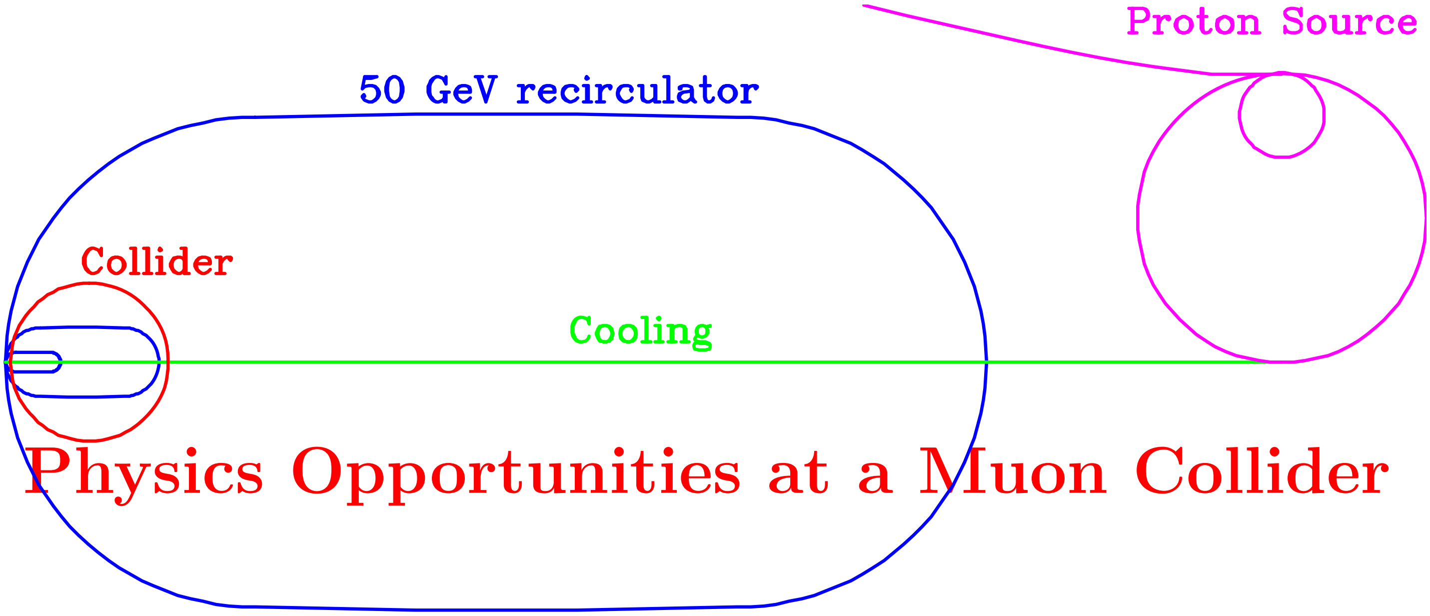

Physics Opportunities at a Muon Collider

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Muon Collider main page:

http://www.cap.bnl.gov/mumu/mu_home_page.html

Muon Collider R&D Status Report:

http://www.cap.bnl.gov/mumu/status_report.html

Princeton Muon Collider page:

