



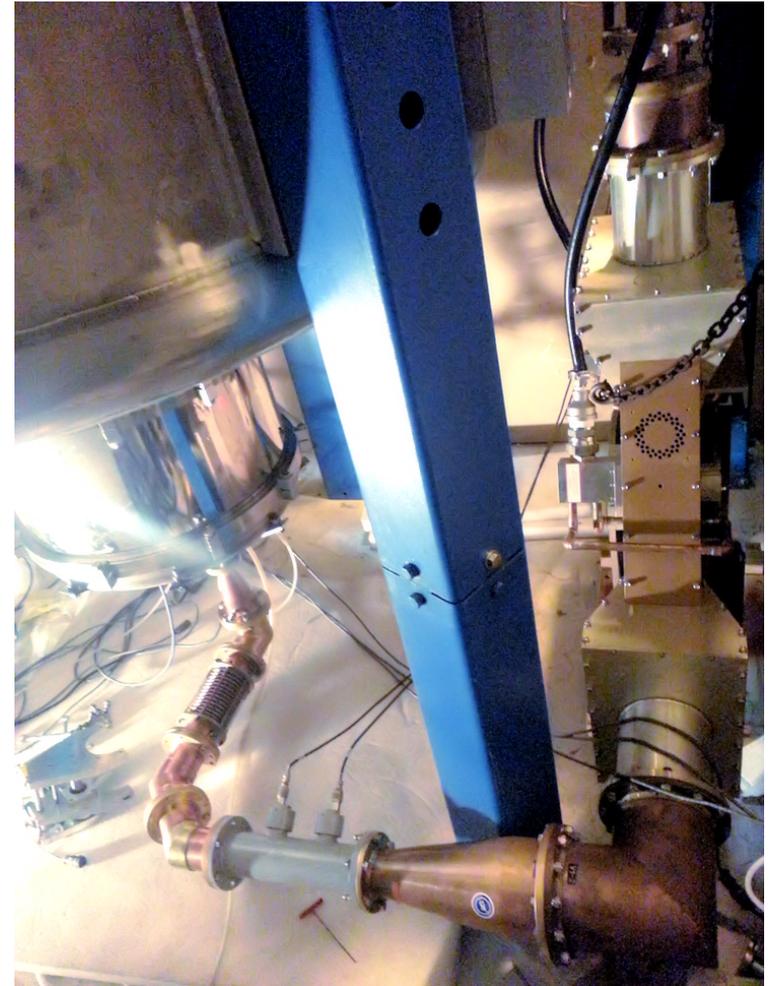
Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

RF Power Sources

(a brief history)

Ralph J. Pasquinelli
PIP-II Machine Advisory Committee
9-11 March 2015

162.5 MHz Comark 10 kW Test Stand at Argonne



Testing of Couplers at the Argonne Facility since 2013

162.5 MHz 10 kW Circulator for Test Stand at Argonne



Four Failures in developing a 10 kW circulator at 162.5 MHz



325 MHz 10 kW Test Stand at Meson Detector Building



Bruker (now Sigmaphi) Amp failed on first turn on. Power supply sent back to France to be fixed.

Once fixed, the RF section failed. Bruker field engineer came to FNAL for a day to attempt a fix. That did not work and full unit returned to France for repair.

Amp is working fine now and supplies RF power for both coupler testing and cavity tests.

2-650 MHz 30 kW Test Stand at Meson Detector Building



Three Comark 650 MHz IOT stations operational since 2011. We capitalized on the Digital TV revolution.

No 650 MHz components to test

1.3 GHz 30 kW Test Stand at Meson Detector Building



One of the three IOT stations has been converted to 1.3GHz with a CPI 30 kW CW internal cavity IOT.

1.3 GHz is no longer part of PIP-II.

This system will be used to test cavities in the existing horizontal test cave. For ASTA, LCLSII, ???

System is commissioned and ready.

2-162.5 MHz 75 kW Sigmaphi RFQ Amplifiers at CMTF



Two amps delivered in June 2014
Commissioning took 6 months!

