Infrastructure For LHCb Upgrade Workshop

February 20th, 2015

SURVEY EXISTING TECHNIQUES AND REQUIREMENTS

Jean-Christophe GAYDE, Pascal SAINVITU (CERN EN-MEF-SU-EM)

SU Experiment Metrology team

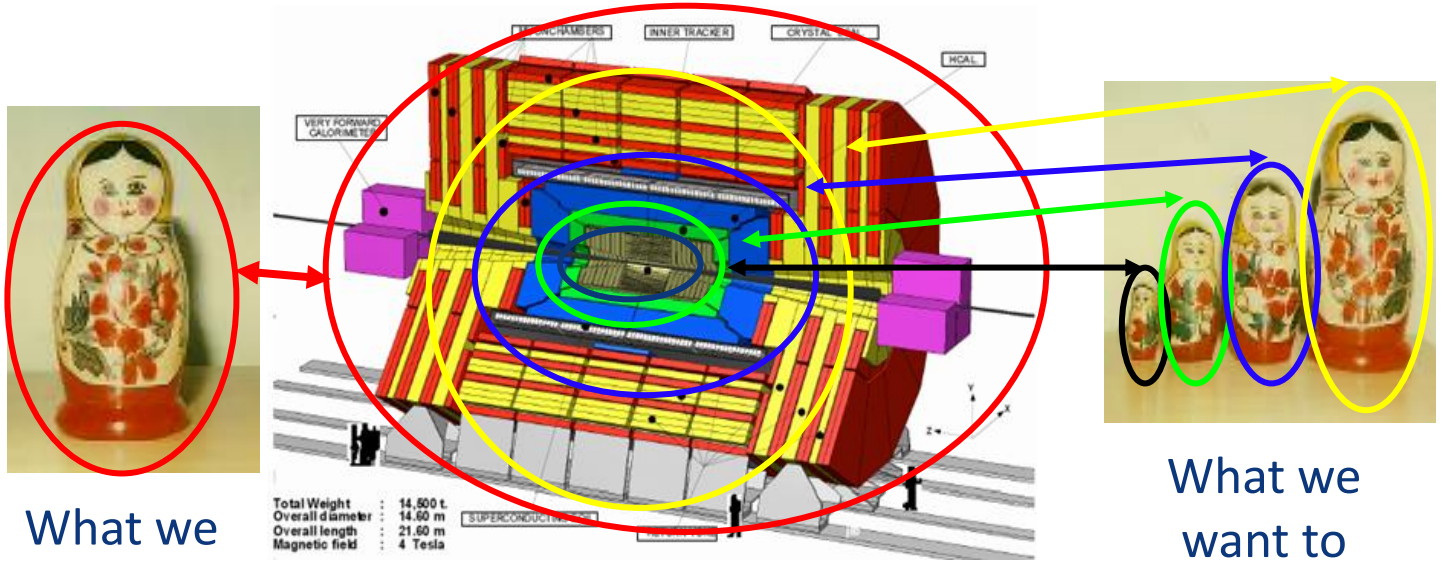
- SU-Experiment Metrology team is part of the Large Scale Metrology Section EN/MEF-SU

- Mandate:
  - The geometrical infrastructure for the detector installation
  - Detector metrology for assembly and alignment on the beam lines
  - The as-built measurements following with the installation phases

- This includes:
  - Prototypes
  - Deformation tests,
  - Quality control,
  - Pre-assembly and Assembly in surface halls or in the caverns
  - Alignment and Positioning

Detectors and Experiments

- A Russian Doll like configuration



What we see

What we want to know

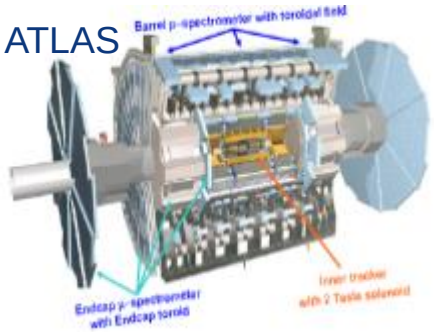
- Also true at detector level
  - Link between inner parts and external references;
  - Link between detector modules and the assembly fiducial marks

