MRO Delay Line ICD

Metrology System to Beam Combining Facility

ICD INT-406-VEN-0012

The Cambridge Delay Line Team

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1 ICD Description

ICD Number	Sub-systems		Org	Owner	Brief description and preliminary contents
INT-406-VEN-0012	Metrology System	BCF	UoC	MF	Relates metrology bench, services and electronics racks etc to BCF (BCA) area. • Location and requirements of metrology bench • Location and requirements of electronics racks • Service connections, heat removal etc.

2 Change Record

Revision	Date	Authors	Changes
0.1	2007-08-10	MF	First draft version
0.2	2009-05-20	MF	Major revision to account for choice of Agilent laser. Details of modules, including VME requirements and metrology cabling.
0.3	2009-06-16	MF	Revised IP module to Acromag IP470A: p6 Revised utility power requirement to metrology system: p7 Description for powering additional receiver modules added: p8
0.4	2009-10-05	MF	Corrected optical fibre code to E1705E on page

3 Notification List

The following people should be notified by email that a new version of this document has been issued:

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4 Scope

This document describes the interface requirements for the metrology system within the BCF. This includes the size and positioning of the metrology table(s), the accommodation of electronics associated with the metrology system, cabling requirements and services. The layout of the metrology system on the table is not specifically part of this interface.

5 Acronyms and Abbreviations

BCA Beam Combining Area
BCF Beam Combining Facility
BRS Beam Relay System
DL Delay Line
DLA Delay Line Area
ICD Interface Control Document
ICS Interferometer Control System
SCS Supervisory Control System
MROI Magdelena Ridge Observatory Interferometer
UoC University of Cambridge
NMT New Mexico Tech
OPD Optical Path Delay
TBC To be confirmed
TBD To be determined

6 Applicable Documents

DOCUMENTS

AD1 Top Level Requirements INT-406-TSP-0002

AD2 MROI Delay Line Derived requirements INT-406-VEN-0107

DRAWINGS

AD3 MROI Beam Combining Facility

.

7 Reference Documents

RD1 Delay line to Beam Relay system (INT-406-VEN-0008)

RD2 Delay line to metrology system (INT-406-VEN-0010)

RD3 Metrology System to Beam Relay System (INT-406-VEN-0013)

RD4 Parts list for the MROI Metrology System

RD5 5517FL Laser Head User Manual

RD6 M3 Architectural Dimension Floor Plan AR101

RD7 Metrology system drawing set

RD8 Internal memo (email from T Coleman 2009-05-29)

8 Introduction

This ICD describes the facilities and services which the metrology system requires to be provided in the BCF. There are four areas of interface: the metrology table in the inner BCA; the placement of electronics chassis in the outer BCA; the cabling between the electronics chassis and subassemblies on the metrology table; and the services required at the metrology table and the electronics chassis.

The size and positioning of the metrology table is closely associated with the delay lines which the metrology system feeds (information on the interface between the delay lines and the metrology system is contained in RD2 and the layout of the components on the metrology table is presented in RD4). Access to the delay line end-plates close to the table and also to components on the table is very important and since space in the inner BCA is limited some further compromise may be necessary e.g. incorporating some of the other optical components required in the BCA on the metrology table.

To meet heat loading limitations in the inner BCA (RD8), most of the electronics associated with the metrology system is located in the outer BCA while the laser head, located on the metrology table, is to be ventilated by forced air drawn in from and returned to the outer BCA.

9 Requirements

9.1 Metrology Table

9.1.1 Metrology table area and location

A metrology table area of 7.2m minimum by 0.6m minimum is required to support the optical layout for 10 delay lines fed by up to two laser heads. It may comprise several tables but must behave as one monolithic table.

Access is required to the front (closest to the delay lines) and rear of the table for adjustment of various optical components and the shear camera. This places a maximum practical width on the optical table of 1.8m.

The distance between the end-plate of each delay line and the nearest edge of the metrology table should not be less than 0.75m. This allows sufficient space for the protection mechanism of the DL science beam exit window to project a further 250mm in front of the end-plate (the surface of which is 100mm from the inside wall of the BCA) thus allowing at least 500mm clear for personnel access to the delay lines or the metrology table.

The laser head is to be mounted at the south end of the table but provision should be made for mounting a second laser at the N end of the table if room permits. At least 850mm between the end of the table and the centreline of the nearest delay line is required to accommodate the laser head and branch mirrors.

