COMPONENT SPECIFICATION

Pick Off Telescope Requirements

APPROVALS:	DATE	REV	DCN NO	BY	CHK	DCC	DATE
drawn: Michael Smith, Jonathan Kern	8/28/98						
CHECKED:							
APPROVED:							
DCC RELEASE:							

1 SCOPE

This is a specification for the PO Telescope. This device is an afocal, off-axis Mersenne reflecting 8X beam-reducing telescope.

2 APPLICABLE DOCUMENTS

2.1. LIGO Documents

LIGO-960641-05, Electronic Submissions to the Document Control Center
LIGO-E960022, Vacuum Compatibility, Cleaning Methods and Compatibility Procedures
LIGO-E960050, Vacuum Compatible materials list
LIGO-E980129-00-D, Ligonian VI-B, 8x magnification, 1.3m,
AutoCAD 14 files, See “Preliminary Design of PO Telescope” on page 7.

2.2. Other Documents

MIL-C-675C

3 REQUIREMENTS

3.1. Performance characteristics

3.1.1. Optical Characteristics

3.1.1.1 Clear Aperture

The mirrors and the mechanical assembly shall allow unobstructed passage of an entering 160mm diameter collimated optical beam centered on the optical axis, which exits through the output port as a 20mm diameter collimated beam.

3.1.1.2 Primary Mirror

3.1.1.2.1 Front Surface

Radius of curvature -3048 mm +/- 30

Conic constant	-1.000 +/- 0.002
Tilt tolerance, reference to back surface	+/- 0.003 deg
Clear aperture	200.7 mm
Edge displacement	108.00 +/- 0.12 mm
Diameter	203.2 +0.0, -0.1 mm
minimum edge thickness	43 mm +/- 0.5 mm
Surface quality	<l/8 wave peak to valley@ 633 nm over clear aperture
Surface finish	60/40
Surface roughness	<100 Ang

3.1.1.2.2 Back Surface

Surface quality	fine ground, >300 grit

3.1.1.3 Secondary Mirror

3.1.1.3.1 Front Surface

Radius of curvature	-381 mm +/- 4
Conic constant	-1.000 +/- 0.002
Tilt tolerance, reference to back surface	+/- 0.003 deg
Clear aperture	32.0 mm
Off-axis displacement	26.20 +/- 0.01 mm
Diameter	34.0 +0.0, -0.1 mm
Minimum edge thickness	20.0 +/-0.1 mm
Surface quality	<l/8 wave peak to valley@ 633 nm over clear aperture
Surface finish	60/40
Surface roughness	<100 Ang

3.1.1.3.2 Back Surface

Surface quality	fine ground, >300 grit

3.1.1.4 Mirror Coating

Front surface only	
Wavelength	1064 nm
Polarization	s
Incidence angle	4 deg
Reflectivity	>99.9%
Durability	per MIL-C-675C

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3.2. DESIGN AND CONSTRUCTION

3.2.1. Materials

3.2.1.1 Mirrors

Substrate material	Zerodur or fused silica
Edge chamfer	0.25 mm @ 45 deg +/- 10deg

3.2.1.2 Mechanical Parts

It is desired that aluminum be used for all metal components, to the greatest extent possible. All materials must conform to LIGO document “LIGO-E960050, Vacuum Compatible materials list”. No anodizing, lubricants or elastomers are permitted, and all machined parts must be machined dry (no coolants, except water). Care must be taken in selecting materials which are threaded or slide against one another, to prevent galling.

3.2.2. Mechanical Characteristics

3.2.2.1 PO Telescope Mechanical Assemblies

The PO Telescope consists of the following mechanical assemblies: 1)primary mirror mount, 2)secondary mirror mount, 3)telescope housing, 4)optical reference plate, 5) output flange, 6)front support, 7)tilt yoke, 8)height and tilt alignment fixtures, 9)input aperture alignment target, and 10) primary mirror aperture alignment target.

3.2.2.2 Telescope Configuration

The PO Telescope is used in two orientations, 1) **down**, primary mirror on the bottom, and 2) **up**, primary mirror on the top; in conjunction with two fixed heights and two adjustable heights; for a total of eight unique configurations; as shown in figure 1. The optical centerline height and the pitch angle are determined by the lengths and the attachment points of the front support and the rear tilt yoke support. The yaw angle is determined by translating the front support parallel to the optical table with respect to the rear tilt yoke support. The front of the telescope is the end where the secondary mirror is mounted, and the rear of the telescope is the end where the primary mirror is mounted.

3.2.2.3 Telescope Supports

All eight configurations and optical centerline heights shall be set with only three universal supports: 1) fixed length front support, 2) fixed length rear support, and 3) tilt yoke.

3.2.2.4 Height and Tilt Adjustment Range

As a minimum; the height, height range, and tilt angle adjustments shall cover the range of values shown in Table 1 on page 4. The heights are measured from the surface of the optical table.

