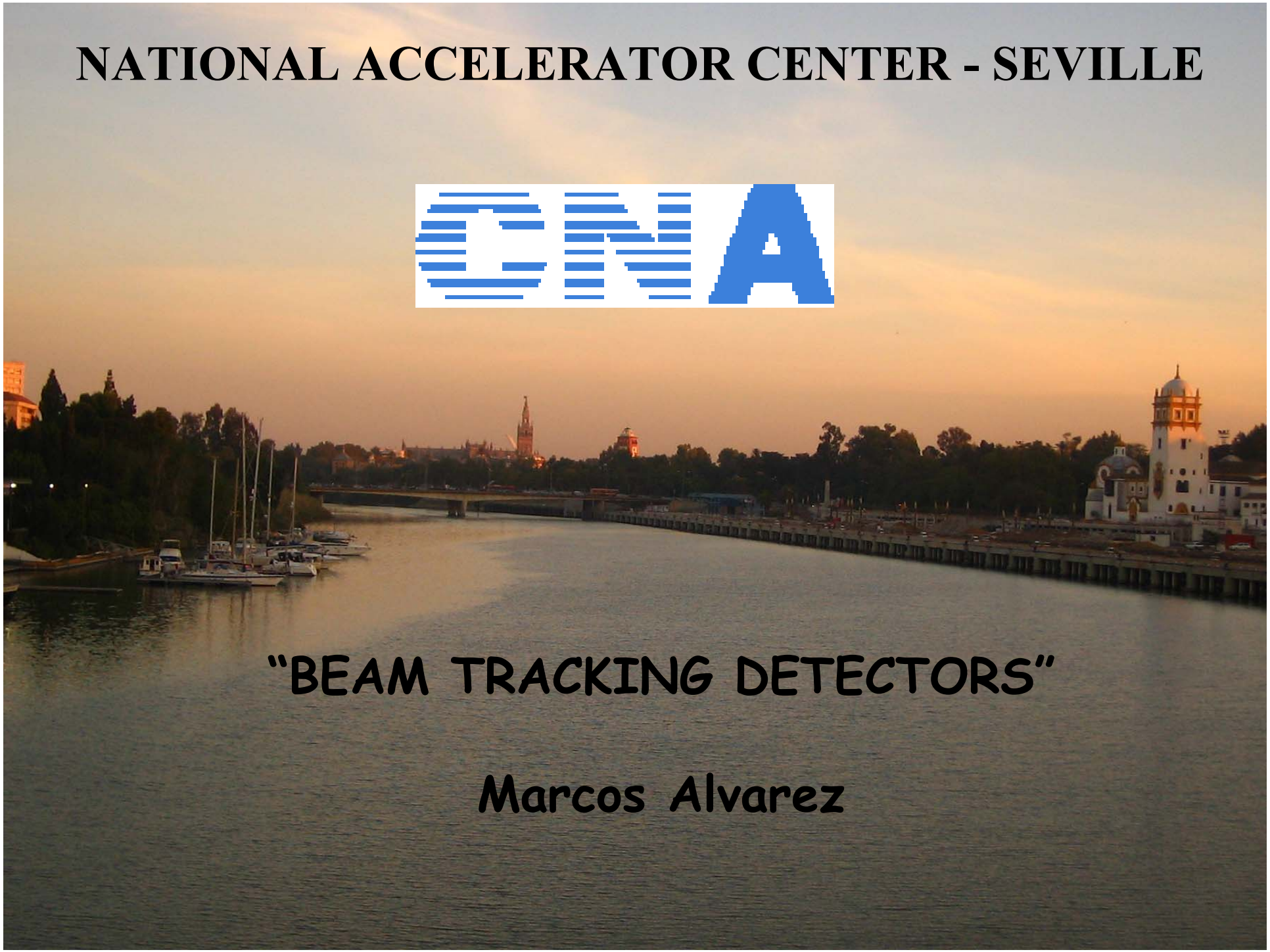
NATIONAL ACCELERATOR CENTER - SEVILLE



"BEAM TRACKING DETECTORS"

Marcos Alvarez

On behalf of:

- Dr. Joaquín Gomez Camacho;

  (DITANET steering committee member from CNA-Seville).
- Beam Tracking Detectors (BTD) collaboration;

  (GANIL - CEA (Saclay) – CNA (Sevilla)); Dr. Julien Pancin (GANIL).
- Slowed Down Beam collaboration;

  (GSI – U. Köln – CNA); Dr. Plamen Boutachkov (GSI) {previous talk}.
- CNA – IMSE (Microelectronic National Institute) - University of Seville.

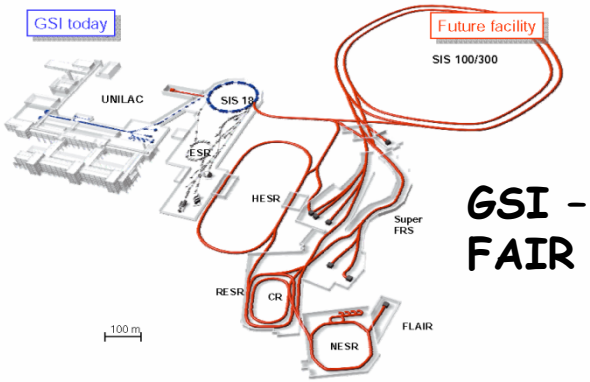
  (different groups and Spanish government projects).
- Basic Nuclear Physics (FNB) group of CNA:

  B. Fernández, Z. Abou-Haïdar (Ditanet), A. Bocci (Ditanet), A. Garzón, J. Praena and J. P. Fernández and M. Alvarez.

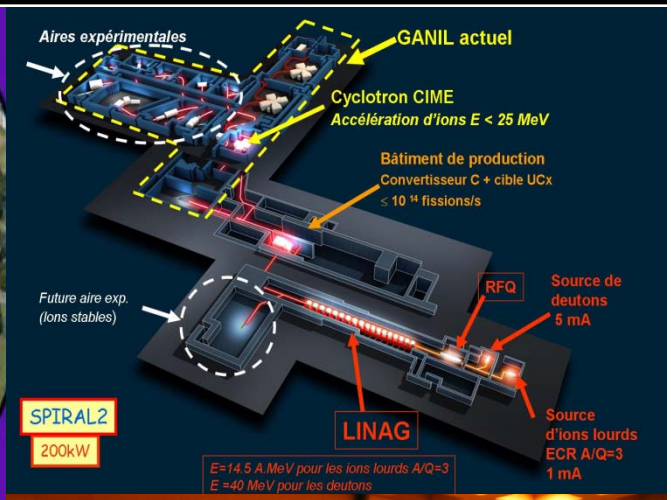
In collaboration with and supported by

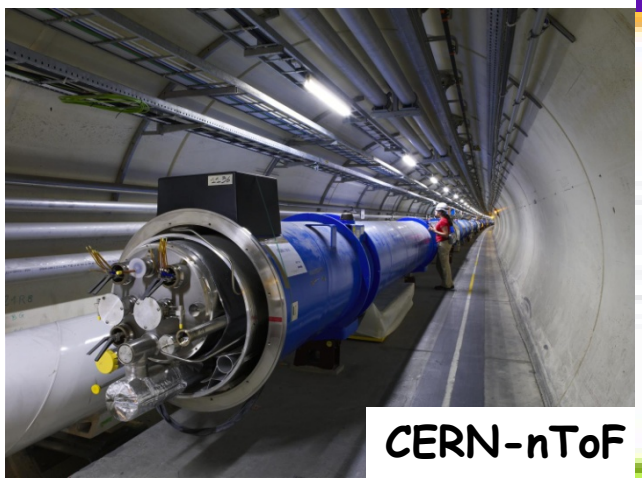
DITANET – PROJECT (2008)

FAIR - Facility for Antiproton and Ion Research



GSI – FAIR

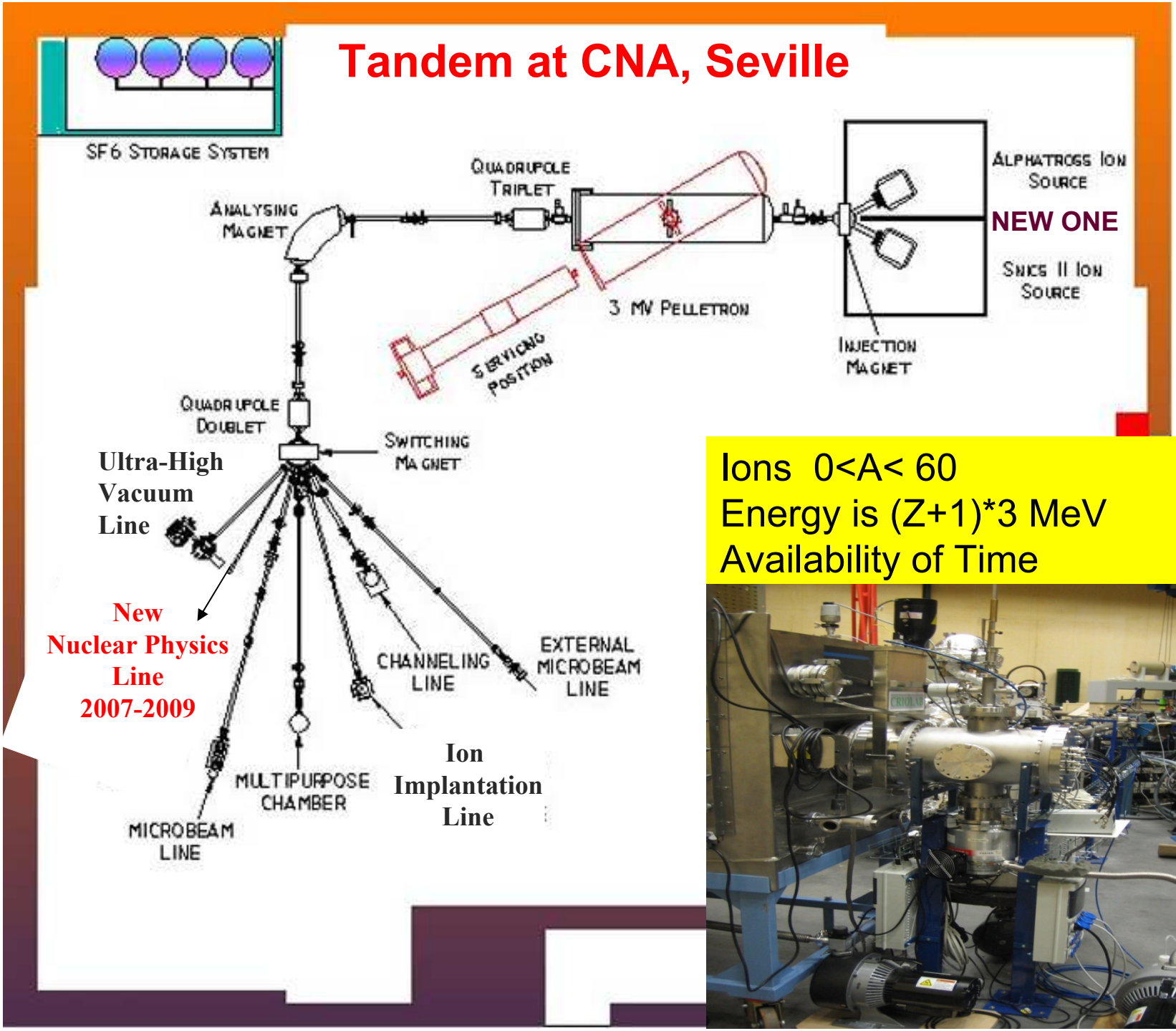




CERN-nToF


Excellent environment to test detectors, electronic devices and acquisition systems.
Currents 1pA - 1μA
Energies 500KeV – 25MeV
Ion beams H - Cu
CNA - 3 MV TANDEM - SEVILLE (TOOL)
CNA
Centro Nacional De Aceleradores

