



Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

High Level RF for PXIE

Ralph J. Pasquinelli

PIP-II Tuesday technical meeting

14 July 2015

Sigmaphi ad for IPAC 14



SIGMAPHI
ACCELERATOR TECHNOLOGIES

YOUR PARTNER
IN ELECTRO AND
SUPERCONDUCTING
MAGNETS,
POWER
CONVERTERS,
RF AMPLIFIERS
AND KLYSTRON
MODULATORS

www.sigmaphi.fr

High Power Solid State Amplifier
80kW CW and Pulse 162MHz

We will be happy
to welcome you at IPAC 14

Booth
47 & 52

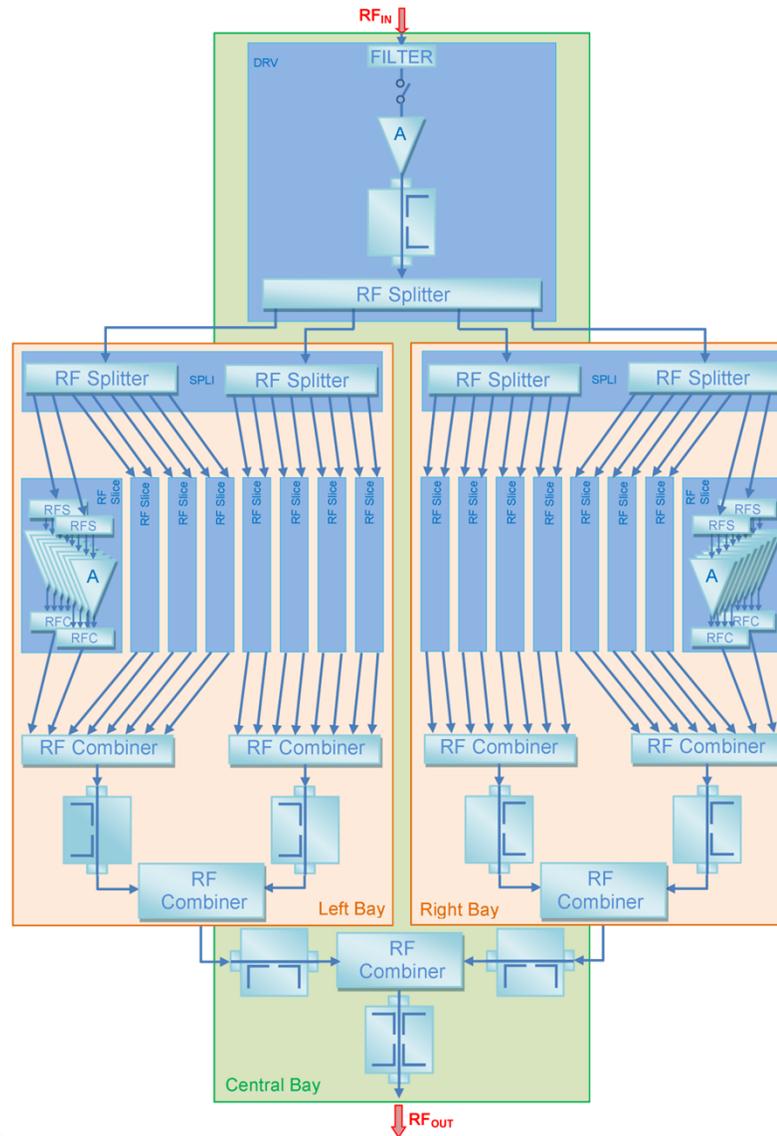
IPAC 14
International Congress Center Dresden, Germany
June 15 - 20, 2014



PXIE RFQ RF installation at CMTF

RF Block Diagram

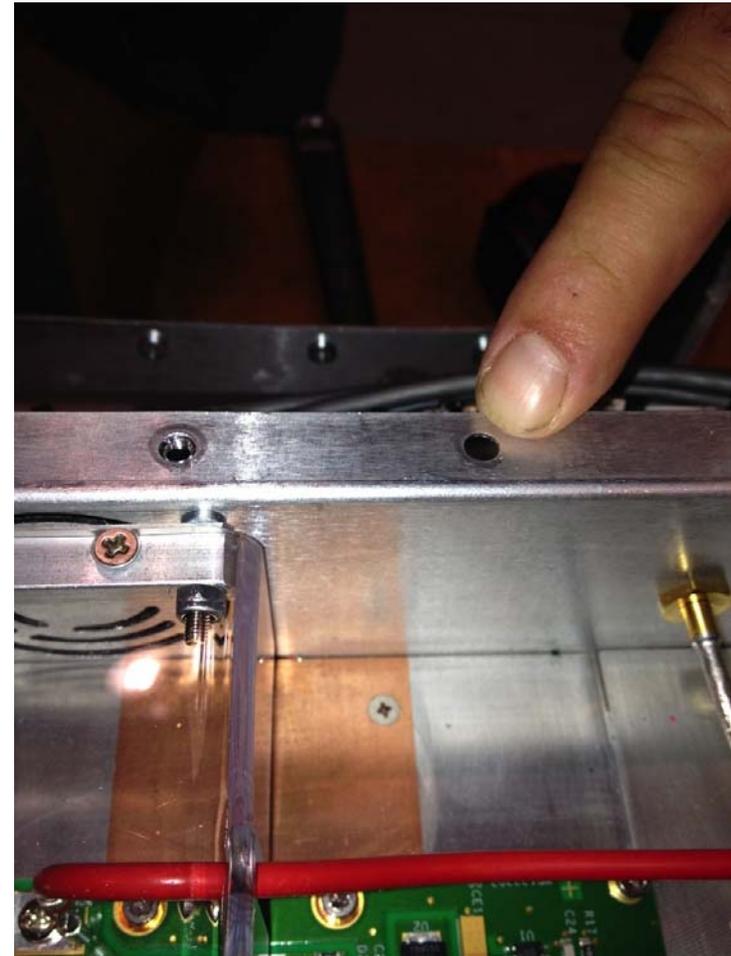
128-600 Watt
Modules Combined
to make 75kW



One of the missing PEM nuts.
On one of the slices, we opened
the top panel and found the nut
straddling the input Wilkinson.

This photo of the spare slice.
Three screws were missing, but
no nuts found in the chassis.
make 75kW

A dangerous place for metal to
be floating around.



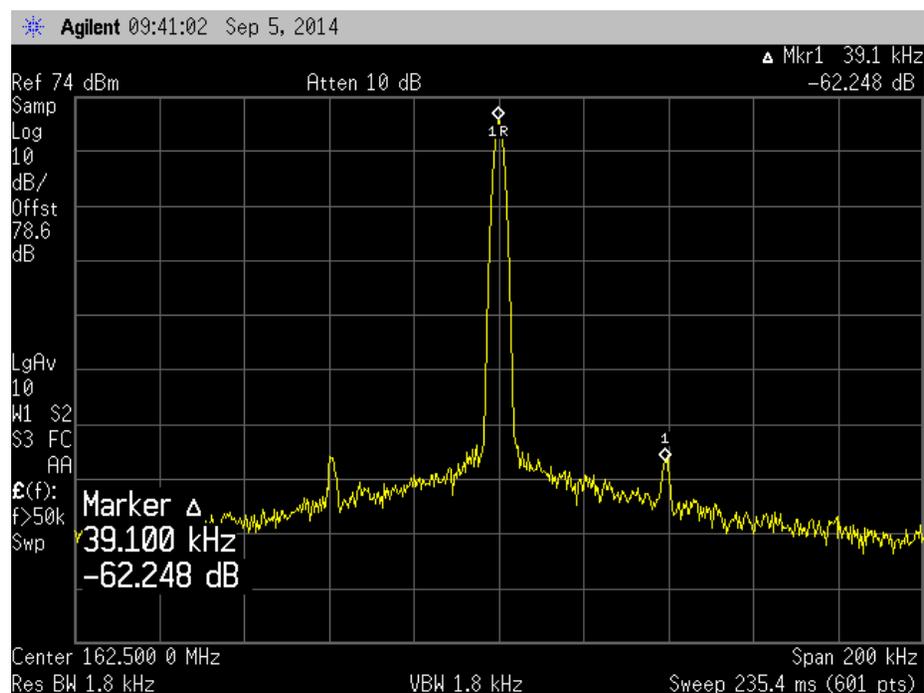


The RF input coax as found on spare slice left, after we moved it, right. We are also concerned about the bias coax, tan lines, that also lay over the Wilkinson splitter.

