HL-LHC cryogenic BPMs
Status and objectives for 2020

D. Gudkov, M. Krupa, G. Schneider

WP13 meeting - 27/01/2020
HL-LHC BPMs

<table>
<thead>
<tr>
<th></th>
<th>BPMQSTZA</th>
<th>BPMQSTZB</th>
<th>BPMQSWZA/B</th>
<th>BPMQBCZA/B</th>
<th>TOTAL</th>
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<tr>
<td>Series</td>
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<td>Prototypes</td>
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# HL-LHC BPMs (Q6-Q6)

<table>
<thead>
<tr>
<th>Code</th>
<th>Location</th>
<th>Distance from IP [m]</th>
<th>Aperture [mm]</th>
<th>Warm or cold</th>
<th>Stripline or button</th>
<th>Tungsten shielding</th>
<th>Electrode orientation</th>
<th>Parasitic bunch crossing timing [ns]</th>
<th>New or existing</th>
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</thead>
<tbody>
<tr>
<td>BPMQSTZA</td>
<td>Q1 (IP side)</td>
<td>21.853</td>
<td>Octagonal 101.7 / 99.7</td>
<td>Cold</td>
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<td>0° / 90°</td>
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<td>Button</td>
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<td>Existing (need new spares)</td>
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<td>Q4 (arc side)</td>
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<td>Button</td>
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<tr>
<td>BPMYA</td>
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<td>Button</td>
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<td>Existing</td>
</tr>
</tbody>
</table>
Main areas of focus in 2019

- Fine details of mechanical design of all BPMs
- "Pre-prototype" manufacturing with EN/MME
- Integration of BPMs and cables inside the cryostats
- Moving D2 BPMs from the warm-side to inside the cryostat
- Responsibility-sharing memorandum and BINP collaboration
- Descoping of the warm stripline BPM and the custom alignment platform
- Tuning of the stripline feedthrough electromagnetic design
- Thermomechanical and impedance simulations with new data
BPMQSTZA – Q1 cryogenic stripline

- Design almost complete:
  - Minor dimensional corrections ongoing (e.g. compensation of Cu coating thickness)
  - Cooling pipe routing – to be verified when CWT integration is ready
  - Cable routing – only preliminary, as above
BPMQSTZB – Q2-D1 cryogenic striplines

- Design almost complete:
  - Minor dimensional corrections ongoing
  - Cable routing finished, cryostat flange positioned at the bottom
  - Simplification of tungsten absorber thermalisation under consideration – MME simulations requested

- All cables equal length (1 m) and installable
Stripline feedthrough and electrode

- **Feedthrough**
  - Late design modification - screw from M5 to M6, flange dimensions change
  - Prototype flanges made and tested with TE/VSC
  - Electromagnetic design optimised for the companies

- **Electrode**
  - Prototype made with EN/MME modifications ongoing to simplify machining

- **Identification**
  - Each feedthrough and electrode with asset number
  - Each BPM port engraved with label for orientation (A/B/C/D)
Heat load on cryogenic striplines

- Electron cloud:
  - BPM body: 5.5 W
  - Striplines: 200 mW each

- Collision debris:
  - Tungsten: 150 mW each

- Electric signals:
  - Cables: 10 mW each

- MME simulations completed in Nov 2019

- ABP simulations ongoing

D1 BPM: 73.7 m
Stripline coating layers

- Gold: thin strike
- Copper: 100 um
- Amorphous carbon: 100’s nm
- Need of aC coating of the electrodes and coaxial ports discussed with ABP:
  - Electrodes – to be coated
  - Ports – could be left uncoated
- Tooling designed for Au, Cu, aC coating: in production
BPMQBCZA/B – D2 cryogenic buttons

- Mature design:
  - Quasi-symmetric body
  - Integrated into D2 QQS, compatible with welding and cutting machines
  - Eccentric copper inserts – inter-beam distance change at the BPM
- Cable routing finished
- Detailed design of an active cooling ongoing

All cables equal length (1.3 m) and installable
**Button electrode**

- Electromagnetic design:
  - Based on the LHC button
  - Assumes a SiO2 vacuum seal
  - Fused silica ring used to support the metal electrode
  - Compatible with a standard DN40CF flange
  - Detailed design to be done when going into procurement

![](chart.png)
Button BPM coating

- Work on tooling not yet started – waiting for the final body design
- Same coating strategy as for the stripline BPMs:
  - Flash of gold
  - 100 um copper layer
  - 100’s nm amorphous carbon
- Button electrodes coated with amorphous carbon
- Coating after assembly or on individual parts to be discussed
BPTX + APWL

