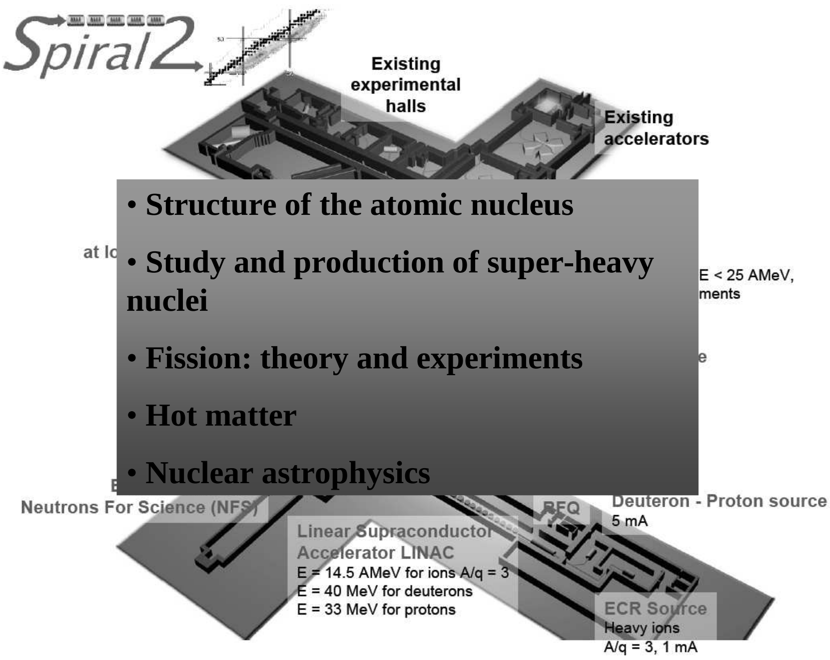
GANIL Spiral 2

Beam Tracking with Low Pressure Gaseous Detectors in Nuclear Physics

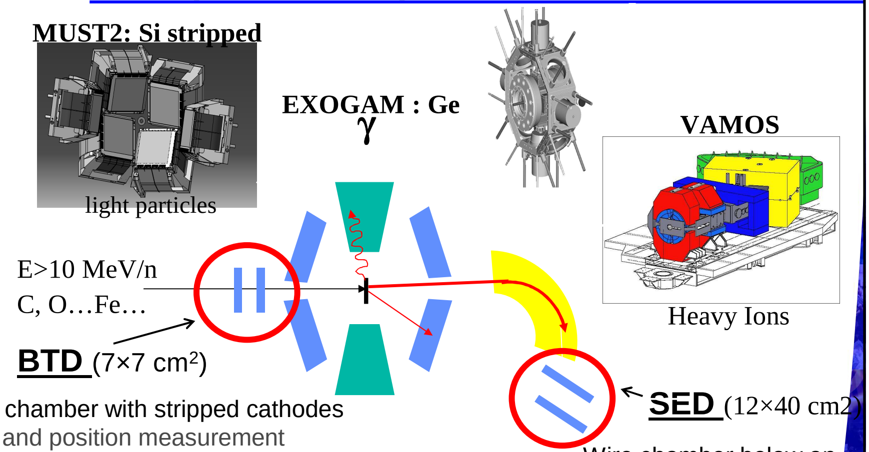
- Scientific interest
- Technical solutions
- Micromegas at low pressure
- Futur experiments

GANIL Spiral 2



- Structure of the atomic nucleus
- Study and production of super-heavy nuclei
- Fission: theory and experiments
- Hot matter
- Nuclear astrophysics

Example of an experiment at GANIL



BTD (7×7 cm²)

- Wire chamber with stripped cathodes
- Time and position measurement event by event
- 2x0.9 µm mylar foils
- 2x1.5 µm mylar foils
- 2x3.2 mm of iC_4H_{10} at 8 mbar (CATSI)
- 2x1.6 mm of iC_4H_{10} at 8 mbar (CATSII)

⇒ 550 µg/cm² in beam

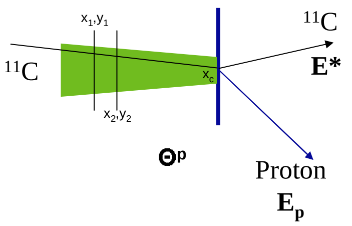
SED (12×40 cm2)

