



ID de Contribution: 21

Type: Non spécifié

Detector Developments For Radiation Physics Applications at GIP ARRONAX.

vendredi 5 décembre 2025 10:45 (25 minutes)

Abstract: The C70XP cyclotron at ARRONAX, located in Saint Herblain [1], is capable of delivering different types of particle beams: Protons and alpha particles up to 70 MeV & deuterons up to 35 MeV. At the cyclotron level, in standard mode, bunches of ions can be delivered with a duration of 3ns separated by 33ns each, and beam intensities ranging from very low (< 1 pA) to very high (up to 350 μ A for protons and 70 μ A for alpha particles). A chopper device installed in the injection part of the cyclotron allows the adjustment of frequency rates and irradiation durations [2], enabling a wide range of mean dose rates, from low (< 1 mGy/s) to high (> 1 MGy/s). Various research activities are being conducted in the dedicated AX vault, including preclinical radiotherapy studies, such as investigating the Flash effect on sparing healthy tissues through ultra-high irradiations in short durations, biological sample irradiation [3], radiolysis of water [4] & ion beam analysis of cultural heritage objects [5]. However, for these applications, precise online control of the beam characteristics, such as intensity, geometric profile, and energy, is crucial, and this is achieved through implementing a set of detectors in the beam line.

A Faraday cup is used as a calibration reference, providing an absolute measurement of the beam intensity that is independent of the dose rate. Recently, DIAMMONI detector, based on 4 single-crystal CVD diamonds, has been developed [6]. It is designed to operate in two complementary modes: train mode, for high flux conditions, where it integrates the total charge per train of bunches (> 100 particles per bunch, up to 1 μ A) enables halo and precise time measurements (Train duration: DT, inter- train duration: DIT); and bunch mode, for low flux conditions, where it counts the number of particles per bunch (1–100 particles per bunch; < 1 nA). An ultra-thin beam profiler PEPITES (10 μ m WET), based on secondary electron emission, has already been developed and installed in the beamline to measure beam profiles at low intensities [7]. It is composed of two segmented electrodes of 32 gold strips of nanometric thickness deposited on a thin polymer membrane (CP1, 1.5 μ m). In addition, a novel beam profiler based on beam-induced air fluorescence detection with multiple PMTs - allowing simultaneous timing and profile measurements at high intensities- is under development [3], [8].

Thus, the main objectives of our project are to determine the operational ranges, characterize the performances (dose rate response, linearity) of these detectors, and to investigate radiation-induced damage in DIAMMONI & PEPITES, as a function of particle type, energy, and fluence. More specifically, for DIAMMONI we are interested to quantify the charge collection efficiency and the effect of thermal annealing on restoring the detector performance and for PEPITES, to study the impact of radiation damage on the mechanical and electrical properties of the polymer and to enhance the electronic card to operate under ultra-high dose-rate “FLASH” conditions. In parallel, we will finalize the PMTs profiler prototype, quantify its sensitivity and spatial resolution, develop a Python-based simulation model, and validate the simulation by experimental measurements.

Keywords: Particle Beam; Detectors; Beam Monitoring; Beam Profiler; Dose rate response; Ultra High Dose Rate; Radiation damage.

DIAMMONI: ANR-20-CE42-0004

PEPITES: ANR-17-CE31-0015

References:

- [1]F. Haddad et al., “ARRONAX, a high-energy and high-intensity cyclotron for nuclear medicine,”Eur. J. Nucl. Med. Mol. Imaging, vol. 35, no. 7, Art. no. 7, Jul. 2008, doi: 10.1007/s00259-008-0802-5.
- [2]F. Poirier et al., “EPD110 - THE ARRONAX PLATFORM FOR PROTON FLASH IRRADIATION: FROM BEAM PRODUCTION TO THE TARGET,”Phys. Med., vol. 94, p. S105, Feb. 2022, doi: 10.1016/S1120-1797(22)01681-7.
- [3]M. Evin et al., “Methodology for small animals targeted irradiations at conventional and ultra-high dose

