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The MAGIC Central Pixel System (1st Version)

José Luis Lemus
<jllemus@gae.ucm.es>
Luis Ángel Tejedor
<luistejedor@gae.ucm.es>
Juan Abel Barrio
<barrio@gae.ucm.es>
Valeria Scapin
<valeria@gae.ucm.es>
Diego Herranz
<diegoherranz@gae.ucm.es>

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Abstract

This document contains technical data about the new Central Pixel System now installed in MAGIC. This special pixel allows a simultaneous Gamma and Optical observation.

Contents

1 Introduction

The main purpose of the Central Pixel is to analyze the slow variation of the optical flux of different types of sources. The simultaneous observation in the optical and γ-ray regimes can provide real-time ephemeris for periodicity search in γ-rays.

This task is performed by a dedicated PMT, placed in the very center of the camera. When on-axis observation, the light of the source is reflected into this position, and the slow variations of the intensity are transmitted to a dedicated DAQ system and to the standard MAGIC DAQ.

Due to the unfocussing of the camera when pointing to a source at infinity and to the Point Spread Function (PSF) due to the misaligning of the mirrors not all the light coming from a punctual source is collected by the Central Pixel.

The light of the night sky background, however, is isotropically distributed, so is not affected by the defocusing and contributes to decrease the signal to noise ratio of the source and the necessary time of observation. These factors result in a decrease of the signal to noise ratio, and thus in the importance of a low-noise electro-optical system.

Most of the objects to be observed with the Central Pixel emit at frequencies between 1 Hz (Blazars) and 1 kHz (pulsars and Gamma Ray Bursts). The characteristic emission frequency of the Crab Pulsar is 30 Hz. These values fix the 3 dB bandwidth of the readout system of the Central Pixel (1 Hz - 1 kHz). The slow variation of the PMT anode current must be integrated, and the resulting value transmitted through an electro-optical transceiver to the data acquisition system.

2 The Central Pixel system

The MAGIC Central Pixel system consists of a fully modified photosensor to readout chain. The light from the source is received by a standard MAGIC PMT that has a modified DC branch in order to catch slow light variations. Namely, the bandwidth of that branch is increased from the 8 Hz of a normal DC branch to over 3 kHz. That DC branch is fed to both the standard DC monitoring system and to an additional optical transmitter that sends the signal down to the Control house. Once there, it is converted and adapted for standard Domino readout and also sent to a Central Pixel PC (PC40) for a dedicated readout.

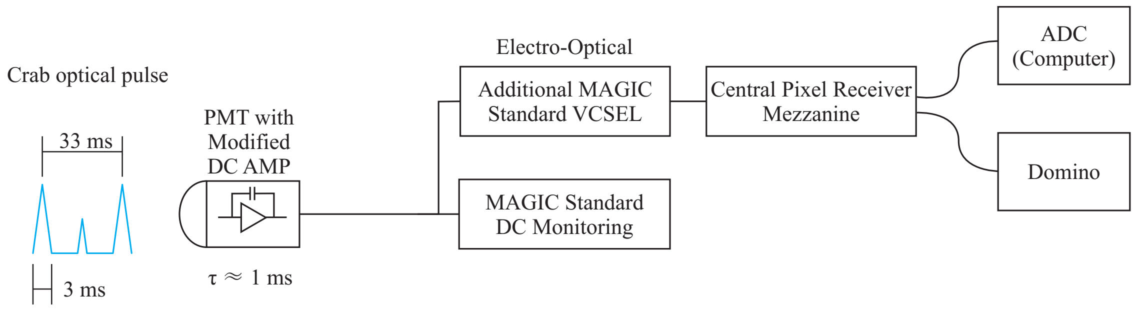


Figure 1: *Central Pixel system diagram.*

3 The Central Cluster

Pixels in MAGIC cameras are bundled in clusters. Each of those clusters contains seven pixels in an hexagonal disposition with one in the middle. So it comes to reason that in order to have a central pixel in the camera, the central pixel of a cluster has to be modified, and then that cluster has to be installed in the center of the camera.

Figure 2: *MAGIC II cluster.*

All the clusters have been designed and manufactured in Munich, at the Max Plank Institut für Physik. They allowed us to have one of them and also gave us all the mechanical and electrical details so we could modify it properly. In the next subsection there are brief instructions for unmounting the cluster.

3.1 Basic Central Cluster mechanical aspects

A cluster of MAGIC is a delicate and complex piece of equipment. So dismounting it properly is mandatory. See figure 3. The steps to access the central photomultiplier are as follows:

1. Remove the 4 Torx screws at the back of the cluster.
2. Move a bit the back panel so the plates can slide out, one at each time.
3. With a 3 mm Allen screwdriver, remove the three screws that hold the cover of the PMTs and the Winston cones
4. With a phillips number 2 screwdriver, remove the two nylon screws that hold the PMT to the cluster

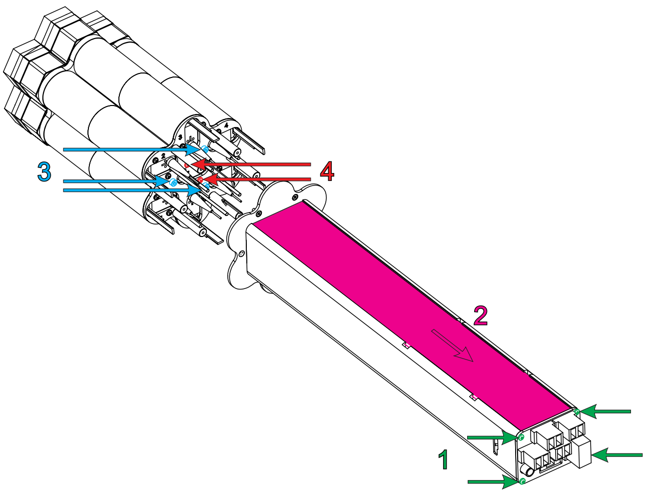


Figure 3: *Central cluster mechanics.*

3.2 The Central Pixel photo sensor

The PMTs installed in MAGIC have attached to them several electronic boards (see figure 4). The three nearest to the PMT itself come directly from the manufacturer of the PMT, Hamamatsu. They are responsible for generating the high voltage and feeding it to the PMT's dynodes. This high voltage is generated by a using a DC multiplying topology called Cockroft-Walton and is controlled by one of the signals that come from the clusters slow control board.

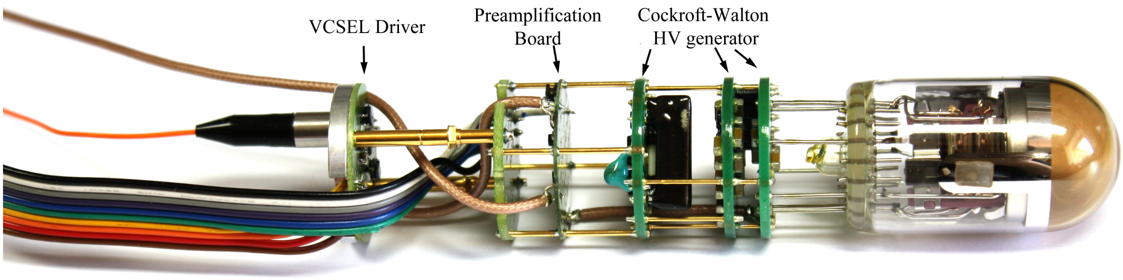


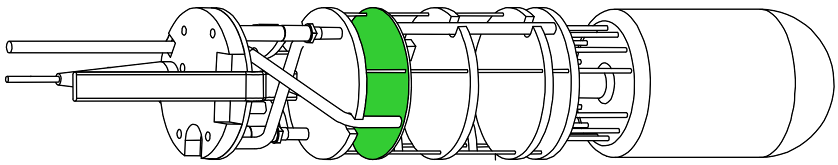
Figure 4: *MAGIC 2 PMT.*

The fourth board from the photomultiplier is the DC sensing and AC preamplification board. In order to transmit the slow variations, this board had to be modified for the Central Pixel. Such modifications will be discussed in the next chapter.

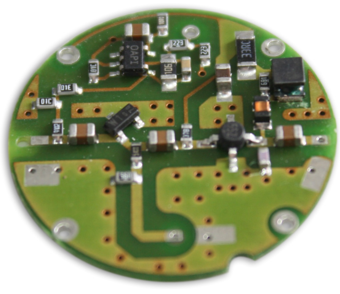
Finally the last of the boards, and attached to the mechanical fixation of the group, is the VCSEL temperature sensor and driver board.

3.3 The PMT preamplification board

As we saw in the previous chapter, the preamplification board is the fourth board counting from the PMT itself. It is a double layer board with components on only one side (see figure 5).



(a) a



(b) b

Figure 5: *The DC current and preamp board location (a) and picture (b).*

The PMT behaves like a current source (in this case, sink) and the original board component values limited the bandwidth to around 8 Hz. Which is more than enough for a DC current monitoring, but is not enough to be able to see the light variations of a Pulsar. In the Crab Pulsar's case, the optical signal period is around 33 ms, with a pulse width of around 3 ms. That is, in order to have at least two samples in each pulse, the bandwidth of our signal has to be 1 kHz or more.

