Silicon Detector Alignment 13 May 2013

GOAL: Place SVT in the nominal beamline within 100 microns in the vertical and 250 microns in the horizontal. Internal alignment of the SVT of silicon detectors will be less than 30 microns.

Comments:

1) Takashi 13 May 2013

To be consistent, "50 microns" in the GOAL statement should be "30 microns". Done KCM

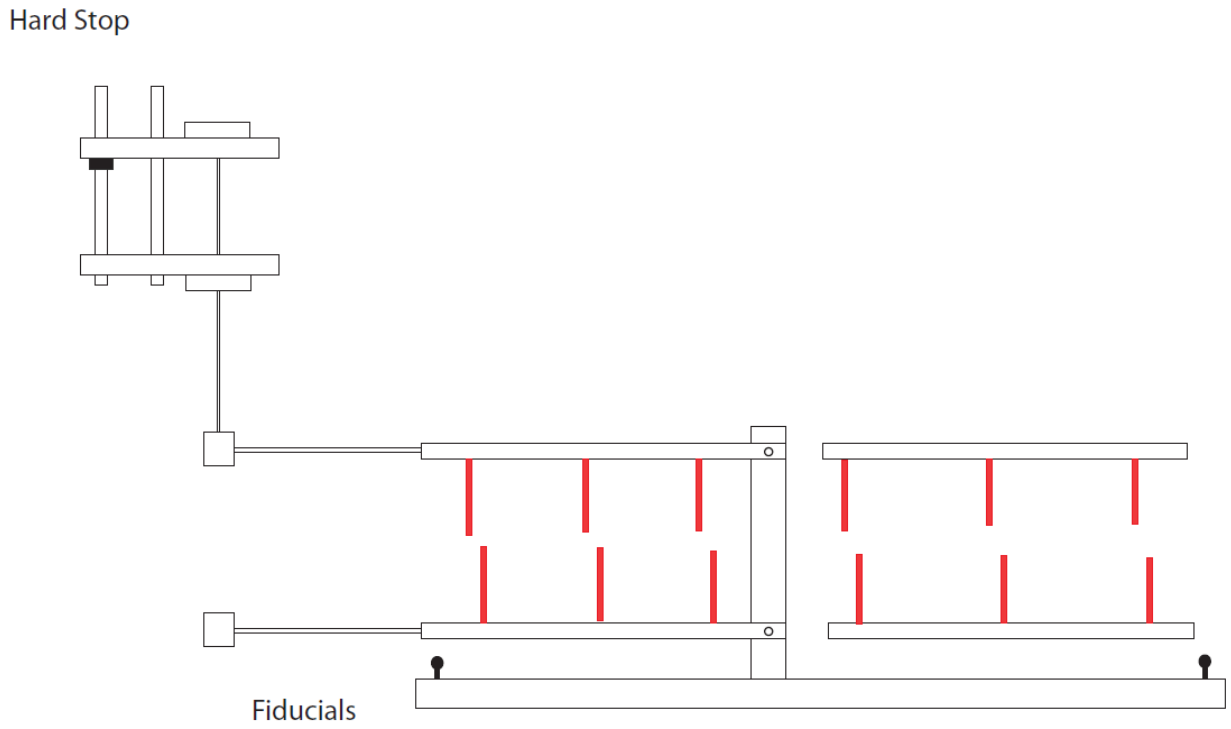
I think the key is Section B). Both the SVT base plate and the Ecal vacuum chamber will be installed relative to the magnet vacuum chamber. The yaw, pitch, roll angles of the vacuum chamber need to be measured. The pitch angle should be zero, but we need to find out how precisely they can set the chamber. One side wall (beam left, or beam right) must be surveyed precisely so that we know where we place the base plate. The straight beamline (no chicane field) may be known more precisely. We need to talk to Jlab people.

Takashi

I) Alignment and Survey

This note uses information from "SVT Alignment and Survey for Hall B Installation" by John, Takashi and Marco, 9 April 2012.

A) Laboratory Alignment



- Fiducials
  - Fiducials on both ends of base plate on each side are visible from end (yaw, tilt and x-y-z can be measured on each of the four fiducials.
  - Stepping motor against in and out stops (visible from side perpendicular to beam)

    - Rod connecting silicon to stepping motor shaft (near where connection is made and visible from front and side).
- Position the SVT detector with respect to the reference fiducials on the base plate.
- With the stepping motors for the upper and lower planes in the out position measure the location of the silicon lower edge (for the upper plane) and upper edge for the lower plane. Repeat measurements with the stepping motors against the stops closest to the beam. Also measure rod fiducials relative to in/out stepping motor fiducials.
- Expected accuracy is ~25 microns (1 mil). Required accuracy < 50 microns. The sensors can be placed in the support plate within this accuracy.
- Survey stepping motor fiducials and rod fiducials with silicon detector installed in vacuum chamber before pulling a vacuum. Under vacuum survey stepping motor fiducials.
- The 15 mrad dead zone is set when the support plate is horizontal. Make sure there is no sag in the support plate.
- SVT support plates are set parallel to the base plate. Make sure there is no sag in the base plate.
- SVT sensor positions can be known within 50 microns relative to the fiducials on the base plate.