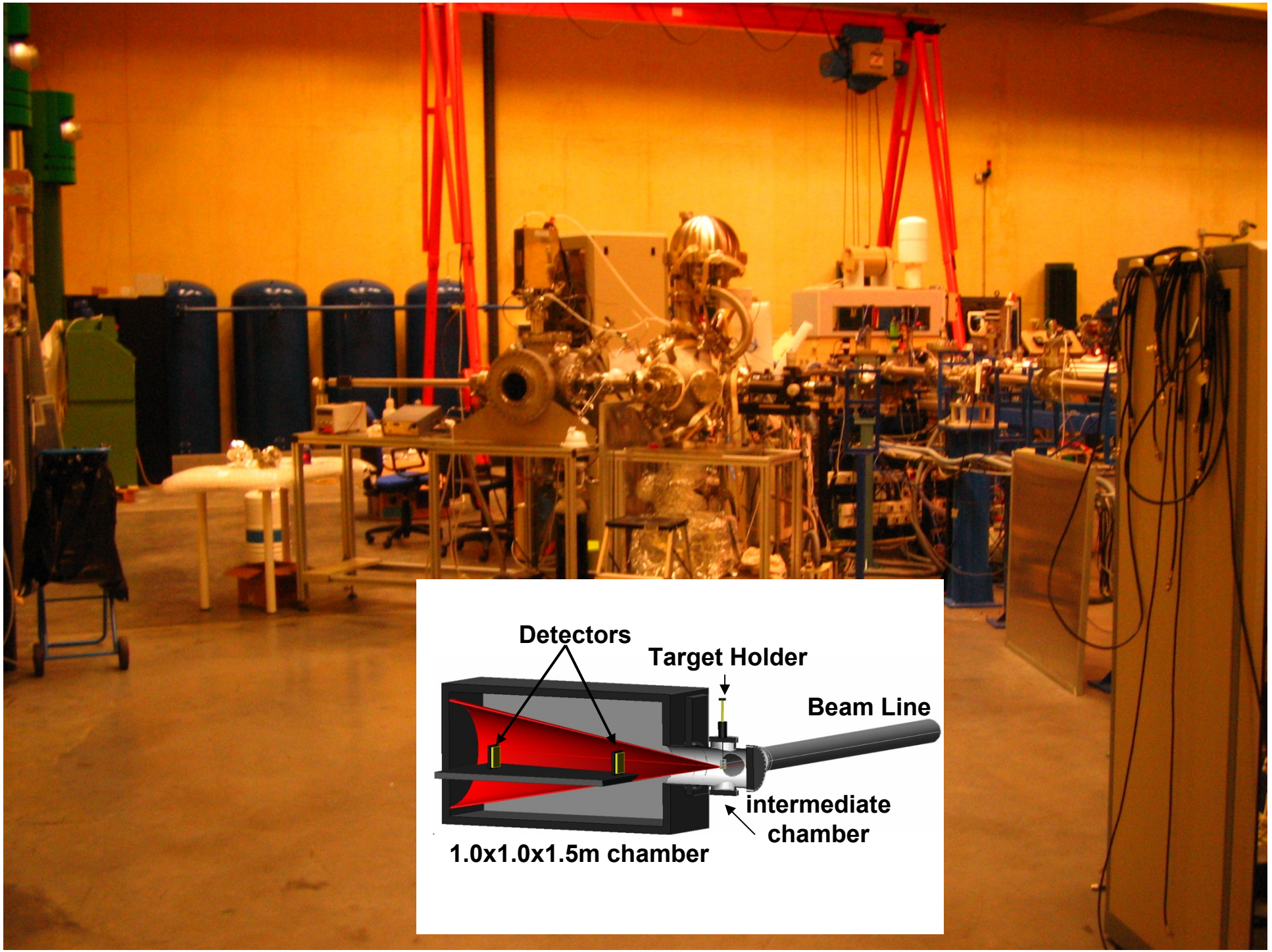
Tandem at CNA, Seville

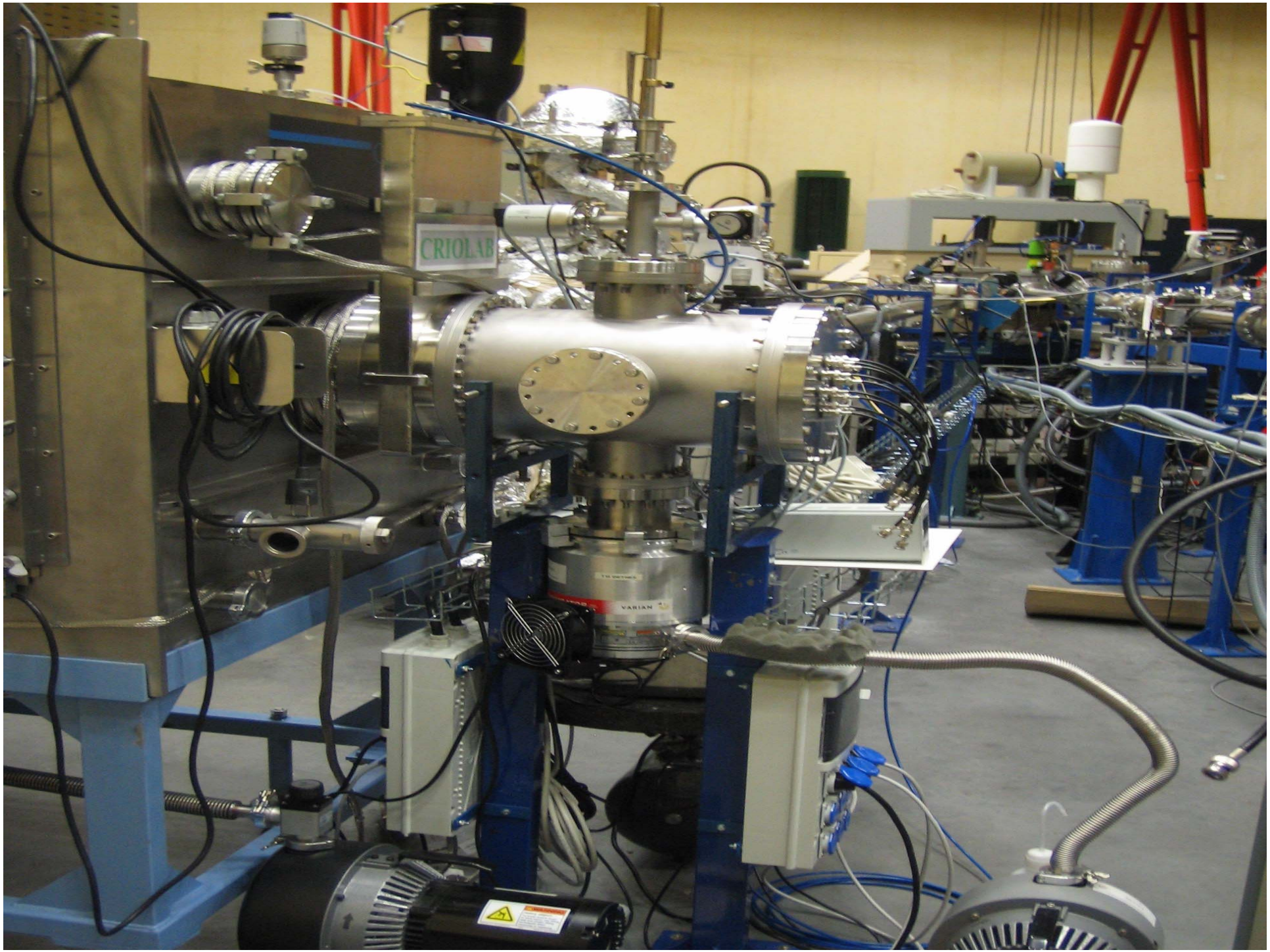


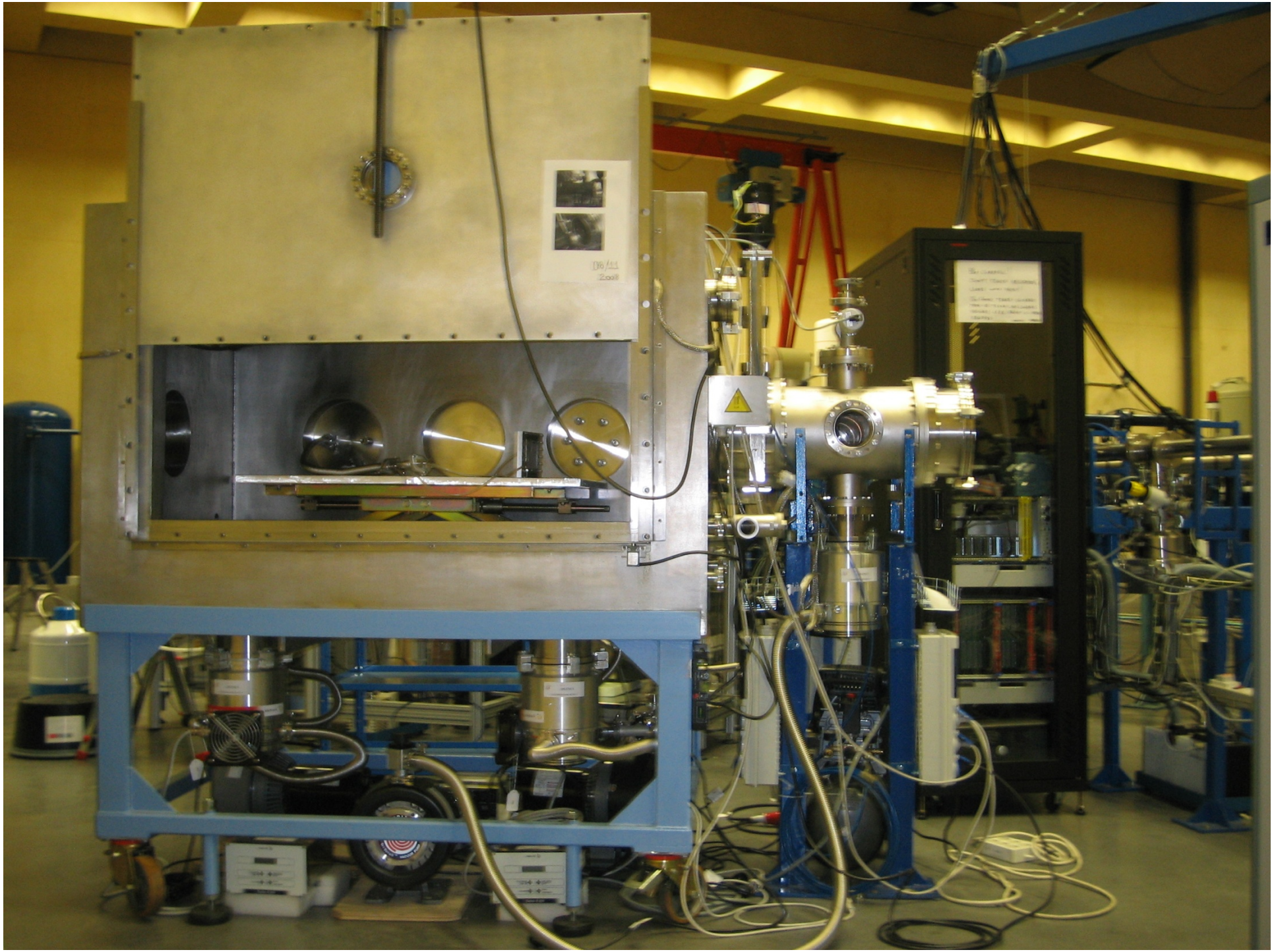
Ions 0<A< 60
Energy is (Z+1)*3 MeV
Availability of Time

TANDEM AREA DEDICATED TO MOUNT
A NEW NUCLEAR PHYSICS LINE (2007):