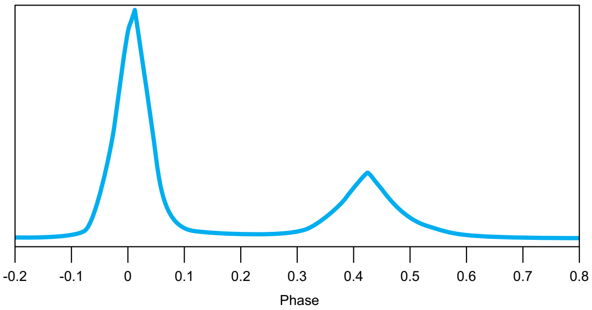


Figure 6: *Crab Pulsar pulsation*

In order to get that bandwidth, several of the components of the preamp board had to be substituted (see table 1).

Component	Original Value	Replaced with
C1	100 nF	10 nF
R7	91 kΩ	0 Ω
R1	10 kΩ	470 kΩ
R9	1 MΩ	4.7 kΩ
R10	10 MΩ	100 kΩ
C9	1 nF	100 pF

Table 1: *PMT Preamp replaced values.*

In order to transmit the signal to the following stage, the initial idea was to get it from the Anode_I_Out output cable. But doing it so, there is another bandwidth limitation, because that cable is connected to an ADC readout that has a low-pass filter at the input to prevent the ADC switching to go back and leak into the AC branch preamplifier. That filter sets that cable's high cut frequency to 13 Hz. So in order to get higher frequencies there were two choices:

- Modifying that ADC filter so the high cut frequency was higher, which would mean changing both the output resistors of the DC monitoring and the input resistor of the filter, located at the Slow control board in the cluster.
- Getting our signal from somewhere else *before* that limitation. Which would mean basically that we would need to add another cable summed to the 10 cable ribbon that comes out of each PMT.

The second option was chosen, as it was a cleaner solution and didn't mean to modify other boards asides from the PMT ones. So we soldered a cable (Cpix_Out signal) directly to the operational amplifier output and drove that cable along with the others into the cluster. The whole modified schematic can be seen in figure 7. The layout of the preamp board and the tapping point of the cable can be seen in figure 8.

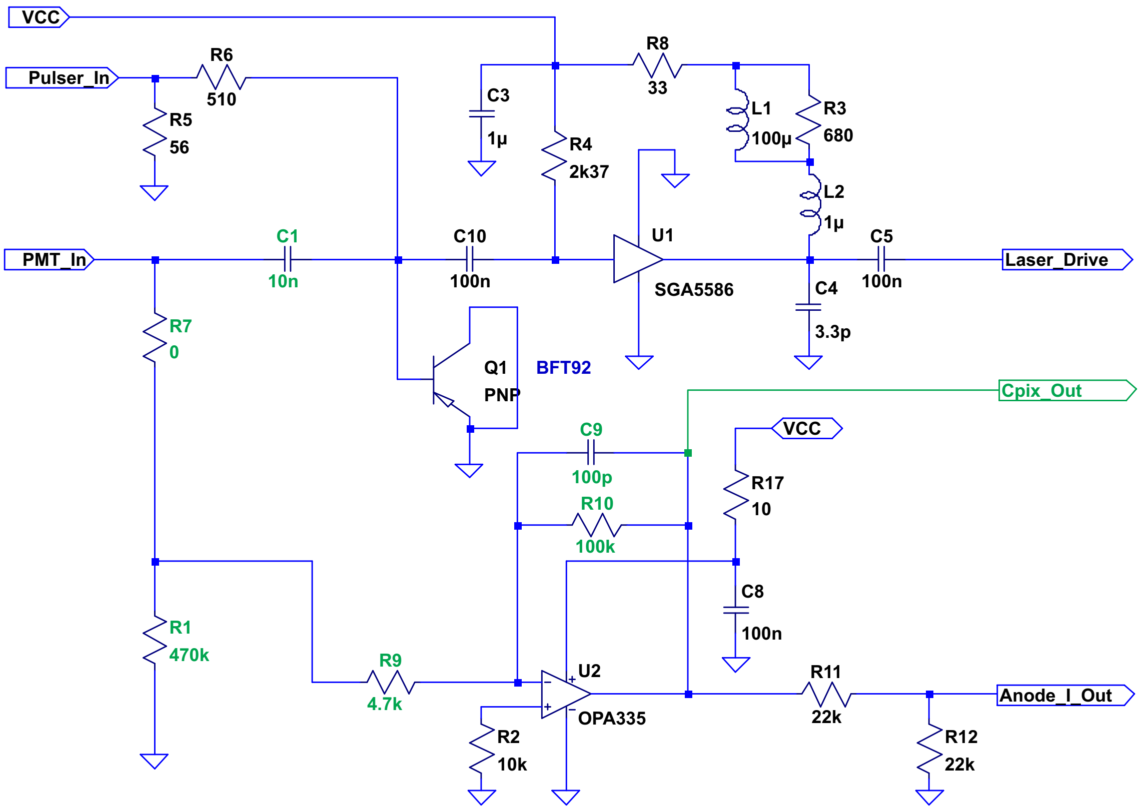


Figure 7: *Modified PMT Preamp Schematic.*

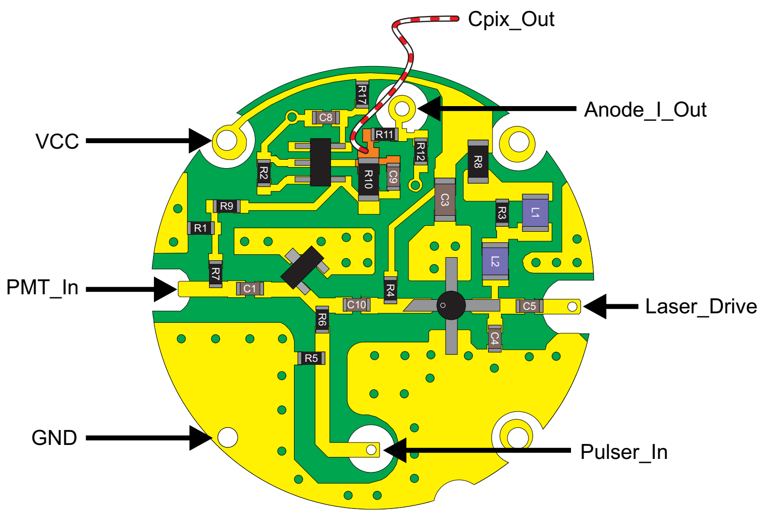


Figure 8: *PMT Preamp Board Layout.*

3.4 The Central Pixel Optical transmitter

The analog output signal from every pixel of the MAGIC camera is transmitted to the Counting house using an optical fiber. As a result, the data transmission lines are both light (in weight) and thin, asides from immune to radio interference. On the other hand they are also fragile so they were designed so there were spare fibers as a redundancy measure. The central pixel signal takes advantage of one of those spare fibers to drive its slow analog signal to the readout in the counting house. In order to achieve such optical transmission, an electrical to optical converter is needed to convert the electrical output of the modified preamp board and adapt it to the needs of the special Central pixel receiver.

