Ion Cooler for TAMU-TRAP Facility

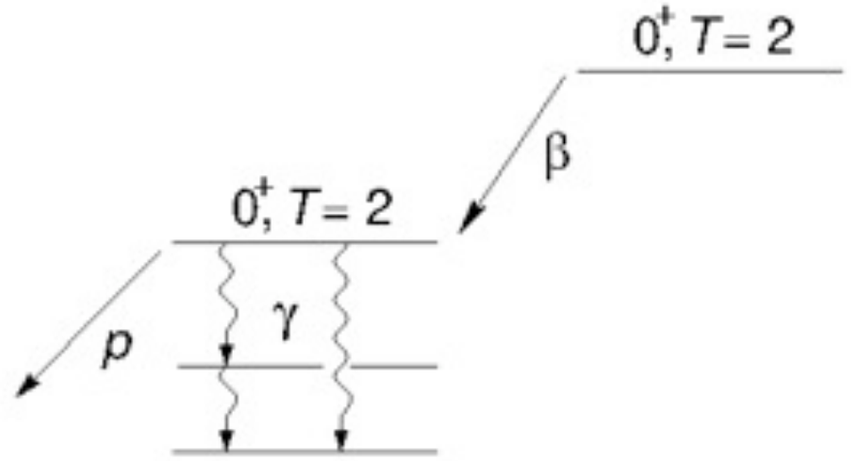
Natalie Foley, Hillsdale College
Advisors: Dr. Dan Melconian, Dr. Praveen Shidling

Outline

- Introduction and Goals of Experiment
- Purpose of an RFQ and How it Works
- My Contributions
- Outlook - Next Steps for Project

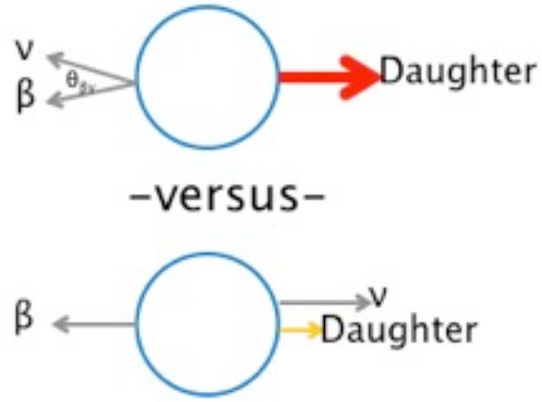
Introduction

- learn about weak interaction through beta-neutrino correlation of beta decay
  - angles between beta particles and neutrinos
- observe isospin T=2 beta-delayed proton decay
  - proton-rich
  - far from stability
  - two-step nuclear decay



Introduction

- unstable nucleus ejects beta particle, then proton



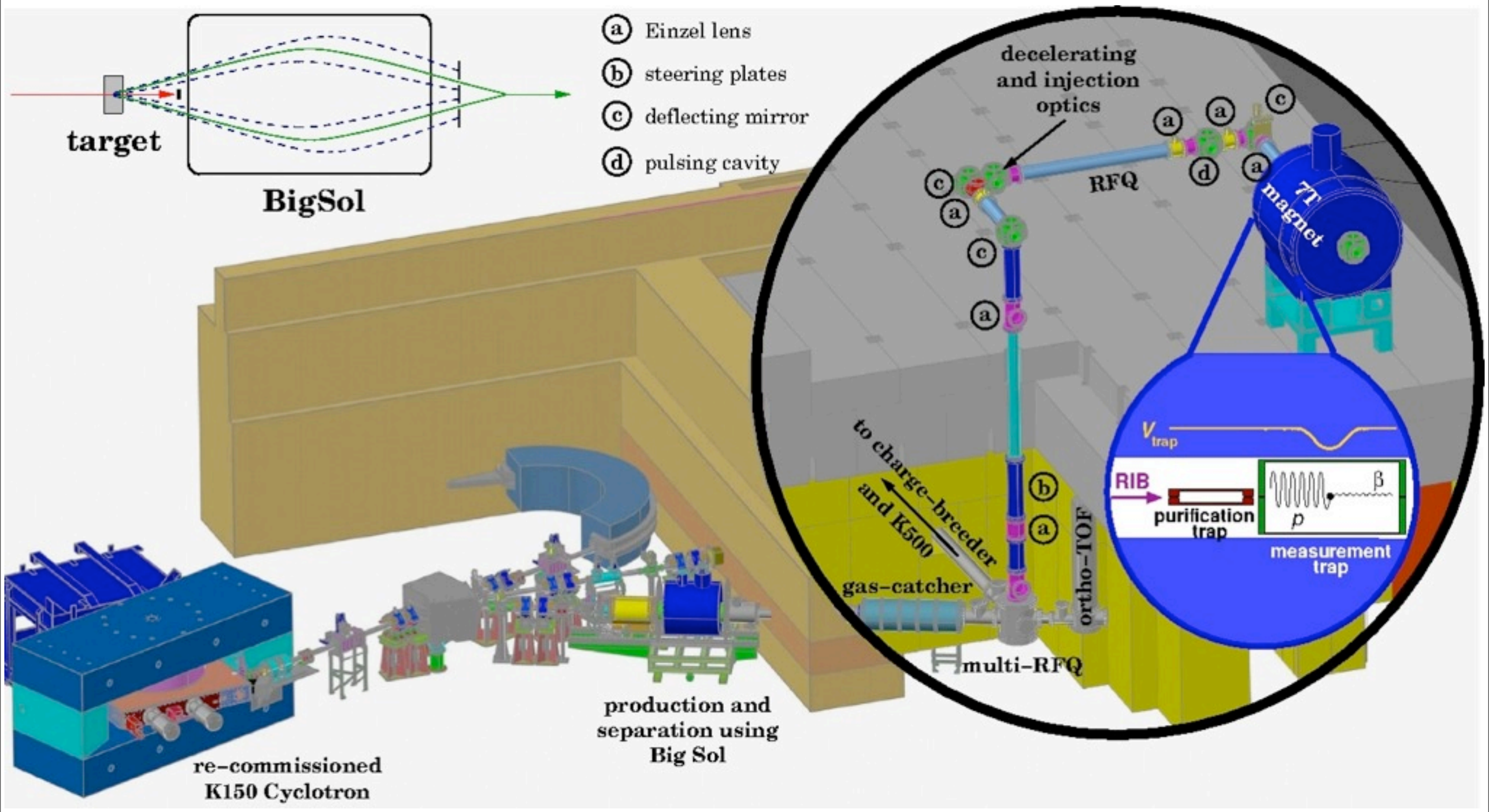
- measure distribution of angles between beta particle and neutrino as ejected from nucleus

- neutrino can't be measured directly, but angle between neutrino and beta particle is inferred from proton energy

