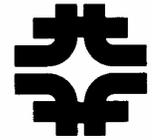




The Fermilab Research Program

Michael Witherell
Annual Program Review
June 8, 2005

Fermilab Today



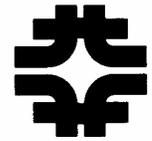
Fermilab leads the United States in carrying out research in particle physics, the exploration of the fundamental nature of matter, energy, space and time.

Overarching goals:

- Maximize the U.S. role in the global program of particle physics research.
- Provide the facilities needed for new discoveries in particle physics.
- Develop new technology needed to advance particle physics in the future.



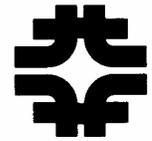
The Fermilab research program



Fermilab

- operates the Tevatron program;
 - CDF and Dzero
- operates a unique neutrino program;
 - MINOS with NuMI vs
 - MiniBooNE with Booster vs
- is building up the CMS research program to optimize the advantage to US researchers and to CMS.
- conducts a growing R&D program on the accelerators and detectors that are needed for the future;
- develops excellent particle astrophysics experiments;
- nourishes theoretical groups who work on the issues that drive experimental particle physics.

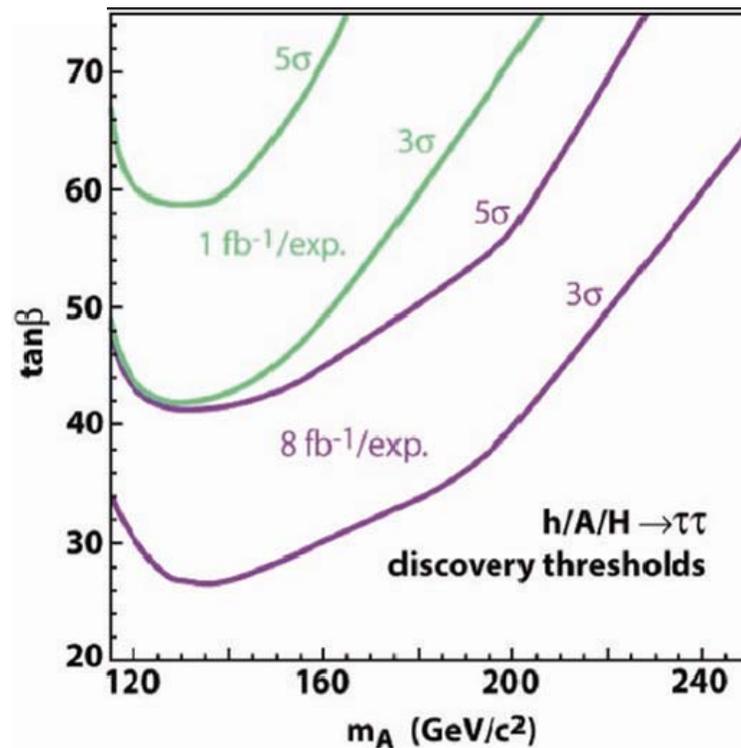
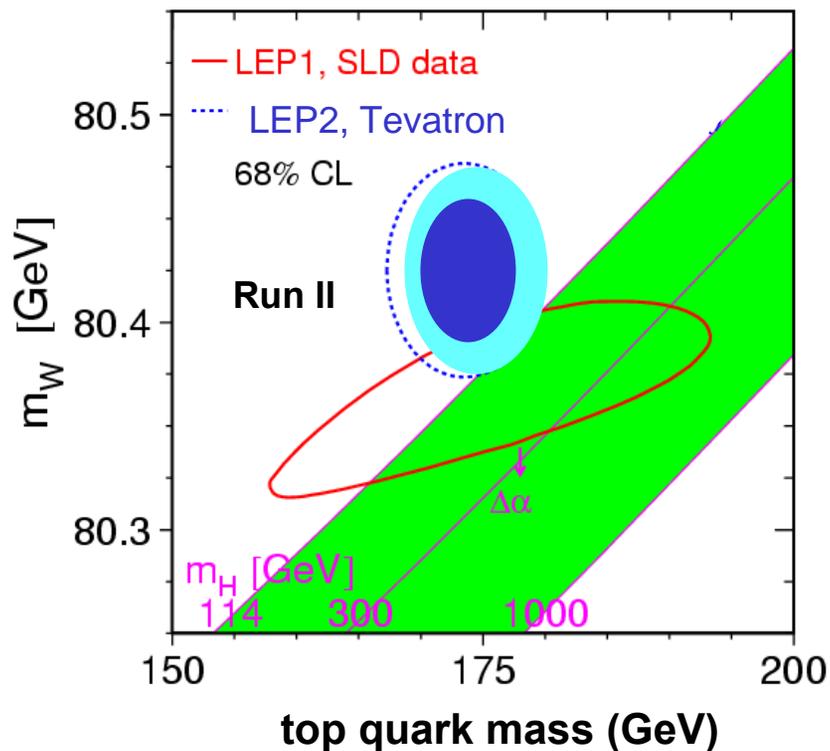
The Run II Campaign



- We are in the middle of a campaign to optimize the science done throughout this period.
 - Organize entire laboratory to support the accelerator effort.
 - Build and install luminosity upgrade projects 2004-2006.
 - Deliver luminosity continuously 2004-2009.
 - Maintain efficient detector operation with modest upgrades.
 - Grow the computer capacity to keep up with the growing data sample.
 - Work with the collaborations to do the best the physics possible with Run II data.

