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Draft of the
PHENIX Management Plan

10 March 1994

Cost and Schedule Review Copy

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The PHENIX Management Plan provides the baselines and controls that the PHENIX and RHIC Projects will follow to meet the technical, cost, and schedule goals for the PHENIX detector at RHIC. This plan will be reviewed and updated as required, with revisions made by agreement among the signed participants.

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TABLE OF CONTENTS

1.0 Introduction	1
1.1 Physics Motivation.....	1
1.2 Detector Overview.....	2
1.3 Cost and Schedule Overview.....	4
2.0 Cost and Schedule Summary	6
2.1 Methods and Procedures.....	6
2.1.1 Basis of Estimate	6
2.1.2 Contingency Analysis.....	7
2.1.3 Work Breakdown Structure.....	7
2.2 Cost Summary	9
2.2.1 Total Cost	9
2.2.2 Construction Budget Authority.....	10
2.3 Cost Profile.....	13
2.4 Schedule Summary	15
2.5 Critical Path Method Analysis	15
2.6 Project Milestones	16
2.7 WBS Documentation	17
2.7.1 WBS Book.....	17
2.7.2 WBS Notes Book.....	17
3.0 Management Organization.....	19
3.1 RHIC Project Management Overview	19
3.1.1 DOE Organizaion.....	19
3.1.2 RHIC Project Organization at BNL	20
3.2 PHENIX Project Management Overview	21
3.2.1 Institutional Responsibilities.....	25
3.2.2 Related Institutional Activities	26
3.2.3 Memoranda of Understanding.....	27
3.2.4 Internal Review and Meeting Policy.....	30
3.2.5 Cost Performance Reporting.....	31
3.3 Funding	31
3.3.1 PHENIX Construction Funds	31
3.3.2 Other Funding	32
4.0 Work Plan.....	33
4.1 Magnets (WBS 2.5.1)	33
4.2 Detector Systems: Mechanical (WBS 2.5.2) and	33
Front-end Electronics (WBS 2.5.3).....	33
4.3 DAQ/Trigger/Computing (WBS 2.5.4)	35
4.4 System Engineering and Integration (WBS 2.5.5).....	36
4.5 Project Management (WBS 2.5.6).....	36
5.0 Procurement Plan	37
5.1 Introduction.....	37
5.2 Magnets.....	38
5.1.1 Outer CM Coils	38

5.1.2 Magnet Steel	38
5.2 Ring Imaging Cherenkov Counter	38
5.2.1 Mirrors	39
5.2.2 Photomultiplier Tubes.....	39
5.3 Electromagnetic Calorimeter	39
5.3.1 Photomultiplier Tubes.....	39
5.3.2 PMT Base Assemblies	39
5.4 Data Acquisition System	39
6.0 Design Standards, Quality Assurance, Environmental Safety and Health	41
6.1 Design Standards	41
6.1.1 Policy	41
6.1.2 Computerized Data Bases.....	41
6.1.3 Drawing Number System.....	42
6.1.4 Release Process	42
6.1.5 As-built Drawings	42
6.2 Quality Assurance.....	42
6.2.1 Overview.....	42
6.2.2 Quality Assurance Objectives.....	43
6.2.3 Quality Assurance Implementation.....	43
6.2.4 Management and Assessment.....	43
6.3 Environment, Safety and Health	43
6.3.1 Overview.....	44
6.3.1.1 Introduction and Scope.....	44
6.3.1.2 Objectives.....	44
6.3.1.3 Organization and Responsibilities	44
6.3.1.4 Documentation and Training	45
6.3.1.5 Experiment Safety.....	45
6.3.1.6 Visitors.....	45
6.3.2 Emergency Preparedness	45
6.3.3 Compliance	45
7.0 Management.....	47
7.1 Management Control	47
7.2 Technical Control	47
7.3 Schedule Control	48
7.4 Cost Control	49
7.5 Configuration Management.....	49
7.6 Contingency Funding	50
7.7 Progress Reports and Variance Analysis.....	50
Appendix A: PHENIX Global Schedule	51
Appendix B: PHENIX Collaboration List.....	65
Appendix C: PHENIX Institutional MOU Template	69

1.0 INTRODUCTION

1.1 Physics Motivation

The primary goals of the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) are to detect the quark-gluon plasma (QGP) and to measure its properties. Many of the potential signatures for the QGP are measured as a function of a well-defined common variable to see if any or all of these signatures show simultaneous anomalies due to the formation of the QGP. In addition, basic quantum chromodynamics phenomena, collision dynamics, and thermodynamic features of the initial states of the collision are studied.

The strategy behind the PHENIX experiment is to simultaneously study lepton, photon, and hadron signatures for the QGP in the *same* experiment. Table 1.1 lists the signatures for the QGP that are addressed by PHENIX.

Table 1.1 Signatures for the QGP Addressed by PHENIX

QGP Signature	Probe
<i>Deconfinement (Debye Screening of QCD Interactions)</i>	
$r(\Upsilon)\approx 0.13\text{ fm} < r(J/\psi)\approx 0.29\text{ fm} < r(\psi')\approx 0.56\text{ fm}$	Muons, Electrons
$J/\psi \rightarrow e^+e^-$ at $y\approx 0$	
$J/\psi \rightarrow \mu^+\mu^-$ at $y\approx 2$	
$\psi', \Upsilon \rightarrow \mu^+\mu^-$ at $y\approx 2$	
<i>Chiral Symmetry Restoration</i>	
Mass, Width, Branching Ratio:	Electrons
$\phi \rightarrow e^+e^-, K^+K^-$, with $\Delta m \leq 5\text{ MeV}$	Hadrons
Baryon Susceptibility: Production of Antinuclei	
Narrow σ -meson	
<i>Thermal Radiation from a Hot Gas</i>	
Prompt γ , Prompt $\gamma^* \rightarrow e^+e^-, \mu^+\mu^-$	Electrons, Muons, Photons
<i>Nature of the Phase Transition</i>	
First-order: Entropy Jump	Hadrons
Second Rise in $\langle p_T \rangle$	
Spectra of π , K, p	
Second-order: Fluctuations	Hadrons, Photons
$N(\pi^0)/N(\pi^+ + \pi^-)$, $d^2N/d\eta d\phi$	
<i>Strangeness and Charm Production</i>	
Production of K^+, K^-, K^0	Hadrons
$\phi \rightarrow e^+e^-, K^+K^-$ at $y\approx 0$	Electrons
$\phi \rightarrow \mu^+\mu^-$ at $y\approx 2$	Muons
D-meson: $e\mu$ coincidence	
<i>Jet Quenching</i>	
High p_T Jets via Leading Particle Spectra	Hadrons
<i>Space-Time Evolution</i>	
HBT Correlations for $\pi\pi$ and KK	Hadrons

Leptons and photons arise from the plasma phase and probe it directly, whereas the more copious hadrons provide complementary information about the hadronization phase transition. Lepton pairs (dielectrons and dimuons) are measured to study various properties of vector mesons, such as the mass, the width, and the degree of yield suppression due to the formation of the QGP. The effect of thermal radiation on the continuum is studied in different regions of rapidity and mass. The $e\mu$ coincidence is measured to study charm production and backgrounds to the continuum dilepton spectrum. Photons are measured to study direct emission of single photons and to study π^0 and η production. Charged hadrons are identified to study the spectrum shape, production of antinuclei, the ϕ meson (via $K^+ K^-$ decay), jets, and two-boson correlations. The measurements are made down to small cross sections to allow the study of high p_T spectra, and J/ψ and Υ production. Recognizing that some of the potential signatures involve rare processes and small effects, the PHENIX detector is designed to be capable of taking data at the highest luminosities expected at RHIC. To extract new physics from these data, it is important that systematic measurements of $p + p$, $p + A$, and $A + A$ collisions are performed, as well as $A + A$ collisions over a range of beam energies and species.

1.2 Detector Overview

Eleven detector subsystems and a magnet subsystem comprise the baseline PHENIX detector. In addition, on-line and off-line subsystems provide the data acquisition, trigger, and computing infrastructure for the experiment. The components, acceptances and functions of the detector subsystems are summarized in Table 1.2. Figure 1.1 is a three-dimensional cutaway view of the PHENIX detector, showing the location of the various components of the detector subsystems.

In order to have uniform p_T acceptance for dielectrons, an axial field magnet was chosen with two electron detectors, the centers of which are separated by 135° in azimuth (ϕ). Electrons and positrons are detected by this two arm spectrometer, each arm subtending 90° in azimuth (ϕ) and ± 0.35 units in pseudorapidity (η), roughly equivalent to a polar angle (θ) acceptance of $\pm 20^\circ$ centered at θ equal to 90° . The solid angle of each arm is 0.94 sr. Electron identification is performed using the following detector subsystems: Cherenkov radiation detected in the ring imaging Cherenkov counters (RICH), energy loss of the charged particles in the time expansion chambers (TEC), and time-of-flight and electromagnetic showers in lead-scintillator (PbSc) and lead-glass (PbGl) calorimeters. Within the aperture for the electron measurement are detector subsystems with limited acceptance for photons, using the PbGl calorimeter ($\Delta\phi = 45^\circ$, $\Delta\eta = \pm 0.35$), and for charged hadrons, using a high precision time-of-flight (TOF) array ($\Delta\phi = 30^\circ$, $\Delta\eta = \pm 0.35$). The PbSc also measures photons with an energy resolution close to that achieved in the PbGl; together, they comprise the PHENIX electromagnetic calorimeter (EMCal). A forward spectrometer ($10^\circ < \theta < 35^\circ$) around the beam axis is used to track and identify muons. In addition, a silicon detector array is installed over a wide angular region ($\Delta\eta = \pm 2.7$) to measure event multiplicity, and two beam-beam counter arrays determine the vertex position and provide a timing start signal.

Figure 1.1: Cutaway View of PHENIX Detector

Table 1.2 Detector Subsystems in the Baseline PHENIX Detector

Subsystem	$\Delta\eta$	$\Delta\phi$	Purpose and Specifications
<i>Magnets</i>			
Central Magnet	± 0.5	360°	Up to 1.0 T·m
Muon Magnet	1.1-2.5	360°	0.72 T·m for $\eta = 2$, 0.36 T·m for $\eta = 1.3$
<i>Inner Detectors</i>			
Silicon (MVD)	± 2.7	360°	$d^2N/d\eta d\phi$, Precise Vertex
Beam-Beam counters (BB)	$\pm(3.1-4.0)$	360°	Start Timing, Fast Vertex
<i>Tracking System</i>			
Drift Chambers (DC)	± 0.35	$90^\circ + 90^\circ$	Momentum and Mass Resolution, $\Delta m/m = 0.4\%$ at $m=1$ GeV
Pad Chambers (PC)	± 0.35	$90^\circ + 90^\circ$	Pattern Recognition, and Tracking for Non-bend Direction
Time Expansion Chamber (TEC)	± 0.35	$90^\circ + 90^\circ$	Pattern Recognition, Tracking after RICH, and dE/dx
Ring Imaging Cherenkov Detector (RICH)	± 0.35	$90^\circ + 90^\circ$	Electron Identification
Time-of-Flight System (TOF)	± 0.35	30°	Hadron Identification, $\sigma < 100$ ps
<i>Electromagnetic Calorimetry</i>			
Lead/scintillator calorimeter (PbSc)	± 0.35	$90^\circ + 45^\circ$	e/π Separation at $p > 1$ GeV/c by EM Shower and $p < 0.35$ GeV/c by Time-of-Flight
Lead-glass calorimeter (PbGl)	± 0.35	45°	K/e Separation at 1 GeV/c by Time-of-Flight for dE/dx Photon Detection
<i>Muon Arm</i>			
Muon Tracker (μT)	1.15-2.35	360°	Tracking for Muons
Muon Identifier (μID)	1.15-2.35	360°	Iron Absorbers and Chambers for μ /hadron Separation

A full description of the detector may be found in the PHENIX Conceptual Design Report, January 1993, and the Conceptual Design Report Update, November 1993.

1.3 Cost and Schedule Overview

The PHENIX baseline detector costed in the present Management Plan is the detector discussed in Section 1.2, but with certain components either deferred or reduced in initial scope for budgetary reasons. As outlined in the Plan, the baseline detector meets the requirements of having a total DOE construction cost estimate, including contingency, of \$36.7M (in FY 1993 dollars), and having a profile that is consistent with the budget authority available to PHENIX as

set by the RHIC Project Management in December 1993. Elements of the proposed detector that are deferred or reduced to meet the budget authority requirements include:

1. Deferral of the central magnet inner coils.
2. A 25% reduction of the central arm readout channels in the subsystems outside the inner tracking.
3. Deferral of the muon magnet coil.
4. Deferral of the muon arm instrumentation (μT and μID).
5. Deferral or reduction of portions of the trigger, data acquisition and computing systems that are required for the highest luminosity running.

The PHENIX baseline detector is scheduled to begin commissioning in August 1998, and will be ready for data taking with colliding beams in 1999, when RHIC is scheduled to begin physics running.

The current cost and schedule of the PHENIX project was generated using Microsoft (MS) Project software. All cost and schedule information for the subsystems that comprise PHENIX were entered into the MS Project database in order to develop an integrated cost and schedule for the project. The cost and cost profile results generated from MS Project are formatted for presentation and publication using MS Excel. These software tools will be used to manage the cost and schedule of the PHENIX for the duration of the construction phase of the project.

2.0 COST AND SCHEDULE SUMMARY

In this section the methods and procedures used for developing the cost and contingency estimates, schedules and profiles are discussed. The basis for estimating costs, the contingency analysis, and the format of the Work Breakdown Structure (WBS) are discussed in Sections 2.1.1 - 2.1.3. The cost estimates, profiles, and schedules are summarized in Sections 2.2-2.4. In addition, the construction project is analyzed and discussed briefly from the point of view of critical path method analysis in Section 2.5.

2.1 Methods and Procedures

The PHENIX Collaboration adopted a commercial software package, MS Project, for use in generating the individual subsystem cost estimates and schedules, as well as the overall cost and schedule of the project. All subsystems' cost and schedule information was entered into and developed using MS Project. In MS Project, costs, schedules, and cost profiles were all determined from a single database, into which were entered scheduled Tasks with assigned Resources. Resources are comprised of both Manpower (EDIA and fabrication/test/installation labor) and Fixed Costs (purchased items). Subsystem managers thus created their cost estimates, schedules, and cost profiles from MS Project simultaneously in a fully integrated way.

Microsoft Excel was integrated with MS Project as a *presentation tool* for generating the WBS book and other cost reports. A custom written MS Excel macro extracts the cost information from the MS Project database and inserts it into a preformatted MS Excel spreadsheet for publication. This integrated package (MS Project and Excel) will be used by subsystem managers to track actual costs and work done, for reporting to the PHENIX Management, RHIC Management and DOE. This information will be used to generate the monthly Cost Performance Report, which is described in Section 3.2.5.

2.1.1 Basis of Estimate

Cost estimates and schedules were created by using a WBS to define tasks down to the lowest level necessary for the given subproject, and then entering these tasks and their resources into MS Project. The organization of the PHENIX WBS is described in Section 2.1.3.

The WBS and the MS Project files for all the subsystems were defined and created by physicists and engineers responsible for the work. The experience of these individuals was the basis for the cost estimate. Factors determining the actual cost and work associated with the subsystem construction include: experience gained from prior similar projects, engineering judgment, actual vendor quotes, or vendor budgetary estimates. The contingency on the estimate (see Section 2.1.2) is linked to the degree of confidence in the method of estimation, as well as other factors.

The overall PHENIX cost estimate (see Section 2.2) and cost profile (see Section 2.3) were developed in MS Project by rolling up the approximately 50 subprojects defined at RHIC WBS

level 4 (e.g., WBS 2.5.2.1, MVD mechanical structure). The WBS level 4 items that are upgrades and the Level 3 trigger and routing layer have WBS numbers "reserved" for future use; they are not considered in the present cost estimate. The 50 subprojects are the responsibility of the subsystem managers (i.e., the Detector Council members), and the overall estimates are the responsibility of PHENIX Project Management.

2.1.2 Contingency Analysis

A contingency percentage was assigned to every task in the WBS that has resources assigned to that task. The contingency is a measure of the risk involved in completing the task, or, as mentioned above, the degree of confidence in the method of estimation. An effort was made to standardize contingency estimation across all subsystems. Table 2.1 lists the guidelines used to set the "normal" contingency on typical costs. Guidelines for assigning above- or below-normal contingencies are described below the table.

Table 2.1 PHENIX Guidelines for Setting Contingency Percentages

Type of Cost Estimate	Normal Contingency (%)
Catalog price, off-the-shelf items	10
Vendor quote, from established drawings	15
Vendor estimate, from design sketches	20
Engineering judgment, based on previous fabrication	20
Engineering judgment, based on a new design	25

In each category, it was assumed that a WBS item has some critical or noncritical impact on the subsystem schedule. If an item is viewed to be noncritical to the subsystem schedule, 5% was subtracted from the contingency value; whereas, if the item is viewed to be critical to the schedule, 5% was added to the contingency. In addition, if there were special risk factors associated with an item, the contingency percentage was increased as necessary, and documented in the WBS Notes book. In general, contingencies greater than about 50% had to have very good, defensible justifications. A zero percent contingency was applied to the costs of items that have already been procured, since the actual cost of the item is known.

Project contingency has been computed "line-by-line" in the WBS as described above. However, contingency is actually applied to the project according the guidelines and rules set forth in Section 7.5.

2.1.3 Work Breakdown Structure

The Work Breakdown Structure (WBS) is a task definition scheme in outline form, which is open-ended. The WBS number of a task can have as many levels as necessary, depending on how detailed the breakdown is. In the case of PHENIX, WBS items are numbered 2.5.[C].[D].[E]. The leading "2" represents RHIC Detectors and "5" represents PHENIX in the RHIC WBS

organization. The level 3 number, [C], is the PHENIX subsystem group, and the level 4 number, [D], denotes a PHENIX subsystem. In the PHENIX WBS format, a complete detector subsystem, for example the Drift Chamber, appears under WBS 2.5.2.4 (mechanical systems) *and* under WBS 2.5.3.4. (front-end electronics systems). Table 2.2 lists all the subsystem groups (level 3) and subsystems (level 4) in the PHENIX project by WBS number.

