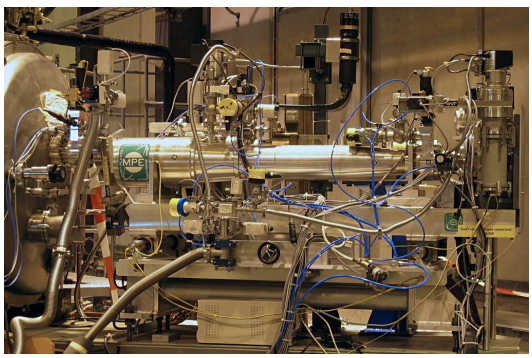
CAST – CERN Axion Solar Telescope

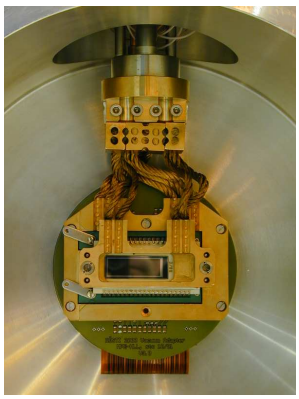
With the CERN Axion Solar Telescope – CAST – we use a prototype LHC superconducting dipole magnet to search for a hypothetical pseudoscalar particle, the axion. The axion is with the neutralino one of the leading dark matter candidates. Based on data acquired in 2003 we set a new upper limit on the axion to photon coupling constant.

A possible axion source is the innermost core of the Sun where axions can be produced via Primakoff effect. With the CAST experiment at CERN (European Organization for Nuclear Research), we search for such solar axions, using a $L = 9.3\,\mathrm{m}$ long and $B = 9.0\,\mathrm{T}$ strong superconducting LHC prototype magnet providing a homogeneous transversal magnetic field to convert axions to observable X-ray photons via inverse Primakoff effect. The resulting photons are expected to be thermally distributed in the energy range of 1–$7\,\mathrm{keV}$ with a mean energy of $4.2\,\mathrm{keV}$ and can be observed with conventional X-ray detectors. The tracking system of CAST allows us to follow the Sun with the magnet for $1.5\,\mathrm{h}$ during sunrise and sunset. Due to the higher sensitivity of the CAST experiment compared to earlier experiments, we were already able to improve existing upper limits on the axion photon coupling constant $g_{a\gamma\gamma} \propto (BL)^{-1/2}\, t^{-1/8}\, b^{1/8}$ by a factor of ≈ 5 for axion masses $10^{-2}\,\mathrm{eV} < m_\mathrm{a} < 0.2\,\mathrm{eV}$ based on data acquired in 2003. In the second phase of CAST planned for 2005–2007, we will expand the sensitivity of CAST to higher axion masses $m_\mathrm{a} > 0.2\,\mathrm{eV}$ by filling the magnet tubes with a buffer gas. This will allow us to scan the parameter space favored by theoretical axion models for the first time.



Left: The X-ray telescope and the pn-CCD detector in operation at the superconducting magnet at CERN.

Right: The pn-CCD detector located in the focal plane of the X-ray telescope.



As the most sensitive detector system of CAST, we developed a Wolter I type grazing incidence X-ray mirror optics which was originally designed as a prototype for the German X-ray satellite ABRIXAS. The pn-CCD detector located in the focal plane of the X-ray telescope is a prototype of the fully depleted EPIC pn-CCD on-board of ESA's XMM-Newton mission which was developed at the MPI Halbleiterlabor. The detector is optimized for low background application by passive shielding and improved software rejection techniques. The combination of a focusing optics and a detector with high spatial and spectral resolution, improves the signal to background ratio of the CAST experiment by a factor of ≈ 200 compared to a detector system without optics.

The MPE/MPI CAST Team