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| **Cornell High Energy Synchrotron Source** | | | | |
| **Doc#:** SOP-DET- NNN | **Procedure:** Use of “multi\_pilatus\_v4.mac” to run multiple Pilatus detectors from SPEC in various trigger modes, with support for fly-scanning using the USBCTR. | | | **Prepared by:** ARW |
| **Rev.:** 3 | **Date Revised:** 8/17/2020 | **Date Effective:** | **Date Expires:** | **Approved by:** |

**Purpose**

To run one or more Pilatus detectors within SPEC scans, using one of a variety of different trigger modes. For instance:

1. Perform “tseries”, “dscan” or “mesh” scans where a snapshot is obtained for each point in the scan, for each configured detector, and saved to a directory on CHESS\_DAQ.
2. Perform “pil\_movie <Nimages> <dwell>” to initiate an image series from one more pilatus detectors.
3. Perform “flyscan” or “flymesh” to obtain high frame-rate images from one or more Pilatus detectors. (scans provided by flyscan\_v4.mac)

**Equipment and Setup Needed**

1. PILATUS Pixel Array Detector(s) and associated power supplies, dry N2, chiller (for Pilatus 300K and above). See PILATUS hardware SOPs for details, but note that the macros described here supersede the SPEC macros described in those documents (as of August 2020).
2. A working EPICS IOC for each PILATUS.
3. For saving images to CHESS\_DAQ: Station-specific CHESS\_DAQ location mounted on station computer. For example, “/mnt/currentdaq” on the PILATUS control computer should point to “/nfs/chess/daq/20NN-N/id3b”. These macros also permit saving images to the Pilatus control computer.
4. “STATION\_ID” global variable defined within SPEC to match the string appearing in CHESS\_DAQ, e.g. “id3b”. (Best to assign in userlist.mac or station.mac)
5. Trigger-mode-specific wiring for trigger modes other than “Internal”.
6. Macro set loaded into SPEC. For example if the macro file “multi\_pilatus\_v4.mac”. is located in the “Macros” directory of the station home directory, then issue “udo multi\_pilatus\_v4.mac”

**Safety – see hardware specific SOPs.**

**Overview**

Sections **A-C** below provide several example command sequences for particular setups, each sharing the same minimal command sequence: **pil\_setup** and **pil\_on**. The additional commands **pil\_setdir** and **pil\_settrig** are required to change the target directory and/or trigger mode, and **pil\_von/voff** is provided to lend command line access to video modes. The complete function list is provided in Section **D**, and Section **E** gives an example SPEC session, showing macro output and the resulting image files resulting from 1D and 2D scans.

**Procedure**

**NOTE: Ensure detector window is covered with the protective plate when not in use to prevent damage from exposure.**

**A. Example 1: one detector with internal triggering (the 300K as “PIL5”)**

|  |  |
| --- | --- |
| **Command** | **Action** |
| pil\_setup PIL5 | Sets up the detector with EPICS prefix “PIL5” as Pilatus number “0”, to save images to the current directory on CHESS\_DAQ. |
| pil\_settrig “Internal” | Selects Internal trigger mode use when taking snapshots within scans. NOTE: this has no effect on the TriggerMode EPICS PV until a scan is performed. |
| pil\_on | Turns all detectors (in this case, only PIL5) “on”, such that a spec scan will trigger one snapshot per scan point. |
| pil\_movie 10 .1 | Immediately take 10 images, 0.1-second each. (no metadata). |
| tseries 5 .5 | Perform a five-point time series, taking a half-second snapshot at each point. Images will have the format:  <specfile\_PIL5\_SCAN#\_POINT#> |
| dscan samx 0 5 1 | Perform a single motor scan, taking a 1-second snapshot at each point. Images have the same format as above. |
| mesh samx 0 1 samz 0 1 1 | Perform a 2D, 2-motor scan, taking 1 second snapshots at each. point. Images will have the format:  <specfile\_PIL5\_SCAN#\_ROW#\_POINT#> |
| pil\_off | Turn off snapshot acquisition. |
| pil\_unsetup all | Erase SPEC’s knowledge of PILATUS detectors and associated macros. (This amounts to erasing the associative array “PIL”) |