Table 2.2 PHENIX WBS Level 3 and 4 Items

WBS #	Subsystem	WBS #	Subsystem
2.5.1	Magnet Systems	2.5.4	DAQ/Trigger/Computing
2.5.1.1	Outer Coil	2.5.4.1	Data Collection Modules
2.5.1.2	Inner Coil (<i>deferred</i>)	2.5.4.2	Subevent Transfer Buffers
2.5.1.3	Central Magnet Steel	2.5.4.3	Event Builder
2.5.1.4	Muon Coil (<i>deferred</i>)	2.5.4.4	Level 1 Trigger
2.5.1.5	Muon Magnet Steel	2.5.4.5	Level 2 Trigger (<i>deferred</i>)
2.5.1.6	Muon Identifier Steel	2.5.4.6	Level 3 Trigger (<i>deferred</i>)
		2.5.4.7	Routing Layer (<i>deferred</i>)
2.5.2	Detector Systems (Mechanical)	2.5.4.8	Master Timing and Control System
2.5.2.1	MVD	2.5.4.9	On-line Computing System
2.5.2.2	BB	2.5.4.10	Simulation Computing
2.5.2.3	HBD (<i>upgrade</i>)	2.5.4.11	Off-line Computing
2.5.2.4	DC	2.5.4.12	Common Computing
2.5.2.5	PC	2.5.4.13	Common DAQ
2.5.2.6	TEC		
2.5.2.7	RICH	2.5.5	System Engineering & Integration
2.5.2.8	TOF	2.5.5.1	Detector Carriages
2.5.2.9	EMCal (PbSc)	2.5.5.2	Facilities
2.5.2.10	EMCal (PbGl)	2.5.5.3	Integration
2.5.2.11	EMCal (CsI) (<i>upgrade</i>)	2.5.5.4	Installation
2.5.2.12	μ T (<i>deferred</i>)	2.5.5.5	Detector Test and Commissioning
2.5.2.13	μ ID (<i>deferred</i>)	2.5.5.6	Safety & Environmental Protection
2.5.3	Detector Systems (FEE)	2.5.6	Project Management
2.5.3.1	MVD	2.5.6.1	Quality Assurance
2.5.3.2	BB	2.5.6.2	Site Management
2.5.3.3	HBD (<i>upgrade</i>)	2.5.6.3	Budget Tracking and Reporting
2.5.3.4	DC		
2.5.3.5	PC		
2.5.3.6	TEC		
2.5.3.7	RICH		
2.5.3.8	TOF		
2.5.3.9	EMCal(PbSc)		
2.5.3.10	EMCal (PbGl)		
2.5.3.11	EMCal (CsI) (<i>upgrade</i>)		
2.5.3.12	μ T (<i>deferred</i>)		
2.5.3.13	μ ID (<i>deferred</i>)		
2.5.3.14	Common FEE System Work		

The level 5 number, [E], indicates the major construction steps associated with each subsystem. Subsequent levels depend on the degree of breakdown required to describe the task adequately for purposes of assigning resources to the associated tasks. Table 2.3 lists the level 5 WBS categories in the PHENIX project.

Table 2.3 PHENIX WBS Level 5 Categories

Level 5	Category
1	EDIA
2	Prototyping
3	Fabrication
4	Assembly
5	Test/Installation

2.2 Cost Summary

2.2.1 Total Cost

If built "from scratch" entirely in the US, the cost of the baseline detector would be about \$70.6M. This total *cannot* be compared directly to the approximately \$42M quoted in the January 1993 CDR as the total cost for the following reasons:

1. The stretch-out of the construction period had the effect of increasing slightly the cost of project manpower.
2. A few subsystems, notably the DAQ, the μ ID, and the integration and installation task were increased in capability, in part due to our interactions with the TAC and the Muon Arm Review committee. The responses to their concerns and suggestions has had an impact on the total cost of the project.
3. The value of the Japanese contribution to PHENIX has increased mostly because of the change in the value of the Yen since January 1993.
4. Most importantly, the so-called total cost presented in the January 1993 CDR was in fact *not* the full US cost of the baseline as estimated at that time. As pointed out at the February 1993 TAC review of the CDR, there was no consistent basis for that \$42M total: some items (such as the shish-kebab EMCAL) listed at the Russian cost, others (such as the magnet system) listed at the US cost, and still others (such as the "free" lead-glass EMCAL from the CERN program) left out. In response to that valid criticism, we have endeavored to account for the US cost of every piece of the baseline and include it in the total.

Apart from such issues, the total cost estimate has risen slightly, as is typically the case when a bottoms-up reestimate is made following a year of further R&D and engineering work. This type

of increase is seen not only in the total cost but in the cost covered by PHENIX construction funds. This increase was about 14% between the February 1993 CDR review and the November 1993 Technical, Cost and Schedule review. Since November 1993 the total cost estimate has been quite stable.

In summary, the large apparent difference in the total cost does not represent a change in the conceptual detector design or a change in strategy for funding the construction. It is a combination of factors, the primary one being that the present total is a complete accounting of the U.S. cost.

2.2.2 Construction Budget Authority

The funding plan takes account of known foreign contributions and cost reductions of \$23.2M, US collaborating institution contributions of \$4.2M, deferred costs of \$11.7M, and pre-operations funds of \$1.5M. The foreign and collaboration contributions are listed in Section 2.3.2, "Other Funding."

Following the November 1993 Technical, Cost and Schedule Review, additional elements of the PHENIX detector were deferred or reduced to meet the budget authority requirements. Specifically, these are:

1. A 25% reduction of the central arm readout channels in the subsystems outside the inner tracking (RICH, PC2, TEC, PC3, and EMCal).
2. Deferral of construction of 2 (out of 6) layers of the TEC, which were in any case not intended to be instrumented until the TRD upgrade.
2. Deferral of the muon magnet coil.
3. Deferral or reduction of portions of the trigger, data acquisition and computing systems that are required for the highest luminosity running.

Subtracting the foreign contributions, institutional contributions, deferred or reduced items, and pre-operations funds from the total U.S. costs leaves a cost in terms of PHENIX construction funds of \$30.0M (without contingency), as shown in Table 2.4.

Table 2.4 Baseline PHENIX Cost Summary

Item	Cost (\$M)
Total U.S. Cost of the Baseline	70.6
Foreign Contributions and Cost Reductions	-23.2
US Collaboration Contributions	-4.2
Deferred Items	-11.7
Pre-operations Funds	-1.5
PHENIX Construction Funds (without contingency)	30.0
Contingency (averages 22%)	+6.6
Total PHENIX Construction Funds	36.6

Contingency has been estimated in bottoms-up fashion and totals \$6.6M. In terms of PHENIX construction funds, this is a 22% contingency. With contingency added, the fully estimated cost in terms of PHENIX construction funds is \$36.6M. This is summarized in Table 2.4.

The details of the cost estimate are contained in the documents described in Section 2.7. A RHIC WBS level 4 summary cost of the PHENIX detector is shown in Table 2.5. A pie chart based on Table 2.5 is shown in Figure 2.1 for the total cost of the PHENIX baseline detector, showing the funding percentages, including deferred items, coming from various sources.

Figure 2.1 Pie chart for the total cost of the PHENIX baseline detector, showing the funding percentages, including deferred items, coming from various sources. These percentages do not include contingency costs and are calculated in FY1993 dollars. Refer to Table 2.5 for actual costs.

Table 2.5 PHENIX Detector Cost Summary Table (in FY 1993 dollars)

WBS	Item	Profiled Numbers							DOE Cont (%)	DOE Cont (k\$)
		Total	DOE	US-Japan	Pre-Ops	Institution	Deferred			
5.1	Magnet Systems	8812	4663	470	0	2835	844	27.28		1271
5.1.1	Outer Coil	957	414	470	0	72	0	11.99		50
5.1.2	Inner Coil	503	48	0	0	29	426	0.00		0
5.1.3	Central Magnet Steel	2861	1606	0	0	1255	0	29.03		466
5.1.4	Muon Coil	517	113	0	0	82	323	11.04		13
5.1.5	Muon Magnet Steel	2989	1496	0	0	1398	96	30.45		455
5.1.6	Muon ID Steel	985	985	0	0	0	0	29.18		287
5.2	Detector Systems (Mech.)	30910	7219	6441	0	12187	5064	21.39		1544
5.2.1	MVD	1337	1037	0	0	300	0	28.68		297
5.2.2	BB	498	0	444	0	54	0	0.00		0
5.2.4	DC	1273	636	0	0	636	0	24.56		156
5.2.5	PC	1534	1359	0	0	175	0	18.49		251
5.2.6	TEC	1825	1376	0	0	186	263	19.85		273
5.2.7	RICH	4829	0	4763	0	66	0	0.00		0
5.2.8	ToF	1460	0	1234	0	226	0	0.00		0
5.2.9	EMCal (PbSc)	7468	2489	0	0	4979	0	19.81		493
5.2.10	EMCal (PbGl)	5640	120	0	0	5520	0	19.12		23
5.2.12	Muon Tracker	3390	38	0	0	44	3307	20.00		8
5.2.13	Muon ID	1657	163	0	0	0	1493	25.74		42
5.3	Detector Systems (FEE)	10879	6116	1595	0	958	2309	21.58		1318
5.3.1	MVD	749	649	0	0	100	0	28.74		186
5.3.2	BB	213	0	195	0	18	0	0.00		0
5.3.4	DC	796	796	0	0	0	0	23.14		184
5.3.5	PC	1806	1622	0	0	90	94	19.73		320
5.3.6	TEC	1533	737	0	0	708	85	13.72		101
5.3.7	RICH	1217	0	1040	0	42	135	0.00		0
5.3.8	ToF	502	0	359	0	0	143	0.00		0
5.3.9	EMCal(PbSc)	642	572	0	0	0	70	22.17		127
5.3.10	EMCal (PbGl)	691	691	0	0	0	0	22.58		156
5.3.12	Muon Tracker	1062	0	0	0	0	1062	0.00		0
5.3.13	Muon ID	719	0	0	0	0	719	0.00		0
5.3.14	Common FEE	1049	1049	0	0	0	0	23.23		244
5.4	DAQ/Trigger/Computing	12004	7955	244	0	542	3263	21.13		1681
5.4.1	Data Collection Modules	2069	1127	0	0	0	942	17.21		194
5.4.2	Subevent Transfer Buffers	326	320	0	0	0	7	23.33		75
5.4.3	Event Builder	2526	1108	0	0	0	1419	18.46		204
5.4.4	Level 1 Trigger	1617	1240	244	0	0	133	14.83		184
5.4.5	Level 2 Trigger	664	123	0	0	0	541	29.40		36
5.4.8	Master Timing	316	279	0	0	0	36	23.14		65
5.4.9	On-line Computing	2672	2672	0	0	0	0	25.00		668
5.4.10	Simulation Computing	181	118	0	0	63	0	24.10		28
5.4.11	Off-line Computing	750	656	0	0	94	0	25.00		164
5.4.12	Common Computing	252	0	0	0	252	0	0.00		0
5.4.13	Common DAQ	631	312	0	0	133	186	20.03		63
5.5	System Eng. & Integration	5894	2703	0	1458	1312	221	22.17		599
5.5.1	Detector Carriages	598	536	0	0	62	0	20.81		112
5.5.2	Facilities	1483	1181	0	0	80	221	24.15		285
5.5.3	Integration	1190	573	0	28	589	0	19.01		109
5.5.4	Installation	1892	209	0	1258	424	0	23.85		50
5.5.5	Test and Commissioning	371	94	0	145	132	0	22.36		21
5.5.6	S & E P	159	108	0	27	25	0	20.49		22
5.6	Project Management	2217	1402	0	0	815	0	11.82		166
5.6.1	Quality Assurance	1154	662	0	0	492	0	10.80		71
5.6.2	Site management	445	277	0	0	167	0	16.44		46
5.6.3	Budget Tracking	619	463	0	0	156	0	10.51		49
Totals		70616	30057	8750	1458	18648	11702	21.89		6579
PHENIX Construction Funds (with contingency)			36636							

2.3 Cost Profile

Figure 2.2 shows the overall fiscal year cost profile that is required to meet the schedule to build the PHENIX detector presented in Appendix A. Shown in the figure (in FY 1993 dollars) are the estimated spending profile of PHENIX construction funds, the target profile set by RHIC Management December 1993, and the accumulated difference between these two profiles. A positive value of the accumulated difference in a given fiscal year means that there is sufficient budget authority to cover the estimated requirement for construction funds in that year. In generating the estimated spending profile in Figure 2.2, a yearly distribution of contingency funds was assumed. The assumed distribution of contingency funds (in FY 1993 dollars) is shown in Table 2.6

Figure 2.2 The construction funds profile (based on Table 2.6) needed to build the PHENIX baseline detector is shown in dark gray. The RHIC target profile for PHENIX is shown in light gray. The accumulated difference between the two profiles is shown in black.

Table 2.6 PHENIX Detector Construction Funds per Fiscal Years (in FY 1993 dollars)

WBS	Item	FY93	FY94	FY95	FY96	FY97	FY98	FY99
5.1	Magnet Systems	433	1285	1403	1525	17	0	0
5.1.1	Outer Coil	90	174	51	85	15	0	0
5.1.2	Inner Coil	44	4	0	0	0	0	0
5.1.3	Central Magnet Steel	121	550	436	498	0	0	0
5.1.4	Muon Coil	58	5	0	48	2	0	0
5.1.5	Muon Magnet Steel	120	458	257	660	0	0	0
5.1.6	Muon ID Steel	0	93	659	234	0	0	0
5.2	Detector Systems (Mech.)	86	1003	2543	1815	1216	540	16
5.2.1	MVD	0	132	505	311	12	76	0
5.2.2	BB	0	0	0	0	0	0	0
5.2.4	DC	0	11	206	220	159	40	0
5.2.5	PC	0	110	841	165	126	115	2
5.2.6	TEC	56	295	303	321	274	126	0
5.2.7	RICH	0	0	0	0	0	0	0
5.2.8	ToF	0	0	0	0	0	0	0
5.2.9	EMCal (PbSc)	29	364	595	741	609	139	13
5.2.10	EMCal (PbGI)	0	21	0	18	36	44	0
5.2.12	Muon Tracker	0	0	0	38	0	0	0
5.2.13	Muon ID	0	69	94	0	0	0	0
5.3	Detector Systems (FEE)	0	845	960	810	3423	79	0
5.3.1	MVD	0	10	217	111	310	0	0
5.3.2	BB	0	0	0	0	0	0	0
5.3.4	DC	0	155	201	32	406	2	0
5.3.5	PC	0	29	81	106	1355	52	0
5.3.6	TEC	0	20	56	60	579	25	0
5.3.7	RICH	0	0	0	0	0	0	0
5.3.8	ToF	0	0	0	0	0	0	0
5.3.9	EMCal(PbSc)	0	0	0	169	403	0	0
5.3.10	EMCal (PbGI)	0	0	0	320	371	0	0
5.3.12	Muon Tracker	0	0	0	0	0	0	0
5.3.13	Muon ID	0	0	0	0	0	0	0
5.3.14	Common FEE	0	630	406	13	0	0	0
5.4	DAQ/Trigger/Computing	0	498	1375	2820	1997	1055	212
5.4.1	Data Collection Modules	0	81	134	771	88	54	0
5.4.2	Subevent Transfer Buffers	0	64	99	72	79	7	0
5.4.3	Event Builder	0	74	151	369	473	40	0
5.4.4	Level 1 Trigger	0	38	76	473	357	234	63
5.4.5	Level 2 Trigger	0	37	76	7	3	0	0
5.4.8	Master Timing	0	0	36	230	14	0	0
5.4.9	On-line Computing	0	150	540	641	629	606	106
5.4.10	Simulation Computing	0	0	28	32	19	29	9
5.4.11	Off-line Computing	0	51	235	158	90	87	34
5.4.12	Common Computing	0	0	0	0	0	0	0
5.4.13	Common DAQ	0	0	0	67	245	0	0
5.5	System Engineering & Integration	123	300	1262	603	208	163	46
5.5.1	Detector Carriages	35	61	65	306	69	0	0
5.5.2	Facilities	7	101	1055	15	3	0	0
5.5.3	Integration	81	113	117	112	75	69	7
5.5.4	Installation	0	0	0	121	15	54	19
5.5.5	Test and Commissioning	0	0	0	25	19	33	17
5.5.6	S & E P	0	25	24	25	25	7	3
5.6	Project Management	86	264	296	287	194	194	91
5.6.1	Quality Assurance	43	127	126	127	96	96	48
5.6.2	Site management	7	30	53	54	54	54	26
5.6.3	Budget Tracking	36	107	107	107	45	45	18
Fiscal Year PHENIX Totals (w/o cont.)		728	4192	7828	7862	7053	2031	385
Applied Contingency		0	0	450	1050	2500	2100	479
Fiscal Year PHENIX Totals (w/ cont.)		728	4192	8278	8912	9553	4131	844
PHENIX Construction Funds (w/o cont.)								30059
PHENIX Construction Contingency								6579
PHENIX Construction Funds (w/ cont.)								36637

2.4 Schedule Summary

The cost estimate of the PHENIX construction project assumes a construction schedule consistent with the start of physics running at RHIC in FY 1999. The summary schedule is found in Appendix A of this document. The project start date is taken to be 1 January 1994, although some construction funds have been expended in FY 1993. The current PHENIX Global Schedule (see Section 2.5) is too large for inclusion in the Management Plan. It is shown in the introduction of the February 1994 Work Breakdown Structure (WBS) book. Detailed subsystem schedules are included in each section of the WBS book.

