GSPC detectors development for neutron reflectometry and SANS Instruments
WP22 / Task 22.2

Objective :
The proposed JRA aims at the development of new detector technologies based on Gaseous Scintillation Proportional Counters (GSPC) improving the performance of high resolution detectors used in reflectometry or time resolved SANS.

Task 22.2 will explore the perspectives of Gaseous Scintillation Proportional Counters based on 3He-CF4 gas mixtures at high pressure and various charge amplifying structures (MSGC, ITO-MSGC, GEM) read out by position sensitive light detecting devices.

1. **Performances of the MILAND MWPC for neutron reflectometers**

2. **Multitube development for reflectometers and SANS Instruments**

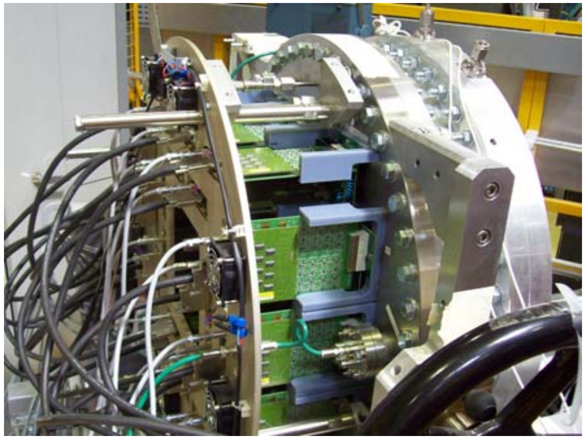
3. ***GSPC development at the ILL (→ G. Manzin see next presentation)***

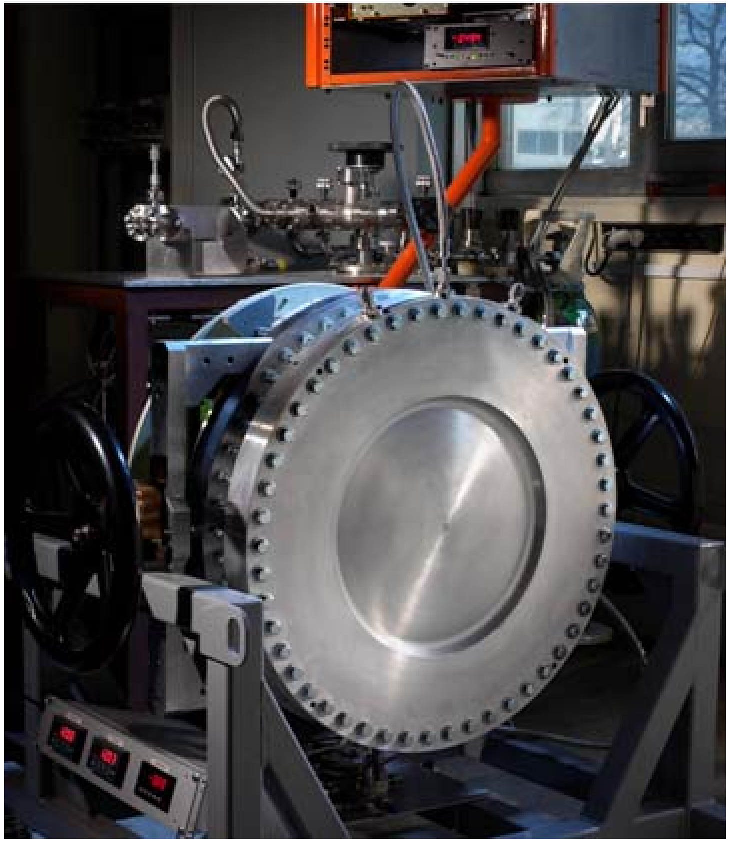
4. **Criteria to define technical specifications in Task 22.2**

5. **Multitube MSGC with parallel charge division readout**

6. **Task 22.2 organisation (very preliminary)**

MILAND MWPC for reflectometers





Description

Sensitive area 318 mm x 318 mm

Absorption gap 5.4 mm (20 mm optional)

