



Solid State RF Power Amplifier for CEBAF*

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Thanks to Rick Nelson (JLAB) for his collaboration.

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Outline:

- Company profile
- Motivation, requirements, and existing CEBAF klystrons
- Solid-state amplifier development
- Conclusion

Company profile:

FAR-TECH: founded in 1994, “Fusion and Accelerator Research”

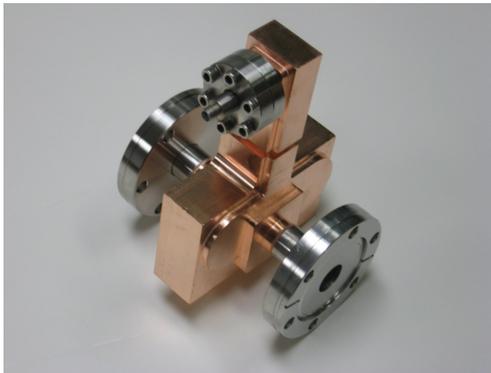
Areas of expertise:

Particle accelerator systems

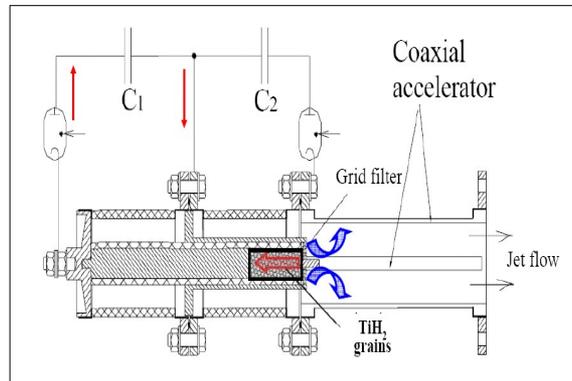
Computational physics and code development

Fusion and plasma research

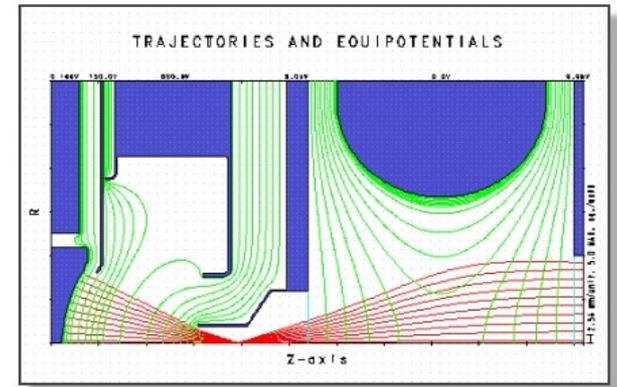
Some representative projects/capabilities:



Beam Quadrupole Monitor



Tokamak disruption mitigation using Fullerene (C₆₀)



PBGUNS code

Existing klystron technology



klystron and socket assembly

338 klystrons are used:

- 6.5 kW CW linear regime, ~8 kW peak
- Narrow band centered around 1497 MHz

Replacement and refurbishment costs have increased.

Peak efficiency is around 40%, actual operating point is closer to 33% efficient:

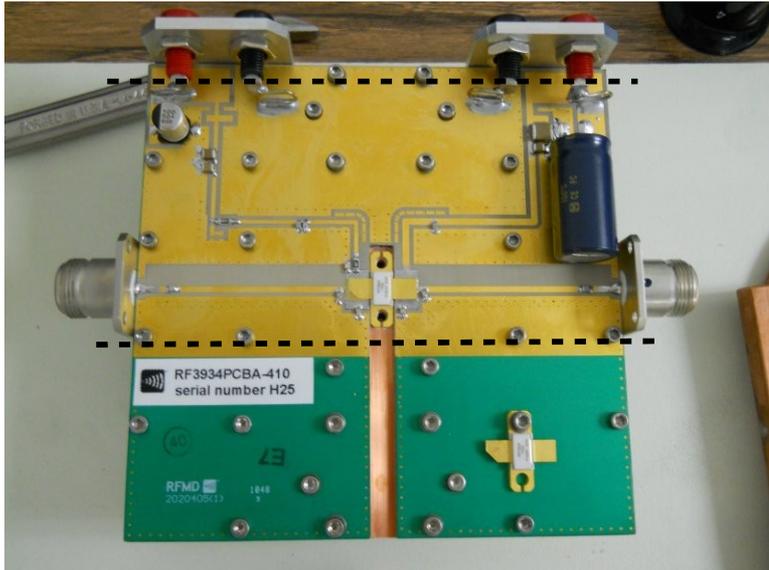
There is room for improvement!

