Integration of the ZEUS MVD silicon strip telescope in EUDAQ Software

Summerstudent Program 2009, DESY

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9th September 2009

Abstract

This report covers the integration of the ZEUS MVD telescope in the EUDAQ framework. The aim is to insert the MVD into a more comprehensive data acquisition system, which includes the Trigger Logic Unit and in priciple also the DUT. In this way the configuration of all the system can be done via the EUDAQ Run Control and the integration of the user system is simplified.

Contents

1 Introduction

DESY offers the possibility to use three test beam lines (21, 22, 24) to test various high energy physics detectors. The energy of the electron beam from DESYII is 1-6 GeV and in each experimental area there are all the necessary infrastuctures including the beam telescope, that is use to determine the particle tracks. The telescope in test beam area 22 is the ZEUS MVD Telescope, build for the testing of the modules of the ZEUS micro vertex detector; currently it is used by many groups to evaluate the performance of their devices. The MVD Data Acquisition system consist of a MVME6100 single board computer and a Linux PC. This system was chosen since it is also the hardware used for the EUDET telescope and know-how on this system will be available for a number of years. In the following sections the integration of the ZEUS MVD telescope DAQ Software in EUDAQ framework (used precisely for the EUDET JRA1 telescope), will be described. In addition there will be also a part dedicated to the configuration of TLU.

The DESY Test Beam

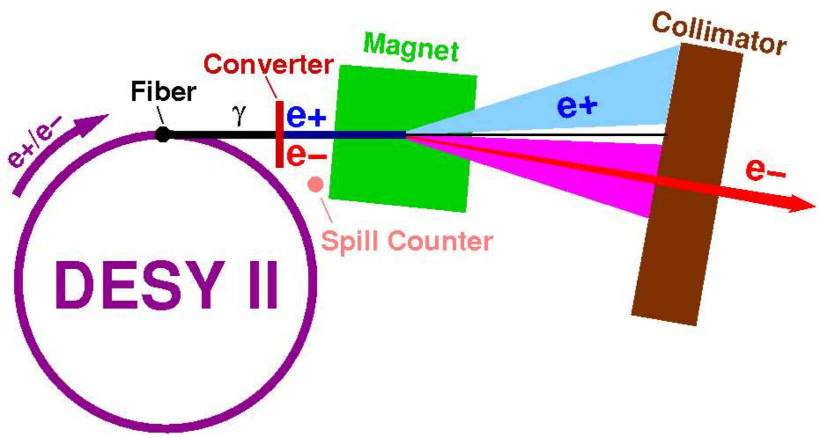


Figure 1: Layout of the DESY test beam.

A Bremsstrahlung beam generated by a 7 μm carbon fibre (primary target) in the circulating electron synchrotron beam DESY II provides the electrons/positrons used for the test beam. A secondary target, a metal plate, convert these Bremsstrahlung photons into a horizontal fan; a set of collimators form the extracted beam. There is a magnet to control the energy of the beam. This test beam provides electron energies from 1 to 6 GeV/c. In this range the electrons are minimum ionising particles (MIPs). The Bremsstrahlung spectrum has a $\frac{1}{E}$ dependence. The accelerator control room handles the fibre target and the beam intensity in DESY II. The test beam user conctats the control room if changes are necessary. The magnet settings for the selection of the momentum, the choice of the conversion target and the collimator settings are under control of the test beam user.

2 The ZEUS MVD Telescope - Overview

Originally, the ZEUS MVD Telescope was designed and constructed by the ZEUS collaboration to test the modules for the Micro Vertex Detector (MVD). Since then it was used by many different groups to study newly developed detector systems. It consists of three detector reference planes mounted on opical bench (controlled by the user from the test beam hut), power supply, trigger system, data acquisition electronics and software.

Telescope hardware

The hardware characterization of the readout system is presented:

- three silicon strip detectors on optical bench, located in a metal box with thin aluminium windows on beam line to minimize multiple scattering. Each of them provides three space coordinates for a track to the telescope (the modules are a version of a CERN development). Every detector consists of two 300 μm single-sided silicon sensor of 32mm$\times$32mm size with a strip pitch of 25 μm and a readout pitch of 50 μm; the strip directions of the two sensors in a module are perpendicular to each other. The 640 readout strips on each sensor are readout by the VA2 chips (ha messo una nota!!!).
- three plastic finger scintillators with small PMTs, two of them are in front of the beam before the first plan and the other one after the three planes. These are used for the trigger system.
- a NIM crate with the power supply for photomultipliers (12 V and 0-1 V steering voltage), the power supply for silicon strip detectors (0-60 V) and the level shifter for analog signal from telescope.

