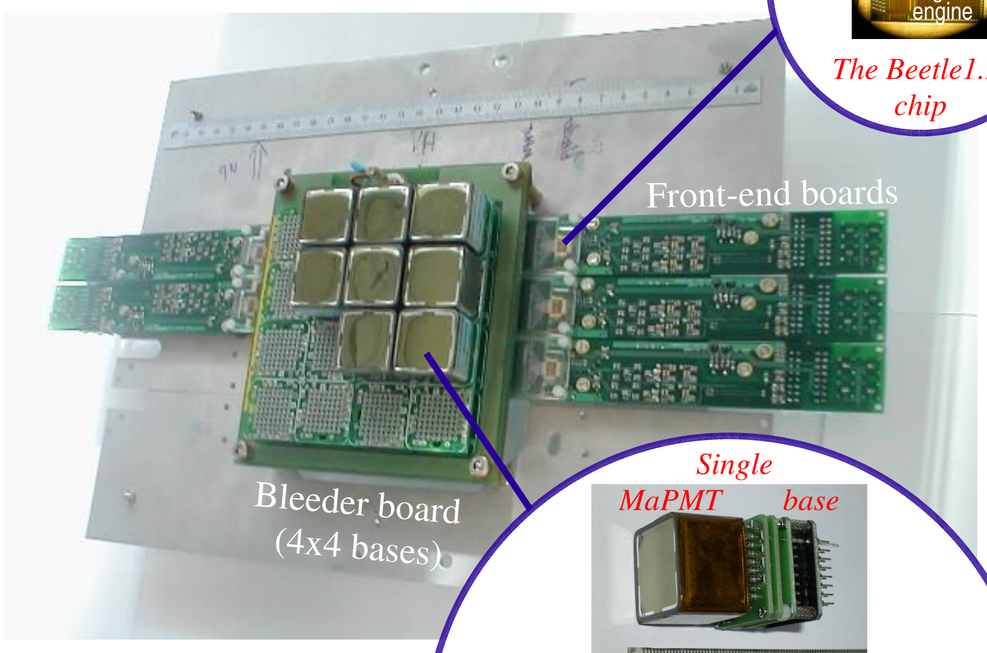
Performance of 8- and 12-Dynode Stage Multianode Photomultipliers

Reinhardt Chamonal, Stephan Eisenhardt , The University of Edinburgh,
For the LHCb MaPMT RICH Group

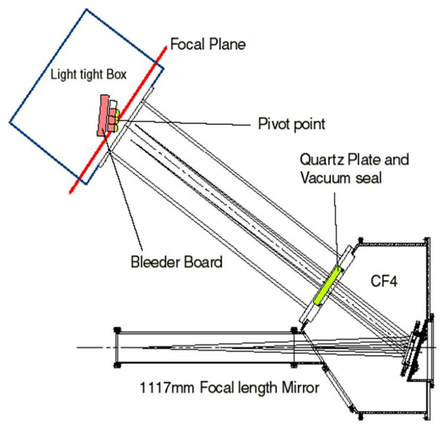
The 64-channel Multianode Photomultiplier (MaPMT) has been evaluated as a candidate photo-detector for the LHCb Ring Imaging Cherenkov (RICH) counters. The newly available 8-dynode stage MaPMT was tested in particle beams at CERN. The MaPMT signals were read out directly with the Beetle1.2 chip which was designed for the LHCb environment and operates at 40MHz. The photon yield and signal losses were determined for a cluster of 3x3 close-packed MaPMTs. The performance of the 8-dynode stage MaPMT was compared to that of the 12-dynode stage MaPMT which has a larger intrinsic gain. The Beetle1.2MA0 readout chip was custom designed to match the dynamic range of the 12-dynode stage device. This option shows a superior signal-over-noise behaviour.

