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# The Fermilab Program and the FY2004 Budget

**Michael Witherell**

**HEPAP Meeting**

**March 7, 2003**

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# The Fermilab Program

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## Area of Particle Physics

- Theoretical Physics, Phenomenology & Data Analysis
- Electroweak Physics
- Lepton Flavor Physics
- Quark Flavor Physics
- Unification Scale Physics
- Cosmology & Particle Physics
- Particle-Astrophysics

## Fermilab program

Particle and Astro  
Theory groups

Tevatron\*, LHC\*\*, LC

NuMI\*, MiniBooNE

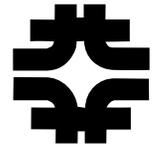
BTeV, CKM

SloanDSS, CDMS\*

Auger\*

\*ongoing construction projects

The breadth of the Fermilab program reflects the US  
HEP program.



# The Distribution of Effort

- The rough fraction of the laboratory research budget that supports the various programs:

Program	FY04 Funds (\$M)	% of total research
<b>Tevatron Collider</b>	<b>136</b>	<b>70</b>
Neutrino Program	22	11
LHC*	2+9	1+5
Accelerator R&D	9	5
Exp. Astrophysics*	3.5+1	2+1
BTeV	2	1
CKM	2	1
Fixed Target	3	1.5
Theory	4.5	2.5

**\*First number is Fermilab base funding, second is from LHC project or outside sources.**



# Programs and Facilities

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Program	Physicists	Facilities
Tevatron Run II	1200	collider, detectors, computing
Neutrino	260	neutrino beams, large detectors
US-CMS	300	detector, computing, research
US-LHC		accelerator systems
Astro (Sloan, CDMS, Auger)	450	{ detectors telescope, data processing
Quark Flavor	210	accelerator complex, detectors
Lattice QCD	60	commodity cluster computing facility

No experimental programs have been approved for funding since NuMI in 1999.

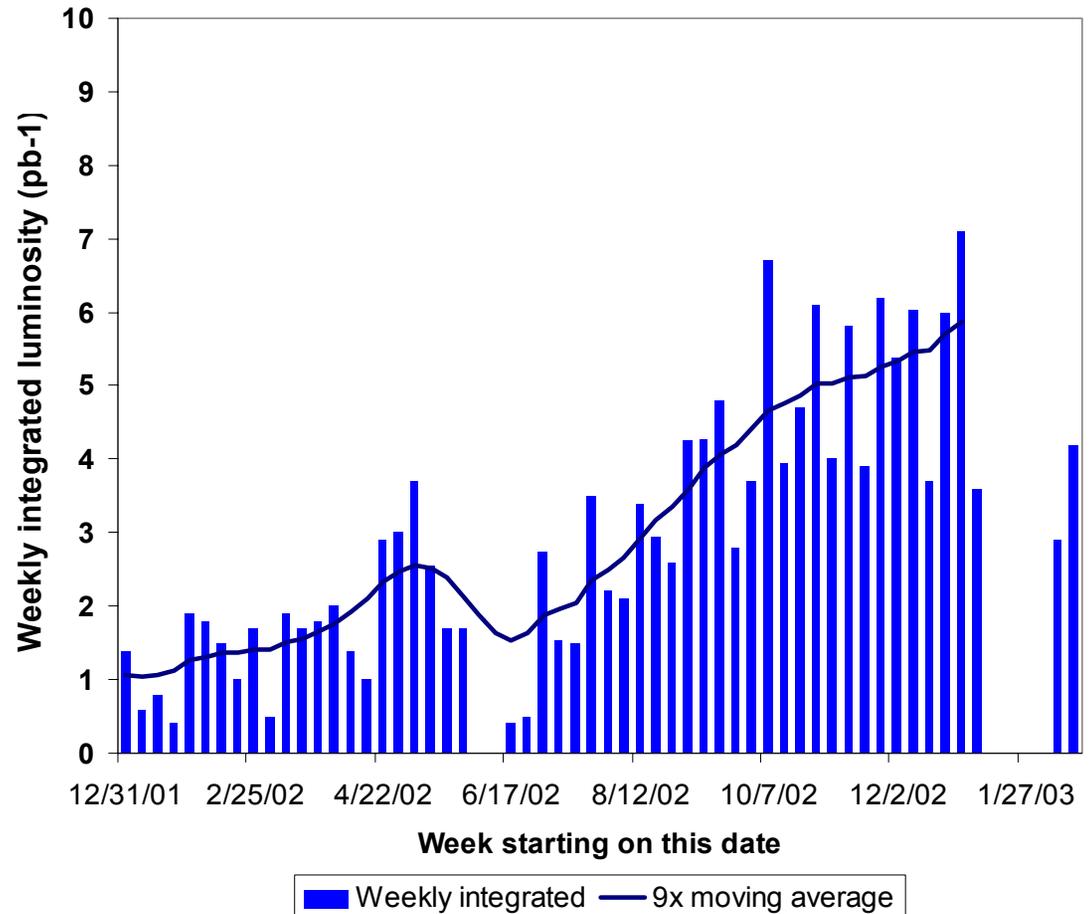
Since then we have been executing approved projects and moving into operations, and in the case of CDF and D0, starting an upgrade.

