Rayonix info

Geometry

Examples of the rayonix geometry description files can be found under

/reg/g/psdm/detector/alignment/rayonix/calib/Camera::CalibV1/XppEndstation.0:Rayonix.0/geometry/

Matrix shape and detector pixel size depend on detector model.

Depending on binning schema the segment level geometry description in the geometry files can be defined as

MTRX:V2:<number-of-rows>:<number-of-columns>:<pixel-size-in-rows-um>:<pixel-size-in-cols-um>, for example for Rayonix MX170-HS

- MTRX:V2:3840:3840:44.5:44.5
- MTRX:V2:1920:1920:89:89
- MTRX:V2:960:960:178:178
- MTRX:V2:384:384:445:445

V2 stands for matrix geometry definition in Cartesian coordinates with origin in the center of matrix, positive x axis along ascending column number, y - along descending row number.

If V2 is omitted, natural mapping of matrix to Cartesian coordinates is applied with origin in pixel (0,0), positive x axis along ascending row number, y - along ascending column number.

Pixel size

MS340-HS un-binned pixel size is 44.271 ± 0.026 m

44.271 um - pixel size investigation saga

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2022-06-16 3:53 PM
O'Grady, Paul Christopher <cpo@slac.stanford.edu>
Hi,
Our lab uses a number of rayonix cameras.
We would like to know the precise pixel size of the MX340-HS
described here:  https://www.rayonix.com/product/mx340-hs/
MX340-HS | Rayonix, LLC
A very large area, high speed detector for the most demanding X-ray science applications.
Consists of a 4 x 4 tiled array of frame-transfer CCD modules,
with 340 x 340mm² square active area, tiled without gaps in the imaging area.
www.rayonix.com. For example, that page says 1x1 binning pixel size is 44um,
but 2x2 binning is 89um (which implies 44.5um per pixel).
We suspect this is a “rounding” issue. Can you email us the precise pixel size?

Also, that page says the 4x4 array is “tiled without gaps”.
Is that because it is a monolithic piece of silicon,
or are there actually several different silicon pieces that
are mechanically assembled with tight tolerances?

Thank you for any thoughts!
chris


2022-06-16 5:53 PM
Christine R.A. Muchmore <cram@rayonix.com>
Hello Chris

The actual unbinned pixel size for the MX340-HS detectors is 0.0443 mm.
The accurate binned pixel sizes can be derived from that number by
simply multiplying according to binning.

Yes, brochures and promotional materials have rounded numbers.
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"Also, that page says the 4x4 array is “tiled without gaps”.
Is that because it is a monolithic piece of silicon, or are there
actually several different silicon pieces that are mechanically assembled with tight tolerances?"

So these are CCD's mounted on the small ends of fiberoptic glass tapers.
The large ends of the fiberoptic glass tapers are squared and fused
together (tiled) at the front of the detector, such that the gaps
are much smaller than a pixel. There are no silicon pieces to be assembled,
this is not a hybrid pixel detector (ASICs bump-bonded to Silicon sensors),
instead they are integrating detectors with fast frame-transfer CCDs.
The attached brochure has a small picture of one of those tiled
340mmx340mm FO taper arrays on page 2.

I assume you were using the MX340-HS at BioCARS at the APS.
This beamline produces too high a photon count to use with the
hybrid pixel array detectors (they would miss photons, because
the next one arrives before the pixel has finished processing the last photon).
That is why BioCARS has this integrating Detector.
They are trying to install an ePix10k hybrid pixel array
(ASICs bump-bonded to the silicon sensors you mentioned) from SLAC,
which is also integrating and switches gain when the photon flux
becomes too high (much like the Jungfrau from PSI).

Hope this helps,
-Christine

Christine R.A. Muchmore <cram@rayonix.com>
Chris,

Sorry I just inspected your email address more closely -
you must be using the MX340-HS at LCLS.
At an XFEL you obviously also have very high photon rates
and need to integrate.
Several ePix10k's must be deployed at LCLS.

