



## Costs to Build Fermilab in 1984 Dollars

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It is of current interest to examine the costs incurred to date to build Fermi National Accelerator Laboratory and to determine what those costs are when stated in FY 1984 constant dollars. The appended tables are in support of this exercise and are based on all costs for Equipment items (reduced by obsolescence) and all Plant Projects which have been appropriated through FY 1984. Also included are non-plant costs which are required to complete the Energy Saver, Tevatron I and II projects (i.e., Equipment and R&D in support of Construction). This study makes the assumption that all funding through FY 1984 will have been costed by the end of FY 1986. Those costs incurred in FY 1985 and FY 1986 have been deflated to FY 1984 dollars. See Appendix A for the DOE inflation factors used in the conversion to FY 1984 dollars.

The costs are identified in three categories. The Accelerator Facilities includes all accelerator components, the buildings which enclose them and utilities which support them. The Experimental Facilities include all beam lines, enclosures, utilities and experimental equipment which are usable in current experimental programs. The Support Facilities include lab and office space, shops, assembly facilities, roads, grounds and the utilities which do not specifically support the Accelerator or Experimental Facilities, etc.

### 200 BeV Construction Project

The original funding to build Fermilab was received from the Atomic Energy Commission via a line item construction project called the 200 BeV Accelerator Facility Project (Project No. 542-68-4F). In column 1 of Table I, the costs incurred in each year of the construction project are escalated to 1984 dollars and an average escalation factor of 2.635 for the life of the project is derived by dividing the total then year cost into the total constant FY 1984 cost.

In Table II, the component costs have been rearranged from the close-out cost report for the 200 BeV project to correspond to the above defined categories. To arrive at the 1984 costs we then applied the average inflation factor determined in the first table. We took this approach since our records for the years in which costs were incurred are not easily arranged into the three facilities under consideration.

## Facility Enhancements

Accelerator Improvement and General Plant funds have been appropriated, beginning in FY 1976, to enhance the facilities for increased energy, intensity, reliability and work facilities. Capital Equipment funds have also been provided since early in the project. Most of the equipment funds were furnished to assemble experimental apparatus and to provide the secondary beam lines needed to serve the needs of the experiments. Other major uses of Equipment funds have been for computers, the Central Helium Liquefier, Nitrogen Reliquefier and Site equipment. The Accelerator Improvement and General Plant funds have been used for enhancements of both Accelerator Facilities and Experimental Facilities with substantial amounts of General Plant funds having also been used to enhance the Support Facilities. After examining the records of these three funds we have assigned the Accelerator Improvement & General Plant costs to the three categories, based on the nature of each of the numerous sub-projects. For the equipment allocation to each of the three facilities, the assumption is first made that equipment acquisitions early in the history of the project are now essentially obsolete and therefore little or no value is recorded. In the FY 72 through FY 74 period, a major effort went into building the 15' Bubble Chamber which is not presently in a state of obsolescence and is so reflected in our presentation. A recollection of the activities that were underway in the early years and a reference to the equipment section of the program budget submissions permitted the allocation of the escalated, "non-obsolete" annual equipment costs to the three facilities.

Since 1978 there have been four line item construction projects funded which have also enhanced the Fermilab facilities. The first of these was the Hadron Bubble Chamber project which provided superconducting components for beam lines and superconducting coils for the 30" hydrogen bubble chamber magnet.

The second line item project was the Energy Saver which together with R&D funds in support of the Construction Project and equipment funds for the Central Helium Liquefier and Magnet Test Facility, has increased the proton energy from the Accelerator Facilities to 700 GeV to date and which will eventually yield 1 TeV protons.

The Tevatron II project funded the upgrade of extraction systems from the Energy Saver as well as the Experimental Facilities for the higher proton energies available from the Saver. In addition, the Industrial Center Building which we have classified under Support Facilities was funded by the Tevatron II Project. At this time the Tevatron II project is still underway.

Tevatron I is the fourth line item construction project which is currently being built to provide antiprotons for high energy colliding beams in the Energy Saver (Tevatron). This project also provides additional refrigeration and RF components for the Saver and experimental enclosures and assembly areas for the pp colliding beams.

The total project costs for these line item projects as well as AIP, GPP, Equipment and the original 200 BeV Project are summarized in Table I.

Operating funds have not been included in any of these estimates except for R&D funds for the Saver, TeV I and TeV II construction projects where those funds were determined to be necessary in support of the construction activities.

