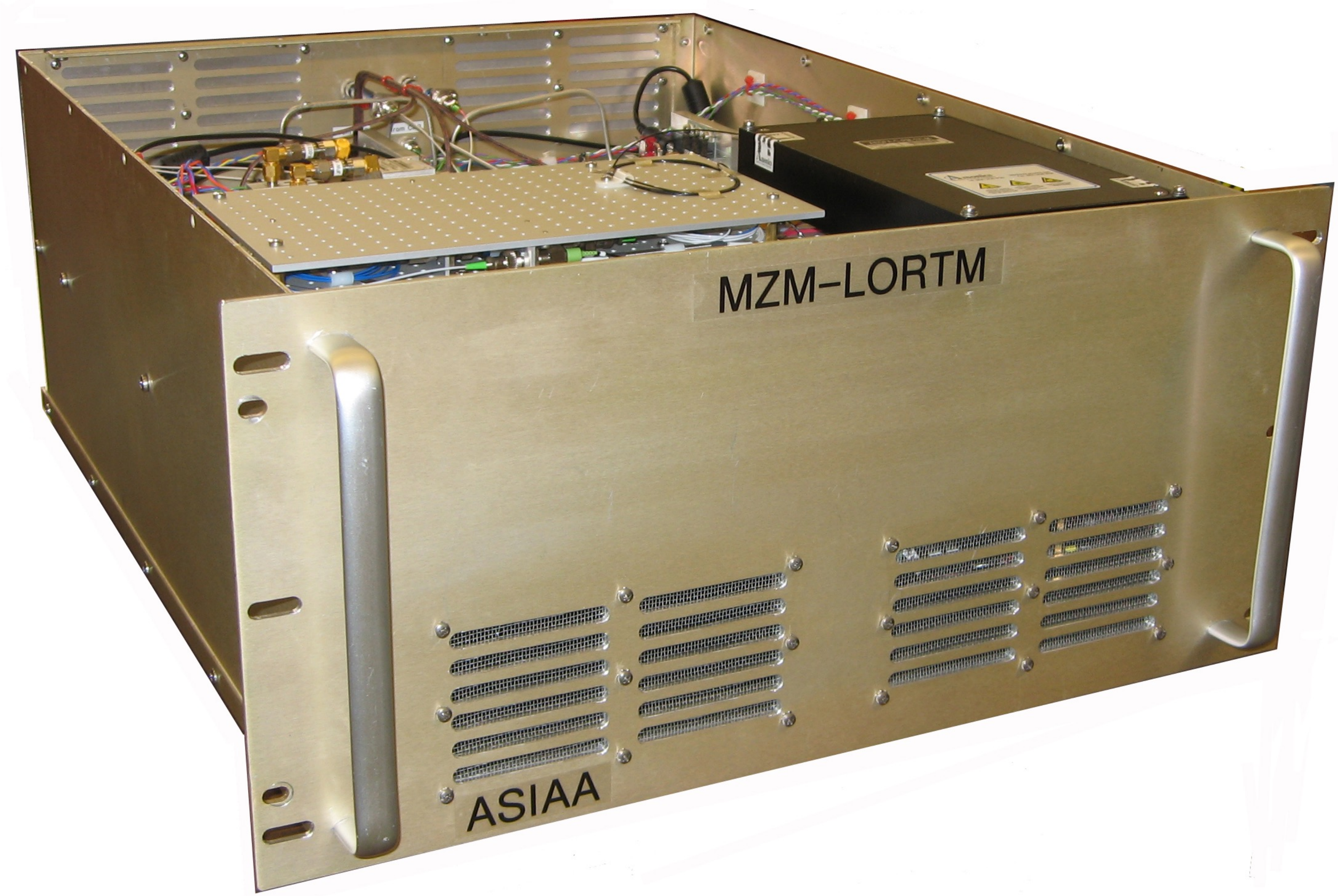
MZM LORTM Upgrade

Atacama Large Millimeter Array - Taiwan

Academia Sinica
Institute of Astronomy & Astrophysics



D. Kubo / R. Srinivasan / J. Han

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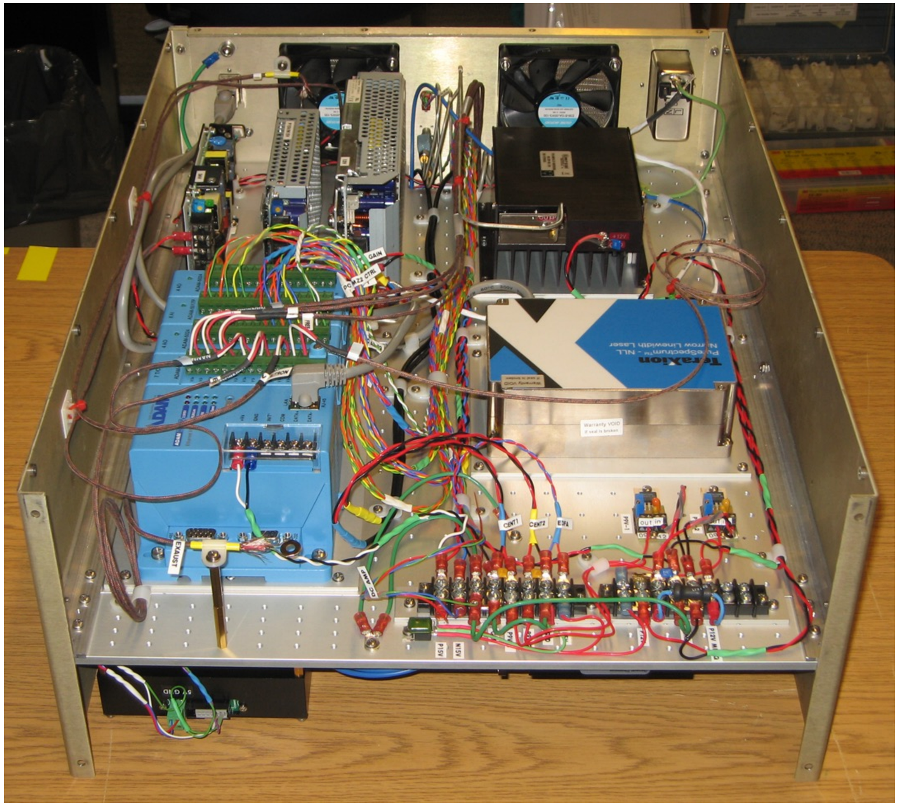
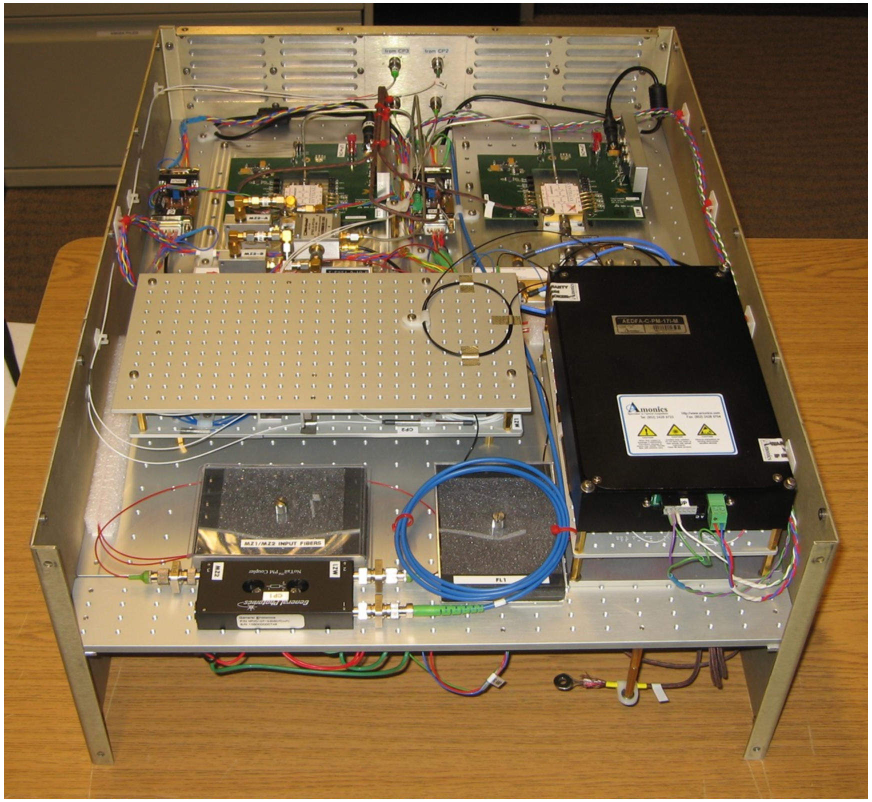
Photo of completed MZM LORTM



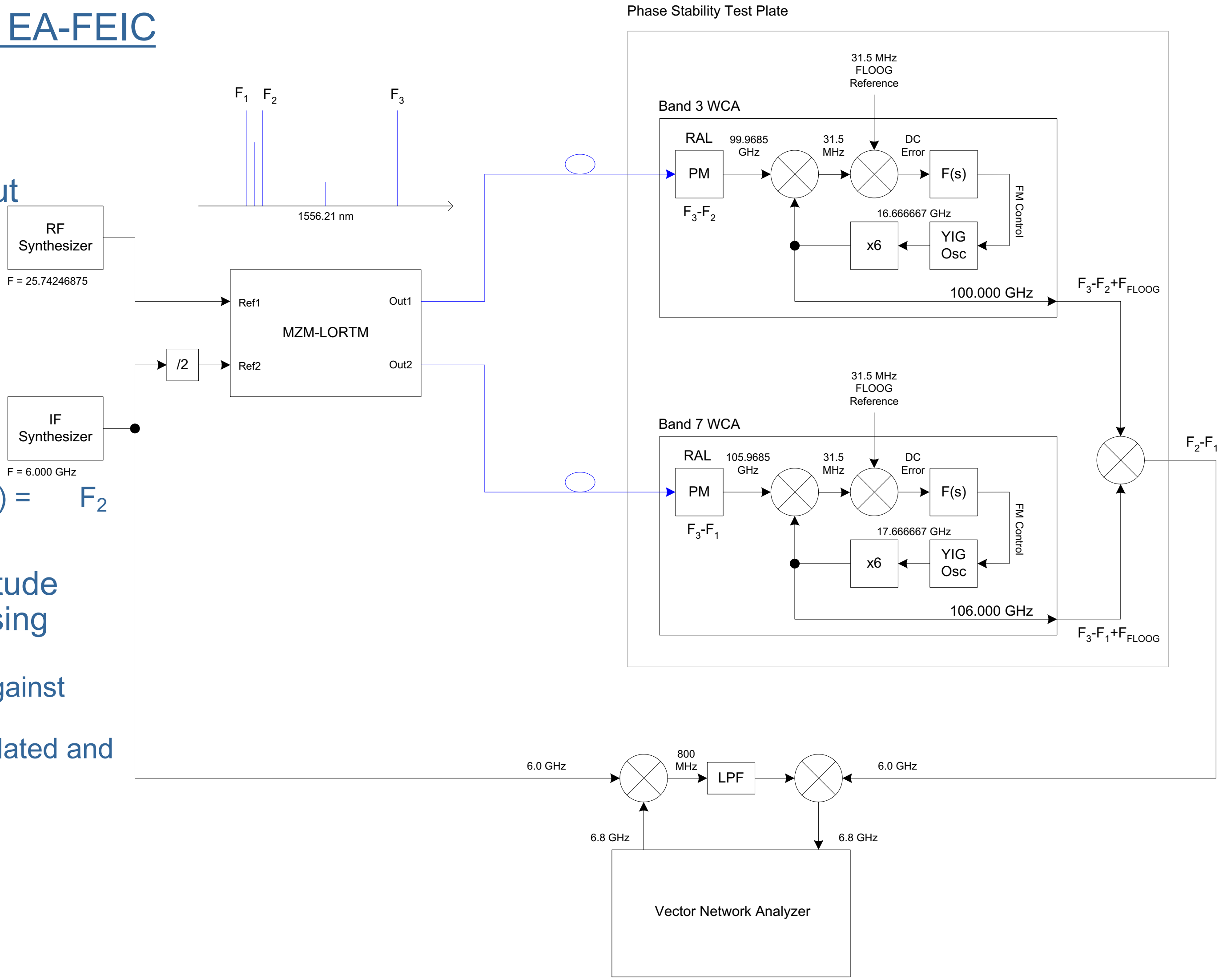
Bottom view



Top view

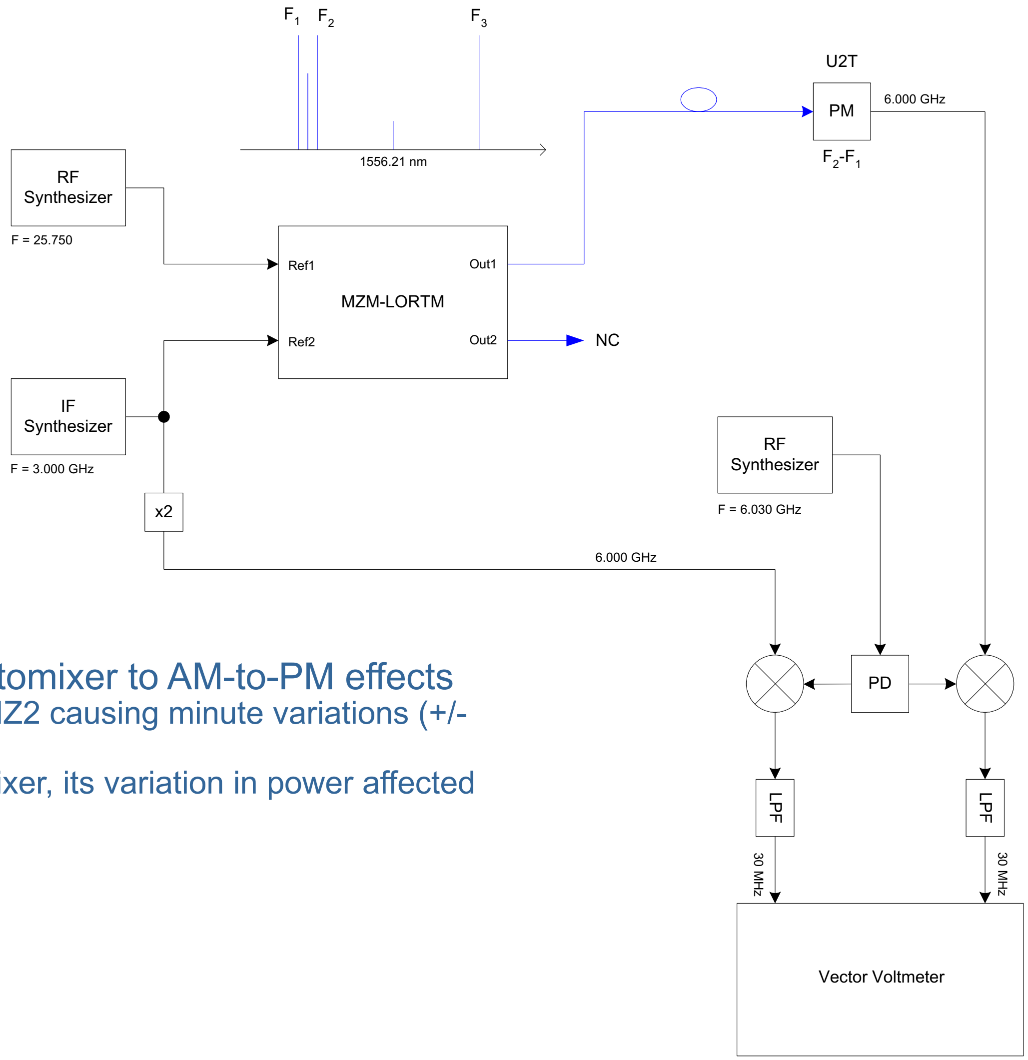
Phase Stability Test Setup, EA-FEIC

- Utilizes WCA PLLs to lock to different pairs of optical tones
- PLLs track phase of PM output out to about 4 MHz
  - Spurs & noise outside of tracking BW is ignored
  - Cleans up LO
- Difference between 2 PLL outputs represent desired IF = $F_2 – F_1$ signal
  - $F_3 - F_1 - F_{FLOOG} – (F_3 - F_2-F_{FLOOG}) = F_2 – F_1$
- Desired IF is phase & amplitude compared to reference IF using VNA
  - Phase is recorded and plotted against time
  - Allan Deviation of phase is calculated and plotted against time interval



Phase Stability Test Setup, Hilo Lab

- We do not have access to WCAs in Hilo so had to come up with a comparable scheme
- Used low frequency U2T mixer to directly detect the $F_2 - F_1$ difference
  - Ignores the F_3 optical tone
  - No PLLs to clean up spurs and noise
- Desired IF is phase and amplitude compared to reference IF using VVM
- Initial tests with MZM-LORTM resulted in very pessimistic results
  - ~3 degrees peak-to-peak over 1 minute timescales
  - Same test at EA-FEIC resulted in ~1 degree peak-to-peak



- Isolated problem to extreme sensitivity of U2T photomixer to AM-to-PM effects
  - F_3 from MZ1 was beating against the suppressed F_3 from MZ2 causing minute variations (+/- 0.1 dB) in the F_3 optical tone power
  - Though the F_3 tone was not being used by the U2T photomixer, its variation in power affected the desired $F_2 - F_1$ difference

Primary Indication – Unit fails Allan Deviation

Trouble-shooting Summary (26 April to 27 May, 2011)

- Variations in IF (Ref2) input power has a large affect on phase
- 32 degrees phase movement per 1 dB of power change
- Synthesizer output power variation is < 0.01 dB (< 0.32 degrees peak-to-peak)

- Variations in DC bias to MZ2 input has a large affect on phase
- Bias A, B, and C → +16, -17, and +28 degrees per 1 V
- ADAM + DC Amplifier produce < 1 mV variation (< 0.28 degrees peak-to-peak)

- Regulated 9VDC supply (P9V_REG) which powers the Centellax amplifiers contributed to the fast phase fluctuations
- Variation period << 1 second
- Noticeable but not significant amount

- Adding impedance matching pads to ports A and B of MZ2 provided a reduction in the slow phase fluctuations
- Variation period > 1 second
- Reduction was noticeable but not always repeatable

