Compact 1 MeV Electron Accelerator

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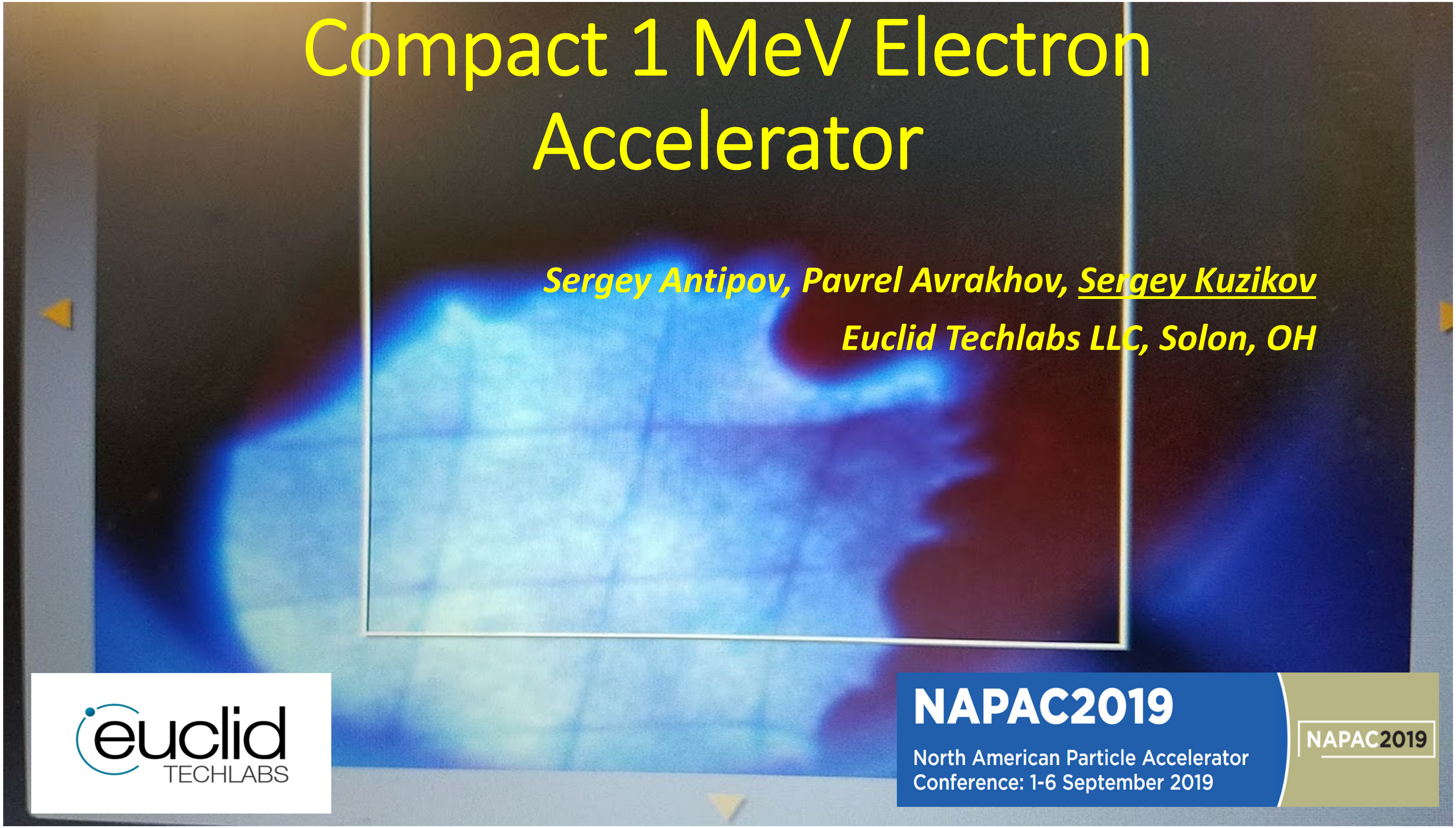


euclid TECHLABS

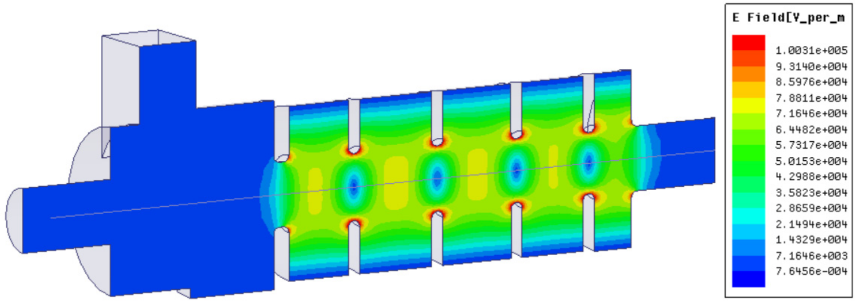
NAPAC2019

North American Particle Accelerator Conference: 1-6 September 2019

NAPAC2019

Introduction

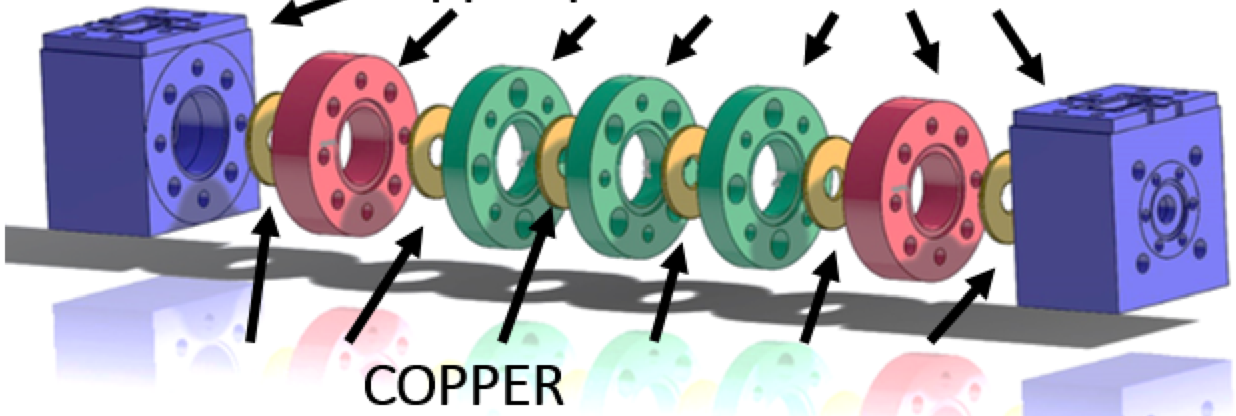
- Phase I SBIR grant from DOE – DNN (PM Dr. Donald Hornback)
- Based on Euclid’s Patent US9913360B1
- 9 month project duration
- RF design of 1 MeV accelerator fed by 200 kW magnetron
- Mechanical design
- Full fabrication
- Microwave tuning and testing
- DC gun test
- High power conditioning to designed gradient of 12 MV/m



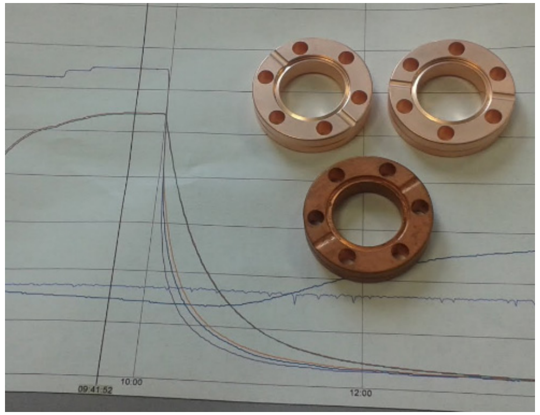
Ford T (1908-1927) - **$850**

VW Beetle (1938-2003) - **990 DM**

Brazeless accelerator benefits: cost + flexibility



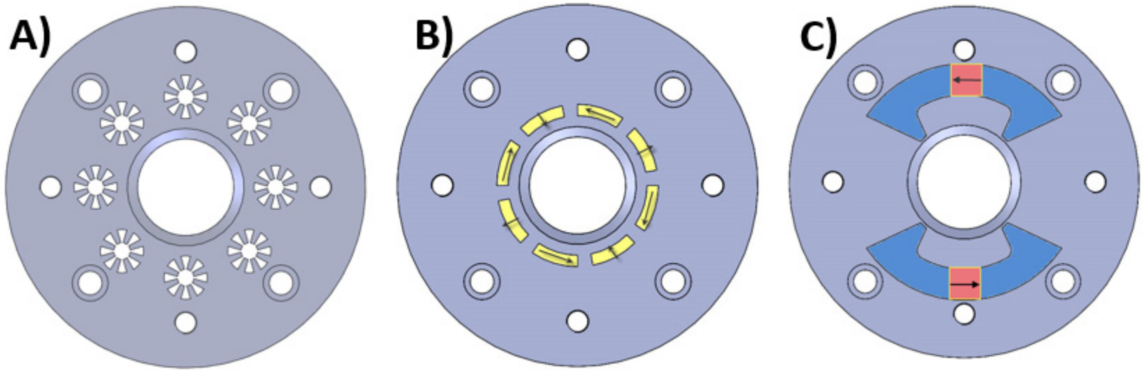
Additional embedded features in brazeless assembly. A) Efficient **heat spreader channel cooling**. B) Halbach array **magnetic optics**. C) Traditional permanent magnet quadrupole



