Linac4 Beam Coordination Committee - Meeting 3 held on 25 August 2009

Present: Rocio Chamizo; Mohammad Eshraqi; Roland Garoby; Frank Gerigk; Thomas Hermanns; Mark Jones; Alessandra Lombardi; Remo Maccaferri; Serge Mathot; Stephan Maury; David Nisbet; Uli Raich; Suitbert Ramberger; James Stovall; Maurizio Vretenar; Thomas Zickler.

1. Minutes of the last meeting

The minutes of the last meeting have been approved with the following correction:

R. Chamizo remarked that during the meeting it was stated that neither the head nor the tail dump should see any beam during normal operation and both become protection dumps. In the draft version this was only recorded for the head dump.

S. Maury stated that the requested funding for the new chopper version has been made available since the last meeting and the work has started.

2. Design of EMQs for the CCDTL inter-tank area (Th. Zickler)

Based on the different space and field requirements for the DTL, CCDTL and PIMS, a common list of parameters can be deduced. In the DTL, an inner radius of 27 mm is assumed which is the minimum to accommodate a pick-up of a few millimetres between the vacuum chamber and the magnet. Currently a maximum of 106 mm length are available. On the CCDTL the outer dimensions are limited by the position of the coupling cells. No drawing of the CCDTL prototype is available. For the PIMS the situation is equally restricted in length as for the DTL. The maximum required integrated gradient is 2.2 T in the DTL region.

A quadrupole design was presented that would fulfil all the requirements except for the specification of the power converters. The stable flat top extends over 1000 µs, however errors of several percents due to persistent currents need to be compensated. During the meeting, it was not clear if the power converters are able to compensate this variation. The good field radius is 18mm for a gradient variation of $\pm 5 \cdot 10^{-3}$ but could still be further optimised in 3d simulations if required. (The variation of the magnetic field is a factor 5 lower.) All designs assume cooling by natural convection.

The inductance of this design was found to be 14.8 mH. Assuming a ramp rate of 450 kA/s, a supply voltage of up to 2800 V would be required. However, the specification of the power converter foresees a maximum voltage of 1000V and a current of 200A. Concerning the dynamic behaviour, instead of lengthy 3d simulations, a measurement on a similar magnet and a power converter at the 3 MeV test stand has been undertaken. The measurements show a considerable field error over several 100 µs. A flat top of 2 ms would therefore be required. Eddy currents in the vacuum chamber (stainless steel AISI 316 LN) disappear after ~100 µs and remain in the shadow of the magnet eddy currents. In conclusion, a design was found that would fit in all areas; however the power converter specification is not fulfilled.

2.1. Discussion

F. Gerigk confirms that there are no drawings of the Russian CCDTL prototype but insists that the dimensions between CCDTL cavities of one module are already defined since a long time and constant over all CCDTL modules.

M. Vretenar would like to know why the flat top has been decreased form 1.2 ms to 1 ms. R. Garoby and F. Gerigk consider this length is correct. A. Lombardi remarks that this is just the required beam time.

R. Garoby would like to know if the flat top stability is expressed as percentage on the full field.

M. Vretenar comments that the change of power converter specification would be a disaster. One could foresee a special version for the DTL magnets but in general the converters were expected to fit with all magnets. Some parameters could be further optimized like the aperture. The large aperture is only required at the DTL inter-tank areas which could be treated separately.

Th. Zickler responds that the aperture is also required in order to reach the requested field quality of the good field region.

F. Gerigk remarks that the distance of PIMS modules from an RF point of view could still be increased; however the consistency with beam optics and the position of the waveguide ducts needs to be checked. A. Lombardi expects that there could be a margin of up to 50 mm.

A. Lombardi also reminds that the 56 mm long magnets of Linac2 could possibly be used in Linac4 as they provide the required field over a much shorter length. T. Zickler comments that the bore is smaller and the pick-up would not fit inside.

