Frictional Cooling Studies

Studies at Columbia University/Nevis Labs

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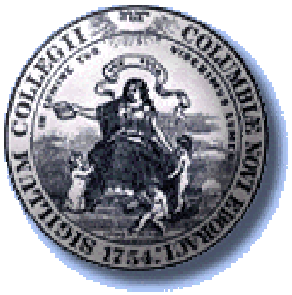
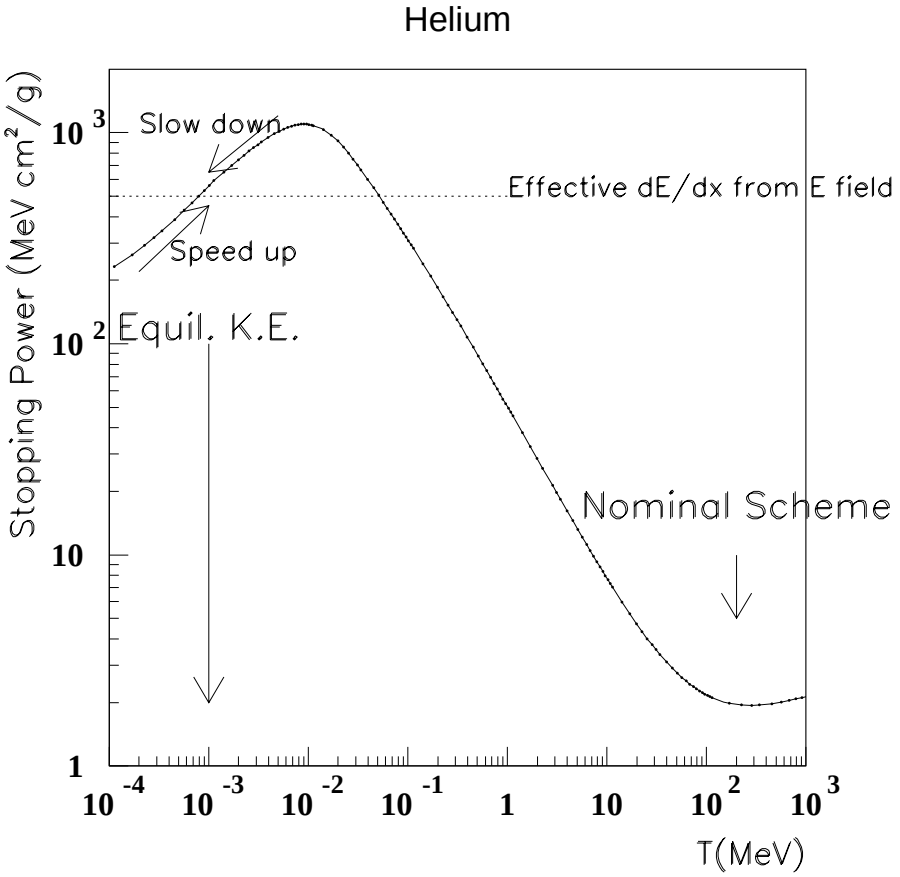


Frictional Cooling

- Bring muons to a kinetic energy (T) range where dE/dx increases with T
- Constant E-field applied to muons resulting in equilibrium energy



Problems/Comments:

- large dE/dx @ low kinetic energy

  ➡ low average density

- Apply $\vec{E} \perp \vec{B}$ to get below the dE/dx peak
- μ+ has the problem of Muonium formation

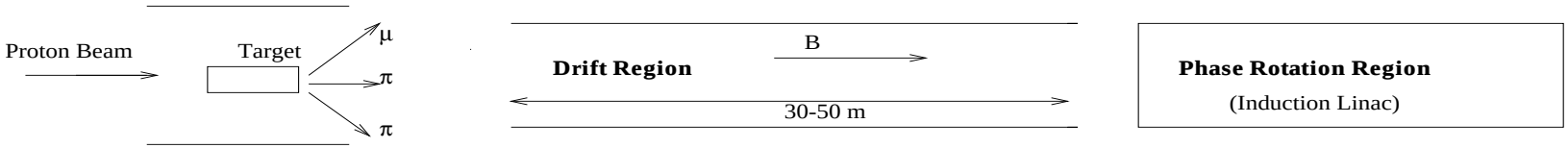
  ➡ σ(Mμ) dominates over e-stripping σ in all gases except He

