

CSPAD Geometry and Alignment - Deprecated



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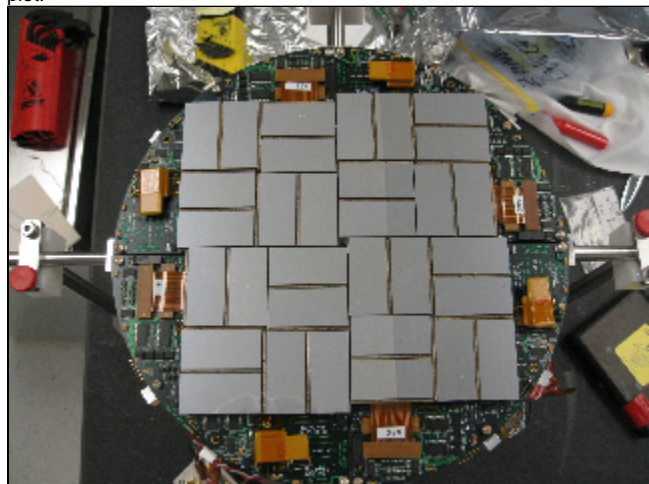
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Introduction

Cornell SLAC Pixel Array Detector (CSPAD) is an imaging X-ray detector made of silicon sensors (2x1) covering about 20x20cm² surface, as shown in the plot:



Pixel coordinates in 2x1 sensor chip are known with sub-micrometer precision. Construction of the detector allows significant freedom in relative positions of 2x1 sensors. To get precise pixel positions in the detector the 2x1 sensor coordinates needs to be calibrated. In this note we describe geometry of the CSPAD detector, optical and quad alignment procedure, parameters, and software providing access to precise geometry information.

2x1 Sensor Geometry

The 2x1 sensor geometry was tested with microscopic measurement. Two slides from Chris Kenney's presentation shows the pixel sizes:

CS-PAD Pixel Pitch

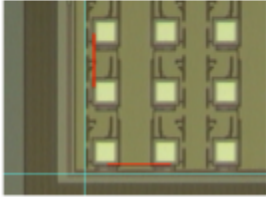
In the design files the ASIC and sensor pitches are not 110.0 microns

The designed pitch is 109.92 microns

Measurements on the wafers confirm both pixel pitches are 109.92 microns within a few nanometers

This is a cumulative effect so the difference across an ASIC is about 16 microns

Separation between Red and Blue lines indicates cumulative difference between 110.00 μm and 109.92 μm pitch across an ASIC.

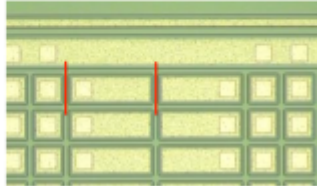


C. Kenney 9/2010

Inter-ASIC Pixel Pitch

Elongated pixels in the center of a sensor are designed to span the gap between the pair of ASICs.

These two columns of pixels are 109.92 μm by 274.8 μm in area.



[The same slides in PDF format.](#)

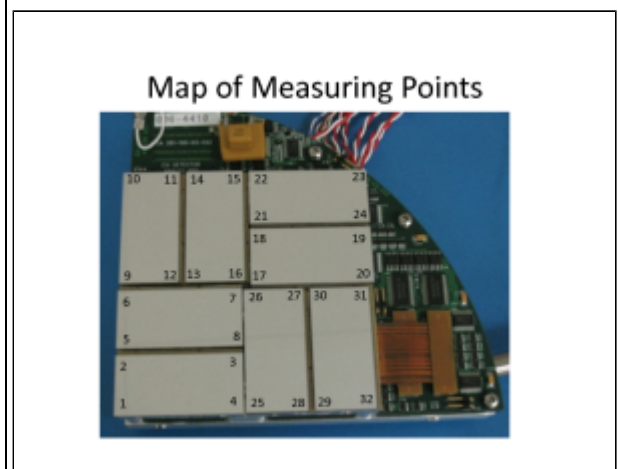
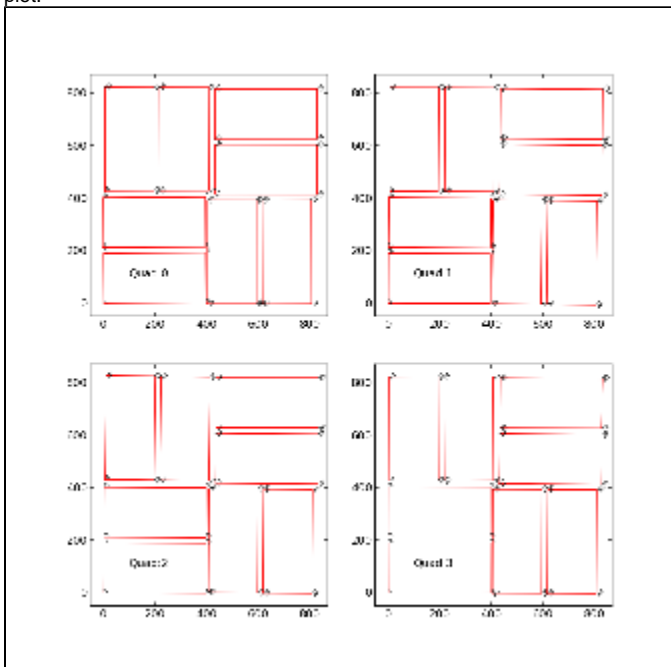
Important 2x1 features:

