Low Energy Muon Cooling : Frictional Cooling

Studies at Columbia University &Nevis Labs

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MUon COoling Studies

- Introduction
  - Target Optimization
  - Problem of Multiple Scattering at low energies
- Test Lab at Nevis
  - Experiment at PSI
  - Plans for the future

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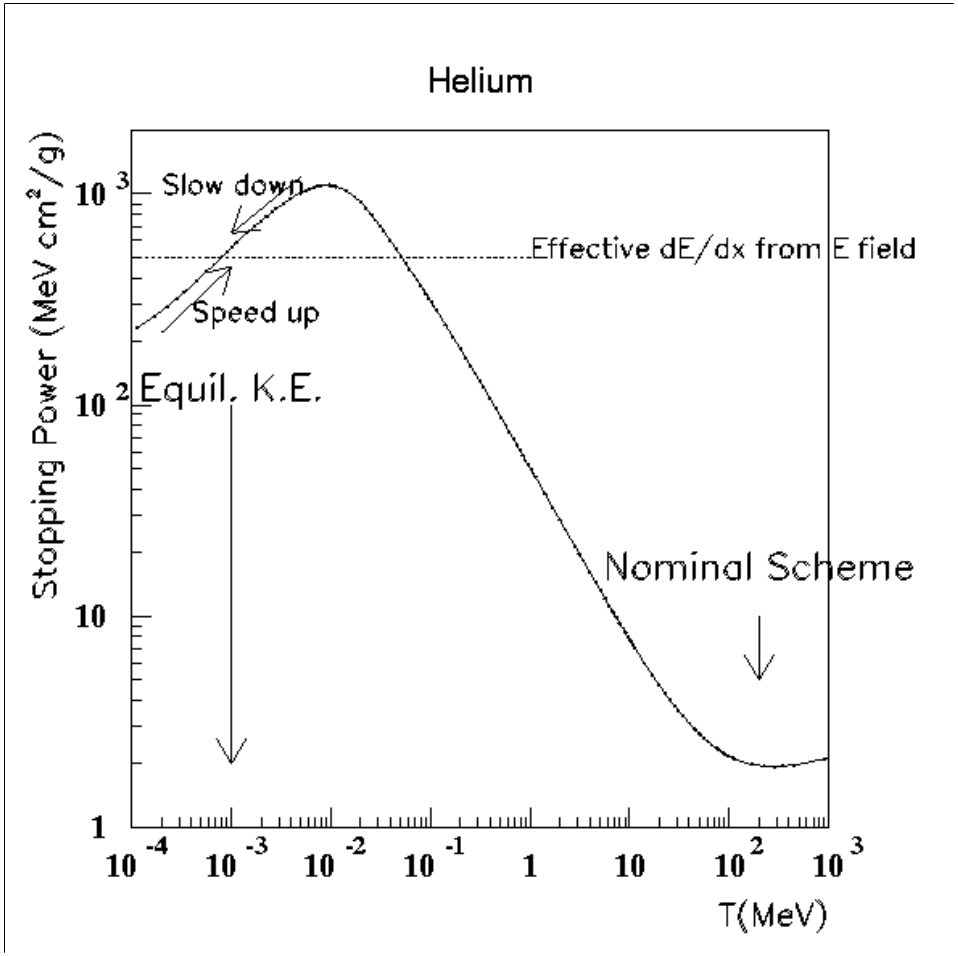
Frictional Cooling

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



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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=1μs so a scheme for reacceleration must be developed

