Plan for Fermilab:
Fermilab Steering Group Report

Young-Kee Kim
Nov. 29, 2007, HEPAP

On March 22, 2007, Steering Group formed by Pier Oddone
to develop a roadmap for FNAL's accelerator-based HEP program

- Interim Status Report to HEPAP: July 13, 2007
- Internal Report to Pier Oddone: Aug. 7, 2007
- Final Report: Sep. 18, 2007
- Presentation to P5: Sep. 24, 2007

http://www.fnal.gov/directorate/Longrange/Steering_Public/

Outline

1. Guidelines in Forming the Plan

   developed by the Steering Group based on Charge

2. Physics with Intensity Frontier
3. Alignment with ILC
4. Intense Proton Facility Project X
5. Specific Physics Examples with Project X

6. Steering Group's Proposed Plan

Guidelines in forming the plan

Developed by the Steering Group

based on Charge

Guidelines in forming the plan

1. The LHC program is our most important near-term project given its broad science agenda and potential for discovery. It is essential to support the physics analysis, computing, and accelerator and detector upgrades.

Guidelines in forming the plan

2. The particle physics community's highest priority for investment toward the future is the ILC, based on our present understanding of its potential for breakthrough science.

   Fermilab will continue to participate vigorously in the international R&D program for the ILC and to be one of the leaders in the global ILC effort. The laboratory will strive to make the ILC at Fermilab a reality by accomplishing the preparatory work required for the U.S. to bid to host the ILC.

Guidelines in forming the plan

3. There is a need for a physics program in case the timeline for ILC is stretched out.

   This program will be an opportunity to do exciting physics that complements discoveries at energy frontier facilities and to make further progress on ILC technology. The program should provide great discovery potential, support ILC R&D and industrialization as well as R&D on future accelerators beyond the ILC and the LHC. It should strengthen ties with the university community and with other laboratories. The plan must be robust and flexible.

Integrated Plan

Guidelines in forming the plan

4. Fermilab will continue a phased program of particle astrophysics including dark matter and dark energy.

   The program will allow complementary discoveries to those expected at the accelerator-based particle physics programs. These non-accelerator-based efforts are outside the Steering Group's charge, and are not included in the plan.

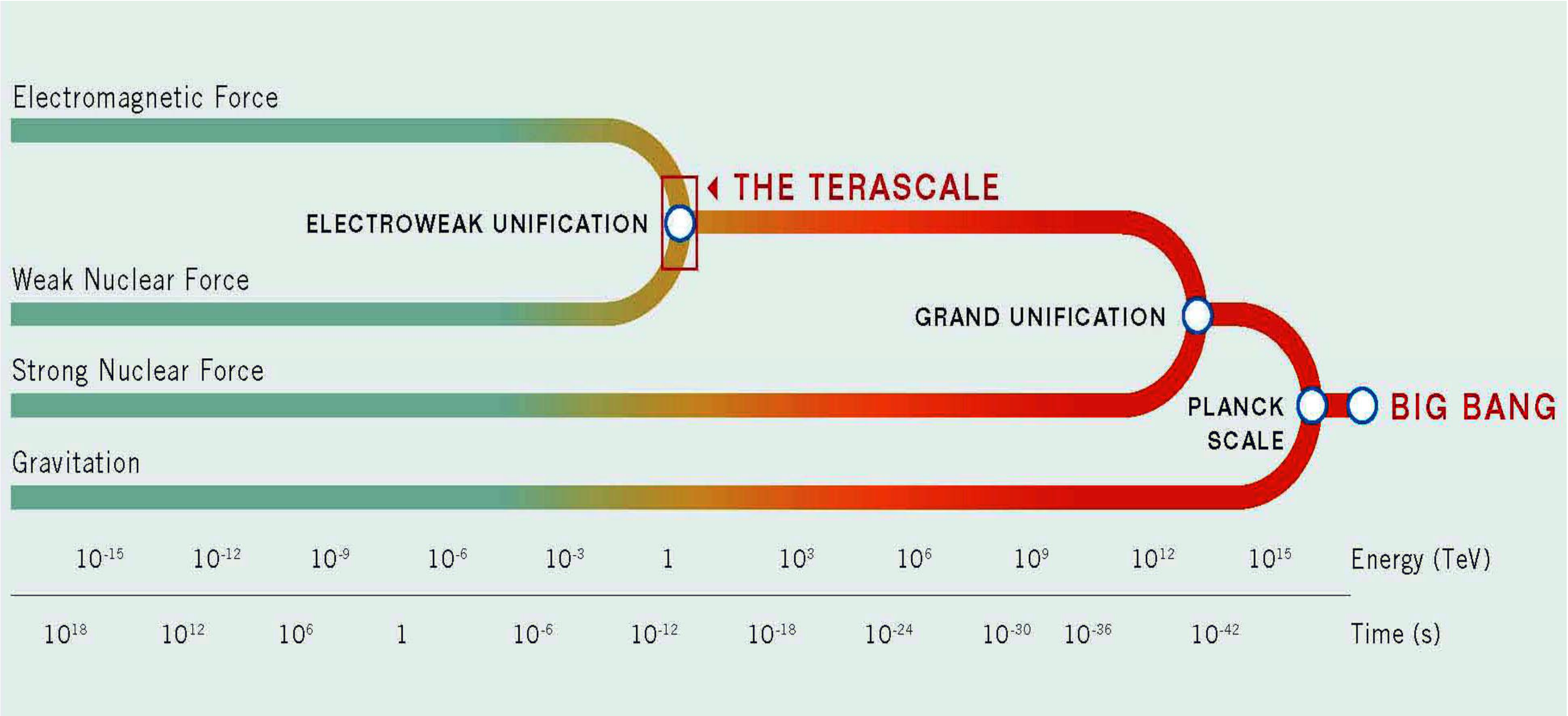
Physics

Big Questions

0. What is the origin of mass for fundamental particles?
1. Are there undiscovered principles of nature: new symmetries, new physical laws?
2. How can we solve the mystery of dark energy?
3. Are there extra dimensions of space?
4. Do all the forces become one?
5. Why are there so many kinds of particles?
6. What is dark matter? How can we make it in the laboratory?
7. What are neutrinos telling us?
8. How did the universe come to be?
9. What happened to the antimatter?

Based on "The Quantum Universe," *HEPAP 2004*

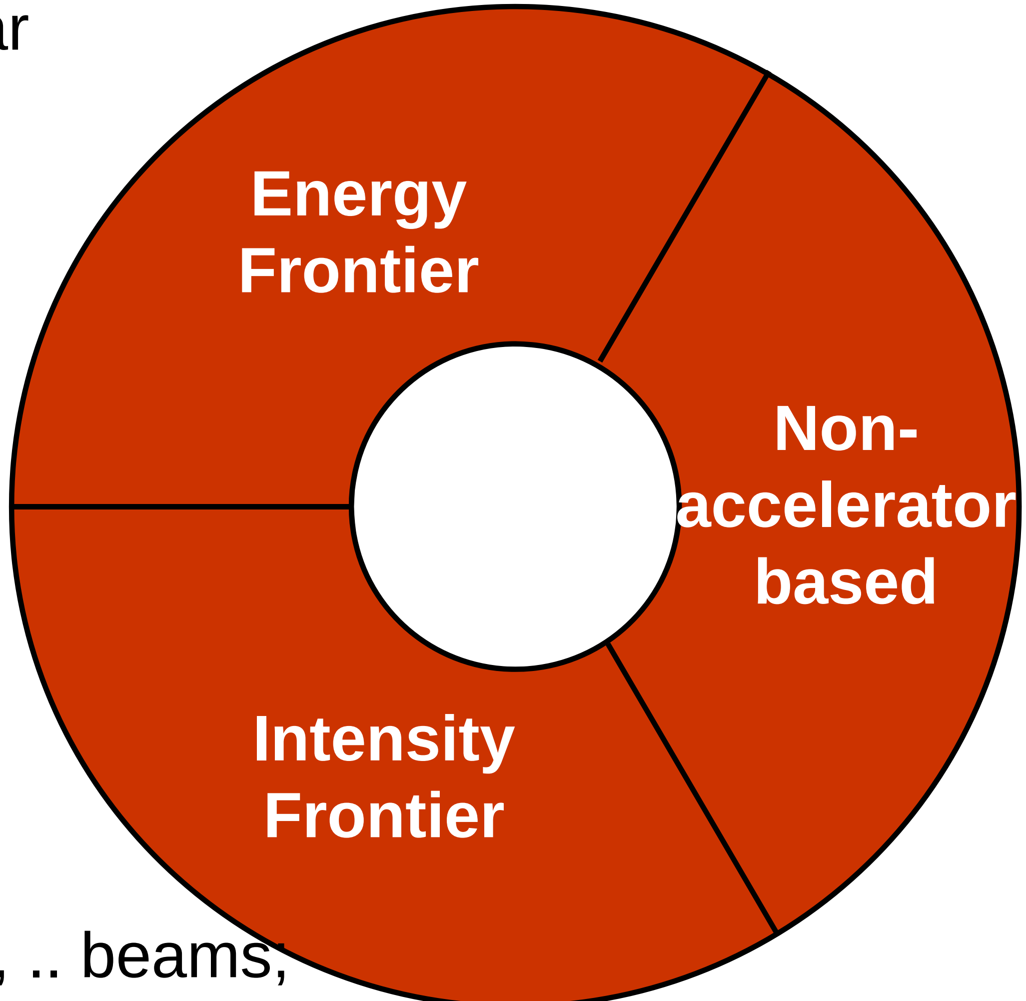
Toward



Electromagnetic Force
THE TERASCALE
ELECTROWEAK UNIFICATION
Weak Nuclear Force
GRAND UNIFICATION
Strong Nuclear Force
PLANCK SCALE
BIG BANG
Gravitation
10-15 10-12 10-9 10-6 10-3 1 10³ 10⁶ 10⁹ 10¹² 10¹⁵ Energy (TeV)
10¹⁸ 10¹² 10⁶ 1 10-6 10-12 10-18 10-24 10-30 10-36 10-42 Time (s)

Tools

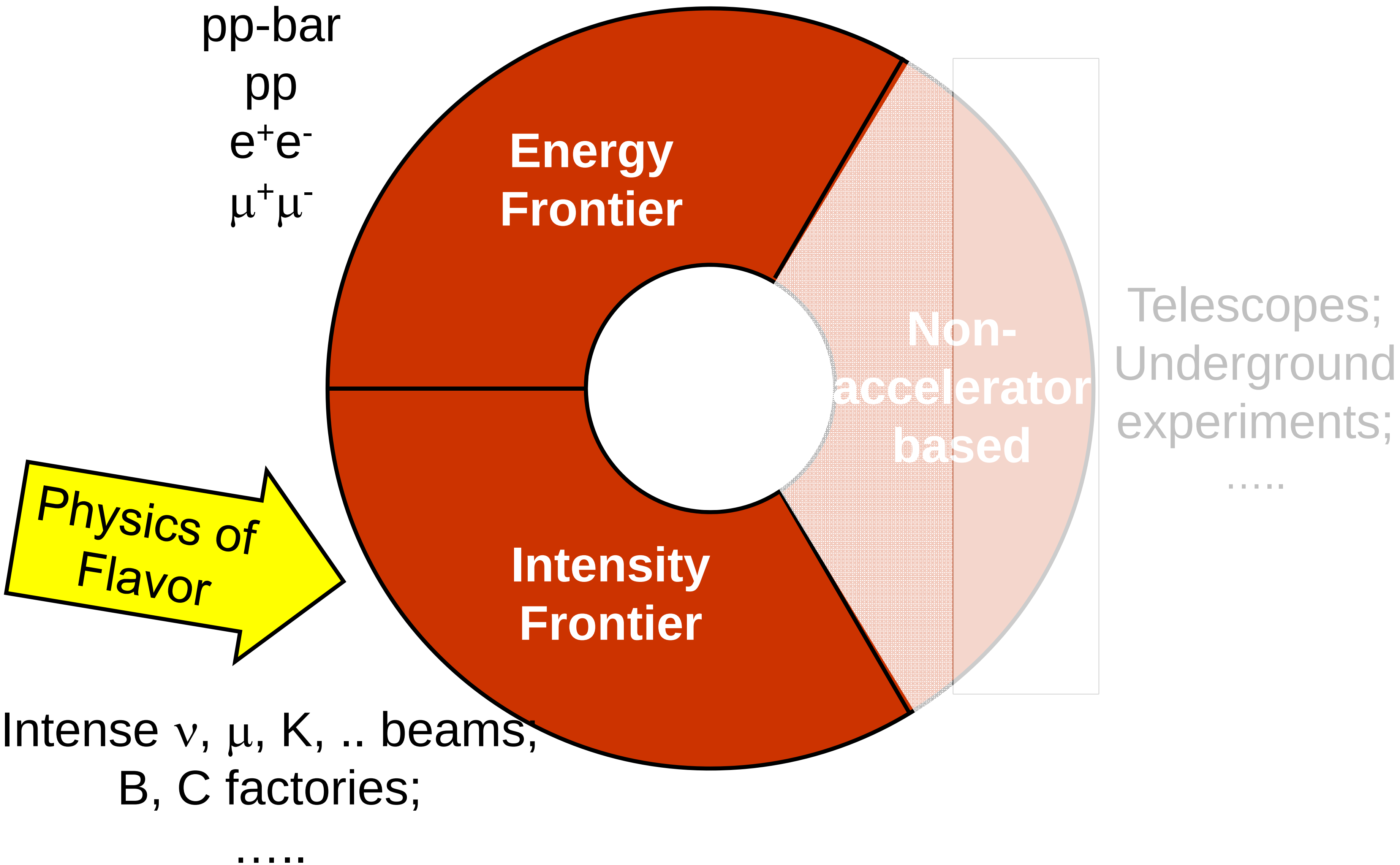
pp-bar
pp
e^+e^-
$\mu^+\mu^-$



Telescopes;
Underground experiments;
.....