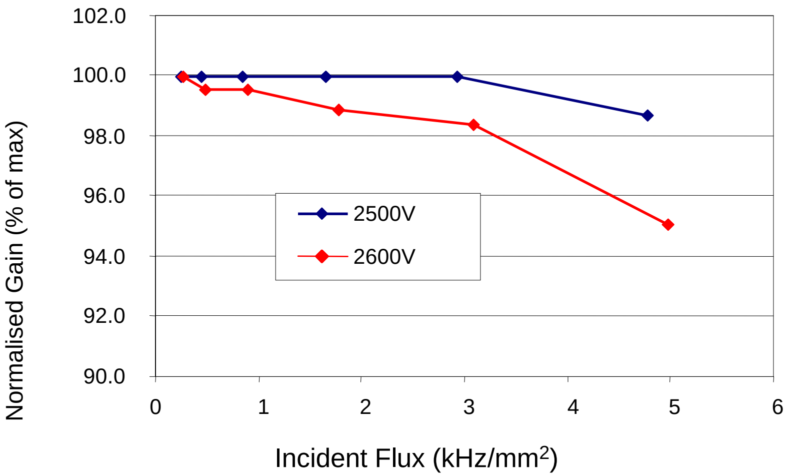
Gas mixture of ^{3}He and CF_4 at 15 x 10^5 Pa.

Anode plan: 320 wires (+ field wires) every 1 mm readout individually

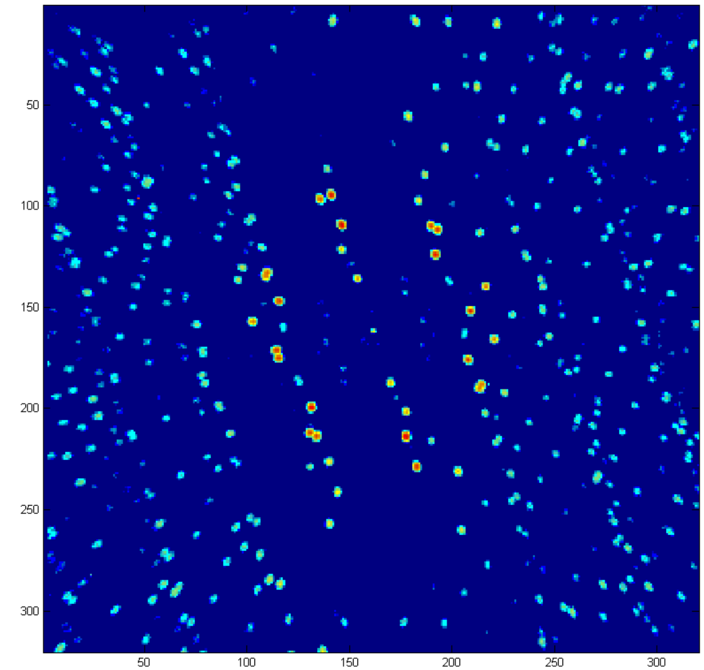
2 Cathode plan: 320 wires each (+ field wires) every 1 mm + interconnection between the 2 cathode plans (320 readout channels)

MILAND MWPC results

Spatial resolution FWHM: 1.4 mm on the anodes and 1.2 mm on the cathodes.
Standard deviation of errors: 11 µm on the anodes, and 15 µm on the cathodes.
Uniformity: Anode 0.9% / Cathode 6.5%
Global count rate: 0.7 MHz with 10% eff loss (still under investigation)



Variation of the amplification gain in function of the local flux for 2 values of the Anode voltage



Lysozyme crystal, measured on D16 by superimposing images obtained during an angular scan.
The detector was mounted at 35 cm from the sample.
Total acquisition time : 16 hours