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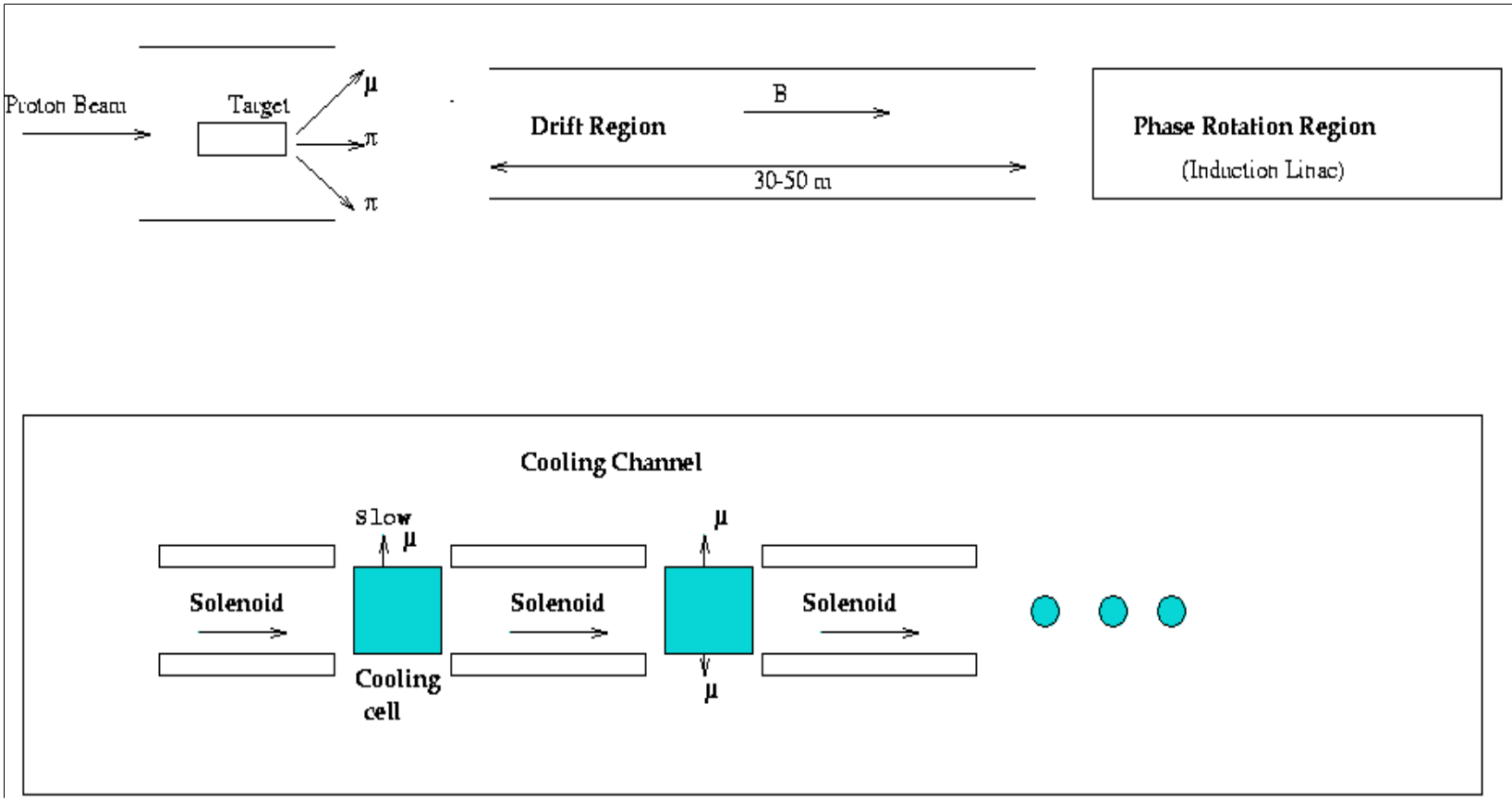
Basic Design



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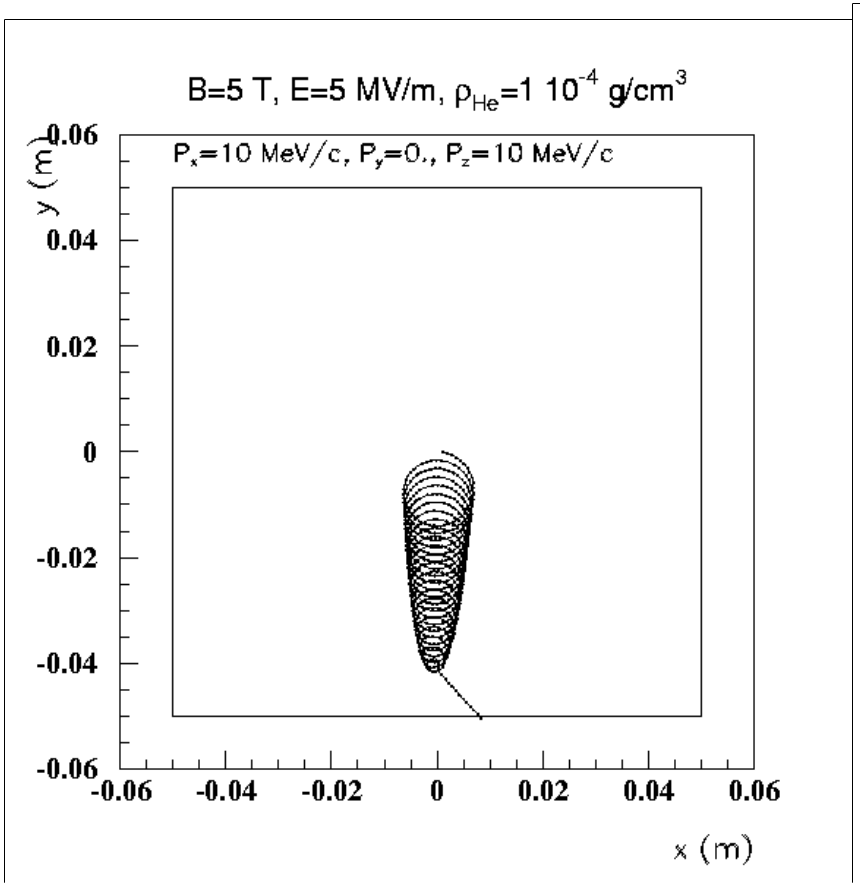
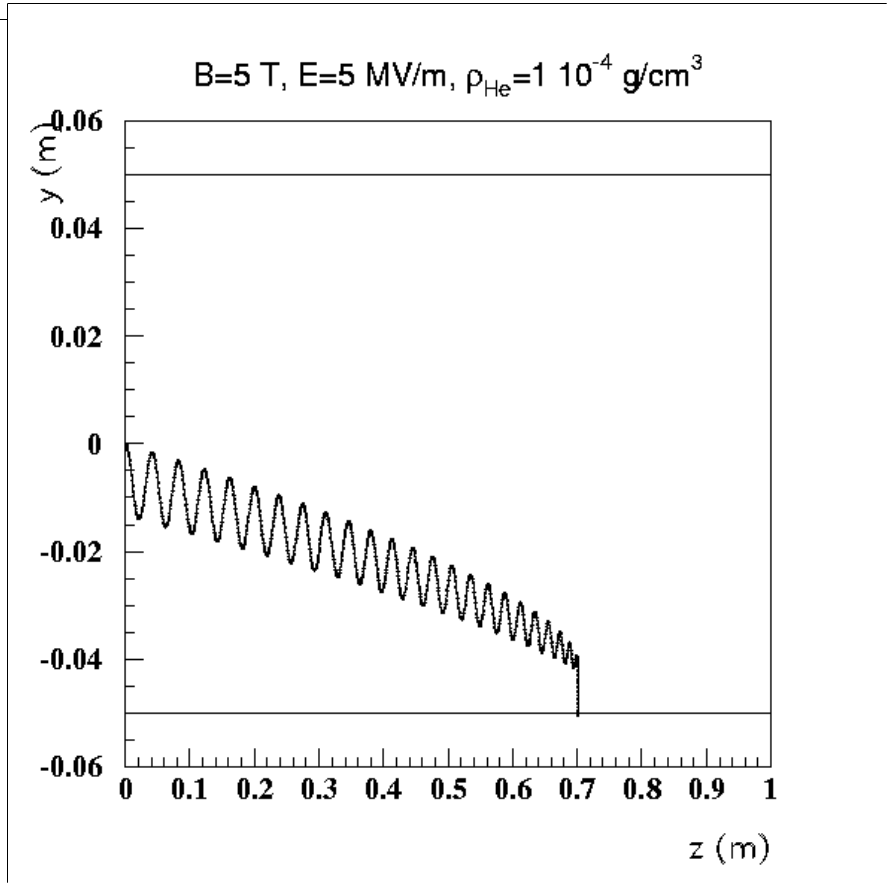
Muon Motion in Cooling Cell





