STAR Engineering Change Request/Notice Form

Please Supply the following information and click on the Ësubmit" button. To clear the information and start again click on the Ëreset form" button. If you need more information click here.

Requested by: *Daniel Cebra for the FTPC group*

Date: *20-Aug-98*

Level: *II*

Safety Impacting: *No specific safety impact, however this system will transport the UV beam from a class IV laser. The design of this system will meet or exceed standards of safe UV laser operation.*

STAR Drawing or STAR Note # *Refer to SIM140-A-1 and SIM153-A-1, which are included in this submission, but not specifically modified in this request.*

Revision from: Revision to:

Institution ECN Number (if applicable): *None*

Drawing, STAR Note, or Document title: *None*

"Used on" Drawing Number (if applicable): *None*

Description of Change

When the envelope for the FTPC was defined, a volume for the laser calibration system was forseen, but the details of its exact routing and extent were not determined. This ECN defines the spatial volume requirements of the laser calibration system for the FTPC and requests that this space be reserved on the controlled integration drawings which detail the various subsystem envelopes. Further details are included in the attached document.

Reason for Change:

The envelope for the FTPC laser calibration system had not previously been defined.

Impact on Other Sub-systems/Safety:

The FTPC laser calibration system will need to trace a transfer path from the Nd:YAG laser (shared with the central TPC laser calibration system) to the back plane of the FTPCs. The transfer path is proposed to be traced across the back face of the pole tip and then through a angled tube to the back plane of the FTPC. The routing of the laser path crosses the gap between the magnet's outer ring and pole tip; this will require approval of the magnet group, as removal of the FTCP laser tubing will be an additional step required in the pole tip removal process. The laser path then passes across the back face of the pole tip, in the region where the magnet group controls the envelope for fixing the pole tip removal tool. This routing was *choosen to avoid a spatial conflict with either End Calorimeter group, although both should sign off on this request. The laser routing then proceeds up to the rim of the η=2.0 hole, passing beneath the power and water utilities; the magnet group should also sign off on this. From the edge of the η=2.0 hole, the laser path will take an angled trajectory up to the back plane of the FTPC. This provides some small reduction in volume for the passage of cooling air to the SVT and TPC inner field cage. Finally, at three points around the circumference of the outer ring of the FTPC back plane, laser insertion boxes will extend a few inches beyond the FTPC envelope; this will again reduce the volume available for the flow of cooling air, but should otherwise not conflict with other sub-systems. And finally, the laser calibration system will require that the laser beam be diverted periodically from the central TPC to the FTPCs; this will have a minor impact on central TPC calibrations operations.*

There are always safety concerns with the routing of the beams of a class IV laser. To meet standards, the beam will be fully enclosed with only tool-assisteded entry points. A safe operating procedure will have to be developed and signed off upon by the BNL laser safety officer prior to operation of the system.

Impact on Cost and Schedule:

The cost of the FTPC laser calibration system will be the responsibility of the FTPC group. No serious impact on the STAR baseline project schedule in expected.

FTPC Laser Calibration System

Pupose: The laser calibration system for the FTPCs is needed for three primary puposes:

- It will serve as the absolute calibration of the effective drift velocity, which is essential for accurate track location along the radial direction. The FTPCs employ a $1/r$ electric field which results in a radius dependent drift velocity.
- It will provide calibrated, straight beams from which to infer corrections for spatial distortions.
- It will serve as a permanently available testing facility for the FTPCs.

Requirements: Drift distortions will confuse the analysis if they are not fully understood. The most proven technique is through the use of a laser calibration system to provide artificial tracks at pre-determined locations. An automated control system that uses position information from fiducial photodiodes and CCD camera as feedback to maintain alignment greatly facilitates operation and functionality of the laser system. The requirements for a good measurement of drift velocity are more demanding in a radial TPC than in a standard configuration because the drift velocity is non-uniform. The electric field can be held to vary as $1/r$ relatively accurately; however, the drift velocity of a given gas is a non-linear function of electric field. Therefore, in order to accurately determine the spatial positions of hit clusters, it is essential to measure the drift velocity as a function of r in the FTPCs. A single-point method, such as the use of the innermost tracks, is not adequate for determining a velocity profile, nor is a single external drift velocity monitor chamber.

Description of the Laser Calibration system: We will develop a laser calibration system for the FTPCs. Calibration for a *radial* TPC is essential since the electrons are drifting in a non-uniform (radial) electric field and hence their drift velocity is changing as they drift outward. In addition, the siting of the FTPCs close to the pole tip of the magnet endcap means that there may be complicated magnetic field distortions. Thus, calibration laser beams at a number of radii are essential.

In order to reduce costs and to reduce the integration challenge associated with defining spatial volumes for the FTPC laser system, we have decided to use the same lasers as the central TPC. There are two lasers which will independently provide beams to the East and West ends of the STAR detector. These lasers are located on the South side of the STAR detector, situated between the magnet backlegs and the South Electronics gallery. Each is a Nd:YAG laser, frequency quadrupled to supply a 266 nm UV beam. The exit optics of these lasers leave a broad beam, in the center of which a small glass bead is suspended. This glass bead produces a diffraction pattern downstream. The profile of the beam can be described as follows: the overall beam radius is approximately 7 mm. There is a bright central peak extending to a radius of about 2 mm, then a 2 mm gap. The second maximum occurs at a radius of about 4 mm, and has a peak intensity about twice that of the central poisson dot. The intensity falls off over the next 3 mm. In the laser calibration system for the central TPC, this region from 4 to 7 mm is used to illuminate bundles of 7 pick-off mirrors. These pick-off mirrors are made 1 mm diameter quartz fibers which have been cut at a 45^o angle and coated to reflect 266 nm laser beams. The close packed bundles thus pickoff seven 1 mm diameter beams. For the FTPCs, we will make use of the same broad beam and small pickoff mirror concept.

Figure 1 illustrates the basic concept of the calibration system. We have elected to use the minimum number of laser beams necessary. For the FTPC, it was felt that 15 beams would meet this requirement. A minimum of three azimuthal locations is necessary to study the distortion implicit in a slight misalignment of the FTPC with the magnet axis. And radially, it was felt the at least three beams would be necessary in order to measure the non-uniform drift velocity. The additional two angled beams allow a complete study of the velocity profile as a function of radius, which is required for good radial space point reconstruction. Therefore, the proposed system employs 3 sets of 5 beams, for a total of fifteen beams. Ample power from the primary laser beam is available for these fifteen beams (there will be only two beam splitters in the laser path). This should ensure that there is always ample laser power to ionize the gas.

