Prospects of Neutrino Flavor Measurements with PUEO

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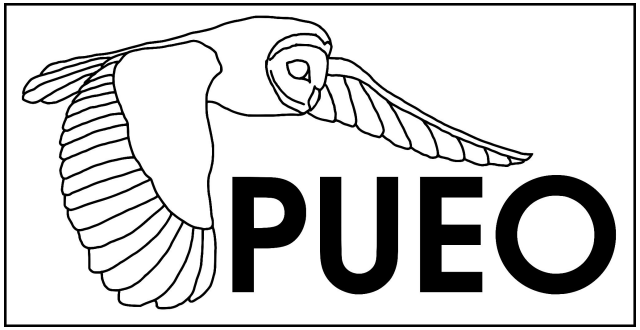
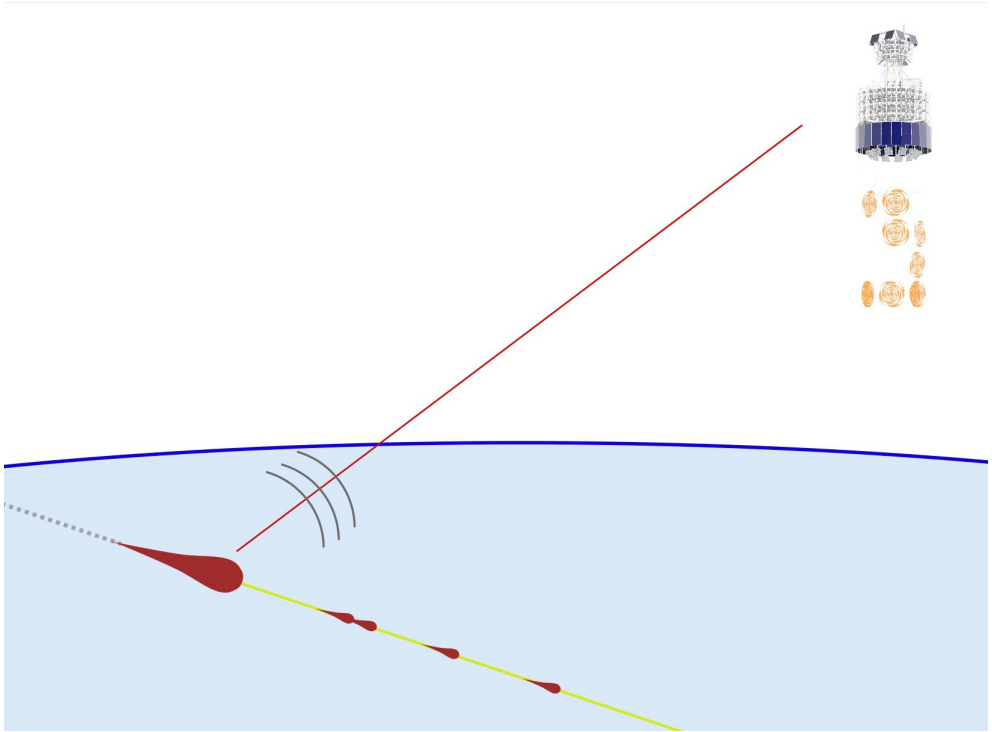
for the PUEO collaboration



Sensitivity to Flavor

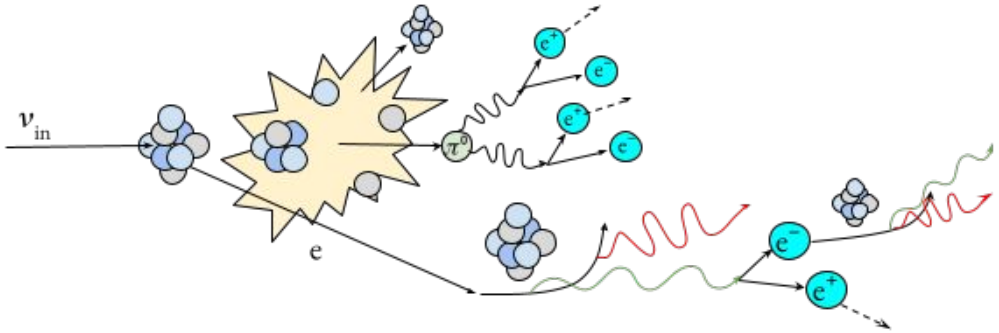
- Tau channel from LF instrument
- Secondary leptons from in-ice interactions
- ν_e:
  - Generates EM shower
- ν_μ and ν_τ:
  - μ or τ propagates
  - Secondary showers emit radio signals

PUEO should be able to see these!



