High rapidity scaling for FPF simulations

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14 April 2022

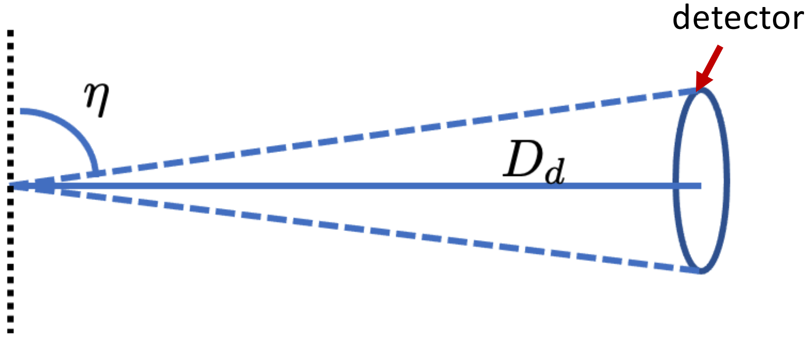
Presentation by Wenjie Wu & Jianming Bian on March 31, 2022

- used incident tau neutrinos distributed uniformly over the detector face.
- approximate scaling behavior in rapidity shows where this is valid

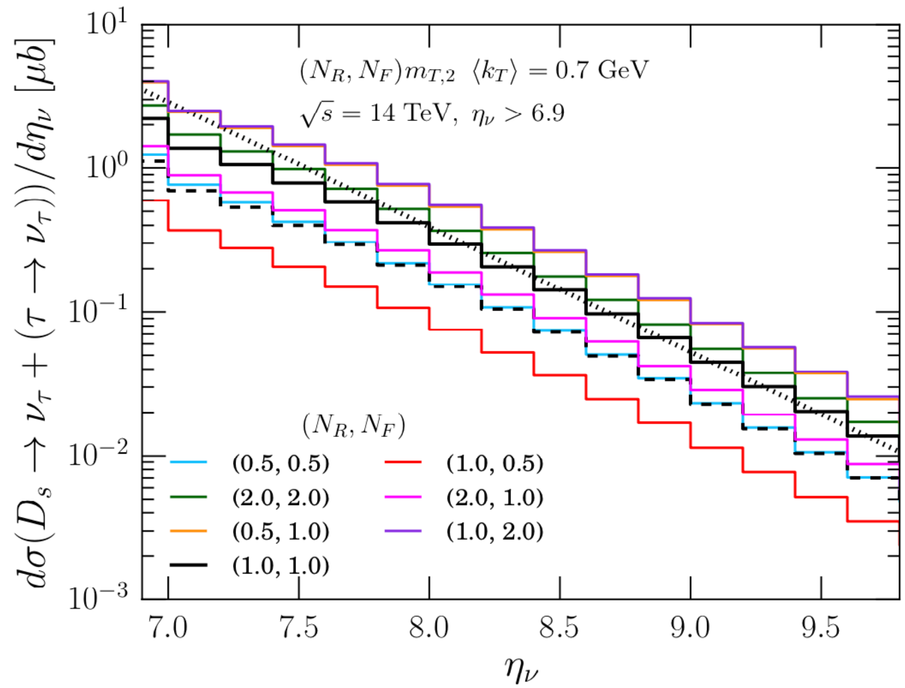
Area scaling of the high rapidity neutrinos

$$\frac{d\sigma}{d\eta_\nu} \simeq \left(0.214\ \mu\text{b}\right) e^{-2(\eta_\nu - 8.3)}$$

