

Status Report: 21
Status as of: 30 September 2002

Contract Title:

BOOSTER
APPLICATIONS
FACILITY



Performing Organization:
Location:

Brookhaven Science Associates
Brookhaven National Laboratory
Upton, New York 11973-5000

Reporting Period:

August 1, 2002 – September 30, 2002

1) **Project Objective:**

The purpose of this project is to provide a new experimental facility and beam line and undertake accelerator modifications required to take advantage of heavy-ion beams from the Brookhaven AGS Booster accelerator for radiation effects studies of importance for the NASA Space Program.

Heavy ions will originate in the Brookhaven MP-6 tandem accelerator and be transported to the Booster synchrotron for acceleration to the required energies.

Concurrent operation of the Booster for space radiation research and other kinds of research applications will be achieved by utilizing independent tandem injectors. The beam species and energy for both applications will be independent. Beams from either Tandem will be switched into the common injection line. At the Booster a new slow extraction system will be implemented which will require extensive accelerator modifications and rearrangements. A new beam line and tunnel enclosure will be built to transport the extracted beam to the experimental facility. Uniform beam intensities will be provided over rectangular areas ranging in size from about 1 cm to about 20 cm.

Other existing on-site facilities, such as the medical Department's extensive animal handling installations will also be utilized. Dosimetry and local access control will be provided through a local facility control room.

The conventional facilities to be constructed for the Booster Applications Facility will provide experimental space and support facilities. A labyrinth connects the experimental area with the laboratory support building. The target room is provided with a concrete beam stop imbedded in the back wall. The entire facility is shielded by 15 feet of earth equivalent shielding over the top of the target rooms and transport lines. The laboratory building contains support laboratories, including temporary biological specimen holding and preparation areas, as well as radiological laboratories for work with cell cultures and tissues. Also included are a dosimetry control room, a mechanical service equipment area and rooms for radioactive storage and miscellaneous items.

Power supplies for the beam transport magnets and various other equipment will be located in a power supply building, a pre-engineered steel frame construction.

The funds requested will also provide for spares and facility commissioning.

2) **Technical Approach Changes:**

No change.

Project Head's Summary Assessment:

	<u>Last Month</u>	<u>This Month</u>
Cost:	satisfactory	satisfactory
Schedule	satisfactory	satisfactory
Technical	satisfactory	satisfactory
Overall	satisfactory	satisfactory

W.B.S. 1.0 BAF Construction Summary: The conventional construction and Booster Modification installation are complete. Power supply commissioning is complete with the exception of the Beam Line Dipole, Booster D3 and Booster D6 power supplies. Vacuum system installation in the Beam line is 95 % complete and testing continues. Commissioning continued this reporting period.

W.B.S 1.1 Conventional Construction: Complete

W.B.S. 1.2 Booster Modifications: (Critical Path)

1.2.1 New Extraction Equipment: Complete.

1.2.1.1 Thin Septum: The Thin septum Magnet was installed in the Booster tunnel and run at 2000 amps which is maximum current. The control system was wired and the drive system was tested. The spare septum magnet and drive system is about 20% complete.

1.2.1.2 Thick Septum: A water leak was found in the first article magnet just prior to installation in the Booster ring. The leak was located at a lug/conductor braze joint. The magnet was completely disassembled to repair the conductor assembly. This was also an opportunity to bake out the vacuum chamber again to reduce the persistently high out-gassing. After the magnet was reassembled, two more times water leaks were found in the copper elbows of the back leg conductors, each after baking out the assembled magnet. The causes of failure were determined to be poor weld quality, insufficient clearances to allow for differential expansion between magnet steel and copper conductors, and differential temperatures between parts during bake out. The magnet was repaired using conductors from the spare magnet. Changes were made to the bake out procedure and clearances between magnet parts were increased to reduce the stresses on the conductors. The magnet was installed in the Booster and baked out successfully. There were no water leaks. The magnet has not yet been powered since the reassembly. Design changes to remove the weld joints in the back leg conductors are being considered.

1.2.1.3 Foil Stripper Assembly: The stripper/collimator/flag assembly has been installed in the first article magnet, now located in the Booster ring. These components are operational remotely using the control system.

