BaBar Calorimeter DAQ
System Overview

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1. INTRODUCTION

This document provides an overview of the BaBar Electromagnetic Calorimeter (EMC) readout system. The following documents deal with specific parts of the system in more detail:

Document[1]	Contact
Pre-amp Description	G. Haller
CARE Description	G. Haller
Barrel On-Detector Mechanics	?
End-Cap On-Detector Mechanics	?
ADC Board Description	J. Dowdell
Barrel and End-cap I/O Board Description	J. Dowdell
DAQ Transition Board Description	D. Price
EMC Personality Module Description	P. Olley
Environmental Monitoring Board	T. Meyer
Grounding and Shielding Plan	J. Dowdell
Interface Specification	J. Dowdell
On-Detector and Off-Detector Environmental Monitoring	T. Meyer

This document is, in general, organised in a top-down order. This means some of the terms and concepts used may not have been encountered before by a first time reader. The intention is to give the reader the big picture first, then fill in the blanks.

[1] At the time of writing not all of these have been written.

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FIGURES

2. REVISION HISTORY

Date Issued	Description of Revisions
29-Aug-96	· Changed to US letter paper. · WWW address changed.

3. Mapping of Crystals to DAQ Elements

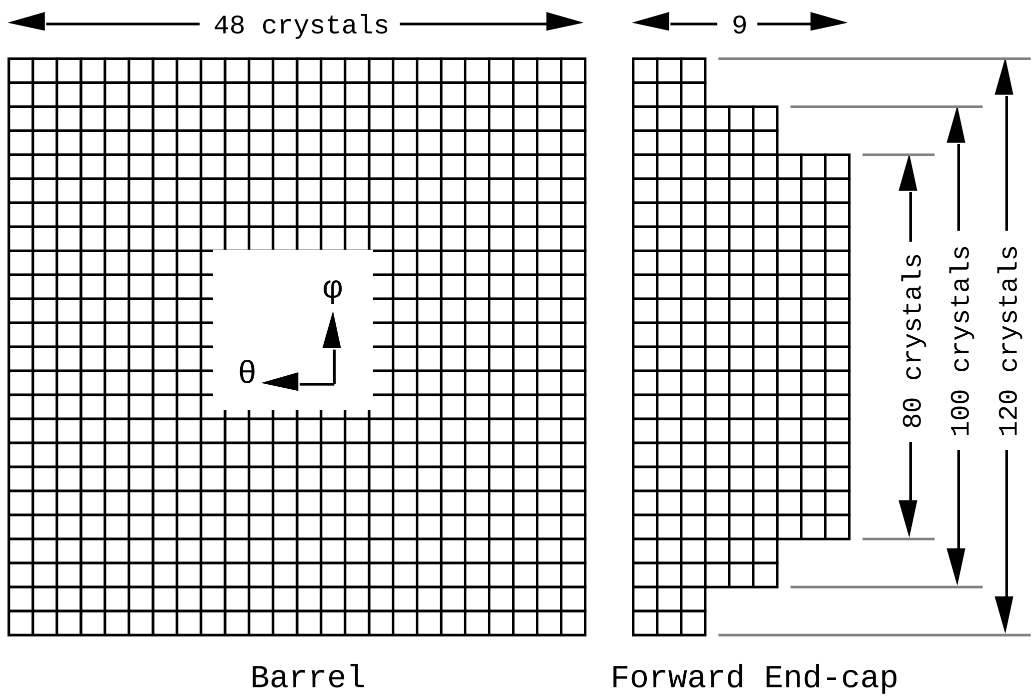

Figure 1 — The arrangement of crystals in the detector

The crystals are arranged as shown in a flattened view in Figure 1.

- In the barrel there are 48 crystals along the barrel by 120 around. Total: 5760 crystals.
- In the forward end-cap there are nine rings of decreasing size: three of 120 crystals, three of 100 crystals and three of 80 crystals. Total: 900 crystals.
- The backward end-cap has been staged, but hooks will be left for it to be added to the DAQ and trigger systems later.

The total number of crystals in the calorimeter is 6660.

