Alignment in PANDA
***W**ork **I**n **P**rogress*

Setting the scene

Misalignments

Towards a strategy

Next steps

Alignment processes

Typically 3 step process:

- 1. Measure element (e.g. wire, pixel) position during construction of sub-detector using coordinate measuring machines and similar devices.
- 2. Measure relative position of sub-detectors after assembly using surveying techniques such as lasers, photogrammetry.
  - Relative position to fixed reference points which can be referenced to beam-line
  - Only works for detectors you can see.
- 3. Track based alignment
- Applies to tracking detectors including muon chambers
  - Then use tracks to align calorimeters as trackers measure position better (usually) than calorimeters

Photogrammetry – basic info

- A 3-D coordinate measuring technique (accuracy ~ 1/10mm)
- Uses photographs as the fundamental medium for metrology
- The fundamental principle is triangulation

- From photographs from at least two different locations, “lines of sight” can be developed from each camera to points on the object.

- These lines of sight are mathematically intersected (special software) to produce the 3-D coordinates of the points of interest.

Photogrammetry workflow

Record	Process	Analyse	Output	Disseminate
• Overlapping photographs from any still digital camera	• Align Photos • Point cloud creation • Mesh generation • Texture generation • Export Mesh .obj .ply .stl	• False colour based on elevation • Elevation contours • Variable angle lighting • Texture manipulation • Stereo 3D imaging Anaglyphic Side-by-side Interlaced	• Animation .wmv .mov .avi .swf • Still image • 3D files .obj .ply .stl • 3D Rapid protoyping	• Cloud Computing e.g. Dropbox • Interactive • Online databases • Web • Video

Data shared remotely via Cloud computing services

Misalignment sources I: Construction tolerances

- Construction tolerances

unavoidable geometrical tolerances in the production of parts, such as mis-positioning of wires strips within a layer and relative shifts in the layer-superlayer assembly.

- Measure relative positioning of the different internal parts of sub-detector during construction to be within the required tolerances.
- Q: What are the required tolerances for each detector?
- Compare with construction drawings and cosmic data to provide corrections to the nominal sub-detector geometry when necessary.

Misalignment sources II: Detector assembly

- Detector assembly, closing tolerances:

Installation tolerances & gravitational distortions of return yoke lead to static deformations of steel support, results in displacements of sub-detectors up to several millimetres with respect to their nominal positions.

- After each system installation, perform survey measurements (e.g. Possibly use photogrammetry, as mentioned by GSI Alignment)
- Q: Wat is the required alignment precision for each system?
  - Barrel systems: EMC, DIRC & ToF, STT & MVD
- These measurements provide an initial geometry
- Q: Is geometry distorted after movement to in-beam position?

Misalignment sources III: Solenoid effects

- Solenoid effects

Magnetic field distortions lead to deformations of the return yoke, at the level of a few mm (?) They result in further displacement of sub-detectors.

- The new detector geometry resulting from the magnetic forces can be accessed with measurements of in-situ monitoring system and track based alignment techniques.
- Q: Does any sub-detector require in-situ alignment monitoring?
- Q: What are the requirements to use track based alignment only?

Misalignment sources IV: Time-dependent effects

- Time-dependent effects

During operation, thermal instabilities and other time-dependent factors can cause dynamic misalignments at the sub-millimetre level.

- Q: Does any sub-detector require in-situ alignment monitoring?
- Q: What are the requirements to use track based alignment only?

