Pion multiplicity study update

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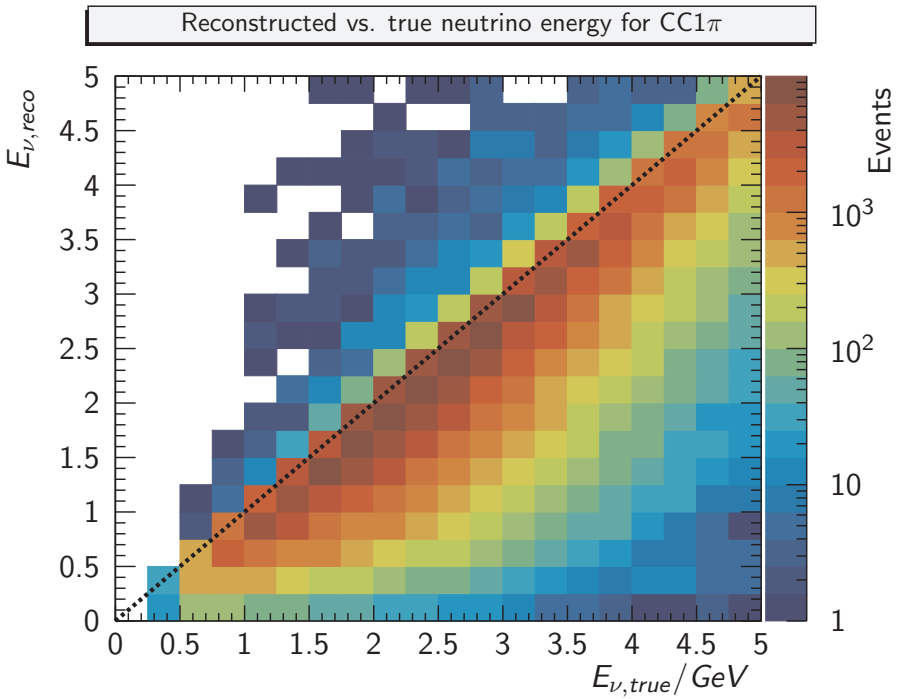
Recap

- Aim is to use gas TPC samples (seperated by pion multiplicty) along with NuWro fake data to see if the HPgTPC can be used to determine issues with our interaction model
- Gas TPC samples use pseudo-reconstruction based upon GEANT4 energy deposits
- NuWro fake data generated through reweighting process in CAFAna

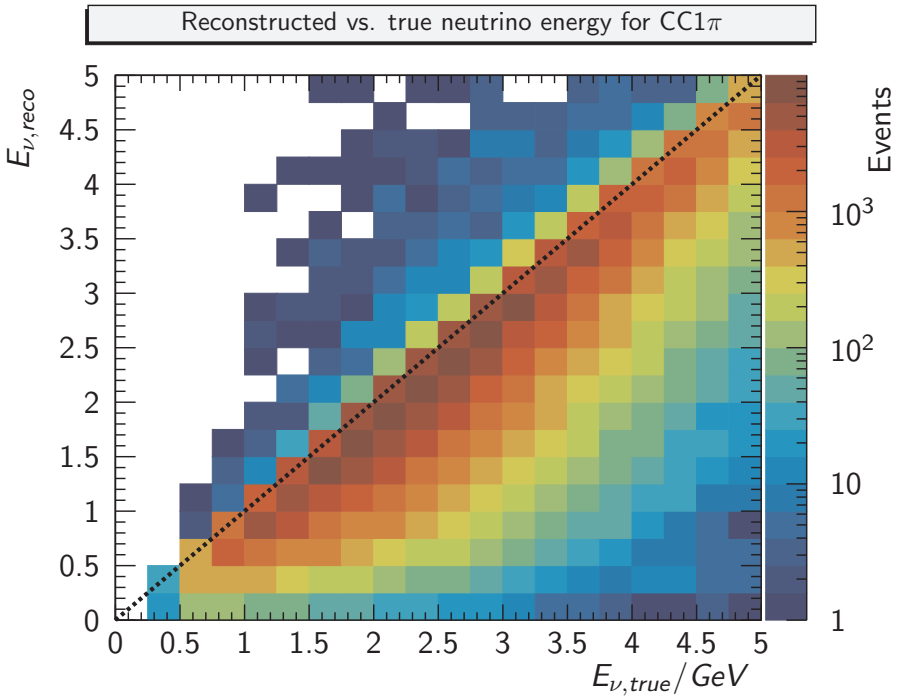
Updates to samples / reconstruction

- Previously, saw some kind of bias within the gas true vs reco distributions – suggested that this may be caused by lack of fiducial cut
- Now a fiducial cut for the samples – event vertex must have $r < 200$ cm and $|x| < 200$ cm