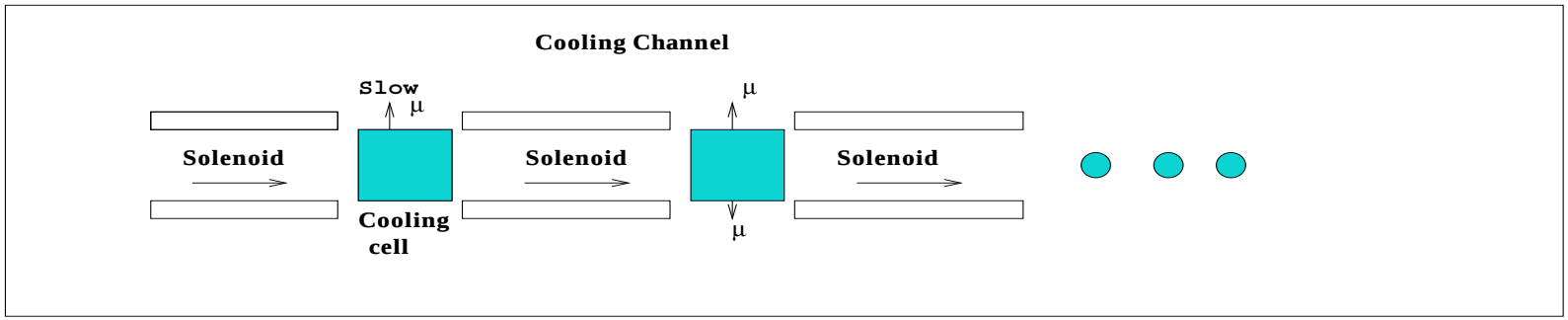
- μ– has the problem of Atomic capture

  ➡ σ calculated up to 80 eV not measured below ~1KeV

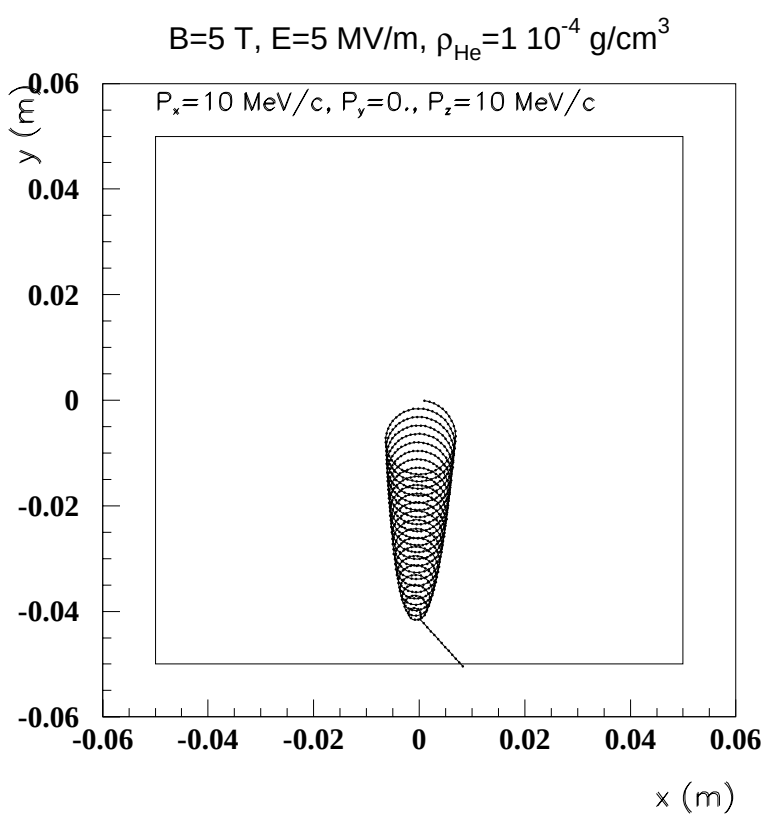
- Cool μ's extracted from gas cell T=1 KeV so a scheme for reacceleration must be developed