Electron Neutrinos

- EM shower on top of hadronic shower
- Offset between EM and hadronic shower maxima
- LPM effect: EM shower becomes longer and irregular
- Interference between radio signals from both showers



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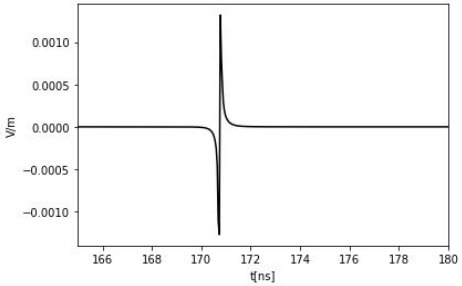
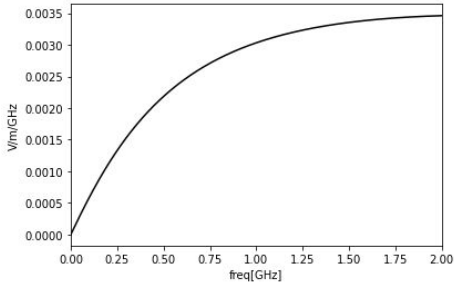
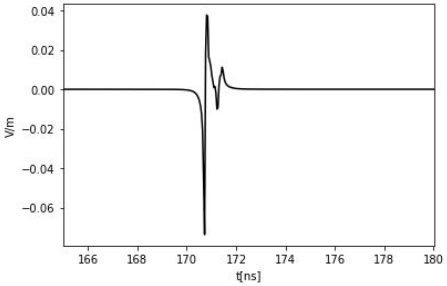
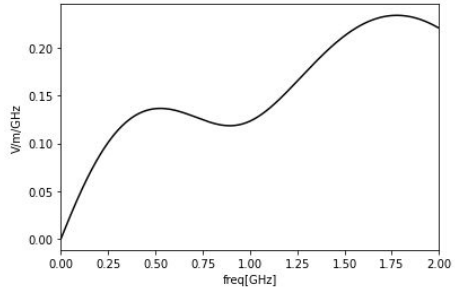
Hadronic shower





