Module Specification: Alignment and Testing Requirements

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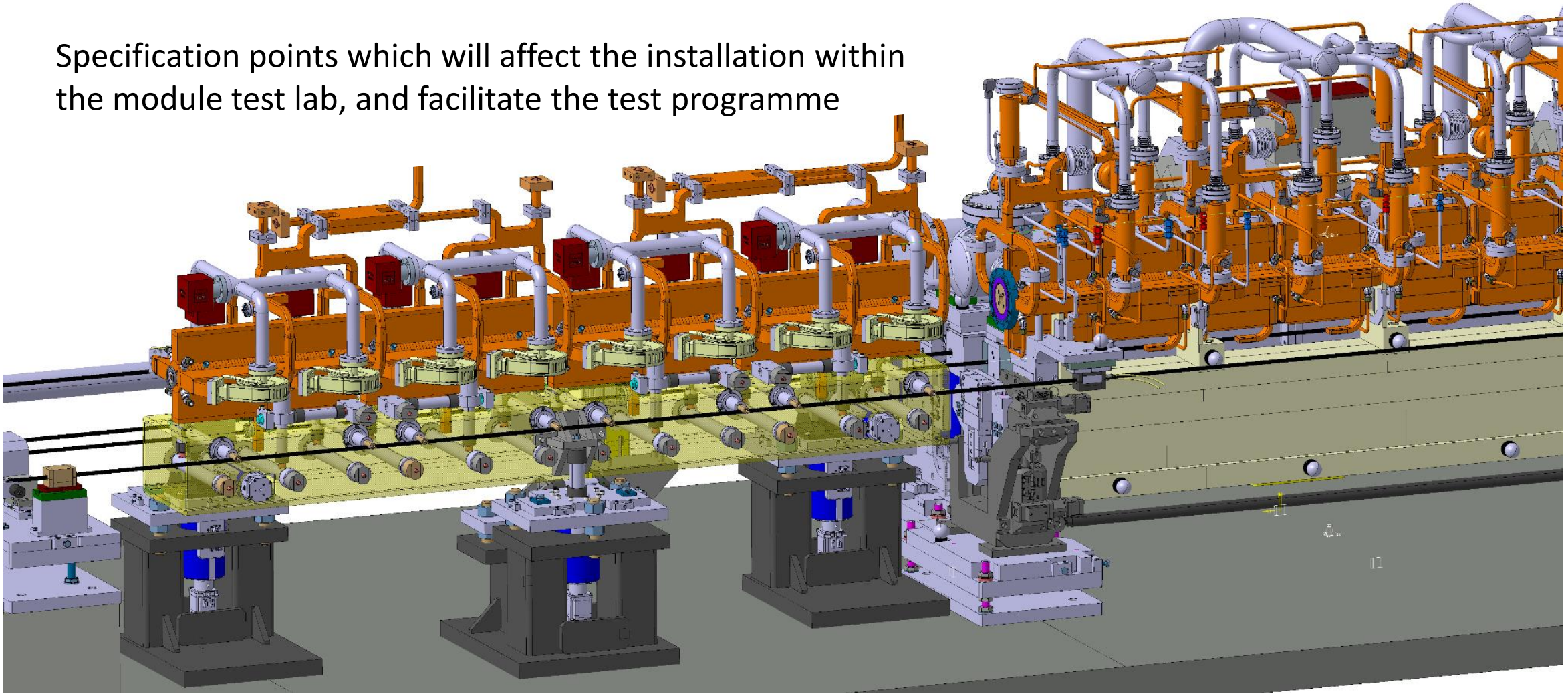
Lab Installation & Testing Programme

Specification points which will affect the installation within the module test lab, and facilitate the test programme



