Working group to study the feasibility of installing a crab cavity in the SPS: CCinS

Elias Métral

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CURRENT COMPOSITION OF THE WG

- **Elias Métral (chairman)**: Beam dynamics issues and impact on SPS availability
- **Frank Zimmermann (linkman with KEK)**: What are the boundary conditions and goals of the experiment?
- **Nicolas Gilbert (tbc)**: Space and integration
- **Giovanna Vandoni**: Vacuum
- **Joachim Tuckmantel**: RF
- **Nicolas Delruelle**: Cryogenics
- **Jorg Wenninger**: Machine protection
- **Rama Calaga**: USLARP
- **Olivier Brunner (tbc)**: Klystron
- **If specific questions:**
  - **Ralph Steinhagen (tbc)** => BI (Head-Tail monitor etc.)
  - **Elena Shaposhnikova** => RF

GOAL OF THE WG

- **Have a feasibility result by the end of 2009**

WEB LINK

- **http://emetral.web.cern.ch/emetral/CCinS/CCinS.htm**

Statements on Crab Cavities from CERN

(Steve Myers, Director of Accelerators and Technology)

1. Following the success of KEKB, CERN must pursue the use of crab cavities for the LHC, since the potential luminosity increase is significant.

2. A final crab-cavity implementation for the LHC has not yet been settled. Both "local" and "global" crabbing schemes are still under consideration for the LHC upgrade phase II. Future R & D should focus on compact cavities which are suitable for both schemes.

3. One possible show-stopper has been highlighted: machine protection, which is critical for LHC. The effect of fast cavity changes needs to be looked at with high priority. Mitigation schemes such as raising the Q value of the cavity to ~10^6 (from ~10^5 at KEK) will be studied.

4. Another important issue is the impedance. Since the LHC revolution frequency changes during acceleration, the detuning of the cavity may be more difficult than was the case for KEKB, and other measures (like strong damping of the dipole mode) need to be examined.

5. High reliability of the crab cavities is essential; the trip rate should be low enough not to perturb LHC beam operation.

6. Validation cavity tests in the LHC itself are not deemed essential. It is considered plausible to install a new system in the LHC without having tested a prototype in the LHC beforehand. As in all new colliders, this has been done with many other components.

Relevant points for this WG

7. Demonstration experiments should focus on the differences between electrons and protons (e.g. effect of crab-cavity noise with beam-beam tune spread; impedance; beam loading) and on reliability & machine protection which are critical for the LHC.

8. A beam test with a KEKB crab cavity in another proton machine is considered useful, meaningful and sufficient (for deciding on a full crab-cavity implementation in LHC) if it addresses the differences between protons and electrons.

9. Possible modifications of LHC Interaction Region 4 during the 2013/14 shutdown should be studied to evaluate the feasibility of installing and testing crab-cavity prototypes, and of accommodating a possible global crab-cavity scheme.

10. The timing of the crab-cavity implementation should be matched to the short and long-term goals and to the overall CERN schedule, and be in phase with the experiment upgrades.

11. The crab-cavity infrastructure should be included in all other LHC upgrades scenarios.

12. Crab cavities can increase the LHC luminosity without an accompanying increase in beam intensity, thereby avoiding negative side effects associated with high intensity and high stored beam energy. This opinion has been endorsed by the general-purpose high-luminosity experiments.

MAIN TOPICS OF INTEREST FOR THIS WG

1) What do we want to measure and can we / how etc. / measure it in the SPS? Do we have the conditions and instrumentation etc.? One should focus on the difference between electrons & protons, reliability and machine protection (which are critical for LHC)

2) What do we need to install in the SPS (all the equipments, total length, weight, etc.)? Will KEK give us the crab cavity and the Klystron (or only the crab cavity)?

3) As it is a superconducting cavity, do we have the necessary cryogenics? Where (is it fixed or can we move it etc.)?

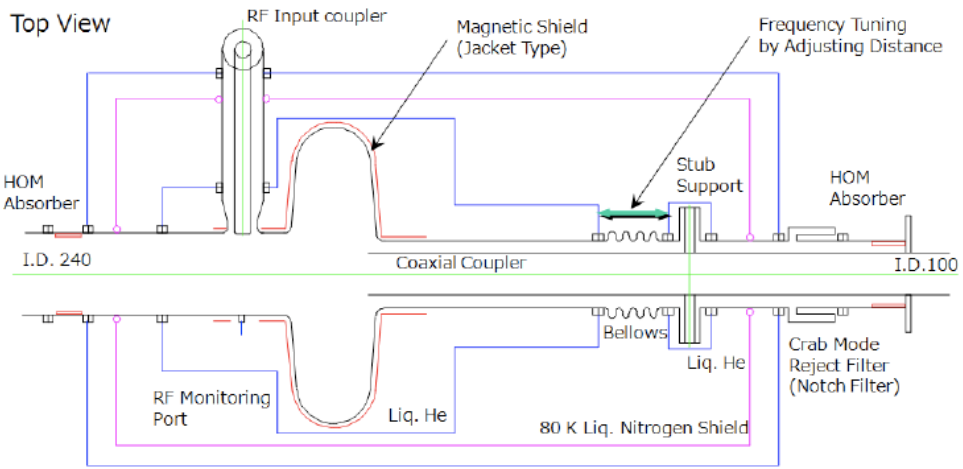
4) Where could this be installed?

5) Check the aperture + impedance effects + SPS availability etc.

6) First estimation of manpower, time schedule and cost

SOME SLIDES FROM RAMA CALAGA (1/3)

KEK-B Cavities In SPS



KEK Freq: 508.9 MHz

SPS frequency: 510.6 - 511 MHz

Energy swing: 26 - 450 GeV

Dynamic swing: 100 - 200 kHz

Power: 50-120 kW (Qext: 2×10^5, 2.55 kHz BW)

Operational tuner stroke ~100 kHz

Maximum possible ~200 kHz

Speed: 1 kHz/s (active feedback required)

SOME SLIDES FROM RAMA CALAGA (2/3)

Impact on SPS, WG

Location: LSS4 (old cryo equipment) else LLS5

- Cryogenics (under investigation)

Added impedance

- Beam stability (Fixed target, CNGS, LHC)

Additional instrumentation

- LHC BPMs, head-tail monitor, emittances: need specifications

RF Power & Controls (under investigation)

Civil Enginnering issues

- Cavity aperture: 94-200 mm diamater (left-right) – compatible with SPS
- Cryomodule length: 5m (flange to flange)
- Cryomodule radius: ~0.5-1m (need to verify additional protrusions)
- Cryomodule weight: ~5 tons

SOME SLIDES FROM RAMA CALAGA (3/3)

SPS Tests Objectives

Feasibility of crab cavities in a hadron machine (circulate)

KEK-B cavity performance

- Static & dynamic frequency tuning, impedance, ramping, reliability

Machine protection, interlocks and worst case scenarios

- For example: one turn failure (voltage or phase)

Beam instrumentation specifications

- Measurement of optics, emittances, beam losses, etc...

Safe beam operation (low intensity) & reliability

- Beam tests, measurements (orbits, tunes emittances, optics, noise)
- Collimation, impedance (intensity increase), beam-beam effects (BBLR)

Intensity dependent measurements (emittance blow-up, impedance)

Beam loading with & w/o Rf feedback & orbit control

WORK ORGANISATION

- **Proposition to attack the different points listed in "Main topics of interest for this WG"**
  - **1st inputs by Frank, Rama (and Elias)**
  - **Then we will follow the prioritized list**

- **Try and meet every week**