Research activities at CNA

Alessio Bocci

CNA-University of Seville

Basic Nuclear Physics Group (FNB)

DITANET - PostDoc

Outline

- Brief introduction on diamond detectors
- R&D for beam tracking @ CNA
- Facility for testing nuclear instrumentation
- Test with diamond detectors
- Medical applications
- Conclusions

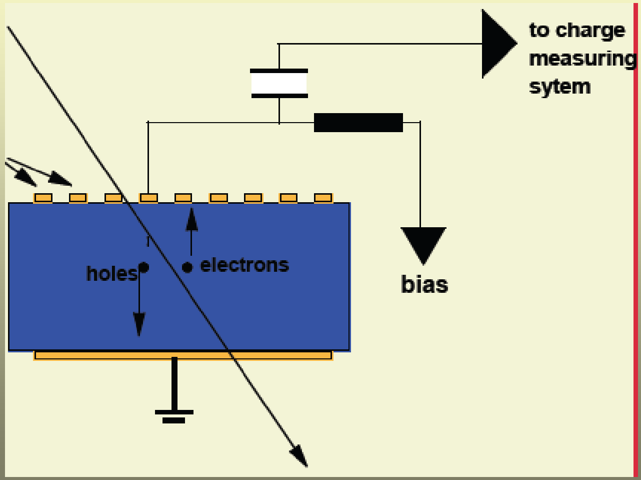
Motivation for Diamond devices

Diamond is an appealing material for radiation detectors

- Highly radiation hardness
- Chemical inertness
- Mechanically robust
- High electric charge mobility => fast response time
- Low dielectric constant => low capacitance => low noise
- Low dark currents (<1 pA) => low noise

Detection of XUV photons, Ion particle beams

Diamond devices for its versatility allow their use in many fields:
Synchrotron X-ray beam monitoring
Ion spectroscopy
Space applications
Radiotherapy
etc.



Motivation for Diamond devices

Diamond is an appealing material for radiation detectors

- Highly radiation hardness
- Chemical inertness
- Mechanically robust
- High electric charge mobility => fast response time
- Low dielectric constant => low capacitance => low noise
- Low dark currents (<1 pA) => low noise

CNA is interested to

Ion particle beams

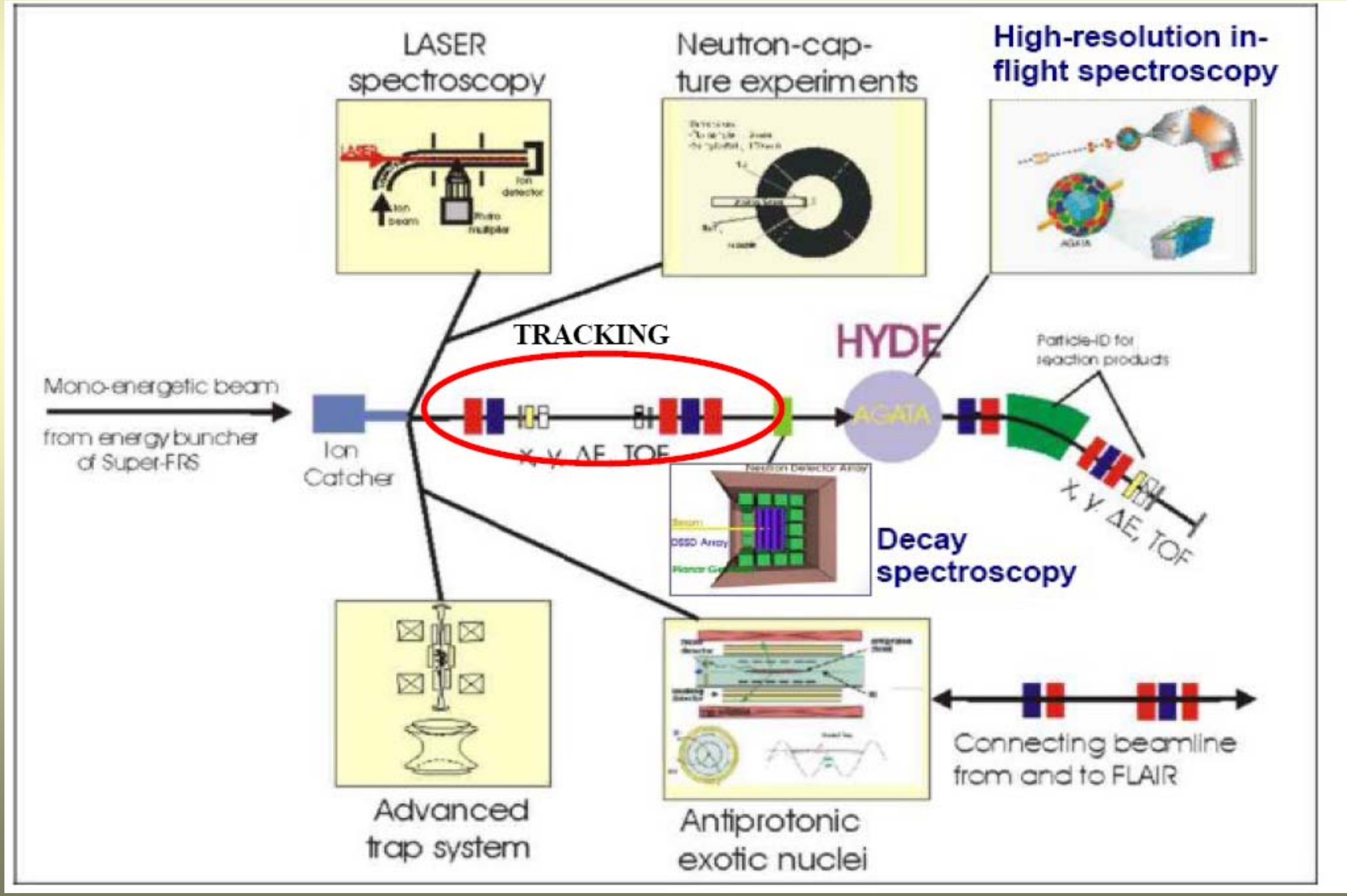
R&D with research institutions and private companies
Testing devices with Ion beams
at CNA facility