Some linac quench protection trips are really caused by klystron glitches.

Can help sub-critical reactor application.

Any new technology must be a drop-in replacement for the existing tube.

Final transistor stage specs are key to overall system parameters.



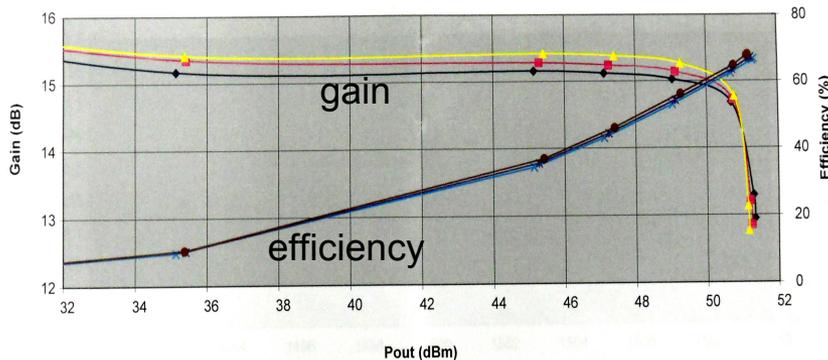
120W module based on a GaN transistor has been selected.

GaN is new technology: this specific part did not exist at time of Phase II proposal.

Efficiency of 62-63% has been achieved.

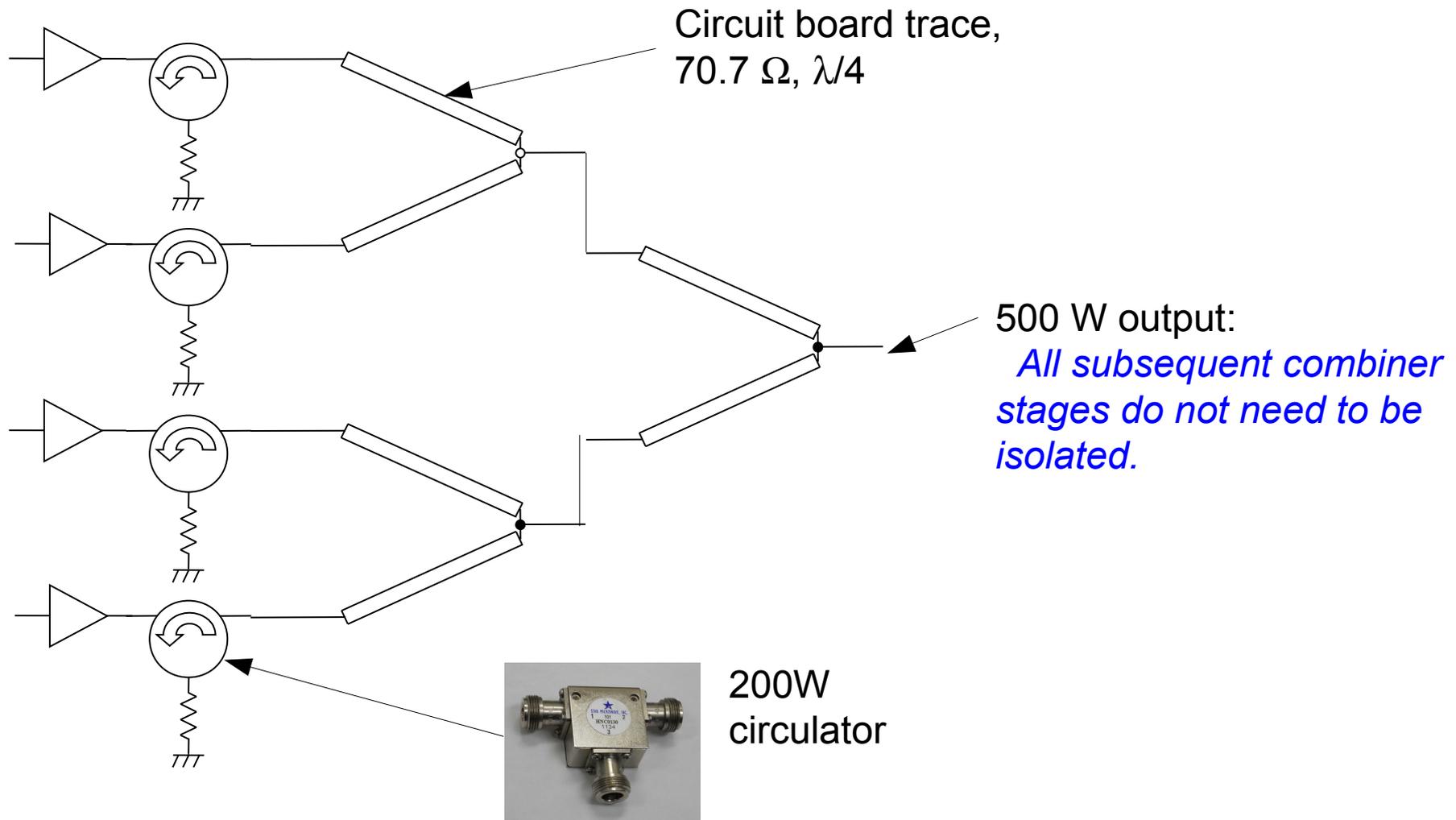
Reliability and MTBF can in principle be very good: >200K hours. Relies on good thermal design (see later slide).

