ECE Senior Design Project:
Resonant Cavity Field Profiler

2022 SPRING SEMESTER

About Us…

***Starfire Industries LLC* located in Champaign, IL USA (near *University of Illinois*)**

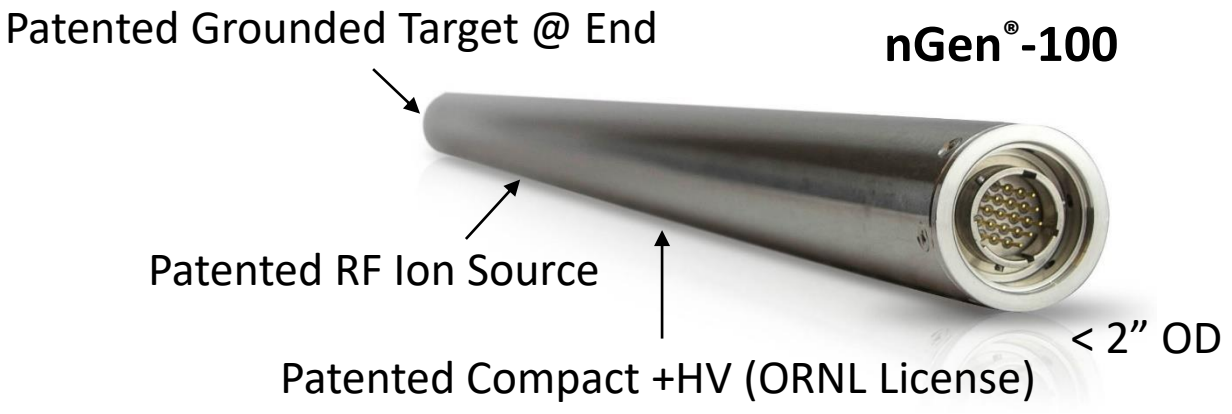
- ~35 employees, including 6 PhDs
- 14,000 ft^2 engineering, lab/test and production space
- Complete vertical integration from R&D, manufacturing, applications testing and support
- Making neutron generators and pulsed plasma sources for 10+ years!

Products:

- nGen® portable neutron generators
- Centurion® transportable MeV particle accelerators
- IMPULSE® pulsed power modules for sputtering
- RADION™ plasma sources for PECVD & Etching

Internship/Co-Op Program:

- M.S. & M.Eng. Program + Ph.D. (planned)



Project Background

RF accelerator systems use a resonant cavity

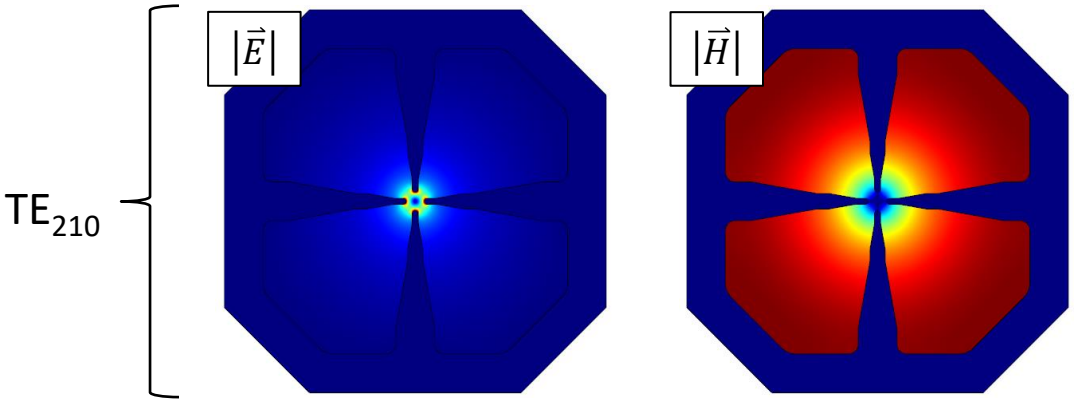
- Shaped cavity interior converts oscillating fields into directed particle acceleration
- Operation requires precisely controlled EM field profile

