DECTRIS
Next Generation X-Ray Detectors

Technical Specification and Operating Procedure

PILATUS 2M

Detector System



Version 1.7

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1 Document History

Actual document

Version	Date	status	prepared	checked	released
1.7	22.07.2011	released	PS, BS	SC, DB	SB

1.1 Changes

Version	Date	Changes	released
1.0	18.08.2008	First release	PS
1.4	29.01.2010	Connection cables and temperature sensors	BS
1.4.1	18.02.2010	Signal levels	BS
1.4.2	19.02.2010	Power input	BS
1.5	09.04.2010	Dimensions and grounding	BS
1.5.1	21.04.2010	Power supply description	SB
1.5.2	04.10.2010	Various improvements	SB
1.7	22.07.2011	Thicker sensors and conformity with standards	SB

2 How to use this Technical Specification

Before you start to operate the PILATUS 2M detector system please read this technical specification and the user manual thoroughly.
The technical specification and the user manual together form the user documentation.

2.1 Address and Support

DECTRIS Ltd.
Neuenhoferstrasse 107
5400 Baden
Switzerland
Phone: +41 56 500 21 00
Fax: + 41 56 500 21 01

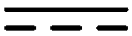
Email: support@dectris.com

Should you have questions concerning the system or its use, please contact us via phone, mail or fax.



Before you ship the system back, please contact us to receive the necessary transport and shipping information.

2.2 Explanation of Symbols

Symbol	Description
	Important or helpful notice
	Caution. Please follow the instructions carefully to prevent equipment damage or personal injury.
	DC-current
	AC-current
	Ground

2.3 Explanation of Terms

Term	Description
MCB	Module Control Board
DCB	Detector Control Board
DAC	Digital to Analog Converter

2.4 Use of the PILATUS 2M

The PILATUS 2M detector system has been designed for the detection of X-rays from synchrotrons or laboratory sources.
It is intended for indoor use only.
For other applications, please contact DECTRIS for additional information.

 Do not use the detector in vacuum

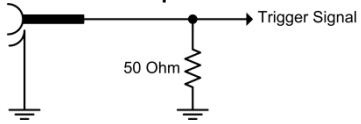
The PC can be mounted in a standard 19 inch rack, which has to be properly grounded.

 Make sure that the PC has adequate ventilation.

3 Technical specification

Number of modules	3 x 8 = 24	
Sensor	Reverse-biased silicon diode array	
Sensor thickness	320 µm	450 µm
	3 keV: 48% 8 keV: 95% 15 keV: 51%	3 keV: 48% 8 keV: 96% 15 keV: 64%
Pixel size	172 x 172 μm^2	
Module size	83.8 x 33.5 mm^2	
Format	1475 x 1679 = 2'476'525 pixels	
Area	254 x 289 mm^2	
Intermodule gap	x: 7 pixels, y: 17 pixels, 7.97 % of total area	
Dynamic range	20 Bits = 1’048’576	
Counting rate per pixel	> $2x10^6$ X-ray/sec	
Energy range	4.5 – 36 keV	
Energy resolution	500 eV	
Adjustable threshold range	4 – 18 keV	
Threshold dispersion	50 eV	
Readout time	2.3 ms	
Framing rate	30 Hz	
Point-spread function	1 pixel	
Data formats	Raw data, TIF, EDF, CBF	
External trigger/gate	3.3 - 5V, 3 different modes	
Software interface	Through socket connection; Clients for EPICS, SPEC and stand-alone operation are available	
Cooling	Water-cooled	
Operating temperature (internal)	23°C	
Dimensions (W x H x D)	384 x 424 x 455 mm^3	
Weight	Approx. 42 kg	

3.1 Ratings

Device	Definition
Detector Power Input	100 - 240 VAC, 50-60 Hz, 220 Watt Can be connected to all common supply voltages.
Detector External Trigger Input	2.0 V - 5.0 V High level 0.0 V - 0.8 V Low level 50 Ohm Impedance  Trigger Signal … to internal circuit 5.0 V absolute maximum ⚠ Applying a higher voltage will destroy the input.
Detector Enable output	5 V TTL (max. 100 mA)
PC	100 - 240 VAC; 12 A 50/60 Hz 870 Watt Hot-Plug Power Supplies Can be connected to all common supply voltages.
Cooling unit	230V, 50Hz Power Input: 2000W Flow: 14 l/min Pressure: 0.5 bar

3.2 Ambient Conditions

The PILATUS 2M detector is designed only for indoor use. The following ambient conditions must be fulfilled:

Condition	Range
Operating temperature:	+20° to +35°C
Operating humidity:	< 80% at 20°C, non-condensing
Storage temperature	+15° to +40°C
Storage humidity	< 40% at 20°C, non-condensing


Note that the interior humidity under operating conditions must be < 25%, see section 6.


When storing the detector make sure the temperature and humidity inside the transport box doesn't exceed the specified range. Use drying agent.


If the detector system is stored at low temperature, make sure that no condensation moisture develops.