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

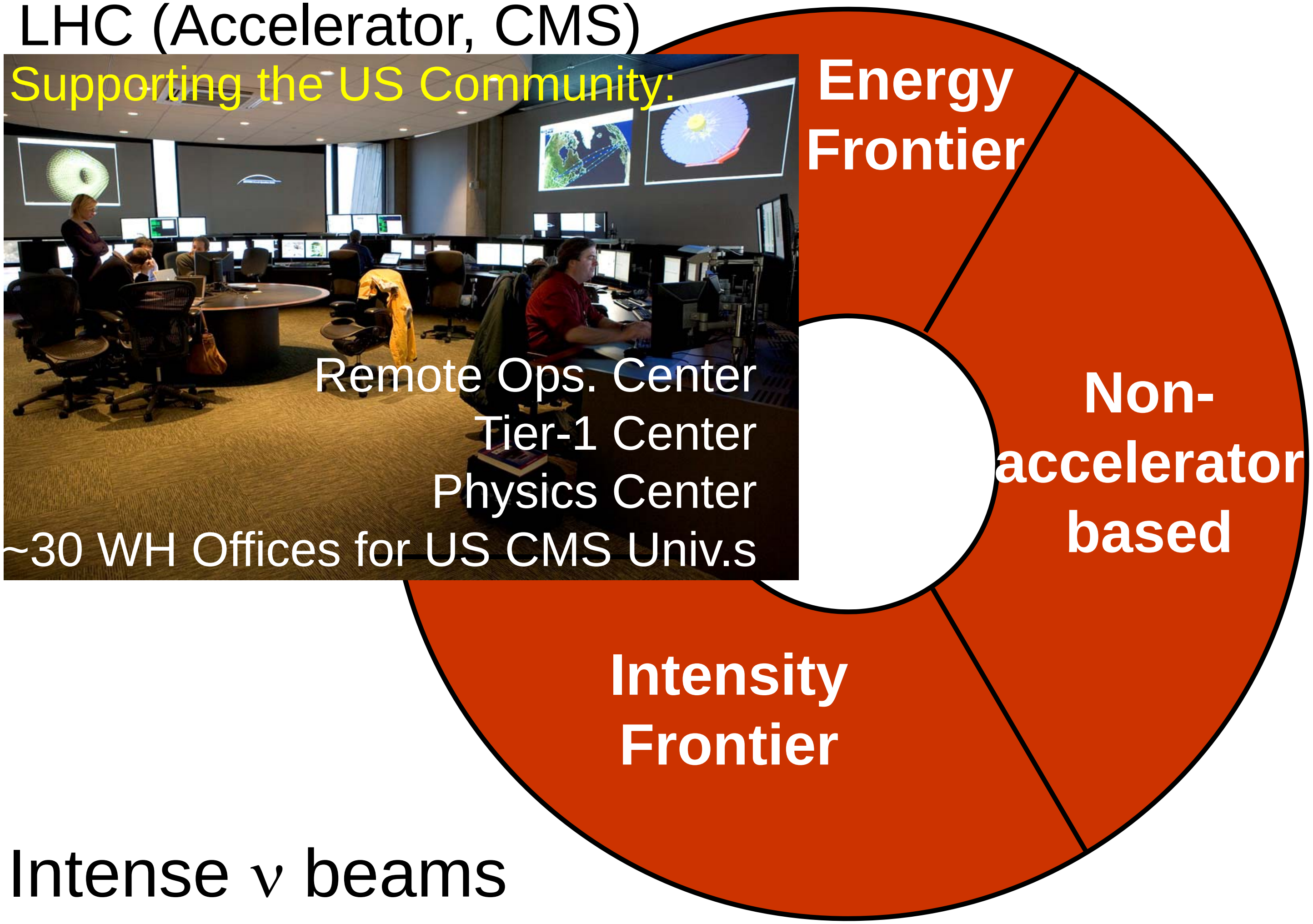
Accelerator-Based Tools



Tools / Programs at Fermilab

Tevatron (CDF, DZero), ILC R&D, μ Collider R&D

LHC (Accelerator, CMS)



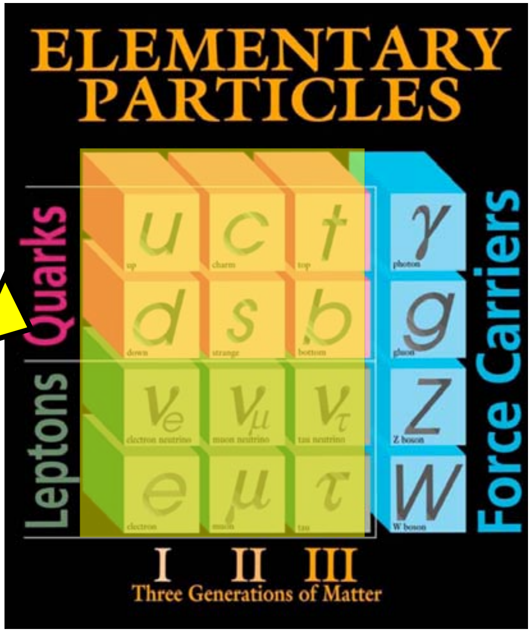
SDSS
Pierre Auger
CDMS
COUPP
DES
SNAP R&D

Intense ν beams

MINOS, MiniBooNE, SciBooNE, MINERvA, NOvA

Physics of Flavor

- In the SM, flavor is
  what deals with the fermion sector
  - Family replicas
  - Mass spectra
  - Mixings
  - Flavor phenomena have significantly contributed to shaping modern particle physics.



- Beyond the SM,
  flavor phenomena cover a wide landscape.
  - FCNC: various SUSY models / parameters
  - New flavors: new generations, exotic partners
  - CP Violation can reside in gauge/Higgs couplings

Flavor Physics: Connection to LHC and Beyond

- Complements New Physics searches at LHC
  - New Terascale LHC discovery will raise flavor and unification questions
    - most likely not accessible or only crudely accessible at LHC.
    - Flavor programs could
      - Measure systematically the new FV and CPV couplings i.e. flavor structure of New Physics.
      - Distinguish SUSY Breaking mechanisms
    - Flavor physics is unification physics.

- Extends New Physics searches beyond LHC
  - New Physics at scales beyond LHC
    - could give measurable flavor effects
    - Flavor programs – unique opportunity to explore up to ~1000 TeV.

Electroweak Symmetry Breaking and Flavor

- EWSB is intimately related to flavor:
  - No EWSB → fermions degenerate → no visible flavor effect
- In most EWSB models, flavor plays a key role. e.g:
  - Technicolor: FCNC
  - Supersymmetry: top mass
  - Extra-dimension: fermionic mass spectrum
  - Little Higgs: top partners

Energy Frontier – Intensity Frontier Connection

The Gauge Sector
Higgs
EWSB

⟺

The Flavor Sector
Mixings, Masses,
CPV, FCNC,
LFV, EDM, ...

Energy Frontier

Intensity Frontier

Neutrinos
Charged Leptons
Quarks

- What is dark matter?
- What is the origin of neutrino mass?
- What is the origin of the Baryon Asymmetry of the Universe?

Questions driven by experimental facts: proven shortcomings of the SM

- Why SU(3)xSU(2)xU(1)? Are there new forces? GUT?
- Why 3 generations, their properties
  - Mass spectra, Mixing patterns
- Pointlike? Substructures? Strings?

Questions driven by theoretical curiosity, will evolve with new data

- Why D=3+1?
- What is dark energy?

Questions still lacking a solid, calculable theoretical framework for their formulation

Michelangelo Mangano, 2007-11-16
Intensity Frontier Physics Workshop

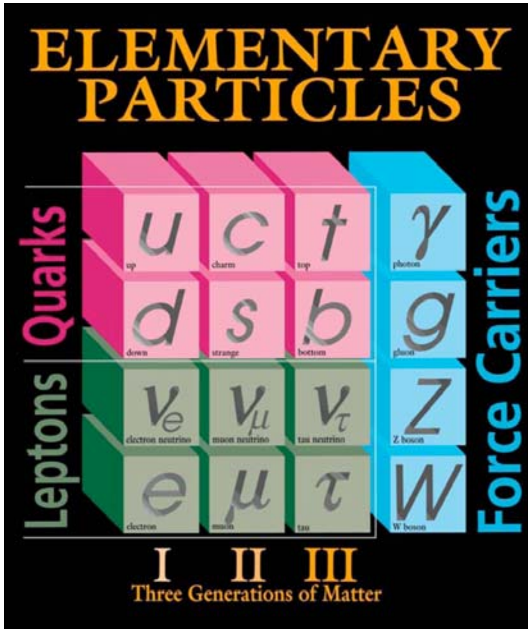
Empirical proof that the SM is incomplete:

- Neutrino masses
- Dark matter
- Baryon asymmetry of the universe

at least two are directly related to flavor.

Neutrino Masses

- Neutrinos:
  - produced much excitement.
  - the only new physics seen so far in the lab.
  - provide direct access to new physics:



- Unification:
  - The existence of ν masses and mixings
    - implies breaking of a symmetry (ν flavor)
    - points toward new symmetries (unification) and new breaking of symmetries (charged lepton flavor violation and lepton CP violation)
  - Supersymmetry + ν see-saw mechanism implies CLFV.
  - Supersymmetry + ν see-saw + CLFV would reveal key aspects of the unified origins of matter.

- Cosmology:
  - Extra CP violation in the neutrino sector

Baryon asymmetry of the universe

- Possible scenarios
  - Electroweak baryogenesis
    - will be tested at LHC and ILC.
  - Leptogenesis (lepton-driven baryon asymmetry)
    - is strongly suggested by the same ideas that link neutrinos to unification.

The Big Questions

Intensity Frontier

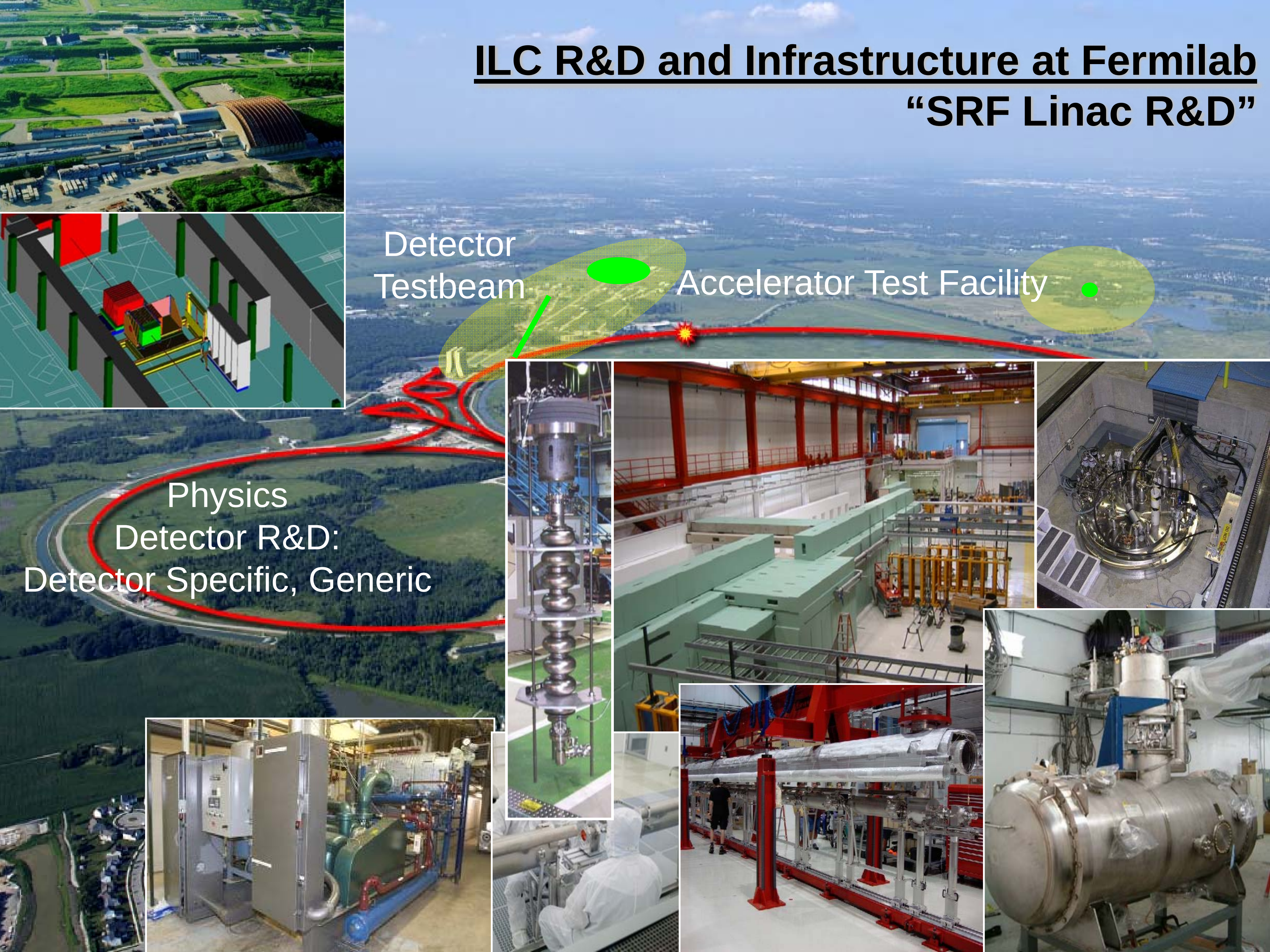
0. What is the origin of mass for fundamental particles?
1. Are there undiscovered principles of nature: new symmetries, new physical laws?
2. How can we solve the mystery of dark energy?
3. Are there extra dimensions of space?
4. Do all the forces become one?
5. Why are there so many kinds of particles?
6. What is dark matter? How can we make it in the laboratory?
7. What are neutrinos telling us?
8. How did the universe come to be?
9. What happened to the antimatter?

