Presented by: Nick Barov
For: 2012 SBIR Exchange Meeting

An Energy-Efficient RF Power Source for the Jefferson Laboratory CEBAF Linac*

*** Work supported by DOE Office of Nuclear Physics**

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Outline

Company intro/capabilities

JLAB Power Amplifier Progress

Plan for Final Test

Commercialization

Conclusion

People:
N. Barov, X. Chang, and D. Newsham, FAR-TECH, Inc.

Thanks to:
R. Nelson, JLAB

FAR-TECH, Inc. Management and Facility

- Located in San Diego, CA
- Founded in 1994, formerly known as Fusion and Accelerator Research (FAR), to pursue fusion and accelerator related research, technology and development.
- Core staff of 16 (14 PhDs)
- Facility:
  - Linux cluster (88 processors) with 96GB of memory via Infiniband connection; 15 TB redundant storage
  - RF, UHV, laboratory and assembly

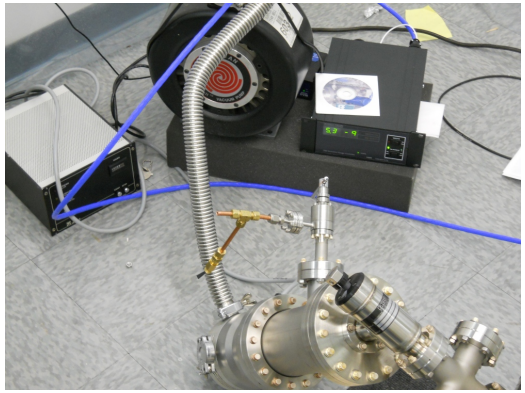
RF Test and Fabrication

Capabilities:

- CAD, HFSS, ACE3P modeling
- RF test equipment
- Class 1000 clan room
- Vacuum station, RGA
- Relationship with machine shops
- Consultants (mech. eng.; braze)
- Access to CNC equipment

RF Test Area

Soft-wall cleanroom



Vacuum equipment

JLAB Solid State Amplifier

Motivation:

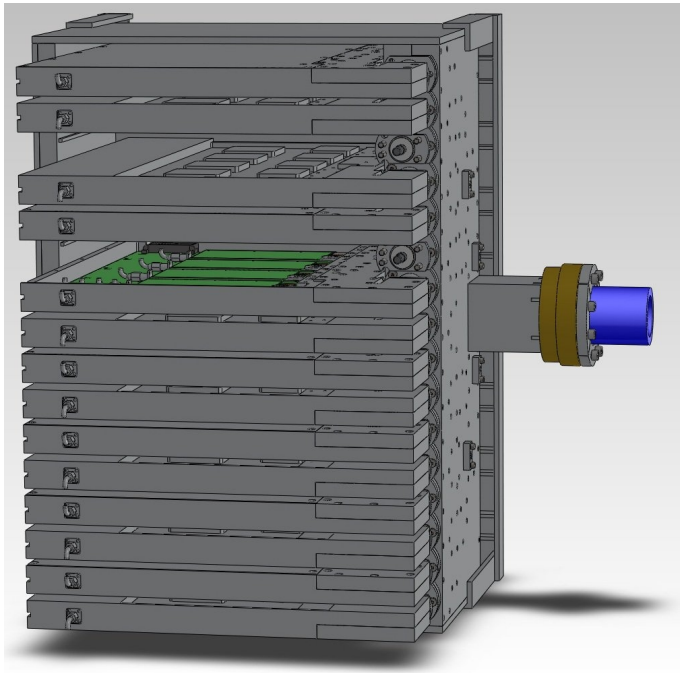
- Present klystrons are inefficient (<33% efficiency).
- Some nearing end-of-life.
- Replacements are becoming more costly.

