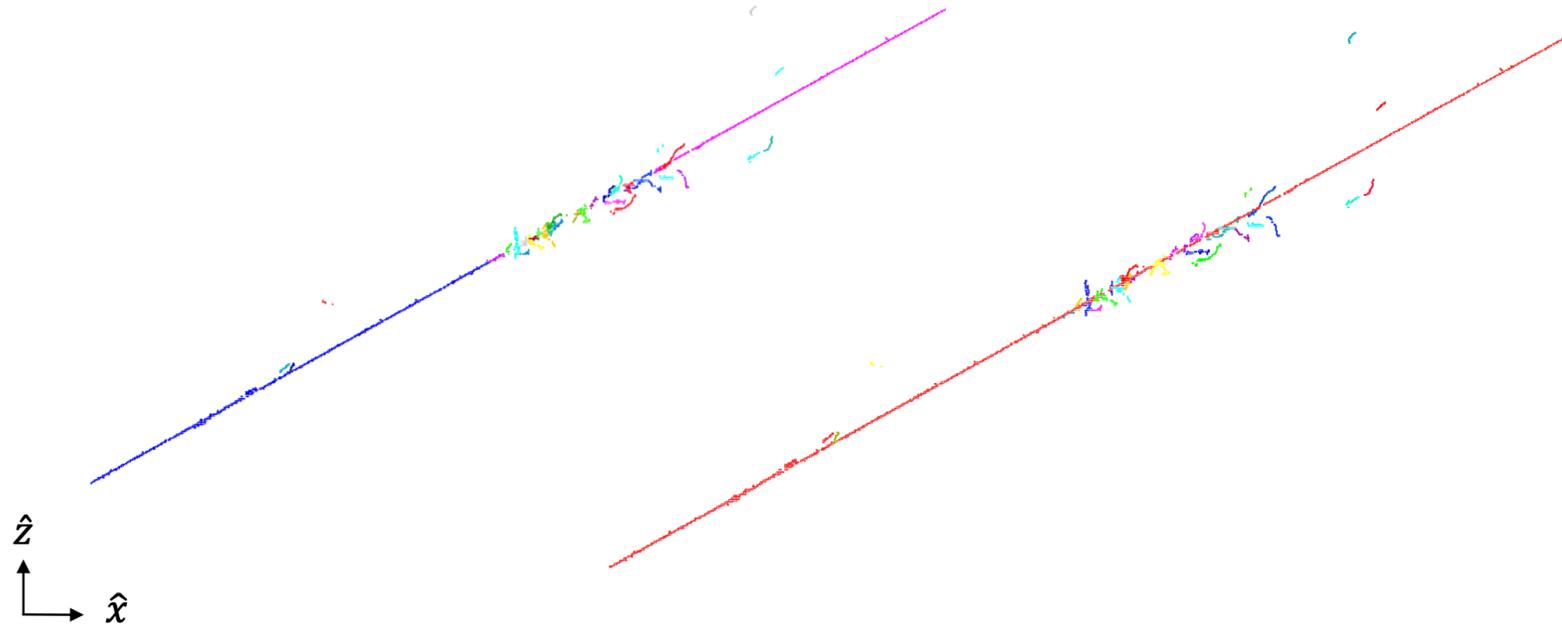


Image from Isobel

PeLEE

- Searching for $1e0p + 1eNp$ events (= MiniBooNE LEE signal channel)
- CRT-cuts have large impact on the $1e0p$ channel, but they're currently not included for the signal event selection.
- The algorithm has the potential to help in reducing backgrounds.

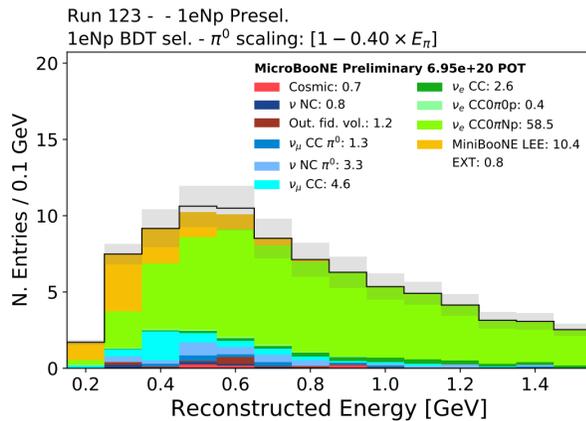


Figure 40: BDT-based selection for $1eNp0\pi$ with cuts at 0.67 and 0.70 for the π^0 and non- π^0 variables respectively.

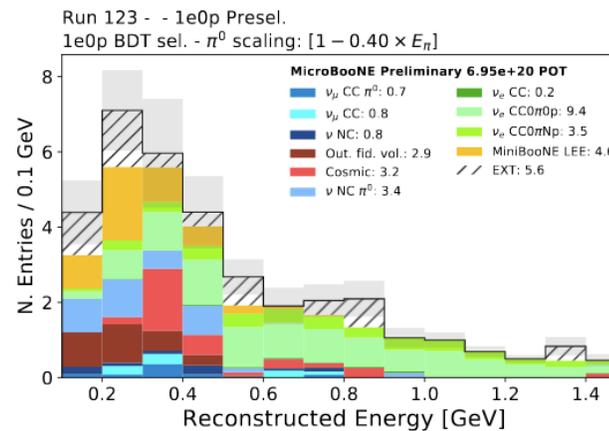
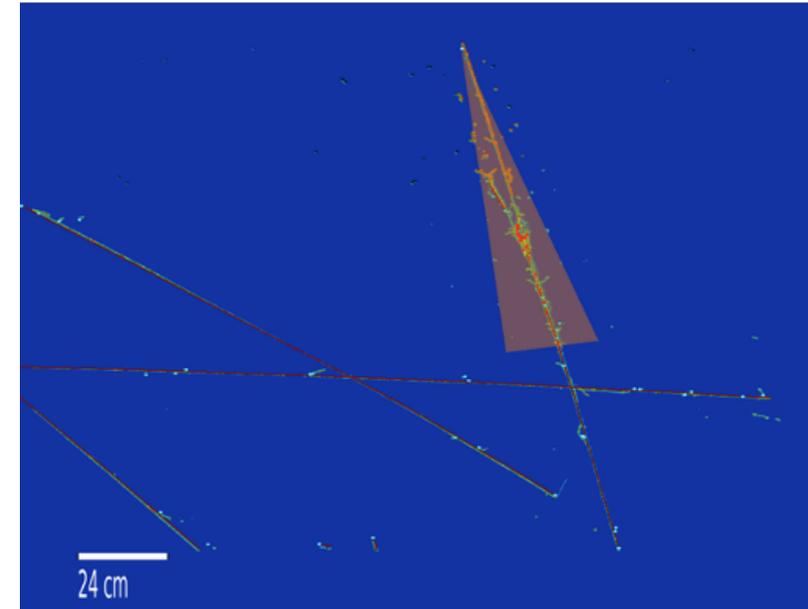


Figure 47: BDT selection for $1e0p0\pi$ events, scaled up to the full $10.1e20$ POT data set.



