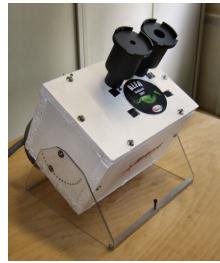


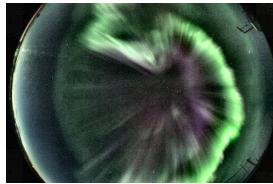


# SUPERDARN



# MALFRA

## Mobile Auroral Light Fine Resolution Analysis



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# MALFRA PHOTOMETERS

TSR

**TECHNICAL SPECIFICATION  
REQUIREMENTS**

+ DD

**DEFINITION DOCUMENT**

Prepared by :	<b>M. Godefroy / E. Seran</b>	Visa
Date :	27 octobre 2007	
Reference :	<b>MALFRA-PHOT-DD-03</b>	
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## Revisions



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## 1. OBJECT

This document describe the definition of the MALFRA-PHOTOMETER instrument. It will be used as technical specification requirements to manufacture the instrument.

## 2. DOCUMENTATION

Applicable documents are

- |                          |                |
|--------------------------|----------------|
| - STB + DD MALFRA        | MALFRA-DD-04   |
| - Environment Protection | MALFRA-EP-01   |
| - STB + DD MALFRA Niger  | MALFRA-N-DD-01 |
| - STB + DD ALFA dôme C   | ALFADC-DD-02   |
| - STB + DD ALFA          | ALFA-DD-01     |

## 3. OVERALL DESCRIPTION

### 3.1 PROJECT OBJECTIVES

MALFRA (Mobile Auroral Light Fine Resolution Analysis) + MALFRA PHOTOMETERS are derived from the ALFA project. The main objective is to develop a mobile and autonomous optical instrument to perform fine measurements of auroral arcs or other light phenomena. This project is made of 1 all sky camera with an horizontal spatial resolution of ~100 m and 2 high sensitivity photometers

### 3.2 INSTRUMENT INFORMATION

*p 15 and 16*

MALFRA PHOTOMETERS experiment is an autonomous and mobile optical instrument to measure the intensity and the position of light sources in the visible spectrum between **0.3 to 10 kR**.

#### 1. Study of the auroral dynamics

1.1 Coordinated measurements of the ground-based all-sky camera + photometers and of the plasma instruments onboard the ionospheric satellite Demeter provide the dataset which allows to perform the detailed analysis of the ionospheric modifications due to intense energy/mass exchange during sub-storm development. Remote observations made by the camera give quasi-instantaneous image of photoemissions produced by the collisions and charge exchanges between the energetic particles of the magnetospheric origin and the charged and neutral particles that populate the low ionosphere. Even if the emission intensities are highly representative, since they carry indirect information related to the energy and intensity of the precipitating electrons (or, more precisely, their energetic tails), only a small part of the input energy goes to the lightening. The main part of energy is released into the plasma acceleration and heating which are subsequently resulted in the modifications of the entire conducting layer with a partial energy/mass return back to the magnetosphere. In-situ observations onboard the Demeter satellite in the upper ionosphere inside and in vicinity the magnetic tubes which carry the upward current allows to survey the source (upward current) and its consequences (ion/electron acceleration and outflowing, downward current, wave excitation etc.).

1.2 Coordinated observations of the all-sky + photometers and the cameras from the ALIS network allows to study

- dynamics of the sub-storm development;
- estimate the altitude of the emission (triangulation);
- deduce the electron energy from the relative intensity of the emissions with the different wave length;
- estimate the contribution of each emission line into the integral RGB signal etc.

**3.2.1 Photometer optical subsystem**

- |                         |                                |
|-------------------------|--------------------------------|
| - Sensors               | optical, fix (S2281 Hamamatsu) |
| - Field of view / image | 9° to 50° / circular           |
| - Output                | Analog signal                  |
| - Filtering             | Yes if needed                  |
| - Weather protection    | No                             |
| - Working               | Dark conditions                |

**3.2.2 Electronic subsystem**

- |                         |   |
|-------------------------|---|
| - Analog part           | install outdoor   |
| - Analog output signals | Yes   |
|                         | 4 channels : Photometer 1 current + Photometer 2 current + photometer 1 |
|                         | Temperature + housing temperature                                       |
| - Numerical part        | No  |
| - Link to ADC           | Short coaxial cables  |

**3.2.3 ADC subsystem****install indoor**

- |                          |                                     |
|--------------------------|-------------------------------------|
| - ADC                    | NI USB-6008                         |
| - Powered                | From USB                            |
| - Available ADC channels | 8 SE or 4 DI                        |
| - N ADC bits             | 12 (DI)                             |
| - ADC input ranges       | +20 / +10 / +5 / +2.5 / +1.25 / +1V |
| - Max ADC sample rate    | 10 Ks/sec                           |
| - Available digital I/O  | 12                                  |
| - Available DAC channels | 2                                   |

**3.2.4 Monitoring / data processing**

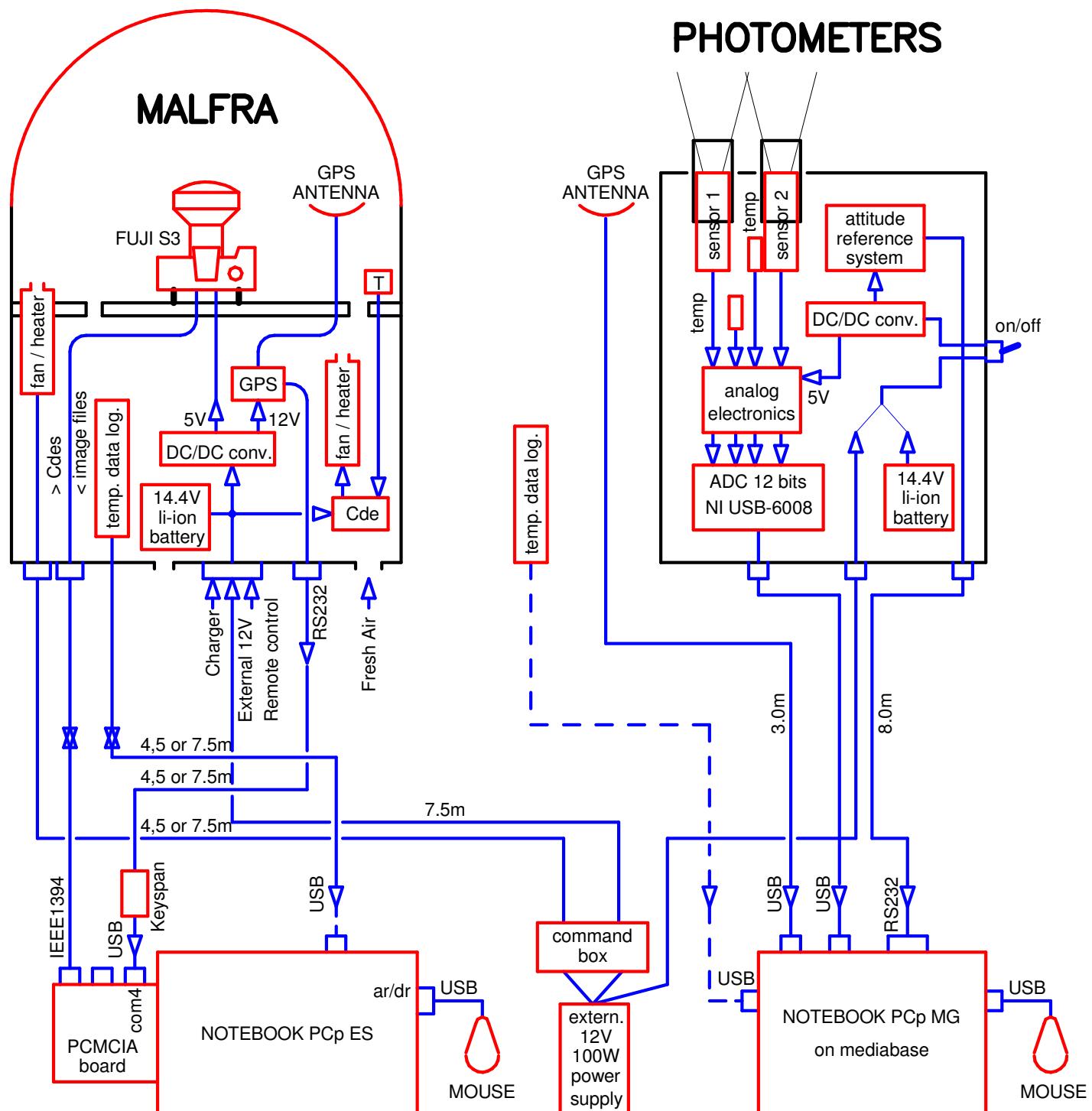
- |                      |                                   |
|----------------------|-----------------------------------|
| - Informatic system  | Laptop PC / Windows XP            |
| - Software           | LabWindows CVI rev 8              |
| - Monitoring         | Yes                               |
| - Working modes      | On request by software            |
| - Data processing    | Digital filtering                 |
| - Local data storage | In PC laptop hard disk or USB key |