The PILATUS 2M is equipped with a temperature and humidity control, see section 6

4 Dimensions and Connectors

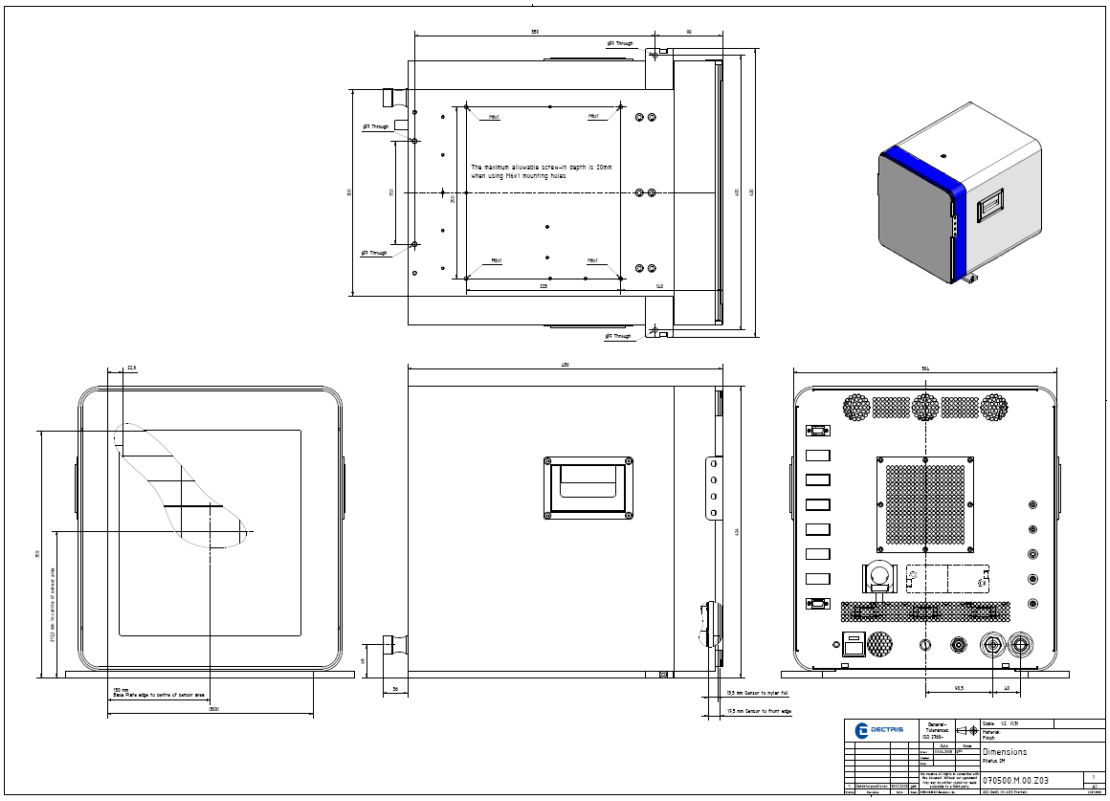


Figure 1. Drawing of the PILATUS 2M detector (printed separately in the user documentation folder)

4.1 Pilatus 2M Detector

4.1.1 Front Side of the Detector

The detector comes with a protective cover (1 mm, low carbon steel sheet metal 1.0330, St12) for the front window which should be removed for operation. The sensors are behind a 12 µm thick Mylar ® (PET) foil coated with 100 nm aluminum to protect it from dust and touch.

The cover has a mounting edge on top and can be removed by carefully pulling at the bottom (see figure below) and lifting it away.
When mounting the cover, make sure it is first hooked on the mounting edge centered and then slowly lowered.



Figure 2. Mounting the protective cover

Do not touch the Mylar ® foil.

The cover may not protect the detector from direct synchrotron beam.



Figure 3. PILATUS 2M detector with cover in place (front view)



Figure 4. PILATUS 2M detector with cover removed (front view)

4.1.2 Backside of the Detector

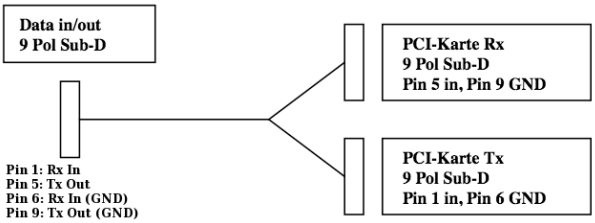


Figure 5. PILATUS 2M detector viewed from the back

4.1.3 The status LEDs

LED	Description
Power	If green, all supply voltages are ok. If red, module power is off. This can be caused by over/under temperature, too much humidity or too high module current (One or more modules may come into oscillations, see section 11).
Temp	Normally green. Turns red when the detector temperature or humidity is out of the limits (see section 6).
EN	Yellow, detector is making an exposure.