The following physical constraints are placed on the grouping of crystals into ADC cards by the mechanical design:

- The barrel is built from 40 strong-backs in φ, each three crystals across and 48 long.
- The end-cap is built from 20 modules in φ, each containing 45 crystals.

The trigger tower geometry has not been fixed, but does not appear to impose additional constraints, since all proposed geometries have so far been realisable with the mapping that will be described, or are able to be adapted off-detector.

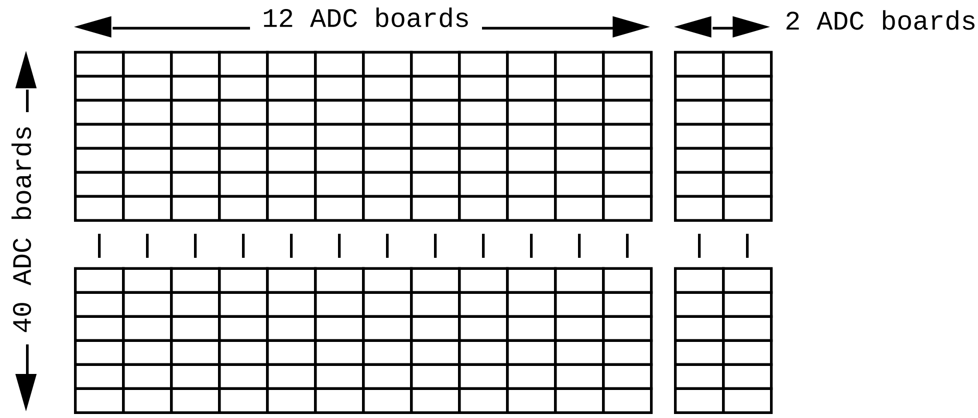

Figure 2 — Mapping of crystals to ADC boards

The crystals are mapped into ADC boards as shown in Figure 2.

- In the barrel there are 40 ADC boards in φ (one per strong-back) by 12 along the barrel (physically positioned as six at either end of the barrel).

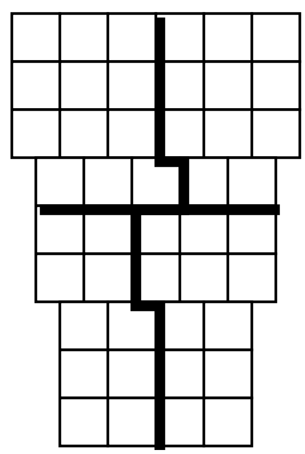

Figure 3 — Mapping of ADC cards in the end-cap

- The end-cap is roughly divided into two rings in θ of forty cards in φ. The mapping of crystals into ADC boards is not obvious (as it is in the barrel). A possible scheme is shown in Figure 3 that maps four ADC boards onto one module. This is clearly not geometrically as clean as in the barrel and some of the channels in the twelve channel ADC boards are unused, but it matches the barrel quite well and allows the barrel ADC cards to be reused.

The EMC DAQ system uses 140 DAQ boards to perform energy and time feature extraction from the digitised waveforms using a digital matched filter. The maximum number of crystals that can be processed by one board, and keep up with a 2kHz trigger rate, is 48 crystals. Therefore four ADC cards are connected to one DAQ board.

In the barrel these four ADC boards are in a group of two cards in φ and two in θ. In the end-cap the four ADC boards are the boards in each physical module of the end-cap.

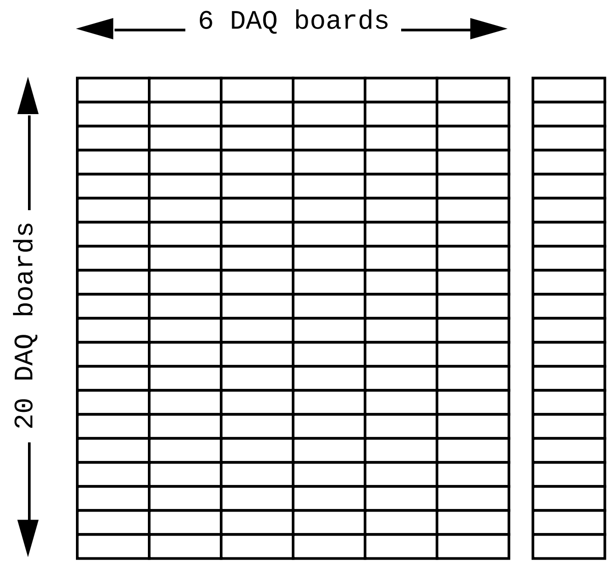

Figure 4 — Mapping of DAQ boards to crystals

Figure 4 shows the mapping of DAQ boards to crystals. In the barrel there are twenty DAQ boards around in φ by six along in θ. In the end-cap there are twenty DAQ boards (corresponding to one per physical module).

