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BaBar Electronics Readout Module Requirements

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Abstract

**This note is a PRELIMINARY DRAFT.
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Contents

I Requirements

I-A Requirements imposed by the system architecture

FUNCTIONAL REQUIREMENT A.1: The Readout Module (ROM) must provide a common interface for each subsystem to the fast control system, the event dataflow system including calibration and user diagnostics, the slow control and monitoring system, the software environment and software for the hardware interface.

Justification: The Babar electronics and computing groups have established a set of common interfaces that all subsystem should adhere to.

By generalizing the architecture to all systems down to the point of contact with the detector front-ends we can avoid substantial engineering costs associated with developing special purpose interfaces for every subsystem. A common set of interfaces also reduces the overall maintenance, software, and training needed to bring the experiment online and in continuous operation. Each detector electronics sub-system shows common interface for event data readout, fast control. Within this commonality all front-ends can still have unique interfaces to the detector mounted electronics, unique interfaces to the fast trigger, and detector specific data formats and monitoring requirements.

There are five principal common interfaces in the ROM. 1) The interface to the detector front-end elements (FEE). 2) The event data readout port by which all event data passes from the sub-system detector electronics to the data acquisition event collection network and into the L3 processing farm. 3) A fast control system which provides high speed trigger information pertinent to informing the sub-system electronics of the disposition of event triggers as well as providing timing and state information. The fast control system further provides for the synchronization of the flow of data, for reset and initialization, and for the throttling of triggers. 4) The slow control electronics interface is responsible for initializing the system with calibration constants, programs, as well as electronics monitoring and beginning and ending runs. 5) The software environment and code level interface is common between readout module and readout controller since this allows code reuse between these two units and unifies the buffer management software in the crate based electronics. The use of a real-time Unix kernel in the crate based electronics also extends the use of the buffer management software into the UNIX L3 processor farm. These five systems interact with the hardware and with each other in the control of the detector in accordance with the Babar architecture and require the adherence of the electronic systems to the describe protocols.

Status: Concurrence has been achieved in the establishment of an architecture with common protocols. The details of all of the protocols for the major interfaces are still under development. The dataflow, fast control, and slow control systems have not yet been reviewed and interface definitions will become stable only when these system conceptual designs have matured.

FUNCTIONAL REQUIREMENT A.2: The readout module must adhere to the Babar standard and common readout protocols. The ROM must record an input data stream after a level 1 accept from a front-end system, buffer this input event stream, perform a user defined operation of data reduction or formatting if any, then transfer the processed event stream out through the VME backplane. These operations occur under the control of the fast control system and the dataflow control.

Justification: The Babar experiment has adopted a common electronics readout architecture.

Status: Complete.

FUNCTIONAL REQUIREMENT A.3: The ROM must decouple the different timescales of the front-end interfaces and fast control from the operation of the dataflow and software control.

Justification: The Babar experiment is making heavy use of software and software control methodologies, these methods can have long latencies compared to the short intervals between triggers. This requirement is derived from the small deadtime requirement in the DAQ system.

Status: Only simple modeling of the buffer management control software has occurred and performance tests are not anticipated during the development cycle of the ROM.

FUNCTIONAL REQUIREMENT A.4: The ROM shall support a common buffer management methodology.

Justification: A common buffer management software is likely to be required by the DAQ system.

Status: The buffer manager on the ROM and on the ROC are likely to be identical codes. If this is this case both ROM and ROC will likely have a derived requirement of having identical operating systems.

FUNCTIONAL REQUIREMENT A.5: A standardized code development environment shall be provided.

Justification: The DAQ system will be have sophisticated codes in C and C++ in the ROM, ROC, and on the L3 farms controlling the dataflow. These codes will be shared between these systems and code management, debugging, and reliable and efficient compilation will be important in minimizing code development time and overall cost.

Status: The Wind River release of the C complier and debugger for potential ROM and ROC targets is scheduled for early this year.

FUNCTIONAL REQUIREMENT A.6: The ROM must be able to implement data formatting, zero suppression, gain and pedestal correction, and waveform processing at the 2 KHz maximum average trigger rate for systems that have raw data rates that would saturate the bandwidth on the VME backplane.

