An optical fibre BLM system at the Australian Synchrotron Light Source

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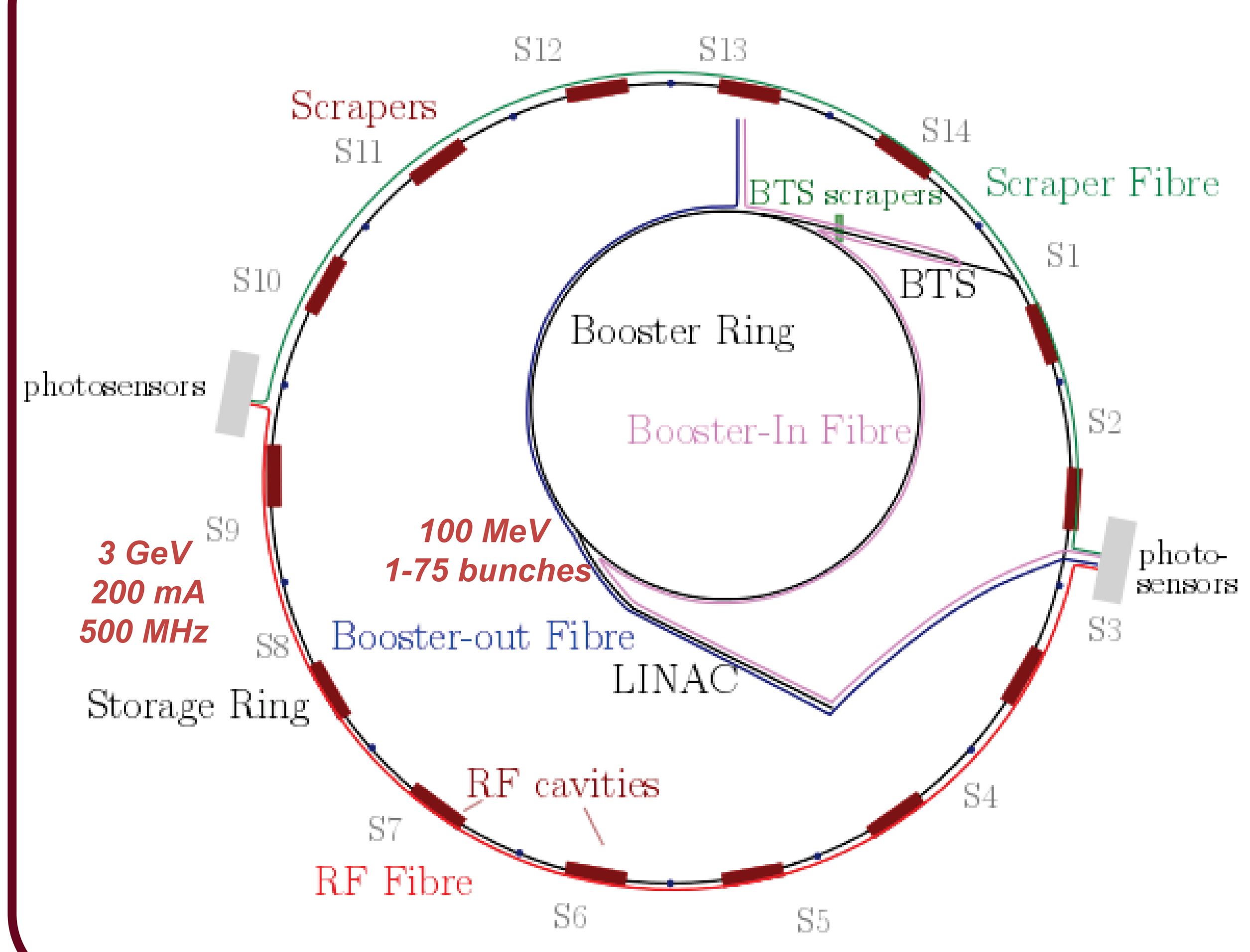
Abstract

