Optical Beam Loss Monitor for RF Cavity Characterisation

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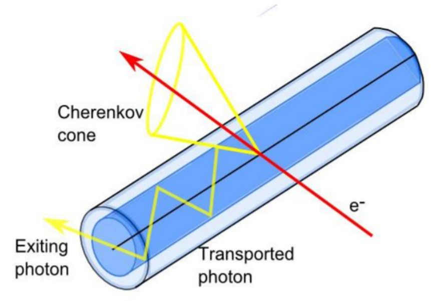
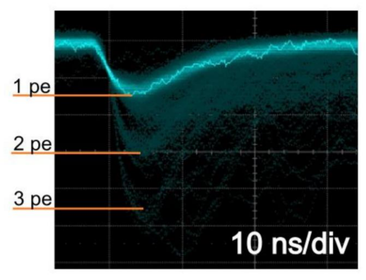
Abstract

Beam Loss Monitors (BLMs) based on optical fibres have been under development for many years as an alternative solution to commonly used monitors, such as ionisation chambers. Optical BLMs (oBLMs) maintain standard BLM functionality but can also provide machine protection over an entire beam line, excellent position and time resolution, whilst being insensitive to damage from radiation. oBLMs can also be used for the characterisation of RF cavities during commissioning and operation.

The Task: RF cavity breakdowns The Solution: oBLMS based on Cherenkov radiation in fibers

The operating principle of an oBLM is based on Cherenkov radiation, generated as a result of electromagnetic radiation crossing the fibre originating from beam loss which can occur when the charged beam hits any obstacle, including the beampipe. The threshold energy for an electron to produce a Cherenkov radiation in the quartz-made fibre is 175 keV.