Features:

- >55% efficiency
- Graceful degradation
- MTBF can be high; simple repair

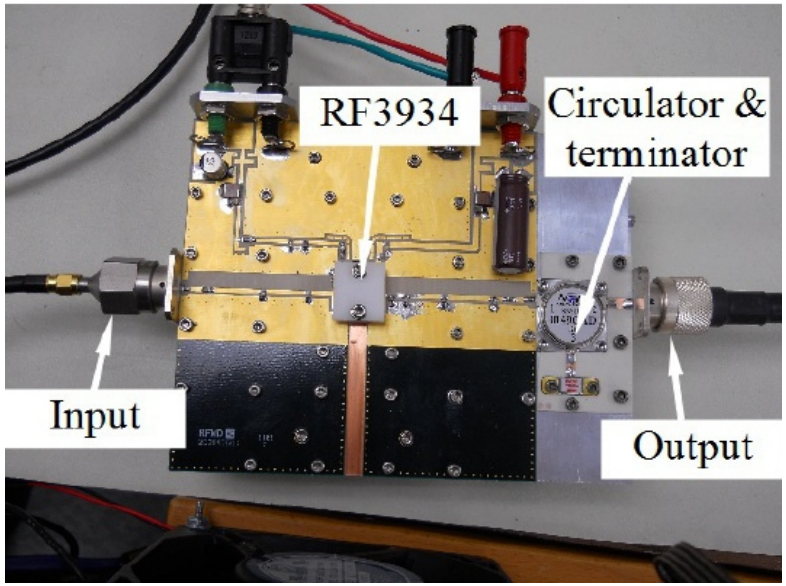
Specifications:

- 1497 MHz CW Operation
- 6.5 kW, Linear Mode

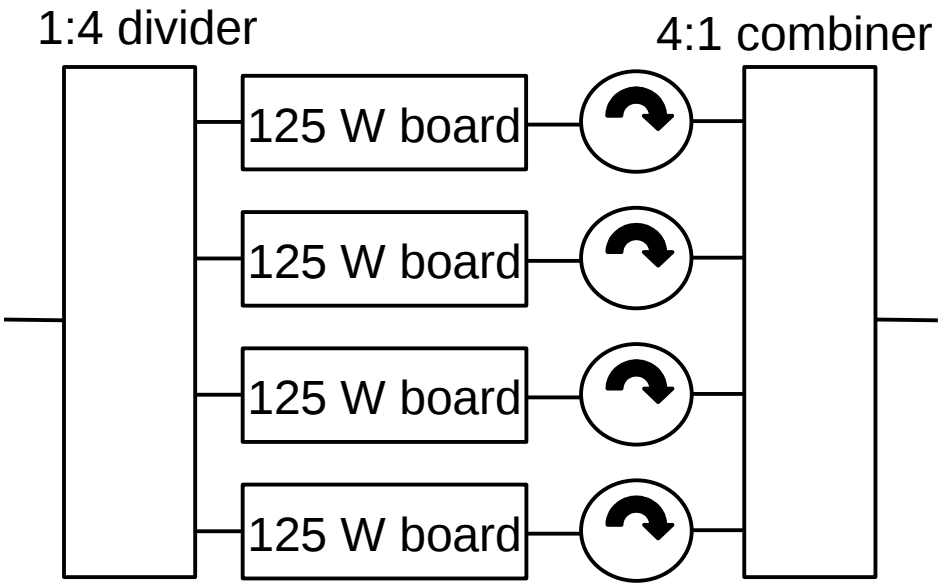


Amplifier rendering
(pre-amplifier not shown)

