CASCADE-U

A 10-Boron based high count-rate area detector for UCN

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Modern Challenges to Ultra Cold Neutron Detector Technology

Ultra Cold Neutrons (UCN) have developed during the past decades to be popular probes for experiments of the low energy, precision type, targeting fundamental physics interactions. New, modern measurements have been proposed, which all rely upon very high density, modern UCN-sources with up to 1000 UCN/cm^3. Once such sources with fifty- to one hundred-fold higher density than current highest intensity source (ILL, PF2) will be available, modern detection devices with the respective rate-capabilities as well as 2-dimensional resolution will be needed.

With a future EDM-experiment at PSI in mind, we adapted the CASCADE neutron detector for the application as an UCN-detector (CASCADE-U). In spite of the fact that UCN sources provide a beam of unusually large divergence and any experimental data is expected to show quite little spatial structure (the beam-line could rather be seen as a tube emitting UCN gas), detection with spatial resolution can and will be a valuable tool in UCN experiments and was thus included. It will allow to analyze data with respect to beam homogeneity as well as beam divergence and to discriminate against halo-effects. Likewise in ultra low intensity applications, spatial information will further allow to realize in-situ background and border effect analysis.

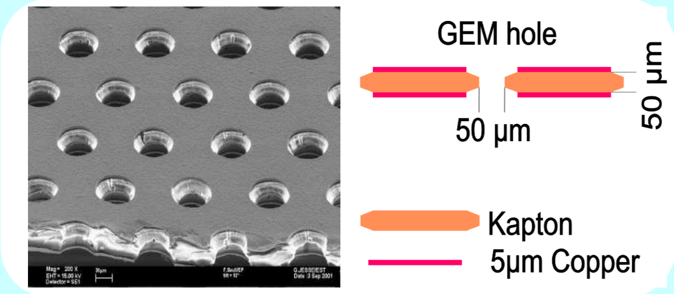
For detailed information about the detector principle: please look at our homepage under **www.n-cascade.com**.

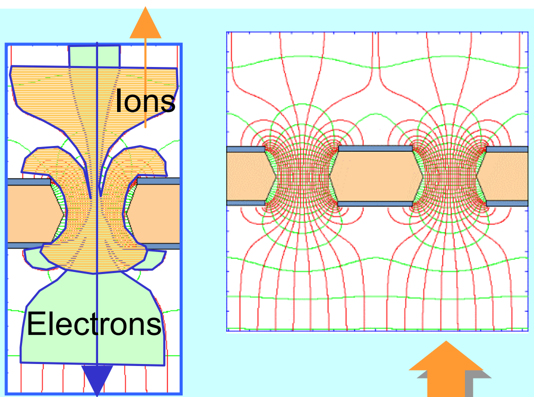
CASCADE-U detector concept

It is a hybrid, solid converter gas detector. The detector has the conceptual advantage of inherent high count-rate capability, insensitivity to magnetic fields, minimal sensitivity to thermal neutron- as well as gamma-background (always present at UCN-sources), high robustness and finally a charge detection mechanism independent of the neutron converter, giving an overall low operating pressure and thus allowing to minimize detector window thickness. UCN-detection efficiency (meaning the probability that an incoming UCN will traverse the window and be detected) can thus be found as high as 90%.

The detector was layed-out for a sensitive area of 100x100 mm^2. It is contained in a detector housing filled with counting gas. UCN enter through a thin entrance window made of pure Aluminum, which is actually employed as drift electrode also. An enhanced detection efficiency for UCN is thus achieved, as the material load as well as the number of humidity coated surfaces and interfaces, that may cause severe up-scattering or UCN absorption, is greatly reduced. The drift electrode is coated with a layer of ^{10}B, the solid neutron converter. It is followed by the converter gap of 2-8 mm width, a GEM-foil, the transfer gap and finally a readout electrode, pixilated into 8 x 8 square fields of 12 mm width each. The entire detector is filled with a counting gas adapted to minimizing UCN-interaction.