- Many coordinate systems to deal with such as:
  - Sub-detectors, detectors, physics and survey system, CCS …

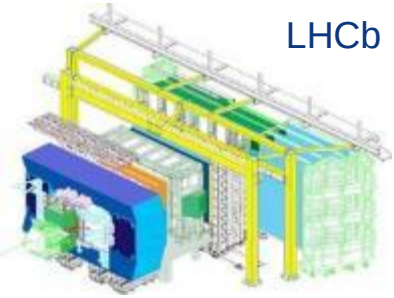
Where is SU-EM involved?

Survey for all the Experiments at CERN + ISOLDE and HIE-ISOLDE

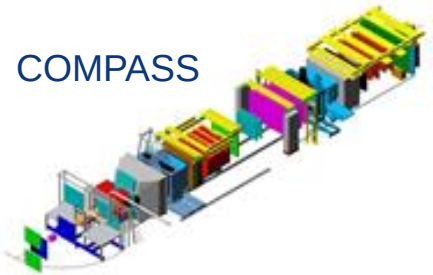
ATLAS



LHCb



COMPASS

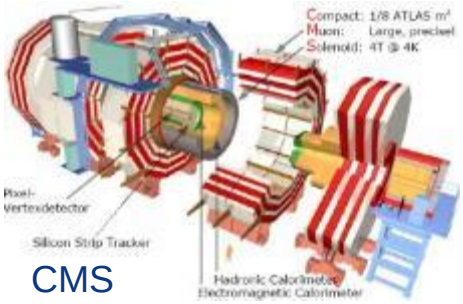


LHC Experiments

- ALICE
- ATLAS
- CMS
- LHCb

and Non-LHC

- NA61
- NA62
- CAST
- Isolde
- HIE-Isolde
- All experiments of North and East Areas
- etc.



