STANFORD UNIVERSITY
W.W. HANSEN EXPERIMENTAL PHYSICS LABORATORY
GRAVITY PROBE B, RELATIVITY GYROSCOPE EXPERIMENT
STANFORD, CALIFORNIA 94305-4085

PRE-INTEGRATION UV FIBER OPTICS CHECK-OUT

GP-B SCIENCE MISSION PROCEDURE

7 December, 1998

PREPARED ______________________________ ____________________
B. Clarke, RE Charge Control Date

APPROVED ______________________________ ____________________
J. Janicki, Safety Engineer Date

APPROVED ______________________________ ____________________
R. Brumley, Gyro Manager Date

APPROVED ______________________________ ____________________
D. Bardas, Integration Manager Date

APPROVED ______________________________ ____________________
B. Taller, QA & Safety Date

APPROVED ______________________________ ____________________
S. Buchman, Hardware Manager Date

TABLE OF CONTENTS

1 SCOPE

This document provides the procedure for checking the Probe-C fiber optic cabling, after delivery to Stanford. It assumes that Probe-C is mounted on the Precision Manipulator per P0205(SM) in the HEPL Class 10 Cleanroom, and the Probe Vacuum Shell has been removed per P0376(SM). This procedure checks for optical continuity from the optical LEMO connectors at the top hat (UV1A through UV4B) to the optical LEMO connectors at the cold end connector block (UV1A through UV4B). This procedure also estimates the optical insertion loss of each fiber cable, in the UV @254 nm.

1.1 Acronyms

The following acronyms are used in this document

PM	Precision Manipulator
T-_Q	SIA Temperature Sensor
T-_P	Probe Temperature Sensor
H-_P	Probe Heater
H-_Q	Probe Heater
GRT	Germanium Resistance Thermometer
SD	Silicon Diode
TB_	Terminal Block X
DMM	Digital Multimeter
BPS_	Belleville Preload System
SIA	Science Instrument Assembly
HEPL	Hansen Experimental Physics Lab
GPB	Gravity Probe B
QA	Quality Assurance
ITD	Integration and Test Director
NA or N/A	Not Applicable
SM	Science Mission
Mohm or M?	Meg Ohm
V	Volt
I	Current
I-_	Top Hat Connector
HEX_	Heat Exchanger
UV	ultra violet

2 APPLICABLE DOCUMENTS

2.1 Plans and Procedures

P0059	GPB Contamination Control Plan
P0057	Stanford Magnetic Control Plan
P0205(SM)	Mounting Probe on Precision Manipulator
P0376(SM)	Removing the Probe Vacuum Shell
Op Order Log #: PRC0610	Final UV Fiber Optic Cable Acceptance Testing (Lockheed)
LMMS drawing 1C34103, Rev C, sheet 6	GYROS CABLE CONNECTOR INTERFACE

3 GENERAL REQUIREMENTS

3.1 Environmental Requirements

This procedure will be conducted in the Stanford Class 10 Cleanroom in the HEPL facility.

3.1.1 Cleanliness

The Class 10 clean room where this integration takes place shall be maintained at the cleanliness levels per GPB Contamination Control Plan P0059. Certified Class 10 cloth garments shall be worn in the Class 10 clean room.
Personnel should always work downstream of the probe relative to the HEPA wall, and avoid putting any part of their body between the HEPA wall and the probe.

3.1.2 Particulate Contamination

All parts and tools shall be cleaned using methods consistent with achieving Mil Spec 1246B Level 100 cleanliness. In addition, all parts shall be maintained at level 100 cleanliness per Procedure P0059. A portable particle counter shall monitor downstream of the local work area, to ensure that particulate counts are consistent with GP-B Contamination Control Plan P0059.

3.1.3 Magnetic Contamination

Parts to be handled are in Zones 2A, 2B, and SP. Also possibly Zone 3 if circumstances require during testing. Take all necessary precautions to keep tooling and handling free of magnetic contamination. Tools that come in contact with these components must be of Beryllium Copper, Phosphor Bronze, ceramic, copper, brass, titanium, mating GP-B flight connectors, as well as appropriate plastics.

3.2 Integration Personnel

3.2.1 Integration and Test Director

The Integration and Test Director (ITD) shall be Bruce Clarke. He has overall responsibility for the implementation of this procedure and shall sign off the completed procedure. The Gyroscope Manager, R. Brumley, shall also sign off this procedure.

3.2.2 Other Personnel

All personnel participating in this procedure shall work under the direction of the ITD who shall determine whether the person is qualified. Different people will likely be designated at different times. For this procedure, participating integration engineers are expected to be (at various times) Chris Gray, R. Brumley and Tim Carson and/or other LMMS personnel. Section 6 will show all appropriate signatures.

3.3 SAFETY

Safety Engineering to be notified prior to start of this procedure.

3.3.1 General
Personnel working in the Class 10 Cleanroom must be cognizant of the base of the Precision Manipulator, and take special care to avoid tripping or bumping into it.