Based on "The Quantum Universe," *HEPAP 2004*

Intensity Frontier:
Alignment with the ILC

– Development of an accel. facility aligned with ILC
– Compatible with the ILC schedule
– Positioning Fermilab as a credible host for the ILC

ILC R&D and Infrastructure at Fermilab
"SRF Linac R&D"



Science + Alignment with ILC

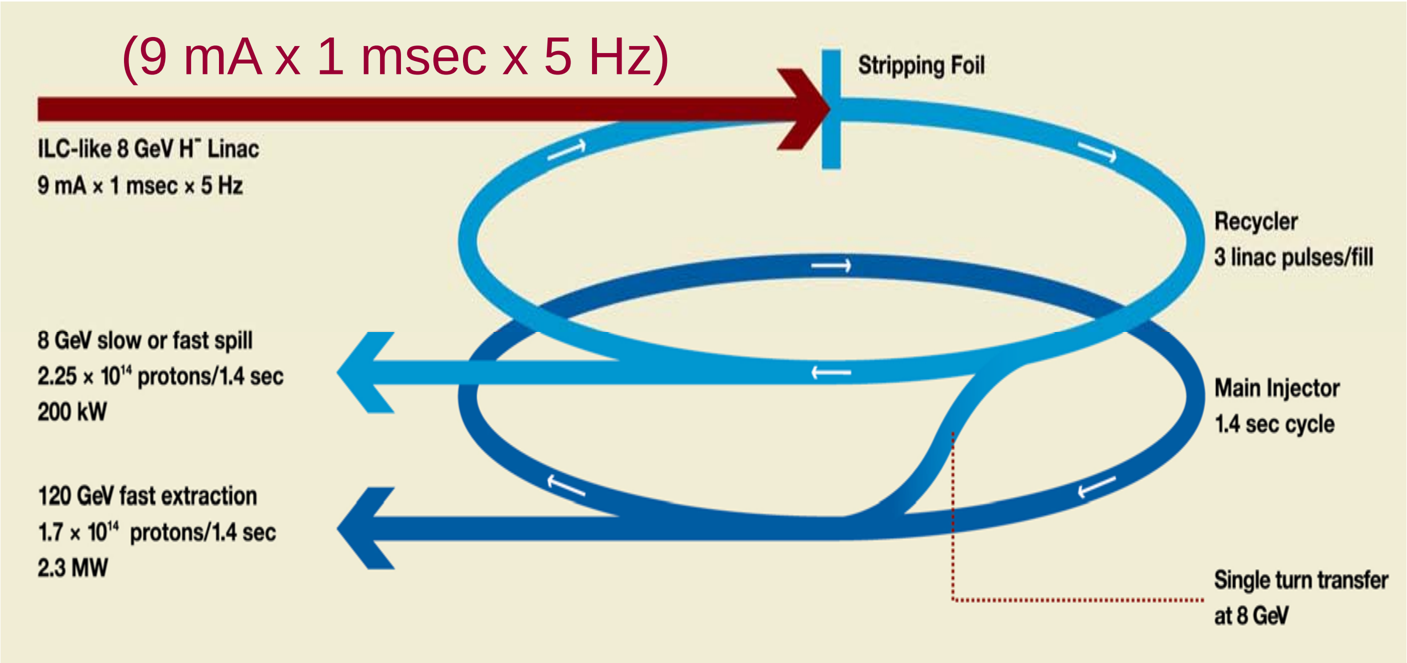
Project X

Project X = 8 GeV ILC-like Linac
+ Recycler
+ Main Injector

National Project with International Collaboration

Project X: Properties

8 GeV H⁻ Linac with ILC Beam Parameters: ~1.5% ILC Linac



100 – 200 kW
at 8 GeV
+
>2.0 MW
at 50-120 GeV

Linac:

No ILC (< 0.6 GeV)

ILC-like (0.6 ~ 2.4 GeV) – 15 crymodules

ILC-identical (2.4 ~ 8 GeV) – 24 crymodules

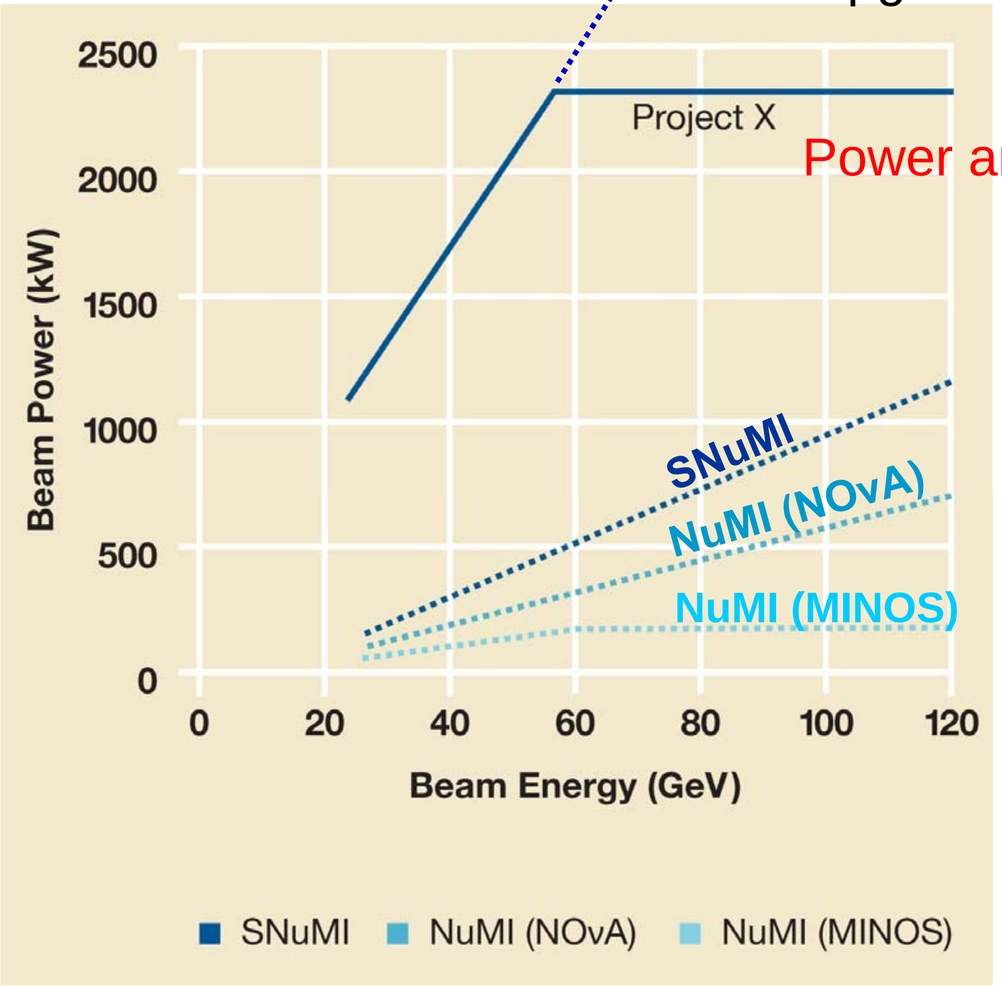
Cavities, Cryomodules,
RF and Cryogenic Distribution

Vehicle for National & International Collaboration

Project X: Proton Beam Power

Main Injector Protons

Possible path
w/ MI upgrade



Power and Flexibility

Recycler 8 GeV Protons

with 120GeV 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.

Physics Opportunities with Project X

– Neutrinos
– Charged Leptons: Muons
– Quarks: Neutral and Charged Kaons

A Few Flagship Measurements

Neutrinos

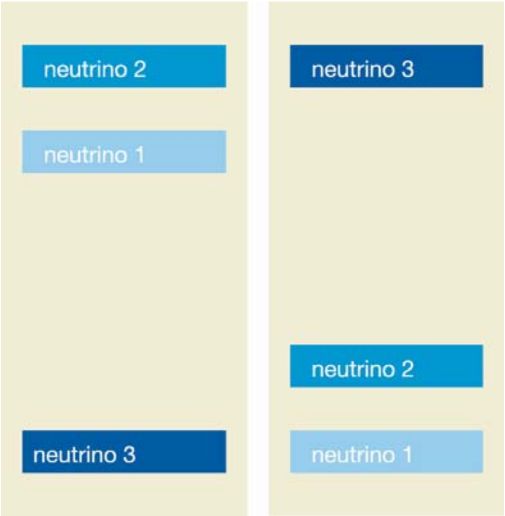
- Needed Experiments
    1. value of $\sin^2 2\theta_{13}$
    2. Are neutrino masses Dirac or Majorana?
    3. Is the mass ordering normal or inverted?
    4. CP violation

- High intensity neutrino beams

  addressing questions 1, 3, and 4, Project X will greatly enhance Fermilab's current world-class program of neutrino science.

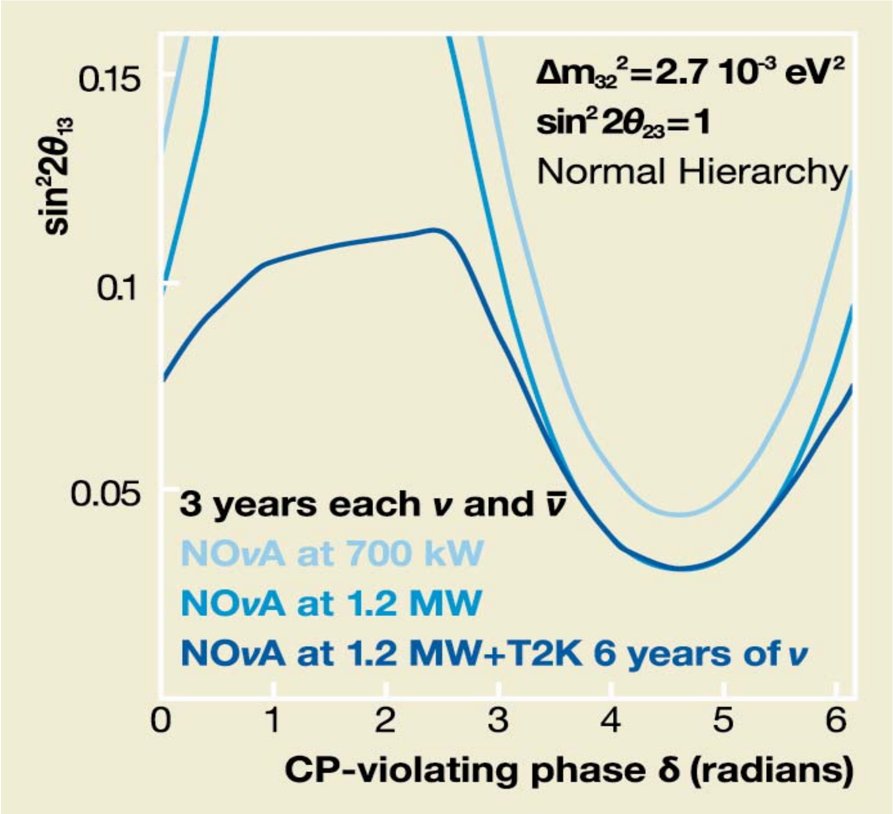
Neutrino Oscillation

NOvA will be competitive with the T2K experiment.
Ability of NOvA to determine the ν mass hierarchy is unique.



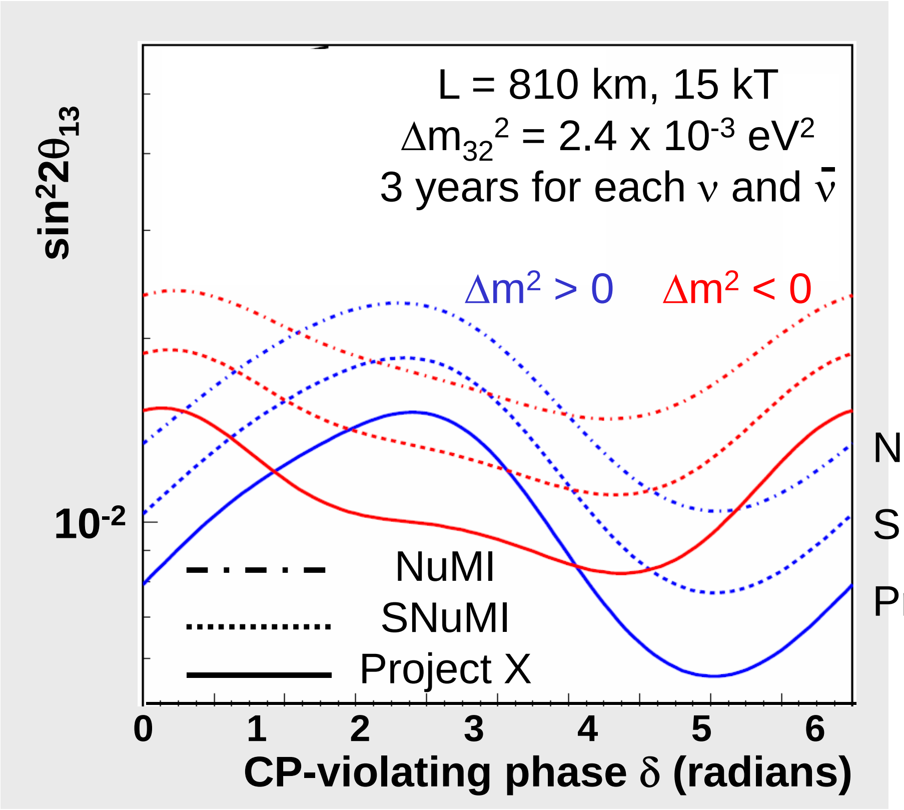
Neutrino mass hierarchy

Ability to resolve mass ordering
at 95% CL (NOvA, NOvA + T2K)



Neutrino Oscillation

Ability of NOvA experiment to observe $\sin^2 2\theta_{13} \neq 0$ at 3σ significance

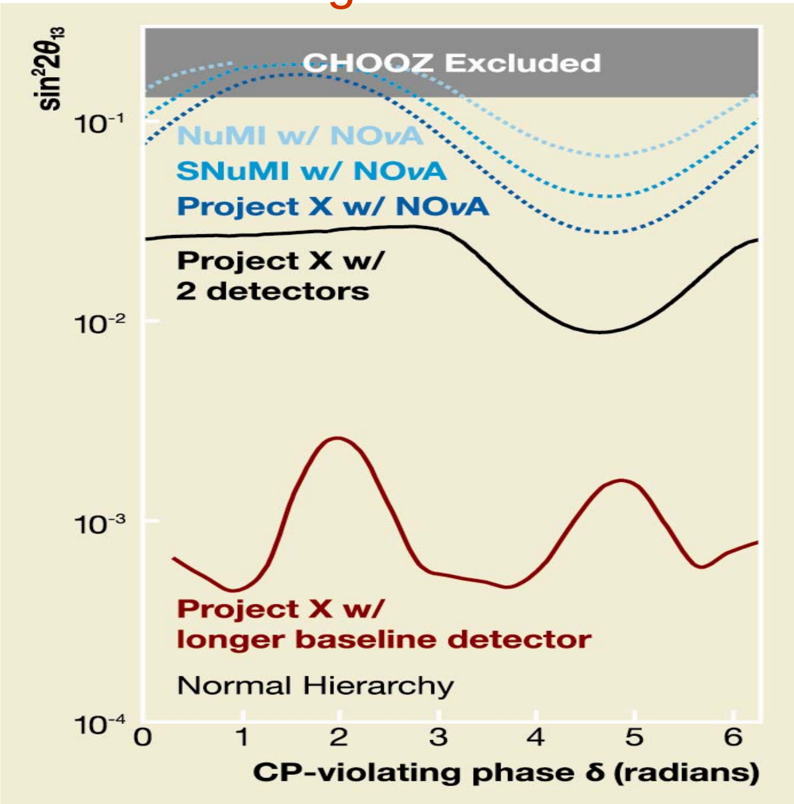


(Courtesy of Gary Feldman)