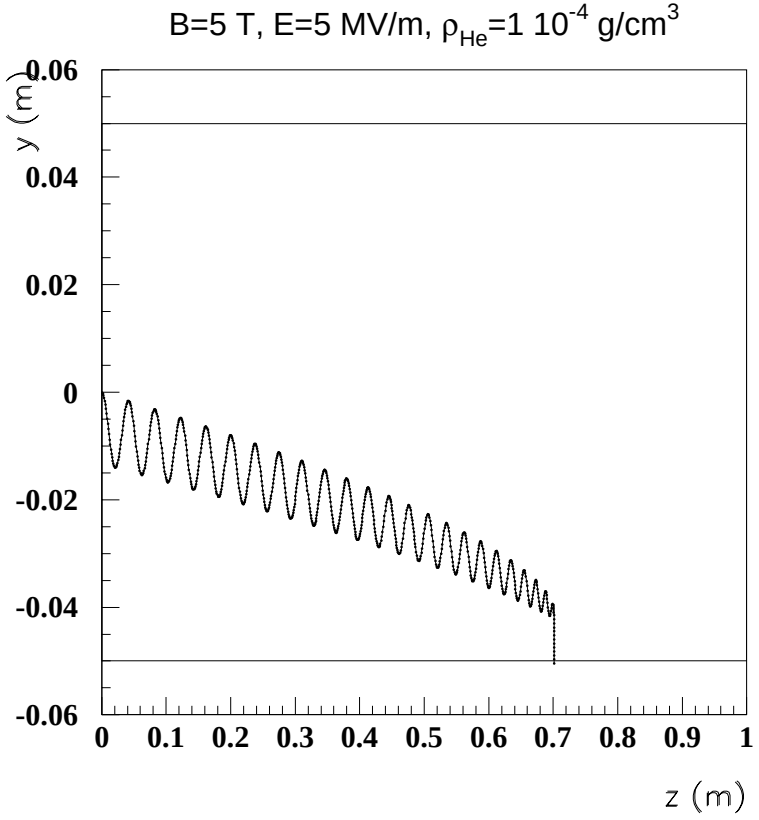
Basic Design





Muon Motion in Cooling Cell



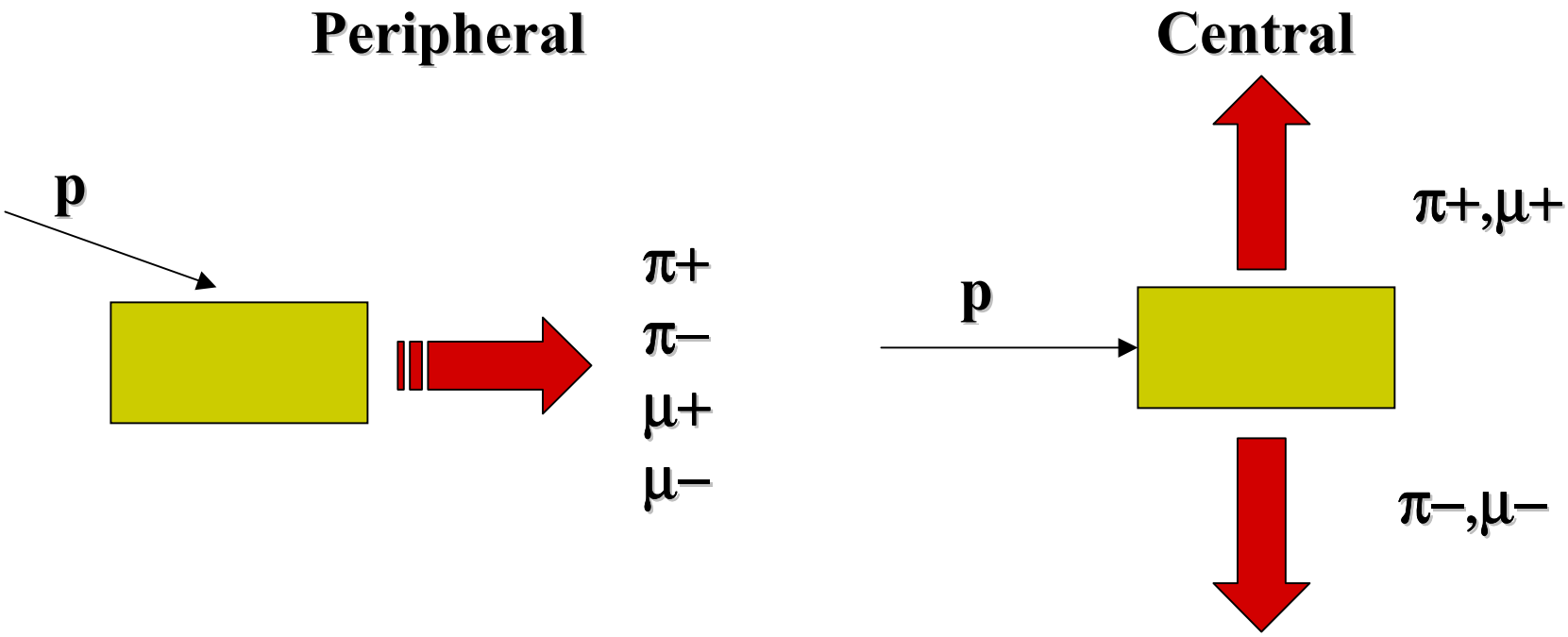


Target Optimization

- Want low energy muons hence need to optimize pion production accordingly for:
  - Proton Driver Energy
  - Target Material
  - Target Dimensions
  - Target Orientation