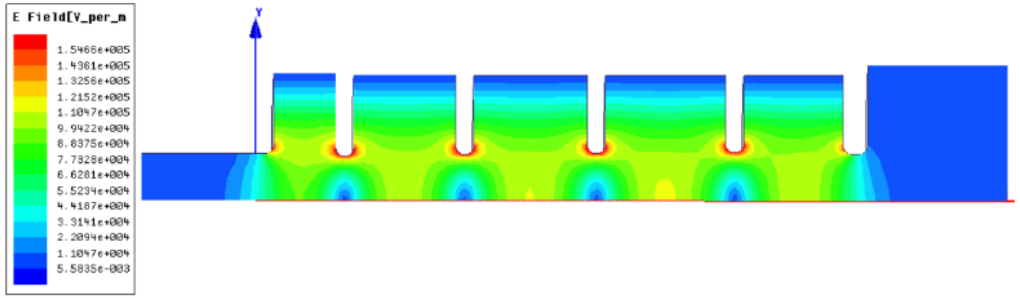
Copper plating is robust

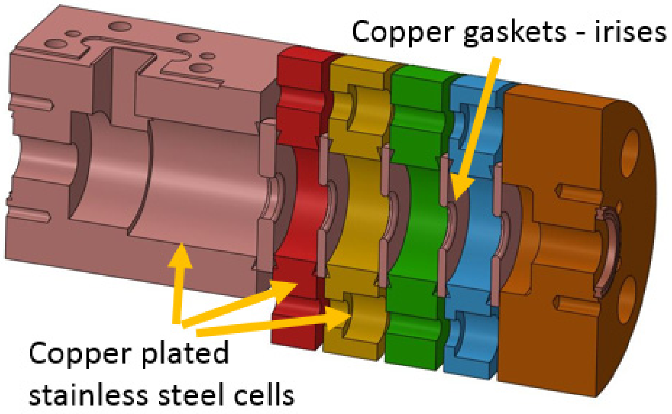
Conflat – like technology + batch copper plating

