

Cheetah configuration and documentation

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Downloading, compiling and installing Cheetah

Some day there will be an explanation of how to download and install Cheetah. For now, find someone who has already compiled Cheetah and ask for help ☺

A set of brief instructions on cheetah installation has been added to the cheetah folder of the github cheetah repository. The instructions currently specify changes needed in PATH and LD_LIBRARY_PATH so that psana (the interface program to the LCLS data files) can find the appropriate cheetah-psana modules which are used to extract and process the data.

Running Cheetah

Running Cheetah without a script

Cheetah can be run on its own, but is most easily used in conjunction with a script such as crystfinder – which does a lot of useful housekeeping. Here's a quick example of a workflow without using a script:

0) Check that the cheetah program is in your path:

```
> cheetah -h
```

If all goes well, you'll see a brief list of Cheetah options. Currently, this is not very helpful, hence the need for this section...

1) Create a new directory, which is where you would like the output of Cheetah will be written.

```
> mkdir r0090
> cd r0090
```

2) Let's say you would like to analyze run 90, in which case there are a few XTC data files in the directory /reg/xtcdir with names like "e158-r0090-s01-c00.xtc". Firstly, you should write the paths to those files into a text file, which we will then provide to Cheetah as an input:

```
> find /reg/xtcdir -name '*r0090*.xtc' > xtcfiles.txt
```

3) In order to run Cheetah, you'll need a configuration file, which contains the instructions and tunable parameters needed to carry out this processing job (more on that later...). Cheetah automatically searches for a configuration file called "cheetah.ini" in the current directory. You'll probably have a bunch of ".ini" files in some directory (say, "/reg/myinis"), so you should copy the appropriate .ini file for this job into the current directory

```
> cp /reg/myinis/test.ini cheetah.ini
```

4) Now you are ready to run cheetah:

```
> cheetah -l xtcfiles.txt
```

Once Cheetah has completed the job, you will find several log files, along with hdf5-formatted data files containing individual "hits", summed "powder" patterns, SAXS profiles, etc. (more on Cheetah output later).

Configuration files

Cheetah behavior is specified by the user through a configuration file. Within a configuration file is a list of “keywords” that cheetah recognizes, and the user-specified values. There are two types of keywords; “global” keywords that affect the analysis of all data, and “detector” keywords that affect only one particular detector.

Global keywords may be specified in the following way:

```
keyword = value # comment
```

Note that whitespace is ignored completely, and everything following a # symbol is ignored. Keywords are not case sensitive, and if a keyword is unrecognized by Cheetah the program will exit.

Detector keywords may be grouped together. One way to group keywords is to use forward slashes, as follows:

```
group1/keyword1 = value
group1/keyword2 = value
group2/keyword1 = value
group2/keyword2 = value
```

The labels `group1` and `group2` can be any word. An alternative way to specify groups is the following:

```
[group1]
keyword1 = value
keyword2 = value
[group2]
keyword1 = value
keyword2 = value
```

Generally, the use of brackets will simply prepend the group within the brackets to all subsequent keywords. Empty brackets are allowed, which would specify global keywords. Detector keywords that have not been assigned a group will automatically be assigned to the “first” detector.

Cheetah will ultimately be capable of performing peakfinding/hitfinding on multiple detectors. At the moment, these operations will only be performed on the first detector in the configuration file.

Setting up Cheetah and the crystfinder script

- Set up the crystfinder script to automate everything
- Configure cheetah.ini
 - o Select the right detector
 - o Select background processing options
 - o

Tuning

Optimising crystal hit finding

- Set `hitfinderADCthreshold` low enough, but not too low.
-

Optimising processing speed

- Set `nthreads` to 72 (on cfelsg) or 16 (on most other servers)
- Check I/O speed limit using `ioSpeedTest`
- Turn off powder pattern creation (which skips mutex locks around summation of powder patterns)
- Increase amount of time between calculation of running background (recalculation mutex blocks all worker threads)
-

Most commonly adjusted keywords

These are the most important keywords you’ll probably ever want to tweak – the rest can likely be left alone.

