“The Cyclotron Kids’” 2 MeV Proton Cyclotron

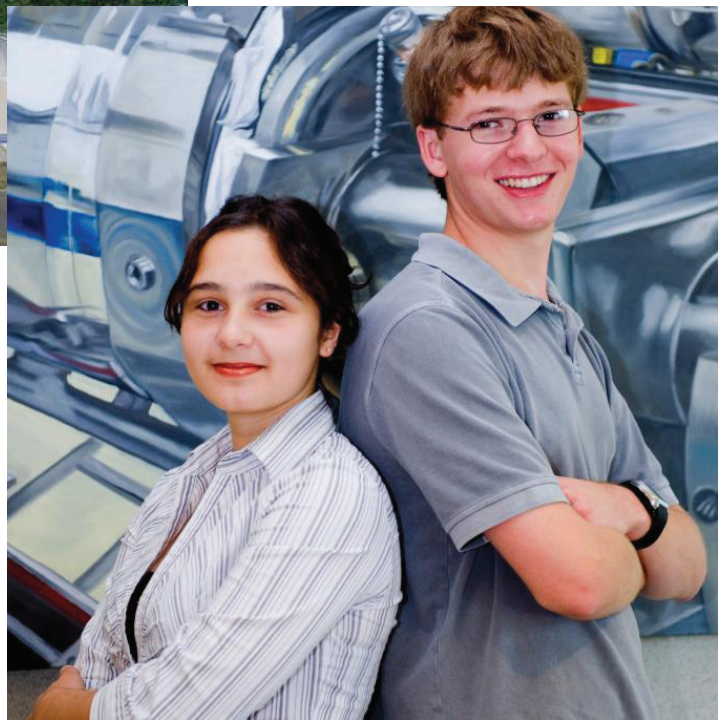
Heidi Baumgartner, MIT Class of 2014

Cyclotrons ’13, Vancouver,

September 18, 2013

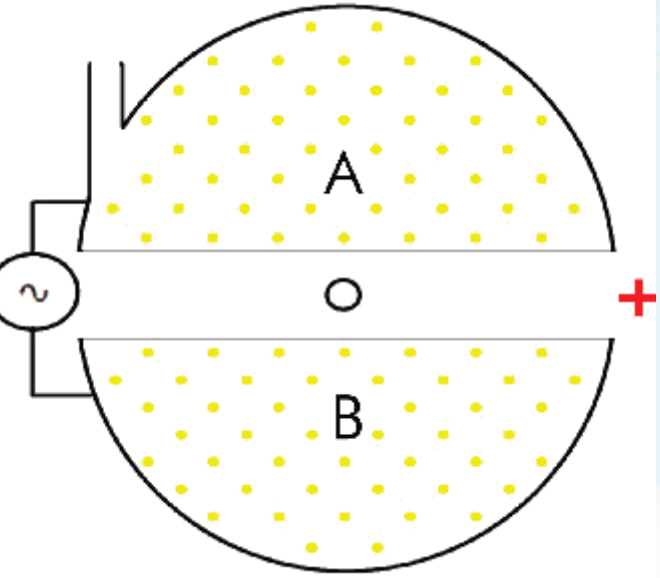
It began at summer camp…

Kopernik Observatory, Binghamton NY



Heidi Baumgartner, Peter Heuer and German Diagama met in their freshman year of high school

Some Googling convinced us it couldn't *possibly* be that hard. Right?



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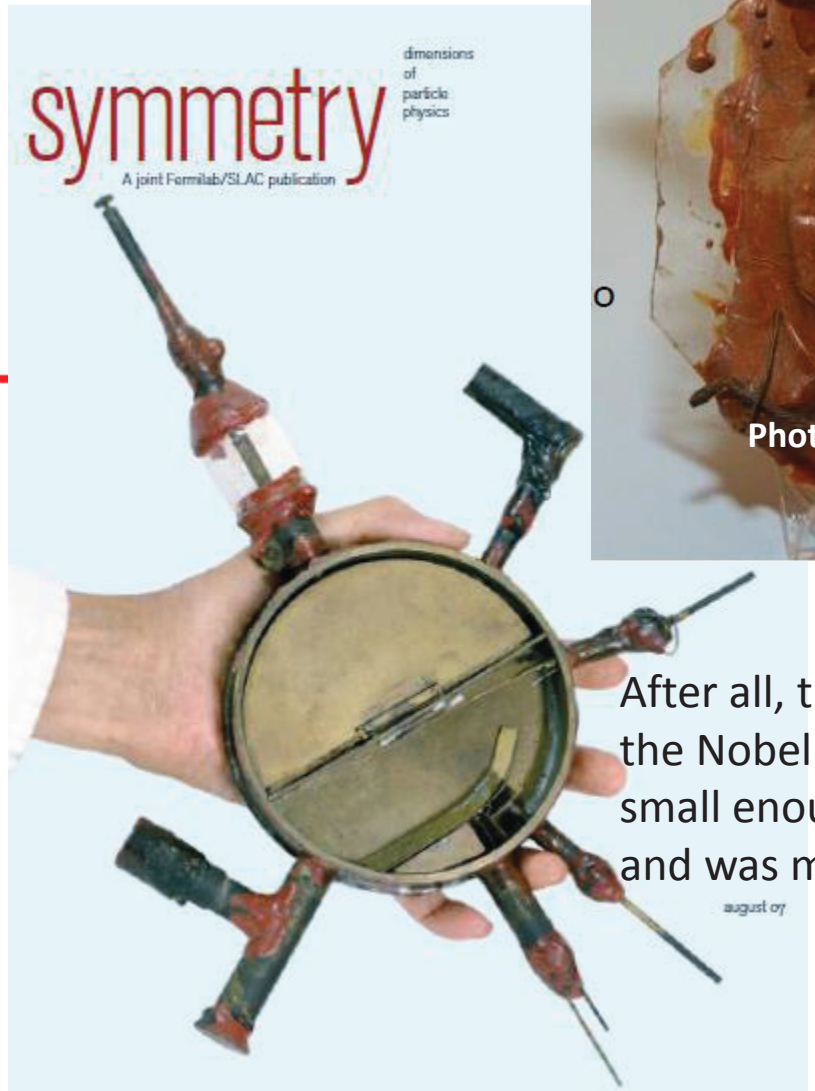

