Monday 15 April 1996
K. Reece
RCR.

Minutes of meeting: Radiation Safety Committee

Date: Wednesday 10 April 1996

Present: D. Beavis, H. Brown, G. Bunce, J. Cullen, A. Etkin, W. Glenn, E. Lessard, W. MacKay, A. McGeary, R. Miltenberger, S. Musolino, C. Pearson, A. Pendzick, K. Reece, C. Schaefer, A. Stevens, R. Thern.

Subject: g-2 target review.

A summary was provided to the RSC by C. Pearson, H. Brown and G. Bunce (RSC file) that included an overview of the intended operating parameters for the g-2 target as well as the results of an engineering review for target stresses and temperatures. Also in this handout is a description of the target assembly. Briefly, the g-2 target consists of a sequence of Nickel disks mounted on a rotating (60 rpm) shaft parallel to the beam direction. Rotation of the disks assures that no two consecutive beam pulses (incident on the outer edge of the disks) hit the target in the same location. These rotating disks then "sit" in a water bath. Bearings for the shaft are radiation resistant Nickel - Graphite; however, it is not determined what affect the "wet" environment would have on them (corrosion ?). The ends of the target assembly have thin (3 mil) Aluminum windows; but the enclosure is not "fully enclosed" since there is an external drive mechanism to rotate the shaft. Target integrity can be viewed through a borescope port (port shielding in place during operation) from the blockhouse aisle.

FNAL has used a similar target (Nickel, although aligned w/the shaft normal to the beam direction such that the beam passes through a chord of each disk) as the target for the p-bar source. Differences between FNAL and AGS beam parameters include; FNAL proton beam is 125 GeV/c (AGS = 24 - 28 GeV/c), FNAL beam size = 0.02" FWHM (AGS ~ 0.2" FWHM), FNAL pulse length = 16μs (AGS ~ 10 - 80ns). Experience at RHIC in these type of stress calculations indicate the z-direction stresses dominate and it was not clear at this meeting that the calculations/modeling were fully 3-dimensional. Another meeting of an RSC sub-committee will be held (w/Chien Pai) next week to review the model details, (another concern is the decrease in the maximum stress of the target material as it "work hardens" with beam).

Water concerns: There is a target water bath and ~ 2 gallon buffer tank integral to the target assembly. Water associated with the target is cooled via a closed loop heat exchanger with a ~ 300 gallon capacity. Other elements on this heat exchanger include V1Q1 & Q2 and V1D1 & D2. The V target cave and heat exchanger location have sumps that will contain a static spill. Water conductivity will be monitored as part of the deionizing process.

<u>Air concerns:</u> water bath and buffer tank will have vent lines to the outer blockhouse aisle; these have three separate filters (including one for water vapor and a HEPA filter). The V target door is "solid" to prevent air flow into the blockhouse. The air enclosure should be reviewed around the V primary beam pipe from the U-line and behind the target to similarly limit the exchange of air. There is no intended air release from this enclosure.

<u>RSC Check-off list:</u>

1. Heat exchanger pump room will be controlled and posted as a High Radiation Area.
2. Target rotation, water level and flow will be monitored (and interlock the beam ?).
3. V target gate will be controlled by procedure to limit access **only** with the use of a job specific RWP for **each access.**
4. External (in the blockhouse aisle or pump house) water filter bag to contain "pieces" of the target material.
5. Air enclosure around beam pipe at entrance from the U-line and behind the target sealed as well as possible.

cc: RSC w/o attachments
RSC file w/attachments

3 April 1996
C. Pearson, H. Brown, G. Bunce

An Overview of the g-2 Target

The g-2 target is used to produce 3 GeV pi^+ or pi^-, which decay to muons, which are then stored in the g-2 ring. The production target must accept 6 x 10^13 protons every 2 seconds when g-2 runs alone, for a one month period. In 1996, g-2 will generally take all protons from a selected AGS cycle, on demand. We expect that we would begin with the AGS loaded with a single bunch (1/8 AGS). We will want to test the target with 8 bunches of high intensity for a period of time--possibly one shift. Our goals will be to commission the target and beamline, detector tests in the g-2 ring, and to assure ourselves, as much as possible, that the target will work for 1997.

The g-2 experiment uses a fast extraction of one AGS bunch (tens of nanoseconds long) at a time, with the next bunch of protons extracted 33 milliseconds later. The bunch length is very short, and the protons heat the target instantaneously, generating a shock pulse in the target material. This shock, along with average heating and the damage from accumulated radiation, are the concerns addressed in the target design.

The experiment requires a source <0.2" FWHM and <15 cm long, with little or no material to beam left. The latter prevents a sudden intensity increase at the experiment when muons are selected in the beamline and injected into the ring.

We have based the target design on the Fermilab antiproton production target. They use a 125 GeV proton beam, 3 x 10^12 protons per 3 seconds, 1.6 microseconds bunch length, 0.02" FWHM transverse size, incident onto a nickel target, 0.5 interaction length (7.5 cm long). The nickel is a disk which rotates in steps, every 75 pulses. The beam hits the disk on the edge, along a chord. Their targets are air-cooled. Their targets survive 1 year runs (10^7 seconds). Their shock would be about a factor 10 greater than ours, their average heating would be a factor 40 smaller than ours, and their accumulated radiation would be similar to ours.

Our design uses a stack of 6" diameter nickel disks which the beam hits on the face, near the left edge. The disks are partially submerged in water and rotate at 60 rpm. There are 24 disks, 1/4" thick, separated by 1/16" gaps. The longitudinal divisions reduce stress from differential heating along the beam.

The target thermal characteristics were studied using the ANSYS program, for both instantaneous and average heating (Chien Pai). We obtain an instantaneous pressure rise of 29 Kpsi. Since each succeeding bunch strikes a spot on the target which is 0.6" from the preceeding bunch's impact point, and stress from average heating is 4 Kpsi, there would be a total pressure of 33 Kpsi at the time of the bunch. This assumes that the target rotates and is water-cooled. The tensile strength of nickel is 50-96 Kpsi. The instantaneous temperature increase in the target in the core of the beam region would be 88 deg. C, and the average temperature would be 42 deg. C. The melting point of nickel is 1450 deg. C. If the target stopped rotating and we continued to hit it with beam, the average pressure would rise to 48 Kpsi, giving a total pressure at the time of the bunch of 77 Kpsi.

The target radioactivity has been studied by Ed Lessard and C. Schaefer. For a 5 week irradiation, 60 TP every 2 seconds, they obtain an exposure rate at 1′ of 925 Rem/hour, 425 Rem/hour after 1 day, [illegible]77 Rem/hour after 1 week, and 120 Rem/hour after 1 year.

The target will be enclosed with 3 mil aluminum windows, with the rotation shaft projecting through the enclosure. The cooling water is dammed and cycled through a holding tank. Target rotation is monitored and the AGS acceleration must be prevented if there is a target rotation failure. Water flow and holding tank level are monitored. A boroscope can be inserted to examine the target. Our major concern is embrittlment from shock and radiation. If there is disintegration on the edge of the target we expect to see it with the boroscope. Any flakes or powder would be contained.

The target is located in an iron block, hung from above and located with pins. The target is replaced by replacing the entire block/target assembly by crane.

We have provided a 6" thick iron shutter to block off the target if work is required upstream on either the instrumentation or the upstream magnets.