12 Data Acquisition and Triggering

12.1 Introduction

The Data Acquisition System (DAQ) reads the event information and writes data to mass storage. Monitoring the detector performance (PMT rates, trigger rates), slow control of the hardware components (HV, thresholds, trigger) and execution of calibration runs are additional functions. Capability to do online event-filtering is desirable.

AMANDA has unique experimental advantages compared to other High Energy Neutrino Detectors:

- All essential electronic components and the DAQ are located above the ice.
- Upgrades of all components (trigger, electronics, DAQ) are easily possible. This allows for
  - Upgraded trigger schemes for larger arrays, incorporating all already deployed PMTs
  - DAQ upgrades for higher data rates (higher effective detector areas).
  - New dedicated physics trigger (e.g. HE-shower trigger),
  - Upgrades in the calibration tools
- The muon trigger for current arrays can be kept simple due to low PMT noise rates.
- Reliability requirements for electronic components are comparable to laboratory experiments.
- Even a complete electronics redesign is possible if needed for a km^3-detector.

These advantages allow for an 'evolutionary' development of the detector, according to gathered experimental experience - important for this new field.

The AMANDA-B electronics system had been almost entirely build from commercial electronic modules. Main exceptions are: the SWAMP-Amplifiers, the DMAD-trigger unit and the SNMP/GRB-DAQ system. The muon event trigger is a majority logic for a fixed coincidence window. The bus system used is CAMAC, with its limitations in readout speed and processing power. The DAQ uses a commercial software package with limited performance.

For AMANDA-II, a new DAQ with a modern architecture is in preparation. The upgrade includes the following steps:

- Transition to a modern and flexible VME–based DAQ in 1997/98
- Newly deployed modules are to be readout by VME modules, all existing CAMAC electronics (AMANDA-B) are incorporated
- The AMANDA-II trigger will in 1998 be a majority trigger as for AMANDA-B. New trigger strategies for noise suppression (towards km^3) and extended online event filtering will be developed in 1998 and implemented in 1998/99.

- For the km^3 detector or even the 1999 stage of AMANDA-II, we consider the possibility to adapt the existing SNO-electronics for AMANDA, with its ASIC-based high packing density giving cost-reductions.

Below, we discuss the event trigger, describe the current AMANDA-B DAQ system and its upgrade towards AMANDA-II, to be installed in the 1997/98 campaign.

12.2 Trigger and Data Rates

The **muon event trigger** for AMANDA-B and AMANDA-II is designed to trigger muon tracks passing through or nearby the array, as well as electromagnetic (and hadronic) shower events (see sect.2). It is a conceptually simple majority trigger logic, requiring a minimal number of PMTs hit in a fixed coincidence time window τ_{coinc} :

$$N_{hit} \geq N_{trigger}. \qquad (Trigger - Level - 0)$$

N_{hit} is the total number of hit OMs in the array for a coincidence time window τ_{coinc} of typically 2 μsec. For the current arrays, this time is defined by the geometrical scale of the full array: The times to pass the largest geometrical distance inside AMANDA-B–10 are 1.4 μsec and 1.9 μsec for a relativistic particle and for straight traveling light, respectively. The trigger threshold $N_{trigger}$ was set to 8 for AMANDA-B-4 and is set to 16 for AMANDA-B-10. Fig.84 shows the hit time distribution of all PMTs in an event as recorded by the Time-to-Digital converters (TDCs) for AMANDA-B-4 (shown is only the first hit for multiple hits on a PMT). The low hit density at the start of the trigger window demonstrates the high efficiency of this trigger condition.

Cable delays of signals from PMTs further down in the ice reduce the acceptance for down-going (background) muon tracks compared to up-going (signal) muons. This effect is small for AMANDA-B and AMANDA-II, and is taken into account in the Data Analysis by MC-Simulation.

We mention that, contrary to this simple majority trigger, experiments like DUMAND or NESTOR (with much higher in-situ noise rates) have to perform already for their 200-PMT-arrays complicated local underwater triggering [46], in order to handle the high data and trigger rates.

For the AMANDA km^3–detector, the simple array-majority trigger will have to be modified, since larger number of PMT and increased muon crossing time (increased τ_{coinc}) result in too high accidental noise trigger rates. A noise-rejecting trigger would help in AMANDA-II already.

