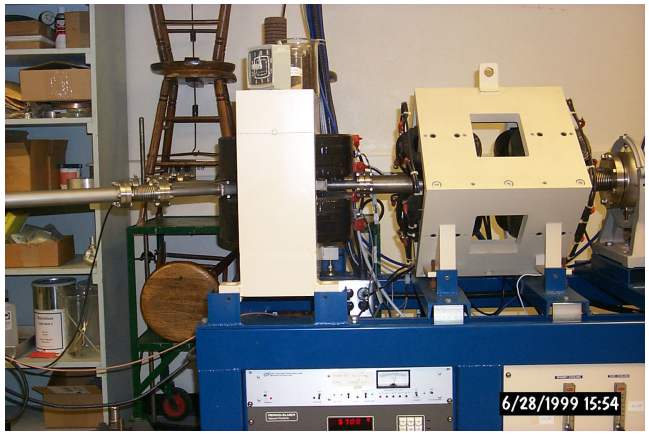
Magnetic Steering of Ions

- The steering magnets are a momentum filter (or here, a really crude mass spectrometer.)
- A momentum filter is a device which separates charged particles based on their momentum (or kinetic energy, which is proportional to their momentum).
- When a charged particle passes through a magnetic field with a component of its velocity perpendicular to the magnetic field, the charge will feel a force and it will move in the direction of the applied force.
- The magnetic force is given by $\vec{F} = q\vec{v} \times \vec{B}$



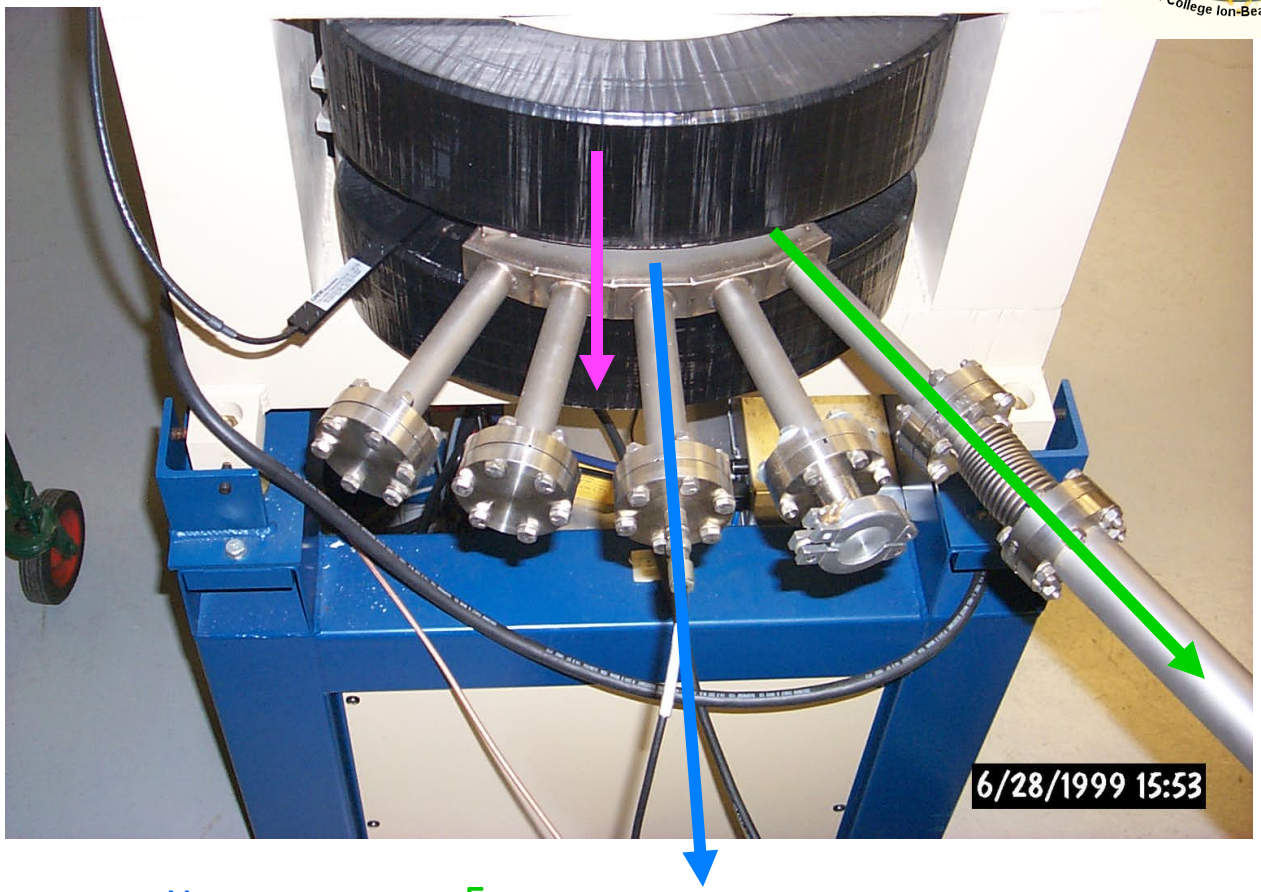
Side view of steering and quadrapole magnets