- HL-LHC baseline BPTX installed close to Q4, on the IP side
- LHC BPTX has 60 mm aperture but > 80 mm needed for HL-LHC
- Option to reuse existing spare BPMWI (80 mm)
  - 6 available but not-fully conform (4 w/o Cu, 2 bad surface)
- Replacing APWL’s (RF pickups) with BPM-like monitors an option
Installation and alignment

- Memorandum “Responsibility share between BE-BI, EN-SMM TE-VSC and TE-MSC for the assembly of HL-LHC Inner Triplet and D2 Cryogenic Beam Position Monitors” signed and released – everything seems to be clear and agreed upon
- “Alignment and mechanical tolerances for HL-LHC” specification recently discussed at the WGA – BPM specific details to be closely followed up with R. de Maria
- Design of tooling for installation and alignment not yet started – needs progress in 2020
- We will require mock-up interconnects / QQS to test the installation procedure – schedules need to be discussed with the appropriate teams soon as high priority
Project lifecycle

- Dmitry prepared project lifecycle with detailed milestones

0. Manufacturing study
1. BPM design
2. CERN prototyping
3. BINP prototyping
4. BINP series
5. Assembly and validation
6. Installation
BPM delivery schedule

- BPM installation now as a step in magnet production
  - Linked to WP2 schedule – we need to be updated
  - Almost all BPMs ready before LS3 starts
Specifications

- Final functional specification and engineering specification for the three BPM types being written
- Engineering specification is required before we start series production at BINP
  - ~ 30% ready – more details from Dmitry
  - Very detailed document
- Aiming to release both documents this year, ideally should be ready by June
- Following HL-LHC procedures
Budget and EVM

- Excel table updated as we learn the real costs
- No major changes in the total cost so far
- Detailed BOM for each BPM type under preparation – a major excel table update will follow
- By when do we need to prepare the exact split CERN / BINP?
- Is it worth creating additional budget codes for easier follow-up?
- How do we address production at BINP in EVM?
Possible budget code split

<table>
<thead>
<tr>
<th>Raw materials</th>
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<tbody>
<tr>
<td>Stainless steel</td>
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<thead>
<tr>
<th>Mechanics</th>
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<tr>
<td>Prototyping</td>
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<td>Stripline electrodes</td>
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<th>RF components</th>
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<tr>
<td>Stripline feedthroughs</td>
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<tr>
<th>Quality assurance, control and installation</th>
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<tbody>
<tr>
<td>Quality management</td>
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M. Krupa / Cryo BPMs status and plans / 27/01/2020 / WP13 meeting
Procurement overview (1)

- **BPM feedthroughs**
  - 370 units needed (prototypes, series, spares)
  - 3 bids received on 20 February 2019 (from 9 invited suppliers)
  - Significant differences among the offers
  - Procurement going on slowly – change of design, simulations of manufacture’s design, bad collimator experience...

- **Cryostat flanged feedthroughs**
  - ~ 60 units needed (prototypes, series, spares)
  - Tendering currently on hold
  - Strategy do be defined based on BPM experience
Procurement overview (2)

- **Cryostat cables**
  - Very limited number of reliable suppliers
  - ~ 300 SiO2 RF cables needed (proto, series, spares)
  - Tendering strategy to be re-discussed with HL PO
  - Technical specification by mid 2020 – no Q1 cable routing yet
  - J. Daricou will be kept in the loop

- **Button electrodes**
  - 40-50 needed (prototypes, series, spares)
  - Electromagnetic design ongoing
  - Button BPM workshop in May 2019 at Diamond (UK)
    - Feedback from other facilities
    - Feedback from suppliers
    - Price enquiry late 2020
Procurement overview (3)

- Raw material for BPM bodies
  - ~ 40 blocks of 316LN needed (prototype, series, spares)
  - ~ 80 “blocks” of OFE Cu needed (prototype, series, spares) – exact dimensions and types under discussion
  - 316LN for prototypes already ordered

- Machined tungsten absorbers
  - 88 units needed
  - Tendering via VSC beam screen contract
  - Pre-series (10 units) delivery early 2020
  - Series delivery late 2020

- Cooling tubes
  - 112 tubes + connections needed (series, spares)
  - To be specified and purchased soon
Goals for 2020

- Release of manufacturing drawings for the three BPM types
- Release of functional and technical specifications for the three BPM types
- Complete documentation for manufacturing at BINP
- Technical / engineering visit to BINP
- Final BPM Design Review around June – Gerhard’s presentation
- Manufacturing Readiness Review around September
- Qualification of stripline feedthrough prototypes
- Price enquiry for cryogenic cables and button electrodes
Thank you for your attention