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PO Telescope		Relative dim, in			
		nominal height gimbal, in	nominal height front support, in	height range, in	tilt angle, deg
2K	ITMx	17.87	17.87	0.0	0.0
2K	ITMy	17.87	17.87	0.0	-0.2
2K	APS	10.43	10.40	0.5	-1.1
2K	BS	17.87	17.87	0.0	-0.1
4K	ITMy	15.91	15.91	0.0	0.0
4K	ITMx	15.91	15.91	0.0	0.0
4K	APS	8.78	8.75	0.5	-1.1
4K	BS	15.91	15.89	0.0	-0.6

Table 1: Height, height range, and tilt angle for the PO Telescopes

Additional mounting holes shall be provided on the sides of the telescope housing so that the front telescope supports can be moved to eliminate mechanical interferences with adjacent telescopes.

3.2.2.5 Focussing and Alignment of the Output Beam

The specified secondary mirror mount will provide focussing and alignment adjustments for the output beam. See “Secondary Mirror Mount” on page 6.

3.2.2.6 Positioning and Fastening Requirements

The telescope assembly shall be positioned anywhere and securely fastened to the surface of the HAM SEI optical platform by means of the array of 1/4-20 tapped holes in a 2in X 2in pattern on the platform using clamps, as shown in figures 3, 4, 5 , and 6.

3.2.2.7 Height and Tilt Alignment Fixtures

3.2.2.7.1 Tilt Yoke Assembly, Differential Screw Mover

The differential screw mover, as shown in figure 2. shall translate the tilt yoke assembly transverse to the optical axis within the required positioning range, with a minimum positioning repeatability of 0.01 inch.

3.2.2.7.2 Pitch Adjustment Mechanism

A removable pitch adjustment mechanism will be positioned under the PO Telescope approximately at the center of gravity to provide a fine pitch tilt adjustment. The pitch adjustment mechanism shall provide all the required pitch angles, within a minimum angle repeatability of 5×10^{-5} rad. The pitch adjustment mechanism

shall allow the PO Telescope to translate in the plane of the optical table, while maintaining the minimum tilt repeatability.

3.2.2.7.3 Yaw Adjustment Mechanism

A removable yaw adjustment mechanism will be positioned at the front end of the PO Telescope to provide a fine yaw tilt adjustment. The yaw adjustment mechanism shall provide all the required yaw angles, within a minimum angle repeatability of 5×10^{-5} rad.

3.2.2.8 Input Aperture Alignment Target

A removable alignment target shall be placed at the entrance aperture of the PO Telescope within $\pm10\times10^{-3}$ in of the optical centerline.

3.2.2.9 Primary Mirror Aperture Alignment Target

A removable alignment target shall be placed in front of the primary mirror of the PO Telescope within $\pm10\times10^{-3}$ in of the optical centerline.

3.2.2.10 Optical Reference Surface

The optical reference surface shall be mounted perpendicular to the sides of the housing to within $\pm0.7\times10^{-3}$ rad.

3.2.2.11 Output Flange

An alignment telescope (not part of this specification) will be centered co-linear with the output optical centerline by means of the output flange which mounts to the optical reference surface. An adjustment means will be provided so that the output flange shall be positioned to within $\pm10\times10^{-3}$ in of the optical centerline, with a minimum positional repeatability of $\pm2\times10^{-3}$ in. The inside bore of the output flange shall be perpendicular to the optical reference surface to within 5×10^{-5} rad.

3.2.2.12 Mechanical Tolerances

3.2.2.12.1 Primary Mirror Mount

The flat mounting surface of the primary mirror shall be fixed mounted parallel to the optical reference surface within $\pm5\times10^{-5}$ rad.

The center of the primary mirror shall be fixed mounted within $\pm4\times10^{-3}$ in of the nominal primary mirror optical centerline.

3.2.2.12.2 Secondary Mirror Mount

The PO Telescope housing shall provide a compatible mounting interface for the secondary mirror mount whose preliminary design is detailed in the following referenced drawings.

LIGO-D980314-00-D - Y-Axis Top Plate <Secondary Mount
LIGO-D980315-00-D - X-Y Interface Plate <Secondary Mount
LIGO-D980316-00-D - Y-Top End Plate <Secondary Mount
LIGO-D980317-00-D - X-Axis Way Plate <Secondary Mount
LIGO-D980318-00-D - Fixture Spring Block <Secondary Mount
LIGO-D980319-00-D - Flexure <Secondary Mount
LIGO-D980320-00-D - End Plate <Secondary Mount
LIGO-D980321-00-D - Angle Plate <Secondary Mount

3.2.2.13 Mechanical Vibration Characteristics

The telescope, and its associated mounting structure shall have no internal mechanical resonances <100Hz.

