Report on the activity in WP22 at the ILL until April 2010

Tasks 22.2.3 & 22.2.4

MSGC-GSPC: a high resolution and fast n-detectors for neutron reflectometry

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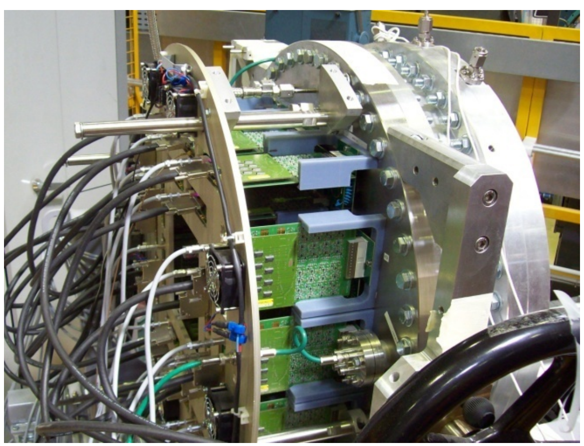
State of the art: gas detectors

MWPC/charge division @ BNL → Resol 0.5 mm / Area: 5 cm x 5 cm (ratio 1%)

MSGC/charge division @ Tokyo University → Resol 0.6 mm / Area: 3 cm x 3 cm (ratio 2%)

MILAND (MWPC/parallel readout) @ D16/ILL→ Resol 1.4 mm / Area: 32 cm x 32 cm (ratio 0.4%)

MILAND (MWPC with 1 mm anode pitch, 5 mm gap, 15 bars pressure) is the best detector in terms of spatial resolution relative to the surface area (which is the useful parameter)
Global counting rate is 0.7 MHz @ 10% dead time correction
Local counting rate is ~ 5-10 kHz/mm^2, limited by space charge effect and pile-up effect



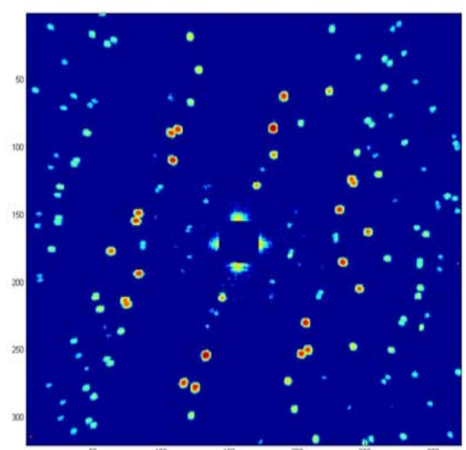


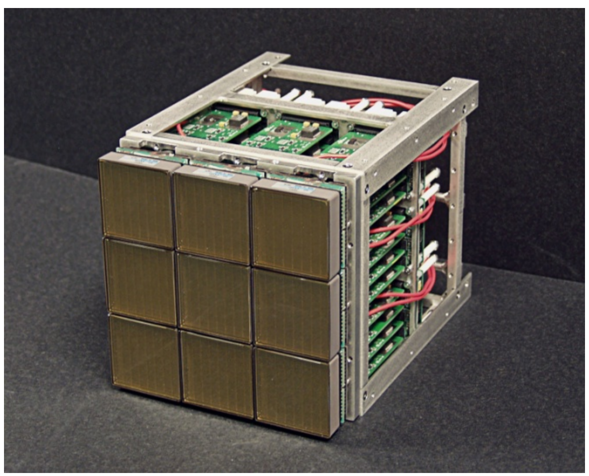
Image obtained on the D16 instrument with a lysozyme crystal, by superimposing images obtained during an angular scan

State of the art: solid scintillators

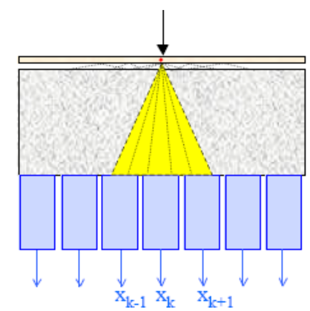
1.3 mm resolution has been measured at SNS with an Anger camera and a GS20 scintillator.

Unlike a gas detector this detector is not limited in size, and do not suffer from parallax.

The GS20 is reasonably fast (200 ns decay time), and much easier to handle compared to a GSPC.



Active area: 15cm x 15cm
Scintillator: 2mm GS20 Li glass
PMT H8500: 64 anodes of 6mm x 6mm
Pixels gain compensated



Improving the resolution would require a scintillator producing more photons per neutron : not yet available.

For neutron reflectometers, there is a need for detectors with 20 cm x 20 cm sensitive area with improved spatial resolution and local count rate.