The idea is, to accept high PMT-multiplicity events unbiased, and have for lower multiplicities additional rejection power against noise dominated events. A simple way to do this will be majority triggering for sub-detectors (e.g. string-wise) with lower $N_{trigger}^{string}$ and combining sub-triggers at the array level. Since for a large volume detector a high amount of high energy muons will range out within the detector, new trigger schemes for several muon energy regions could be possible (e.g. lookup tables or signal processor boards for 'quasi-local trigger cluster' finder

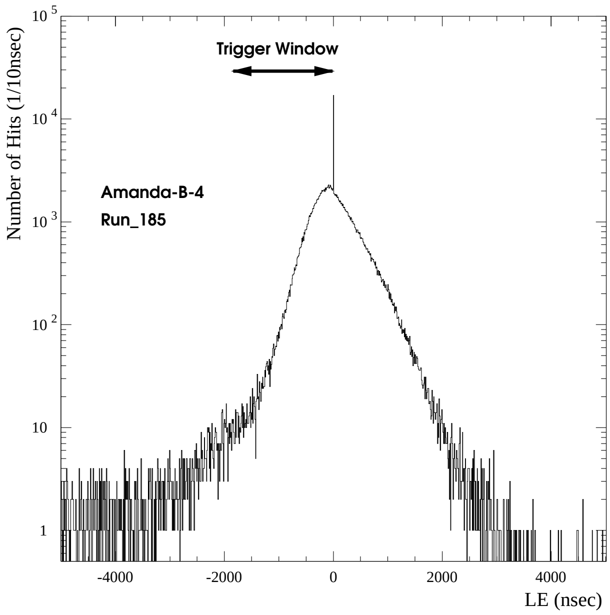

Figure 84: Distribution of all PMT hit times (first leading edges ('1st LE')) for the AMANDA-B-4 detector in standard trigger mode: trigger threshold $N^{array}_{trigger}$=8, $\tau_{coinc} = 2\mu sec$. The peak at LE=0 corresponds to the trigger signal position, fixed in time with respect to the Stop signal of the TDC.

or fast array-track-finding algorithms). Also, special algorithms for 'shower trigger' as well as rough 'very high energy' filter are considered.

Various trigger schemes for the large arrays are currently under MC-consideration. For trigger-level-0, existing trigger-hardware has to be modified (DMAD system, see sect.12.3.1) or to be build (lookup–tables or signal processor boards). The upgraded AMANDA-II–DAQ will leave flexibility for additional level-1 trigger to be implemented either at VME or DAQ-Host level. We are also investigating, to which extent a more sophisticated trigger system would allow for lower trigger-level-0 thresholds and modified coincidence windows τ_{coinc}, leading to higher effective areas for AMANDA-II already.

Four **external triggers** are accepted by AMANDA-B and AMANDA-II, apart from the muon trigger: AMANDA-A (see sect.4), the South Pole Air Shower Arrays SPASE-1 and SPASE-2 (see sect.8.2.1), and the Čerenkov Telescope GASP (pointing towards AMANDA-B). All triggers cause a readout of the AMANDA-B detector ('Slave trigger' mode). The rate for each of the external triggers is typically $\approx$1-2 Hz.

Trigger rates observed for AMANDA-B-4 are 23 Hz for a threshold $N_{trigger}$=8, for AMANDA-B-10 at $N_{trigger}$=16 the measured rate is $\sim$80 Hz.

Data rates for AMANDA-B-10 are 33 kB/s for the muon trigger $N_{trigger}$=16. This amounts to 2.5 GB/day (after data-compression). The data are written to a total of 18 DAT-tapes per week. A fast preliminary off-line filter for up-going neutrino event candidates reduces the data rate to about 70 MB per day, which are send back to the home institutions via satellite links (available AMANDA bandwidth currently is $\leq$100 MB/day). The full data sample is shipped from Pole once per year (at station opening in November).

As a reasonable upper limit for the data rate to tape for AMANDA-II in 1997/98, we define about 2-4 times the current rate, i.e $\leq$ 10 GB/day. This assumes that no major efforts are done to upgrade the South Pole off-line processing and tape handling power. For the trigger rate, the current MC estimate gives $\leq$200 Hz for $N_{trigger}$=16 (see 5). The majority trigger threshold $N_{trigger}$ will finally be adjusted in accordance with above data rate limits and the dead-time of the new DAQ.

12.3 AMANDA–B

12.3.1 AMANDA-B Electronics

The information recorded for each AMANDA muon trigger consists of TDC values (leading edge and time-over-threshold [TOT] for up to 8 hits per PMT), one ADC value per hit PMT, and additional information (the event UTC-time, delivered by a Global Positioning System receiver [GPS], and trigger flags).

The AMANDA-B principal scheme is given in figure 85. Apart from the SWAMP-modules and the DMAD trigger system, all major AMANDA-B electronic components for muon registration are commercial CAMAC- and NIM-modules.

