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Internal Cost Review of the RHIC II Project

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January 2007

Collider Accelerator Department
Brookhaven National Laboratory

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BROOKHAVEN NATIONAL LABORATORY

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of the

RHIC II Project

Physics 266

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Michael Harrison Date

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Andrew McNerney Date

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Erik Johnson Date

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Thomas Roser Date

Summary

Project costs were conservatively estimated in several areas and opportunities' exist to reduce scope, e.g., magnets, power supplies and conventional facilities. If ESH&Q, R&D and supporting scientific staffing are not included, a TPC of less than $100 M is possible. An integrated schedule was not presented which will be essential for an accurate cost estimate.

The C-A Department is fortunate to have a very experienced staff in place to carry out the project.

Introduction

An internal project cost review was held on January 4, 2007 to solicit an assessment of the cost and scope of the RHIC II project at an early stage of the project. In particular, input was requested on what additions would be needed for a Lehman type review.

In addition to the presentations, an excellent project overview (RHIC II White Paper) was made available before the review. An integrated schedule for project execution has not yet been developed. There were also fairly recent realizations that some of the RHIC diagnostics do not need to be moved, but can be relocated within the 2 o'clock area. This will most probably have a very beneficial impact on the overall project cost and schedule.

Comments and Recommendations on Presentations:

1. Project Overview………………………………………...……I. Ben-Zvi

It was agreed that defining CD-4 as "Commissioning ends and CD4 is achieved when a beam from the E-Cooler circumnavigates the tunnel "is an excellent decision. At some point a straw man schedule will be necessary since it does impact most estimates in some way and is necessary to predict resource needs external to the Department. No R&D costs were presented but commissioning (pre-ops) was included. Also, the project should if possible use equipment that is available from the R&D effort.

2. Conventional Facilities…………………………...……....A. Pendzick

Conventional facilities are 13% of TPC. The service building is 9,300 sq.ft. Use of existing 1002 service building and reduction of requirements for power supplies should reduce this substantially.

Also, water-cooling system is presently marginally above BRAHMS capabilities. Reduction of transport magnets (see sections 8 & 9) should make it possible to use existing BRAHMS water-cooling system. This could reduce costs by having a smaller service building (- $1M) and eliminating a new water system ($1M). These changes would lower power requirements for ac, water and power supply systems and may eliminate need for new power feed.

Vibration specifications are needed for the conventional construction with to deal with the affects of the refrigeration system.

The radiation shielding in the connection tunnel needs scrutiny.

The Project should work with Plant Engineering to weigh the pros and cons of using an outside AE firm and to develop realistic costs for construction oversight

3. RHIC Ring Modifications……………………...………...G. McIntyre

There is good understanding of what is needed to accomplish the modifications of RHIC. The only main issue here is scheduling the required approximately 10 months RHIC shutdown. This could be done with two shutdowns (RHIC modifications plus e cooling components) with the longest being ~ 7 months. The pitching magnets and undulators are not yet included (+ $1.0M).

4. Instrumentation Relocation…………………………......……T. Russo

The latest plan for instrumentation involves leaving the devices at 2 o'clock but relocating in this region. This potentially saves most of the cost. The estimate needs a rework. (- $2M).

5. Injection System…..……………………….………………........A. Burrill

Injection system assumes implicitly the on-going R&D program is completed. There ensued a discussion about how to handle scientific manpower and "taking credit "for design work done as part of Navy work for PED reductions in this part of the project. Risk analysis assumes no R&D program, which again seems somewhat conservative. A successful demonstration of the injector for the ERL would change many of the assumptions used for the estimate.

It was assumed that R&D on Diamond cathode is not successful. This may be fine for now to give a good estimate for the contingency range.