# Weekly integrated luminosity

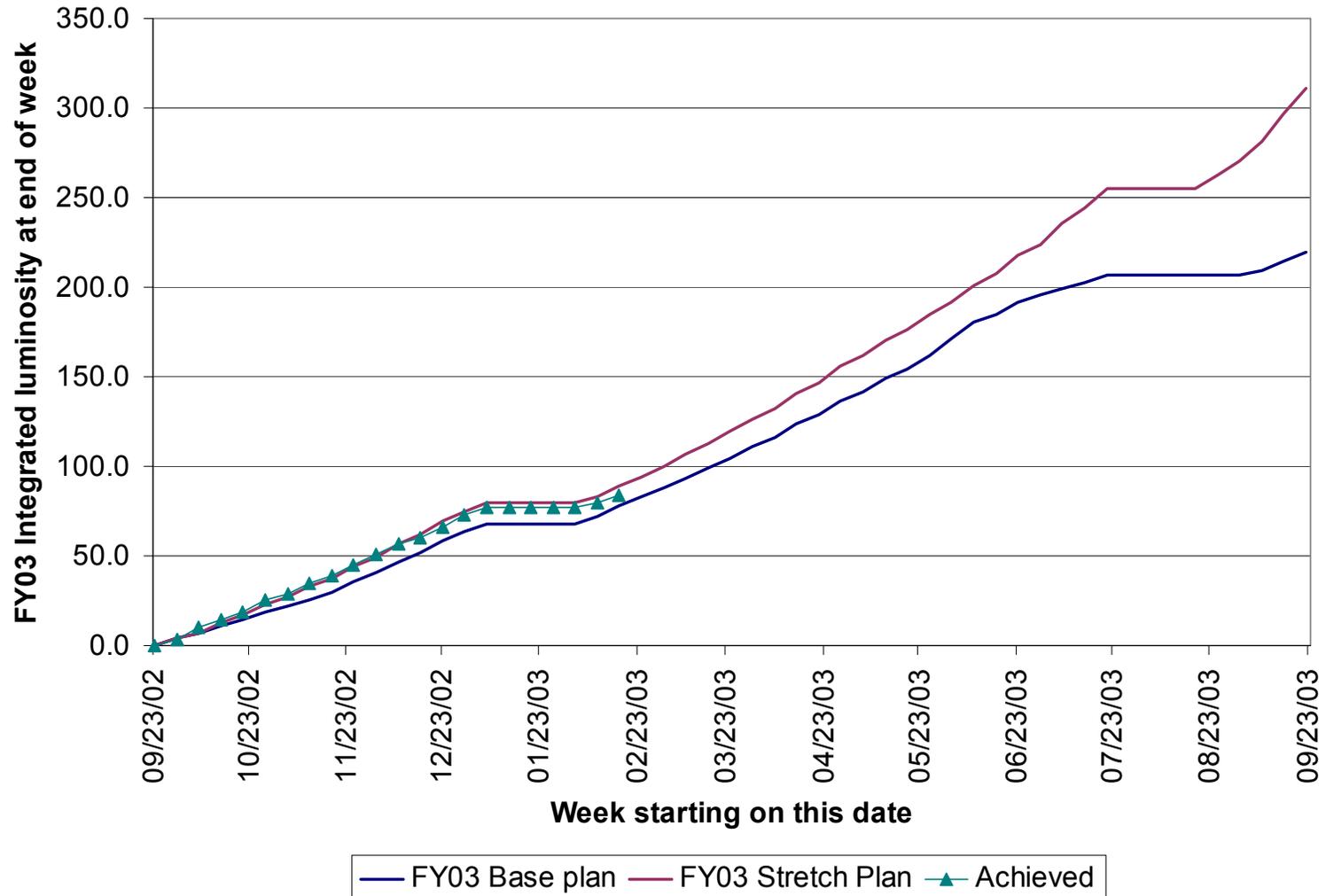
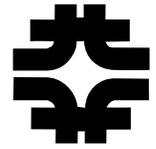
At end of CY 2002

- At start of year
- Best week =  $7.1\text{pb}^{-1}$ 
  - 1.4
- Typical week =  $5\text{-}6\text{pb}^{-1}$ 
  - 1.0
- Best initial luminosity =  $3.6 \times 10^{31}\text{cm}^{-2}\text{s}^{-1}$ 
  - 1.0

The shutdown was designed to remove at least one bottleneck.

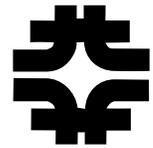


# FY 2003 Plan



# Run II Physics for Summer 2003

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- Sample of  $\sim 200 \text{ pb}^{-1}$  with more powerful detectors, somewhat higher energy
- Top quark measurements
  - $>3$  x Run I sample
- Bottom, charm quark measurements
  - First round of results with  $B, B_s, \Lambda_b$ , charm samples
- Jet distributions at highest  $p_T$
- Searches for exotic high-mass states