Figure 2 provides an overview of the laser beam transfer path from the point where the beam is diverted from the central TPC toward the FTPCs. The diversion takes place in the vicinity of the laser entry bore hole through the magnet's outer ring. The bore hole is behind Box A on the diagram. The bore hole is located on the magnet outer ring, 145 degrees to the south of vertical, at a radial distance from 9 to 12 inches out from the inner radius (113 to 116 inches). Box A will be a 8X6X4 aluminum box which be be fixed to the magnet's outer ring. Inside Box A, a motorized flipper, which can be remotely controlled, will divert the laser beam to a 2" aluminum tube which will run across the back face of the pole tip to Box B. Box B is an 6X6X4 aluminum box located on the vertical axis (6 o'clock) location at a radial distance spanning from 72-78 inches. This box is a few inches above the fixation of the pole tip to the outer ring. The laser will then travel through a 2 inch aluminum tube along the vertical axis of to Box C. Box C is a 4X4X4 inch aluminum box which is suspended by brackets above the edge of the η=2.0 bore hole. From Box C, the laser will travel through a 1 inch aluminum tube to an insertion point in Box D on the back face of the FTCPs.

Figure 3 shows details of Box A. The Box needs to be large enough to fully enclose two mirror mounts and the motorized flipper. In addition, there needs to be enough space allowed for the broad beam to avoid clipping the edges of the various mounts. A two mirror solution was chosen for the flipper because the model 8891 is the only commercial motorized flipper available and it mount 1" optics. As this beam is close to one inch in diameter, one can only employ 1" optics for close to normal incidence.

Figure 4 shows details of Box B, which houses a model 8852 picodriver. The picodriver is a required element of the laser alignment system, which keeps the laser beams at their fiducial locations. The picodriver mounts a 2" mirror which is necessary to fully reflect to broad beam.

Figure 5. shows details of Box C and its fixation to the pole tip. This box contains a single 2" mirror to fully reflect the broad beam. The support braces extend 2 inches below the edge of the bore hole and four inches into it. A one inch aluminum tube is selected as the exit from this box because space of the back plane of the FTPC is extremely tight and only the minimum size necessary is allowed.

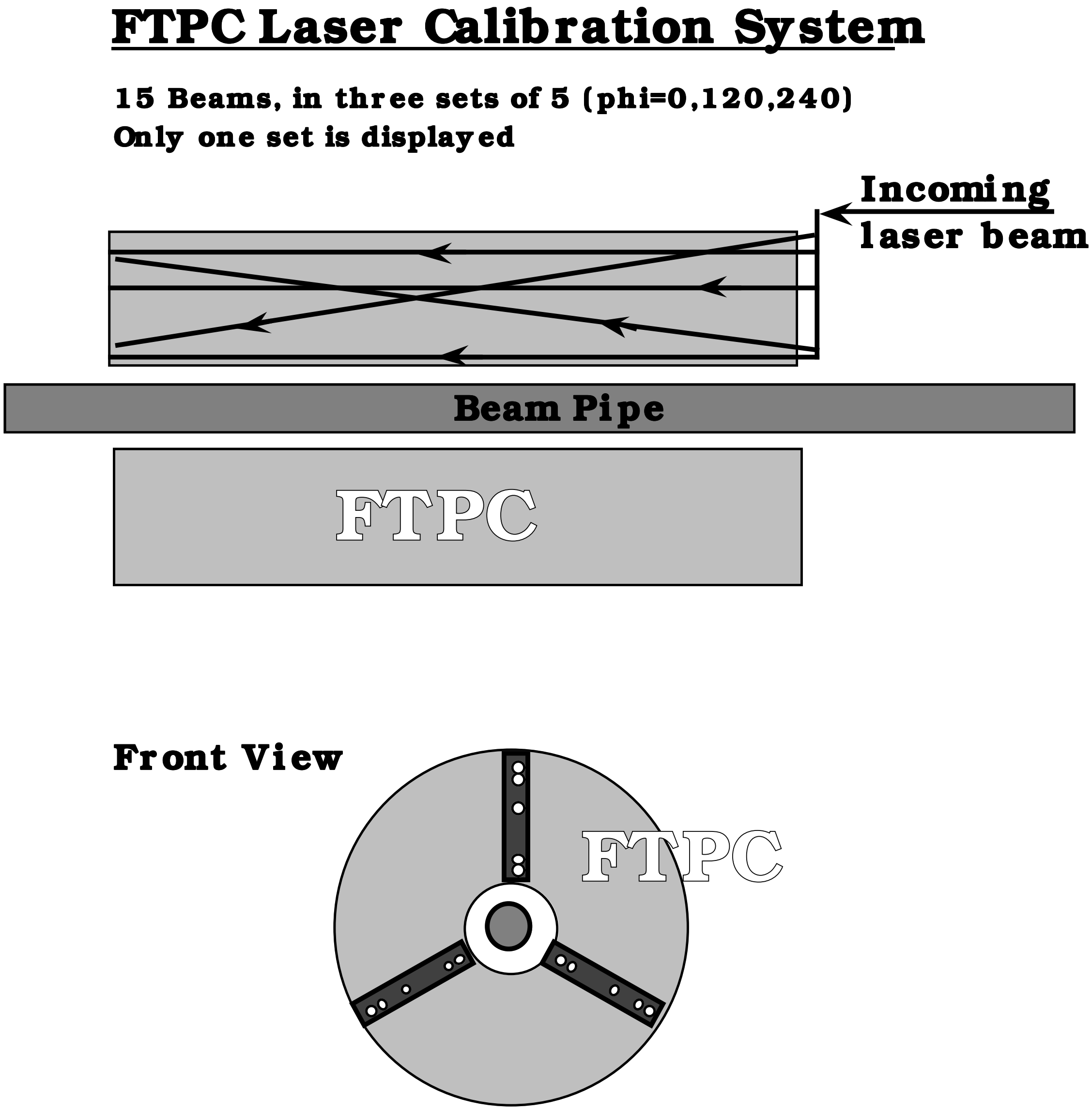
Figure 6. shows details of Box D. Box D is a 7X5X1.2 aluminum box fixed to the back plane of the FTPC. The requirements for laser calibration and for alignment of the laser as well as the spatial constraints on the back plane of the FTPCs make this the most constrained box. It is essential for operation of the laser system that the two fiducial points (monitored by CCD1 and CCD2) be fixed to the back plane of the FTPC, and never removed during the lifetime of the detector. These two fiducial points define the laser vector. If one of these is ever removed or adjusted there is a good chance that it will never be possible to determine the correct incident laser direction and the calibration system will lose some or all of its functionality. A vector is defined by five variables, usually three spatial coordinates and two angles. It is the job of the laser alignment system to make sure that the incident beam always follows the same vector regardless of any small variations in the mechanical components along the path. This is achieved by installing two motorized mounts, each with at least two controllable degrees of freedom (the picodrivers each have three degrees of freedom, we will normally only utilize two degrees of freedom for each driver). If one assumes that one spatial coordinate is fixed (the location of a fixed mirror along the length of the laser beam path varies very little), then it is preferable to have one motorized mount control the two remaining spatial coordinates (Picodriver 1, in Box B), and the second (Picodriver