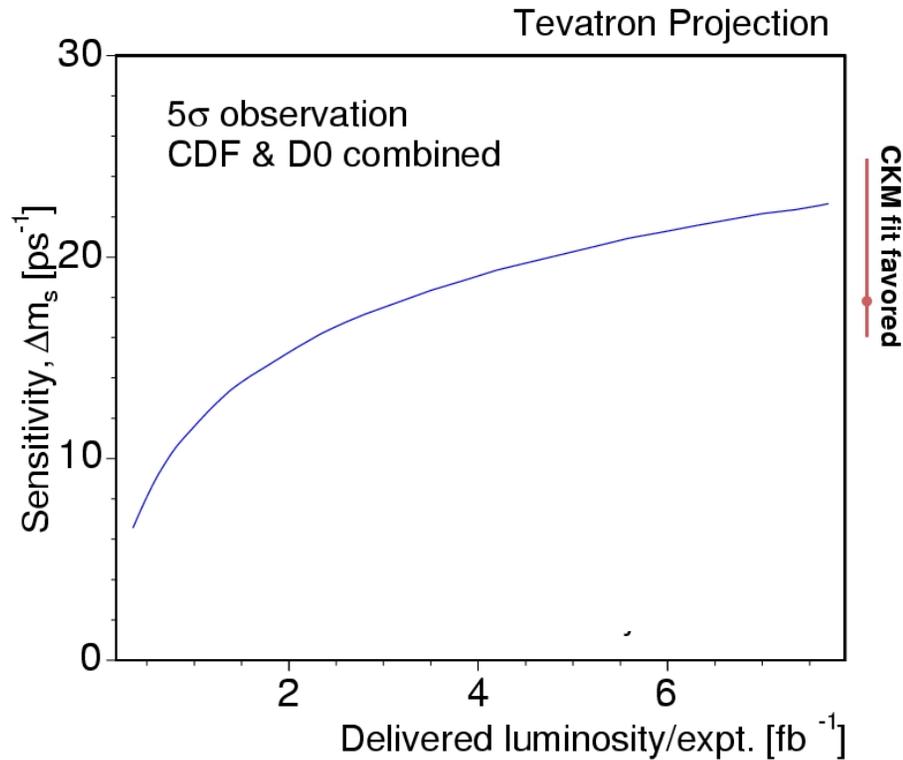
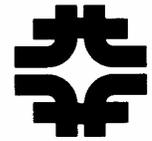


Run II Physics



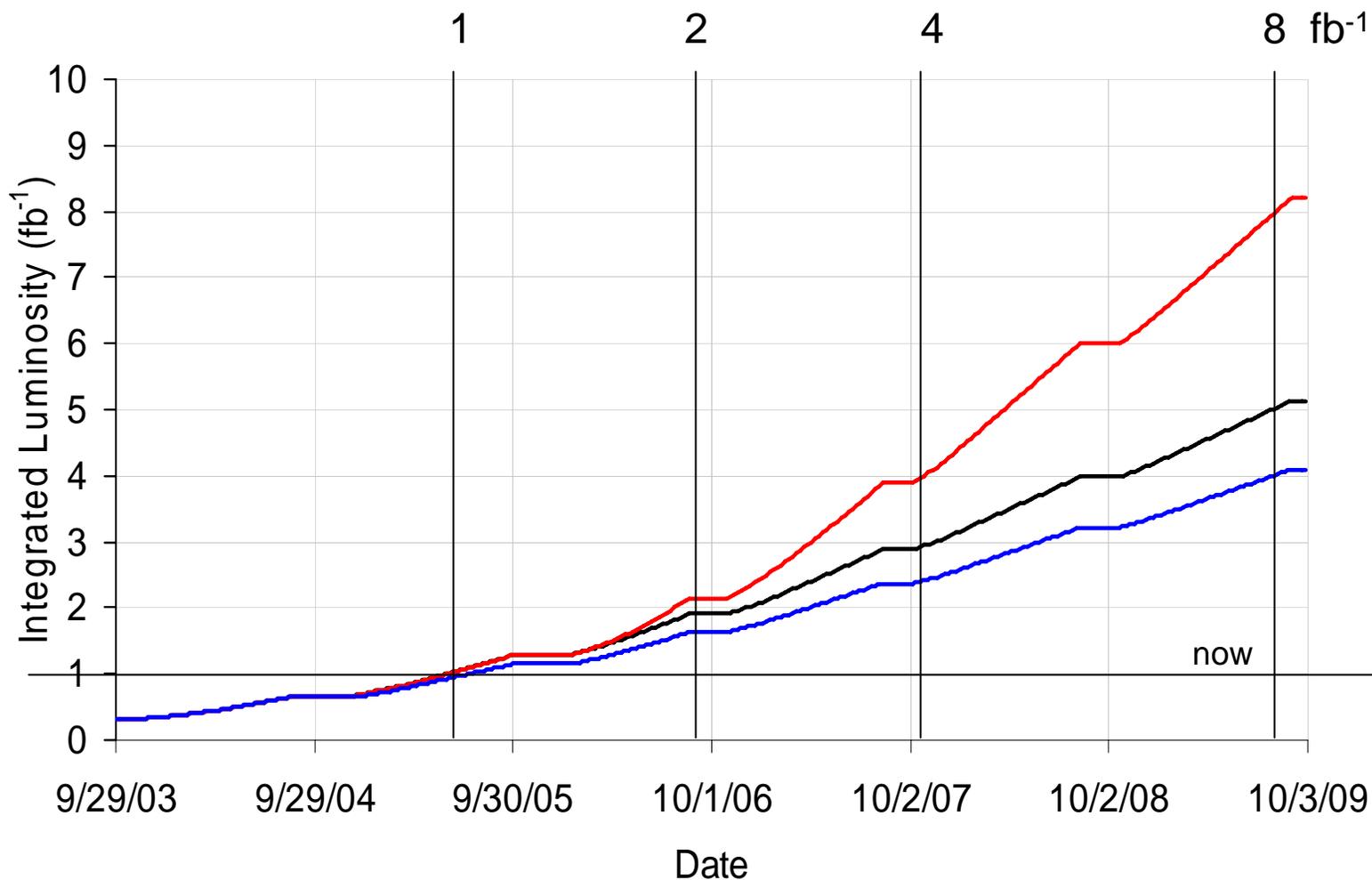
- Test SM Higgs, constrain mass
- Search for MSSM Higgs