- Reducing optical AM-ing had a large affect in reducing the slow phase fluctuations
- Variation period > 1 second
- 3 sources of AM-ing: LSB, USB, and carrier
- Setup in Hilo was particularly sensitive to AM-ing

Troubleshooting Summary (cont'd)

- All optical components post MZ1 and MZ2 are sensitive to temperature variations
- Variation period >> 1 second
- MZ2 is particularly sensitive

- Absolute temperature of MZ2 affects both slow and fast phase fluctuations
- Cooler operation provides better performance
- Repeatable results

Summary of Upgrades Performed on MZM-LORTM

– Optical FBG plate (x2)

- Replaced Avensys carrier suppressing FBGs with a 2nd TeraXion sideband suppressing FBGs for increased optical rejection

– Optical combiner plate (new)

- Relocated combiner circuitry from deck to new combiner plate (partially isolated from deck temperature via brass stand-offs)
- Moved Avensys carrier suppressing FBG to combiner plate
- Added 2nd wide Avensys carrier suppression FBG for increase suppression and rejection of 1st harmonic

– General optics

- Relocated all optical components (with exception of laser) to top deck, including MZ1 and MZ2 plates
- Moved laser to bottom deck because 30W power dissipation (and not sensitive to small temperature fluctuations)
- Sealed off top deck from convection air flow, cooling is entirely through conduction through the deck plate

– Centellax / MZ2 plate

- Relocating MZ1 and MZ2 plates to top deck created a new thermal problem for MZ2
- Added TE cooler under MZ2 to lower operating temperature (to improve “Normal-Mode” performance)
- Monitor TE cooler drive voltage via ADAM AI module (channel 6)

– Miteq IF power amplifier

- Removed cooling fans (+12VDC bus was being corrupted by fans) and relocated near rear panel air intake
- Added Pi filter to isolate amplifier from +12VDC bus (amplifier has Vicor +12 to +28V DC-DC switcher, corrupts +12VDC bus)
- Moved IF power divider to near MZ2, used hard 90 degree connections instead of long semi-rigid coax
- Added 2 dB impedance matching pads just prior to ports A & B of MZ2

Summary of Upgrades Performed on MZM-LORTM

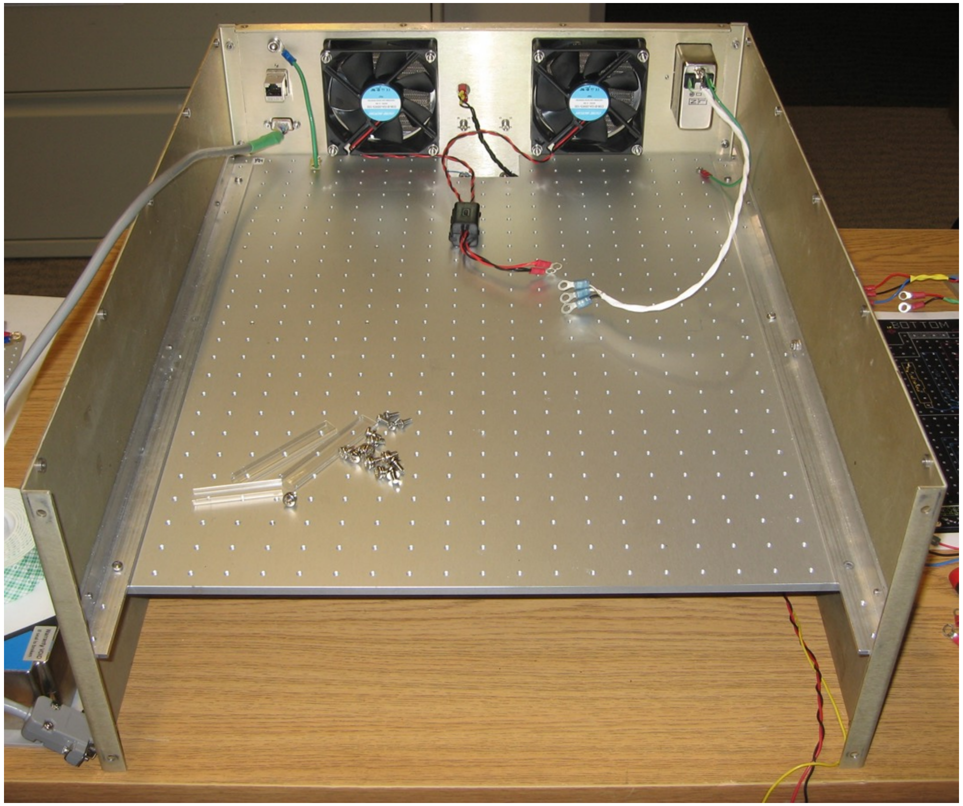
– DC amplifier (x2)

- Relocated to top deck for tuning ease
- Added monitors to DC amplifier outputs using ADAM AI module (channels 0 – 5)

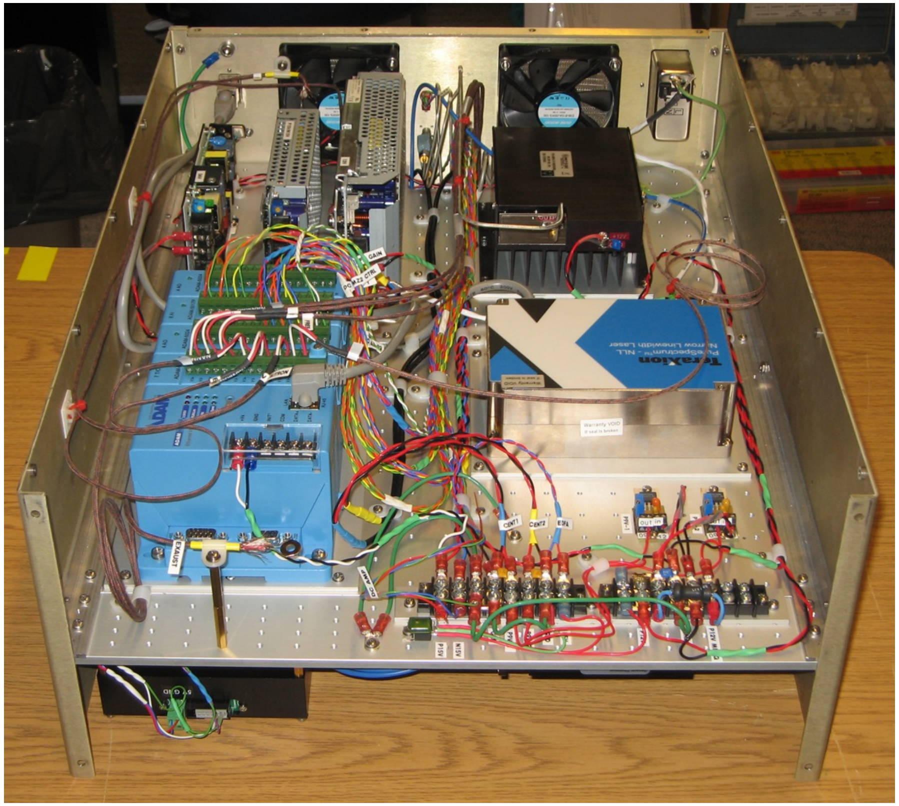
– Mechanical

- Closed off rear panel exhaust vents
- Extended fixed deck plate to isolated top from bottom
- Added exhaust vents to lower portion of front panel
- Modified front panel rack mounting holes to be directly compatible to TeraXion LORTM

Bottom – Electrical / RF



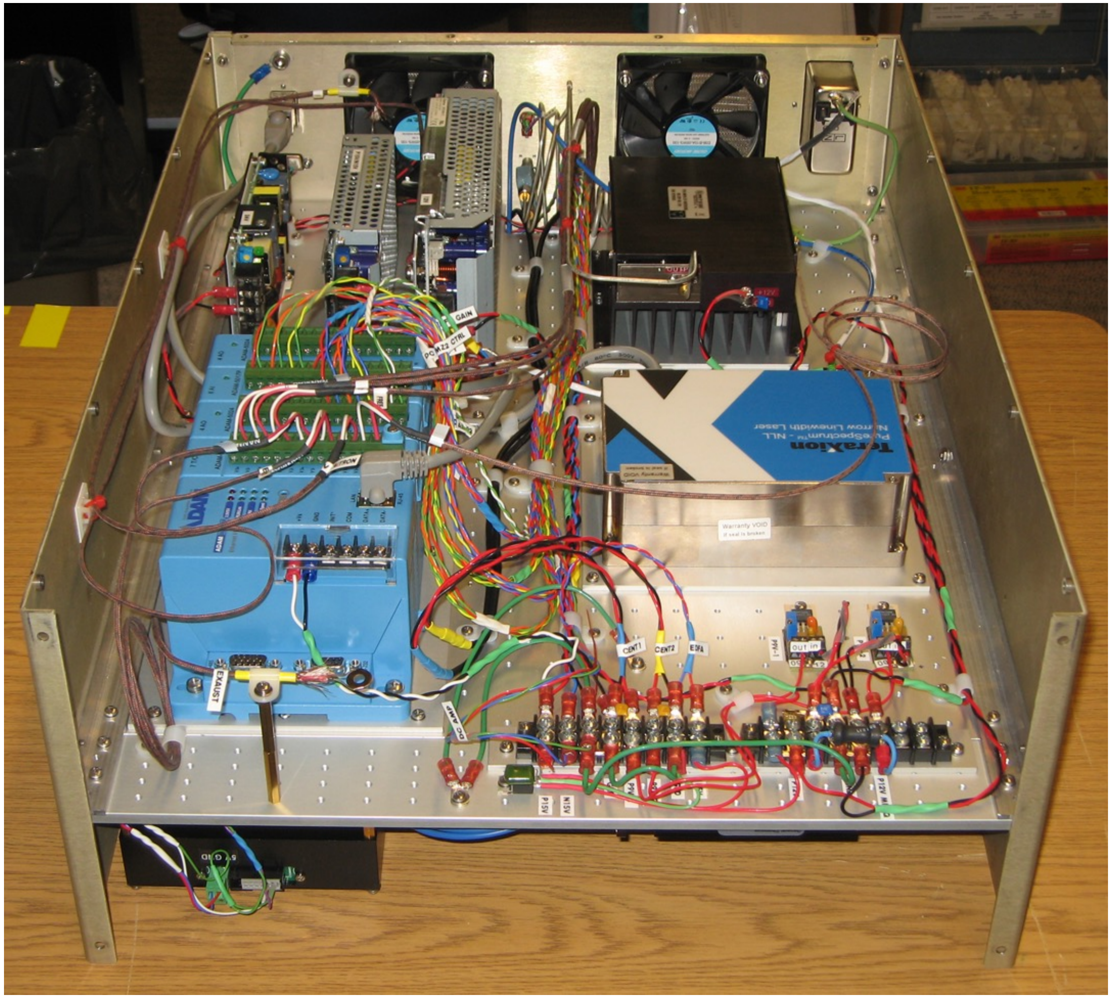
Bottom deck stripped of all components, 2011 June 1



Completed Rework, 2011 June 15

Bottom – Electrical / RF (cont'd)

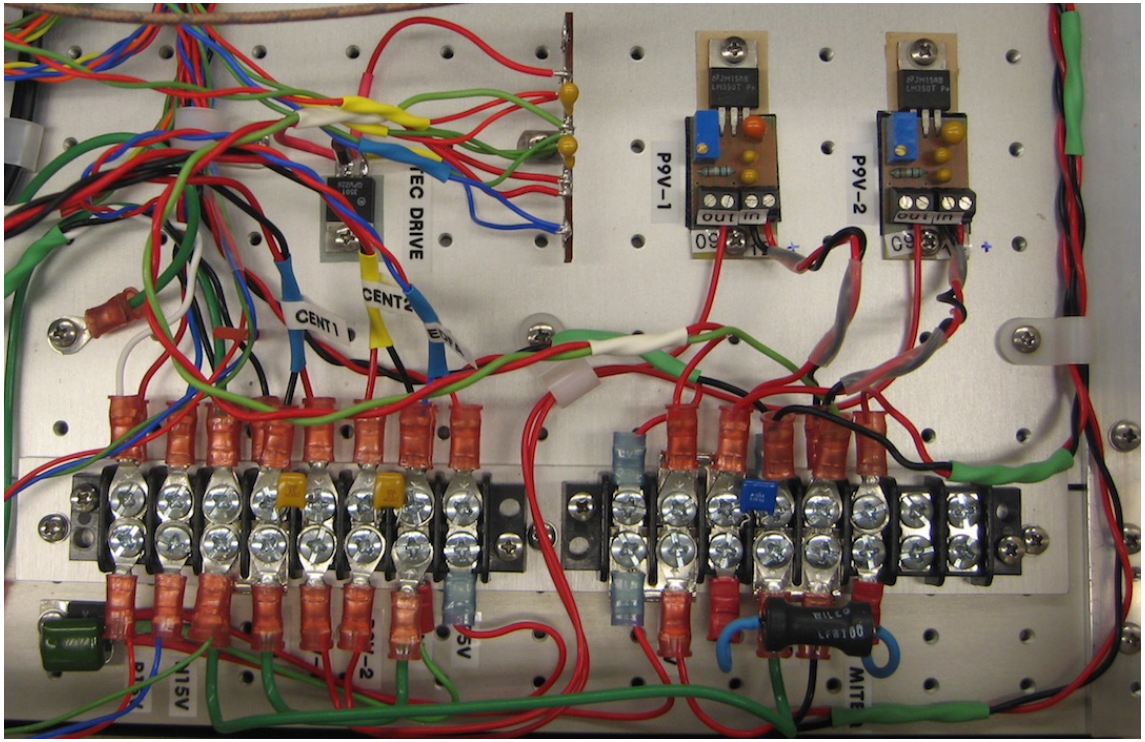
- Miteq IF power amplifier
  - Relocated to bottom deck
  - Removed attached fans and aligned with rear panel fan (fans corrupted +12V power bus)
- DC power
  - DC terminal blocks relocated to bottom on extender plate
  - Regulators (x3) relocated to bottom
- Laser relocated to bottom
- All bottom components are force air cooled
- Bottom temperature monitors:
  - Intake air (sensor #3)
  - Exhaust air (sensor #4)
  - +12V Daitron supply (sensor #5)
  - Miteq power amplifier (sensor #6)



Completed chassis – angled view of bottom deck

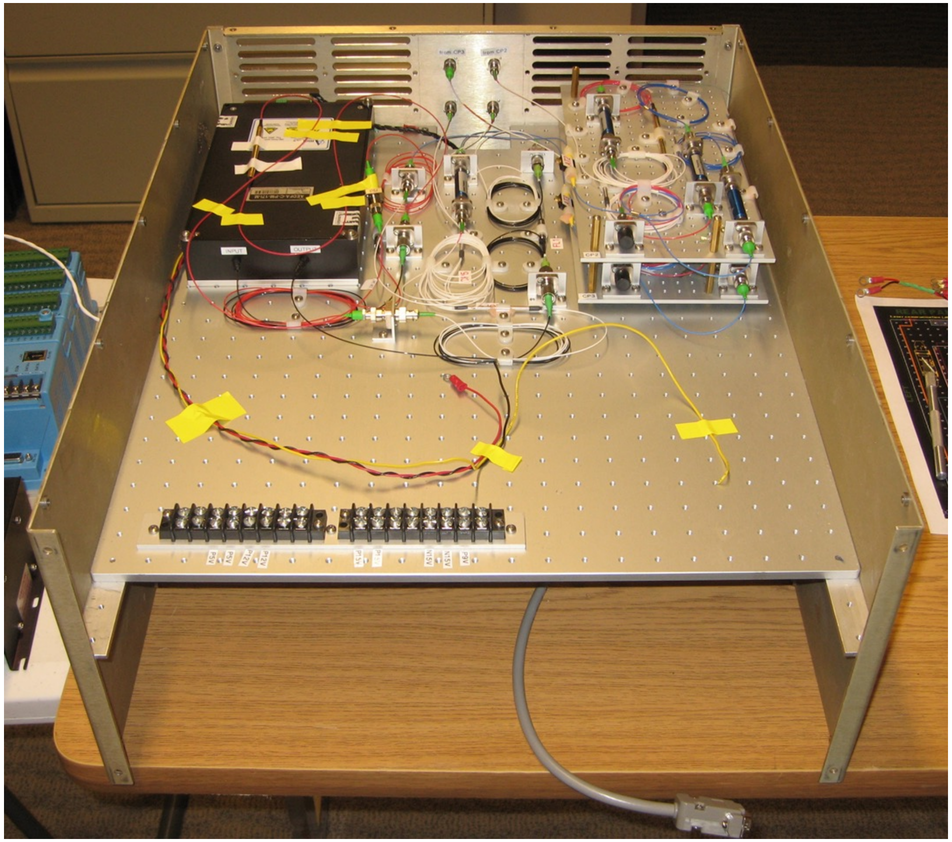
DC Power Bus

- Power bus relocated to extender plate
- Separated P9V_REG regulators to individually power 2 Centellax power amplifiers (9V @ 1.8A each)
- Added EMI Pi filter to +12V to Miteq
  - Miteq power amplifier has internal +12V to +28V DC-DC converter
  - Noise from DC-DC converter corrupted +12V DC power bus
- Added TE cooler variable regulator
  - TE cooler for MZ2
  - Variable voltage drive 1.2 to 5.5V, adjustment via rear panel mounted Bourns pot
  - 3A max

