Optical Read-out Links for ATLAS Calorimeters

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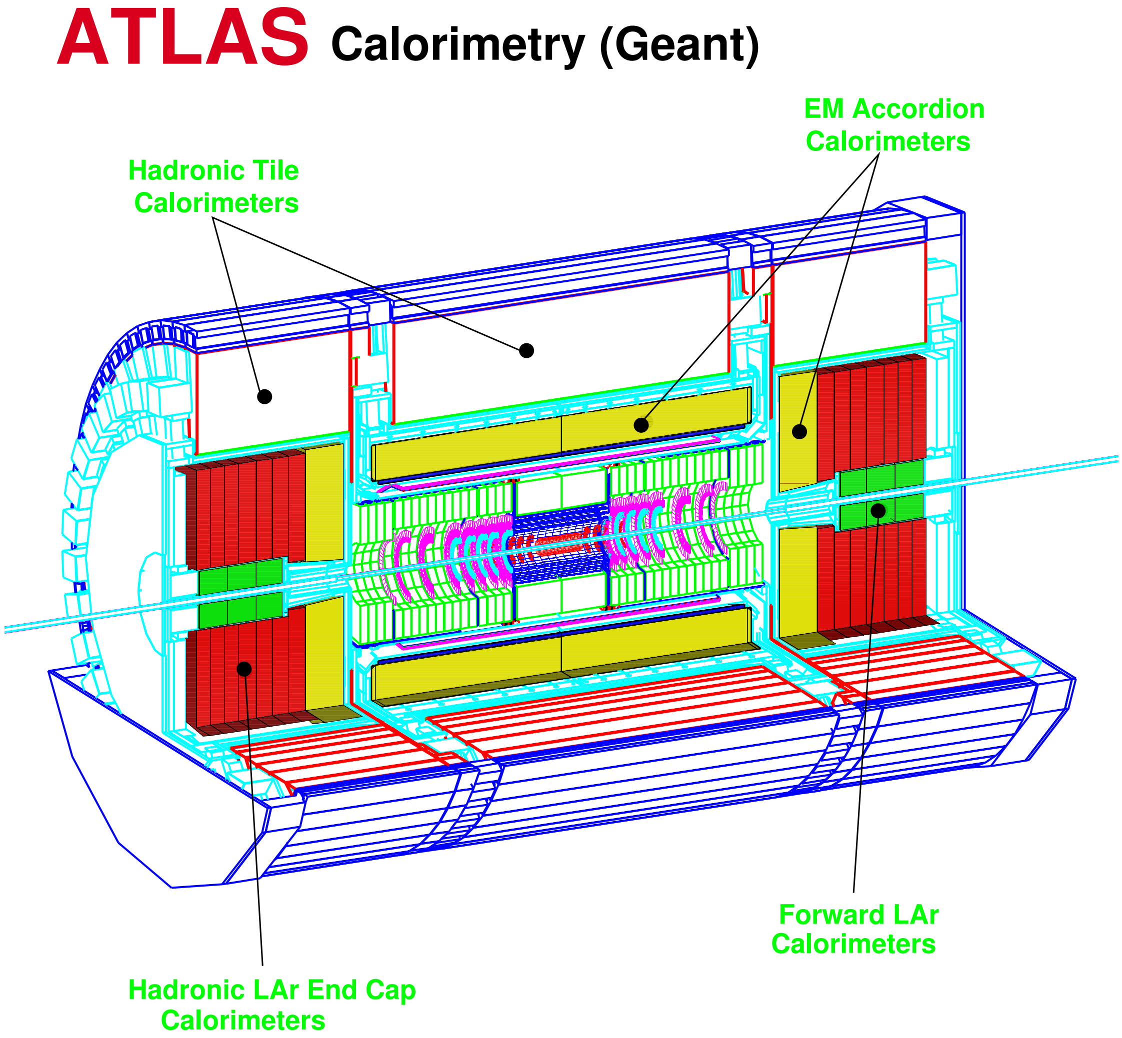
Overview

