Characterization of a new transparent charged particle beam profiler based on secondary electrons emission

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*A new type of profiler is under development and will equip the beam line of the Arronax Cyclotron [1]. The profiler must measure the beam lateral shape in a broad range of energy 15 - 70 MeV and a wide range of intensity 100fA - 100nA, for alpha, proton and deuteron particles. The beam lateral profile is measured through segmented electrodes consisting of nanometric thick gold strips deposited on a thin polymer membrane (below **10µm** water-equivalent thickness).*

The choice of the type of polymer depends on its tolerance to radiations. Several irradiation campaigns with 68 MeV proton beams have been conducted to evaluate the irradiation damages on an 8µm polyimide (Kapton) with the deposited dose (up to 10^7 Gy). Optical spectroscopy and light microscopy have been used to characterize the damages induced in the polymer. .

ARRONAX Cyclotrons

Beam	Energy range (MeV)	Intensity (µA)
Proton	30-70	1e-6-->375
	17	<50
Deuteron	15-35	<50
Alpha	68	1e-6--> 70

ARRONAX « Accelerator for Research in Radiochemistry and Oncology at Nantes Atlantic » [1] aims at producing innovative radionuclides for research in nuclear medicine and at performing research in:

-Radiobiology and radiolysis

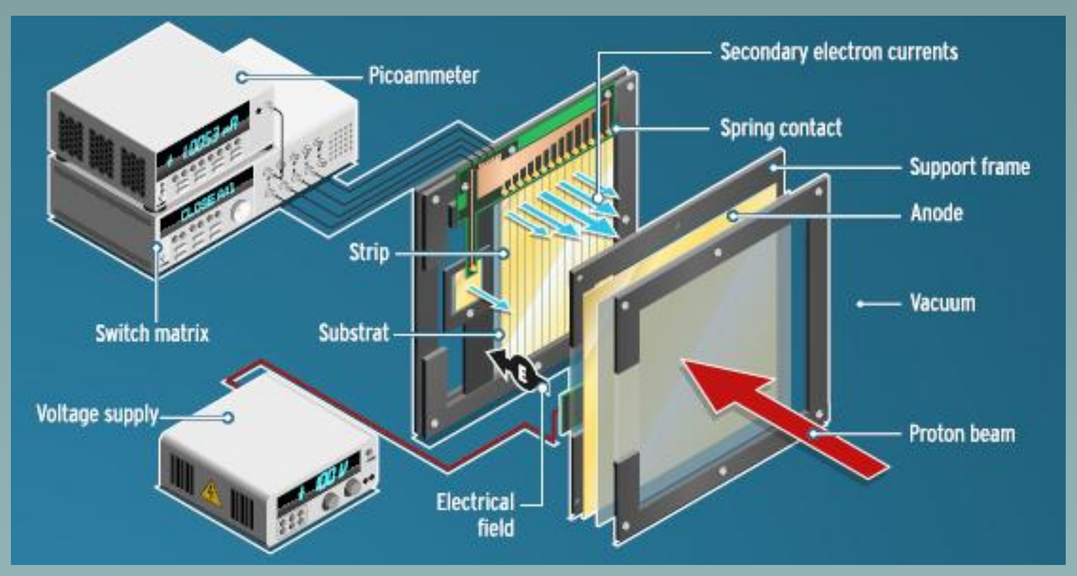
-Nuclear and atomic physics (cross section measurements)

-Ion beam analysis (PIXE and PIGE at high energy up to 70MeV)

-Characterization of detectors response under irradiation

[1]: http://www.cyclotron-nantes.fr

New beam profiler PEPITES [2]



