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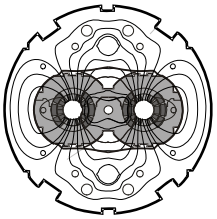

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Functional Requirements

LHC TUNE APPLICATION – HIGH LEVEL REQUIREMENTS

Abstract

The required functionality of the Baseband Tune Measurement application are enumerated and described. This application is foreseen for operational use in the LHC control room.

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0.3	26-April-2007	9	Third draft
0.4	01-June-2007	8	Fourth draft
0.9	16-July-2007	8	Fifth draft
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Table of Contents

1. INTRODUCTION

The betatron tune values of each LHC beam are measured by the Base-Band Tune system (BBQ). Pickups in the LHC tunnel provide beam position information. Front-end electronics based on Direct Diode Detection (3D) [1] produces a baseband signal that is digitized and then presented to a VME based Data Acquisition Board (DAB). The DAB takes the input data and computes Fast Fourier Transforms in real time.

The Tune Application will allow the operator to initiate measurements, compute underlying beam parameters and view the results, and store them. In addition to single tune measurements, the application will be able to initiate a series of measurements to compute the coupling and chromaticity and corresponding response matrices. It should also be able to provide control of these parameters through LSA. To aid in the commissioning of the automatic feedback loops foreseen for LHC operation, the application should be able to provide semi-automated control of these beam parameters including the possibility of fill-to-fill feed-forward. It would also need to perform these functions in the long term during re-commissioning.

Beam excitation for the tune measurement is provided by dedicated tune kickers, or transverse dampers, or dedicated strip-line kickers. Control of the latter two is via the DAB.

The application interface to the hardware is through a FESA front-end. The front-end acquires data from the DAB, and can modify configuration parameters for the tune measurement and beam excitation functions it controls. The FESA class is BQBBQLHC.

There are two complete systems, each consisting of horizontal and vertical pickups for each of the two beams. The first is used to provide traditional information including FFT measurements and the underlying raw data, as well as the measured tune to the control room in response to beam excitation of finite duration. The second is a dedicated Phase Locked Loop (PLL) system. This system measures and tracks the tune generally in response to low level continuous excitation. As variations occur, the PLL system sends tune and coupling measurements to the orbit feedback controller for its use in computing corrections to stabilize the beam. Though the hardware is the same, the DAB firmware and FESA software differ for the PLL and FFT based systems. Data from both these systems will be acquired and displayed by a single application.

1.1 ABOUT THIS DOCUMENT

The functional requirements for the Base-Band Tune Application are listed and described here. It is anticipated that this software application will be used by AB/OP and others in the CERN Control Centre during the commissioning and operation of the LHC. An expert application is also foreseen that will allow detailed diagnostics and control of all system parameters. There is clear scope for synergy between the two applications and use of common functionality should be pushed as far as possible.

First, we present an overview of the application functionality; the objectives, the roles and responsibilities. Then we present the formal requirements.

The priorities of the requirements are listed as either “Critical” or “Expected.” The former means that the application absolutely must have this feature. The latter means that the application should have it, but it will not be necessary in the initial version(s) of the application.

2. APPLICATION OVERVIEW

2.1 OBJECTIVES

The tune application provides the operator interface for measuring and controlling the tune of the LHC beams. Excitation parameters are configured and a measurement initiated. The application acquires FFT and tune data from the front-end, computes tunes, displays the data, and may optionally store and retrieve measurement data. The same application reads and displays data from the PLL system. This application is intended to provide the functionality needed for routine operation of the LHC.

By initiating a series of measurements together with other types of beam modulation it will also be used to measure coupling and chromaticity and other parameters.

Also required is a measurement “daemon” that will continuously acquire the measured tune. This daemon could perform data analysis (such as peak finding). The daemon will re-publish designated data for input into, for example, the logging system.

2.2 ROLES AND RESPONSIBILITIES

The BBQ FESA front-end interfaces with the DAB. The DAB in turn interfaces to the BBQ electronics, the damper or strip-line exciters, and the feedback system. The high level application will exclusively access the system data and parameters via the FESA front-end.

Configuration of the tune kicker will be made through this application but via a separate front-end. There is interaction with the timing system to synchronize firing the tune kicker with data acquisition. Interaction with the timing system may also be required for synchronization of tune measurements with injection and with RF manipulation for chromaticity determination.

Tune, chromaticity and coupling feedback is anticipated. This document does not address the provision of appropriate functionality to Operations for commissioning and control of these systems.

3. FUNCTIONAL REQUIREMENTS

The functionality and the scope, performance and concurrency of the tune application are discussed and presented in this section.

3.1 FUNCTIONALITY

The functionality of the tune application is listed here. It is divided into 4 sections, based on the general capabilities required.

3.1.1 BASIC CONSIDERATIONS

The tune application will be written using the standard LSA framework.

Num	Title	Description	Priority
1.10	Common	The tune application shall be written in the standard LSA architecture.	Critical
1.20	Look and Feel	The tune application shall have the standard LSA look and feel.	Critical
1.30	Communication	The application shall follow standard JAPC/CMW and real-time feedback communication protocols.	Critical
1.40	Security	The application shall use Role-Based Access Control for authentication and authorization to protect against unauthorized use.	Critical

Table 3-1: General requirements.

