中央研究院
天文及天文物理研究所
ACADEMIA SINICA
Institute of Astronomy and Astrophysics

GLT Electronic System Overview and Status

- **Local Oscillator System Overview and Status**
- **Intermediate Frequency Signal Overview and Status**

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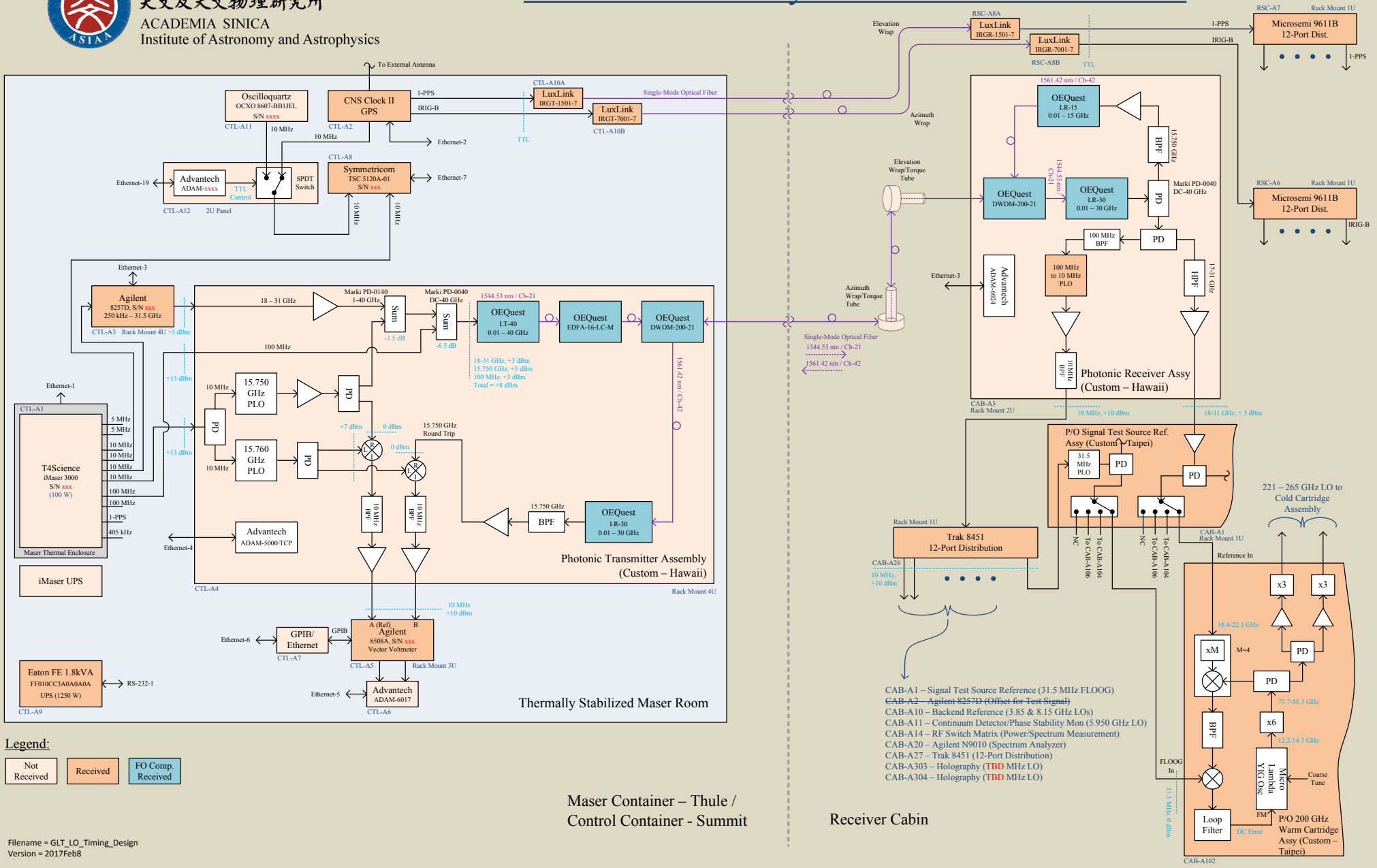
Local Oscillator System Overview and Status



Legend:

Not Received	Received	FO Comp. Received

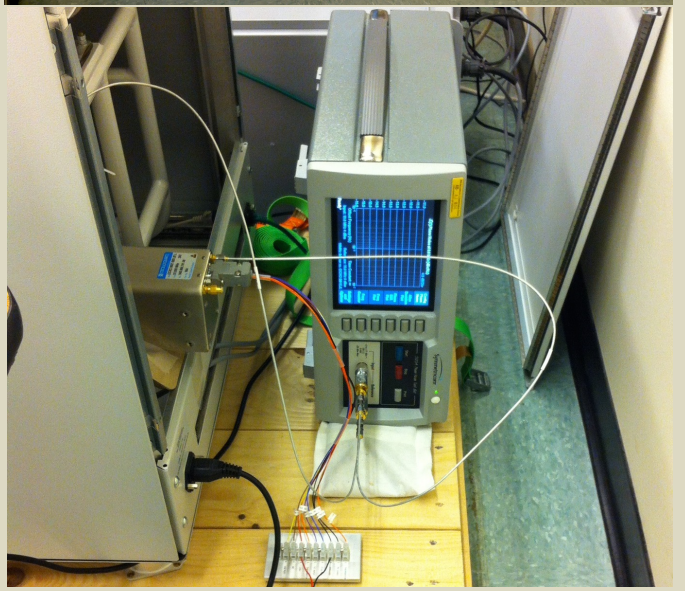
Filename = GLT_LO_Timing_Design
Version = 2017Feb8

Local Oscillator System Overview and Status

Items that Require Attention:

- **Maser** (CTL-A1), T4Science iMaser 3000, responsibility - **Shepherd Doeleman**
  - Quantity of 1 unit (our original unit was S/N 073)
  - Will be ordered & delivered with thermally controlled enclosure
  - **Estimate to delivery in Thule – July 14, 2017 (TBR)**
    - Not required for single dish operation (can lock to GPS receiver)
    - Stability improves with time after transportation and installation

- **10 MHz Reference Crystal** (CTL-A11), tentatively Rakon, responsibility – **Shepherd Doeleman**
  - Quantity of 1 unit
  - **Estimate to delivery in Thule – July 14, 2017 (TBR)**
    - Not required for single dish operation, used to verify health of maser
    - Used to verify stability of maser

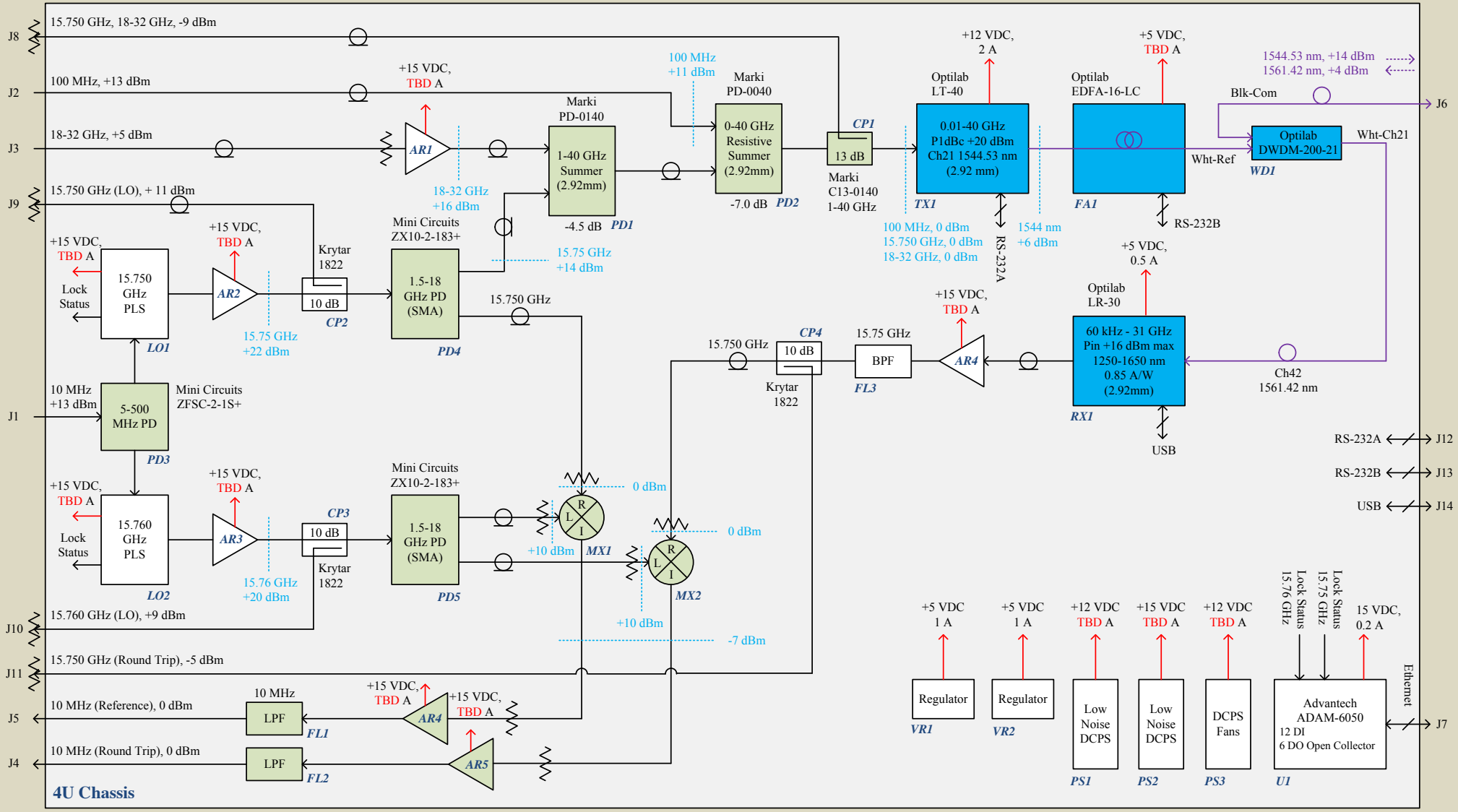


○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- **Photonic Transmitter Assembly** (CTL-A4), ASIAA custom design, responsibility – **Derek Kubo**
  - Quantity of 2 units, includes 1 spare
  - Presently in electrical/mechanical design phase (identifying components, placing orders…)
  - **Estimate to complete first unit in Hilo – June 2, 2017**

○ Local Oscillator System Overview and Status



Filename = Photonics_Tx_Rx_Design
Version = 2017Feb27

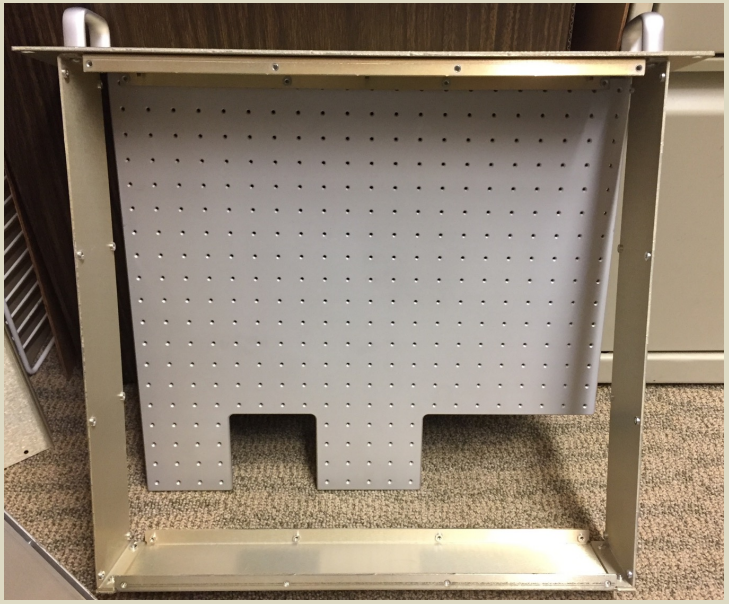
Schematic, Photonics Transmitter Assembly

