The CASCADE Neutron Detector:
The Large Area, Position Sensitive Detector Solution, Capable to Cope with SNS Count Rates and Sub-µs Timing Requirements

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Is there a detector crisis?

Modern spallation neutron sources like the SNS will provide an immense neutron flux that concentrates today`s strongest neutron flux at ILL/Grenoble in short, periodic pulses. The time structure calls for exploitation in time of flight measurements (TOF), where never-heard-of studies will be feasible at intensities higher by up to three orders of magnitude.

Nevertheless, intensity as well as time structure post an enormous challenge on neutron detection devices, for currently employed technology is by far inadequate for coping with the proposed specs, where allready in practice to date, many instruments operate with beam attenuators of some kind or another.

With the SNS in operation, high intensity Debeye-Scherrer rings, to give a vivid picture, will sweep over detectors with every pulse. If the SNS and equally well the JSNS or ESS are to be exploited along the lines of all the propositions that served to justify the public investment, enormous advances in neutron detection technology need to be realized in the near future.

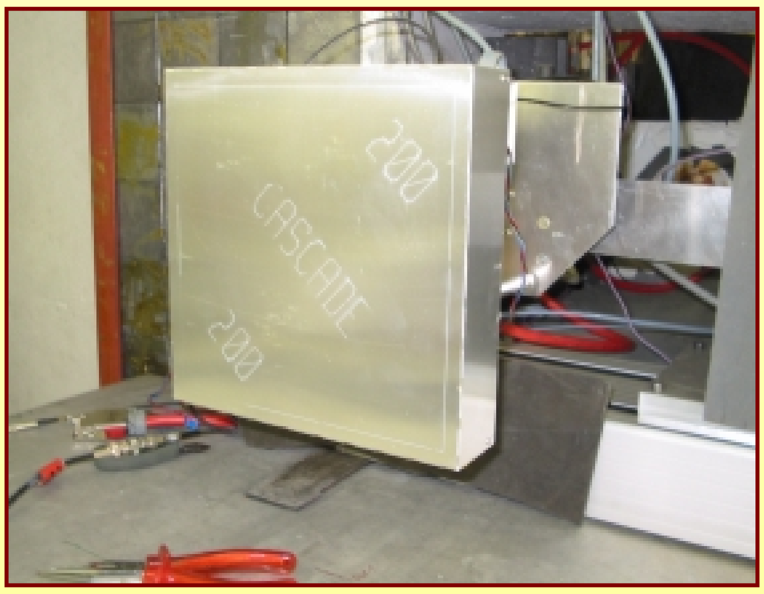
CASCADE is a solution!

The CASCADE detector is a GEM-based hybrid solid converter gas detector. GEM-technology inherently provides a rate capacity on the order of 10^7 Hz/cm^2. The GEM is operated in a mode transparent for charges. It serves as the perfect substrate for the solid converter, allowing to cascade several converter layers one behind the other without loss of position information.

This concept results in an entirely disentangled neutron detection scheme: Neutron cnversion, charge transport and amplification as well as charge collection result to be entirely independent processes. In consequence, an enormous technical advantage over current detector technology is at free universal disposition for specialized applications.

The neutron detection bottleneck shifts to data read-out electronics and its bandwidth. High energy physics has allready been there, and we can learn how to approach and solve this challenge:

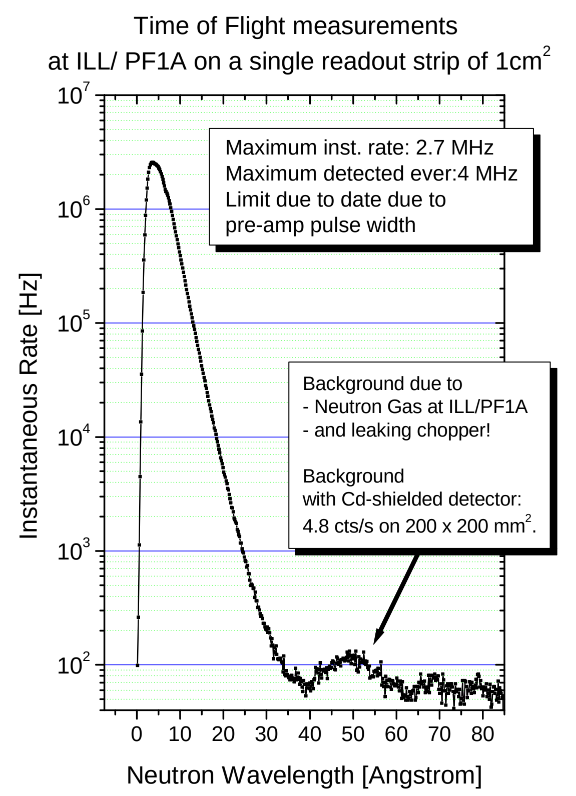
Highly integrated ASIC-technology allows to realize thousands of individual detection channels at non-proportional cost. We are the first to have transferred ASIC-technology from high energy physics to neutron detection. Rate capacity can be realized according to need through the ASIC electronic front-end.



Current Size 200x200mm²

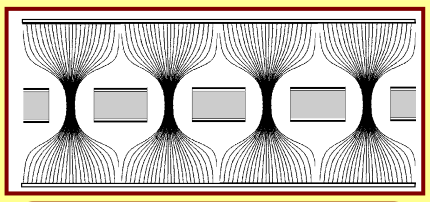
Features:

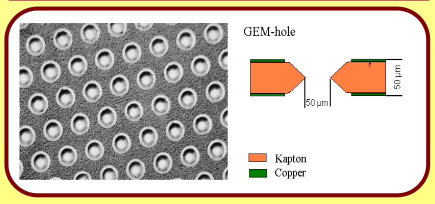
- Operation at ambient pressure gives lightweight detectors:
  - thin window, e.g. < 500µm Aluminum
  - large sensitive area (300 x 300 mm² with < 15% blind area)
  - easy and quick to service, detector service within 2h!
- The cascade of Boron-10 coated GEM-foils allows detection efficiency of 50% for thermal neutrons (1.8 Å), up to 80% for cold neutrons.
- Spatial resolution approx 3 mm, down to 1mm for customized solutions
- Micro structured GEM-foils provide count rate capacity up to 10^7 n/cm²s
- Low Z converter material (^{10}B), high energy of charged conversion products together with the property of being a gas detector, makes the CASCADE-detector insensitive to γ-background.
- Continuous purge of cheap counting gas avoids ageing effects encountered in other detectors. This translates to long term stability as well as long lifetime.
- Potential for sub-µs time resolution, opening the door towards new TOF applications.
- Highly integrated ASIC front-end
- Quick adaptation to application through FPGA data processing

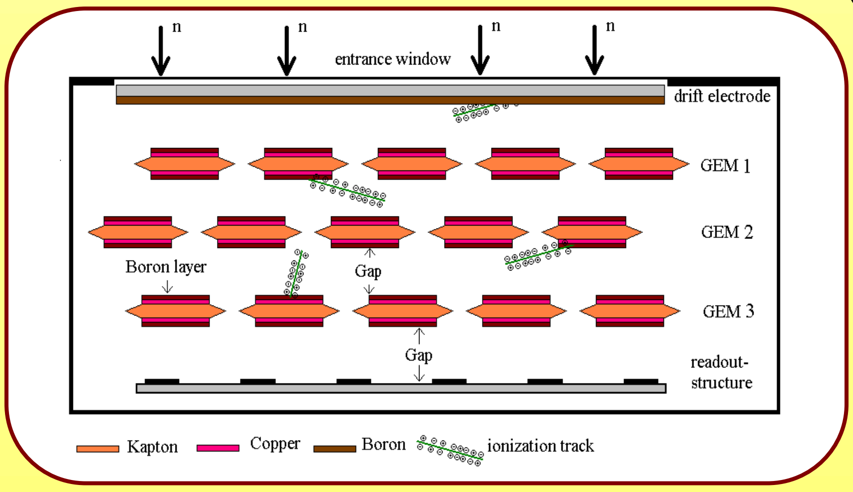


Rate Capability

GEM-Technology







Timing Res.