Detector configuration

- **detectorName** (`CxiDs1`)
- **geometry** (`geometry/cspad_pixelmap.h5`)

Calibration and masks

- **darkcal** (`darkcal.h5`)
- **badPixelmap** (`badpixels.h5`)

Background subtraction

- `cmModule` (0)
- `subtractBehindWires` (0)
- `useSubtractPersistentBackground` (0)
- `useLocalBackgroundSubtraction` (0)

Hit finding algorithms

- `hitfinderAlgorithm` (3)
- `hitfinderADC` (100)
- `hitfinderNPeaks` (50)
- `hitfinderMinPixCount` (3)
- `hitfinderMaxPixCount` (20)
- `hitfinderSNR`

Energy spectrum

- `espectrumTiltAng` (0)
- `espectrumDarkfile`
- `espectrumScaleFile`

What gets saved

- `saveHits` (0)
- `saveAssembled` (1)
- `saveRaw` (0)

Other

- `nThreads` (16 or 72)

Complete listing of keywords

Many of these are power user settings designed for turning on or off features in testing.

Detector configuration

`detectorName` (CxiDs1)

Recognized options for **cspad** are:

- `"CxiDs1"`: cspad near detector
- `"CxiDs2"`: ??
- `"CxiDsd"`: cspad far detector
- `"XppGon"`: cspad on XPP beamline (not tested, and no idea why this is referenced as a goniometer???)

Recognized options for **pnccd** are:

- Hooks in place, bit not yet implemented

`detectorType` (cspad)

Recognized options are:

- `"cspad"`
- `"pnccd"`

This field could be deleted – specifying detectorName should be enough to set this internally

`geometry` (geometry/cspad_pixelmap.h5)

Path to an hdf5 file specifying the real-space coordinates of each pixel. The hdf5 data fields are /x /y /z. The x coordinate corresponds to data fast scan coordinates (pixels that are nearest neighbors in memory), while y is slow scan. The z coordinate is the relative offsets of each detector panel. Units are meters (values are first divided by pixel size variable to get coordinates of pixels in space).

Note: see the keyword pixelSize-- it is important that this is consistent with the units in the geometry!

pixelSize (0.000110)

Size of pixels in meters, defaults to values for the cspad detector.

defaultCameraLengthMm

The default camera length (in mm) to use in the event that the detector position encoder value is not available in the XTC data stream.

defaultPhotonEnergyeV

The default photon energy (in eV) to use in the event that the beamline data is not available in the XTC data stream.

detectorZpvname (CXI:DS1:MMS:06.RBV)

The LCLS EPICS process variable name needed for accessing the encoder value for the detector camera length.

Calibration and masks

darkcal (darkcal.h5)

Path to an input hdf5 file containing a dark current measurement. Cheetah can create a "darkcal" from a dark run; see the generateDarkcal keyword. The hdf5 data field is "/data/data". Units are ADU. Darkcals should NOT be gain corrected. Make sure the detector gain settings of the darkcal match that of the run.

gaincal (gaincal.h5)

Path to an input hdf5 file containing the gainmap. By default the raw data will be multiplied by this map, although it can be inverted by setting invertGain=1. The hdf5 data field is "/data/data".

invertGain (0)

Divide by the gain map, rather than multiplying (in case gain map is supplied as gain per pixel, rather than value to multiply pixel values by).

peakMask (peakmask.h5)

Path to an input hdf5 file indicating where to search for peaks. The hdf5 data field is "/data/data".

badPixelmap (badpixels.h5)

Path to input hdf5 file indicating bad pixels. Essentially, this has the same effect as a gainmap. The hdf5 data field is "/data/data"

Background subtraction

Proper subtraction of electronic and photon background is essential – there are many options.

useDarkcalSubtraction (1)

Toggle the use of the darkcal map.

useBadPixelmap (0)

Toggle the use of the bad pixel map.

useGaincal (0)

Toggle the use of the gain map.

cmModule (0)

One of three possible methods for subtracting common mode offsets from individual ASICs. Common mode noise on each ASIC fluctuates randomly from frame to frame and must be estimated from the read out signal itself. Common mode is estimated as the lowest 10% of pixel values in each ASIC. 10% value can be set to something else by the user if desired. This option assumes the lowest 10% of values represent only detector electronic noise - be careful of using this when there are no dark areas on the ASIC.