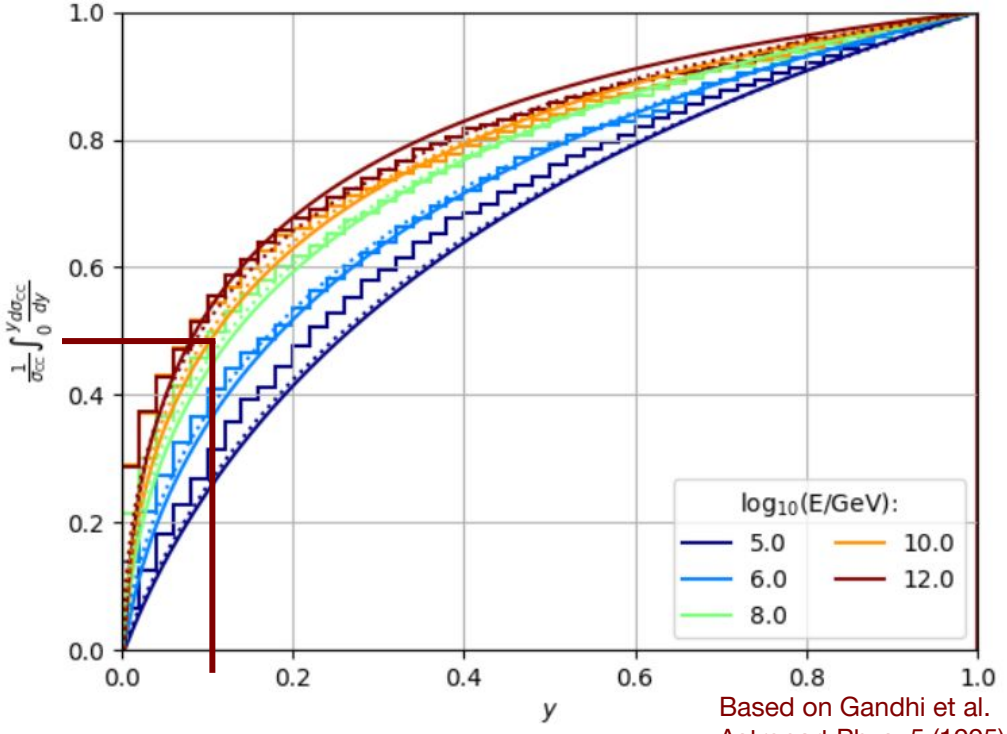
Hadronic + EM shower





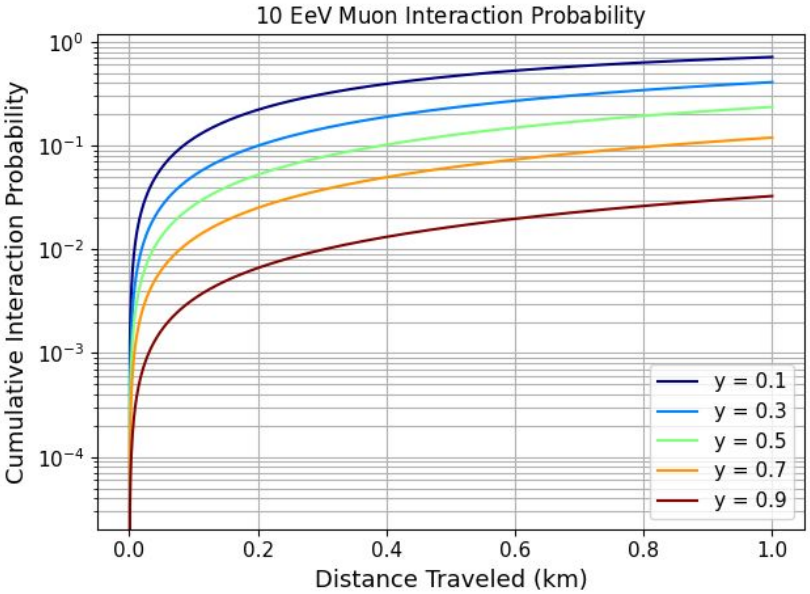
Muon and Tau Neutrinos

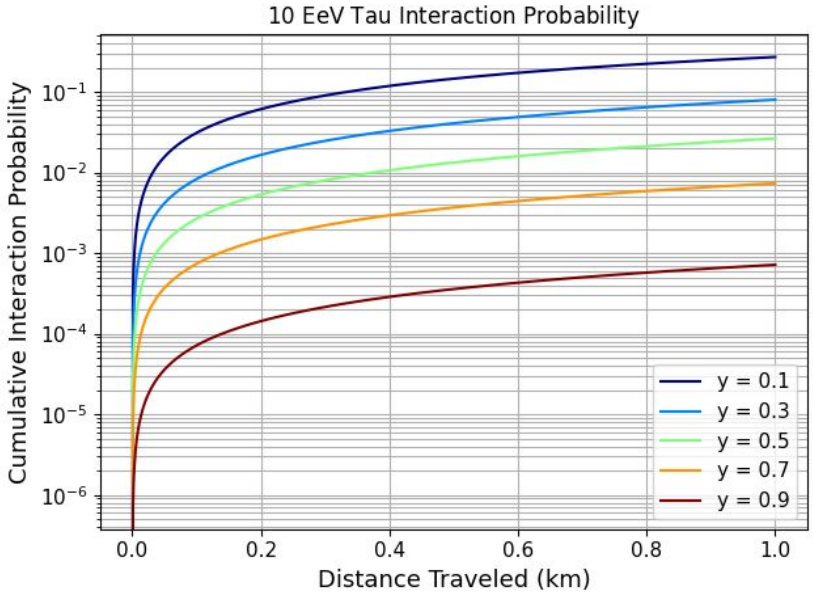
- Inelasticity distribution is heavily tilted towards low y
- Almost half the time 90% or more of the energy goes into the mu/tau



Based on Gandhi et al. Astropart.Phys. 5 (1995)