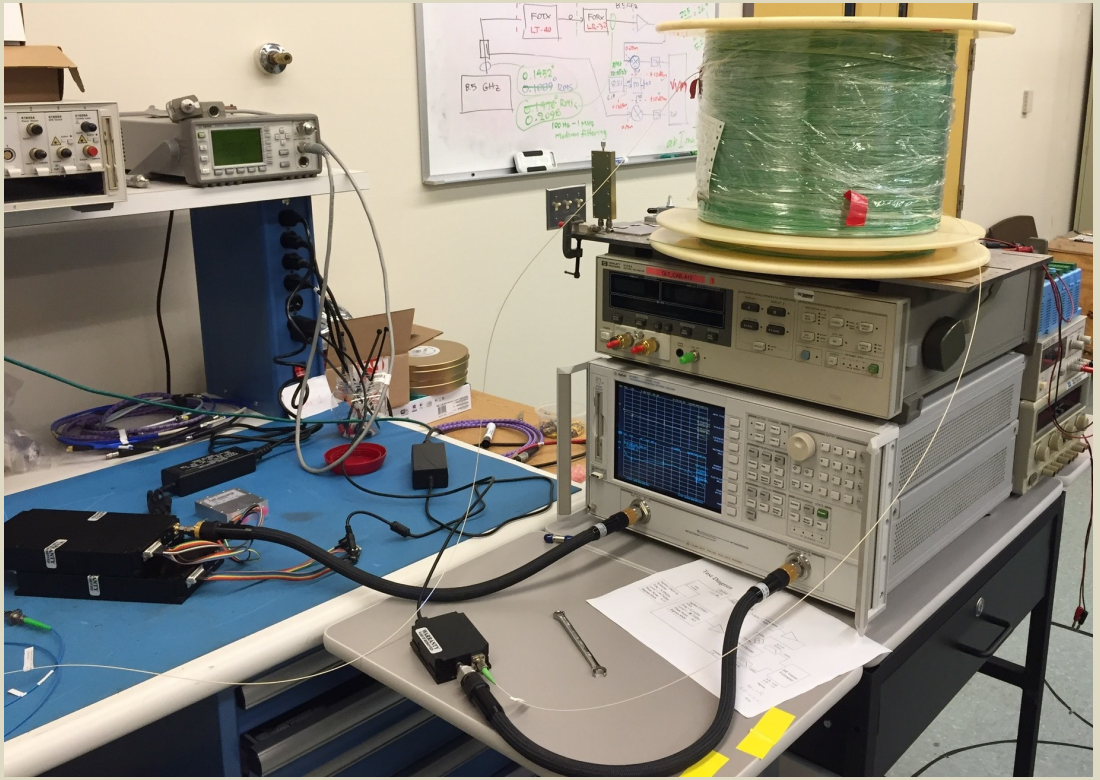
Ordered | Received

○ Local Oscillator System Overview and Status

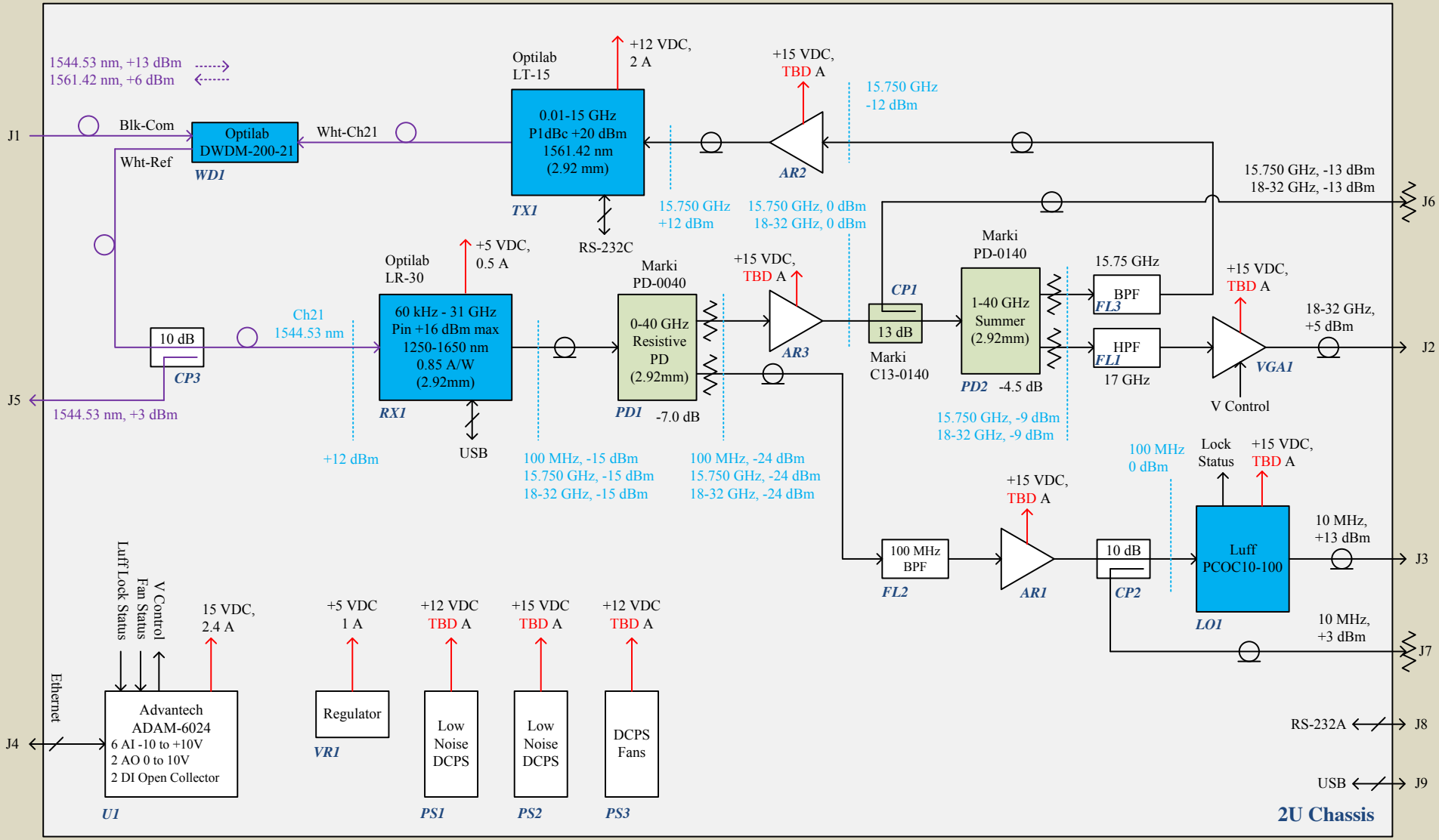
○ Items that Require Attention (continued):

- **Photonic Receiver Assembly** (CAB-A3), custom design, responsibility – **Derek Kubo**
  - Quantity of 2 units, includes 1 spare
  - Presently in design phase (identifying components, placing orders…)
  - **Estimate to complete first unit in Hilo – June 2, 2017**





○ Local Oscillator System Overview and Status



Filename = Photonics_Tx_Rx_Design
Version = 2017Feb27

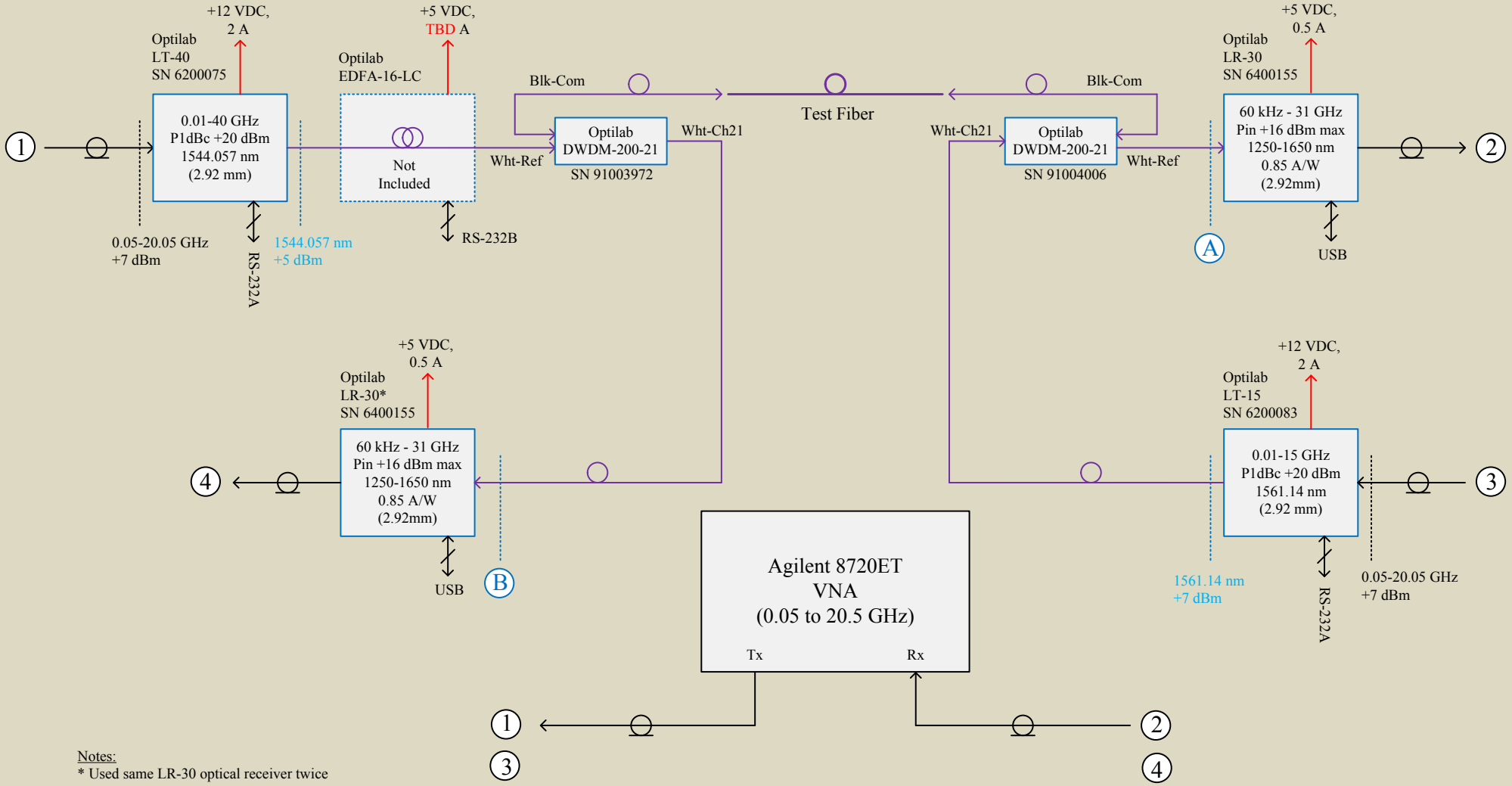
Schematic, Photonics Receiver Assembly

Ordered | Received

Local Oscillator System Overview and Status

Items that Require Attention (continued):

- Photonic Transmitter/Receiver Performance - Ranjani Srinivasan/Derek Kubo

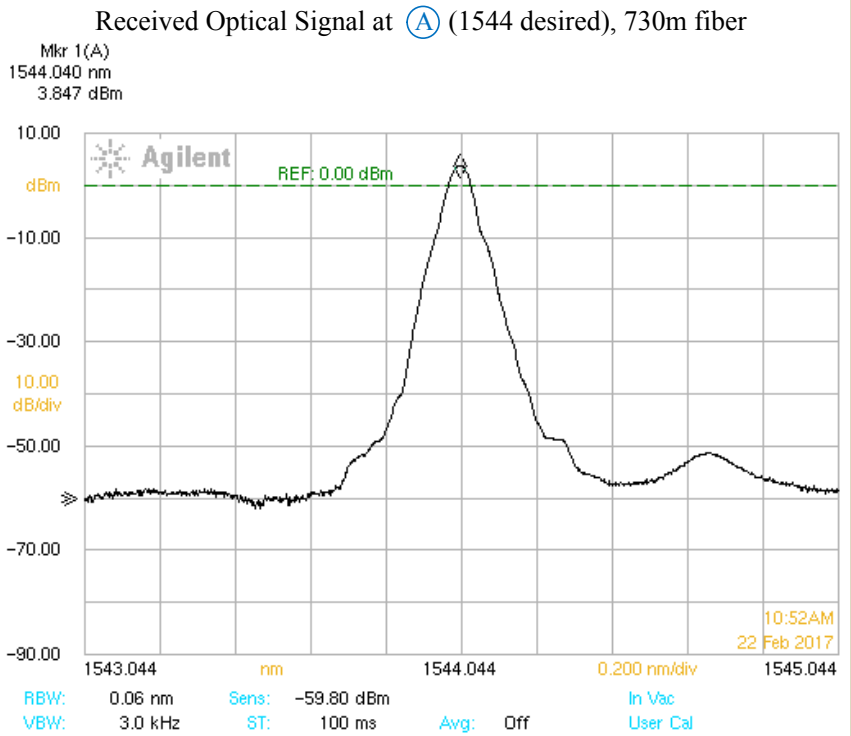


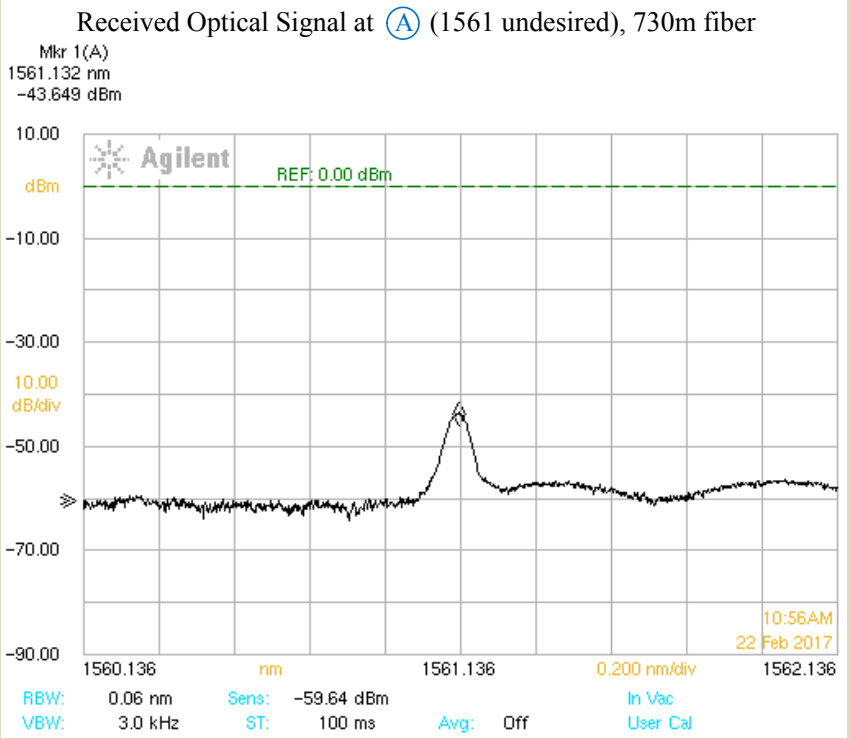
Notes:
* Used same LR-30 optical receiver twice

○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- Photonic Transmitter/Receiver Performance - Ranjani Srinivasan/Derek Kubo
  - Forward Optical Transmission Performance (100 MHz, 15.75 GHz Pilot Tone, 18-31.5 GHz LO)