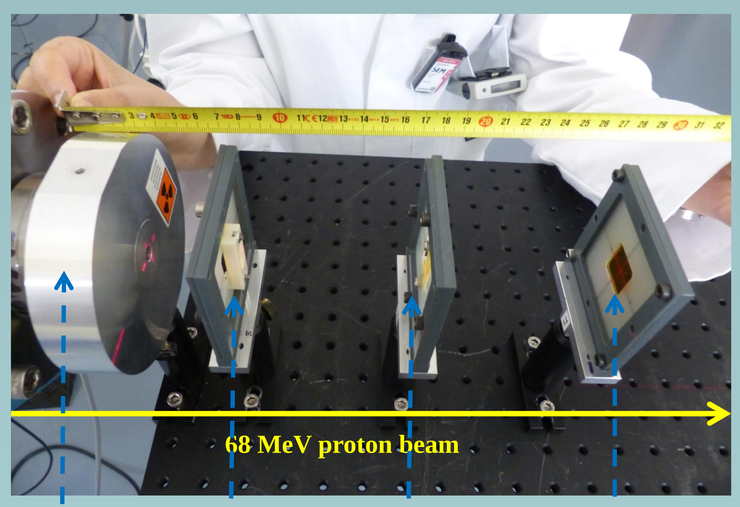
-The beam lateral profile is measured through 50 nanometric thick gold strips deposited on a thin polymer membrane (<10 µm water-equivalent thickness)

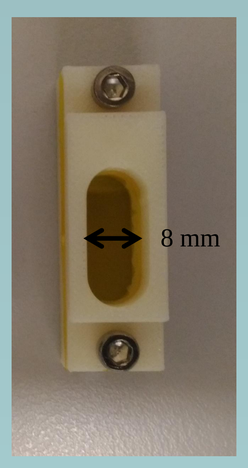
-The aim is to monitor the beam continuously during irradiations at Arronax with beam intensity < 10nA/cm²:

- The small thickness of the detector disturbs very little the incident beam, and consequently, the associated heating is very small
- The polymer structure should be tolerant to radiations (dose, rate dose, low and high LET)

[2]: Development of an ultra-thin beam profiler for charged particle beams, B. Boyer et al, https://doi.org/10.1016/j.nima.2018.09.134

Kapton Irradiation setup





Kapton 8µm with the sample holder

-Kapton samples was irradiated under ambient air and at room temperature. The Kapton, aromatic polymer, has been reported, with high resistances to gamma and electron beams up to 10 MGy of irradiation [3].

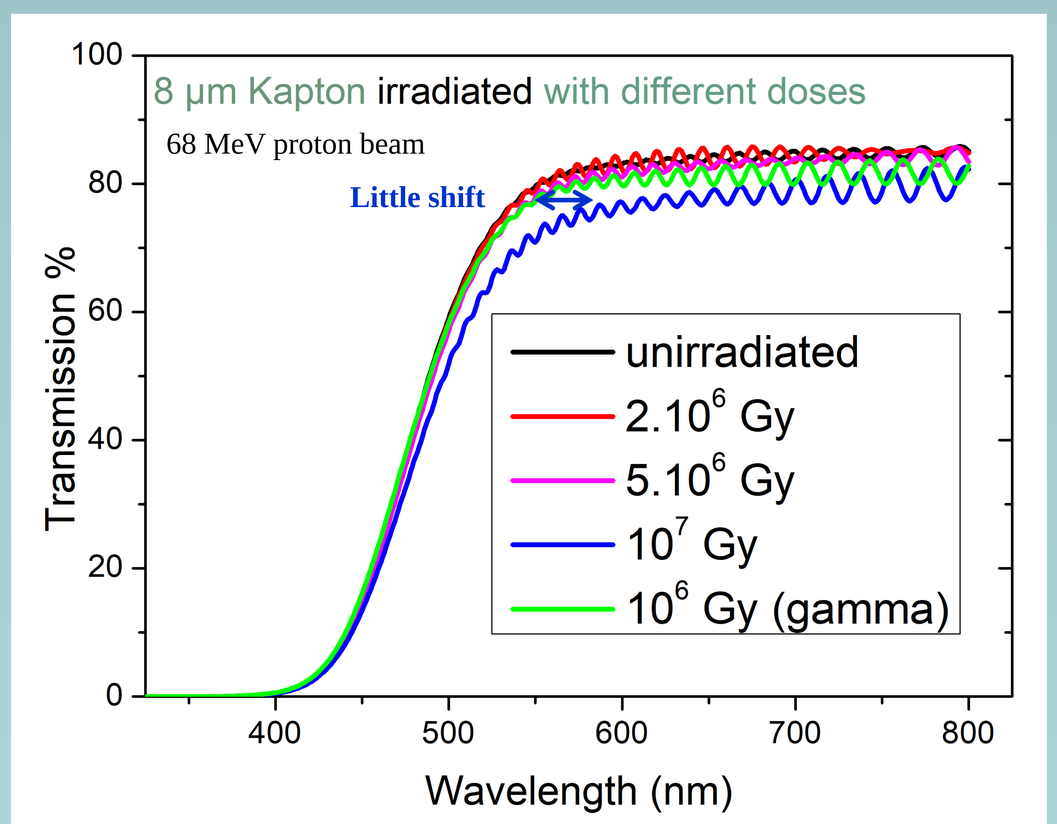
-Beam intensity: 150 -200 nA, doses: 2, 5, and 10 MGy (equivalent 10 years operation with low beam intensity <10nA/cm² at cyclotron Arronax).

