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Proposition of Alignment Concept For ATLAS/CMS TAS in Hi-Lumi LHC

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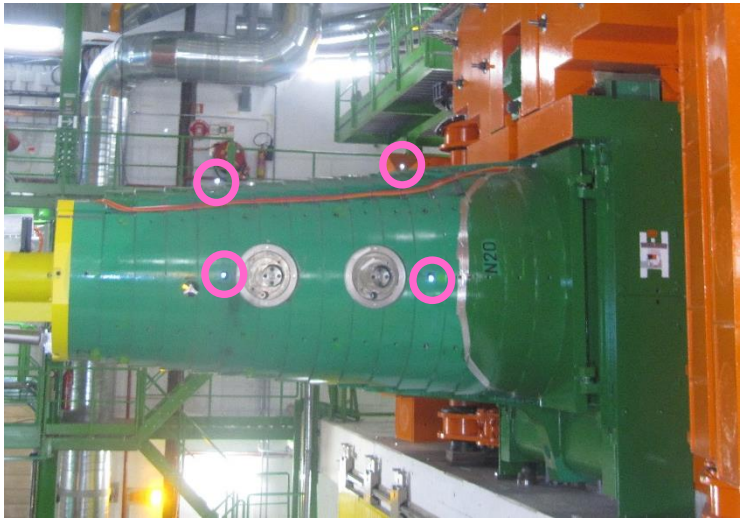
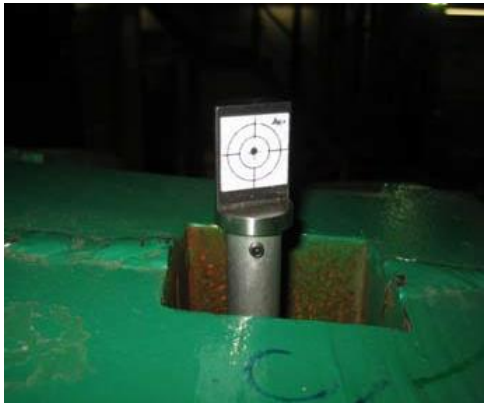
Actual ATLAS TAS concept

- TAS alignment based on bars attached to TAS and traversing the JFC and JFS shielding
- Bars are made of two parts
  - 1st part fix inside TX1STM
  - 2nd part removable in JFS and supports the targets
- 2nd part needs to be (dis-)mounted for opening/closing
- Z-coordinates of 2 top points determine vertical alignment
- X-coordinates of 2 side points determine radial alignment
- Alignment in single configuration possible (experiment closed, shafts open, cherry-picker available)
- Regular manual intervention with constraints on configuration, planning, access, exposure

Actual CMS TAS concept

- TAS alignment based on bars attached to TAS and traversing the FIN shielding (green)
- Single parts of bars stay permanently
  - 1st fix part inside FIN
  - Retro-targets are mounted as targets
- Rotating shielding needs to be open for measurement
- Z-coordinates of 2 top points determine vertical alignment
- X-coordinates of 2 side points determine radial alignment
- Manual intervention with constraints on configuration, planning, access, exposure





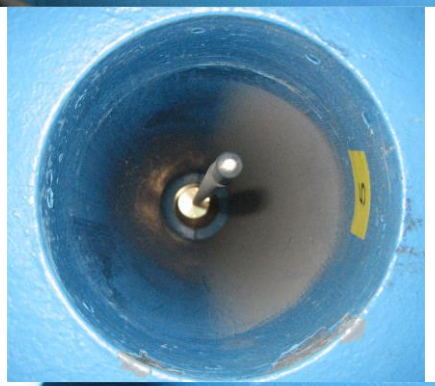
Reduction of bars (ATLAS)

- **Proposition to keep only the 1st part of the bars that stay permanently in TX1STM**
- **Install survey targets directly on the end of the first bar**
- **Stay inside the TX1STM envelope inclusive target**
- **Do the TAS measurement/alignment without JFS**

Advantages:

- No access needed to install bars or dismounting
- Gain of time in ATLAS schedule
- More flexibility for alignment slot
- Less risks of damage
- Permanent full plugs in JFS possible
- Installation risk lower (ex. Tige_2 C-side)

Photos without shielding plugs!



Constraints:

- No measurement in run configuration!
- Very limited possibilities in short access scenarios
- Higher exposure for manual adjustment (no JFS)
- Survey configuration to be changed (visibility in ATLAS).
- No direct link to survey gallery => slightly less precise

Change flexible bars to rigid tubes

Proposition to replace flexible bars by rigid tubes to gain significantly in stiffness

Advantages:

- Fiducialisation with 3D points instead of single direction
  - CONTROL of alignment due to redundancy
  - 12 measured coordinates for 6 parameters
  - Identification if single point is damaged or deformed
- Measurement of TAS in longitudinal position possible
- Identification of TAS rotation around beam axis
- Better stability for the targets and no external support like cylinders and crosses are needed
- Reduction of weight which reduces the sag

Constraints:

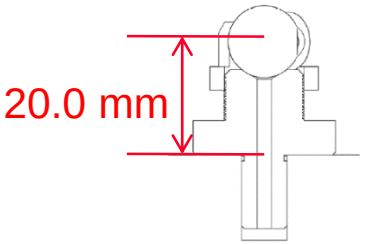
- Tubes need more space as movements due to bake-out or vacuum pumping need to be taken into account
  - Bars have been flexible, tubes could get damaged
- Plugs in TX1STM need to be modified/changed

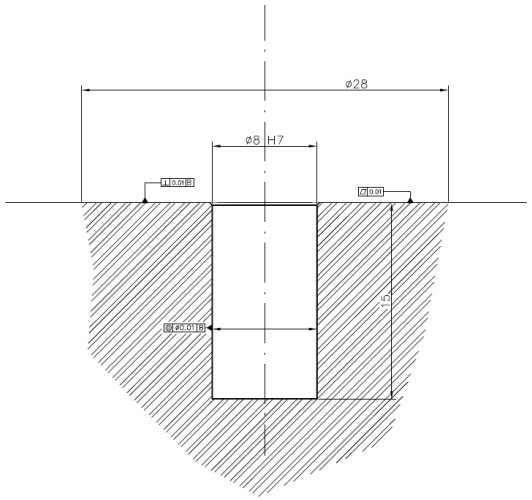
Example:
- SS 15 mm outer diameter
- SS 11 mm inner diameter
- Special interfaces to connect to TAS and target

Interfaces on bars

Interface of bar to survey targets

- Interface holes to be changed from 10H7 to 8H7
- Easy access and handling for fixation screws
  - M3 or M4 headless screws are to be replaced
  - Rapid access in case of cleaning, exchange





Interface and fixation of bar/tube to TAS

- So far risk to unscrew the 1st bar with each new installation
- Unknown reproducibility of bar inside TAS
- Ex. 12H7 guidance with M8 end for fixation on TAS

8H7 reference hole
28 mm contact surface
15 mm depth

Change of Instrumentation

With respect to TAS installation the equipment developed

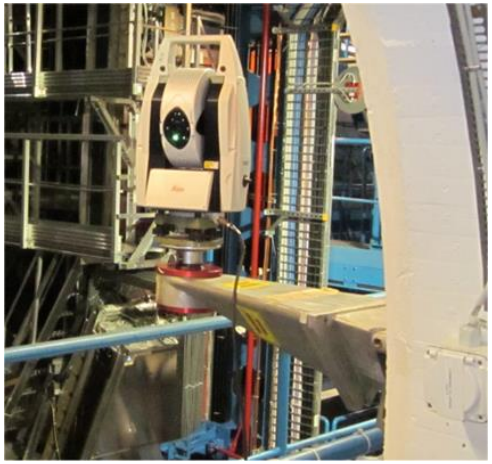
- Laser Tracker precision better than 0.1 mm
  - Theodolite precision absolute ~0.3 mm, relative 0.2 mm
  - Retro targets precision absolute ~0.5 mm, relative 0.3 mm
- => high preference for Laser Tracker

Advantages:

- Laser tracker is used for most measurements in ATLAS/CMS
- Sensor and acquisition software is available in EN-ACE-SU
- As up-to-date equipment in ACE-SU it will be maintained or replaced by equivalent
- Laser tracker uses same target for angles and distance (no access for regular exchange during measurement)
- Precision independent of operator (no manual measurement)

Constraints:

- Laser tracker works exclusively on prisms
- Prisms need to be installed permanently (or temporarily)



Specifications for precision Leica AT402
15µm + 6µm/m MPE
7.5µm + 3µm/m typical
➔ Precision at 10m distance < 0.05mm typical (1 sigma)

Change of Targets

Advantages:

- Different reflectors exist on the market (size, type)
- Non-magnetic devices exist (ceramic)
- Compatible with laser trackers available at CERN
- Size and weight of target support could be reduced
- Radiation hard up to 10 MGy (test crab cavities)
- No access needed for measurement (if permanent)

Constraints:

- Long-term maintenance could be necessary
  - Cleaning from dirt, dust
  - Protection?
- Costs per prism ~1000-1500 EUR
  - 8 prisms per experiment needed (permanent)
  - Prisms available for temporary installation
    but access needed in this case! Exposure?
- Prism supports need to be manufactured (design is available)

Conclusion

Following the lessons learned from the actual system the list of propositions is:

- Change to single fixed bar (as CMS)
- Change to tubes
- Change to Laser Tracker
- Change to permanent retro reflectors

Major advantages:

- Less interventions in ATLAS as no mounting/dismounting of bars
- Measurement of 6DOF for TAS
- Controlled measurements
- Shorter interventions
- More precise measurements
- Measurement system exists (AT401) => no development, high reliability
- No active components on TAS or shielding => limited maintenance on TAS

Questions:

- How much moves TAS during bake-out?
- How much moves TAS during vacuum pumping?
- What are the radiation levels outside JFC and JFS in HL-LHC?

Constraints:

- No real-time monitoring
- **No measurement in run configuration! At least top of JFS to be dismounted respectively rotational shielding open**
- Cost of prisms as permanent targets
- Modification of plugs (ATLAS)
- New configuration for survey network

Comments? Ideas?

Thanks for your attention!

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