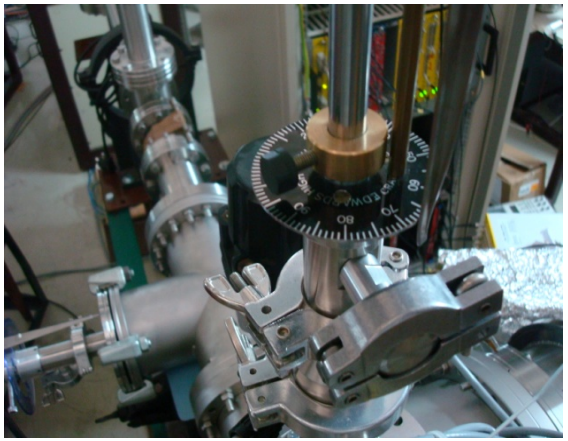
A STRUCTURE TO PERFORM TRACKING STUDIES

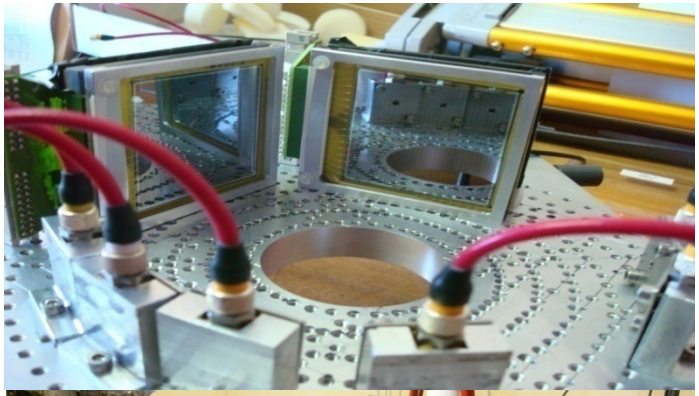

Detectors
Target Holder
Beam Line
intermediate
chamber
1.0x1.0x1.5m chamber

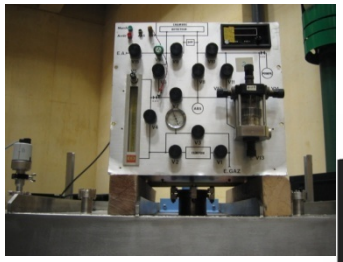

CRIOLAB
VARIAN



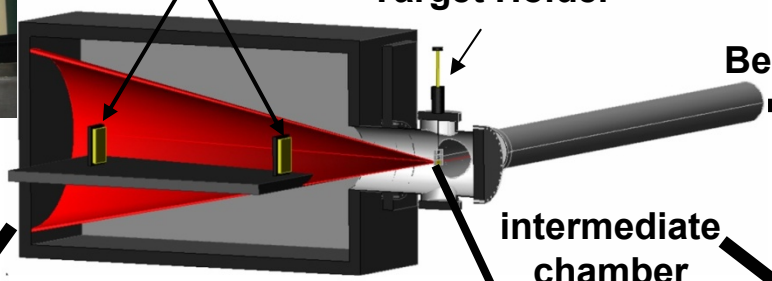
Centro Nacional de Aceleradores

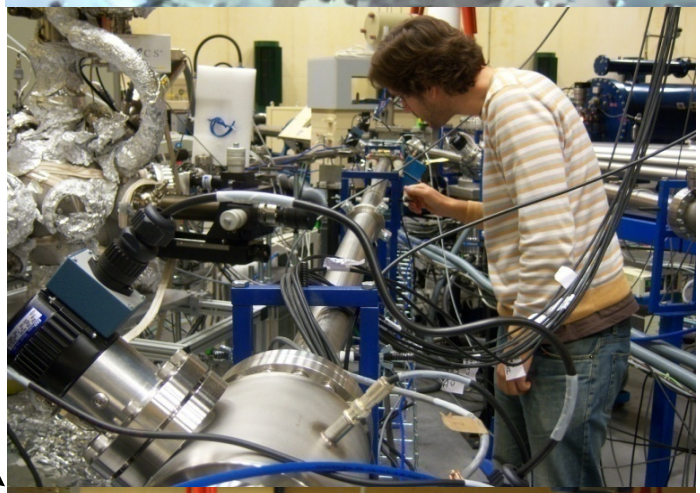


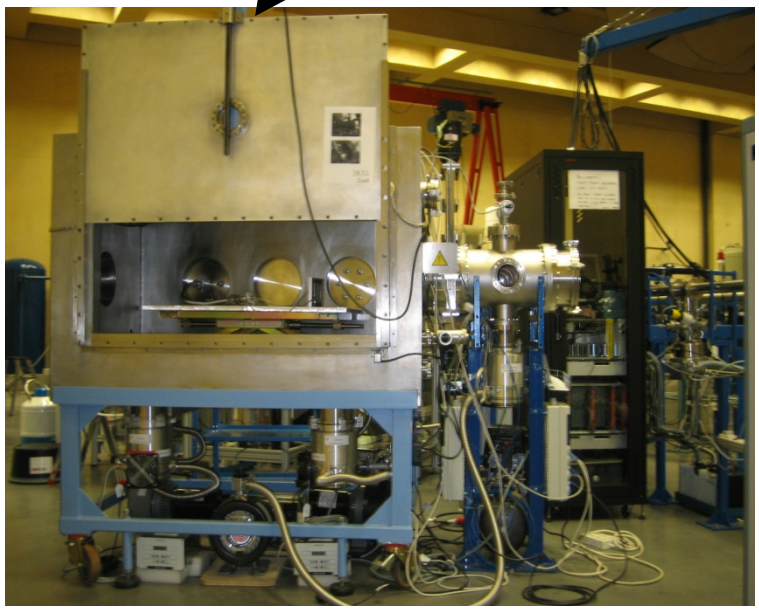


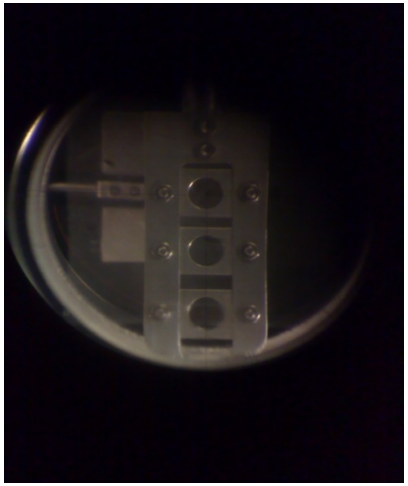


Central of GAS

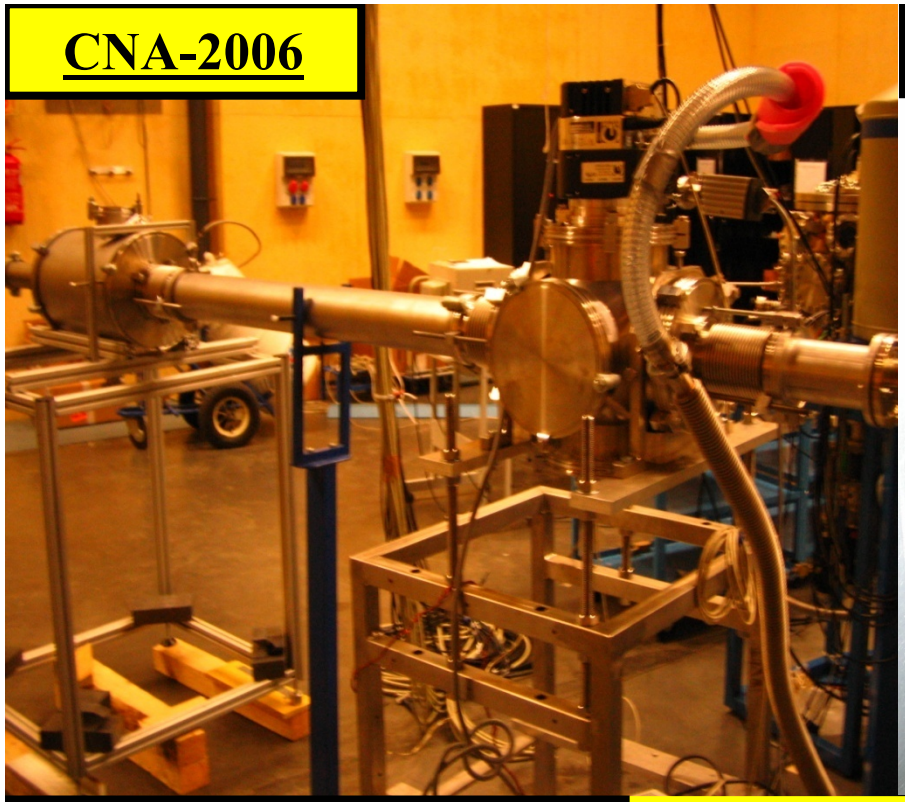




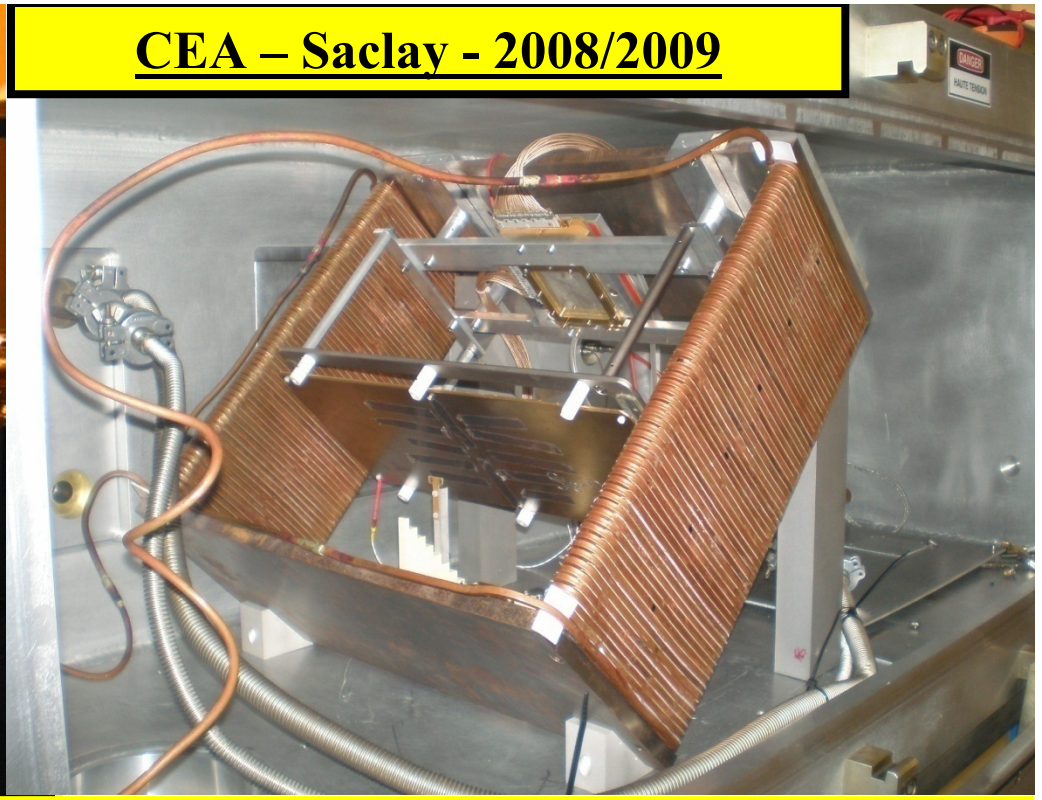




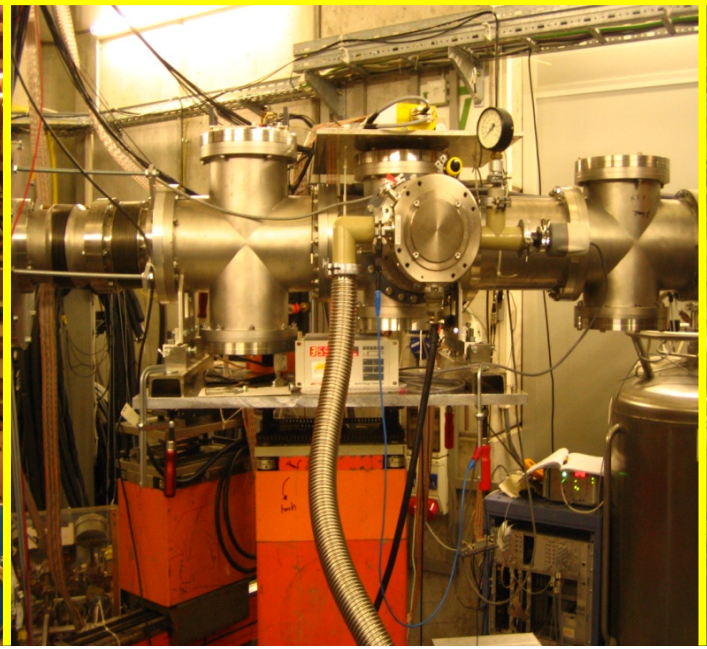
CNA-2006

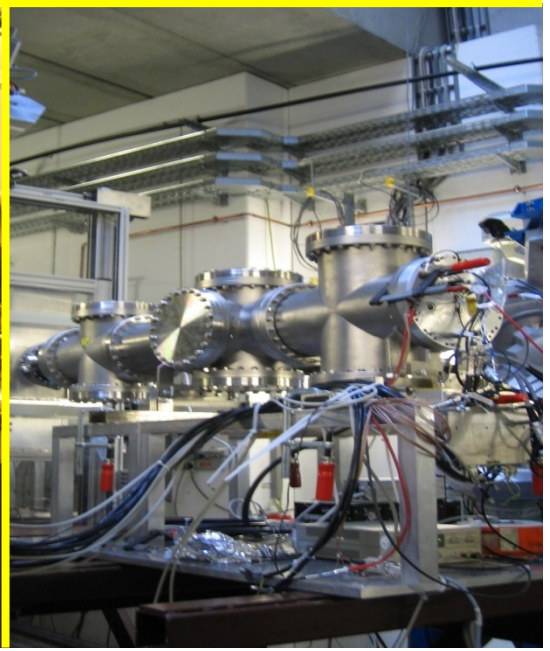


CEA – Saclay - 2008/2009

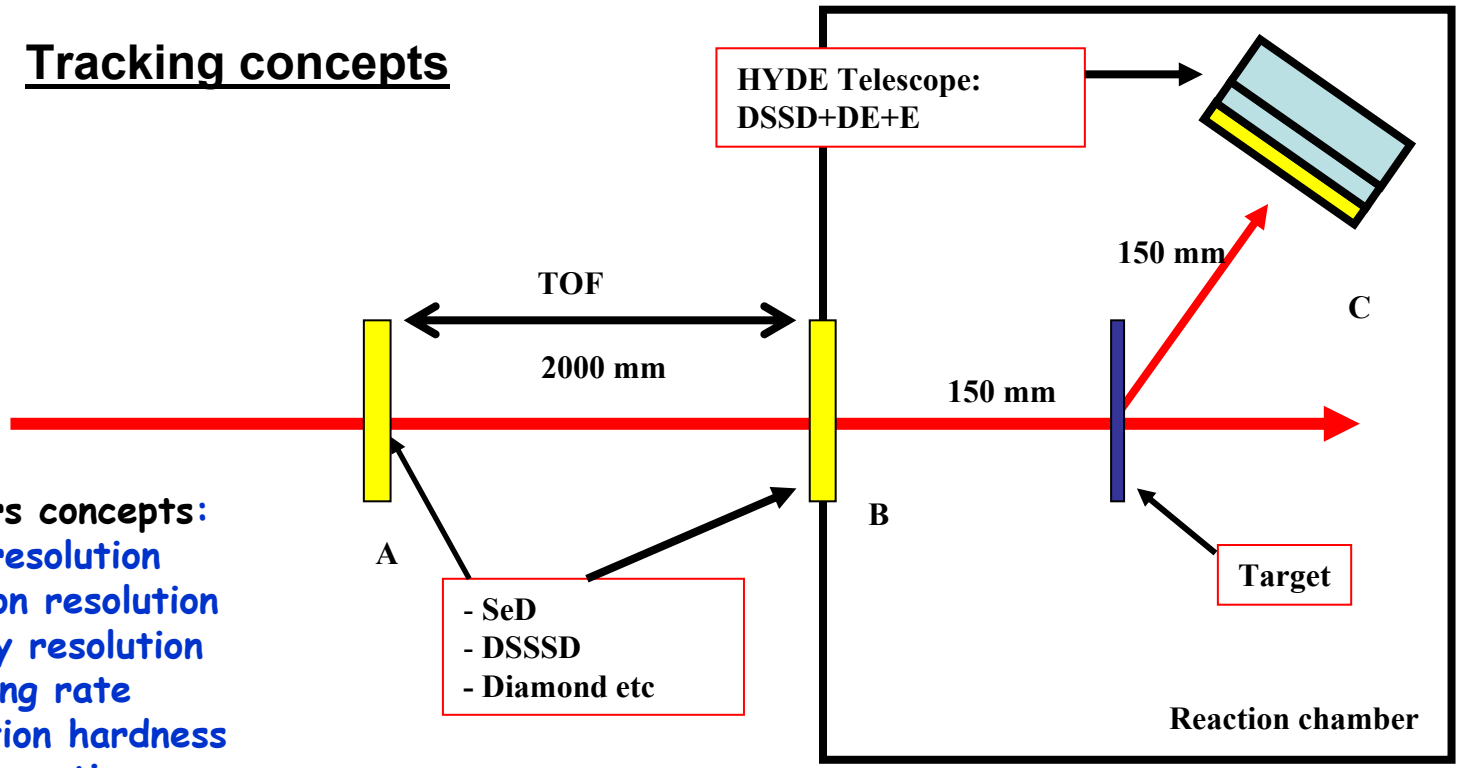


GSI – 2005/2007/2008



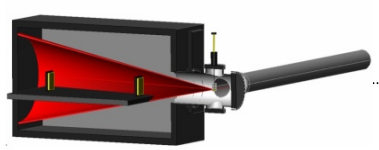


Tracking concepts

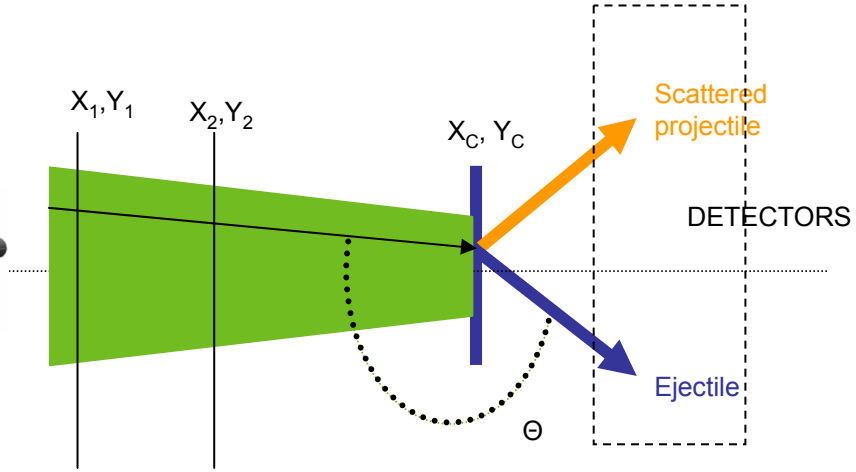


Detectors concepts:

- ❑ time resolution
- ❑ position resolution
- ❑ energy resolution
- ❑ counting rate
- ❑ radiation hardness
- ❑ posible active areas
- ❑ noise level



Tracking structure
CNA-Seville



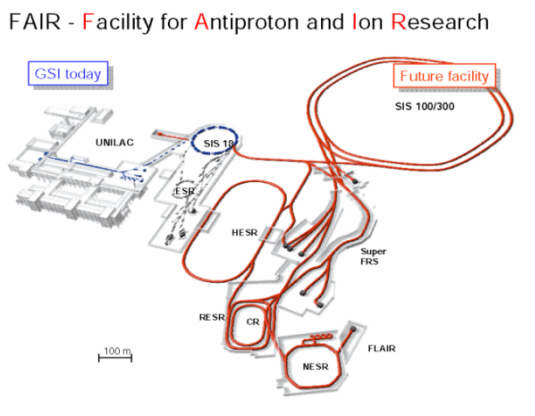
Radioactive Ion beams

- LARGE ACCEPTANCE
- LOW BEAM INTENSITY
  (below 10^5 pps)

Increasing with the future particles accelerators (>10^6pps)
High counting rate capability!!

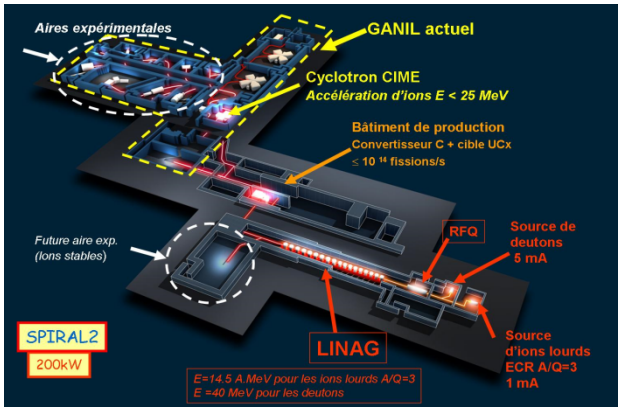
Looking for beam tracking system for future particle accelerators:

- ► small and large area tracking system for different new experiments;
- ► good position, energy and time resolutions;
- ► the corresponding integrated fast electronics (FPA and ADC).
- ► with the possibility of working with high counting rate;
- ► the corresponding radiation hardness, and
- ► low level noise.



The ideal detector for tracking:

- Possibility of a large area version 20x20cm; 50x50cm…
- Counting rate > 10^6 particles/sec (mainly for future facilities)
- with corresponding radiation hardness and
- NO noise degradation
- Time resolution (with beam) ≤ 100ps
- Energy Resolution ΔE/E ~ 1%
- Position Resolution ~ 1mm



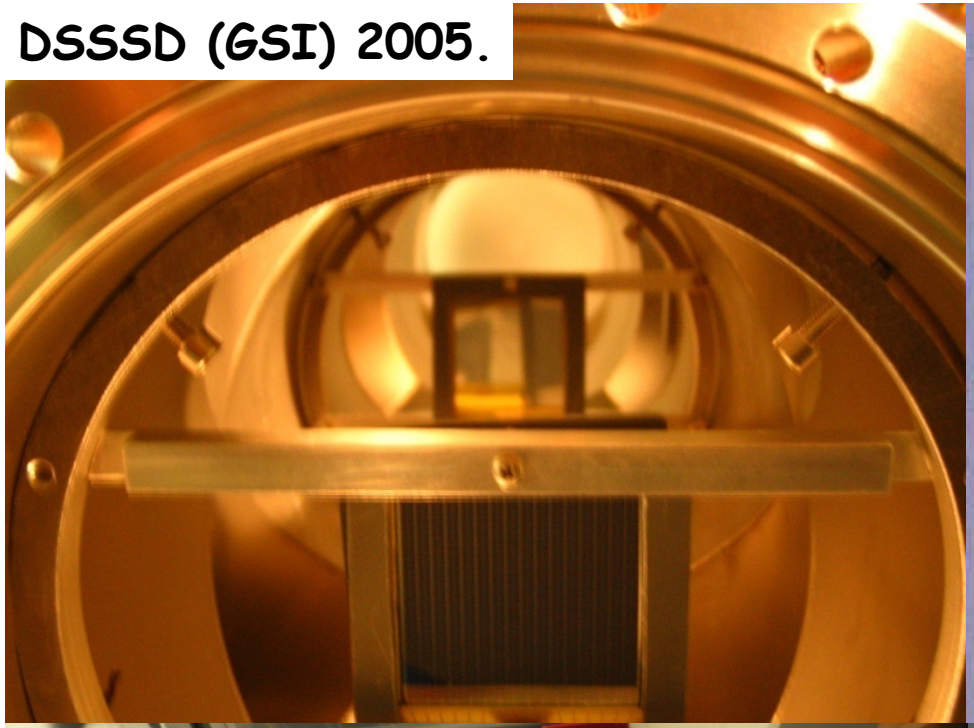
Beam tracking detectors for radioactive ions

Interested institutions (FAIR): **(GSI; LNL; GANIL; CEA Saclay; U-Manchester; U-Huelva; STFC Daresbury; IKP-Köln; U-Surrey; U-Liverpool; U-York; IPN Orsay; IFIN-HH; IFJ-PAN Krakow and Univ. of Seville/CNA).**

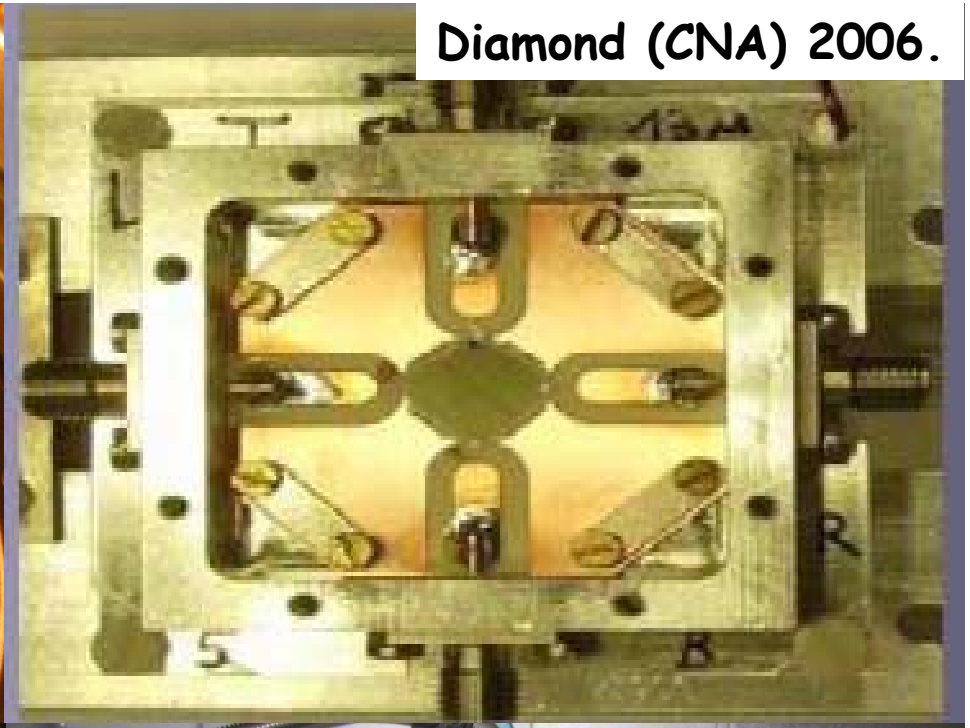
Candidates:

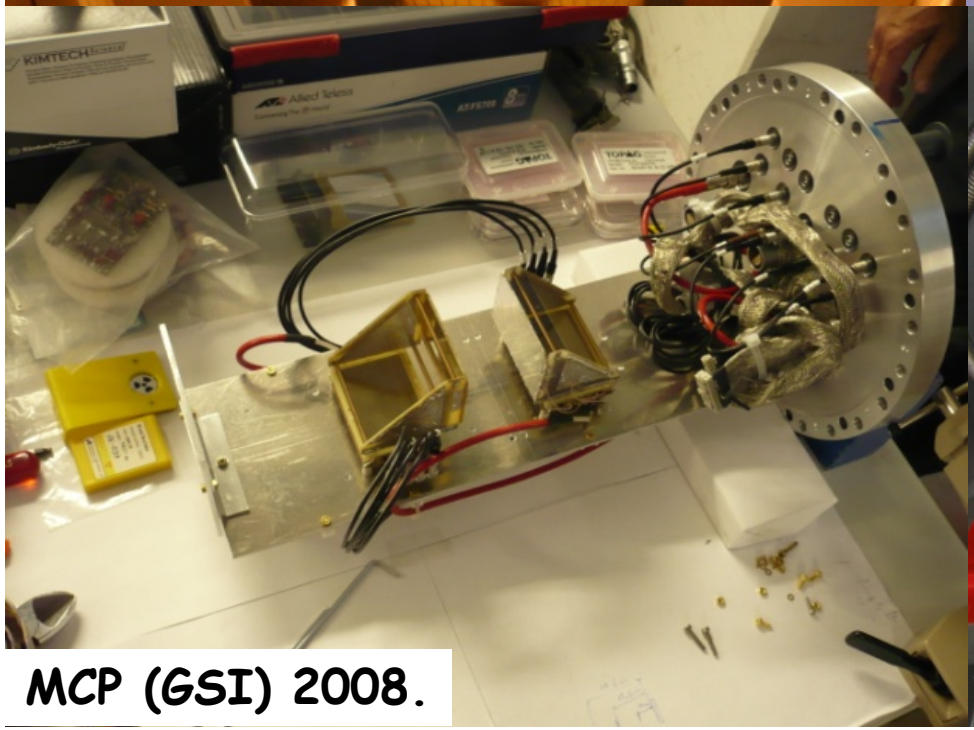
- Low-pressure gas-amplification detectors *with dedicated ASIC electronics*;
  - Se-D (Secondary electron Detector). A large area detector.
    Need of fast pre amplifiers, electric and magnetic field applied.
  - An alternative is the low-pressure "MICROMEGAS" detectors. High counting rate, radiation hardness.
    Different sizes and coupling to low pressure are under investigation.
- Diamonds detectors are very fast, very high counting rate capability and radiation-hard. Good energy resolution.
  Large area is not available and it is an expensive technology.
- DSSSD and organic-scintilator detectors. Good performance;
  but limited counting rate and radiation hardness. Good for test proposal!
- Micro Channel Plates MCP detectors. Excellent time and position resolution.
  Large area readout to be investigated.

DSSSD (GSI) 2005.

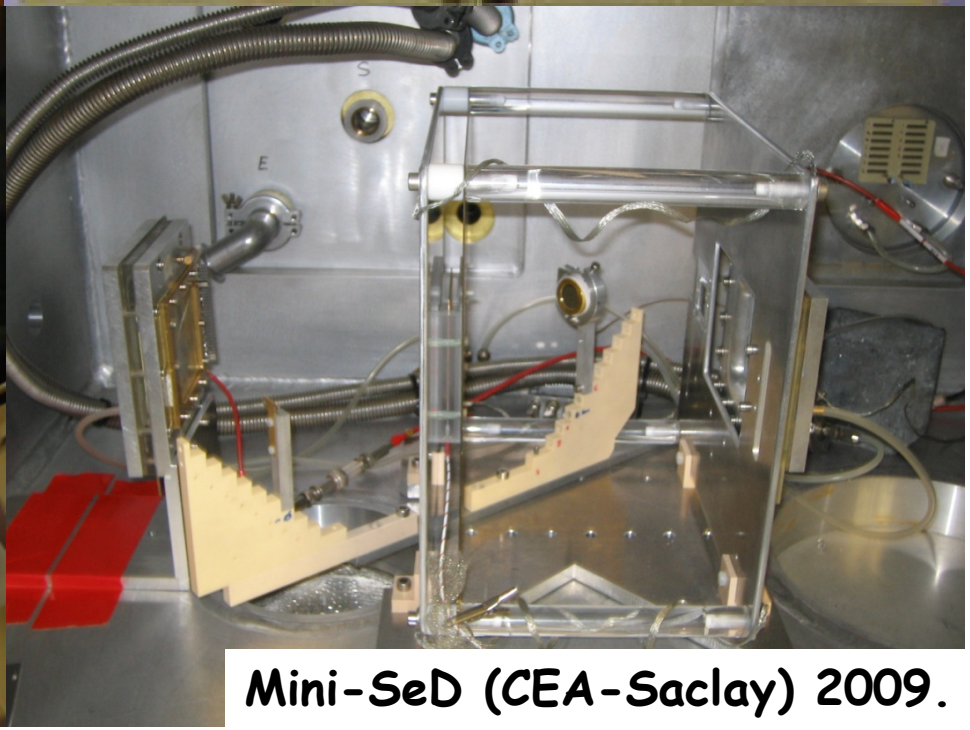


Diamond (CNA) 2006.



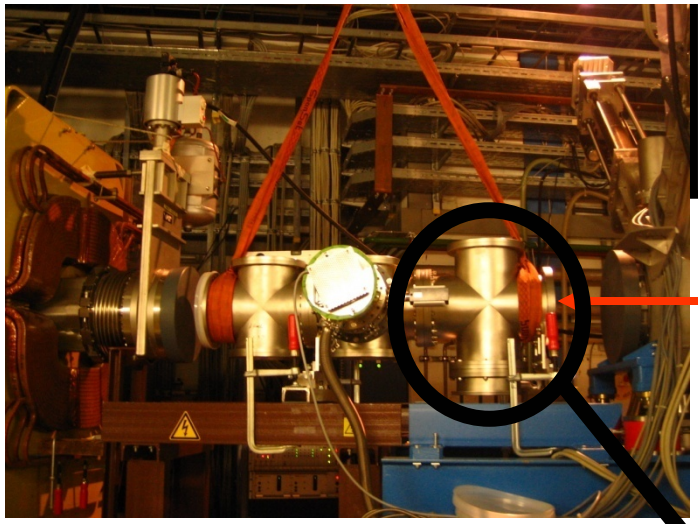


MCP (GSI) 2008.



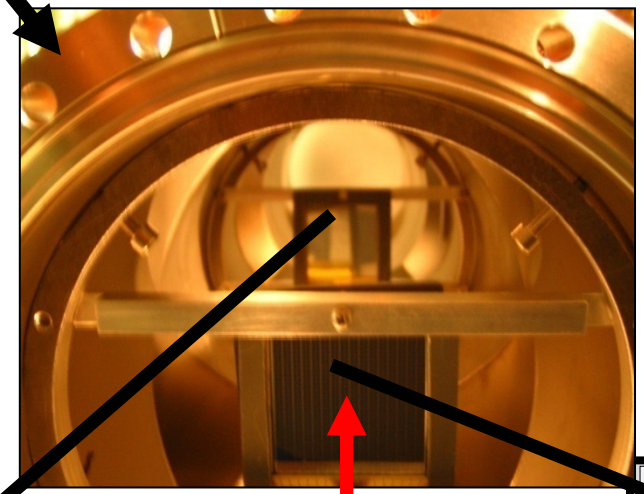
Mini-SeD (CEA-Saclay) 2009.