All four fiducials must be visible from front and back of the magnet.

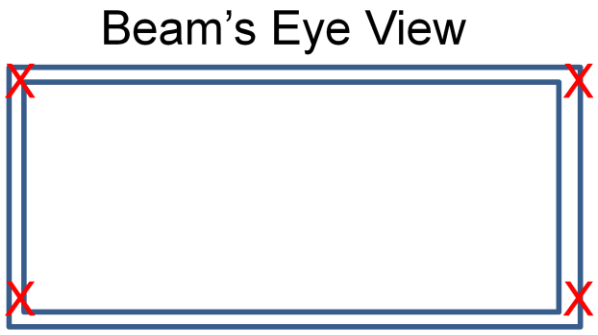
- Flex joint connection may not be reproducible.
- Two flanges on the linear stage may have ~100 microns height uncertainty.
- Hard stop is set in situ so that the edge of the first layer sensor is 400 microns from the beam.
    - Make the support plates and the base plate parallel.
    - Move the linear stage so that the sensor edge is closer to the beam by 100microns.
    - Set hard stop.

B) Installation Alignment

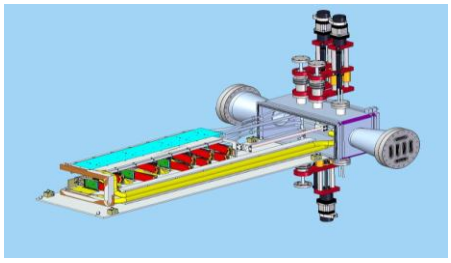
After mating the ECal vacuum chamber to the silicon detector vacuum chamber survey fiducials on both vacuum chambers (resurvey under vacuum). Expected accuracy is ~150 microns. Required accuracy is < 250 microns.

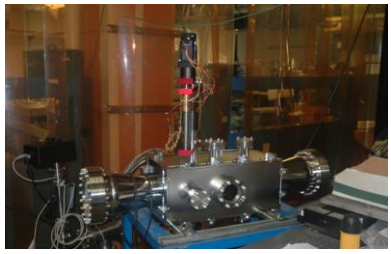
1) Survey the nominal beamline; establish fiducials on the analyzing magnet and magnet vacuum chamber with reference to beam height and transverse position (x, y). Jlab to provide survey information on the position of the present Magnet Vacuum Chamber before installation:

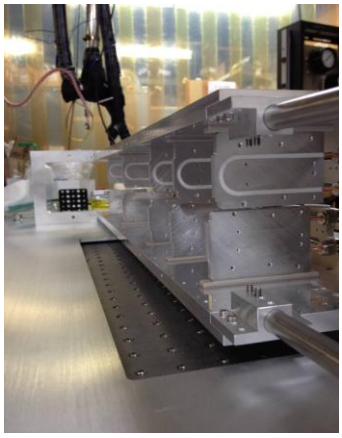
- Height with respect to nominal beam height, each end of bottom plate.
- x-position of vacuum chamber wall on beam's right, each end of chamber.
- precise z position of upstream flange mating surface at 4 corners.



2) Position the SVT and the ECal vacuum chambers with respect to the nominal beam position and direction (with the chicane system energized). The ECal Vacuum chamber lateral position is defined by where the nominal electron beam exits into the "electron hole". The center of the ECal vacuum chamber must also be positioned at the nominal beam height. Set height of upstream point to nominal baseplate height (i.e., required to center beam in magnet vacuum chamber). Set average height of downstream points to level the reference plane in z. Set relative heights of downstream points to level the baseplate references in y direction.



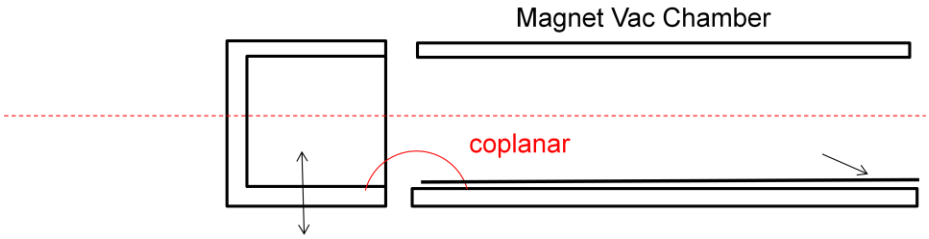




3) Attach SVT vacuum box.

- Make Vacuum Box bottom inner surface coplanar with inner surface of the magnet vacuum chamber.
- Make Vacuum Box beam's right inner surface coplanar with corresponding inner surface of magnet vacuum chamber.
- Attach Vacuum Box to Magnet Vacuum Chamber.