The metrology table should be positioned at least 600mm from the south wall of the BCA to allow personnel access.

9.1.2 Metrology table height

The height of the table is determined by the height of the metrology beam expander assembly and the incoming science beam height above the BCA floor. The nominal height of the centre of the incoming science beam above the BCA floor is 1.6m. The base of the metrology system is 355mm below this and therefore the *nominal* height of the top surface of the metrology table is 1265mm above the floor with an allowance of +/-0.25mm for height setting and +/-0.1mm in the table surface error. Adjustment of the height of the metrology table (with a sensitivity of approximately 0.1mm) must be provided as there is no height adjustment in the individual metrology beam expander assemblies.

9.2 Electronics

Rack space in the outer BCA is required for a single 12U height VME crate is required for the metrology measurement system. The parts required for the VME system are listed in RD4 but a portion of the table is reproduced here in Table 1. In addition to the VME power supply at least 13 slots will be required depending on the disc drive and any other peripheral devices/interfaces.

Rack space in the outer BCA is required to hold the power supply block for the laser head. The Agilent laser has a power block rather than a rack-mountable module and a second block or 15V PSU will be needed when more receivers are powered. Space is also require to hold up to 10 Agilent receiver modules which receive signal from the remote sensors over optical fibre and convert it to voltages which are then connected to the measurement board. A 3U height unit should be sufficient to house these modules and the power supplies.

Rack space of 15U for up to 10 1U height shear camera computer modules with a 0.5U minimum spacing between each is required. They need not occupy the same rack as the VME system nor all be contained in one rack.

The positioning of the rack(s) in the outer BCA used for housing the electronics should take into account the available cable tray routes and the maximum cable lengths detailed in the following section. The preferred location of all the electronics is in a single rack located in the outer BCA close to the south end of the metrology table as shown in Figure 1 in the appendix.

Table 1 Electronics in the rack positioned in the outer BCA

Component	N°.	Size[4]	Supplier	Part Number
Laser head power supply [2]	1	-	Agilent	10884B
Remote receiver [1]	1-10	-	Agilent	E1709A
VME system				
VME card frame	1	16		(13 slot min, with power supply and fan cooling)
VME CPU plus disc drive[5]	1	1 + 2	Concurrent Technologies	VP325/022-23U plus options as required
Measurement board [3]	1-5	1	Agilent	10898A
IP carrier board	1	1	TEWS	TVME200-10
8-channel D-A IP pack	1	-	Acromag	IP-220A-16
Digital IO IP pack	1	-	Acromag	IP470A
Custom interface board	1	3	Cambridge	Drawing set
Timing and frequency processor	1	1	Symmetricom	TTM635VME-VCXO
Shear System		-		
Shear camera computer[1]		-	Eurotech	APOLLO-ICE-G-P1.8FL-512M-AC-NO_O/S
Keyboard	1	-		Unspecified
Monitor	1	-		Unspecified
KVM switch	1	-		Unspecified

Notes:-

[1] One needed for every delay line.
[2] Number depends on how many receivers are powered
[3] One needed for every 2 delay lines.
[4] Indicates module width for VME modules
[5] VME cards are also available with on-board disc drives. Alternatively modules are available with disk, DVD, floppy and other interfaces as required.

9.3 Cabling

Cabling between components on the metrology table and the electronics rack(s) is identified here in Table 2.

Table 2 Cabling between metrology system components.

Source (Met Table)	**Destination** (Outer BCA)	**Function**	**No.**	**Cable Type**	**Maximum cable length**
Interferometer remote sensor	Remote receiver	Measurement signal	1-10	Agilent E1705E opt 400	20m
	Remote receiver to VME System measurement board	Measurement signal	1-10	Agilent N1250A	5m
Laser Head	VME System measurement board	Reference signal	1	Agilent 10881C [1]	20m
Laser Head		Power supply and control	1	Agilent 10881C [1]	20m
Shear Camera	Shear Cam Computer	Shear image	1-10	Firewire	10m plus 4.5m repeater as required

Notes: [1] This is a single cable combining power supply and reference signal (see appendix)

9.4 Services

The following services are required for the metrology system:

- Utility power for the VME rack
- Utility power for up to ten shear camera computers each fitted with 180W power supply.
- Utility power for the Laser head and receiver module power supplies 200W
- One network socket at the metrology table. (Gigabit Ethernet recommended for displaying shear camera images)
- Ten network sockets for the shear camera computers. (Gigabit Ethernet recommended)
- Ducting/cable trays for connections between metrology table and equipment rack(s)

9.5 Thermal loading

The laser will dissipate 35W while warming up but approximately 23W while in normal operation. A significant proportion of this heat should be removed to meet the dissipation requirement of no more than a total of 20W [TBC] apportioned to the metrology system within the inner BCA (RD1 & RD2). Each shear camera will dissipate less than 1W and no explicit cooling will be necessary.