S271 TEST (2005) and Experiment (2006) @ GSI:



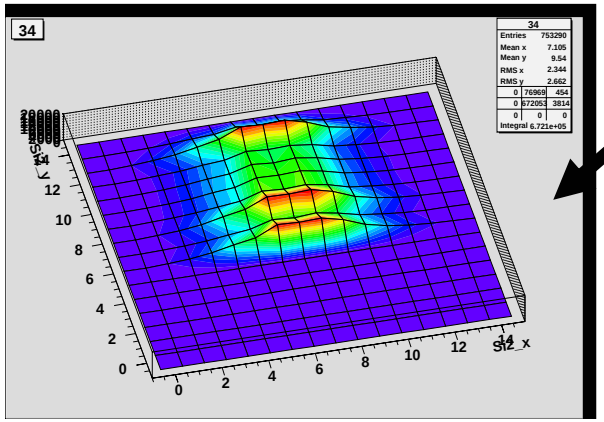
^{8}B BEAM TRACKING

DSSSD's 16x16 strips:
tested as "beam profile monitor" (2005) and
used as impact position monitor, on target (2006).

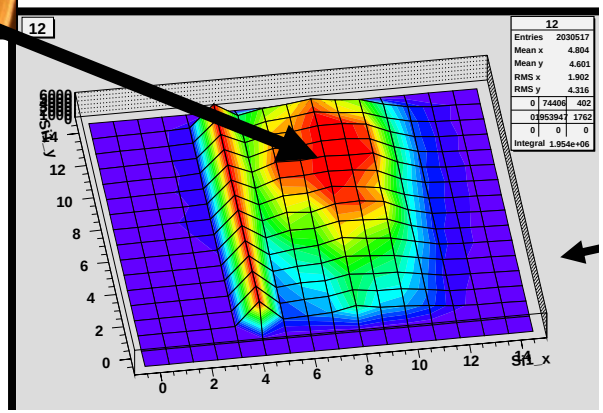


Counting rate: 10^{4} pps
Beam energy: 250 MeV/u
Spot: 3cm x 5cm

- **Good performance for DSSSD tracking @ FRS conditions;**
- **Good candidate for tests proposals!**



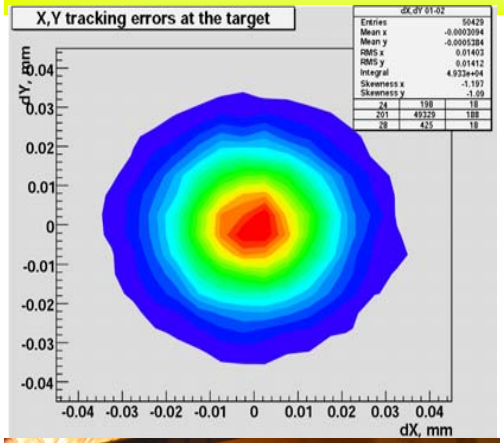
BEAM



Experiment S271 (19Mg decay) at GSI – 11/2006, S2-FRS

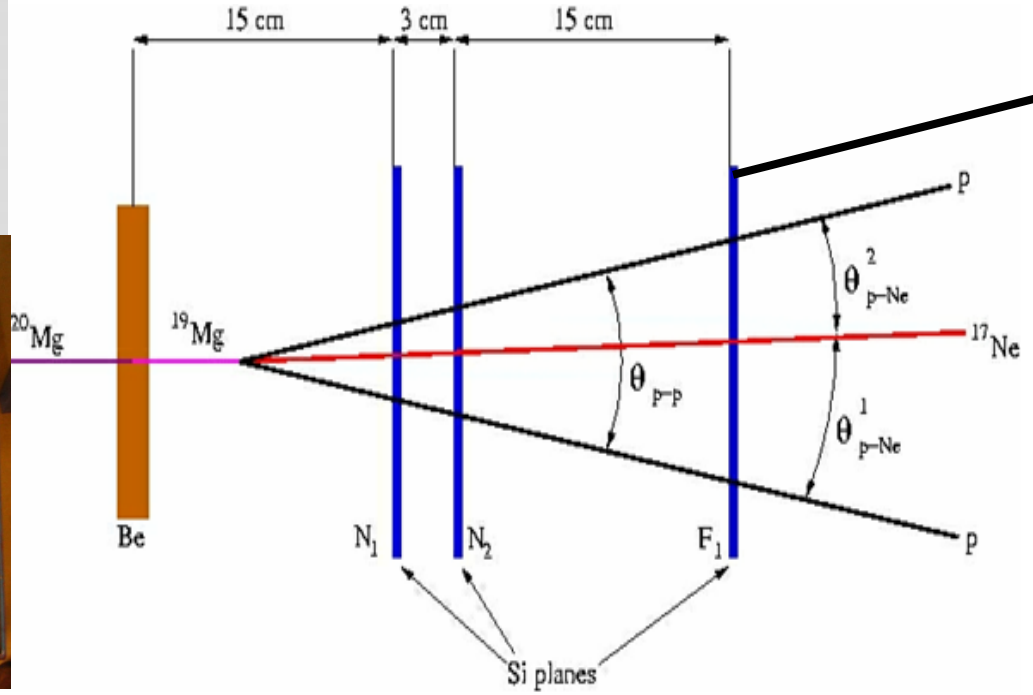
Two proton radioactivity of 19Mg by tracking decay products, *I. Mukha et al.*

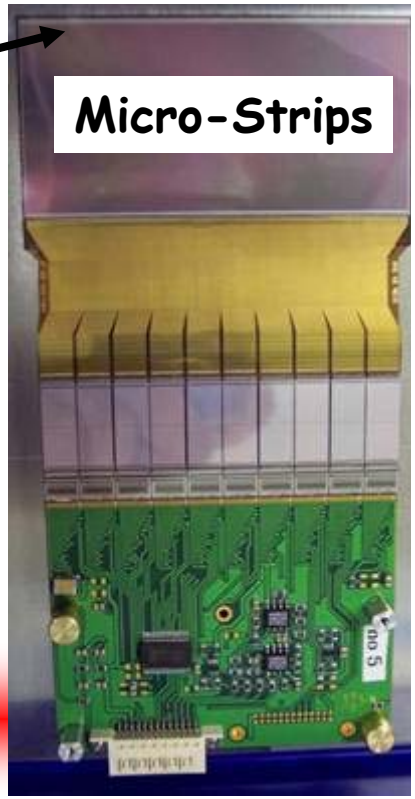
Tracking scheme in the GSI experiment S271, "Two-proton decay of ^{19}Mg"



Reaction Fragments tracking

- Phys. Rev. Lett. 99, 182501 (2007).
- Phys. Rev. C 77, 061303 (2008).
- Phys. Rev. C79 061301(R) (2009).





Fragmentation ^{20}Mg->^{18}Ne+p+p

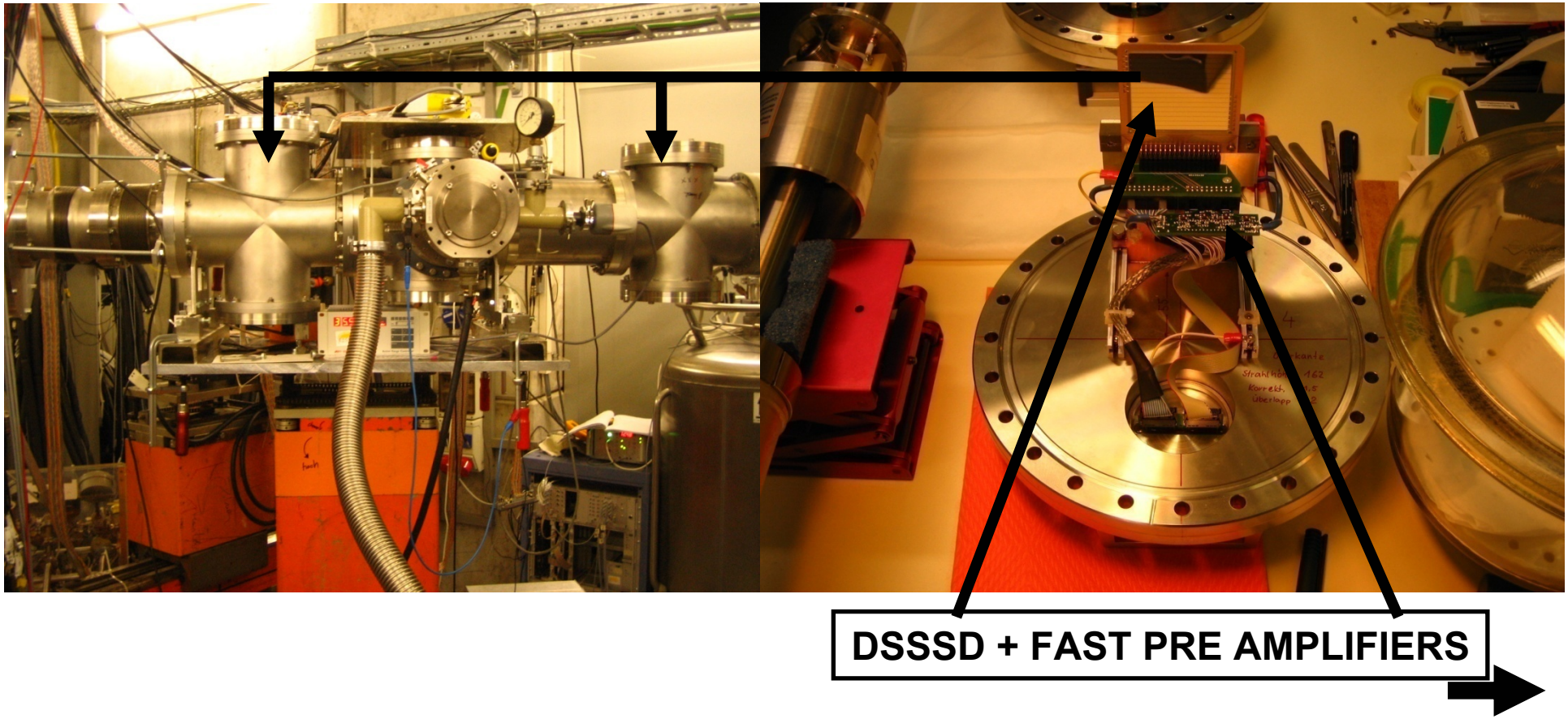
Reaction ^{20}Mg->^{19}Mg->^{17}Ne+p+p

TEST S310 (Slowed down simulations) at GSI - 08/2007, S2-FRS

► Development of fast timing for a large area DSSSD was initiated;

►Test experiment at UNILAC: 40μm, 5x5cm DSSSD were tested with pre-amps developed @ GSI;

► Dr. Plamen Boutachkov talk!!!



TEST - Experiment (Slowed down beams) at GSI - 09/2008, S2-FRS

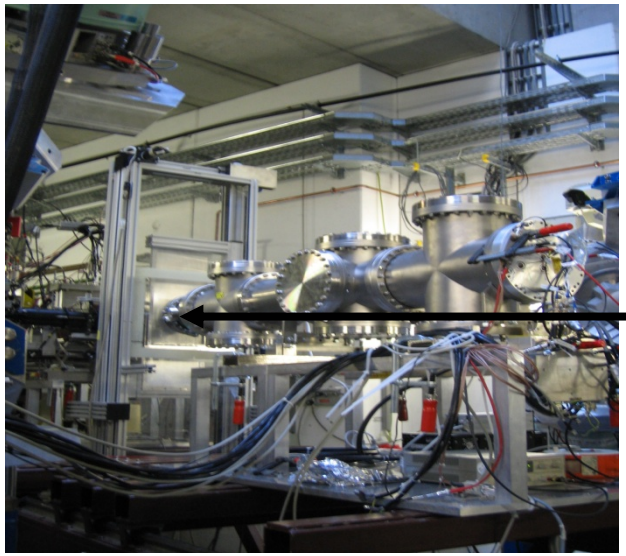
A 600MeV/u of 64Ni beam is slowed down to 2MeV/u by Al degraders;

Energy of the slowed and scattered 64Ni ions is measured by a TOF method, before target with a scintillator detector and after target with the MCP detector.

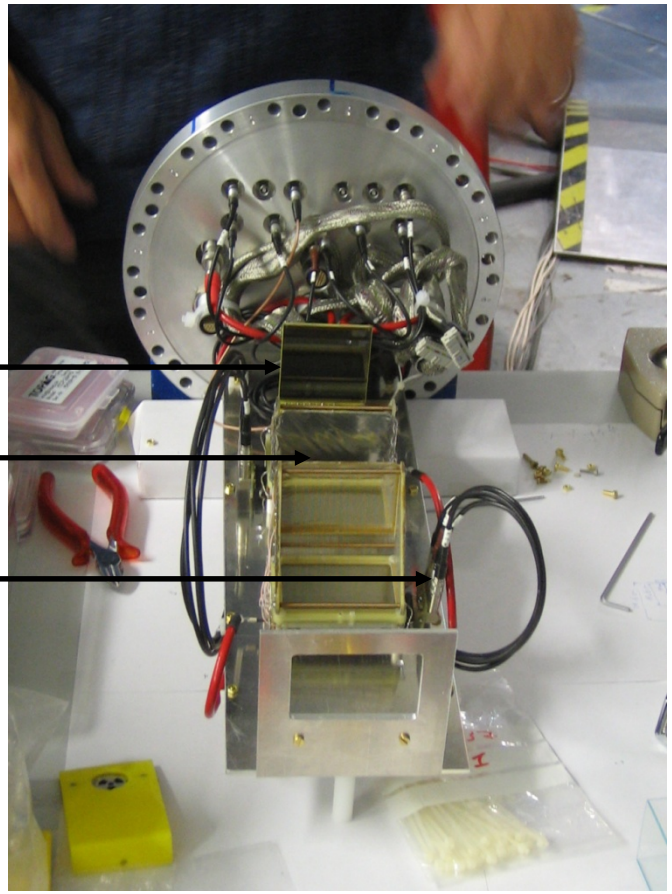
The Si detector stop the particles detecting their energy; ExTOF analysis.

The MCP detector consisted of a thin 6cmx4cm foil; associated to the fast pre-amp.

► Dr. Plamen Boutachkov talk!!!



Silicon
+
Multi Channel Plate
+
FPA (Dubna)
+
Scintillator



Application of Diamond Detectors in Tracking of Heavy Ion Slowed Down Radioactive Beams (2006)

Acta Phys. Pol. B38, 1293 (2007).

Irradiation of thin CVD diamond detectors with low energy 100MHz of p,α,7Li beam was performed:

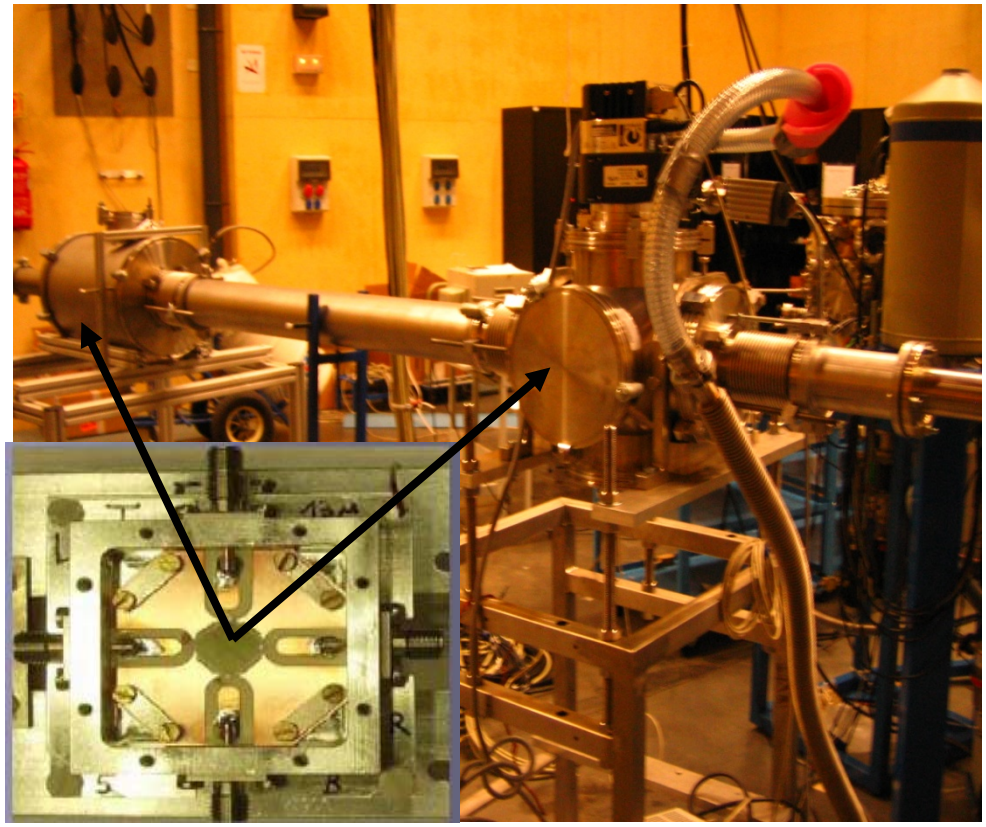
ΔE/E<1% of a SC CVD diamond detector was achieved.

TIME Resolution ~ 100ps

Low dead time
(70% of efficiency) and

satisfactory radiation hardness.
No signs of degradation or noise.

Counting Rate : 10^{7-9} particles/s



Limitation: To cover a large surface using very thin single crystal diamond films!

MOTIVATION for mounting a dedicated Nuclear Physics Line!!!

