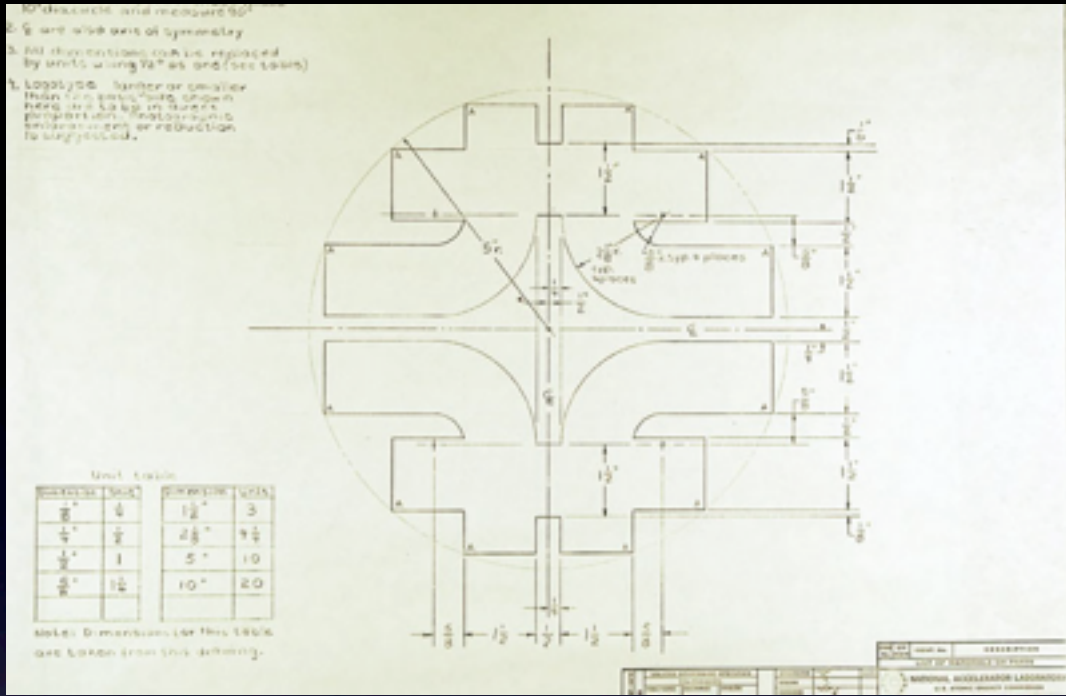


A View from the US

Patricia McBride, Fermilab

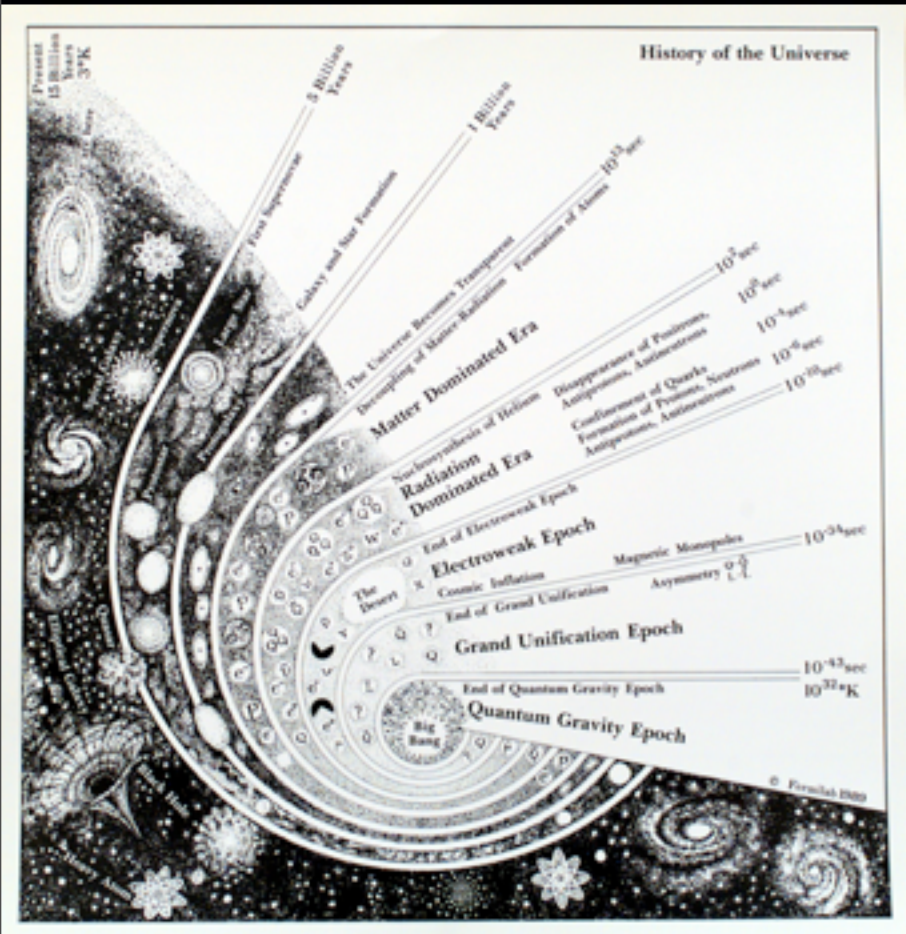
March 31, 2010

IOP

A view from the US

- *Usual Disclaimer - the views presented here are mine.*
- *Apologies to all the many projects, papers and people I am not able to mention.*

A personal view from the US



History of the Universe by Angela Gonzales

"At such a difficult moment, there are those who say we cannot afford to invest in science, that support for research is somehow a luxury at moments defined by necessities. I fundamentally disagree. Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been before."

— President Barak Obama, 27 April 2009

A personal view from the US

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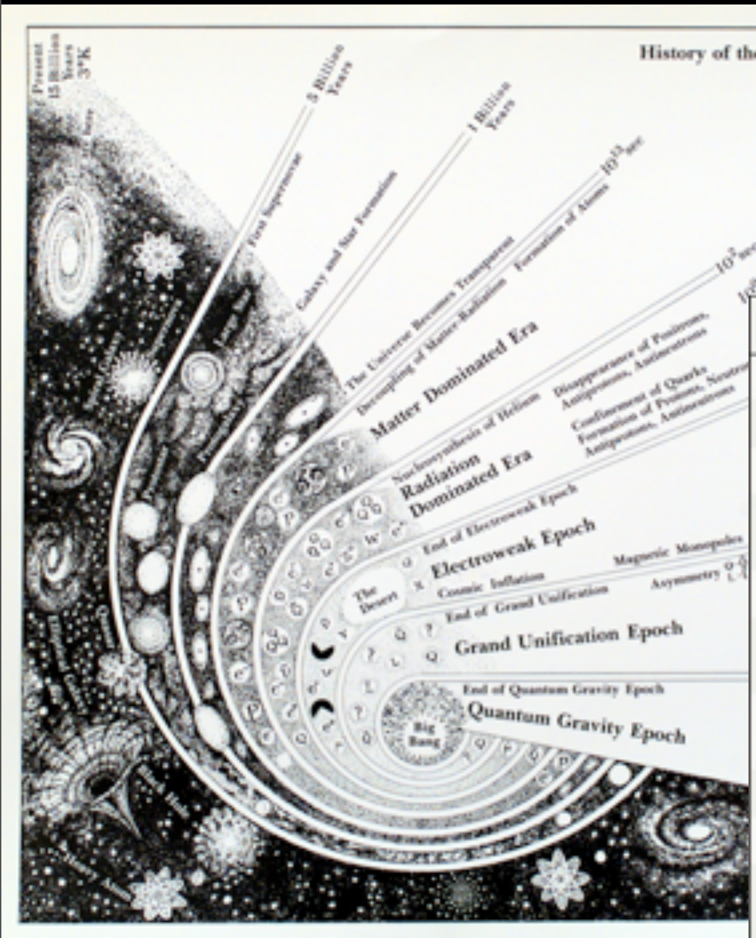
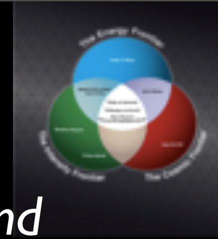


History of the Universe by Angela Gonzales

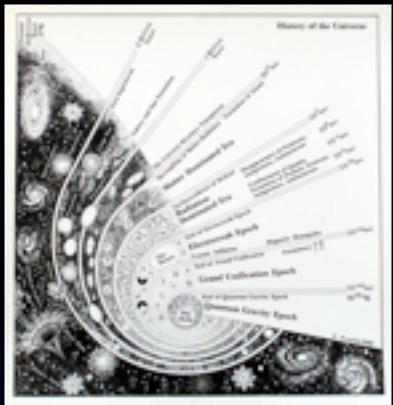
OBAMA'S BUDGET REQUEST FOR 2011 (US$ million)

Agency	2009 (actual)	Stimulus	2010 (enacted)	2011 (president's request)
National Institutes of Health	30,396	10,400	31,089	32,089
National Science Foundation	6,490	3,002	6,873	7,424
Department of Energy's Office of Science	4,773	1,633	4,895	5,121
NASA	17,782	1,002	18,724	19,000
National Oceanic and Atmospheric Administration	4,454	830	4,853	5,554
National Institute of Standards and Technology (core funding)	820	580	862	922
Environmental Protection Agency	7,633	7,220	10,298	10,020
US Geological Survey	1,044	140	1,112	1,133
Department of Defense (basic and applied research)	6,830	0	7,204	6,475
Department of Homeland Security (science and technology)	933	0	1,006	1,018

A view from the US

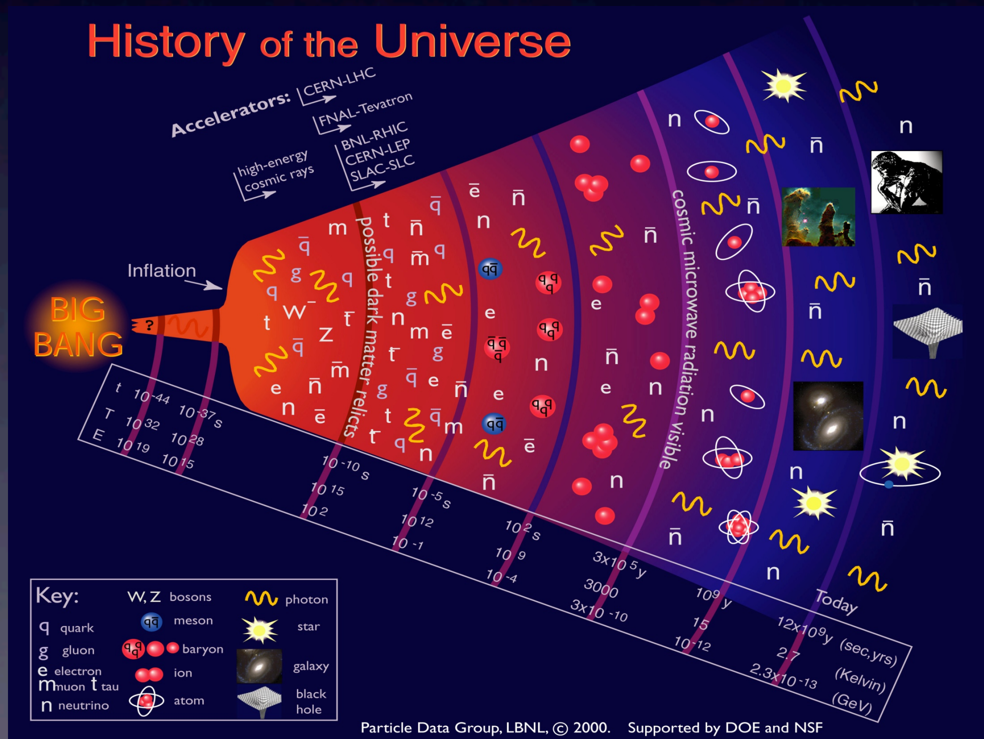


View 1989



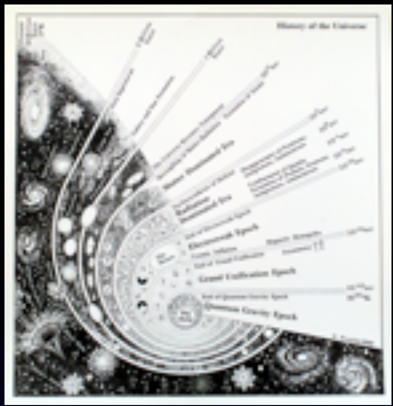
Particle Physics - The view of my neighbors

- *My neighbors read about the LHC in magazines and newspapers and have read Angels and Demons.*
- And they follow the LHC progress in the New York Times (http://www.nytimes.com/info/large-hadron-collider/ or could keep up-to-date on twitter and facebook

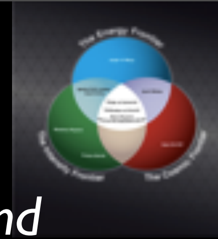


A view from the US

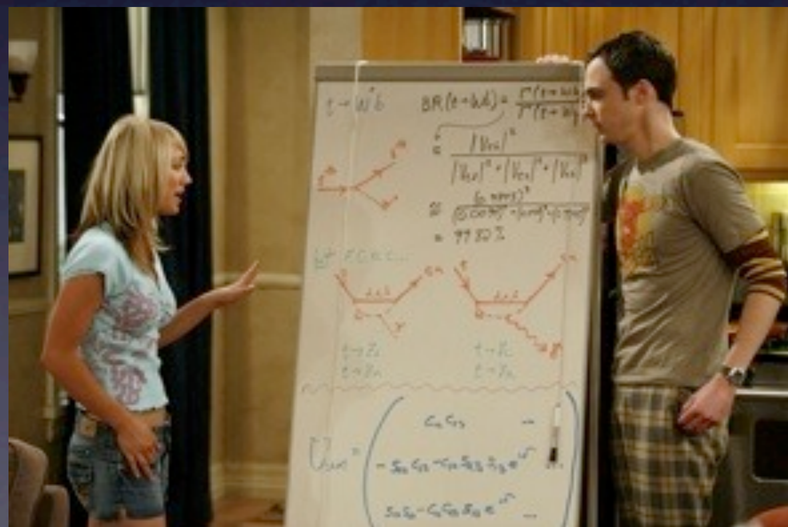
View 1989



Particle Physics - The view of my neighbors



- *My neighbors read about the LHC in magazines and newspapers and have read Angels and Demons.*
- And they follow the LHC progress in the New York Times (http://www.nytimes.com/info/large-hadron-collider/ or could keep up-to-date on twitter and facebook
- *But if they go to Wikipedia* - The Big Bang Theory is an American sitcom...