4.1.4 Connectors and Connecting Cables/Pipes

Connector	Description
DATA 1 (D1)	Data connection 1 Cable: Use only the included cable. Custom made cables or extensions will not work.  Minimum bending radius in a fix installation: 5 times the cable diameter. Minimum bending radius in a flexible installation: 15 times the cable diameter. Details of pins: 
DATA 8 (D8)	Data connection 2 Follow the cabling rules of connection 1.
Power	Main voltage 100 – 240 VAC; 50/60 Hz, Fuse 6.3A UL recognized to UL 60950/CSA 22.2 No. 60950-00, and TUV approved to EN 60950-1 Cable: Power cable with an IEC/C13 connector.
EXT IN	External Trigger Input Use a Lemo ® Type 00 (NIM-CAMAC) cable. For ratings see 3.1
EN OUT	TTL output signal; high when counting is enabled. Use a Lemo ® Type 00 (NIM-CAMAC) cable. For ratings see 3.1

Connector	Description
Ground 	Functional ground of the detector system.  Although the detector might be grounded via the mounting bolts, the detector can be grounded additionally via the functional ground connector at the back (M6 screw-in tap hole) to establish a defined grounding.
N2	Nitrogen for humidity control. For details see section 5.4. Pipe: Use a pipe with outer diameter of 6 mm and an inner diameter of 4 mm (e.g: Legris Type 1025U06).
Di-H2O	Use deionized water for cooling. Pipes: Use for inlet and outlet a pipe with an inner diameter of 9 mm.

The fixation pieces and the transport hook are stored on the back of the detector.

4.2 Computer

The computer is a high power server with two proprietary data acquisition cards to communicate with the detector.

The PC should be kept behind a firewall and should not have outside internet access.

The operating system is optimized for high speed data acquisition and has a custom kernel: Therefore, do not permit any software upgrades on the kernel!

Do not install or run any other software on the computer, except as tools and software necessary to configure your data acquisition protocol.



Figure 6. Connectors at the PCI Mezzanine Card for data acquisition

Connector	Description
RX	Receive data
TX	Transmit data

4.3 Cooling Unit

The PILATUS 2M detector system is equipped with a cooling unit for temperature stabilization of the detector head.
The tubes and the detector are equipped with self-sealing valves to avoid dripping when connecting or disconnecting the tubes. There is no fixed limitation on the length of the tubing.



Figure 7. Connection for cooling tubes on the Pilatus 6M detector

Before operating the cooling unit, please read the user manual of the cooling unit.

When connecting or disconnecting the cooling hoses, turn off the detector and the cooling unit.

When operating the detector, the cooling unit must be always on.

Use opaque tubing to avoid the growth of algae.

Operating temperature	The cooling unit has always to be set to a temperature of 23°C.
Operating pressure	0.5 bar

Do not set the temperature of the cooling unit below the recommended operating temperature. Condensing moisture can develop and damage the detector.

5 Installing the Detector System

5.1 Carrying

The detector has been delivered in a robust transport box. Please keep this transport box for transport or storage purpose.
The detector has a transport hook which has to be used for carrying the detector.



Figure 8. PILATUS 2M with mounted transport hook

⚠ Only use an appropriate lifting device with a carrying capacity of at least 50 kg to move the detector

⚠ The handles on the side of the detector are only for positioning not for lifting.