# Run II Luminosity

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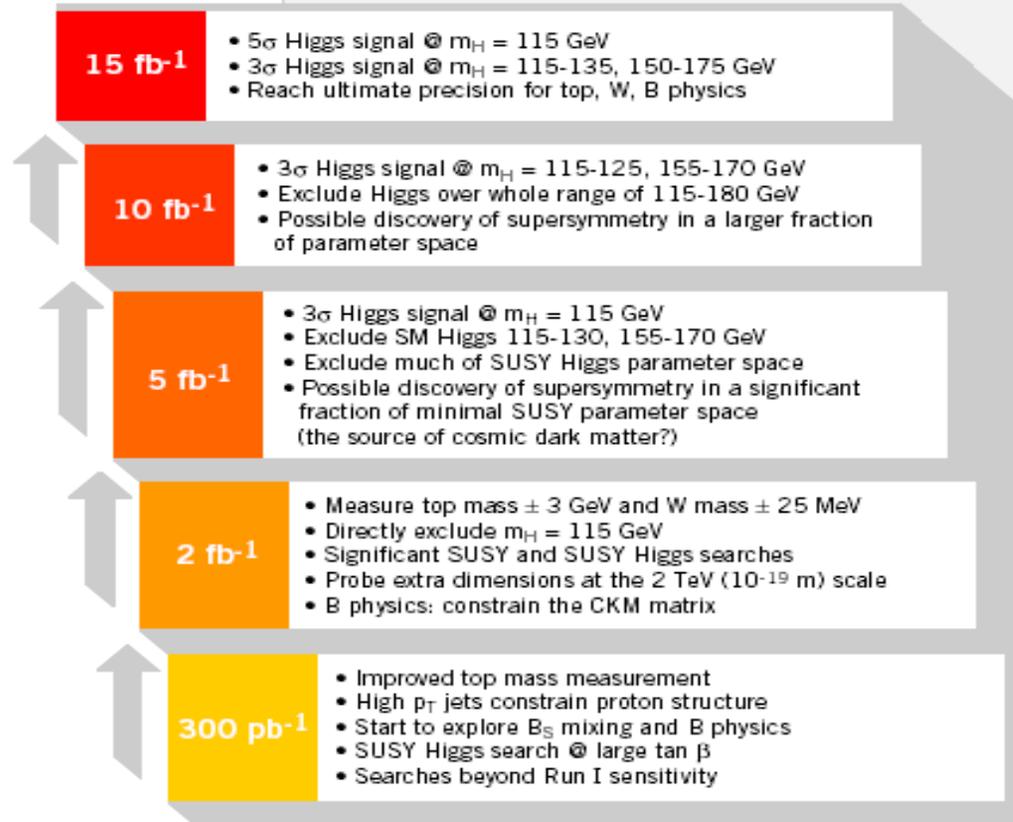
The official luminosity goal for Run II was defined in the data sheet for the Main Injector Project:

- “The Tevatron proton-antiproton colliding beam luminosity will be increased to at least  $5 \times 10^{31} \text{cm}^{-2} \text{sec}^{-1}$ .”
- We will obtain greater luminosity with a sustained program of experience and improvements, and by adding the Recycler.
- We are preparing an integrated plan for Run II upgrades to be submitted on 6/1/03.
  - $6\text{-}8 \times 10^{31}$  without the Recycler
  - $\sim 1 \times 10^{32}$  with the Recycler as postaccumulator
  - $2\text{-}3 \times 10^{32}$  with the Recycler and electron cooling

# Collider Physics Goals



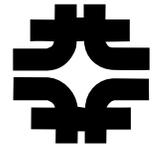
## Run II Physics Program



*Each gain in luminosity yields a significant increase in reach and lays the foundation for the next steps*

# DOE Review: Long-range future

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- “Reaching the base luminosity goal of 6.5 inverse femtobarns delivered by the end of the year 2008 will be a *significant challenge*. The committee found that a well thought out plan exists for luminosity improvement in FY 2003, but comparatively little detailed scheduling and resource planning beyond FY 2003.”
  - “The laboratory's technical approach for increasing luminosity over the next six years is sound and well motivated and, if successfully implemented, will maximize the integrated luminosity over this time period.”

# Fermilab Response: Future

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- **We agree.**
  - Reaching the base goal for integrated luminosity by FY 2008 presents a significant challenge.
  - Detailed schedule and resource plan beyond FY 2003 would be presented this summer.
- **Luminosity delivered per detector by the end of FY 2008(FY 2010):**
  - Base goal:  $6.5(10)\text{fb}^{-1}$
  - Stretch goal:  $11(17)\text{fb}^{-1}$
- **We will run CDF and DØ until the LHC experiments start to produce physics results that dominate our picture.**
  - We expect to be running to FY 2009-10.
  - Outcome depends on available funding.

# Run IIb Detector Upgrades

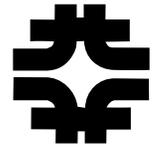
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- In June, PAC recommended laboratory approval to CDF and D0 upgrade projects that would
  - replace radiation-damaged silicon detectors with new detectors of simpler design with more radiation-hard technology.
  - upgrade data acquisition and triggers to deal with higher luminosity.
- We held successful Lehman baseline reviews in September.
  - No action items, recommended reduced contingency, which we accepted
- External Independent Review completed in Nov. 2002
- ESAAB approval on December 17, 2002
- Sensor and SVX4 orders going out