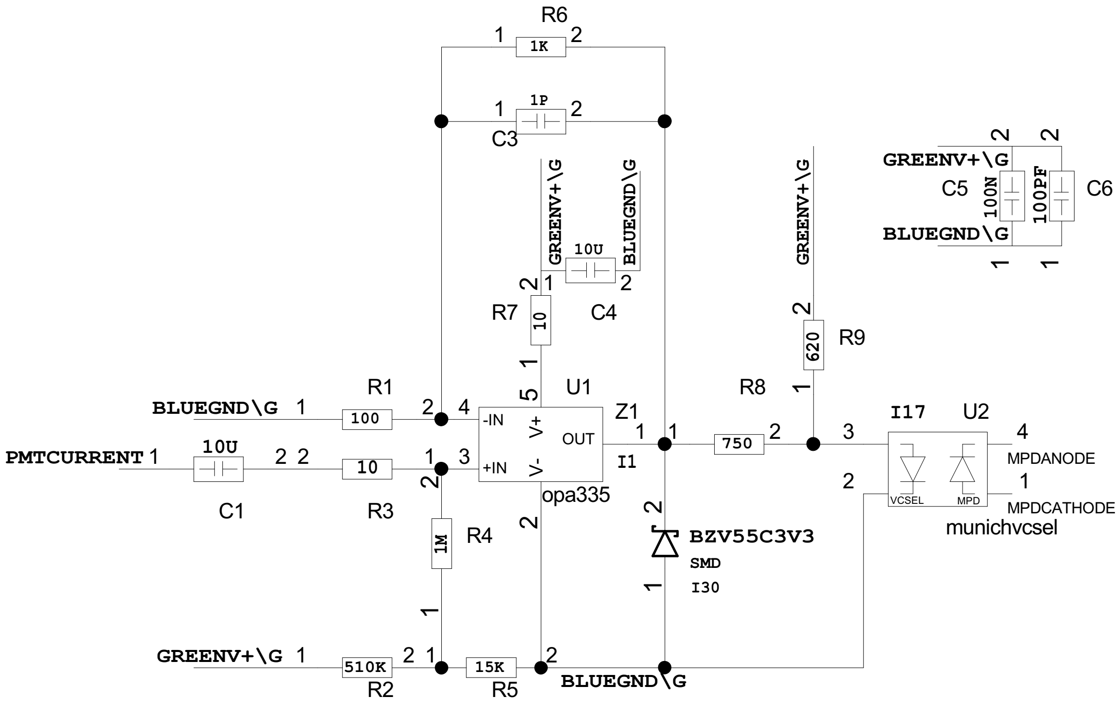


Figure 9: *Optical Transmitter Schematic.*

The schematic of this board (figure 9) is fairly simple. Basically it contains a single stage consisting of an operational amplifer in a non-inverting configuration driving a VCSEL laser. As a precautionary measure, a Zener diode limits the output voltage of the operational amplifier in order not to burn the VCSEL. This circuit's high impedance also allows a minimum alteration of the load of the DC current monitor, so there is no discernible change when it is connected. In order to get the power supply, this board takes advantage of the ribbon cable attached to the central PMT, and gets its GND and +5Vcc signal by using a standard IDC connector. The signals of the PMT ribbon cable are listed in table 2. While cables 1 to 4 are mainly for VCSEL use, cables 5 and 6 (BlueGND and GreenV+) are for the preamp board. It fits then that they also provide us with the GND and +5Vcc signals.

No.	Wire color	Signal	Type	Range ; Input/Output Impedance
1	Brown	Laser Bias	Input	0 to 6ma, 3ma typ. ; 100 Ohm
2	Red	Temp	Output	-40 to +125C, 251 to 1315 mV ; 1500 Ohm, 100 nF, 10 uA max
3	Orange	+5V	Supply	286 uA typ., 3.5 mA max. ; 10 Ohm
4	Yellow	VCSEL PD current	Output	0 to 5V (0 to 10uA PD) ; 1500 Ohm, 100 nF
5	Green	+5V	Supply	80 mA nominal ; 10 Ohm
6	Blue	Ground	Supply	
7	Violet	PMT HV Sense	Output	0 to 2.27V (0 to -1250V PMT) ; 1500 Ohm, 10 nF
8	Grey	PMT HV Control	Input	0 to 1.25V (0 to -1250V PMT) ; 100 kOhm
9	White	PMT current	Output	0 to 2.5V (0 to 50uA PMT) ; 11 kOhm
10	Black	Ground	Supply	

Table 2: *PMT ribbon cable signals.*

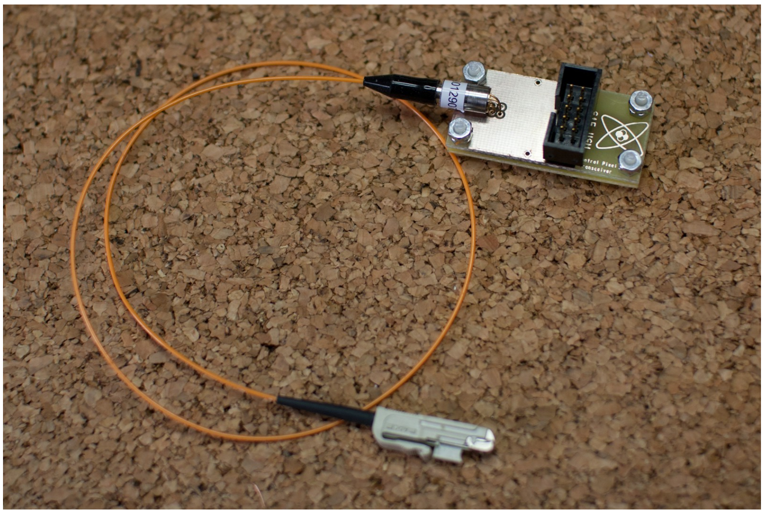


Figure 10: *Optical Transmitter.*

Then the board is located inside the body of the Central Cluster (see figure 11).

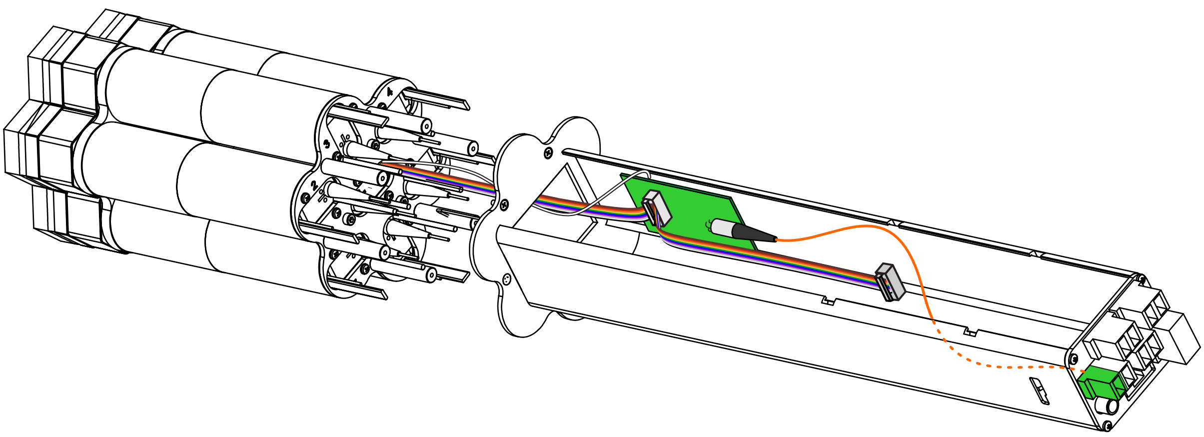
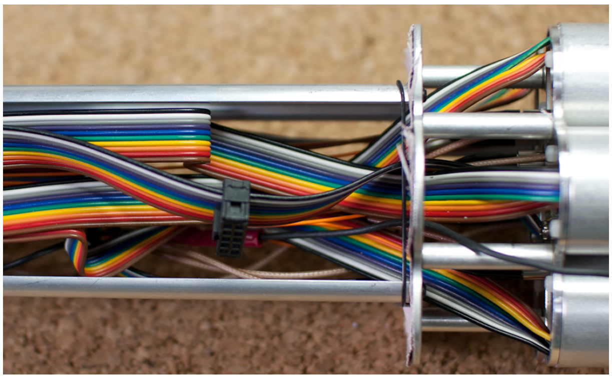
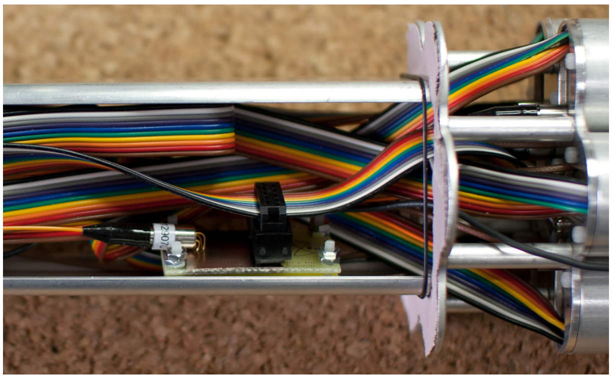


Figure 11: *Optical transmitter location.*

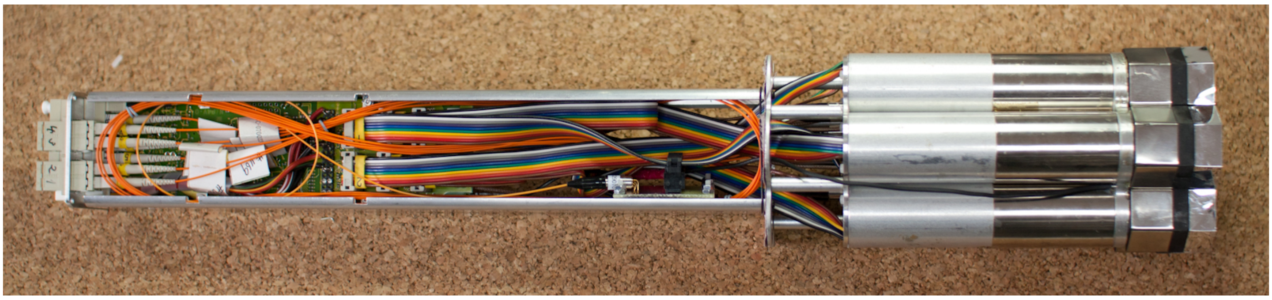
In order to get the power we placed a standard 16 pin IDC connector.