3.2.2.14 Size and Weight

- Maximum size envelope — See “PO Telescope, side and end view” on page 9.
- Maximum weight of telescope without supports — <55 lb

3.2.3. MARKING

3.2.3.1 Optical Alignment Marks

Edge tick-mark shall be placed to indicate orientation of mirror next to the optical axis:

- 0.24 +/- 0.05 mm wide x 20 mm +/- 2 mm long.

3.2.3.2 Optical Serial Number

A serial number identifying a component set of primary and secondary mirrors shall be etched, ground or sand-blasted next to the alignment mark. The serial number shall be of the format PAR-XX-Z, where

- XX is incremental for each set of mirrors, starting at 01
- Z is the current revision letter of this specification

3.2.3.3 Mechanical Serial Number

A serial number shall be etched, ground or sandblasted on each telescope housing. The serial number shall be of the format PAR-XX-Z,, where

- XX is incremental for each housing, starting at 01

- Z is the current revision letter of this specification

4 TEST PROCEDURES

The assembled telescope performance shall be verified by the following test procedures

4.1. WAVEFRONT DISTORTION

Interferogram of transmitted wavefront across clear aperture, @1064nm wavelength

4.2. Transmissivity

Transmissivity measurement across clear aperture, @1064nm wavelength

4.3. Vibration Test

TBD

5 DOCUMENTATION

- 1) Vibration analysis
- 2) Working drawings for component parts, in AutoCad 14 format on LIGO title block
- 3) Top assembly drawing, in AutoCad 14 format on LIGO title block
- 4) DOD-STD-100,MIL-STD-1000 and ANSI-Y14.5M 1982 standards applied where appropriate
- 5) Compliance Certification for items 3.1, 3.2, 3.3 and 4.0

6 ENVIRONMENTAL CHARACTERISTICS

The PO Telescope will operate in an ultra high vacuum environment, at room temperature (68F,+/-4F). The device shall be fabricated of UHV compatible materials. Acceptable materials are detailed in LIGO Document E960022-03

7 PRELIMINARY DESIGN OF PO TELESCOPE

A preliminary design for the PO Telescope is described in the following AutoCAD 14 files, which are available on the FTP site ftp//ligo.caltech.edu/pub/COS/PO_Telescope/.

LIGO-E980129-00-D - Ligonian VI-B, 8x magnification, 1.3m <Optical Arrangement
LIGO-D980391-00-D - PO_Telescopes_table_elevations.dwg <Heights of 8 various PO telescopes
LIGO-D980392-00-D - Front_Support_Fixed.dwg <Front Support
LIGO-D980393-00-D - Tilt_Yoke_Assembly.dwg (5 drawings) <Rear Support, Fixed & Adjustable

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LIGO-D980314-00-D - Y-Axis Top Plate <Secondary Mount
LIGO-D980315-00-D - X-Y Interface Plate <Secondary Mount
LIGO-D980316-00-D - Y-Top End Plate <Secondary Mount
LIGO-D980317-00-D - X-Axis Way Plate <Secondary Mount
LIGO-D980318-00-D - Fixture Spring Block <Secondary Mount
LIGO-D980319-00-D - Flexure <Secondary Mount
LIGO-D980320-00-D - End Plate <Secondary Mount
LIGO-D980321-00-D - Angle Plate <Secondary Mount
LIGO-D980396-00-D - PO_Telescope_elevation.dwg <General Mechanical Arrangement
LIGO-D980397-00-D - Differential_Screw_Mover (4 layouts).dwg <Table Positioner