CMS

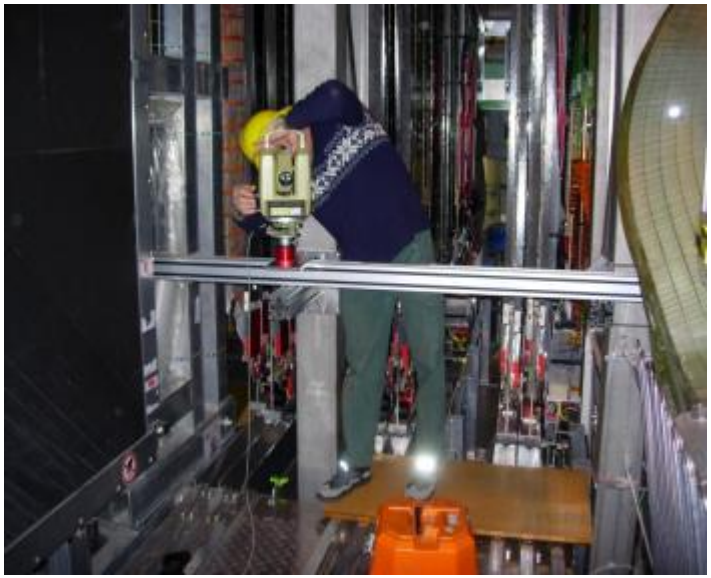
ALICE

HIE-ISOLDE

AND OTHERS …

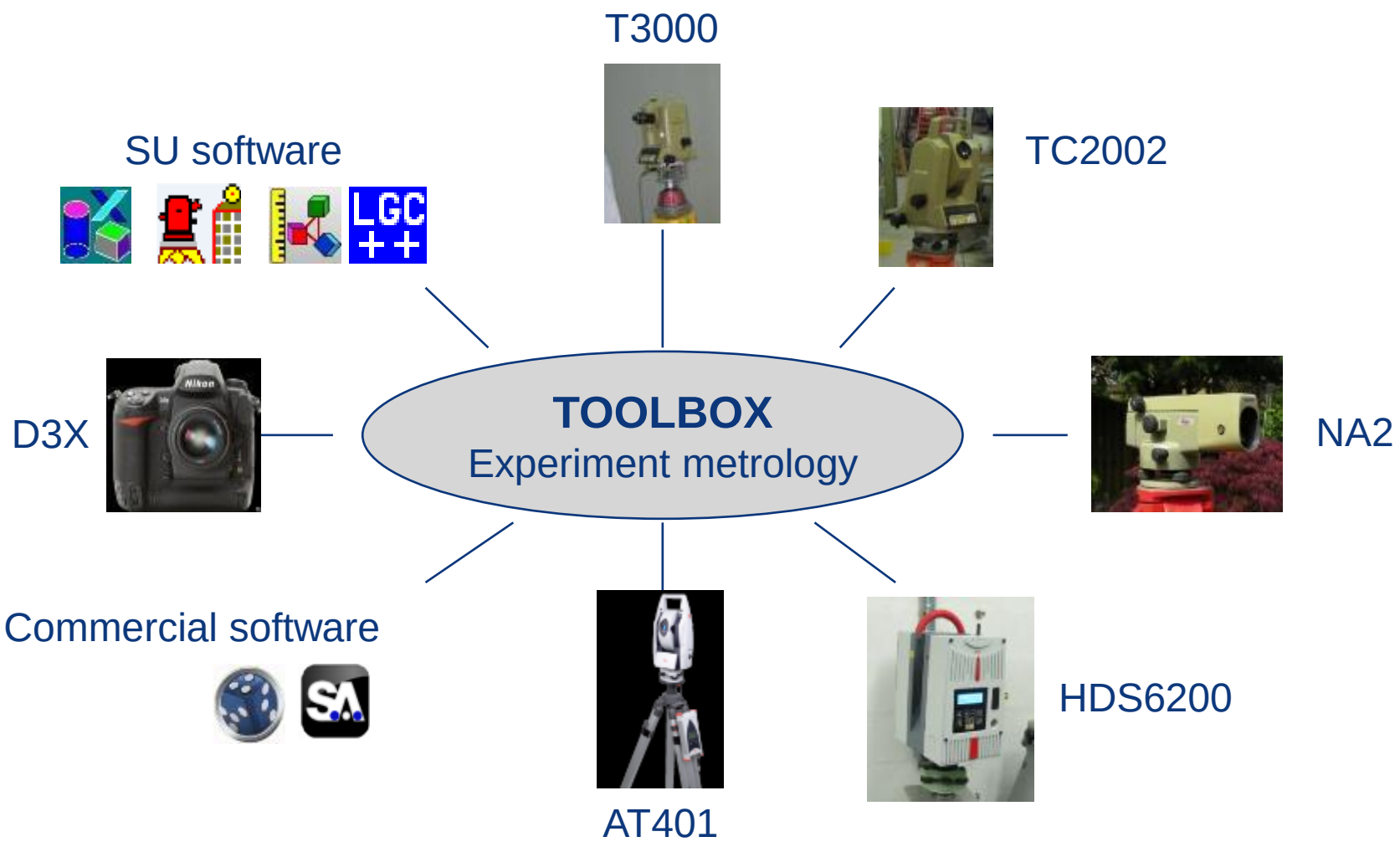
When is SU-EM involved?

- At all phases of the projects:
  - At very early stage at the design phase
  - Prototyping and tests
  - Manufacturing
  - Pre-assembly
  - Assembly phases of detectors
  - Experiment construction
  - Alignment and positioning phases in the caverns or experimental areas during construction, Technical Stops, Shutdowns, Machine Developments



- *Usual measurement precision (at 1 sigma level)*
  - *Detector control at manufacturing before assembly 0.03-0.3 mm (max. 0.5 mm)*
  - *Deformation of detectors under special conditions ~ 0.1 mm*
  - *Relative position of detectors wrt other detectors < 0.5 mm*
  - *Absolute position of detectors wrt accelerator geometry < 1.0 mm*

Survey Toolbox



➔ Line of sight between instrument and object required!