Structure cost ~ $20K

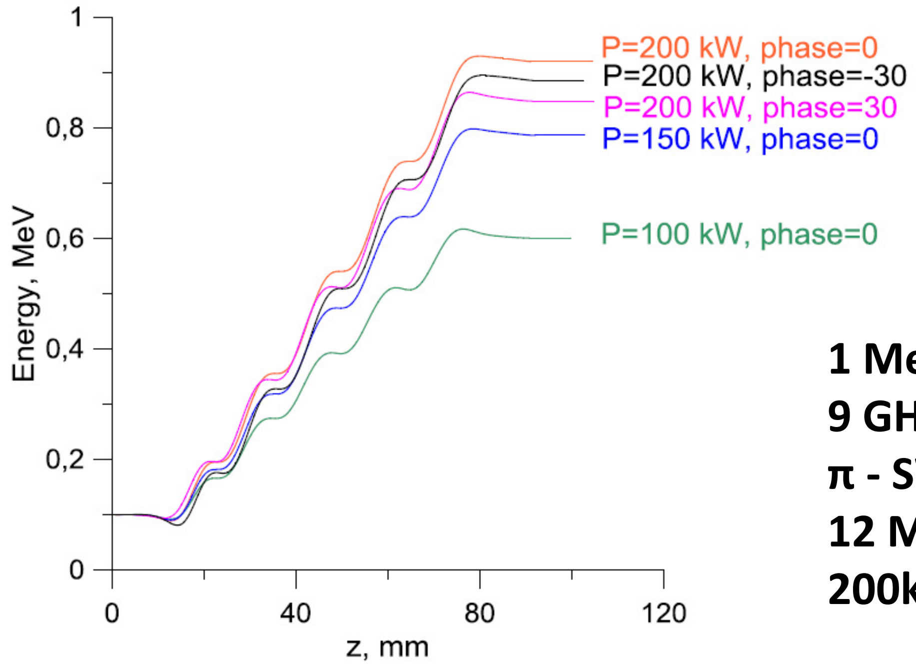


1 MeV Standing Wave Accelerator

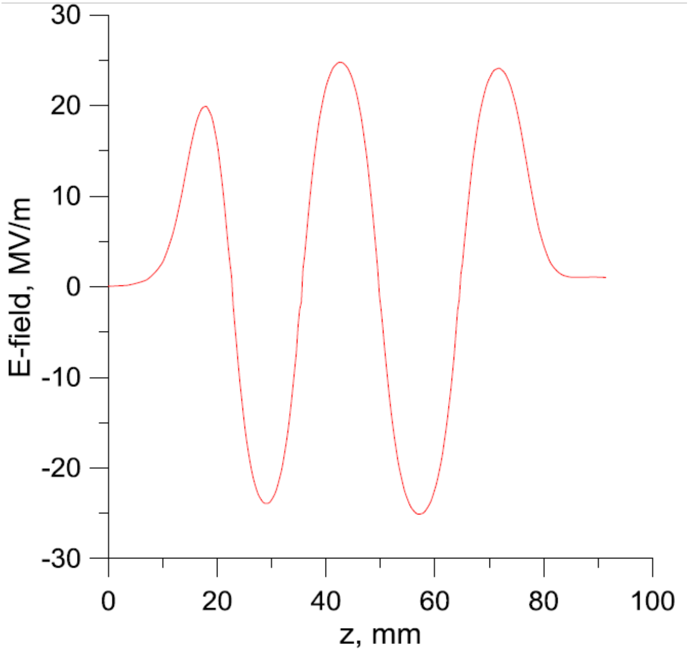




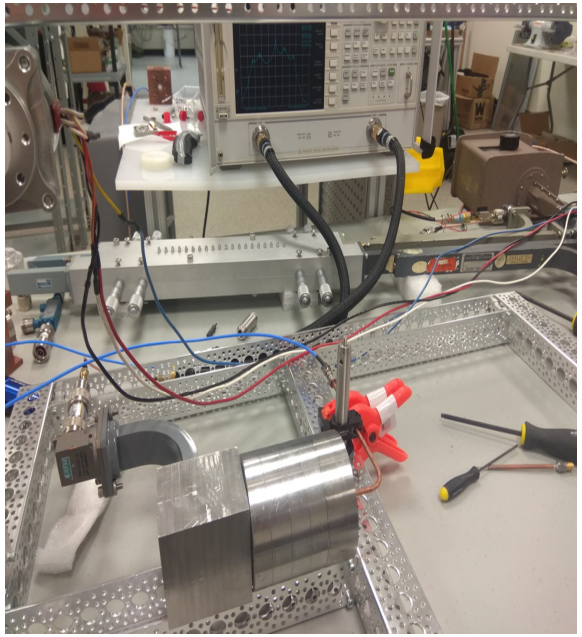
S. Antipov, US Patent US9913360B1

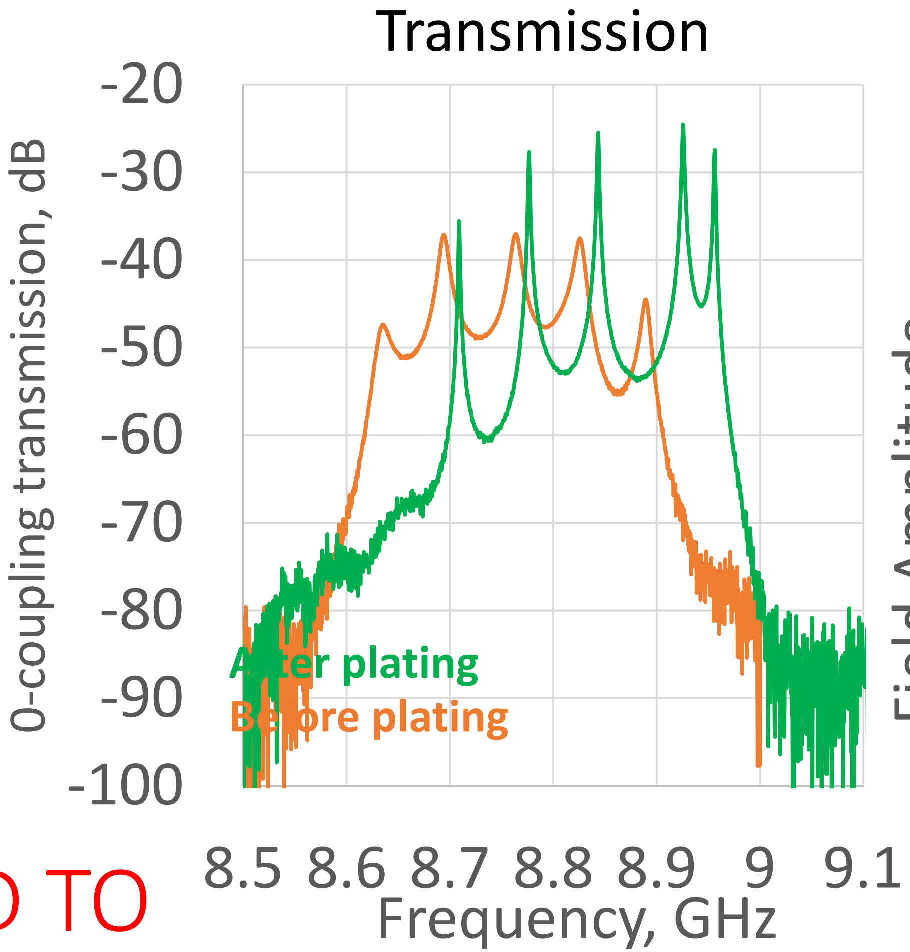


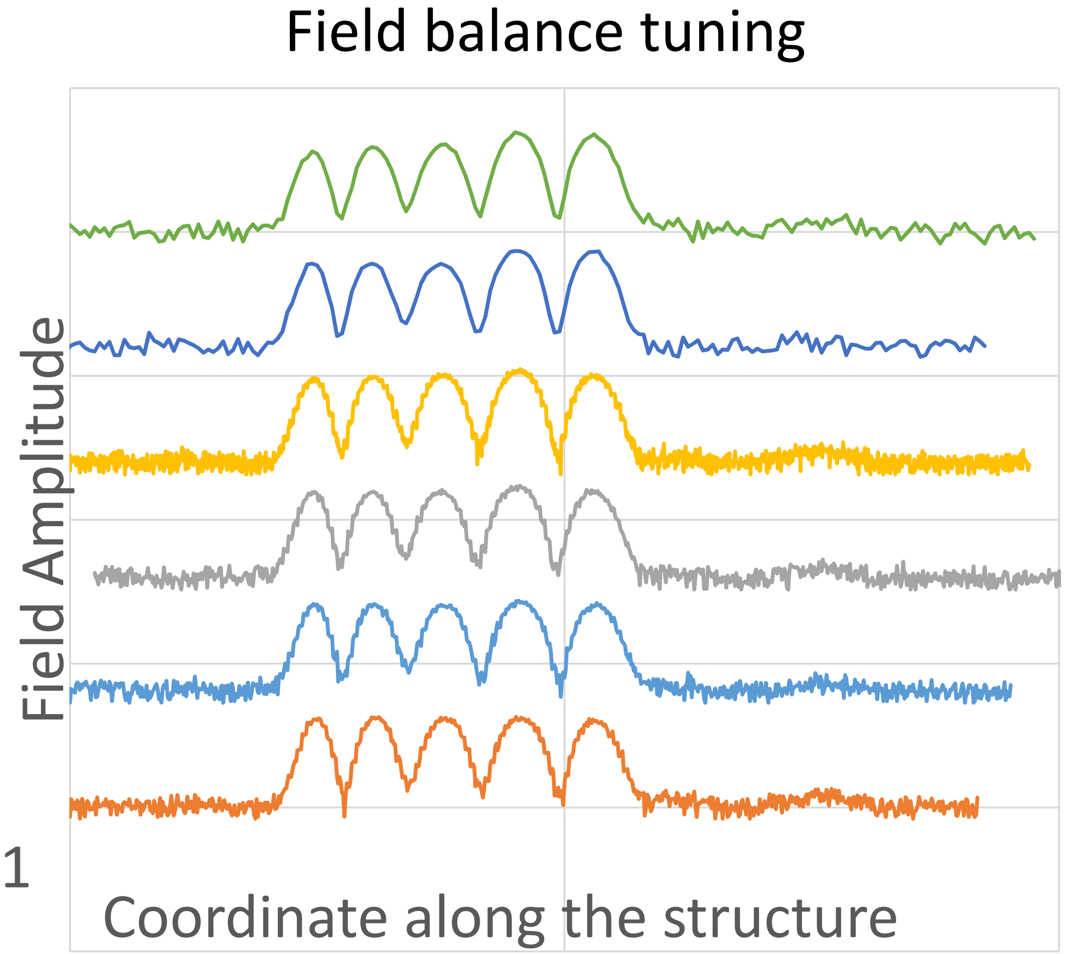
1 MeV
9 GHz
π - SW
12 MV/m
200kW



Initial Microwave Testing and Tuning



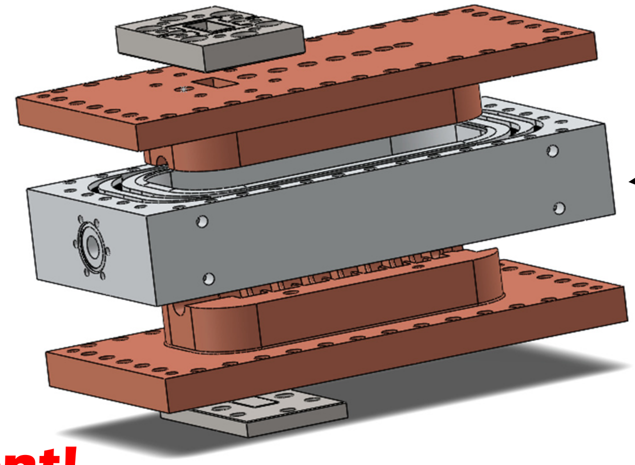




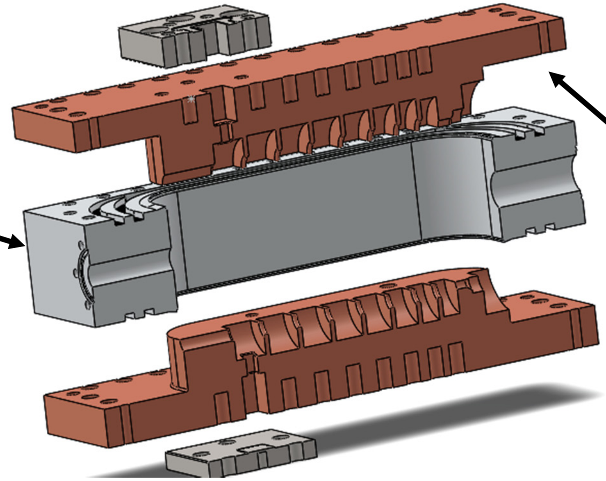
CONDITIONED TO 12 MV/m!

Brazeless Split Block Idea and 1 MeV Engineering Design

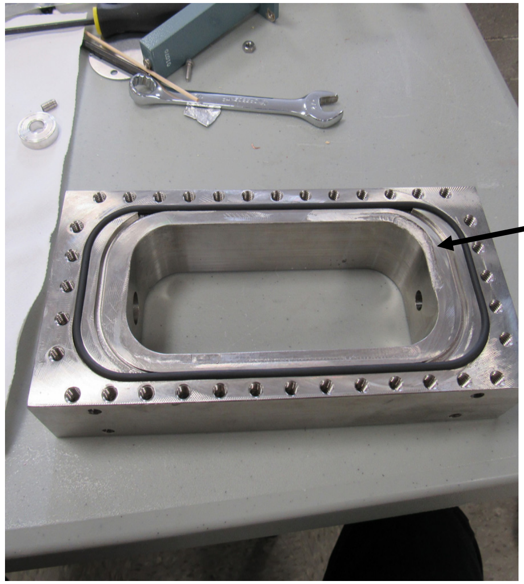
I need high gradient!