# Run II Accelerator Plan: next steps

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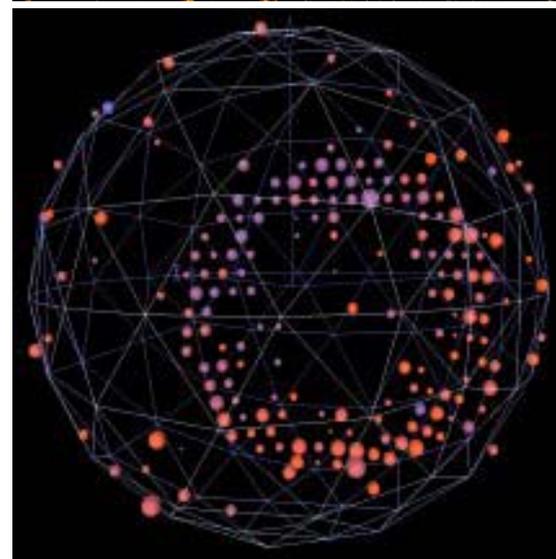
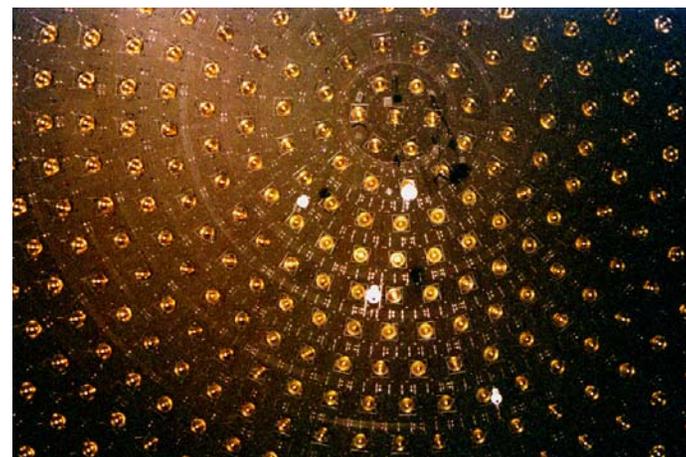


- We are working on a detailed plan with resource-loaded schedule for the full scope of accelerator upgrades.
  - Accelerator Advisory Committee 2/4-6
  - Director's review (M. Tigner, chair) 5/5-7
  - Plan with schedule submitted 6/1
  - DOE review by 8/1

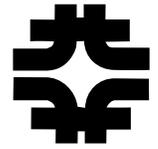
# MiniBooNE is running.



- First event September 2002
- Neutrino Beam operates 140 hrs per week
- Events match Monte Carlo
- **News from February, 2003: record beam intensities**
  - $4.5 \times 10^{16}$  p/hr standalone
  - $3.6 \times 10^{16}$  p/hr when also stacking antiprotons
  - Improvement  $\sim 1.7$
- Currently at  $\sim 4 \times 10^{18}$  pot per week
- Increases in intensity while under strict limits on booster losses
  - MP02 Magnet – installed Jan. shutdown
  - shorter extraction notch
  - improved booster orbit
  - Collimator shielding – designed, under construction, to be installed this summer.



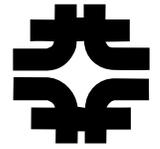
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E-mail from yesterday evening:

“ $5.5 \times 10^{16}$  protons were delivered to MiniBooNE between 6PM and 7PM this evening, passing the official beams division  $5 \times 10^{16}$  milestone - which means beer if I'm not mistaken.”

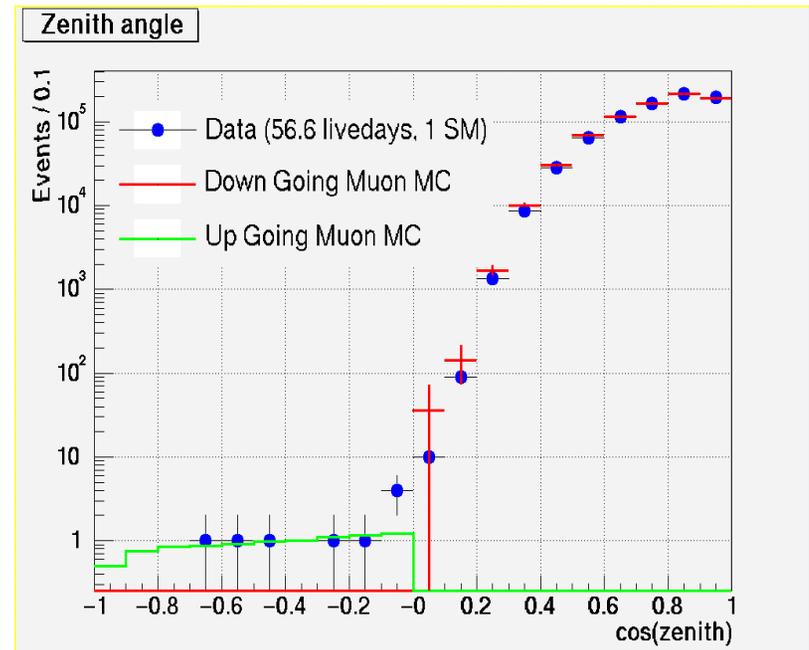
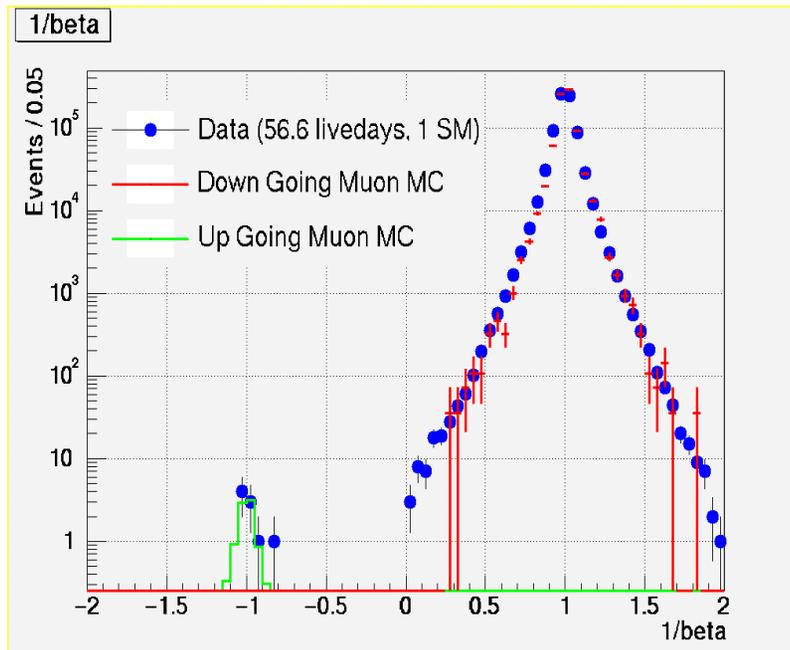
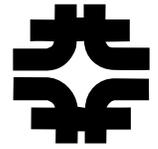