http://puhep1.princeton.edu/mumu/

AIP Conference Proceedings, Vols. 352, 372, 435 & 441

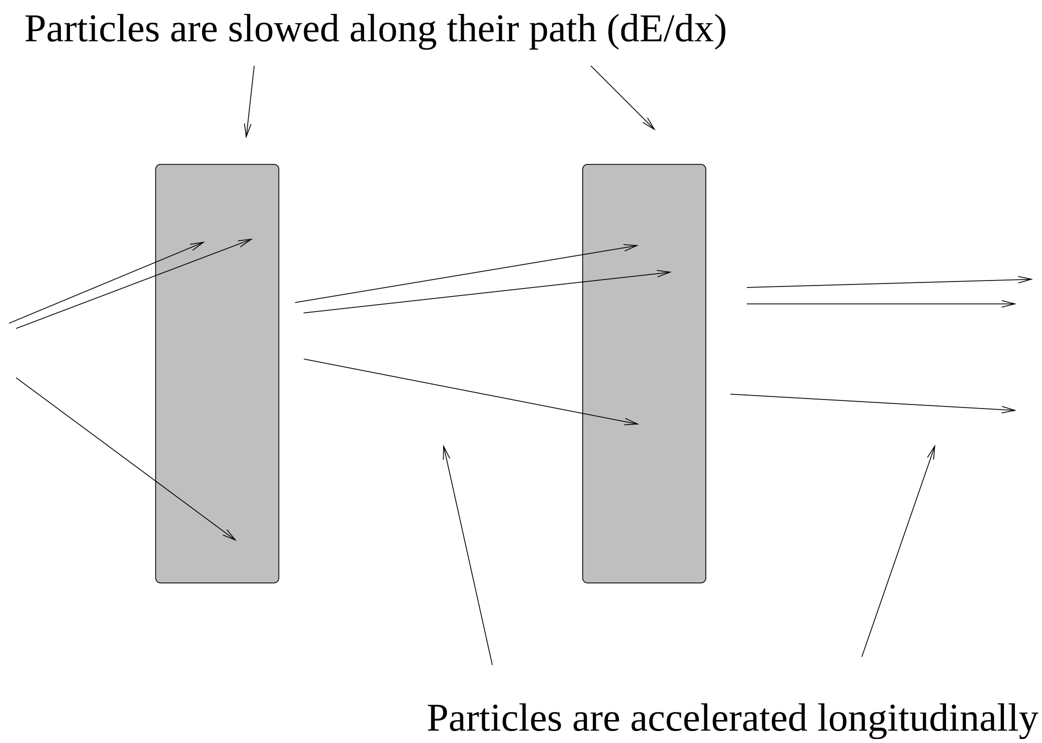
I Want to Believe...

- That elementary particle physics will prosper for a 2nd century with laboratory experiments based on innovative particle sources.
- That a full range of new phenomena will be investigated:
  - Neutrino mass $\Rightarrow$ a 2nd 3×3 (or larger?) mixing matrix.
  - Precision studies of Higgs bosons.
  - A rich supersymmetric sector.
  - ... And more ....
- That our investment in future accelerators will result in more cost-effective technology, that is capable of extension to 10's of TeV of constituent CoM energy.
- That a **Muon Collider** is the best option to accomplish the above.

Ionization Cooling

(An Idea So Simple It Might Just Work)

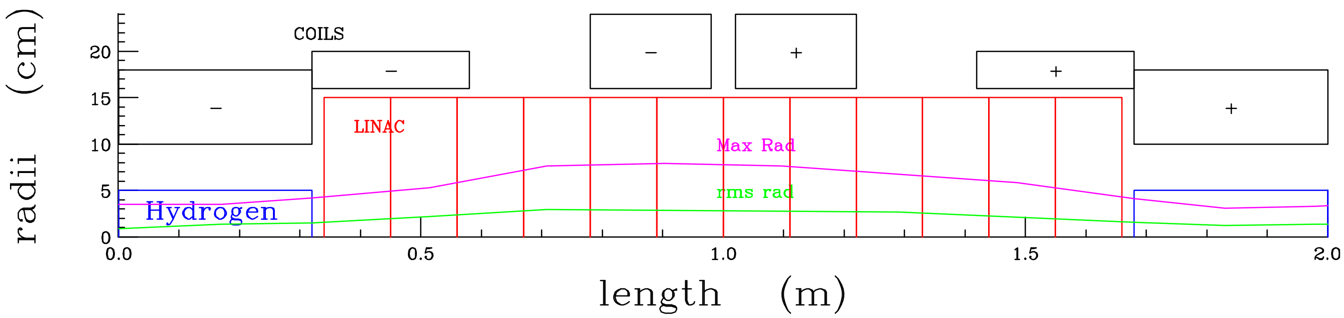
- Ionization: takes momentum away.
- RF acceleration: puts momentum back along z axis.
- $\Rightarrow$ Transverse "cooling".



- Origin: G.K. O'Neill, Phys. Rev. **102**, 1418 (1956).
- But won't work for electrons or protons.
- So use muons: Balbekov, Budker, Skrinsky, late 1960's.