2, in Box D) control the two angular degrees of freedom. In order to remove any covariance between the two picodrivers, one should install CCD1 in a location where it is influenced only by picodriver 1. We choose to install the CCD immediately behind the Mirror of picodriver 2. Some small fraction of the incident beam will be transmit through the mirror and this is sufficient to illuminate the scintillator screen which is viewed by CCD1. Adjustments to picodriver 2 will not effect the location of the transmit beam. Therefore, picodriver 2, must be mounted on the backplane of the FTPCs so that CCD1 can be positioned immediately behind it. There is a 30 mm hieght constraint for Box D, this precludes bringing the incident beam directly to a mirror mounted on picodriver 2, instead we choose to bring the incident beam to a 45 degree prism. We elect to use a prism to make this 90 degree reflection, because the 30 mm hieght constraint does not allow for a 2" optic to be mounted at a 45 degree angle. The 1" prism is able to reflect the full beam. The beam is reflected toward picodriver 2 at close to normal incidence, which allows the use of 1" optics and for CCD1 to be mounted behind the mirror where the fraction of the beam that is transmit can be used to illuminate the scintillator screen. In the current layout of Box D, CCD1 extends beyond the FTPC envelope, as do other empty regions of the BOX. It is possible to re-orient CCD1 to avoid this, however this would elongate Box D. After much consideration, we have elected to use beam splitters to divide the intensity of the primary laser beam between the three insertion rods. The first beam splitter, identified as M1 on the figure, will be a reflect one third of the light toward insertion rod 1. The location of this beam splitter is constrained by the requirement that it avoid the RHIC beam pipe. A second beam splitter with 50% reflectivity will direct another third of the original beam intensity toward insertion rod 3, while the directly transmit beam will be incident on insertion rod 2. A last beam splitter with 10% reflectivity will be positioned immediately prior to insertion rod 1. This will reflect a small fraction of that beam back to CCD2, providing the longest possible beam path and therefore the best precision possible for the alignment system. The two beam splitters within Box D will need to be custom optics. They will have to be large enough not to clip the broad beam, but small enough to fit into the 30 mm height limitation. These will have to be rectangular prisms, coated to reflect 22 nm light at a given angle of incidence. The beam splitter that reflects 10% the of beam 1 back to CCD2 can be a standard 1" optic with the appropriate coatings.

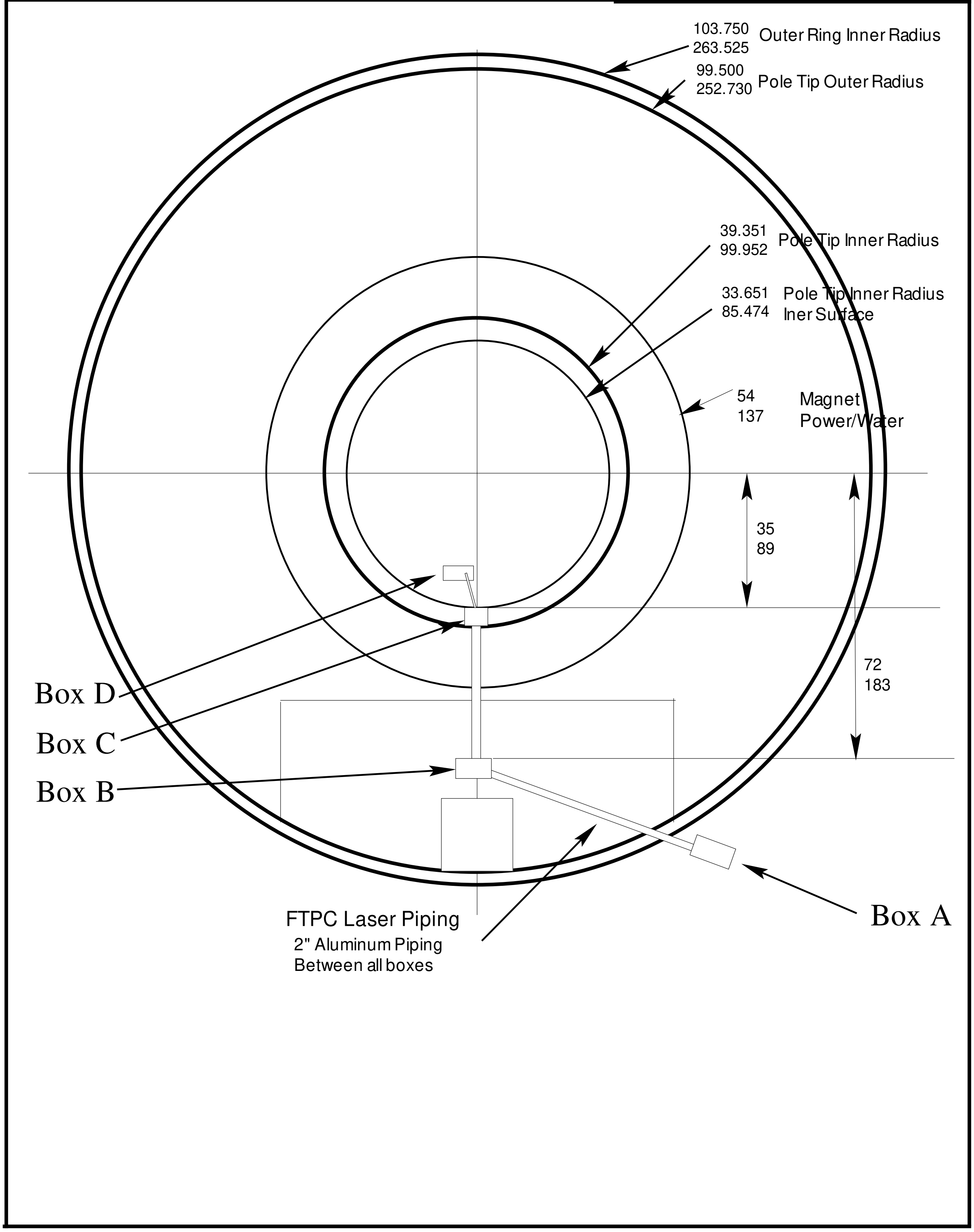
Figure 7 shows the distribution of the laser beams across the back plane of the FTPC. The beams exiting from Box D will be transported across the back plane of the FTPC in one inch diameter tubes. Four beams will need to be transported across the back plane; one for each of the three insertion rods, and one reflected beam necessary for alignment. The precision of the alignment system is linearly dependent upon the path length of this alignment beam. Also note that each insertion rod extends one inch beyond the FTPC envelope. In addition to this one inch an additional inch of space would be required for a housing to adequate for laser safety. Inside this housing will be a mount housing a tandem prism set. Half inch 45 degree prisms are needed to reflect the laser beams first into the z direction, and then along the insertion rods. Positioned along the insertion rods will be five pickoff mirrors made from 1 mm quartz fibers.

Figures 8 and 9 are included for reference. These figures are the integration groups drawings that define the spatial envelopes of the various subsystems.

Also included (in the non-electronic versions of this document) are a parts list and xerox copies of the relevant pages from the vendors catalogues detailing the specific components of the system.