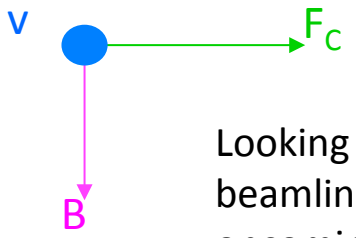
Steering of Ions

B points straight down to the floor from the upper to the lower magnet.

The velocity vector of the charges is coming out of the machine at you. This is called the zero-degree beamline.

Choosing the field appropriately (to match the particle's energy bends the charges to your right and down the 30° beamline.





Looking down the beamline at the oncoming charge

A Couple of Quick Calculations

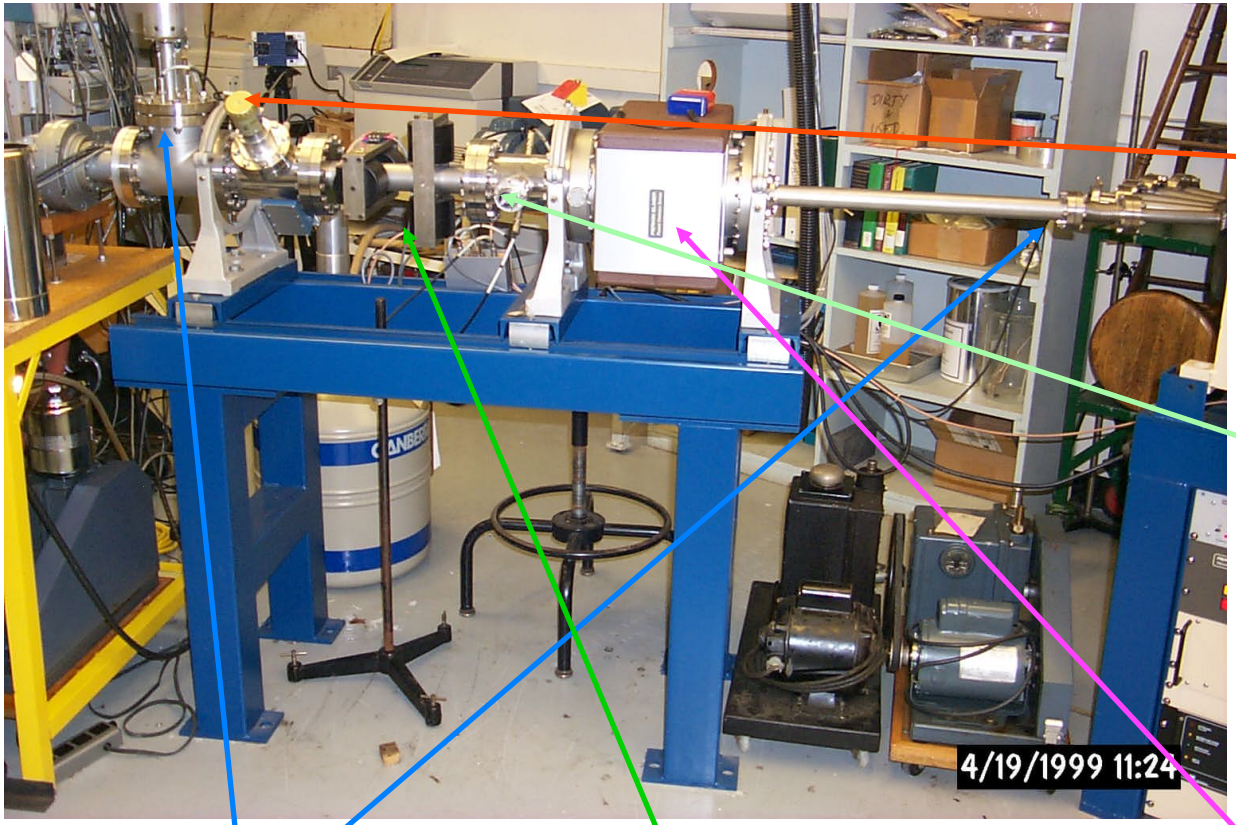
- So, we've accelerated the proton and calculated its energy and speed.
- Now can we steer it in the magnetic field? If so, what is its orbital trajectory, or radius?
- The proton feels a force given by $\vec{F} = q\vec{v} \times \vec{B}$.
- This makes the particle travel in a circle of radius *r* due to the centripetal force it feels.

