Boron Detectors - alternatives to ^{3}He tubes

CASCADE - a high resolution time-of-flight detector

The CASCADE detector [1] was developed by the Heidelberg instrumentation group, which aims for the development of novel systems for neutron detection, especially in the field of Neutron Resonance Spin Echo (NRSE) techniques. The counting tube technology was put aside, replaced by solid sate neutron converters, of which pure Boron-10 exposed best features.
To overcome the firsthand limitations of a all-solid converter material it was mandatory to set up a system combining different new technologies. The benefits reveal in a high rate capability up to the MHz range, negligible low gamma sensitivity, a x/y spatial resolution of 2.5 mm and z-resolution (time-of-flight) far below 100 µm. For a stack of eight layers an efficiency of about 60% can be reached at 5 Angstroms.

A closer view inside ----------

Boron converts neutrons by inducing an alpha decay releasing a charged particle, having a range of only a few micrometers in the solid. Therefore the medium explicitly has to be thin, decreasing the detection probability of such a single layer to considerably low values. CASCADE now is the principle of stacking several of these layers on top of one another. This requires a substrate for the converter being transparent for charge and this is fulfilled by the Gas Electron Multiplier (GEM) technology - thin foils of a perforated insulator coated on both sides with copper. A precisely adaptable voltage applied between both sides will lead to charge multiplication[1] for those electrons entering the holes. The charge then drifts towards the readout with its pixel size of 1.6 mm.

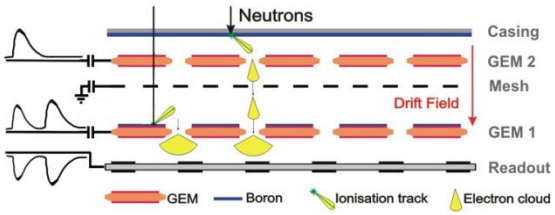

Fig. 1: Schematic cross section of a cascade detector

Furthermore, to locate the exact layer the neutron converted in, the mirror charge induced by the electron cloud traversing the stack is measured. Due to the large energy deposit of the alpha decay, the neutron signal can be discriminated against any background.

Applications ----------

Following the demands of advanced neutron scattering techniques, CASCADE is able to detect high frequent intensity modulations, a prerequisite for going beyond standard sample interaction times [2]. Spectrometers like RESEDA and MIRA at the FRM II are already equipped with a CASCADE installation.

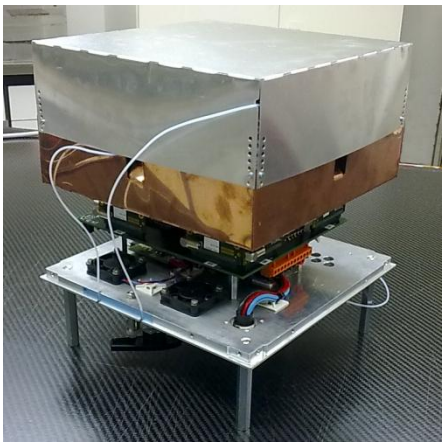

Fig. 2: A bare CASCADE system in 20x20 cm^2 with active detection volume (aluminum cover) and readout electronics (below)

References:

[1] M. Klein, C.J. Schmidt, "*CASCADE, neutron detectors for highest count rates in combination with ASIC/FPGA based readout electronics*", Nucl. Instr. and Meth. A 628 (2011) 9-18

[2] W. Häußler et al., "*Detection of high frequency intensity oscillations at RESEDA using the CASCADE detector",* J. Phys.: Conf. Ser. 251 012067 (2010)

[1] operation in any standard counting gas (mixture)