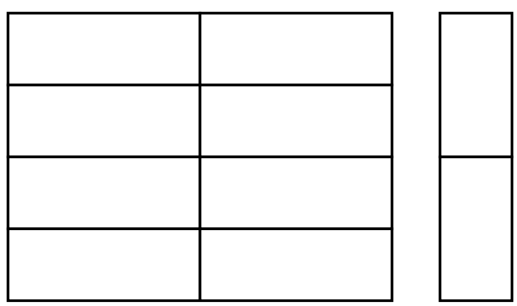

Figure 5 — Mapping of crystals and ADC boards to DAQ crates

Figure 5 shows the mapping of DAQ cards to DAQ crates. In the barrel there are fifteen feature extraction DAQ boards in a DAQ crate and one DAQ board providing the C-LINK and D-LINK to the front-end. There are therefore four DAQ crates in φ, by two in θ. In the end-cap there are ten feature extraction DAQ cards in a DAQ crate (corresponding to one half of the end-cap), plus the C-LINK/D-LINK interface DAQ card.

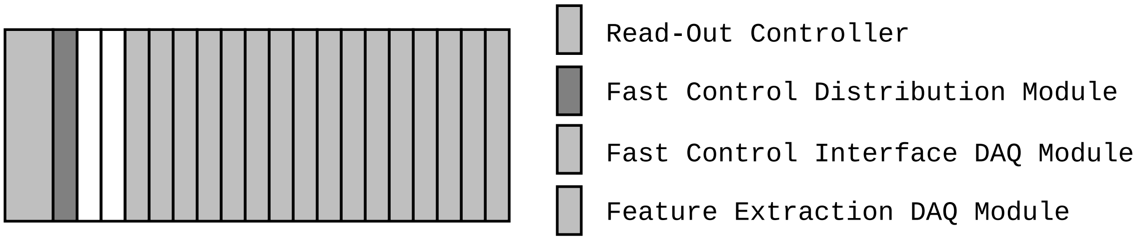

Figure 6 — A barrel DAQ crate

A diagram of the cards in a barrel DAQ crate is shown in Figure 6. The end-cap DAQ crates differ only in the number of feature extraction DAQ modules.