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Target Optimization

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

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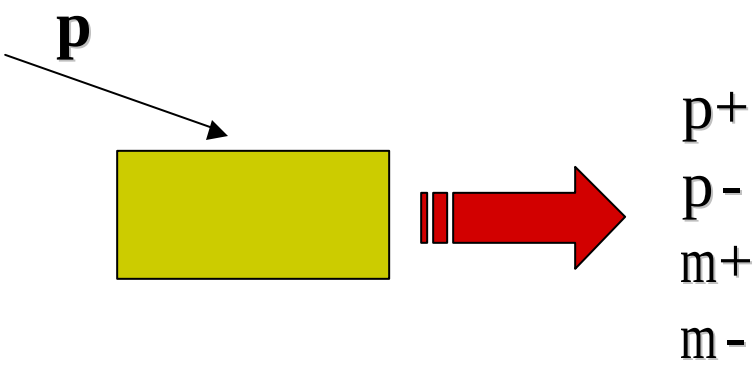
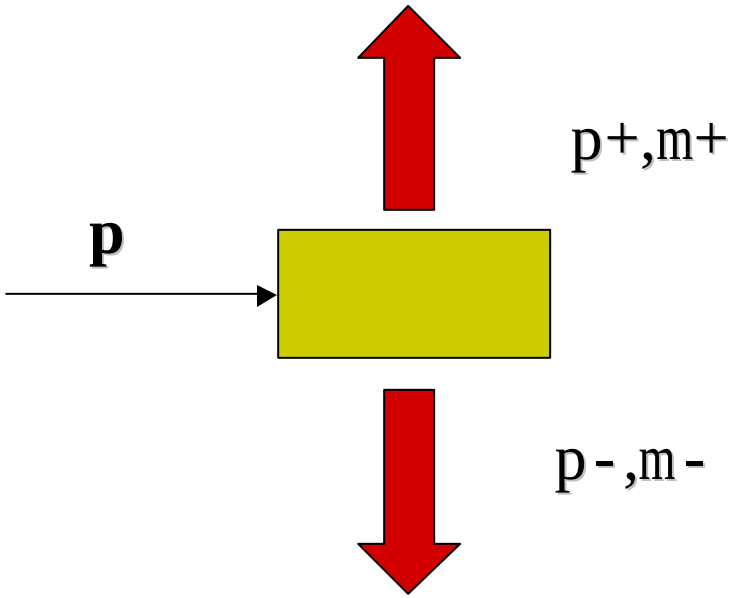
Magnet Capture

Peripheral



Central



- **+ve & -ve in same channel**
- **Separate charges at source**

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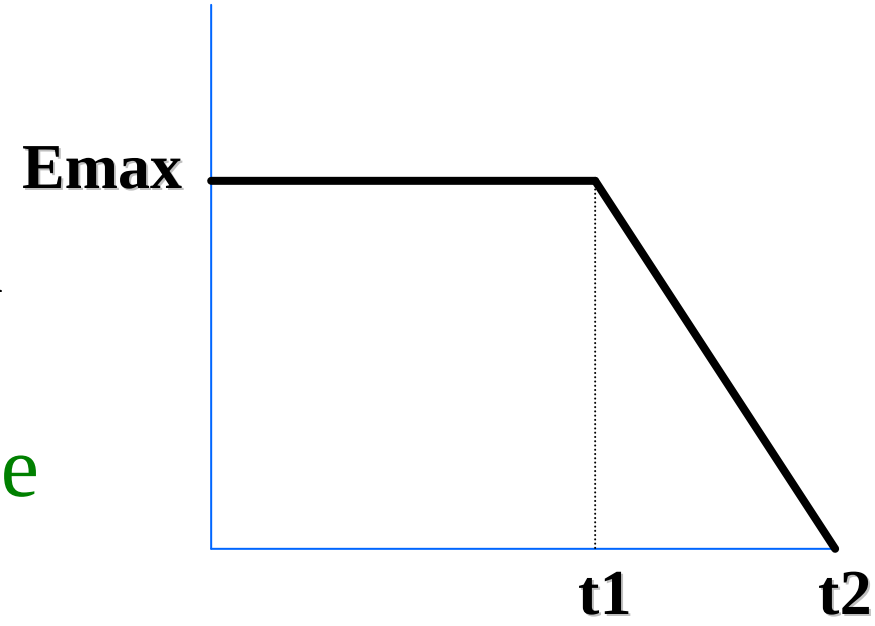
Phase Rotation