3.3.2 Hardware Safety
Extreme care must be taken to avoid accidentally bumping the Probe or damaging the connectors. Connector savers or equivalent adapters, shall be used to protect the connector pins from damage during the measurements. A properly grounded ESD wrist strap must be worn while mating to or de-mating from Probe connectors.

3.3.3 Maximum Number of People in Cleanroom
Under normal operating conditions, there shall be no more than 5 people in the Class 10 Cleanroom. This is to avoid violating legal make up air requirements, and to provide an efficient workspace. Exceptions for short periods only must be approved by Doron Bardas, Integration Manager.

3.4 Quality Assurance

Integration shall be conducted on a formal basis to approved and released procedures. The QA program office shall be notified of the start of this procedure. A Quality Assurance Representative designated by B. Taller shall review any discrepancy noted during this procedure, and approve its disposition. The presently designated QA Representative is A. Nakashima. Upon completion of this procedure, the QA Program Engineer, B. Taller or P. Unterreiner, will certify his concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the designated place(s) in this document. Discrepancies will be recorded in a D-log or as a DR per Quality Plan P0108

3.5 Red-line Authority

Authority to red-line this procedure is given solely to the ITD and QA representative. Approval by the Hardware Manager shall be required if experiment functionality may be affected. QA Program Engineering concurrence is required before final review/buyoff (on last page) of the completion of the activity described in this procedure.

3.6 Procedure Computerization Special Requirements

Because of cleanliness requirements in the Class 10 room, and to conveniently record data directly into the procedure thus generating the "as-built" document, the procedure will be handled in a paperless fashion until completed. A Laptop computer containing an electronic version of this procedure will be operated by the ITD or QA Representative and data shall be recorded by typing directly into the electronic file.

Following completion of the procedure, a hard copy of the "as-built" procedure shall be printed ***and signed off by all the designated parties***. It shall then be filed including an electronic copy into the data base.

The electronic editing of this document shall be as follows:

- Data will be inserted into the document using normal font, i.e. non-bold, non-italic
- "Signatures" shall be designated by **BLACK CAPITAL BOLD LETTERS**.
- "Redlines" shall be in ***RED BOLD ITALICS*** to make them distinguishable both on the Laptop screen and on the hard copy printout.
- Digital pictures shall be inserted into the document where appropriate.

4 REQUIRED EQUIPMENT

4.1 Flight Hardware

P/N 1C34115-102 Probe-C Assembly, w/o sunshade

4.2 Commercial Test Equipment

Description	Model	Serial Number	Calibr. Exp. Date
(2) Keithly Autoranging Picoammeter (mark these as 1 and 2 using a suitable cleanroom tape and marker).	485 (or similar)	0574456 284094	9/4/99 N/A
HP 0-25 V Dual Channel DC Power Supply	E3620A (or similar)	KR51302524	9/4/99
Jelight Co. Inc. Mercury vapor discharge lamp w/power supply.	PS-2000-20 (or similar)	Batch B1048	N/A
(2) Resonance Ltd. Cs-Te photodiode	Cs-Te M-D-L	A302 K769	6/4/99 6/4/99

4.3 Mechanical/Electrical Special Test Equipment

Description	Part No.	Rev. no.	Serial No.	Certification Date
2) SMA/LEMO (male) fiber jumpers	SK-486-101	-	Op# PRC0682	4/29/98
(1) LEMO/LEMO (female/female) fiber jumper	SK-486-102	-	Op# PRC0682	4/29/98
(2) SMA/SMA fiber jumper	N/A	N/A	N/A	N/A

4.4 Tools

Description	Number required
Pen light	1
BNC to banana adapter	1
Coaxial cable w/BNC connectors, 6' or longer	4
BNC tee	1

4.5 Expendables

Description	Quantity
Freon	N/A, on hand.
Ethyl Alcohol	N/A, on hand.
Filtered Compressed Air (acceptable for Class 10 use)	N/A, on hand.
Lint free wipes and swabs (acceptable for class 10 use)	N/A, on hand.

Note: No computer software is needed to perform this procedure.
Ion sprayers not required, since the SIA is not installed during this procedure.

5 FIBER OPTIC CABLE CHECK-OUT

Started **12-15-98** **at** **13:00** **Signed:** **HAIG YENGOYAN**
date time ITD or QA Representative

5.1 Initial Preparations

5.1.1 Insure the optical surfaces of all fiber optic jumpers are clean by wiping them with ethyl alcohol on a lint free wipe and drying with compressed air. Do not replace any plastic caps after cleaning the fiber ends.

5.1.2 Clear off an appropriate cleanroom table and position it under the Top Hat. On this table place the two picoammeters (marked previously as 1 and 2), HP DC power supply, two Cs-Te diodes and Jelight housing w/power supply.

5.1.3 Refer to Figures 1 and 2 when setting up the equipment as outlined in steps 5.1.4 through 5.1.8.

5.1.4 Connect the input of one of the picoammeters to one of the two Cs-Te diodes using an 6' BNC cable. Connect the input of the other picoammeter to the other Cs-Te diode using an 6' BNC cable. The readout connector on the diodes is marked "R" or "Readout". Note in Table II which picoammeter is reading which diode.

