1 Upgrade of the calorimeters data acquisition system

This section concerns the data acquisition of the H1 central calorimeters, namely: the liquid argon calorimeter, the iron tail-catcher, the backward spacal calorimeter and the PLUG and VLQ calorimeters.

The architecture of the system is described in details in [1]. H1 calorimeters are seen from the H1 central data acquisition through two independent branches. One branch is dedicated to the calorimetry data consisting of about 75000 channels sampled with high precision. The second branch deals with the calorimeter trigger data. In each branch data are compressed by a set of DSP processors acting in parallel, and then gathered and formatted by a single 29K processor. The VME crates interconnections are based on the VIC system from CES.

As regards performance, the design goals of the discussed upgrade are to lower the 1^{st} order dead time on a single trigger down to 0.8 ms and to reach an average dead time of 10 % at 120 Hz trigger rate in standard luminosity conditions. To this respect only the calorimetry branch will be discussed. The trigger branch already meets the 1^{st} order dead time specification and will directly benefit from the improvements on the calorimetry side for 2^{nd} order dead time.

1.1 Present status and limitations of the system

1.1.1 Performance

The measured parameters of the calorimetry branch are the following:

- 1^{st} order dead time on a single trigger : 1.100 ms independent of event size.

  The 1^{st} order dead time is limited by the speed of the ADC sequencing, which presently takes 1.050 ms. The extra 0.050 ms resulting in a total 1.100 ms dead time should be easily removable.

- 2^{nd} order dead time tails : up to 3-5 ms and affecting a few % of the events.

  In standard luminosity conditions, tails marginally increase the average dead time by about 0.01 ms. Second order dead time tails occur for events triggering before the event builder has finished emptying the DSP buffers of the previous event. Their amount is governed by the limited level of DSP internal buffering (2 events only) and/or the speed of the DSP emptying through the VIC branch. The present speed is 1.3 μs per 32-bit data, resulting in an average DSP emptying time of 2.5 ms per event.

- Total event building time by the 29K : about 4 ms in average.

  The resulting saturation rate of the calorimeters data acquisition is about 200 Hz, with an average dead time of 15 % at 100 Hz trigger rate.

1.1.2 Management

The system is controled by one central OS9 station embedded in the VME and connected to a VAX cluster through a dedicated hardware link. A second independent OS9 station performs slow control tasks like high voltage set-up and monitoring. In addition, each warm calorimeter has a dedicated OS9 test station for decoupled tests.

The software is organized in 2 levels :

- a low-level process implemented in the OS9 for a direct management of the VME hardware.
- high-level processes implemented either in the OS9 or the VAX's. They provide test and calibration procedures through requests to the low-level process.

The calorimeters management is presently suffering from a lack of automization of the calibration procedures and the absence of diagnostic procedures.

1.2 Possible improvements

Improvements can be brought to both the performance and the management of the system.

1.2.1 Performance improvement

First priority is the decrease of the 1^{st} order dead time, second priority the decrease of the 2^{nd} order tails.

- 1^{st} order dead time

  Two actions can be taken :

  - Optimization of the ADC sequencing loop :
    With the present hardware, a 10 % improvement can still be reasonably expected, bringing down the 1^{st} order dead time to 0.95 ms.
  - ADC exchange with faster pin-to-pin compatible ADC chips :
    The availibility of such chips and the technical feasibility of the exchange is under study. It would allow to reach the goal of 0.8 ms but might require in addition some adaptation at the Front-End level, which was designed for 0.9 ms.

- 2^{nd} order dead time

  The level of DSP internal buffering is not possible to change easily with the present hardware. Action has therefore to concentrate on the event building part: decreasing the average DSP emptying time to the level of the 1^{st} order dead time would remove most of the tails. Two options are under study:

  - Optimization of the present 29K code. A factor 2 in the block-moving speed should still be reachable.
  - Replacement of the 29K processor by a processor with faster IO on the VME/VSB/VIC. Possible candidates are PowerPC boards with a PVIC interface.

1.2.2 Management improvement

A better management of the system can be reached with an integrated hardware providing a better framework for software development.

- Hardware environement

  It is proposed to replace the central OS9 station and the VAX cluster by a set of UNIX stations. Part of them will be embedded in the VME for central calorimeter hardware management, slow control and standalone warm calorimeters operation. The others will be external to the VME and will cover the high level tasks presently done on the VAX cluster. All UNIX stations should be inter-connected on a fast private ethernet network connected to the outside world through a filtering device. Possible candidates for the VME embedded UNIX station are PowerPC boards running the lynxOS real time system. More freedom is available for the choice of the external UNIX stations.

  The whole system should be seen as a single system using standard UNIX communication tools.

- Software development

  The present existing software packages have to be adapted to the above new integrated hardware. Keeping the hierarchy between the lower and higher levels, this mainly consists in integrating the present VAX and OS9 high levels into a single UNIX high level, and redefining the inter-process communication using standard UNIX tools.

  The upgraded hardware and software set-up will offer a better environement for further development of automatic calibration, checking and diagnostic procedures.

1.3 Costs, manpower and time planning

1.3.1 Costs

- Pin-to-pin compatible ADC: availibility and price to be checked
- VME embedded UNIX real time station :

  10 KDM offset (development package) + 15 KDM per station

  To be potentially exchanged :

  - central calo OS9
  - slow control OS9
  - 3 warm calo standalone stations
  - 2 29K's
  - plus 2 spares

  resulting in a total of about 140 KDM

- General purpose Unix station : 20 KDM

  2 UNIX stations would advantageously replace the present VAX cluster. Together with one spare this amounts to about 60 KDM.

  One such station is planned to be purchased soon by Dortmund.

1.3.2 Manpower

The necessary manpower together with possible contributions in discussion are listed below :

- 1 full time physicist on site, acting as project coordinator and implementing the system core adaptation.
- hardware and software engineers support :
  - hardware support expected from Paris VI.
  - support of 1 software engineer offered by Paris VI for the adaptation of the OS9-VAX low-level software architecture to the UNIX environement.
  - support of 1 software engineer offered by Dortmund for adaptation of slow control procedures and administration of the external UNIX stations during installation.
  - support for the UNIX installation in discussion in Marseille.
  - VAX expertise for the VAX $\rightarrow$ UNIX migration expected from Munich.
- 1 physicist for management and extension of high-level calorimeter tools.
- temporary physicist contributions to the adaptation of existing high-level calorimeter tools :
  - contribution to the adaptation of the present calibration package expected from Orsay.
  - contribution to the adaptation of the present trigger calibration package expected from Munich.
- dedicated contributions to front-end optimizations :
  - analog electronics adaptation (if needed) expected from Orsay.
  - ADC/DSP optimization and adaptation (if possible) by Saclay.
  - 29K code optimization done by Paris VI.

1.3.3 Time planning

The main difficulty consists in implementing the above changes without interfering with data taking. A possible schedule would be :

- 97-98 shut-down :
  - implement optimized ADC sequencing.
  - implement optimized event building code.
  - experience VME UNIX station by replacing the spacal OS9.
  - append a UNIX station to the present VAX cluster.

- 98-99 :
  - adapt and extend software of calorimeter procedures (slow control, calibration, diagnostic) in view of the 99-2000 shut-down release.
- 99-2000 shut-down :
  - update ADC chips (if done)
  - update the event builder hardware (if done)
  - full migration of the OS9-VAX system to UNIX.

References

[1] F. Descamps and C. Vallée, "Data Acquisition for the H1 Calorimeters", H1 note H1-10/92-256 and Proceedings of the III. Int. Conf. on Calorimetry in High Energy Physics, Corpus Christi (1992).