Justification: The calorimeter system provides data that requires digital filtering, and does not suppress uninteresting data (sparsing) such as data below pedestal or below some physics derived energy threshold.

Status: The need for data formatting, zero suppression, and waveform processing is currently driven by bandwidth and processing requirements only in the calorimeter system. The calorimeter system provides data that requires digital filtering, and does not suppress uninteresting data (sparsing) such as data below pedestal or below some physics derived energy threshold. No other system has the implicit requirement that this processing occur on the ROM. If the calorimeter system could achieve significant zero suppression of data prior to processing and adopted a triggered readout architecture then both bandwidth and processing considerations would eliminate the requirement that this processing occur on the ROM (e.g. could occur on ROC).

FUNCTIONAL REQUIREMENT A.7: The ROM must support the triggered readout architecture of Babar. The triggered readout initiates the flow of data from upstream elements onto the ROM upon a level 1 accept and under the command of the ROM. The transmission of data to the ROM is initiated by a specific read command sent to the upstream element by the ROM.

Justification: This is the adopted architecture for the SVT, DIRC, and IFR and has been reviewed by these systems in their respective preliminary design requirements review and conceptual design review. The SVT has further committed this architecture to a critical path IC development.

Status: The Calorimeter system currently stands apart as the sole untriggered system in Babar. As an untriggered system data flows continuously and at high rate to the ROM where data must be stored during the level 1 latency. This architectural variant is still under consideration. This architecture would drive a requirement that the ROM support a dual-ported memory structure. The combination of the calorimeter being untriggered and not having the data threshold suppressed would additionally drive a requirement that raw data not be sent from the front-end interface to the event data readout port (VME) interface.

I-B Requirements imposed by Dataflow

FUNCTIONAL REQUIREMENT B.1: The ROM must be able to buffer data during L2 decision and pending L3 readout.

Justification: The system architecture requires the upgradability of the readout to three tiered trigger.

Status: Simplified models of the event building protocol indicate that storage of fifteen events or more is sufficient to make the deadtime associated with the filling of buffer queues to be completely negligible. This will determine the size of the pending L3 readout buffers. Modeling of the architecture with a L2 trigger has not occurred and is not expected during the development cycle of the ROM.

FUNCTIONAL REQUIREMENT B.2: The ROM buffer depth must not contribute significantly to the deadtime.

Justification: The DAQ system places an overall limit on the deadtime for the detector.

Status: The buffer depth, and number of buffer pools depends on the adoption of the untriggered readout for the calorimeter.

FUNCTIONAL REQUIREMENT B.3: The ROM must be able to provide raw data (unprocessed) when requested by the fast control system.

Justification: The dataflow system is expected to require this feature.

Status: The need for the unprocessed raw data has not yet been determined and this requirement is under consideration.

FUNCTIONAL REQUIREMENT B.4: The event data being transfered from a ROM to the ROC must be accompanied by a trigger number and time tag.

Justification: The time and event synchronization of the detector data is required to guarantee complete and valid events. This requirement exists in order to provide error checking in the data stream and to facilitate error detection and recovery.

Status: Completed.

I-C Requirements imposed by Fast Control

FUNCTIONAL REQUIREMENT C.1: The ROM must adhere to all applicable interface protocols defined by the fast control system.

Justification: The purpose of the Fast Control System is to support the control of dataflow through the BABAR Electronics System. It provides a mechanism for distributing the "60MHz" System Clock. It also provides a mechanism for broadcasting prompt commands (referred to here as global fast control commands) and for collecting inhibit signals (referred to here as Busy signals). The Fast Control System may be designed so as to enable its use as a more general medium for prompt messaging with the Electronics System; however, at present it is not required to have that function.

Status: The interface definition of the fast control system to the ROM has not been completed, but adherence to the definition will be required.

FUNCTIONAL REQUIREMENT C.2: Each ROM must receive the System Clock from the Fast Control Distribution Module in its crate and distribute the clock to its associated Front-End Elements.

Justification: A detector-wide System Clock (SysClk) destined for Front-End Elements (FEEs) originates in the Fast Control System (FCS). A Fast Control Distribution Module (FCDM) is planned for each crate in order to distribute the clock to the ROMs.