**B. Example 2: two detectors and external triggering ( “PIL5” and “PIL9”)**

|  |  |
| --- | --- |
| **Command** | **Action** |
| pil\_setup PIL5 0 PIL5  **or**  pil\_setup PIL5 PIL5 | Sets up the detector with EPICS prefix “PIL5” as Pilatus number “0”, to save images to the “PIL5” subdirectory of the current directory on CHESS\_DAQ. |
| pil\_setup PIL9 1 PIL9 | As above, but sets up the detector “PIL9” as Pilatus number “1”, to save images to the “PIL9” subdirectory |
| pil\_settrig “Mult. Trigger” | Selects Multi trigger mode on both detectors when taking snapshots within scans. This implies that there is digital output / hardware trigger hooked into both detectors, that will go “high” for each point in any scan. |
| pil\_on 0 1 **or** pil\_on | Enable in-scan snapshots for both detectors. |
| “tseries”, “dscan”, and “mesh” | Perform scans as in Example 1. Images will have the format  <specfile\_PIL#\_SCAN#\_POINT#> or <specfile\_PIL#\_SCAN#\_ROW#\_POINT#> for 1D or 2D scans, respectively. |
| pil\_off 0 | Turn off detector 0, such that only PIL9 will take images. |

**C. Example 2: three detectors in fly mode ( “PIL5”, “PIL9” and “PIL6”)**

**In addition to “multi\_pilatus\_v4.mac”, this functionality requires “flyscan\_v4.mac”**

|  |  |
| --- | --- |
| **Command** | **Action** |
| pil\_setup PIL5 | Sets up the detector with EPICS prefix “PIL5” (the 300K) as Pilatus number “0”, to save images to the current CHESS\_DAQ directory. |
| pil\_setup PIL9 1 | As above, but sets up the detector “PIL9” (a 200K) as Pilatus number “1”. |
| pil\_setup PIL6 2 | As above, but sets up the detector “PIL6” (a 100K) as Pilatus number “2”. |
| pil\_settrig “Mult. Trigger” | Selects Multi trigger mode on both detectors when taking snapshots within scans. For fly scanning (below), this requires that the USBCTR device is setup as described in flyscan\_v4.mac, with step signal from the MDCP going into it, and the “CLK1” output going to the detectors. Also: a digital I/O output (see FLY\_TRIGCHAN in id3b\_NI\_DIO.mac ~/Macros) goes to the USBCTR. |
| pil\_on 0 1 2 **or** pil\_on | Enable in-scan snapshots for all detectors. |
| flysetup | Set up the fly mode fast and slow motors, and verify USBCTR setup. |
| flyscan 10 .5 100 | Scan the fast flymode motor 10 mm, taking 0.1 second. images every 0.5 mm (20 images). Images have the format  <specfile\_PIL#\_SCAN#\_POINT#>. |
| flymesh 10 .1 2 .1 50 | Perform a 10 mm x 2 mm 2D flymode map, with 0.1 mm pitch and 50 miliseconds per point (100 x 20 point map). Images have the format  <specfile\_PIL#\_SCAN#\_ROW#\_POINT#>. |