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

$$r = \frac{m_p v_p}{qB} = \frac{1.67 \times 10^{-27} kg \times 2.05 \times 10^7 \frac{m}{s}}{1.6 \times 10^{-19} C \times 0.6214 T} = 0.344 m = 34.4 cm$$

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

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



Beam profile monitor

Energy controller

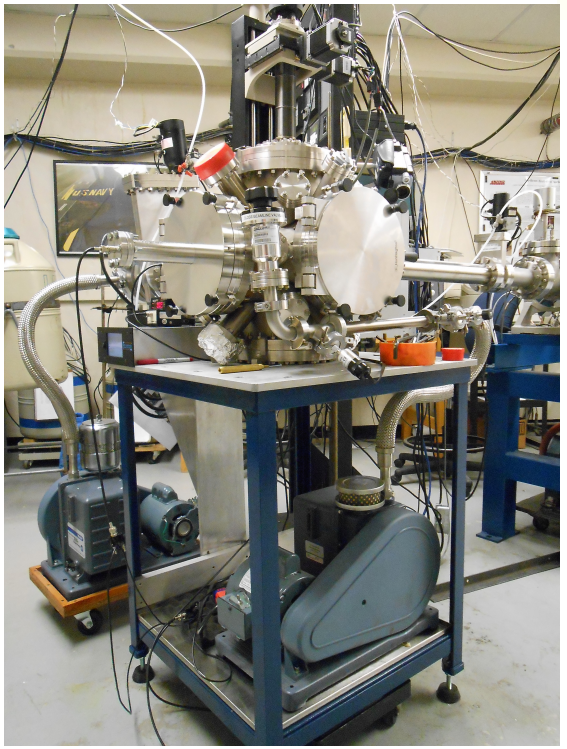
Faraday cups

Horizontal and Vertical steering magnets

Ion pump (not in use)

The scattering chamber

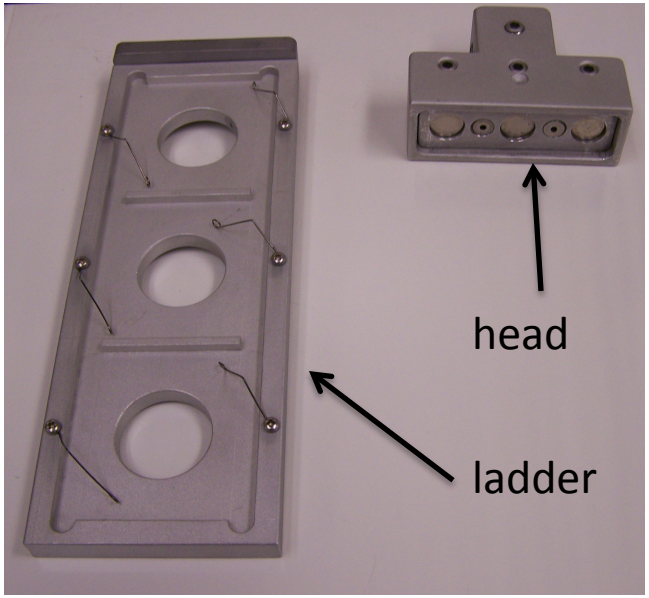
This is where the experiments are done.

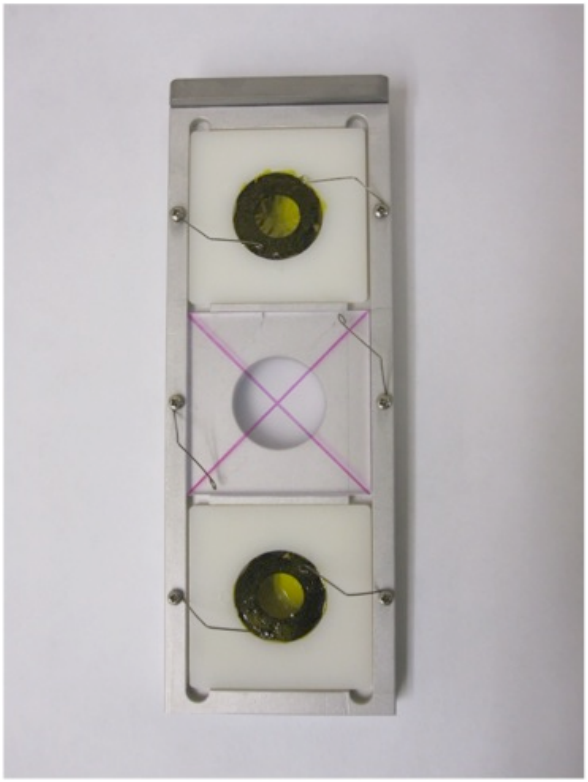


•The scattering chamber is a 10” multi-port Conflat system with a 3-axis target manipulator mounted on top.