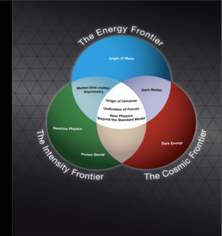


Follow the physics with David Saltzberg's unofficial blog for the TV show http://thebigblogtheory.wordpress.com/

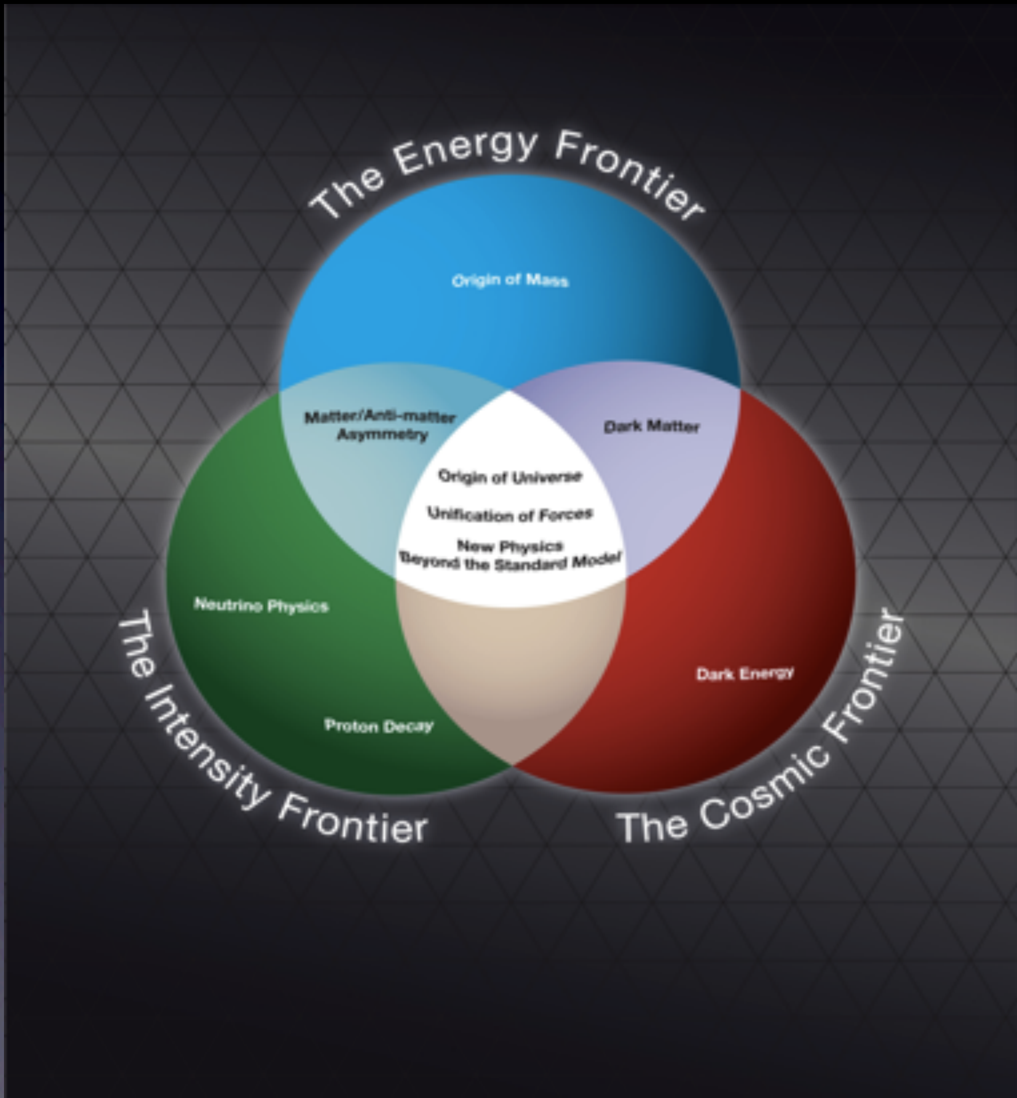
A view from the US

A Particle Physicist viewing the world

- *Adapting to a changing world is a challenge for all of us. In a world of constrained budgets we need to*
  - *Improve global planning and cooperation on the important physics priorities,*
  - *Improve collaboration between the university groups and the large national (and international) laboratories - particularly for detector R&D,*
  - *Improve outreach and education (I think we are doing well in this area but we cannot become complacent.)*
- *Action needed:*
  - *the international community in planning international and global projects ⇒ ICFA (International Committee on Future Accelerators)*
  - *community of particle physicists ⇒ inside the US - American Physical Society/Division of Particles and Fields*



Particle Physics View



In the US planning for particle physics is discussed by HEPAP, P5 - the Particle Physics Project Prioritization Panel (~5 years) and the National Research Council (~10 years).

P5 report from May 2008

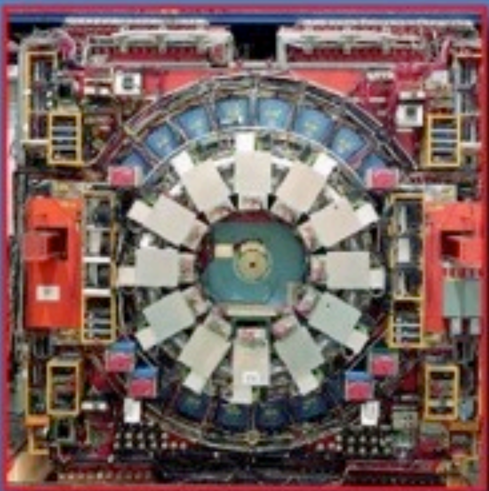
"US Particle Physics: Scientific Opportunities

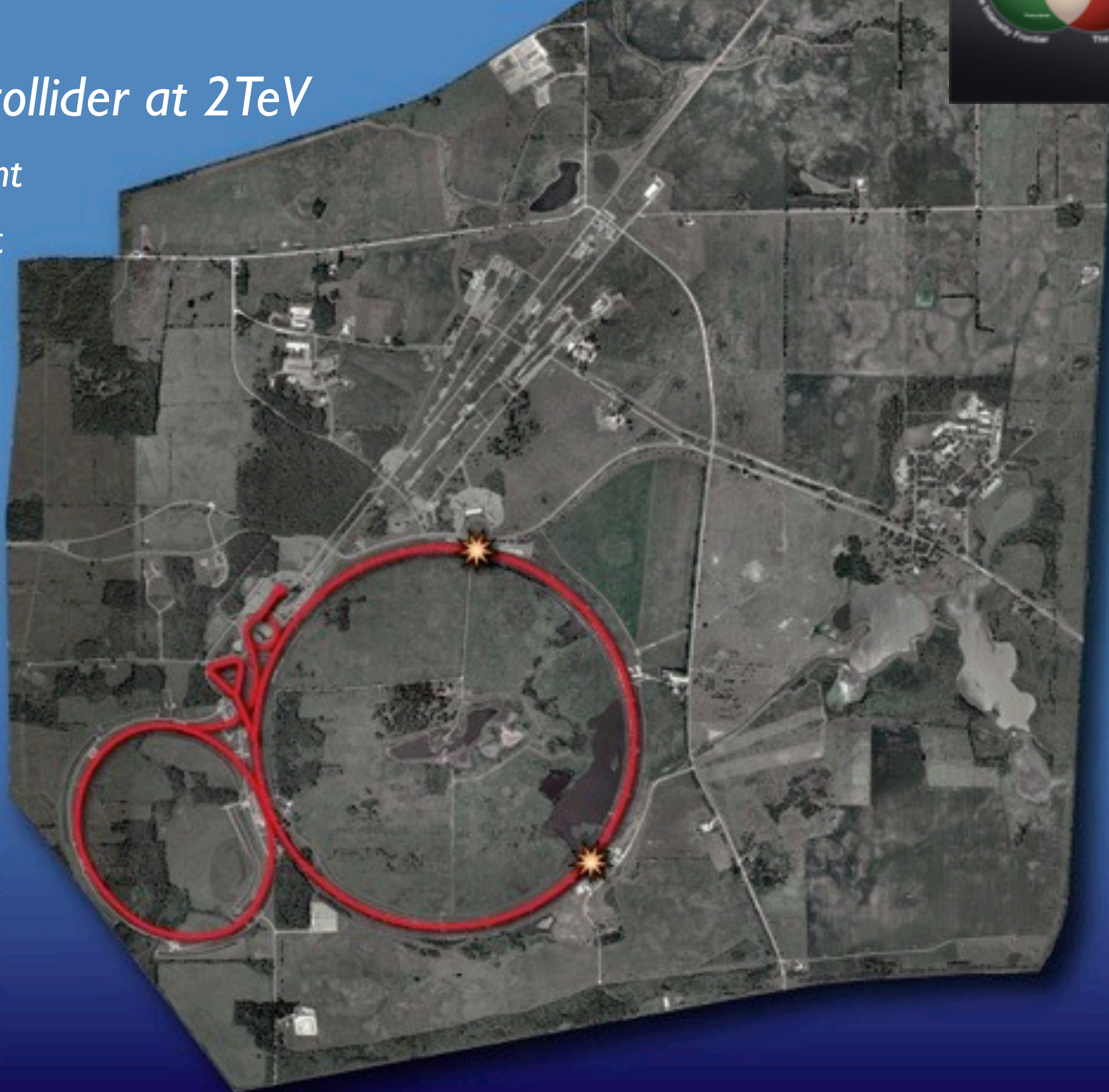
A Strategic Plan for the Next Ten Years"

A view from the US

The Energy Frontier in Batavia

- *The Tevatron collider at 2TeV*
  - *CDF experiment*
  - *D0 experiment*





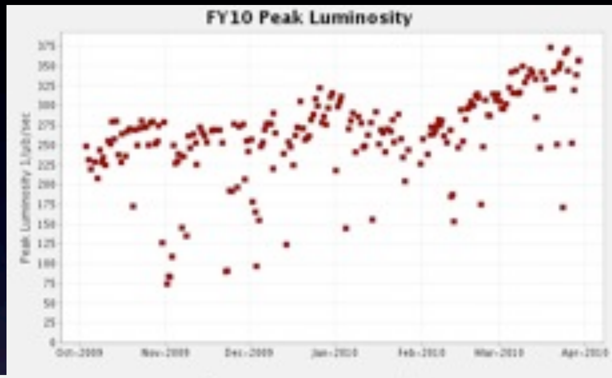
The Tevatron Collider - breaking intensity records

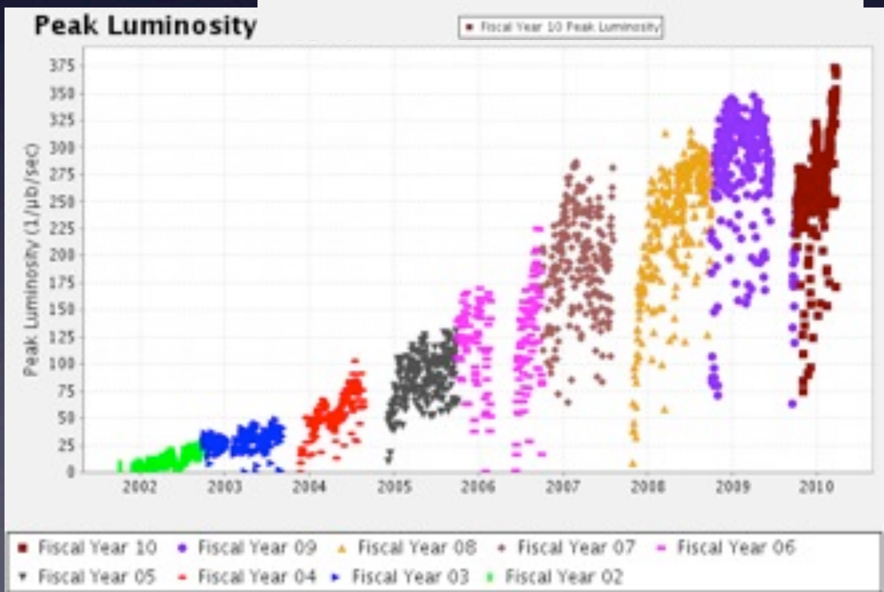
Record initial peak luminosity: 3.76 10^{32}