Observation of B_s

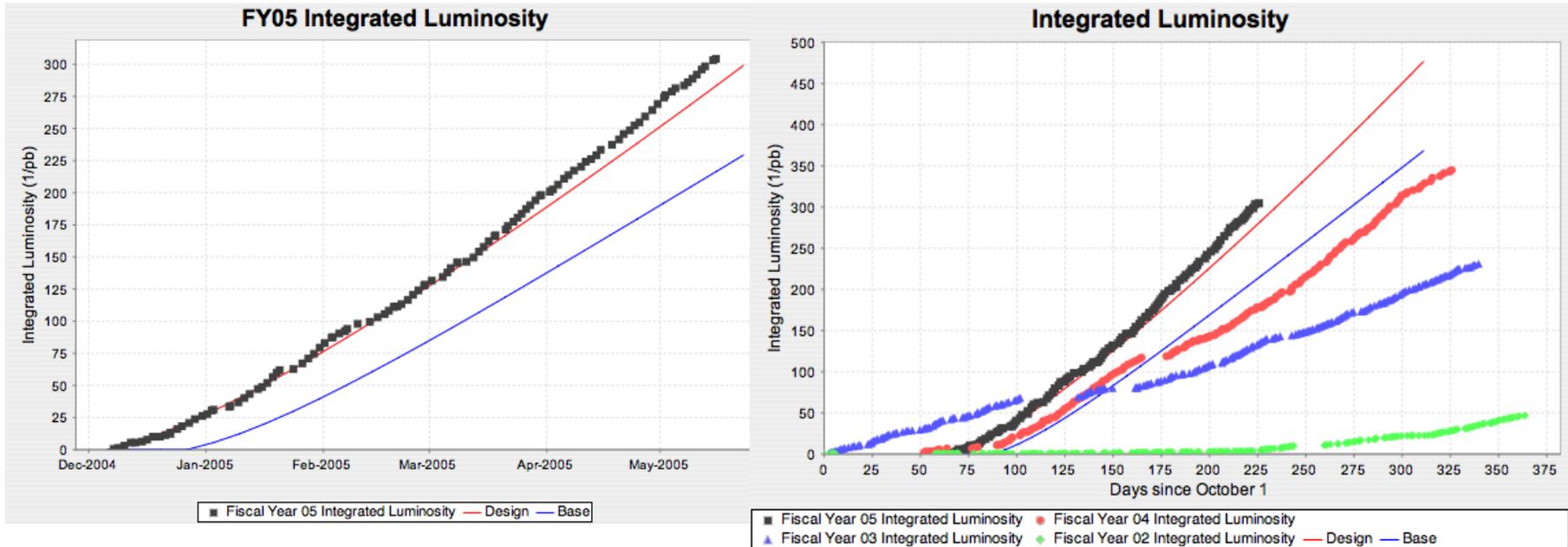
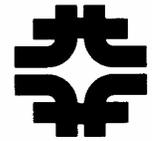


- Project $\sim 5\sigma$ observation at favored value

Projected Integrated Luminosity



Run II: FY 2004 Plan and Status



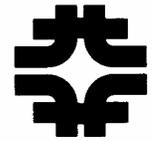
Run II Integrated luminosity $\sim 0.65 \text{ fb}^{-1}$ on 10/04; plan $\sim 1.1 \text{ fb}^{-1}$ by 10/05;
in mid-June we will pass 1 fb^{-1} .

As of 5/17/05, 9 days ahead of the FY05 design curve with 0.31 fb^{-1} .