⚠ Make sure the detector is always moved by 2 persons

⚠ When using the transport hook, make sure it is properly tightened

⚠ When moving the detector, make sure the protection cover is mounted

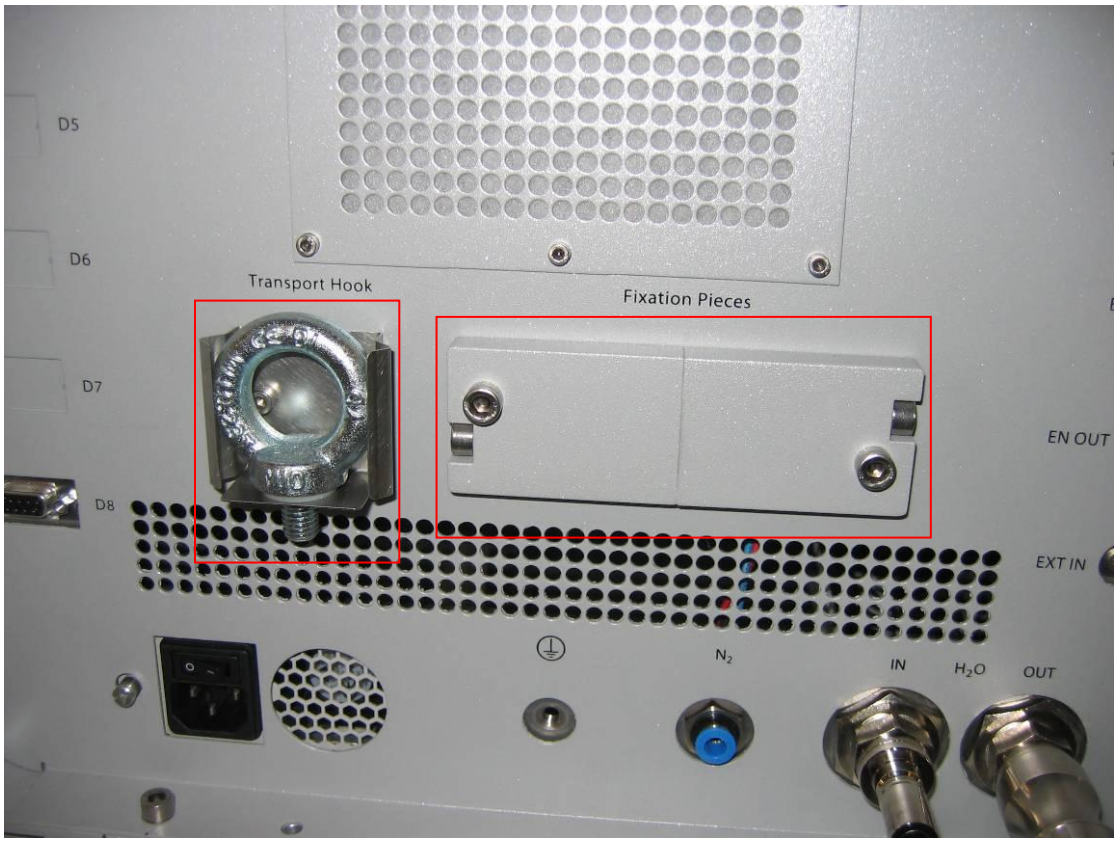


Figure 9. The transport hook and the fixation pieces are stored at the back of the detector

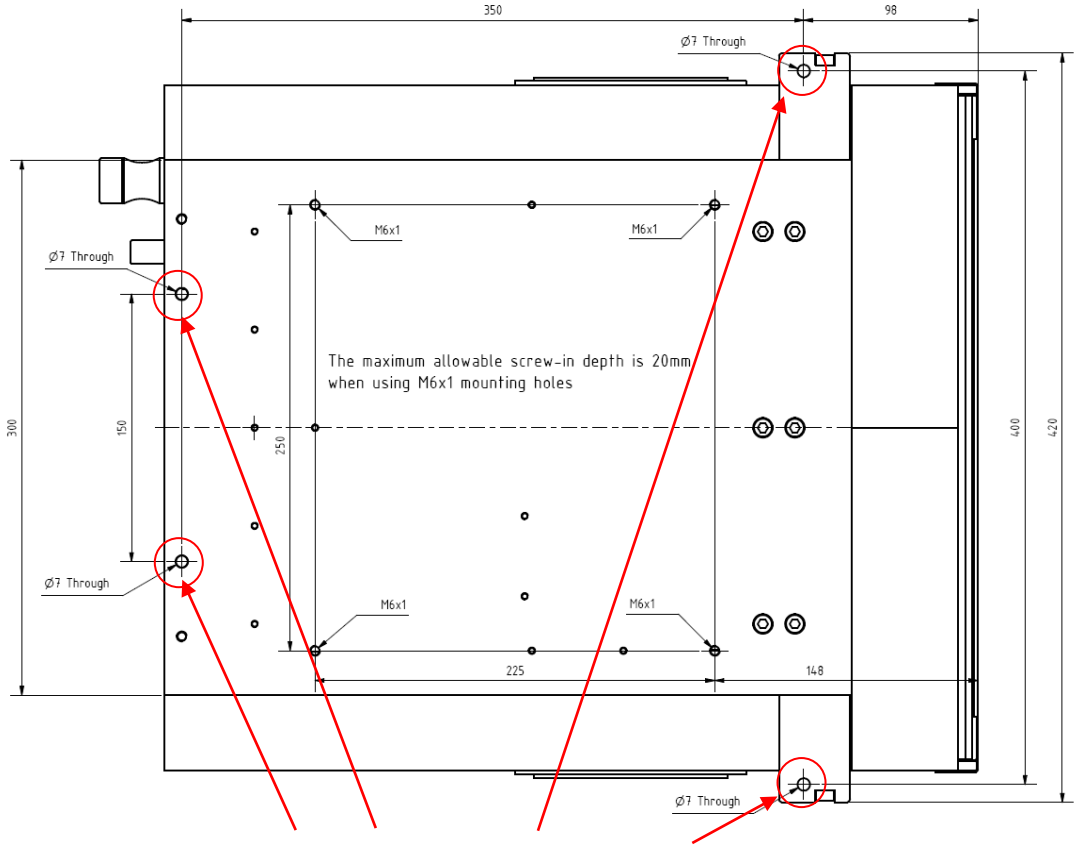
5.2 Mounting

The detector can be mounted in two ways:

5.2.1 Mounting from Above

Use the detachable mounting pieces, which are stored on the back of the detector. These mounting pieces have to be mounted on the base plate of the detector.