FTPC Laser Calibration System
15 Beams, in three sets of 5 (phi=0,120,240)
Only one set is displayed
Incoming
laser beam
Beam Pipe
FTPC
Front View
FTPC

UCD NPG DRAWING NUMBER	REV.	STAR DRAWING NUMBER	REV.	REV. DATE	RHIC/STAR FTPC
		FTPxxx-A-1	A	18-Aug-98	Laser Calibration System
DRAWN BY Daniel Cebra	COG ENG	PROD APP		STAR WBS 4.6.6	Transfer Path
INSTITUTION UC DAVIS		DRAWING SIZE			



UCD NPG DRAWING NUMBER	REV.	STAR DRAWING NUMBER FTPxxx-A-1	REV. A	REV.DATE 20-Aug-98	RHIC/STAR FTPC
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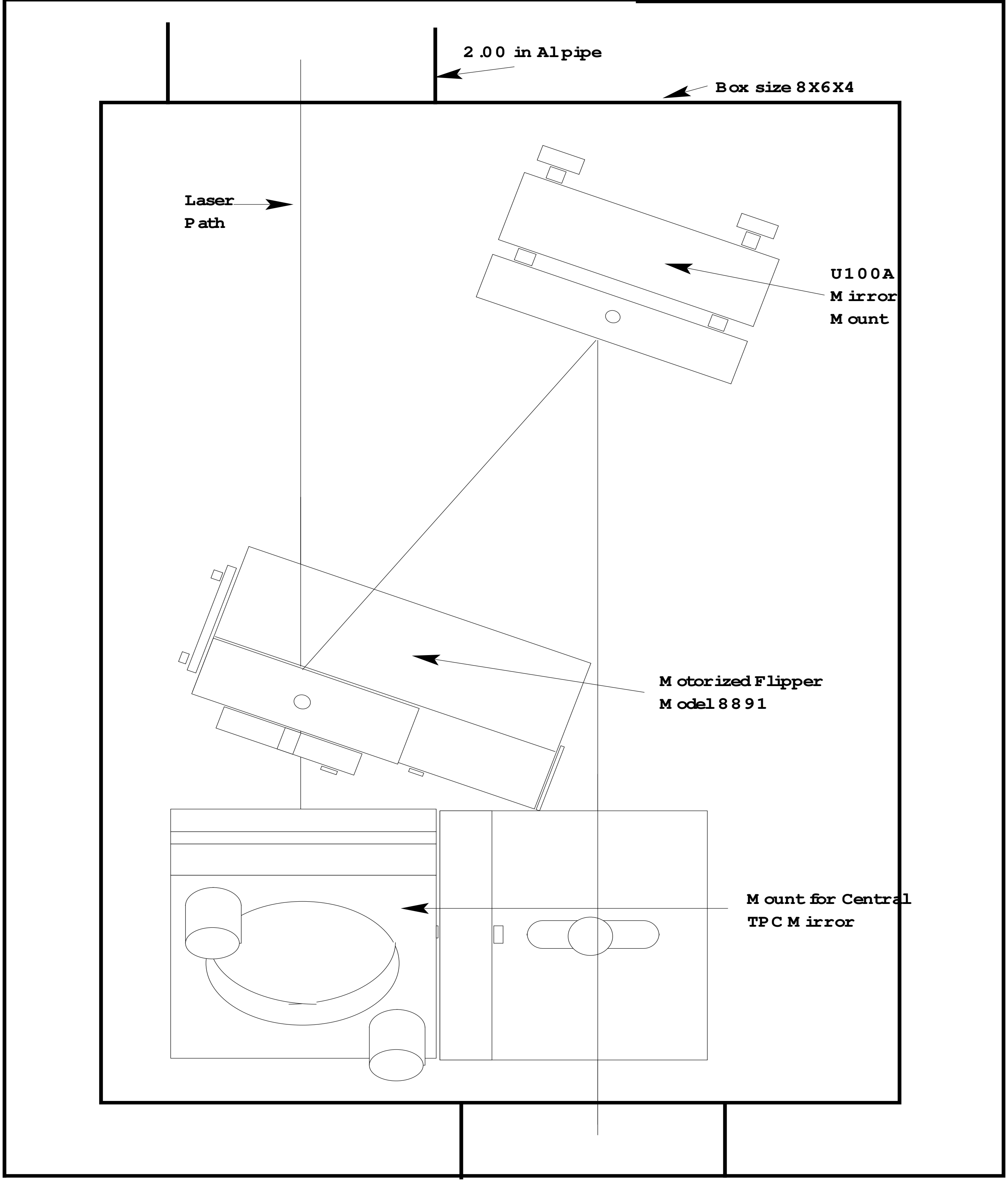
INSTITUTION UC DAVIS		DRAWING SIZE			Box A



