CLIC issue: *Quadrupole Stabilization*

1. **Short technical description and corresponding category(ies) of issues:**

   Active electromechanical feedback on all MB quadrupoles (approx 4000) and on all 4 FF quadrupoles in both planes (most important in the vertical plane) in order to maintain the ultra low beam emittance and in order to keep the beams in head-on collision.

Feasibility	Performance	Cost
x	x	x

2. **CLIC nominal parameter issues and comparison with state of the art**

   Nominal parameters for Quad stabilization:

   a) Main beam Quadrupole: Stabilize the center of the quadrupole field to an rms value below 1nm in the vertical plane for the frequency range above 1 Hz
   b) FF quadrupole: Stabilize the center of the quadrupole field to an rms value below 0.18 nm in the vertical plane for the frequency range above 4 Hz. This tolerance is the most tight specification, which will be needed if no intra-bunch feedback is available and if the last FF quadrupoles sit on independent support structures. In case of an existing feedback and of a different support system vibrations up to 1nm rms above 4 Hz can be tolerated.

   (Main beam accelerating structures: The Jitter tolerance is for the moment 170 nm; no active feedback foreseen; validity of that assumption to be studied on prototypes.)

   State of the Art:

The first assumption is that by stabilizing the mechanical shell of a quadrupole the magnetic center is stabilized to the same level. This assumption will have to be verified experimentally.

The mechanical stabilization of a simple (= rectangular brick) mechanical object in clear laboratory conditions down to the level needed for the FF magnets has been shown at CERN and elsewhere.

But in none of the above demonstrations the gain factor of the used feedback could be measured, such that an assessment of feasibility of achieving the requested stabilization within an "accelerator noise environment" is not possible presently.
Hence
a) Measurement data of ground motion, environmental noise in an accelerator and noise in the vicinity of a physics detector are missing in order to quantify the excitation spectra
b) The achievable gain factor of an active feedback on real mechanical prototypes has to be measured. The quadrupole designs will have to be optimized for low Q mechnical

resonances. This could possibly exclude laminated magnets, in which case the bandwidth of these magnets will too slow to use them with an additional winding as dipole correctors in the required beam based feedback. Alternatively the quadrupoles will have to be moved for this feedback.

3. **R&D program presently set-up**:

I. campaign of measurements of ground motion and environmental vibrations. Ready in Q3/2009.
II. Design of Main Beam Quad and construction of a prototype. Ready Q2/2010.
III. Installation of this prototype in CTF3 and experimental verification of mechanical stability (Q4/2010)
IV. Stabilization experiments at LAPP for a simple cantilever mockup of a FF magnet.
V. Studies on options for FF magnet technology and options for FF magnet support structures.
VI. Validation of magnet axis stability through a beam experiment at CESRTA
VII. Further developments for stability diagnostics (beyond geophones, i.e. laser interferometers, other)

4. **What performances will realistically be achieved (Target Performances):**

by end 2010

Mechanical stability demonstration and assessment of Main beam Quad in CTF3.
Mechanics optimized for passive damping. Gain of external feedback below 100.
Final Stability will depend on environmental noise.
Meeting specification for MB Quad of 1nm rms above 1 Hz is probable.

by end 2012 (including FP7)

Mechanical stability of a superconducting FF magnet at ATF2.
Mechanics optimized for passive damping. Gain of external feedback below 100.
Final Stability will depend on environmental noise. Severe specifications in terms of noise reduction will result for the physics detector.
Meeting specification of 0.18 nm is challenging, if not unlikely.

5. **Comments on validation of CLIC parameters issues by comparison with Target Performances:**

The stabilization of the FF magnets is very critical. Fortunately the FF (only 4 quads) is a unique system, which can be optimized/replaced during the commissioning phase of the machine. On the contrary the stabilization of the MB quadrupoles is a large capital investment, which must work to specifications from the beginning.

6. **Optional: What additional R&D could be set-up to eventually reach the validation of nominal CLIC parameters (estimation of resources and schedule?)**

   a) A factor 2 roughly speaking can be gained in the vibration tolerance for the FF magnets in case a fast intra-pulse position feedback is available around the IP. The complication of this feedback is:
   - high precision and fast BPM inside the physics detector
   - high bandwidth, low latency radiation hard analog feedback amplifier within physics detector
   - ultra fast feedback kicker within physics detector.
   For a first design of this feedback an electronics engineer with RF experience, vacuum experience and radiation hardness experience will be needed for 6 months to 1 year.

   b) Up to a factor 5 can be gained in vibration tolerance for the FF magnets in case these magnets are commonly supported by an ultra rigid structure or by a structure which can assure that predominately common mode vibrations occur. The MDI WG will have to take up this issue.