According to the schedule, installation of the detector in the Major Facility Hall starts (with the μ ID absorber and the magnet subsystem) in November 1994. A desirable feature of the schedule would be to have the inner detectors and at least one complete central arm installed well before (on the order of one year before) the scheduled start of physics running at RHIC. This is so the detector (including data acquisition system) could be commissioned and thoroughly system-tested. However, the present schedule, which has been adjusted to accommodate the funding profile, shows only about two months for this commissioning period. This assumes an April 1999 start of colliding beam running at RHIC.

2.5 Critical Path Method Analysis

In order to understand what components of PHENIX and its subsystems are determining the construction schedule, Critical Path Method (CPM) analysis is used. The critical path through a project is defined as that sequence of tasks with no "slack time." Microsoft Project can easily show which tasks are on the critical path; CPM analysis involves understanding the project's schedule and schedule risks in terms of the critical path.

It is important to understand the critical path at two levels in PHENIX: (1) at the subsystem level, where the work is done and costs incurred; and (2) at the global level, where subsystem schedules interact with one another to produce an overall schedule.

Microsoft Project allows one to link together separate subprojects which interact with one another, producing a critical path through all the linked subprojects. In PHENIX, this linking is carried out in the following specific case: For a given detector subsystem, there are two subprojects, a mechanical one and a front-end electronics one. These two are linked together to produce a subsystem critical path.

From a global point of view, the schedule impact of a detector subsystem is primarily contained in its "ready to install" date(s). These dates for all the subsystems (together with other system constraints, such as "Major Facility Hall beneficial occupancy date," "install detector A before detector B," etc.) form the input to a MS Project file called the "PHENIX Global Schedule" (PGS). We have opted for a manual link (in the form of dates and constraints) between the subprojects and PGS. The reason for this choice is based on the fact that subsystem managers will be using the MS Project files to manage the subsystem construction. As a result, they will need to modify files to reflect reality as the project progresses. For this reason it was decided not

to try to maintain a fully-linked set of 50 project files to produce a global schedule and critical path. The PGS will be updated by the PHENIX Project Office on a regular basis as part of Project Management's oversight and reporting responsibilities.

The PGS critical path output is too large for inclusion in the Management Plan. It is shown in the introduction of the February 1994 Work Breakdown Structure (WBS) book. The critical paths for each subsystem are included in each section of the WBS book

2.6 Project Milestones

The summary schedule is shown in Appendix A. From that summary we present in Table 2.6 several major milestones in the PHENIX construction project. As shown below, we expect to be able to start this commissioning in January 1999 with one of the two central arms plus inner detectors, and with the entire baseline detector in February 1999.

Table 2.6 Major PHENIX Construction Milestones

Date	Milestone
September 1994	Beneficial Occupancy of MFH
November 1995	Start muon ID steel and magnet installation
January 1997	Magnets installed, tested and mapped
April 1997	Central arm support structures ready for installation
April 1997	Start installation of detectors in central arm #2
February 1998	Start installation of detectors in central arm #1
March 1998	DAQ subsystem fabrication complete
August 1998	Complete installation, cabling and testing of detectors in arm #1
September 1998	Start Installation of inner detectors
October 1998	All detector subsystem fabrication complete
December 1998	Complete installation cabling and testing of inner detectors
January 1999	DAQ installation complete, ready for commissioning
January 1999	Start of commissioning with arm #1 + inner detectors
February 1999	Complete installation, cabling and testing of detectors in arm #2, and continue commissioning with full baseline detector
April 1999	Data-taking with colliding beams

Table 2.6 does not explicitly show milestones related to the Muon Arm instrumentation because of its deferred status. Its schedule is shown in detail in the WBS book assuming January 1994 for the start of design. The instrumentation is all ready for installation by January 1997 with this assumption. This is to be compared with 1998 start dates for central arm and inner detector installation. Therefore, if additional funding can be secured within a year or so of the start of PHENIX project funding, it is expected that the muon arm will also be commissioned and ready for data-taking with the rest of the baseline.

2.7 WBS Documentation

Two additional review documents accompany the February 1994 version of the PHENIX Management Plan, as part of the material prepared for the 9-10 March 1994 Baseline Review of the PHENIX detector. The February 1994 PHENIX Work Breakdown Structure (WBS) book and the PHENIX WBS Notes book are revised and updated versions of the books used for the November 1993 review. The February 1994 Management Plan, WBS book, and WBS Notes book supersede the November 1993 documents. As with the previous books, the WBS book contains the cost estimates, schedules, and profiles for the detector subsystems and infrastructure of PHENIX, and the WBS Notes book gives dictionary entries, basis of estimate summaries, and contingency analyses for each WBS entry.

2.7.1 WBS Book

The February 1994 WBS book contains an introductory section that contains the high-level (RHIC WBS level 4) summary cost estimate, schedule, profiles, and global critical path analysis. The summary cost estimate is broken down into EDIA, Labor and Fixed Cost (M&S) categories. Also shown in the summary cost estimate are the contingency and contingency percentage, plus the non-DOE contributions and deferred costs.

Following this are sections for each subsystem. In each section are summary cost estimate, schedule, critical path analysis, and profile at RHIC WBS level 5. This summary information is followed by the detailed cost estimate and schedule sheets. The detailed sheets are typically carried down to level 7 or 8.

The cost estimate, schedule, and manpower and cost profiles were all derived from a single, integrated, resource-driven estimate for the construction of each subsystem. Microsoft Project was used by all subsystems for preparing cost estimates, schedules, profiles, and critical path analysis. Total project cost, schedule, profile, and critical path analysis was generated by rolling-up all the subsystem files.

2.7.2 WBS Notes Book

The WBS Notes book contains three sets of commentary on the WBS entries: Dictionary, Basis of Estimate, and Contingency Analysis. These three appear side-by-side next to the WBS number

for that entry. The purpose of the Notes is to help in evaluating the cost and schedule of the subsystem components at the WBS level at which they are generated. The Dictionary entry is a description of the item, indicating briefly its nature and function in the subsystem, how it is built, and other relevant information. The Basis of Estimate entry describes briefly how the cost estimate was determined (e.g., vendor quote, actual cost of a previous project, engineering estimate, etc.). The Contingency Analysis entry gives reasons, if any, for using a relatively high or low contingency percentage for each item. "Normal" contingency is typically 20 or 25%. The reasons for departure from normal contingency is typically risk related (see Section 2.1.2).

3.0 MANAGEMENT ORGANIZATION

3.1 RHIC Project Management Overview

Construction of the baseline PHENIX detector (Magnet, Subsystem mechanical and front-end electronics, DAQ, Trigger, Installation, detector conventional facilities and on-line computing) is being undertaken as part of the RHIC Project for DOE. The management responsibilities for the project are described in detail in the RHIC Project Management Plan. The DOE organization elements and the RHIC Project Management at BNL, as it relates to detectors, are summarized here.

3.1.1 DOE Organization

The DOE organizational relationships to the RHIC project are shown in Fig. 3.1. The Division of Nuclear Physics provides overall programmatic guidance for the project. This office reviews and approves project cost, schedule and technical baselines, provides coordination with other DOE Headquarters Offices, and reviews the RHIC Construction Project on a semiannual basis.

Figure 3.1: DOE RHIC Program/Project Organization.

The DOE's Brookhaven Area Office (BHO) has field management oversight responsibility for the project. The DOE RHIC Project Manager has the principal BHO responsibility for the execution of the project.

3.1.2 RHIC Project Organization at BNL

The BNL Director has overall responsibility for the direction of all Laboratory activities, including those needed to design, build, and operate the RHIC facility. Primary responsibility for the scientific direction of the RHIC Project, including both R&D and construction activities, has been delegated to the RHIC Project Head. The Laboratory's Associate Director for High Energy and Nuclear Physics, as chairman of the Program Advisory Committee for experiments in high energy and nuclear physics at the Laboratory, is responsible for the physics program at RHIC.

The RHIC Project organizational chart is shown in Fig. 3.2. The Project Head is responsible for the entire execution of the RHIC R&D, design, and construction programs, including the detector projects. The two Associate Heads, one for the collider systems and one for the detector projects, exercise the technical control of those major areas of the RHIC Project.

Figure 3.2 RHIC Project Organizational Chart.

The Associate Head for Detectors and Experimental Support has primary responsibility for the completion of RHIC WBS 2 (detectors, integration with other experimental support requirements, and preparation of the experimental program within technical, cost and schedule baselines). The Associate Head for Detectors and Experimental Support oversees the following areas:

1. Detector research and development projects.
2. The design, construction, and installation of the initial complement of detectors, with the assistance of the selected experimental groups (e.g., PHENIX).
3. Planning and operation of the experimental halls.

Within the RHIC organization, the PHENIX Spokesperson and Project Director report to the RHIC Associate Head for Detectors and Experimental Support.

3.2 PHENIX Project Management Overview

The PHENIX collaboration consists of over 375 scientists, engineers, and graduate students from 45 institutions in 10 countries. The full collaboration list as of February 1994 is shown in Appendix B. This large international collaboration is supported by U.S. resources and significant foreign resources.

The management organization for the PHENIX Project is depicted in Fig. 3.3. The executive body is called Project Management, and consists of a Spokesperson, Project Director, Deputy Project Director, Project Engineer, and Assistant for Project Management. This group is invested with authority to interact with RHIC Project Management for purposes of designing, constructing, installing, commissioning, and operating the PHENIX detector at RHIC.

Project Management (PM) carries out its responsibilities with the help of an Executive Council (EC), a Detector Council (DC), and a Project Office. The EC is an international group of senior physicists whose function is to monitor the performance of PM and to advise it on collaboration policy issues. Detector subsystem leaders comprise the DC, which is charged with the design, construction, test, and installation of the detector.

Project Management maintains day-to-day contact with the office of the RHIC Associate Head for Detectors and Experimental Support via the PHENIX Liaison Physicist.

Figure 3.3: PHENIX Management Organization.

The specific responsibilities of the members of Project Management and others shown in Fig. 3.3 are as follows:

Spokesperson: Shoji Nagamiya

- a) Serves as the EC chairperson.
- b) Represents the will of the collaboration in the PM, as expressed through the EC.
- c) Maintains communication among the collaborating institutions and organizes collaboration meetings.
- d) Promotes activity regarding non-DOE resources.
- e) Deals with issues concerning the scientific welfare of PHENIX students and junior scientists.
- f) Organizes scientific presentations (e.g., external reviews).

Project Director: Sam Aronson

- a) Has responsibility for completion of the construction project on schedule and within the cost estimate.
- b) Has responsibility for magnet, mechanical and system integration (WBS 5.1, 5.2 and 5.5) design, construction, installation and commissioning. Acts as integration physicist for these efforts.
- c) Has responsibility for R&D, engineering, and overall project cost estimate.
- d) Serves as the DC chairperson and organizes DC meetings.
- e) Interfaces with RHIC and BNL management.
- f) Has responsibility for contact with vendors.
- g) Organizes technical presentations (e.g., external reviews).
- h) Conducts periodic internal reviews of detector subsystems through the DC.

Deputy Project Director: Glenn Young

- a) As delegated by the Project Director, may share overall responsibility for project cost and schedule.
- b) Has responsibility for electronic and computing (WBS 5.3 and 5.4) design, construction, installation and commissioning. Acts as integration physicist for these efforts.
- c) Serves as the DC vice-chairperson.
- d) Interfaces with RHIC and BNL management.
- e) Has responsibility for contact with vendors.
- f) Organizes technical presentations (e.g., external reviews).
- g) Conducts periodic internal reviews of detector subsystems through the DC.

Project Engineer: Leo Paffrath

- a) Coordinates the subsystem engineering efforts.
- b) Has responsibility for the overall integration and installation engineering, which include developing and writing procedures ensuring compliance with QA standards.
- c) Has responsibility for the cost estimate, project tracking and variance analysis.
- d) Directs the Project Office.

Assistant for Project Management: Walter Kehoe

- a) Directs preparation of PHENIX review documents (e.g., CDR, Management Plan).
- b) Coordinates the PHENIX AGS testbeam program.
- c) Coordinates monthly Cost Performance Reporting to the RHIC Project.
- c) Assists the Project Director with day-to-day activities (e.g., meeting organization).

Liaison Physicist: Brant Johnson

- a) Interfaces between the PHENIX and RHIC projects on management and administrative issues (e.g., cost, schedule, installation, facilities, QA, ES&H).
- b) Interfaces between the PHENIX and RHIC projects on technical issues (e.g., beam pipe, shielding, magnet).

Executive Council:

- a) Consists of PM plus representatives from the collaboration selected by the spokesperson. The members of the EC are:
 - P. Braun-Munzinger, R. Hayano, S. S. Kapoor, V. Manko, S. K. Mark, J. Moss, I. Otterlund, F. Plasil, R. Santo, Z. X. Sun, N. Tyurin, A. Vorobyov, K. Yagi, and Z. P. Zheng
- b) Approves overall scientific priority and policy, advises on detector physics specifications.
- c) Advises on budget and management policy.
- d) Approves admission of new collaborators.
- e) Approves publication policy.
- f) Conducts periodic reviews of PM performance.

Detector Council:

Consists of PM plus subsystem team leaders or designated alternates. The members of the DC are:

- T. Carey, H. Hamagaki, B. Jacak, W. Kinnison, C. Maguire, Y. Miake, E. O'Brien, S. Sorensen, J. Thomas, S. White, G. Young, and W. Zajc

Each DC member *individually*

- a) Has responsibility for the design of his/her subsystem(s).
- b) Has responsibility for cost estimates and schedules for his/her subsystem(s) design, prototype development, construction and installation.
- c) Organizes his/her subsystem(s) working groups and their activities.
- d) Participates in regular DC meetings at BNL on project status, integration, and other issues.
- e) Has QA and ES&H responsibilities for his/her subsystem(s) design and implementation.

Project Office:

- a) Has responsibility for technical and administrative functions in support of the project.
- b) Prepares documentation to fulfill PHENIX reporting requirements.
- c) Publishes and archives PHENIX Technical Notes.

3.2.1 Institutional Responsibilities

The institutional responsibilities in the PHENIX Collaboration for designing and constructing the baseline PHENIX detector are listed in Table 3.1. The Work Plan describes (see Section 4) the tasks for which the institutions are responsible.

Table 3.1 Institutional Responsibilities Listed by WBS Item and Subsystem Component

WBS	Subsystem Component	Institution(s)
2.5.1	<i>Magnets</i>	
	Outer Coil	LLNL, KEK
	Muon Coil	LLNL
	Magnet Steel	LLNL, PNPI, Efremov
	Muon ID Steel	LLNL
	Magnet Electrical Controls	LLNL, PNPI, Efremov
	Magnetic Field Measurements	PNPI, BNL, LLNL
	<i>Multiplicity Vertex Detector</i>	
2.5.2.1	Mechanical	LANL, UC Riverside, Alabama
2.5.3.1	Front-end Electronics	ORNL, LANL
	<i>Beam-beam Counters</i>	
2.5.2.2	Mechanical	Hiroshima
2.5.3.2	Front-end Electronics	Columbia, Hiroshima
	<i>Hadron Blind Detector (upgrade)</i>	
2.5.2.3	Mechanical	MIT
2.5.3.3	Front-end Electronics	MIT
	<i>Drift Chambers</i>	
2.5.2.4	Mechanical	PNPI, BNL
2.5.3.4	Front-end Electronics	PNPI, LLNL, KEK
	<i>Pad Chambers</i>	
2.5.2.5	Mechanical	McGill, IHEP-Beijing, Lund, BNL
2.5.3.5	Front-end Electronics	McGill, Lund, BNL, ORNL
	<i>Time Expansion Chamber</i>	
2.5.2.6	Mechanical	BNL, Yale
2.5.3.6	Front-end Electronics	BNL
	<i>Ring Imaging Cherenkov Detector</i>	
2.5.2.7	Mechanical	FSU, INS-Tokyo, Tokyo, Stony Brook
2.5.3.7	Front-end Electronics	INS-Tokyo, Columbia
	<i>Time-of-Flight Counters</i>	
2.5.2.8	Mechanical	Tsukuba, IMP-Lanzhou, Columbia
2.5.3.8	Front-end Electronics	Columbia, Tsukuba
	<i>Electromagnetic Calorimeter</i>	
	- <i>Lead/Scintillator</i>	
2.5.2.9	Mechanical	IHEP-Protvino, BNL
2.5.3.9	Front-end Electronics	ORNL, IHEP-Protvino

Table 3.1 Institutional Responsibilities Listed by WBS Item and Subsystem Component, Continued

WBS	Subsystem Component	Institution(s)
	<i>Electromagnetic Calorimeter</i>	
	- <i>Lead-glass</i>	
2.5.2.10	Mechanical	Kurchatov, Münster, ORNL
2.5.3.10	Front-end Electronics	ORNL
	<i>Electromagnetic Calorimeter</i>	
	- <i>High Resolution Crystals (upgrade)</i>	
2.5.2.11	Mechanical	Stony Brook, BNL
2.5.3.11	Front-end Electronics	Stony Brook, BNL
	<i>Muon Tracker</i>	
2.5.2.12	Mechanical	LANL, LSU, BARC
2.5.3.12	Front-end Electronics	LANL, LSU, ORNL
	<i>Muon Identification</i>	
2.5.2.13	Mechanical	ORNL, CIAE, GSU
2.5.3.13	Front-end Electronics	ORNL
2.5.4	<i>DAQ/Trigger/Computing</i>	
	Data Collection Modules	Columbia
	Subevent Transfer Buffers	Columbia
	Event Builder	Columbia
	Level-1 Trigger	ISU/Ames
	Level-2 Trigger (<i>deferred</i>)	Columbia
	Level-3 Trigger (<i>deferred</i>)	Columbia
	Routing Layer (<i>deferred</i>)	BNL, LANL
	Master Timing System	BNL, ORNL
	On-line Computing System	LANL, BNL, Columbia, ORNL
	Simulation Computing	Vanderbilt and entire Collaboration
	Off-line Computing	Tennessee/ORNL and entire Collaboration
	Common Computing, Common DAQ	BNL, ORNL, LANL
2.5.5	<i>System Engineering and Integration</i>	BNL
2.5.6	<i>Project Management</i>	BNL

3.2.2 Related Institutional Activities

Table 3.2 lists the other commitments of the PHENIX collaborating institutions. The table indicates the present status of these activities and the type of commitment the PHENIX collaborators have made to these experiments.