- Wire chamber below an emmisive foil
- Time and position measurement
- 1x0.9 µm aluminised mylar foils

⇒ 125 µg/cm² in beam

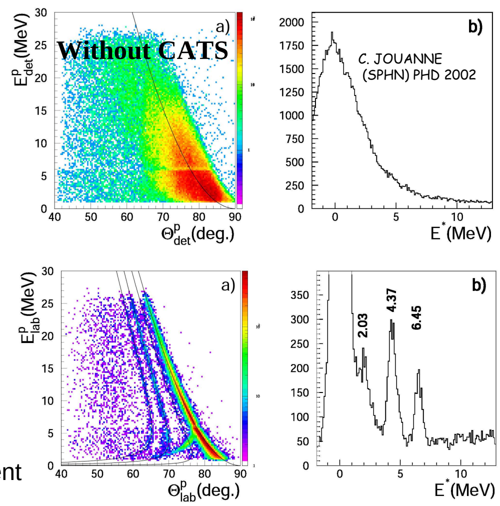
Effects of Trajectory Reconstruction with BTD

^{11}C (p,p') 40.6 MeV/n



Exotic Beam
Large emittance

⇒ Need of Time & position measurement
Event by event
without straggling (< 1 mrad)

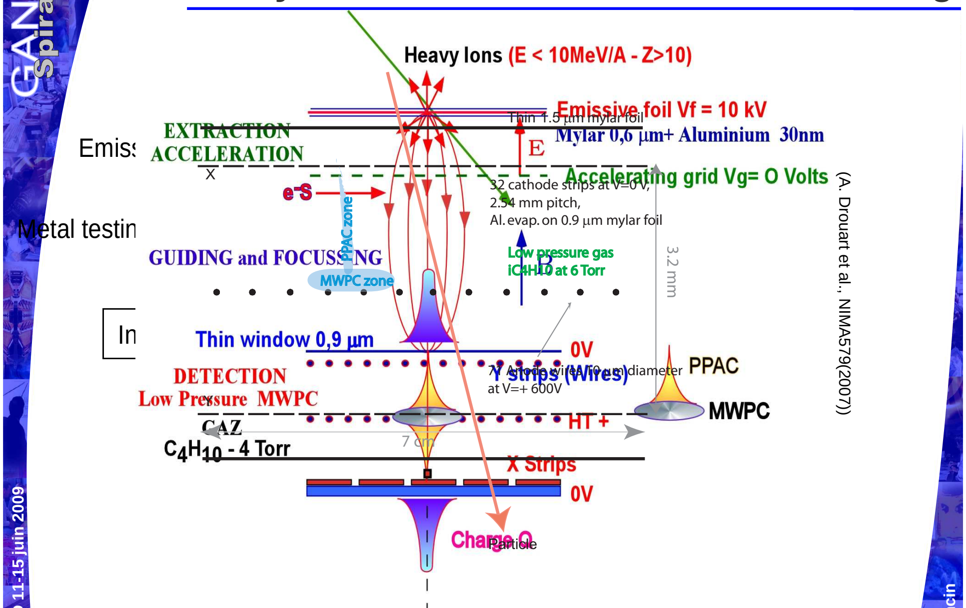


- In the framework of the new facilities **SPIRAL2 or FAIR(GSI)**: need for detectors dedicated to heavy ions or fission fragments at lower energies (< 7 MeV/n)
  ⇒ decrease thickness of material in beam
- Use of a secondary electrons detector with an emissive foil for beam tracking (less than 125 µg/cm2 instead of 550 µg/cm2)

^{132}Sn @ 10 MeV/u
➔ δθ = **0.47 mrad** (FWHM)
(**1.82** mrad avec BTD)
^{132}Sn @ 5 MeV/u
➔ δθ = **0.94 mrad** (FWHM)
(**3.67** mrad avec BTD)
⇒ **Factor of 4 better**

- Based on SED principle but with only 70x70 mm^2
- Achieve same characteristics in time and spatial resolution (500 ps (FWHM) et 1 mm (FWHM)) with a magnetic field (or not??)
- Increase counting rate capabilities to 10^6 Hz