Sorry I jumped to the conclusion that you collect at APS...
-Christine
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Christine R.A. Muchmore. Ph.D.
COO
Rayonix, L.L.C.
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ph:847 869 1548   fx: 847 869 1587
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O'Grady, Paul Christopher <cpo@slac.stanford.edu>
On Jun 17, 2022, at 3:21 PM, Christine R.A. Muchmore <
On Jun 17, 2022, at 3:21 PM, Christine R.A. Muchmore <cram@rayonix.com> wrote:

Sorry I jumped to the conclusion that you collect at APS…
No worries, Christine. Thank you for the excellent answers about
the MS340 … very much appreciate that!

2022-06-20 9:25 AM
Dubrovin, Mikhail
Hi Chris,

Very good progress in understanding of rayonix pixel size!
To close this issue, we need to clarify a couple of other questions.

We also use MX170-HS made of 2x2 tiles https://www.rayonix.com/product/mx170-hs/
Are they made of the same tiles as MX340-HS? Otherwise, we need in their pixel size too.

If stitches between tiles are so precise,
we would expect accuracy in coordinate ~1pixel on scale of entire detector.
Corrected pixel size 44.3um relative to used 44um
brings a huge coordinate difference on the full detector scale

0.3um * 7680 pixels = 2304 um (or 2.3 mm).
Next digit in pixel size gives about order of magnitude
smaller correction 0.23mm, that is about 5 pixels.
This means that we need in a couple of more digits in pixel size
in addition to corrected value 44.3um.
Alternative question would be about precise matrix size.
For example, 340x340 mm should be known with precision of 1 pixel.
Then pixel size is 340mm/7680 = 44.271 um.
Tiny detail might be the size of 340mm is between edges of border
pixels or their centers?

Thank you for moderation,
Mikhail

O'Grady, Paul Christopher <cpo@slac.stanford.edu>
On Jun 20, 2022, at 9:25 AM, Dubrovin, Mikhail <
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Alternative question would be about precise matrix size.
For example, 340x340 mm should be known with precision of 1 pixel.
Then pixel size is 340mm/7680 = 44.271 um.
Tiny detail might be the size of 340mm is between edges of border pixels or their centers?

Hi Mikhail,

I think your idea above is an excellent one:
it feels like the total sensor size (with an error of perhaps 1mm
because of the number of significant figures supplied).
So pixel size is (340mm += 1mm)/7680 = .044271mm+-.000130mm
which feels like it would be high enough precision for us.
I would vote to go with that number, but if you would like
to be absolutely certain I’m happy to contact the manufacturer.
Let me know what you would prefer,
chris

2022-06-20 3:07 PM
Dubrovin, Mikhail
Chris, It would definitely worth to contact Christine again with these questions.
Precision 340 +/- 1mm is not enough for us.
We need in precision 340.??mm +/- 0.04mm or similar values translated to the pixel size.
Then question about MX170-HS is also important for old experiments.
Mikhail

O'Grady, Paul Christopher <cpo@slac.stanford.edu>
On Jun 17, 2022, at 3:17 PM, Christine R.A. Muchmore <
On Jun 17, 2022, at 3:17 PM, Christine R.A. Muchmore <cram@rayonix.com> wrote:

The actual unbinned pixel size for the MX340-HS detectors is 0.0443 mm.

Hi Christine,

If I could trouble you a little more (if you know the answers).
Here at LCLS we’re very interested in precise-as-possible pixel positions.
It feels like the best way to calculate that would be from
the MX340 sensor dimension of 340mm/7680pixels = 44.271um/pixel.
Is it possible to add some significant-figures to the 340mm number? (e.g. 340.27mm?).
  Might also be good to know if that measurement is
pixel-center-to-pixel-center or outer-edge-to-outer-edge (makes a difference of 1 pixel).

And, if possible, would be good to have that number for both MX340 and MX170.

Thank you again!