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



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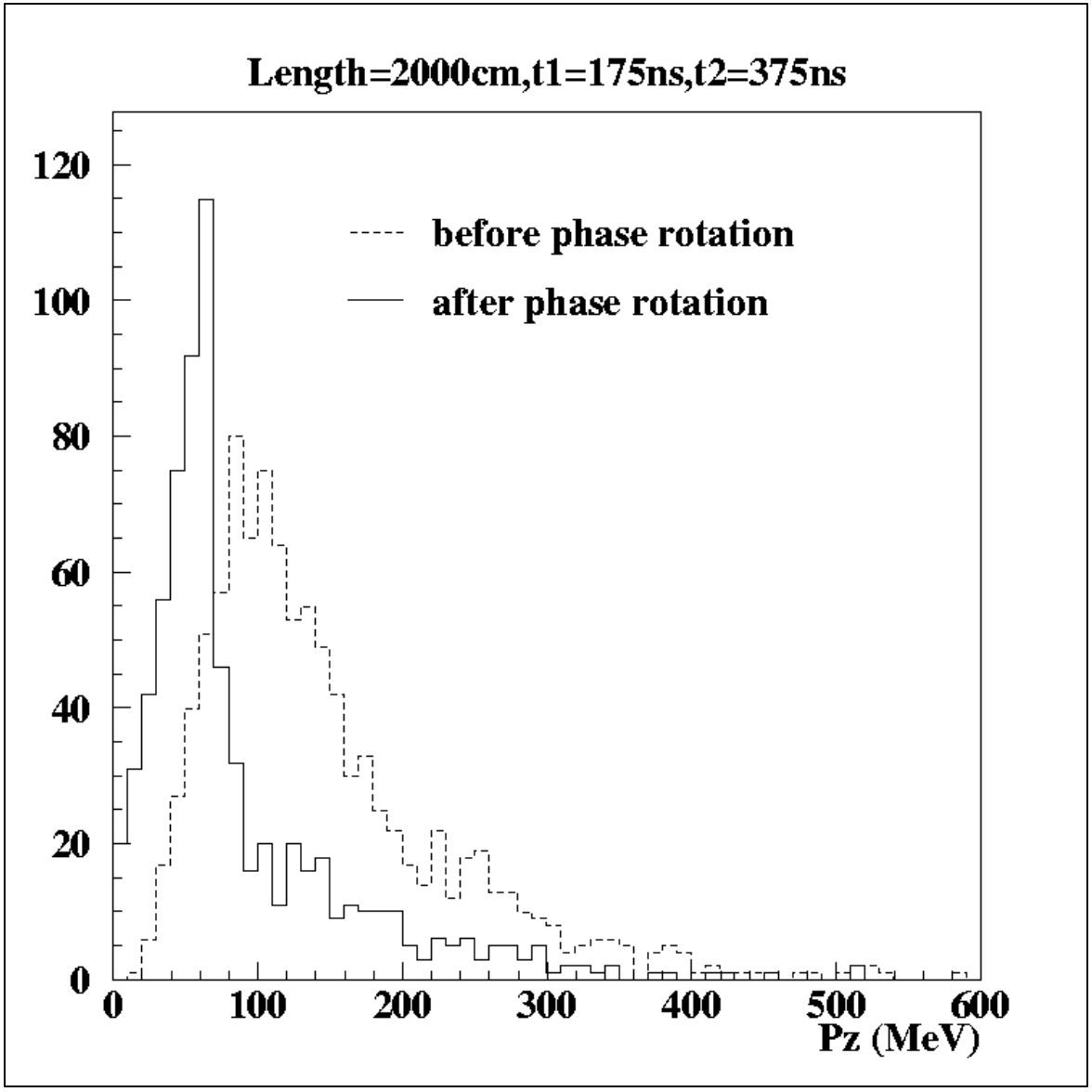

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Multiple Scattering

- To date simulations only considered continuous dE/dx
- May turn out that component of E-field parallel to B-field needed
- Technically difficult because of large angle scatters at low energies