Need to combine 64 transistor outputs, each board 3"X5".

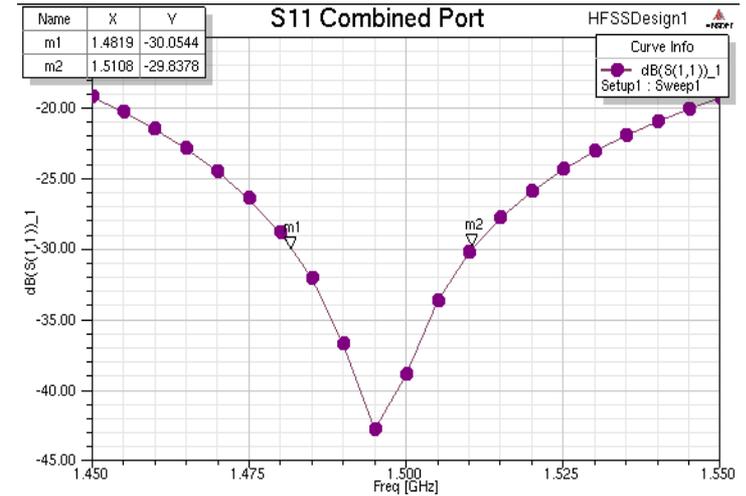
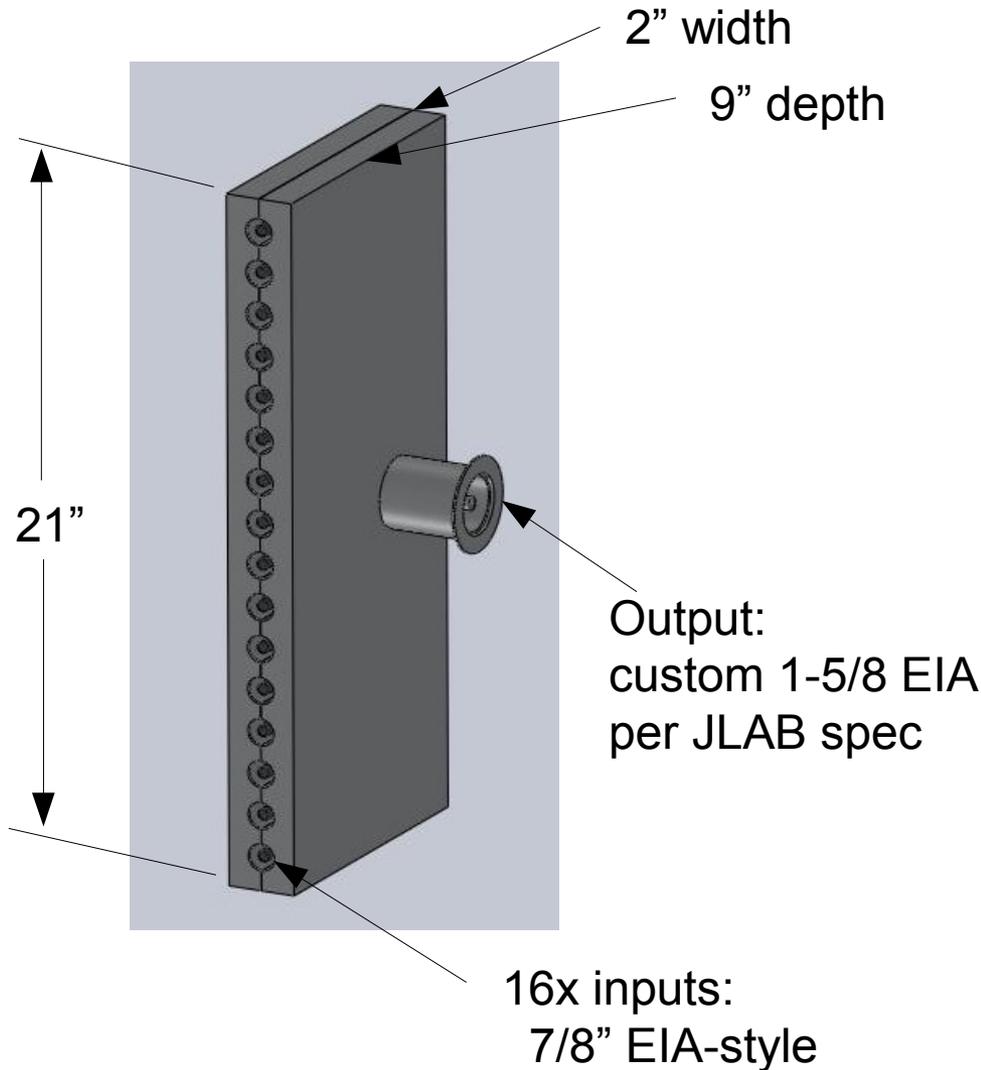


Characteristics at 1495, 1500, 1505 MHz

Power combiner for a 500W module: Isolated network allows graceful degradation.