Lab Installation & Testing Programme

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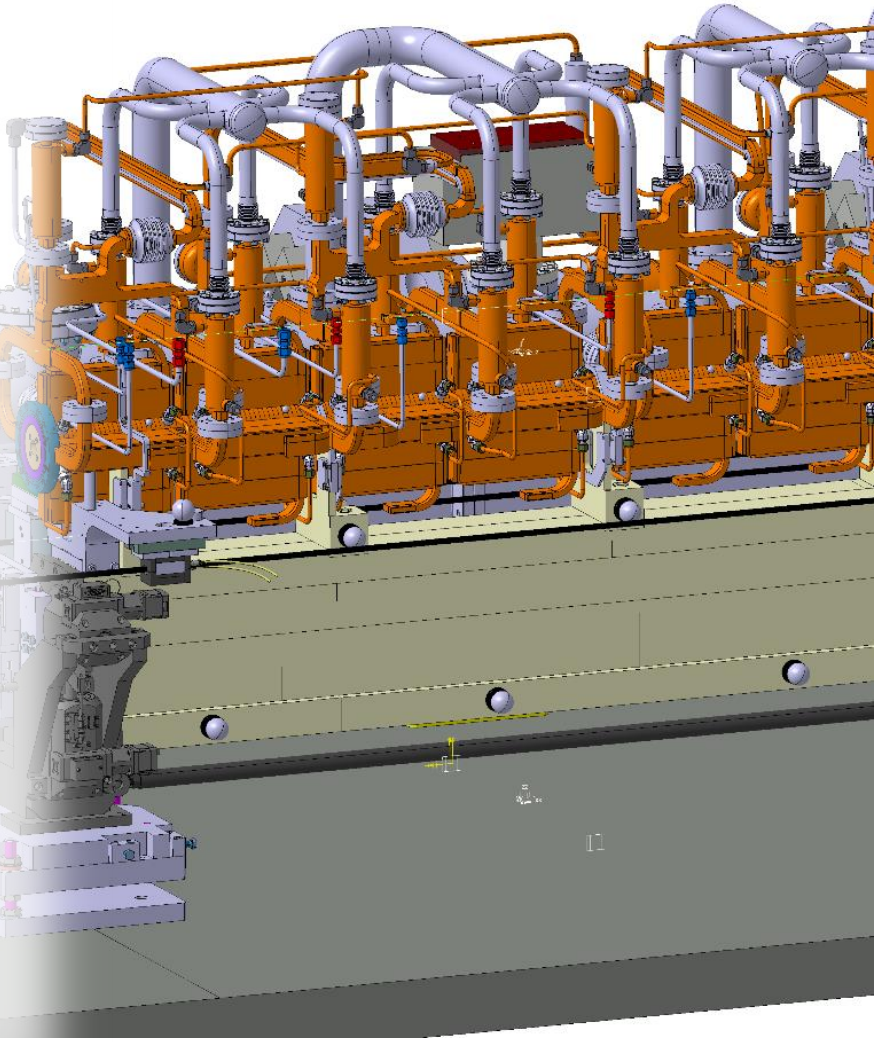
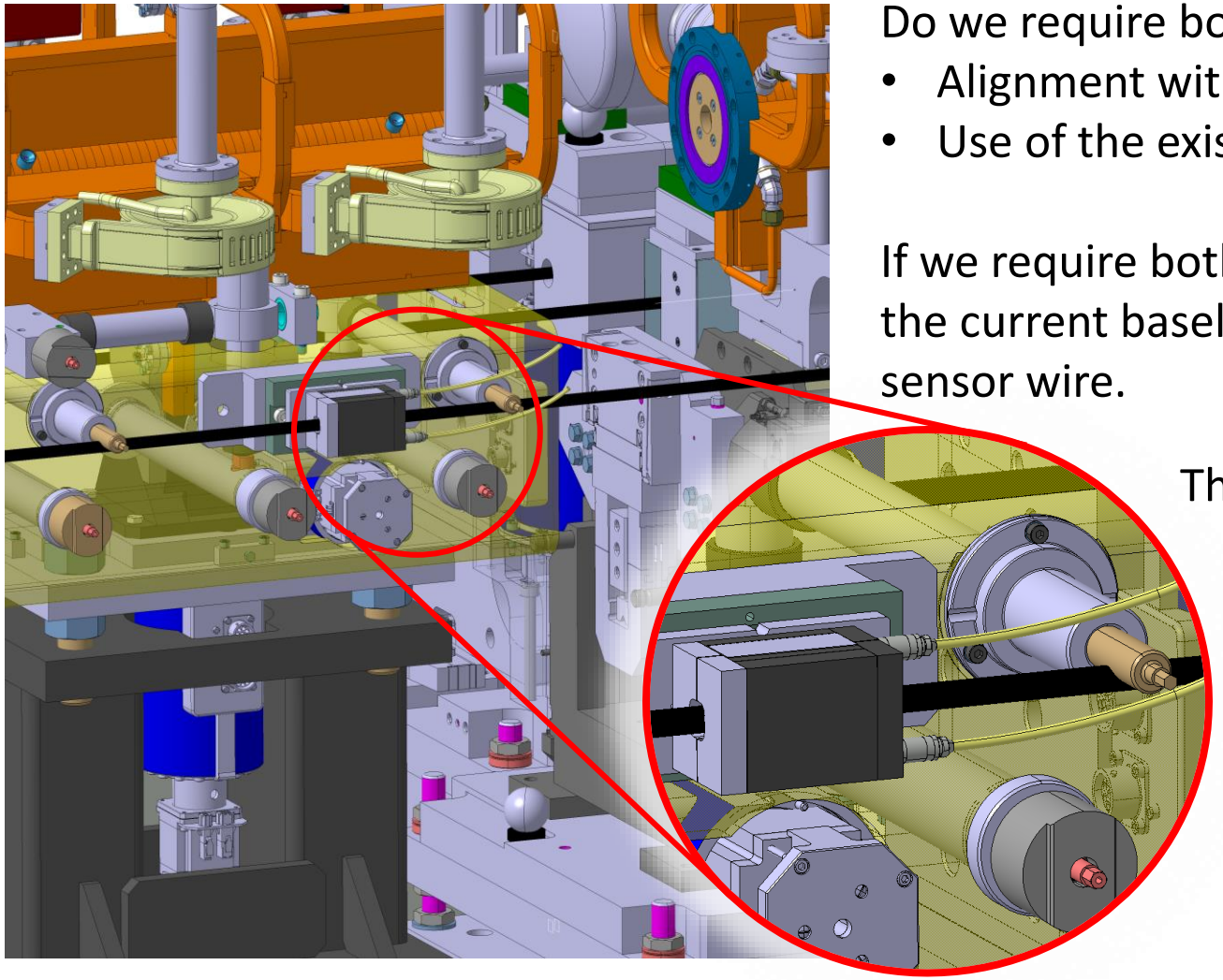
Broken down into:

