Data-Driven cross checks for $\nu_e/\bar{\nu}_e$ selection efficiency in NOvA

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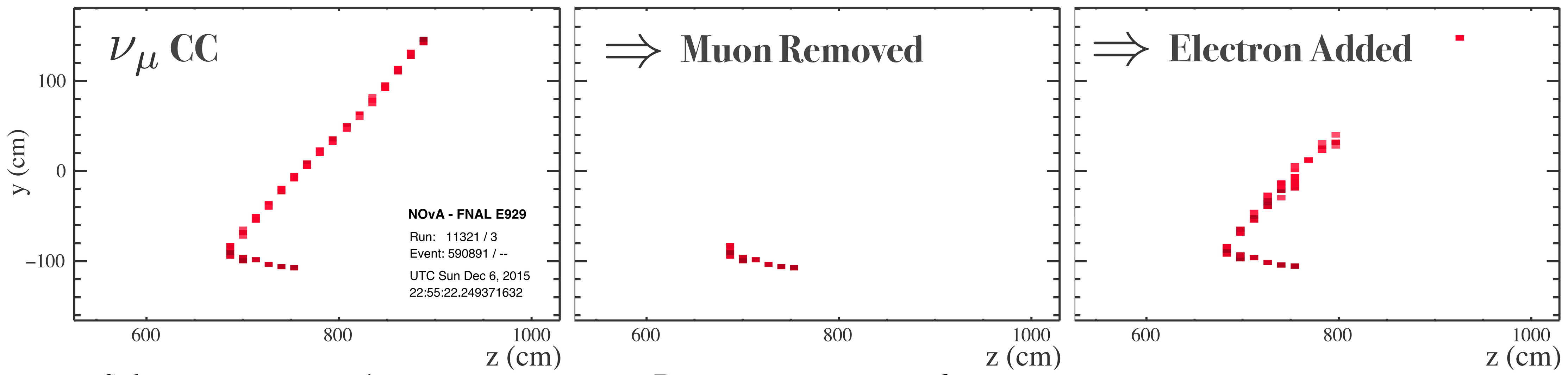
Neural networks at NOvA