Make sure the mounting pieces are mounted and properly tightened

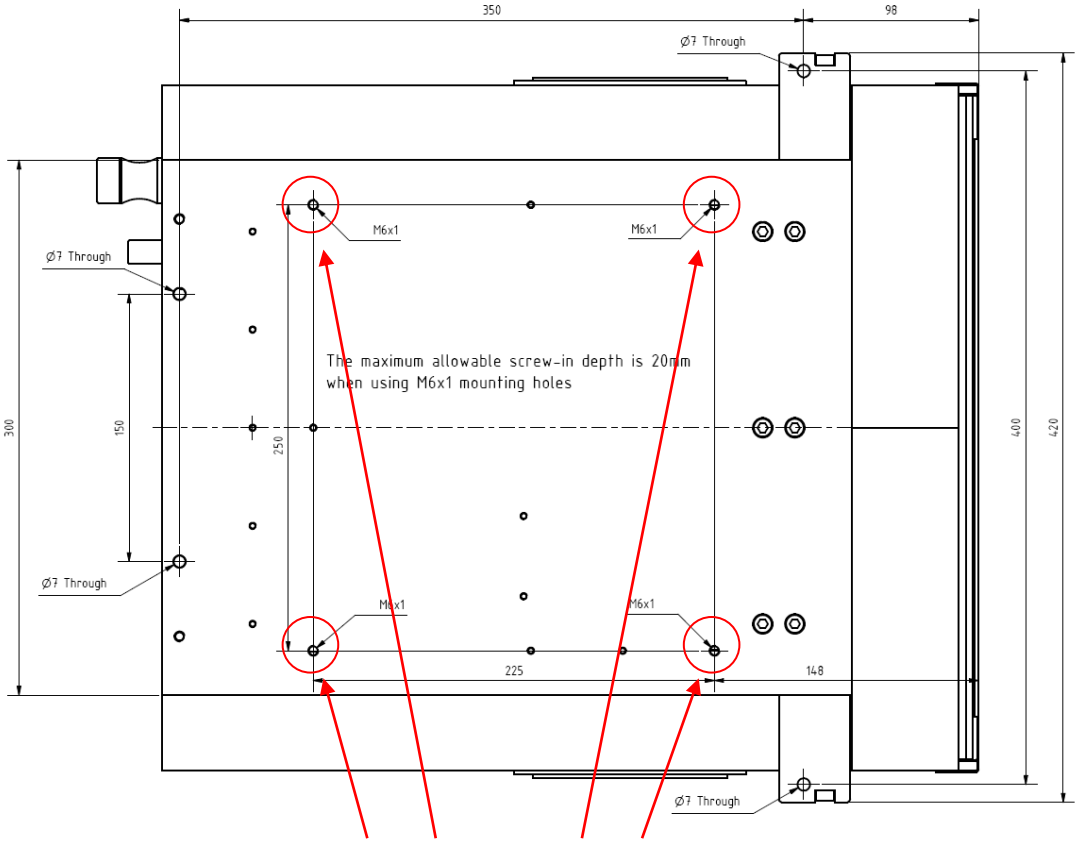


Mounting points when mounting from the top

Figure 10. Mounting from above, bottom view

5.2.2 Mounting from Below

From below with four M6 bolts.



Mounting points when mounting from the bottom

Figure 11. Mounting from below, bottom view

The four M6 bolts should not intrude into the detector more than 20 mm.

Make sure the detector is properly mounted.

Make sure the detector has enough space for proper ventilation (minimum wall distance: 170 mm). Do not operate the detector in a closed environment.

5.3 Grounding of the Detector System

⚠ The main plug of the computer and the power supply of the detector have to be connected to a grounded power outlet.

⚠ Although the detector might be grounded via the mounting bolts, the detector can be grounded additionally via the functional ground connector at the back (M6 screw-in tap hole) to establish a defined grounding.

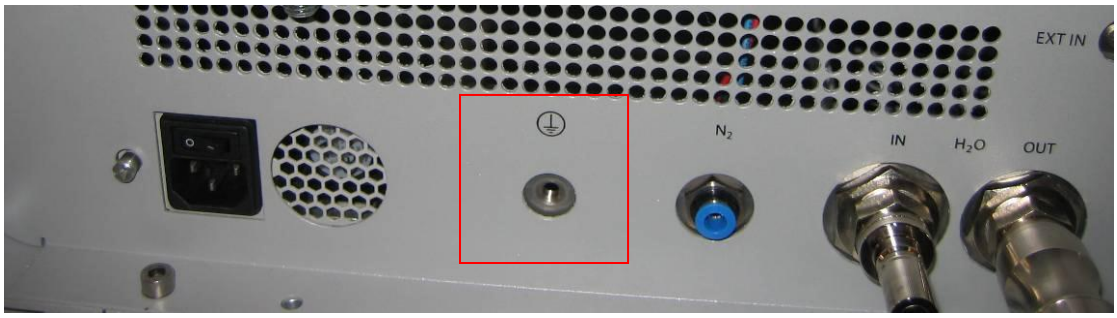


Figure 12. Ground connector on the back of the detector

5.4 Connection to Nitrogen or Dry Air

The PILATUS detector has to be connected to a nitrogen or dry air flow to avoid humidity and condensation when it is outside the storage box. For storage see section 9.

