Constraining neutrino fluxes with the FPF data for SM and BSM studies

Toni Mäkelä, *Felix Kling, Sebastian Trojanowski*

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Introduction

- The FPF has a broad physics scope, in which neutrinos play an important role
- Various BSM effects could affect the shape / magnitude of the neutrino spectra. We could look at e.g.:
  - Oscillations
  - Enhanced tau neutrino production from dark vectors
  - Solving the cosmic ray muon excess puzzle
  - …etc
- To see how well such models can be constrained, we need to estimate the uncertainty of neutrino flux predictions
  - Important step in understanding SM and the stream towards refining BSM searches

Introduction

- Examine various predictions for the neutrino spectra
  - A broad envelope of established predictions from various groups:
    - Different generators and methods
  - Seek to cover the phase space with these broadly spread predictions:
    - Enables accommodating for possible changes in shape and normalization

- Presenting a model / tool for combining these
  - Using a Fisher information approach for estimating uncertainties
  - Indicates FPFs constraining power for various physics processes

The model

- Construct a model *m* giving amount of neutrinos as an average over all N_g predictions *G*

$$m(\{\lambda_i\}_{i=1}^{N_g-1}) = \frac{1}{N_g}\left[G_0\left(1-\sum_{i=1}^{N_g-1}\lambda_i\right)+\sum_{i=1}^{N_g-1}G_i\left(1+N_g\lambda_i-\sum_{j=1}^{N_g-1}\lambda_j\right)\right]$$

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- **Obtain info matrix**
- **Perform eigenvector analysis**
  → ***Uncertainties!***

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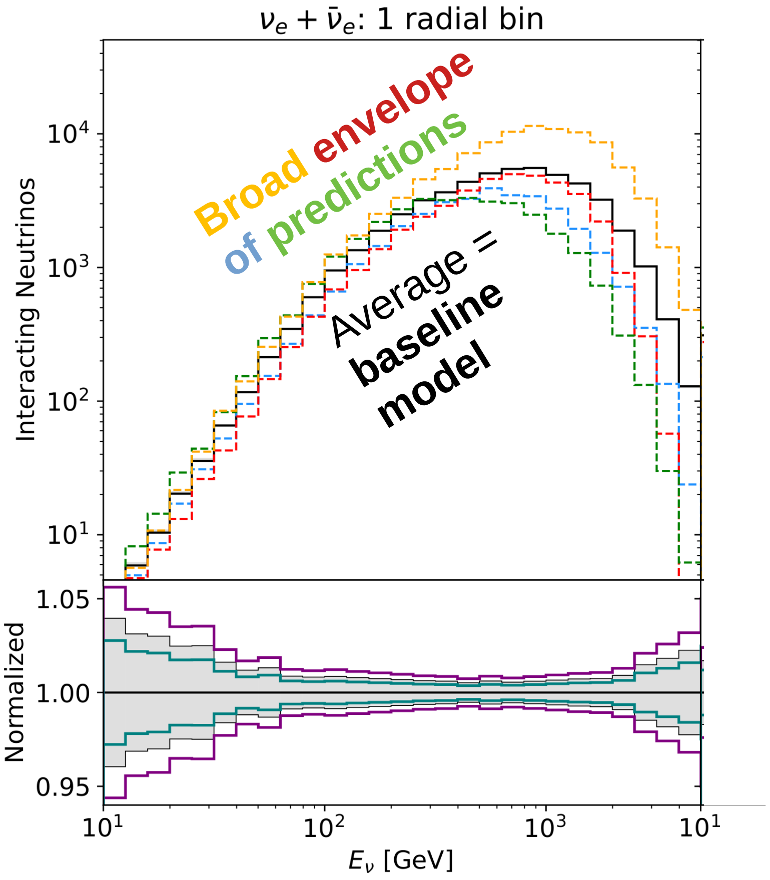
The neutrino spectra