Table 3.2 Commitments to Other Experiments by PHENIX Collaborators

Experiment	Phase	Institution(s)	Hardware Involvement
BNL E802/ E859	Data Analysis	BNL, UC Riverside, Columbia, INS-Tokyo, LLNL, Tsukuba	Tracking, TOF, Cherenkov Complex,
BNL E814	Data Analysis	BNL, LANL, McGill, Stony Brook, Yale	Calorimetry, Tracking TOF
BNL E862	Data Analysis	ISU	Trigger, Target Foils
BNL E864	Construction	ISU/Ames, Yale, Georgia State	TOF, Level 2 Trigger
BNL E866	Construction and Data Acquisition	BNL, UC Riverside, Columbia, INS-Tokyo, LLNL, Tsukuba	Tracking, TOF, TPCs
BNL E877	Construction and Data Acquisition	BNL, McGill, Stony Brook,	Calorimetry, Tracking, TOF
BNL E878	Data Acquisition and Data Analysis	Columbia	
CERN NA44	Data Acquisition and Data Analysis	Columbia, LANL	Cherenkov Counter
CERN WA80 WA93	Data Analysis	Lund, Kurchatov, Münster, ORNL	Calorimetry, Trigger
CERN WA98	Data Analysis	Lund, Kurchatov, Münster, ORNL	Calorimetry, Trigger
FNAL E866	Setup	LANL, ORNL, LSU	On-line and Off-line Computing

3.2.3 Memoranda of Understanding

Memoranda of Understanding (MOU) between the RHIC Project Office, PHENIX Project Management and individual institutions have been created in three different styles:

1. **Individual Institutional MOU:** For all US institutions plus McGill University, Canada, and Lund University, Sweden, an MOU between the RHIC Office, PHENIX Management and the relevant institution has been prepared. Items covered in these MOUs include tasks, manpower profile, institutional cost and schedule, institutional and PHENIX-provided resources, and other important issues. Signatures are provided by each institutional spokesperson, each institution's responsible person(s), PHENIX management, and the RHIC Office. The present status of these MOUs is summarized

in Table 3.3. The plan is to complete all the MOUs before the end of FY 1994. Appendix C of this document is the template used to create the Institutional MOUs.

2. **MOU with PHENIX-J:** Because the Japanese institutions have their own organizational unit, called PHENIX-Japan, a special MOU was created between the RHIC Office, PHENIX Management, and PHENIX-J. The items described in this MOU are nearly identical to the MOU described above. The main difference is that the signatures are given by two representatives of the organization of PHENIX-J. In addition, the signature of the spokesperson is provided for in the manpower profile table. The PHENIX-J managers act in consultation with the PHENIX Project Management on issues of cost and schedule. Concerning the planning, scheduling, and funding, a full description is given in the WBS. Because the tasks of the PHENIX-J institutions are well defined and described in WBS, they are not repeated in the MOU.
3. **International Agreement plus Manpower Table:** In some cases, an "Interlaboratory Collaborative Agreement" between Brookhaven National Laboratory and the participating institution has already been signed and has been used for money transfer from BNL to that institution. In these cases, or, in cases similar to it, the "Agreement" document plus "Manpower Table" are prepared. The status of this category is summarized in Table 3.4.

For the usage of Pb-glass detectors a special MOU was signed between the RHIC Office, PHENIX Management, and institutional representatives who participate in this effort. For these institutions (Münster and Kurchatov), the manpower tables have been prepared to supplement this MOU.

Table 3.3 Status of MOUs (other than those described in Table 3.4) as of 2/17/94

Institution	Draft of MOU	Manpower Table	Schedule Table	Signature	Comments
U. Alabama	NO	Available	--	--	--
BNL	YES	Done	99% done	Working	Nearly the final version
UC-Riverside	YES	Done	Working	Not yet	--
Columbia	YES	Done	Working	Not Yet	--
FSU	YES	Done	Working	Not Yet	--
Georgia State	YES	Done	No need	Not yet	Nearly the final version.
Idaho NEL	NO	--	--	--	--
Iowa State	YES	Done	Working	Not Yet	--
LLNL	YES	Done	99% done	Working	Nearly the final version
LANL	YES	Done	Working	Not Yet	--
LSU	YES	Done	No need	Working	Nearly the final version

Table 3.3 Status of MOUs (other than those described in Table 3.4) as of 2/17/94, continued

Institution	Draft of MOU	Manpower Table	Schedule Table	Signature	Comments
MIT	YES	Done	No need	Not yet	--
Stony Brook	YES	Done	No need	Not yet	--
ORNL	YES	Done	Working	Not yet	--
Tennessee	YES	Done	Working	Not yet	--
Vanderbilt	YES	Done	Working	Not yet	Nearly the final version.
Yale	YES	Done	Working	Not yet	--
McGill	YES	Done	Working	Not yet	--
Lund U.	YES	Done	No need	Working	--
PHENIX-J	YES	Done	No need	Working	Nearly the final version.

Table 3.4 Status of International Agreement as of 2/17/94

Institution	General Agreement (incl. MOU)	Attachment for R&D	Construction Budget
Russia			
IHEP--Protvino	Signed	Signed	In preparation
PNPI	Signed	Signed	In preparation
JINR	Signed		
INR-Moscow	Not yet [†]		
ITEP-Moscow	Not yet [†]		
China			
CIAE	Signed		
IHEP--Beijing	Signed		
Peking U.	Not yet [†]		
IMP-Lanzhou	Not yet [†]		
India			
BARC	In progress		
Korea + Brazil	Not yet [†]		
CERN--WA80/93			
Kurchatov/Münster	Signed		

[†] No aggressive actions have been taken from PHENIX Project Management.

3.2.4 Internal Review and Meeting Policy

Periodic internal reviews and regular meetings of the PHENIX Detector Council are important mechanisms for helping the PHENIX Project Management maintain control over the technical, cost, and schedule issues involved in constructing the PHENIX detector.

All subsystems in the PHENIX detector are required to undergo internal reviews, in order to:

1. Specify design, performance, cost and schedule criteria.
2. Review technical design readiness prior to procurement.
2. Review the technical, cost and schedule progress to completion.
3. Certify compliance with Environment, Safety and Health (ES&H) regulations.
4. Ensure fulfillment of Quality Assurance (QA) standards.

The reviews will be organized by the subsystem managers and PHENIX Project Management, assisted by the Detector Council, other collaboration members, and, as needed, outside experts and RHIC ES&H personnel. They will be scheduled at a time appropriate to the development of the subsystem, as indicated in the project schedule, or when determined necessary by the PHENIX Project Management. For each review, the material presented at the review and recommendations from the review will be summarized in a written report, and copies of the report will be published as a PHENIX Technical Note and archived with the PHENIX Project Office.

Regular meetings of the PHENIX Detector Council (DC) provide the Project Management with an important vehicle for overseeing and guiding the design and construction of the detector. The DC meetings are held approximately every six to eight weeks, and meeting length varies depending on the agenda. The structure of a typical two-day DC meeting is shown in Table 3.5. At each DC meeting, the subsystem managers (i.e., the DC members) give brief status reports on their subsystem. In addition, the status of one subsystem is reviewed in detail by the DC. The transparencies from these meetings are collected and published as a PHENIX Technical Note.

Table 3.5 Typical Detector Council Meeting Structure

Time	Day 1	Day 2
Morning	PM Business	DC Reports
Afternoon	Subsystem Review	DC Reports / PM Summary
Evening	EC Meeting	as needed

The PHENIX Executive Council (EC) often meets during the DC meetings to advise and assist the Project Management on collaboration issues. The functions and membership of the DC and EC are described in Section 3.3. Lastly, meetings of the entire PHENIX Collaboration are held on a twice yearly basis.

3.2.5 Cost Performance Reporting

Each month the subsystem managers are required to submit to the PHENIX Project Management brief status reports that describe the progress on the construction project for which they are responsible. These reports will include current cost and schedule information, as well as technical progress. The technical, cost, and schedule information from these reports will be gathered by the Project Management, and they will prepare a monthly Cost Performance Report (CPR) for submission to the RHIC Project Management. The cost and schedule information in the CPR will be presented at RHIC WBS level 3 (e.g., 2.5.1) for inclusion into TRAKKER.

3.3 Funding

The PHENIX baseline detector cost estimate, profile and schedule is summarized in Section 2, and shown in detail in the February 1994 Work Breakdown Structure and WBS Notes books. In the course of setting a baseline that meets the budget and profile targets imposed on PHENIX by the RHIC Management, most subsystems' cost estimates and schedules were modified since the November 1993 Technical, Cost and Schedule review. Cost reductions and schedule delays were made to meet the target budget authority and funding profile.

The funding plan for the PHENIX baseline detector includes substantial components outside PHENIX construction funds. Below we discuss the PHENIX construction funds and other sources of funding.

3.3.1 PHENIX Construction Funds

As indicated in Section 1.3, the RHIC construction funds required (in FY 1993 dollars) are \$36.6M, which includes a contingency of \$6.6M. These funds are primarily spent by U.S. and Russian collaborating institutions in PHENIX. The average contingency on the funds spent in Russia is 28%, while the overall average contingency on the detector is 22%. We do not include in PHENIX construction funds contingency on other funds, such as direct contribution by the PHENIX-J collaboration and institutional contributions. These funds are assumed to carry their own contingency.

3.3.2 Other Funding

We identify several sources of PHENIX funding outside the RHIC Project construction funds. These are:

1. **Institutional Contributions:** Several US collaborators are contributing, primarily in the form of engineering manpower, technician manpower, and DAQ development hardware:
 - BNL \$3285k (TEC, EMCal, DAQ, Sys. Eng., Proj. Man.)
 - LLNL \$297k (Magnet)
 - LANL \$492k (MVD, DAQ, μ T)
 - ORNL \$77k (DAQ)
 - Vanderbilt U. \$48k (DAQ)
2. **RHIC Operating Funds:** We identify test and commissioning tasks for detector subsystems that are primarily engineering and technical support manpower. Starting in FY 1998 and lasting until detectors operations start in FY 1999, we estimate X man-months for this effort, which is assumed to be covered by:
 - RHIC Pre-ops \$1458k (Test, Commission)
3. **Cost Reductions:** Several foreign collaborators are contributing subsystems at less than the US cost estimate with a combination of in-kind contributions and lower local costs:
 - PNPI. (St. Petersburg, Russia) \$3138k (Magnet, DC)
 - IHEP (Protvino, Russia) \$4998k (EMCal/PbSc)
 - Kurchatov (Moscow)/Münster \$5500k (EMCal/PbGl)
4. **Direct Contributions:** The PHENIX-J collaboration, a consortium of Japanese institutions in PHENIX, is contributing specific components built with Japanese funds. A number of other foreign collaborating institutions are also contributing manpower and/or purchased items to PHENIX:
 - PHENIX-J \$8750k (CM coils, BB, RICH, TOF, DAQ)
 - Hiroshima U. (Japan) \$72k (BB)
 - Lund U. (Sweden) \$204k (TEC FEE)
 - McGill U. (Canada) \$200k (PC)
 - Tokyo-INS (Japan) \$108k (RICH)
 - Tsukuba U. (Japan) \$226k (TOF)

In addition, discussions are in progress with several other non-U.S. collaborators and potential collaborators in an effort to secure other direct contributions or cost reductions.

4.0 WORK PLAN

This section describes briefly the plan for constructing the PHENIX baseline detector. The description follows the RHIC WBS at level 4. The institutional responsibilities, which are also summarized in Table 3.1, are as described in the institutional memoranda of understanding and international lab-to-lab agreements.

Procedures for accepting hardware for installation into the PHENIX detector will be written by the Project Engineer and System Integration Engineer. These procedures will ensure that all components built for the PHENIX detector comply with the QA standards outlined in the RHIC Quality Assurance Manual (DS-1 Design Standards, Appendix 2), or a detailed set of procedures that are written specifically for the task and approved by both the PHENIX Project Management and RHIC Detectors QA. Each subsystem manager will be responsible for defining their respective procurement plans and implementing subsystem specific QA standards, in compliance with the PHENIX procedures.

4.1 Magnets (WBS 2.5.1)

The central magnet (CM), the muon magnet (MM) and the muon identifier (μ ID) absorber have been designed by LLNL. The steel for both magnets will be fabricated and preassembled in Russia under the PNPI-BNL agreement. The principle supplier in Russia is the Efremov Institute of Electrophysical Apparatus (St. Petersburg). The outer coils for CM are designed by LLNL and are being fabricated in Japan under the direction of KEK. The inner CM coils are designed by LLNL but the fabrication is deferred. The MM coil is designed by LLNL, and its fabrication is deferred. The μ ID absorber fabrication will be the subject of competitive bid.

The μ ID absorber and MM will be assembled in place in the Major Facility Hall (MFH) collision area. These elements are the first in the installation sequence. The CM will be assembled at the same time in the MFH assembly area and rolled into place on the collision point. The two magnets will be powered up and mapped in their final locations; PNPI will be responsible for the mapping.

4.2 Detector Systems: Mechanical (WBS 2.5.2) and Front-end Electronics (WBS 2.5.3)

2.5.2.1, 2.5.3.1 Multiplicity/Vertex Detector (MVD): The silicon system is designed, fabricated and installed by LANL, University of California-Riverside and University of Alabama. Discussions are in progress concerning the possibility of production of the silicon detector wafers in Taiwan. The front-end electronics (FEE) is being developed by ORNL and fabrication is the responsibility of LANL. The MVD will be fully assembled and tested at LANL prior to shipping to BNL.

2.5.2.2. 2.5.3.2 Beam-beam (BB): The Hiroshima University group is designing and constructing the BB arrays. The FEE development is the responsibility of Columbia (Nevis Laboratories), Columbia University. FEE fabrication and testing will be done in Japan by the Hiroshima group.

2.5.2.3. 2.5.3.3 Hadron-blind Detector (HBD): This device is a planned *upgrade* to PHENIX and is not in the baseline. MIT is responsible for the R&D program aimed at developing the HBD mechanics and electronics.

2.5.2.4. 2.5.3.4 Drift Chamber (DC): The PNPI group is designing and building the mechanical components of the DC under the PNPI-BNL agreement. The FEE development and fabrication is the responsibility of LLNL, PNPI and BNL.

2.5.2.5. 2.5.3.5 Pad Chambers (PC): McGill University and Lund University groups are responsible for design and fabrication of the three PC layers. IHEP-Beijing is also participating in the PC effort. Discussions are in progress concerning fabrication of the PC cathode printed circuit boards in China under direction of IHEP-Beijing. FEE circuits have been developed by BNL, ORNL, and Lund; Lund and McGill will be responsible for FEE fabrication.

2.5.2.6. 2.5.3.6 Time Expansion Chamber (TEC): BNL and Yale University are taking responsibility for designing and building the TEC mechanical and FEE (BNL only) components. The TEC will be fabricated and tested at BNL.

2.5.2.7. 2.5.3.7 Ring Imaging Cherenkov Counter (RICH): Design and fabrication of the RICH mechanical system is primarily the responsibility of University of Tokyo, INS-Tokyo, Florida State University and SUNY-Stony Brook. The FEE is being developed at Columbia (Nevis Laboratories) and will be fabricated by INS-Tokyo. LLNL is responsible for the design of the gas-handling system. Assembly and testing of the RICH will take place at BNL under the direction of the INS and FSU groups.

2.5.2.8. 2.5.3.8 Time-of-Flight (TOF): The Tsukuba University group is designing and fabricating the TOF counters, with participation from IMP-Lanzhou. Mechanical engineering on the mounting of the TOF array, and electronic engineering for the FEE is being provided by Columbia (Nevis Laboratories).

2.5.2.9. 2.5.2.10. 2.5.3.9. 2.5.3.10 Electromagnetic Calorimeter (EMCal): The baseline version of the EMCal consists of Pb-scintillator (PbSc) "shish-kebab" (75%) and Pb-glass (PbGl, 25%). The PbSc portion is being designed and fabricated by IHEP-Protvino under the terms of the IHEP-BNL agreement. The PbGl portion is presently under construction for use in the CERN experiment WA-98. Its inclusion in PHENIX is covered by an MOU between BNL, ORNL, Münster University, and the Kurchatov Institute. PbGl "supermodules" will arrive at BNL from CERN in time for assembly into the PHENIX EMCal. IHEP is responsible for the design and fabrication of the mechanical support structure for both the PbSc and PbGl calorimeter walls. PbGl and PbSc supermodules will be shipped to BNL and assembled into calorimeter "walls" at BNL. The FEE for both portions of the EMCal is the responsibility of ORNL and IHEP.

2.5.2.11, 2.5.3.11 High Resolution Crystal EMCAL (HRX): This is a planned *upgrade* to PHENIX and is not in the baseline. SUNY-Stony Brook and BNL are performing the R&D for the HRX development.

2.5.2.12, 2.5.3.12 Muon Arm Tracking (μ T): LANL will design and fabricate the mechanical and FEE components of the tracking system for the muon arm. Louisiana State University and BARC (Bombay, India) will also be involved in the fabrication and ORNL is providing FEE engineering. This detector element is *deferred* in the baseline PHENIX detector.

2.5.2.13, 2.5.3.13 Muon Identifier (μ ID): ORNL is designing the μ ID detector planes. ORNL and CIAE will take responsibility for fabrication of detector planes. Georgia State University is also expected to be involved in the μ ID fabrication and testing. ORNL is responsible for the FEE. This detector element is *deferred* in the baseline PHENIX detector.

4.3 DAQ/Trigger/Computing (WBS 2.5.4)

2.5.4.1, 2.5.4.2, 2.5.4.3 Data Collection Modules, Subevent Transfer Buffers, Event Builder: These elements of the data acquisition system are the responsibility of Columbia (Nevis Laboratories) for both design and fabrication.