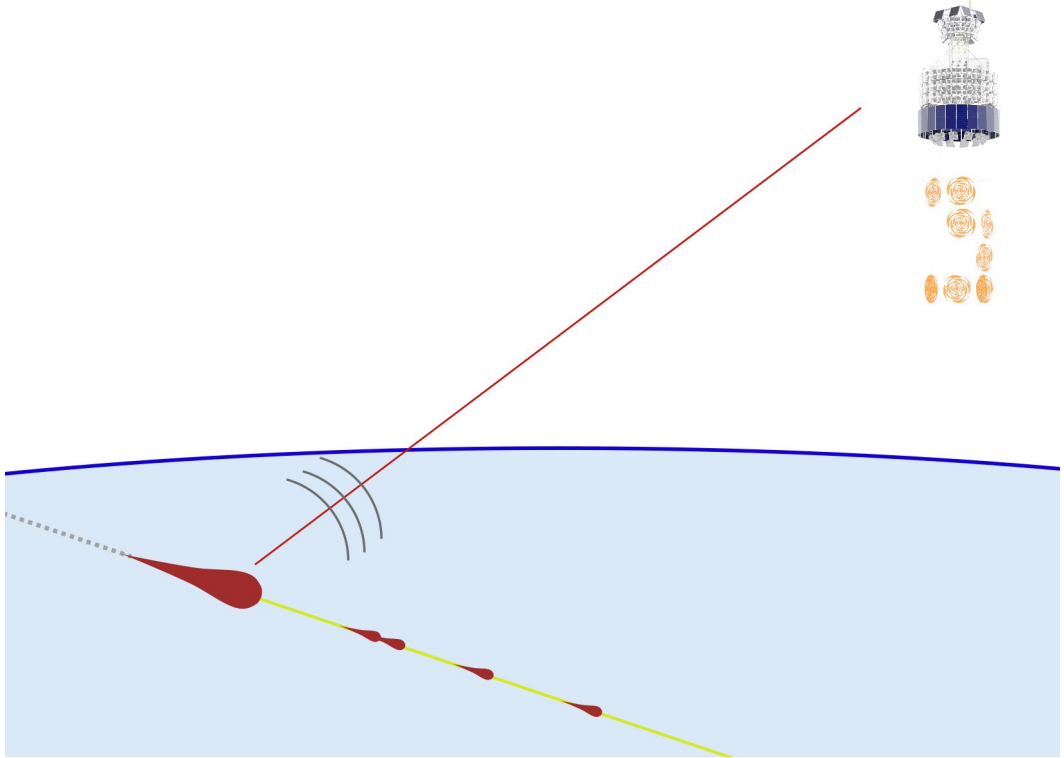
Muon and Tau Neutrinos





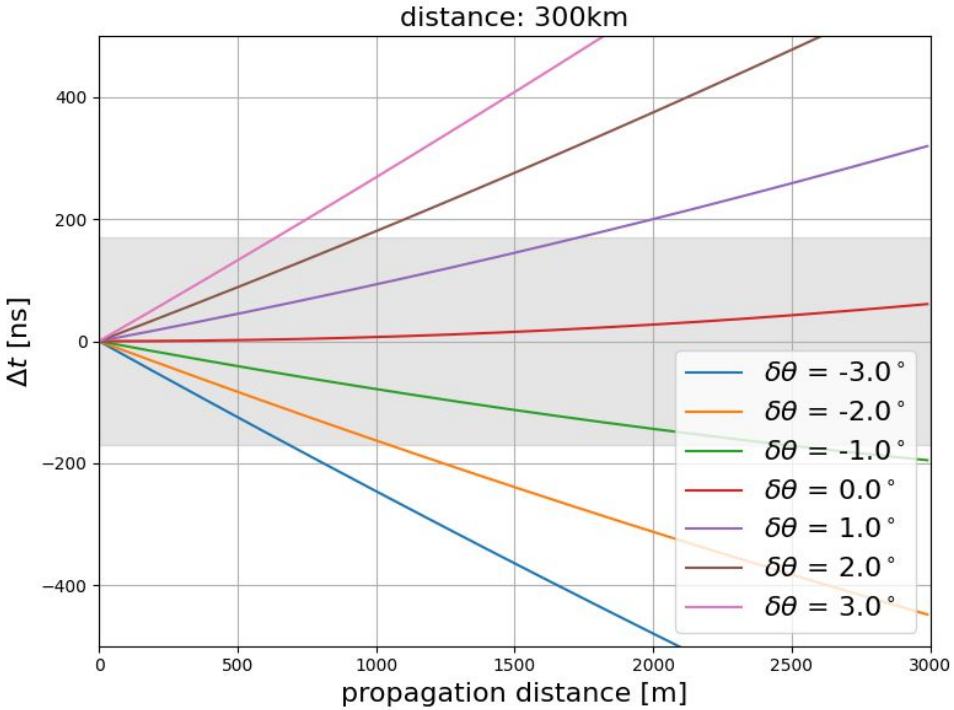
Radio Signals from Secondary Showers

- Events seen by PUEO will be O(100km) away
- Secondary showers are guaranteed to be seen at the Cherenkov angle!



