

High-Output Pulsed Power Source

PI/Presenter: Alexander Yu. Smirnov, Ph.D.

DOE SBIR Award DE-SC0021548

DOE NP SBIR/STTR Phase II PI Exchange Meeting, August 15, 2023

- Founded in 2004
- ~50 employees and growing
- 30,000 ft² headquarters in Santa Monica, CA



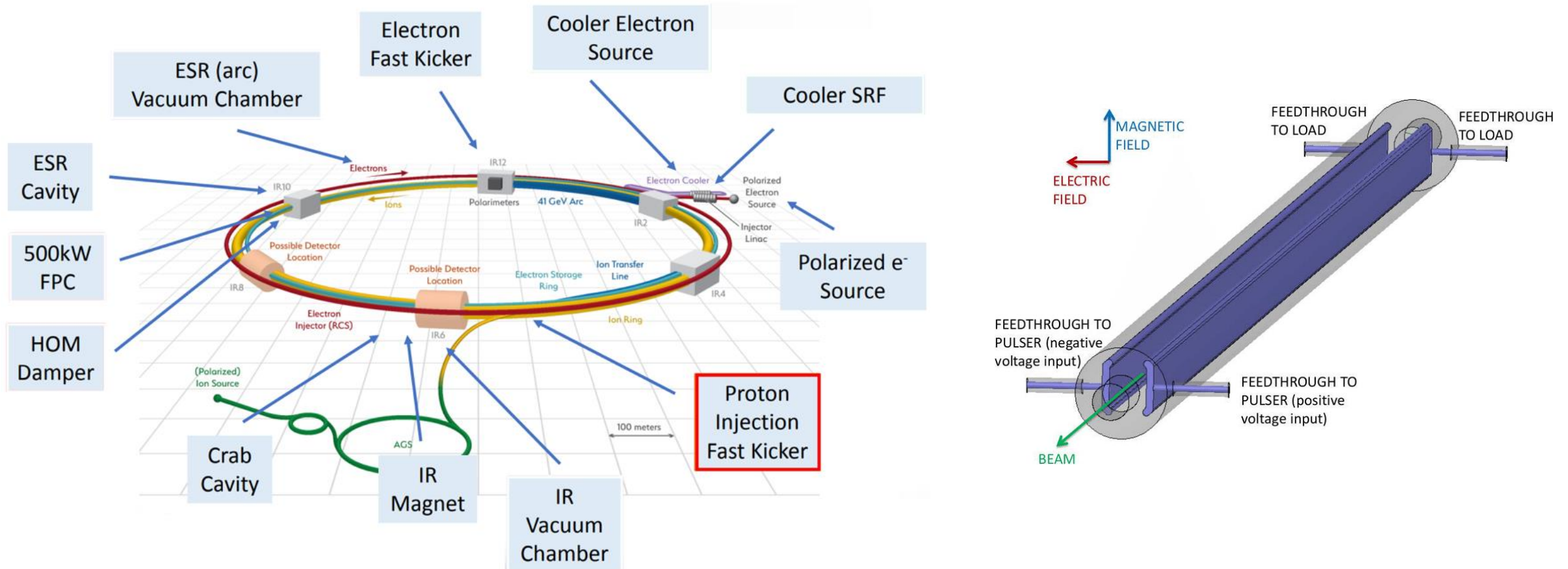
- Accelerator R&D, design, engineering, manufacturing and testing all under one roof in a dynamic, small-business setting



- Multiple CNC milling and turning centers, > \$3 million investment
- Dedicated “clean shop” for RF and UHV machining
- Full-suite of inspection equipment, including CMM
- 10 highly-skilled machinists
- ISO 9001 compliant quality system



- Brookhaven National Laboratory has recently been selected as the site for the Electron-Ion Collider (EIC). The EIC will consist of two intersecting accelerators, one producing an intense beam of electrons, the other a high-energy beam of protons or heavier atomic nuclei, which are steered into head-on collisions. One of the sections of the EIC beamline will require a hadron injection kicker system (~ 20 kickers)
- The injection kicker system for EIC will be required to support single bunch transfers with a bunching frequency of 24.6 MHz