5.1.5 Connect the HP DC power supply to the "G" or "Bias" connector on both of the Cs-Te diodes. Use BNC to banana connectors and 6' BNC cables such that the potential between the center pin and the corresponding shield on each diode is – 25 VDC (bias the diode with –25 VDC).

5.1.6 Connect the SMA/SMA fiber jumper from the Jelight housing to one of the diodes. This diode will monitor the lamp. Note in table II which diode and picoammeter is monitoring the lamp.

5.1.7 Connect one SMA/LEMO (p/n SK-486-101) to the Jelight housing.

5.1.8 Plug in the AC power cords for the picoammeters, HP DC power supply and Jelight power supply. Power on all these devices. Set the picoammeters to autoscale. Adjust the HP DC power supply to put – 25 VDC on the diode bias connector. Note the time that the lamp was turned on. Note the initial current reading from the corresponding diode.

Time Lamp on @ : __13:10__12-15-98________ Initial diode reading: _____0.5__ nA

5.1.9 Allow the lamp to warm for 20 minutes. Steps 5.1.10, 5.1.11 and 5.2 may be performed while the lamp is warming.

5.1.10 The Probe should be horizontal on the Precision Manipulator at a height of approximately 4 feet, with the cold end toward the observation window.

5.1.11 Rotate the probe so that the Top Hat and cold end LEMO connectors you are working on are in a position convenient for mating the connector.

Completed **12-15-98** at **13:20** Signed: **HAIG YENGOYAN**
date time ITD or QA Representative

5.2 Confirm Fiber Optic Connector Pairs

Started **12-15-98** at **13:23** Signed: **HAIG YENGOYAN**
date time ITD or QA Representative

5.2.1 Using the pen light, shine light into one LEMO connector on the Top Hat without touching the connector with the pen light. Have an assistant verify by visual inspection the corresponding connector at the cold end connector block. Record the verification of this connector pair with a check mark in the "VERIFIED" column in Table I. Do this for all the fiber optic LEMO connectors on the Top Hat. If any of the cold end LEMO connectors is found not to have a corresponding Top Hat connector, stop the procedure and notify QA.

TABLE I – OPTICAL CABLE CONNECTOR PAIRINGS

TOP HAT LEMO	COLD END LEMO	VERIFIED	REMARKS
UV12 I	UV2A	NO LIGHT	Verified using the 1C34103 Rev. C copy
UV12 II	UV2B	X	Verified using the 1C34103 Rev. C copy
UV12 III	UV1B	X	Verified using the 1C34103 Rev. C copy
UV12 IIII	UV1A	X	Verified using the 1C34103 Rev. C copy
UV34 I	UV3A	X	Verified using the 1C34103 Rev. C copy
UV34 II	UV3B	X	Verified using the 1C34103 Rev. C copy
UV34 III	UV4A	X	Verified using the 1C34103 Rev. C copy
UV34 IIII	UV4B	X	Verified using the 1C34103 Rev. C copy
PM I	*UV5D*	X	Verified using the 1C34103 Rev. C copy
PM II	*UV5C*	X	Verified using the 1C34103 Rev. C copy
PM III	*UV5B*	X	Verified using the 1C34103 Rev. C copy
PM IIII	*UV5A*	X	Verified using the 1C34103 Rev. C copy

ADDED THE PROOF MASS CABLE TO THE CHART AND CHANGED LISTING TO CORRELATE TO THE PROBE MARKINGS. – HAIG YENGOYAN 12/15/98

Completed **12-15-98** **at** **13:54** **Signed:** **HAIG YENGOYAN**
date time ITD or QA Representative

5.3 Measure Probe Fiber Cable Throughput at 254 nm

Started **12-15-98** **at** **13:59** **Signed:** **HAIG YENGOYAN**
date time ITD or QA Representative

5.3.1 Before mating the SMA/LEMO (p/n SK-486-101) fiber jumpers to the probe connectors, inspect the LEMO end for cleanliness. Re-clean with ethyl alcohol if necessary.

5.3.2 The male LEMO on the fiber jumpers (p/n SK-486-101) should be wetted sparingly with Freon immediately prior to mating with the probe. Use a clean swab. Care should be taken not to wet the optical surface.

5.3.3 When 20 minutes has passed since the lamp was powered up, record the time and the lamp monitor diode reading.

Time: _14:00____ Diode reading: ___6.02 _____________ nA

5.3.4 For each Top Hat/Cold End LEMO pair in Table 1, connect the LEMO end of the SMA/LEMO fiber jumper from the Jelight source to the Top Hat connector. Connect the other LEMO/SMA jumper from the corresponding Cold End LEMO connector to the as yet unconnected Cs-Te diode. Record this diode s/n and its picoammeter readout in Table II. This is the probe readout. Record the readings from the picoammeters (lamp monitor and probe readout) in Table II.

5.3.5 Figure 2 shows the optical set-up for measuring the insertion loss of the fiber cables.

5.3.6 Fill out columns 2-6 in Table II. Lamp (uW) and Probe (uW) are given by dividing the Lamp (-nA) and Probe (-nA) value by their corresponding diode calibrations. Normalized Probe is given by dividing Probe (uW) by Lamp (uW).

