Effects of firn ice models on radio neutrino simulations using a RadioPropa ray tracer

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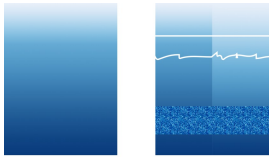
Current software does not handle complex ice models which may result in errors on radio neutrino simulations and reconstructions

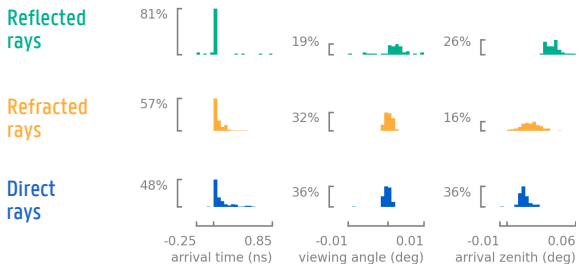
1. Internal reflection / absorption layers (e.g. firn model)
2. Non-single-exponential depth model
3. Horizontal wave modes
4. Birefringence — anisotropic refractive index tensor resulting in polarisation dependent ray bending

Energy
Distance — neutrino interaction
Direction — signal & neutrino



We integrated an iterative RadioPropa [1] ray tracer into NuRadioMC [2] to handle these complex ice features → With this, we investigated the first effects of a firn ice model on the radio simulations

The RadioPropa ray tracer finds accurate solutions



The firn model causes non-trivial time shifts depending on antenna depth and ray type

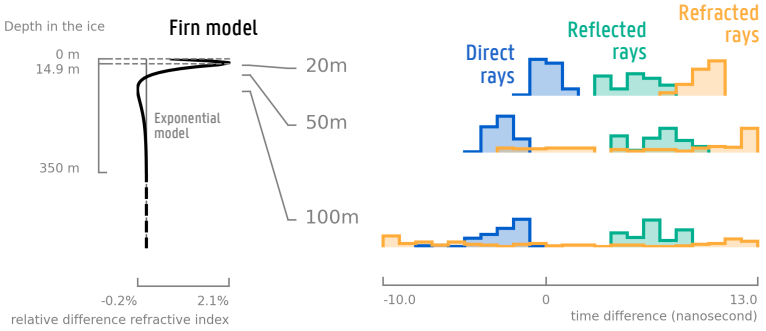
Exponential model — Summit, Greenland

$n(z) = 1.78 - 0.51 \exp(-z / 37.25\ \text{m})$ $\quad z \leq 0$ m

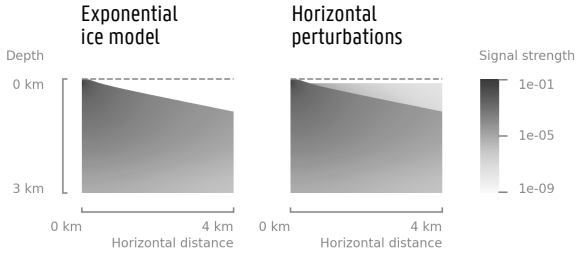
Firn model [3] — Summit, Greenland

$n(z) = 1.78 - 0.50 \exp(-z / 30.8\ \text{m})$ $\quad 14.9\ \text{m} < z \leq 0$ m

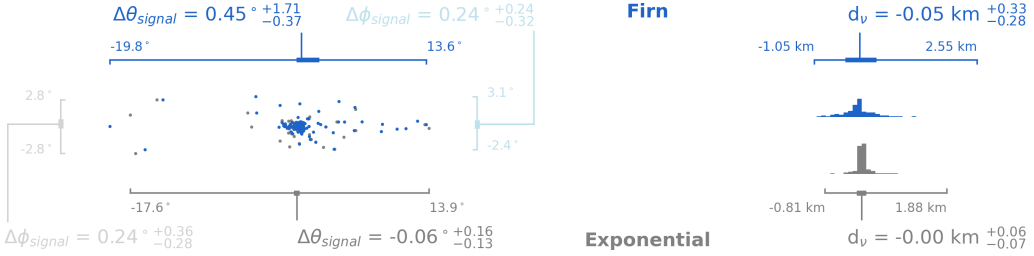
$n(z) = 1.78 - 0.31 \exp(-(z-14.9\ \text{m}) / 40.9\ \text{m})$ $\quad z \leq 14.9$ m



Horizontal wave modes reduce the shadow zone



Therefore, reconstructions of firn simulations experience systematic uncertainties



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References

[1] https://github.com/nu-radio/RadioPropa
[2] https://github.com/nu-radio/NuRadioMC
[3] https://arxiv.org/abs/1805.12576

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