### Summary

The total costs of Accelerator Facilities, Experimental Facilities and Support Facilities (i.e., through FY 1984 plus Tevatron I and II costs to the completion of those projects) and stated in FY'84 dollars are summarized in Table III.

The total facility cost in '84 dollars as shown in Table III is approximately \$1.3 billion dollars. Of that amount, \$0.9 billion relates to the Accelerator and Support Facilities which represent those components of cost associated with the use of Fermilab as an injector and support center for a supercollider.

As mentioned earlier, we have reduced the equipment costs used in this tabulation for obsolescence. We have not made a comparable adjustment for the Plant Facilities although we readily acknowledge that some adjustment is appropriate. Many times improvements result in a replication of a component or facility with the original being demolished or otherwise rendered obsolete. In such cases, the tables included in this study reflect costs somewhat in excess of replacement value. In lieu of making arbitrary judgments on where such conditions exist, we consider it sufficient to only highlight the matter here. The magnitude of such duplication cannot be significant when compared with the total project costs.

TABLE I

Total Cost to Build the Fermilab Facilities - Stated in Then-Year and in FY 1984 Dollars  
(In Thousands)

Fiscal Year in Which Cost Was Incurred	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)		Fiscal Year in Which Cost Was Incurred
	200 BeV Accelerator		Accelerator Improvements		General Plant Projects		In-House Energy Management		Energy Saver (a)		Tevatron I (a,b)		Tevatron II (a,b,e)		Hadron Bubble Chamber		Equipment (d)		Total		
	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	Then Year	FY 84	
1968	1,838	6,525															15	50	1,853	6,575	1968
1969	15,237	50,041															60	200	15,297	50,241	1969
1970	38,962	117,393															100	300	39,062	117,693	1970
1971	82,265	223,505															250	750	82,515	224,255	1971
1972	45,582	115,742															6,750	20,000	52,332	135,742	1972
1973	25,294	60,136															7,800	22,000	33,094	82,136	1973
1974	19,309	40,698															3,800	10,000	23,109	50,698	1974
1975	7,445	14,396															4,450	9,000	11,895	23,396	1975
1976	4,841	8,765	203	368	189	342			6,674	13,635							4,200	8,000	16,107	31,110	1976
1977	2,482	4,115	1,844	3,058	533	884	1	2	10,035	19,107							3,450	6,000	18,345	33,166	1977
1978	243	371	1,272	1,941	577	880	416	635	14,350	25,489			274	418			3,750	6,000	20,882	35,734	1978
1979			2,387	3,305	1,023	1,416	141	195	17,136	27,118			377	522	870	1,204	6,200*	9,000*	33,684	50,760	1979
1980			2,162	2,708	1,398	1,751	72	90	32,970	43,392			2,158	2,984	620	776	5,550	8,000	47,230	61,701	1980
1981			3,636	4,182	1,753	2,012	226	259	38,241	45,288	4,053	4,839	1,698	2,079	464	533	7,850	10,000	62,071	73,192	1981
1982			2,202	2,381	1,349	1,459	716	774	23,376	26,027	7,886	8,709	6,579	7,312	154	167	13,550	15,000	55,812	61,829	1982
1983			4,728	5,012	1,900	2,014	951	1,009	2,819	2,966	25,815	27,261	19,805	20,972	91	96	17,200	17,958	73,309	77,288	1983
1984			4,850	4,850	2,442	2,442	1,455	1,455	2,628	2,628	56,392	56,392	20,518	20,518			17,800	17,800	106,085	106,085	1984
1985			3,048	2,849	1,200	1,122	544	509			27,488	25,722	16,391	15,353			10,300	9,798	58,971	55,353	1985
1986				900		786					7,124	6,231					5,800	5,210	13,824	12,227	1986
<b>Total</b>	<b>243,498</b>	<b>641,687</b>	<b>27,232</b>	<b>31,440</b>	<b>12,364</b>	<b>14,322</b>	<b>4,522</b>	<b>4,928</b>	<b>148,229</b>	<b>205,650</b>	<b>128,758</b>	<b>129,154</b>	<b>67,800</b>	<b>70,158</b>	<b>2,199</b>	<b>2,776</b>	<b>130,875</b>	<b>189,066</b>	<b>765,477</b>	<b>1,289,181</b>	