**D. Complete Function List and Usages (taken from mult\_pilatus\_v4.mac).**

# **pil\_setup** PREFIX [N] [path\_arg] / pil\_unsetup n1 [n2 ..] | all

# pil\_setup: if N is omitted, use N=0

# e.g. pil\_setup PIL5 (set up PIL5 as the 0th pilatus, and set directory to CWD on DAQ)

# **pil\_unsetup:** Un-setup one or more detectors, explicitly designated by number of “all” for all.

# e.g pil\_unsetup 0 1 (unsetup detectors 0 and 1)

# pil\_unsetup all (unsetup all detectors and delete the associative array “PIL”)

# **pil\_setdir** [n1 [n2 ..]] [newpath]

# **pil\_settrig** [n1 [n2 ...]] trigmode

# Set trigger mode (within spec scans) for 1 or more detectors for 1 or more detectors:

# "Internal", "Ext. Enable","Mult. Trigger", or "Ext. Trigger"

# **pil\_show**:

# Lists Pilati that are set up and whether they are active, etc. Values from PIL

# **pil\_prout**:

# Lists detail (from EPICS PVs) for active detectors, including E-thresh.

# **pil\_on/off**

# set target path for one or more detectors that are already set up

# if newpath is -1 or absent, use current directory, which MUST be on the DAQ

# **pil\_von/voff**

# sets all active detectors to "Alignment" mode and begins taking snapshots.

# **pil\_movie** Nimages dwell

# Sets up and initiates a series of pilatus images by all detectors that are on. If

# the trigger mode is "Internal", then the movie begins immediately. Otherwise the detector

# will await one or more triggers (depending on mode)

# **pil\_im\_get:**

# Usage: pil\_im\_get(n, pv\_suffix [, "string"]) (a standin for e.g.

# epics\_get("PIL5:cam1:<pv\_suffix>" [, "string"])

# **pil\_im\_set:**

# Usage: pil\_im\_set(n, pv\_suffix, val)

# (a standin for e.g. epics\_put("PIL5:cam1:<pv\_suffix>", val)

# **pil\_get/set:** Like pil\_im\_get/set but where "cam1" is absent from the PV string:

# (a standin for e.g. epics\_get("PIL5:<pv\_suffix>" [, "string"])

# **\_pil\_scan\_head:** A pilatus-specific commands to be hooked to “scan\_head” in the standard scan

# sequence. Determines whether Trigger Mode, scan dimensionality, and if flymode is active.

# Note that the file path is set here, but filename string is set in \_pil\_precount, since

# for 2D scans it must be reset for each row.

# **\_pil\_precount:** A hook for user\_precount macro that determines when to set the filename and

# initiate acquisition.

# **\_pil\_file\_setpath, \_pil\_file\_setname:**

# sets filename based on scan dimensionality (and possibly trigger mode)

**E. Example SPEC session**

2439.SPEC> pwd

/mnt/home/chess\_id3b

2440.SPEC> pil\_setup PIL5

Error: pil\_get\_path failed to locate current directory or find STATION\_ID id3b on DAQ

STATION\_ID should be set in userlist.mac or station.mac, e.g.

Error: In pil\_setdir: cannot determine path.

If valid, current path will be retained

pil\_setup: Error determining correct path -- aborting

0 detectors defined

2441.SPEC> cd /mnt/currentdaq/id3b-misc-1/

Now in "/nfs/chess/daq/2020-2/id3b/id3b-misc-1".

2442.SPEC> pil\_setup PIL5

1 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

2443.SPEC> pil\_on

1 detectors defined

Pilatus 0/PIL5 is ON; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

2444.SPEC> newfile

Data file (testpil4)? testpil5

Last scan number (0)?

Using "testpil5". Next scan is number 1.

