Research activities at CNA

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DITANET - PostDoc

1st CARAT Workshop GSI - Darmstadt, December 15, 2009
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.

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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 between 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)
Carsten P. Welsch (University of Liverpool)

20 fellows (3 Postdocs – 17 PhD)

2 position are filled at CNA

Network Members
Carsten P. Welsch (University of Liverpool)

20 fellows (3 Postdocs – 17 PhD)

my past research activities

PhD Thesis

University of Florence
Department of Astronomy
XUV-Lab

Synchrotron radiation

X-ray Spectroscopy
X-ray Astronomy

Post-doc

Diamond detectors

LNF-INFN
Beam diagnostics

Fast IR
HgCdTe detectors
Small facility at CNA
CNA - SEVILLE
TANDEM - 3 MeV

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

Availability of time for testing instrumentation

Tandem at CNA, Seville

Ultra-High Vacuum Line
New Nuclear Physics Line 2007-2009

Ion Implantation Line
Duoplasmatron
Nuclear Beamline at CNA

Gas control station

1.0x1.0x1.5m chamber

10^{-6} \text{ mbar}

Detectors

Target Holder

Beam Line

Intermediate chamber
Experiment at CNA
Application of CVD Diamond Detectors in Tracking of Heavy Ion Slowed Down Radioactive Beams (2007)


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\(^1\)GSI, \(^2\)IFJ PAN Kraków, \(^3\)University of Huelva, \(^4\)University of Seville, \(^5\)UJIN, Dubna
Medical applications
Instrumentation for medical applications

Project Radia

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

Alessio Bocci, CNA - Seville
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 obtained 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!
Cclusions & 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

- SeD
- DSSSD
- Diamond etc

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

HYDE Telescope: DSSD+DE+E

TOF
2000 mm

A

B

150 mm

150 mm

Target

Reaction chamber

Radioactive Ion beams

- 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: 4x4mm², 110-500 μm (GSI Detector Laboratory)

- PC CVDD 4-fold segmented detectors: 1x1cm², 13-60μm (GSI Plasma Physics dept)

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

SC CVD $\Delta E<50$ keV

$\Delta E/E<1\%$ of a SC CVD diamond detector was achieved

TIME Resolution $\sim 100$ps (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!