- The ATLAS calorimeters
- Optical link summary for the hadron calorimeter
- Optical links for the electromagnetic calorimeter
  - A little history
  - Link overview
  - Components
  - Vital statistics
  - Architecture choice
  - Interests and plans
  - Timescale
- Summary

ATLAS Calorimeters



- ATLAS calorimeter system comprises of 2 main components :

  Electromagnetic ... measures energy of electrons and photons

  Hadronic ... measures energy of particles containing quarks (hadrons)

ATLAS Hadronic Calorimetry

No final decision on whether to use optical links to transfer data off detector . . .

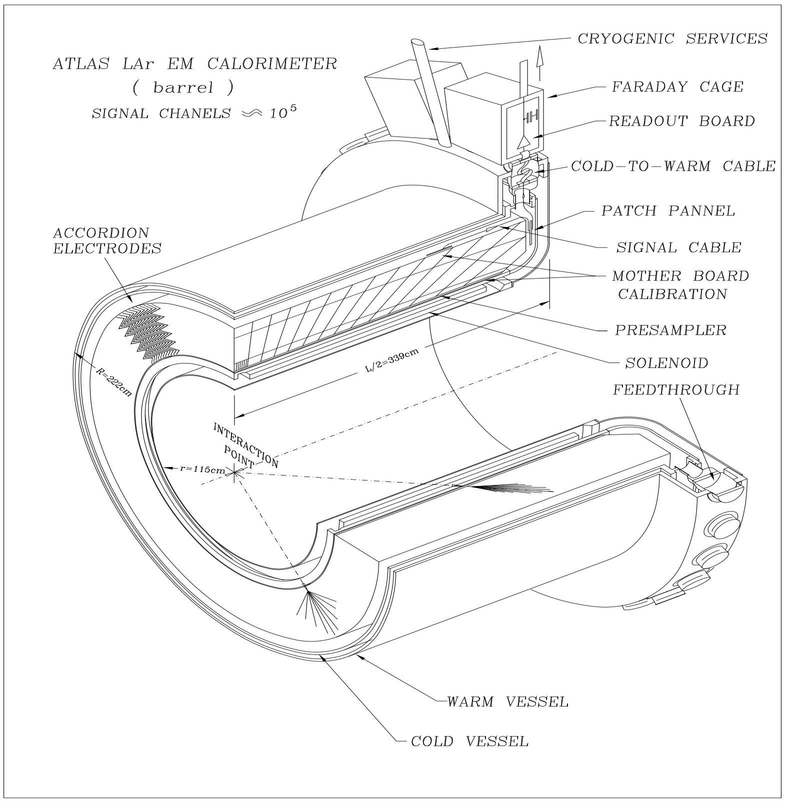
However, if optical links were to be used then they would have to fulfill the following basic requirements :

– 256 links
– Approximately 100 m in length
– Unidirectional
– Each link to transmit at $\sim$50 MB/s
– Emitters in high radiation environment
  (10^{13} n/cm^2, 20 krad over 10 years)
– Could be parallel or serial
– (S-link protocol for read-out)

The electromagnetic calorimeter plans to use digital optical links to transfer data off detector.

This will be covered in more detail now . . .

Electromagnetic Calorimeter



- Large volume of instrumented liquid argon
- $\sim$ 190 000 electronics channels with 16 bit dynamic range
- All channels read out for each trigger
- Poor access to on-detector electronics $\Rightarrow$ excellent reliability essential
- High radiation environment

  25 krad and 3×10^{13} n/cm^2 (over 10 years)

Old timers : CPPM, Marseilles; ISN, Grenoble; KTH, Stockholm

New addition : SMU, Dallas

Some History

Until very recently, efforts were focused on developing an optical link for the transmission of analogue signals.