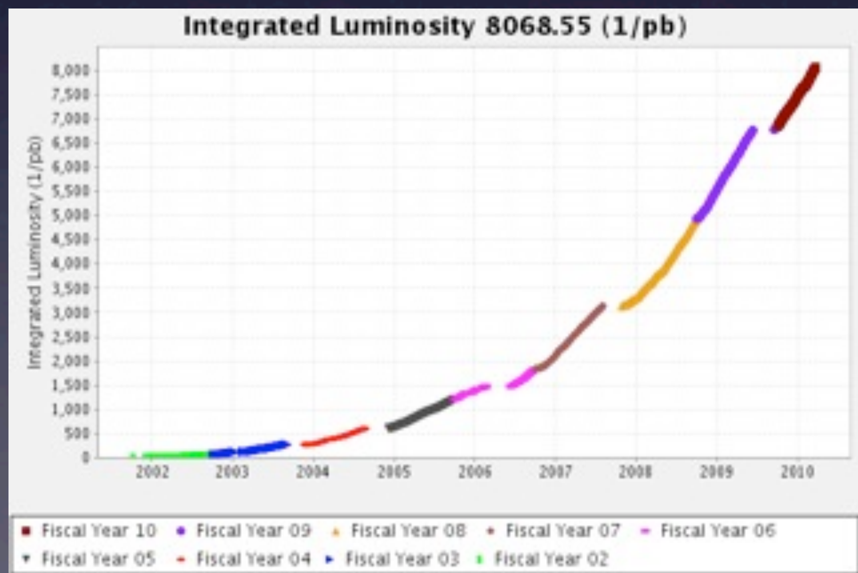
integrated luminosity: > 8 fb^{-1}

> 2 fb^{-1} expected this year

>100 publications/year



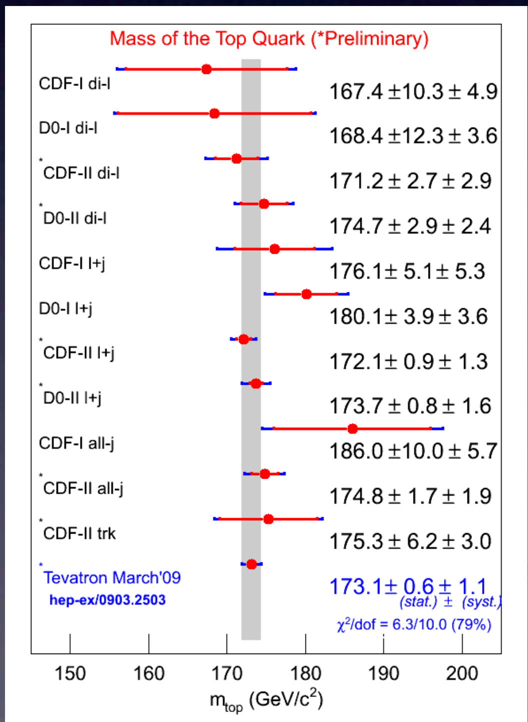




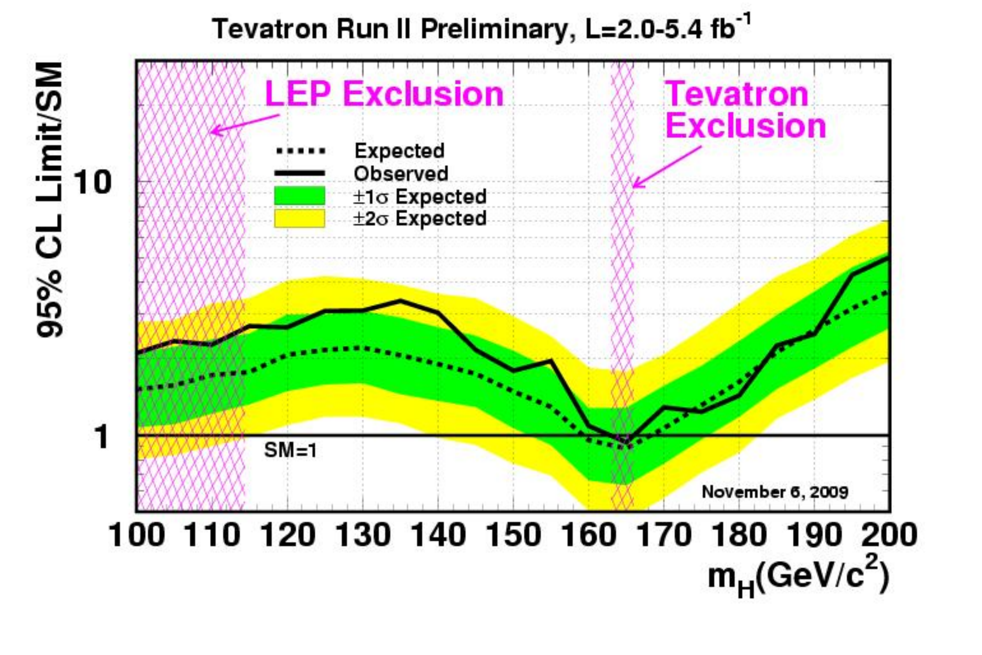
A view from the US

Tevatron Physics Program

- *Discovery of Single Top and Production cross section*
- *W mass: 80.399 ± 0.023*
- *Top mass: 173.1±1.2 GeV (15 years since the top discovery)*
- *Hunt for the Higgs - expect to learn more with more data*

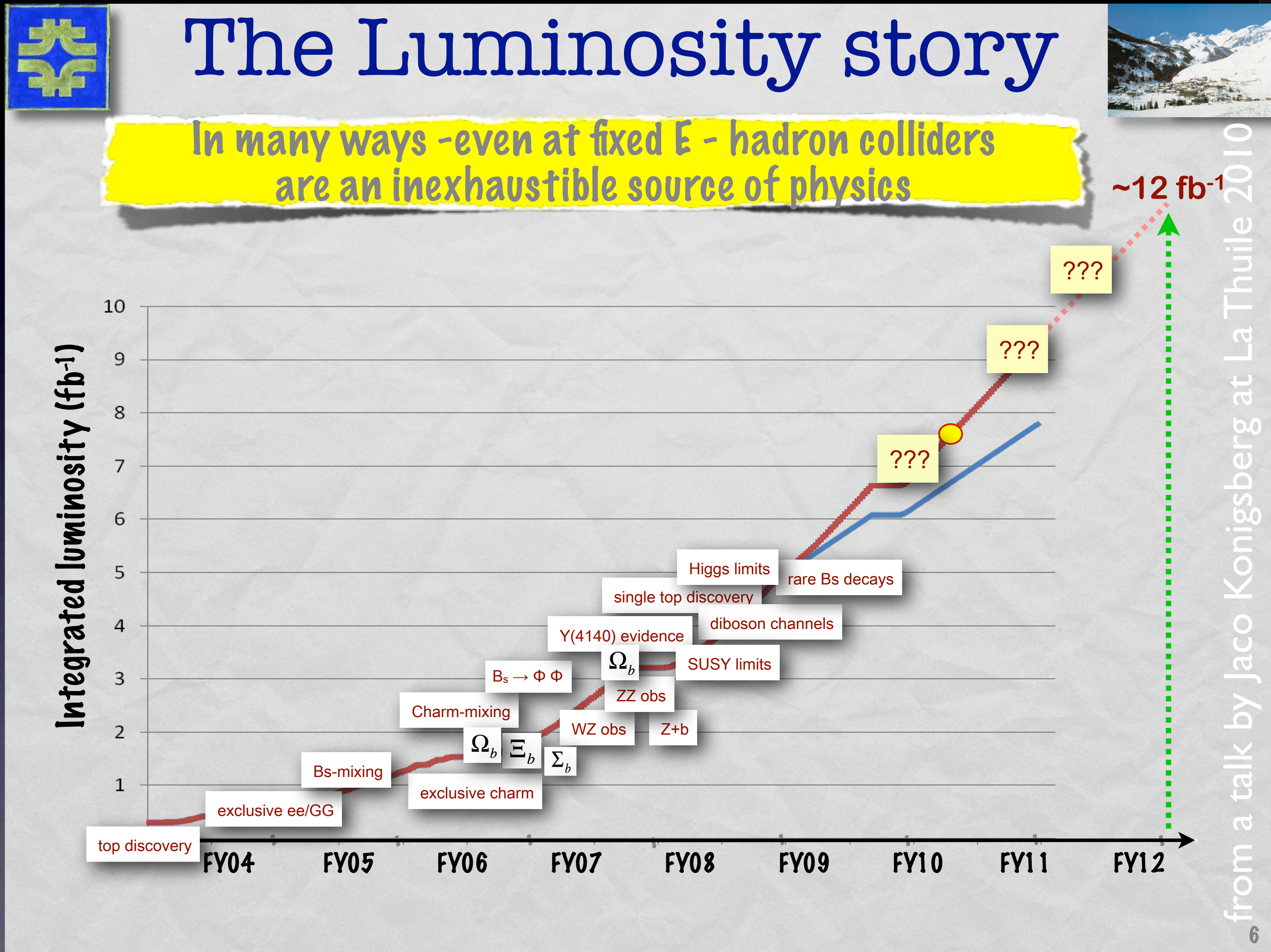


Combined limit from CDF/D0



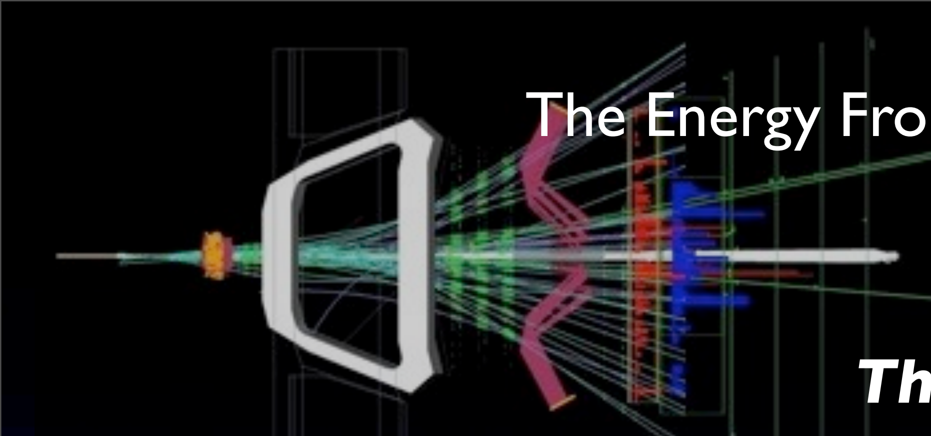
A view from the US

Dreams of New Physics



A view from the US

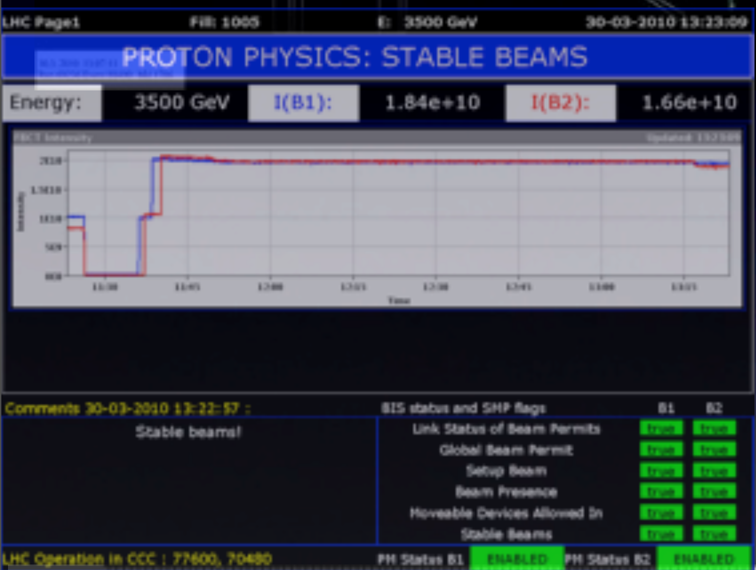
The Energy Frontier moves to the LHC

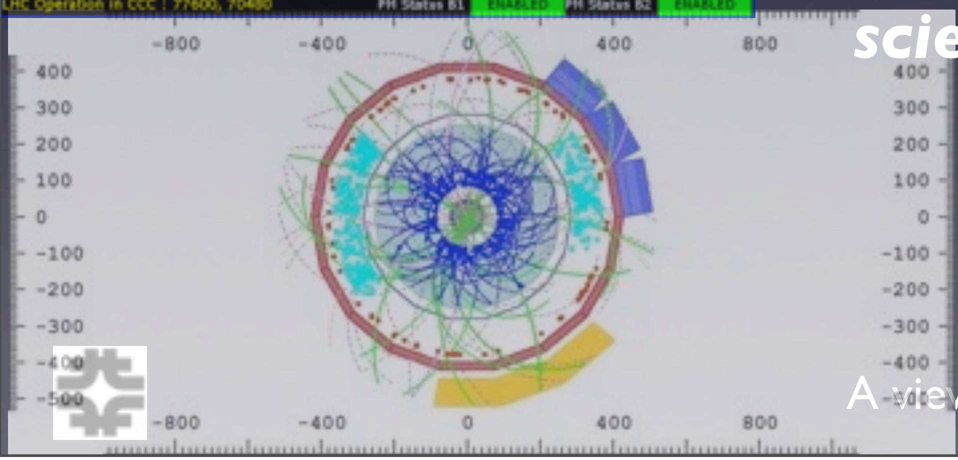


The big event in particle physics and the news of the week!

7 TeV collisions as the world watches.

Many congratulations to CERN and the accelerator team and the experimenters from around the world for this exciting scientific adventure.





A view from the US

March 2010: Women's History Month

Profiles of women at Fermilab online

http://www.fnal.gov/pub/diversity/womens_history/profiles.html

Helen Edwards: "the leader in the design, construction, commissioning and operation of the Tevatron"

CMS Centres in Geneva and Fermilab on March 8, 2010

Figure 1. Percent of faculty positions in physics held by women.

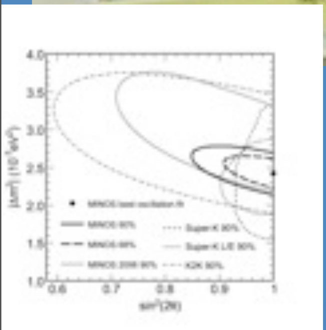
	1998	2002	2006
Academic Rank			
Full Professor	3	5	6
Associate Prof.	10	11	14
Assistant Prof.	17	16	17
Instructor/Adjunct	N/A	16	19
Other ranks	13	15	12
Type of Department			
PhD	6	7	10
Master's	9	13	16
Bachelor's	11	14	19
OVERALL	8	10	13

AIP Statistical Research Center, 2006 Academic Workforce Survey.

