## Dectris Pilatus 3X CdTe Detector Operating Instructions

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These are the instructions for setting up and operating the Pilatus 3X CdTe 300K wide detector that is shared between ChemMatCARS and GSECARS.

## Overview of System

The system consists of the following components:

### Pilatus 3X CdTe detector

The detector is 981 (horizontal) x 1043 (vertical) pixels. The images are 32-bits (4 bytes), so each image is approximately 1MB. The detector must have coolant flow and dry nitrogen gas flow whenever it is powered on. The chiller should say that the coolant temperature is 25 degrees C and the Mode is Normal. The coolant is 2/3 distilled water and 1/3 ethylene glycol. The nitrogen gas pressure must be between 1 bar and 2 bar, or between ~15 PSI and 30 PSI. The flow rate should be 5-10 liters/hour.

Network connections:

Data1: 10 Gbit connection to the Data1 port on the DEC computer. IP address=10.0.10.50.

Data2: 10 Gbit connection to the Data2 port on the DEC computer. IP address=10.0.11.50.

### Detector control computer (DEC)

This is a Dell PowerEdge R430 running Centos 6, kernel 2.6.32. This computer runs the camserver program which controls the detector. The images are read from the detector via 2 10Gbit Ethernet links. The maximum frame rate of the Pilatus is 500 frames/s, which is a data rate of 2 GB/sec. The images are read into a RAM disk (/ramdisk) in this computer. /ramdisk is 32GB in size, so it can hold approximately 8,000 images.

At GSECARS the IP address is: 164.54.160.174 (computer is named dec1565)

Accounts:

Detector account: Username=det, Password=Pilatus2

Root account: Username=root, Password=Villigen

Network connections:

Data1: 10 Gbit connection to the Data1 port on the detector. IP address=10.0.10.1.

Data2: 10 Gbit connection to the Data2 port on the detector. IP address=10.0.11.1.

LAN: This can be connected to the local beamline network, but is not required and is normally not connected. IP address is set by DHCP.

PPU: 10Gbit SFP+ connection to the PPU computing using a black Twinax cable. IP address=10.10.10.100.

### Pilatus Processing Computer (PPU)

This is a Dell PowerEdge R630 running Centos 7, kernel 3.10.0. This computer runs the EPICS IOC software. The IOC communicates with camserver over a TCP socket connection. This computer also runs two software programs supplied by Dectris. The first program is called **furka**, and it copies the images from the /ramdisk on the DEC computer to the /ramdisk on this PPU computer. This copy operation is very fast, since it goes over the 10Gbit link between the PPU and DEC computers. The /ramdisk in the PPU is 320GB, so it can store about 80,000 images. The second program is called **grimsel**. grimsel copies the images from the PPU /ramdisk to two other locations. The first location is a local hard disk in the PPU, which is called /Data. This directory is about 250GB, so it can store about 62,000 images. The second location is a directory on cars5, which is mounted as /cars5/Data. The link to cars5 will currently be 1 Gbit, so it is 20 times slower than the link from the camera to the DEC computer. grimsel does these copy operations automatically, no user intervention is required.

Accounts:

Detector account: Username=det, Password=Pilatus2

Root account: Username=root, Password=Villigen

Network connections:

LAN: This must be connected to the local beamline network. IP address is set by DHCP. Charlie has configured the DHCP server so the machine has the same name, but a different IP address when it is located at ChemMatCARS and at GSECARS. The IP name is always ppu071.cars.aps.anl.gov At ChemMatCARS the IP address is 164.54.162.8, while at GSECARS the IP address is 164.54.160.33.

DEC: 10Gbit SFP+ connection to the DEC computer using a black Twinax cable. IP address=10.10.10.10.

## Starting software on the DEC computer

* Log in to the DEC computer. This can be done with a local keyboard, mouse and monitor, or it can be done using ssh from another computer. Log in to the det account. When logging in locally and if the timeout has expired you need to “swipe up” on the screen using the mouse, dragging the mouse from the bottom of the screen towards the top.
* Logging on remotely:

ssh [det@164.54.160.174](mailto:det@164.54.160.174)

setting up for dac\_user:

as super user (do not copy commands from here, type them in):

/usr/local/bin/mount\_cars5\_gse

rm /DAC

ln –s /cars5/Data/dac\_user/2YYY/IDD\_2YYY-C/ /DAC

(replace YYY with year and C with cycle number)

### Start camserver

**camserver** is the program from Dectris that is used to control the detector. It accepts commands at the console, or can accept commands from a TCP socket connection. The EPICS IOC controls the detector through camserver via a socket connection. We run camserver using the procServ program. procServ is a utility that runs programs in a background task so that they don't die if the terminal window is closed. Connections are made to the process that procServ is running (i.e. camserver) using a telnet session to a local port. We use port 20001. procServ also creates a log file, which is in /home/det/logs/camserver.log.