Status: a) The mechanism for distributing SysClk between the FCDM and ROMs is not yet defined. This mechanism should be defined as part of the design of the FCS and the ROMs. b) SysClk is a signal of approximately 60MHz which is derived by dividing the PEP II RF signal by eight (RF88). It provides the basic synchronization and the precise timing required by the Electronics System.

FUNCTIONAL REQUIREMENT C.3: Each ROM must distribute the System Clock such that the jitter and stability at the Front End Elements is within the requirements of all front-end subsystems. The most stringent subsystem requirement is currently thought to be $+/-$ 0.5 ns.

Justification: The System Clock directly affects the timing performance of the front-end subsystems.

Status: a) Several elements affect the jitter and stability of the System Clock, including the module which extracts the RF signal from the PEP II timing system, the Fast Control System, the ROM, the links (presently called C-links) carrying the clock to the front-end subsystem, and the distribution mechanism (presently called the Transition Card) within the front-end system. The specification of the allowed jitter and stability contribution of each of these elements must be jointly specified as part of the design of the elements. The timing requirements of each detector-specific subsystem must be established in order to finalize this requirement. b) By jitter, we refer to pulse-to-pulse variations in timing over short periods of time. By stability, we refer to drifts over periods of time between calibrations.

FUNCTIONAL REQUIREMENT C.4: Each ROM must be capable of receiving global fast control commands from the Fast Control Distribution Module in its crate.

Justification: Global fast control commands destined for ROMs and for Front End Elements originate in the Fast Control System. A Fast Control Distribution Module is planned for each crate in order to distribute the commands to the ROMs.

Status: a) The mechanism for distributing commands between the FCDM and ROMs is not yet defined. This mechanism should be defined as part of the design of the FCS and the ROMs. b) The global fast control commands which must be received from FCS by the ROMs include: L1Accept Sync Clear Read Event others to be defined. The definition of these commands is defined by the dataflow control system.

FUNCTIONAL REQUIREMENT C.5: Each ROM must be configurable as to whether or not it responds to global fast control commands at a given time.

Justification: At certain times, e.g. during electronics commissioning, some ROMs resident in operational crates will not be operational. Consequently, a mechanism to "mask" the response of particular ROMs while "enabling" the response of others must exist. Global fast control commands are generally of a broadcast nature. In addition, it is anticipated that connectivity between ROMs and FCDMs will have practical limitations. Therefore, the ROM is the most convenient place to mask or enable response to global fast control commands.

Status: The mechanism imagined for configuring the enabling and masking of a ROM is via a command from the Readout Controller (ROC) in the crate containing the ROM.

FUNCTIONAL REQUIREMENT C.6: Each ROM must receive the L1Accept signal and distribute L1Accept to its associated Front End Elements (FEE) with a fixed latency and within the maximum allowable trigger latency.

Justification: The use of fixed level 1 latency simplifies the design of FEEs. Certain FEEs (e.g. SVT ICs) have been designed with fixed latency of a particular value. The L1Accept signal must be generated by the Trigger System and distributed by FCS, ROMs, and detector-specific subsystems within the specified latency (12us). The specification of the allowed latency contribution of each of these elements must be jointly specified as part of the design of the elements.

Status: Completed.

FUNCTIONAL REQUIREMENT C.7: The latency of the trigger, sync, and calibrate signals through the ROM must be fixed.

Justification: Each ROM must distribute time critical signals with a fixed latency to its associated Front End Elements.

Status: Completed.

FUNCTIONAL REQUIREMENT C.8: Each ROM must be capable of transmitting its set of Busy signals to the Fast Control Distribution Module in its crate.

Justification: The ROMs control the transfer of data from FEEs to ROM memory. In order to avoid the loss of data due to buffer overflow or other possible conditions, a prompt mechanism for each ROM to halt the issuance of further trigger accepts (L1Accepts) must exist. FCS provides the prompt mechanism for collecting Busy signals from ROMs and relaying them to the Trigger System.