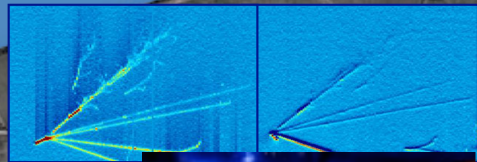
CDF Control Room on March 8, 2010

A view from the US

The Intensity Frontier: Neutrinos from the Main Injector



ArgoNeuT (LAr TPC)

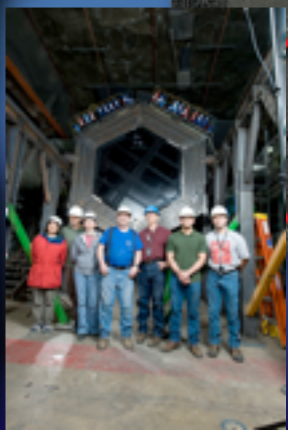


MINOS

MINERvA

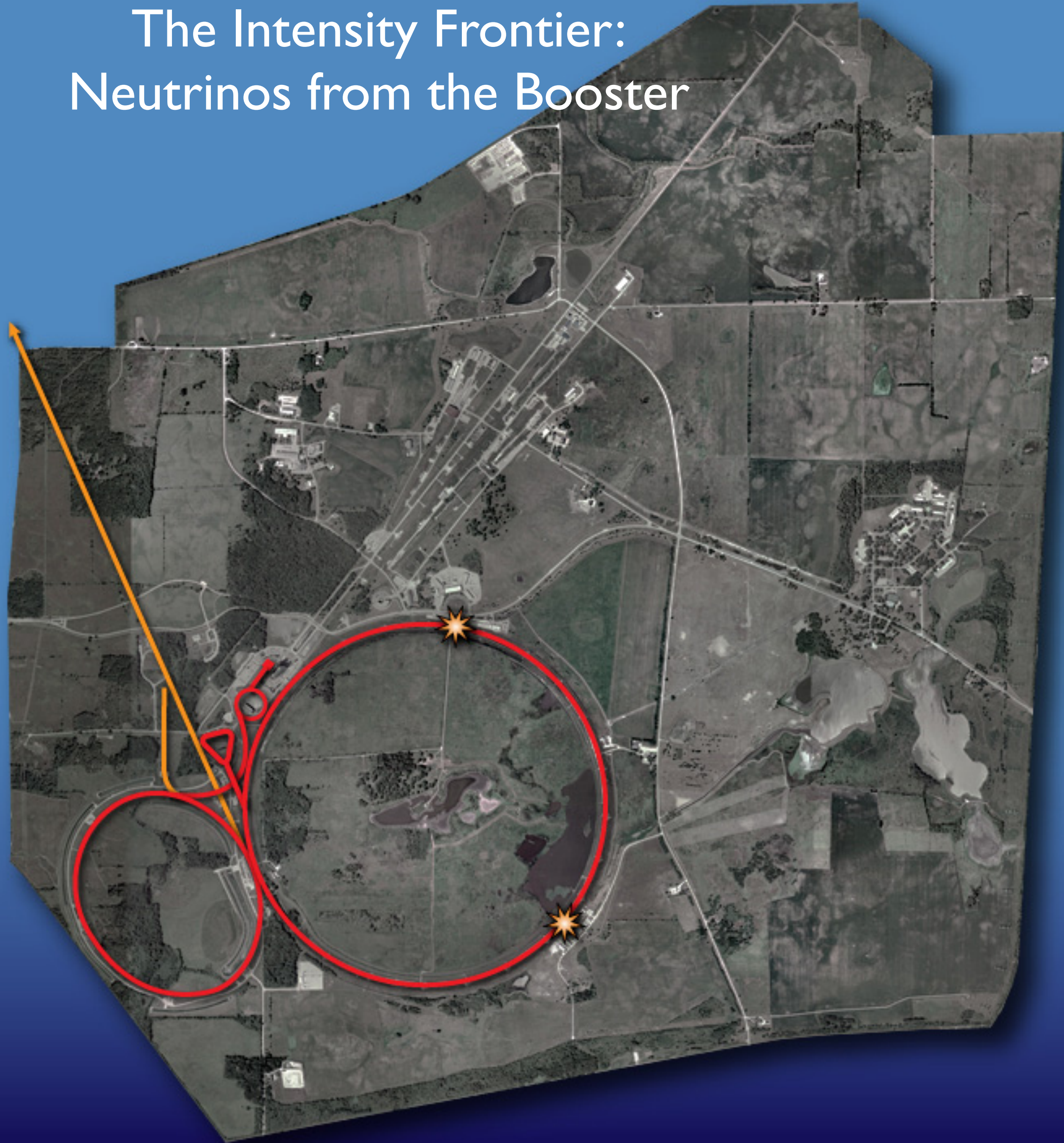
ArgoNeut

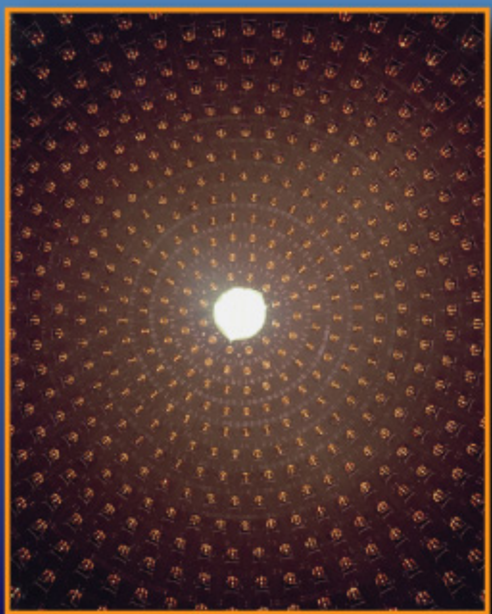
NOvA



The Intensity Frontier: Neutrinos from the Booster

- *MiniBooNE*
- *SciBooNE*
- *MicroBooNE*

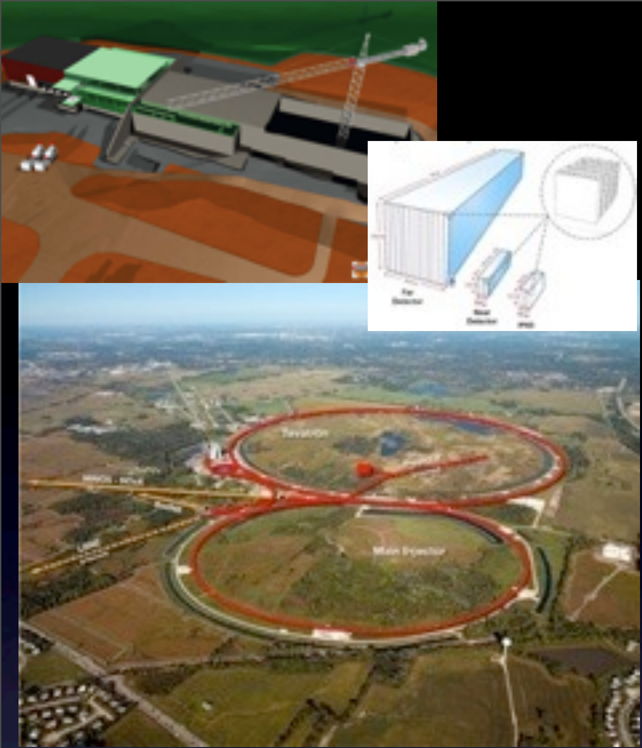


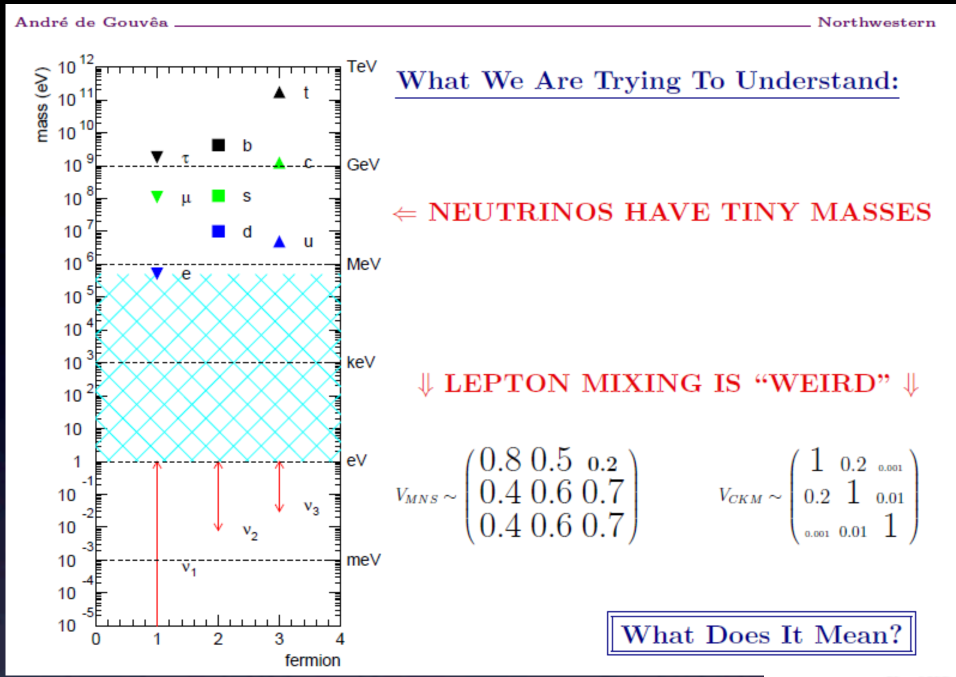


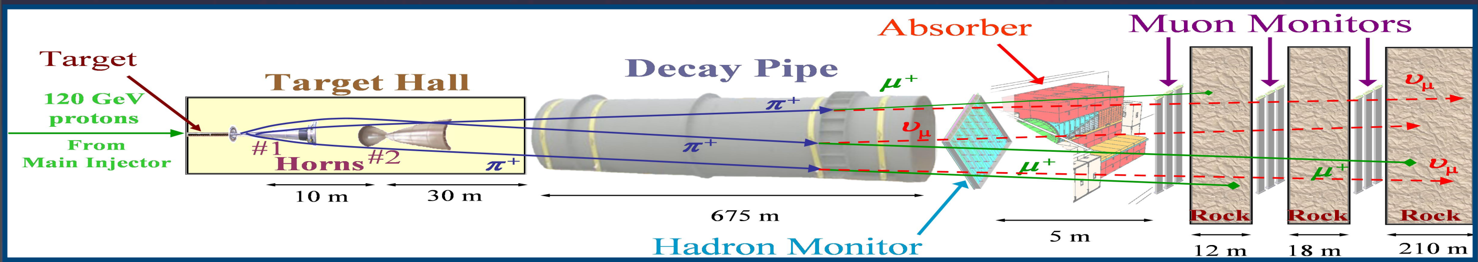
P5 Recommendations - The Intensity Frontier (Neutrinos + rare processes)

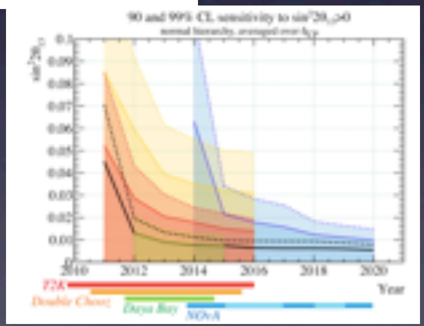
- The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.
- The panel recommends an R&D program in the immediate future to design a multi-megawatt proton source at Fermilab and a neutrino beamline to DUSEL and recommends carrying out R&D on the technologies for a large multi-purpose neutrino and proton decay detector.
- Scientific opportunities through the measurement of rare processes include experiments to search for muon-to-electron conversion and rare-kaon and B-meson decay. Such incisive experiments, complementary to experiments at the LHC, would probe the Terascale and possibly much higher energies.

NOvA









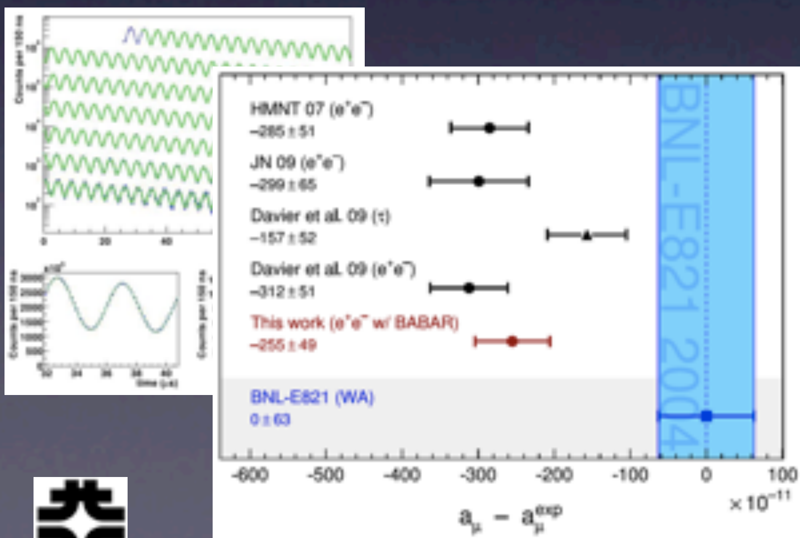
NOvA Far Detector Hall will be complete in Fall 2010

A view from the US

Many Opportunities at the Intensity Frontier

- *Neutrino physics will be the centerpiece of the US-based HEP accelerator program post - Tevatron.*
- *But it is not the only component of an Intensity Frontier Program*
  - *e+e- B factories - exploring options to collaborate on SuperB*
  - *Kaon physics - CP Violation and rare decays using Fermilab facilities*
  - *Looking beyond the SM with muons: Precision measurements and rare decays*

