Hardware Reliability Issues and Effects on Detector Performance, Repair and Maintenance

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Introduction:
Because a large fraction of STAR detector components are located in areas with controlled and limited access, component reliability will become a major concern in detector operations. This note describes the likely schedule on which elements of the STAR detector will be available for repairs and maintenance. This schedule depends on the current collider operating schedule and the accessibility of elements of the detector. The note subsequently presents some ideas on hardware reliability and the applicability of DOE and RHIC Quality Assurance orders to the STAR Detector.

This report is the first draft of a document which will evolve until RHIC operations are well under way. This draft is incomplete especially in the area of RHIC/STAR QA. It is hoped that by releasing this “strawman outline” of the future document early, subsystem managers can begin to plan the proper course of action for their subsystem. Please forward any comments or concerns about the document or current plan to Bill Edwards.

RHIC Collider Operating Schedule: *(Bill Christie, RHIC/STAR Liaison Physicist)*
This operating schedule presented here consists of two parts. First is the plan for the expected annual number of operating hours. This part has been generally accepted by RHIC management. The second part has to do with probable cave access scenarios during the course of the RHIC operating year. This part is influenced by brief discussions with Tom Ludlam, Mike Harrison, and Jon Kotcher, a physicist at Fermilab who knows how cave access worked between the D0 and CDF experiments.

1) RHIC collider operating year
The present plan calls for the RHIC collider to operate 38 weeks per year for nuclear physics. Out of this 38 weeks, 8 weeks are devoted to accelerator studies. This leaves 30 weeks (~5000 hours) for nuclear physics research. Thus, assuming no additional collider operations for high energy physics programs are added to the schedule, there will be 38 weeks per year when access to STAR will be limited, and 14 weeks when access will be relatively easy. The present plan calls for the 14 weeks of shutdown to be contiguous, and probably during the summer.

2) STAR access during collider operation
There are no mutually agreed upon procedures or policies for permitting access to the parts of the STAR detector system which reside in the Wide Angle Hall (WAH) during the 38 weeks per year that the collider is in operation. The following is a synopsis of impressions gathered while talking with Tom Ludlam and Mike Harrison, and what we believe the policy will eventually be.

The general statement from RHIC collider operations is that they don't want the collider to have any scheduled shutdowns other than the annual long shutdown. When RHIC reaches a mature operating mode, a realistic operating efficiency is ~75%. This means that out of a nominal 160-hour week, the machine will be down for ~40 hours. It is assumed that during much of this down time, cave access will be permitted. When asked about short (~1/2 hour) accesses between beam stores, the answer was generally not favorable, but the collider folks realized that this would happen to some degree.

In discussing operations at Fermilab, it was mentioned several times that the CDF experiment was an “8000 pound elephant” that generally got what it wanted. We can probably take this to mean that collider management thinks the large experiments (STAR and PHENIX) will have a strong influence over collider operations. It was also asked how AGS maintenance requirements would impact RHIC operations. The feeling was that the AGS could do most of its maintenance between RHIC fills. If they needed more than the nominal 8-10 hours of a typical RHIC store, it was felt that the last RHIC store could be extended.

When asked what sort of failures would bring down the RHIC collider, the loss of one of the collider magnets was mentioned. It has been estimated that in the first year of operation, a couple of magnets may be lost. After things settled down the failure rate would probably be about one magnet per year. In the best case scenario, where the problem is diagnosed immediately, current predictions are that it would take 4-5 days to cool and replace a magnet.

In a meeting with the experimental side of RHIC operations, it was felt that there would probably be scheduled shutdowns to allow cave access for experimenters. It was thought that a scheduled shutdown would be necessary so that the experiments could arrange to have the appropriate personnel and equipment available for whatever maintenance or repairs are necessary. While stating that nothing was decided on this issue yet, it is thought that a one-half day shutdown per week would be appropriate. In addition to these scheduled shutdowns, short accesses between RHIC stores may be available without much trouble. After a discussion of how unscheduled accesses might work, it was agreed that there would probably be some sort of negotiation process between the experiments. It is envisioned that a designated physicist, probably in the RHIC hierarchy, would ultimately decide whether or not to shut down the machine for unscheduled and/or long experiment access.