All 302 AMANDA-B-10 PMTs are connected to surface by coax- and twisted-pair cables (apart from 21 PMTs connected additionally by optic fibers, see sect.10). They operate at $\approx 10^9$ gain. Signal amplification and high voltage decoupling is done by the SWAMP-Modules ('Swedish Amplifiers'), having adjustable amplification gains (max. 200) in the two output channels. Prompt outputs ('A', see fig.85) are connected to the discriminator inputs and set to gain 100, the 2 μsec delayed output ('B') are fed into the ADCs and set to gain 50 (25 for the coax cables in AMANDA-B-4). As discriminators LeCroy 4413 and 3412E are used.

The gain calibration performed for each PMT adjusts its HV around the pre-calibrated 10^9–value such, that the 1-pe signal at amplifier output 'A' is about 500 mV (400 mV for coax connected PMTs). With a common discriminator threshold of 100 mV (140 mV for the coax signals), a sufficient 1-p.e. trigger efficiency (80-90%) is found. PMTs with lower HV values for 10^9-gain are put deeper in the array, to compensate for losses due to different cable lengths. The discriminator outputs (ECL) are fed into the TDCs and into the Majority Logic Unit (DMAD - 'Digital Multiplicity Adder', see [54]). The DMAD-majority trigger unit is supplying the AMANDA-B muon trigger, see sect.12.2. It is derived from comparing the sum of all 302 input signals, stretched to the selected coincidence window (2μsec), with a threshold value corresponding to $N_{trigger}$ = 16 (AMANDA-B-10).

For AMANDA-B, two sets of discriminators are used, since it was originally planned to operate at two different thresholds (TDC - low threshold for good timing, and DMAD - high threshold for noise free trigger). Currently, both sets are operated at the same threshold, for AMANDA-II only one discriminator per PMT will be kept.

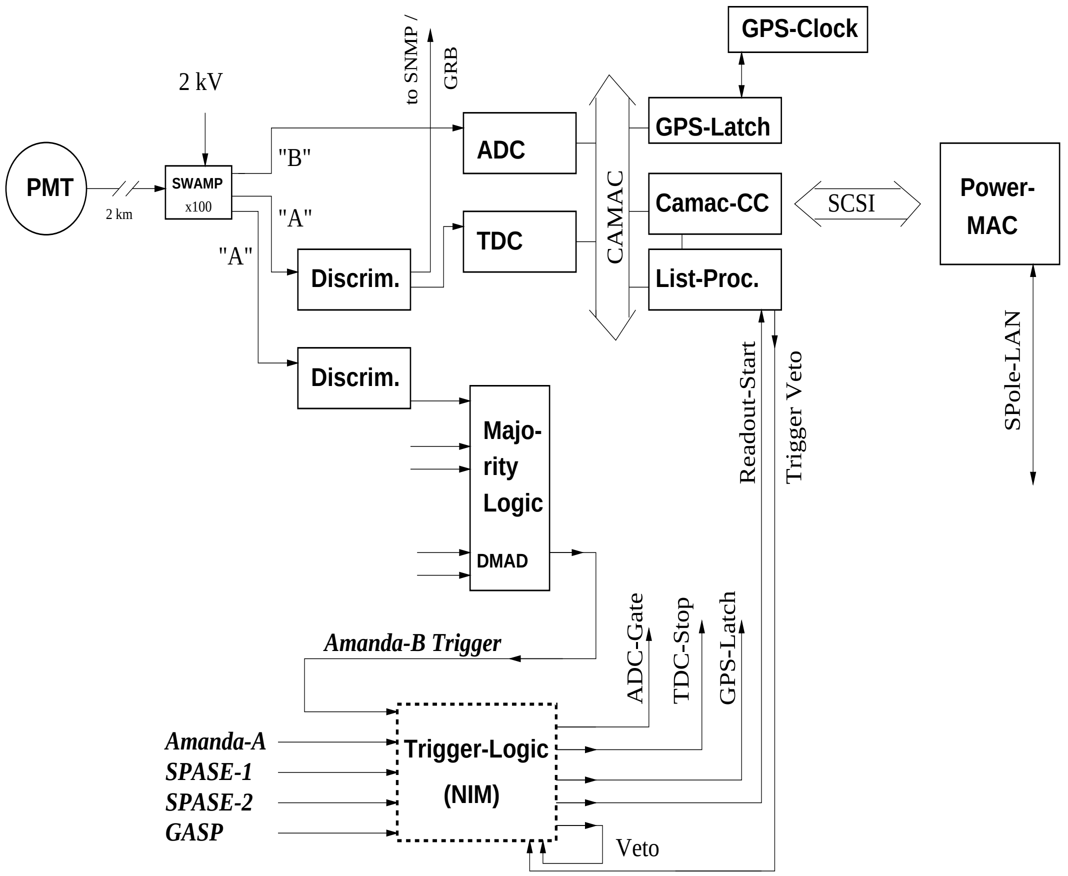

Figure 85: Principal scheme of the AMANDA-B Electronics (1995-1997). CAMAC readout is via the DAQ–Macintosh, connected to South Pole-LAN.