Radiotherapy applications

Collaboration within FAIR @ GSI

CNA is one of the institutions in charge of producing a technical report to present a tracking system candidate for the low energy branch of FAIR

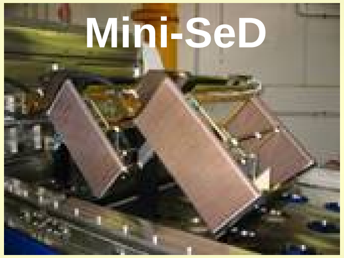
Research and development of beam tracking detectors in a collaboration with CEA-Saclay



Nuclear Physics Group in Seville
Principal investigation lines

- Good experience in experiments with exotic nuclei in different RIB facilities

- Development instrumentation, detectors technology and electronics dedicated to nuclear physics experiments
(collaboration with CEA-Saclay and IMSE-Spain)



- Testing instrumentations, detectors and electronics in its facilities

- Medical Applications
New detectors for IMRT
(collaboration beetwen different institutes)

Basic Nuclear Physics (FNB) group of CNA

- Joaquín Gomez Camacho (CNA director)

  M. Alvarez (Contracted doctor)

  Z. Abou-Haïdar (ESR/Ditanet)
  A. Bocci (PostDoc/Ditanet)
  J. Praena (PostDoc)

  B.Fernández(Technician/PhD-student),
  J. P. Fernández (PhD-student)

  A. Garzón (Engineer)

DITANET

‹‹ novel **DI**agnostic **T**echniques for future particle **A**ccelerators: A Marie Curie Initial Training **NET**work ››

MARIE CURIE ACTIONS

Carsten P. Welsch (University of Liverpool)

20 fellows (3 Postdocs – 17 PhD)

PEOPLE

2 position are filled at CNA

Network Members

cea · CERN · DESY · GSI · HIT · IFIN-HH · Royal Holloway University of London · Universitet Stockholms · Universidad de Sevilla · CNA

Network Partners

ESRF · id Quantique · INFN · Instrumentation Technologies · PSI · THALES · ThermoFisher Scientific · TMD · Diamond Detectors Limited · ViALUX · WZWOPTICAG

DITANET

‹‹ novel DIagnostic Techniques for future particle Accelerators: A Marie Curie Initial Training NETwork ››

MARIE CURIE ACTIONS

Carsten P. Welsch (University of Liverpool)

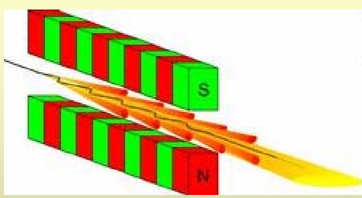
20 fellows (3 Postdocs – 17 PhD)

PEOPLE

my past research activities

PhD Thesis

Synchrotron radiation



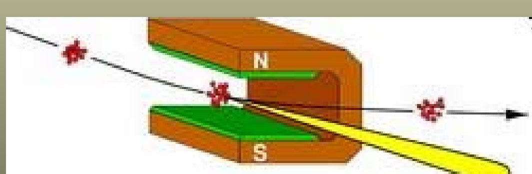
University of Florence
Department of Astronomy
XUV-Lab

