Theia Cross-Section Model Summary

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Cross-Section Model: Current Simulations

- Goal to reproduce DUNE TDR
- Uses:
  - genie v2_12_10d
  - genie_xsec v2_12_10 DefaultPlusValenciaMEC
  - genie_phyopt v2_12_10 dkcharmtau
  - dunefd_genie.EventGeneratorList: "Default+CCMEC"
- 1 Million events generated on DUNE GPVMs for each combination of:
  - ν_e, ν_μ, $\overline{\nu}_e$, $\overline{\nu}_\mu$
  - Nominal and flavor swapped fluxes
  - Oxygen and Argon target
- GHEP, GST, and GTRK files located at /exp/dune/data/users/mastbaum/fd4/gen

Cross-Section Model: Future Simulations

- Goal to adapt current DUNE cross-section model for Theia
- Should use:
  - genie v3_04_00i
  - genie_xsec v3_04_00 AR23_20i_00_000
  - genie_phyopt v3_04_00 dkcharmtau
- Have generated small samples of ν_μ with Oxygen target

Cross-Section Model: Future Simulations

- Summary of AR23_20i_00_000 AKA “DUNE Tune”
  - Nuclear Ground State: Local Fermi Gas + additional correlated high-momentum nucleon tail
  - CCQE: Valencia 1p1h Model
  - 2p2h: SuSAv2 2p2h Model
  - Resonant Interactions: Rein-Sehgal Model
  - DIS: Bodek-Yang Model
  - FSI: hA2018 model
- Additional changes:
  - Additional deexcitation photons for Carbon (from Minerva) and Argon (from Argoneut)
  - Tau decays using Pythia
  - Other parameters from GENIE tune

Cross-Section Model: Uncertainties

- Using full set of uncertainties used in DUNE TDR

- MaCCQE
- VecFFCCQEshape
- MaNCEL
- EtaNCEL
- MaCCRES
- MvCCRES
- MaNCRES
- MvNCRES
- RDecBR1gamma
- RDecBR1eta
- Theta_Delta2Npi
- AhtBY
- BhtBY
- CV1uBY
- CV2uBY
- FormZone

- MFP_pi
- FrCEx_pi
- FrInel_pi
- FrAbs_pi
- FrPiProd_pi
- MFP_N
- FrCEx_N
- FrInel_N
- FrAbs_N
- FrPiProd_N
- CCQEPauliSupViaKF
- Mnv2p2hGaussEnhancement
- MKSPP_ReWeight
- E2p2h_A_nu
- E2p2h_B_nu
- E2p2h_A_nubar
- E2p2h_B_nubar

- NR_nu_n_CC_2Pi
- NR_nu_n_CC_3Pi
- NR_nu_p_CC_2Pi
- NR_nu_p_CC_3Pi
- NR_nu_np_CC_1Pi
- NR_nu_n_NC_1Pi
- NR_nu_n_NC_2Pi
- NR_nu_n_NC_3Pi
- NR_nu_p_NC_1Pi
- NR_nu_p_NC_2Pi
- NR_nu_p_NC_3Pi
- NR_nubar_n_CC_1Pi
- NR_nubar_n_CC_2Pi
- NR_nubar_n_CC_3Pi
- NR_nubar_p_CC_1Pi
- NR_nubar_p_CC_2Pi
- NR_nubar_p_CC_3Pi
- NR_nubar_n_NC_1Pi
- NR_nubar_n_NC_2Pi
- NR_nubar_n_NC_3Pi
- NR_nubar_p_NC_1Pi
- NR_nubar_p_NC_2Pi
- NR_nubar_p_NC_3Pi

- BeRPA_A
- BeRPA_B
- BeRPA_D
- BeRPA_E
- EbFSLepMom_Shift
- C12ToAr40_2p2hScaling_nu
- C12ToAr40_2p2hScaling_nubar
- nuenuebar_xsec_ratio
- nuenumu_xsec_ratio
- SPPLowQ2Suppression
- FSILikeEAvailSmearing
- FRElasPi
- FRElasN
- BeRPA_U
- MnvTune1
- MnvTuneCV
- MnvTune2
- MK Model
- CC Non Res Nu -> l + 1 pi
- Modified proton energy
- Numu -> Nue