Event image supplied by Ivan C from the PeLEE analysis team

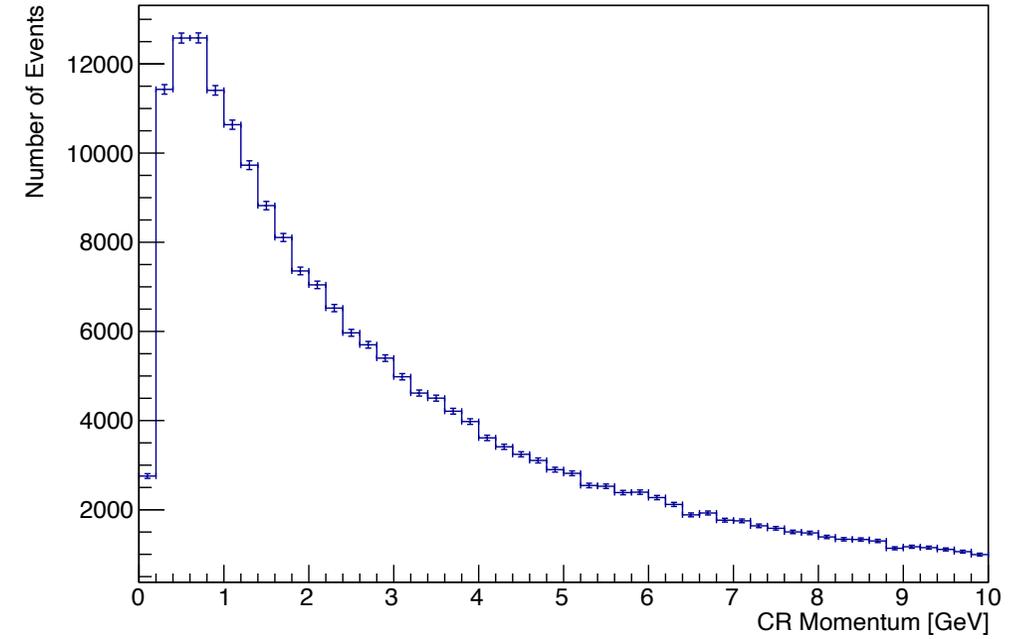
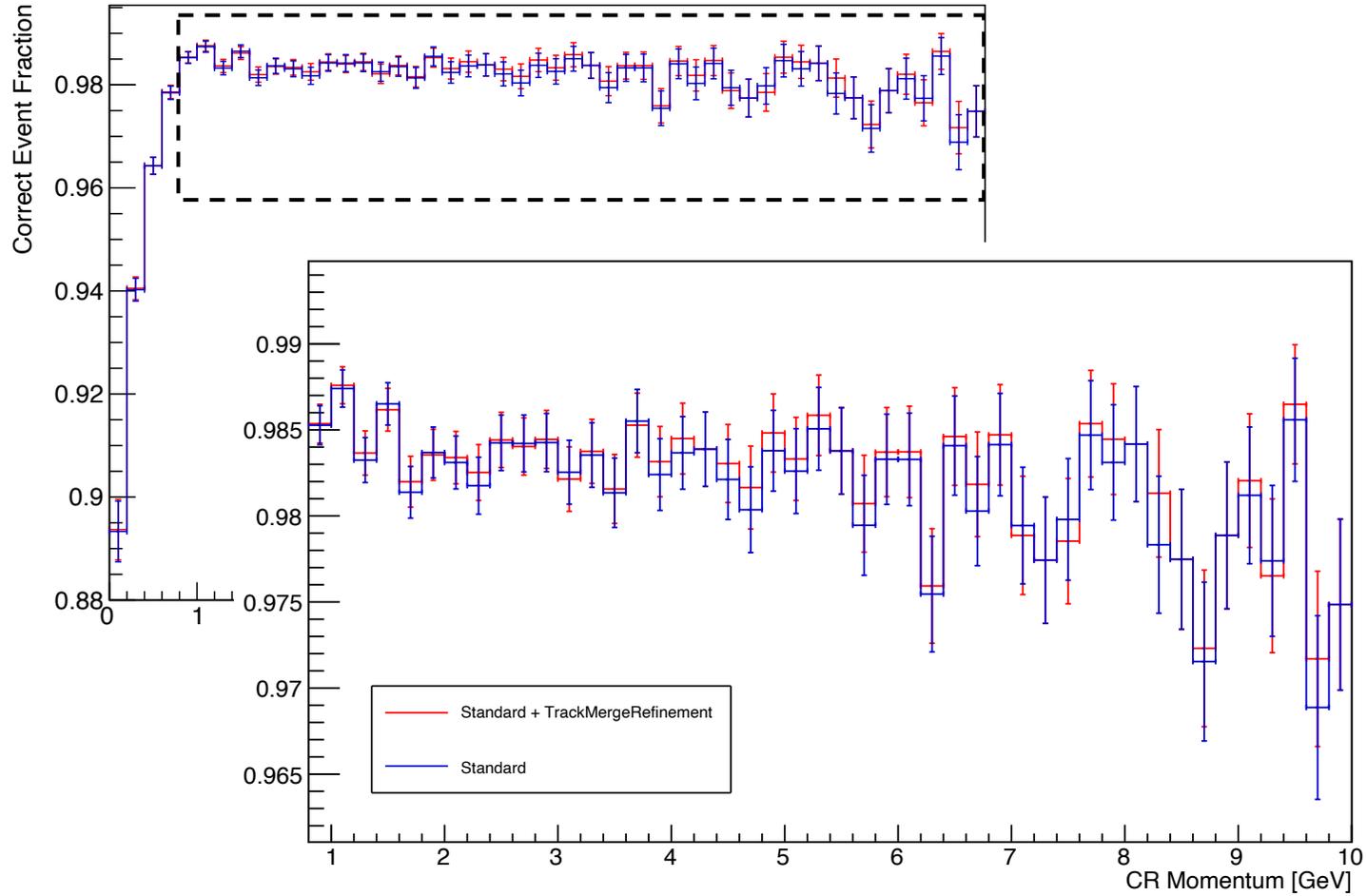
PeLEE Note: DocDB-32933

