TORCH

A Novel Cherenkov Detector for LHCb

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LHCb in the Large Hadron Collider

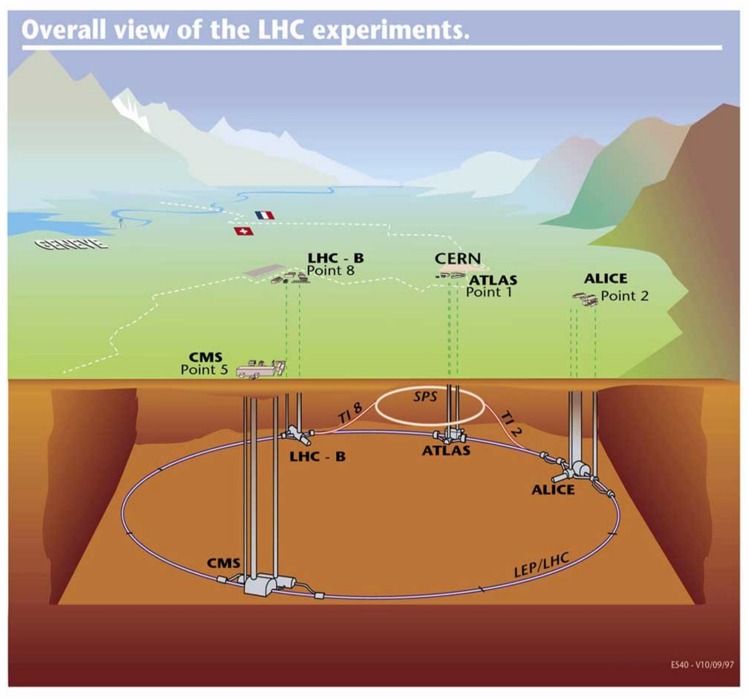

Figure 1: The Large Hadron Collider [1]

The LHCb detector is one of the four large experiments in the Large Hadron Collider. Some of its goals are:

- CP-violation
- Rare decays
- New Physics

TORCH in LHCb

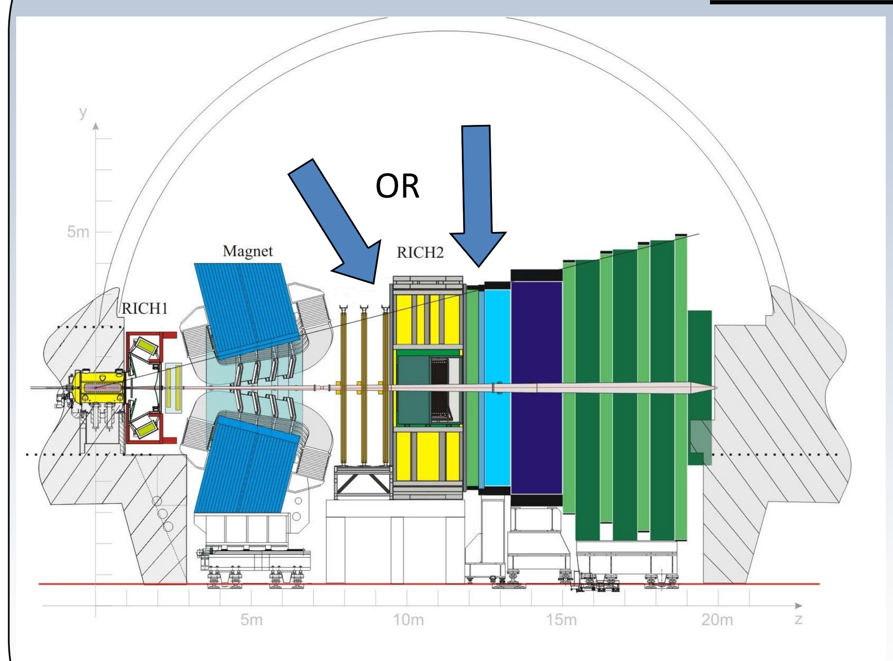

Figure 2: Proposed locations of TORCH in LHCb [2]

TORCH is a new detector for LHCb that is currently in the R&D stage. Together with the RICH it will identify what particles are passing through the detector. It will be placed either before or after the RICH2.

Cherenkov light in TORCH

Charged particles going faster than the speed of light in the medium emit light. This leads to the production of a spectrum of photons according to the Frank-Tamm relation, shown in Figure 3 for TORCH.

