LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Document Type	**LIGO-T990088-01 - D**	10/14/99

COS IFO Alignment Procedure

Michael Smith

Distribution of this draft:

xyz

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project - MS 51-33
Pasadena CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project - MS 20B-145
Cambridge, MA 01239
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

WWW: http://www.ligo.caltech.edu/

1 2K IFO ALIGNMENT

1.1. 2K FMx Alignment

Gate valve #3 will be closed and GV4 will be open during this procedure.

1.1.1. FMx Alignment Apparatus

A schematic of the IR autocollimator set up for alignment of the 2K FMx is shown in figure 1. The COS IR autocollimator no. 1 will be mounted on the IAS tripod using a bayonet mount and height adapter with a two-axis tilt mount. The tripod will be located, using LIGO surveying procedures, on the 2K IFO centerline in the removed spool piece WA-1A location on the x-arm of the IFO. An optical reference flat will be placed inside the manifold on the IFO beam axis, and aligned perpendicular to the IFO beam axis using LIGO surveying procedures. A 940 nm diode laser source will be used to illuminate the reticle of the autocollimator. The retroreflected beam from the reference flat will be viewed through the autocollimator eyepiece by means of a 75mm zoom video camera lens imaging onto a SBIC CCD camera. An alignment target, with a hole and a cross marking the 2K IFO optical centerline, will be placed on HAM 9 in front of the RM, and the reticle projected from IR autocollimator no. 1 onto the target will be viewed with an IR video camera mounted on a tripod in the spoolpiece between HAM9 and BSC4.

1.1.2. Calibration of Autocollimator

1.1.2.1 Pointing angle calibration of autocollimator no. 1

The pointing angle of the COS autocollimator will be established by retroreflecting from a surveyed, pre-aligned reference flat placed on the IFO beam axis inside the manifold near the WA-1A spool piece location, and by tilting the autocollimator to center the image of the retro-reflected reticle pattern on the internal cross hair of the autocollimator.

1.1.2.2 Autocollimator Infinity Focus calibration

A corner cube retroreflector will be placed in front of the autocollimator. The camera focus is set at infinity, and the focus of the eyepiece will be adjusted until the camera image of the cross-hair pattern is as sharp as possible. Finally, the infinity focus of the autocollimator is established by adjusting the autcollimator focus knob until the camera image of the retro-reflected reticle is as sharp as possible.

1.1.3. 2K FMx Alignment Procedure

After the pointing angle of the autocollimator is established, the reference flat will be removed, and the autocollimator beam will transmit through ITMx, reflect from FMx, and project an image of the reticle on the alignment target located in front of the RM.