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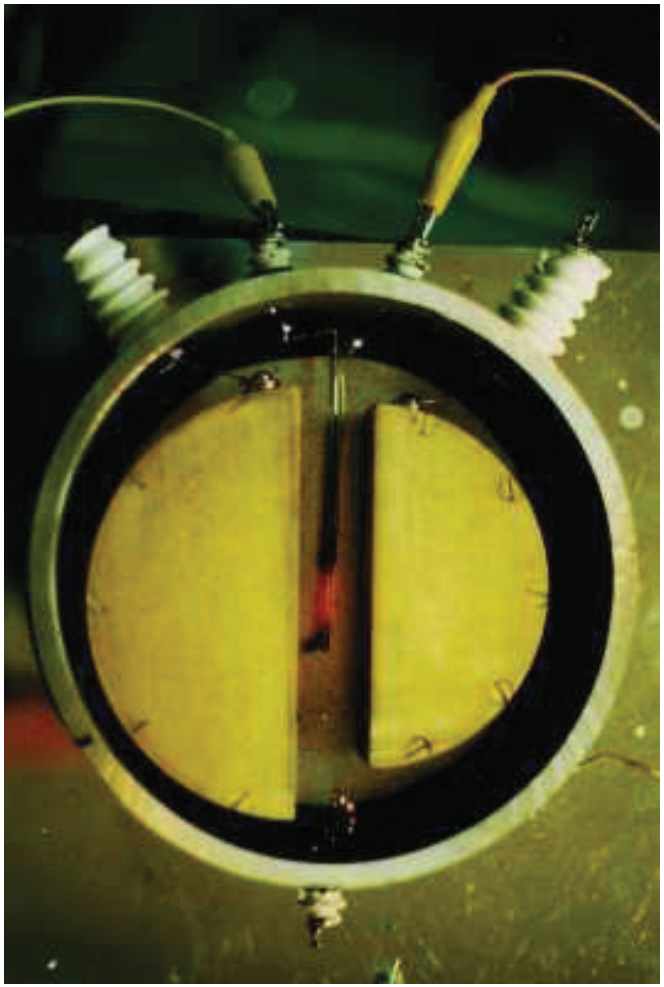
After all, the design that won the Nobel Prize in 1939 was small enough to fit into a hand, and was made with sealing wax.

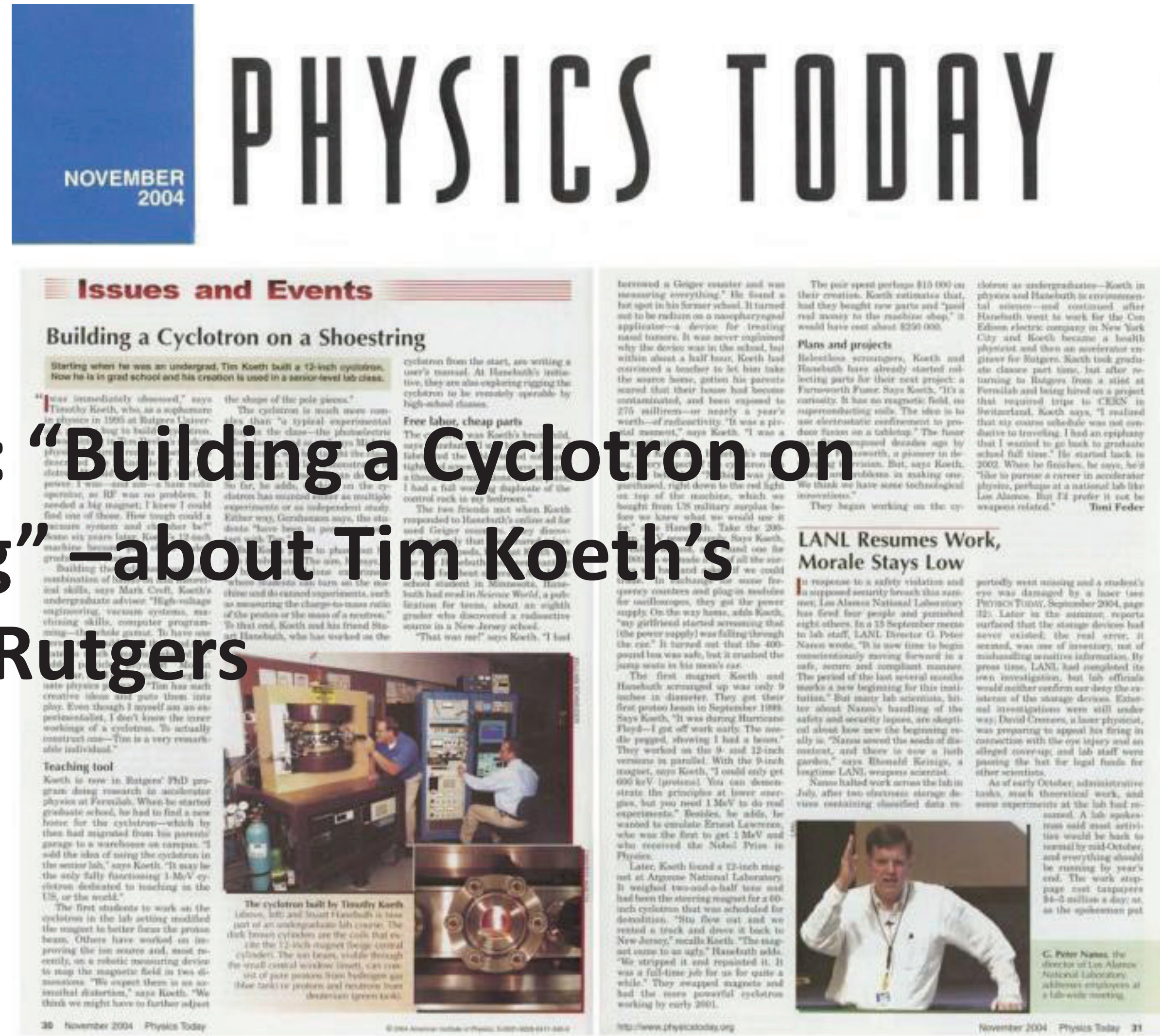
Previous amateur accelerators: Fred Neill



