WP 13 : Beam Diagnostics Conceptual Specifications

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Introduction

WP 13 Tasks

- Cryogenic BLMs & Radiation Hard Electronics
  - Cryogenic BLMs ✓
  - Radiation hard electronics
- Fast WireScanners ✓
- Insertion Region BPMs
  - Cold directional couplers ✓
  - Tungsten shielded cold directional couplers ✓
  - Warm directional couplers ✓
  - High precision electronics for insertion region BPMs
- Luminosity Monitors
- Diagnostics for Crab Cavities
- Upgrade to Synchrotron Light Monitors
  - Upgrade to existing monitor ✓
  - New light source ✓
  - Halo diagnostics
- Beam Gas Vertex Detector
  - Final Implementation ✓
- Long-Range Beam-Beam Compensator
  - Prototype
  - Final Implementation

Cryogenic BLMs

EDMS NO.	REV.	VALIDITY
1366583	0.2	DRAFT

REFERENCE : LHC-BLMC-ES-0001

- HL-LHC Cryogenic BLMs (BLMC) – Baseline (64061)
  - For present BLMs additional signal from accidental losses masked by collision debris
  - Proposal to put radiation detectors inside the coldmass of triplet magnets
  - Dose measured then correspond to dose deposited in the coils
- Performance Objectives
  - Ability to detect secondary particle showers
  - Work in cryogenic environment, high magnetic fields (4T) & withstand up to 20 MGy
- Assumptions
  - Detectors based on CVD diamond or p^+-n-n^+ silicon wafers (detector area ~25mm^2)
  - Present a negligible heat load for the cryogenic system of the inner triplet magnets
  - Longitudinal layout to be determined by FLUKA/GEANT studies
- Location
  - Up to 6 detectors installed inside the cold mass of each triplet quadrupole
- Technical Parameters
  - 1 semi-rigid coaxial cable per detector provides HV (up to 1000V) & extracts signal
- Installation
  - Monitors & cables mounted during assembly of the magnet cold mass in the cryostat
  - Baseline procurement of 100 detectors (96 installed & 4 spares).
  - Equipping 11T dipole & all the spare triplet magnet assemblies requires total of 150 detectors
- Reliability & Availability
  - If monitors break external BLM system still provides protection against damage (not quench)

Fast Wirescanners

EDMS NO.	REV.	VALIDITY
1371094	0.2	DRAFT

REFERENCE : LHC-BWSF-ES-0001

- HL-LHC Fast Wirescanners (BWSF) – Baseline (64062)
  - Installation of fast wirescanners capable of scanning at a speed of up to $20ms^{-1}$
- Performance Objectives
  - Currently system has max speed of 1 ms^{-1}
  - Limits total intensity scanned at injection to $\sim 2.7\times10^{13}$ (~200 nominal bunches).
  - $20ms^{-1}$ allows average beam size measurement with full injected physics beam
  - Goals:
    - Accuracy of 5 μm on beam width, i.e. error of 5% for nominal emittance beams
    - Large dynamic range acquisition system to improve reliability in operation
    - Increase MTBF compared to existing system (no bellows)
- Assumptions
  - Scanners based on prototype currently being tested in the SPS
  - Acquisition system based on diamond detector located downstream
  - Design modifications adequate for machine impedance & RF heating
- Location
  - Beam 1 : 2 H & 2 V scanners located next to the existing scanners in 5R4
  - Beam 2 : 2 H & 2 V scanners located next to the existing scanners in 5L4
- Technical Parameters & Installation
  - Rotative scanner of length 500mm adapted to 80mm warm beam pipe aperture

Tungsten Shielded Cryogenic BPMs

EDMS NO.	REV.	VALIDITY
1371097	0.2	DRAFT

REFERENCE : LHC-BPMSQ-ES-0002

- HL-LHC Tungsten Shielded Cryogenic BPMs (BPMSQT) – Baseline (64063)
  - Measure position of both beams in both planes
  - Essential for maintaining stable orbit at IP
  - Could be used for continuous luminosity optimisation
- Performance Objectives
  - Beam position resolution for each beam of 1μm
  - Fill to fill reproducibility of 10μm
- Assumptions
  - Stripline BPM, tungsten shielding required, 45° stripline orientation & one design fits all
- Location
  - In interconnect between Q2a & Q2b, Q2b and Q3a, Q3a and CP
- Technical Parameters
  - Aperture adapted to beam screen
  - Minimum length 220mm
- Constraints
  - Longitudinal location from IP (1.87 + N x 3.743)m where N = integer (where possible)
- Installation
  - 12 installed + 3 spares
  - 8 cryogenic coaxial cables per BPM with feedthrough location on cryostat to be determined
  - Additional Rack for electronics in UA/UJ each side of LSS with fibre connections to surface