Peripheral **Central**

Magnet Capture

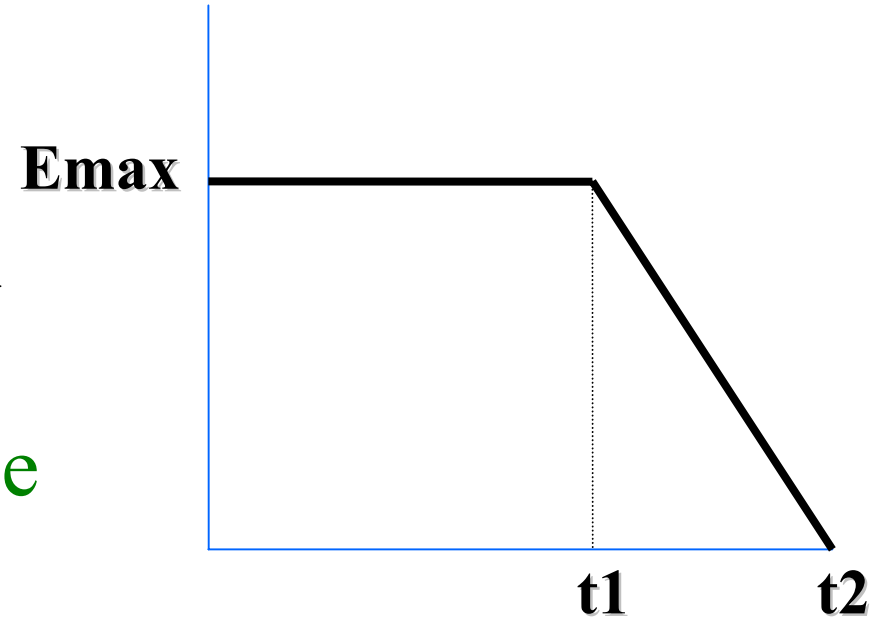


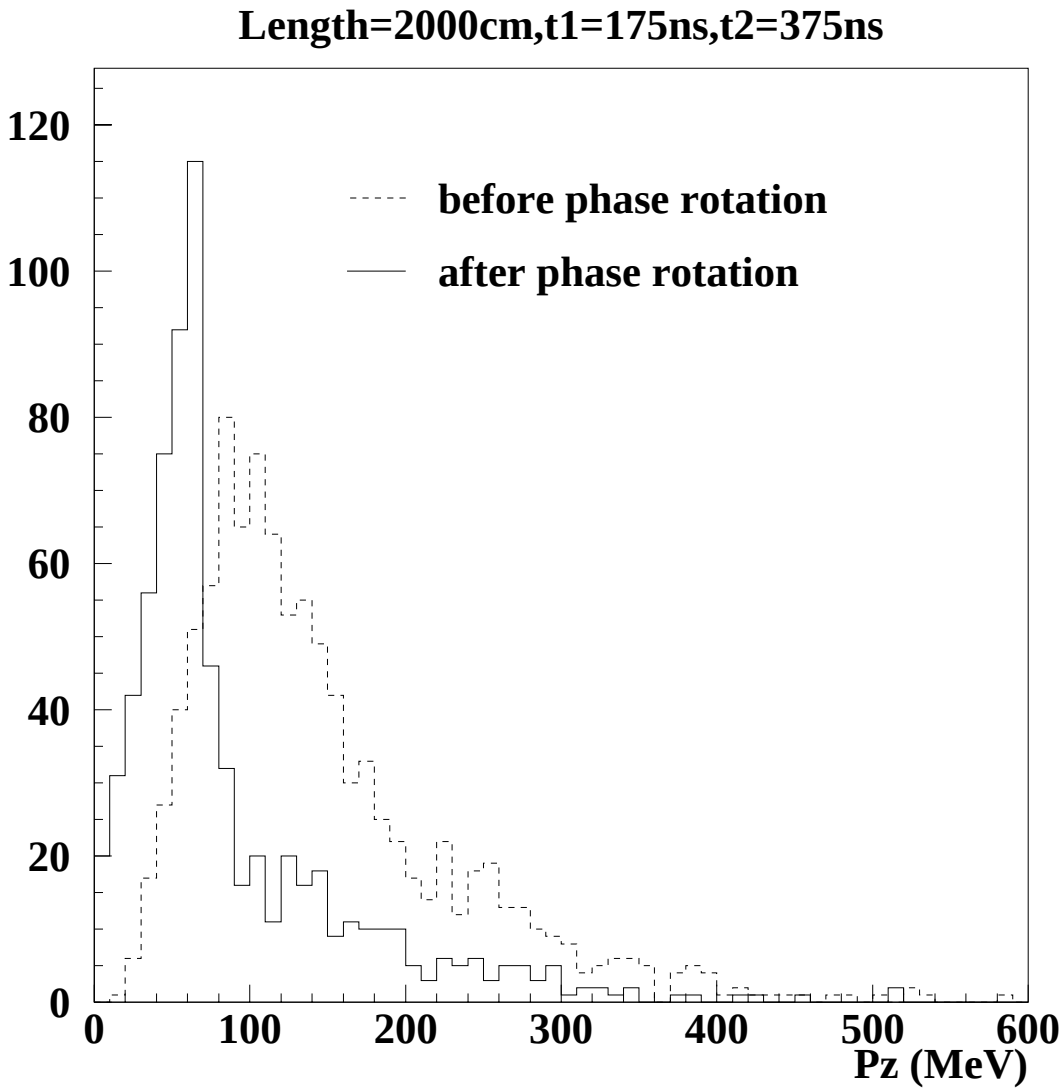
• +ve & -ve in same channel

•Separate charges at source

Phase Rotation

- Apply simple E-field form :
- Optimize muon yield as a function of t1,t2 & Length of the phase rotation region