- Attach support rods to linear shifts. Attach cooling manifolds inside and outside of vacuum box.
- Attach data/power cables to vacuum feedthru. Test linear shifts; pressure test cooling manifold; test cabling.
- Calibrate linear shifts about this beam height. (Note Vac Box may not be perfectly coplanar with Hall B magnet vacuum chamber. This could change the beam position as defined by linear shifts slightly, which is OK.



4) Survey Silicon and Check Linear Shift Calibration

- Set up level downstream of magnet vacuum box, to beam's left of beamline.
- Set upper support plate at nominal horizontal position with linear shift.
- Measure height of layer 1 silicon relative to nominal beam position.
- Measure heights of layers 2-6 silicon.
- Adjust layer 1 silicon height to bring to nominal. Record linear shift.
- Repeat for bottom support plate.

5) SVT Alignment and Survey end run. Note information below is from 2012 test run and procedures need modification for new detector

Jefferson Lab Alignment Group

Data Transmittal

TO: J. Jaros		**DATE:** 24 Apr 2012
FROM: J. Dahlberg	**Checked:**	**#:** B1448

DETAILS:

Below are the results from the HPS detector survey carried out on April 19, 2012. A right handed coordinate system (in millimeters) was established based on the ideal center of the pair spectrometer magnet located 1349.12 cm from CLAS. This is the ideal distance for the HD_ice run. A +X is to the beam left, a +Y is up, and a +Z is downstream. Values which are in **bold** case signify the noteworthy information.

LOCATION	X	Y	Z
FIDUCIAL A	**150.1**	**-59.1**	-1271.7
FIDUCIAL B	**149.2**	**-60.5**	-76.8
FIDUCIAL C		**-60.0**	
DOWNSTREAM C FRAME BOTTOM	56.4	**-56.1**	-187.8
DOWNSTREAM C FRAME TOP	56.4	**55.0**	-197.8
DOWNSTREAM C FRAME VERTICAL CENTER		**-0.6**	
DOWNSTREAM BEAM LEFT VACUUM BOX	**208.0**	69.2	-185.9
DOWNSTREAM BEAM RIGHT VACUUM BOX	**-207.6**	69.5	-160.0
DOWNSTREAM VACUUM BOX HORZ CENTER	**0.2**		
UPSTREAM BEAM LEFT VACUUM BOX	**208.1**	69.8	-1242.7
DOWNSTREAM BEAM LEFT TOP VACUUM BOX	124.3	**88.0**	-180.3
UPSTREAM BEAM LEFT TOP VACUUM BOX	171.1	**89.0**	-1234.9
DOWNSTREAM BEAM LEFT TOP OF BASE PLATE	182.9	**-81.4**	-88.3
DOWNSTREAM BEAM RIGHT TOP OF BASE PLATE	-153.7	**-80.8**	-93.2
UPSTREAM BEAM LEFT TOP OF BASE PLATE	180.5	**-80.5**	-1188.3
MEAS CALIPER HEIGHT OF VACUUM BOX AT UPSTREAM END		**177.4**	

a) Downstream. Laser tooling ball, Fiducials:

- Fiducial A (tooling ball on support plate, upstream, beam's left)
- Fiducial B (tooling ball on support plate, downstream, beam's left)
- Fiducial C (tooling ball on support plate, downstream, beam's right)

- **Measure position of downstream, lower, beam's right corner of upper C bar)**. Get corner by intersecting three planes.
  CUL (C frame, plane of lower surface of upper bar)
  CUD (C frame, plane of downstream surface of upper bar)
  CUR (C frame, plane of beam's right surface of upper bar)
- **Measure position of downstream, upper, beam's right corner of lower C bar**). Get corner by intersecting three planes.
  CLL (C frame, plane of upper surface of lower bar)

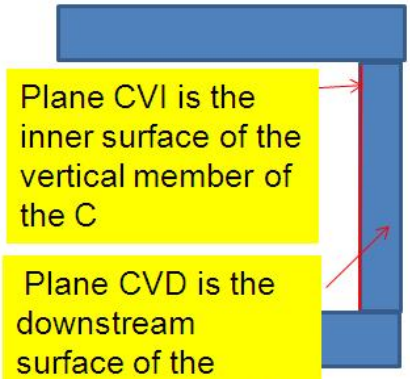
CLD (C frame, plane of downstream surface of lower bar)
CLR (C frame, plane of beam's right surface of upper bar)