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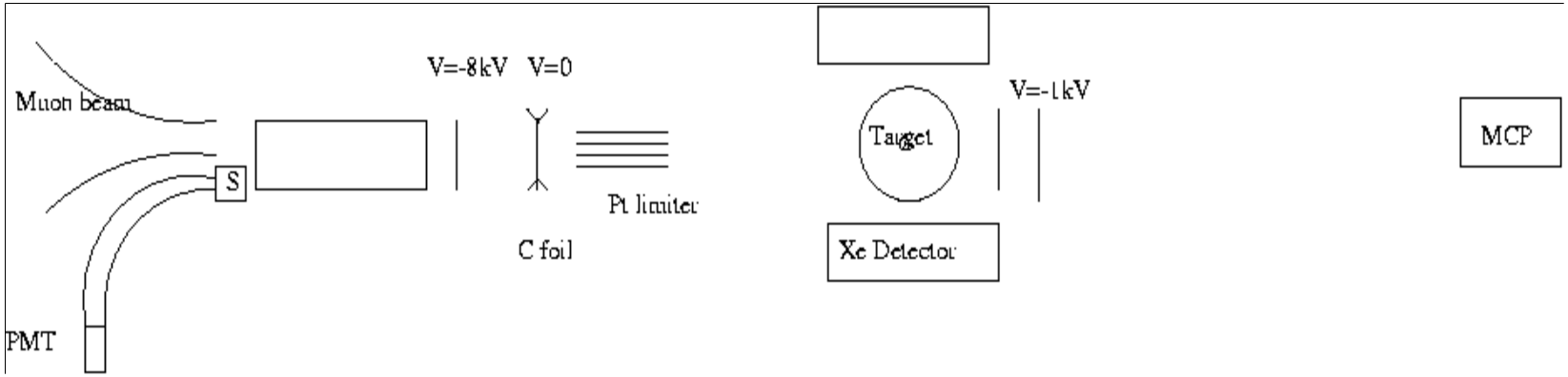
PSI Experiment

- Experiment study Lamb Shift in Muonic Atoms
- Muon Spectrum 10-40KeV
- 5T Magnet with D=20cm bore



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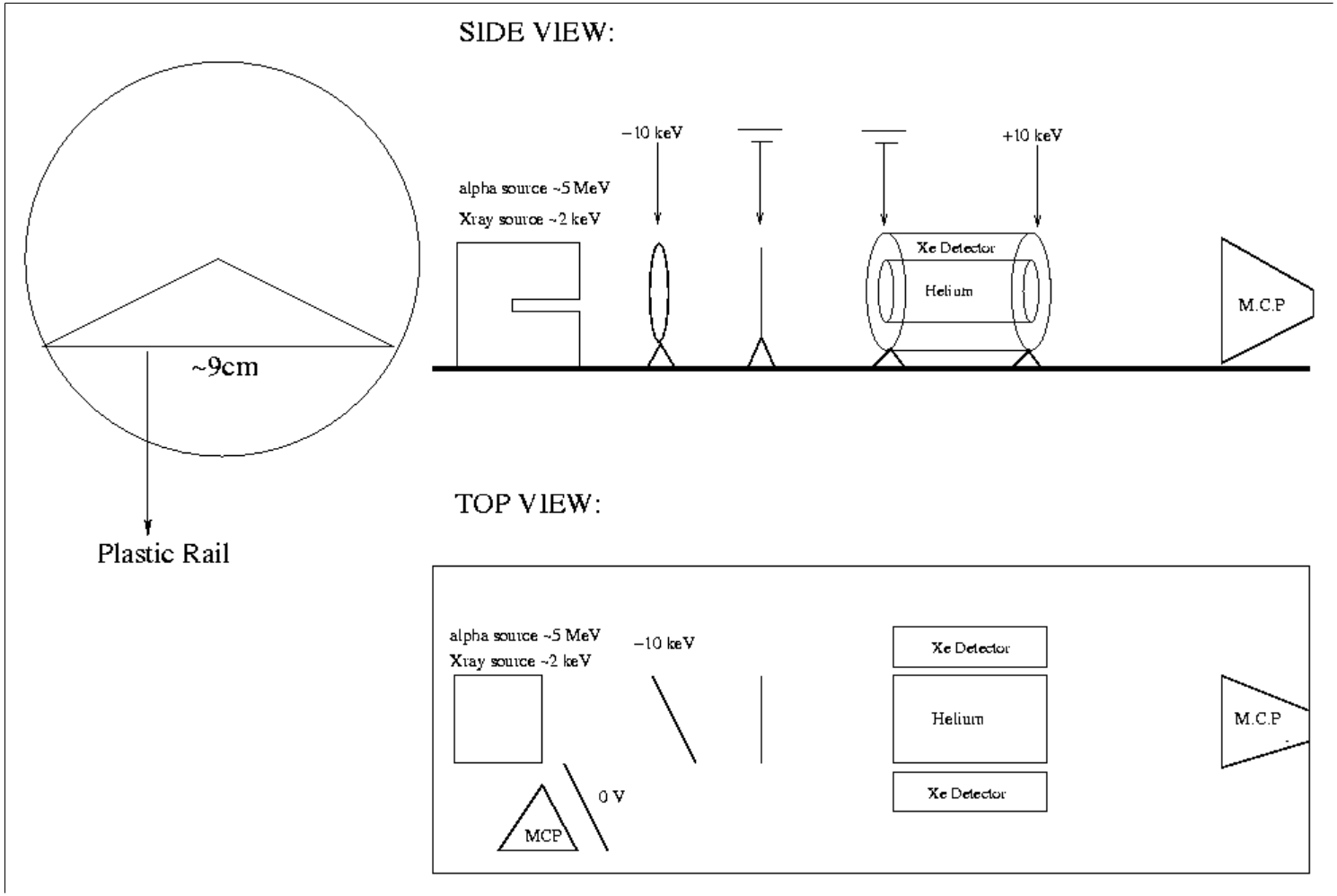
Nevis Setup



