

Penning discharges in the KATRIN prespectrometer

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The KATRIN pre-spectrometer is a MAC-E filter (electrostatic spectrometer with magnetic adiabatic collimation), with the purpose of reducing the background in the KATRIN neutrino mass experiment. First investigations with this spectrometer showed the presence of strong Penning discharges, exhibiting increase of pressure inside of the pre-spectrometer and of power supply leakage current, even for rather small vessel potential and magnetic field. Calculations showed the presence of deep Penning traps at the two end-regions of the prespectrometer, close to the ground electrodes. Experiments indicated a clear correlation between the deepness of the Penning traps and the strength of the discharge; using electrode configurations without Penning traps no discharge was observed. In order to get rid of the deep Penning traps, new shielding electrodes and new ground electrodes were designed, constructed and installed into the spectrometer. The presence of these shielding (antipenning) electrodes solved the strong Penning discharge problem.

Nevertheless, a weaker Penning discharge at higher magnetic field was still present in the KATRIN prespectrometer. The field calculations showed the presence of small size Penning traps at the end of the new ground electrodes, and these traps were responsible for the weak Penning discharges. After removing these small-size Penning traps (with specially designed and constructed ground electrodes), also the weak Penning discharge in the prespectrometer disappeared, and the background level of the prespectrometer decreased by 5 orders of magnitude.

The experiences obtained with the pre-spectrometer were very important in order to avoid Penning discharges inside the KATRIN main spectrometer and at the detector system.