

Summary Readout-Electronics

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- introduction
- front-end electronics
- data transmission
- data processing
- slow control/calibration

input parameters*:

- $\sim 10^4$ photon detectors
- 50 – 100 kHz background rate
- $\sim 5 - 10$ Byte per “hit”



total data rate $\approx 2.5 - 10$ GB/s

*cost \Rightarrow sparse detector \Rightarrow single photon detection

- digitalisation[†]:

off-shore ⇔ on-shore



electronics
clock system
power
mechanics

- data distribution:

address ⇔ time-domain

- data processing:

software ⇔ hardware

[†]original photon signal is digital!

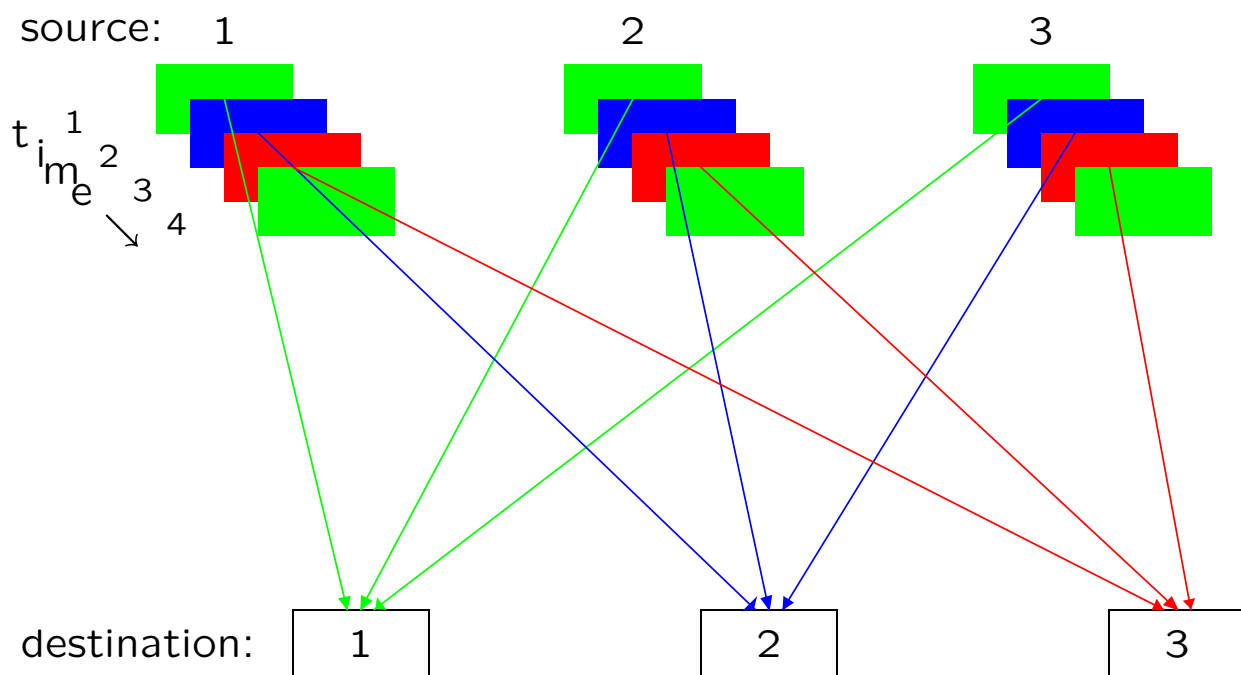
front-end electronics:

- analogue signal processing
 - Time-Over-Threshold
 - rise-time and decay-time
 - total charge
 - sampling (frequency $\sim 100 - 500$ MHz)
 - time accuracy?
 - dynamic range?
- front-end data processing
 - FPGA (= embedded processor)
 - VLSI

- optical modulation
 - 1 colour-fibre for each PMT
 - digital/analogue!
 - direct addressing (slow control)

- data transmission
 - CWDM ($10 \text{ Gb/s} \times \lambda_{1-8} \times 100 \text{ fibres}$)
 - DWDM ($1 \text{ Gb/s} \times \lambda_{1-128} \times 100 \text{ fibres}$)

Data distribution concept:



each destination gets all data of same time slice

data processing:

- comparison with CMS is encouraging
- cost/complexity \Rightarrow fast algorithm(s)
- output ≤ 1 MB/s \Rightarrow reduction $10^3 - 10^4$
- new physics \Rightarrow flexible \Rightarrow software
- efficiency \Rightarrow complete data sample
- logic
 - democratic \Leftrightarrow speed
 - hierarchical \Leftrightarrow detector topology
 - 1 \leftrightarrow 2 SPE \Leftrightarrow photon-detector

- filter criteria:
 - causality (Čerenkov light)
 - slow motion (mono-poles)
 - (a priori) directional information
 - (a priori) time information



software

- slow control
 - embedded processor with local bus
 - each instrument as Ethernet node
 - remote fibre-optic sensing

- calibration/instrumentation
 - what?
 - how often?
 - auto-calibration

calibration:

calibration	photon-detection
read/write slow IO duty cycle $\leq 10\%$ subset of nodes	(mainly) read slow I/fast O duty cycle 100% all nodes



separate physically the calibration and
photon-detection systems

“Hybrid concept” :

- calibration units:
 - number of nodes $\sim 10\%$ of total
 - “known” technology
 - redundancy
 - maintainability
 - low duty cycle \Rightarrow low power
- photon-detection units:
 - number of nodes $\sim 90\%$ of total
 - no maintenance \Rightarrow very reliable
 - low power
 - if R&D completed \Rightarrow “easy” to build

summary:

- workshop is a good start (to be continued)
- significant R&D work started on front-end electronics
- new ideas for data transmission
- data filtering:
 - software way ...
 - physics!
- calibration specifications?