* Type the command

start\_camserver

* This command starts procServ running camserver and listening for telnet connections on port 20001. It then telnets into the localhost on this port, so you will be connected to camserver. You should see a number of messages as camserver starts up. Wait until you get the camserver command prompt “\*”, and type return to make sure camserver is ready for commands. If camserver is already running then there will be brief error message which you can ignore, and it will still telnet to the camserver process.
* You can then disconnect from the procServ process by exiting your telnet session to procServ. Press the Control and ] characters at the same time. You will then get the telnet prompt. Type “quit” to exit telnet.

If the detector is power-cycled then camserver will need to be restarted.

This is an example of the operations described on the previous page. The commands I typed are shown in **boldface**.

[det@ppu071 ~]$ **ssh det@10.10.10.100**

det@10.10.10.100's password:

Last login: Fri Jul 8 21:55:54 2016 from 10.10.10.10

det@dec1248:~> **start\_camserver**

procServ: spawning daemon process: 74852

Trying ::1...

telnet: connect to address ::1: Connection refused

Trying 127.0.0.1...

Connected to localhost.

Escape character is '^]'.

@@@ Welcome to procServ (procServ Process Server 2.6.0)

@@@ Use ^X to kill the child, auto restart is OFF, use ^T to toggle auto restart

@@@ procServ server PID: 74852

@@@ Server startup directory: /home/det

@@@ Child startup directory: /home/det

@@@ Child "camserver" started as: /usr/local/bin/camserver

@@@ Child "camserver" is SHUT DOWN

@@@ procServ server started at: Sat Jul 9 22:51:01 2016

@@@ 0 user(s) and 0 logger(s) connected (plus you)

@@@ ^R or ^X restarts the child, ^Q quits the server

@@@ Restarting child "camserver"

@@@ (as /usr/local/bin/camserver)

@@@ The PID of new child "camserver" is: 74856

@@@ @@@ @@@ @@@ @@@

Read detector hardware definitions from:

/var/local/lib/dectris/config/cam\_data/pidet.def

Read detector module map from:

/var/local/lib/dectris/config/cam\_data/module.map

Building standard xor table

Configured from /etc/dectris/camrc

Camserver configured for PILATUS3 1M, S/N 10-0147

Code release: 7.8.3

Setting default LUT directory for rate correction

Reading LUT from

/var/local/lib/dectris/config/cam\_data/ratecorrection/ContinuousStandard\_v1.1

After rate correction, cutoff = 1165942 counts

Interface #1 (10.0.10.50) is alive

Interface #2 (10.0.11.50) is alive

Connecting to interface #1 (10.0.10.50)

Connecting to interface #2 (10.0.11.50)

Searching for Temperature/Humidity sensors on DCB #01 ID 0x1000

Temperature/Humidity sensor channel #0 enabled on DCB #01 ID 0x1000

MCB power enabled

Number of Arosa boards: 1

Number of Interlaken boards: 2

DCB #01: 2 ethernet ports active

DCB #01 hardware configuration: 0x0110

Setting B\*\*\_M\*\*\_CHSEL PATTERN to 0xffff (hardware pattern: 0xffff)

Training sampling delay... done

Camera image format: 981(w) x 1043(h) pixels

Camserver listening on port 41234

Reading camserver startup file:

/var/local/lib/dectris/config/cam\_data/pidet.set

# set of startup commands for camserver

set B15\_M7\_VTRM 1.8

Setting B\*\*\_M\*\*\_VTRM voltage to integer: 0x2e6 = ~1.801V

set B15\_M7\_VRFS 0.7

Setting B\*\*\_M\*\*\_VRFS voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VDEL 0.8

Setting B\*\*\_M\*\*\_VDEL voltage to integer: 0x149 = ~0.801V

set B15\_M7\_VRF -0.2

Setting B\*\*\_M\*\*\_VRF voltage to integer: 0xd8 = ~-0.200V

set B15\_M7\_VCAL 0.3

Setting B\*\*\_M\*\*\_VCAL voltage to integer: 0x7a = ~0.299V

set B15\_M7\_VCCA 0.7

Setting B\*\*\_M\*\*\_VCCA voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP0 0.7