GAS Electron Multiplier (GEM) invented by CERN: http://cern.ch/gem

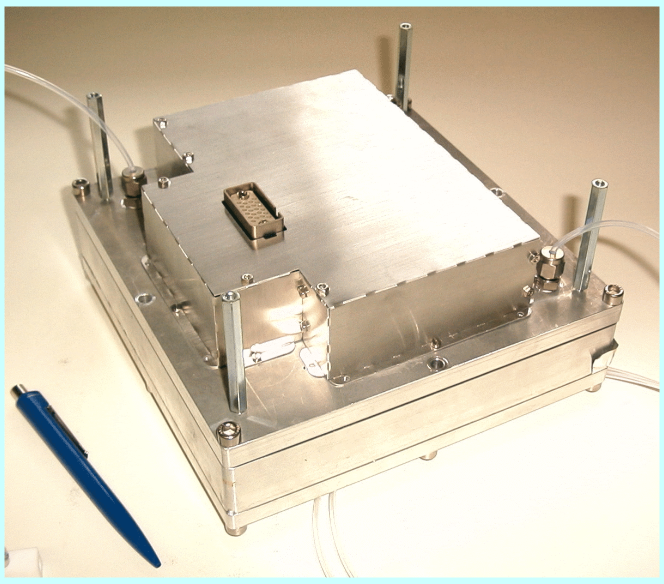




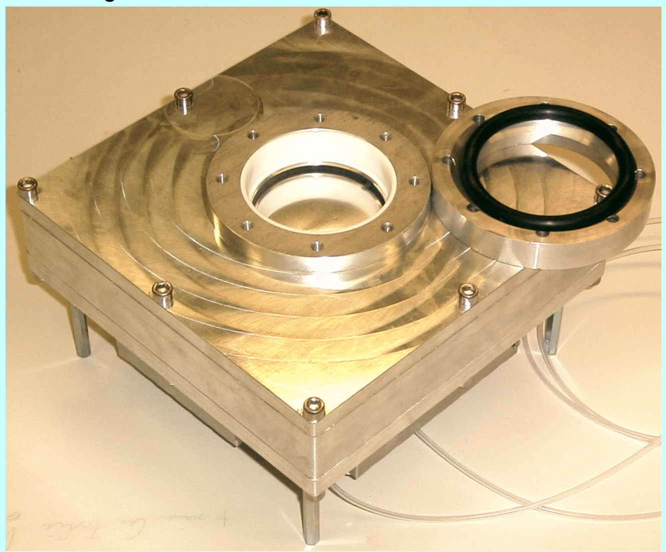
field lines in a GEM hole, pictures by Sauli (CERN)

GEM-Technology

Bottom-flange with shielding of the readout electronics



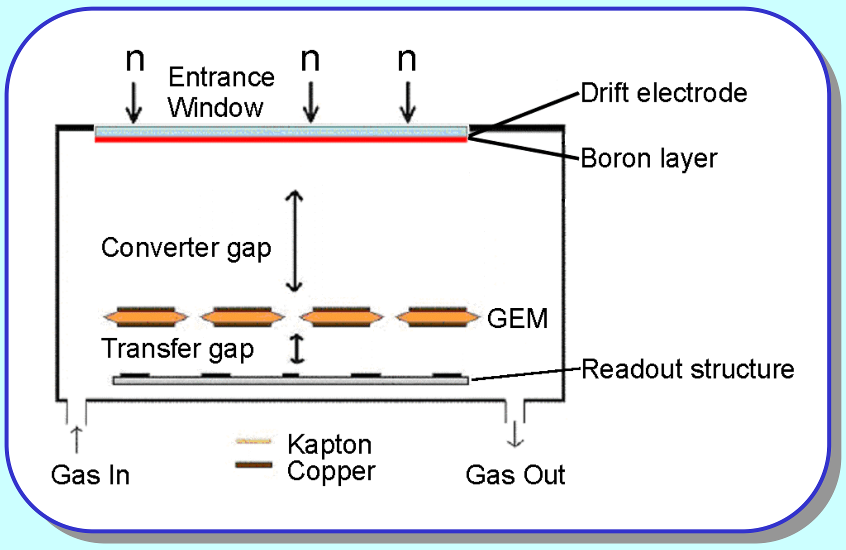
Top-flange with Teflon insulating ring and special Wilson-flange designed to fit the test beam at PF2/ILL, Grenoble



Design

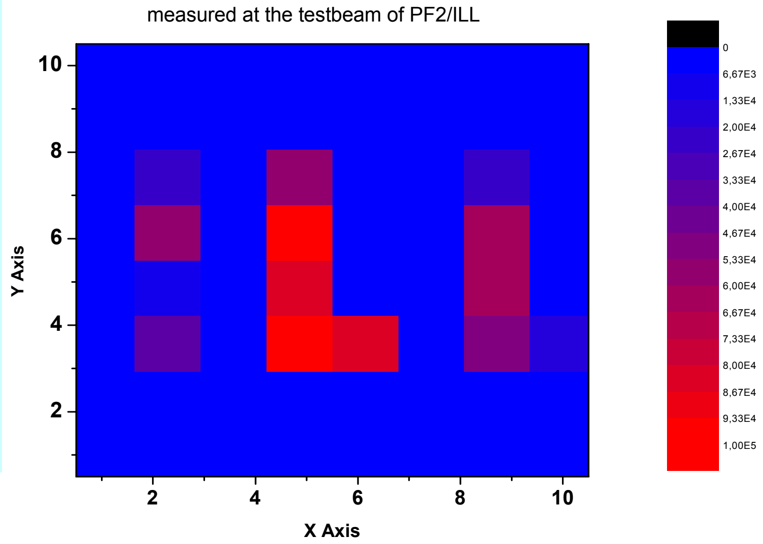
- **Competitive Efficiency** of up to 90% for ultra cold neutrons (4-8 m/s).
- **High count rate capacity** up to 10^7 n/cm^{2}s due to the micro-structured GEM-foils.
- **No γ-background:** Low Z converter material ^{10}B, high energy of α can easy be detected.
- **Long term stability** due to continuous purge of cheap counting gas through detector.
- **Potential for 10µs time resolution.**
- **Position sensitive readout** with 1.2 x 1.2 cm^2 pixel size, variable for customized solutions.

