Discussion
The National HEP Accelerator Based Program

APS, St. Louis

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Present state

- No investment in renewal of national facilities since decision to build NUMI/MINOS in 1998
- For vitality of the field must invest capital: else the business plan is to go out of business !!
- The plan we were on: shut present facilities, don’t start new ones, start the ILC early

Present state

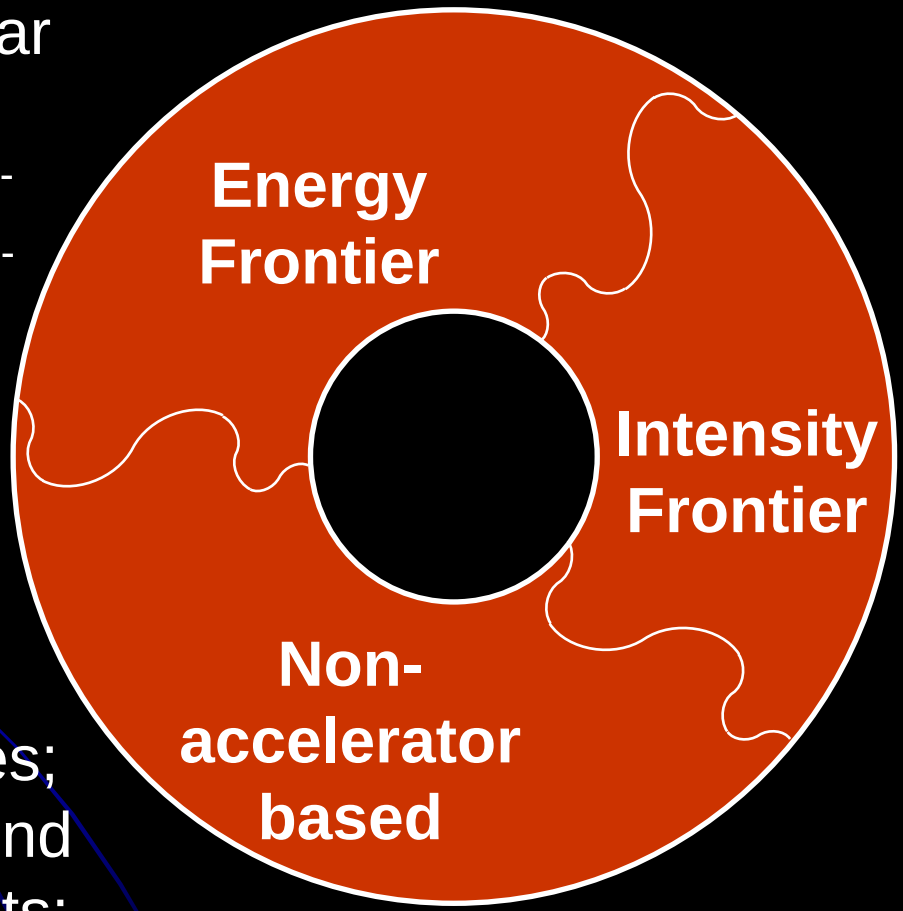
- ILC cost, LHC delays, international picture led DOE to more realistic timeline
- As a consequence we are shutting down $4B worth of facilities with no follow on
- We need a realistic plan within a plausible DOE office of Science budget profile. ILC decision is beyond DOE (it is not immediate).

Getting to a plan

- The physics case must be compelling
- It should be realistic
- It should be world-class in its domain
- It should be adaptable to new discoveries
- It should be the community and laboratory plan

HEP world: tools

pp-bar
pp
e^+e^-
$\mu^+\mu^-$



Intense ν, μ, K, . beams; and B, C factories;

Telescopes; Underground experiments;

The Energy Frontier

- We should run the Tevatron until the LHC has clearly overtaken it
- The LHC is the mainstay of the US program: we will collaborate in physics and upgrades
- Need for a lepton collider:
  - ILC by far the easiest if the energy is right
  - CLIC could reach higher energies later
  - Muon collider could reach several TeV later

The particle astrophysics frontier

- The US program has been a key contributor: COBE, WMAP, discovery of Dark Energy, limits on dark matter, origin of cosmic rays, gravity (LIGO)……