- rates 65 MeV proton beam,”*Phys. Med.*, vol. 120, p. 103332, Apr. 2024, doi: 10.1016/j.ejmp. 2024.103332.
- [4]T. Sarra et al., “Détection et quantification des radicaux libres radio-induits par des faisceaux pulsés de H⁺ et He²⁺,”presented at the Rencontres Rayonnement Radiochimie, Jun. 2024. Accessed: Mar. 18, 2025. [Online]. Available: <https://in2p3.hal.science/in2p3-04660685>
- [5]A. Gillon et al., “Elemental analysis by XRF and HE-PIXE on silver coins from the 16th-17th centuries and on a gilded crucifix from the 12th century,”*Eur. Phys. J. Plus*, vol. 138, no. 10, p. 945, 2023, doi: 10.1140/epjp/s13360-023-04570-5.
- [6]R. Molle, “Conception d’un moniteur faisceau diamant pour le contrôle en ligne de faisceaux pulsés,”*phdthesis*, Université Grenoble Alpes [2020-....], 2024. Accessed: Jan. 31, 2025. [Online]. Available: <https://hal.science/tel-04833098>
- [7]B. Boyer a, R. Cornat e, E. Delagnes d, Y. Geerebaert a, O. Gevin d, F. Haddad b c, C. Koumeir b, F. Magniette a, P. Manigot a, F. Poirier b, M. Rubio Roy f, N. Servagent c, C. Thiebaut a, M. Verderi a, “Development of an ultra thin beam profiler for charged particle beams”.
- [8]F. Ralite et al., “Bremsstrahlung X-rays as a non-invasive tool for ion beam monitoring,”*Nucl. Instrum. Methods Phys. Res. Sect. B Beam Interact. Mater. At.*, vol. 500–501, pp. 76–82, Aug. 2021, doi: 10.1016/j.nimb.2021.05.013.

Auteur: Mlle JBARA, Rania (Nantes Université CNRS/IN2P3/IMT Atlantique, SUBATECH UMR 6457, F-44000 Nantes, France/GIP ARRONAX, 44817 Saint Herblain Cedex,France)

Co-auteurs: M. KOUMEIR, Charbel (GIP ARRONAX, 44817 Saint Herblain Cedex, France/SUBATECH UMR 6457, F-44000 Nantes, France); M. THIEBAUX, Christophe (Laboratoire Leprince-Ringuet CNRS, Ecole polytechnique, Institut Polytechnique de Paris/Palaiseau/France); M. HADDAD, Férid (GIP ARRONAX, 44817 Saint Herblain Cedex, France/SUBATECH UMR 6457, F-44000 Nantes, France); M. GALLIN-MARTEL, Laurent (Laboratoire de Physique Subatomique et Cosmologie (LPSC), 38000 Grenoble, France); M. BERNARDI, Lorenzo (Laboratoire Leprince-Ringuet CNRS, Ecole polytechnique, Institut Polytechnique de Paris/Palaiseau/France); M. VERDERI, Marc (Laboratoire Leprince-Ringuet CNRS, Ecole polytechnique, Institut Polytechnique de Paris/Palaiseau/France); Mme GALLIN-MARTEL, Marie-Laure (Laboratoire de Physique Subatomique et Cosmologie (LPSC), 38000 Grenoble, France); M. SERVAGENT, Noel (SUBATECH UMR 6457, F-44000 Nantes, France); M. GEVIN, Olivier (IRFU, CEA Université Paris-Saclay/Saclay/France); M. MOLLE, Robin (Laboratoire de Physique Subatomique et Cosmologie (LPSC), 38000 Grenoble, France); M. GUILLAUMAT, Rémi (Laboratoire Leprince-Ringuet CNRS, Ecole polytechnique, Institut Polytechnique de Paris/Palaiseau/France)

Orateur: Mlle JBARA, Rania (Nantes Université CNRS/IN2P3/IMT Atlantique, SUBATECH UMR 6457, F-44000 Nantes, France/GIP ARRONAX, 44817 Saint Herblain Cedex,France)

Classification de Session: Instrumentation

Classification de thématique: Instrumentation