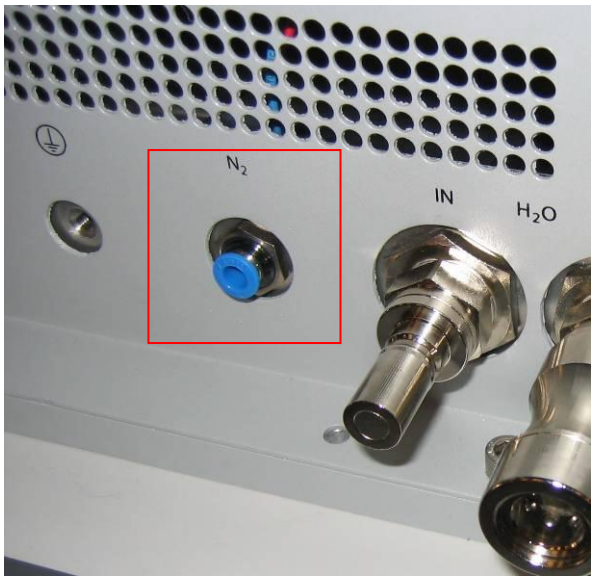


Figure 13. Nitrogen connector on the back of the detector

Humidity can damage the detector. Make sure that the detector is operated in the specified range.

Recommended flow of nitrogen	5-10 liter/h.
As alternative	Oil free, dry air of < 2% relative humidity can be used. Recommended flow: 5-10 liter/h.
Gas pressure	Minimum 1 bar Maximum 2 bar

5.5 Connecting the Cables

To operate the detector, the data cables and the ground should be connected. For specification of cables and pipes see section 4.1.4.

The PILATUS 2M detector is equipped with 2 data cables.

Connect RX to RX and TX to TX on the GigaSTaR Card in the PC. Labels for the connections are printed on the server housing. The single connectors go to the corresponding connector on the back of the detector.



The data cable should be pulled onto the computer connectors with the screws, rather than forcefully pushed on.
A forceful connection can damage the PCI card.



It is important for data integrity that the screws are tightened.



To plug or unplug any cables, turn the detector off.

6 Temperature and Humidity Control

The PILATUS 2M detector head has 3 combined temperature and humidity sensors.
The temperature and humidity control shuts down the power of the detector modules when the humidity or the temperature of the different sensors exceeds or falls below the following limits:

Channel	Location	Shutdown Temperature °C		Shutdown Humidity %
		Low limit	High limit	
0	Power board	15	55	80%
1	Base plate	15	35	80%
2	Detector head	15	45	30% For startup, the humidity has to be below 25%

The fan and the communication with the PC will remain active after a temperature shut down (only shuts down the power of the modules).

To start the detector correctly, please refer to section 7.1 and execute the correct startup procedure.



If the humidity is outside the specified range, the software will prevent powering up the modules and exit with a corresponding message.

```
BCB design frequency = 67 MHz
PMC GigaSTaR device #0: BCB 6 Hardware/Firmware version: 0x1231
PMC GigaSTaR device #0: BCB 6 Firmware build: 0x1ae8
BCB design frequency = 67 MHz
DCB #0: BCB DOUT sampling delays (software) set to 0x1c

3 Temperature / Humidity sensor(s) enabled on DCB 0
*** ERROR - Rel. Humidity (26.4%, channel 2) is too high
Bad return from dcb_initialize()
Camera initialization error -- press <enter> to exit
```

Figure 14. Error message when temperature or humidity is out of range

Make sure that Nitrogen or dry air flow is turned on at the recommended flow rate (according to section 5.4) and then restart the software.