162.5 MHz 75 kW Sigmaphi RFQ Amplifiers at CMTF

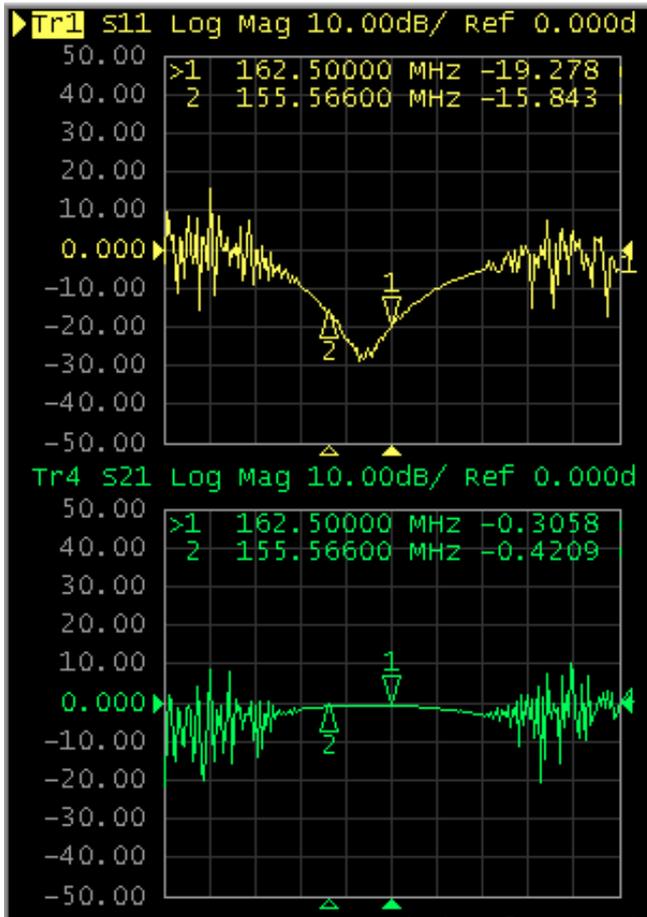
Why You ask?

Trouble, trouble, trouble.... right here in River City
water leaks, failed amp modules, faulty control interface



8 of 32 modules leaked, two failed amp palates,
multiple versions of FPGA code.

162.5 MHz 75 kW RFQ Circulators at CMTF



@85F

Center frequency 162.5 MHz, Span 50 MHz
Water needs to be 83 F for them
to work. Not 95 F as specified
Must adjust LCW temp.

162.5 MHz 3 kW Amplifiers and Circulators for MEBT



COMARK Communications Price Proposal
P#1998 in Response to 250245-RFC
For
Five (5) 162.5MHZ, 3kW CW RF Amplifiers

Five amplifiers and circulators ordered September 2014
Delivery expected late March 2015

Comark provider of Argonne 10 kW amp and IOT amps
Good service record with FNAL

Hoping this product will fare better than earlier procurements.