Introduction

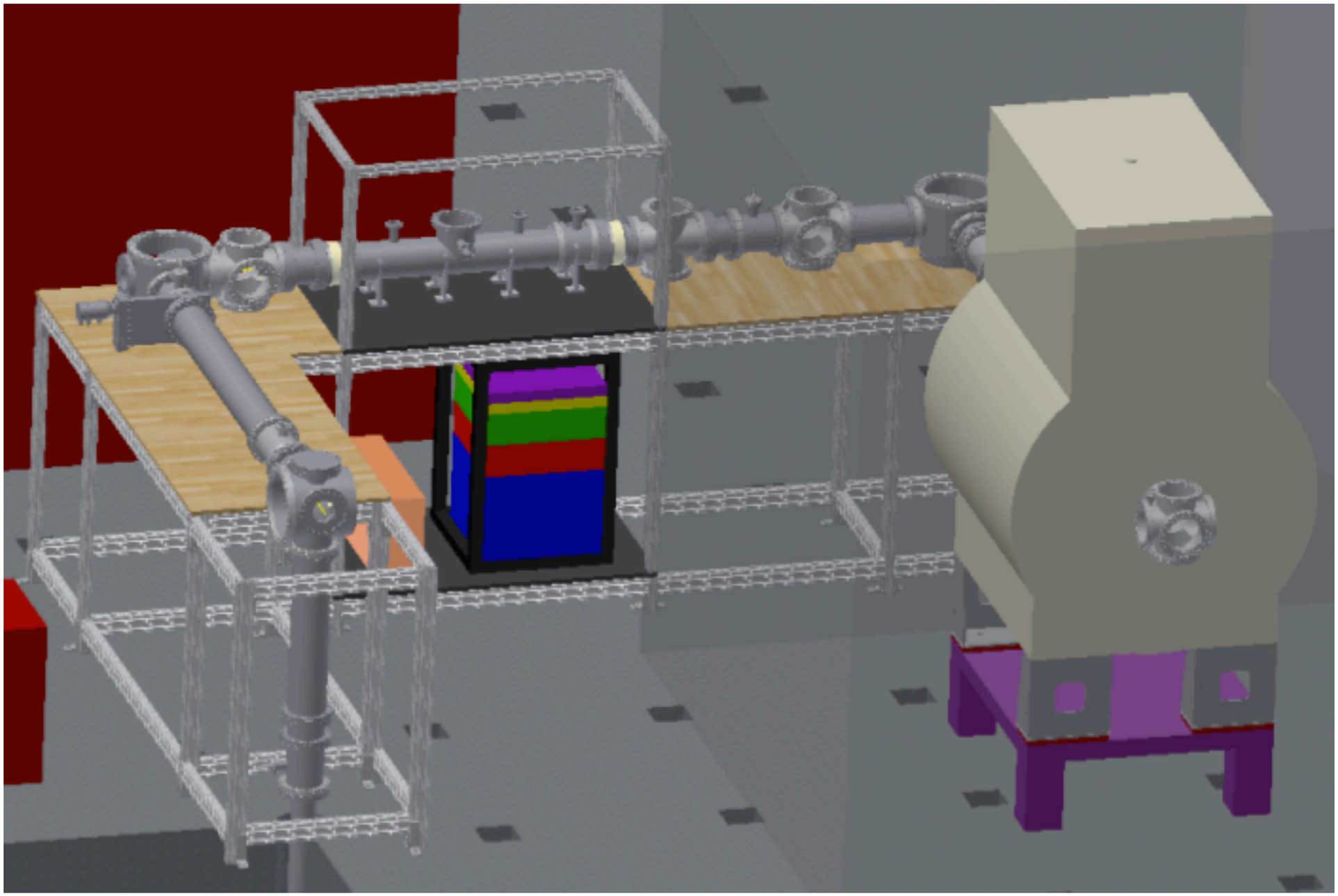
- theoretical expectations from Standard Model: beta particle and neutrino will usually be ejected in same direction
- if experimental results are different, could be indication of new physics

TAMU-TRAP


target
BigSol
a Einzel lens
b steering plates
c deflecting mirror
d pulsing cavity
decelerating and injection optics
RFQ
7T magnet
to charge-breeder and K500
gas-catcher
ortho-TOF
multi-RFQ
RIB
purification trap
measurement trap
ν_{trap}
p
β
production and separation using Big Sol
re-commissioned K150 Cyclotron

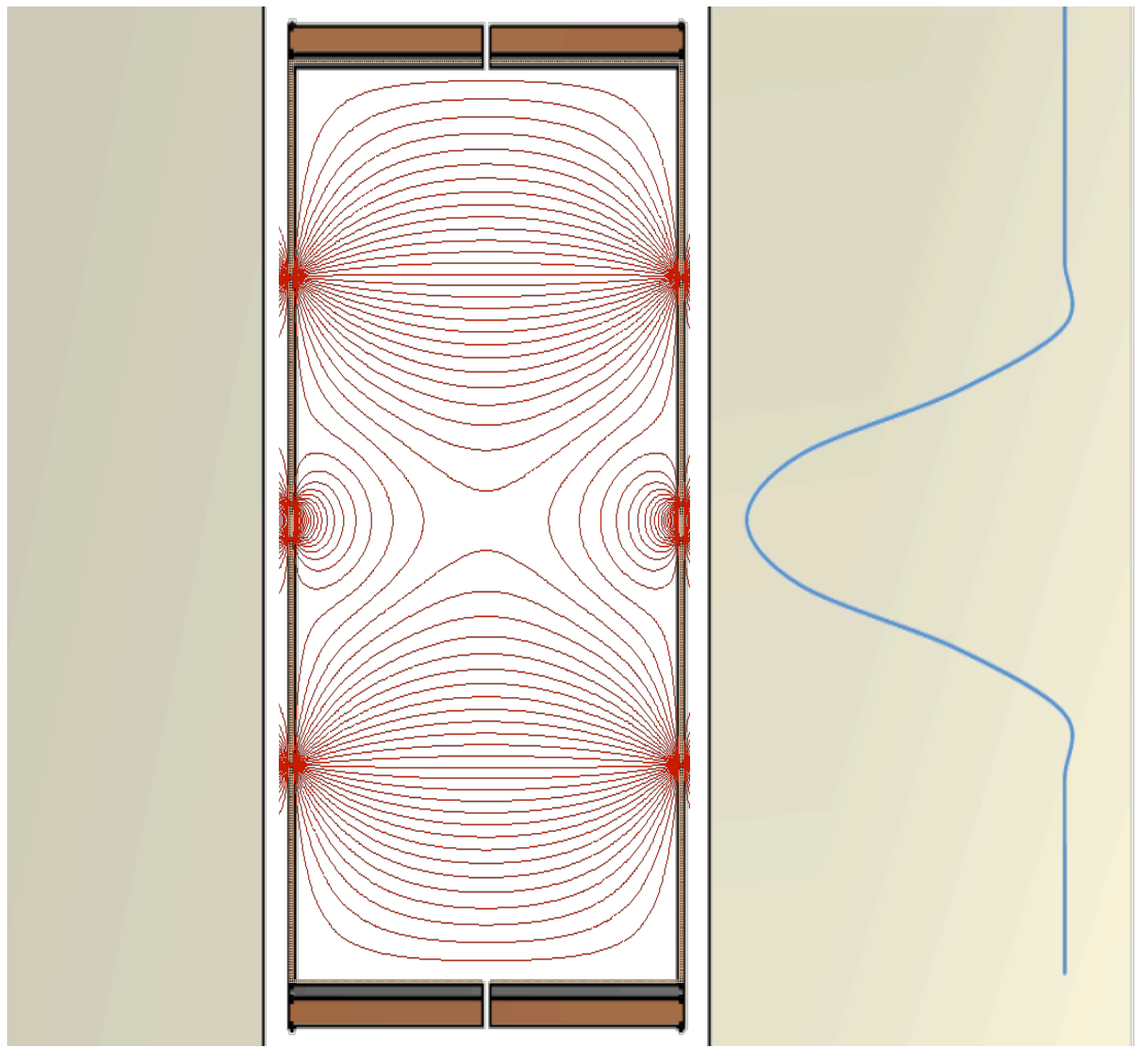
TAMU-TRAP

- new beam line and Penning trap



TAMU-TRAP

- Penning trap uses electric and magnetic fields to trap short-lived charged particles until they decay
  - electric field confines along axis
  - magnetic field confines radially