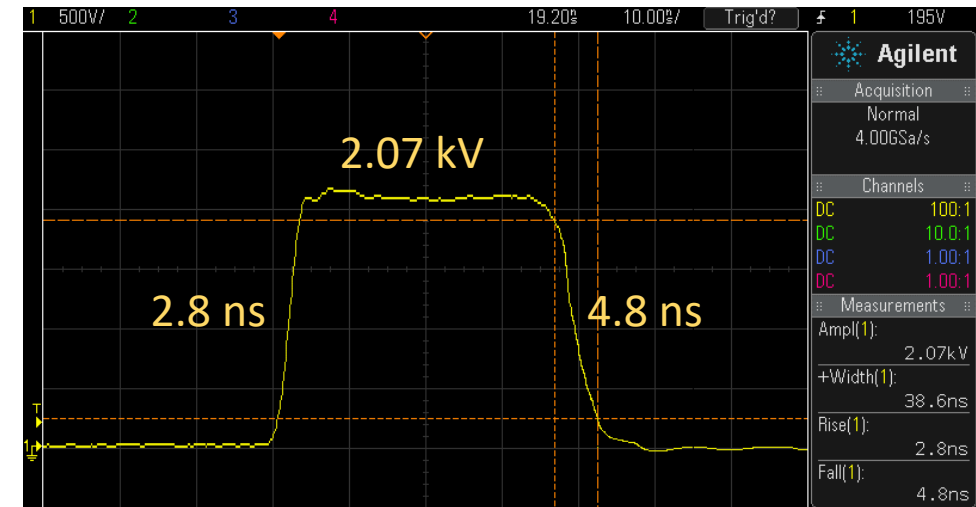


Parameter	Value	Achievements in RadiaBeam's Phase I
Peak Voltage / Current / Power	+/-50 kV / 1 kA / 50 MW	+5.8 kV / 116 A / 673 kW
Average power per channel	Up to 200 W	<3 W
Load Impedance	50 Ohm	50 Ohm
Pulse Width	40 ns including transition times	~40 ns
Rise/fall times	<10 ns each, <20 ns combined	3.0ns / 3.6 ns
Repetition rate	20 Hz normal operation, up to 100 Hz for lifetime test	Tested at 100 Hz for several hours

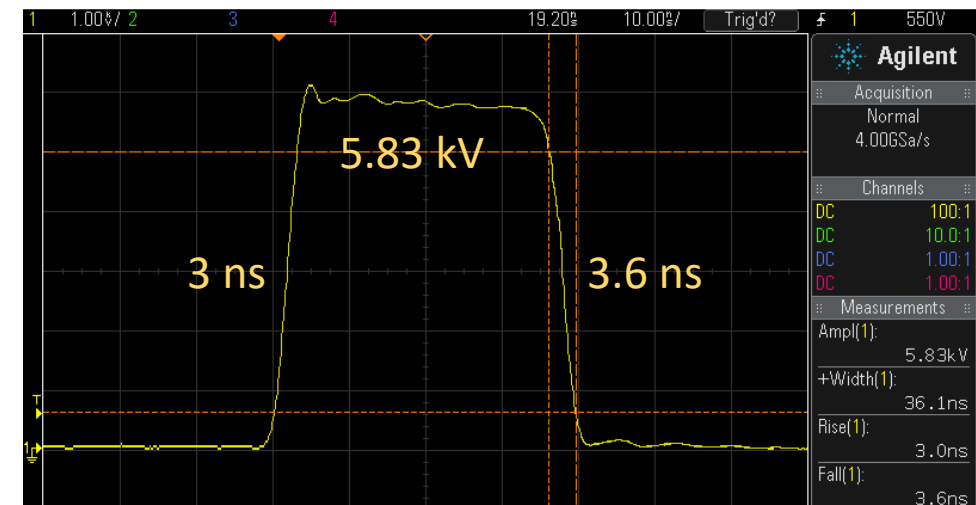
- 3x2 Marx cell configuration in each module: 2 kV / 116 A
- 3 x 2 kV / 116 A modules + PCB-based combiner



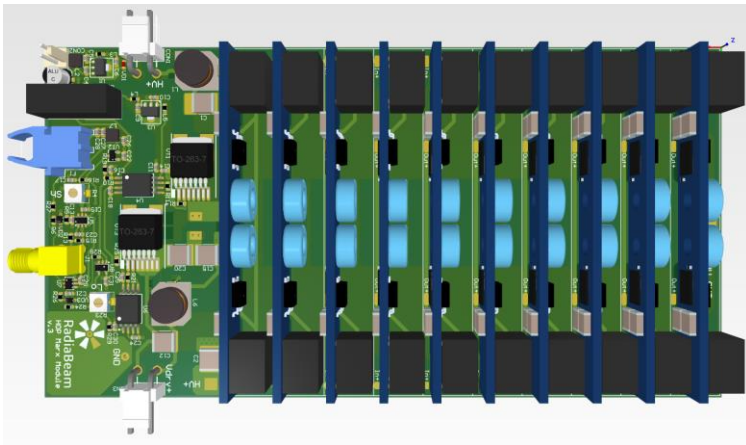
Single 2 kV / 116 A modules output waveform (16.6 Ohm)