Emitters

- LED's and laser diodes investigated
- Radiation hardness evaluated
  (*IEEE Trans. on Nucl. Sci. Vol. 44, No. 3, (June 1997) p.861-865*)
- Final choice : 8-way VCSEL arrays from Sandia National Labs (850 nm)
  (*Proceedings of 3rd Workshop on Electronics for LHC Experiments*)

Receiver

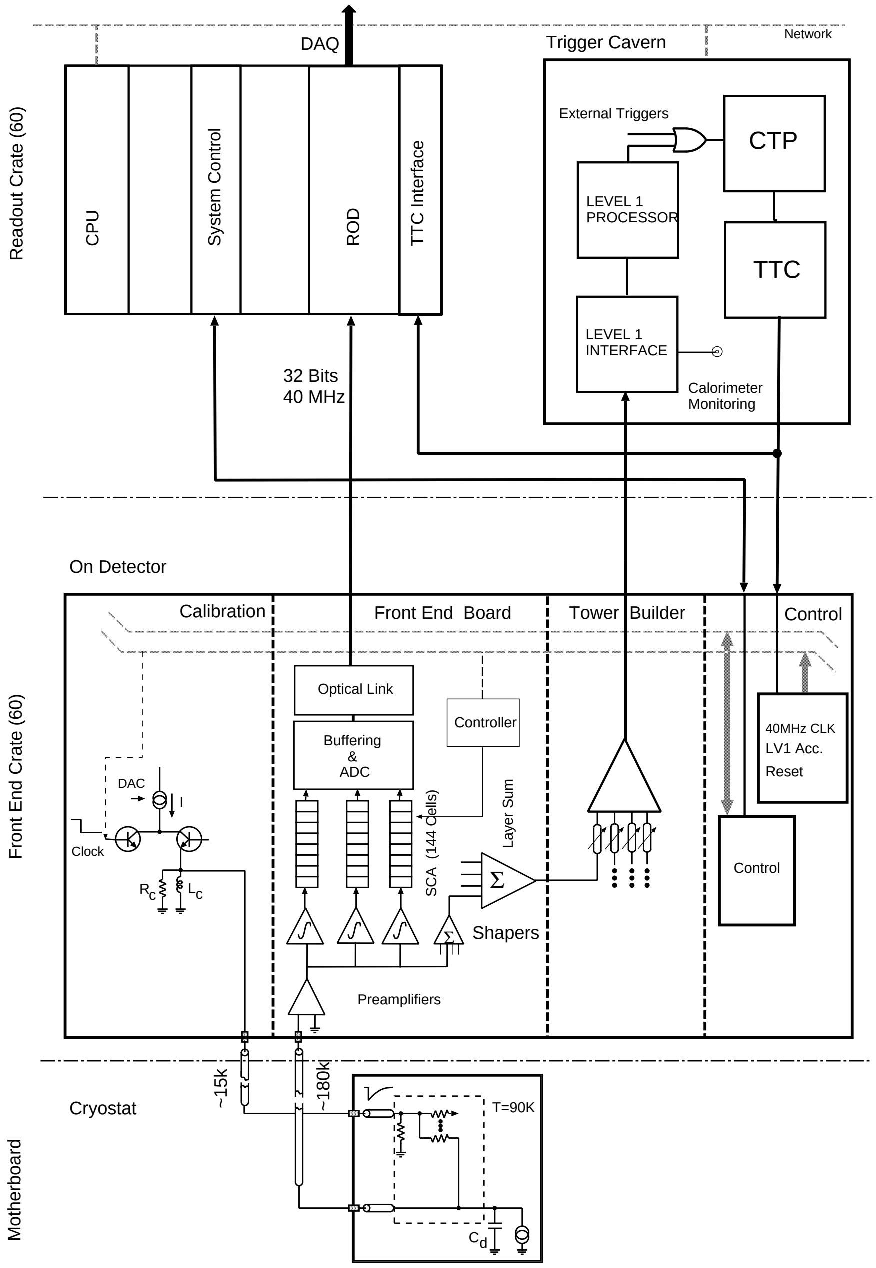
- Si PIN-arrays (AME) coupled to custom transimpedance amplifiers
  (*ATLAS Internal Note LARG-NO-79*)
- Passive coupling based on MT connectors
  (*See AME's presentation*)

Connectics

- Prototype MT-based connectors used to date
- Soon . . . custom-made array connector
  (*See Amphenol's presentation*)

Now, baseline solution is to transfer digital signals from the detector to remote data acquisition electronics ...