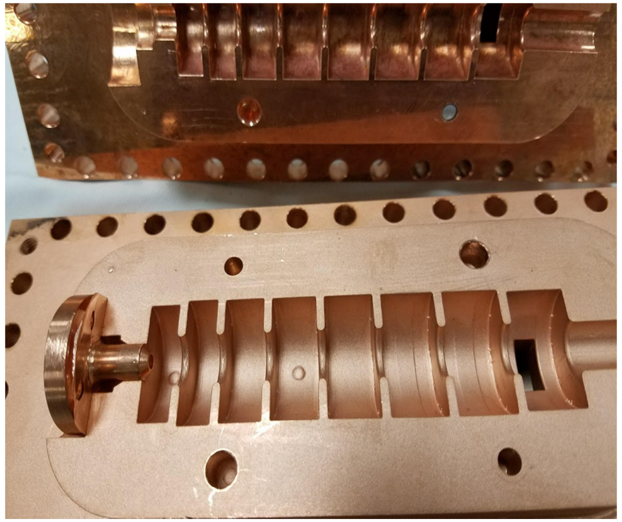
stainless steel



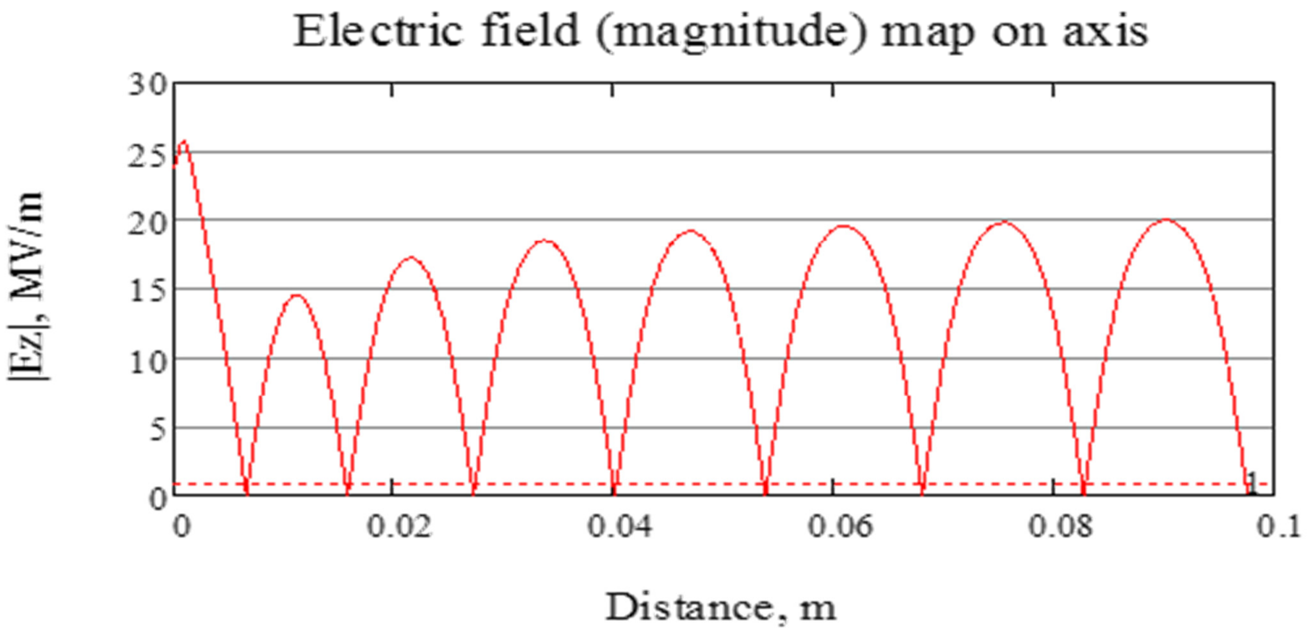
copper

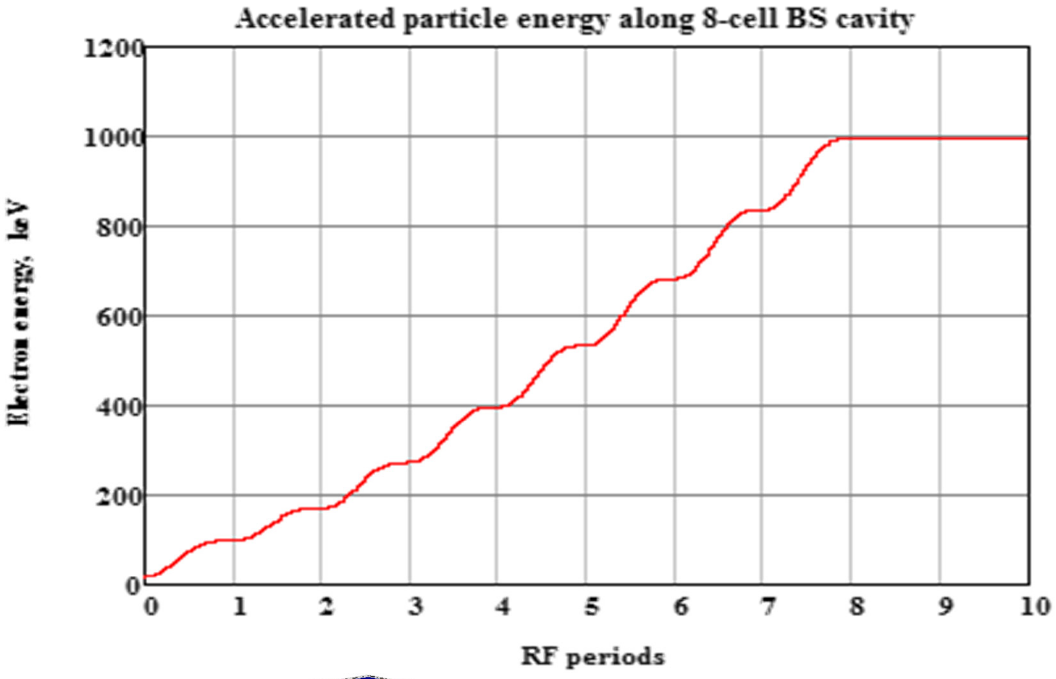


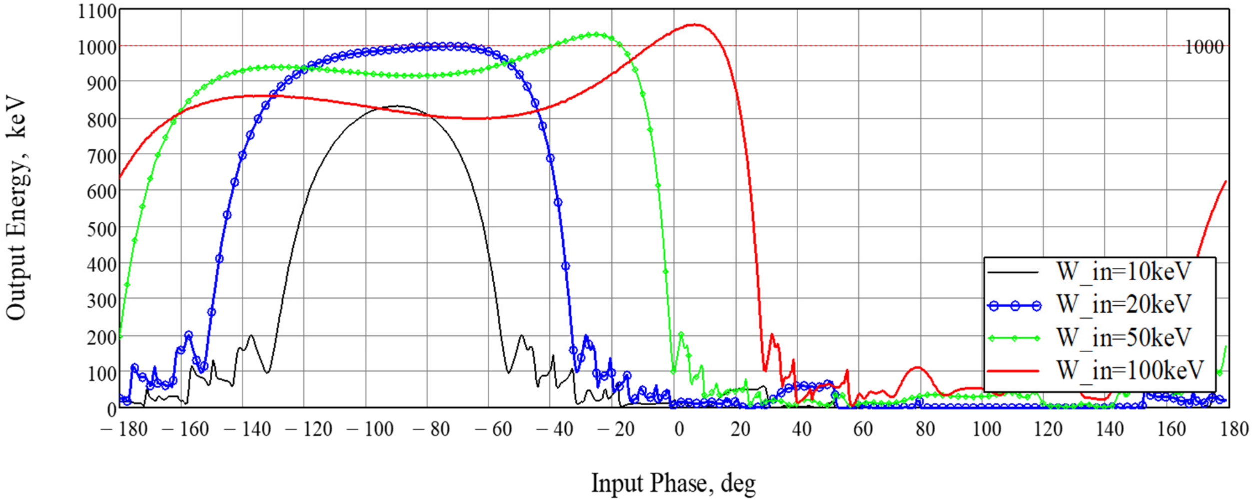
sharp knife

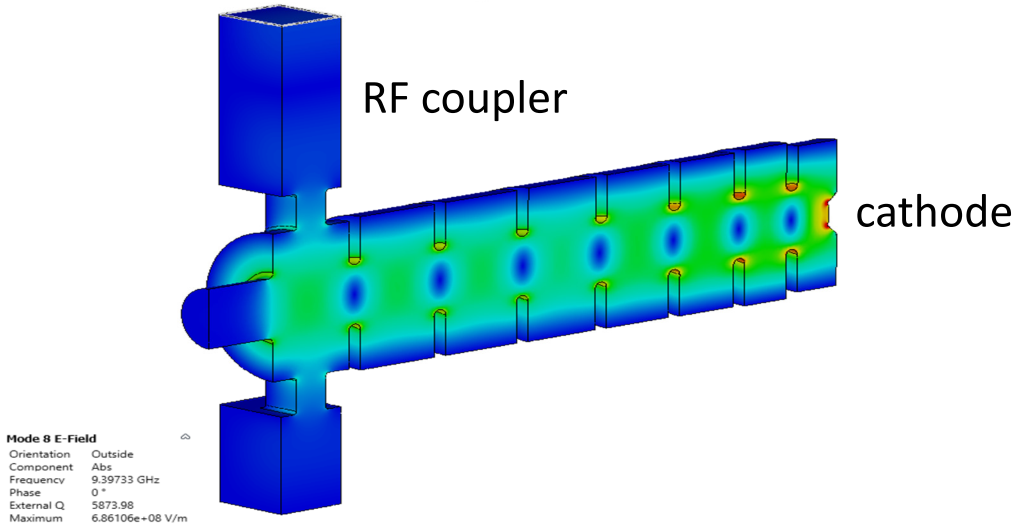


1 MeV Split Block Design



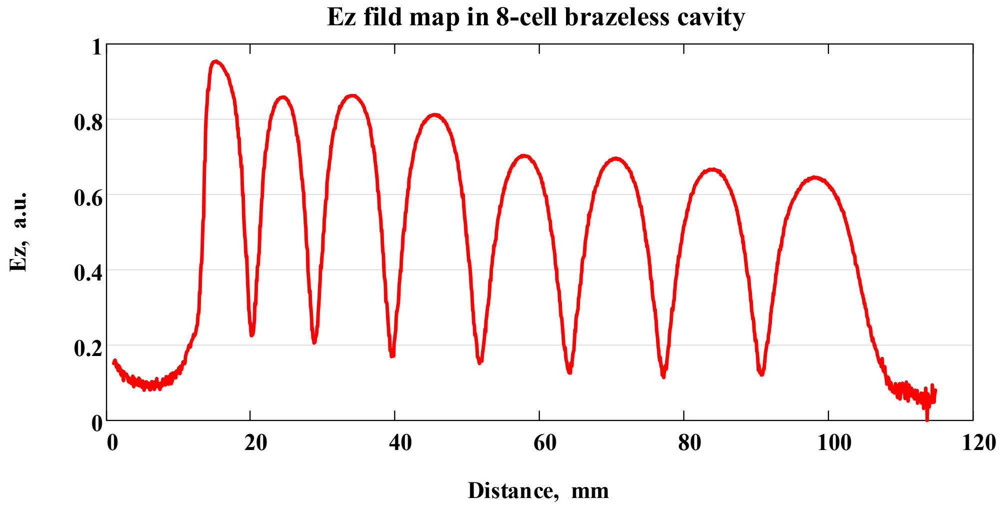




