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Physics Reach Report from WP5

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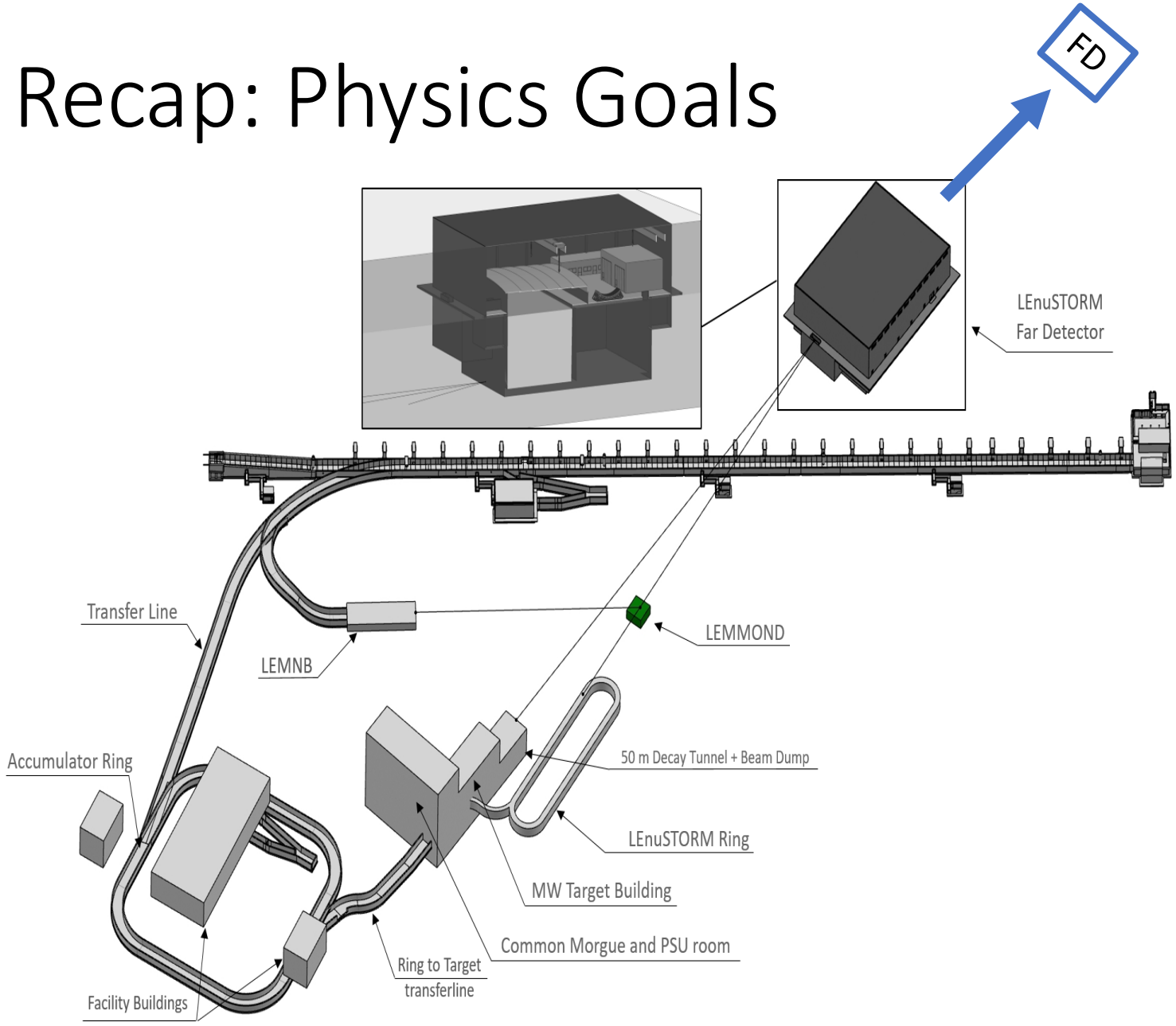
ESS neutrino Super Beam plus

Recap: Physics Goals



A. Non-beam physics at FD

- Atmopsheric neutrino
- Solar neutrino
- Supernova neutrino
- Reactor neutrino
- Geo neutrino

Milestone MS5: Identification of non-beam physics scenarios (WP5)