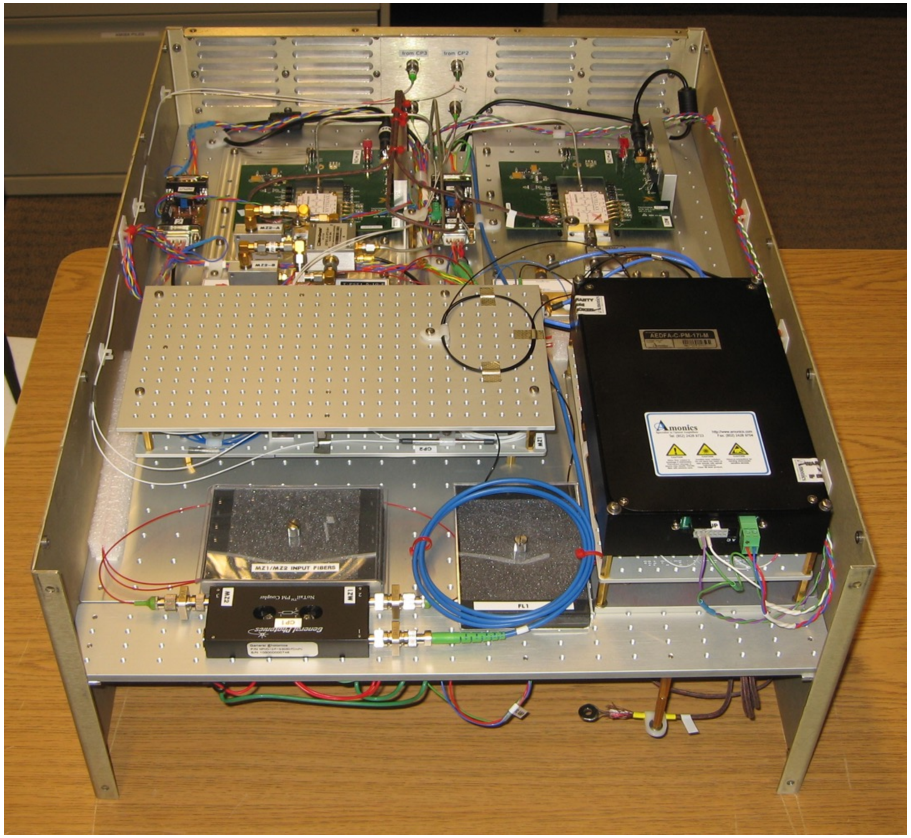


Completed power bus and voltage regulators. Left to right: +15V, -15V, GND, GND, +9V-1, +9V-2, GND, +5V, +12V, +12V, +12V, GND, GND, +12V-ISO, NC, NC

Top – Optical Processing



Partially stripped top deck, 2011 June 1



Completed Rework, 2011 June 15

Top – Optical Processing (cont'd)

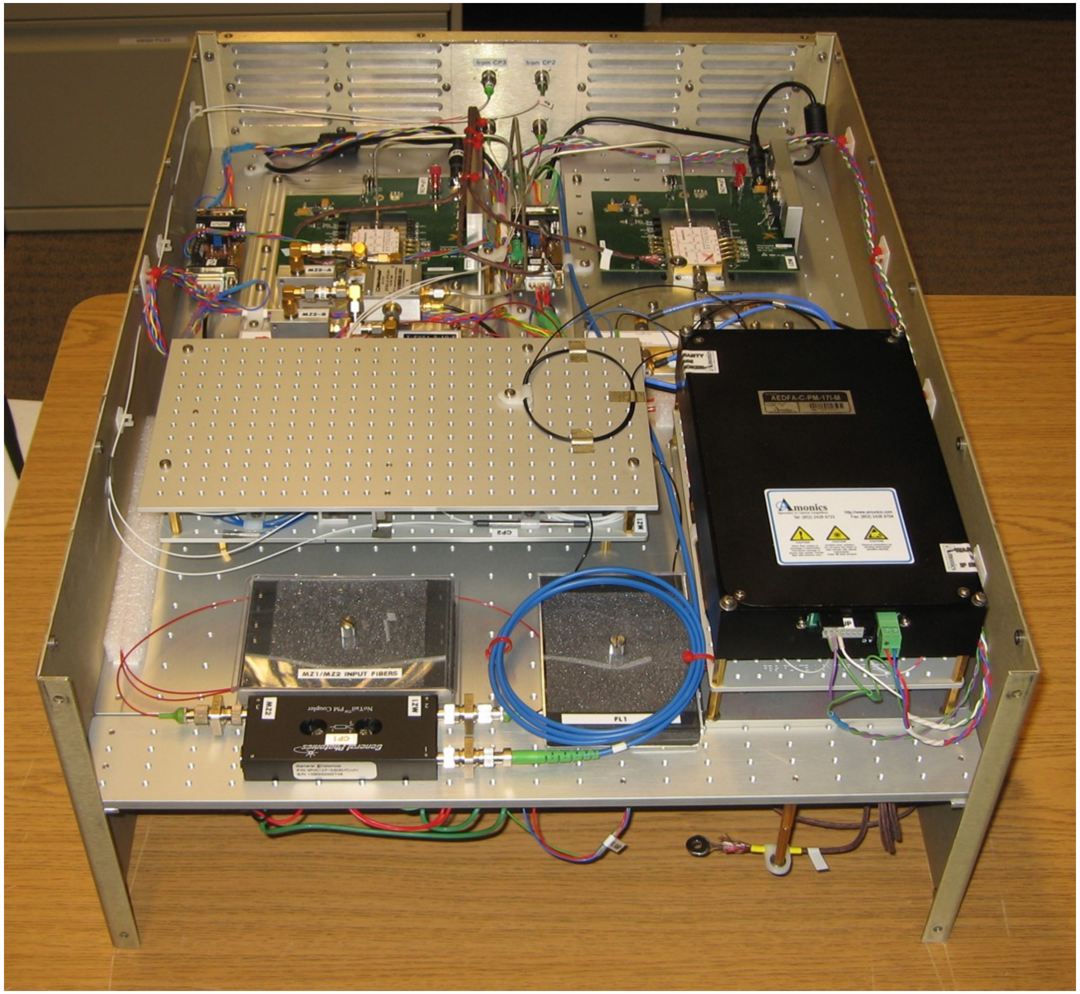
- Centellax/MZM plates (x2)
  - Relocated to top deck
  - Conduction cooled through deck plate
  - Each Centellax amplifier dissipates 16.2W

- MZ1 and MZ2 collocated with Centellax
  - MZ1 radiates 0.6 W
  - MZ2 radiates 1.9 W, additional cooling provided by TE cooler

- Laser relocated to bottom
  - Tests show that laser and output fiber are not sensitive to temperature

- Temperature isolated from environment
  - Rear panel vents are paneled off
  - Gap at front is blocked off with extender plate

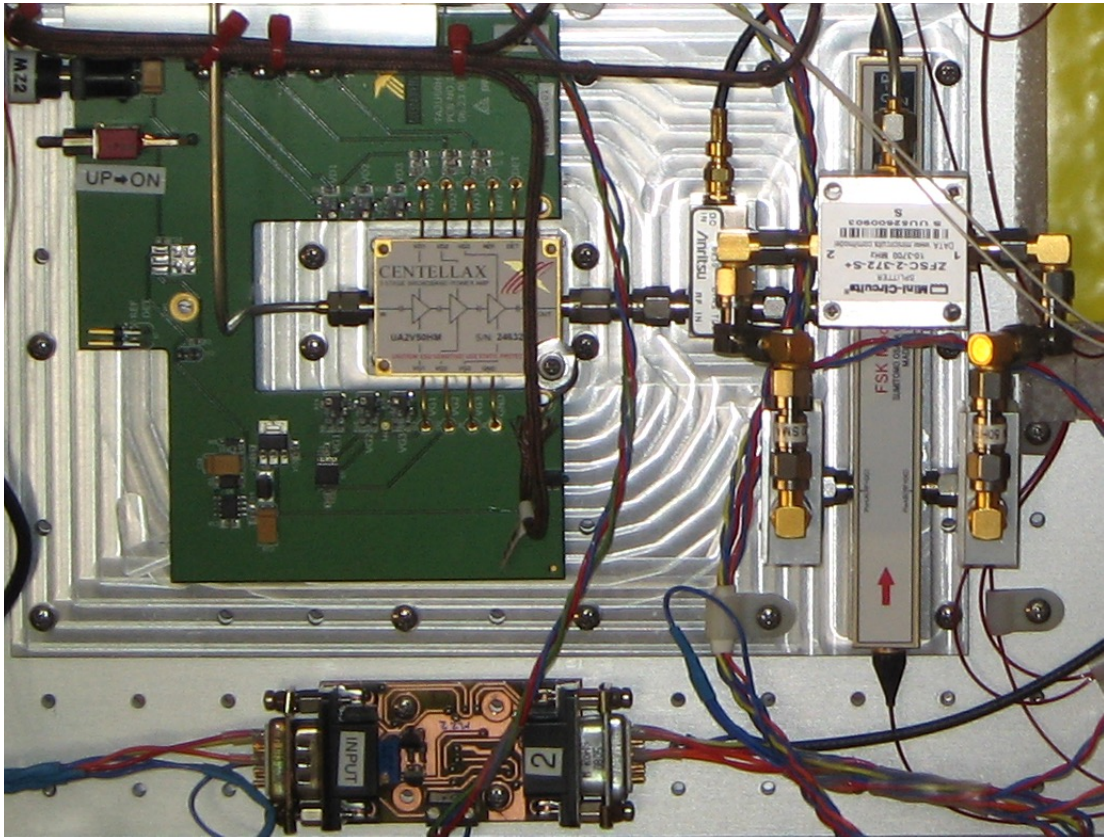
- Temperature monitors:
  - Centellax 1 and 2 amplifiers (sensors #0, #1)
  - MZ2 (sensor #2)



Completed chassis, angled view of top deck

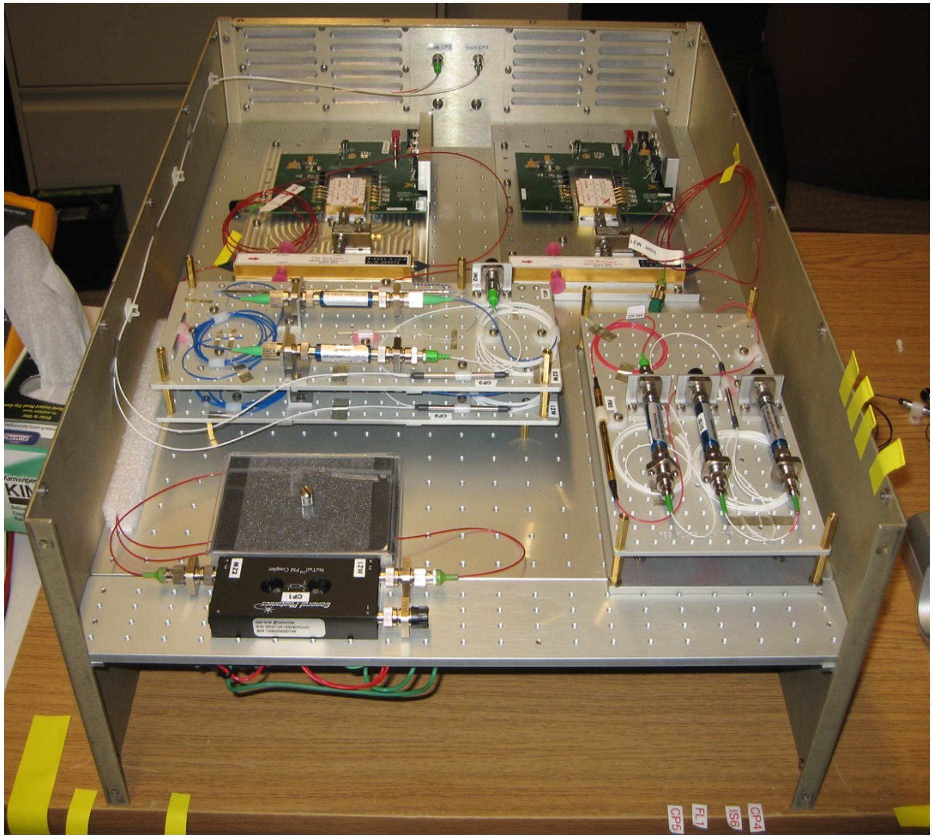
Top – Optical Processing (cont'd)

- Eliminated IF cables from PD to MZ2
  - Used hard connections via adapters
  - Added 2 dB pads for impedance matching
- DC amplifiers relocated to top for easy trim access
- Added DC monitors to ADAM AI module
  - Monitor biases A, B & C for both MZ1 & MZ2 after DC amplifier
  - Monitor TE cooler drive voltage

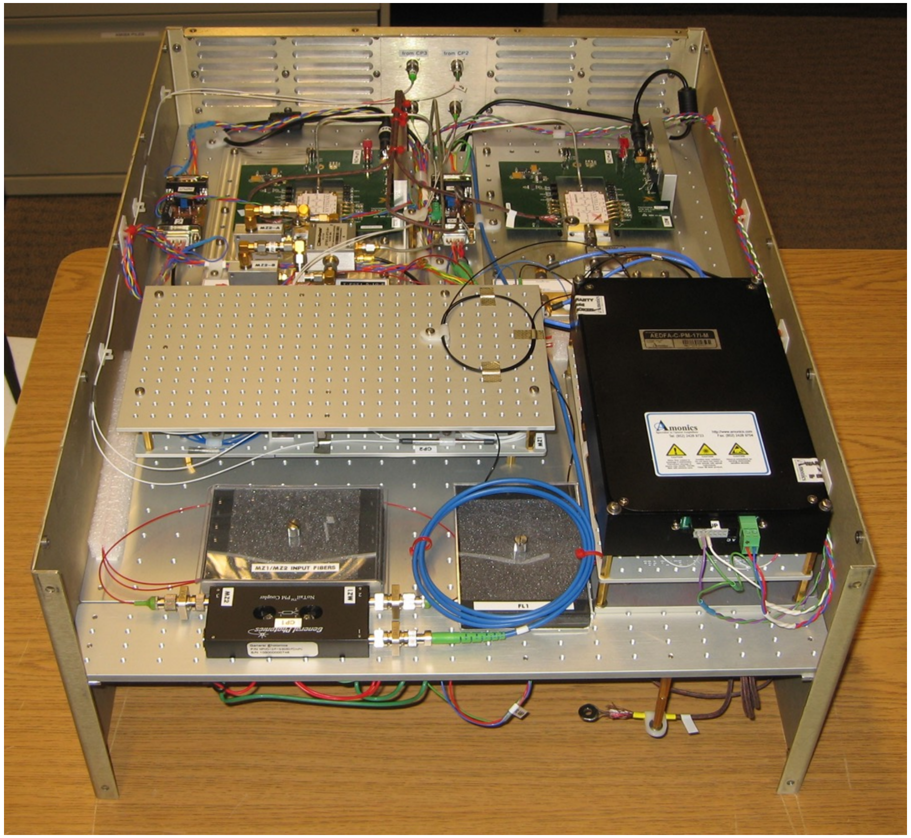


View of Centellax 2 and MZ2, note Mini Circuits power divider with hard connections to MZ2 ports A and B. Associated DC Amplifier is shown below plate.

Optical Plates Installed into Chassis



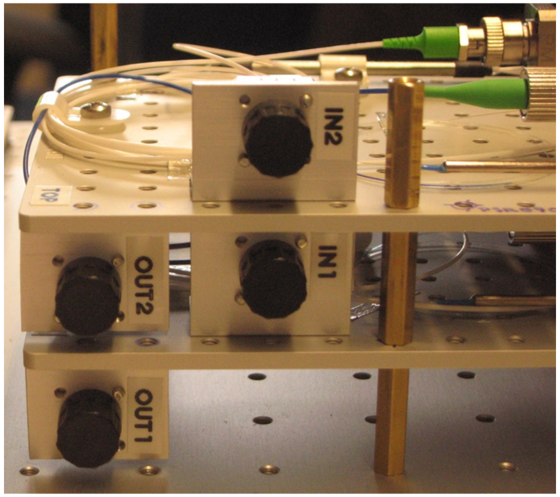
View of stacked FBG plates and Combiner plate



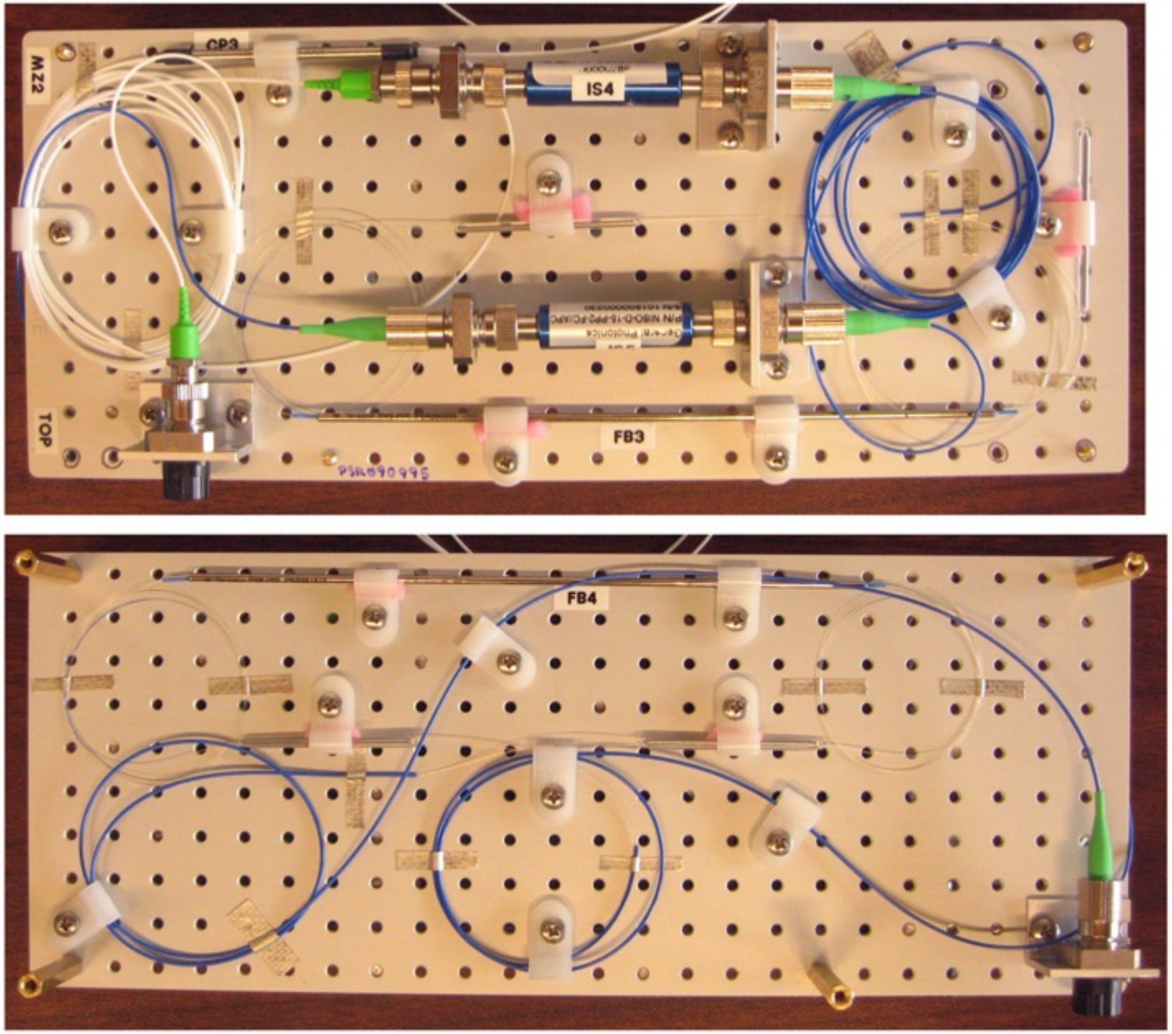
Completed chassis

MZ FBG Plates (x2)