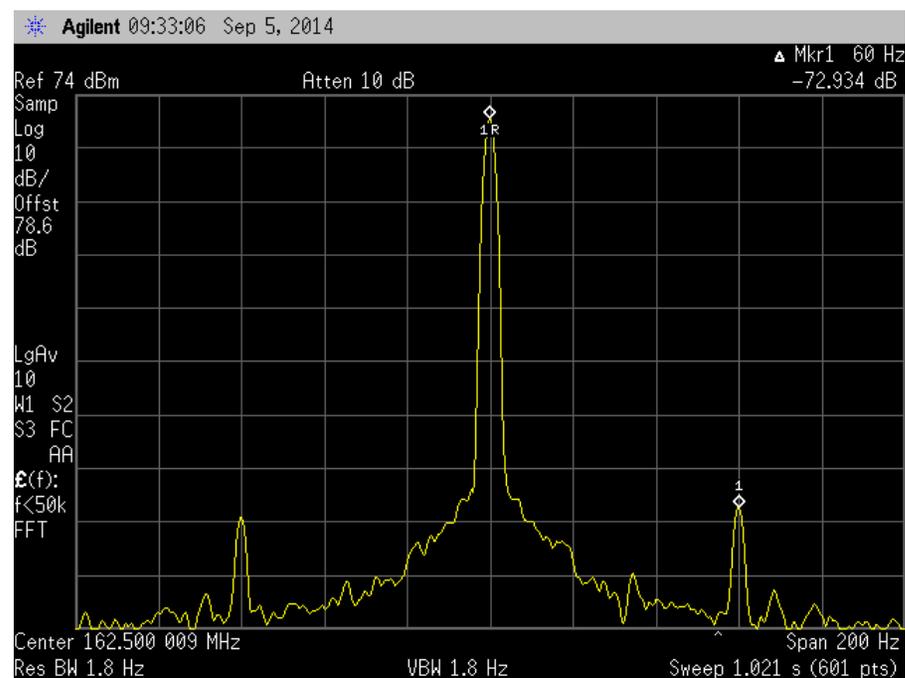


Serial # 01, 12 kW

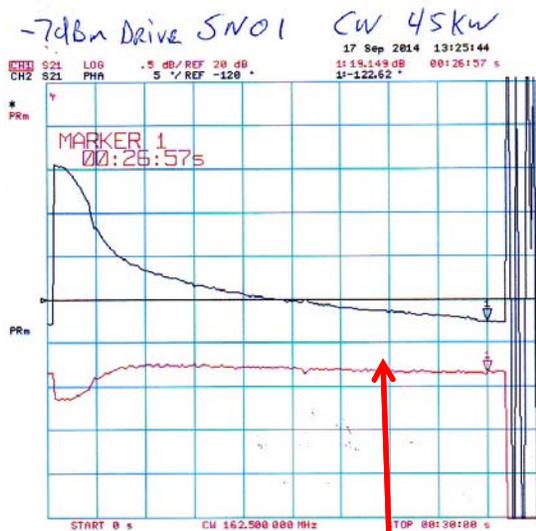
Initially the amp would not run above this power level because our Temperature sensor would provide an external fault for a step in power. Just one of several interface issues to combat.



40 kHz Sidebands



60 Hz Sidebands



CW test at 45 KW for approximately 30 minutes.. Top network analyzer magnitude and phase, bottom forward power and water temperature out.

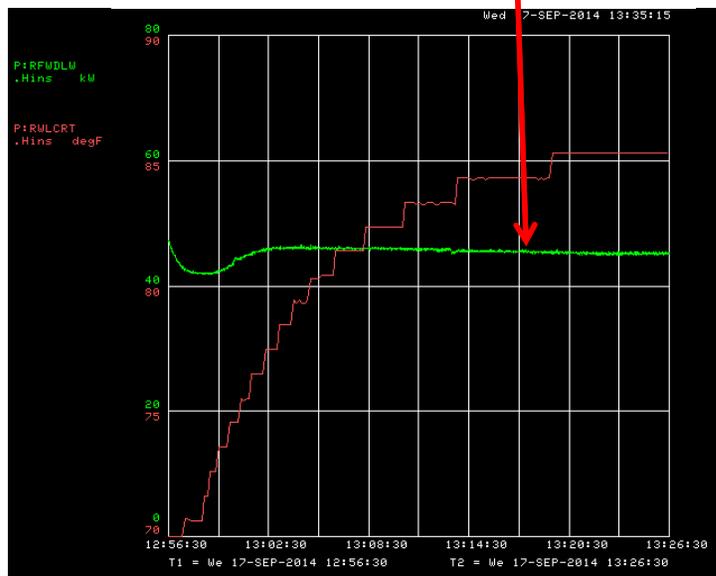
-7 dBm drive from NA

Red arrow shows time synchrony

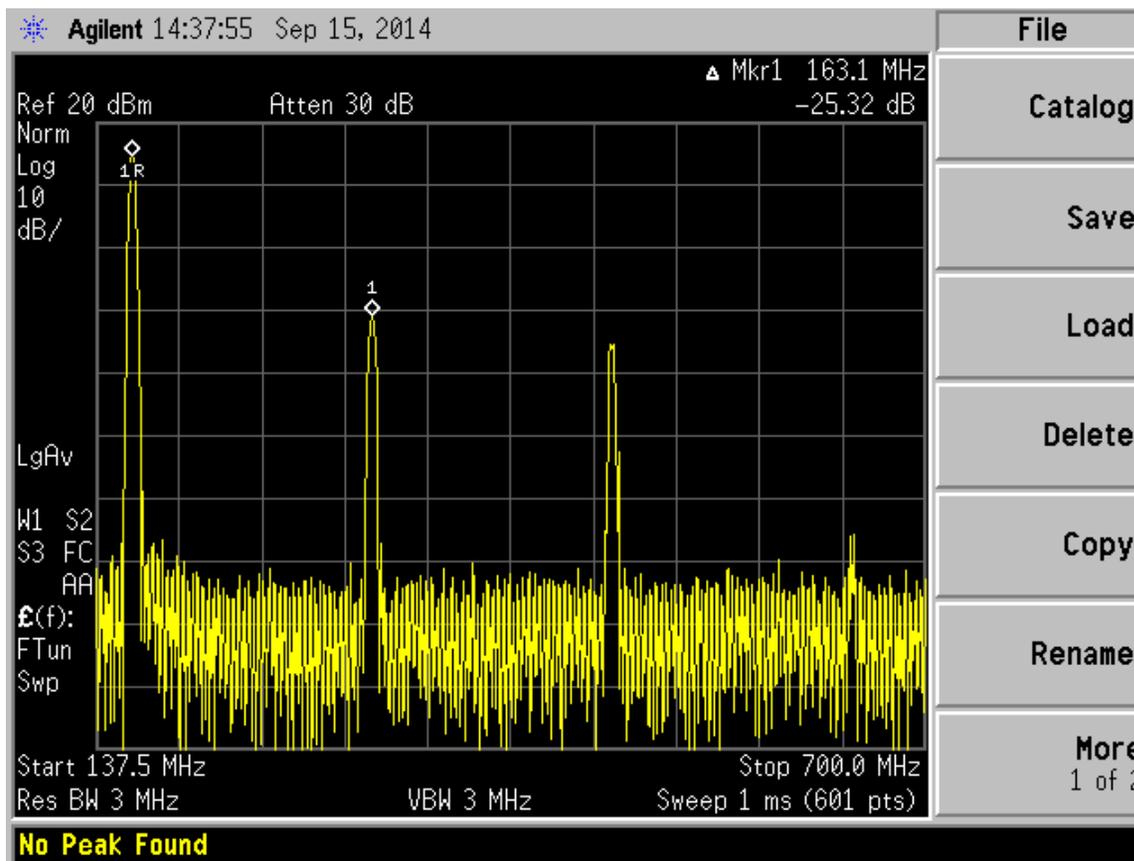
Left bay water temp warning at 84.3F
 Right bay water temp warning at 85.3 F

