



Physics 100 – Module 1

Materials Science and Materials Analysis using a Particle Accelerator

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My Background:

In the department for 16 years

8th time teaching Physics 100.

Teach primarily

Physics 110/111 (Physics for the Life Sciences)

Physics 120/121 (Physics for Majors and Engineers)

Physics 210 (Medical Physics)

Physics 220 (Introduction to Quantum Mechanics)

Physics 300 (Modern Experimental Techniques)

Physics 490/491 (Senior Thesis)



Background continued...

- I am trained as a theoretical physicist in waveguide theory.

Production, propagation, and diffraction of x-rays (a type of electromagnetic wave) through glass capillary fibers.

Includes surface roughness and x-ray attenuation effects.

- I am also an experimental physicist who runs the particle accelerator.

Environmental pollution studies with aerosols/liquids

Environmental pollution near airports – Pb pollution from small aircraft

Medical and Health Physics issues – Hg in Fish/metal distribution in tissues

Soil contamination – Heavy Metals in soils and sediments

Art/Archeometry – dating artifacts by diffusion processes into a sample

My physics hobbies...

Fluid Mechanics
Aerodynamics
Flight and Flight Mechanics
Aircraft Photography



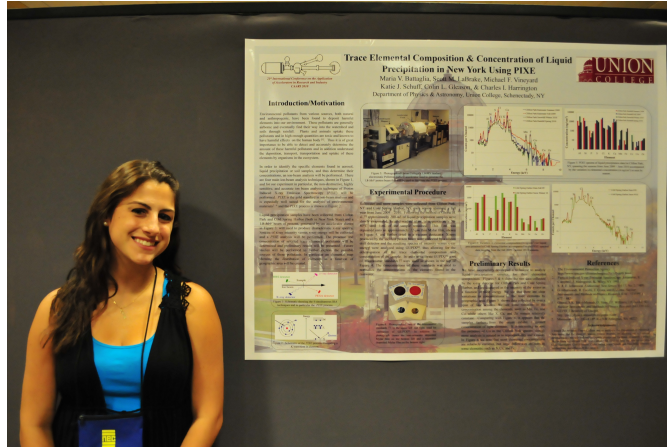
Motion and Gravity



The *Union College Ion Beam Analysis Laboratory*



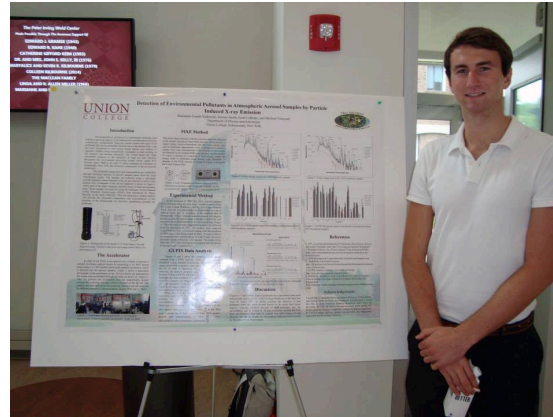
Chad & Colin are now graduate students (at SUNY Buffalo and University of South Carolina), who worked on the analysis of atmospheric aerosols by PIXE/PIGE/RBS/PESA.



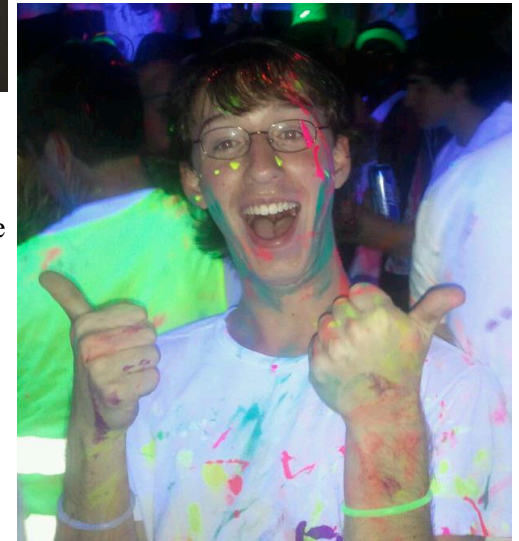
Maria is a Resident Pediatrician on Long Island who worked on liquid precipitation samples and on the development of a procedure for looking at the distribution of metals in animal (skate) tissues. Here she is at CAARI, an international accelerator conference in Fort Worth Texas



Colin is a 4th year graduate student at Penn State who worked on the analysis of atmospheric aerosols by RBS/PESA.