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

Target Ladder Assembly



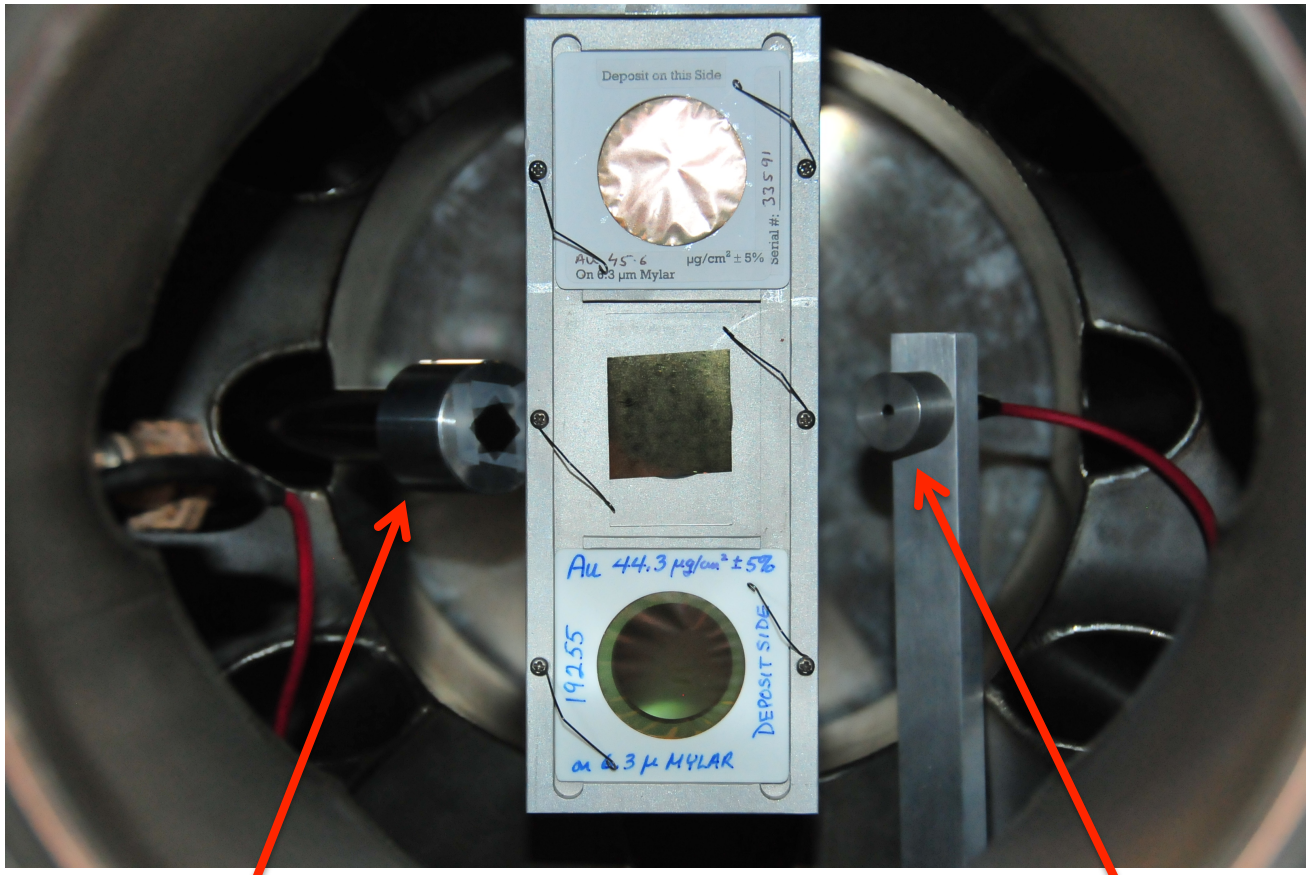


- Inside of the scattering chamber is the target ladder assembly. It is attached to the target manipulator by a "head" by a shaft (not shown) and the ladder is magnetically coupled to the head.

- 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

Environmental Samples

Mass spectrometry

Nuclear reactions

Nuclear structure

Biochemistry

Paleontology

Forensic science.

Art restoration and archeometry

Medicine and Medical Physics