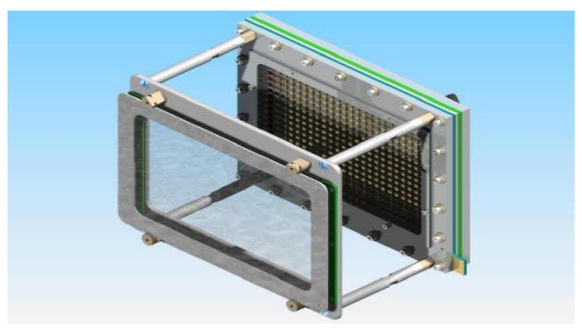
Beam Tracking with Micromegas & Wire Chambers in Secondary Electron Detection Configuration

M.Vostinar [a], B.Fernández[b], J.Pancin[a], M.A.G. Alvarez[b], T. Chaminade[c], S. Damoy[a], D. Doré[c], A. Drouart[c], F. Druillole[c], G. Frémont[a], A. Garzón[b], M. Kebbiri[c], T. Materna[c], E. Monmarthe[c], T. Papaevangelou[c], M. Riallot[c], H. Savajols[a], C. Spitaels[a]

[A]GANIL, CEA/DSM-CNRS/IN2P3 (France)
[b]CNA & FAMN - University of Seville (Spain)
[C]CEA-DSM/IRFU (France)

MOTIVATION

For nuclei identification purposes at the focal plane of S^3, new experimental area of SPIRAL2 at GANIL, it is necessary to reconstruct the trajectories and velocities (by Time of Flight (ToF) method) of nuclei. Classical tracking detectors in beam would generate a lot of angular and energy straggling due to their thickness. One solution could be the use of Se^-D (Secondary electron Detection). It consists of only a thin emissive foil in beam with a low pressure gaseous detector off-beam to detect the secondary electrons ejected from the foil [1]. Moreover, this type of detectors could also be used for classical beam tracking at low energy, or for example at NFS (GANIL) for the FALSTAFF experiment to reconstruct Fission Fragments trajectories. Several low pressure gaseous detectors (wire chambers and micromegas) have been constructed and tested since 2008. High counting rate capabilities and good time resolution, obtained in previous tests, convinced us to make a new big 2D prototype wire chamber and a 2D bulk micromegas at low pressure. For the first time, spatial resolution of the micromegas at low pressure was measured. Different tests have been done in order to characterize time and spatial properties of both prototypes.

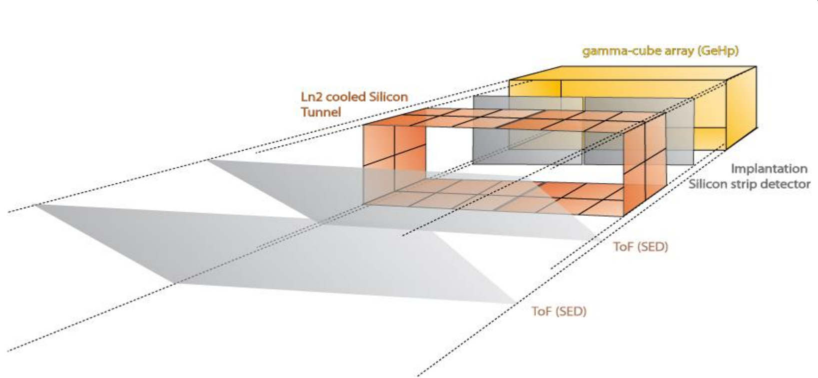


Real Size SeD prototype coupled to a thin emissive foil

Super Separator Spectrometer - S^3

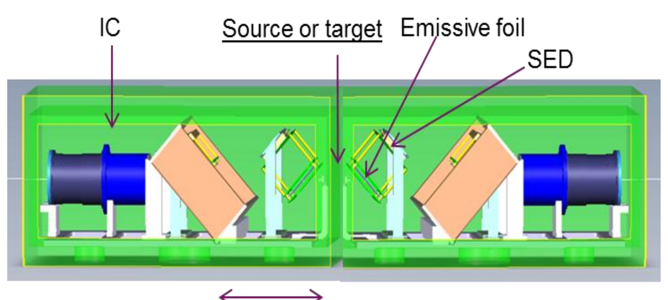
S^3 consists of two parts: magnetic momentum achromat and large acceptance mass spectrometer.

Detection system of S^3 will allow the study of structure of newly synthesized heavy and super heavy elements. Focal plane is a rather standard one and consists of: two tracking detectors (SeD) for ToF and position measurements, one implantation Si detector for implantation of nuclei and emitted α, a "Tunnel" made of 4x4 Si detectors, for escaped α or conversion e^- and an array of HPGe detectors for X and γ rays [2].