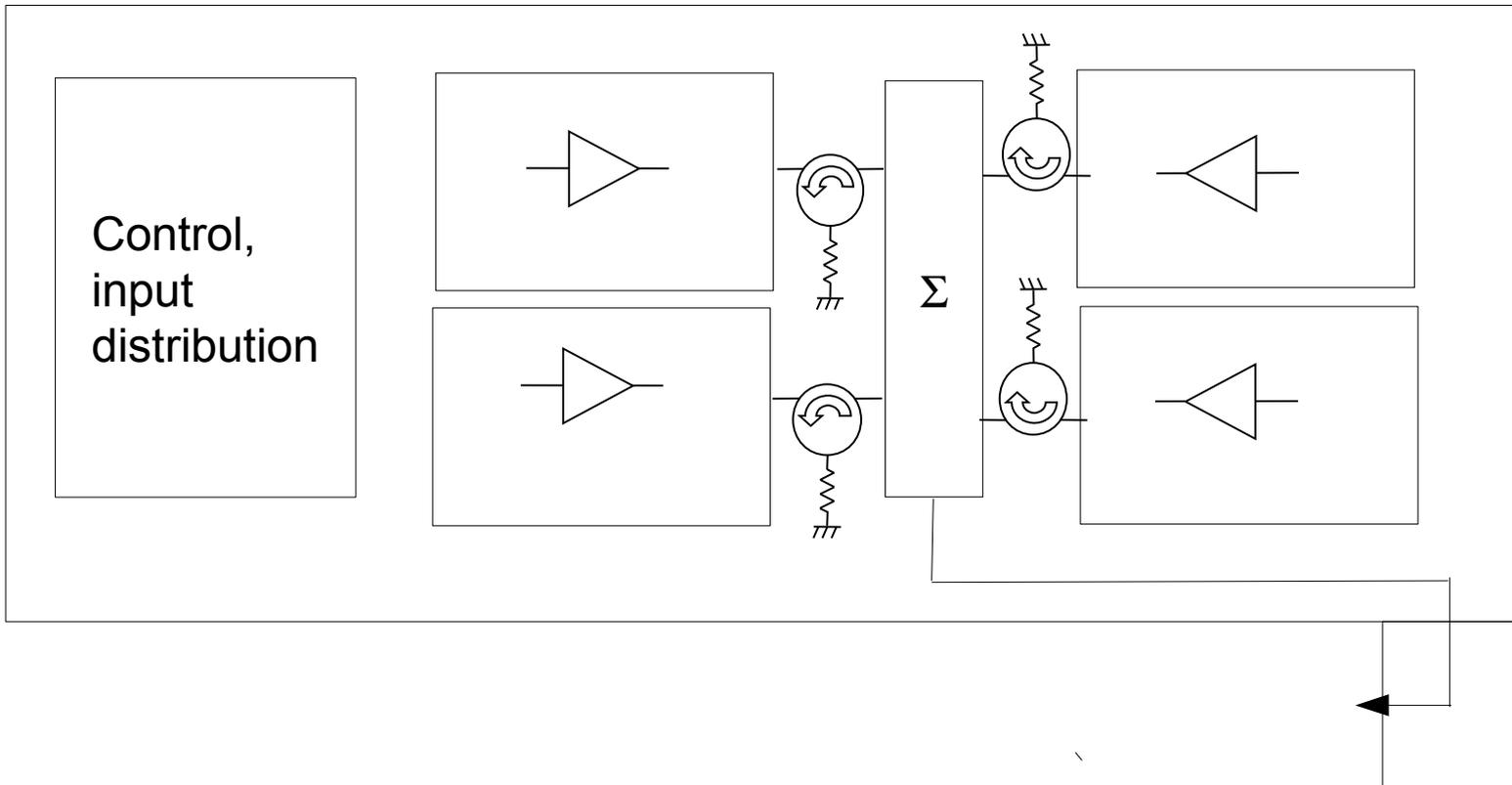
16:1 Combiner Must Handle Full Power