Diamond Detectors for the R3B Experiment at FAIR, Darmstadt

S. Schwertel, M. Böhmer, R. Gernhäuser, R. Krücken, L. Maier, and S. Winkler

www.bl.physik.tu-muenchen.de/bl_rep/jb2007/p090.pdf

- **Time resolution of 60 ps**
- **detector efficiency of 98%**
- **radiation hardness up to 2.5x10^13ion/cm2**

Detector Layout:

- **Detector substract material is a 100µm thick layer of polycristaline PC CVD diamond of size 2.54cm x 2.54cm.**
- **The one side used for position measurement is segmented in 128 strips with a pitch of 200µm and gaps of 20µm.**
- **Back side is used for ToF measurement. It is divided into 16 aluminium strips each with a gap of 50 µm.**

Investigations of new samples of single-crystal CVD-diamond detectors

E. Berdermann, M. Ciobanu, W. de Boer, R. Lovrincic, J. Morse, M. Pomorski, M. Traeger

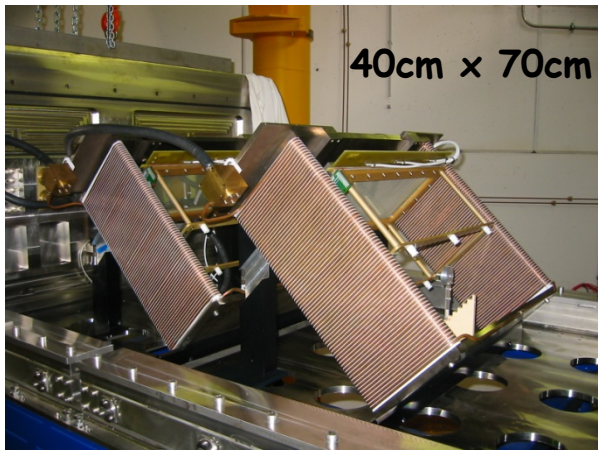
- **3.5mmx3.5mm area**
- **Thickness ~ 50µm**
- **Energy resolution δE~15KeV (δE/E=0.27%).**
- **Counting rate around 10^16 particles/cm2**

GSI Scientific Report 2008

Low Pressure Gas Detector Collaboration

Electronics :	**Thomas Chaminade (IRFU/SEDI)**
Scientific coordinator :	**Antoine Drouart (IRFU/SPhN)**
Detector tests :	**Mariam Kebbiri (IRFU/SEDI)**
Technical coordinator :	**Julien Pancin (GANIL)**
Informatics :	**Yves Piret (IRFU/SEDI)**
Mechanics :	**Marc Riallot (IRFU/SEDI)**

External collaboration : **Begoña Fernandez (University of Seville / CNA)**
Marcos Alvarez (University of Seville / CNA)
Farheen Naqvi (GSI)



- SeD - VAMOS SPECTROMETER (GANIL)
  - Good position resolution 1 - 2mm
  - Time resolution ~ 250 ps
  - Counting rate 10^3 pps (limited by electronics)

- mini SeD (70x70mm and the same parameters of SeD)
  - Place for improvement (time, position, counting rate)
  - small and big active area with the same detector
  - Low cost

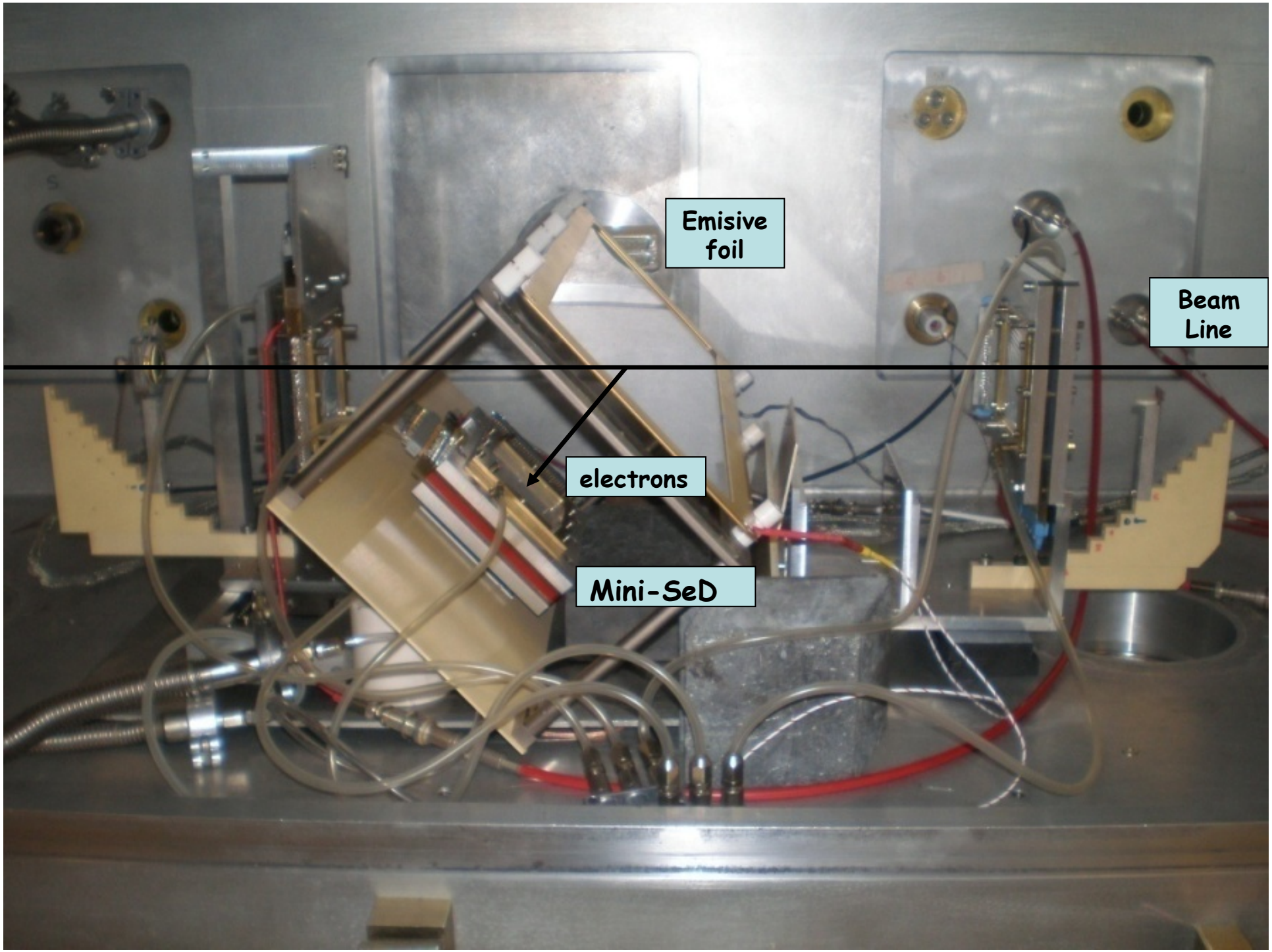
OUR CHOICE!

Quotation for the MiniSeD construction:

Pieces	Dimensions	Thickness	Material	Price+ 19,6%	Price to add*
901V-Piece for the strips	164X120mm	3,2mm	PCB	286eur	
902V-Piece for the anode's wires	100X94mm	1,6mm	PCB	44,55eur	250eur
906V-Piece for the cathode's wires	140X144mm	2,4mm	PCB	176,62eur	460eur
Mylar's window	120X140mm	3,2mm		28eur	80eur
Grille's window	80X80mm	3,2mm	Aislant	28eur	160eur
Aislant pieces for the gasket	140X120mm	1,2mm	Aislant	75eur	80eur
External metal structure(2 pieces)	140X120mm	10mm	Steel	400eur	

Total price estimated: 1242 eur + 1030 eur * !!!!

*To add the first time you construct the pieces

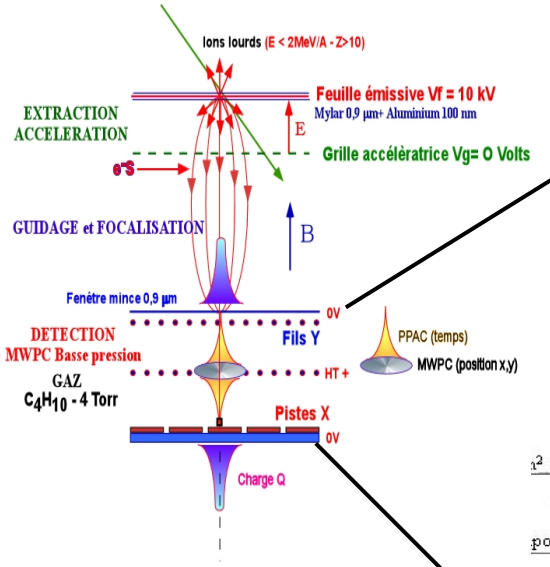

Emisive foil
Beam Line
electrons
Mini-SeD

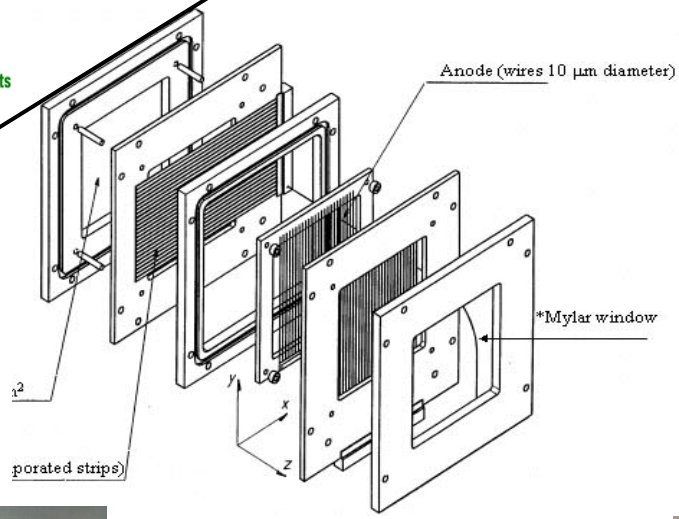
- **SIMULATIONS:**
  - ELECTRIC AND MAGNETIC FIELD
  - CHARGE PRODUCTION
  - ELECTRONIC SIGNALS

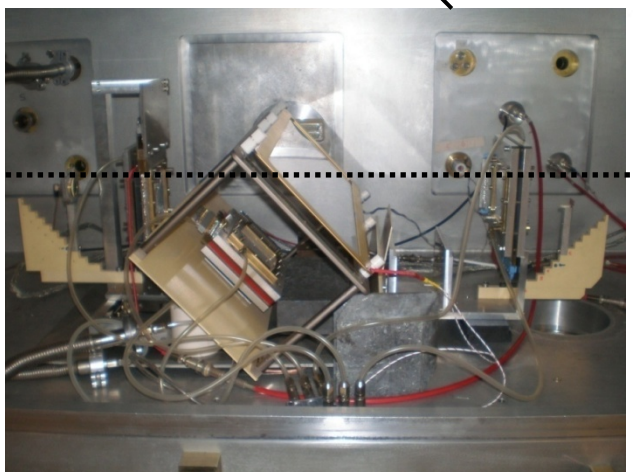
- **CONSTRUCTION:**
  - WINDOWS OF MYLAR
  - STRIP CATHODES (PCB's)
  - WIRE ELECTRODES
  - MECHANICAL PIECES

- **COMPLEMENTAR DEVELOPMENT:**
  - FAST PRE-AMPLIFIERS

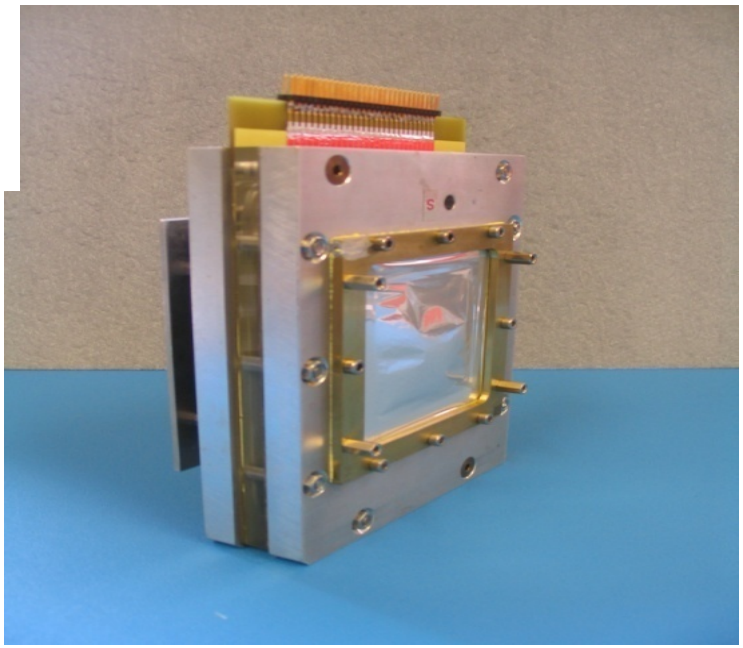
- **TESTS:**
  - AMPLITUDES (operation voltajes)
  - TIME RESOLUTION
  - POSITION RESOLUTION

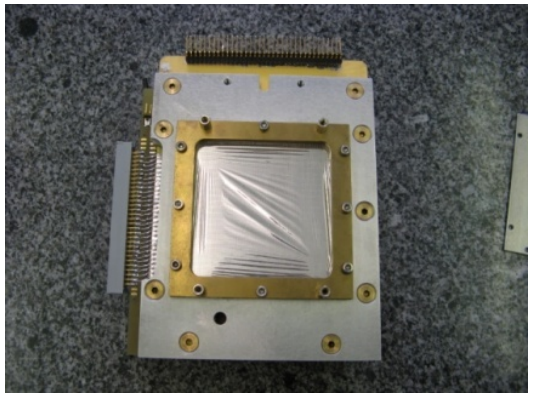




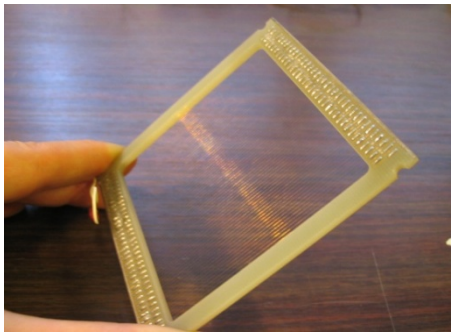


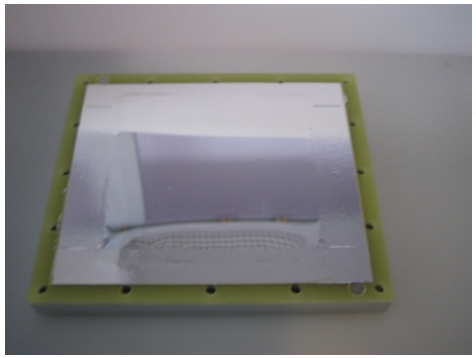
Beam Line

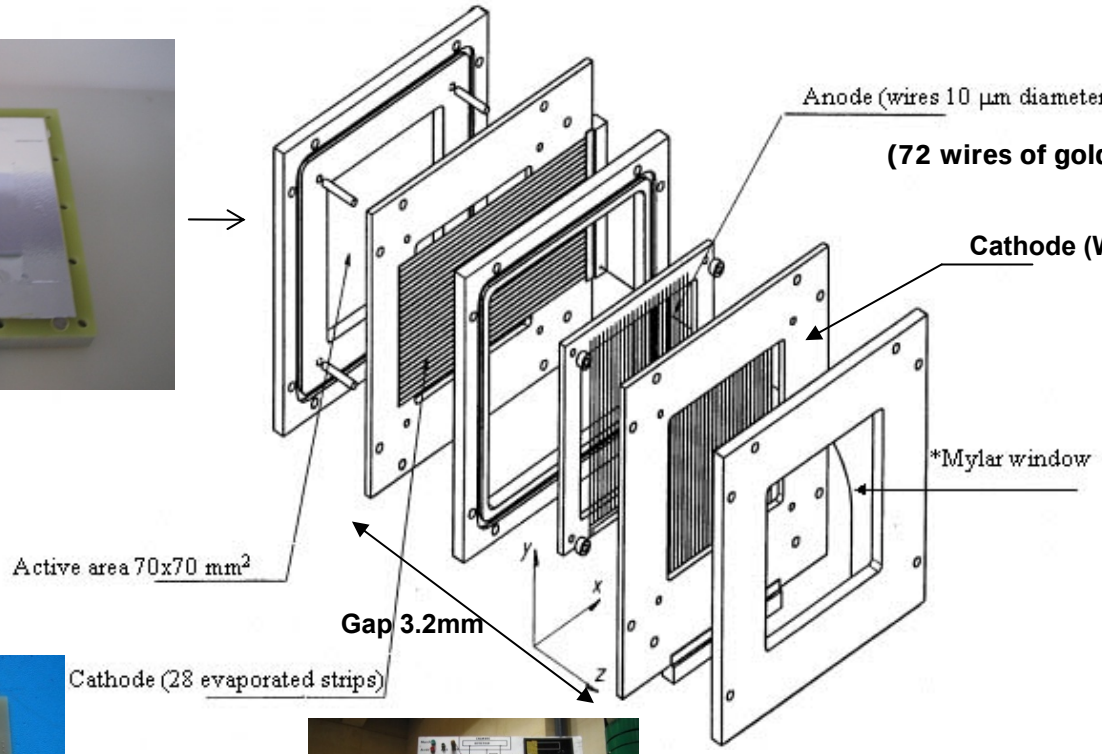


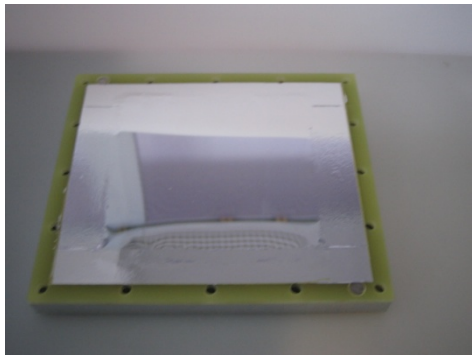


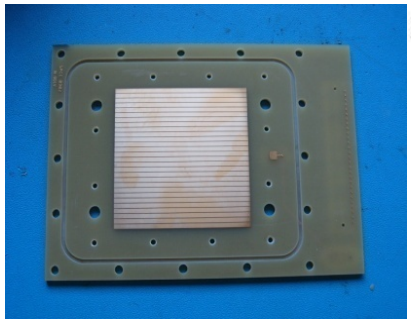
Mini Secondary electron Detector (mini-SeD) the mechanical construction:

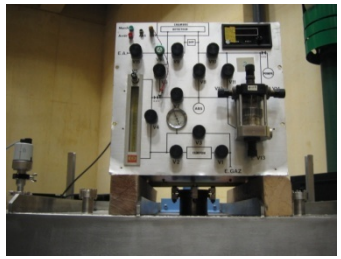






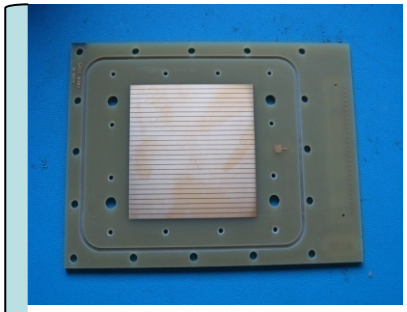
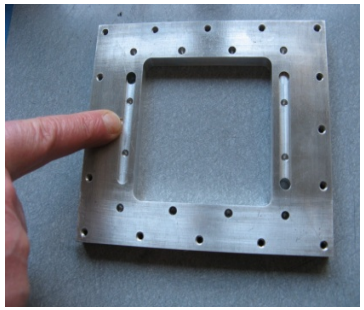
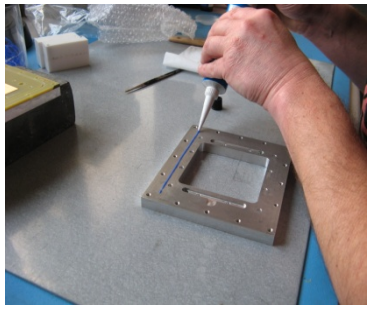
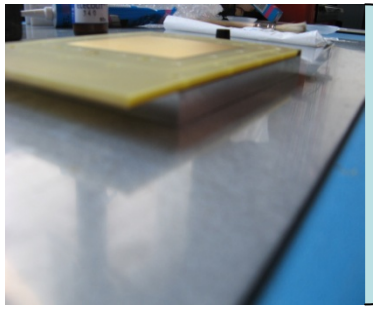