It is important to stress out that the commissioning of S^3 will be done using the tracking detectors. S^3 is supported by French government (EQUIPEX ANR-10-EQPX-46-01).

FALSTAFF at NFS



2 arms of FALSTAFF

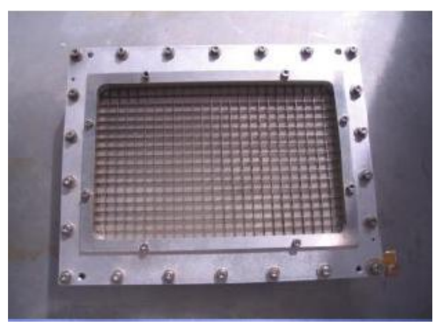
NFS (Neutrons For Science) is a new experimental area consisted of converter cave and Time of Flight (ToF) area.

One experiment foreseen for NFS is FALSTAFF (Four Arm cLover for the STudy of Actinide Fission Fragments) which will allow a simultaneous study of fragment charge, velocity and energy, providing the mass of the fragments before and after the neutron evaporation. Fragment energy will be measured with ionization chambers, while ToF will be done with SeD detectors. Solid angle of FALSTAFF is covered with four arms, where each has two SeD systems and a ionization chamber [3].

Detector prototypes

Real size wire chamber prototype:

- Active area: 200x120 mm^2
- 20 μm diameter anode wires in the middle of 3.2 mm gap
- Anode divided in two parts for capacitance reduction
- 2D pixelated cathode (67(X) +47(Y) cathode strips with 3 mm pitch)
- Strong back with 92.5% transmission to ensure gap thickness homogeneity

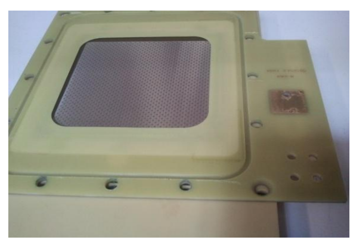


Entrance window of the SeD with the strongback

2D pixellated cathode of wire chambre

Micromegas at low pressure:

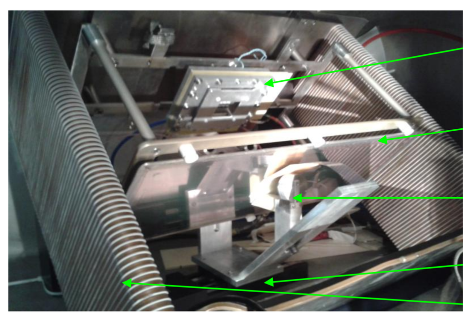
- Active area 70x70 mm^2
- 256 μm amplification gap
- 2.2 mm drift gap
- 2D pixelated cathode (28(X)+28(Y) cathode strips with 2.54 mm pitch)
- Strong back with 92.5% transmission to ensure gap thickness homogeneity



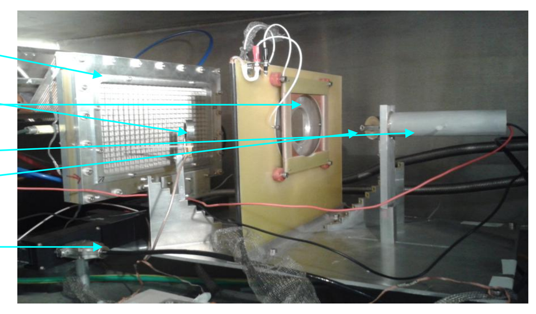
Mesh of the micromegas

Set ups

Spatial resolution -set up



Time resolution- set up

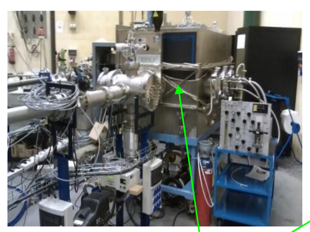


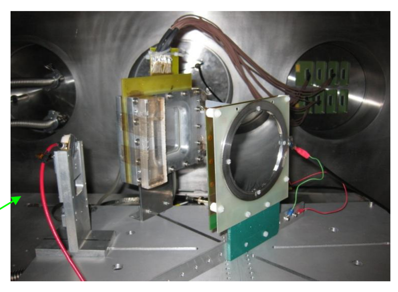
Detector
Si trigger
Emissive foil
PM
^{252}Cf source
Motor
Magnet

Electronics: Daq T2K [4]

