RHIC DETECTOR ADVISORY COMMITTEE

Report of Review on Nov. 22, 2003 at BNL

1. Introduction

The committee, consisting of Peter Braun-Munzinger (chair), Russell Betts, Carl Haber, Berndt Mueller, Rick Van Berg, and Jerry Va'vra[1], met for the second time on Nov. 22, 2003 at BNL, chiefly to evaluate proposals by the STAR collaboration on their "MRPC TOF Detector" and by the PHENIX collaboration on their "Si-Tracker".

Brief reports were also heard on the progress of the various R&D efforts in STAR and PHENIX but time was too short to make a detailed assessment of those. This report will hence concentrate on the main proposals. At the end we will make some remarks on the status of R&D in general and on some technical aspects we heard in the open session.

2. STAR MRPC TOF Detector

The development of a detailed proposal for a TOF in STAR, based on the MRPC technology, is the result of a world-wide concentrated R&D effort over the past few years. The STAR TOF group has contributed to this effort very significantly as it provided a testbed for evaluation of the detector performance under real "battle conditions", i.e. within the real RHIC background environment. Overall the STAR results are very impressive. The detector prototype has even been used for physics results. On the other hand, the committee perceived some issues to be considered by the collaboration. We list them in the following:

1. It is very important to analyze any problem which occurs at this very early stage. In particular, we highly recommend analyzing in every detail why 6 out of 28 modules seem to operate differently. To do this analysis, the TOF detector should be removed from STAR, take all faulty modules carefully apart, and determine that the reason for the deviation is either trivial or significant, An example of a trivial reason could be dust on the electrode surfaces, an improperly assembled unit, a wrong gap due to glass imperfections or the nylon line diameter variation, etc. An example of a significant reason for the malfunction could be: corroded glass surfaces, or development of photosensitive surface film deposits on the cathode surfaces. At first glance, it seems indeed unlikely that glass corrosion or surface chemistry can occur, given the fact that the average charge deposits are less than 2pC per track in this detector (as opposed to 1000pC in BaBar or Belle). Furthermore, one needs to stress that the Belle glass RPCs do work at this point. However, if there is an onset of multiple streamers in 6 out of 28 of the TOF detectors in STAR, the accumulated charge could be higher than 2pC/track. There was a group within the Belle collaboration, which reported buildup of a film on the cathode surface in the test chambers, which was responsible for the breakdown. For more on the film theory

[1] Committee member Don Geesaman could not attend this time.

see: H. Sakai et al., Nucl. Instr. & Meth., A484(2002)153. In their case, the gas contained about 1000ppm of water. The paper proposes a theory that this film has a lower work function, and this causes the spontaneous emission of electrons from the cathode (for the anode such effect does not occur). This film could be easily removed by wiping it with a tissue and ammonia.

2. The composition of glass could easily vary at the ppb level. Manufacturers of simple float glass usually do not care that much about such details. Perhaps, even physicists defending this detector concept may think the same. However, there are a very few people around who understand glass in detail from the first principles. For example, about 50 DIRC PMTs corroded very rapidly in the ultra-pure water from some reason. It turns out that the corrosion of the Borosilicate glass is modulated by only 4ppb of Zn. To see such a minute level requires using ESCA surface analysis methods. In case of DIRC, the ultra-pure water, hungry for ions, removed sodium from the glass. A small amount of Zn played the important stability role from some reason, which is not understood by us, but the manufacturer ETL agrees with our conclusion. In case of the TOF MRPCs, a new variable is that the glass is subject to a very strong electric field, plasma environment and UV light. Only long-term tests or real experiments in a high multiplicity environment, such as the STAR test, will prove that there is no problem. For more on the DIRC glass corrosion in water see: http://www.slac.stanford.edu/pubs/icfa/spring01/paper3/paper3a.html.

3. Both providing and removing ≈25kW of power from the experiment is non-trivial, and air-cooling seems a difficult challenge. We recommend looking seriously at both the cooling technology and total power useage. Water-cooling is likely to be a much more tractable solution than forced air cooling, and several parts of the electronics chain might benefit from additional effort to reduce total power. An obvious possibility is to replace the MAXIM preamp chip with the NINO chip, developed by Jaron's group at CERN or a similar discrete implementation. The advantages of using the NINO chip are a small power consumption ($<$ 50mW), a truly differential input, resulting in a smaller noise, smaller cross-talk and smaller threshold voltage. The chip has ≈1ns peaking time, which also gives a better timing resolution. Signal conversion and power regulation blocks probably also deserve some additional design effort.

4. We recommend keeping a glass coupon from every TOF module. Such samples can be used for subsequent studies if some fault is found in a given detector. These coupons should be subject to ESCA surface analysis.

5. We recommend to do precise charge accounting, in terms of charge per track, charge per cm^2, and as a function of time.

Finally, we would like to point out that a serious effort needs to be undertaken by the collaboration to develop a detailed budget for the construction project.

3. Phenix Si-Tracker

At the 2002 DAC meeting the PHENIX Collaboration presented plans for a silicon vertex detector project to be funded for construction in 2005. The DAC Committee was impressed with that presentation and advised the PHENIX Collaboration to:

1. Evaluate and adopt existing detector and front end electronics technologies in order to avoid an extended development cycle
2. Emphasize the design and development of the basic tracking detector and electronics chain over the mechanical design in the initial R&D phase.

Over the past year the Collaboration has made impressive progress which generally follows this guidance. In particular, a preliminary selection of the ALICE pixel detector and electronics has been made for the inner barrel layer and the new BNL single sided 2D detectors and SVX4 electronics were chosen for the outer three barrel layers. In addition some mechanical concepts were shown as well as a possible concept for the inclusion of a forward tracker.

