Simulated Neutrino Fluxes at the Forward Physics Facility

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Introduction

- Results from this simulation:
  - Provide theoretical expectations for the neutrino fluxes at FASERν2 and FLArE
  - Offer insights to refine hadronic interaction models
  - Highlight the application of FPF results to astroparticle physics: muon puzzle, astrophysical neutrino searches

Simulations

CHROMO:

H. Dembinski, A. Fedynitch, and A. Prosekin, PoS ICRC2023 (2023) 189.

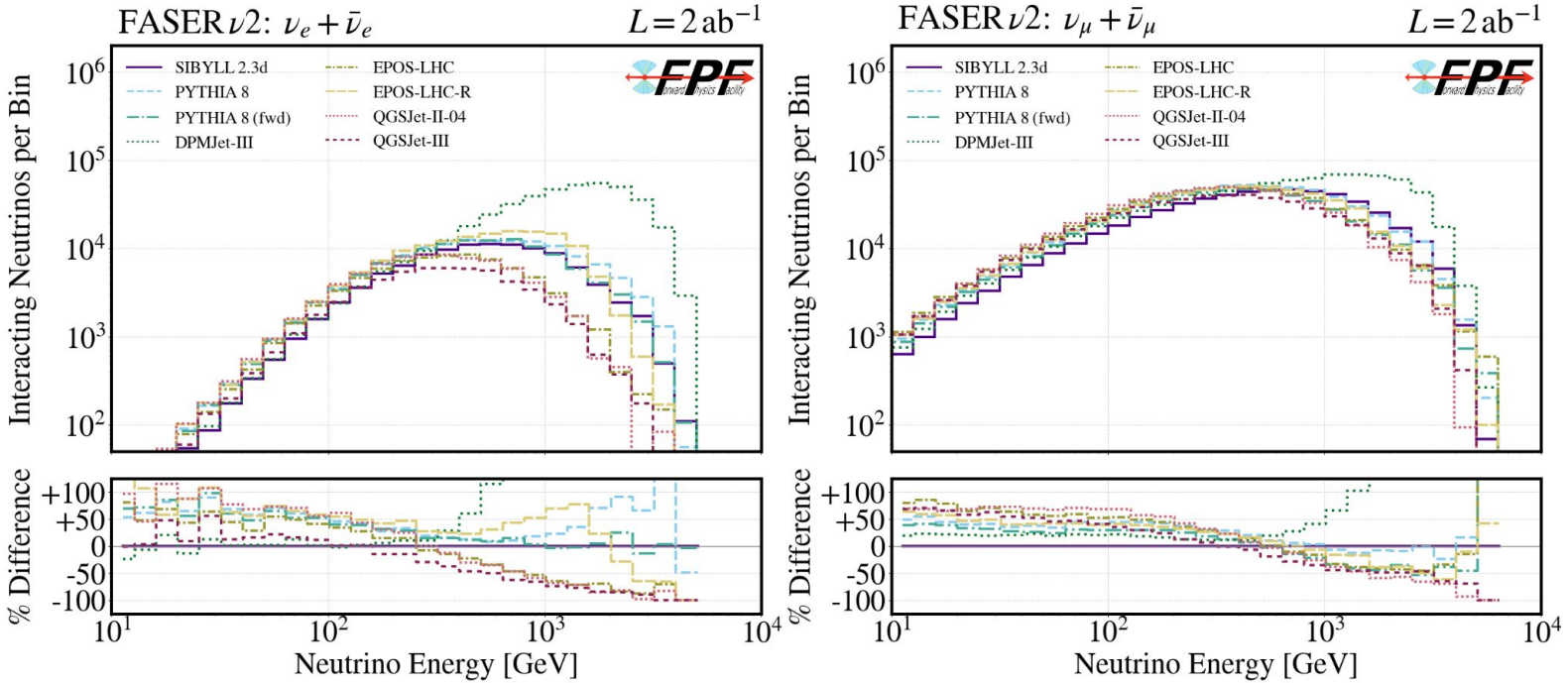
- Generates √s = 13 TeV proton-proton collisions with various hadronic interaction models
- 100,000 collisions generated for each model
  - For a complete list of models, see D. Soldin, I. Coronado, et al., PoS ICRC2025 (2025) 1182
- SIBYLL★ is a series of logically modified versions of Sibyll 2.3d to investigate the muon puzzle:
  - Modifications increase hadronic energy and enhance muon production in extensive air showers
  - Enhanced production of baryon-antibaryon pairs, kaons, or neutral rho mesons
  - To study potential effects that can be observed at the FPF, we lower the energy threshold to √s = 10 TeV