The Details are Delicate

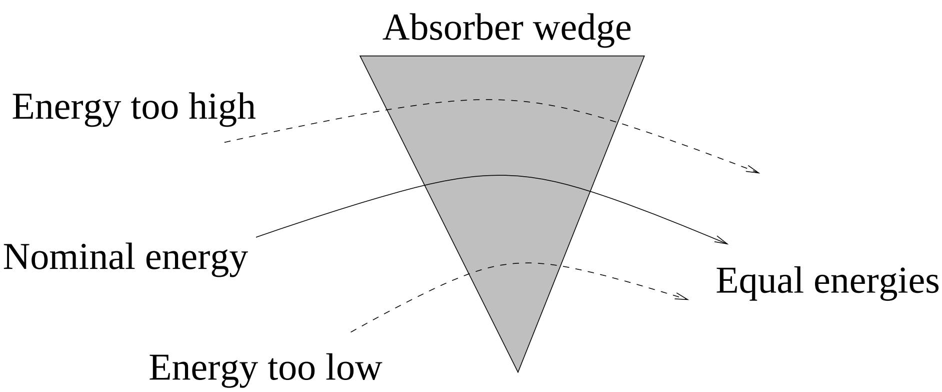
Use channel of LH_2 absorbers, rf cavities and alternating solenoids (to avoid buildup of angular momentum).



The Energy Spread Rises due to "Straggling"

⇒ Must exchange longitudinal and transverse emittance frequently to avoid beam loss due to bunch spreading.

Can reduce energy spread by a wedge absorber at a momentum dispersion point:



What is a Muon Collider?