X-ray Spectroscopy
X-ray Astronomy

Diamond detectors

Post-doc

Synchrotron radiation



LNF-INFN

Beam diagnostics

Fast IR
HgCdTe detectors

Small facility at CNA

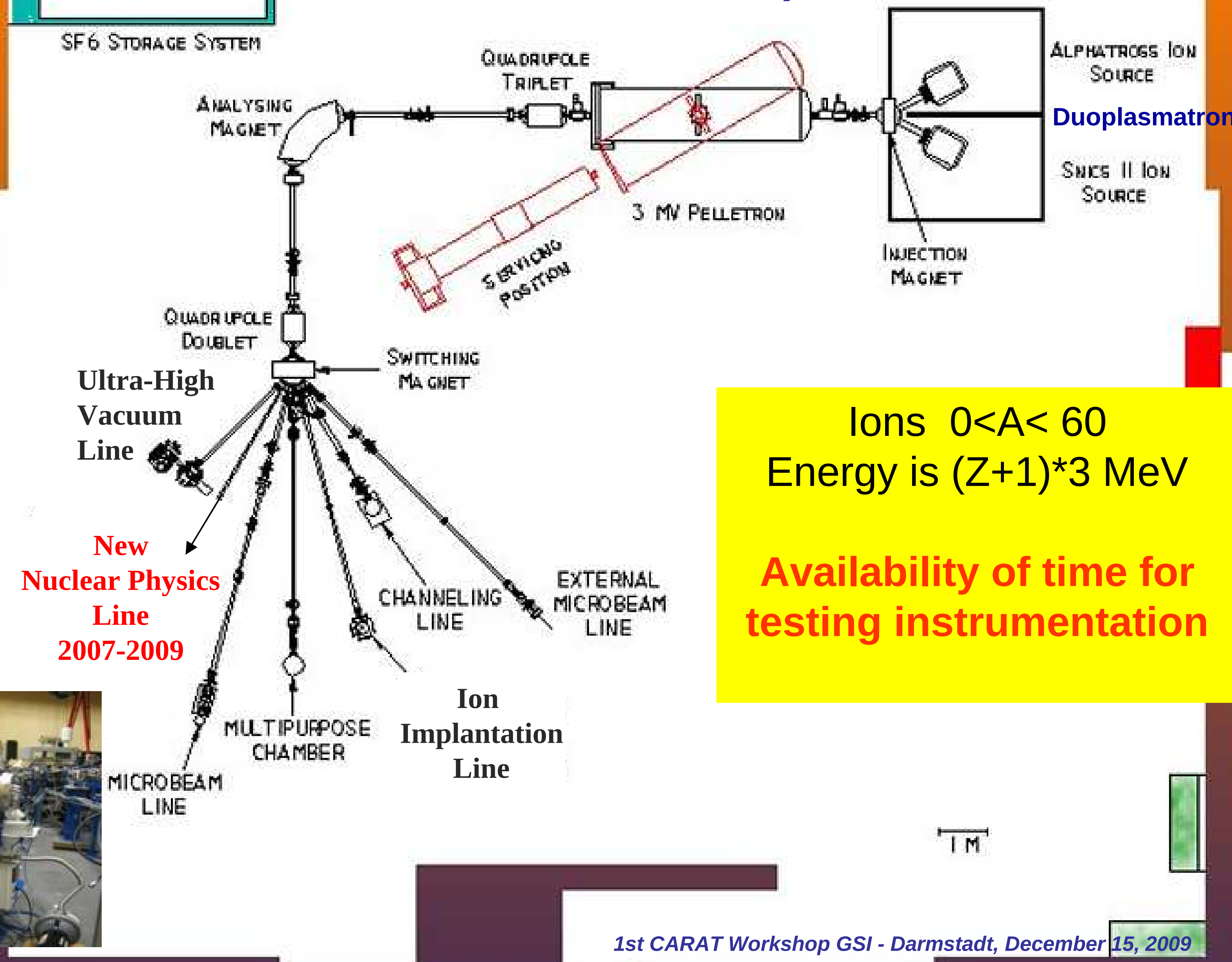
CNA - SEVILLE
TANDEM - 3 MeV

CNA
Centro Nacional De Aceleradores

Currents 1pA - 1µA
Energies
500 keV – 25MeV
Ion beams p, He to Cu
Three different ion sources
Alphatross
SNICS
Duoplasmatron

Excellent environment tool to test detectors, electronic devices and acquisition systems.