6. Superconducting RF Components……..…………………....I. Ben-Zvi

The Superconducting RF components are estimated using AES quotes with built in contingency. At a minimum the project contingency should be reduced to about 10% to reduce double counting. (- $1M)The scope is the gun cavity, the two main ERL cavities and one-third harmonic cavity. The total cost for the four cavities of $14M direct seems high and should be investigated and/or more clearly justified The cavities estimates contain ~ 15 man-years of effort The SRF component estimates are tied into the on-going ERL R&D program in a complicated way. A sole source procurement seems implied which might be difficult to justify.

Also, the existing five-cell cavity can produce the required accelerating gradient and therefore two copies of this cavity would work for the electron cooler making new design work unnecessary. (- $1M).

7. RF Systems ………………………………………….….…A. Zaltsman

The rf system is the same as presently constructed for the test ERL. The contingency of 30% is high in this situation. 20% would be more appropriate (-$0.6M). Also, the PED for the LLRF is 40%. The LLRF system will be based on the LLRF upgrade for Booster, AGS, and RHIC and will be well developed by the time of the RHIC II project. A more appropriate PED is 20% (- $0.5M).

Some concern on limited number of klystron vendors

8. Magnet Systems ……………………………………….……….G. Mahler

The scope is transport magnets, solenoids, pitching magnets and undulators. The pitching magnets and undulators have not been costed. (+ $1M). The PED is very high (45%). There are no particularly difficult performance requirements for the magnet system that would justify such high design costs. 20% would be a more appropriate amount for PED (- $3.7M). The design for the magnet transport calls for 122 quads for the 160 m long transport. With one quadrupole every 1.3 meters this is very much over-designed. It should be possible to design a beam transport with one quad every 3 m or about 50 quadrupoles total. (- $3M).

9. Magnet Electrical Systems ………………………….…….R. Lambiase

The scope includes a total of 475 power supplies. The high contingency of 36% was justified by the uncertainty of the foreign currency exchange rate since most power supply vendors are outside the US. There are plans to have main supplies, trim supplies and corrector supplies for the dipoles magnets and main supplies and trim supplies for the quadrupoles. This seems very redundant. Removing this redundancy and with the reduction of the number of quadrupoles from 122 to 50 (see above) the number of power supplies is reduced from 475 to 260. (- $1.2M) If the proposed scope is actually what is built, the commissioning manpower looks light. Can the number of supplies be reduced by operating them in families? The contingency appears high and arbitrary even considering the foreign currency risk.

10. Power Supply Modifications …………………….. …………D. Bruno

The modifications were well motivated and costed.

11. Beam Instrumentation……….………………………………P. Cameron

The instrumentation of the electron beam transport is quite extensive with 60 BPMs and about 30 profile monitors. No justification for the number of instruments was given. Spares were not costed for current transformers or streak cameras. Instrumentation needs to be evaluated with a view to performing the required accelerator physics measurements.

A careful design of the needed instrumentation should be performed. Loss monitors need to be evaluated for performance in electron/ion environment. It should be determined what loss is acceptable for equipment protection. A reduction of the number of instruments might be possible.

12. Vacuum Systems …………………..……………………………H. Hseuh

Some of the vacuum work will change because some diagnostics (RHIC) will not be moved to sectors 9&10 The $9.3M cost estimate for 360 m of vacuum system seems high, but no single item stands out with the exception of maybe the contingency of 30%, which is high for mainly catalog items.

13.Cryogenic Systems ….…….…………………….……………..Y.R. Than

Well motivated and costed

14. Installation……………………………………….…………..…G. McIntyre

Appears to be in good shape

15.Controls…………………………………………………….....B. Oerter

Well motivated and costed. Scope could be reduced if the number of power supplies is reduced.

16.Commissioning…………………………………………..E. Pozdeyev

Commissioners need to look at worst-case beam loss scenarios.
This effort Includes 47MM of physicists. Scientists might not have to be included in the project. (- $0.5M)

17.Project Management & Controls………………………...K. Mirabella

<u>Cost & Schedule</u>

The assumed schedule of 5.5 years is too long. 4 years is more reasonable. (- $2M). Manpower estimates are based on a fungible scenario not a constant workforce. Project needs to differentiate between FTE's and man-years especially in an environment where the schedule is ill defined. Manpower loading is also a potential issue. Need uniform policy on spares and they should be listed separately.