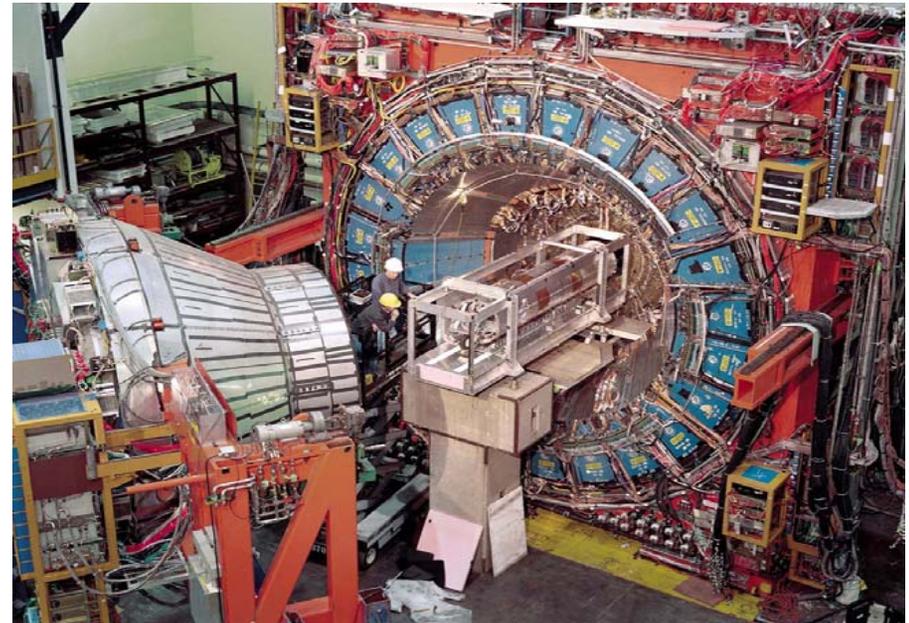
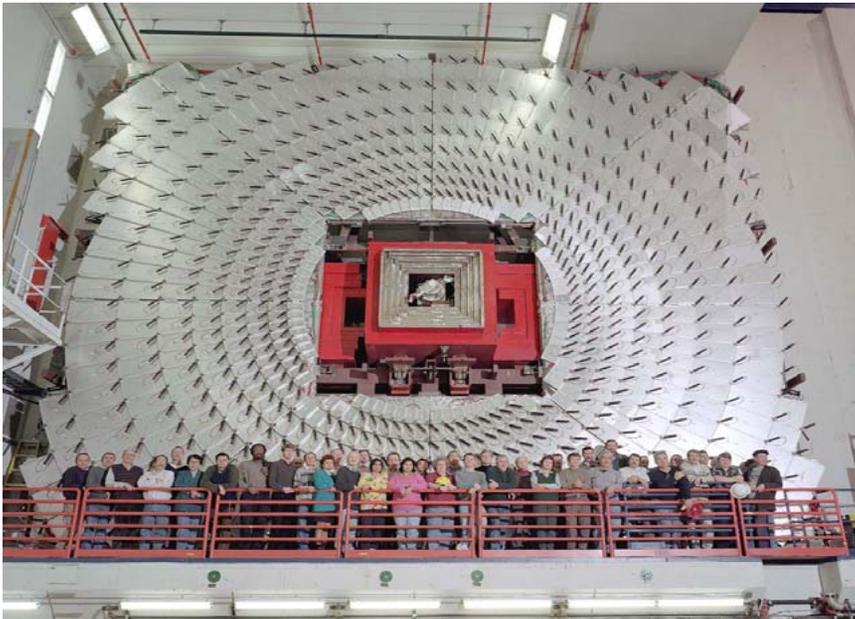
Record week 4/26-5/2: 21 pb^{-1} . Record day 5/14: 4.3 pb^{-1} .

Record luminosity 5/13: $1.27 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$

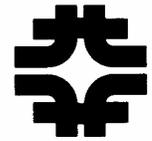
CDF and DZero



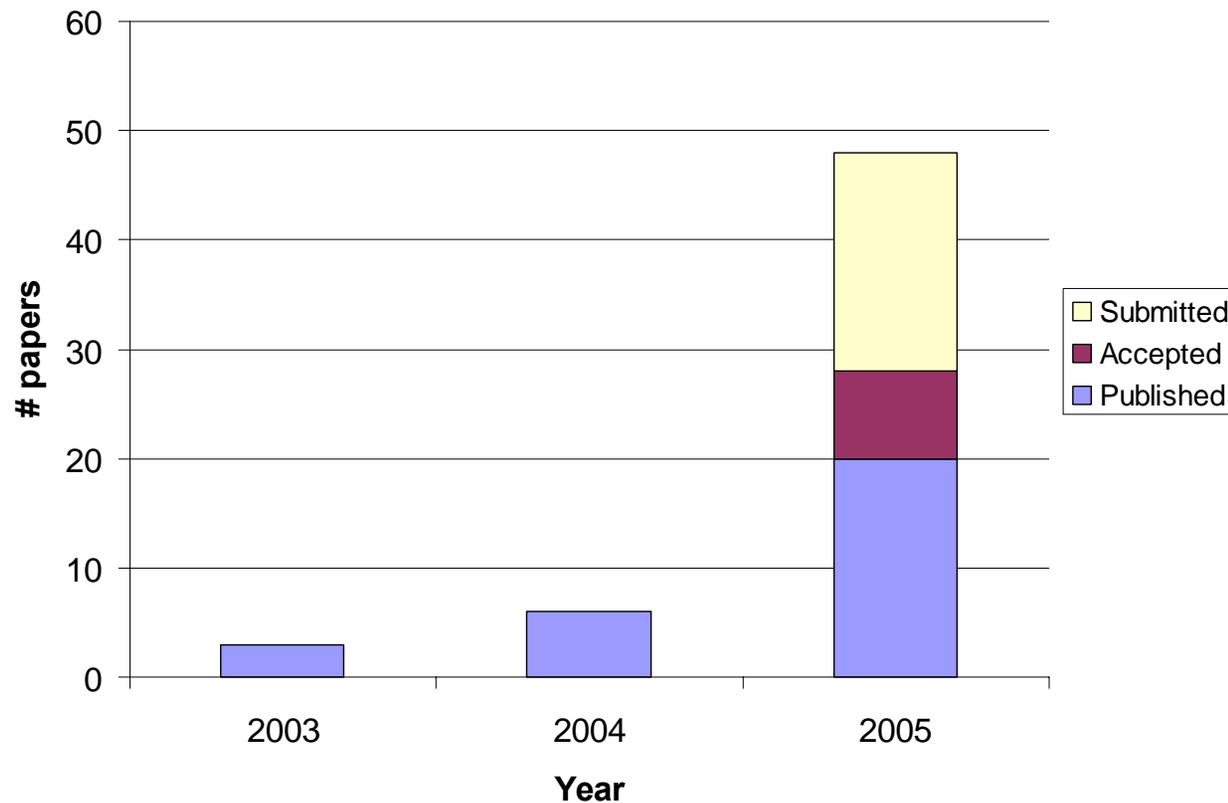
- 1500 collaborators, 600 student & postdocs
- both detectors operating reliably
- mature algorithms for reconstruction and analysis



