Halo-dose Correlation in a Medical Accelerator

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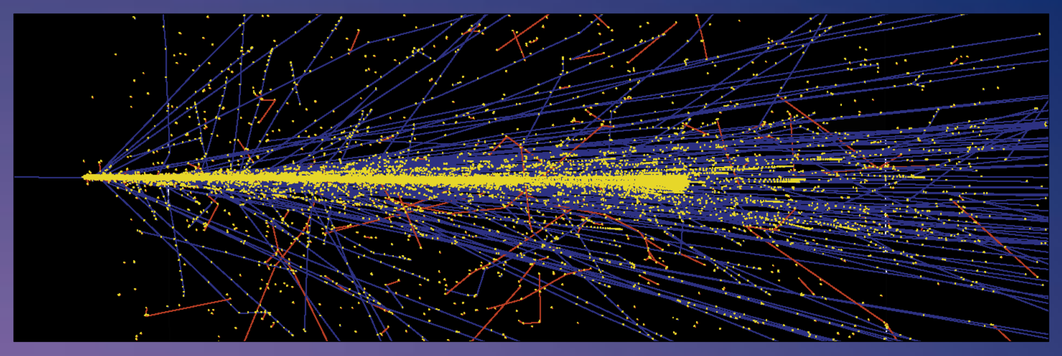
What is Proton beam therapy?

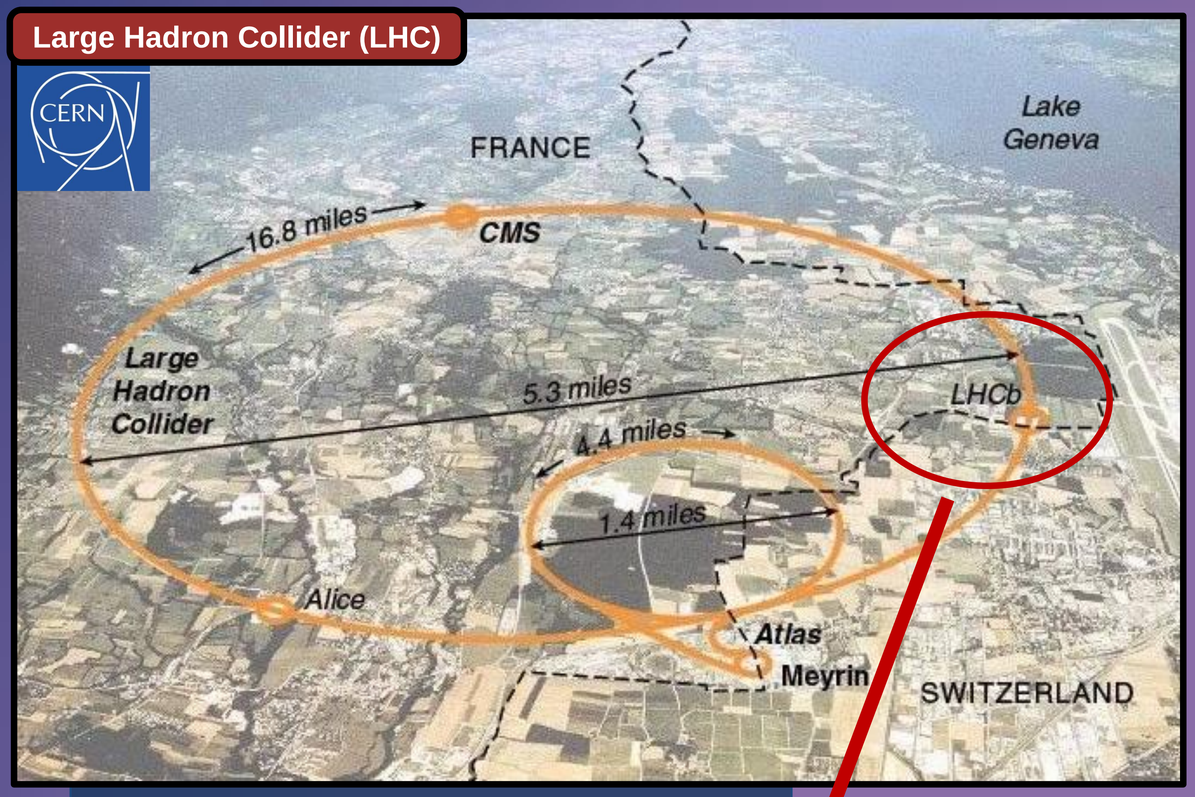
The aim of any treatment using radiation is to non-invasively deliver a sufficient amount of dose to tumour cells whilst sparing healthy tissue. Contrary to conventional radiotherapy which uses high energy X-rays, **Proton therapy** instead uses a beam of high energy protons to target and kill cancers. A charged particle beam offers several advantages as protons can be **accurately steered** towards cancerous cells where they are able to deal **more biological damage** to target sites.