- Clearly a part of any future program: reactor neutrino experiments, JDEM, dark matter searches, neutrinoless double beta decay, LSST, gravity (LISA)……

The intensity frontier

- LHC and non-accelerator experiments tell us little about the neutrino mass hierarchy and nothing about CP violation in neutrino sector, little about couplings of any new particles discovered at LHC and nothing about charged lepton flavor violation

- These issues can be studied at the intensity frontier through a large and rich variety of experiments: essential to complete a unified view. A great opportunity for US facilities to contribute

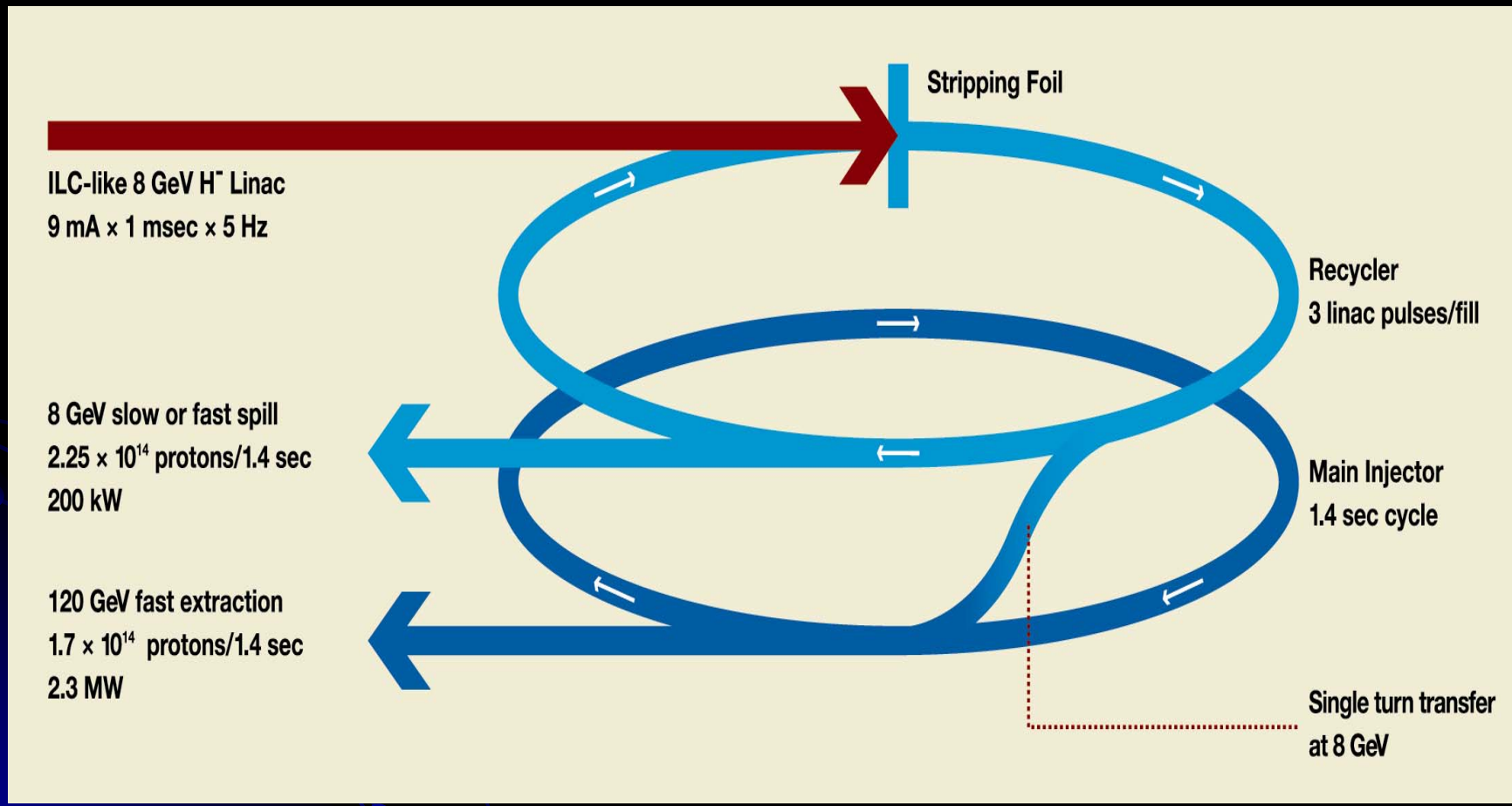
The intensity frontier

- The general rule:
  - If the LHC discovers new particles – precision experiments tell about the physics behind through rates/couplings to standard particles
  - If the LHC does not see new particles – precision experiments with negligible rates in the SM are the only avenue to probe higher energies