3 The DAQ system

The data acquisition system, as shown in Figure 4 for the MVD telescope is a combination of dedicated harware and software. The DAQ hardware consists in:

- VME crate with:

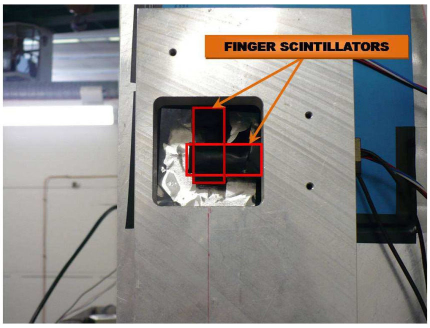


Figure 2: The two scintillators in front of the beam.

  - Sequencer V551B;
  - ADC V550A, in which the channel 0 is used for the plane 1 (the one after the 2 finger scintillators) and the channel 1 for the plane 2;
  - ADC V550C, in which the channel 0 is not used and the channel 1 is used for the telescope plane 3;

- MVME6100 (zentaurus2): special VME single board computer booting from a LINUX PC (zentauruspc).

The CAEN V551B Sequencer Module

The model V551B CAEN C-RAMS Sequencer is a VME module that handles the Data Aquisition from multiplexing front-end chips; the module is well suited to handle the VA family of chips. This sequencer has been developed to control the signal from/to the boards Model V550 (CAEN), the latter taking care of the conversion of the multiplexed signals from the front end boards housing the above chips. The module handles three kinds of signals: signals that interface with the external world, signals that interface with the V550 Modules and signal that interface with the VA. The trigger pulse should be provide by the user to the module to start the whole acquisition; a trigger is accepted if the module is not in a BUSY status. The BUSY infact is a positive open collector signal that indicates that the system cannot accept new events; this condition occours in particular when the ADCs are in the convertion phase (the BUSY is removed when all data read out from the V550 buffer). The DATA READY instead is a signal that indicates, by means of a wired-OR of the DRDY signals coming from the acquisition cards (V550), that at least one of such modules is in DATA READY state and so has data to be read out. A sketch how the modules in the VME crate are linked is shown in Figure 3.

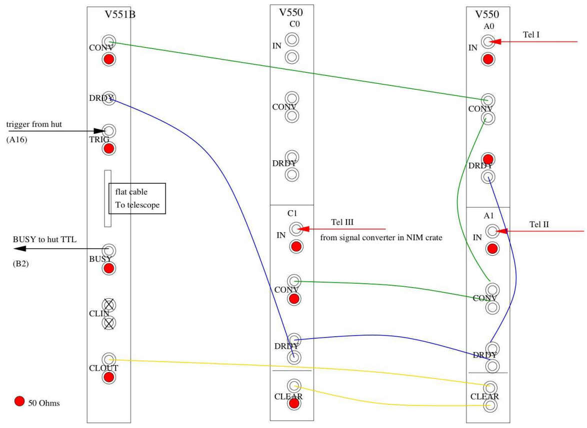


Figure 3: The cabeling of the VME modules.

Data flow

The beam arrives in the experimental area and generates an external trigger; the three scintillators infact receive the pulses and their output signals are combined in an AND coincidence logic to form a trigger signal. Every scintillator is connected by cable to a discriminating module that is placed in the hut. When this module is above threshold, the information is passed to the next module that is the COINCIDENCE module. The coincidence module check if the three signals (coming from the scintillators) are arrived at the same time. In this way you are sure that the signal you have is properly the beam (it could for example be a cosmic ray). Verified this, the coincidence module gives a trigger to the VME sequencer that is situated in the experimental area. The V551B module, received this signal, forces the VA chips to read out the strip signal; these informations go almost directly to the ADCs (infact first passed into a differentional module). When the ADCs memory register becomes full, the sequencer goes in DATA READY Status and the modules are read out (the channels are connected in dasy-chain). The V551B indicates also when the memory register is working (BUSY Status), in this case the sequencer cannot receive more signal. The BUSY Status is turn off when the register memory of the ADCs is empty. The DAQ Software runs on the MVME6100 (zentaurus2). The DAQ Software is needed in order for the DAQ Hardware to work with a PC managing all this operations. Moreover, an automated trigger signal for the use without beam can also be created using a NIM gate generator.