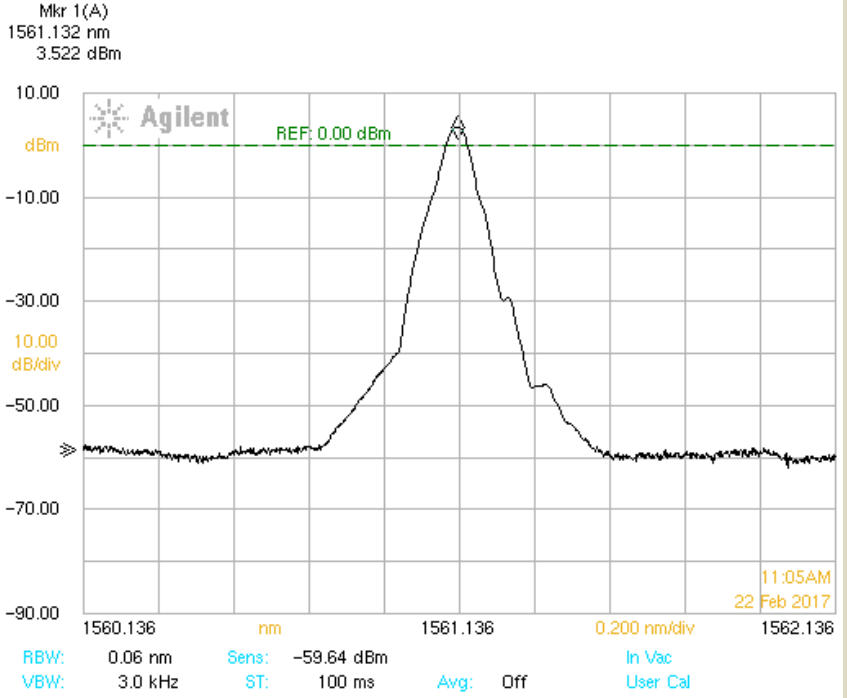


○ Local Oscillator System Overview and Status

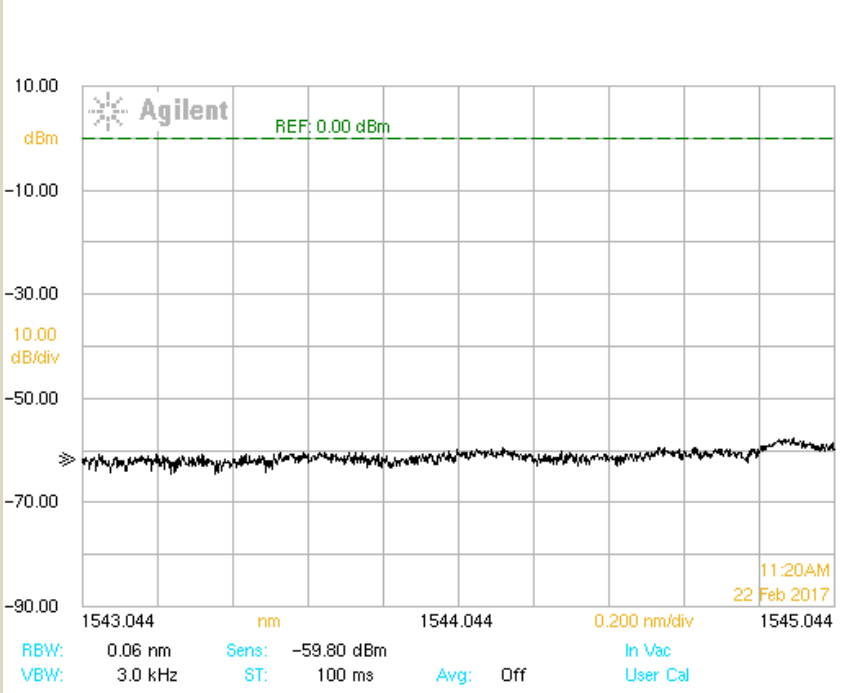
○ Items that Require Attention (continued):

- Photonic Transmitter/Receiver Performance - Ranjani Srinivasan/Derek Kubo
  - Reverse Optical Transmission Performance (15.75 GHz return Pilot Tone)

Received Optical Signal at Ⓑ (1561 desired), 730m fiber



Received Optical Signal at Ⓑ (1544 undesired), short fiber

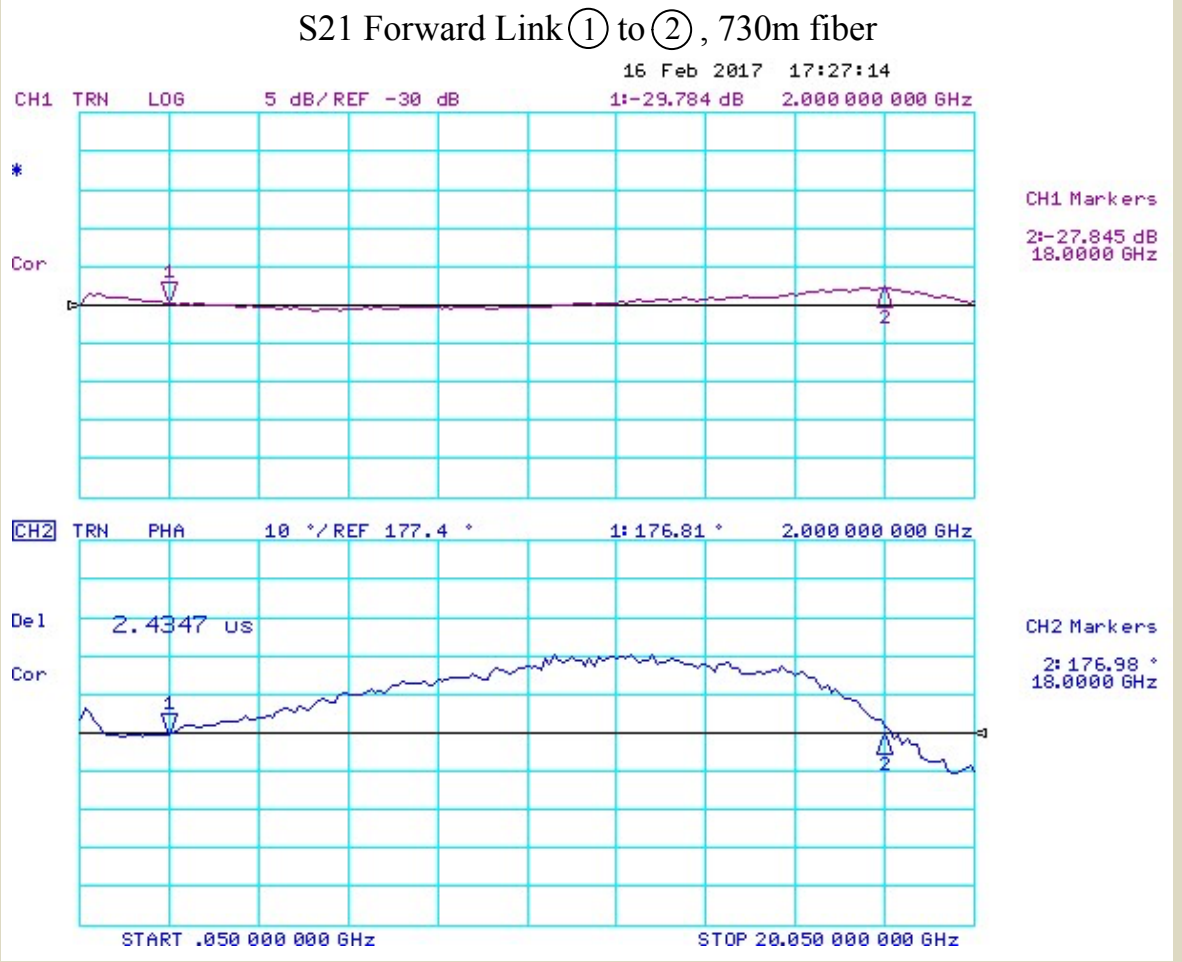


○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- Photonic Transmitter/Receiver Performance
  - Forward RF Transmission Performance (100 MHz, 15.75 GHz Pilot Tone, 18-31.5 GHz LO)
    - VNA max freq 20.5 GHz
    - ~30 dB link loss at 20 GHz (w/o EDFA)
    - Need to perform manual CW/power meter tests to see what happens beyond 20 GHz

S21 Forward Link ① to ②, 730m fiber

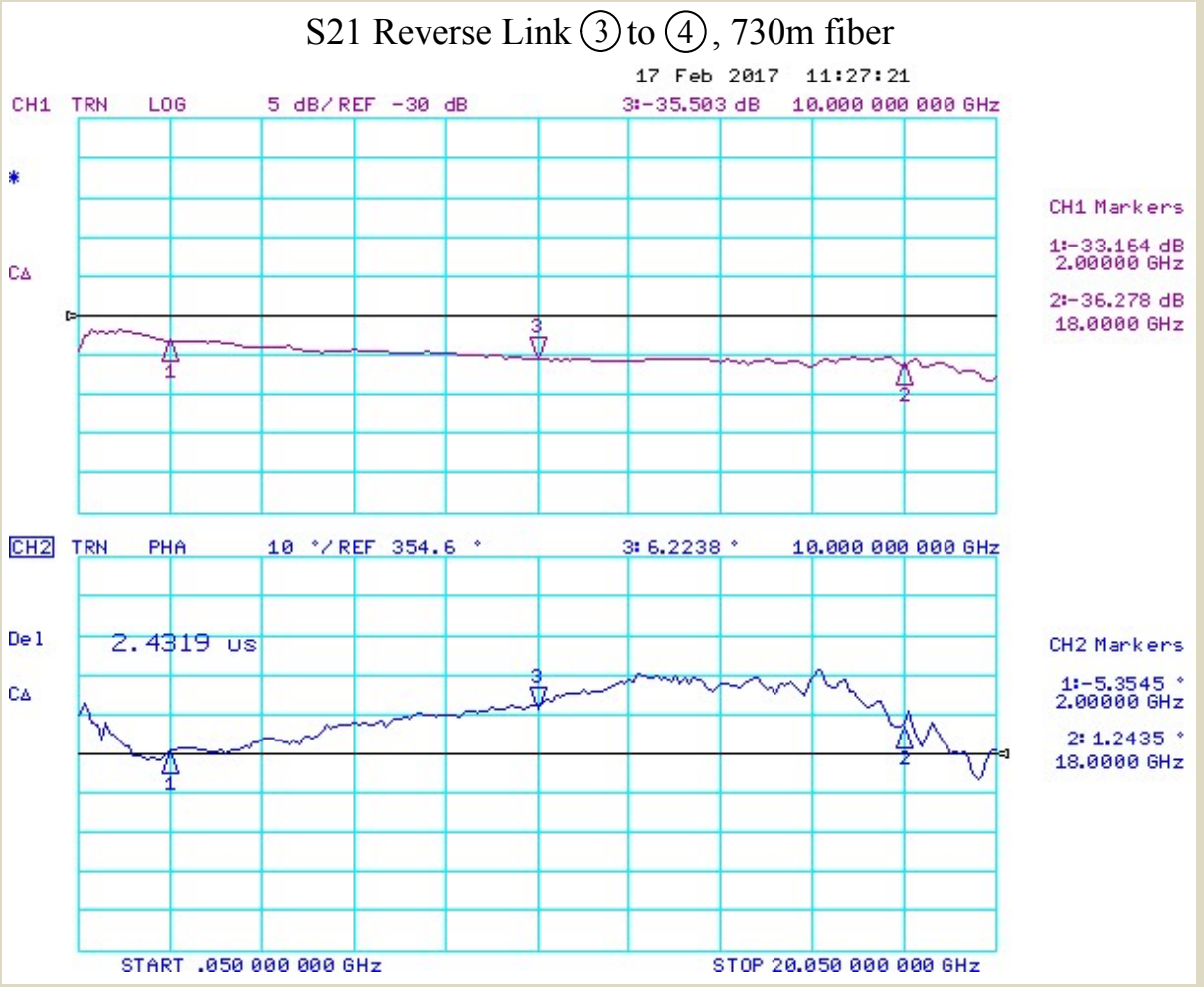


○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- Photonic Transmitter/Receiver Performance
  - Reverse RF Transmission Performance (15.75 GHz return Pilot Tone)
    - 36 dB link loss

