Quad-anode test on real data

Content

Experiment

COLTRIMS (Cold Target Recoil Ion Momentum Spectroscopy)

Data

2019-03-06 info from Peter Walter

```
Walter, Peter <pwalter@slac.stanford.edu> Mon 6/3, 4:29 PM
O'Grady, Paul Christopher; Thayer, Jana B.; Weninger, Clemens; Dubrovin, Mikhail, DAQ Control

Dear all,

Runs with coincidence measurements are 85, 86, and 88-93 from amox27716
A good run for covariance would be run 100.

And here is the code Xiang wrote with the help from Clemens and I.
https://github.com/xianglgithub/Coinc-LCLS
```

on 2019-06-25 runs 91, 92, 93, 100 requested to restore from tape

/reg/d/psdm/AMO/amox27716/xtc/

exp=amox27716:run=100

event_keys -d exp=amox27716:run=100

event_keys...

```
Event#   9
EventKey(type=psana.EvrData.DataV4, src='DetInfo(NoDetector.0:Evr.0)')
EventKey(type=psana.Acqiris.DataDescV1, src='DetInfo(AmoEndstation.0:Acqiris.1)', alias='ACQ1')
EventKey(type=psana.Acqiris.DataDescV1, src='DetInfo(AmoEndstation.0:Acqiris.2)', alias='ACQ2')
EventKey(type=psana.Camera.FrameV1, src='DetInfo(AmoEndstation.0:Opal1000.3)', alias='OPAL3')
EventKey(type=psana.Camera.FrameV1, src='DetInfo(XrayTransportDiagnostic.0:Opal1000.0)', alias='xtcav')
EventKey(type=psana.Bld.BldDataEBeamV7, src='BldInfo(EBeam)')
```

Scripts and files

For exp=amox27716:run=100 in LCLS1 environment

- hexanode/examples/ex-quad-00-data.py - simple psana access to data and draws waveforms overlayed on the same plot
- hexanode/examples/ex-quad-01-cfd.py <Acqiris-chanel-number> - test of CFD (Constant Fraction Discriminator) parameters
- hexanode/examples/ex-quad-02-amox27716-0100-acqiris.py - advanced test of CFD with event loop and graphics
- hexanode/examples/ex-quad-07-proc-data-save-h5.py - processes waveforms in dataset and saves results for peaks in file like amox27716-r0100-e060000-single-node.h5
- hexanode/examples/ex-quad-09-sort-graph-data.py
  - uses processed data from amox27716-r0100-e060000-single-node.h5 or raw (slow) exp=amox27716:run=100 and calibration files
    - /reg/d/psdm/amo/amox27716/calib/Acqiris::CalibV1/AmoEndstation.0:Acqiris.1/hex_config/0-end.dat - control anf config file
      copy of /reg/d/psdm/xpp/xpptut15/calib/Acqiris::CalibV1/AmoETOF.0:Acqiris.0/hex_config/0-end.data
    - /reg/d/psdm/amo/amox27716/calib/Acqiris::CalibV1/AmoEndstation.0:Acqiris.1/hex_table/100-end.dat - table with results of the detector calibration
-

- hexanode/examples/ex-quad-10-sort-data.py - TBD

Waveforms

hex/examples/ex_acqiris_quad_amox27716-0100.py

Acqiris configuration

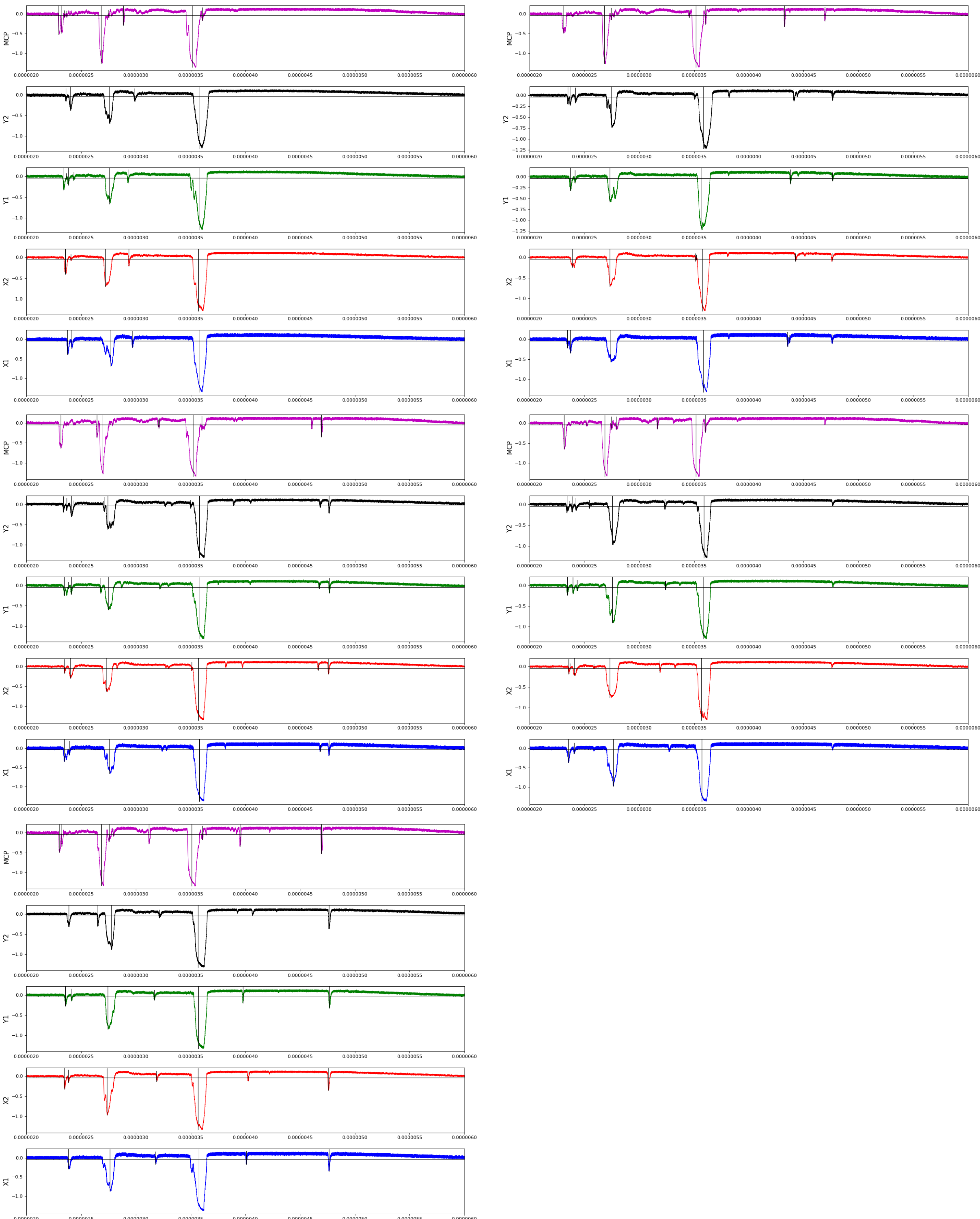
```
dsname = 'exp=amox27716:run=100'
src1 = 'AmoEndstation.0:Acqiris.1' # 'ACQ1'
src2 = 'AmoEndstation.0:Acqiris.2' # 'ACQ2'

Acqiris.1:
  nbrChannels: 8, H-nbrSamples: 44000, H-sampInterval: 2.5e-10
    chan: 0,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000015,  V-offset:
0.000000,  H-pos[seg=0]: -7.8262e-11
    chan: 1,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000076,  V-offset:
-2.000000,  H-pos[seg=0]: -7.8262e-11
    chan: 2,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000031,  V-offset:
0.800000,  H-pos[seg=0]: -7.8262e-11
    chan: 3,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000031,  V-offset:
0.800000,  H-pos[seg=0]: -7.8262e-11
    chan: 4,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000031,  V-offset:
0.800000,  H-pos[seg=0]: -7.8262e-11
    chan: 5,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000031,  V-offset:
0.800000,  H-pos[seg=0]: -7.8262e-11
    chan: 6,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000031,  V-offset:
0.800000,  H-pos[seg=0]: -7.8262e-11
    chan: 7,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 0,   V-slope: 0.000031,  V-offset:
0.800000,  H-pos[seg=0]: -7.8262e-11
wf.shape:  (8, 44000) wt.shape: (8, 44000)
Acqiris.2:
  nbrChannels: 2, H-nbrSamples: 44000, H-sampInterval: 2.5e-10
    chan: 0,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 2,   V-slope: 0.000015,  V-offset:
0.400000,  H-pos[seg=0]: -4.94174e-11
    chan: 1,  nbrSegments: 1,  nbrSamplesInSeg: 44000,  indexFirstPoint: 2,   V-slope: 0.000031,  V-offset:
0.000000,  H-pos[seg=0]: -4.94174e-11
wf2.shape:  (2, 44000) wt2.shape: (2, 44000)
```