Amplitude: With an event duration in the $2\,\mu$sec range for AMANDA-B and the slight bipolar character of the amplifier output pulses, the most precise amplitude measurement is achieved by peak sensing ADCs, gated for $3\,\mu$sec. AMANDA-B uses the 16-channel Phillips ADC7164 with 4 V/12 bit dynamic range, fast enough to follow the rise time of the twisted-pair pulse. Amplitude information is used for correcting the measured leading edge times.

Pulse-shape: The rise time is 60 nsec for twisted-pair transmission and 200 nsec for coaxial cables. At these long rise times, a considerable time-jitter is introduced by time-walk due to pulse shape differences (high amplitudes trigger earlier due to sharper rise, see [4]. Time walk correction for a given amplitude A_i according to $\delta t \sim 1/\sqrt{A_i}$ yields a 1-pe time resolution of $\sigma_{1pe} \approx 3\,$nsec.

TDC: AMANDA-B uses multi-hit TDCs - the LeCroy TDC3377 with 0.5 nsec resolution and up to 8 hits (leading + trailing edges, to allow determination of TOT) in a $32\,\mu$sec time window. Multi-hit capability is useful, since the pulse length contains amplitude information and offers independent cross-talk pulse rejection capability (very small TOT). For optical fiber signals, multi-hits correspond to individual photons arriving, for the coax/twisted-pair signals the detection of afterpulses is a measure for very high amplitudes.

Trigger Logic: The event trigger is build from several NIM-modules, and is the OR of the DMAD-majority trigger signal and the other trigger inputs (AMANDA-B acting as a slave to AMANDA-A, GASP, SPASE-1 and SPASE-2). Once a trigger has been fired, the ADC-gate is opened, the (15 μsec delayed) common TDC-Stop Signal is formed, and the CAMAC readout is triggered with 100 μsec delay. Also, the trigger signal is used to latch a GPS-driven time stamp, delivered by a custom-made CAMAC module (precision 100 nsec). As the main GPS clock a 'TrueTime XL-DC/601' is used. Each AMANDA-B event trigger is vetoing the acceptance of another trigger-input, until the CAMAC readout is finished (see sect.12.3.2).

SNMP/GRB: We note, that two additional, separate trigger systems - the Supernova-Monopole-System and the GRB-system - are connected to another output of the discriminators, see fig.85. These autonomous DAQ are described in sect.13. They search for noise rate instabilities of all PMTs in the array on a scale of a few seconds (supernova neutrino signal) as well as a few msec (possible GRB neutrino signals), see also sect.2. The SNMP- and GRB-DAQs are using custom-made CAMAC boards for the dead-time-free counting rate latching, readout is via Jorway-73A SCSI-CAMAC controller into a PowerMac.

12.3.2 AMANDA-B - DAQ

The AMANDA-B DAQ reads out the 2 CAMAC crates with 20 ADCs and 10 TDCs (2×302 data channels) into the DAQ-Macintosh (a MAC-PowerPC 7200/90), which itself is connected to the South Pole Station LAN (Ethernet), see fig.85.

The DAQ software is based on a commercial package 'KMAX', designed for use in small scale laboratory experiments (similar to LabView). It suffers from speed limitations and general problems with the MAC-OS, when working in real-time applications. In particular, it was found that the only way to stably handle the uninterrupted data-output from MAC to a disk file was writing directly to an NFS-mounted disk over the LAN, which in turn is accessed by another workstation for further processing. This slows down and partly destabilizes the data taking additionally.

The CAMAC controller used is Jorway-73A, a SCSI-driven controller directly connected to the MAC (see [108] for details). Since single instruction CAMAC-access via SCSI is very slow, a List-Processor (LP1341) is included in the system. This List processor, connected to the CC-controller by Auxiliary-Bus, is loaded with a small program with all the CAMAC instructions to readout and setup the modules for the event trigger. This means, that an event trigger directly starts the event handling by the List-Processor, writing data into it's local 32 kB buffer. When this is finished, the List-Processor resets the Veto-flag inhibiting further trigger acceptance during event readout. When the LP1341-buffer is filling up, it is read out in fast CAMAC Block Transfer Mode to the MAC. The occupancy of the LP1341-buffer could in principle be permanently checked from the MAC by CAMAC commands, however since this process would generate significant dead-time to the DAQ, the LP-buffer is instead read out after a preset time interval of 600 msec.