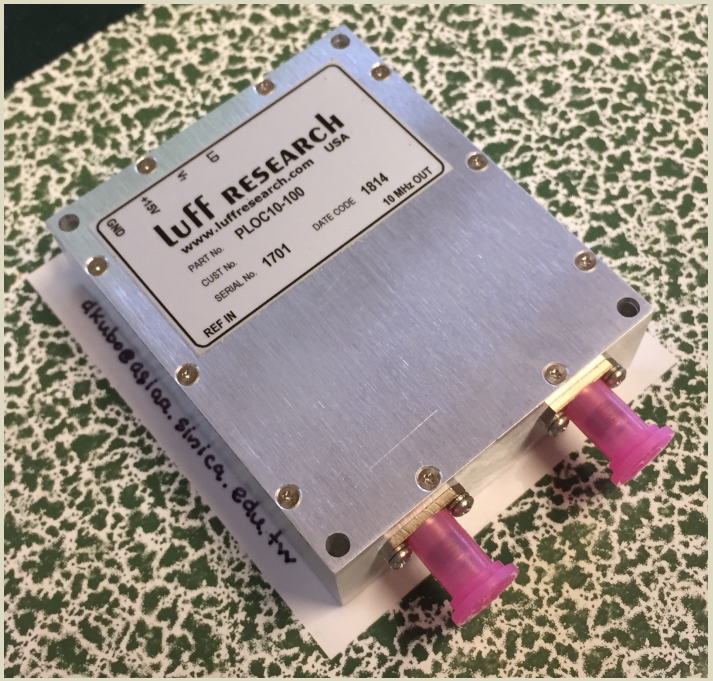
S21 Reverse Link ③ to ④, 730m fiber



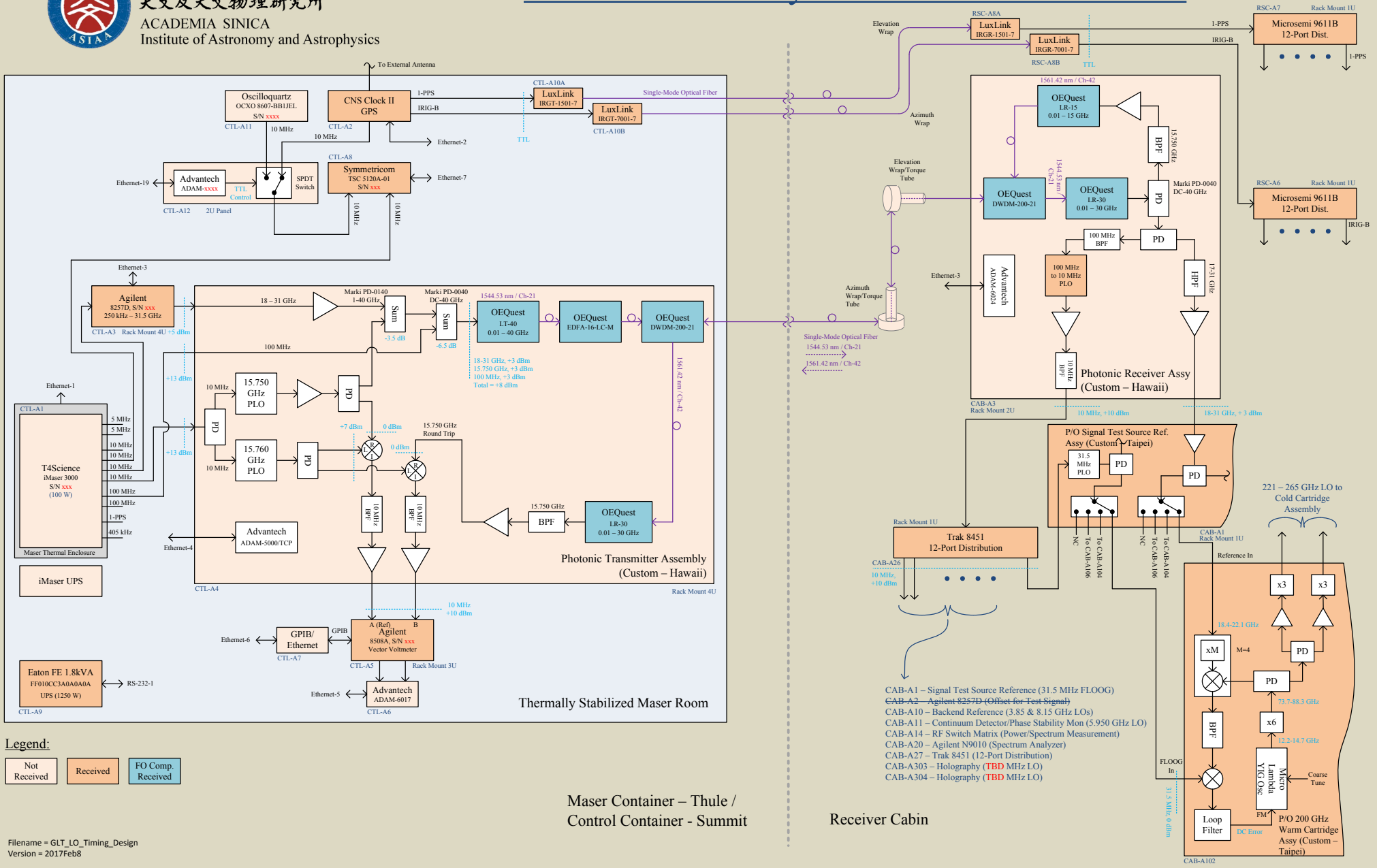
○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- Photonic Transmitter/Receiver Performance
  - 10 MHz reference in Receiver Cabin
    - Used to phase lock the following LOs
      - 3.85 GHz LO for IF Processor (4-6 GHz chunk)
      - 8.15 GHz LO for IF Processor (6-8 GHz chunk)
      - 2.048 GHz (ADC sample clock in R2DBE and Spectrometer)
    - 100 MHz maser output is transmitted over optical link
    - 10 MHz is derived from Luff PLOC10-100 100 MHz to 10 MHz OCXO



Local Oscillator System Overview and Status



Filename = GLT_LO_Timing_Design
Version = 2017Feb8

○ Local Oscillator System Overview and Status

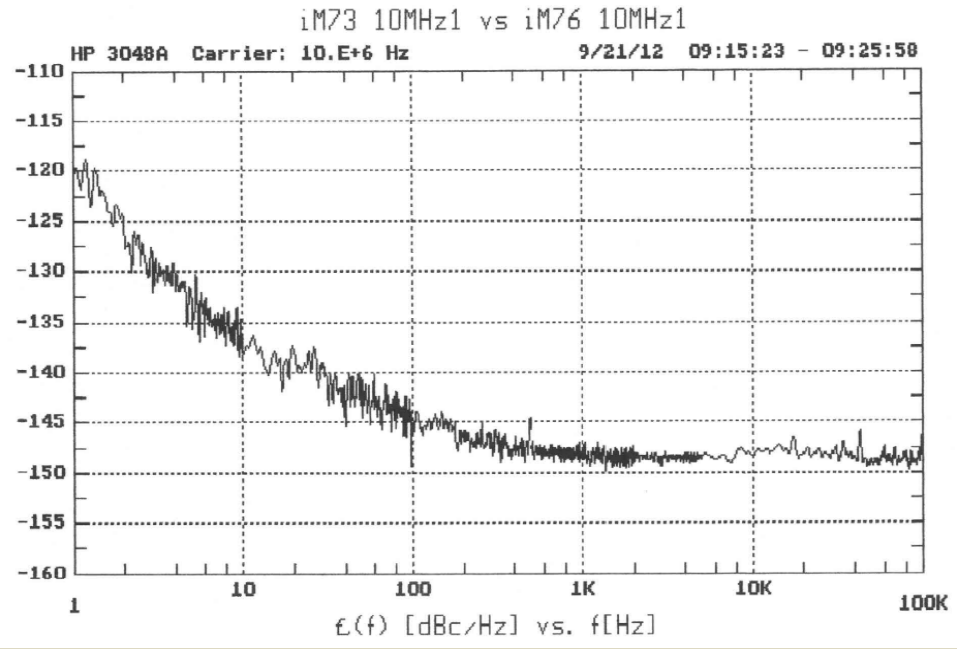
○ Items that Require Attention (continued):

–Photonic Transmitter/Receiver Performance (cont'd)

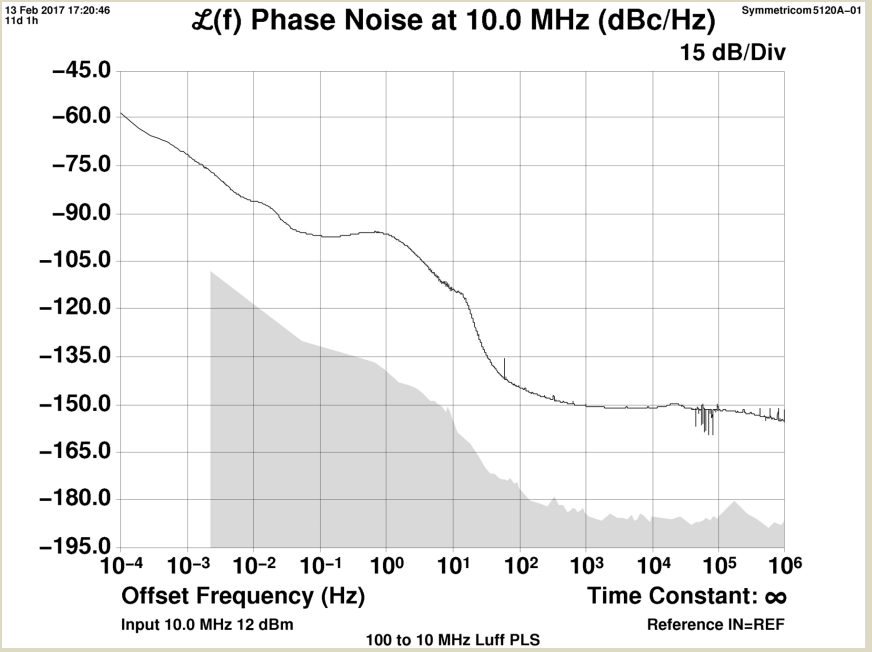
– Used Symmetricom TSC 5120-01 to characterize $\mathcal{L}$(f) maser 10 MHz vs Luff OCXO 10 MHz signals

Offset (Hz)	Maser vs Maser (dBc)	Maser vs Luff (dBc)
1	-120	-96
10	-137	-113
100	-144	-143
1000	-148	-150

4.1.3. 10MHz1 iM73 vs 10MHz1 iM76



Luff Output vs iM61 (SMA maser) – R. Srinivasan



○ Local Oscillator System Overview and Status

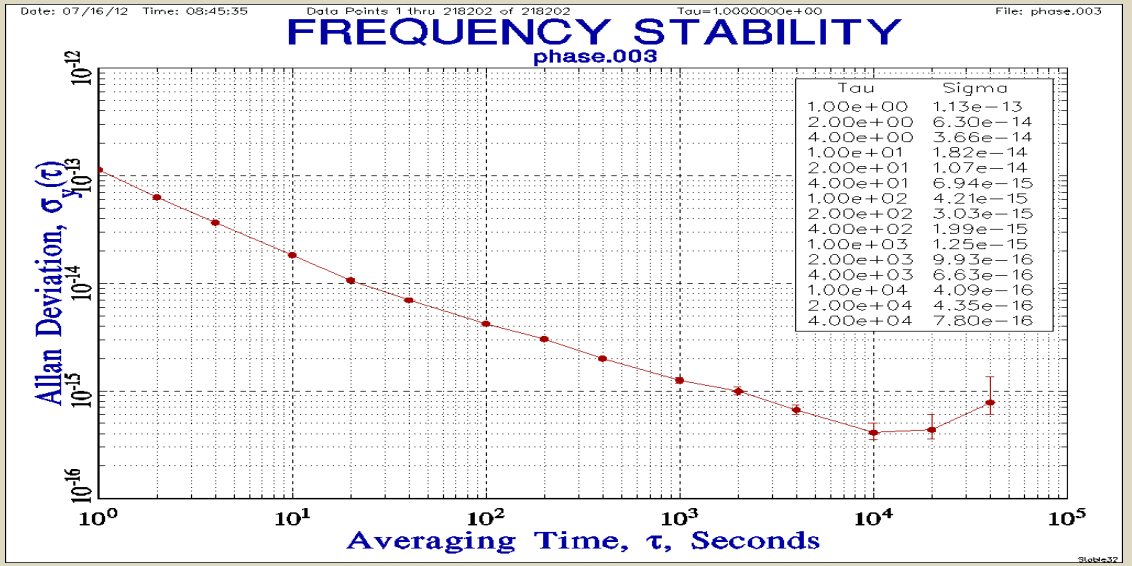
○ Items that Require Attention (continued):

–Photonic Transmitter/Receiver Performance (cont'd)

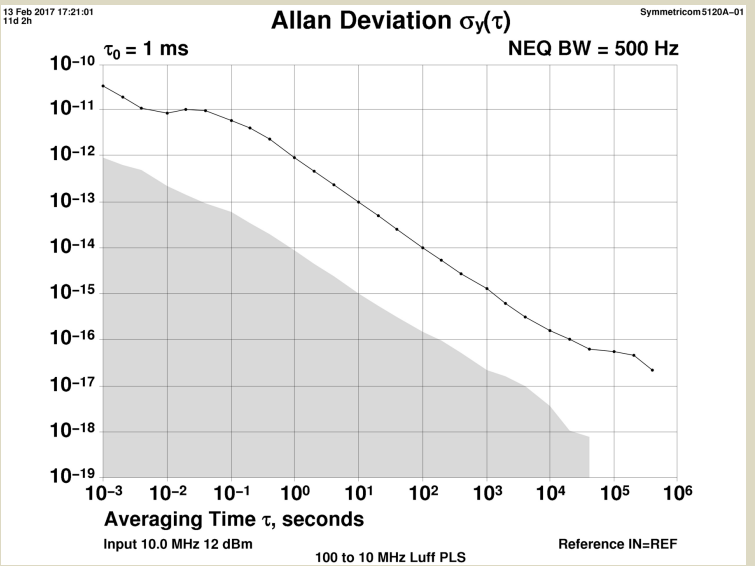
- Used Symmetricom TSC 5120-01 to characterize ADEV of maser 10 MHz vs Luff OCXO 10 MHz signals

Tau (sec)	Maser vs Maser Sigma	Maser vs Luff Sigma
1	1.1E-13	1.0E-12
10	1.8E-14	1.0E-13
100	4.2E-15	1.0E-14
1000	1.3E-15	1.0E-15

iM73 vs iM68 (Raw data: SQRT(2)/2 coefficient can be applied to each result) without drift removed



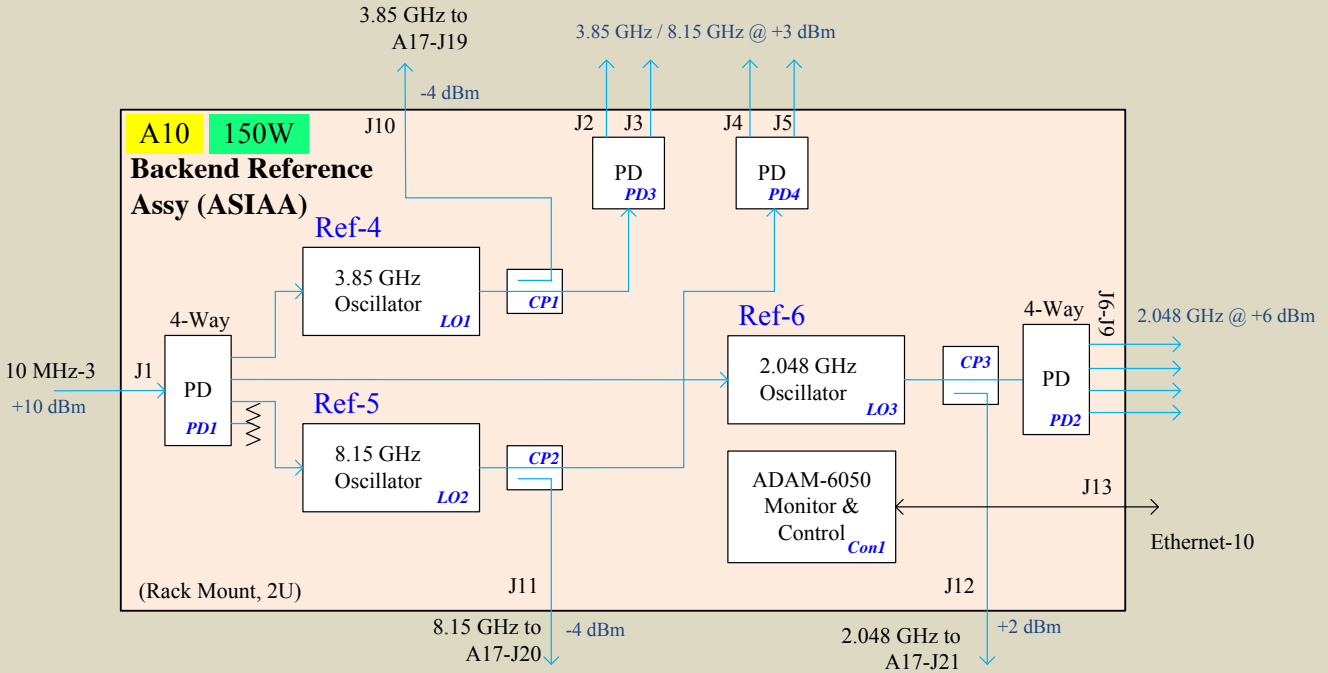
Luff Output vs iM61 (SMA maser) – R. Srinivasan



○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- **Backend Reference Assembly** (CAB-A10), custom design, responsibility – **TBD**
  - Generates and distributes 3.85 GHz and 8.15 GHz LOs for IF Processor units (CAB-A4/A5), and 2.048 GHz ADC sampling clock to ROACH-2 units
    - How many ROACH-2 units will there be? 4 R2DBE + 4 Spectrometers?
  - Quantity of 2 units, includes 1 spare
  - Relatively simple design
  - **Target to complete first unit in Hilo – June 16, 2017 TBR**