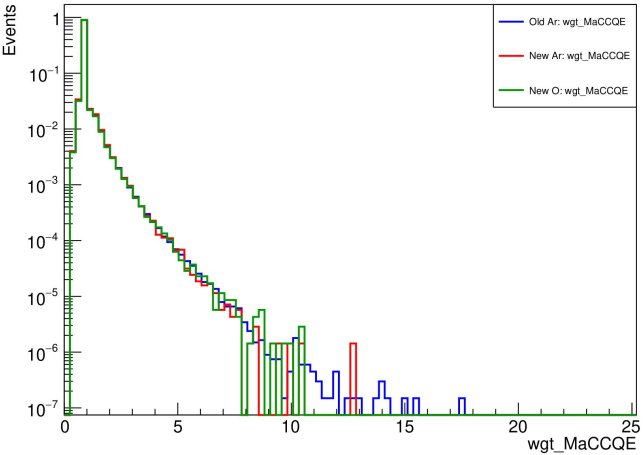
- Full spreadsheet with more info here

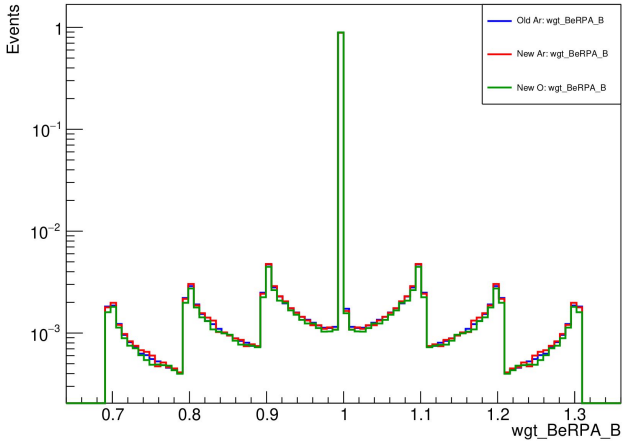
Cross-Section Model: Applying Systematics

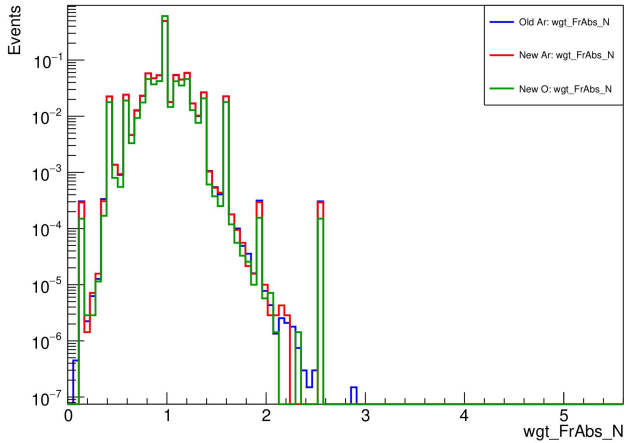
- Applying systematics using GENIE Reweight tool from nusystematics
- Required some updates to work with standard GENIE output files “artless”
- Now working on files produced with GENIE v3 and GENIE v2

Cross-Section Model: Systematics

- Most seem to agree well between old simulation from Guang, and new simulations for both Ar and O







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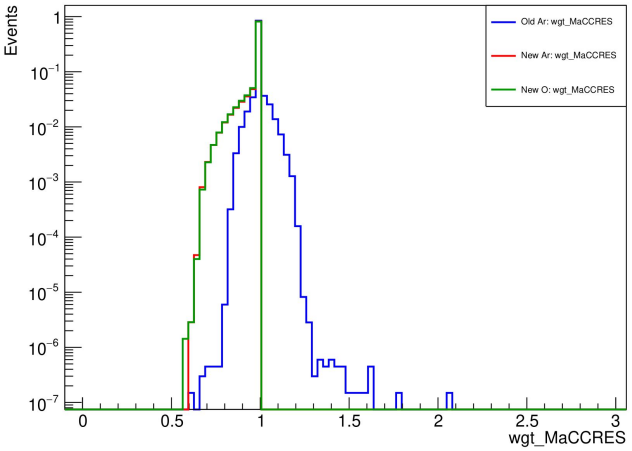
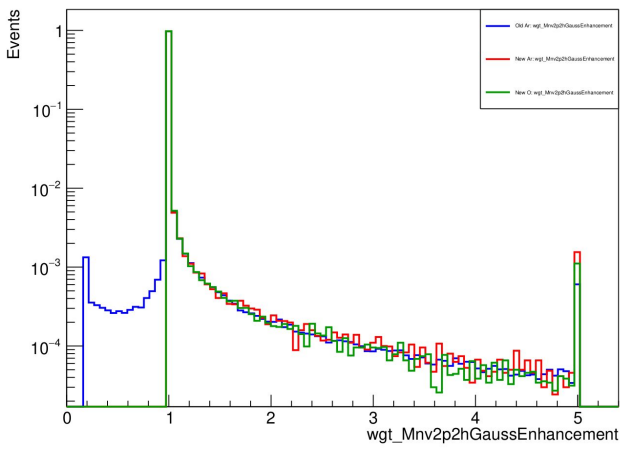
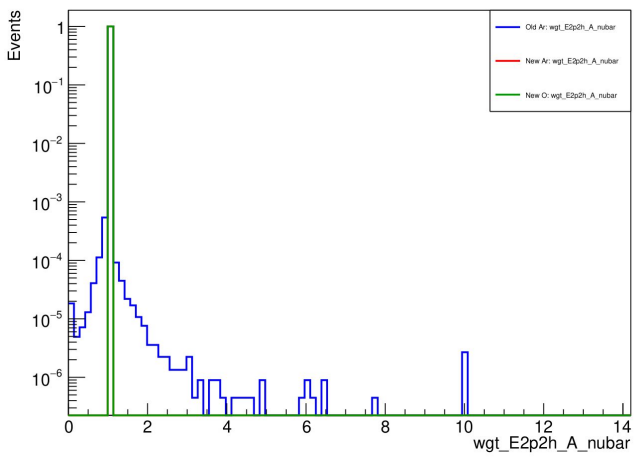
- Others disagree between old and new simulations (some due to new only having ν_μ)