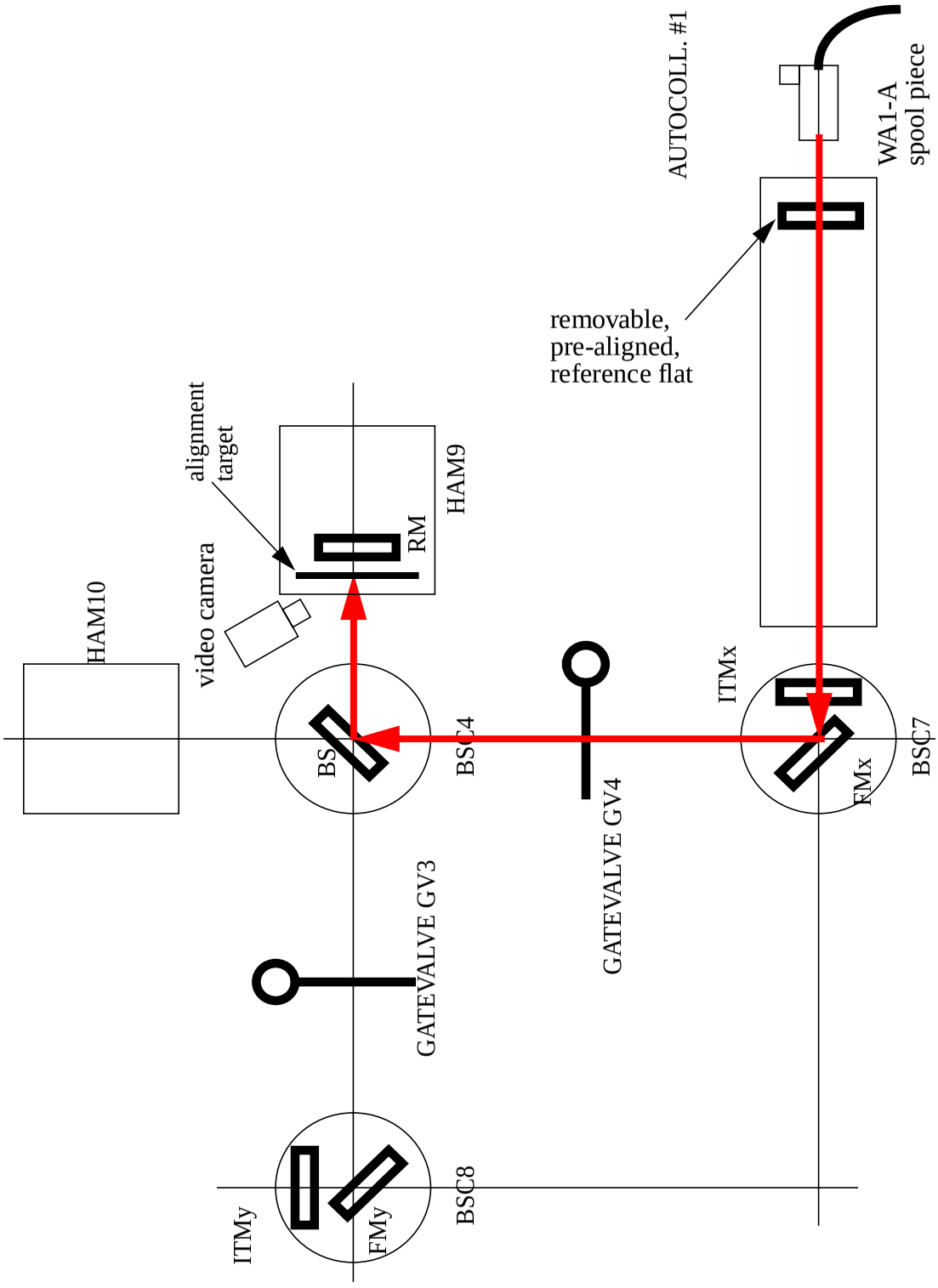

Figure 1: COS Alignment of 2K FMx

1.1.3.1 Alignment Target on HAM9

An alignment target to mark the IFO beam centerline will be placed on HAM9 directly in front of the RM, as shown in figures 5 and 6. The height of the target is referenced to the known height of the optical table. The lateral position of the target is referenced to the center of the optical table, with corrections to account for the actual position of the RM centerline.

The focus control of the autocollimator no. 1 will be adjusted until the projected reticle pattern on the target is as sharp as possible.

1.1.3.2 FMx Tilt Adjustment

The aximuth and elevation tilt angles of the 2K FMx will then be adjusted until the projected reticle is aligned with the cross on the alignment target.

1.2. 2K APS Telescope Alignment

After the FMx has been aligned, the APS telescope will be positioned on HAM 10 and aligned to the transmitted beam from autocollimator no. 1 through the beam splitter, as shown in figure 2.

- COS autocollimator no. 2 will be placed into the holder at the output of the APS telescope for the final alignment of the APS telescope, as shown in figure 3.
- The internal alignment target will be installed near the primary mirror. The APS telescope gimbal mount will be translated horizontally and vertically to center the cross on the target with the projected reticle pattern from autocollimator no. 1. When this is completed, the rear gimbal mount of the APS telescope will be firmly clamped to the HAM 10 optical table.
- The internal alignment target will be moved to the entrance of the telescope, and the front telescope mount will be translated horizontally and vertically to coarsely center the cross on the target with the projected reticle pattern from autocollimator no. 1.
- Finally, the front target will be removed and the input end of the APS telescope will be finely tilted in elevation and azimuth until the internal cross-hair of autocollimator no. 2, at the output of the APS telescope, is aligned with the projected reticle pattern from autocollimator no. 1. When this procedure is accomplished, the front mount of the APS telescope will be locked and firmly clamped to the HAM 10 optical table.