Reconstruction Metrics

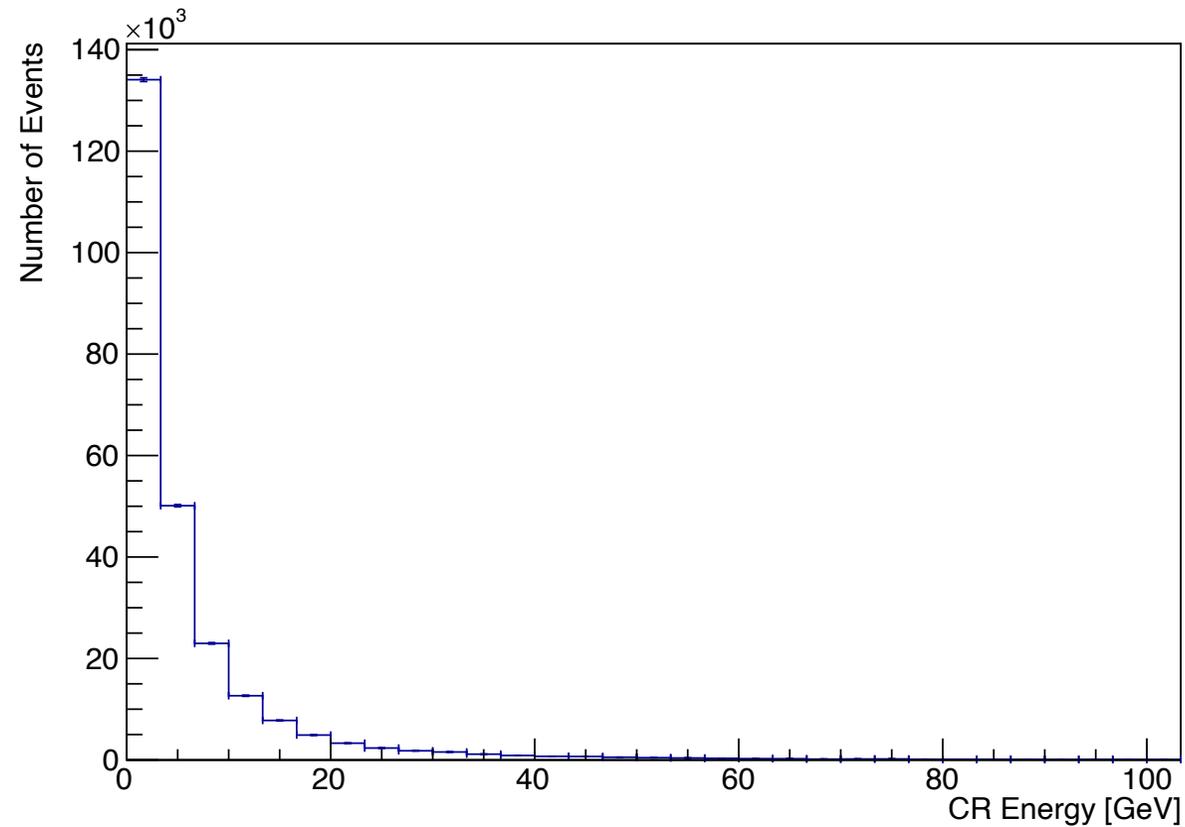
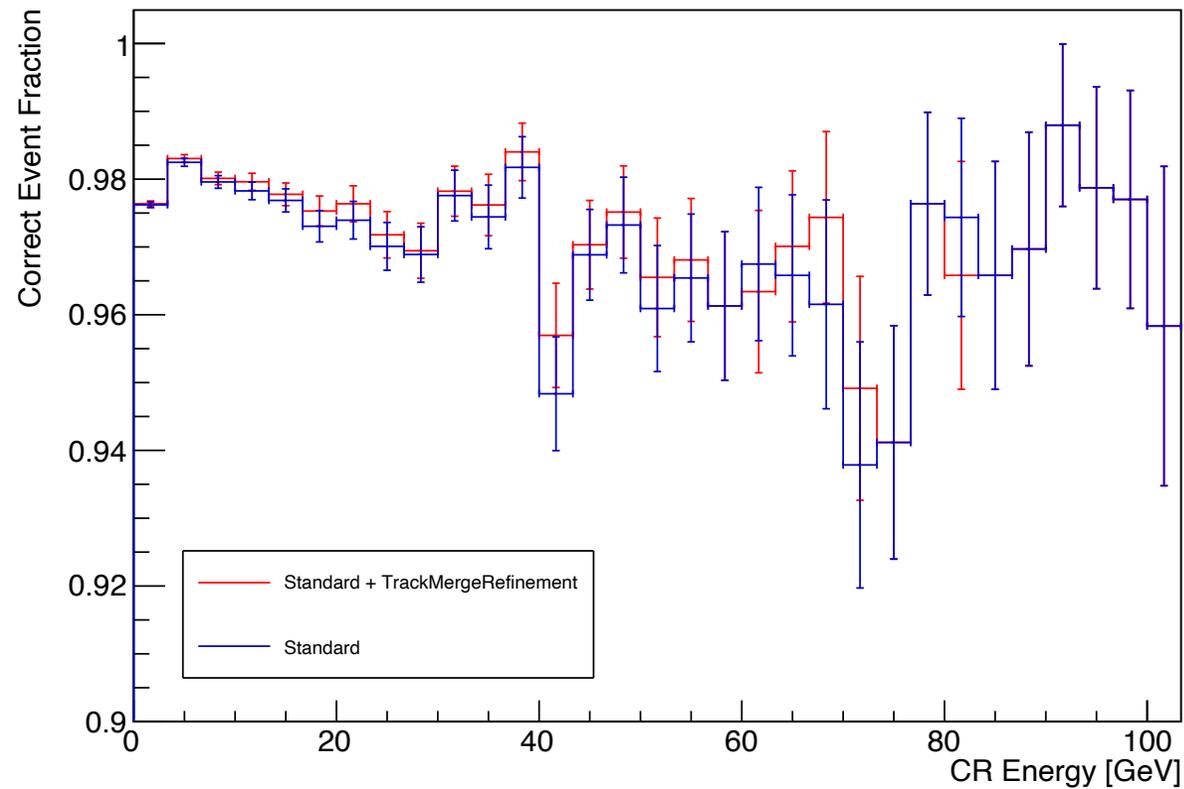
- **Sample:** wvdp_prodgenie_cosrika_p_sce_30k_v08_0_0_4 (~30K events)
- **Completeness:** fraction of MC particle's hits that are shared with a reconstructed particle.
- **Purity:** fraction of reconstructed particle's hits that are shared with an MC particle.
- **Efficiency:** the percentage of "properly reconstructed events" i.e. events with at least one PFO matched to the MC particle.
- **Correct Event Fraction:** fraction of particles with one and only one PFO matched to the MC particle.



