Meeting on Cryogenics Distribution for 400 MHz LHC RF system

26th September 2001

Present:
Edmond Ciapala SL/HRF, Trevor Linnecar SL/HRF, Roberto Losito SL/CT, Volker Rodel SL/HRF, Ralf Trant LHC/ACR, Joachim Tückmantel SL/HRF, Rob Van Weelderen LHC/ACR.

Proposed Agenda:
1) Possibility/impossibility of separate RF cryo plant in Point 4
2) Implications of connection to QRL, service modules etc.
3) Update on points raised in previous meeting of 6th. March 2001
   e.g. - return flow arrangement, operating pressure, safety valves etc.

1. Separate RF cryo-plant

This is based on availability of a plant recuperated from an experiment[1], originally suggested as a possibility by W. Erdt. Now considered unlikely to be accepted, due to our expected severe budget difficulties. The plant would need a substantial upgrade to make it compatible with the rest of the cryo systems e.g. for controls. Furthermore the redundancy provided by two cryo systems feeding the QRL at point 4 would be lost.

2. QRL Connection

Helium is supplied via the header C of the QRL and gas returned via the header D. Ralf explained the proposed layout. See QRL technical specification annex E - page 47/48. There is one service module (SM) on each side of the IP, with two flexible lines from each SM, one to each of the two nearest modules. A layout will have to be established for the routing past the RF high power system (Action - Volker, Ralf)

3. He gas return flow arrangement

Roberto presented the drawing. LHCACSGA0006. A single return outlet comes from the gas collector on the first cavity, the other collectors being inter-connected by a large diameter pipe. Regulation of the ACN LHe bath outlet is achieved by a Pressure Control Valve (PCV), part of the QRL Service Module. Each cavity He tank has a safety vent line. Each of them, or two of them together, will have a Quench protection Valve (QV) on the related cavity cryostat outlet. There are cooling circuits on the two end cones, each with an adjustable return valve (part of the cavity cryostat). Each of the four main coupler extension cooling lines has a small flow restrictor at the coupler input and an adjustable return valve at the output. Except for the gas from the collector outlets towards the QRL and the quench protection valves, all gas will be recovered via the warm recovery line (ACR responsible for that interface: Wolfgang Hees). An updated He flow drawing will be done and will be available via this link LHCACSGA0006 (Action Ralf, S. Girod)

4. Cryogenics related parameters concerning the cavities.

Roberto presented a list of parameters relating to operating pressures and cryogenic consumption. Nominal losses per module are 150 W static plus 20 W per cavity at the nominal 2 MV, making 230 W total. Ralf stated that the definition of operating pressure for the He tank should be clarified, since the originally specified design pressure was 1250 mbar and the operating pressure has now been raised to 1350 mbar. Joachim pointed out that the specified value is based on avoiding very small plastic deformation of the cavity rather than on safety considerations. (Action - Roberto)

5. Operating Pressures – Safety Valves

Ralf stated that the D line pressure is specified at 1300 mbar maximum during normal operation To allow sufficient flow from the cavity for regulation purposes the operating pressure inside the module must be 1350 mbar. (see e-mail by R. v. Weelderen dated 03 April 2001 – summary given below [2]). This is 100 mbar more than was anticipated in the cavity design. The maximum pressure that can be sustained by the He tank and cavity before plastic deformation - and permanent tune change of the cavities - is around 1500 mbar. The maximum pressure which could occur in the header D is 20 bar. The cavities must be protected under all circumstances from such pressures. The PCV should therefore also protect the module from overpressures in the header D by closing at a certain pressure. This can be achieved by having a built-in shut-off mechanism in the PCV.

The QV would be set at 1500 mbar. Rob pointed out that a valve with automatic re-closing, which would be desirable, cannot have much less than 10% pressure difference from being fully closed to fully open. Hence the actual cryostat pressure could be higher for a certain period. The 10% allowed over-pressure determines the valve size. The PCV safety closing pressure must be less than the opening pressure of the QV to prevent gas from the D line escaping through the module. A value of 1400 mbar, just above the normal operating pressure could be chosen, but would require a very small pressure difference between sufficiently open and fully closed. A search for suitable valves for both the QV and PCV should undertaken. (Action - Rob). The PCV protection would probably not be required to react rapidly, since any pressure rise would be relatively slow - even in the event of a catastrophic failure. The rise times have been estimated for various situations and the results should be checked (Action - Rob). The maximum pressure that can be sustained by the He tank and cavity has also to be re-confirmed. (Action - Roberto)

6. Operating Scenarios

Operation with low and high cryogenic power was discussed. Trevor pointed out that during operation with beam it will not be possible to have one cavity off with its voltage compensated by the others. However if one module has to be removed for repair the other module could provide more voltage for a period of operation. The cryo power would go from 230 W to up to 700 W in this module. This may require substitution of the helium inlet control valve (CV) stem for a larger one during that period. Regulation at low power would be more difficult with this valve e.g. while running with little or no RF. The bath heaters could however compensate the power differences, depending on the overall mode of operation. Alternatively a CU93y valve could be put in parallel with the planned CU93x type. It was agreed that the RF operating scenarios and the resulting cryogenics requirements be studied. (Action - Ed, Volker, Joachim and Roberto).

7. RF Module operation and magnet cooldown

During LHC operation cooldown of the RF system cannot start until all magnets are cold, since the QRL D line cannot be maintained at 1300 mbar till all the magnets are cold.

8. Constraints on first testing of the RF system

The QRL will not be available till all the magnets of the related sector are installed. RF testing will therefore not be possible before mid 2005 - according to the actual LHC schedule.

Summary of Actions

1. Layout for the routing Cryo lines past the RF high power system - Volker and Ralf.
2. Checking of He tank design pressure and definition in specifications - Roberto.
3. Clarification of allowable maximum operating and peak He tank pressures - Roberto.
4. Search for suitable valves for QV and PCV - Rob.
5. Check QRL D line pressure rise times and levels for quench and fault situations - Rob.
6. Drawing LHCACSGA0006 to be completed – Ralf, Roberto, S. Girod
7. Establish RF operation scenarios and cryo power requirements, including maximum values - Ed., Volker, Joachim and Roberto.

E. Ciapala 28th September 2001.
Corrected 30th October 2001.

[1] It is now understood that this plant is the one originally installed in the Hall 180, used at present by ATLAS for magnet tests and would be free before LHC operation

[2] Email 4th April 2001 from Rob.
"Udo Wagner and Laurent Tavian verified that for now ACR can guarantee the pressure in the header D for both sectors 3-4 and 4-5 to be 1.30 bar in nominal operating conditions. In between the RF cavities and line-D a valve with a double functionality needs to be installed:
1) To provide pressure control of the RF cavities' helium bath with respect to vacuum.
2) To protect the RF cavities against over-pressurisation from line-D (which can go up to 20 bar in certain operation modes).
ACR will assume a pressure difference of 50mbar between the RF cavities and line-D to be sufficient to fulfil the two fore-mentioned functions.
CONCLUSION: for nominal LHC operating conditions the minimum operating pressure of the RF-cavities' helium bath with respect to vacuum is 1.35 bar +/- a regulation ripple. At this moment the value of this "regulation ripple" cannot be quantified, but should in principle be less than or equal to what was obtained during operation of the LEP-2 RF-cavities"