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Engineering @ Fermilab

An Accelerator Division Perspective

Ralph J. Pasquinelli

July 13, 2014

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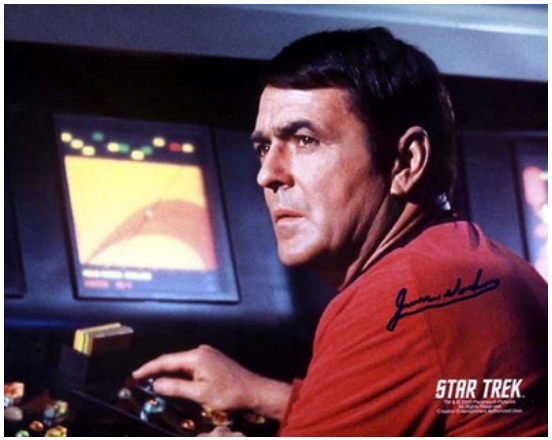
Definition: Engineering

Engineering

Noun

1. The practical application of science to commerce or industry.
2. The discipline dealing with the art or science of applying scientific knowledge to practical problems.
3. ~~A room (as on a ship) in which the engine is located~~

Date "engineering" was first used in popular English literature: sometime before 1781.



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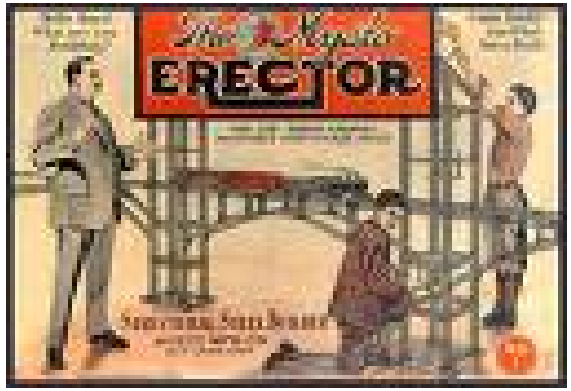

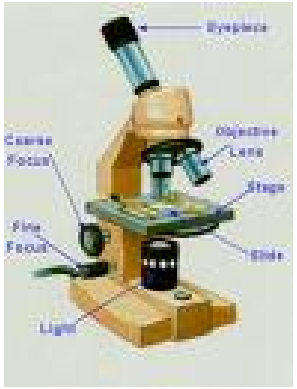

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If you had trouble running the Dilbert video, try this:

https://www-ilcdcb.fnal.gov/Ask-a-Scientist/TheKnack.mpg

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=

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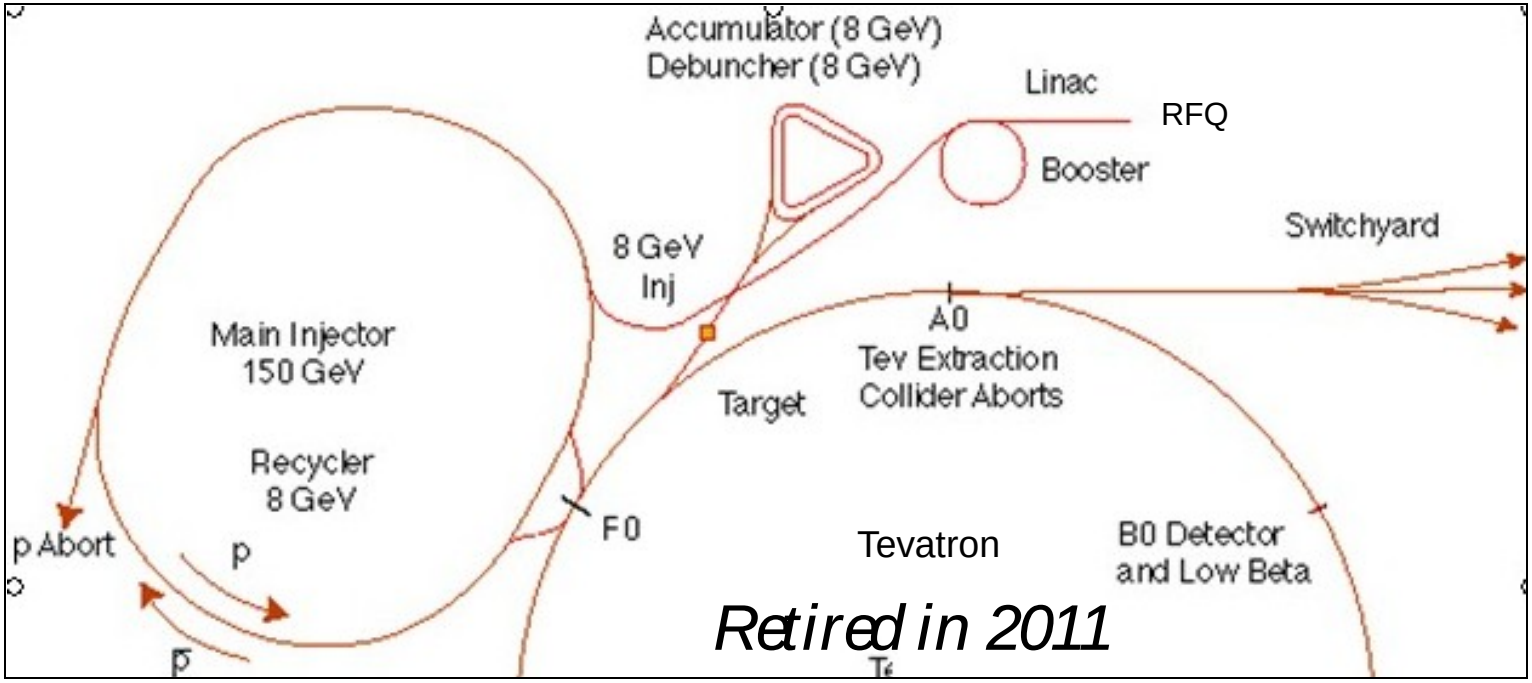
Fermilab's 7 Accelerator Chain



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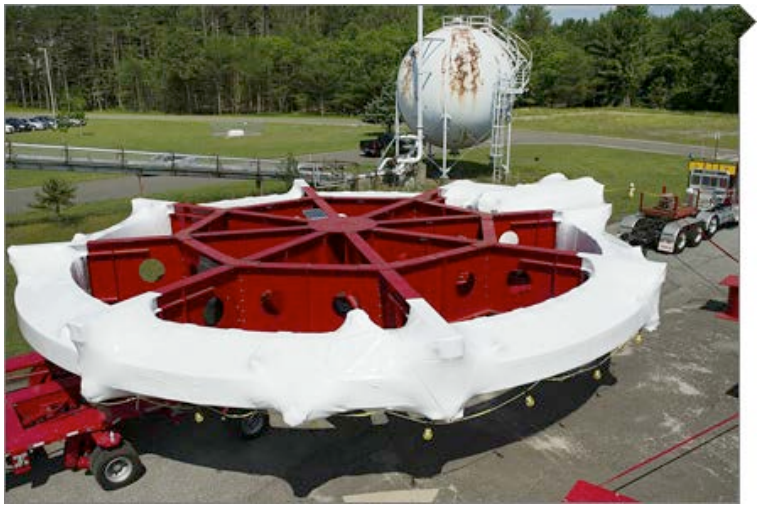

muon g-2

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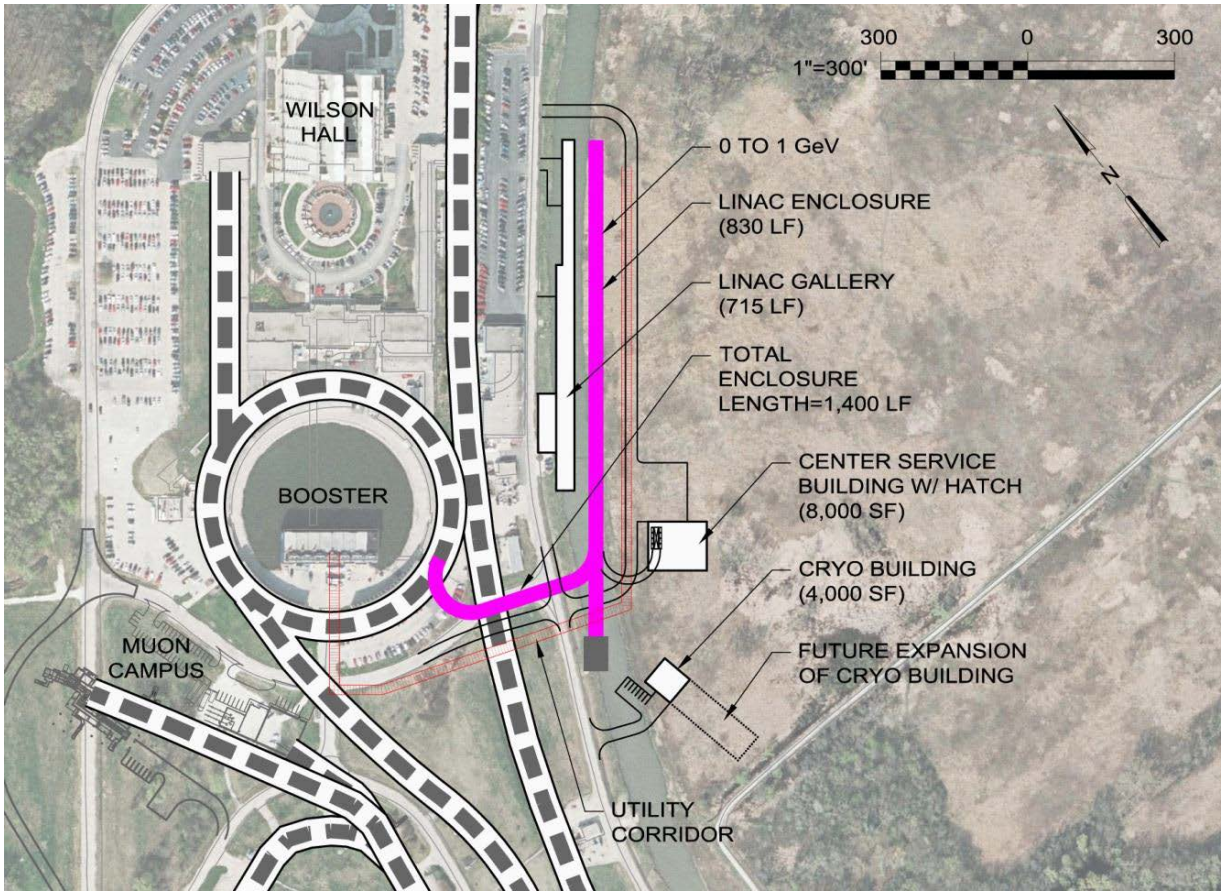
Proton Improvement Plan-II
PIP-II



Will replace Linac with higher energy to 800 MeV using SRF cavities.