Cryogenic BPMs

EDMS NO.	REV.	VALIDITY
1371095	0.2	DRAFT

REFERENCE : LHC-BPMSQ-ES-0001

- HL-LHC Cryogenic BPMs (BPMSQ) – Baseline (64063)
  - Measure position of both beams in both planes
  - Essential for maintaining stable orbit at IP
  - Could be used for continuous luminosity optimisation
- Performance Objectives
  - Beam position resolution for each beam of 1μm
  - Fill to fill reproducibility of 10μm
- Assumptions
  - Stripline BPMs, no tungsten shielding required, 90° stripline orientation & one design fits all
- Location
  - In front of the Q2a
  - Before and after the D1 magnet
- Technical Parameters
  - Aperture adapted to beam screen
  - Minimum length 220mm
- Constraints
  - Longitudinal location from IP (1.87 + N x 3.743)m where N = integer (where possible)
- Installation
  - 12 installed + 3 spares
  - 8 cryogenic coaxial cables per BPM with feedthrough location on cryostat to be determined

Warm BPMs

EDMS NO.	REV.	VALIDITY
1371096	0.0	DRAFT

REFERENCE : LHC-BPMSQW-ES-0003

- HL-LHC Warm BPMs (BPMSQW) – Baseline (64063)
  - Measure position of both beams in both planes
  - Essential for maintaining stable orbit at IP
  - Could be used for continuous luminosity optimisation
- Performance Objectives
  - Beam position resolution for each beam of 1μm
  - Fill to fill reproducibility of 10μm
- Assumptions
  - Stripline BPMs, no tungsten shielding required, 90° stripline orientation & one design fits all
- Location
  - In front of the Q1a
- Technical Parameters
  - Aperture adapted to beam screen
  - Minimum length 285mm
- Constraints
  - Longitudinal location from IP (1.87 + N x 3.743)m where N = integer (where possible)
- Installation
  - 4 installed + 2 spares
  - 8 semi-rigid coaxial cables per BPM connecting to 8 standard coaxial cables

Upgrade of Existing Synchrotron Light Monitors

EDMS NO.	REV.	VALIDITY
1371100	0.2	DRAFT

REFERENCE : LHC-BSR-ES-0001

- HL-LHC Synchrotron Light Monitor (BSR) – Baseline (64066)
  - Construction of an evacuated optical light path
    - from BSRTM.5L4.B2 to UA43
    - from BSRTM.5R4.B1 to UA47
  - Construction of an associated optical hutch in UA43 and UA47
- Performance Objectives
  - Installation of highly expensive & non radiation resistant optical detection equipment
    - Fast cameras for bunch to bunch diagnostics
    - High dynamic range cameras for halo diagnostics
    - Streak cameras for intra-bunch diagnostics
  - Must be located in a low radiation area
  - Easier set-up and alignment
- Technical & Operational Parameters
  - Optical light path consisting of:
    - 100mm diameter evacuated pipe
    - Remotely controlled steering mirrors
    - Distance as short as possible between extraction mirror and optical hutch
  - Optical hutch of at least $10m^2$ with related services
  - Possible need for additional holes between RA43/47 and UA43/47

New Light Extraction System for Synchrotron Light Diagnostics

- HL-LHC Synchrotron Light Monitor (BSR) – Baseline (64066)
  - Construction of a new light extraction system for synchrotron light diagnostics in LSS4
  - Extract light from D4 with in-vacuum mirror located between D4 and D3 on each incoming beam
  - Extracted light sent via optical light path from tunnel to new optical hutch in UA
- Performance Objectives
  - Optical table for existing synchrotron light telescope is full to capacity
    - Need for additional synchrotron light source
  - Fulfil HL-LHC requirements: beam halo, intra-bunch measurements & interlocked abort gap
- Assumptions
  - Measurements only required above 2TeV using edge or central radiation from the D4
  - The possibility to integrate a light extraction system in this region
- Technical & Operational Parameters
  - Low impedance extraction mirror design to minimise RF heating
  - Optical light path consisting of:
    - 100mm diameter evacuated pipe
    - Remotely controlled steering mirrors
    - Distance as short as possible between extraction mirror and optical hutch
  - Optical hutch of at least 10m^2 with related services
  - Possible need for additional holes between RA43/47 and UA43/47