Secondary electrons detector for beam tracking



- Use of new detector type (2D, micromegas, MCP, diamant…)

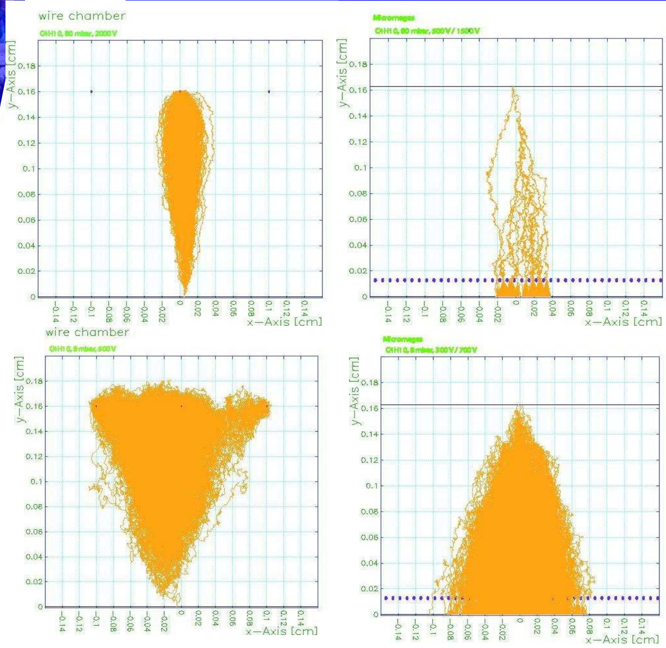
Detector types

- MCPs : good performances but more expensive, more restrictive and limited in size 90x70 mm^2 (SHIP@GSI, PRISMA…)
- Diamond : good performances with polycristalline structure (60x40 mm^2), ΔE possible with monocristalline but only on 10 mm^2 (very expensive)

- **Low Pressure detectors:**
  - Few materials in beam (no angular or energy straggling) and operation in vaccum ⇒ low pressure gas detector
  - Use of pure iC4H10 for its low ionisation energy (about 100 % efficiency needed) and its high quenching power (very low pressure of several mbar)
  - Important gain (E/P…) even in low field region : natural spread of the avalanche, good spatial resolution with low granularity
  - Mean free path of electrons much higher : high electron drift speed and good timing resolution
  - Low drift gap and fast ion collection for high rate capabilities

⇒ **what about Micromegas at very low pressure ??**

Micromegas (at very low pressure) : simulations



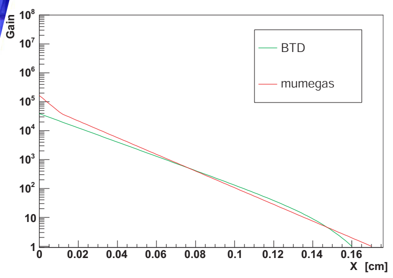
80 mbar

iC_4H_{10}

8 mbar

iC_4H_{10}

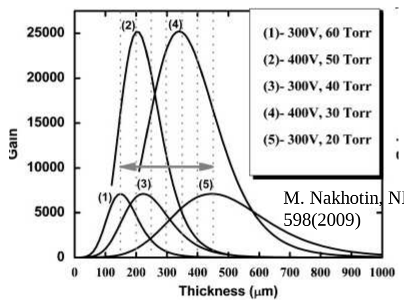
Micromegas : simulations (2)



Using α from GARFIELD at 6 torr of pur iC_4H_{10} (good values but only at low E/P)

• Optimum amplification gap of 600 microns (parallel plate…)

⇒ 128 microns and pre-amplification

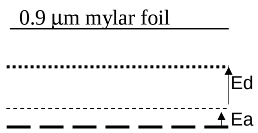


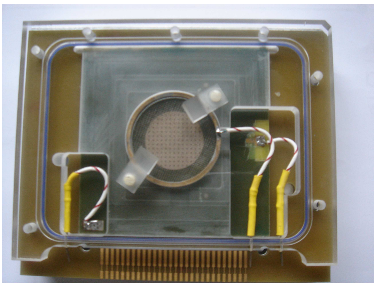
M. Nakhotin, NIMA 598(2009)