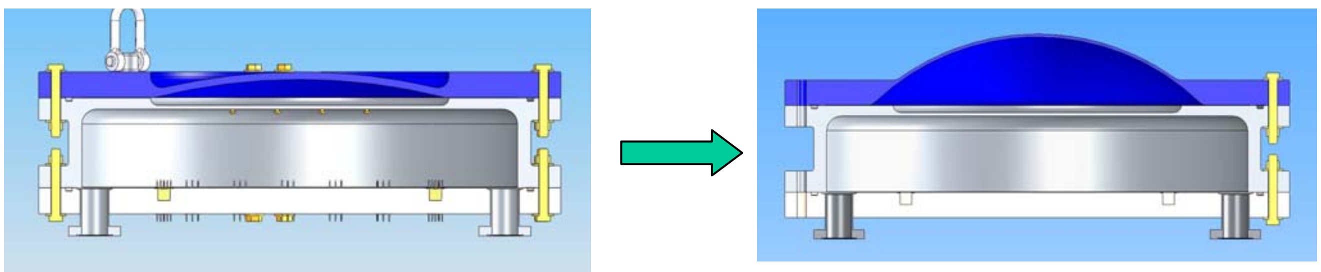
MILAND MWPC for reflectometers

Achievable improvements (currently under study)

- Improve the pressure vessel to minimise the scattering for neutron < 4 Å

- Suppress the double gap (option not needed on reflectometers)

- Replace the Vitton O-ring by an Helicoflex joint (advantage: better gas stability)