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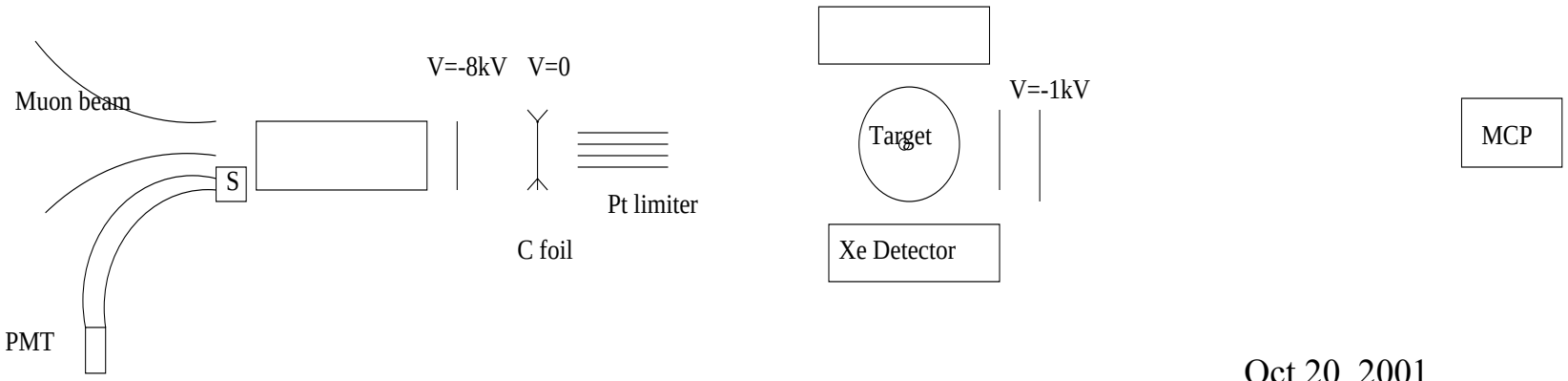
Multiple Scattering

- To date simulations only considered continuous dE/dx
- Technically difficult because of large angle scatters at low energies, and large cross sections. However, simulation almost ready.

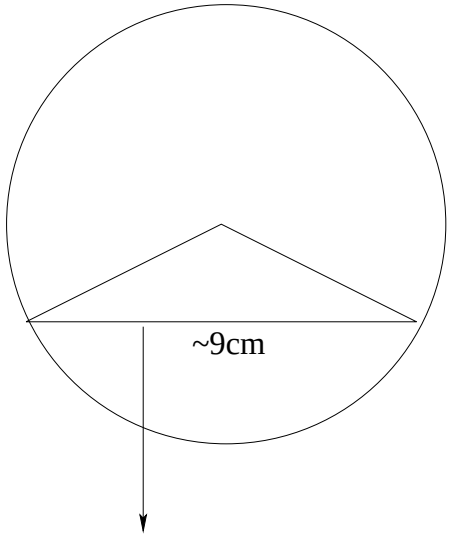
Muon Capture Experiment

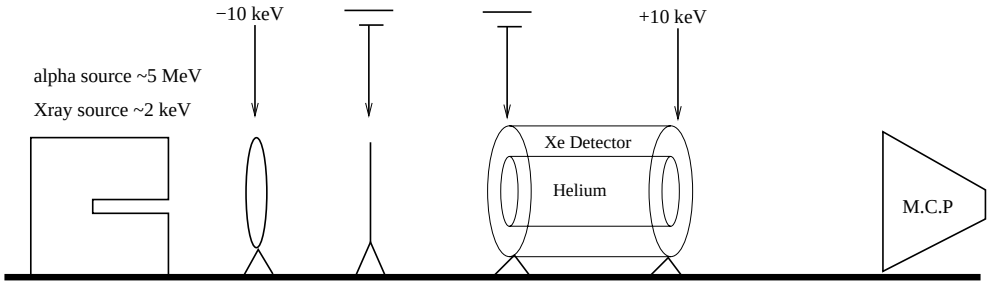
- Experiment at PSI studies Lamb Shift in Muonic Atoms – adopt general scheme.
- Muon Spectrum 10-40KeV
- 5T Magnet with D=20cm bore