Red water temp F

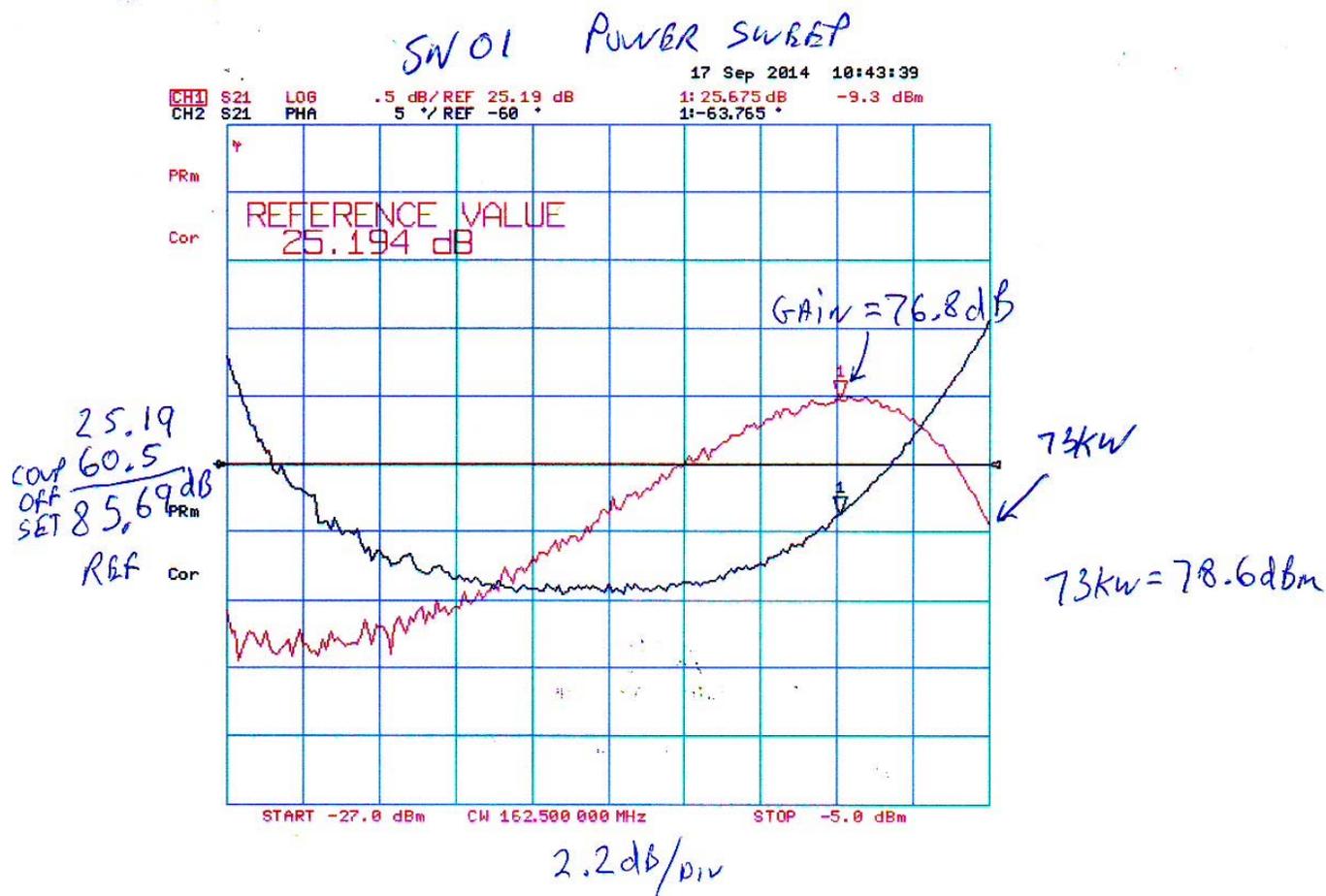
Green forward power watts



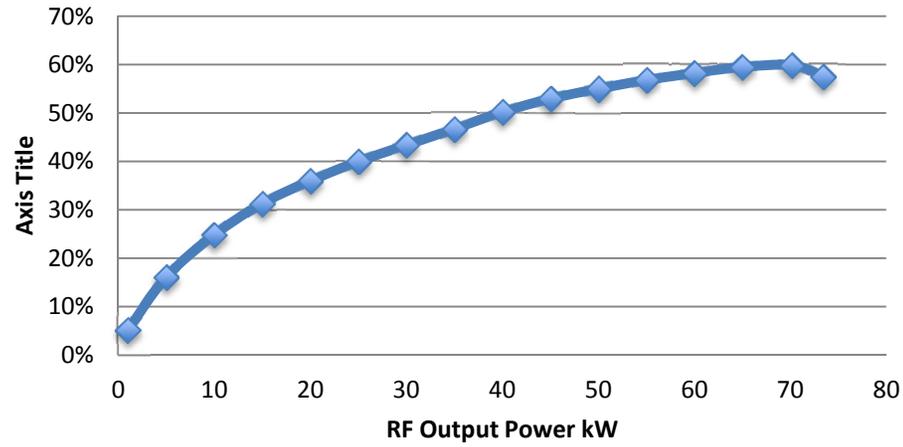
SN01 output harmonics at 75 kW
coupling value at 325 MHz is 6 dB higher so subtract
from marker 2 second harmonic is -31.32 dB



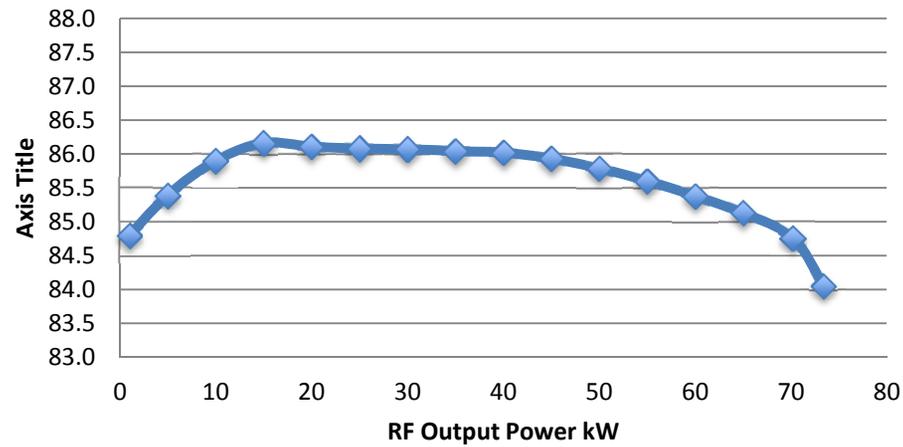
NA Power sweep, 0.5 dB/ div and 5 deg/div