Top-down view of his cyclotron chamber

His homemade vacuum system had a thermocouple gauge in a jar

Previous amateur accelerators: Tim Koeth



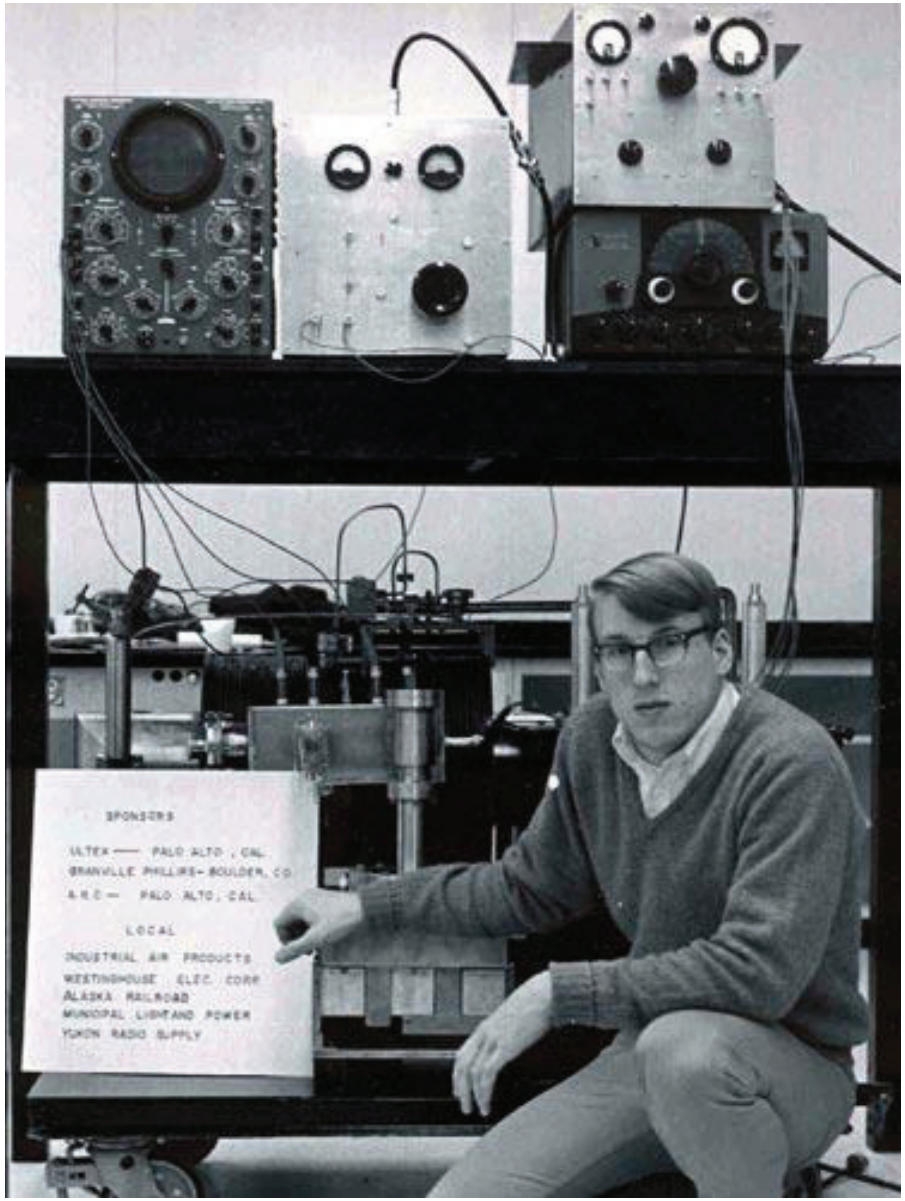
Physics Today: "Building a Cyclotron on a Shoestring" –about Tim Koeth's machine at Rutgers

Previous amateur accelerators: Al Swank

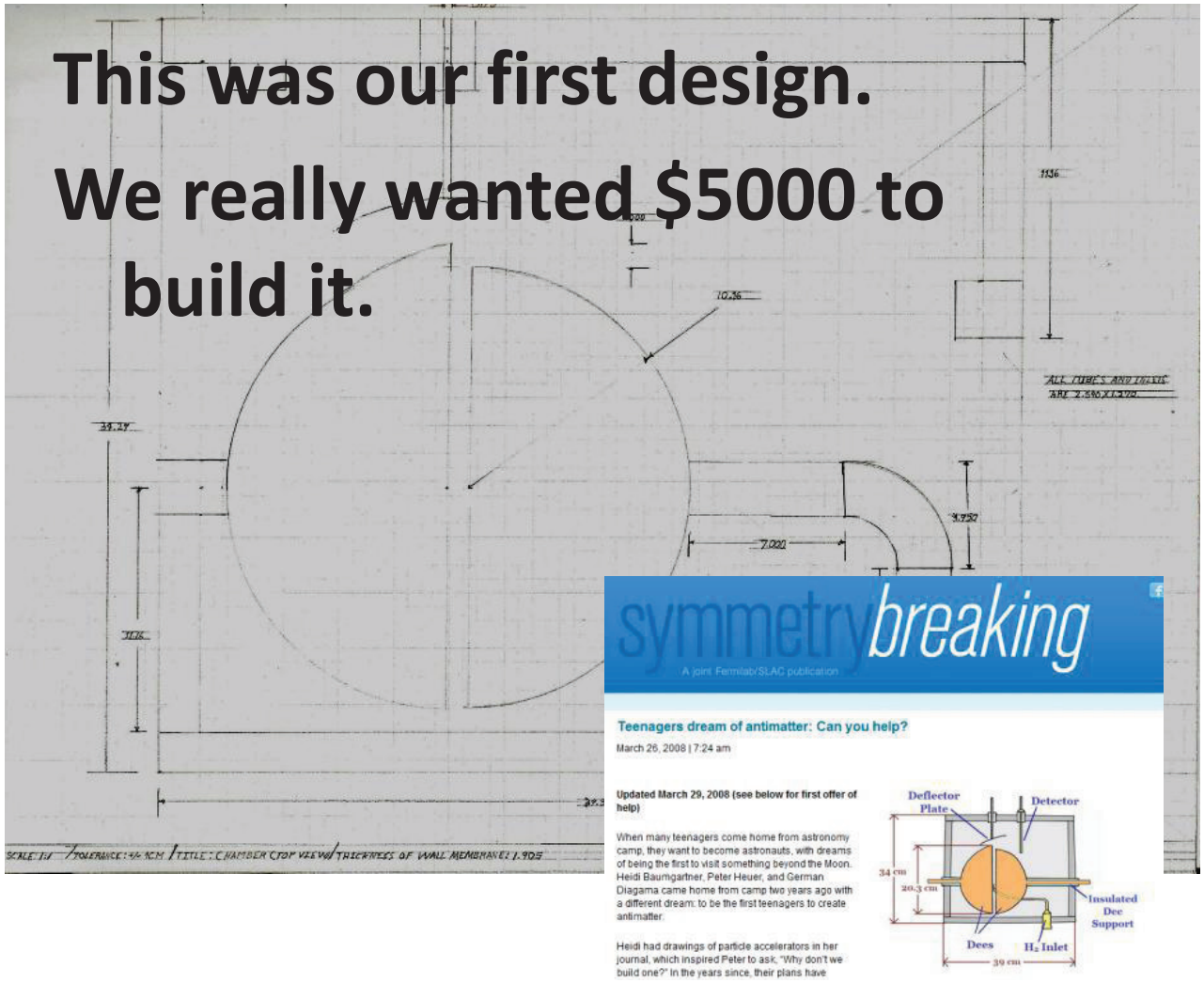
A high school cyclotron project launched him on his career in engineering.

