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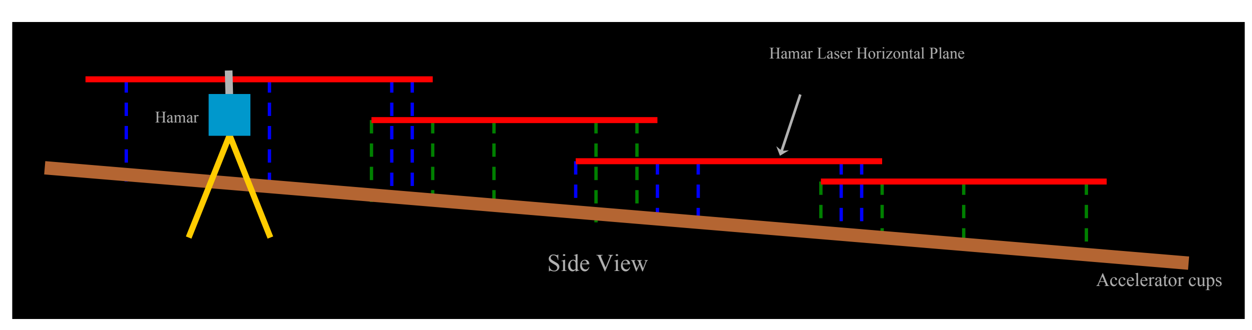
3D Arcing for Offset Measurements with a Hamar Laser

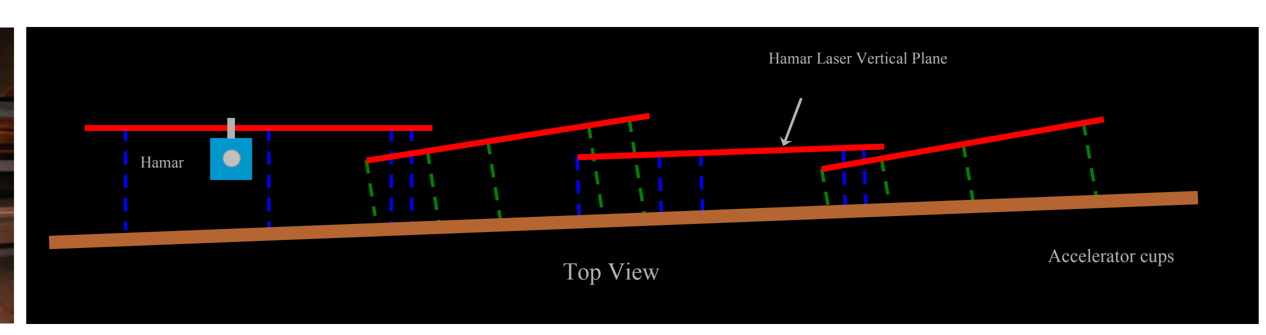
STANFORD LINEAR ACCELERATOR CENTER*

The L-722 Dual Scan Hamar Laser provides two laser planes that are square to one arc second and flat to half an arc second. The enables both a horizontal offset and height measurement to be made using only one setup. This presentation illustrates how the Hamar Laser can be used to align SLAC's accelerator cups making up the three km long LINAC. The read-out unit is attached to a rod allowing for multi-directional arcing thus providing the orthogonal distance to the laser plane. Special Windows software with audio feedback is created so that only one operator needs to be present for the survey.