1.2.2 Power Supplies: Installation complete. Commissioning in process.

1.2.2.1 Thin Septum Supply: The Power Supply resistance monitoring system and buss were installed and commissioning completed.

1.2.2.2 Ejection Septum Supply: The main septum power supply, trim winding supply, resistance monitoring system and buss were installed. Commissioning is in process.

1.2.2.3 Tune Quads Supplies: Installed and commissioned.

1.2.2.4 Sextupole: Installed and commissioned

1.2.2.5 Bumps: Installed and commissioned.

1.2.2.6 Spill Servo: Installation and initial testing complete.

1.2.3 Equipment Modifications: Complete.

1.2.3.1 D4 and D6: Complete. In addition to modifying D4 and D6 vacuum chambers, rebuilt an existing spare half-cell for D7 to accommodate extraction line.

1.2.3.2 D6 Beam Dump and Wall Current Monitor: Complete and installed

1.2.3.3 D3 IPM and Beam Dump Kicker: The D3 IPM has been reinstalled at its new location in D3 straight section.

1.2.3.4 Vacuum System Modifications: Complete. The Booster ring was successfully baked at 250 degrees C. and the vacuum restored after all new components were installed.

W.B.S. 1.3 Beam Transport System

1.3.1 Magnets: Complete.

1.3.2 Power Supplies: All supplies installed. All have been tested except for 10 degree bend supply .

1.3.3 Vacuum System: 98% complete.

1.3.3.1 Beam Tubes, Bellow and Valves: The first two vacuum sectors were baked out at 150°. C and 10 range vacuum has been established in the first section. The instrumentation has been installed and interfaced to a PLC in the BAF upper deck. The 12' diameter vacuum window was installed pumped down and leak checked on the system. The large 12" gate valve used for a security shutter to protect the window has been installed and wired into the security system. High vacuum has been established along the entire BAF line. This WBS is 95% complete.

1.3.3.2 Pumps, Power Supplies and Gauges: All pumps, power supplies and gauges have been installed on the system. This WBS is 100% complete.

1.3.3.3 Vacuum System Instrumentation & Controls: PLC interface wiring began. All gauge and pump cable terminations in buildings 957 & 958 were completed; interlock wiring is in progress. All cable runs were completed. Pump and gauge monitoring and control are available on control system displays. The pump and gauge cables for the devices controlled from building 930UEB were terminated and are operational. Ion pump readings were added to the existing Booster control system Spread Sheet. The fast valve controller was relocated to 957. This WBS is 98% complete.

1.3.3.4 Transport Line Bake-out System: All blankets have been installed and the system has been baked. This WBS is 100% complete.

1.3.4. Instrumentation: 95 % complete.

1.3.4.1 Flags and Cameras: Six camera video stations (D6, R63, R92, R158, R188, BAF Target) Have been installed and set up. Transport flag images (R63, R92, R158, R188) are available for viewing in bldg 957. The Controls group is working on final details before the frame grabber PC is delivered to bldg 957. The D6 flag, R63 flag, and the BAF target

images will be available directly in Main Control.

All Vacuum Chambers, Flags, Motion Control, Illumination systems and light shrouds have been installed and surveyed in the beam line tunnel. The D6 Foil Stripper Camera-Lens-Filter Wheel has been installed in the Booster Tunnel. Fabrication for filter wheels continues.

1.3.4.2 Collimators and Beam Plug: The D6 collimator and the Beam plug were installed and tested.

1.3.4.2 & 1.3.4.4 Ion Chamber, Scintillator & SWIC's: The electronics are installed and ready for commissioning with beam for these systems. Engineering level interfaces are ready for the Ion Chambers & Scintillators. The SWIC's signals will be viewed in the updated version of the SWIC Display application, which is the same technique used during NASA runs in the A3 line. It includes remote control of HV bias, electronics gain, and plunging control.

All four vacuum chambers have been installed and surveyed into the beam line tunnel. All instrumentation packages are built (SWIC-Ion Chamber-Scintillator). R063, R92 and R188 have been tested, pre-surveyed and installed. The air SWIC assembly is being detailed.