Setting B\*\*\_M\*\*\_VCMP0 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP1 0.7

Setting B\*\*\_M\*\*\_VCMP1 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP2 0.7

Setting B\*\*\_M\*\*\_VCMP2 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP3 0.7

Setting B\*\*\_M\*\*\_VCMP3 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP4 0.7

Setting B\*\*\_M\*\*\_VCMP4 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP5 0.7

Setting B\*\*\_M\*\*\_VCMP5 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP6 0.7

Setting B\*\*\_M\*\*\_VCMP6 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP7 0.7

Setting B\*\*\_M\*\*\_VCMP7 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP8 0.7

Setting B\*\*\_M\*\*\_VCMP8 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP9 0.7

Setting B\*\*\_M\*\*\_VCMP9 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP10 0.7

Setting B\*\*\_M\*\*\_VCMP10 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP11 0.7

Setting B\*\*\_M\*\*\_VCMP11 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP12 0.7

Setting B\*\*\_M\*\*\_VCMP12 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP13 0.7

Setting B\*\*\_M\*\*\_VCMP13 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP14 0.7

Setting B\*\*\_M\*\*\_VCMP14 voltage to integer: 0x11f = ~0.699V

set B15\_M7\_VCMP15 0.7

Setting B\*\*\_M\*\*\_VCMP15 voltage to integer: 0x11f = ~0.699V

prog CHSEL 0xffff

Setting B\*\*\_M\*\*\_CHSEL PATTERN to 0xffff (hardware pattern: 0xffff)

THread

DCB #01 ID 0x1000 (Arosa QCEB):

Channel 0: Temperature = 26.1C, Rel. Humidity = 5.8%

dbglvl 1

SetRetriggerMode 1

Retrigger mode is set

Setting default LUT directory for rate correction

Reading LUT from

/var/local/lib/dectris/config/cam\_data/ratecorrection/ContinuousStandard\_v1.1

After rate correction, cutoff = 1163856 counts

SetThreshold Energy 60000 30000

Available threshold settings:

Auto gain 4900 ... 70000 eV

Requested setting: autog; threshold: 30000 eV

Trim directories:

/var/local/lib/dectris/config/calibration/calib\_sn/

/var/local/lib/dectris/config/calibration/calib\_ba/

100% [========================================================================]

204 excluded pixels were read

Setting reduced shaper gain mode

Loading commands from:

/tmp/setthreshold.cmd

Building standard xor table

Imgonly /tmp/trim\_values\_img.tif

Flat field correction loaded from

/var/local/lib/dectris/config/calibration/FF\_p0\_E60000\_T30000\_vrf\_m0p100.tif

Bad pixels loaded from

/var/local/lib/dectris/config/calibration/Mask/badpix\_mask.tif

# Settings: AUTOG 30000 1.164 6 (vrf\_avg = -0.242): threshold: 30000 eV; vcmp (b01\_m01\_c00): 1.164 V; E: 60000 eV

/tmp/trim\_values\_img.tif was written

"/tmp/setthreshold.cmd" was successful

Setting default LUT directory for rate correction

Reading LUT from

/var/local/lib/dectris/config/cam\_data/ratecorrection/ContinuousStandard\_v1.1

After rate correction, cutoff = 1141845 counts

Gapfill -1

Set detector gap-fill to: -1

\*

\*

\*

**(I typed Control ] to exit to the telnet prompt)**

telnet> **quit**

Connection closed.

## Starting software on the PPU computer

After starting camserver on the DEC computer, log out of the DEC computer and return to the PPU computer.

### Check file mounts

There are 3 remote file systems that must be mounted in order to run the detector software.

The IOC boot directory and the EPICS application reside on the Linux machine at GSECARS called corvette, rather than locally on the PPU computer. This makes it much easier to maintain the software, since corvette is always running the most recent stable version of the EPICS software. corvette:/home and corvette:/usr/local are automatically mounted on /corvette/home and /corvette/usr/local when the PPU computer boots. Type the following commands to see if these mounts are present:

ls /corvette/home

ls /corvette/usr/local

If you see files listed when you type these commands then the corvette mounts are OK. If these mounts are not OK the following command can be run (from the root account) to do the mounts.

/usr/local/bin/mount\_corvette

The detector data are copied from the PPU computer to the cars5/Data directory automatically by the grimsel program, so cars5/Data must be mounted. cars5/Data is mounted automatically when the PPU computer boots. It is mounted using the “chemstaff” account if the detector is located at sector 15, and using the “detector” account if the detector is located at sector 13. Type the following command to see if cars5/Data is mounted.

ls /cars5/Data

If no files are listed then cars5/Data need to be mounted. There are 2 scripts to do this. Run whichever script is appropriate (as root).