## Target Hall looking downstream

## MINOS Hall looking upstream

- Surface Buildings and Outfitting construction started 11/1/02
- >416/484 planes of MINOS far detector installed, almost all online
- Cosmic ray studies underway
- Heading toward neutrino beam in early 2005.

# MINOS: Upward-going Muons



# *Accelerator Improvements to Support Run II Goals*

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## Accelerator White Paper 12/18/02

- The **base goal** represents what could be expected if the **majority of accelerator improvements envisioned perform as planned**, while
- the **stretch goal** indicates what could be expected if **essentially everything that is envisioned is successful**.
- The long-term plan includes the strategy for addressing the major risk factors in achieving the long-term stretch scenario, which fall into four major categories:
  - Operational reliability
  - Technical success in major R&D initiatives
  - Proton economics
  - Resources (people and funding)

# *Accelerator Improvements to Support Run II Goals*



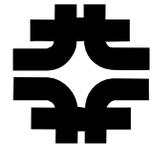
Funding needed to follow the plan:

FY2003	FY2004	FY2005	FY2006
\$286 M	\$309 M	\$321 M	\$334 M

- The figures for FY 2004 and beyond are consistent with Fermilab's FY 2002 budget, corrected for 4% inflation.
- After the massive redirection of effort within the laboratory to support the Run II effort on this year's budget, there is much less potential to move additional resources from the rest of the laboratory next year.
  - CDF and D0 and the NuMI project are the largest components of the research program outside accelerator operations and upgrades.

# Review Report: Resources

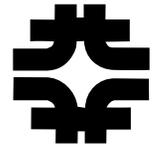
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- “The overall funding level for the nation’s high energy physics program and for Fermilab in FY 2004 and beyond is a major concern, one that could severely impact Fermilab’s ability to deliver on the luminosity goal for the Tevatron complex.”

# Fermilab Response: Resources

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- The funding level will determine the prospects.
  - The expectations for integrated luminosity in Run II are inextricably connected to the funding profile for the laboratory.

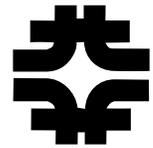
# First: The FY 2003 Budget

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- The budget presented for FY2003 at our Annual Program Review in March, 2002 was \$298.3 M.
- Until February, 2003, we were working with a budget guidance of \$286.4 M, requiring \$11.9 M in cuts.
  - This led to the set of measures discussed at the 11/02 HEPAP meeting.
- The actual FY03 budget is **\$284.9 M**, an additional **\$1.5 M** lower.
  - This is a \$1.6 M increase in base budget, \$5.1 M cut in total budget, from FY2002.
  - The employment inflation increase of 4% is about \$13 M, and the FY03 budget is \$1M below FY02. We therefore have to reduce effort by about **\$14 M** this year.

# FY04 budget request is bad for HEP, HEP, worse for Fermilab.

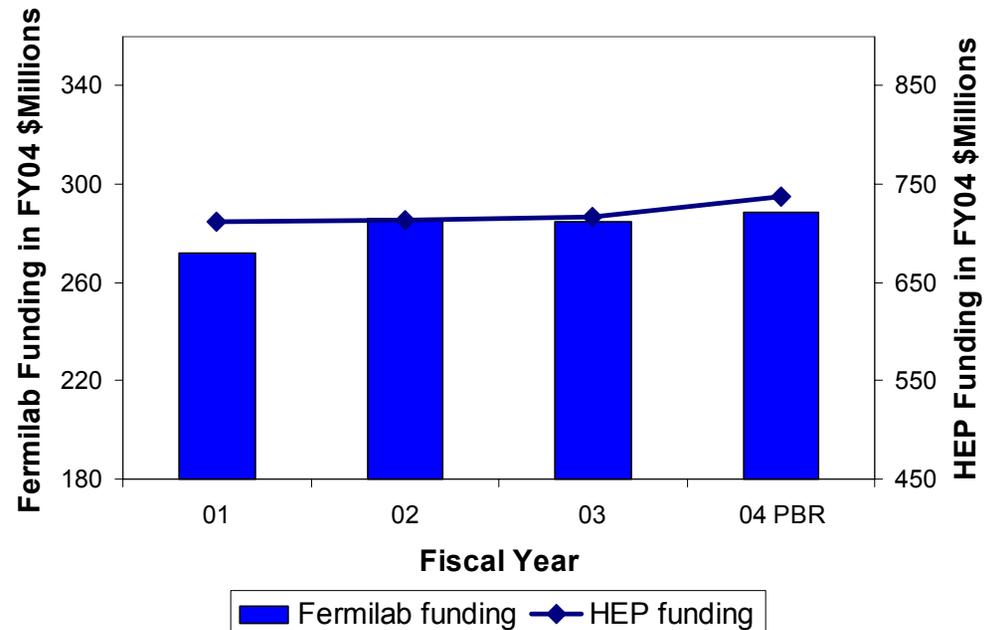


FY	02	03	04	02-04
HEP	713.2	715.7	738.0	3.5%
Fermilab base	286.2	284.8	288.5	0.8%
Fermilab total	310.6	311.6	303.3	-2.4%

Fermilab budget is \$288.5M.