- MZ1 and MZ2 plates are identical with exception of TeraXion FBG filters
- Added 2nd TeraXion FBG filter in cascade to provide additional sideband rejection (note the bare glass fibers)
- 2 plates are design to be stacked

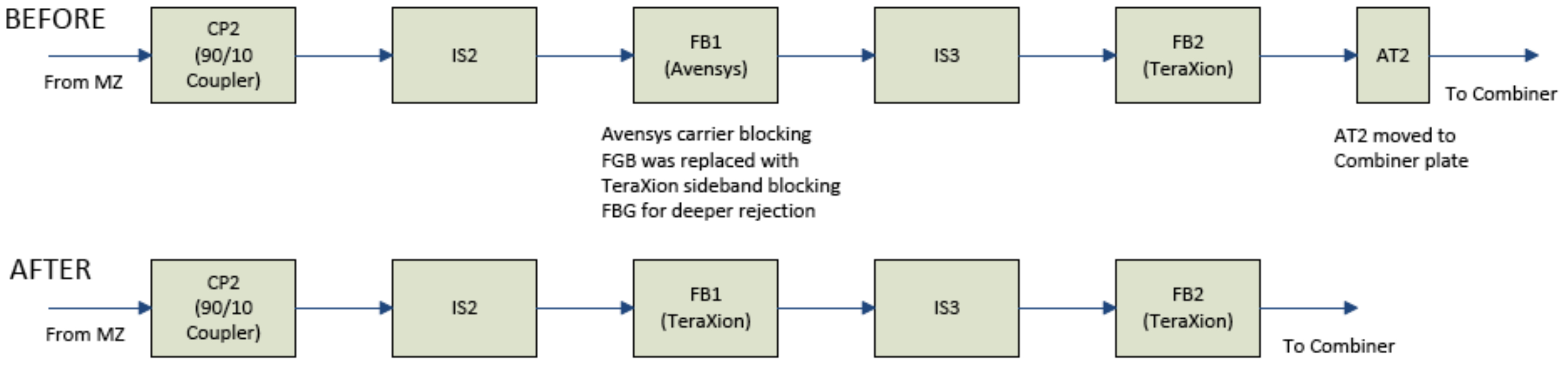


Stack plates, MZ2 on top, MZ1 bottom



Top and bottom views of MZ2 FBG plate assembly

MZ1 & MZ2 FBG Plate Responses



BEFORE

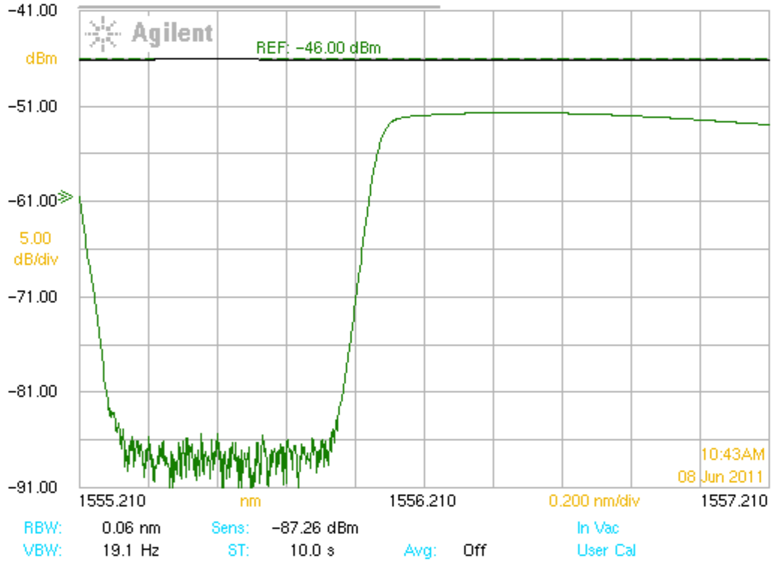
From MZ → CP2 (90/10 Coupler) → IS2 → FB1 (Avensys) → IS3 → FB2 (TeraXion) → AT2 → To Combiner

Avensys carrier blocking FGB was replaced with TeraXion sideband blocking FBG for deeper rejection

AT2 moved to Combiner plate

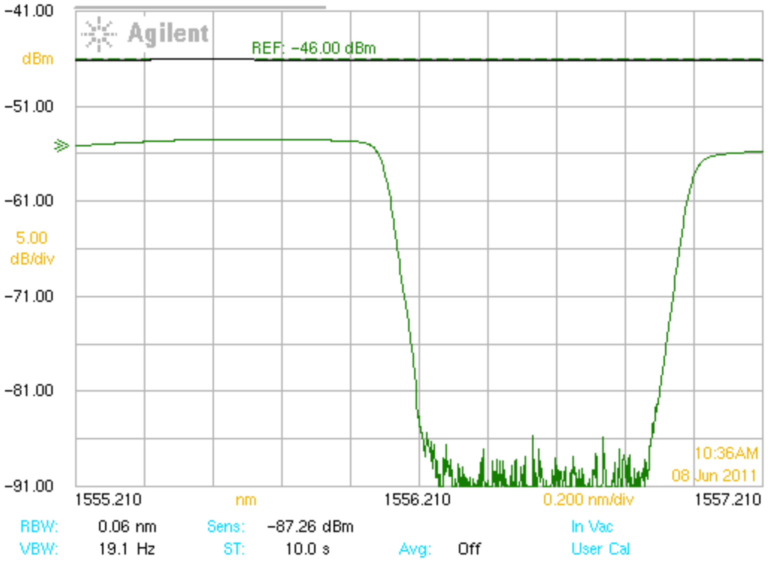
AFTER

From MZ → CP2 (90/10 Coupler) → IS2 → FB1 (TeraXion) → IS3 → FB2 (TeraXion) → To Combiner



RBW: 0.06 nm Sens: -87.26 dBm In Vac
VBW: 19.1 Hz ST: 10.0 s Avg: Off User Cal

MZ1 Plate Response, actual rejection is > 50 dB



RBW: 0.06 nm Sens: -87.26 dBm In Vac
VBW: 19.1 Hz ST: 10.0 s Avg: Off User Cal

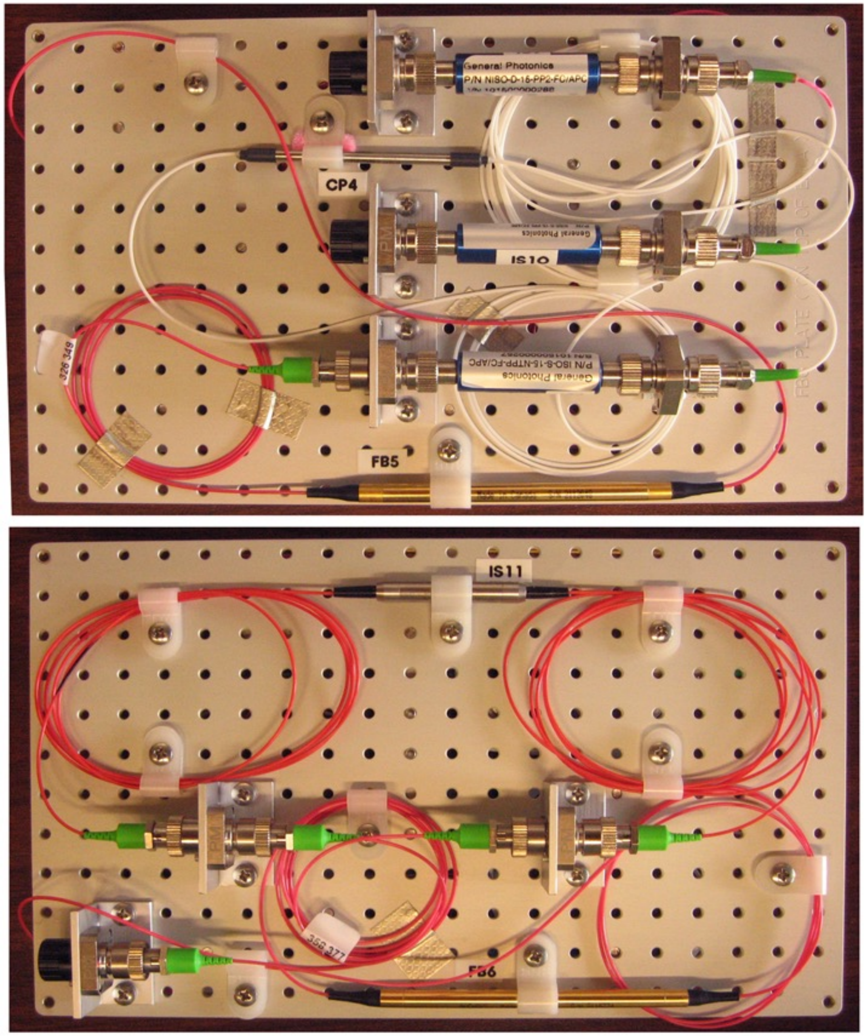
MZ2 Plate Response, actual rejection is > 50 dB

Signal Combiner Plate (x1)

- Relocated carrier rejection Avensys FBG from FBG plate to Signal Combiner plate

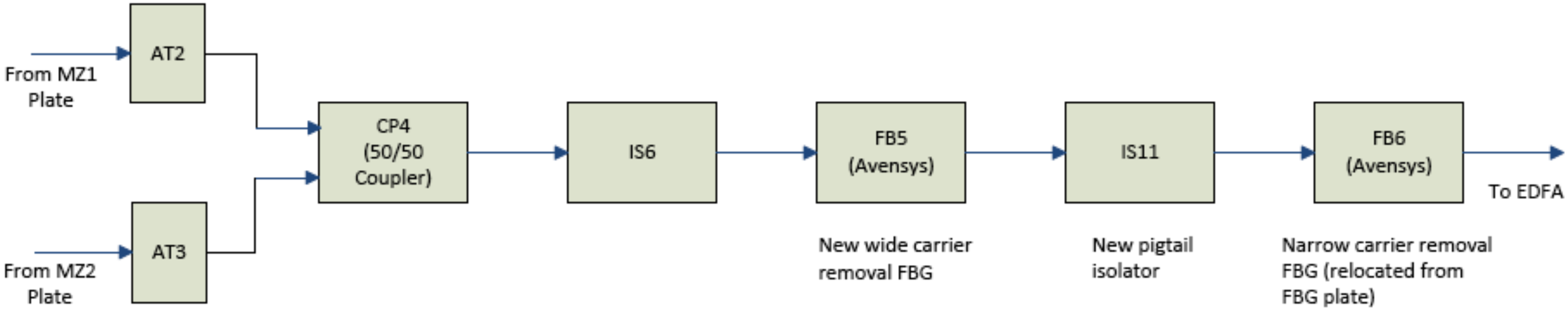
- Used wide and narrow carrier rejection FBG in cascade
  - 2 FBGs provides deeper rejection of laser carrier
  - Wider FBG provides additional rejection of unwanted 1st harmonic

- EDFA stacks on top of Signal Combiner plate



Top and bottom views of Signal Combiner plate

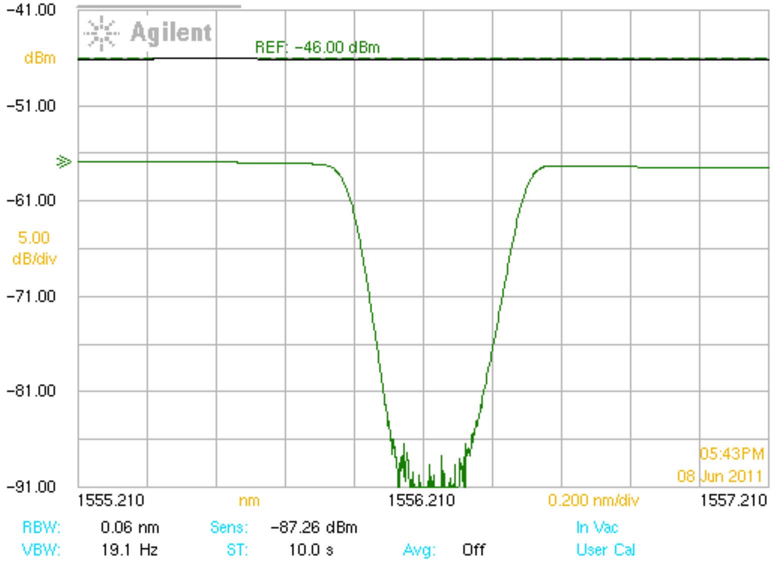
Signal Combiner Plate Responses



New wide carrier removal FBG

New pigtail isolator

Narrow carrier removal FBG (relocated from FBG plate)



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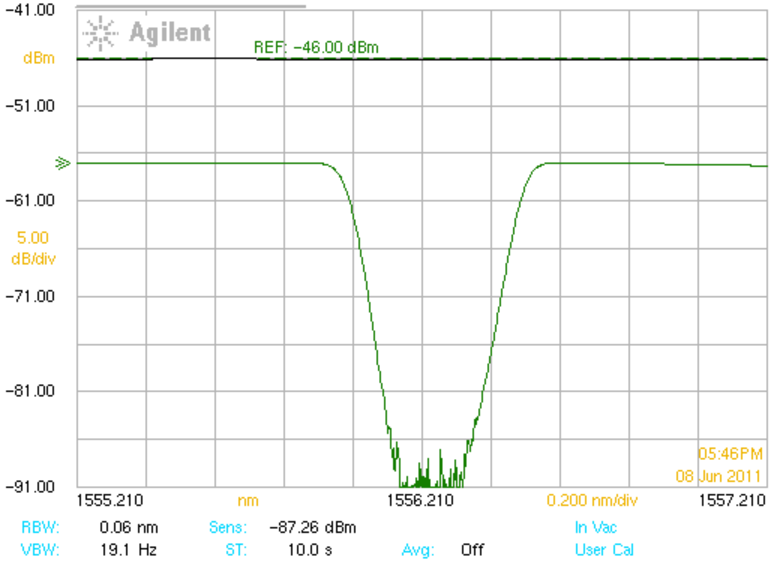
MZ1 input to Combiner output

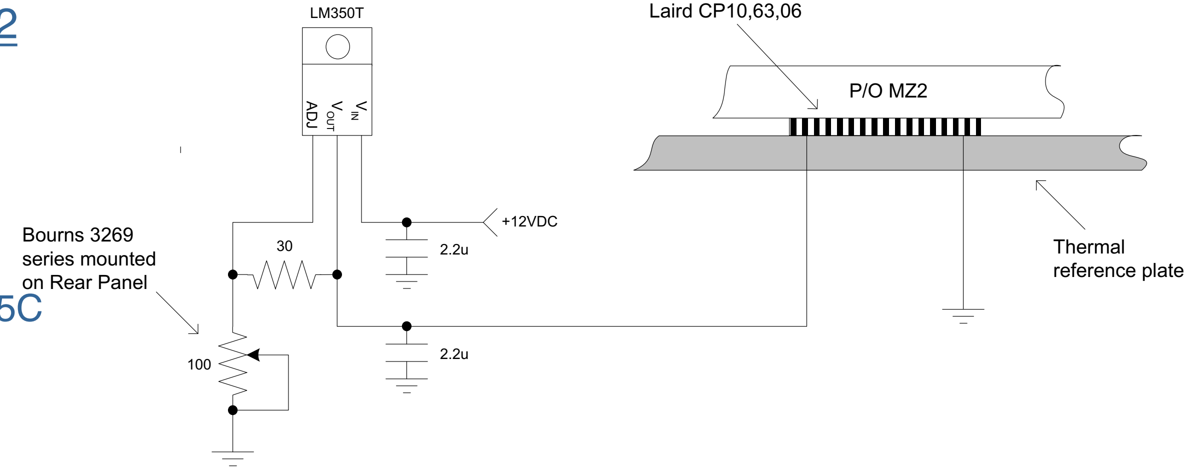


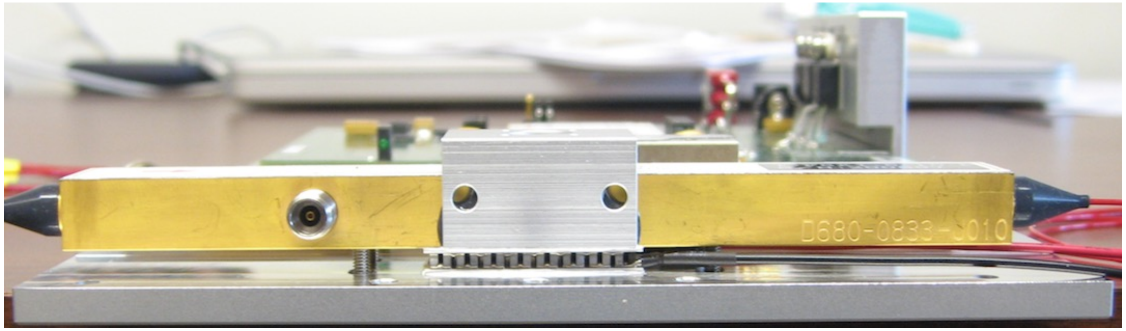
RBW: 0.06 nm Sens: -87.26 dBm In Vac
VBW: 19.1 Hz ST: 10.0 s Avg: Off User Cal