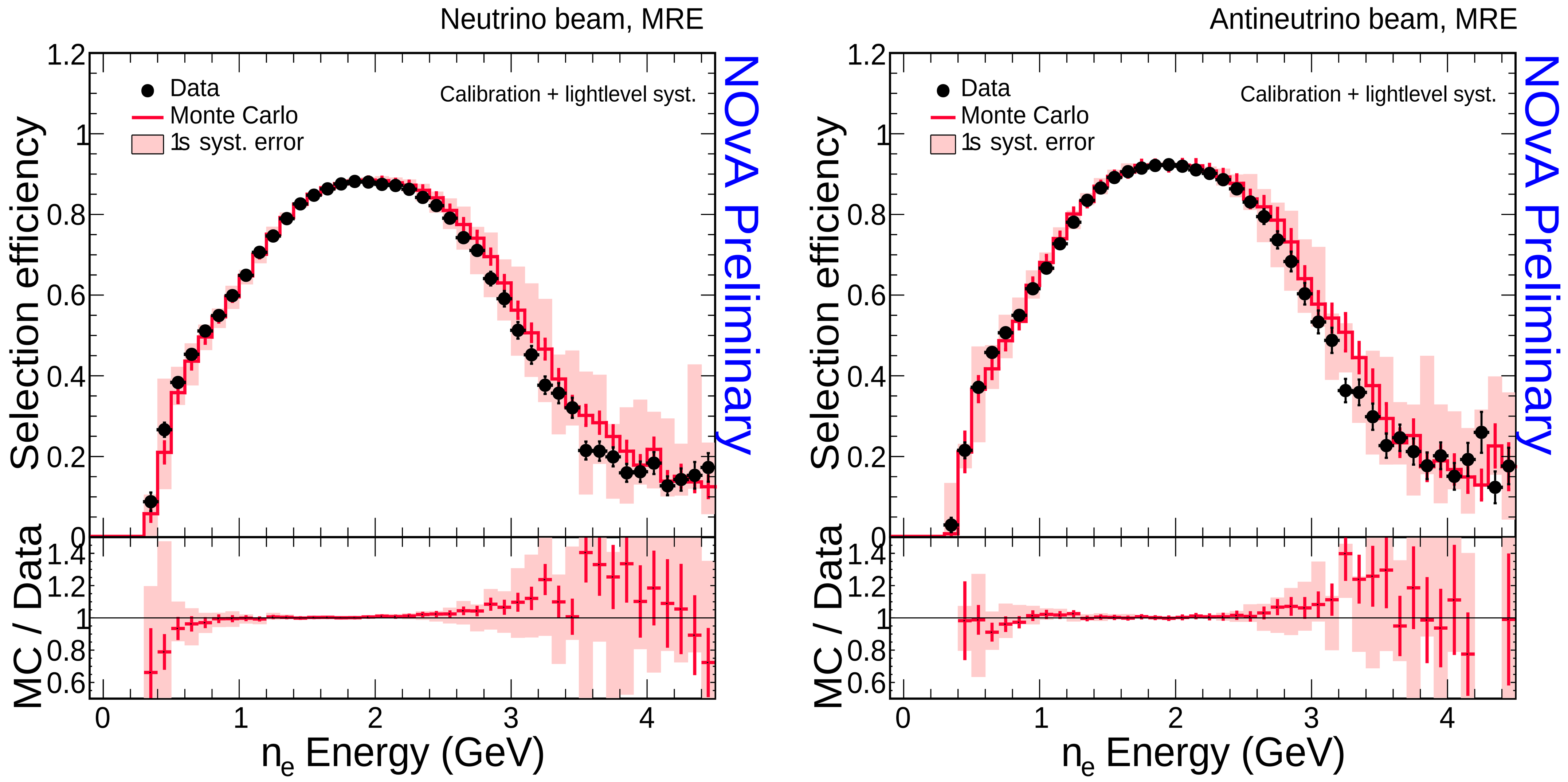
- Event identification is done by our CVN (Convolutional Visual Network).
- Introduces convolution filters to extract features from the hit maps during the training.
- The network is trained on two dimensional views of the event's calibrated hits.
- The views are then combined in the final layers of the network.
- It increased our effective exposure by 30% compared to traditional ID methods.

MR Electron Added (MRE)



Select a muon neutrino interaction from ND data and simulation; → Remove reconstructed muon hits; → Replace with a simulated electron of the same energy as muon.

- Can perform on both data and simulation to compare selection algorithms;
- Hybrid Data/Monte Carlo events allows us to study the impact of any mis-modeling of the hadronic shower on the ν_e selection efficiency by PID.



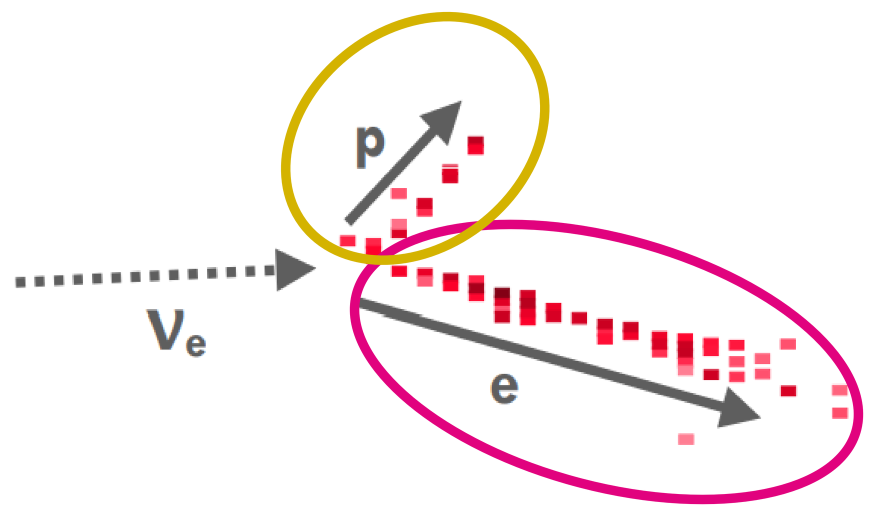
		Preselection	Full Selection	Efficiency	Difference
Neutrino beam 9.5×10^{20} POT	Data	709112	564669	0.796	-0.76%
	MC	772566	619908	0.802	
Antineutrino beam 11.8×10^{20} POT	Data	418245	348151	0.832	-0.46%
	MC	475300	397454	0.836	

The overall PID selection efficiency agrees between data and MC at the <1% level for MRE events both in neutrino and antineutrino beams.