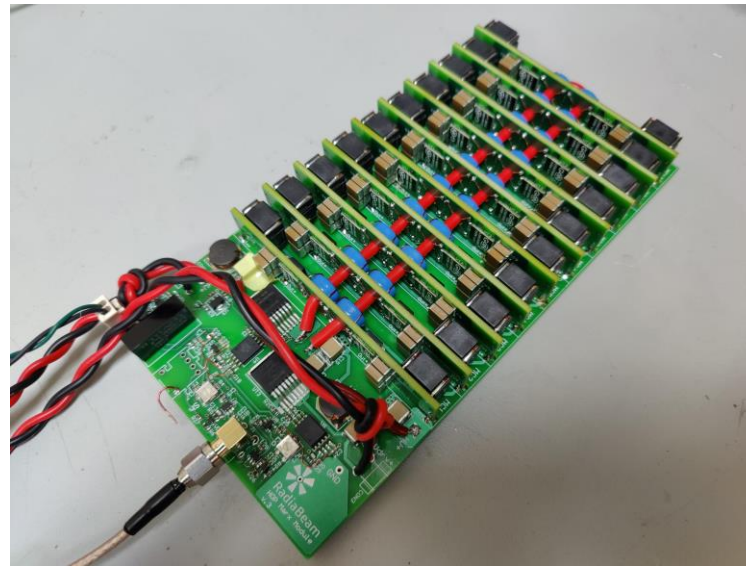
3 x 2 kV modules output waveform (5.83 kV / 116 A / 50 Ohm)



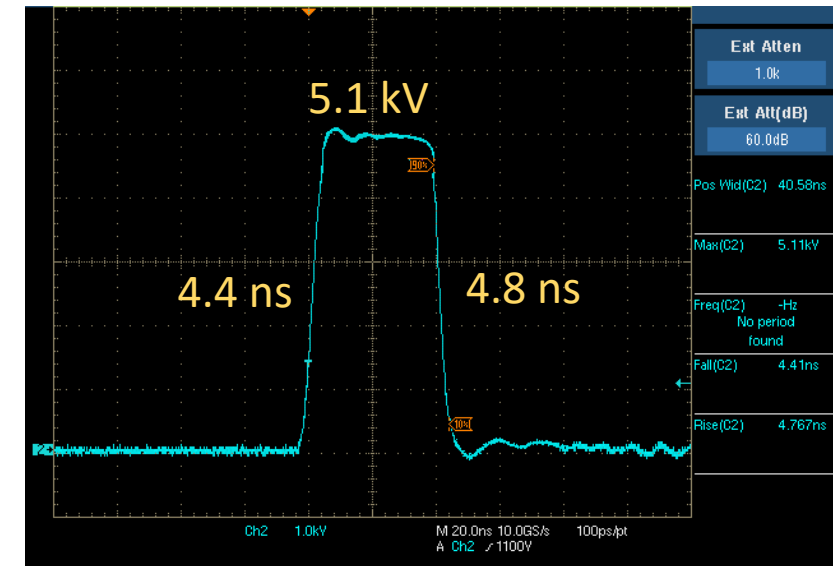
- 2 kV / 116 A -> 5 kV / 167 A
- Major module redesign: improved pulse parameters; compactness; ease of assembly
- 3x2 cells -> 10x2 cells; added protective diodes
- Driver improvements