1. **Considerations for the installation within the lab**
    a) Wire location
2. **Module design considerations**
    a) Fiducialisation of structures
    b) Reference surfaces
3. **Reuse of previous equipment**
    a) Reuse of linear actuators
    b) Reuse of control equipment
    c) Motorisation of support adjustment
4. **Universal Joints**
    a) Test data
5. **PJAS**



WPS Location



Do we require both:

- Alignment with the beam axis of the previous modules
- Use of the existing sensor wires

If we require both, the SAS lateral adjustment points on the current baseline design will likely clash with the sensor wire.

This can be avoided by:

- Modifying the module design
- Rotating the module 180°
- Offsetting the beam axis of the new module
- Moving the sensor wires

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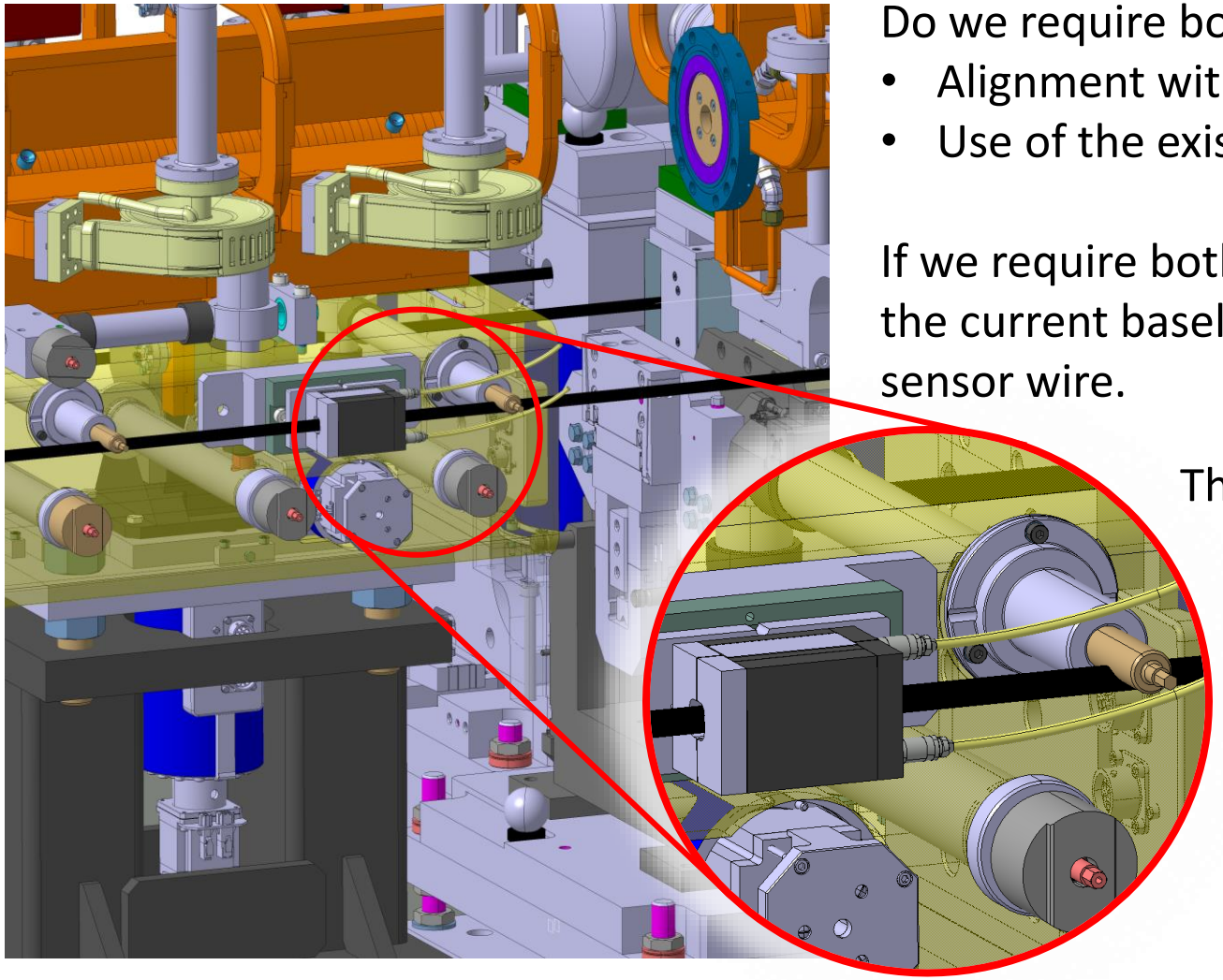

