Units:

Typically work is expressed in units of kiloelectron volts (keV) or Megaelectron volts (MeV). What are these?

- **First let's consider accelerating a charged particle from rest to some speed *v*.**
- **The work done is a product of the charge and the accelerating potential that the charge passes though.**
- **It is like a ball rolling down a hill. There is a conversion of *potential energy* at the top of the hill to *kinetic energy* at the bottom of the hill. The ball starts from rest and at the bottom of the hill has a speed *v* and thus a *kinetic energy* associated with its motion. So too does the charge.**
- **It is repelled away from a like charge at the top of the potential hill and attracted to an opposite charge at the bottom of the potential hill**

$$\text{Work} = W = q\Delta V = \left(1e^{-}\right) \times \left(1\text{Volt}\right) = 1\text{electron} \times \text{Volt} = 1eV$$

Units:

- **Each elementary charge has *1.6x10^-19 Coulombs* worth of charge. Therefore the work done can also be written as:**

$$\text{Work} = W = q\Delta V_{\text{accelerating}} = 1eV = 1e \times \frac{1.6\times10^{-19}\,\text{Coulombs}}{1e} \times 1\text{Volt} = 1.6\times10^{-19}\,\text{Joules}$$

- **An electron-volt is a unit of energy**

- **And our conversion is that *1eV = 1.6x10^-19 J*.**

- **By the work-kinetic energy theorem, the work done accelerating the charge changes the kinetic energy from zero (the charge is initially at assumed to be at rest) to some speed *v* given by**

$$\text{Work} = \Delta\text{Kinetic Energy} = \Delta KE = \frac{1}{2} m_{ion} v_{ion}^2$$

A Couple of Quick Calculations

Comment:

Generally one needs to worry about the speeds of these particles and how they compare to the speed of light.

- Need to include Relativistic effects?

- In other words does the measured speed of the proton equal the theoretical speed of the proton?

This is hard to do… so, we set a limit… and we define a relativistic limit to be when the velocity of the object is less than *one-tenth* the speed of light ($c \sim 3x10^8$ *m/s*) then we do not have to worry about relativistic effects.

Here the velocity is $2.05x10^7$ m/s which is *0.069* times the speed of light, less than the limit, so no relativistic effects.

A Couple of Quick Calculations

- So, we've accelerated the proton and calculated its energy and speed.

- Now can we steer it in the magnetic field? If so, what is its orbital trajectory, or radius?

- The proton feels a force given by $\vec{F} = q\vec{v} \times \vec{B}$.

- This makes the particle travel in a circle of radius *r* due to the centripetal force it feels.

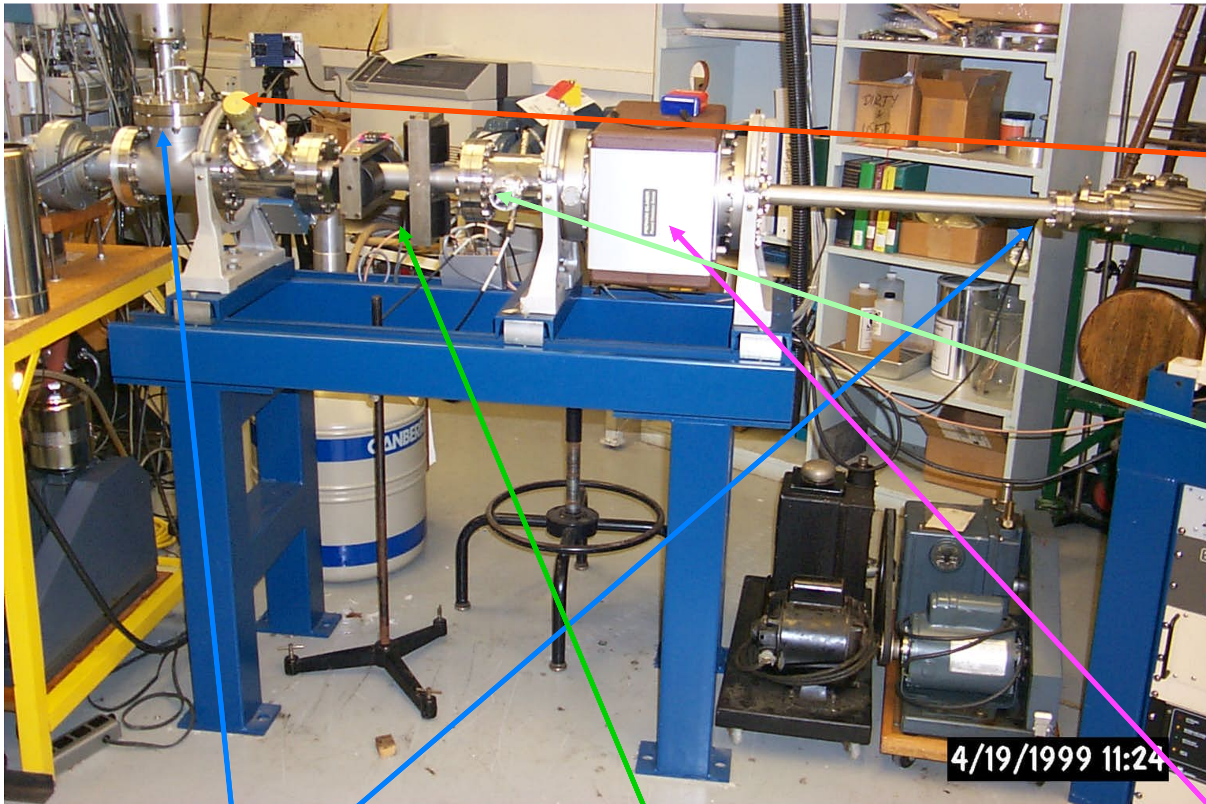
$$F_B = F_C \rightarrow qv_pB = \frac{m_pv_p^2}{r}$$