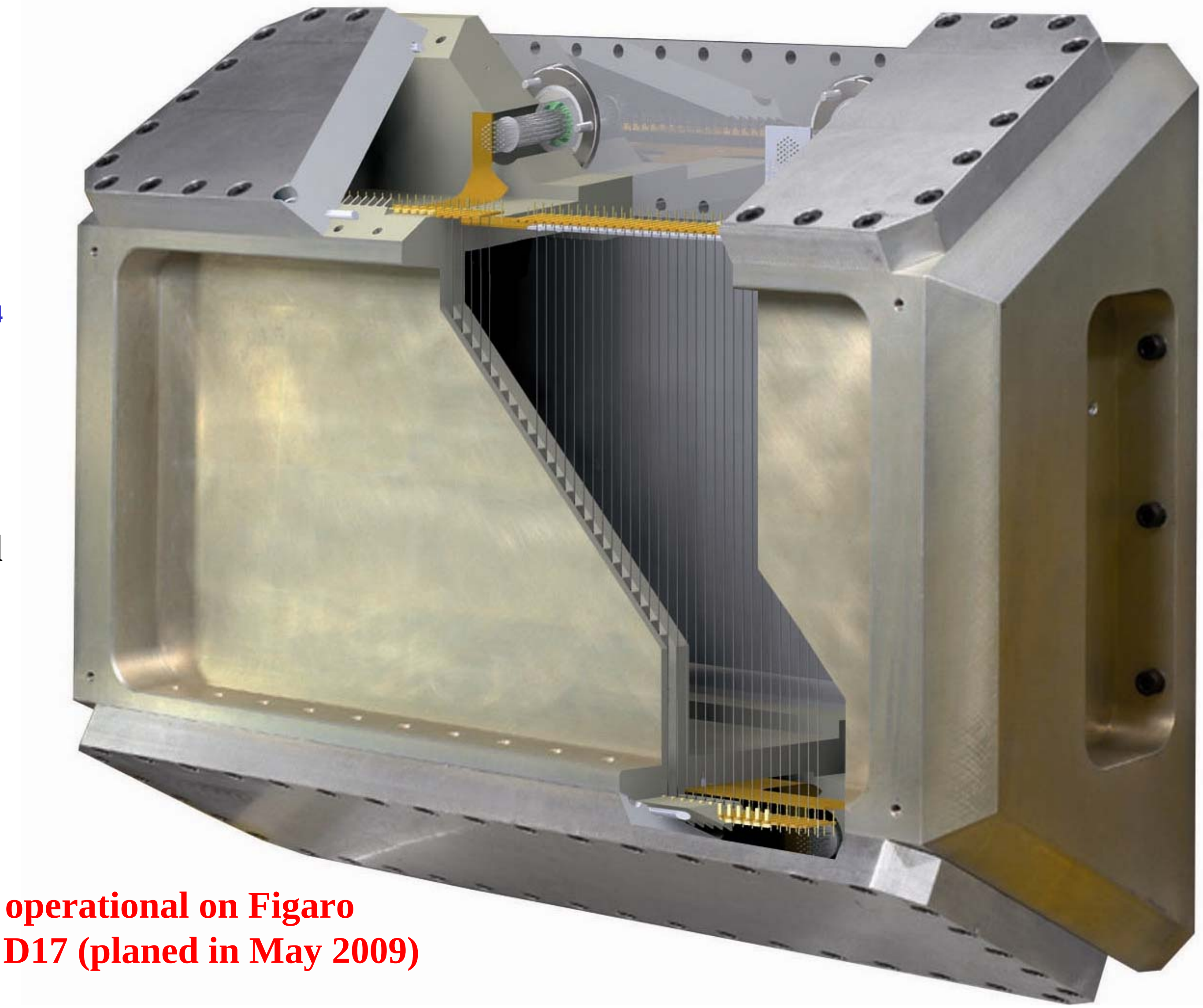


Limitation

count rate, global and local

Multitube: Figaro and D17 reflectometers

- 64 tubes, 6.9 x 6.9 mm2, 300 mm long (250 mm active length)
- separation walls : 0.5 mm
- entrance window : 5 mm thick
- gas 8.10^5 Pa ^3He + 8.10^5 Pa CF_4



Wire Cut EDM (Electron Discharge Machining) → thick insulating layer on the internal surface of the tubes. A chemical surface treatment is required

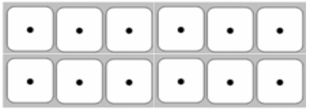
The first detector of this type is operational on Figaro
The second is in fabrication for D17 (planed in May 2009)

Multitube: Figaro and D17 reflectometers

Performances:
-Efficiency: Aluminium is more transparent to neutrons than stainless steel + Square or rectangular tubes
- 2 mm resolution FWHM along the tubes
- 100 kHz/tube (10 kHz local)

Acheivable improvement for reflectometers :

To reduce the path of the tubes to …
- 5 mm possible but probably insufficient
-3 mm ?? Requires 2 layers of tubes



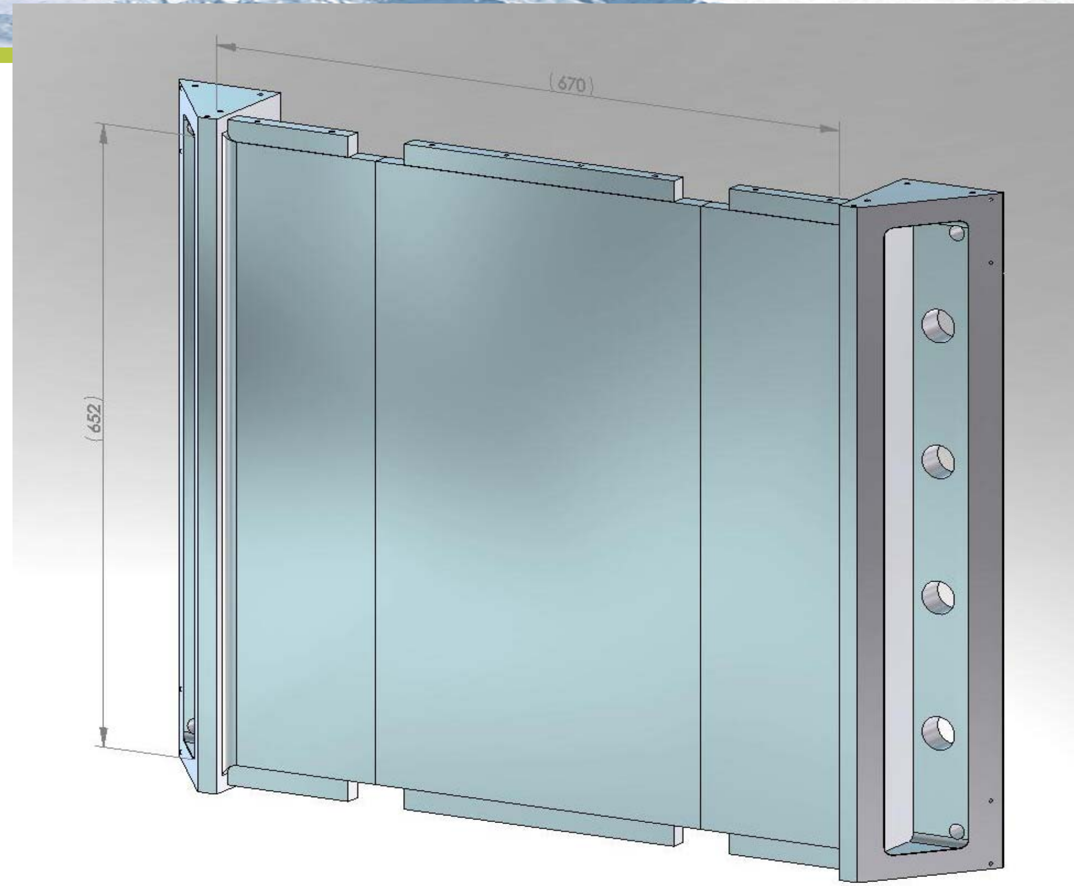
To reduce the wall between the tubes from 0.5 mm to 0.3 mm (by chemical electrolytic etching)