cmFloor (0.100000)

Use lowest x% of values as the offset to subtract (typically lowest 2%)

subtractUnbondedPixels (0)

One of three possible methods for subtracting common mode offsets from individual ASICs. Newer generations of cspad have some pixels unbonded for use in estimating ASIC electronic offsets. In csPAD revision 2 (August 2011) only a few ASICs have unbonded pixels for testing purposes, so this is of limited use at present. Pixel locations are hard coded for testing (generalize later)

subtractBehindWires (0)

One of three possible methods for subtracting common mode offsets from individual ASICs. For some experiments thin wires are placed in front of the detector and cast shadows; the counts behind shadows are used to estimate common mode offsets on each ASIC.

wireMaskFile (wiremask.h5)

Path to input hdf5 file with binary mask specifying pixels behind wires to be used for background estimation. These wires are placed in front of the detector and cast shadows; the counts behind shadows to determine common mode noise.

useAutoHotpixel (1)

Automatically identify and remove hot pixels. Hot pixels are identified by searching for pixels with intensities consistently above the threshold set by the keyword hotpixADC. In this case, "consistently" means that a certain fraction (user-set keyword hotpixFreq) of a certain number of buffered frames (number of frames set by the keyword hotpixMemory) are above threshold. The hot pixel map is updated every hotpixMemory frames. Hot pixels within the corrected data will be set to zero. Note that the search for hot pixels is performed on the correcteddata (probably it should be performed on raw data instead?), so if you decide to change the corrections (e.g. darkcal, gainmap), the resulting hot pixel maps may differ.

useSubtractPersistentBackground (0)

Subtract the pixel-by-pixel median background calculated from the previous N frames (N set by the keyword bgRecalc, but apparently it cannot exceed 50 frames – **it can, if bgbuffer is made large enough**).

useLocalBackgroundSubtraction (0)

Prior to peak searching, transform the image by subtracting the median value of nearby pixels. The median is calculated from a box surrounding each pixel. The size of the box is equal to localBackgroundRadius*2 + 1. Bad pixels and detector edge effects are not accounted for (i.e., if most nearby pixels are bad, the local median will be equal to zero). This is somewhat slower, but very effective for nanocrystal data.

localBackgroundRadius (3)

See keyword useLocalBackgroundSubtraction.

Background calculation tuning

bgMemory (50)

See keyword useSubtractPersistentBackground.

bgRecalc (50)

Strange, this *almost* does the same thing as bgMemory, but if bgRecalc is less than the default value of bgMemory, that default value will be used?

This sets how often the program pauses to recalculate background and hot pixel values. It is typically the same as the buffer size, but since recalculation is a thread blocking process, setting this to happen less frequently (eg: every 200 or 500 frames) speeds up execution.

bgMedian (0.5)

Rather than using the usual median value for background, you can optionally choose any arbitrary K-th smallest element equal to bgMedian*bgMemory. Neat!

bgIncludeHits (0)

Include hits in the background running buffer.

bgNoBeamReset (0)

Used to reset the background buffer whenever LCLS beam dies, defined as when $GMD < 0.2 \text{ mJ}$. (not implemented)

bgFiducialGlitchReset (0)

Used to restart backgrounds when LCLS unexpected changes operating frequency. This was a problem on hot days in the June 2010 data set. (not implemented)

scaleBackground (0)

If photon background is only caused by photon scattering, it will be stronger or weaker depending on the strength of the incident pulse. Assuming signal and background are orthogonal vectors, the background component in current image is found using an inner product between background and the current data frame. OK for crystals, use with caution on other data. This was more of a problem at FLASH than at LCLS, because FLASH is more unstable in intensity.

Automatic hot pixel calculation

hotpixFreq (0.900000)

See keyword useAutoHotPixel.

hotpixADC (1000)

See keyword useAutoHotPixel.

hotpixMemory (50)

See keyword useAutoHotPixel.