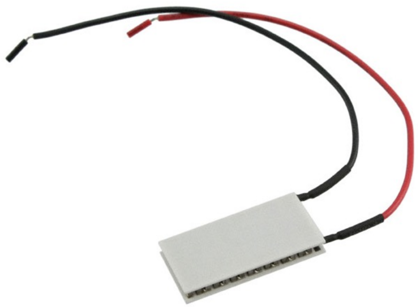
MZ2 input to Combiner output

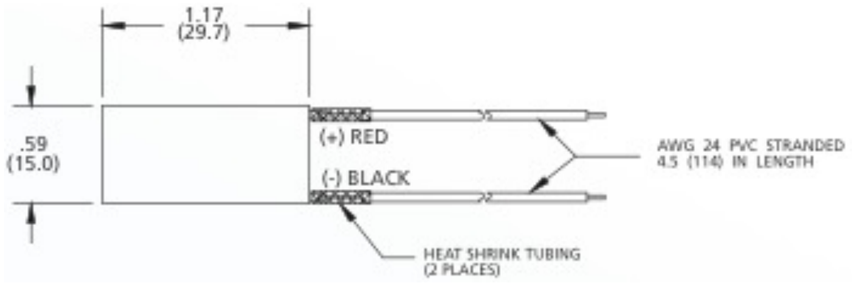
Thermo Electric Cooler beneath MZ2

- Laird CP10,63,06
  - V_{max} = 7.6V (control range 1.2 to 5.6V)
  - I_{max} = 3.0A
  - Q_{max} = 12.7W
- Empirical results with ambient T of 22.5C (RF = 27.75 GHz, IF = 30 GHz)
  - V_{TEC} = 1.5V, T_{MZ2} = 26.5C
  - V_{TEC} = 2.2V, T_{MZ2} = 20C
  - V_{TEC} = 2.4V, T_{MZ2} = 18C
  - V_{TEC} = 2.6V, T_{MZ2} = 17C
- MZ2 temperature varies by several degrees C with different RF and IF frequencies









Rear Panel


J1
OPTICAL OUT1
J2
OPTICAL OUT2
J3
MZ1 TP
J4
MZ2 TP
DANGER
LASER LIGHT
Do NOT view the end of working fibers
LASER CTRL
J8
J7
192.168.0.150
L-com
Cat 5e
E1
GND
TEC CTRL
7.5 dBm @ 25 GHz
J5
RF IN
J6
IF IN
-7.5 dBm @ 3 GHz
S1
EDFA ENABLE
OFF--ON
S2
I
O
90-240 VAC
J10

MZM LORTM Upgrade

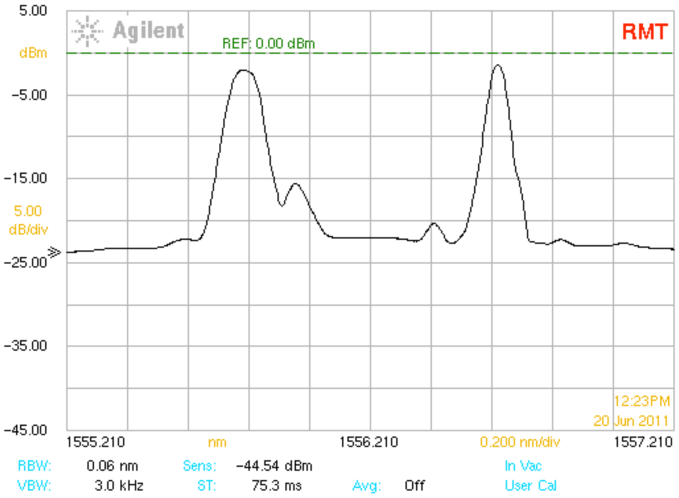
2 Modes of Operation

– Normal Mode: Ports A & B of MZ2 in null-bias mode, port C of MZ1 in full-bias mode

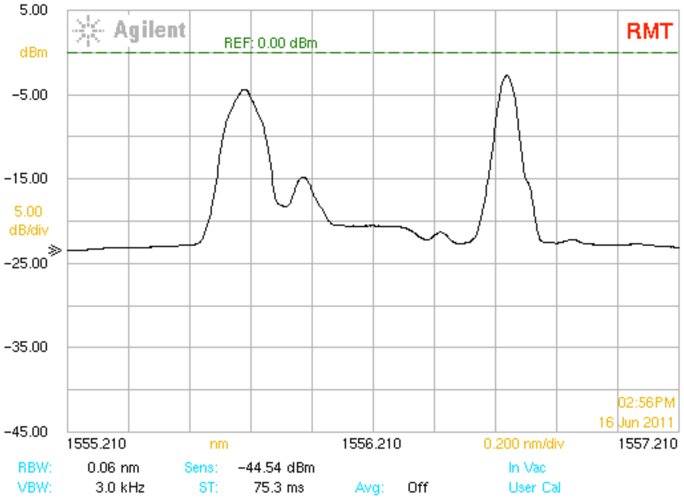
- Produces 2 LSB and 1 USB optical tones (3 tones total)
- WCA lock proven to be reliable for all bands (1 & 5 excluded) at EA-FEIC in 2011 March
- Absolute phase varies strongly as a function of environmental temperature (discovered in March at EA-FEIC)
- Phase stability performance worsens with higher MZ2 temperature, mitigated with TE cooler

– AB-Mode: Ports A & B of MZ1 in full-bias mode, port C of MZ1 in full-bias mode

- Produces 3 LSB and 1 USB optical tones (4 tones total)
- WCA lock reliability not proven
- Phase stability does not worsen with higher MZ2 temperature
- Efficiency (PM RF output vs optical input) is very similar to "normal mode"



Normal Mode – 100/106 GHz

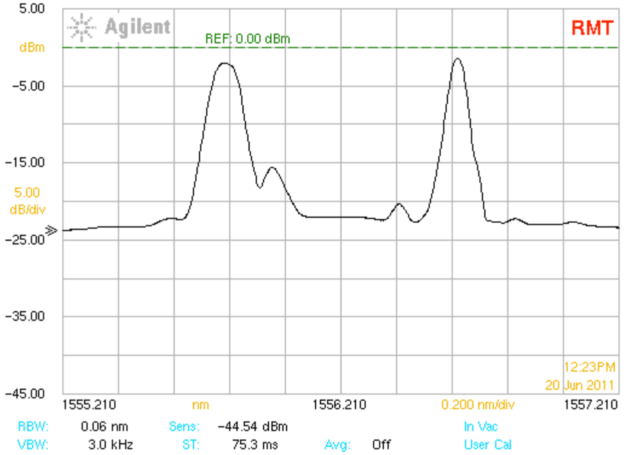


AB-Mode – 100/106 GHz

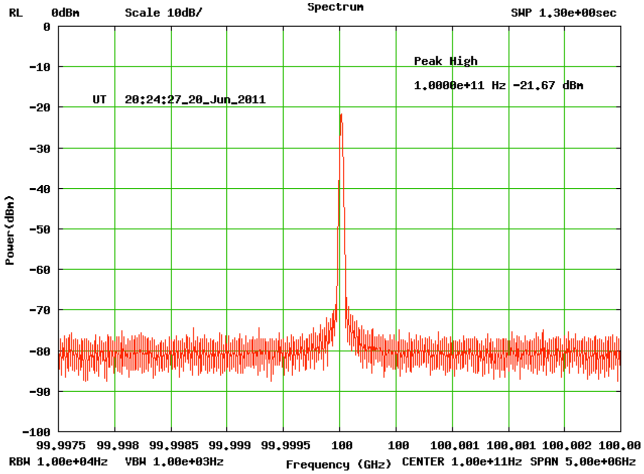
MZM LORTM Upgrade

Normal-Mode

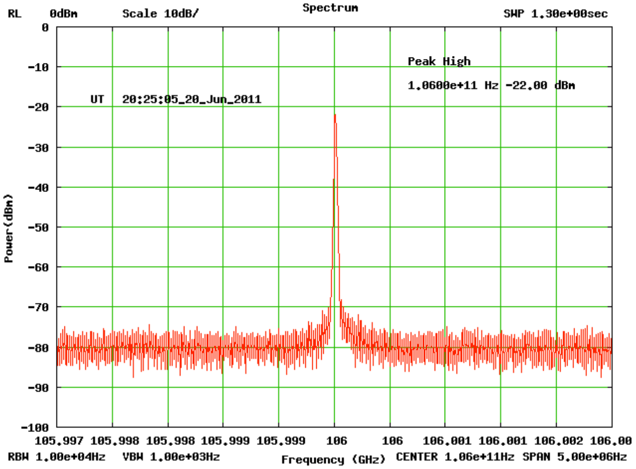
- MZ2 ports A and B in null-bias mode
- Desired tones, LO = 100 GHz, Test Signal = 106 GHz
  - CVR Synthesizer J5 = 25.75 GHz @ +7.5 dBm
  - IF Synthesizer J6 = 3.0 GHz @ -5.5 / -7.5 dBm



Optical output spectrum



100 GHz RF output spectrum from NTT photomixer



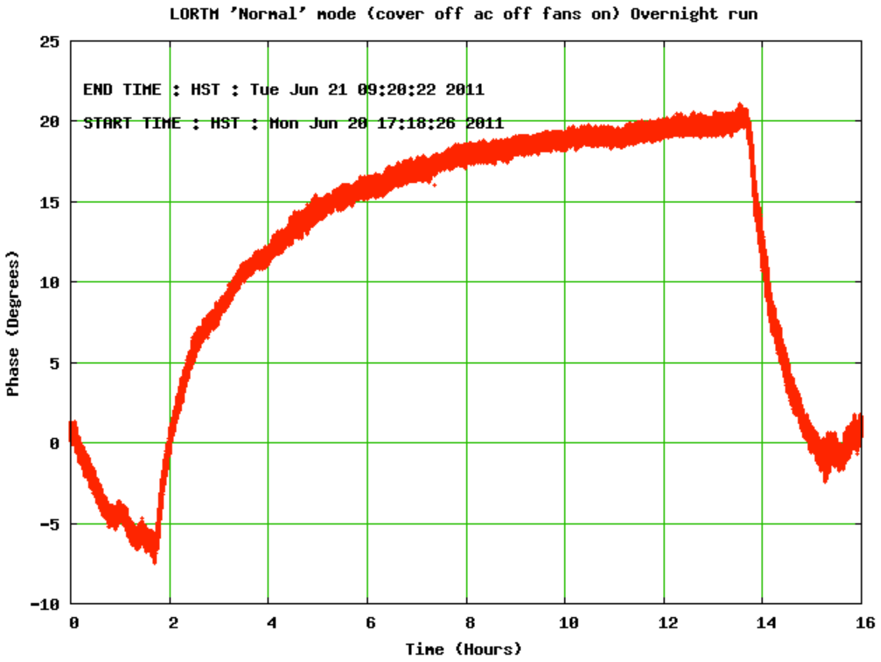
106 GHz RF output spectrum from NTT photomixer

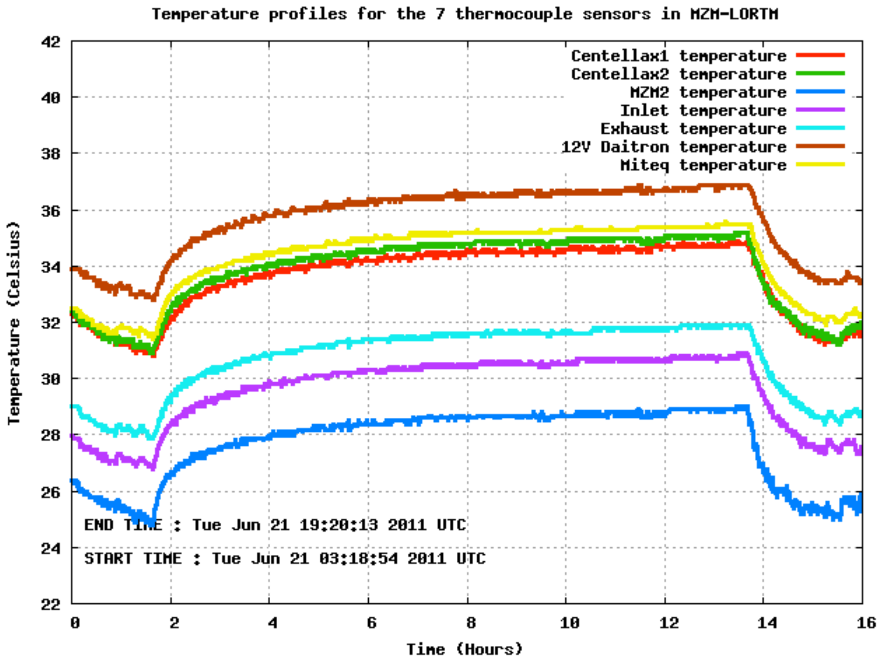
Note the power disparity of only 0.3 dB between the 100 GHz and 106 GHz tones. The WCAs should be able to lock to these 2 signals.

Normal-Mode, 16-hour Run – prior to TEC, top cover off, external fans on

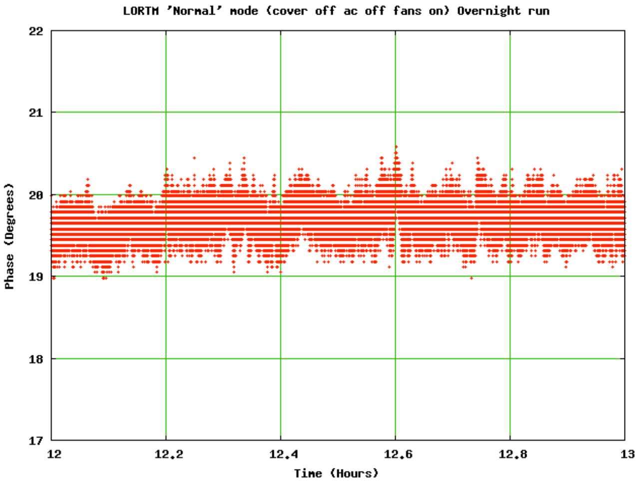
- Prior to installation of TEC, T_{MZ2} = ~26C starting temperature, ~30C ending
- Used external forced air cooling to reduce MZ2 temperature, note the low 25 to 29C “Free – Optics” temperature

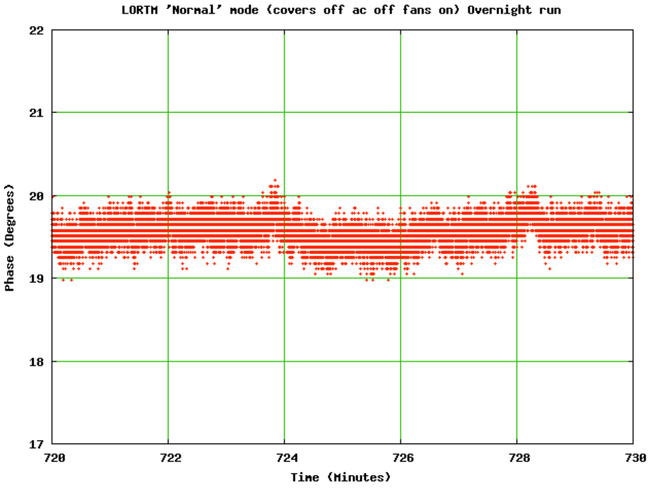
- Lab AC off at 7PM, back on at 7AM
- Intake air temperature change of 25 to 31C (delta of 6) results in -6 to +20 (delta of 26) degrees in phase
- 4.3 degrees phase per 1.0 degree C in temperature
- Estimate that 90% of 4.3 degrees/C is from LORTM unit, independent tests show bench test setup not very sensitive to ambient air temperature





Normal-Mode, 16-hour Run – prior to TEC, top cover off, external fans on (cont'd)


LORTM 'Normal' mode (cover off ac off fans on) Overnight run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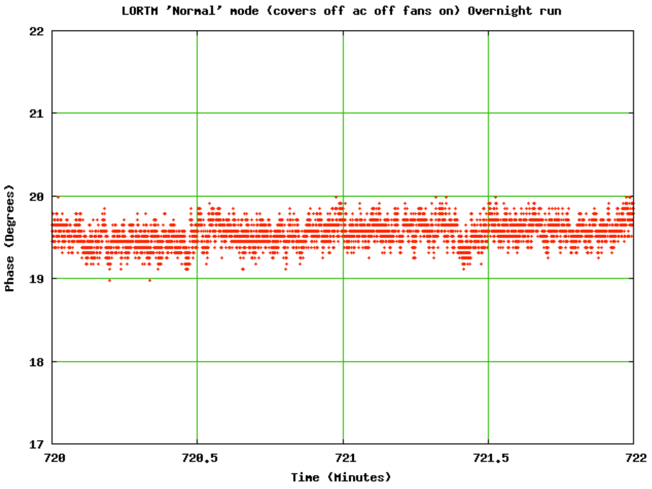
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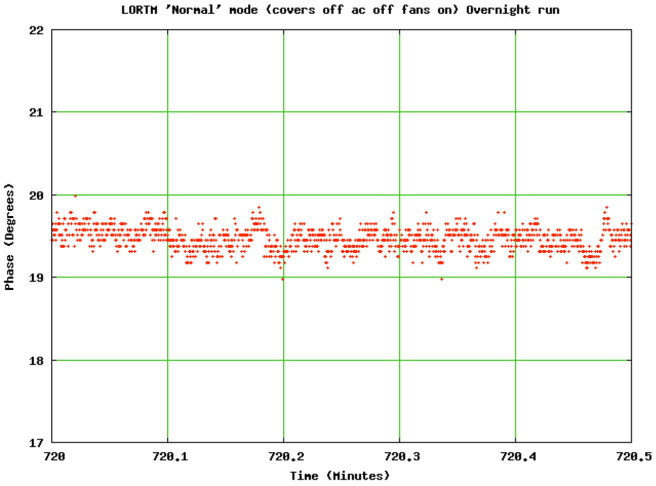
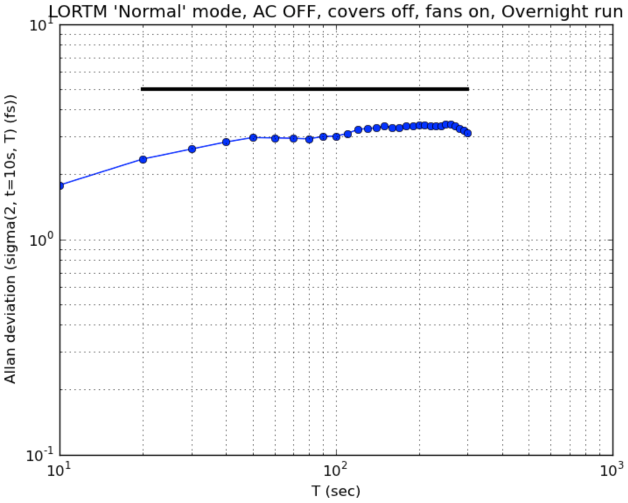

