HL-LHC IT String Day IV

FRAS - Status / Lessons learned / Upcoming activities

(WP19 / collaboration BE-GM, BE-CEM, BE-ICS)

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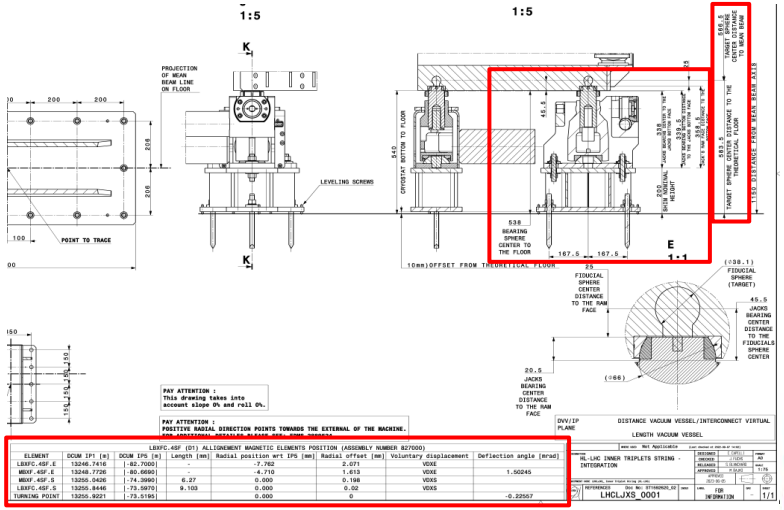
Objectives

- Installation drawing and pre-alignment – Lessons learned
- Infrastructure progress for FRAS
- WPS cable validation – Status and lessons learned
- Quality assurance for FRAS
- Commissioning and Individual System Test
- Upcoming activities

Installation drawing and pre-alignment

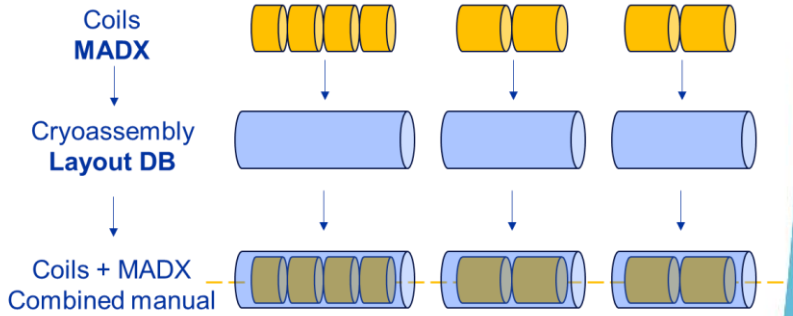
Installation drawing

- **Drawing to be a template for HL-LHC**
- First discussion: Jan 2023
  Release: Jun 2023
  Still undergoing some changes
  (jacks orientation information to be included to ease installation phase)
- All points to be traced should be on one drawing
- **Transition WARM/COLD - decision not to apply for IT String**
  A strategy for drawings and values storage must be defined for LS3
- Installation drawing EDMS:
  https://edms.cern.ch/document/2894368
- Thanks to IT feedback a strategy for general installation drawings for equipment on the beam is under development on a test case of the collimators between TAXN and D2:
  https://edms.cern.ch/document/3137037



MAD-X

- **BE-GM traces on the floor beam points of the cryo-assembly**
- **No cryo-assembly in MAD-X, only coils**
- **Cryo-assemblies coming from Layout DB**
- **What's the solution?**
  For IT String - Layout DB and MADX information combined manually
  For the future – Combined information provided by Layout DB under discussion – E2A Engineering to Alignment project



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 "BPMQSTZW.4L5.B1"  "MONITOR"         5.34600000000137 0 0 -1668.2054814 2449.119672 2653.23681671518 3.09038530888022 0 0 0 0           0
 "DRIFT_1"          "DRIFT"           6.61399999999776 1.26759999999635 0 -1668.14057890807 2449.119672 2651.97047882176 3.09038530888022 0 0 0
 "VMBXFB.4L5"       "MARKER"          6.61399999999776 0 0 -1668.14057890807 2449.119672 2651.97047882176 3.09038530888022 0 0 0 0           0
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 "DRIFT_3"          "DRIFT"           7.17400000000271 0.0100000000020373 0 -1668.11191532577 2449.119672 2651.41121287514 3.09038530888022 0 0
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Jacks tracing and installation