Injection Locked 2.45 GHz Magnetron



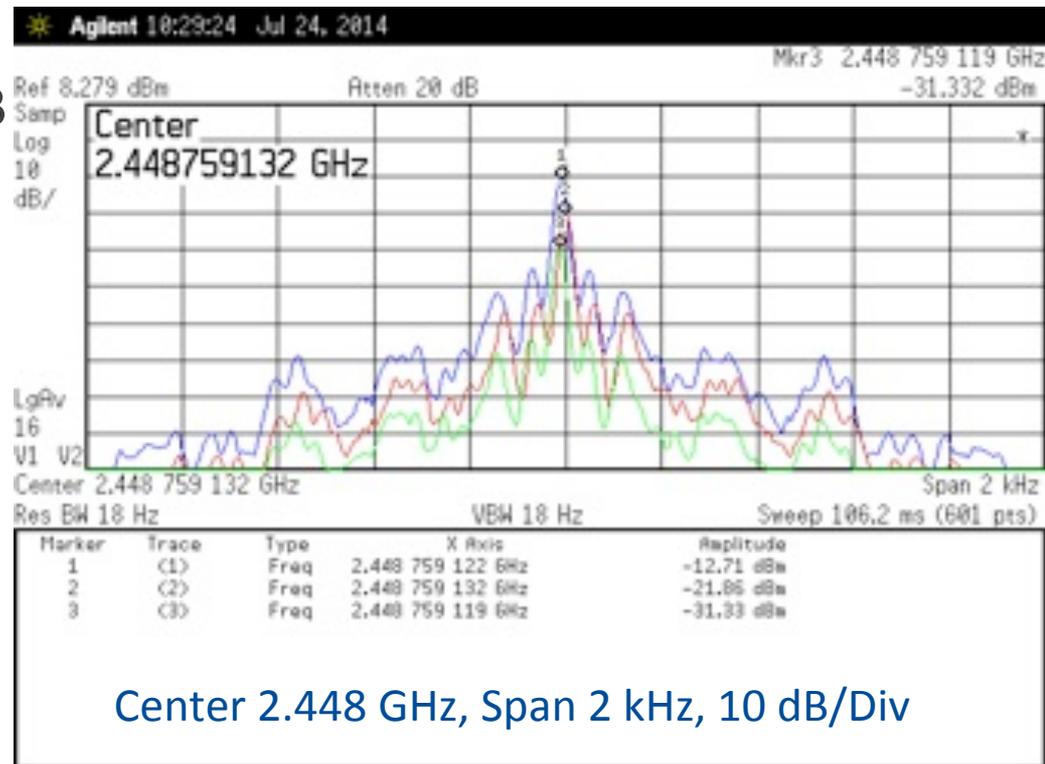
A0 Test Stand

Commercially procured 2.45 GHz 1.2 kW magnetron
Loaned SRF cavity from Jefferson Lab
Testing took place over one week period in July 2014.
PM modulation results published in JINST
National and International patents pending



Injection Locked 2.45 GHz Magnetron Performance

- Phase modulation of injection signal allows for full vector control
- Amplitude of carrier varies by Bessel function coefficients
- Demonstrated regulation performance with single SRF cavity
 - 0.3% amplitude rms
 - 0.26 degrees rms
 - dynamic range exceeds 30 dB



Injection Locked 650 MHz or 1.3 GHz Magnetron

- Next Step is to develop an operational system at a desired frequency and power level.
- Large Non Recurring Engineering (NRE) cost for development of a new magnetron and DC power source.
- Estimate of \$2 million over two or three years to complete
- One source of magnetron development funding possible with SBIR Phase II with Calabazas Creek Research (CCR).

Deliverables in the near and far term

- 162.5 MHz 3 kW amps for MEBT and first HWR: March 15, 2015
- Balance of 162.5 MHz 7 kW amps for HWR: Q4FY17
- SSR1&2 325 MHz amplifiers from India: Q1FY17
- RF power sources for 650 MHz, could be magnetron, IOT, or solid-state technology: Q3FY17

Deliverables from India

- First 3 kW 325 MHz amplifier delivered August of 2014.
- Amplifier operated early October 2014 for 2 hours before one of the four amp modules failed. Delay in testing due to infrastructure water cooling and electrical hook up.
- On instructions from BARC, do not operate until module is replaced.
- We have been waiting since October 2014 for a replacement module.
- This is a prototype amplifier for RF power testing purposes, not compatible with controls or interlocks.
- A new set of guidelines has been written for interfacing and acceptable floor space. A very detailed specification must be written.

Deliverables from India

- RRCAT has produced operational 75 kW amps at 505 MHz for operating INDUS II.
- Modified version of this amp for 650 MHz operation is in progress.
- 10 kW 325 MHz amp from BARC scheduled for end of this year in India.
- 30 kW 650 MHz amp from RRCAT scheduled for end of this year in India.
- India is slated to supply complete RF systems including RF power, LLRF, and interlocks, so we are waiting for a detailed proposal to be reviewed at FNAL before start.
- Visiting Indian Engineers (starting Summer 2015) should smooth this process.

The best laid plans of mice and men
often go astray

Your plan



Reality