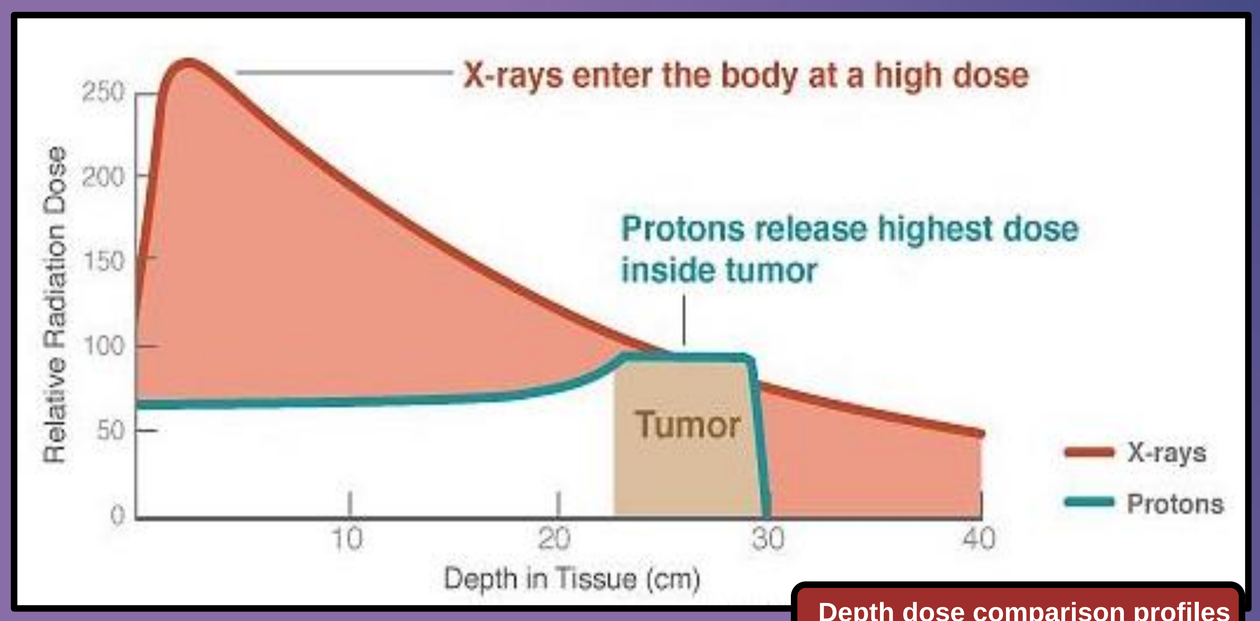


Why Proton Therapy?

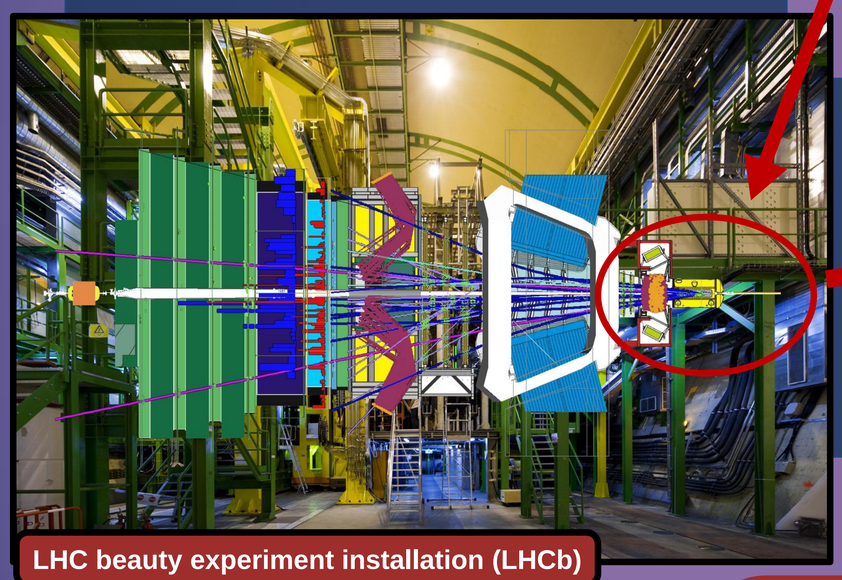
- Protons transfer maximal amounts of energy at a depth (Bragg Peak) which can be specified at the tumour site
- Lower excess dose than conventional x-ray photon radiotherapy
- Sharp fall off means negligible dose after the target area