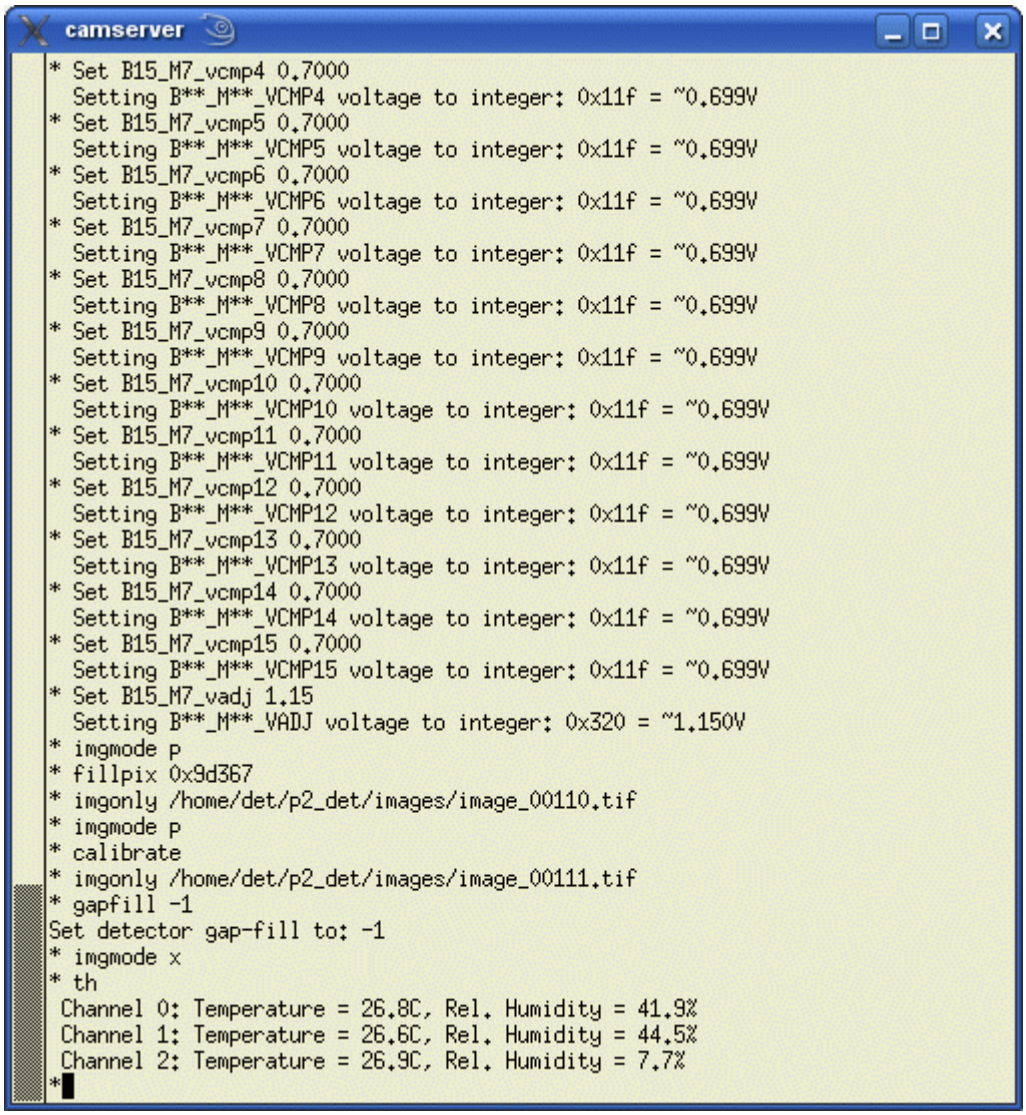


Figure 15. Correct start-up message

Check the humidity with the following command "thread" in Camserver. This reads and displays the actual temperature and humidity of all sensors as shown above.

7 Getting Started

Before operating the detector, make sure you have read the previous chapters in the technical specification and the user manual.



Check these items before turning the detector system on:

- Mount the detector properly
- Connect the detector to power
- Connect the detector to nitrogen or dry air at the recommended flow rate
- Connect the water tubes. Make sure they are properly mounted on both sides
- Connect the PC and the detector data cables
- Attach monitor and keyboard to the computer

7.1 Startup Sequence

- Turn on nitrogen or dry air flow at least 30 minutes before turning on the detector
- Turn on the PC
- Start a shell
- The default path is: /home/det
- Change the directory to: p2_det
- Turn on both power switches at the back-side of the detector
- Turn on the cooling unit at the same time as the detector is started
- Type runtvx.
  Runtvx starts a script file which initializes the detector system and opens the Camserver and TVX windows.

7.2 First Commands

See the detailed description of all commands in the User Manual.
Type the following commands in TVX:

- *rbd*; self test of the detector (digital part of the pixel)
- *calibdet*; self test of the detector (analog part of the pixel)
- *cam setthreshold 5900 (example for a setthreshold of 5.9 keV)*: sets the energy threshold of the detector. It is important that a threshold is set. Otherwise the detector is not trimmed.
  In normal operation, the threshold should always be set to 50% of the energy of the incoming X-rays. See user manual for more information!
- *expose 10*; creates an image with an exposure time of 10 seconds

8 Turning off the Detector

- Turn off cooling system
- Turn off the power switch of the detector
- Do not remove nitrogen/dry air connection and leave it at the recommended flow rate according to section 5.4.

9 Storing the Detector

Even if the detector is not in operation, it is recommended to maintain the Nitrogen or dry air flow.
In case the detector is stored, please follow these instructions:

For storage of up to 1 week:
Store the detector in the storage box and add 200 g drying agent (i.e. silica gel) into the storage box.

For storage longer than 1 week:
Pack the detector into a plastic bag, add drying agent into the plastic bag and seal the plastic bag.
Then place the detector in the storage box and add 200 g drying agent (i.e. silica gel) to the storage box.
Check the humidity inside the box frequently to comply with the storage requirements in chapter 3.2

10 Cleaning and Maintenance

The housing can be cleaned with a soft tissue.

⚠ The Mylar ® foil should not be touched or cleaned

The PILATUS 2M detector system is almost maintenance free.

The following procedures have to be done periodically:

What	When	Who
Check and, if necessary, clean the air filter on the back of the PILATUS 2M	Every month	User
Replace the air filter on the back of the PILATUS 2M	Every 12 months	User
Check the tightness of the cooling tubes	Every week	User
Replace the cooling liquid	Every 12 months	User

