Work packages related to SPL cryo-modules

Goals:

1. **Identification of integration needs: components type, interfaces, functional needs (ex.coolingf)**
2. **Define the road map to a functional specification for alignments, thermal budgets, mech.layouts, cryogenics specs (pressures & temperatures), construction codes…**
3. **Limits of scope of CEA and CNRS contributions**
4. **Uncovered items and possible distribution**
5. **Define the key ingredients for defining a layout for tunnel interfaces: longitudinal layout, interconnect space, coupler layout (vertical, lateral?)**

Identified issues:

6.
7. **Type of coupler, integration needs, mechanical interface**
8. **Type of tuner, integration needs, interface to cavity helium vessel**
9. **Magnetic shielding design & integration (internal? external?)**
10. **Quadrupole magnets: definition of requirements, possible solutions**
11. **alignment requiements and assembly principles. See Mark Jones for desy person**
12. **HOM impact on cryo-modules**
13. **cryogenics distribution architecture: general requirements and possible schemes, slope, H/W related issues (ex. Valve boxes)**
14. **standardization of hi and lo beta cryomodules**
15. **mechanical and vibration studies. 4.5 K perturbations.**
16. **thermo-mechanical simulation studies: cool-down/warm-up transients**
17. **testing instrumentation: cryo, mechanical vibrations…**

	Task	**description**	**interested institute**	**deadline**
1			CERN	
2				
3				
4				
5				
6		**Vibration studies on 4.5 K perturbations.**		
7				

The following new are foreseen:

The following discussion subjects need to be addressed:

- Organisation of work package within the collaboration.
- Do we need HOM couplers? How can we come to an answer?
- How many failing cavities can we accept and what kind of gradient spread is acceptable (task 2)?
- Do we need to work on H- stripping via blackbody radiation or has FNAL covered the subject completely?
- Longitudinal momentum collimation?
- other issues?

1. Transverse collimation

The collimation studies for CERN accelerators involve several different steps. The experience with the LHC collimation system has shown that an online coupling between the optics tracking codes and the shower simulation codes (mainly FLUKA) would significantly streamline and enhance the overall calculation capabilities. It is therefore proposed to start collaboration for designing and implementing a suitable generic interface which will allow two-way exchanges of particle 4-vectors and positions between tracking codes and FLUKA. The interface will enable the feeding of runtime into the shower code particles which are entering into possible showering elements (ie collimators), and to feedback to the tracking codes possible shower debris of interest for further tracking into the following machine elements. A semi-automatic algorithm for cross-generating the geometry description of the accelerator main elements should be also developed.

After this first step the study of the collimation system for LINAC4 should include the following steps:

1. The study of collimators to intercept beam power of 10,25,50 Watts at energies between 50 and 160 MeV. The output of this study should be the definition of the collimator geometry, collimation material and the, necessity to cool the various levels of intercepted power. After this step a decision on the feasibility of collimation in the linac can be taken (issue of space available).

2. The study of the activation of the collimators themselves and of downstream elements together with the shielding requirements for each collimation section.

3. The study of a collimation system for the 160 MeV transfer line between the LINAC4 and the booster (low duty cycle operation only, no severe space restrictions) to have the possibility to “clean” the linac beam before injection in the booster with the aim to reduce the activation of the injection septum.

4. The study of two different approaches for beam collimation in the SPL: i) a “distributed collimation approach”, where small collimators are placed between each cryo-module to intercept beam power between 10 and 50 W. ii) “bulk collimation”, where beam collimation is only done at 2 or 3 locations between 160 MeV and 5 GeV, but then for higher beam power levels: 100 to 1000 W.

5. For the SPL the outcome of the study should be: i) which scheme is more suitable in order to minimize machine activation, ii) geometry of the collimators and suitable collimation materials, iii) activation and heat-load for downstream elements (cryo-modules!), iv) optimum position for the (distributed) collimators: before, after, or in between quadrupole doublets.

Status

The studies have started for Linac4 within the Cockroft Institute.