B. New physics at NDs (LEMMOND and END)

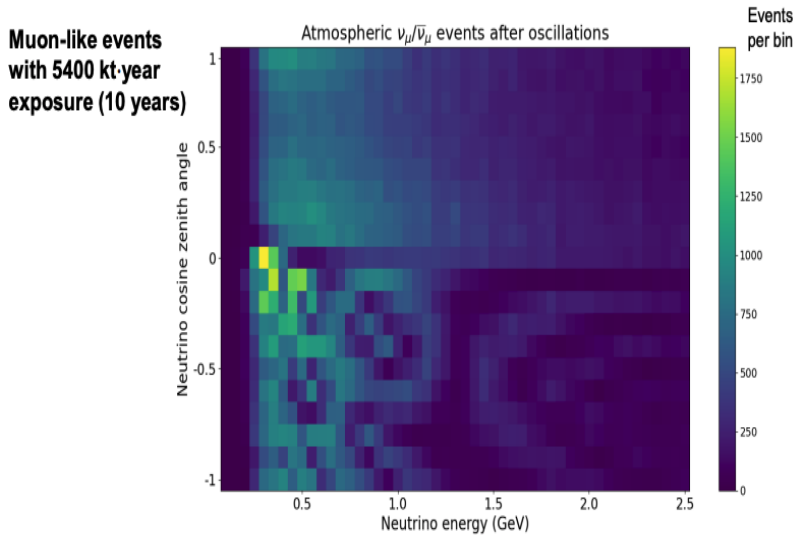
- Sterile neutrino
- Non-unitarity
- Other non-oscillation BSM physics

C. Additional physics studies

- Standard scenario at FD using ESS beam systematics, cross-section models etc

- New Physics scenario at FD using ESS beam NSI, Decoherence, Long-Range Forece etc

Atmospheric Neutrino



Studies being performed by KTH group

1st Annual Meeting: (i) Preliminary results on simulation of atmopshereic neutrinos are presented

(ii) First results on mass ordering and NSI searches are presented

Since then: (i) Detailed analysis are done on simulation, measurement of neutrino mass ordering and measurement of θ_{23} and Δm^2_{31}

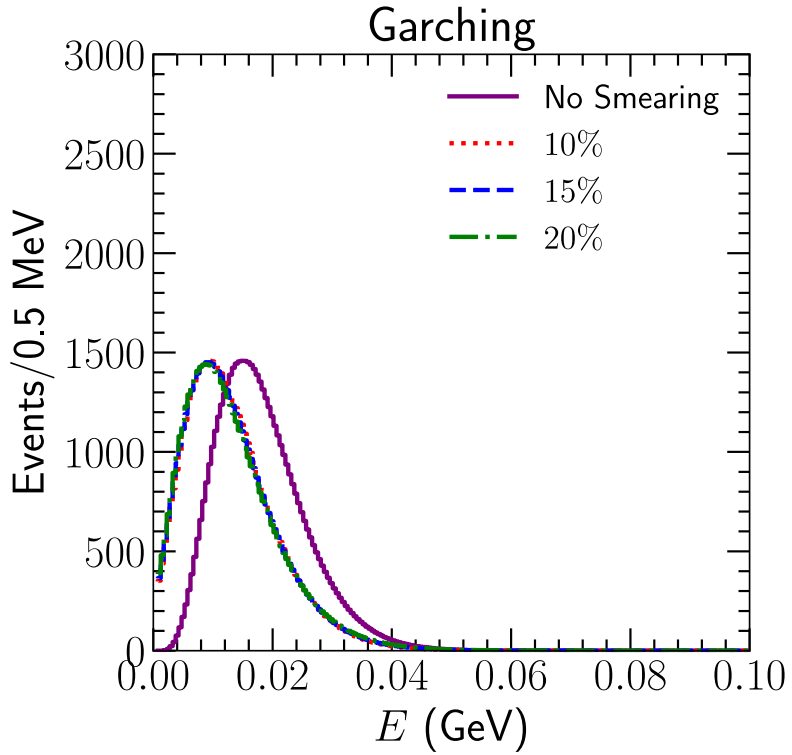
(ii) Article to appear in JHEP soon

J. Aguilar et al. [ESSnuSB], ``Exploring atmospheric neutrino oscillations at ESSnuSB,'' arXiv:2407.21663 [hep-ex]

(iii) Detailed analysis of NSI is ongoing

This Meeting: Progress will be presented by Sampsa

Other Non-beam Physics



Supernova neutrinos – RBI group

- 1st Annual Meeting: Expected event rates were calculated for three different supernova flux models
- Since then: Oscillation effects have been included for standard and 3+1 scenario
- This Meeting: Progress will be presented by myself

Solar neutrinos – Rome group

- 1st Meeting: -
- Since then: Preliminary analysis has been initiated
- This Meeting: Progress will be presented by Alessio