Photogrammetry

- Image acquisition needs no stable station
  - Photos taken on platform, scaffolding or cherry-picker
- Mobile System with ‘high’ precision
  - Off-site interventions in factory (Pisa, Aachen…)
  - Clean rooms, assembly halls and experimental caverns
  - Inner detector components < 1m (1 sigma < 50 microns)
- Limited measurement time for large amount of points
  - Short interruption for installation, production process
- Camera system
  - PC (windows XP, W7)
  - Nikon D2X–12MP / D3X–24MP (Full Frame)
  - Wireless module
  - Different lenses (17-28 mm)
  - Top flash, ring flash
- Software
  - AICON 3D Studio V. 10.0 – DPA PRO

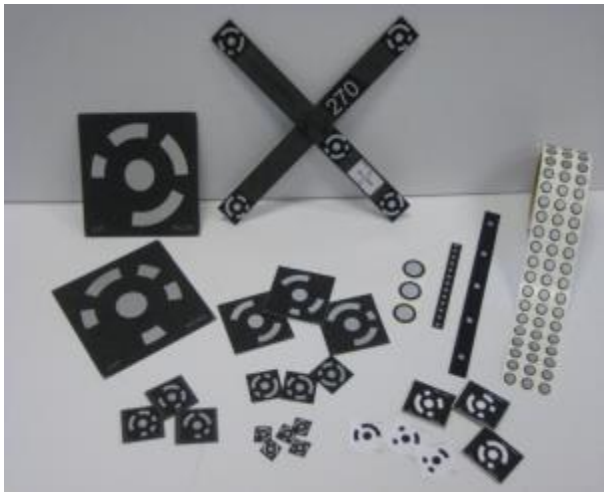
Photogrammetry

- References for scale
  - Carbon fibre scale bars (max. 1.5 m)
  - Geodetic measurements

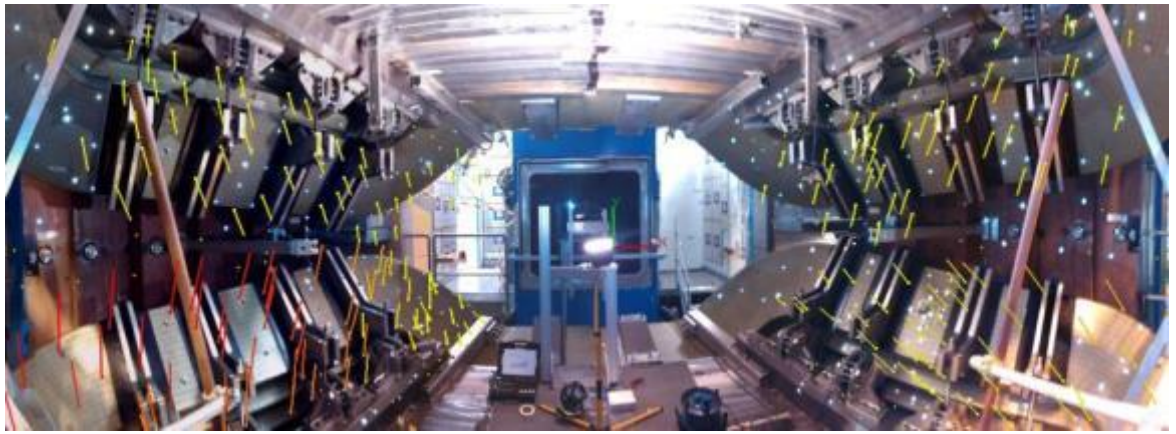
- Targets
  - Coded / non-coded
  - Retroreflective / non-retroreflective
  - Button targets Hubbs / GMS / Aicon
  - Sticker targets of different types

System optimized for measurement of signalized points only = highest precision

➔ We have to access and touch the detector



Photogrammetry examples



- Displacement and deformation of the Dipole coil during consolidation

- Photogrammetry of TT balconies and link to external fiducial marks

Leica AT401

- Laser tracker in “theodolite” housing
- As flexible and light as theodolite
- Measures on special prisms
- For different volumes (max. +/- 80 m) as :
  - experimental cavern network
  - individual detectors
- Instrument can be remotely controlled