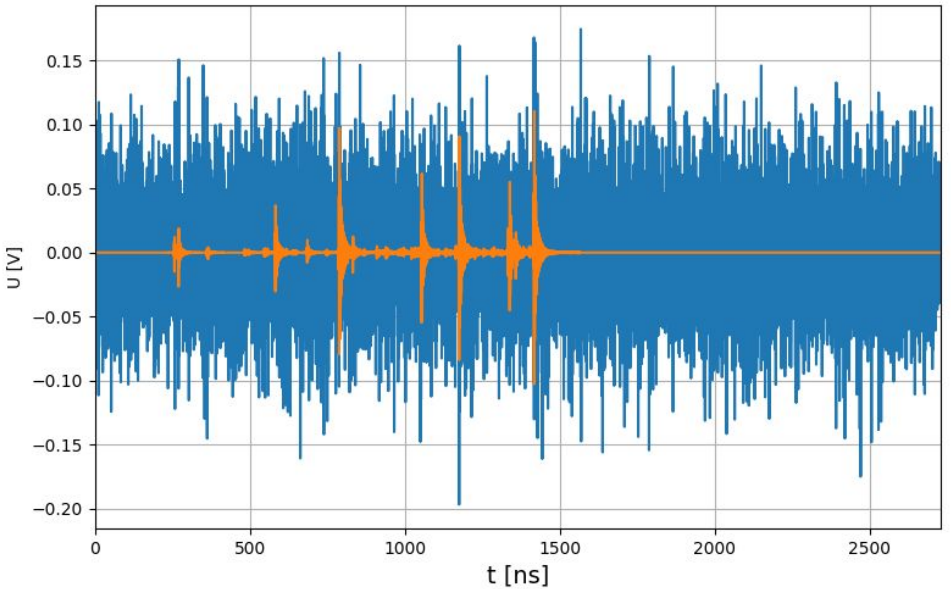
Time Compression Effects

- At the Cherenkov angle, radio emissions are compressed in time
- This applies to the time between showers too
- Secondary radio signals are likely to appear in recorded window
- This lets us look for sub-threshold events



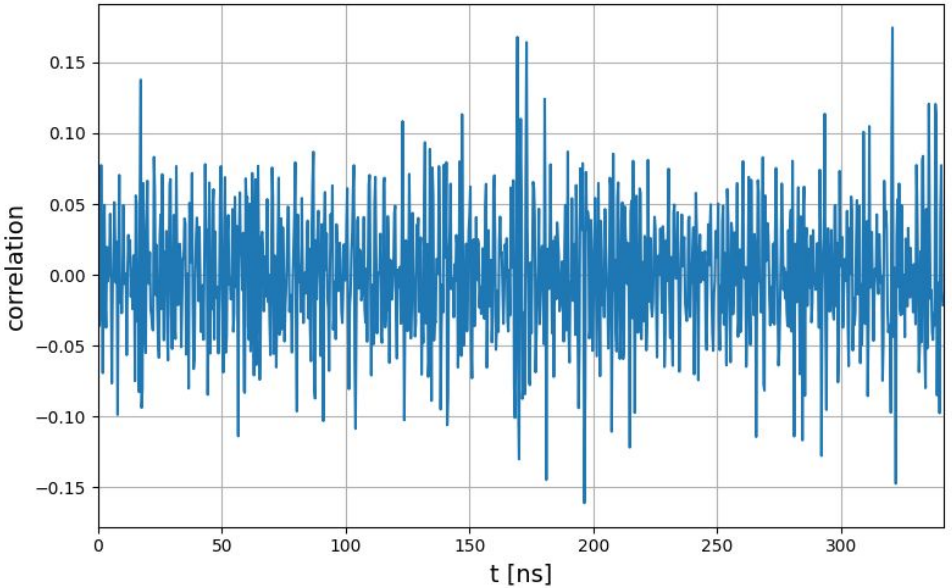
Secondary Shower Simulation

- Lepton propagation with NuLeptonSim [arxiv:2311.03646]
- Lepton is propagated until it enters atmosphere or bedrock
- Signal generation & propagation with NiceMC [PoS (ICRC2023)1154]
- Detector simulation with PueoSim