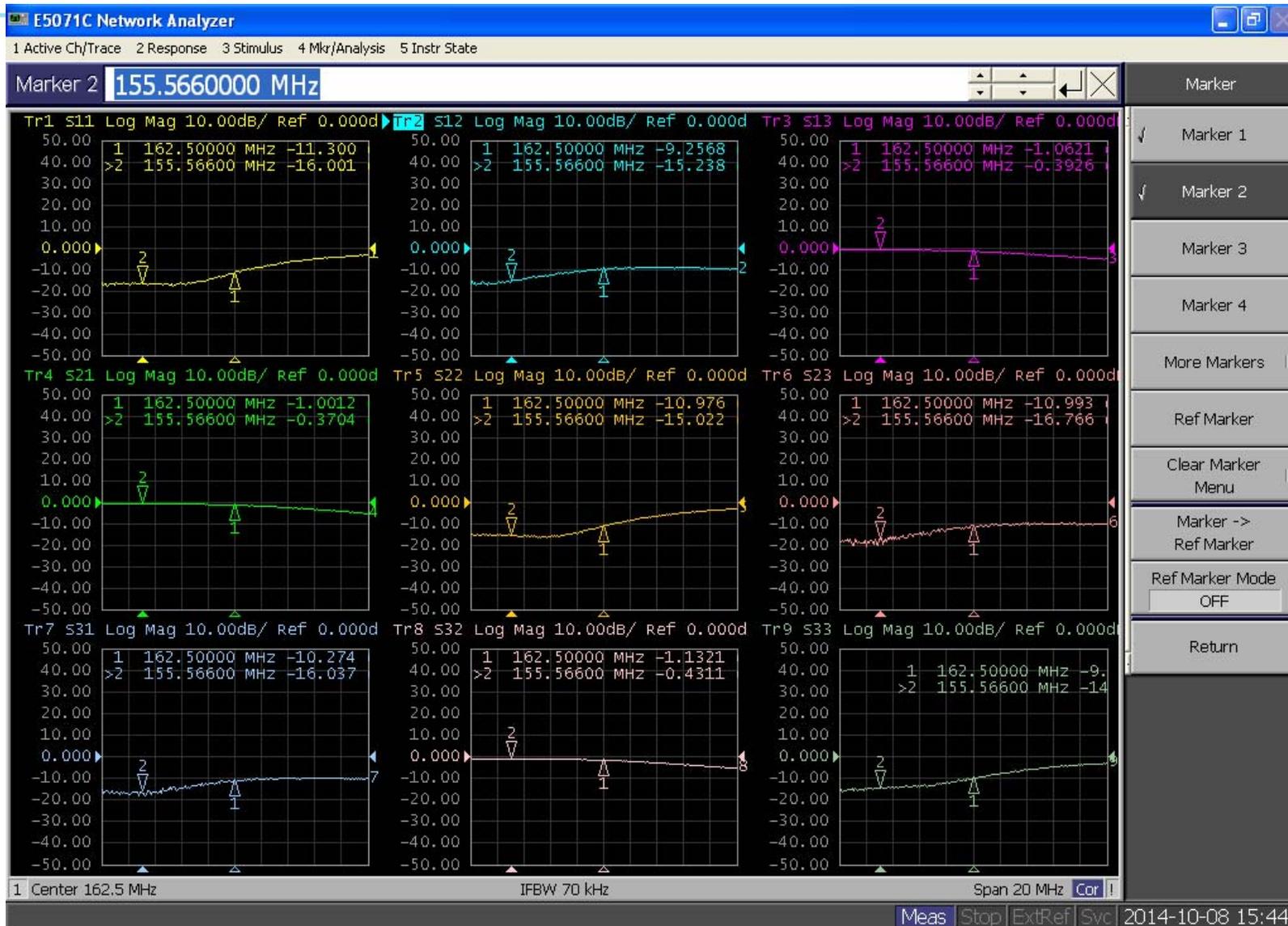
SN01 Efficiency



SN01 gain dB



Circulator performance vs Input Water Temperature = 68.6 F



Circulator performance vs Input Water Temperature = 74.5 F



Circulator performance vs Input Water Temperature = 80.4 F

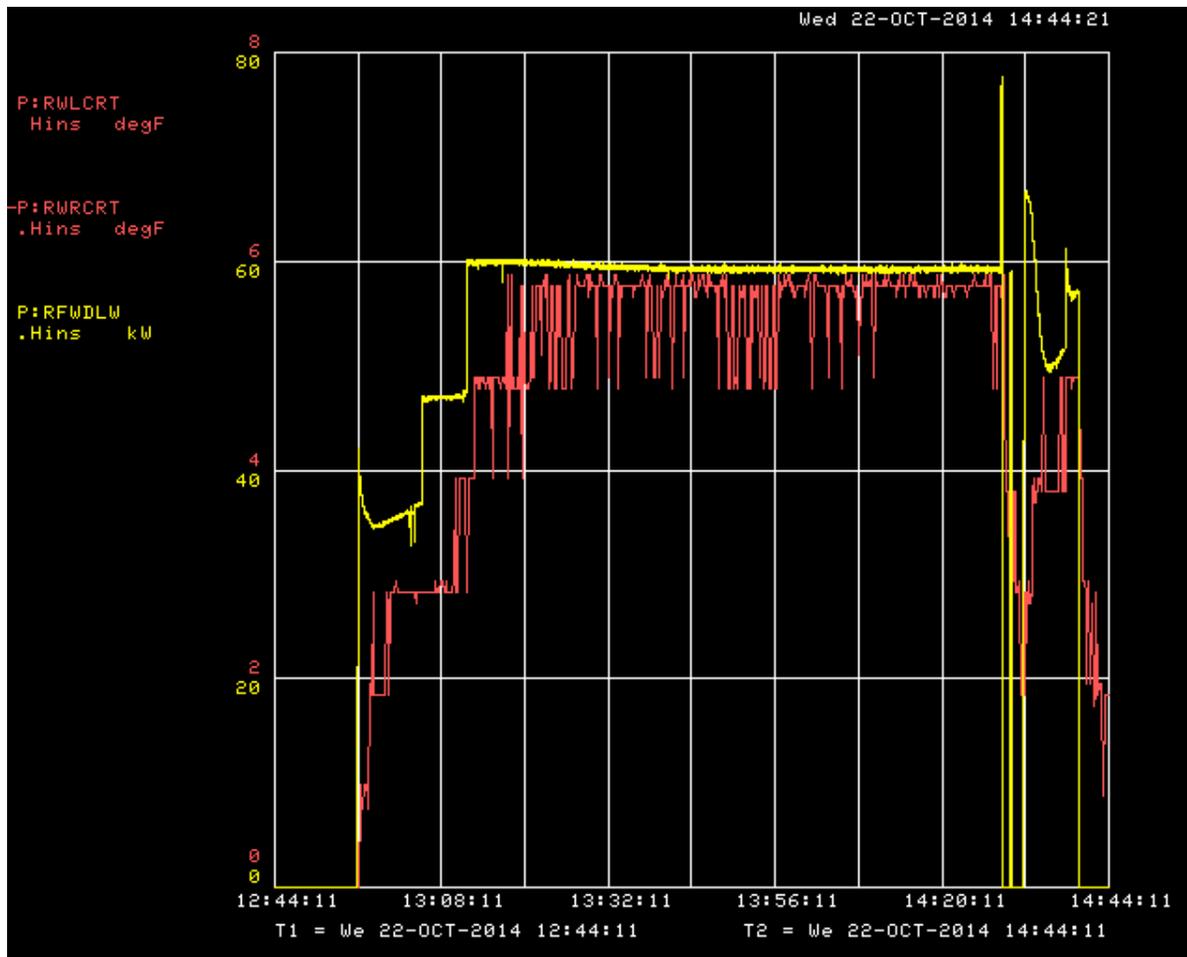


Circulator performance vs Input Water Temperature = 85 F

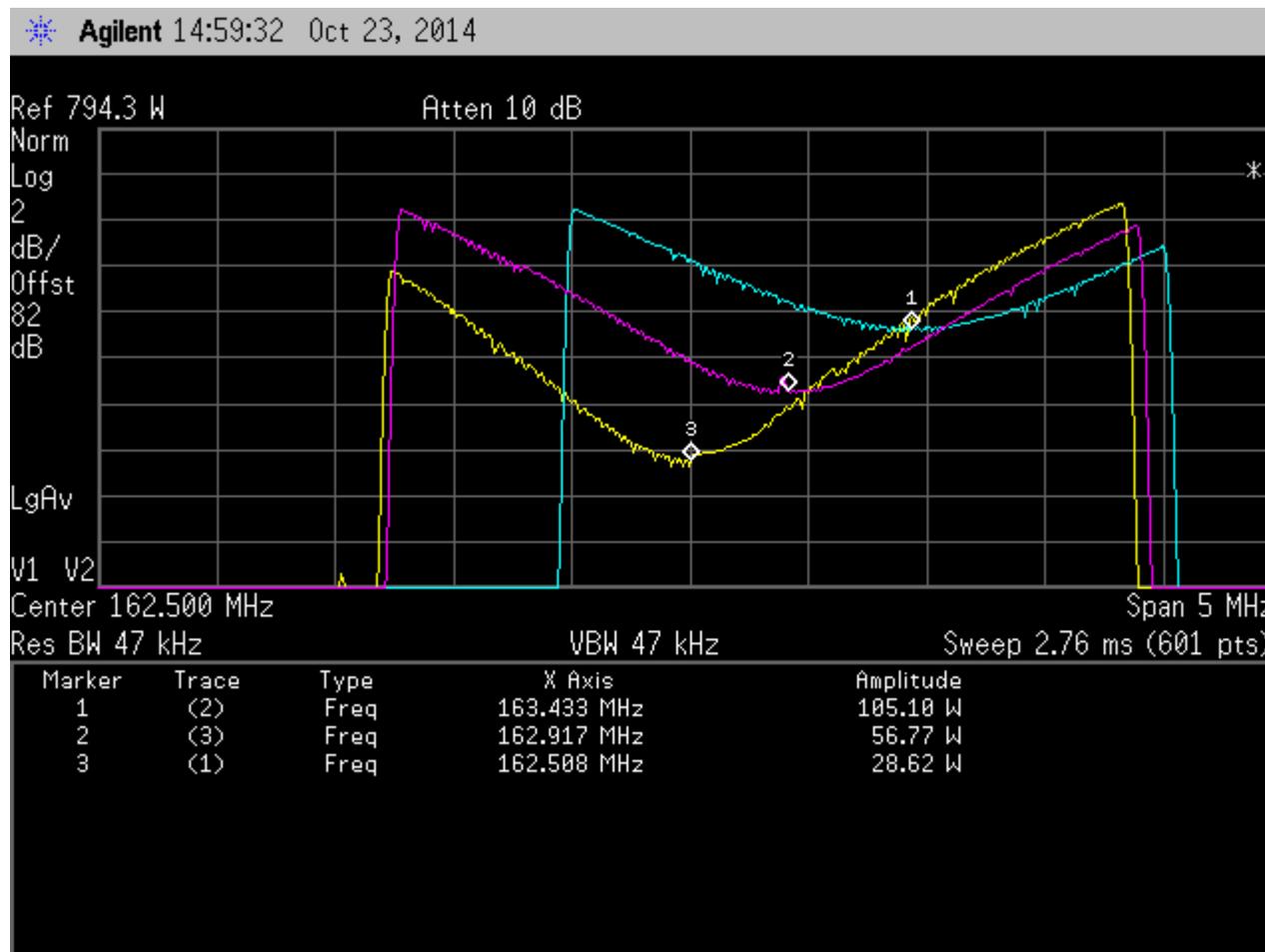