- **BE-GM traced:**
  Pillars, Beamline + parallel line, Beam pts, Jacks, Anchors, DFX/DCM and Jumpers
- **Manual tracing**
  note for LS3: 40m/day (considering the abovementioned)
- **Survey is looking into robotic solutions to improve efficiency**

- **Jack installation and position control**
  Q1 – Q2a – D1 done
- **LS3 prediction** – 1 week / LSS side (only for position control)
- **Installation workflow well defined and implemented with EN-ACE, gathering feedback for LS3**
  https://edms.cern.ch/document/2757081
- **The jack heads should be adjusted and fixed in the middle of their range before the installation and control – implemented at the manufacturer's level?**

Full Remote Alignment System (FRAS)

Infrastructure progress on IT String test

- **GYPOS Racks**

Equipment in progress on GYPOS03=SM18, 04 and 05. (Sensor racks)

- **GYPOP patch racks**

Equipped with HLS heating and Motors patch. Waiting for their installation on Magnet Line to be equipped with OF.

- **Optical Fibre pulling**

Updated with EN/EL/FO. Postponed after magnet installation. To be rediscussed for HL-LHC planning

- **Pillars tracing**

Updated position traced on Q1 side. D1 side to be done. 0.5 day per side

- **Water network installation**

Main water pipe installed and validated. 3 days for installation of supports and main pipe.

WPS cable checks on IT String test – Lessons learned

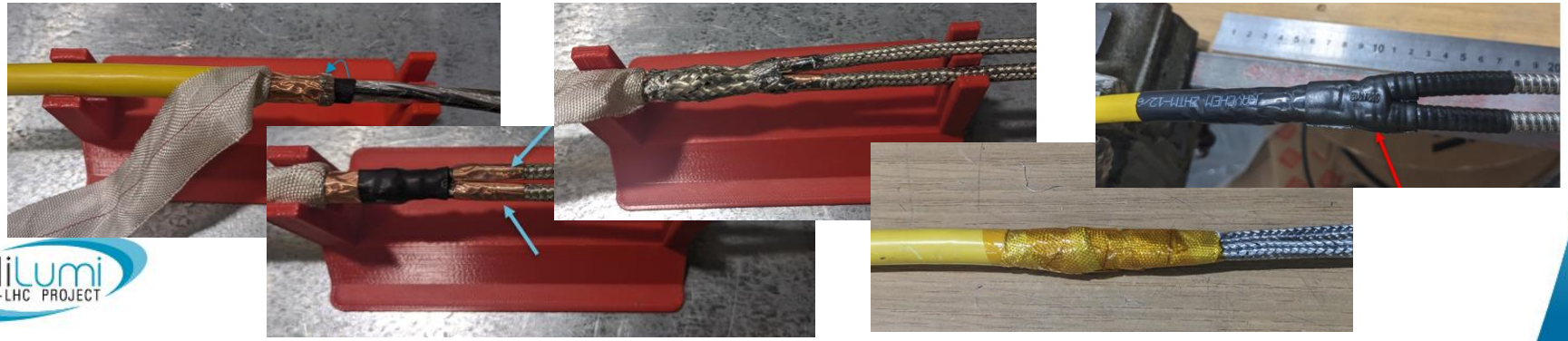
Objectives:

- Cable connection for IT String.
- Collaboration between BE/GM and EN/EL.
- EN/EL gathers experience for HL. BE/GM gets some feedback on the procedure.