W.B.S. 1.4 Controls and Personnel Safety System

1.4.1 Controls: 92% complete.

1.4.1.1 Distributed systems: The RTDL link for BAF and the Booster is operational and is providing time stamps for all BAF equipment.

1.4.1.2 Central Services: Wave form generator power supply interface software has undergone the first stage of commissioning and is in operational use. Software development is complete for beam line power supply, vacuum, and instrumentation systems. The software is ready for commissioning. Application software development is complete for Optics Control and Booster Orbit Control applications. These applications are in operational use. Some software development and commissioning remains for the Main Magnet application.

1.4.1.3 Process Controls: All controls except the dosimetry system and the interface to the dosimetry have been installed and tested. System integration is progressing.

1.4.1.4 Personnel Safety System: The Accelerator Readiness Review(ARR) review of the Access Control System(ACS) was completed in August. The ACS is ready for beam commissioning.

W.B.S. 1.5 Experimental Area Outfitting:

1.5.1 Dosimetry Control: The hardware and software for the dosimetry system are nearing completion. Approximate delivery dates have been set for all components. During a teleconference between LBNL and BNL staff, a plan was made for jointly testing and integrating the system components, leading to complete delivery of the system to BNL by March 2003.

The first end-to-end test of the system, using prototype recycling integrator and accelerator interface boards, is scheduled for November 15, 2002 at LBNL.

Software: BNL will have a full set of software by the end of December, although development will continue as system testing and integration proceeds. Test versions of the software are being sent to BNL as they are completed, and BNL staff are familiarizing themselves with it, including writing some small service routines.

Hardware: The ion chambers are done, and will be shipped to BNL by the end of October, for testing with beam in November.

The range shifter is done, and is being tested at LBNL. It will be shipped to BNL in November.

Fabrication of the long cables is proceeding. These cables will make it possible to locate all dosimetry system electronics outside of the target hall.

The first set of prototype recycling integrator and irradiation control module boards was delivered and tested in September. The core Xylinx code and communication between the Xylinx and the rest of the board were found to be working. A number of minor problems were found, and a second prototype of each board is being fabricated. These prototypes will be tested in November and go into production in December. While production proceeds, the prototypes will be used in the end-to-end system test.

System Handover: BNL staff continue to interact with their LBNL counterparts. There will be two visits by members of the BNL team to LBNL - one each in December and January - for training in how to test and operate the system.

1.5.2 to 4 Support rooms: Purchasing of equipment and installation continues.

W.B.S. 1.6 Long Term Support Lab: Outfitting 98% complete.

W.B.S. 1.7 Installation and Services: 98% complete.

1.7.1 Electric Power Distribution: Complete

1.7.2 Equipment Cooling Water: Installation and testing complete.

1.7.3 Installation: Stub tunnel installation is complete. The only remaining major task is run & test of the D1/2 power supply and dc and ac hook-ups

Commissioning: Development of the detailed plan is complete and several power supply systems have been commissioned

W.B.S. 1.8 Project Services

1.8.1 Project Management: In consultation with the DOE Project Manager \$101,000 was assigned from contingency. This leaves a balance of \$555,000 on \$2,261,886 remaining to be expensed and committed. The details of these actions are outlined in section 3(f) and Table IV.
The installation of the Booster modifications was completed this reporting period.

1.8.2 Fiscal: No change.

1.8.3 Environment, Safety and Health: The Accelerator Readiness Review process is well underway and approval for the first stage of Project commissioning is scheduled for completion before October 21st.

Quality Assurance: No issues.

3) Summary Status Assessment and Forecast

a) Financial Status

A total of \$31,083,114 was expensed or obligated of the \$31,005,000 available. Costs represented \$30,824,001 and open commitments stood at \$259,113. The Project Total Estimated Cost (TEC) is \$31,657,000. The Total Project Cost (TPC) is at \$33,900,000.

b) Table II shows detailed expenses and commitments.

c) Table III shows the projected project spending profile.