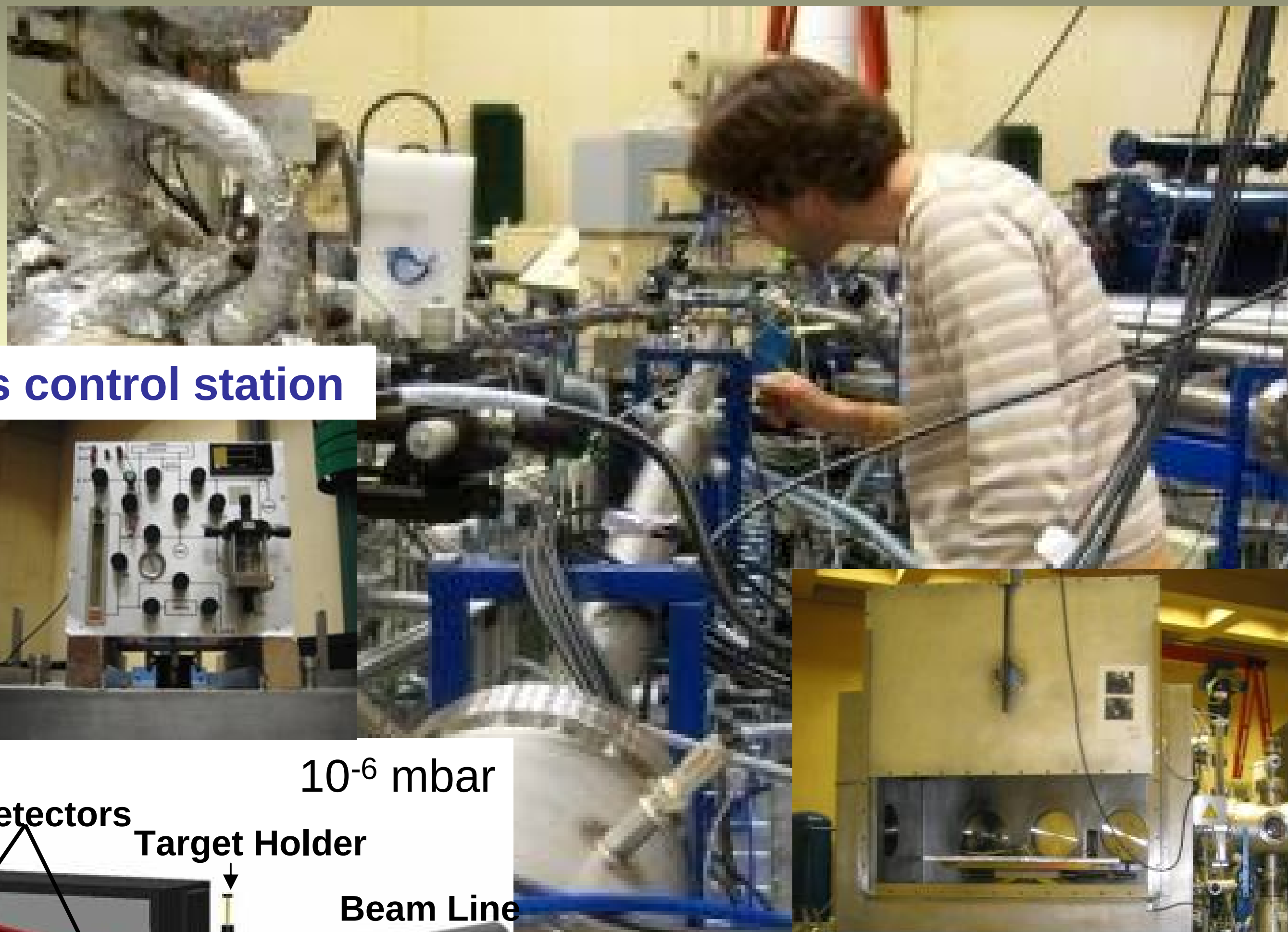
Tandem at CNA, Seville



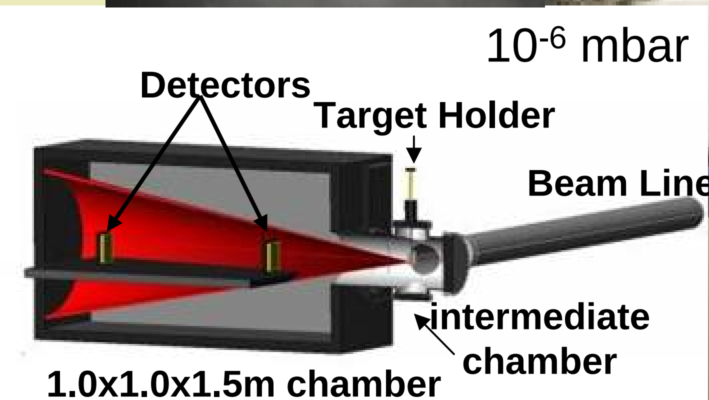
Ions 0<A< 60
Energy is (Z+1)*3 MeV

Availability of time for testing instrumentation

Nuclear Beamline at CNA



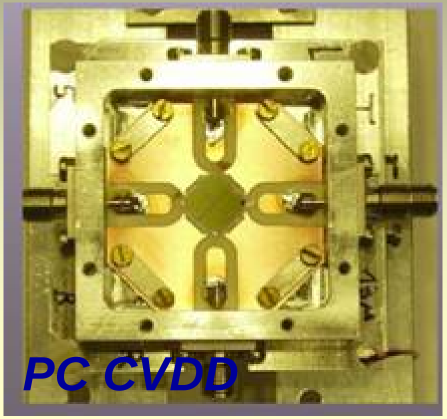
Gas control station

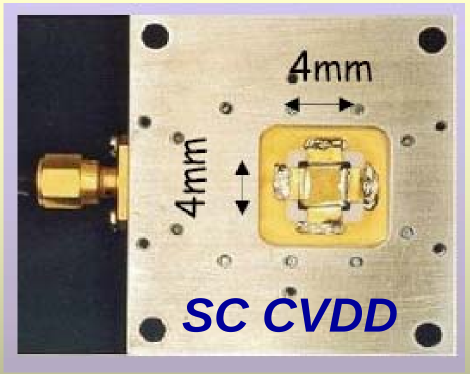


Experiment at CNA

Application of CVD Diamond Detectors in Tracking of Heavy Ion Slowed Down Radioactive Beams (2007)

GSI





Acta Phys. Pol. B38, 1293 (2007)

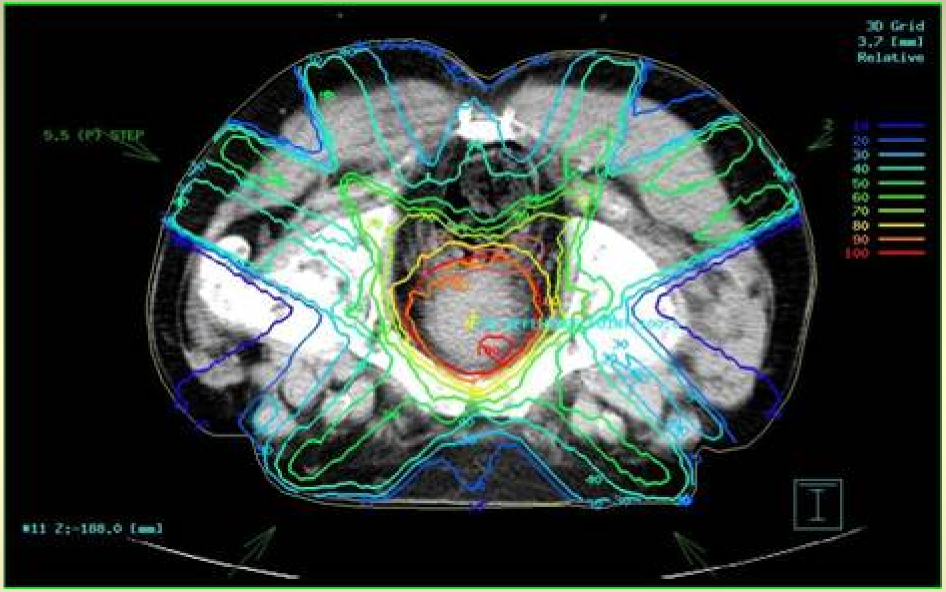
L.Acosta[3], M.Alvarez[4], P.Bednarczyk[2], E.Berdermann[1], R.Berjillos[3], J.M. Espino[4], J.L.Flores[4], J.Gerl[1], M.Górska[1], I.Kojouharov[1], I.Martel[3], I.Mukha[4], M.Pomorski[1], M.Rębisz[1], B.Voss[1], R.Wolski[5]