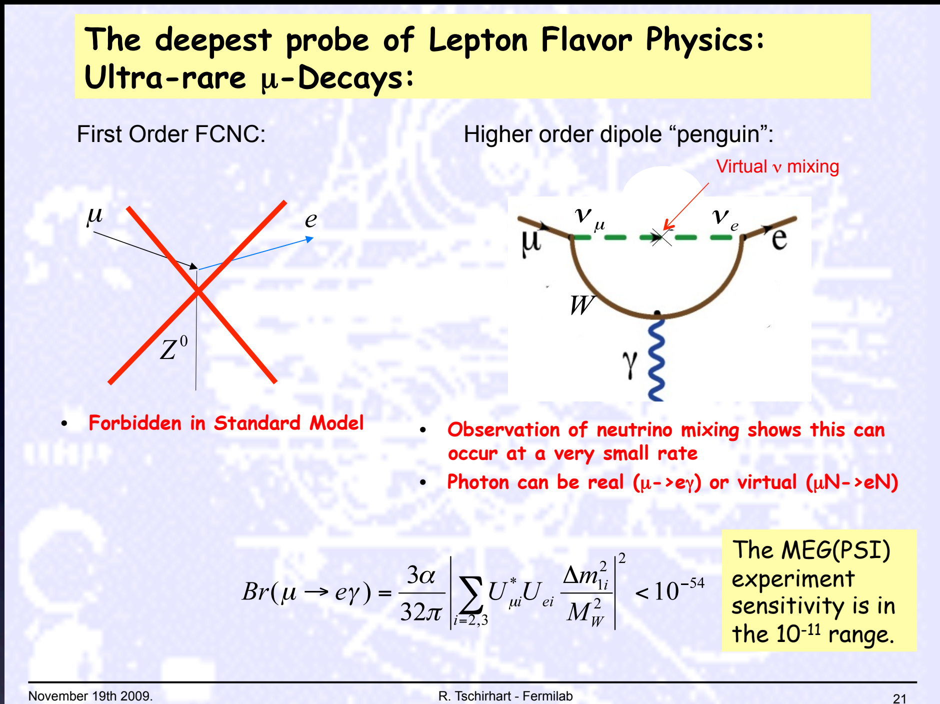
P-989 - proposal to move the BNL experiment to Fermilab is under consideration



plots from BNL 821 g-2

A view from the US

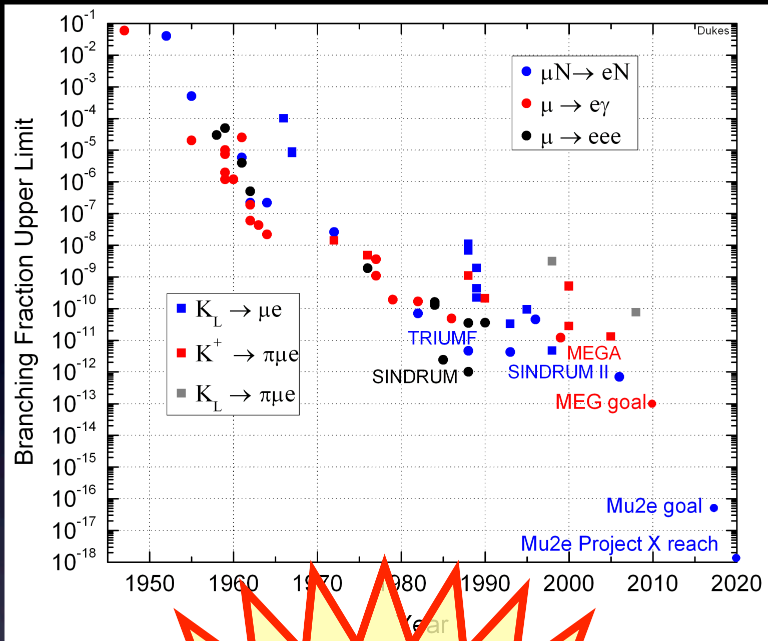
Mu2e at Fermilab



- Rare muon decays at the Intensity Frontier:
  - $\mu^- N \rightarrow e^- N$ Muon to electron conversion in the field of a nucleus
  - Sensitive to New Physics at scales 10^3-10^4 TeV
- Mu2e is an experiment to exploit the existing Booster (8 GeV)
  - $\approx 2.5 \times 10^{17}$ muons/year
  - Uses the Debuncher for stacking and the Accumulator for extraction

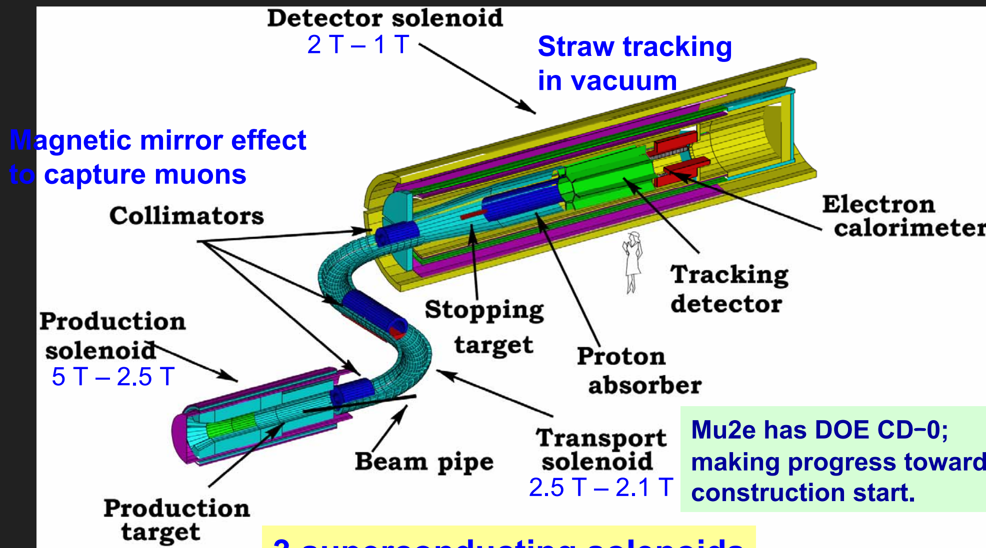
A view from the US

Learning from muons - at the limits of the intensity frontier



Mu2e at Fermilab intends to improve sensitivity by ~10,000 and then up to ~1,000,000 with Project X!

Mu2e at Fermilab



Mu2e has DOE CD-0; making progress toward construction start.

3 superconducting solenoids
non-uniform fields (graded, 1 curved)

J.Ritchie

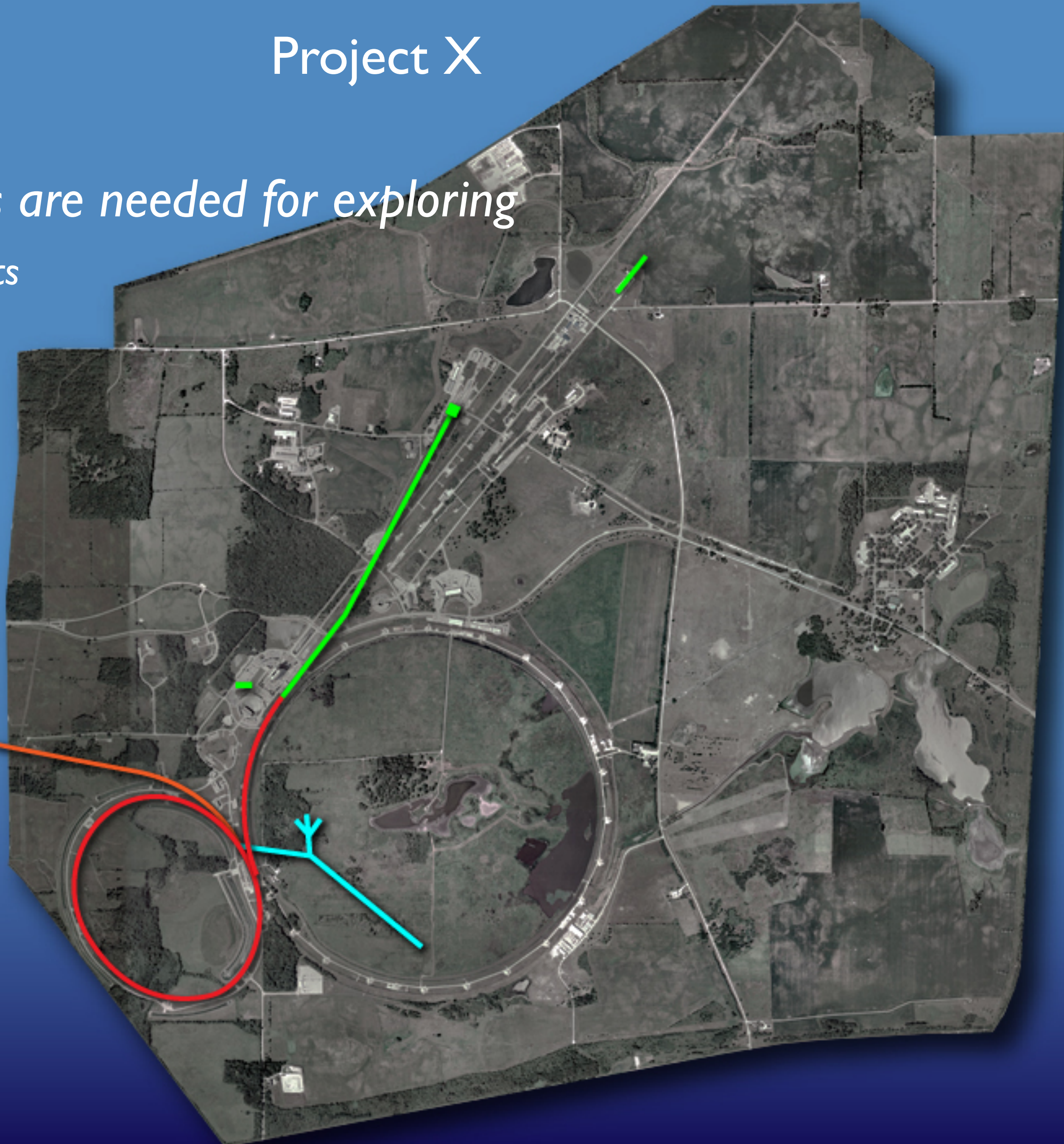
February 14, 2010 APS Meeting 11

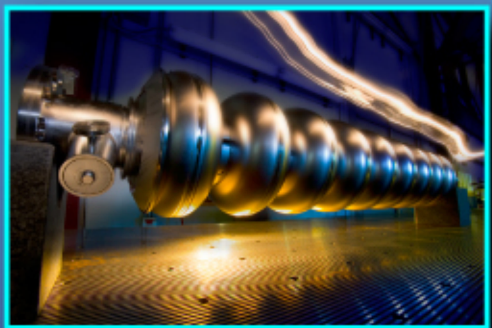
A view from the US

Wednesday, March 31, 2010

Project X

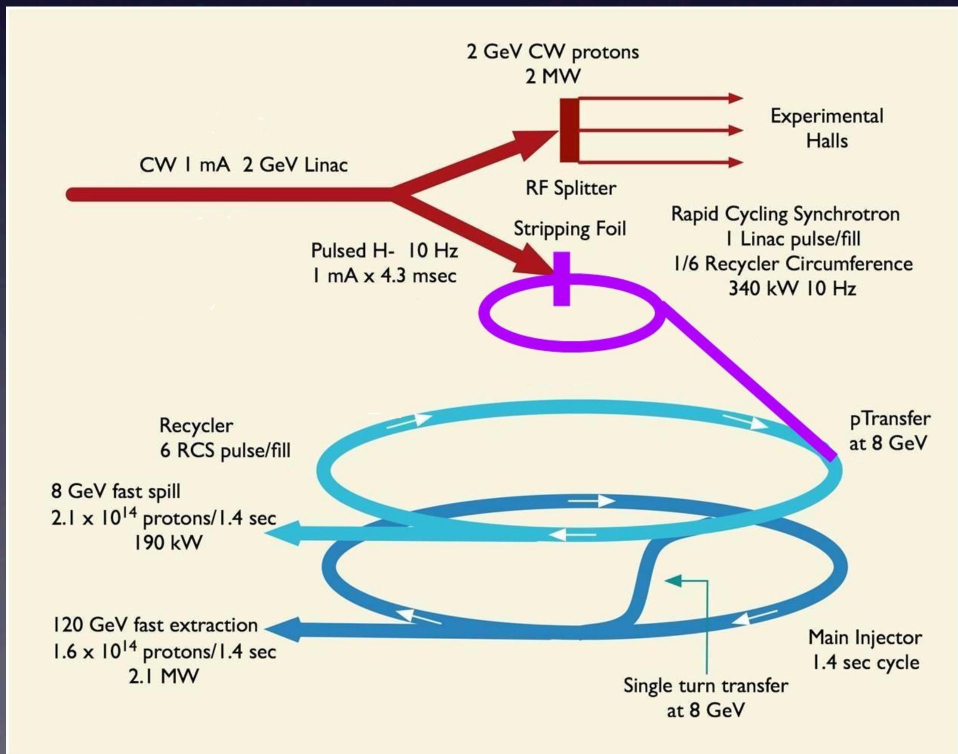
- *Intense beams are needed for exploring*
  - *Neutrino Physics*
  - *Muon Physics*
  - *Kaon Physics*





Project X requirements

- **2-3 GeV protons,** 2 MW CW (continuous pulses at 325 MHz)
  - *Rare processes + precision measurements*
  - *flexible time patterns and pulse intensities*
- **8 GeV protons,** *20 – 200 kW: rare processes + precision measurements*
- **60 – 120 GeV protons**, 2 MW (to Homestake) for neutrinos



Project X

Project X is central to Fermilab's strategy for future development of the accelerator complex:

Energy Frontier: Aligned with ILC technology development; Fermilab as potential site for ILC or a Muon Collider

Intensity Frontier: World leading program in neutrinos and rare processes; Fermilab as potential Neutrino Factory site

- The facility could be constructed over the period ~2013 - 2017
- Integrated effort on Project X, ILC, and Muon Facilities
- Collaboration for design studies being formed