Potential cost savings recommended in this report could be ~ $15M or TPC of $97 M. Using equipment from R & D facility could save an additional $7M.

<u>Some presentation suggestions from Erik Johnson :</u>

The format for the sub-talks was basically pretty good, and I endorse the idea of making them as similar as possible. I would suggest changing the contingency and risk slides to ‘Risks and Mitigation’. The point would be to show that you have identified the risks, and have mitigation measures in mind. In addition one can break out the types of risks as technical, cost and schedule (see Dicks talk for example). This also aligns with the ‘standard’ formulae for setting the ‘bottoms up contingency’.

For the overview presentation one may also wish to have a high level Risks and Mitigation slide. This basically becomes the early version of the ‘Risk Registry’.

Some overview of the manpower, cost and contingency distribution in an overview presentation would also be welcomed. From the talk materials and the table provided by Kerry, I made up a spreadsheet. The numbers may not be an accurate reflection of the presentations (there was some duplication) and will almost certainly change. The following table is only an example of the kind of thing some of us would look for (or prepare ourselves) as a reviewer on a Lehman panel.

					TEC	Fraction		
		Cost	Contingency			Const		
		k$	k$	%	Total			
1	Injection System	2,126	878	41.3%	3,004	2.7%		
2	SC RF Components	11,214	2,404	21.4%	13,618	12.2%	24,864	22.3%
3	RF Systems	6,348	1,894	29.8%	8,242	7.4%		
4	Magnet Systems	10,038	1,774	17.7%	11,812	10.6%	11,812	10.6%
5	Magnet Electrical Systems	4,160	1,480	35.6%	5,640	5.1%	5,640	5.1%
6	Beam Instrumentation	6,414	1,142	17.8%	7,556	6.8%		
7	Electron Beam Dump Systems	163	37	22.7%	200	0.2%		
8	Vacuum Systems	7,084	2,176	30.7%	9,260	8.3%	9,260	8.3%
9	Cryogenics Systems	8,894	2,718	30.6%	11,612	10.4%	11,612	10.4%
10	RHIC Ring Component Modifications	4,121	701	17.0%	4,822	4.3%	4,822	4.3%
11	Safety Systems	42	8	19.0%	50	0.0%	9,791	8.8%
12	Control Systems	1,591	394	24.8%	1,985	1.8%		
13	E-Cooling Installation	7,405	1,816	24.5%	9,221	8.3%	9,221	8.3%
14	Conventional Facilities	10,463	3,515	33.6%	13,978	12.5%	13,978	12.5%
15	Commissioning	2,825	848	30.0%	3,673	3.3%	10,643	9.5%
16	Project Management	5,808	1,162	20.0%	6,970	6.2%		
		88,696	**22,947**	**25.9%**	**111,643**		**111,643**	**100%**

This highlights the relatively small portion of the project in conventional facilities, and the relatively large portion in the injection/SCRF/RF power systems (22% of the project in direct cost).

Similar tables for FTE distribution are informative as well:

		FTE					
		1.2	1.3				
1	Injection System	2.1	3.1				
2	SC RF Components	5.22	7.74				
3	RF Systems	4.5	2.84				
4	Magnet Systems	36.05	4.22	RHIC		ERL	
5	Magnet Electrical Systems	1.76	8.1	1.25	7.22	0.51	0.88
6	Beam Instrumentation	3.68	9.07				
7	Electron Beam Dump Systems						
8	Vacuum Systems	13.83	9.68				Vacuum
9	Cryogenics Systems	4.34	9.68				0.55
10	RHIC Ring Component Modifications	5.45	30.55				
11	Safety Systems						
12	Control Systems	3.14	3.41				
13	E-Cooling Installation	2.83	49.41				
14	Conventional Facilities	6.21	3.15				
15	Commissioning	5.5	8.5				
16	Project Management	21.35	19.45				
		116	**169**	**285**			

