Report on a visit to BNL – 23-26 September 2002

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Discussions with Leif Ahrens, Mai Bei, Angelika Drees, John Escallier, Geoge Ganetis, Christoph Montag, Brian Oerter, Dejan Trbojevic, Steve Peggs, Mike Harrison, Robert Mitchnoff, Waldo McKay, Fulvia Pilat, Thomas Roser, Arlene Wu Zhang and others

The mission report has been written from notes according to our understanding of the discussions. The content has not been crosschecked with colleagues from BNL.

RHIC prepares a run with collisions of deuterons and gold to start in December

- Injection takes between 10-20 min, ramping less than 2 min. During the ramp the optics is squeezed, and transition needs to be crossed. Separation between beams needs to be maintained. A typical store takes 7-10 hours.

- RHIC starts to experience intensity dependent effects that could be from photo-electrons. Therefore in parts of the machine solenoids are being installed.

- It is **strongly recommended considering only one ring operating alone** (no beam in other ring). The interlock system and the other protection systems should allow for such functionality.

- The environmental parameters were not appropriate (too high temperature and humidity) - caused a lot of problems.

- **Many connectors** in some of the systems were not correctly mounted and **gave a lot of trouble**. The connectors are being replaced. In other systems identical connectors were installed, and there are no problems. It is assumed that some of the “cableurs” did not do a proper job.

- For the **beam loss monitor system, full coverage of the ring is recommended**. Since for the LHC the beam loss monitors do not cover the centre of a half cell (dipole magnets), it would be of interest to ensure **radiation monitoring in the areas where beam loss monitors would not detect losses.** It was discussed if other electronics (for example quench protection electronics) could include elements to monitor the radiation dose.

- The **time for detecting a loss and dumping the beam** is in the order of **3 turns** (seems to be similar for all accelerators). In order to reduce the time between detection of a fast beam loss and the beam dump at the LHC, could one install **very fast monitors close to the collimators**?

- For the interlock and beam dump, **single point failures should be considered**. Such a failure at the TEVATRON: a counter was set to the value of –1, and this value could never be reached. The machine started to ramp-down with full beam, and many magnets quenched.

- In RHIC: about 1000 power converters, 620 with 48 A. There are two main circuits per ring. The main dipole magnets (0.5 MJ/magnet) have diodes for protection but no heaters. The DX magnets (0.8 MJ) are the most critical magnets and heaters are used for protection.

- The most critical magnets are the **DX dipoles**, where the aperture is limited. A crossing angle has been introduced in order to optimise the aperture.

- Initial operation of the system was difficult because of **lack of time for proper commissioning, and because of lack of debugging tools.** Post mortem was not fully available ("what causes an interlock"). Time stamping is of great importance. Bad cable connections contributed to the problems.

- Only one magnet operating at 50 A had to be replaced. One diode had to be replaced. At room temperature, it was measured that the diode was faulty. At this time a current of 0.1 A is send through the magnets that allows measuring the voltage across all magnets.

- Now, after some time of operation, there are 1-2 weeks of operation without power converter failures indicating a good MTBF.

- In the recent run, about three beam induced quenches were recorded.

- The Real Time Data LINK (RTDL) sends the current in the dipole magnets to the DSPs for the protection. In case of failure of the link, this looks like a quench, and the quench loop is broken.

- Before a thunderstorm, the machine is switched off.

- A new system is being put into place **to monitor state changes of power converters, quench protection and interlocks**. The system allows for post-mortem, and records events with an accuracy of about 50 micro.s. This will allow to measure if a quench occurred first, or if the power converter had a failure. The unit is called “timing resolver”.

- BLMs: Only the electronics that is **“slow”** is used inside the beam interlock system - test our electronics at RHIC?

- Five kickers extract the beam into a dump block is about 20 m downstream. The kick strength is 1.28 mrad, the rise-time 900 ns, with a voltage of 28 kV. The tolerance for energy tracking is 5 %. Re-triggering takes some time because of cables lengths. Some beam has been sent into a silicon detector of one experiment. There is an interlock for the kicker that does not allow kicking if the vacuum pressure is too high. No evidence for self-triggering (disputed - contradictory information).

- During one week only two out of five kicker were firing, the system still performed ok

- Pre-firing of the thyratrons depends on the voltage, and the pre-triggering rate could be reduced from about 10/months to approximately zero

- At the TEVATRON, the excitation of the 7th order resonance in the abort gap turned out to very efficient in order to clean the gap. An interesting idea is to mix the signals from a BPM directly with the discharge waveform of the kicker that allows monitoring the abort gap directly without any timing

- Possibility to make dedicated experiments for measuring quench thresholds, by sending a very low intensity beam into some magnets

Machine interlock systems => Bruno