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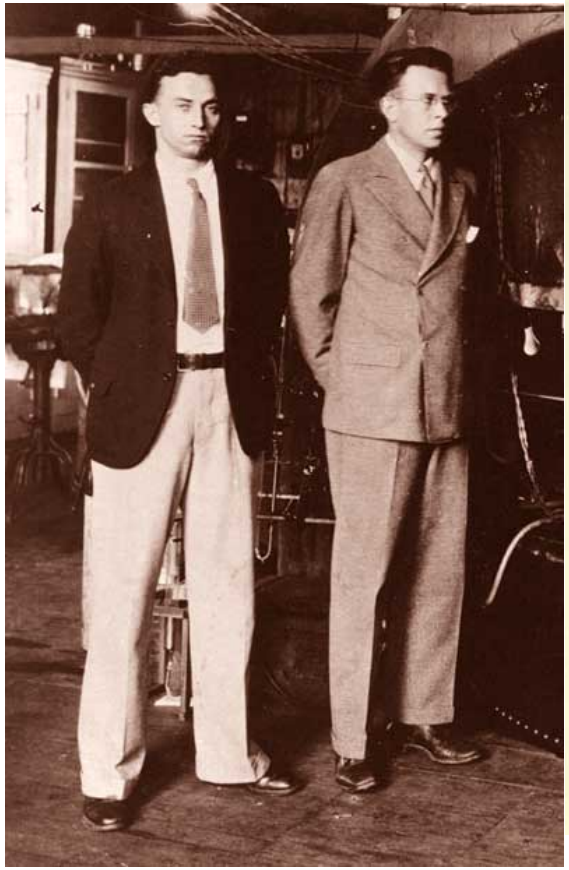
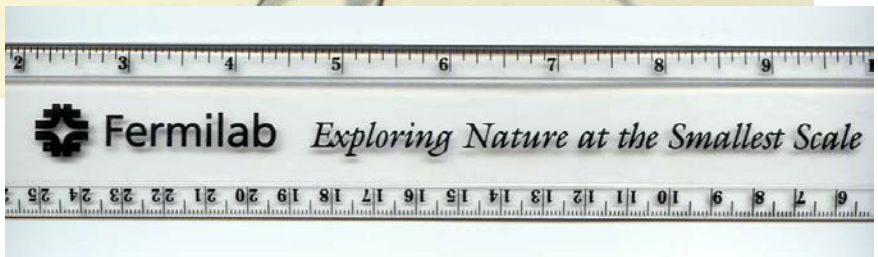
Early Accelerator 1930: Livingston & Lawrence's 4.5 inch Cyclotron





Electrical Engineering

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345,000 Volts
Electrical Power
60 Megawatts

Electric Bill
$20 Million Annually

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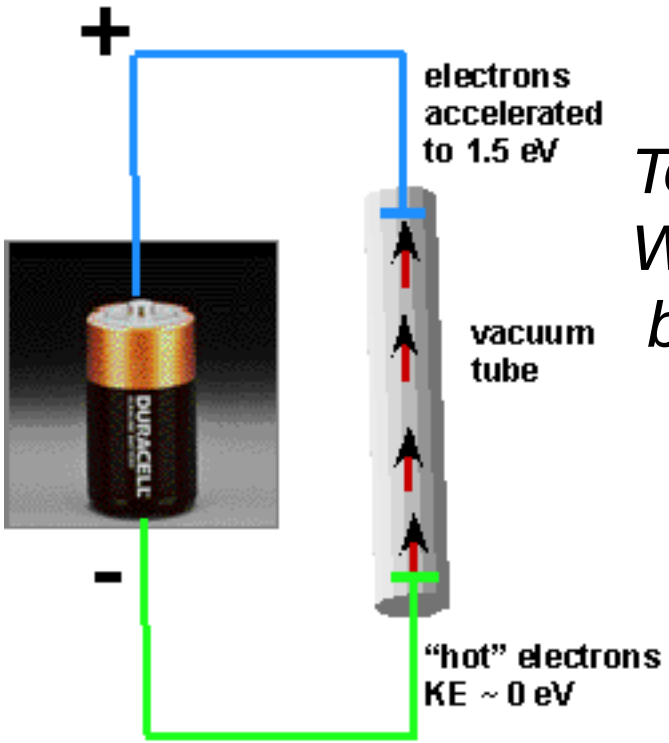
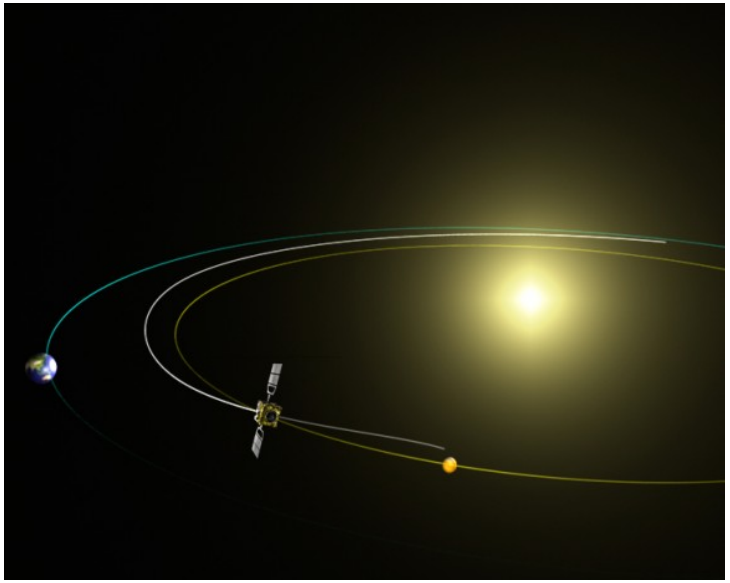
Energy measured in electron volts eV



To get 980 GeV
Would take 650
billion batteries



A 2 inch long battery
Would require
20 million mile
Chain of batteries!!!

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Electrostatic Accelerators at Fermilab

Cockroft Walton

750 KeV

Pelletron

4.3 MeV

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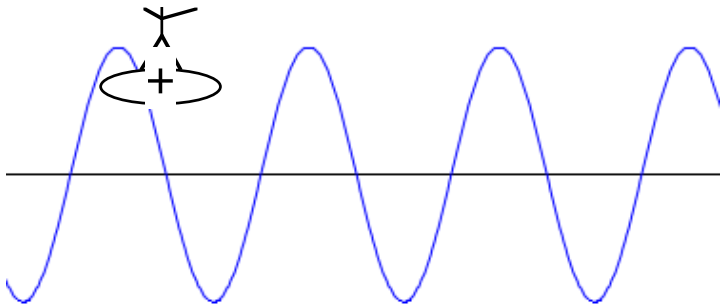

Use Radio Frequency Waves to Accelerate

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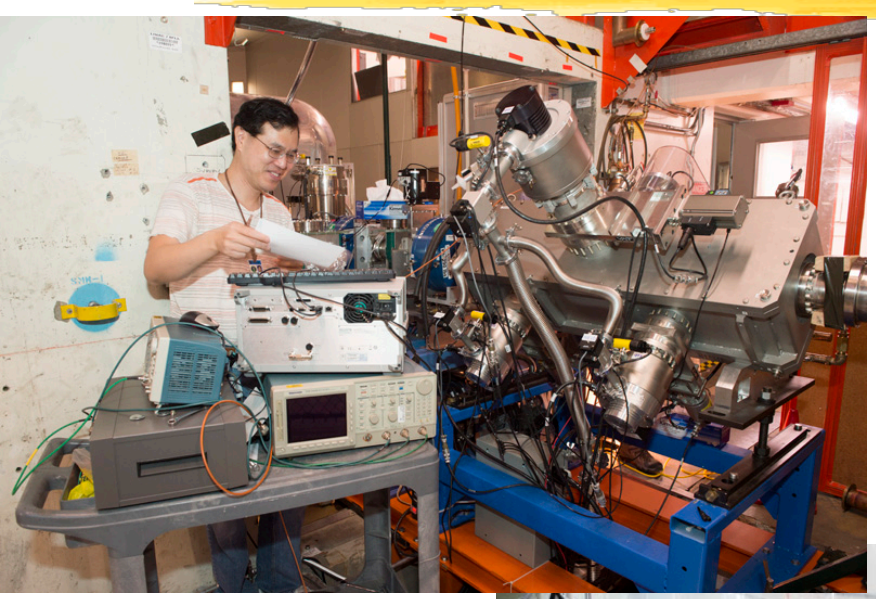
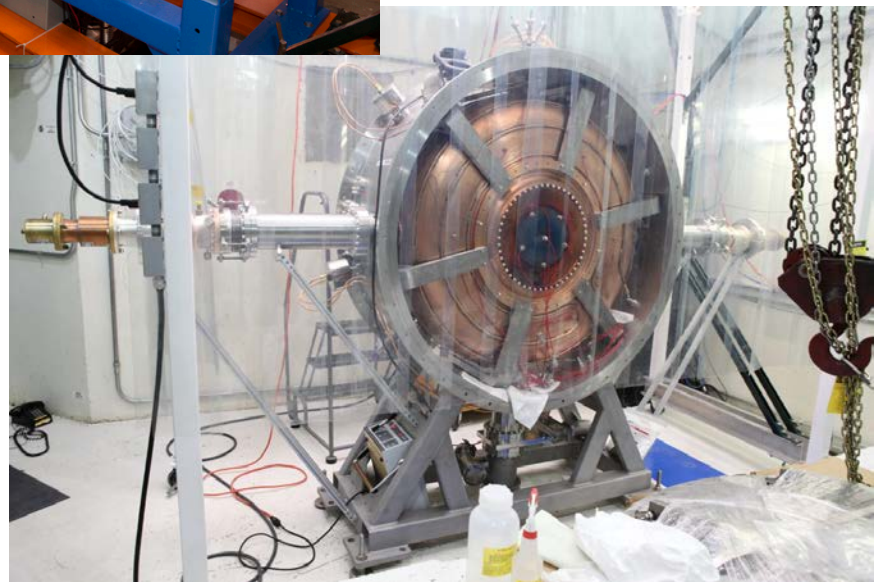