Apart from the speed limitations of the system as it is operating now (33 kB/s data rate), additional drawbacks of the AMANDA-B DAQ are: Very limited detector monitoring and missing slow control functions. In particular the HV-power supplies (a LeCroy 1440 and a 1450 system), are operated from a VT100 terminal only. Due to the DAQ-architecture, there is no way to have a 'remote-login' to the system via e.g. a low speed-connection like the satellite-link to the Pole (for 'remote'-login the Timbuktu package is used over the Pole-LAN). This is essential for remote debugging during the winter.

The AMANDA-B DAQ is performing stable for this season. It is taking data at a trigger rate of ~80 Hz, with more than 90% uptime. Since this system is obviously not facing the needs of future detectors, the collaboration decided to upgrade it towards AMANDA-II.

12.4 Upgrade for AMANDA–II

12.4.1 Electronics

The new DAQ system will be based on VME, connected to a Unix DAQ-Host workstation via Ethernet. A sketch of the setup is given in fig.86. All essential CAMAC modules operating in AMANDA-B (10 TDCs, 20 ADCs, 40 Discriminators) are maintained, to save money and keep the transition smooth. TDC- and ADC-CAMAC modules are readout into VME, using the VSB-driven CAMAC-Controller CBV-610, as explained in sect.12.4.3. To access the 3 slow-control CAMAC-crates (housing the 4413- and 3412E-Discriminators, see fig.86), existing SCSI CAMAC-Controllers Jorway-73A (see sect.12.3.1) are used. These will be connected to a separate SCSI-interface on the DAQ-Host.

TDC: PMTs to be deployed in 97/98 campaign will be read out by VME-TDCs CAEN V673A [77]. These TDCs are very similar in performance to to the LeCroy TDC3377, used in AMANDA-B. The CAEN V673A is a 64 channel multi-hit/multi-event 6U-VME TDC, with a time resolution of 1 nsec, double pulse resolution of 8 nsec for up to 16 hits per channel (max. 64 μsec time window), operating in Common-Stop mode. All 126 fiber signals will have their TDC channel, some of the twisted pair cables will, for calibration purposes, also be connected to VME-TDCs.

Amplitudes: The intrinsic good timing of the fiber signals makes a time walk correction with amplitudes as for coax/twisted-pair obsolete. Amplitude measurement for physics analysis will be partially possible by counting the numbers of fiber-pulses (isolated in time photons) and their TOTs. Corresponding calibration measurements will be done with the installed PMTs in 1997/98. If the fiber technology will be successful, we consider an analysis of the pulse shape (waveform digitization). This will give essential amplitude information for very high energy events (shower and muons). Tests are underway, see e.g. the two Digital Optical Modules installed in 1996/97 [17, 38].

GPS: A VME-module to latch trigger signals and interface the GPS-clock to VME is under development, it is a modification of a board built for the L3-Cosmic experiment at CERN.

SNO-Electronics: In parallel to the implementation of the multi-hit TDCs, tests to adapt the custom-made SNO-electronic system [42] for AMANDA may be performed during the 1997/98-expedition. The main advantage would be reduction of cost, also power consumption and a higher packing density. The SNO experiment ('Sudbury Neutrino Observatory') [40] with it's 10000 PMTs operating in single-p.e.mode has, from a data acquisition point of view, a lot of similarities with the AMANDA detector. The SNO-electronics are based on three SNO-designed ASICs (Amplifier, Discriminator, Analog storage). According to [41], an adaptation of the SNO-electronics to the needs of AMANDA-II seems realistic, provided sufficient manpower and spare ASICs exist after the SNO detector commissioning. For the km^3 detector-scale, a redesign of the electronics (possibly including the ASICs) would be necessary.

12.4.2 DAQ Layout

The new DAQ uses for the first stage of AMANDA-II a single VME-CPU board only. It will be a RIO-2/8062 board (PPC604/200MHz) with VSB-interface. For a trigger signaled to the VME trigger module, the VME-CPU board sequentially reads out the CAMAC TDCs and ADCs, as well the VME TDCs. A VME-GPS interface module latches the GPS time needed to do astronomy and synchronization with SPASE-1/SPASE-2/GASP. For 1997/98, data analysis on the VME-CPU will be kept to a minimum.

To guarantee full bandwidth, the VME is interfaced via a 'private' Ethernet subnet to the DAQ-host, as seen from fig.86. Data storage to disk files will be local on the DAQ-Host, as opposed to the NFS-mounting under MAC-OS for AMANDA-B. For further analysis and output to tape, data are transfered via the LAN. The DAQ-Host is a Linux Pentium-II/200 MHz or a DEC-Alpha. On the DAQ-Host, data received from VME are processed: Event building and storage, quality checks, histograming for online-monitoring and data supply for event display are the main tasks. Slow control runs in parallel, checking for HV, status of the VME-/CAMAC-modules. Depending on the availability of fast trigger algorithms these can be implemented already in 1997/98. The new DAQ allows to do PMT gain calibration runs, avoiding to use a separate DAQ for this purpose, as done with AMANDA-B.