Increasing demands on high energy accelerators are triggering R&D into improved beam loss monitors with a high sensitivity and dynamic range and the potential to efficiently protect the machine over its entire length. Optical fibre beam loss monitors (OBLMs) are based on the detection of Cherenkov radiation from high energy charged particles. Bearing the advantage of covering more than 100 m of an accelerator with only one detector and being insensitive to X-rays, OBLMs are ideal for electron machines. The Australian Synchrotron comprises an 100 MeV 15 m long linac, an 130 m circumference booster synchrotron and a 3 GeV, 216 m circumference electron storage ring. The entire facility was successfully covered with four OBLMs. This contribution summarises a variety of measurements performed with OBLMs at the Australian Synchrotron, including beam loss measurements during the full booster cycle from beam injection to steady state and measurements of steady-state losses at the storage ring. Different photosensors, namely Silicon Photo Multipliers (SiPM) and fast Photo Multiplier Tubes (PMTs) have been used.

Installations at the Australian Synchrotron



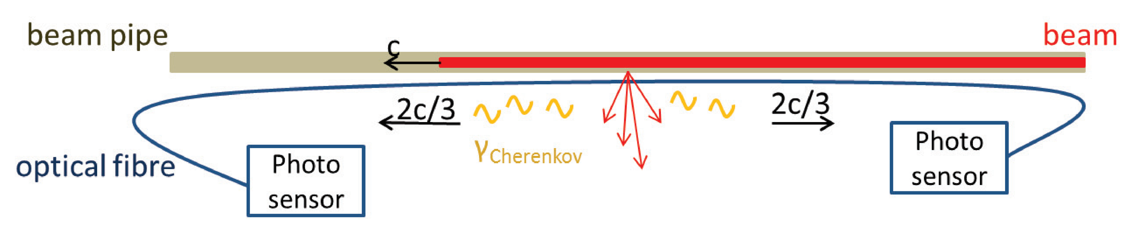
Proposed technology: optical fibre BLM (OBLM)

Detection of high energy charged particles via Cherenkov effect

X – ray insensitive

→ Quartz optical fibres

→ 125 m, 200 μm core diameter



Scraper fibre: Storage Ring Scrapers

RF fibre: Storage Ring RF cavities

Booster-In fibre: LINAC, quadrants 3,4 of Booster, Booster To Storage ring (BTS) line + scrapers

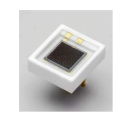
Booster-In fibre: LINAC, quadrants 1,2 of Booster