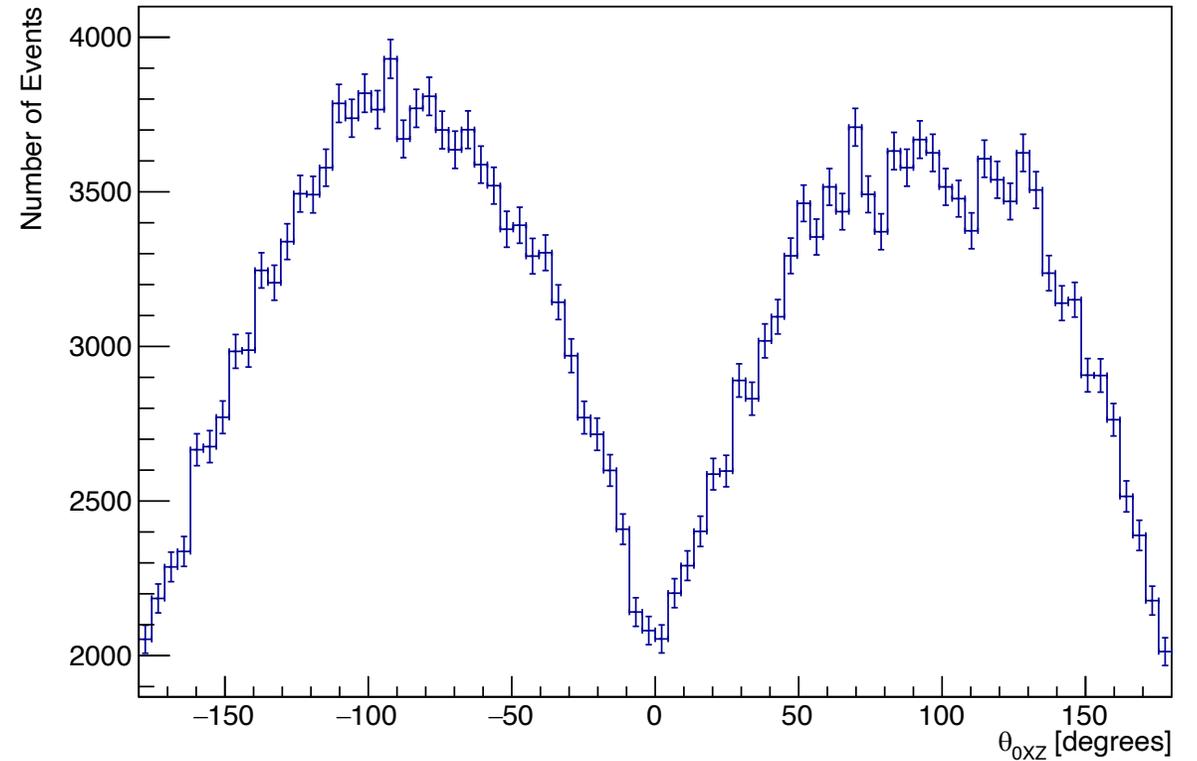
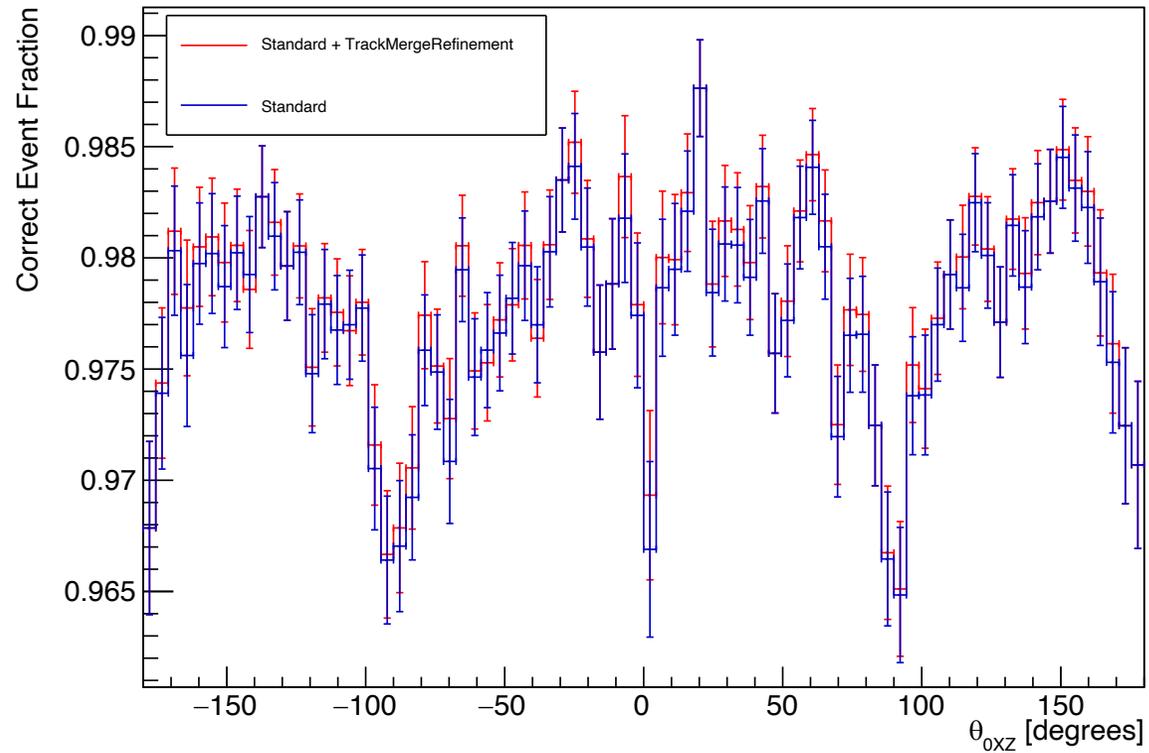
Momentum



