Beam Diagnostics for the MC-60 Cyclotron at the Clatterbridge Centre for Oncology

UNIVERSITY OF LIVERPOOL

Tomasz Cybulski, Carsten Peter Welsch
University of Liverpool, L69 7ZX Liverpool, UK
Cockcroft Institute, WA4 4AD Daresbury, UK

Clatterbridge Centre for Oncology NHS
NHS Foundation Trust

Abstract

Hadron therapy has proven to be a very sophisticated and precise technique in cancer treatment. A particular advantage of hadron therapy is the precise dose distribution, which can be limited exactly to the tumour volume, thus decreasing the dose in the organs at risk. The Scanditronix MC-60 cyclotron's proton beam has been continuously serving in radiotherapy of ocular carcinoma at the Clatterbridge Centre for Oncology, Wirral, UK for over 25 years. The precision of the Bragg peak location is determined by the following beam parameters: The proton beam energy, the energy spread and beam position. In addition, the dose delivered to the tumour volume depends also on the beam current. Three quality assurance monitors will be developed and tested as part of this work: The LHCb VELO detector for non-invasive beam position and current measurements, Faraday Cup for reference measurements of the LHCb VELO detector and a multi-leaf Faraday Cup for energy measurements.

Fig. 1. MC – 60 cyclotron and treatment room at the Clatterbridge Centre for Oncology.

Scanditronix MC – 60 Cyclotron characteristics	
Ions	p
Energy [MeV]	62
Current [µA]	50
Acceleration method	RF
RF frequency [MHz]	25,7
Harmonic modes	2

LHCb VErtex LOcator (LHCb VELO)

The LHCb VELO detector is a semi-circular position sensitive Silicon detector system. It provides position information in radial (R) and azimuthal (φ) direction through two detector halves put together. The readout is triggered by the 40 MHz clock of the Beetle ASIC, combined with LHCb VELO data acquisition boards. The detector was designed to work in a severe radiation environment close to the proton collision region in the LHC.

The LHCb VELO was recently installed at the end of the 62 MeV proton beam line at the Clatterbridge Centre for Oncology to test its application as a beam monitor at energies lower than it was designed for. The measurements showed that it is possible to monitor both, the beam spot and the beam halo.

Further experimental work will cover the possible installation of the detector as a non-invasive real time monitor for the MC-60 Cyclotron. There, based on measurements in the tail region, beam current and beam position shall be determined. .

LHCb VELO module selected features	
Inner / outer radius [mm]	8 / 42
Detectors plate thickness [µm]	300
Material type	(Si) n^+ - on – n type
Φ – sensor inner / outer strip pitch [µm]	Inn. reg. 35.5/78.3 Out. Reg. 39.3/96.6
R – sensor stripes pitch [µm]	Increasing radially 40.0 – 101.6
The Beetle chip clock frequency [MHz]	40
Trigger decission [ns]	25
Readout window width [ns]	1.75

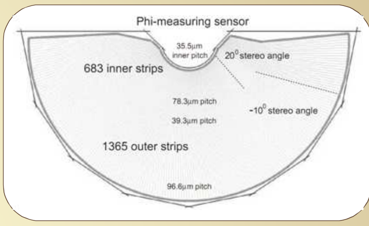

Fig. 2. The LHCb VELO φ – type design

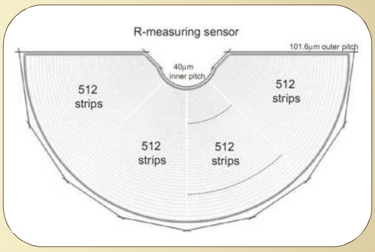

Fig. 3 The LHCb VELO R – type design.

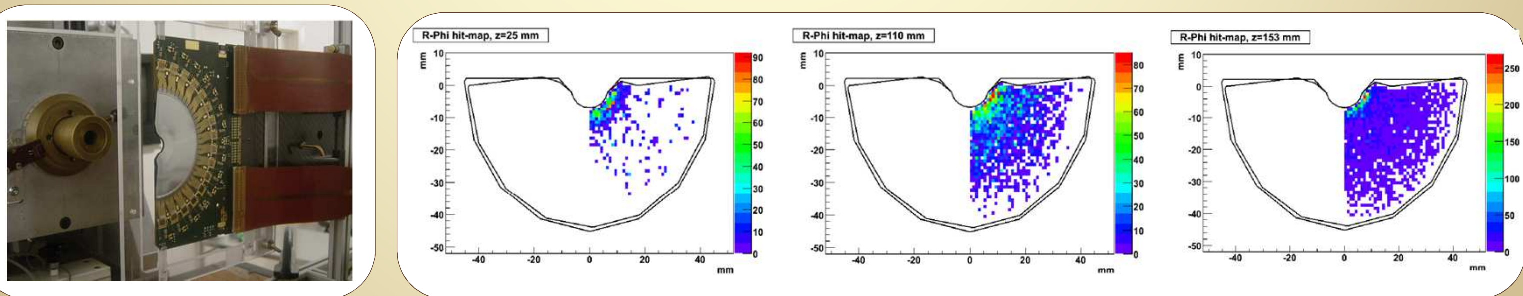

Fig. 4. First 'proof of principle' experimental results at MC-60 @ CCO [3]. Shown are VELO measurements at three different locations: 25 mm, 110 mm and 153 mm from the collimator aperture.

Outline of further works on detectors

Faraday Cup

In a first step, detailed FLUKA simulations will be carried out to optimize the geometry of a 'classic' Faraday Cup. This cup will be used for cross-correlation between the LHCb VELO signal and the total beam current. The secondary emission particle flux from for example electrons and back-scattered protons will be determined to quantitatively estimate the signal loss and optimize the suppressing fields.

Multi-layer Faraday Cup

A MLFC will be used to measure the beam energy and energy spread. The strongly mono-energetic 62 MeV-beam at CCO significantly decreases the achievable spatial resolution. Simulation studies to optimize the ratio between energy resolution and signal level will be carried out.

References

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Tomasz Cybulski, e-mail: tomasz.cybulski@guasar-group.org

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