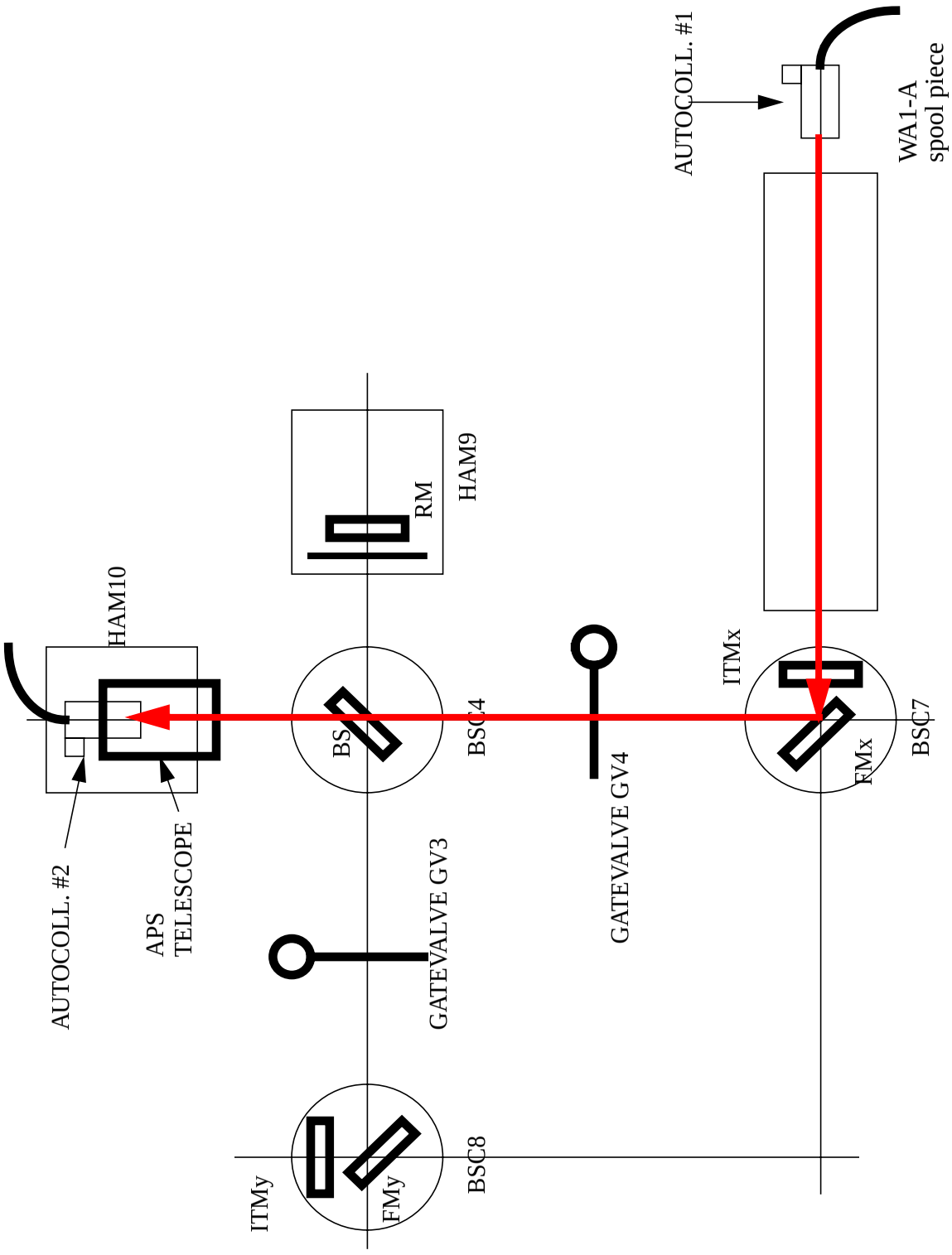

Figure 2: COS Alignment of 2K APS Telescope

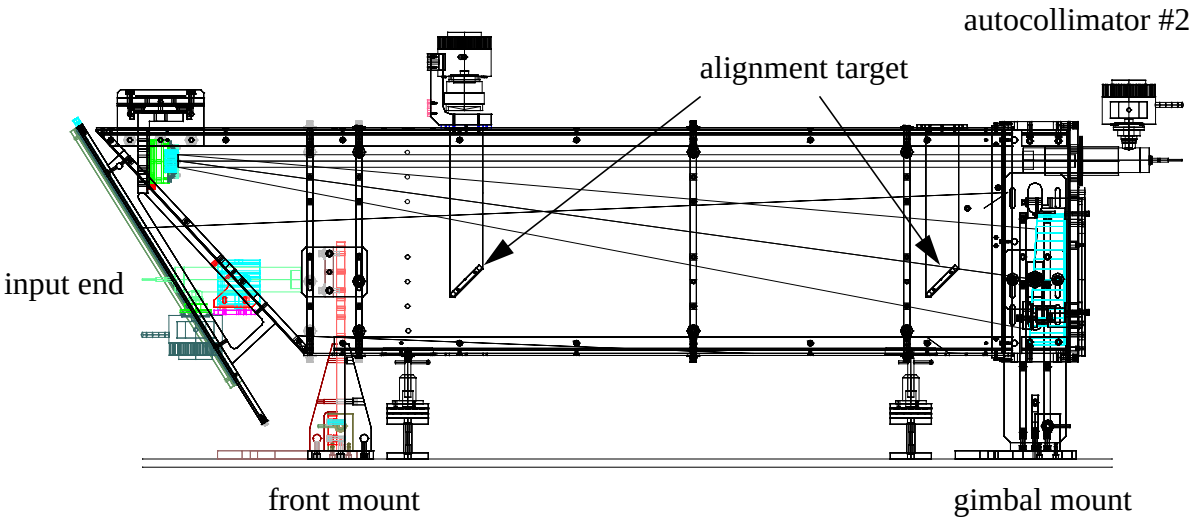

Figure 3: 2K APS Telescope Alignment

1.3. 2K RM ALIGNMENT

1.3.1. Autocollimator Behind the RM

Autocollimator no. 2 will be mounted in a two-axis tilt holder on a two-stage Velmex slide mechanism and positioned on the 2K IFO centerline behind the RM on HAM 9, as shown in figures 4, 5, and 6.

The hole in the alignment target allows the central portion of the projected reticle pattern from the reference beam of autocollimator no. 1 to transmit through the RM and be received by autocollimator no. 2.

1.3.1.1 Pointing Angle Alignment

The pointing angle of autocollimator no. 2 will be aligned by adjusting the elevation and azimuth tilt angles of autocollimator no. 2 until the internal cross-hair is aligned with the received reticle pattern from the projected reference beam.

1.3.1.2 Centering Alignment

The centering of autocollimator no. 2 with the reference beam will be accomplished by translating autocollimator no. 2 horizontally and vertically, using the Velmex slide mechanism, until a target placed at the center of the input aperture of autocollimator no. 2 is aligned with the projected reference reticle pattern.