UCD NPG DRAWING NUMBER	REV.	STAR DRAWING NUMBER	REV.	REV.DATE	RHIC/STAR FTPC
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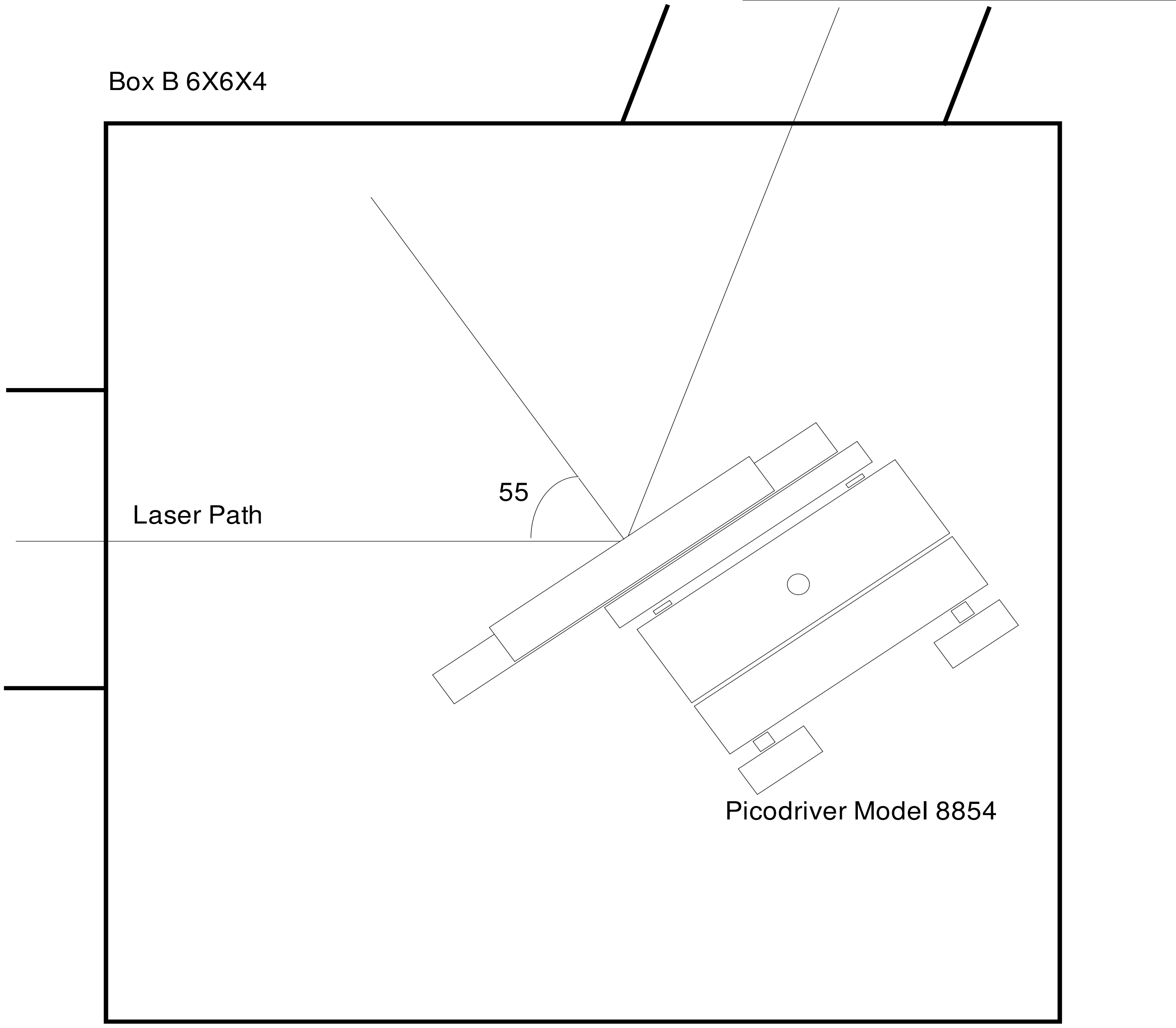
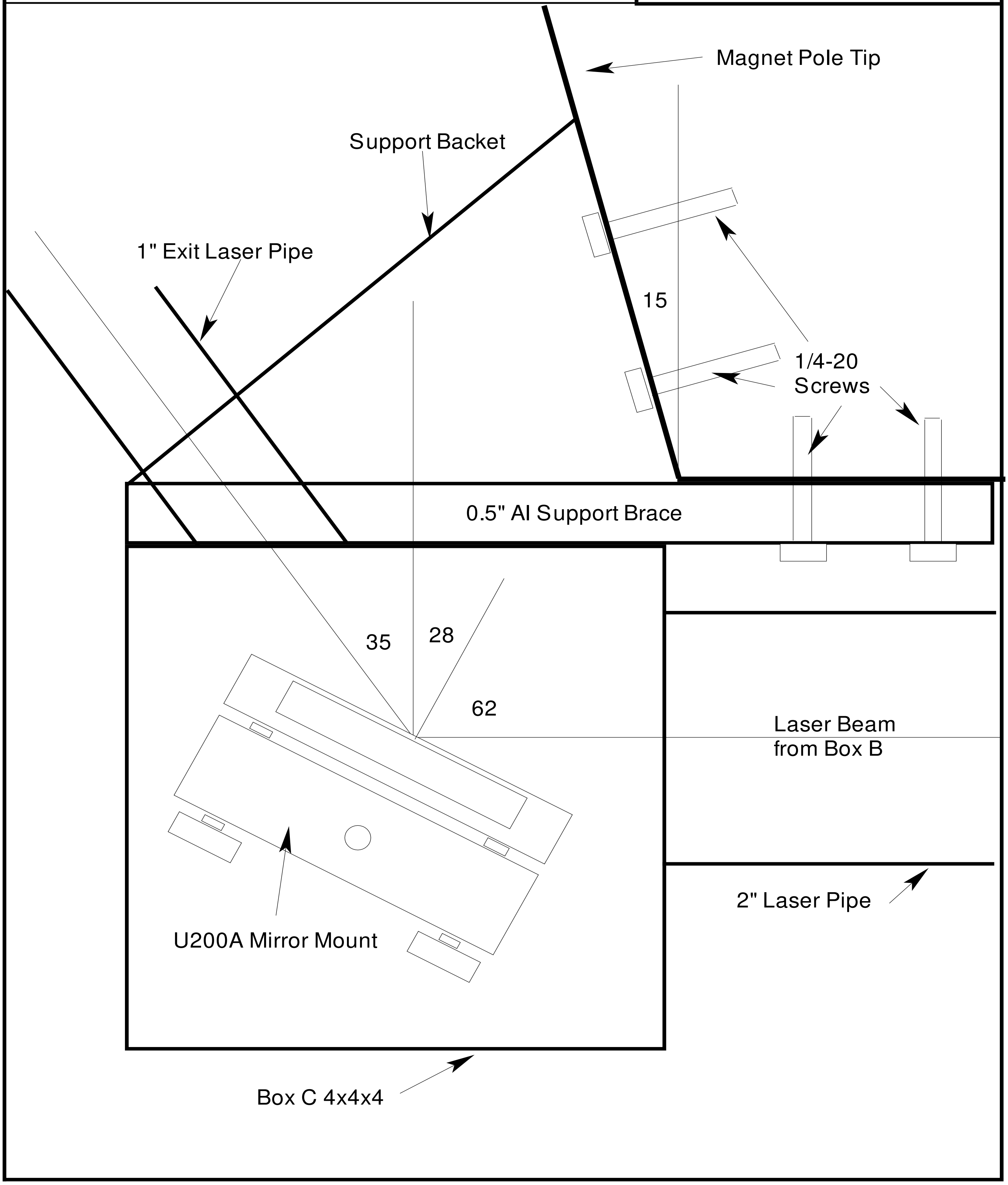
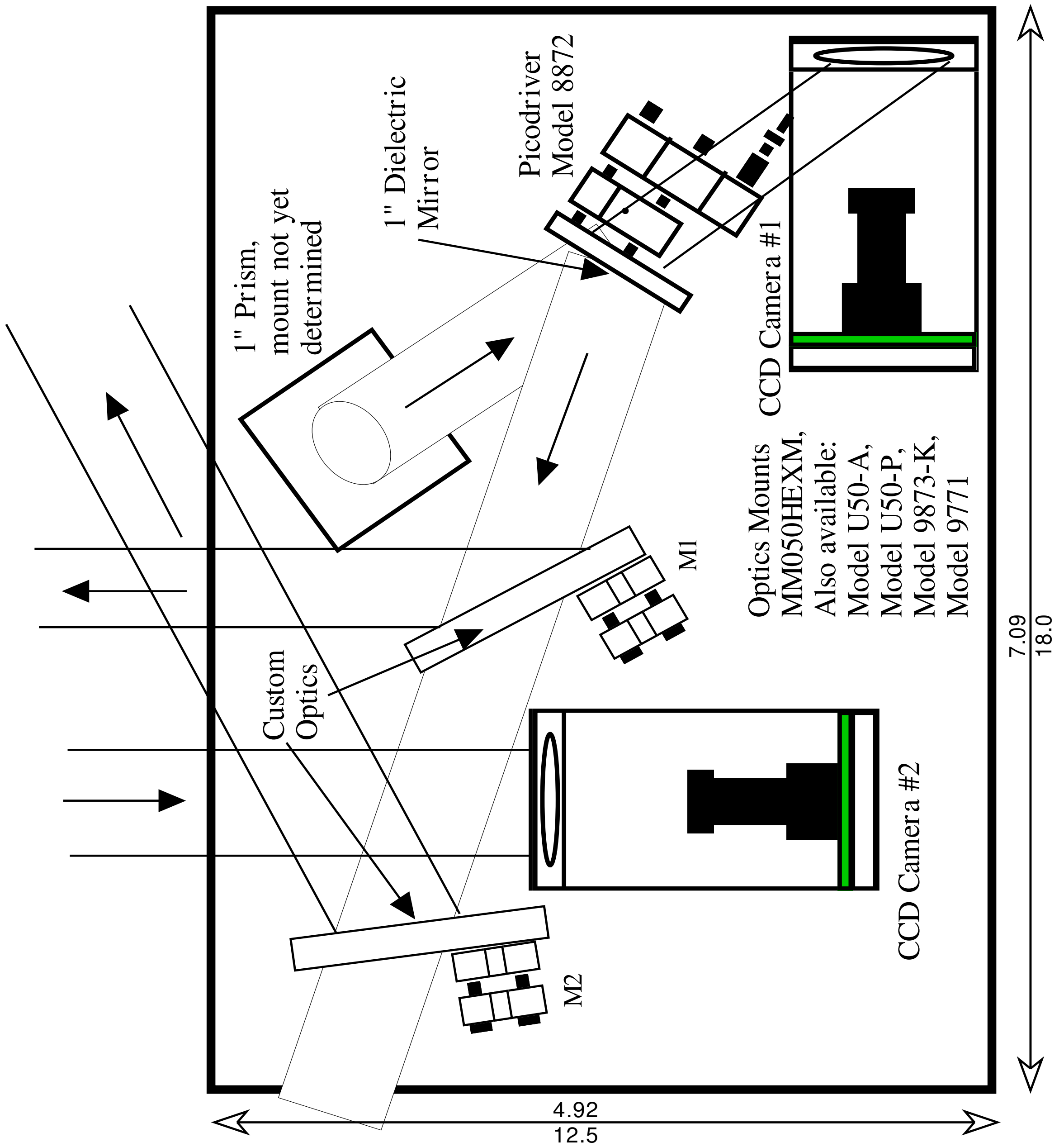
DRWN BY Daniel Cebra	COG ENG	PROD APP		STAR WBS 4.6.6	Laser Calibration System
INSTITUTION UC DAVIS		DRAWING SIZE			Box B