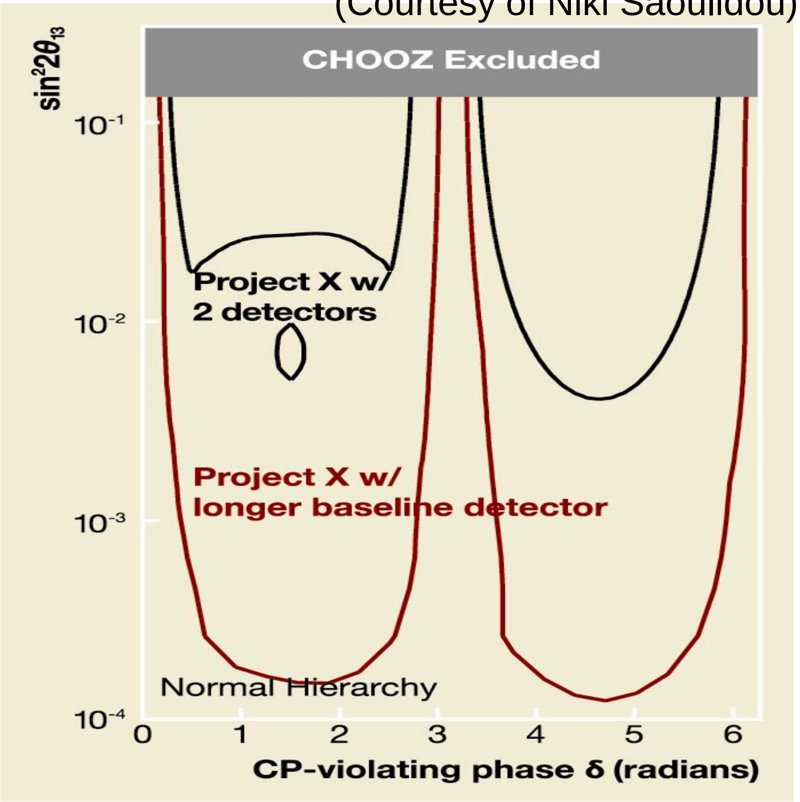
Neutrino Oscillation

95% CL (dotted) and 3σ (solid) sensitivity with 3 years of each ν and $\overline{\nu}$

Mass Ordering



CP Violation (Courtesy of Niki Saoulidou)



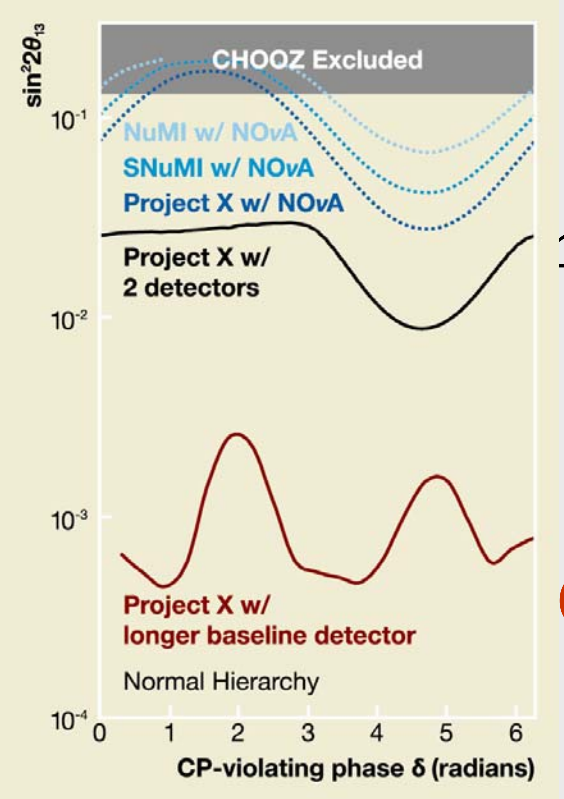
2 100kt LAr detectors at 1st(700 km) & 2nd(810 km) oscil. maxima w/ NuMI beamline

One 100 kt LAr (or 300 kt water Cerenkov) at 1300 km using a wide-band ν beam

A large ν detector in DUSEL would also be a world-class proton decay detector, addressing *"Do all the forces become one?"*

Neutrino Oscillation (Mass Ordering)

Project X



(Courtesy of Niki Saoulidou)

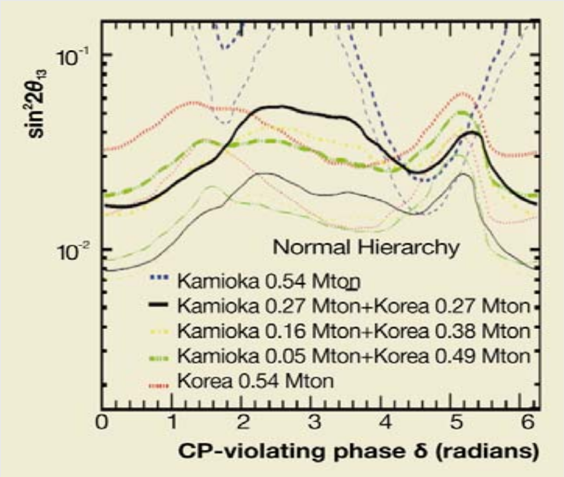
2 100kt LAr detectors at
1st (700 km) & 2nd (810 km)
oscillation maxima
using NuMI beamline

100 kt LAr
(or 300 kt water Cerenkov)
at 1300 km
using a wide-band ν beam

3σ sensitivity.
3 years of ν + 3 years of $\bar{\nu}$ run

J-PARC Upgrades

4 MW beam

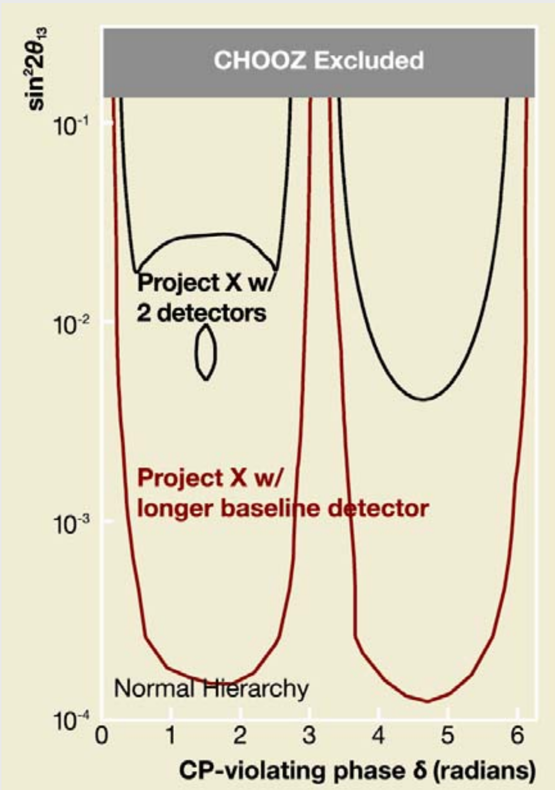


Phys. Rev. D72, 033003 (2005)

2σ (thin lines),
3σ (thick lines) sensitivity.
4 years of ν + 4 years of $\bar{\nu}$ run

Neutrino Oscillation (CP Violation)

Project X



(Courtesy of Niki Saoulidou)

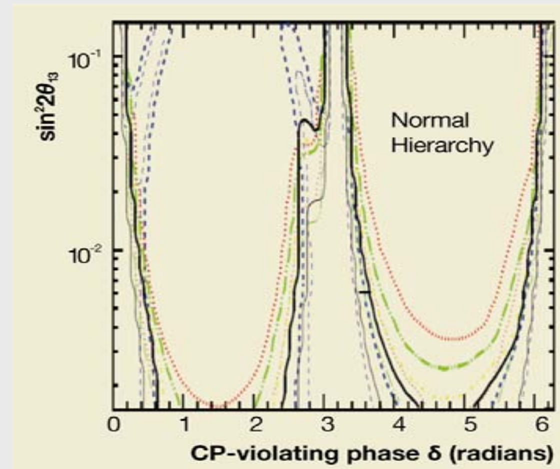
2 100kt LAr detectors at
1st (700 km) & 2nd (810 km)
oscillation maxima
using NuMI beamline

100 kt LAr
(or 300 kt water Cerenkov)
at 1300 km
using a wide-band ν beam

3σ sensitivity.
3 years of ν + 3 years of $\bar{\nu}$ run

J-PARC Upgrades

4 MW beam



Phys. Rev. D72, 033003 (2005)

2σ (thin lines),
3σ (thick lines) sensitivity.
4 years of ν + 4 years of $\bar{\nu}$ run

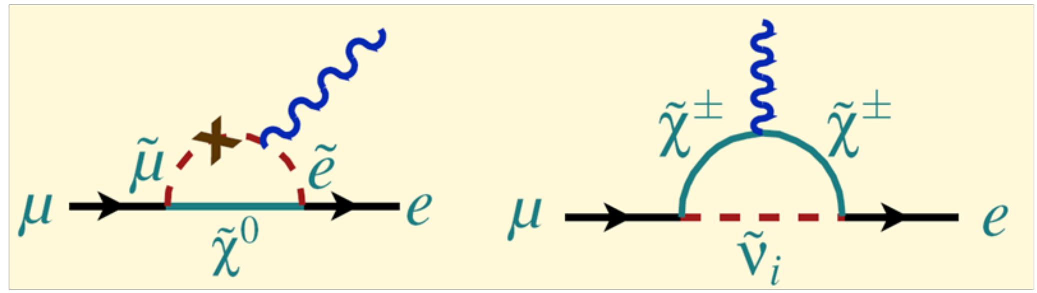
Neutrino Oscillation

- Quite apart from their relative sensitivities,
  - the Japanese and U.S. programs would operate under different physical conditions.
  - In the U.S. program, there could be
    - higher beam energy
    - a wide-band-beam
    - a single large detector, possibly using liquid-argon technology
    - 1300 km away.
  - In the Japanese program, there could be
    - lower beam energy
    - a narrower-band beam
    - a single large water-Cerenkov detector, 300 km away

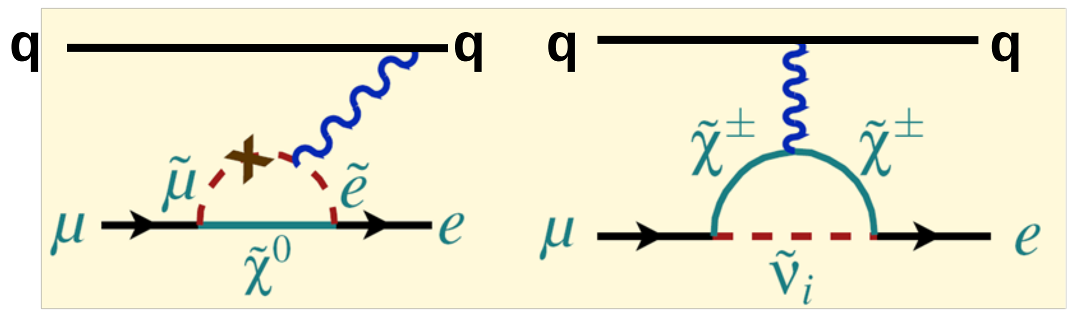
      or, a split version of this detector, with part of it 300 km away and the rest in Korea, about 1000 km away