See for example energy analysis optical systems planned in task 17.2 of the neutron optics JRA in NMI3.

Our goal is to demonstrate the feasibility of a detector with the following performances:

- Resol 0.5 mm / Area 20 cm x 20 cm (ratio 0.25%)

- Counting rate > 10 kHz (local) / 1 MHz (global)

^{3}He footprint

The total volume of ^{3}He used in the full size detector will be of the order of 30 liters

BF_3 substitution can't be envisaged due to the high pressure needed

Technical choice (why a MSGC-GSPC ?)

• Integrating devices (Image plate, CCD) provide very good spatial resolution, but are gamma sensitive and do not provide TOF Information

• Silicon detectors have a low efficiency

Gas detectors are limited in position resolution by :
- particle range in the gas → Require High quenching gas pressure
- parallax effect → Require High 3He pressure and/or long distance to sample
- distance between electrodes → Micro-pattern detector (GEM, MSGC, Micromegas)

… and in counting rate by :
- electronics readout → Readout with PMTs of light emitted during gas avalanches induced by neutron interaction →faster signals compared to charge signal
- space charge effect → Micro-pattern detectors are known for their high count rate performance

MSGC is the only Micro-pattern detector that has demonstrated stable operation at high quenching gas pressure

MSGCs allow very small electrode pitch, typically 0.5 mm on a size of 20 cm x 20 cm.

MSGC-GSPC principle

Light readout

- The avalanche scintillation light produced by each neutron on the anodes of the MSGC is measured with a matrix of PMTs.

- Standard PMTs (not UV sensitive) will be used to minimize the detector cost (~100 PMTs needed for a full size 20cm x 20 cm detector)

-The center of gravity will be processed online electronically with FPGAs circuits.

Pressure vessel

- 6 bars of CF_4 must be added to 4 bars of ^3He in order to achieve 0.5 mm resolution

- The high pressure of CF_4 helps to reduce the dead time and thus to maximize the count rate capability (expected <dead time >~50 ns)

- The glass window will be reinforced with a thick flange to support the 10 bars internal pressure. This flange will have holes to insert PMTs in contact with the window.

- The electron time collection must be minimized with a high drift electric field. One important objective of task 22.2.4 is to develop a drift electrode which sustain several +kV

Measurements

Parallel charge division MSGC200

Counting rate; ageing effect; resolution along the anode strip

MSGC80 coupled to 4 PMTs

MSGC: 80 mm x 80 mm, 1 mm pitch, virtual cathode

No beam available for position measurements

→ Primary and secondary light study

MSGC500

MSGC: 90 mm x 90 mm, 0.5 mm pitch, Anode-cathode on the front

→ Primary and secondary light study

4 PMTs

Mask measurements with a ZnS scintil (+simulation)

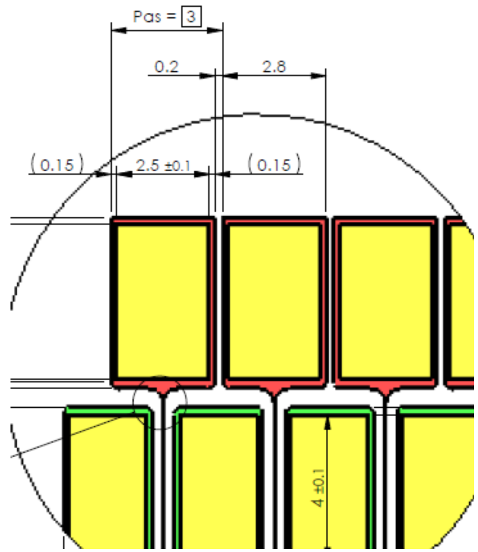
Task 22.2.3: Measurement with the parallel charge division MSGC200

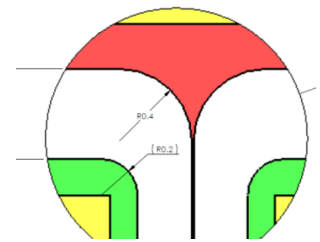
The ILL is developing a new MSGC (MSGC200) operating with a parallel charge division readout.