Electronics: Matacq card

Set-up for beam test at CNA Seville

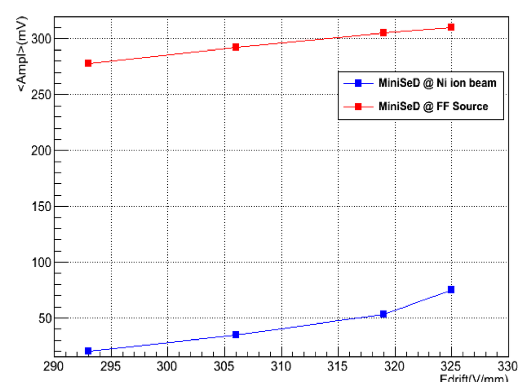


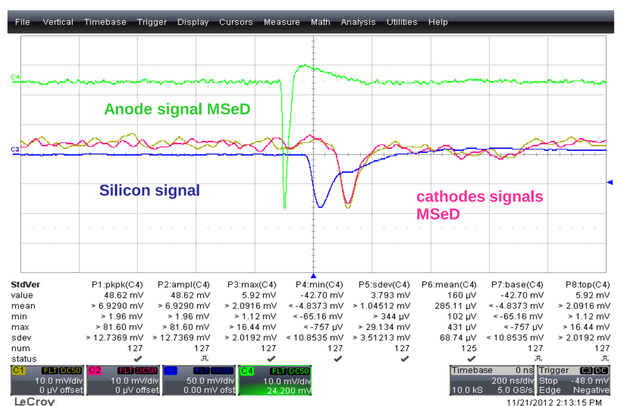


Tracking chamber

Conditions:

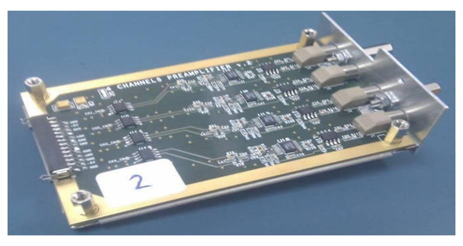
- Tracking chamber FNB line of the 3MV TANDEM @ CNA Seville
- Ion beam: $^{58}Ni^{+14}$ at 0.7 MeV/n
- Intensity: 100 pA





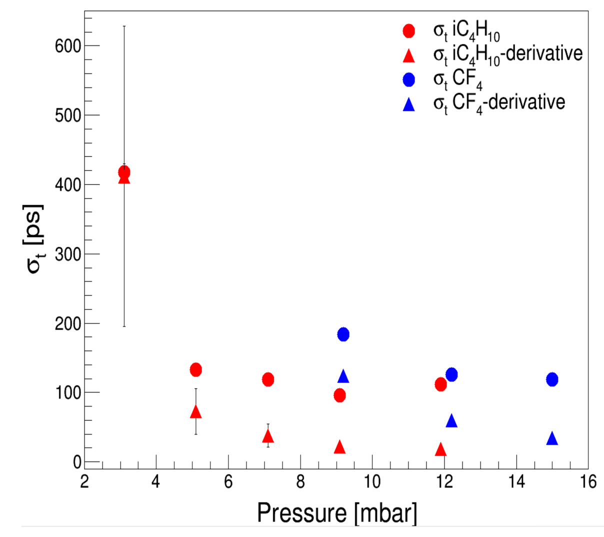
Development of a Pre-Amplifier for secondary electron detectors (SEDA) [5]:

- 4 channels every PCB
- Rise time & Fall time 10 ns (entrance signals)
- Rise time ~ 50ns (output signals)
- Shaping time between 140 and 170 ns (output signals)
- SNR ~ 60
- Rate ~ 10^6 pps



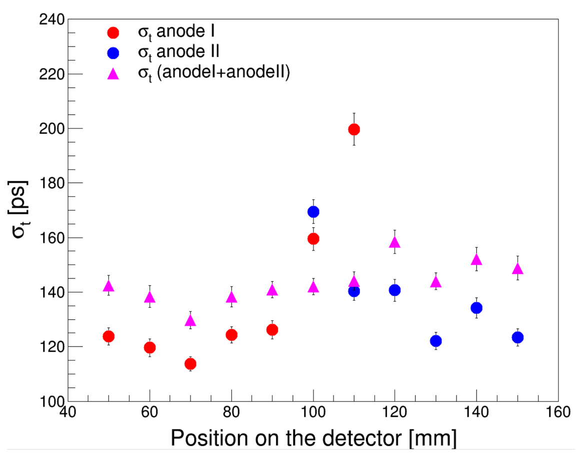
Characterization of micromegas and three wire chambers with ^{252}Cf source at GANIL