3D design

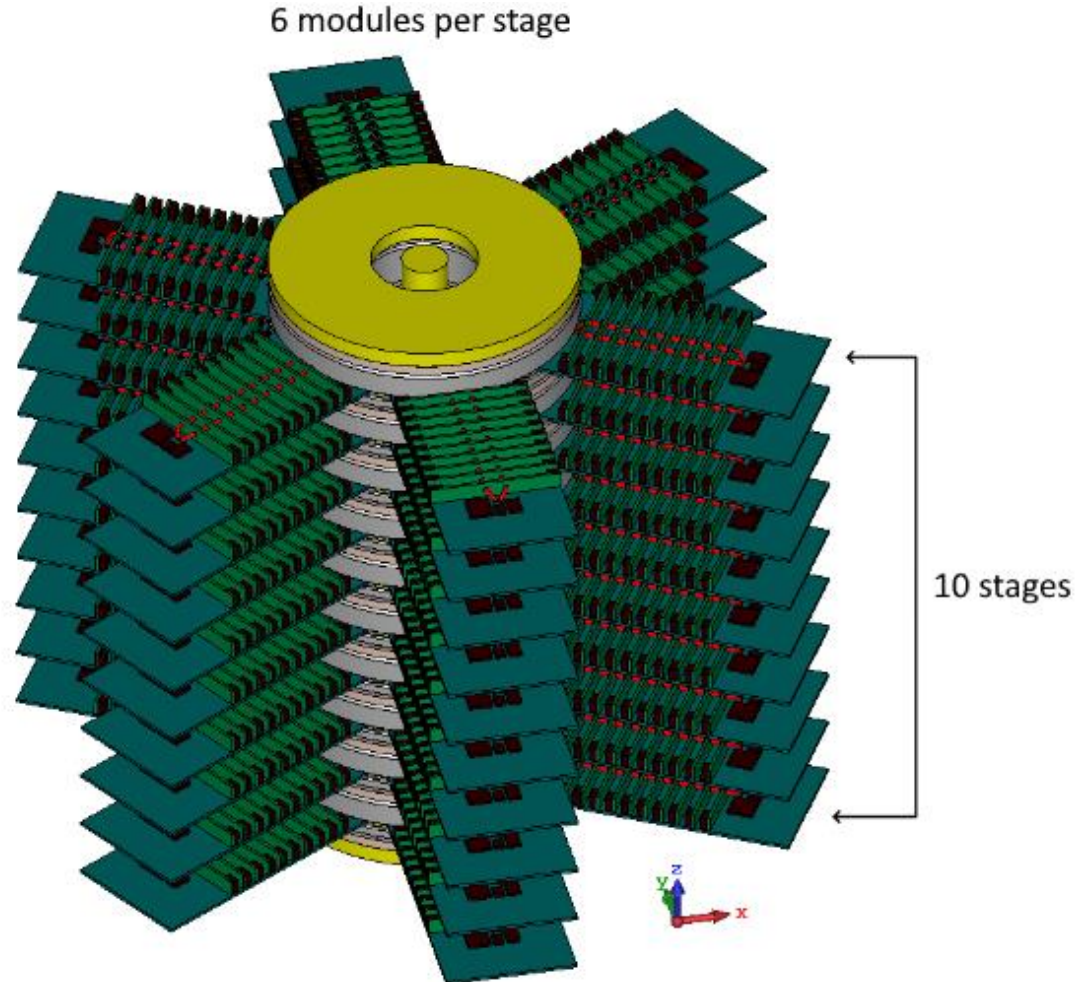
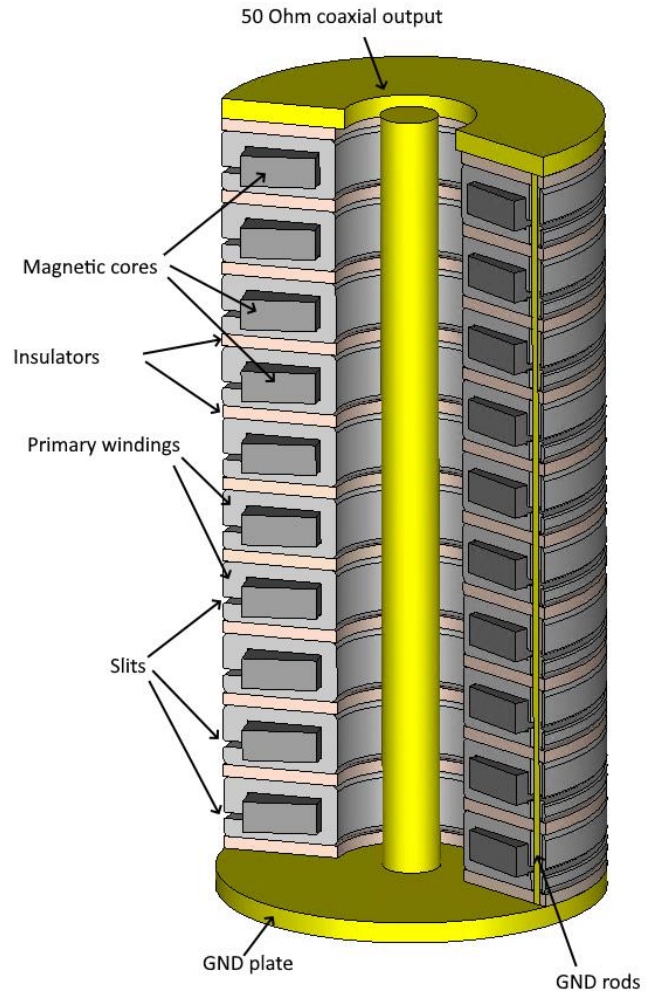