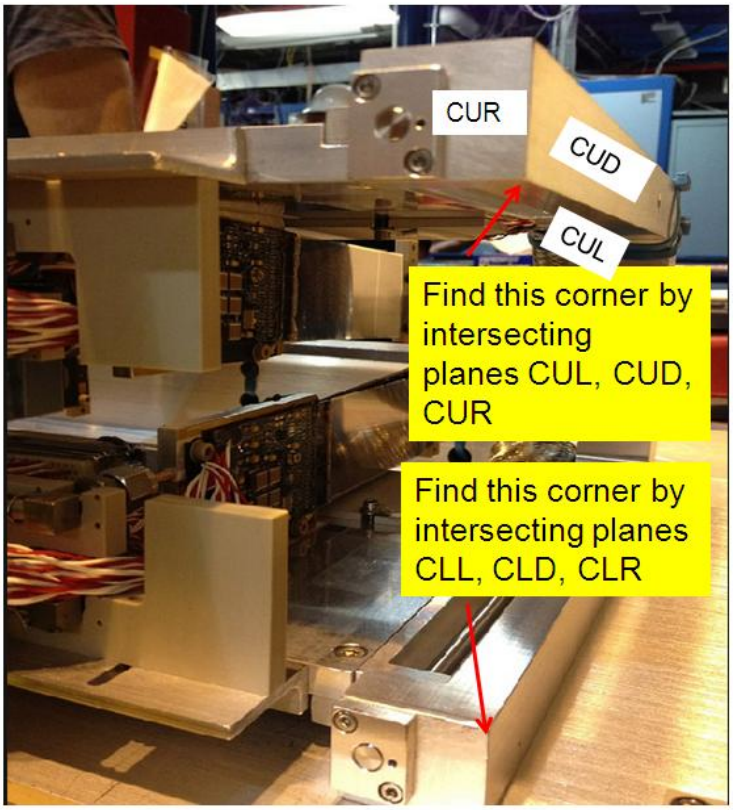
- **Measure vertical line formed by intersecting inner surface and downstream surface of C frame vertical member**
  CVI (C frame, plane of inner surface of vertical member)
  CVD (C frame, plane of downstream surface of vertical member)

View of "C" showing desired measurement positions

Measure three planes of upper and lower C bars, and determine corner locations

Measure the line of inter-section (shown in red) of Planes CVI and CVD





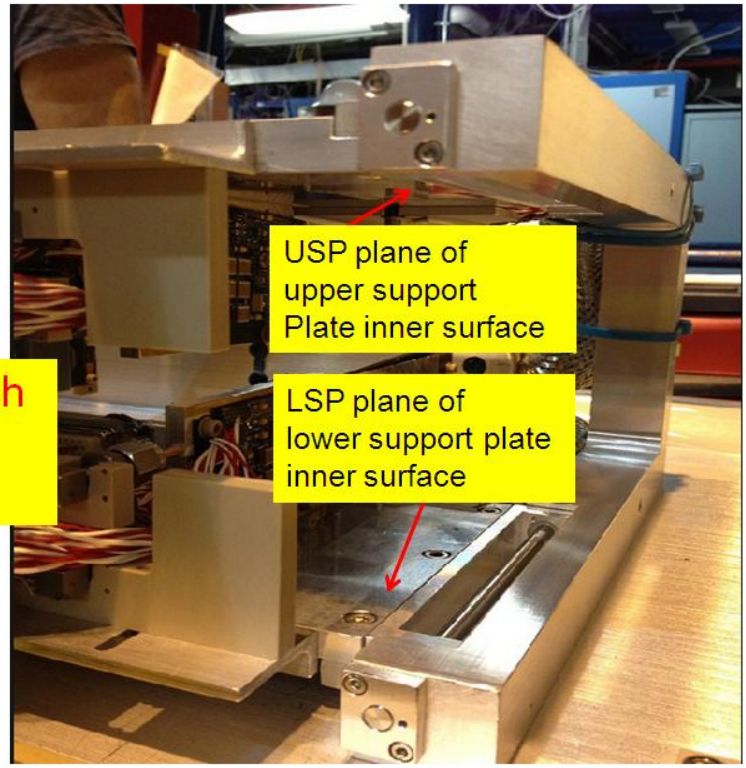
b) Requested Measurements II: Downstream laser tooling ball, cont.

Measure planes of upper and lower support plates near downstream end

- SP (plane of the lower support plane near downstream end)
- USP (plane of the upper support plane near downstream end)

View of support plates showing desired measurement positions

Measure planes of the inner surfaces of support plates at downstream end, both upper and lower plates



Be very careful not to touch Si detector or electronics Extremely delicate

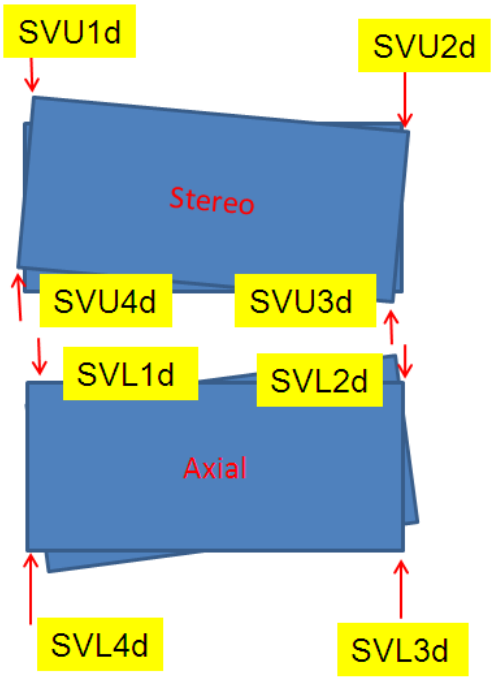
c) Measurements III: Downstream with level to measure vertical positions of corners of silicon sensor.