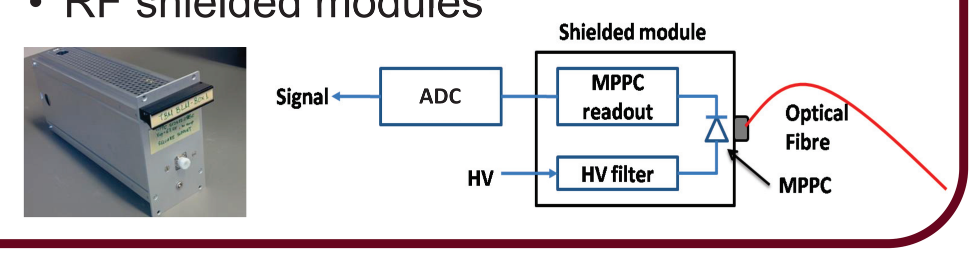
Examined photosensors

Hamamatsu fast PMT H10721-210

Hamamatsu SiPM MultiPixel Photon Counter (MPPC) S12572-015C

- Transimpedance amplifier
- RF shielded modules



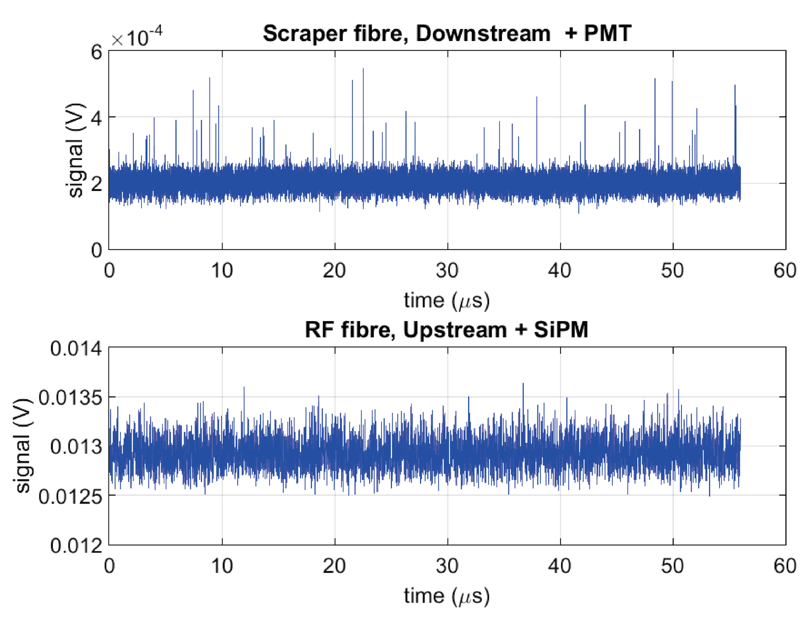


Storage Ring Cycle

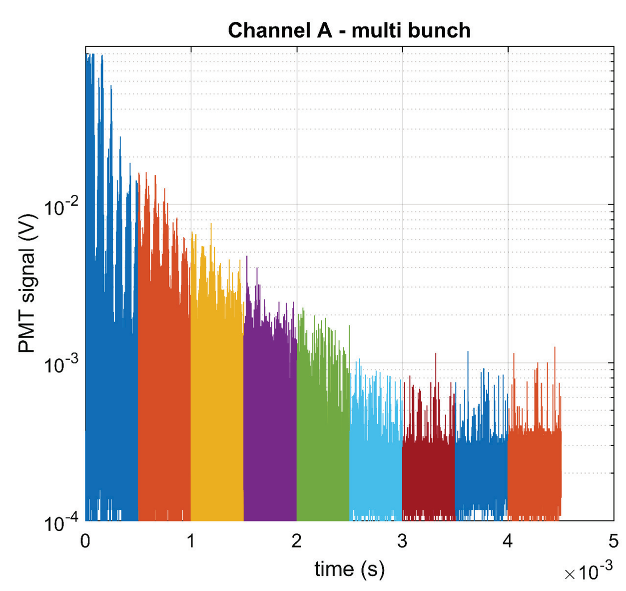
- Beam loss data of different points of the synchrotron cycle were acquired by changing the trigger timing
- Background measurement to define cutoff value (only signals with $V>V_{cutoff}$ were taken into account)

Photosensors at Sector 2 (S2)

	fibre	Photon direction	photosensor	V_{cutoff}
Channel A	Scraper	downstream	PMT	0.0006 V
Channel B	RF	upstream	SIPM	0.0137 V