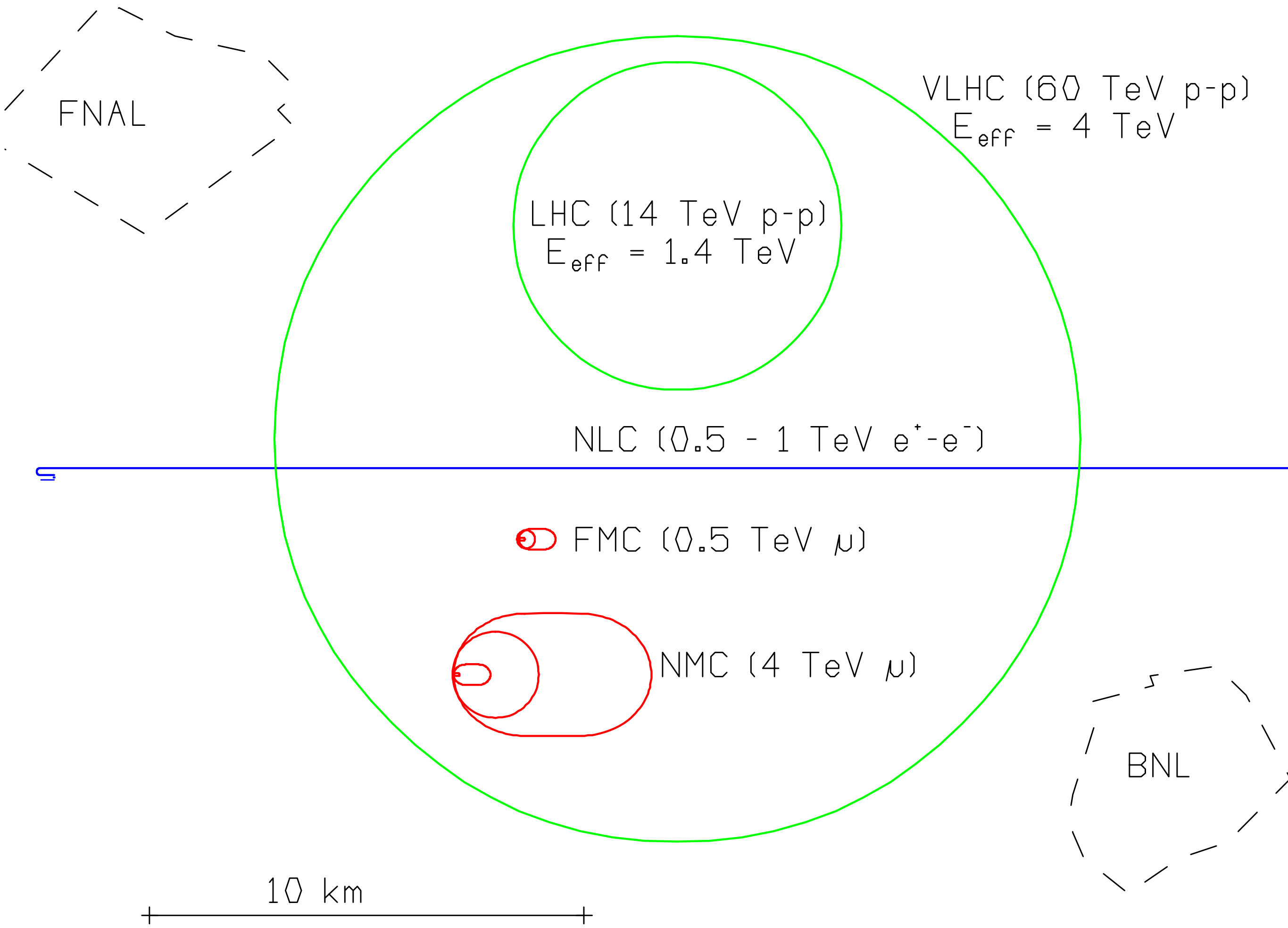
An accelerator complex in which

- Muons (both μ^+ and μ^-) are collected from pion decay following a pN interaction.
- Muon phase volume is reduced by 10^6 by ionization cooling.
- The cooled muons are accelerated and then stored in a ring.
- $\mu^+\mu^-$ collisions are observed over the useful muon life of ≈ 1000 turns at any energy.
- Intense neutrino beams and spallation neutron beams are available as byproducts.

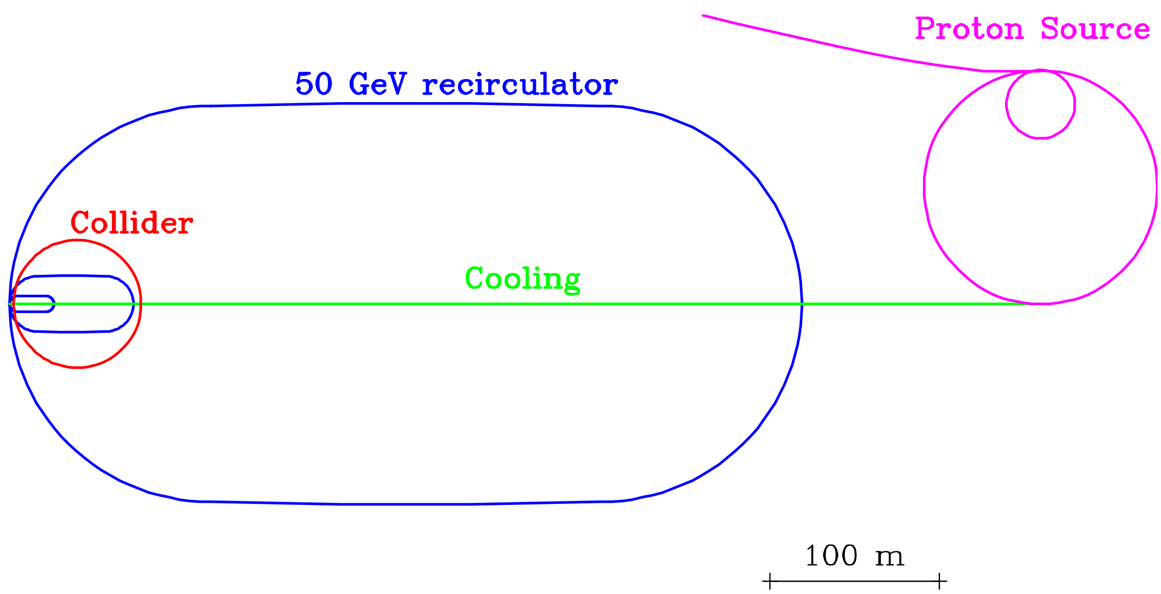
Muons decay: $\mu \to e\nu \qquad \Rightarrow$

- Must cool muons quickly (stochastic cooling won't do).
- Detector backgrounds at LHC level.
- Potential personnel hazard from ν interactions.