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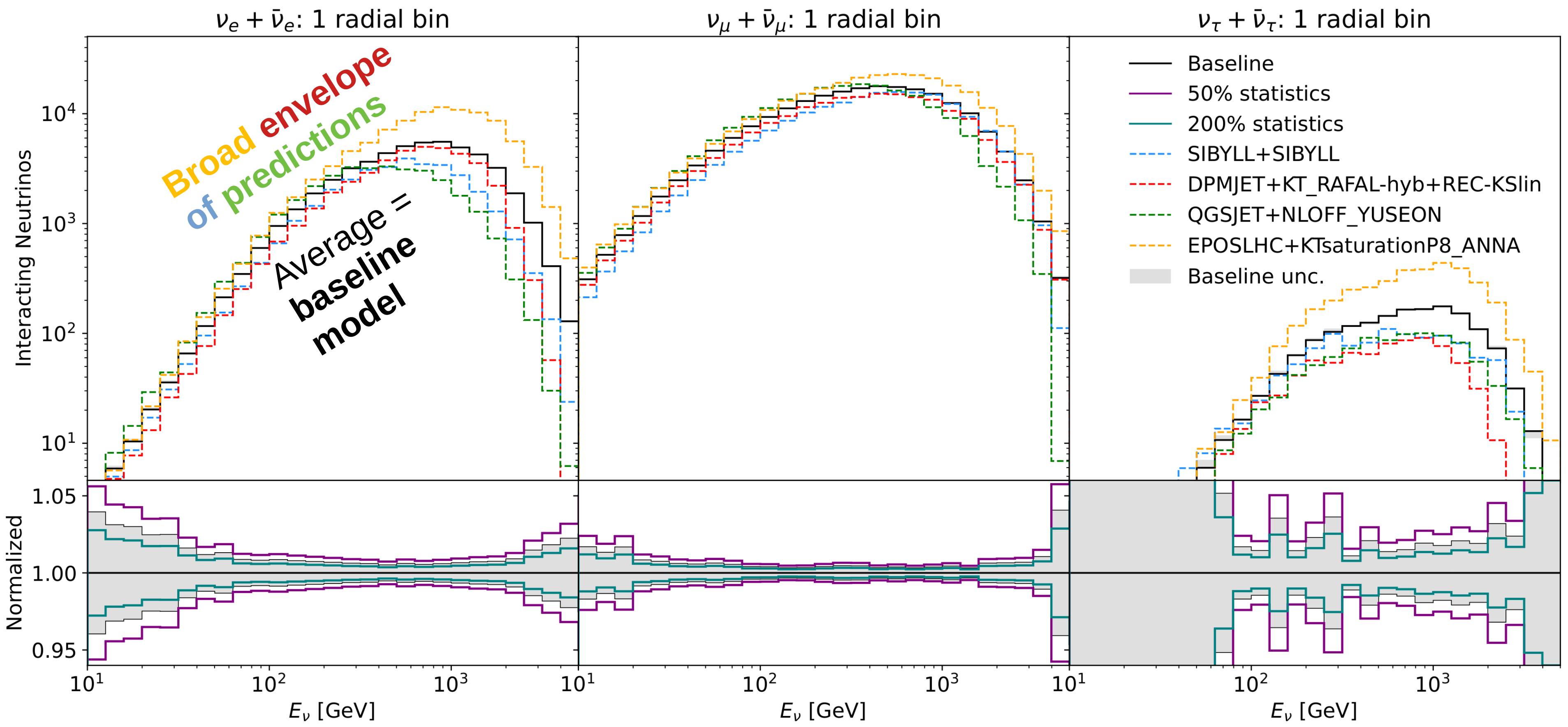
The neutrino spectra

Separate spectra for neutrino flavors (no outgoing lepton charge discrimination here)



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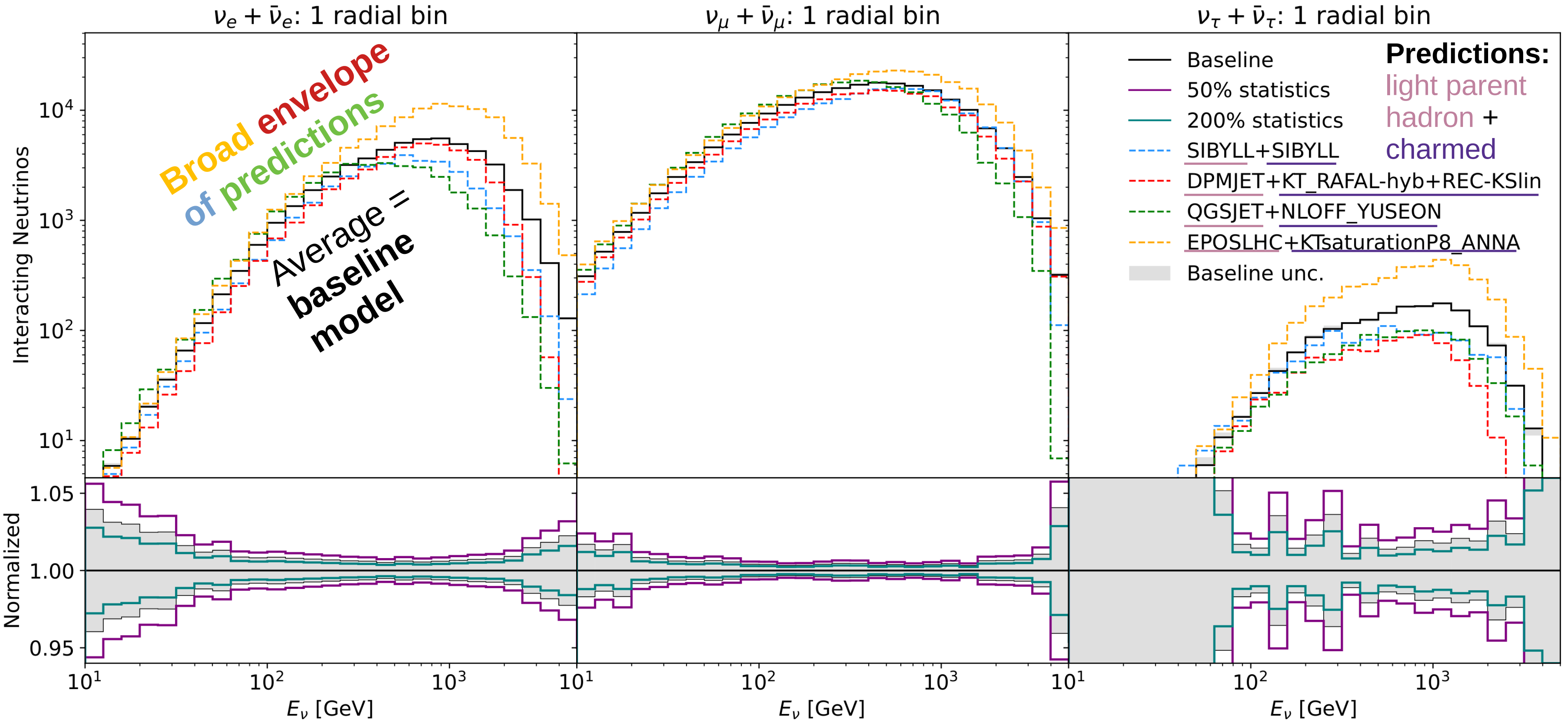