/usr/local/bin/mount\_cars5\_cmc

/usr/local/bin/mount\_cars5\_gse

### Start the EPICS IOC

* EPICS IOC must be started with one of the following commands:

start\_epics 13

start\_epics 15

* The first command starts the EPICS IOC in the directory corvette/home/epics/support/CARS/iocBoot/ioc13Pilatus300K with the PV prefix 13PIL3. The second command starts the EPICS IOC in the directory corvette/home/epics/support/CARS/iocBoot/ioc13Pilatus300K with the PV prefix 15PIL3: This command starts procServ running the EPICS IOC and listening for telnet connections on port 20001. It then telnets into the localhost on this port, so you will be connected to the IOC shell. You should see a number of messages as the IOC starts up. Wait until you get the IOC shell command prompt and type return to make sure the IOC is ready for commands. If the IOC is already running when you type the start\_epics command then you will get a brief error message which you can ignore, but it will telnet OK to the IOC shell.
* You can then disconnect from the procServ process by exiting your telnet session to procServ. Press the Control and ] characters at the same time. You will then get the telnet prompt. Type “quit” to exit telnet.

### Start medm (optional)

If you are logged in locally with a monitor and want to run medm to display the Pilatus detector control screen type the command

start\_medm 13

or

start\_medm 15

This can also be used if you are connected via ssh with X11 tunneling enabled (e.g. ssh -Y). An medm display for the Pilatus detector can be run from other computers with the command

medm -x -macro “P=13PIL300K:, R=cam1:” pilatusDetector.dl &

or

medm -x -macro “P=15PIL300K:, R=cam1:” pilatusDetector.dl &

Of course this display can also be opened as a related display from other medm screens, such as 00Start.adl at GSECARS.

### Start ImageJ (optional)

If you are logged in locally with a monitor and want to run ImageJ to view the images type the command

ImageJ &

Go to Plugins/EPICS\_areaDetector/EPICS AD Viewer to open the viewer. Enter the prefix 13PIL3:image1: or 15PIL3:image1: in the PVPrefix field in the EPICS AD Viewer window.

## File Saving

In the EPICS areaDetector medm screen the FilePath PV must start with /ramdisk. The next element in the path must be a directory on cars5 which is writable from the account which has mounted /cars/Data, i.e. either chemstaff or detector accounts on cars5. The first part of the path might be /ramdisk/chemmat if the chemstaff account is being used, or /ramdisk/dac\_user if the detector account is being used and it is a diamond anvil cell experiment. The remainder of the path can be chosen as desired by the user. If the directories in that path do not exist they will be created by the grimsel file copying program, both locally in /ramdisk and /Data, and remotely on cars5/Data.

The following is an medm screen shot of the Pilatus screen when the path is set to /ramdisk/chemmat/Pilatus\_Tests. The Pilatus\_Tests directory did not previously exist on cars5, it was automatically created by grimsel when it copied the files.

# It is also possible to use any of the areaDetector file plugins to save the data. This has the advantage that one can add additional metadata to the files, using the areaDetector NDAttributes. Such metadata can include any EPICS PVs, any detector parameter, etc. Metadata can be stored in files created by the TIFF, HDF5, and netCDF file plugins. If a file plugin is being used to save the data, then one would normally want to prevent grimsel from also storing files on cars5. This can be done by editing the file /etc/grimsel\_dectris.conf. It contains the following lines near the end

#For each storage such a section is needed

#Arbitrary identifier for the storage

storageID dataPilatus

#Type: either INTERNAL, EXTERNAL or OPTIONAL

type EXTERNAL

# Target directory

target /cars5/Data

#number of copy processes

n\_copy\_processes 20

To disable grimsel from copying to cars5 put a comment character “#” in front of the 4 lines that are not commented above. grimsel then must be restarted with the command (as root):

service grimsel restart

Eventually files in the /ramdisk and /Data directories on the PPU must be deleted. grimsel will do this automatically every time the furka program is restarted as follows (as root):

service furka restart

It is important to make sure that the files have been successfully copied to cars5 before executing the above command. grimsel will delete all of the files in /ramdisk and /Data when furka is restarted, even if the files have not been successfully written to cars5!

**Shutting down the detector**

1. As a superuser type the command:

shutdown now

1. Turn off the detector power
2. After a while turn off the cooling and disconnect all connections.