Air cooling for the laser head (RD5 and Figure 6) is required to be a minimum of 4m/s at the 50mm diameter exit port, at ambient temperature, to remove 80% of the power dissipated in the head.

10 Design

10.1 Metrology Table

The optical layout of the metrology system provides for ten channels of metrology from a single laser which is placed at one end of the metrology system. Provision for a second laser at the other end of the table should be made in case one is required to maintain sensitivity of the measurement system. This requires a table area which is long and narrow though the width could be increased to a standard size or more, if needed to accommodate other BCA optics, but in any case no more than 1.8m. The layout of the laser metrology system for the ten delay lines is described in RD4.

The distance between the inside of the south wall of the BCA and the centre of the first delay line pipe is 5 feet 11 ¾ inches i.e. 1.82m (according to the architectural drawing given in RD6). The preferred placement of the optical table along the N-S direction is such that there will be a 0.9m space between the inner BCA wall and south end of the metrology table. This provides a distance of 920mm between the edge of the table and the centre of the first delay line pipe (accommodating the 850mm minimum requirement) and allows for cables from components on the table to be routed into the cable tray directly above that end of the table. The diagram in Figure 1 in the appendix shows the laser mounted at the S end of the table and the dimensions for positioning the table. The layout drawing for the metrology bench within the BCF is available (AD3).

10.2 Connections

The connections between metrology components are listed in Table 2. Each cable is described in more detail in this section.

10.2.1 Laser metrology

The laser head cable carries both the power supply to the head and the laser reference signal from the head. The cable is 20m long and has a single connector at the laser but splits into to connectors at the other end. See Figure 3 and Figure 4 for how the cable is connected. The remote sensor is not shown in Figure 3 but connects to the remote receiver using a 20m glass optical fibre. The remote receiver is connected to the VME measurement board using a 5m cable. Agilent require that the receiver modules are powered by +15V which is supplied via the measurement board to which they connect however the measurement board itself does not provide this power, it is sourced externally and a suggested arrangement is outlined below.

A specially configured front panel ribbon cable is required to carry the reference signal from the first measurement board to each of the other measurement boards in the system. It is not recommended to carry the +15V supply to other measurement boards using this cable because the laser head power supply can only supply two measurement modules at most when a 20m laser head cable is used. Therefore a different power supply arrangement is required for supplying power to receivers via their measurement boards.

The measurement board does not supply the +15V however but all reference and signal input connectors (as well as the front panel ribbon cable link which carries the reference signal to other measurement boards) have this power connection bussed. Provided one of the two front panel reference signal connectors (dual measurement board) is supplied with +15V then a receiver module plugged into either or both channels will be powered. The first two receivers get power from the first measurement board via the reference signal cable from the laser head. Further receivers are powered from their respective measurement boards provided one of the other reference input sockets is supplied with power from the local +15V power supply in the rack.

It is suggested that this additional +15V power supply provides power to each additional measurement board via an individual cable which is plugged into one of the reference channel cables.

The power supply should be sized to provide 2.5A at +15V ±1V (for up to 8 receivers which each take <270mA).

10.2.2 Shear Camera

No allocations are made but it should be noted that the shear camera fire-wire cable length is limited to 20m for superior cable. If standard cable is used the limitation becomes 10m. Use of a repeater allows an additional 4.5m of cable to the standard 10m length. The repeater draws power from the fire-wire cable and therefore it would be undesirable to use more than one repeater per cable. Cable trays are approximately 2.5m above floor level and therefore cable length from the table surface to a tray directly above (if one is available) is approximately 1.25m. The distance of the furthest shear camera from the south wall is nominally 7.6m. Allowing the cable to rise and travel through the wall by the shortest route and then fall to the same level implies a further 3m length making the total minimum length for this run 10.6m.

10.2.3 Mirror mount control

There is no cabled arrangement envisaged for controlling the motorised mirror mounts which are incorporated into the metrology beam expander blocks. A handset may be plugged into the mirror mount to be adjusted. If remote operation from outside the BCA is desired then further cabling and interfacing would be necessary.