RFQ

SRF Cavity



MICE Cavity

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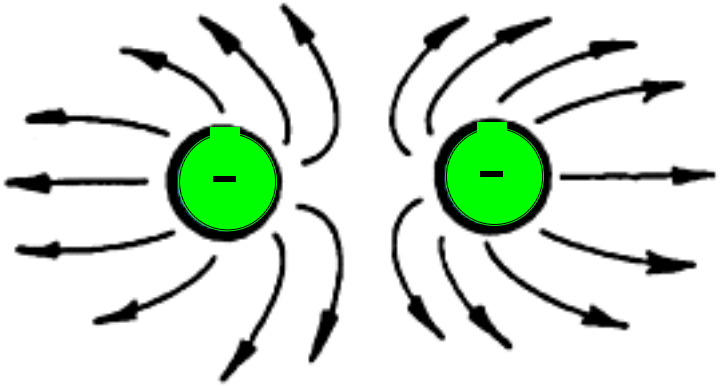
Like Charges Repel



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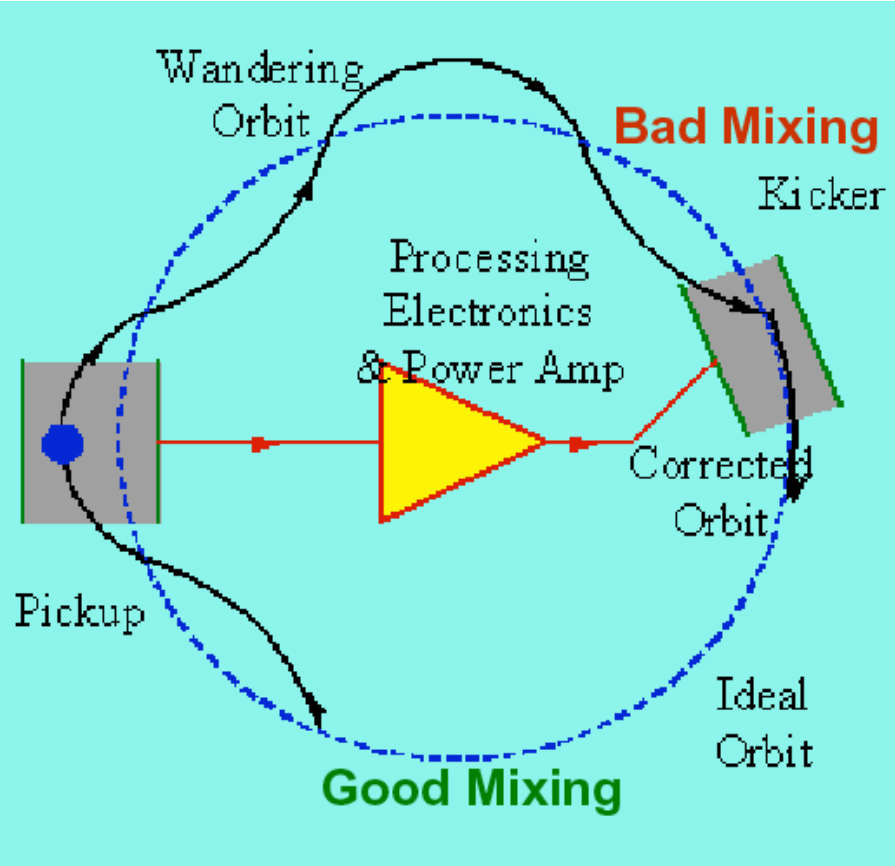
Simon Van der Meer

Stochastic Cooling



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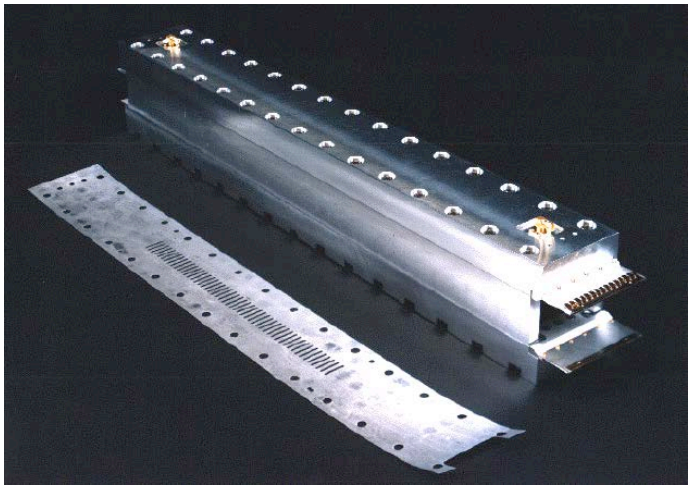
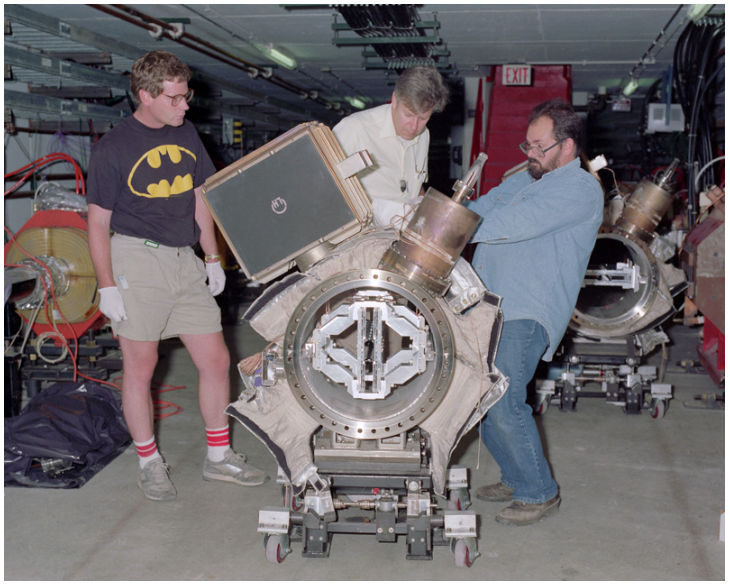
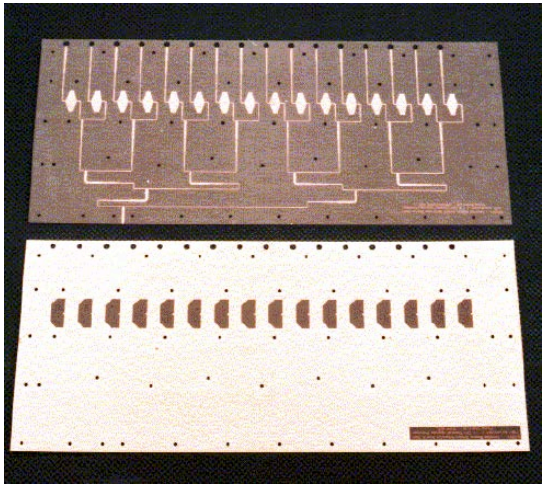


Slotted Waveguide Structure



Printed Circuit Arrays



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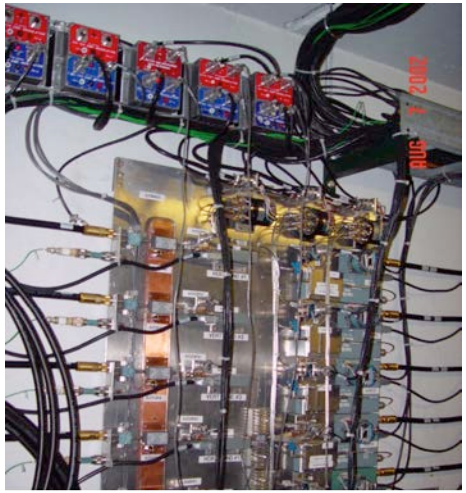
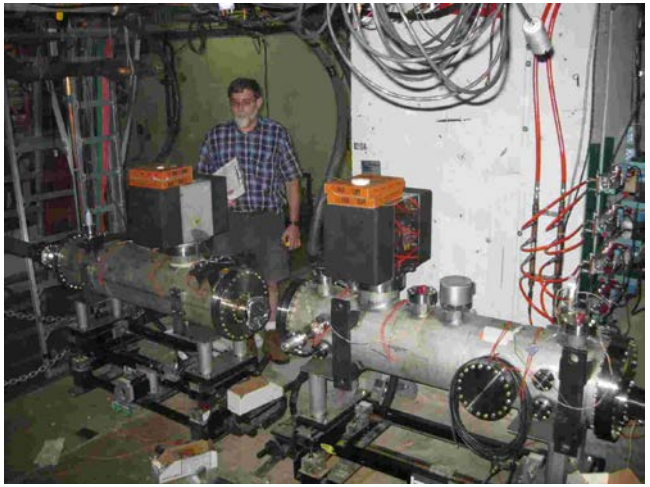
TWTs, Kickers, Microwave Hardware