TAMU-TRAP

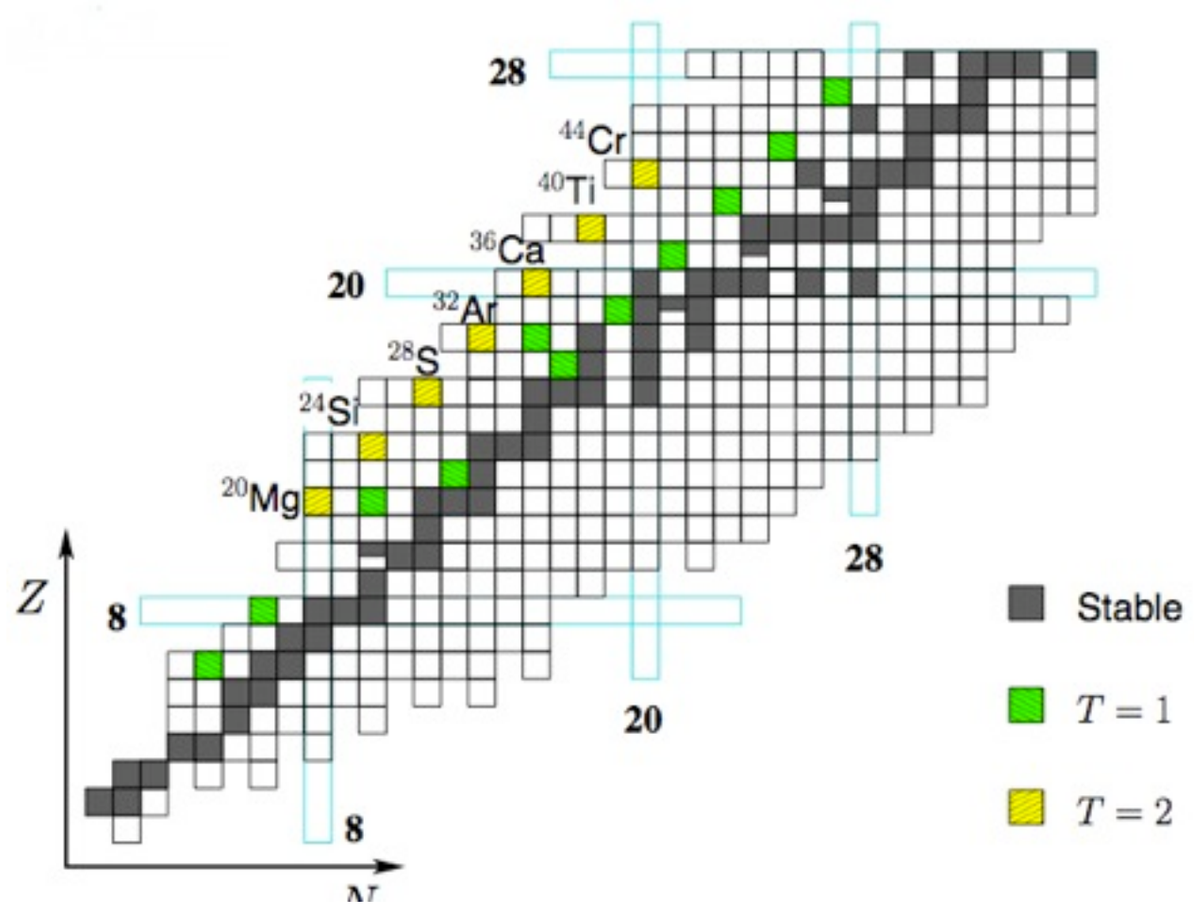
- will also include steerers, lenses, and RFQ Paul trap
- will also have ability to be used for precision mass measurements, laser spectroscopy, other decay studies, and more

Goals

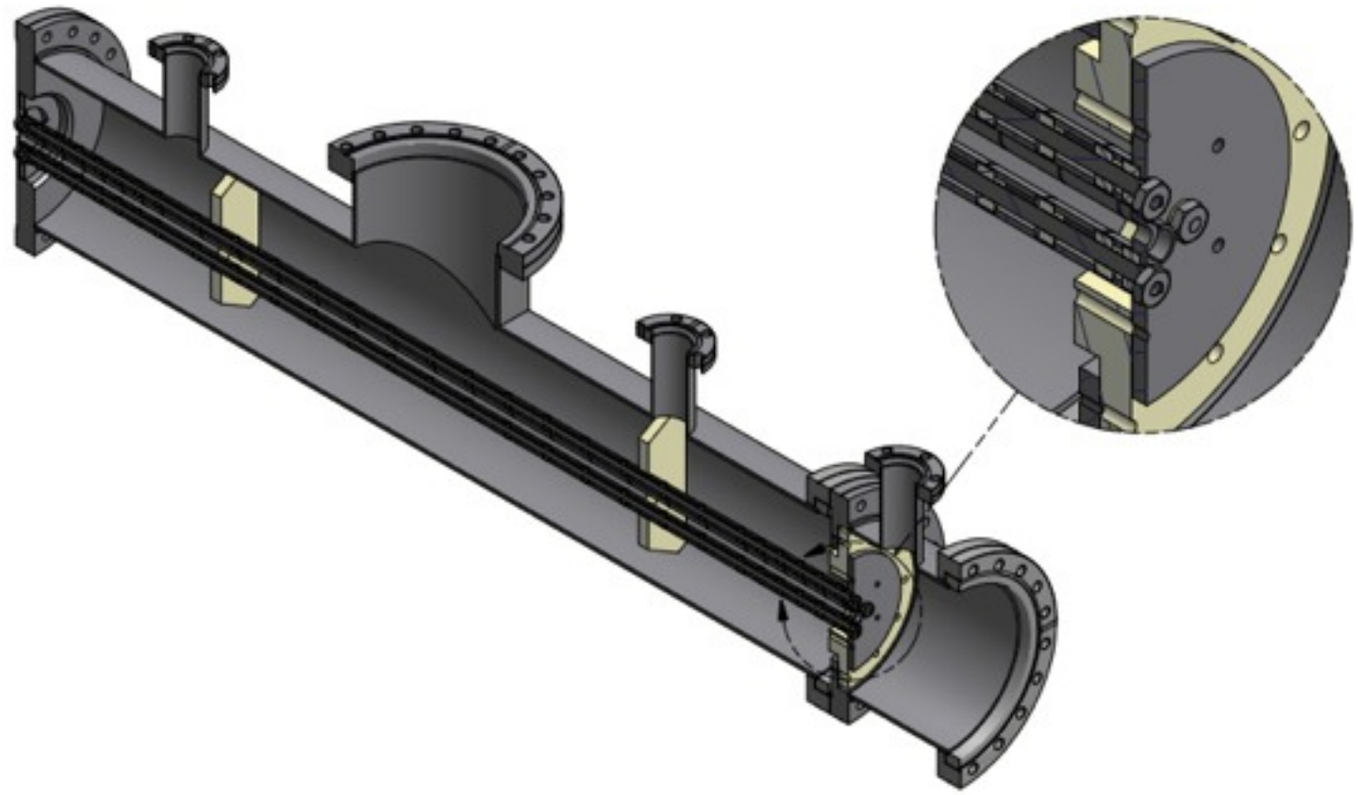
- experiments measuring decay of ^{32}Ar have been done at a different facility
  - begin with that isotope
  - will have least surprises; know somewhat what to expect