10.2.4 Grounding

In ‘Chapter 3 System Design Considerations’ of the Agilent Laser User Manual on laser measurement systems, a subsection entitled ‘System Grounding’ describes the grounding practise that should be adopted. This section is reproduced in Figure 8. The body of the laser will be connected to the metrology table while the receiver modules will be mounted in the rack containing all the other metrology electronics. This arrangement should be sufficient to comply with the grounding advice but if local regulations require that the metrology table be grounded then an earth loop will be created which may affect the signal to noise in the system. If explicit grounding of the metrology table is required then the best method would be to route that ground with the laser head cable and connect it to an earthing point in the metrology rack. In this way the loop area is minimised and it is unlikely that any other currents can flow through this earth link. Alternatively the laser head mounting plate could be electrically isolated from the table using very thin insulating film.

10.3 Laser cooling

To prevent uncontrolled air exchange between inner and outer BCA an insulated enclosure will be placed over the laser head and air introduced into it so that it can enter the cooling ports of the head. The exit port of the laser will connect to the outside of this enclosure to ensure that air is forced through the laser head.

A conduit system to bring air from the outer BCA into the laser head enclosure and remove it again is to be installed above each laser location at either end of the optical table. The interface details for this enclosure are yet to be determined. [TBD]

11 Appendix

Figure 1: showing the minimum size and preferred position of metrology table.

Figure 2: showing the relationship of the metrology table surface to the incoming science beam height and the nominal metrology table height above the inner BCA floor.

Figure 3: the Agilent single channel cabling arrangement

Figure 4: the Agilent 10881C laser head cable

Figure 5, 6 & 7: Specifications for the Agilent 5517FL and 5517GL laser heads.