<u>Principle</u>:

Each anode is readout individually on both ends for position measurement

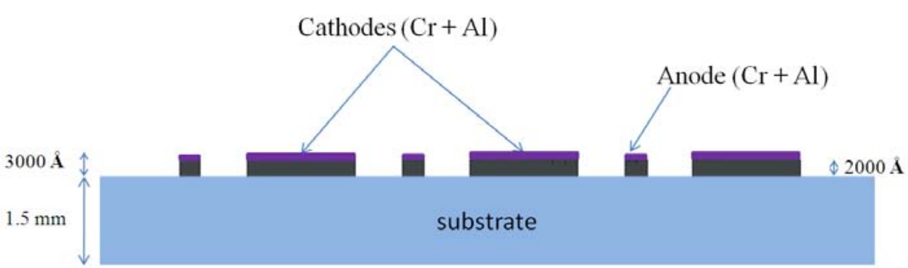
If 2 neighbouring anodes are fired simultaneously, the signals are summed

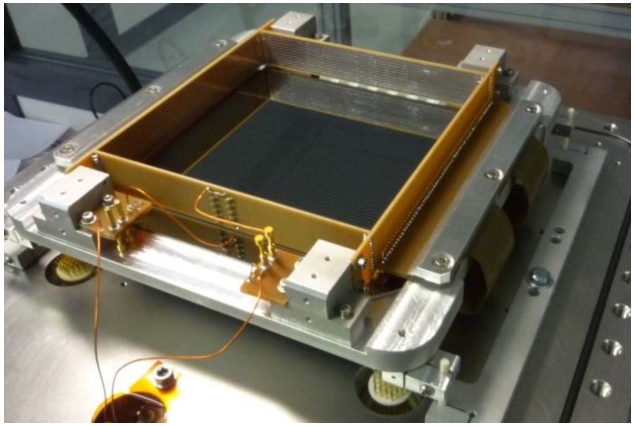




3 mm pitch

Al on top of the anodes (to reduce resistivity)



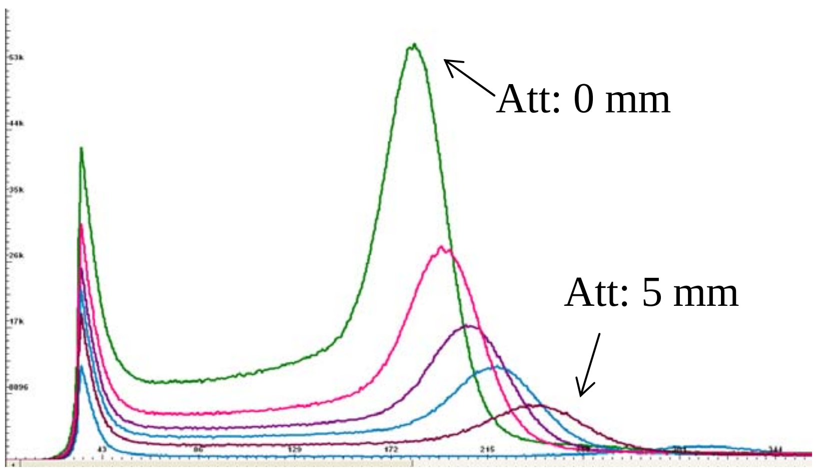


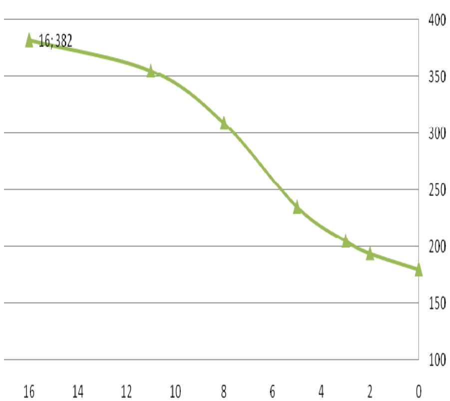
This detector may find applications where a resolution of 0.5 mm is needed only in one direction and a few mm in the other direction