d) Schedule Status

<u>Milestones completed</u>	<u>Baseline</u>	<u>Actual</u>
Title I Start	11/01/98	11/01/98
Booster Modification Start	04/01/99	04/01/99
Title II Start	04/01/99	04/01/99
Title I Complete	06/31/99	06/31/99
Conventional Construction-Start	08/15/99	08/15/99
Booster Penetration Complete	10/15/99	10/29/99
Title II Complete	06/30/00	06/30/00
Beam Transport Design-Complete	09/30/00	09/30/00
Booster Mod. Design-Complete	06/30/01	06/30/01
Safety Analysis Document (SAD) Complete	09/30/01	06/15/01
Conventional Construction Complete	06/30/02	07/31/02
Booster Modification Installation Complete	09/30/02	09/30/02
<u>Milestones Upcoming</u>	<u>Baseline</u>	<u>Forecast</u>
Beam Line Installation Complete	12/31/02	12/31/02

d) The critical path for the Project is indicated in Figure 1. WBS 1.2 was completed this reporting period. Beam operations are scheduled to begin October 7 and the first attempt to extract beam to the BAF beam line is scheduled for October 21. The critical path will move to the beam line installation (WBS1.3.) when beam extraction is accomplished.

e) Baseline Change Proposals – During this reporting period, the budgets for the following W.B.S.'s were augmented/decreased with transfer of funds to and from contingency. The justifications for the modifications are given in Table IV. There is no change in scope or total

project cost.

<u>WBS</u>	<u>Description</u>	<u>New Budget</u>
1.2.2	Power Supplies	\$2,817,000
1.2.3	Equipment Modifications	\$1,407,000

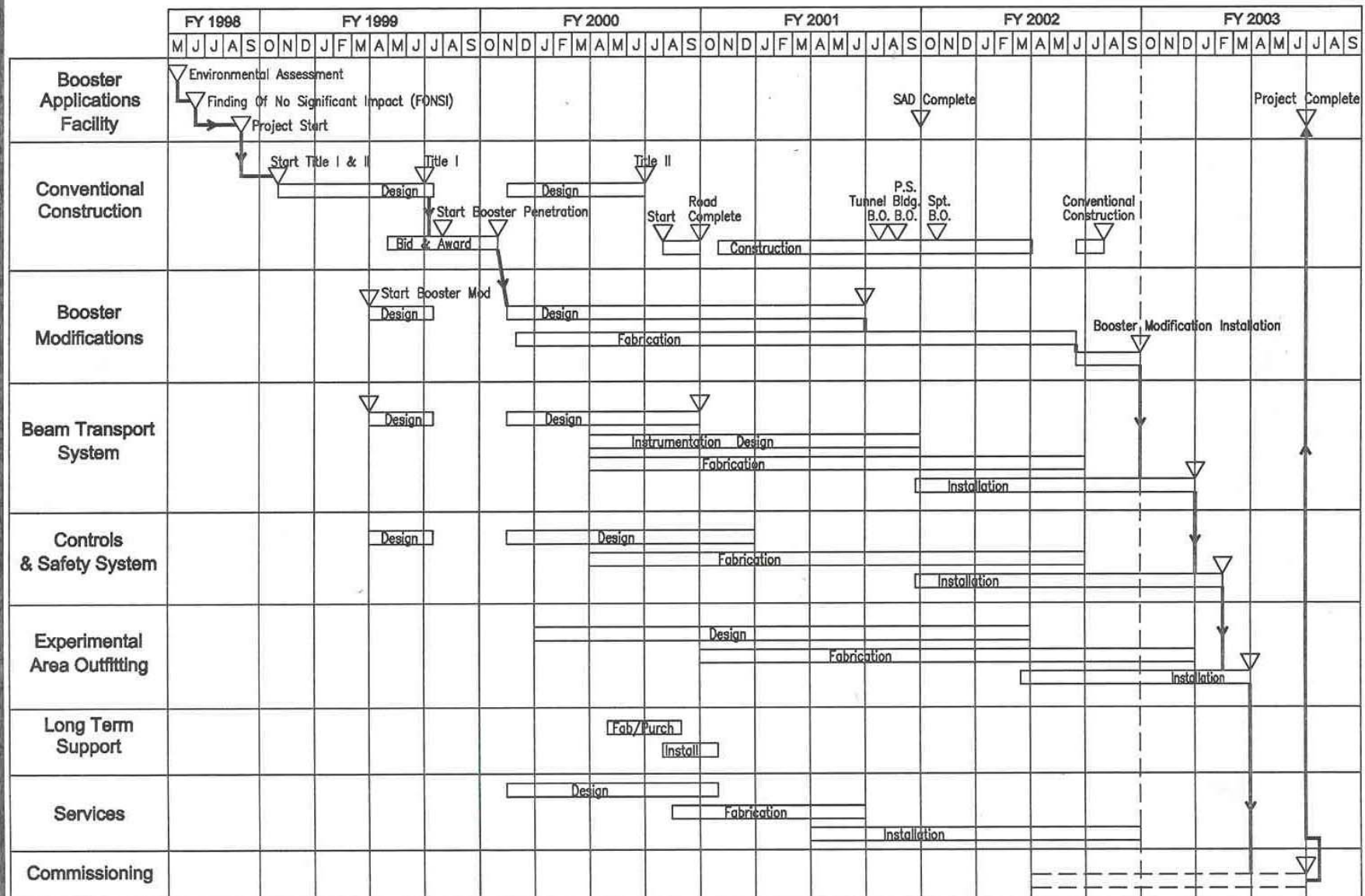
- g) Cost Performance: Figure 2 provides a measure of project performance relating the planned budget profile versus expenses and commitments. Obligations and expenses were \$22,000 less than planned, and expenses were \$219,000 less than forecast. These differences are not significant at this stage of the Project.