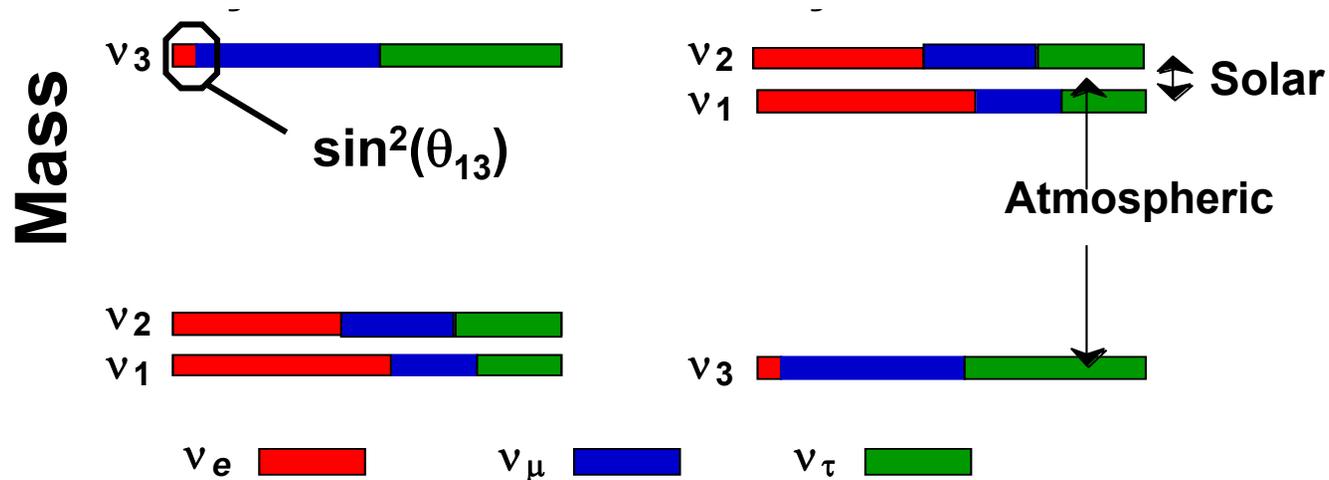
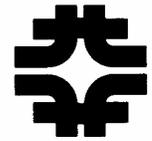
CDF & DZero Physics



Publication of Run II results is in the inflationary era:

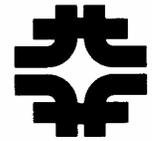


The Neutrino Program

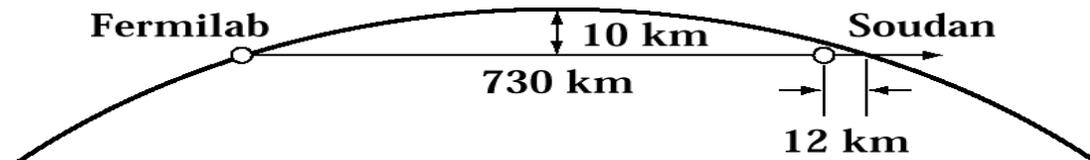


- Fermilab has the only experiments now operating with accelerator-produced neutrinos.
 - MiniBooNE with Booster Neutrino Beam
 - NuMI/MINOS with NuMI neutrino beam

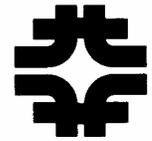
MINOS



- Verify dominant $\nu_\mu \rightarrow \nu_\tau$ oscillations
 - See the characteristic oscillation energy dependence
 - Set a limit on sterile neutrino contributions
 - Study unconventional explanations: neutrino decay, extra dimensions, etc.
- Precise measurement of the atmospheric Δm_{23}^2 : $\sim 10\%$
- Search for $\nu_\mu \rightarrow \nu_e$ oscillations: 3σ discovery about a factor of 2 below the CHOOZ limit.



NuMI-MINOS status



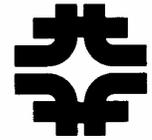
The NuMI construction project is complete.