Ben is a Senior who is looking at ERDA



Jeremy is 2nd year graduate student at Uconn (and former PHY100 student) who worked on his senior thesis on the accelerator studying lead emissions from small airplanes at Schenectady airport.

Some past and present research students

What does the *UCIBAL* study?

Applications of Nuclear Physics to Environmental Problems



Solids – soils, trees, tissues

Liquids – water, wines, blood

Gas – atmospheric aerosols



http://www.conserve-energy-future.com/wp-content/uploads/2013/04/Smoke_from_airplane.jpg



<http://www.offthehoof.co.uk/2013/03/how-to-avoid-environmental-pollution/>



<http://ocean.nationalgeographic.com/ocean/critical-issues-marine-pollution/>

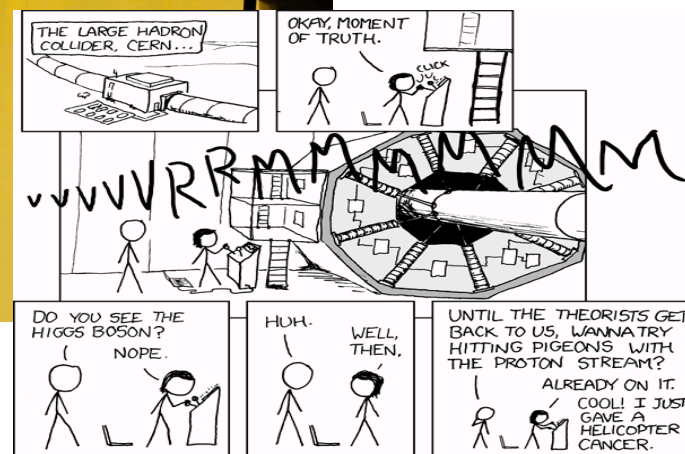
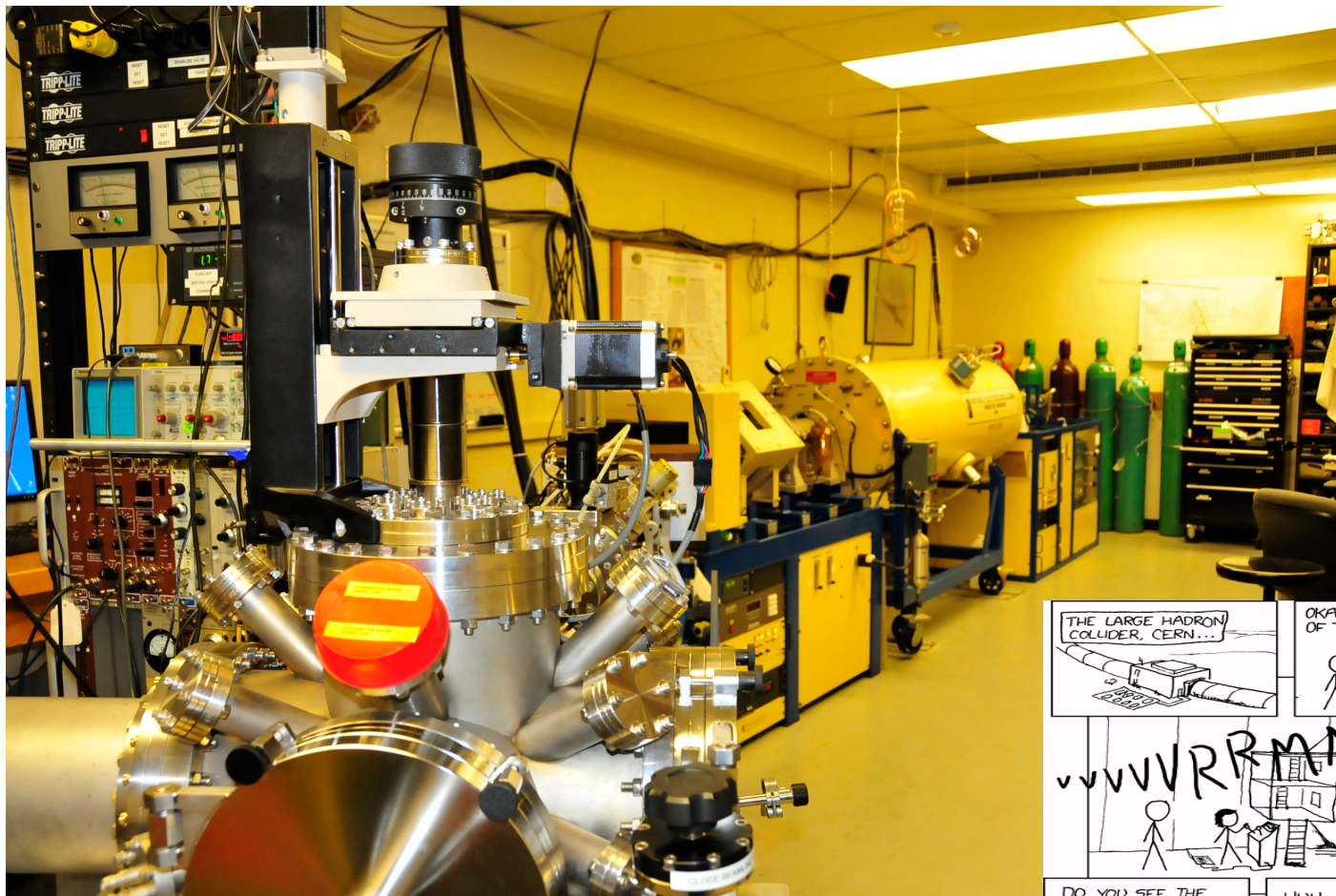
Game Plan....



