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PROPOSAL TO THE PSC

AN EXPERIMENT ON PROTON RADIOGRAPHY AT THE PROTON SYNCROTRON

CERN[1] - SACLAY[2]

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The first experiments performed at CERN in 1975[1,2] have shown that the nuclear scattering of protons at energies around 1 GeV permits to obtain 3 dimensional radiographies with volume resolutions of a few mm^3, a sensitivity to chemical composition different from the one of X-rays and the possibility to obtain a clean distribution of the hydrogen atoms, quite independent of the other atomic constituents.

While the runs with physical "phantoms" simulating the situation encountered with living bodies confirmed all the expected qualities of the method, only short runs could be done with living tissues. The runs performed with a mouse afflicted with a tumour showed a clear difference in interaction rates between the tumour and the surrounding tissues. Although very encouraging, these results suffered from the very weak intensity of the parasitic available beam (10^4 protons/burst) and the small acquisition rate capability of our experimental set-up (a few events/burst). The interaction density was at most 4 events/mm^3, while the limiting dose for human tissues would correspond to about 500 events/mm^3. In 1976 the experiments were continued at SACLAY[3] with a parasitic beam of 1.1 GeV from SATURNE. The experimental set-up permitted to acquire about 50 events/burst and an interaction rate of 35 events/mm^3 could be reached after 4 days of irradiation.

An experiment has been undertaken in collaboration with a medical team[4] and a section of the vertebral column was radiographed. The spinal marrow cannot be radiographed "in vivo" by X-rays because of the stray absorption by the chest; it is instead clearly visible with proton scattering and the results are confirmed by an EMI scanner in the isolated piece of spinal column. The absorption should play a negligible role with 1 GeV protons and this is a clear case when the best X-ray techniques may well lie behind nuclear proton scattering. The fact that calcium is not very different from the surrounding tissues as far as the cross-section is concerned is in most cases very advantageous compared to X-rays.

The specific interest in radiography by proton scattering has not been weakened by the recent spectacular progress in X-ray radiography by the computer assisted tomography. The fact that several high energy machines are going to be used for therapy reinforces the interest in the development of this radiographic technique. A small fraction of the beam used for the destruction of the malignant tissues could be used to give a better knowledge of the tissues that will have to be irradiated.

At Saclay, SATURNE stops 1st of May 1977, for a period of 18 months. It will then deliver beams very well suited for proton radiography (adjustable energies between 0.6 and 1.5 GeV, duty cycle of 45%).

In the meanwhile we would like to perform experiments with the following aims :

1) Development of detectors and acquisition systems with a data acquisition rate permitting the radiography of human being. A few minutes should permit to get the data with the maximum admissible dose.

2) Determination of the characteristic features of this type of radiography, for human tissues, as compared with computed assisted tomography.

We request for this purpose, a beam at the CERN Proton Synchrotron that will allow us certainly to clarify the second point and to make a big step in the direction of the construction of the optimum data acquisition system that will have to be used for in-vivo experiments.

We have undertaken the construction of a detector system that should permit the acquisition of 10^4 events/burst; it consists in a set of multiwire proportional chambers with around 1500 wires (see Fig. 1), followed by a fast CAMAC readout into a HP 21 MX E computer. A micro-programming option in the computer should allow the reduction of the row data to the vertex of the interaction on line, at a rate approaching 10^4 events/PS burst. Data so collected will then be displayed either directly or on our existing colour display system.

In a few hours dead parts of the human body would be analysed with an image quality comparable to computed assisted tomography. Very rapidly we will learn the advantages and limitations of the method.

We are working in close connection with several medical teams which have expressed their interest in the method. Because of their unique penetration properties in thick materials, fast protons can also open interesting possibilities in industrial cast heavy materials failure diagnostic.

Beam requests

- Protons of energy close to 1 GeV
- A contamination about 50% pions is tolerable
- No momentum resolution requirement
- A beam of 10 x 10 cm^2 at the target position is optimum
- An intensity of 10^5 to 2 x 10^5 proton/burst is requested. It permits to reach the maximum event rate acceptable by the data taking system
- Length of the experimental system : 4 meters.

Date

The experimental system can be ready at the end of June. We would like to stay 6 months in the experimental area in order to be in a position to analyse the different samples and modify experimental conditions according to our results.