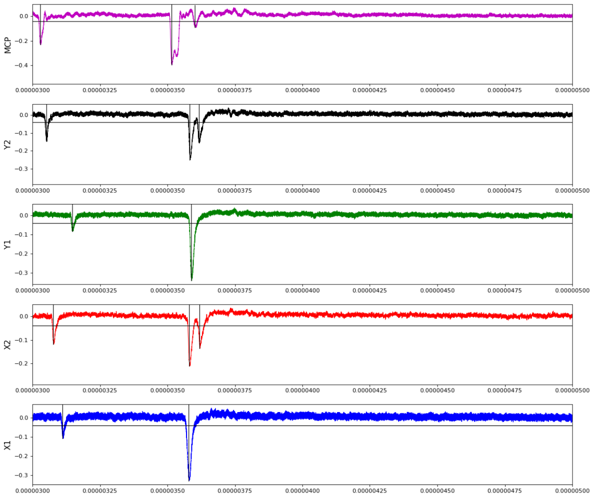
Association of channels of AmoEndstation.0:Acqiris.1

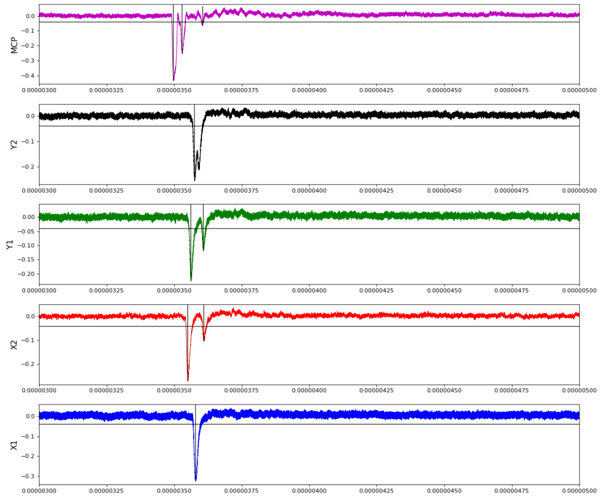
ch = (2,3,4,5,6) - all other channels of Acqiris.1 and 2 are empty or noisy

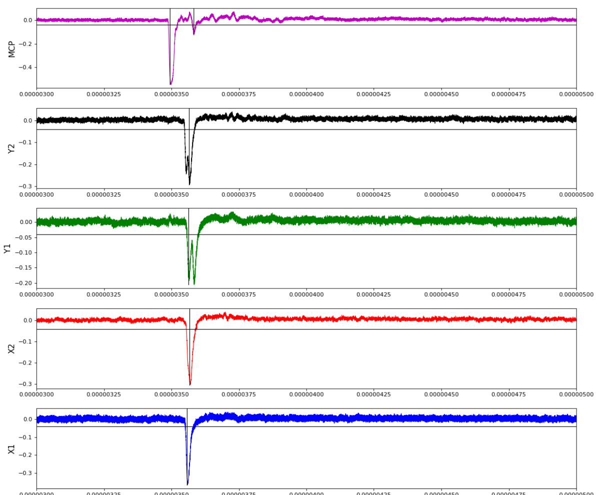
ylab = ('X1', 'X2', 'Y1', 'Y2', 'MCP')



Other run amox27716 run 91 with lower hit density



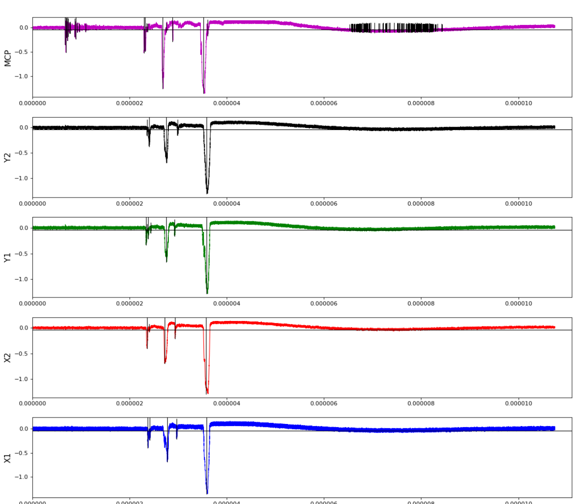




Data processing

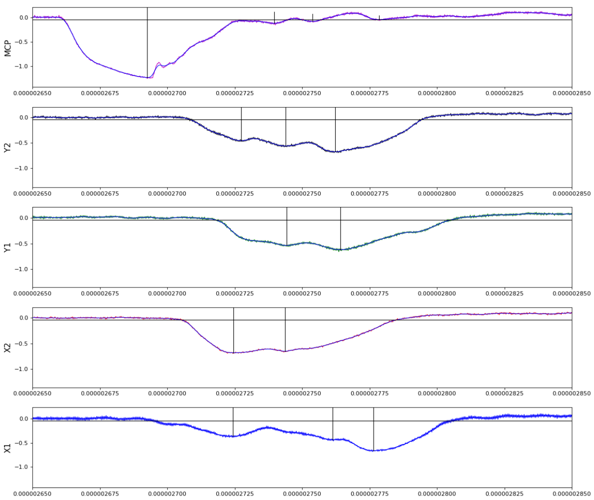
- hexanode/examples/ex-quad-02-amox27716-0100-acqiris.py - play with waveform parameters and the part of waveform WITHOUT NOISE!
- hexanode/examples/ex-quad-07-proc-data-save-h5.py - set w-f selection parameters data, detector channels, run over data and create hdf5 file.

Total waveform with problematic peak reconstruction in MCP channel:



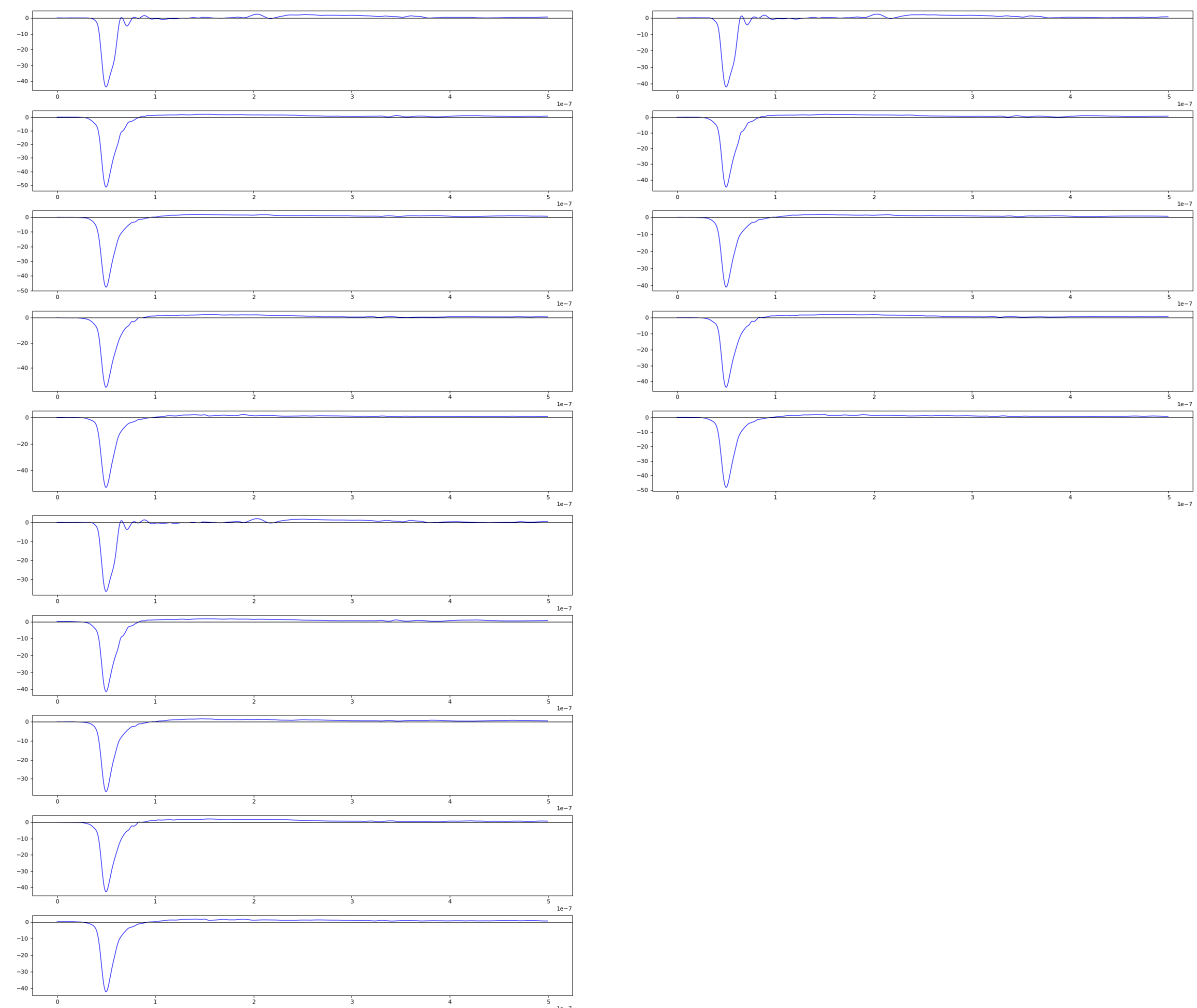
Test of local extreme peak-finder

Version of peak finder searching for local extremes after filtering



Wavelets estimation

Waveform per channel averaged over 1k raw events with selection of a single peak for amox27716 runs 91,92, and 93



Calibration

Updated on 2020-10-08

Current hex-/quad-anode calibration procedure is not automated, and needs in expert manual operations...