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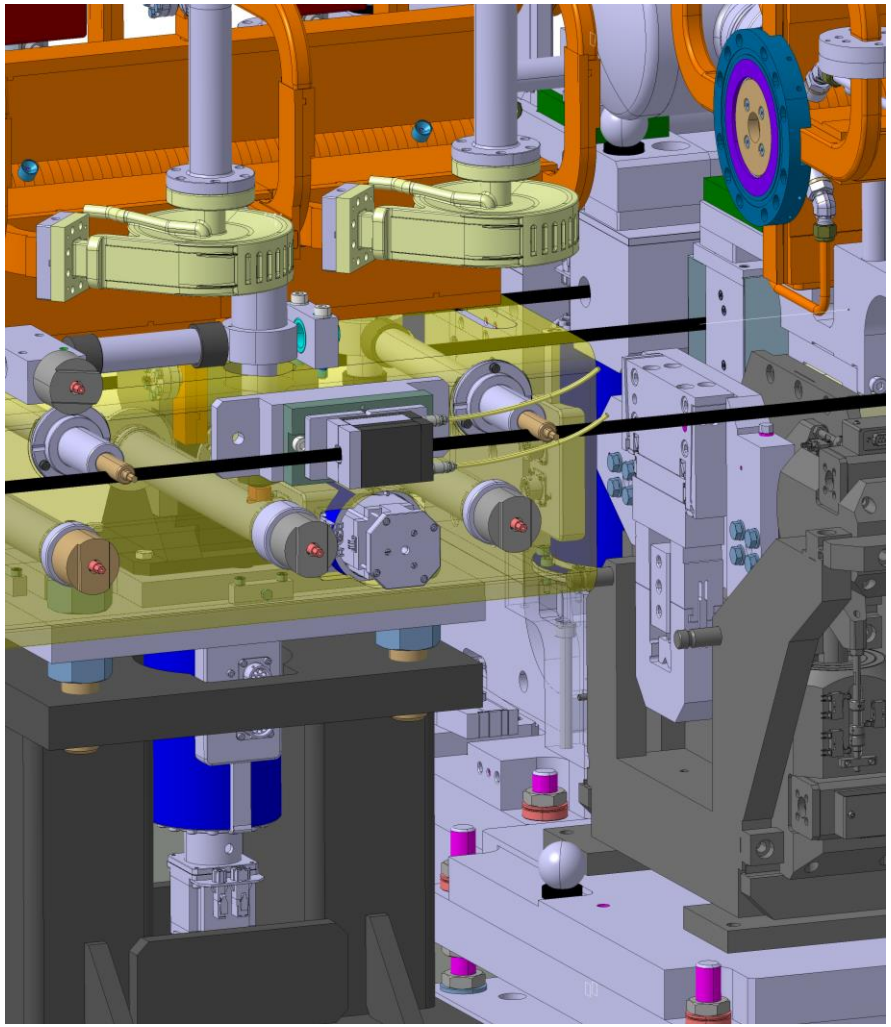