$$A_d(\eta_1) \simeq 4\pi D_d^2 e^{-2\eta_1}$$
$$= D_d^2 \Omega_\nu(\eta_1)\,,$$

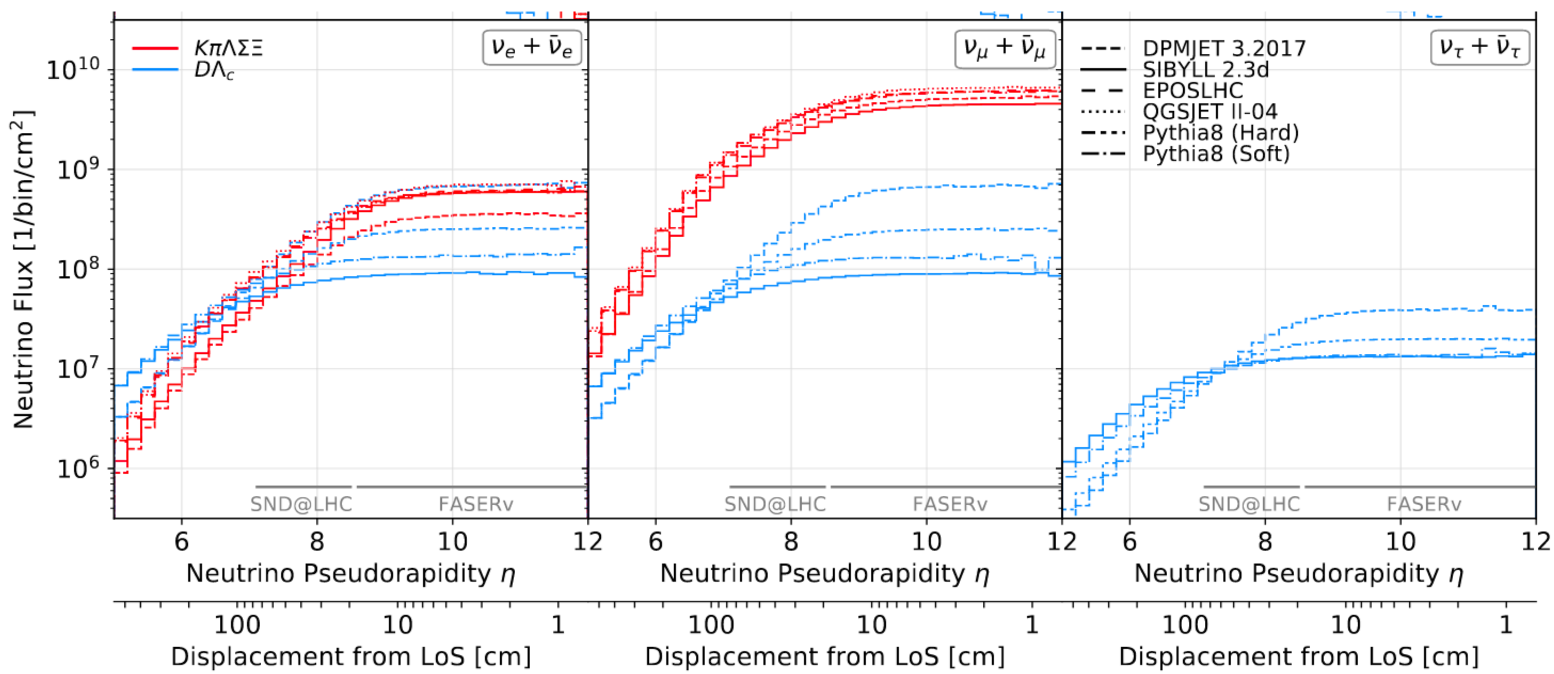


(integrated over neutrino energy)