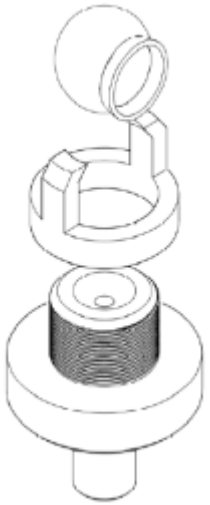
  ➔ automation possible (ALARA)
- Instrument has same support as theodolite

  ➔ existing survey infrastructure can be used
- Specifications for precision
  - 15µm + 6µm/m MPE
  - 7.5µm + 3µm/m typical

    ➔ Precision at 10m distance < 0.05mm typical (1 sigma)

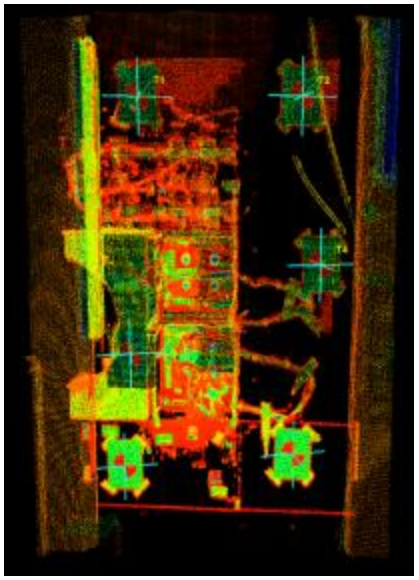
Leica AT401

- AT401 is measuring with respect to previous equipment:
  - 5x better for distances
  - 2x better for angles
- Targets are prisms with 1.5” and 0.5” diameter and adapters
- Interchangeable tooling to photogrammetric and total station targets