To improve the calibration procedure (and the uniformity)

Limitation: **local count rate**

Multitube: D33 SANS

128 tubes
pitch : 5 mm
Entrance window: 5 mm thick
Tube separation: 0.5 mm
Tube internal dimension : 4.7 mm x 7 mm
Pressure of 3He : >= 10 bars
Useful Length : >64 cm



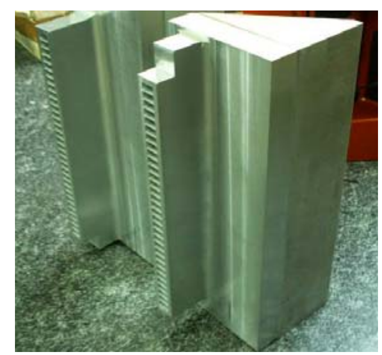
Performances

- Resolution along the tube : 5 mm FWHM
- Efficiency > 80% : between 2.5 Å & 20 Å
-100 kHz/tube (20 kHz local)
Much better than MWPCs !

Acheivable improvement for SANS:
1 m tubes with 5 mm path

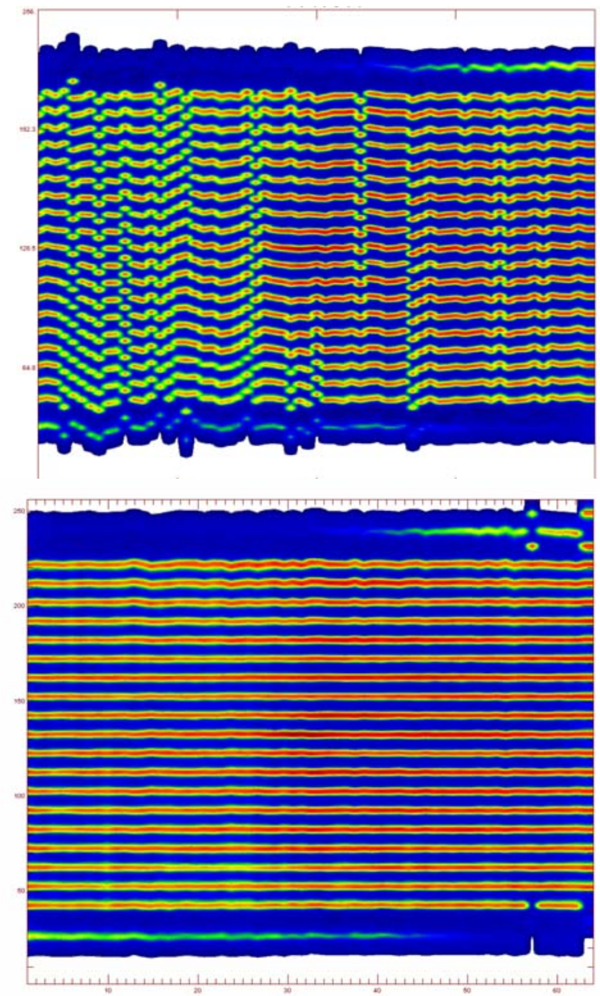
Limitation
count rate and resolution : ok for SNS