Completed **12-15-98** at **14:44** Signed: **HAIG YENGOYAN**
date time ITD or QA Representative

5.4 Baseline Measurement and Calculation of Insertion Loss

Started **12-15-98** at **14:45** Signed: **HAIG YENGOYAN**
date time ITD or QA Representative

5.4.1 Disconnect the LEMO connectors from the probe at the Top Hat and at the Cold End. Connect the LEMO/LEMO (female/female) fiber jumper (p/n SK-486-102) between then two SMA/LEMO jumpers as shown in Figure 3. Record the picoammeter readings in Table III on the row "baseline w/LEMOs".

5.4.2 Replace the SMA/LEMO – LEMO/LEMO – LEMO/SMA cable assembly with a single SMA/SMA jumper as shown in Figure 4. Be sure to use the same lamp port that was previously connected to the probe though jumpers. Record the picoammeter readings in Table III on the row "baseline w/o LEMOs".

5.4.3 Fill out Table III using calibrations from Table II. Insertion loss is calculated for each connector pair as $-10*\log_{10}$(Normalized Probe/Normalized Probe Baseline). "Insertion Loss w/LEMOs" uses "Normalized Probe Baseline" w/o LEMOs, "Insertion Loss w/o LEMOs" uses "Normalized Probe Baseline" w/ LEMOs.

Completed **12/15/98** **at** **15:00** **Signed:** **HAIG YENGOYAN**
date time ITD or QA Representative

TABLE II - OPTICAL CABLE INSERTION LOSS

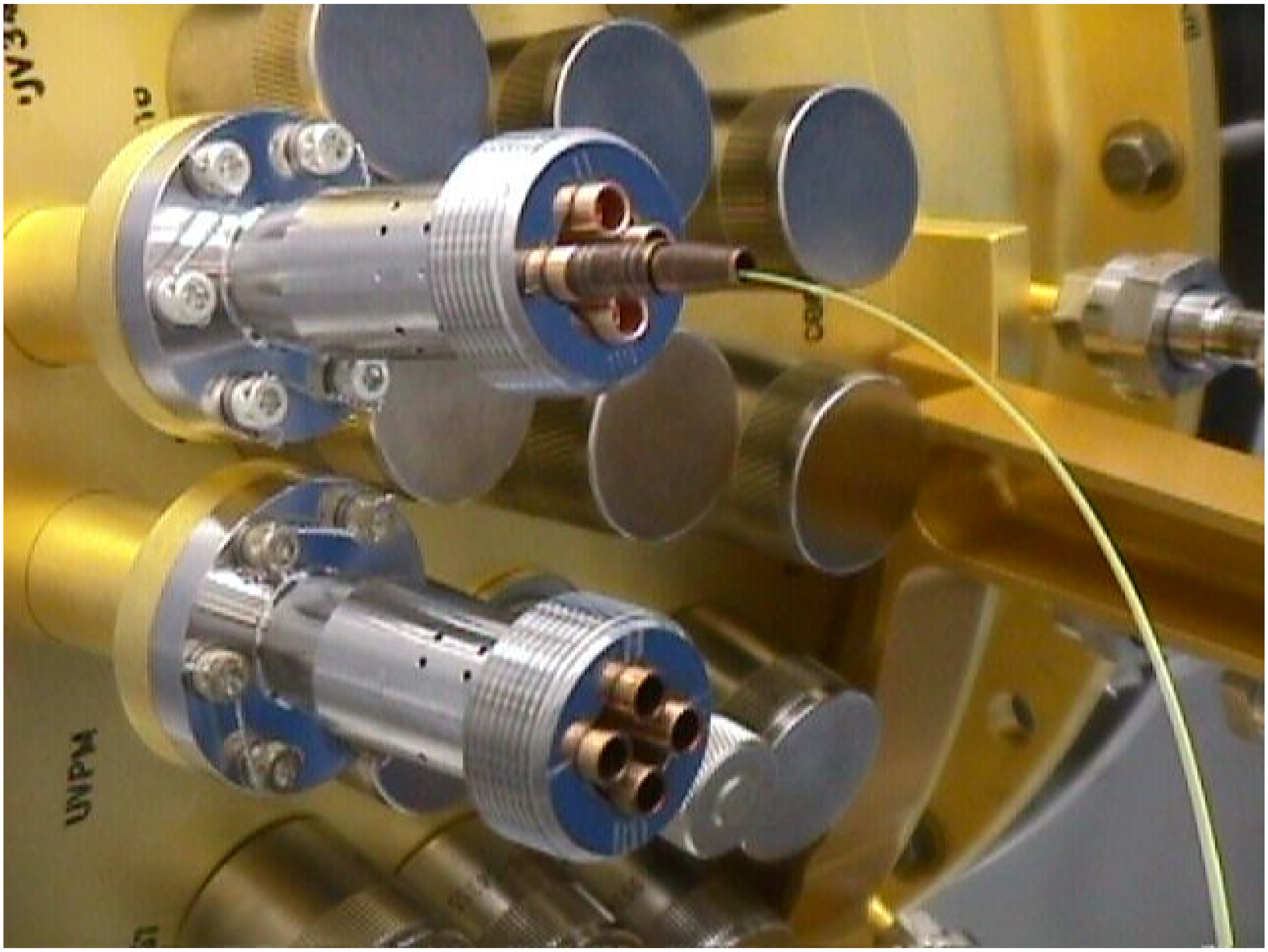
Picoammeter s/n	Picoammeter label	Cs-Te diode s/n	"Lamp" monitor OR "Probe" readout	Calibration (nA/uW)	
284094	1	A302	Lamp	6.63	
574456	2	K769	Probe	9.60	
Connector Pair (top hat/cold end)	Lamp (-nA)	Probe (-nA)	Lamp (uW)	Probe (uW)	Normalized Probe
UV12 I / UV2A	No Light	No Light	#VALUE!	#VALUE!	#VALUE!
UV12 II / UV2B	6.53	1.85	0.985	0.193	0.196
UV12 III / UV1B	6.54	1.58	0.986	0.165	0.167
UV12 IIII / UV1A	6.55	1.61	0.988	0.168	0.170
UV34 I / UV3A	6.51	1.70	0.982	0.177	0.180
UV34 II / UV 3B	6.52	1.47	0.983	0.153	0.156
UV34 III / UV4A	6.53	1.79	0.985	0.186	0.189
UV34 IIII / UV4B	6.54	1.92	0.986	0.200	0.203
PM I / UV5D	6.47	1.46	0.976	0.152	0.156
PM II / UV5C	6.48	1.65	0.977	0.172	0.176
PM III / UV5B	6.51	2.05	0.982	0.214	0.217
PM IIII / UV5A	6.50	2.31	0.980	0.241	0.245