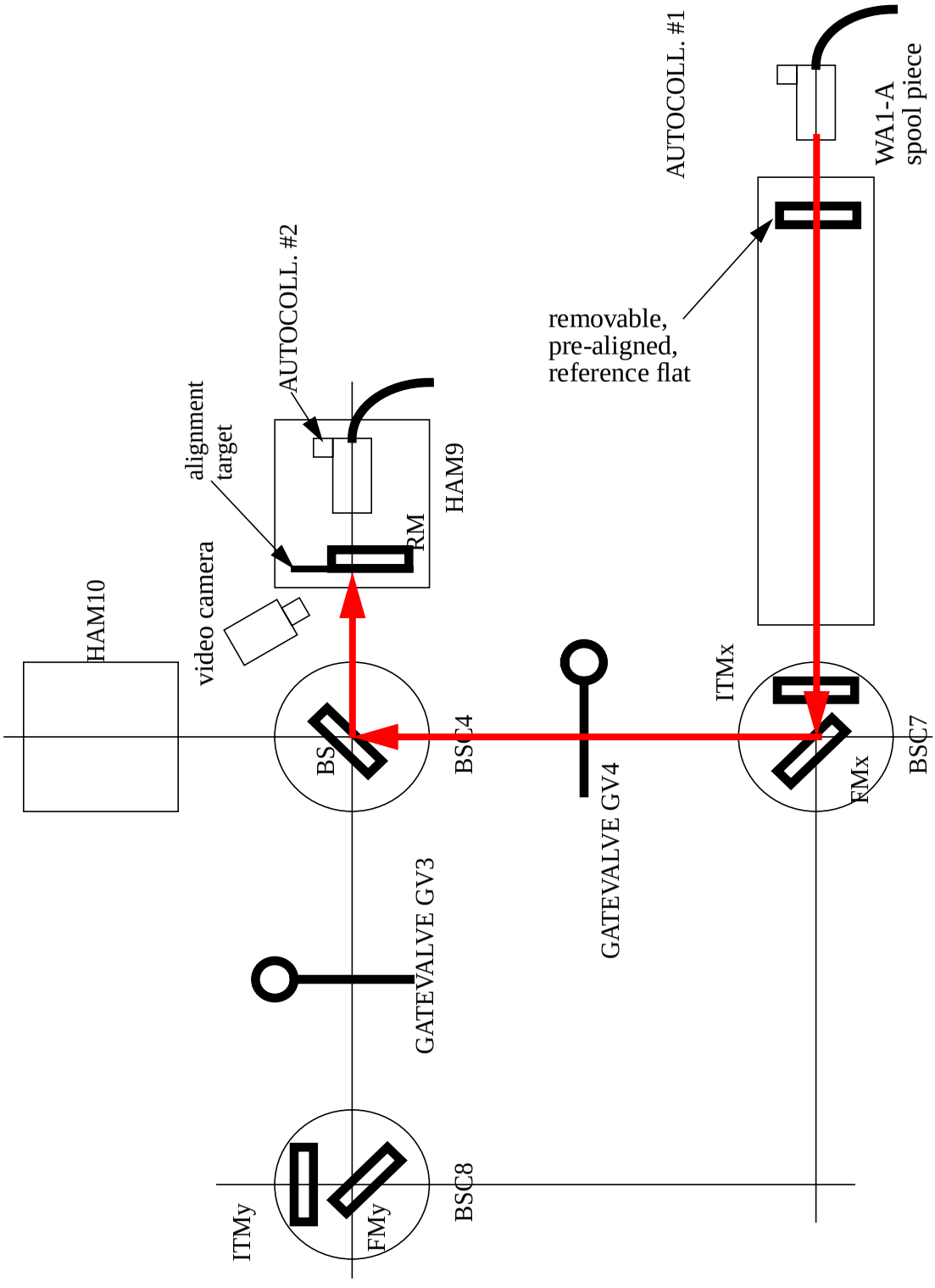

Figure 4: Alignment of RM

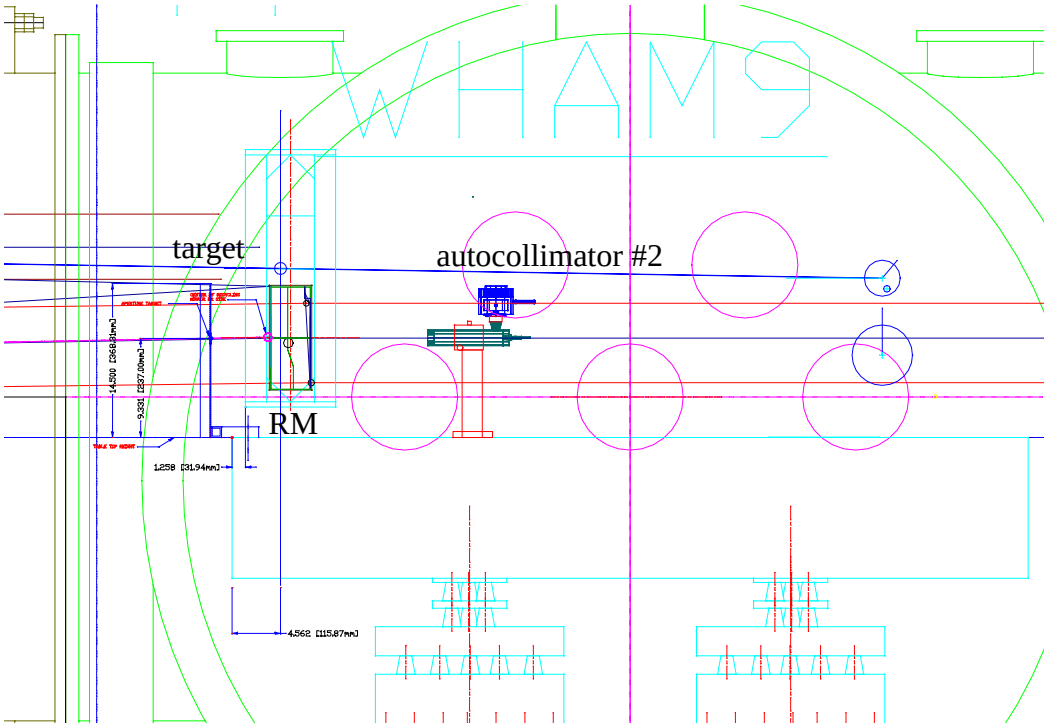

Figure 5: Alignment Target and Autocollimator on HAM9, Elevation View

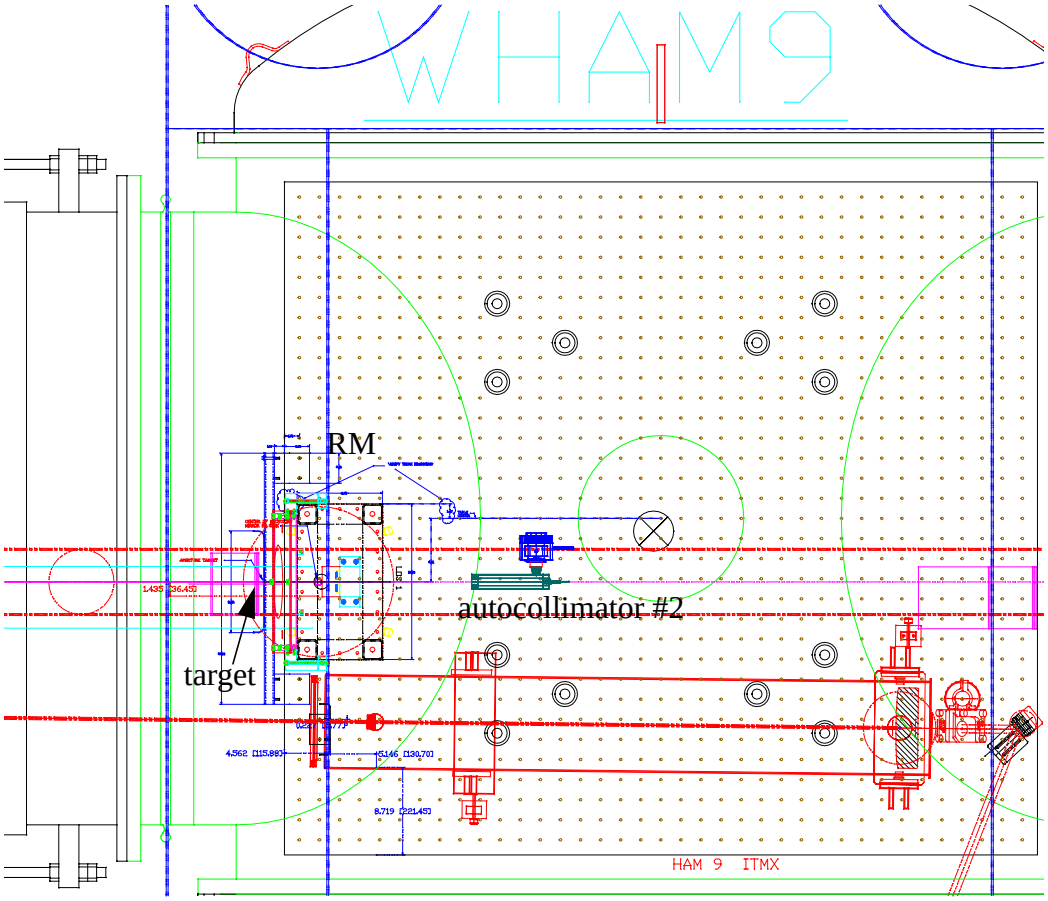

Figure 6: Alignment Target and Autocollimator on HAM9, Plan View

1.3.1.3 Alignment Iteration

The pointing angle of autocollimator no. 2 will be finalized by repeating the pointing angle alignment step described above.

1.3.2. 2K RM Alignment

Now the angular alignment of the RM can be checked by turning on the 940 nm illumination source of autocollimator no. 2 and retroreflecting from the HR side of the RM. And the elevation and azimuth tilt angles of the RM can be adjusted to agree with the pointing angle of autocollimator no. 2.

1.4. 2K FMy Alignment

Gate valve #4 will be closed and GV3 will be open during this procedure.

The 2K FMy mirror will be aligned by projecting a reference beam from the autocollimator behind the RM, passing through the BS, reflecting from the FMy, reflecting from the ITMy, and

returning to the BS and reflecting toward the aligned APS telescope on HAM10, as shown in figure 7.

Autocollimator no. 1 will be placed at the output end of the APS telescope. The elevation and azimuth tilt angles of FMy will be aligned until the projected reference reticle pattern is centered on the internal cross-hair of the autocollimator at the output of the APS telescope.

1.5. APS Steering Mirrors Alignment

Autocollimator no. 2 will be placed at the input end of the APS telescope, as shown in figure 8. Projecting from autocollimator no. 2 with a 990 nm diode laser illumination source and viewing with a camera through autocollimator no. 1, the autocollimator no. 2 will be pointed in elevation and azimuth until the projected reticle is aligned with the internal cross-hair of autocollimator no. 1, at the output of the APS telescope.

Autocollimator no. 1 will now be removed from the output of the APS telescope. The projected reticle pattern from autocollimator no. 2 will be progressively focussed on each steering mirror, shown in figure 9, and the steering mirror will be centered on the reticle pattern and pointed toward the next mirror to define the desired beam path on the HAM10 optical table. The last steering mirror will be pointed to project the output reticle pattern onto a surveyed target which marks the center of the APS output window of HAM10.

