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Proposal for R&D on BABAR at Princeton U. in FY96

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SUMMARY

We propose to undertake R&D related to two topics: IR commissioning, and drift chamber construction. Only M&S funds are sought, as ED&I and labor costs are already supported via our DoE grant. A brief cost breakdown is:

IR Commissioning	
Differential synchrotron-radiation detector based on Si wafers	$20k
EPICS compatible workstation for readout control	$10k
Drift Chamber Construction	
Studies of diamond tooling	$5k
Studies of carbon-fiber composites	$20k
Ultrasonic testing of drilled carbon-fiber samples	$5
Studies of gas handling/aging	$5k
continued prototyping of a readout scheme based on SCA's	$5k
TOTAL	$70k

1. IR COMMISSIONING

1a. Introduction

A plan for instrumentation at the BABAR interaction region during the 1997 high-energy-ring commissioning and 1998 low-energy-ring commissioning is being formulated by a group coordinated by Tom Mattison and myself. At present the plan is still informal, so R&D requests at this time are not fully mature. However, it is timely that work begin during FY96.

The major goals of the IR commissioning effort are perceived of as an evaluation of machine backgrounds, primarily MeV-scale charged particles and photons from lost beam electrons, and keV photons from synchrotron radiation. Luminosity monitoring is performed in a separate effort. BABAR detector prototyping is a secondary concern.

It is generally agreed that silicon devices are most relevant for studies of synchrotron radiation, although gas tracking might play a small role. For MeV charged particles, silicon devices, gas tracking, both plastic and inorganic (CsI) scintillators, and Cerenkov detectors can be used. For MeV photons, inorganic scintillators are the best devices.

The backgrounds emanate from distributed sources upstream and downstream of the e+e- interaction point, and so have trajectories that are quasi-parallel to the beams, in contrast to e+e- collision products.

The logistics of mounting the background studies is complicated by the presence of the BABAR support tube. The details of what form of support tube is installed when, and what vacuum tube is installed during the 1997 run are not presently available. This renders planning for IR commissioning at radii less than that of the support tube somewhat speculative at present. Nonetheless, this is the region where backgrounds are likely to be highest. so deserves early emphasis if possible.

In IR commissioning meetings associated the last two BABAR collaboration meetings various people have expressed interest in participating in the IR commissioning studies. Typically this interest arises from a desire to know whether a particular subsystem will have background problems, and detectors are proposed based on prototype components of that subsystem. A smaller number of people are motivated primarily by the issue of PEP-II performance.

It is important that the focus of the IR commissioning effort remain the improvement of the quality of e+e- collisions (and not just a test beam for BABAR components).

However, since the IR commissioning in not on either the PEP-II or BABAR WBS, resources for IR commissioning are more readily available if the justification is as a test beam. Therefore such R&D funds as are available in FY96-98 will play a crucial role in permitting the IR commissioning to stay close to its primary mission.

1b. Preview of a set of IR Commissioning Detectors

>From discussions in the IR commissioning working groups I have abstracted the following scenario for detectors. (However, this summary does not yet represent a thoroughly discussed consensus.)

1b1. IR configuration

It would be preferable if the temporary vacuum tube during the 1997 commissioning had a radius close to the final value -- even if the cooling is done via 4 water tubes localized in azimuth at +-45, +-135 deg.

It would also be preferable if the final support tube is not installed during the 1998 commissioning, but rather replaced by an open frame of 4 tubes.

1b2. Inside the support tube (study both lost particles and synch. rad.)

A set of silicon p-i-n detectors will monitor total rates at numerous points on the surface of the beam pipe. (P. Burchat)

A movable stack (or stacks) of p-i-n detectors can monitor synchrotron radiation. (K. McDonald) A variation based on a single silicon strip detector mounted edgewise is proposed by M. Ronan.

Some set of prototype SVT wafers may be available for tracking studies.