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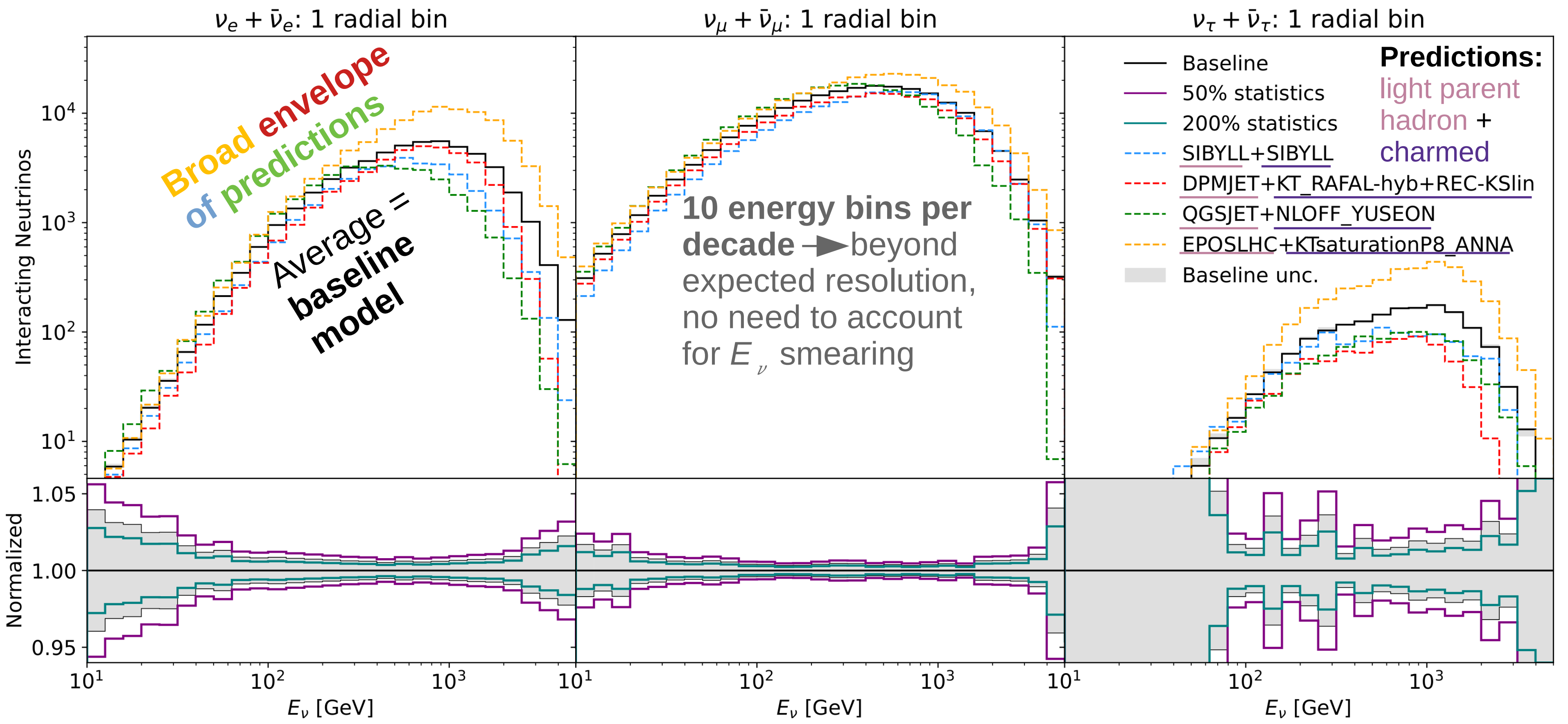

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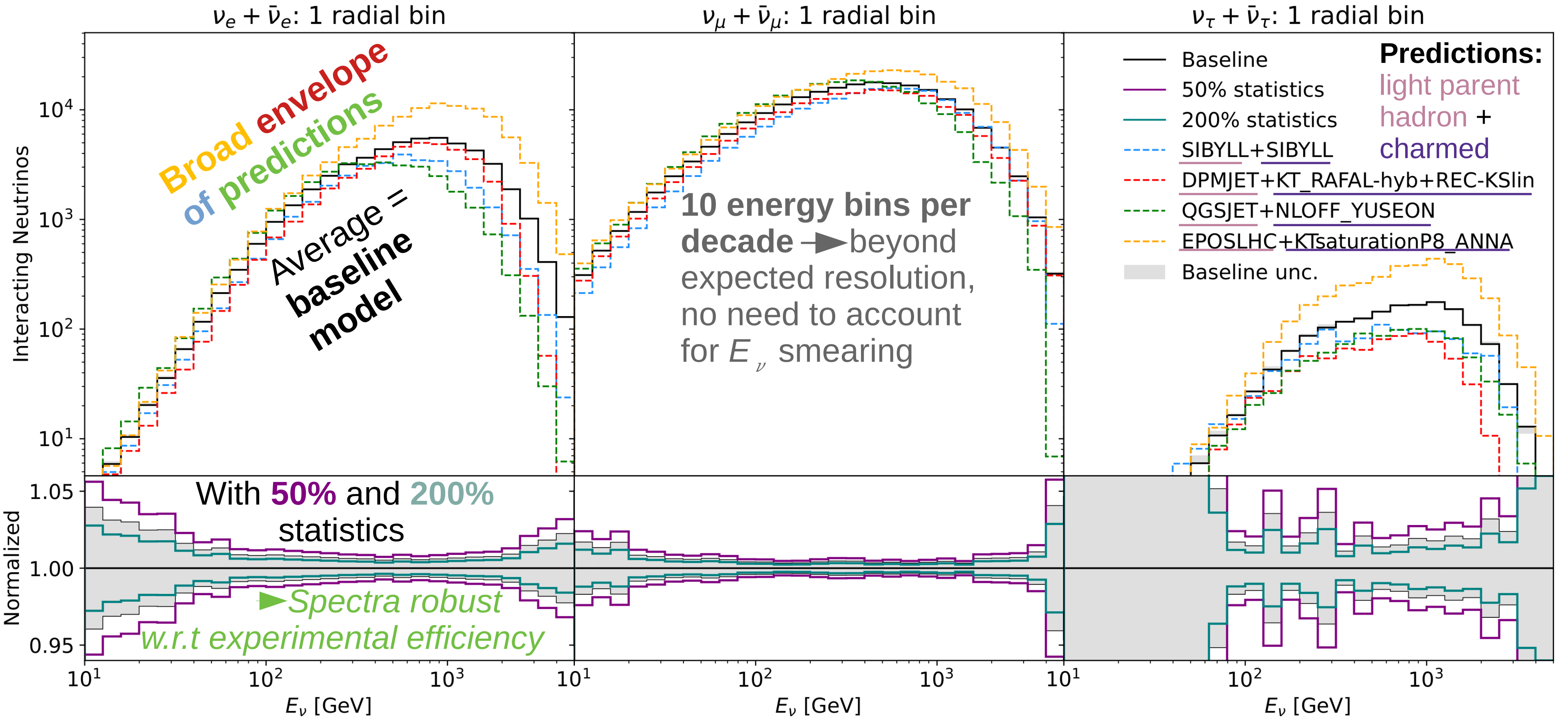