(a)



(b)



(c)

Figure 12: *Placing of the IDC connector in the central pixel ribbon (a) and and the board inside the structure (b). Finally, a view of the complete cluster (c).*

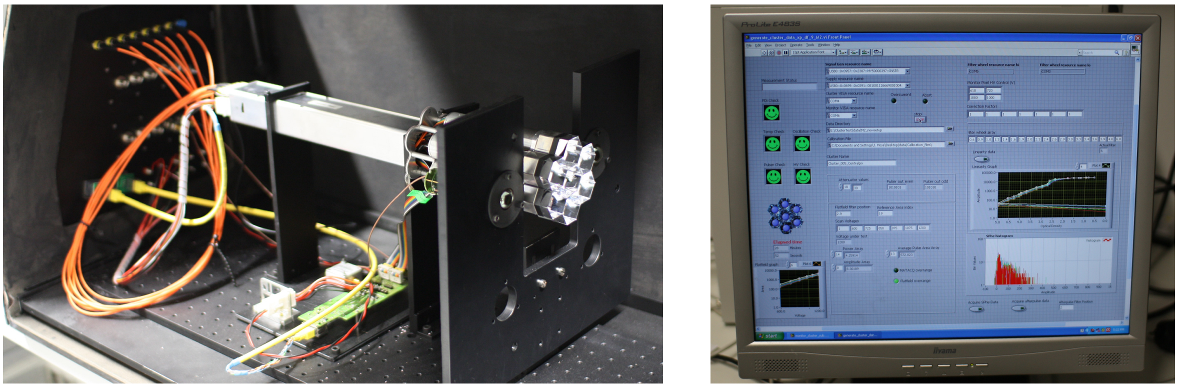
The final result is a bit compressed inside the cluster (see figure 12.c), but otherwise perfectly fine.

3.5 The Central Pixel AC branch

One of the goals of this system was to overcome the greatest limitation that the previous Central Pixel had, that is, being able to use the normal Cherenkov branch asides from the optical one. Thanks to the help of the people from the MPI für Physik in Munich, and particularly Thomas Schweizer and David Fink, we were able to fulfill these objectives:

1. Standard DC monitoring for the central pixel. The range of the DC monitoring was among the expected values.
2. Standard AC branch. The central pixel behaved just like the others in the cluster.
3. New fiber output sensible to slow light variations. They were tested with a LED, throwing a Bandwidth of 3.4 kHz.

Furthermore, the Central Cluster was tested in the MPI's Cluster testbench, in January 2012 succeeding in all the standard tests (see figures 13.a and 13.b)



(a) (b)

Figure 13: *The Central Cluster inside the MPI's bench in Munich (a) and its results (b).*

3.6 The Central Cluster installation and personal safety

The Central Cluster is installed in the center of the M2 camera. In order to inspect it (or to install it again) you have to follow the correspondent safety rules in order to access the camera, remove the front lid (see the safety equipement in the figures).
Remember that when performing any technical work on it make sure to check and follow the indications on "Safety and Health Rules at the MAGIC Site", especially those related to "experts" and "restricted areas". All safety aspects to be considered depend on the circumstances the operations are performed. Special attention must be paid to situations that can introduce additional risks, which must be evaluated before performing any task. Report to GLIMOS before performing any task inside restricted areas. Do not work alone. Before entering the telescope fenced area make sure you are equipped with helmet, walkie- talkies and to bring all the required tools. Check also the weather conditions and take the appropriate protection measures.

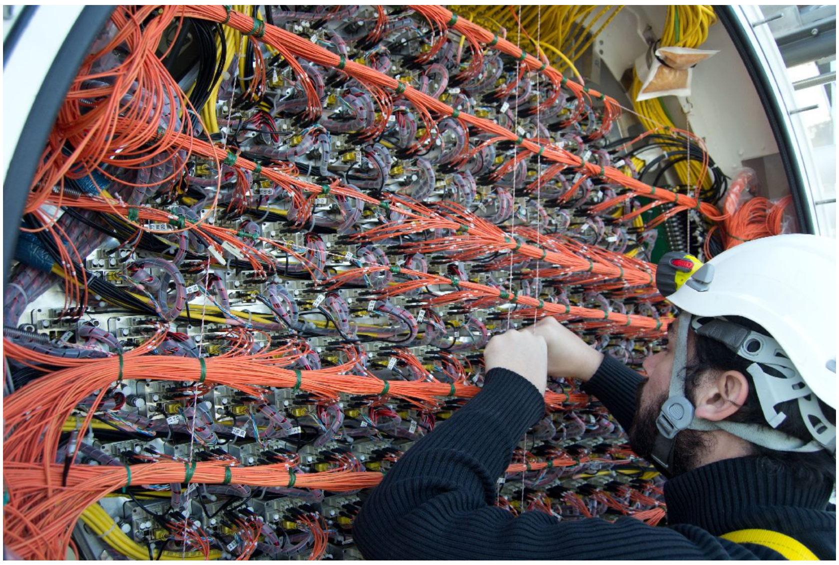


Figure 14: *Unplugging the previously installed cluster.*

Figure 15: *Removing Front Lid.*

Figure 16: *Installation of Central Pixel.*

4 The Central Pixel Optical receiver

In order to process the optical signal that comes from the camera to the counting house for its digitalization, a receiver board is needed. The low frequency signal characteristics of the Central Pixel output makes it impossible to use a standard Monster Board receiver analog channel. Thus, Channel 1[1] of Monster Board is *replaced* with the Central Pixel Optical receiver.

4.1 Board overview

This is the schematic overview.

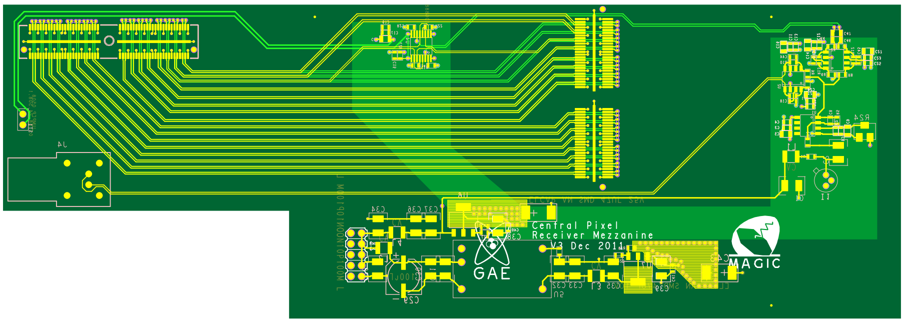


Figure 17: *Receiver Layout.*

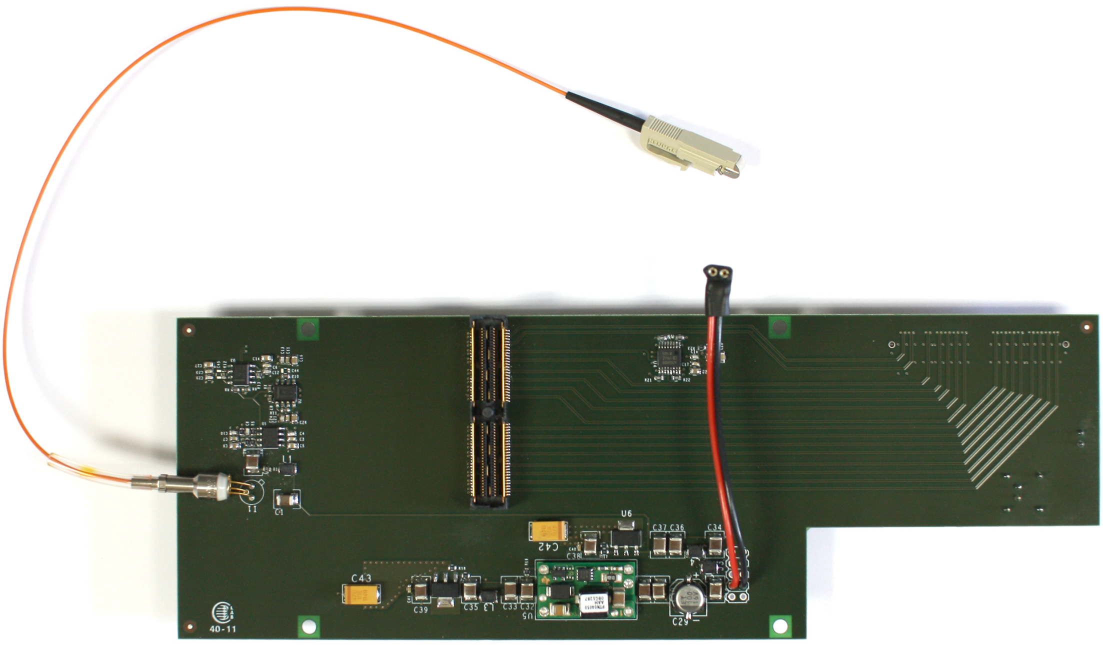


Figure 18: *Central Pixel Receiver Mezzanine.*

[1]Channel 1 is selected because it is the noisiest in the Monster Board as seen in the quality control of those boards.