Table I
BAF Project Milestones

	<u>Projected</u>
Project Start	10/01/98
Title I Start (Preliminary Design)	11/01/98
Booster Modification Design Start	04/01/99
Title II Start (Final Design)	04/01/99
Title I Complete	06/31/99
Conventional Construction Start	08/15/99
Booster Penetration Complete	10/15/99
Title II Complete	06/30/00
Booster Modifications Design Complete	06/30/01
Beam Transport System Design Complete	09/30/00
Safety Analysis document (SAD) Complete	09/30/01
Conventional Construction Complete	07/31/02
Booster Modifications Installation Complete	09/30/02
Beam Transport System Installation Complete	12/30/02
Experimental Equipment Installation Complete	03/31/03
Project Complete	06/30/03

Figure 1

Booster Applications Facility Master Milestone Schedule



→ Critical Path

* Milestones are for task completion unless otherwise noted.

Figure 2

BAF Performance Measurement

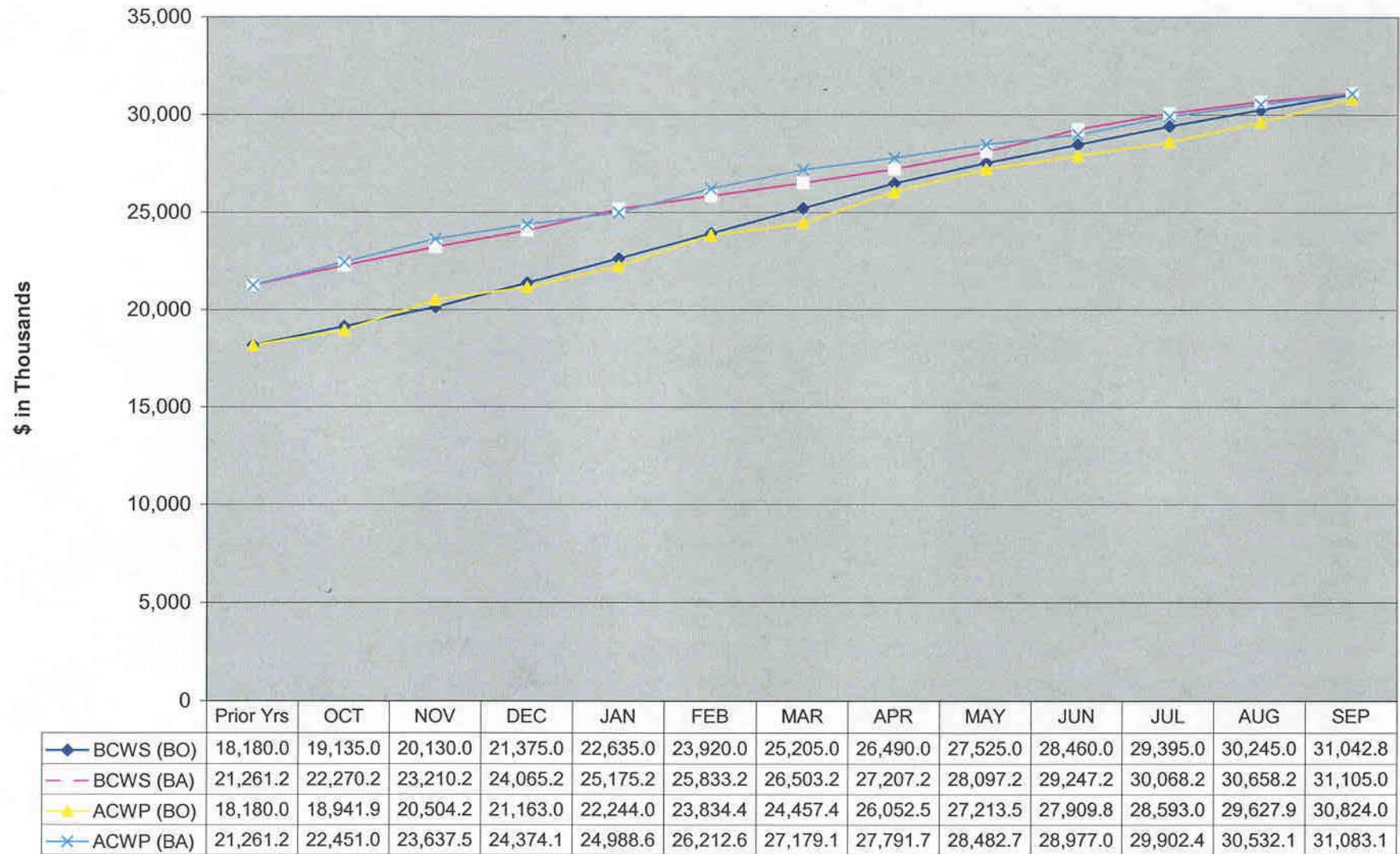


TABLE II
BOOSTER APPLICATIONS FACILITY (BAF)
EXPENSE and COMMITMENTS
As of September 30, 2002

	Budget	Salary & Wage	EXPENSES Other Labor	Material & Contracts	Overhead	TOTAL EXPENSES	COMMIT.	TOTAL EXP. & COMMIT	BALANCE AVAILABLE