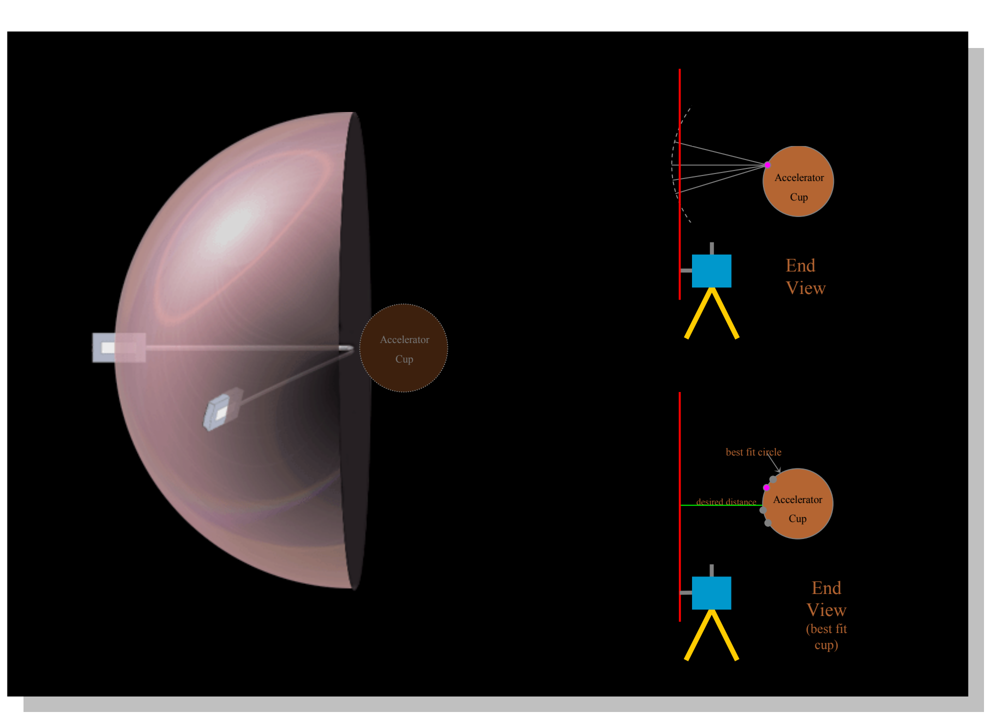
Testing the Hamar Laser on Accelerator Cups



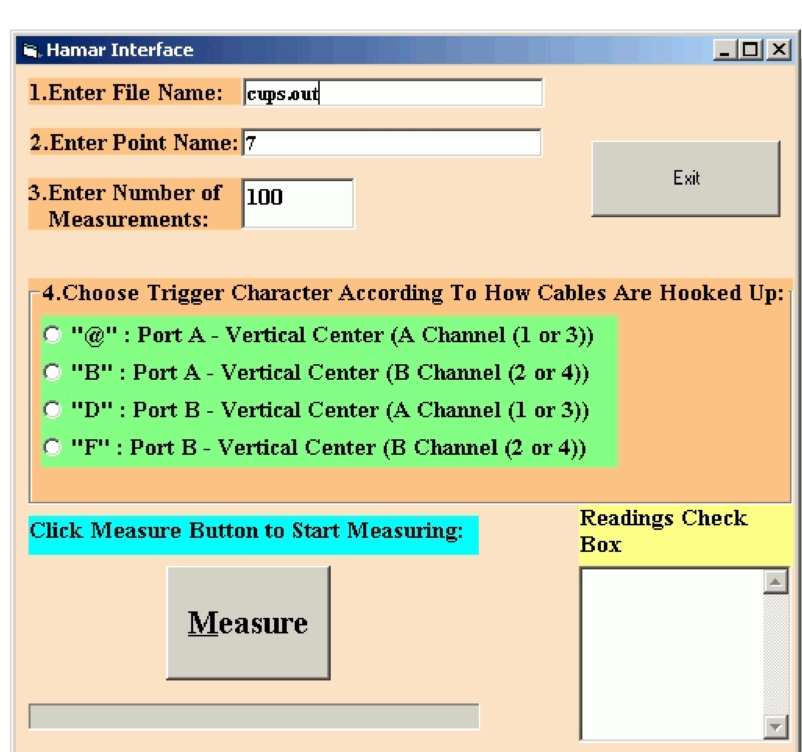
The relative horizontal position of the cups is measured. In the drawings one can see a top or side view of the stack of accelerator cups with the Hamar laser positioned to one side. In both views planes for three more set-ups is shown. By overlapping some of the cups being measured each subsequent set-up, a common reference can be computed. This establishes a continuous survey of relative cup positions. For example, by using the horizontal plane, the relative position (height) of the cups will be measured along the whole length (note the exaggerated slope in the drawing). Only one set-up is needed next to the beam-line to simultaneously measure both planes and a perfectly bucked-in line is not necessary.



Minimum Distance



The read-out unit follows the shape of a sphere as the rod is arced. Fitting to this sphere will not be necessary to solve for the distance since the operator invariably arcs the rod through the orthogonal position and the computer easily finds the smallest value. To measure an accelerator cup it was thought necessary to repeat this spherical "arcing" for at least three other points on the same cup (see figure). Once a minimum of four points have been measured along with their spacing, a circle fit could automatically compute the value that represents the desired minimum distance (again, see figure). This fit was thought to be necessary to guarantee that the most accurate final orthogonal value would be found. On the contrary, testing has shown that the operator can easily place the rod at the most extreme cup position (within the accuracy of the Hamar unit) without any additional data. This means that only one point per cup is necessary.