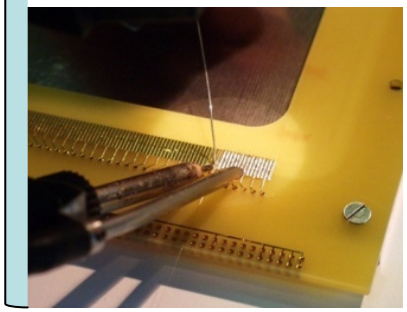
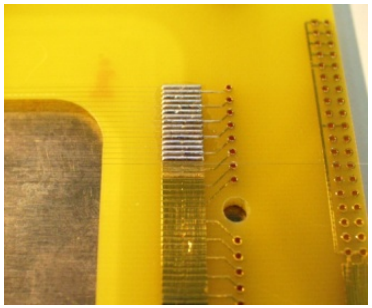
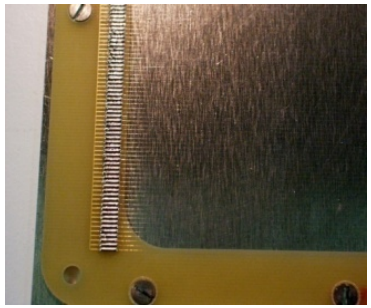
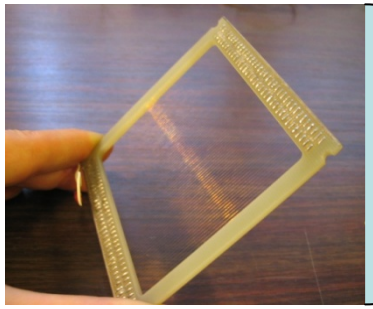


MECHANICAL CONSTRUCTION:

ELECTRODES

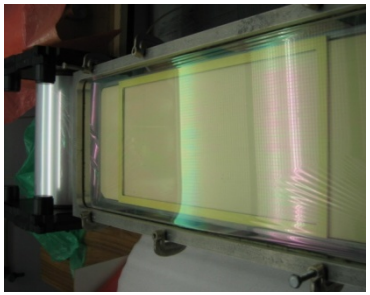





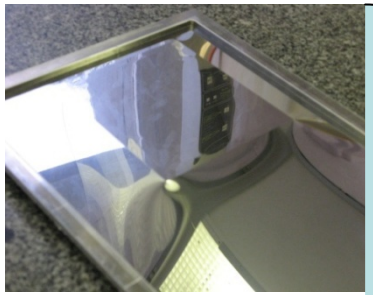
CATHODE

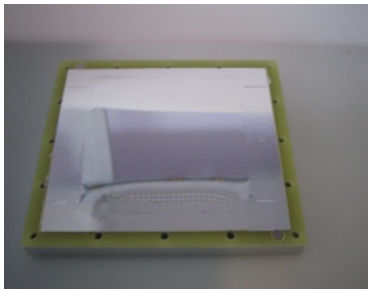
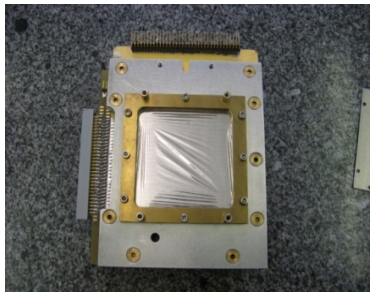
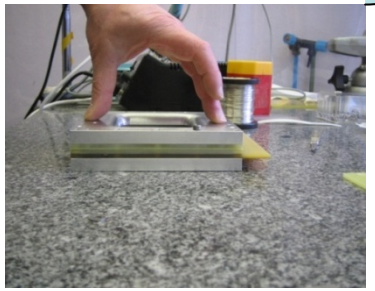
ANODE

MYLAR

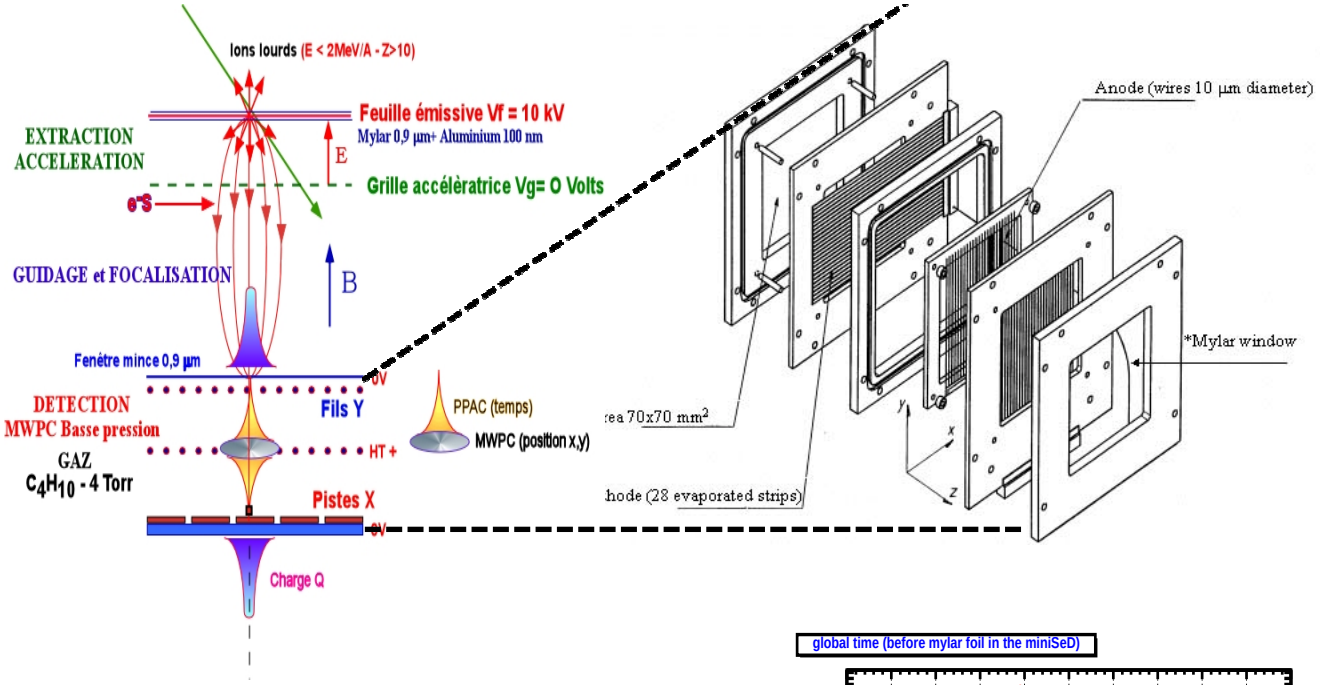



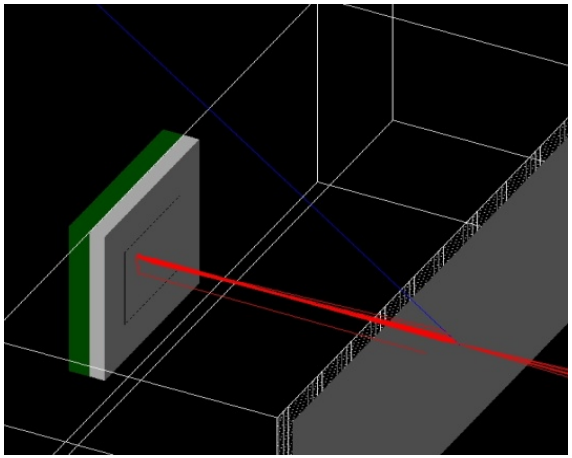


MYLAR

FINAL PRODUCT: Mini-SeD prototype

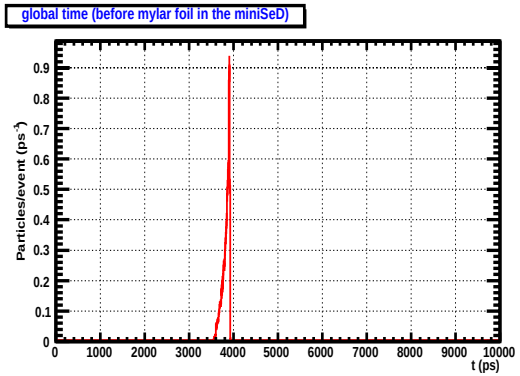


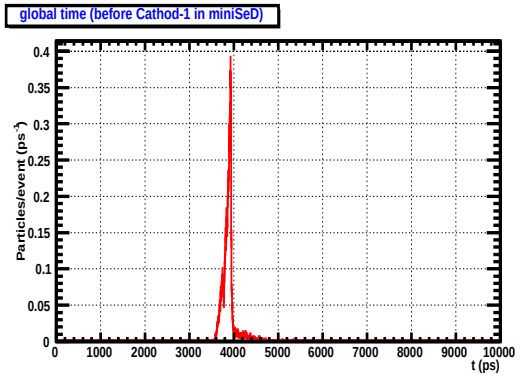


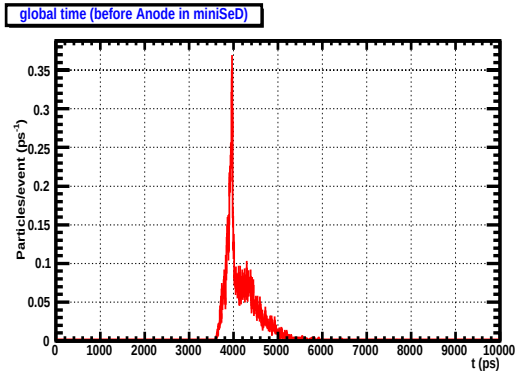
We introduce all detector parameters in GEANT4 and simulate the charge production and time fluence, which is the input to the pre-amp simulations.

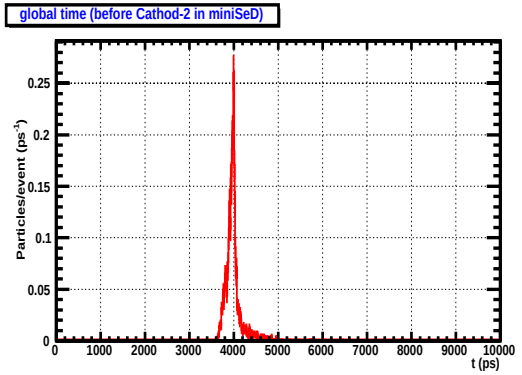
- **Energy of the incident beam = 1-20MeV/u**
- **Aluminized mylar tickness = 0.9µm**
- **Extraction voltage = 10KV**
- **Magnetic Field = 100G**
- **C4H10 gas at ~4 Torr**
- **Cu stripers**
- **FR4 PCB**
- **10 µm goldened tungsten (anode)**
- **50 µm goldened tungsten (cathode)**
- **different gaps**
- **Eletric field=600V**