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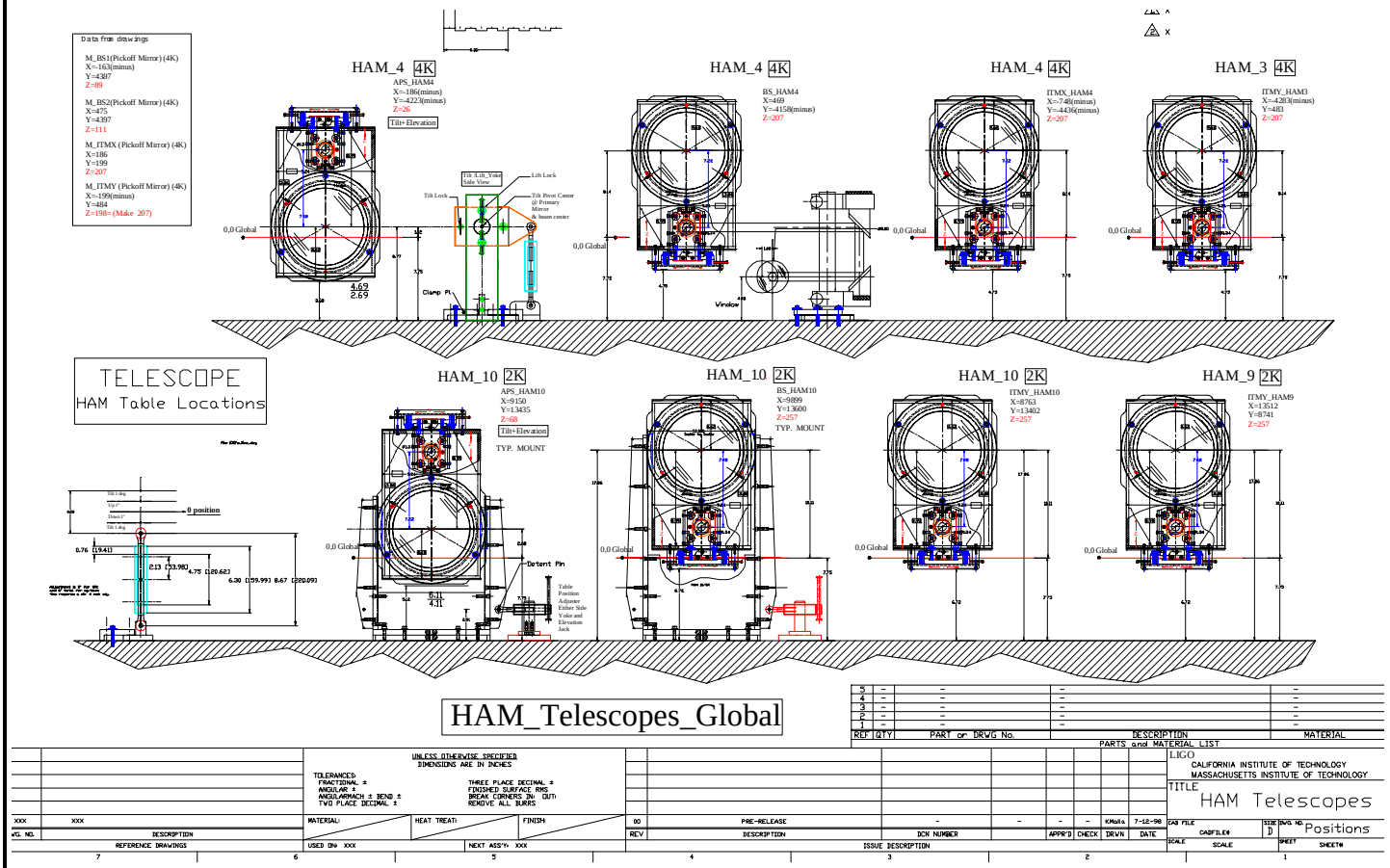

Figure 1: Eight PO Telescope configurations

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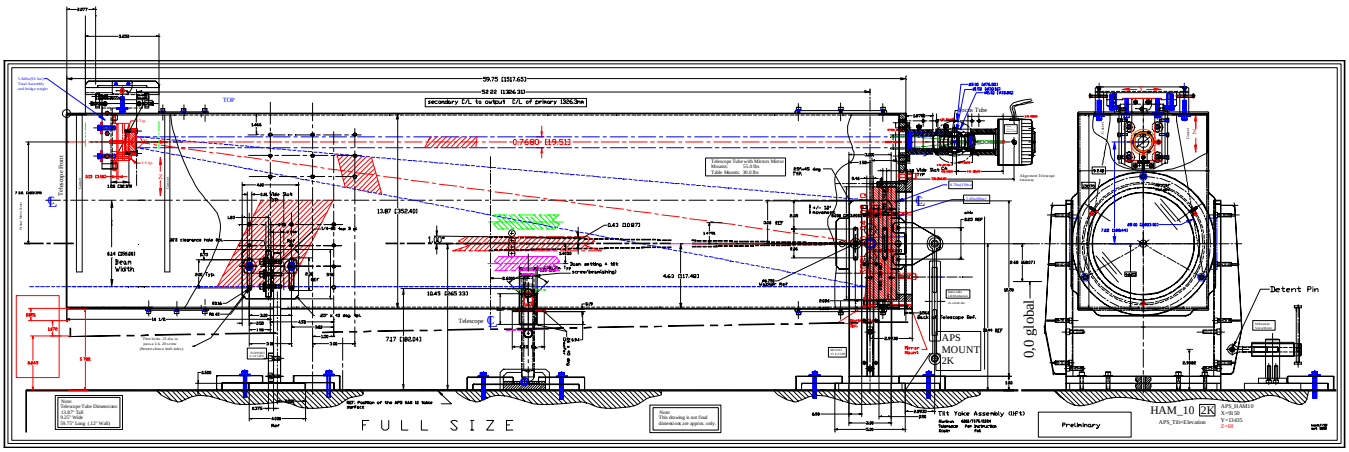