- SVU1d (Silicon , upper sensor, upper left corner)
- SVU2d (, upper right corner)
- SVU3d (, lower right corner)
- SVU4d (, lower left corner)

- SVL1d (Silicon, lower sensor, upper left corner)
- SVL2d (, upper right corner)
- SVL3d (, lower right corner)
- SVL4d (, lower left corner)

Downstream looking upstream

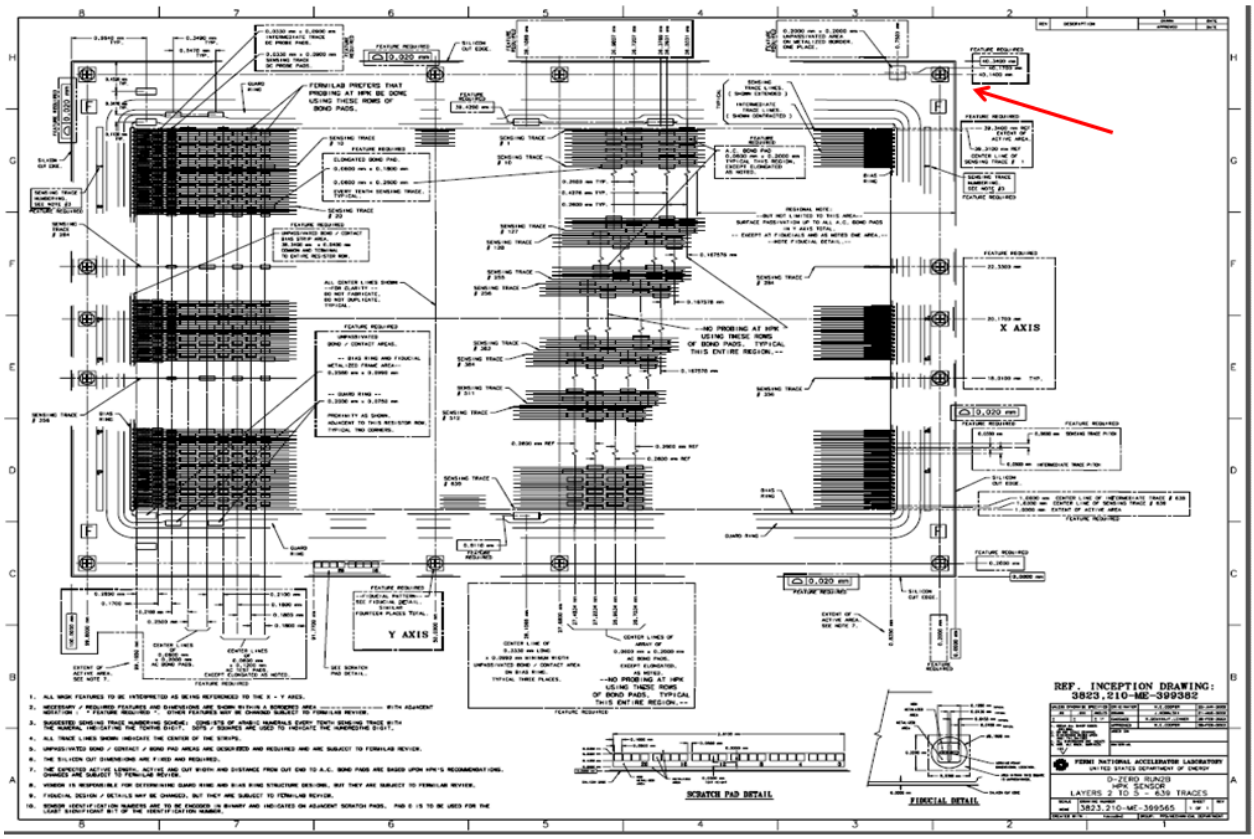
Vertical measurements (y) at all four corners of si wafer are top priority:
SVU1d, SVU2d, SVU3d, SVU4d for upper;
SVL1d, SVL2d, SVL3d, SVL4d for lower.



Do fiducials exist in the corners or are the corners of the silicon detectors measured?

- Above measurements assume can cleanly measure height (y) of the corners. Some corners should be cleanly visible; others may be harder to sight on.
- An alternative, if visible in the level, are fiducial markings placed on the surface of the silicon detectors. If they are used, please use the fiducials closest to the corner locations above.
- The fiducial locations are shown in the next slide.

