CHARACTERIZATION OF DETECTORS FOR BEAM LOSS MEASUREMENTS

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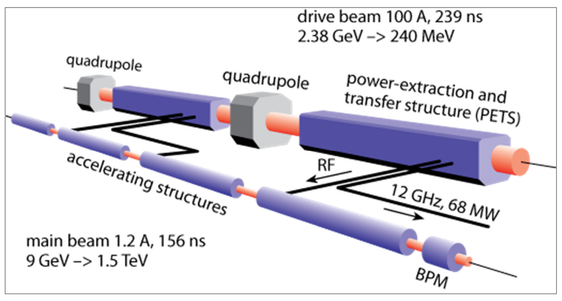
Abstract

Silicon Photomultipliers (SiPMs) are a good candidate for use as beam loss detectors in an accelerator due to their insensitivity to magnetic fields, compactness and relatively low voltage working regime. Furthermore, when used in a great numbers, they are significantly cheaper to mass-produce than more conventional detectors, such as Ionization Chambers. To be able to evaluate the application potential of SiPMs in an accelerator, it is necessary to quantify their fundamental parameters as a particle detector, as well as in combination with an optical fiber used for signal generation. In this contribution an experimental and analytical study to determine the time resolution, light sensitivity and dynamic range of a Cherenkov light detector, based on SiPMs, is presented.

CLIC Two Beam Modules



CLIC two beam module schematic

Main Beam (MB):
- 2 linacs (21km)
- Total no. of quadrupoles *4200*

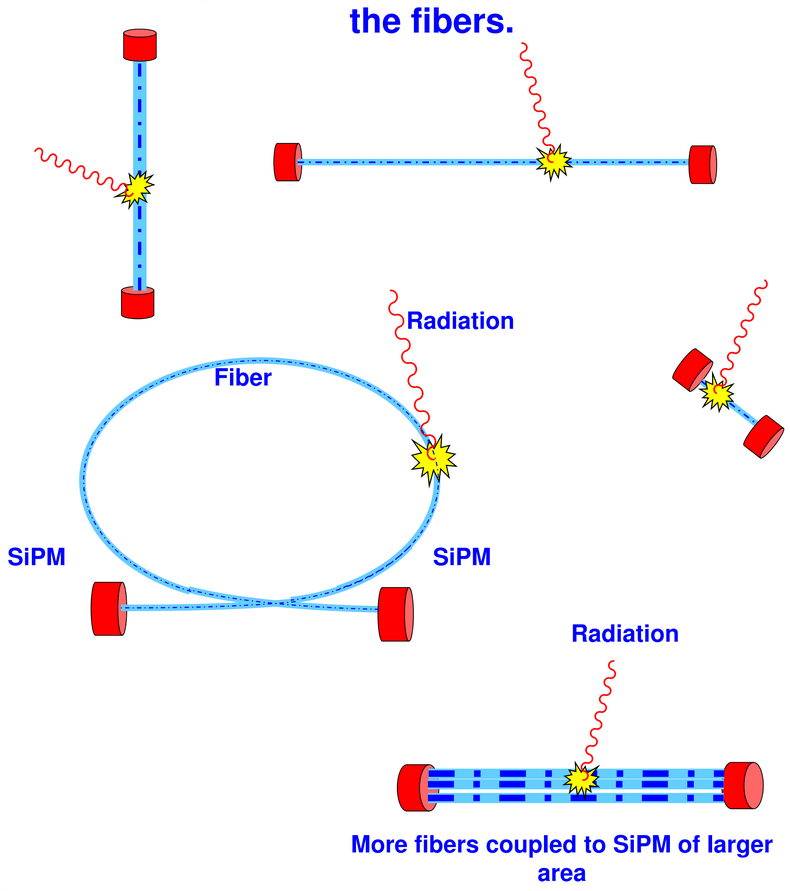
Drive Beam (DB):
- 48 decelerators (875m)
- Total no. of quadrupoles *41500*

	Energy [GeV]	Train duration [ns]	e⁻/train	Rep Rate [Hz]
DB	2.4-0.24	243.7	$1.54 \cdot 10^{14}$	50
MB	9-1500	156	$1.16 \cdot 10^{12}$	50

➢ BLM Technology used at LHC based on Ionization chambers is feasible but expensive (more than 45000 monitors required for two beam modules)

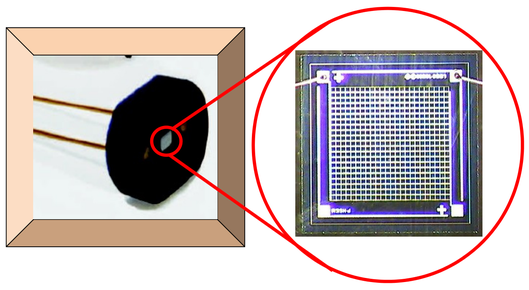
➢ Investigate alternative BLM technologies => e.g. **Scintillating and Cherenkov Fibers**

Geometric efficiency: is possible to change the length and the thickness of the fibers.



