Qualification of DIRICH readout chain

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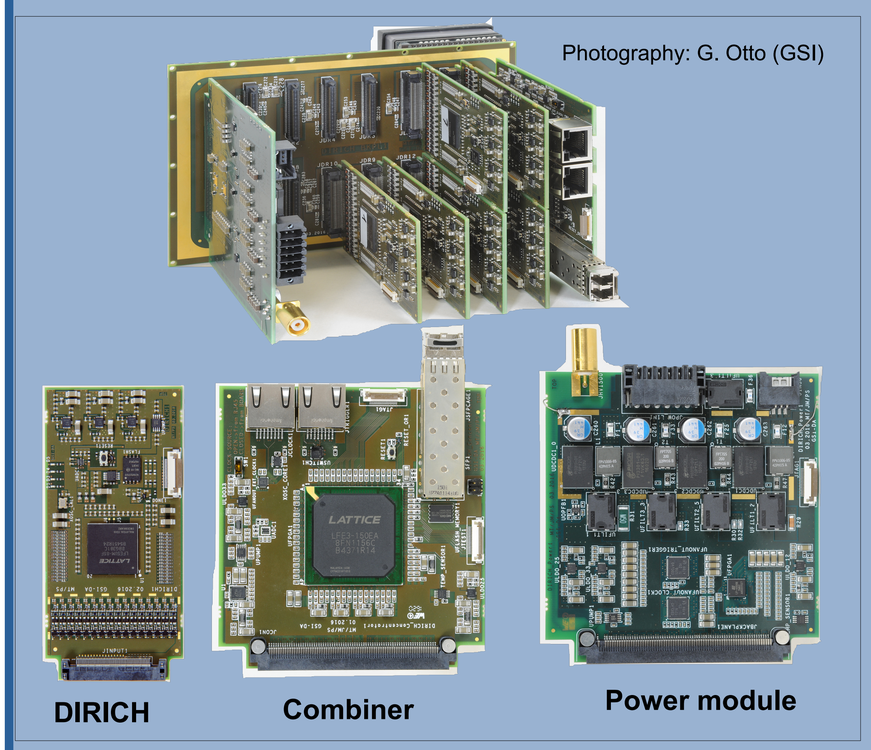
DIRICH readout chain



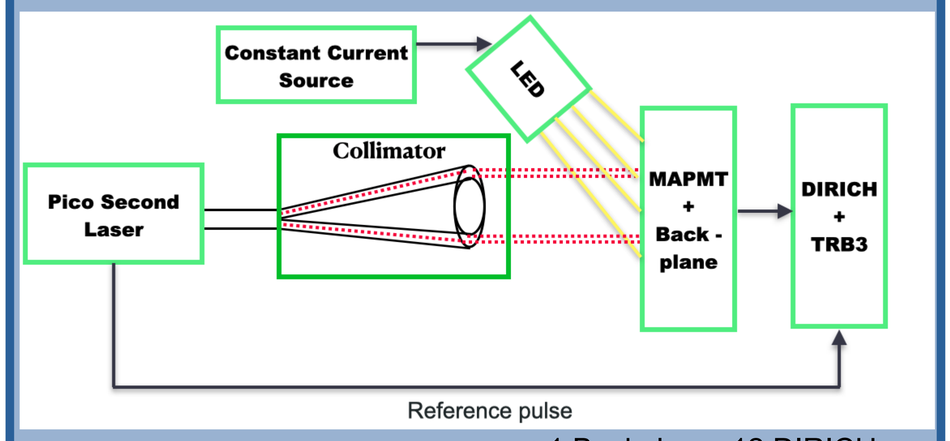
- Low power modular FPGA based readout chain.
- Six 64ch HAMAMATSU H12700 MAPMTs and readout electronics connected by backplane which provides light and gas tight seal.