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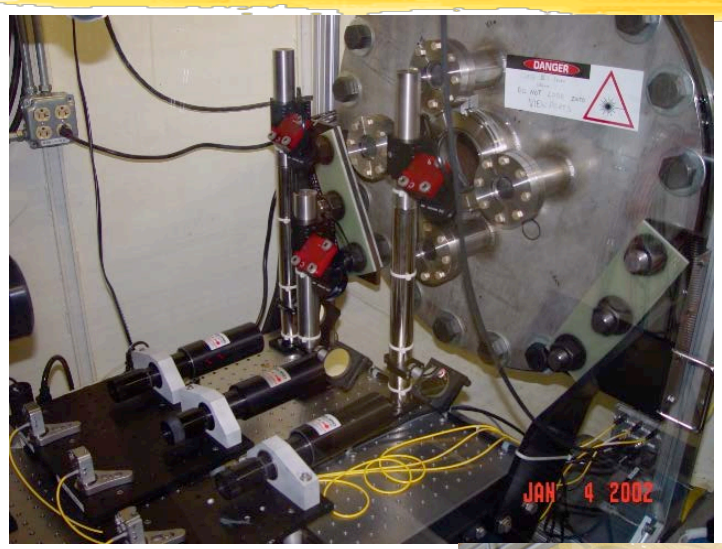
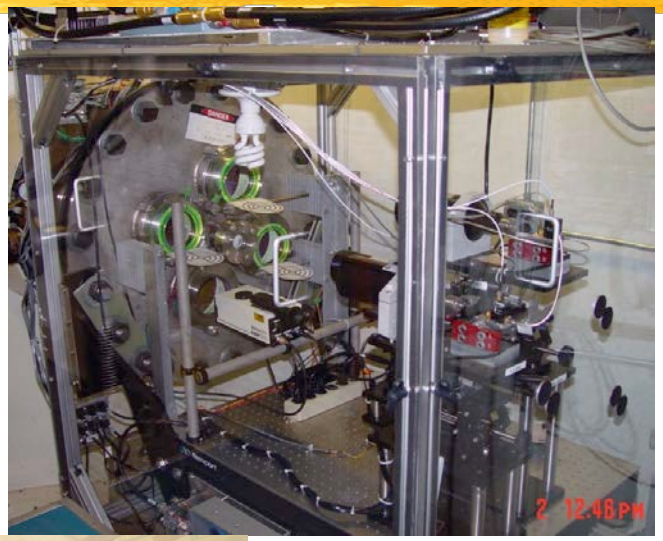
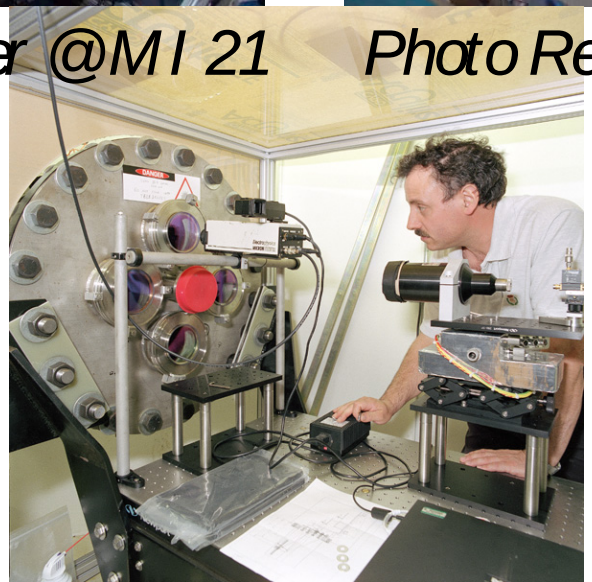




Laser Transmitter @MI 21

Photo Receiver @MI 11

Recycler Laser Link



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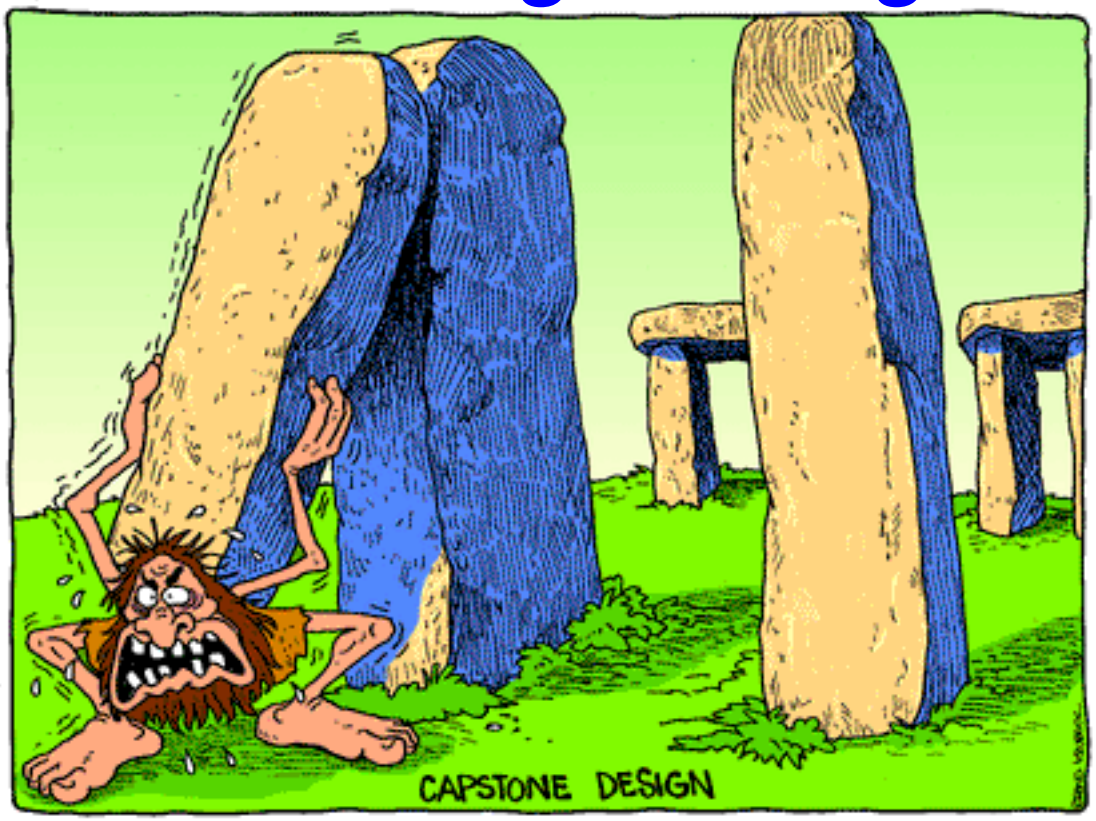
Civil Engineering



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Antiproton Source Ground Breaking 1983 *R. J. Pasquinelli*

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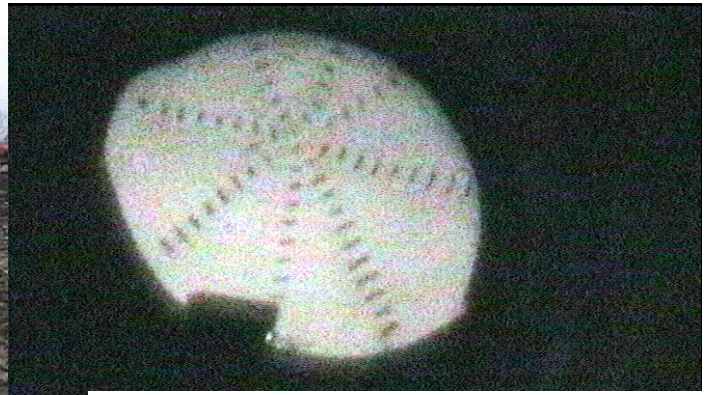