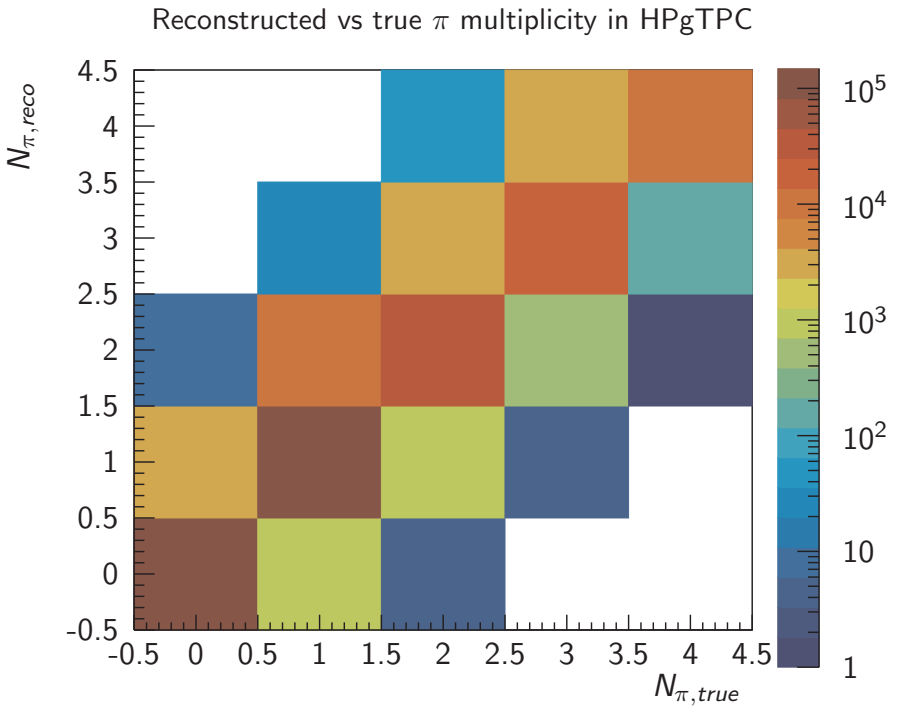
Updates to samples / reconstruction

- Turns out that FV is not the cause of this
- Peak in true - reco distribution is at $\pi^{\pm}$ mass
- Caused by high energy pions ($P_{reco} > 1.5$ GeV/c) being mis-ID'd as protons
- Leads to m_{π} mistakenly being added back in

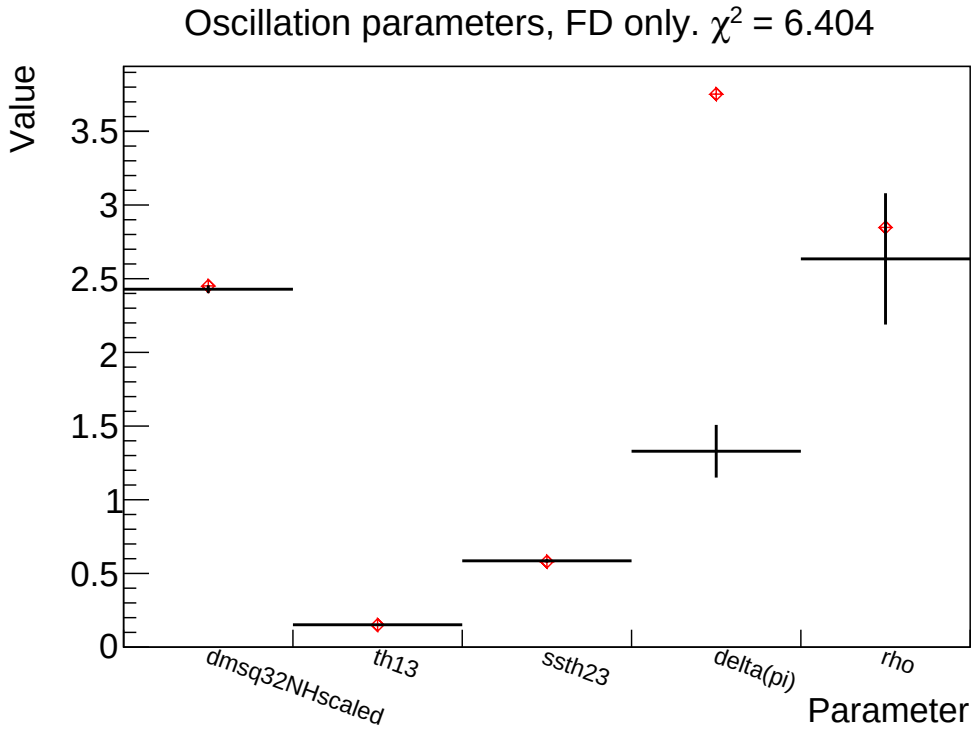


Updates to samples / reconstruction

- Additonally, now have samples defined by *reconstructed* pion multiplicity rather than true
- Reconstruction requires minimum track length
- For $\pi^0 s$, require that decay photons do not overlap with one another