TABLE III – BASELINE MEASUREMENT AND FIBER CABLE INSERTION LOSS

	Lamp (-nA)	Probe (-nA)	Lamp (uW)	Probe (uW)	Normalized Probe Baseline
Baseline w/ LEMOS in path	6.54	3.44	0.986	0.358	0.363
Baseline w/o LEMOs in path	7.74	8.21	1.167	0.855	0.733
Connector Pair (top hat/cold end)	Insertion Loss w/oLEMOs (dB)	Insertion Loss w/ LEMOs (dB)	COMMENT		
UV12 I / UV2A	#VALUE!	#VALUE!	No Connection		
UV12 II / UV2B	2.69	5.73			
UV12 III / UV1B	3.38	6.43			
UV12 IIII / UV1A	3.30	6.35			
UV34 I / UV3A	3.04	6.09			
UV34 II / UV 3B	3.68	6.73			
UV34 III / UV4A	2.83	5.88			
UV34 IIII / UV4B	2.53	5.58			
PM I / UV5D	3.68	6.72			
PM II / UV5C	3.15	6.20			
PM III / UV5B	2.23	5.27			
PM IIII / UV5A	1.70	4.75			

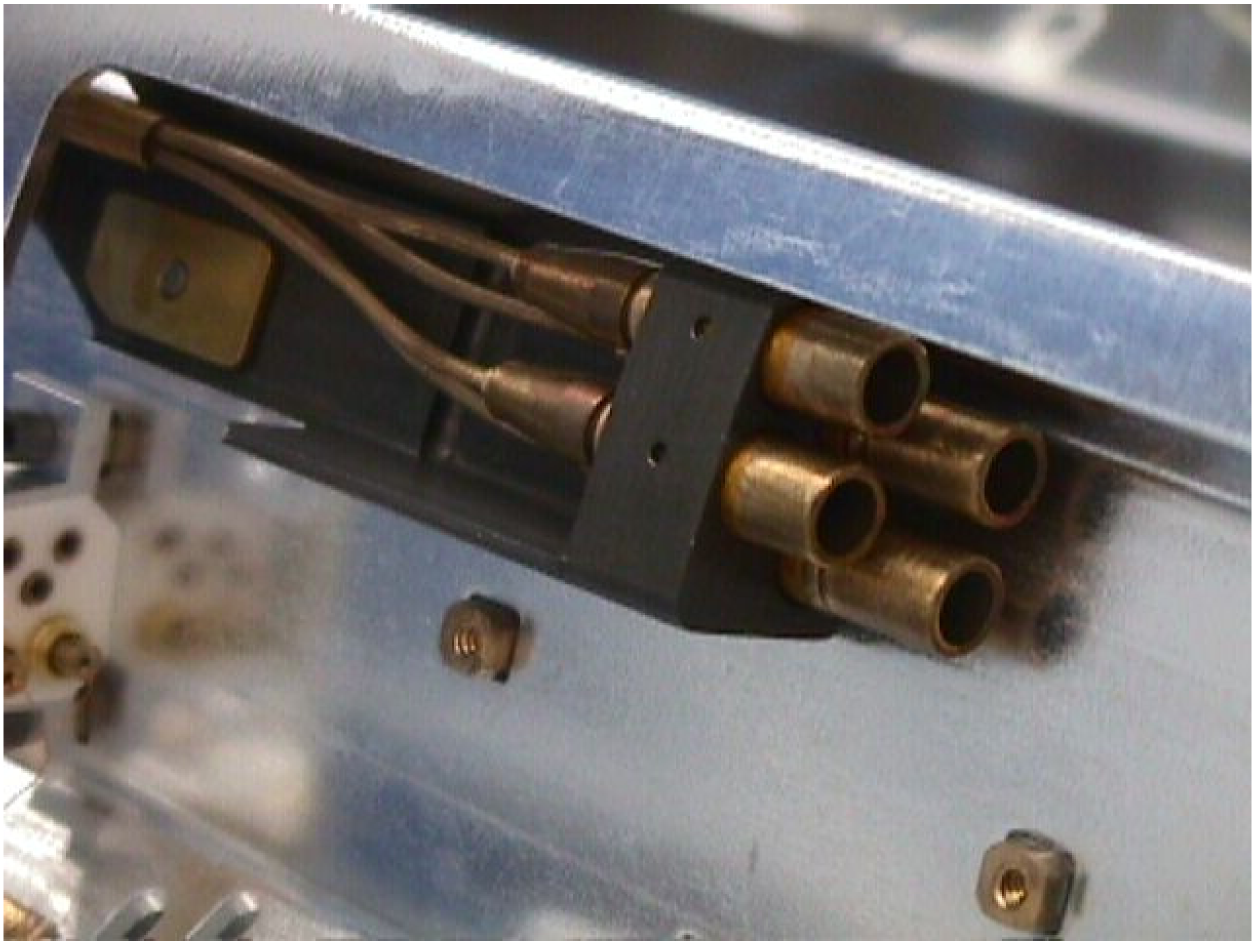
NOTE: ONE MATE / DEMATE WAS PERFORMED ON EACH CONNECTOR EXCEPT FOR UV12 I/UV2A. – HAIG YENGOYAN

