CONCEPTUAL SPECIFICATION

CONTRUCTION OF A NEW OPTICAL LIGHT EXTRACTION SYSTEM FOR SYNCHROTRON LIGHT DIAGNOSTICS IN LSS4 WITH AN ASSOCIATED OPTICAL LIGHT PATH AND OPTICAL HUTCH

[LHC-BSR]

WP13

Equipment/system description

This specification concerns the contruction of a new light extraction system for synchrotron light diagnostics in HL-LHC. Synchrotron light from the D4 magnet will be extracted with an in-vacuum mirror located between D4 and D3 on each incoming beam to the left and right of Point 4. The extracted light will be sent via an optical light path from the tunnel to the respective UA in LSS4, where it will be used in a purpose built optical hutch

Layout Versions	**LHC sectors concerned**	**CDD Drawings root names (drawing storage):**
Baseline	LSS4	LHC BSR

TRACEABILITY

Project Engineer in charge of the equipment	**WP Leader in charge of the equipment**
E. Bravin	R. Jones

Committee/Verification Role	**Decision**	**Date**
PLC-HLTC/ Performance and technical parameters	Rejected/Accepted	2014-07-08
Configuration-Integration / Configuraration, installation and interface parameters	Rejected/Accepted	20YY-MM-DD
TC / Cost and schedule	Rejected/Accepted	20YY-MM-DD
Final decision by PL	Rejected/Accepted/Accepted pending (integration studies, …)	20YY-MM-DD

Distribution: HL-TC

Rev. No.	***Date***	***Description of Changes*** *(major changes only, minor changes in EDMS)*
1.0	2014-06-06	Creation Date

1 CONCEPTUAL DESCRIPTION

1.1 Scope

This specification concerns the contruction of a new light extraction system for synchrotron light diagnostics in HL-LHC. Synchrotron light from the D4 magnet will be extracted with an in-vacuum mirror located between D4 and D3 on each incoming beam to the left and right of Point 4. The extracted light will be sent via an optical light path from the tunnel to the respective UA in LSS4, where it will be used in a purpose built optical hutch.

1.2 Benefit or objective for the HL-LHC machine performance

The optical table for the existing synchrotron light telescope is full to capacity with 5 optical lines used for different diagnostics. The additional HL-LHC requirements to measure beam halo and intra-bunch position variations using synchrotron light necessitates the use of an additional synchrotron light source. This can be achieved by using the light emitted by the D4 magnet on the incoming beam left and right of Point 4.

The special optical detection equipment used for these new measurements, such as fast cameras, high dynamic range cameras and streak cameras, are highly expensive and do not resist radiation. In order to be able to use them for beam diagnosics in HL-LHC they must be located in low radiation areas. A light path is therefore required between the extraction mirror in the tunnel and the accompanying optical hutch, to be built in both UA43 and UA47, where the optics and camera are located. These devices would be used for bunch to bunch diagnostics (fast camera), halo diagnostics (high dynamic range camera) and intra-bunch crab cavity diagnostics (streak camera). The understanding gained from such instrumentation could be crucial for a good understanding of HL-LHC operation and subsequent optimization.

1.3 Equipment performance objectives

The system should be able to extract the synchrotron light emitted by the D4 and transport this light with as little distortion as possible via an optical light path to a new optical hutch located in UA43/47.

TECHNICAL ANNEXES

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Assumptions

It is assumed that these measurements are only required above 2TeV, where the edge or central radiation from the D4 is sufficiently high. It is also assumed that it is possible to integrate a light extraction system in this region.

2.2 Equipment Technical parameters

The extraction mirror will need to be located some 20m from the D4 magnet towards D3 on the incoming beam on each side of Point 4. An enlarged vacuum chamber will be required in this region to accommodate both the light and particle beam.

The optical path will be of at least 100mm diameter and will require remotely controlled steering mirrors at each corner junction. A reservation for a circular volume with 200mm diameter cross-section for this path should therefore be integrated into the layout. The optical path will need to be vacuum tight as it shall be kept under a moderate vacuum to limit abberations.