The DAQ is organized in a client-server concept, allowing for remote TCP-access for control and monitoring purposes (via South-Pole LAN, and also via Satellite link). This is shown in fig.87, overviewing the program functionality outlined above.

For the first stage of the AMANDA-II detector, the DAQ shall operate at a trigger rate of ≤ 300 Hz with acceptable dead-time. For the currently MC-predicted event rate of $\approx$200 Hz at threshold $N_{trigger}$=16 we expect a tape data rate of ~ 100 kB/s (~ 10 GB/day). Flexibility during setup is needed, since rate and event size predictions depend on not precisely known ice properties and experimental conditions (e.g. cross talk, PMT noise). The experimental trigger threshold will finally be adjusted to match the $\sim$10 GB/day limit.

For less rigid trigger conditions and/or a larger detector, an upgrade of the proposed DAQ. will be done. These higher detector read-out rates (≥ 1 MB/s) are available at the expense of either changing most of the CAMAC-TDCs and ADCs to VME, or at least dedicating VME-CPUs to each of the CAMAC-VSB branches (see sect.12.4.3), by going to a Fast-Ethernet connection between VME and DAQ-Host and by adding CPU-Power on the DAQ-Host to perform efficient online rejection.

To summarize, the main features of the AMANDA-II DAQ are:

- Monitoring detector performance

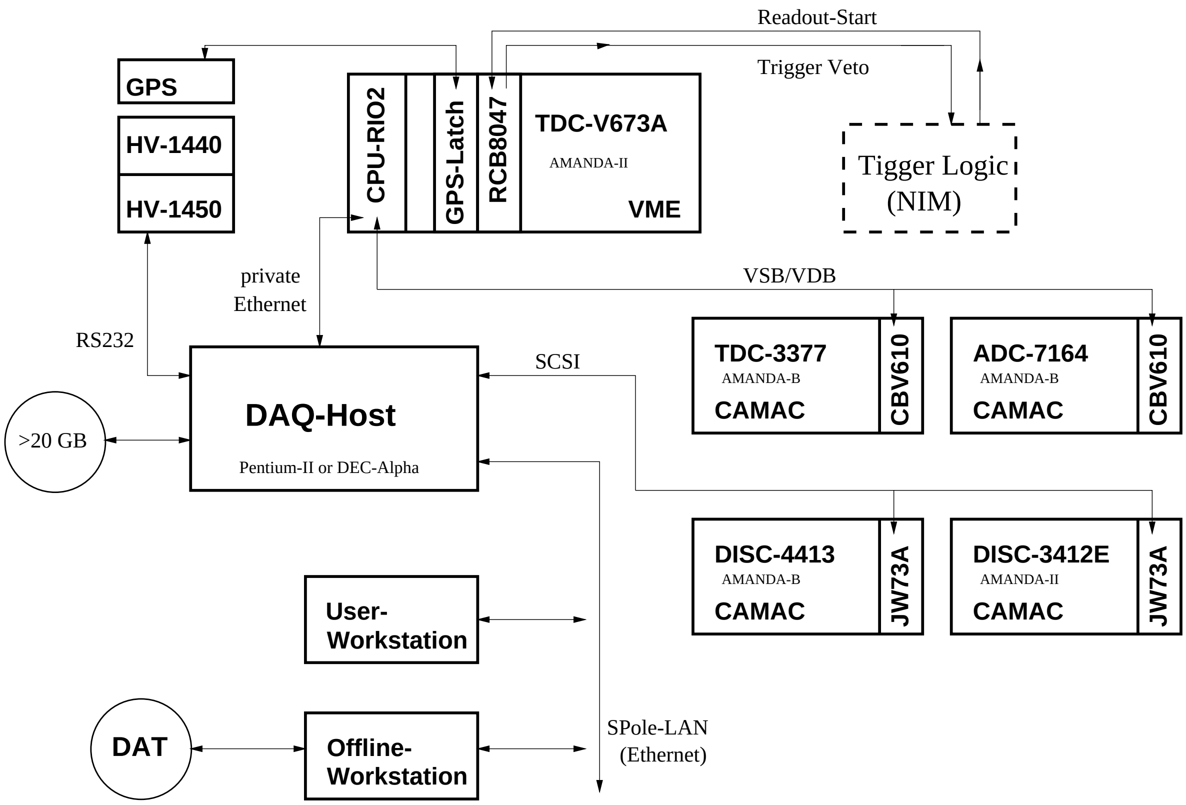

Figure 86: Simplified block scheme of the AMANDA-II VME-based DAQ systems, to be installed in the 1997/98 season. Details of the electronics and trigger system are omitted (see fig.85).