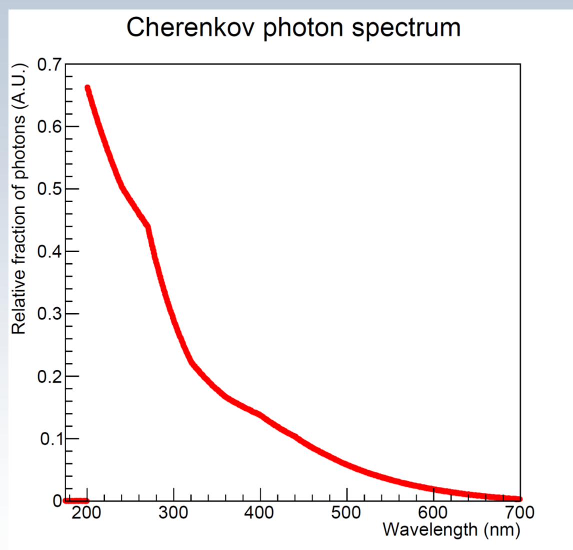

Figure 3: Photon spectrum in quartz

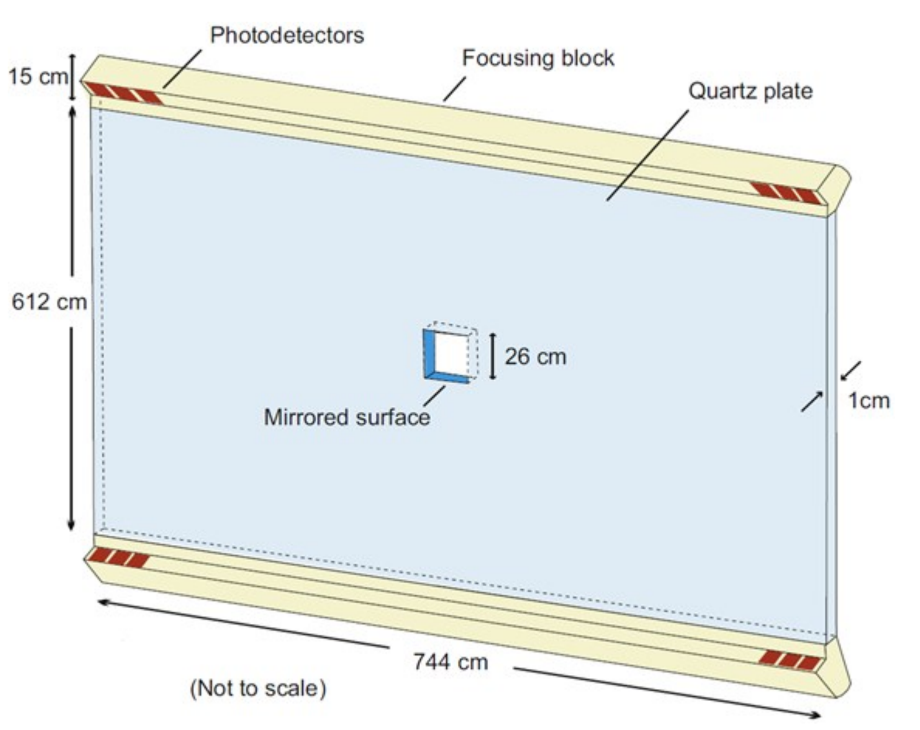

Figure 4: Simplified TORCH design [3]

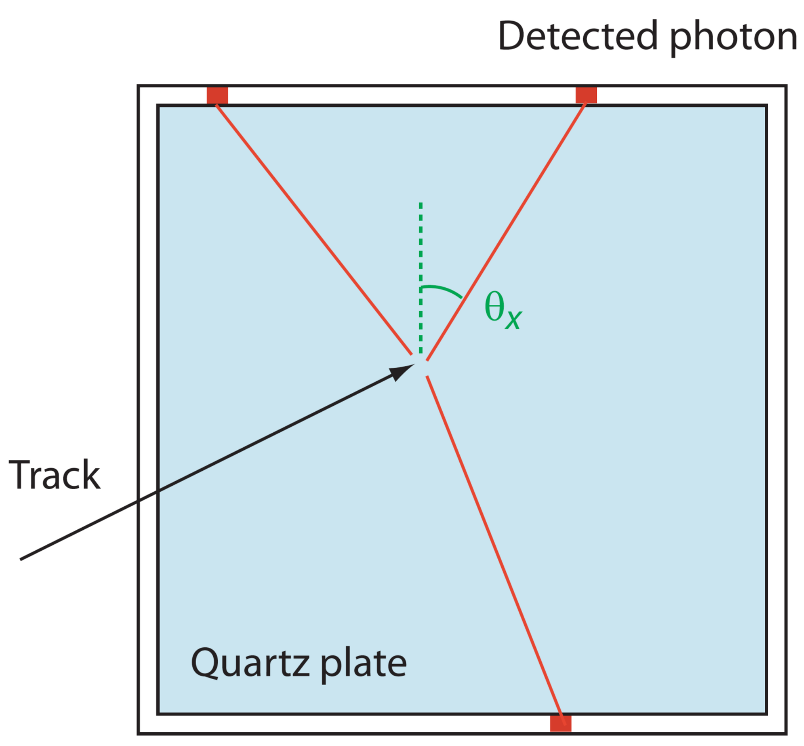

Figure 5: Example of photon paths [4]

Time of Flight

To identify an unknown particle passing through the detector the time of flight (TOF) from the interaction point is used. Because momentum is known from the other detectors in LHCb, this information can then be used to tell the particles apart - a heavier particle would have a lower velocity for the same momentum. Essentially, TORCH is a very precise stopwatch.