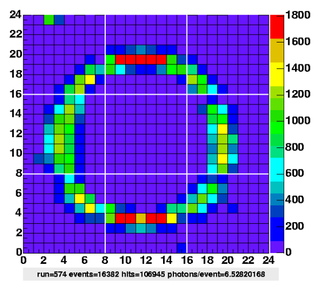


8-Dynode Stage MaPMTs in Test Beam

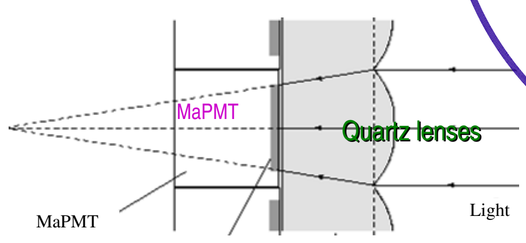
8-dynode stage Multianode Photomultiplier Tubes (MaPMT) equipped with quartz lenses have been tested in particle beams at CERN. Close-packed as a 3x3 array they detect the Cherenkov photons forming a ring in the focal plane of the LHCb experiment RICH1 prototype. The beam consisted of 95% π^- and 5% e^- with a momentum of 10 GeV/c. The 1m long radiator vessel was filled with CF4 gas at 800mbar determining the ring diameter on the detector plane. The MaPMTs were read out by the Beetle1.2 chip mounted on front-end boards each capable of reading out two MaPMTs at a rate of 40MHz.

The RICH1 prototype

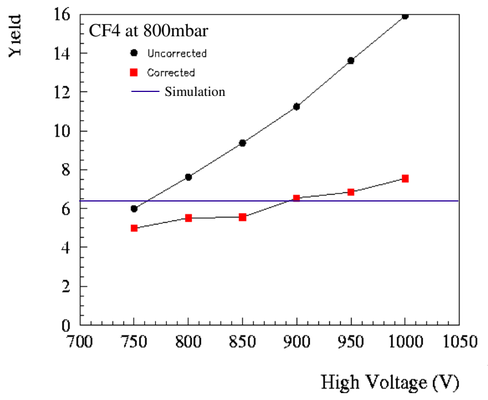




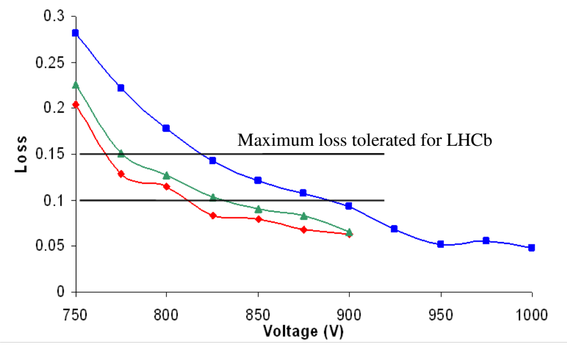
Integrated number of hits over 16400 events taken at 900 V



MaPMT equipped with lens



Photon yield before and after correction (background+cross talk)

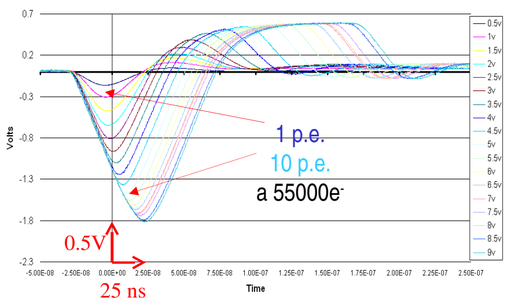


LED signal loss vs. high voltage (for 3 ways of calculating the loss)

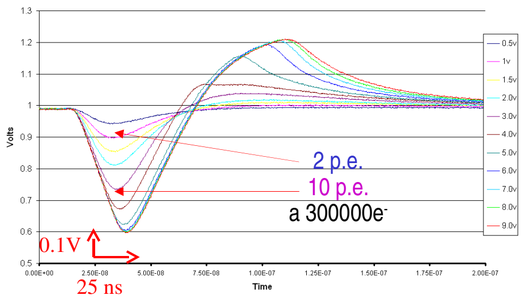
Comparison 8- vs. 12-Dynode Stage

The 8-dynode stage MaPMTs were read out with the Beetle1.2 chip designed for silicon sensors in the LHCb environment. The chip reads out 128 channels at a rate of 40MHz. In this setup the average single photon signal corresponds to 2 MIP (~60mV) after the pre-amplifier.

