ESSnuSB+: non-beam neutrino physics and sterile neutrinos at near detectors

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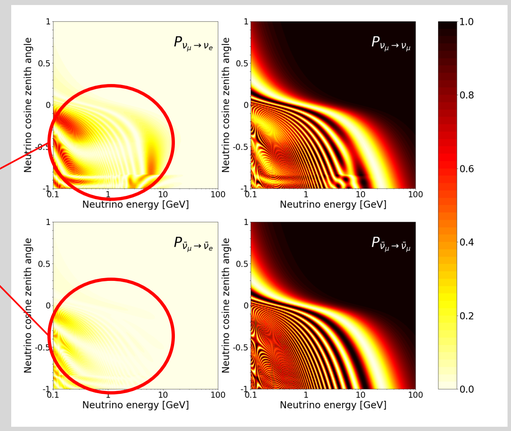
Roma Tre Neutrino Theory Group

See also poster #55 for target station design

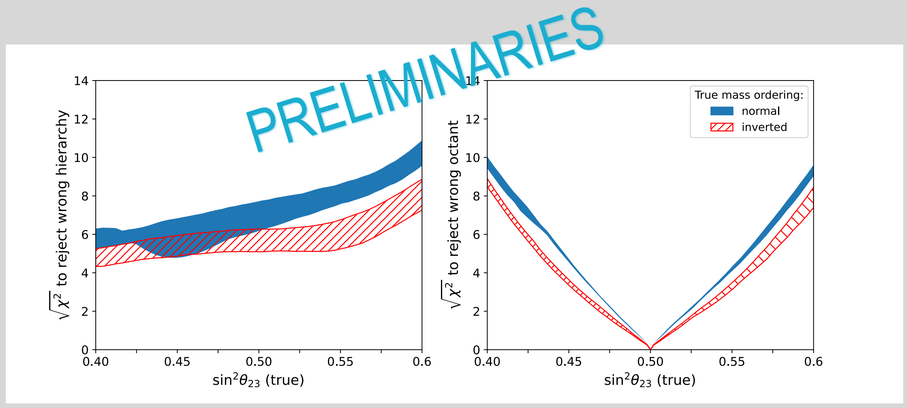
Atmospheric Neutrinos

Atmospheric neutrinos will be observed at the Far Detector. Gadolinium doping may help with the neutrino/antineutrino discrimination

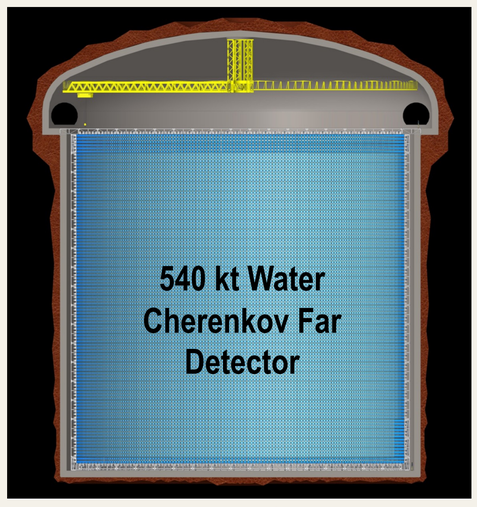
Different matter effects for neutrinos and antineutrinos



Sensitivity to atmospheric parameters + sensitivity to mass hierarchy and atmospheric angle octant



+ Geoneutrinos ?
+ DNSB ?



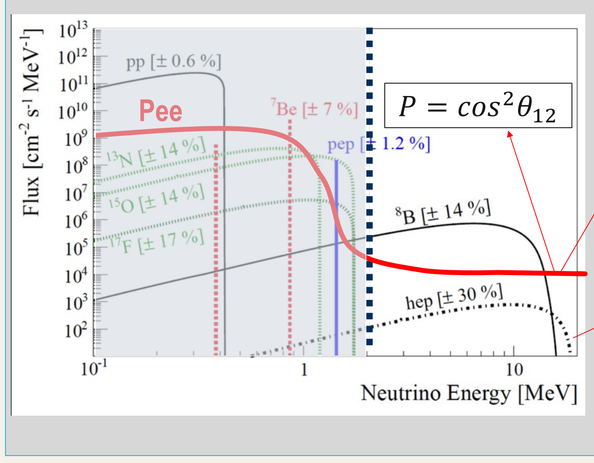
Solar Neutrinos

Solar neutrinos comes from several nuclear reaction inside the Sun. These low energy neutrinos have a maximum of 19 MeV energy.