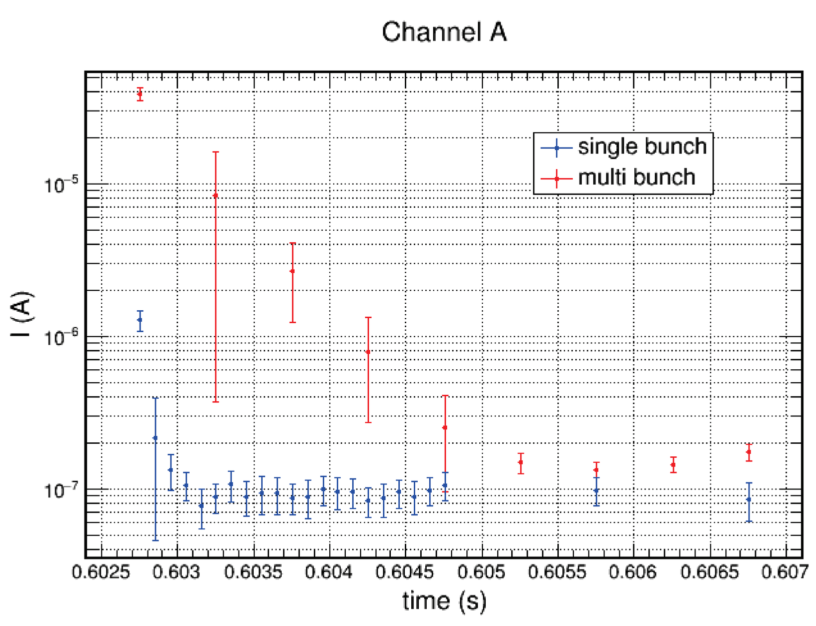
Background measurement



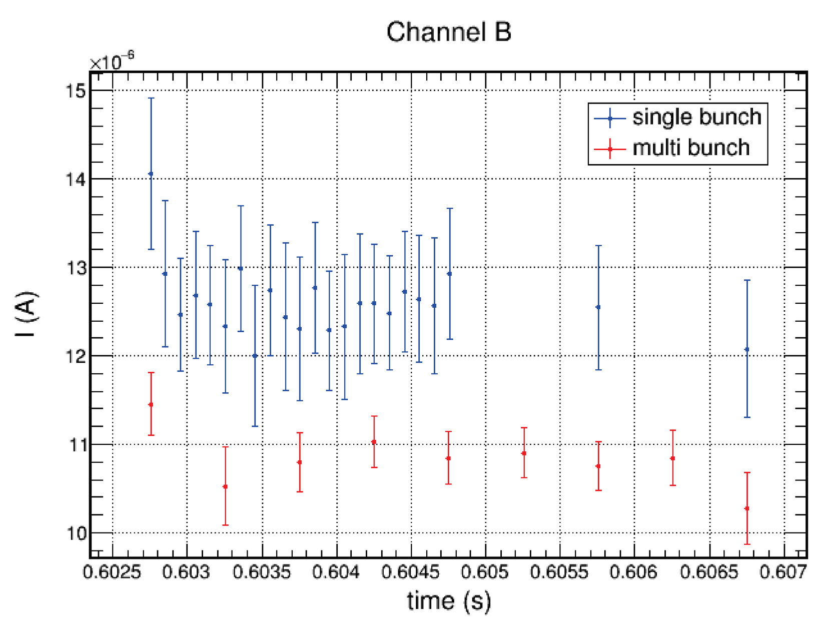
Average signals of the Scraper fibre for the different trigger timings, concatenated

Bunches	Scrapers	Time window	Shots per tr. timing
1	Open	56 μs	50
75	Nominal	500 μs	25

- Beam cleaning by scrapers
- Scraper fibre: multi bunch (nominal scrapers) shows higher losses than single bunch (open scrapers)
- RF fibre: single bunch shows greater losses than the (cleaned by scrapers) multi bunch case → steady state losses