Status: a) The set of Busy signals is not yet defined. The set is presently thought to consist of at least a Buffer Full signal and a Buffer Almost Full signal. The definition of the set of possible Busy signals must be determined as part of the design of dataflow control. b) The mechanism for communicating Busy signals between the ROMs and FCDM is not yet defined. This mechanism should be defined as part of the design of the FCS and the ROMs.

FUNCTIONAL REQUIREMENT C.9: Each ROM must be configurable as to whether or not it transmits its Busy signal at a given time.

Justification: At certain times, e.g. during electronics commissioning, some ROMs resident in operational crates will not be operational. Consequently, a mechanism to "mask" the response of particular ROMs while "enabling" the response of others must exist.

Status: The mechanism imagined for configuring the enabling and masking of a ROM is via a command from the Readout Controller (ROC) in the crate containing the ROM.

FUNCTIONAL REQUIREMENT C.10: Each ROM must be configurable as to whether it initiates the Read Event command sent to its associated Front End Elements or whether it receives Read Event externally.

Justification: Although the normal operating mode will involve the ROM issuing a Read Event in response to a L1Accept, there will be modes of operation (e.g. during subsystem commissioning or dataflow diagnostics) that will be facilitated if the issuance of Read Event can be synchronized across a crate of ROMs (or across a subsystem).

Status: a) This requirement is not strict. However, a mode of operation in which Read Event can be synchronized across a crate is highly desirable. b) When configured for an external Read Event, the ROM must provide an appropriate mechanism to signal the source of the Read Event when it is not ready for a Read Event command. c) The source of an external Read Event command is not yet determined. It could be the ROC, or the FCDM, or either. d) ROM configuration for this mode is assumed to be via the ROC in the ROM crate.

FUNCTIONAL REQUIREMENT C.11: The ROM must be able to maintain a timebase using the system clock signal and the timebase should be synchronized to other readout modules and systems using a "sync" signal expected to be defined in the fast control interface.

Justification: The fast control system is expected to define this signalling.

Status: Still pending definition of the fast control system.

FUNCTIONAL REQUIREMENT C.12: The ROM should be able to execute a rapid clearing of buffers using "clear" signal expected to be defined in the fast control interface.

Justification: The fast control system is expected to define this signalling.

Status: Still pending definition of the fast control system.

FUNCTIONAL REQUIREMENT C.13: Each ROM must be capable of transmitting a request for resynchronization to the Fast Control Distribution Module in its crate.

Justification: Dataflow control requires that ROMs have a mechanism for detecting the loss of synchronization either by one or more of its associated FEEs or by itself. Dataflow control also requires that ROMs have a mechanism for signalling the loss of synchronization and for requesting resynchronization. FCS provides a mechanism for transporting the request for synchronization.

Status: a) The most effective mechanism for transporting requests for resynchronization has not yet been established. Possibilities include via FCS or via ROCs. The optimum mechanism will be determined by the promptness of response required, which is determined in turn by the frequency of requests and the time required to resynchronize. These must be determined by the design of the dataflow and of the ROM. b) ROM configuration for this mode is assumed to be via the ROC in the ROM crate.

FUNCTIONAL REQUIREMENT C.14: Each ROM must be capable of executing the role of calibration controller for its associated Front End Elements, if so required by a detector-specific subsystem.

Justification: Timely calibration of FEEs is a required function of the Electronics System. Calibration functions may be executed more promptly if executed in parallel, for instance under the control of individual ROMs in parallel. Therefore, some calibration functions may require parallel control of calibration by the ROMs.

Status: This requirement is not established. Furthermore, it is not a requirement imposed by FCS.

I-D Requirements Imposed by the Trigger

FUNCTIONAL REQUIREMENT D.1: The ROM must be able to receive and process events at a 2 KHz average rate.

Justification: The maximum average rate of first level triggers is expected to be 2 KHz.

Status: Completed, unless new trigger calculations indicate a different rate.

FUNCTIONAL REQUIREMENT D.2: The ROM must not process events unless a L1 accept signal is delivered No L1 reject signal is defined.

Justification: The fast control protocol defines a L1 accept signal but does not define a L1 reject signal.

Status: Completed.

FUNCTIONAL REQUIREMENT D.3: ROM must be able to accept L1 triggers with a minimum spacing of 1.5 microseconds.

