SOLEIL Upgrade case : main findings from the first studies

Proposed RF systems :

- *A fundamental one* at 352 MHz, consisting in 4 NC cavities of the ESRF-EBS type, each powered by one of the SSA's presently operating in SOLEIL.
- *A harmonic one*, consisting in a cryomodule of the Super3Hc type with 2 "HOM free" passive SC cavities, scaled at 3 or 4 times 352 MHz. It is aimed at lengthening the bunches up to about 100 ps FWHM (3 to 4 times their natural length) and on the other hand at producing relatively short bunches, around 10 ps FWHM, with lower beam intensity and relaxed emittance for X-ray experiments.

1. As we could anticipate, the transient beam loading (TBL) in hybrid mode is the most critical issue. The 3/4 filling mode presently in use at SOLEIL will not be feasible in the Upgrade. With such a gap, the TBL mostly annihilates the bunch lengthening from the harmonic system and we have not found a relevant way of compensation. It can be partially compensated with a feedforward as proposed by KEK but it is not sufficient.
2. We cannot rely on the harmonic system for providing significant Landau damping, as we could expect ; it can even act in the opposite way and lower the CBI thresholds.
3. We could also expect a limitation from the AC Robinson instability at low average current, in particular in single bunch mode (I_b = 20 mA), when the cavities are tuned close to the first synchrotron sidebands. However, the good news is that Mbtrack computations show stable conditions at I_b as low as 10 mA.
4. We have not yet selected the harmonic number, h = 3 or 4 ; h = 3 allows for longer bunches, however h = 4 provides several advantages (more favorable for short and single bunch modes, less space, higher gradient, smaller tapers, …).

SOLEIL Upgrade case : upcoming investigations

- Refine the estimate of the beam life time for the complete RF system, fundamental + harmonic, (vs fundamental voltage and harmonic parameters).
  Can the 4th harmonic system, which provides less bunch lengthening than the 3rd one, nevertheless achieve long enough lifetime ?
- Our Super3HC type system allows for operating the 2 cavities with opposite phases, one providing + 2 V_{opt} , the other one – V_{opt} , instead of V_{opt} / 2 from each one, V_{opt} corresponding to the « flat potential » case. In principle, this should improve the stability conditions → To be checked.
- Refine the study of AC Robinson instability limits in single bunch mode for h = 3 and 4 and analyze the dipole-quadripole mode coupling effect (See R.A. Bosch et al, PRAB, Vol. 4, 074401, 2001).
- Estimate the effect of RF feedbacks (direct, or single mode) on Robinson instability.
- Compare CBI thresholds (Landau damping from HC) for h = 3 and 4.
- Estimate the max tolerable gap(s), with and without TBL compensation → Could be useful to provide additional damping.
- Tests in SLS with S3HC in order to crosscheck the computed results from Mbtrack and Elegant in terms of TBL and AC Robinson Instability. The program of tests has been communicated to all the partners, long time ago, but not yet done, due to the Covid pandemic. Same tests were planned in BESSY; is that still a thing to be done ?

WP2 (Cont'd)

Cases to be studied with the different codes :

- SOLEIL-U with SC cavities (passive ~~& active) and with NC cavities (passive & active)~~
- ESRF-EBS with NC cavities (active & passive) and with SC cavities (active & passive)
- BESSY II with present 1.5 GHz NC cavities and BESSY VSR
- KEK-LS with NC cavities (passive & active) SLS with Super3HC
- SLS with Super3HC
- The conditions of tests in SLS and BESSY, as described below
- Include models for RF feedback that may be needed to cope with the Robinson instability and for the system of TBL compensation (feedforward into a broad band cavity)

Main tests to be performed in both SLS and BESSY :

- Look for the AC Robinson instability threshold in decreasing the average current while setting the tuning of the harmonic cavities such to maintain their voltage at nominal value; repeat it for different values of the voltage
- Check the impact of the filling pattern
- Evaluate the impact on the instability threshold of the fundamental voltage & tuning
- For different gaps, evaluate the effect of the TBL on the bunch length & Robinson instability
- Study the effect on the instability of a direct RF feedback

Each partner has appointed a local coordinator :

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