Insertion loss for each LEMO pair must be < 9 dB.

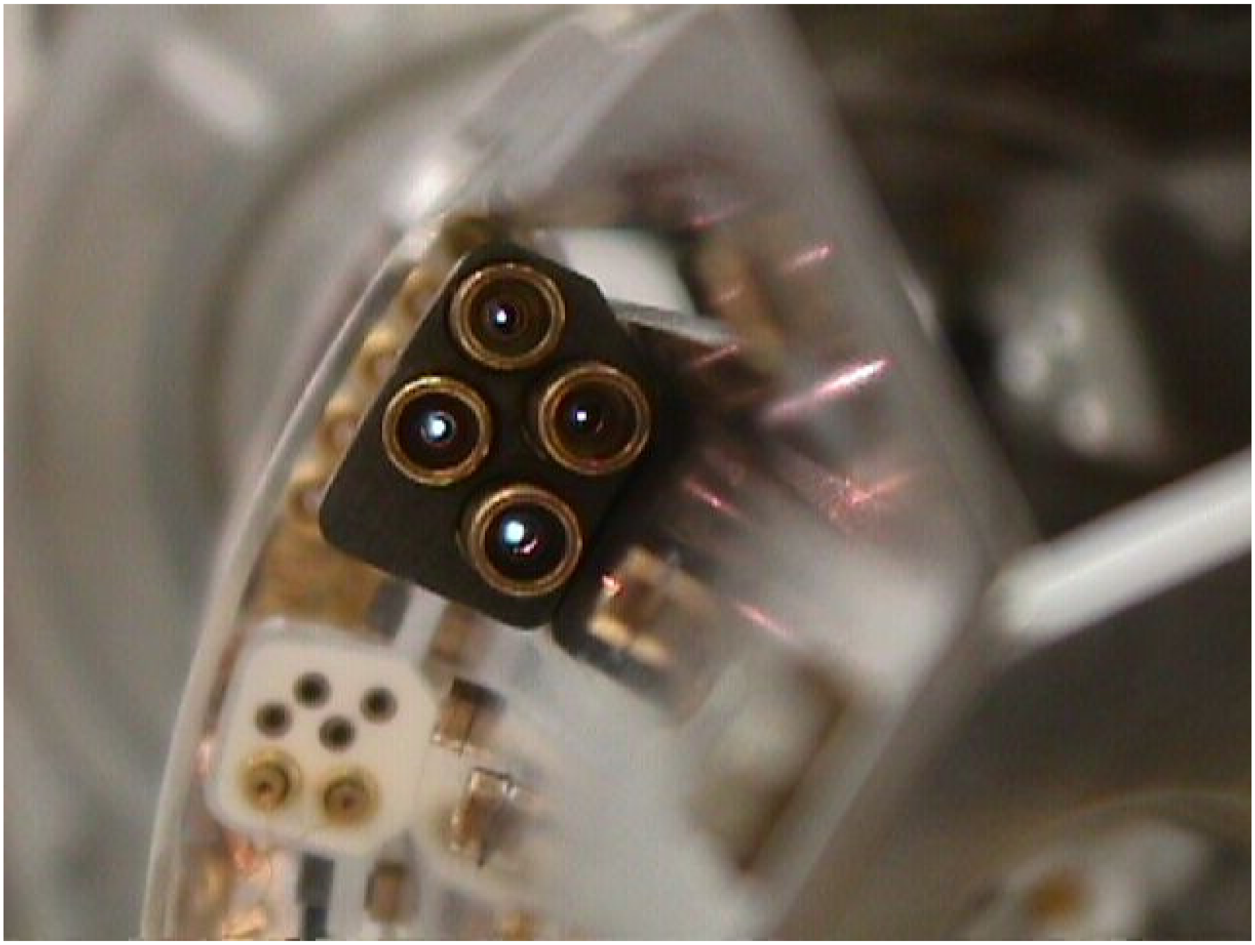


TOP HAT FIBER OPTIC INTERFACE
UVPM - I through IIII and UV34 - I through IIII shown. Input fiber connected to UV34 – I.

CLOSE-UP UV12 – I through IIII



COLD END FIBER OPTIC INTERFACE
UV3A, UV3B, UV4A, UV4B shown.



COLD END FIBER OPTIC INTERFACE
UV3A, UV3B, UV4A, UV4B shown head-on. Fibers at top hat connector (UV34 – I through IIII) are being illuminated with a flashlight.

