DETECTING THE UNDETECTABLE ?

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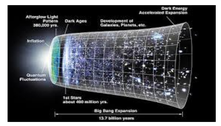
Abstract

Beam halo monitoring is an essential device to measure the halo's produced in any particle accelerator. These halo particles are associated with negative effects such as emittance growth , space-charge, *etc*. An ideal candidate to detect and possibly control these halo particles at the tail of a transverse beam distribution is a monitor based on a high-definition digital micro-mirror device (HD-DMD) technology. The HD-DMD based halo monitor uses the exploitation of light generated by charged particle beams traditionally used for beam profile diagnostics. The contribution presents the development of this monitor.

Purpose



•To explore the fundamental building blocks of matter and our universe.

•To exploit the use of particle beams for applications, e.g. proton therapy for the treatment of cancer.

•Types of accelerators:

Challenges

Charged-particle acceleration and transport is a very complex procedure and requires various methods and tools for the particle beam to be produced in the accelerator.

To do so, we need to:
• Design and develop Innovative diagnostic methods to monitor and detect the beams we are creating.
•Be able to measure the particle beam precisely without having any negatives effects on the accelerator and its components.
•Manufacture beam diagnostics devices with low cost and easy maintenance.

Optimization of the performance of the accelerator is important to:
•Make sure the particles are transported to the required experiment or user with a high transmission and minimum particle losses are made.

Research

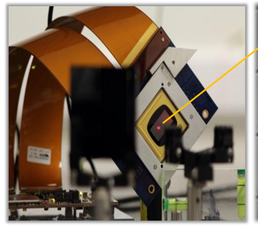
Within the oPAC and the QUASAR Group, cutting edge research in accelerator science and technology is done in the area of detecting and imaging the faint particles of a beam located at large radii with a low intensity distribution.

However, most of the existing techniques are unable to measure the faint particles.

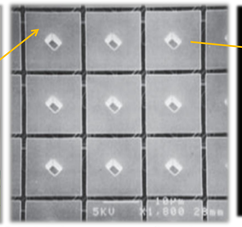
The developments into a micro mirror-based ***halo monitor*** that is capable of measuring transverse profiles with a dynamic range of better than 10^5. This monitor uses the latest high definition mirror matrix, providing even higher frame rates and better spatial resolution.

The **DMD** (**D**igital **M**icro-**M**irror **D**evice) uses the DLP Discovery 4100 platform with a 0.95 1080p chipset created by:

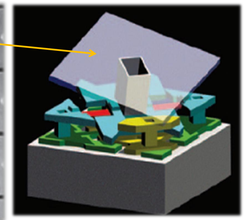
Texas Instruments for enabling high-definition and high performance spatial light filtering.



HD-DMD



SEM image of mirrors



Single mirror pixel

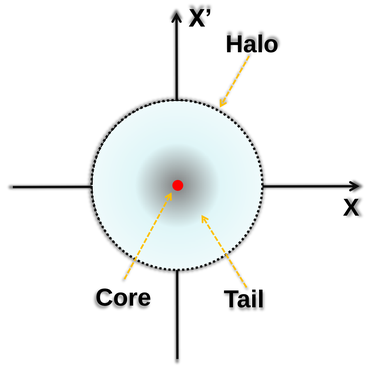
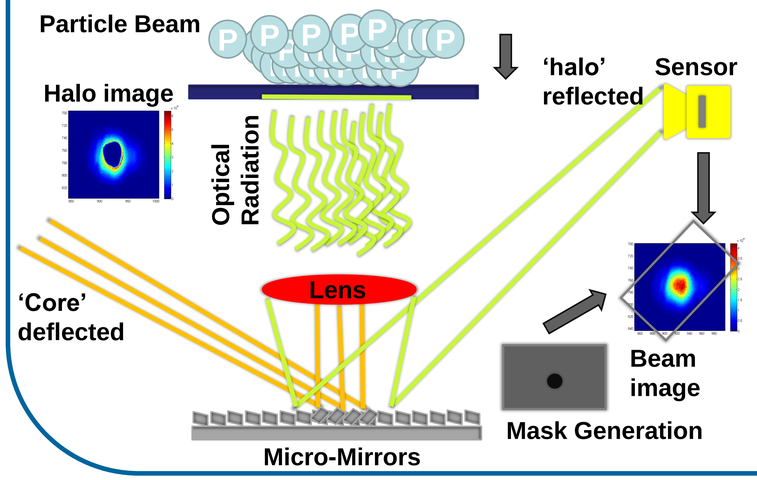


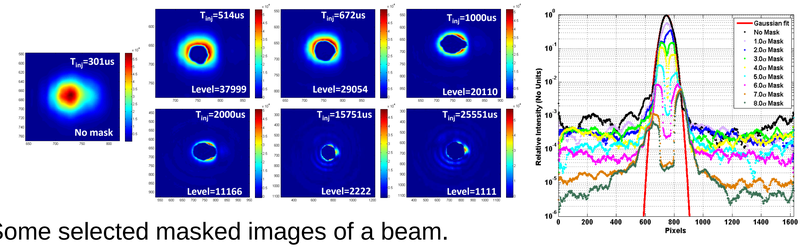
Illustration of beam halo

This is a promising method for providing knowledge on beam losses which originate in the low-density halo that extend far from the beam core.

•**The HALO Monitor Measurement Principle:** The DMD is used as an adaptive optical masking device, where each mirror in the DMD can be controlled individually to direct light into different directions depending on the micro mirror state.



•**Beam halo imaging with masking at different mask sizes:**



•Some selected masked images of a beam.
•The achieved high dynamic range measurement for the beam using a DMD.

Further Reading:

•*B.B.D. Lomberg, C.P. Welsch, 'Beam Halo Monitor based on an HD Digital Micro Mirror Array', Proc. IBIC 2013, Oxford, UK (2013)*
•*H. D. Zhang, R. B. Fiorito, A. G. Shkvarunets, and R. A. Kishek, 'Beam halo imaging with a digital optical mask', Phys. Rev. ST Accel. Beams 15, 072803 (2012)*

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www.opac-project.eu

www.quasar-group.org