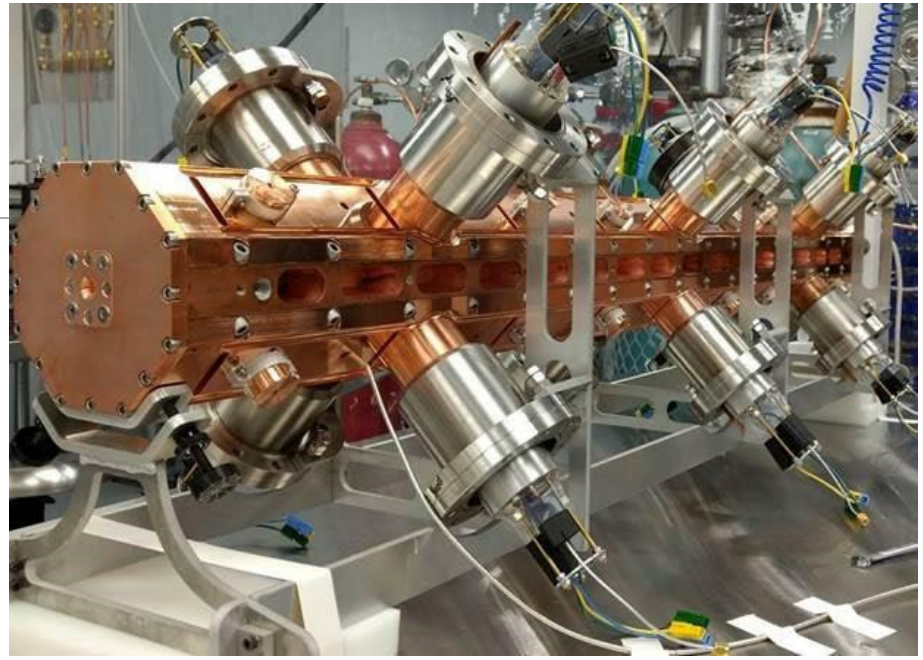
Tuning the cavity field is an iterative process

- Measure field profile → adjust tuning slugs if needed → repeat

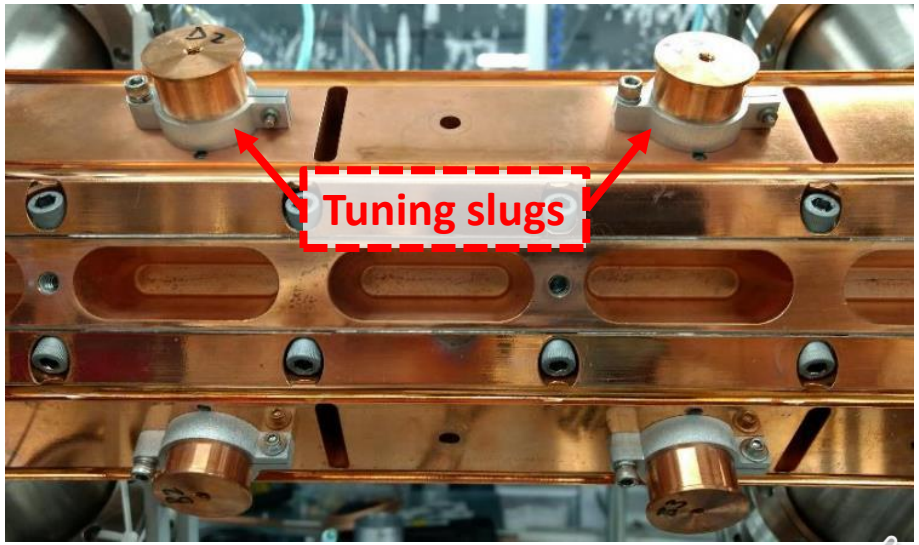
Field profile is inferred via a 'bead-pull' technique

- A metal bead on a nylon wire is pulled through the cavity
- The bead causes a shift in the resonant frequency of the cavity based on the magnetic field strength at the bead's location