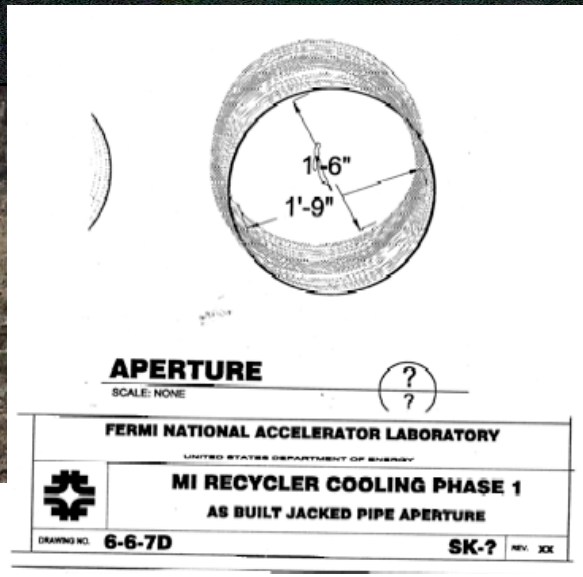

Recycler Light Pipe Installation

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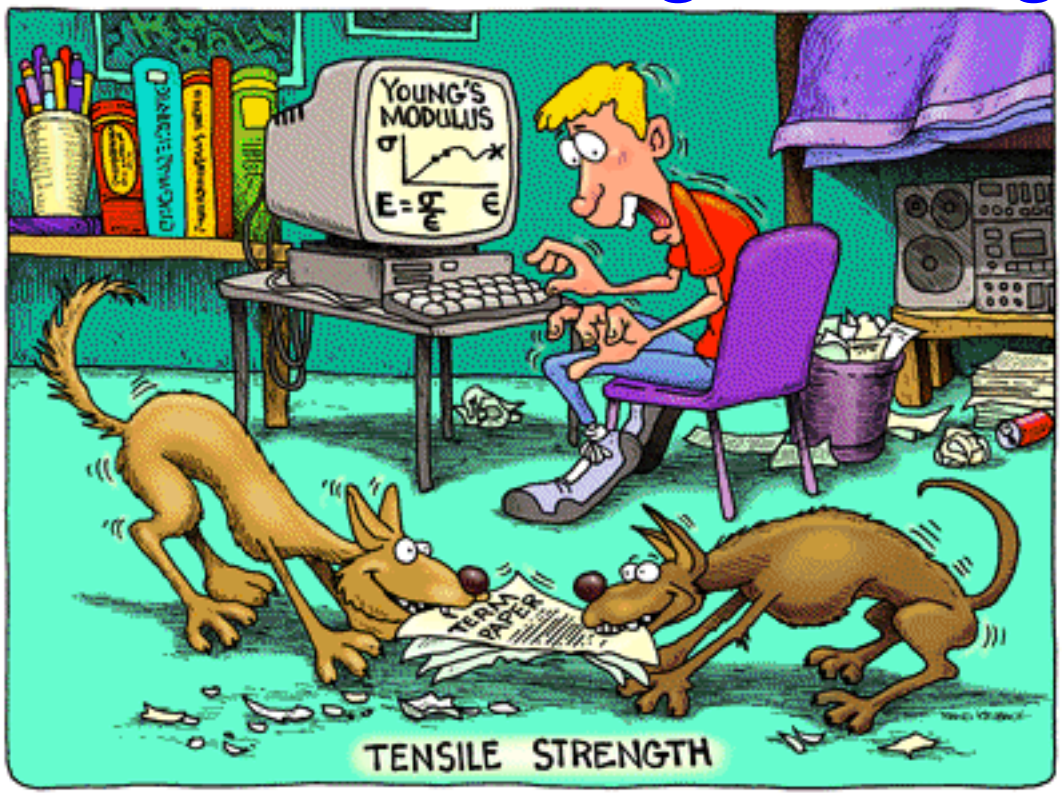
Mechanical Engineering



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Water Cooling Systems

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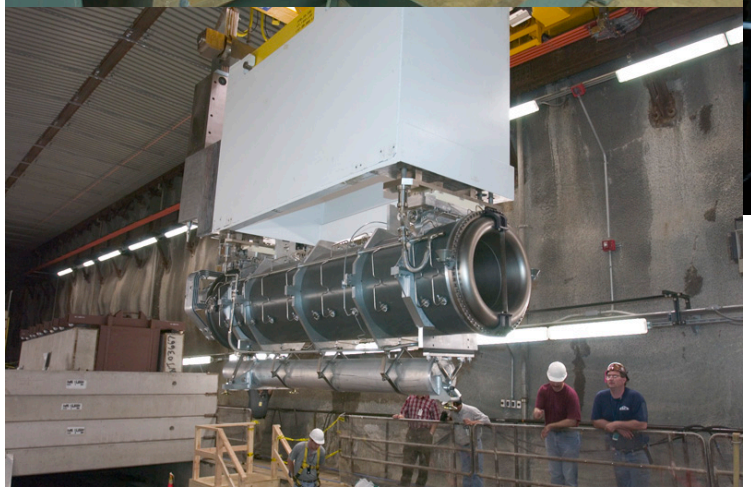

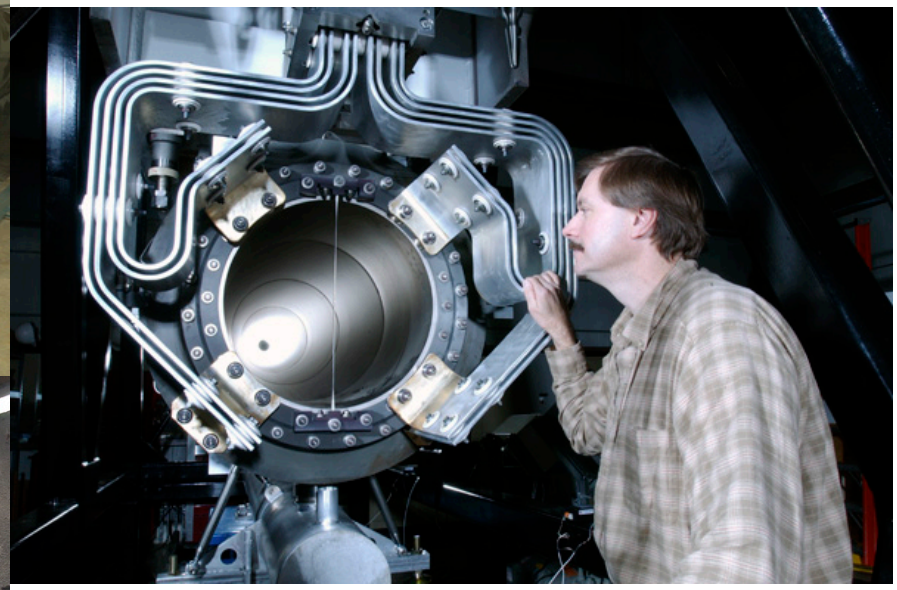

NuMI Magnetic Horn

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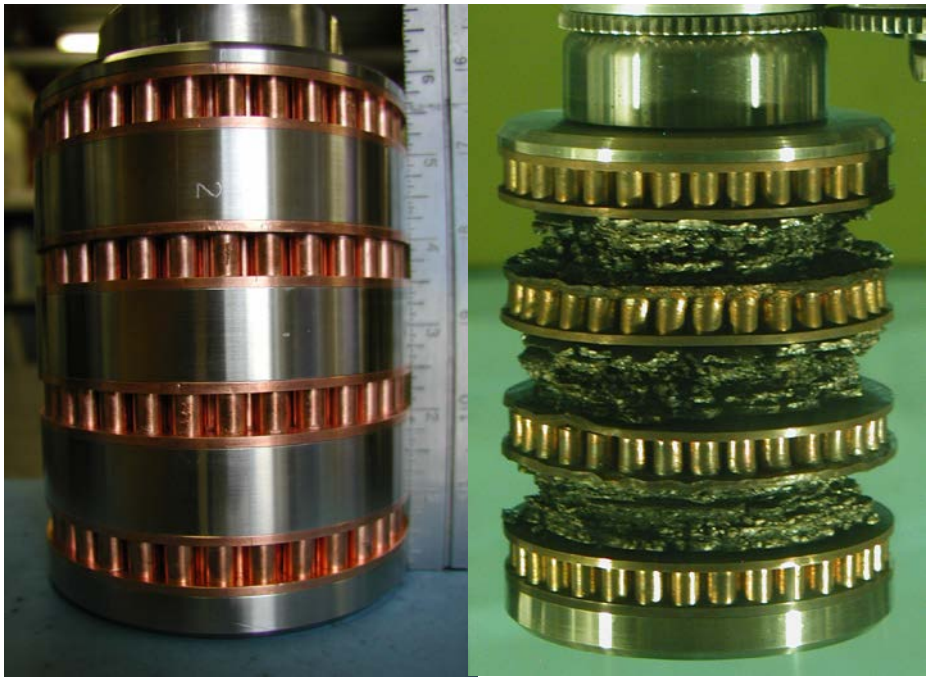
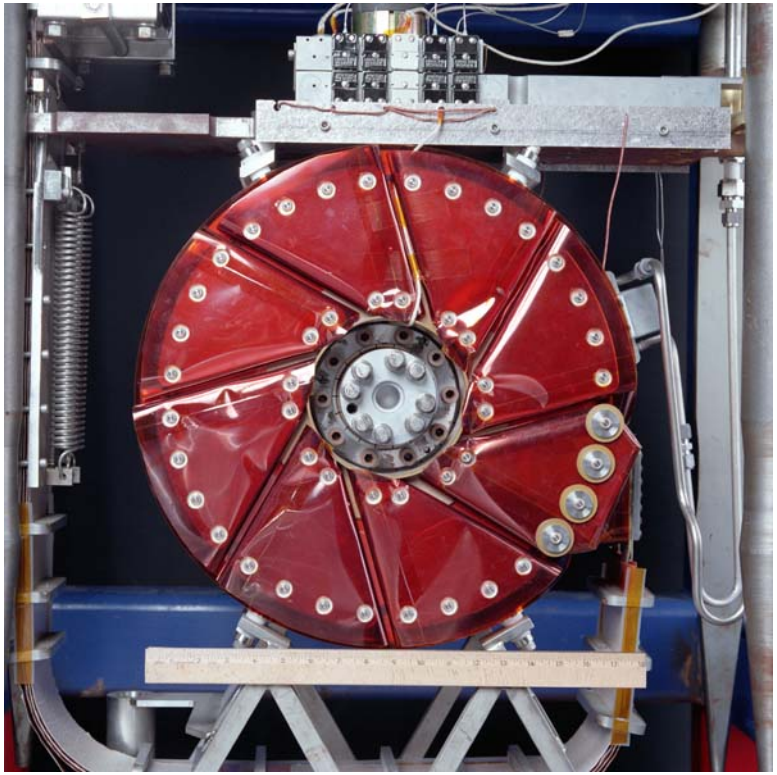
Before *After 10^{19} protons*