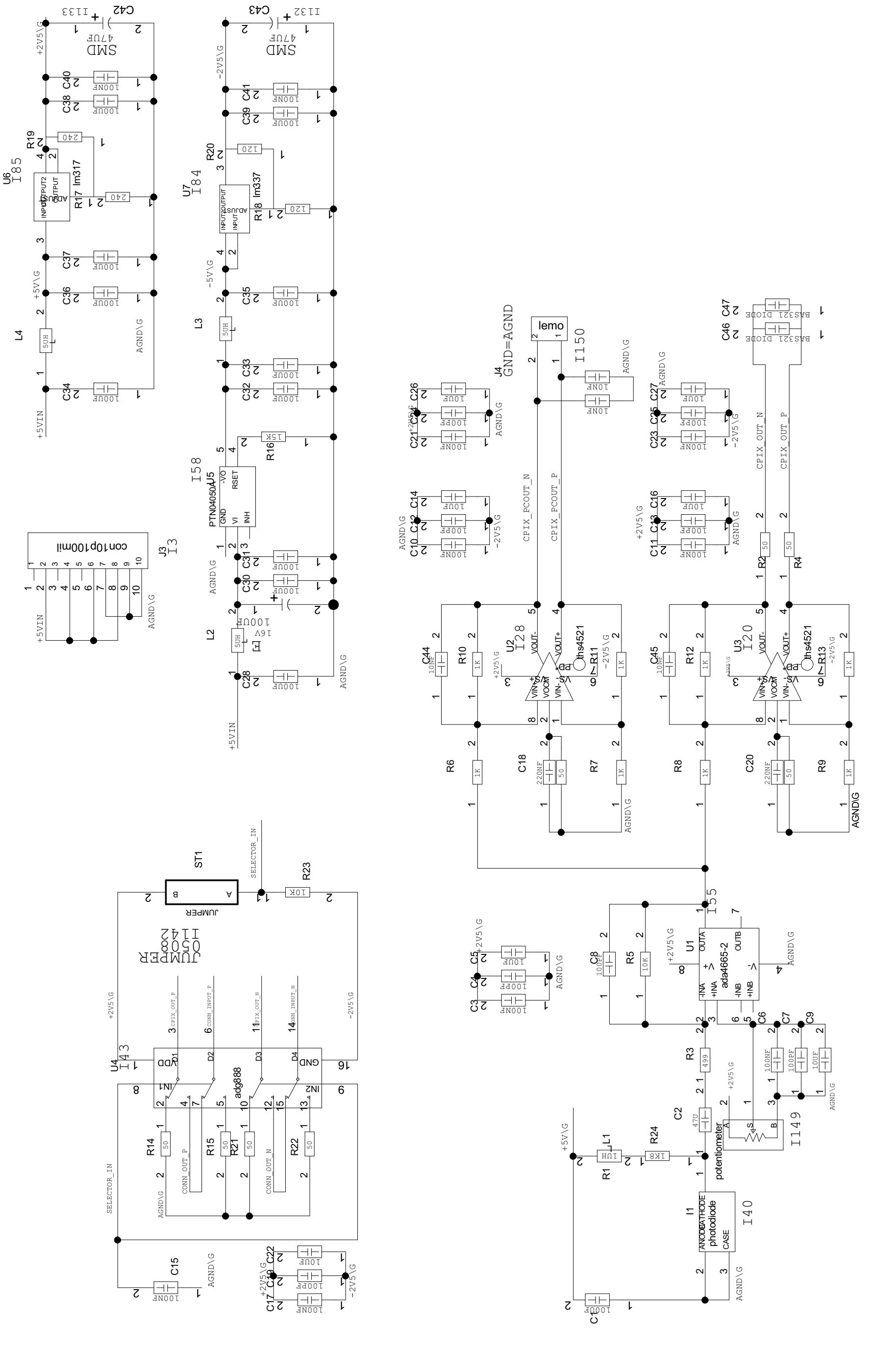


Figure 19: *Receiver Schematics.*

4.2 Input stage

The first element of the input stage is a photo diode, which is the element responsible for converting the optical signal coming from the camera to an electric one. Basically, with the proper DC current polarization, the photodiode will allow current proportional to the light that it receives, that is, the more light, the more current it draws.

The figure 20 shows the input stage waveforms[2]. The waveform present at the output of the photodiode *(Original)* goes through a coupling capacitor which removes the DC component *(Without DC)*. Because the next op-amp operates at single positive supply, it is necessary to add a positive offset for the signal to be above 0V at all times. There is a potentiometer which allows to set a DC value on the negative input of the op-amp (U1) and thus, producing the desired offset. The signal is amplified (also inverted) and remains above 0V *(Amplified (inverted) + offset)*.

It is necessary to adjust the offset using the potentiometer until the signal remains above 0V and thus, it is not cropped.

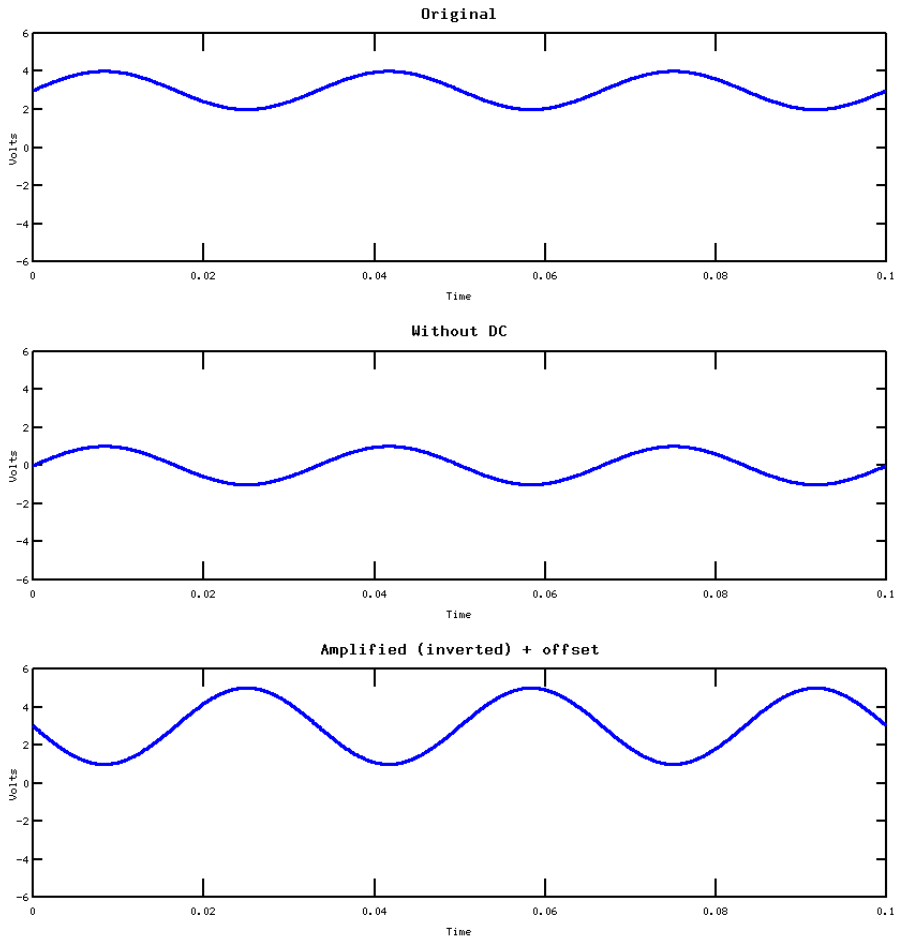


Figure 20: *Input stage waveforms.*

[2]This figure is just a simplification made as an example to show why it was necessary to add an offset. Actual waveforms may differ notably.

4.3 Single ended to differential conversion

After amplifying the signal as explained in the previous section, signal is converted to differential and sent to Domino (as if it were a normal pixel) and to PC40 simultaneously via a LEMO bipolar connector.

Clipping diodes on the output connected to Domino, limit the voltage range so it never exceeds the maximum input allowed by Domino.

Output series resistors on THS4521 op-amp Domino branch are required for stability when driving capacitive loads greater than 1 pF.

4.4 Power supply

Domino expects a symmetric signal and thus, a symmetric power supply is needed in the Central Pixel Optical receiver.

5V power supply is taken from Monster Board (see figures 23 and 24). Using that power supply, 2.5V and -5V are generated on the Central Pixel Receiver. Also, from -5V, -2.5V are generated. Design is similar to that on Monster Board (IFAE) because it has been taken from there.

4.5 Calibration switch

The Monster Board has a calibration function that sets a DC voltage on its outputs. To be able to do the calibration with Central Pixel installed, there is a jumper in Central Pixel Receiver which, when closed, allows the original signal coming from Monster Board channel 1 to reach the output instead of Central Pixel signal.

To achieve this, an analog CMOS switch (Analog Devices ADG888) is used. This switch has a bandwidth greater than 10 MHz, much more than the few kHz needed. The schematic can be seen in figure 19. The physical jumper can be seen in figure 26.