2445.SPEC> ls

2446.SPEC> tseries 5 1

Total 5 points, 6 seconds

Scan 1 Mon Aug 17 18:33:11 2020 file = testpil5 spec user = chess\_id3b

tseries 5 1 0

# Time Seconds ic1 Seconds ic2 azer bedh diode VBPM VER VBPM HOR

1 detectors defined

Pilatus 0/PIL5 is ON; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

0 0.0000 1 110 1 317 1382 0 0 0 0

1 1.3421 1 110 1 318 1385 0 0 0 0

2 2.6180 1 110 1 317 1381 0 0 0 0

3 3.8892 1 109 1 317 1384 0 0 0 0

4 5.1671 1 109 1 316 1380 0 0 0 0

2447.SPEC> pil\_setup PIL5 1

2 detectors defined

Pilatus 0/PIL5 is ON; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

Pilatus 1/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

2448.SPEC> ls

2449.SPEC> pil\_off

2 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

Pilatus 1/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

2450.SPEC> pil\_on 1

2 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

Pilatus 1/PIL5 is ON; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

2451.SPEC> wm xrfx xrfz

xrfx xrfz

xrfx xrfz

User

High 139.92500 150.00000

Current 1.00000 22.00000

Low -60.07500 -130.00000

Dial

High 57.03550 67.03550

Current -81.88950 -60.96450

Low -142.96450 -212.96450

2452.SPEC> mesh xrfx 0 1 2 xrfz 21 22 2 .5

Total 9 points, 6.3 seconds

Scan 2 Mon Aug 17 18:34:45 2020 file = testpil5 spec user = chess\_id3b

mesh xrfx 0 1 2 xrfz 21 22 2 0.5

# xrfx xrfz Seconds ic1 Seconds ic2 azer bedh diode VBPM VER VBPM HOR

2 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

Pilatus 1/PIL5 is ON; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

Inside \_pil\_file\_setname: n\_slow = 0

0 0.0000 21.0000 0.5 58 0.5 160 691 0 0 0 0

1 0.5000 21.0000 0.5 58 0.5 160 691 0 0 0 0

2 1.0000 21.0000 0.5 58 0.5 160 691 0 0 0 0

Inside \_pil\_file\_setname: n\_slow = 1

3 0.0000 21.5000 0.5 58 0.5 160 690 0 0 0 0

4 0.5000 21.5000 0.5 58 0.5 161 692 0 0 0 0

5 1.0000 21.5000 0.5 59 0.5 160 692 0 0 0 0

Inside \_pil\_file\_setname: n\_slow = 2

6 0.0000 22.0000 0.5 58 0.5 160 691 0 0 0 0

7 0.5000 22.0000 0.5 58 0.5 160 692 0 0 0 0

8 1.0000 22.0000 0.5 57 0.5 161 691 0 0 0 0

2453.SPEC> ls

2454.SPEC> pil\_off

2 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

Pilatus 1/PIL5 is OFF; Mode: Internal; path:/mnt/currentdaq/id3b-misc-1

2455.SPEC> pil\_settrig "Mult. Trigger"

2 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Mult. Trigger; path:/mnt/currentdaq/id3b-misc-1

Pilatus 1/PIL5 is OFF; Mode: Mult. Trigger; path:/mnt/currentdaq/id3b-misc-1

2456.SPEC> pil\_unsetup 1

1 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Mult. Trigger; path:/mnt/currentdaq/id3b-misc-1

2457.SPEC> pil\_on

1 detectors defined

Pilatus 0/PIL5 is ON; Mode: Mult. Trigger; path:/mnt/currentdaq/id3b-misc-1

2458.SPEC> flymesh 5 1 2 1 500

Estimated length of scan in seconds / minutes / hours : 11 / 0.2 / 0.00

Scan Origin is x=1.00, y=22.00

x pitch: 1

y pitch: 1

x scan size: 5

y scan size: 2

dwell: 500

Fast axis speed is 8000 Hz, 2.00 mm/sec

Normal speed of xrfx is 50000 Hz = 12.50 mm / sec

Desired scan speed is 8000 Hz = 2.00 mm sec

Total 3 points, 2.1 seconds

Scan 3 Mon Aug 17 18:36:23 2020 file = testpil5 spec user = chess\_id3b

flymesh xrfx 1.5 5.5 4 xrfz 22 24 2 0.5

# xrfz Seconds ic1 Seconds ic2 azer bedh diode VBPM VER VBPM HOR

Using 3 counters from "USBCTR2:MCS".