Justification: This is the defined minimum interval between level 1 triggers and was derived from the requirements of the SVT readout, the speed of the fast control system to throttle triggers, and the response time of the drift chamber.

Status: The 1.5 microsecond interval greatly exceeds the interval needed to meet the deadtime requirements of the experiment, so larger minimum intervals are still acceptable if justified.

FUNCTIONAL REQUIREMENT D.4: ROM must be able to interpret L2 accept and reject signals.

Justification: A level 2 trigger, though not expect to be installed in the initial configuration of the experiment, is an upgrade option.

Status: Completed.

FUNCTIONAL REQUIREMENT D.5: ROM must be upgradeable through hardware or software to receive and process events at 10 KHz.

Justification: Future luminosity upgrades of the accelerator may lead to increased backgrounds and trigger rates.

Status: This "safety" margin appears to be already implemented in the designs of the front-end systems. Providing this same margin the in design of the ROM would also make good sense if the cost is minimal.

FUNCTIONAL REQUIREMENT D.6: ROM must be able to deliver fully processed or partially processed events and other information such as hit maps to the L2 or L3 software filters.

Justification: The level 2 or level 3 software filter algorithms will require hit information especially from the silicon vertex detector in order to eliminate most lost particle debris trigger background processes.

Status: Software filter algorithms based on simple hit maps are sufficient to reduce the trigger rate to the physics rate. This data could also potentially be provided by the ROC.

I-E Requirements Imposed by Software Interfaces

FUNCTIONAL REQUIREMENT E.1: The ROM must support the VxWorks Operating System in a mode that allows both remote login (for debugging purposes) and access by the Readout Controller.

Justification: The VxWorks operating system has been chosen as the standard real-time system for BaBar. As such it will be resident in the Readout Controllers and other VME modules. It provides a highly interactive debugging and communication environment as well as supporting the hard real-time requirements necessary during data taking.

By requiring that the ROM support the VxWorks Operating System, considerable savings are possible, both in programming productivity (because of the experience already gained in the use of VxWorks in other VME modules) and robustness, but also in cost savings since the large number of target licenses allows

BaBar to negotiate a very favorable cost per license across the entire project.

Status: The VxWorks requirement is firm. Other aspects are preliminary.

FUNCTIONAL REQUIREMENT E.2: The ROM must support the VxWorks operating system and be compatible with a C runtime environment and operate with Wind River Systems debuggers and C language compilers.

Justification: The dataflow and buffer management code are designed to operate with VxWorks system calls. These codes are written in the C language.

Status: The selection of VxWorks was initially driven by the choice of EPICS as the slow controls software for the ROC. The requirement is now completed.

FUNCTIONAL REQUIREMENT E.3: The ROM software must provide a software interface to low level operations on the hardware.

Justification: A standardized library of code that interfaces to the hardware decouples changes in register definitions and mappings as well as easing the development cycle and simplifying the access of higher level code to the hardware.

Status: The specification of this software definition has not been completed.

FUNCTIONAL REQUIREMENT E.4: The ROM software must provide a code level functional interface to sequences of operations that operate on the hardware.

Justification: The user code must be able to access front-end elements and perform operations upon the hardware. These accesses may involve sequences of operations upon the hardware. This user code can be resident on the ROM or the ROC. A library of procedural functions the access to the hardware from both the ROM and ROC and to simplify the users knowledge of specific and complex operations.

Status: This library is clearly desirable, however the establishment of this as a requirement is not strict. The specification of this software definition has not been completed.

FUNCTIONAL REQUIREMENT E.5: The ROM must provide adequate instruction and data store for having a resident operating system, buffer management code, user code, calibration constants, and event store.

Justification: Sufficient memory must exist to provide the full functionality of the code.

Status: Completed, however the amount of memory needed has not yet been determined. The VxWorks software may take up from 512Kbytes to 1 MByte although the kernel is less than 100 Kbytes. Most of the extra memory requirement of the software is driven by having a runtime shell and by the requirements of the shared memory driver and shared buffer pool and by running a network stack. A shell and a network stack are not likely to be requirements during data taking operation; however, they could be very useful for debugging applications.