Features



2D position sensitive

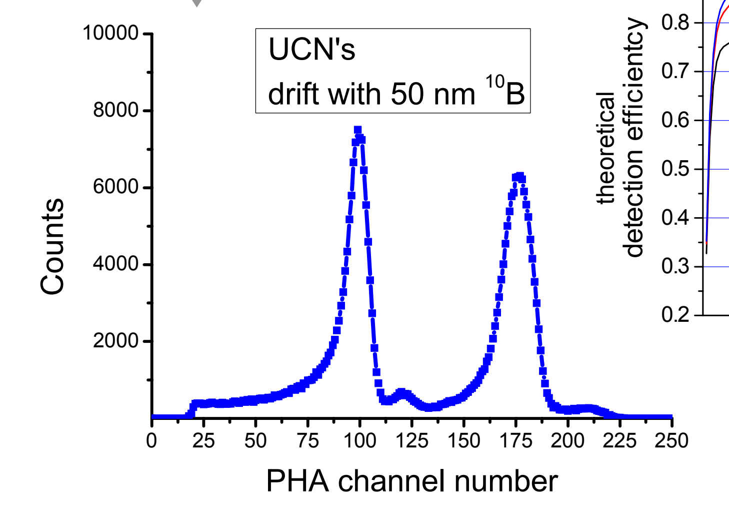
measured at the testbeam of PF2/ILL

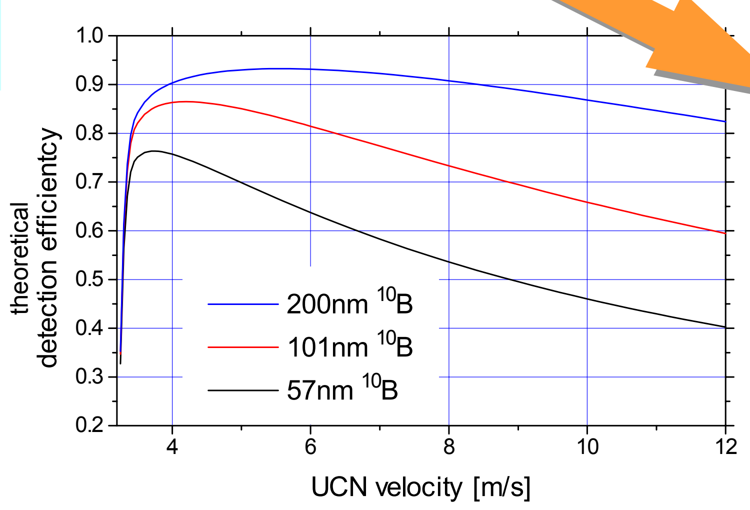


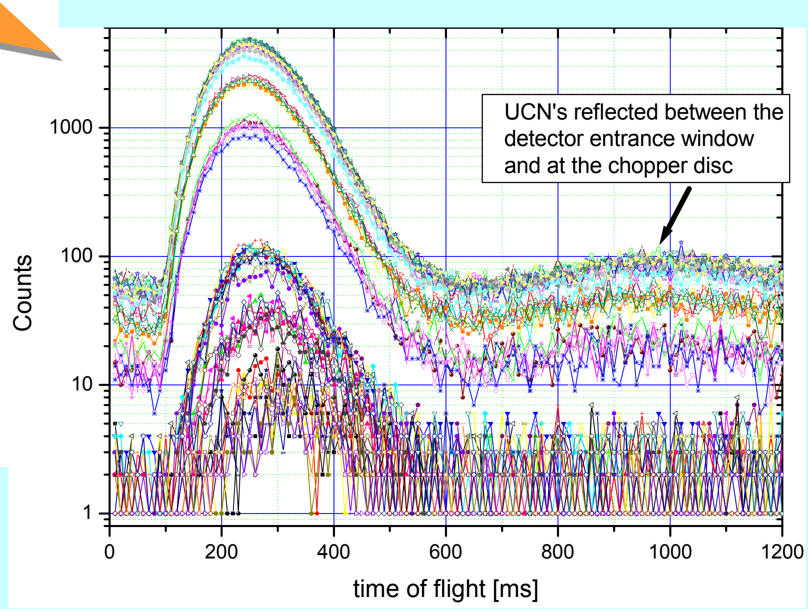
TOF simultaneously on all channels

PHA

Efficiency







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