Stanford Linear Accelerator Center, Stanford, California, USA

Portable Wire Measurement System

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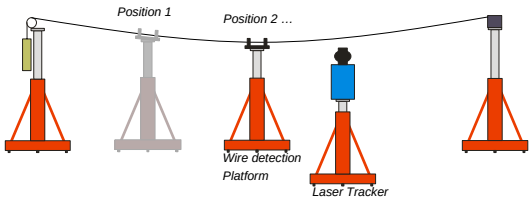
SLAC is building the Linac Coherent Light Source (LCLS), a machine which introduces new challenges to the alignment process. Electron beams can be steered with magnets, we do not have this option with light, therefore it is necessary to position components relative to each other (+/- 0.8 mm) over long distances (500 meters). The setup is in a narrow tunnel where traditional network measurements can not be applied to achieve this accuracy. A solution is to introduce a tensioned wire spanning several hundred meters that defines a straight line. Measurements to the wire are integrated into the traditional network measurements, thereby stiffening the network. In this poster we present our portable wire measurement system, its development and investigations.

Introduction

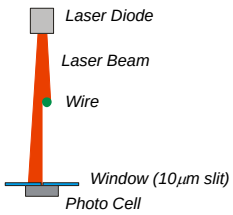
The principle of these wire measurements is to use the straightness of a stretched wire and to measure to this straight line at multiple points. For this particular system a platform is used which can be positioned relative to the wire. The platform carries a prism in order to integrate the wire measurements into regular network measurements. To avoid any errors based on different sensors, this system uses only one mobile platform which is always positioned relative to the wire in the same way.



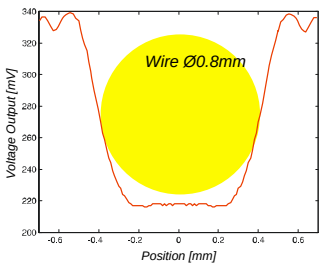
Wire Detection System

A monofilament fishing line (80lb test) is used for the wire due to its good weight to strength ratio and its smooth surface. We position our platform relative to it and use the platform as a representation of the straight line.
The detection of the wire is based on the partial blockage of a laser beam by the wire before it reaches a photo sensor. In front of the photo sensor is a 10 micrometer wide window to increase the sensitivity of the system.

Laser system



Scan of a wire with the laser system



Measurement Platform

The platform has 4 wire detectors, two vertical and two horizontal. They are used to position the platform in the x-and y-direction and to set the yaw and the pitch. The roll of the platform is controlled by a bubble level.

To reduce electronic drift or the influence of ambient light on the readings we measure both sides of the wire thus measuring two points in a short period of time and in close spatial proximity. The mean value of the two readings represents the center of the wire.

System Details

Air Flow

One problem with a long wire is its exposure to airflow which results in vibration and deflection of the wire. An experiment with a 250 m wire resulted in vibrations with an amplitude of > 100 μm. A solution is to surround the wire with plastic sheets.

Kinks

To determine the effect of kinks in the wire two parallel wires were stretched over a distance of 80 m and the distance between them was measured at multiple points with an interferometer. After deliberately introducing a kink in the wire the measurements were repeated. No measurable effect of the kink could be found.

Electro static charge

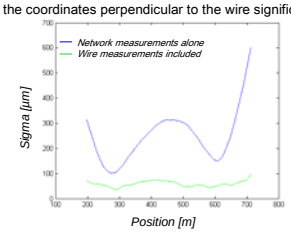
There is no measurable deflection of the wire by charging the plastic cover. A charged Plexiglas rod held 20 mm from the line results in a deflection of 20 μm. The effect of plastic sheets is expected to be 25-100 times smaller. As a precaution the relative humidity can be increased by spraying water onto the plastic sheets thereby discharging the plastic.

Network Results

For the installation of a new experiment a network had to be setup. Over a distance of 500 m we installed 393 points and measured 1146 triplets (distance, Hz- and V- angle) from 69 tracker setups, 465 height differences and 57 wire offset measurements to two wires (240m long and 370m long).
For the calculation of the network we assumed the following standard deviations:
Laser Tracker: σ_D=50 μm, σ_{Hz}=70 μm/m, σ_V=100 μm/m
Level: $\sigma_{\Delta h}$=70 μm
Wire offset measurement: $\sigma_{\Delta o}$=30 μm

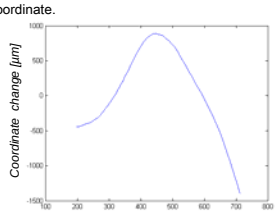
Impact of wire on standard deviations

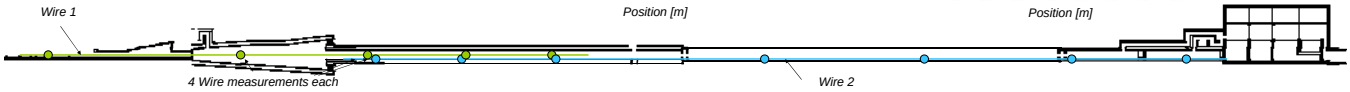
The wire measurements improve the a posteriori std. of the coordinates perpendicular to the wire significantly.



Impact of wire on coordinates

The wire measurements also changed the estimated coordinate.





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