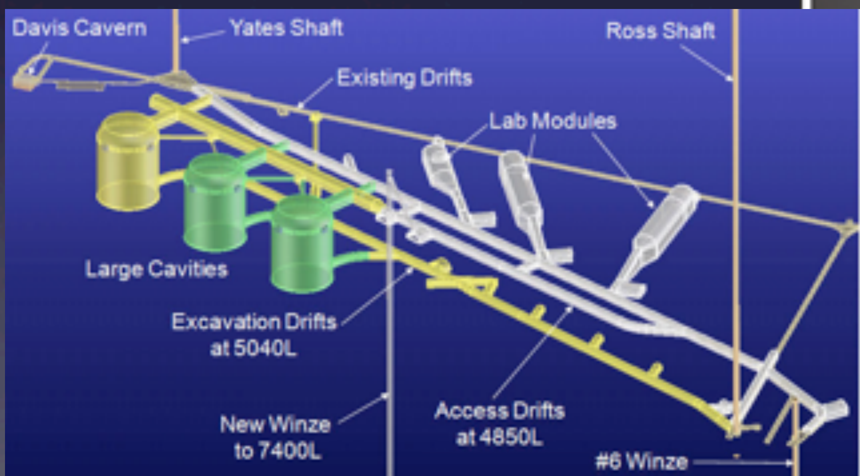
LBNE - Long Baseline Neutrino

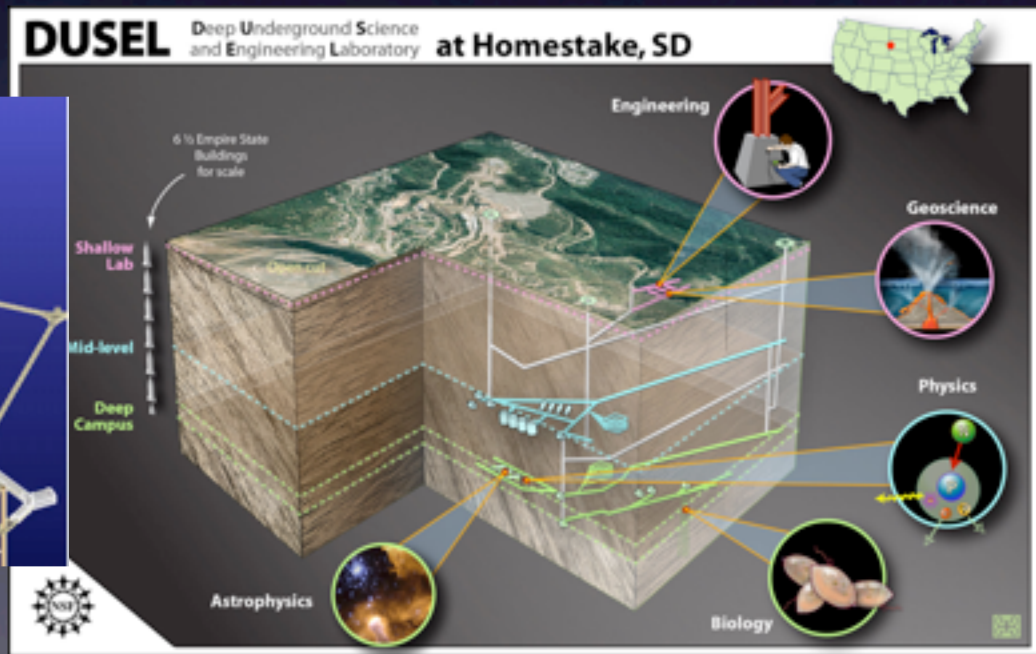
Phase 1 Detector
Phase 2 Full Size Detector
(Proton Decay, Supernova)

Phase 1: 700 kW
Phase 2: Project X
(2.3 MW)

Underground Science - DUSEL

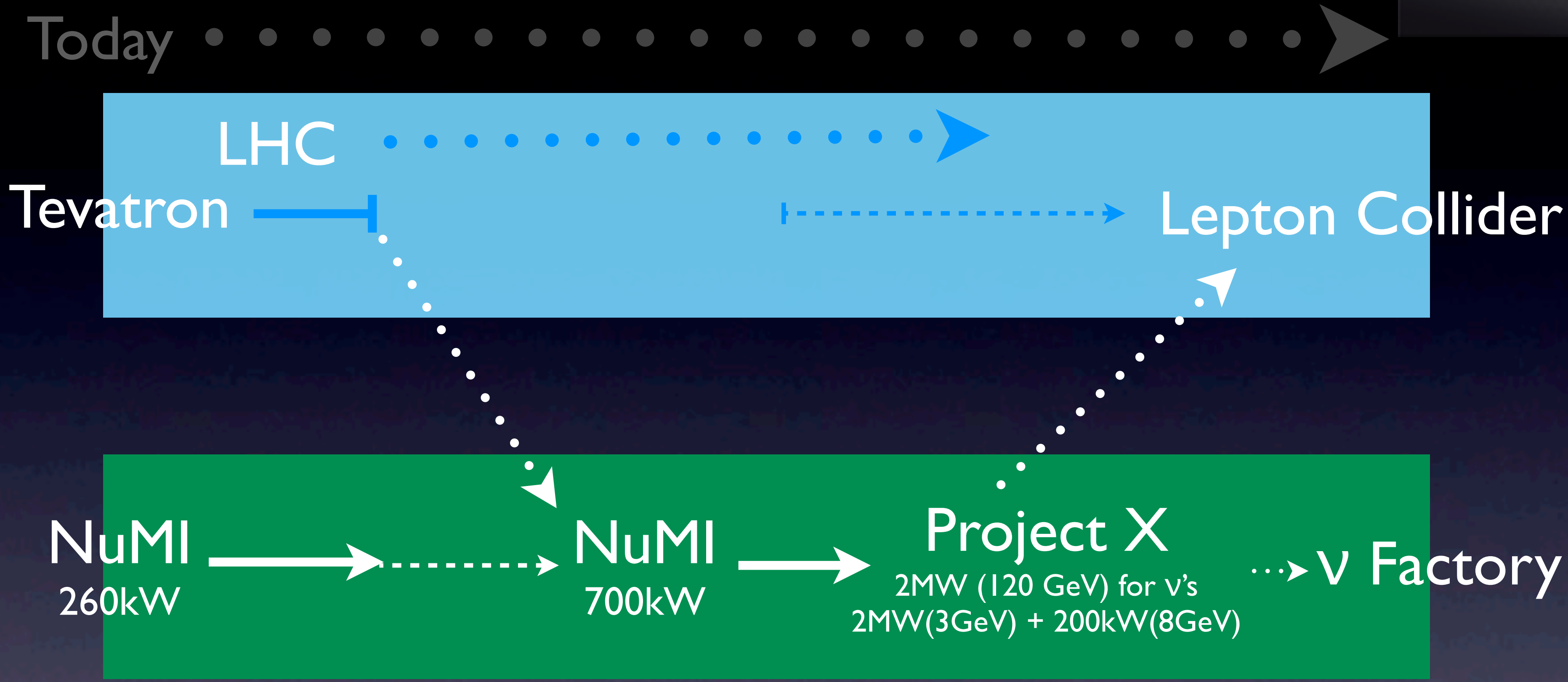
- The National Science Foundation selected the 8000-foot-deep Homestake mine in the Black Hills of South Dakota for the site of the proposed Deep Underground Science and Engineering Laboratory (DUSEL) in 2007.
- In 2008 - P5 panel, urged the funding agencies "to make this facility a reality as rapidly as possible."
- Anticipating the approval of the DUSEL plans for additional caverns and laboratories at the 4850- and 7400-foot levels of the mine in 2011.





A view from the US

Planning for Fermilab Accelerators



MINOS
MiniBooNE
SciBooNE
ArgoNeut

MicroBooNE
MINERνA

NOνA

LBNE
1300km baseline ν

Mu2e
Muon g-2
K+

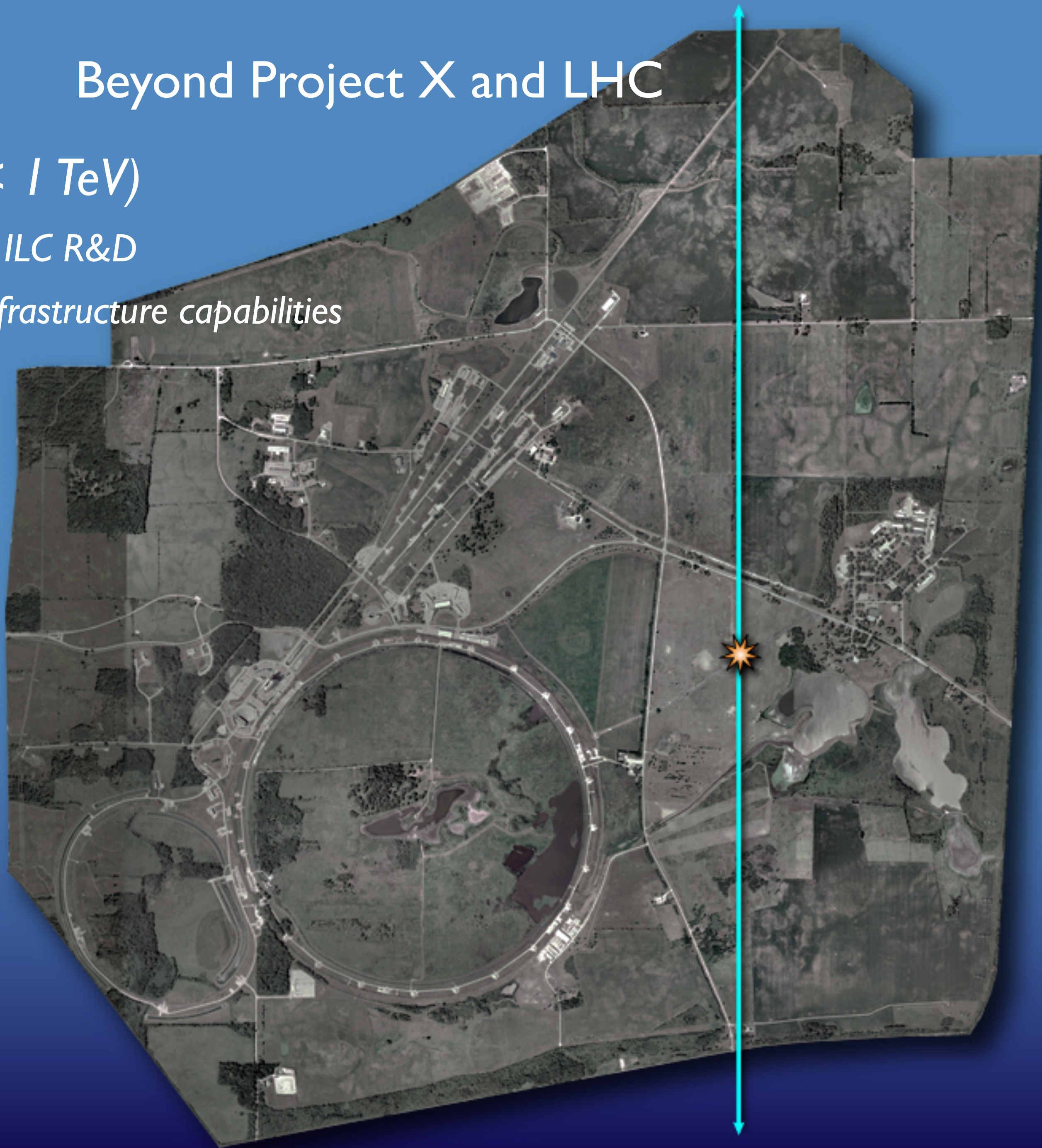
Mu2e II
Muon g-2 II,
K^0/K^L, K^+
Nuclear Physics

A view from the US

not to scale

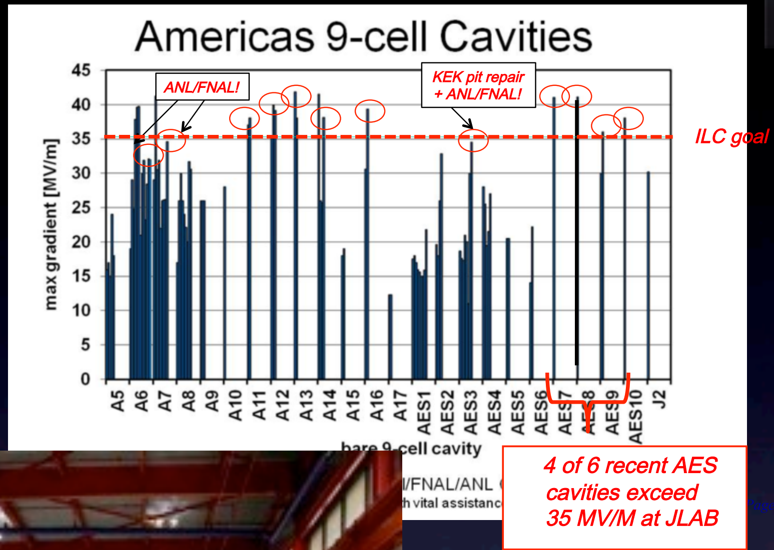
Beyond Project X and LHC

- *ILC (Energy < 1 TeV)*
- *Continued support ILC R&D*
- *Enhancing SCRF infrastructure capabilities*
- *Detector R&D*



SCRF infrastructure

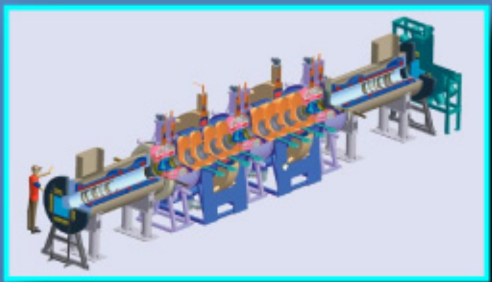
- *SCRF technology enables the future accelerator program and is a key component of the following proposed projects:*
  - *International Linear Collider*
  - *Project X*
  - *Muon Collider*
  - *in addition is needed for Light Sources, ERL, ADS, etc.*
- *Work is needed to "industrialize" cavity production at the required gradients/yields.*