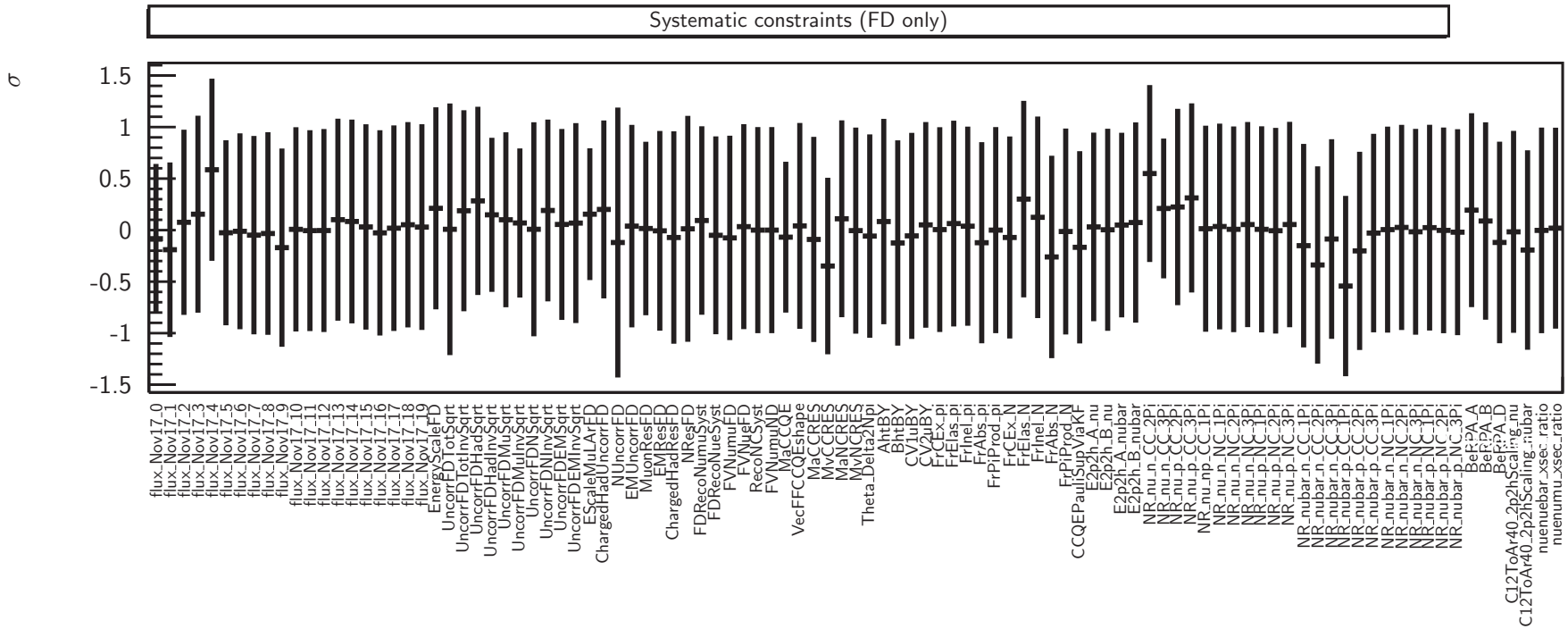


Fitting efforts - FD only



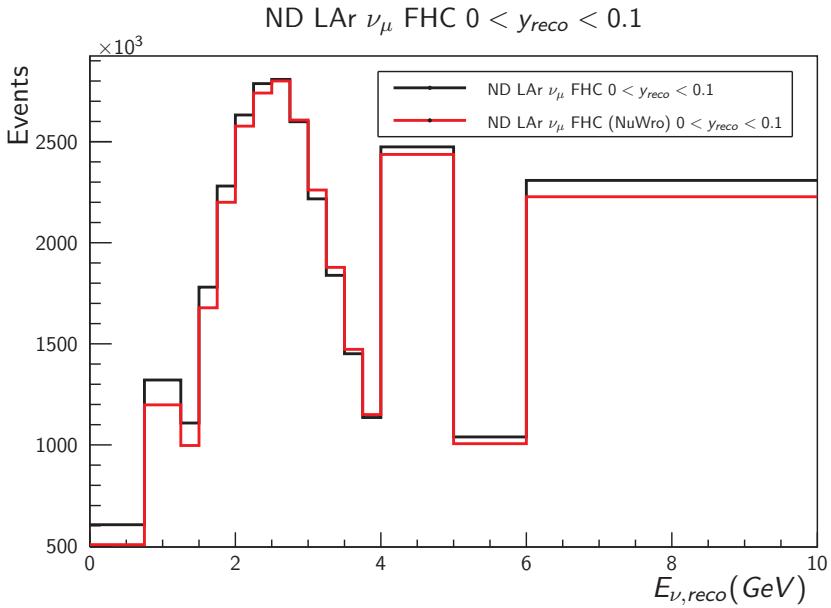
- Reproducing an FD only fit with full systematics leads to biased oscillation parameters but a low χ^2 – hard to detect that we have the wrong answer
- Red is true values of oscillation parameters while black shows the post-fit constraints