**3.2.4 Housekeeping**

- |                            |                           |
|----------------------------|---------------------------|
| - Sensor position          | Attitude Reference System |
| - Event datation           | PC time or WS5011 GPS     |
| - Sensor temperature       | AD590                     |
| - Internal box temperature | AD590                     |
| - Outside box temperature  | USB Data Log              |

**3.2.5 Powering**

14.4V Li-ion battery or 12V external power supply

**3.3 BLOCK DIAGRAM**




#### 4. TECHNICAL SPECIFICATION REQUIREMENTS / DEFINITIONS

##### 4.1 INSTRUMENT

###### 4.1.1 Monitoring

Monitoring	TSR	DD	Model (-20°/+40°)
Sampling periodicity	fix	1 mS / channel	1 mS / channel
Analog gains (electronics)	----	2	2
ADC analog scale (NI USB-6008)	+ - 5V and + - 1V	+ - 5V and + - 1V software	+ - 5V and + - 1V software

###### 4.1.2 Measures

Optic	TSR	DD	Model (-20°/+40°)
Field of view	20° to 45° (manually adjustable)	9, 14, 22, 38° and 15, 20, 30, 50° manually adjustable	9, 14, 22, 38° and 15, 20, 30, <b>50°</b> manually adjustable
Image type	Circular	-----	-----
Filters	Polarized or interferential	Polarized or interferential	Polarized or interferential
Current dynamic "max"	100 nA max	Gain min and +5/-5 = 50 nA Gain max and +5/-5 = 10 nA Gain max and +1/-1 = 2 nA	Gain min and +5/-5 = <b>50 nA</b> Gain max and +5/-5 = 10 nA Gain max and +1/-1 = 2 nA
Current resolution (nA/bit)	10 pA min	Gain min and +5/-5 = 25 pA Gain max and +5/-5 = 5 pA Gain max and +1/-1 = 1 pA	Gain min and +5/-5 = 25 pA Gain max and +5/-5 = <b>5 pA</b> Gain max and +1/-1 = <b>1 pA</b>
Maximum noise	5 pA cc	1 pA cc	0.9 pA cc

###### 4.1.3 Servitudes

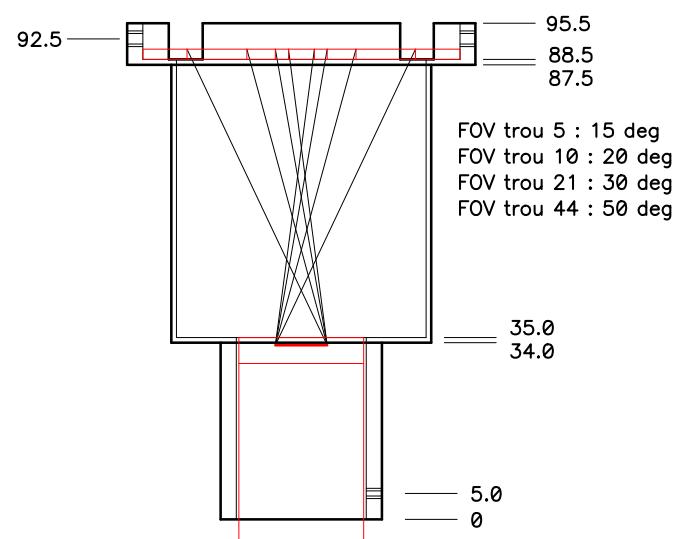
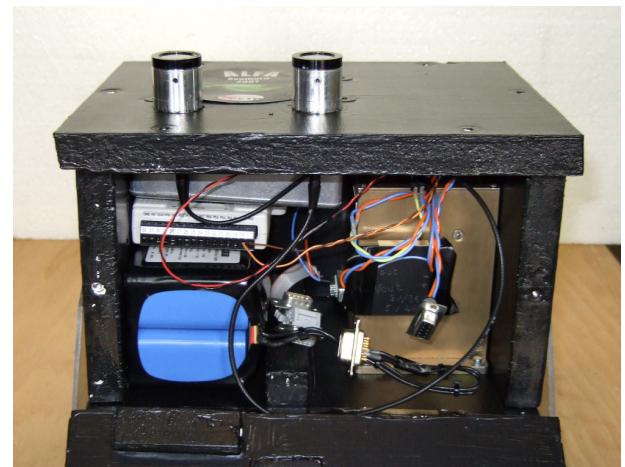
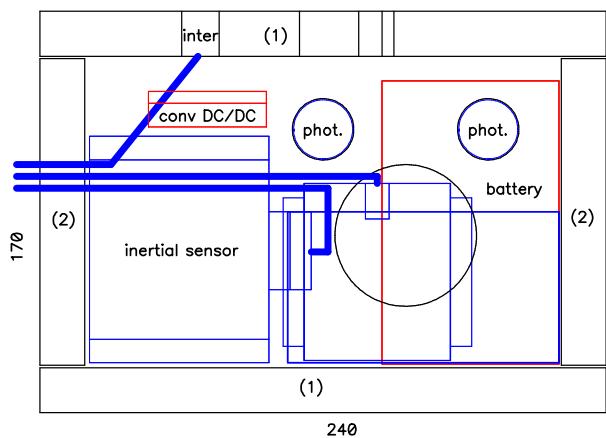
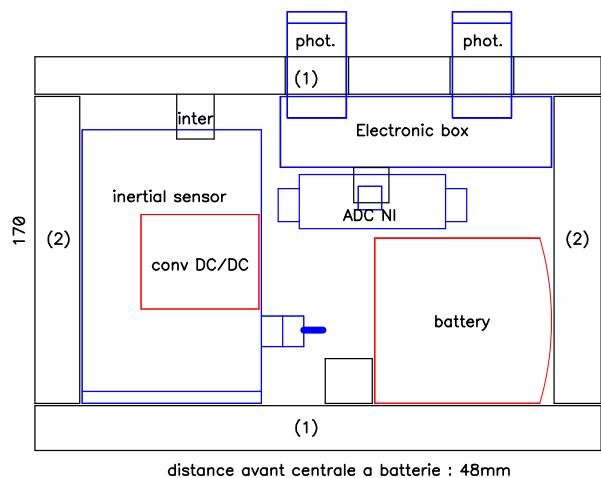
	TSR	DD	Model (-20°/+40°)
Current datation	PC date/time	PC date/time or dedicated GPS	PC date/time or dedicated GPS
Position : latitude / longitude / altitude	Attitude reference system	AHRS400	AHRS400
Internal air temperature	-30°C to +40°C	AD590	AD590
Sensor temperature	-30°C to +40°C	AD590	AD590
Protection against mist and frost	no	no	no

###### 4.1.4 Operational use

	TSR	DD	Model
Distance between instrument and PC	min 5m	8m	8m
External minimum temperature	-30°C	-30°C	Tested at -20°C
Internal minimum temperature	0°C	-10°C	-4°C after 7h (ext -20°C)
Autonomy on battery	6 h min	32h	32h