Two prototypes are in fabrication

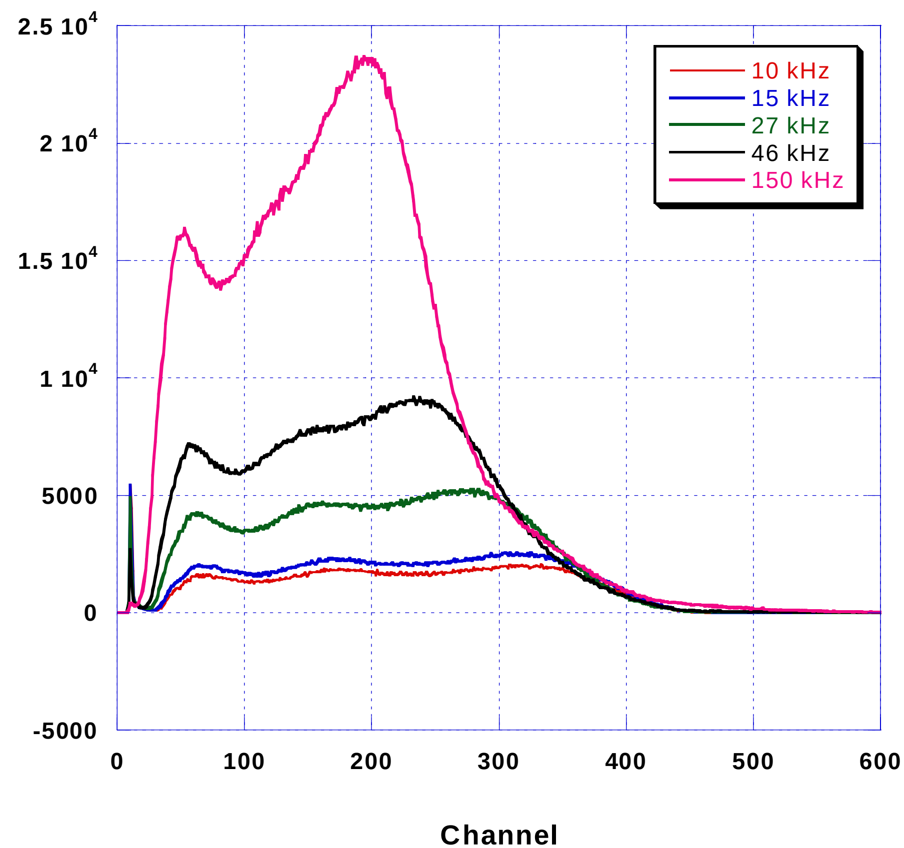


Multitube results

Figaro off-line calibration



Global count rate on one Figaro tube



Criteria to define technical specifications in Task 22.2

The developed technique must open new prospects compared to charge readout detectors currently under development. There is not much to win for SANS (Multitubes already perform well) → focus on reflectometry. Extrapolating actual development on the MILAND and Multitube detectors, the following performance is under reach for reflectometry with moderate effort:

MWPC:
1 mm x 1 mm spatial resolution (with a sensitive area reduced to 25 cm x 25 cm)
Count rate : 1 MHz global; 10-20 kHz local
MILAND internal mechanics simplified (Single gap or low gas pressure + cathode readout only)