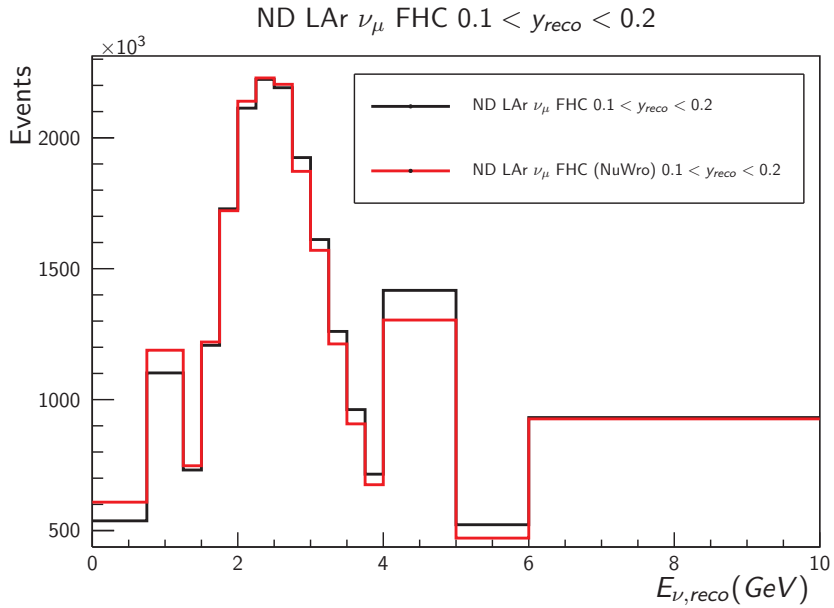
Fitting efforts - FD only



- Systematics remain close to their nominal values ($\sigma = 0$)
- Together with oscillation parameters they're able to 'absorb' the difference introduced by the shift to NuWro

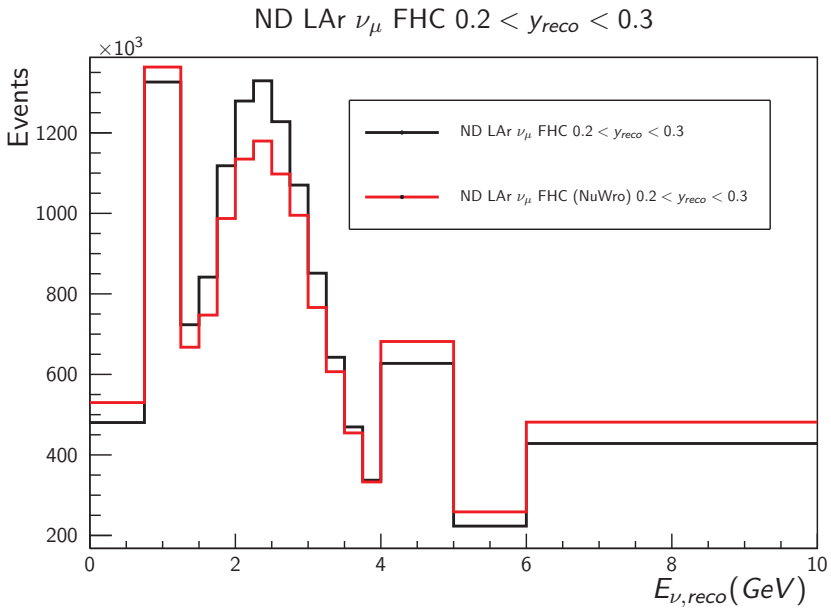
LAr ND samples

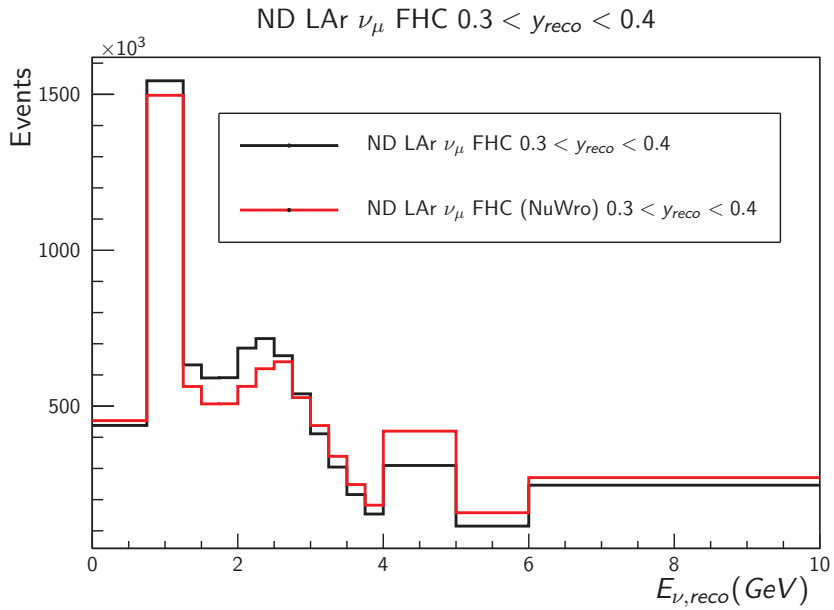




- Shown here are the 1D projections of the ND analysis bins with both the nominal sample and with the NuWro reweights
- At low values of y_{reco} relatively small discrepancies between GENIE and NuWro