Action: Clarify the reference for the flat top stability. (**Th. Zickler**)

Action: A new iteration for longer magnets in the PIMS area shall be undertaken. A. Lombardi provides the aperture and good field region required. Th. Zickler provides the required length. A. Lombardi verifies beam optics with the new magnet length. (**A. Lombardi, Th. Zickler**)

Action: Th. Zickler and D. Nisbet need to find a compromise in the magnet and power converter specifications. (**R. Maccaferri, Th. Zickler, D. Nisbet**)

Action: M. Vretenar proposes to have another meeting on the same subject in a month's time where the results on all actions shall be discussed. **(BCC, R. Maccaferri, Th. Zickler, D. Nisbet)**

After the meeting Th. Zickler provided an updated design for the inter-tank areas of the CCDTL and the PIMS where the integrated gradient is 1.8 T at maximum. Assuming a ramp over 1 ms, the ramp rate can be reduced to 80 kA/s and the maximum voltage remains below 900 V. D. Nisbet confirmed that two magnets can only be put in series if the ramp rate and thus the voltage per magnet would be reduced even further.

3. Design of PMQs for the CCDTL inter-tank area & consequences for beam dynamics (Alessandra Lombardi)

The CCDTL area consists in 7 modules with 3 quadrupoles per module. Aster Enterprises did a preliminary design of a PMQ that would fit the space requirements with a bore diameter of 40 mm available for the beam, an outer diameter of 85 mm and a length of 100 mm, and which would provide the integrated gradient of 1.6 T or possibly more. The good field region is 75% of the bore (15 mm radius). The studied scenario would replace two thirds of EMQs at locations of coupling cells which limit the available transverse space.

The consequences on beam dynamics have been analysed based on four criteria: emittance, current, variations of phase advance and capability to transport 50 MeV beam. In conclusion, EMQs provide more flexibility but no issue for beam dynamics with PMQs has been discovered. Concerning radio protection, the presence of cobalt in PMQs might require technical solutions for hands-on maintenance in a HP-SPL.

3.1. Discussion

F. Gerigk asks if in the simulations only the transverse emittance was increased as he would be interested to see the longitudinal emittance.

Action: Analysis of beam transport with increased longitudinal emittance (**A. Lombardi**).

J. Stovall comments that the degradation of PMQs by irradiation should not be a problem. Tests for SNS had been undertaken at CERN some time ago and showed that there should be no evidence of degradation in the accelerator and if there would be degradation it should be slow and flat.

F. Gerigk wonders if shielding wouldn't be required in an HP-SPL.

D. Nisbet wonders if the PMQs wouldn't be all different. A. Lombardi comments that this is indeed the case by groups of 2 or 3 magnets. Every magnet would be custom tuned.

M. Vretenar would like to know if the tuning could be done at CERN if required. A. Lombardi reports that tuning of a Russian PMQ has been done already and that the tuning of the Aster magnets is achieved by adjusting screws on each block. It should not be a problem.

S. Maury wonders what happens if a magnet is hit by the beam. A. Lombardi remarks that the SmCo material would exceed the critical temperature and loose magnetisation. J. Stovall comments that in tests SmCo crumbled when hit straight on.

M. Vretenar remarks that for the EMQs rather length than diameter is the critical parameter. It would be worthwhile to consider changing the strategy and to replace the 7 EMQs with PMQs at the inter-module areas where space is tight due to further beam diagnostics; in the inter-tank areas with coupling cavities, length is not as critical. J. Stovall agrees and considers it better to have more diagnostics and rather fewer knobs to turn.

4. Cost comparison of PMQs vs. EMQs (M. Vretenar)

The difference in cost between 14 PMQs and 14 EMQs plus cables plus 6 power converters amounts to about 150'000 CHF.

4.1. Discussion

S. Ramberger remarks that in case a power converter for every EMQ is needed, the cost savings would be considerably larger.

5. AOB

No AOB.

Suitbert Ramberger

Next meeting: Tuesday 8 September, 16:00, room 354 1-001