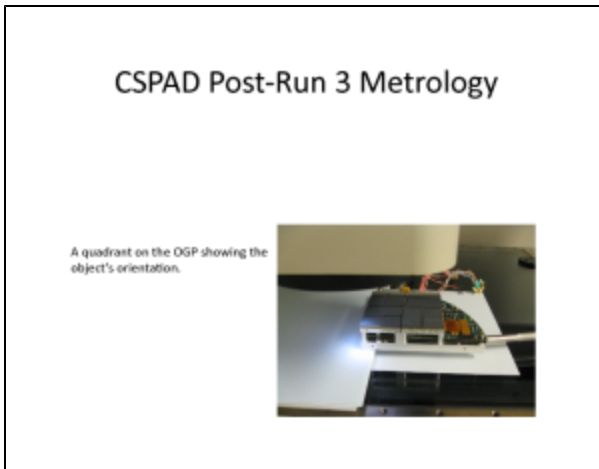
- Number of rows x columns = 185 x 388. (In DAQ notation of rows and columns is interchanged...)
- Most of pixels have size 109.92 x 109.92 μm^2 .
- Gap between two ASICS is covered by the two rows of elongated pixels with size 109.92 x 274.8 μm^2 .
- Two versions of sensors have different dimensions between corners, so it is reasonable to define pixel coordinates w.r.t. the sensor center.

Optical measurement

Optical measurement is maintained by Chris Kenney. Detector or its quad is installed on microscope table and 3-d coordinates of all 2x1 sensor corners are measured with precision about 8 μm (RMS) in x-y plane. All corners in the measurement are numerated in arbitrary order. It is expected that numeration order should be the same for different measurements. This procedure depends on CSPAD construction;

- For CSPAD with movable quads (i.e. for CXI) optical measurement is done separately for each quad. The numeration of corners is shown in the plot:



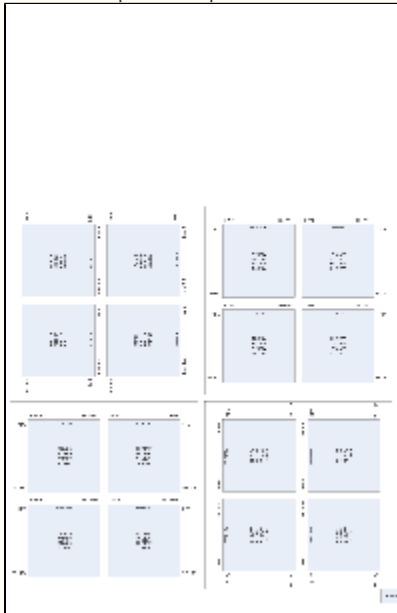


The same plots in PDF format: [CSPAD quad metrology](#) and [CSPAD pixel layout in quads](#).

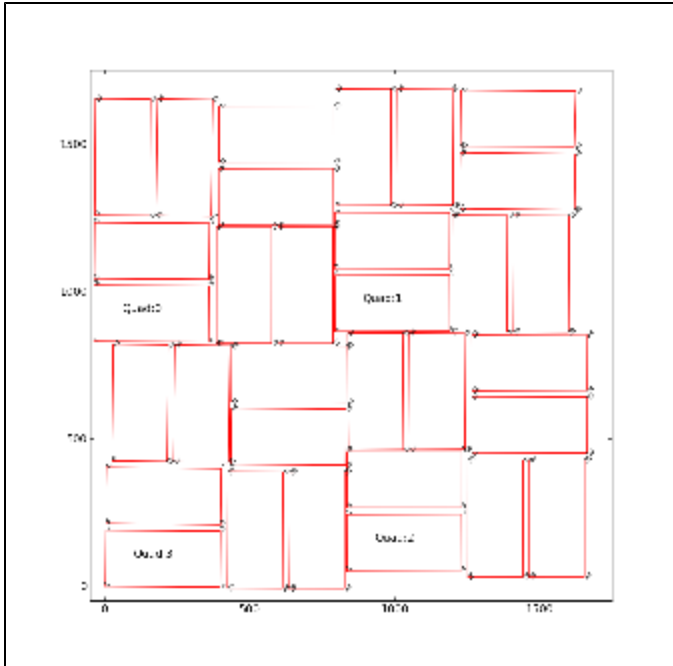
For each quad measurement is started from the point #1 which in assembled detector is closest to the beam. The 1-st point (x,y,z) coordinates are re-set to (0,0,0) in the beginning of measurements. At the end, it is checked that the 1-st point coordinates are reproduced within precision of measurement.