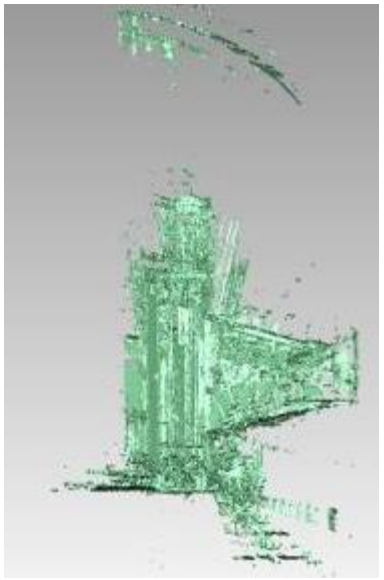


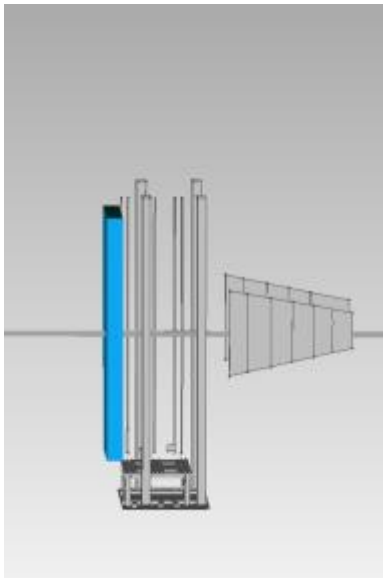
Leica HDS 6200 3D Laser Scanner

HCAL module



IT, OT and Dipole area



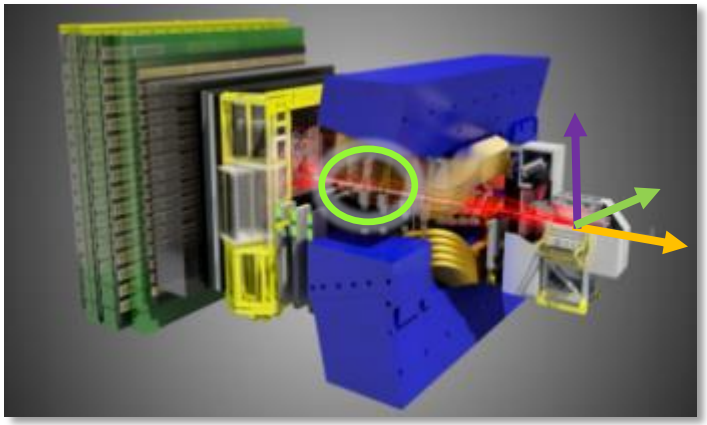


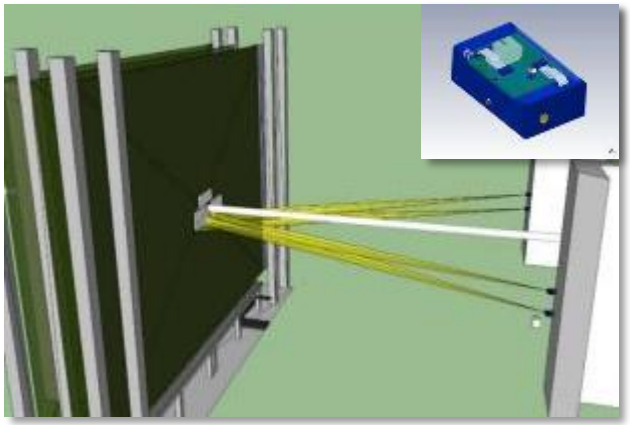
- Up to 1 000 000 points/sec
- Phase shift distance measurement
- Point accuracy at 5m = +-3mm
- Spot size = 5.0mm @ 10m
- Field of view: 360° x 310°
- Point cloud as result

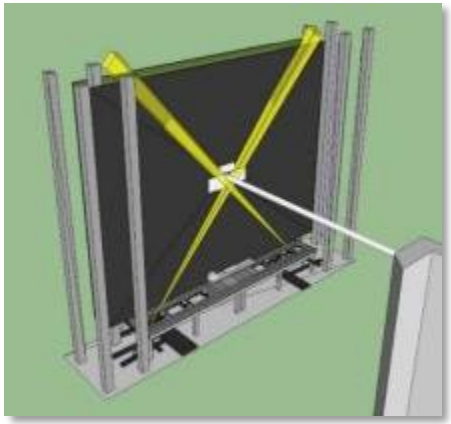
- As built / Integration
- Other 3D scanners existing
- Better precision
- … Needed for upgrade?

Monitoring system development

- SU-EM is also involved in development of monitoring systems
- Example: IT monitoring system - Collaboration SU-EM / LHCb / IT / EPFL





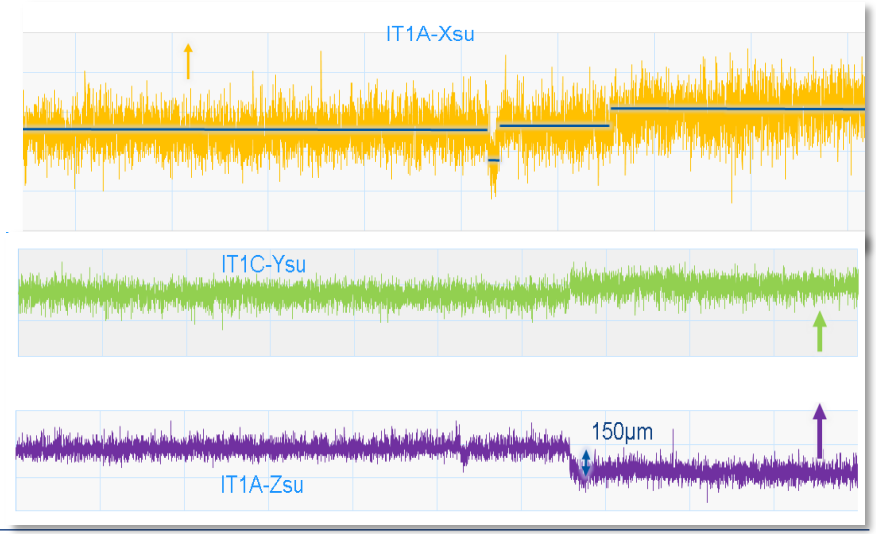


R&D

Low material target and support

Additional flash

First results



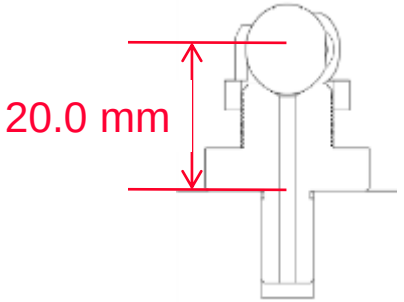
SU-EM involvement must start at very early stage