$$r = \frac{m_pv_p}{qB} = \frac{1.67\times10^{-27}kg\times2.05\times10^{7}\frac{m}{s}}{1.6\times10^{-19}C\times0.6214T} = 0.344m = 34.4cm$$

- Once the charges leave the magnetic field the force vanishes and they continue in a straight line toward the scattering chamber.

The UCIBAL
Union College Ion-Beam Analysis Lab

A few odds and ends on the way to the scattering chamber….



Beam profile monitor

Energy controller

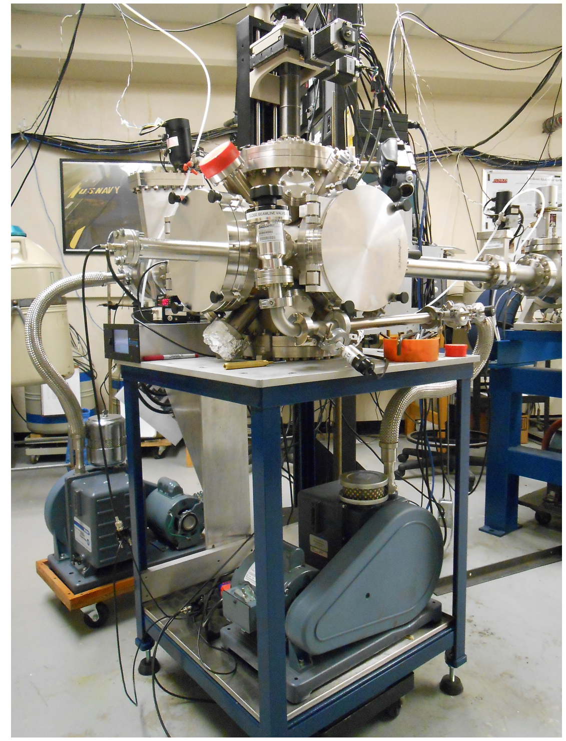
Faraday cups

Ion pump (not in use)

Horizontal and Vertical steering magnets

The scattering chamber

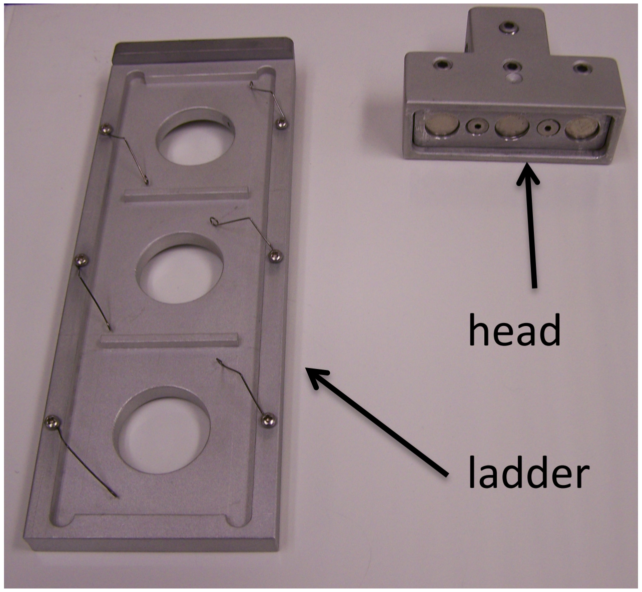
This is where the experiments are done.

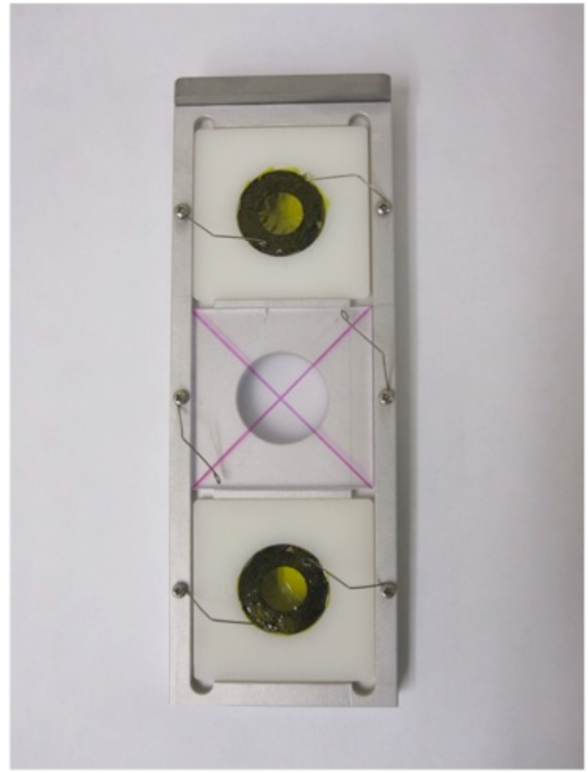


•The scattering chamber is a 10” multi-port Conflat system with a 3-axis target manipulator mounted on top.