Assembled module

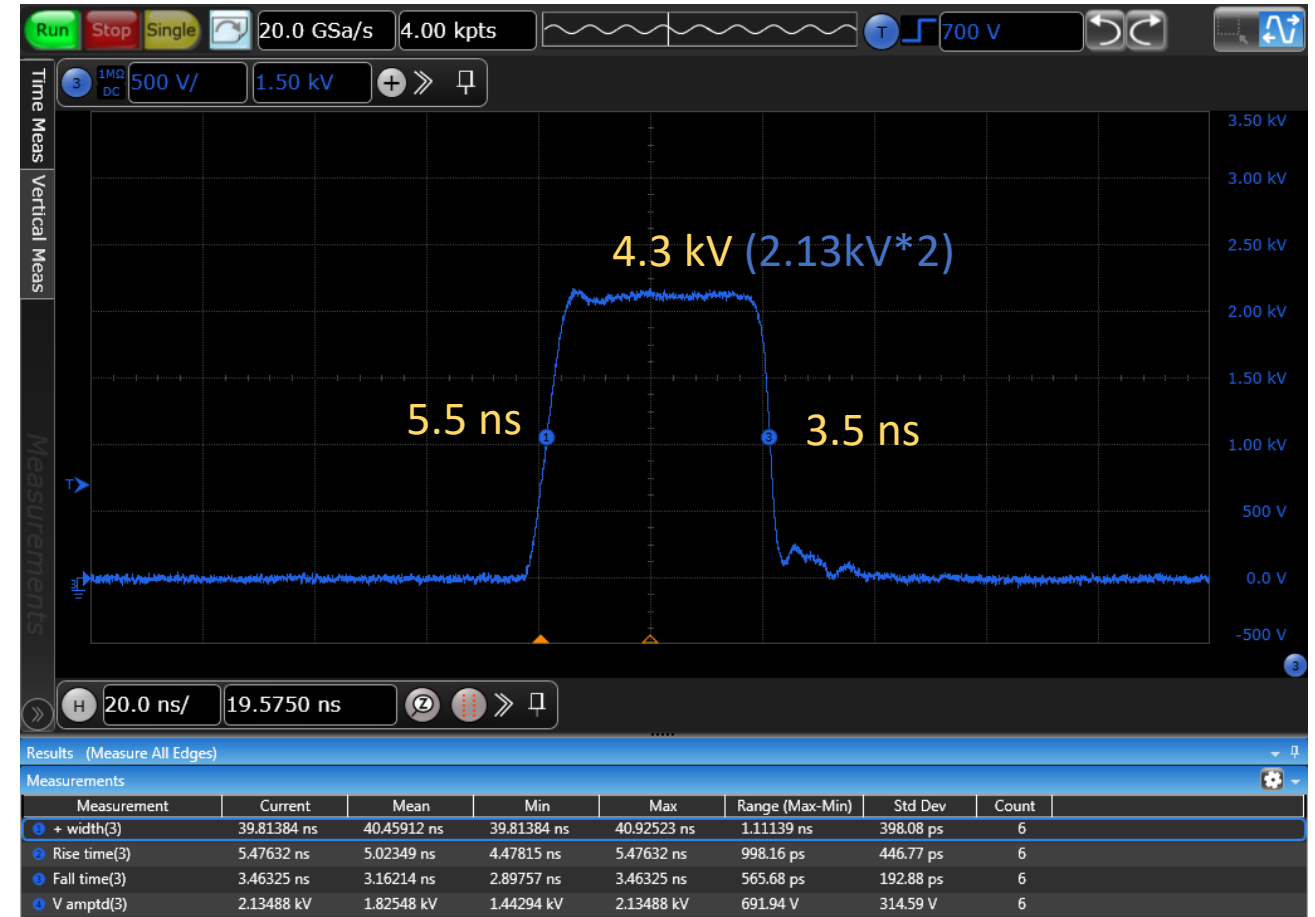
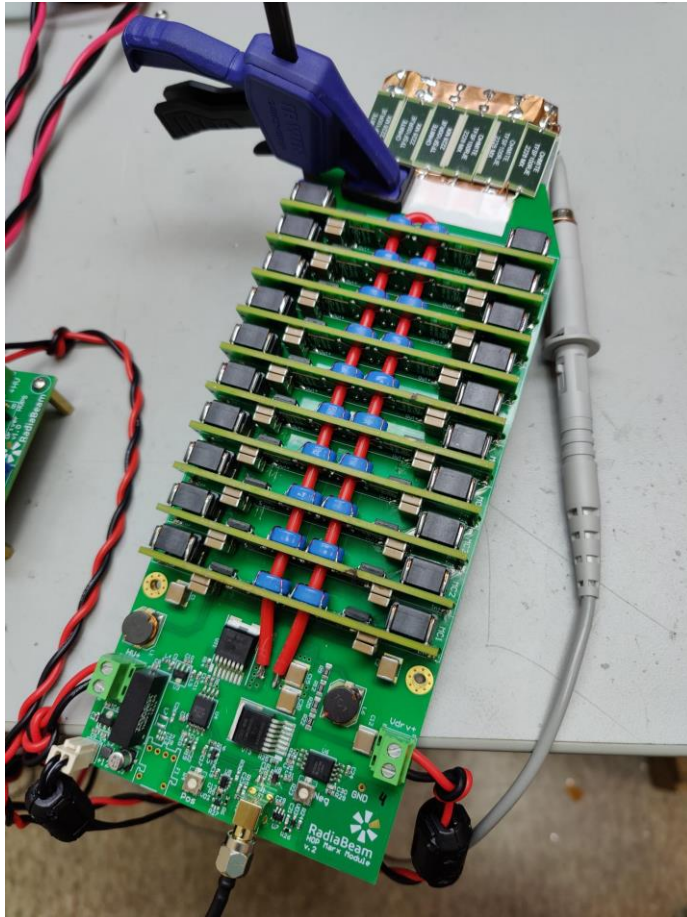