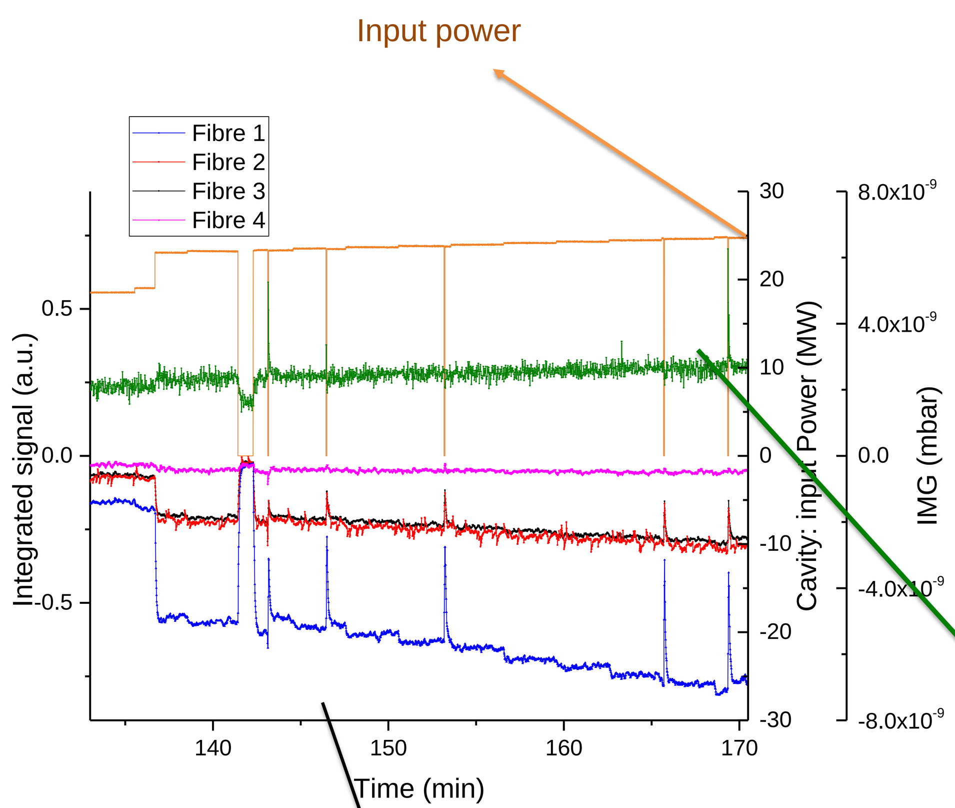


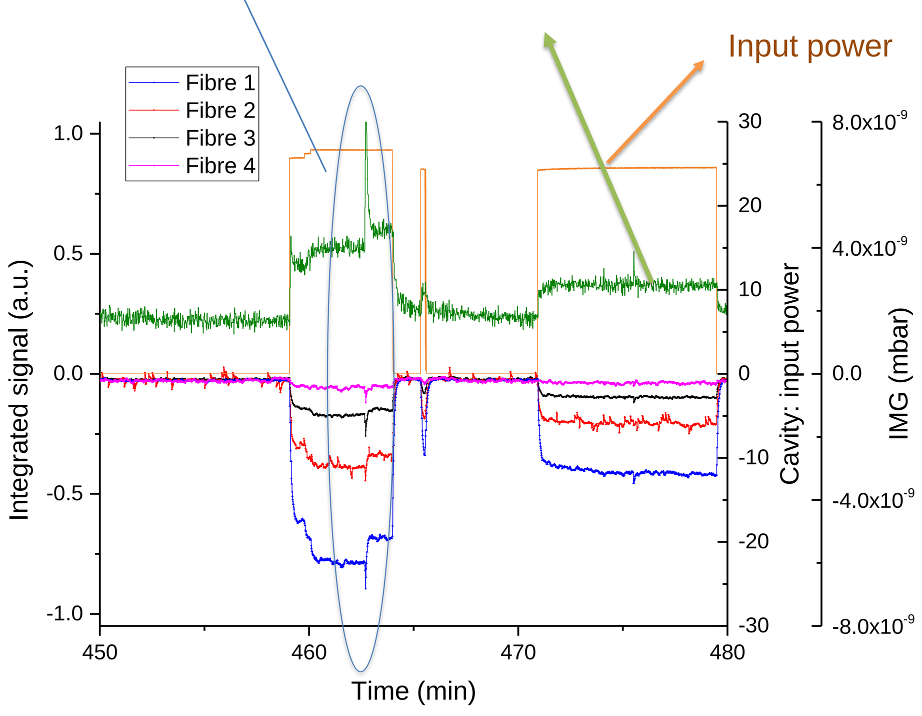
As the accelerating gradient of a cavity depends on the input power, the energy of primary particles arising due to field emission in the structure causes the particle showers to increase, which are then detected by the oBLMs.

efficient 4-channel oBLMs cavity monitoring

The cavity input power and the collected signal from the oBLM sensors show a correlation, and the increase in the input power changes proportionally with the absolute signal.

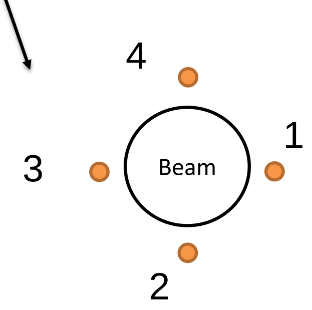
Clear change in oBLMs signal and clear peak in pressure demonstrates the response of the oBLMs to building up field emission