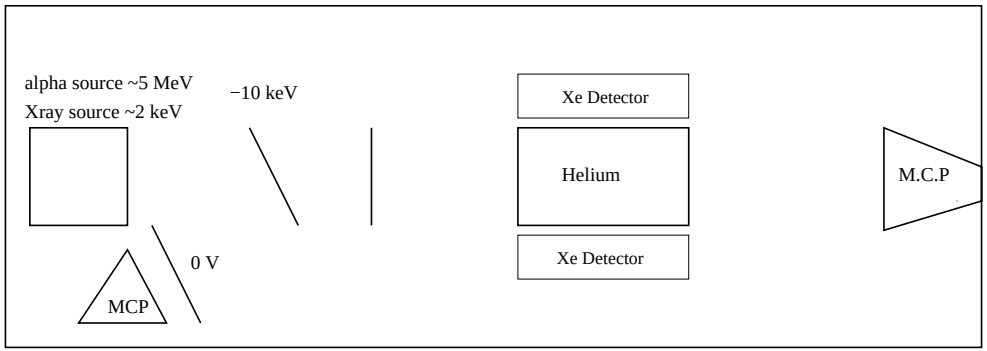
Nevis Setup

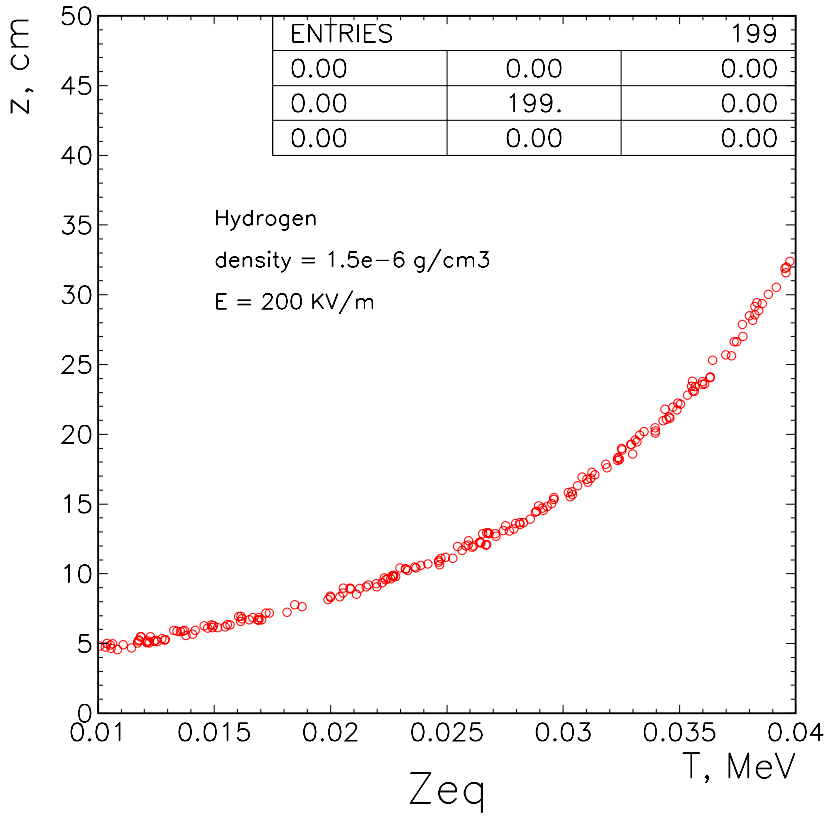
SIDE VIEW:

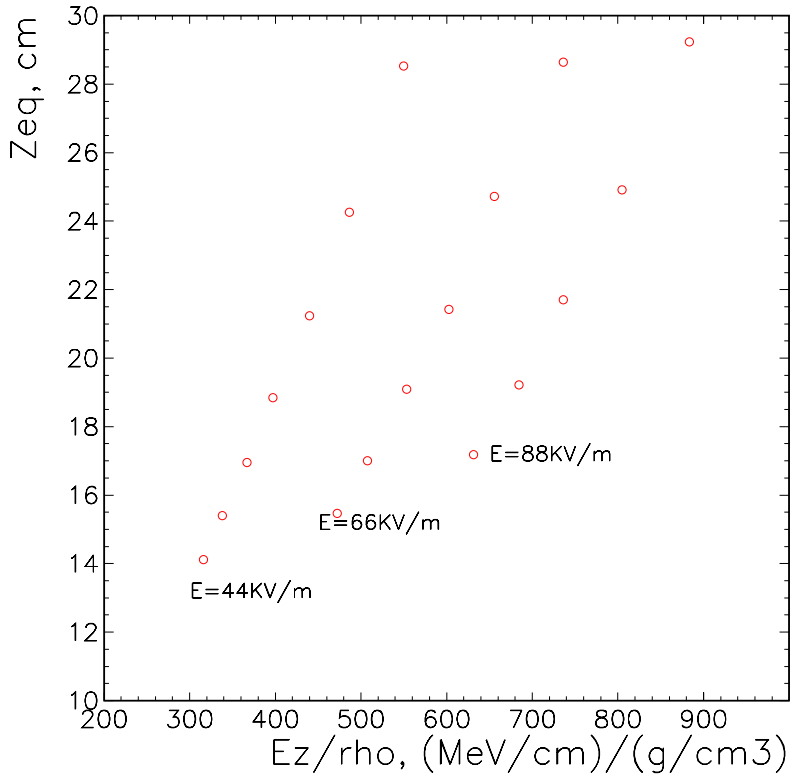




TOP VIEW:







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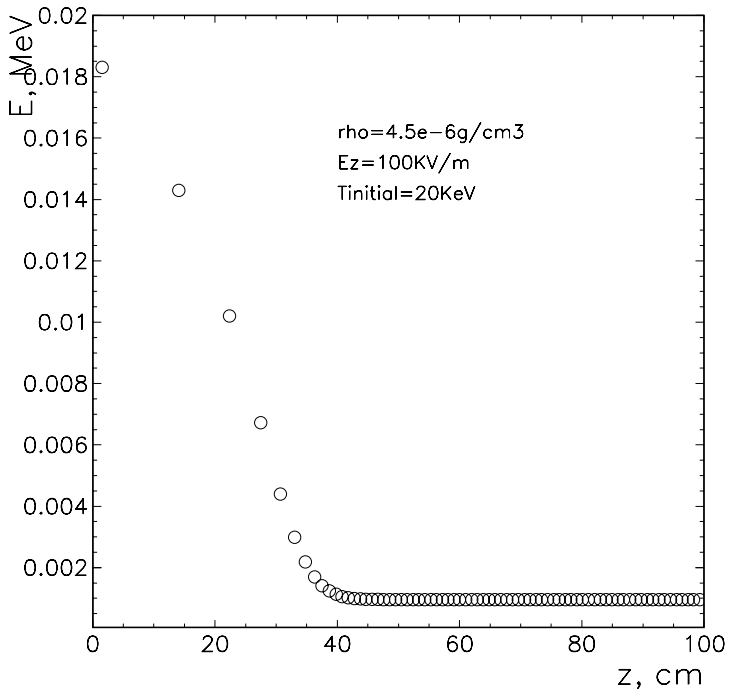
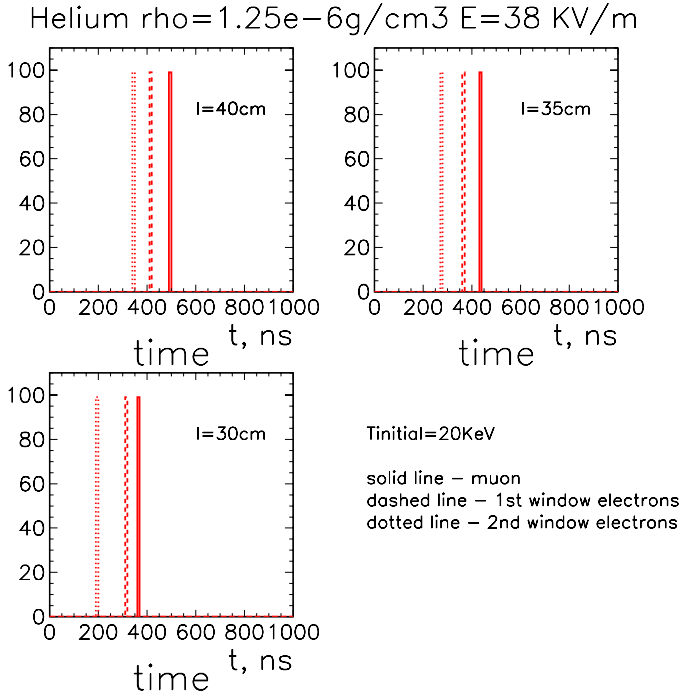

E, MeV
z, cm
rho=4.5e−6g/cm3
Ez=100KV/m
Tinitial=20KeV

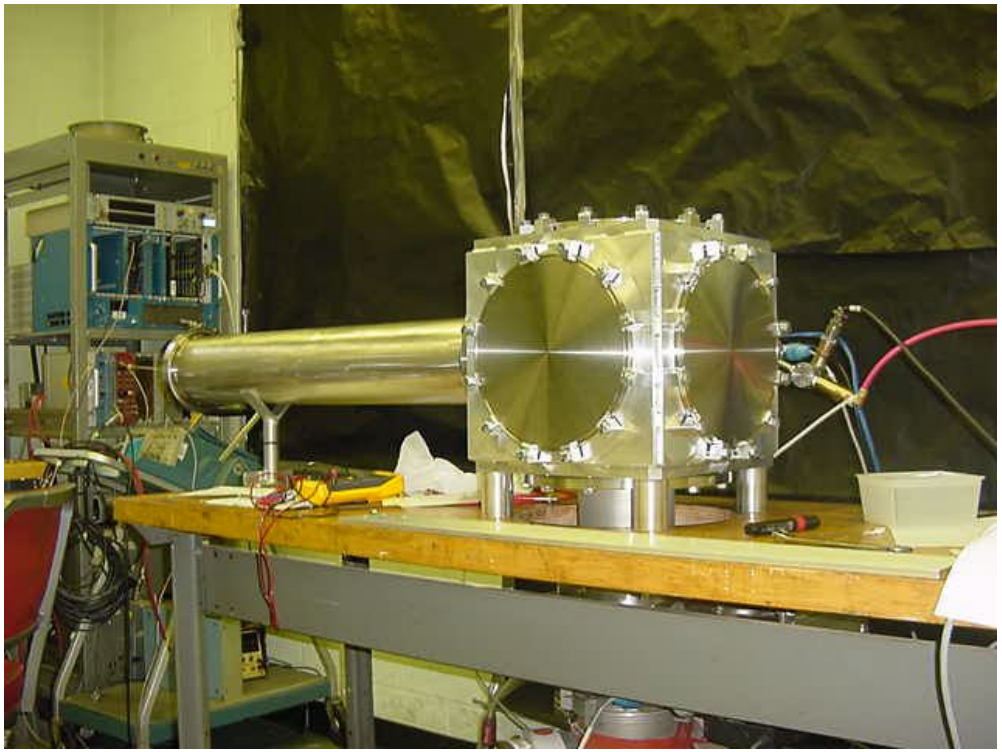

Helium rho=1.25e−6g/cm3 E=38 KV/m
l=40cm
l=35cm
l=30cm
time
t, ns
Tinitial=20KeV
solid line – muon
dashed line – 1st window electrons
dotted line – 2nd window electrons