- Additionally, neutrino oscillations, charged lepton flavor violation necessary for GUT models

US and the intensity frontier

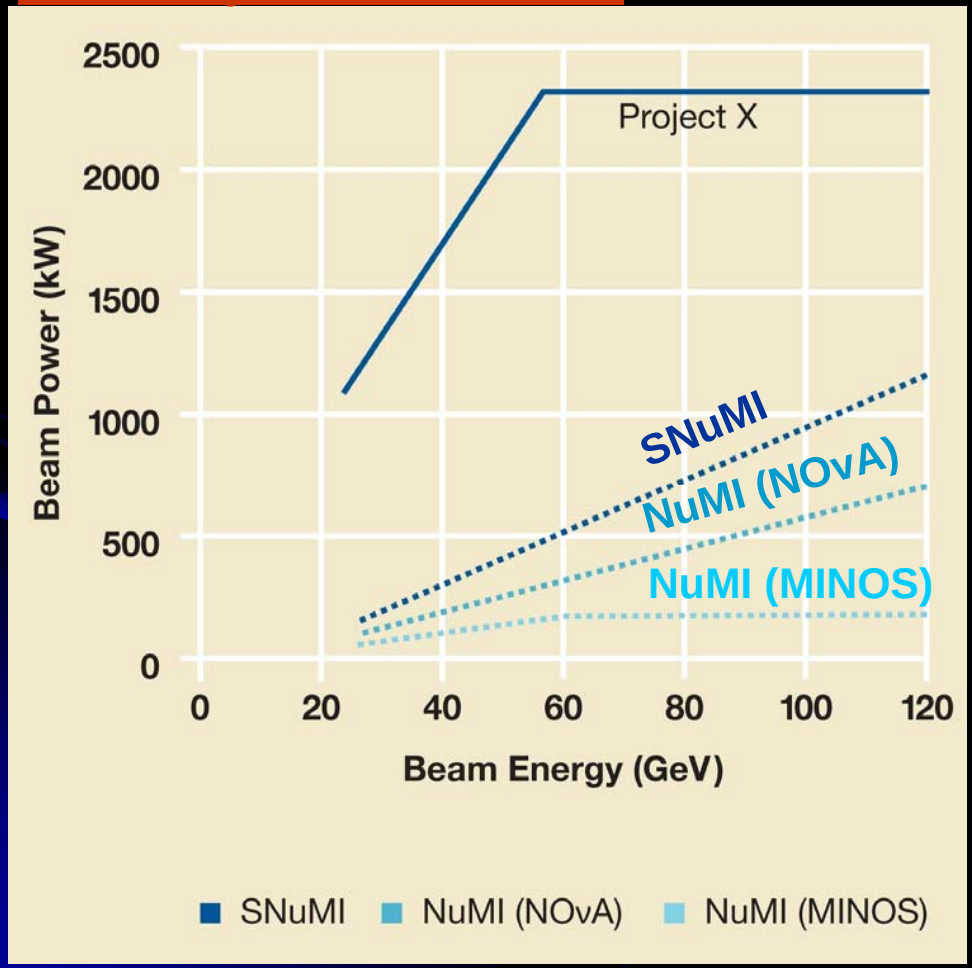
- A program with a new injector for Fermilab:
  - Can exploits the large infrastructure of accelerators: Main Injector (120 GeV), Recycler (8GeV), Debuncher (8 GeV), Accumulator (8 GeV)
  - Provides the best program in neutrinos, and rare decays in the world (great with DUSEL)
  - Positions the US program for an evolutionary path leading to neutrino factories and muon colliders

Project X and the intensity frontier



Project X: Beam power / flexibility

Main Injector Protons



Recycler 8 GeV protons with 120 GeV MI protons

200 kW	(Project X)
0*	(SNuMI)
16 kW	(NuMI-NOvA)
17 kW	(NuMI-MINOS)
35-year-old injection (technical risk)	

* Protons could be made available at the expense of 120 GeV power.