Transistor Board and 500W Module

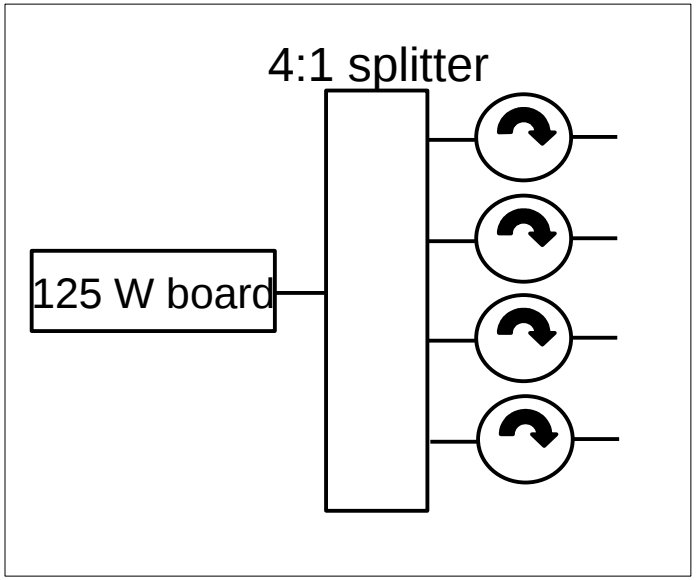


125W Board and Circulator
Based on GaN Transistor

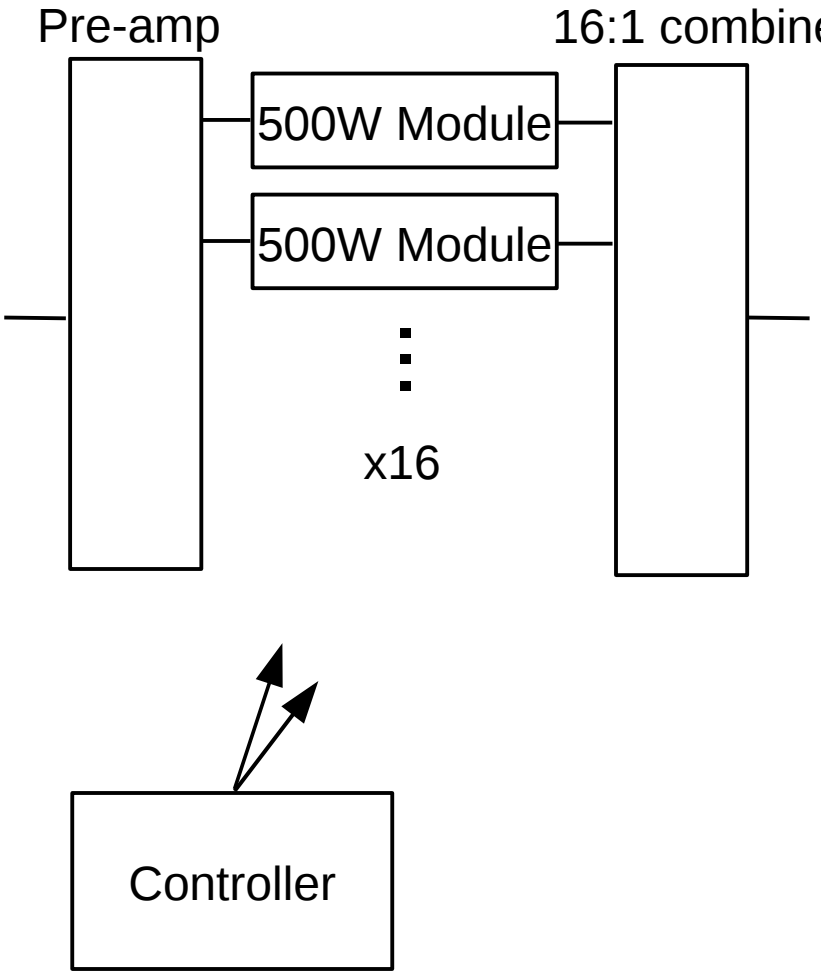


500 W Module Diagram

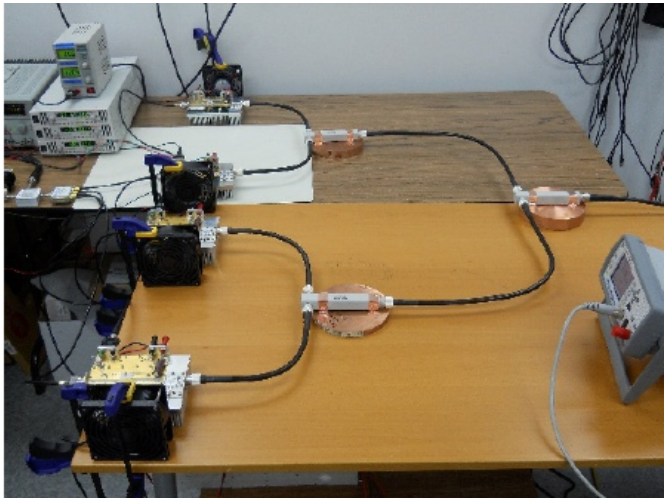
System Layout

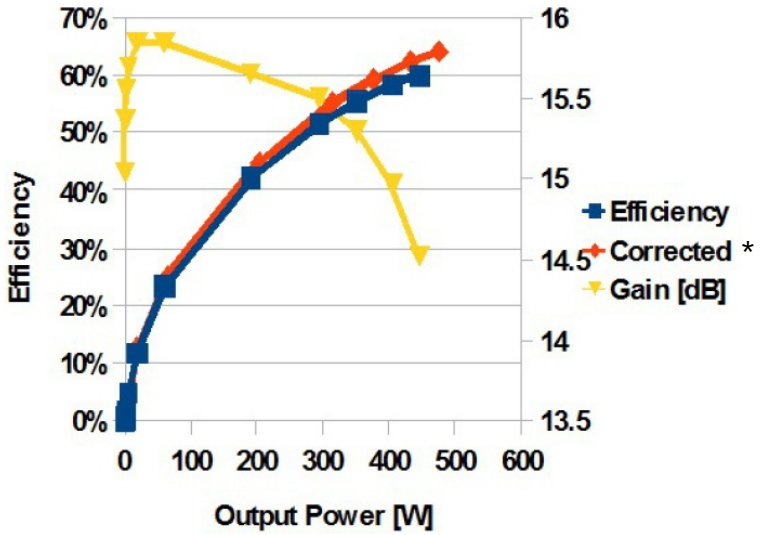


Preamplifier 1 of 4 Sections



4:1 Combiner Test Results

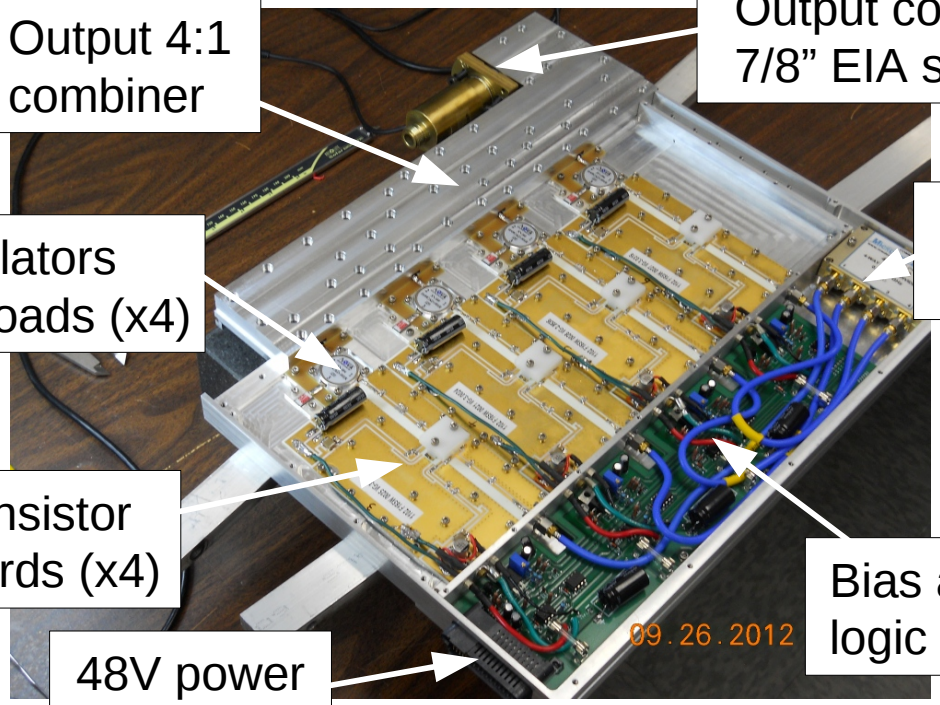




*to account for cable losses

Meets JLAB spec for linearity/compression at 400W
Efficiency at 400W per operating point in excess of 60% (drain efficiency)

500W Module Recently Tested



Physical:
- 14” x 15” x 1”
- Approx 8 lbs.
- 16 units per amp

Results:

The unit was operated at the nominal 400W operating point, 6 hours.
Testing and optimization continues.