This is down 7% relative to inflation since FY2002.

- These are the critical years for collider upgrade.
- General reduction will take it down further.
- The proposal for ambitious upgrading of the Tevatron has not yet been funded.



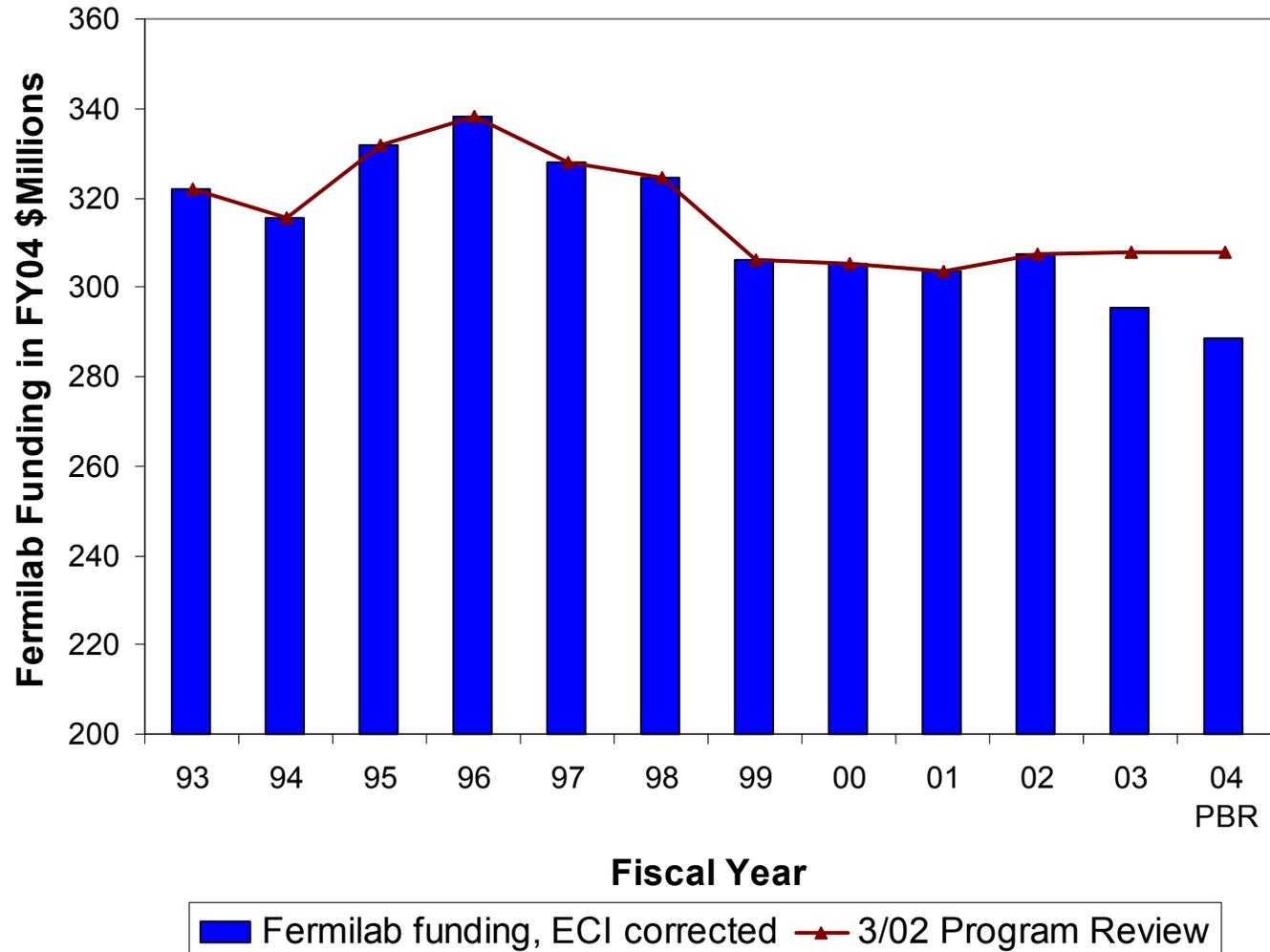
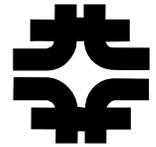
# Funding changes 02-04

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<b>FY</b>	<b>02</b>	<b>03</b>	<b>04</b>	<b>02-04</b>
<b>HEP</b>	713.2	717.9	738.0	3.5%
<b>Fermilab</b>	286.2	284.9	288.5	0.8%
<b>SLAC</b>	161.0	160.5	169.9	5.5%
<b>LHC</b>	49.0	60.0	48.8	-0.4%
<b>LBNL</b>	28.8	28.6	36.0	25.0%
<b>BNL</b>	21.2	15.7	15.0	-29.2%
<b>ANL</b>	8.1	8.2	8.0	-1.2%
<b>Univ.</b>	115.5	122.0	126.1	9.2%