Project X: expandability

- Initial configuration exploits alignment with ILC
- But it is expandable (we will make sure the hooks are there):
  - Three times the rep rate
  - Three times the pulse length
  - Three times the number of klystrons
- Would position the program for a multi-megawatt source for intense muon beams at low <8 GeV energies – very difficult with a synchrotron.

Project X: it is the best source

- Neutrino program at 120 GeV (2.3 MW); 55% recycler available at 8 GeV (200kW)

- We can develop existing 8 GeV rings to deliver and tailor beams, allowing full duty cycle for experiments with the correct time structure: *K* decays, μ → e conversion, *g-2.*

- High rate experiments do not decrease protons-on target for the neutrino program at 120 GeV.

Project X and the Universities

- Plan was developed with the community through the Steering Group
- It will enable students, faculty and university technical resources to be applied to a challenging range of experiments from design to physics
- It will push technological detector development: such as LAr TPC and very high rate technology

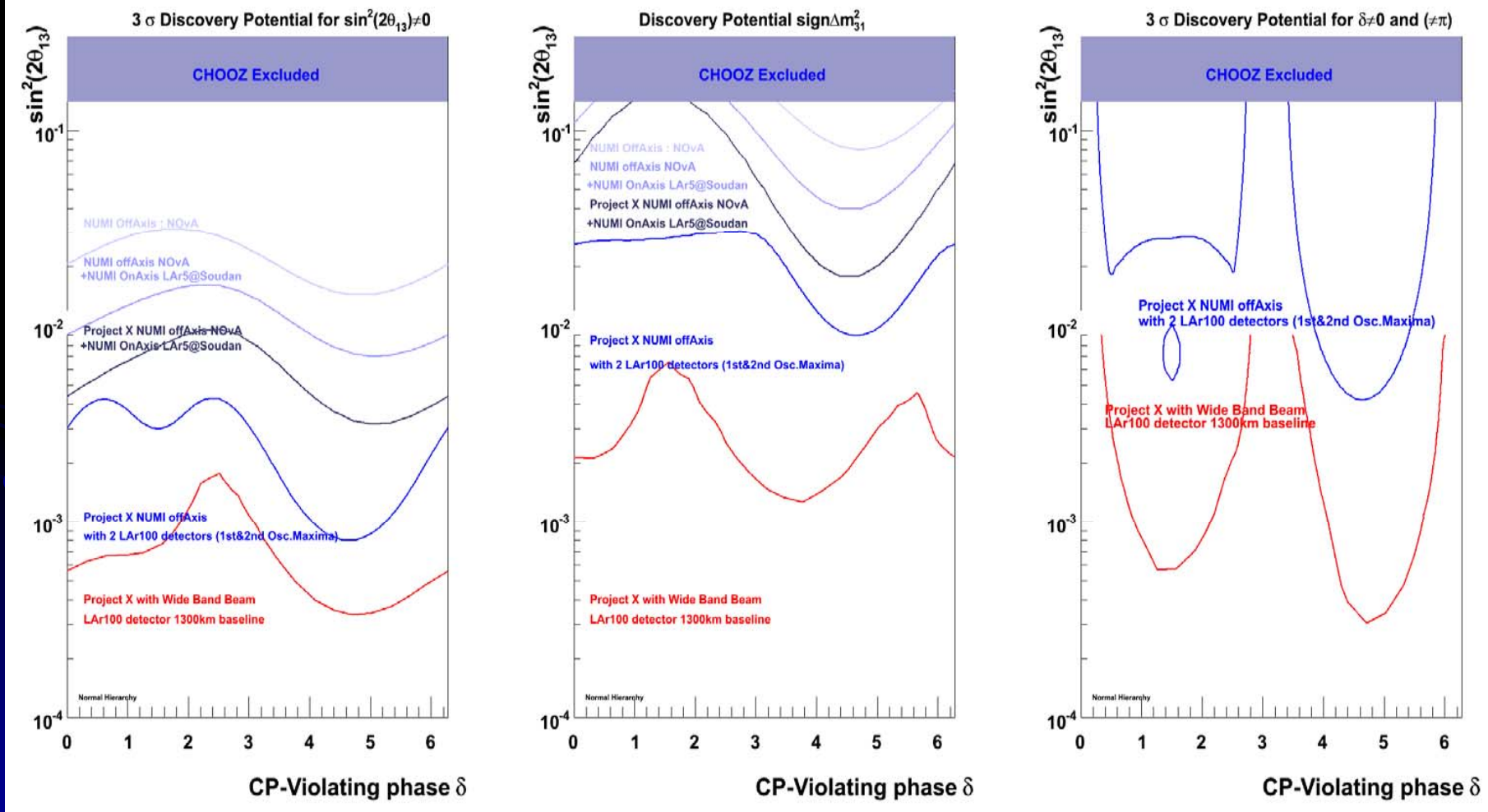
Example: neutrino strategy

- Build NOvA. With T2K and reactor: best shot at neutrinos, first glimpse of mass hierarchy depending on $\sin^2 2\theta_{13}$.

- Develop beamline, caverns/detectors for DUSEL – with new beam-line from Project X it is the ultimate super-beam experiment (water or LAr)

- If neutrino factory is needed – large endowment with source and beamline done

Example: neutrino strategy



Example: μ to e conversion

- Could start with Booster beam: already better than MECO experiment; together with NOvA a great program for the early part of the decade
- If signal found at 10^{-16} level: study A dependence, with full Project X
- If signal not found, extend search with full Project X and extensions to higher beam levels

Muon – electron conversion

New Physics Scale (TeV)

10,000

1,000

(Courtesy of Andre de Gouvea)

Potential FNAL μ → e conv. expt.
10^{-17} ~ 10^{-18} (Project X)