UCD NPG DRAWING NUMBER	REV.	STAR DRAWING NUMBER	REV.	REV.DATE	RHIC/STAR FTPC
		FTPxxx-A-1	A	20-Aug-98	
DRWN BY Daniel Cebra	COG ENG	PROD APP	STAR WBS 4.6.6		Laser Calibration System
INSTITUTION UC DAVIS		DRAWING SIZE			Box C



UCD NPG DRAWING NUMBER	REV.	STAR DRAWING NUMBER FTPxxx-A-1	REV. A	REV.DATE 20-Aug-98	RHIC/STAR FTPC
DRWN BY Daniel Cebra	COG ENG	PROD APP		STAR WBS 4.6.6	Laser Calibration System
INSTITUTION UC DAVIS		DRAWING SIZE			Box D



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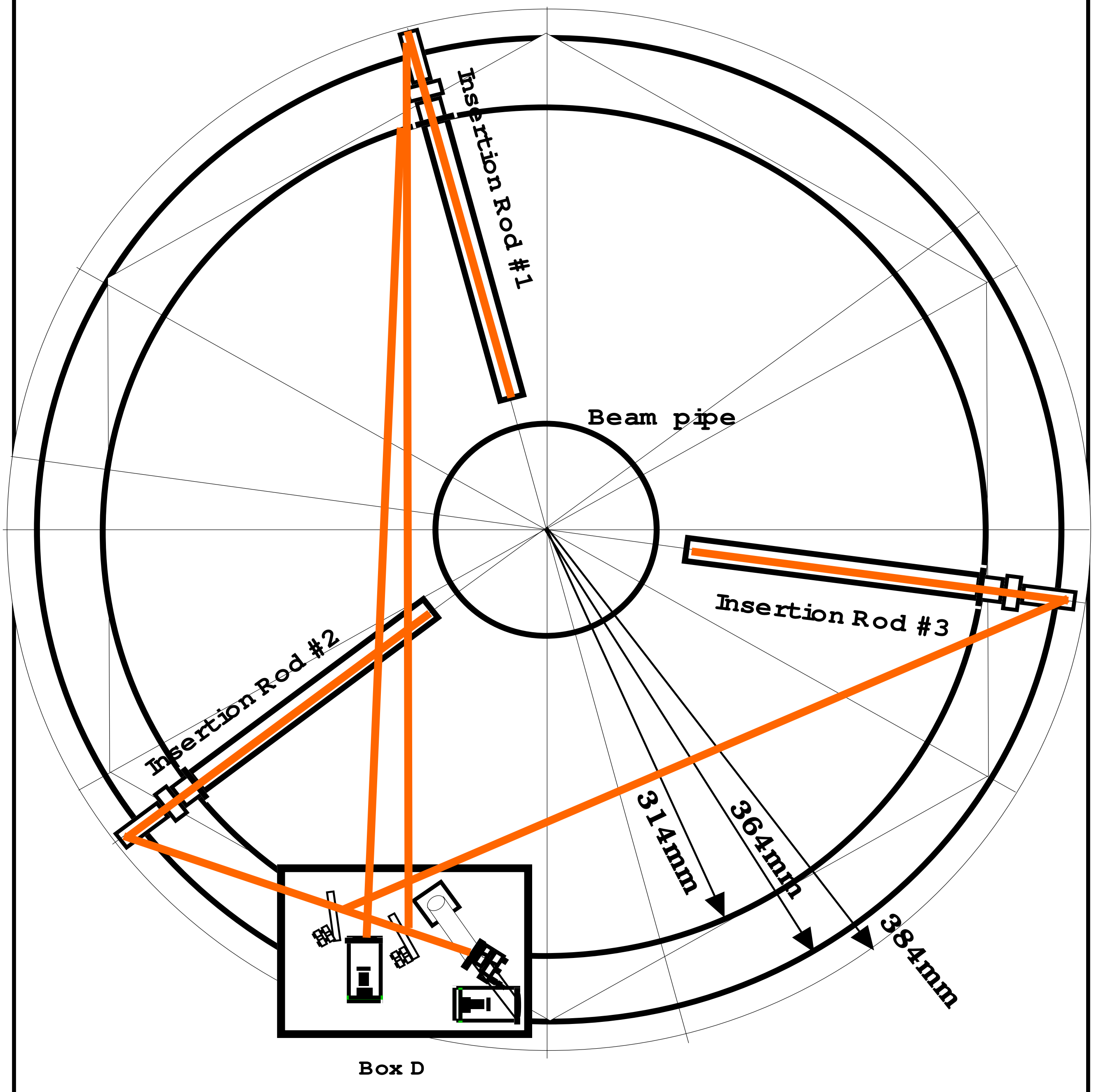
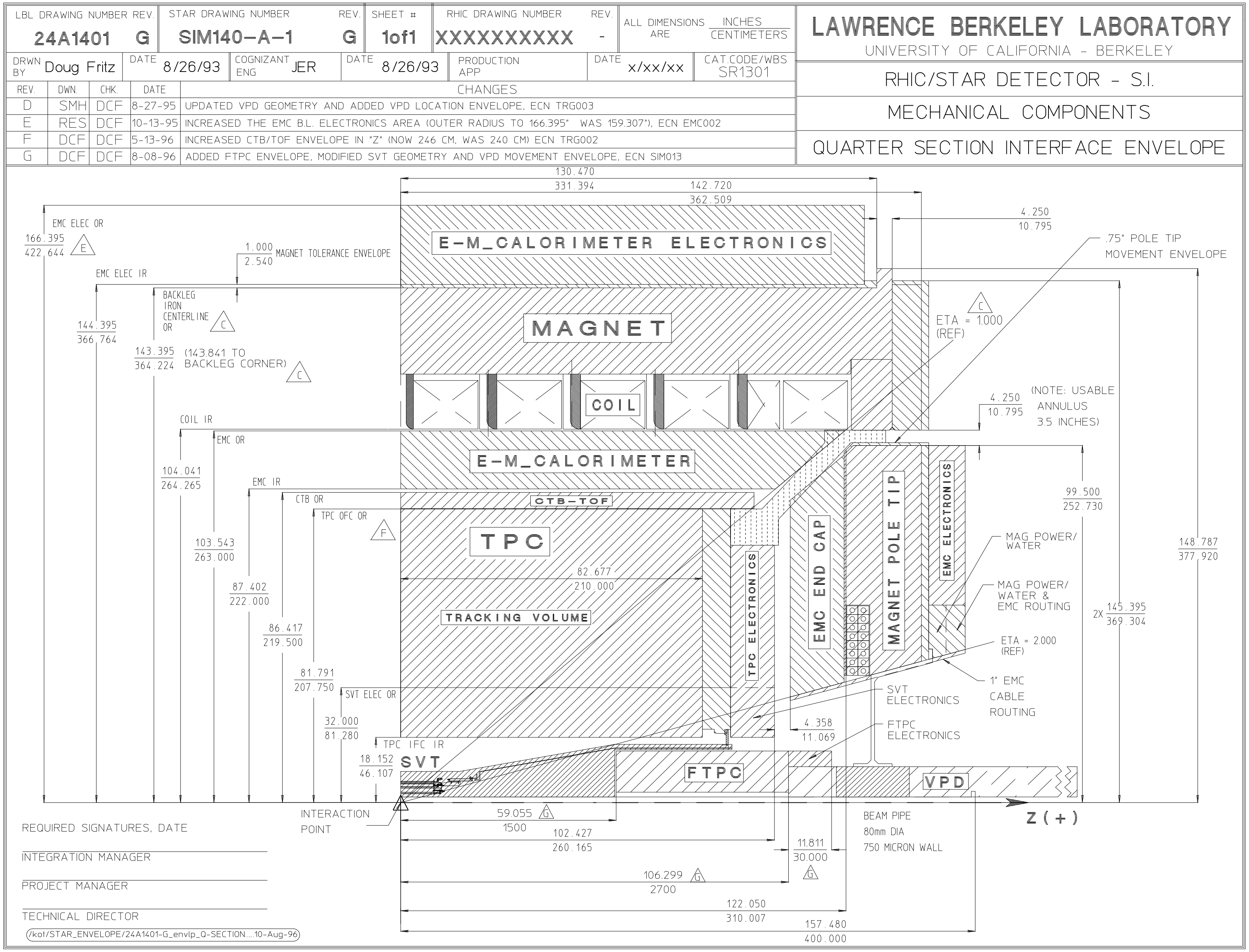
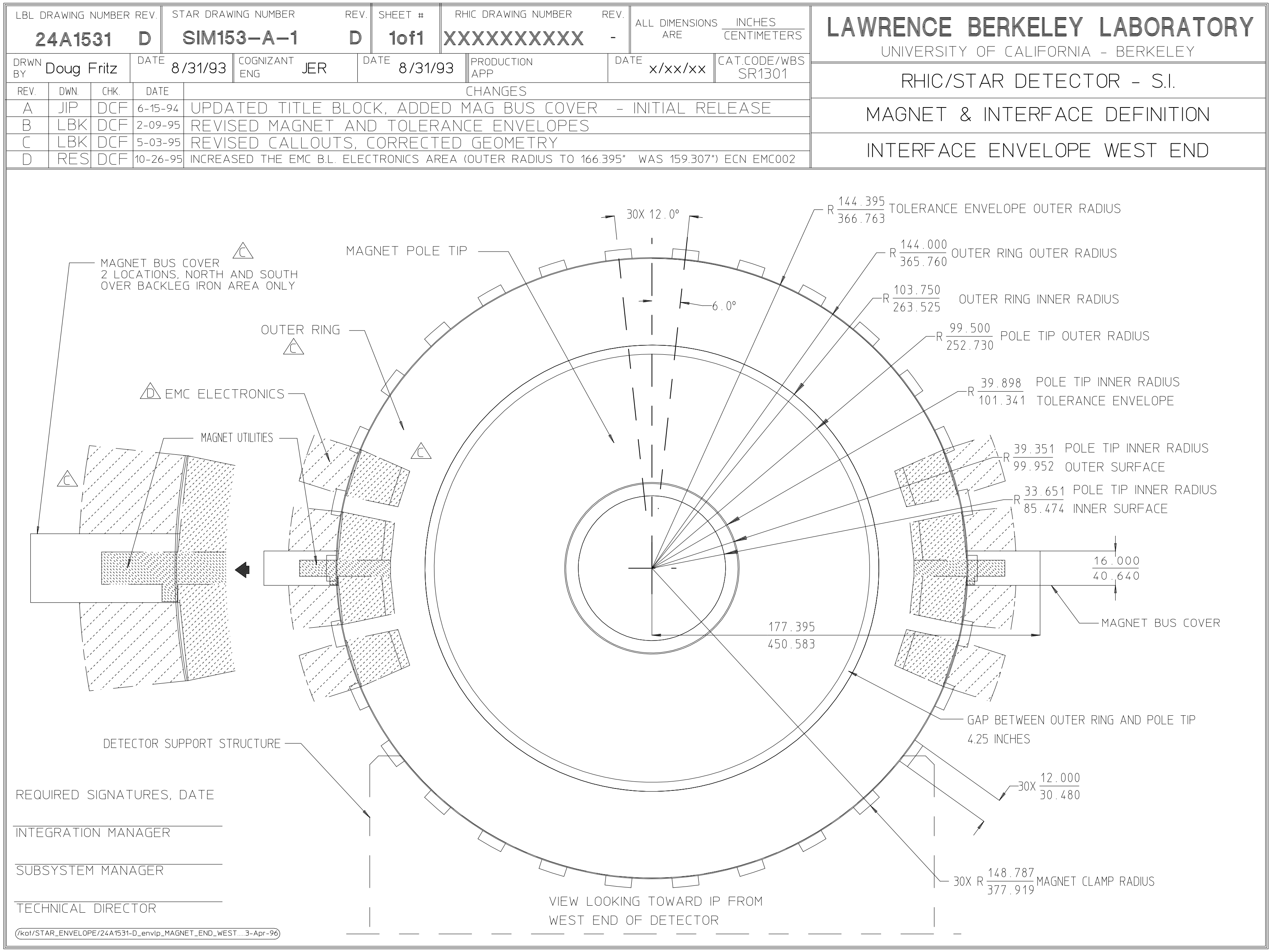
INSTITUTION UC DAVIS		DRAWING SIZE			Laser Distribution




