

First conclusions from the discussions in WG 2

contributors in bold green characters; deadlines in red, most of them are still missing

On the geometrical β of high energy cavities

From considerations of the total length of the linac **no imperative argument was found for building up the high energy SPL from cavities with a β different from 1**. Several arguments are in disfavour of a lower β . From considerations of the peak surface electric field or the peak surface magnetic field being the limiting field, the maximum gradient for $\beta = 0.92$ would be 3 or 7 % lower, respectively. In addition to that, the dissipated power, being inversely proportional to the shunt impedance, is supposed to be 20 % larger, which has to be confirmed.

On the electromagnetic computation of HOMs and their damping

In most of the recent work on $\beta < 1$ cavities, the power deposited inside the cavity was determined that is induced by HOMs at a harmonic frequency of the bunch repetition time with a longitudinal E field component. In addition to that, similar as in a circular accelerator, the bunch excites HOMs the frequency of which may not coincide with a machine line and may lead to beam break up. A threshold condition for beam breakup depends on, amongst other parameters, **the required loaded Q of the HOM and needs to be figured out**. Computer codes as available at JLAB and SNS may be used for this (**TRIUMF**). A study performed at SNS showed a beneficial effect of a high loaded Q, an apparent contradiction to accepted practice, which should be better understood.

On cold tests of HOM couplers; HOM absorber vs. antenna coupler

Computer simulations of mode propagation inside cavities and between cavities have made large progress in recent years, thanks to new theoretical models. The experience gained for XFEL may be beneficially extended to the SPL. In addition, the damping action provided by HOM couplers may be successfully simulated by these codes (**Uni Rostock**). To test these simulations on a warm model cavity is not really worthwhile; **they should be performed on a cold cavity (CERN), preferentially at larger gradients than nominal**. HOM absorbers in or close to the beam tubes, potentially easier to install, are being developed, may be cooled by LN_2 , but have to cope with tolerable power dissipation into the helium bath. HOM antenna dampers, more difficult to design and assemble, are mature and allow a safe evacuation of the HOM power to a room temperature load, provided they are actively cooled. They may in addition be used for beam diagnosis. Both options may provide viable technical solutions. **The HOM antenna damper can be used as designed at present.**

On how to convincingly demonstrate a nominal gradient of 25 MV/m ($\beta = 1$ cavities) on a cryo-module

The gradient of 25 MV/m was considered to be possible to achieve, however at the upper end of present technology. A lower gradient would lead to an increase in length of the SPL, resulting in larger investment costs. **Unanimous agreement was on the necessity of applying the standard recipe, close to what is established for the XFEL or KEK, including electro-polishing**. As the electro-polishing equipment is concerned, however, it will be made available at **Saclay** (by the EuCard programme) as of about 2010, which is late for the demonstrator cryo-module due for mid 2011. **It is therefore mandatory that such equipment be built up (CERN) fast and that, to bridge the time gap before completion, industry (ACCEL, HENKEL) may be involved.**

As to the number of cavities to be manufactured and processed, the spectrum of opinions was broad. However, in view of the technological challenge of the SPL project, a number of cavities not lower than 8 was proposed that should comply to the specification (i. e. $E_a = 25$ MV/m inside a cryo-module). Preferentially this batch of 8 cavities should be processed at the same place within a relatively short period according to a predefined and agreed protocol (that of XFEL). If needed, the processing might be split onto 2 or 3 premises, with 4 cavities each (BNL and/or Saclay and CERN).

Manufacturing capacities were identified as sufficient, being located in BNL (AES), TRIUMF (Pavac), Saclay, CERN, ESS (Bilbao, Spain) and Soltan Institute (close to Warsaw, Poland).

The issue on diagnosis equipment (on-line, or off-line) was also addressed. In view of the restricted time until the test of the demonstrator cryo-module, the manufacture of a complete T-mapping system was considered as unrealistic. However, **relatively light compensatory quench diagnosis systems, such as T-mapping of the cell identified as faulty, or a second sound quench location system, or a Questar like optical system, should be rapidly assessed and subsequently set up (CERN).**

The most complete demonstrator consists of a fully equipped cryo-module with 8 cavities, focusing elements, and the required ancillary equipment, such as fast and slow tuners, power couplers and HOM couplers (if needed), tested at the nominal inclination of the ground level under high RF power (1 MW per cavity) by mid 2011.

The next less ambitious, but still meaningful demonstrator version could consist of a similar cryo-module, but only one cavity fully equipped (**summer 2011**). This option would allow demonstrating a sufficient number of cavities with nominal performance, being a statistical issue, and also the correct functioning of the ancillary elements, proving their sound design.

Any other more downgraded setups are considered less meaningful.

More data on the statistical performance of SPL type cavities will be provided by the TRIUMF - INP - Orsay collaborative effort to have $\beta = 0.65$ cavities produced in industry.

On how to assemble and test a fully or partially equipped cryo-module

For assembling the full cryo-module, a 15 m long class 10 rail-equipped clean room is available at SM18, in close vicinity of the cold test area. The class 10 online monitoring equipment needs to be refurbished. The assembly procedure as applied now for the LHC cryo-modules is different from usual practice for the high gradient structures, as used in XFEL and FLASH (DESY) and should be re-assessed.

As came out of the study on frequency and temperature, the SPL cryo-module is operated at a bath temperature of 2 K. Hence the test of the demonstrator must be performed under similar conditions at CERN, with high RF power.

The SM18 test place, consisting of 4 vertical cryostats and 2 horizontal bunkers of 15 m length each, is designed for 4.5 K operation under steady state conditions and low RF power, with the possibility to cool down to 2 K without simultaneous replenishment. In addition, the heat losses in the IHe transfer lines are relatively large. **Hence the SM18 cryogenic installation must be refurbished, the**

bunkers possibly extended in length, and the RF power station must be upgraded to comply with the power needs of the fully assembled SPL cryo-module (CERN, spring 2011).

The 704 MHz high power RF equipment could replace the present 352 MHz equipment in use for the LINAC 4, which may be moved elsewhere as of 2011.

With regard to the vertical tests, the SM18 cryogenic test zone is being extended to 704 MHz low power capability.

On ancillary equipment

Power coupler: In the Framework 6 program HIPPI activity, a 704 Hz high power coupler for 1 MW pulse operation was developed, which is to be tested very soon at CEA Saclay. It is a coaxial antenna type coupler with a single room temperature window. However, the mechanical design has to be adapted to the SPL cavity and cryo-module.

BNL is preparing a dual power coupler (2 X 0.5 MW CW in opposite position) to be tested soon. The impact of a single or dual coupler on the beam should be studied (**TEMF Darmstadt**). First field calculations are available at BNL and may be used for benchmarking.

A large experience on power coupler conditioning and interlocking is available at CERN (the LHC power coupler was operated up to 575 kW in full reflection).

In all design considerations, priority is attributed to the requirements of the high power SPL.

Frequency tuner: The Saclay combined slow/fast frequency tuner also developed under HIPPI may be modified for the SPL. It is being successfully operated in FLASH, though under less demanding conditions. Therefore it should be repetitively tested with a cycle number typical of the lifetime of SPL.

BNL is also preparing a tuner test, the results of which will be available soon.

The power coupler and frequency tuner for SPL should be based on the previously described prototypes. The supplier must be defined rather soon (**spring 2009**).

Magnetic shielding: The cavity should not be exposed during cool-down to a static magnetic field exceeding about 1 μ T. Several solutions are presently used (i.e. a double shield outside and inside the cryostat, or a single shield inside the cryostat) and must be integrated into the design of the cryostat.