ATTACHMENT A

Internal Cost Review
of the
RHIC II Project (RHIC II)
Bldg. 911 Large Conference Room
January 4, 2007

AGENDA

8:30 Welcome/Introduction………………...……..……......D. Lowenstein
8:40 Project Overview…………………………………...……I. Ben-Zvi
9:00 Conventional Facilities………………………...……....A. Pendzick
9:20 RHIC Ring Modifications…………………...………...G. McIntyre
9:40 Instrumentation Relocation……………………......……T. Russo
10:00 Injection System….……………………..…………….......A. Burrill
10:15 Superconducting RF Components……..…………………....I. Ben-Zvi

10:30 Break

10:45 RF Systems……………………………………….….…A. Zaltsman
11:00 Magnet Systems…………………………………..……….G. Mahler
11:15 Magnet Electrical Systems……………………….…….R. Lambiase
11:35 Power Supply Modifications………………….. ………….D. Bruno

12:00 Lunch

1:00 Beam Instrumentation……….…………………………….P. Cameron
1:20 Vacuum Systems………………..……………………….H. Hseuh
1:40 Cryogenic Systems….…….…………………..……………..Y.R. Than
2:00 Installation………………………………..………...…G. McIntyre

2:20 Break

2:40 Controls……………………………………………………...B. Oerter
2:55 Commissioning………………………………………..E. Pozdeyev
3:10 Project Management & Controls………………………...K. Mirabella
3:20 Final Questions/Callbacks……………………………………..TBD

4:30 Adjourn

ATTACHMENT B

Perspective on CD-0 (Erik Johnson)

The stated scope of the review was to assess the credibility of the cost estimate in its present state. From my perspective it is also useful to remember that this is being done as part of the drive to obtain a CD0 (Mission Need) decision from DOE. The CD0 statements I have seen usually have three elements:

Declaration of mission need (What DOE needs to have in its portfolio)
Objectives for the project (How the project addresses the mission need)
Cost Range

In the case of RHIC II I presume the declaration of the mission need will hinge on a physics case that requires high luminosity beams beyond the capabilities of the current RHIC complex. The physics justification has certainly been worked up and for my purposes I'll assume its compelling, if for no other reason than the fact that DOE has evidently entered into a dialog with BNL on the project, so the first element is met.

For the second element, the BNL proposal will be the E-cooling activities which were presented in the review. It will be somewhat tricky to make the proper definition for the project and its completion. As was mentioned in the review the most plausible case will be generation of electron beam, transport to the intersection areas with the RHIC machine and energy recovery, without interaction with the actual RHIC beam. The CD0 statement will most likely require some kind of beam parameters (e.g. current and emittance) as well as any other parameters that would credibly couple to the mission need target, i.e. the luminosity increase that cooling is simulated to provide. The separation of the RHIC II electron machine commissioning from any actual RHIC operation, as outlined during the review, seems like a very good idea to me. It will, however, make it essential to include in the scope of the project any diagnostics that would allow you to prove you have achieved the performance metrics. This should be part of the planning associated with preparing a CD0 statement.

The third element, establishing a cost range, was notionally the focus of the review and in my opinion is off to a very promising start. A great deal of thinking has gone into assessing the scope of the project. As noted by the team itself, some major elements have yet to be costed (the undulators come to mind for example). The team also noted that the schedule had not yet been developed. For many projects the schedule can be quite notional to establish the TPC, but I believe it will be important to work to reasonable detail for RHIC II both to be credible, and to assure adequate funding when you do get the project funded. Of particular concern are the coordination with RHIC physics operation, and the potentially very large number of people who are needed to work the project in a fairly compressed time. To establish the cost base line, the project needs to be convinced that it's manpower profile is realistic, and that it's schedule (and shift structure) can support timely completion of the project.