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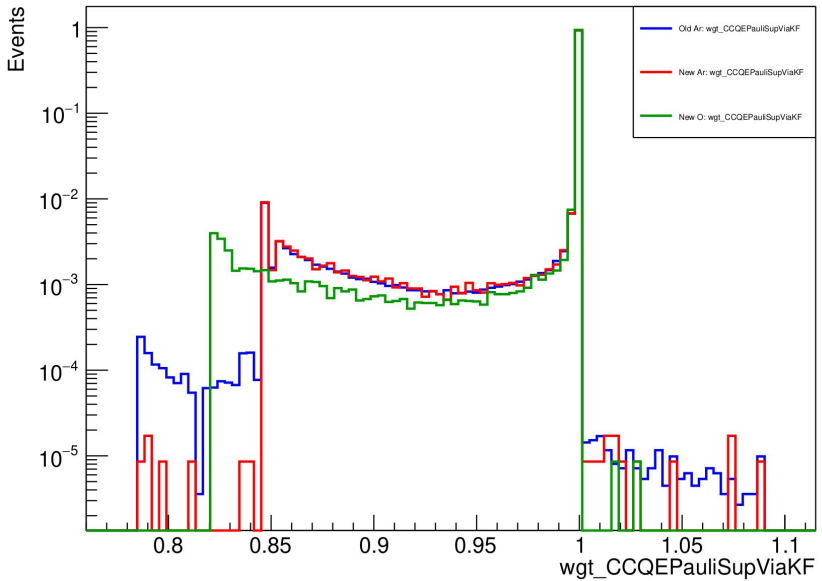

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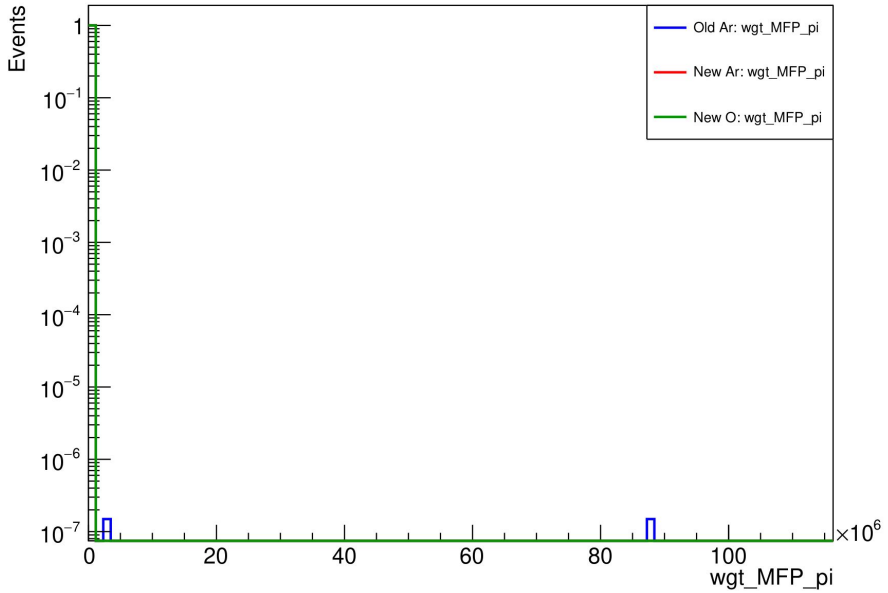
- Others disagree between old and new simulations (some due to new only having ν_μ)
- At least one with disagreement between Ar and O (but probably expected)
- A few crazy outliers in the old simulations



Cross-Section Model: Systematics

- An example of ±1σ MaCCQE systematic error bands on outgoing lepton energy for 100k ν_μ events on Ar (left) and O (right)