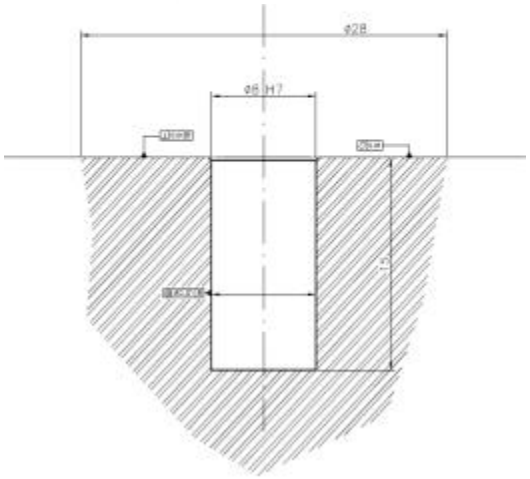
- Discussion with coordinators / project leaders / physicists / engineers / designers
  - Define precisely the needs and find reasonable solutions
    - What has to be measured?
    - With respect to what?
    - At what stage?
    - Where?
    - What is the required precision / error budget?
  - Define all stages when survey will be needed
  - Include alignment to the design (references, integration work)
  - Define local coordinate systems
  - Estimation of the resources needs

- This is extremely important
- Without this survey could be impossible
- Standards exist / suitable solutions can be discussed

Detector preparation

- Survey reference points / Fiducial marks
  - Different survey targets have to be placed on object
  - 3D – survey reference hole
    - ➔ best solution, highest flexibility
- Define survey reference holes on detector
  - Already early in the design phase
  - Reference hole accessible and visible during ALL phases
  - At relevant position on stable support
  - On individual detector elements as later on assembled groups
  - For theodolite, laser tracker or photogrammetry
  - Coordinates are given at the centre of survey target
  - Sensitive elements are referred to reference holes by constructor





8H7 reference hole
28 mm contact surface
15 mm depth

WARNING: the values are given as indications
Every new values must be discussed and agreed!

In order to help in the preparatory stages

SURVEY QUESTIONNAIRE

From : .....
To : **Jean-Christophe GAYDE EN/MEF-SU (see addresses below)**
Date : .....

EXPERIMENT	.LHCb.....
NAME OF THE DETECTOR	.SciFi-Tracker.....
NAME OF THE PEOPLE RESPONSIBLE	.Proj. Leader: Ulrich UWER.....
	.....
INSTITUTION	.Univ. Heidelberg.....
ADDRESS	.....
E-MAIL	.....
FAX	.....

1.	Has your detector to be determined in the coordinate system of your experiment (i.e. in the data base of the off-line software)?	yes	no	1.0
2.	From the geometrical point of view, is your detector a single unit ?	yes	no	2.0
	If not, how many pieces are they ?	.....	.....	2.1