FUNCTIONAL REQUIREMENT E.6: The ROM must provide a power-up boot, UART interface, and timers, for conforming to the requirements of VxWorks.

Justification: Wind River has a very strong preference for developing board support packages for hardware with a complete set of minimal functionality that include boot, serial interface (UART), and user defined timers.

Status: Completed.

I-F Requirements imposed by the communication protocol with the front-end systems

FUNCTIONAL REQUIREMENT F.1: The ROM must provide a serial fiber-optics transmission link (C-link) for electronics control of the front-end electronics systems.

Justification: The Babar electronics and computing groups have established a common interface protocol between the ROM and the front-end systems that all subsystems should adhere to.

Status: Firm

FUNCTIONAL REQUIREMENT F.2: The ROM must provide a serial fiber-optics receiver link for reception of data from the front-end electronics systems.

Justification: The Babar electronics and computing groups have established a common interface protocol between the ROM and the front-end systems that all subsystems should adhere to.

Status: Firm

FUNCTIONAL REQUIREMENT F.3: The protocol transmitted on the serial C-link must adhere to the protocol described in BaBar Note 281 , "BaBar Protocol for Electronics Control and Dataflow between the Read-Out Module and the Front-End Electronics Systems"

Justification: The Babar electronics and computing groups have established a common interface protocol between the ROM and the front-end systems that all subsystems should adhere to.

Status: Firm

FUNCTIONAL REQUIREMENT F.4: The ROM must be able to accept and handle data transmitted from the front-end electronics systems which adheres to the protocol described in BaBar Note 281 , "BaBar Protocol for Electronics Control and Dataflow between the Read-Out Module and the Front-End Electronics Systems"

Justification: The Babar electronics and computing groups have established a common interface protocol between the ROM and the front-end systems that all subsystems should adhere to.

Status: Firm

I-G Requirements imposed by front-end systems in general

FUNCTIONAL REQUIREMENT G.1: The personality module must adhere to Babar standards for front-end communications.

Justification: The Babar experiment has adopted a common protocol for communications with the front-end systems.

Status: A serial protocol that uses a 800 nm wavelength 50 micron fiber with an SC type dual connector and 1 mW of launched optical power as the physical medium is currently being tested. The transmission protocol is based on the gigabit serializer/deserializer manufactured by Hewlett Packard under the trade name G-link, a 20/24 bit proprietary transmission protocol. The physical protocol and transmission protocols are being tested for adherence to timing stability (drift and jitter) requirements. A Babar defined protocol for the data format that establishes the command, data, and control protocols for both the uplink and downlink have been completed.

FUNCTIONAL REQUIREMENT G.2: The ROM must be able to generate through internal operations the complete suite of front-end "sub-system specific" commands.

Justification: The front-end interface protocol defines a set of "sub-system specific" commands.

Status: Completed.

FUNCTIONAL REQUIREMENT G.3: The ROM must maintain a model of front-end buffer occupancies and provide signaling to the fast control interface to prevent overruns.

Justification: When a trigger is issued it is a requirement of the architecture that buffer space is available. This ensures that complete events will be taken.

Status: Completed.

FUNCTIONAL REQUIREMENT G.4: The personality module must be able to send "read event" commands at appropriate times after the issuance of a trigger. The read event must follow a trigger by no less than 1.5 microseconds and readout strobes can not be issued until the previous readout is completed.

Justification: Several front-end systems cannot accept a read event until the data is processed following the trigger. This processing interval is 1.5 microseconds.

Status: Completed.

I-H Requirements imposed by front-end systems – Calorimeter

FUNCTIONAL REQUIREMENT H.1: The ROM must be able to download calibration constants for the look-up table correction amounting to 32 Kwords per channel where each word is 18 bits. Calibration constants must be calculated locally prior to entry in the look-up tables.

Justification: The calorimeter electronics uses a large look-up table to normalize and linearize raw data values.

Status: Completed.

FUNCTIONAL REQUIREMENT H.2: The ROM must be able to provide source calibration using a locally derived trigger.

Justification: No conceivable physics justification since the high rate of Bhabhas provides a continuous source of monitoring information during running.

Status: The installation and availability of multi-MeV sources in the Babar detector is considered problematic.