1.1 Conventional Construction	6,635,000	133,094	973,483	4,922,055	600,031	6,628,663	5,000	6,633,663	1,337
1.2 Booster Modifications	5,989,000	2,150,761	717,583	2,155,085	988,578	6,012,007	13,488	6,025,495	(36,495)
1.3 Beam Transport System	5,491,000	2,115,674	358,860	2,023,119	859,945	5,357,598	148,825	5,506,423	(15,423)
1.4 Controls & Personnel Safety System	1,647,000	673,227	145,248	577,427	285,095	1,680,997	8,500	1,689,497	(42,497)
1.5 Exp. Area Outfitting	3,264,000	90,799	30,957	2,855,085	257,889	3,234,730	9,761	3,244,491	19,509
1.6 Long Term Support Lab	456,000		2,095	345,905	61,003	409,003	26,011	435,014	20,986
1.7 Installation & Services	3,656,000	999,041	288,668	1,857,681	471,909	3,617,299	738	3,618,037	37,963
1.8 Project Services	3,139,000	1,040,817	91,402	295,113	1,654,274	3,081,606	7,359	3,088,965	50,035
CONTINGECY	0					0		0	0
SPARES	653,000	35,235	74,185	428,895	102,480	640,795	37,891	678,686	(25,686)
Commissioning	175,000	104,448	2,137	9,527	45,191	161,303	1,540	162,843	12,157
1 BAF Construction	31,105,000	7,343,096	2,684,618	15,469,892	5,326,395	30,824,001	259,113	31,083,114	21,886

TABLE III
BOOSTER APPLICATIONS FACILITY (BAF)
COST ESTIMATE
Spending Profile
(\$ in Thousands)