2.5.4.4 Level 1 Trigger: Ames Laboratory and Iowa State University have the responsibility for design and fabrication of the Level 1 trigger hardware.

2.5.4.5, 2.5.4.6 Level-2 and 3 Triggers: These elements of the trigger are *deferred* in the baseline PHENIX detector; they are the responsibility of Columbia (Nevis Laboratories).

2.5.4.7, 2.5.4.8 Routing Layer and Master Timing and Control System: BNL, LANL and ORNL share the responsibility for these portions of the data acquisition system. The routing layer is *deferred* in the baseline PHENIX detector.

2.5.4.9 On-line Computing System: LANL, BNL, Columbia and ORNL are sharing the responsibility for specifying the data collection and communication hardware, and as well as for implementing the system. They will also share in the design the software for the on-line system. This work is closely linked to Simulation and Off-line Computing efforts.

2.5.4.10 Simulation Computing: Vanderbilt University is coordinating the continuing effort to create, maintain and use a fully integrated simulation package. This software effort involves many, if not most, of the other PHENIX institutions in writing specific, detector-dependent pieces of these codes. This work is closely linked to On-line and Off-line Computing efforts.

2.5.4.11 Off-line Computing: University of Tennessee/ORNL are responsible for coordination of the design and implementation of the off-line analysis codes. This software effort involves many, if not most, of the other PHENIX institutions in writing specific, detector-dependent pieces of these codes. This work is closely linked to On-line and Simulation Computing efforts.

2.5.4.12, 2.5.4.13 Common Computing and Common DAQ: BNL, LANL, and ORNL are responsible for coordination of the computing efforts and the specification and acquisition of common elements. This work is closely linked to On-line, Off-line and Simulation Computing efforts.

4.4 System Engineering and Integration (WBS 2.5.5)

Brookhaven National Laboratory is responsible for this effort, which includes the following WBS level 4 items:

- 2.5.5.1 Design and construction of detector support carriages.
- 2.5.5.2 Modifications to the MFH site, including the track system for movement of the central magnet and the detector support carriages.
- 2.5.5.3 Creation and management of a detector integration plan, including configuration control drawings.
- 2.5.5.4 Creation and execution of a detector installation plan.
- 2.5.5.5 Creation and execution of a plan for commissioning the detector and conducting full system tests.
- 2.5.5.6 Creation and execution of a Safety and Environmental Protection plan for the PHENIX construction project which is consistent with BNL and RHIC S&EP plans.

The plans for integrating, installing, commissioning, and testing the detector components will be written by the System Integration Engineer and the System Integration Physicists. They are responsible for coordinating and implementing these plans, as well as updating and modifying the plans as needed. The PHENIX Safety Coordinator is responsible for writing and ensuring compliance with the Safety and Environmental Protection plan.

4.5 Project Management (WBS 2.5.6)

Brookhaven National Laboratory is responsible for this effort, which includes the following WBS level 4 items:

- 2.5.6.1 Engineering change control, quality assurance, including both scientific and technical aspects of the project.
- 2.5.6.2 Management of the MFH site for the construction project.
- 2.5.6.3 Budget tracking, cost estimate updating, and financial reporting to RHIC project management.

5.0 PROCUREMENT PLAN

5.1 Introduction

In this section major procurement items in the PHENIX construction project are identified. For present purposes, "major" is defined as individual purchases or acquisitions for which the estimated cost exceeds \$400,000. These items are listed in Table 5.1. This effort will be performed in consultation with the BNL Division of Contracts and Procurements.

Table 5.1 Major Procurement Items for the Completion of the PHENIX Project.

WBS	Description	Cost Estimate	Means of Procurement	Start/Duration
2.5.1.1.3.1.2	CM Outer Coil Fabrication	\$400,000	Fab. in Japan; Japanese Funds	Oct. 93/50 weeks
2.5.1.3.3.3	CM Steel Fabrication	\$755,400	Fab. in Russia under BNL-PNPI Agreement	March 94/96 weeks
2.5.1.5.3.3	MM Steel Fabrication	\$844,700	Fab. in Russia under BNL-PNPI Agreement	March 94/97 weeks
2.5.2.7.3.4.1.2	RICH Mirror Fabrication	\$892,000	Competitive Bid; Japanese Funds	Feb.-95/75 weeks
2.5.2.7.3.5.1.2	RICH PMT Procurement	\$600,000	Competitive Bid; Japanese Funds	Nov. 94/20 weeks
2.5.2.7.3.5.1.3	RICH PMT Procurement	\$487,500	Competitive Bid; Japanese Funds	Sept.-95/20 weeks
2.5.2.7.3.5.1.4	RICH PMT Procurement	\$487,500	Competitive Bid; Japanese Funds	Sept.-96/20 weeks
2.5.2.7.3.5.1.5	RICH PMT Procurement	\$487,500	Competitive Bid; Japanese Funds	Aug.-97/20 weeks
2.5.2.9.3.1.13	EMCal PMT Procurement	\$560,000	Buy in Russia under BNL-IHEP Agreement	March-94/120 weeks
2.5.2.9.3.1.14	EMCal PMT Base Ass. Procurement	\$480,000	Buy in Russia under BNL-IHEP Agreement	April 95/100 weeks
2.5.4.3.3.4.2	Event Builder DSP Procurement	\$655,400	Competitive Bid	Jan. 97/16 weeks

In subsequent sections these items are dealt with individually. In general, there are three basic means of acquisition:

1. Fabrication or procurement in Japan or the US with Japanese funds. In these cases, an international competitive bidding process will be followed.
2. Fabrication or procurement in Russia with DOE funds under the terms of a laboratory-to-laboratory agreement. In these cases, PHENIX is providing funds on a schedule

specified in a technical attachment to the appropriate agreement, and the Russian laboratory is procuring or fabricating the item under Russian guidelines.

3. Fabrication or procurement with DOE funds. In these cases, US/DOE procurement rules apply.

5.2 Magnets

The major procurement items in this category are the outer coils for the central magnet and the steel for the central and muon magnets (CM and MM). In order to meet the requirements of the overall construction schedule, CM and MM procurement is already in progress. According to the PHENIX installation schedule, CM and MM must be assembled and in place in the Major Facility Hall at RHIC by the end of 1995. By agreement with RHIC project management the acquisition of these early, long-lead-time items has started prior to full approval of the PHENIX construction project. The necessary agreements have been signed and the transfer of DOE funds is about to begin.

5.1.1 Outer CM Coils

The coils for CM consist of two outer coils and two inner coils. The inner coil pair is a deferred item in the baseline. The outer coils are being procured by the PHENIX-J collaboration in Japan, using Japanese funds. The procurement process is under way and the funds will be committed during the current Japanese fiscal year.

5.1.2 Magnet Steel

The magnet steel fabrication is to be done in Russia as part of the St. Petersburg Nuclear Physics Institute (PNPI) collaboration in PHENIX. The detailed specifications, production schedule and QA requirements are included in Technical Attachment 3 to the PNPI-BNL Interlaboratory Agreement on PHENIX Construction. The schedule calls for purchase of raw materials in March 1994, completion of fabrication in Russia in October 1995, and arrival in the US in November 1995.

5.2 Ring Imaging Cherenkov Counter

The RICH counter is a contribution of the PHENIX-J collaboration in Japan; it is funded by the Japanese. Certain portions are being designed and procured by US collaborators in PHENIX.

5.2.1 Mirrors

The large thin mirrors are being designed and prototyped by the Florida State group. The mirror replication process is a major procurement, which will be done by international competitive bid under Japanese rules. Based on experience with the CM outer coils, we expect the bidding process to take about six months. According to the schedule, mirror prototype development concludes at the end of FY 1994, leaving sufficient time to go through the bidding and awarding process prior to the start of fabrication. A list of potential vendors is being compiled now.

5.2.2 Photomultiplier Tubes

The RICH requires 6400 PMTs, with a total cost estimate of over \$2,400,000. Because of the expected rate of Japanese funding for PHENIX, this is broken into five equal annual acquisitions. Each of these is required to be an international competitive bid under Japanese rules.

5.3 Electromagnetic Calorimeter

Three quarters of the EMCal coverage is the so-called "shish-kebab" PbSc design. It is being designed and built in Russia by PHENIX collaborators at IHEP-Protvino and other institutions. Funds will be transferred to IHEP in accord with the provisions of Technical Attachments to the BNL-IHEP Interlaboratory Agreement on PHENIX construction. IHEP will then procure components for the EMCal under Russian rules. Major procurements are the PMTs and the PMT base assemblies.

5.3.1 Photomultiplier Tubes

The PMTs required for the shish-kebab EMCal are the result of a joint development project, funded by RHIC R&D funds, between IHEP and MELZ, a major PMT producer in Russia. The PMT, model FEU-115M, will therefore be a sole-source procurement by IHEP from MELZ, and negotiations are presently underway. According to the schedule, procurement will start in March, 1994 and spread over two years, governed by the rate of production agreed to by MELZ.

5.3.2 PMT Base Assemblies

The PMT bases are being designed at IHEP and will be produced in quantity in Russian industry. In this case, evaluation of several potential suppliers will be conducted over the next few months. The schedule shows procurement to start in April 1995, so there is sufficient time for the evaluation process.

5.4 Data Acquisition System

In the DAQ/Trigger/Computing area the major procurements involve purchase in quantity of digital signal processors for the Event Builder. This part of the detector is primarily the responsibility of Columbia (Nevis Laboratories). The procurement will follow DOE rules and involve RFPs, RFQs, and vendor technical evaluation prior to the award of contracts. We expect this process to take four to six months.

To meet the schedule, the Event Builder processors must be procured about three years from now. It thus appears that there will be sufficient lead time to complete the required procurement processes.

6.0 DESIGN STANDARDS, QUALITY ASSURANCE, ENVIRONMENTAL SAFETY AND HEALTH

6.1 Design Standards

The following design standards are intended to assure that a complete set of engineering documents are provided for each RHIC detector and its related subsystems. These design standards are detailed in the RHIC Quality Assurance Manual (RHIC Design Standards DS-1, Appendix 2).

6.1.1 Policy

A complete set of engineering drawings should contain: drawings lists, parts lists, and data base references for easy retrieval. Before production baseline is established, engineering drawings for R&D, prototypes, and preproduction should be prefixed with the letters "RD". This will then be removed prior to formal release. All baseline engineering drawings should fall under the guidelines of the PHENIX detector engineering control revision and engineering change control. Tooling engineering drawings are not covered by these standards, however, they should be stored and maintained for the lifetime of the respective detector. Where applicable, technical manuals (including testing and operating procedures), detector specifications, test fixtures, and tooling should be provided and maintained.

6.1.2 Computerized Data Bases

The PHENIX Collaboration will assume the primary responsibility for the development and maintenance of computerized data bases for all the necessary engineering drawings. These databases should be maintained for the lifetime of the detector. As-built drawings should be kept with the RHIC Project for centralized archival. The archival system should protect against the premature use of a drawing that is under revision prior to final approval.

All data bases should be readable on CAD stations utilizing AUTOCAD release 11 or higher, PCAD release 4.55 or higher, or ViewLogic. Should different software be utilized, it is the responsibility of the detector group to provide the means to translate the drawings into the above mentioned systems.

Databases should be secured to prevent unauthorized changes and backup files and tapes should be located in at least one facility other than where the data are generated or changed.

6.1.3 Drawing Number System

The drawing numbering system should conform to the RHIC Project structure. The PHENIX detector assignment (RHIC level 3) is 2.5, which should be followed by RHIC Detector Group Numbering System that is defined in the RHIC Quality Assurance Manual (RHIC Design Standards DS-1, Appendix 2).

6.1.4 Release Process

The PHENIX Collaboration shall develop procedures for the release of baseline engineering drawings. The release process should include provisions to assure:

1. Compliance with design standards.
2. Reviews by the appropriate cognizant engineer and physicist.
3. All released documents shall bear the signature of the cognizant engineering and physics subsystem manager.
4. Any changes to baseline drawings should adhere to the PHENIX detector control process.

6.1.5 As-built Drawings

At the conclusion of the detector construction phase, a complete set of as-built drawings should be maintained at BNL.

6.2 Quality Assurance

Quality Assurance standards should be applied during the design, fabrication, and integration of detector components and systems to assure the success of both PHENIX, as well as the scientific program at RHIC. This section describes the QA policies, plans, and procedures to be implemented within the PHENIX Collaboration.

6.2.1 Overview

It is the policy of the RHIC Project that all activities be performed at a level of quality that is appropriate to achieving the scientific, technical, operational, and administrative objectives. To implement this policy, the RHIC Project has established a QA Program based on DOE Order 5700.6C and implementation guide DOE-ER-STD-6001-92, the BNL QA Program, and the specific needs of RHIC. This sets standards for organizational responsibilities, appropriate documentation and training.

The PHENIX detector collaboration is expected to plan, document and implement a QA program, to the extent needed, to ensure successful construction and operation of these detectors.

6.2.2 Quality Assurance Objectives

The following general QA objectives are established for the detector program:

1. To ensure that all components and systems are designed, constructed and integrated to the specifications established.
2. To ensure that each RHIC detector and related systems and subsystems perform to their required objectives and specifications.
3. To ensure that proper documentation is maintained for the lifetime of the detectors.

6.2.3 Quality Assurance Implementation

The Associate Project Head for Detectors & Experimental Support is responsible for establishing and implementing a QA program covering the RHIC detector activity in accordance with the RHIC QA Program. The PHENIX Project shall develop a QA program and towards this end the detector project director shall designate a specific individual who is responsible for QA coordination and implementation.

Collaborators at other U.S. national laboratories and universities can either follow the RHIC QA program or their own provided the latter meets the requirements outlined in DOE Order 5700.6C, and was prepared in accordance with DOE-ER-STD-6001-92, "Implementation Guide for QAP for Basic and Applied Research".

Collaborators at international institutions shall follow either the RHIC QA manual or a detailed set of procedures that are written specifically for the task and approved by both the PHENIX Project Management and RHIC Detectors QA.

6.2.4 Management and Assessment

It is the responsibility of the PHENIX collaboration to carry out periodic evaluations of the effectiveness of their Quality Assurance programs. Progress on Quality Assurance matters and implementation will be included in the periodic reviews of the PHENIX detector by the RHIC Project Management and DOE (Section 7).

6.3 Environment, Safety and Health

This section describes the policies and procedures to ensure Environmental, Safety and Health (ES&H) protection on all RHIC project detector activities. The paragraphs below present an

overview of key issues. Policies, procedures and descriptive information are contained in the RHIC Safety and Environmental Administration Policy and Procedures Manual (SEAPPM).

6.3.1 Overview

6.3.1.1 Introduction and Scope

The ES&H program fully supports the BNL ES&H policies and requirements. The ES&H program for the design, construction, installation, test and operation of the detectors and supporting systems is intended to ensure a safe working environment. The RHIC Project will establish ES&H program requirements for detectors and experimental facilities. Individual detectors will identify specific ES&H issues, will develop appropriate plans and detailed requirements, and will establish specific procedures as needed.

6.3.1.2 Objectives

The following general objectives are established for the ES&H program for detectors:

1. To comply with federal, state and local laws, rules and regulations.
2. To prevent accidents or loss of life or equipment during detector-related work.
3. To prevent any environmental contamination during detector development, commissioning, and operation.

6.3.1.3 Organization and Responsibilities

Brookhaven National Laboratory has established the Safety & Environmental Protection Division which is responsible for developing laboratory-wide ES&H policy and standards and independent oversight.

The RHIC Project Management is responsible for establishing overall policies and requirements for ES&H during development, commissioning and operation of the detectors and related experimental systems. The Project has overall responsibility for ensuring compliance with appropriate ES&H requirements. Review and advisory committees have been appointed by the Project Head to support the overall ES&H Program. Sub panels may be appointed to address safety issues related to individual subsystems or aspects of a detector project.

Individual experiments and detector project managers bear the responsibility for identifying specific ES&H issues and hazards, and to ensure appropriate safeguards and procedures for addressing those risks.

6.3.1.4 Documentation and Training

The RHIC SEAPPM and the Brookhaven National Laboratory ES&H Manual provide line implementation in accordance with the ES&H policies and, where applicable, a Safety Assessment Document will be provided by PHENIX to detail the hazards and safety envelope.

All participants in the RHIC detectors, while at BNL, will be provided with the training and information required to ensure that they have the knowledge to perform their duties in a manner which does not unduly place them or others at risk. This includes briefings and presentations to communicate ES&H policies and standards that are relevant to assure safety on detector-related activity. Facility specific training will be provided on such issues as electrical, cryogenic, radiation and chemical safety, as well as issues related to detector transportation, installation and testing activities.

6.3.1.5 Experiment Safety

Each detector or experiment will implement environment safety and health program elements as outlined in the RHIC SEAPPM and BNL ES&H Manual. All potential hazards and safety issues during engineering, transportation, installation, test, startup and operation of the detectors will be addressed. Health and safety issues and requirements associated with construction and usage of experimental facilities will be defined and coordinated with the RHIC Project safety personnel.

6.3.1.6 Visitors

All visitors to BNL are responsible for becoming acquainted with and following all BNL ES&H rules and procedures. In general, guests will not be allowed unescorted access to non-office areas without permission, certification, and escort by staff with appropriate training. The escorts will be responsible for the safety of visitors.

6.3.2 Emergency Preparedness

The PHENIX personnel, while at BNL, will adhere to the RHIC Local Emergency Plan. Emergency preparedness involves the readiness to protect personnel, property and the general public from potential hazards arising from emergencies.

6.3.3 Compliance

Individual PHENIX Safety Coordinators are responsible for clarifying compliance requirements and assisting in the resolution of complaints or deviations related to safety.

Participants in detector-related activity performed at institutions other than BNL (both domestic and international locations) will adhere to the local ES&H laws, rules and regulations in place at those locations. Best management practices to assure safety will be sought and applied. Detector project managers and subsystem managers, will ensure that specific safety issues and safeguards are identified during the design process and communicated to fabrication, test and installation personnel regardless of the institution involved.