WIRED, Dec. 2005: “The Cyclotron Comes to the ‘Hood”:

“Local lawmakers rushed to introduce emergency legislation banning the use of cyclotrons in home businesses”



First funding attempts



Published a post in the blog “symmetry breaking.”

Got a donated vacuum pump

Sent out letters asking for sponsorship to enter a science fair

It worked! Jefferson Lab sponsored us

Some lines from the original email we received from Andrew Hutton, Head of the Accelerator Division of JLab:

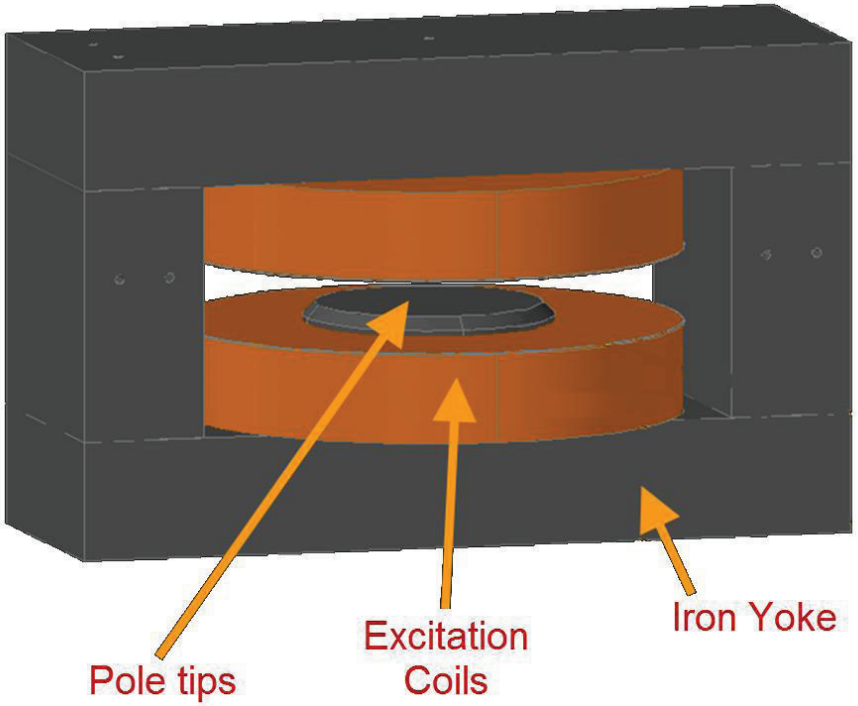
“We have talked it over here at the lab and we have decided to help you realize your goal by being your sponsors.”

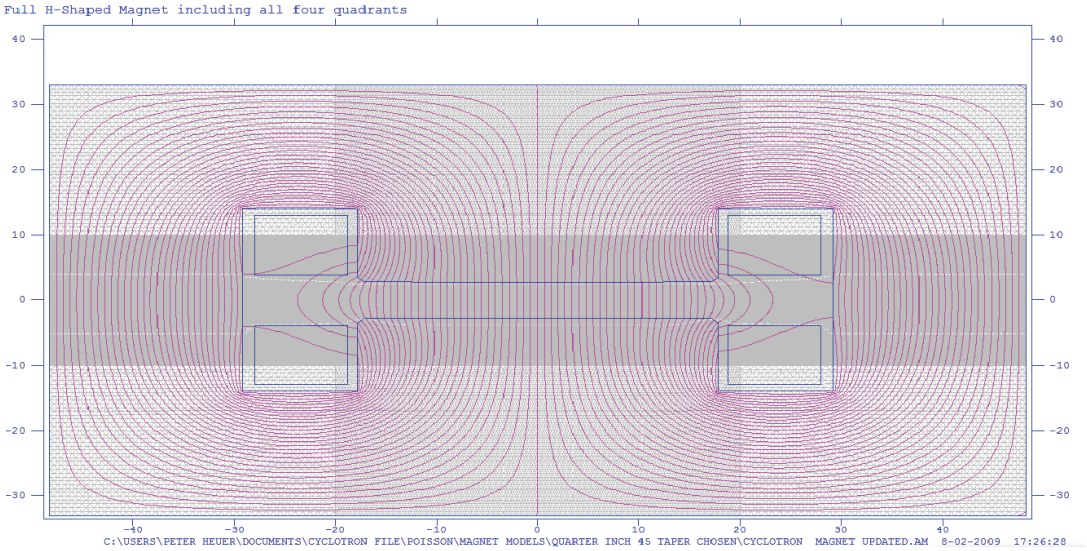
“I must say that I really appreciated the enthusiasm you have shown in developing the project and your nerve in approaching the President of the America Institute of Physics for money!”

“Safety and security are paramount here, as in the rest of the country, so we are not comfortable with the idea that you build the cyclotron in your basement - I can't imagine how many zoning laws that might violate! “

“We are looking forward to making your dream a reality.”