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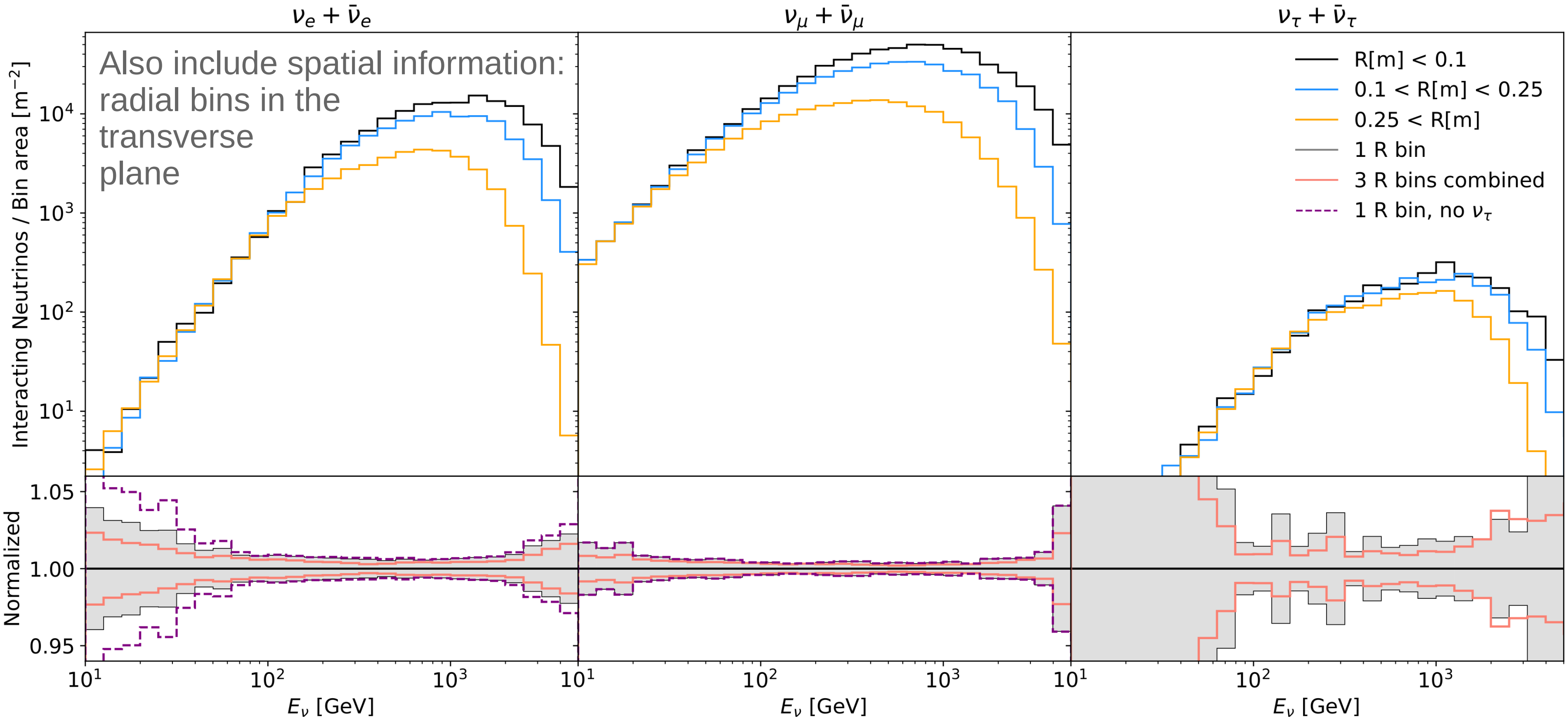
The neutrino spectra