## 5. MECHANICAL ARCHITECTURE

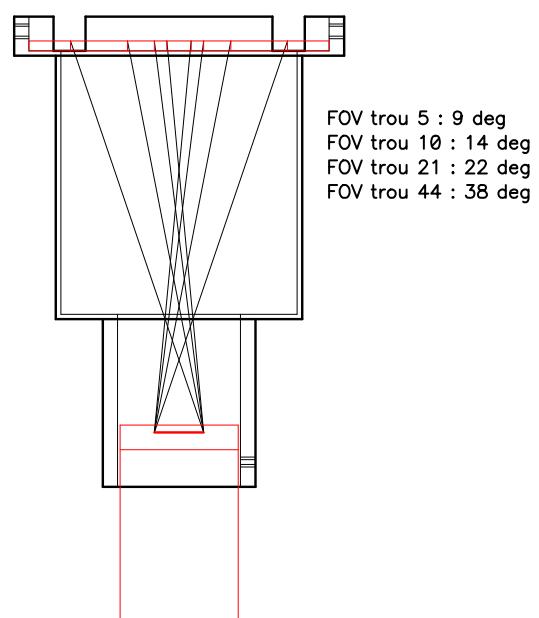
### 5.1 MECHANICAL CONCEPT



**5.2 DIMENSIONS** L 240 mm l 170 mm H 170 mm

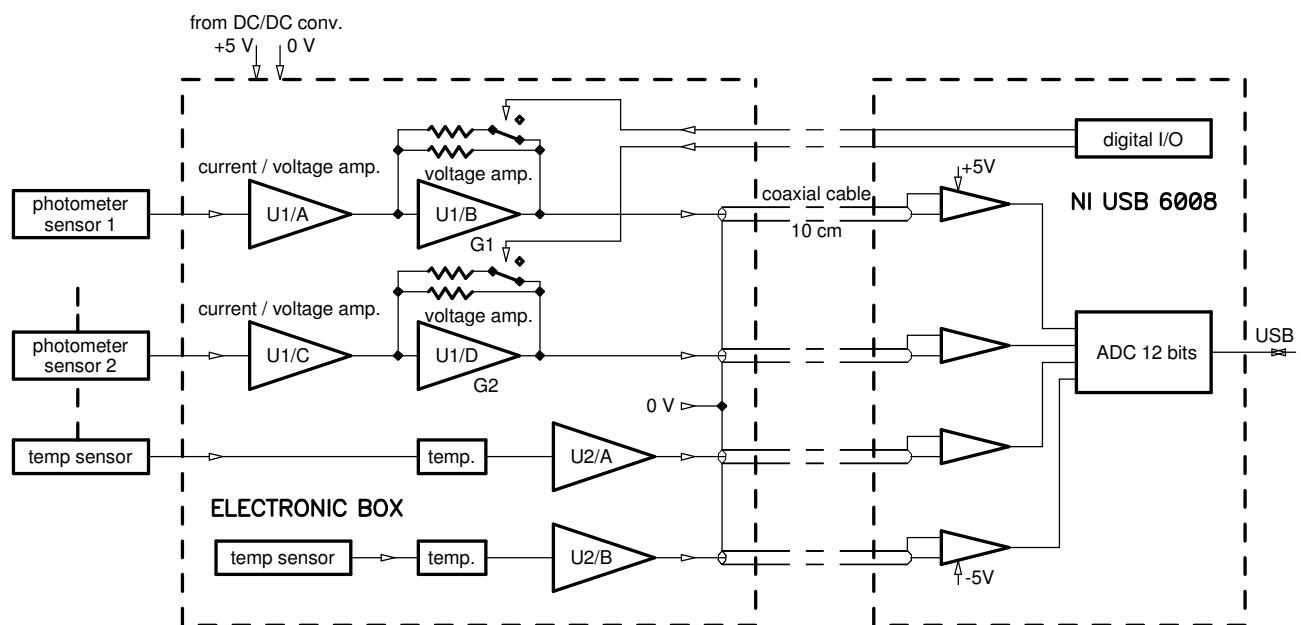
### 5.3 WEIGHT

Complete instrument weight (without ext. cables)	<b>3.3 kg</b>
<i>Housing</i>	<b>320 g</b>
<i>Inertial subsystem</i>	<b>646 g</b>
<i>Battery 14.4 avec câble</i>	<b>1252 g</b>
<i>DC/DC converter + cables + inter</i>	<b>94 g</b>
<i>Photometer sensor+ cylindrical support</i>	<b>36 g</b>
<i>Filter holders + FOV adjustment</i>	<b>300 g</b>
<i>Electronic box + NI6008</i>	<b>290 g</b>
<i>Electronics + internal cables (estimation)</i>	<b>40 g</b>
<i>Positioning support</i>	<b>310 g</b>
	<b>-----</b>
	<b>3290 g</b>



## 6. ELECTRONIC ARCHITECTURE

### 7.1 ANALOG ELECTRONICS



#### Electronic box

U1/A and U1/C	<b>33 nA / V (R 30 M)</b>
U1/B and U1/C	G1min = <b>3.3</b> (R 23K) ou G1max = <b>17</b> (R 160K)
U2/A and U2/B	G = <b>10</b>
Rise / fall time	<b>40 mS</b> (0 to 99%)

#### ADC NI USB-6008

12 bits (DI) = 4096 bits for +5V ... **2048 bits for 0 to +5V**

#### Commands

Gain selection from 2 NI 6008 I/O bits

#### G photometer min

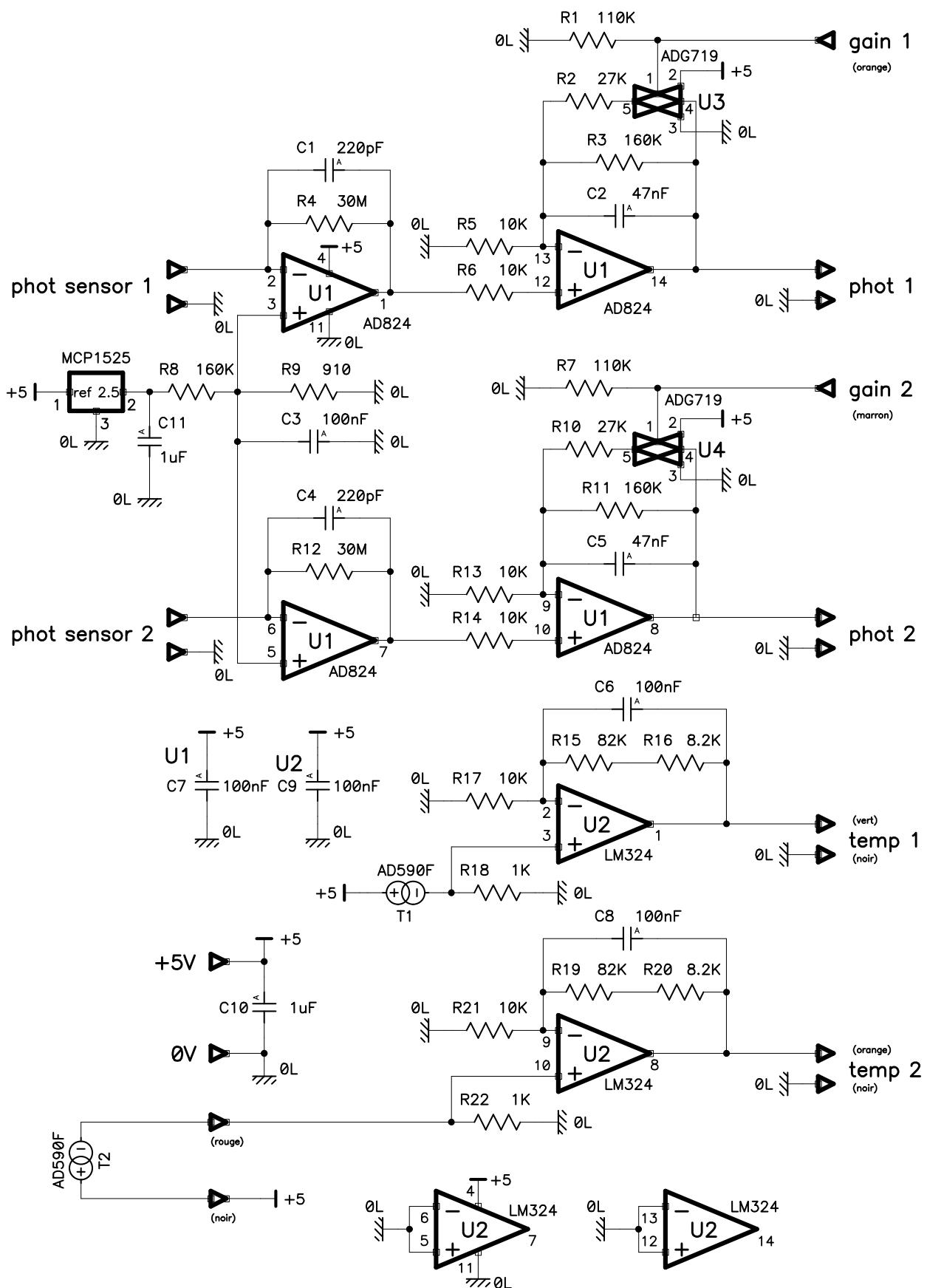
Measured I max	+5V	<b>50 nA</b>
Digital LSB value	2.5mV	<b>25 pA / bit</b>
Rem : full moon = 37 nA		