Simulations

Fast Neutrino Flux Simulation:

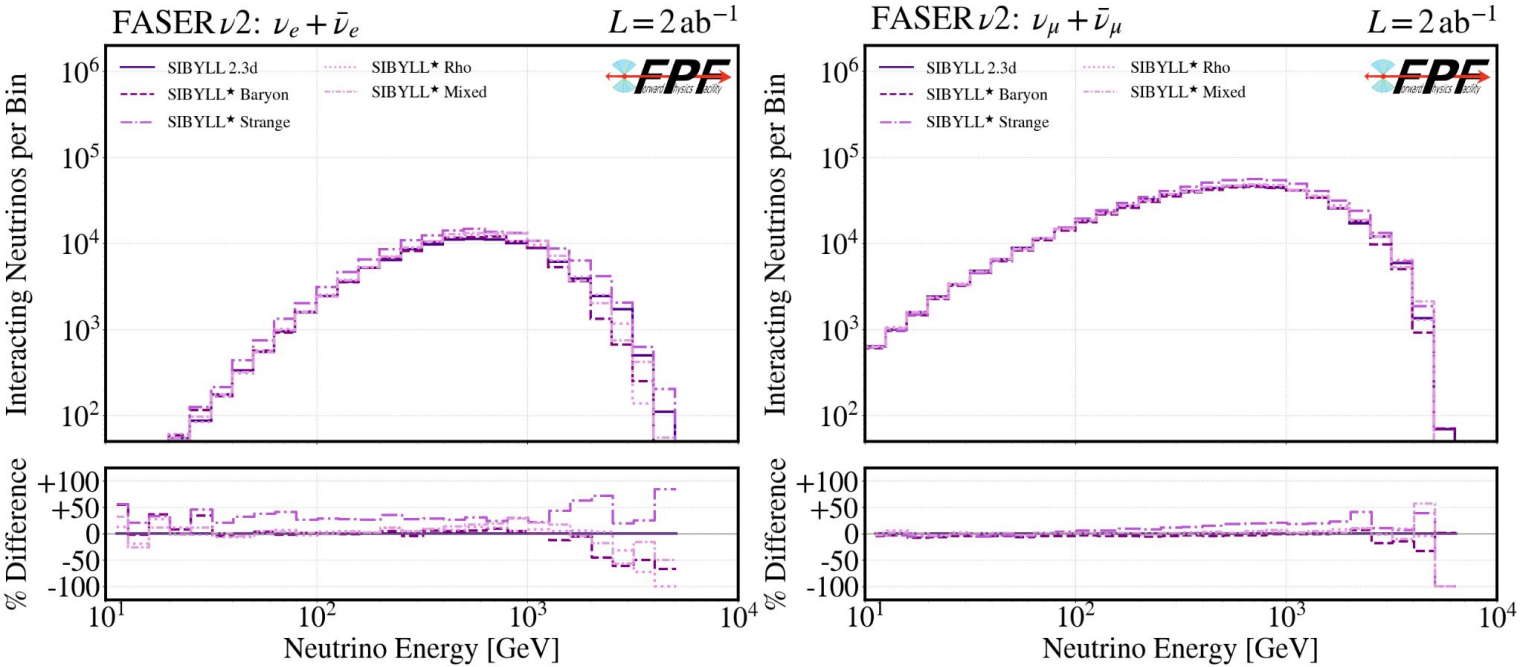
F. Kling and L.J. Nevay, Phys. Rev. D 104 no. 11, (2021) 113008.

- Handles the propagation of all particles [BDSIM]
- Decay into neutrinos [Pythia 8.2]
- Interaction of neutrinos within the FPF detectors [GENIE]



- Model predictions differ greatly, especially at higher energies
- Model differences are much larger than the anticipated uncertainties at the FPF