LORTM 'Normal' mode (covers off ac off fans on) Overnight run


LORTM 'Normal' mode, AC OFF, covers off, fans on, Overnight run

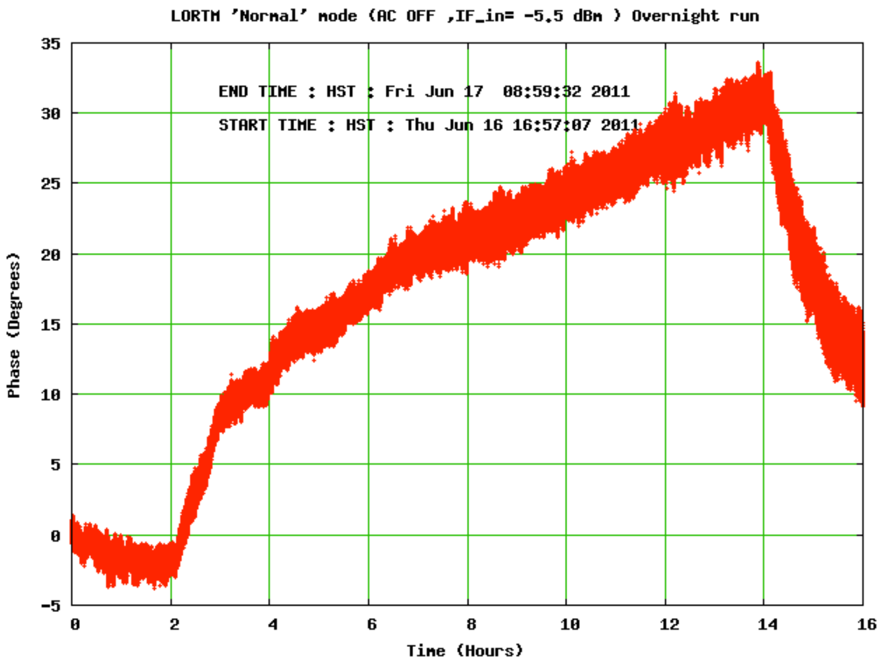
Note the good Allan Deviation performance (100, 106 GHz):

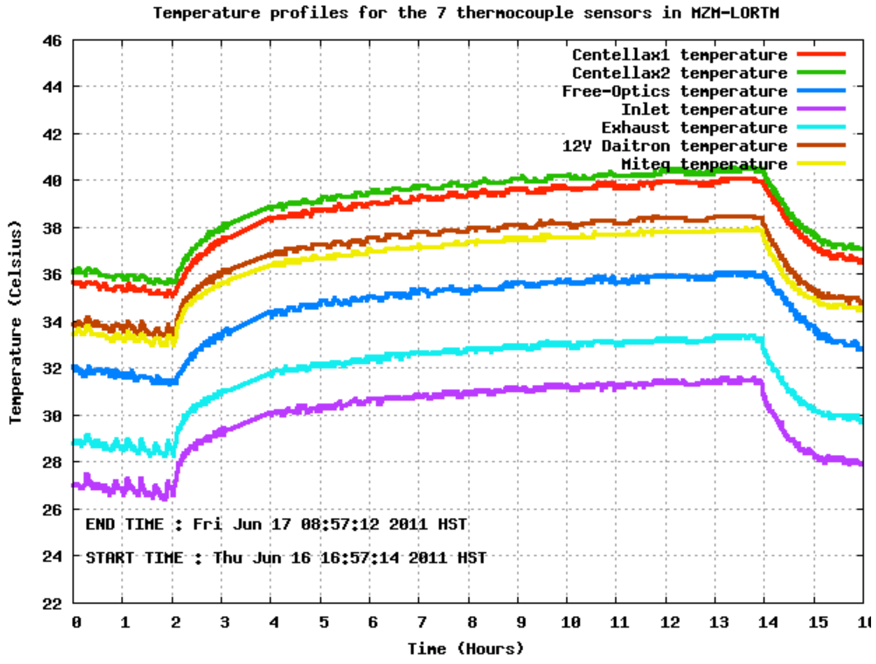
- 1.8 fsec at 10 sec
- 3.0 fsec at 100 sec
- 3.0 fsec at 300 sec

Can't run without top cover (defeats thermal isolation)

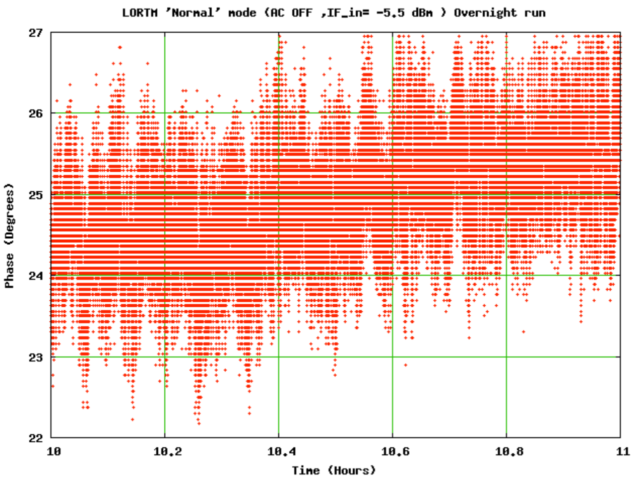
Normal-Mode, 16-hour Run – prior to TEC, top cover on

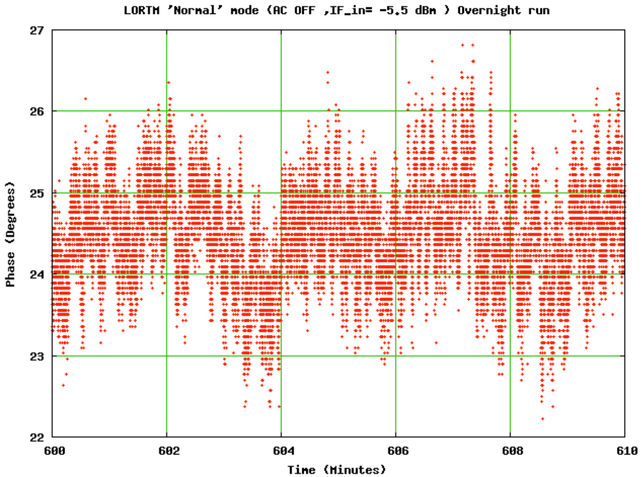
- Prior to installation of TEC, T_{MZ2} = ~33C starting temperature, ~37C ending
  - High MZ2 temperature is due to lack of convection cooling
  - Phase stability performance worsens as MZ2 temperature increases
- Lab AC off at 7PM, back on at 7AM
  - Intake air temperature change of 27 to 31.5C (delta of 4.5) results in -2 to +31 (delta of 33) degrees in phase
  - 7.3 degrees phase per 1.0 degree C in temperature

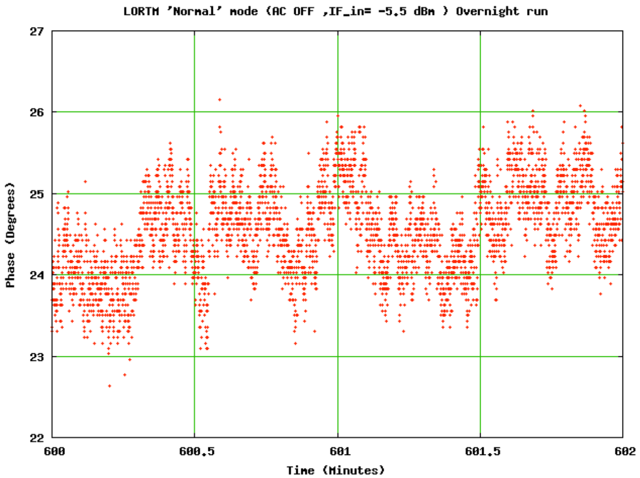


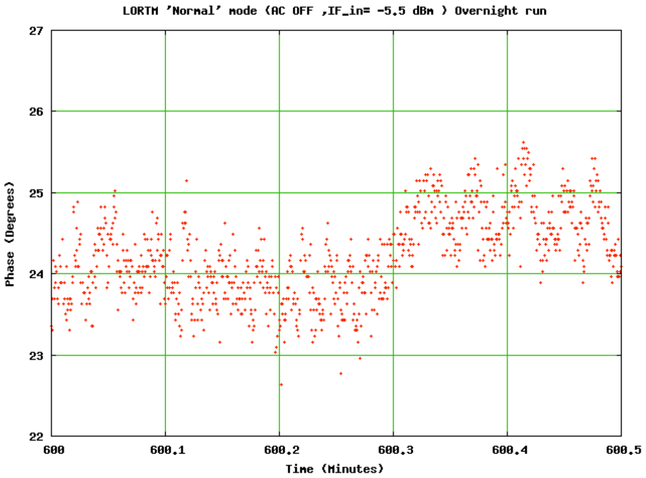


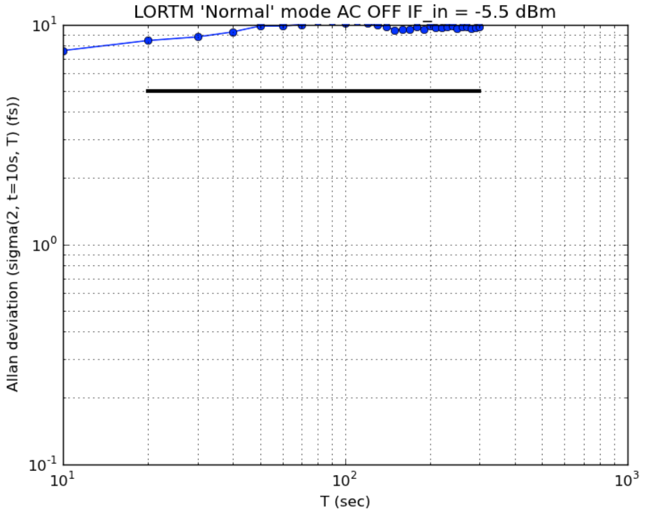
Normal-Mode, 16-hour Run – prior to TEC, top cover on (cont'd)











Note the extremely poor Allan Deviation performance (100, 106 GHz):

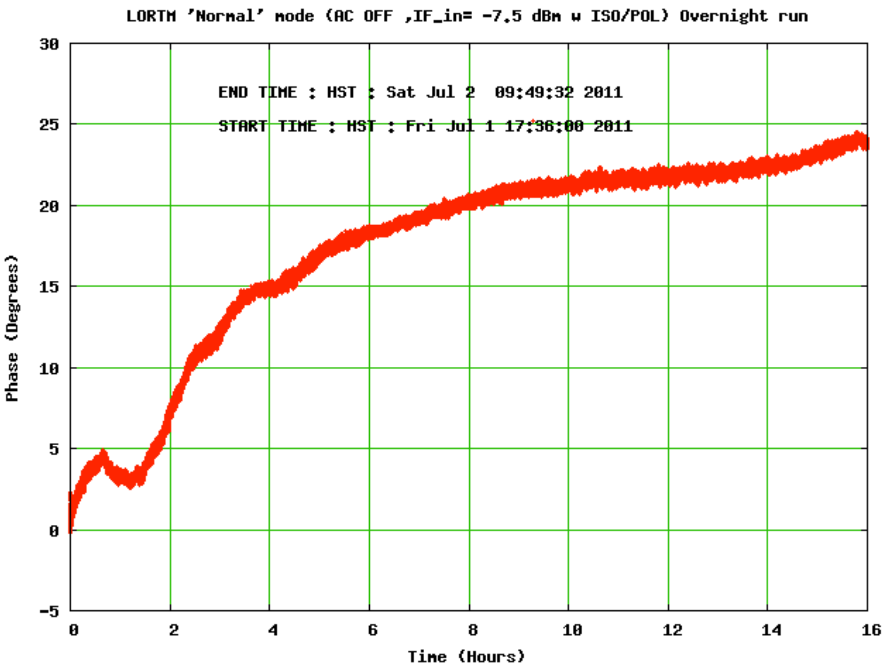
- 8.3 fsec at 10 sec
- 10.0 fsec @ 100 sec
- 10.0 fsec at 300 sec

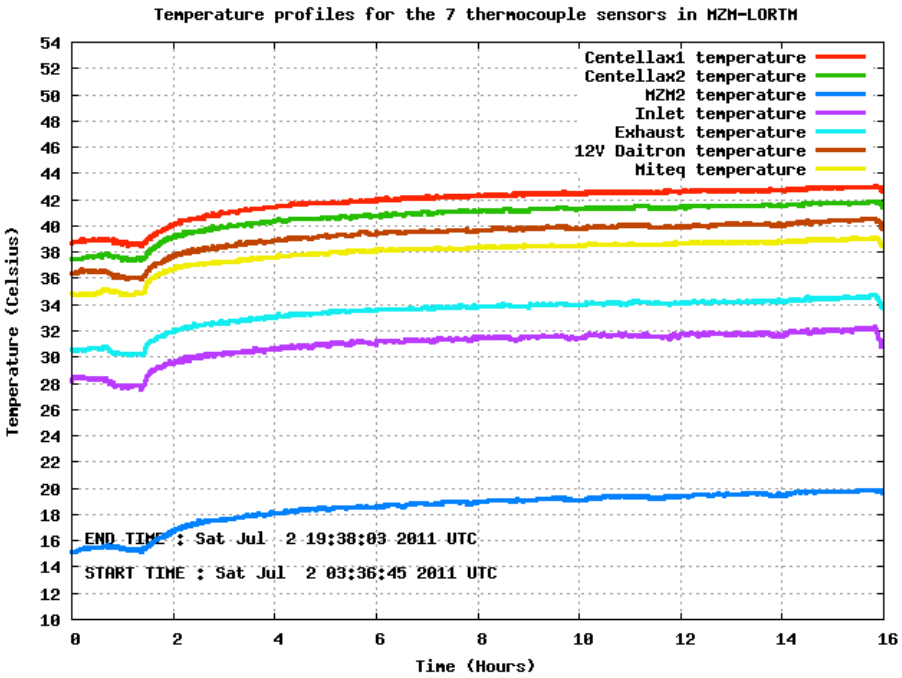
Installation of top cover produces warm (33 – 37C) MZ2 temperatures → degraded phase stability performance

Normal-Mode, 16-hour Run – with TEC, top cover on

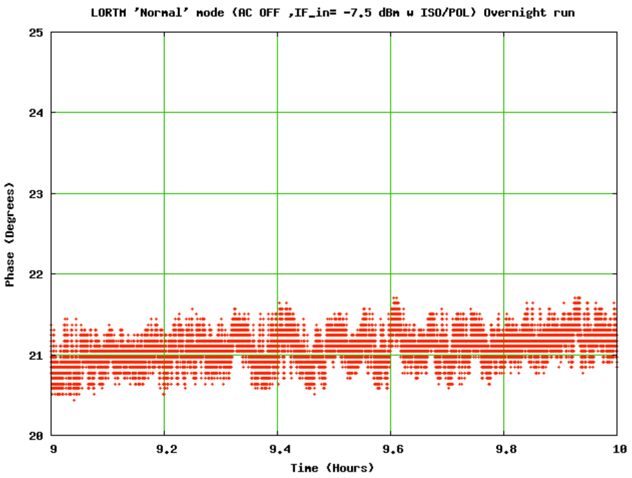
- V_{TEC} = 2.8V, T_{MZ2} = 15C starting temperature, 20C ending
  - Note drastic improvement of phase stability with MZ2 cooled
  - Phase stability is no longer strongly dependent on MZ2 temperature

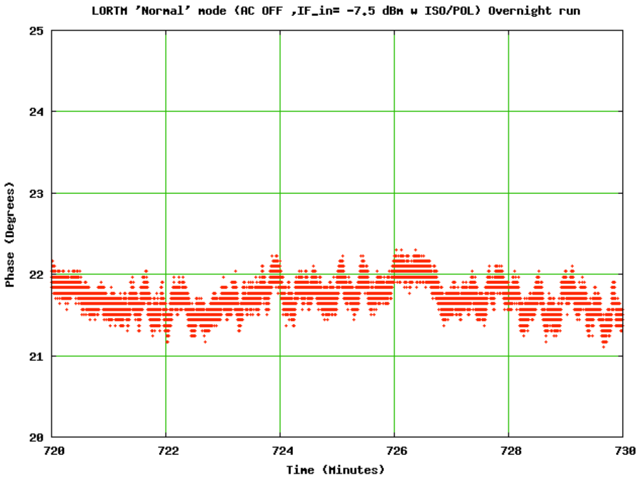
- Lab AC off at 7PM, back on at 7AM
  - Intake air temperature change of 28 to 32C (delta of 4.0) results in 3 to 23 (delta of 20) degrees in phase
  - 5.0 degrees phase per 1.0 degree C in temperature