Example scripts

- example scripts reside in the directory `lcls2/psana/psana/hexanode/examples/`
- calibration of quad-anode requires two passes over ~10^5 events data set. There are two different approaches for calibration;
    1. **slow calibration** - run script like `ex-24-quad-proc-sort-graph.py` two times directly on xtc2 data file for waveform processing and calibration.
    2. **faster calibration** (x2 faster, especially helpful at development) - run script like `ex-22-data-acqiris-peaks-save-h5.py` or `ex-22-data-acqiris-peaks-save-h5-xiangli.py` once on xtc2 data file for waveform processing and save intermediate results for number of hits per channel and times per channel in compact hdf5 file.
        - run script like `ex-23-quad-proc-sort-graph-from-h5.py` two times on hdf5 data file for calibration.
- **Approach 2 is used for further example because compact hdf5 file with 60k events is available in `/reg/g/psdm/detector/data_test/hdf5/amox27716-r0100-e060000-single-node.h5`, but real xtc2 data files are not available yet.**

What needs to be done in two calibration passes

Calibration pass 1

- edit file copied from `hexanode/examples/configuration_quad.txt`
    - set the 1-st parameter "command" to 2.
    - make sure that the beginning 10 lines of this script are consistent with what you are doing, e.g.

```
2        // -1 = detector does not exist, 0 = just read (no sort/calib), 1 = sort, 2 = calibrate
fu,fv,fw, w_offset, 3 = generate correction tables and write them to disk

0        // hexanode used (yes = 1, no = 0)                                  (Parameter 1101)
0        // 0 = common start, 1 = common stop (for TDC8HP and fADC always use 0)

1        // TDC channel for u1 (counting starts at 1)                        (Parameter 1129)
2        // TDC channel for u2 (counting starts at 1)                        (Parameter 1130)
3        // TDC channel for v1 (counting starts at 1)                        (Parameter 1131)
4        // TDC channel for v2 (counting starts at 1)                        (Parameter 1132)
0        // TDC channel for w1 (counting starts at 1)                        (Parameter 1133) HEX
ONLY
0        // TDC channel for w2 (counting starts at 1)                        (Parameter 1134) HEX
ONLY
5        // TDC channel for mcp(counting starts at 1)  (0 if not used)        (Parameter 1135)
```

- in the script like `ex-23-quad-proc-sort-graph-from-h5.py` set path to the file `configuration_quad.txt` e.g. `' calibcfg' : '/reg/neh/home4/dubrovin/LCLS/con-lcls2/lcls2/psana/psana/hexanode/examples/configuration_quad.txt',`
- After event loop is completed, this script generates a lot of histograms (BTW output histograms are controlled by the kwargs dict, see ex-23*).
- Look at resulting histograms and edit `configuration_quad.txt`
    - use Time sum U and V plots to set peak time value in Parameter 1108,1109
    - then Halfwidth of the peak in this distribution to set Parameter 1115, 1116
    - then Halfwidth of the u(ns), v(ns) distribution to set Parameter 1118, 1119
    - manually set scale-factor for layer U and V (mm/ns) Parameter 1102, 1103

Calibration parameters in the configuration_quad.txt

```
-133.0  // offset to shift timesum layer U to zero (in nanoseconds)     (Parameter 1108)
-142.6  // offset to shift timesum layer V to zero (in nanoseconds)     (Parameter 1109)
0       // offset to shift timesum layer W to zero (in nanoseconds)     (Parameter 1110) HEX ONLY

0.      // offset to shift the position picture in X                    (Parameter 1106)
0.      // offset to shift the position picture in Y                    (Parameter 1107)

5.5     // halfwidth (at base) of timesum layer U (in nanoseconds)      (Parameter 1115)
5.5     // halfwidth (at base) of timesum layer V (in nanoseconds)      (Parameter 1116)
5.5     // halfwidth (at base) of timesum layer W (in nanoseconds)      (Parameter 1117) HEX ONLY

1       // scalefactor for layer U (mm/ns)                              (Parameter 1102)
1       // scalefactor for layer V (mm/ns)                              (Parameter 1103)
1       // 0. scalefactor for layer W                                   (Parameter 1104) HEX ONLY
1       // 0. offset layer W (in nanoseconds)                           (Parameter 1105) HEX ONLY

80.     // runtime layer u (in nanosecods)                              (Parameter 1118)
80.     // runtime layer v (in nanosecods) 0 means: same as u           (Parameter 1119)
0.      // runtime layer w (in nanosecods) 0 means: same as u           (Parameter 1120)

40.     // radius of active MCP area (in millimeters)                   (Parameter 1111)(always a
bit larger than the real radius)
20.     // deadtime of signals from the anode                           (Parameter 1121)
20.     // deadtime of signals from the mcp                             (Parameter 1122)

1       // use position dependend correction of time sums?   0=no 1=yes (Parameter 1124)
0       // use position dependend NL-correction of position? 0=no 1=yes (Parameter 1125) HEX ONLY
```

2019-08-15 Achim Czasch about calibration parameters

```
Achim Czasch <czasch@roentdek.com>
Thu 8/15/2019 1:56 AM
Hi Mikhail,

> Could you remind me please, what is a right order
> to adjust parameters and calibrate new detector?

yes, there is a sequence that must be followed in the correct order:
a) First you must set the parameters in the config file so that the time sum peaks get shifted to zero.
b) Then you set the 'runtime'.
c) Then you set the xy calibration factors so the that image gets the size that you think is right.
(and set the xy offset parameters so that the image is well centered.)
d) Then you set 'radius'. This value should be 1 or 2 mm larger so that it really includes all hits.

best,
Achim

==================================
Achim Czasch <czasch@roentdek.com>
Fri 8/16/2019 12:00 AM
Hi Mikhail,

> Scale factors converting time to coordinate are not important now. > because I am not aware about precise
detector geometry.

For the DLD (not HEX) you must set the 2 calibration factors
manually later.
Example: If you have MCPs with 40mm active diameter then you must
the factors so that the image has a diameter of 40mm.
The factors for x and y will be slightly different to achieve a round image.

> >> b) Then you set the 'runtime'.
> Could you remind me please, how can I get this value(s)?

You plot x1-x2 (units: ns) in a 1D-plot.
Then logy-scale.
Now you can see a distribution that ranges from
-z to +z (z is just a number here).
For 'runtime' you chose z + 2 ns.

> But, distributions of the time_sum for u and v look flat, even without calibration tables.

The errors that are corrected are within about +-4 ns.
So maybe you must zoom in a bit (in the y-scale).
But for a DLD this correction not so important.

> Still, it looks important to have an ability to calibrate potential differential non-linearity
> of the delay lines. I hope this is possible for QUAD-anode, right?

Not as easily as with the HEX. With a HEX we have a 3rd layer.
This layer provides the additional info that we need to make
an automatic linearity calibration of the 3 delay lines.
But with a normal DLD we do not have enough information.
So this algorithm can not be applied.
You can use a pin hole mask and measure the non-linearity manually.
Then you can apply another code from us that will spit out correction tables.
But this process is very very tedious and time consuming - and if you change something
(cable lengths, even voltages) then you may have to do it again.

best,
Achim
```

Calibration pass 2

edit file `configuration_quad.txt` and set the 1-st parameter "command" to 3.

edit script like `ex-23-quad-proc-sort-graph-from-h5.py` and set pass where time correction table will be saved, e.g. `'calibtab' : '/reg/neh/home4/dubrovin/LCLS/con-lcls2/lcls2/psana/psana/hexanode/examples/calibration_table_data_new.txt'`

run again script `ex-23-quad-proc-sort-graph-from-h5.py`

check results in `calibration_table_data_new.txt`

Post calibration arrangements

edit file `configuration_quad.txt`

set the 1-st parameter "command" to 1.

set Parameter 1124 in configuration_quad.txt

Both, configuration and calibration files need to be saved in calibration DB for automated data processing. This operation needs in actual experiment and detector names, run, timestamp, etc. Preliminary deployment commands:

```
cdb add -e amox27716 -d tmo_quadanode -c calibcfg -r 100 -f configuration_quad.txt     -i txt -u dubrovin
cdb add -e amox27716 -d tmo_quadanode -c calibtab -r 100 -f calibration_table_data.txt -i txt -u dubrovin
```

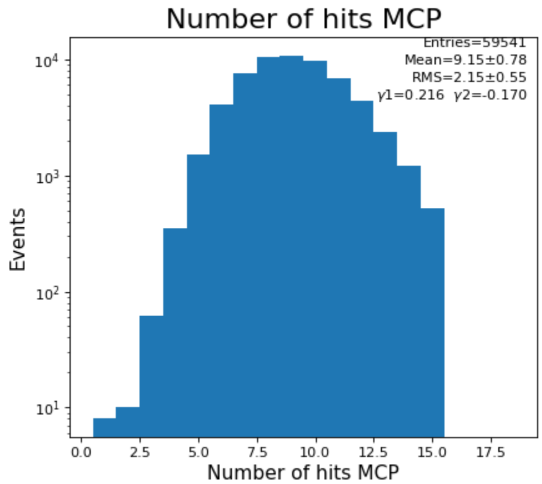
Content of the DB can be explored with GUI started by command `calibman`.