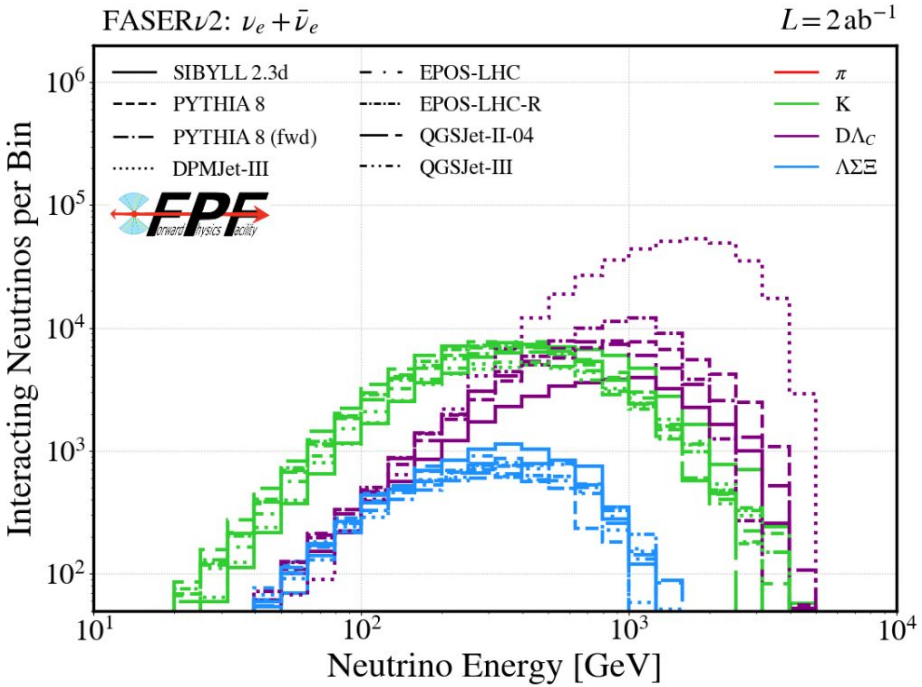
D. Soldin et al., PoS ICRC2025 (2025) 1182

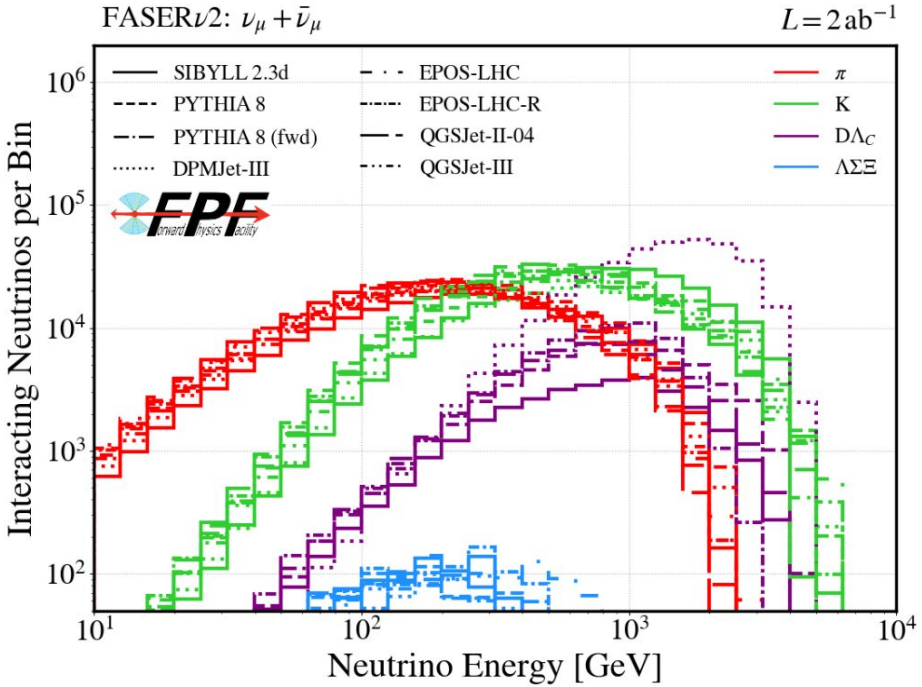


- ~30-50% increase in difference for the kaon enhancement model SIBYLL★ Strange

- SIBYLL★Baryon: charge-neutral combinations of two or three pions are replaced with pp nn pairs
- SIBYLL★Strange: charge-neutral combinations of two or three pions are replaced with neutral kaon pairs
- SIBYLL★Rho: π^0 are directly substituted with ϱ^0
- SIBYLL★Mixed: combines ϱ^0 and baryon pair enhancements