Figure 2: PO Telescope, side and end view

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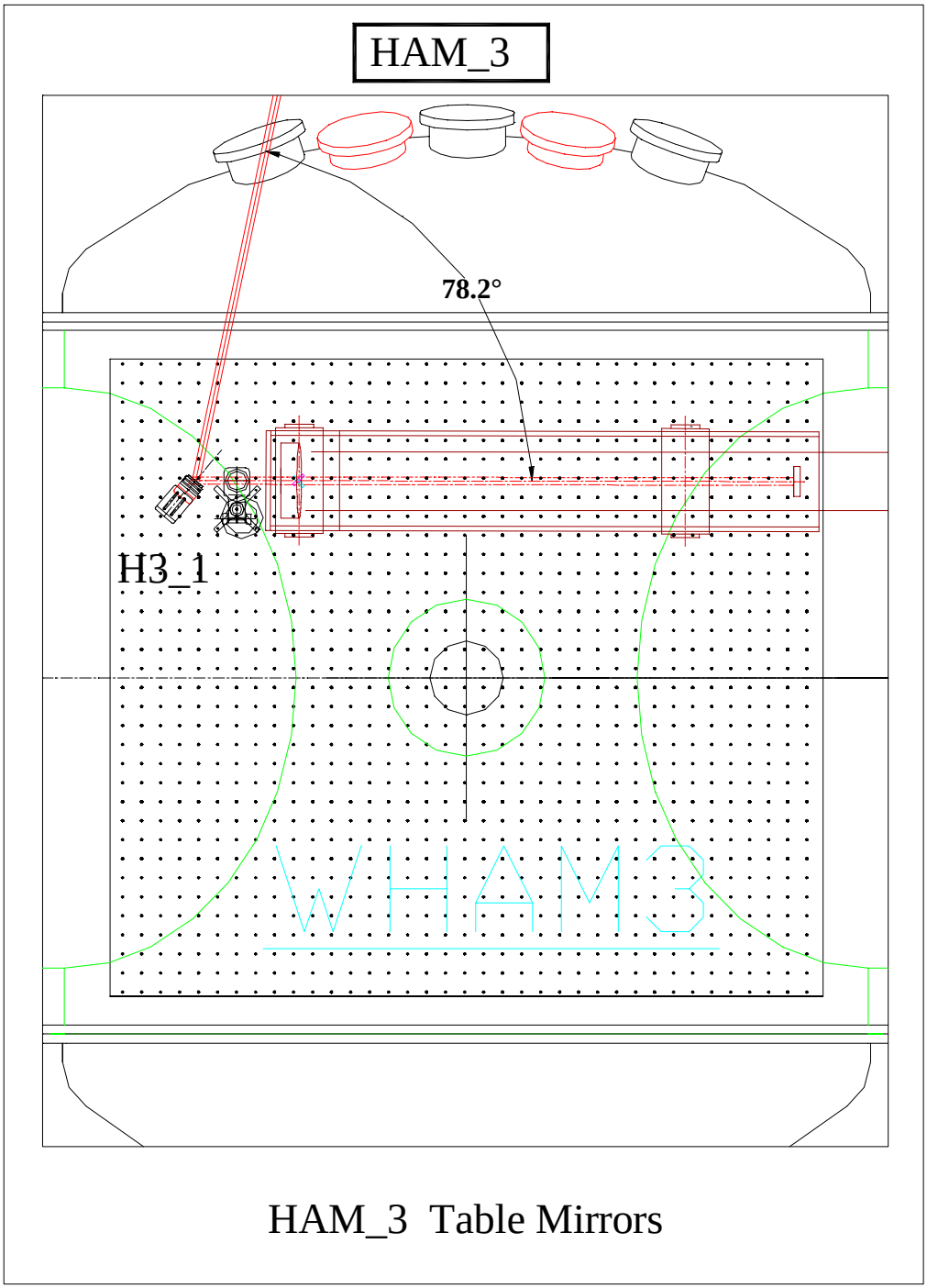