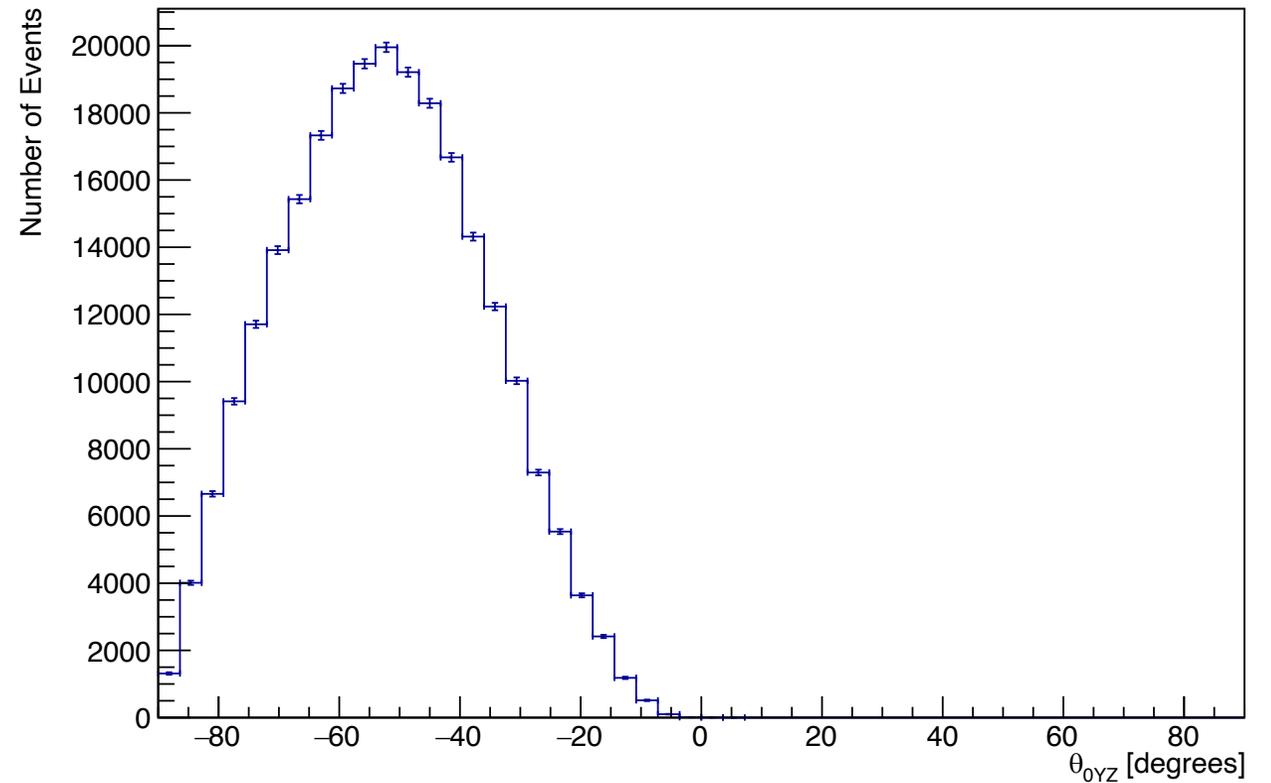
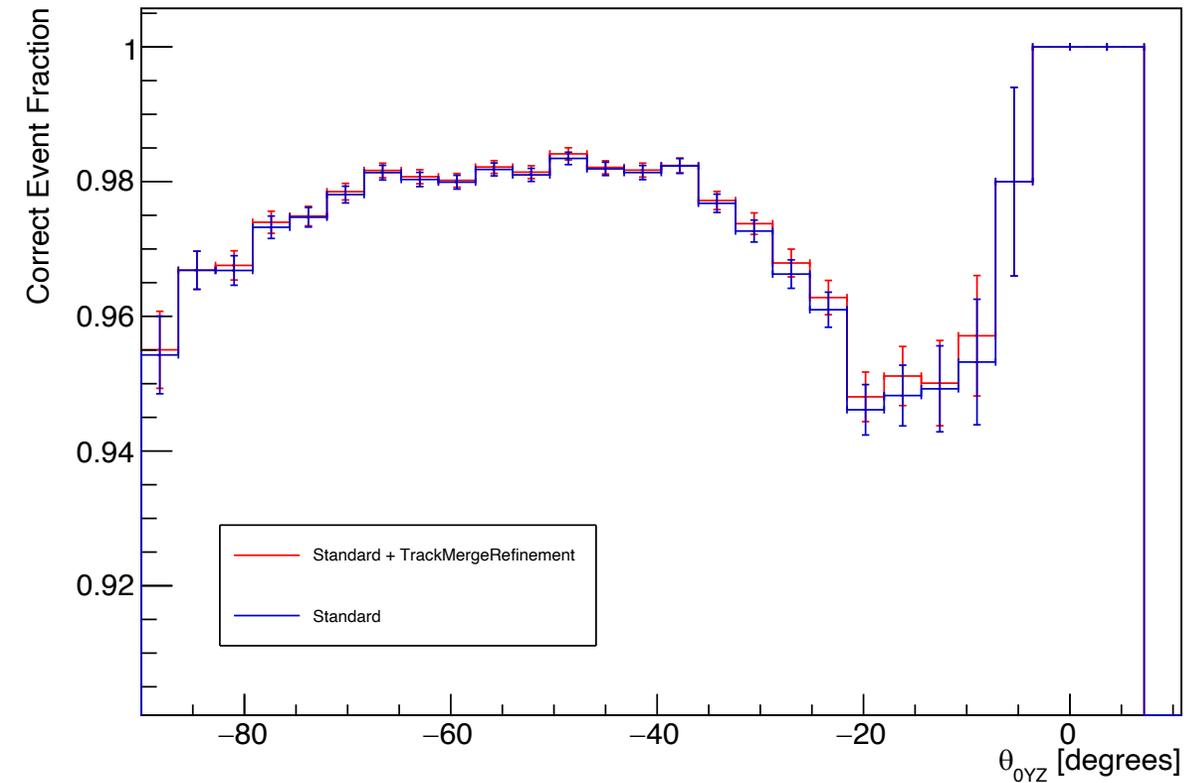
Energy