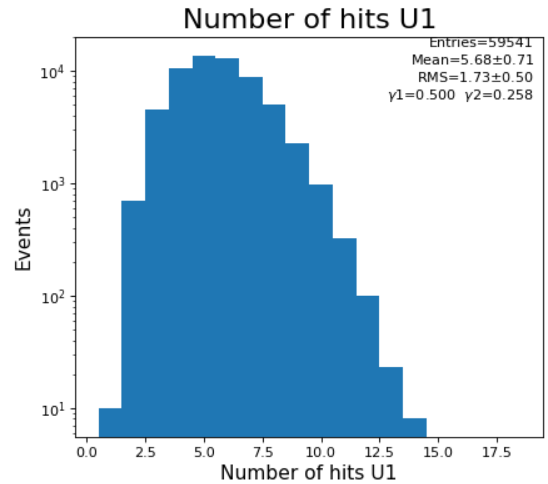
Automated data processing

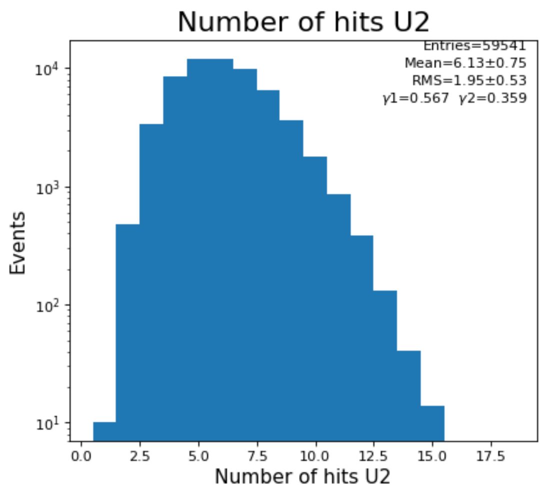
See examples `ex-24*` or `ex-25*`.

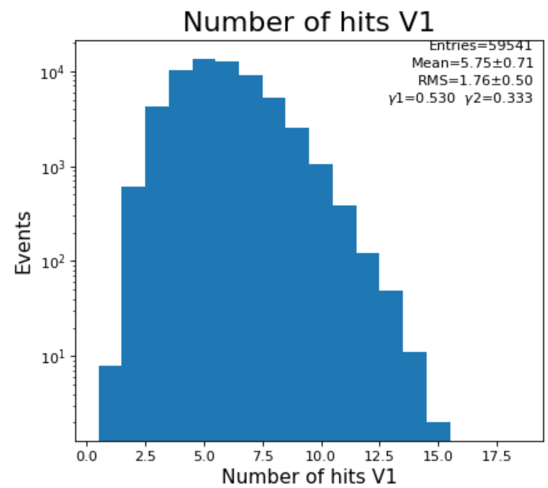
Plots

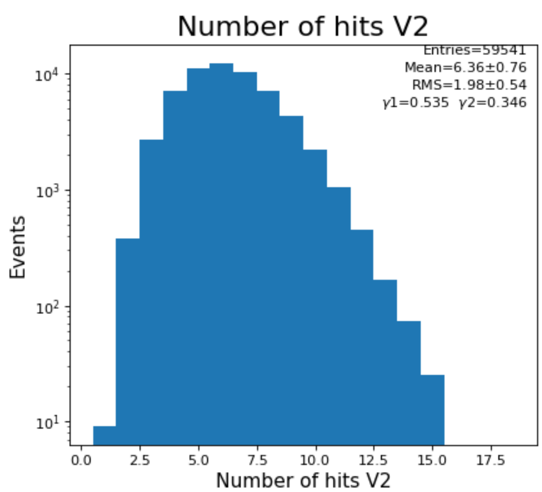
Number of hits per channel



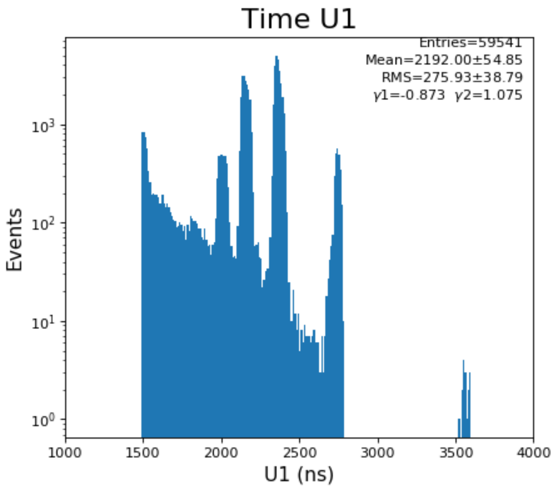


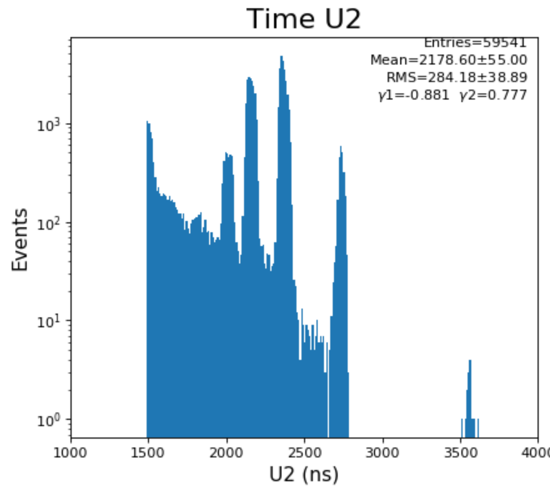


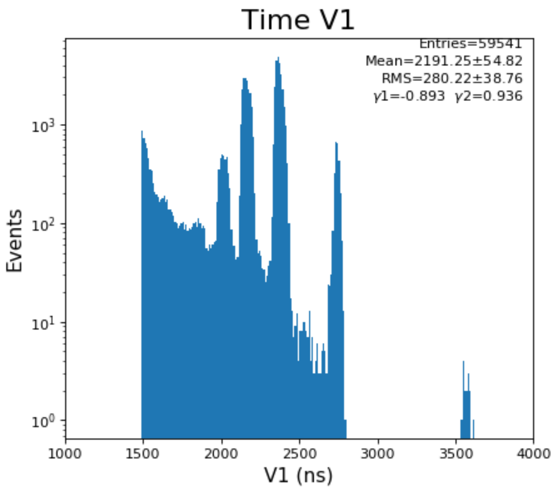


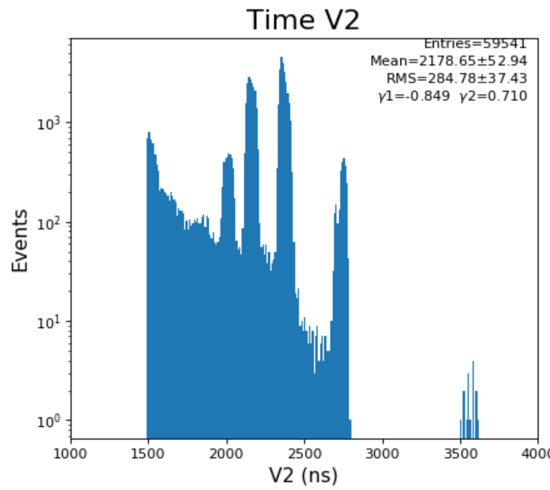


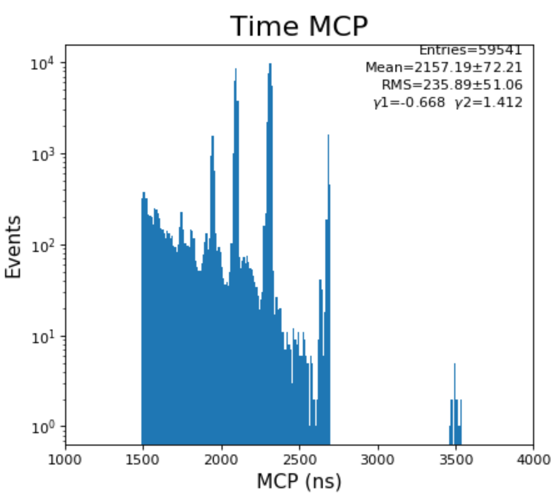
Spectra of time per channel, Spectra of U, V (ns)