Scraper fibre, Downstream + PMT

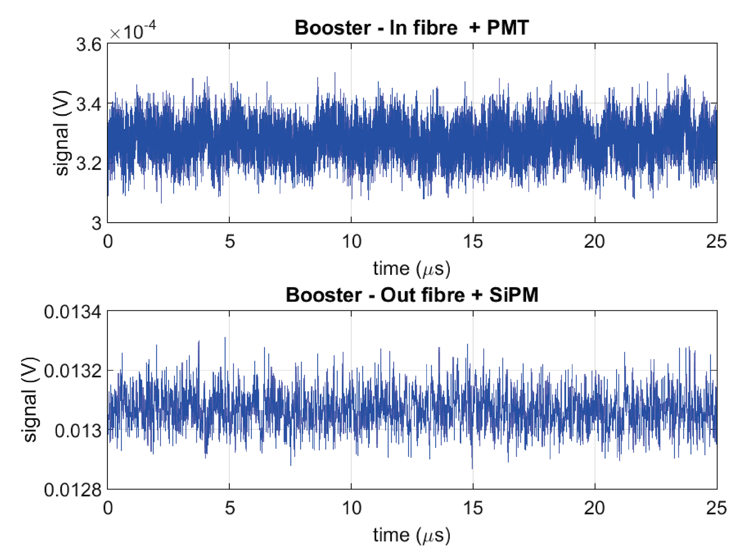


RF fibre, Upstream + SiPM

Booster Cycle

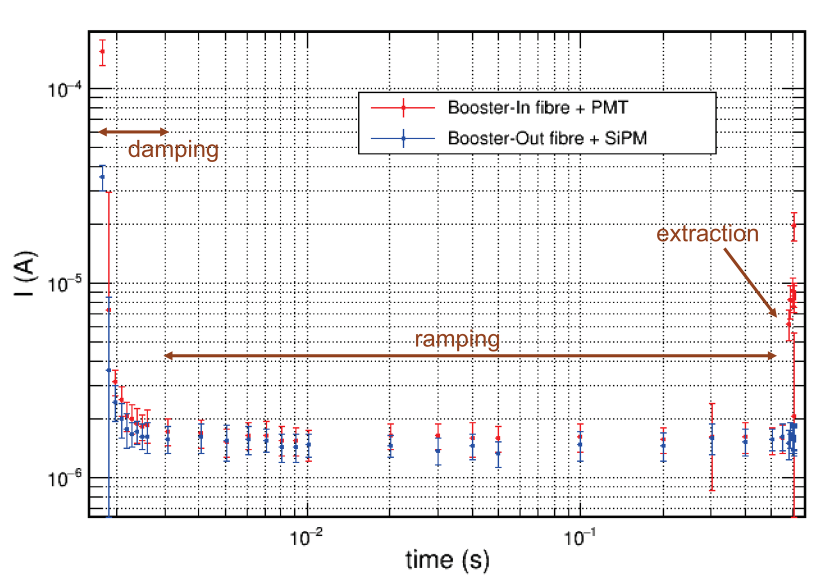
- Beam loss data of different points of the booster cycle were acquired by changing the trigger timing
- 50 shots per point, 25 μs time window
- Only signals with $V>V_{cutoff}$ were taken into account

fibre	photosensor	Covers BTS	V_{cutoff}
Booster - In	PMT	yes	0.00036 V
Booster - out	SIPM	no	0.0134 V

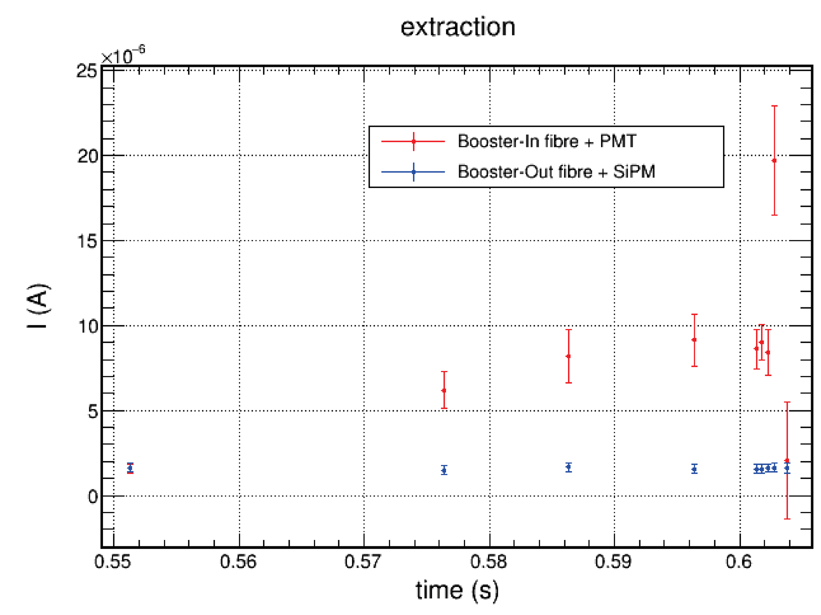


Background measurement

- Quantitative comparison of the two photosensors (gain / number of Cherenkov. photons can be different)
- Exponential behavior, characteristic of the beam damping, observable
- Beam extraction into Storage Ring detected by Booster-In fibre, covering the BTS line / scrapers



Booster Cycle



Zoom into extraction to Storage Ring

Conclusions

- Four OBLMs are sufficient to cover the Australian Synchrotron Light Source
- OBLMs are capable of detecting losses during beam injection to the storage ring
- OBLM are capable of detecting steady-state losses
- Two photosensors, a PMT and an SiPM, examined, showing similar behaviour with main difference their noise levels.

Acknowledgment

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