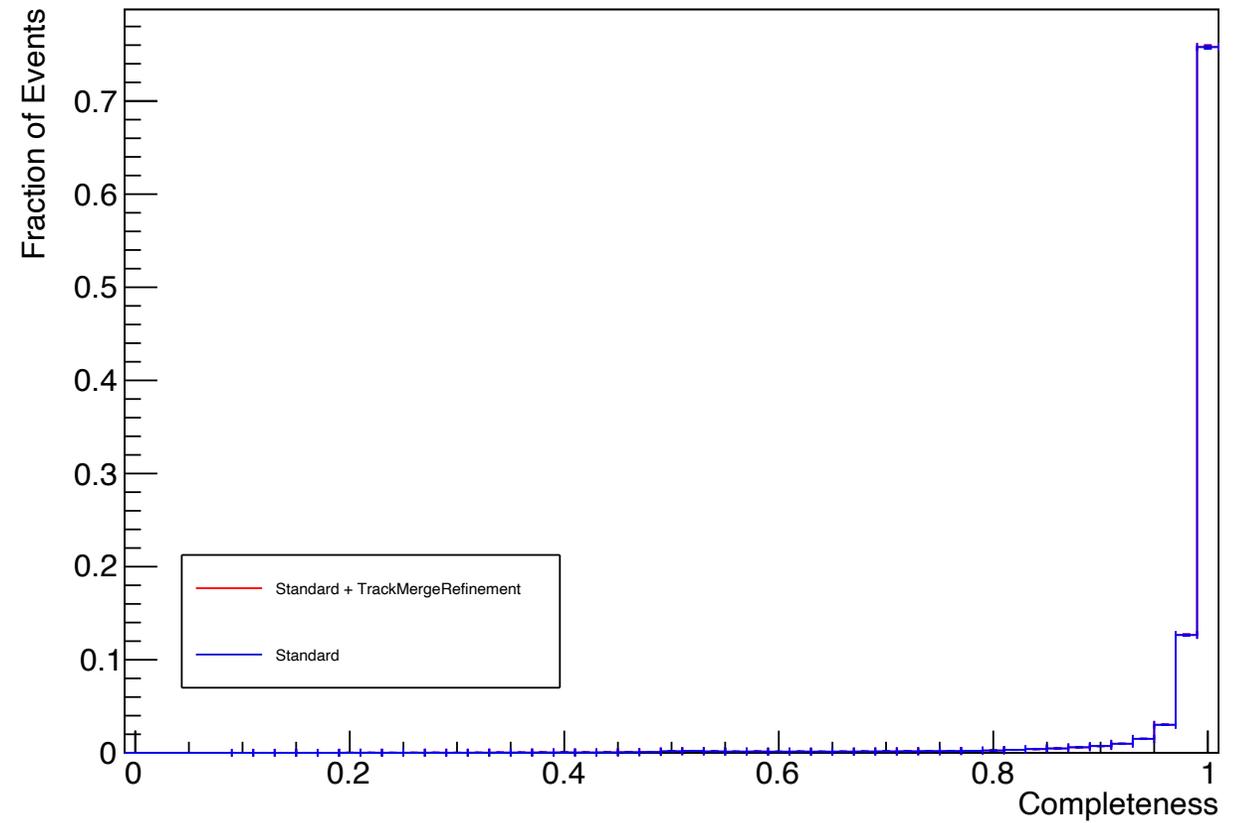
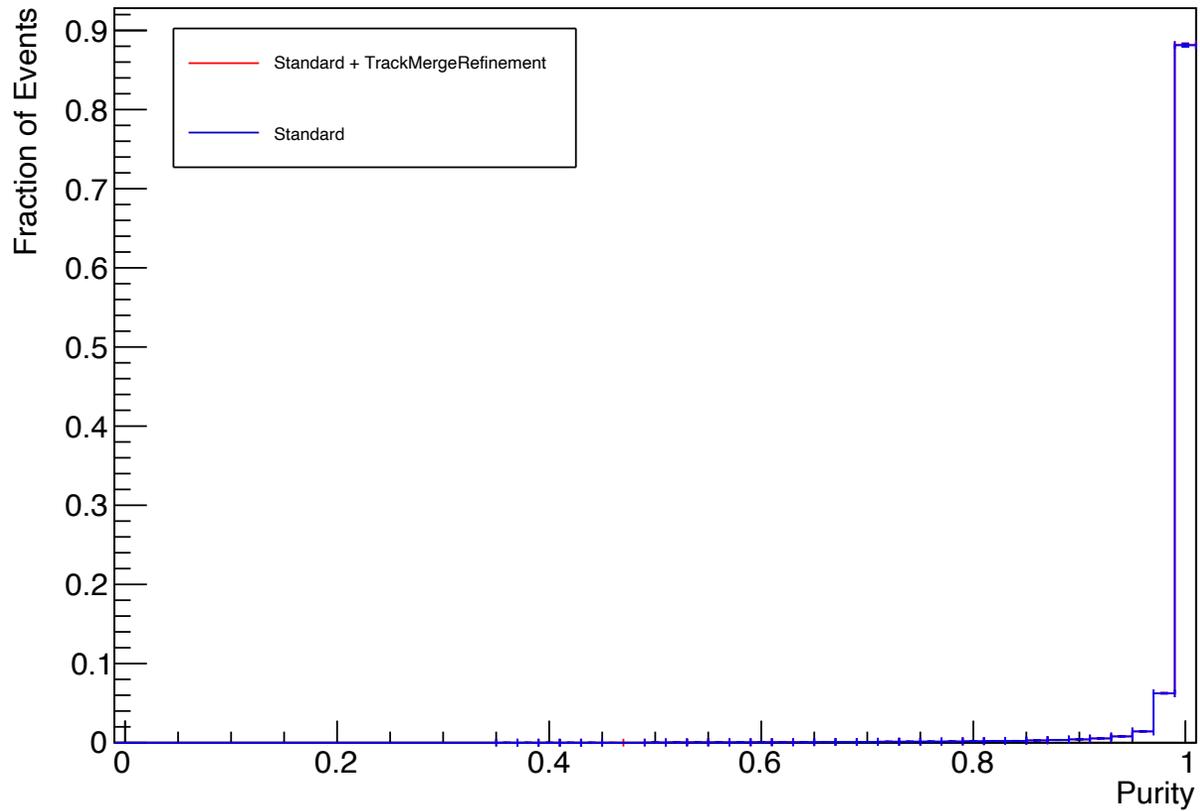
ThetaXZ - angle between z- and x-axis



ThetaYZ - angle from XZ plane



Purity and completeness



	Metric	CR All	CR Muon	CR Proton	CR Electron	CR Photon	CR Other
Standard	Completeness	96.06%	97.64%	89.99%	57.37%	72.37%	85.31%
	Purity	99.02%	99.06%	99.12%	97.03%	98.73%	98.12%
	Efficiency	98.18%	98.81%	95.27%	87.27%	88.71%	96.74%
	CEF	95.03%	97.7%	81.7%	42.7%	57.2%	77.2%
Standard + TrackMergeRefinement	Completeness	96.09%	97.67%	90.05%	57.33%	72.37%	85.13%
	Purity	99.03%	99.08%	99.13%	96.98%	98.73%	97.87%
	Efficiency	98.19%	98.82%	95.27%	87.32%	88.72%	95.65%
	CEF	95.12%	97.8%	81.7%	42.8%	57.2%	75.0%
Difference	Completeness	+0.03%	+0.03%	+0.06%	-0.04%	+0.00%	-0.18%
	Purity	+0.01%	+0.02%	+0.01%	-0.05%	+0.00%	-0.25%
	Efficiency	+0.01%	+0.01%	+0.00%	+0.05%	+0.01%	-1.09%
	CEF	+0.09%	+0.1%	+0.0%	+0.1%	+0.0%	-2.2%
nEvents		265,751	249,351	698	4479	11,131	92

