Near-to-Far Extrapolation in Transverse Momentum at NOvA

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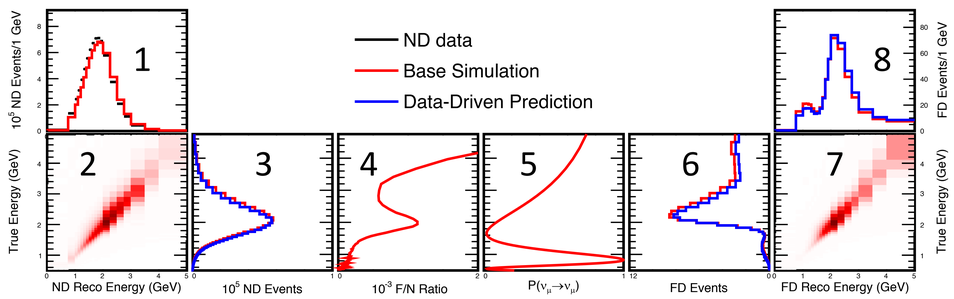
Near-to-Far Extrapolation



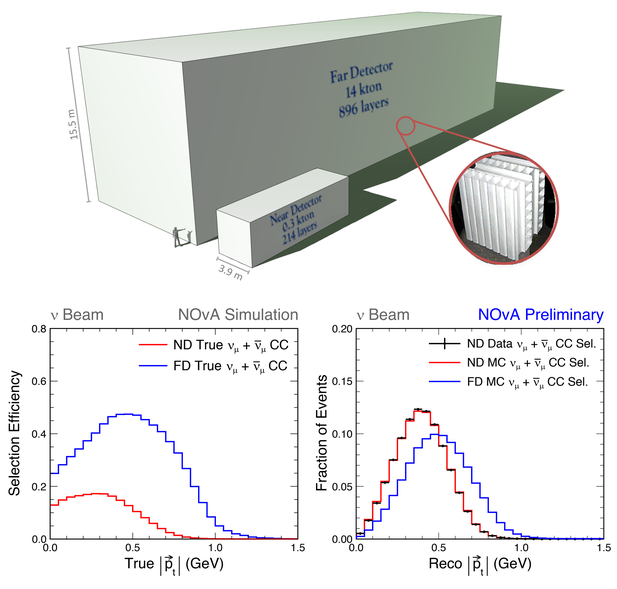
The NOvA 3-flavor oscillation analysis extrapolates the Near Detector (ND) ν_μ charged current (CC) E_ν spectrum to the Far Detector (FD) to give a data-driven prediction of the ν_μ disappearance and ν_e appearance signals at the FD

Uncertainties on the extrapolated predictions are reduced by correlations between the functionally identical ND and FD in event selection, reconstruction, flux, and the neutrino interaction model

The extrapolation for ν_μ disappearance is divided into 4 bins in hadronic energy fraction called quartiles. For ν_e appearance the ND ν_μ CC data and intrinsic beam ν_e background are extrapolated separately

1. ND Data Reco E_ν
2. Reco-to-True E_ν Weighting
3. ND True E_ν
4. Far / Near Ratio
5. Oscillations
6. FD True E_ν
7. True-to-Reco E_ν Weighting
8. Predicted FD Reco E_ν

Near-Far Differences and Transverse Momentum



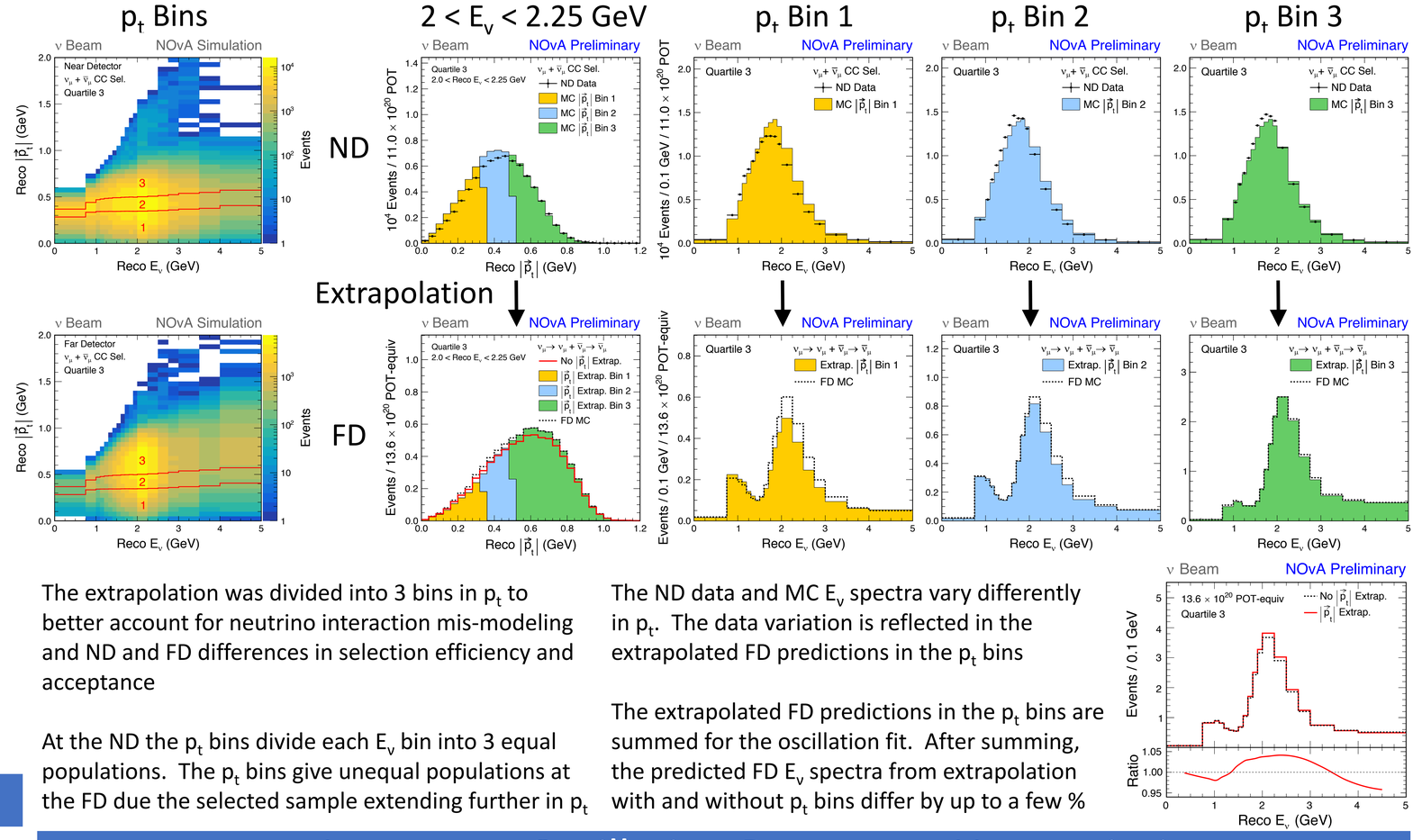
The ND and FD differ in size, which leads to differences in selection efficiency and acceptance due to containment of the final state lepton and hadronic recoil