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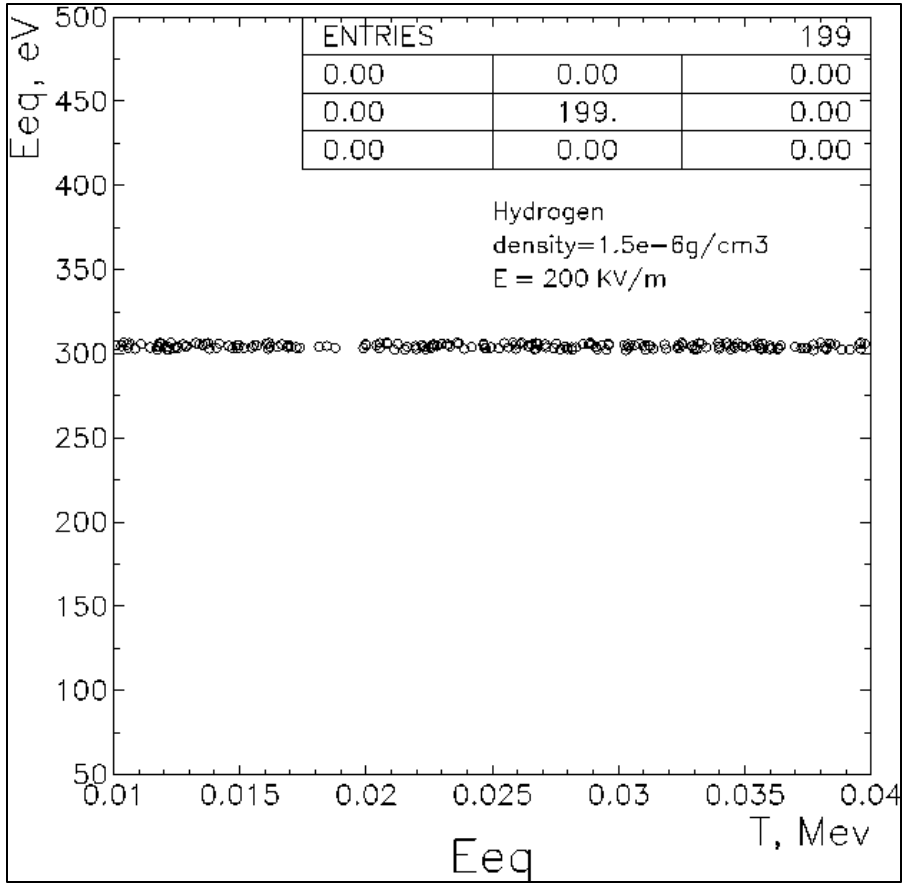
Simulation @ Nevis

- Vary E-field, density & length of gas cell
- Simulation with no Multiple Scattering
- E-field parallel to B-field so muons do not stop



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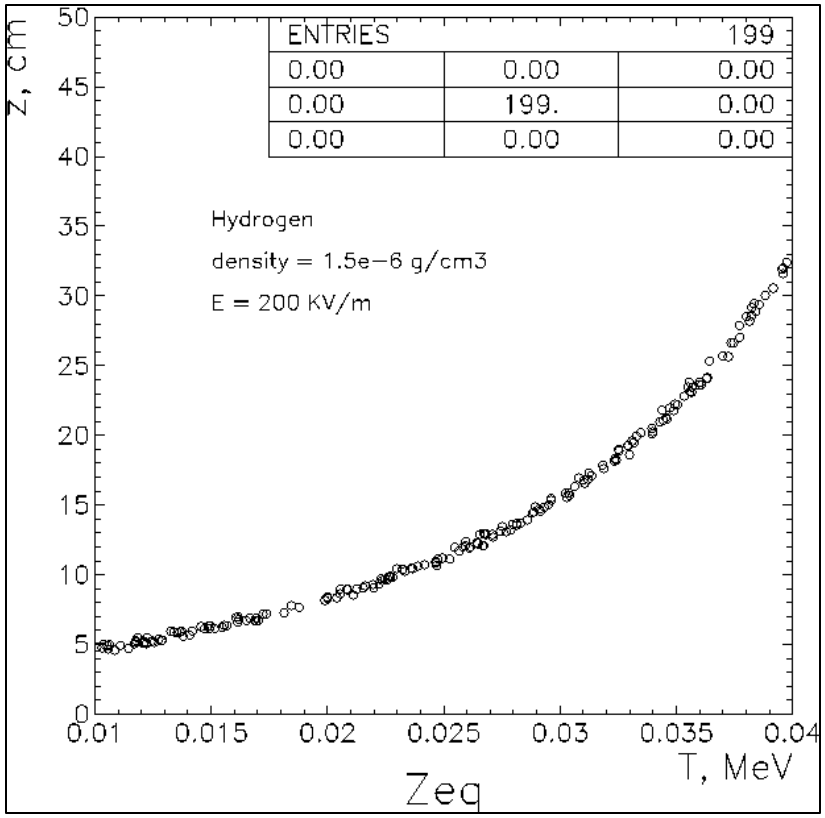