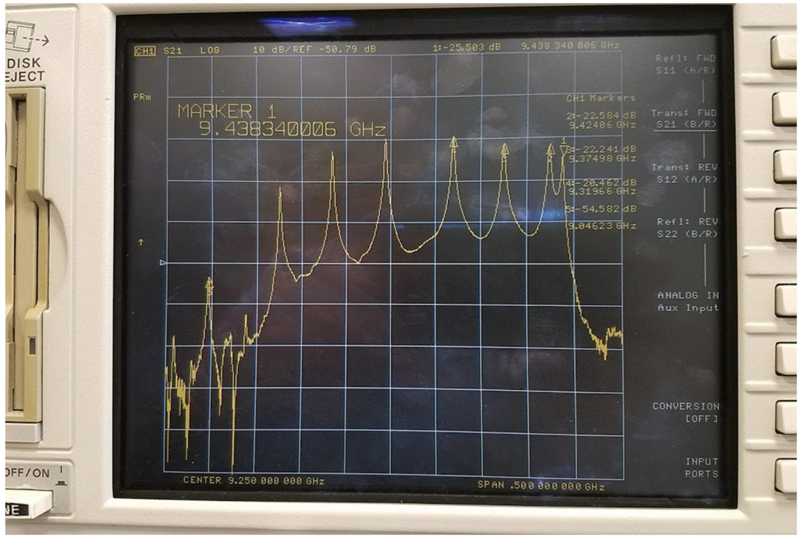


1 MeV Split Block Testing

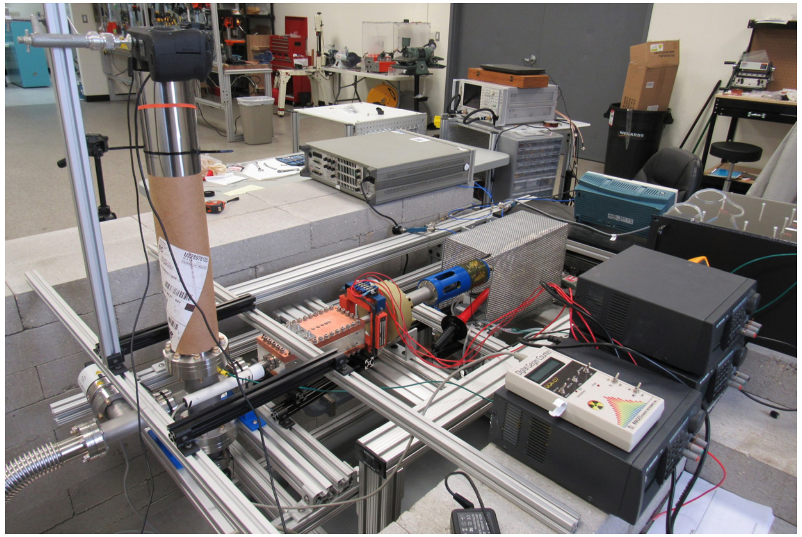
Operation frequency	9430 MHz
RF source	Magnetron
RF power	200 kW
Peak surface electric field	23 MV/m
Accelerating cavity length	111 mm
Shunt impedance	4.7 MOhm
Input beam energy	20 keV
Output beam energy	1 MeV