Pixel saturation

maskSaturatedPixels (0)

Search each image for saturated pixels, and mask them prior to further analysis. Saturated pixels are identified by a simple global threshold value set by the keyword pixelSaturationADC.

pixelSaturationADC (0)

See keyword maskSaturatedPixels.

Hit finding algorithms

hitfinder (0)

Specify the hitfinder algorithm. Various flavours of hitfinder:

- 1 - Number of pixels above ADC threshold
- 2 - Total intensity above ADC threshold
- 3 - Count Bragg peaks (intensity threshold)
- 4 - Use TOF
- 5 - Count Bragg peaks (threshold + gradient + extras)
- 6 - Count Bragg peaks (based on signal-to-noise ratio)

Note that the choice of hitfinder influences what is reported in the log files.

First, do these steps (regardless of the hitfinder choice):

Build a buffer, which is a replica of the corrected data. Values in the buffer array will be set to zero as those pixels are analyzed and rejected. If `hitfinderUsePeakmask != 0`, then multiply the buffer by this array before moving on.

Now, depending on the algorithm, do these steps:

Algorithm 1:

- 1) Count the pixels within the buffer that are above the (user-defined) `hitfinderadc` value.
- 2) Also, sum the values of the pixels that meet the criteria of step 1.
- 3) If the number of pixels is greater than the value of (user-defined) `hitfindernat`, count this frame as a hit.
- 4) Report the number of pixels in the log files as `npeaks` and as `nPixels`.
- 5) Report the total counts (intensity) as `peakTotal`

Algorithm 2:

Same as algorithm 1, except that the criteria for a hit is now that the `*intensity*` is greater than `hitfindernat`, rather than the pixel count.

Algorithm 3:

Briefly, this is what happens:

- 1) Scan the buffer, module-by-module, searching for "blobs" of connected pixels which all meet the criteria of being above the threshold defined by the keyword `hitfinderADC`. A pixel can be "connected" to any of its eight nearest neighbors. If its "connected" neighbor is "connected" to another pixel, then all three are mutually "connected" to each other.
- 2) If a blob contains more than `hitfinderMinPixCount` connected pixels, and less than `hitfinderMaxPixCount` pixels, it is counted as a peak.
- 3) The center of mass and integrated intensity is calculated for the blob (this is the peak position and integrated intensity).
- 4) If there are more than `hitfinderNpeaks` peaks, and less than `hitfinderNpeaksMax`, then count this as a hit.

Some important keywords:

- `hitfinderNAT`
- `hitfinderADC`
- `hitfinderMinPixCount`
- `hitfinderMaxPixCount`
- `hitfinderNPeaks`
- `hitfinderNPeaksMax`
- `hitfinderCheckMinGradient`: Before considering a peak candidate,

check that the intensity gradient is above this threshold.
Here, the "gradient" is the mean square derivative of the
"above/below" and "upper/lower" pairs of pixels connected
to the pixel of interest.

- hitfinderMinGradient: Threshold for the above keyword.
- hitfinderCheckPeakSeparation: After locating peaks, throw out all the peak pairs that are too close together.
- hitfinderMaxPeakSeparation: Threshold for the above keyword.

This algorithm also calculates a quantity called "peak density"?
What's being reported in the log files?

Algorithm 4:

Use time-of-flight data... details later...

Algorithm 5:

Similar to 3, to be documented another day...

Algorithm 6:

Firstly, create a combined mask which indicates hot pixels, saturated pixels, bad pixels, pixels specifically masked at the peakfinding stage (keyword peakmask), and pixels outside the specified resolution range (keywords hitfinderLimitRes, hitfinderMinRes, hitfinderMaxRes). These pixels will never be considered for further analysis.