- We're going to use a what?
- Accelerator – What it is, What it does. Energy and velocity calculations.
- *PIXE* – Basics, Theory and Sample calculations.
- Modifications to the *PIXE* Theory.
- Materials Analysis of a sample using *PIXE* and the accelerator.



We're going to use a what? A particle accelerator?



http://sciencegeekgirl.com/files/2008/12/large_hadron_collider1.png?w=300

The Pelletron Particle Accelerator



- Built by the National Electrostatics Corporation
- Acquired in 1991
- Replaced 450 kV Van-de-Graff accelerator
- In the process of writing a grant proposal for ~1.5 million dollars for a new accelerator which if funded would be installed in 2018.
- Our current accelerator has 4 main components

Ion production

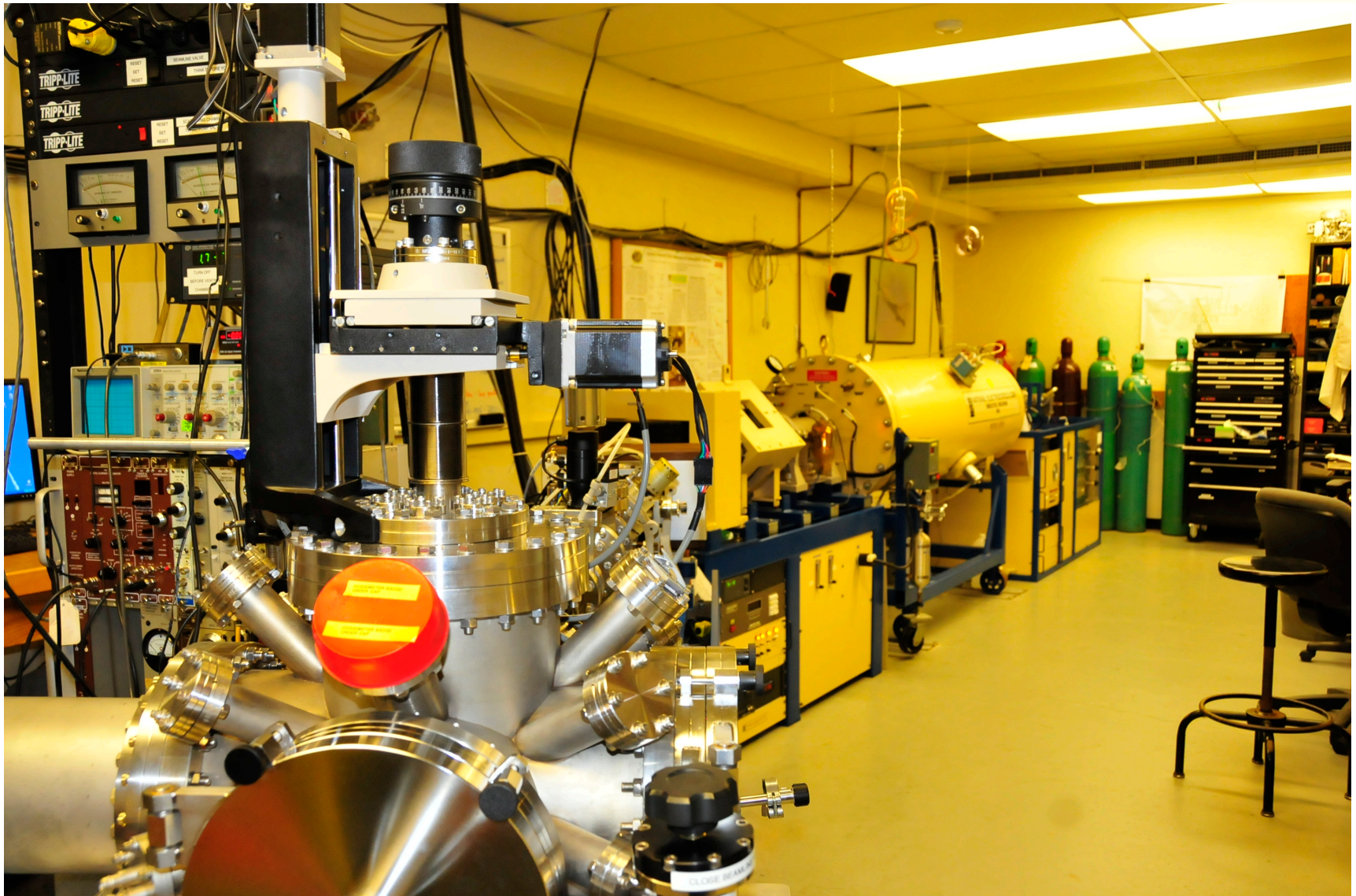
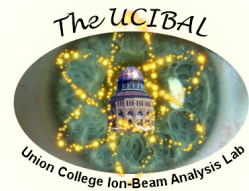
Two-Stage (tandem) acceleration of ions