The length of the path from the extraction mirror to the hutch should be kept as short as possible, which may require additional holes to be drilled between the tunnel and the UA. This also implies that the optical hutch is located in a position in the UA directly opposite the extraction mirror, which may require the relocation of racks in that area.

Table 1: Equipment parameters

Characteristics	Units	Value
Optical path diameter	Mm	100 (minimum)
Optical Hutch surface area	m^2	10

2.3 Operational parameters and conditions

The extraction mirror must be designed such as to present as low an impedance as possible to the particle beam. It must also be capable of withstanding any induced RF heating. The location of the mirror edge with respect to the beam will depend on its distance from the D4 and the allowed aperture in that location. Once aligned the mirror will be kept in a fixed position.

The optical path will need to be kept under a moderate vacuum to limit abberations. The steering mirrors in the optical path will be remotely controllable for alignment during operation.

2.4 Technical and Installation services required

Table 2: Technical services

Domain	Requirement
Electricity & Power	Light Path • Local control cabling for each of the optical path steering mirrors. Optical Hutches • Standard 220V outlets • Equipment Rack • Ethernet • Fibre-optic cabling
Civil Engineering	• Possible need for additional holes between RA43/47 and UA43/47 • Construction of a light tight optical hutch of dimensions 2.5m x 4m in both UA43 and UA47
Vacuum	• The optical light extraction path will form an integral part of the vacuum system and will require modifications to the vacuum layout in this area. • An enlarged vacuum chamber will need to be constructed for one beam pipe between D4 and the new extraction mirror tank located some 20m downstream. • The optical path between the RA and UA will need to be maintained under a moderate vacuum.

Table 3: Installation services

Domain	Requirement
Alignment	The extraction mirror tank will need alignment to the beam axis.

2.5 Reliability, availability, maintainability

This system is foreseen for diagnostics only and is therefore not critical in terms of reliability and availability.

2.6 Radiation resistance

The materials for the extraction mirror and the motors used to control the steering mirrors will need to be able to resist a moderate level of radiation.

2.7 List of units to be installed and spares policy

- Extraction mirror tank 20m from D4 towards D3 for B1 in 4.L and B2 in 4.R
- Optical light path from new extraction tank for B1 to UA43
- Optical light path from new extraction tank for B2 to UA47
- Optical hutch in UA43 and UA47

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

The longitudinal distance of the extraction mirror to D4 will depend on the separation required between the optical beam and the particle beam, but is likely to be in the 20-30m range. The longitudinal distance of the optical hutch in the parallel UA to the extraction mirror needs to be kept as short as possible.

3.2 Volume

The optical light path will represent a volume equal to a cylinder of 200mm diameter long its entire length. The optical hutch will have a volume of 25m^3 assuming a 2.5m high roof.

3.3 Installation/Dismantling

Installation of the extraction mirror tanks and associated enlarged vacuum chamber sections will need to be coordinated with the VSC Group.

4 PRELIMINARY INTERFACE PARAMETERS

4.1 Interfaces with equipment

Interfaces with the vacuum systems in LSS4.

5 COST & SCHEDULE

5.1 Cost evaluation

Baseline APT (budget code : 64066 – HL-LHC Synchrotron Light & Halo Diagnostics).

5.2 Approximated Schedule

Simplified schedule by years

Table 4: Simplified Schedule

Phase	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Engineering specification												
Design & Integration												
Procurement												
Installation – Commissioning												

5.3 Schedule and cost dependencies

No particular constraints to be noted.

6 TECHNICAL REFERENCE DOCUMENTS

- To be provided

7 APPROVAL PROCESS COMMENTS FOR VERSION X.0 OF THE CONCEPTUAL SPECIFICATION

7.1 PLC-HLTC / Performance and technical parameters Verification

Comments or references to approval notes. In case of rejection detailed reasoning

7.2 Configuration-Integration / Configuraration, installation and interface parameters Verification

Comments or references to approval notes. In case of rejection detailed reasoning

7.3 TC / Cost and schedule Verification

Comments or references to approval notes. In case of rejection detailed reasoning

7.4 Final decision by PL

Comments or references to approval notes. In case of rejection detailed reasoning