Footprints

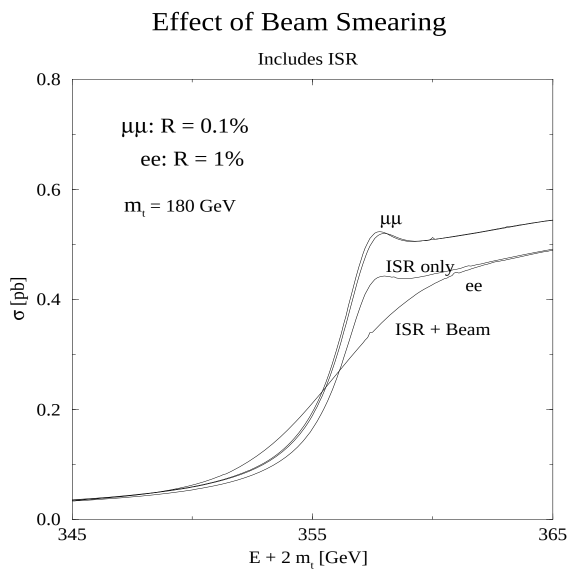


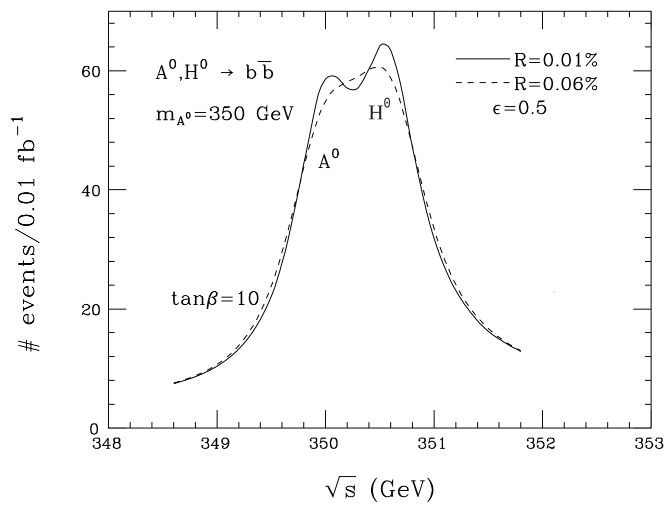
A First Muon Collider to study light-Higgs production:



The Case for a Muon Collider

- More affordable than an e^+e^- collider at the TeV (LHC) scale.
- More affordable than either a hadron or an e^+e^- collider for (effective) energies beyond the LHC.
- Precision initial state superior even to e^+e^-.





- Initial machine could produce light Higgs via s-channel:

  Higgs coupling to μ is $(m_\mu/m_e)^2 \approx 40,000\times$ that to e.

  Beam energy resolution at a muon collider $< 10^{-5}$,

  $\Rightarrow$ Measure Higgs width.

  Add rings to 3 TeV later.

- Neutrino beams from μ decay about 10^4 hotter than present.

Future Frontier Facilities

(A Personal Assessment)

- Hadron collider (LHC, SSC): $\approx$ \$100k/m [magnets].

  $\approx$ 2 km per TeV of CM energy.

  Ex: LHC has 14-TeV CM energy, 27 km ring, $\approx$ \$3B.

- Linear e^+e^- collider (SLAC, NLC(?)): $\approx$ \$200k/m [rf].

  $\approx$ 20 km per TeV of CM energy;

  But a lepton collider needs only $\approx 1/10$ the CM energy

  to have equivalent physics reach to a hadron collider.

  Ex: NLC, 1.5-TeV CM energy, 30 km long, $\approx$ \$6B (?).

- Muon collider: $\approx$ \$1B for source/cooler + \$100k/m for rings

  Well-defined leptonic initial state.

  $m_\mu/m_e \approx 200 \Rightarrow$ Little beam radiation.

  $\Rightarrow$ Can use storage rings.

  $\Rightarrow$ Smaller footprint.

  Technology: closer to hadron colliders.

  $\approx$ 6 km of ring per TeV of CM energy.

  Ex: 3-TeV muon collider $\approx$ \$3B (?).

The Muon Collider Collaboration

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