○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

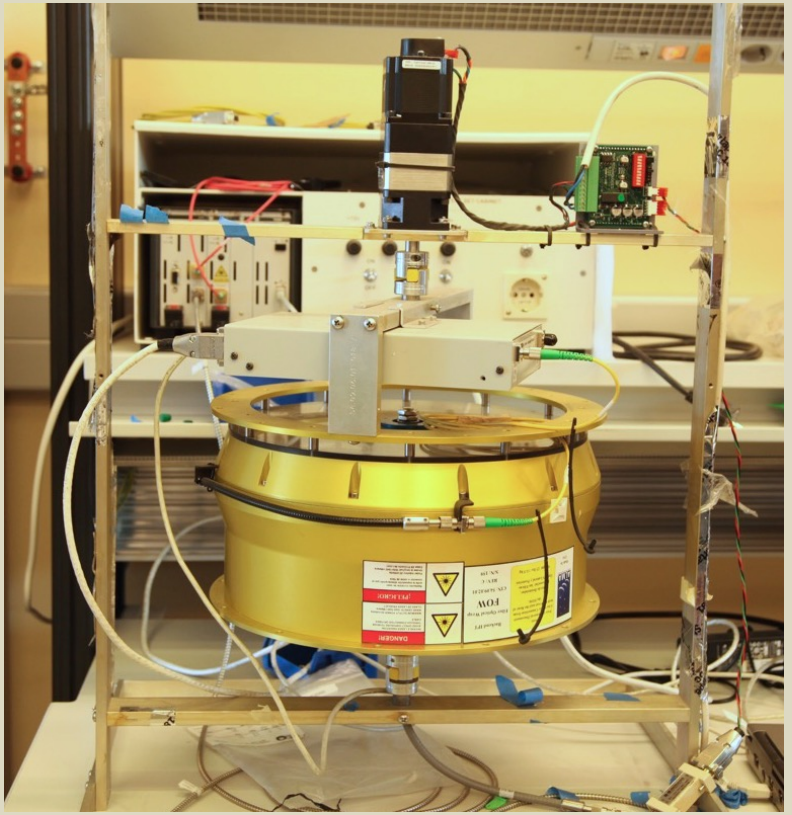
- **10 MHz Switch Panel** (CTL-A12), custom design, responsibility – **Derek Kubo**
  - Quantity of 1 unit
  - **Estimate to complete in Hilo – April 14, 2017**

- **Fiber Optics System**
  - Robin Identified a Single-Mode Fiber, AFL LA0489C6111N1as Potential Candidate [1]
    - Non-armored, 48 single-mode fibers, 6 compartments/12 fibers per (4 compartments used)
    - 19 of the 48 fibers will be used (29 spares)
    - 0.61 inches OD (15.4 mm)
    - Minimum bend radius, installation 12.2 inches (-30 to +50 C)
    - Minimum bend radius, operation 6.1 inches (-55 to +70 C)
      - **Supplier is concerned about physical movement below -30 C and didn't recommend use of this cable**
      - **Minimum order 5 km (~16,000 feet)**
  - Currently Researching other Suppliers, responsibility – **Derek Kubo / Bill Snow**
    - Concern of high optical loss at 1550 nm due to contraction of buffer at low temperatures [2]
    - Considering the use of normal fiber cables rated to -30 C and running heat tape + insulation along the entire lengths of fiber cables
    - **Target Fiber Optic Cable delivery date in Thule - TBD**

○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

- **Fiber Optics System** (continued)
  - Azimuth and Elevation Wrap/Torque Tubes, custom design, responsibility – **Philippe Raffin**
    - Quantity of 3 units, includes 1 spare
    - **Estimate to delivery in Thule – TBD**
    - Alternate place holder – Use normal communication fiber to Receiver Cabin for LO and monitor round-trip phase for VLBI viability
      - We know empirically that the JCMT wraps don't adversely affect VLBI
      - JCMT's Azimuth wrap is somewhat complex and large in diameter
    - Potential option – Robin Hu has suggested a fiber optic rotary joint



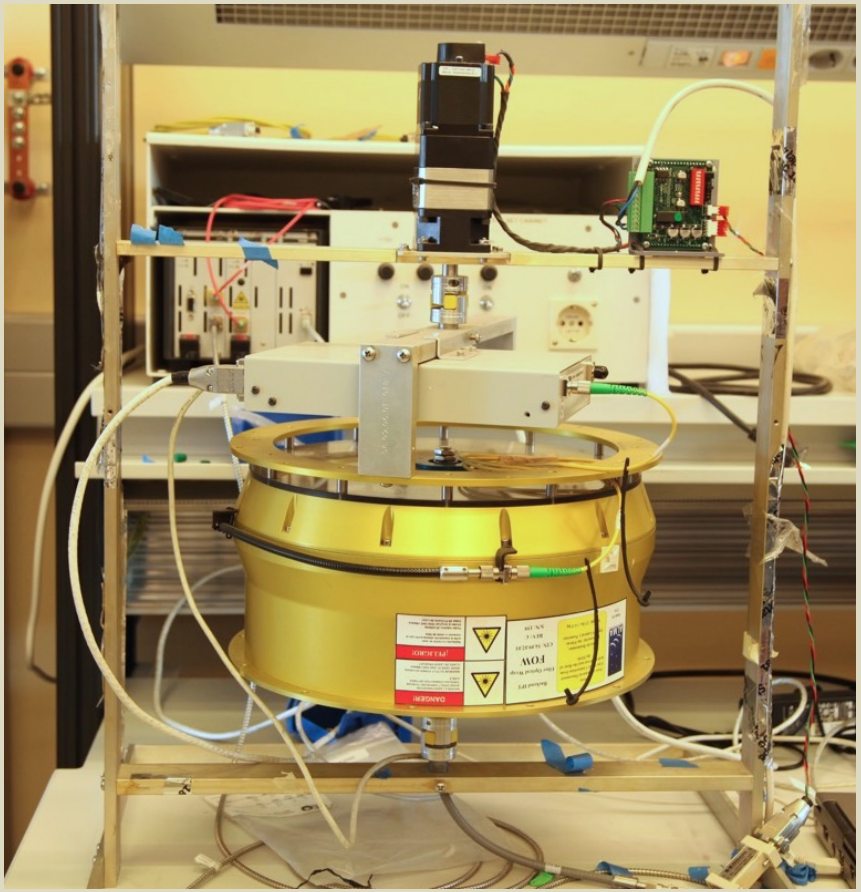
Ming-Tang Chen

○ Local Oscillator System Overview and Status

○ Items that Require Attention (continued):

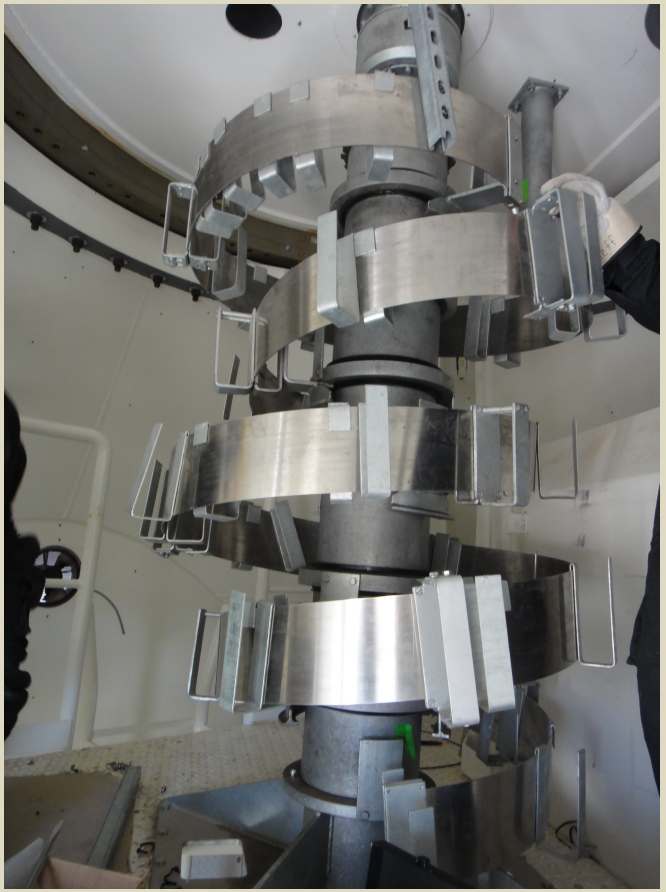
- **Fiber Optics System** (continued)

ALMA Custom LO Fiber Wrap



Ming-Tang Chen

GLT Spiral Az Wrap for Power and Comm Fibers

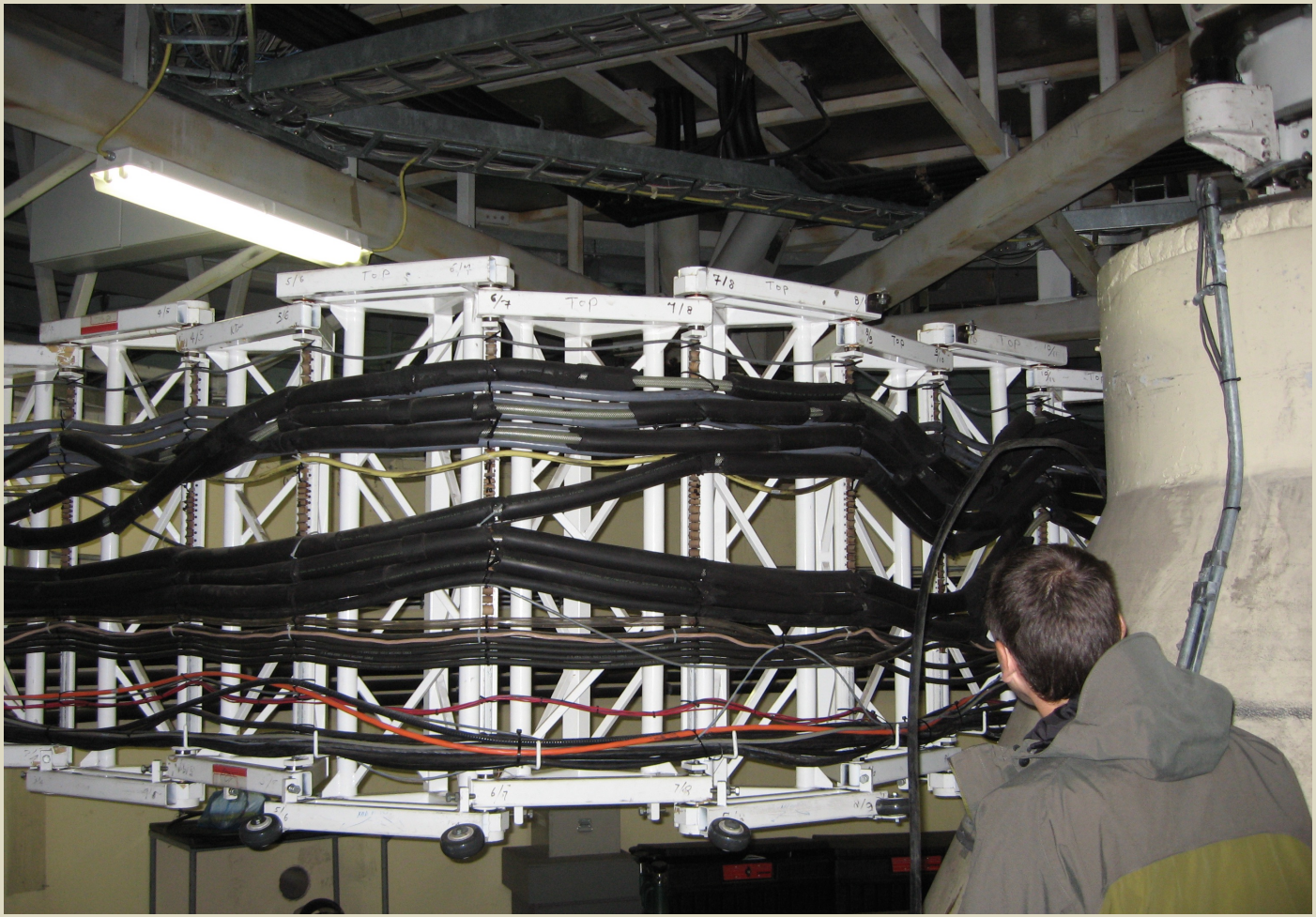


Philippe Raffin

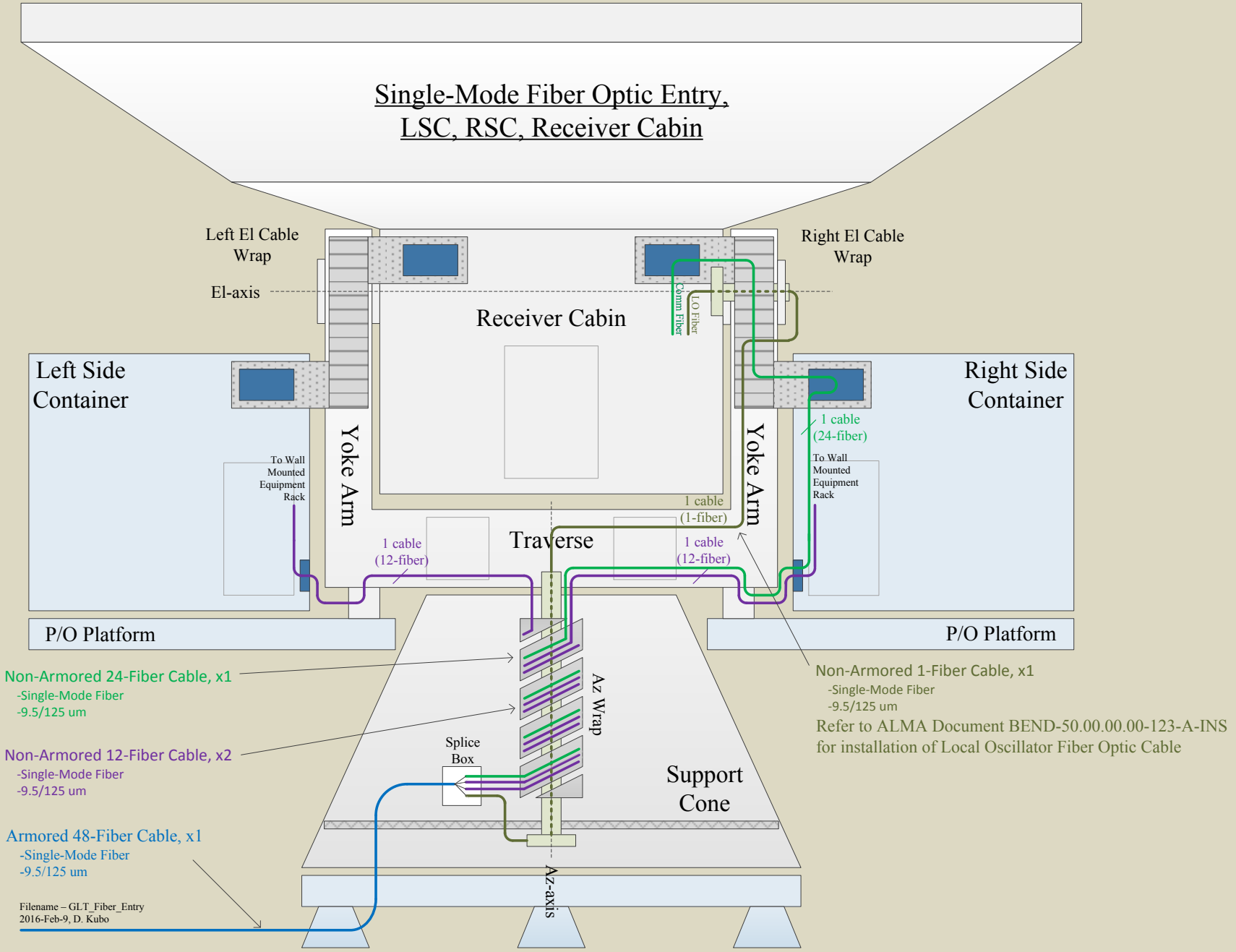
○ Items that Require Attention (continued):