#### G photometer max

Measured I max	+5V	9.8 nA ... avec offset +0.25V : <b>9.5 nA</b>
Digital LSB value	2.5mV	<b>5 pA / bit</b>

#### G photometer max

Measured I max	+1V	2.0 nA ... avec offset +0.25V : <b>1.5 nA</b>
Digital LSB value	0.5mV	<b>1 pA / bit</b>



**Mesures sur électronique MG (calculées / mesurées)**

R2	27K	27.04	<b>Phot 1 response</b>
R3	160K	157.8	G (I) = 33.52 nA/V      G1 (V) = 3,316      G2 (V) = 16,83      Offset = 14,38 mV
R4	30M	29.83	* Offset G low mesuré = 47,7mV      * Offset G high mesuré = 240mV
R5	10K	9.968	** Bandwidth 0-99% : Gmin 25mS / Gmax <b>40mS</b> (+ et -)
R8	160K	157.9	
R9	910	909	<b>Phot 2 response</b>
R10	27K	27.03	G (I) = 33.52 nA/V      G1 (V) = 3,320      G2 (V) = 16,88      Offset = 14,31 mV
R11	160K	158.0	* Measured "G low" offset = 47,9mV      * Measured "G high" offset = 241mV
R12	30M	29.83	** Bandwidth 0-99% : Gmin 25mS / Gmax <b>40mS</b> (+ et -)
R13	10K	9.949	
R15	82K	81.68	<b>Temp 1 (box) response</b>
R16	8.2K	8.196	G1 = 0,998mV/°C      G2 = 10,02      GT = 10,00 mV/ °C
R17	10K	9.960	2,973V pour 23,0°C means a shift of +1.3°C
R18	1K	9.980	<b>Temp 2 (sensor) response</b>
R19	82K	81.76	G1 = 0,998mV/°C      G2 = 10,04      GT = 10,02 mV/ °C
R20	8.2K	8.238	2.954V pour 22,7°C means a shift of -0.4°C
R21	10K	9.955	Vref 2.5 = 2.512V
R22	1K	9.980	

\* Measured offsets with sensors disconnected

\*\* Bandwidth measured with sensor lighted by a LED

**Measures with injected current thru R =200M****Photometer 1      G high**

Vin	Iin	Vout
1.484	7.420	4.000
1.086	5.43	3.000
0.687	3.435	2.000
0.289	1.445	1.000

Measured G = 1.99 nA / V    offset = **240 mV**

Computed G = **1.992 nA / V**

**Photometer 1      G low**

Vin	Iin	Vout
7.969	39.84	4.000
5.945	29.72	3.000
3.928	19.64	2.000
1.907	9.53	1.000

Measured G = 10.1 nA / V    offset = **47.7 mV**

Computed G = **10,11 nA / V**

**Photometer 2      G high**

Vin	Iin	Vout
1.475	7.375	4.000
1.080	5.400	3.000
0.684	3.420	2.000
0.290	1.450	1.000

Measured G = 1.98 nA / V    offset = **240 mV**

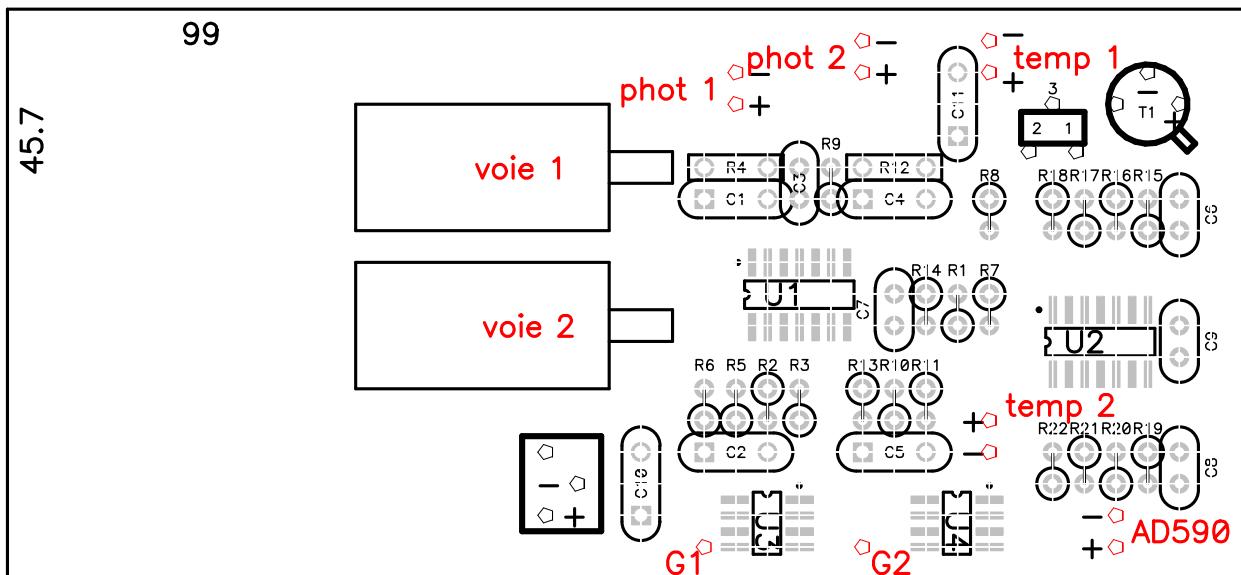
Computed G = **1.986 nA / V**

**Photometer 2      G low**

Vin	Iin	Vout
7.957	39.75	4.000
5.941	29.70	3.000
3.925	19.62	2.000
1.907	9.53	1.000

Measured G = 10.1 nA / V    offset = **47.7 mV**

Computed G = **10,10 nA / V**



Phot 1 NI6008 channel AI0

Temp 1 box

NI6008 channel AI3

G phot 1

P0.0

Phot 2 NI6008 channel AI1

Temp 2 sensor

NI6008 channel AI2

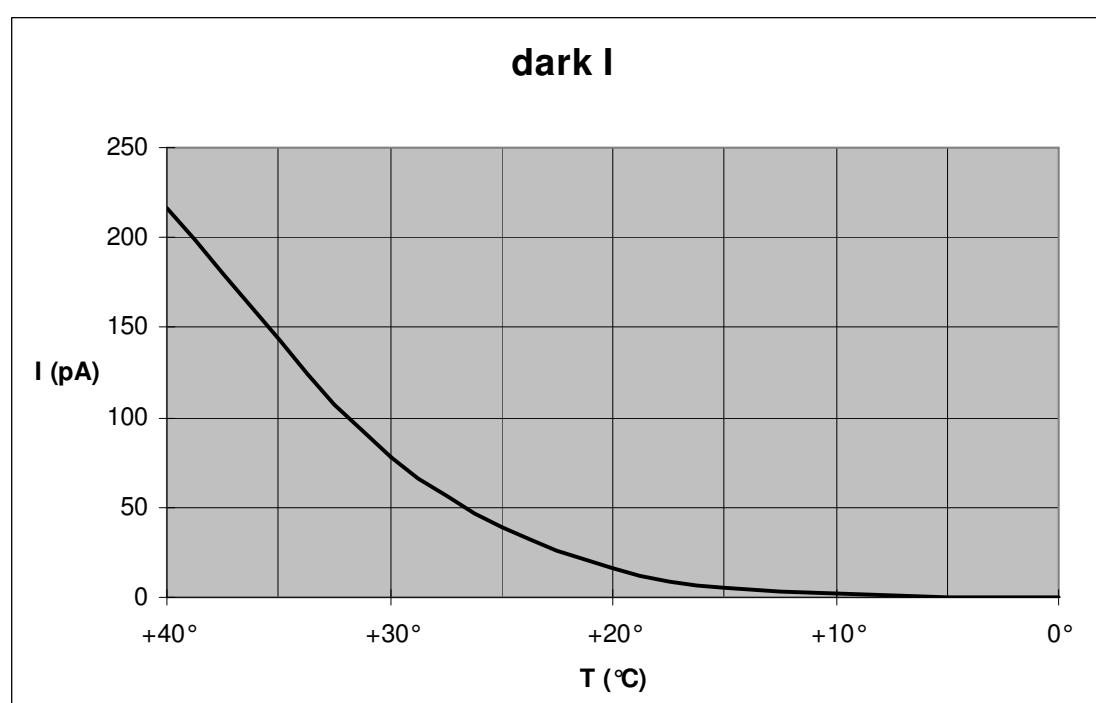
G phot 2

P0.1

**Dark current**

2281-1 dark current 6 pA to 300 pA on datasheet (f reverse voltage and temperature )