Localize point of conversion through signal on each GEM

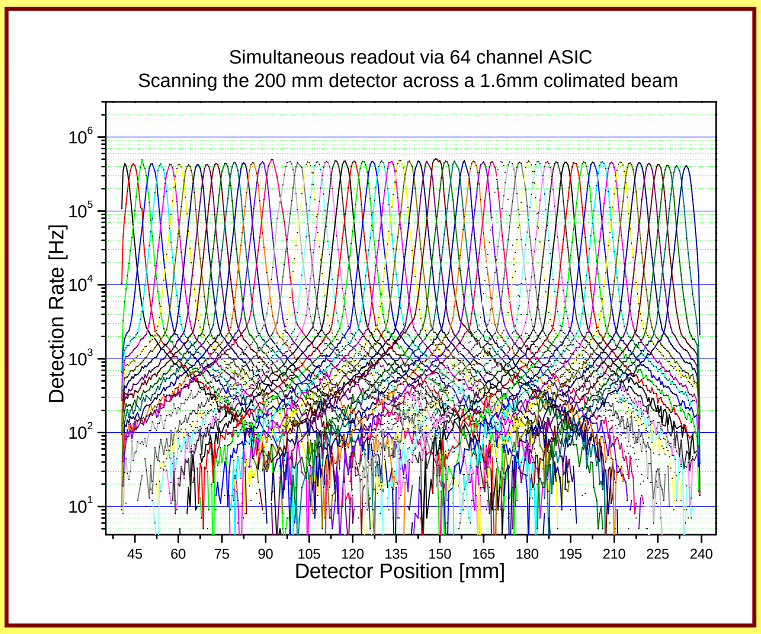
Experimental proof to be realized.

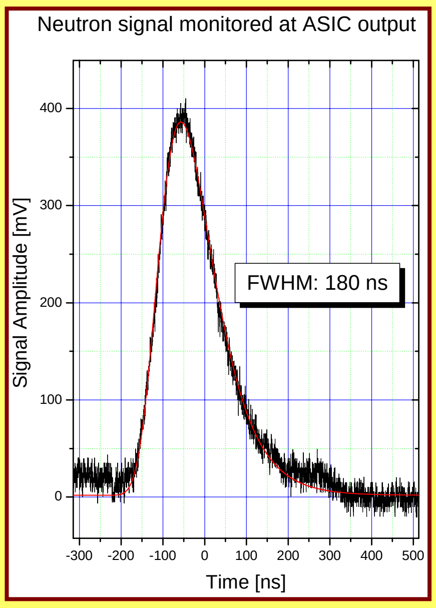
$\Delta t = \Delta s/v < 1\mu s$

64-Channel ASIC Readout

Signal

Modularly Scaleable, Industrially Manufactureable, Robust and Serviceable





CASCADE is a modular concept which allows customized solutions to best suit specific application needs in terms of

- Sensitive Area
- Count Rate Capacity -> Readout Electronics
- Timing Resolution

CASCADE is developed to allow for large scale industrial production…
for SNS, a prototype is not enough!

CASCADE is robust! All prototypes have proven to operate immediately after construction and transport to a neutron source. Two hour exposure to a capture flux of ~ 5×10^9 cm^{-2} s^{-1} yielded the detector operational.

CASCADE can be serviced with negligible down-time:
On test campaigns, the detector was frequently opened, GEM modules were removed or interchanged and reassembled with a down-time of less than two hours.

To do: Prove GEM-readout for timing experimentally, realize x-y readout, set up 64-channel simultaneous TOF, integrate second option ASIC, expand size to 300x300 mm², explore high bandwidth data bus systems, realize optical data link, transfer to large area Boron coating process