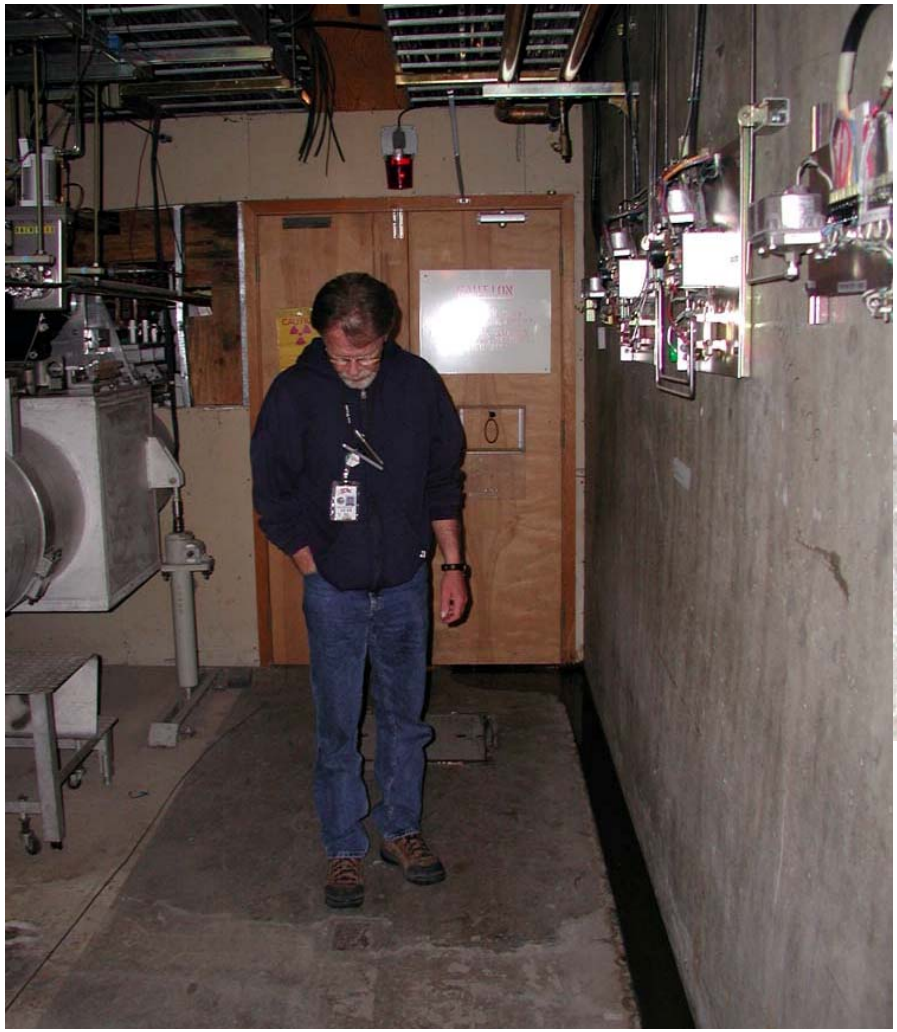
Station-100

From its Definition to its Realization
both in the Tunnel and Outside

Definition

- The “2 mile SLAC linac” is actually 10000 ft. It was designed with a downward slope heading eastward. In its middle, the slope of the accelerator with respect to the local gravity vector is 5 mrad. All the designs of the accelerator have been made in this pitched system which is called the linac system.
  - The z axis is the accelerator tube axis and the origin is at the beginning of the accelerator.
  - The y axis is perpendicular to the z axis pointing up in the plane of the accelerator and the gravity vector at the middle.
  - The x axis just completes the system to make it Right Handed.
- Instead of using the z coordinate as is, tradition asks for a station position along the accelerator:
  - Station-100 = 100+00 = (z=10000ft)
- The linac is divided into 30 sectors. So a sector is 333.333 ft long. There are marks on the floor to indicate the beginning of each sector:
  - Station-100 floor marker = tunnel brass plate 31

