Development of a cryogenic x-ray detector and an application for kaon mass measurement

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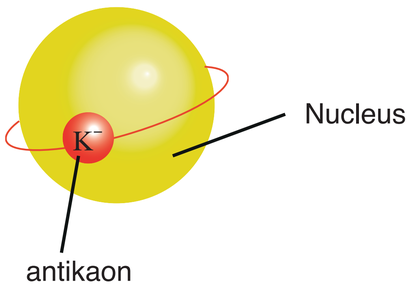
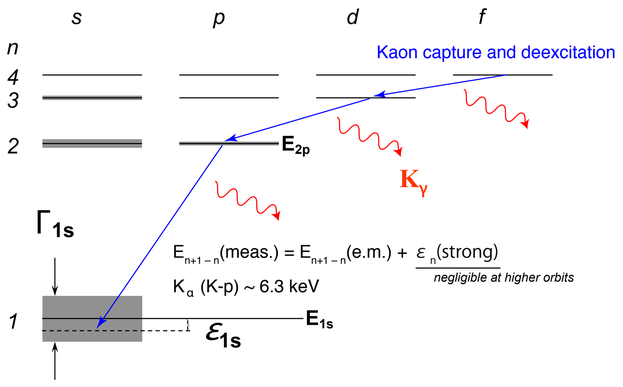
Kaonic Atoms

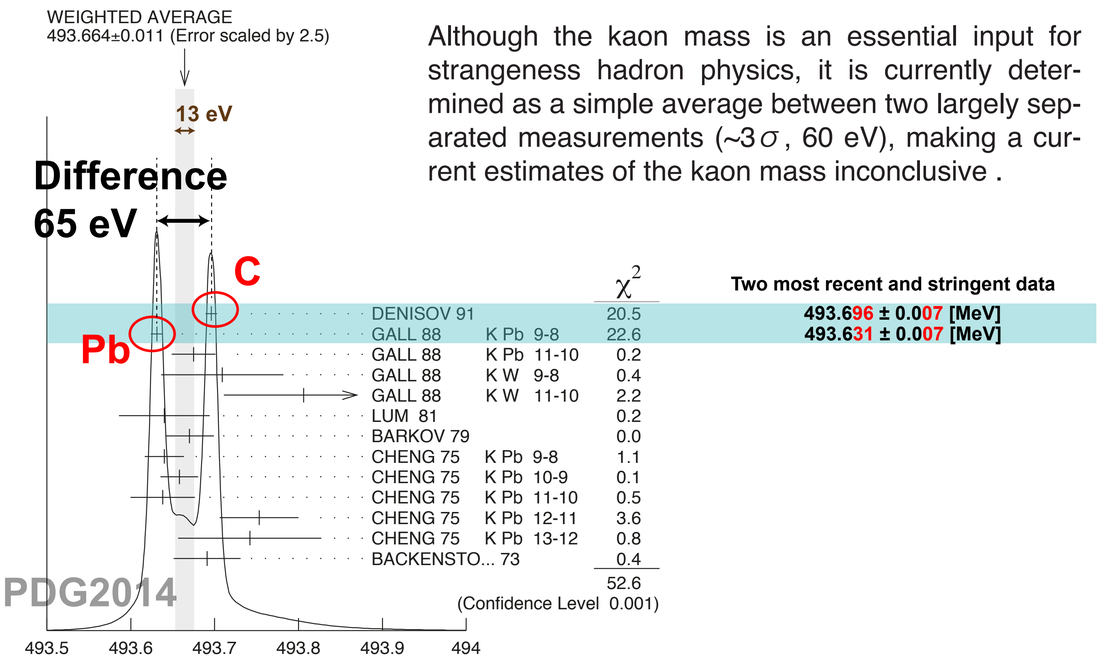


X-ray spectroscopy of kaonic atoms is an excellent tool for studying the chiral symmetry breaking with strange quarks. Kaonic atoms are QED bound systems in which the heavier, negative kaon replaces an electron. Studies of exotic mesonic atoms have provided important information on strong interaction (hadron) physics.

The negatively charged kaon is bound by the Coulomb interaction at higher orbit but also effected by the strong interaction at lower energies.



Kaon Mass



Although the kaon mass is an essential input for strangeness hadron physics, it is currently determined as a simple average between two largely separated measurements (~3σ, 60 eV), making a current estimates of the kaon mass inconclusive .

