# Mock data with ND-driven reweighting

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# Motivation

- As I showed at the last CM, the PID capabilities of the HPgTPC allow different exclusive final states to be separated out – further details here
- In turn, differences in the interaction model can be determined through differences in kinematics
- We want to propagate these differences through to our FD samples which allows us to (hopefully) fix the issue

# Reconstructed $Q^2$ for reconstructed final state selections
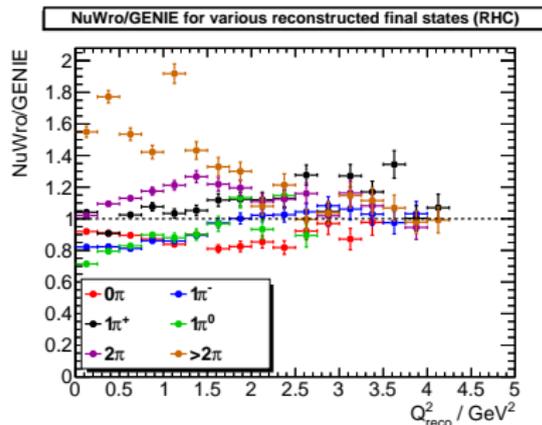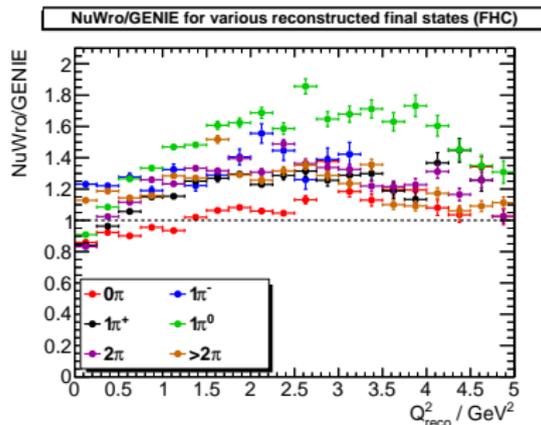


- Within CAFAna, take ratio of nominal HPgTPC sample to its NuWro-reweighted counterpart
- Aimed to do this with $Q^2_{reco}$ for a variety of different reconstructed final state $\pi$ multiplicities
- One can clearly see clear differences in the reconstructed observables

# Reweighting function from $Q^2$ in ND

- The next step is to use this information

- Take our nominal (GENIE) FD prediction and reweight events based upon information extracted from the ND

- Compare our 'data' (NuWro mock data) to this reweighted MC

- (Hopefully) see a reduction in our $\delta_{CP}$ bias

- This was where I was at during the last CM



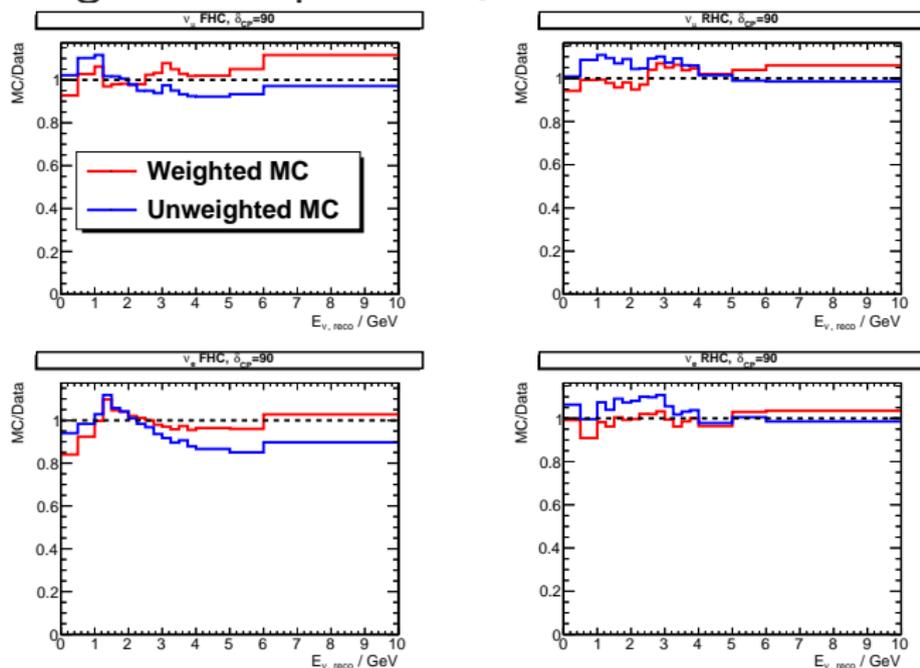NuWro/GENIE for various reconstructed final states (FHC)