Figure 3: PO Telescope 4K ITMy, orientation

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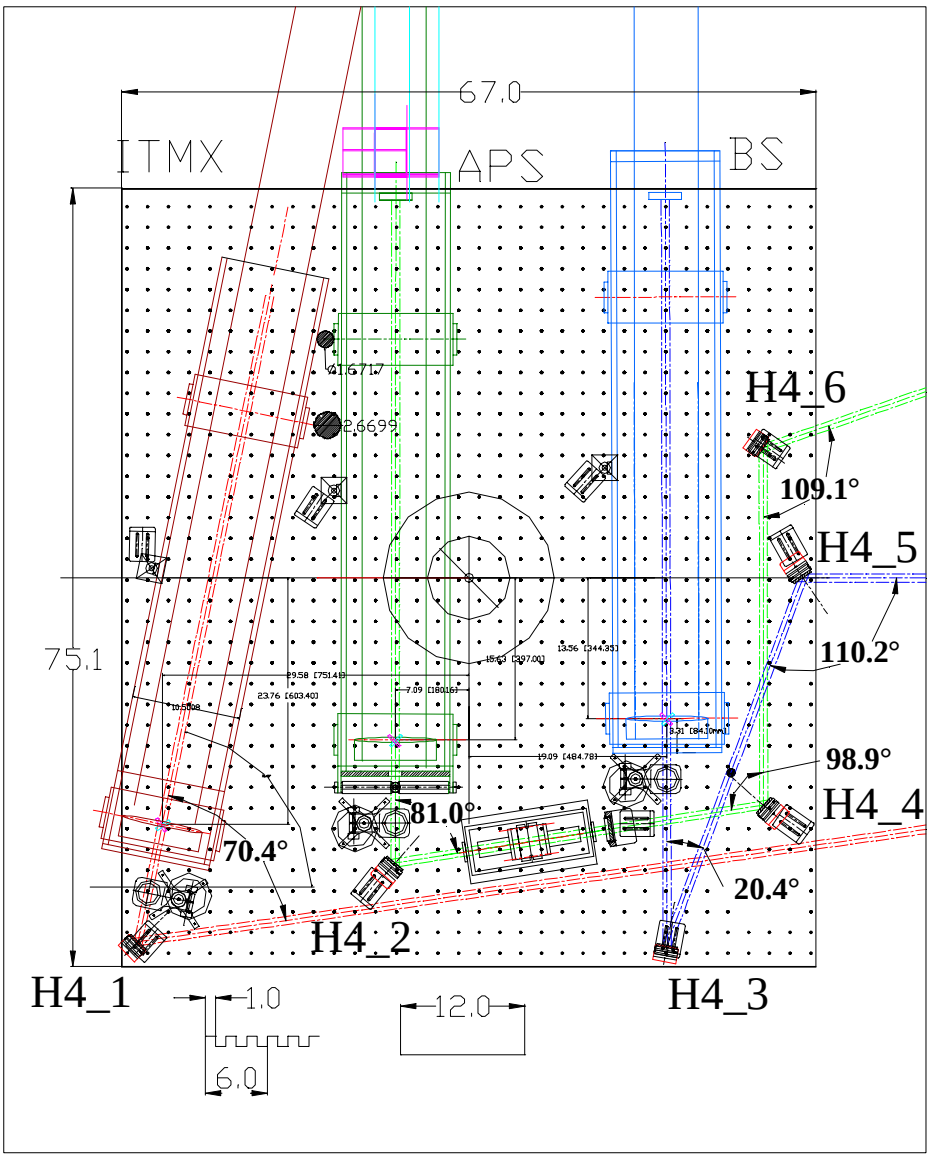

HAM_4 Table Mirrors

Figure 4: PO Telescopes 4K ITMx, 4K BS, 4K APS orientation

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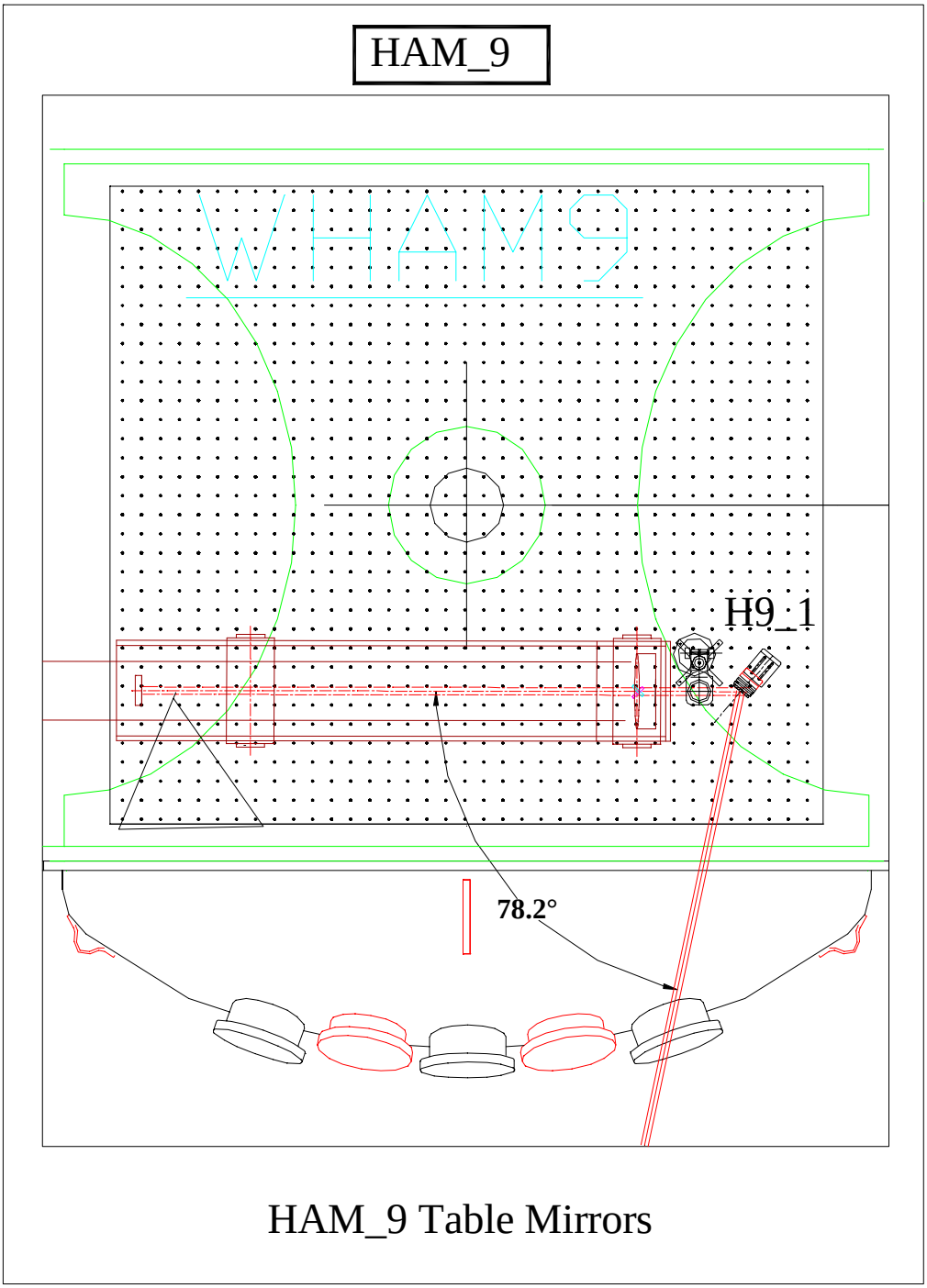