1 vs 3 radial bins



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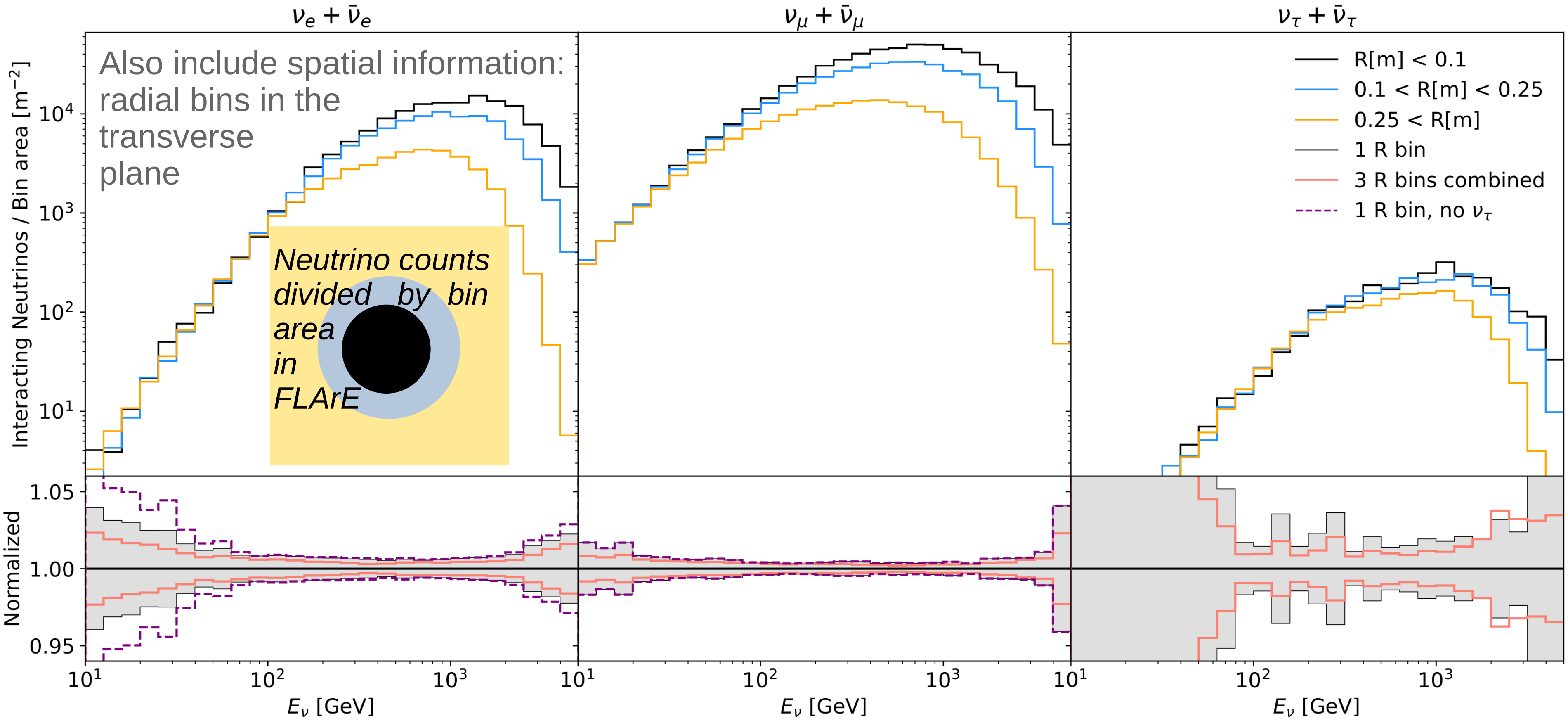

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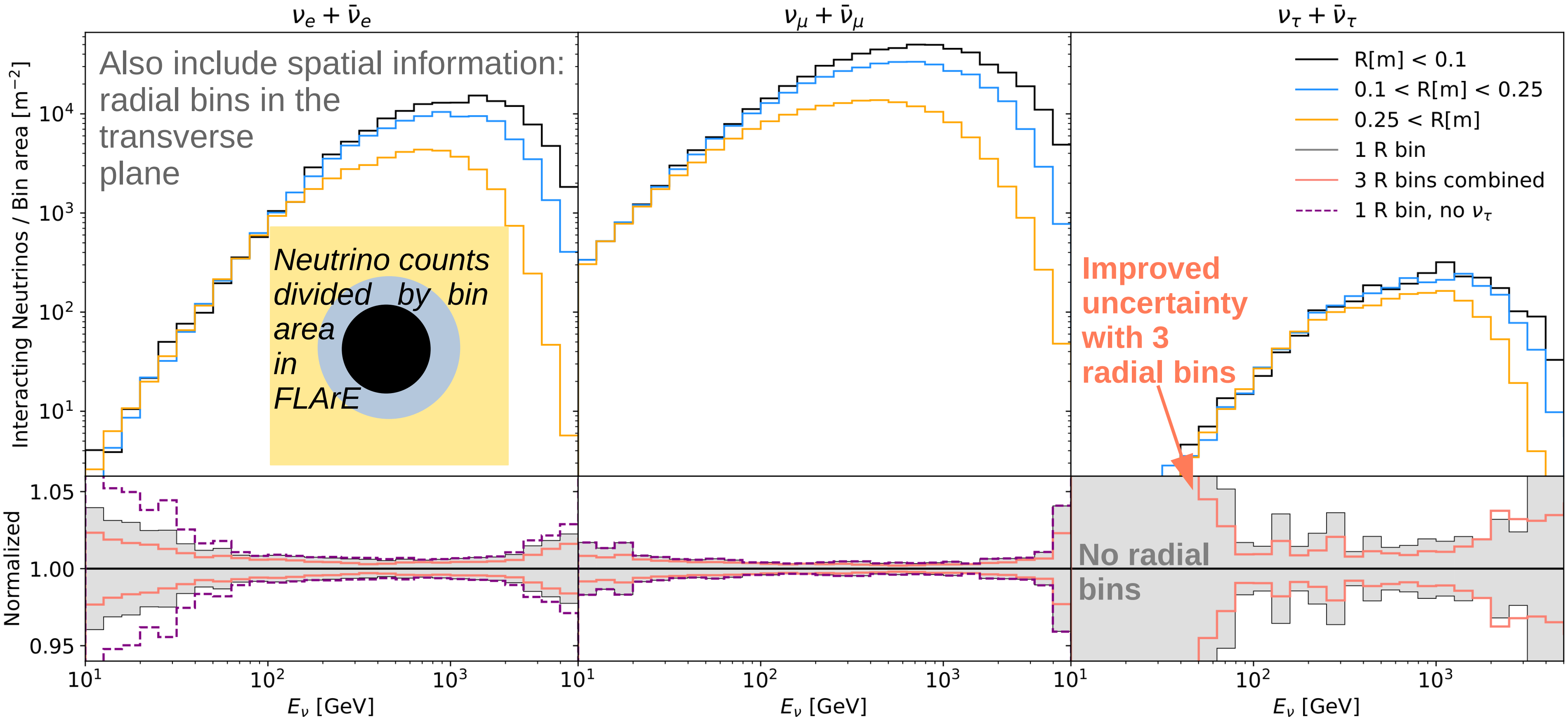

