Specification about an experiment on imaging for hadrontherapy at the HIT Center

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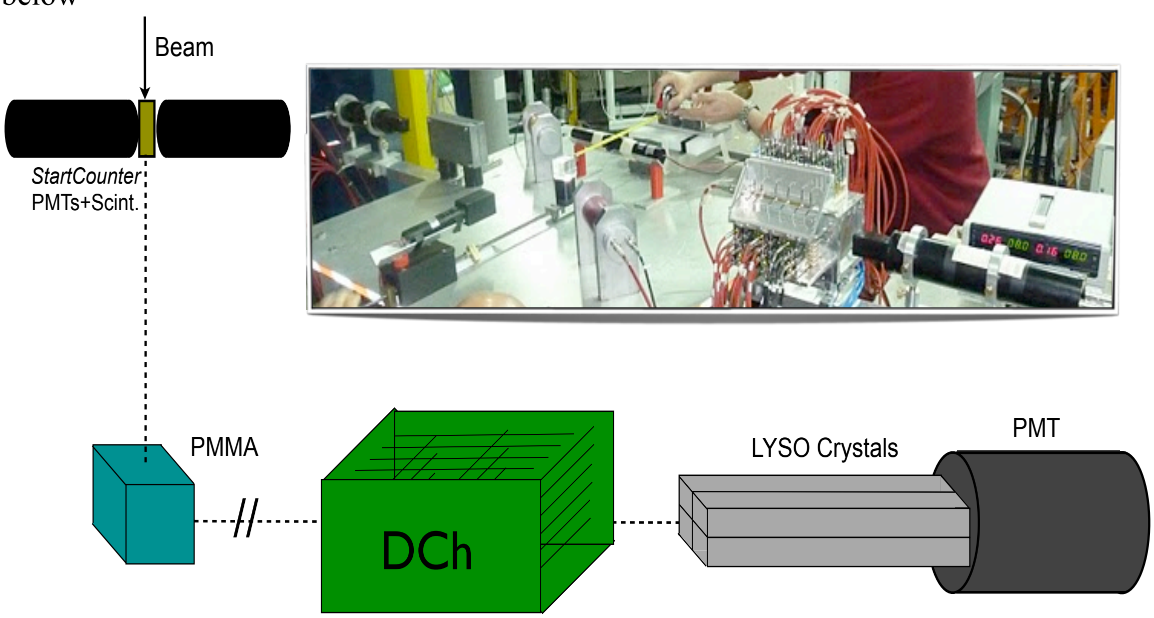
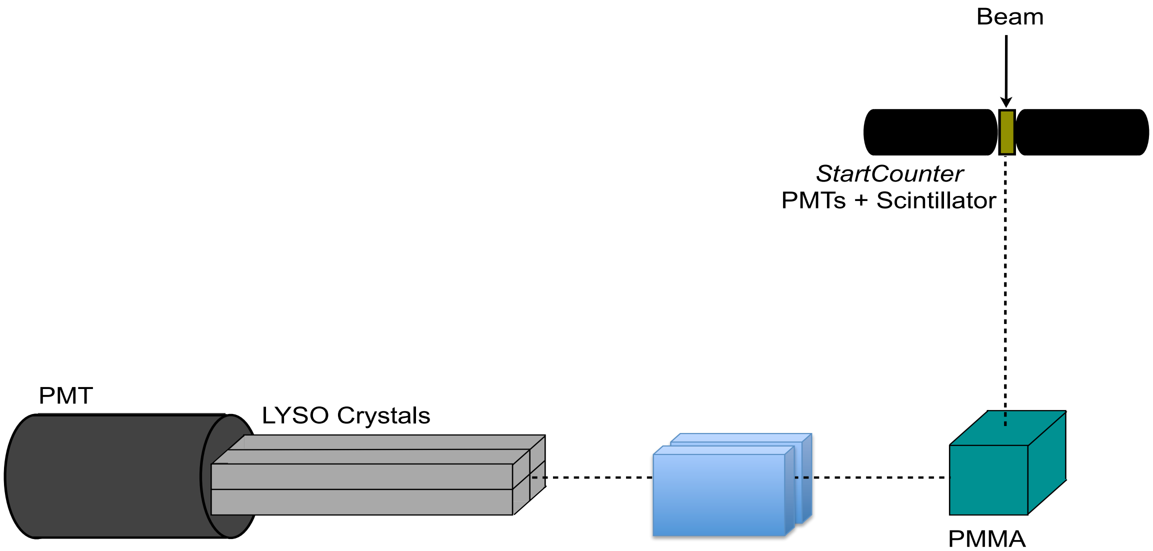
The experimental setup