T °C	I pA
+10°	2.7
+12°	4
+14°	5.7
+16°	8.1
+18°	11.4
+20°	16
+22°	22
+24°	31
+26°	43
+28°	59
+30°	80



**7. ELECTRICAL POWER CONSUMPTION / AUTONOMY****- Instrument power consumption**

	<b>5V</b>	<b>14.4V</b>
Electronics	0.1 W	
Attitude Reference System		4 W
DC/DC converter efficiency	0.1 W	
	-----	
<b>Total</b>		<b>4.2 W</b>

**- Autonomy (14.4 V battery)**

+20°C (160 W/h)	38 h
0°C (135 W/h)	<b>32 h</b>

**8. CONNEXIONS ON PCp MG using Mediabase**

- USB Mouse	rear / middle / up
- USB NI6008	rear / middle / down
- USB GPS	rear / right / down
- USB temp data logger	rear / right / up or left
- USB key	rear / right / up or left

## 9. SOFTWARE

**4 analog channel to measure** (use of NI 6008 ADC acquisition system)

- Photometer sensor 1
- Photometer sensor 2
- Photometer sensor temperature
- Internal box temperature

NI 6008 input voltage range will be set nominally at +5V and optionally at +1V

Each photometer channel will have 2 possible gains (switched inside electronic box)

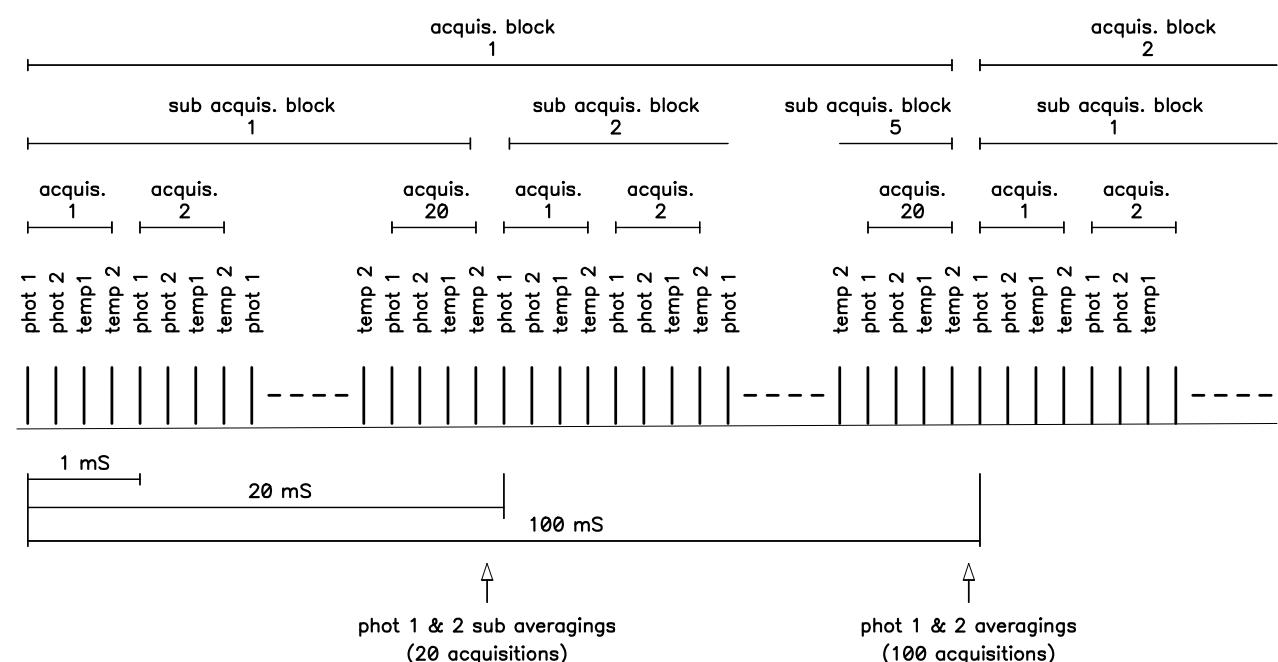
**Comment :** Photometer analog outputs are biased by a voltage offset depending of the gain : 50mV with gain min et 255 mV with gain max.

### Acquisition timings

Final timing resolution of the 2 photometer data will be **100 mS**

Final timing resolution of the 2 temperature data will be identical to photometer resolution (not necessary but easier for software)

- NI 6008 sampling frequency will be **4 KHz**
- Sampling periodicity for each channel will be **1 mS** : “acquis.”
- NI 6008 will be set to obtain sub-blocks of xx acquisitions equivalent to **50 mS** for example : “**sub acquis. block**”
- The **50 photometer sub acquis.block** data will be called “**point de base**” (rem : to minimise data loss)
- After **100 acquisitions** (2 sub-acquis. blocks added) photometer data will be **averaged** and called “**point de mesure and selection gain**”





**Comment :** 100 mS timing resolution could be improved to 80, 60, 40 or 20 mS, depending of digital filtering efficiency

#### Définitions

- **Gain photomètre** : min or max

- 1 photometer “**point de sélection de gain**” will the averaging result of **20, 40, 60, 80 or 100 successive acquisitions** (1, 2, 3, 4 ou 5 subblocks) for each photometer

- 1 photometer “**point de mesure**” will the averaging result of **100 successive acquisitions** (1 block) for each photometer

- 1 “**GR selected point**” will be the selection of 1 point on 1, 1 point on 10 or 1 point on 100 for the graphic display on the screen

- 1 “**FI selected point**” will be the selection of 1 point on 1, 1 point on 10 or 1 point on 100 for the data storage in the “photometer” file

- **HK** (Housekeeping)

- . Photometer temperature
- . Inside box temperature
- . Date / hour / minute / second / millisecond
- . 3 photometer position data : positioning system X Y Z axes data

- **Dark current** : Measurement of 1 “point de mesure” for each photometer with optical entrances closed

- **Sky background current** : Measurement of 1 “point de mesure” for each photometer with optical entrances open and during no luminous events.