Steering of ions

Scattering chamber



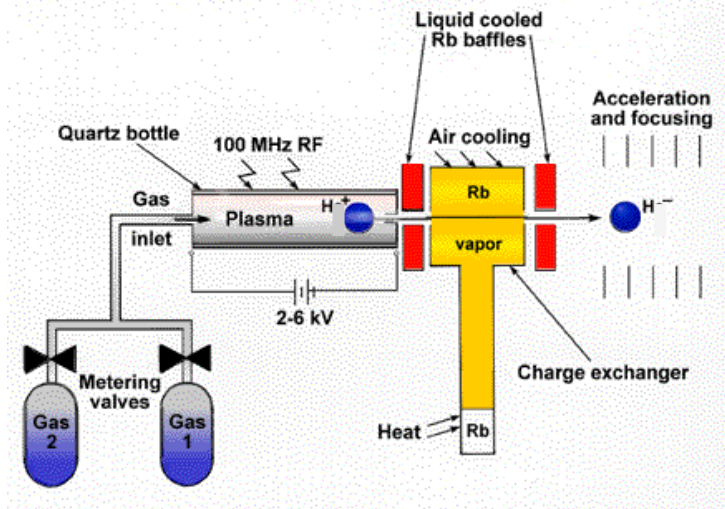
The Pelletron Particle Accelerator



The Source: Ion Production

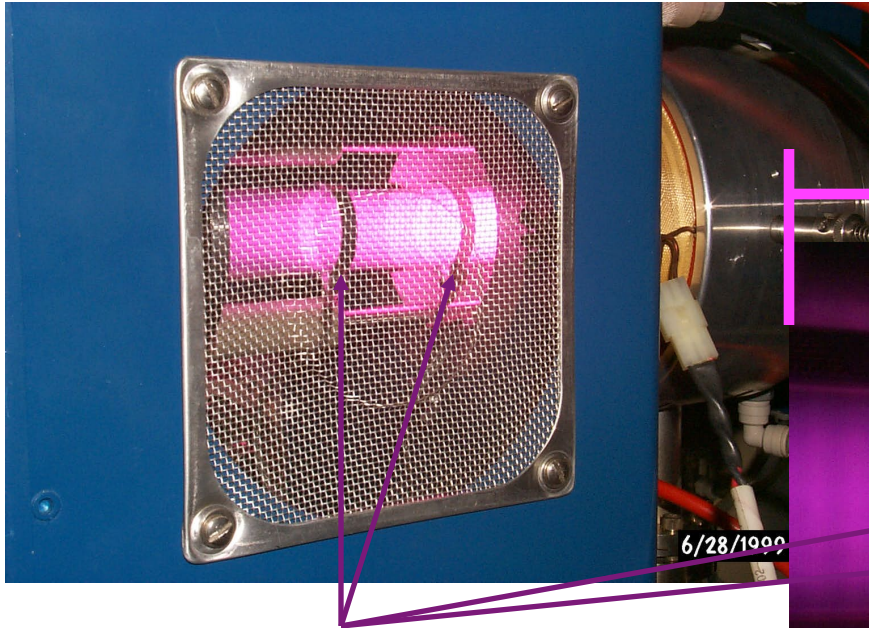


- H or He gas is bled into the gas inlet.
- 100MHz Radio Frequency (RF)
electromagnetic energy is dumped into the quartz bottle which produces H^+ , He^+ , He^{++} and other ions.
- A potential difference of about 3.6kV for H or He is applied across the bottle.
- This accelerates the ions out into the charge exchanger.