Reactor and Geo Neutrinos

Reactor neutrinos

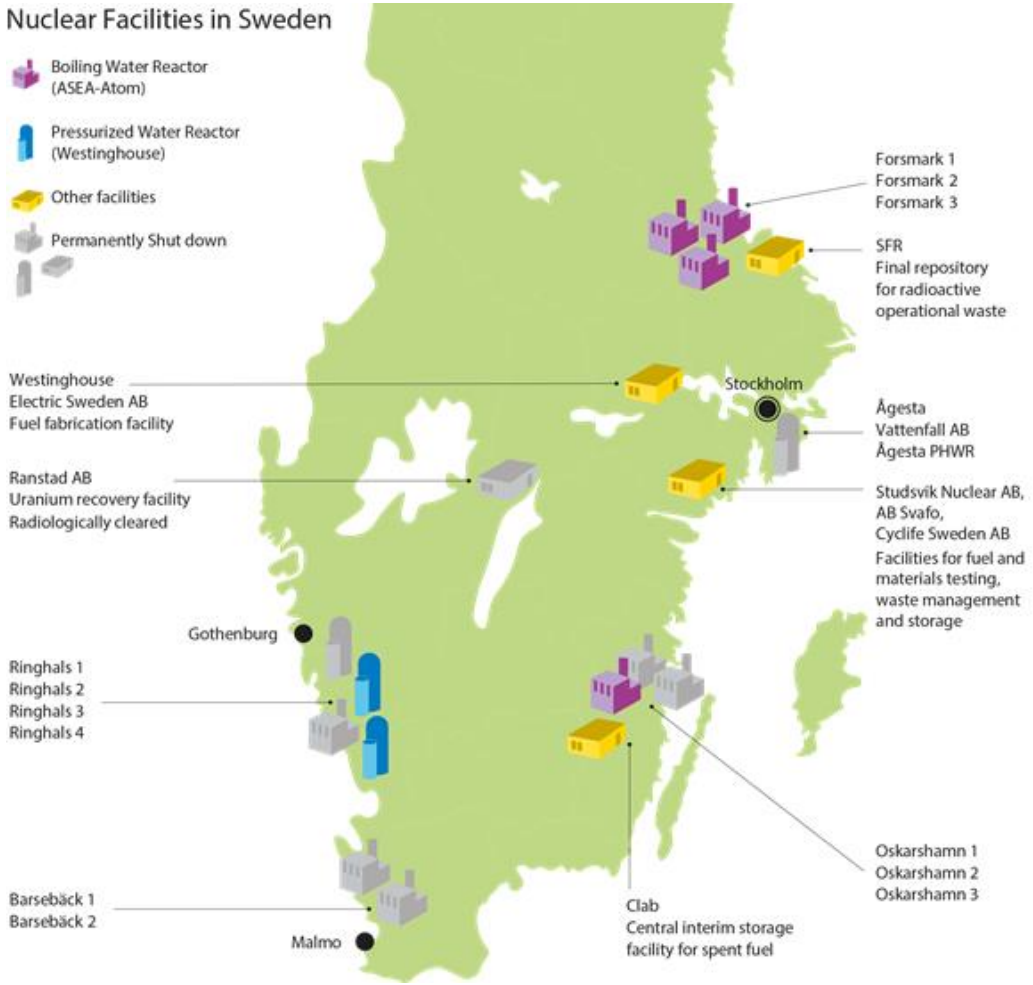
-3 nuclear power plants with 6 reactors in total in operation in Sweden

-Forsmark (3 reactors), Oskarshamn (1 reactor), and Ringhals (2 reactors)

- Distances:

Forsmark–Zinkgruvan:248km
Oskarshamn–Zinkgruvan:181km
Ringhals – Zinkgruvan: 247 km