Micromegas: test of the 1st prototype

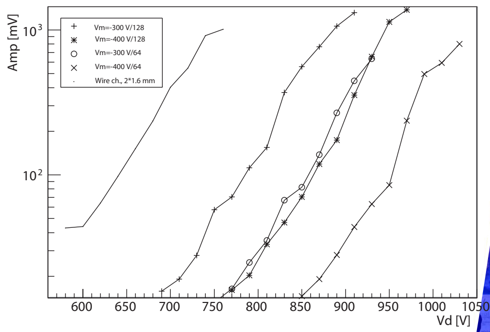
Bulk Micromegas prototype:

• adapted to BTD mechanics
• 64 to 128 µm amplification gap
• 1 to 3 mm drift gap



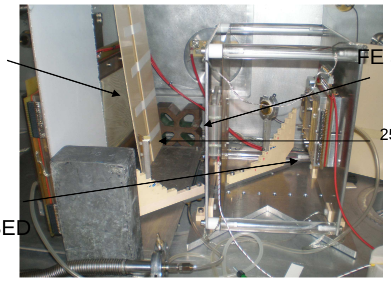


• Signal measurement with an alpha source (ΔE ≅ 10 keV) at 8 mbar (d_g=2 mm):
Good signal dynamics, amplitude and rise time (7 to 9 ns)



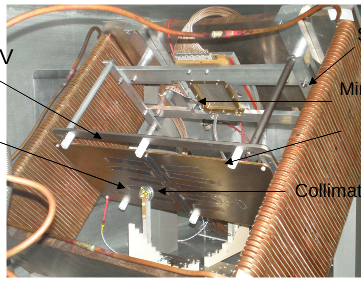
Test bench

Time resolution

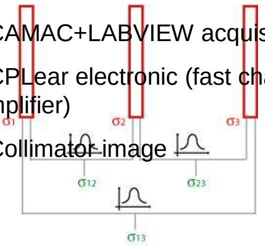


- 3 detectors with equivalent σt
- Signals registered with MATACQ and off-line analysis
- no TOF dependence
- Z selection with Si detector

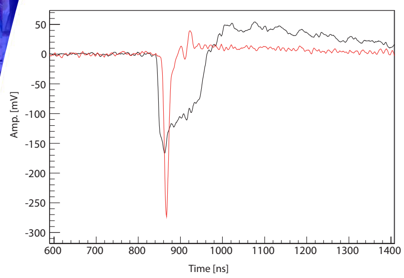
Spatial resolution

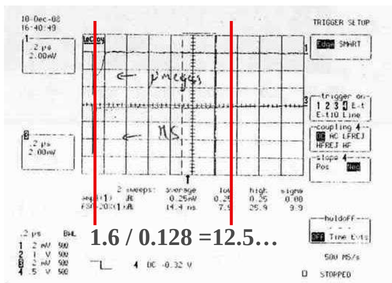


- CAMAC+LABVIEW acquisition
- CPLear electronic (fast charge amplifier)
- Collimator image



Micromegas : time resolution with emissive foil





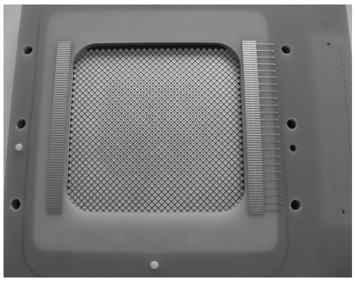
Parameters	σ_t [ps] (+/- 30)
4 Torr/910 V/350 V/2 mm (60 pf)	855
6 Torr/830 V/350 V/1 mm (60 pf)	650
4 Torr/790 V/380 V/2 mm (30 pf)	1280
4 Torr/760 V/380 V/2 mm (30 pf)	1340
4 Torr/760 V/380 V/2 mm (30 pf) (with cuts)	936

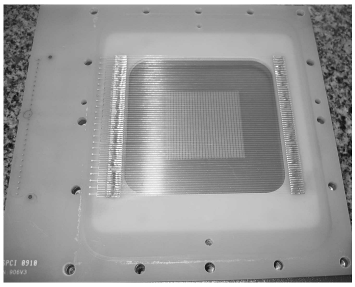
Time resolution degraded compared to wire chamber (σ < 300 ps):