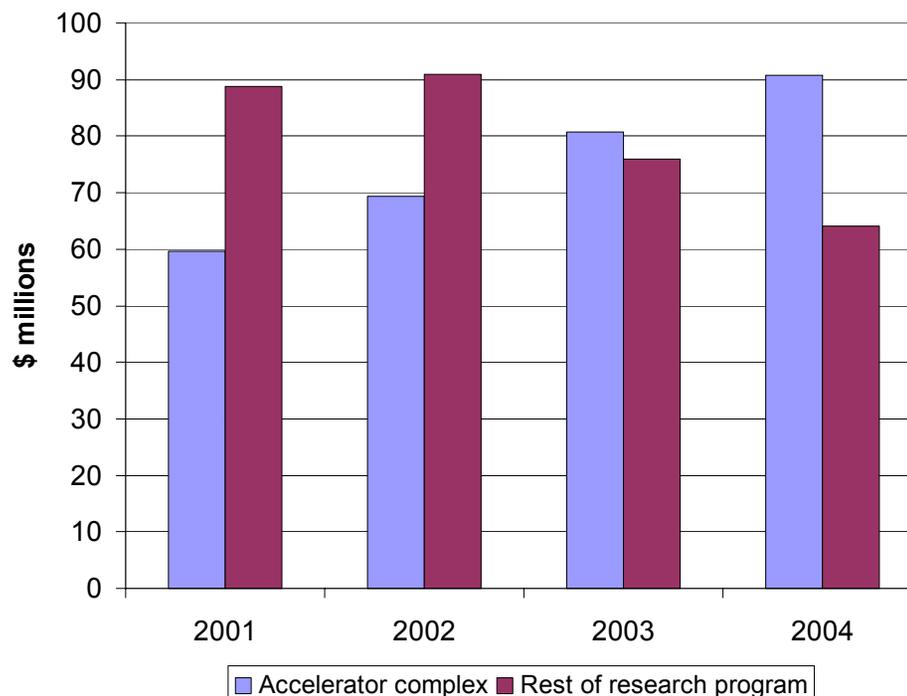
# Fermilab funding, inflation corrected



# Accelerator effort grows within a flat Fermilab budget for 3<sup>rd</sup> year.

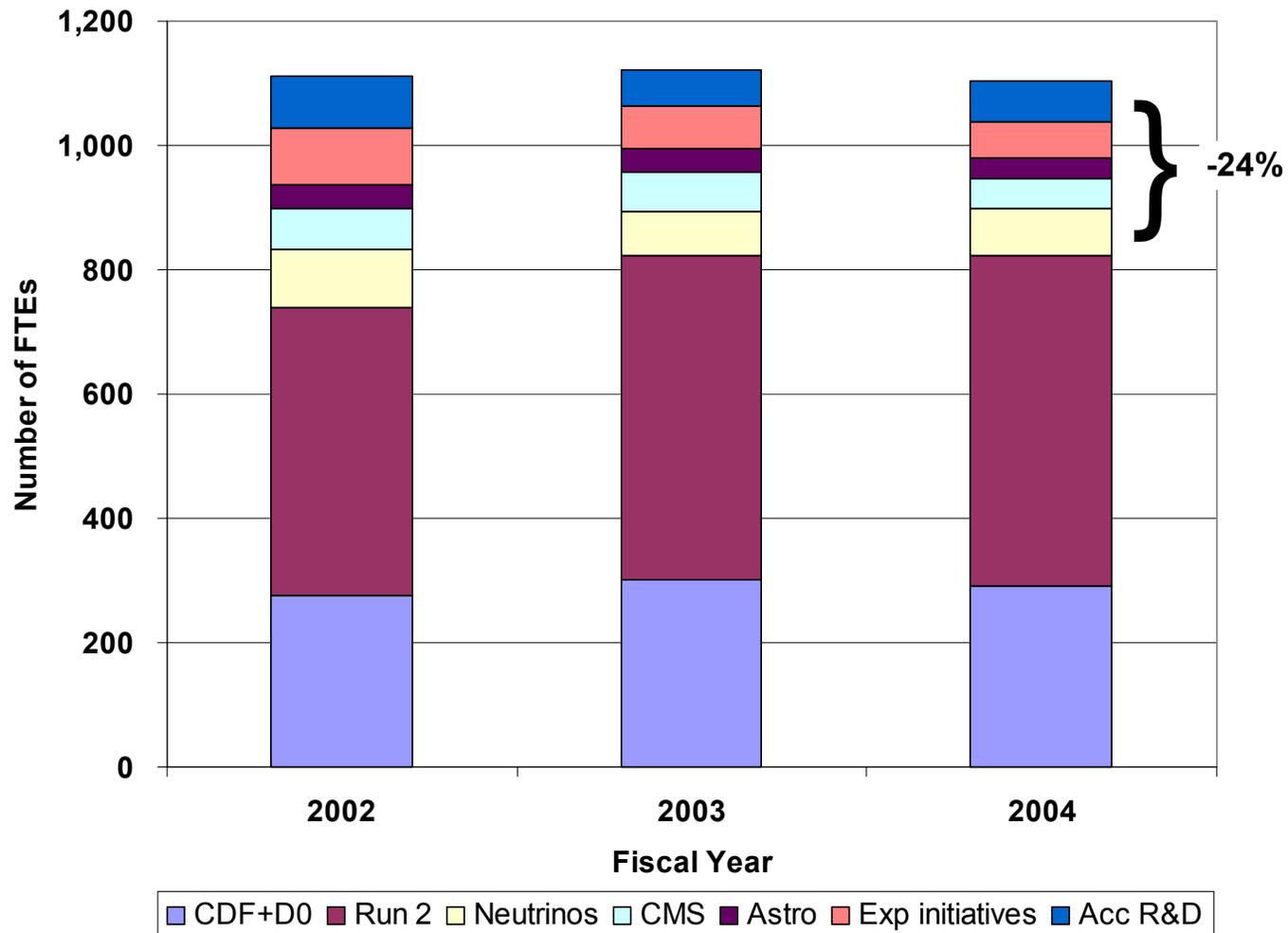
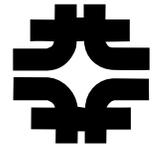