Each pixel in each detector panel (one panel at a time) will be inspected. Initially, we are searching for a simple "trigger" to indicate the possibility of a peak, with more stringent tests to follow. Here's how it works:

- 1) If the pixel intensity (in raw ADC units) is below the threshold set by hitfinderADC, skip this pixel.
- 2) If any of the eight nearest neighbor pixels has a greater intensity, skip this pixel.
- 3) If the above tests pass, the signal-to-noise ratio (SNR) will be calculated as follows: the mean background intensity $\langle I \rangle$ and the standard deviation $\text{sig}(I)$ are calculated from a concentric square annulus, with its radius specified by the keyword hitfinderLocalBGRadius. The thickness of the annulus is specified by the keyword hitfinderLocalBGThickness. (For example, if the radius is 1, and the thickness is 1, then only the nearest 8 pixels will be considered in this calculation.) The SNR for this pixel is equal to $(I - \langle I \rangle) / \text{sig}(I)$.
- 4) If the background-corrected intensity $(I - \langle I \rangle)$ is less than the threshold hitfinderADC, skip this pixel.
- 5) If the SNR value is below the value hitfinderMinSNR, skip this pixel.
- 6) If the above tests pass, a test for how many *connected* pixels also meet the above criteria will be performed. If the number of connected pixels falls within the (inclusive) range [hitfinderMinPixCount , hitfinderMaxPixCount], then this will be counted as a peak. Note that connected pixels are masked, and will not be considered for further analysis.
- 7) The centroid of the peak will be calculated (within the box of radius equal to hitfinderLocalBGRadius).
- 8) Once a peak is found, a test will be performed to check that there are not other peaks that are too close to this one. The limiting distance is set by the keyword hitfinderMaxPeakSeparation. If a closer peak is found, it will be eliminated if it has lower SNR than this peak, else the current peak will be eliminated. (Note that, currently, this does not guarantee that some closely-spaced peak pairs will not be found, but will eliminate most of them).
- 9) Once the last pixel has been analyzed, if the number of peaks found is in the (inclusive) range [hitfinderMinPeaks, hitfinderMaxPeaks], then this pattern will be considered a hit.

Hitfinder tuning

hitfinderAlgorithm (3)

See the keyword hitfinder.

hitfinderADC (100)

See the keyword hitfinder.

hitfinderNAT (100)

See the keyword `hitfinder`.

hitfindertit (1283604304)

See the keyword `hitfinder`. Is it TAT or TIT?

hitfinderCluster (0)

This does nothing at the moment.

hitfinderNPeaks (50)

See the keyword `hitfinder`.

hitfinderNPeaksMax (100000)

See the keyword `hitfinder`.

hitfinderMinPixCount (3)

See the keyword `hitfinder`.

hitfinderMaxPixCount (20)

See the keyword `hitfinder`.

hitfinderLocalBGRadius (4)

See the keyword `hitfinder`.

hitfinderLocalBGThickness (1)

See the keyword `hitfinder`.

hitfinderLimitRes (0)

See the keyword `hitfinder`.

hitfinderMinRes (1000000000)

See the keyword `hitfinder`.

hitfinderMaxRes (0)

See the keyword `hitfinder`.

hitfinderUsePeakMask (0)

See the keyword `hitfinder`.

hitfinderUseTof (0)

Does choosing hitfinding algorithm 4 accomplish the same thing?

hitfinderTofMinSample (0)

?

hitfinderTofMaxSample (1000)

?

hitfinderTofThresh=1283604304

?

Specifying what gets saved in exported frame HDF5 files

saveHits (0)

Save the hits to individual hdf5 files. Exactly what will be saved is determined by the keywords saveRaw, saveAssembled, savePeakInfo, saveDetectorCorrectedOnly, saveDetectorRaw, and possibly more...

saveAssembled (1)

Save the data which has been interpolated into a physically correct image (as would be seen on a sheet of film), based on the geometry file. Note that this will take up more space on disk, but provides an image which can be analysed/displayed as if the detector were one CCD. Also, note that geometry is updated sometimes, and you will need to re-run all of your hitfinding if you intend to store the data only in assembled form. The hdf5 field is /data/assembleddata, and has zeros where there is no data. If present, it will be symbolically linked to the field /data/data.

saveRaw (0)

Save corrected data in the hdf5 files, in data layout as read from the detector, without interpolation into a physically realistic image. The hdf5 data field is /data/rawdata. Note that the word "raw" does not mean uncorrected (!) as one might think; it just means that it has not been interpolated onto a larger (zero-padded) array based on the geometry file (this one is the "assembled" data set).