Muons for Charged Lepton Flavor Violation

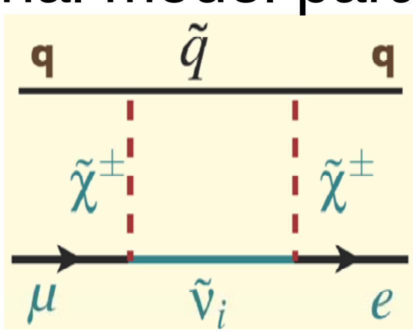
μ → eγ Transition



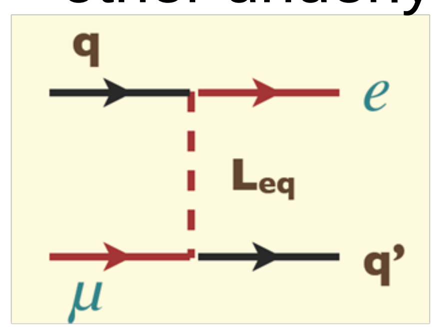
μ → e Conversion in Nucleus

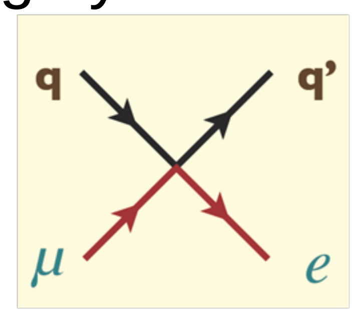


Sensitive to additional model parameters

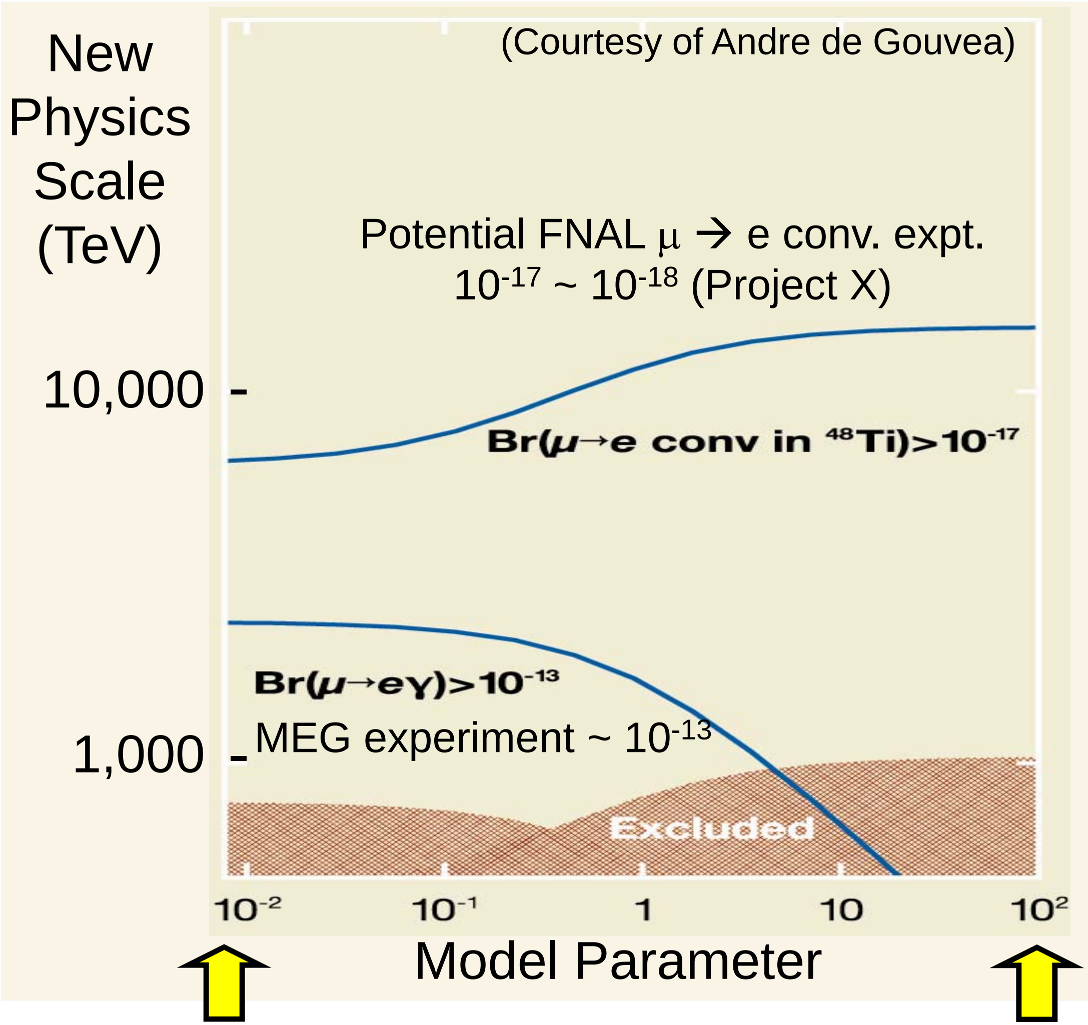


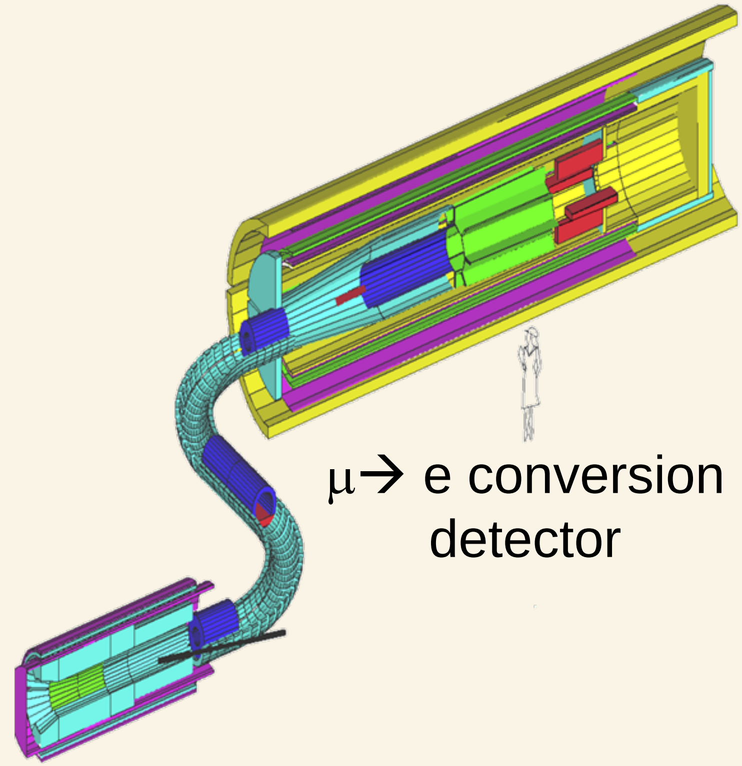
other underlying dynamics

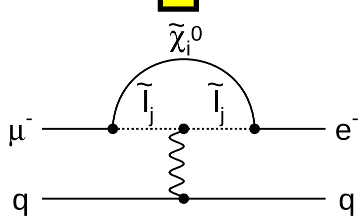




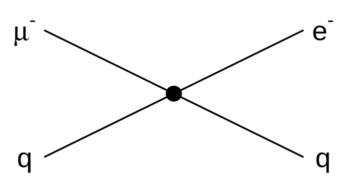
μ → e Conversion







SUSY



Compositeness

$\mu \rightarrow e$ Conversion

Supersymmetry

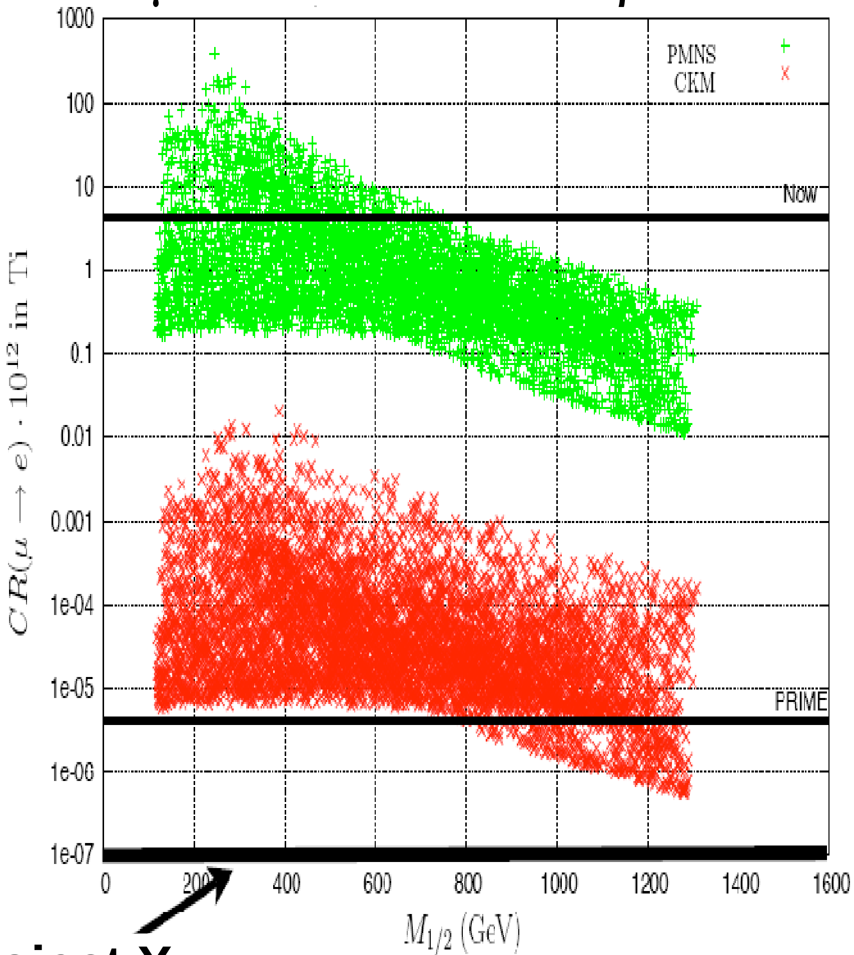
and

Charged Lepton Flavor Violation

If supersymmetry is discovered at LHC,
one of the most compelling challenges
will be to connect this discovery
to charged lepton flavor violation.

μ → e Conversion

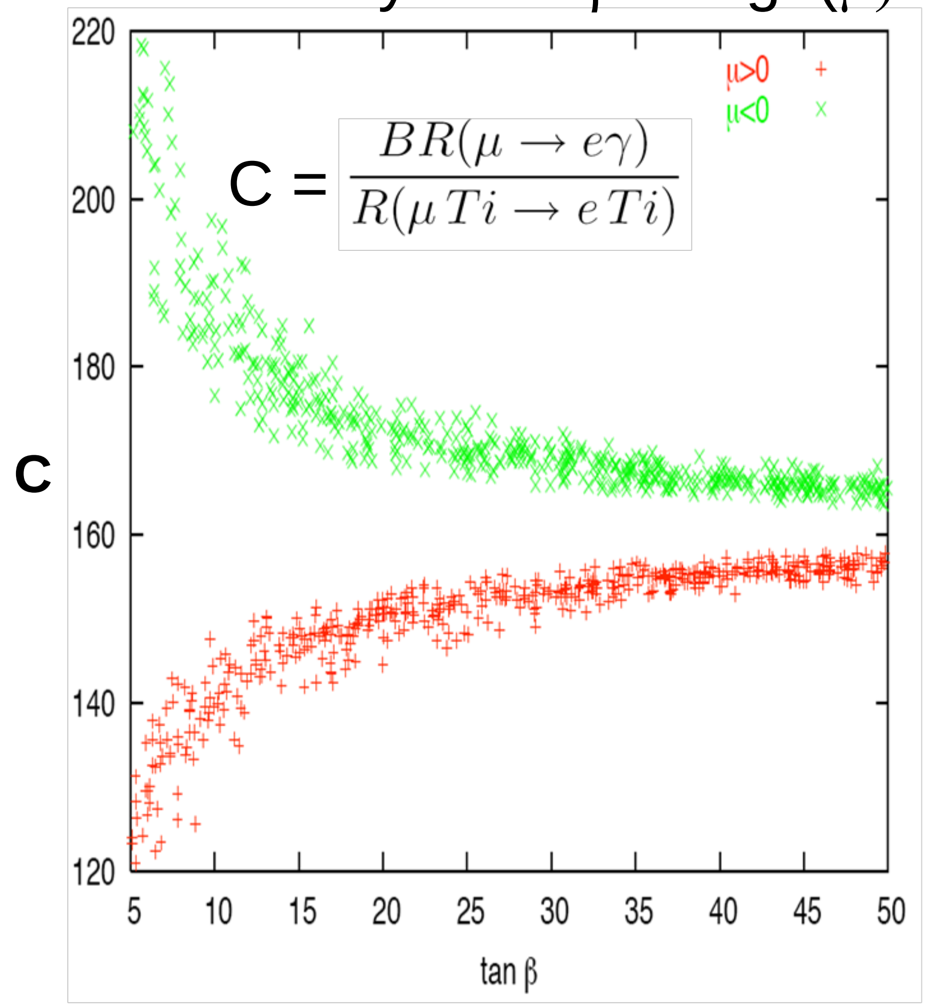
μ→ e in Ti at tanβ = 10



Project X Reach

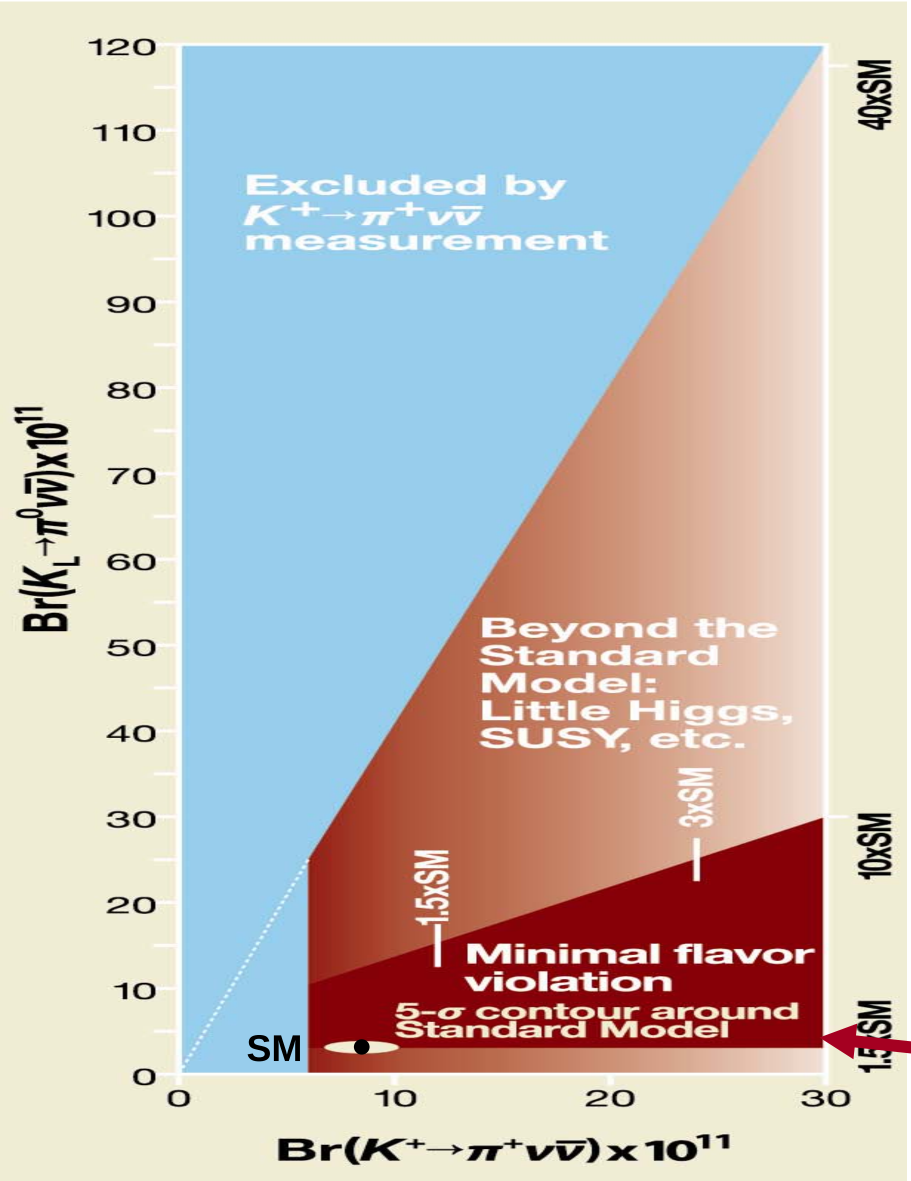
L. Calibbi, A. Faccia, A. Masiero, S. Vempati, hep-ph/0605139

sensitivity to tanβ & sign(μ)