Figure 8 System Grounding considerations

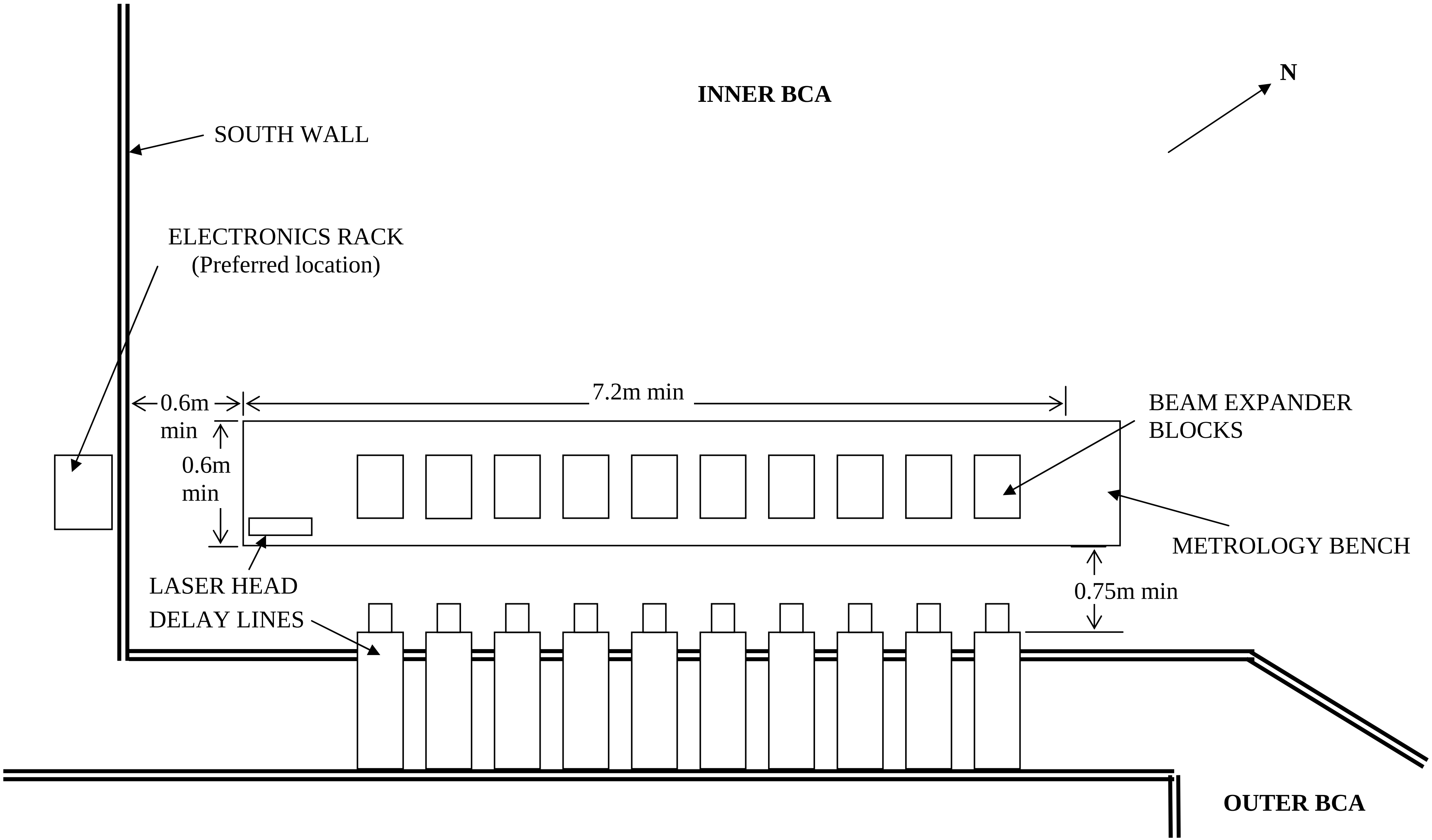

Figure 1Placement of metrology table in the inner BCA

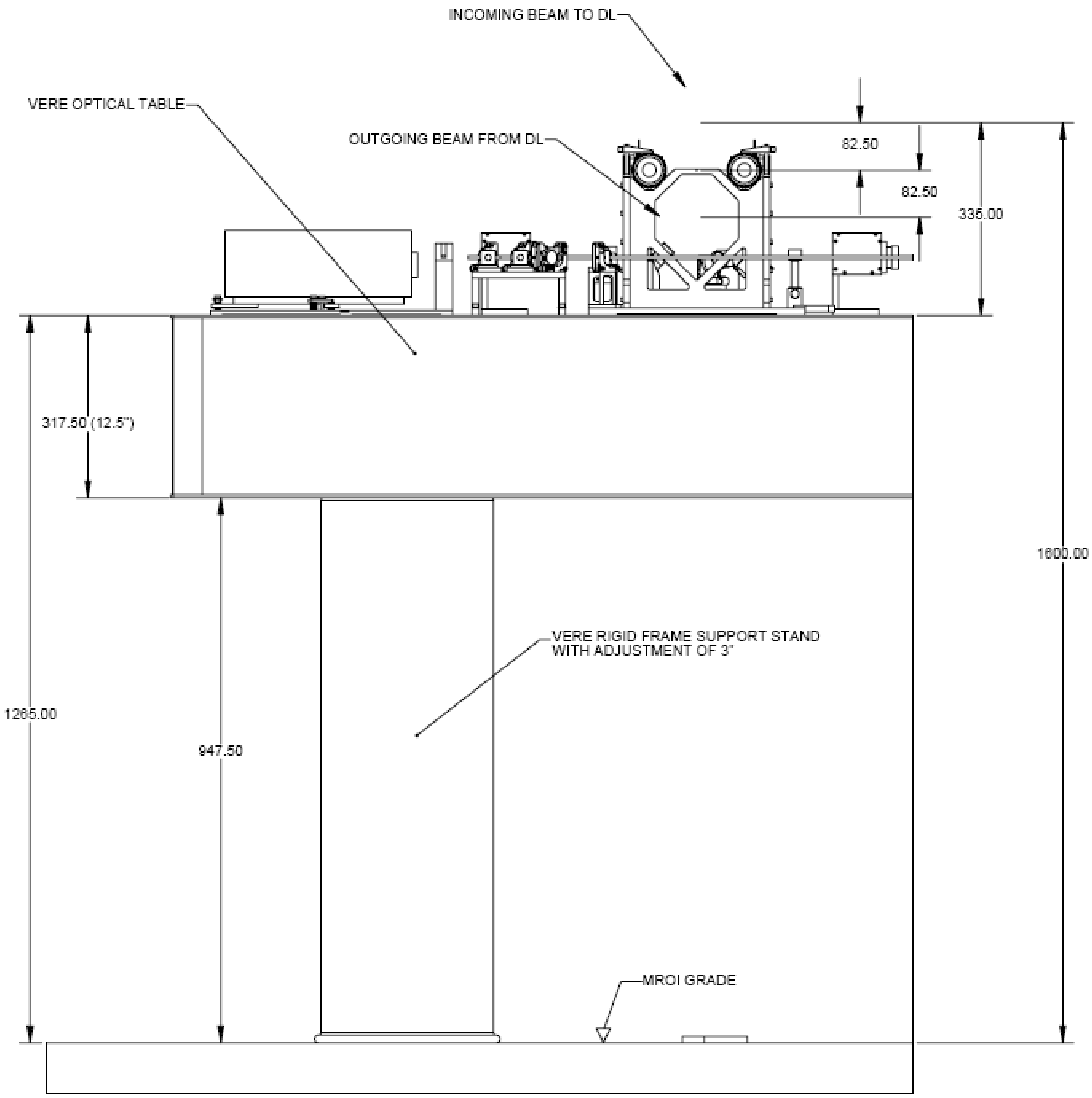

Figure 2 Position of the top surface of the metrology table with respect to the incoming science beam height (355mm) and the nominal dimension for the metrology table height above the inner BCA floor 1265mm (extracted fromAD3) .

Figure 6 shows typical connections to the laser head, axis board and the 10881A/B/C or 10791A/B/C laser head cables. Not shown are the spade lugs of the 10881D/E/F laser head cables used with a power supply other than the 10884B.

The figure also shows a typical connection of a receiver to an axis board. There are a variety of receivers and receiver cables to choose from. For more information on the receivers, cables and axis boards, see the Laser and Optics User's Manual or the individual receiver and axis board manuals.