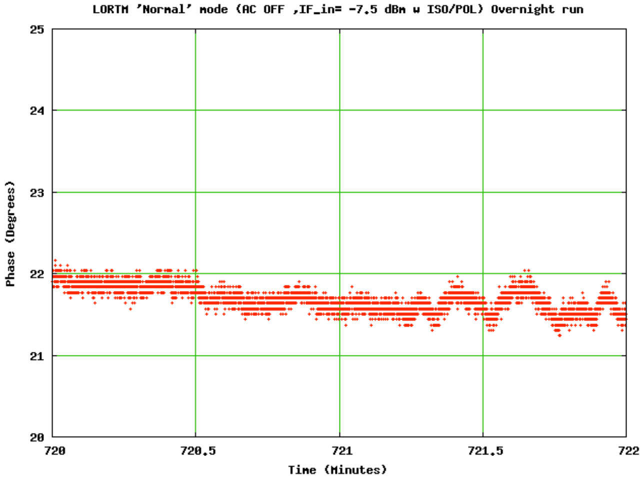


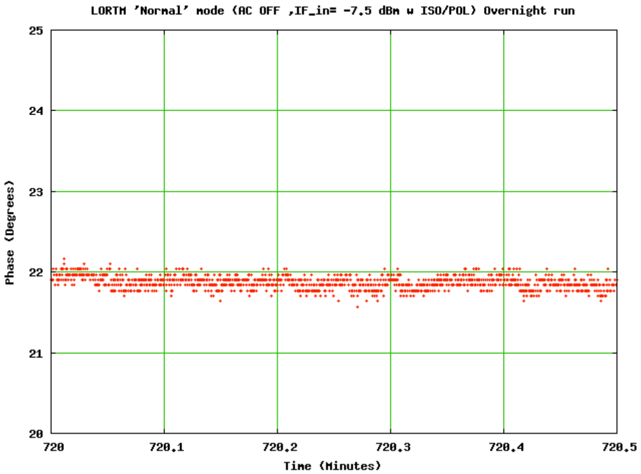


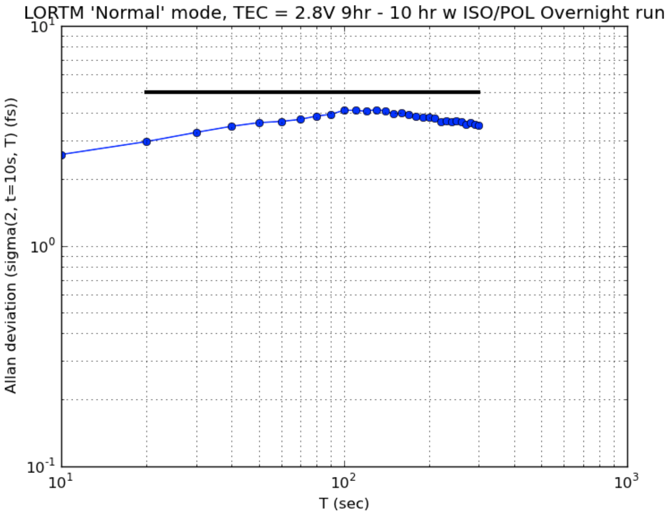
Normal-Mode, 16-hour Run – with TEC, top cover on (cont'd)











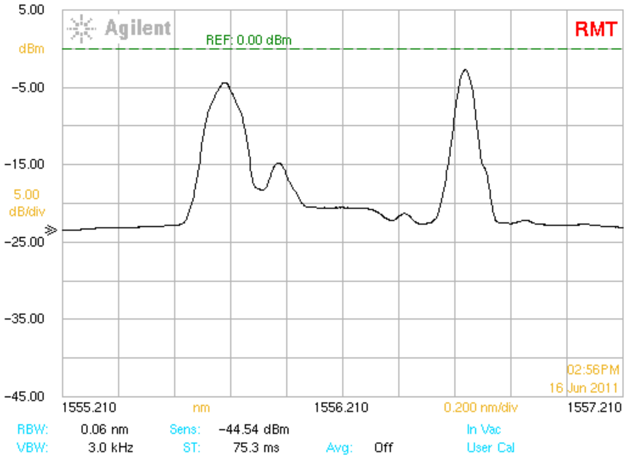
Performance is much improved

- 2.4 fsec at 10 sec
- 4.0 fsec at 100 sec
- 3.3 fsec at 300 sec

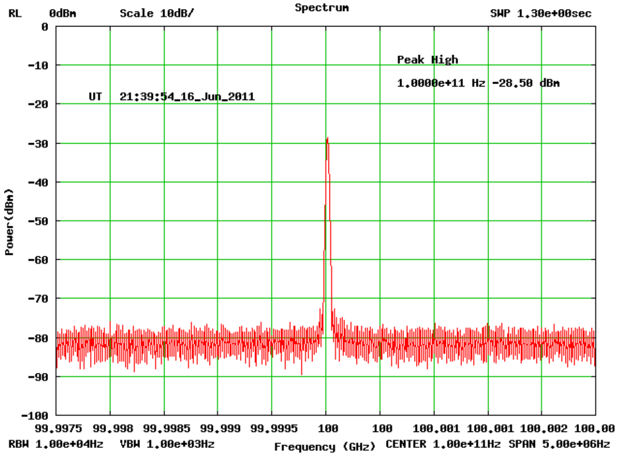
AB-Mode

- MZ2 ports A and B in full-bias mode

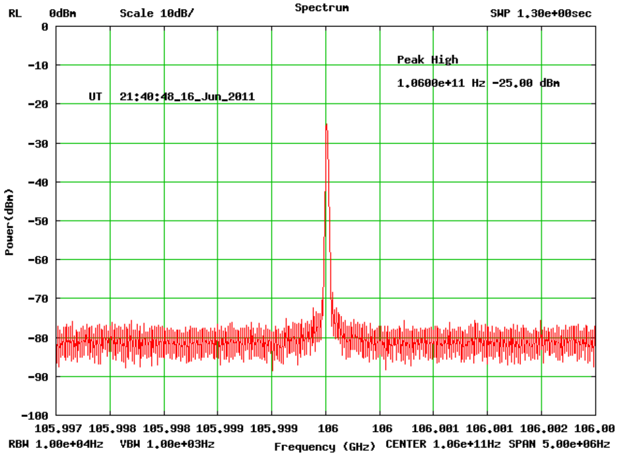
- Desired tones, LO = 100 GHz, Test Signal = 106 GHz
- CVR Synthesizer J5 = 26.5 GHz @ +7.5 dBm
- IF Synthesizer J6 = 3.0 GHz @ -5.5 dBm



Optical output spectrum



100 GHz RF output spectrum from NTT photomixer



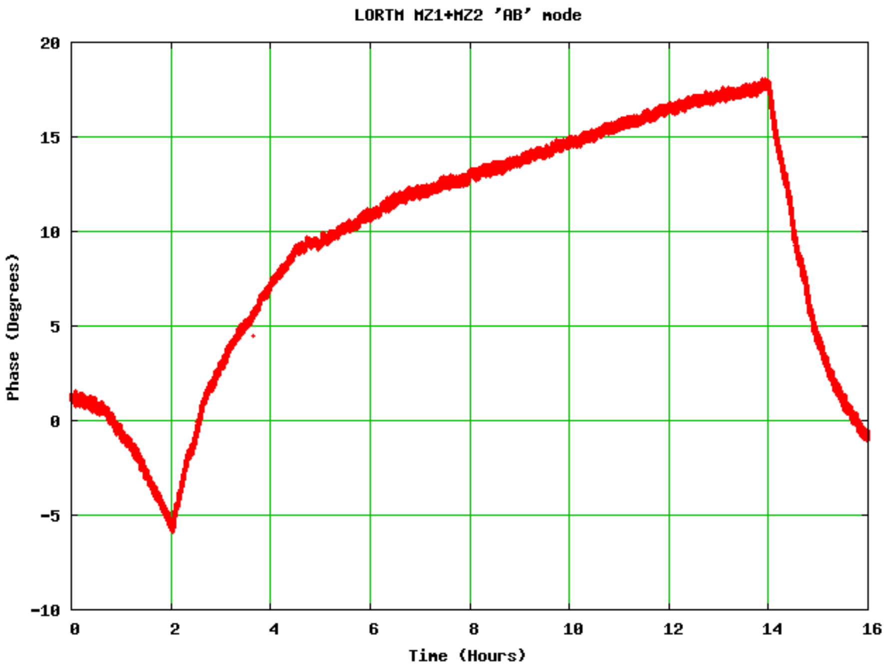
106 GHz RF output spectrum from NTT photomixer

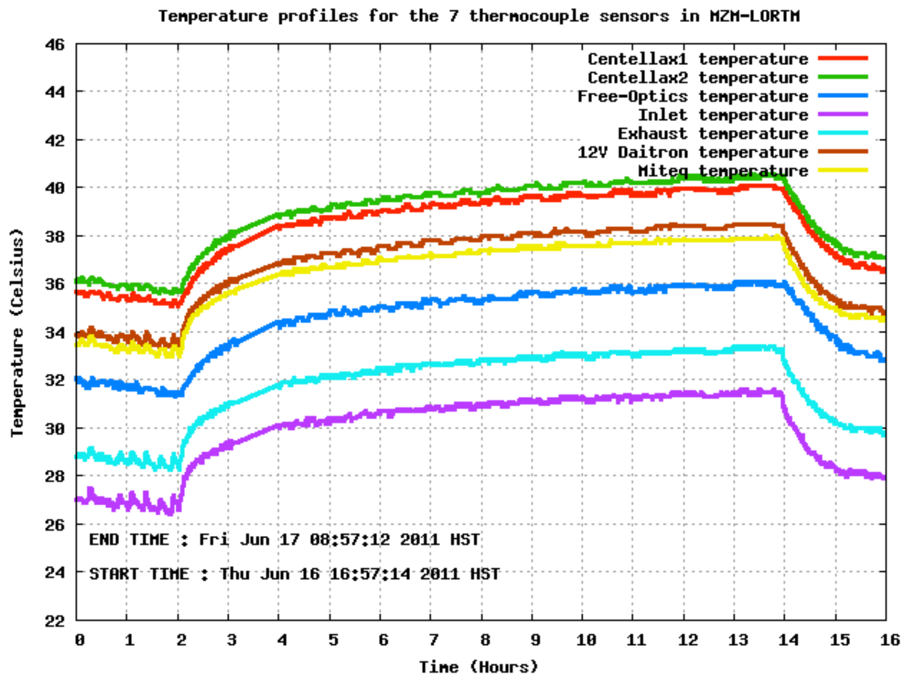
Note the power disparity of only 3.5 dB between the 100 GHz and 106 GHz tones. The WCAs should be able to lock to these 2 signals.

AB-Mode, 16-hour Run - prior to TEC, top cover on

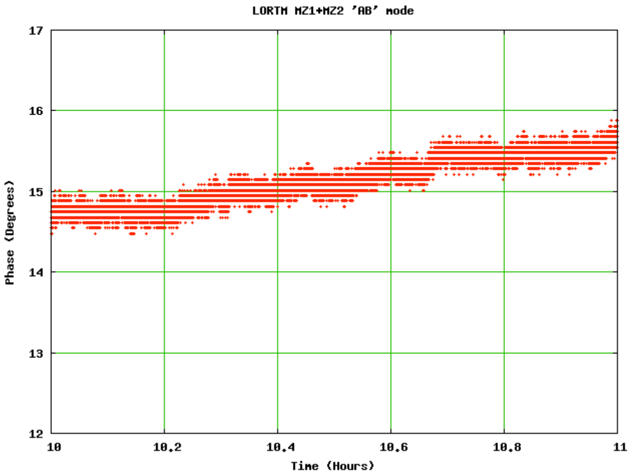
- Lab AC off at 7PM, back on at 7AM
- Unit sealed with all covers on

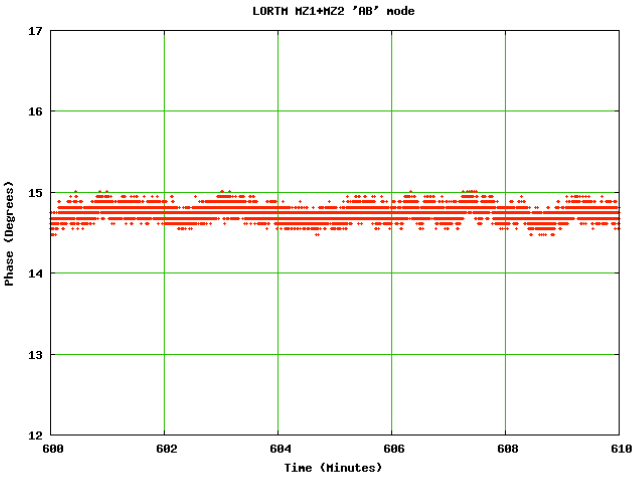
- Note the very strong relationship between temperature and phase
- Intake air temperature change of 27 to 31.5C (delta of 4.5) results in -6 to +17.5 (delta of 23.5) degrees in phase
- 5.2 degrees phase per 1.0 degree C in temperature

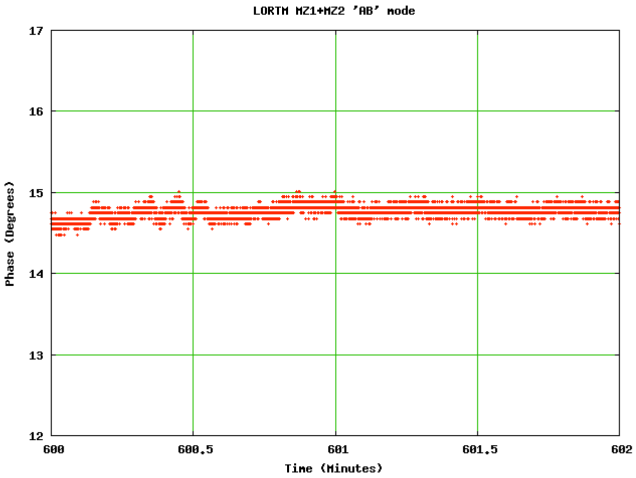


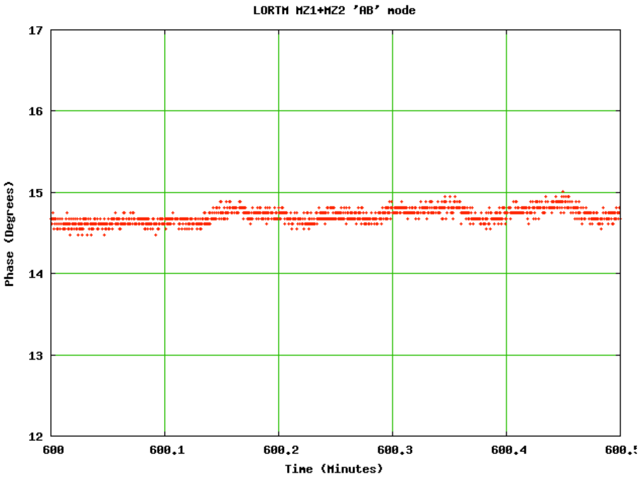


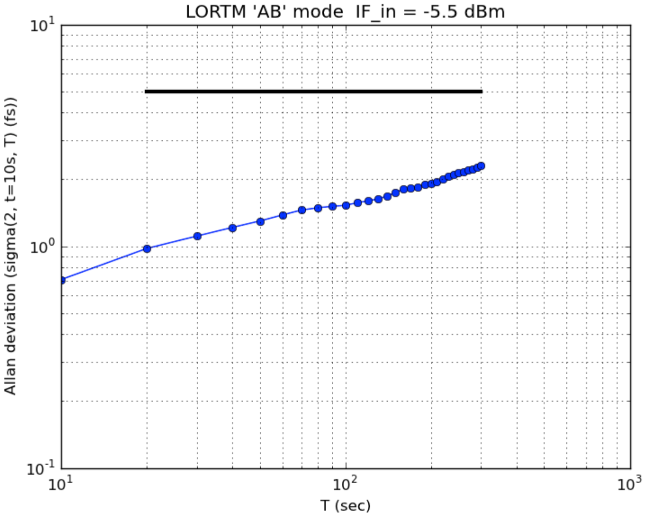
AB-Mode, 16-hour Run - prior to TEC, top cover on (cont'd)











Note the excellent Allan Deviation performance (100, 106 GHz):

- 0.7 fsec at 10 sec
- 1.4 fsec at 100 sec
- 2.2 fsec at 300 sec

Performance is independent of MZ2 temperature

AB-Mode WCA Lock Issues

- Optical LSB consists of 3 optical tones which beats against single USB tone to produce 3 RF output tones from photomixer
  - LO WCA and TS WCA must lock reliably to desired 2 tones and ignore 3rd tone
  - If one of the 3 tones is significantly larger (> 4 or 5 dB) than the other two then it will prevent lock to the weaker tone

- Band 2 will definitely have a problem to lock at an IF center frequency of 8 GHz
  - Will be OK if choose 6 GHz IF
  - 6/(2*N) = 3 GHz which is within our IF range

- Band 7 will likely be problematic
  - May be able to lock WCAs by fine adjusting the IF power level to the LORTM

- Band 8 may be problematic
  - May be able to lock WCAs by fine adjusting the IF power level to the LORTM

BAND	IF RANGE (GHz)	IF CENTER (GHz)	N	IF/(2*N) (GHz)	F_{LOW} POWER	F_{CENTER} POWER	F_{HIGH} POWER	DELTA POWER	
								CENTER - LOW	CENTER - HIGH
1	4 to 12	8	1	4	NOT	SUPPORTED			
2	4 to 12	8	1	4	98.0 -39.0	106.0 -17.5	114.0 -41.5	21.5	24.0
3	4 to 8	6	1	3	100.0 -25.3	106.0 -21.8	112.0 -30.8	3.5	9.0
4	4 to 8	6	2	1.5	103.0 -27.0	106.0 -25.3	109.0 -23.5	1.7	-1.8
5	4 to 8	6	6	0.5	NOT	SUPPORTED			
6	6 to 10	8	3	1.333	103.3 -26.6	106.0 -24.2	108.7 -24.3	2.4	0.1
7	4 to 8	6	3	1	104.0 -25.5	106.0 -34.0	108.0 -26.7	-8.5	-7.3
8	4 to 8	6	6	0.5	105.0 -22.0	106.0 -27.0	107.0 -26.2	-5.0	-0.8
9	4 to 12	8	9	0.444	105.11 -21.8	106.00 -25.5	106.89 -25.2	-3.7	-0.3
10	4 to 12	8	9	0.444	105.11 -21.8	106.00 -25.5	106.89 -25.2	-3.7	-0.3

Summary of Allan Deviation Performances in Hilo Lab (100 / 106 GHz)