Two most recent and stringent data

493.696 ± 0.007 [MeV]
493.631 ± 0.007 [MeV]

Detector

μ-calorimeters with magnetic penetration thermometers (MPT):

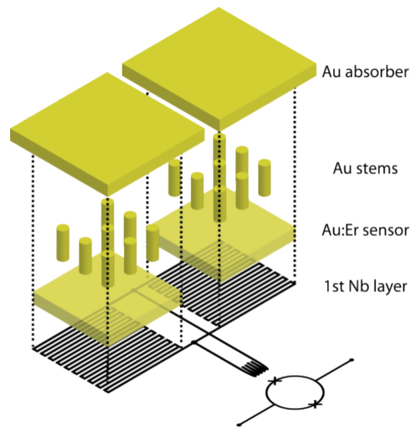
Replace paramagnetic T-sensor with superconductor with low Tc

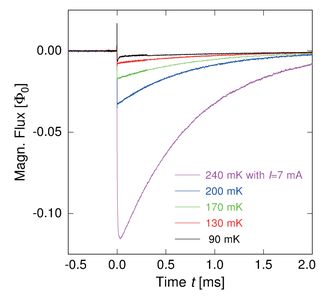
Use T-dependent flux penetration as thermometer

Compared to MMCs, MPTs offer 10 times larger T-sensitivity,

smaller sensor heat capacity at higher temperatures,

larger noise margin for multiplexing …





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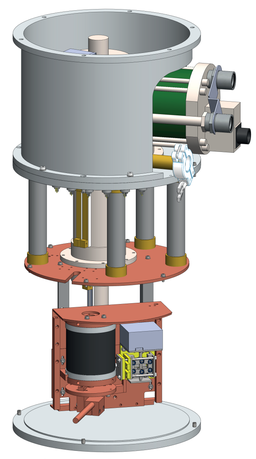
Cryostat

A cryostat especially designed for use with LTDs is being constructed. Based on a GM-4K cooler and a single-stage ADR, it will be usable at temperatures between 1K and 30mK.

A high-level of integration, new heat-switch, magnet and electronics designs should make the cryostat robust, reliable and very easy to use.



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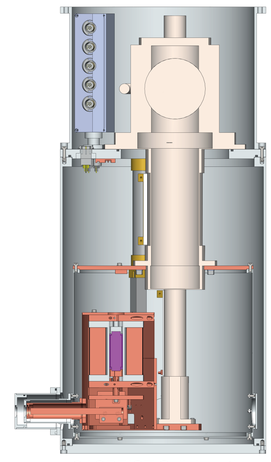

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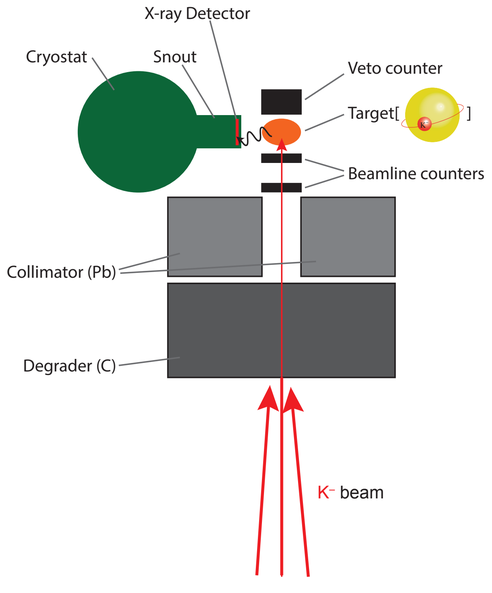
Experiment

At the Stefan Meyer Institute, we plan to use the detector system to make an improved measurement of the mass of the kaon.

We will be testing various designs of cryogenic detectors working at 500mK with a view to achieving the necessary resolution at ~10 keV x-ray energies created in kaonic atoms.

Later stages of the project should see lower temperatures and higher resolutions, with improved count rates in an optimised experimental set-up.

Kaon beam is to be provided by the J-PARC (Tokai, Japan) or DAΦNE (Frascati, Italy) facility.



ASPE!CT Collaboration

The ASPE!CT project is a collaboration of industrial and research companies, and the Stefan Meyer Institute in Vienna. We are developing a commercially viable, cryogenic detector platform. The first phase of the project will produce a cryogen-free, single-stage, adiabatic demagnetisation refrigerator for use at sub-Kelvin temperatures. The project aims to advance the technology into the realm of reliable, compact, black-box, touch-button devices, which can be used for a wide range of cryogenics sensors. Later stages of the project will push the temperature range to 30mK, and introduce continuous, high-power, low-temperature cooling.