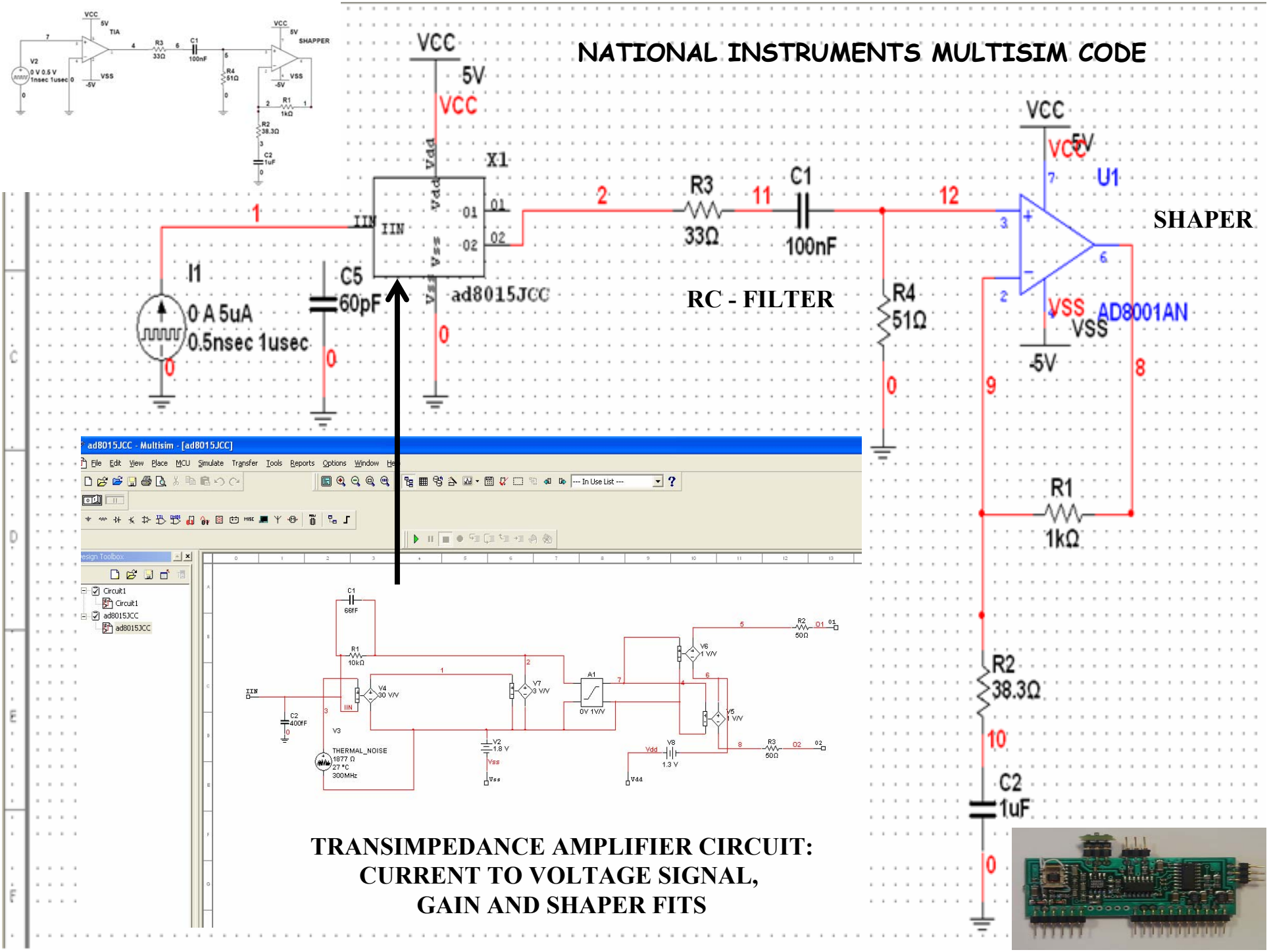
SIMULATIONS

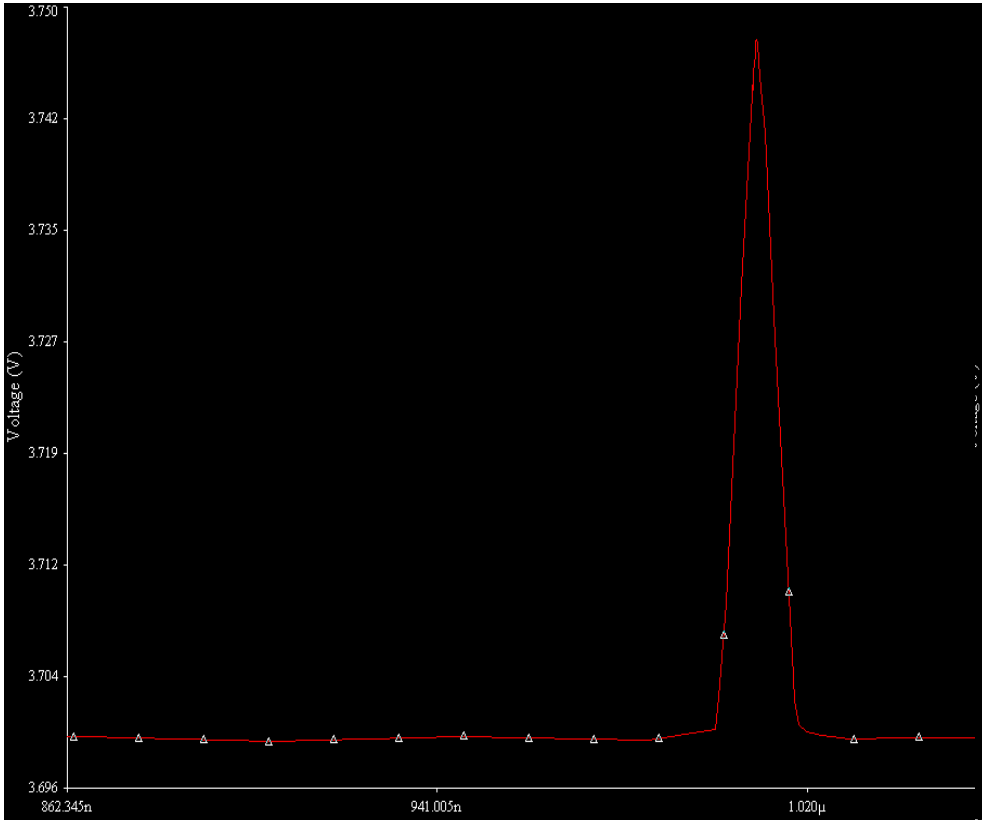


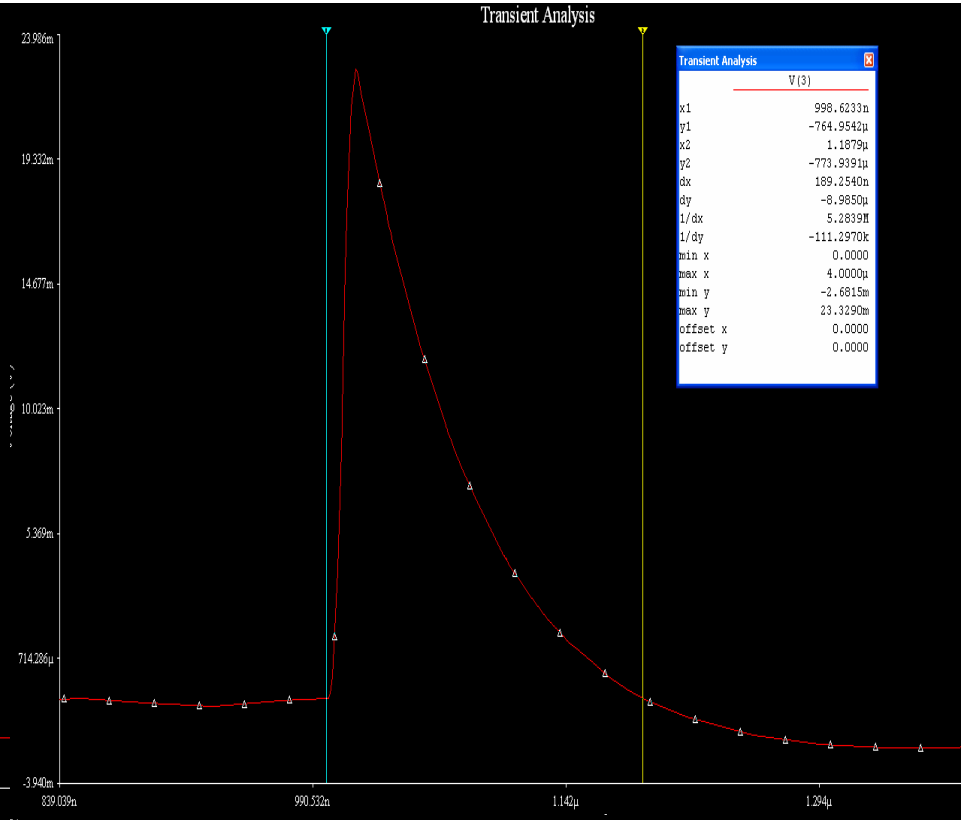


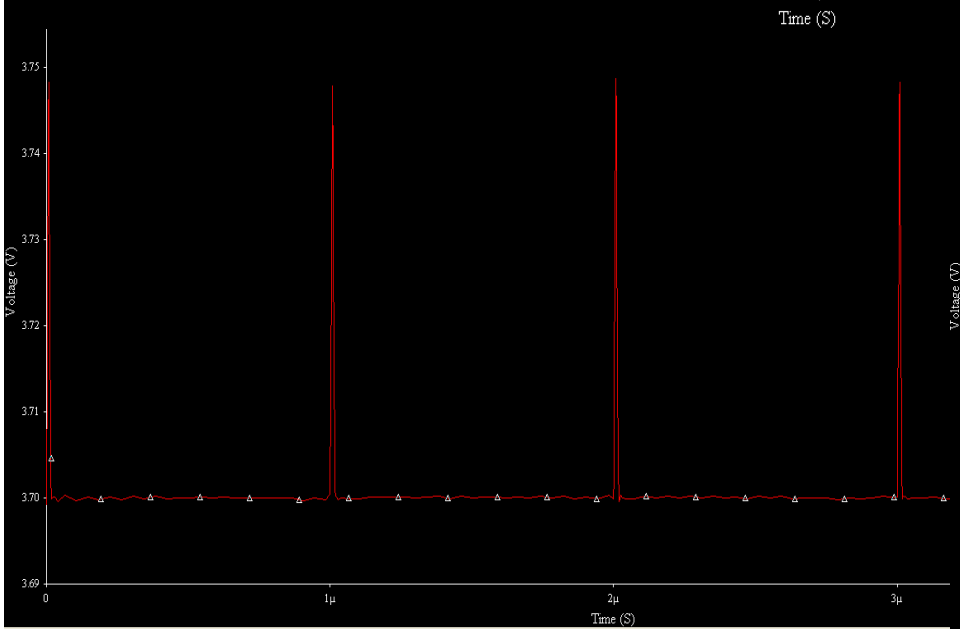


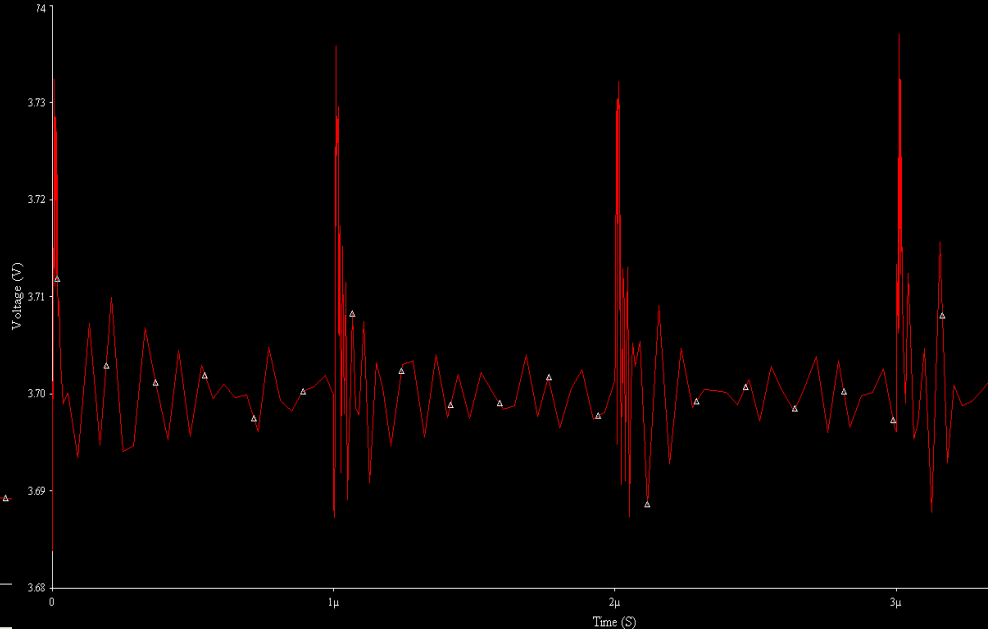



NATIONAL INSTRUMENTS MULTISIM CODE
SHAPER
RC - FILTER
TRANSIMPEDANCE AMPLIFIER CIRCUIT:
CURRENT TO VOLTAGE SIGNAL,
GAIN AND SHAPER FITS
ad8015JCC - Multisim - [ad8015JCC]
AD8001AN
ad8015JCC
VCC
5V
VSS
-5V
R3
33Ω
C1
100nF
R4
51Ω
R1
1kΩ
R2
38.3Ω
C2
1uF
C5
60pF
I1
0 A 5uA
0.5nsec 1usec
U1
X1
IIN

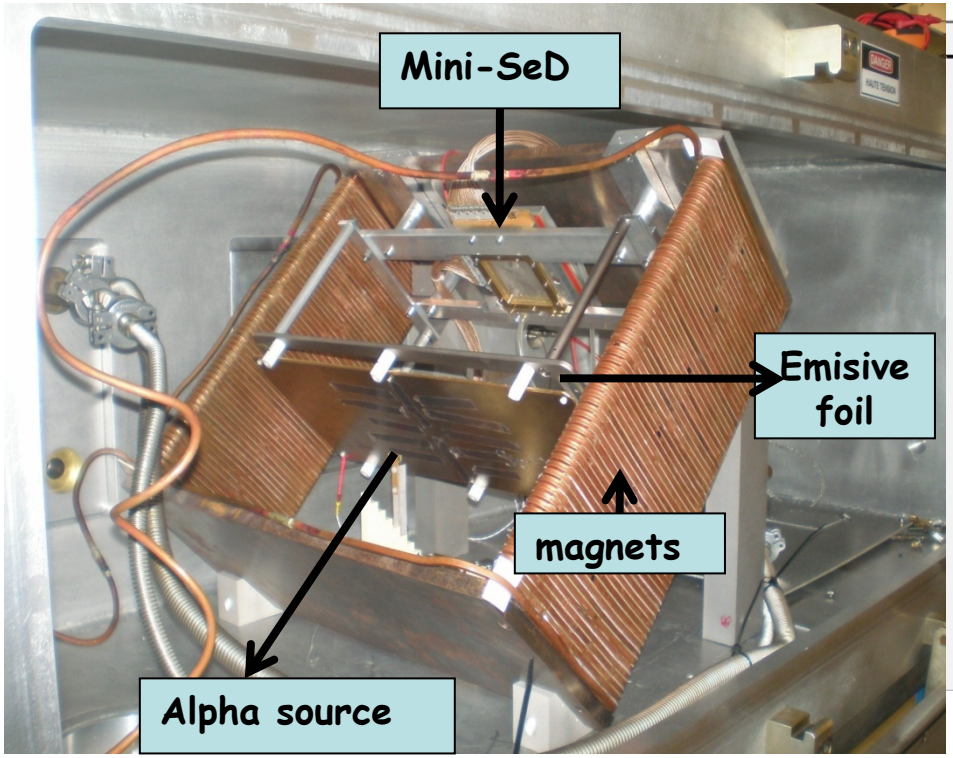

3.750
3.742
3.735
3.727
3.719
3.712
3.704
3.696
Voltage (V)
862.345n
941.005n
1.020µ
Time (S)

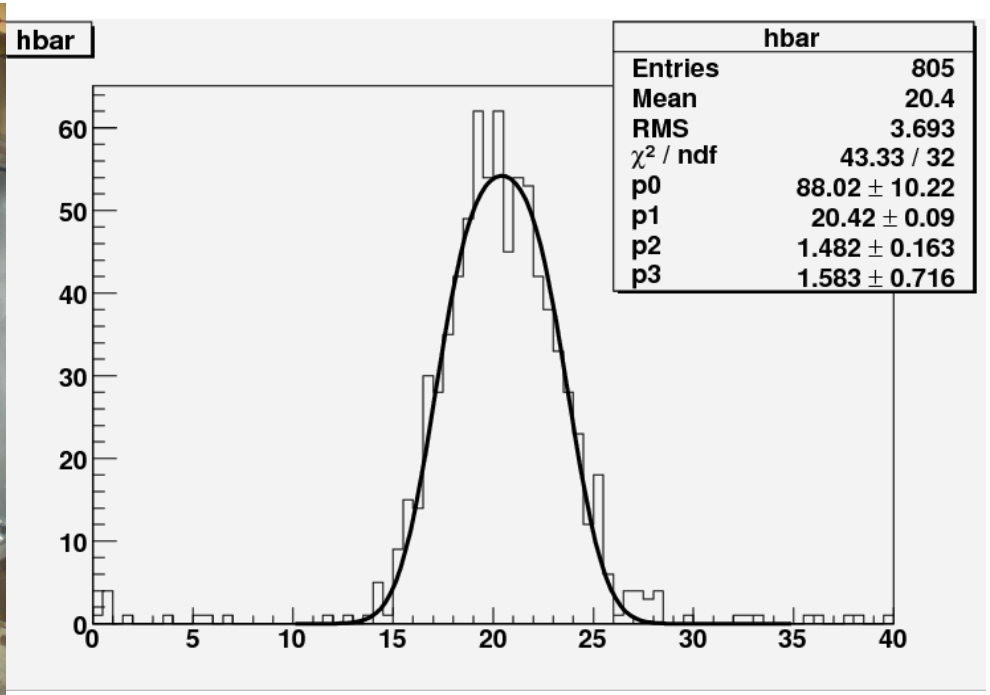

Transient Analysis
23.986m
19.332m
14.677m
10.023m
5.369m
714.286µ
-3.940m
839.039n
990.532n
1.142µ
1.294µ
Transient Analysis
V(3)
x1 998.6233n
y1 -764.9542µ
x2 1.1879µ
y2 -773.9391µ
dx 189.2540n
dy -8.9850µ
1/dx 5.2839M
1/dy -111.2970k
min x 0.0000
max x 4.0000µ
min y -2.6815m
max y 23.3290m
offset x 0.0000
offset y 0.0000

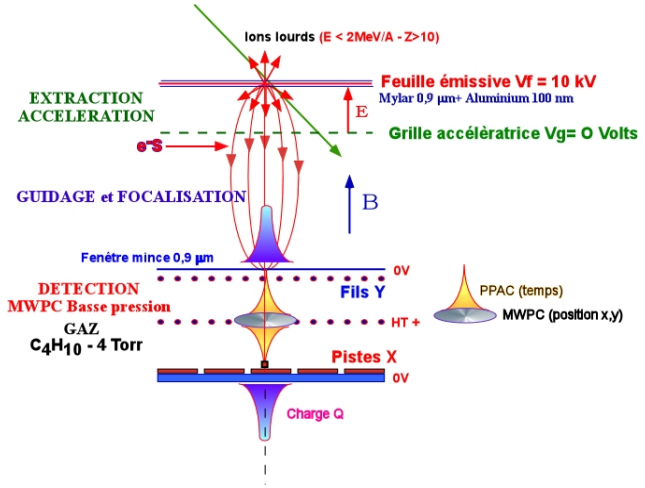

3.75
3.74
3.73
3.72
3.71
3.70
3.69
Voltage (V)
0
1µ
2µ
3µ
Time (S)


74
3.73
3.72
3.71
3.70
3.69
3.68
Voltage (V)
0
1µ
2µ
3µ
Time (S)

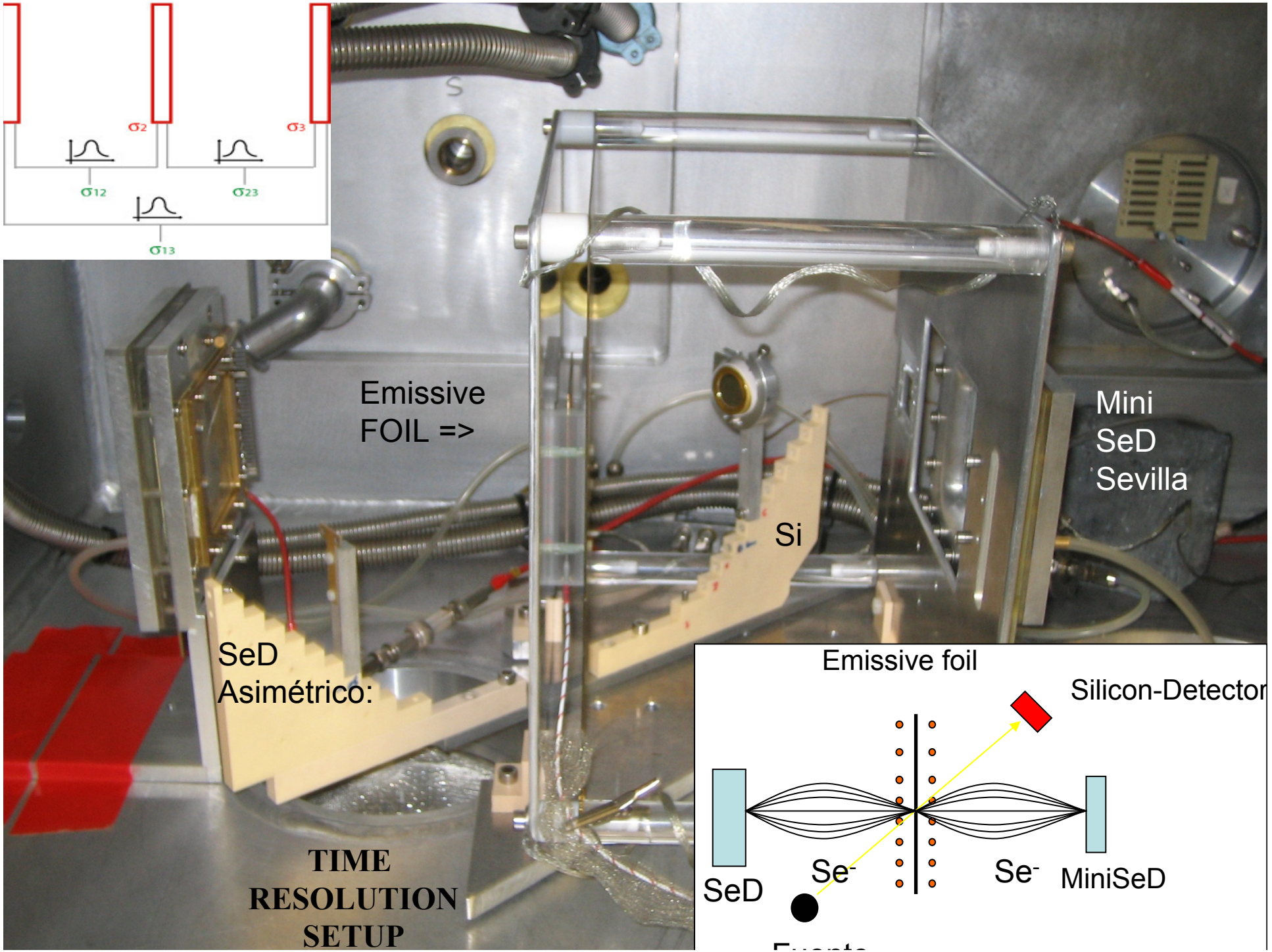
POSITION SIGNALS AND MEASUREMENTS (CATHODE):



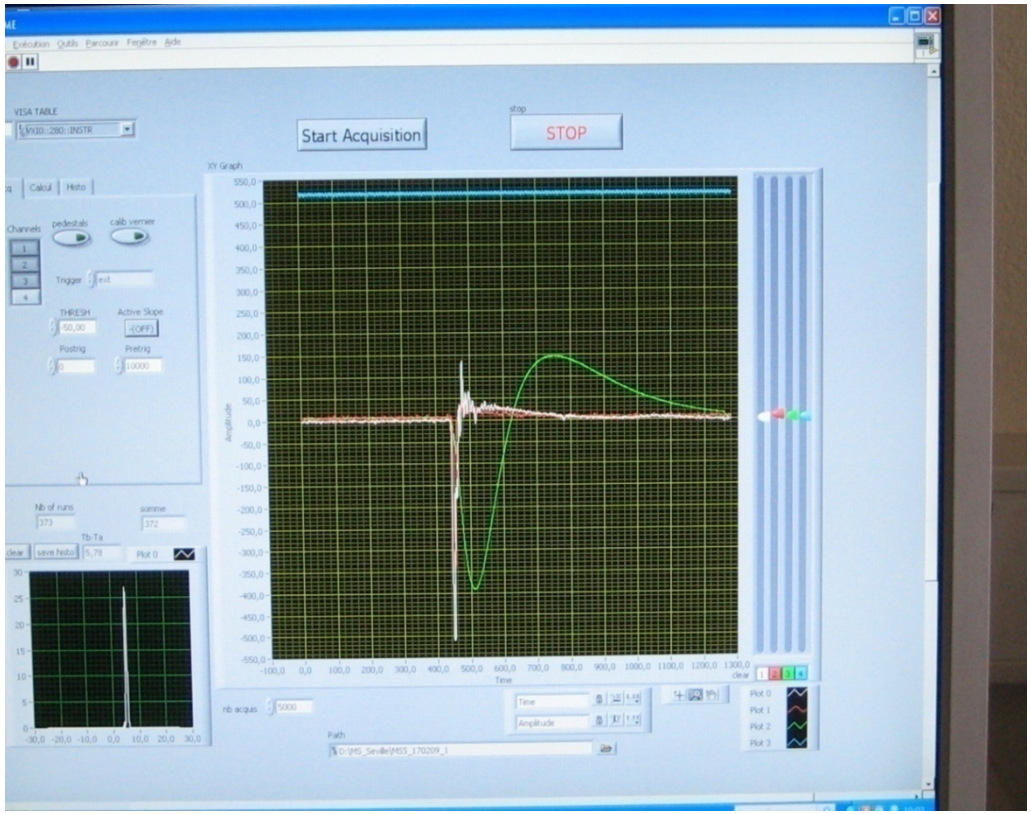


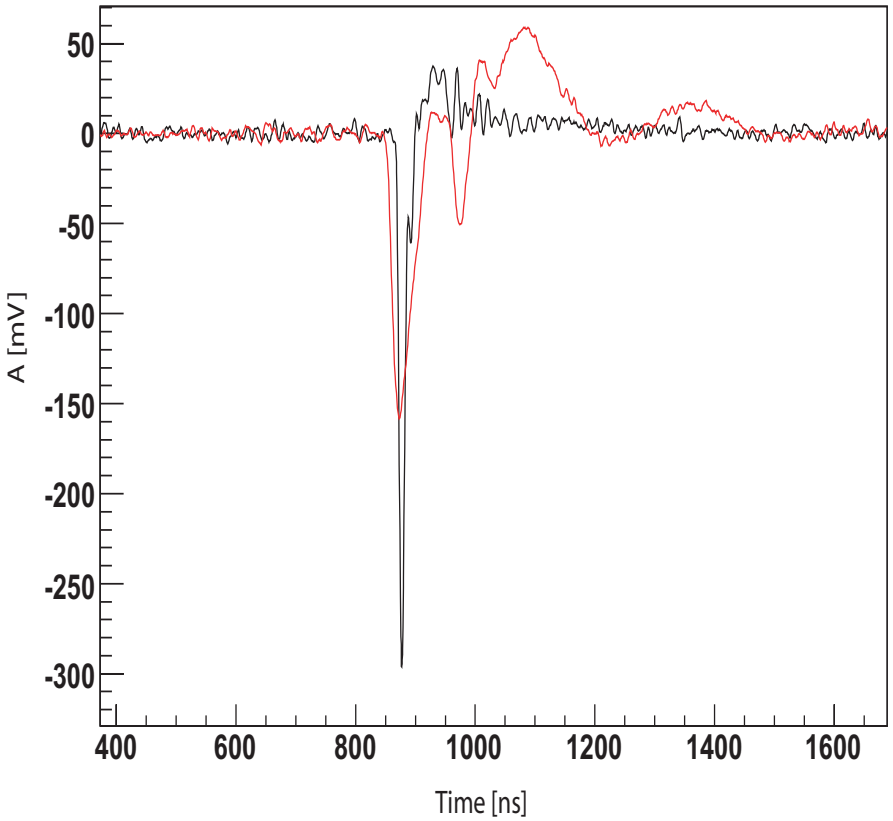


Cathode signal amplitude	≈50mV
Rise time	≈8ns
bandwidth	≈30ns


σ2
σ3
σ12
σ23
σ13
Emissive
FOIL =>
Mini
SeD
Sevilla
Si
SeD
Asimétrico:
TIME
RESOLUTION
SETUP
Emissive foil
Silicon-Detector
SeD
Se-
Se-
MiniSeD