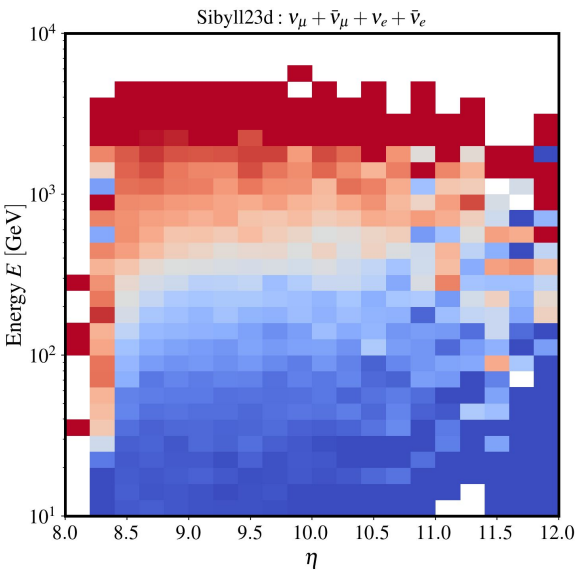
D. Soldin et al., PoS ICRC2025 (2025) 1182

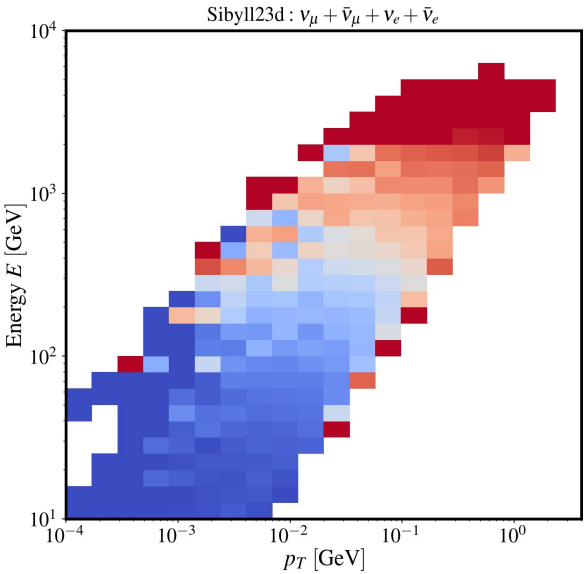


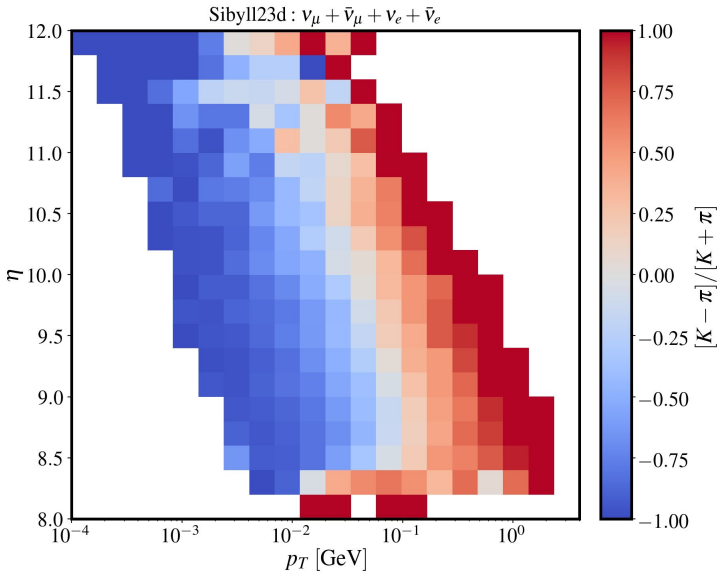


- Neutrinos from pion and kaon decays have distinct energy spectra, which allows them to be differentiated. This has been demonstrated by FASER.

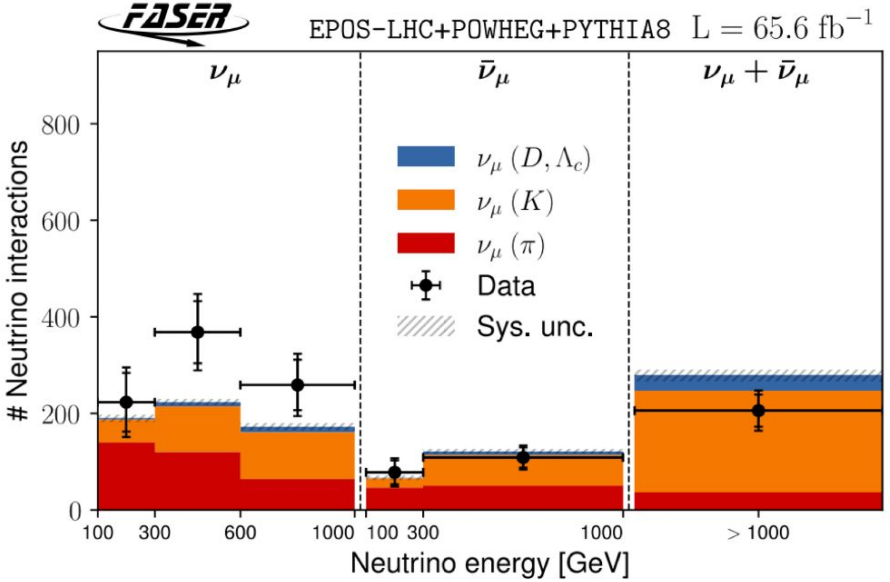
FASER Collaboration, Phys. Rev. Lett. 134 (2024)