Goals

- continue with ^{20}Mg, ^{24}Si, ^{28}S, ^{36}Ca, ^{40}Ti, and ^{44}Cr
  - all follow same T=2 beta-delayed proton decay
- should behave similarly
- all produced at Cyclotron



RFQ



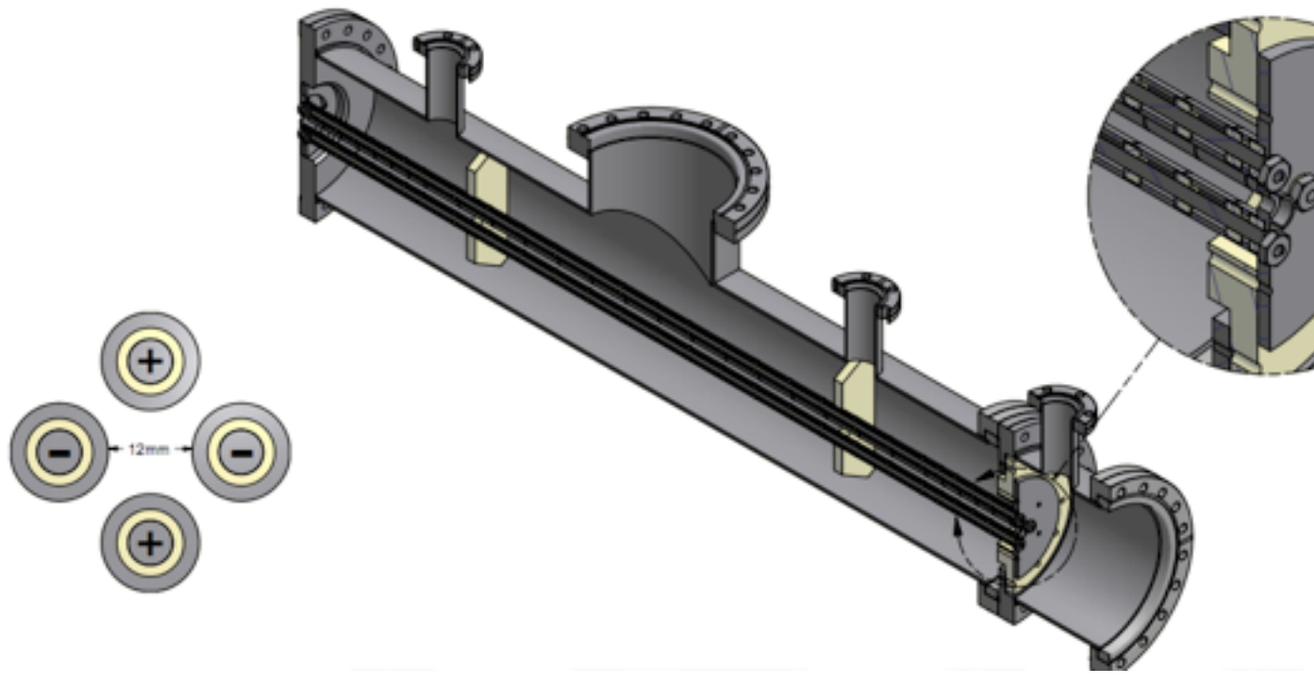
- Why do we need an RFQ?
  - slows & bunches particles
    - only way Penning trap will accept them

RFQ

- Radio Frequency Quadrupole Paul trap
- two main functions:
  - Slow: contains ^{4}He gas - collisions with ions slow them down
  - Bunch: electric potentials guide particles to end of RFQ and hold them until released into Penning trap

RF Voltage

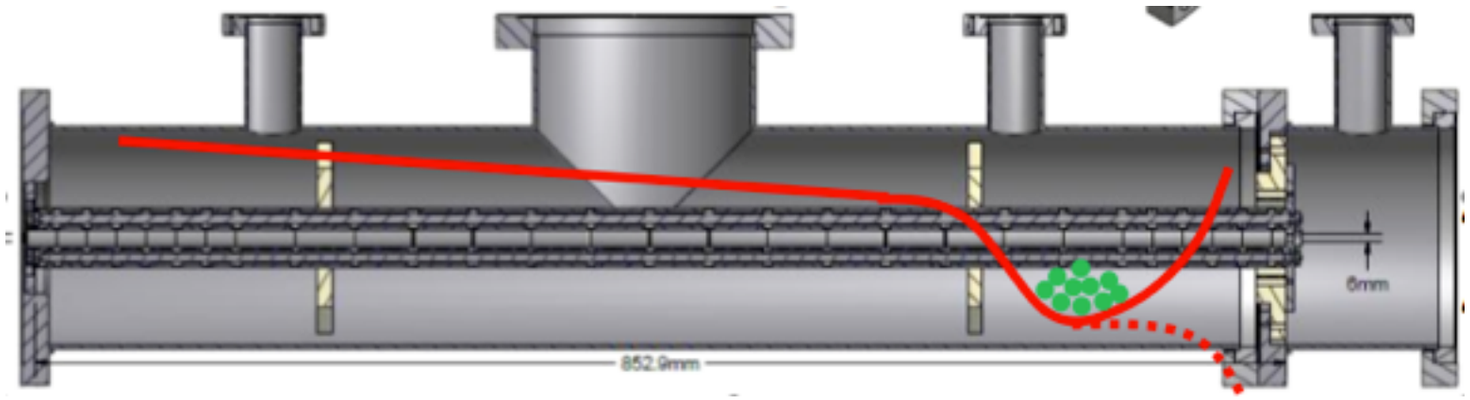
- 4 rods run length of RFQ
- opposites receive RF in phase
- adjacents receive RF 180° out of phase
- experiences force from all 4 rods