7.0 MANAGEMENT

7.1 Management Control

The PHENIX detector is the principal responsibility of the PHENIX Collaboration, for which the Spokesman and Project Director (PHENIX Managers) will exercise the primary management functions. Construction of the baseline PHENIX detector is part of the RHIC construction project. The overall responsibility for managing the RHIC Project to meet technical, cost, and schedule objectives lies with the RHIC Project Management; that is, the RHIC Project Head and, for the detectors, the Associate Project Head for Detectors and Experimental Support. Those parts of the detector construction effort that the collaborating groups take on are managed through formal bilateral agreements, which are executed between the RHIC Project (BNL) and each of the participating institutions, and utilize the management structure which exists within PHENIX. The detector will be subject to periodic review by the RHIC Project Management and DOE. The RHIC Project Management is also advised by a Technical Advisory Committee, which is convened by the Associate Project Head to review and evaluate progress of detector construction.

Changes to the technical, cost, and schedule parameters of PHENIX require the approval of the PHENIX Managers, the RHIC Project Management, the DOE Project Manager, and the Director of Energy Research, as described below and summarized in Table 7.1.

7.2 Technical Control

The PHENIX Project Director has the responsibility for the day-to-day operational management and control, within the constraints of baseline documents (CDR, Management Plan, CDR Update, WBS book, and WBS Notes book), of all the technical decisions regarding R&D, engineering, fabrication, assembly, installation, testing, and acceptance of all detector components. Procurements equal to or greater than \$400,000, and those aspects of installation and commissioning that are coupled to other aspects of the RHIC construction project, will be carried out with the assistance and approval of RHIC Project Management.

Overall control of the technical means by which the various components of the detector are achieved is the responsibility of the PHENIX Project Director. The PHENIX Project Director will delegate, as appropriate, to the Subsystem Managers the responsibility for meeting the requirements of each of the level 4 WBS elements (each PHENIX subsystem is a RHIC level 4 WBS element).

Any changes that have a cost or schedule impact on a RHIC level 4 element require the approval of the PHENIX Managers. Any change in the ability of a RHIC WBS level 4 element to meet the physics goals, as outlined by the collaboration in the CDR and the CDR Update, or the addition or deletion of a RHIC level 4 element, require the approval of the PHENIX Managers and the Associate Project Head for Detectors and Experimental Support. Changes in the total cost or overall schedule of the PHENIX detector require approval of the PHENIX Managers, the

Table 7.1 Approval Levels for Changes to PHENIX Technical, Cost, Schedule Parameters

Type of Change	Approval Level Required			
	PHENIX Managers	RHIC Project	DOE Project Manager	DOE ER
Change in the technical capability of a RHIC WBS Level 4 element	Yes	Yes		
Addition or deletion of a RHIC WBS Level 4 element	Yes	Yes		
Revision of estimated cost of RHIC WBS Level 4 element	Yes			
Change in the overall estimated cost of PHENIX to the RHIC project, including allocated contingency	Yes	Yes	Yes	
Change in estimated cost of PHENIX causing an increase in the total cost of the detectors program for RHIC	Yes	Yes	Yes	Yes
Change to PHENIX control milestones	Yes	Yes		
Change to a DOE control milestone by 3 months or more	Yes	Yes	Yes	

Associate Project Head for Detectors and Experimental Support, the RHIC Project Head, and the DOE RHIC Project Manager.

7.3 Schedule Control

The PHENIX Management developed a baseline schedule that sets forth the major activities and decision points essential for the completion of the baseline PHENIX detector. The baseline schedule includes integration and optimization of activities related to the design, procurement, fabrication, testing, installation, and commissioning needed to bring the baseline detector on line to perform its stated mission. Detailed schedules at the control account level will be developed and interconnected into an activity flow chart that integrates construction activities within all respective PHENIX WBS elements. Coordination of PHENIX WBS schedules with other RHIC WBS elements will be made as necessary. The integrated schedule will identify the critical path of the baseline PHENIX detector. The baseline PHENIX schedule must always be consistent with the funding allocation for all RHIC detectors, based on the profile presented in the annual RHIC Construction Project Data Sheets, which shall reflect the required PHENIX construction funding profile appearing in Section 2 of this plan.

The schedule will contain a sufficient number of Control Milestones, so that summary schedules can be produced and progress readily ascertained for management review. Appropriate Project level milestones will be selected from these control milestones for incorporation into the RHIC Project Master Schedule. These schedules will be the basis for monthly status and performance reporting.

Cost and schedule performance reports will be reviewed with the RHIC Project Management on a monthly basis. Progress reviews at six to eight month intervals will be conducted by the Technical Advisory Committee. In addition, DOE semiannual reviews of the RHIC Project will include progress on detector construction.

7.4 Cost Control

The basis for cost control, which includes budget planning and cost reporting, is the Baseline Cost Estimate, developed to RHIC WBS level 4 or below.

A control account structure was established within the BNL accounting system in conjunction with the PHENIX baseline WBS and updated as necessary. Each RHIC level 4 subsystem will have a cost account manager identified within the PHENIX collaboration. PHENIX managers will report costs, collected at RHIC WBS level 4, which will include a breakdown by materials, labor, subcontracts, and other object classes as defined by the Project. The RHIC Project cost and schedule control system (TRAKKER) will be updated with this information and used to track construction progress and satisfy further reporting requirements. Cost control by lower WBS levels will be the responsibility of the Subsystem Managers. The baseline cost estimate and schedule milestones comprise the Performance Measurement Baseline for TRAKKER.

The RHIC Project is required to submit a monthly Cost Performance Report (CPR) to the DOE. Thus, PHENIX Management is required to report data in sufficient detail on a monthly basis, at RHIC WBS level 4, that will allow for the completion of the PHENIX section of the CPR. Variances from cost baselines will be analyzed by the Subsystem Managers and reviewed by the PHENIX Managers with actions initiated as necessary. Variances exceeding established thresholds will require a variance analysis report (see Section 7.7 below).

7.5 Configuration Management

The PHENIX Project Management will develop a configuration management plan by which the technical baselines are determined and changes to those baselines are controlled, documented and verified. The plan outlines the roles and responsibilities of the personnel involved as well as the procedures to be followed in identifying, assessing, reviewing and approving such engineering changes.

7.6 Contingency Funding

Contingency funds included in the PHENIX cost estimate are to cover materials, labor, conditions, and risk situations that are an intrinsic part of the intended scope of work but are not specifically allowed for elsewhere in the estimate, due to uncertainty either as to their existence, nature, likelihood of occurrence, or magnitude of effect.

Because contingency is not assigned to specific segments of work, it is therefore not considered part of the Performance Measurement Baseline. All changes from baseline costs shall be traceable so that contingency applications can be tracked.

At the beginning of each fiscal year, the PHENIX Management, working with RHIC Project Management, will determine what portion of the year's construction funds is to be set aside as contingency funds and report this amount to the DOE. Contingency funds are not allocated to individual subsystems as part of the baseline detector cost. The contingency fund is managed by the PHENIX Project Director, whose decisions on how to allocate the contingency fund are subject to the approval of the RHIC Project Head. Guidelines given in the RHIC Project Management Plan apply to the allocation of contingency funds.

In cases where the assignment of contingency funds results in a change in the amount of funds to be transferred to one of the collaborating groups, this fact is to be documented in an amendment to the formal agreement (i.e., the MOU) previously concluded with that group.

7.7 Progress Reports and Variance Analysis

The reporting of costs and submission of data for cost performance reporting is discussed in Section 7.4. In addition, progress will be reported monthly to the RHIC Project Management, in narrative form, at RHIC WBS level 4. The monthly report will include a discussion of project milestones met and not met, quality assurance and safety issues addressed, cost variances determined to be below the thresholds, a detailed analysis when the thresholds are exceeded, and other relevant issues and problems.

APPENDIX A: PHENIX GLOBAL SCHEDULE

PHENIX - Global Schedule

PHENIX - Global Schedule

ID	Description	Duration	1992				1993				1994				1995				1996				1997				1998				1999			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
28	DC Arm 1 - Assembly & Test	132d																																
29	DC Arm 2 - Assembly & Test	125d																																
30	Pad Chambers	1183d																																
31	PC FEE - Design, Proto & Common Fab.	865d																																
32	PC Mech - Design, Proto & Common Fab.	488d																																
33	PC1 Arm 1 - FEE & Mech. Assy. & Test	533d																																
34	PC2&3 Arm 1 - FEE & Mech. Assy. & Test	569d																																
35	PC1 Arm 2 - FEE & Mech. Assy. & Test	248d																																
36	PC2&3 Arm 2 - FEE & Mech. Assy. & Test	282d																																
37	Time Expansion Chamber	1369d																																
38	TEC FEE - Design & Fab.	1045d																																
39	TEC Mech. Arm 1 - Design & Fab.	1014d																																
40	TEC Mech Arm 2 - Design & Fab.	1334d																																
41	TEC Arm 1 - Assembly	75d																																
42	TEC Arm 2 - Assembly	35d																																
43	Ring Imaging Cherenkov Counter	1443d																																
44	RICH FEE - Arm 1 - Design & Fab.	1067d																																
45	RICH FEE - Arm 2 - Design & Fab.	1307d																																
46	RICH Mech. - Arm 1 - Design & Fab.	1135d																																
47	RICH Mech. - Arm 2 - Design & Fab.	1433d																																
48	RICH Arm 1 - Integrated Test & Assembly	10d																																
49	RICH Arm 2 - Integrated Test & Assembly	10d																																
50	Time of Flight	960d																																
51	TOF FEE - Design & Fab.	780d																																
52	TOF Mech. - Design & Fab.	960d																																
53	Tof - Ready to Install	1d																																
54	EMCal Lead Scint.	1287d																																

PHENIX - Global Schedule

ID	Description	Duration	1992				1993				1994				1995				1996				1997				1998				1999			
			01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04				
55	PbSc FEE - Design & Fab.	312d													1/22								4/1											
56	PbSc Mech.. Arm 1 - Design & Fab.	1137d					5/3																		9/9									
57	PbSc Mech. Arm 2 - Design & Fab.	1282d					5/3																				3/31							
58	PbSc Arm 1 - Assembly	221d																					4/2				2/4							
59	PbSc Arm 2 - Assembly	81d																							12/16		4/7							
60	EMCal Lead Glass	1106d																																
61	PbGI FEE - Design & Fab.	345d													10/23											2/14								
62	PbGI Mech. - Design & Fab.	1046d					10/5																			10/7								
63	PbGI - Assembly	101d																							8/12		12/30							
64	Muon Tracking	1355d																																
65	MUTK - FEE - Design & Fab.	491d													12/22												11/7							
66	MuTk - Mech. - Design & Fab.	1324d					9/1																							9/28				
67	MuTk - Assembly	31d																										9/29		11/10				
68	Muon Identification	1118d																																
69	MuID - FEE - Design & Fab.	325d													11/20											2/14								
70	MuID - Mech. - Design & Fab.	442d													6/1											2/8								
71	MuID Hangers - Fab.	41d													9/2		10/28																	
72	MuID - Assembly	410d																								2/17				9/11				
73																																		
74	Data Acquisition System	1456d																																
75	Common FEE - Design & Prototype	429d													1/3												8/24							
76	Data Collection Modules	780d																																
77	Data Collection Module - Design & Prototype	619d													1/27												6/11							
78	DCM - Fab. & Test	161d																								6/12		1/22						
79	Sub Event Transfer Buffers	801d																																
80	Subevent Transfer Buffer - Design & Prototype	761d													1/4																12/3			
81	STB - Fab. & Test	40d																									12/4		1/28					

PHENIX - Global Schedule

55

PHENIX - Global Schedule

PHENIX - Global Schedule

ID	Description	Duration	1992				1993				1994				1995				1996				1997				1998				1999			
			01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04
136	Install Magnet Systems	254d																																
137	Install Mu ID Steel & Chamber Hangers	71d																																
138	Install Muon Magnet Steel	73d																																
139	Install MM Coil	25d																																
140	Install Central Magnet Steel	52d																																
141	Install Outer CM Coil	33d																																
142	Magnet Mapping	50d																																
143	Map CM and MI.1	50d																																
144																																		
145	Install Common Systems	140d																																
146	Assemble Carriages in MFH	60d																																
147	Test Arm 1 Carriage	40d																																
148	Test Arm 2 Carriage	40d																																
149	Install Temporary Track System	20d																																
150																																		
151	Install/Connect/Survey/Test Detector Systems	480d																																
152	Detector Installation - Arm - 1	152d																																
153	Install EMCAL(PbSc) in Arm 1 Carriage	41d																																
154	Install TEC/PC2&3 in Arm 1 Carriage	22d																																
155	Install RICH in Arm 1 Carriage	22d																																
156	Install DC/PC 1 in Arm 1 Carriage	40d																																
157	Move Arm-1 Detector to Collision Hall	10d																																
158	Connect Arm-1 Cabling to Counting. House	5d																																
159	Initial in Place Alignment -Arm -1	6d																																
160	Detector Installation - Arm - 2	480d																																
161	Install ToF in Arm 2 Carriage	58d																																
162	Install EMCAL(PbGI) in Arm 2 Carriage	11d																																

PHENIX - Global Schedule

ID	Description	Duration	1992				1993				1994				1995				1996				1997				1998				1999			
			01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04
163	Install EMCal(PbSc) in Arm 2 Carriage	21d																																
164	Install TEC/PC2&3 in Arm 2 Carriage	22d																																
165	Install RICH in Arm 2 Carriage	20d																																
166	Install DC & PC1 in Arm 2 Carriage	40d																																
167	Move Arm-2 to Collision Hall	5d																																
168	Initial in Place Alignment -Arm -2	6d																																
169	Connect Arm-2 Cabling to Counting. House	5d																																
170	Install Beam Pipe	10d																																
171	Inner Detectors	134d																																
172	Install MVD	30d																																
173	Install BB FEE	60d																																
174	Install BB Mech.	60d																																
175	Muon Arm Installation	43d																																
176	Ready to Install Muon Tracking Chambers	1d																																
177	Ready to Install Muon ID Chambers	1d																																
178																																		
179	Install Common DAQ Systems	240d																																
180	Carriage Bases	148d																																
181	Install Racks in Carriage Bases	15d																																
182	Install Cabling Systems in Carriage Bases	62d																																
183	Install Cooling Water Distribution System in Carria	5d																																
184	Common - DAQ Engineering Tests	86d																																
185	Counting House	186d																																
186	Install Racks in Counting House	100d																																
187	Install Cabling Systems in Counting House	62d																																
188	Install Cooling Water Distribution System in Counti	18d																																
189	Common - DAQ Engineering Tests	86d																																

PHENIX - Global Schedule

ID	Description	Duration	1992				1993				1994				1995				1996				1997				1998				1999			
			01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04	01	02	03	04
190	Other DAQ	106d																																
191	Install MFH to Counting House Cabling System	62d																																
192	Install LV Power Supplies & Distribution System	14d																																
193																																		
194	Install DAQ Electronics	365d																																
195	DCM Installation & Test	311d																																
196	STB Installation & Test	215d																																
197	EB Installation & Test	270d																																
198	Timing - Installation	5d																																
199	DAQ Ready for Commissioning	1d																																
200	Install Level 1 Trigger:	675d																																
201	Level 1 Trigger: Assy. & Install	358d																																
202	Level 1 Trigger: Test	542d																																
203	Install Level 2 Trigger	311d																																
204	Level 2 Trigger - Installation	31d																																
205	Level 2 Trigger. - Test	281d																																
206																																		
207	COMMISSIONING	21d																																
208	Arm 1 - Ready for Commissioning	1d																																
209	Arm 2 - Ready for Commissioning	1d																																
210	Inner Detectors - Ready for Commissioning	1d																																
211	Muon Arm - Ready for Commissioning	1d																																
212	Project Complete	1d																																

Critical

End Milestone

Summary

Noncritical

Start Milestone

PHENIX - Global Schedule

(Details)