- MINOS is starting to operate for physics.
 - developed technique for operating with small leak in target cooling system
 - running together with slip-stacking, at intensity of $\sim 1.5 \times 10^{13}$ p @ 0.4 Hz, 2×10^{16} p/hr, 0.1 MW

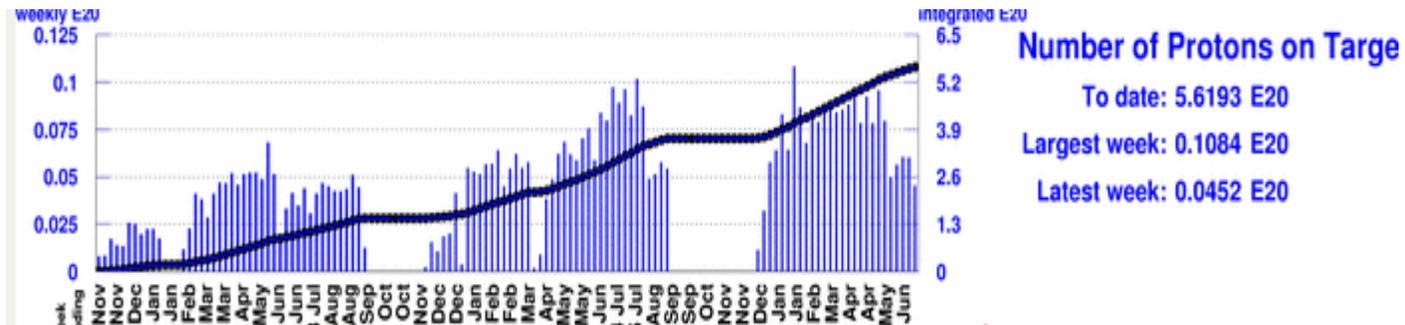


1/21: The first event in the near detector
3/20: The first event in the far detector
5/1: Start of regular operation

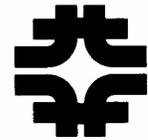
MiniBooNE



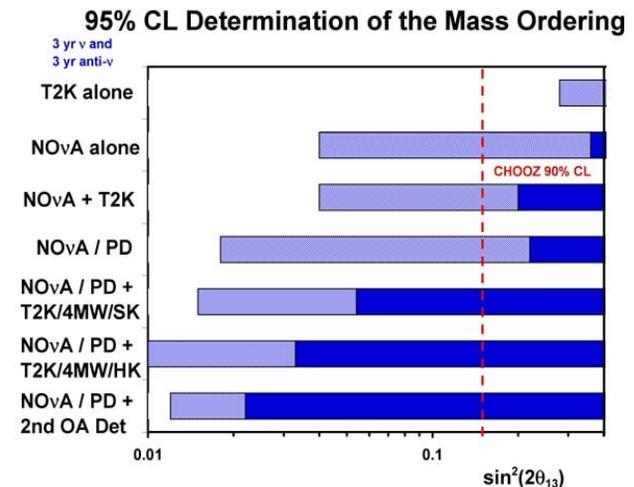
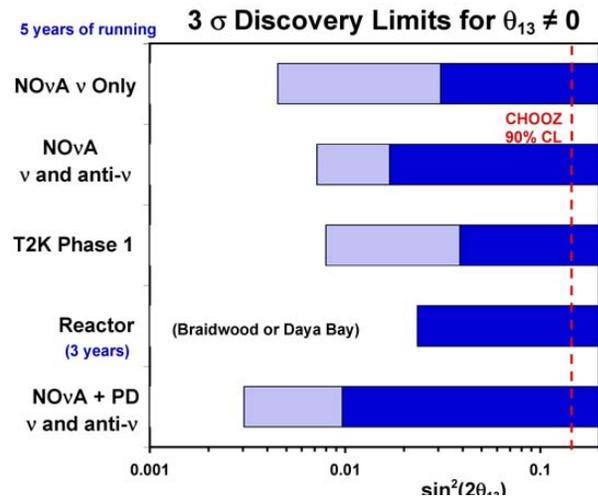
- MiniBooNE is designed to follow up on the LSND evidence of a $\nu_\mu - \nu_e$ oscillation at high Δm^2 .
 - If MiniBooNE confirms LSND, it will change the worldwide neutrino program overnight.
- The beam and experiment are running well.
 - Installed new horn during shutdown.
 - Reached 5.62×10^{20} p.o.t., well beyond the milestone of 5×10^{20}
- The result on ν_e appearance will be known by the end of 2005.



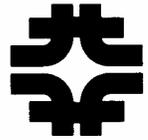
NOvA



- We have granted stage 1 approval to NOvA, a large off-axis neutrino experiment using the NuMI beam. It provides
 - the most sensitive search for $\nu_{\mu} \rightarrow \nu_{\epsilon}$ at the wavelength of atmospheric oscillations;
 - a good measurement of θ_{13} if it is not too small; and
 - a unique capability to resolve the mass hierarchy.
- NOvA is the first stage of a flexible program where each stage can be planned according to what has been learned in previous stages.

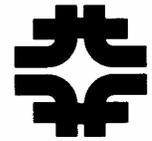


Minerva



- We have also given stage 1 approval to Minerva, a smaller neutrino experiment designed to operate in the NuMI beamline at short baseline. It is designed to provide measurements of exclusive neutrino cross sections at energies crucial for oscillation experiments.
- The existing measurements come from bubble chamber experiments in the 1970s.

CMS at Fermilab

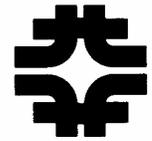


- The US-CMS has delivered many detector systems, but much of the work on tracking systems is still ahead.
- Fermilab is moving to make it possible for scientists on US-CMS to take full advantage of the LHC data. This requires collecting here
 - computing infrastructure,
 - leaders in CMS computing and software,
 - a critical mass of intellectual talent involved in the research.