641,687  
243,498 = 2.635 =

Average Inflation  
Factor Over the  
Life of the Project

- (a) Plant plus R&D in support of the Plant Project  
(b) Same as (a) plus equipment in support of R&D  
(c) Includes FY 1978 PE&D  
(d) Represents original cost reduced for obsolescence  
\*Major computer

Table II

200 BeV Construction Project in FY 1984 Dollars  
(in thousands)

<u>Accelerator Facilities</u>		<u>Cost</u>	<u>Total</u>
Linear Accel. Housing		8,022	
Linear Accel. Components		43,242	
Booster Accel. Housing		12,064	
Booster Accel. Components		46,178	
Main Accel. Housing		55,586	
Main Accel. Components		156,985	
Cross Gallery		7,046	
Control System Components		12,613	
External Beam Area Components	(1/2)	25,755	
Utilities	(2/3)	25,956	
Central Utility	(1/2)	5,725	
Imp. to Land & Land Rights	(1/3)	<u>5,526</u>	
			404,698
<u>Experimental Facilities</u>			
External Experiments		80,392	
External Beam Area Components	(1/2)	25,754	
Utilities	(1/3)	12,785	
Imp. to Land & Land Rights	(1/3)	5,526	
Shielding		<u>2,290</u>	
			126,747
<u>Support Facilities</u>			
Main Support Buildings		71,608	
Industrial Buildings		9,563	
Central Utility	(1/2)	5,725	
Imp. to Land & Land Rights	(1/3)	5,692	
Temp. Facilities		14,020	
Standard Equipment (Misc.)		<u>3,634</u>	
			110,242
			<u>641,687</u>

Table III

Summary of Fermilab Facility Costs  
in Then Year and FY 1984 Dollars  
(in thousands)

	<u>Accelerator Facilities</u>	<u>Support Facilities</u>	<u>Sub total</u>	<u>Experimental Facilities</u>	<u>Total Laboratory</u>
Original 200 BeV Construction Project	\$404,700	\$110,250	\$514,950	\$126,550	\$641,500
Accelerator Improvement Projects	16,250		16,250	15,200	31,450
General Plant Projects	6,050	7,250	13,300	1,050	14,350
In House Energy Management Projects	600	1,250	1,850	3,050	4,900
Equipment	17,325	6,375	23,700	165,350	189,050
Line Item Construction Projects					
Energy Saver (a)	205,650		205,650		205,650
Tevatron I (a)(b)	128,750		128,750		128,750
Tevatron II (a)(b)		3,400	3,400	66,750	70,150
Hadron Bubble Chamber				2,775	2,775
 Total Laboratory	 <u>\$779,325</u>	 <u>\$128,525</u>	 <u>\$907,850*</u>	 <u>\$380,725</u>	 <u>\$1,288,575</u>

\*Current value of those Fermilab Facilities which would serve as an injector to a Super Superconducting Collider

(a) Includes R&D costs necessary to complete construction

(b) Includes Equipment Costs in support of R&D



DIRECTOR'S OFFICE

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DEC 12 1983

Mr. Philip V. Livdahl  
Acting Deputy Director  
FERMILAB  
P. O. Box 500  
Batavia, Illinois 60510

Dear Mr. Livdahl:

SUBJECT: HIGH ENERGY PHYSICS ESCALATION RATES

Based on my March 30, 1983, letter, please find attached the High Energy Physics escalation rates for the next Tevatron I and Tevatron II Project Reviews.

Sincerely,

Andrew E. Mravca  
Area Manager

Enclosure:  
Escalation Rates

cc: L. Lederman, w/encl.  
T. Kirk, w/encl.  
J. Peoples, w/encl.  
N. Jordan, w/encl.