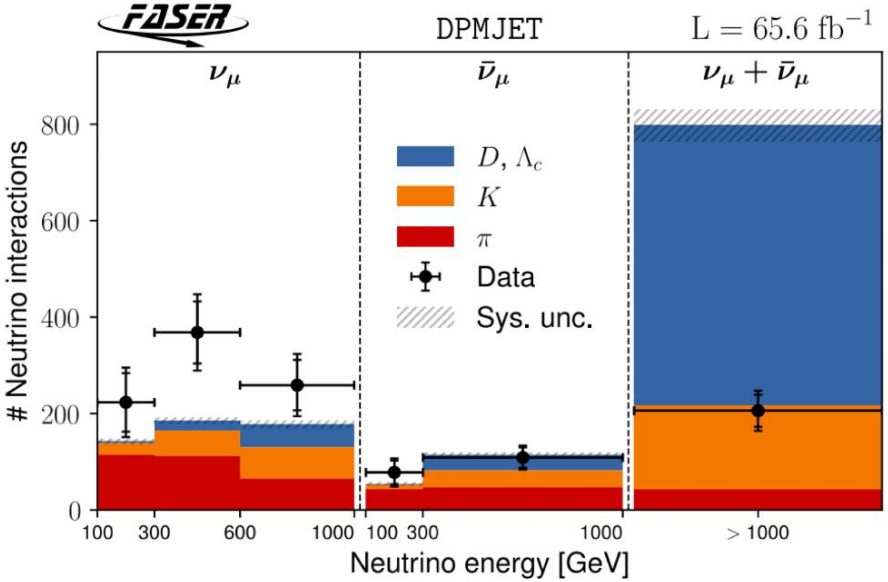




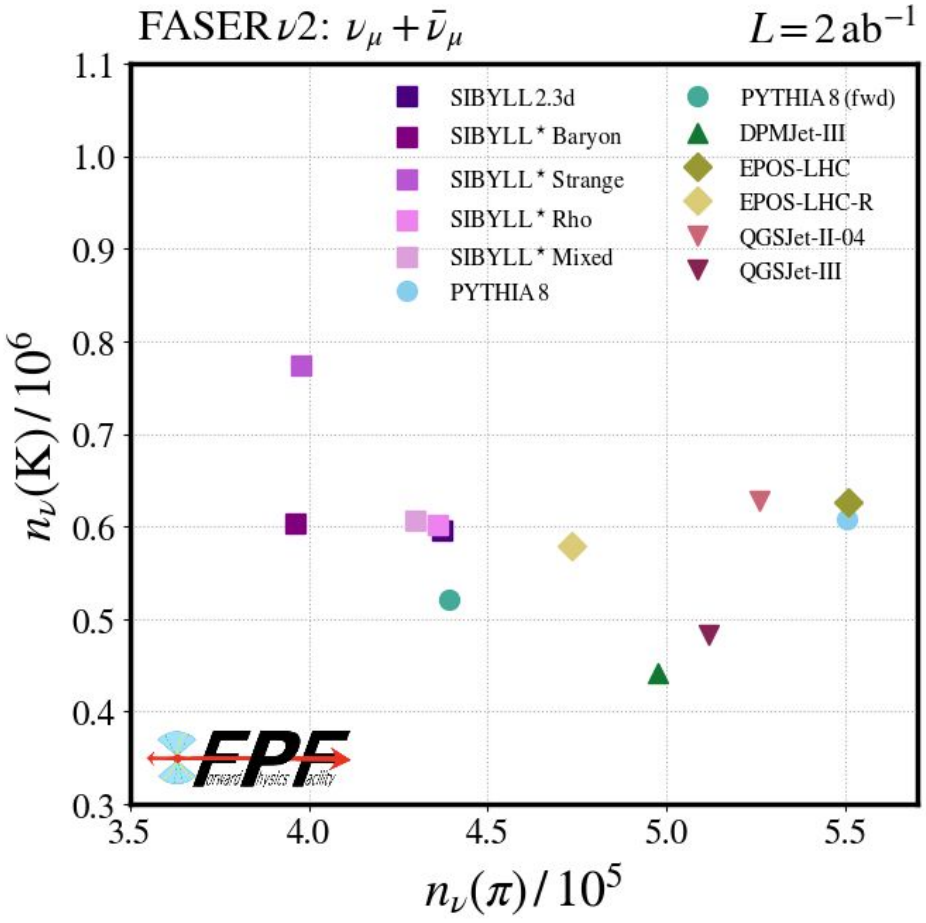


- Neutrinos from pions and kaons may be differentiated using various parameters





FASER Collaboration, Phys. Rev. Lett. 134 (2024)