- S/N ratio
- Thick micromesh (30 µm / 5 µm)
- Spread of the avalanche modified at low pressure: gas avalanche seen later in micromegas
- **Important capacitive effect due to pre-amplification (cut on Eion/Ee-)**
- **Investigate capacitance influence**

Other prototypes…

- **3 prototypes to test:**
  - 1 mini-SED “classical” : OK in space and time
  - 1 mini-SED 2D
  - 1 new micromegas-SED: spatial reso. And improvement of time reso.
- **Tests in real beams at GANIL (2010) or CNA in Sevilla**
- **Define a new electronic :**
  - Gassiplex currently used on SED : too slow
  - Tests done with CPLEAR electronics (fast charge preamplifiers)
    - Coupled to QDCs
    - Threshold / strip to integrate
  - ASIC



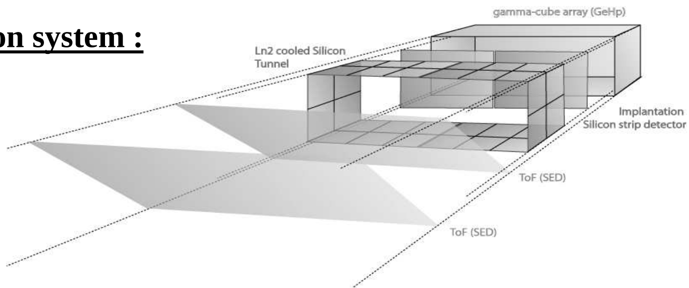


S3 (Super Separator Spectrometer): Focal Plane Detection System

• Stable beam at high intensity from SPIRAL2 LINAG

• Super heavy spectroscopy, multi nucleon transfer…separate rare events from intense background

Detection system :



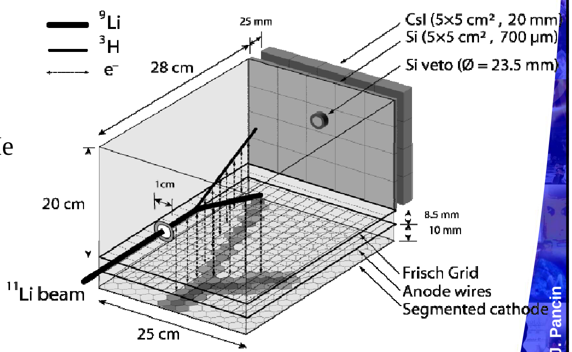
Time of flight + tracking detection (E < 5 MeV/n):
- 120 strips per detector (1 inch wide strips on 20×10 cm^2)
- Time resolution < 1 ns (FWHM)
- Spatial resolution < 1.5 mm (FWHM)
- Counting rate 10^6 p/cm^2/s

⇨ Front-end electronic
⇨ DAQ & command/control

ACTAR : Active Target

- Direct and resonant reactions with light ion beam and fission fragments (5 MeV/n)
- Low rates of exotic nuclei but almost 100 % efficiency
- No thick target disturbing the beam
- Low energy recoils detected with low threshold
- Excitation function with single tuning

MAYA (+ lateral detection) :
- wires, micromegas or GEMs
- Several gases (pur iC_4H_{10} or He mixture varying P)
- Dynamic range
- Hybrid meshes
- GET collaboration



C.E. Demonchy *et al.* (NIMA **573**, 145 (2007))

GANIL Spiral 2

BTSED Team at IRFU and GANIL

- Electronics : T. Chaminade (IRFU)
- Scientific coordinator : A. Drouart (IRFU), H. Savajols (GANIL)
- Detector tests : M. Kebbiri (IRFU), JF Libin (GANIL)
- Technical coordinator : J. Pancin (GANIL)
- Acquisition : Y. Piret (IRFU)
- Mechanics : M. Riallot (IRFU), P. Gangnant (GANIL)

Collaborations :
- B. Fernandez, M. Alvarez (Universidad de Sevilla) (2008/2009)
- Farheen Naqvi (University of Köln) (2008)

And the others…

To conclude…

• SED 2D very interesting for large sizes in Y direction: check gain homogeneity, good timing properties

• Good behavior of Micromegas at very low pressure (till 4 torr): improve time resolution, measure spatial resolutions, to test at 10^7 Hz in beam

• Make an effort on simulations at low pressures

• In beam tests

Still some work…

If you have any questions???