Circulator Performance

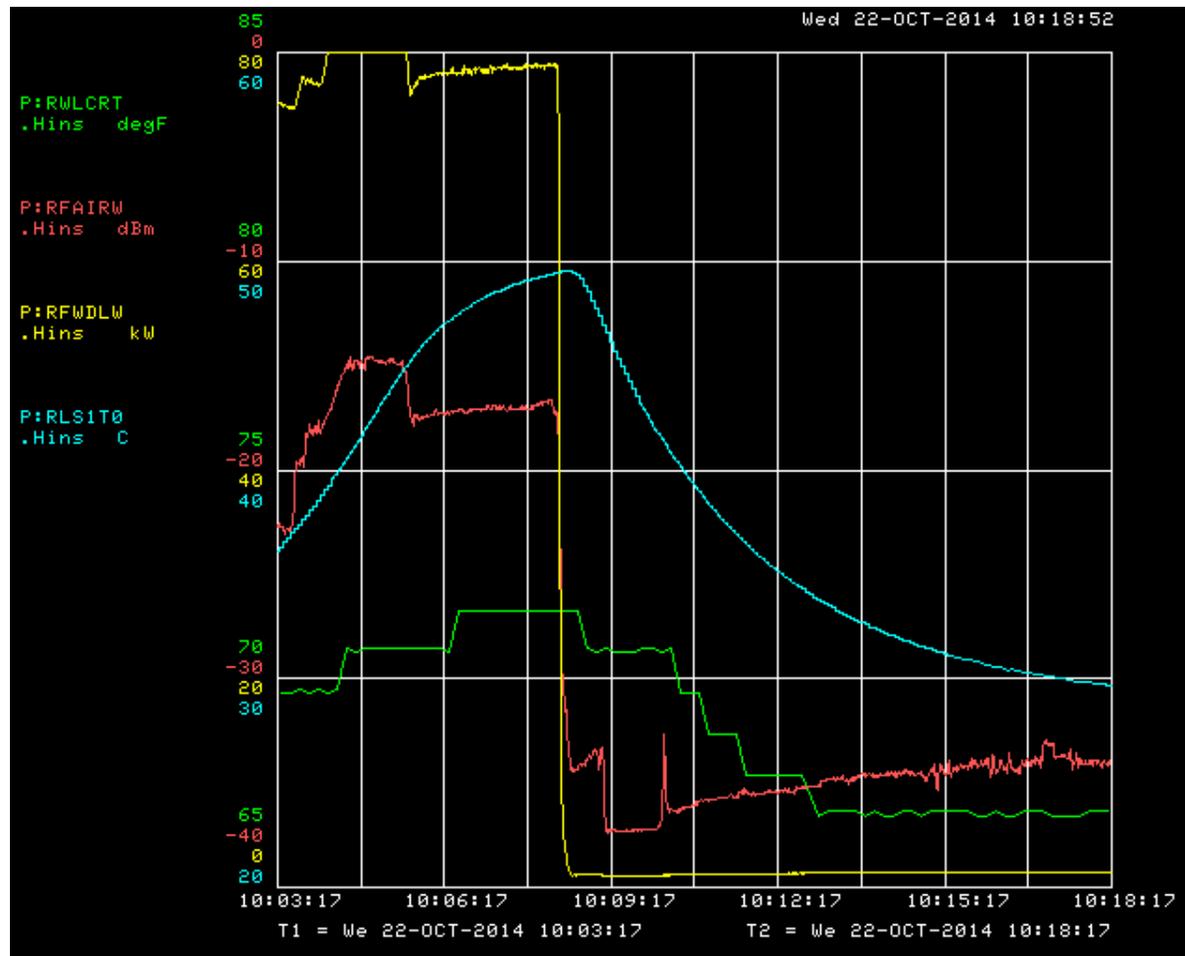
Input Water Temperature = 85 F, red is the difference between input and output water temp
yellow is the forward power out of the amplifier. Water flow is 4.1 GPM. At 60 kW, the
delta T is approximately 6 deg F. The thermal impedance between the water channels
and the ferrite disc requires this lower operating water temperature.