While the progress shown was impressive and commendable, the Committee judged that the technical design was not yet up to the level of a Proposal since a number of questions were left open and insufficient experience was gained with the various technologies. The Committee believes,however, that a viable design is close and is confident that a good detector can be built.

The Committee recommends the following actions be taken in order to move to a mature Construction Proposal (the order is not prioritized).

1. The argument for pixels on the inner layer is strong. It is less clear whether the second layer should be pixels or strips. This should be explored and documented further.
2. Rapid convergence on the chosen front end electronics technologies and clarification of any issues concerning utility of the various technologies in both the barrel and forward systems. To the extent that the number of technologies under discussion can be reduced from 3 to 2 that would be a worthwhile endeavor. Construction of test modules including the chosen detector design integrated with the chosen front end chips.
3. For the strip layers, the issues of zero suppression (sparse readout), AC vs DC coupling, and front end chip choice are intimately related. For example, in a DC coupled system the pedestal will be affected strip by strip by the integrated leakage current. This may degrade the efficiency of a zero suppressed readout since pedestal fluctuations will broaden the threshold for zero suppression. It is key that all these issues be understood and a coherent approach adopted which accounts for the entire chain from detector through off- detector readout cards. Once the approach is adopted, the entire chain needs to be prototyped rapidly in a realistic configuration (strip lengths, channel counts, etc.) so direct experience with the behavior and limitations of the chosen technology is gained.

4. To the extent possible the project should utilize the considerable silicon expertise resident at BNL in the Instrumentation Division. The fact that the new single sided detectors under consideration were developed at BNL is one of the attractive feature of that design.

5. An organizational structure for the project needs to be clearly defined and adopted which delineates clear responsibilities for technical tasks and fiscal management.

6. The schedule presented includes a rather short time allocated for production activities. The Collaboration should include an explicit construction model in the Proposal. This should include expected rates for assembly of various components (readout cards, detector modules, etc) based upon engineering estimates or vendor quotes. This is should also include a discussion of facilities, infrastructure, and fixturing for assembly and test which accounts for the development, acquisition, and cost of these.

7. The object which integrates detectors, hybrid (ROC), and front end chips with a mechanical substrate (variously called a ladder or module) is the fundamental building block of the tracker. When the final technology selection has been made a clear design for this object needs to be prototyped and presented as part of the Proposal. For example, the material in radiation lengths will be strongly affected by this design. The actual sizes, areas, and layouts of components need to be accounted for here. (For example the ROC presented at the review is probably too small to hold all the components and traces required to serve the SVX4 chip?)

The Committee makes the following recommendation with regard to the issue of forward layers.

1. If the Collaboration intends to eventually include the forward tracking layers then these should be explicitly accommodated in the mechanical, cooling, and services design at all stages of the development.

2. If the forward layers are to be installed as an upgrade this should not require a rebuild of the barrel.

3. In general, the interaction between the barrel and forward projects needs to be defined more clearly. The operative assumption is that the barrel is proposed for physics in 2008 and that the forward detector is on a longer timescale. The Proposal should therefore make a standalone case for the barrel with cost, schedule, plans, and technologies for the barrel clearly defined. If the barrel cannot be ready for physics in 2008 then the development of a unified barrel and forward design may be worth considering.

4. General remarks about the R&D program

The program presented STAR and PHENIX in their overview talks shows that despite financial restrictions there is now a rather broad R&D effort in place with, in general, rather good progress. We note, however, that the two projects which STAR and PHENIX would like to bring forward to construction are both strongly based on R&D performed within the framework of the CERN LHC program. The timescale and effort needed to develop new detector technologies into mature projects is considerable and corresponding funds need to be invested if the RHIC R&D program is to yield results in a reasonable time frame.

5. Other projects

In the following list a few concerns/recommendations concerning some of the other R&D projects.

5.1. Phenix HBD

a) The results presented by I. Tserruya on the non-linear behavior of GEM gain in CF4 gas using α particles are not understood by the committee members. According to our knowledge, such results were not yet reported in literature. A GEM detector should simply work as a parallel plate chamber, i.e., its gain is very linear all the way up to the Raether limit (10^8 electrons), where a spark should occur. It is more likely that some GEM in the test set up has developed a fault, perhaps a slight surface discharge at a certain voltage or plasma density, which started to divide the voltage across the GEM. We recommend repeating the test with several sets of GEM foils. Certainly, this test result should not be used as an argument that GEM-based detectors are fine for the applications at RHIC. One urgently needs to put a GEM detector into STAR or PHENIX, as we suggested last time.

5.2. GEM-TPC

Considerable progress was reported by C. Woody and N. Smirnov. Similar comments as in the HBD section apply for the use of GEM's in the TPC read-out. The work on ion feed-back is important but a few % of feed-back is probably not feasible at high gains and high rates. The proposed prototype needs to be built as soon as possible so that actual tests of such a detector can proceed, both with cosmic rays and lasers and in-beam.

5.3. Active pixel development

Considerable further R&D is needed to develop the planned MIMOSTAR detector system. First tests with an Fe^{55} source did not exhibit the expected response. This urgently needs to be further studied. The milestones for the active pixel array shows several cycles of design, foundy submission, testing, and thinning over a period of about one year. This looks very ambitious. Concerning the mechanical lay-out a serious effort should be made of the impact of keeping the FTPC's in STAR at the time when the APS detector is ready for installation.