WBS	ELEMENT	TOTAL	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003
1.1	Conventional Construction	6,635	290	80	4,628	989	648	0
1.2	Booster Modifications	5,989		282	1,747	1,886	2,074	0
1.3	Beam Transport System	5,491		56	961	2,547	1,927	0
1.4	Controls & Personnel Safety System	1,722		8	497	579	563	75
1.5	Exp. Area Outfitting	3,364		0	1,200	679	1,385	100
1.6	Long Term Support Lab	456		0	343	0	113	0
1.7	Installation & Services	3,656		9	1,237	1,117	1,293	0
1.8	Project Services	3,789	10	165	985	650	1,329	650
		31,102	300	600	11,598	8,447	9,332	825
	Contingency	555	0	0	0	0	0	555
1 (TEC)	BAF Construction (BA AY \$)	31,657	300	600	11,598	8,447	9,332	1,380
	Spares	844			50	266	337	191
	Commissioning	1,399					175	1,224
1 (TPC)	Total Project Cost (BA AY \$)	33,900	300	600	11,648	8,713	9,844	2,795
1 (TPC)	BAF Construction (BO AY \$)	33,900	300	600	5,348	11,932	12,644	3,076

TABLE IV
BAF CHANGE CONTROL
\$1000's

Date	Change No.	W.B.S.		Base Line	Change	Adjusted Base Line	Contingency Increase (Decrease)	Contingency Balance	Description
06/30/00	1	1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8	Contingency Overhead Escalation FCR	3,803 3,742 4,478 1,236 2,710 851 1,708 1,129 3,796 4,649 1,912 993	870 1,109 1,160 321 358 104 463 2,129 1,037 0 0 0	4,673 4,851 5,638 1,557 3,068 455 2,171 3,258 4,833 0 0 0	4,833	4,833	Modified WBS elements to include overhead, escalation and FCR.
08/31/00	2	1.1		4,673	425	5,098	(425)	4,408	Vendor bid exceeded estimate
08/31/00	3	1.7		2,171	68	2,239	(68)	4,340	Vendor bid exceeded estimate
11/30/00	4	1.0		31,100	800	31,900	200	4,540	Modified spending profile to coincide with NASA operating plan
11/30/00	5	1.0		Changed Project Completion Date from 09/30/02 to 06/30/03					Modified schedule to match spending profile
11/30/00	6	1.3		Changed Completion Date from 04/31/02 to 09/30/02					Modified schedule to match spending profile
11/30/00	7	1.4		Changed Completion Date from 05/30/02 to 03/31/03					Modified schedule to match spending profile
11/30/00	8	1.5		Changed Completion Date from 06/30/02 to 03/31/03					Modified schedule to match spending profile
11/30/00	9	Commissioning		Changed Completion Date from 09/30/02 to 06/30/03					Modified schedule to match spending profile
11/30/00	10	1.1		5,098	600	5,698	(600)	3,940	Vendor Change orders to cover soil conditions, upgrading water line under beam tunnel & Plant Engineering oversight
11/30/00	11	1.2.1		1,322	200	1,522	(200)	3,740	Design effort exceeded estimate
11/30/00	12	1.2.2		1,982	200	2,182	(200)	3,540	Vendor bid exceeded estimate
11/30/00	13	1.7.1		353	200	553	(200)	3,340	Substation reconditioning more extensive than estimated

TABLE IV
BAF CHANGE CONTROL
\$1000's
(continued)