As a result, the ND and FD selected samples differ in kinematic range and shape

A quantity sensitive to these differences is the transverse momentum of the final state lepton, p_t

p_t is also sensitive to data-MC differences arising from neutrino interaction mis-modeling

Extrapolation in Transverse Momentum



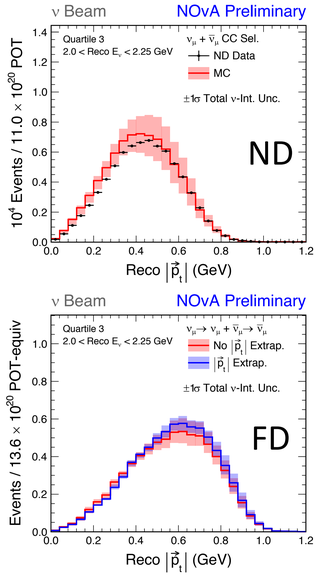
The extrapolation was divided into 3 bins in p_t to better account for neutrino interaction mis-modeling and ND and FD differences in selection efficiency and acceptance

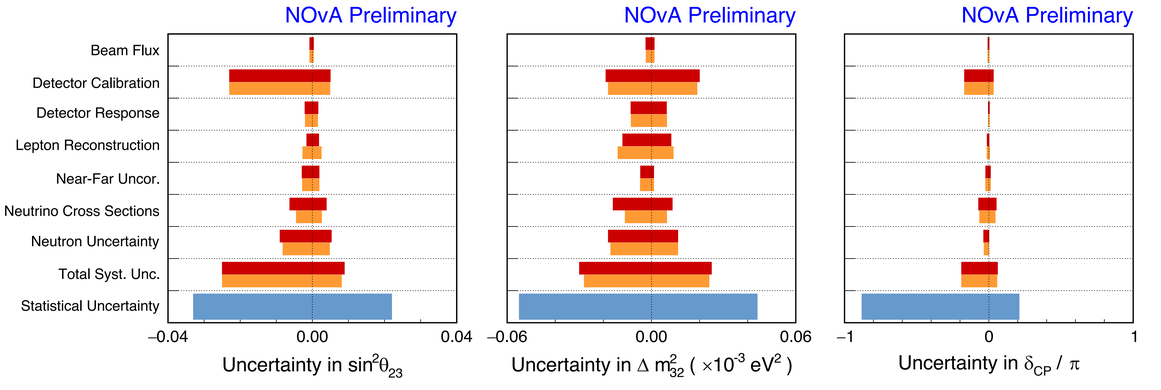
At the ND the p_t bins divide each E_ν bin into 3 equal populations. The p_t bins give unequal populations at the FD due the selected sample extending further in p_t

The ND data and MC E_ν spectra vary differently in p_t. The data variation is reflected in the extrapolated FD predictions in the p_t bins

The extrapolated FD predictions in the p_t bins are summed for the oscillation fit. After summing, the predicted FD E_ν spectra from extrapolation with and without p_t bins differ by up to a few %

Impact on Oscillation Parameter Uncertainties





Extrapolating in p_t bins reduces the total neutrino interaction model uncertainty on the FD predictions and the measured oscillation parameters

Extrapolating in p_t bins also reduces uncertainties that affect the reconstructed hadronic energy (e.g. Detector Calibration and Neutron Uncertainty), which results from correlation between the hadronic recoil and p_t