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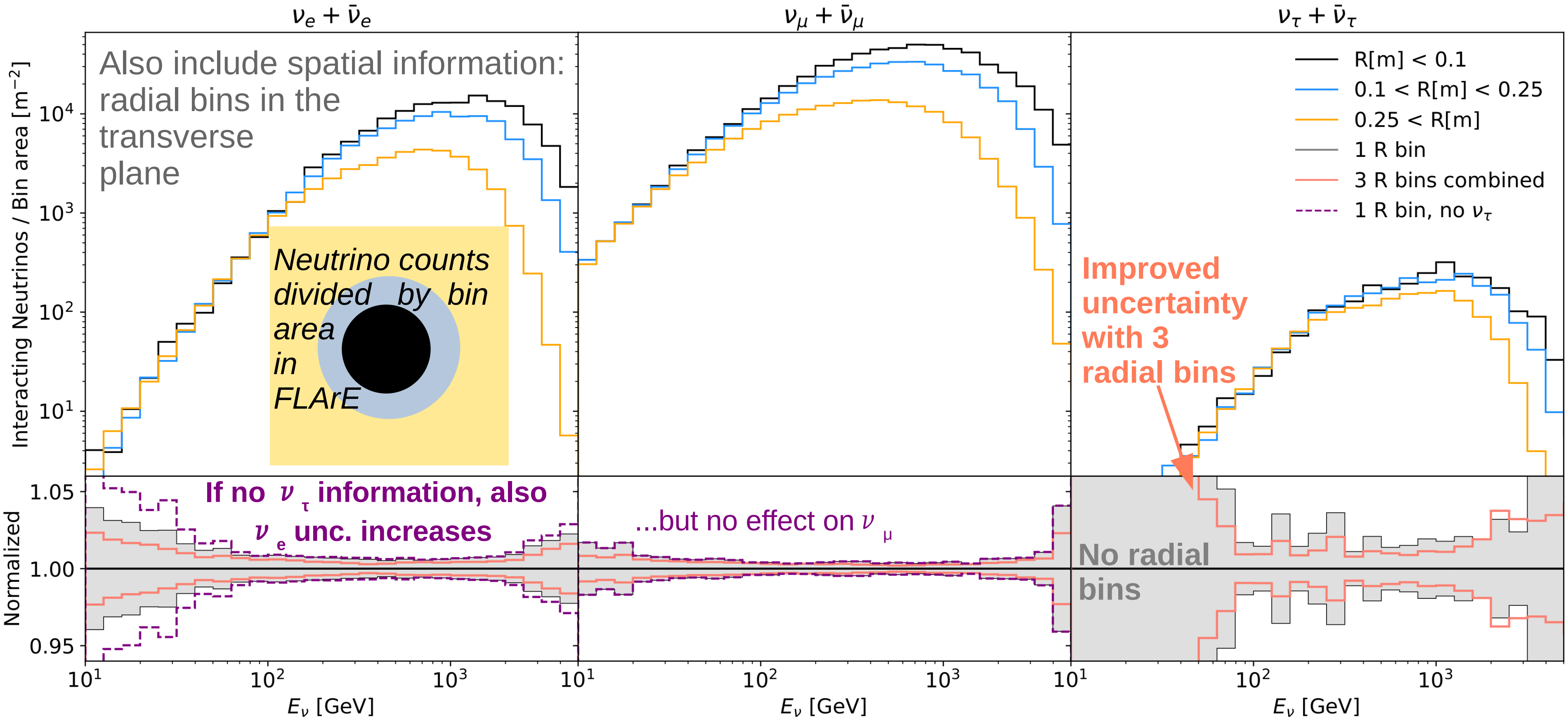