- **Fiber Optics System** (continued)

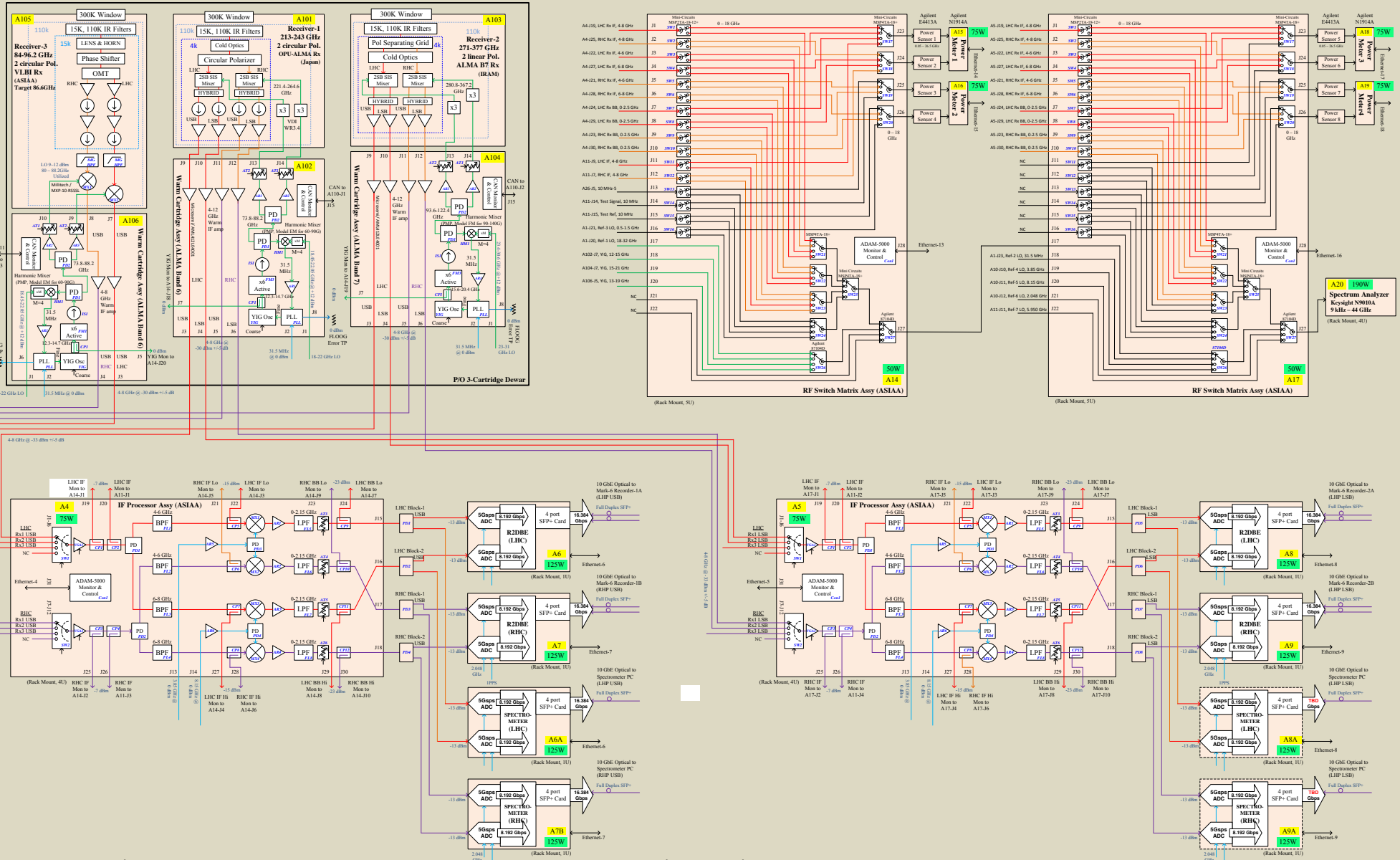
JCMT Azimuth Wrap



Single-Mode Fiber Optic Entry, LSC, RSC, Receiver Cabin



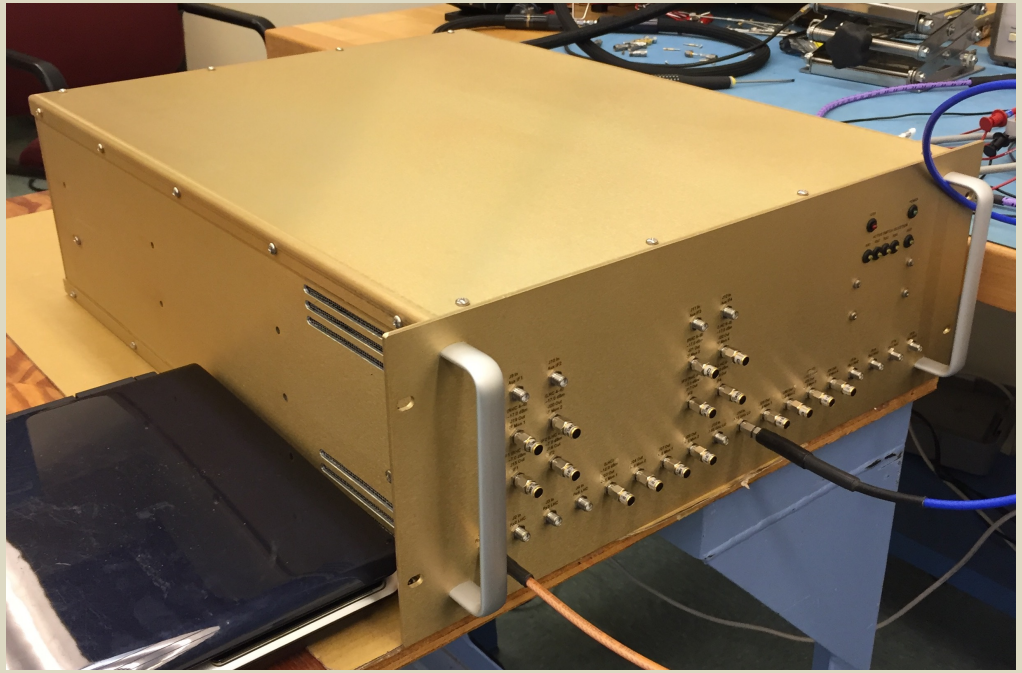
○ Intermediate Frequency Signal Overview and Status

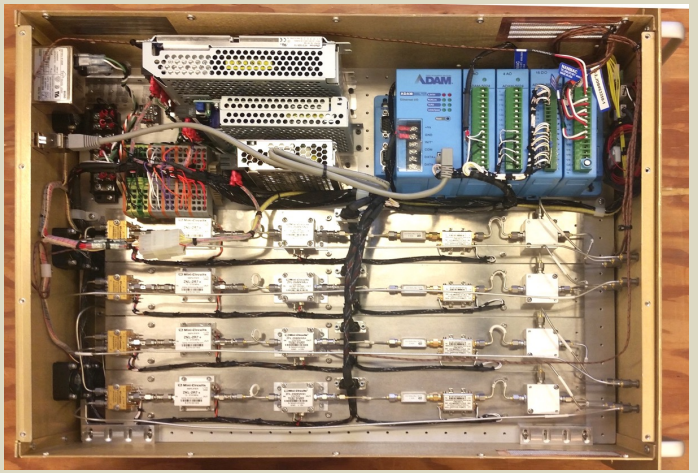


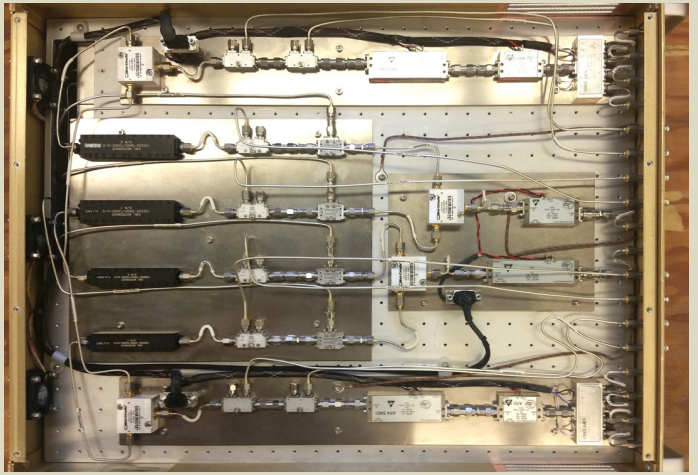
○ Intermediate Frequency Signal Overview and Status

○ Items that Require Attention:

- **IF Processor Assembly** (CAB-A4, A5), custom design, responsibility - Ryan Chilson
  - 3 units, 2 operational + 1 spare
  - SN01 assembly/test complete
  - SN02/03 **Estimate to complete in Hilo – May 19, 2017**

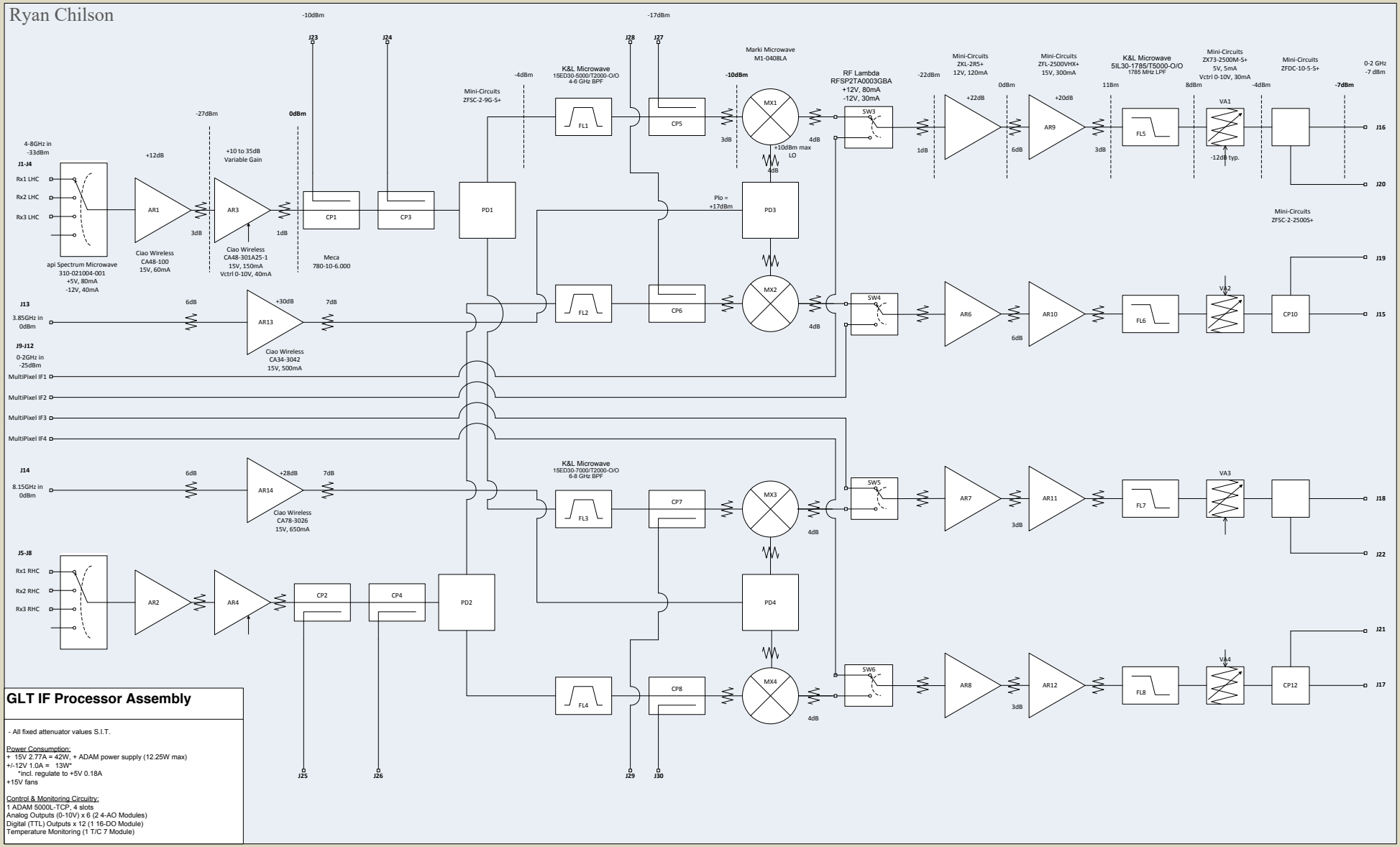






Ryan Chilson

○ Intermediate Frequency Signal Overview and Status



GLT IF Processor Assembly

- All fixed attenuator values S.I.T.