Maybe the field name is misleading? Would saveUnassembled be better?

savePeakInfo (1)

Save the peak center of mass (two coordinates), intensity, and number of pixels to the hdf5 and log files. These values are specified in the "assembled" and "raw" coordinate systems. Look to the hdf5 fields /processing/hitfinding/peakinfo* for this information. More details later.

saveDetectorCorrectedOnly (0)

Even if background subtraction is used for hit finding, back up to image with only detector corrections subtracted and save this instead. Useful for preserving the water ring, for example.

If set to non-zero value, save the data which has only the following operations done to it (in this order):

- 1) Subtract darkcal
- 2) Subtract common mode offsets
- 3) Apply gain correction
- 4) Multiply by bad pixel mask

If set to zero, then you get these additional corrections (in this order):

- 5) Subtract running (persistent) background
- 6) Subtract local background
- 7) Zero out hot pixels
- 8) Multiply by bad pixel mask (again)

If the keyword saveDetectorRaw is set, then none of the above corrections will be applied (therefore, this keyword has no effect).

saveDetectorRaw (0)

Image will be saved exactly as represented in the XTC data stream, regardless of what detector corrections and photon background subtraction is used for hit finding. This option is mainly of interest to detector groups who want to look at data in as raw a form as possible, or for low-level diagnostics on common mode, electronic noise, etc.

As the name suggests, save the intensity values with no corrections applied, even though the corrections were done prior to hitfinding. This keyword trumps the keyword saveDetectorCorrectedOnly. Note that this keyword may be confused with saveRaw, which has to do with the question of padding the array and interpolation, not data processing.

hdf5dump (0)

Write every nth frame to an hdf5 file, regardless of whether it was found to be a hit.

Creation of calibration files

generateDarkcal (0)

Create a darkcal from a given run (which should contain dark data -- i.e. data without the X-ray beam on). Takes the average of all patterns, and output a "darkcal" hdf5 file named rXXXX-darkcal.h5 in the end. Essentially, this option tricks cheetah into thinking every frame is a "hit". The darkcal is the average, not the sum, unlike the usual "powder" patterns. If you set generatedarkcal=1, the following keywords will be modified so everything works as expected:

```
cmModule = 0;
cmSubtractUnbondedPixels = 0;
subtractBg = 0;
useDarkcalSubtraction = 0;
useGaincal=0;
useAutoHotpixel = 0;
useSubtractPersistentBackground = 0;
hitfinder = 0;
savehits = 0;
hdf5dump = 0;
saveRaw = 0;
saveDetectorRaw = 1;
powderSumHits = 0;
powderSumBlanks = 0;
powderthresh = -30000;
startFrames = 0;
saveDetectorCorrectedOnly = 1;
```

generateGaincal (0)

Automatically create a gain map file from flat field data. Works, but the output likely needs tweaking by hand in IDL/Matlab. All patterns will be summed to form an average, which is then divided by the median value of the image. (The median value is therefore gain = 1.) The gainmap will be saved as "rXXXX-gaincal.h5". At the moment, the gainmap is set to zero where it is outside of the bounds 0.1 and 10. When setting generategaincal=1 the following keywords will be modified so everything works as expected:

```
cmModule = 0;
cmSubtractUnbondedPixels = 0;
subtractBg = 0;
useDarkcalSubtraction = 1;
useAutoHotpixel = 0;
useSubtractPersistentBackground = 0;
useGaincal=0;
hitfinder = 0;
savehits = 0;
hdf5dump = 0;
saveRaw = 0;
saveDetectorRaw = 1;
powderSumHits = 0;
powderSumBlanks = 0;
powderthresh = -30000;
startFrames = 0;
saveDetectorCorrectedOnly = 1;
```

saveInterval (1000)

Periodically save running sums and update the log file at this interval.

Image summation (powder patterns)

powderSumHits (1)

Record and save the summed (not averaged) intensities from frames determined to be hits. Will be saved as the file named powderSumHits.h5. The hdf5 data field is /data/data.

powderSumBlanks (1)

Record and save the summed (not averaged) intensities from frames determined to be non-hits. Will be saved as the file named powderSumBlanks.h5. The hdf5 data field is /data/data.

powderthresh (-20000)

Apply this intensity threshold before powder summation. Setting to ~500 typically captures only peaks; setting to 0 sums only positive values; setting to -20,000 typically sums everything.