4. THE ELECTRONICS SYSTEM

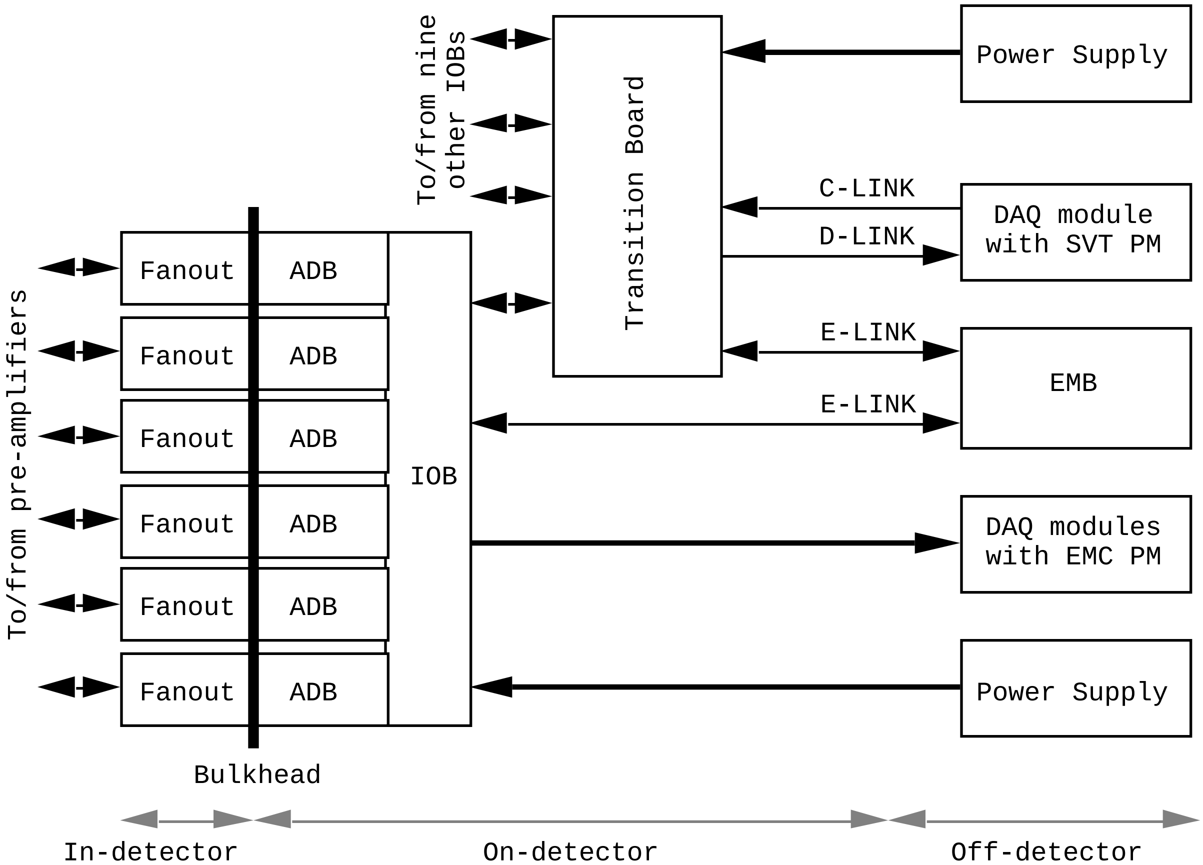

Figure 7 — On-Detector Electronics Block Diagram

A block diagram of the electronics in the barrel is shown in Figure 7. This diagram is intended to show the types of and relationship between the modules. The interfaces shown in this figure are for reference only.

The acronyms stand for:

- ADB ADC Board
- IOB I/O Board
- EMB Environmental Monitoring Board

In the end-cap the number of ADBs per IOB is four not six.

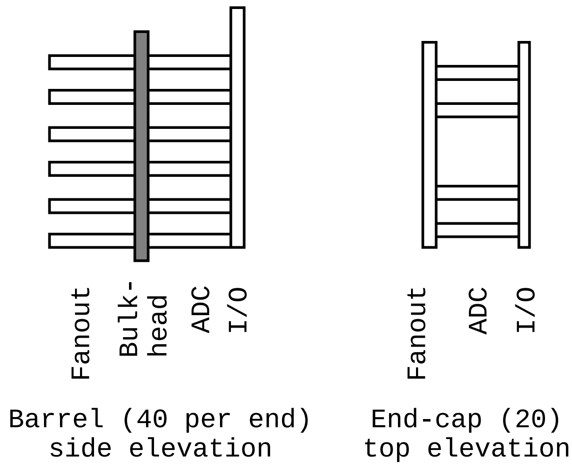

Figure 8 — Physical arrangement of on-detector electronics

The physical arrangement of the on-detector electronics is shown in Figure 8. Note that the barrel is shown in side elevation and the end-cap in top elevation.

- In the barrel, each fanout card connects to twelve crystals in a 3 (in φ) by 4 (in θ) area. Six fanout cards cover half of a strong-back. Each fanout card connects directly to an ADC card through a bulk-head. This bulk-head will be used to improve the gas tightness of the barrel and to allow servicing of the ADC cards without disturbing the connections to the pre-amp. Six fanout-ADC combinations are connected to one I/O board.
- In the end-cap the fanout board connects to all 45 crystals in an end-cap module (one twentieth of the end-cap). Four ADC boards (the same boards as in the end-cap) plug in to the fanout card and an I/O board connects them together. This I/O board will be physically different from that in the barrel. The endcap fanout board serves the same purpose as the bulkhead and fanout boards in the barrel.