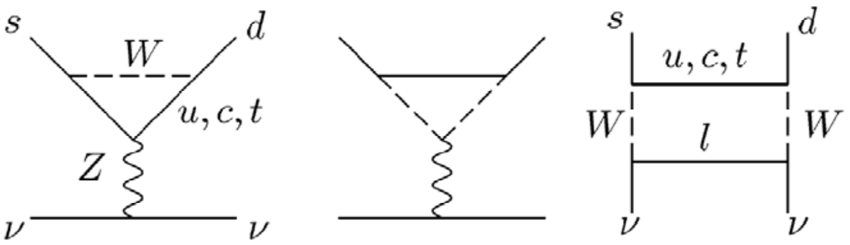


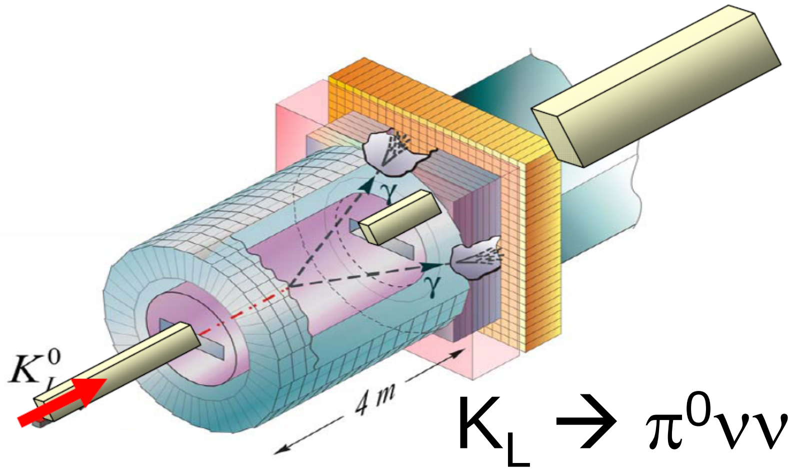
C. Yaguna, hep-ph/0502014

Kaons: Rare Decays $K^+ \to \pi^+\nu\nu$, $K_L \to \pi^0\nu\nu$



SM Leading diagrams





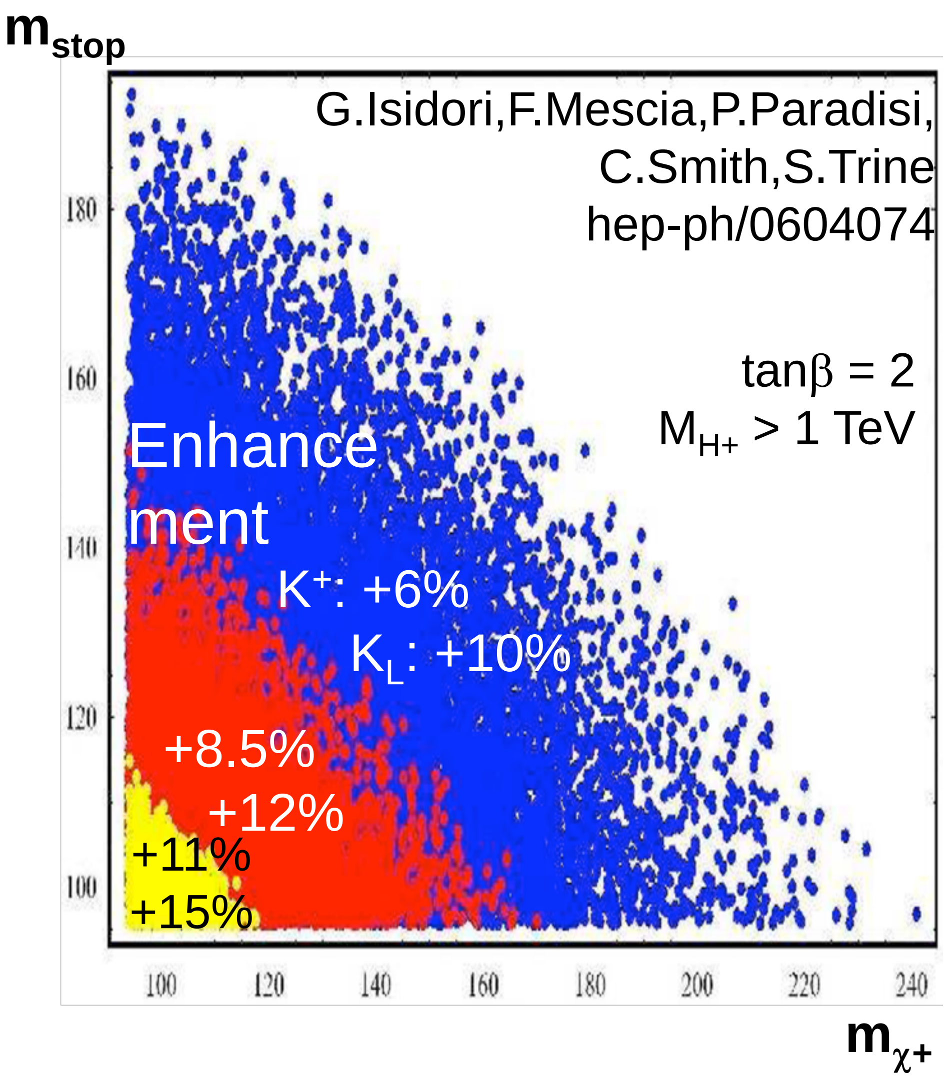
$K_L \to \pi^0\nu\nu$

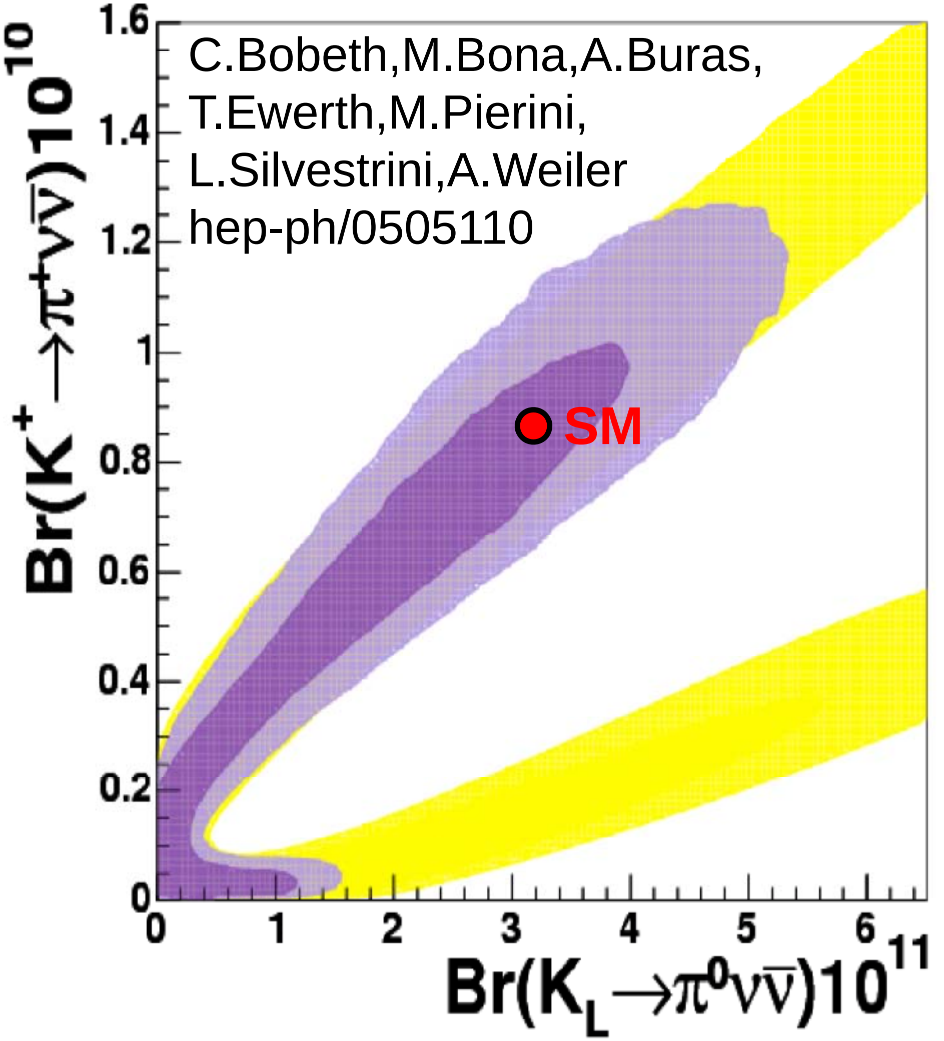
Experiment Concept

an almost-MFV World

Kaons: Rare Decays

MFV SUSY Effects on K → $\pi\nu\nu$





Kaons: Rare Decays

- an almost-Minimal Flavor Violation World
  - Measuring small deviations from SM – of great importance.
    - SUSY breaking scale, Flavor symmetries related to unification, Compositeness, extra dimensions, etc.
  - Directly complementary to central physics program at LHC.
  - Experimental focus – theoretically & experimentally clean
    - Small errors: ~ a few %; require ~1,000 clean Kaon events

$K^+ \rightarrow \pi^+\nu\nu$	#evnts	$K_L \rightarrow \pi^0\nu\nu$	#evnts
CERN NA48 (by 2012)	~160	J-PARC I (by 2012)	~4
		J-PARC II (by ~2016)	~100
Potential FNAL (w/o Proj.X)	~600	Potential FNAL (w/o Proj.X)	~200
Potential FNAL (w/ Proj.X)	~1500	Potential FNAL (w/ Proj.X)	~1000

(FNAL: 5 year running)

Plan (Roadmap) for Fermilab

Plan for Fermilab (1)

- Fermilab's highest priority is discovering the physics of the Terascale by participating in LHC, being one of the leaders in the global ILC effort, and striving to make the ILC at Fermilab a reality.

- Fermilab will continue its neutrino program with NOvA as a flagship experiment through the middle of the next decade.

Plan for Fermilab (2): ILC Onshore

- If the ILC remains near the timeline proposed by the Global Design Effort, Fermilab will focus on the above programs.

- If the ILC departs from the GDE-proposed timeline,

  in addition Fermilab should pursue neutrino-science and precision-physics opportunities by upgrading the proton accelerator complex.

  - If the ILC start must wait for a couple of years, the lab. should undertake the SNuMI (an upgrade of NuMI) project.

  - If the ILC postponement would accommodate an interim major project, the lab. should undertake Project X for its science capability and ILC alignment.

Plan for Fermilab (3): ILC Offshore

- If the ILC is constructed offshore,

  in addition Fermilab should pursue neutrino-science and precision-physics opportunities by upgrading current proton facilities while supporting the ILC as the highest priority.

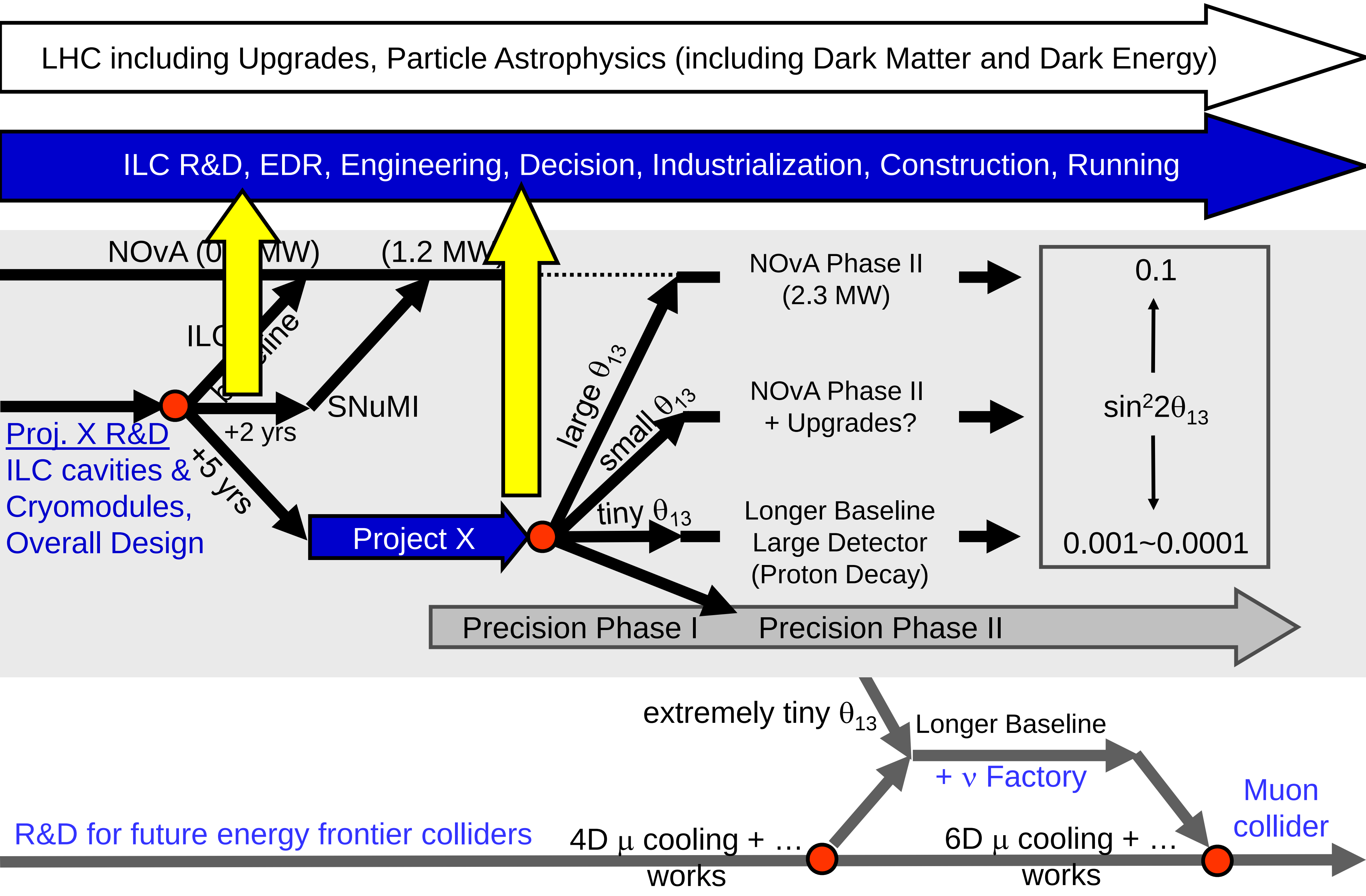
  – The laboratory should undertake SNuMI at a minimum.