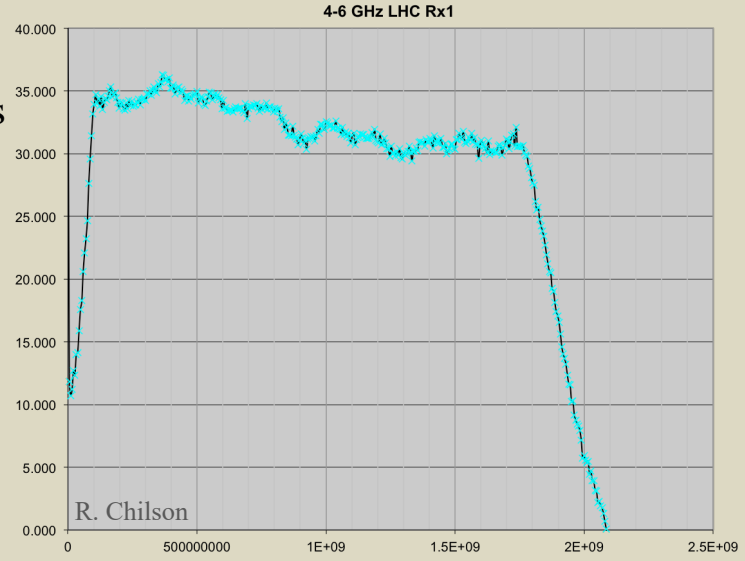
Power Consumption:
+ 15V 2.77A = 42W, + ADAM power supply (12.25W max)
+/-12V 1.0A = 13W*
*incl. regulate to +5V 0.18A
+15V fans

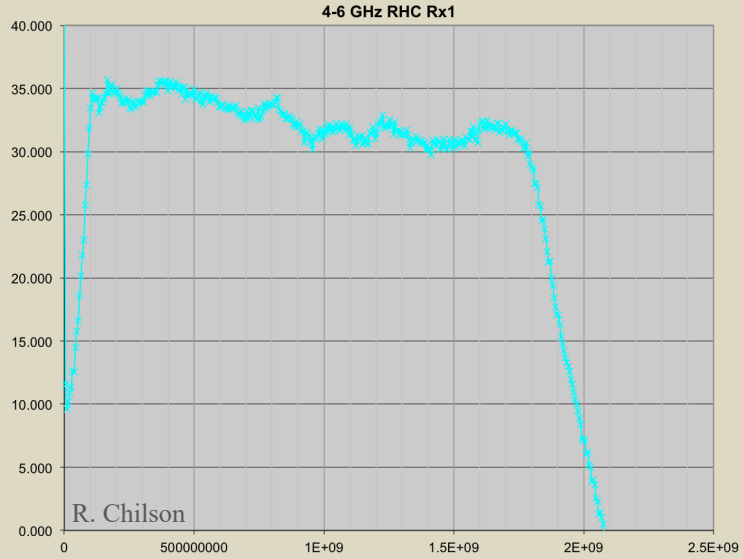
Control & Monitoring Circuitry:
1 ADAM 5000L-TCP, 4 slots
Analog Outputs (0-10V) x 6 (2 4-AO Modules)
Digital (TTL) Outputs x 12 (1 16-DO Module)
Temperature Monitoring (1 T/C 7 Module)

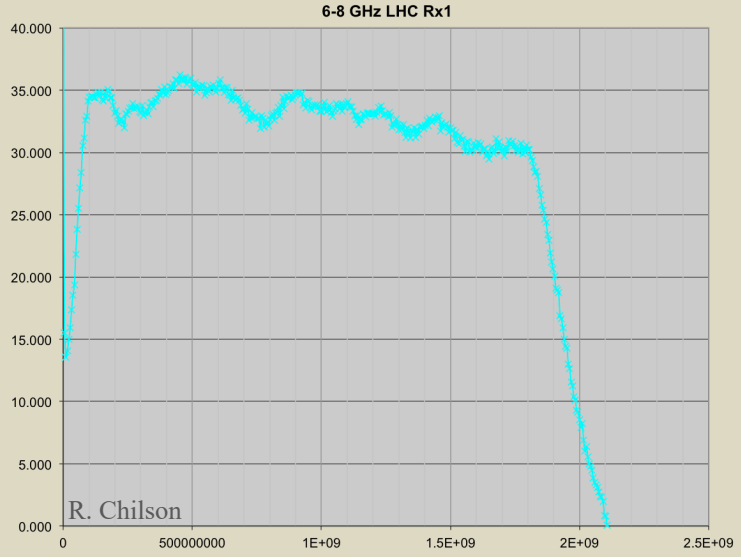
○ Intermediate Frequency Signal Overview and Status

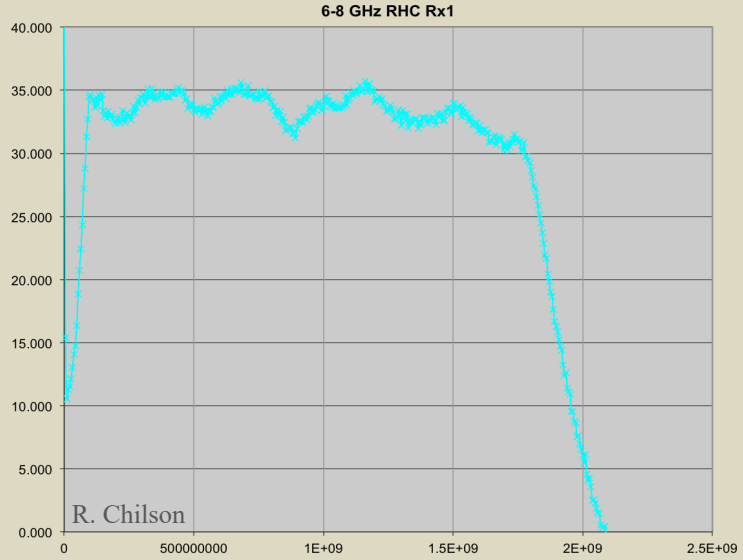
○ Items that Require Attention (continued):

- **IF Processor Assy**
  - Swept responses





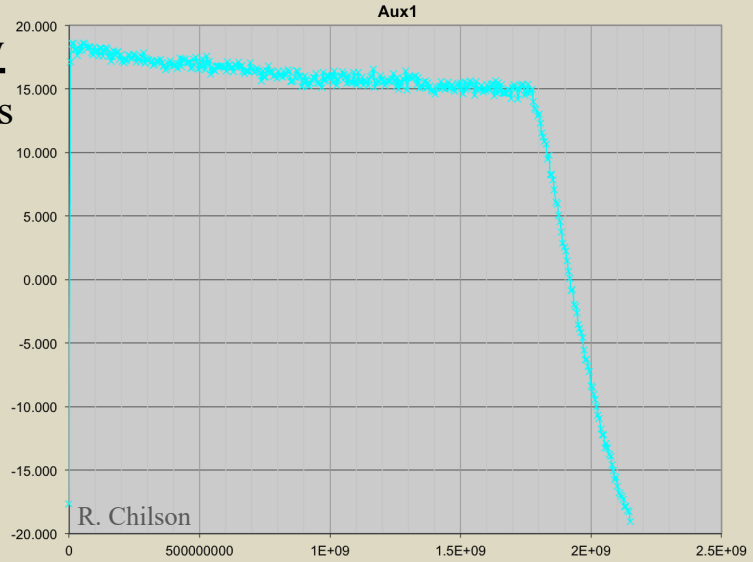


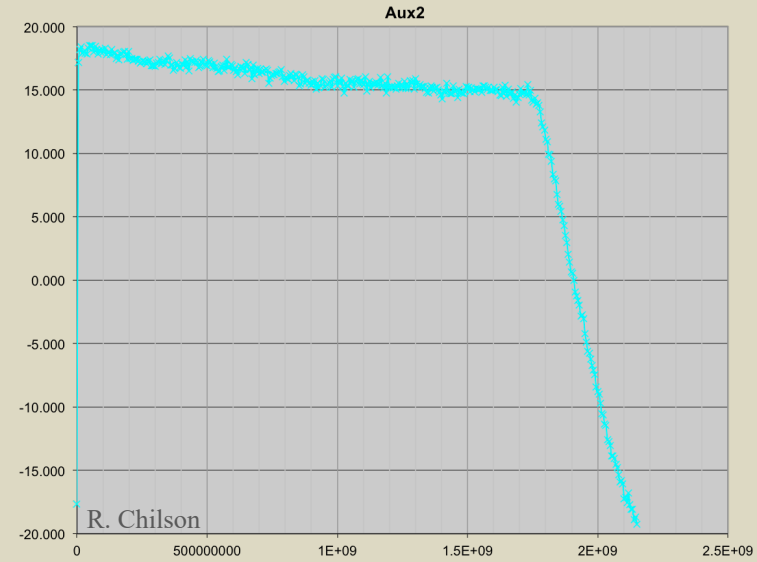


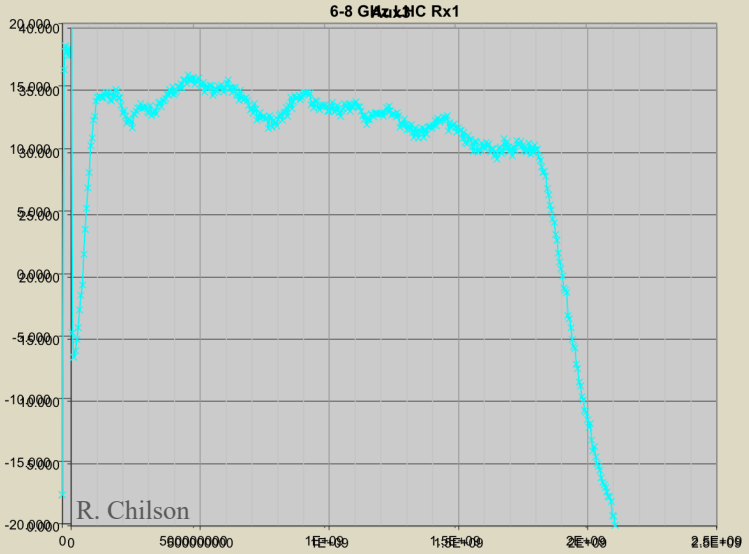
○ Intermediate Frequency Signal Overview and Status

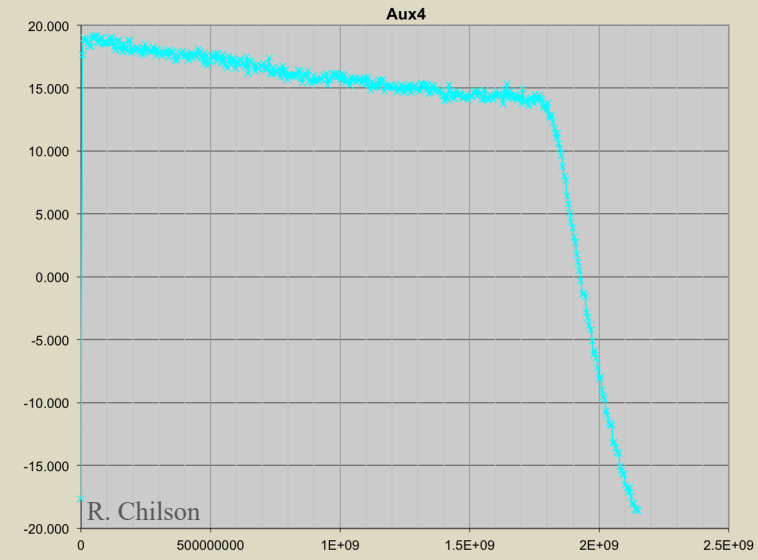
○ Items that Require Attention (continued):

- **IF Processor Assy**
  - Swept responses





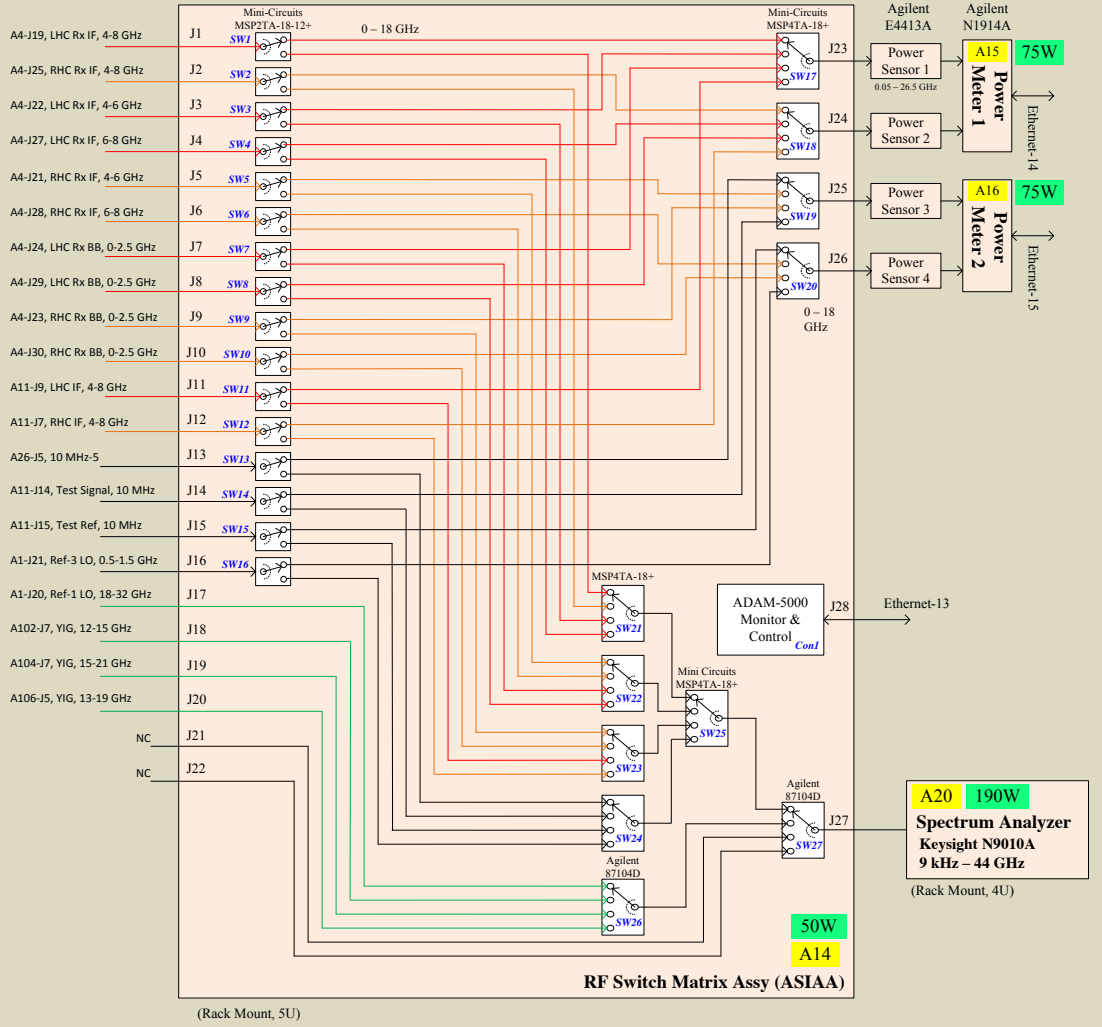




○ Intermediate Frequency Signal Overview and Status

○ Items that Require Attention (continued):