Repeatability Test Results

Test Number	Reading (mm)	Std Dev (µm)
1	-1.5842	± 27
2	-1.2342	± 16
3	0.4264	± 308*
4	-2.3595	± 19
5	-0.9004	± 16
6	-2.1387	± 22
7	-2.6213	± 21
8	-2.0244	± 19
9	-1.7215	± 19
10	-1.0349	± 39
		* rod slipped

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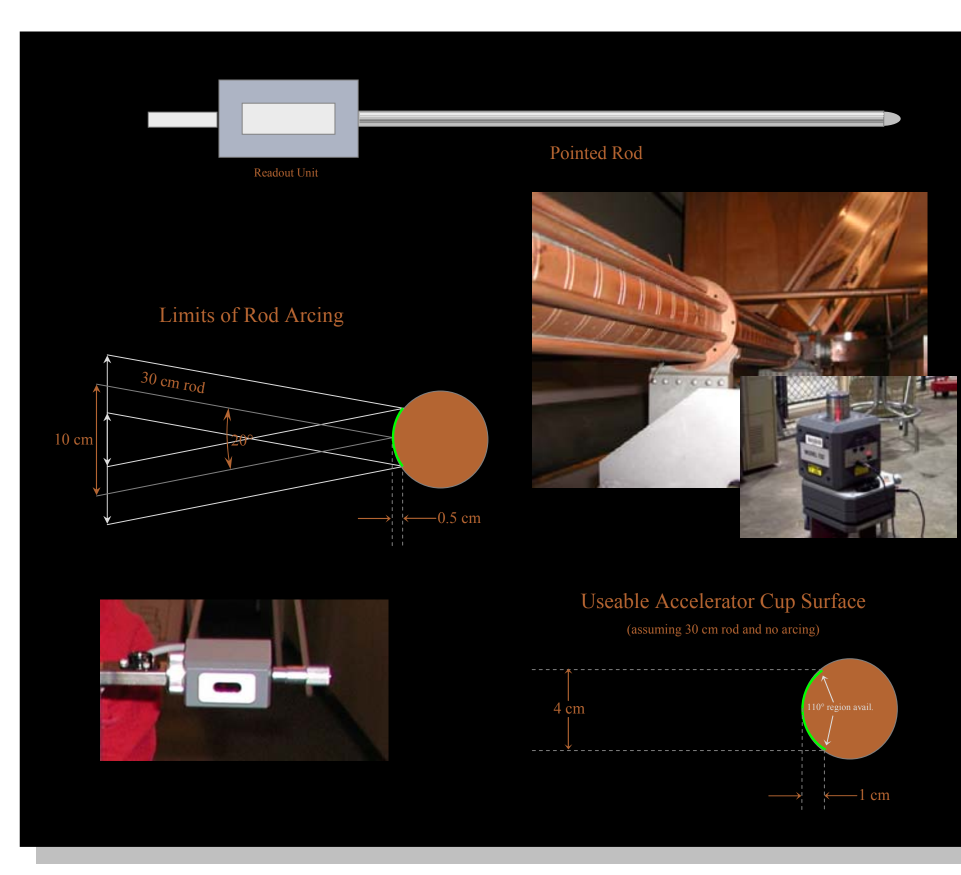
* The Stanford Linear Accelerator Center is operated by Stanford University for the U.S. Department of Energy

Measurable Cup Surface



The above illustrations demonstrate what portion of the accelerator cup is measurable. The desired measurement is the shortest orthogonal distance to the cup relative to the plane created by the Hamar laser (see "Minimum Distance" section to the left). The read-out unit is attached to the end of a pointed rod. The point on the other end is placed against the cup of interest and arced as one does in traditional optical tooling, *except* that instead of measuring the smallest distance while arcing in a circle, one measures the smallest distance *while arcing through a sphere* (see "Minimum Distance" section again). Each time a new minimum distance is found, the connected laptop computer emits a distinct sound effect. By using sound, only one operator needs to be present during the measurements since auditory feedback provides all the necessary information.