Muon Removed (MR) Cross Checks

- Because our CVN is trained using simulated events, there is potential that differences between data and simulation can affect the CVN performance.
- There are too few ν_e's in our ND from the beam to be of use to directly check the CVN's ν_e selection.
- Instead, Muon Removed (MR) Cross Checks are used to compare the PID selection efficiency of our CVN on samples from both data and simulation of easily identifiable and abundant muonic events.
- Each MR Cross Check isolates either the hadronic or electromagnetic component to check each component's mismodelling effects on PID selection separately.

The CVN performance of the hadronic component is done with MR Electron Added using ν_μ CC events in out ND.



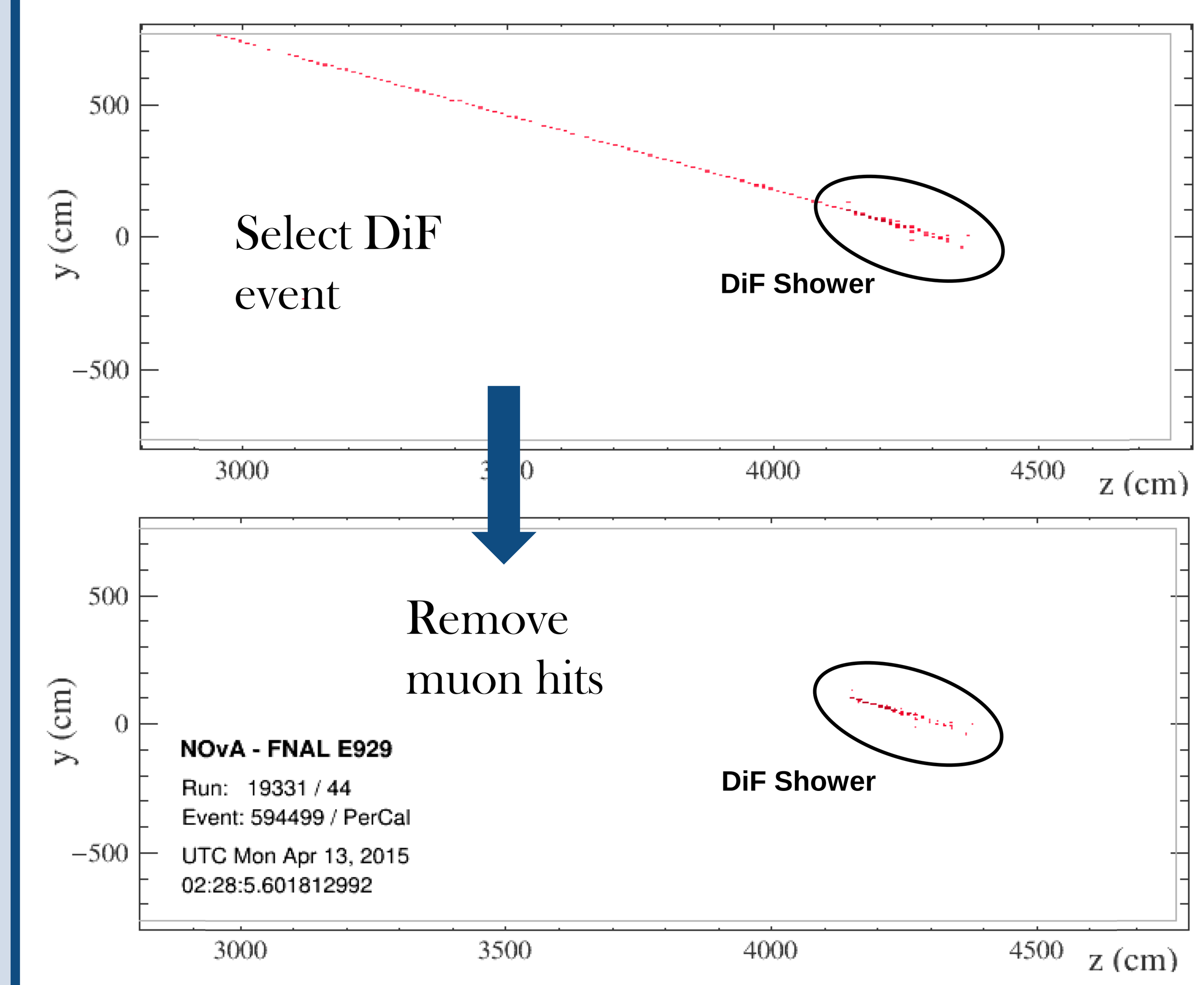
The CVN performance of the electromagnetic component is done using MR Decay in Flight using cosmic muons at our FD.

