Minutes of the SPL working group

meeting no. 83

date: 11. April 2007

present: G. Bellodi, P. Bourquin, C. Carli, F. Caspers, C. De Almeida Martins, M. Eshraqi, R. Garoby, F. Gerigk, T. Kroyer, D. Küchler, S. Lanzone, E. Mauro, S. Maury, J.P. Royer, T. Meinschad, J. Tückmantel, U. Wagner, R. Wegner

agenda

1. General remarks (Roland Garoby)
2. Solid-state long-pulse power modulators for Linac4 and slim SPL" (Carlos De Almeida Martins)
3. Cryostats and cryogenic infrastructure for the slim SPL (Udo Wagner)
4. Options for the slim SPL (Frank Gerigk)
5. Tour de table
6. next meeting

1. Funding, FP7, and general news (Roland Garoby)

R. Garoby reported on the reaction of the SPC (Scientific Policy Committee) review panel to the White Paper which asks for extra resources during the years 2008 - 2010. While the report is overall positive (especially for Linac4), there is a clear request to compare the costs of a RCS (Rapid Cycling Synchrotron) based PS2 injector with a low-duty cycle SPL. The RCS solution is studied by M. Benedikt (& A. Fabich) and will be compared with the numbers for a low-duty SPL assembled by F. Gerigk. Since the comparison is needed by the end of April it will be very difficult to quote hard cost figures for both machines and so the comparison will be inspired by a similar exercise which was done at Fermilab. They reported a price difference of approximately 30% in favour of the RCS solution but it is expected that in the CERN case this difference will be smaller. The new name proposal for the low-duty SPL is LP-SPL (Low Power SPL).

2. Solid-state long-pulse power modulators for Linac4 and slim SPL" (Carlos De Almeida Martins)

C. De Almeida Martins presented (slides) a feasibility study for these modulators together with an estimate of the required space. More detailed presentations on the power supply for the 3 MeV test stand will be given on April, 20th, 16:00 in 866-2D-05. The pulse length definition used in the talk includes the rise time (0 to 99%, usually around 100 us) plus the flat top. The most advanced development is the modulator for the 3 MeV test stand (modulator peak power 2 MW, 2 Hz, 800 us pulse length. This device should be assembled by the end of this month and will then be tested. The rack consists of 3 departments for (right to left) i) commercially available power supplies & electronics, ii) ABB solid state switch plus power supply, iii) pulse transformer and capacitor bank plus an oil retainer at the bottom. Starting from this topology several modified versions were estimated (quoted is always the output power of the respective klystron): i) standard Linac4/LP-SPL modulator for 1 MW klystrons (800 us, 2 Hz, 100 kV), ii) Linac4/LP-SPL modulator for one 2.5 MW klystron or two LEP klystrons (800 us, 2 Hz, 140 kV) which is ~20% longer and ~25% wider than option i), iii) LP-SPL modulator for one 5 MW klystron or two 2.5 MW klystrons (800 us, 2 Hz, 140 kV) which is ~35% longer and ~50% wider than option i), iv) Linac4 modulator for the case that Linac4 is the front-end of an LP-SPL with lower current and longer pulse length (for one 4 MW klystron, 1.2 ms, 2Hz, 112 kV) which is 75% longer and 65% wider than option i) and v) as iv) but with 2.2 ms pulse length: almost twice as big as option i). It should be noted that with increasing duty cycle and power output the modulators become more efficient: for option i) the average power over volume quotient [kW/m^3] is around 0.7 while for option v)

this value amounts to 2.2. The price for the different options scales approximately with the volume of the devices. The purpose of this study was to estimate the impact of the different pulse schemes on the modulators and to foresee enough space in the Linac4 tunnel in case Linac4 will operate as the front-end of an LP-SPL. From the subsequent discussion we can draw some conclusions for the following scenarios:

- **Linac4 drives the LPSL using 0.6 ms beam pulses at 40 mA:** the foreseen modulators can do the job,
- **Linac4 drives the LPSL using 1.2 ms beam pulses at 20 mA:** the short pulse modulators cannot be upgraded to the longer pulse lengths, one should install from the beginning modulators that can be used in long-pulse mode (~1.5 ms for the power supplies), the volume and price increase for the modulators is ~30%,
- **Linac4 drives an injector linac plus RCS at 10 Hz, ~0.2 ms pulses:** the same modulator topology as for the above options can be used but all power supplies in Linac4 have to be exchanged, unless one invests into multi-purpose modulators from the beginning which can do the standard (long) pulses at 2 Hz and the shorter pulses at 10 Hz (extra cost no known),
- **Linac4 drives the full SPL at 50 Hz:** a completely different modulator topology will be used and all modulators in Linac4 have to be exchanged.