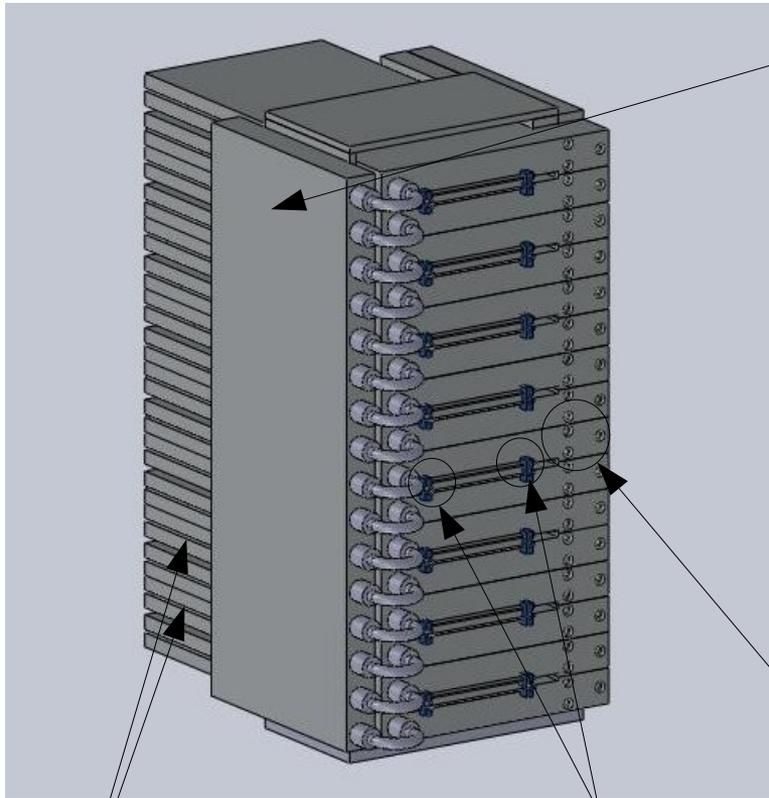
Good match over 30 MHz range.

