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Review of Recycler vacuum upgrades For the September 2003 Shutdown Closeout Summary

Recap:

The committee was impressed with the analysis of the observed emittance growth in the Recycler. The observed emittance growth is on the order of 10 pi mm-mrad per hour, a factor of 2.5-5 higher than the design goal. The acceptances of the synchrotron have been measured, both horizontal and vertical, using injection mis-steering and independently using noise sources. The observed dependence of beam intensity with time is consistent with the measured acceptances and emittance growth rate. While there could be many sources of emittance growth -- and likely there are others -- it is clear that the major source is completely consistent with Coulomb scattering with residual gas molecules. Various other mechanisms could be envisioned, such as power supply noise, mechanical vibrations, and so on, but the evolution of low-energy tails in the energy distribution points to interactions of the beam particles with other material or gas particles. RF noise can possibly generate longitudinal emittance growth as well, however the resulting energy distribution would be symmetric about the central energy. The fact that the distribution develops a low-energy straggling consistent with dE/dx losses with the residual gas points directly to multiple Coulomb scattering as the major cause.

The committee feels that the analysis of the emittance growth mechanism is convincing and that the residual gas is the most probable cause. However, the analysis of the Recycler vacuum system readings is inconsistent with the beam measurements. The beam measurements of emittance growth and energy distribution would predict an average vacuum pressure of about 3e-9 Torr (H_2), whereas the vacuum model based upon ion pump readings gives pressures roughly 10 times smaller. Additionally, a pressure of 3e-9 Torr would saturate the TSPs in 10-20 days, whereas these pumps last on the average of 100 days, more consistent with the vacuum model. This inconsistency is unaccounted for, and may be pointing to a small localized region of unmonitored high pressure somewhere in the ring.

Major recommendations:

Although there are inconsistencies in the data that are not understood, the committee is convinced that the emittance growth and lifetime problems are due to residual gas, hence something should be done about the vacuum. The committee concluded that the plan for instrumentation upgrades and some other repair work, plus a ring-wide bakeout is a reasonable plan and should be executed. There do not seem to be reasonable alternatives.

The technical crews should be composed as much as possible from the previously trained techs, those who were trained during the last shutdown and before. The schedule is predicated on trained techs.

Additional Experiments:
Before shutdown some beam-based experiments could be done to investigate neutralization effects

1. Lifetime/emittance growth dependence on beam current. Higher current will trap more electrons, which may have observable effects.
2. P-bars behave very differently to neutralization effects. It would be very useful to have some measurements done with p-bars, perhaps without cooling. In addition, although dust does not seem to be the cause of the emittance growth problems – if it were, we would expect that the emittance growth would not be so smooth in time – there may be dust present. Dust effects are expected to be worse with a negative beam, so it would be useful to investigate that possibility now.
3. Beam shaking is an experiment that could reduce any trapping effects and might have measurable consequences.
4. It might be useful to vary the gas composition by shutting off ion pumps in a few sectors.

There are some experiments that might be done with the mockup that would be useful in the short or long run:

1. Experiment with baking out some complicated sections with hot air or nitrogen in the beam tube. This technique might be useful in areas with complicated equipment like cooling tanks, but needs to be tested off-line.

There are some procedures that are recommended for the bakeout and other shutdown activities. These are in the spirit of bringing procedures in line with the best vacuum system practices.

1. Cooling tanks, flying wires, all installed stuff need to be precleaned, pretested in the lab before being installed in the ring.
2. Appendages such as ion pumps and RGAs should go higher than 250 C, (to get the Argon out) or at least as high as they can achieve. Extra power should be supplied, if necessary to do this simultaneously with global bakeout.
3. The beam tube near magnetic material should not be raised above 120 C.
4. Additional power, equipment and manpower to bake more sectors simultaneously should be seriously considered. This will create time contingency, which might be important. For example, allowing more time for leak checking would be good. Finding leaks is very effective.
5. Degassing of all filaments at end of bakeout, and multiple firing of all Ti filaments to reduce creation of hydrocarbons. Multiple = up to 10 firings.
6. The committee recommends putting IG remote read back and an RGA on each turbo pump to monitor pressure and leak status during and after bakeout, and as a bakeout interlock.
7. One member of the committee noted that CERN AA had a large number of clearing electrode supplies that can read very low currents. Since the AA is no longer operating, he recommended that someone talk to Fleming Peterson (CERN) to see if they are available.

8. The committee was concerned that poor procedures for letting up and flushing with dry gas were used. Care should be taken that the gas not be from pressurized bottles, but be boil-off from LN2 Dewars, and that the plumbing into the vacuum system be clean and dry. Local LN2 Dewars in the tunnel are best, but could be a safety issue.
9. The committee thought that small houses or tents be constructed over the sections of the ring that are open in order to prevent dust or smoke from entering the beam tube. Sort of mini clean rooms. Working under such tents could be a safety issue.
10. Beam tubes and other vacuum components should never be washed with hydrocarbons after they are vacuum degassed at high temperature.
11. It would be a good idea to set up a real cleaning area with vapor degreasing, clean rooms, and so forth.