Neutrino Factory and Muon Collider at BNL

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- ongoing work as part of the U.S. Muon Collaboration

- local group: interested in novel accelerator aspects of these facilities
  - simulation work on system design and beam dynamics
  - 1-4 MW targetry issues (AGS E-951)
  - ionization cooling (MUCOOL, MICE)

- facilities provide broad range of physics opportunities

Summary

Neutrino Factory

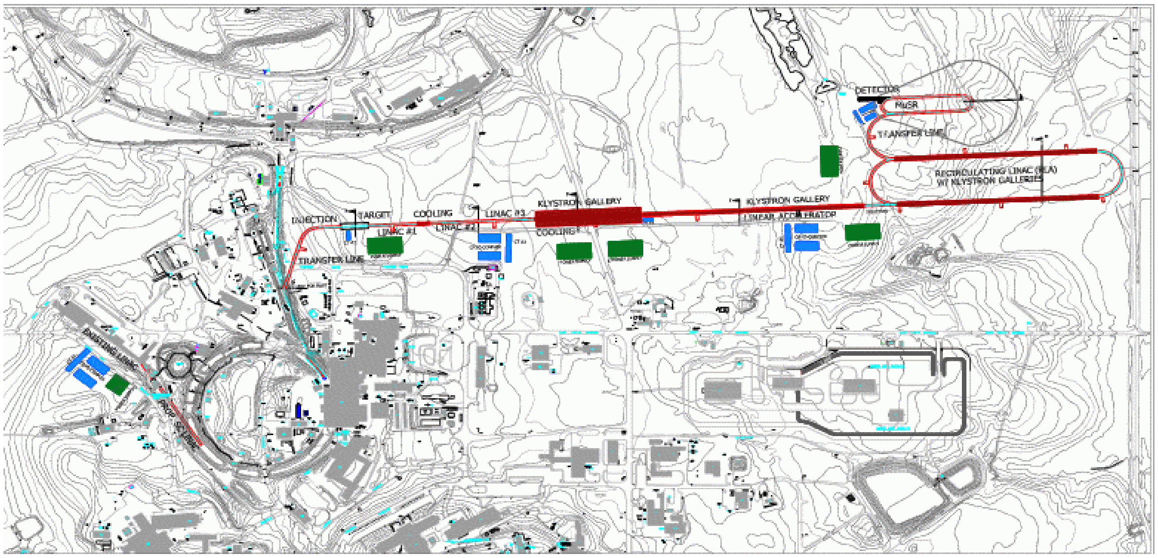
- neutrinos produced in decay of 20 GeV μ in storage ring
- get large ν flux at distant detectors
- ν_e beam allows clean signal in the detector
- measure θ_{13}, ν mass ordering, CP violation?
- staging construction allows other physics results

Muon Collider

- circular, 0.1-10 TeV $\mu^+ \mu^-$ collider
- precise measurement of Higgs mass and total width
- possible upgrade path to a 3-10 TeV lepton collider

Neutrino Factory

- get ν from decays in high energy μ storage ring
- have completed two fairly detailed feasibility studies



features

well characterized, pure ν beam, e.g. $\mu^- \rightarrow e^- \ (\nu_e)\ \nu_\mu$

can use ν_e component to look for wrong-sign μ in detector

high energy decays gives well collimated ν beam => high ν flux

$E_\nu \sim 10$ GeV, 10^{20} μ decays/yr

~1000 ν CC events/kt/yr at Homestake

could store both μ charges => distinguish by timing

good measurement of θ_{13}, mass ordering, CP violation?

high statistics non-oscillation ν physics at near detector

$\sin^2 \theta_W$, structure functions, …

issues

detector must measure sign of particle charge

optimize performance/cost

more work on ring optics to reduce flux uncertainty

Possible staging of the Neutrino Factory construction

- many physics opportunities are possible before the facility is completed

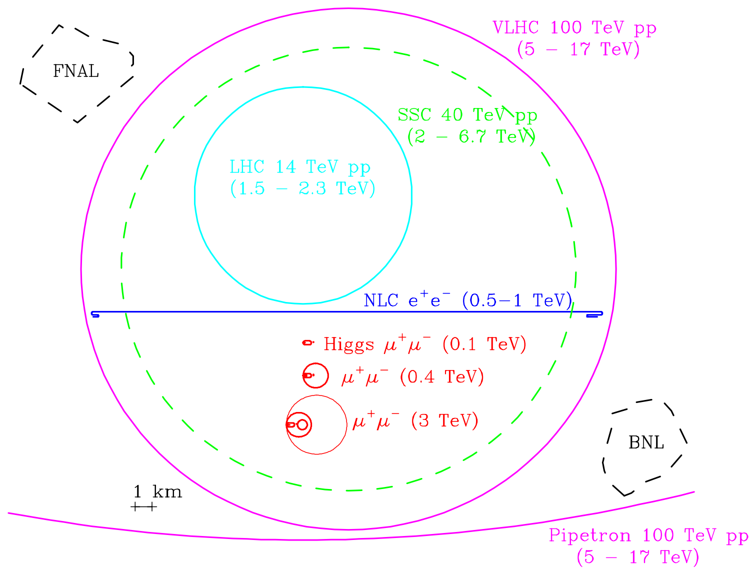
1. proton driver and target station (24 GeV p, 6x intensity of AGS)
    add external beam line from the target
        ν superbeam - long baseline oscillations
        ν near detector – electroweak, structure …
        lepton flavor violation
        rare K decays

2. front end through cooling (200 MeV μ, 4 10^{13} /s, $\delta p/p \sim 5\%$, $P \sim 16\%$)
    add extraction line
        EDM

3. complete linac (3 GeV μ)
    add extraction line
        g – 2

4. accelerators and storage ring
    2^{nd} generation ν experiments

Muon Collider



features

- point particles (lower required beam energy than protons)
- good energy resolution
  - beam energy can be found from μ decay asymmetry
  - less beamstrahlung than electrons
    - smaller beam energy spread at collisions
- can use ring geometry (presumably cheaper than HE LC)
- Higgs factory
  - luminosity ~ 10^{31} / cm^2 / s
  - enhanced s-channel coupling over electrons, ~4000 Higgs/yr
  - precise measurement of Higgs mass and total width
- possible upgrade path to a 3-10 TeV lepton collider
  - luminosity ~ 7×10^{34} / cm^2 / s at 3 TeV
  - s-channel production of heavy supersymmetric Higgs

issues

- lots of R&D is still needed
  - technical solution to 10^6 cooling factor
    - ring coolers, lithium lens, ?
  - 4 MW upgrade for AGS and target system
  - high gradient RF cavities, …
  - mitigating ν radiation problem above 3 TeV
- cheapest possible acceleration method is very important

Possible long range plans (legal disclaimer: this is only my opinion)

Neutrino Factory

2005 Feasibility Study 3 (cost savings ideas, incl. buncher, FFAGs)
2006 ZDR (complete, integrated system design; preliminary costs)
2007 MICE and 1 MW targetry experiment results; DOE OK
2008 CDR (fully engineered design; bottom-up cost estimate)
2009 proposal to DOE
2011 start construction
2017 ready for physics

Muon Collider

2004 simulations; R&D on 4 MW target, lithium lens, cooling ring injection
2007 feasibility study 1
2010 MICE-2 results on ring and lithium cooling; targetry results
2011 ZDR; DOE OK
2013 CDR
2014 proposal to DOE
2016 start construction
2023 ready for physics?