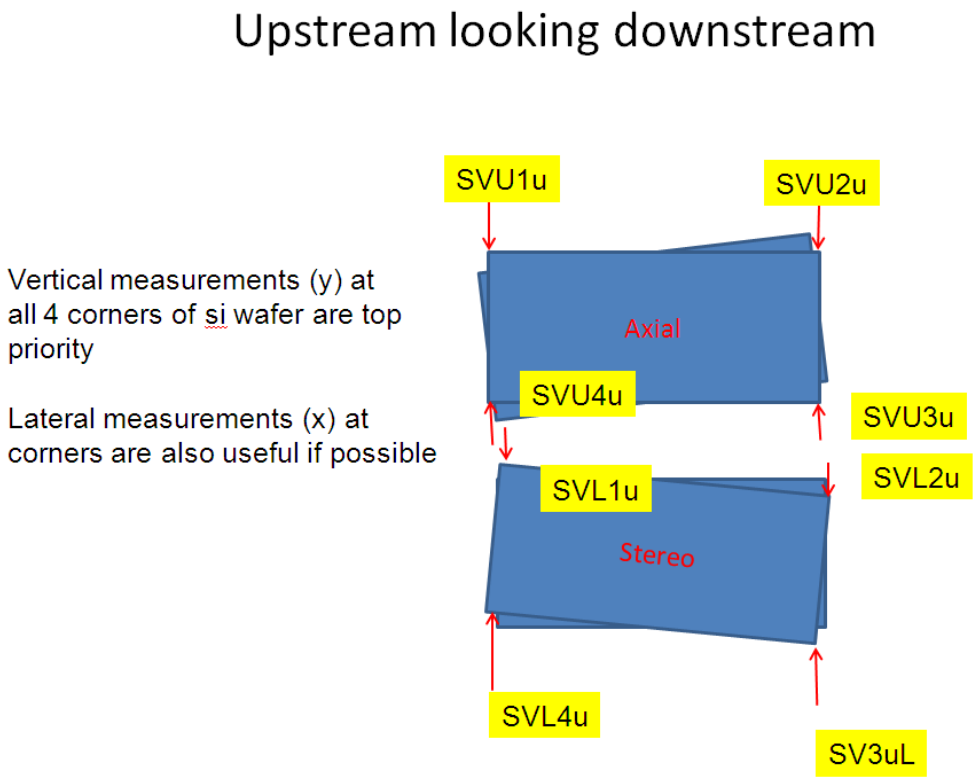
Silicon Detector Fiducials

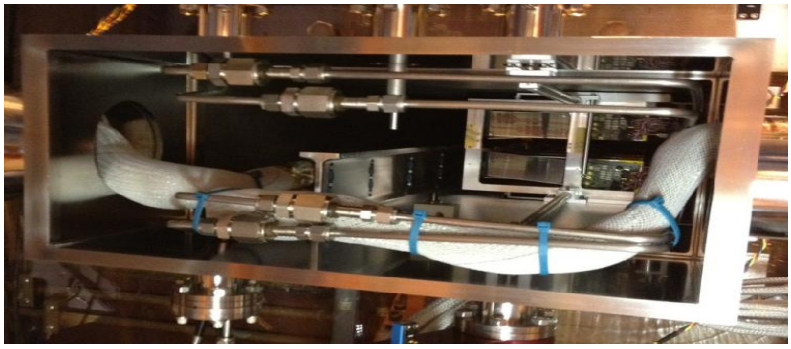


View from downstream of “C” and si modules

d) Measurements IV: Upstream with level to measure vertical positions of all four corners of silicon sensor.

- SVU1u (Silicon sensor, upper sensor, upper left corner)
- SVU2u (, upper right corner)
- SVU3u (, lower right corner)
- SVU4u (, lower left corner)
- SVL1u (Silicon sensor, lower sensor, upper left corner)
- SVL2u (, upper right corner)
- SVL3u (, lower right corner)
- SVL4u (, lower left corner)





View from upstream looking downstream, through SVT Vac Box
Note actual view has more interference with vertical mover rods

e) Measurements V: Measure Support Plates upstream end with laser tooling ball

Measure the lower corners of the upper support plate, beam's left and beam's right, and the upper corners of the lower support plate.

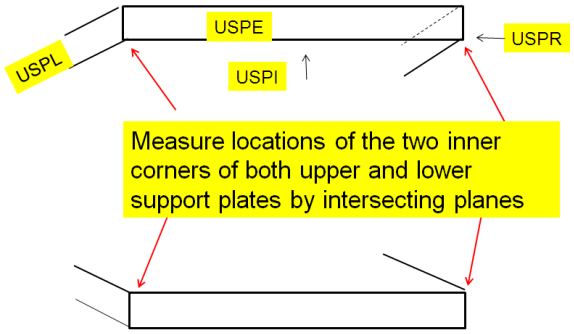
Determine corners by intersecting the relevant planes called out below.