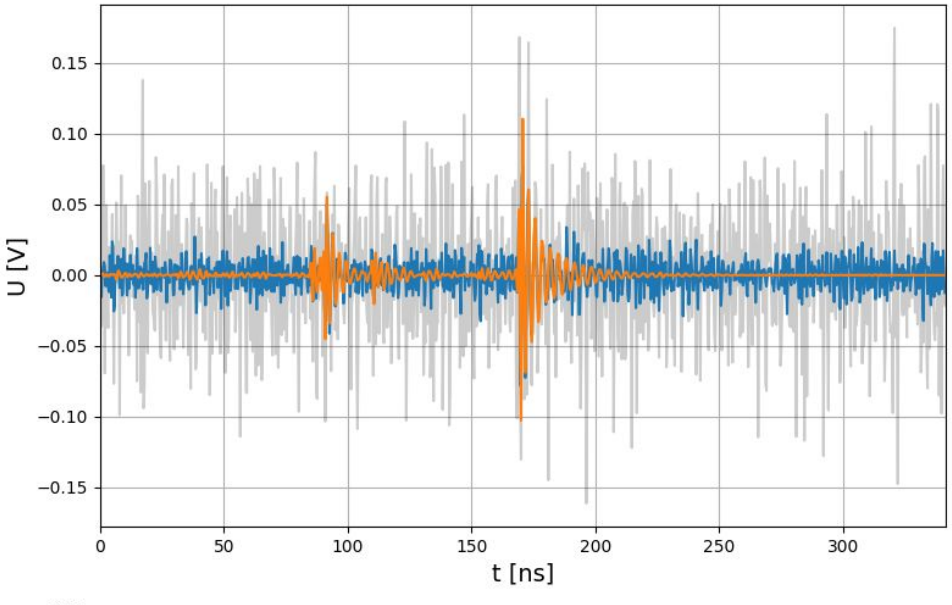
Secondary Shower Search

- Assumptions:
  - We triggered on the largest radio pulse in the waveform
  - We know this event is a neutrino
  - We know where the radio signal from the neutrino is
- Goal: Show that there are more showers in the recorded waveform



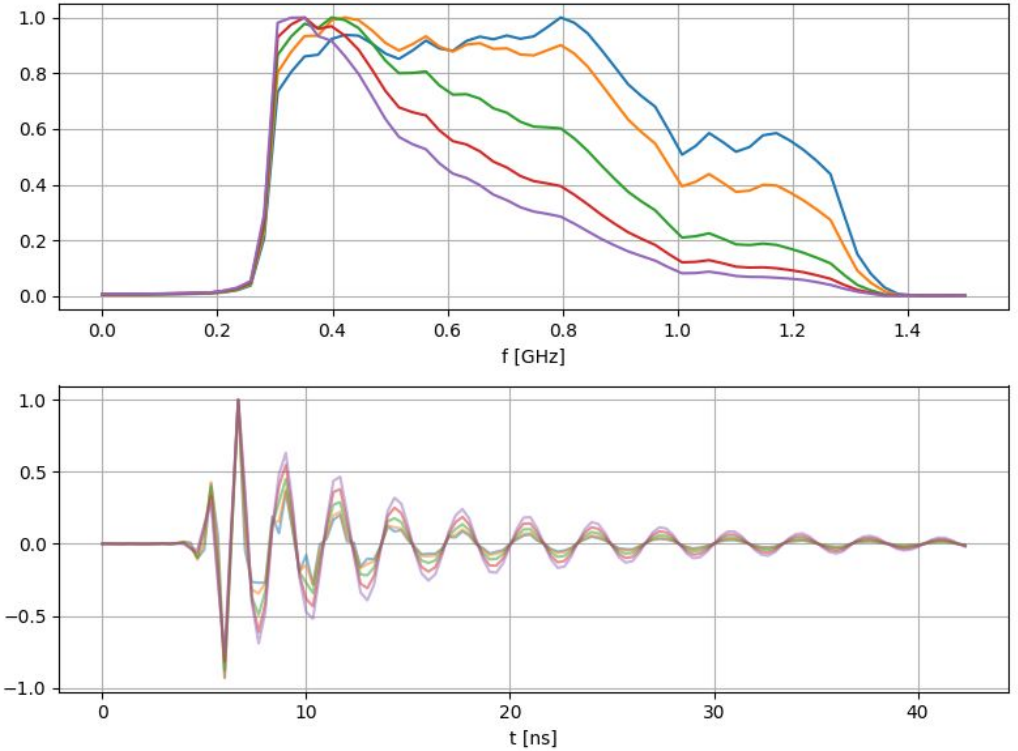
Beamforming

- Combine signals from 20 channels
- Time offsets determined from main RF pulse
- Choose between Vpol and Hpol channels



Templates

- Templates from Askaryan pulse folded with antenna & amplifier response
- Multiple templates for different viewing angles
- Choose template that best fits main RF pulse
- Background estimate from correlations with noise