The order of points in optical measurement does not coincide with [numeration of 2x1 in DAQ](#), as shown in the plot (and in [PDF file](#)):



- For CSPAD with fixed quad geometry (i.e. for XPP) optical measurement is done for entire detector. The numeration of corners in this case is shown in the plot:



The 1-st corner of the 3-rd quad (x,y,z) coordinates are re-set to (0,0,0) in the beginning of measurements. At the end, it is checked that the 1-st point coordinates are reproduced within precision of measurement.

Corner coordinates are measured in micrometers (um) and are saved in the xlsx format table, also containing numeration of quads and points. Then, xlsx format table is converted to the text file format in order to use it in python script.

Example of tables for CXI:

- [Metrology in XLSX](#)
- [Metrology in TXT](#)

Example of tables for XPP:

- [Metrology in XLSX](#)
- [Metrology in TXT](#) Python script converts this table to the table with standard numeration of points in quads:
- [Metrology in standard TXT](#)

Then, text table with "standard" numeration of points in quads is feed to the python script which provides quality check of optical measurement and evaluates the alignment parameters for quads. In the beginning, this script changes the numeration of points adopted in optical measurement to numeration of 2x1 used in DAQ. Further, all calibration parameters are associated with numeration of 2x1 sensors and quads in DAQ.

Quality Check Procedure

For quality check of optical measurement we calculate

S1 - 1st short side length of 2x1

S2 - 2nd short side length of 2x1

L1 - 1st long side length of 2x1

L2 - 2nd long side length of 2x1

D1 - 1st diagonal of 2x1 between corners 1 and 3

D2 - 2nd diagonal of 2x1 between corners 2 and 4

dS and dL are the deviations of the 1st and 2nd corner along the short and long sides, respectively. The sign of all dS are chosen in order to provide correct sign for the tilt angle (the same direction for all 2x1 sensors).

<dS/L> - the tilt angle of 2x1 averaged over two sides in radians.

angle(deg) - the same angle in degrees.

dD = D1 - D2

d(dS) = dS1 - dS2

d(dL) = dL1 - dL2

dz3(um) - signed distance from 2x1 sensor plane and corner 3, where the 2x1 sensor plane contains the corner points p1, p2, and p4. This plane is defined by the vectors $v_{21}=p_2-p_1$, $v_{41}=p_4-p_1$, and their orthogonal vector

$$v_{ort} = [v_{21} \times v_{41}].$$

Scalar product with normalization defines the distance from point 3 to the 2x1 plane containing 3 other points:

$$dz3 = (v_{31} \cdot v_{ort}) / |v_{ort}|.$$

Quality check parameters expected for perfect geometry:

S1=S2, L1=L2 - the 2x1 sides should have equal length and width,
D1=D2 - the 2x1 diagonals should be equal,
 $dS1 = dS2 \quad ? \quad (388/185) \cdot dL1 = (388/185) \cdot dL2$ - tilt angle should provide consistent deviation for all corners,
 $dD=0$, $d(dS)=0$, and $d(dL)=0$ - within precision of measurement.
 $dz3(\mu m) = 0$

Everything, excluding $\langle dS/L \rangle$ and $\text{angle}(\text{deg})$, are in micrometers.

Example of the table with quality check results:

pair: D2	S1 dD	S2 d(dS)	dS1 d(dL)	dS2 dz3(um)	L1	L2	dL1	dL2	$\langle dS/L \rangle$	angle(deg)	D1
Quad 0											
pair: 0	20891	20913	200	222	43539	43541	-102	-100	0.00485	0.27766	48298
48297	1	-22	-2	2.981							
pair: 1	20910	20894	293	277	43540	43535	-127	-132	0.00655	0.37506	48302
48289	13	16	5	-23.986							
pair: 2	20890	20906	99	83	43536	43536	42	42	0.00209	0.11976	48290
48293	-3	16	0	-3.034							
pair: 3	20897	20895	131	133	43545	43543	65	63	0.00303	0.17369	48299
48297	2	-2	2	6.003							
pair: 4	20911	20896	-30	-45	43549	43547	17	15	-0.00086	-0.04934	48303
48306	-3	15	2	-5.994							
pair: 5	20901	20898	10	7	43540	43544	-8	-4	0.00020	0.01119	48296
48299	-3	3	-4	9.993							
pair: 6	20904	20903	104	105	43536	43540	55	59	0.00240	0.13752	48302
48290	12	-1	-4	52.002							
pair: 7	20901	20901	-7	-7	43545	43543	-3	-5	-0.00016	-0.00921	48299
48301	-2	0	2	14.001							
Quad 1											
pair: 0	20913	20914	-343	-342	43540	43550	165	175	-0.00787	-0.45066	48313
48303	10	-1	-10	-24.002							
pair: 1	20898	20901	-145	-142	43548	43551	62	65	-0.00330	-0.18880	48300
48309	-9	-3	-3	-23.005							
pair: 2	20895	20903	-151	-159	43535	43532	-74	-77	-0.00356	-0.20400	48289
48291	-2	8	3	-17.995							
pair: 3	20872	20909	-235	-272	43341	43354	-37	-24	-0.00585	-0.33507	48201
48036	165	37	-13	-13.010							
pair: 4	20940	20904	-455	-491	43527	43554	214	241	-0.01086	-0.62242	48309
48309	0	36	-27	1.101							
pair: 5	20910	20903	-302	-309	43546	43546	145	145	-0.00702	-0.40196	48304
48307	-3	7	0	6.016							
pair: 6	20901	20919	-421	-439	43529	43539	-213	-203	-0.00988	-0.56593	48296
48298	-2	18	-10	-8.026							
pair: 7	20907	20907	-452	-452	43548	43539	-201	-210	-0.01038	-0.59475	48315
48294	21	0	9	-8.982							
Quad 2											
pair: 0	20914	20914	-25	-25	43536	43540	10	14	-0.00057	-0.03290	48300
48300	0	0	-4	-11.013							
pair: 1	20901	20897	7	3	43546	43536	-1	-11	0.00011	0.00658	48293
48300	-7	4	10	4.036							
pair: 2	20899	20903	-256	-260	43533	43539	-127	-121	-0.00593	-0.33954	48293
48294	-1	4	-6	-1.023							
pair: 3	20912	20904	-210	-202	43540	43547	-106	-99	-0.00473	-0.27106	48300
48306	-6	-8	-7	24.004							
pair: 4	20910	20903	-543	-550	43535	43536	261	262	-0.01255	-0.71923	48298
48299	-1	7	-1	0.004							
pair: 5	20904	20905	-241	-240	43538	43544	111	117	-0.00552	-0.31647	48298
48301	-3	-1	-6	-6.024							
pair: 6	20903	20902	21	22	43539	43543	8	12	0.00049	0.02829	48298
48298	0	-1	-4	8.999							
pair: 7	20902	20903	82	81	43546	43547	35	36	0.00187	0.10723	48300
48306	-6	1	-1	9.995							
Quad 3											
pair: 0	20902	20898	-82	-86	43536	43543	30	37	-0.00193	-0.11054	48289

48302	-13	4	-7	1.994								
pair: 1	20900	20904	79	83	43548	43541	-35	-42	0.00186	0.10658	48301	
48301	0	-4	7	-17.993								
pair: 2	20912	20894	181	199	43536	43535	97	96	0.00436	0.25005	48298	
48289	9	-18	1	10.011								
pair: 3	20912	20905	119	126	43539	43538	57	56	0.00281	0.16121	48296	
48301	-5	-7	1	-16.000								
pair: 4	20894	20912	-454	-436	43534	43545	212	223	-0.01022	-0.58560	48303	
48296	7	-18	-11	2.023								
pair: 5	20906	20919	-336	-323	43527	43535	155	163	-0.00757	-0.43369	48295	
48294	1	-13	-8	5.993								
pair: 6	20902	20905	-203	-206	43537	43525	-89	-101	-0.00470	-0.26916	48293	
48287	6	3	12	2.981								
pair: 7	20900	20897	-140	-137	43539	43544	-68	-63	-0.00318	-0.18225	48298	
48296	2	-3	-5	29.997								

This quality check works well to catch significant typos in input table. In case of obvious typos input table can be corrected. When the quality check is passed successfully the alignment parameters are saved and deployed under the `calib`.

Summary for 2x1 flatness check: mean and standard deviation of the minimal distance between point3 and the plane containing points 1,2, and 4:

Mean and standard deviation [um]: 0.376 +- 15.818

Alignment parameters from optical measurement

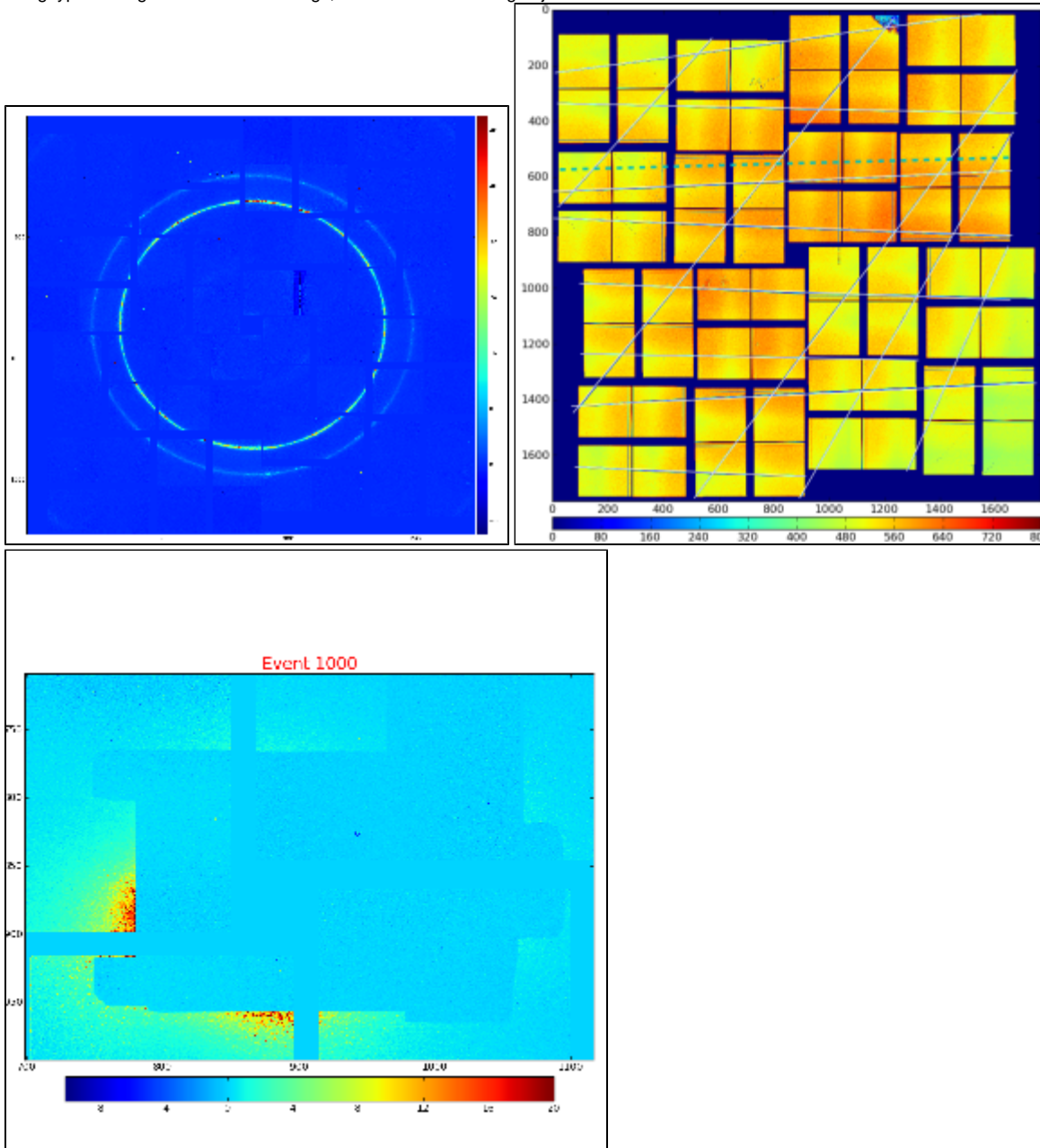
From optical measurement we extract coordinates of the center of each 2x1 sensor and its tilt angle, that populates the calibration types `center` and `tilt`, respectively.

The center coordinates are evaluated as an averaged over 4 corners measurements for each axis. Additional correction to the center coordinate `center_corr` can be applied if the optical measurement has (non-)obvious problems.

The `tilt` parameters are the same as "angle(deg)" from quality check results table. The `tilt` parameters are used along with `rotation` to completely define orientation of 2x1 in quad (for CXI) or in detector (for XPP).

Alignment of quads in the detector

For CSPad with fixed quad geometry (like in XPP) optical measurement of entire detector (should) produces complete information for geometry alignment. For CSPad with moveable quads (like in CXI) quads relative position needs to be adjusted through the alignment parameters for quads. It is usually done using typical images with diffraction rings, wires or other shading objects:



Although few algorithms of automatic quad alignment were tried, we did not find good generic way for automated quad tuning. Currently, the quad tuning parameters in `marg_gap_shift` and `offset_corr` are adjusted manually for runs with specific images.

Detector geometry model

In calibration parameters all coordinates are defined in terms of pixel size 109.92 μ m. In this units the reserved square space for each quadrant is 850x850. The margins, shifts and gaps in `marg_gap_shift` are defined for these quads. The `offset` and `offset_corr` are defined for low-left angle of the rotated by $n \times 90$ degree quad. Size of entire CSPad image does not matter for this alignment.

Alignment parameters

Location of alignment parameters and file naming conventions

The official space for CSPad alignment parameters is

```
/reg/d/psdm/<INSTRUMENT>/<experiment>/calib/CsPad::Calib<VERSION>/<CSPad-name>/<type>/<run-range>.data
```

For example:

```
/reg/d/psdm/CXI/cxi80410/calib/CsPad::CalibV1/CxiDs1.0:Cspad.0/geometry/1142-end.data
```

The file name consists of the run range followed by the `.data` extension, for example, `0-end.data`, `11-end.data`, `47-52.data`, etc.

Description of types

Recommended calibration type

In 2014 new universal detector geometry software is implemented and documented in the [Detector Geometry](#) page. In this approach detector geometry calibration information is located in a single file of type

- `geometry` - contains hierarchical description of all detector components; for example for CSPAD, sensors' location and rotation in the quads, quads - in the detector, detector - in the setup, etc.

Currently all psana modules which deals with image and pixel coordinates can work with calibration type `geometry`.