Measured 5.1 kV / 166 A (30 Ohm)

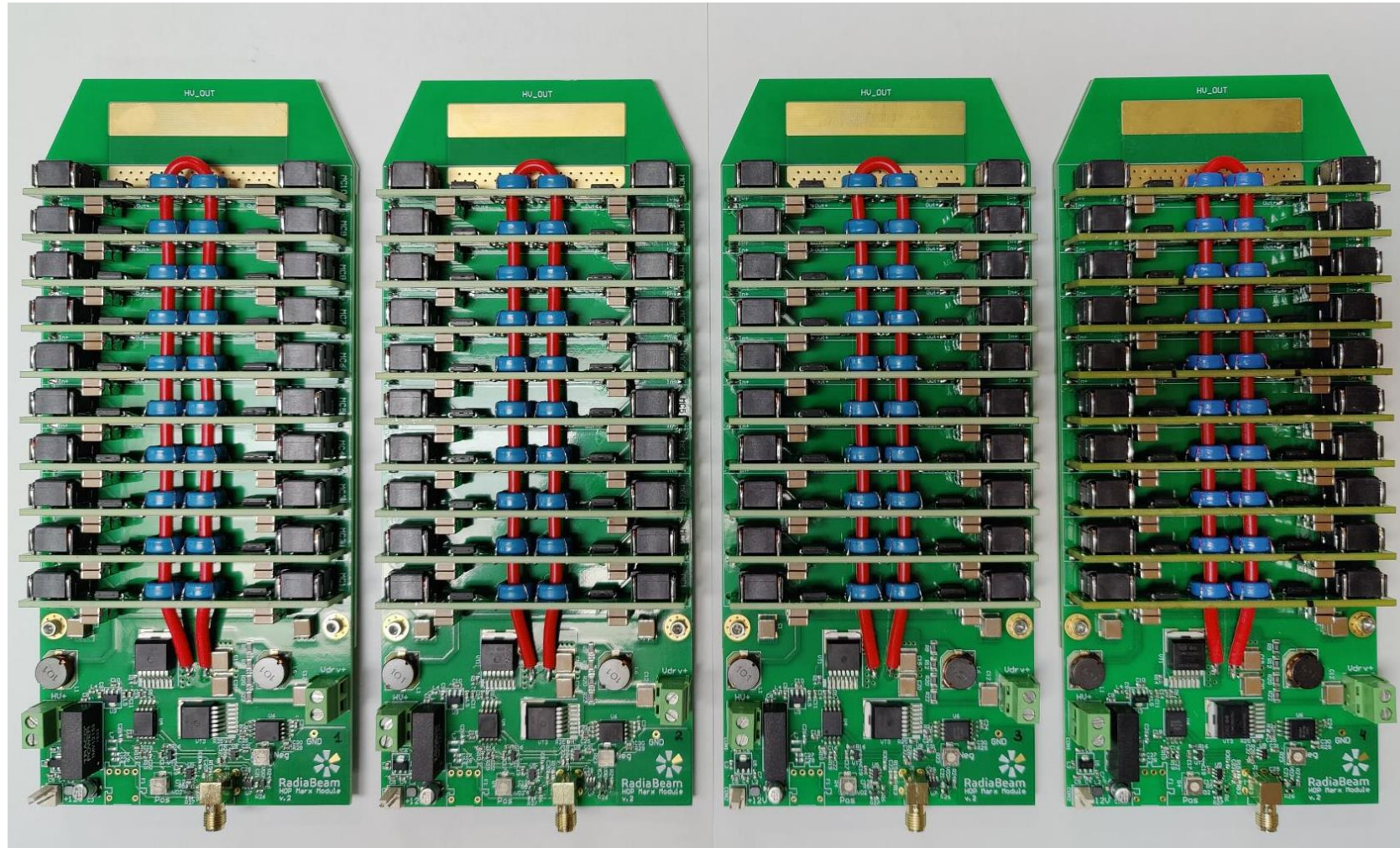
- 5 kV / 167 A modules
- 6 modules per stage = 1 kA; 10 stages = 50 kV – 50 Ohm equivalent