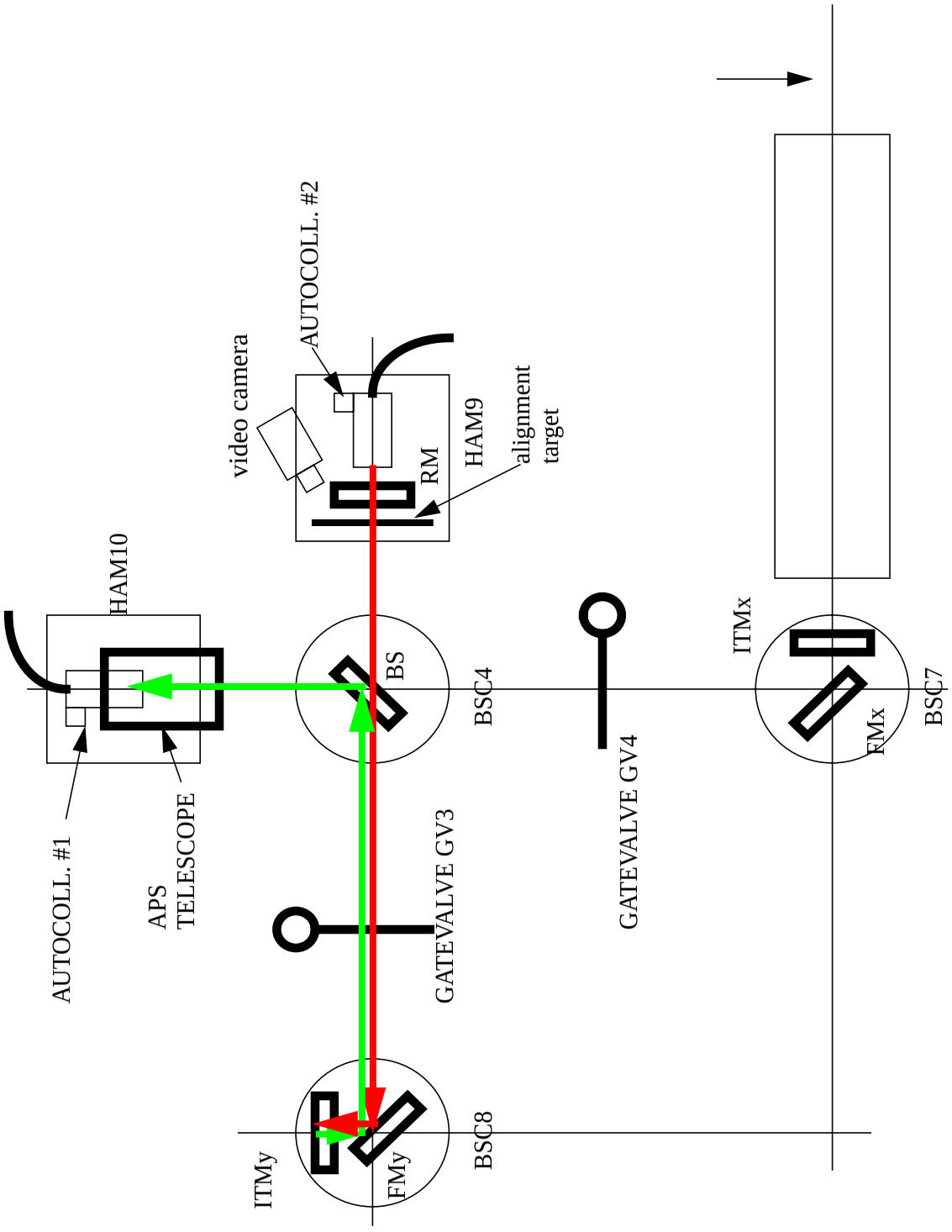

Figure 7: COS Alignment of 2K FMy

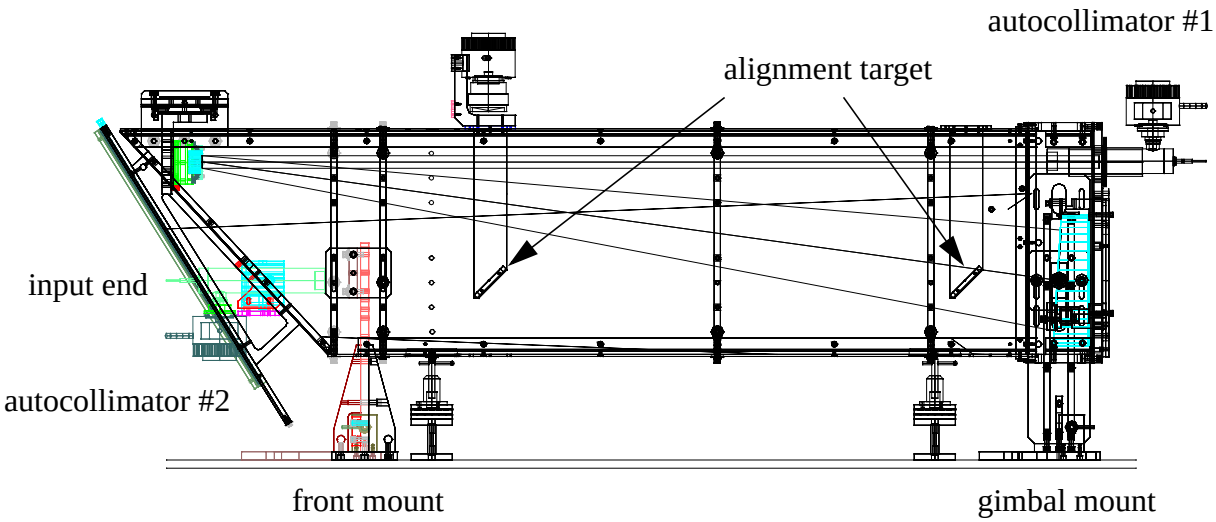

Figure 8: 2K APS Telescope Steering Mirror Alignment Beam

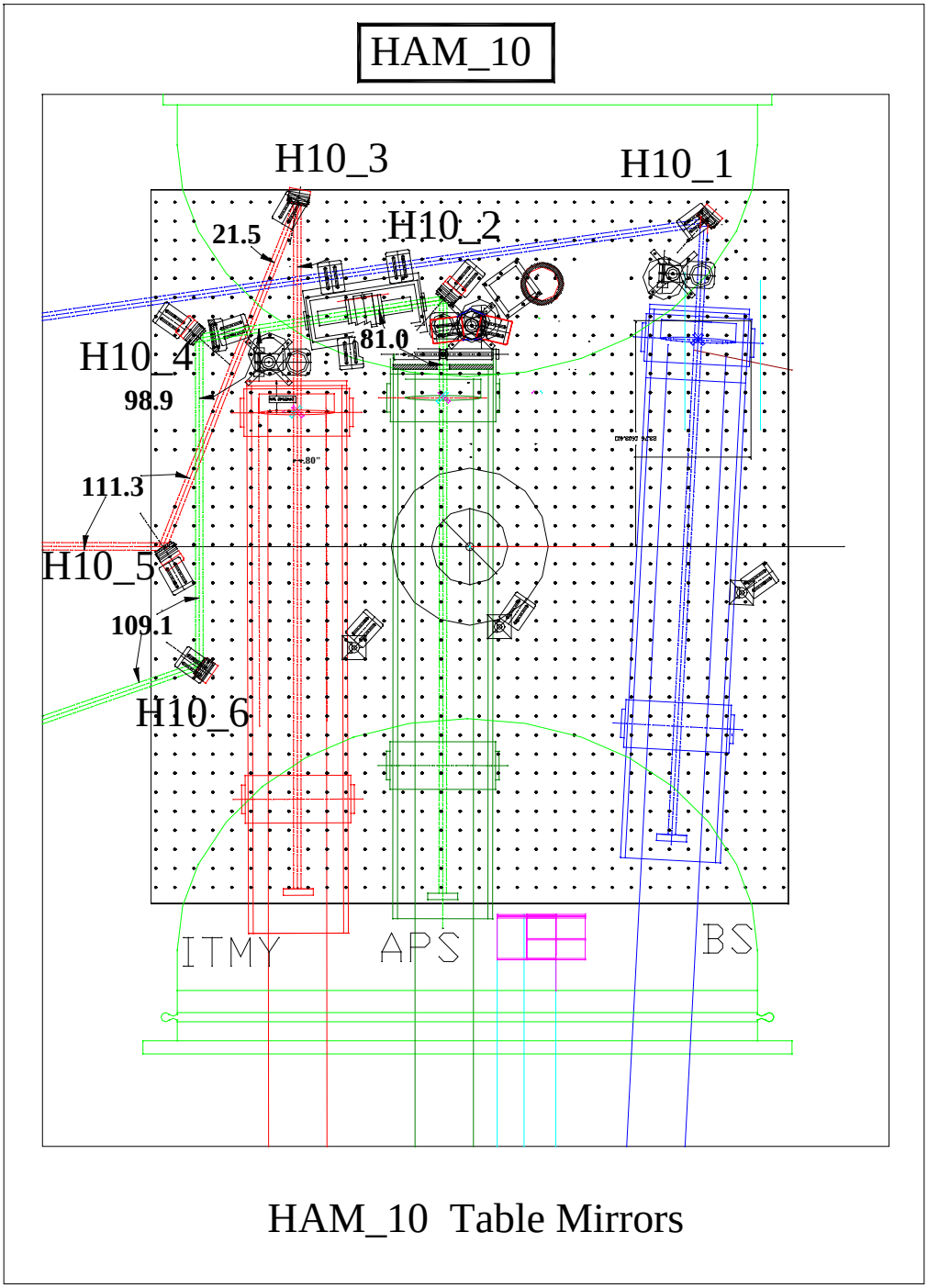

Figure 9: PO Telescopes 2K ITMy, 2K BS, 2K APS orientation

1.6. 2K ETM Telescope Alignment

1.6.1. 2K ETM Telescope Alignment Apparatus

A schematic of the IR autocollimator set up for alignment of the ETM telescope is shown in figure 10. The COS IR autocollimator will be mounted on the IAS tripod using a bayonet mount and height adapter with a two-axis tilt mount. The tripod will be located, using LIGO surveying procedures, on the 2K IFO centerline in the removed spool piece located adjacent to the gate valve GV10 at the y-midstation of the IFO. A 940 nm diode laser source will be used to illuminate the reticle of the autocollimator. The retroreflected beam from the ETM mirror will be viewed through the autocollimator eyepiece by means of a 75mm zoom video camera lens imaging onto a SBIC CCD camera. An alignment target, with a hole and a cross, will be placed at the entrance to the ETM telescope on the optical centerline, and the reticle projected from the IR autocollimator onto the target will be viewed with an IR video camera mounted on a tripod inside the BSC6 chamber.

1.6.2. Calibration of Autocollimator

1.6.2.1 Pointing angle calibration of autocollimator no. 1

The pointing angle of autocollimator no. 1 will be established by retroreflecting from the HR surface of the ETM mirror, and by tilting the autocollimator to center the image of the retro-reflected reticle pattern on the internal cross hair of the autocollimator.

1.6.2.2 Autocollimator Infinity Focus calibration

A corner cube retroreflector will be placed in front of the autocollimator. The camera focus is set at infinity, and the focus of the eyepiece will be adjusted until the camera image of the cross-hair pattern is as sharp as possible. Finally, the infinity focus of the autocollimator is established by adjusting the autcollimator focus knob until the camera image of the retro-reflected reticle is as sharp as possible.

1.6.2.3 Projected Reticle Pattern

The projected reticle pattern will be focussed onto the surface of the alignment target at the entrance to the ETM telescope by means of the focus knob on the autocollimator.

1.6.3. 2K ETM Telescope Alignment Procedure

1.6.3.1 Alignment of Entrance Aperture of ETM Telescope

The lateral position and azimuthal orientation of the entrance aperture of the telescope will be coarsely adjusted by positioning the telescope mounting post on the BSC optics table and clamping to the table with the hold down clamps. The elevation of the telescope will be coarsely adjusted by means of the slotted vertical mounting base.