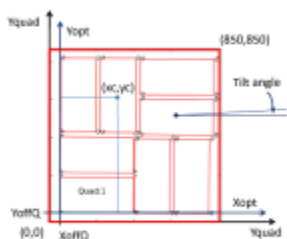
Deprecated calibration types

All CSPAD geometry alignment parameters are split for 9 types:

- `center` - x, y, z center position of each 2x1 for all quadrants. Obtained from optical measurement.
- `center_corr` - additional manual correction to the center parameter. Can be applied if the optical measurement has (non-)obvious problems.
- `marg_gap_shift` - margins, gaps, and shifts between quads, as explained below. Obtained from image-based tuning.
- `offset` - x, y, z coordinates for 4 quads. Fairly-reasonable assigned before tuning of the `offset_corr` and `marg_gap_shift` parameters.
- `offset_corr` - additional correction to the offset. Comes from image-based tuning.
- `quad_rotation` - 4 quad rotation in n*90 degree. Comes from basic geometry.
- `quad_tilt` - 4 quad tilt in fractional degree. Has never been used. In latest optical measurement is accounted through the global 2x1 coordinate measurement in the detector.
- `rotation` - 8 2x1-rotation angle for 4 quads in n*90 degree. Comes from basic geometry.
- `tilt` - 8 2x1-tilt angle for 4 quads in fractional degree. Comes from optical measurement.
- `center_global` - x, y, z center position of all 2x1 in the detector. Obtained from optical measurement for XPP-type detectors, and can be evaluated from other parameters or image-based tuning for CXI-type detectors.

Geometry parameters for 2x1 sensors in quad

- **center:** (x_c, y_c) – 2x1 center in optical measurements frame
- **tilt:** Tilt angle of 2x1 in optical measurements frame
- **marg_gap_shift:** X_{offQ}, Y_{offQ} – offset of optical frame in quad frame (to keep all numbers positive)



Positioning quads in detector

offset=offset_center: $(xq+dqx, yq+dqy)$ – quad position in (X,Y) frame

tilt_quad: Tilt angle of the quad in (X,Y) frame

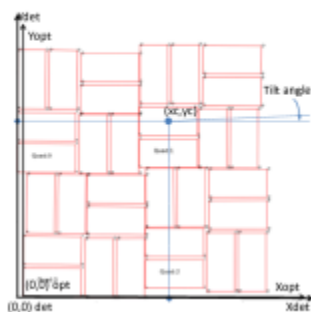
marg_gap_shift:

- X_{offQ}, Y_{offQ} – offset of the quad frame in the detector frame (to keep all numbers positive)
- $gapX, gapY$ – adjust space between quads in X and Y directions
- $shiftX, shiftY$ – adjust shift between quads in X and Y directions



Geometry parameters for 2x1 sensors in CSPAD

- **center_global:** (x_c, y_c) – 2x1 center in detector frame (to keep all numbers positive)
- **tilt:** Tilt angle of 2x1 in optical measurements frame



The same plots in PDF: [CSPAD-geometry-parameters.pdf](#)

CSPAD position parameters w.r.t. IP:

- **beam_vector**- (description given by TJ Lane) a R^3 vector pointing from the interaction site to the location of **beam_intersect** (below), along the direction the beam travels. The magnitude of this vector is the distance between the interaction site and the rough plane of the detector.
- **beam_intersect**- (description given by TJ Lane) a R^3 vector pointing from the origin (of CSPAD?) to the **beam_vector**, and intersecting the beam in an orthogonal manner. This can intuitively be thought of as the "center" of the detector – and will be that center in the case that the detector is completely contained in a plane normal to the beam, and the origin is in that plane.

File format for calibration types

geometry

See for details [Detector Geometry](#).

center

Tail of the path: center/<run-range>.data

Parameters: x,y,z coordinates of 8 2x1 centers in 4 quads in pixels:

```

x0q0 x1q0 x2q0 x3q0 x4q0 x5q0 x6q0 x7q0
x0q1 x1q1 x2q1 x3q1 x4q1 x5q1 x6q1 x7q1
x0q2 x1q2 x2q2 x3q2 x4q2 x5q2 x6q2 x7q2
x0q3 x1q3 x2q3 x3q3 x4q3 x5q3 x6q3 x7q3

```

```

y0q0 y1q0 y2q0 y3q0 y4q0 y5q0 y6q0 y7q0
y0q1 y1q1 y2q1 y3q1 y4q1 y5q1 y6q1 y7q1
y0q2 y1q2 y2q2 y3q2 y4q2 y5q2 y6q2 y7q2
y0q3 y1q3 y2q3 y3q3 y4q3 y5q3 y6q3 y7q3

```

```

z0q0 z1q0 z2q0 z3q0 z4q0 z5q0 z6q0 z7q0
z0q1 z1q1 z2q1 z3q1 z4q1 z5q1 z6q1 z7q1
z0q2 z1q2 z2q2 z3q2 z4q2 z5q2 z6q2 z7q2
z0q3 z1q3 z2q3 z3q3 z4q3 z5q3 z6q3 z7q3

```

Typical values:

199.14	198.05	310.67	98.22	629.71	629.68	711.87	499.32
198.52	198.08	311.50	98.69	627.27	627.27	712.35	499.77
198.32	198.04	310.53	97.43	626.68	628.45	710.86	498.01
198.26	198.04	308.70	96.42	627.66	628.04	711.12	498.25
308.25	95.11	625.60	625.70	515.02	727.37	198.53	199.30
307.18	95.08	622.98	623.51	514.99	727.35	199.27	198.94
307.68	95.09	623.95	625.29	512.32	724.63	198.04	200.35
307.39	95.12	627.57	626.65	518.03	730.95	200.02	199.70
0.31	0.12	0.05	0.12	0.28	0.24	0.40	0.27
0.45	0.36	0.62	0.33	1.02	0.92	1.30	1.07
0.23	0.22	0.11	0.15	0.24	0.20	0.60	0.42
0.25	0.21	0.12	0.10	0.35	0.28	0.66	0.40

center_corr

Tail of the path: center_corr/<run-range>.data

Parameters: x,y,z coordinate corrections of 8 2x1 centers in 4 quads in pixels:

```

dx0q0 dx1q0 dx2q0 dx3q0 dx4q0 dx5q0 dx6q0 dx7q0
dx0q1 dx1q1 dx2q1 dx3q1 dx4q1 dx5q1 dx6q1 dx7q1
dx0q2 dx1q2 dx2q2 dx3q2 dx4q2 dx5q2 dx6q2 dx7q2
dx0q3 dx1q3 dx2q3 dx3q3 dx4q3 dx5q3 dx6q3 dx7q3

```

```

dy0q0 dy1q0 dy2q0 dy3q0 dy4q0 dy5q0 dy6q0 dy7q0
dy0q1 dy1q1 dy2q1 dy3q1 dy4q1 dy5q1 dy6q1 dy7q1
dy0q2 dy1q2 dy2q2 dy3q2 dy4q2 dy5q2 dy6q2 dy7q2
dy0q3 dy1q3 dy2q3 dy3q3 dy4q3 dy5q3 dy6q3 dy7q3

```

```

dz0q0 dz1q0 dz2q0 dz3q0 dz4q0 dz5q0 dz6q0 dz7q0
dz0q1 dz1q1 dz2q1 dz3q1 dz4q1 dz5q1 dz6q1 dz7q1
dz0q2 dz1q2 dz2q2 dz3q2 dz4q2 dz5q2 dz6q2 dz7q2
dz0q3 dz1q3 dz2q3 dz3q3 dz4q3 dz5q3 dz6q3 dz7q3

```

Typical values:

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Parameters: x,y,z coordinates of 4 quad "origins" in CSPad pixel matrix:

Typical values:

Due to historical reason `offset` and `offset_corr` parameters are defined in rotated frame... (this is a mess...) :

Typical values:

marg_gap_shift

Tail of the path: marg_gap_shift/<run-range>.data
Parameters:

offset of 2x1s in quad (for tilt)

/

offset of quads in entire image (for tilt)

/

gaps

/

shifts

/

XOffQ XOffD gapX shiftX

YOffQ YOffD gapY shiftY

ZOffQ ZOffD gapZ shiftZ

Typical values:

15 40 0 32

15 40 0 32

0 0 0 0

quad_rotation

Tail of the path: quad_rotation/<run-range>.data
Parameters: rotation angle of 4 quads in CSPad in n*90 degree:

Aq0 Aq1 Aq2 Aq3

Typical values:

180 90 0 270

quad_tilt

Tail of the path: quad_tilt/<run-range>.data
Parameters: rotation angle correction (tilt) of 4 quads in CSPad in degree:

dAq0 dAq1 dAq2 dAq3

Typical values:

0 0 0 0

rotation

Tail of the path: rotation/<run-range>.data
Parameters: rotation angle of 8 2x1 in 4 quads in n*90 degree:

A0q0 A1q0 A2q0 A3q0 A4q0 A5q0 A6q0 A7q0
A0q1 A1q1 A2q1 A3q1 A4q1 A5q1 A6q1 A7q1
A0q2 A1q2 A2q2 A3q2 A4q2 A5q2 A6q2 A7q2
A0q3 A1q3 A2q3 A3q3 A4q3 A5q3 A6q3 A7q3

Typical values:

0 0 270 270 180 180 270 270

0 0 270 270 180 180 270 270

0 0 270 270 180 180 270 270

0 0 270 270 180 180 270 270

tilt

Tail of the path: tilt/<run-range>.data
Parameters: rotation angle correction (tilt) of 8 2x1 in 4 quads in degree:

dA0q0 dA1q0 dA2q0 dA3q0 dA4q0 dA5q0 dA6q0 dA7q0
dA0q1 dA1q1 dA2q1 dA3q1 dA4q1 dA5q1 dA6q1 dA7q1
dA0q2 dA1q2 dA2q2 dA3q2 dA4q2 dA5q2 dA6q2 dA7q2
dA0q3 dA1q3 dA2q3 dA3q3 dA4q3 dA5q3 dA6q3 dA7q3

Typical values:

-0.33819 0.00132 0.31452 -0.03487 0.14738 0.07896 -0.21778 -0.10396
-0.27238 -0.00526 0.02545 0.03066 -0.03619 0.02434 0.08027 0.15067
-0.04803 -0.00592 0.11318 -0.07896 -0.36125 -0.31846 -0.16527 0.09200
0.12436 0.00263 0.44809 0.25794 -0.18029 -0.00117 0.32701 0.32439

center_global

Tail of the path: center_global/<run-range>.data
Parameters: x,y,z coordinates of all 2x1 centers in the detector in units of pixel size (109.92 um).
As usually, the matrix-style of the coordinate system is used:

+-----+-----+-->y
| Quad 3 | Quad 0 |
|-----+-----+
| Quad 2 | Quad 1 |
|-----+-----+
|
V X

x0q0 x1q0 x2q0 x3q0 x4q0 x5q0 x6q0 x7q0
x0q1 x1q1 x2q1 x3q1 x4q1 x5q1 x6q1 x7q1
x0q2 x1q2 x2q2 x3q2 x4q2 x5q2 x6q2 x7q2
x0q3 x1q3 x2q3 x3q3 x4q3 x5q3 x6q3 x7q3

y0q0 y1q0 y2q0 y3q0 y4q0 y5q0 y6q0 y7q0
y0q1 y1q1 y2q1 y3q1 y4q1 y5q1 y6q1 y7q1
y0q2 y1q2 y2q2 y3q2 y4q2 y5q2 y6q2 y7q2
y0q3 y1q3 y2q3 y3q3 y4q3 y5q3 y6q3 y7q3

z0q0 z1q0 z2q0 z3q0 z4q0 z5q0 z6q0 z7q0
z0q1 z1q1 z2q1 z3q1 z4q1 z5q1 z6q1 z7q1
z0q2 z1q2 z2q2 z3q2 z4q2 z5q2 z6q2 z7q2
z0q3 z1q3 z2q3 z3q3 z4q3 z5q3 z6q3 z7q3

Typical values:

477.78	690.20	159.77	160.06	277.17	64.77	591.30	591.01
990.78	989.30	1105.38	891.19	1421.65	1423.66	1502.28	1289.93
1143.85	932.00	1461.86	1463.74	1349.75	1562.62	1032.39	1033.60
633.06	632.80	518.88	731.75	200.62	198.75	118.50	331.23
1018.54	1019.42	1134.27	921.94	1451.06	1451.01	1532.55	1319.23
1173.24	960.71	1490.18	1491.45	1374.97	1587.78	1058.56	1061.14
658.23	658.54	542.73	755.26	225.91	224.22	146.39	358.27
507.44	720.59	189.73	190.28	306.25	93.65	620.68	619.85
1.00	1.04	0.64	1.14	0.05	-0.03	-0.18	0.45
0.92	1.37	0.26	-0.02	0.62	0.13	1.35	1.25
-2.10	-1.76	-3.00	-2.29	-3.85	-4.20	-3.63	-2.94
1.83	1.57	2.23	2.31	1.91	2.07	1.41	0.54

beam_vector

Tail of the path: beam_vector/<run-range>.data

Parameters: 3 components of the vector:

```
bv_x bv_y bv_z
```

Typical values:

```
0 0 0
```

beam_intersect

Tail of the path: beam_intersect/<run-range>.data

Parameters: 3 components of the vector:

```
bi_x bi_y bi_z
```

Typical values:

```
0 0 0
```

Pixel coordinate reconstruction

The list of CSPad geometry alignment parameters is over-defined; different parameters can be used to get the same final effect on pixel coordinate. It is done intentionally in order to keep flexibility in the alignment stage.

Algorithm description will be added soon.

```
Xoffset_qi = XOffQ + xqi + dxqi + [-gapX+shiftX, -gapX-shiftX, +gapX-shiftX, +gapX+shiftX]
Yoffset_qi = YOffQ + yqi + dyqi + [-gapY-shiftY, +gapY-shiftY, +gapY+shiftY, -gapY+shiftY]
...
```

Software supporting CSPAD geometry

Recommended software to access pixel geometry and produce image is described in [Detector Geometry](#).

Deprecated packages

There is a couple of packages which reconstruct CSPAD pixel coordinates and images developed in C++ and python code;

- C++-based package: [Psana Module Catalog - Old#Package CSPadPixCoords](#).
- Description of C++ package supporting calibration types: [CSPAD Geometry Software \(depricated\)](#).

- Python-based package:
 - [CSPad image producer in Python \(DEPRICATED\)](#)
 - [CSPAD pixel coordinates and image producer in Python](#)

Other useful documents:

- Note about organization of the calibration database: [CsPad calibration in translator](#).

References

- [Detector Geometry](#) - confluence page
- [CSPAD in DAQ](#) - schematic description of CSPAD geometry available in DAQ.
- [CSPAD quad metrology](#) - slides for CXI type CSPAD quads
- [CSPad pixel layout in quads](#) - pdf file with numeration of ASICs in the CSPAD quads