Small sets of straw tubes may be installed to detect tracks parallel to the beams. (D. Pitman)

A small, movable CsI crystal may also be useful here. (K. McDonald -- if no other sponsors)

1b3. Outside the support tube (study mainly lost particles)

A movable ring (or pair of rings) of detectors including CsI crystals, scintillators, and perhaps gas devices such as ion chambers or even tracking chambers; to study backgrounds relevant to the drift chamber. (T. Mattison)

A movable 3x3 (up to 5x5) array of CsI crystals; to study backgrounds relevant to the CsI calorimeter. (C. Hearty)

A water Cerenkov tank; to study background relevant to the DIRC radiator. (DIRC group) (An entire DIRC bar + readout would not be out of order in my opinion.)

1b4. Availability of Information

The IR commissioning detectors should provide a prompt (= online) signal the characterizes the main results of the background measurement. This signal should be available on the PEP-II control system for correlation with machine parameters by PEP-II staff. CAMAC appears to be the hardware for this type of data transfer.

In addition, it is expected that more detailed information is recorded for later analysis by the IR commissioning physicists. For the latter, prototype pieces of the BABAR DAQ system may be relevant.

The EPICS system may provide the needed link between the two types of data acquisition.

1c. The Present R&D Proposal

One of the few needed background detectors not closely related to a regular BABAR subsystem is one that emphasizes synchrotron radiation. It should provide a means of distinguishing keV x-rays from MeV charged particles and photons.

This can be accomplished by a differential device that samples radiation rates after a sequence of absorbers.

As a example, a stack of 60 300-micron thick Si wafers would absorb most x-rays of 200 keV or less.

A differential-rate spectrum at, say, 10 energies: 20, 40, 60, ... 200 keV, could be obtained by reading out only 10 of these 60 wafers (the others being 'junk' silicon), namely wafers 1, 2, 3, 6, 10, 15, 22, 30, 39, 49 and 60.

This stack would be surrounded by a lead shield with a small aperture to provide directionality.

We propose to construct such a device in FY96, along with a CAMAC based readout controlled by an EPICS-compatible workstation. For this we seek $20k + $10k, respectively.

We note that during the 1997 IR commissioning the synchrotron radiation backgrounds will be quite different from those during the 1998 commissioning. That is, critical understanding of these backgrounds will come only in 1998 (or later!). However, due to the very constrained schedule in 1998, as well as the constrained mechanical environment inside the support tube, I strongly recommend that work begin in FY96.

2. DRIFT CHAMBER CONSTRUCTION

2a. Introduction

Recently we have begun considering the merits of Princeton participation in the BABAR drift chamber construction in view of two concerns:

The non-US and US efforts on this subsystem seem less thoroughly integrated than in other subsystems.

There remains some uncertainty as to the funding level for drift chamber construction from NSERC-Canada.

We are by no means fully informed as to the details of the drift chamber project, but impressions formed at the last BABAR collaboration meeting have prompted an interest in mechanical issues (and now dominate over past considerations of the electronics).

Princeton participation might be of advantage to BABAR in adding a contingent of relatively experience physicists with excellent in-house mechanical and electronic support staff. For example, I believe we could readily perform all machining for the drift chamber assembly fixturing here at Princeton, including precision drilling of the carbon-fiber end plates -- at a cost of materials only.

Further, an introductory survey of the proposed drift chamber construction techniques suggests that the favored options are at the high-cost end of spectrum. It seems prudent to invest promptly in R&D to verify whether lower-cost options might not serve as well. We certainly encourage this to be done within the existing drift-chamber group, but it may be that the addition of our effort would advance the time frame over which this R&D could be accomplished.

2b. Proposed R&D

2b1. Diamond Tooling

We understood that only carbide tooling and not diamond tooling is being considered for machining of the carbon-fiber endplates for 2 reasons:

No vendor could be found for the desired tool size.

The spindle rates of machines under consideration are too slow for diamond machining.

However, diamond machining at high spindle rates (~ 30,000 rpm, and correspondingly high feed rates => lower overall machine time => lower cost if machine time must be pair for) is the recommended procedure in the industry. Diamond machining is at least 10 times faster than that under discussion with carbide tools.