Date	Change No.	W.B.S.		Base Line	Change	Adjusted Base Line	Contingency Increase (Decrease)	Contingency Balance	Description
11/30/00	14	1.7.2		641	300	941	(300)	3,040	Detailed design increased cost
12/30/00	15	1.3.2		1,513	(250)	1,263	250	3,290	Vendor bids lower than estimate
12/30/00	16	1.3.4		2,007	(150)	1,857	150	3,440	Detailed design resulted in lower device costs
12/30/00	17	1.3.1		599	400	999	(400)	3,040	Vendor bids exceeded estimate, design effort exceeded estimate
12/30/00	18	1.2		Booster Modification Completion Date changed from 10/31/01 to 08/31/02					RHIC operating schedule modified, eliminating FY01 summer shutdown
01/20/01	19	1.2		Design complete extended from 12/31/00 to 06/30/01					Design effort extended due to loss of personnel
09/30/01	20	1.8		3,659	(160)	3,499	160	3,200	Reduced budget due to projected lower project burden and fiscal and FS&H expenses.
09/30/01	21	1.1		5,698	200	5,898	(200)	3,000	Increase engineering design effort for electrical distribution & building modifications
09/30/01	22	1.7		2,739	160	2,899	(160)	2,840	Increased budget required for higher than expected vendor bids
11/30/01	23	1.1		5,698	602	6,300	(602)	2,238	Increase required for HVAC controls, doors and canopy at alcove, HVAC duct work, structural steel work, berm liner, engineering and inspection and overhead costs increases.
11/30/01	24	1.2		5,251	100	5,351	(100)	2,138	Increase required for D3 septum development and buss work fabrication for D3 and D6 power supply installation.
11/30/01	25	1.3.1		999	25	1,024	(25)	2,113	Increase required for magnet monitoring system and octupoles.
11/30/01	26	1.7		2,899	197	3,096	(197)	1,916	Increase required for electrical distribution system transformer rework and cooling system changes for power supplies.
01/31/02	27	1.1		6,300	300	6,600	(300)	1,616	Increased cost for engineering oversight.

TABLE IV
BAF CHANGE CONTROL
\$1000's
(continued)

Date	Change No.	W.B.S.		Base Line	Change	Adjusted Base Line	Contingency Increase (Decrease)	Contingency Balance	Description
01/31/02	28	1.2.1		1,472	100	1,572	(100)	1,516	Development and manufacturing costs exceeded estimates.
01/31/02	29	1.2.3		1,547	(200)	1,347	200	1,716	Design and manufacturing costs lower than estimate.
01/31/02	30	1.3.1		1,024	200	1,224	(200)	1,516	Fabrication and procurement exceeded estimate.
01/31/02	31	1.3.2		1,263	(300)	963	300	1,816	Procurement costs lower than estimate.
01/31/02	32	1.3.3		1,620	100	1,720	(100)	1,716	Fabrication costs exceeded estimate.
01/31/02	33	1.4.2		486	100	586	(100)	1,616	Design change added costs to building access system.
3/31/02	34	1.2.1		1,572	50	1,622	(50)	1,566	Cover increased manufacturing costs for thin septum magnet
3/31/02	35	1.2.2		2,532	150	2,682	(150)	1,416	Cover installation effort and materials for power supplies
3/31/02	36	1.5.1		2,706	296	3,002	(296)	1,120	Additional software and hardware effort required to complete Dosimetry system
3/31/02	37	1.7.3		1,245	50	1,295	(50)	1,070	Increased effort in survey and installation coordination
3/31/02	38	1.8.4		122	165	287	(165)	905	Funding to re-rout storm line located under Booster B 6 Dump
3/31/02	39	Spares		1,294	(450)	844	450	1,355	Spares estimate more than as built shops and manufacturer's costs
5/31/02	40	1.1		6,600	60	6,660	(60)	1,295	Cost increase for retaining wall
5/31/02	41	1.2.1		1,622	50	1,672	(50)	1,245	Magnet measurement cost increase
5/31/02	42	1.3.1		1,224	(135)	1,089	135	1,380	Magnet system came in under budget
5/31/02	43	1.7.1		700	25	725	(25)	1,355	Re-installation of repaired transformer
5/31/02	44	1.7.2		1,151	100	1,251	(100)	1,255	Control system cost increases
5/31/02	45	1.7.3		1,295	250	1,545	(250)	1,005	Rigging and survey costs exceeded estimates
5/31/02	46	1.8.4		272	75	347	(75)	930	Beam dump cap under estimated
7/31/02	47	1.1		6,660	(25)	6,635	25	955	Credits from Vendor
7/31/02	48	1.2.1		1,672	93	1,765	(93)	862	Installation underestimated
7/31/02	49	1.2.2		2,682	110	2,792	(110)	752	Buss work had to be reworked

TABLE IV
BAF CHANGE CONTROL
\$1000's
(continued)

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