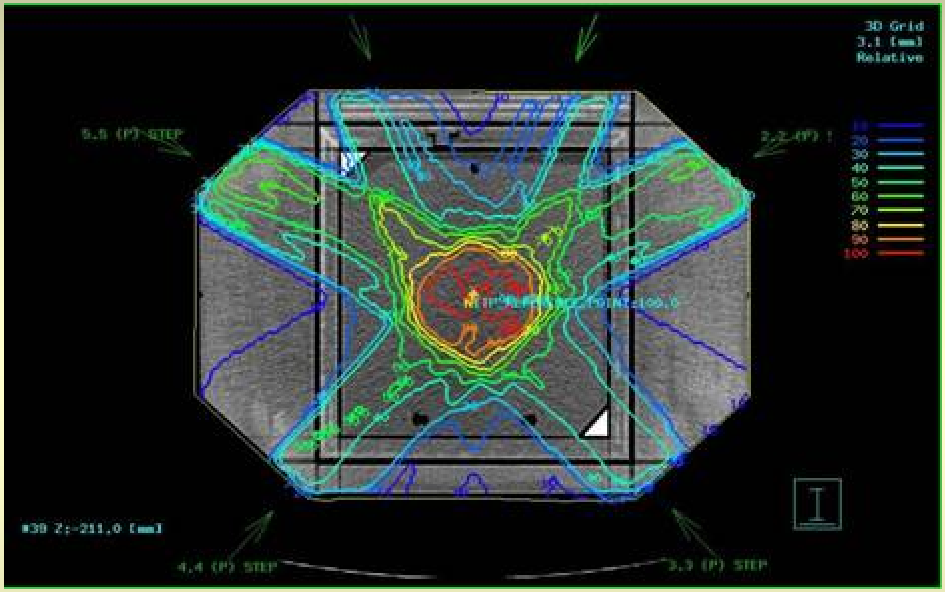
[1]GSI, [2]IFJ PAN Kraków, [3]University of Huelva, [4]University of Seville, [5]UJINR, Dubna

Medical applications

Instrumentation for medical applications

Project Radia





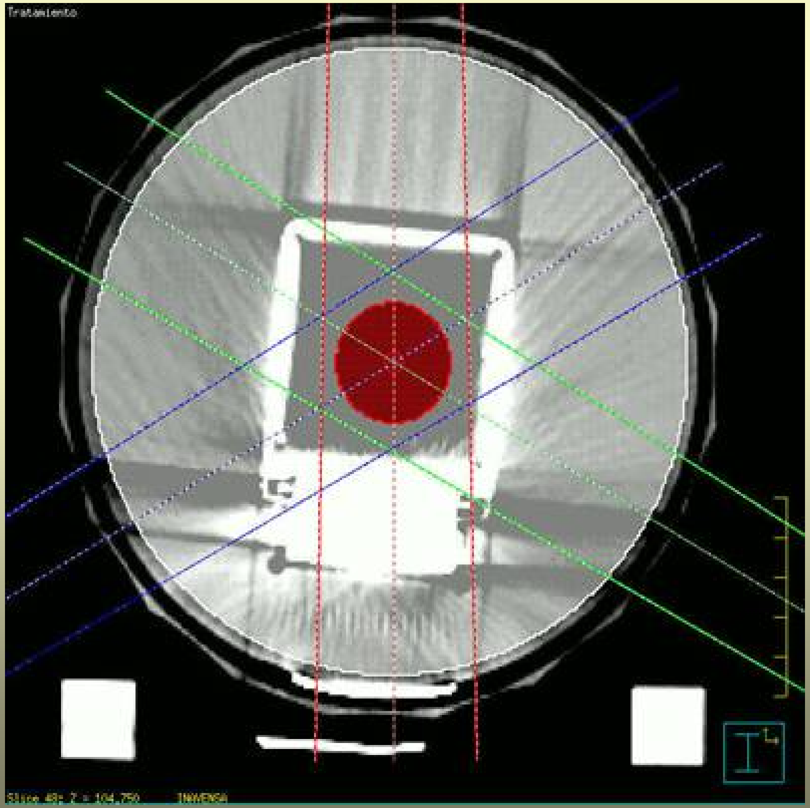
Collaboration beetween

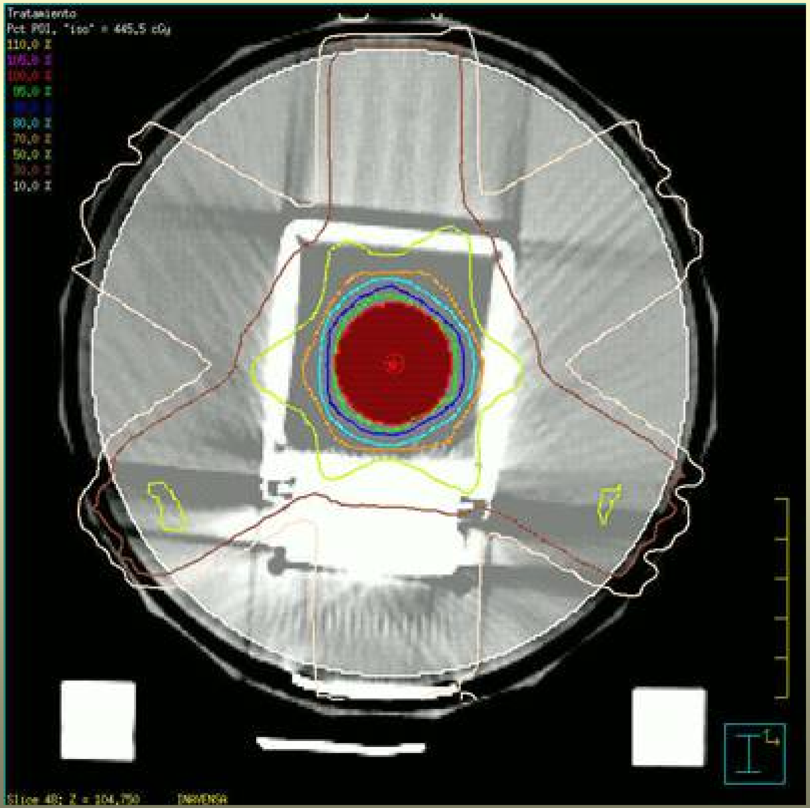
National Accelerator of Center - CNA
Department of Atomic, Molecular and Nuclear Physics
School of Engineer
(University of Seville)
Hospital Virgen Macarena (Seville)
Inabensa Company

IMRT
Intensity modulated radiotherapy

Project Radia

Feasibility study of a new detection system for the verification of dose treatment with IMRT