Genham Diamond Tool, a leading supplier to the US aerospace industry, is prepared to make diamond tools for carbon-fiber drilling to any specification, including those relevant for BABAR, for about $200 a bit in single quantities.

These bits should be used in a high-speed air spindle, such as manufactured by Volstro for $1200, which can be mounted on any standard mill.

Genham estimates the tool lifetime to be about 2000-2500 holes in 1-cm-thick carbon-fiber epoxy. Clearly a test would be needed to verify this.

We propose to explore the use of the diamond tooling as quickly as possible and seek $5k for this.

2b2. Carbon-Fiber Composites

There are numerous vendors who will make carbon-fiber composite structures to custom shapes, and they all charge rather high prices (apparently $750-1500 per square foot of 1-cm-thick material).

The fiber sheets are available with various moduli of elasticity, which eventually determines the bending stiffness important to BABAR. The standard material has a modulus of 30-34M, with specialty materials available with moduli in excess of 50M at nearly double the cost.

The sheets are bonded together in one of several processes. Apparently the mechanical strength resulting from the various processes is similar, the differences relating more to temperature performance.

A call to Composite Horizons elicited a statement that BABAR presently prefers the higher cost, high-temperature process that leaves greater thermal stresses in the material, compared to the more standard epoxy or cyanate ester processes. The latter is the process preferred by the SDC group during the SSC era.

We are not fully informed as to the choices here, but it appears wise to evaluate the more standard process promptly.

The evaluation should include characterization of the stiffness of the material before and after drilling hole patterns as needed for the BABAR drift chamber.

It is recommended by composite vendors that we consult with an ultrasonic testing firm to characterize possible micro-cracking of internal fibers during the drilling process.

The evaluation should include both high and low modulus materials.

The quantity of material should be sufficient to permit diamond machining studies of tool lifetime.

All of this leads to a somewhat substantial cost, given the high price of the carbon-fiber material.

Taking 10 square feet as a batch size, the batch cost will be $7.5-15k depending on the modulus.

We propose to purchase $20k of material in two batches of different moduli, but standard (epoxy or cyanate ester) processing for testing.

We also propose $5k for ultrasonic testing of the drilled materials.

2b3. Gas Handling/Aging

Princeton is well prepared to address issues of gas handing, monitoring and aging should additional effort be considered useful here.

In the SSC era we performed extensive R&D on chamber gases and have excellent facilities that can be used for BABAR issues.

We are prepared to take a role in construction of the final gas system, which should include precision pressure and flow regulation, oxygen and moisture monitoring, a residual gas analyzer for other trace monitoring, plus a test drift-chamber cell.

Should BABAR wish to encourage activity in this direction, $5k of R&D funding would be appropriate towards prototype test chambers for long-term gas studies.

2b4. Electronics.

For some time now we have been pursuing a drift chamber readout scheme based on analog storage in switched capacitor arrays. Prototype implementations in CAMAC and FASTbus are now being tested on the bench.

Of course, repackaging of the readout components is required for compatibility with the BABAR readout architecture. Should BABAR wish to support this option during FY96, we seek $5k that would be used to produce a BABAR-compatible version of the readout.

2b5. Wire Type

In its effort to minimize the radiation length of the drift chamber, BABAR proposes to use aluminum wire somewhat thinner than in previous drift chambers. The suggests increased risks in both manufacturing and stringing.

We are not well informed as to the state of R&D on this critical issue. Should additional effort be appropriate here we are prepared to participate.

2b6. End Plate Design

At the last BABAR collaboration the design of the endplates was considered to be largely a closed issue -- certainly desirable from a scheduling point of view. It does appear that the design is quite intricate, suggesting higher risks than a simpler design. Since several issues will not be tested prior to final production, it seems wise to be extremely cautious here.

Should Princeton become more involved in the drift chamber construction we would at a minimum make a serious review of the end-plate design -- understanding that making changes at a late date entails its own risks.