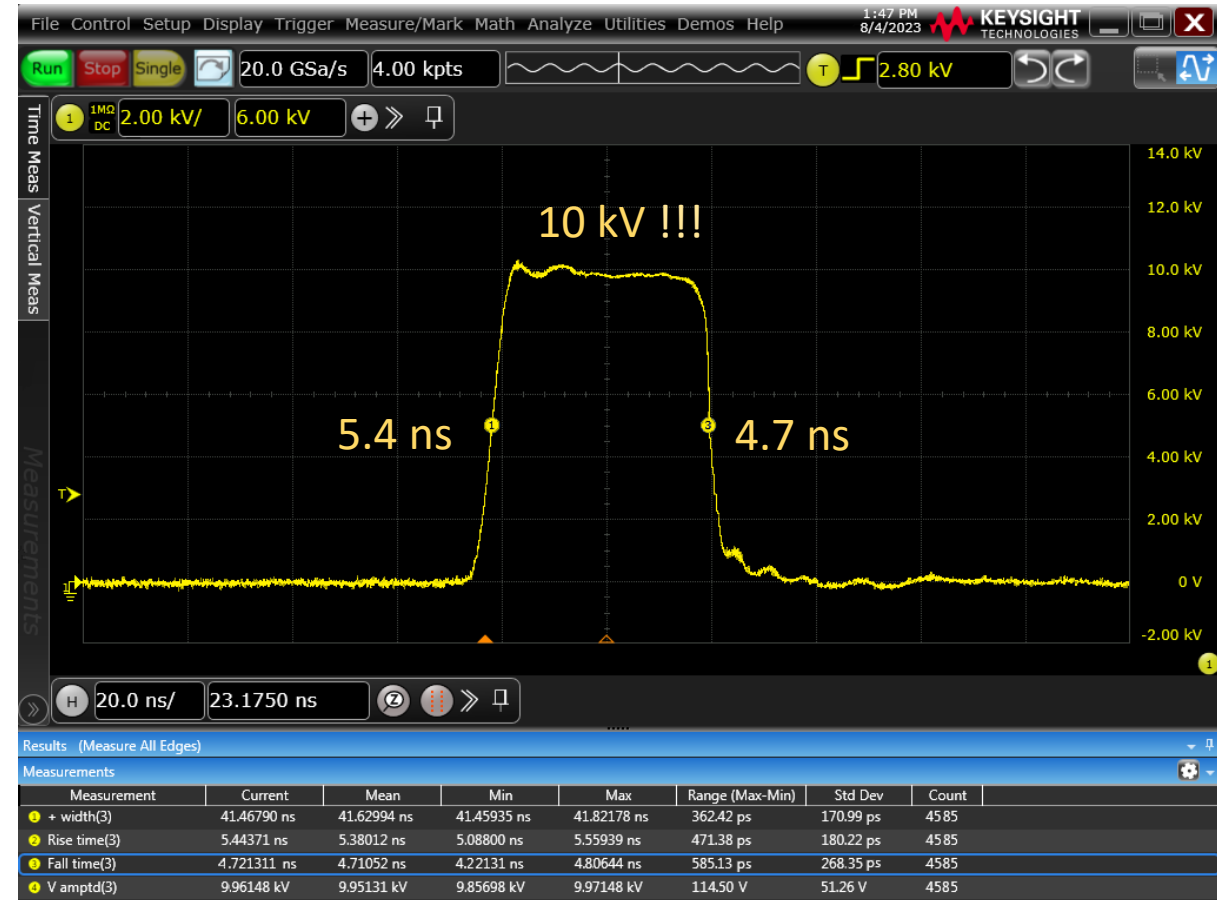
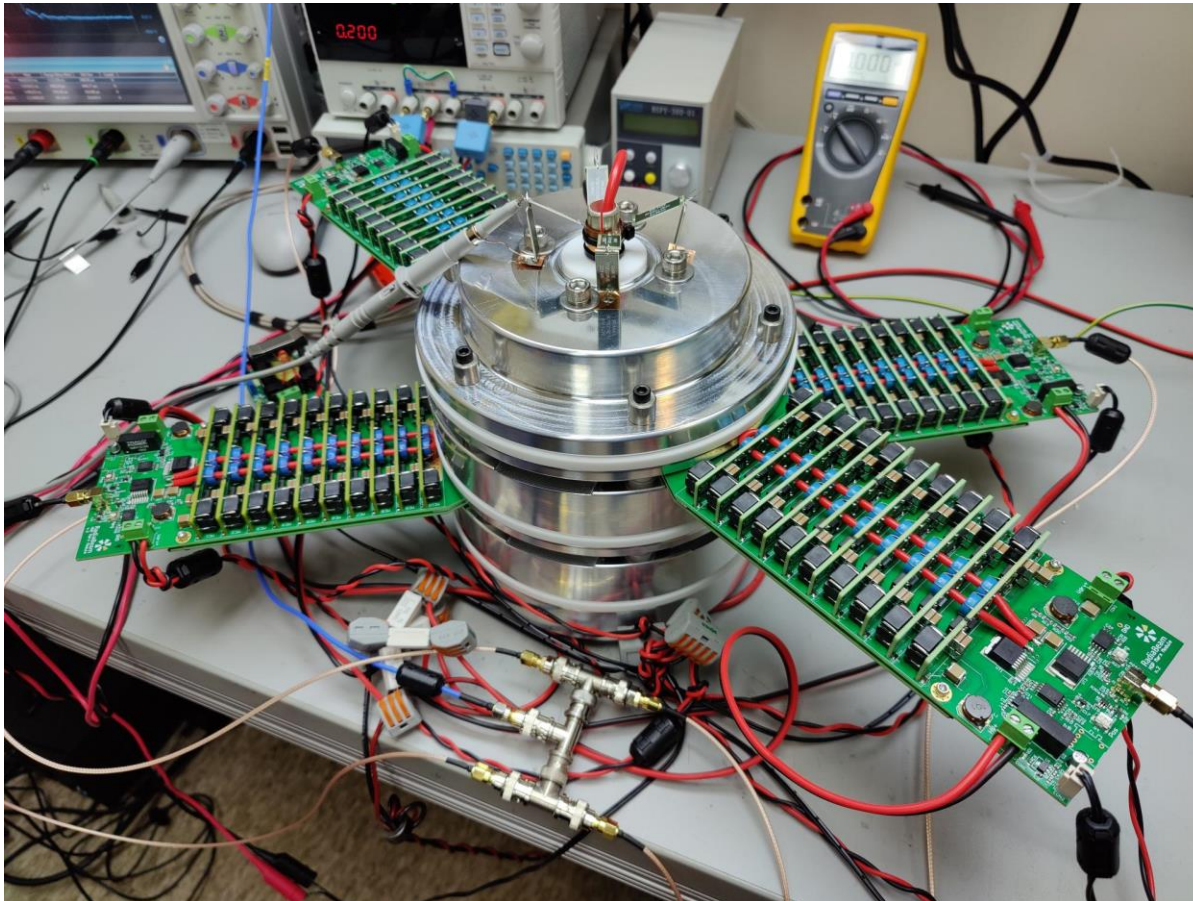
- 5 kV /166 A modules
- 10x2 Marx cells configuration – 30 Ohm load
- Rearranged + and GND terminals for easy connection to the IA



- 5 kV /166 A modules
- 10x2 Marx cells configuration – 30 Ohm load



- 5 kV /166 A modules
- 2x2 Inductive adder configuration – 30 Ohm load



- Testing 3...6 modules per stage with 2-stage IA prototype
- Simulate 6 modules * 10 stages and optimize dimensions
- Fabricate full-scale 6*10 IA
- Assemble and test 60 modules