SiPM → SiliconPhotoMultiplier

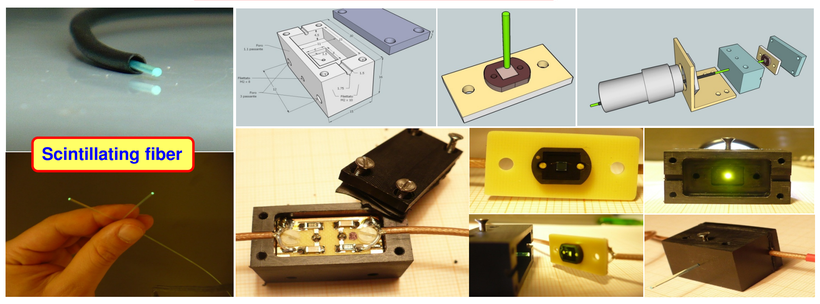
1. array of a Single Photon Avalanche Diode (SPAD) biased beyond breakdown (Geiger mode)
2. the avalanche is quenched by means of integrated resistors
3. sensitive to single photon



Scintillation Light BLM (SLD)

- ➢ Scintillating **Fibers (polyvinyl-toluene)**
- ➢ Length 30 cm
- ➢ Diameter 1 mm
- ➢ Two SiPM SensL

Opto-mechanical supports for fiber - SiPM



Cherenkov Light BLM (CLD)

- ➢ Multimodal standard plastic **Fiber**
- ➢ Length 150 cm
- ➢ Diameter 1 mm
- ➢ 1 SiPM Photonic

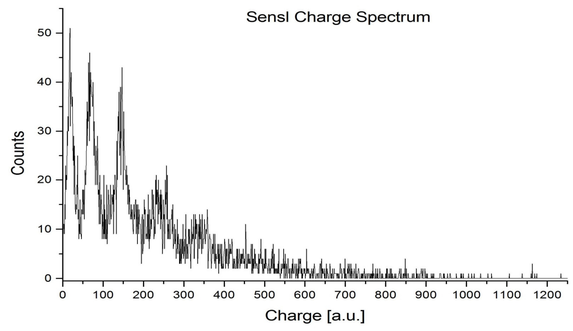
Bench tests on detectors

- Response to blue laser light (410nm) at very low intensity, to determine photon resolving power and time resolution.
- Test on long distance blue light detection (100m fiber) – to verify the feasibility of a SiPM as Cherenkov Light detector (few photons, ~410 nm).
- Test on high energy particles detection, using a scintillating fiber – to study alternatives to standard optical fibers.

Parameters obtained from bench tests (100m fiber)

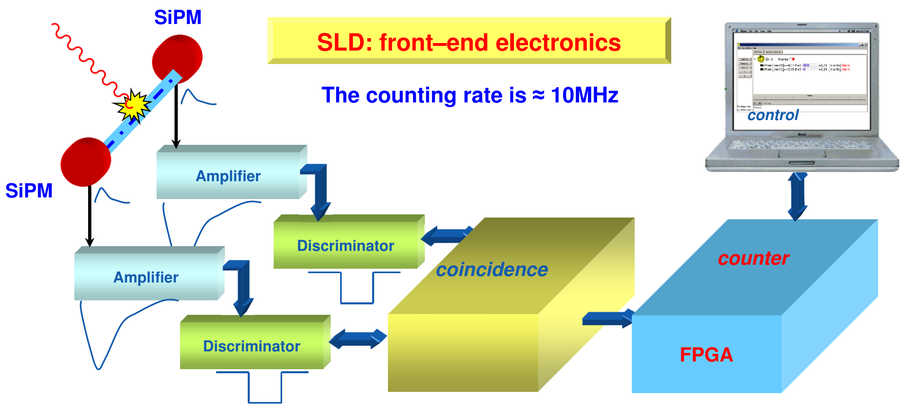
•Time Resolution: 1 ns

•Photon Resolviong Power: 6



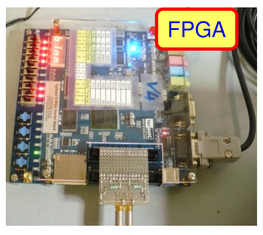
Charge spectrum of the tested SiPM in case of a 100m fiber and 4% laser nominal intensity. The number of peaks roughly indicate the number of photons resolved.

Test at CTF3

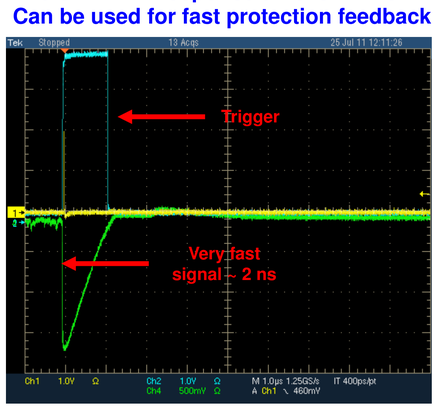


Beam Parameters at OTR

Energy: ~112MeV
Rep Rate: 0.8333Hz
Pulse duration: 250ns
Bunch charge: 1.15nC
Bunch Frequency: 12 Ghz



The SLD BLM response time is ~ 2 ns. Can be used for fast protection feedback



No screen - Beam on (green: SLD; blue: CLD)