FUNCTIONAL REQUIREMENT H.3: The ROM must provide a mechanism for sharing data between modules for the purposes of implementing calorimeter energy threshold suppression.

Justification: Suppression of calorimeter signals based on an energy threshold will require at a minimum that crystals neighboring a crystal with an energy deposition over threshold be contained in the data stream. This due to the spreading of electromagnetic showers into multiple CsI crystals.

Status: The suppression of calorimeter signals based on an energy threshold has not been finalized.

FUNCTIONAL REQUIREMENT H.4: A single ROM must also be able to perform feature extraction after zero suppression and this will require 7 SPECint to achieve the 2 KHz throughput assuming a 48 channel input stream. If no zero suppression is adopted then the requirement becomes 100 SPECint and a bus bandwidth of 12 MB/s is allocated to this data.

Justification: See informal notes by J. Nash and W. Innes on performance benchmarks for the calorimeter data feature extraction algorithm. These calculations indicate that 100 SPECint of processing is required to perform the necessary data reduction. In theory this processing can be minimized by only performing the calculation selectively on channels that are occupied. Occupancy can be determined a priori by using the "FEX" flag (see page 22 of the calorimeter electronics system description). This flag is available to the ROM CPU in the input data stream. The definition of this flag is: "this flag indicated whether this [channel] is worth feature extracting in and of itself. At the time of writing the mechanism for feature extraction has not been fully specified ..."

A calorimeter channel could be selected for feature extraction if the channel or a neighbor is over some predefined energy threshold. The FEX flag information can be summarized at the board level for communication to neighboring ROMs. In the TDR, the flux of particles into the whole calorimeter is given by flux = 15.7 * exp(-E/3.5) Photons/usec/MeV at nominal background and the flux over a given threshold is 55 * exp(-E/3.5) Photons/usec/MeV. At ten times background the flux of photons in the whole calorimeter is 30 photons/usec over a 10 MeV threshold and 1.8 photons/usec over a 20 MeV threshold. One can calculate the probability that a channel must be feature extracted given the number of crystals in the calorimeter and in the region in and surrounding that section physically mapped into a single ROM. Here it is assumed that a crystal that abuts a crystal that is over threshold must be processed irrespective of its own energy value. The algorithm used here assumes that the crystals along each of the four edges of the rectangular group mapped into a ROM are summarized into a four separate flags and transmitted to the neighboring ROM. For a 10 MeV threshold the probability at ten times the nominal background is 7.2%, and at 20 MeV threshold the probability is 0.4%. The requirement of 7 SPECint scales the calculation by J. Nash assuming a 7% feature extraction probability per channel.

Status: The suppression of below threshold channels is still under discussion.

FUNCTIONAL REQUIREMENT H.5: A single ROM must be able to store and have readout the times and energies from 48 channels per event. This will require 1 byte per time datum and 2 bytes per energy datum. The ROM must then achieve 288 Kbytes/sec readout throughput of data assuming no energy threshold suppression of channels.

Justification:

Status: The event data collection network is not designed to deal with the aggregate bandwidth of all ROMs in the calorimeter (40 MB/s) unless some energy threshold suppression is applied. The TDR assumed an 84% reduction in bandwidth due to threshold suppression.

I-I Requirements imposed by front-end systems – Drift Chamber

FUNCTIONAL REQUIREMENT I.1: A single ROM must be able to interface to 512 Drift Chamber channels and perform sparsed feature extraction to determine dE/dx sums. At ten times nominal background and 2% occupancy this will require 3 SPECint to achieve the 2 KHz throughput.

Justification: A simple model of the drift chamber feature extraction indicated that it takes 2.5 microseconds per hit to perform the dE/dx summation on the input waveform on a 60 MHz PPC601 processor.

Status: The number of channels per ROM for the drift chamber electronics has not yet been determined.

I-J Requirements imposed by front-end systems – SVT

FUNCTIONAL REQUIREMENT J.1: A single ROM must be able to format, and gain/pedestal correct at a 2 KHz average rate the sparsified data at ten times the nominal background. This corresponds to 400 hits per DAQ board when a board maps to a phi wedge representing approximately 1/24th of the detector and is along the median plane of the detector where the background peaks. This has been benchmarked in a simplified algorithm to require 10 SPECint.