Trigger Rates at different levels,
'Physics' quantities (Amplitudes, $\Delta T_{i,j}$ for PMT-pairs,...), Event-Display

- Higher level trigger:

  Level-1 – VME: hit-topology filter
  Level-2 – DAQ-Host: time/amplitude–based upward-filter

- On-line data stream splitting for separate event classes (speed up off-line analysis)

- Calibration from the main DAQ, not from a separate setup

- Full HV - slow control: HV-setting, monitoring (including complete logging) .

At a later stage, both the SNMP- and the GRB-DAQ could be incorporated into the AMANDA-DAQ. This would give full online access to the PMT performance (noise glitches), implies however a full redesign of these DAQs (see sect.13).

The AMANDA-II DAQ is capable of interfacing to the proposed SNO-electronics (see sect.12.4.1), which has a VME-interface. A hybrid electronics setup with a few SNO-channels added to the standard AMANDA-electronics is possible.

12.4.3 The CAMAC–VME Interface

The decision is to stay for the near future with the existing CAMAC-TDCs and ADCs, which determine the AMANDA-II trigger dead-time due to the low readout speed. We have put some effort into selecting an optimal interface between VME and CAMAC, to optimize for trigger rate, price and design flexibility for future performance gain.

CAMAC readout into VME (as opposed to direct readout into the DAQ-Host) is giving highest performance within an VME-based architecture, as well as independence on the DAQ-Host platform.

A detailed comparison was made between two systems, selected out of a number of commercial VME–CAMAC interconnection systems, both used in High Energy and Nuclear Physics:

- VSB–driven Controller CBV-610 (STRUCK)
- CAMAC–Branch–Driver CBD-8210 (CES) with Standard A2-CAMAC Crate Controller.

VSB ('VME–Subsytem–Bus') is a standard VME-extension, it's differential extension VDB al-

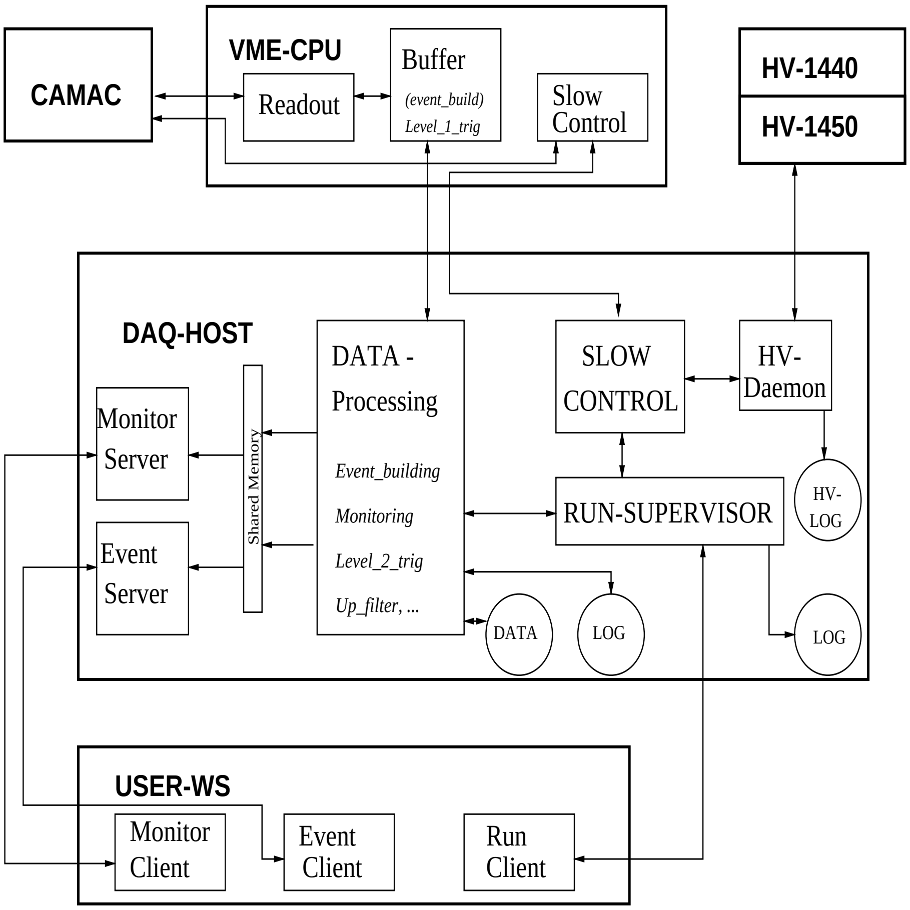

Figure 87: Sketch of task distribution in the DAQ under development for AMANDA-II.

lows for max. 15 crates connected to up to 50 m. The CBD-8210 VME-module and the A2-CC-Controller are connected via a standard Branch Highway Cable (max. 7 crates).