DC Voltage

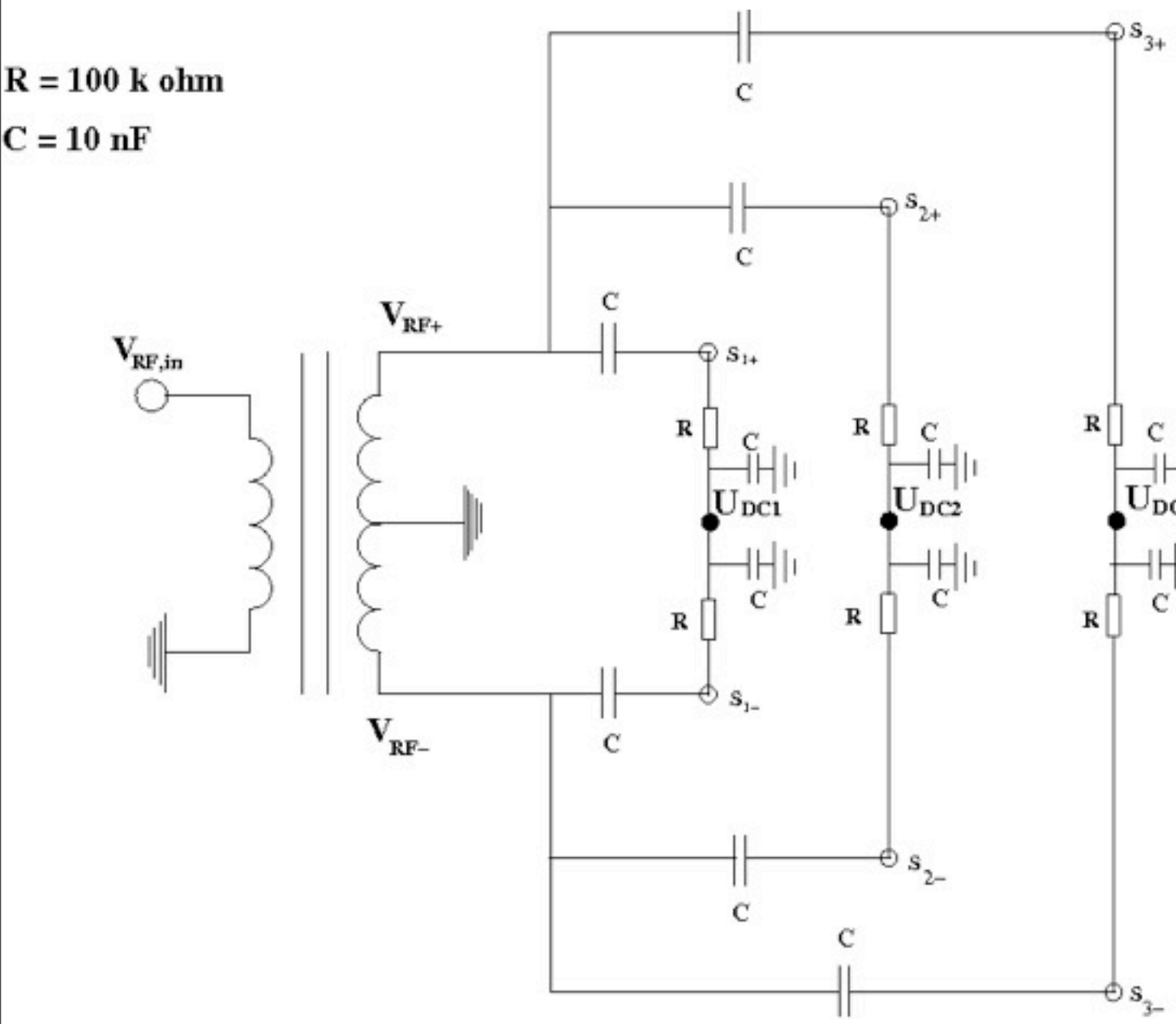
- DC voltage decreases from about 9V to 2V over length (83cm) of RFQ
- each rod divided into 28 segments
- segments each receive different voltages
- allows voltage to be adjusted as function of position

DC Voltage

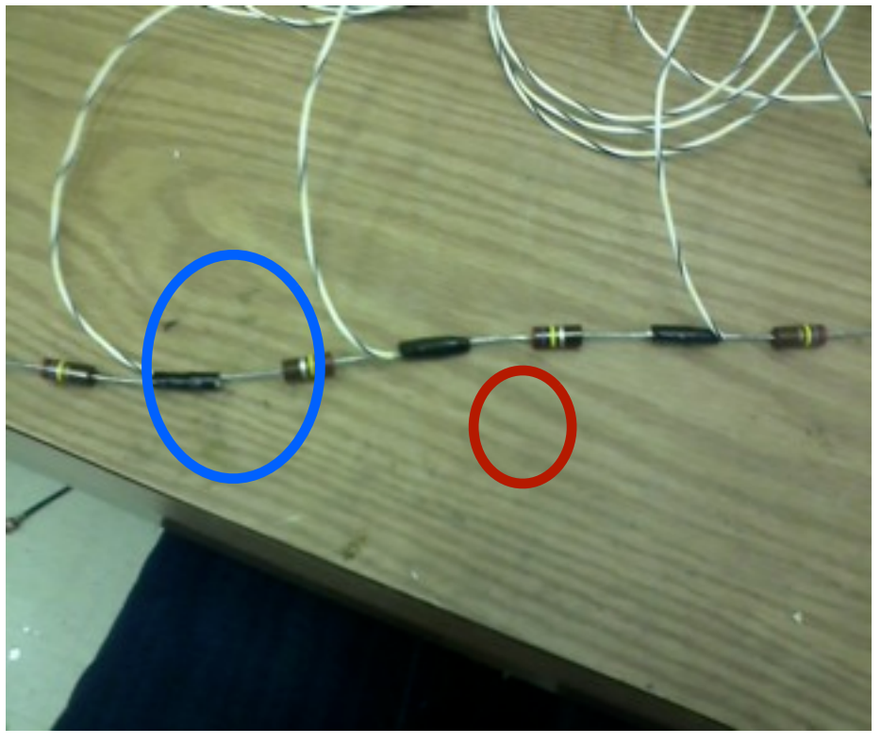


- guides ions towards end of RFQ
- creates potential valley to bunch and hold ions
- releases ions into Penning trap every few ms by dropping voltages of end segments
- low emittance (position and velocity spread) - necessary for loading Penning trap

Circuits

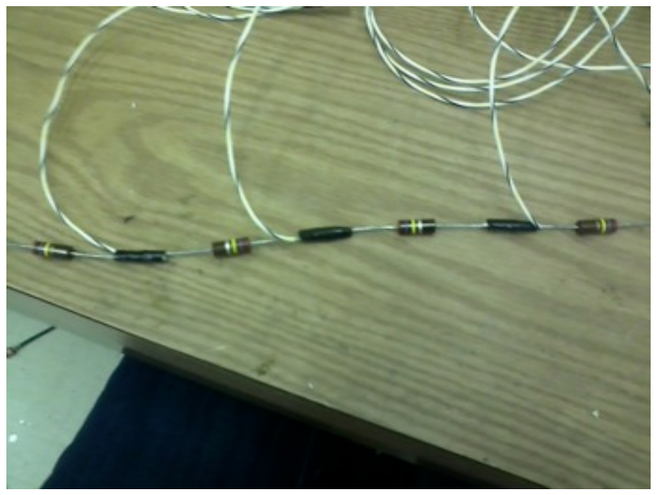


- circuit diagram for connecting RF and DC voltages
- connect RF and DC to segment with one wire
- separate connection points for RF+ and RF- (out of phase with each other)



Circuits

- low pass filter blocks RF high frequency from damaging DC power supply
- transformer divides RF into RF+ and RF-
- voltage divider decreases DC voltage in small steps
  - resistors connected in series