NuFit 4.0

Bias for 68% of $\delta_{CP}$ values is ≤14°
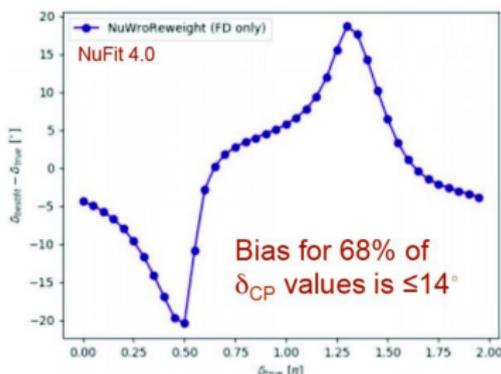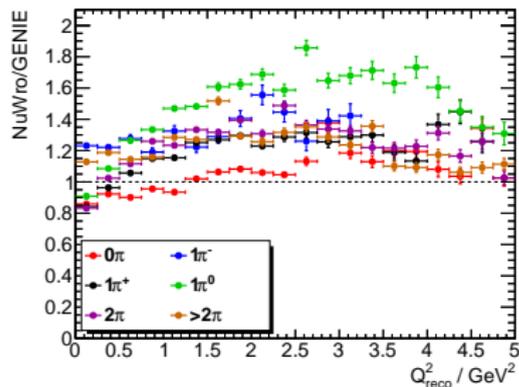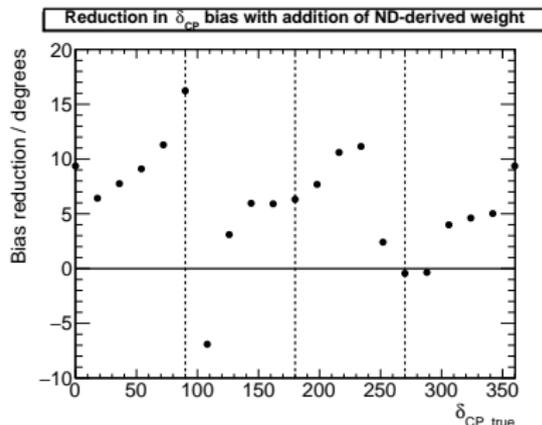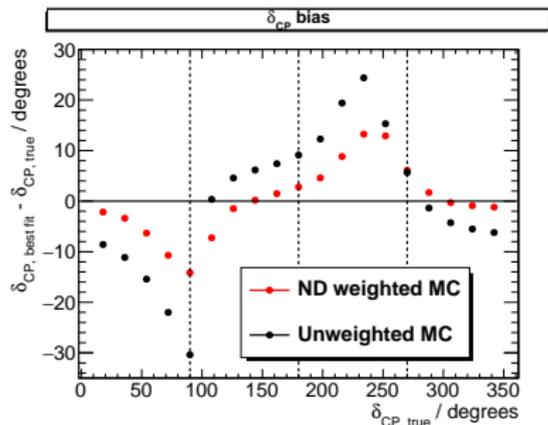
# Reweighting FD samples in $Q^2$
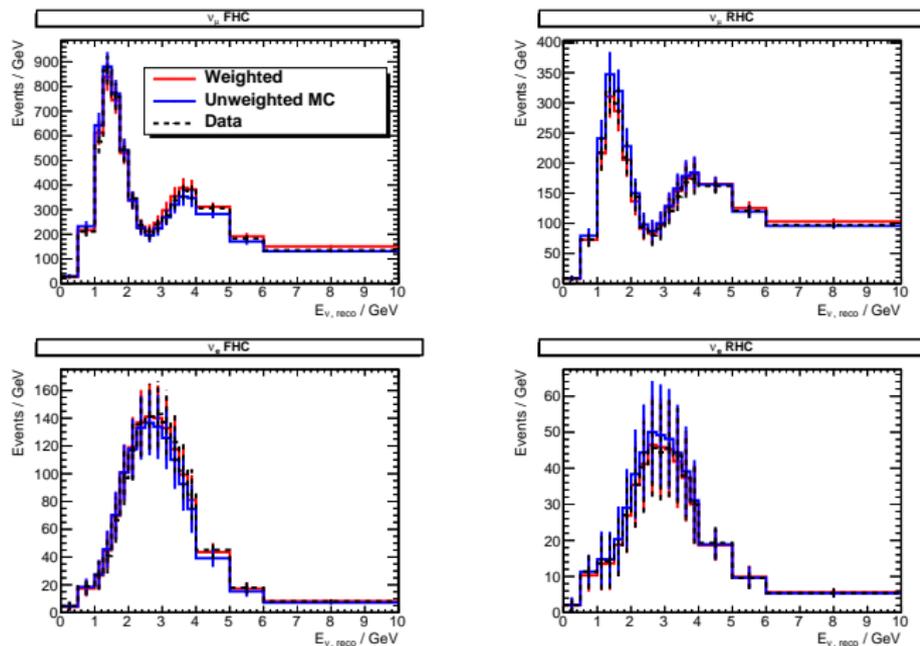


