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Real Time Imaging of Antiproton Annihilation for Medical Applications

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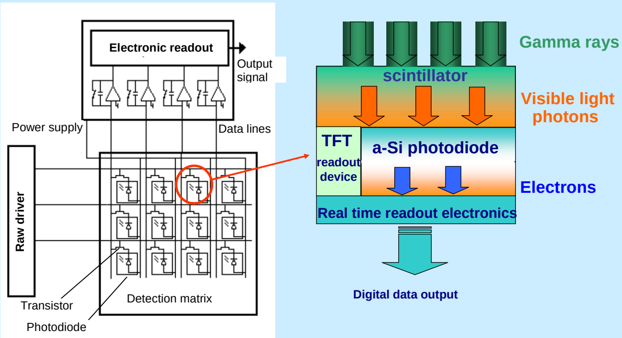
INTRODUCTION : Imaging antiprotons

First results of real time imaging of the high energy gamma rays coming from antiproton annihilation with the protons in the nuclei of a biological cell are presented. These results are obtained with IRIS, a patented amorphous silicon high resolution detector. We are able to demonstrate the potential for imaging the point of annihilation

The main application is the imaging of the proton-antiproton annihilation for medical purposes, e.g. cancer treatment on a biological cell level.

IRIS detector for high energy gamma rays :



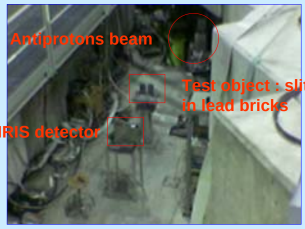
Characteristics of IRIS :

- Based on large area pixel matrix, thin film amorphous silicon technology,
- Energy range : up to several hundreds MeV for gamma-rays,
- Dynamic visualization,
- High frame rate : up to 10 images per second,
- Active area : 20 cm x 20 cm or 41 cm x 41 cm,
- Pixel size : 750 µm x 750 µm, 400 µm x 400 µm down to 50 µm x 50 µm,
- Wide dynamic range,
- ADC resolution : 16 bits (65536 gray levels),
- IRIS-View, software package for PC for acquisition, visualization, data storage and tele-medecine.

THE SETUP

Data were taken at the AD, antiproton decelerator facility at CERN. An external beam of 47.8 MeV antiprotons was deposited on a biological target. The antiprotons were delivered in pulses of approximately 3 x 10^7 particles during 200 nanoseconds at 90 seconds intervals. The high energy gamma rays, ~10^8 into 4π steradians, were produced by the proton-antiproton interaction in the biological target. The gamma rays have an energy distribution with a peak about 150 MeV. The IRIS detector was placed 50 cm away from the target, with lead shielding protection for the on-line electronics.

The tests objects were slits between lead bricks, placed between the stopping point of antiprotons in the target and the detector.

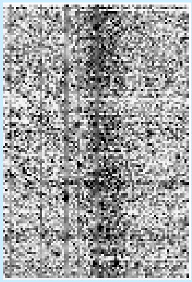


AD experiment room

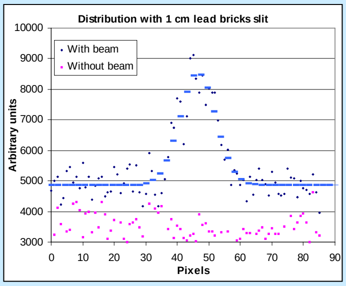
AD control room

THE RESULTS :
Gamma rays were visible within the slits.

Lead bricks slit of ~1 cm thick



The slit is visible in the medial part of the image.

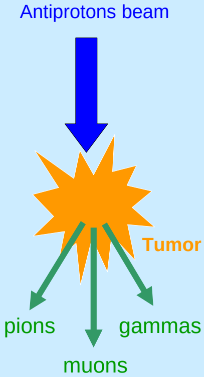


Distribution histogram.
IRIS pitch size 750 µm.
FWMH : ~11 mm.

FUTURE APPLICATION : Antiprotons for cancer treatment

The biological effects of photons and particles of ordinary matter are well known and widely used in cancer therapy. Photon (x-ray) therapy has been used for almost one century. Proton cancer therapy exists worldwide and a few heavier ion therapy centers are active.

Presently, production of positrons and antiprotons is a well known technique. Now, with CERN being the world leader in antiproton physics, the time has come when a study of the biological effects of antiprotons is reality.



Antiprotons, as charged particles, are easy to focus with a corresponding electromagnetic optics. The annihilation phenomenon could be controlled within the 3D space of the biological target, or the human body in the future, which would be the breakthrough in radiotherapy. When the antiprotons slow down to a certain critical velocity, they annihilate, producing a variety of particles, thus making “implose” the biological cell.

Thus, the annihilation could be considered as a breakthrough way for “implantation” of particle sources inside the tumour with a 3D precision. The question that follows is: what are the effects of ‘implanted’ emitters.

The relatively low energy particles, created after an annihilation are expected to deposit biologically effective high LET (Linear Energy Transfer) radiation in the immediate vicinity of the annihilation point. After leaving the body, the high-energy pions, muons, and gamma-rays could be used for real time imaging.

CONCLUSION : These first results are very promising.
Our aim is to set-up the foundations for a cancer therapy with antiprotons.