3.1.2 BASIC MEASUREMENT AND DISPLAY CAPABILITIES

The tune application is responsible for performing tune measurements. Excitation and other parameters are configured, the measurement is initiated, and data are read and displayed. The following modes of operation are possible:

Tune-FFT system:

- Monitoring of spectra with no excitation
- Measurement from single kick excitation by tune-kicker
- Measurement from chirp excitation via transverse damper

Tune-PLL system:

- Measurement from continuous excitation via transverse damper
- Measurement from continuous excitation via strip-line

Num	Title	Description	Priority
2.05	Excitation Control	The tune application shall allow the operator to select the beam excitation method from none/tune kick/damper/strip-line. It should ensure that excitation by the FFT and PLL systems does not conflict.	Critical
2.10	Excitation Control	The tune application shall allow the operator to set parameters associated with the selected excitation method including the strength and duration, and which of the two beams to excite.	Critical
2.15	Front-end, DAB, and PLL Control	The tune application shall allow setting of BBQ front-end, DAB or PLL parameters as needed to identify problems and optimize feedbacks.	Expected

2.20	Data	The tune application shall acquire FFT data from the FFT system, and tune and coupling results from the PLL system, for each beam.	Critical
2.25	Data Display	The tune application shall display the most recently measured values and excitation parameters.	Critical
2.30	Time Display	The tune application shall plot the measured tunes as a function of time.	Critical
2.35	Resonance Line	The tune application shall display the measured tune as a function of time on a resonance line plot.	Expected
2.40	FFT Display	The tune application shall be able to plot single FFT spectra with the tune peak noted.	Critical
2.45	FFT Data Display	The tune application shall plot the FFT spectrum as a function of time as a contour or waterfall plot. It should be possible to select a slice from this plot for detailed display.	Expected
2.50	3-D display	The tune application shall provide a full 3-D display of the FFT versus time.	Expected

Table 3-2: Measurement and Display Capability Requirements.

3.1.3 BEAM PARAMETER CALCULATIONS

The tune application shall be able to calculate the tune, coupling, and chromaticity from FFT data and PLL data acquired from the front-ends.

Num	Title	Description	Priority
3.10	Calculation	The tune application shall be able to calculate the tune from FFT data using possibly modified search parameters.	Critical
3.20	Coupling Calculation	The tune application shall be able to measure the coupling using the closest tune approach method as a supplement to the measurements made by the PLL system.	Expected
3.30	Coupling Calculation	The tune application shall be able to calculate the coupling through cross-term amplitudes for both the FFT and PLL systems.	Expected
3.40	Chromaticity	The tune application shall be able measure the chromaticity by measuring the tune variation in response to RF frequency or phase modulation. LSA functions will exist to configure the RF system for this measurement.	Expected
3.50	BTF	The tune application shall be able to measure the Beam Transfer Function	Expected
3.60	Tune Width	The tune application shall be able to measure the tune with using either the FFT or PLL system.	Expected

Table 3-3: Tune calculation requirements.

3.1.4 DATA ARCHIVING AND RETRIEVAL

It should be possible to store and retrieve FFT and tune data. The tune application should be able to log tune values it has computed, and be able to read files generated by the post-mortem system. It does not itself produce post-mortem files.

A daemon process shall run independently of the application. The daemon shall acquire a configurable list of properties, possibly process the data, and re-publish to high level client such as the logging and fixed display systems.

Num	Title	Description	Priority
4.10	Data Storage	The tune application shall be able to archive blocks of FFT data and resulting beam parameter calculations in a standard format under operator control.	Critical
4.20	History	The tune application shall be able to read and display archived data. It shall be possible to apply different peak search parameters to the data and redisplay it. If started during a store, it should be able to read and display tune/chromaticity/coupling data since the start of the current store.	Critical
4.30	Logging	The tune application is not responsible for writing data to the logging system, this will be done by a separate, persistent daemon process.	Critical
4.40	Post Mortem	The tune application should be able to read and display tune data stored by the Post-Mortem system. It should also be able to read post-mortem buffers directly from the front-end.	Expected

Table 3-4: Data archiving and retrieval requirements.

3.2 SCOPE, PERFORMANCE AND CONCURRENCY

Num	Title	Description	Priority
5.10	Scope	The scope of the tune application shall be limited to the BBQ hardware and beam excitation controllers attached to the BQBBQLHC front-end, and the interaction with the user to manipulate these items. It also interacts with the tune kicker, and with RF system for chromaticity measurement. It shall not be required to interact directly with other application software.	Expected
5.20	Performance	The tune application shall be able to acquire, display, and archive data generated at the “back to back” rate in the front-end for of order 200 seconds early in the ramp to monitor and diagnose effects prior to and during the snap-back. It should be able to acquire and display tune, chromaticity and coupling parameters at a reduced rate (1/10 Hz) for the entire store.	Expected

5.30	Concurrency	More than one instance of the tune application may run simultaneously. But it is acceptable for one of these instances to initiate a reservation on control of the beam excitation hardware. Note the tune kicker may also be operated in an AC-dipole mode under control of a separate application. That application should participate in the reservation process for the tune kicker.	Expected

Table 3-5: Scope, performance and concurrency.

4. REFERENCES

[1] LHC-Project-Report-853 “The Principle and First Results of Betatron Tune Measurement by Direct Diode Detection”.

[2] LHC-B-ES-0009 (EDMS 463763) “On the Measurement of Tunes, Coupling, and Detuning with Momentum and Amplitude in the LHC”.