Link Overview

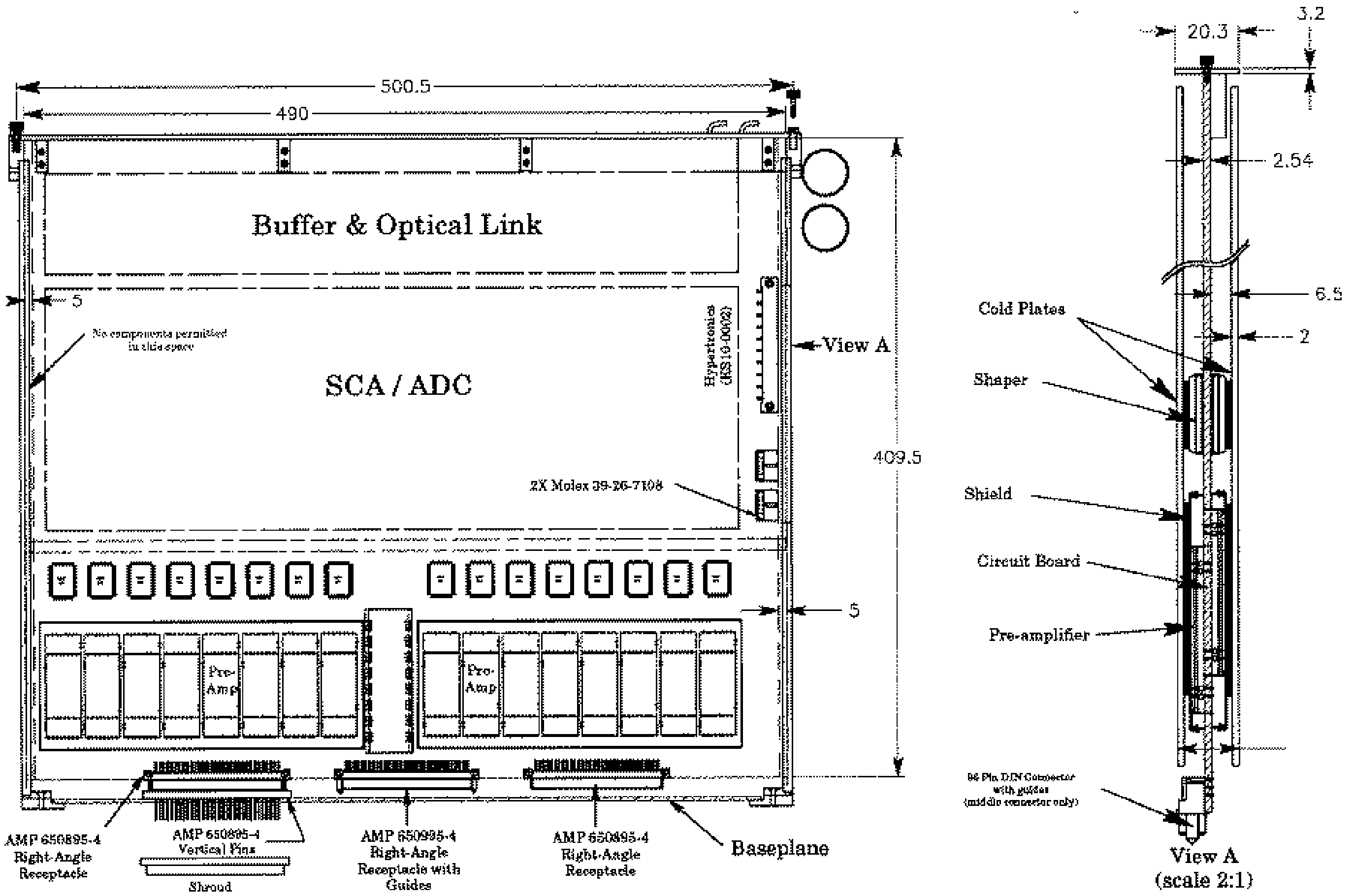


- Approximately 1600 links @ $\sim$ 1.2 Gb/s

- Emitters in high radiation environment

(10^{13} n/cm^2, 20 krad over 10 years)