Given the energy threshold of WC detectors (roughly 4.5 MeV), only two components of the neutrino flux can be observed:

-Boron-8 neutrinos → Measurement of solar parameters

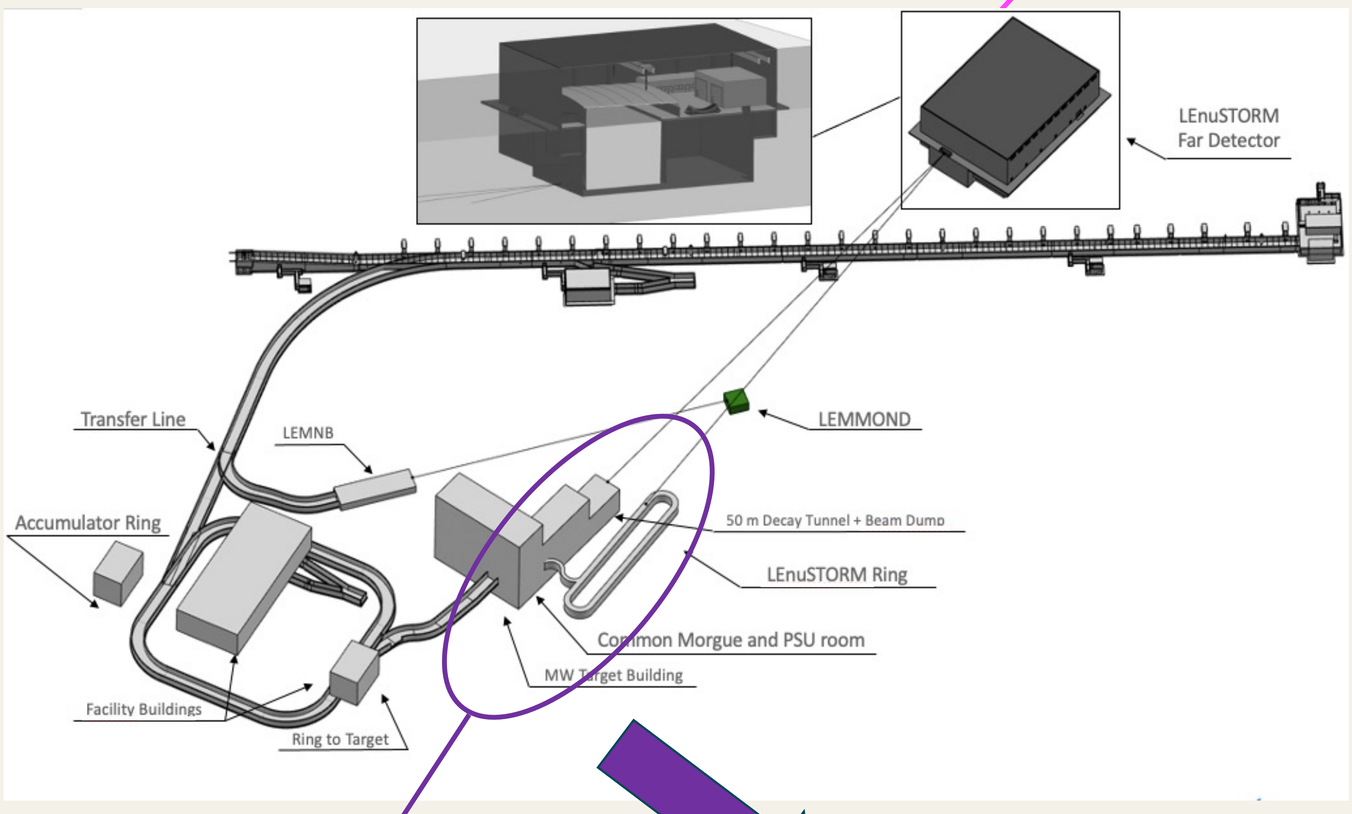
-hep neutrinos → Discovery of neutrinos from He-3 fusion



