3.3 Effects of the Event Building link communication latency

The maximum Dimuon trigger rate as a function of the Event Building link communication latency is shown in Figure 5. If the link latency is the default 100 µs, the Dimuon trigger rate can not be higher than about 480 Hz, otherwise the system will be overloaded. As Figure 5 shows, the link latency must be less than 1 ms if a minimum of 300 Hz Dimuon trigger rate is required for experimental statistics of dimuon events.

The realative error of the trigger rates is the same as in Figure 3, i.e. less than 3% in the worst case.

The measured Central event rate values for the different Event Building link communication latencies are shown in Figure 6. The required 50 Hz event rate can be reached only if the link latency is less than 300 µs.

4. Summary

In this paper we have presented the simulation results of the ALICE data acquisition system stimulated by two different kinds of event: very large central events at low rate and small dimuon events at high rate. The aim of the simulations was to find the performance limitations of the DAQ system, i.e. the equilibrium state of the system at different conditions. The figures shown in this paper are the results of two different methods: the Dimuon trigger rate values are obtained by several test runs, and the Central event rate values are the output statistics of the simulations done at the dimuon trigger rates at which the system is in equilibrium.

The Dimuon event size decreases almost linearly as a function of the Dimuon trigger rate, if the trigger rate is between 200 Hz and 800 Hz. In order to reach a minimum of 300 Hz dimuon event rate, the dimuon event size can not be higher than 320 KByte, and it must be even less if the required event rate is higher.

Using 240 KByte dimuon events, the bandwidth of the Event Building links influences the Dimuon trigger rate only if it is less than 90 MByte/s, otherwise the fixed 82 Mbyte/s bandwidth of the Detector Data links will limit the dimuon event rate at about 490 Hz, and the central event rate at 50 Hz. If the event Building link bandwidth is less than 80 Mbyte/s, the central event rate can not reach the desired 50 Hz.

The Dimuon trigger rate depends linearly on the Event Building link communication latency between 0.1 and 1.3 ms. According to the decreasing characteristics, the link latency can not be higher than 1 ms if the required dimuon event rate is 300 Hz. With lower link latency, higher dimuon event rate can be reached.

5. References

The Dimuon trigger inter arrival time was changed by steps of 0.05 ms, thus the relative error of the Dimuon trigger rate values of Figure 3 is less than 3% in the worst case.

Figure 3. Maximum Dimuon trigger rate as a function of the EB link bandwidth

Figure 4. Maximum Central event rate as a function of the EB link bandwidth

Figure 4 shows the maximum values of the Central event rate which can be reached at different Event Building link bandwidths. For example, using 60 MByte/s links, the Central event rate is about 40 Hz when the system is in equilibrium. If the system is overloaded, this rate will decrease dramatically, as shown in the previous simulations [2].

Figure 5. Maximum Dimuon trigger rate as a function of the EB link communication latency

Figure 6. Maximum Central event rate as a function of the EB link communication latency
and the output rate of the dimuon LDCs), thus we refer to the rate of both trigger levels as Dimuon trigger rate later on. Each of the highest possible Dimuon trigger rate values was always the result of several test runs, and we accepted the trigger rate values only if the occupancy of the infinite buffers was statistically constant during the 10 second simulation run. Unlike the Dimuon trigger rate, the Central event rate values were measured (output statistics of the simulator program) when we found the equilibrium state of the system.

3.2 Relation between the Dimuon event size and the Dimuon trigger rate

First we introduce how the Dimuon event size depends on the Dimuon trigger rate, if we use 80 MByte/s Event Building links and 0.1 ms communication latency on the Event Building and the Flow Control links. Figure 2 shows the relation between the two parameters in the case of 2 and 3 dimuon LDCs. For example, if the Dimuon trigger rate is 300 Hz, the average Dimuon event size can not be higher than 320 KByte in the case of 2 dimuon LDCs, otherwise the buffer occupancy of the dimuon LDCs starts to increase statistically. If the buffers are finite and the system is overloaded, the buffers will get saturated and the event rate will decrease dramatically [2].

Since the Dimuon event size was changed by steps of 10 KByte to find the equilibrium state of the system, the relative error of the Dimuon event sizes of Figure 2 is less than 8% in the worst case.

Figure 2. Maximum Dimuon event size as a function of the Dimuon trigger rate

3.2 Effects of the Event Building link bandwidth

Figure 3 shows the maximum Dimuon trigger rate as a function of the Event Building link bandwidth. In order to get this curve we fixed the Dimuon event size at 240 KByte and varied the bandwidth of the Event Building links. It is interesting that the maximum trigger rate is around 490 Hz and does not increase any more if the Event Building link bandwidth is higher than 90 MByte/s. This is due to the fixed Detector Data link bandwidth, which limited not only the central event rate but even the dimuon event rate.
The distribution of the time interval between two consecutive trigger signals followed an Exponential distribution without any limitation. The mean value of the inter arrival time was fixed at \( \mu_c = 2.5 \text{ ms} \) (400 Hz) for the TPC subevents and the default mean value was the same \( \mu_d = 2.5 \text{ ms} \) for the dimuon subevents.

The tpc FECs (i.e. that were connected to the corresponding tpc LDCs) had buffers only for a single TPC subevent. Until all of the central FECs were not read out by the LDCs, the central trigger signals were discarded, so the input event rate of the LDCs was essentially determined by the bandwidth of the Event Building links. The bandwidth of the Detector Data links was fixed at 82 MByte/s to be able to transfer 50 central events of average size per second, thus the maximum available event rate at the input of the tpc LDCs was always 50 Hz, even if the Event Building links could have transferred higher data rate. In the dimuon FECs and in all LDCs, infinite buffers were supposed in order to see when the buffer occupancies start to increase statistically, i.e. the system is overloaded. The buffer size of all GDCs was 100 MByte that was enough for two central events of maximum size, since a central GDC had to be able to receive the subevents of a new event while it was transmitting the whole previous event to the Permanent Data Storage device.