ID	Description	Duration	Start	Finish	Predecessors	Successors	WBS Ref.
1	PHENIX Project	1783d	6/1/92	3/31/98			
2	Project Starts	1d	6/1/92	6/1/92			
3	DESIGN & FABRICATION	1761d	7/1/92	3/31/98			
4							
5	Magnet Systems Design & Fabrication	1088d	7/1/92	8/30/96			
6	MUID Steel	537d	11/2/93	11/22/96			
7	MUID Steel Design and Construction	537d	11/2/93	11/22/96		137	5.1.6.1.1
8	Muon Magnet	1088d	7/1/92	8/30/96			
9	MM Steel Design & Construction	915d	7/2/92	1/3/96		138	5.1.5.1.1.1
10	MM Coil Design & Construction	1088d	7/1/92	8/30/96		139	5.1.4.1.1
11	CENTRAL MAGNET	913d	7/1/92	12/29/96			
12	CM Steel Design & Construction	912d	7/2/92	12/29/96		140	5.1.3.1.1.1
13	CM Outer Coil Design & Construction	630d	7/1/92	11/29/94		141	5.1.1.1.1.1
14							
15	Detector Systems Design & Fabrication	1444d	5/3/93	11/12/98			
16	Multiplicity Vertex Detector	1103d	3/1/94	5/21/98			
17	MVD FEE - Design & Fab.	813d	5/10/94	6/19/97		19	5.3.1.1.1.1
18	MVD Mechanical - Design & Fab.	619d	3/1/94	2/23/96		19	5.2.1.1.1.1
19	MVD Assembly	240d	6/20/97	5/21/98	17,18	172	5.2.1.3.2.7
20	Beam-Beam Counters	825d	8/30/93	10/25/96			
21	BB FEE - Design & Fab.	750d	8/30/93	7/12/96		173	5.3.3.1.1
22	BB Mech. - Design & Fab.	806d	9/27/93	10/25/96		174	5.2.2.1.1
23	Drift Chambers	1043d	4/1/94	3/31/98			
24	DC FEE Arm 1 - Design & Fab.	858d	4/1/94	7/15/97		28	5.3.4.1.2.1
25	DC FEE Arm 2 - Design & Fab.	918d	4/1/94	10/7/97		29	5.3.4.1.2.1
26	DC Mech. Arm 1 - Design & Fab.	742d	4/1/94	2/3/97		28	5.2.4.1.1
27	DC Mech. Arm 2 - Design & Fab.	914d	4/1/94	10/1/97		29	5.2.4.1.1
28	DC Arm 1 - Assembly & Test	132d	7/16/97	1/15/98	26,24	156	5.2.4.4.1
29	DC Arm 2 - Assembly & Test	125d	10/8/97	3/31/98	26,27	166	5.2.4.4.2
30	Pad Chambers	1183d	12/1/93	6/12/98			
31	PC FEE - Design, Proto & Common Fab.	865d	12/1/93	3/25/97		34FS-348d,35FS-58d,36,33	5.3.5.1.1.1
32	PC Mech - Design, Proto & Common Fab.	488d	1/3/94	11/15/96		33FS-88d,34,35,36	5.2.5.1.1
33	PC1 Arm 1 - FEE & Mech. Assy. & Test	533d	7/17/95	7/30/97	32FS-88d,31FS-442d	156	5.2.5.3.6.2.1
34	PC2&3 Arm 1 - FEE & Mech. Assy. & Test	569d	11/24/95	1/28/96	31FS-348d,32	154	5.2.3.1.1
35	PC1 Arm 2 - FEE & Mech. Assy. & Test	248d	1/3/97	12/16/97	31FS-58d,32	166	5.2.5.3.7.2.1
36	PC2&3 Arm 2 - FEE & Mech. Assy. & Test	282d	5/15/97	6/12/98	31,32	164	5.2.5.3.7.1.1
37	Time Expansion Chamber	1369d	7/1/93	9/29/98			
38	TEC FEE - Design & Fab.	1045d	1/3/94	1/2/98		41,42	5.3.6.1.1
39	TEC Mech. Arm 1 - Design & Fab.	1014d	7/1/93	5/20/97		41	5.2.6.1.2.1
40	TEC Mech Arm 2 - Design & Fab.	1334d	7/1/93	8/11/98		42	5.2.6.1.2.1
41	TEC Arm 1 - Assembly	75d	1/5/98	4/17/98	38,39	154	5.2.6.4.4
42	TEC Arm 2 - Assembly	35d	8/12/98	9/29/98	38,40	164	5.2.6.4.9
43	Ring Imaging Cherenkov Counter	1443d	5/4/93	11/12/98			
44	RICH FEE - Arm 1 - Design & Fab.	1067d	10/11/93	11/11/97		48	5.3.7.1.2.1
45	RICH FEE - Arm 2 - Design & Fab.	1307d	10/11/93	10/13/98		49	5.3.7.1.2.1
46	RICH Mech. - Arm 1 - Design & Fab.	1135d	5/4/93	9/8/97		48	5.2.7.1.1.1
47	RICH Mech. - Arm 2 - Design & Fab.	1433d	5/4/93	10/29/98		49	5.2.7.1.1.1
48	RICH Arm 1 - Integrated Test & Assembly	10d	11/12/97	11/25/97	44,46	155	5.2.7.5.1.2
49	RICH Arm 2 - Integrated Test & Assembly	10d	10/30/98	11/12/98	45,47	165	5.2.7.5.2.2
50	Time of Flight	960d	5/3/93	1/3/97			

PHENIX - Global Schedule

(Details)

ID	Description	Duration	Start	Finish	Predecessors	Successors	WBS Ref.
51	TOF FEE - Design & Fab.	780d	9/1/93	8/27/98		63	5.3.8.1.1.1
52	TOF Mech. - Design & Fab.	980d	5/3/93	1/3/97		63	5.2.8.3.4.1
53	Tof - Ready to Install	1d	1/6/97	1/6/97	51,52	161	
54	EMCal Lcr 1 Scint.	1287d	5/3/93	4/7/98			
55	PbSc FEE - Design & Fab.	312d	1/22/96	4/1/97		58,59	5.3.9.1.1.1
56	PbSc Mech. Arm 1 - Design & Fab.	1137d	5/3/93	9/9/97		58FS-326d	5.2.9.1.2
57	PbSc Mech. Arm 2 - Design & Fab.	1282d	5/3/93	3/31/98		59FS-76d	5.2.9.1.2
58	PbSc Arm 1 - Assembly	221d	4/2/97	2/4/98	55,56FS-326d	163	5.2.9.4.8
59	PbSc Arm 2 - Assembly	81d	12/18/97	4/7/98	55,57FS-76d	163	5.2.9.4.12
60	EMCal Lead Glass	1106d	10/5/93	12/30/97			
61	PbGI FEE - Design & Fab.	345d	10/23/96	2/14/97		63	5.3.10.1.1.1
62	PbGI Mech. - Design & Fab.	1048d	10/5/93	10/7/97		63FS-41d	5.2.10.1.2.1
63	PbGI - Assembly	101d	8/12/97	12/30/97	61,62FS-41d	162	5.2.10.4.3
64	Muon Tracking	1355d	9/1/93	11/10/98			
65	MUTK - FEE - Design & Fab.	491d	12/22/96	11/7/97		67	5.3.12.1.1.1
66	MuTk - Mech. - Design & Fab.	1324d	9/1/93	9/28/98		67	5.2.12.1.2.1
67	MuTk - Assembly	31d	9/28/98	11/10/98	65,66	176	5.2.12.5.7
68	Muon Identification	1118d	6/1/94	9/11/98			
69	MuID - FEE - Design & Fab.	325d	11/20/96	2/14/97		72	5.3.13.1.1.1
70	MuId - Mech. - Design & Fab.	442d	6/1/94	2/8/98		72,71SS+60d	5.2.13.1.1.1
71	MuId Hangers - Fab.	41d	9/2/94	10/28/94	70SS+60d	137	5.2.13.3.1.2
72	MuId - Assembly	410d	2/17/97	9/11/98	69,70	177	5.2.13.4.2.4
73							
74	Data Acquisition System	1456d	9/1/93	3/31/99			
75	Common FEE - Design & Prototype	429d	1/3/94	8/24/96			5.3.14.1.1.1
76	Data Collection Modules	780d	1/27/94	1/22/97			
77	Data Collection Module - Design & Prototype	619d	1/27/94	6/11/96		78	5.4.1.1.1
78	DCM - Fab. & Test	161d	6/12/96	1/22/97	77	196	5.4.1.3.1.1
79	Sub Event Transfer Buffers	801d	1/4/94	1/28/97			
80	Subevent Transfer Buffer - Design & Prototy	761d	1/4/94	12/3/96		81	5.4.2.1.1
81	STB - Fab. & Test	40d	12/4/96	1/28/97	80	196	5.4.2.3.1
82	Event Builder	911d	1/4/94	7/1/97			
83	Event Builder - Design & Prototype	791d	1/4/94	1/14/97		84	5.4.3.1.1
84	EB - Fab. & Test	120d	1/15/97	7/1/97	83	197	5.4.3.3.1
85	Master Timing	370d	6/2/96	10/31/96			
86	Timing - Design, Prototype, & Fab.	370d	6/2/96	10/31/96		198	5.4.8.1.2
87	Common DAQ	140d	5/30/96	12/11/96			
88	Common DAQ - Design & Prototype	140d	5/30/96	12/11/96		181,182,183,187,186,188,	5.4.13.1.2
89	Level 1 Trigger	1051d	3/2/94	3/11/98			
90	Level 1 Trigger - Design	1002d	3/2/94	1/1/98			5.4.4.1.1.1.1
91	Level 1 Trigger - Prototype	635d	7/28/96	1/1/98			5.4.4.2.1.1.1
92	Level 1 Trigger - Fab.	513d	3/25/96	3/11/98			5.4.4.3.1.1.1
93	Level 2 Trigger	857d	6/3/94	9/15/97			
94	Lev. 2 Trigger - Design	240d	6/3/94	5/4/95			5.4.5.1.1
95	Lev. 2 Trigger - Prototype	181d	11/13/95	7/22/96			5.4.5.2.1.1
96	Lev. 2 Trigger - Fab.	121d	3/31/97	9/15/97			5.4.5.3.1
97	On - Line Computing	1304d	4/1/94	3/31/99			
98	On-Line Computing Overall Project	1304d	4/1/94	3/31/99			5.4.9.1.1
99	Release v. 0.3	24d	12/9/96	1/9/97			5.4.9.6.3.3.1
100	Release v. 1.0	20d	4/10/97	5/7/97			5.4.9.6.3.4.1

PHENIX - Global Schedule

(Details)

ID	Description	Duration	Start	Finish	Predecessors	Successors	WBS Ref.
101	Release v. 1.2	20d	3/5/98	4/1/98			5.4.9.6.3.6.1
102	Release v. 2.0	20d	6/11/98	7/8/98			5.4.9.6.3.7.1
103	Release v. 2.2	20d	3/4/99	3/31/99			5.4.9.6.3.9.1
104	Simulation Computing	1411d	9/1/93	1/27/99			5.4.10.1.1
105	Off-Line Computing	1399d	10/1/93	2/10/99			5.4.11.1.1
106							
107	Common Systems	854d	6/29/93	10/4/96			
108	Carriage systems - Design, Procurement	585d	6/29/93	8/28/95		110,109	5.5.1.1.1
109	Carriage systems - Fab.	265d	10/2/95	10/4/96	108	146	5.5.1.3.1
110	Temporary track system - Fab.	150d	11/30/95	6/26/96	108	149	5.5.1.3.6
111	Facilities	315d	9/1/93	11/15/94			
112	Facilities - Design, Procurement, Construction	315d	9/1/93	11/15/94		128,129,130,131,133,134,	5.5.2.1.2
113	Installation Design	225d	10/2/95	8/9/96			
114	PHENIX Installation - Design, Analysis, & Procure	225d	10/2/95	8/9/96		153,161	5.5.4.1.1
115	Commissioning Planning	330d	1/1/96	4/4/97			
116	Commissioning plan - Design & Analysis	330d	1/1/96	4/4/97		208,210,211,209	5.5.5.1.1
117							
118	INSTALLATION & TEST	1167d	9/1/94	2/19/99			
119	Site Availability	208d	9/1/94	6/15/95			
120	Multi Purpose Lab. - Occupancy	1d	3/31/95	3/31/95			5.5.2.3.1.2
121	MFH. - Occupancy	1d	9/1/94	9/1/94		146,128,129,130,131,133,	5.5.2.3.1.3
122	Counting House - Occupancy	1d	6/15/95	6/15/95		188,186,187	5.5.2.3.1.1
123	Cooling Tower Available	1d	1/2/95	1/2/95		129	5.5.2.4.6
124	Modify Existing Systems in MFH	281d	11/16/94	11/15/95	121,112	137	5.5.2.3.1.5
125	Install Facilities	663d	11/16/94	5/30/97			
126	Initial Hall Survey	57d	11/16/94	2/2/95	121,112	137	5.5.2.4.2.1
127	Conventional Facilities	153d	11/30/94	6/30/95			
128	Install Power Distribution Systems	113d	1/25/95	6/30/95	112,121	143,133,184,189	5.5.2.4.5
129	Install Cooling Water Distribution System	125d	1/3/95	6/26/95	123,112,121	133,184,189	5.5.2.4.10
130	Install Additional Environment Control	40d	12/28/94	2/21/95	112,121	143,161,153	5.5.2.4.13
131	Install Other Conventional Facilities	70d	11/30/94	3/7/95	112,121	147,148	5.5.2.4.9
132	Detector Facilities	663d	11/16/94	5/30/97			
133	Install & Test Magnet Power Supplies	60d	7/3/95	9/22/95	129,112,121,128	143	5.5.2.4.4
134	Install Gas Lines from Gas Storage House	125d	11/16/94	5/9/95	112,121	154	5.5.2.4.10
135	Install Cabling to Counting House	60d	3/10/97	5/30/97	112,121,191	158	5.5.2.4.8.1
136	Install Magnet Systems	254d	11/23/95	11/12/96			
137	Install Mu ID Steel & Chamber Hangers	71d	11/23/95	2/29/96	7,124,126,71	138	5.1.6.4.1
138	Install Muon Magnet Steel	73d	3/1/96	6/11/96	9,137	140,139,177	5.1.5.4.3
139	Install MM Coil	25d	10/9/96	11/12/96	10,138,141	143	5.1.4.4.3
140	Install Central Magnet Steel	52d	6/12/96	8/22/96	12,138	146,141	5.1.3.4.3
141	Install Outer CM Coil	33d	8/23/96	10/8/96	13,140	143,139	5.1.1.4.5
142	Magnet Mapping	50d	11/13/96	1/21/97			
143	Map CM and MM	50d	11/13/96	1/21/97	141,133,139,130,128	157,177	5.1.1.5.2
144							
145	Install Common Systems	140d	10/7/96	4/18/97			
146	Assemble Carriages in MFH	60d	10/7/96	12/27/96	140,121,109	147,149	5.5.1.3.8
147	Test Arm 1 Carriage	40d	1/27/97	3/21/97	146,149,131	153,148FS-20d	5.5.1.4.1
148	Test Arm 2 Carriage	40d	2/24/97	4/18/97	149,147FS-20d,131	161,182,183,181,192	5.5.1.4.2
149	Install Temporary Track System	20d	12/30/96	1/24/97	110,146,121	147,148	5.5.1.3.6
150							

PHENIX - Global Schedule

(Details)

ID	Description	Duration	Start	Finish	Predecessors	Successors	WBS Ref.
151	Install/Connect/Survey/Test Detector Systems	480d	4/21/97	2/19/99			
152	Detector Installation - Arm - 1	152d	2/5/98	9/4/98			
153	Install EMCaI(PbSc) in Arm 1 Carriage	41d	2/5/98	4/2/98	58,147,114,130	154	5.2.9.6.2
154	Install TEC/PC2&3 in Arm 1 Carriage	22d	4/20/98	5/19/98	153,41,134,34	155	5.2.6.6.1
155	Install RiCH in Arm 1 Carriage	22d	5/20/98	6/18/98	154,48	156	5.2.7.5.1.3
156	Install DC/PC 1 in Arm 1 Carriage	40d	6/19/98	8/13/98	155,28,33	157	5.2.4.6.1
157	Move Arm-1 Detector to Collision Hall	10d	8/14/98	8/27/98	143,156	158,159,170	5.5.4.4.1.6
158	Connect Arm-1 Cabling to Counting. House	5d	8/28/98	9/3/98	157,135	208	5.5.4.4.1.7
159	Initial in Place Alignment -Arm -1	6d	8/28/98	9/4/98	157	208	5.5.4.4.6
160	Detector Installation - Arm - 2	480d	4/21/97	2/19/99			
161	Install ToF in Arm 2 Carriage	58d	4/21/97	7/9/97	148,53,114,130	162	5.2.8.4.4
162	Install EMCaI(PbGI) in Arm 2 Carriage	11d	12/31/97	1/14/98	161,63	163	5.2.10.6.2
163	Install EMCaI(PbSc) in Arm 2 Carriage	21d	4/9/98	5/7/98	162,59	164	5.2.9.6.4
164	Install TEC/PC2&3 in Arm 2 Carriage	22d	9/30/98	10/29/98	163,42,36	165	5.2.6.6.2
165	Install RiCH in Arm 2 Carriage	20d	11/13/98	12/10/98	164,49	166	5.2.7.5.2.3
166	Install DC & PC1 in Arm 2 Carriage	40d	12/11/98	2/4/99	165,29,35	167	5.2.4.6.2
167	Move Arm-2 to Collision Hall	5d	2/5/99	2/11/99	166,170	168,169	5.5.4.4.2.8
168	Initial in Place Alignment -Arm -2	6d	2/12/99	2/19/99	167	209	5.5.4.4.2.9
169	Connect Arm-2 Cabling to Counting. House	5d	2/12/99	2/18/99	167	209	5.5.4.4.6
170	Install Beam Pipe	10d	8/28/98	9/10/98	157	172,174,167	5.5.4.4.3.2
171	Inner Detectors	134d	6/1/98	12/3/98			
172	Install MVD	30d	9/11/98	10/22/98	19,170	210	5.2.1.5.5
173	Install BB FEE	60d	6/1/98	8/21/98	21	210	5.3.3.6.2
174	Install BB Mech.	60d	9/11/98	12/3/98	22,170	210	5.2.2.6.2
175	Muon Arm Installation	43d	9/14/98	11/11/98			
176	Ready to Install Muon Tracking Chambers	1d	11/11/98	11/11/98	67	211	5.2.12.5.9.2
177	Ready to Install Muon ID Chambers	1d	9/14/98	9/14/98	138,143,72	211	5.2.13.6.3.1
178							
179	Install Common DAQ Systems	240d	12/12/96	11/12/97			
180	Carriage Bases	148d	4/21/97	11/12/97			
181	Install Racks in Carriage Bases	15d	4/21/97	5/9/97	88,148	184	5.4.13.3.11.4
182	Install Cabling Systems in Carriage Bases	62d	4/21/97	7/16/97	88,148	184	5.4.13.3.12.1
183	Install Cooling Water Distribution System in	5d	4/21/97	4/25/97	88,148	184	5.4.13.3.10.3
184	Common - DAQ Engineering Tests	86d	7/16/97	11/12/97	183,182,181,129,128,192	195,198	5.4.13.5.1
185	Counting House	186d	12/12/96	8/28/97			
186	Install Racks in Counting House	100d	12/12/96	4/30/97	88,122	189	5.4.13.3.3.1
187	Install Cabling Systems in Counting House	62d	12/12/96	3/7/97	88,122	189	5.4.13.3.12.1
188	Install Cooling Water Distribution System in	18d	12/12/96	1/6/97	88,122	189	5.4.13.3.8.3
189	Common - DAQ Engineering Tests	86d	5/1/97	8/28/97	188,187,186,129,128	197,198,195,196	5.4.13.5.1
190	Other DAQ	106d	12/12/96	5/8/97			
191	Install MFH to Counting House Cabling Syste	62d	12/12/96	3/7/97	88	135	5.4.13.3.12.1
192	Install LV Power Supplies & Distribution Syst	14d	4/21/97	5/8/97	88,148	184	5.4.13.3.13.3
193							
194	Install DAQ Electronics	365d	8/29/97	1/21/99			
195	DCM Installation & Test	311d	11/13/97	1/21/99	78,184,189	199	5.4.1.4.1.1
196	STB Installation & Test	215d	8/29/97	6/25/98	81,189	199	5.4.2.4.1
197	EB Installation & Test	270d	8/29/97	9/10/98	84,189	199	5.4.3.4.1
198	Timing - Installation	5d	11/13/97	11/19/97	86,184,189	199	5.4.8.6.1
199	DAQ Ready for Commissioning	1d	1/22/99	1/22/99	195,196,197,198	210,211,208,209	
200	Install Level 1 Trigger:	675d	5/7/96	12/7/98			