- **Photometer gain configuration**

- Each photometer gain will be configured separately using 2 bits of the NI 6008 digital port

- The gain configuration will be manual or automatic

- In the automatic mode, software will determine gain changes using the value of «point de selection de gain » (see definition above)

- The switch of a gain from min to max will be performed if the value of “point de selection de gain” is equal or superior to 90% of +5V full scale (4.5V). This value will be set by the operator

- The switch of a gain from max to min will be performed if the value of “point de selection de gain” is equal or lower to 80% of +5V full scale (4.0V). This value will be set by the operator

Rem : The threshold values for gain changes will be corrected by the dark current value (electronic offset + dark current)

#### Measurement datation

- From GPS or PC time

- GPS or PC time : automatic selection

- PC time set from GPS data

**Data recording**

- Continuous recording of
  - . Date + time
  - . Positioning system data (X Y Z)
  - . “FI selected point”
  - . photometer gains
  - . Temperatures
- A night of measurements can reach 10h
- The instrument can be switch ON/OFF several times during a night of measurements
- Possibility to have 1 file for a entire night of measurements or different files if ON/OFF

**Special functions**

- A dark current measurement can be made and store at any time (separately on phot 1 and 2)
- A background current measurement can be made and store at any time (separately on phot 1 and 2)

**Screen display**Real time digital display*On command*

- Dark current photometer 1 (last measurement)
- Dark current photometer 2 (last measurement)
- Sky background current photometer 1 (last measurement)
- Sky background current photometer 2 (last measurement)
- Photometer **point 1**
- Photometer **point 2**

*Continuously with a refresh periodicity : 1s TBC*

- Photometer sensor 1 temperature
- Photometer sensor 2 temperature
- Photometer **point 1** (real time)
- Photometer **point 2** (real time)
- GPS data : time + number of satellites
- Positioning system data : X Y Z angles

Real time graphic display

- Photometer 1 **GR selected points** + photometer 2 **GR selected points**
- 2 separate graphs
- Graph length : 10s to 100s (configurable)
- Scale : Y axe **in nA and linear** (adapted to the selected gain)

Long time graphic display : real time and replay

- Photometer **GR selected points** 1 and 2 on 1 graph
- 1 separate graph
- Graph length : **1h to 20h** (configurable)
- Data coming from “photometer” recorded file
- Scale : **in nA and linear**

**Settings by operator**

- Name of “photometer” file
- **FI selected points** to record in “photometer” file      3 values : 1/ 1, 1/10, 1/100
- **GR selected points** to display in each graph      3 values : 1/ 1, 1/10, 1/100
- **Gain configuration** manual or auto
  - Number of **sub acquis. blocks** used to determine the gain of a the photometers in auto mode
  - Threshold value to go from gain max to gain min
  - Threshold value to go from gain min to gain max
- **Gain selection** in manual mode
  - . phot 1 : min ou max
  - . phot 2 : min ou max
- **Graph display** with or without subtraction
  - . no subtraction
  - . dark current subtracted
  - . sky background subtracted

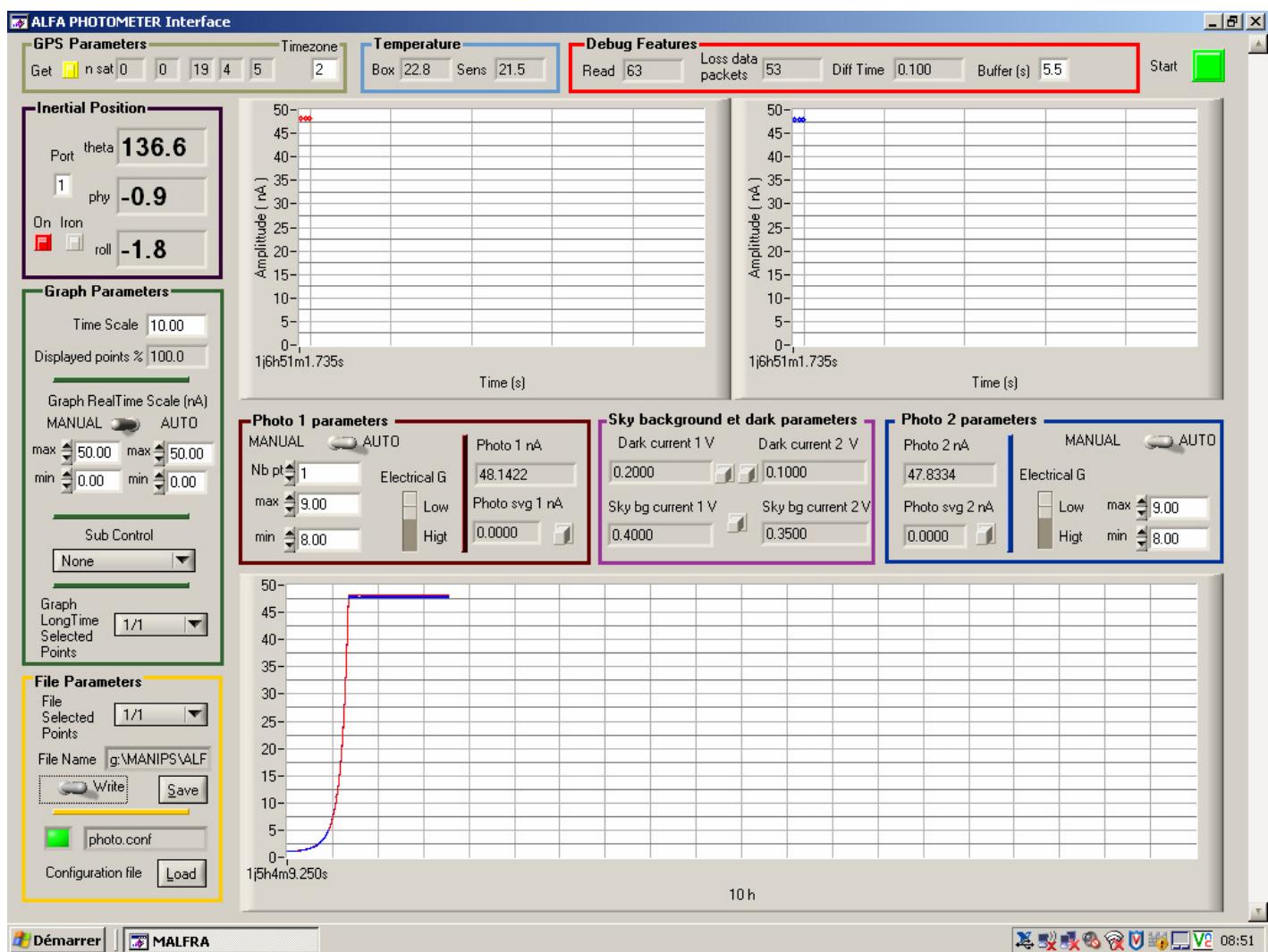
**Fichier de configuration**

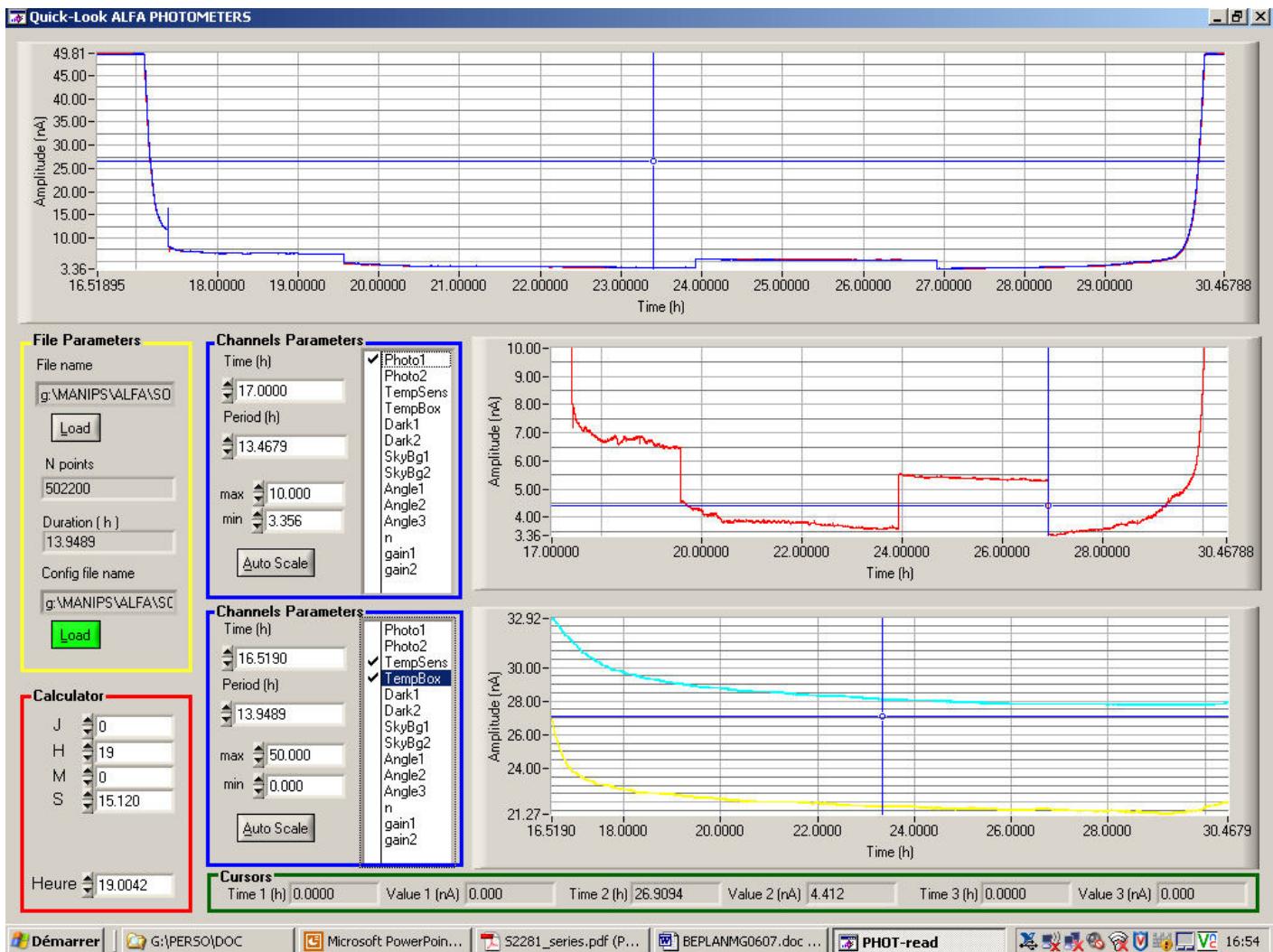
Fichier contenant les paramètres par défaut utilisés par le logiciel à son lancement