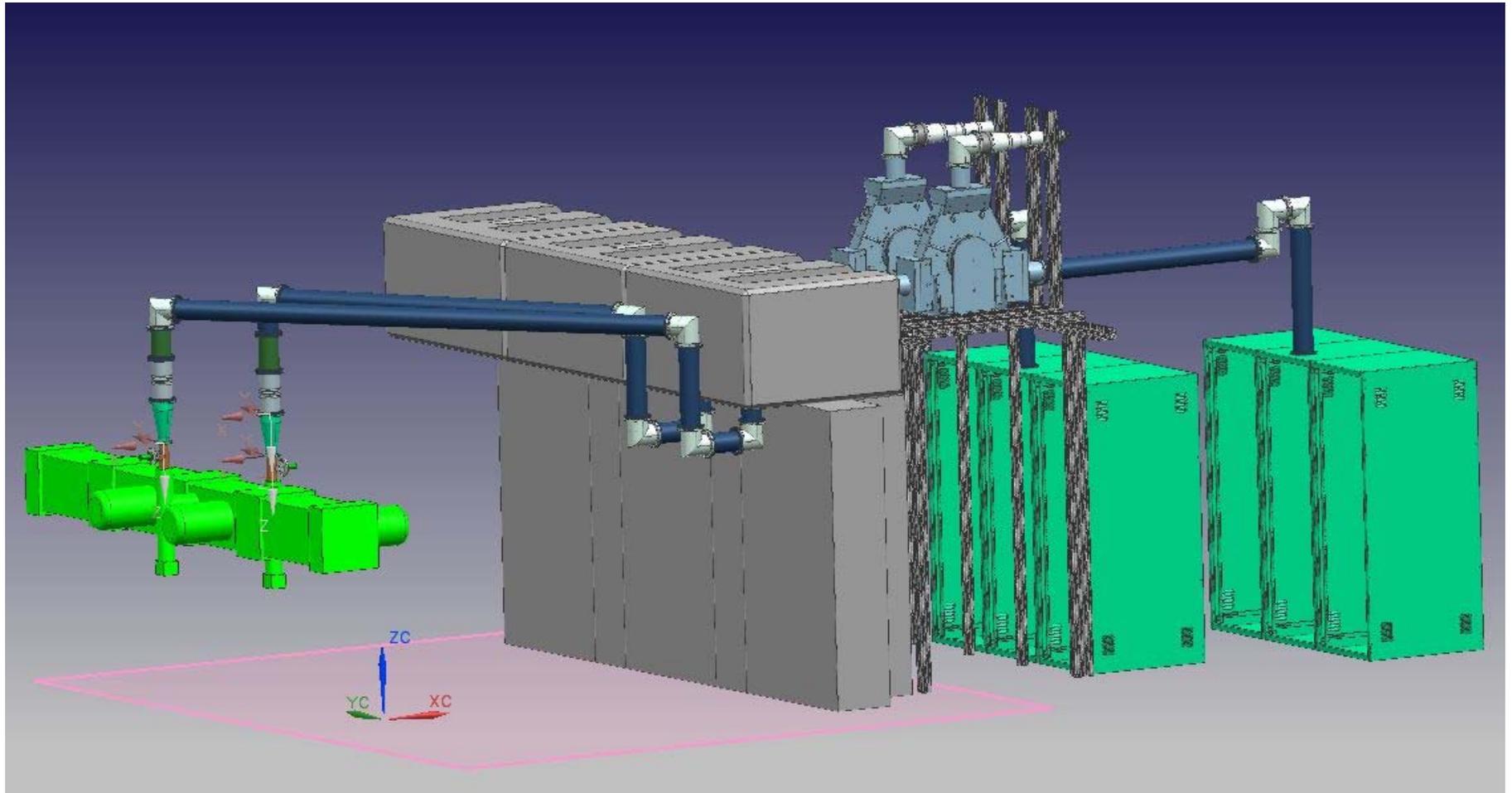
Measurement of reflected power as a function of the set point on the water skid at 65 kW amp power **50 ohm load**. Blue is 85 F, magenta is 84 F, yellow is 82.5 F and the sweet spot. This is with only one amp running and the LEBT energized. As more loads are added, the temperature at the circulators may vary and adjustments made.



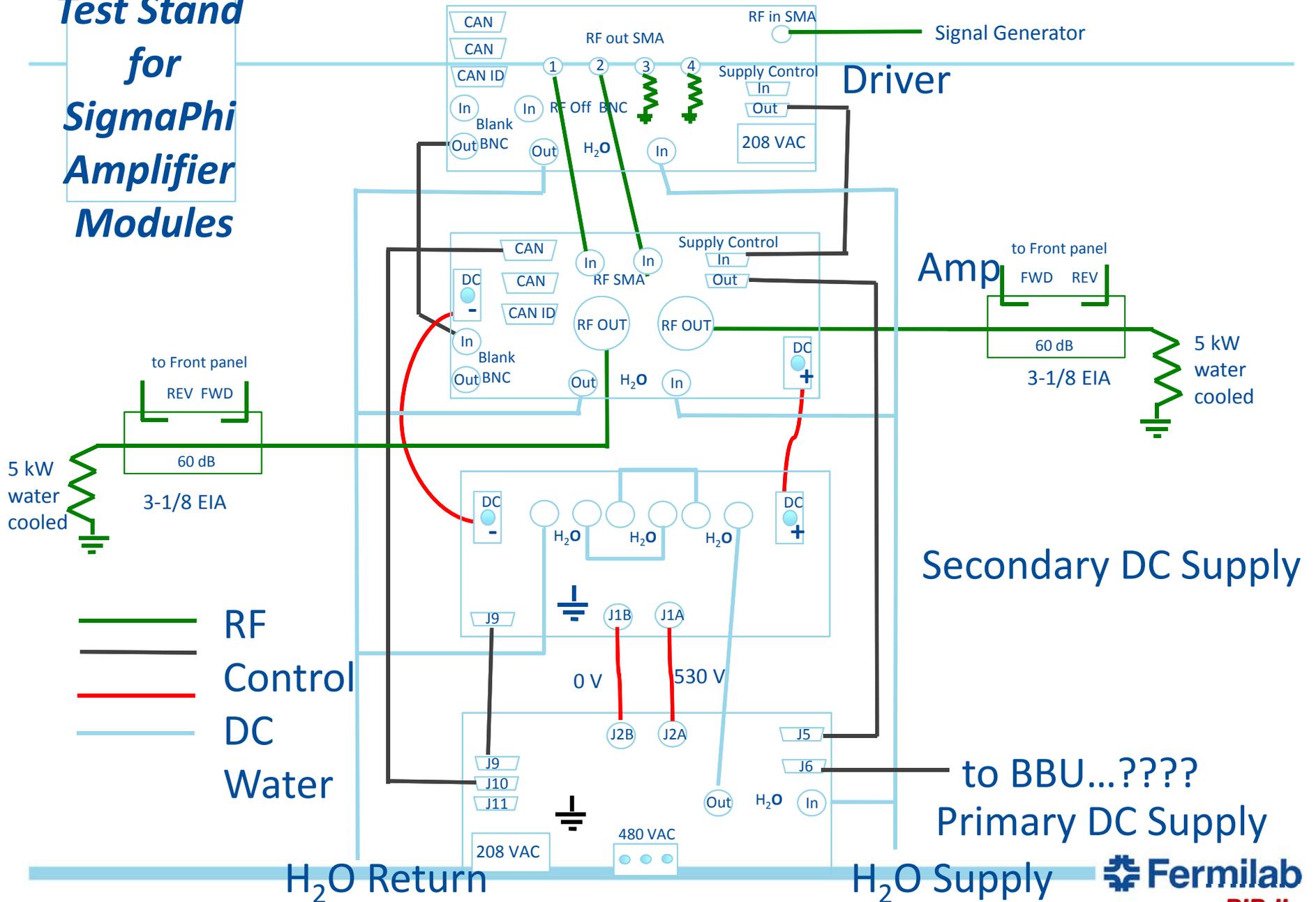
Running at 74 kw (yellow), temperature of transistors in C (blue), radiated power dBm into room antenna (red), cooling water temperature (green). Abrupt turn off of power to see time constant, about ten minutes to stabilize transistor temp, six minutes for the water loop.