4.6 Central pixel receiver installation

The Central pixel receiver board (from now on in this section just "Receiver") installation requires preparing the Monster Receiver board (from now on just Monster) that it is going to be attached to. First, it is important to notice that there are two types of Monsters in MAGIC: the 2.1 version, whose serial numbers begin with "PROD" and the Sumtrigger version, whose serial numbers begin with "MGE". The Receiver can be used with both, but as was explained in the previous section, the power supply pins are located in different places of the boards. However, there is a flexible cable that can be used for both configurations.

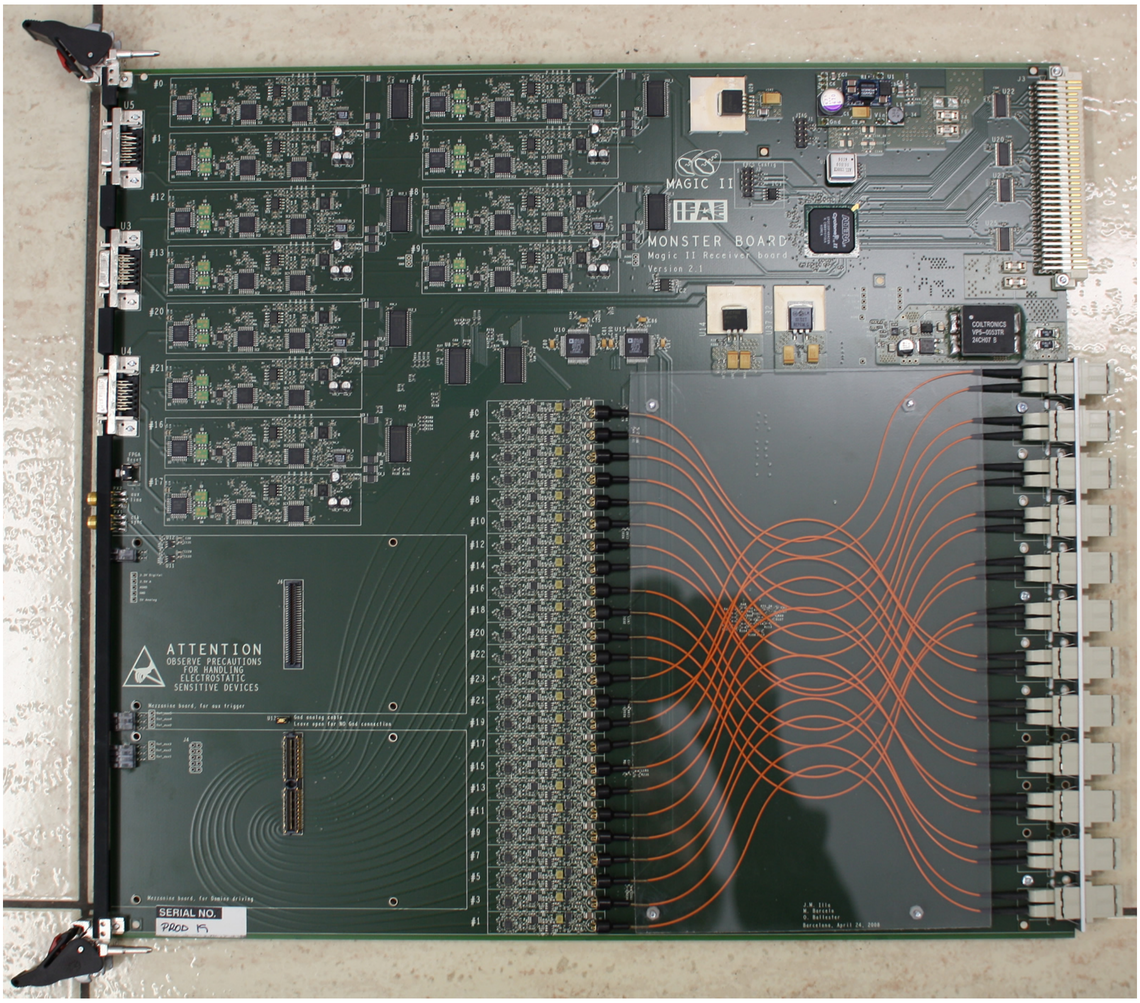


Figure 21: *Monster Receiver board v2.1.*

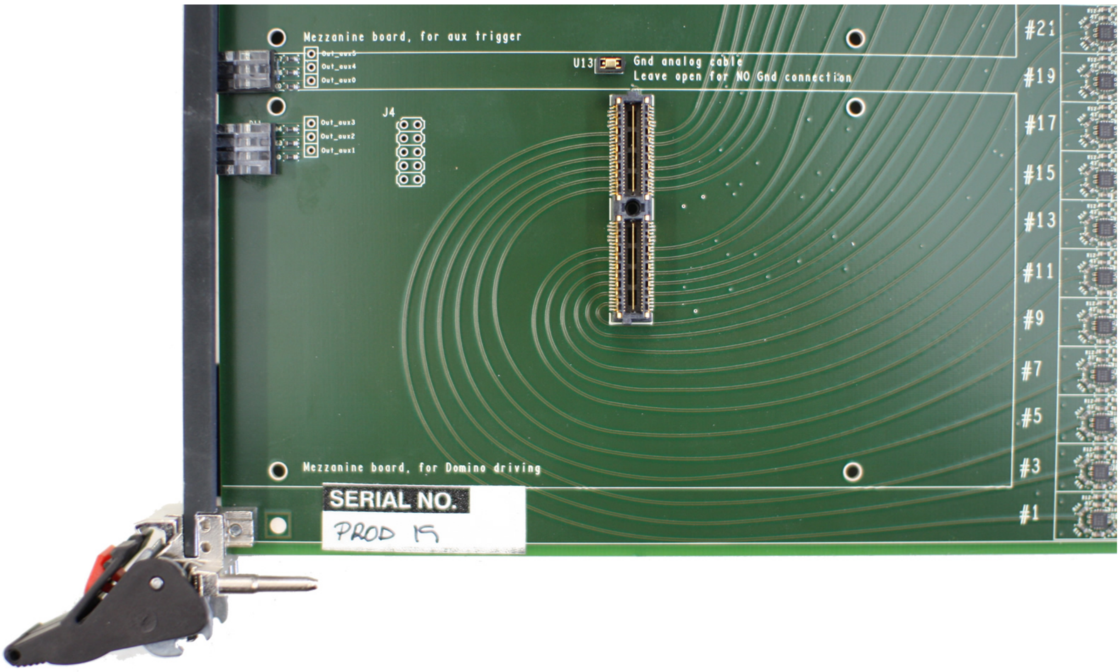


Figure 22: *Analog outputs on Monster Board. Central Pixel Mezannine connects here.*