MULTITUBE:
1.5 mm x 3 mm with a double layer of square tubes, 25-30 cm long
Count rate : 50 kHz local; >10 MHz global (uniform irradiation)
Simple and robust design

The best detectors for reflectometry are limited nowadays either by the counting rate capability (MWPC), or by the spatial resolution (Multitube).
The spec of the detector to develop in Task 22.2 can be defined as follows (to be discussed):

25 cm x 25 cm sensitive area / 1 mm spatial resolution FWHM / 100 kHz local count rate

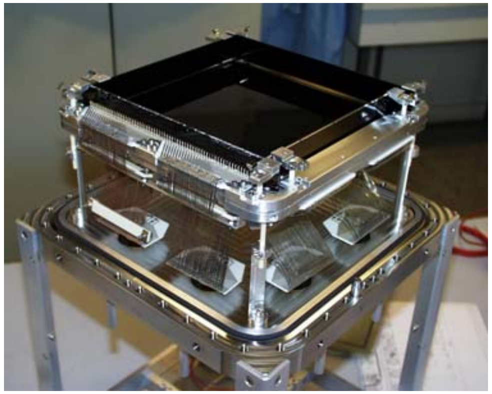
→ Micro-pattern detectors must be used to limit space charge effect.

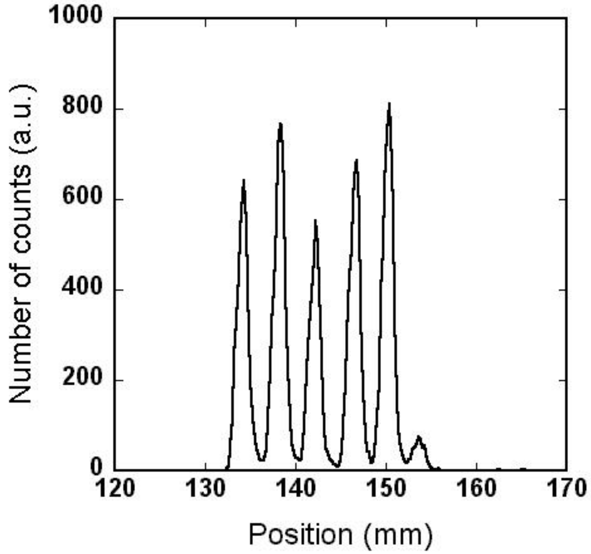
MSGC with Parallel charge division readout for reflectometers

Principle:
Each Anode is readout on both ends for charge division + the other direction is measured by C.O.G.

A prototype has been studied several years ago at the ILL → count rate limitation due to space charge effect on the substrate (cathodes are on the rear side).
Max local count rate = 3 kHz/mm of anode

A new prototype is in fabrication with anodes and cathodes on the front side.
Anodes are in Aluminium to reduce the electrical resistance
→ Much higher expected local count rate but questionable about the amplification gain.
Results will be presented at the next WP22 meeting





This charge readout MSGC might be a good challenger for WP22 But is it scalable to 25 cm x 25 cm ?

Alternative: to use several MSGC optically readout

Resolution: 1.3 mm FWHM with 2 bars of CF_4 → corresponds to the limit of the gas
Resolution below 1 mm can be achieved !

Optical versus charge mode (Francisco, Corsica, 2008)

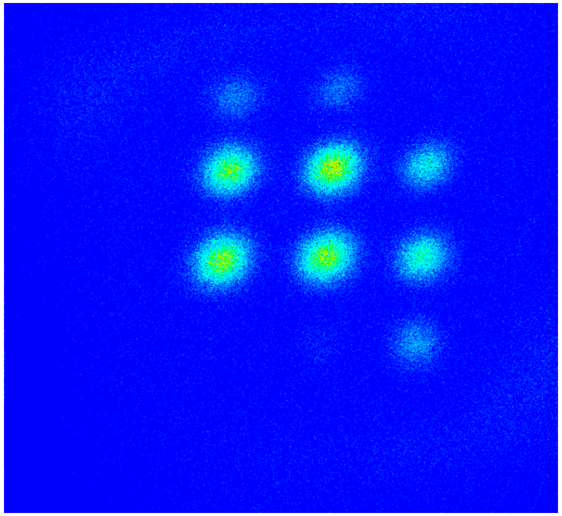
General considerations to build Neutron position sensors based on gaseous Photo-luminiscence (to be discussed again !)