The transition boards will be mounted in quadrants in the barrel and on each half-shell in the end-cap. The number and position of EMBs is still to be decided.

The total numbers of modules required is:

Module	Acronym	Quantity required
Pre-amplifier Board		6660
Barrel Fanout Board	B–FOB	480
End-cap Fanout Board	E–FOB	20
ADC Board (for the barrel)	ADB	480
ADC Board (for the end-cap)	ADB	80
Barrel I/O Board	B–IOB	80
End-cap I/O Board	E–IOB	20
Transition Board		10
SVT Personality Board		10
EMC Personality Board	PM	140
DAQ Board		150
Environmental Monitoring Board	EMB	?

4.1 Data transmission to DAQ

Data is digitised on the detector and transmitted directly to the EMC personality modules on DAQ boards in the DAQ crates. The transmission is via optical fibre.

Because this transmission is continuous (regardless of whether the data belongs to a trigger or not) it is referred to as untriggered.

The raw ADC plus range data is corrected and converted to a linear scale using Look Up Tables (LUTs) on the personality module.

The corrected energy in all crystals in a trigger tower is summed for each 3.7 MHz sample period and sent to the trigger system.

The transfer of data from the personality module into the VRAM on the DAQ board is likely to be triggered. Possible ways for making it look “triggered” are being investigated.

4.2 Fast Control Distribution

Fast control information is transmitted to the front-ends using the C-LINK. Register readback comes via the D-LINK.

Sixteen 59.5 Mbit/s serial data streams (the C-LINKs) are carried by one fibre-optic link. In both the barrel and the end-cap the terminus of the C-LINK is the I/O board. Therefore the fibre-optic link has to be converted to electrical and demultiplexed to ten destinations. This function is performed by the transition board.

The connections between the transition board and each I/O board are:

- 59.5 MHz clock from transition board to I/O board (recovered by the G-LINK)
- 59.5 Mbit/s serial data stream (the C-LINK) from transition board to I/O board
- 59.5 Mbit/s serial data stream (the D-LINK) from I/O board to transition board
- 59.5 MHz clock from I/O board to transition board (to drive the G-LINK).

The return clock from I/O board to transition board means that we do not need to use a delay line on the transition board to generate the clock for the return G-LINK — the system will be self-aligning. This will reduce the chance of errors in setting up the delay and maximise the set-up time available to the G-LINK.

These signals could be driven using differential positive-ECL over a 10 way shielded IDC cable. There will be one such cable to each I/O board, the cable lengths should be cut approximately the same length.

We should quantify what our requirement is on the difference in phase of the clocks at the I/O board and whether we need to take special measures to meet this requirement.

Refer to the I/O Board description for a complete list of fast control commands and how they are handled.

4.3 Power Supplies

Power is supplied to each I/O board or transition board from an independent floating supply. The power supplies required by the electronics and their estimated current requirements are described in the relevant module description.

In general the supply voltages available are:

- +50 to +80V for depleting the photodiode. The adjustment range of this voltage is not yet set.
- +9V to +12V for regulating down to either +6V or +5V to power sensitive or analogue components.
- –5V for analogue components.
- +5V to power digital electronics.

4.4 Environmental Monitoring

There are several classes of quantity that can be monitored:

- quantities relating to the detector itself (like temperatures, humidity)

  These are measured by discrete sensors and are connected directly to the EMB and digitised on the EMB. The EMB is connected to the environmental monitoring system via a serial link.

- quantities related to the on-detector electronics (regulator output voltages, bias voltages, Finisar transmitter)

  These quantities are digitised on the IOB and transferred to the EMB via the ELINK.

- quantities related to the power supplies (power supply voltages, currents)

  These quantities are either digitised by the power supply or a module in VME. If they are digitised by the power supply, the supply is connected to the environmental monitoring system via a serial link.

- quantities related to the Finisar receivers on the DAQ boards (received optical power)

  These quantities are digitised by ADCs on the personality module. The magic of EPICS is then used to make them available to the environmental monitoring system using TCP/IP.