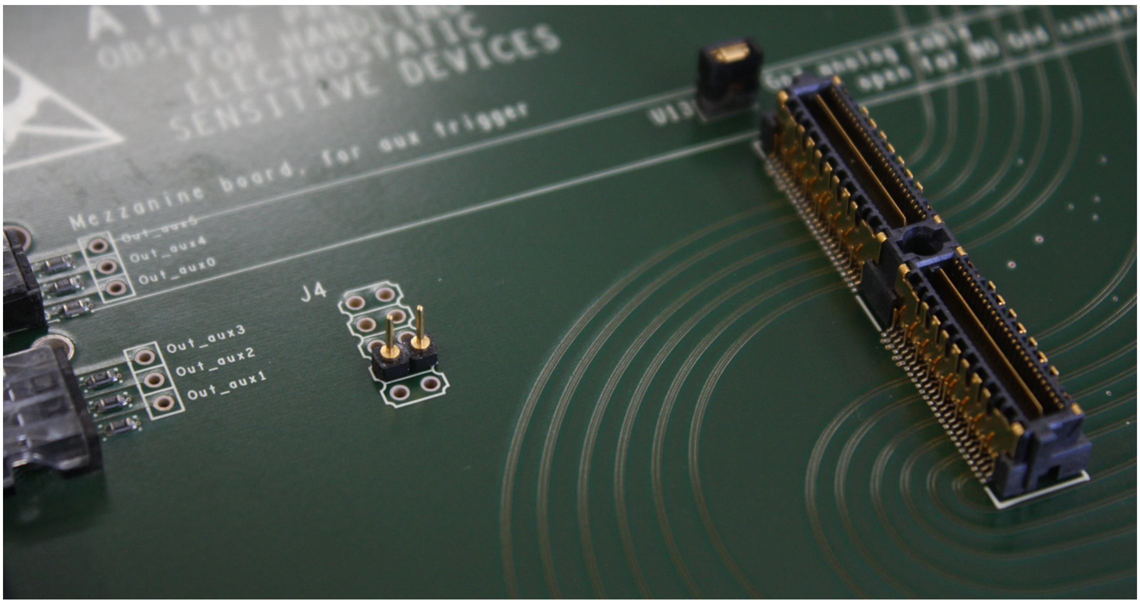


Figure 23: *Power supply pins (J4).*

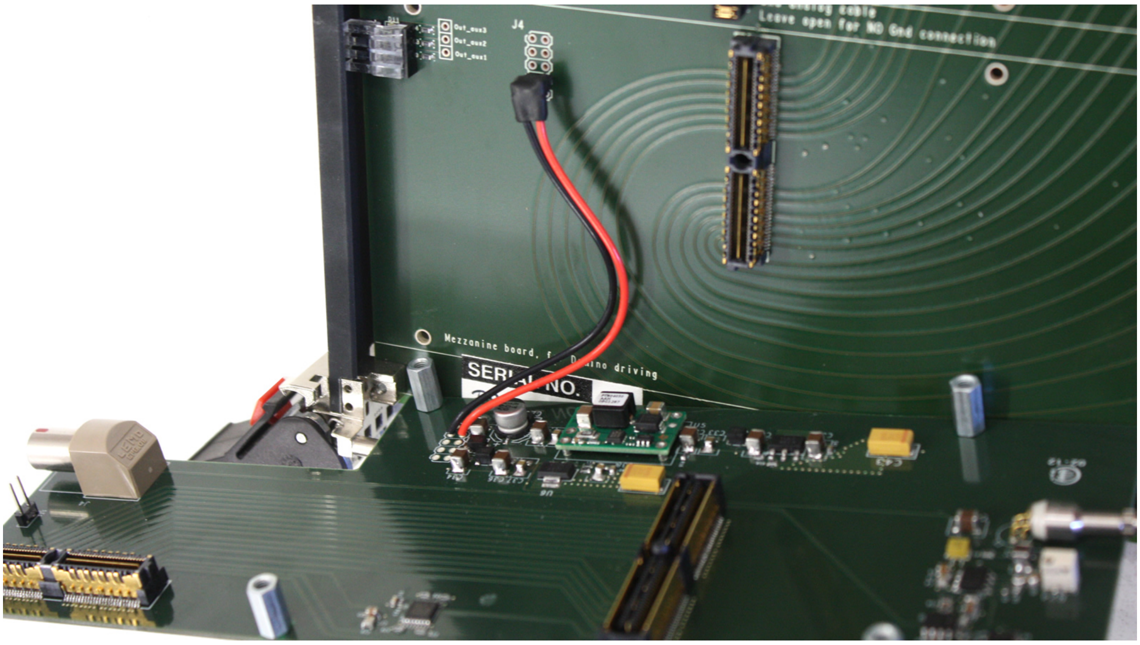


Figure 24: *Central Pixel Receiver power supply connection to Monster Board.*

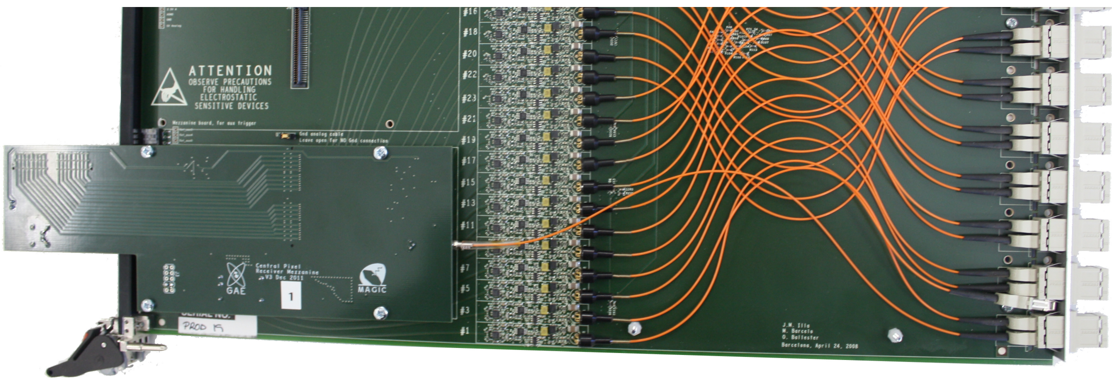


Figure 25: *Central Pixer Receiver installed on Monster Board.*

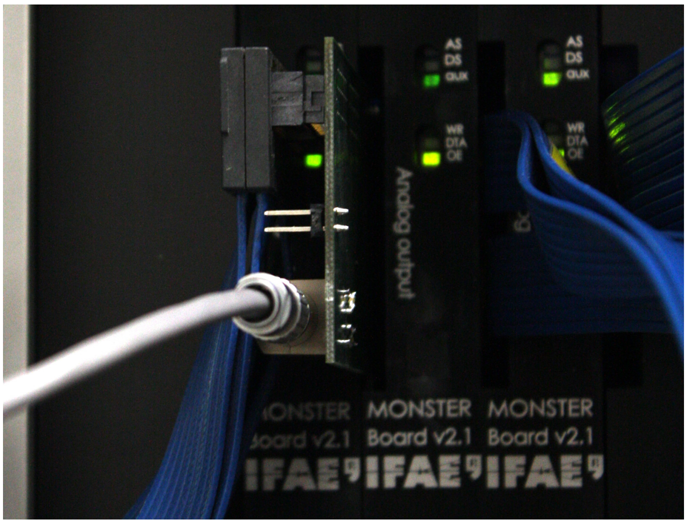


Figure 26: *Central Pixer Receiver installed on Monster Board and outside connections. Calibration switch visible.*

Figure 27: *Central Pixer Receiver installed on Monster Board (left one) vs standard Monster Boards.*

5 The Central Pixel PC: PC40

The computer dedicated to the signal readout is a Dell PowerEdge R310 (PC alias: PC40). As could be find in the MAGIC device list, informations about PC40 are:

- Net alias: centralpixel
- PC alias: pc40
- Powerswitch: 2
- Port: 7
- Physical location: electronics room
- Rack: 3

PC40 is connected to the ADC card and the computer is used to acquire the optical central pixel data. This is done running the script: /home/magic/cpix-daq (i.e. "/home/magic/cpix-daq 5" for 5 minutes. For detailed data taking instructions see the central pixel TOM section).
This script creates 2 files: a log and a dat file. It calls the C program which actually communicates with the ADC card that converts the central pixel signal in a digital one and saves the data with a sampling rate of 10 kHz (i.e. 100μs). As explained in more detail in sections 5.2 and 5.3, an absoluted timestamp is also given to the data, using two signals coming from our GPS as inputs of the ADC card also.

The source code is available at /home/cpix/ainidaq/. There is a git repository on the same folder. The most important source files are:

- LP_contAcquire3Chan_sample-ext_ReadNtpTime.c: C program which configures ADC card parameters, starts the adquisition and synchronizes with GPS and NTP for accurate timing.
- cpix-daq: script that runs the C program above and creates a a log and a dat file.

The ADC card is a National Instrument PCIe 6251 M Series, a high-speed multifunction data acquisition (DAQ) device optimized for a superior accuracy at fast sampling acquisition. The device have a NI-MCal calibration technology for improved measurement accuracy and six DMA channels for high-speed data throughput. Has an onboard NI-PGIA 2 amplifier designed for fast settings times at high scanning rates ensuring a 16-bit accuracy even when measuring all channels at maximum speeds. Some specifications of the card are listed in table 3.

Analog Inputs	AI resolution	ADC resolution	Sampling Rate	Timing accuracy
8 differential or 16 single-ended	16 bits	16 bits	1.25 MS/s	20 ppm of sample rate

Table 3: *NI PCI 6251 specific information*

The experimental set up and the produced data files are described in the next subsections.

5.1 Connections to the ADC card

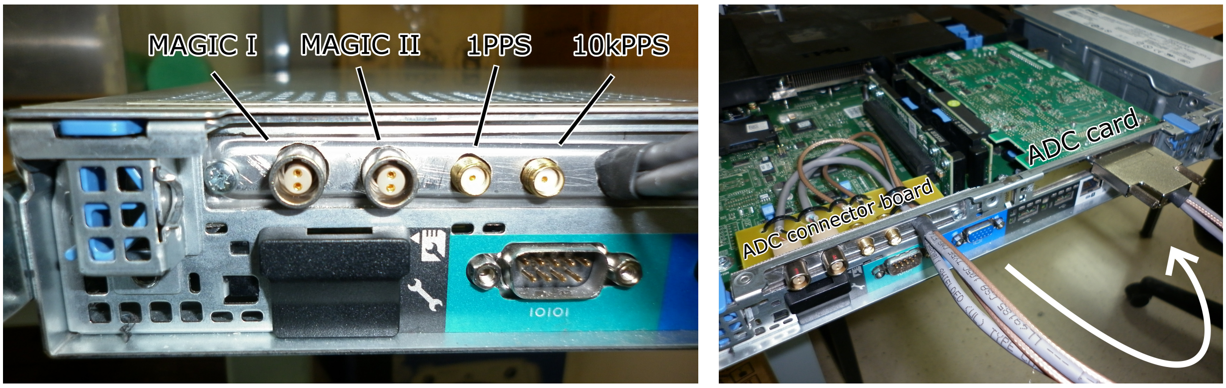
The inputs of the ADC used are:

INPUT 1 Differential. MAGIC 1 old central pixel. This is the signal that comes from the Central Pixel Receiver connected to MAGIC 1 central pixel. Please notice that there will be NO Central Pixel in the new camera of MAGIC 1. Connected to /Dev1/ai0 input of ADC (because it is a differential signal, it is connected to /Dev1/ai0 (+) and /Dev1/ai8 (-)).