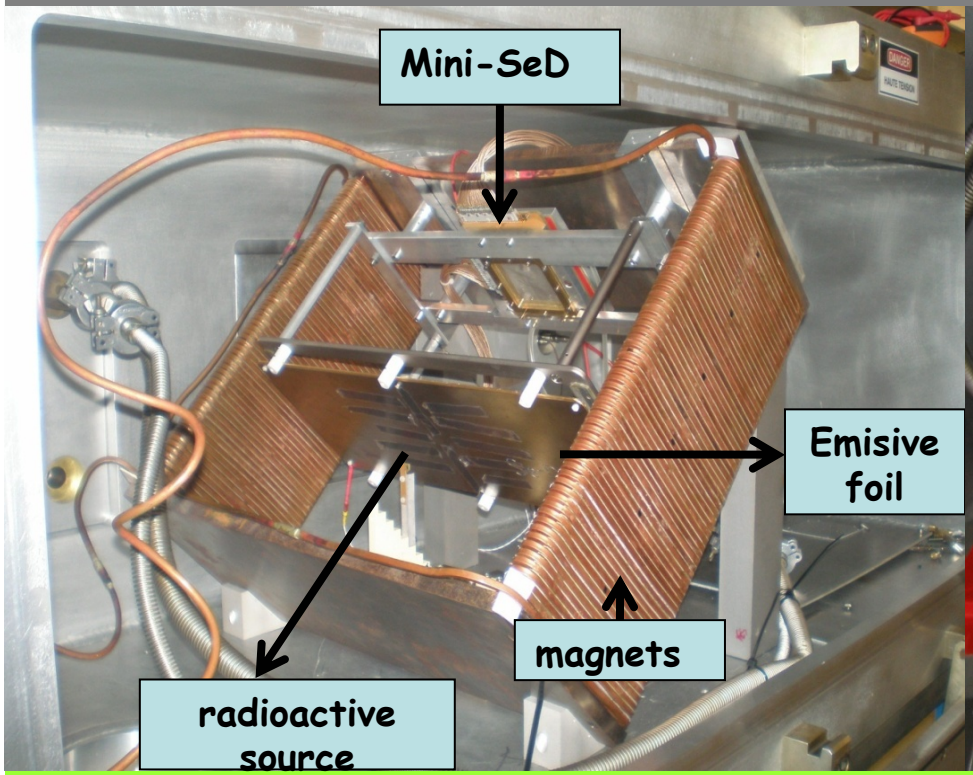
TIME SIGNALS AND MEASUREMENTS (ANODE):

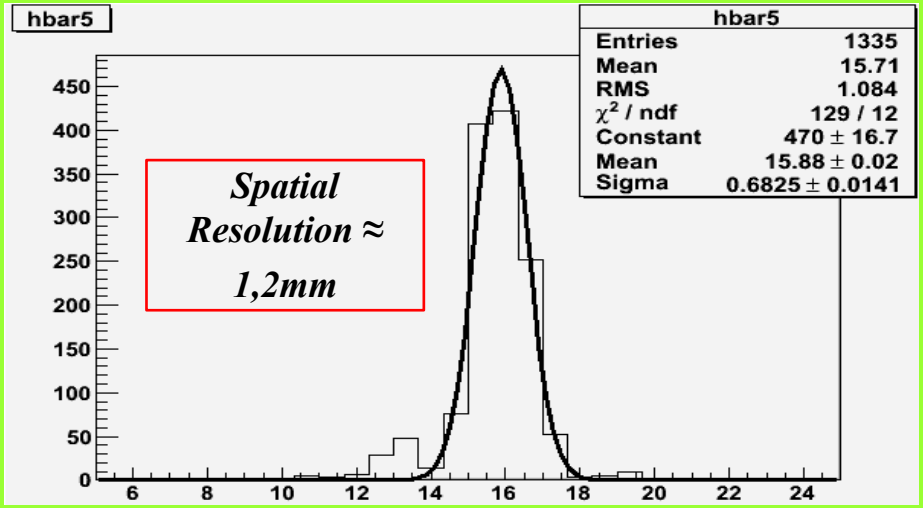


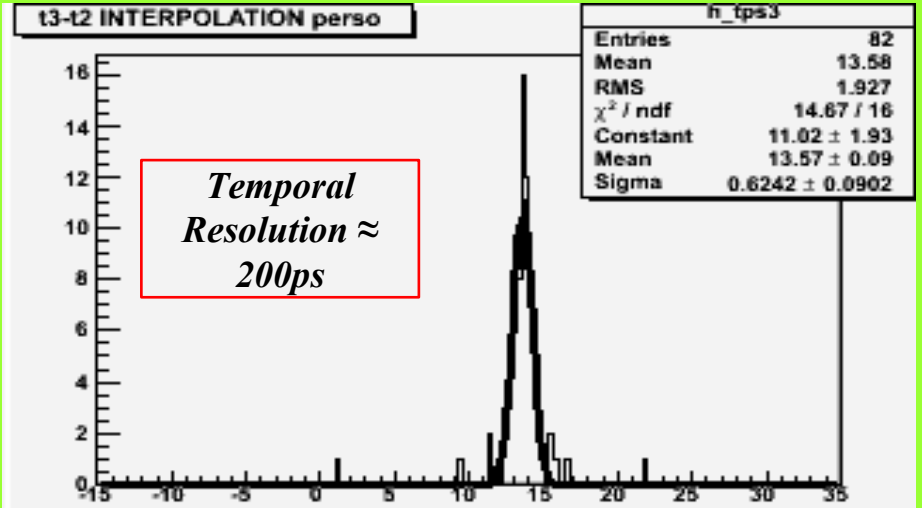


Signal amplitude	≈150mV
rise time	≈6ns
banwidth	≈20ns

TIME AND POSITION RESOLUTION RESULTS:

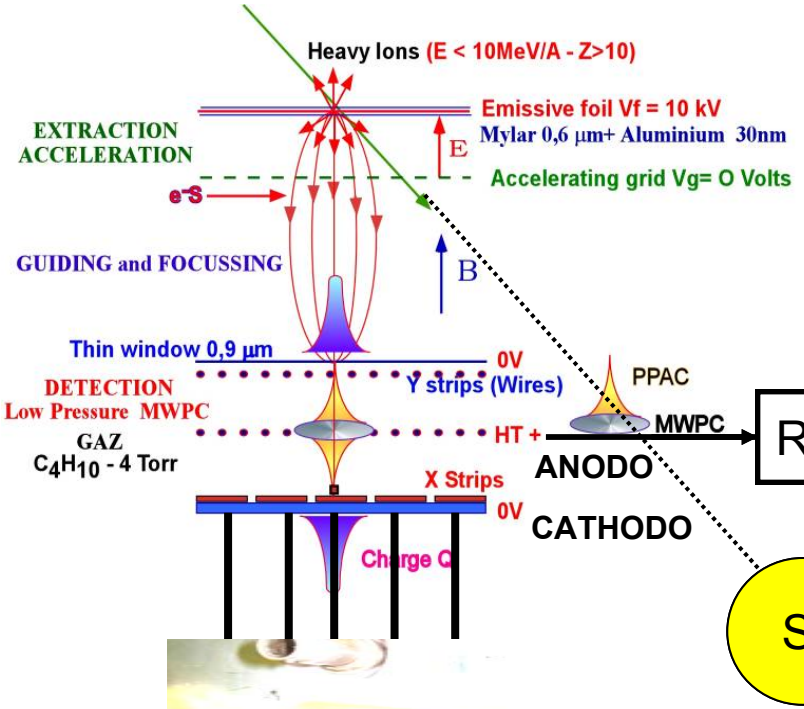


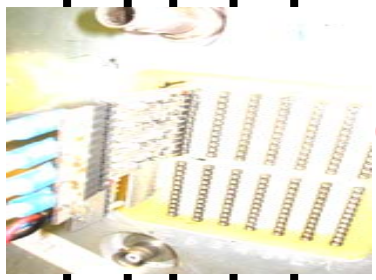


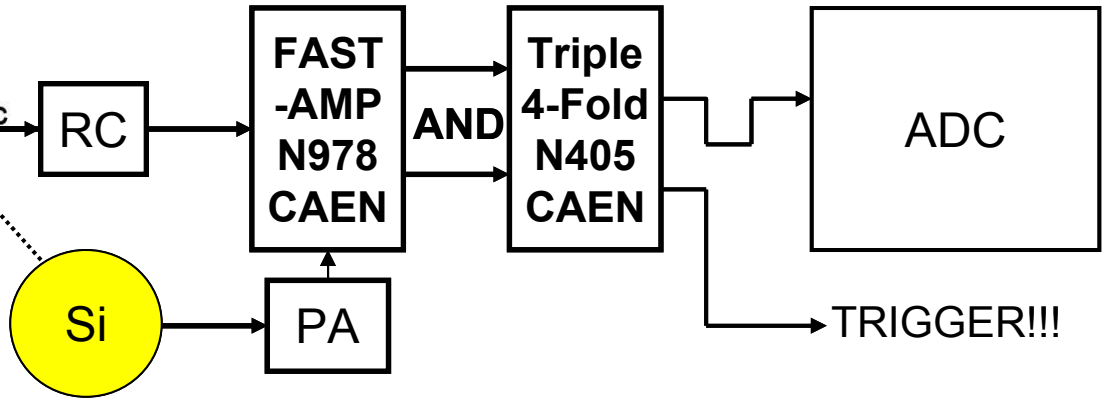


ASOCIATED ELECTRONICS:

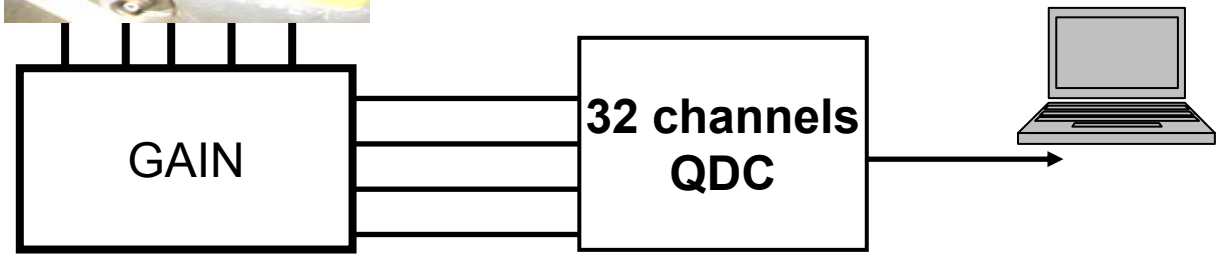
Under constant development
(ASIC – MATACQ/AFTER)





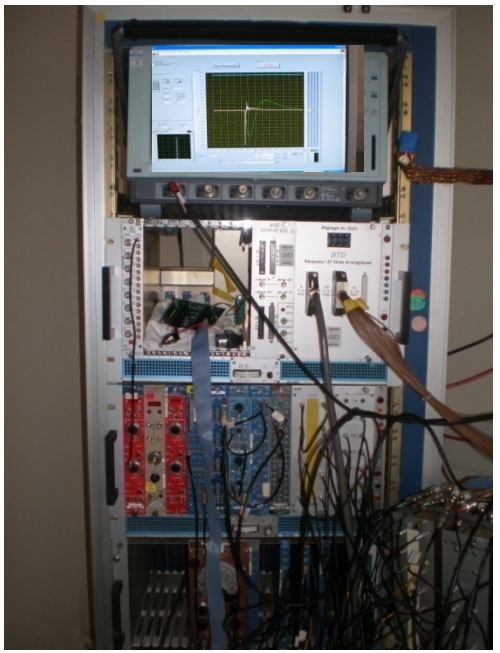


Complementar development!!! Common interest!!



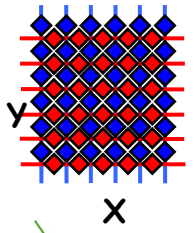
Cathode signal amplitude	≈50mV
Rise time	≈8ns
bandwidth	≈30ns

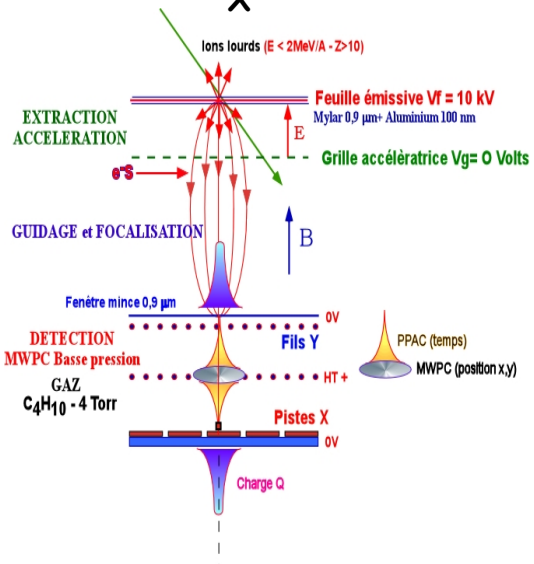
Cathode signal amplitude	**(Simulations) ≈30mV**
Rise time	**≈300ps**
banwidth	**BW x GAIN**

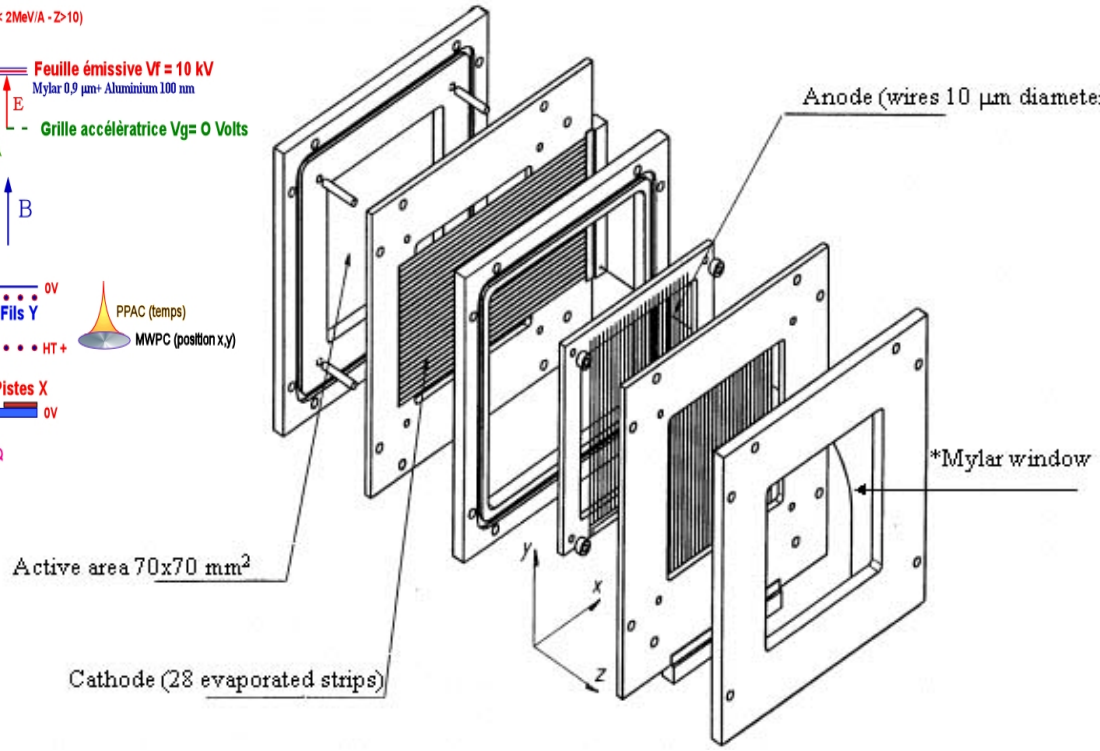


- **SIMULATIONS:**
  - ELECTRIC AND MAGNETIC FIELD
  - CHARGE PRODUCTION
  - ELECTRONIC SIGNALS

- **CONSTRUCTION:**
  - WINDOWS OF MYLAR
  - STRIP CATHODES (PCB's)
  - WIRE ELECTRODES
  - MECHANICAL PIECES

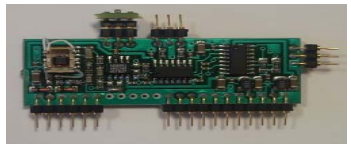




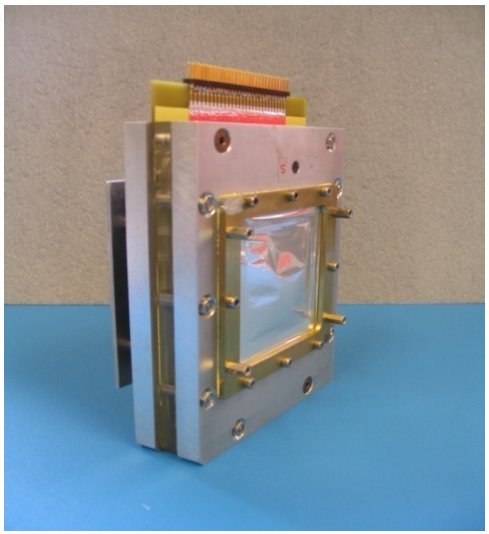


- Time resolution better than 100ps.
- Positon resolution lower than 1mm.
- Counting rate of 10^6pps (at least).

- **COMPLEMENTAR DEVELOPMENT:**
  - FAST PRE-AMPLIFIERS



- **TESTS:**
  - AMPLITUDES (operation voltajes)
  - TIME RESOLUTION
  - POSITION RESOLUTION



Coclusions & Outlooks

RESULTS:

•SeD presents comparable results for small (70x70mm) and big (40x70cm) active area;
•Even using old and slow pre-amplifiers we got position resolutions of order of 1mm and time resolution of 200ps;
•The integration between GEANT4 and Multisim simulations are very promising for drawing new fast amplifiers circuits, which must improve the counting rate capabilities.

Next steps:

•To construct new mini-prototypes and test it with different sources (2009-2010);
•To perform first tests of mini-SeD and other mini-detectors prototypes @ GANIL accelerator (2010);
•Perform different tests of beam tracking detectors prototypes @ CNA;
•New developments of electronics (fast and integrated pre-amplifiers).