Task 22.2.3: Measurement with the parallel charge division MSGC200

Count rate Measurements on one anode

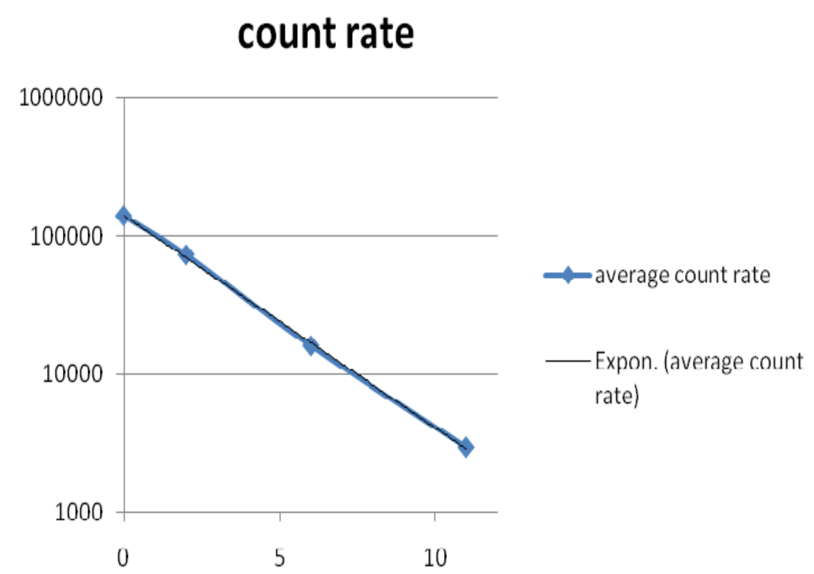
Direct Beam
~ 22.19k Hz/mm





Amplification gain versus neutron flux

Plexiglass of different thickness are used to attenuate the beam

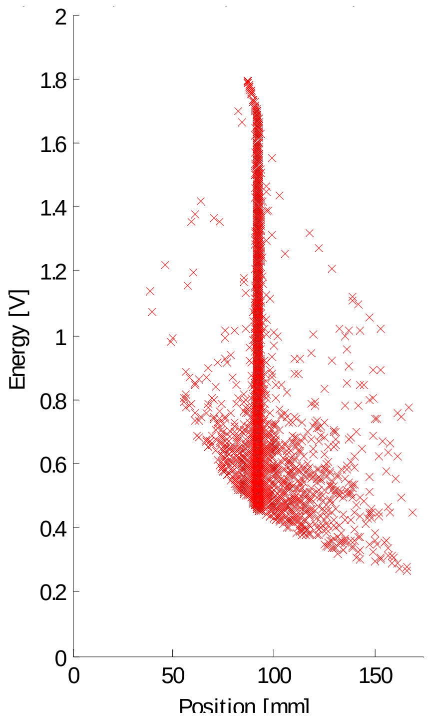


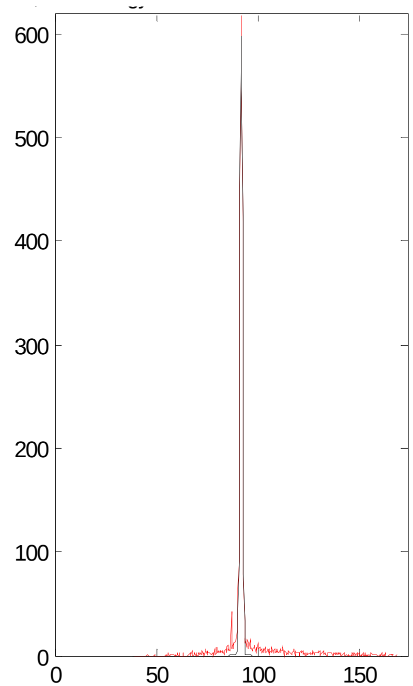
The detector supports more than 100 kHz without efficiency losses
(slit perpendicular to the anode, 2 mm width)

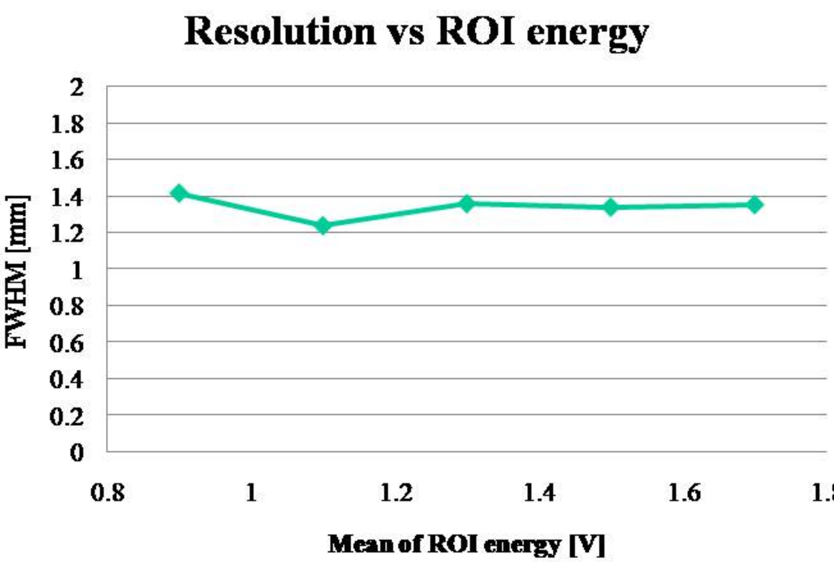
Task 22.2.3: Measurement with the parallel charge division MSGC200

Position resolution on one anode

3 bars CF4







Ampli: 120nsec 0.75V/pC