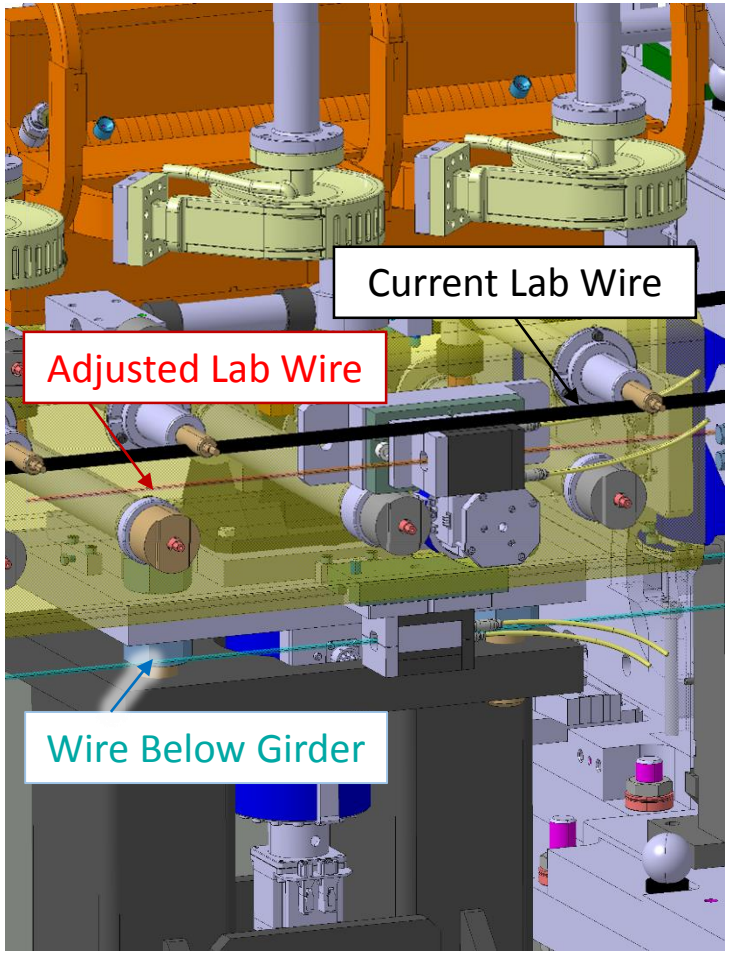
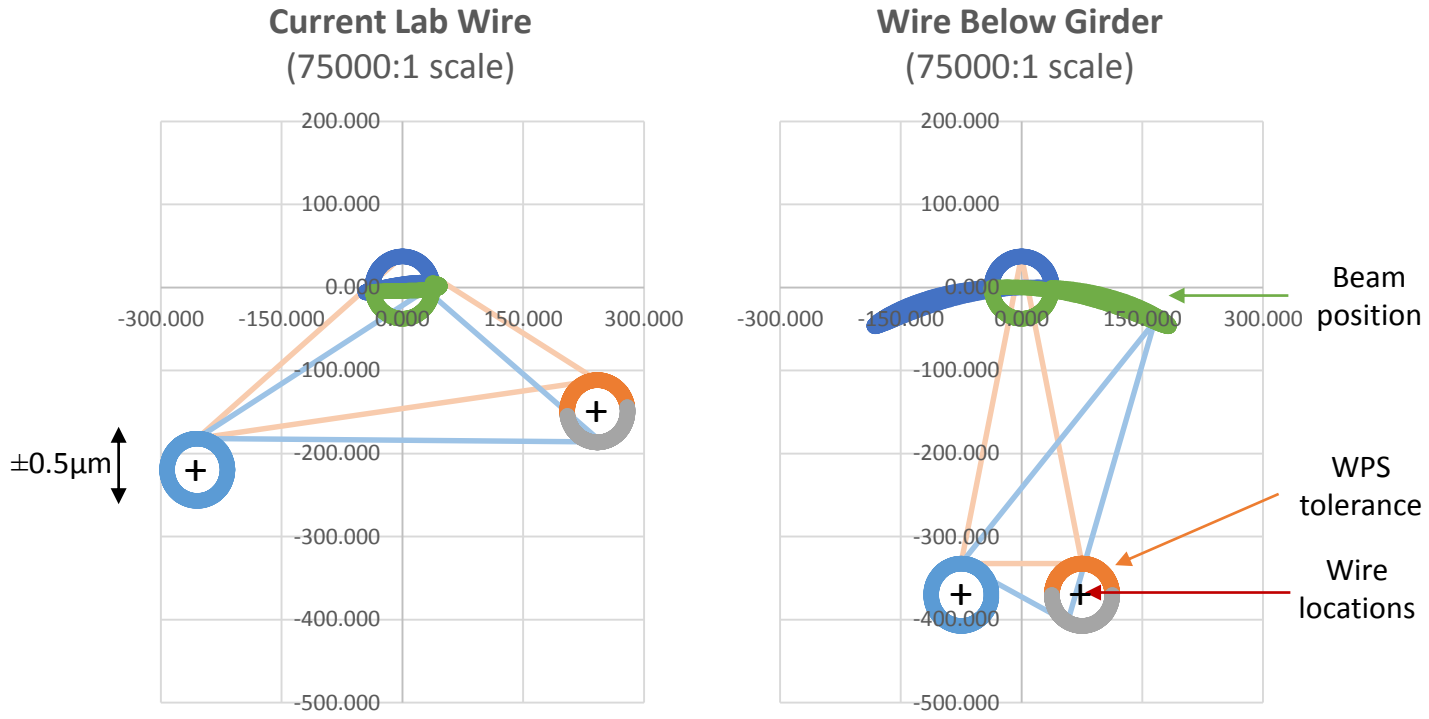