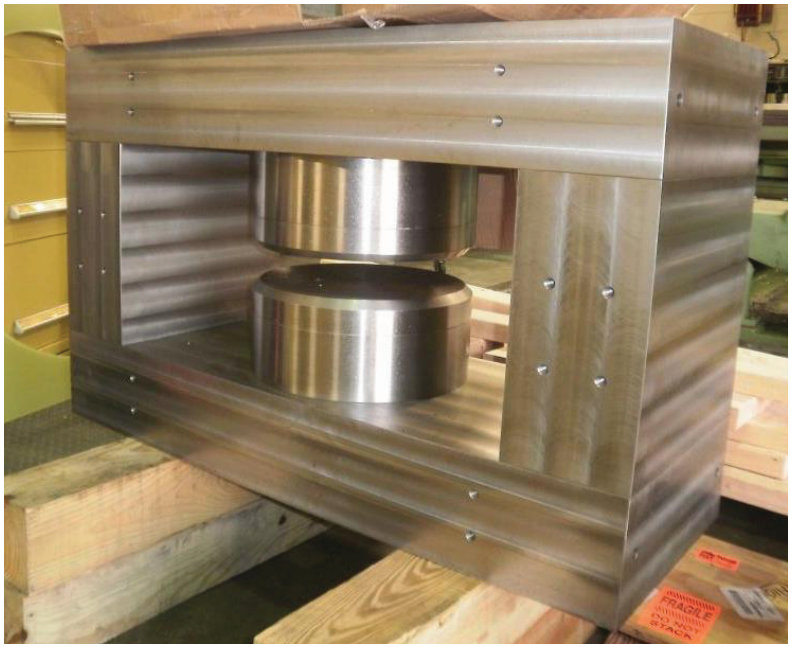
Electromagnet design

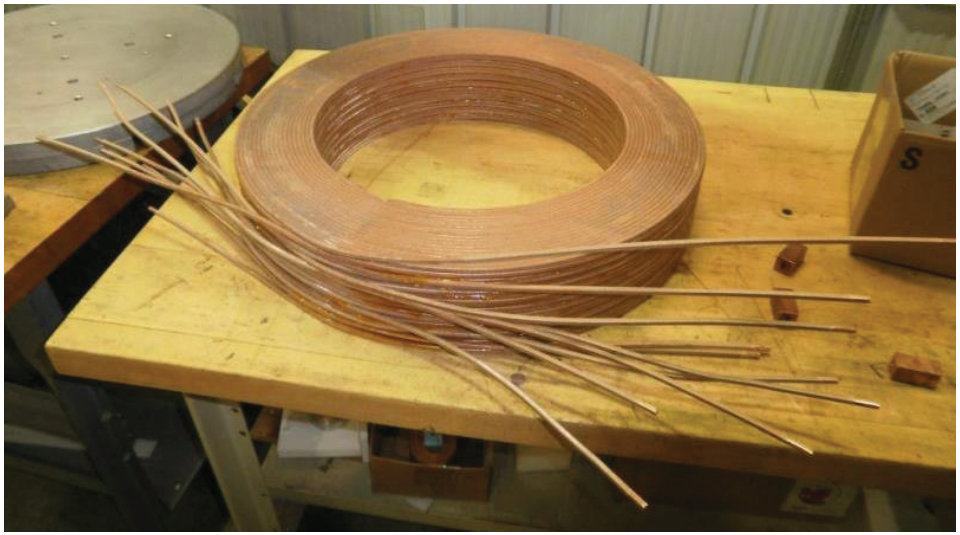


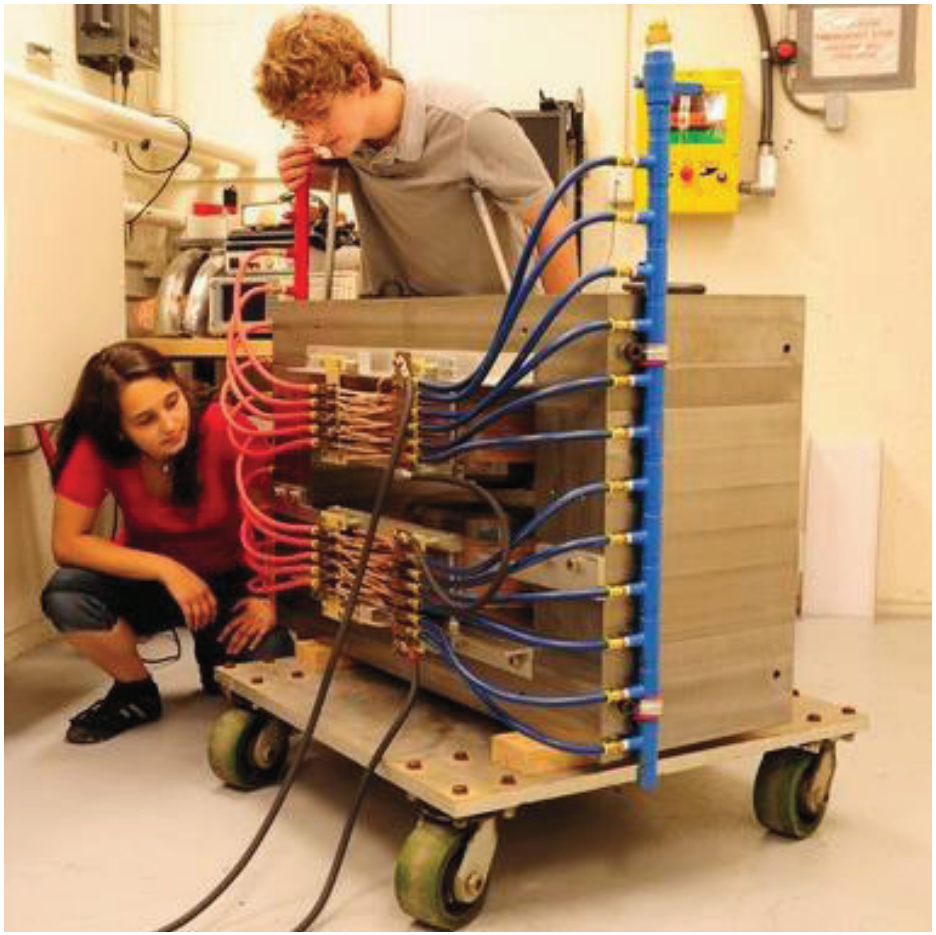


1.6 Tesla
100A, 120V (12 kW)
4 Tons
Slight taper for weak focusing
Simulations with POISSON

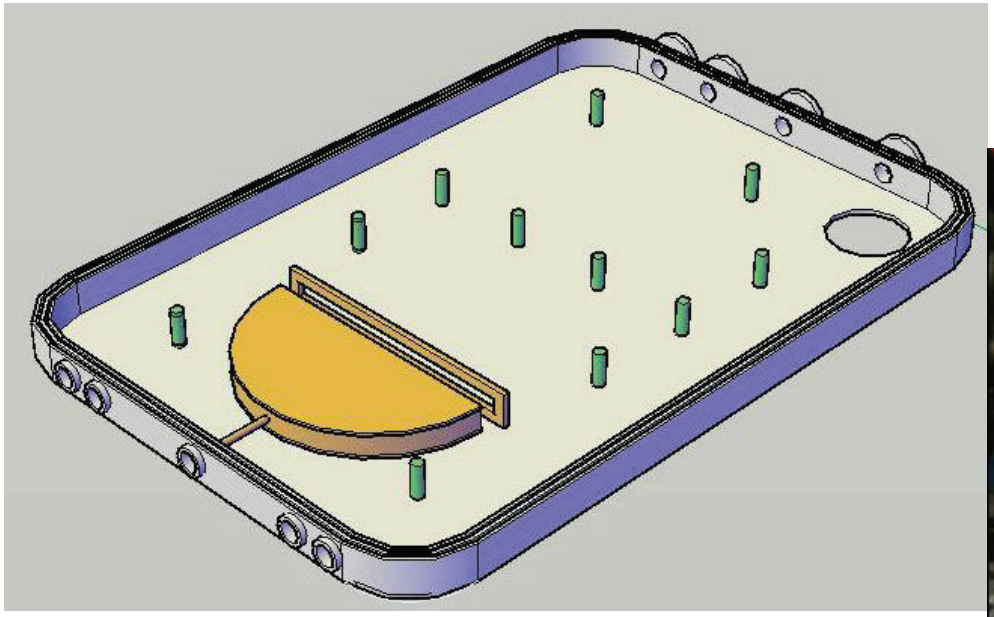
Electromagnet construction