Contamination

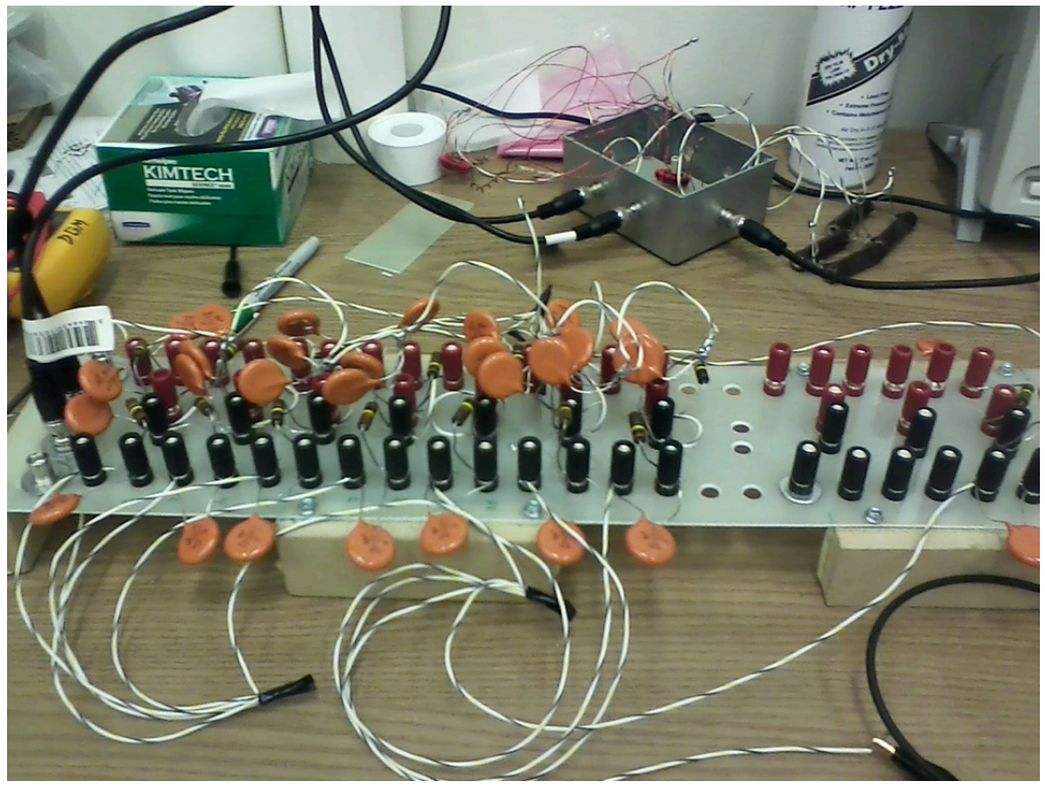
- contaminants combine with ions to form molecules
  - biases measurements and adds background to data
- Fill with ^{4}He, but don't want interference from contaminants
  - ^{4}He inert; won't form molecules

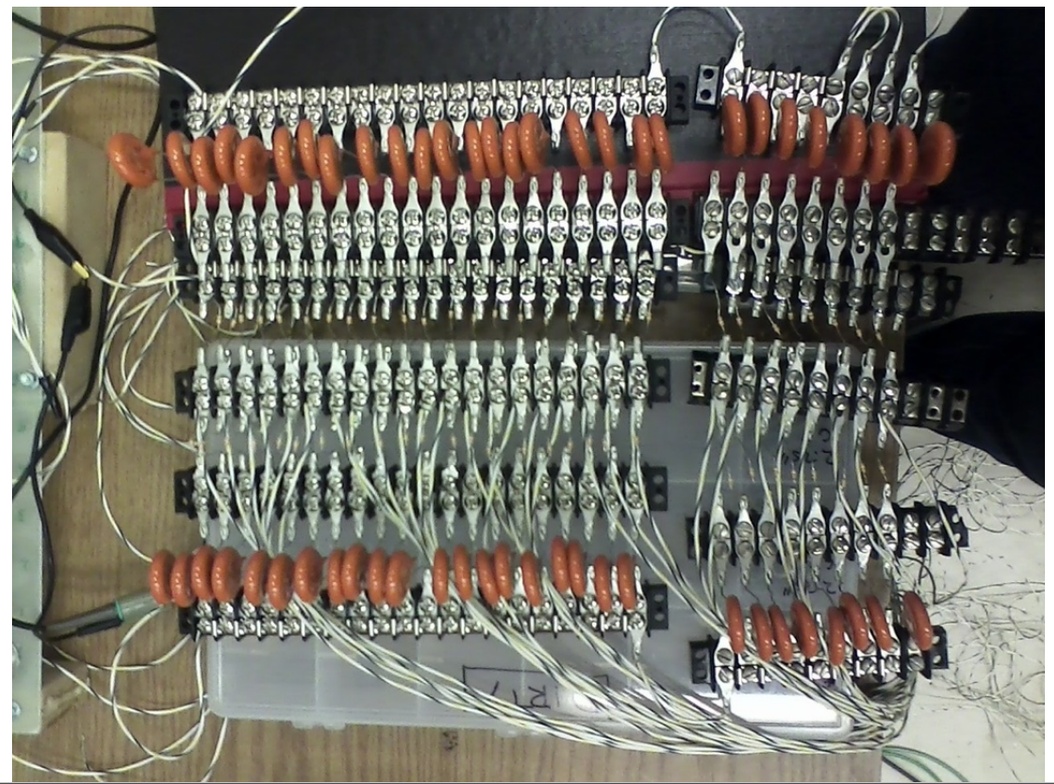
Progress - Cleaning

- cleaned all parts to remove contaminants
  - ultrasonic cleaner
  - rinsed with water, then alcohol
  - wore gloves, stored parts in foil

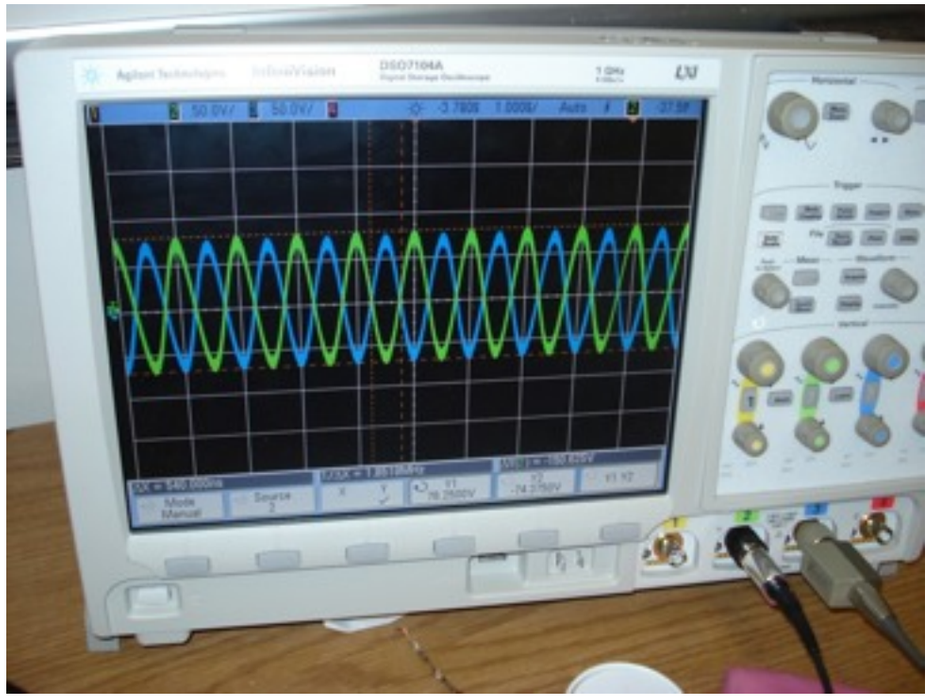
Progress - Electronics

- circuits first assembled & tested on breadboard
- worked as expected, so assembled smaller components





