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ASPECTS FOR THE DESIGN OF THE TRIGGER AND DATA ACQUISITION AT DAΦNE*

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ABSTRACT

DAΦNE with his high luminosity and large crossing frequency constitues a demanding environment respect to the trigger and the data acquisition systems of the experiments operating on the machine. In this context, relevant aspects for the online are the expected rates, the timing, the data throughput and the involved CPU power.

1. EXPECTED RATES

Fig. 1 shows the expected rates obtained by integrating the differential cross sections of the process $e^+e^- \to \phi$ and of the QED processes $e^+e^- \to e^+e^-$, $e^+e^- \to \mu^+\mu^-$ and $e^+ e^- \to \gamma\gamma$ and by taking into account three values of luminosity corresponding to different stages in the evolution of the machine.

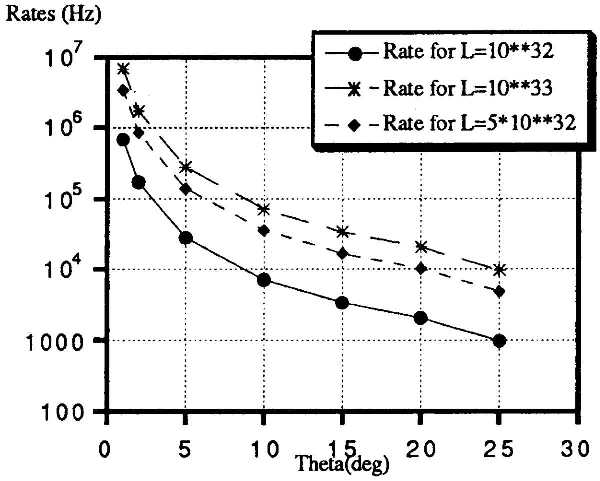

Fig.1. Rates vs. azimuthal opening of the apparatus.

The breakdown of the total rate into the different components is shown in Table 1 for the case $8.5° \leq \theta \leq 171.5°$, corresponding to the maximum azimuthal range in which the detector can operate.

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Table 1. Rates (KHz) for 8.5° ≤ θ ≤ 171.5°.

	$L = 10^{32}\ cm^{-2}\ s^{-1}$	$L = 5 \times 10^{32}\ cm^{-2}\ s^{-1}$	$L = 10^{33}\ cm^{-2}\ s^{-1}$
$e^+e^- \to \phi$	0.48	2.40	4.8
$e^+e^- \to e^+e^-$	9.01	45.05	90.1
$e^+e^- \to \gamma\gamma$	0.22	1.10	2.2
$e^+e^- \to \mu^+\mu^-$	0.01	0.05	0.1
Total	9.72	48.60	97.2

The total rate from physics events is largely dominated by Bhabha scattering up to the angular region 25° ≤ θ ≤ 155° for which the cross sections of ϕ-production and Bhabha scattering are comparable. The quoted numbers are to be intended as lower limits to the total rate in the apparatus since the background events (from the machine and cosmic rays) and the physics events due to the higher order QED are not taken into account.

With a bunch crossing rate of about 70 MHz(1) and a rate of physics events of about 100 KHz the average number of interactions per beam crossing is $1.4 \cdot 10^{-3}$; this gives a small chance of having two overlapping events per trigger.

2. ACQUISITION PARAMETERS

In this section are indicated the requirements to the trigger and data acquisition systems coming from the physics goal to be achieved and from the performances of the machine evolving with the time.

• Rates

Bhabha scattering is the dominating process mainly in the forward region of the detector. While the physical interest on this process does not justify that all the events are written on the output media, nevertheless a sample, uniform in θ, of Bhabha events can be used for calibrating the detector. The prescaling of Bhabha (Table 2) events should be performed in the first stages of the data acquisition by using collinearity triggers in the central chamber and/or in the calorimeter.

Table 2. Rates (KHz)

	$L = 10^{32}\ cm^{-2}\ s^{-1}$	$L = 5 \times 10^{32}\ cm^{-2}\ s^{-1}$	$L = 10^{33}\ cm^{-2}\ s^{-1}$
Physics events	>10	>50	>100
Logged events (Bhabha scaled)	1	5	10

• Triggers and Timing

We assume that the first level trigger is made in hardware. Starting from the rates due to the physics events and allowing a 10% of dead-time (mainly related to the Bhabha events), then the maximum time for obtaining an answer from the first level trigger is given in Table 3.

Table 3. Maximum allowable answer time (μs) for the 1^ level trigger.