Beam Gas Vertex Detector

EDMS NO.	REV.	VALIDITY
1371103	0.2	DRAFT

REFERENCE : LHC-BGV-ES-0001

- HL-LHC Beam Gas Vertex Detector (BGV) – Baseline (64067)
  - One BGV detector per beam for non-invasive beam size measurements
  - Foreseen for installation between Q6 and Q7 in LSS4 left and right
  - Space reservation : LHC-BGV-EC-0001 (EDMS 1282994)

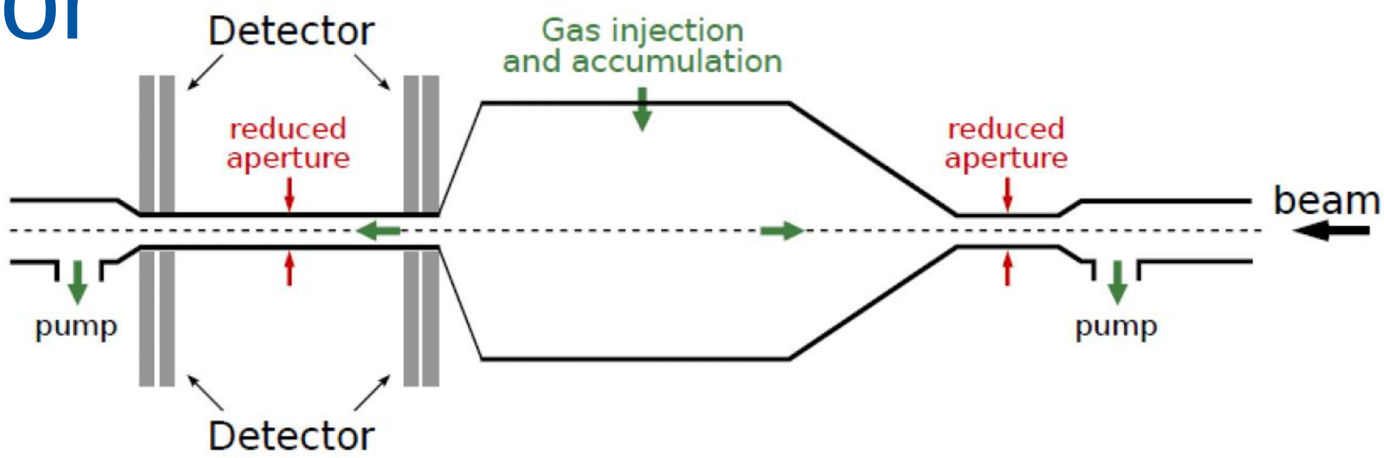
- Performance Objectives
  - Bunch width measurements with a 5 % resolution within 1 minute
  - Beam width measurements with an absolute accuracy of 2 % within 1 minute
  - Would allow meaningful measurements during the energy ramp
  - Could measure beam halo, longitudinal density & longitudinal beam profile

- Assumptions
  - Based on prototype currently being installed
    - Optimised design for HL-LHC
    - New detectors & acquisition electronics
  - Final HL-LHC optics allows installation within reserved zone in LSS4

Beam Gas Vertex Detector

EDMS NO.	REV.	VALIDITY
1371103	0.2	DRAFT

REFERENCE : LHC-BGV-ES-0001



- Technical & Operational Parameters
  - Operates with neon gas injection at pressure of 6×10^{-8} mbar
  - Pressure outside tank area should remain below 6×10^{-9} mbar
  - Aperture at detector should be as small as possible to improve accuracy
  - Total length ~8m per BGV station
  - ~100 cables and 2 additional racks per BGV station

- Further Assumptions
  - Design adequate for machine impedance & RF heating
  - Gas pressure not severely detrimental to radiation dose in the neighbouring arc sections

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