3.1 MVD DAQ Software

The Data Acquisition Software for the MVD Telescope, written by Łukasz Maczewski, runs on zentaurus2 and consists of several phases that occur in chronological order. In the

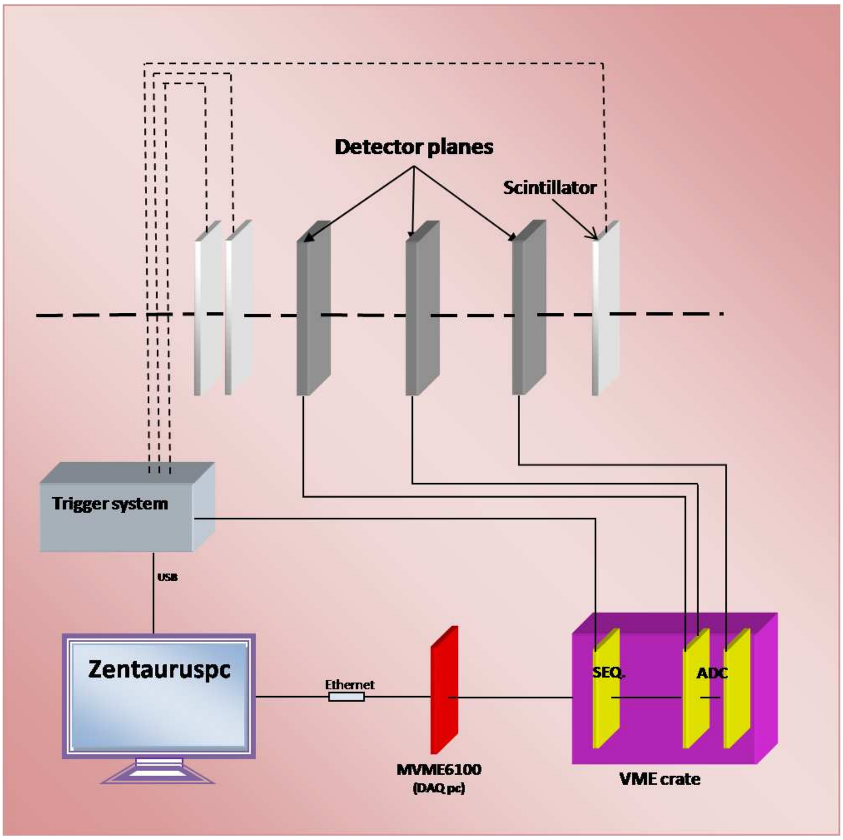


Figure 4: The DAQ system of the ZEUS MVD silicon strip telescope.

main routine, there is first the inizialisation of the VME modules, using functions defined in an external VME library, and then the user menu. The user can interact selecting one of the shown letters (not case-sensitive); the warning is to make a calibration run before taking data. In the calibration part 1000 events are taken and determined pedestal and noise values for every channel (in total 1280) of the three telescope planes. In autotrigger mode the program itself send a signal to the V551 module causing it to start a conversion cycle. The calibration has to be made without beam, to avoid that particles should be counted. The program wait for the DATA READY signal from the V551 module, then it looks into the WORD COUNTER register of each ADC of the V550 modules and read out datas from each FIFO. The program calculates the pedestal and threshold for each channel. At the end of this calibration run the informations are showed in ASCII histograms. The run mode is similar to the pedestal one except that the user has to provide more details: number of run, number of events and comment. All the data of one event is put into one integer array, called EVENT. At the end of the event, when the FIFOs are read out, the EVENT array is stored in a file and resetted for the next event. To analyse data taken by the DAQ is used a ROOT-based software called TELAna that is installed on zentauruspc; during my summer student program I used this sofware to verify my work about the reduction of noise problems in the telescope as showed in section 4.1.