PHENIX - Global Schedule

(Details)

ID	Description	Duration	Start	Finish	Predecessors	Successors	WBS Ref.
201	Level 1 Trigger: Assy. & Install	366d	7/24/97	12/7/98			5.4.4.4.1
202	Level 1 Trigger: Test	542d	5/7/96	6/3/98			5.4.4.5.1.1
203	Install Level 2 Trigger	311d	9/15/97	11/23/98			
204	Level 2 Trigger - Installation	31d	9/15/97	10/27/97			5.4.5.4.1
205	Level 2 Trigger. - Test	281d	10/27/97	11/23/98			5.4.5.5.1
206							
207	COMMISSIONING	21d	1/25/99	2/22/99			
208	Arm 1 - Ready for Commissioning	1d	1/25/99	1/25/99	158,159,116,199	212	5.5.5.5.1
209	Arm 2 - Ready for Commissioning	1d	2/22/99	2/22/99	168,169,116,199	212	5.5.5.5.2
210	Inner Detectors - Ready for Commissioning	1d	1/25/99	1/25/99	172,173,174,116,199	212	5.5.5.5.3
211	Muon Arm - Ready for Commissioning	1d	1/25/99	1/25/99	177,116,199,176	212	5.5.5.5.5
212	Project Complete	1d	2/23/99	2/23/99	208,209,210,211		

APPENDIX B: PHENIX COLLABORATION LIST**February 1994**

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K. Pope, N. Smirnov (on leave from PNPI)

Individual Participation:

V. Emel'yanov (MEPI, Moscow), R. Schlueter (LBL), R. Vogt (LBL)

APPENDIX C: PHENIX INSTITUTIONAL MOU TEMPLATE

Memorandum of Understanding among RHIC Project Office, PHENIX Management and *The Collaborating Institution*

Outline

This Memorandum of Understanding (MOU) outlines the activities that members of *(the Collaborating Institution)* are carrying out in the PHENIX Collaboration. The goal of the *(the Collaborating Institution)* group is the design, construction, commissioning, and initial operation of the *(PHENIX detector component)* to be utilized in PHENIX for nuclear physics research.

The spokesperson for the *(the Collaborating Institution)* participants is *(Name)*.

The members of the *(the Collaborating Institution)* group will participate in all aspects of the design, construction, testing, installation, and operation of the *(PHENIX detector component)*. They will also participate in related activities necessary for integration of the *(PHENIX detector component)* into the PHENIX construction and project. Unless otherwise specified, all detector components will be tested, delivered to RHIC in operating condition in accordance with the PHENIX specifications for that component and integrated into the PHENIX detector.

PHENIX/RHIC construction money shall be the primary source of funds to construct the *(PHENIX detector component)*. The *(the Collaborating Institution)* group will provide laboratory space for the assembly of the *(PHENIX detector component)* and for the initial test.

Scientific Participation in PHENIX

The primary function of the agreements signed by RHIC, PHENIX and each institution participating in PHENIX is to specify the various responsibilities for construction and implementation of the PHENIX detector. It is understood that all member institutions of the PHENIX collaboration who participate actively in the construction phase of the detector will be involved in the physics analysis of data obtained with PHENIX.

Since institutions constructing the PHENIX detector will be investing heavily in the success of PHENIX, it is necessary to specify some of the principles guiding the PHENIX collaboration. The PHENIX Collaboration Bylaws define the membership and governance of the PHENIX collaboration. The PHENIX Management Plan specifies how the PHENIX Construction Project will be carried out. The PHENIX Publication Policies document describes the access to the data and publication of the results of PHENIX. The PHENIX management, as specified in these three documents, will act as the representative of the PHENIX collaboration in all matters. The Memoranda of Understanding will be appended to the PHENIX Management Plan.

AGREEMENT TO COLLABORATE

This agreement describes the scope of work, assignment of responsibilities, management planning, schedule, reporting requirements and funding, associated with the Relativistic Heavy Ion Collider project (*PHENIX detector element*) collaboration. This agreement is satisfactory to the BNL RHIC Project management, PHENIX management, and (*the Collaborating Institution*).

I. SCOPE OF WORK

I.A. DESCRIPTION OF TASKS

The following tasks (*identified by their respective RHIC WBS level 4 numbers, or level 5 numbers, if necessary*) have been outlined in the PHENIX Conceptual Design Report and the PHENIX management plan (written in Section 3.2.3), as being within the responsibility of (*the Collaborating Institution*), (*such tasks could include design and construction, documentation, testing, installation, and operating of the detector components as well as activities relating to integration of described components into the PHENIX detector.*)

Unless otherwise specified, all detector components will be tested and delivered to RHIC in operating condition.

Task 1: example- WBS Number 5.2.1.2.1. Silicon Wafers & Electronics (MVD).

Task 2:

Task n:

I.B. INSTITUTIONAL RESOURCES

(*the Collaborating Institution*) will commit the following resources (*e.g. engineering manpower, machine shops, laboratory space for assembly, computer aided design equipment, computers for data analysis*) towards the completion of the agreed upon tasks:

Task 1: example- (*Name*), Mechanical Engineer, will provide the 100 days of mechanical structure fabrication for the Silicon detector (WBS 5.2.1.1.). The Electronic Engineering for the Silicon detector will be contracted out and paid for by (*the Collaborating Institution*) as will the remainder of the Mechanical Engineering. Assembly will be done in the (*the Collaborating Institution*) Equipment Assembly Area.

Task 2:

Task n:

I.C. PHENIX PROVIDED RESOURCES (from RHIC construction funds)

1. Materials (or monies to purchase them) necessary for the construction of the (*PHENIX detector component*).
2. Updated specifications for detector component after initial agreement upon such specifications between PHENIX and (*the Collaborating Institution*) group.
3. Funds for shipping the detector component from (*the Collaborating Institution*) to BNL.
4. Transport, rigging, unloading and installation of completed assemblies shipped to BNL from (*the Collaborating Institution*).
5. (*Please list any other resource necessary, such as: stands and rigging equipment required for installation, cabling, monitoring and control of a specific system ...etc.*).

I.D. PERSONNEL/ASSIGNMENT OF RESPONSIBILITIES

Table 1 lists the names of all the participating individuals and the portion of their real time which will be dedicated to the above mentioned tasks. The contact person and the overall manager are also identified and the responsibilities towards each task are outlined.

(Please list tasks by WBS element number whenever possible.)

If for any reason the work is unable to continue at (*the Collaborating Institution*), all components and documentation will be transferred to PHENIX at RHIC.

I.E. DESIGN STANDARDS, QUALITY ASSURANCE, AND ES&H

It is agreed that the construction tasks under this agreement will follow design standards for engineering drawings and archiving, and comply with Quality Assurance and Environmental Safety and Health practices as outlined in Section 6 of the PHENIX Management Plan. All tasks and detector subsystems will be subjected to reviews by the RHIC Experiment Safety Committee.

II. PLANNING, SCHEDULES AND FUNDING

Table 1: Manpower Profile for FY93 through FY99

Collaborating Institution: PHENIX University

Contact Person and Overall Manager: Dr. A. Phenix

Name	Position	RF*) in %	% Fraction for PHENIX in the FY							Funding Source	Project in PHENIX
			'93	'94	'95	'96	'97	'98	'99		
A. Phenix	PR	65	90	100	100	100	100	100	100	Univ/DOE	Coordination
B. Electron	ACPR	70	60	70	70	70	80	100	100	Univ/DOE	Electronics Trigger
C. Photon	ARS	100	100	100	100	100	100	100	100	DOE	Frontend, Trigger
E. Hadron	PD	100	100	100	100	—	—	—	—	DOE	Simulation
F. Muon	PD	100	5	—	—	—	—	—	—	DOE	—
J. Global	PD	100	100	?	?	?	?	?	?	RHIC R&D	TOF-hard + Frontend
New Postdoc	PD	100	—	80	80	80	—	—	—	DOE	Trigger
New Postdoc	PD	100	—	—	80	80	80	—	—	DOE	TOF construction
New Postdoc	PD	100	—	—	—	100	100	100	—	DOE	Trigger, Frontend
New Postdoc	PD	100	—	—	—	—	100	100	100	DOE	Offline
New Postdoc	PD	100	—	—	—	—	—	100	100	DOE	Trigger
New Postdoc	PD	100	—	—	—	—	—	—	100	DOE	TOF installation
A. Newton	GS	100	5	—	—	—	—	—	—	DOE	—
B. Einstein	GS	100	10	10	—	—	—	—	—	DOE	Beam test
C. Planck	GS	100	10	10	—	—	—	—	—	DOE	Beam test
D. Bohr	GS	100	10	10	—	—	—	—	—	DOE	Beam test
E. Fermi	GS	100	10	10	10	—	—	—	—	DOE	Beam test
F. Landau	GS	100	—	30	10	10	—	—	—	DOE	TOF simulation
G. Dirac	GS	100	—	30	10	10	—	—	—	DOE	Chip performance test
New Student	GS	100	—	30	10	10	—	—	—	DOE	Chip performance test
New Student	GS	100	—	—	30	20	20	—	—	DOE	Simulation
New Student	GS	100	—	—	30	20	20	—	—	DOE	TOF construction
New Student	GS	100	—	—	—	30	30	30	—	DOE	Chip performance test
New Student	GS	100	—	—	—	30	30	30	—	DOE	Simulation
New Student	GS	100	—	—	—	—	50	100	100	DOE	TOF installation
New Student	GS	100	—	—	—	—	50	100	100	DOE	TOF installation
New Student	GS	100	—	—	—	—	—	100	100	DOE	TOF installation
New Student	GS	100	—	—	—	—	—	100	100	DOE	TOF calib. + Offline
New Student	GS	100	—	—	—	—	—	—	100	DOE	TOF calib. + Offline
New Student	GS	100	—	—	—	—	—	—	100	DOE	TOF calib. + Offline
A. Mechan	ME	100	25	25	25	—	—	—	—	PHENIX	TOF mech. eng.
B. Trigger	EE	100	50	50	50	50	50	50	50	PHENIX	Trigger design
C. Chip	EE	100	50	50	50	50	50	50	50	PHENIX	Trigger+Frontend des.
New Enginner	EE	100	25	100	100	100	100	100	100	PHENIX	Trigger design & test
New Enginner	EE	100	—	50	100	100	100	100	100	PHENIX	Trigger design & test
New Administrator		100	—	50	100	100	100	100	100	DOE	Accounting, filing

*) RF = Overall research fraction at one's work.

PR = Professor, ACPR = Associate Professor, ASPR = Assistant Professor,
 SP = Senior Physicist, PH = Physicist, ARS = Associate Research Scientist,
 PD = Postdoc, GS = Graduate Student,
 EE = Electronic Engineering Staff, CE = Computer Engineering Staff,
 ME = Mechanical Engineering Staff, T = Technician.

Table 2: Funding Split at Phenix University

Name	Position	% Fraction for PHENIX in FY							Funding Source
		'93	'94	'95	'96	'97	'98	'99	
A. Phenix	PR	48/11	53/12	53/12	53/12	53/12	53/12	53/12	Univ/DOE
B. Electron	ACPR	34/08	40/09	40/09	40/09	46/10	57/13	57/13	Univ/DOE

Note#1: On Table 1 it is written that Professor Phenix receives the support from both University and DOE. He receives actually 9 month salary from University and 2 month salary from DOE. If the reserach fraction is uniform over the year for him, then the University contribution to PHENIX in FY93 is:

• $0.65 \times 0.9 \times (9/11) = 0.48 = 48\%$,

and the DOE contribution to PHENIX construction in FY93 is:

• $0.65 \times 0.9 \times (2/11) = 0.11 = 11\%$.

Therefore, the first column (FY'93) for Professor Phenix is 48/11.

This section specifies funding requirements, schedules and milestones for completion of each task consistent with the available resources and the corresponding funding profiles. This must be provided in a format consistent with the RHIC Project management system following the WBS structure given in Section 2.1.3 of the PHENIX management plan.

Since construction funds will be expended, it is agreed that no laboratory or university overhead charges should be levied on such expenditures.

It is understood that funds will be committed by PHENIX/RHIC on a fiscal year basis.

Note: The following tables need not be completed at the present moment, since the full WBS descriptions have to be provided to fill the tables!! The Project Management will provide tables, by the help of DC members, for your review after the completion of WBS!!

Task 1: -example MVD

Table 2.1.: Funding Profile in Fiscal Year from RHIC in K\$'s.

(Provide this table in a separate sheet!)

Table 2.2.: Funding Profile from Institution.

(Provide this table in a separate sheet!)

Table 2.3.: Schedule and Milestones.

(This table is similar to that written in WBS. Provide this in a separate sheet!)

Table 3: Summary of FTE Expected for PHENIX Construction

Funding Source	# of FTE for Construction in the FY							Total
	'93	'94	'95	'96	'97	'98	'99	
University	0.82	0.93	0.93	0.93	0.99	1.10	1.10	6.80
Existing DOE (staff)	2.24	3.01	3.01	3.01	3.22	3.25	3.25	20.99
Existing DOE (student)	0.45	0.70	0.70	0.70	1.50	3.60	5.00	12.65
Additional DOE (Staff)	—	—	0.80	0.80	0.80	1.00	1.00	4.40
Additional DOE (Student)	—	0.60	0.30	0.60	0.50	1.00	1.00	4.00
RHIC R&D	1.00	—	—	—	—	—	—	1.00
PHENIX Constr. Fund	1.50	2.75	3.25	3.00	3.00	3.00	3.00	19.50
Total	6.01	7.99	8.99	9.04	10.01	12.95	14.35	69.34

Note#1: On Table 1 both Professor Phenix and Professor Electron obtained support from University and DOE. Using Table 2, the University contribution to PHENIX for these two professors in FY93 is:

- $0.48 \text{ (Prof. Phenix)} + 0.34 \text{ (Prof. Electron)} = 0.82$,
- while the DOE contribution to PHENIX construction in FY93 is:
- $0.11 \text{ (Prof. Phenix)} + 0.08 \text{ (Prof. Electron)} = 0.19$

Note #2: In FY 93, therefore, the contribution to PHENIX from the existing DOE fund becomes as follows:

- $0.19 \text{ (faculty)} + 2.05 \text{ (for ARS and PD supported by DOE)} = 2.24 \text{ (for staff)}$,
- $0.45 \text{ (for students)}$.

In addition, one postdoc is supported by RHIC R&D in the above table.

Note#3: This institution requests one additional postdoc from FY95. The first "New Student" in the table is the replacement of Dr. F. Muon, whereas the second "New Student" in the table is a new addition.

Also, this institution requests additional graduate students from FY94. Since "staff" and "student" are very different in budget, write them separately.

Note#4: The example is for the University. For National Laboratory, if the funding source is from the Director's fund, for example, then this funding must be from its own institution and not DOE. Otherwise, the funding for the regular staff is normally from DOE (or NSF).

Note#5: Some staff member is supported 60% from PHENIX and 40% from DOE. Although this case does not exist in Table 1, please divide that person into two categories by 60-40.

Contingency funds will be handled in accordance with the guidelines agreed upon in the PHENIX Management Plan.

III. REPORTING REQUIREMENTS

Following Section 7.4 of the PHENIX Management Plan, progress on these tasks will be reported to the PHENIX management which in turn will report to the RHIC Project Management on a monthly basis, in narrative form, at the WBS level 4. This should include any milestones met and not met, Quality Assurance and Safety issues, and a general discussion of costs incurred and variances.

The work on these tasks within the overall detector construction will be subjected to periodic review by the RHIC management and DOE. RHIC Project Management will be advised by a Technical Advisory Committee convened by the Assoc. Project Head to review and evaluate progress of detector construction.

IV. SPECIAL CONSIDERATIONS

1. All items bought or fabricated using RHIC funds shall be accompanied by relevant documentation and will remain the property of RHIC. Any (*the Collaborating Institution*) property installed as part of the PHENIX experimental equipment shall have its identifying property tag. However, it shall remain part of the PHENIX equipment until it is decommissioned or replaced upon approval by PHENIX/RHIC.
2. PHENIX/RHIC will have the final authority for the acceptance of all deliverables and retains the right to terminate or renegotiate this Agreement if the requirements of specification, schedule and costs cannot be met by (*the Collaborating Institution*).
3. The continuation of this agreement is dependent on the approval of funds for both parties for each fiscal year.
4. This Agreement may be amended as necessary upon written approval of the signatories to this Agreement.

V. SIGNATURES

The undersigned have agreed to fulfill to the best of their abilities the terms of this agreement between *(the Collaborating Institution)* and the Brookhaven National Laboratory RHIC project. *(please sign and date)*

_____ Dr. (Name) Spokesperson <i>(the Collaborating Institution)</i>	_____ Date	_____ Dr. (Name (chair)) Department Chair	_____ Date
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_____ Dr. Shoji Nagamiya Spokesperson PHENIX Collaboration	_____ Date	_____ Dr. Samuel H. Aronson Project Director PHENIX Collaboration	_____ Date
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_____ Dr. Thomas Ludlam Associate RHIC Project Head Detector and Experimental Support RHIC Project	_____ Date
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DATE

FILMED

6/14/94

END