Antiproton Production Target



Lithium Lens

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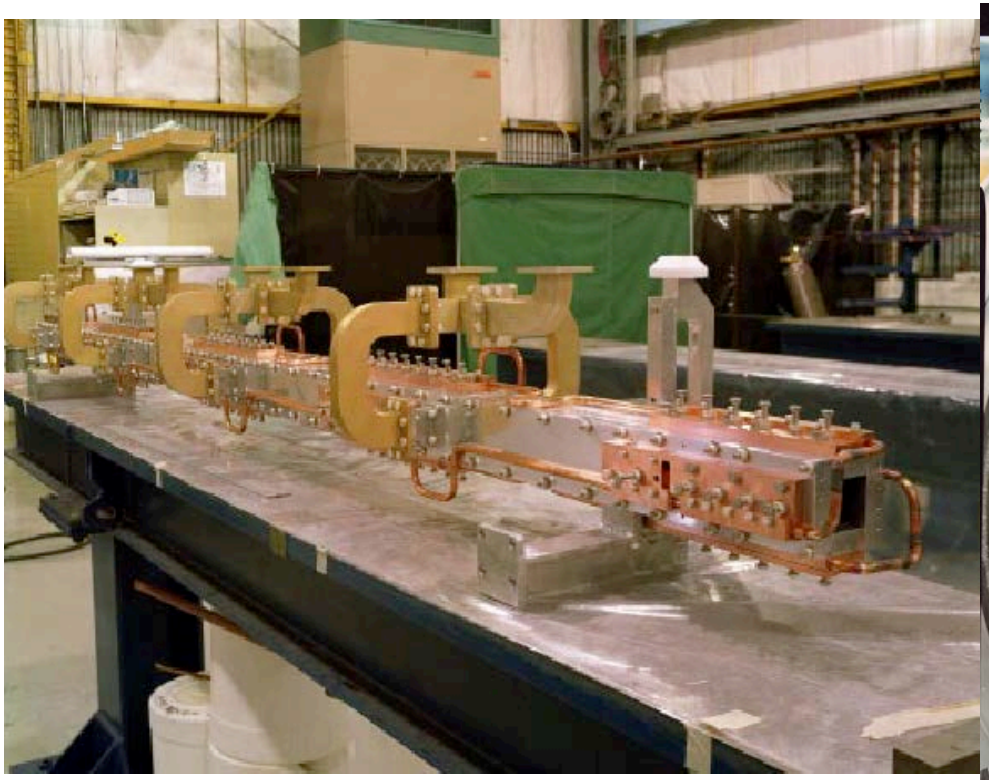

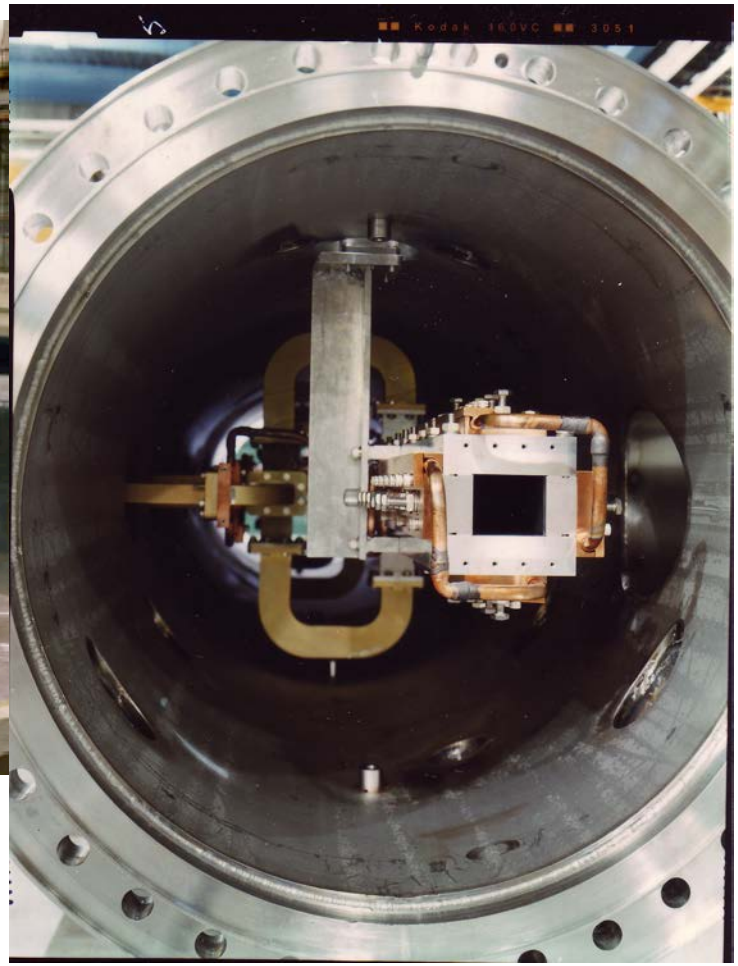

Slotted Waveguide Assembly

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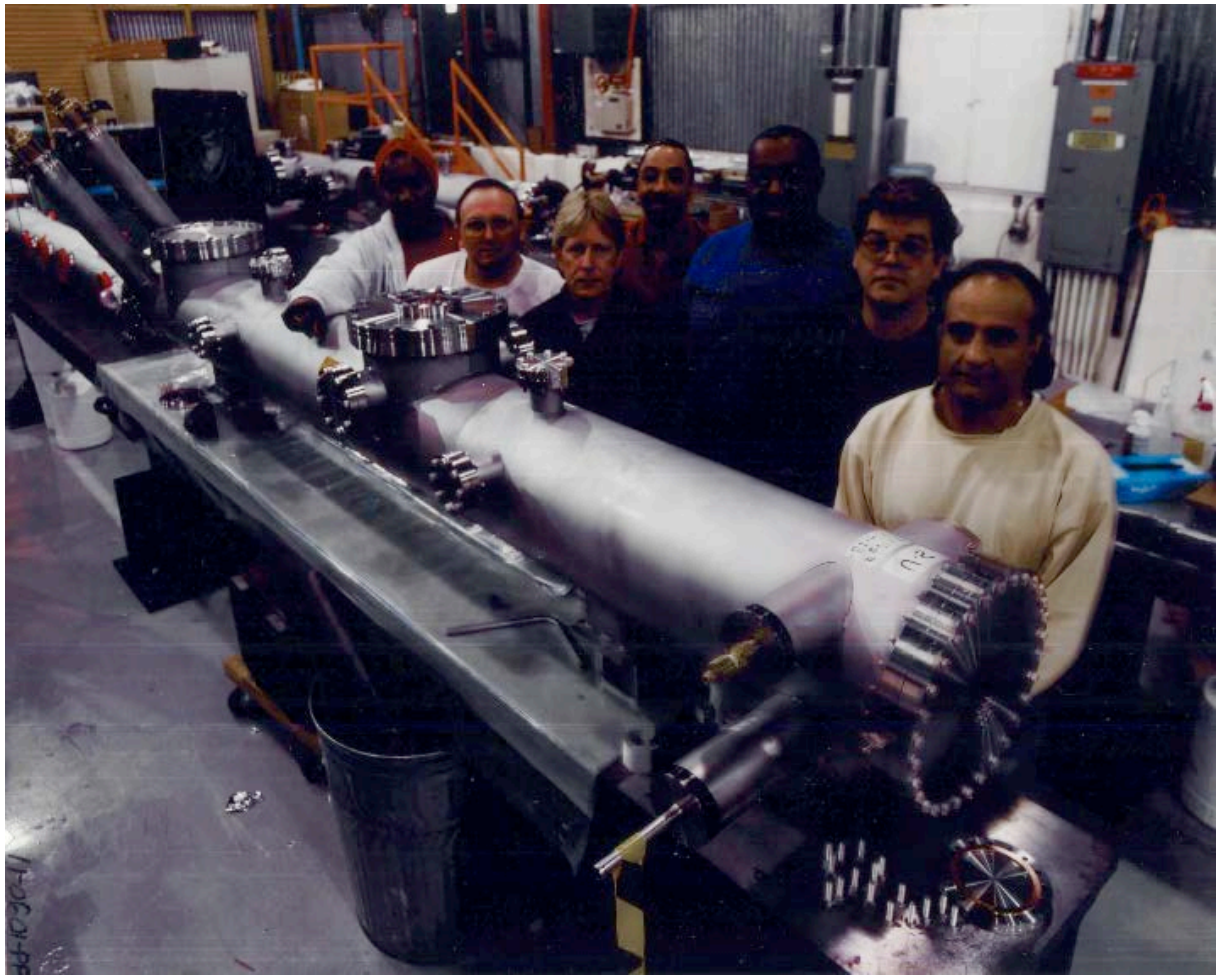