Alignment scheme



Test Stand for SigmaPhi Amplifier Modules



Buncher cavity conditioning setup (June-July, 2015)

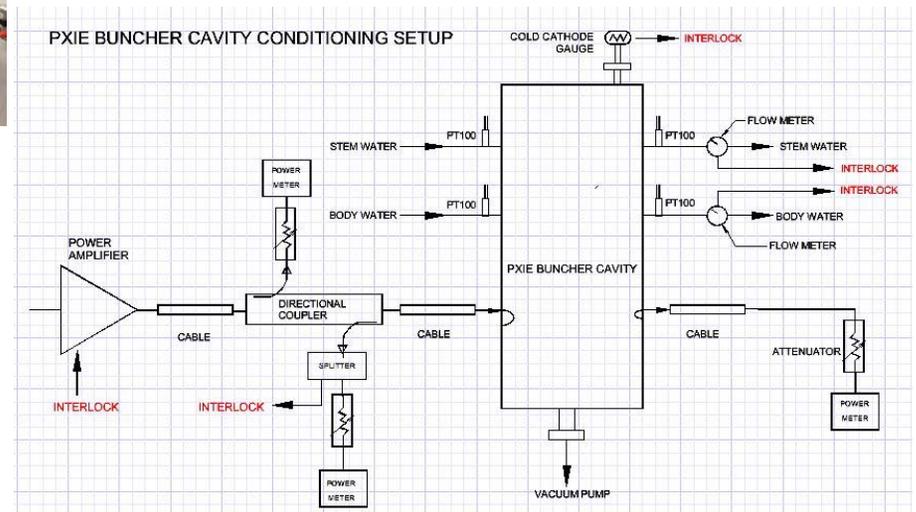


Pickup loop

Comark amplifier
(3kW 162.5MHz)

Directional coupler

Tuner



MEBT Cavity

Cavity is conditioned up to 1720 W (in the cavity). Operate at this power level for 3 days (8 hours/day).

Reflected power: ~ 5 W

Vacuum: $\sim 1.2 \text{ E } -8$ torr

Cooling water ΔT ($T_{\text{out}} - T_{\text{in}}$) is 2.1 F (Stem), 0.7 F (Body) at 1720 W level, flow rate: $\sim 3.8 - 4$ GPM

Resonant Frequency shift: ~ -17 kHz

COMARK

Low Input

TURN OFF CARRIER



VIEW HISTORY

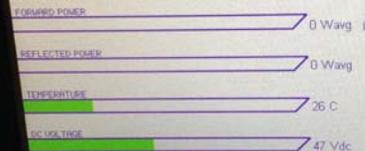
DATE	TIME	EVENT
29-Apr-2015	2:31 PM	Low Input
29-Apr-2015	2:30 PM	Carrier Off
29-Apr-2015	2:16 PM	Interlock Fault
29-Apr-2015	12:08 PM	Carrier Off
29-Apr-2015	2:15 PM	Interlock Fault
29-Apr-2015	12:06 PM	Carrier Off
29-Apr-2015	2:15 PM	Interlock Fault
29-Apr-2015	12:06 PM	Carrier Off
29-Apr-2015	2:14 PM	Interlock Fault
29-Apr-2015	12:03 PM	Carrier Off

CLEAR HISTORY

BACK TO MAIN / FWD (W) 0 / RFL (W) 0 / TEMP (C) 26 / DC (V) 47 / ATTN 0 / MODE MAN / 2:35PM / 29-Apr-2015

COMARK

TURN OFF CARRIER



SYSTEM SETTINGS / FWD (W) 0 / RFL (W) 0 / TEMP (C) 26 / DC (V) 47 / ATTN 39 / MODE 95 / 3:45PM / 29-Apr-2015

Comark 162.5 MHz 3 kW CW amplifier

- Observed issues delaying delivery of the balance of units.
- History feature does not show events in chronological order
- Forward power readback poor below 500 watts
- No air filters
- water flow meter readback is “flakey” varying between 2-24 liters/min
- control interface connection required bypass capacitors for stable operation.
- Interface optical couplers unable to sink adequate current.

COMARK

TURN ON
CARRIER



VIEW HISTORY

DATE	TIME	EVENT
1-May-2015	9:21 AM	Interlock Fault
1-May-2015	9:17 AM	Carrier Off
1-May-2015	9:20 AM	Interlock Fault
1-May-2015	9:20 AM	Carrier Off
1-May-2015	9:19 AM	Carrier On
1-May-2015	9:00 AM	Interlock Fault
30-Apr-2015	9:49 PM	Carrier Off
1-May-2015	9:18 AM	Interlock Fault
30-Apr-2015	9:37 PM	Carrier Off
1-May-2015	8:52 AM	Interlock Fault