Challenges:

- MBB4 cable connection manufacturing done during last EN/EL Campaign 2024
- Very specific cable termination – requirement to split cable in two, adding armouring and additional shielding.
- Procedure documented in EDMS 2896721 (version 7, following various iterations and feedback)

Excerpts from manufacturing procedure



WPS cables validation bench

General principles

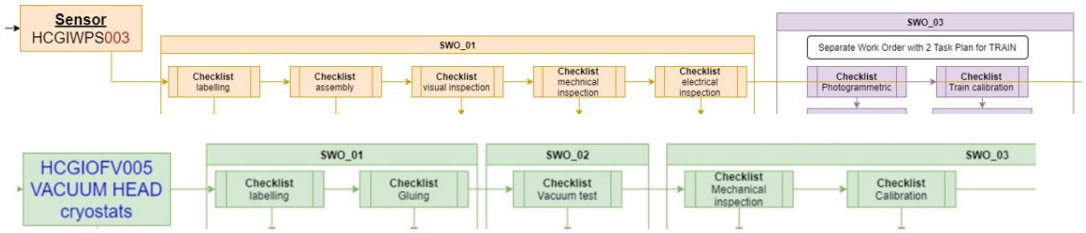
- Cable capacitance must remain constant during movement. Internal shielding must be fully secured to prevent capacitance changes.
- The WPS Validation bench uses a reference sensor and 3d printed elements to limit minimum bend radius.
- A series of tests are performed to ensure the cables are wired as intended and are mechanically robust:
  - Movement of wire inside reference sensor to known positions
  - Mechanical handling of the cable whilst acquiring continuously: Bending /compression / shaking. If the internal structure moves, the bench will detect a change in the readings.
  - 2 days for check of 37 MBB4 cables

Rack side

Sensor side

Quality assurance on IT String test

Assets and sensors going through dedicated workflow for assembly, checks before installation and calibration



Custom fields on magnets under implementation

D11 Non Connection Side		
D11NConnX	0.000102	m
D11NConnY	4.905051	m
D11NConnZ	-0.245668	m
Bellow Connection Side		
Beam Screen Extremity CS ID	MGTAP01-Conn_Flange-V	m
Beam Screen Extremity CS X	0.0001	m
Beam Screen Extremity CS Y	-5.605625	m
Beam Screen Extremity CS Z	-0.0003	m
Bellow Non Connection Side		
Beam Screen Extremity NCS ID	MGTAP01-NConn_Flange-V	m
Beam Screen Extremity NCS X	-0.0002	
Beam Screen Extremity NCS Y	5.605625	m
Beam Screen Extremity NCS Z	0.0004	m
Target FSI NConn1		
IDTNConn1	MGTAP01-TFSI_NConn_1	
XTNConn1	-0.322959	m
YTNConn1	3.343124	m
ZTNConn1	-0.143588	m

Functional positions defined in Layout and published in EAM

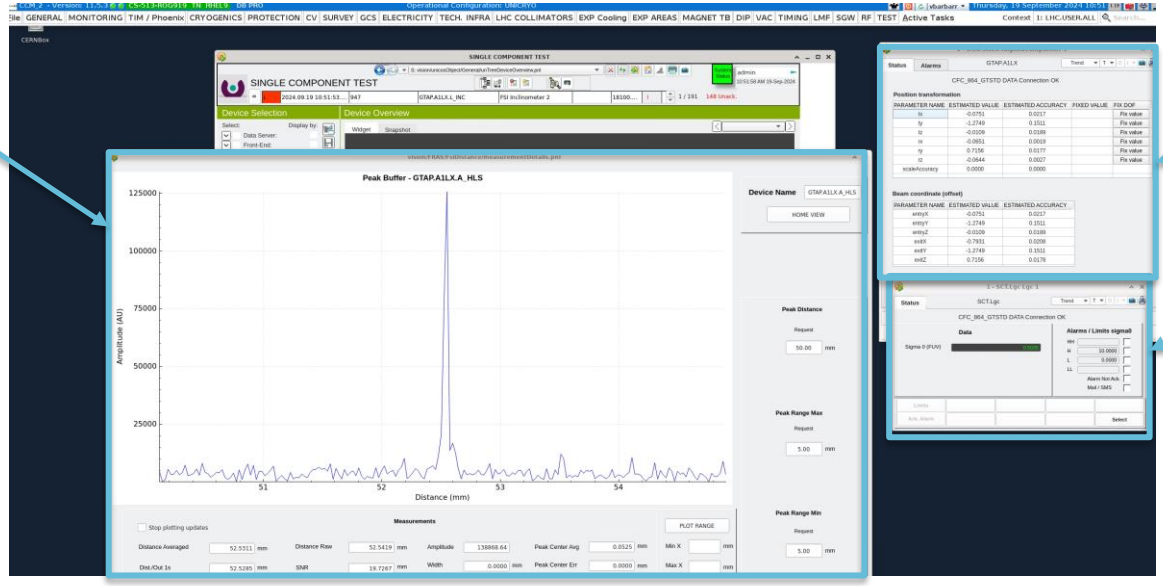
- LQXFE.1SF - *Single Aperture (150 mm) Inner Triplet Assembly Q1 in 1R and 5L*
  - LMQXFA.1SF - *Cold Mass Assembly for Single Aperture (150mm) with MQXFA Quadrupole*
  - MQXFA.A1SF - *150mm Single Aperture Nb3Sn Magnets (Q1,Q3)*
  - MQXFA.B1SF - *150mm Single Aperture Nb3Sn Magnets (Q1,Q3)*
  - VSMSH.1SF.X - *Vacuum Screen - Beam Screen Mask - Series - Tungsten Shielding 16mm*
  - GIOFDM.A1SF.E - *FSI air distance measurement on Magnet*
  - GIOFVM.A1SF.A - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.B - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.C - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.D - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.F - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.G - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.H - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.K - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.L - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.N - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.P - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GIOFVM.A1SF.Q - *FSI Vacuum and cryogenic optical instruments on magnets*
  - GISIM.A1SF.B - *Support for Inclinometer on Magnet*
  - GISIM.A1SF.N - *Support for Inclinometer on Magnet*
  - GISRM.A1SF.L - *Roll Angle Sensor Support, always situated where the double jacks are situated*
  - GISSXM.A1SF.A - *Sensor Support interface on Magnet*
  - GISSXM.A1SF.D - *Sensor Support interface on Magnet*
  - GISSXM.A1SF.F - *Sensor Support interface on Magnet*
  - GISSXM.A1SF.L - *Sensor Support interface on Magnet*
  - GISSXM.A1SF.Q - *Sensor Support interface on Magnet*