Large Hadron Collider (LHC)

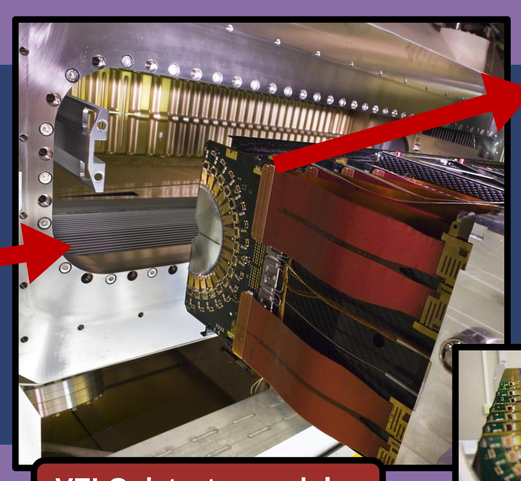




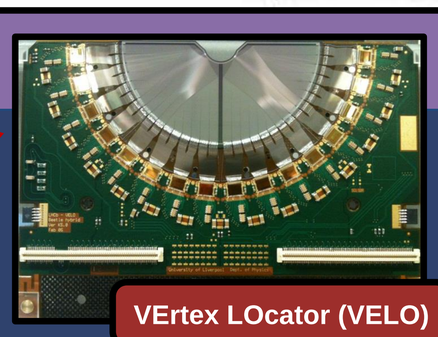
Depth dose comparison profiles



LHC beauty experiment installation (LHCb)



VELO detector modules

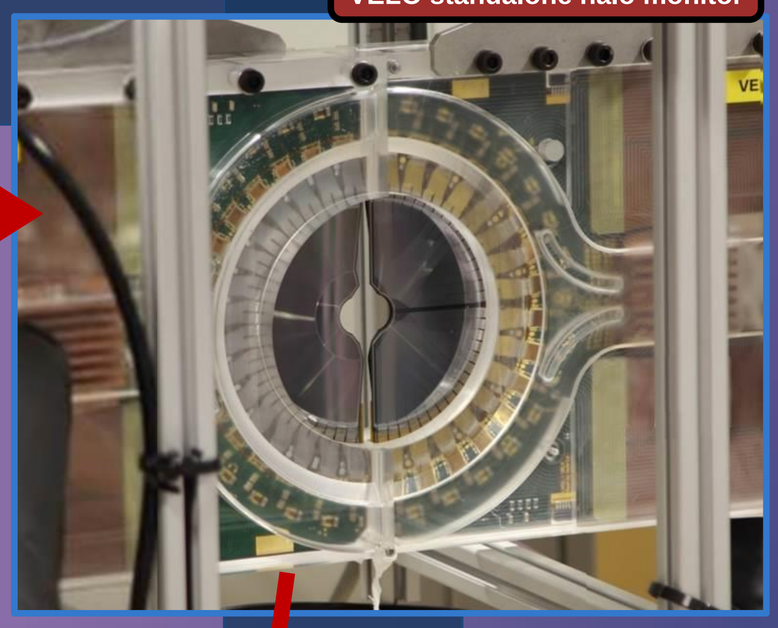


VErtex LOcator (VELO)

Non-invasive beam monitor

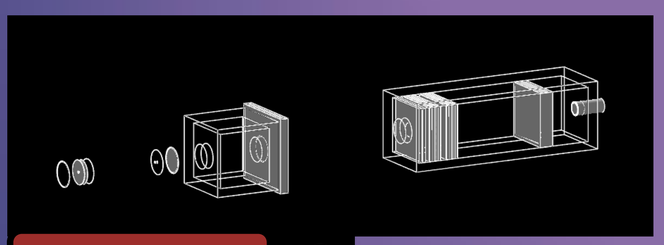
- Semi-circular silicon halves
- 8 mm aperture radius
- Radial (R) & Azimuthal (φ) sides
- 2048 diode micro strips / sensor
- Correlate halo measurements & dose

VELO standalone halo monitor

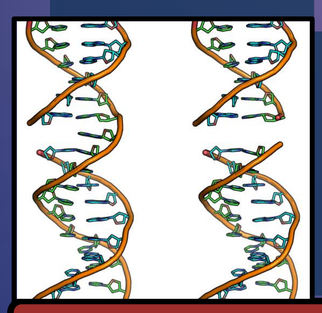


What is VELO?