  – Alternatively, the laboratory should undertake Project X if resources are available and ILC timing permits.

Plan for Fermilab (4)

- In all scenarios,
  - R&D support for Project X should be started now, with emphasis on
    - expediting R&D and “US” industrialization of ILC cavities and cryomodules,
    - overall design of Project X.
  - R&D for future accelerator options concentrating on a neutrino factory and a muon collider should be increased.
  - The laboratory should support detector R&D and test-beam efforts for effective use of future facilities.

Sketch of Integrated Plan



Conclusions

- The Steering Group plan
  - gives the highest priority to energy-frontier physics with the LHC and the ILC.

- If the ILC is delayed,
  - the Steering Group's plan keeps Fermilab and U.S. particle physics on the pathway to discovery in the domain of the physics of flavor (neutrinos and precision physics), while advancing the technology of the ILC.

  - the Steering Group proposes Project X, an intense proton-beam facility: a linear accelerator with the planned characteristics of the ILC at ~1.5% of the ILC linac, combined with existing Fermilab accelerator rings.

Conclusions (cont.)

Project X

0. What is the origin of mass for fundamental particles?
1. ➡ Are there undiscovered principles of nature: new symmetries, new physical laws?
2. How can we solve the mystery of dark energy?
3. Are there extra dimensions of space?
4. ➡ Do all the forces become one?
5. ➡ Why are there so many kinds of particles?
6. What is dark matter? How can we make it in the laboratory?
7. ➡ What are neutrinos telling us?
8. ➡ How did the universe come to be?
9. ➡ What happened to the antimatter?

Based on "The Quantum Universe," *HEPAP 2004*

Conclusions (cont.)

- Project X
  - would provide unique experiments to address these profound questions
  - would serve many scientific users.
  - would prepare future generations of U.S. particle physicists to exploit the potential of accelerator-based scientific opportunities in the U.S. and worldwide.
  - would help pave the way to the extremely powerful energy- and intensity-frontier facilities beyond the ILC
    - a neutrino factory and a muon collider

Engaging HEP Community in the Process

- Physics groups
  - Neutrino Science
  - Precision Physics
- For all Steering group activities, include
  - Physics group members
  - ILC GDE leaders
  - DOE, NSF Representatives
  - HEPAP Chair / Deputy Chair
  - P5 Chair
  - Chairs of Fermilab/SLAC Users Executive committees
- Public website:

http://www.fnal.gov/directorate/Longrange/Steering_Public/

- Reach out for input / ideas
  - DPF & DPB members
  - Meetings with FNAL staff
  - Meetings with HEP collaborations
  - Talks at Users meetings / Town-Hall meeting at FNAL, SLAC
  - Presentations at ANL, BNL, LBNL
- Received 16 proposals and many letters

2nd face-to-face meeting at Fermilab, July 9-10, 2007

Communication to Community about the Report

- Fermilab
  - All Hands meeting with Fermilab staff
  - Town Hall meeting with Users
- Reviews
  - Fermilab Accelerator Advisory Committee
  - Fermilab Physics Advisory Committee
  - DOE Annual Program
- Presentation at P5 and HEPAP
- Seminars in US
- Seminars outside US
  - UK, Germany: October, November, 2007
  - Japan, CERN, France: March – April 2008
- Workshops
  - Accelerator & Technology: Nov. 12-13, 2007 (~174 participants)
  - 1st Physics workshop: Nov. 16-17, 2007 (~250 participants)
  - 2nd Physics workshop: ~Late Jan, 2008

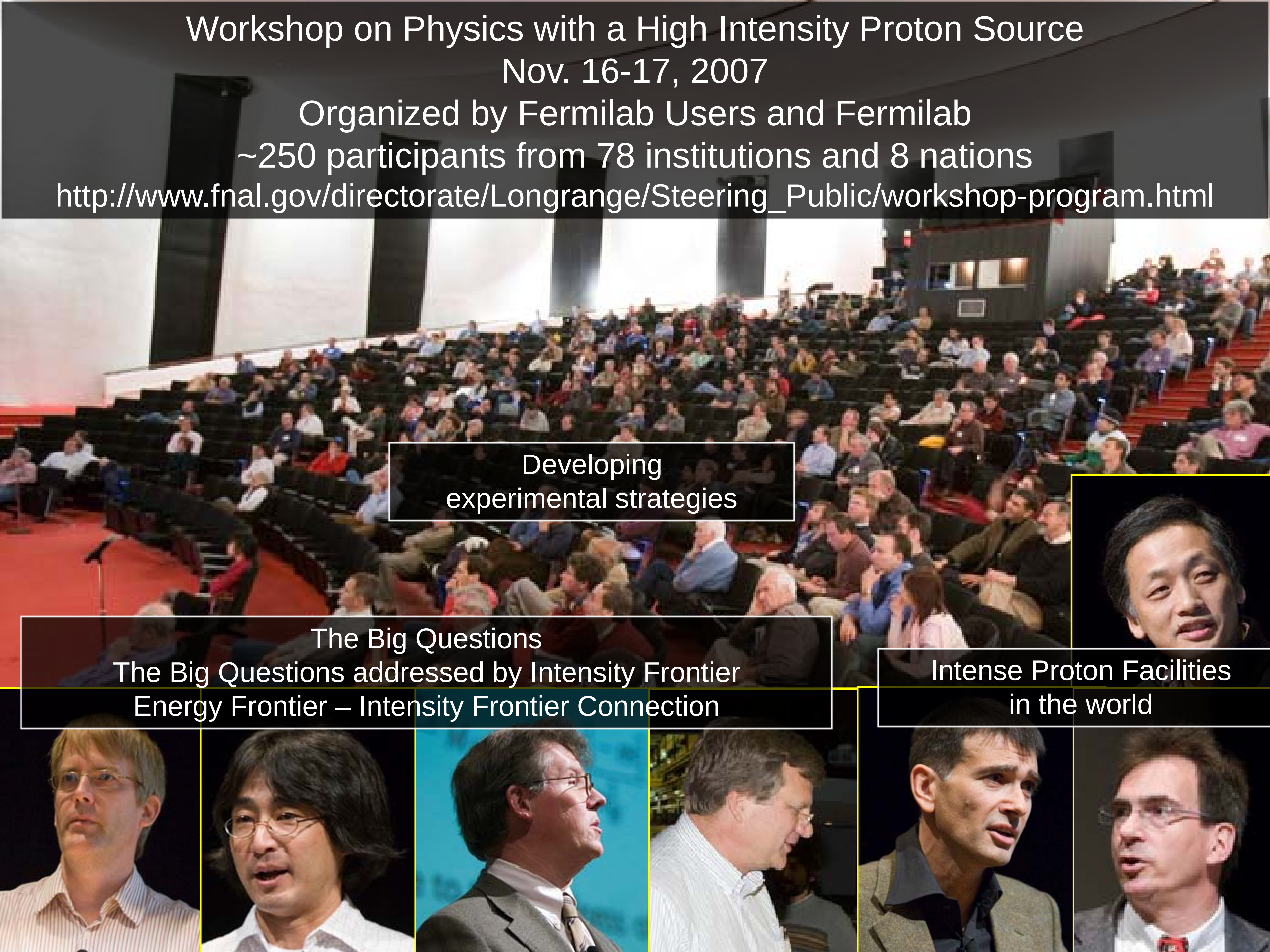
Project X Accelerator Physics and Technology Workshop

Nov. 12-13, 2007

174 participants from 25 institutions and 4 nations

http://projectx.fnal.gov/Workshop/

- To discuss accelerator physics and technology issues of Project X
- To explore possible areas of overlap and interest between various particle accelerator laboratories and universities


Workshop on Physics with a High Intensity Proton Source
Nov. 16-17, 2007
Organized by Fermilab Users and Fermilab
~250 participants from 78 institutions and 8 nations
http://www.fnal.gov/directorate/Longrange/Steering_Public/workshop-program.html
Developing
experimental strategies
The Big Questions
The Big Questions addressed by Intensity Frontier
Energy Frontier – Intensity Frontier Connection
Intense Proton Facilities
in the world

What we are asking now:
“support of Project X R&D”

Backup Slides

Fermilab Director Pier Oddone
formed Steering Group to develop roadmap
for Fermilab's accelerator-based HEP program.

March 22, 2007

Steering Group Charge

In his remarks to HEPAP, Undersecretary Orbach requested a dialog with the HEP community:

"In making our plans for the future, it is important to be conservative and to learn from our experiences. Even assuming a positive decision to build an ILC, the schedules will almost certainly be lengthier than the optimistic projections. Completing the R&D and engineering design, negotiating an international structure, selecting a site, obtaining firm financial commitments, and building the machine could take us well into the mid-2020s, if not later. Within this context, I would like to re-engage HEPAP in discussion of the future of particle physics. If the ILC were not to turn on until the middle or end of the 2020s, what are the right investment choices to ensure the vitality and continuity of the field during the next two to three decades and to maximize the potential for major discovery during that period?"

Steering Group Charge (cont.)

With the encouragement of the Office of Science and the support of Professor Mel Shochet, the chair of HEPAP, Fermilab will develop a strategic roadmap for the evolution of the accelerator-based HEP program, focusing on facilities at Fermilab that will provide discovery opportunities in the next two to three decades. This roadmap should keep the construction of the ILC as a goal of paramount importance. To guide this proposal, the Fermilab Director has appointed a Steering Group consisting of members from Fermilab and the national particle and accelerator physics community to insure that the plan serves national needs. The Steering Group will also engage additional constituents in the analysis of the various physics opportunities.

Steering Group Charge (cont.)

The Steering Group will build the roadmap based on the recommendations of the EPP2010 National Academy report and the recommendations of the P5 subpanel of HEPAP. The Steering Group should consider the Fermilab based facilities in the context of the global particle physics program. Specifically the group should develop a strategic roadmap that:

1. supports the international R&D and engineering design for as early a start of the ILC as possible and supports the development of Fermilab as a potential host site for the ILC;

2. develops options for an accelerator-based high energy physics program in the event the start of the ILC construction is slower than the technically-limited schedule; and

3. includes the steps necessary to explore higher energy colliders that might follow the ILC or be needed should the results from LHC point toward a higher energy than that planned for the ILC.

Steering Group Charge (cont.)

I am asking Deputy Director Kim to chair the Steering Group.

Any recommendations that might be relevant to the FY09 budget should be transmitted as early as possible.

The Steering Group's final report should be finished and delivered to the Fermilab Director by August 1, 2007. This deadline would allow for presentations to the DOE and its advisory bodies before the structuring of the FY2010 budget.

Steering Group Membership

Fermilab and national particle and accelerator physics community

Eugene Beier	U. Penn
Joel Butler	Fermilab
Sally Dawson	BNL
Helen Edwards	Fermilab
Thomas Himel	SLAC
Steve Holmes	Fermilab
Young-Kee Kim (chair)	Fermilab / U.Chicago
Andrew Lankford	UC Irvine
David McGinnis	Fermilab
Sergei Nagaitsev	Fermilab
Tor Raubenheimer	SLAC
Vladimir Shiltsev	Fermilab
Maury Tigner	Cornell
Hendrick Weerts	ANL

Engaging HEP Community in the Process

Engaging HEP Community in the Process

The Steering Group subsequently formed physics groups (subgroups)
to provide advice on the best physics opportunities.
Physics groups drew upon university/lab scientists, largely from outside Fremilab.

Neutrino Science

Eugene Beier	U Penn
Deborah Harris	Fermilab
Ed Kearns	Boston Univ.
Boris Kayser	Fermilab
Sacha Kopp	UT Austin
Andy Lankford (chair)	UC Irvine
Bill Louis	Los Alamos

Precision Physics

Joel Butler	Fermilab
Brendan Casey	Brown
Sally Dawson (chair)	BNL
Chris Hill	Fermilab
Dan Kaplan	IIT
Yury Kolomensky	UCBerkeley/LBNL
William Molzon	UC Irvine
Kevin Pitts	UIUC
Frank Porter	CalTech
Bob Tschirhart	Fermilab
Harry Weerts	ANL

Engaging HEP Community in the Process

- For all Steering group activities, include
  - Physics group members
  - ILC GDE leaders, HEP / ILC program managers in DOE and NSF
  - HEPAP Chair / Deputy Chair, P5 Chair
  - Chairs of Fermilab/SLAC Users Executive committees

- Public website: http://www.fnal.gov/directorate/Longrange/Steering_Public/
  - Agendas
  - Presentations
  - Minutes
  - Documents
  - Publicly accessible

- Meetings
  - Weekly teleconference
  - 2 face-to-face meetings
  - SG daily meeting toward the end

2nd face-to-face meeting at Fermilab, July 9-10, 2007

Engaging HEP Community in the Process

- Reach out to HEP community for input / ideas
  - Message sent out to DPF & DPB members
  - Meetings with FNAL staff
  - Meetings with HEP collaborations
    - CDF, DZero, MINOS, MiniBooNE, MINERvA, NOvA, ILC TTC, US CMS, …
  - Presentations at Users meetings / Town-Hall meeting
    - FNAL, SLAC
  - Presentations (seminars) / Discussions
    - ANL, BNL, LBNL
  - Fermilab Today articles (through Public Affairs Office)
  - Meeting with ILC GDE Executive Committee
  - Many meetings with individuals
  - ….