Christine R.A. Muchmore <cram@rayonix.com>
Paul,
That would not be an adequate way to calculate the pixel position,
because it completely ignores the magnification and distortion the FO tapers impose.
The actual CCD has a pixel size around 14 micron.
The 340mm number refers to the front of the FO tapers,

i. e. The X-ray sensitive surface. Again, there are no silicon sensors
like you have with ASICs like the ePix10k (which Rayonix is commercialising together with SLAC).
You would end up with incorrect positions and much too small a pixel size.

The precision is determined by the Xray measurements and calculations
Rayonix uses to calculate the pixel position and size.
The details are proprietary.

Please consider that Rayonix has done these distortion corrections
for 20 years very successfully. Many institutions have tried
to design their own algorithm and ended up with much worse data
then they get by using the Rayonix factory calibration.
Not just LCLS, but ever scientist at every beamline worldwide
wants these numbers as accurate and precise as possible. We are aware of that.

Rayonix is closed for Juneteenth today, but tomorrow I can send you an example of a raw image.
-Christine

2022-06-21 12:14 PM Dubrovin, Mikhail
Hi Chris,
Good try, but sorry, it was a bad idea to ask "alternative question"
about precise value for 340mm. Indeed, she is right CCD panel edges
might be quite fuzzy due to tapered shape of the electric field at
the very edge. Still, it would be nice to get precise design
dimensions of the ONE SEGMENT electrode with capacitors
with size "around 14 um". We need in step of these electrodes
with precision of 3 digits after the dot like 14.NNN because of huge number of pixels.

For example, MS340-HS consists of 4x4 segments,
segment dimension is 7680/4 = 1920 pixels of ~44um of each side and
1920*3 = 5760 pixels of size ~14um.
So, precision 0.001um x 5760 = 5.76 um which
is about half of this pixel size on full dimension of this segment.
I am pretty sure that the dimensions of the matrix of 5760x5760 "capacitors"
should be known with at least pixel size precision.

Another words, to get right answer we need to ask right question.
Mikhail

2022-06-22 11:49 AM
Ross Doyle <ross@rayonix.com>
Dear Chris,
You could use 44.271 um as the best estimate for the unbinned pixel size,
and multiples of that for binned pixels. That's somewhat beyond
the tolerances of the exact imaging area size (340mm x 340mm),
but it's the target expansion number we use in our calculations
to make the calibration tables. Also, to answer your question,
the corrected pixel space is 340mm x 340mm, pixel edge to pixel edge.
Best regards,
-Ross

From: O'Grady, Paul Christopher <cpo@slac.stanford.edu>
Sent: Wednesday, June 22, 2022 12:01 PM
To: Dubrovin, Mikhail <dubrovin@slac.stanford.edu>
Subject: Fwd: MS340-HS pixel size and "gap" question

Hi Mikhail,
I think the answer below is good enough for our purposes. Do you agree?

2022-06-22 2:24 PM
Dubrovin, Mikhail
Hi Chris,
Thank you for efforts to shed light on this murky issue.
Yes, I do. Hope this will convince our scientists.
And I can use this size for implementation.

To completely convince myself, I would prefer to see a schematic

design drawing of a single CCD panel charge moving electrodes
of capacitors/pixels ~14um with precise dimensions from edge to edge.
Map of squares/rectangles should not be a "proprietary information", right?
These dimensions should not depend on electric field shape
at the edge and inter-panel gap uncertainties.
If Christine confirms that these pixels map has dimensions
(340mm/4) 85x85mm with precision of 1 pixel width, I will absolutely be happy.

Also, we did not get answer about panels of MS170-HS.
Are they the same as for MS340-HS? It is the same topic question, so you may merge them in one question.
Mikhail

2022-06-22 3:04 PM
Dubrovin, Mikhail
Just in order to stimulate this discussion, I found scientific publication based on data of this detector
http://www.photocrystallography.eu/pubs/2020/Szarejko-J-Synchrotron-Rad-2020-27-405.pdf
where pixel size is used as 44um sharp. So total error in distance measurement is ~0.5%.
Can't comment on how important this error for measurement is....
And I am pretty sure that this is not the only publication.
Mikhail

2022-06-28 3:06 PM
Dubrovin, Mikhail
Dear Christine and Ross,

Thank you for sharing with us precise information about Rayonix detector.
It is hard to overestimate how important for our measurements is information
about un-binned pixel size 44.271 um. For example, currently in our experiments
Rayonix's pixel size is 44um that gives distance measurement precision ~0.5% only,
that means ~2mm (or ~47 pixels) error on the full detector scale 340mm...
Presumably, this is not a design accuracy of this detector.