-In parallel, samples are irradiated with a gamma source (Cs137) available at Arronax. The accumulated dose until now is 1MGy.

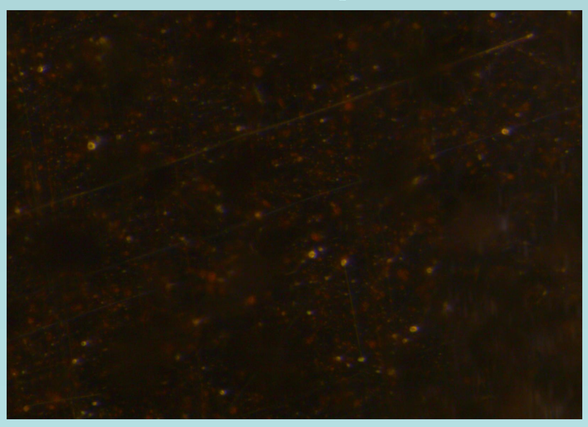
-The irradiated sample was analysed by UV-Vis spectroscopy and light microscope.

[3] Hanks, C. L. and Hamman, D. J. Radiation Effects Design Hand Book, NASA-CR-1787, 1971, Sec. 3

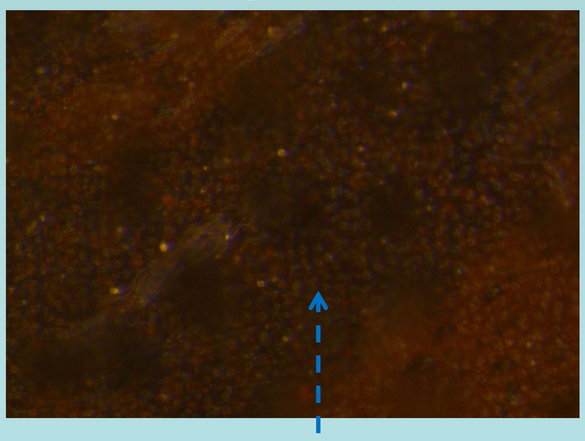
Preliminary results



Unirradiated Kapton



Irradiated Kapton (10MGy)



Micropores (1µm-10µm) due to the volatile products (H_2, N_2, CO_2)

Conclusion and Perspectives

-The optical properties of Kapton have been slightly changed after irradiation of 10MGy with a 68 MeV proton beam. However, micropores were observed on the irradiated surfaces.

-Next steps:

-analyze the irradiated surface with the Scanning Electron Microscopy (SEM) and measure the conductivity during and after the irradiation

-Investigate the response of another aromatic polyimide CP1 of 1,5µm thickness.