

KSETA report 2021

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This report summarizes my Ph.D. research progress from June 2021 to January 2022. This time period corresponds to part of the first year of my Ph.D. candidacy in Experimental Astroparticle Physics. I am working with the next generation experiment KATRIN which has been set up in Karlsruhe. The Karlsruhe Tritium Neutrino Experiment(KATRIN) is designed for the sensitivity to the effective mass of the electron antineutrino of $0.2\text{eV}/c^2$ (90% C.L). KATRIN will provide a completely model independent measurement of the ν -mass. My research keenly focuses on the analysis of neutrino mass and search for the sterile neutrino at the tail of the β decay spectrum. My research methodology is empirical and consists of three phases and I am standing at the very dawn of the phases. The detailed view of the phases and my progress are summarized below in chronological order.

The first phase is designed to get familiarised with the analysis framework and code base, which further extends to the Monte Carlo based generation and analysis of spectrum models. The second phase involves my active participation in measurement campaigns: neutrino-mass data-taking and calibration runs and analysis of measurement campaigns for sterile neutrinos. Here I plan for participating in publications of the measurement campaigns and combined analysis. During the third and final phase I will be working on the combined analysis of KATRIN data for sterile neutrinos with high statistics, including detailed assay of systematic uncertainties and finally write the PhD thesis.

I joined my work remotely from second week of June 2021 and got admitted to the winter semester on 30th June 2021. This is the point from where the first stage of my work begins. I started gathering a suite of information regarding KATRIN from the sources named below:-

- Direct neutrino mass determination from kinematic methods [1]
- Tritium beta-decay and neutrino mass, physics of the gaseous molecular tritium source of KATRIN, MAC-E filter spectroscopy method [2]
- Impact of sterile neutrinos on the beta-decay spectrum [3]
- Statistical methods used in the KATRIN analysis [4]

Till today I am continuing on vivid study of these papers and also spending a major part on my learning as well. I got a chance to attend the 8TH KSETA Plenary workshop 2021 virtually held from September 27-29,2021. All the talks were immensely informative and intriguing as well. I then attended the KSETA Topical Courses from October 11-15,2021 via zoom. I followed the detailed lectures on topics

- Broad introduction into modern experimental particle physics.
- Neutrino mass phenomenology
- Low-Temperature (Superconductive) Detectors.

I joined my work in person from 2nd December 2021. Currently I am gradually getting involved within the analysis framework and attending the regular group meetings and acquiring more knowledge on the analysis tools and softwares. I attended the virtual workshop on Neutrino-Nucleus Interactions in the Standard Model and Beyond at CERN which was quite helpful in broadening and in the advance of my knowledge in the concerned topics covered. This event was held from Jan 17-21,2022.

Next steps

The KATRIN experiment is in operation, after 17 years of construction. The creativity and care in its design are bearing fruit with a factor of 2 improved limit in only one month of data taking. So I am aiming to fully contribute my efforts and dedication in due course till it reaches its limit of sensitivity, either finding the neutrino mass or setting a limit in the vicinity of 0.2 eV. After following the group and the regular works I feel that I shall strengthen my basics and concepts of programming language, data analysis and statistical methods and Particle Physics in order to assist my team effectively. I have discussed the same with my supervisor, Prof Dr. Kathrin Valerius, who was kind to support and provide her consent on this proposal of mine. We are now looking for possible courses and classes fitting my interest where I can learn the aforesaid classes. We are also planning to get me some training with particle experiments and instrumentation. During this summer semester I will prioritize on my learning and building the skills that will make me contribute to the ongoing research of KATRIN more efficiently.

References

- [1] Joseph A. Formaggio, Andre Luiz C. de Gouvea, R. G. Hamish Robertson, Direct Measurements of Neutrino Mass, **Physics Reports** **914**, 1-54 (2021).
- [2] E. W. Otten, C. Weinheimer, Neutrino mass limit from tritium beta decay, **Rept. Prog. Phys.** **71** 086201 (2008).
- [3] M. Aker et al. (katrin-all), Bound on 3+1 active-sterile neutrino mixing from the first four-week science run of KATRIN, *Phys. Rev. Lett.* **126**, 091803 (2021).
- [4] M. Aker et al. (katrin-all), Direct Measurement of ν -mass, **Physical Review D**, Vol. **104**, No. **1**, 012005.