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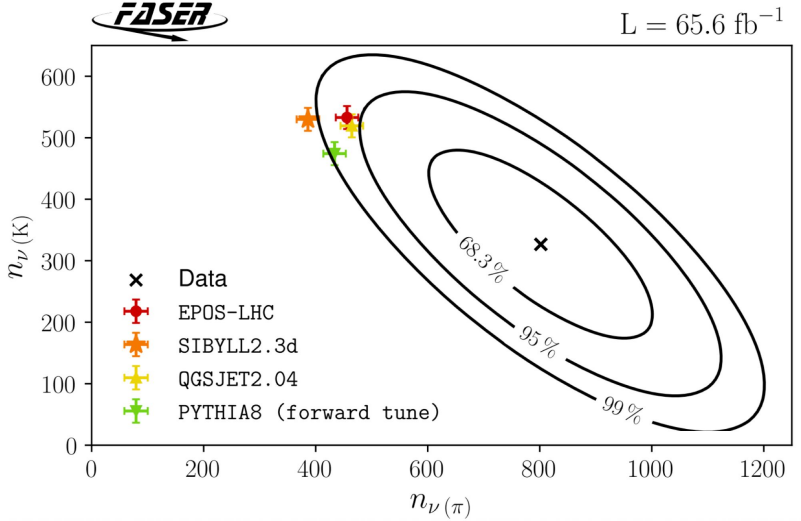
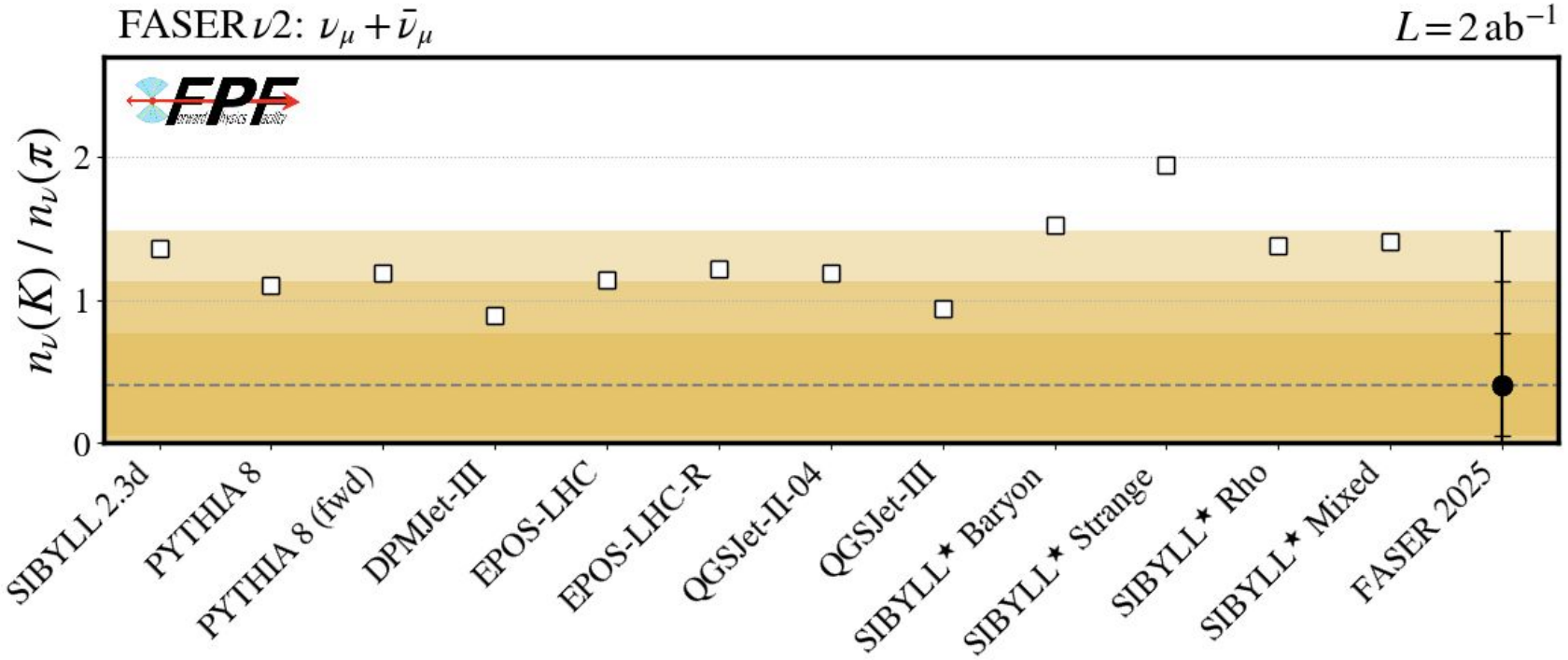
- Differences between model predictions are huge!