There is still a couple of question to completely satisfy curiosity of our scientists.
Beside MX340-HS we also use MX170-HS. Can we assume that MX170-HS is made of similar size tiles?
Otherwise, we need in its pixel size with similar accuracy.
From this conversation is clear that the tile does not have uncertainties
of entire detector such as gaps between tiles and distortion of electric
field at the edges. Can we assume that a single tile pixels area has
dimensions 85 x 85 mm (from pixel edge-to-edge) with effective 1920x1920 pixel
period of 44.271 um?
Can we also assume that the tile size 85mm is known with at least precision
of pixel size ~44um? Please give us better estimate if you can.
Scientists need in this systematic uncertainty.
Best regards,
Mikhail

2022-06-28 3:45 PM
Ross Doyle
Dear Mikhail,
1) Yes, you can use the same pixel size for the MX170-HS since
it has the same module size and number of pixels per module.
2) The fiber optic taper front end for each module is ground (machined) to 85mm x 85mm
and bonded to its neighbors. Actually, I checked and our official tolerance
allows a bonding gap of up to 50um between neighboring elements, however the typical
gap is significantly better than the tolerance. There are no electric fields that
have anything to do with the X-ray interaction, the X-rays interact with a GadOx
phosphor screen and are converted to light, which is detected.
Also, although there can be a physical gap between bonded neighboring
fiber optic taper elements, the gap region is not insensitive
to X-rays that hit there due to light spreading in the phosphor layer.

Best regards,
-Ross

2022-06-28 4:55 PM
Dubrovin, Mikhail

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Dear Ross,

That is great news which solves all our problems.
Rounding our discussion, we will use tile dimensions as
85.00 +/- 0.05 mm (now I found it in the pdf file too),
which can be transformed to the pixel size by division on 1920 pixels
44.271 +/- 0.026 um.

Sorry, I was talking about electric field because did not understand construction
of this device and had an impression that CCD is mounted on the front window.
In general, it would be nice to see a schematic chart (presumably with dimensions)
roughly explaining how detector is organized.

Thank you for help.
Mikhail
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- the X-rays interact with a GadOx phosphor screen and are converted to light, which is detected.
- MX170-HS consists of 2x2 tiles of the fiber optic taper with total 3840 x 3840 un-binned pixel
- MX340-HS consists of 4x4 tiles of the same size with total 7680 x 7680 un-binned pixel
- the fiber optic taper front end for each module is ground (machined) to 85mm x 85mm, with 1920 x 1920 un-binned pixels
- official tolerance 85.00 ± 0.05 mm
- or transformed to pixel size 44.271 ± 0.026 m.

Deploy geometry file for Rayonix

Test command to deploy geometry file for Rayonix and check its content is:

geometry_deploy_constants -e xpptut15 -r 240 -d XppEndstation.0:Rayonix.0 -D -c ./calib
less ./calib/Camera::CalibV1/XppEndstation.0:Rayonix.0/geometry/0-end.data

Deployed file should have segment geometry descriptar with pixel size specified precision in m with three digits after the dot, e.g. MTRX:V2:1920:1920:88.542:88.542

Omitting parameter -c ./calib will deploy geometry under experimental calib directory.

Alternatively, in releases grater than ana-4.0.43 correct geometry will be substituted on fly in the detector interface. Test example is available as

python <path>/Detector/examples/test-issues-2022.py 9

References

- Rayonix MX170-HS (specifications pdf) 170x170 mm²
- Rayonix MX340-HS (specifications pdf) 340x340 mm²