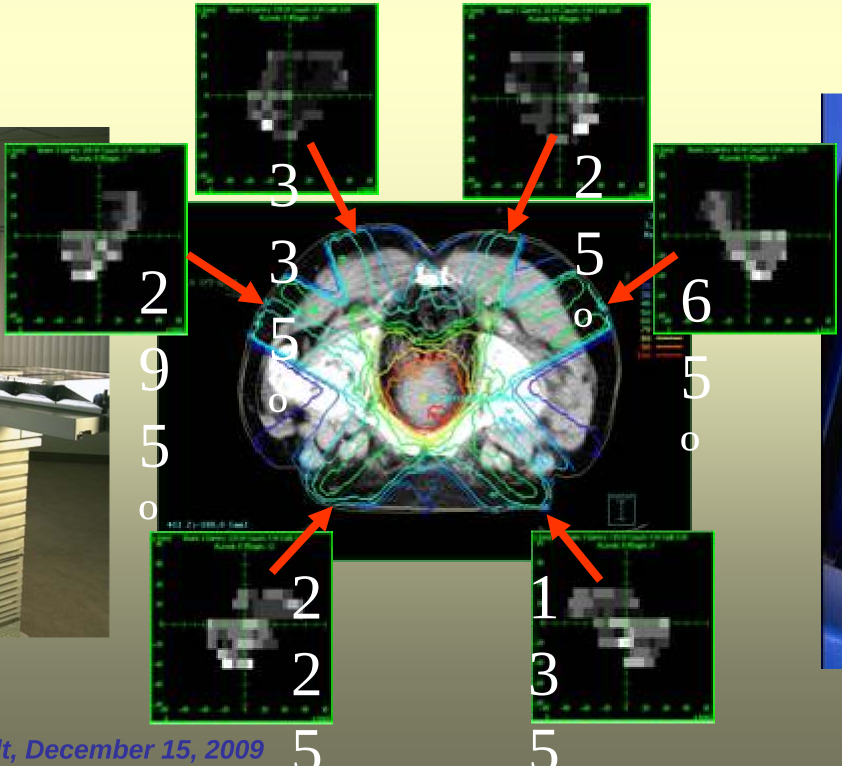


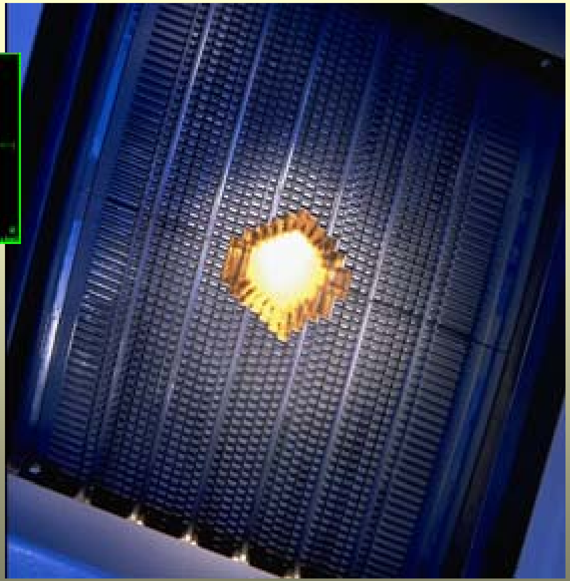
IMRT
Intensity modulated radiotherapy

IMRT uses high energy beam photons (i.e. 6 or 10 MeV) to treat malignant diseases

IMRT allows to deliver dose to a 3D target
1) Irradiating the patient through many beams, in different directions and entry points
2) Modulating in space the fluence of each radiation field

This can be obtaing using LINAC accelerators equipped with multileaf collimators





Detectors for IMRT

A commercial single-sided SSD has been used in the detection system

Preliminary results are encouraging
but an improvement in the spatial resolution
is necessary (pixellated 2D detectors)

Micron Semiconductor
Area 50 mm x 50 mm
Thickness 500 microns
16 strips

Phantom
with inside
the detector

New Detectors

We are investigating the use of new detectors

CVD diamond are especially appealing in modern radiotherapy techniques such as in photon IMRT

Nearly tissue equivalent (Z=6)
Radiation hardness
Energy independent response

We are interested to use CVD diamond detectors for IMRT pre-treatment of doses and to develop collaborations with other research institutions in this application

Conclusions

- A new Nuclear Physics line is available at CNA for testing any kind of nuclear instrumentations (detectors, electronics, acquisition systems)

- Proposals for testing diamond detectors are very welcome!

- We are interested to open collaborations (e.g. with institutions that take part in DITANET network) for investigating the use of diamond in beam tracking and for testing samples in different RIB facilities

- We are interested to investigate the use of diamond devices for IMRT applications and to open a collaboration with other research institutions

Thank you
for
your attention!