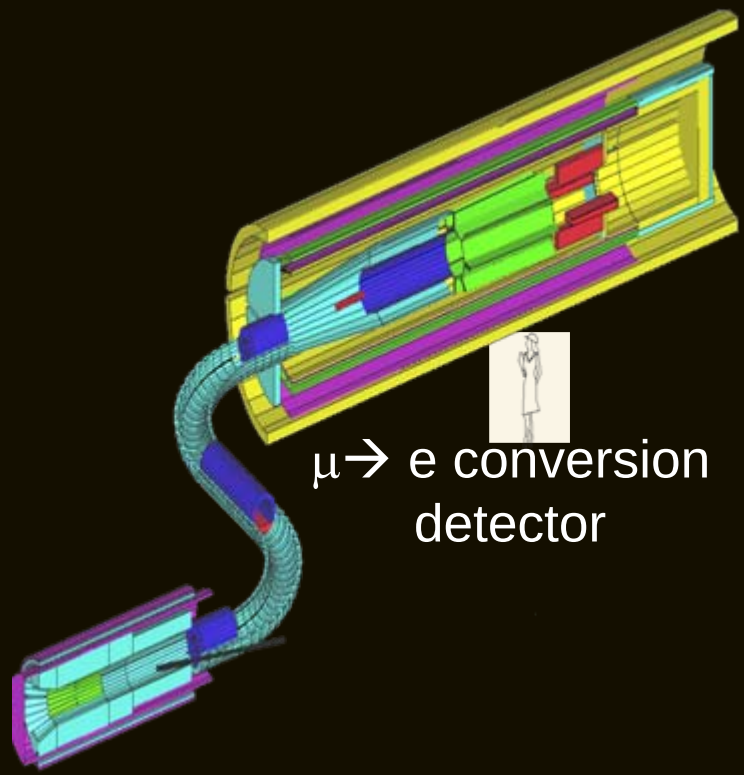
Br(μ→e conv in ^{48}Ti)>10^{-17}

Br(μ→eγ)>10^{-13}
MEG experiment ~ 10^{-13}

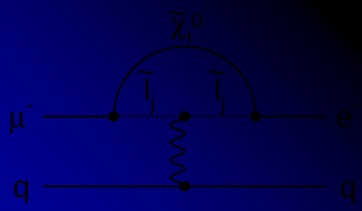
Excluded

10^{-2} 10^{-1} 1 10 10^{2}

Model Parameter



μ→ e conversion detector



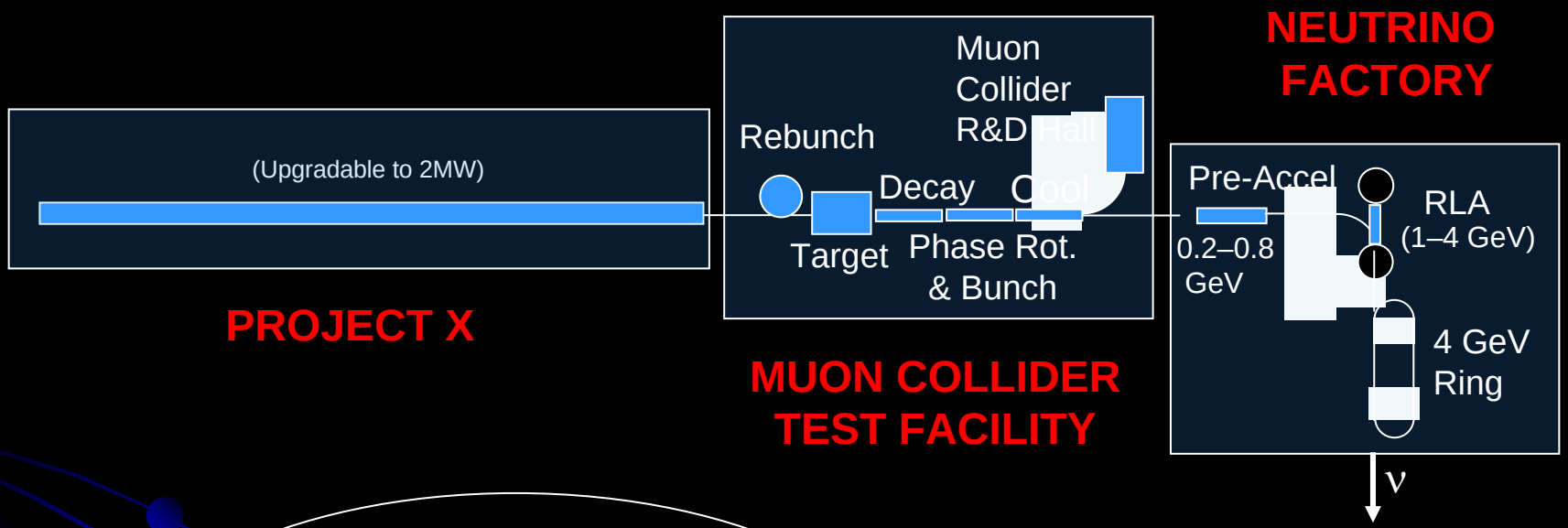
SUSY

Compositeness

Example: evolutionary path to ILC

- Project X linac develops US capabilities towards an ILC
- Positions Fermilab as potential host
- Positions US to contribute on major part of the ILC
- Allows concrete collaboration with potential partners