In the LinacTunnel



Station-100 linac floor marker

LCLS Undulator Coordinate System

E. Bong, P. Emma, C. LeCocq, T. Montagne, J. Welch

LCLS-TN-03-8, April 16, 2004

0.476
%Nominal
Slope of linac at
Station-100

Definition of
Station-100

10000ft=3048m

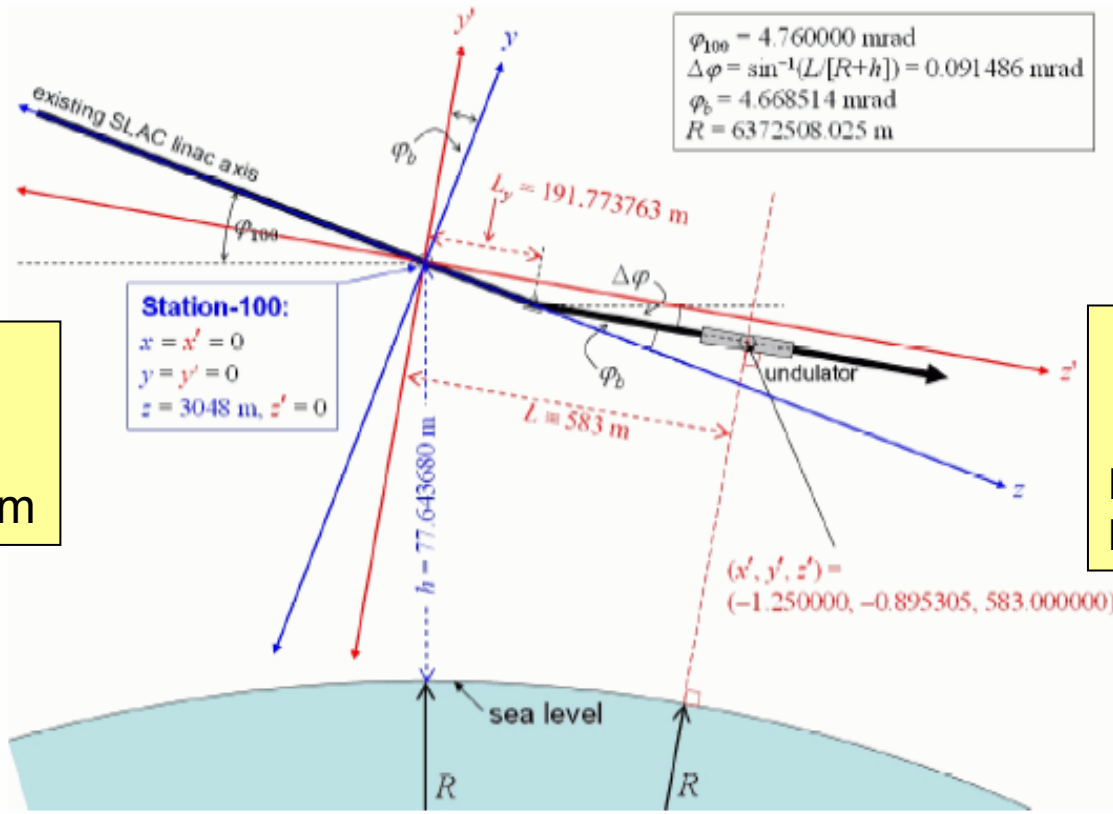


Figure 1: SLAC linac coordinate system (x, y, z), and LCLS undulator system (x', y', z').