Bead pull measurement

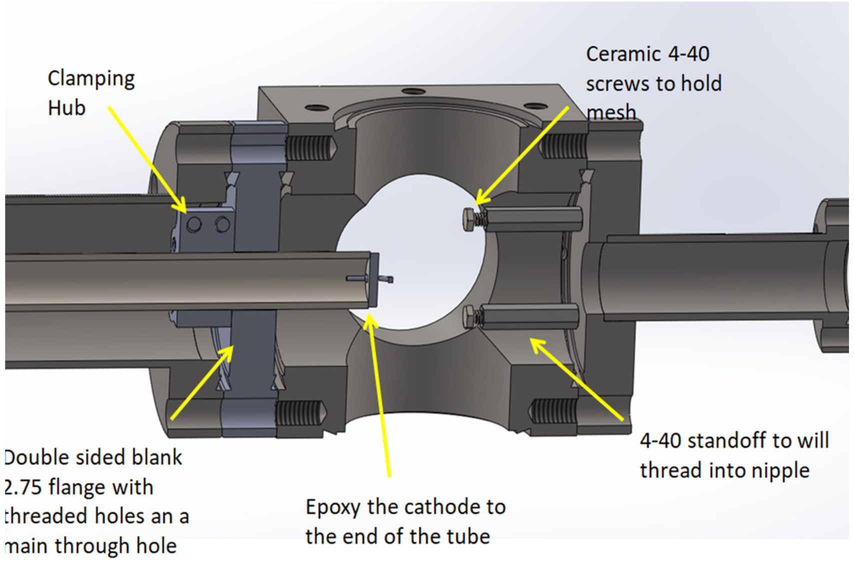


S_{11} measurement

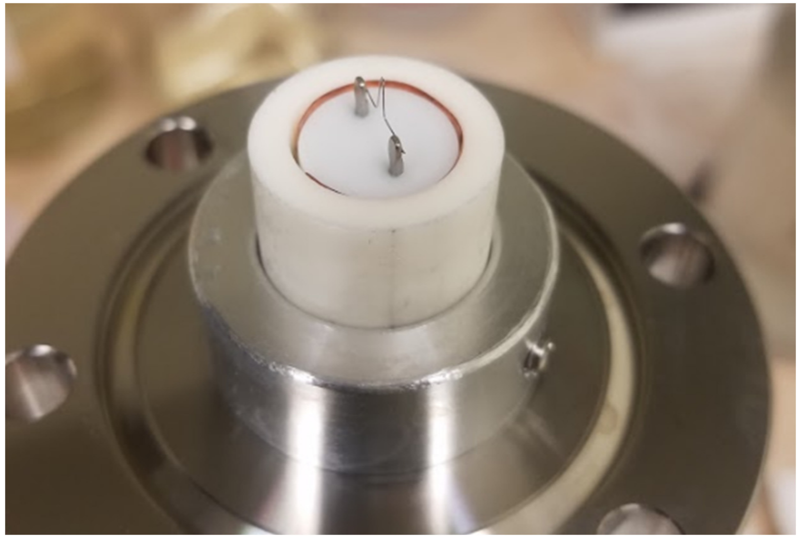


DC Gun Developments

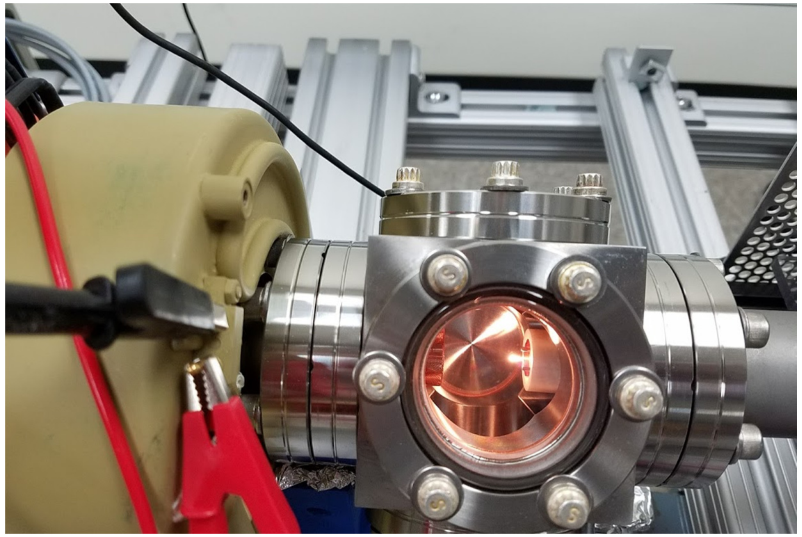
Parameters:
voltage – up to 25 kV
current – 250 μA
regime – 0-10 Hz
duty cycle – 10^{-5}