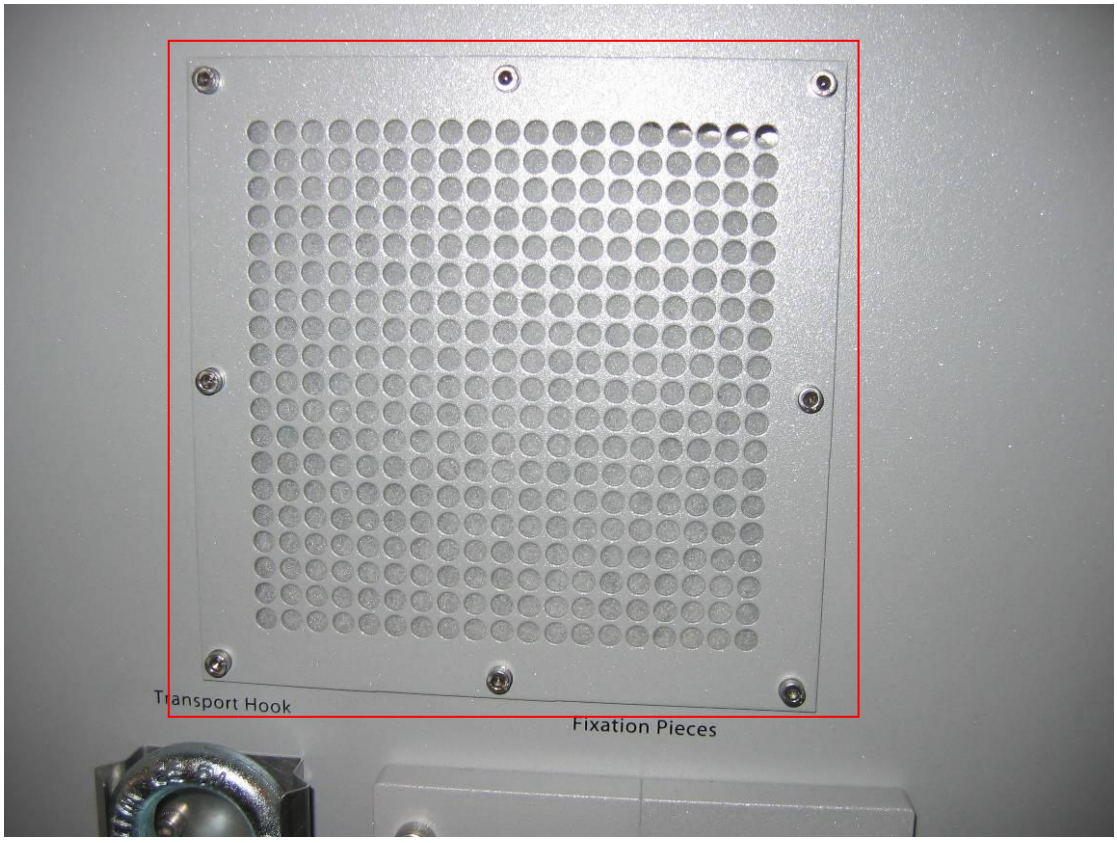


Figure 16. Air filter on the back of the detector

11 Faults

Problems	Causes	Solution
PC doesn't start properly	• PC is not properly powered up • PCI card is not properly mounted	• Depending on the type of the PC, there are switches on the back and on the front of the PC which have to be in the correct position. • Open the PC and check that the PCI cards are properly mounted and tightened
Detector shuts down	**Temperature or humidity error** See section 6 for shut down values. Check the LEDs on the back of the detector: If the temperature and the power LED is red, a temperature or humidity error has occurred	• Wait until the detector cools down • Restart the detector again. • Check the temperature of the detector with the command in camserver: type"thread" • Check that the ventilator of the detector is running properly and the ventilation holes are not covered • Check the flow of nitrogen or dry air
Detector shuts down	**Over current** Threshold level set too low and the detector starts oscillating	• Increase the threshold level: In TVX type: setthreshold midg 5000
Images look strange after initialization	Detector is not properly initialized	Run the following commands in TVX: • *setdac* • *calibdet* • *expose 1*
After a trigger command has been issued camserver reports an error	After issuing the trigger command in camserver a trigger has to occur within 15 seconds	Make sure the trigger command occurs within 15 seconds
Detector housing is humid	Temperature of the cooling unit to low	Shut down the detector immediately and check the temperature of the cooling unit
Detector housing is humid	Temperature of the cooling unit to low	Shut down the detector immediately and check the temperature of the cooling unit

12 Certification Tests

The product is in conformity with the listed standards.

Applied standards / Normes appliquées / Verwendete Normen

EN 61000-6-2: 2005 (IEC 61000-6-2: 2005)	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments Compatibilité électromagnétique (CEM) - Partie 6-2: Normes génériques - Immunité pour les environnements industriels Elektromagnetische Verträglichkeit (EMV) - Teil 6-2: Fachgrundnormen - Störfestigkeit - Industriebereich
EN 61000-6-4: 2007 (IEC 61000-6-4: 2006)	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards – Emission standard for industrial environments Compatibilité électromagnétique (CEM) - Partie 6-4: Normes génériques - Norme sur l'émission pour les environnements industriels Elektromagnetische Verträglichkeit (EMV) - Teil 6-4: Fachgrundnormen – Fachgrundnorm Störaussendung - Industriebereich
EN 61326-1: 2006 (IEC 61326-1: 2005)	Electrical equipment for measurement, control and laboratory use - EMC requirements -- Part 1: General requirements Matériel électrique de mesure, de commande et de laboratoire - Exigences relatives à la CEM -- Partie 1: Exigences générales Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen -- Teil 1: Allgemeine Anforderungen