- Dark current phot 1
- Dark current phot 2
- Sky background phot 1
- Sky background phot 2
- Seuil haut de changement de gain (pour les 2 photomètres)
- Seuil bas de changement de gain (pour les 2 photomètres)
- N sous-blocs pour changement de gain
- Gamme de tension d’entrée du NI 6008 (+-5V ou +-1V)
- Fonction de transfert phot 1 G min (ax + b)
- Fonction de transfert phot 2 G min (ax + b)
- Fonction de transfert phot 1 G max (ax + b)
- Fonction de transfert phot 2 G max (ax + b)
- Datation GPS ou PC
- **FI selected points** (1/ 1, 1/10, 1/100)
- **GR selected points** (1/ 1, 1/10, 1/100)

**Commands by operator**

- Dark current measurement (on both photometers)
- Sky background measurement (on both photometers)
- Start / stop of continuous measurements


**REAL TIME SOFTWARE**



## READING SOFTWARE



## FICHIER DE CONFIGURATION

```
#####
#Configuration générale de l'instrument ALFA-PHOTOMETRES
#####
#Graph selected points: 1 / 10 / 100
1
#File selected points: 1 / 10 / 100
1
#Input voltage range : 1 / 1.25 / 2 / 2.5 / 4 / 5
5
#Sampling rate Hz: 1 <-> 2500
1000
#Nombre d'acquisition par sous blocs ( doit etre un sous multiple du sampling rate ) :
50
#Nombre de sous blocs par point de mesure :
2
#Fréquence de rafraichissement de l'affichage en s
0.1
#Nombre de lignes dans le buffer d'écriture sur le disque
600
#####
#Acquisition photometre 1
#####
#Dark current 1: en nA
0.2
#Sky background current 1: en nA
0.4
#Fonction de transfert du photometre 1 gain low: a x + b
9.81823 x + -0.587407
#Fonction de transfert du photometre 1 gain hight: a x + b
1.96960 x + -0.518342
#Gain manuel / auto 1: 0 / 1
1
#Nombre de blocs a prendre pour le gain auto : 1 / 2 / 3 / ... / 10
1
#Seuil supérieur 1: en nA
9
#Seuil inférieur 1: en nA
8
#Gain par default 1: 0 / 1
0
#####
#Acquisition photometre 2
#####
#Dark current 2: en nA
0.1
#Sky background current 2: en nA
0.35
#Fonction de transfert du photometre 2 gain low: a x + b
9.75791 x + -0.591995
#Fonction de transfert du photometre 2 gain hight: a x + b
1.95426 x + -0.522816
#Manual auto 2: 0 / 1
1
#Seuil supérieur 2: en nA
9
#Seuil inférieur 2: en nA
8
#Gain par default 2: 0 / 1
0
#####
#Acquisition thermometre Senseur
#####
#Fonction de transfert du thermometre 1 : a x + b
98.5221675 x + -273.43
#####
#Acquisition thermometre Boite
#####
#Fonction de transfert du thermometre 2 : a x + b
98.5221675 x + -273.53
```