We would also like to emphasize that this project leads to developments of interest for high energy physics. Our goal is to accept finally 10^6 good events/sec. Some of us are working on the same problem for X-ray acquisition systems like the spherical drift chambers. These experiments are a good opportunity to develop techniques of most general interest in many field.

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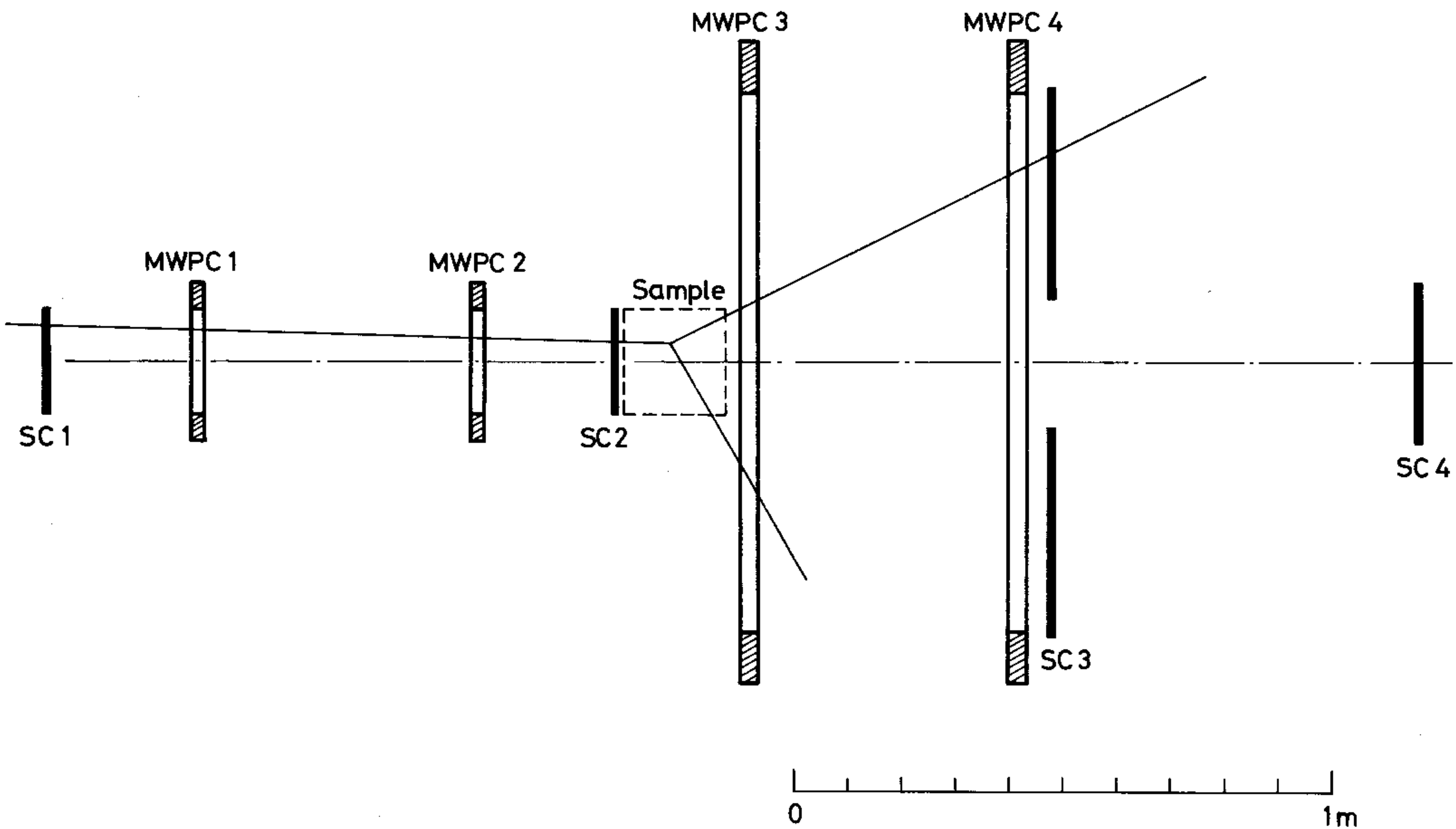

Experimental . setup