1 detectors defined

Pilatus 0/PIL5 is ON; Mode: Mult. Trigger; path:/mnt/currentdaq/id3b-misc-1

DEBUG: Beginning \_scan\_on deff

Restoring xrfx velocity to 50000 Hz

before move

after move

Normal speed of xrfx is 50000 Hz = 12.50 mm / sec

Desired scan speed is 8000 Hz = 2.00 mm sec

Begin row 1 of 2; raster xrfx to 6.000

In fly\_precount -- about to send EraseStart

Inside \_pil\_file\_setname: n\_slow = 0

In fly\_getcounts -- about to send stopall

0 22.0000 2.5 283 2.5 813 3462 0 0 0 0

Restoring xrfx velocity to 50000 Hz

before move

after move

Normal speed of xrfx is 50000 Hz = 12.50 mm / sec

Desired scan speed is 8000 Hz = 2.00 mm sec

Begin row 2 of 2; raster xrfx to 1.000

In fly\_precount -- about to send EraseStart

Inside \_pil\_file\_setname: n\_slow = 1

In fly\_getcounts -- about to send stopall

1 23.0000 2.5 283 2.5 804 3457 0 0 0 0

Restoring xrfx velocity to 50000 Hz

before move

after move

Normal speed of xrfx is 50000 Hz = 12.50 mm / sec

Desired scan speed is 8000 Hz = 2.00 mm sec

Begin row 3 of 2; raster xrfx to 6.000

In fly\_precount -- about to send EraseStart

Inside \_pil\_file\_setname: n\_slow = 2

In fly\_getcounts -- about to send stopall

2 24.0000 2.5 284 2.5 810 3455 0 0 0 0

Restoring xrfx velocity to 50000 Hz

Returning to xrfx = 1.00, xrfz =22.00

Scan time elapsed in seconds / minutes / hours : 13 / 0.2 / 0.00

2459.SPEC> ls

1 testpil5\_PIL5\_002\_000\_0001.tiff testpil5\_PIL5\_003\_000\_0004.tiff

crl\_align testpil5\_PIL5\_002\_000\_0002.tiff testpil5\_PIL5\_003\_001\_0000.log

n testpil5\_PIL5\_002\_001\_0000.tiff testpil5\_PIL5\_003\_001\_0000.tiff

test testpil5\_PIL5\_002\_001\_0001.tiff testpil5\_PIL5\_003\_001\_0001.tiff

testdir testpil5\_PIL5\_002\_001\_0002.tiff testpil5\_PIL5\_003\_001\_0002.tiff

testpil1 testpil5\_PIL5\_002\_002\_0000.tiff testpil5\_PIL5\_003\_001\_0003.tiff

testpil5 testpil5\_PIL5\_002\_002\_0001.tiff testpil5\_PIL5\_003\_001\_0004.tiff

**testpil5\_PIL5\_001\_0000.tiff** testpil5\_PIL5\_002\_002\_0002.tiff testpil5\_PIL5\_003\_002\_0000.log

testpil5\_PIL5\_001\_0001.tiff testpil5\_PIL5\_003\_000\_0000.log testpil5\_PIL5\_003\_002\_0000.tiff

testpil5\_PIL5\_001\_0002.tiff **testpil5\_PIL5\_003\_000\_0000.tiff** testpil5\_PIL5\_003\_002\_0001.tiff

testpil5\_PIL5\_001\_0003.tiff testpil5\_PIL5\_003\_000\_0001.tiff testpil5\_PIL5\_003\_002\_0002.tiff

testpil5\_PIL5\_001\_0004.tiff testpil5\_PIL5\_003\_000\_0002.tiff testpil5\_PIL5\_003\_002\_0003.tiff

**testpil5\_PIL5\_002\_000\_0000.tiff** testpil5\_PIL5\_003\_000\_0003.tiff testpil5\_PIL5\_003\_002\_0004.tiff

2460.SPEC> pil\_off

1 detectors defined

Pilatus 0/PIL5 is OFF; Mode: Mult. Trigger; path:/mnt/currentdaq/id3b-misc-1

**F. Trigger Wiring**

The following wiring diagrams correspond to two different ways to use the “Mult. Trigger” mode with the Pilatus detectors. In the first case, SPEC supplies a single trigger to the USBCTR, just before beginning fly-scan motor motion. (This is currently done by one of the digital I/O lines on the National Instruments counter-time board). Subsequently, the output from scalar channel 7 on the USBCTR triggers frame advances on the Pilatus, as well as advancing channels for its own multi-channel scalars (used to collect ion chamber signal during each frame).

In the 2nd case, Pilatus triggering is performed with the “output” signal from the “standard” CHESS counter/timer board. NB: Often this signal is buffered before being sent to the Pilatus.