Radial intensity profiles (SAXS/WAXS profiles)

saveRadialStacks (0)

Save hdf5 files containing radial profiles, image-by-image. Masked pixels will not be integrated. More details here some day.

radialStackSize (10000)

How many radial profiles in each hdf5 "radial stack" file.

Energy spectrum

espectrum1D (1)

Toggles the creation of a 1D line output of the beam energy profile, calculated by integration of the energy spectrum CCD along the line of the stripes in the spectral profile.

espectrumDarkSubtract (1)

Toggles the removal of a mean background from the CCD before calculation of the 1D integrated spectrum. A background is calculated when the *generateDarkcal* flag is set to 1

espectrumTiltAng (0)

Input which specifies the tilt of the spectral stripes with respect to the horizontal axis of the CCD. The angle is defined so that a positive value relates to a clockwise rotation of the spectral stripes from the horizontal. This can be calculated from the first run of the experiment from an image of the spectrum CCD camera in the event hdf5 file in the field "/data/espectrumCCD". This value is likely to change if the spectrum CCD is moved, i.e. in the event of an energy change or X-ray beam re-focusing.

espectrumLength (1080)

Number of pixels along the energy axis of the spectrum CCD camera. Defaults to the value for the long axis of an Opal2K CCD of 1080 pixels

espectrumWidth (900)

Number of pixels along the beam profile axis of the spectrum CCD camera. Defaults to the value for the short axis of an opal2K CCD of 900 pixels

espectrumSpreadEV (40)

Value of the energy spread seen by the energy spectrum CCD camera in eV. Defaults to 40

espectrumDarkfile ()

Path to the energy spectrum dark calibration file created from a dark calibration run. The filename will have the format rXXXX-energySpectrum-darkcal.h5. If the *spectrumDarkSubtract* keyword is set to 1 and no file path is given or the specified file does not exist the program will terminate.

spectrumScalefile (0s)

Path to a file which is used in an attempt to calibrate the spectral profile to absolute energy values. At the end of each run a spectrum integrated over the whole run is calculated, the maximum in this run-integrated spectrum is assigned the average beam energy value (as reported by *global->meanPhotonEnergy*eV). A scale is generated based on the known energy spread of the spectrum CCD and saved in the rXXXX-integratedEnergySpectrum.h5 file. The scale can be assigned to individual events by either re-running cheetah with the scale file belonging to that run or the scale from a previous run can be applied. If no file is given or the file specified does not exist the individual event spectra are output with zeros for the energy scale (the program does not terminate)

Time of flight spectrometer (Acqiris)

tofName (CxiSc1)

Is this relevant to our pump laser diode trace?

tofName (CxiSc1)

Name of Acqiris device in XTC data stream

tofChannel (1)

Acqiris channel number

Multithread tuning and speed optimization

nThreads (16)

Run this many worker threads in parallel (one worker thread per LCLS event). Set to 1x-2x the number of cores on the machine.

- 72 or 144 on cfelsgi (72 physical cores)
- 16 is more than adequate on most servers (eg: compute farm at SLAC uses 12 or 16 core machines)

Speed may saturate before all threads are busy if data transfer makes cheetah I/O limited (check with ipSpeedTest), or if competing access to shared variables results in mutex locks (happens when too many threads write to powder patterns or running background buffer at once).

useHelperThreads (0)

This doesn't appear to do anything at the moment??

This currently does nothing. It was intended for computing backgrounds asynchronously with processing data frames.

threadPurge (10000)

Periodically pause and let all threads finish. On cfelsgi we seem to get mutex-lockup on some threads if we don't do this. *But we should check again – this may have been something else, and we can drop (or simply not mention) this keyword.*

Data processing flow: skipping XTC frames

startAtFrame (0)

Skip all frames in the xtc file prior to this one (no processing done).

What happens when there are multiple xtc files? Does cheetah concatenate the events in all of the xtc files, or does cheetah start at this frame in each xtc file?