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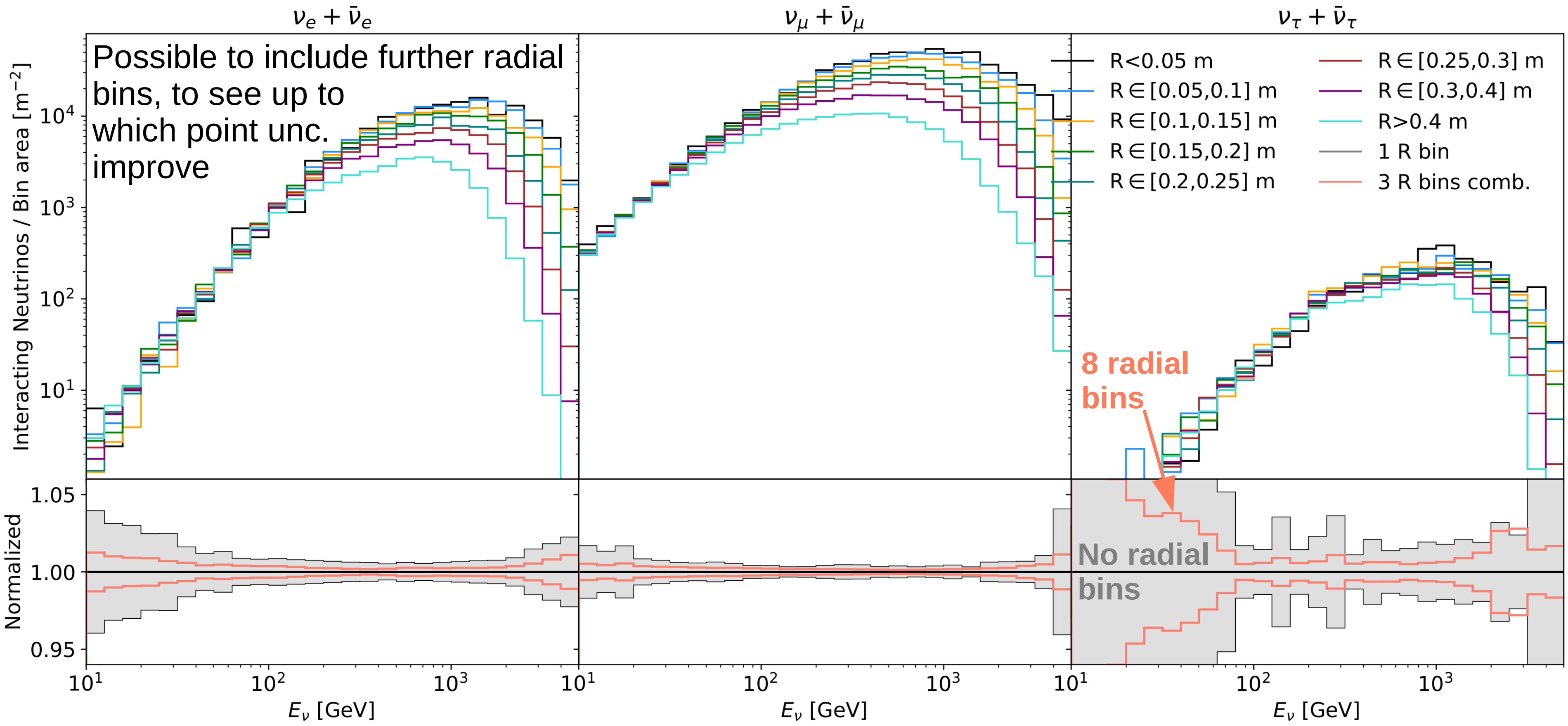
The neutrino spectra

1 vs 8 radial bins



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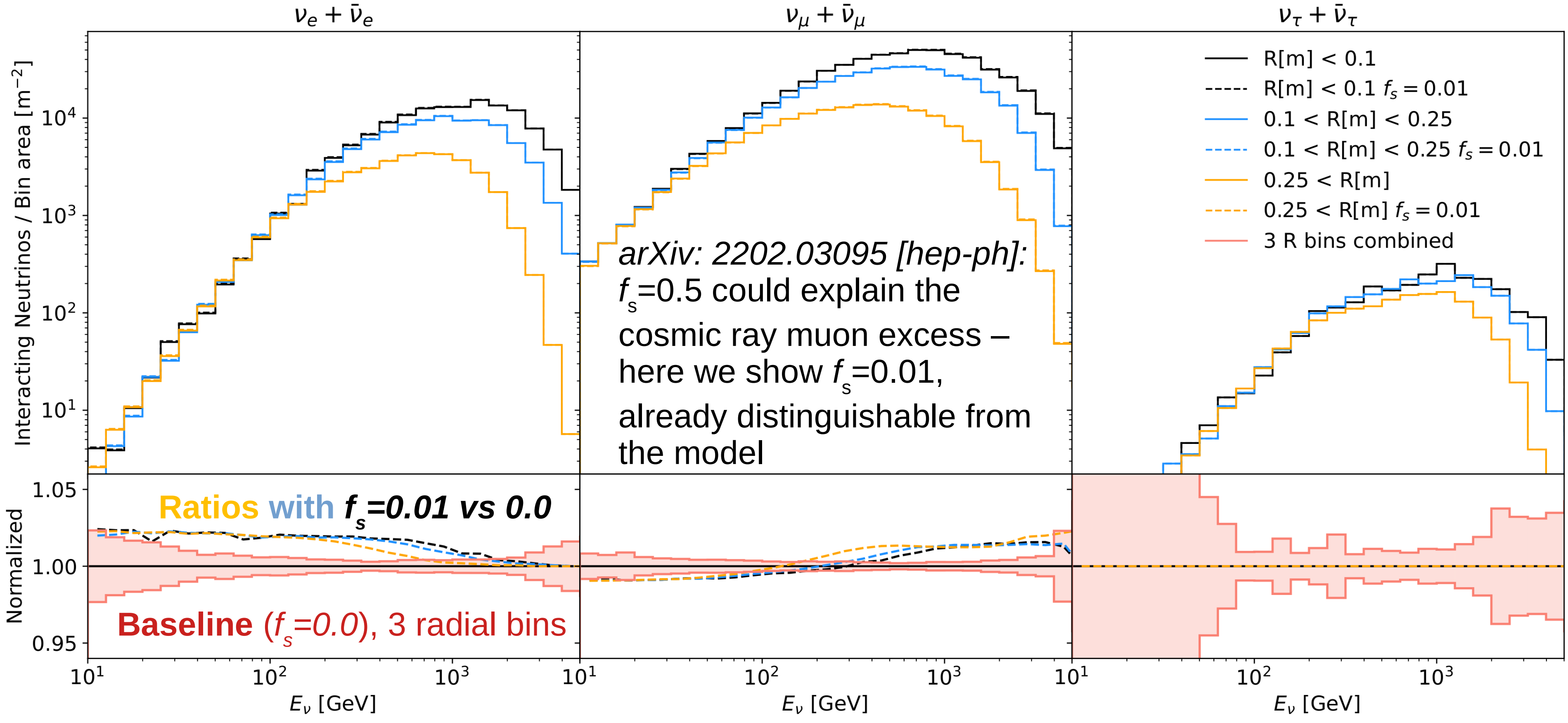
Enhanced strangeness