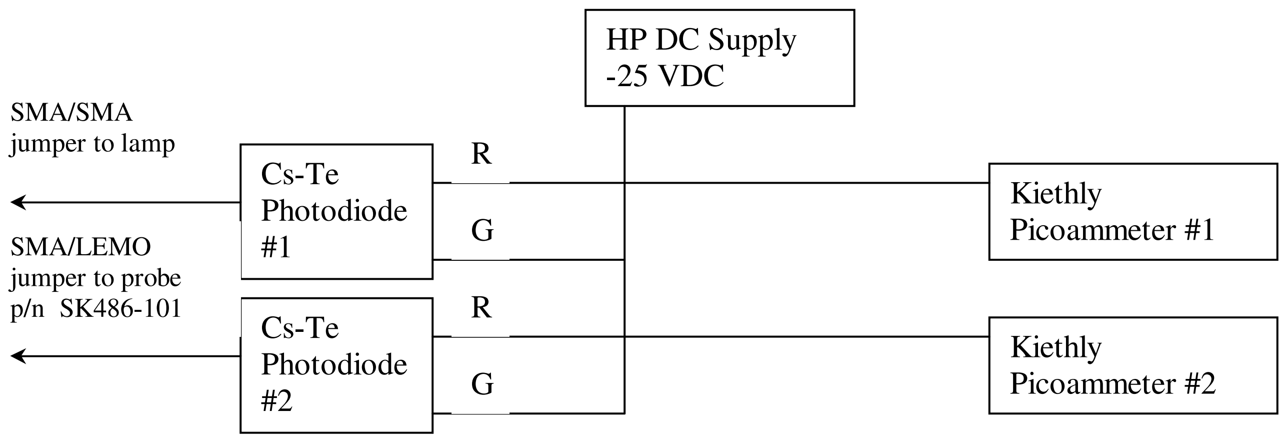


FIGURE 1 – Electronics Set-up

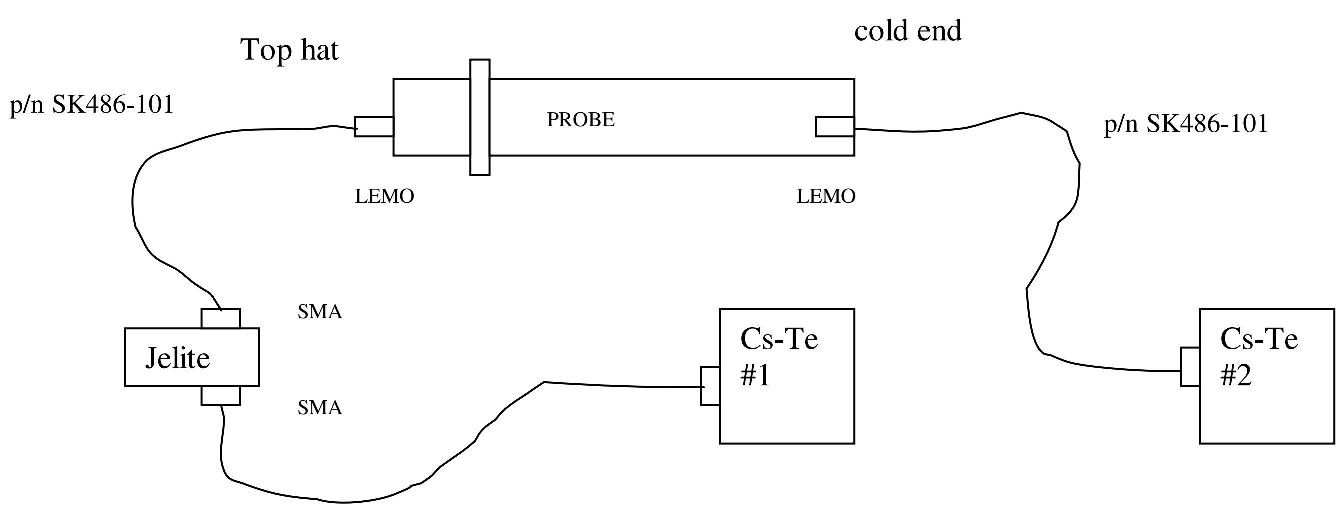


FIGURE 2 – Optical Path Set-up

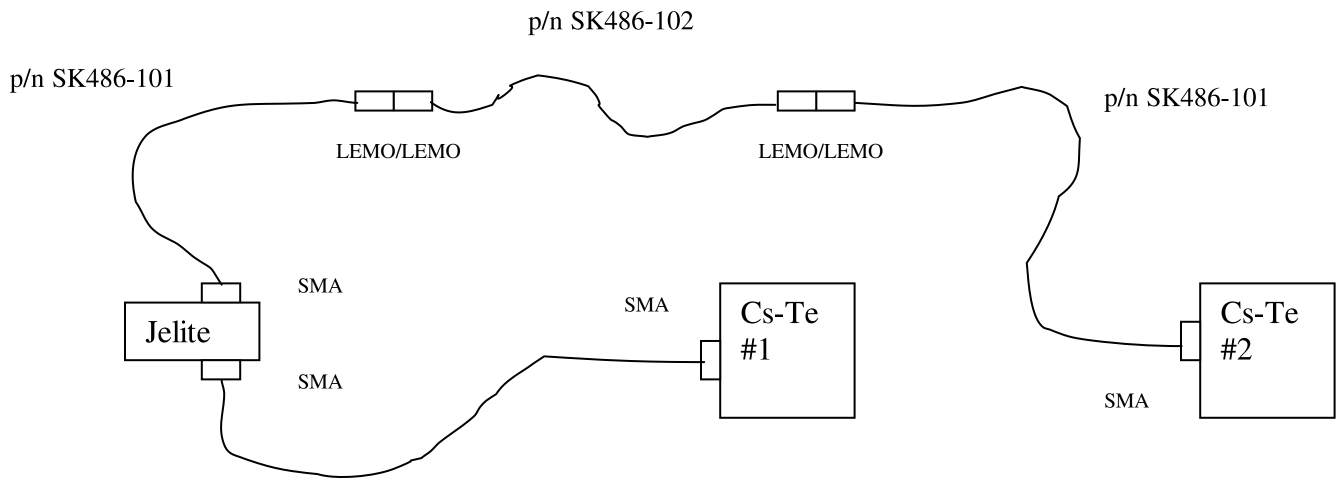


FIGURE 3 – Baseline Optical Path w/Lemos

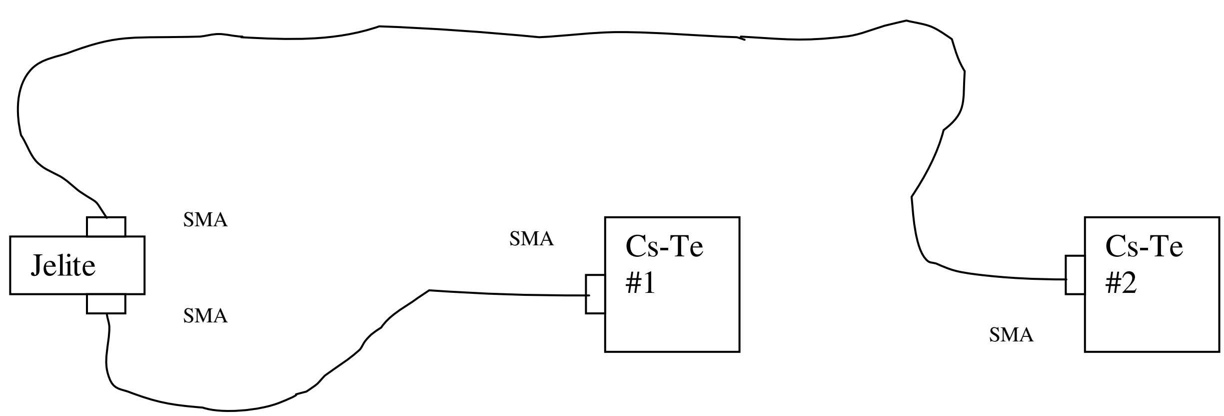


FIGURE 4 – Baseline Optical Path w/o Lemos

6 PROCEDURE COMPLETION

The results obtained in the performance of this procedure are acceptable:

Integration Engineer(s)

_____**BRUCE CLARKE**________ Date ___**12/15/98**__

_________**TIM CARSON** _____ Date ______**12/15/98**_

_____________________________ Date ______________

Discrepancies if any:

ITD ______________________ Date ______________

Gyro Manager ______________________ Date ______________

The information obtained under this assembly and test procedure is as represented and the documentation is complete and correct:

Integration Manager _______________________________ Date ______________

QA Representative ______**HAIG YENGOYAN**______ Date ___**12/15/98**___

QA Program Engineer_____________________________ Date _____________

7 DATA BASE ENTRY

The following data shall be entered into the GP-B Data Base:

a) Name, number and revision of this procedure

b) An electronic copy of this document

c) A copy of the “as-built” procedure with data and pictures, when completed.