The timing information of every single photon that is detected is used to pinpoint the exact time at which the charged particle passed through the plate. The timing resolution required per track is σ_t < 12.5 picoseconds to distinguish pions and kaons with 3σ certainty [3]. Thus, the number of photons that can be detected dictates how well the detector works. This technique is a completely novel way to identify these particles.

Monte Carlo Simulation

Using the Frank-Tamm relation mentioned above, the simulation generates photons that are then propagated through the detector. The number of photons that can be detected is plotted for each point on the plane.

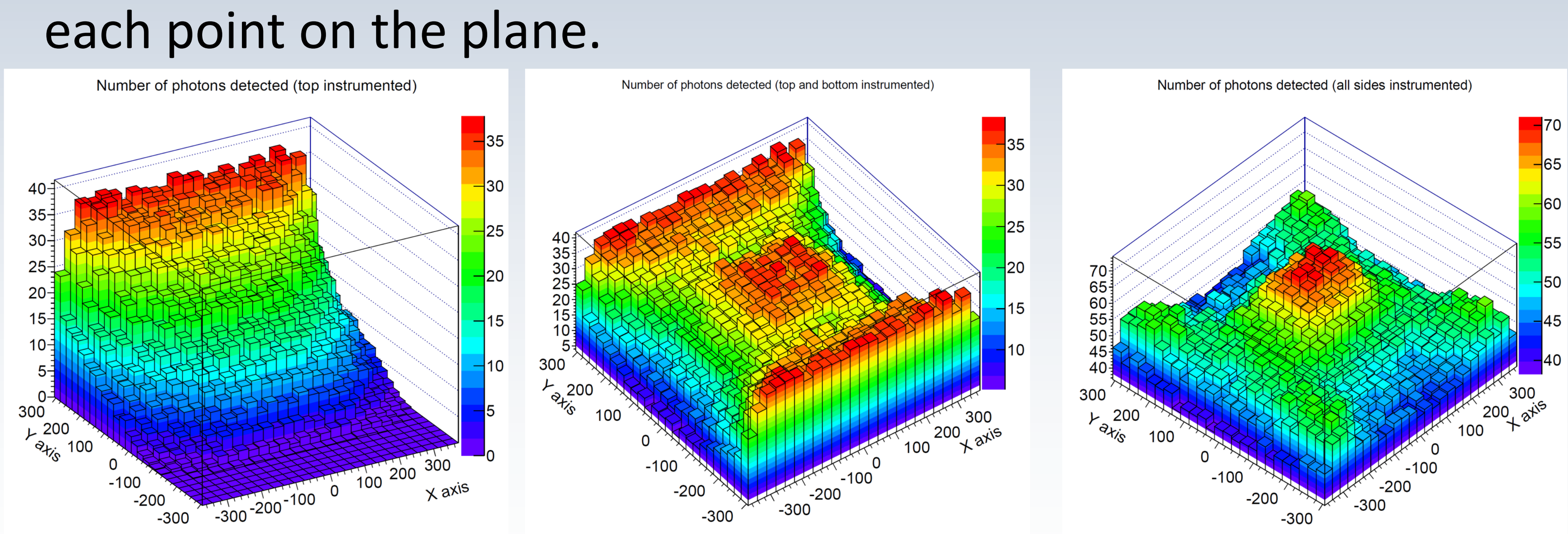

Figure 6: Number of detectable photons from Monte Carlo for several detector layouts

Conclusion & Outlook

Most of the simulation work has now successfully been completed and is yielding valuable data and insight. One of the main conclusions is that if only one side of the detector is instrumented, it will have very poor performance, as shown in Figure 6.

In the near future work will start on testing the actual photon detectors. The target of this, over the coming years, is to determine the actual achievable time resolution of these (novel) detectors and determine their suitability for TORCH.

[1] Atlas.ch (2005) ATLAS Experiment - Photos. [online] Available at: http://www.atlas.ch/photos/lhc.html [Accessed: 29 May 2013].

[2] CERN Document Server (2008) LHCb layout_2. [online] Available at: http://cds.cern.ch/record/1087860/ [Accessed: 29 May 2013].

[3] M.J. Charles, R. Forty, *"TORCH: Time of flight identification with Cherenkov radiation"*, Nuclear Instruments and Methods in Research A **639** (2011) 173-176.

[4] The LHCb Collaboration; *"Letter of Intent for the LHCb Upgrade"*; CERN-LHCC-2011-001; 29 March 2011 (v2).

The TORCH project is funded by an ERC Advanced Grant under the Seventh Framework Programme (FP7), code ERC-2011-ADG proposal 299175.