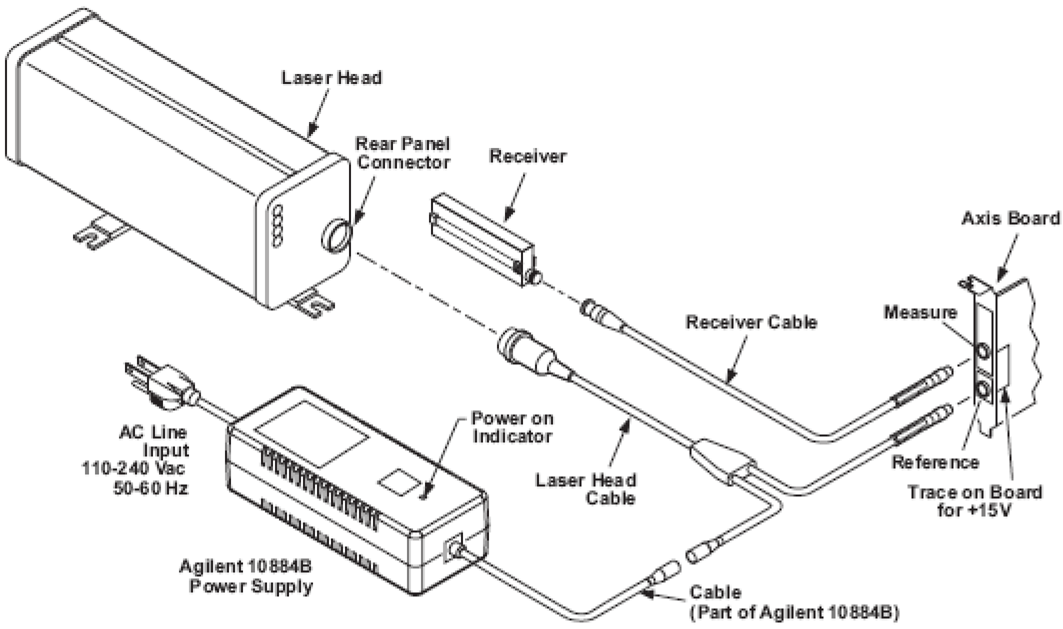

Figure 6 Installation of laser system cables

Figure 3 The Agilent cable arrangement for laser head, power supply, receiver and measurement board. The remote sensor is not shown but connects to the receiver via an optical cable. The Agilent power supply block and the receiver module(s) are to be located in the outer BCA.

5 Connecting Agilent 10881A/B/C or N1251B to the Agilent 10884B Power Supply:

a Connect the ac line cord to the input connector of the 10884B power supply.

b Plug the ac line cord into an operating ac line outlet.

The 10884B power supply has no power switch. As soon as it is plugged in, it will provide output power and the Power ON LED will light.

Figure 4 The Agilent 10881C Laser head cable.