- Advantages of optical readout
  - Electronics decoupled from detection media
  - No induced breakdown
  - Insensitive to electronic noise or RF pickup signals
  - Real multi hit capability with true pixel readouts - complex events, image redundancy
  - Large areas without dead spaces - optical systems (lenses, mirrors, fibbers and tapers)

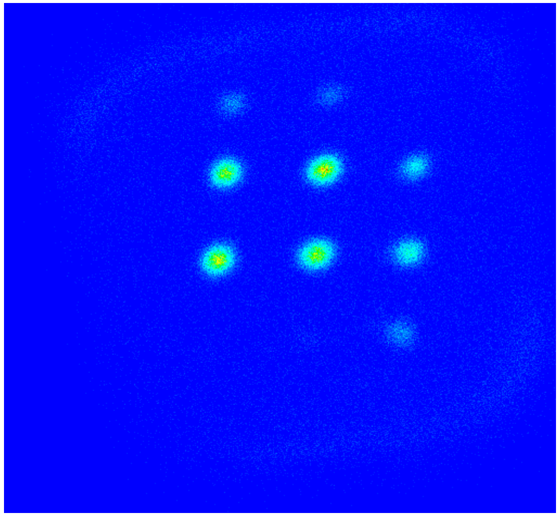
- Disadvantages
  - Transparent windows are needed
  - Efficiency of optical elements can be low
  - Optics are difficult to design and assemble
  - Size
  - Price

BiDim80, 4 PMTs, square packing, 30mm PMTs

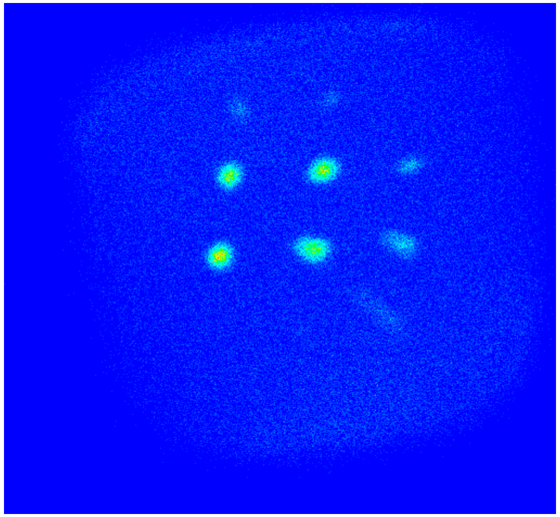
MSGC 1600V



MSGC 1900V



MSGC 2200V



Saturation seems to occur. Maybe gas limitation !

Task 22.2 Organisation

Remarks

- There is no difference between the 2 modes concerning space charge effect → It can be studied independently of the readout mode
- Parallax error is not an issue for reflectometry
- Solid Scintillator are maybe less performing (less light), but they must be considered as a reference (they are much easier to use, and cheaper !). We must follow the development at SNS.
- MSGC Fabrication takes time and is expensive. We develop new layout only if necessary

Tasks description (preliminary)

- Study the MSGC500_ILL (10 cm x 10 cm ; 0.5 mm pitch) in both charge and light readout to characterise the amplification gain and light yield.
- Study different gas and geometries to optimise the dead time, the amplification gain, the light yield, and the space charge effect.
- Study the life-time of the detector in function of gas purity, and amplification gain
- Measure the spatial resolution in function of the scintillator-to-photocathode distance, and adapt the geometry of the detector → Transparent MSGC maybe not necessary.
- Design study of a 25 cm x 25 cm detector for reflectometry.