1. **Modifying the module design**
   a) Reducing the width of the girder to 200mm would allow the existing wires and beam axis to be used, but would sacrifice structure roll resolution
2. **Rotating the module**
   a) Rotating the module 180° would avoid the clash and maintain the alignment, but the drive beam wires would make the adjustment difficult
3. **Offsetting the beam axis of the new module**
   a) Raising the beam height of the new module by ~20mm would avoid the clash
   b) Offsetting the beam ~50mm to the left
4. **Moving the sensor wires**
   a) Would allow direct mounting of WPS on the sides or underside of the girder (this might not be sensible due to the possible roll error this can introduce).
   b) Support ‘arms’ likely required for MBQ compatibility

WPS Location Errors

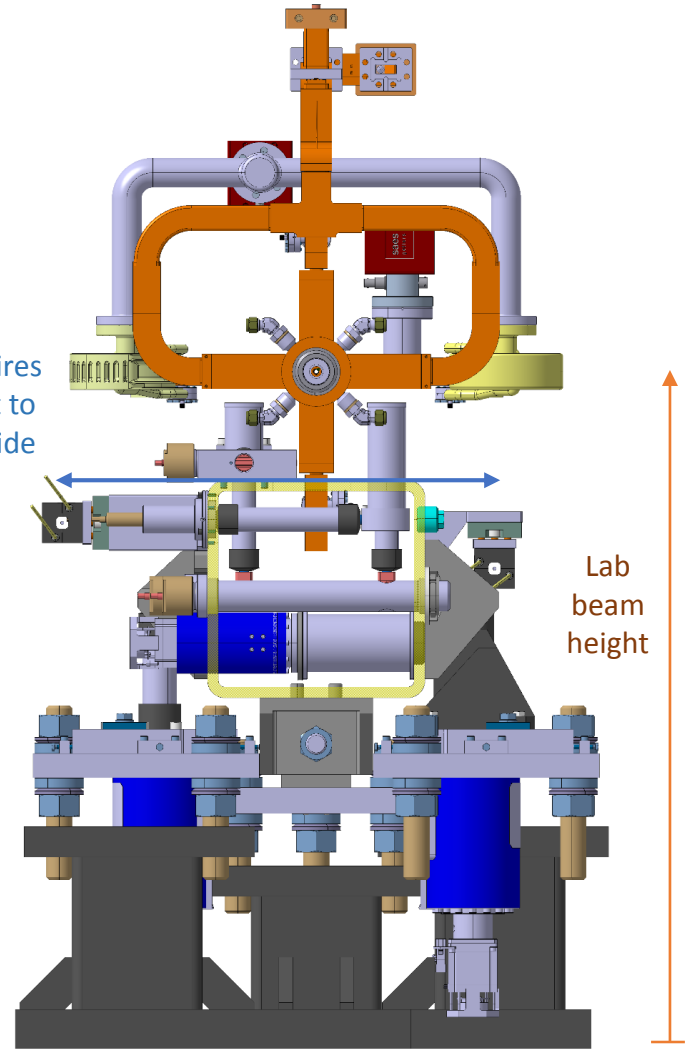




WPS Location	Coordinate Relative To Beam [mm]				Beam Point Error+/- [µm]		Relative Accuracy	
	X_1	Y_1	X_1	Y_1	X	Y	X	Y
Current Lab Wire	-255.0	-219.4	242.0	-149.0	0.616	0.500	81.14%	100.00%
Wire Below Girder	-75.0	-370.0	75.0	-370.0	2.517	0.500	19.87%	100.00%

Mounting the sensor wires below the girder will lower the roll position sensitivity

Girder Dimensions (Module)



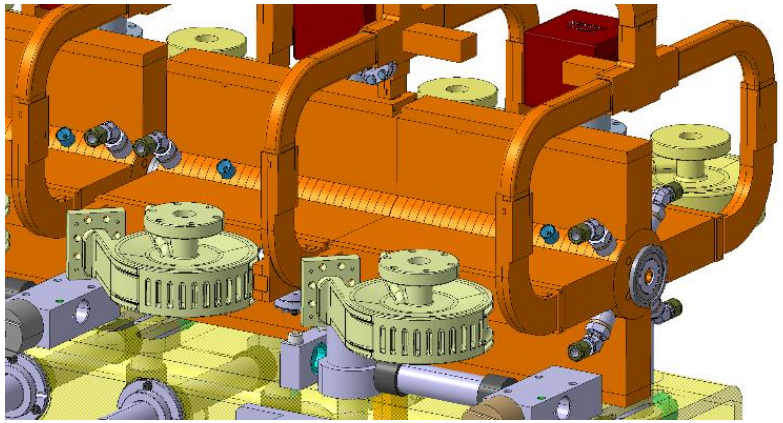
Currently looking at 250mm Square Section

1. **Pros**
   a) Similar width to the round-disc and rectangular-disc structures
   b) Space below the SAS adjustment for actuators etc.
2. **Cons**
   a) No space below the girder for wire sensors
   b) If we maintain the lab beam height, the vertical actuators are close to the floor
   c) Cannot maintain lab beam axis and wire locations, would need to go down to 200mm wide girder

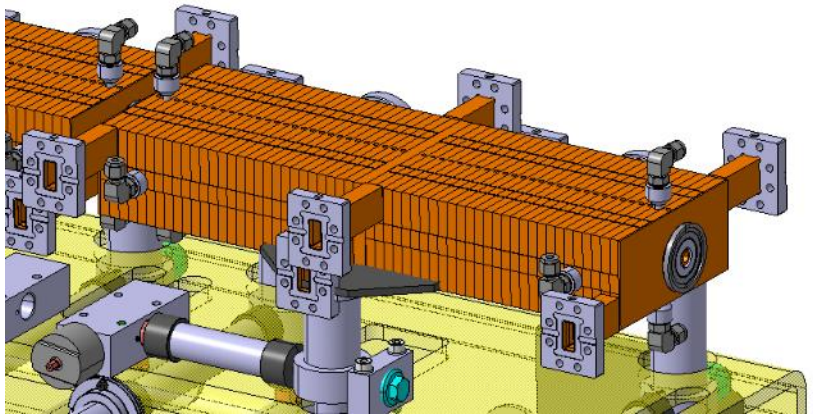
Structure Design & Alignment

Structure considerations:

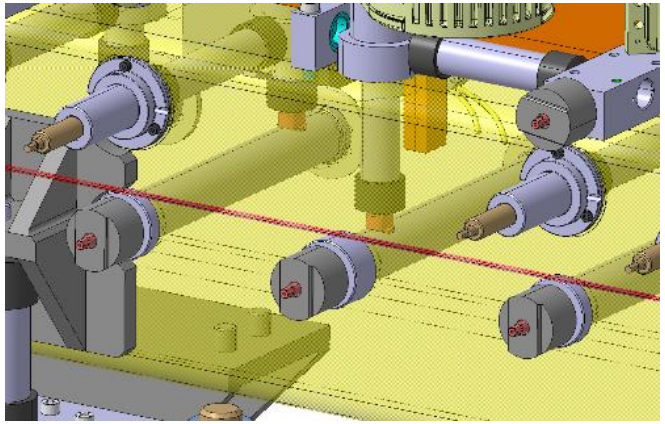
1. Structure alignment?
   a) What are the requirements for fiducialisation?
   b) What is the longitudinal reference?
   c) What are the requirement for outside geometry, and are there differences for the rectangular or round disc structures?
2. What adjustment range is required?
3. What are the requirements for compatibility with the motorised adjustment support system
   a) Current designs simply copy the adjustment interface from the drive beam quadrupole system – is this appropriate?



Round disc structure



Rectangular disc structure



Structure adjustment points

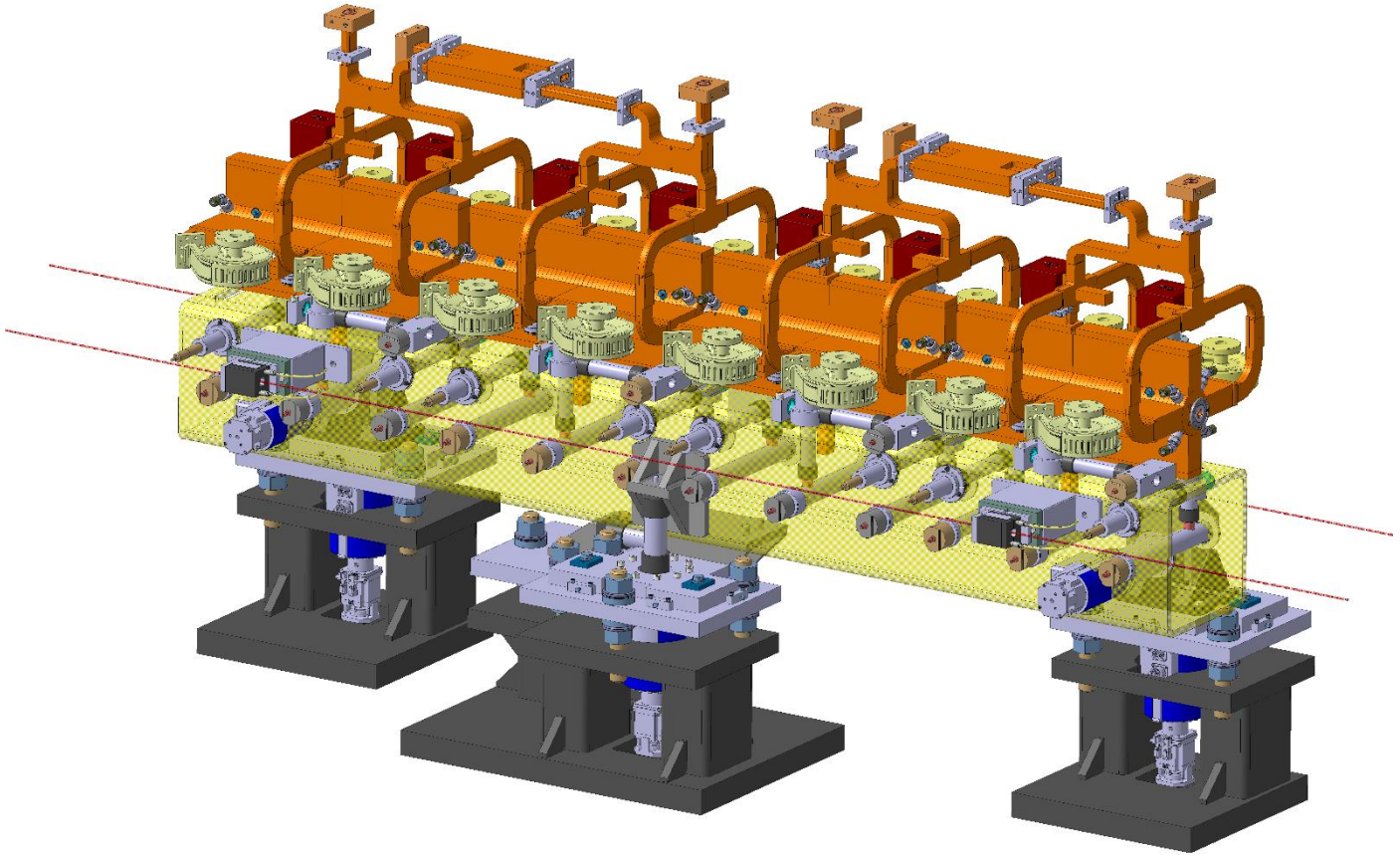
Module Design & Alignment

Module considerations:

1. Module alignment?
    1. What is the longitudinal reference?
    2. Is the adjustment for the longitudinal axis passive?
2. What adjustment range is required?
3. Are the previous linear actuators suitable?