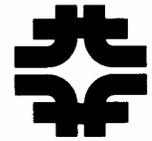
The new LHC Physics Center on the 11th floor.

LHC Accelerator Program

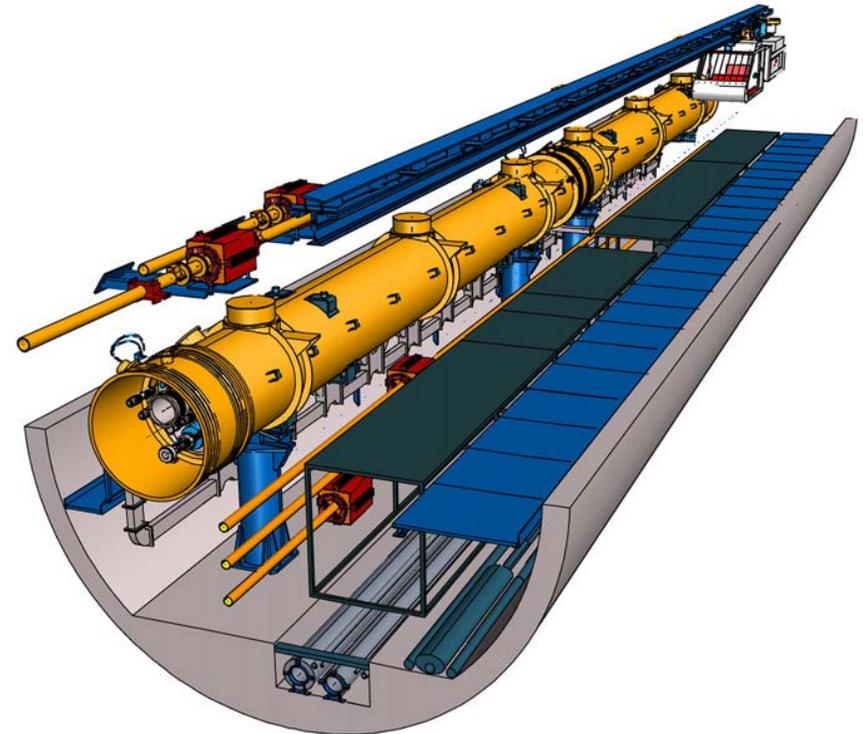


- The US-LHC accelerator project continues to finish good magnets and send them to CERN.
- Fermilab is also the host laboratory for the LHC Accelerator Research Program (LARP).
 - Steve Peggs has a Fermilab appointment as program manager for this effort.
 - US accelerator physicists will on commissioning the LHC
 - US cryogenic magnet experts will work to develop higher-strength quadrupoles using new SC materials to increase luminosity
- We are studying the design of a remote operations center serving both LARP and US-CMS.

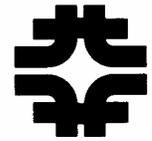
The International Linear Collider



- The revolutionary discoveries at the LHC will focus additional attention on the science program of the International Linear Collider



Fermilab and the ILC

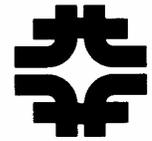


- We stated to the International Technology Recommendation Panel:

“In the event of a cold decision Fermilab would be ready and able to assume the leadership role in establishing a U.S. collaboration to push the SCRF development under the aegis of an international LC organization.”

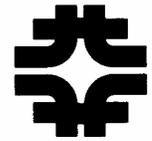
- We have a responsibility and a strong interest to follow through on this commitment.
- We have made a lot of progress in about 6 months.
- The centerpiece of the superconducting rf development will be the Superconducting Module & Test Facility.

Fermilab and the ILC



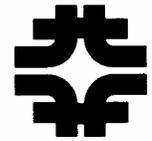
- We were limited to \$3 M of support for linear collider per year, 2000-2004.
 - This was fixed in our budget document, not a Fermilab decision.
- We also were host to a small but effective program in superconducting rf development.
- With DOE's concurrence, we were able to redirect both of these programs into ILC R&D within the tight budget constraints of FY 2005. We immediately assembled a team that can be immediately redirected to support the SCRF work.
- We will need to increase this further to keep ILC moving at the desired rate in '06 and '07.

Fermilab as a site for the ILC



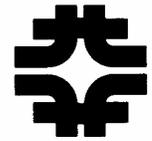
- We believe Fermilab has several advantages as a site.
 - a site nearby an operating HEP lab
 - large supply of trained and talented people
 - very good geology
 - modest power and construction costs
 - convenient to international airport
- Ray Orbach has announced that Fermilab will be the U.S. site advanced to the Global Design Effort.

Experimental Astrophysics



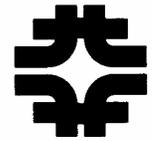
- The experimental particle astrophysics efforts are making excellent progress.
 - The Sloan Digital Sky Survey is producing important discoveries continuously. The extension is now funded.
 - The Cryogenic Dark Matter Search (CDMS) has first results from a short run with one tower in Soudan. They are leading the world already.
 - The Auger cosmic ray observatory is the largest operating cosmic ray array. Construction of the full observatory continues in Argentina.
 - The Dark Energy Survey collaboration is growing and is well along in developing a funding plan.
 - There is a small R&D program on JDEM.
- On November 1, we established the Particle Astrophysics Center with Rocky Kolb as head.
 - unifying experimental and theoretical astrophysics

Theoretical Particle Physics



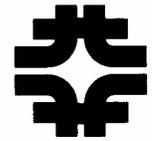
- The Fermilab particle theory group is doing excellent theoretical research related to all of the principal areas of experimental particle physics.
 - They do very well at training theoretical particle physicists working on problems relevant to the experimental program.
- The strong lattice QCD group has teamed with university groups in proposing to DOE a coordinated lattice QCD strategy for the U.S.
- The group has an important role in planning the U.S. program in particle physics.