LBL DRAWING NUMBER REV.
24A1401 G
STAR DRAWING NUMBER REV.
SIM140-A-1 G
SHEET #
1of1
RHIC DRAWING NUMBER REV.
XXXXXXXXXX -
ALL DIMENSIONS ARE INCHES / CENTIMETERS
DRWN BY Doug Fritz
DATE 8/26/93
COGNIZANT ENG JER
DATE 8/26/93
PRODUCTION APP
DATE x/xx/xx
CAT.CODE/WBS SR1301
REV. DWN. CHK. DATE CHANGES
D SMH DCF 8-27-95 UPDATED VPD GEOMETRY AND ADDED VPD LOCATION ENVELOPE, ECN TRG003
E RES DCF 10-13-95 INCREASED THE EMC B.L. ELECTRONICS AREA (OUTER RADIUS TO 166.395" WAS 159.307"), ECN EMC002
F DCF DCF 5-13-96 INCREASED CTB/TOF ENVELOPE IN "Z" (NOW 246 CM, WAS 240 CM) ECN TRG002
G DCF DCF 8-08-96 ADDED FTPC ENVELOPE, MODIFIED SVT GEOMETRY AND VPD MOVEMENT ENVELOPE, ECN SIM013
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY
RHIC/STAR DETECTOR - S.I.
MECHANICAL COMPONENTS
QUARTER SECTION INTERFACE ENVELOPE
E-M_CALORIMETER ELECTRONICS
MAGNET
COIL
E-M_CALORIMETER
CTB-TOF
TPC
TRACKING VOLUME
TPC ELECTRONICS
EMC END CAP
MAGNET POLE TIP
EMC ELECTRONICS
SVT
FTPC
VPD
Z (+)
EMC ELEC OR 166.395 / 422.644
EMC ELEC IR 144.395 / 366.764
1.000 / 2.540 MAGNET TOLERANCE ENVELOPE
BACKLEG IRON CENTERLINE OR 143.395 / 364.224 (143.841 TO BACKLEG CORNER)
COIL IR 104.041 / 264.265
EMC OR 103.543 / 263.000
EMC IR 87.402 / 222.000
CTB OR 86.417 / 219.500
TPC OFC OR 81.791 / 207.750
SVT ELEC OR 32.000 / 81.280
TPC IFC IR 18.152 / 46.107
INTERACTION POINT
130.470 / 331.394
142.720 / 362.509
82.677 / 210.000
4.250 / 10.795
.75" POLE TIP MOVEMENT ENVELOPE
ETA = 1.000 (REF)
4.250 / 10.795 (NOTE: USABLE ANNULUS 3.5 INCHES)
99.500 / 252.730
MAG POWER/ WATER
MAG POWER/ WATER & EMC ROUTING
ETA = 2.000 (REF)
1" EMC CABLE ROUTING
SVT ELECTRONICS
FTPC ELECTRONICS
4.358 / 11.069
148.787 / 377.920
2X 145.395 / 369.304
BEAM PIPE 80mm DIA 750 MICRON WALL
59.055 / 1500
102.427 / 260.165
11.811 / 30.000
106.299 / 2700
122.050 / 310.007
157.480 / 400.000
REQUIRED SIGNATURES, DATE
INTEGRATION MANAGER
PROJECT MANAGER
TECHNICAL DIRECTOR
(/kot/STAR_ENVELOPE/24A1401-G_envlp_Q-SECTION....10-Aug-96)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24A1531 D
STAR DRAWING NUMBER REV.
SIM153-A-1 D
SHEET #
1of1
RHIC DRAWING NUMBER REV.
XXXXXXXXXX -
ALL DIMENSIONS ARE INCHES / CENTIMETERS
DRWN BY Doug Fritz
DATE 8/31/93
COGNIZANT ENG JER
DATE 8/31/93
PRODUCTION APP
DATE x/xx/xx
CAT.CODE/WBS SR1301
REV. DWN. CHK. DATE CHANGES
A JIP DCF 6-15-94 UPDATED TITLE BLOCK, ADDED MAG BUS COVER - INITIAL RELEASE
B LBK DCF 2-09-95 REVISED MAGNET AND TOLERANCE ENVELOPES
C LBK DCF 5-03-95 REVISED CALLOUTS, CORRECTED GEOMETRY
D RES DCF 10-26-95 INCREASED THE EMC B.L. ELECTRONICS AREA (OUTER RADIUS TO 166.395" WAS 159.307") ECN EMC002
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY
RHIC/STAR DETECTOR - S.I.
MAGNET & INTERFACE DEFINITION
INTERFACE ENVELOPE WEST END
30X 12.0°
6.0°
R 144.395 / 366.763 TOLERANCE ENVELOPE OUTER RADIUS
R 144.000 / 365.760 OUTER RING OUTER RADIUS
R 103.750 / 263.525 OUTER RING INNER RADIUS
R 99.500 / 252.730 POLE TIP OUTER RADIUS
R 39.898 / 101.341 POLE TIP INNER RADIUS TOLERANCE ENVELOPE
R 39.351 / 99.952 POLE TIP INNER RADIUS OUTER SURFACE
R 33.651 / 85.474 POLE TIP INNER RADIUS INNER SURFACE
16.000 / 40.640
MAGNET BUS COVER
177.395 / 450.583
GAP BETWEEN OUTER RING AND POLE TIP 4.25 INCHES
30X 12.000 / 30.480
30X R 148.787 / 377.919 MAGNET CLAMP RADIUS
VIEW LOOKING TOWARD IP FROM WEST END OF DETECTOR
MAGNET BUS COVER
2 LOCATIONS, NORTH AND SOUTH
OVER BACKLEG IRON AREA ONLY
MAGNET POLE TIP
OUTER RING
EMC ELECTRONICS
MAGNET UTILITIES
DETECTOR SUPPORT STRUCTURE
REQUIRED SIGNATURES, DATE
INTEGRATION MANAGER
SUBSYSTEM MANAGER
TECHNICAL DIRECTOR
/kot/STAR_ENVELOPE/24A1531-D_envlp_MAGNET_END_WEST 3-Apr-96