Figure 5: PO Telescope 2K ITMx, orientation

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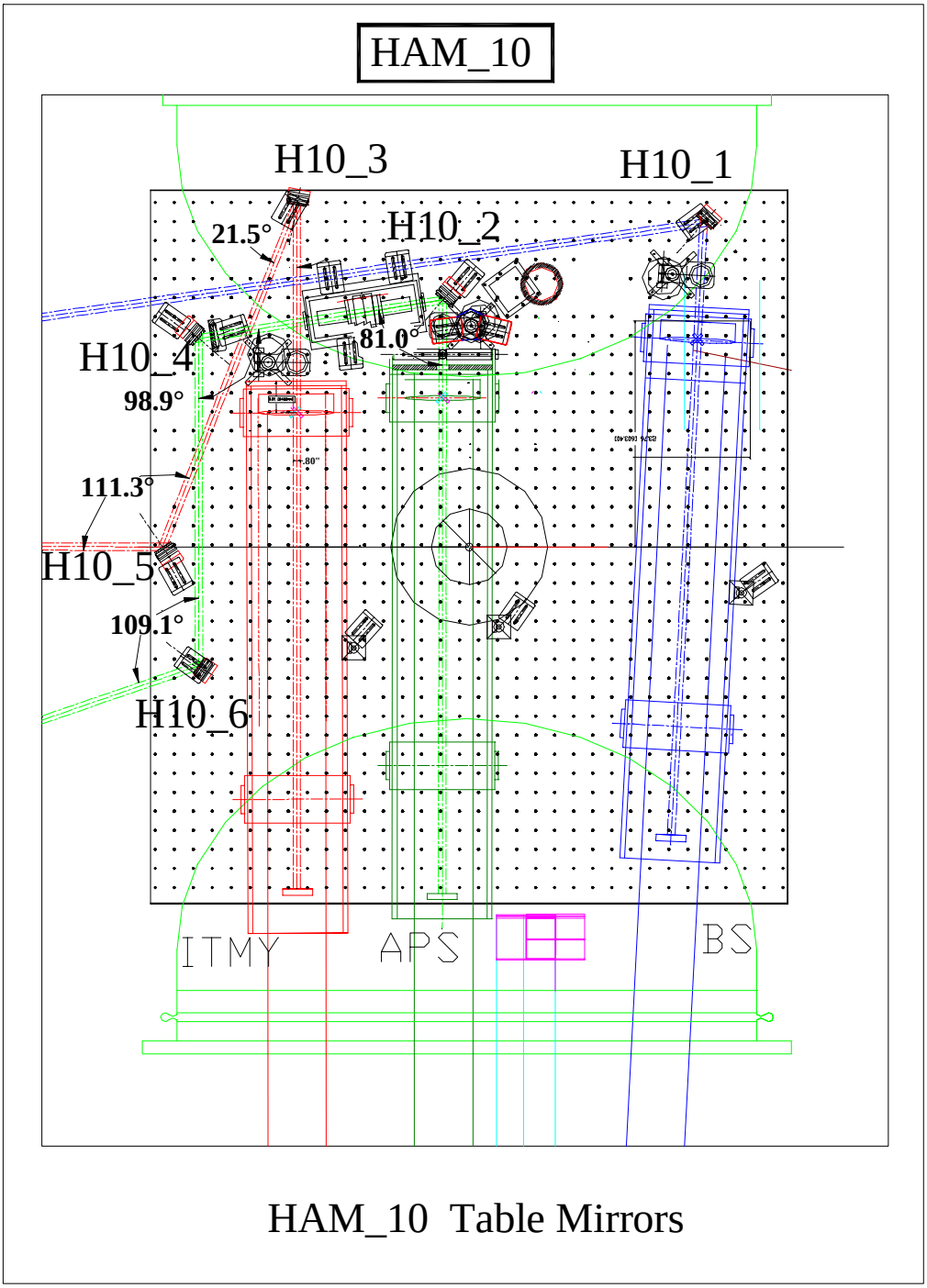