CLEAR HISTORY

BACK TO
MAIN

FWD (W)
0

RFL (W)
0

TEMP (C)
23

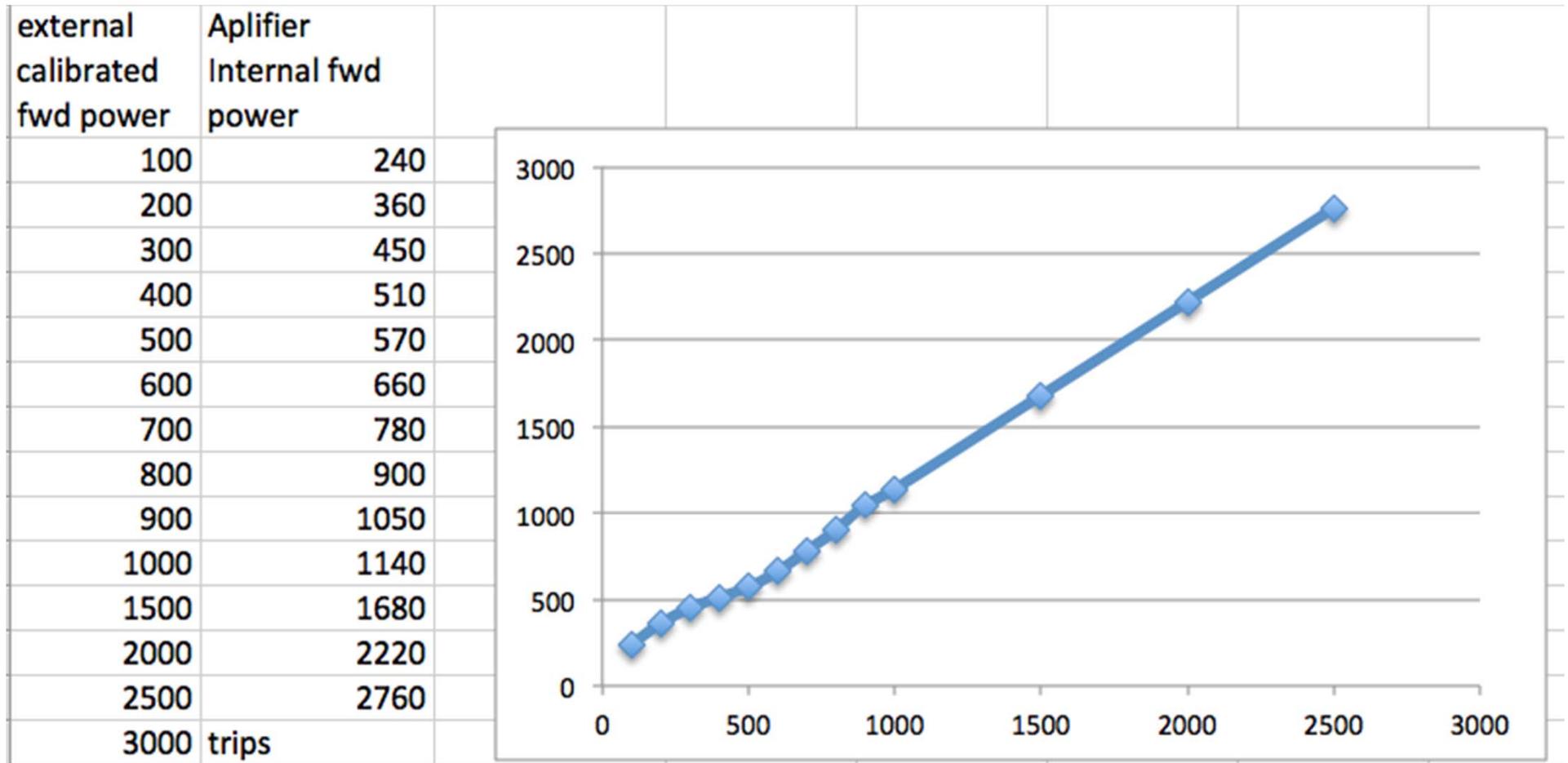
DC (U)
46

ATTEN
39

MODE
MAN

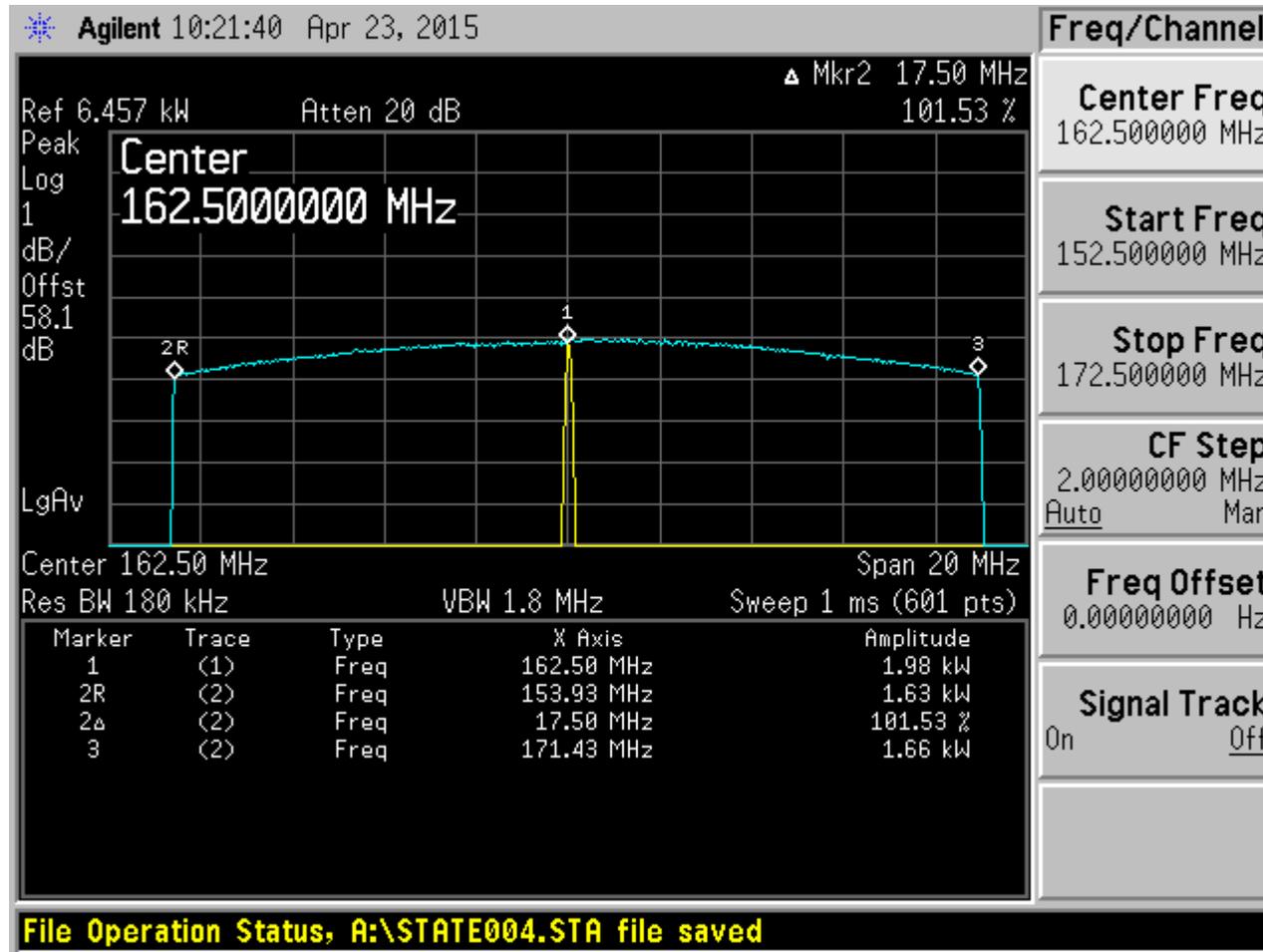
9:31 AM
1-May-2015

Comark 162.5 MHz 3 kW CW amplifier



Comark 162.5 MHz 3 kW CW amplifier

1 dB bandwidth @ 2 kW is 17 MHz



Summary

- High Level RF has been tested extensively in CW mode
- When water returns both the RFQ and MEBT amplifier will be tested in pulse mode
- Rigid coax on site is being cleaned at CMTF
- 6" flex coax fully tested to 75kW CW
- Will need to procure only a few sections of 6" rigid coax for the RFQ, with delivery a week to ten days after order.
- A source of connectors has been found for the Cablewaves 1-5/8" coax. There are almost 2000 feet on sight that could be used for PXIE MEBT, HWR, SSR1. Connectors are approximately \$350 each.