The Event Building links were used for dedicated connections between the LDCs and the GDCs. This interconnect network based on a 32x32 switch, which required 20 \( \mu s \) to create a dedicated connection [5], during which time no other connection could be built. The default value of the Event Building link bandwidth was set to 80 MByte/s.

The default communication latency of the Event Building links was set to 100 \( \mu s \), and the same value was fixed in the Flow Control links. The communication latency is defined as the time from when an application (on the source side) sends a message with 1 byte application data till when another application (on the destination side) receives that message [6]. So this latency can be regarded as a dead time on the links, which may include token passing time as well [7].

The Storage links between the GDCs and the PDSs were supposed to have the same features as the Event Building links.

The Event Destination Manager (EDM) had two functions: to control the event building process and to send L2 trigger signals to the LDCs to read out the FECs. In order to separate the event building process from the control and trigger operation, we supposed an additional Flow Control link between the EDM, the LDCs and the GDCs. The Flow Control link was used only to send “free” signals from the GDCs to the EDM, and to send multicast L2 trigger signals to the LDCs. Since these messages are very short messages (typically one frame or packet), the transfer time of these messages was set to 100 \( \mu s \) according to the link communication latency.

As a destination assignment scheme we used fixed sequential order at the LDCs and Round Robin at the GDCs, which resulted in a traffic like the Barrel-shifter [5].

### 3. Simulation results

#### 3.1 Input and output parameters

We have simulated 10 second data acquisition runs. Variable input parameters were the Dimuon subevent size, the EB link bandwidth and the EB link communication latency. The output parameters of the simulations were the Dimuon L1 trigger rate and the Central event rate. When the system is in equilibrium, the Dimuon L1 and L2 trigger rates are just equal (since the generated dimuon data rate is not higher than the read-out rate of the dimuon FECs...
sages (GDC free signals, FEC read-out trigger signals for the LDCs). In order to avoid the uncertainty of the scalability, we simulated a real 32x32 system, although it required more CPU time than the simulation of a reduced system. (The simulation of 10 seconds of data acquisition requires at least 20% more CPU time for a 32x32 system than for a 16x16 system.)

Instead of the proposed data structure [1], we used only a simplified model of that as described here. Each central event was composed of 30 TPC subevents and 2 dimuon subevents, but a dimuon event was composed of only 2 dimuon subevents. It means that only 2 LDCs (dimuon LDCs) and 2 GDCs (dimuon GDCs) participated in the dimuon event building process. The dimuon LDCs could receive dimuon subevents and the tpc LDCs could receive TPC subevents. The dimuon GDCs were reserved exclusively for dimuon events and only the rest 30 GDCs (central GDCs) took part in the central event building.

![Figure 1. Simulated architecture of the ALICE DAQ system](image)

The physical events and the L1 trigger signals were generated by the Event Generator (EG). The Event Generator produced subevents of different size for each FEC. The distribution of subevent sizes followed Gaussian distribution. The standard deviation was $\sigma_c=10\%$ of the mean value for the TPC subevents and $\sigma_d=20\%$ of the mean value for the dimuon subevents. The default mean value of the dimuon subevent size was set to $\mu_d=0.12$ MByte, which corresponds to 0.24 MByte total dimuon event size, and the TPC subevent size was fixed at $\mu_c=1.3$ MByte, which corresponds to about 39 MByte total central event size, since the 2 dimuon LDCs always received dimuon subevents, even in the case of a central trigger.

Only a part of the whole subevent size distribution function was taken into account because the size of the real physical events are limited. So we cut a range from the Gaussian distribution curve around the mean value. The width of this range was defined by a subevent range factor. The subevent range factor was $f_c=10\%$ of the mean value for the TPC subevents and $f_d=20\%$ for the dimuon subevents. (This restriction resulted in about 35% lower deviation of the subevent sizes, i.e. $\sigma^*_c=6.5\%$ for the TPC subevents and $\sigma^*_d=13\%$ for the dimuon subevents.)
1. Introduction

The Heavy Ion Experiment ALICE is one of the three future experiments in the LHC at CERN. At the ALICE experiment, the detectors will produce two different kinds of data flow simultaneously: very large events (up to 39 MByte) at a low rate (40 Hz) and small events (up to 0.25 MByte) at a high rate (up to 1000 Hz). There will be two types of the large events (Central events and Minimum Bias events), whose combined data traffic corresponds to events of up to 40 MByte at 50 Hz event rate, and referred to as central events. The small events are called dimuon events [1].

Previously we have carried out simulations to see how the system performances will vary if one of the basic input parameters is changed, provided that only central events are generated [2]. In this paper we present simulation results when both kinds of events are generated at the same time. The simulation results will show the limits of the data acquisition system, i.e. the input parameter values at which the system is still in equilibrium and the global input data rate just does not exceed the global output data rate. The graphs presented in this paper will probably help to find an optimal parameter set for the DAQ system.

We used a simplified version of the simulator program ALSIM [3] which is written in MODSIM II language [4].

In the subsequent chapters, first we describe the simulation setup with the default values of the input parameters, then we present the simulation results, and finally we give a brief summary of the results.

2. Simulation setup

The simulated architecture of the ALICE DAQ system is shown in Figure 1, where dashed lines correspond to zero delay, and arrows represent the flow of events and control mes-