16:1 Power Combiner

Results:

- Two combiners built, including pressure window
- Tested to better than 20 MHz bandwidth (below -30 dB return loss)
- Less than +/-1% imbalance of individual inputs

16:1 combiner

Preparation for Final Test

Tasks:

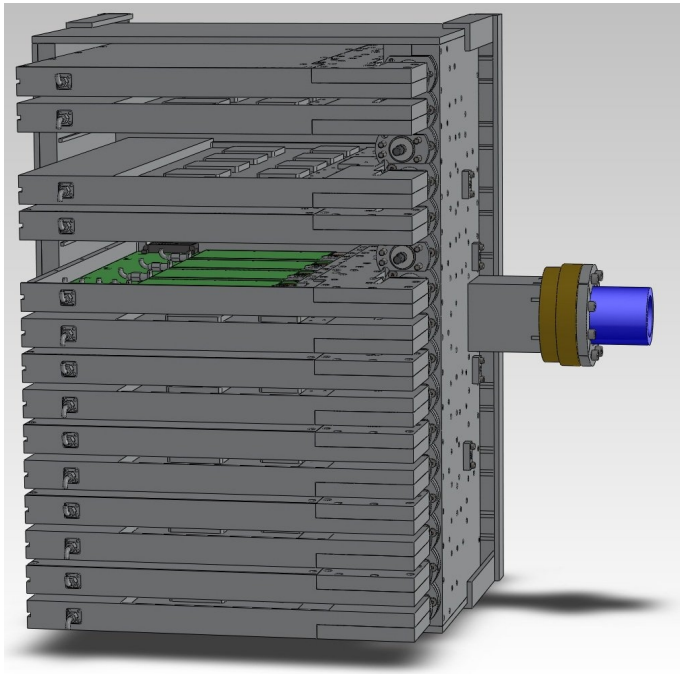
1) Ramp up module production

2) Build pre-amplifier

3) Module 24 hr. burn-in

4) Assemble amplifiers; conduct several 24 hr. burn-in tests

5) Deliver to JLAB



Economics: Klystron vs. Solid-State

Assuming a device (solid-state amp or klystron) must be purchased, how to choose in favor of more expensive solid-state amp?

	Efficiency	Cost of device	Cost of electricity/yr*
Klystron	28%	$32k	$11.3k
Solid-state amp	58%	$55k	$5.4k

*Assumptions:
6.5 kW, 4300hr/yr, 0.01$/kw, 90% efficiency of power supply (mains to 48V or 12 kV)

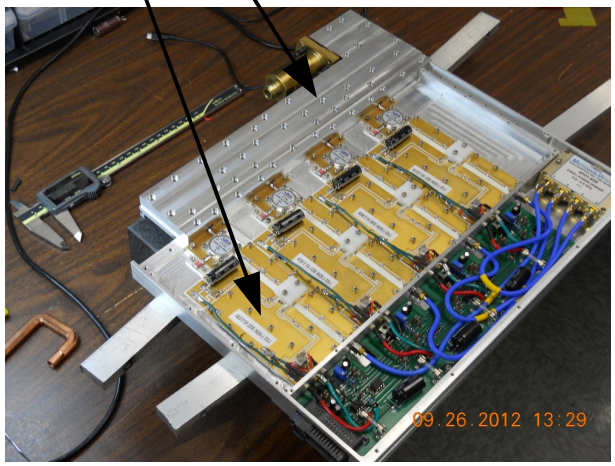
Rate of return:
Excess cost of $23k is paid back at a rate of $5.8k/yr due to energy savings, therefore achieving payback in 4 years.

Re-Tune for 1300 MHz Operation?

1) Redesign 16:1 combiner

2) Slight change to 4:1 combiner

3) Retune transistor matching circuits.



Use scenario: Project X Linac (Included in 2013 SBIR Solicitation, for our design is ready to commercialize).

Conclusion

On-track to deliver first amplifier in early 2013

Many commercialization opportunities