Letters / Proposals from the Community

Letters

1. John Marriner (May 5, 2007)
2. Norman Gelfand (May 8, 2007)
3. Stanley Brodsky (May 31, 2007)
4. Steve Geer et al. (June 8, 2007)
5. Buck Field (June 12, 2007)
6. Chuck Ankenbrandt et al (June 12, 2007)
7. Maury Goodman (July 7, 2007)
8. ……

- One Page Proposals
  1. 6 GeV ILC Test Linac - Giorgio Apollinari and Bob Webber (May 7, 2007)
  2. LAr TPC in FNAL's Neutrino Beams - David Finley (May 29, 2007)
  3. Precision Neutrino Scattering at Tevatron - Janet Conrad and Peter Fisher (May 29, 2007)
  4. Very Large Cherenkov Detector - Milind Diwan et al (June 5, 2007)
  5. From Tevatron to Muon Storage Ring - Terry Goldman (June 6, 2007)
  6. Antimatter Gravity Experiment - Thomas Phillips (June 7, 2007)
  7. Neutrino Oscillation with high energy/intensity beam - Henryk Piekarz (June 10, 2007)
  8. Space-Time Ripples Study - Nikolai Andreev (June 11, 2007)
  9. Fixed Targer Charm Expt - Jeff Appel and Alan Schwartz (June 11, 2007)
  10. Stopped Pion Neutrino Source - Kate Scholberg (June 11, 2007)
  11. UNO Experiment - Change Kee Jung (June 11, 2007)
  12. n-nbar Transition Search at DUSEL - Yuri Kamyshkov (June 11, 2007)
  13. 8GeV cw Superconducting Linac - Ankenbrandt et al. (June 12, 2007)
  14. Neutrino Expt with 5kton LAr TPC - Fleming and Rameika (June 12, 2007)
  15. MicroBooNE - Fleming and Willis (June 12, 2007)
  16. Δs - Rex Tayloe (June 14, 2007)

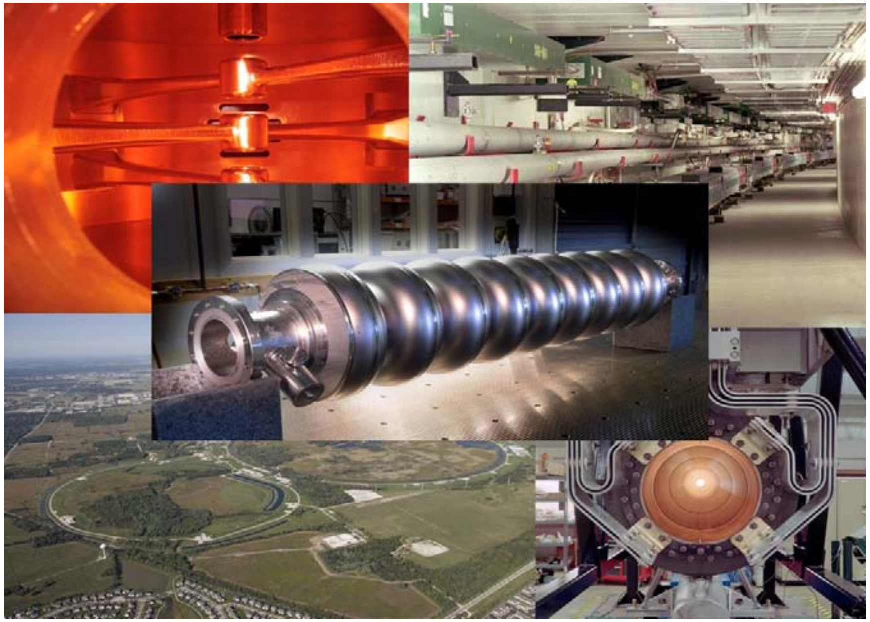
- Expression of Interest (EOI)
  1. mu to e conversion - William Molzon (May, 2007)
  2. me to e conversion - E.J. Prebys, J.P. Miller et al (May, 2007)
  3. Klong to pi0 nu nu - D. Bryman et al (June 11, 2007)

- Letter of Intent (LOI)
  1. Low- and Medium-Energy Anti-Proton Physics - D. Kaplan et al (June 1, 2007)

Accelerator Physics and Technology Workshop

November 12-13, Fermilab

- Organized by Fermilab
  - Stephen Holmes
  - David McGinnis
  - Vladimir Shiltsev



- Goal:
  - To discuss accelerator physics and technology issues of Project X and explore possible areas of overlap and interest between various particle accelerator laboratories and universities.
- Website:
  - http://projectx.fnal.gov/Workshop/

Time	Topic	Speaker
Nov. 12 Morning	Project X Overview Low Energy Linac Overview High Energy Linac Overview Recycler Overview Main Injector Overview 120 GeV Targeting Overview	David McGinnis Bob Webber Sergei Nagaitsev Alex Valishev Valeri Lebedev Jim Hylen
Nov. 12 Afternoon Nov. 13 Morning	Working Group Breakout Sessions Low Energy Linac High Energy Linac Recycler Main Injector 120 GeV Targeting Report	Working Group Chairs BobWebber(FNAL) / Ostroumov(ANL) Nagaitsev(FNAL) / Adolphsen(SLAC) Valishev(FNAL) / Roser(BNL) Lebedev(FNAL) / Corlett(LBNL) Martens(FNAL) / Simos(BNL)
Nov. 14 Afternoon	Working Group Reports Summary and Future Plans	Working Group Chairs David McGinnis

Workshop on Physics w/ a high intensity proton source

November 16-17, Fermilab

- Jointly organized by Fermilab UEC and Fermilab
  - Kevin Pitts (Fermilab UEC Chair)
  - Young-Kee Kim

- Goals:
  - Understand how the intensity frontier facilities address the great questions of particle physics.
  - Understand energy frontier – intensity frontier connection.
  - Clarify and expand upon the physics case for Project X.
  - Provide the particle physics community an opportunity to learn about the physics.
  - Review frontier proton facilities in other regions.
  - Prepare the 2nd physics workshop in ~Jan. 2008.

- Website:
  - http://www.fnal.gov/directorate/Longrange/Steering_Public/workshop-physics.html

Time	Topic	Speaker
Nov.13 8:30 – 10am	Answering the Great Questions Questions about the Quantum Universe Intensity Frontier of Quantum Universe	 Joe Lykken (Fermilab) Hitoshi Murayama (UCB/LBNL)
Nov. 13 10:30 – 12:30	Proton Programs in other regions J-PARC PSI GSI CERN Kaon	 Taku Yamanaka (Okaka) Alessandro Baldini (Pisa) Klaus Peters (GSI) Augusto Ceccucci (CERN)
Nov. 13 1:30 – 3:30pm	Steering Group Report and Project X SG Recommendations Accelerators Physics	 Young-Kee Kim (Fermilab/UChicago) David McGinnis (Fermilab) Jon Bagger (Johns Hopkins)
Nov. 13 4pm	W&C Seminar: Summary of Nov.13	Michelangelo Mangano (CERN)
Nov. 14 Morning	Working Group Breakout Session Neutrinos Muons, Kaons Antiprotons Working Group Reports	Working Group Chairs Flemming(Yale) / Kearns(Boston) De Gouvea(NW) / Molzon(UCI) Tschirhart(FNAL) / Yamanaka(Osaka) Kaplan(IIT) / Peters(GSI)
Nov. 13-14	Poster Session	Brendan Casey (Fermilab)

Physics workshop: institutions

- ANL
- Alabama
- Arizona
- Barnard college
- BNL
- Boston Univ.
- Caltech
- Carolina
- CERN (Switzerland)
- Chicago
- Chonnam Nacional Univ. (Korea)
- Columbia
- Delhi
- DOE
- Duke
- Florida
- FNAL
- GSI Darmstadt (Germany)
- Hbar Tech
- Hope
- IHEP, Protvino
- IIT
- Imperial collage (UK)
- Indiana
- INFN, Ferrara (Italy)
- INFN, Genova
- INFN, Milano Bicocca
- INFL,Padova
- INFN, Pisa
- INFN, Trieste
- INFN, Udine
- Iowa State
- JHU
- Kansas
- Kyoto (Japan)
- KEK (Japan)
- LANL
- LBNL
- Luther College
- Muons Inc
- ND
- New Mexico State
- NIU
- NSF
- NW
- Ohio
- Osaka Univ.
- Rice Univ.
- Rochester
- SLAC
- SMU
- Stony Brook
- Tokyo Institute of Technology (Japan)
- Tufts
- UBC (Canada)
- UCBerkrley
- UCSB
- UIUC
- U.Bologna (Italy)
- U.Colorado
- U.Iowa
- U.Manchester (UK)
- U.Mass, Amherst
- U.Michigan, Flint
- U.Michigan, Madison
- U.Minnesota
- U.Mississippi
- U.Lagos (Nigeria)
- U.Penn
- U.Pittsburgh
- U.South Carolina
- U.Texas, Austin
- U.Valencia (Italy)
- U.Virginia
- U.Wisconsin, Madison
- Wane State
- Yale

Physics Workshop: Nations

- Canada
- Germany
- Italy
- Japan
- Korea
- Nigeria
- Switzerland
- UK
- USA

Reviews on
the Steering Group’s Proposal

Fermilab’s Accelerator Advisory Committee
(August 8-10, 2007)

Membership

John Corlett (chair)	LBNL
Swapan Chattopaddhyay	Cockcroft
Gunther Geschonke	CERN
Georg Hoffstaetter	Cornell
Kwang-Je Kim	ANL
Shin-ichi Kurokawa	KEK
Michiko Minty	DESY
Hasan Padamsee	Cornell
Stephen Peggs	BNL
Tor Raubenheimer	SLAC
Hans Weise	DESY

AAC Comments

- The committee strongly supports the plan presented
  - Provides options for the future of accelerator based HEP at Fermilab
  - Has broad scope, addresses near and far-term activities
    - Critical for healthy future of HEP in the U.S.

- Evolution of the plan has benefited from Fermilab leadership in pursuing options
  - Establishment of processes leading to strong alignment of Project X with ILC

- The committee strongly supports plans for Project X
  - needs to be ready with an engineering design in the 2010 timeframe
  - An immediate strong start is recommended.

- We congratulate the Project X team on an innovative design
  - Supportive of ILC, neutrino sector, muon colllider
  - A prudent backup in case of delay to the ILC

- We recommend that Fermilab be considerate of potential misinterpretations of the priority of ILC wrt Project X.

Fermilab's Physics Advisory Committee
(November 1-3, 2007)

Membership

Hiroaki Aihara	University of Tokyo
John Carlstrom	University of Chicago
Sally Dawson (chair)	BNL
Sarah Eno	University of Maryland
Fabiola Gianotti	CERN
Rolf-Dieter Heuer	DESY
JoAnne Hewett	SLAC
Steven Kahn	SLAC
Boris Kayser	Fermilab
Francois Le Diberder	CNRS/IN2P3
Daniel Marlow	Princeton University
Robert McKeown	Caltech
Ian Shipsey	Purdue University
Rick Van Dooten	Indiana University

PAC Comments (Draft)

- The Committee commends the lab and the Steering Group on having carried out a thoughtful and comprehensive planning exercise.
- The Steering Group's report offers a strategic plan for the most desirable scenario, wherein the ILC proceeds according to a technically driven schedule, as well as scenarios where progress on the ILC is slower than one might like as a result of the challenges surrounding the funding of a large international project.
- Developing a plan that provides for an exciting interim physics program, while keeping the lab on a technological path that is aligned with that of the ILC is clearly prudent.
- Moreover, the Steering Group's plan provides a way forward even in scenarios where the ILC is delayed indefinitely by incorporating R&D on advanced accelerator concepts such as a neutrino factory and a muon collider.

Kaons in the world (per year)

Facility	Duty Factor	Clock hours	Beam hours	Projected # of K → $\pi\nu\nu$
CERN-SPS (450 GeV)	30%	1420	405	40 (charged)
Booster Stretcher (8GeV, 16kW)	90%	5550	5000	50 (charged)
Tevatron-Stretcher (120 GeV)	90%	5550	5000	200 (charged)
ProjectX Stretcher (8GeV, 200kW)	90%	5550	5000	300 (charged)
JPARC-I (30 GeV)	21%	2780	580	~1 (neutral)
BNL AGS (24 GeV)	50%	1200	600	20 (neutral)
JPARC-II (30 GeV)	21%	2780	580	30 (neutral)
Booster Stretcher (8GeV, 16kW)	90%	5550	5000	50 (neutral)
ProjectX Stretcher (8GeV, 200kW)	90%	5550	5000	300 (neutral)

J-PARC - Neutrino:Kaon = 50%:50%

Fermilab Expt. vs KOPIO

Presentation by Doug Bryman (UBC) at Physics Workshop (Nov. 16-17, 2007)

Straw "Person" Assumptions
(For Comparison with KOPIO Design)

- 45 degree cross sections at 8 GeV are 0.5 x those at 24 GeV for 1 GeV kaons
  (>50% uncertainty – see Sergei's talk).
- Beam aperture 0.05 x the area of the KOPIO wide beam.
- Optimization for 1 $\mathbf{K_L}$ **decay/bucket** results in a large recovery factor.
- Detector acceptance increased relative to KOPIO by 50%:
  larger detectors (25%); improvede acceptance (25%).
- Minimal accidental losses (until X2).

$$K_L^0 \to \pi^0 \nu \bar{\nu}$$

Straw "Person" Order of Magnitude Estimates

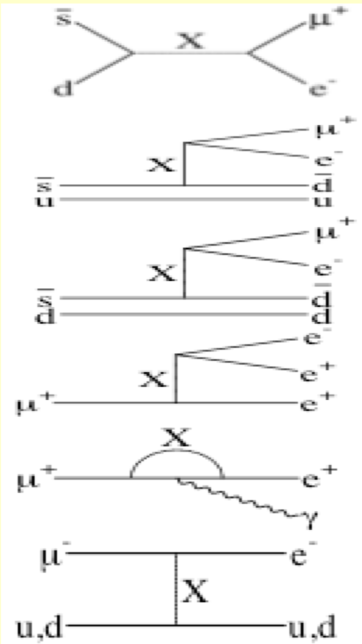
	FNAL Booster X0	FNAL Proj X1	FNAL Proj X2
Events/yr	50	300	600
5 yr. Precision(%)	8	4	3

Rough estimates based on extrapolations from KOPIO design.

Flavor-Changing Neutral Currents (FCNC) beyond SM

Current examples – probing high energy scales

S. Geer



Br($K_L \rightarrow \mu e$)	$< 4.7 \times 10^{-12}$	$M_X > 150$ TeV
Br($K^+ \rightarrow \pi\mu e$)	$< 4 \times 10^{-11}$	$M_X > 31$ TeV
Br($K_L \rightarrow \pi\mu e$)	$< 3.2 \times 10^{-19}$	$M_X > 37$ TeV
Br($\mu \rightarrow eee$)	$< 1 \times 10^{-12}$	$M_X > 86$ TeV
Br($\mu \rightarrow e\gamma$)	$< 1.2 \times 10^{-11}$	$M_X > 21$ TeV
Normalized Rate	$< 6.1 \times 10^{-13}$	$M_X > 365$ TeV

Depending on couplings, scales could be as low as ~1TeV

Great potential for synergy between LHC and Flavor

Opportunities with Project X