HIGH ENERGY PHYSICS  
COST AND PRICE CHANGES

OPERATING			CAPITAL EQUIPMENT		CONSTRUCTION	
Calendar Year	Percent Change	Index	Percent Change	Index	Percent Change	Index
1950	1.0%	0.341	1.8%	0.347	5.3%	0.210
1951	7.9%	0.344	9.5%	0.354	7.5%	0.222
1952	2.2%	0.371	-0.6%	0.387	3.3%	0.238
1953	0.8%	0.379	-0.1%	0.385	3.5%	0.246
1954	0.5%	0.382	0.3%	0.384	3.4%	0.255
1955	-0.4%	0.384	0.2%	0.386	3.6%	0.263
1956	1.5%	0.383	2.8%	0.386	4.3%	0.273
1957	3.6%	0.388	3.6%	0.397	4.2%	0.285
1958	2.7%	0.402	2.3%	0.411	4.1%	0.297
1959	0.8%	0.413	-0.2%	0.421	3.4%	0.309
1960	1.6%	0.417	0.2%	0.420	2.4%	0.319
1961	1.0%	0.423	0.3%	0.421	2.1%	0.327
1962	1.1%	0.427	0.4%	0.422	2.1%	0.334
1963	1.2%	0.432	0.2%	0.424	2.4%	0.341
1964	1.3%	0.437	1.0%	0.425	3.1%	0.349
1965	1.7%	0.443	1.2%	0.429	3.0%	0.360
1966	2.8%	0.451	2.5%	0.434	4.2%	0.370
1967	3.0%	0.463	3.4%	0.445	4.5%	0.386
1968	4.1%	0.477	3.5%	0.460	6.5%	0.403
1969	5.5%	0.497	3.3%	0.476	8.1%	0.430
1970	5.1%	0.524	4.9%	0.492	9.0%	0.464
1971	6.4%	0.551	2.4%	0.516	10.9%	0.506
1972	4.7%	0.586	2.0%	0.528	7.0%	0.561
1973	8.9%	0.614	5.3%	0.539	6.8%	0.601
1974	8.1%	0.668	6.9%	0.567	12.8%	0.642
1975	12.5%	0.722	30.3%	0.607	9.0%	0.724
1976	7.0%	0.812	5.9%	0.790	6.8%	0.789
1977	7.3%	0.869	9.6%	0.837	9.2%	0.842
1978	7.2%	0.933	9.0%	0.917	8.7%	0.920
1979	11.2%	1.000	10.5%	1.000	10.2%	1.000
1980	14.7%	1.112	13.6%	1.105	10.5%	1.102
1981	13.6%	1.275	9.0%	1.255	9.1%	1.218
1982	8.2%	1.449	5.4%	1.368	6.2%	1.329
1983*	7.6%	1.568	6.1%	1.442	2.0%	1.411
1984*	5.3%	1.687	0.7%	1.530	6.0%	1.439
1985*	6.5%	1.776	4.8%	1.541	7.0%	1.525
1986*	7.0%	1.892	6.4%	1.615	7.0%	1.632
1987*	7.4%	2.024	7.4%	1.718	6.5%	1.746
1988*	7.7%	2.174	4.8%	1.845	7.0%	1.860
1989*	7.2%	2.341	6.2%	1.934	7.0%	1.990
1990*	7.1%	2.510	6.0%	2.054	6.7%	2.130
1991*	7.0%	2.688	5.7%	2.177	7.1%	2.272
1992*	7.2%	2.876	6.5%	2.301	7.0%	2.434

\* Forecast Estimate -- October 1983

## Appendix A (Page 3)

## Inflation Factors to Convert to Constant FY 1984 Dollars

Fiscal Year	Operating Cost		Equipment			Plant		
	Annual %	Index	Annual %	Index	Annual %	Index		
1968	4.1	3.5762	3.5	3.3579	6.5	3.5502		
1969	5.5	3.3898	3.3	3.2506	8.1	3.2842		
1970	5.1	3.2253	4.9	3.0988	9.0	3.0130		
1971	6.4	3.0313	2.4	3.0262	10.9	2.7169		
1972	4.7	2.8952	2.0	2.9669	7.0	2.5392		
1973	8.9	2.6586	5.3	2.8176	6.8	2.3775		
1974	8.1	2.4594	6.9	2.6357	12.8	2.1077		
1975	12.5	2.1861	30.3	2.0228	9.0	1.9337		
1976	7.0	2.0431	5.9	1.9101	6.8	1.8106		
1977	7.3	1.9041	9.6	1.7428	9.2	1.6581		
1978	7.2	1.7762	9.0	1.5989	8.7	1.5254		
1979	11.2	1.5973	10.5	1.4470	10.2	1.3842		
1980	14.7	1.3926	13.6	1.2738	10.5	1.2527		
1981	13.6	1.2259	9.0	1.1686	9.1	1.1482		
1982	8.2	1.1330	5.4	1.1087	6.2	1.0812		
1983	7.6	1.0530	6.1	1.0450	2.0	1.0600		
1984	5.3	1.0000	4.5	1.0000	6.0	1.0000		
1985	6.5	0.9390	4.8	0.9542	7.0	0.9346		
1986	7.0	0.8776	6.4	0.8968	7.0	0.8735		