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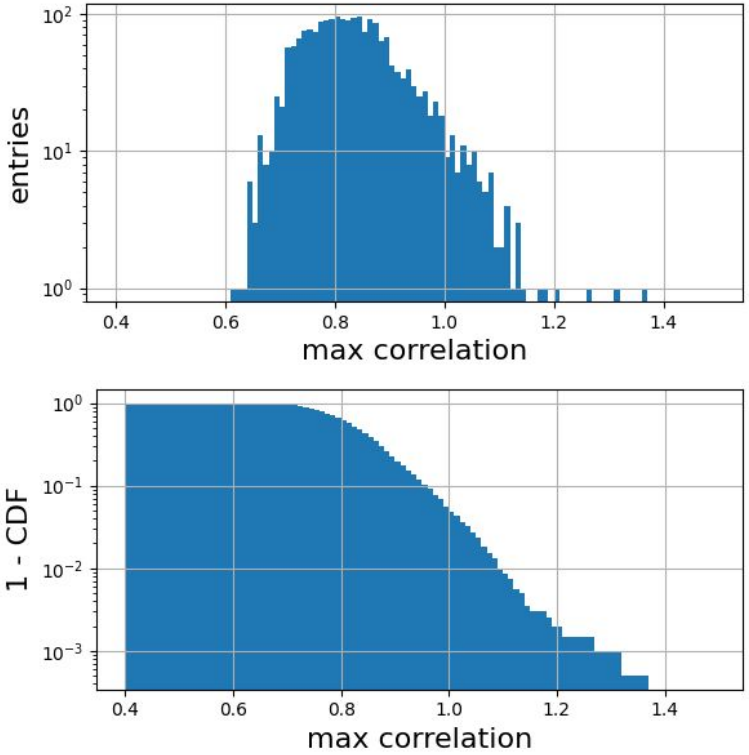
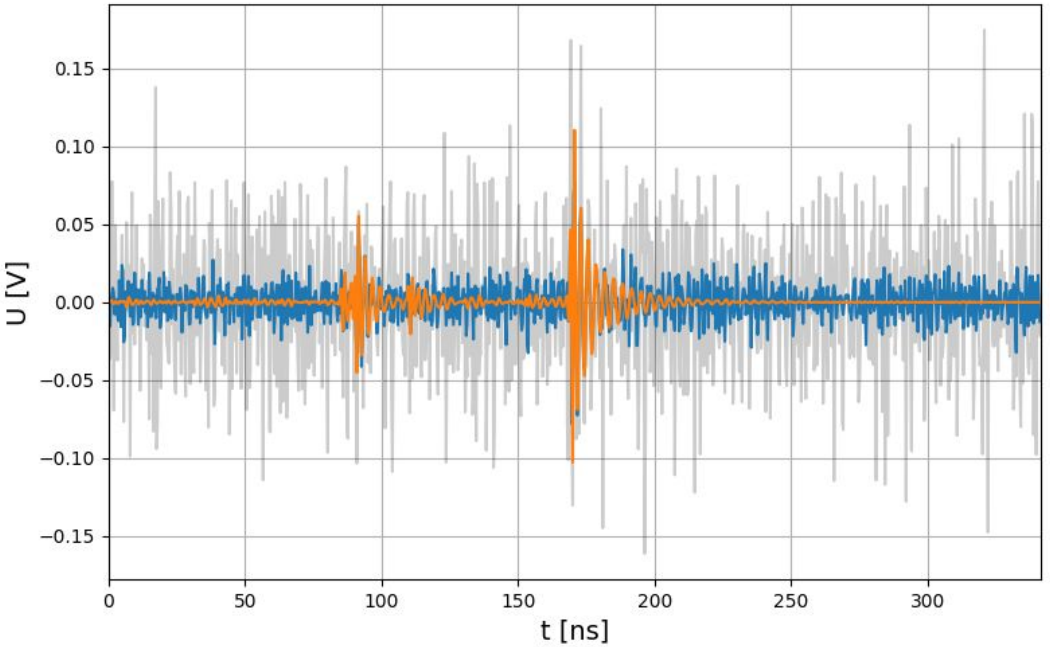


Template Correlation

- Correlate template with recorded waveform
- Mask region around main RF pulse
- Check of correlation is above x percentile