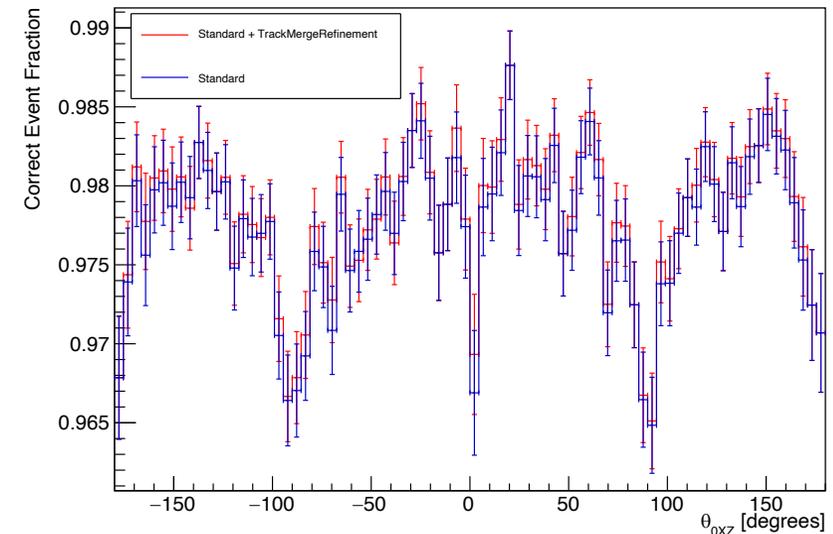
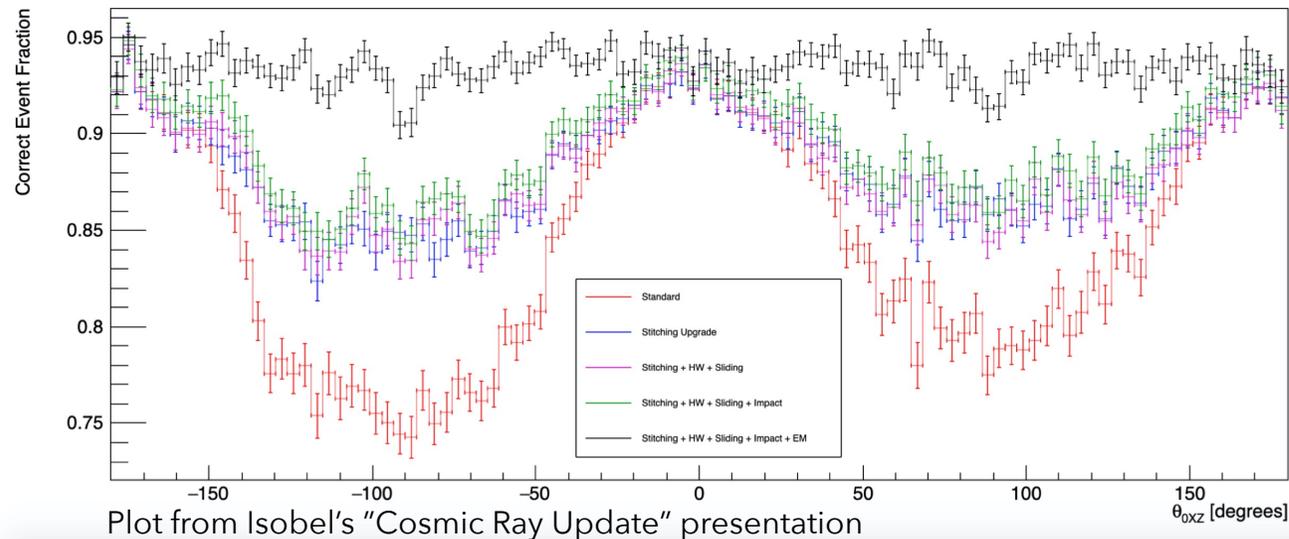
	Matched PFOs	CR Other		
		π^+	π^-	other primary
Standard	0	4.5%	2.1%	0.0%
	1	79.5%	76.6%	0.0%
	2	9.1%	14.9%	100%
	3+	6.8%	6.4%	0.0%
Standard + TrackMergeRefinement	0	2.4%	4.3%	0.0%
	1	79.5%	72.3%	0.0%
	2	9.1%	17.0%	100%
	3+	6.8%	6.4%	0.0%
Difference	0	+0.0%	+2.2%	+0.0%
	1	+0.0%	-4.3%	+0.0%
	2	+0.0%	+2.1%	+0.0%
	3+	+0.0%	+0.0%	+0.0%
nEvents		44	47	1

← Matched PFOs for CR Other split up by event type

Summary of Results

Comparison to DUNE FD improvements

- DUNE FD improvements are much more prominent.
- Performance metrics are already high in MicroBooNE cosmic pass without the additional algorithm.
- Differences: surface vs underground detector, single vs multiple drift volumes.



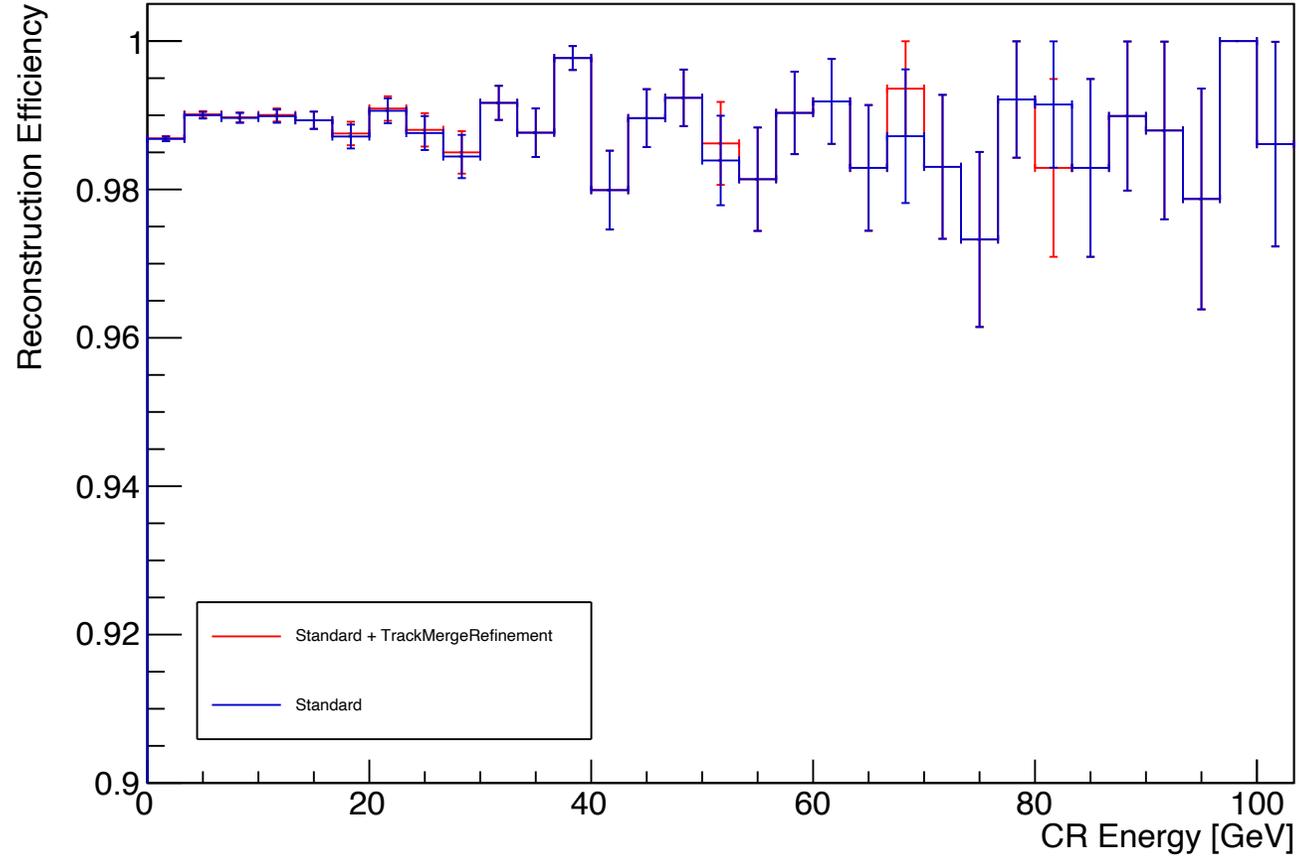
Next steps

- Scan through the CR electron and CR other events for which the performance degrades.
- If feasible, adjust the algorithm to fix the events which now fail.
- Another possibility: implement the algorithm to run on failed CR muon events only.
- PeLEE: apply this to broken CR muon tracks in the analysis.

