

CALIFORNIA INSTITUTE OF TECHNOLOGY
Laser Interferometer Gravitational Wave Observatory (LIGO) Project

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Subject: LIGO Coordinate System

In response to Action Item #46 (Project Control Meeting), we propose that the following (or similar) designation of a LIGO coordinate system be incorporated into the LIGO System Specification. Terminology here (e.g., "corner station," "end station," "right arm") follows that defined in Vol. 2, Section IV.A (p.10) of the LIGO construction proposal. We recommend that a section of the System Specification be allocated to defining these terms.

The coordinate systems specified below consist of a set of local "plumb" systems, one for each LIGO building, linked together by a "facility global" coordinate system for each site which describes the optical plane of the facility. For essentially all construction purposes identified to date, the local "plumb" systems can be used for hardware assembly/installation, occasionally supplemented by a correction angle between the local and facility global coordinates. The global systems are used for surveying and locating each building (including fiducial reference points within each building for use with the local coordinate systems), and construction of the beam tubes.

A separate document with interpretive information and tables of useful numbers (e.g., angles between coordinate system axes) may prove to be of value, but can be separated from the System Specification.

x.1. DEFINITIONS

x.1.1 Facility Global Coordinate System

Each LIGO facility is characterized by a right-handed Cartesian coordinate system (XG, YG, ZG) defined as follows:

- the XG axis lies along the nominal clear aperture axis of the right arm (Northwest arm, WA site; Southwest arm, LA site) of the LIGO vacuum system.
- the YG axis lies along the nominal clear aperture axis of the left arm (Southwest arm, WA site; Southeast arm, LA site) of the LIGO vacuum system.
- the great circle planes containing the XG and YG axes are orthogonal.

- the XG and YG axes intersect at a point inside the corner station; this point is the origin of the facility global coordinate system.
- the ZG axis passes through the origin and is normal to the plane defined by the XG and YG axes.
- positive directions for XG and YG proceed from the corner station toward the end stations; the positive direction for ZG proceeds away from the earth.

x.1.2 Building Coordinate Systems

Each LIGO building is characterized by a locally defined right-handed Cartesian coordinate system (x, y, z), connected to the facility global coordinate system, as follows:

x.1.2.1 Corner station coordinate system

- the x and y axes are horizontal and point toward the end stations; the z axis points toward the zenith.
- the x and y axes lie in the great circle planes containing the XG and YG axes.
- the origin of the corner station coordinate system coincides with the origin of the facility global coordinate system.

x.1.2.2 Right-arm mid and end station coordinate systems

- the x and y axes are locally horizontal; the z axis points toward the zenith.
- the x axis lies in the great circle plane containing the XG axis.
- the origin of the end station coordinate system lies on the XG axis at the global position $XG=4000.00\text{m}$ (TBR); the origin of the mid station (WA site only) coordinate system lies on the XG axis at $XG=2018.00\text{m}$ (TBR). These locations correspond to the central axis of the initial test mass chamber installation in each building.
- the origin of the mid point (LA site only) coordinate system lies on the XG axis at $XG=\text{TBD}$.

x.1.2.2 Left-arm mid and end station coordinate systems

- the x and y axes are locally horizontal; the z axis points toward the zenith.
- the y axis lies in the great circle plane containing the YG axis.
- the origin of the end station coordinate system lies on the YG axis at the global position $YG=4000.00\text{m}$ (TBR); the origin of the mid station (WA site only) coordinate system lies on the YG axis at $YG=2018.00\text{m}$ (TBR).
- the origin of the mid point (LA site only) coordinate system lies on the YG axis at $YG=\text{TBD}$.

2. SPECIFICATION

The coordinate systems defined above are specified (for each facility) by:

- the latitude, longitude and elevation of the origin of the facility global coordinate system;

- the directions of the great circle planes containing the XG and YG axes; and
- the elevation of the origins of the local coordinate systems for each end station.

These points are referenced to survey reports and are anticipated to be updated from time to time as new survey data become available.

WA SITE

Origin:	Latitude:	TBD, ref. tbd
	Longitude:	TBD, ref. tbd
	Elevation (EL ₀):	TBD, ref. tbd
XG axis:	Direction:	TBD, ref. tbd
	Elevation @ XG=4000m	=EL ₀ -1.22m (TBR)
YG axis:	Direction:	TBD, ref. tbd
	Elevation @ YG=4000m	=EL ₀ +1.22m (TBR)

LA SITE

Origin:	Latitude:	TBD, ref. tbd
	Longitude:	TBD, ref. tbd
	Elevation (EL ₀):	TBD, ref. tbd
XG axis:	Direction:	TBD, ref. tbd
	Elevation @ XG=4000m	=EL ₀ (TBR)
YG axis:	Direction:	TBD, ref. tbd
	Elevation @ YG=4000m	=EL ₀ -1.22m (TBR)

WEA:bb

cc: G. Sanders

Chronological File

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