3.2 EUDAQ

The main objective of my work is to incorporate the MVD telescope and its DAQ in a more general data acquisition system, EUDAQ, which fits with any hardware, is easy-to-use and allows you to add other devices including the TLU. EUDAQ in particular is a portable desktop DAQ system written in C++, it was designed for use with the EUDET JRA1 beam telescope but, it is useful for my purpose because it is not tied to any specific hardware, and as already mentioned, could be used with other setups with portable and easy-to-use DAQ. It runs on Linux, Mac OS X, and Windows (under cygwin). It relies on very few external libraries, using POSIX for threading and sockets for communication; Qt4 is used for the graphical applications, since it is portable between the relevant platforms. Several producer tasks communicate with a global run control using sockets. These producer tasks connect to the hardware of the beam telescope, to the TLU and eventually to the DUT. Data from all producers is sent to the central data collector and can be monitored by several processes. An online ROOT-based monitor shows online data quality monitoring histogram, one LogCollector task receives log messages.

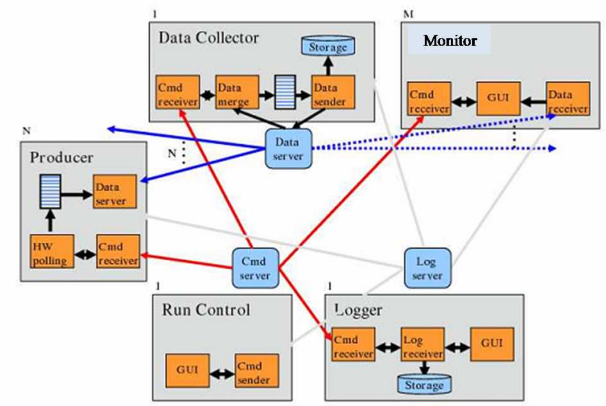


Figure 5: Layout of EUDAQ Software.

3.2.1 The Producer

To integrate the telescope into the EUDAQ system you must write the producer, infact the MVD DAQ can not be controlled by the EUDAQ RunControl (this latter sends commands to the other tasks). Generally a producer consists of these parts: initialisation phase, event loop, data reading, sending event and reset of the busy Status; finished the process, the program wait for a new trigger. The initialization part is done only once before the starting run; the system was enabled to receive events and waits for the moment that the trigger arrives. To verify if this latter is arrived the process continues polling the hardware; when the trigger arrives the reading phase starts and the datas are sent to the RunControl with 'SendEvent', at the end the busy is resetted and the process starts again waiting for a new trigger. There will be created two configuration file: one for the data taking and the other one for the calibration, in the first file the threshold will be 0 while in the second one the quantity that you want.

3.3 The Trigger Logic Unit

Another important goal of my work is the installation of the TLU in the system. In this case, the issue is different because the TLU producer already exists in the EUDAQ software. The next step is therefore to mount properly the hardware and to run it. It is important to add a trigger logic unit because for a user telescope is a simple easy-to-use trigger system, to allow for example a rapid installation of the device under test. The TLU has two main functions: provide 'classic' beam-test trigger system and keep a record of the arrival time of each trigger; hence it can operate as time-to-digital converter for triggerless or self-triggered DUT. Both modes are active simultaneously, allowing triggered and triggerless/self-triggered DUT to be mixed in the same beam-test.

4 Results

My DESY summer results are listed above:

- found noise problems in telescope and reduced them; taken data in test beam
- installed latest version of EUDAQ
- prepared MVD producer
- gotten TLU v0.1 running, through the use of a dummy cable

4.1 Reduction of noise problems in MVD Telescope

The results of a data taking run with pedestals and thresholds in the ADC modules set to zero are presented in Figure 6; as already mentioned I have used the TELAna analysis software. The wiring had been modified and improved since the last data run.