Implementation



- One optical link per board (1600 in total)
- Thickness restrictions !
- Strict power consumption limits (few Watts per board for optical link electronics)

Components

Emitters and Receivers

- Currently centred on 850 nm links
- Cheaper than telecom. driven 1300 nm and 1550 nm
- Emitters ⇒ VCSEL laser diodes
  Narrow beam, low current threshold, radiation tolerant (lenses ?!), high MTBF, compatible with GHz signals.
- Receiver ⇒ Silicon PIN photodiodes
  Cheap !

Connectors

- Serial ⇒ ST type (metal ?)
- Parallel ⇒ only MT at present
  Keen to see how market develops . . .

  (Plan to run continuous fibres if possible . . .)

Fibres

- Current experience with multimode fibres
- Large core ⇒ easy alignment, low insertion losses
- Short distances ⇒ dispersion not a worry
- Will need to be rad. hard and well protected !

Link Summary

- Approximately 1600 unidirectional links
- Speed $\sim$ 1.2 Gb/s
- Length between 70 and 200 metres (depending on location of data acquisition electronics)
- Parallel or serial architecture ...
- Tolerable bit error rate $\sim 10^{-9}$ (no active correction, but parity checks performed)
- Radiation resistance

  25 krad and $3\text{x}10^{13}$ n/cm^2 (over 10 years)
- Few Watts per link (including serializer !)
- Strict size constraints

Architecture Choice

	Parallel	Serial
Electronics	• Rad. hard 'slow' serializer • 'Slow' (100's MHz) clock • Interference with preamps ?	• Rad. hard 'fast' serializer • Fast (GHz) clock • Interference with preamps ?
Architecture	• Data and clock on separate lines (very small BER) • HUGE data moving capacity • Array components (commercial support ?)	• Data and clock combined • Well supported commercially • Easier to evisage redundant solutions ?
Packaging	• Development needed • Radiation hardness (plastics) • MT / other array connectors ?	• Easier (ST etc.) • Radiation hardness (lenses etc.)
Time	• Longer development time	
Cost	• ??? ...	• ? ...

Interests and Plans

- Following market trends for serial and parallel Gigabit links. Keen to build strong collaborative relationships with manufacturers.
- Currently studying both 'homemade' links and commercial solutions (radiation hardness !).
- In both cases reliability and reproducibility of link components is a major concern.
-
- Recently completed neutrons irradiation studies (10^{13} n/cm^{2}) of :
  - Honeywell VCSEL's (ST-housed)
  - Mitel VCSEL's (ST-housed)
  - A Honeywell VCSEL array
  - Hewlett Packard G-Link chips (PLL)
  - Amphenol connector material
- More irradiations are planned. Aim for more realistic study of complete links.
- Full test of first complete module of calorimeter in 'test-beam' at CERN in Spring 1998. Aim to test both serial and parallel read-out links (no radiation !).

Indicative Timescale

1997

Architecture choice

1998

1999

Design and Development

2000

Production, testing and burn-in

2001

2002

Installation

Summary

- ATLAS electromagnetic calorimeters to use digital gigabit optical links to transfer data to remote data acquisition electronics

- Maybe for hadronic calorimeter too (50 MB/s)

- Key requirements :
  - Highly reliable
  - Radiation resistance (drivers, emitters and fibres)
  - Quality assurance
  - Keen to to follow commercial solutions . . .
- Would welcome close collaboration with industry !