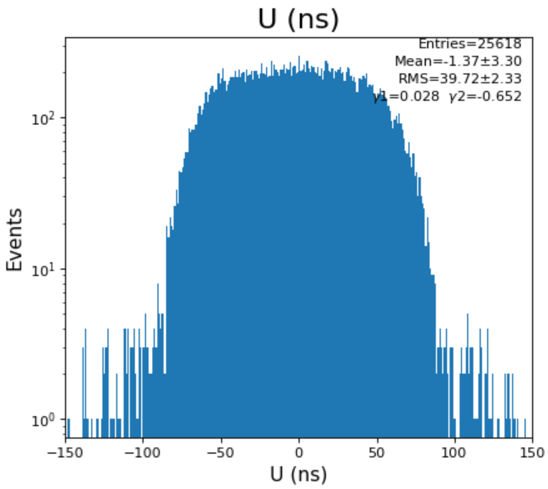


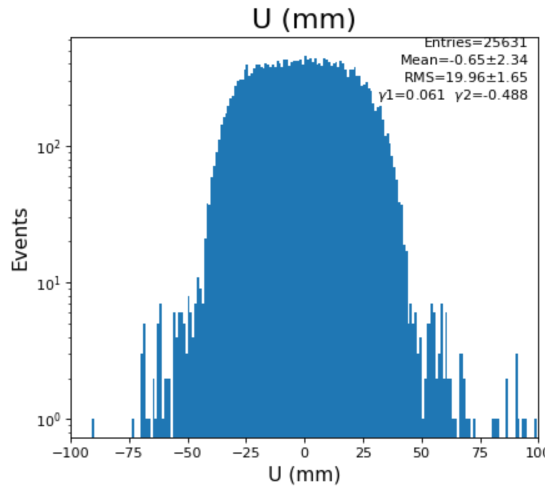


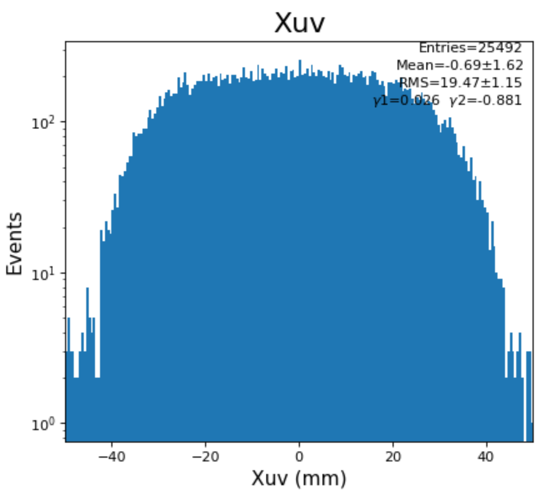


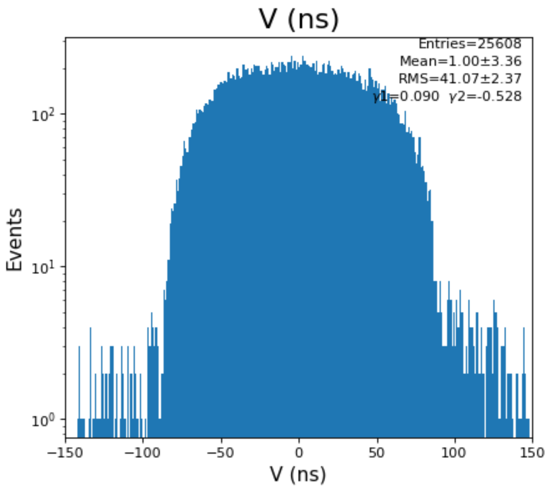


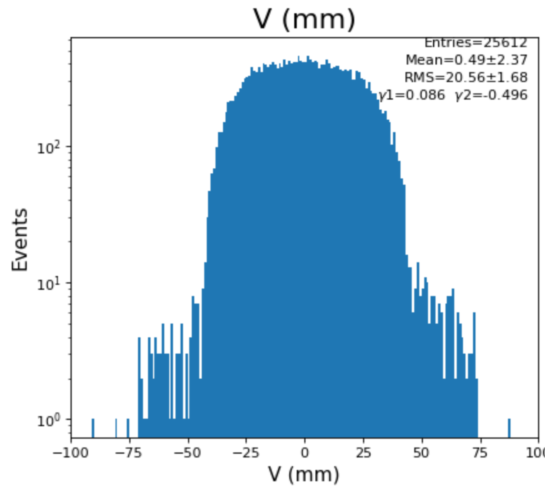
Spectra of U, V (mm)

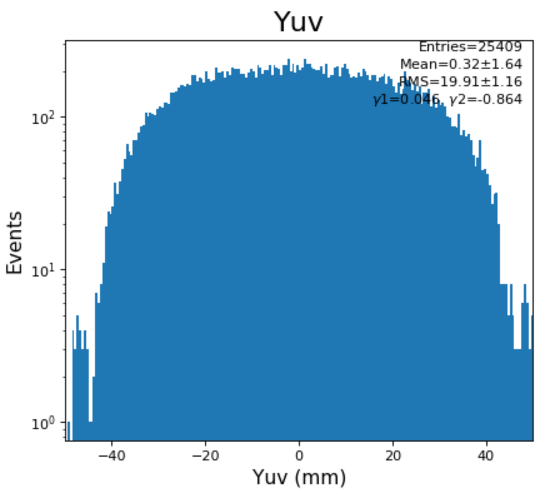

U (ns)
Entries=25618
Mean=-1.37±3.30
RMS=39.72±2.33
γ1=0.028 γ2=-0.652
Events
U (ns)


U (mm)
Entries=25631
Mean=-0.65±2.34
RMS=19.96±1.65
γ1=0.061 γ2=-0.488
Events
U (mm)

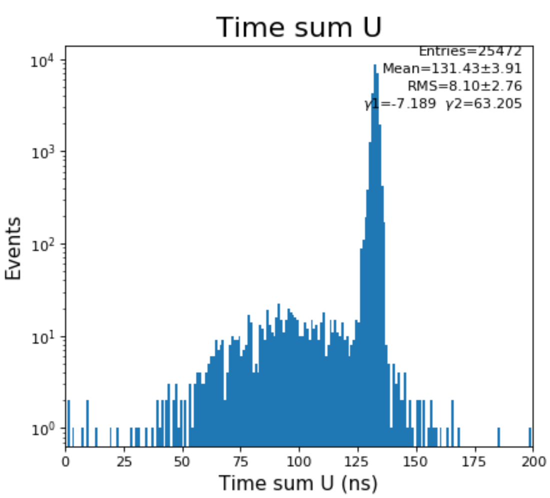

Xuv
Entries=25492
Mean=-0.69±1.62
RMS=19.47±1.15
γ1=0.026 γ2=-0.881
Events
Xuv (mm)