- Reweigh pion counts by $(1 – f_s)$, kaons by $(1 + f_s F)$, $F = N_\pi^{TOT} / N_K^{TOT}$



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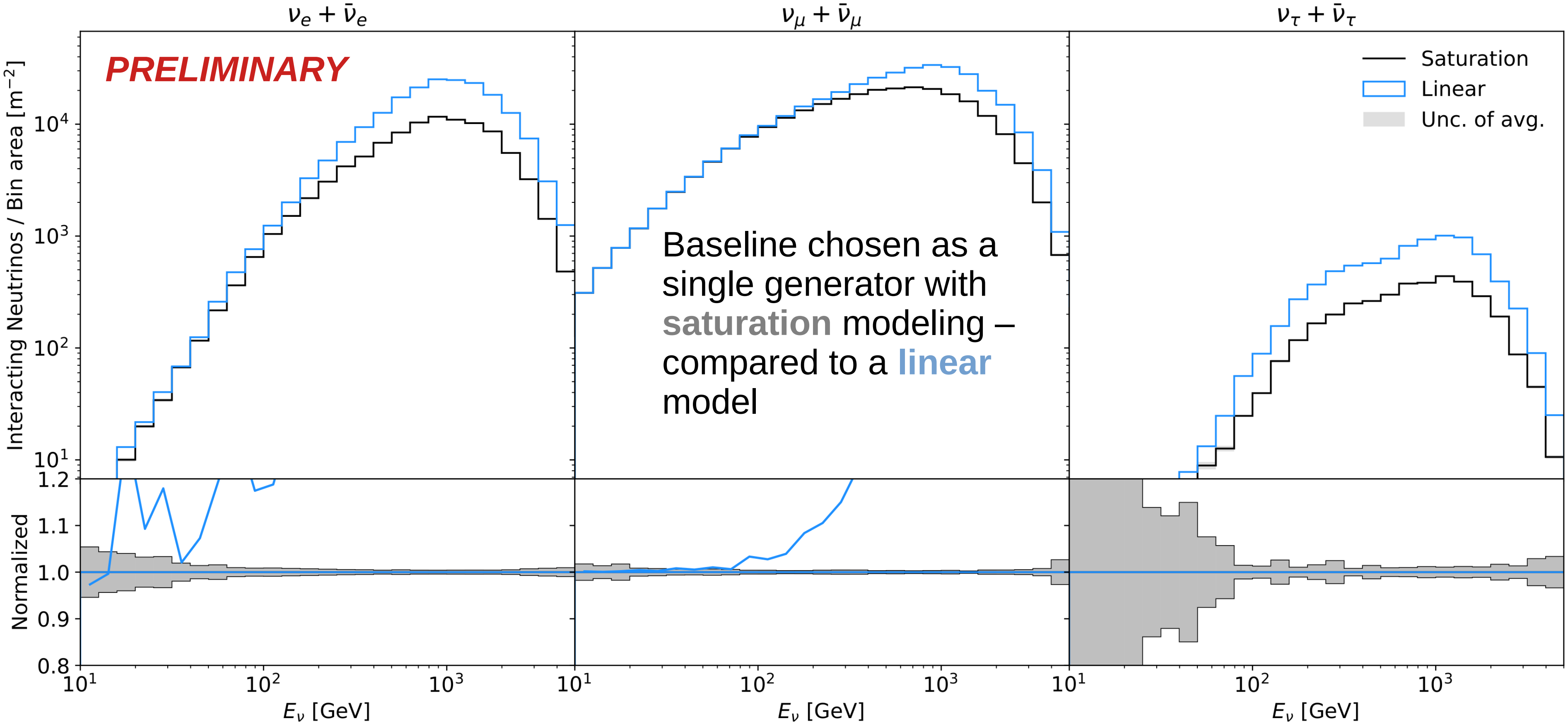
Summary and outlook

- We have presented a model and machinery for evaluating the impact of various physics effects on neutrino spectra at FPF
  - Possible to estimate ultimate precision achievable at FPF
- Allows studying enhanced strangeness, gluon saturation etc
  - Physics goals not limited to SM!
- Proceed to applying the tool to BSM studies:
  - oscillations in the presence of heavy sterile neutrinos
  - BSM enhanced production of tau neutrinos e.g., due to the presence of light tau-philic gauge bosons charged under $U(1)_{B-3L\tau}$

Thanks for your attention!

Back-up

Gluon saturation



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