Agilent 5517FL Laser Head Specifications (Standard, 5517FL-009, and 5517FL-300)

PHYSICAL CHARACTERISTICS

Dimensions: See Figure 77 on page 353

Weight: 3.4 Kilograms (7.5 pounds)

Magnetic Field Strength (Non-Operating):

Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged Laser Head.

Clearance Required for Cabling: 10.16 cm (4 in) beyond back

POWER

Power Input Requirements:

+15 Volts ±0.3 Volts at 2.2 Amperes maximum

-15 Volts ±0.3 Volts at 0.02 Ampere maximum

Heat Dissipation: 23 watts (during operation)
35 watts (during warmup)

Venting : Allows forced air cooling to reduce the power dissipated into the application. **Heat exhaust efficiency (typical, depends on envirnomental conditions):** 75%

Warmup Time: less than 10 minutes (4 minutes typical)

LASER BEAM CHARACTERISTICS

Type: Helium-Neon, Continuous, Two-Frequency

Maximum Beam Power Output: 1 milliwatt

Minimum Beam Power Output: 65 microwatts

Beam Diameter: 6 millimeters, 0.25 inch, typical
9 millimeters,0.35 inch, typical (5517FL-009)

Vacuum Wavelength Accuracy (3 sigma, lifetime): ±0.1 ppm

Vacuum Wavelength Stability (typical 1 hour): ±0.002 ppm

Vacuum Wavelength Stability (typical lifetime): ±0.02 ppm

Nominal Vacuum Wavelength: 632.991354 nanometers

Safety Classification:

Class II Laser Product conforming to U.S.

National Center for Devices and Radiological

Health Regulations 21 CFR 1040.10 and 1040.11.

OUTPUTS

Reference Frequency: ≥ 7.0 MHz
Reference Frequency (5517FL-300): ≥ 7.2 MHz

Figure 5 Specification sheet for the Agilent 5517FL laser head

5517GL High Speed Laser Head

The Agilent 5517GL is a high speed and low heat laser head designed to reduce heat load in the vicinity of the laser source and to increase the beam power over 120uW and the stage speed up to 1m/s (pm) as long as the products are used with Agilent's E1709A electronics*1. With the low heat design, typically, some (80%) of the electrical input power is removed by cooling air pulled from the laser head (referred to below as 'heat exhaust efficiency'). The 5517GL contains an automatically tuned Helium-Neon laser, control circuits, and a reference optical receiver. The laser generates a coherent, collimated, two-frequency beam of light. This is a Class II Laser Product conforming to U.S. National Center for Devices and Radiological Health Regulations 21 CFR 1040.10 and 1040.11.

*1: Please call Agilent Sales Representatives to check configuration and performance as system.

PHYSICAL CHARACTERISTICS
Dimensions: See figure, below
Weight: 3.2Kg
Enclosure: Type IP10 per IEC 529
Magnetic Field Strength (Non-operating): Does not exceed 5.25 milligauss at a distance of 460 cm (15 ft) from any point on the surface of the packaged laser head.
Clearance Required for Cabling: 10.16 cm (4 in) beyond rear panel.
POWER
Power Input Requirements:
+15 Volts ±0.3 Volts at 2.2 Amperes maximum
-15 Volts ± 0.3 Volts at 0.02 Amperes maximum
Heat Exhaust Efficiency: 80% typical

Airflow conditions: 4 m/s (min), exiting head through 50 mm diameter duct at room temperature.
LASER BEAM CHARACTERISTICS
Type: Helium-Neon, Continuous, Two Frequency
Maximum Beam Power Output: 1 milliwatt
Minimum Beam Power Output at shipment:
168 microwatts, spec to be finalized
Power Output after 3 years: 120 microwatts
Beam Diameter (visible): 9 mm (0.75 in) typical
Vacuum Wavelength Accuracy (3 sigma, lifetime): 0.1 ppm
Vacuum Wavelength Stability (typical 1 hour): 0.002 ppm
Vacuum Wavelength Stability (typical lifetime): 0.02 ppm
Vacuum Wavelength (Nominal): 632.99137 nm
OUTPUTS
Reference frequency: 7.2 MHz, spec to be finalized
This is a CE mark product *(Expected date of completion: Dec 2007)*

Figure 6 Specification sheet for the Agilent 5517GL laser head. The laser dissipation is expected to be the same as the 5517FL laser head.