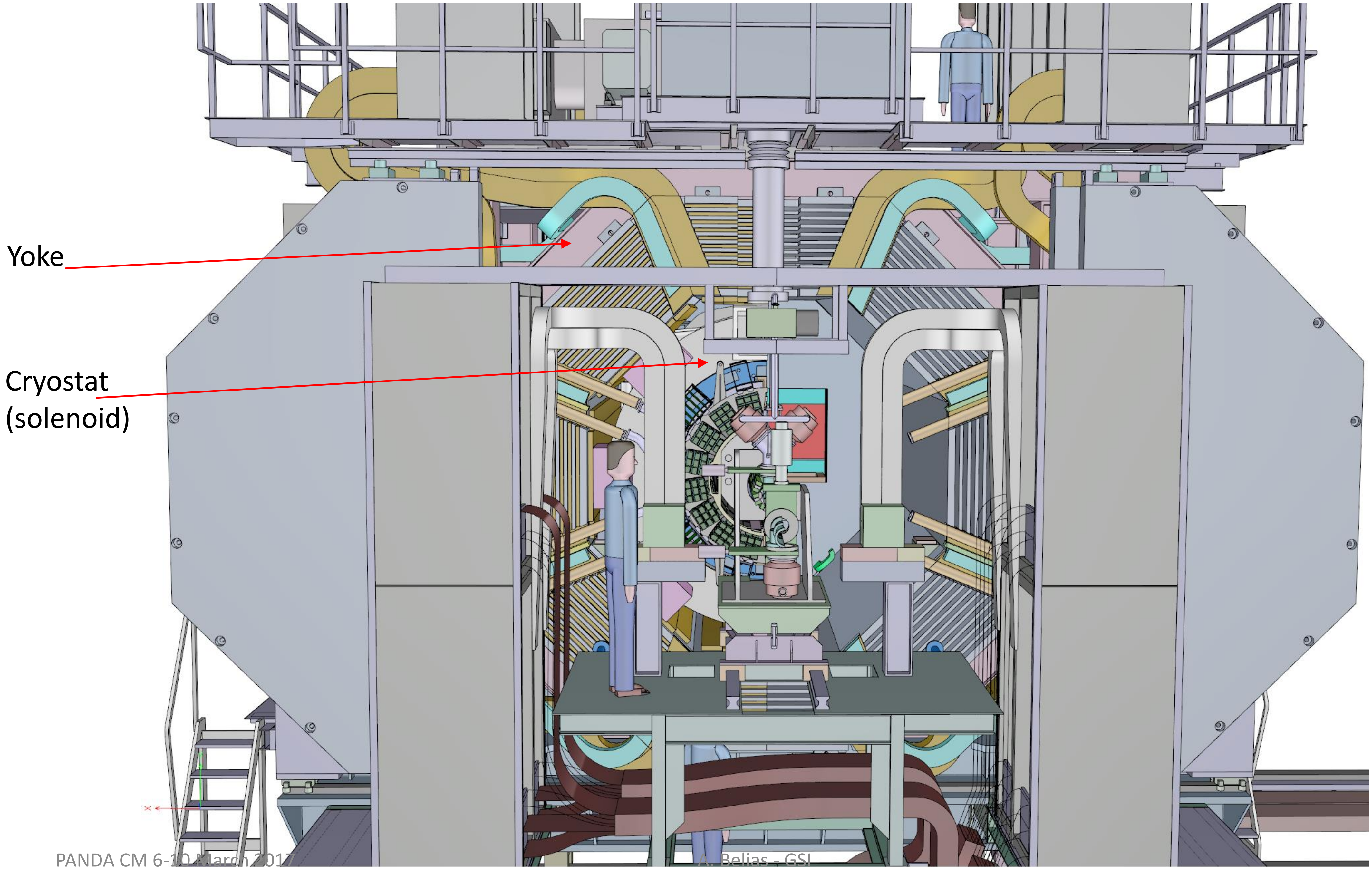
Measurements for surveys

- Two main types of measurement are commonly required in surveys:
- Global measurements – the measurement of something with respect to an external reference (i.e. position measurement with respect to Geographic IS)
- Relative measurements – the measurement of something with respect to something else within the same survey (the position of one point in a survey with respect to another)
- For PANDA we´ll use relative measurements to determine positions of the sub-detectors as-is state "Ist-Zustand"; no adjustments planned

Towards a strategy

- Determine fixed reference points in the hall for both detector positions, parking position and in-beam position
- Determine fixed reference points on the yoke and the cryostat (solenoid)
- Must have free line of sight to reference points in hall & HESR magnets near PANDA in the beam position
- Use same reference points cryostat (solenoid) & yoke for B-field mapping
- Survey yoke and cryostat (solenoid) relative to fixed points in hall & HESR
- Survey during TS installation sequence; EMC, DIRC & ToF, STT & MVD
  - Each detector with fixed reference points visible wrt fixed refernce points on the cryostat (solenoid) & yoke(?)

- Next, a view of the TS ready build as seen by a surveyor


Yoke
Cryostat
(solenoid)

Next steps - Homework

- Write down the alignment requirements for each sub-detector
- Estimate effects of misalignmend sources
- Write down the installation procedures for each installation step

- Determine & refine alignment strategy for PANDA with GSI alignment group
  - In close cooperation with all systems involved

- Our requirements, the hall geometry & installation sequence define which survey apparatous is best suited
  - GSI Alignment group will provide advise; surveys will be done by contractor