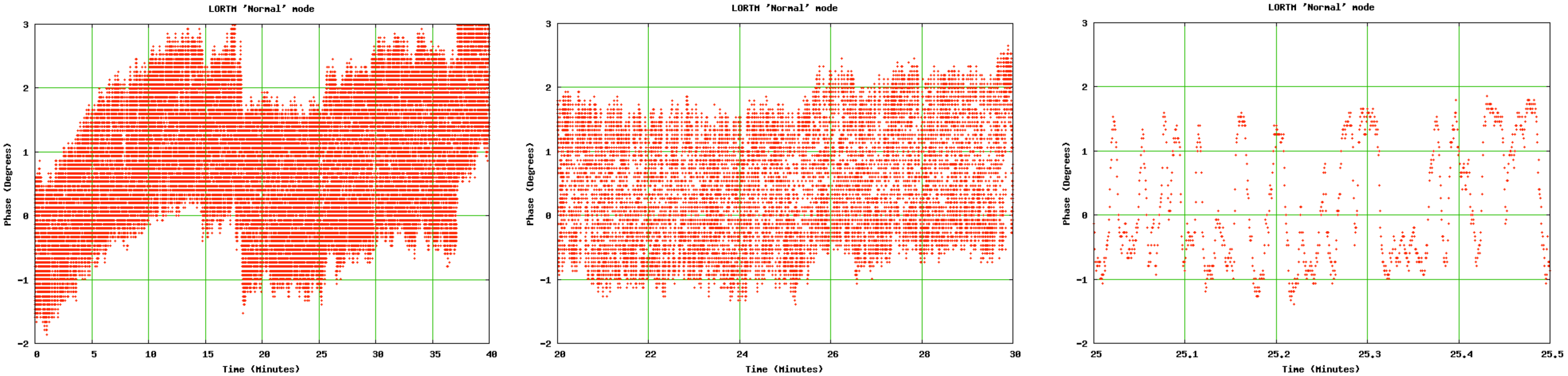
– Can only perform Allan Deviation tests at night when lab AC is off (due to compressor cycling on/off)

- Downside of AC off is that room temperature progressively warms from ~22 to ~26C due to accumulated heat
- Optimal DC biases for MZs change with environmental temperature
- RF gains for both Centellax and Miteq power amplifiers reduce with increasing temperature

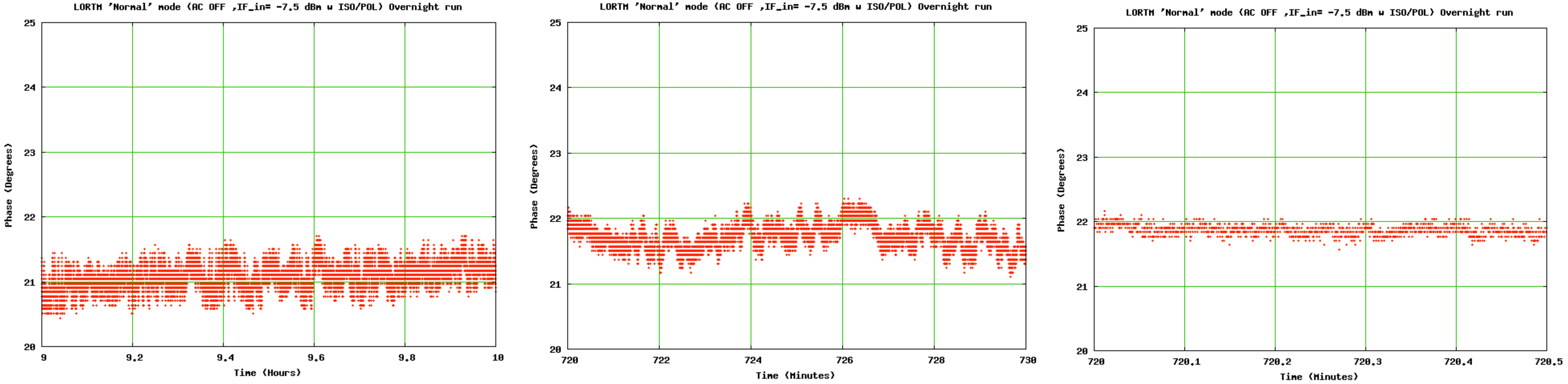
Mode	Top Cover	V_{TEC}	Intake Air Temp		T_{MZ2}		T_{CENT1}		Allan Deviation (fsec)			Δphase/ΔC
			Start	End	Start	End	Start	End	10 sec	100 sec	300 sec	
Normal	Off, aux cooling	N/A	27.0	31.0	~27	~31	31.0	35.0	1.8	3.0	3.0	4.3
Normal	On	N/A	27.0	31.5	~33	~37	35.0	40.0	8.3	10.0	10.0	7.3
Normal	On	2.8V	28.0	32.0	15.0	20.0	38.5	43.0	2.4	4.0	3.3	5.0
AB	On	N/A	27.0	31.5	~32.5	~37	35.5	40.0	0.7	1.4	2.2	5.2

Comparison of Phase Performance (before/after rework)

- Before rework, 27 April 2011



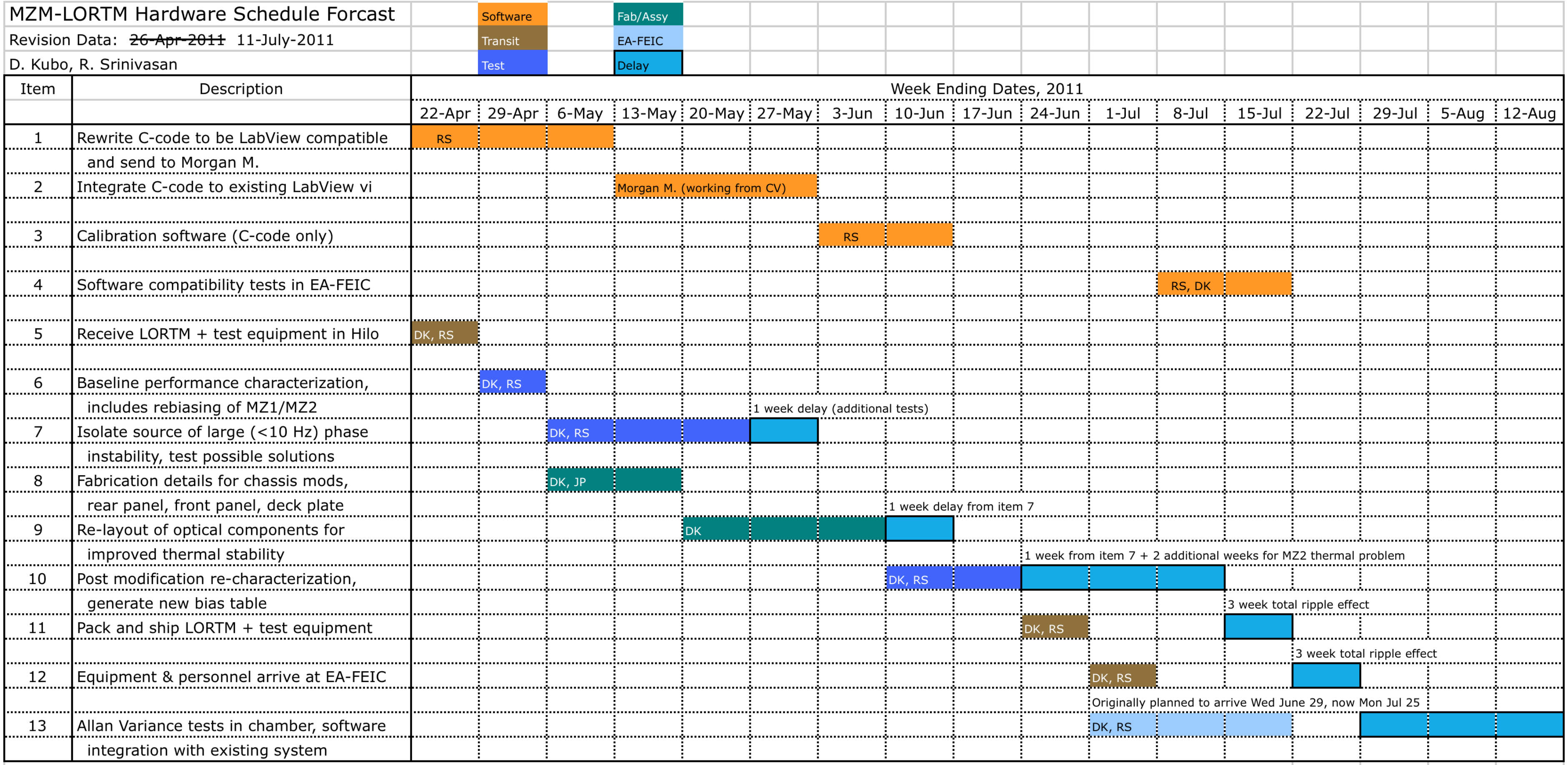
- After rework, 2 July 2011



Mechanical

- EMI chassis
  - 19.0 x 22.0 x 8.75 inches (W x D x H), depth excludes front panel handles and rear panel connectors
  - Rack mountable (front panel mounting holes made compatible with TeraXion LORTM)
  - 47 LBS (21.4 kg)
- Total AC power consumption 131 Watts (fully active with TE cooler enabled)

MZM LORTM Upgrade



MZM-LORTM Hardware Schedule Forcast
Revision Data: ~~26-Apr-2011~~ 11-July-2011
D. Kubo, R. Srinivasan

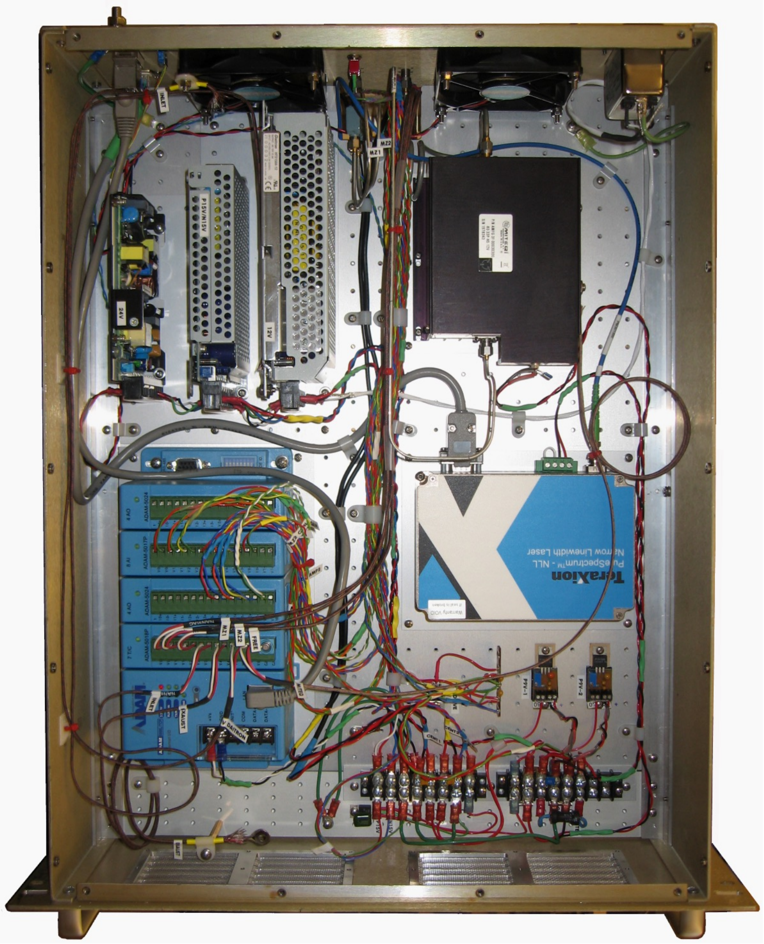
🟧 Software
🟫 Transit
🟦 Test
🟩 Fab/Assy
░ EA-FEIC
▨ Delay

Item	Description	Week Ending Dates, 2011																
		22-Apr	29-Apr	6-May	13-May	20-May	27-May	3-Jun	10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug
1	Rewrite C-code to be LabView compatible	🟧 RS	🟧	🟧														
	and send to Morgan M.																	
2	Integrate C-code to existing LabView vi				🟧 Morgan M. (working from CV)	🟧	🟧											
3	Calibration software (C-code only)							🟧 RS	🟧									
4	Software compatibility tests in EA-FEIC												🟧 RS, DK	🟧				
5	Receive LORTM + test equipment in Hilo	🟫 DK, RS																
6	Baseline performance characterization,		🟦 DK, RS															
	includes rebiasing of MZ1/MZ2						1 week delay (additional tests)											
7	Isolate source of large (<10 Hz) phase			🟦 DK, RS	🟦	🟦	▨											
	instability, test possible solutions																	
8	Fabrication details for chassis mods,			🟩 DK, JP	🟩													
	rear panel, front panel, deck plate								1 week delay from item 7									
9	Re-layout of optical components for					🟩 DK	🟩	🟩	▨									
	improved thermal stability										1 week from item 7 + 2 additional weeks for MZ2 thermal problem							
10	Post modification re-characterization,								🟦 DK, RS	🟦	▨	▨	▨					
	generate new bias table													3 week total ripple effect				
11	Pack and ship LORTM + test equipment										🟫 DK, RS			▨				
															3 week total ripple effect			
12	Equipment & personnel arrive at EA-FEIC											🟫 DK, RS			▨			
												Originally planned to arrive Wed June 29, now Mon Jul 25						
13	Allan Variance tests in chamber, software											░ DK, RS	░	░		▨	▨	▨
	integration with existing system																	

General Description: The MZM-LORTM is presently producing large phase fluctuations between the optical reference signals for the LO and Signal source. At present the unit cannot pass the 5 fsec phase stability requirement (10 to 300 second). Our goal, therefore, is to identify the cause of the large phase fluctuation and implement an appropriate hardware solution. As a secondary but non-trivial issue, the MZM-LORTM phase stability had indications of being very sensitive to minute changes in ambient air temperature. We will address this issue by re-packaging the optical hardware to be thermally insulated from the ambient air. As a parallel activity, the software is being rewritten for compatibility with the existing LabView vi currently in use at EA-FEIC. This schedule should be considered as an aggressive timeline.

Chassis Before & After Rework

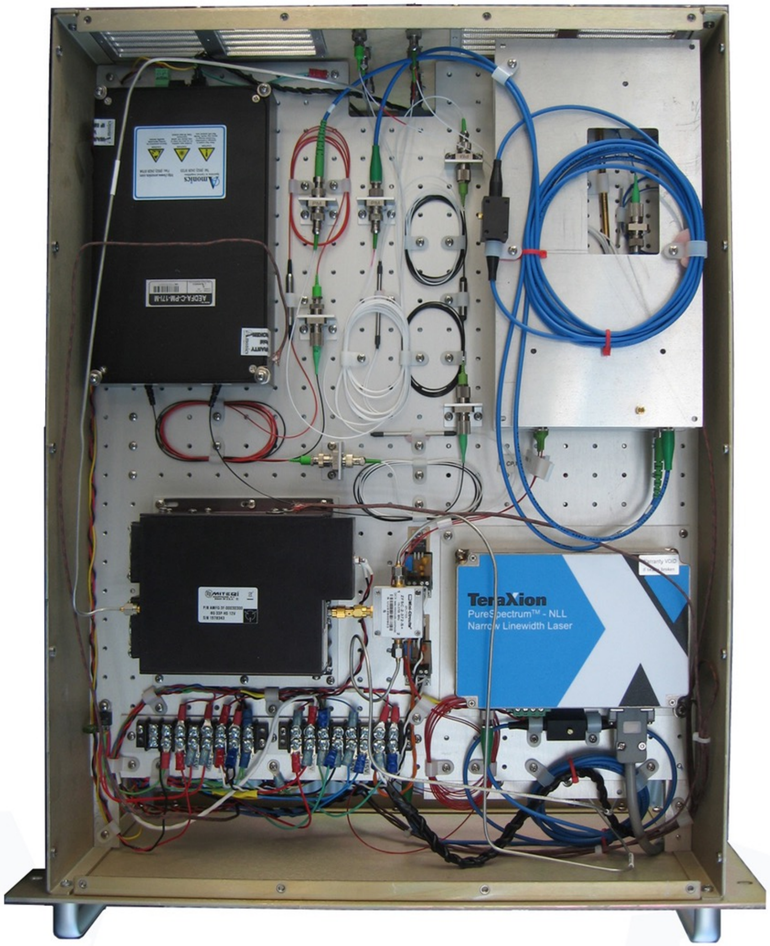
Bottom deck - before



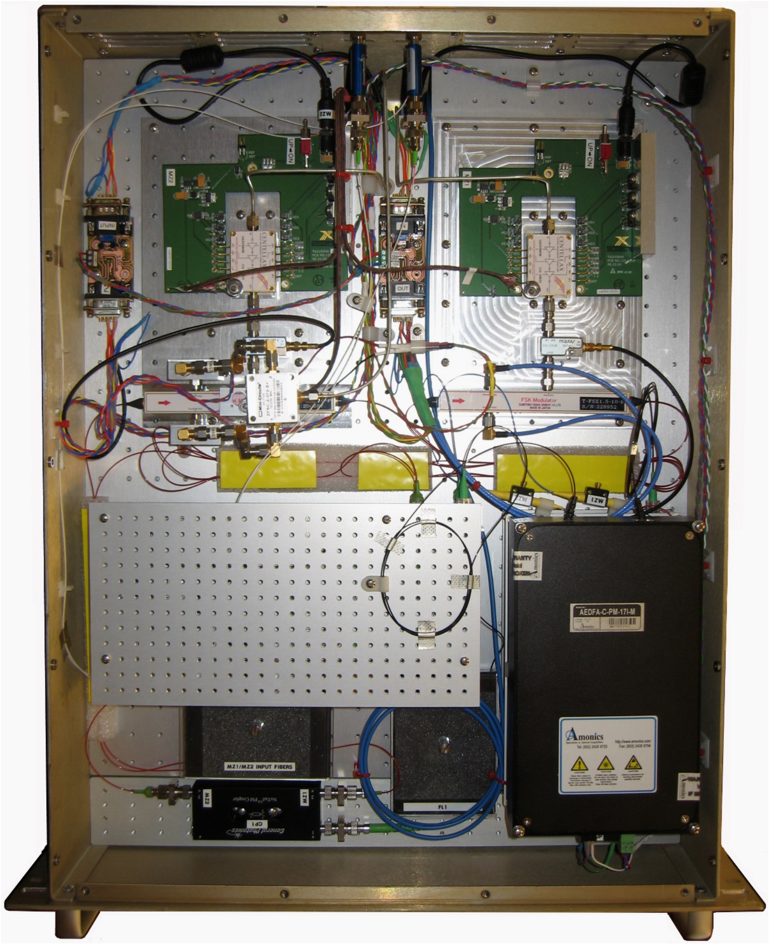
Bottom deck - after

MZM LORTM Upgrade

Chassis Before & After Rework (cont'd)



Top deck - before



Top deck – after