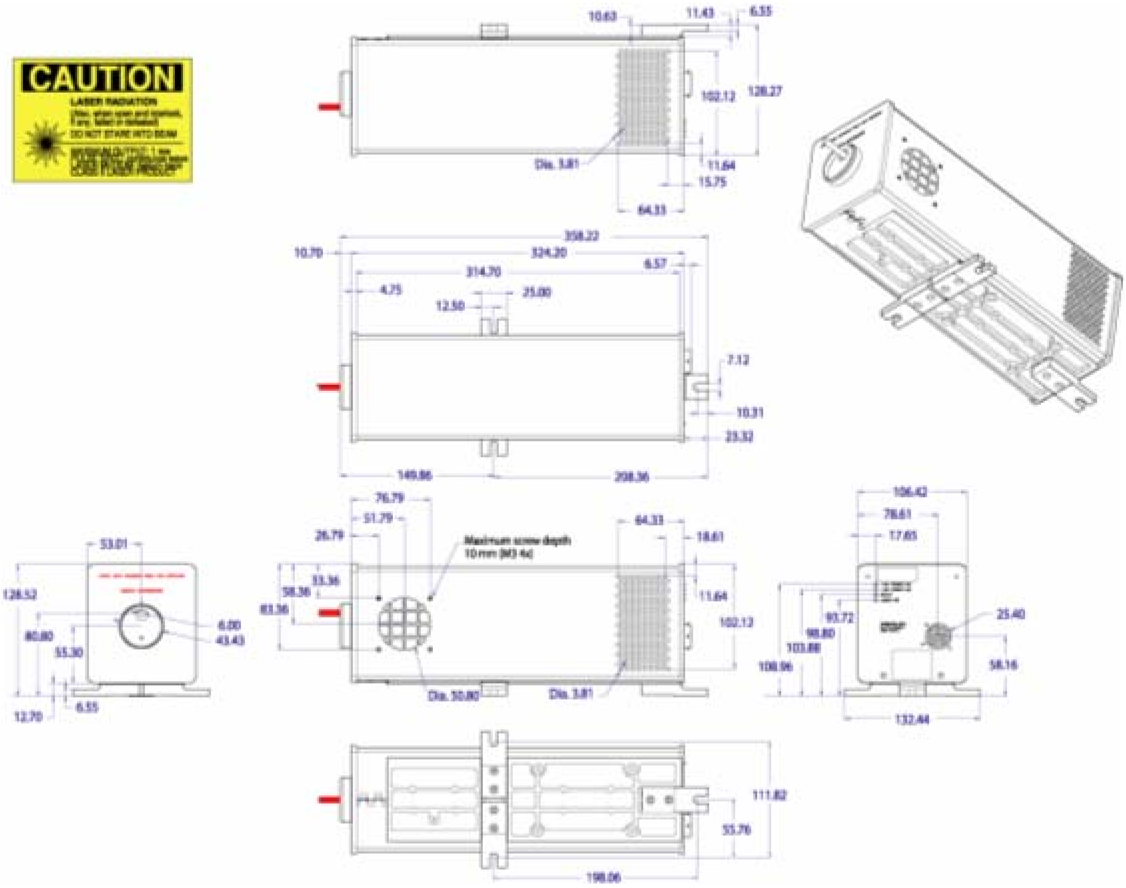

Figure 7 Specification sheet for the Agilent 5517GL laser head showing laser dimensions. Note that a different mounting arrangement will be used so the three feet shown here will be removed (see RD7).

System Grounding

Be sure to consider electrical grounding requirements as you plan and install your Agilent laser measurement. Grounding is important for safety reasons, but your grounding arrangement can also affect your laser system's performance.

Best practice requires that all system components that are connected to electrical ground should be connected to ground at a common point, not at separate points. Your electrical ground connections should radiate from a single point. Using more than one grounding point could create a ground loop, which could introduce an unacceptable level of electrical noise into the electronics.

Signal grounds on each Agilent laser head, each Agilent receiver and the Agilent laser measurement system electronics are all connected to their respective chassis. To prevent ground loops they all should be grounded through one common point.

The Agilent 10780C or Agilent 10780F receiver mounting is isolated from ground by using the nylon screws supplied.

A system using VME electronics (Agilent 10898A, Agilent 10897B, and Agilent 10895A axis boards), PC electronics (Agilent 10885A axis board) or PCI electronics (N1231A axis board) should be grounded through the electronics power line.

Figure 8 Extract from Agilent Laser System User Manual