Interesting point, and I have not tested this - myana.cc and main.cc code dictates this behavior presently. I suspect it is in order – to test we could print the fiducials and see whether they skip go in sequence as expected, or jump at the start of a new XTC file

stopAtFrame (0)

Skip all frames in the xtc file after this one. Setting to 0 means to ignore this setting.

See question about startatframe above, regarding the case of multiple xtc files.

Currently, the program does not end when this frame is reached; it just keeps running until the end of the xtc file(s), doing nothing other than printing a message indicating that it is skipping to the end of the file. Maybe this can be fixed, but probably the change needs to happen in the myana.cc or main.cc code. Or we do an exit(1) and let the program simply die.

startFrames (0)

Number of frames at the start of processing used for background estimates, etc, before starting hit finding etc.

ioSpeedTest (0)

Run through events in xtc file, reading in all data, but do no data processing (don't spawn worker threads). Useful for checking raw I/O speed to determine whether the process is I/O bound or CPU/mutex bound.

Misc

debuglevel (2)

Sets verbosity level of the output (how much diagnostic junk is printed to screen)

Cheetah output files

rXXXX-sumBlanksRaw.h5

as the name suggest, this is simply the sumation of blank frames (non-hits)

rXXXX-sumBlanksRawSquared.h5:

As the name suggests...

rXXXX-detectorX-class0-sum.h5:

rXXXX-detectorX-class1-sum.h5:

rXXXX-integratedEnergySpectrum.h5:

file containing the run-integrated 1D energy spectrum for all hits. Field "energySpectrum/runIntegratedEnergySpectrum" contains the spectrum. Field "energySpectrum/runIntegratedEnergyScale" contains the 'calibrated' energy scale and the field "energySpectrum/ runIntegratedEnergySpectrum_maxindex" contains the pixel index of the highest value in the run-integrated spectrum.

rXXXX-sumBlanksRawSigma.h5:

NOT AS THE NAME SUGGESTS; this one is divided by the number of frames.

Same goes for rXXXX-sumHitsRaw and so on...

There is a symbolic link called /data/data, but what it links to depends on parameters in the ini file.

map log files to variables in the code:

framefp:

```
FrameNumber    threadInfo->threadNum
UnixTime       threadInfo->seconds
EventName      threadInfo->eventname
```

```

npeaks      threadInfo->nPeaks
nPixels     threadInfo->peakNpix
totalIntensity threadInfo->peakTotal
peakResolution threadInfo->peakResolution
peakDensity threadInfo->peakDensity

```

cleanedfp

```

#          global->runNumber
Filename   info->eventname
npeaks     info->nPeaks
nPixels    info->peakNpix
totalIntensity info->peakTotal
peakResolution info->peakResolution
peakDensity info->peakDensity

```

Cheetah output HDF5 structure

This table attempts to show the structure of the individual event output HDF5 file datafields

LCLS_2013_Feb12_r0194_053144_17343.h5				
/LCLS		/data		/processing
	/detector0-EncoderValue		/data	/energySpectrum-tilt
	/detector0-Position		/energySpectrum1D	/hitfinder
	/detector1-EncoderValue		/energySpectrumCCD	/peakinfo
	/detector1-Position		/energySpectrumScale	/peakinfo-assembled
	/ebeamCharge		/radialAverage0	/peakinfo-raw
	/ebeamL3Energy		/radialAverage1	/pixelmasks
	/ebeamLTUAngX		/radialAverageCounter0	
	/ebeamLTUAngY		/radialAverageCounter1	
	/ebeamLTUPosX		/rawdata	
	/ebeamLTUPosY		/rawdata0	
	/ebeamPkCurrBC2		/rawdata1	
	/eventTimeString			
	/evr41			
	/f_11_ENRC			
	/f_12_ENRC			
	/f_21_ENRC			
	/f_22_ENRC			
	/fiducial			
	/machineTime			
	/phaseCavityCharge1			
	/phaseCavityCharge2			
	/phaseCavityTime1			
	/phaseCavityTime2			
	/photon_energy_eV			
	/photon_wavelength_A			