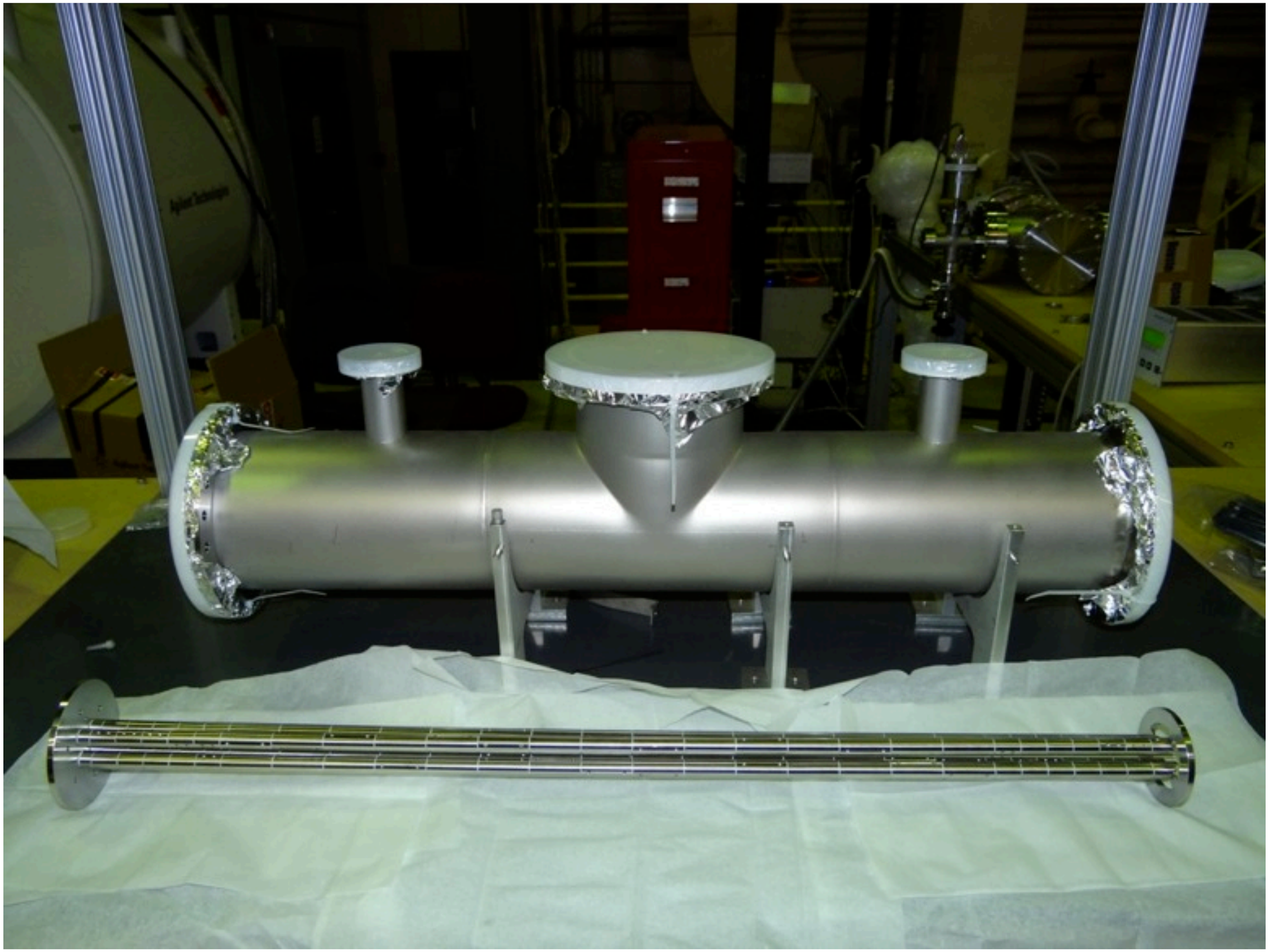
Progress - Electronics



- testingwith oscilloscope and multimeter
- RF+ and RF- different amplitudes by 10-20%
  - not sure how crucial to experiment
  - transformer may need adjustment