Coclusions & Outlooks

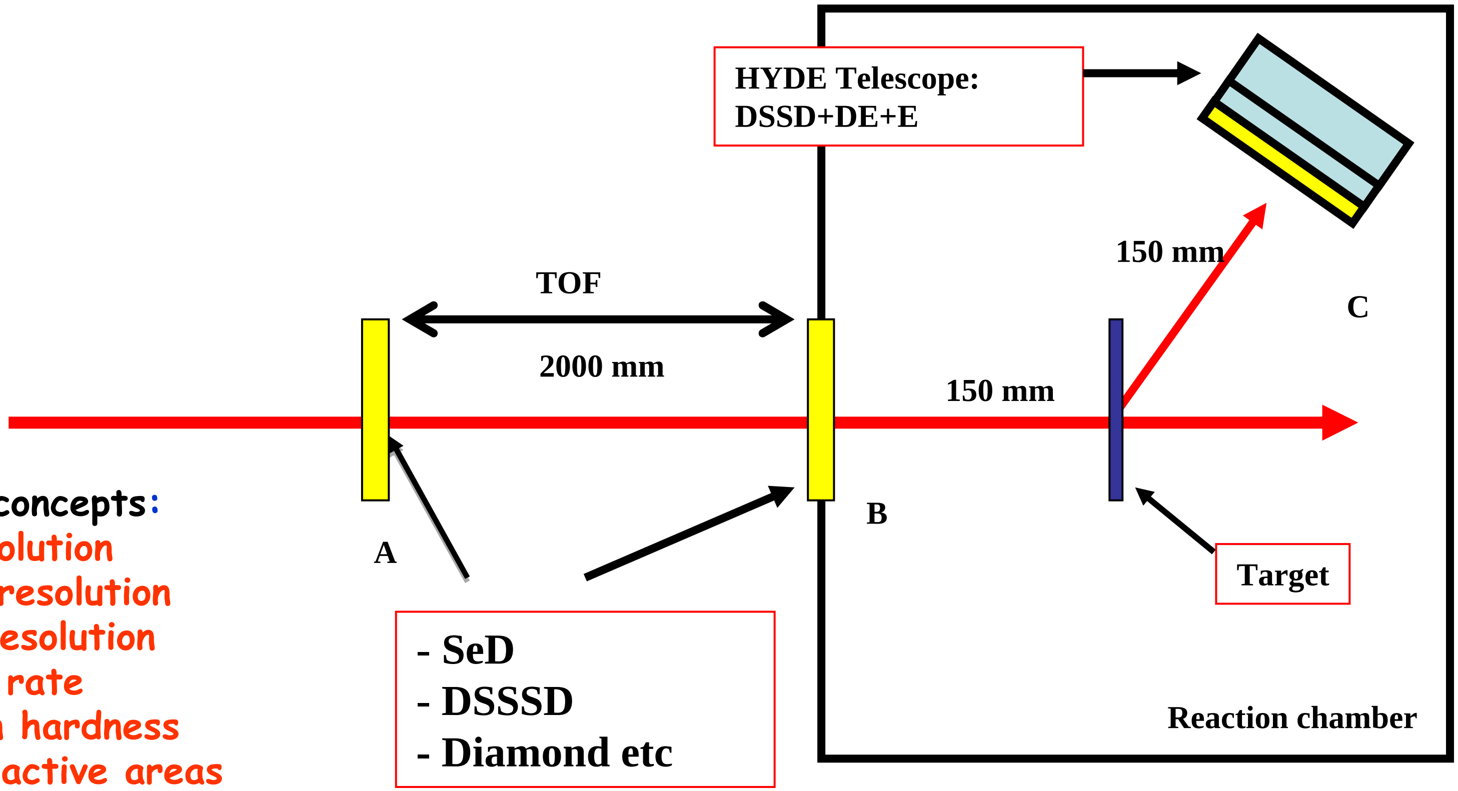
RESULTS:

- **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).**

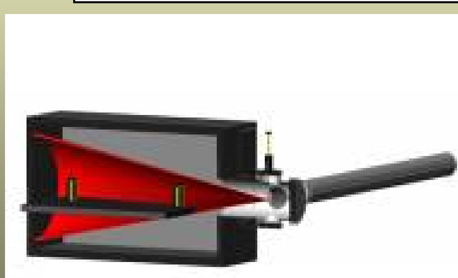
Tracking concepts



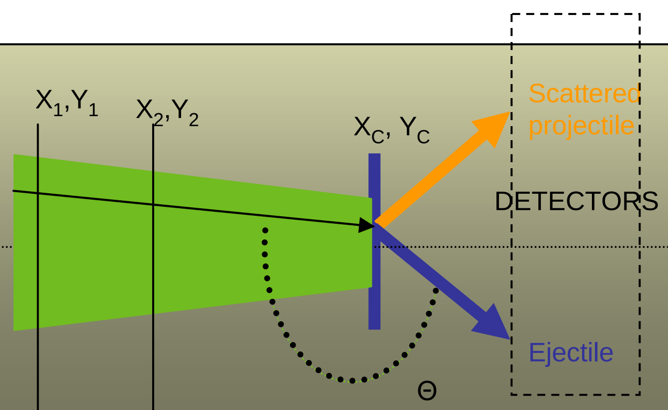
Detectors concepts:

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

Radioactive Ion beams



Tracking structure
CNA-Seville

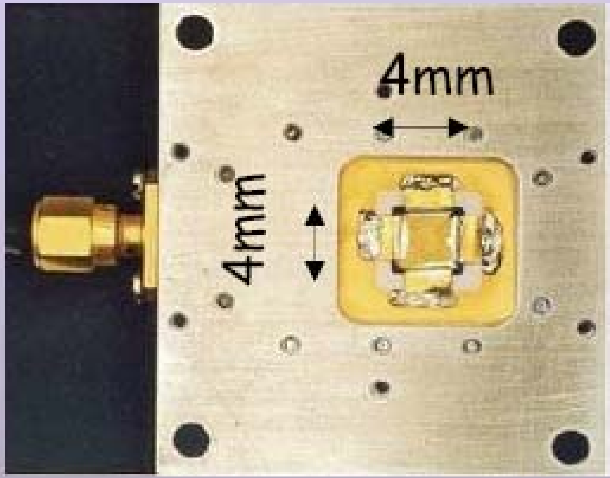


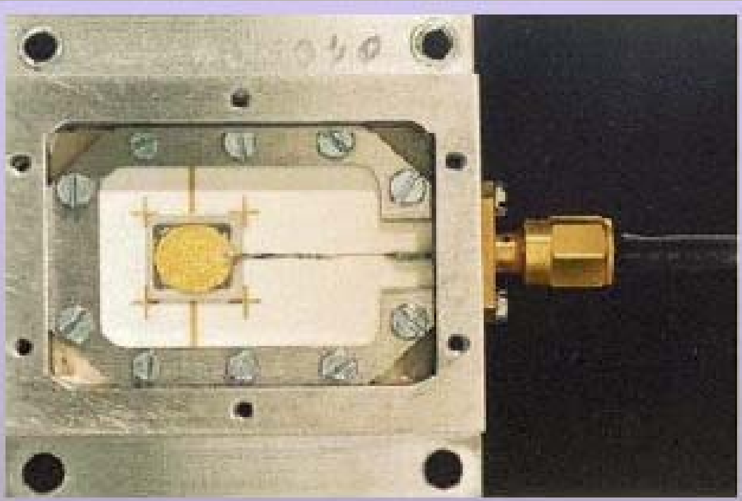
- LARGE ACCEPTANCE

- LOW BEAM INTENSITY
  (below 10^5 pps)