INPUT 2 Differential. MAGIC 2 central pixel. This signal comes from the Central Pixel Receiver connected to MAGIC 2. Connected to /Dev1/ai1 input of ADC (because it is a differential signal, it is connected to /Dev1/ai1 (+) and /Dev1/ai9 (-)).

INPUT 3 Single-ended. 1PPS signal. This signal comes from the GPS and is synchronized to UTC. Although this is a single ended signal, it is connected in a differential mode so it can be configured like the previous two inputs. Signal is connected to /Dev1/ai2 (+) and ground is connected to /Dev1/a10 (-).

INPUT 4 Single-ended. 10kPPS signal. This signal also comes from the GPS and serves as a sampling signal to the ADC. That is, the ADC takes its samples at the pace indicated by this signal. Connected to /Dev1/PFI7 input of ADC.



(a) ADC connector board inputs. (b) ADC connector board to ADC card.

Figure 28: *PC40 rear.*

In order to allow this easy access with standard connectors like LEMO and SMA, it was necessary to create an ADC connector board. It has the four inputs shown in figure 28(a) and connects them to the ADC board as shown in figure 28(b).

5.2 Timing considerations

There are some considerations that need to be taken into account for timestamping the data. From the moment that the optical signal arrives to the camera until it gets to PC40 there is a delay that can be subdivided this way:

- Camera to Receiver delay
- Signal propagation in the receiver's delay
- Differential cable from the receiver to the PC's delay

The overall delay should be taken into account but won't be discussed in this chapter. Nevertheless, once the signal physically arrives to the PC, there are some important considerations.

Both the sampling (10kPPS, ten kilosamples per second) and the change of second (1PPS, One pulse per second, that is, 1Hz) signals come from the GPS. They are generated from the same Rubidium Oscillator, and that means that the delay between them is constant. That delay is 20 μs from rising edge to rising edge and from the 1PPS to the 10kPPS signal.

Also, the ADC needs some time from the moment that the sampling signal (10 kPPS) tells it to capture (rising edge) until it *actually* samples each signal. This happens because the ADC card has only one analog to digital converter, so it has to do the conversions one after the other. Each conversion needs one *convert period* to be done. The first conversion may take a little longer.

Figure 29 shows a simplified scheme[3].

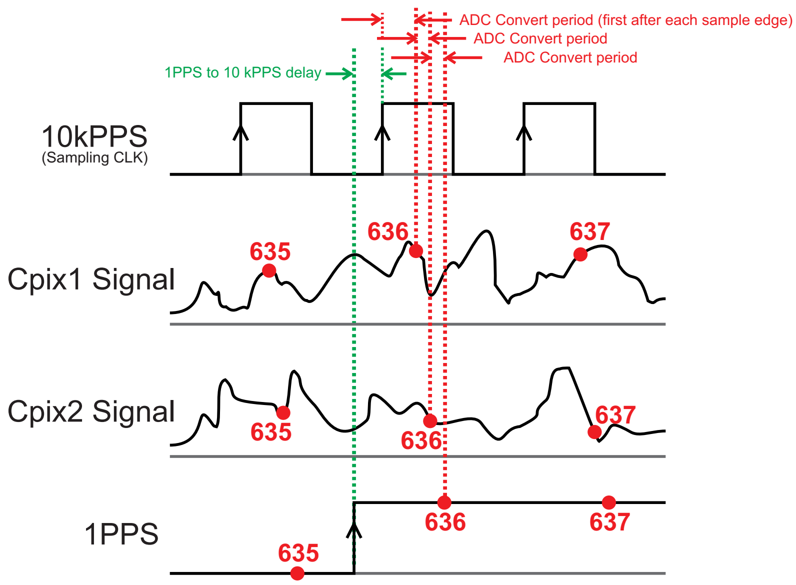


Figure 29: *Timing of ADC signals.*

[3] Actual variation rate of the Cpix1 and Cpix2 signal is much slower so sampling is done correctly (which does not occur in the figure) and also, Convert period is not so important.

5.3 Timing algorithm

The algorithm used for absolute time synchronization does the following:

- Start sampling.
- Ask computer for time[4] and store it.
- Start searching through the samples looking for a positive edge in 1 PPS signal. With every sample, 100μs are added to the time stored.
- When the positive edge in 1 PPS is found, the timestamp of the first sample after the edge is set to the closest integer second of the time stored.
- From this moment, time is synchronized. Knowing the absolute time of one sample, as the Rubidium oscillator is very precise, the time of the rest of samples can be determined because they are sampled every 100μs.

Please note that the ADC convert delay hasn't been taken into account, is assumed to be negligible on our purpose. If it were necessary to improve the accuracy it could be measured or calculated and added to the final timestamp.
Figure 30 shows an example of the data file generated. Data columns are: MJD, Fraction of day, M1 Cpix Signal (V), M2 Cpix Signal (V), 1PPS Signal (V) and Sample index. No sample is written to the file until the first 1 PPS positive edge is found.

```
#VERSION 4.0 TIME_MIN 5.00 SAMPLING_PERIOD_SEC 0.00010 VOLTAGE_RANGE_MILLIVOLTS 2000
#Starting readout at Year 2012, Month 4, Day 12, Hour 20, Minute 45, Second 57.5968317
56029 0.86525462986111 -0.0711000605 -0.1086879332 1.0558450373 3965
56029 0.86525463101852 -0.0712933144 -0.0971249115 1.0558450373 3966
56029 0.86525463217593 -0.0711000605 -0.1016341678 1.0558450373 3967
56029 0.86525463333333 -0.0706813439 -0.1028581088 1.0558450373 3968
56029 0.86525463449074 -0.0711644785 -0.1028581088 1.0558450373 3969
56029 0.86525463564815 -0.0707135528 -0.1033090345 1.0558450373 3970
56029 0.86525463680556 -0.0707457618 -0.1010221973 1.0558450373 3971
56029 0.86525463796296 -0.0706813439 -0.0949347012 1.0558450373 3972
...
```

Figure 30: *Example of ADC file contents.*

IMPORTANT: Please note that readout started approximately at second 57.6 and that the first sample shown is the 3965th. Since samples are 100μs apart, 3965 x 100μs is 0.3965 seconds which is approximately the time elapsed from readout start until the start of the following second. If there were any incoherency here, the Central Pixel Timing would probably be wrong.

[4]Computer time is NTP synchronized with an NTP server. GPS rack in La Palma acts as the NTP server giving the computer time an accuracy in the order of 1ms. This accuracy is not enough and that is the reason why the 1 PPS signal is used to improve it.

5.4 Important info about computer time resolution

To retrieve the time from computer, the function ntp_gettime(struct ntptimeval *tptr) is used. This function[1] writes the time in the ntptimeval structure pointed by tptr.

The *ntptimeval* structure[1] contains a timeval structure[2] whose elements are:

long int tv_sec This represents the number of whole seconds of elapsed time.

long int tv_usec This is the rest of the elapsed time (a fraction of a second), represented as the number of microseconds. It is always less than one million.

However, in PC40, using Scientific Linux, *tv_usec* is actually the number of nanoseconds and not microseconds.
It seems that depending on the linux distribution, *tv_usec* can contain microseconds or nanoseconds. We need to know the resolution in order to add seconds and microseconds or nanoseconds into a single float variable in one of the following manners:

- time = tv_sec + 1E-6*tv_usec (if microseconds resolution)
- time = tv_sec + 1E-9*tv_usec (if nanoseconds resolution)

To know the resolution we use ntp_adjtime(struct timex *tptr)[1] which is a function to set and retrieve settings. If the *modes* element of the *timex* structure is set to zero, ntp_adjtime(...) does not change anything and just reads settings. The structure *timex* has an element, *status*, in which one bit indicates if resolution is nanoseconds or microseconds. This bit can be checked using STA_NANO as a mask. The following code is a resumed version of the code present in the actual program, but gives an idea of the procedure.

```
struct timex DH_timex;
float64 subsecondScale;

[...]

//Resolution check: us or ns
DH_timex.modes=0;          // modes=0 doesn't change anything
                           // when calling ntp_adjtime();
ntp_adjtime(&DH_timex);

if(DH_timex.status & STA_NANO){ //Mask to get only the STA_NANO bit
    subsecondScale=1E-9;
}else{
    subsecondScale=1E-6;
}//End of resolution check
```

6 The Central Pixel technical details

Cpix fiber: bundle 50 fiber 19

Connected to: crate 2 (VME counting) Rack 2, upper crate. Channel 1 of receiver in Slot 3

Cpix board 1 (of 2).

References

[1] *High Accuracy Clock*, GNU.
`http://www.gnu.org/software/libc/manual/html_node/High-Accuracy-Clock.html`

[2] *Elapsed Time*, GNU.
`http://www.gnu.org/software/libc/manual/html_node/Elapsed-Time.html`