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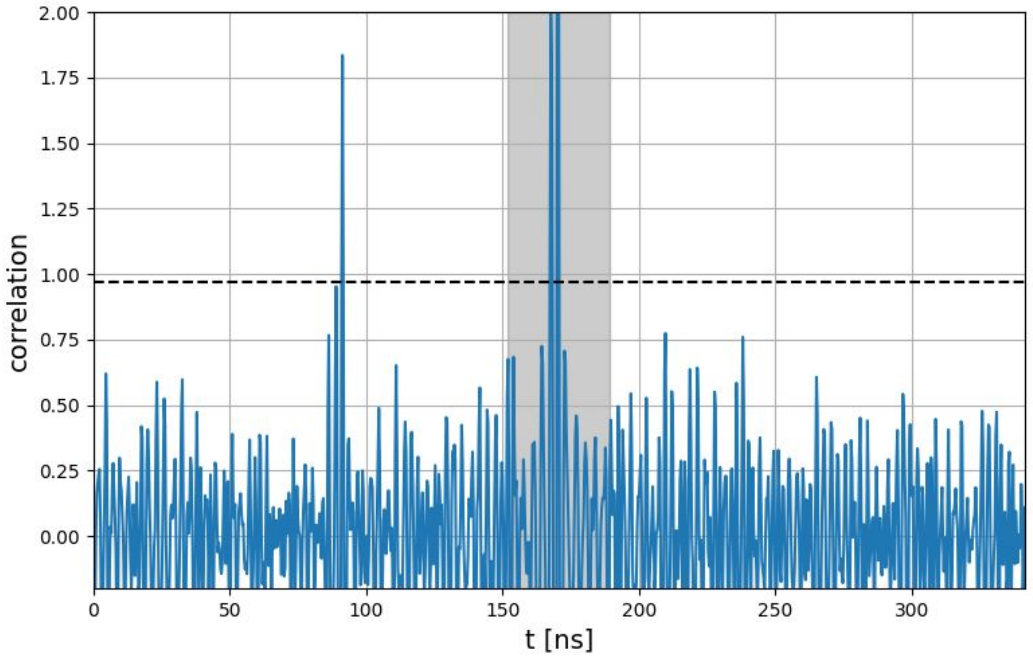
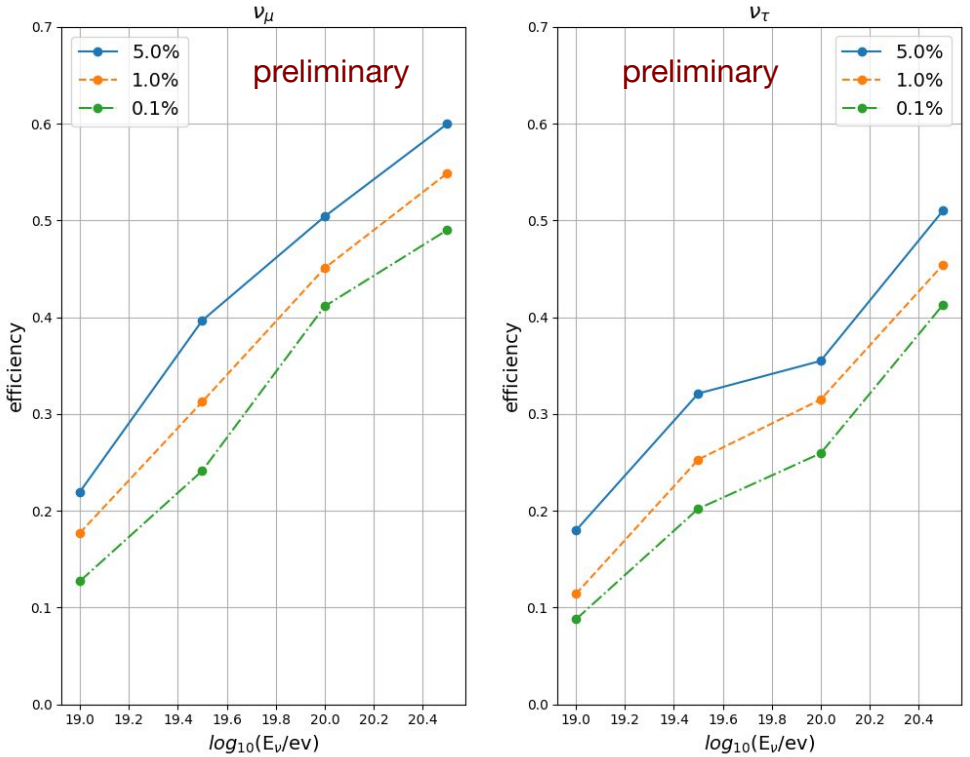


Efficiencies

- We can see a large fraction of secondary showers!
- Analysis still has a lot of room for improvement
- Double triggers could add to this further



Conclusions

- PUEO will have 3 channels sensitive to flavor:
  - Earth-skimming ν_τ through low frequency instrument
  - ν_e through signal spectrum
  - $\nu_\mu + \nu_\tau$ through secondary showers
- Potential to measure all 3 neutrino flavors
- Sensitivity to be determined, but first results look promising!