Reducing the risk of proton therapy with prompt gamma

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Radiotherapy Types

- Radiotherapy is one of the existing medical applications to **deal with tumors**. It uses **ionizing radiation** to destroy cells in the volume;
- Radiotherapy can be divided in two main groups:
  1. **Conventional Radiotherapy** which uses **photons** (X-rays and γ-rays) or electrons;
  2. **Heavy charged particles Radiotherapy** which uses **protons** or ions with atomic number > 1.

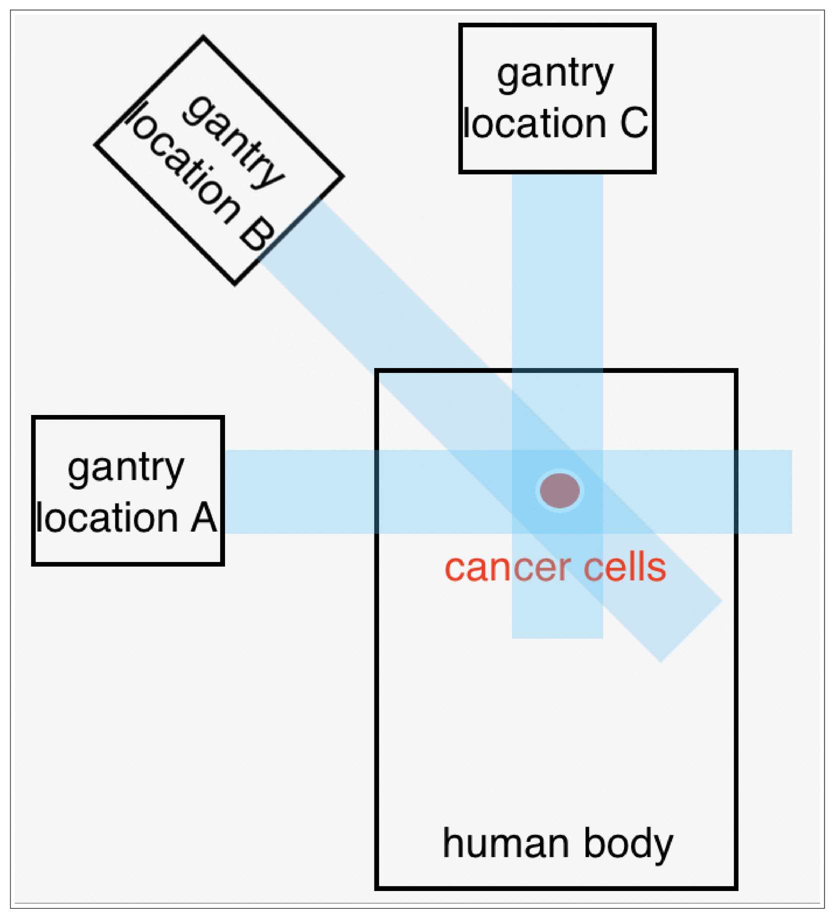

Figure 1:Schematic of conventional radiotherapy.

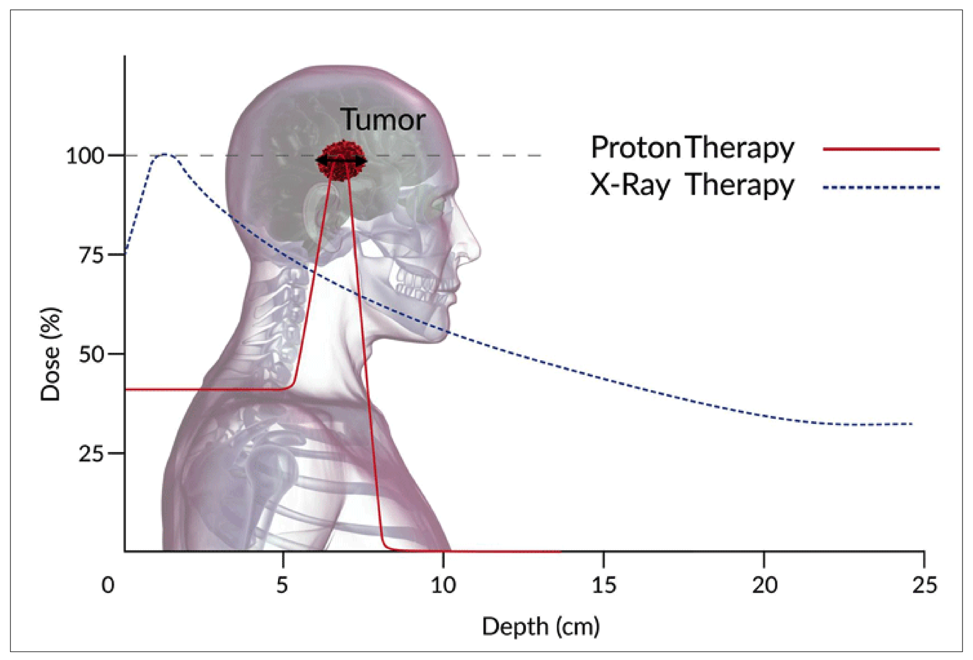

Figure 2:Proton therapy versus conventional radiotherapy radiation dose as function of tissue depth.