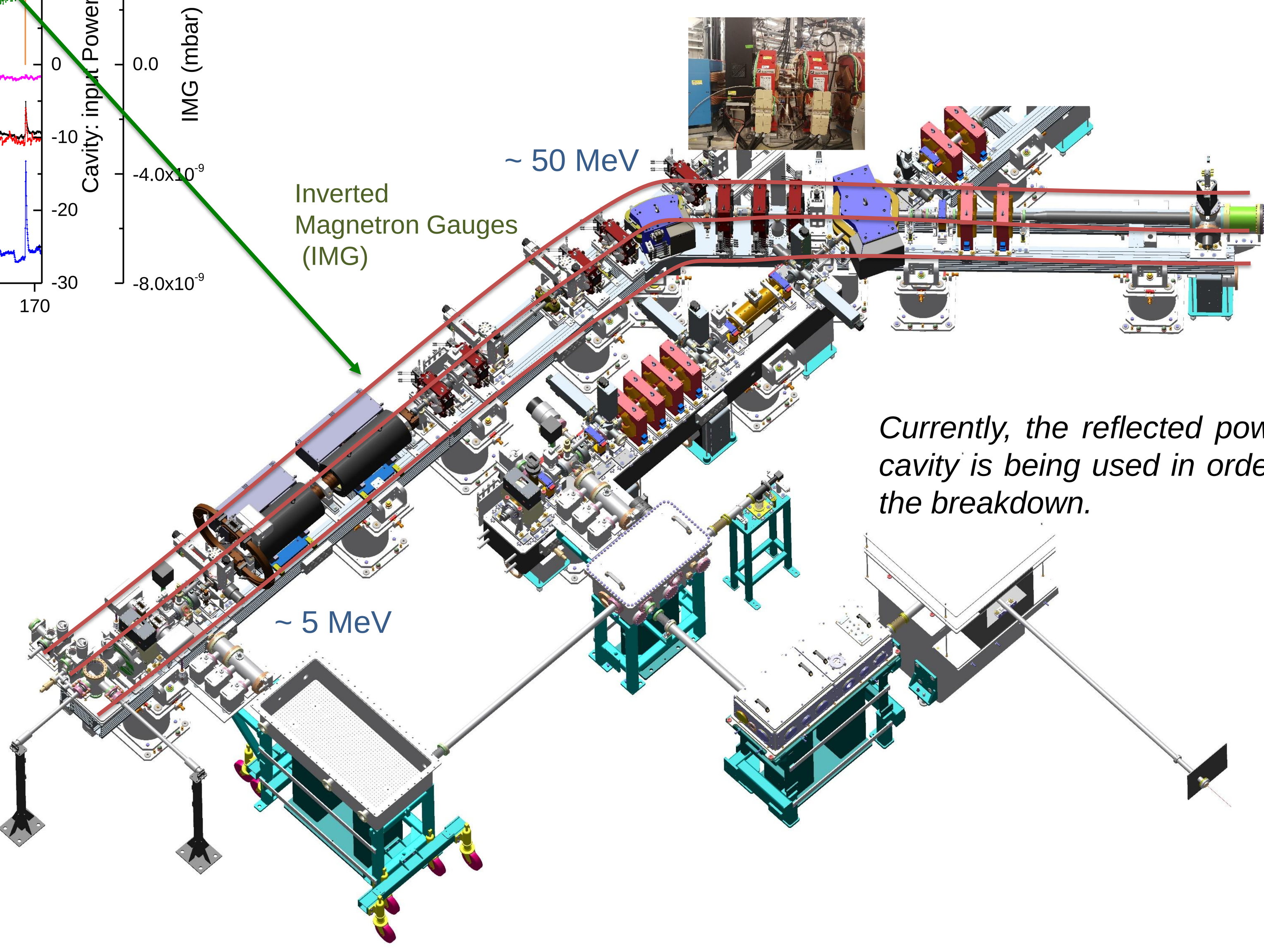
Verification: the signal is plotted together with the pressure readings from the Inverted Magnetron Gauge, which is located close to the cavity. An increase in electron field emissions, leads to sparking, which breaks the vacuum, leading to increased pressure which can be picked up by the oBLM systems.

Signals from four independent fibres



- 4 independent sensors
- Upstream signals

CLARA (Compact Linear Accelerator for Research and Applications) is a Free-Electron-Laser (FEL) test facility under construction at Daresbury Laboratory. The accelerator will be a 250 MeV electron linac capable of producing short, high-brightness electron bunches. The CLARA front end, on which the oBLM system has been installed, consists of a 2.5 cell RF photocathode gun, and a 2m S-band (2998.5MHz) accelerating structure.