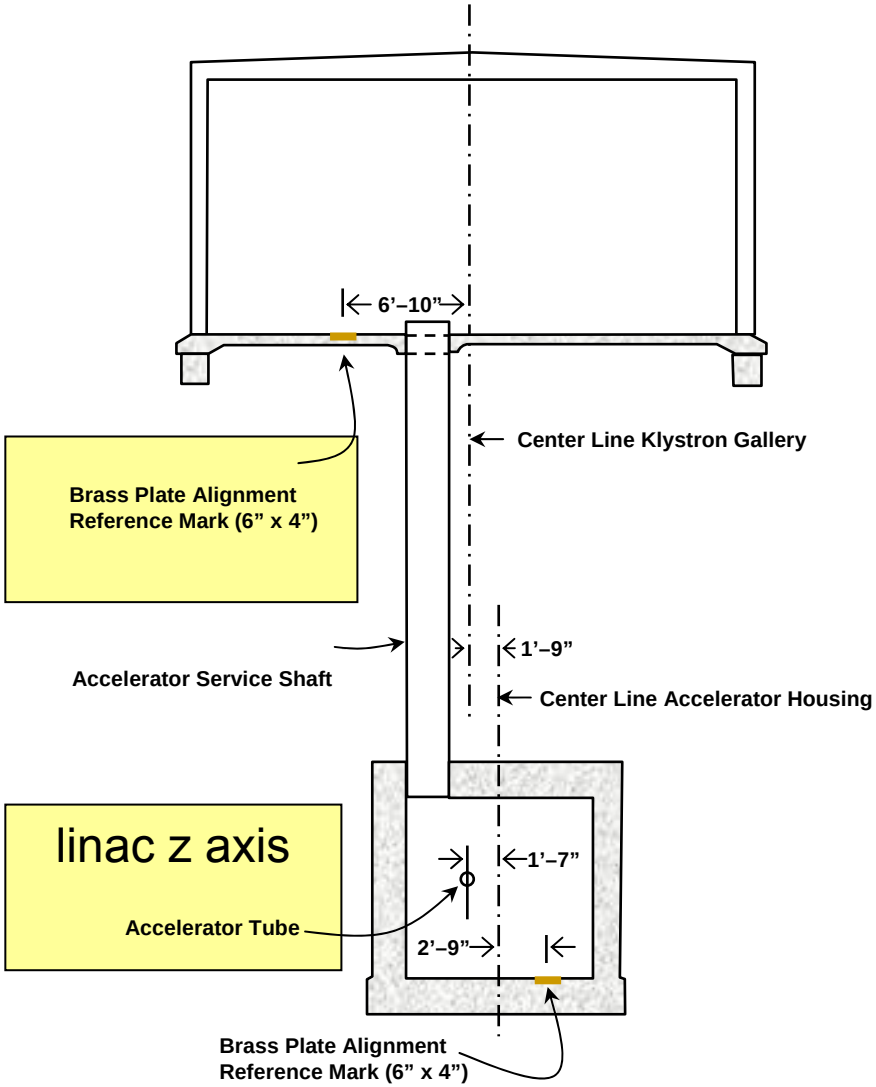
Values adopted
for SLC

R = 6372508.025m
MSL=77.643680m

How to Access this Information at the Surface Level

- During the linac construction, it was well thought of and a new set of brass plates were installed in the klystron gallery.
- During PEP construction, a set of 8 monuments were established (see “PEP Site Survey by the National Geodetic Survey” also known PTM #85 R1). None of these marks have been used recently.
- During the SLC construction, a set of 7 pillars and 5 other markers were installed around the campus and observed by a combination of theodolites, distance-meters and GPS observations:
  http://www-group.slac.stanford.edu/met/Align/GPS/GPS_Site_Network.html
- In the Research Yard, within the FFTB tunnel, the ESA and ESB buildings.

In the Klystron Gallery



Typical Section of

Klystron Gallery and

Accelerator Housing

Looking East

SLAC Drawing # SK - GE 5153 - A

Station-100

- In the linac system:
  - Station-100 is: z=10000' x=0 y=0
  - Station-100 floor marker is: z=10000' x=-4'4''
  - Station-100 klystron gallery marker is: z=10000' x=7'
- The transformation from the linac system to a leveled coordinate system centered at Station-100 is given by $Z = \cos(s_{100})\,(z-z_{100}) + \sin(s_{100})\,y$ where $s_{100}=0.00476$ rad.
  - Station-100 is: Z=0 X=0 Y=0
  - Station-100 floor marker is: Z = -0.0092m assuming that the floor is about 1.9m down from the beam.
- This value of -9.2mm was entered without its sign in the alignment database. A memo dated 10/30/91 states this fact and outlined its impact on the new FFTB magnet locations. The main consequence is that the SLC coordinate system origin has its origin shifted improperly 18.4mm. One should be reminded too that the slope of the linac at Station-100 was chosen as -0.474% by the SLC designers instead of the -0.476% value for the linac design.

So Where is Station-100 in the Tunnel?

- During the Summer Downtime of 2004, AEG performed a specific survey in the area of Station-100 in order to get the as-built positions of quads 50Q1, 50Q2 and 50Q3 as well as bend 50B1.
- There are no fiducials on these quads, so center positions were obtained by a combination of surface shots and as-built dimensions. The adjustment was carried out in the SLC monuments system.
- Later the results were expressed in the pitched linac system using the nominal pitch value for the accelerator at Station-100, i.e. -0.00476 rad.