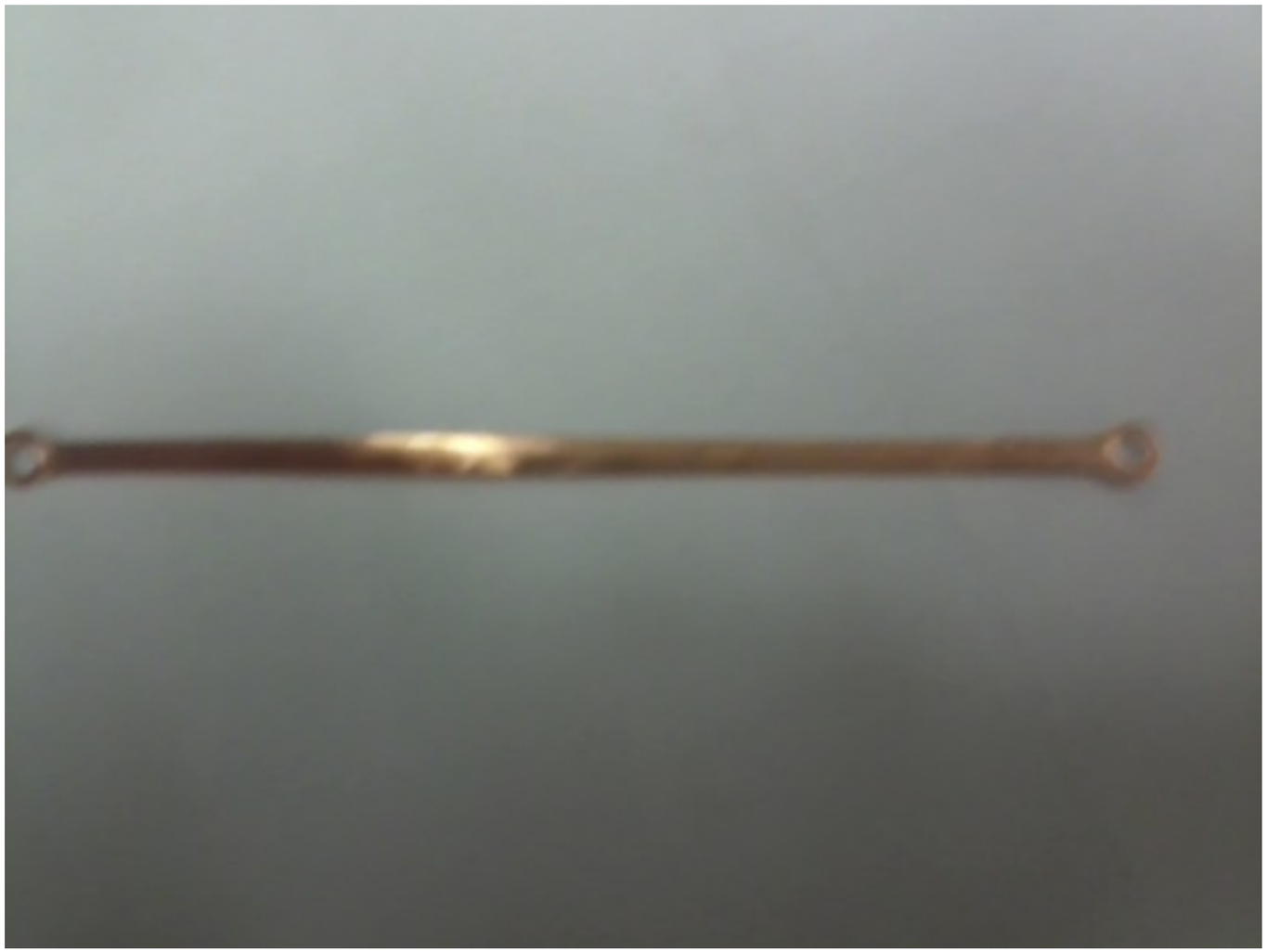
Progress - Assembly

- segments have been assembled into rods



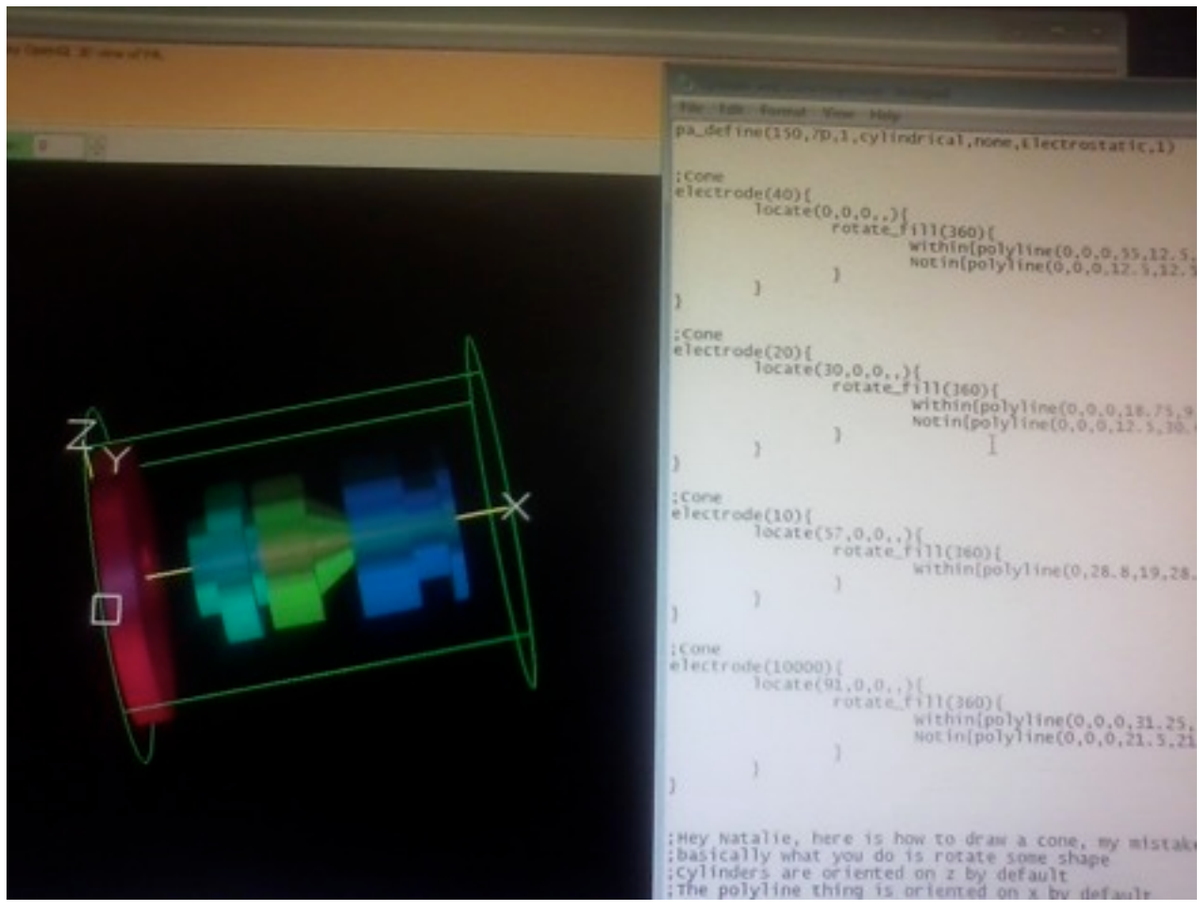
AutoCAD

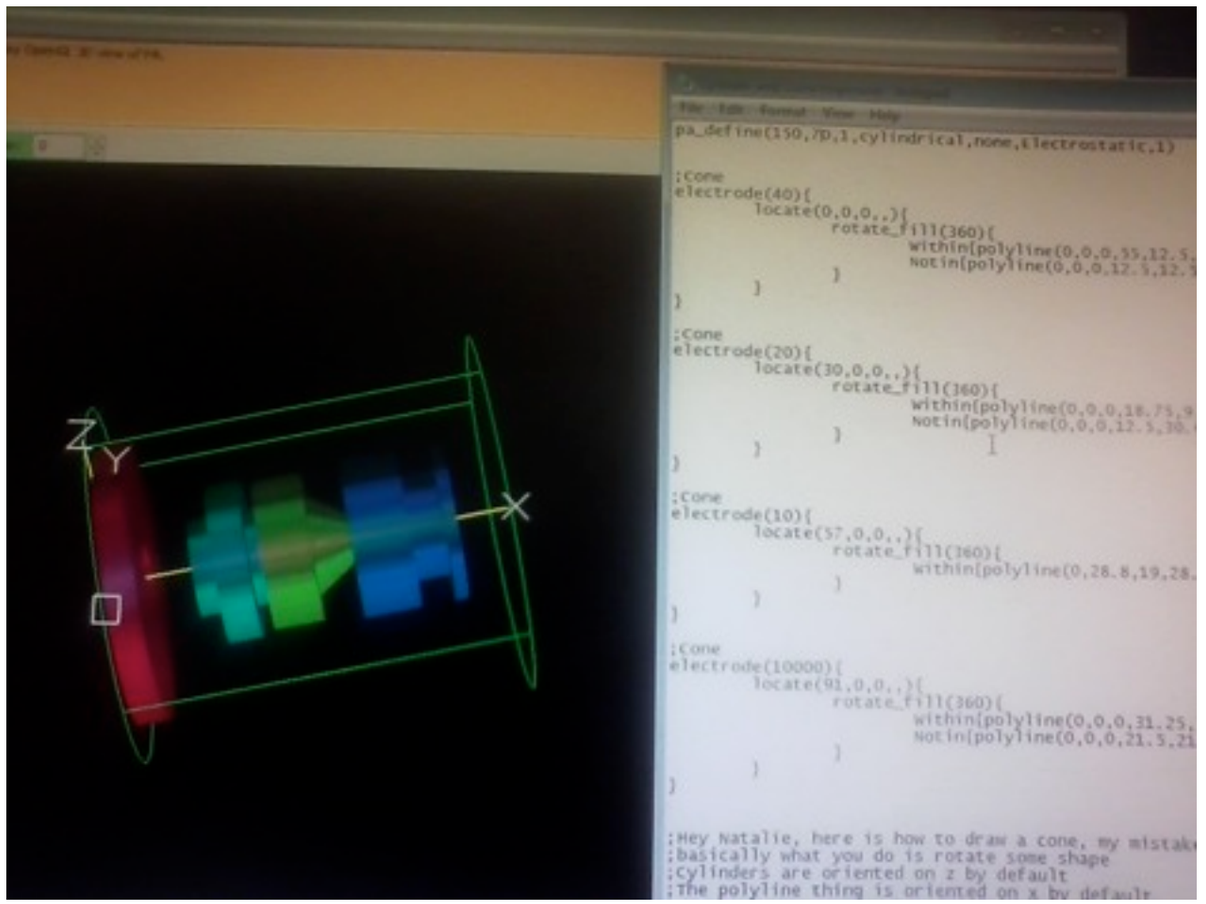
- designed and had copper connectors built



SIMION

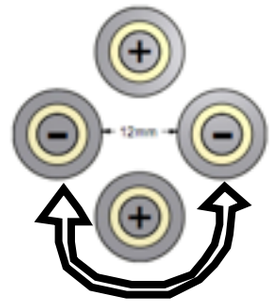
- possible ion source designs and emittances
- continued by Yakup





Outlook

- fix transformer so RF+ and RF- are same amplitude
- attach electronics to segments
  - connect segments with same phase RF using either copper connectors or



- test RFQ with off-line ion gun
  - build here from SIMION designs
- place in beam line

Acknowledgements

- Thanks to:
  - Dr. Dan Melconian, Dr. Praveen Shidling, Mike Mehlman for mentoring
  - Dr. Sherry Yenello for leading the Cyclotron REU program and Lauren Heilborn for organizing
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