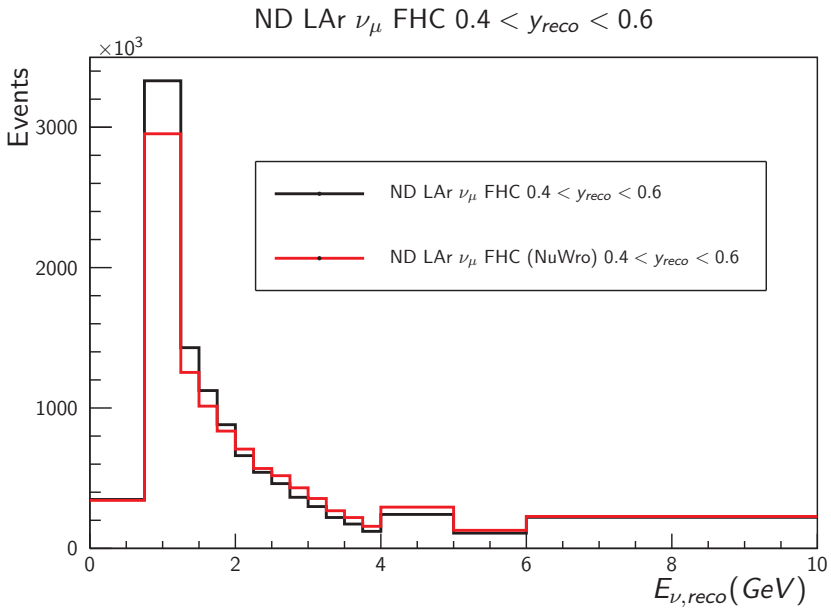
LAr ND samples

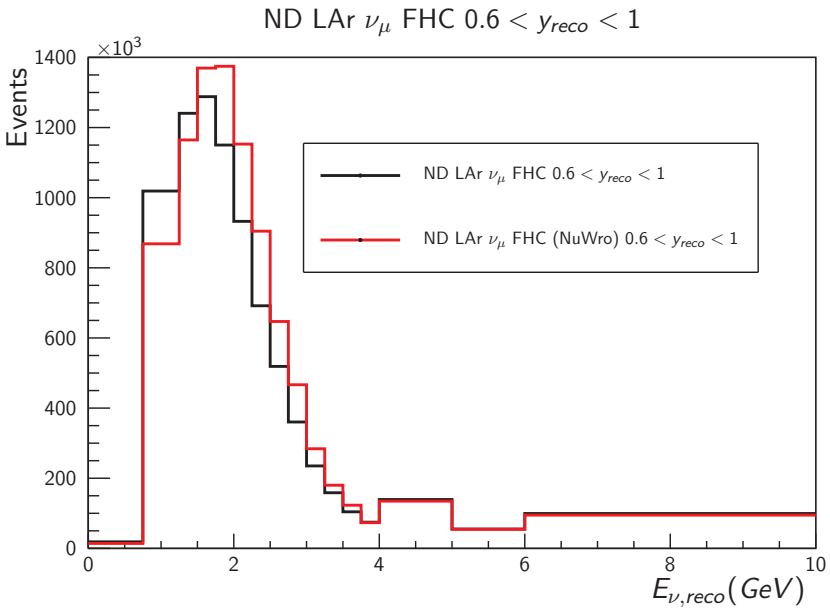




- Begin to see greater discrepancies as we move to more inelastic interactions

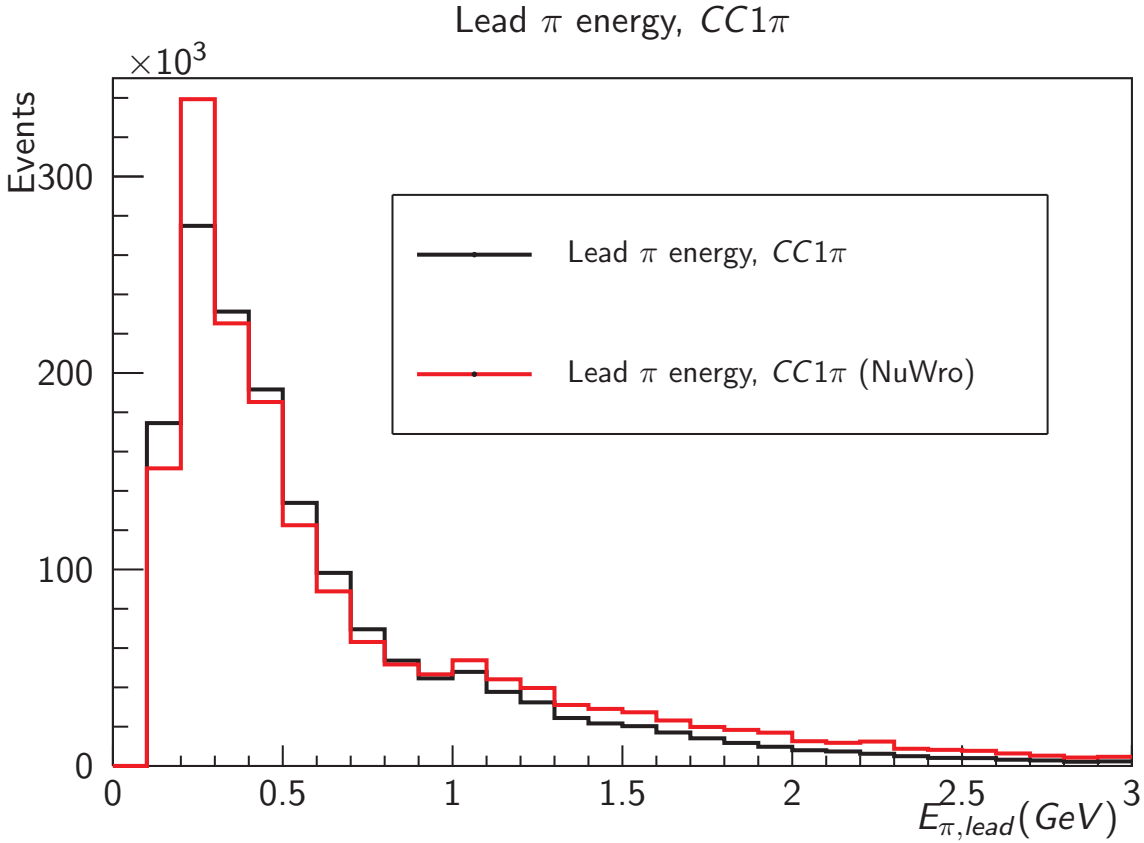
LAr ND samples





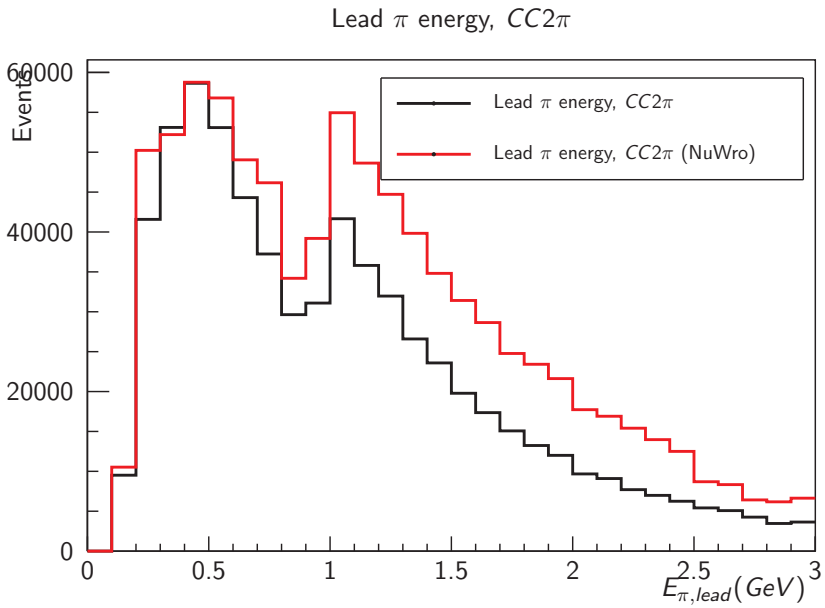