Example: evolutionary path muons



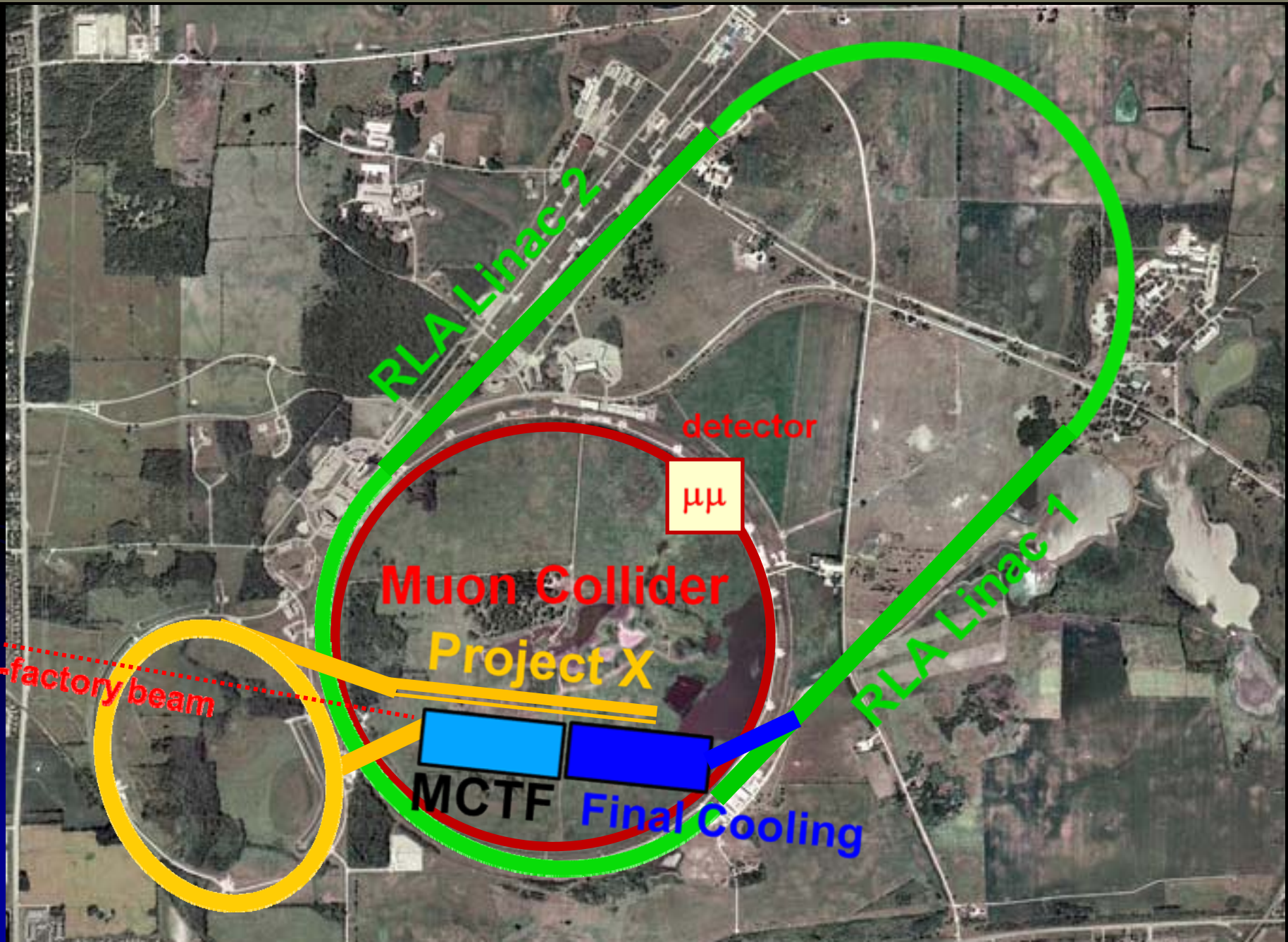
Illustrative Vision

Three projects of comparable scope:

- Project X (upgraded to 2MW)
- Muon Collider Test Facility
- 4 GeV Neutrino Factory

Far Detector
at Homestake

1.5-4 TeV Muon Collider at Fermilab



Conclusion

- It is possible to design a base program that satisfies the criteria listed earlier in this talk:
  - Runs the Tevatron until overtaken by LHC
  - Builds NOvA, a first step in world class neutrino program, and experiments such as mu → e to make vital program for the first part of next decade
  - Builds Project X as the best high intensity platform in the world with beamline to DUSEL for late in the decade
  - Develops the technology for the ILC in the US through Project X and positions the US well for an ILC anywhere
  - Supports particle astrophysics and LHC upgrades
  - Has a “long throw” in terms of future possibilities at the intensity frontier (neutrino factory) and energy frontier (muon collider)