VSB-driven CAMAC Controller are interesting for future system upgrades: VME-CPUs that have a direct VSB–bus access allow for a hierarchical architecture as outlined in fig. 88. Data collection from each CAMAC crate is operating parallel the the other CAMAC crate(s), without any VME-Bus operations. The resulting CAMAC data speed enhancement will go at least proportional with the number of 'VSB branches' (e.g. a factor of 2 for the current 2-CAMAC-Crate setup of AMANDA-B). We note, that a flexible 'Multi–Branch–System' package developed at GSI-Darmstadt is using the CBV-610 Controllers in a large number of experiments [15].

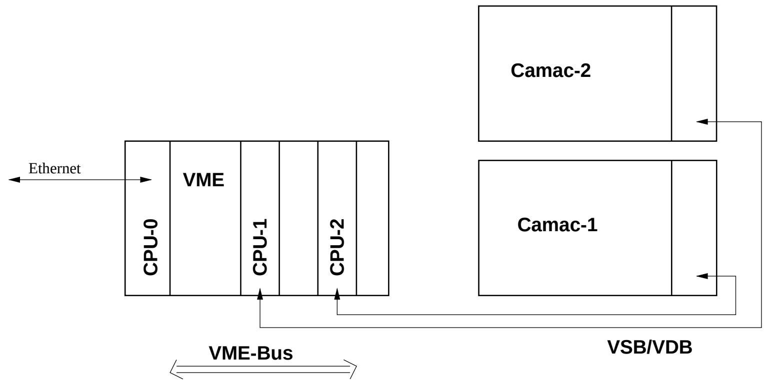

Figure 88: Parallel CAMAC readout into separate VME-CPUs with a VSB based CAMAC Controller avoiding any VME-data traffic except fast block transfer to the main VME-CPU.

Tests with the CBD-8210 and the CBV-610 were made with a VME crate operated by a MVME162 CPU-board (68040/25 MHz under VxWorks 5.2), with an Ethernet connection to the DESY-Zeuthen LAN.

For pure VME-CAMAC speed measurements, we timed single CAMAC read and read&write operations from a VME C-program (direct module addressing without CAMAC-Library overhead). We find a $\approx 40\,\%$ better performance for the CBV-610, as given in table 5. This results from the additional VME instructions required for the CBD-8210 to access the CAMAC-QX–status. Without QX-acces, a read-cycle lasts $2.5\,\mu$sec. The VSB-version of the CBD-8210 (CBD-8110), offered by CES, suffers from the same limitation as the CBD-8210.

Table 5: CAMAC cycle time measurement for two different VME-CAMAC Branch Drivers, corresponding data rates are calculated for 16 bit CAMAC operations.

	CBD-8210		CBV-610	
Timed Operation	Cycle Time	Data Rate	Cycle Time	Data Rate
1 read cycle	$3.9\,\mu$sec	510 kB/s	$2.7\,\mu$sec	740 kB/s
1 read/write cycle	$7.3\,\mu$sec		$5.4\,\mu$sec	

CAMAC readout through VME and the Zeuthen–LAN to a Host-Workstation was measured to be at least 350 kB/s, for this limited test-setup. This result and the above quoted CAMAC cycle times depend on the VME CPU-power available. We will use a 200 MHz PowerPC board (RIO-2-8062/CES), giving an optimal utilization of the CAMAC limit (1 μsec per cycle), with the VME–DAQ-Host network not interfering the data taking.

According to the above arguments, and the 15–20 % lower system cost for the STRUCK solution, we decided to use the VSB-driven CBV-610 controller for TDC and ADC readout.

12.4.4 Time schedule

The new DAQ system is under development at DESY–Zeuthen. It will be installed during the expedition 1997/98, including detector monitoring and slow control. Remote debugging and maintenance of the system, as well as run-coordination during the Australian winter-period from DESY will be essential to guarantee stable run conditions at the Pole (estimated manpower 20-30 % person).

12.5 Upgrades

Upgrades will be necessary in the next years in accordance with the rising number of PMTs and with changes in the electronics systems, as well as for more sophisticated triggering (on VME-CPU and DAQ-Host).

We did not discuss in this section off-line processing including reconstruction at the Pole. Taking into account that the AMANDA detector is in a permanent upgrade process for the next years, this is a nontrivial task. Nevertheless, we want to adress this issue in 1998/99.