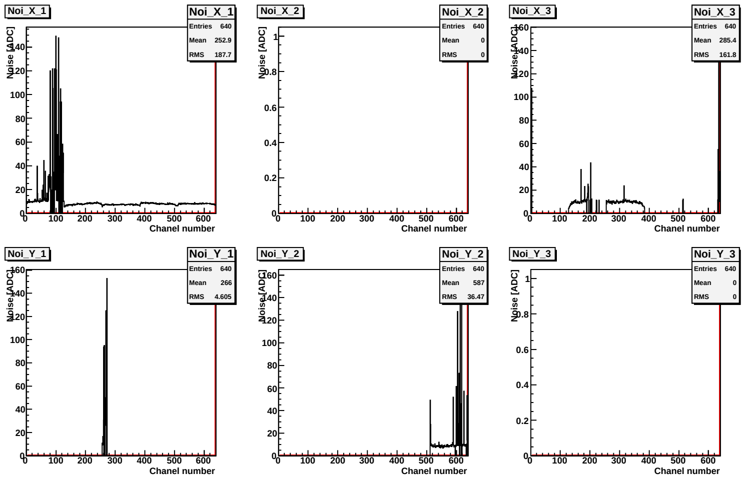


Figure 6: Noise distribution af all the planes.

4.2 Latest EUDAQ version

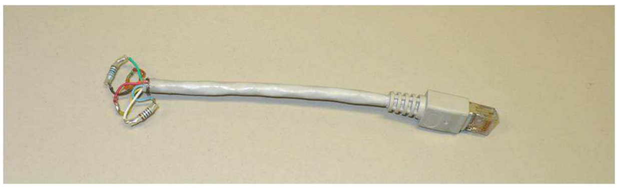
I found some problems in the computer setup which prevented a smooth compilation (wrong version of QT). Afterwards the new version of EUDAQ (772M) was compiled on zentauruspc, it is located in /home/eudet/eudaq2. To run it you have to type ./STARTRUN in the eudaq2 folder, then it will appear the following default windows: the Run Control, the Log Collector, the Data Collector and the TLU Producer. The Run Control handles the operations from all these tasks, in particular in the EUDAQ RUN Control window you can select the configuration from many different possibilities. In the status part you can see the Run number, the current rate and the scaler numbers. In the lowest part of the window you can find the state of all the different producers. In case of a problems the underlying colour changes to red.

4.3 MVD producer

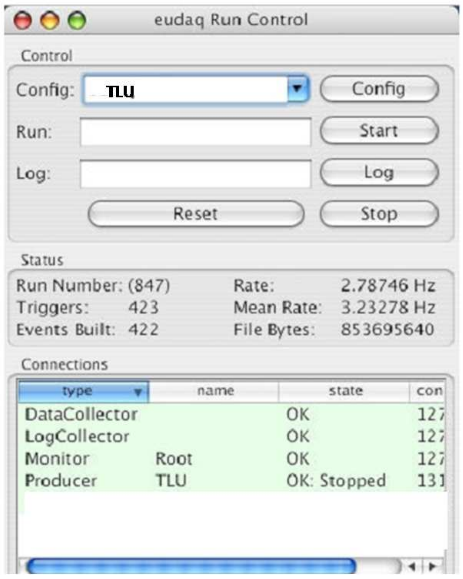
I have written, with the help of Emlyn Corrin, the producer for the MVD telescope, in order to integrate it in the EUDAQ software. It is located in zentauruspc:/home/eudet/eudaq2/mvd/src and it is called MVDProducer.cxx. This producer include the code MVDController.cc in which there is the configuration of various settings, for example the initialisation of the modules, number of channels and of ADCs. The MVD producer instead consists main of these three parts: the main loop, the start run, and the stop run. At the end the process waits for the new trigger.

4.4 TLU version 0.1 and dummy cable

I got the TLU version 0.1 running; to do this I did not mount it in the whole system, infact I used a dummy device, just to check the correct operation of the Trigger Logic Unit. A dummy DUT is a special device driver creating for testing purposes; it does not correspond to any real device but can be configured to have arbitrary number of properties and channels. This device has a scope trigger created automatically when device has pulse channels. Since this cable was not available, I assisted Ulrich Kötz that made one, it is shown in Figure 7(a). I will put the instruction. The TLU is not configured yet because it has to be moved inside the test beam area to be connected to the telescope. When these changes will be made, in order to configure the TLU in EUDAQ you have to type ./STARTRUN in the eudaq2 folder and in the Run Control you have to select the config file 'TLU' in the fold-down menu besides CONFIG and press CONFIG (as shown in Figure 7(b)). This config is done in a way that only the TLU starts. When the config file is selected, you can press START and you should see the event counter starting.



(a)



(b)

Figure 7: a) Dummy DUT. b) The EUDAQ Run Control window with the TLU configuration file selected.