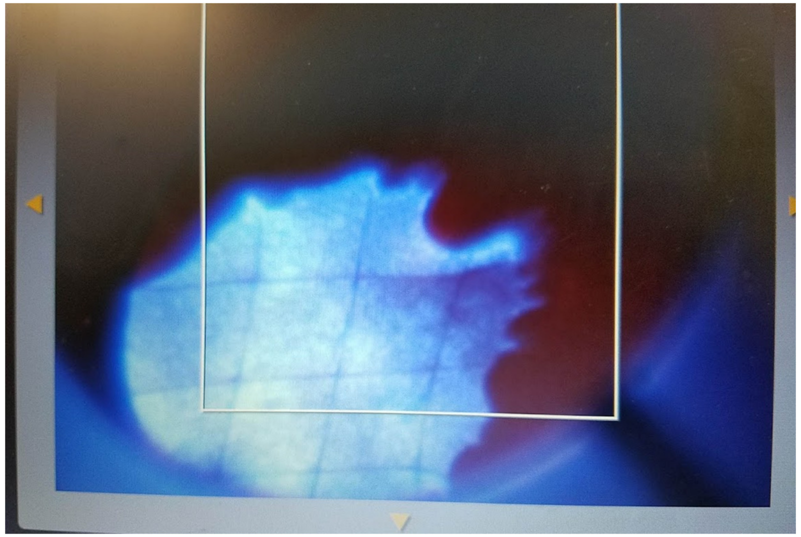


Gun layout



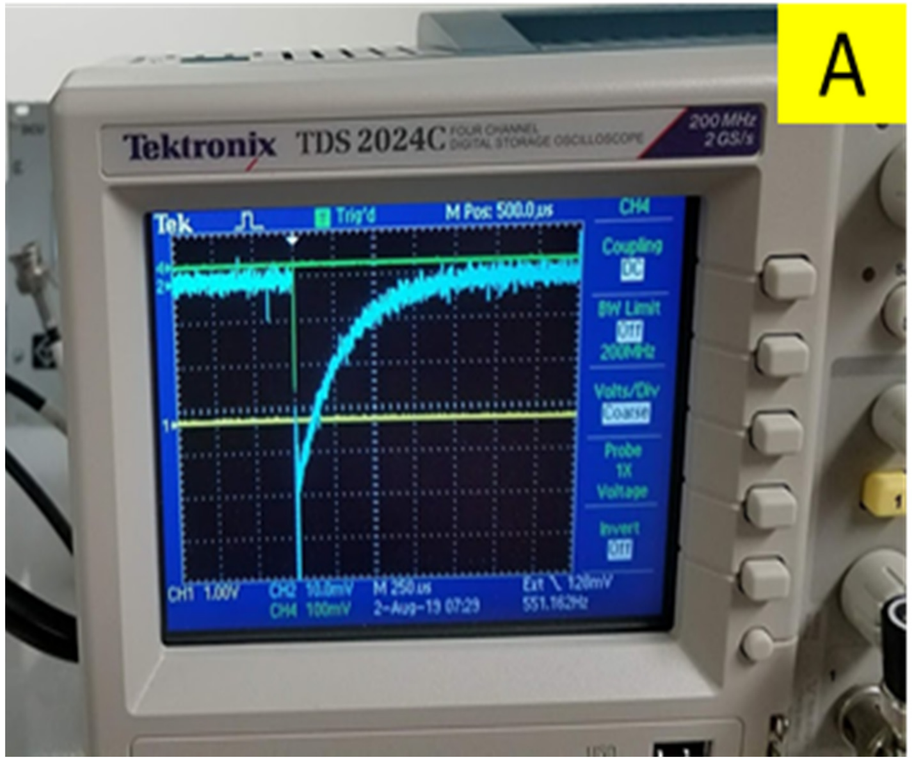
Gun packaging

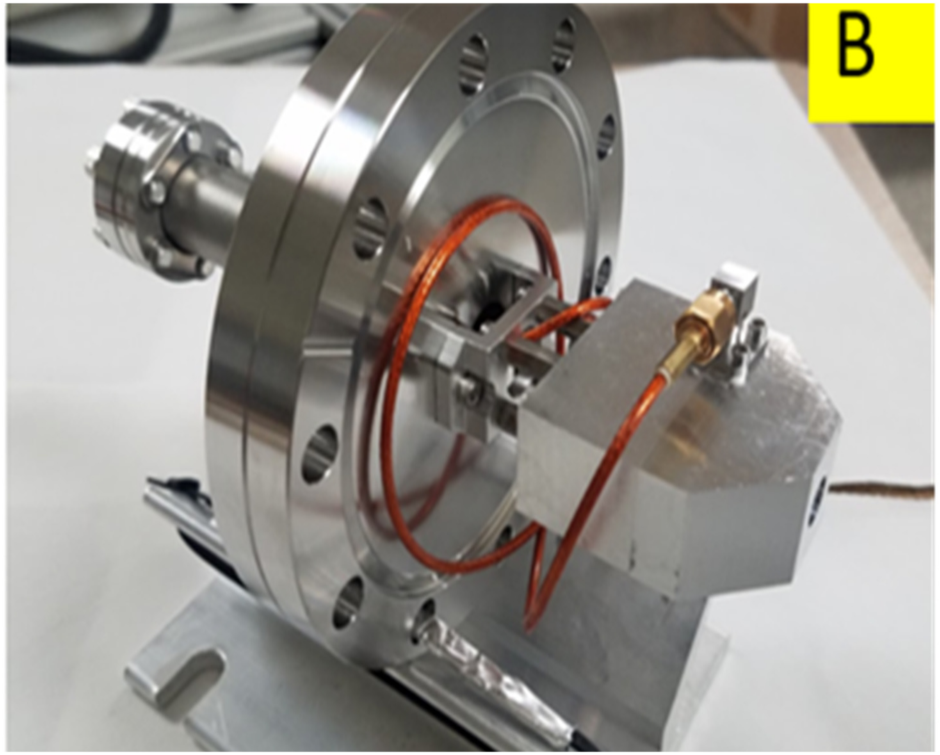




Beam “fingerprint” on phosphorus screen

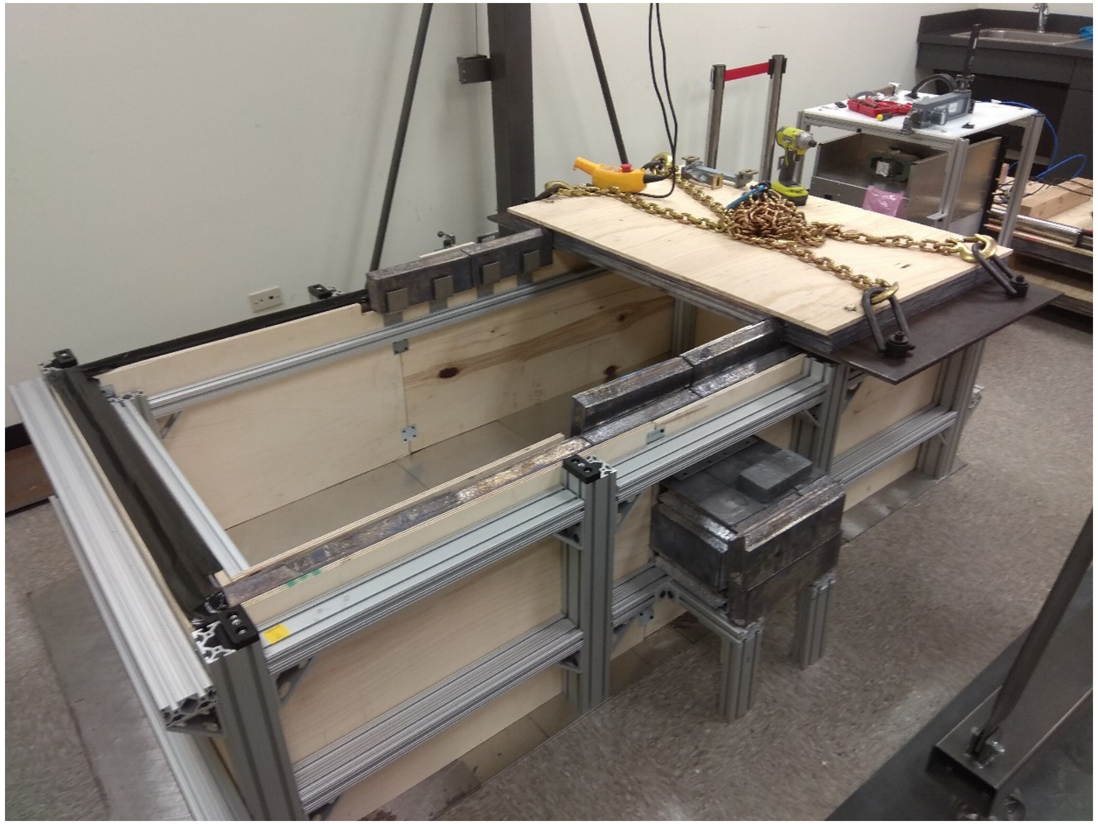
Beam Monitor with Silicon Sensor Embedded in High-Q RF Cavity



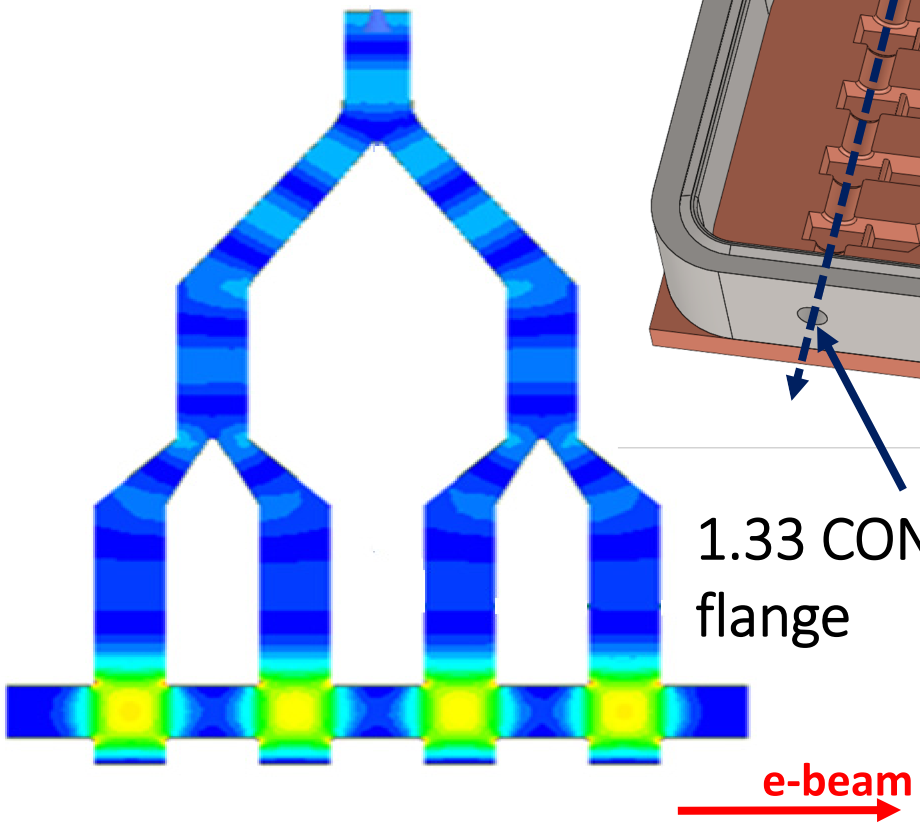


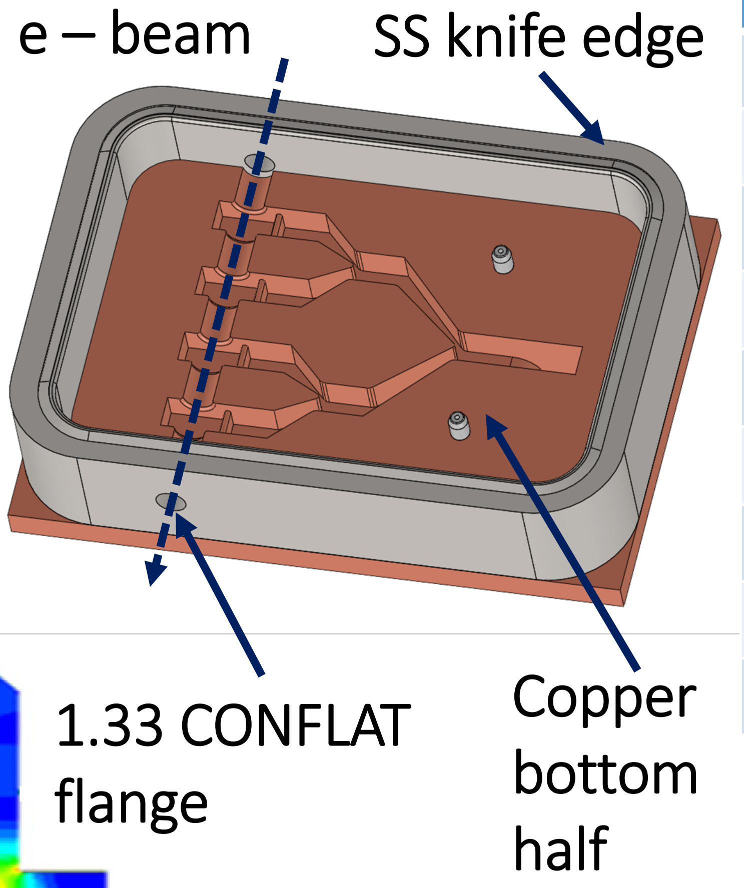
It has much larger signal to noise ratio than Faradey cup or fluorescent screen.