While this cave access policy will probably go through a long process of discussion, politics, and negotiation, the end result will likely be very close to the following:

- Scheduled access once per week, probably for about 12 hours, used if necessary
- Short cave accesses available between stores, but their use will probably be dissuaded by the collider operations group and may have to be justified to an outside overviewer
- Unscheduled access on a case-by-case basis considered via negotiation with the other experiments, and ultimately decided by a designated physicist in the RHIC hierarchy
- Random, primarily short access during collider down time on the order of tens of hours per week.

STAR Maintenance Scenarios: *(Joseph Rasson & Howard Matis, STAR SI)*
Design decisions often affect the maintenance requirements of hardware. The ability to access different elements of the detector for repair or service is dependent on the machine operating schedule (discussed above), and the time required to gain access to these portions of the detector. For instance, it is estimated that it will take about one day to unbolt and retract the magnet poletip, setup the access scaffold system and secure access to the detector. A second day will be required to close and align the poletip. Therefore, for elements located behind the poletips, a collider shutdown of more than 2 days is required for any service. An opportunity for this kind of service may only happen a couple of times a year.

Based on the current detector configuration, STAR service and maintenance scenarios can be divided into the following 5 categories:

1) Scenarios requiring access to racks and equipment in the DAQ/Computer and control rooms and access to equipment in the assembly and equipment buildings. This equipment is available continuously. It is not affected by the RHIC operating schedule.

2) Scenarios requiring access to racks and equipment on the rack platforms in the WAH. This equipment will be available when the collider is down for short time periods and access to the WAH is granted. It is envisioned that a minimum of a one-half hour down time will be required to gain access to this area.

3) Scenarios requiring access to equipment on the outside surfaces of the detector such as EMC phototubes, TPC laser system, detector hydraulic alignment system, XTPC Front end electronics, etc. It is envisioned that a

minimum of 2 hours of collider shutdown will be required to gain effective access to repair something in this area of the detector.

4) Scenarios requiring access to equipment on the inner face of the poletip, outer face of the TPC, CTB/TOF, etc. Because it will require approximately 2 days to extract and re-insert the poletip, it is planned that a shutdown of 2 & 1/2 days or more will be required for service of equipment in this area.

5) Scenarios requiring access for removal of a TPC Sector, correction of an internal TPC field cage problem, service of the SVT, addition of any upgrade hardware such as TOF modules and electronics, the XTPC, etc., will take significantly longer than any of the above situations, and therefore they should only be planned for week- to month-long shutdowns, or for the 3-month summer shutdown.

If the collider operating schedule discussed in the section above is true, service scenarios 2 and 3 will be available often, perhaps weekly. An opportunity to service equipment behind the poletip, as in scenario 4, may only occur a few times per year. All other service and major upgrades, such as in scenario 5, will have to wait for the summer shutdown.

Reliability Issues for Detector Hardware: *Bill Edwards & Dick Jared (STAR Chief Engineers)*
Detector element reliability is determined by many factors including the quality of specified components, the element design, and the degree of redundancy. Reliability, however, is not the only factor that determinines the ability of the detector to collect useful physics data. A system designed such that a single component failure affects many small, solid angle regions dispersed over a larger area, may result in low performance, but the data collected may still be useful. The paragraphs below present several ideas for improving both the “up time” and the usefulness of data collected from detector elements.

by Design -

by Providing Redundancy -

by Specification of Components in Procurement -

DOE and RHIC Quality Assurance Policy

To be added later by STAR QA Engineer with input from Yousef Makdisi (RHIC Experimental Program QA)