- Total power < 7 GW : One order of magnitude less than kamLAND



Geo neutrinos

Not much expertise at this moment

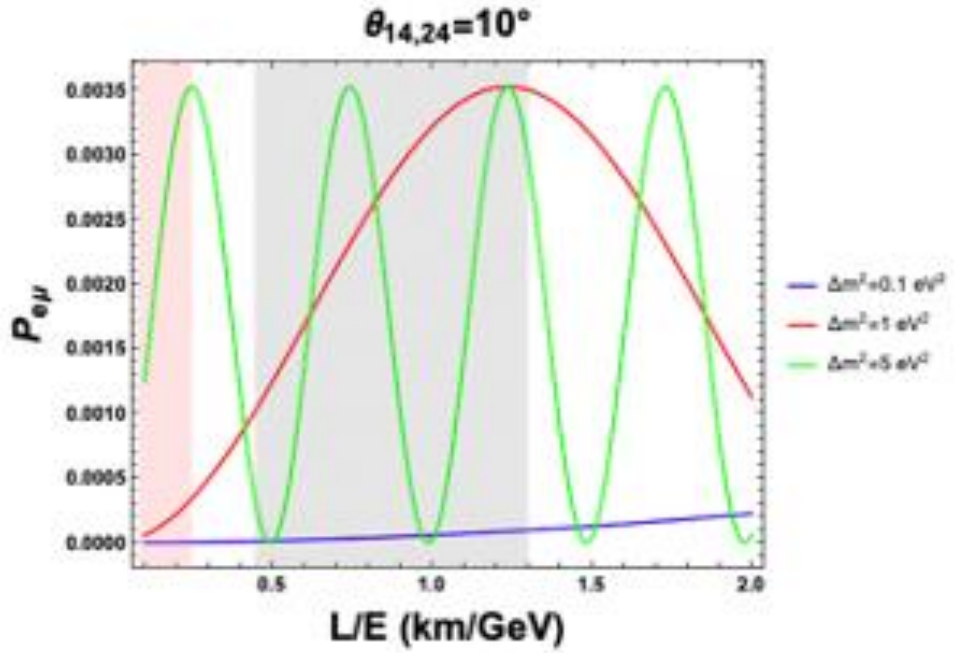
https://www-pub.iaea.org/MTCD/publications/PDF/cnpp2022/countryprofiles/Sweden/Sweden.htm

Sterile Neutrino

Studies being performed by RBI and Rome group

1st Annual Meeting: (i) Current status of sterile neutrinos were presented

(ii) Sensitivity at END and LEMMOND using the beams from ESS, LEMNB and LEnuSTORM was shown at the Probability level



Since then: (i) Fluxes are obtained for LEMNB from WP6

(ii) First sensitivity for 3+1 scenario has been estimated for LEMMOND using LEMNB

(iii) Study of effect of decay pipe is ongoing

This Meeting: Progress will be presented by Doris

Additional Physics Studies

Scalar NSI – RBI and KTH group

- 1st Annual Meeting: Results were presented
- Since then: Article has been published

J. Aguilar *et al.* [ESSnuSB], ``Study of nonstandard interactions mediated by a scalar field at the ESSnuSB experiment,'' Phys. Rev. D **109** (2024)

Decoherence – RBI and Rome group

- 1st Annual Meeting: Results were presented
- Since then: Article has been published

J. Aguilar *et al.* [ESSnuSB], ``Decoherence in neutrino oscillation at the ESSnuSB experiment,'' JHEP **08** (2024), 063

Long Range Force – RBI and Rome group

- 1st Annual Meeting: -
- Since then: Sensitivity has been estimated
- This Meeting: Progress will be presented by Alessio

Since Last Meeting

- Done: Scalar NSI and Decoherence papers has been published
- Ongoing: Progress has been made in atmospheric, supernova and sterile
- Initiated: Work on solar neutrinos and long range force has been initiated
- Long-term: Reactor and Geo for future

Publication Table

WP5 id	Title	Corresponding authors	Type of publication (WP or collaboration)	arXiv id	Journal name	DOI	Status
1	Study of non-standard interaction mediated by a scalar field at ESSnuSB experiment	William Brorsson, Sandhya Choubey, Monojit Ghosh and Deepak Raikwal	Collaboration	arXiv:2310.10749	Phys. Rev. D	10.1103/PhysRevD.109.115010	Published
2	Decoherence in neutrino oscillation at ESSnuSB experiment	Monojit Ghosh, Alessio Giarnetti, Aman Gupta and Davide Meloni	Collaboration	arXiv:2404.17559	JHEP	10.1007/JHEP08(2024)063	Published
3	Exploring atmospheric neutrino oscillations at ESSnuSB	Sandhya Choubey, Tommy Ohlsson and Sampsa Vihonen	Collaboration	arXiv: 2407.21663	JHEP		With the journal
4	Exploring Long-Range Force in Neutrino Oscillation at ESSnuSB Experiment	Monojit Ghosh, Alessio Giarnetti, Aman Gupta and Davide Meloni	Collaboration				In progress
5	Searching non-standard interactions with atmospheric neutrinos at ESSnuSB	Sandhya Choubey, Tommy Ohlsson and Sampsa Vihonen	Collaboration				In progress

Thank You