Time resolution – real size wire chamber prototype

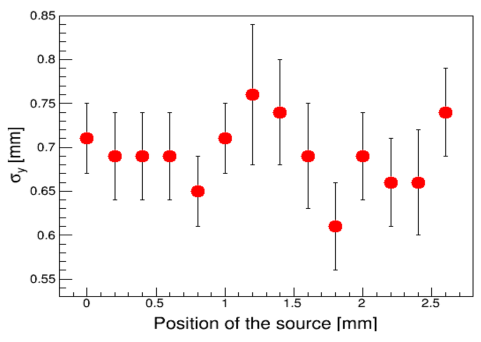


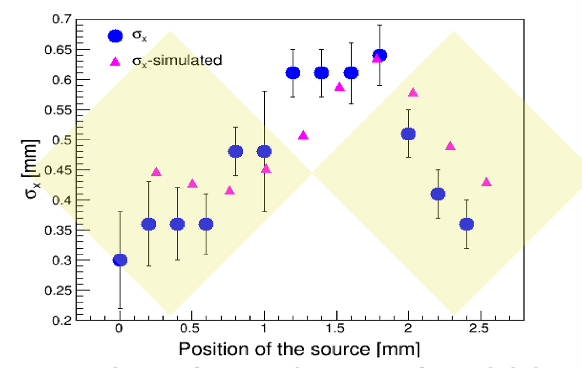
The optimum configuration regime for obtaining time resolution of ~100ps is iC_4H_{10} at 9mbar. These values are compared to the signal derivative at 30% indicating the contribution of noise and detector performances.

The time resolution is rather stable (~120ps) over the surface of the detector except at the middle. The sum of the signals show that it is possible to recover the resolution with a small loss due to the addition of the noise of two anodes.



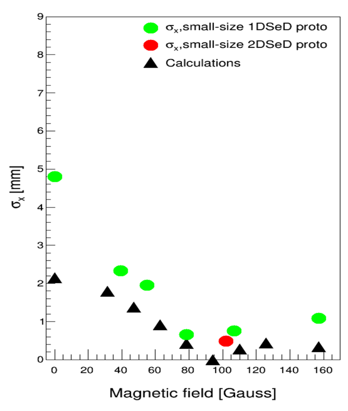
Spatial resolution – micromegas and wire chambers

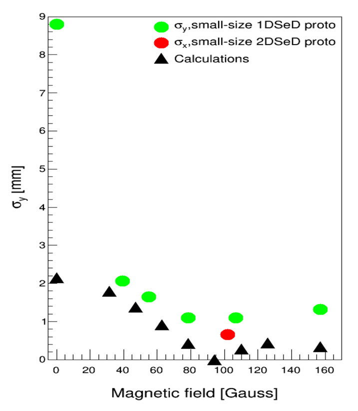




Spatial resolution is dependent on the place the e^- cloud hits the pad plane (improving when signal is registered on the pad and degrading when it is registered in between two pads). We are able to reproduce the behavior with a simulation.

Both, measurements and calculations show that there is an optimum magnetic field. Mathematical calculation is following the shape of the data. 2D wire chamber prototype has a resolution of 0.5 mm (X) and 0.7 mm (Y) sigma. While 1D proto (former geometry) has 0.7 mm (X) and 1.1 mm (Y) sigma





Conclusions & Outlook

Wire chambers:

- The spatial resolution, at optimal magnetic field, of small-size 2D prototype is 0.5 mm (X) and 0.7 mm (Y) σ
- The resolution could be improved by choosing a smaller pitch of the pad plane (confirmed by simulation)
- Taking into account the performances which have to be achieved, below 1 mm FWHM, the prototypes need to be modified
- Time resolution of all wire chambers is around 120(30)ps

Micromegas:

- Spatial resolution of micromegas is really good, around 0.5 mm in both directions (X and Y) σ because of the small gap (2 mm)
- We can see the influence of the pitch of the pad plane in the same manner as for the wire chambers
- Time resolution of micromegas was tested [6] and it is ~200(50)ps

Additional:

- New small size wire chamber prototype with 1.5 mm pitch is ordered and needs to be tested
- Preparing for the in beam tests
- Choice of the final design of the detector
- Connect the system to the final electronics card GET (General Electronics for TPCs) founded by France ANR-09-BLAN-60203-01

References:

[1] A.Drouart et al, NIMA579(2007)
[2] H.Savajols et al, Technical proposal for SPIRAL2-S^3(2010)
[3] D.Doré et al, FALSTAFF : a new tool for fission fragment characterization(2013)
[4] P.Baron et al, IEEE transaction on 55-3(2008)18
[5] A.Garzon et al., MEJ (2013)
[6] J.Pancin et al, JINST7:C03017(2012)

Acknowledgments:

We would like to thank the people at CEA-DSM/IRFU/SEDI for constructing the micromegas bulk detector. Also we would like to thank the French (EQUIPEX program) and the Spanish (Spanish Research Project FPA2009-08848) government for the support.