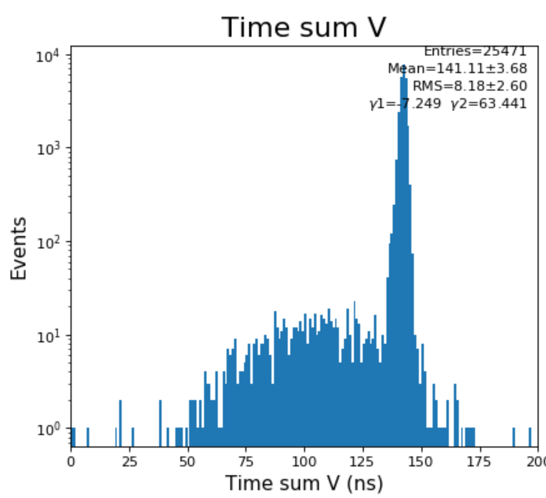




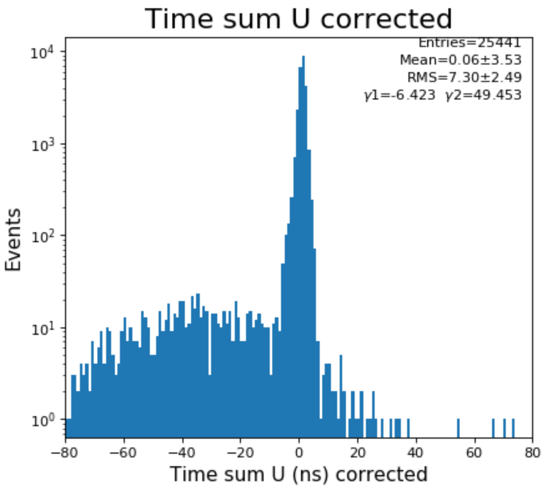


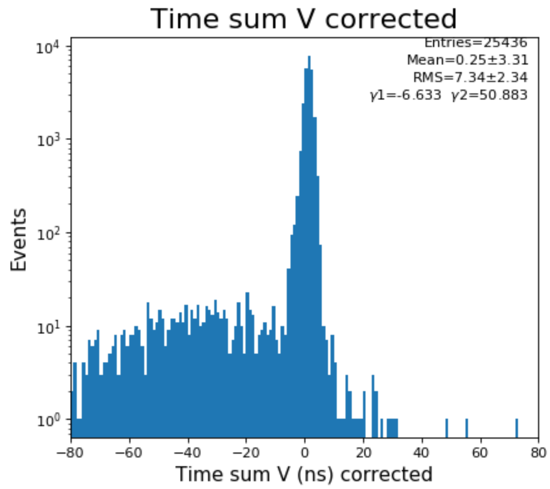
Time sum (ns) for U, V



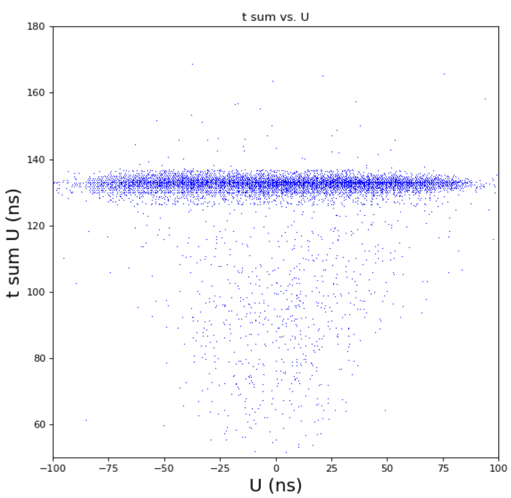


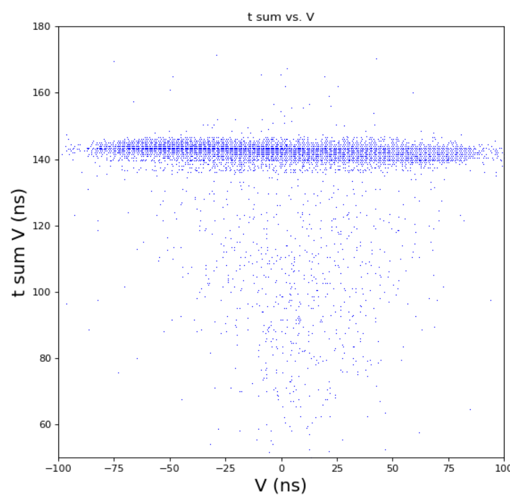
Time sum (ns) corrected for U, V

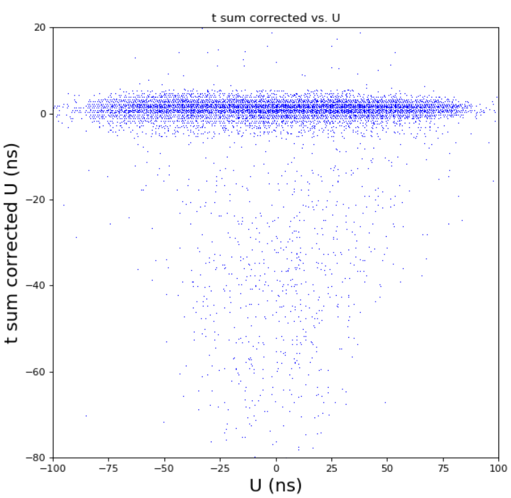


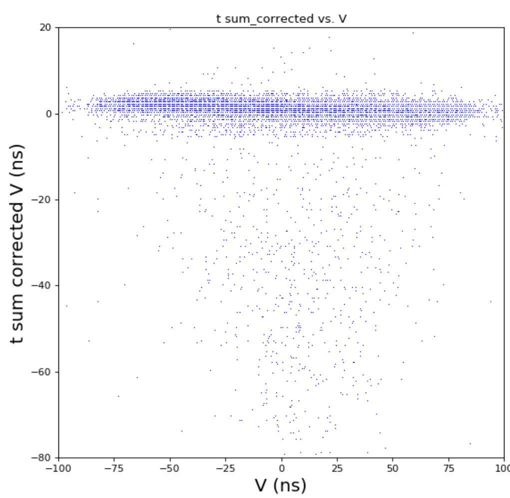


Time sum vs. variable U, V

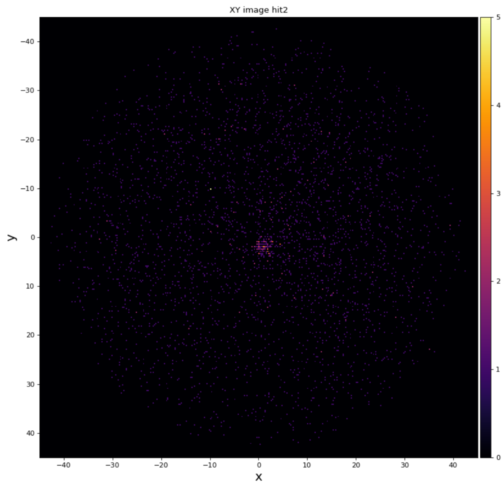


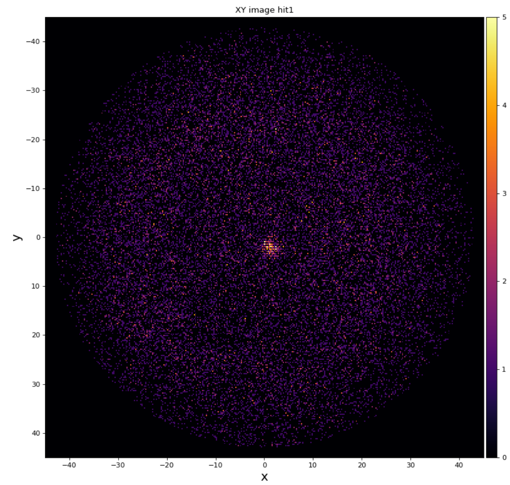


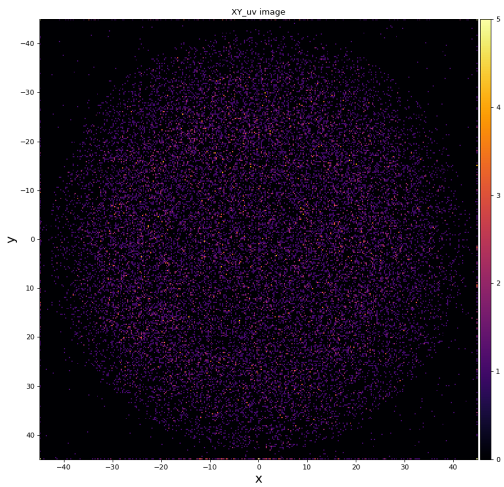




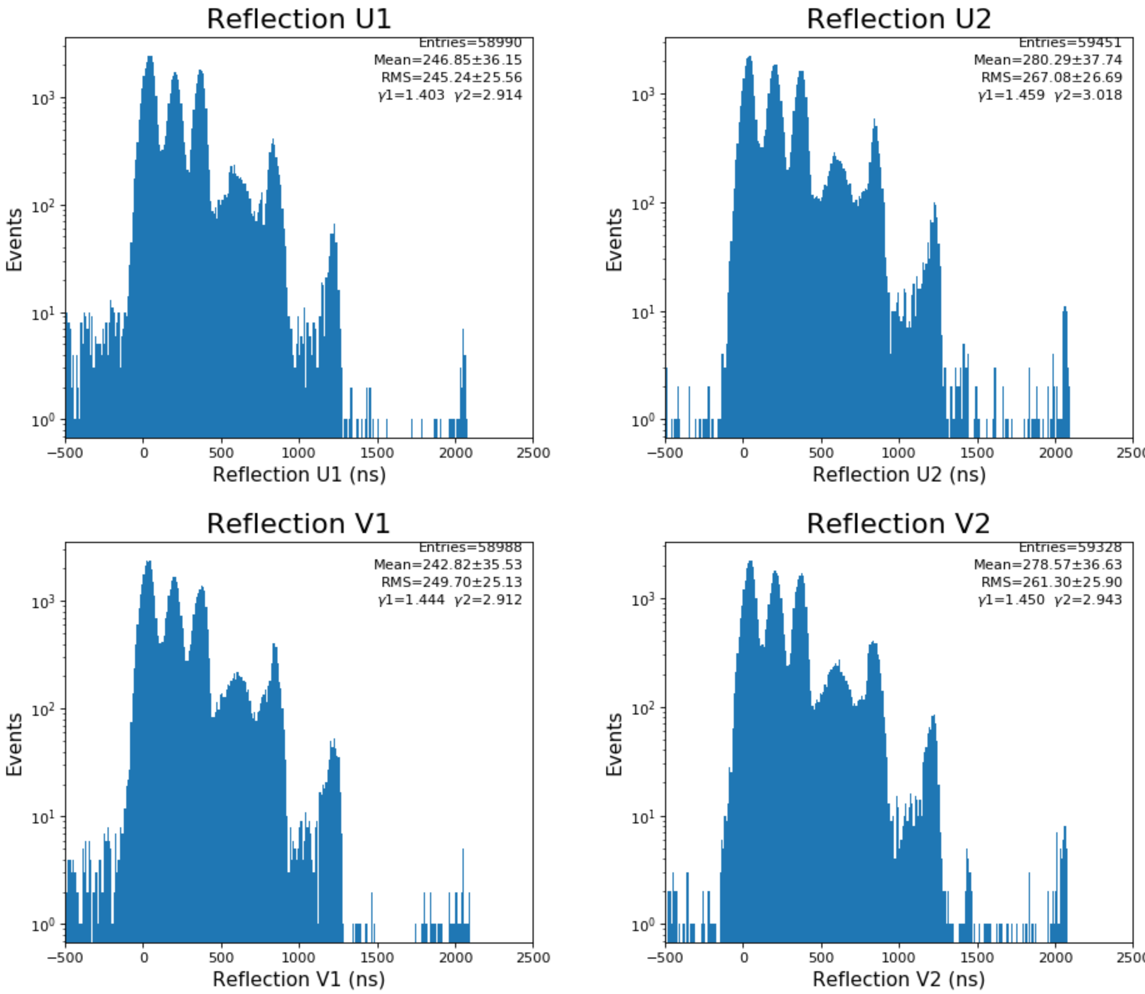