- USPI (plane of inner surface of upper support plane)
- USPL (plane of the beam's left surface of the upper SP)
- USPR (plane of the beam's right surface of the upper SP)
- USPE (plane of the upstream end surface of the upper SP)

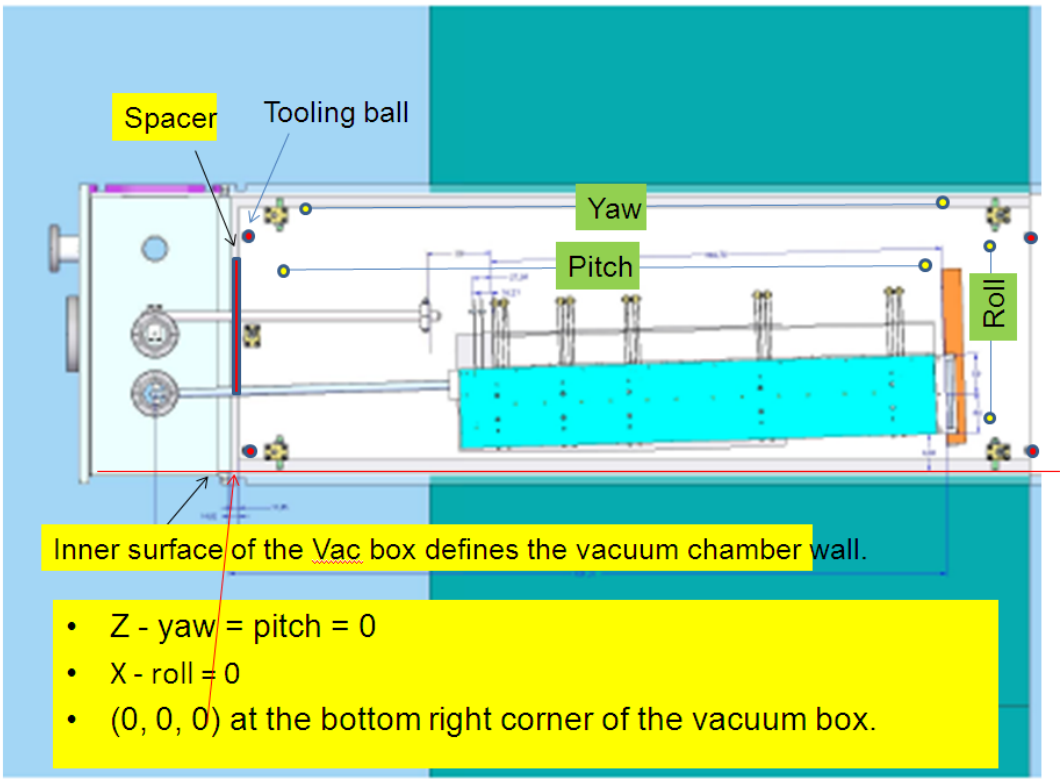
Repeat procedure for the lower support plate:

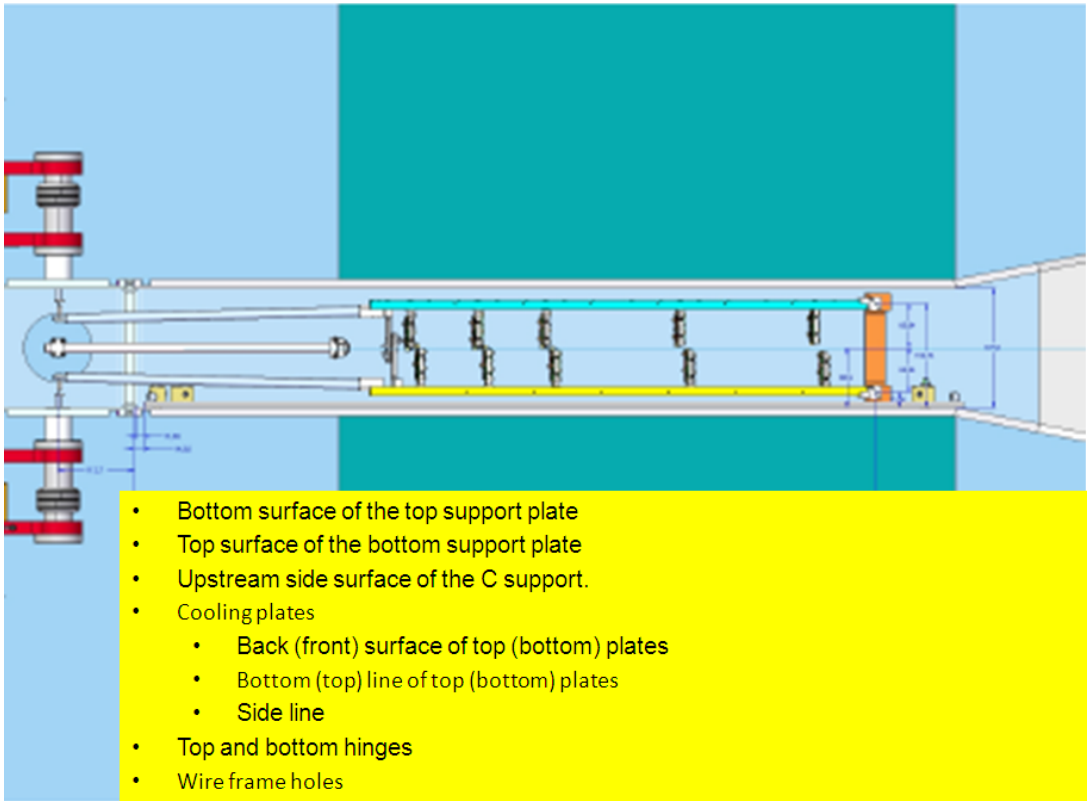
- LSPI
- LSPL
- LSPR
- LSPE

Upstream Measurements of Support Plates

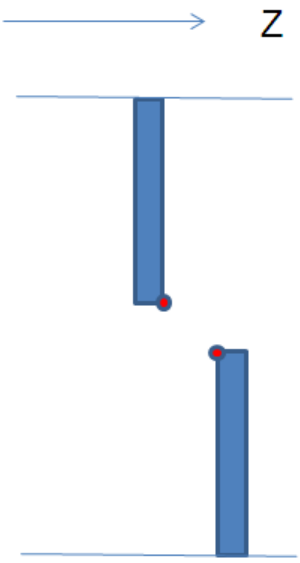


f) Survey Results





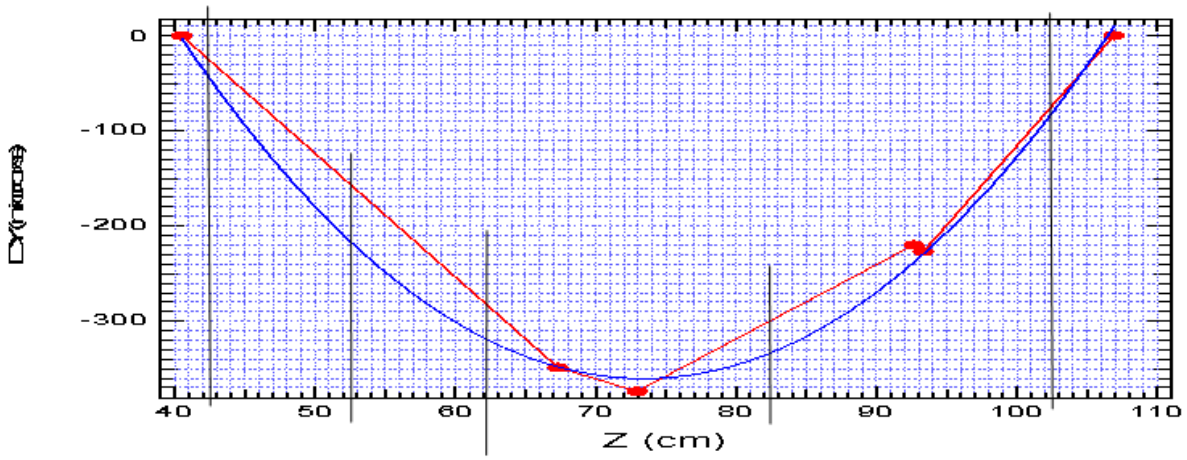
Cooling plates



	Z (mm)	X (mm)	Y (mm)	Pitch (mrad)	Yaw (mrad)
Top #1	+1.23	415.89	138.60	94.20 +0.05	5.4	28.2
Top #2		516.12	141.70	95.43 -0.17	2.2	28.6
Top #3		616.34	144.86	97.01 -0.14	-1.8	28.6
Top #4		816.07	150.78	96.63 -0.02	-0.6	30.1
Top #5		1016.10	156.85	99.84 +0.19	-1.7	28.9

	Z (mm)	X (mm)	Y (mm)	Pitch (mrad)	Yaw (mrad)
Bottom #1	+1.52	425.24	139.61	90.55 -0.18	3.0	28.8
Bottom #2		525.08	142.42	88.98 -0.40	0.9	29.3
Bottom #3		625.24	145.32	87.60 -0.43	3.7	29.1
Bottom #4		825.16	151.14	88.28 -0.54	3.2	28.8
Bottom #5		1024.67	156.64	85.99 -0.13	4.7	28.2

Support plate sag



	Sag (microns)	Sag wrt #1 (microns)	Dead zone (mr)
1	-45.6	0	15
2	-216.1	-170.5	15.85
3	321.2	-275.6	15.92
4	-332.9	-287.3	15.57
5	-81.8	-36.2	15.05

Hinges

	i	j	k	Diameter (mm)
Top	0.9996	-0.0010	-0.0292	6.01
Bottom	0.9996	-0.0006	-0.0294	5.95

	z	x	y	i	j	k
C-Clamp	1090.13	253.25	87.32	-0.0293	-0.0001	-0.9996