The LHCb Detector Upgrade & Challenges

Multi-anode Photomultiplier tubes (MaPMT)

Fast, sensitive to single photons, large active area, excellent granularity, radiation hard, from Hamamatsu:

- R13742 (Custom variant of R11265) 1 in, 64 (8 × 8) pixels for RICH 1 and RICH 2
- R13743 (Custom variant of R12699) 2 in, 64 (8 × 8) pixels for RICH 2 peripheral area only
- External readout electronics

The aim of the procedure:
- Verify minimal contractual specifications
- Characterise - average gain, uniformity, peak-to-valley ratio, dark count rate
- Organise MaPMTs in groups of 16 based on common HV performance

Challenges:
- High-numbers to be tested over two years
- 3100 × R13742
- 450 × R13743

Requirements for testing:
- Reliability
- Redundancy
- Elevated automation

The Photon Detector Quality Assurance

The PDQA Test Bench

Fully integrated FE readout with Data Acquisition and Environment Control:
- Graphical User Interface
- LabVIEW GUI
- XML for conf. human readable
- Low-level in C++ for performance
- CERN ROOT for data analysis
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The Automated System

In the past two years, testing involved a strict schedule and highly standardised procedure. 4 test stations were successfully set up in 2 different test facilities - Edinburgh, UK and Padua, Italy.

- General API
- Easily adapted to other projects
- LabView GUI
- Low-level in C++ for performance
- XML for conf. human readable
- CERN ROOT for data analysis

Microservice Architecture

Design was chosen to ensure reliability and high availability. The architecture provisions independent auto-recoverable microservices and native multi-threaded operation.

System Model & Communication

The system is designed as an FSM with independent and self-sufficient states. Each state can communicate with several microservices to accomplish tasks. State transitions occur when a state calls another and exits. States determine internal logic based on successfully performing their tasks. Communication is parallel and messages are verified.

Results

Comparing Hamamatsu datasheet values for gain 1 in (left) and 2 in (right). The average gain is one of the most important parameters. We require a gain of at least a 1M electrons.

Conclusion

The QA operated by the automated system tested a total number of 3100 & 450 (1 in & 2 in) MaPMTs. The system was deployed on four stations in two labs and consistently characterised 16 × 1 in (4 × 2 in) PMTs per station per day. The results show excellent gain, uniformity and single photon resolution. Moreover, the automation allowed for thorough consistency between the two labs and overall efficiency increase.