- **Switch Matrix Assembly** (CAB-A14/A17), custom design, responsibility – TBD
  - 3 units, 2 operational + 1 spare
  - Required for Servo Control of IF and Baseband power levels within IF Processor (CAB-A4/A5) as well other units
  - Part of Built-in Test Equipment
    - Permits remote monitoring of power levels and spectra of critical signals such as LOs and IF receiver outputs
  - Relatively simple electrical design but mechanically challenging
  - **Target to Complete SN01/02 July 14, 2017** TBR

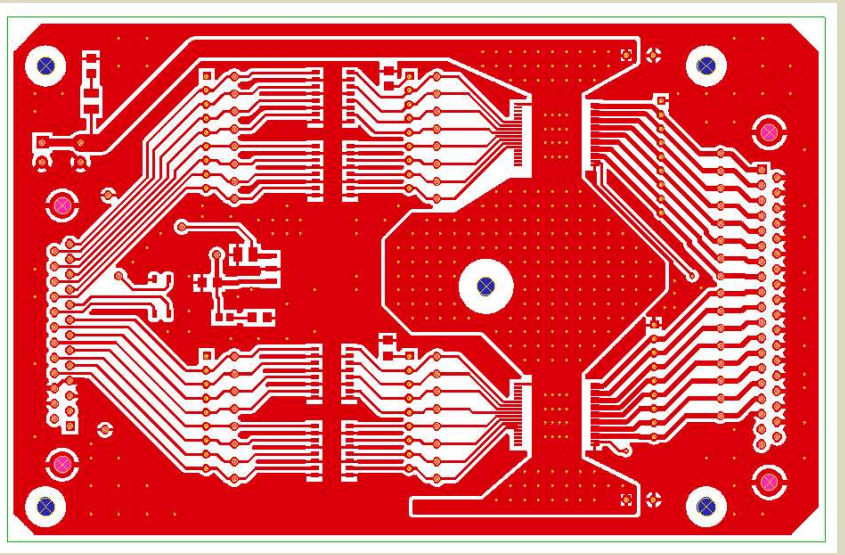


○ Intermediate Frequency Signal Overview and Status

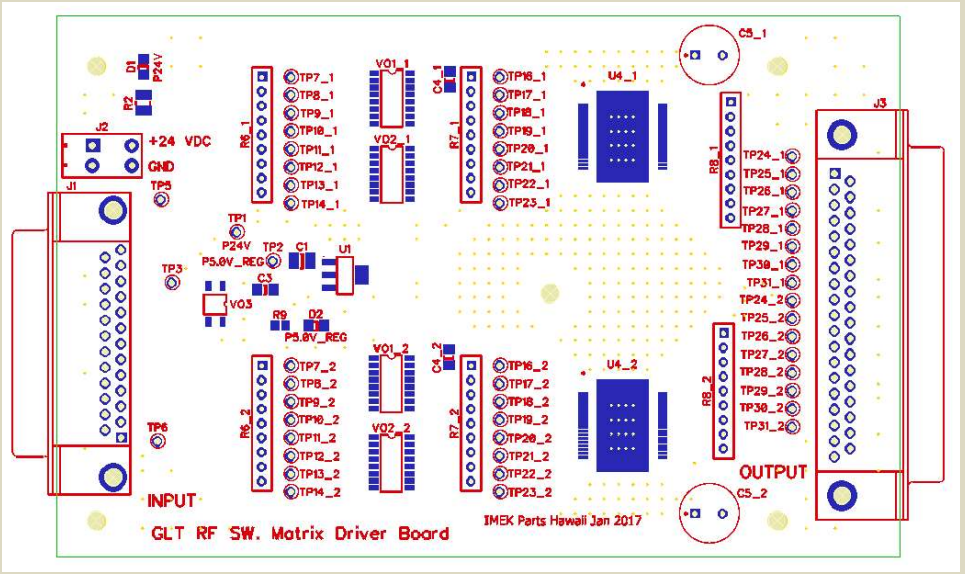
○ Items that Require Attention (continued):

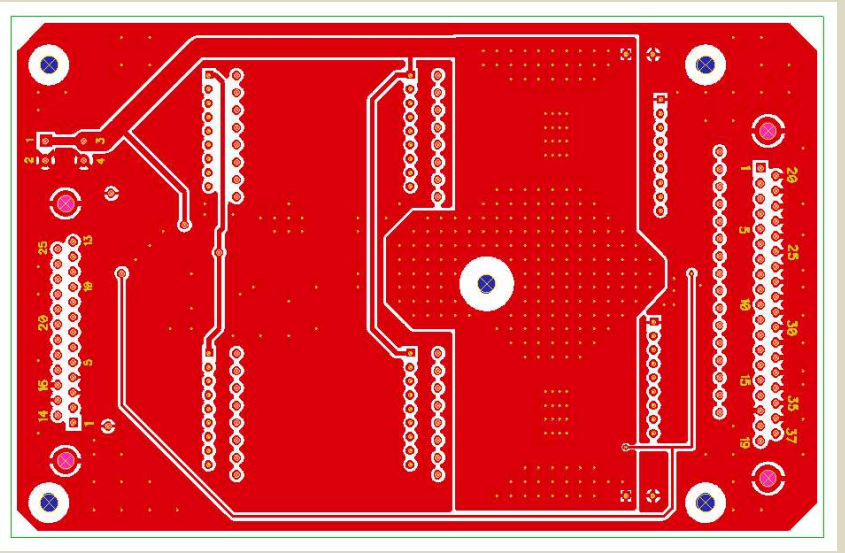
- **Switch Matrix Assembly** (continued)
  - Developed a PCBA for control of the 27 switches
    - 72 control positions
  - Will begin board fabrication/assembly in March
  - **Target to Complete SN01/02 July 14, 2017** TBR

IMEK PARTS



IMEK PARTS

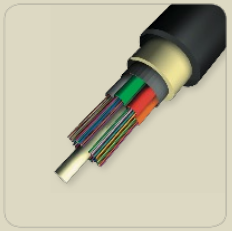




References:

[1]

AFL **Fiber Optic Cable**



Extreme Low Temp LSZH Double Jacket I/O Loose Tube (LA Series)

The LA-Series is specially designed for applications that demand reliable performance in harsh environment installations. The cable construction incorporates a variety of packaging technologies that allow the product to operate in extremely low temperatures, mechanically abusive installations and highly caustic and acidic environments. The key to the reliable, ultra-high performance is the specially designed cable core and the dual layer jacketing system.

The cable core is constructed using materials and engineered geometry that optimizes the isolation of the optical fibers from the stresses and strains imparted on the cable and commonly realized in extreme environments. The outer jacketing is designed to further protect the ruggedized core assembly with a multiplying system made up of a double-ply, low smoke zero halogen (LSZH) flame resistant jacketing system that integrates a strong layer of aramid yarn between the inner and outer sheaths.

Applications

Network Connectivity for:

- Oil and Gas fields
- Low Temperature Environments
- Refineries
- Mining
- Mass Transit

Features

- Fiber Range 12-144
- OFNG-LS Listed, CSA-FT4
- IEEE Flame Test
- ICEA S-104-696
- CSA 22.2 No. 230 and 232
- Increase tensile load rating
- Chemical Resistance testing per ASTM D412
- 2X Crush Resistance compared to standard fiber optic cables
- 2X Cold Impact Resistance compared to standard fiber optic cables
- Self-supporting capability (contract factory for system design support)

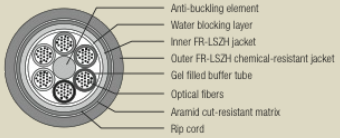
Temperature Range

	FIBER COUNT	
	12-72 FIBERS, 6-POSITION CORE	12-144 FIBERS, 8- AND 12-POSITION CORES
Operating	-55°C to +70°C	-60°C to +70°C
Storage	-60°C to +70°C	-60°C to +70°C
Installation	-30°C to +50°C	-30°C to +70°C

Mechanical

PARAMETER	VALUE
Crush	440N/CM
Cold Impact	8.8 N*m
Tensile	
Installation	1,000 lbs (4,450N)
Operational	400 lbs (1,780N)

Cable Components



AFL **Fiber Optic Cable**

Extreme Low Temp LSZH Double Jacket I/O Loose Tube (LA Series)

Fiber Specifications

FIBER TYPE	MAXIMUM ATTENUATION (DB/KM)				OVERFILL LAUNCH MIN. BANDWIDTH (MHZ•KM)		GIGABIT ETHERNET MIN. LINK DISTANCE (METERS)	
	850 NM	1300 NM	1310 NM	1550 NM	850 NM	1300 NM	850 NM	1300 NM
(6) 62.5/125 GIGA-Link™ 300	3.5	1.2	N/A	N/A	200	600	300	550
(5) 50/125 GIGA-Link™ 600	2.9	0.9	N/A	N/A	500	500	600	600
(L) 50/125 Laser-Link™ 300	2.9	0.9	N/A	N/A	1500	500	900	550
(9) Single-mode	N/A	N/A	0.35	0.25	N/A	N/A	N/A	5000
(Q) Non-zero Dispersion-shifted Single-mode	N/A	N/A	N/A	0.25	N/A	N/A	N/A	N/A
(K) AFL G.657.A1 Single-mode	N/A	N/A	0.35	0.25	N/A	N/A	N/A	5000

Gigabit Ethernet Minimum Link Distances are based on "bandwidth"/modal dispersion constraints.
Actual link distances may be constrained by attenuation, depending on specific loss budget.

Ordering Information

6-POSITION, -50°C OPTION	FIBER COUNT	NOMINAL DIAMETER		NOMINAL WEIGHT		MAXIMUM TENSILE LOAD LBS (N)		MINIMUM BEND RADIUS INCHES (CM)	
		INCHES	MM	LBS/1,000 FT	KG/KM	INSTALLATION	OPERATION	INSTALLATION	OPERATION
LA012✶C6111N1	12	0.606	15.4	154	229	1000 (4,450)	400 (1,780)	13 (31)	6 (16)
LA024✶C6111N1	24	0.606	15.4	154	229	1000 (4,450)	400 (1,780)	13 (31)	6 (16)
LA048✶C6111N1	48	0.606	15.4	153	227	1000 (4,450)	400 (1,780)	13 (31)	6 (16)
LA072✶C6111N1	72	0.606	15.4	152	225	1000 (4,450)	400 (1,780)	13 (31)	6 (16)

8-POSITION AND 12-POSITION, -60°C OPTION	FIBER COUNT	NOMINAL DIAMETER		NOMINAL WEIGHT		MAXIMUM TENSILE LOAD LBS (N)		MINIMUM BEND RADIUS INCHES (CM)	
		INCHES	MM	LBS/1,000 FT	KG/KM	INSTALLATION	OPERATION	INSTALLATION	OPERATION
LA012✶C8111N1	12	0.673	17.1	184	273	1000 (4,450)	400 (1,780)	14 (35)	7 (18)
LA024✶C8111N1	24	0.673	17.1	184	273	1000 (4,450)	400 (1,780)	14 (35)	7 (18)
LA048✶C8111N1	48	0.673	17.1	184	273	1000 (4,450)	400 (1,780)	14 (35)	7 (18)
LA072✶C8111N1	72	0.673	17.1	184	273	1000 (4,450)	400 (1,780)	14 (35)	7 (18)
LA096✶C8111N1	96	0.673	17.1	184	273	1000 (4,450)	400 (1,780)	14 (35)	7 (18)
LA144✶CC111NI	144	0.823	20.9	250	371	1000 (4,450)	400 (1,780)	17 (42)	9 (21)

✶ Fiber Types – Replace asterisk (✶) in AFL number with number in the Fiber Specifications table above.

References:

[2]

Proceedings Article

Low-temperature transmission loss in loose tube fiber optic cables

Philip B. Grimado ; Osman S. Gebizlioglu ; M. J. Zammit ; Gabor D. Kiss
[+] Author Affiliations

Proc. SPIE 2290, Fiber Optic Materials and Components, 29 (September 28, 1994); doi:10.1117/12.187431

Text Size: A A A

From Conference Volume 2290

Fiber Optic Materials and Components
Hakan H. Yuce; Dilip K. Paul; Roger A. Greenwell
San Diego, CA | July 24, 1994

Abstract

abstract

Large optical losses in singlemode fibers have been reported in loose tube fiber optic cables exposed to extremely low temperatures (-20 degree(s)C to -40 degree(s)C). These losses have occurred predominantly at 1550 nm (although some transmission systems at 1310 nm have also been affected) in aerial cables and were confined to the cable section adjacent to a splice closure. Optical transmission measurements on commercial fiber optic cables that were subjected to temperature cycling in an environmental chamber indicated that thermal contraction of buffer tubes at low temperature was the major contributor to fiber bending-induced loss. While the buffer tube thermal shrinkage occurs, optical fibers contained in the tube undergo nearly zero contraction. Consequently, the fibers buckle against the buffer tube inner wall, causing bending-induced losses. Cables with an initially low fiber excess length-to-buffer tube inner diameter ratio, and strong buffer tube-to-central member coupling exhibit minimal loss. It has been demonstrated in the laboratory that the low-temperature optical loss can be suppressed by effective coupling of the cable sheath to the central member.

Topics

Optical fiber cables ; Optical fibers ; Single mode fibers ; Transmittance

Citation Philip B. Grimado ; Osman S. Gebizlioglu ; M. J. Zammit and Gabor D. Kiss "Low-temperature transmission loss in loose tube fiber optic cables", *Proc. SPIE* 2290, Fiber Optic Materials and Components, 29 (September 28, 1994); doi:10.1117/12.187431; http://dx.doi.org/10.1117/12.187431