

Field Emission Sources for Astro-Particle Physics Projects

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ABSTRACT

Vacuum and cryogenics are technologies employed by various large-scale experiments in the field of astro-particle physics. Electron sources in vacuum are used for detector calibration with e-guns for mono-energetic electrons and other purposes. Electron rates from fA to mA are required. Here we report on three projects where arrays of field emission sources (FES) are investigated as alternative to the usually used hot filaments or UV light illuminating a thin layer of metal. Both techniques produce light and heat that can be a problem for cold, light sensitive particle detectors.

The first project is the Karlsruhe TRItium Neutrino (KATRIN) experiment [1], which aims to determine the mass of neutrinos from high-precision spectroscopy of electrons from tritium beta-decay. A FES based e-gun (20 keV) operated close to the light-sensitive SDD detector array is being developed.

The second project is the Einstein Telescope (ET), the next generation gravitational wave observatory being planned in Europe [2]. The UHV cryostats for the 10-K mirrors of the low frequency laser interferometers require very good vacuum conditions that produce less than one monolayer of ice per year on the cold mirror surfaces. This may require regular in-situ cleaning of the mirrors, best without producing stray light or excessive heat. A working group started developing FE-based electron emitters (200 eV) for this purpose.

The third experiment (XLZD) is a next generation Dark Matter (DM) detector using 60 to 80 tonnes of liquid Xe in a time-projection-chamber (TPC) to detect the elusive signal of hypothetical DM particles, so-called WIMPS. Electrons from Xe atoms ionized by a WIMP are drifted in an electric field through the liquid Xe. They can be captured by electro-negative impurities before reaching the detectors. Continuously removing any trace of radioactive isotopes as well as electro-negative molecules from the Xe is mandatory to reach the required sensitivity of less than one background event per year. The use of FE sources is investigated to improve the cleaning process of the Xe.

References

[1] KATRIN Collaboration et al., Science 388, 180–185 (2025)

[2] M. Branchesi et al., Science with the Einstein Telescope, JCAP07(2023)068

[3] XLZD Collaboration et al. The XLZD Design Book, Eur. Phys. J. C 85, 1192 (2025).