$L = 10^{32} cm^{-2} s^{-1}$	$L = 5x10^{32} cm^{-2} s^{-1}$	$L = 10^{33} cm^{-2} s^{-1}$
10	2	1

The maximum processing time of the data acquisition chain for a complete event is given (0% dead-time) in Table 4.

Table 4. Maximum allowable event processing time (ms).

$L = 10^{32} cm^{-2} s^{-1}$	$L = 5x10^{32} cm^{-2} s^{-1}$	$L = 10^{33} cm^{-2} s^{-1}$
1	0.2	0.1

The electronic for the readout should be equipped with multiple buffers. This looses the requirements to the readout operation as shown in Table 5.

Table 5. Maximum allowable readout time (μs) vs. Number of Front-end buffers.

Number of buffers	$L = 10^{32} cm^{-2} s^{-1}$	$L = 5x10^{32} cm^{-2} s^{-1}$	$L = 10^{33} cm^{-2} s^{-1}$
1	100	20	10
2	390	78	39
4	730	146	73

3 - EVENT LENGTH AND DATA THROUGHPUT

This item is subject to a big uncertainty since many details on the detectors, like the number of electronic channels and the readout scheme, are not yet available. It is possible to guess that the contribution to the event size coming from the central chamber could be of the order of 2-3 KByte/event, including noisy hits, and the one coming from the calorimeter could be in the range 1.5-15 Kbyte/event; the average event length could range from 5 to 20 Kbyte.

Table 6 shows the final data throughput of the acquisition system as derived from the rate of the events to be written and the event size.

Table 6. Final data throughput (MByte/s) of the data acquisition system.

$L = 10^{32} cm^{-2} s^{-1}$	$L = 5x10^{32} cm^{-2} s^{-1}$	$L = 10^{33} cm^{-2} s^{-1}$
5-20	25-100	50-200

These bandwidths could be accommodated by the new technology in data storage, expected for the next years (capacity of the order of 100 GByte/medium and rate of the order of 30 MByte/s).

The amount of data to be collected in one year of operation of the machine is shown in Table 7, assuming that the machine will deliver the peak luminosity for 50% of the time.

Table 7. Amount fo data (TByte) produced in one year

$L = 10^{32}\ cm^{-2}\ s^{-1}$	$L = 5x10^{32}\ cm^{-2}\ s^{-1}$	$L = 10^{33}\ cm^{-2}\ s^{-1}$
75-300	375-1500	750-3000

- **Data reduction**

Software techniques can be used to compress data in order to cope with the high bandwidth; an example is the Huffman algorithm gaining a factor 2 in the occupancy, when applied to zero-suppressed data, and a factor 6-7 when applied to not zero-suppressed data.

The online processing of the events could give the possibility of writing directly reconstructed physical quantities instead of raw data; this technique must be carefully evaluated since it is not yet clear that an effective reduction of the data can be achieved.

Finally, the event filtering based on topologies could lower up to a factor 2 the number of events to be written, by dropping the K^+K^- decays of the ϕ, and up to a factor 300 by retaining only the CP violating events.

It is obvious that the two last destructive techniques can be applied only when a complete knowledge of the detector behavior is achieved.

4 - CPU POWER

By scaling down the CPU time needed to process an event in the Aleph experiment the figure obtained is 0.15 s/event on a 7.5 MIPS CPU.

The number of units (100 MIPS each) needed to process the events generated at DAΦNE is given in Table 8.

Table 8. CPU's number needed in the online environment in terms of 100 MIPS units.

$L = 10^{32}\ cm^{-2}\ s^{-1}$	$L = 5x10^{32}\ cm^{-2}\ s^{-1}$	$L = 10^{33}\ cm^{-2}\ s^{-1}$
12	60	- 120

5. CONCLUSIONS

At this stage it is not possible to anticipate detailed trigger and data acquisition schemes, since they are dependent on the type of detectors to be used and on the technologies available in the next few years; the performances required to the data acquisition system are quite higher if compared with those offered by the present day systems.

It is clear that designs(2) planned for more demanding environments, like LHC and SSC, in which, however, the amount of data to be written is similar to the one requested by DAΦNE, are also adequate to our purposes (even if those systems will become operating on the time scale of the year 2000). As an example, Fig.2 is attempt to merge the numbers quoted in the previous sections into a scheme based on switching devices(3) and fast data links.

Finally, we want to stress that one of the most important requirement to the trigger and data acquisition systems for an experiment operating at DAΦNE is the scalability of the components, in order to adapt the characteristics of the systems to the improvements in the performances of the machine.