Theoretical Astrophysics



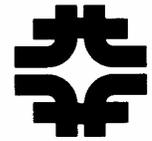
- The Fermilab theoretical astrophysics group has been a leader in research at the overlap of particle physics, cosmology, and astrophysics.
 - NASA renewed the grant that partially funds this group.
 - Members of the group directly participate in the SDSS science, as they will on JDEM.
- The group has an important role in planning the U.S. program in astroparticle physics.

Computing at Fermilab



- Fermilab is a leader in the development of the large-scale computing facilities needed for particle physics.
 - Run II computing project was a success.
 - We are planning the computing evolution for the rest of Run II.
- Fermilab is also leading the US-CMS computing and software effort.
- Other special projects
 - SciDAC
 - Grid projects
 - Lattice QCD project

The last year at Fermilab



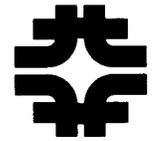
- Run II

- Increased Run II integrated luminosity from ~ 0.5 to 1.0 fb^{-1} .
- Increased record luminosity from 0.7 to $1.23 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$.
- Integrated Recycler into routine operations.
- Set new records for stacking rate using slip-stacking.
- Installed the e-cooling apparatus into the Recycler.
- Produced a lot of physics results

- Neutrinos

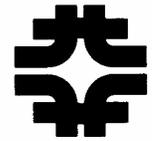
- Completed NuMI project and celebrated.
- Commissioned NuMI beamline.
- Started MINOS physics run.
- Increased MiniBooNE total POT from $2.8\text{E}20$ to $5.6\text{E}20$.
- Installed Replacement MiniBooNE horn.

The last year



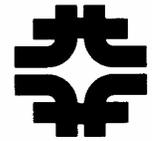
- External 120 GeV beams
 - Operated MIPP experiment measuring central production of hadrons.
 - Operated Main Injector test beam.
- Experimental astrophysics
 - Operated CDMS-II in Soudan, produced results that are best in the world, installed more detectors.
 - Built toward full Auger while taking data with largest operating array.
 - Operated SDSS and made important discoveries.
 - Developed Dark Energy Survey.
 - Did some work on the Joint Dark Energy Mission.

The last year



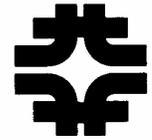
- We published the long-range plan in May, 2004 and took several immediate steps to implement it.
 - advanced ILC R&D and advanced ILC organization.
 - started SCRF test facility, SMTF.
 - did Proton Driver design study and technical review.
 - did Proton Driver physics study.
 - developed NO ν A and smaller neutrino experiments
 - established LHC physics center (LPC).
 - launched LHC accelerator research program (LARP).
 - established Center for Particle Astrophysics.
 - are reacting to cancellation of BTeV in FY 2006 budget request

Fermilab's core capabilities



1. Construction and operation of accelerator facilities for particle physics
2. Construction and operation of experimental facilities for particle physics and particle astrophysics
3. Research, design, and development of accelerator technology
4. High-performance scientific computing and networking
5. International scientific collaboration
6. Theoretical particle physics and astrophysics

The U.S. HEP program: major components in 2010



1. Higgs, supersymmetry, extra dimensions, etc. at colliders

- Atlas and CMS @ LHC
- building (ILC)

2. Lepton flavor

- MINOS
- (MECO)
- SNO, other solar expts
- building (NOvA, Reactor, $\beta\beta(0\nu)$, Minerva)

3. Quark Flavor

- (KOPIO)

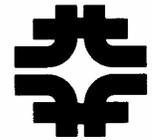
4. Particle Astrophysics

- Auger South & (North)
- GLAST, Veritas
- Ice Cube
- (Super)-CDMS, (Xenon)
- (DES), building (LSST, JDEM)

Fermilab is host laboratory of those in red.

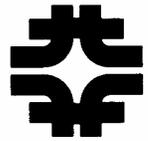
(Experiments without funding approval)

Summary



- Fermilab has a broad physics program matched to the most compelling issues in particle physics.
- The Fermilab accelerators are simultaneously providing beams for two unique particle physics programs.
 - The Tevatron collider is operating at record levels for CDF and DZero.
 - The proton accelerators are reliably providing intense beams to MINOS and MiniBoone in the neutrino program
 - All experiments are running well.
- Exciting physics is coming out and it will get better.
- The particle astrophysics program is hitting full stride.
- We are starting to invest more in ILC and neutrinos.

A final word



- Fermilab has a new, even more central role in the future of US HEP.
- This new role brings new responsibilities to the laboratory and to others.
 - Fermilab has a responsibility to optimize the entire U.S. particle physics program and to align itself with the priorities of that program.
 - The particle physics community in the U.S. and the Office of High Energy Physics have a responsibility to support the laboratory and keep it viable as a platform for building the future.