- **Conventional Radiotherapy (CRT)**:
  1. **Broad** dose deposition profile;
  2. Multiple beams increase ratio of dose in healthy to cancer cells;
  3. Large deposition of dose before and after the tumor.
- **Proton Therapy (PT)**:
  1. Dose profile peaks at Bragg Peak;
  2. Minimal dose deposition after Bragg Peak;
  3. Pencil-like therapy.

Dose Profile Monitoring

- Bragg Peak needs to be accurately known, its position affects the location of the delivered dose;
- The aim is to monitor the Bragg Peak position in vivo conditions;
- Simulations show the possibility to achieve resolutions in the order of millimeter [1].

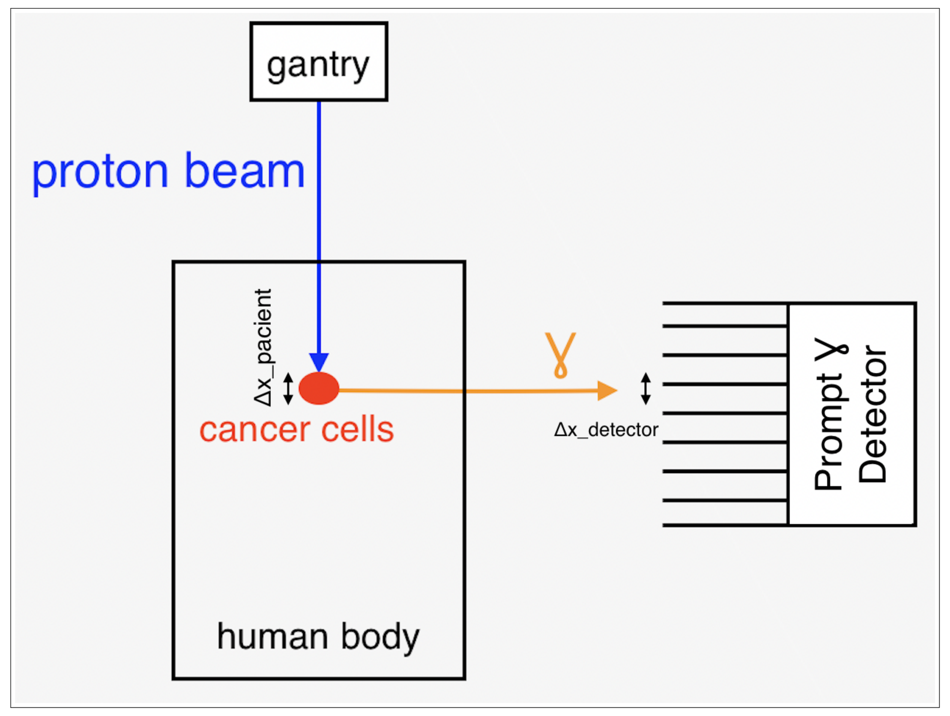

Figure 3:Schematic of proton therapy - proton beam and γ ejection.

Geometry

- The detector is placed orthogonal to the beam path;
- Pixelization and collimators allow spatial resolution in the beam direction.

Detection

- Each pixel is composed by a crystal coupled to a light sensor;
- The collimator is a series of high density material blades isolating each crystal.

