

TORCH: a large-area detector for high resolution time-of-flight measurement

Thursday, 25 May 2017 09:00 (18 minutes)

The TORCH concept is based on the detection of Cherenkov light produced in a quartz radiator plate. It is an evolution of the DIRC technique, extending the performance by the use of precise measurements of the emission angles and arrival times of detected photons. This allows dispersion in the quartz to be corrected for, and the time of photon emission to be determined with a target precision of 70 ps per photon. Combining the information from the 30 or so detected photons from each charged particle that traverses the plate, exceptional resolution on the time-of-flight of order 15 ps should be possible. The TORCH technique is a candidate for application in a future upgrade of the LHCb experiment, for low-momentum charged particle identification. Over a flight distance of 10 m it would provide clean pion-kaon separation up to 10 GeV, in the busy environment of collisions at the LHC. Fast timing will also be crucial at higher luminosity for pile-up rejection.

A 5-year R&D program has been pursued with industry to develop suitable photon detectors with the required fast timing performance, fine spatial granularity (0.8 mm-wide pixels), long lifetime (5 C/cm² integrated charge at the anode) and large active area (80% for a linear array). This is being achieved using 6 × 6 cm² micro-channel plate PMTs, and final prototype tubes are expected to be delivered early in 2017. Earlier prototype tubes have demonstrated most of the required features individually, using fast read-out electronics that has been developed based on NINO+HPTDC chips. A small-scale prototype of the optical arrangement has been tested in beam at CERN over the last year, and demonstrated close to nominal performance. Components for a large-scale prototype which will be read out using 10 MCP-PMTs, including a highly-polished synthetic quartz radiator plate of dimensions 125 × 66 × 1 cm³, are currently being manufactured for delivery on the same timescale. The status of the project will be reviewed, including the latest results from test beam analysis, and the progress towards the final prototype.

Summary

The TORCH detector is an evolution of the DIRC technique, for precision time-of-flight over large areas, being developed for a future upgrade of the LHCb experiment. The R&D project is delivering high-performance photon detectors and an optical system in synthetic quartz for a large-scale prototype. The status of the project will be reviewed, including the latest results from test beam analysis and progress towards the prototype.

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Session Classification: R1-Particle identification(2)

Track Classification: Particle identification