5 Conclusion

The next step is certainly that one to configure the whole system, the TLU and the MVD telescope, in the EUDAQ software. The project is almost completed, only some hardware changes should be done: the computer has to be moved from the hut to the experimental area and a second computer has to be brought as terminal to the hut; then the TLU will be connected directly to the sequencer. The final goal of this work therefore is to get the telescope to work completely with EUDAQ and all the electronic to finally add the devices under test, as sketch in Figure 8. Unfortunately I will not be here in DESY to see the finalization of the work because of the conclusion of the summerstudent program.

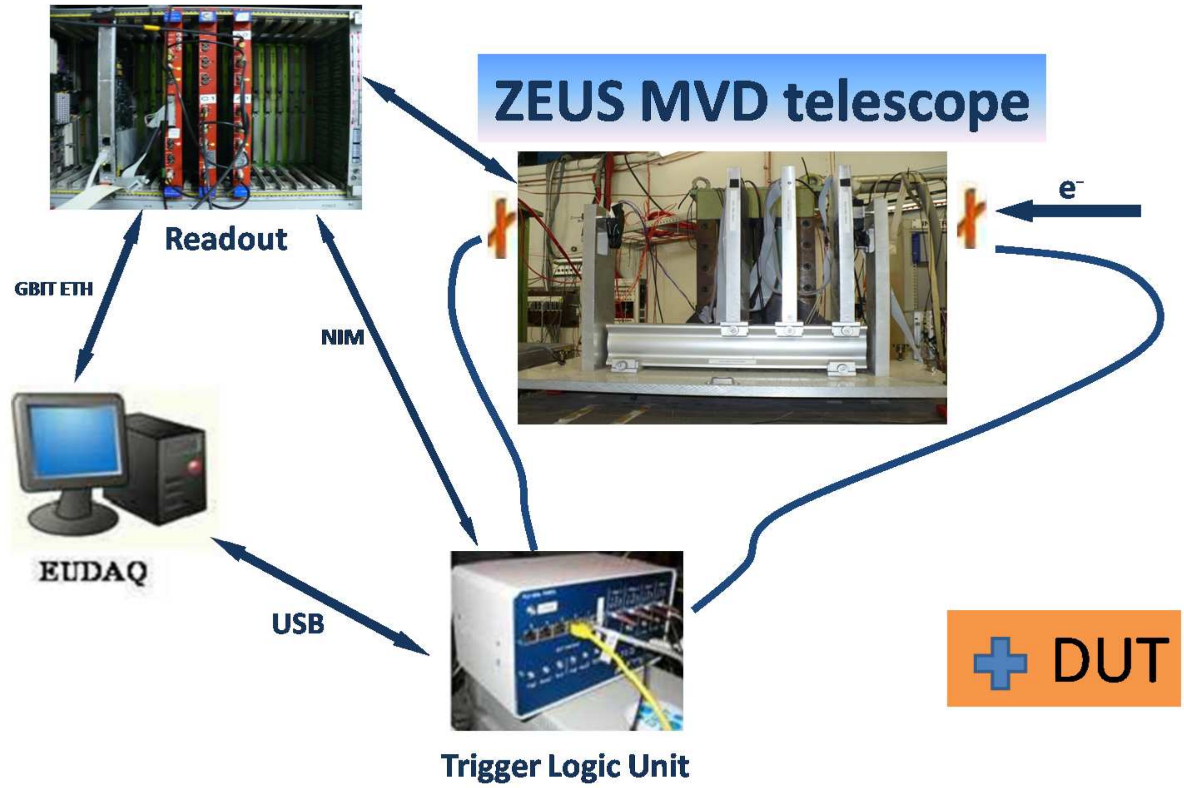


Figure 8: Integration of the MVD silicon strip telescope in EUDAQ framework.

6 Acknowledgements

I want to thank Ingrid-Maria Gregor for helping me with the work answering my questions, solving my doubts and overall for giving me good advice on how to approach the world of experimental physics. I want to thank Łukasz Maczewski who explained me the data acquisition software and several hardware components, also Ulrich Kötz who showed me how to make a dummy DUT. Thanks also to Emlyn Corrin for giving me programming solutions. Finally I have to thank my teachers Massimo Caccia and especially Antonio Bulgheroni for encouraging me to try this wonderful adventure.

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