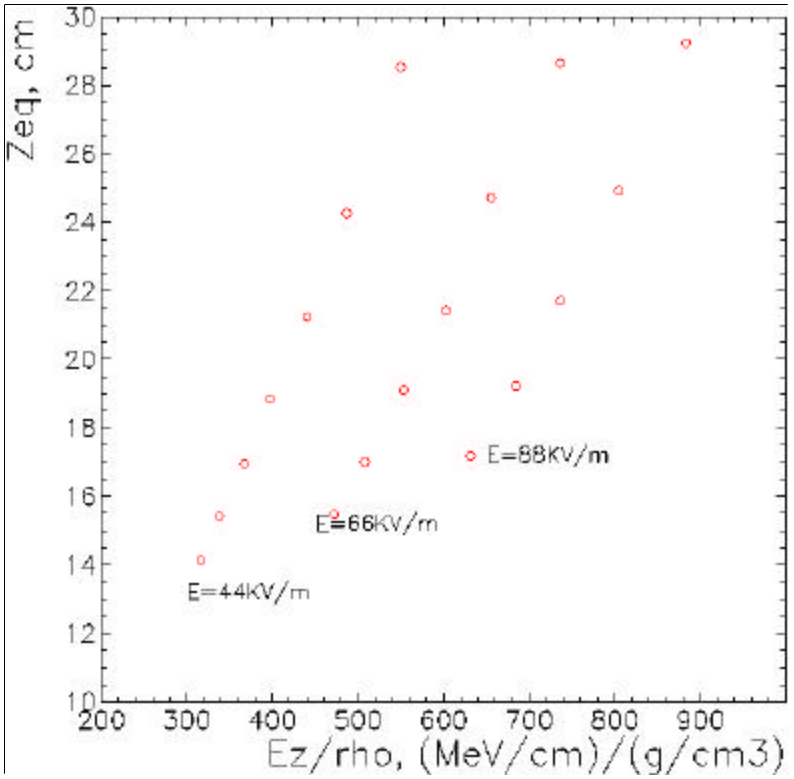

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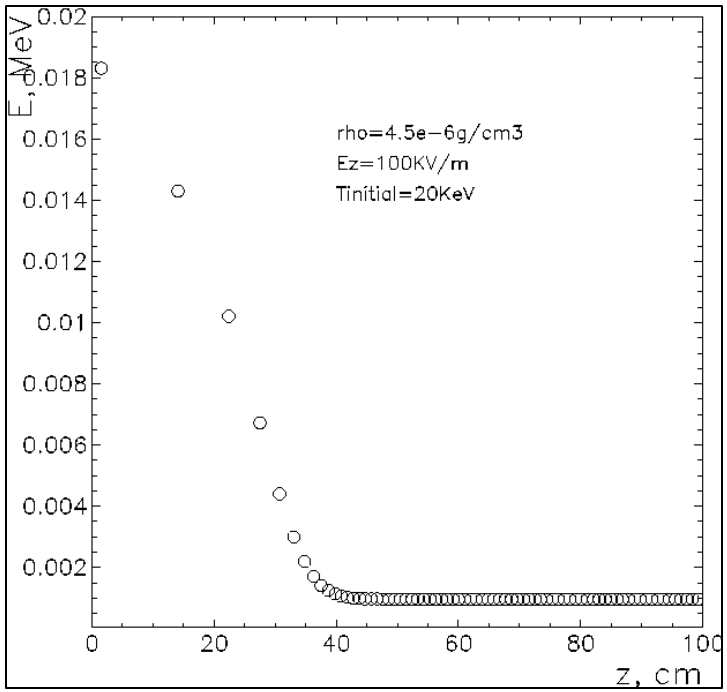