•Samples are placed inside and can be moved horizontally in a plane, vertically, and rotated about a central axis.

Target Ladder Assembly



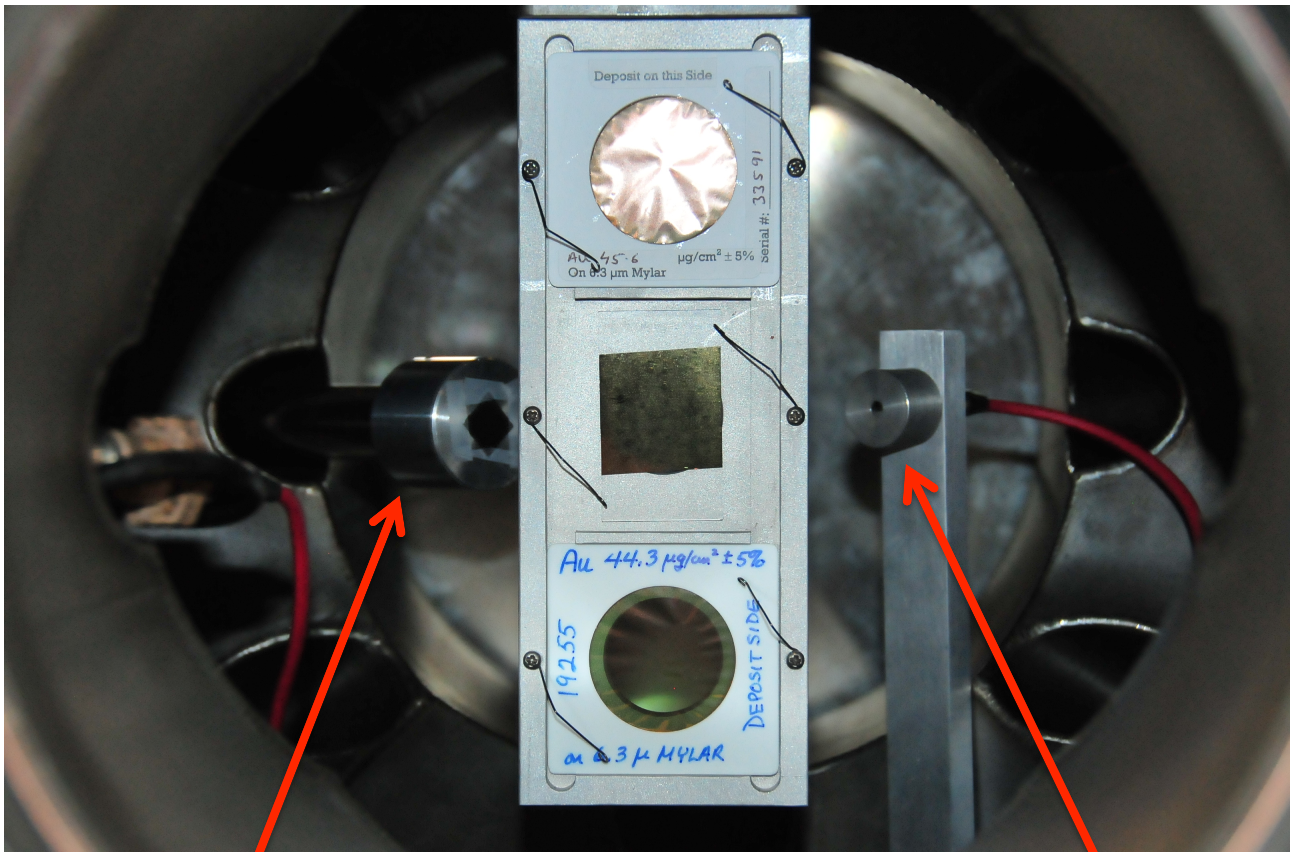


• Inside of the scattering chamber is the target ladder assembly. It is attached to the target manipulator by a "head" by a shaft (not shown) and the ladder is magnetically coupled to the head.

• Three targets at a time may be analyzed using the ion beam.

Inside the scattering chamber

The ion beam enters facing you and passes thought the targets



X-ray detector (for *PIXE*)

Si surface barrier detector (for *RBS* & *PESA*)

Uses of a particle accelerator

Materials Analysis

Mass spectrometry

Nuclear reactions

Nuclear structure

Biochemistry

Paleontology

Forensic science.

Art restoration and archeometry