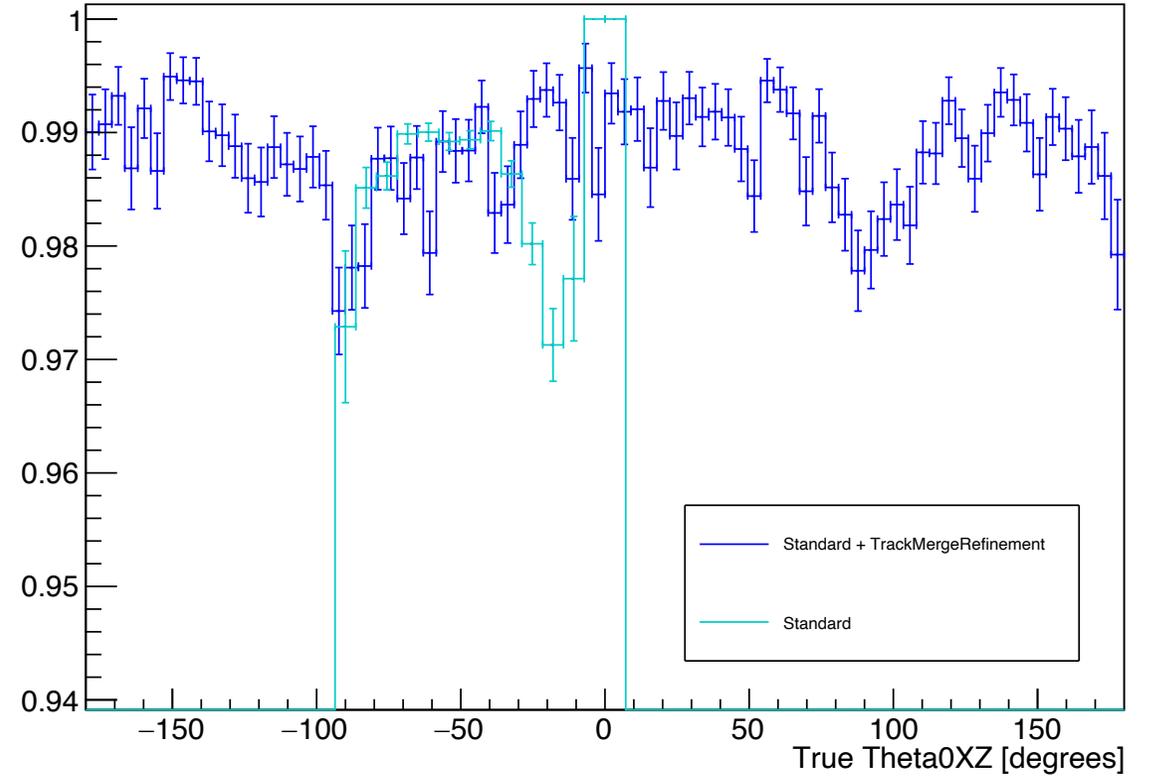
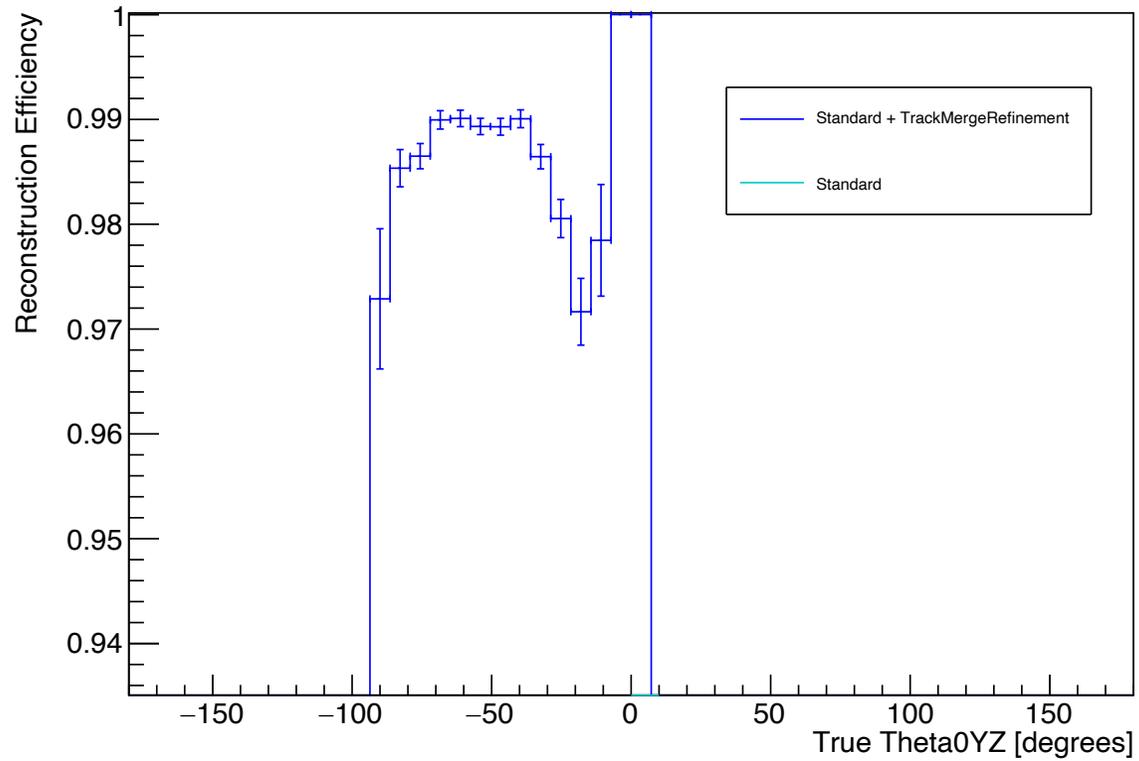
Thanks for listening

Backup slides

CR energy efficiency



CR momentum direction efficiency



CR momentum efficiency