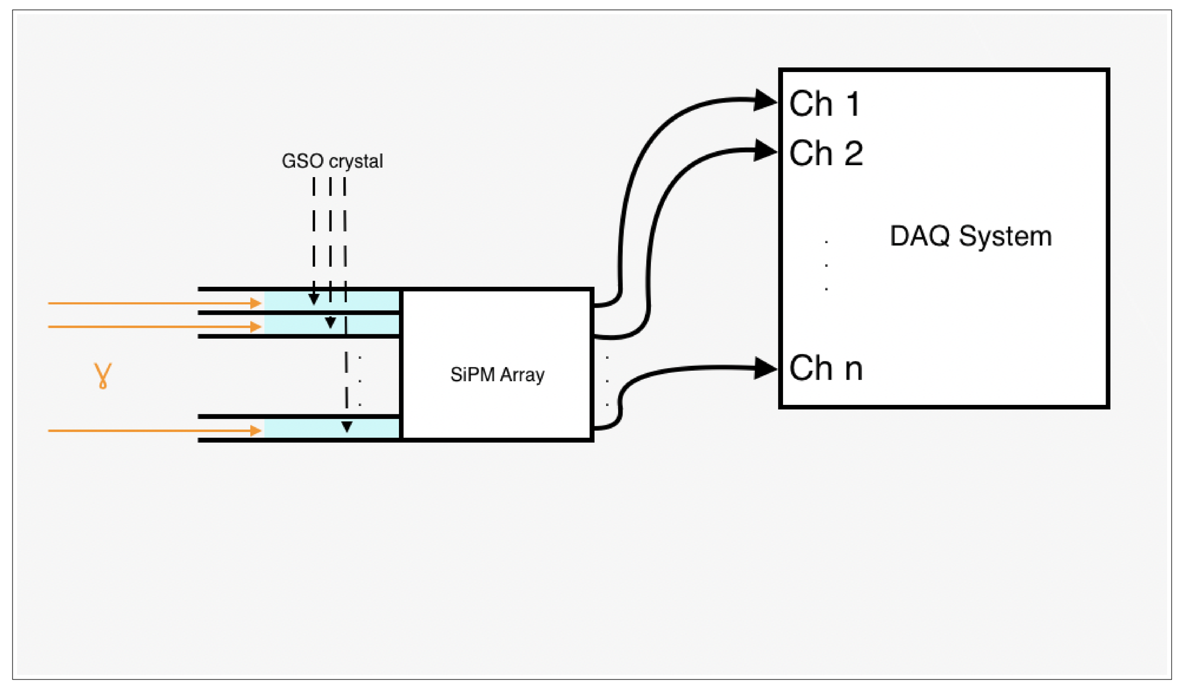

Figure 4:Schematic of the GSO crystal, SiPM and DAQ system.

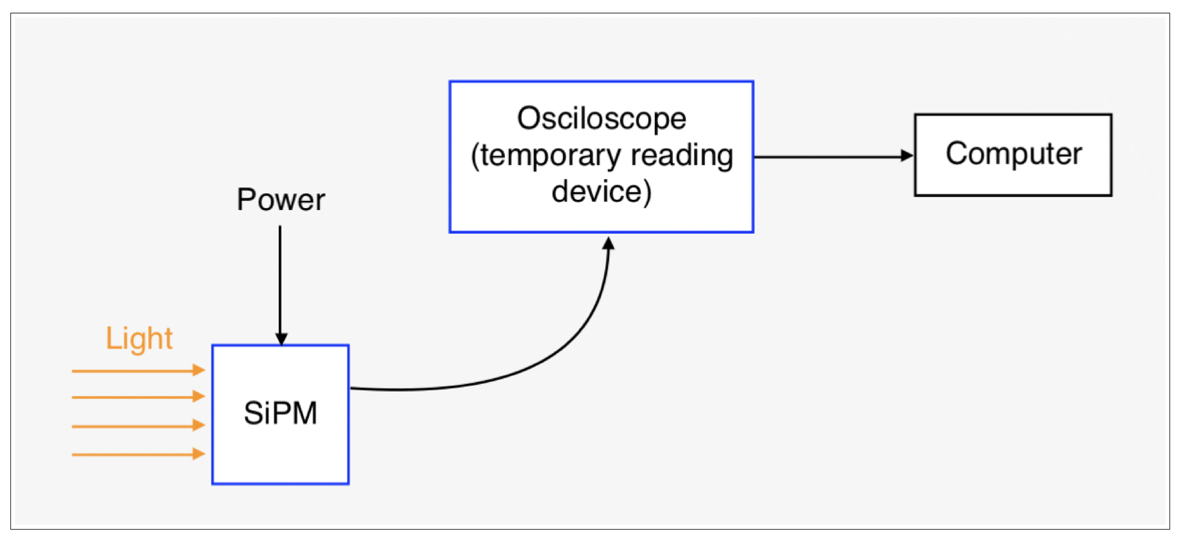

Figure 5:Schematic of preliminary system composed by the SiPM, oscilloscope and computer.

Instrumentation

- The solution has to be capable of handling a large number of sensors;
- The Baseline scintillator is BGO crystals;
- The main candidate for light sensor is SiPM;
- It is expected to have a large volume of scintillators and a number of pixels O(100);
- Techniques to reduce noise and enhance dynamic range are being pursued;

What was made

- Temporary solution based in oscilloscope to study the requirements of the system and possible simplifications.
- Oscilloscope based setup, figure 5;
- Preliminary data acquisition from the oscilloscope to the computer;
- Temporary data processing made using ROOT.

What comes next?

- Using the system with radioactive sources, study its behaviour and then compare the performance of a simpler system, scalable to a large number of channels;
- It will probably be based in the ROC ASIC chips from the OMEGA group with which LIP has experience.

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References

[1] Paulo Crespo, Patricia Cambraia Lopes, Hugo Simões, Rui Ferreira Marques, Katia Parodic, and Dennis R Schaart.
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