xy image for hit1 and 2



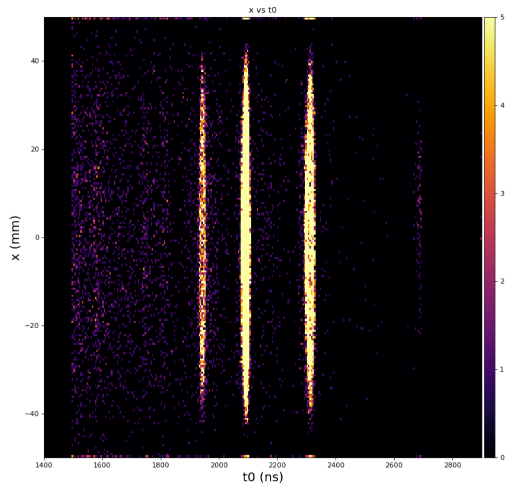


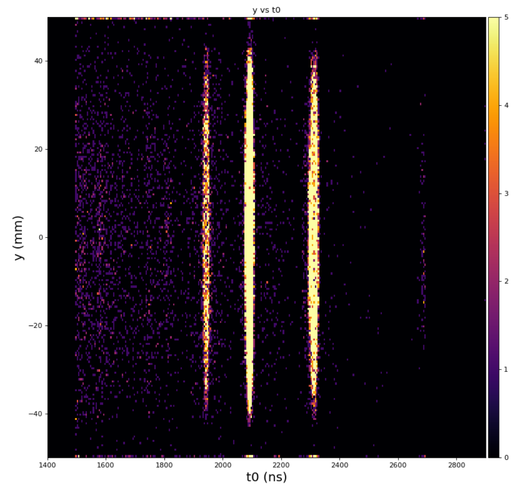


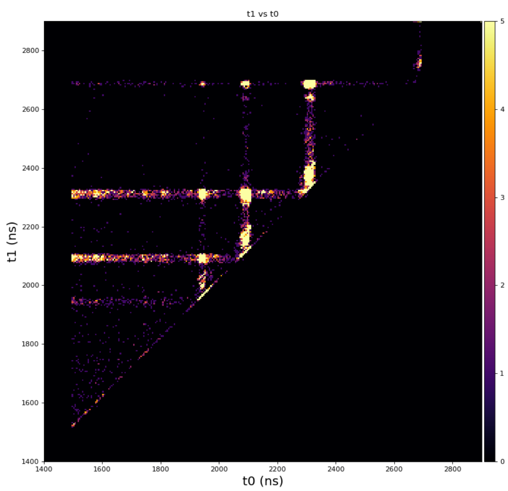
Reflection for all channels



Physics plots t1,x,y vs t0

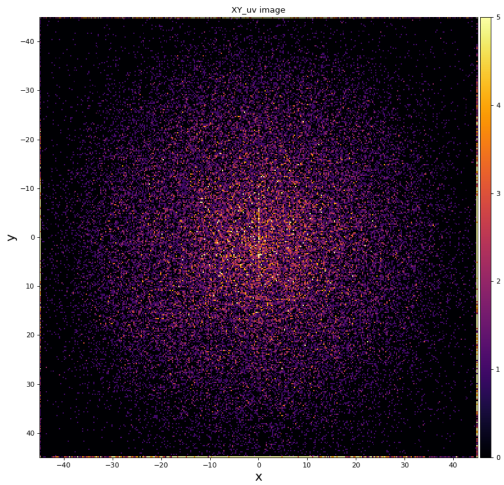


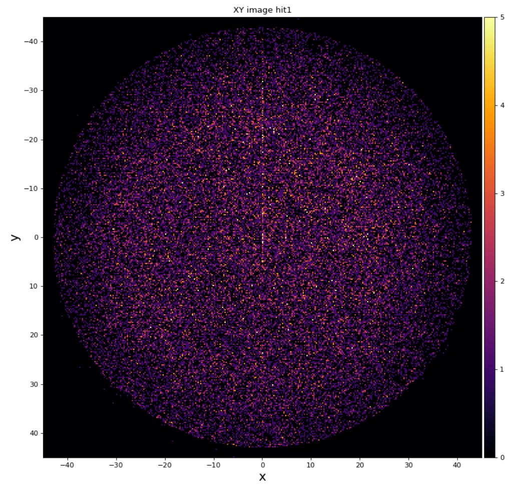


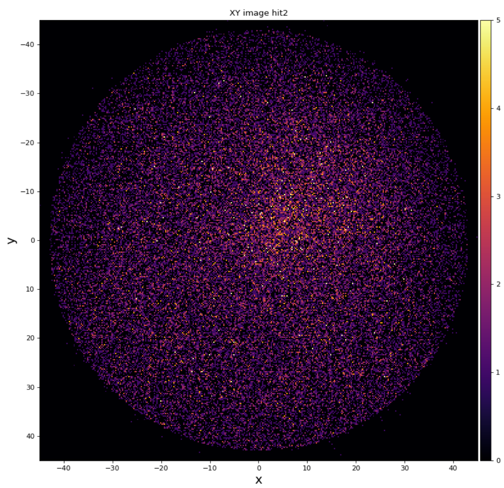


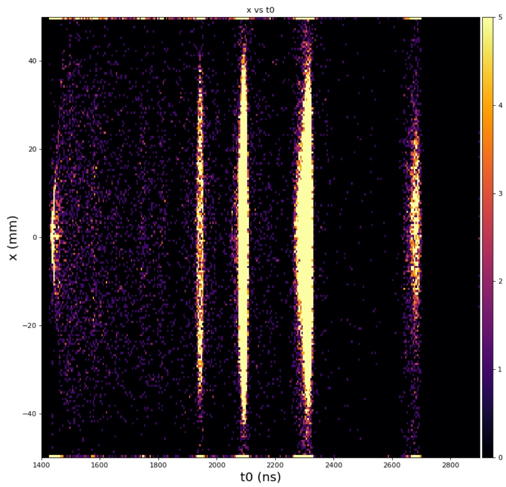
Calibrated plots

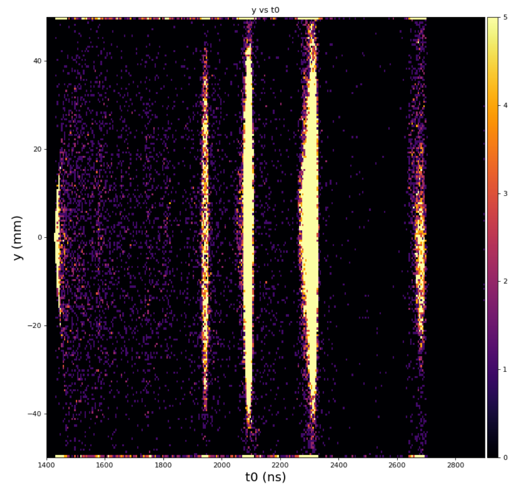
hexanode/examples/ex-quad-09-sort-graph-data.py with command 1 (after calibration command 2,3) set in configuration_quad.txt.