500W Module Block Diagram

Each 500W module is 6"X16"X1.125"

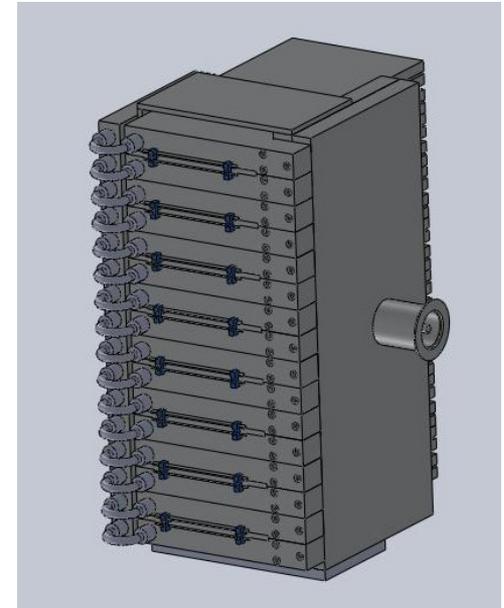


Simple module interchange: Unfasten five screws and two connectors.



Input amplifier

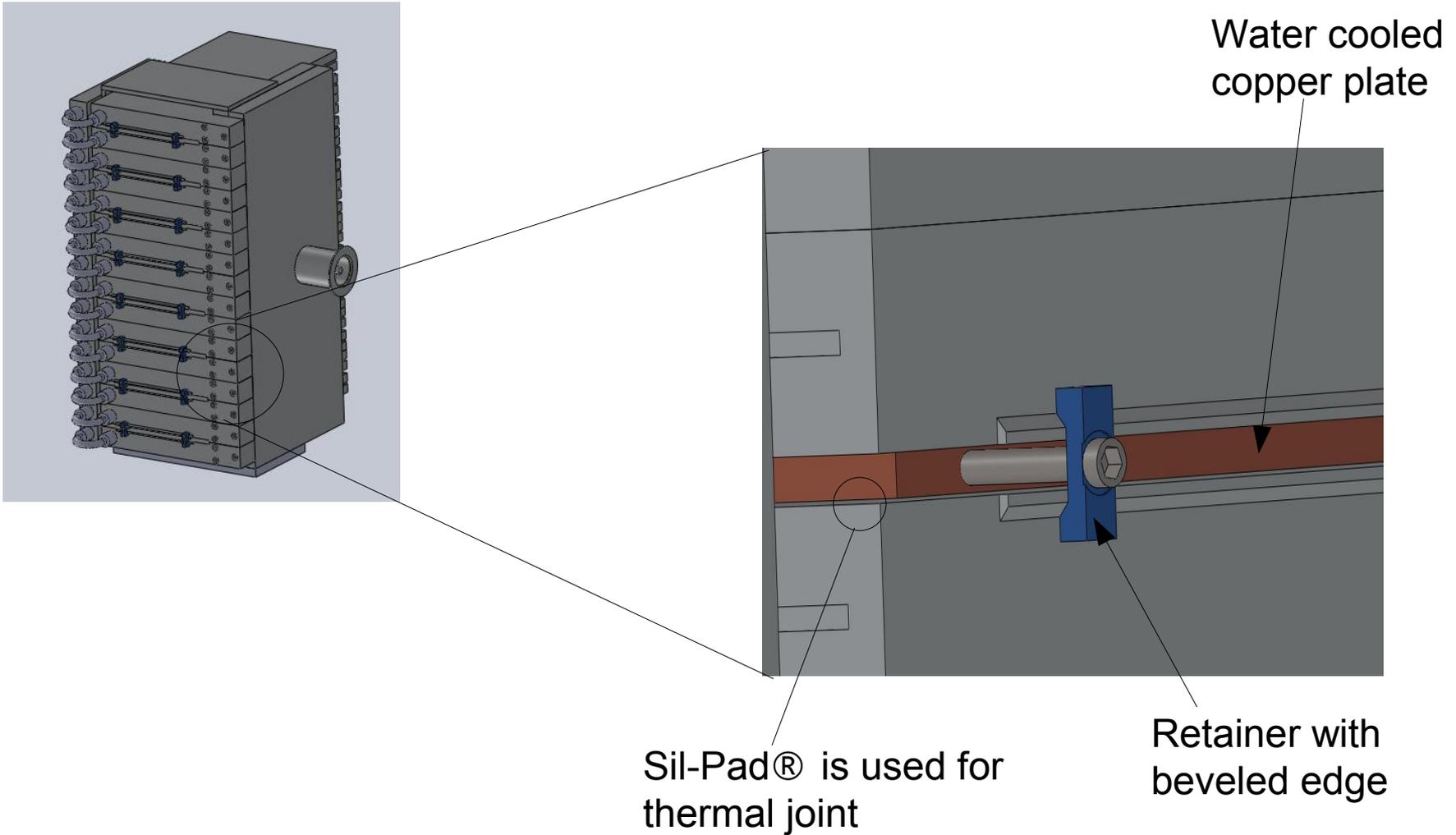
RF flange hardware



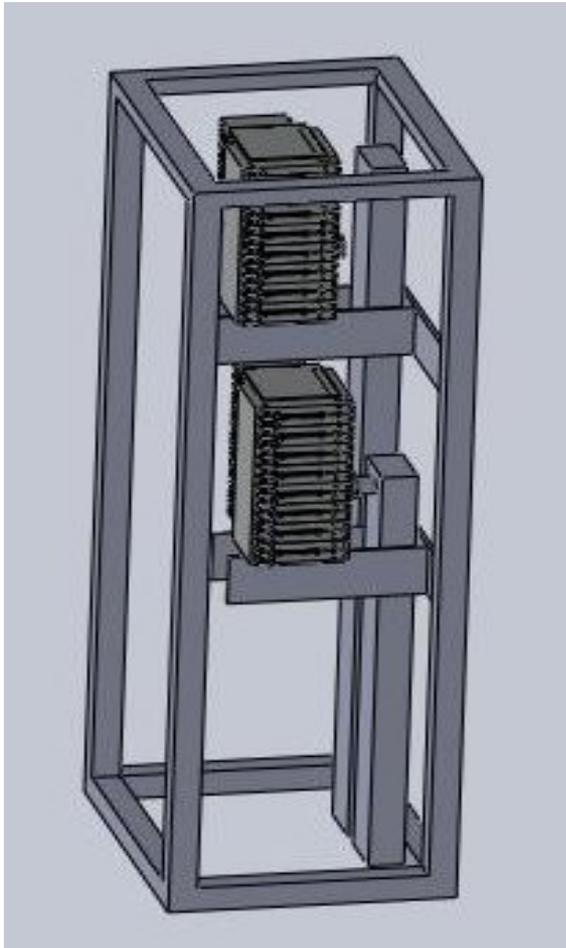
Grooves at either end of modules

Retainers force modules against water cooled plate

Thermal design: Modules are forced against a water cooled copper plate.



View of a two-amplifier installation.



48V DC power supply (not pictured):

In Phase II, need to mount the individual supplies near each amplifier.

Beyond Phase II, might want to power eight amplifiers from one bulk supply.

Conclusion

Solid-state RF amplifiers are an efficient and robust technology for powering a CW linac.

FAR-TECH has performed the design, tested sub-components, and is launching fabrication of the power amplifier.