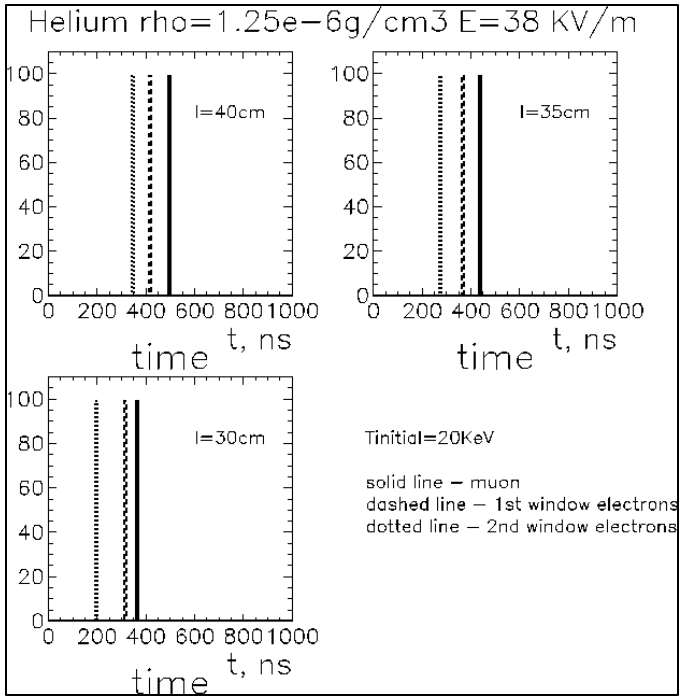

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Goals of Experiment

- 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

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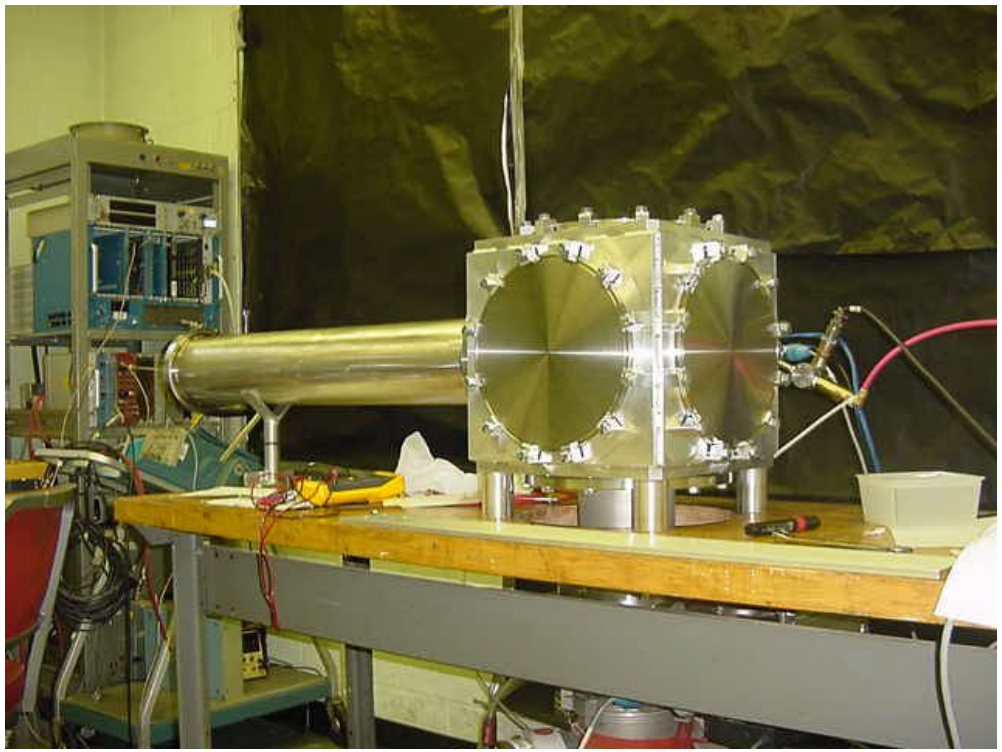
Nevis lab:

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



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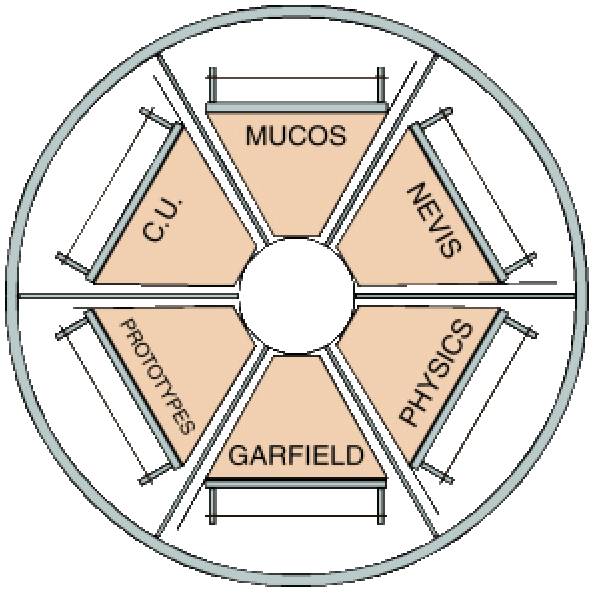
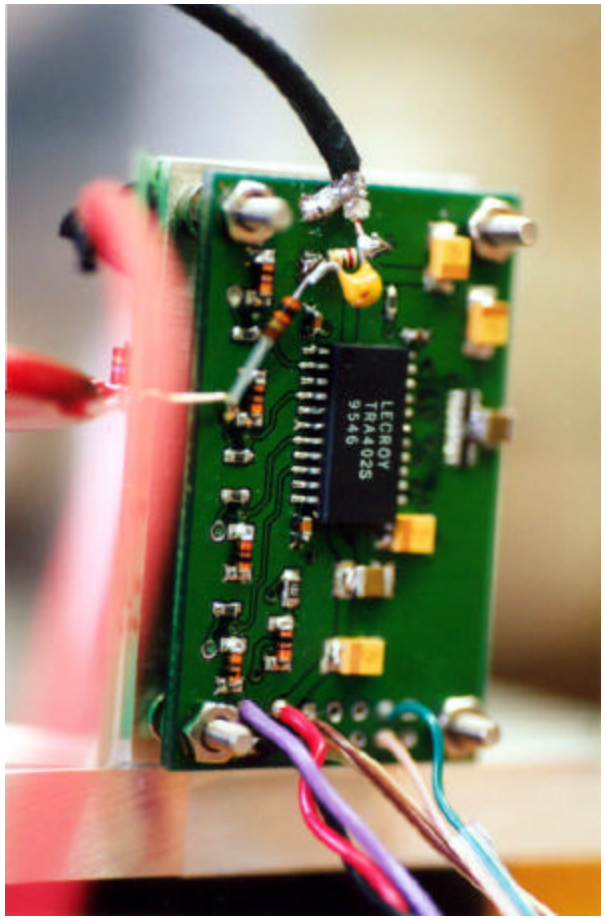
MWPC X-ray Detector





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

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Summary

- Exciting alternative concept for muon cooling
- Possibility to cool both signs at once
- Experiment to measure μ^- capture cross section planned…..STAY TUNED
- Different Simulations/Optimizations will be integrated in GEANT4.3