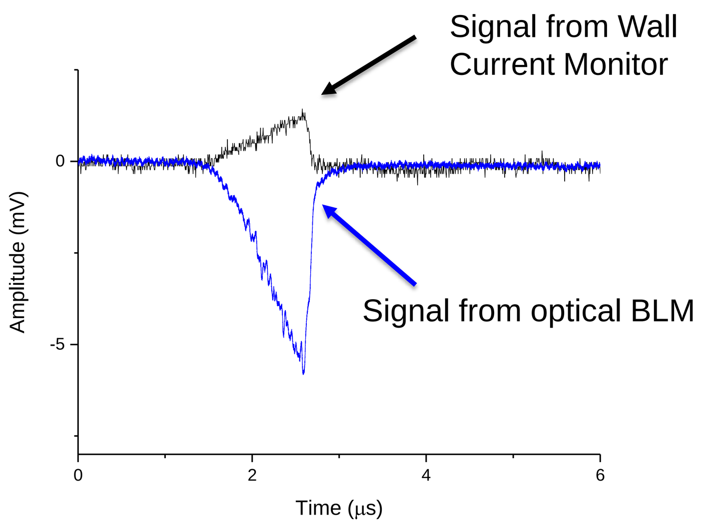


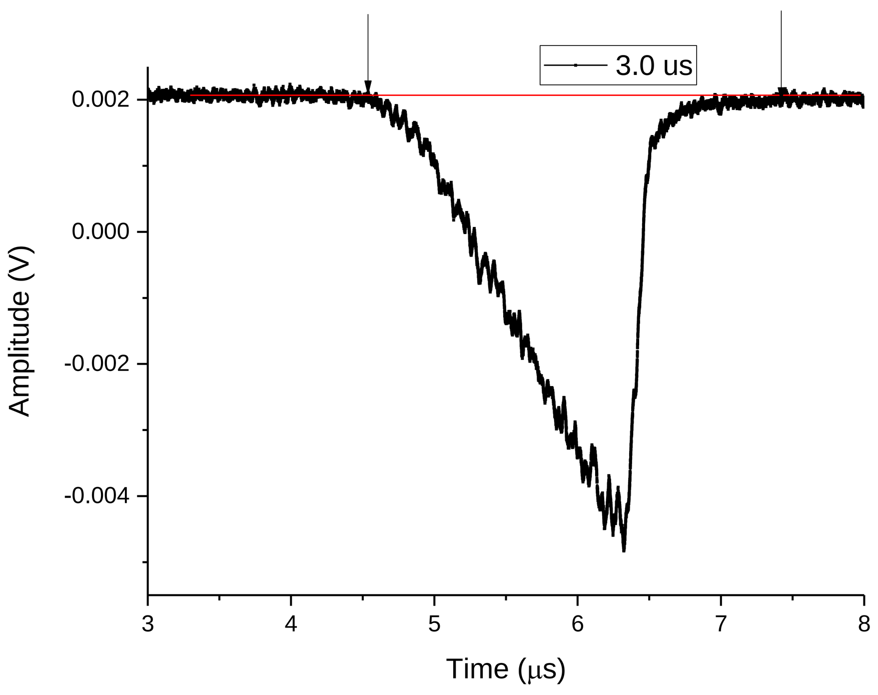
Currently, the reflected power from the cavity is being used in order to monitor the breakdown.

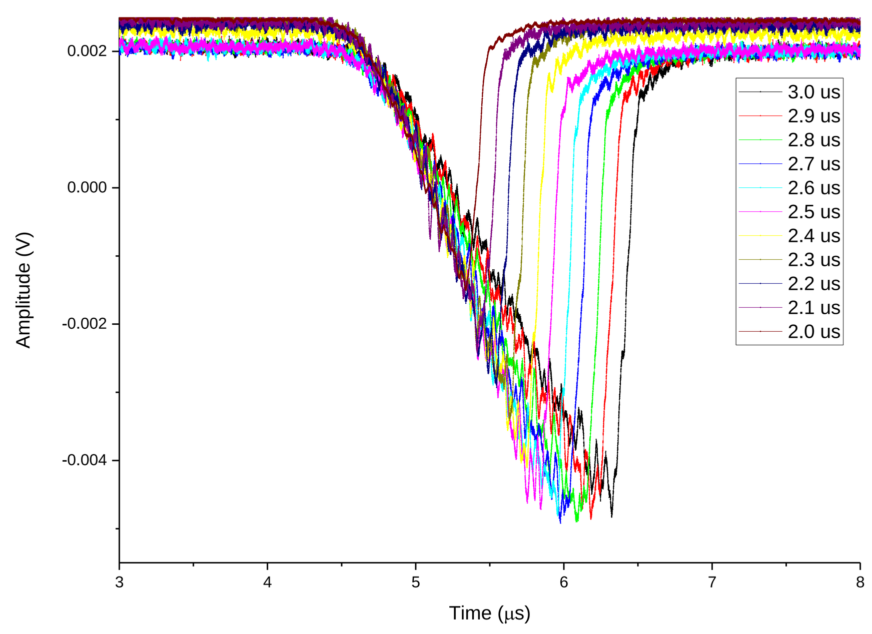
Pulse length variation

The oBLMs signals were obtained during the dark current studies during conditioning of the RF photogun. The response of the oBLM signal to variations in the RF pulse length has been measured. An RF pulse of ~10MW power was sent to the cavity, and the pulse width was varied within 3.0 μs to 2.0 μs. The RF pulse can be reconstructed from the oBLM signal. :

Dark Current Measurements







RF pulse	From BLM	Area (10^(-9) V*s)
3	3	7.128
2.9	2.82	7.0015
2.8	2.76	6.767
2.7	2.66	6.2645
2.6	2.53	6.1336
2.5	2.43	5.8233
2.4	2.3	4.864
2.3	2.1	4.0612
2.2	1.85	3.48975
2.1	1.7	2.85
2	1.6	2.1505

http://www.cockcroft.ac.uk
http://www.quasar-group.org

D-beam ltd produces oBLMs. For more information please find us on www.d-beam.co.uk