- The H^+ or He^+ charges pass through a low density Rubidium (Rb) vapor and through charge-exchange collisions pick up extra negative charges.
- The H^- or He^- charges continue on into the accelerator.
- Of course there are other ions that are also accelerated (N^- , O^- , ...)

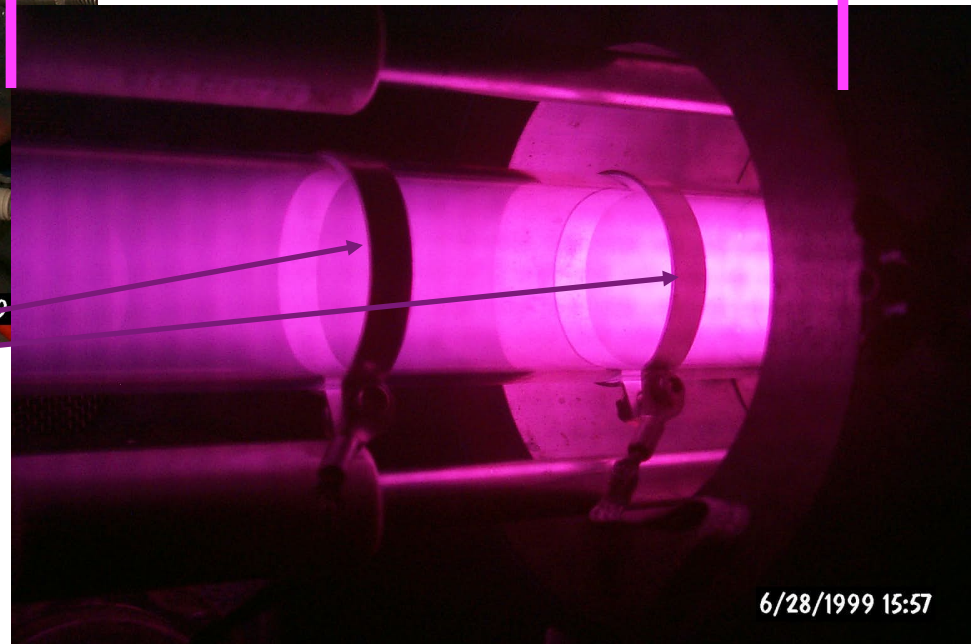


<http://www.pelletron.com>

Ion Production and Plasma Source



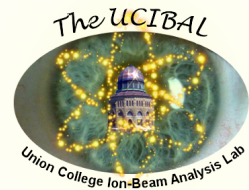
DV = 3kV to 6kV



Looking into the back end bottle. The metal bands are what couples the RF source to the bottle.

Characteristic glow of a hydrogen plasma.