■ Weighted MC moves significantly closer to the mock data

# Reweighting FD samples in $Q^2$



- Weighted MC moves significantly closer to the mock data

# Fitting results



- Used this reweighted MC in an FD-only fit with the full TDR systematics
- Data is the NuWro reweighted MC
- Weighting gives a significant reduction of in $\delta_{CP}$ bias at nearly all values

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# Comparison with a 'LAr only' ND sample

- Compare this with a sample where we say we are unable to easily separate out our final states
- To do this I again used a $Q^2_{reco}$ reweighting function but using only a CC inc. sample from the HPgTPC

# Comparison with a 'LAr only' ND sample
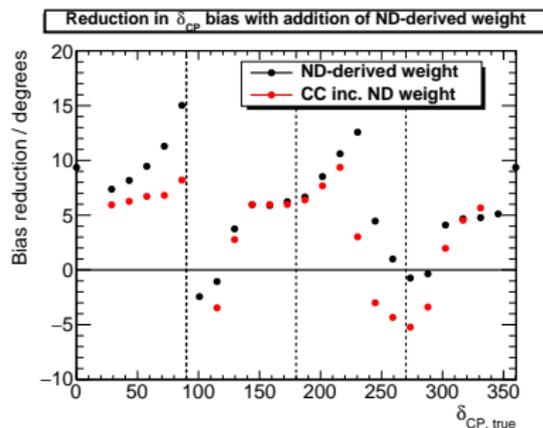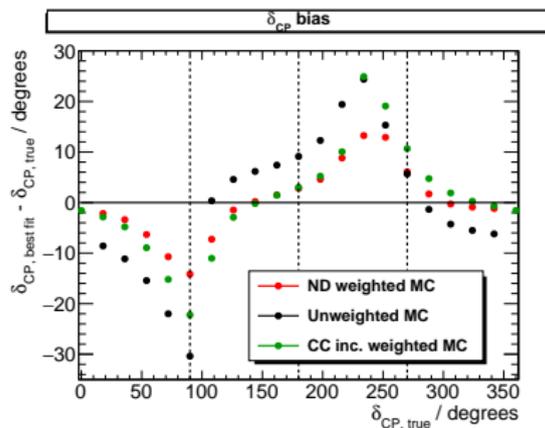


■ We still see a reduction in $\delta_{CP}$ bias but it is reduced at most points

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# Next steps

- Aim now is to find a reweighting function which maximises the bias reduction
- See a significant reduction just using $Q^2$ but can probably do better using a 2-dimensional reweighting
- At the moment I am working on implementing a reweighting in $q_0$ and $q_3$