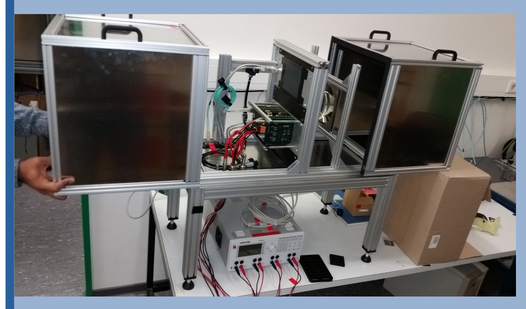
DIRICH front-end module (FEB) :
- Reads out half MAPMT (32 + 1 channels).
- Each channel features own inverter amplifier, FPGA based discriminator and TDC (Lattice ECP5).
- Leading and trailing edge measurements → Time over Threshold.
- Leading edge timing precision ~ 20 ps RMS.

Combiner module :
- Combines data from 12 DIRICH-FEBs to 2.4 Gbit link to common readout interface.
- Distributes clock input to individual FEBs.

Power module :
- Distributes high voltage for PMTs (~ -1000V).
- Distributes low voltages to read out modules via onboard DCDC convertors (32V → {1.1,1.2, 2.5, 3.3V}).

Measurement set-up

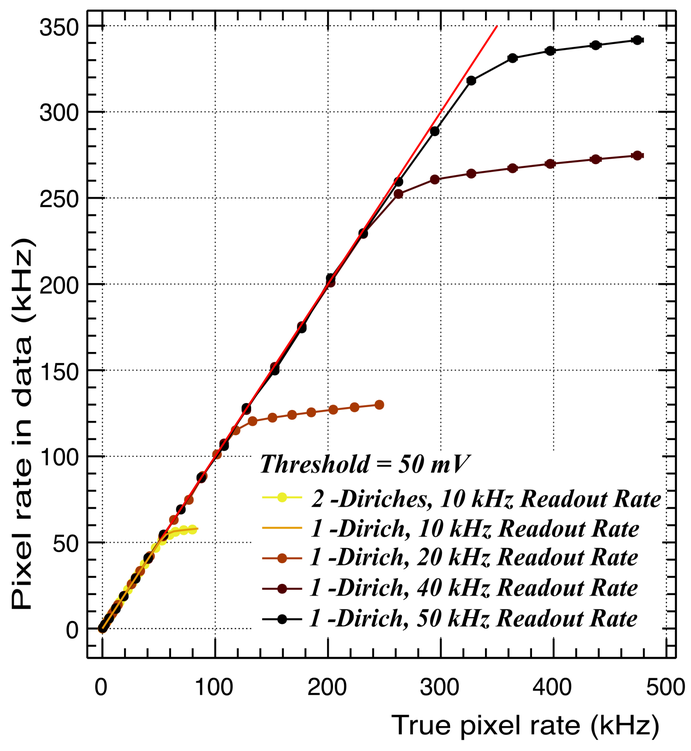




- 1 Backplane, 12 DIRICH-FEBs, 6 MAPMTs.
- Enclosed by light tight box to allow for single photon measurements.
- Quasi free-streaming readout using regular readout trigger (provided to FEBs by trigger readout board (TRB3)).
- 2 light sources : Picosecond pulse Laser (Ring), Pulsed LED (homogeneous).

