A radiation tolerant fibre optic readout system for the LHCb Silicon Tracker

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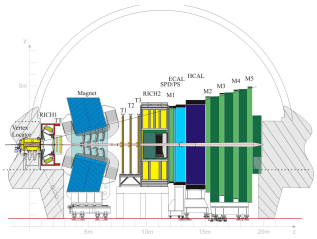
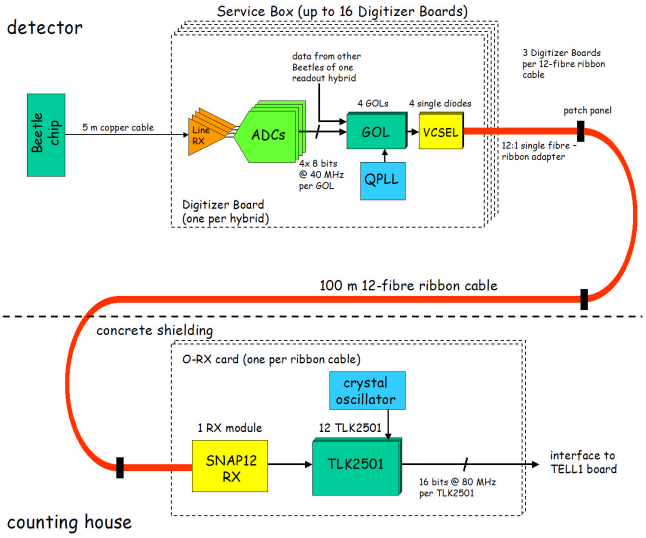
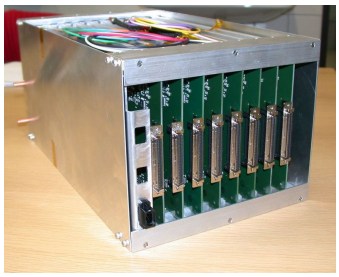
on behalf of the LHCb Silicon Tracker group



- LHCb Silicon Tracker covers the regions of highest track densities in the tracking system
- two separate subdetectors
  - Trigger Tracker (TT)
  - Inner Tracker (IT)
- TT subdetector covers the full acceptance angle
- three IT stations only cover innermost part around the beampipe (outer areas are covered by the Outer Tracker (OT) based on straw tubes)

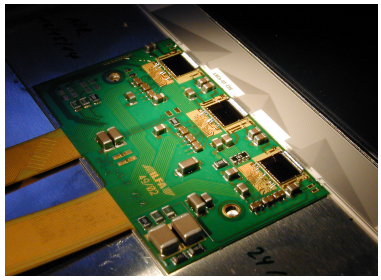


- preseries production of four half-scale prototypes of a Silicon Tracker Service Box with eight Digitizer Boards each
- each Service Box prototype is capable of digitizing and transmitting data at a total net data rate of 40.96 Gbit/s
- mechanical testbed as well as readout system for the burn-in teststands (under construction at the University Zurich and CERN for quality assurance of the TT and IT sensor modules respectively)



task	subdetector group
single VCSEL transmitter configuration (moderate radiation levels <15 krad)	Silicon Tracker group, Zurich
commercial multi-channel transmitter configuration (low radiation levels <1 krad)	Muon Trigger group, Marseille
common optical cable tender	CERN
optical multi-channel receiver card	Outer Tracker group, Heidelberg
eye diagram + bathtub measurements	Muon group, Frascati
bit error rate measurements	RICH group, Oxford Outer Tracker group, Heidelberg

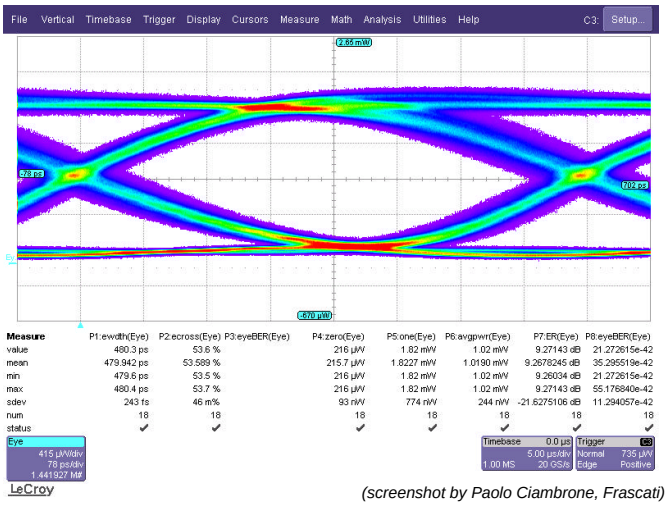
- Silicon Tracker subdetectors based on silicon strip detectors, thicknesses ranging from 320 to 500 µm
- chosen according to the required signal over noise performance after an expected lifetime of 10 years
- 128-channel charge integrators (BEETLE), designed in a 0.25 µm CMOS process incorporate radiation hardening layout techniques.
- no significant performance degradation up to a total ionizing dose of 10 Mrad



	Trigger Tracker	Inner Tracker	Total (Silicon Tracker)
sensor channels	143360	129024	272384
readout hybrids	280	336	616
BEETLE readout chips	1120	1008	2128
analogue BEETLE output channels	4480	4032	8512
transmission distance [m]	50	120	
avg. trigger rate	1.1 MHz		
digital resolution	8 bit		
total data rate [Gbit/s]	1262	1135	2397

- digital optical transmission scheme for reliable data transport to the counting house
- commercial off-the-shelf parts used where possible to keep overall system cost low
- all on-detector electronics (except for readout hybrid) located in 'Service Boxes' just outside the detector's acceptance:
  - minimizes the amount of dead material in the detector
  - simplifies access and relaxes radiation tolerance requirements
- single fibres from VCSEL devices are joined inside each Service Box into up to six 12-fibre ribbon cables (industry-standard MTP connector)
- indiviudal radiation qualification for all parts of the transmitting section without available radiation sensitivity data with protons of 60 MeV energy and doses up to 300 krad
  - expected dose at the planned installation location: 15 krad in 10 years.
- displacement damage was investigated by a separate irradiation with neutrons
- no components showed performance variations significant to the planned operation in the experiment

- many LHCb subdetectors have similar requirements in terms of data bandwidth and transmission distance
- most subdetectors have agreed in 2003 on a single optical link system
  → large parts are common among the different subdetectors.
- main differences between the groups concern the exact length of the fibre cable and the transmitting section (analogue as well as digital data have to be transmitted)



(screenshot by Paolo Ciambrone, Frascati)