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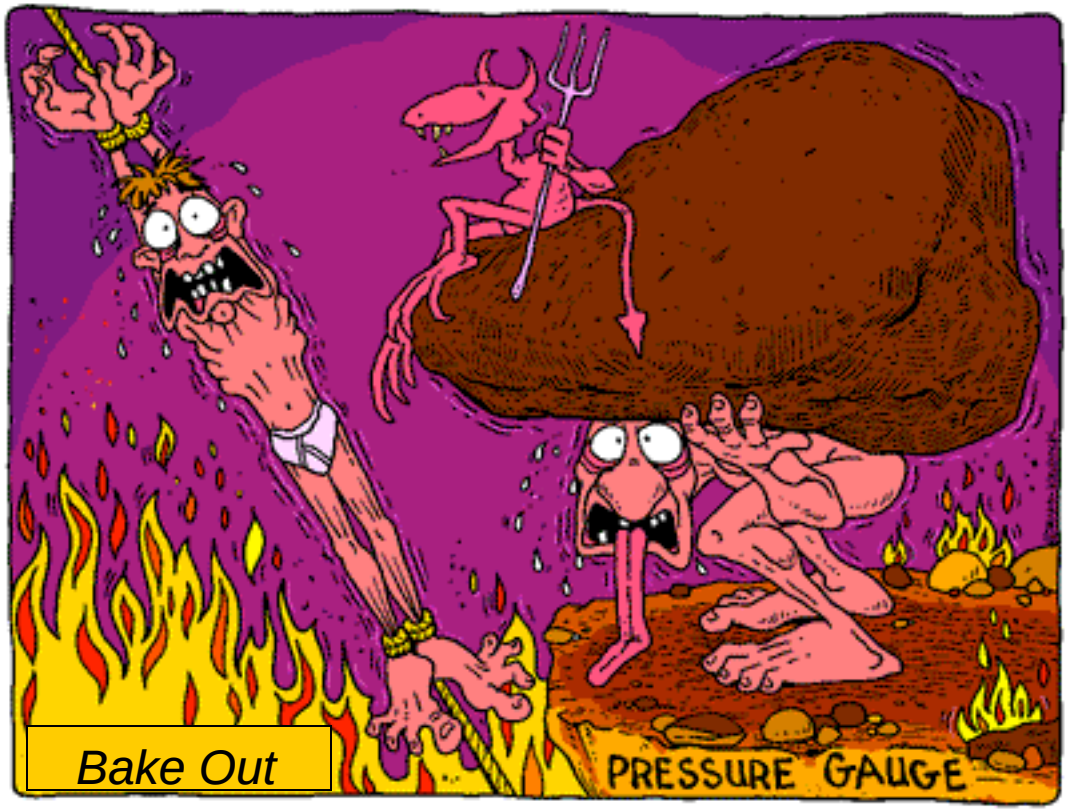
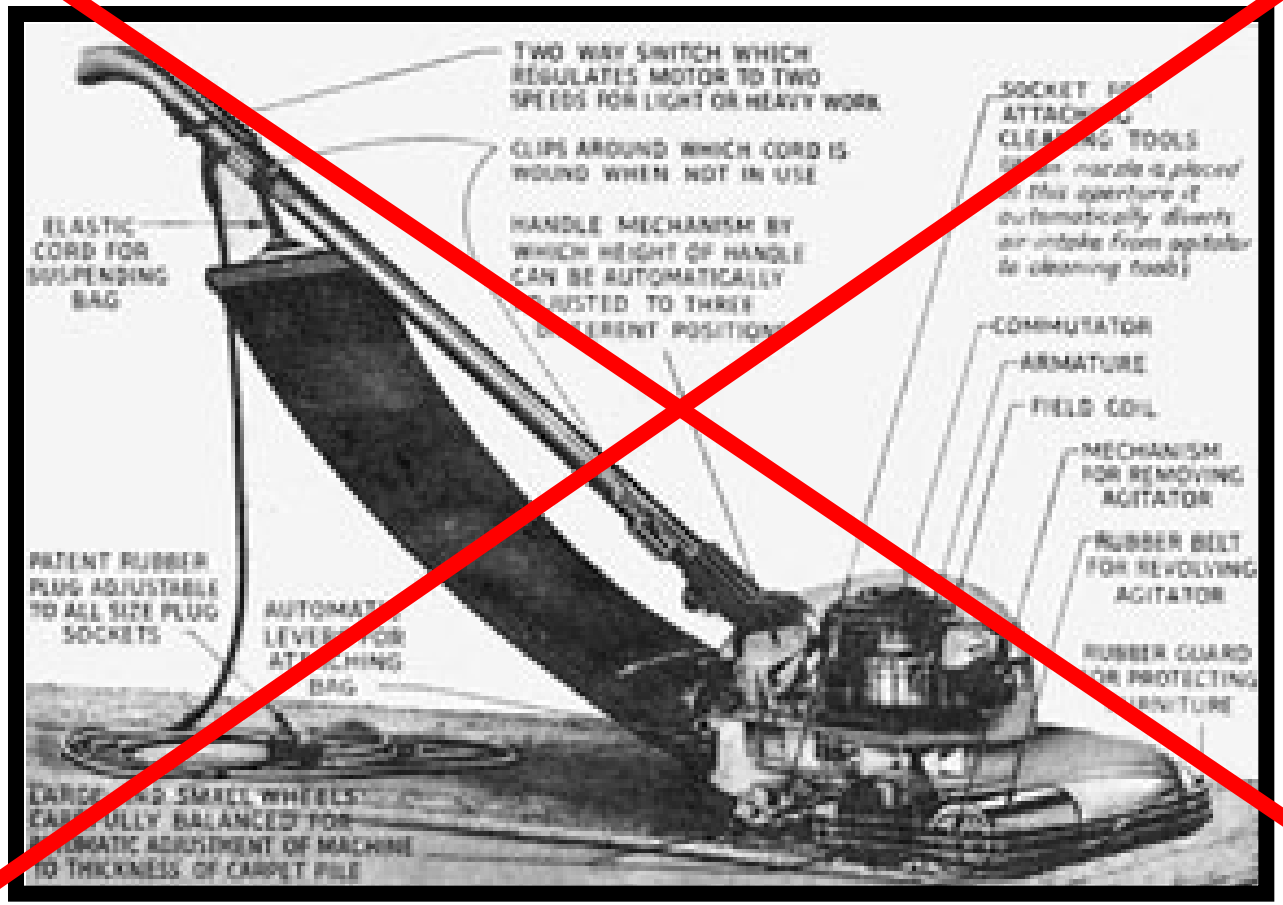
Vacuum Engineering



NOT HOOVER!



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Once your pour out the soda, the bottle Is NOT empty!

It contains about 1000000000000000000000000 Atoms of Air Approximately 10^{23}

At sea level, about 10^{20} atoms of air per cubic centimeter (cc) creates a Pressure of 760 mm of Hg or 760 Torr

Accelerator Vacuum 10^{-10} Torr About 10^{7} atoms per cc

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Vacuum Bake Out

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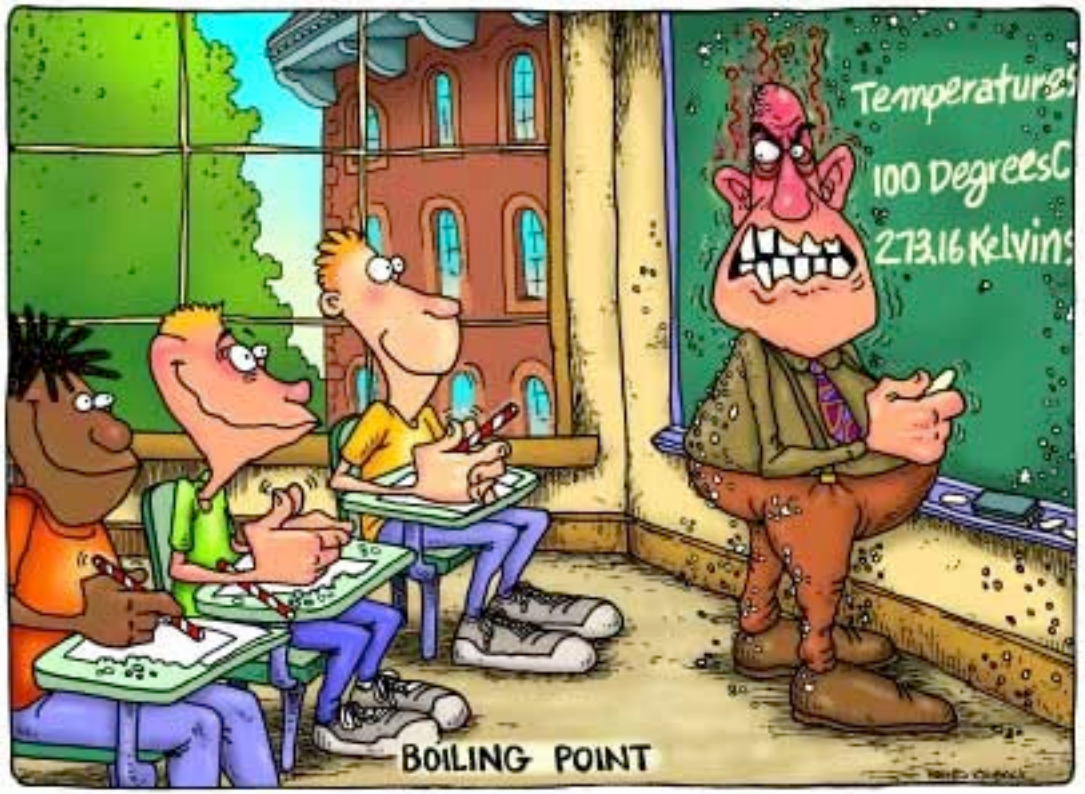
Cryogenic Engineering