We propose the measurement of energy spectrum and rate of the secondary particles produced by the interaction of a beam of therapeutical interest with a Poly-methyl methacrylate (PMMA) target. In particular we aim to study the charged particle flux and the prompt photons component.
The experimental setup that will study the charged component will be composed as shown below



The arrival time of the beam will be given by a fast plastic scintillator before impinging on the PMMA. The LYSO crystal, placed at 90^0 with respect the beam and at a distance of the order of 50 cm from the phantom, will give the energy and the TOF both of the neutral and charged

components , while the charged particles will be tracked by the chamber.
We also plan to instrument the opposite side with respect to the phantom to study the prompt photon capability to monitor the dose profile. The schematic of the this part of the experimental apparatus is shown in the following figure



An accurate selection of prompt photons, amongst all neutral secondary components, can be pursued exploiting the excellent time resolution of LYSO crystal detector. A collimator in front of the crystal will allow to analyze the spatial distribution of the emission point of such a radiation.
The FEE electronic system and the DAQ are based on NIM+VME system + PC. We would provide all the electronics, cables, rack, DAQ, DAQ pc.

The measurements

a) "imaging":
The beam of interest for this measurement would be ^{4}He, ^{16}O, protons, ^{12}C, ^{7}Li, in decreasing order of interest.

We would like to measure at 3 different angles with respect to the beam axis: 70^0,90^0,110^0, both for the neutral and charged components, to probe the angular dependence of the energy spectrum.
During this data taking we would like to investigate the possibility to reconstruct the Bragg peak position exploiting the information carried by charged particles produced in the PMMA during irradiation.
The beam energy should in principle be changed during the data taking to move the Bragg Peak position.

b) "fragmentation":
The same setup, with little modifications, could measure the yield of fragments of different

species produced by such beams (preferentially on thick targets). The geometry should be adapted for this measurement, to have larger path for the fragment so to better exploit the TOF information. The fragments should be detected at different angles by the LYSO crystals placed at 1.5 m from the target.
If there is an interest in such a fragmentation measurement (for example for He or O) we could try to arrange a double data taking setup, changing the standard geometry for the “imaging” experiment in the different geometry for the requested “fragmentation” experiment. The possible target for fragmentation (e.g. water target) should be provided.

A solution to have both these measurements done at the same time could also be envisaged.

The logistic related with this measurement

1) possibility to use non flammable gas bottles in the experimental room (AR/CO_2 mixture for drift chamber). Possibility to have AR and CO2 gas bottles provided by the Center.
2) possibility to have the really modest flux (about 2 l/h) of gas exhausted in air. If this is not possible we need to have a plastic gas piping out of the experimental room.
3) possibility to place some electronics nearby the experimental site (within 1-2 meters)
4) To have a physical space around the irradiated phantom of the order of 2 meters to allow us to place the detectors
5) To have an electronic signal from the machine to signal the change in position of the Bragg peak, whenever the energy changes.
6) The beam rate should not exceed 1-2 MHz
7) The microscopic (in time) structure of the beam should not give 2 or more ions in the same microbunch (length ~ 200 ns?) in more than 10-20% of the events.
8) The setup needs 12-18 hours (the longer the better) to be mounted, cabled, tested, adjusted in time for trigger, adc gating etc etc.
9) We need to know the radioprotection procedure to have access to the Center 30 days in advance the data taking.
10) Availability of lead (or iron) bricks for the shielding of the detectors.
11) It could be useful, even if not necessary, the availability of standard radioactive sources.

A key point in the experiment preparation is the mechanics. Since we would like to measure at a sub-millimeter level the Bragg Peak position, we should know as soon as possible the layout of the experimental room to build suitable structure to hold and move the detector (see angle scan). If a pre-existing structure (tables, or other) is available we should know as soon as possible the geometry to match the detector inside this existing structure.
To prepare the experiment we should know also if it would be possible to have cables going from the experimental room to the control room, and how many cables we are possibly allowed to take out. In principle we would need order of 40 cables going out. If is not possible to have signal cables going out we should at list have the possibility to go out with an optical fiber to control the VME daq or to plug the DAQ pc-server in a ethernet connection inside the exp. Room.

It could be useful to have stable environmental condition or to monitor the temperature.

We do not need:

- To take data in a unique solution: we can stop and restart without recalibrate the setup, if the setup is not dismounted.
- To have a monitor of the dose: the beam will be counted by the start counter scintillator read out by multihit tdc to give the correct ions number. A comparison with the monitoring system of the Center of course is welcome.
- To have phantoms made for us. We can provide them.
- Computing, data storage.