Bunker (now construction completed)



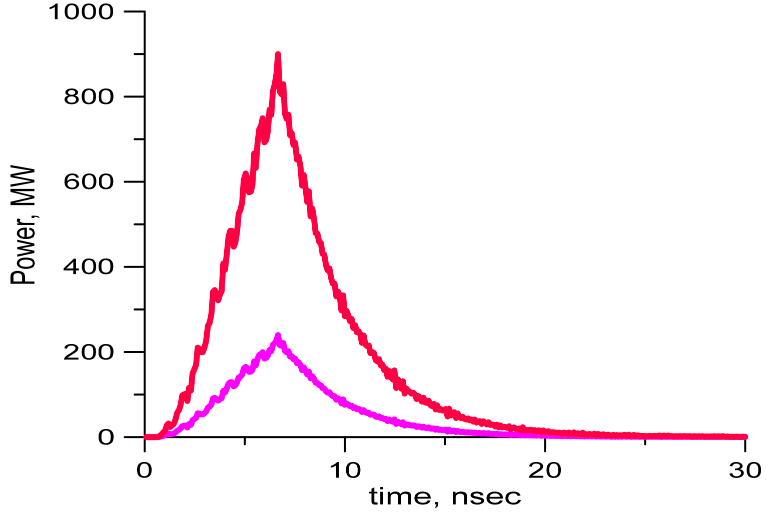
11.7 GHz AWA Power Extractor





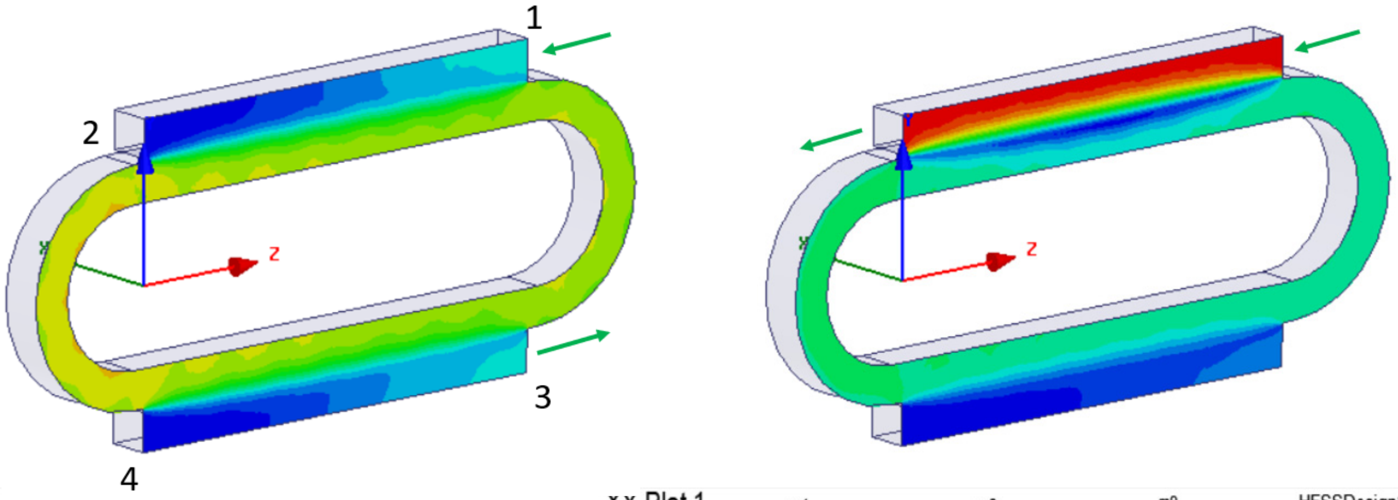
Parameters	Q=25 nC	Q=50 nC
Q-factor	220	220
Bunch train frequency	11.7/9 GHz	11.7/9 GHz
Bunch length	1.2 mm	1.8 mm
Max. surface E-field	530 MV/m	1030 MV/m
Max. surface H-field	1.23 MA/m	2.38 MA/m
Pulsed temperature rise	65°	240°
Shunt impedance	325 kΩ	325 kΩ
Pulse duration	10 ns	10 ns
Output power (4 cells)	240 MW	900 MW

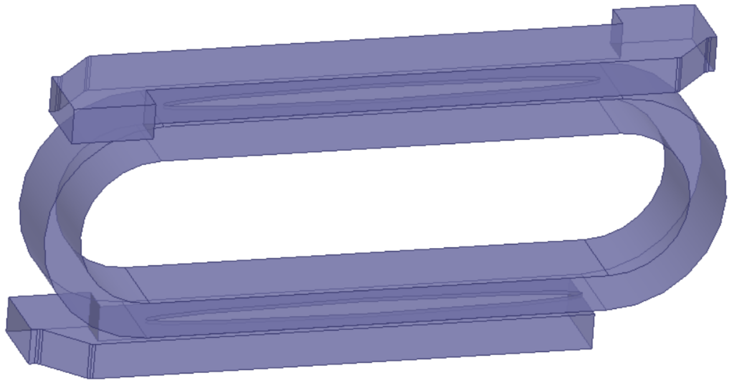
*Low Loaded Q=225 for short pulse wakefield

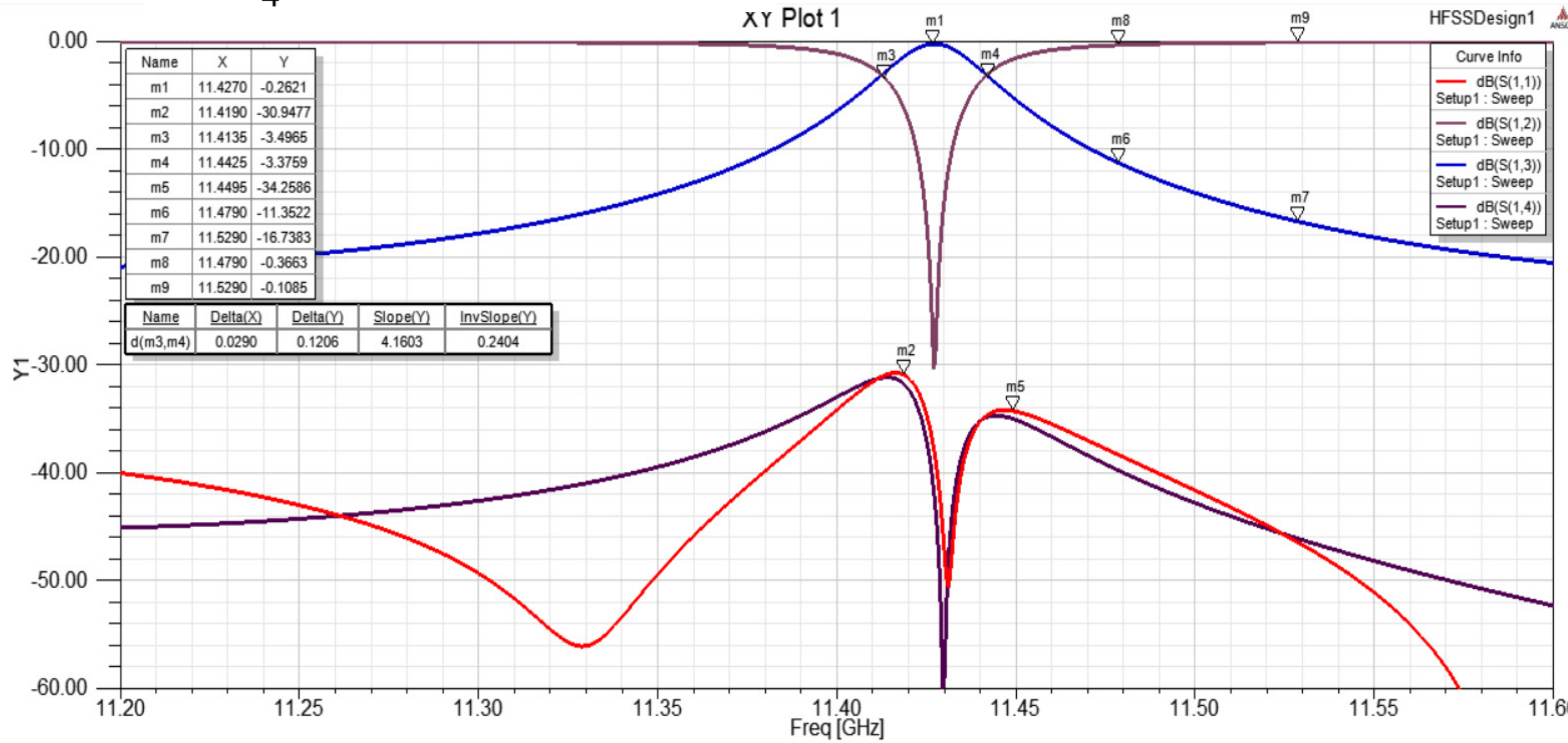


11.4 GHz RF Switch in E-Plane

<u>Idea:</u> A chirped pulse produced by high-power RF amplifier allows fast power steering.







Summary

- **Brazeless split block^{new} – high gradient brazeless technology!**
- **Everything (structure, DC gun, beam diagnostics) is ready for 1 MeV test excepting bunker certification**
- **Brazeless technology is appealing for lots of applications: RF power extractor, RF switch, RF gun, RF undulator etc.**

Acknowledgement

- **Funded by DOE SBIR Phase II**

AWA Staff

Our group at Euclid:

- **Sergey Kuzikov**
- **Sergey Antipov**
- **Pavel Avrakhov**
- **Edgar Gomez**
- **Ed Dosov**

Collaborator

- **Alexander Vikharev IAP (Russia)**