- Begin to see greater discrepancies as we move to more inelastic interactions

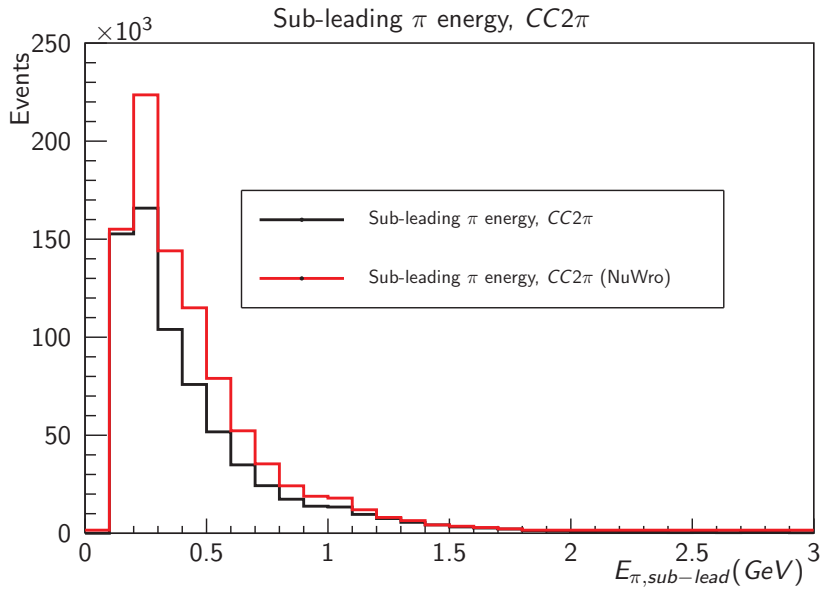
Comparison with exclusive samples in HPgTPC – CC1π



- For events with a low pion multiplicity, leading π energy distribution looks quite similar across generators