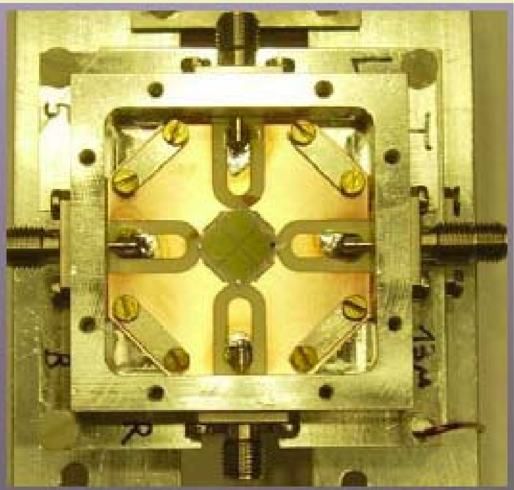
Increasing with the future particles accelerators (>10^6pps)
High counting rate capability!!

Diamond detectors tested at CNA





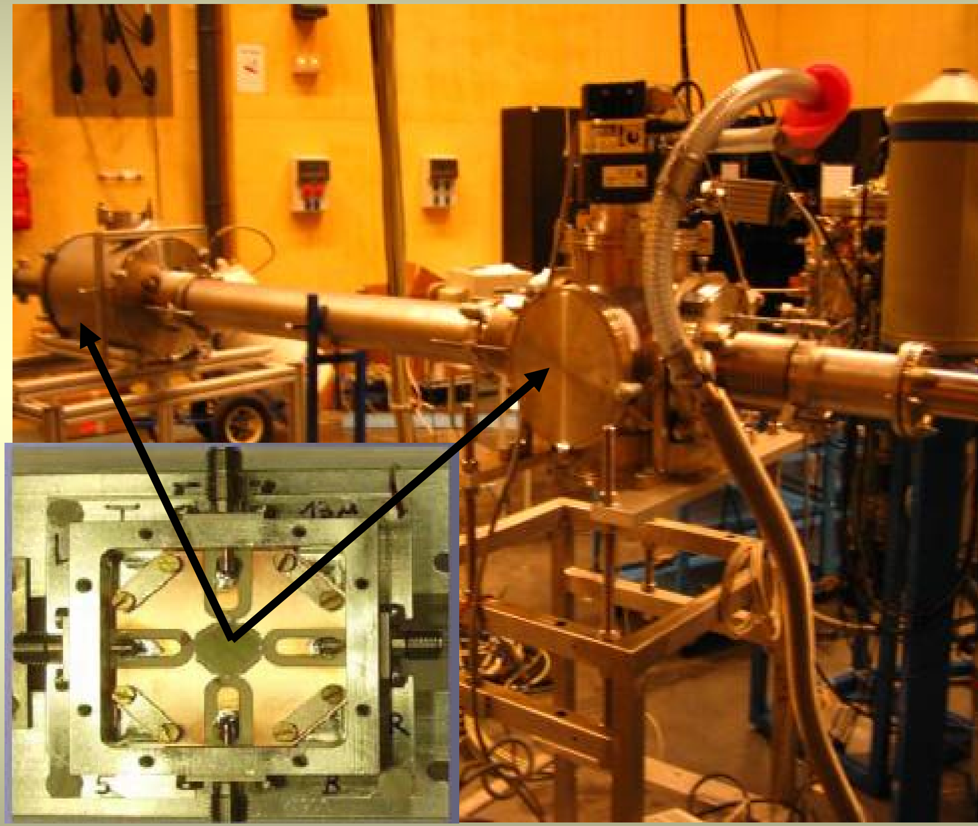
- SC CVDD detectors: $4\times4mm^2$, 110-500 μm (GSI Detector Laboratory)



PC CVDD 4-fold segmented detectors: $1\times1cm^2$, 13-60μm (GSI Plasma Physics dept)

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:

SC CVD ΔE<50 keV

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

TIME Resolution ~ 100ps
(both for PC and SC)

estimated beam flux: 10^7-10^9 particle/s cm^2

Low dead time
(70% of efficiency) and
satisfactory radiation hardness.

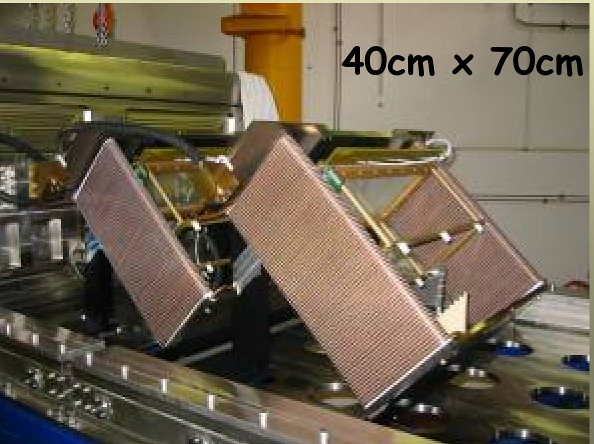
No signs of degradation or noise.

MOTIVATION for mounting a dedicated Nuclear Physics Line!!!

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!