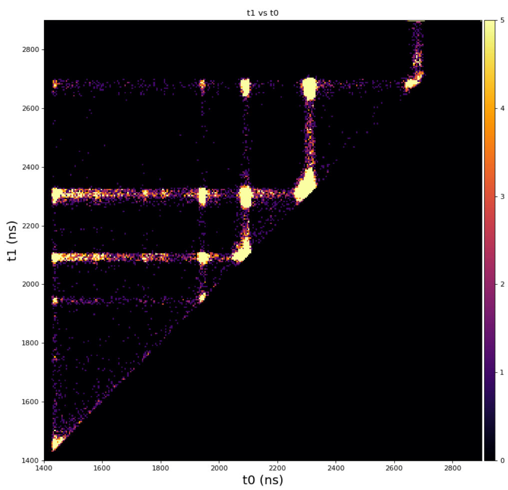

XY_uv image
x
y


XY image hit1
x
y


XY image hit2
x
y







Soft on LCLS2

Examples

https://github.com/slac-lcls/lcls2/blob/master/psana/psana/hexanode/examples/

ex-20-data-acqiris-access.py - access to detector waveforms

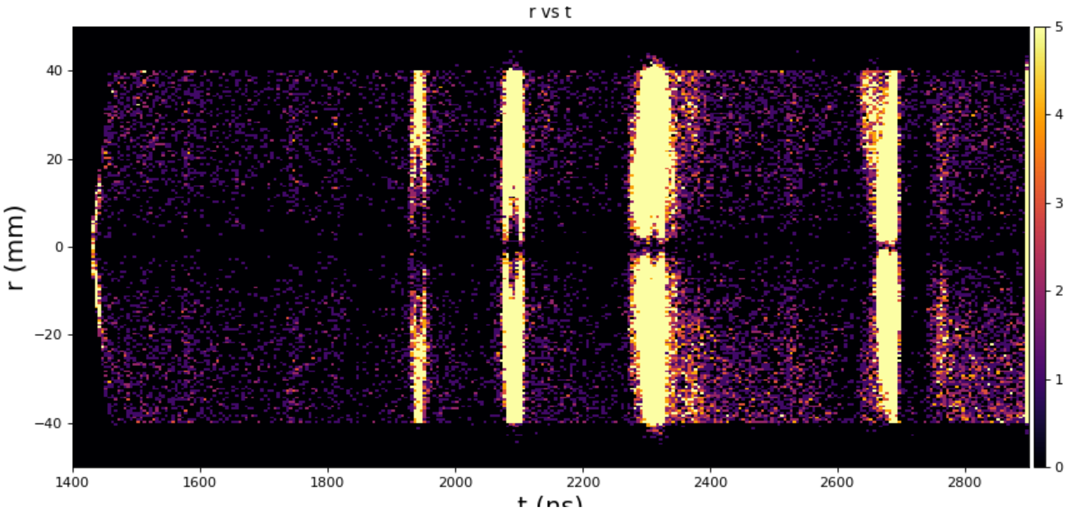
ex-21-data-acqiris-graph.py - plot waveforms and found peaks

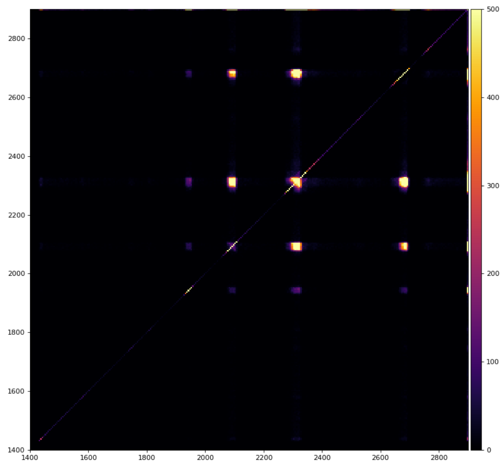
ex-22 - 24 - intended for calibration and representative graphics

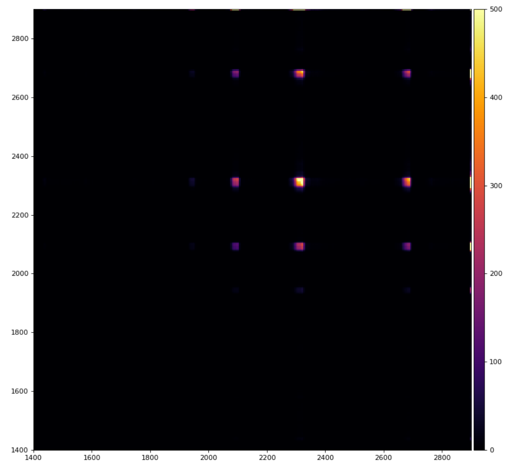
ex-25-quad-proc-data.py - reads waveforms from xtc2, find peaks, and reconstruct hits using Roentdec library

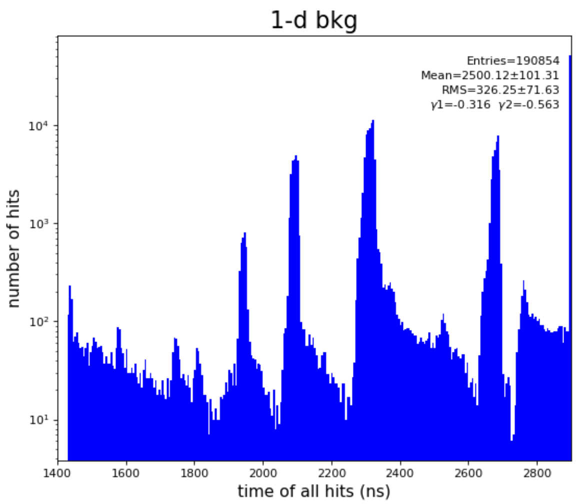
Physics plots

From ex-23-quad-proc-sort-graph-from-h5.py or ex-24 if xtc2 file is available:









XTC2 trick

Only useful channels will be selected in xtc2. This hack is temporary available in

psana/psana/detector/test_detectors.py

Status on 2022-01-12

Project history

- This project was started with Timur Osipov in April 2015 in the framework of LCLS(1).
- RoentDec Co. commercially produces hex-/quad-anode cameras. Achim Czasch in co-operation with Timur has developed C++ library to process waveforms and sort signals from MCP with 2-/3-delay lines to reconstruct hits.
- Library is supplied in form of built module, without code to hide "secret" hit sorting algorithm.
- My job was to adopt this C++ library in our python algorithms.
- cython interface was developed to access in python major classes/methods of this c++ library.
- In the frame of this project unique development was done in the waveform analysis for peak finding; CWT/DWT - Current/Discrete Waveform Transformation, wavelet decomposition, BPF-Band Path Filter. This project was stopped as low-priority.
- In ~2019 RoentDec library and its pythonic interface were adopted in lcls2.
- ~2019 Xiang Li successfully replaced me in analysis business. Xiang brought his own CFD peak finder. I am still responsible for RoentDec library pythonic interface.

Recent development

Few days ago Chris asked me to check if RoentDec library interface still works. Due to relocation of different python and c++ modules in development of lcls2 software, compilation of examples for quad-anode was broken in ps-4.5.5/10. Now all visible issues are fixed and examples are working properly. Need in new release greater than ps-4.5.10.

List of test examples

Examples resides in lcls2/psana/psana/hexanode/examples/*

- ex-20-data-acqiris-access.py - access and print waveforms (times and intensities)
- ex-21-data-acqiris-graph.py - the same as ex-20 but with graphic plots
- ex-22-data-acqiris-peaks-save-h5.py - waveform processing by the (psana version of CFD) peakfinder and saving results in hdf5 file, 1000 events per 10 sec - 100Hz
- ex-22-data-acqiris-peaks-save-h5-xiangli.py - waveform processing by the (Xiang Li's version of CFD) peakfinder and saving results in hdf5 file, - 100Hz
- ex-23-quad-proc-sort-graph-from-h5.py - process peaks from hdf5 and apply RoentDec hit sorting algorithms, generate all signature-plots - 59999 events processing time = 104.848 sec or 0.001747 sec/event or 572.246 Hz
- ex-24-quad-proc-sort-graph.py - process peaks from xtc2 data and apply RoentDec hit sorting algorithms
- ex-25-quad-proc-data.py - similar to ex-24, demo how to get proc.xyrt_list
- ex-26-calibconsts.py - demo of access to calibration constants from DB
- ex-27-calib-pop-rbfs-xiang.py - demo of access to "rbfs" calibration constants from DB

Status on 2023-10-10

- Due to transition of software from psdm to s3df all ex-2*-* examples were updated

  ```
  modified:   ex-20-data-acqiris-access.py
  modified:   ex-21-data-acqiris-graph.py
  modified:   ex-22-data-acqiris-peaks-save-h5-xiangli.py
  modified:   ex-22-data-acqiris-peaks-save-h5.py
  modified:   ex-23-quad-proc-sort-graph-from-h5.py
  modified:   ex-24-quad-proc-sort-graph.py
  modified:   ex-25-quad-proc-data.py
  modified:   ex-26-calibconsts.py
  modified:   ex-27-calib-pop-rbfs-xiang.py
  new file:   ex_test_data.py
  ```

- File ex_test_data.py is added to define DIR_DATA_TEST depending on environment variable DIR_PSDM:

  ```
  DIR_ROOT = os.getenv('DIR_PSDM')  # /cds/group/psdm ON psana OR /sdf/group/lcls/ds/ana/ ON s3df
  DIR_DATA_TEST = os.path.join(DIR_ROOT, 'detector/data2_test/xtc')
  ```

  Then access to *.xtc2 files:

  ```
  FNAME = '%s/%s' % (DIR_DATA_TEST, 'data-amox27716-r0100-acqiris-e000100.xtc2')
  ```

- Also changed access to the files in the package:

  ```
  DIR_ABSPATH = os.path.abspath(os.path.dirname(__file__)) # absolute path to .../psana/hexanode/examples

  +            'calibcfg' : '%s/configuration_quad.txt' % DIR_ABSPATH,
  +            'calibtab' : '%s/calibration_table_data.txt' % DIR_ABSPATH,
  ```

  All test examples are working.

References

Hexanode detector test on data

Hexanode users' examples

TMO data flow spread sheet

Covariance mapping

2019-11-01-Peter-Walter-article.pdf