	Pitched Linac				SLC Monument System		
	Z (m)	X (m)	Y (m)		Z (m)	X (m)	Y (m)
50Q1M	-1.84120	-0.00116	0.00093		89998.15883	69999.99884	2077.65339
50Q2M	14.31535	-0.00093	0.00085		90014.31519	69999.99907	2077.57641
50Q3M	18.82622	-0.00012	0.00109		90018.82601	69999.99988	2077.55518
50B1M	20.88911	-0.00129	0.00136		90020.88888	69999.99871	2077.54563
JP30_8*	-15.12174	-0.42367	-0.25295		89984.87723	69999.57634	2077.46273
JP30_9*	-2.77286	-0.42462	-0.25398		89997.22596	69999.57538	2077.40292
Sta100M	0.01806	-1.32608	-1.67538		90000.01008	69998.67392	2075.96825

** The x offset for the jack point fixture is 16.635"*

2004 AEG Tunnel Analysis

- X Analysis
  - The brass plate marker of Station-100 is measured at -1.32608 m. The design value as indicated in the drawing SK-GE-5153–A is 4’4’’, leading to a difference of about 5 mm.
  - The previous local survey was made on January 1997. Here is a summary table of the x position in mm:

	Q1	Q2	Q3	JP8	JP9
• 1997	-1.1	-1.0	-0.3	-1.1	-2.1
• 2004	-1.1	-0.9	-0.1	-1.1	-2.1

- Z Analysis
  - In the note LCLS-TN-03-8, two values are quoted from the deck :
    - Station-100 to Q1 -1.85754 m
    - Station-100 to Q2 14.32508 m
  - The numbers from the previous slide are referring to Station-100 implied in the monument coordinates, i.e. the one used for SLC. They must then be shifted by -18.4mm as indicated in the 10/30/91 alignment memo:
    - Station-100 to Q1 -1.84120 - 0.0184 = -1.85754 m
    - Station-100 to Q2 14.32508 - 0.0184 = 14.32508 m
  - The comparison of these two sets of numbers show a discrepancy of about 2 mm for Q1 and 28 mm for Q2. The same alignment memo states that “In October 1984, Q2 was moved upstream 2.5 cm because of mechanical interference with its installation”. With this in mind the 2004 measured z positions for Q1 and Q2 are respectively 2 mm and 3 mm upstream. Because of the choice of instrumentation, the limited geometry for the resections, the absence of fiducials on the quads and the difficulty to center on a mark on a brass plate, 0.5mm is a reasonable guess for the RMS on these z measurements.

2004 AEG Work for LCLS Layout

- Because of our GPS base station, AEG is now able to produce State Plane Coordinates for all outside work on the SLAC site:
- http://www-group.slac.stanford.edu/met/Align/GPS/GPS_Intro.html

- A transformation between SLAC and State grid has been established based on the following points:
  - Klystron gallery brass plates for sectors 1, 2, 3, 21, 28, 29, 30
  - M20 under metallic tower
  - SLC pillars: AAA, M32, M33, M36, M40, M41
  - Research yard points: SPPS010, 020, 040, 060, 070, 080, 090
- http://www-group.slac.stanford.edu/met/Align/LCLS/LCLS.html

SLAC-State Grid Transformation

http://www-group.slac.stanford.edu/met/Align/TechAnalysis/2004/LCLS_Direction_Layout_PartII.pdf

$$\begin{pmatrix} Z - Z_{M40} \\ X - X_{M40} \end{pmatrix} = k \begin{pmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{pmatrix} \begin{pmatrix} E - E_{M40} \\ N - N_{M40} \end{pmatrix}$$

ZM40 = 60.54993 m	α = 7.498092°	EM40 = 1849150.024 m
XM40 = -2.41764 m	k = 1.000055	NM40 = 603088.745 m

$$\begin{pmatrix} E - E_{M40} \\ N - N_{M40} \end{pmatrix} = k^{-1} \begin{pmatrix} \cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha \end{pmatrix} \begin{pmatrix} Z - Z_{M40} \\ X - X_{M40} \end{pmatrix}$$

N.B. This model has been designed for general mapping purposes. It is a "cm transformation".

So Where is Station-100 in the Open?