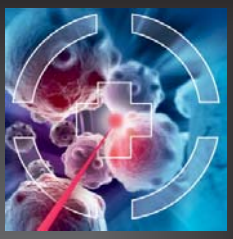
Beam Diagnostics for Medical Accelerators

C.P. Welsch, Cockcroft Institute and The University of Liverpool, UK
on behalf of the OMA Consortium



Abstract

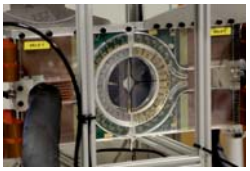
The Optimization of Medical Accelerators (OMA) is the aim of a new European Training Network that has received 4 ME of funding within the Horizon 2020 Programme of the European Union. OMA joins universities, research centers and clinical facilities with industry partners to address the challenges in treatment facility design and optimization, numerical simulations for the development of advanced treatment schemes, and beam imaging and treatment monitoring.
This poster presents an overview of the network's research into beam diagnostics and imaging. This includes investigations into applying detector technologies originally developed for high energy physics experiments (such as VELO, Medipix) for medical applications; integration of prompt gamma cameras in the clinical workflow; identification of optimum detector configurations and materials for high resolution spectrometers for proton therapy and radiography; ultra-low charge beam current monitors and diagnostics for cell studies using proton beams. It also summarizes the network-wide training program consisting of Schools, Topical Workshops and Conferences that will be open to the wider medical and accelerator communities.

Research

Continuing research into the optimization of medical accelerators is urgently required to assure the best possible cancer care for patients and this is one of the central aims of OMA. The network's main scientific and technological objectives are split into three closely interlinked work packages (WPs): Beam imaging and diagnostics, treatment optimization and facility design and optimization. Here, examples from the beam diagnostics work package are shown.

Beam Imaging and Diagnostics *(U Liverpool/Cockcroft Institute)*

The Vertex Locator (VELO) which was developed for the LHCb experiment at CERN, is an example of a silicon micro-strip detector positioned around the experiments interaction region. By the use of two types of strip geometries the radial and azimuthal coordinates of traversing particles are measured. VELO provides precise measurements of track coordinates which are used to reconstruct the primary collision vertex as well as displaced secondary vertices that are characteristic of B-meson decays. It is hence a promising technology for non-invasive real time beam monitoring applications.



Photograph of the VELO detector that will be used as online beam monitor for quality assurance.

Project goals :

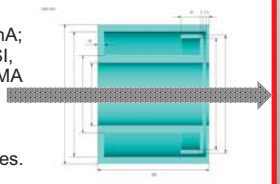
- Design, build up and test a stand-alone monitor for online beam monitoring;
- Link it to an overall diagnostics concept with other Fellows working on facility design and optimization;
- Optimize the local positioning, control, ventilation (with dry air) and cooling system;
- Carry out measurements to establish a halo-dose correlation data base for different machine settings.

RF-based Measurement of Ultra Low Charges *(PSI)*

To complement information about the beam, it would be highly desirable to monitor its intensity in a parasitical way that does not affect the beam during measurement. Currently, ionization chambers are the most commonly used detector type for beam intensity measurement. However, they use thin foils which are passed by the beam and decrease the beam's quality by scattering. A sensitive RF-based current monitor will be developed to mitigate this problem.

Project Goals

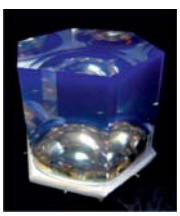
- Measurement of beam currents as low as 0.3 nA;
- Based design on previous developments at PSI, but take into account developments at other OMA partners through secondments;
- Use prototype for scans at PROSCAN;
- Fully characterize prototype and assess implementation into operating and future facilities.



Schematic of non-invasive beam current monitor.

Calorimeter for Proton Therapy and Radiography Optimization *(UCL)*

An accurate calorimeter can provide valuable quality assurance measurements of treatment protons. The majority of this time is spent verifying the Bragg Peak and depth dose curve of several proton beam energies. These energy QA measurements take significant time to set up and adjust for different energies. Existing calorimetry technology will be adapted for precise measurement of proton energy in a clinical setting.



Photograph of the SuperNEMO prototype.

Project Goals:

- Existing Geant4 simulations will be adapted to optimize detector configuration for proton therapy;
- Measurements will be made with the Clatterbridge proton beam to fully characterize the performance of the detector;
- Results will be used to form the basis of the calorimetry stage for a proton CT system.

Training

R&D into medical accelerators is ideally suited for researcher training as it requires inter-disciplinary expert knowledge in a number of different fields ranging from biomedicine, oncology, Monte Carlo studies, electronics and imaging systems to accelerator science and technology. A structured combination of local and network-wide trainings is a central idea in the definition of all training projects within OMA.

International Schools
INFN, CNAO and Medaustron

Three 1-week Schools, open to all OMA Fellows, as well as up to about 50 external participants, will be organized during the life time of the project. These will cover the following areas:

- **Monte Carlo Simulations.** This will cover geometry definition, material assignment, analysis, dose calculations, different solvers and post processors, as well as data visualization tools and will be held at INFN in **autumn 2017**.
- **Medical Accelerators.** Basic principles of medical accelerators, treatment schemes, clinical assessment of effectiveness and regulations governing the application of medical accelerators, biomedical and oncological aspects of particle cancer therapy. This will be held at CNAO **in June 2017**.
- **Particle Therapy.** This school will take place at Medaustron in **spring 2019** and cover advanced and combined techniques, such as real time beam monitoring, variable energy and intensity beam delivery for 3D tumor 'painting', online beam and patient imaging.

A limited number of scholarships will be provided for external participants. Information about all schools will be announced via the web, social media and the network's quarterly newsletter.

Topical Workshops
Venues across the network

The network will organize a series of Topical Workshops that will also be open to external participants. A typical workshop will bring together 30-50 experts and will last 2 days. This includes:

- 1st OMA Topical Workshop
  Facility Design Optimization for Treatment: PSI, **November 2017**.
- 2nd OMA Topical Workshop
  Diagnostics for Beam and Patient Monitoring: CERN, **February 2018**.
- 3rd OMA Topical Workshop
- *Accelerator Design & Diagnostics:* CNAO, **May 2018**.

The OMA Fellows will also participate in a *COSYLAB Academy* and receive dedicated researcher skills training, including scientific writing, project management, IPR, and presentation skills. They will also benefit from intra-network secondments that will provide them with cross-sector experience.

International Conference and Symposium
GSI/CNA and University of Liverpool, UK

In the last year of OMA, a 3-day international conference on medical accelerators will be organized, with a focus on the methods developed within the network.
OMA will also organize a major Outreach Symposium that will showcase the research results to the wider public that will take place in **Liverpool in June 2019.**

Photograph from the OMA kickoff meeting, held in Liverpool, UK.

Whilst the beneficiary and associated partners were defined at proposal stage, the project encourages additional institutions to join the network. **Information on how to join can be obtained directly from the coordinator.** A regular **newsletter** will be distributed from **autumn 2016.**

c.p.welsch@liverpool.ac.uk

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http://www.oma-project.eu