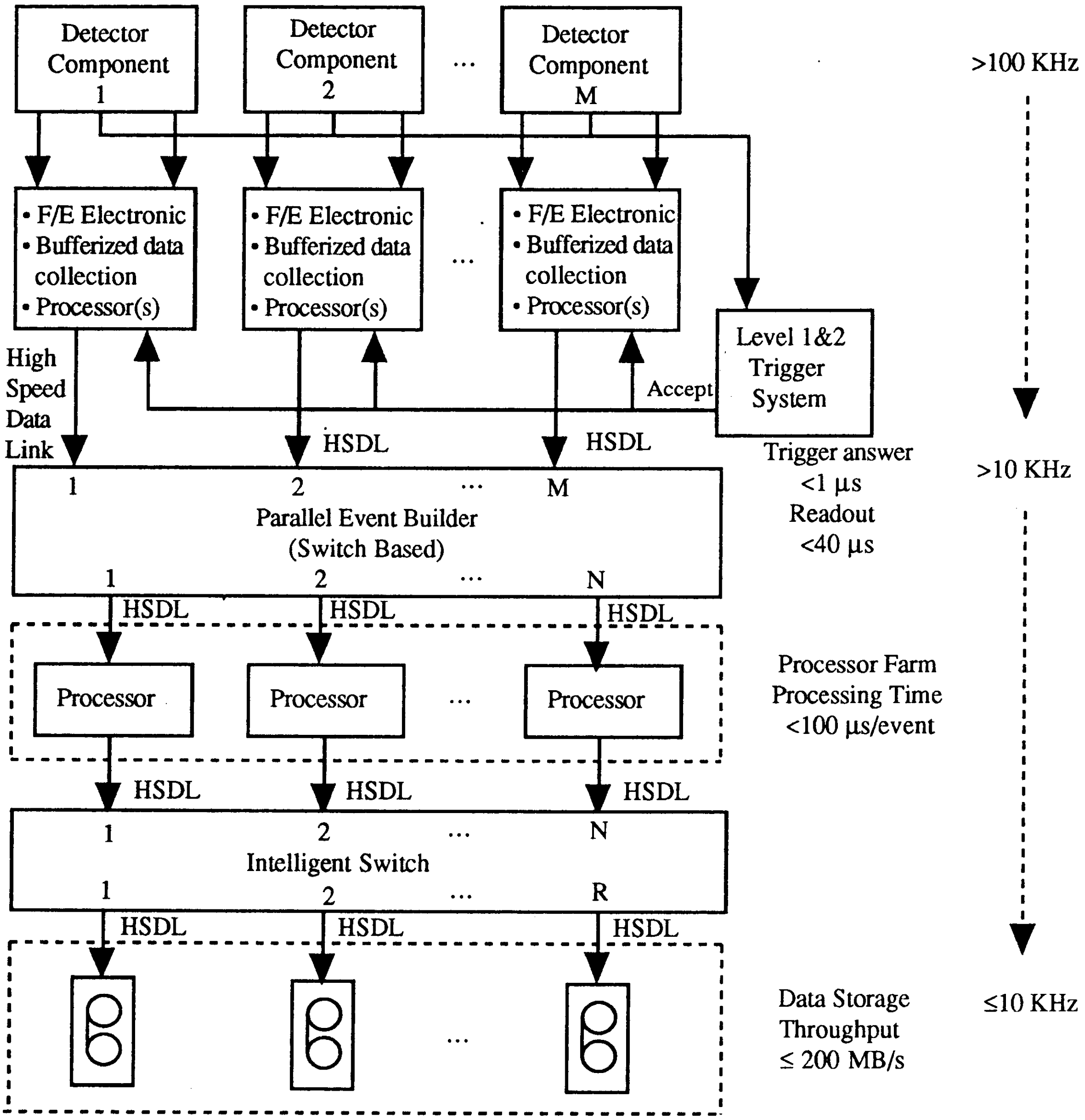

Fig. 2. Possible acquisition scheme

REFERENCES

(1) Proposal for a ϕ-Factory, LNF-90/031 (1990).

(2) N.Ellis et al., Large Hadron Collider Workshop, Aachen 1990, 505, CERN 90-10.

(3) E.Barsotti et al., Computing for High Luminosity and High Intensity Facilities, Santa Fe 1990, 82, AIP Conf. Proceedings 209.
M.L. Ferrer, Proceedings of this Workshop.