FASER Collaboration, Phys. Rev. Lett. 134 (2024)



- The FPF is uniquely positioned to test and constrain these uncertainties to refine hadronic interaction models

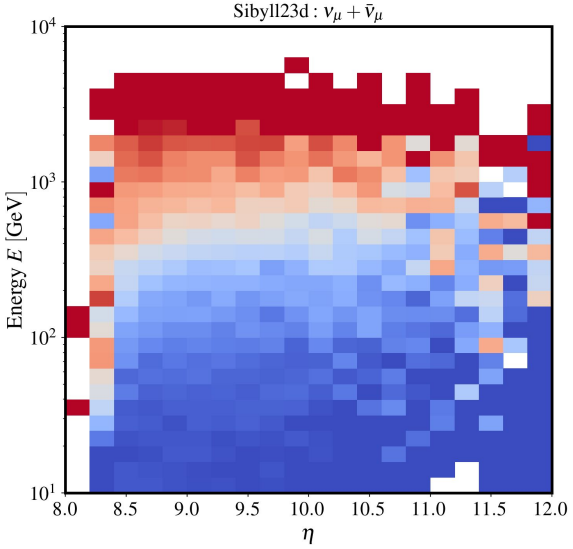
D. Soldin et al., PoS ICRC2025 (2025) 1182

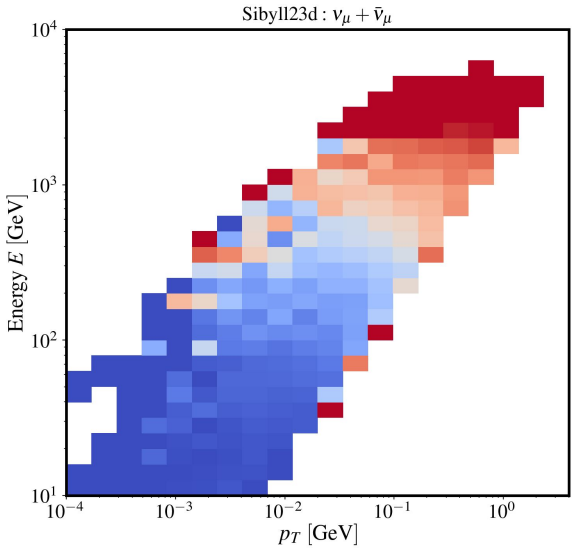
Conclusion

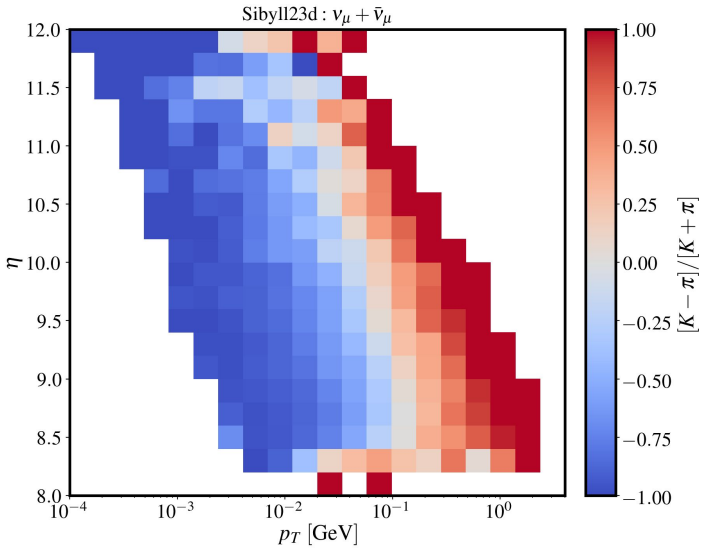
- Flux measurements at the FPF are anticipated to constrain the individual flux components with percent-level precision, providing a test of hadronic interaction models
- These advancements will provide better understanding of multi-particle production in extensive air showers, thereby enhancing our understanding of the highest energy cosmic rays
- FPF measurements will refine uncertainties in high energy astrophysical neutrino searches