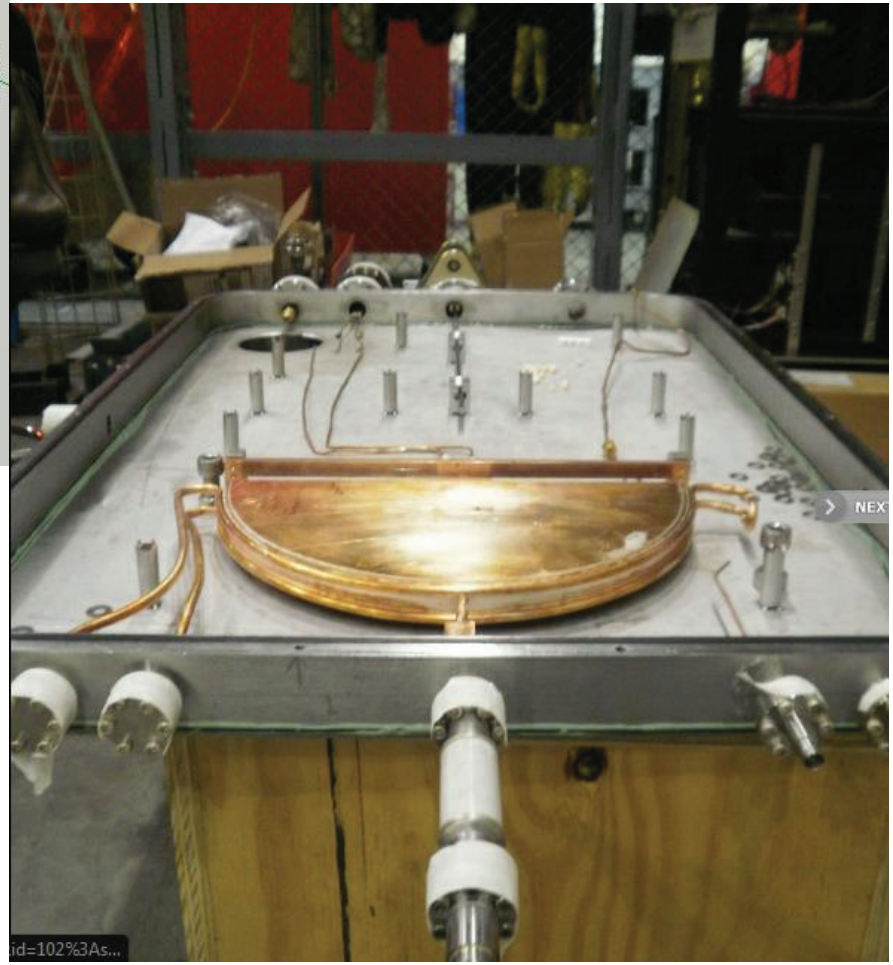






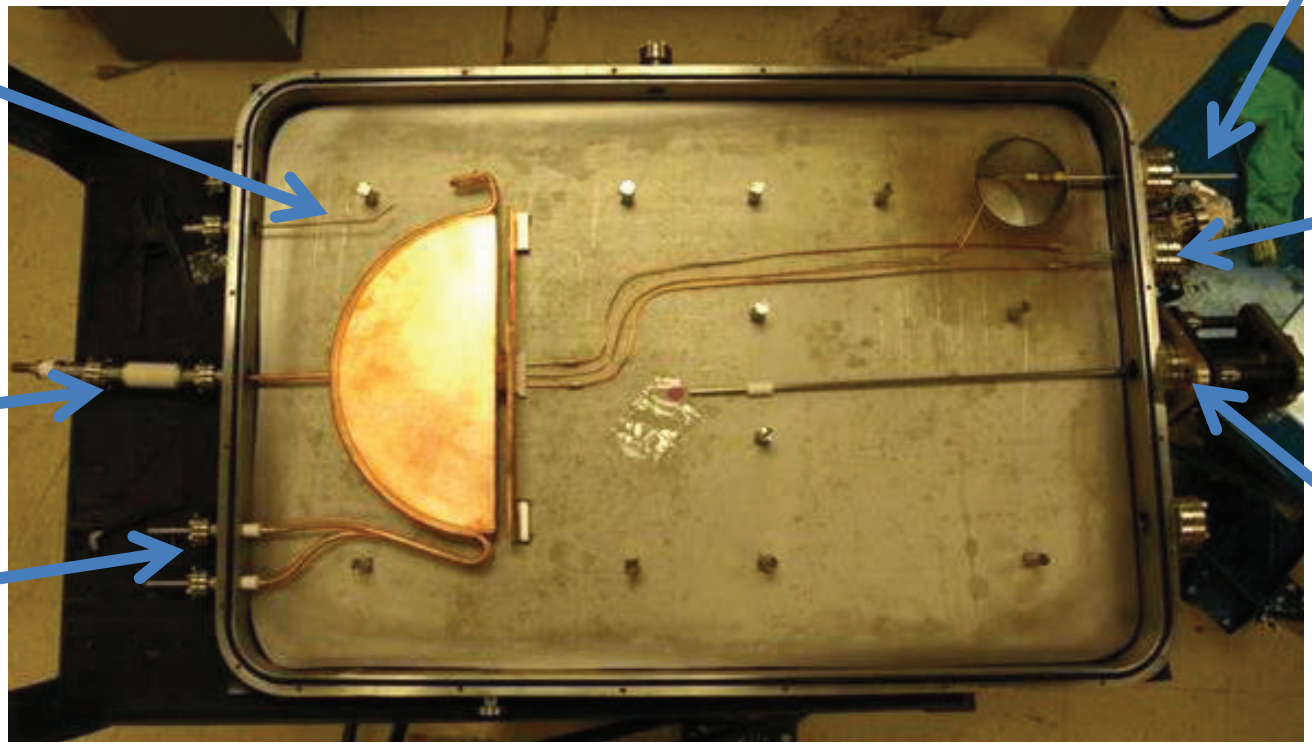
Vacuum Chamber





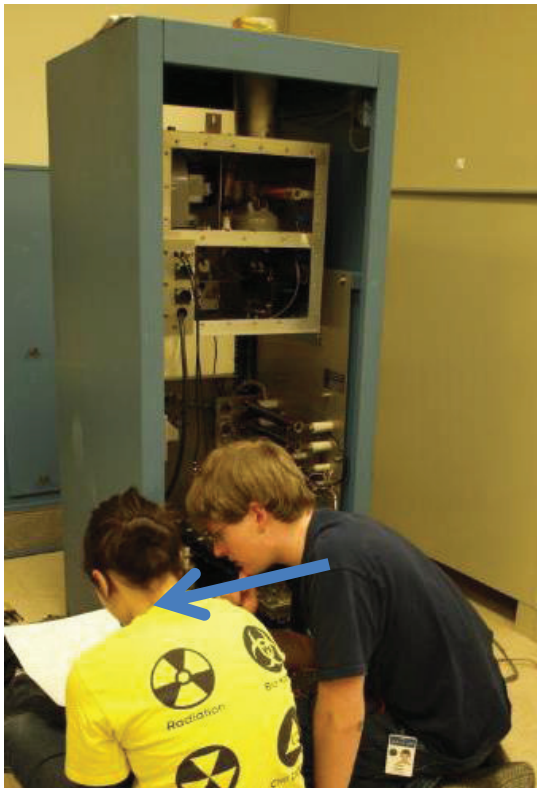
- Approximately 2’x3’; large area for good vacuum conductance
- Two inches (10cm) high due to magnet constraints
- Large plates bowed in: needed internal supports
- One dee, one grounded “dummy dee”