https://edms.cern.ch/document/1074957

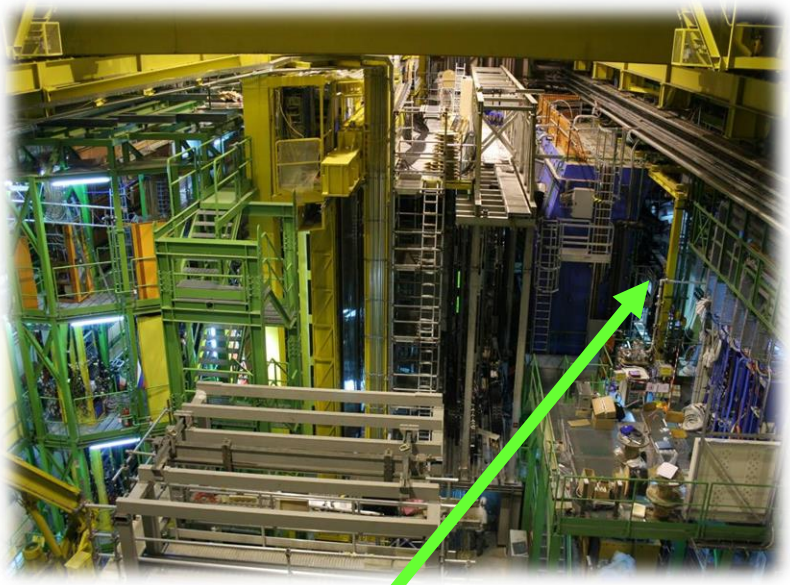
Summary and future upgrade

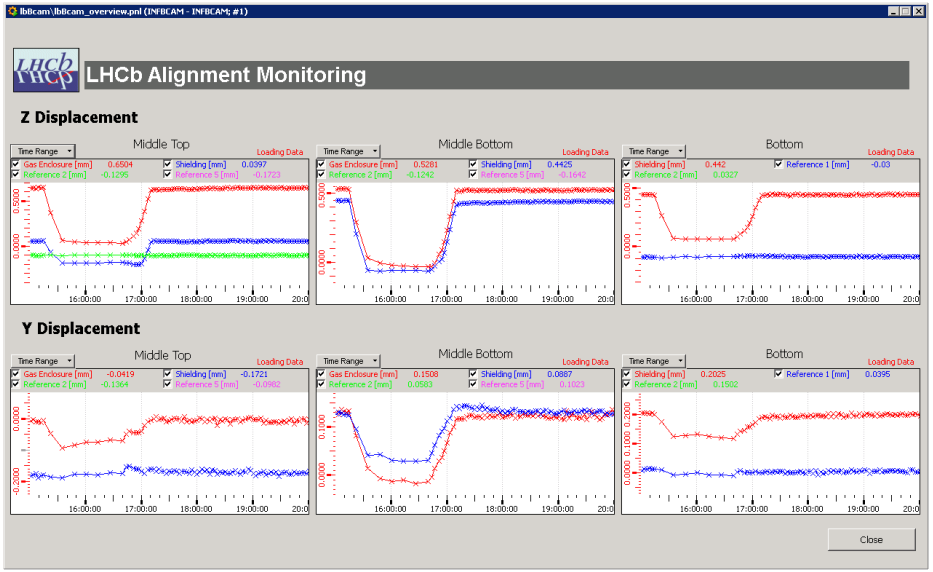
- **SU-EM can be involved in survey requests for detector upgrades**
  - Design / Validation / Test phase / Construction / Installation
- **Survey is flexible in method and can adapt it to working conditions**
  - SU-EM decides as function of the constraints the optimal technique
  - Measurement equipment has progressed since LHC construction
- **An early discussion for each individual detector is necessary**
  - Permanent contact between SU and detector responsible
  - SU participation at early stages
  - Include survey needs in the design
    - References carry the detector geometry information
    - NO references → High risk that NO precise survey can be performed!
    - Mechanical adjustment systems need also to be integrated
- **Detector installation/maintenance will be more complex – ALARA**
- **Questionnaire can be found at:** https://edms.cern.ch/document/1074957

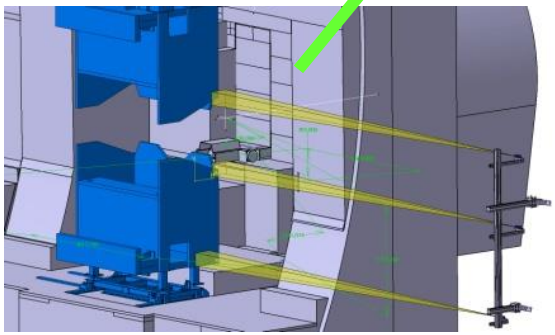
Thanks for you attention

LHCb RICH1 Gas Enclosure and Shielding monitoring

Monitoring during magnet ramp-up







- Proposal of a BCAM based monitoring system
- Coordination of the project with resources from LHCb
  - Integration / Design / Mechanic / Installation / Cabling
  - DAQ and processing software
- Integrated to the LHCb control system

Movement monitoring from the LHCb Ctrl Room with a precision of 30 microns