Goals of Experiment

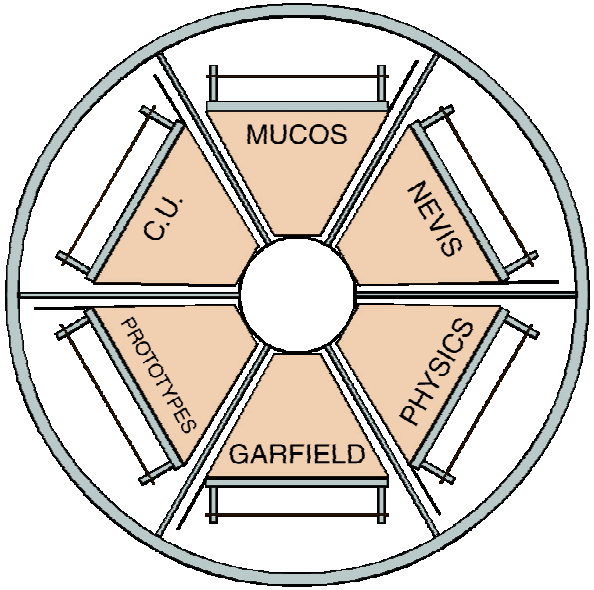
- Measure X-ray released from capture in Gas Atom
- Check understanding of energy loss, multiple scattering
- Measure μ- capture cross section at low energies in He & H2

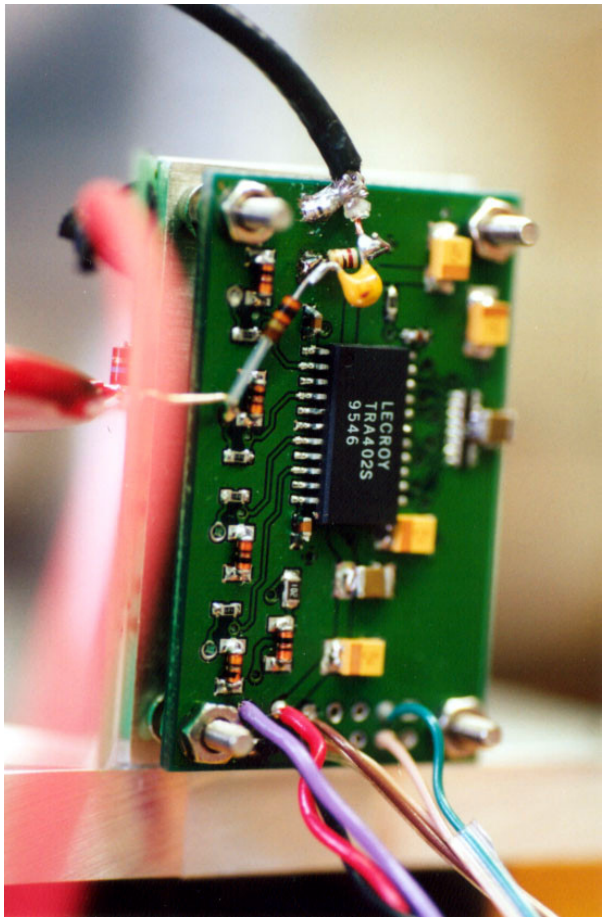
Nevis lab:

- Multipurpose Vacuum Chamber
- Fast Logic Readout
- MCP Detector
- X-ray MWPC development underway



MWPC X-ray Detector





- 4 channel prototype
- Possible extension to tracker – track decay e- from captured μ-

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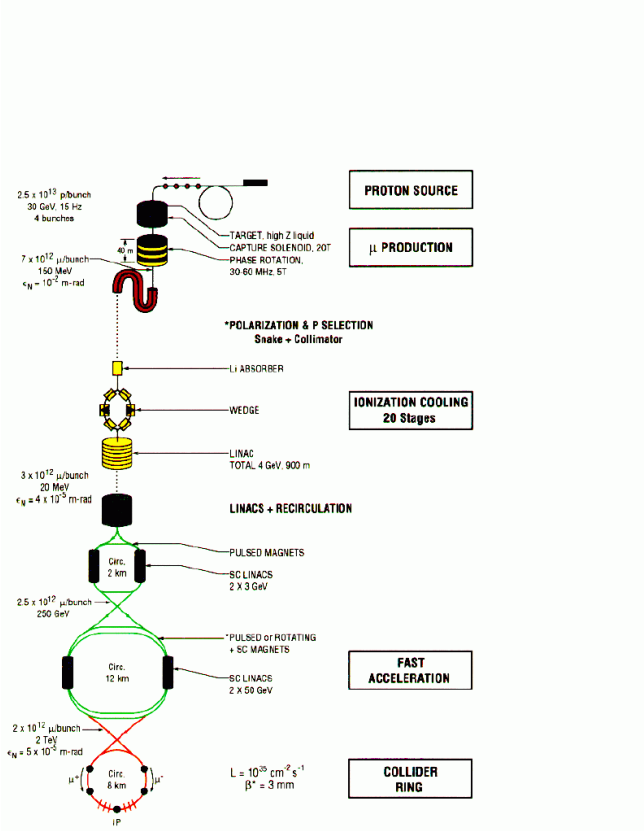
Summary



- Muon Colliders promise a bright future for HEP
  - Physics Factory, Higgs, ν's, s-channel resonances
- Major hurdle is cooling but efforts are going forward with a plan to demonstrate emittance exchange
- Exciting alternative concept for muon cooling
  - Frictional Cooling
  - Possibility to cool both signs at once
  - Experiment to measure μ- capture cross section planned…..STAY TUNED