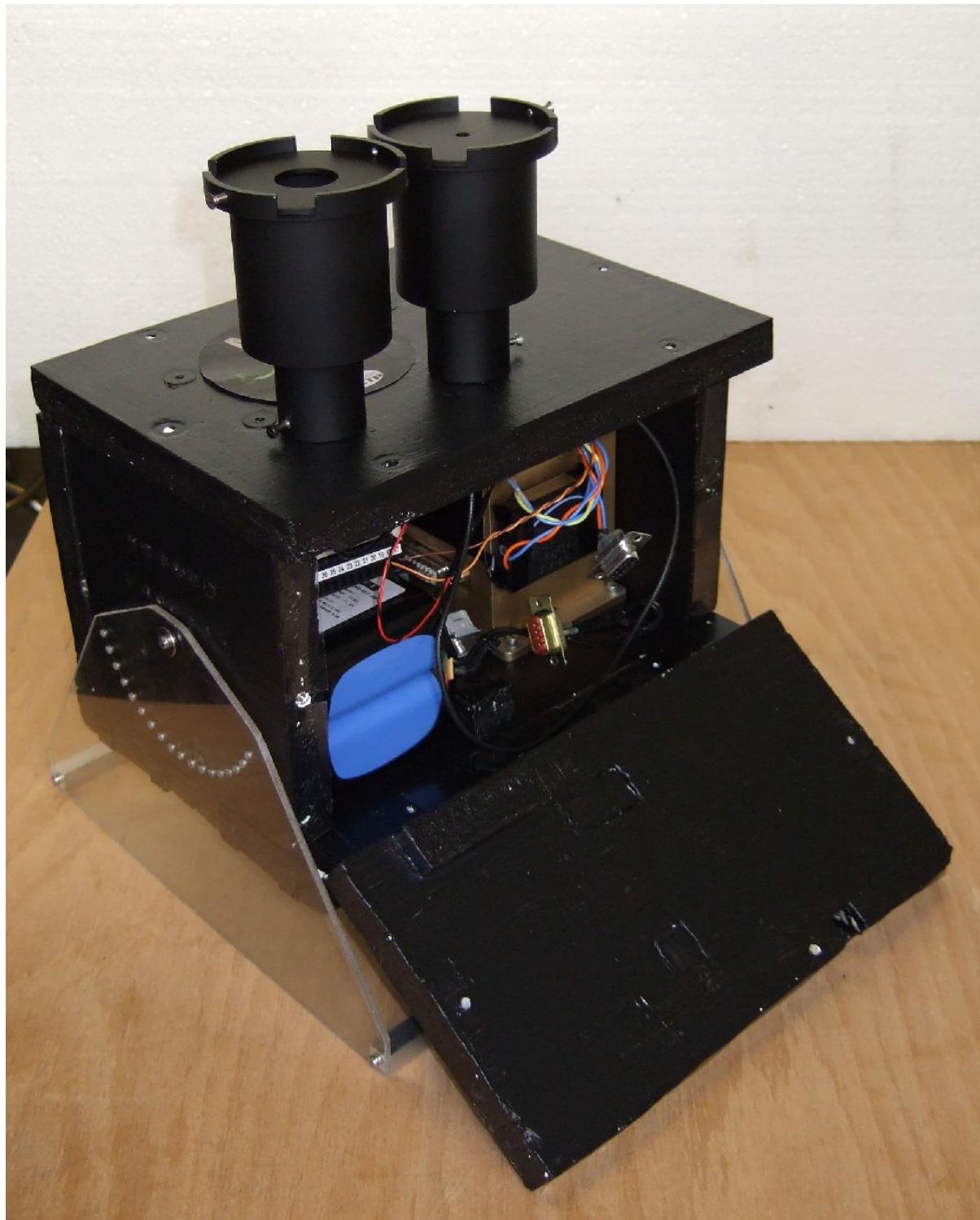
**MALFRA – PHOTOMETERS**

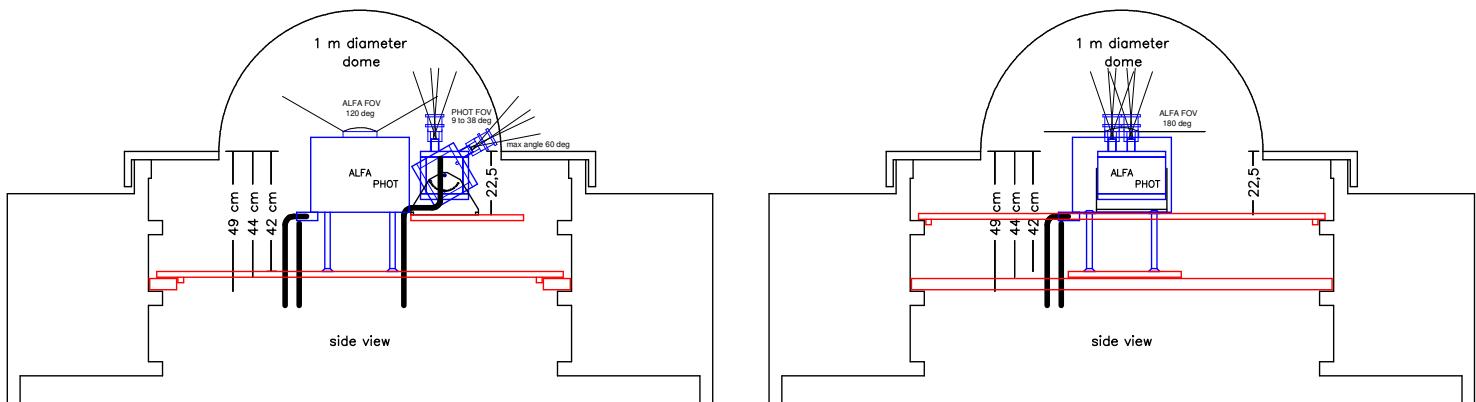
Reference ALFA-PHOT-DD-03 page 21/24

Edition 0

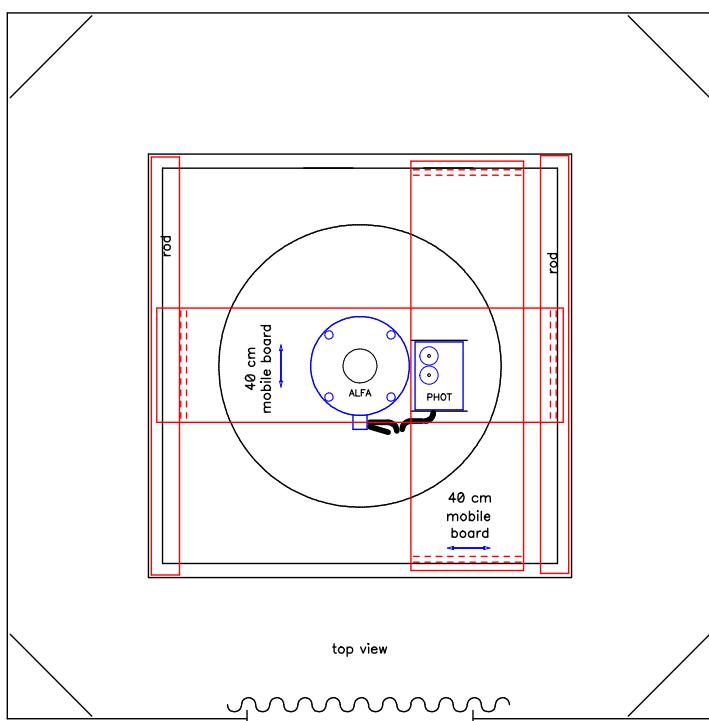
Revision 3

30 09 07



**INSTALLATION IN SVALBARD NEW STATION**


if the dome window is 150 x 150 cm  
 the parts detailed below can be fabricated with written dimensions



2 x rods : 149 x 10 x 5 cm

2 x boards : 146 x 40 x 2 cm

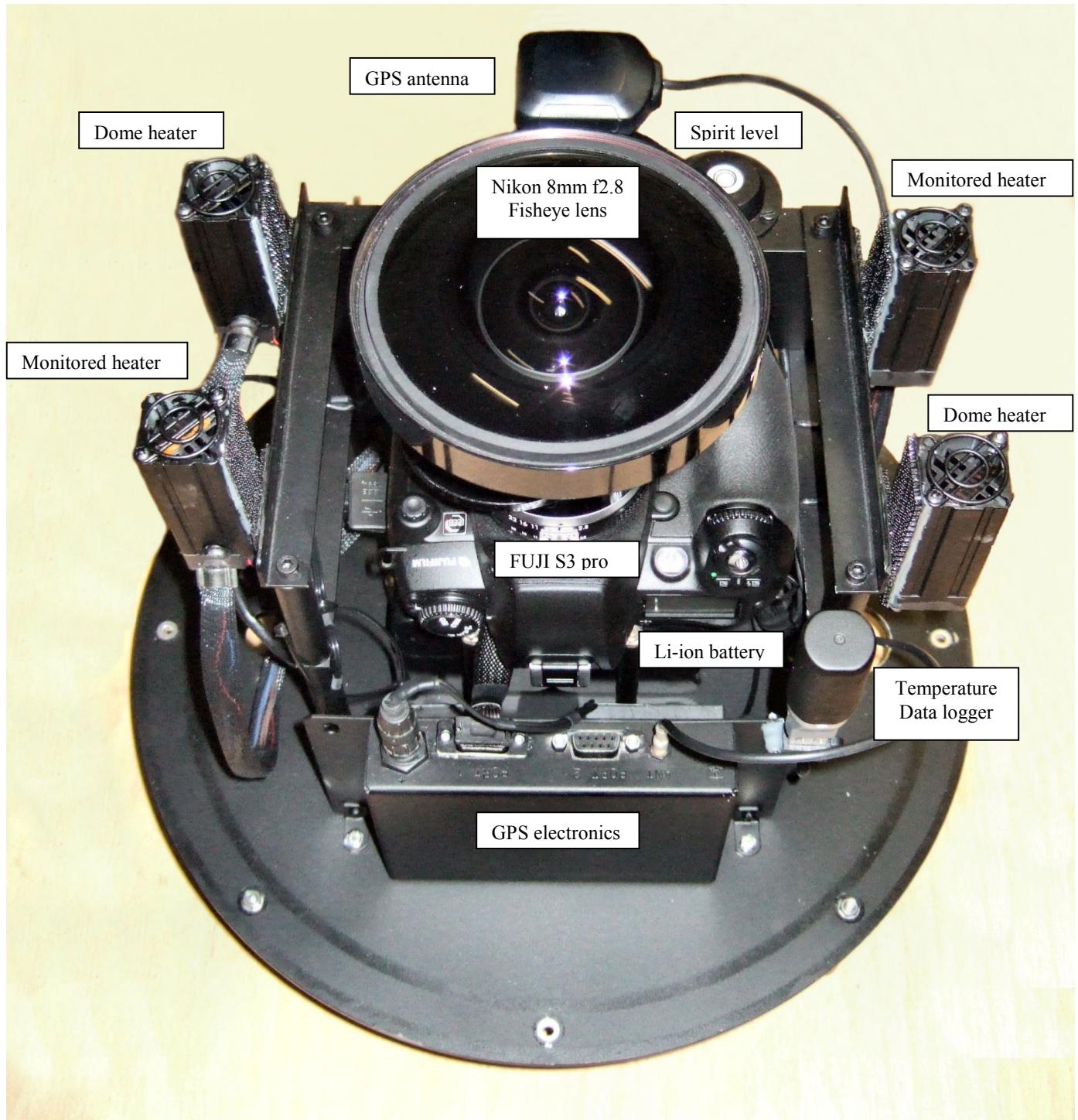
4 x small rods : 40 x 2 x 2 cm

assembling

ALFA allsky board

ALFA photometer board

## MALFRA



**MALFRA**