Starfire's prototype, compact 4 MeV D+ RFQ cavity



A close-up view of the tuning slugs used for field shaping

Project Description & Block Diagram

A functional block diagram for the proposed project is shown at right

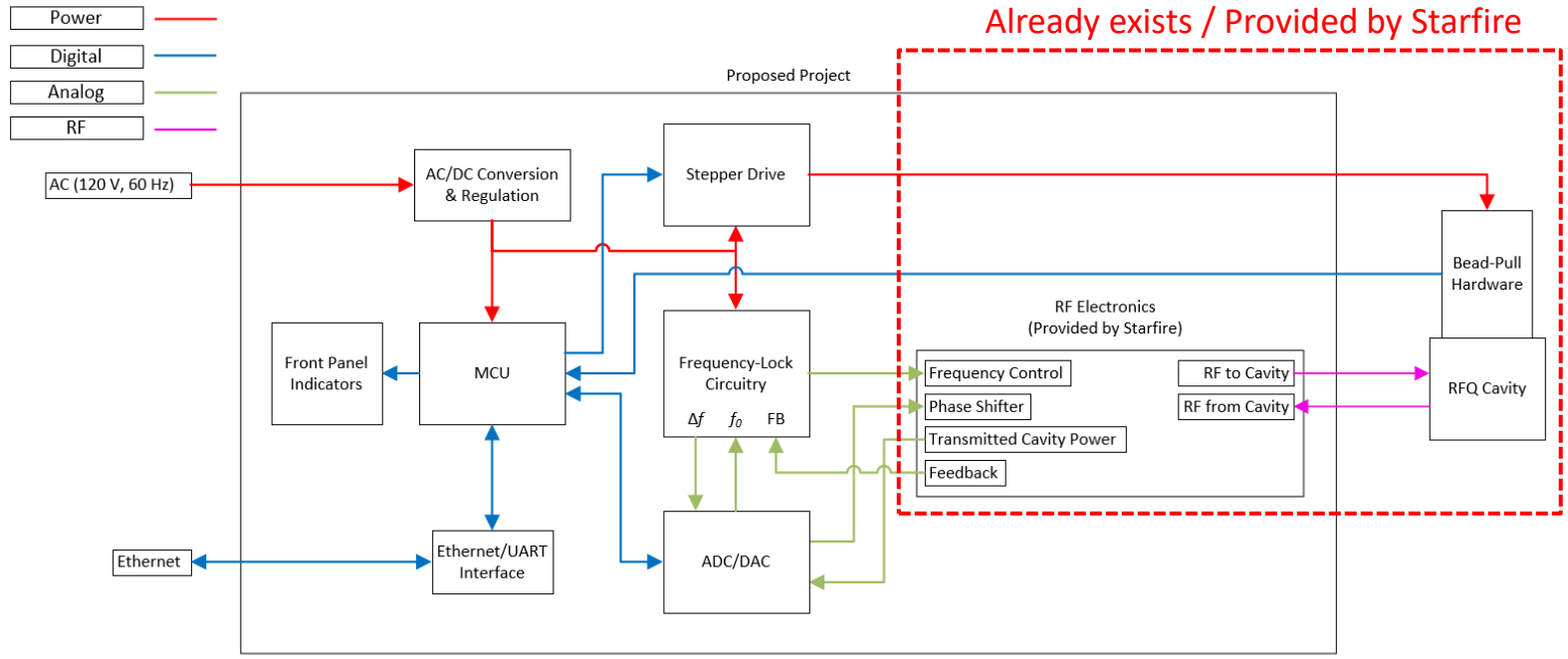
- The RF circuitry, RF cavity, and bead-pull hardware will be provided by Starfire

RF circuitry accepts control signals for controlling frequency and phase shift

- Feedback output is proportional to $(\omega_{res} - \omega)$

The proposed project is to design & build a system capable of:

1. Supplying drive signals to a stepper motor to step the metal bead through the 4 quadrants of the RFQ cavity
2. Maintain a drive frequency that is equal to the resonant frequency
3. Record the frequency shift as a function of the metal bead's position
4. Interface with a PC to allow the user to set operating conditions and to transfer/save data for subsequent analysis



A block diagram of the proposed system. The RF electronics, beadpull hardware, and RFQ cavity all exist at Starfire. Their design and construction are outside of the scope of this project.