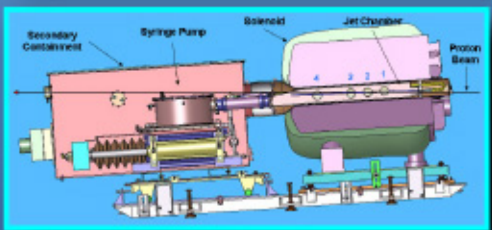


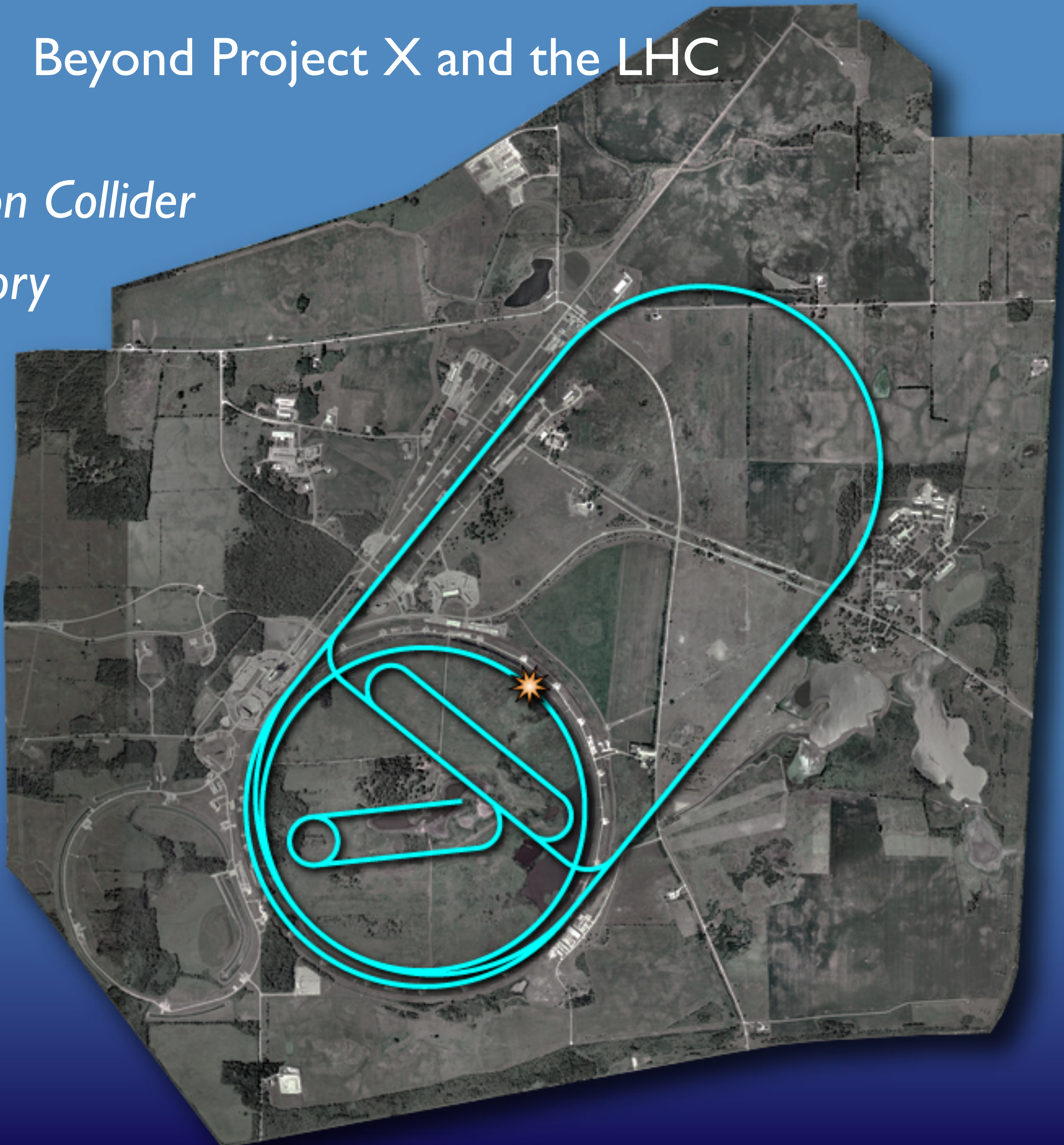
A view from the US

Beyond Project X and the LHC

- *Multi TeV Muon Collider*
- *Neutrino Factory*







Looking to the future: Lepton Colliders

- *LHC data is expected to give us more information about the desired energy for a future lepton collider at the energy frontier*

- *the alternatives for a multi-TeV collider are:*
    - *e+e– linear accelerator (X-band NLC-type or two-beam CLIC-type);*
    - *μ+μ– collider (MC); or*
    - *a plasma wakefield e+e– linear accelerator driven either by lasers or by short electron bunches.*

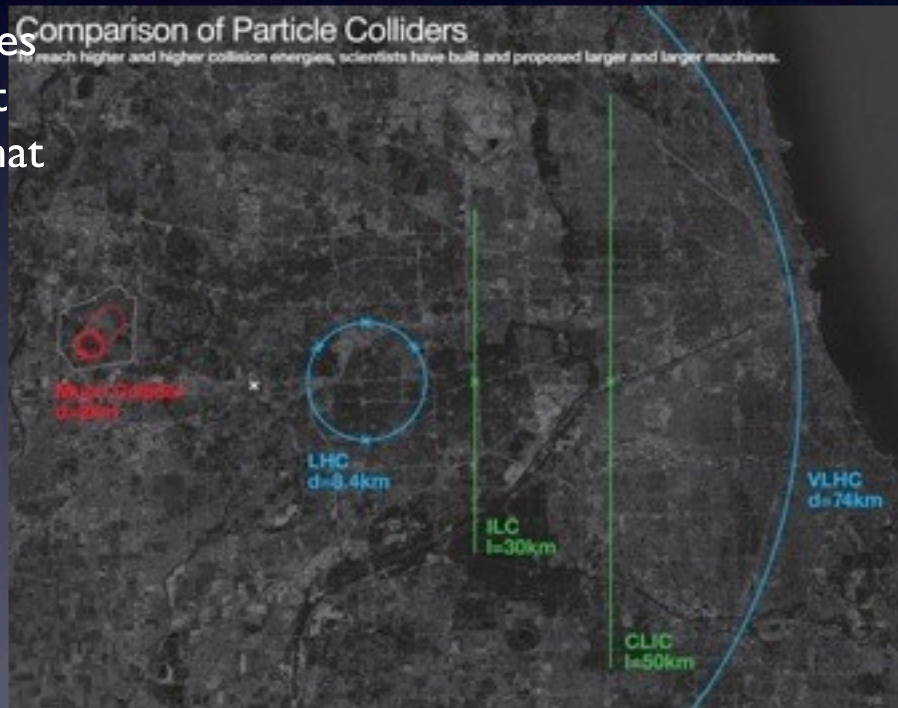
- *A proposal for a multi-year national MUON ACCELERATION R&D program has been submitted.*

US Muon Accelerator Program (2010-2016)

- A Design Feasibility Study Report (DFSR) for a multi-TeV Muon Collider (MC) including an end-to-end simulation of the Muon Collider accelerator complex
- Technology development and system tests that are needed to inform the Muon Collider Feasibility (DFSR) studies.
- Contributions to the International Neutrino Factory Design Study (IDS-NF) to produce a Reference Design Report (RDR) for a Neutrino Factory by 2013.

The Energy Frontier - the scale of the future

We expect that new physics results from the LHC and from the next generation of neutrino experiments (Double Chooz, Daya Bay, T2K, and NOvA) will provide the worldwide HEP community with the knowledge it needs to identify which types of facilities are best suited to fully exploit the exciting new physics opportunities that will undoubtedly arise.



A view from the US

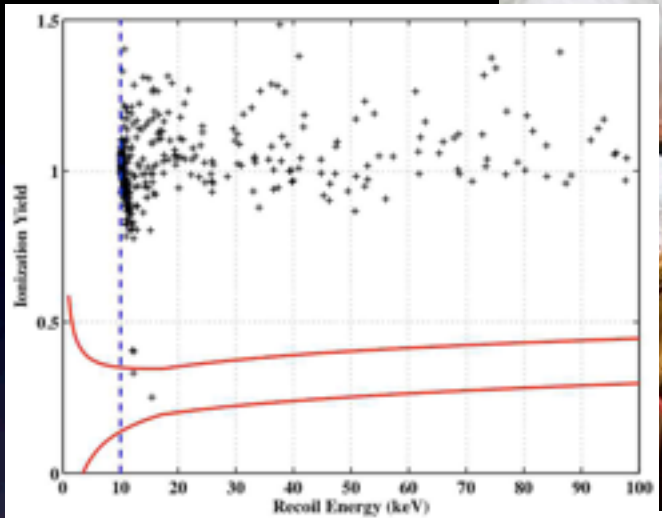
Planning for the Cosmic Frontier

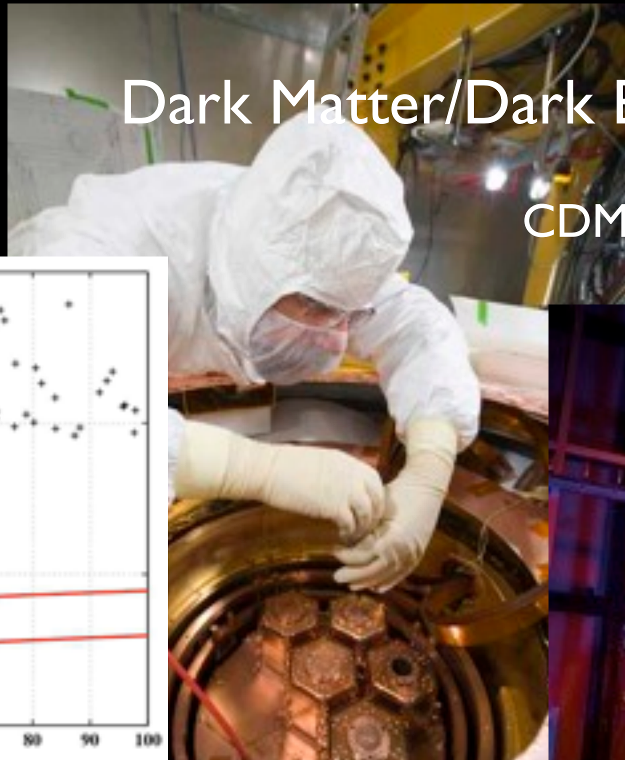
- The Cosmic Frontier can provide unique opportunities to discover physics beyond the Standard Model and to directly address fundamental physics: the study of energy, matter, space, and time.
  - ***Dark matter***
  - ***Dark energy***
  - ***Cosmic particles*** *(high-energy cosmic rays, gamma rays, neutrinos)*
  - ***CMB*** *(B-mode polarization)*
- *The science of the Cosmic Frontier:*
  - *Rapidly evolving field with a multitude of new results and interesting developments*
  - *The science is on the boundary between particle physics and astrophysics (the experiments live there as well and the experimenters too)*
  - *Many interesting proposals for future experiments - unfortunately will have to make choices due to funding constraints while at the same time supporting current projects*

A view from the US

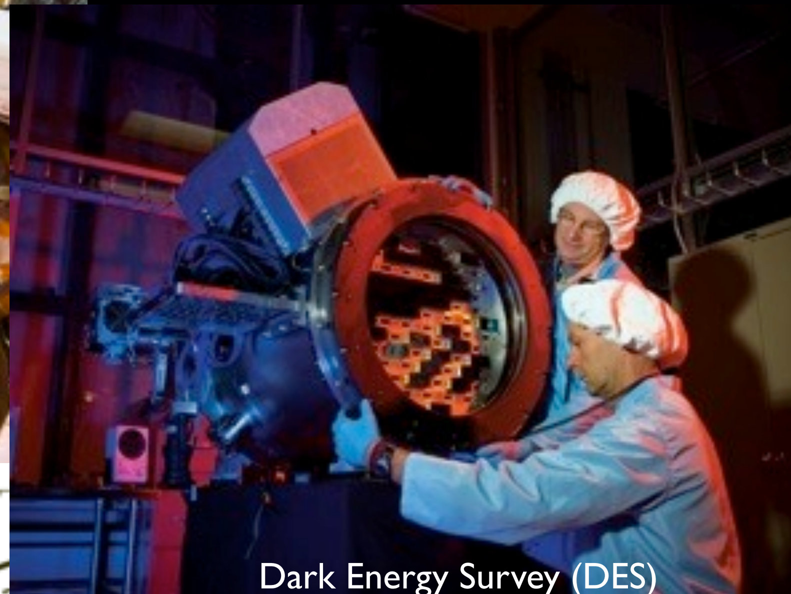
Dark Matter/Dark Energy

recent CDMS -II results





CDMS



Dark Energy Survey (DES)

Future:

SuperCDMS-Soudan 15kg

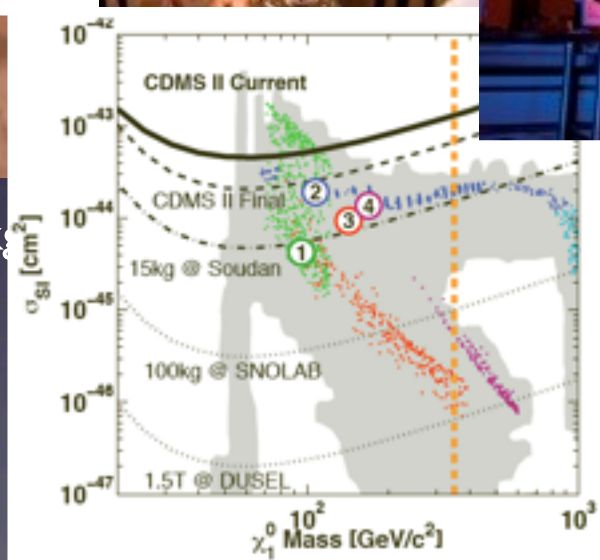
2011-2012: 5 10^{-45} cm^2

Super CDMS-SNOLAB 100kg

2014-2017: 3 10^{-46} cm^2

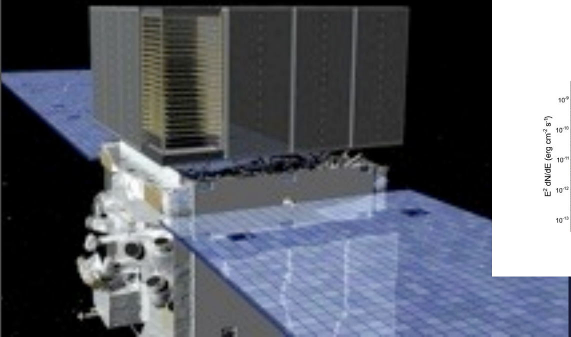
GEODM DUSEL 1.5 tonne

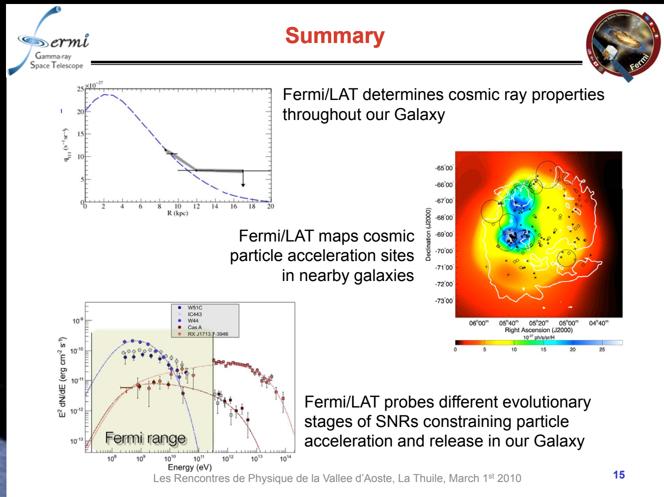
2017-2021: 2 10^{-47} cm^2



A view from the US

Cosmic Frontier in Space - Fermi Mission



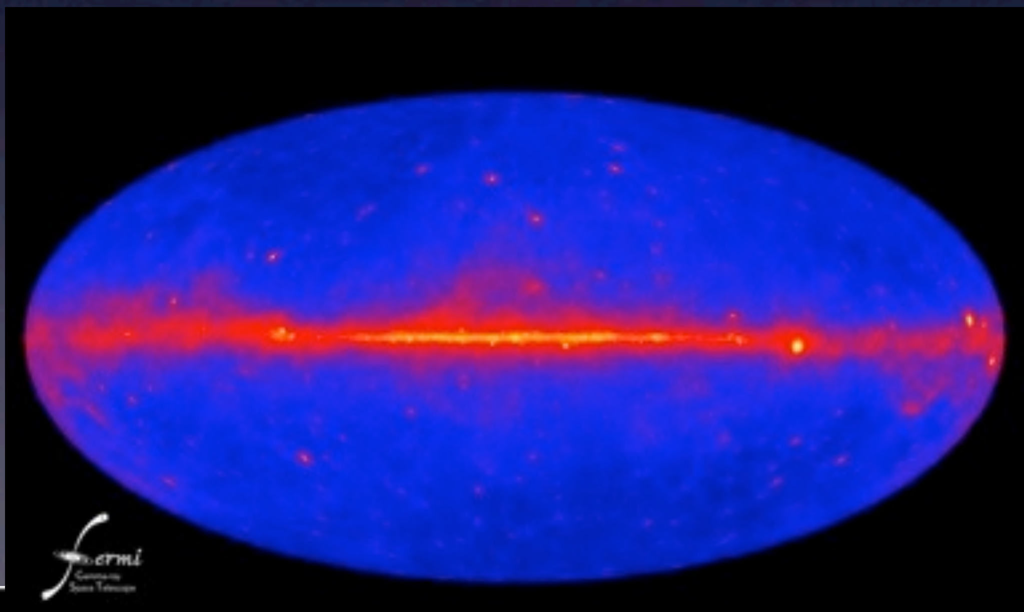


Jurgen Knödlseder at La Thuile

Fermi has observed the gamma-ray sky in the 20 MeV to >300 GeV (LAT) energy range with incredible sensitivity

and has already set *constraints on the nature of dark matter during the first year.*

They expect improvements with higher statistics and a better understanding of the backgrounds - instrumental and astrophysical.



A view from the US

Planning the Cosmic Frontier

- Particle Astrophysics Scientific Assessment Group (PASAG) recent summary of priorities for the US program:
  - **Dark matter** and **dark energy** remain extremely high priorities.
  - Dark energy funding, which receives the largest budget portion, should not significantly compromise U.S. leadership in dark matter, where a discovery could be imminent.
  - Dark energy and dark matter funding together should not completely zero out other important activities in the particle astrophysics program. The recommended programs under the different scenarios follow the given prioritization criteria.
- National Resesarch Council Astro2010 “Decadal Survey” of activities in astronomy and astrophysics is still ongoing.
- In addition, the *OECD Global Science Forum Working Group on Astroparticle Physics follows on the European ASPERA and ApPEC processes.*

Summary

- *Particle physics is a global science. LHC is an excellent example of how this global collaboration can work.*
- *The race is on - expecting exciting results at the summer conferences as the Tevatron and LHC experiments explore the energy frontier.*
- *Looking forward to enhanced power at the intensity frontier and for a new generation of experiments.*
- *Accelerator science has expanded well beyond discovery science.*
- *Exploring the universe without accelerators - Particle physics pushes plans for underground science and for cosmic exploration.*
- *Illuminating the dark world - searches for dark matter using a variety of approaches captivates all of us.*

Many Thanks

- *Many, many thanks to the organizers for being great hosts and providing this wonderful venue for us to discuss physics together.*
- *The combination of Particle and Astroparticle Physics brings out the best in both areas.*

- *We are followining your lead - the DPF and DAP (American Physical Society) are planning to host a joint meeting in 2011.*

- *IUPAP C11 is looking into the format for the traditional summer conferences (ICHEP, Lepton Photon).*
  - *If you have ideas, please send me an email.*

http://www.iupap.org/

More information

US participation in the LHC

- More than 1,700 scientists, engineers, students and technicians
- 89 universities, seven U.S. Department of Energy (DOE) national laboratories, and one supercomputing center
- US participation is supported by the DOE’s Office of Science and the National Science Foundation (NSF).
- Participation in the experiments and the accelerator and planning for the upgrades.

The Energy Frontier - Muon Collider

- Muons created ($p \rightarrow \pi \rightarrow \mu$)

  low production rate so target must survive multi-MW beam

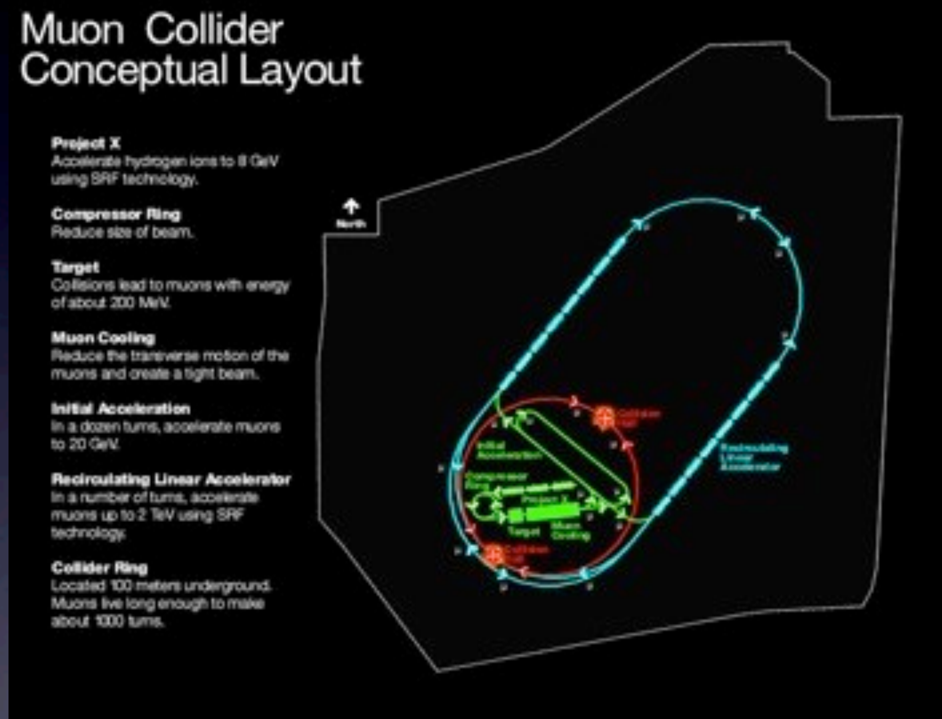
  large energy spread and transverse phase space implies the need for emittance cooling and high-acceptance acceleration system and collider/decay ring

- Muon lifetime (2.2 μs at rest)

  need fast beam manipulation

  - high-gradient RF cavities for cooling
  - ionization cooling
  - fast acceleration system

  decay electrons - heat load in magnets and backgrounds in collider detector



Accelerator R&D - broader impact

Major areas for accelerator R&D:

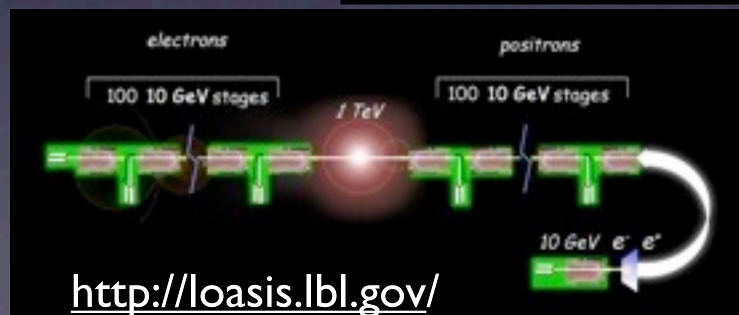
- Discovery Science (Particle, Nuclear Physics)
- Energy and Environment
- Medicine and Biology
- Security
- Industrial Applications

The Future?

Laser Wakefield Acceleration

A laser pulse traveling through a plasma accelerates bunches of free electrons in its wake.

The Department of Energy Office of Science recently hosted a workshop on the planning for accelerator technology R&D - merging of science and technology goals societal impacts.



http://loasis.lbl.gov/

A view from the US

The cosmic frontier program

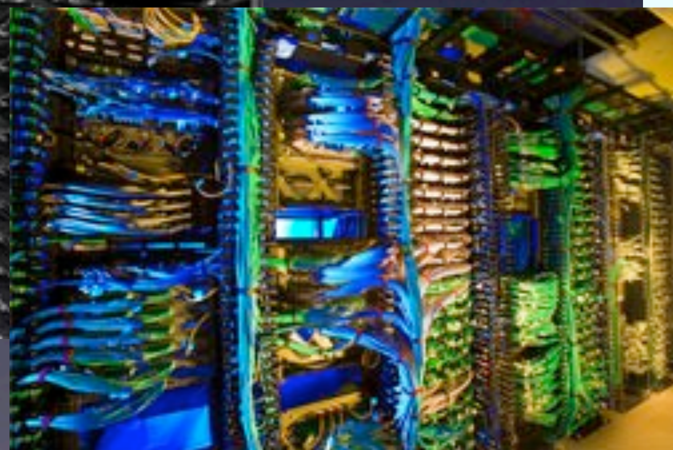
- *A broad, exciting fast moving program*
- *Many on-going experiments addressing the physics of the cosmic frontier: Fermi, AMS, VERITAS, Pierre Auger, Boss, CDMS-II, COUPP, LUX, ADMX...*
- *Many projects in progress (DES, SuperCDMS-Soudan...)*
- *Many R&D programs for future projects - priority according to the guidance of the review committees (HEPAP/PASAG and ASTRO2010)*

Many Exciting Opportunities

- Dark matter direct detection:
  - **next-generation (G2) facilities** capable of reaching sensitivity levels better than 10^{-46} cm^2 (about a factor 400 better than present-day limits and a factor ~10 better than expected for the experiments already under construction). Typical target masses of approximately one ton, with a construction and operation cost in the range of $15M-$20M.
  - **third-generation (G3) experiments** surpassing the $10^{-47} cm^2$ level. Target masses of many tons with a construction and operation cost around $50M.
- Dark energy:
  - **several stage-IV projects have been proposed**, including the space-based Joint Dark Energy Mission (JDEM) and the ground-based Large Synoptic Survey Telescope (LSST), which are large, and the medium-scale ground-based BigBOSS project.
- Cosmic particles:
  - highest energy cosmic rays: providing a factor of seven increase in statistics over the existing capabilities of Auger South and building on its achievements and expertise, the **Auger North** facility has been proposed.
  - to understand features in the cosmic ray spectrum at lower energy, the Telescope Array Low Energy extension (**TALE**) has been proposed.
  - very high-energy gamma rays: (i) providing at least an order of magnitude improvement in sensitivity and new capabilities, the large-scale **AGIS** array has been proposed as a joint effort with the European-led CTA project. (ii) **HAWC**, a different kind of ground-based very high-energy gamma-ray detector, at much smaller scale, that would provide a factor of 15 improvement in sensitivity over its predecessor, Milagro. (iii) a small proposal to **upgrade the existing VERITAS detector**.
- CMB:
  - a relatively small level of support has been proposed for Fermilab participation in the **QUIET II** experiment.

Computing for Particle Physics

- *Preparations for LHC computing have produced a successful worldwide computing system that is able to handle the large datasets that we have been eagerly anticipated.*
- *Other experiments at Fermilab and from other fields of science have profited from the infrastructure and tools that have been developed in preparation for the LHC expts.*



A view from the US