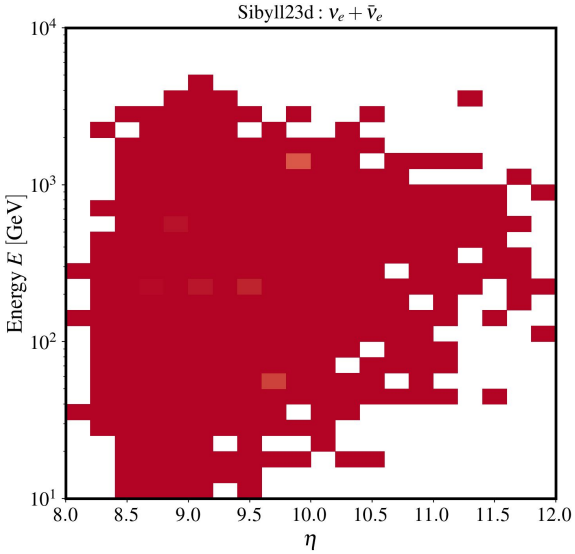
Questions?

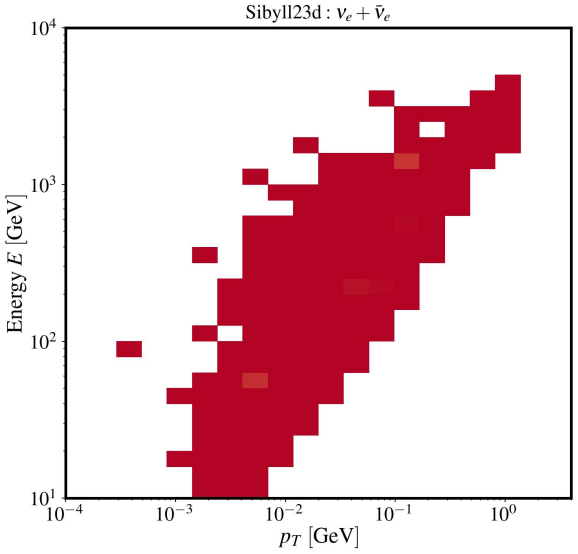
Backup Slides

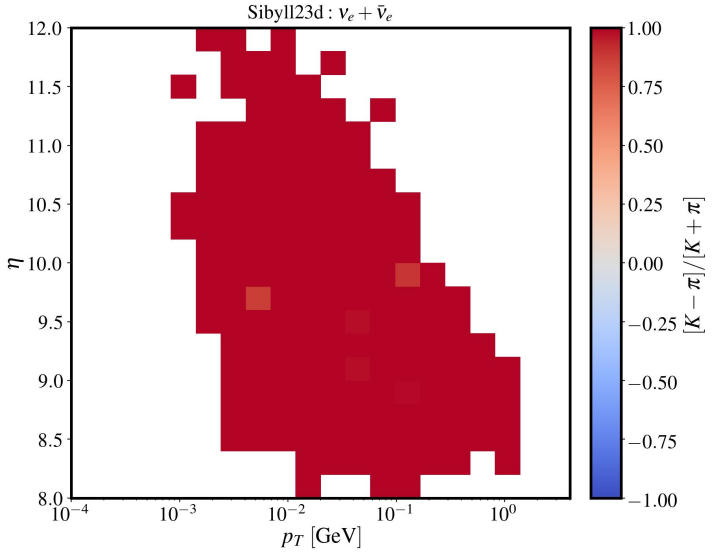

Sibyll23d : $\nu_\mu + \bar{\nu}_\mu$
Energy E [GeV]
η


Sibyll23d : $\nu_\mu + \bar{\nu}_\mu$
Energy E [GeV]
p_T [GeV]


Sibyll23d : $\nu_\mu + \bar{\nu}_\mu$
η
p_T [GeV]
$[K-\pi]/[K+\pi]$


Sibyll23d : $\nu_e + \bar{\nu}_e$
Energy E [GeV]
η


Sibyll23d : $\nu_e + \bar{\nu}_e$
Energy E [GeV]
p_T [GeV]


Sibyll23d : $\nu_e + \bar{\nu}_e$
η
p_T [GeV]
$[K-\pi]/[K+\pi]$