- Fermilab total loses ~6% to inflation.
- Accelerator effort +40% in constant dollars
- Rest of research program -40% in constant dollars
  - neutrino and other experiments
  - accelerator R&D
  - experimental astro
  - theory



	2001	2002	2003	2004	01-04
<b>Accelerator complex</b>	<b>59.6</b>	<b>69.4</b>	<b>80.8</b>	<b>90.8</b>	<b>52%</b>
<b>CDF+D0</b>	<b>39.3</b>	<b>39.5</b>	<b>41.8</b>	<b>45.8</b>	<b>17%</b>
<b>Support</b>	<b>86.2</b>	<b>86.3</b>	<b>86.4</b>	<b>87.8</b>	<b>2%</b>
<b>Rest of research program</b>	<b>88.8</b>	<b>91.0</b>	<b>75.9</b>	<b>64.1</b>	<b>-28%</b>
<b>Fermilab total</b>	<b>273.9</b>	<b>286.2</b>	<b>284.9</b>	<b>288.5</b>	<b>5%</b>

# FTEs in Research Areas



# Incremental Analysis



## Incremental Analysis FY2003 to FY2004

	FY2003	FY2004 Budget Request	Change
<b>Total Salary, Wage and Fringe</b>	<b>178.7</b>	<b>182.6</b>	<b>3.9</b>
<b>Items Below are M&amp;S</b>			
Accelerator Ops and Maintenance	13.3	14.0	0.7
Run II Accelerator Improvements	6.2	11.1	4.9
CDF/D0 Ops and Computing	8.2	8.7	0.5
Run II b Detector Upgrades	7.0	9.5	2.5
NuMI / MINOS	22.2	13.5	(8.8)
MiniBooNE	0.48	0.54	0.1
LHC	11.8	4.8	(7.0)
Future Accelerator R&D	3.5	2.9	(0.5)
Experimental Initiatives	1.8	1.3	(0.5)
Experimental Particle Astrophy.	3.1	1.5	(1.6)
Electrical Power	17.4	18.5	1.1
GPP + UIP	7.5	8.3	0.8
Other M&S	28.9	26.2	(2.7)
<b>M&amp;S Total</b>	<b>131.3</b>	<b>120.7</b>	<b>(10.6)</b>
<b>Total Budget</b>	<b>310.1</b>	<b>303.3</b>	<b>(6.7)</b>
<b>Funding from Other Sources</b>	<b>25.2</b>	<b>14.8</b>	<b>(10.4)</b>
<b>Base Budget</b>	<b>284.8</b>	<b>288.5</b>	<b>3.7</b>



# Impacts of FY03-04 Budgets

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- We continue making an extraordinary shift of resources within the laboratory to support the Tevatron collider program.
- We are maintaining schedule and funding profile on certain select projects
  - NuMI
  - US-LHC, and US-CMS
  - Linear Collider R&D (at a small funding level)
- We are reducing support in other areas to the level below what is needed for reasonable progress.
  - This affects the long-term health of US HEP.

# What we need in FY 2004 compared to FY 2003 actual

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• NuMI/MINOS	- 9 M
• Accelerator 14 M + inflation	+16 M
• CDF/D0	+ 4 M
• Accelerator R&D + other experiments	+ 3 M
• Inflation on SWF not included in above	+ 3 M
• Infrastructure	+ 3 M
• Power	<u>+ 1 M</u>
Total corresponds to <b>\$306 M</b> base	21 M

Increase in FY 2004 budget request  
compared to actual FY 2003  
Shortfall

+ 3.7 M  
**~17 M**

# Impacts of FY 2003-04 budgets

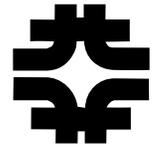
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- HEP did badly, Fermilab did even worse.
- The achievable outcome of Run II depends on the budget level.
- **A small increase in budget gains a lot more science; a small decrease leads to much less.**

# Summary

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- **The Tevatron collider program is back.**
  - Look for the results coming later this month, but especially at Lepton-Photon this summer.
- **The Neutrino program is making good progress.**
  - MiniBooNe is starting its physics run.
  - NuMI is proceeding toward a 2005 start.
- **The FY2003 budget is having negative impact that will last for years.**
- **The FY 2004 budget is even worse for the Fermilab program.**
- **Fermilab will have lost \$20 M in real funding (constant dollars) between FY 2002 and FY 2004.**
  - more after the usual general reduction