The front-end circuit of the Beetle1.2 MA0 chip was designed to accommodate the higher gain of the 12-stage MaPMT. A trade-off between signal overshoot and spill over to subsequent samples lead to a single photon signal of 1 MIP (~30mV) after the pre-amplifier with better signal to noise ratio than in the Beetle1.2

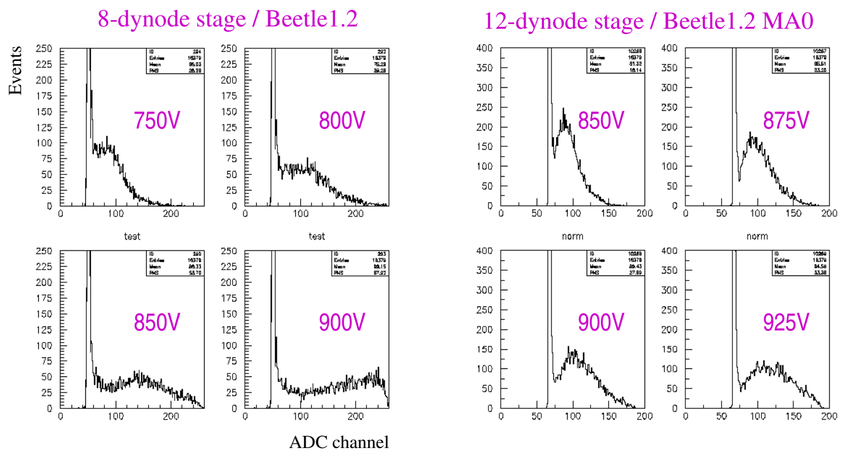


MaPMT pulse shape after amplifier and shaper of the Beetle1.2 (8-dynode stage)

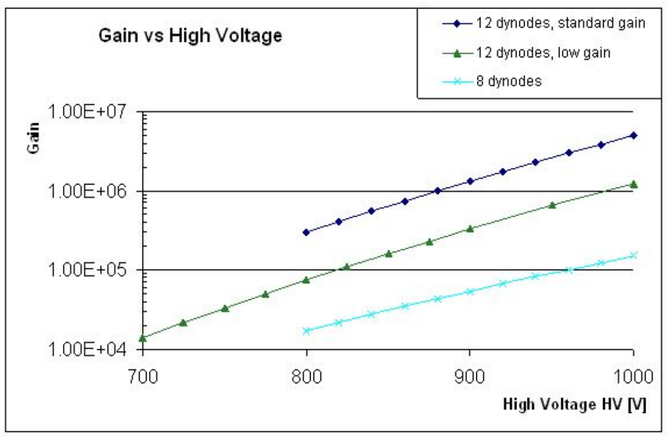


MaPMT pulse shape after amplifier and shaper of the Beetle1.2 MA0 (12-dynode stage)

Pulse height spectra from LED photons



High voltage scans with a LED light source at 470 nm showed that for both MaPMT options the gain doubles every 50 Volts. Both have a clear separation between the photon signal and the pedestal. The 12-dynode stage option has however a lower noise than the 8-dynode stage option (1.0 vs. 1.3 ADC channels)

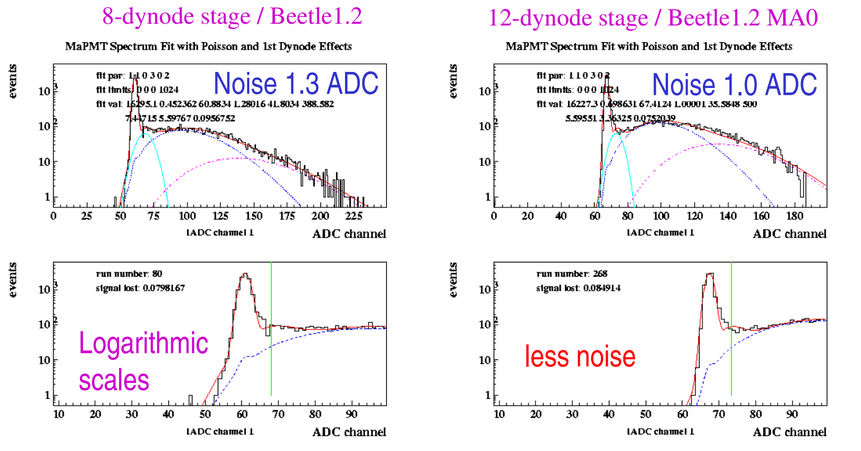


MaPMT gain vs. high voltage: 12-dynode stage with standard gain (top), 12-dynode stage with a low-gain dynode chain (middle) and 8-dynode stage with standard gain (bottom)

Conclusions

Both options are viable solution for the LHCb RICH detectors.

Advantages of the 12-stage MaPMT + Beetle1.2 MA0 option:
- less noise
- favourable overshoot behaviour



MaPMT spectra fits for LED photons