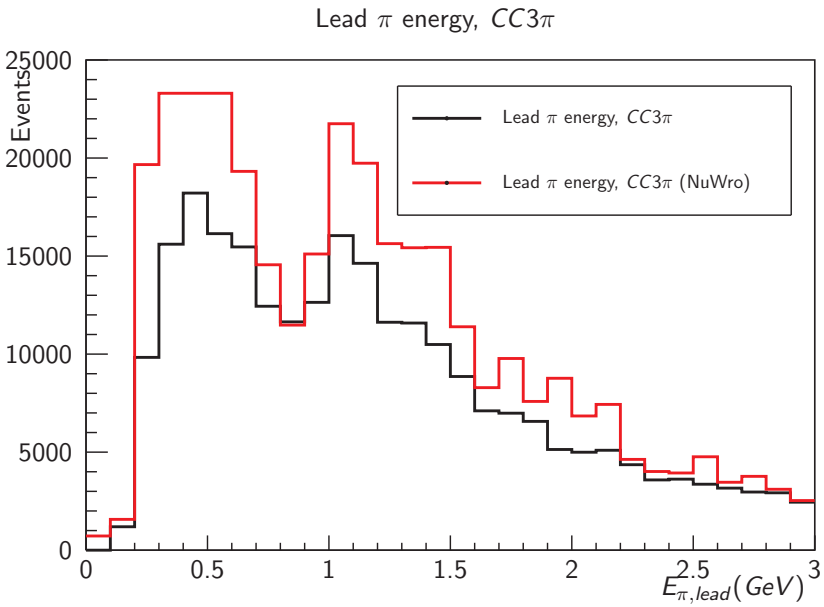
Comparison with exclusive samples in HPgTPC – CC2π

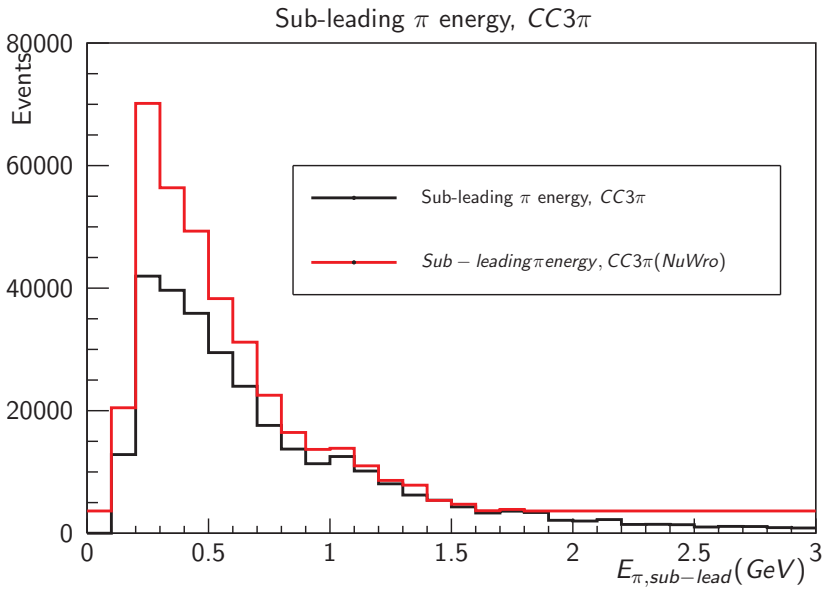




- For higher 2π events we see a significant divergence between the GENIE and NuWro samples

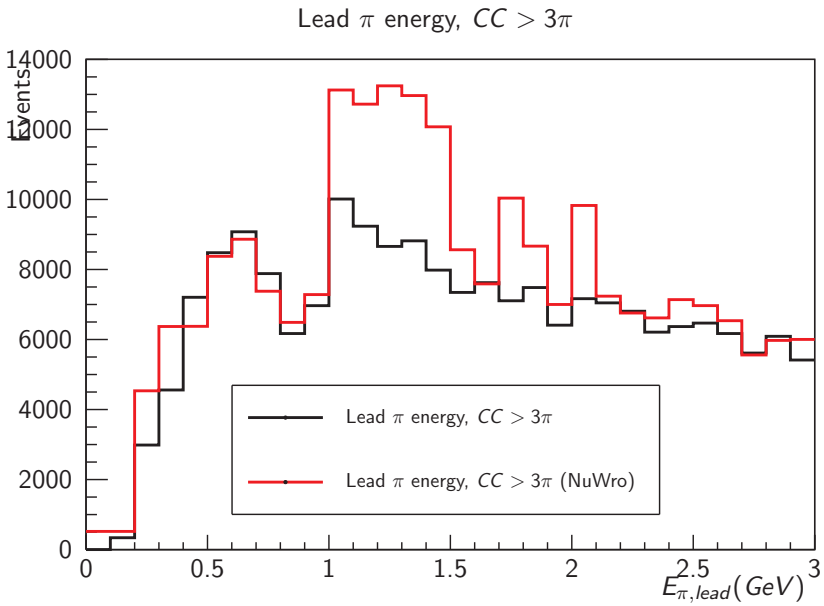
Comparison with exclusive samples in HPgTPC – CC3π