2. Impact of cavity performance

The performance of superconducting cavities can only predicted within certain limits, within which the gradients can vary from cavity to cavity. We assume that this is a static situation, which does not change from pulse to pulse, but rather from one shut-down period to the next. To achieve a stable beam with a well defined energy spread at the end of the linac one needs to define these limits in terms of acceptable gradient spread. Another question concerns linac operation with one or several cavities out of operation. In case of difficulties with a cavity the idea is to remove the cavity from the RF distribution network and only to intervene at the next shut-down. The question is how many cavities in a row (depending on beam energy) can be removed to still guarantee a good beam performance.

3. HOM, proton beams

Inside of CERN a study is conducted to estimate the effects of Higher Order Modes (HOMs) on the beam. In the CERN case a single-particle approach (bunches are modeled as point charges) is taken, which will consider:

1. HOM distribution and characteristics from 3D simulations of the different cavities,
2. HOM frequency scatter,
3. actual time structure of the beam (pulsed and chopped),
4. energy and phase jitter, and transverse offset of the incoming beam,
5. BBU limits due to transverse deflection,
6. energy and phase jitter coming from the SPL klystrons,
7. influence on longitudinal beam dynamics (beam energy, jitter, ..)
8. definition of maximum external Q values for the HOMs,

A comparison of the CERN results with existing codes used in other labs would be highly welcome.

status: So far we have established a list of HOMs and their characteristics. Estimating the worst case heat load in the cavities caused by the HOMs, it seems that we have to limit the external Q of the HOMs to 10^7.

(postponed: HOM + collective effects (?), electron beams)

For the LHeC studies it is envisaged to use a certain fraction of the high-energy section of the SPL as an electron re-circulator, which uses the same beam current as used for proton acceleration. The re-circulator design will be done at CERN and all design aspects, which have an influence on the SPL layout will be studied at CERN.

In the case of a re-circulating beam the danger of Beam-Break-Up (BBU) due to HOMs is significantly higher. Using a similar approach as for protons the limits for external Qs for the HOMs need to be established.

4. Beam distribution for EURISOL

At an intermediate energy of approximately 2.5 GeV, complete beam pulses will be sent via a kicker magnet to EURISOL. The deflection area has to be designed, in order to establish the space- and kicker requirements for the deflection of an H- beam. For the targets it is preferable to have long pulses in order to increase the life time of the targets. The idea is to preserve the full length of the pulses from the SPL and to "shave off" fractions of this pulse to be distributed to 2 or possibly 3 different targets. This can be done by partly stripping the H- beam in an undulator magnet. The remaining H- beam is then deflected with a dipole magnet, while the neutral beam passes the dipole and a stripper foil, converting the neutral beam into a proton beam. This task includes the following aspects:

1. beam dynamics layout of the whole beam distribution system,

2. specification and physics design of the undulator magnets needed for beam neutralization,

3. definition of the physical layout of a 1 or 2 stage partial stripping system,

4. dimensioning of the dipole magnets such that unwanted H- stripping is avoided,

5. loss estimates, shielding requirements,

6. space requirements for an estimate of the needed infrastructure (buildings, shielding),

The points 1 and 6 have to be solved by the end of 2009.

5. Quadrupole specifications

The acceptable higher harmonics of the quadrupoles need to be defined so that the magnet designers can start with their work. The same job was already done for Linac4, meaning that all the tools are available and ready.

5. General machine layout

This task concerns the general layout of the machine, the setting of transverse and longitudinal focusing elements and the incorporation of diagnostics, collimation elements, steerers, etc. Since this task has a high impact on the civil engineering layout, it will be covered in house, so that changes in the lattice can be taken into account as quickly as possible.
During 2009 and 2010, this task will mainly be done by a researcher from ESS-S.

7. Transfer line

The transfer line injects without horizontal bends directly into the PS2. In the vertical plane there are 2 bends, which change the slope of the tunnel from 1.7% to 8.39%, and then from 8.39% to 0%. Between the bends there is a distance of 232 m, and approximately 250 m after the 2nd is the injection area for PS2. The question is if these 2 bends are suitable to perform a longitudinal momentum collimation to remove particles from the beam, which are outside of the regular linac buckets, but which made it to the end of the linac without being lost.

The 2nd question is if there is any need to re-assess the problem of H- stripping via blackbody radiation?

References:

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