CLIC Version considerations:

1. Any significant changes between the lab test module and the final installed CLIC version?



Module model

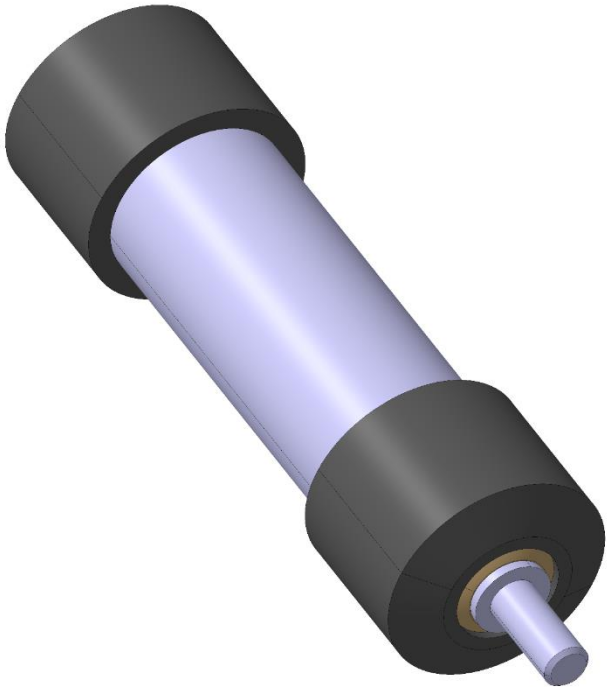
Equipment

Actuators

Which equipment can be reused?

1. Linear Actuators
   a) Were the actuators fit for purpose, and could they be reused?
   b) Do we have enough (3 large, 3 small) spares? CLEAR?
   c) What loads were the two versions rated for, and can the large actuators be inverted & loaded in compression?
   d) Is there potential to reduce the size of the large actuator for CLIC?
   e) Do we have axial stiffness test data?
2. Actuator control equipment
   a) Controllers, power supplies, cables, control software?
3. Wire position sensors?
   a) Capacitive or optical?
4. Any other sensors data loggers?
5. Any other equipment?

Universal Joints



BE-GM Designed Universal Joints

Universal Joints

1. The current module design intends to use the BE-GM designed Universal Joints for the alignment of the structures and the module:
   a) Do we have axial stiffness test data from prototypes?
      - Is this dependent on the angle on the joint?

   b) Have different diameter bearings been considered or tested to increase the stiffness of the joint?
   c) Why was aluminium chosen for the central ‘core’ component?
      - Axial stiffness and thermal expansion?

   d) Do we have design feedback from the prototypes?
      - Wear during use?
      - Material choices?
      - Bearing supplier?

Alignment and Testing Programme

Test Programme Requirements:

1. Requirements for meaningful alignment tests in the Lab?
2. Requirements for meaningful stability tests in the Lab?
3. Requirement and differences for a CLIC installation?
4. Requirements for taking absolute measurements with the PACMAN bench or CMM?
5. Requirements for alignment or adjustment using a mobile FSI measurement system?
6. Requirements for transportation and transportation tests?
7. Requirements for additional sensors and cabling on the test module?

Summary of Questions by Component:

1. **Structures:**
   a) Required number and location of reference surfaces and/or fiducials.
   b) Inclusion of longitudinal reference on the structures.
   c) What is the required adjustment range for the SAS?
   d) System for motorisation of structure support?
2. **Wire Position Sensors:**
   a) Could we move the wire locations to a more favourable location?
      a) This would likely involve moving the reference plates within the lab.
   b) Do we have sufficient Wire Sensors to use?
      a) If so, what type are they (optical or capacitive)?
3. **Actuators:**
   a) Do we have additional spare actuators?
      a) Would we need to disassemble one of the existing modules to reuse the actuators, or can we reuse any actuators from the CLEAR module?
   b) What specification were the actuators designed for?
      a) What loads were the vertical (larger) and horizontal (smaller) actuators designed for?
4. **Control Systems & Power Supplies:**
   a) Do we have the required control systems & power supplies?
      a) Are the control systems and power supplies we have dependent on the reuse of the existing actuator?
   b) Do we have suitable data acquisition and control/command software?
   c) Do we have a suitable data storage solution?
5. **Universal Joints:**
   a) Do we have test data for the prototype universal joints?
      a) Axial stiffness test data?
      b) Feedback from previous prototypes?
      c) Have we considered, explored, or tested larger diameter bearings for higher stiffness joints?
6. **Girder:**
   a) What is the required adjustment range for the girder?
   b) How many axes of active adjustment are required, 5 or 6?
   c) What, if any, longitudinal reference feature is required on the girder?