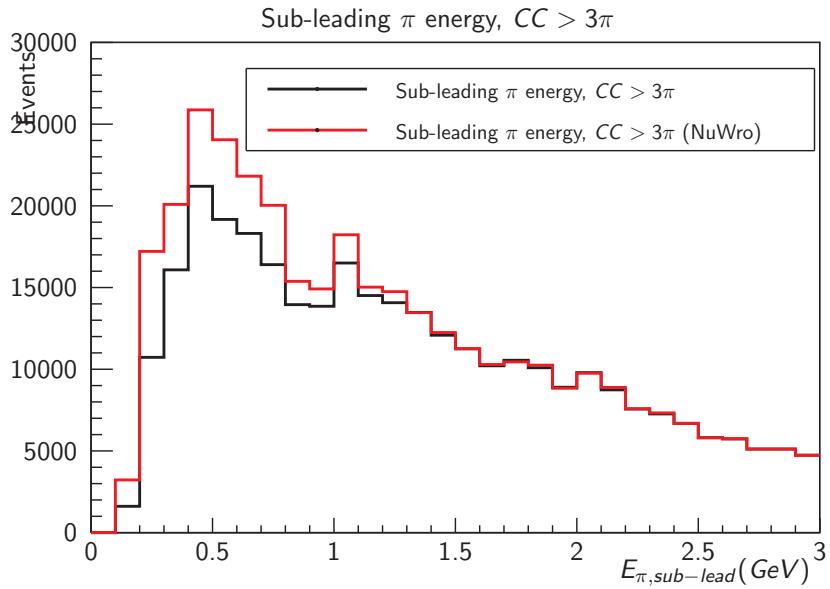




- Similarly, for $CC3\pi$ events there is a significant divergence in the distributions of both the leading and sub-leading pion energy

Comparison with exclusive samples in HPgTPC – CC$> 3\pi$

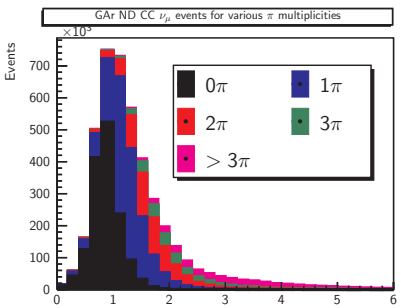


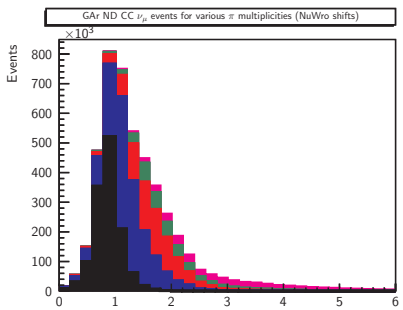


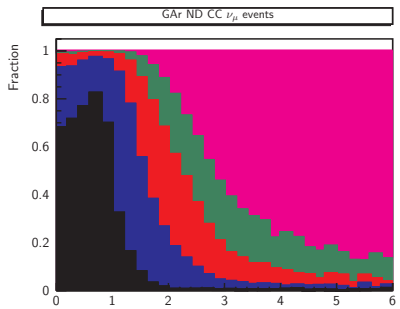
- For events at very high multiplicity the divergences appear to once again not be so obvious
- However, one can see that by using just some of the exclusive HPgTPC samples it would quickly become obvious that there was an issue with out interaction model if our data was like NuWro

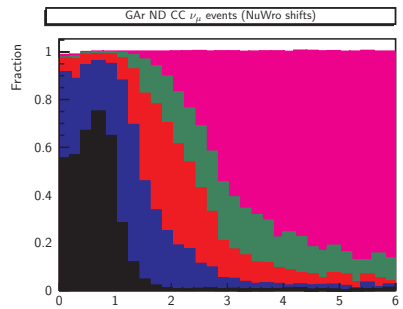
Backup

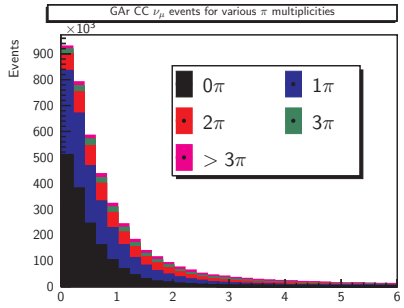
Kinematic distributions within HPgTPC

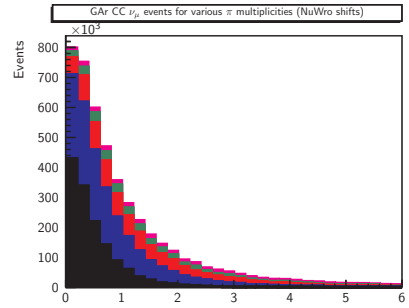


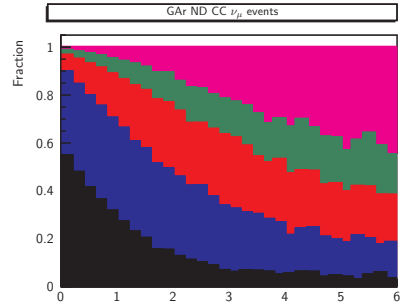


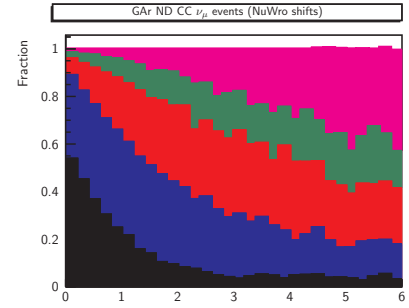












- Reconstructed W
- Reconstructed Q^2

Kinematic distributions within HPgTPC