Kling and Nevay, arXiv:2105.08270

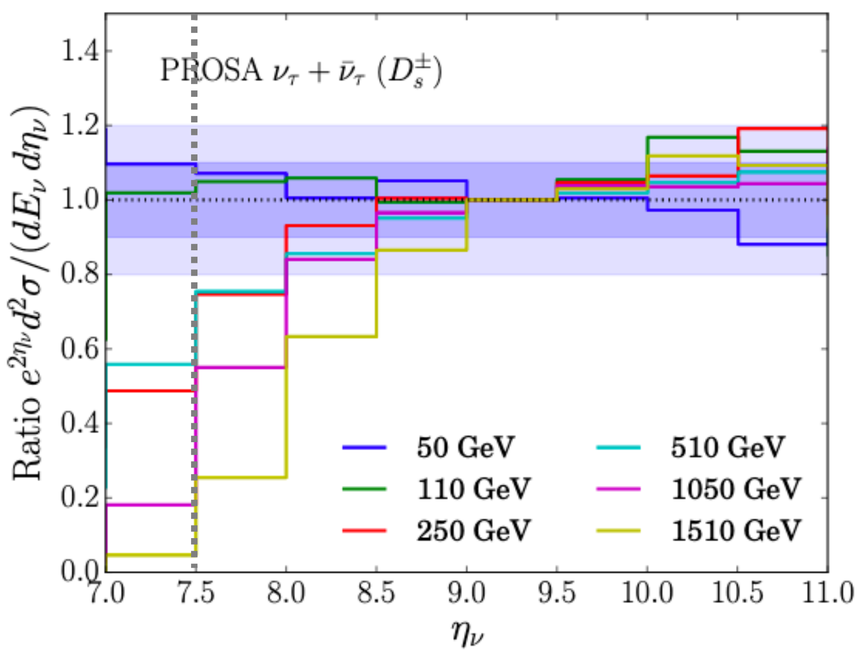
Neutrino flux per unit area

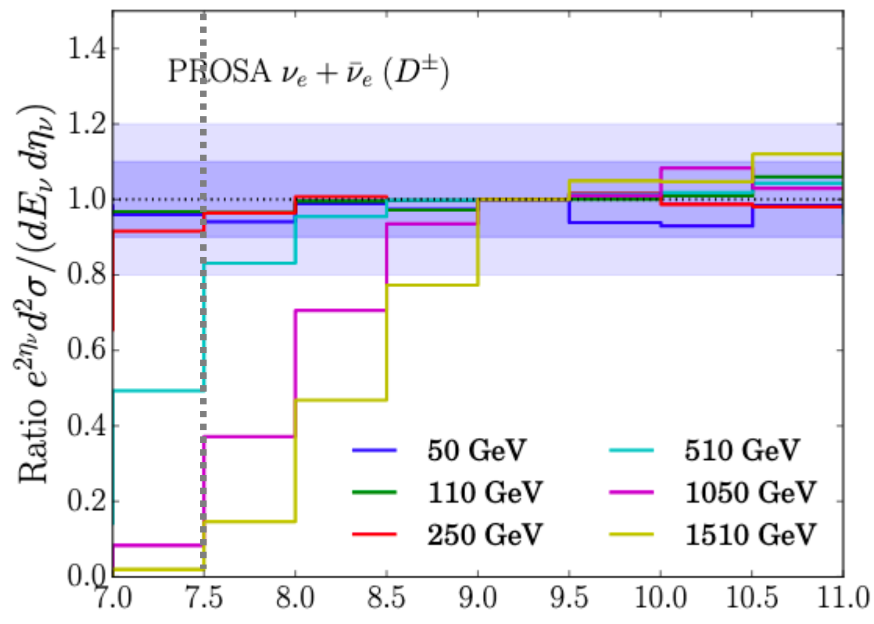


$$\text{Ratio}\left[e^{2\eta_\nu}\frac{d^2\sigma}{dE_\nu\,d\eta_\nu}\right]$$

- Similar scaling behavior in the double-differential (energy and rapidity) for neutrinos.
- To first approximation, can use scaling behavior for *E*<500 GeV.

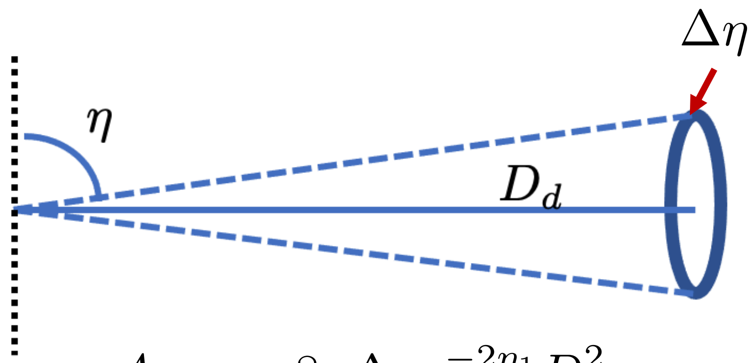
Bands: 10% and 20%.





Bai et al, arXiv:2203.07212

Minimum pseudorapidity of 7.5 for 1x1 m detector @620 m.



$$A_{\text{ring}} = 8\pi\Delta\eta e^{-2\eta_1} D_d^2$$

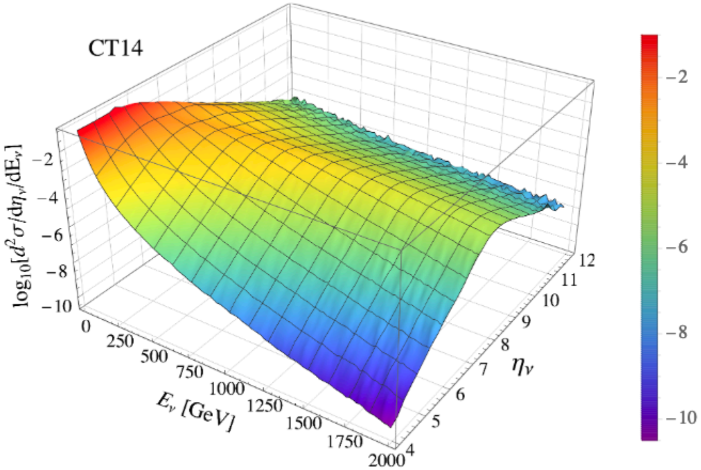
$$\frac{d^2\sigma}{dE_\nu\, d\eta_\nu} = N(E_\nu)e^{-2\eta_\nu}$$

$$\int_{\eta_1}^{\eta_2} d\eta_\nu \, \frac{d^2\sigma}{dE_\nu\, d\eta_\nu} = N(E_\nu)\Delta\eta\, e^{-2\eta_1}$$

$$\frac{1}{A_{\text{ring}}} \int_{\text{ring}} d\eta_\nu \, \frac{d^2\sigma}{dE_\nu\, d\eta_\nu} = \frac{N(E_\nu)}{8\pi D_d^2}$$

as long as the rapidity scaling is valid

For high energies (above 500 GeV) and rapidities between 7.5-8.5, there should be fewer neutrinos per unit area. Pseudo-rapidity of 8.5 @ 620 m is 0.25 m.



$d^2\sigma/(dE_\nu d\eta_\nu)$ in units of μb/GeV for $\nu_\tau+\bar{\nu}_\tau$ from $D_s^\pm$

Bai et al, arXiv:2203.07212

Double differential distribution available in tables (arXiv ancillary files).