Figure 6: PO Telescopes 2K ITMy, 2K BS, 2K APS orientation

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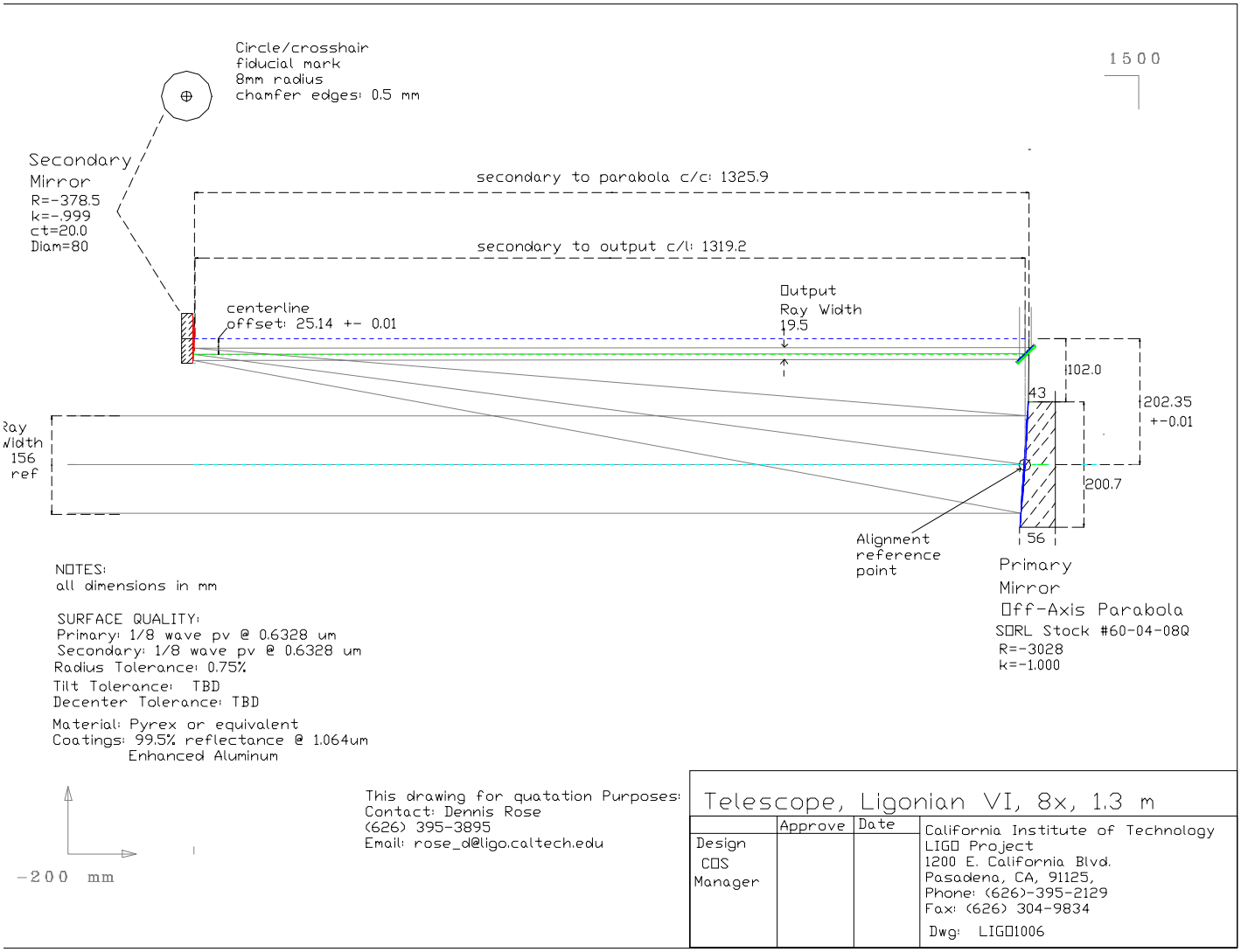

Figure 7: Optical schematic layout for PO telescope