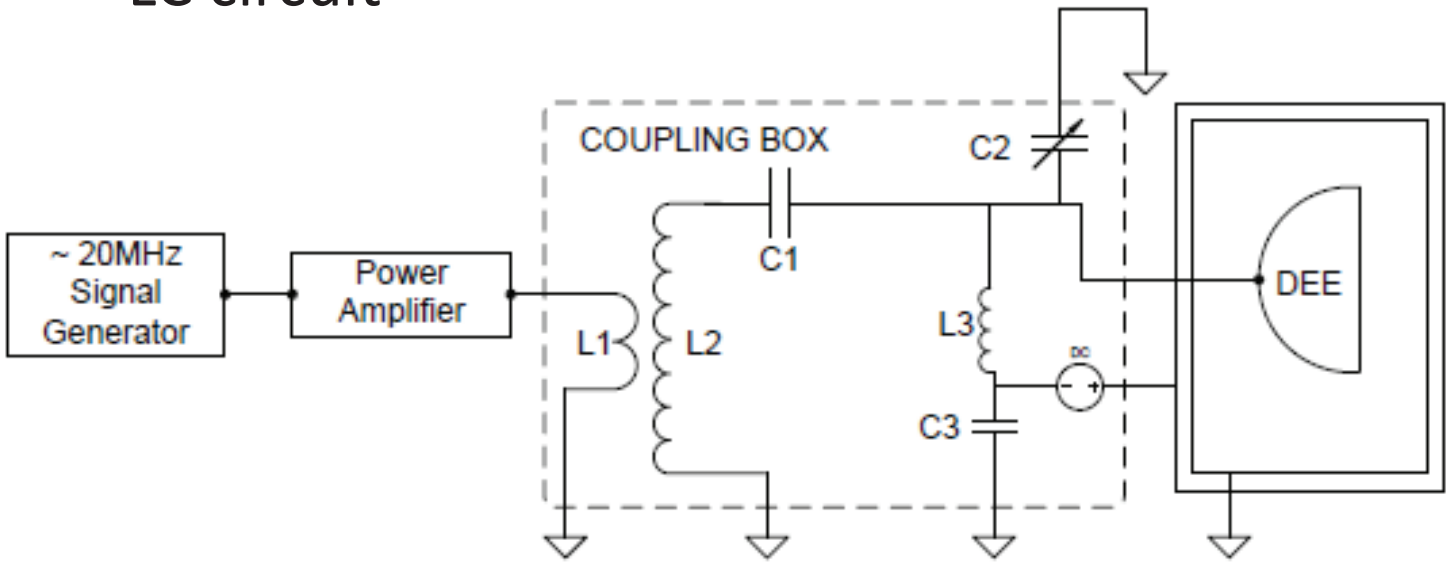
Vacuum Chamber



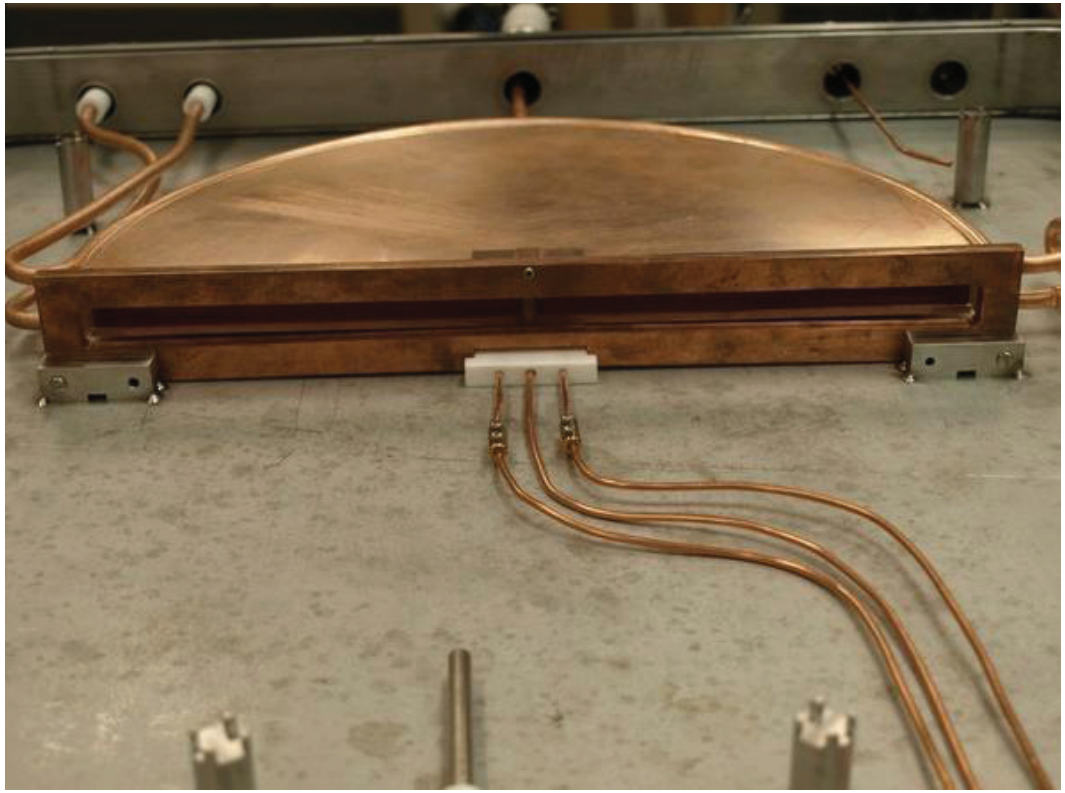
RF System

- 3kW Plasma Therm tube-based power amplifier at 24MHz
- Matching network couples power to the dee
- Resonant circuit made with the capacitance dee and an inductor, power inductively coupled into this LC circuit

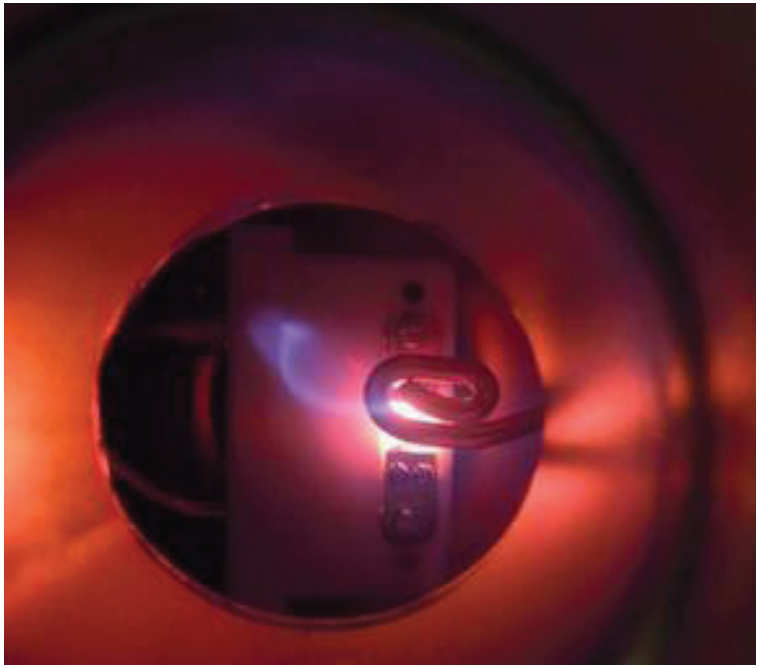




Ion Source

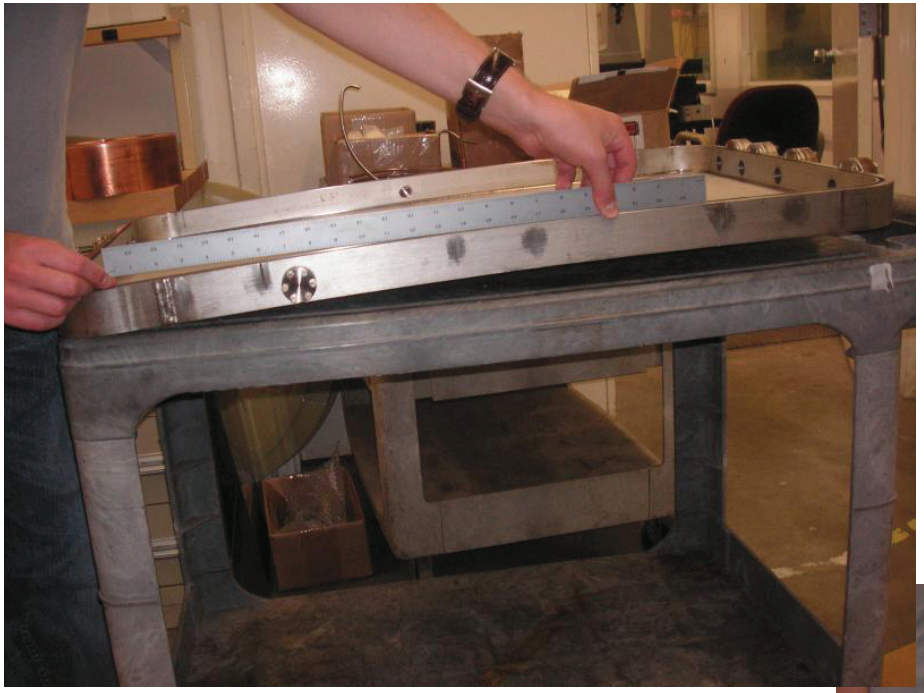


“Chimney” Ion source design
Current in and out, and hydrogen discharge into the middle of the cyclotron.



We tested an oxide-coated nickel filament

Chamber problems



Problems arose from the welding of a thin plate to the frame.

An attempt was made to fix frame warping using flame treatment.

Eventually the bottom plate was ground off, and a viton sheet was used to seal the plate against the frame.

The state of our cyclotron

- Most pieces complete
- Moved to Old Dominion University
- Waiting for the necessary equipment or infrastructure (e.g. distilled water lines)
- And for additional motivated students to continue work on it

We are all “Cyclotron Kids”

If the allure of high energy particles, RF, strong magnetic fields, or vacuum systems has captured your imagination…

It’s up to you to inspire the next ambitious students!

Join the forum and help inspire others:

http://cyclotrons.net

Passcode: cyc-code-123456