Justification: Performing the gain and pedestal corrections to the data in the ROM is a convenient location to perform this function but is not a requirement. In fact this will serve to expand the data from a compact bit mapped format to byte or word aligned data that has a deleterious impact on the readout bandwidth.

Status: Optimization of where gain and pedestal correction is performed (between ROM, ROC, or L3 farm) has not been performed.

FUNCTIONAL REQUIREMENT J.2: A single ROM must be able to store and have readout an average of 400 zero suppressed hits per event at ten times nominal background and at 2 KHz average readout rate (1.6 Mbyte/s). This Monte Carlo calculated rate corresponds to the median plane of the detector where the background is at maximum.

Justification: With the exception of the Calorimeter with an unsuppressed readout the SVT presents the highest readout bandwidth requirement on the ROM. This bandwidth must be readily achieved in order to obtain low deadtimes at high trigger rates.

Status: The physical organization of SVT readout sections into the ROMs has not yet been determined. Different physical groupings can serve to average the high peak occupancies in certain regions of the detector.

FUNCTIONAL REQUIREMENT J.3: A single ROM must be able to provide to L2 a hit map of the occupied SVT phi and z strips at the 2 KHz rate at ten time nominal background. This corresponds to a requirement of 30 SPECint.

Justification: In one possible scenario for a putative level 2 trigger a coarse hit map is provided.

Status: The concept for a L2 trigger is in early stages of development.

FUNCTIONAL REQUIREMENT J.4: The minimum spacing between a level 1 accept and a read event is 1.5 microseconds. The minimum spacing between the completion of event data transmission from the SVT front-end and the next read event is 1.5 microseconds.

Justification: The minimum time interval for the SVT readout chip to perform zero suppression and ready the data for readout is 1.5 microseconds. An attempt to read the data while zero suppression is in progress will result in invalid data.

Status: Completed.

I-K Requirements imposed by front-end systems – DIRC & IFR

I-L Requirements imposed by front-end systems – Level 1 Trigger

FUNCTIONAL REQUIREMENT L.1: A single ROM must be able to perform zero suppression and limited histogramming on the Level 1 Trigger system DAQ data at a rate of up to 2 KHz. This is expected to require no more than 5 SPECint per ROM in each of the calorimeter, drift chamber and global trigger crates.

Justification: The trigger system data is treated in the same fashion as data from a front end system.

Status: The data format and the type of processing required for the trigger data has not been established yet.

FUNCTIONAL REQUIREMENT L.2: The ROM must be able to provide a playback function to trigger diagnostics.

Justification: The trigger requires a stand-alone mode of operation for diagnosing internal failures. This diagnostic mode requires a high bandwidth digital stream that can mimic the signals normally received from the calorimeter and drift chamber. This playback mode is similar to the front-end download mechanism in the ROM for front-end elements.

Status: Completed.

I-M Requirements imposed by Crate standards, power, grounding, and cooling

FUNCTIONAL REQUIREMENT M.1: The ROM must adhere to VME-E 6U electrical specifications.

Justification: The VME-E standard provides significant improvements over VME-D including significantly more power and ground connections which are deficient in VME-D. Also included are additional user defined pins. The VME-E standard provides 3.3 volts power which conforms with the typical voltage requirement of present day memory and processor systems.

Status: No decisions about a Babar crate standard have been made yet.

FUNCTIONAL REQUIREMENT M.2: The ROM must adhere to VME-E mechanical specifications.

Justification: The VME-E standard defines a five row connector that is both backward and forward compatible with the VME-D standard. However, to access 3.3 volt power and the additional user defined pins this new connector must be utilized.

Status: No decisions about a Babar crate standard have been made yet.

FUNCTIONAL REQUIREMENT M.3: The ROM must adhere to Babar crate and backplane standards.

Justification: The distribution of fast control signals will require an enhancement to the VME backplane. Since these signals are time critical the backplane with these enhancements will require standardization across Babar.

Status: No decisions about a Babar crate standard have been made yet.

References

[1] The *BaBar* Collaboration, Technical Design Report, Report SLAC–R–95–457 (1995).

I-N Conclusions