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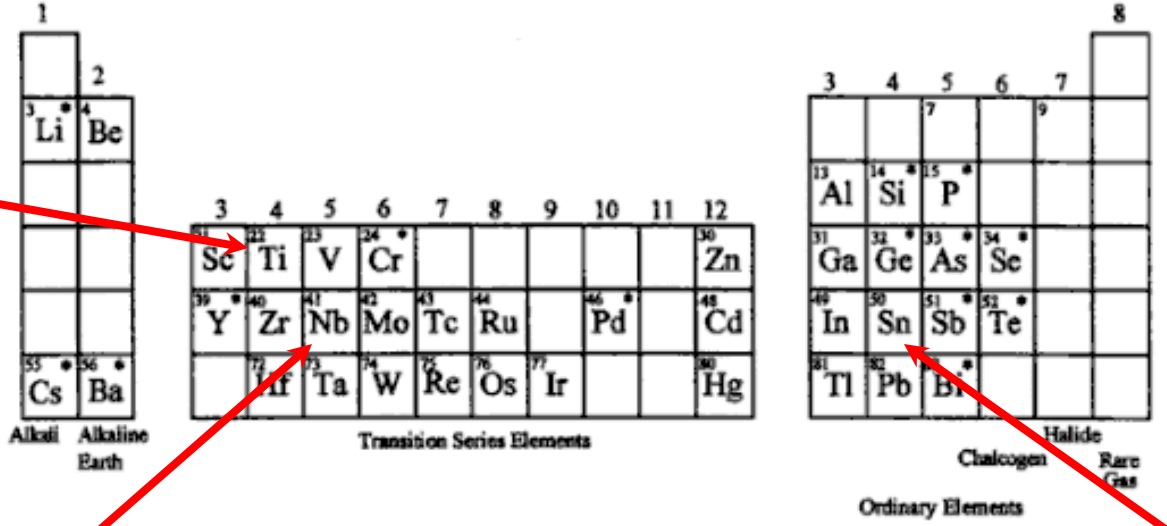
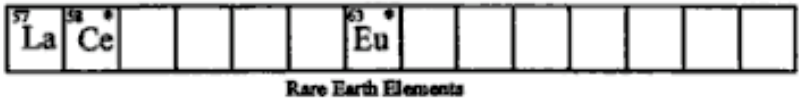
Titanium

Niobium

Tin



Superconducting Elements



[Fits between elements Barium Ba (56) and Lutecium Lu (71)]

Figure 6.1. Periodic table showing the elements which are superconductors. Those elements which superconduct only as thin films or under pressure are so designated with an asterisk. The number of valence electrons N_v of the atoms is indicated at the top of each column.

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Tevatron

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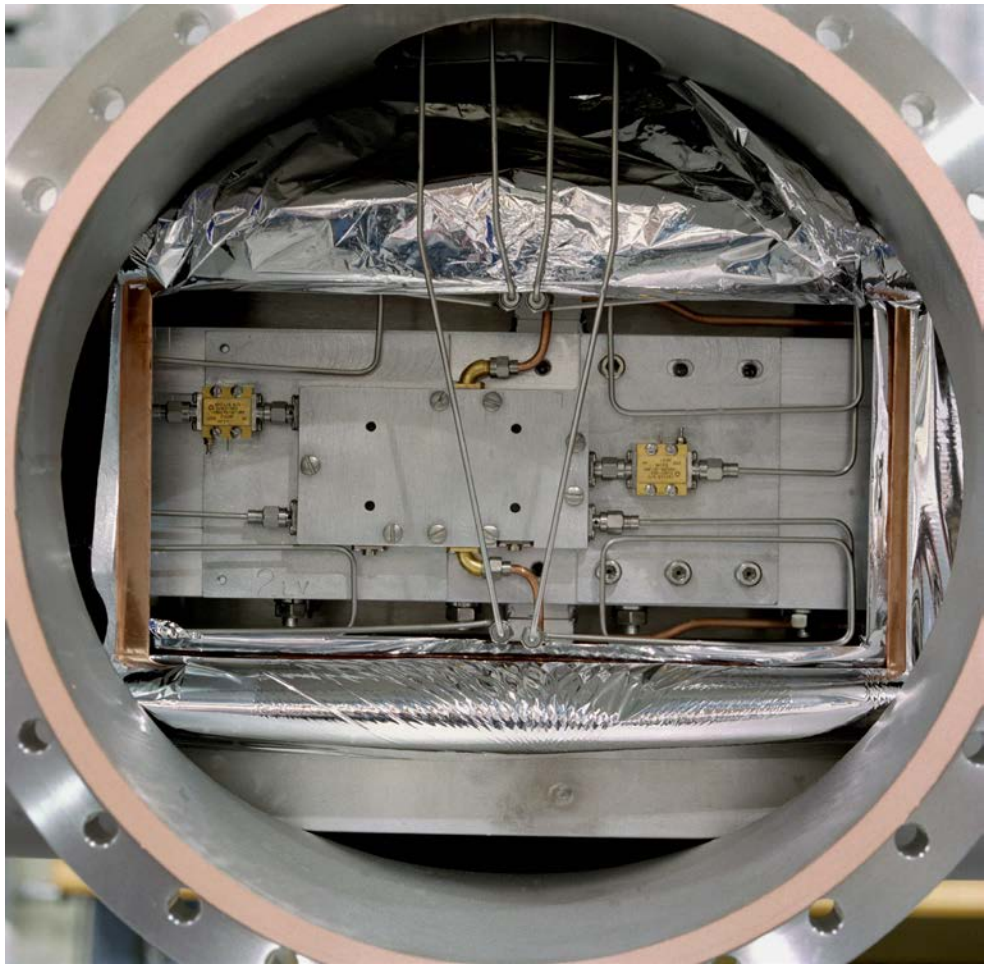
Debuncher
Stochastic Cooling
Cryogenic
Microwave Amplifier
Operates at 4 Kelvin



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Refrigerators

Compressors

Truck Deliveries

Storage

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Recipe: Carefully Combine All the Ingredients

Electrical

Cryogenic

Mechanical

Civil

Vacuum

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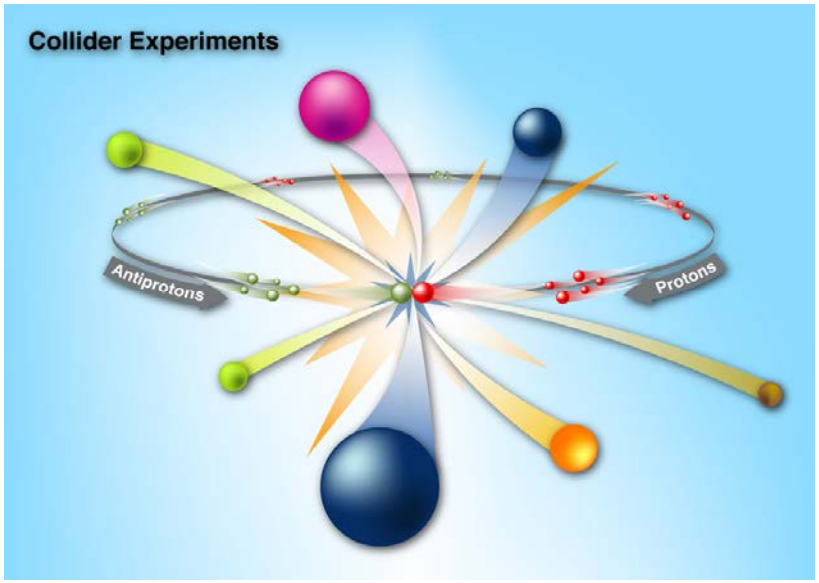
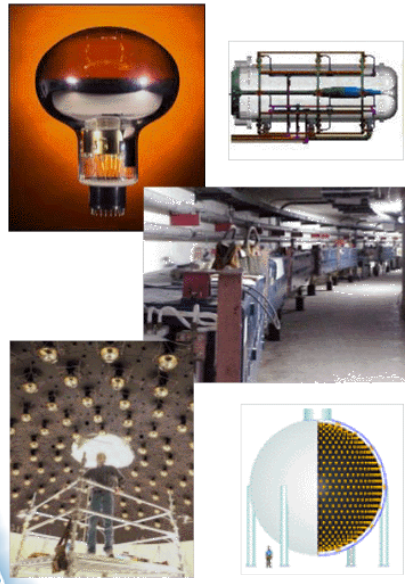
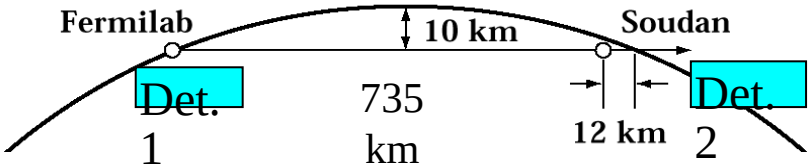


BooNE





NOvA

NuMI

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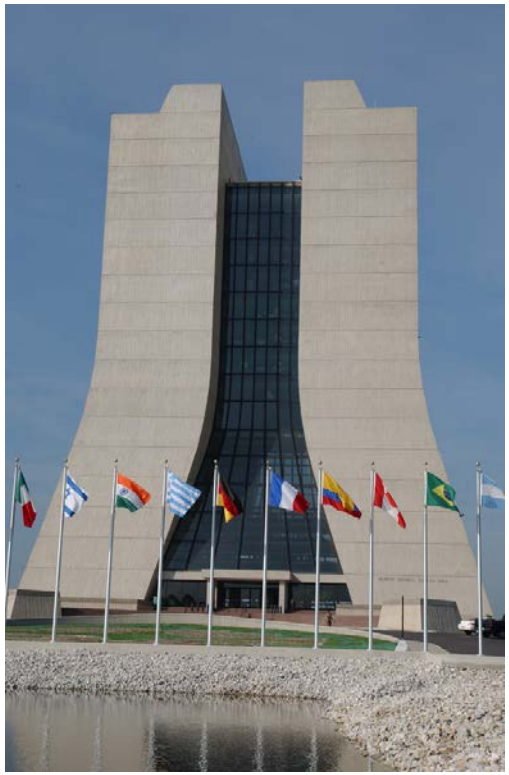

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Thank You

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Agilent teachers corner for cartoons