3. Cryostats and cryogenic infrastructure for the slim SPL (Udo Wagner)

U. Wagner presented (slides) some basic considerations for the cryogenic infrastructure of the slim SPL. First, two options for cryostats in a sloped accelerator tunnel were presented: i) at 4.5 K the heating of the helium creates bubbles and therefore a certain vapour space is needed inside the cavity helium vessel. To create enough vapour space one has to use either short cryo-modules or one has to separate long modules into smaller units with partition walls, this solution seems suitable for 4.5 K and 2 K operation, ii) in the case that no 4.5 K operation is foreseen (no vapour space needed inside the cavity vessel) one can introduce an angle between the liquid helium vessel and the 2 K two-phase header so that the phase header is always horizontal. In both cases the ILC cryostat cannot simply be copied but needs a major redesign (also to house the larger cavities) so that it can be used for the SPL. In the following the different installations for full SPL, slim SPL, 2 K and 4.5 K operation were quantified and costed. In conclusion one can say that:

- in case of the LP-SPL there is no cost saving if a cryogenic system (cryostat, distribution system, etc) is designed for 2 K and then operated at 4.5 K, in fact if both modes of operation are wanted this may even increase the price for the cryostats,
- around 30% cost savings can be made for the cryostat and the cryo-distribution system if the everything is only designed for 4.5 K operation, additionally the maintenance and commissioning should be simplified at 4.5K,
- up to now we don't have experimental evidence that the envisaged high electric gradients for the SPL cavities can be achieved at 4.5 K, first experiments have hinted that in pulsed mode it may be possible to achieve the same high gradients at 4.5 K as in CW mode at 2 K,
- it makes no sense to upgrade the cryo-plant when going from the low-duty SPL to the full-duty machine. The cryo-plant needs complete replacement.

4. Options for the slim SPL (Frank Gerigk)

F. Gerigk presented (slides) preliminary parameters for a low-duty cycle SPL (LP-SPL), the main purpose of which is to provide a low-emittance beam for the LHC injector chain. For the time being its top energy is 4 GeV and it will operate at 2 Hz, delivering 1.5 * 10^14 particles per pulse. The design approach is to design everything such that the full SPL can be installed: tunnel diameter, cooling water pipes, Helium supply lines, electric cabling, etc. In order to reduce the costs with respect to the full SPL one can reduce the average pulse current to 20 mA (instead of 40 mA) which reduces the number of klystrons by a factor of two. As a consequence the pulse length has to be doubled, increasing the needed cooling capacity of the cryo-plant.

Further savings come from a reduced number of surface buildings needed for cryogenics, water cooling, and power converters as well as from the much reduced electric infrastructure (~factor 10 smaller power consumption than for the full SPL). When it comes to comparing the cost of the LP-SPL with an RCS plus injector linac, one should not try to provide absolute cost estimates for each facility but rather work out a relative cost difference. One example for this approach is the comparison of civil engineering costs: Both scenarios need to have Linac4 in a position where it can (at the same time) provide beam to the present PS complex and to the new injector chain. This set-up is necessary to ensure a minimal interruption of LHC production runs. This means that both scenarios will need more or less the same tunnel lengths making it easier to work out a relative cost difference based on tunnel diameters and needed service areas. The next steps will be to consolidate the established parameters and to study a preliminary design of an injector linac for the RCS scenario.

Tour de table

- **M. Benedikt:** remarked (before the meeting) that the PS2 requirements in terms of pulse length are not yet confirmed. Emittance growth due to scattering on the injection foil might put a limit to the maximum acceptable pulse length.
- **T. Meinschad:** remarked (after the meeting) that the currently developed amplifier for the H- source has a maximum pulse length of 1 ms (50 Hz). M. Paoluzzi said (after the meeting) that with minor modification the amplifier will be able to do the job.
- **D. Kuchler:** mentioned that the requested bids for the FP7 framework are in preparation.
- **F. Caspers:** mentioned that a test of the BHSM is being prepared to assess its sensitivity to spurious external noise.

next meeting:

to be announced

-- FrankGerigk - 16 Nov 2007

This topic: SPL > SPLminutes11April2007
Topic revision: r2 - 2007-11-20 - FrankGerigk