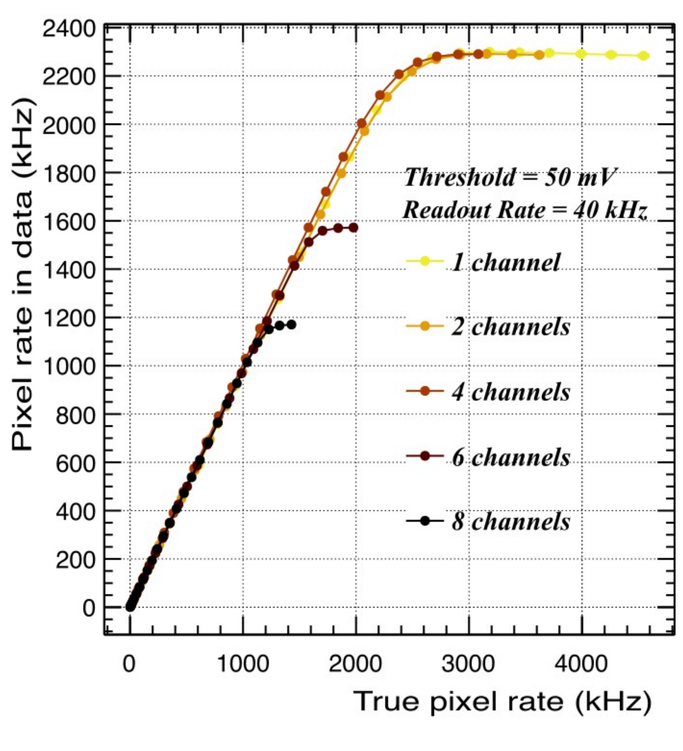
Rate capability measurement

Rate limit full DIRICH (32ch)



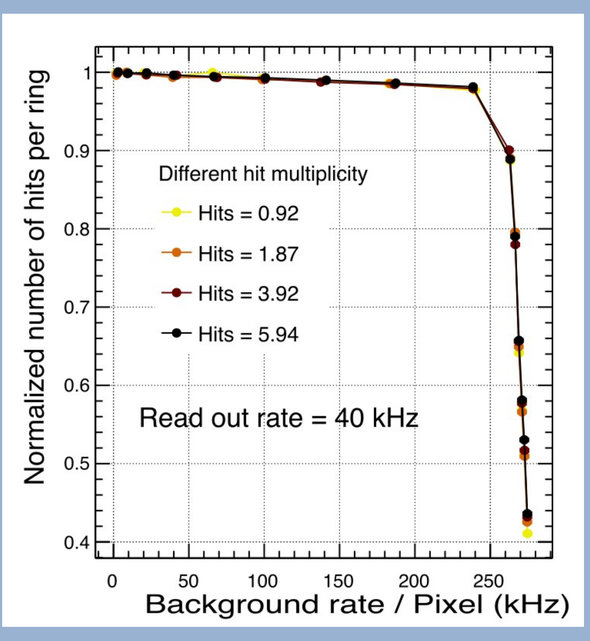
Larger read out rates flush buffers faster leading to saturation at higher data rates.

Rate limit single DIRICH channel

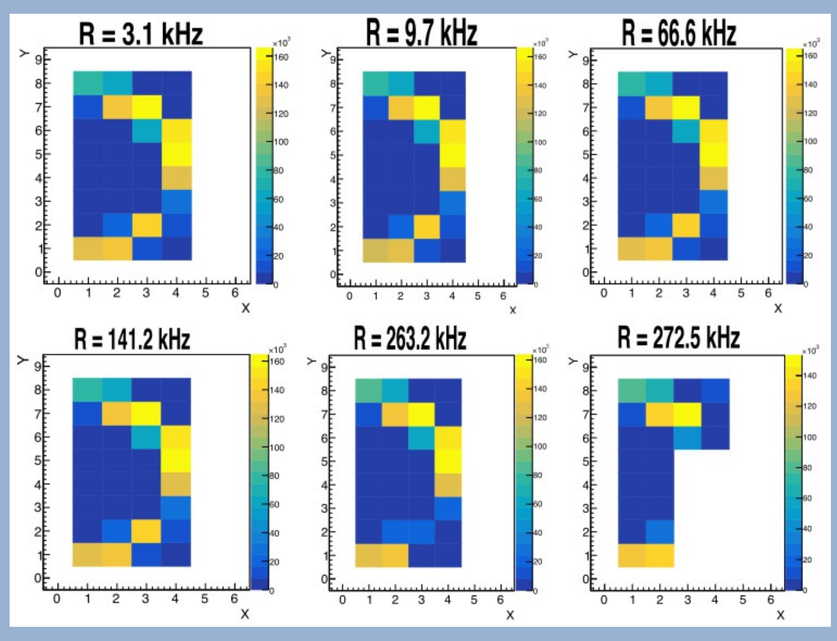


- Reducing number of active channels leads to saturation at higher data rate.
- Overall rate limited by data link, to be increased in future.