VELO is **a detector system** that is being developed specifically for the CCC proton beam. In order to **deliver the protons accurately and safely** to each patient for their specific treatment, certain equipment is necessary to verify the process. VELO will be used **to measure the properties of the beam** and correlate this to the location and **amount of radiation being delivered**. Essential information about the ongoing quality of the treatment can be learnt as VELO transmits this data **during the operation of the beam**, unlike typical quality assurance systems which offer results after the irradiation occurs.

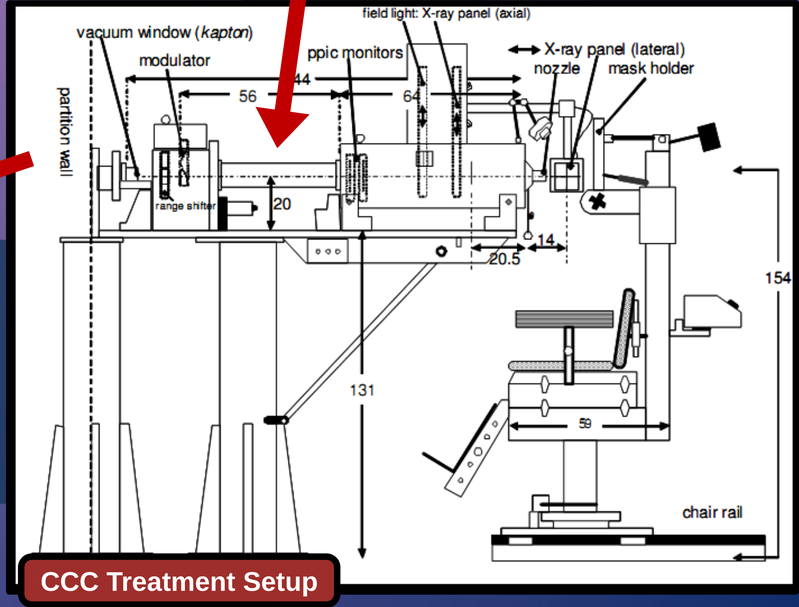


Beam Simulations UCL



DNA Damage & Repair

Cell Studies



CCC Treatment Setup

Treatment at Clatterbridge Cancer Centre

Cell & Simulation studies

- Monte Carlo simulations can generate an accurate approximation of processes based on probabilities
- When considering the effects of radiation and interactions with matter, events are random but their probabilities of occurrence can be calculated
- Simulations are very useful in predicting and investigating complex interactions and their outcomes reflect real life events
- These accurate computational projections of outcomes can then be compared with measurements
- This includes models of beam transport, halo propagation and radiobiological damage and cell response.

Clatterbridge Cancer Centre, Wirral, UK

- 62 MeV proton beam
- Passive scanning beam system
- First proton therapy treatment facility in the UK
- Treated >2830 eye cancer patients since 1989

Scanditronix MC-60 Cyclotron

References

CERN, 2012, For LHCb Talks. http://cds.cern.ch/record/1463546
CERN, 2007. LHCb installs its precision silicon detector. http://cds.cern.ch/record/1068142
Cybulski, T. et al., 2008. a Non-Invasive Beam Monitor for Hadron Therapy Beams
Cybulski, T. et al., 2013. Beam emittance measurements and beam transport optimisation at the clatterbridge cancer centre, IPAC 2013
Cybulski, T., Welsch, C.P. & Jones, T., 2012. NON-INVASIVE BEAM DIAGNOSTICS FOR A 60 MeV PROTON BEAM. In *Proceedings of BIW2012*.
Cybulski, T., 2013, Use of Silicon Detectors for Proton Diagnostics. *PASI workshop.*
I. Pshenichnov, 2015, "Impact of nuclear fragmentation on biological properties of therapeutic ion beams" NUFRA.
Jeandron, M., 2007, Proton Therapy. http://medicalphysicsweb.org/cws/article/opinion/30490
Procure, 2014, What is Proton therapy. https://www.procure.com/Proton-Therapy-Basics/what-is-proton-therapy
Templeton, G., 2015, How does the LHC work? https://www.extremetech.com/extreme/210215-extremetech-explains-what-is-the-large-hadron-collider

http://www.quasar-group.org
http:// oma-project.eu
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