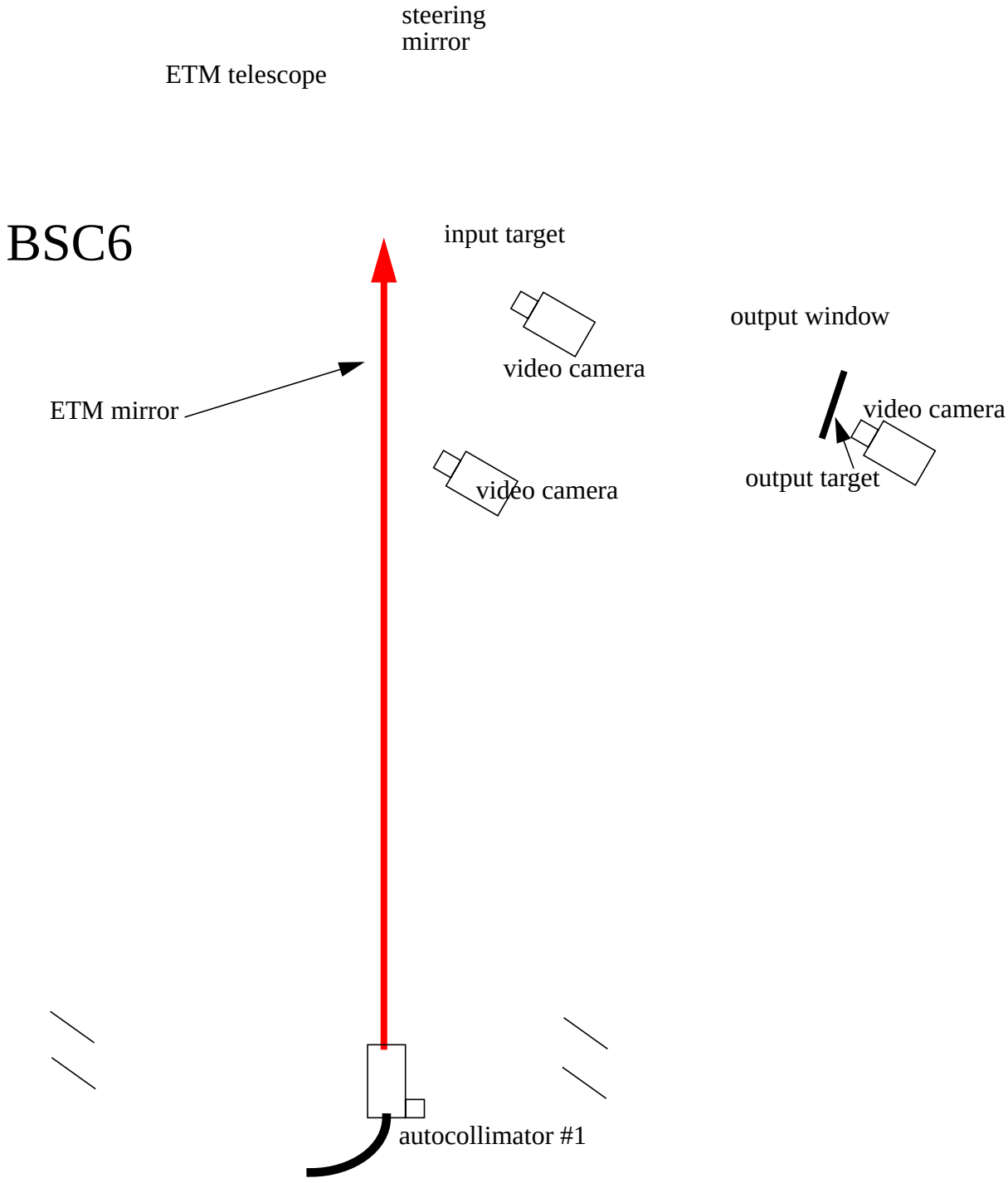

Figure 10: Alignment Apparatus for the ETM Telescope

The fine adjustment of the lateral position, azimuth, and elevation of the entrance aperture of the telescope will be adjusted by means of the fine adjustment screws until the cross of the target at the input of the telescope is aligned with the projected reticle pattern from the autocollimator.

1.6.3.2 Tilt Alignment of ETM Telescope

The steering mirror at the output end of the telescope will be removed. Autocollimator no. 2 will be inserted into the alignment bore at the output end. Autocollimator no. 1 will be set to infinity focus.

The telescope will be tilted in azimuth and elevation by means of the fine adjustment screws on the output side of the telescope mounting structure until the internal cross hair of autocollimator no. 2 is centered with the projected reticle pattern from autocollimator no. 1.

1.6.4. Alignment of ETM Telescope Steering Mirror

Autocollimator no. 2 will be removed from the back of the ETM telescope, and the steering mirror will be installed.

The steering mirror will be coarsely rotated within its mounting base, and finely tilted by means of the x-y mirror adjustment screws until the projected reticle pattern is centered on the cross of the translucent alignment target placed against the outside of the output window. The target will be viewed by an IR video camera outside the BSC6 chamber.

1.7. Alignment of ETM PO Beam Dump

The projected reticle pattern from autocollimator no 1 will pass through the ETM telescope and be directed to the center of the output window. An IR video will be placed inside BSC6 to observe the ETM PO beam dump. The ETM PO beam dump will be positioned on the BSC6 optical table so that the reflected reticle pattern from the output window will hit the center of the beam dump.