Hit efficiency versus rate

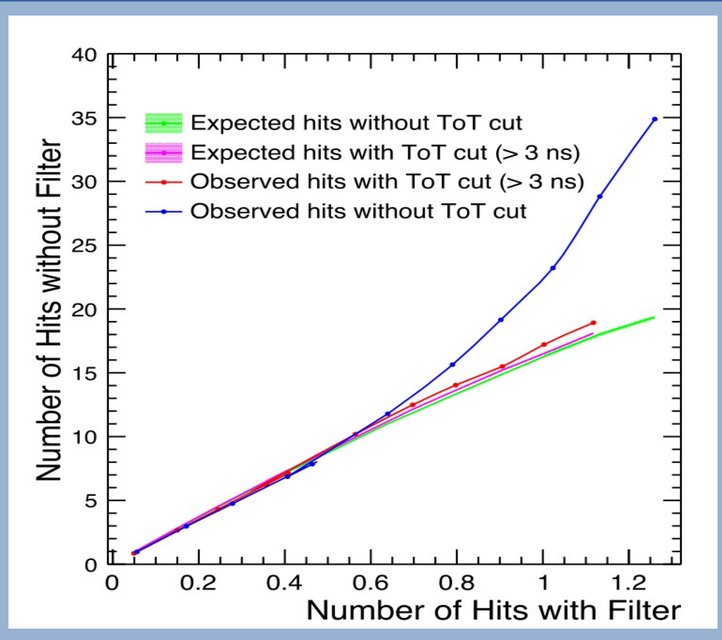


Ring quality at different background rates



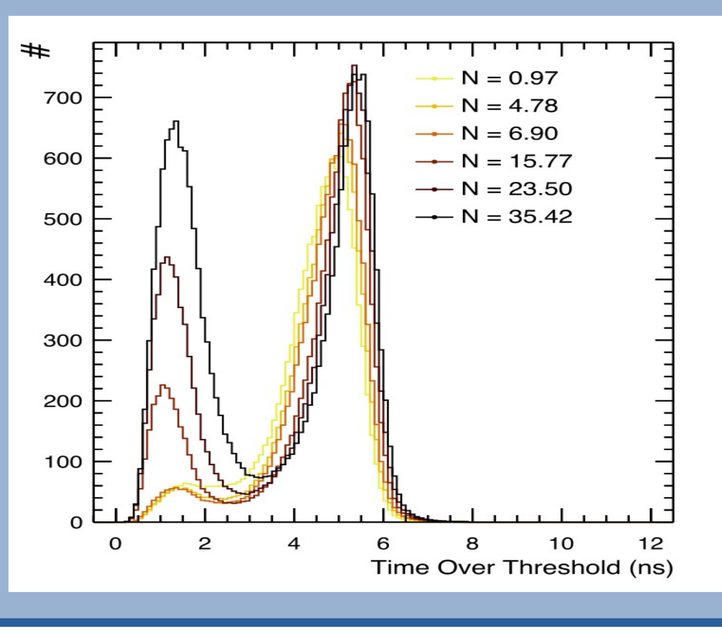
Background rate homogeneously distributed over full MAPMT.

Crosstalk suppression using ToT



- How does MAPMT occupancy effect crosstalk ?
  → Compare hit multiplicity with and without the grey filter of known attenuation.
- Linear increase is expected.
- Additional hits are due to crosstalk.
- Crosstalk can be limited by cutting on ToT.

ToT response of PMT for different occupancies



Summary

- The DIRICH works for high single photon rate with good purity of data (up to 2.2 MHz per pixel readout rate of 40 kHz in the measurement).
- Applying ToT cut on signal helps differentiating single photon hits from crosstalk hits efficiently.

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