The Low Energy End of the Accelerator

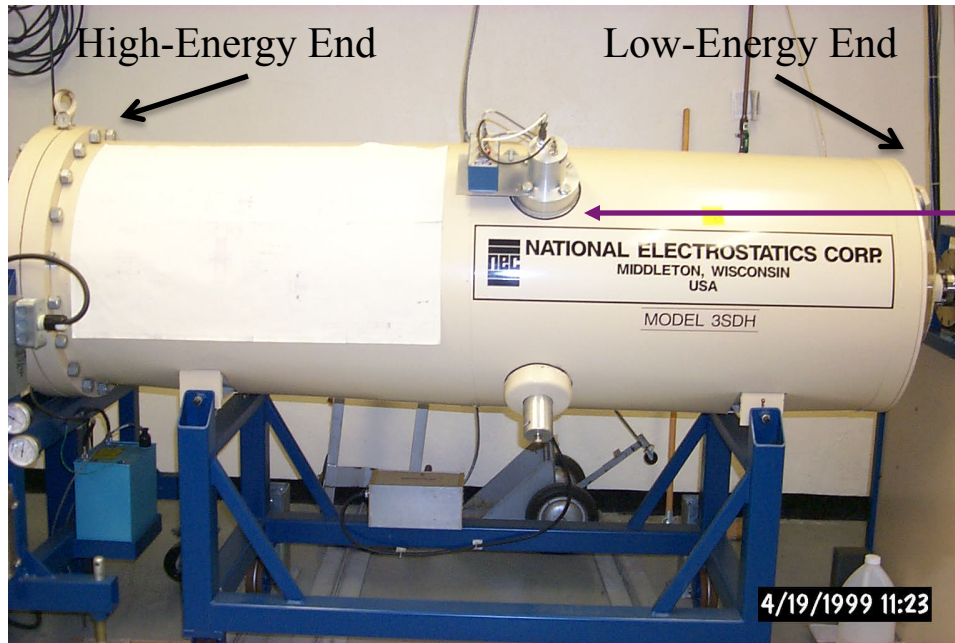


Ion Source or Low-Energy end of the accelerator showing the **Rubidium furnace** and cooling system. The H^+ plasma is the faint pink glow.

Wide view of ion source. This also has a **Faraday cup** in view. The faraday cup is designed to count the number of charges and determine the beam current.



The Accelerator

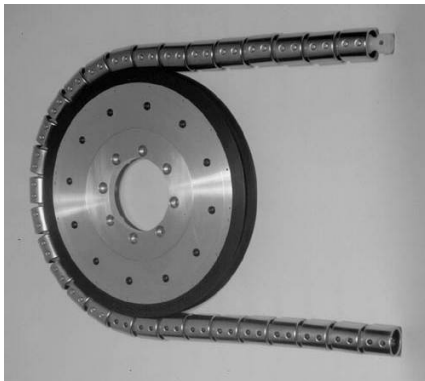


- The resultant positive particle is accelerated away from the terminal back down $1.1MV$ towards the left edge and thus produces a tandem acceleration of the ion species.

- The chain is housed inside of this tank.
- The terminal is in the center.
- From right edge of the photo (the low-energy end) to the terminal a $1.1MV$ is applied.
- From the terminal to the high-energy end there is another $1.1MV$ difference in potential.
- Nitrogen gas is bled from the left end of the photo to the terminal to pull off the added negative charges through another charge-exchange collision.

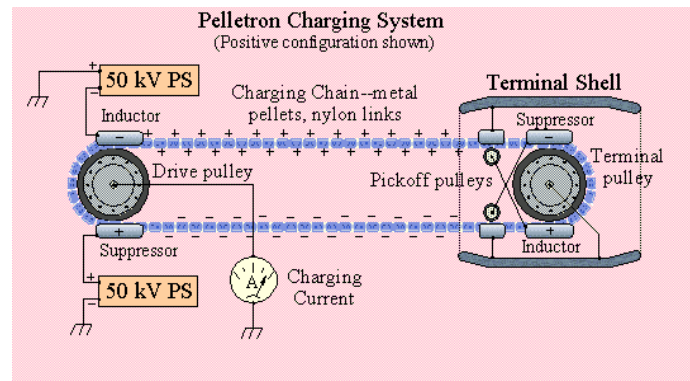
Tandem acceleration of ions

- The negative ions are accelerated toward the center of the pressure tank by a 1.1 MV difference in potential between the low-energy end and the terminal.
- The center of the pressure tank (the terminal) is made positive with respect to the charge exchanger.
- The potential difference is developed by the Pelletron Charging system, which consists of metal pellets and insulating connectors.
- The terminal is charged by induction and is a very stable and reliable system.



Pelletron Chains

<http://www.pelletron.com/charging.htm>



Pelletron Charging System by NEC