HiLumi HL-LHC PROJECT

Computation and Supervision on IT String test

Configuration tool tested on SCT. In progress for automatic generation on IT String

FSI channel supervision



Aligned component parameters

Computation output FUV

Commissioning FRAS on IT String test

1. Visual verification - Basic checks

- Sensor installed correctly
- Cables connected
- Valves open

➢ **Managed with work order at installation phase.**

Systematic for each sensor

Sample control for each Functional position

2. Verification of connections and services after connecting to infrastructure

- Software communication
- Mapping channel/sensor

➢ **Managed with supervision tool (WINCC OA)**

3. Verification of individual equipment interfaced with infrastructure.

- Check data sent by sensors
- Signal quality

➢ **Managed with supervision tool (WINCC OA)**

Commissioning FRAS on IT String test

4. Verification of global service of FRAS.

- FESA computation
- Motor adapters control
- Safety features

➢ **FRAS considered operational after validation of all these steps.**

Upcoming Activities

- EN-EL-FO to blow and splice OF between GYPOS racks and GYPOP under magnets.
- Validate infrastructure for FSI sensors.
- Install sensor supports and interfaces on Q2A and D1.
  - Mechanical installation - validation of our installation procedures and plans
  - Fiducialisation of sensors interfaces (reminder: 1 day without coactivity per magnet)
  - Lessons learnt and update on our procedures
- Install sensors and commissioning
  - Installation of sensors and connection
  - In situ calibration for WPS sensors
  - Lessons learnt and update on our procedures

Summary

IT String test is a major **milestone for WP19:**

- **Single Component Test** has been **crucial** to FRAS preparation for IT String Test.
- FRAS Infrastructure progress is in line with the arrival of magnets
- Sensors and equipment are ready to be installed when each component will be on jacks and infrastructure ready
- First steps of installation showed important changes to be considered for HL:
  - Installation plans for Jack installation (cold/warm transition to appear or not)
  - Optical fibre blowing and splicing into GYPOP patch should be performed before the arrival of magnets
  - Hydraulic network has to be installed before cryo pipes.
  - Good communication between different WPs during installation phase regarding coactivity and “problem” solving
- Discussed workflow (sequence of activities) will have to be respected in the tunnel
- Next steps will allow us to tune and validate the sensors installation procedures as well as the FRAS commissioning steps

Thank you!