D-N asymmetry

B8-hep separation

Neutrino beam

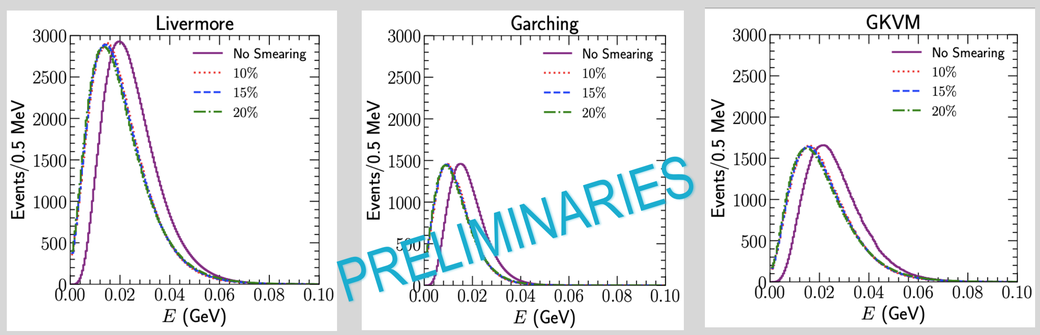


Supernova Neutrinos

A supernova explosion should generate a huge neutrino low-energy flux (up to 20 MeV).

ESSnuSB WC Far Detector will be able to detect a very large number of neutrino events that could be able to discriminate the supernova neutrino spectrum models

$$\Phi_\nu(E) = \mathcal{N}\left(\frac{E_\nu}{\langle E_\nu \rangle}\right)^\alpha e^{-(\alpha+1)\frac{E}{\langle E_\nu \rangle}}$$



Total number of events:

Livermore	GKVM	Garching
148,686	88,528	51,068

Short baseline physics: Neutrino cross section measurements with:

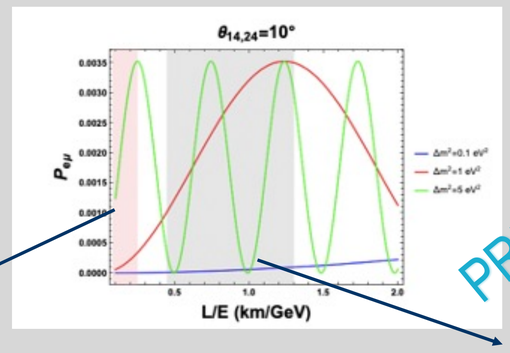
- **ENUBET-like** low energy monitored muon neutrino beam
- **nuSTORM-like** low energy muon and electron neutrino beam from muon decays

Sterile neutrinos at ESSnuSB+ near detectors

Sterile neutrinos oscillations at short baseline might reduce the disappearance events or create unexpected appearance events

$$P_{\mu e} = sin^2(2\theta_{\mu e})\, sin^2\left(\frac{\Delta m^2_{41} L}{4E}\right) \qquad P_{\mu\mu} = 1 - sin^2(2\theta_{\mu\mu})\, sin^2\left(\frac{\Delta m^2_{41} L}{4E}\right)$$

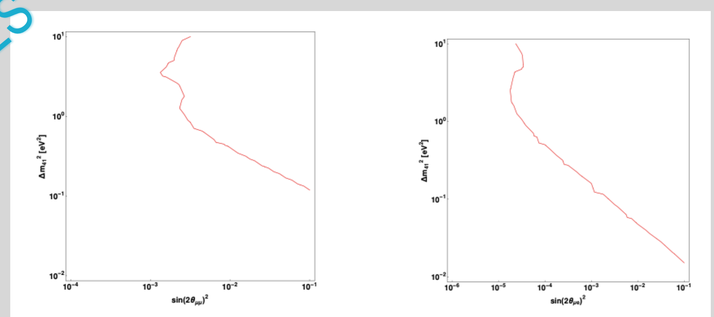
LEnuSTORM: two detectors fit, might resolve oscillation for $\Delta m^2_{41} \sim 1\ eV^2$



$50\ m\ ND$

$250\ m\ FD$

LE-ENUBET: great limits using ESSnuSB FD, might resolve decay ***pipe length effects*** using the beam monitor



References

Alekou, A., et al. "The ESSnuSB design study: overview and future prospects." *Universe* 9.8 (2023): 347.