$$\text{CVN selection efficiency} = \frac{\text{events selected by PID}}{\text{events before PID}}$$

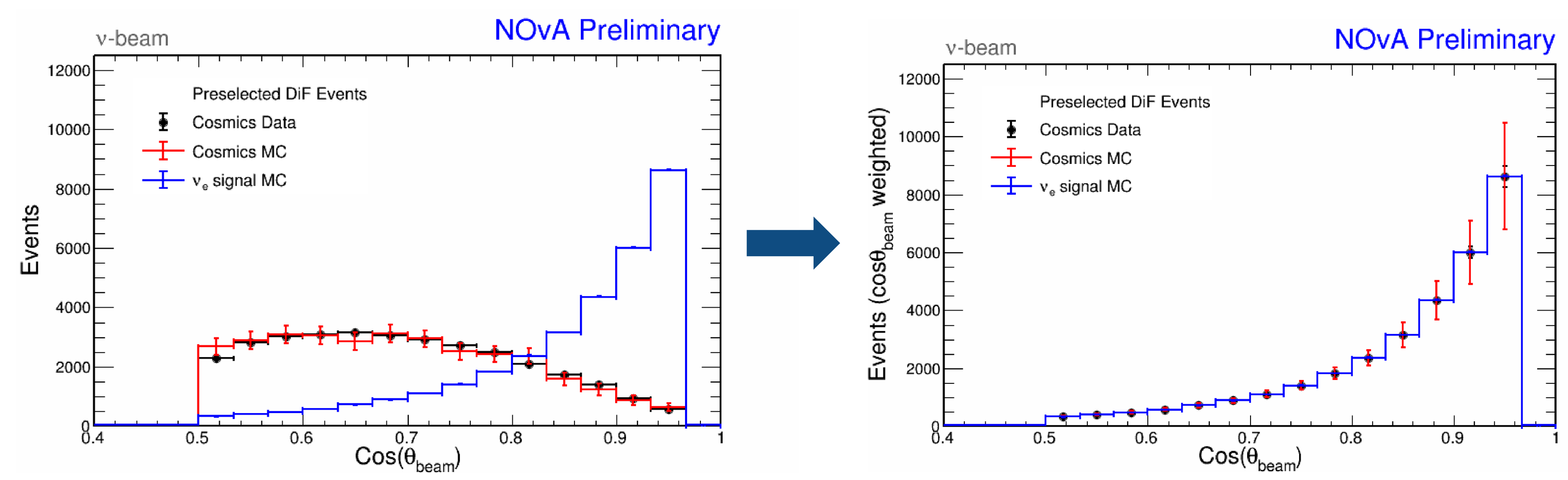
Conclusions

- The resulting PID selection efficiency between data and MC in both MRE and MRDiF show agreement consistent with our uncertainties, showing the CVN selection is generally robust in ν_e ($\bar{\nu}_e$) CC signal selection.
- Future work will include adapting the MRDiF procedure for use with ND data to make a comparison of our CVN performance between the detectors.

MR Decay in Flight (MRDiF)



- Use FD cosmic data and simulation to look for muons that enter the detector and decay in flight (MRDiF).
- Muonic hits are removed leaving behind pure electromagnetic showers.
- To more closely match our ν_e signal, events are reweighted by their angle to the beam before calculating selection efficiency.



The overall PID selection efficiency for MRDiF events agrees within our uncertainties between data and simulation and both in neutrino and antineutrino beams.