Wire Scanner
Mechanical Design Concept

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2nd BI Forum

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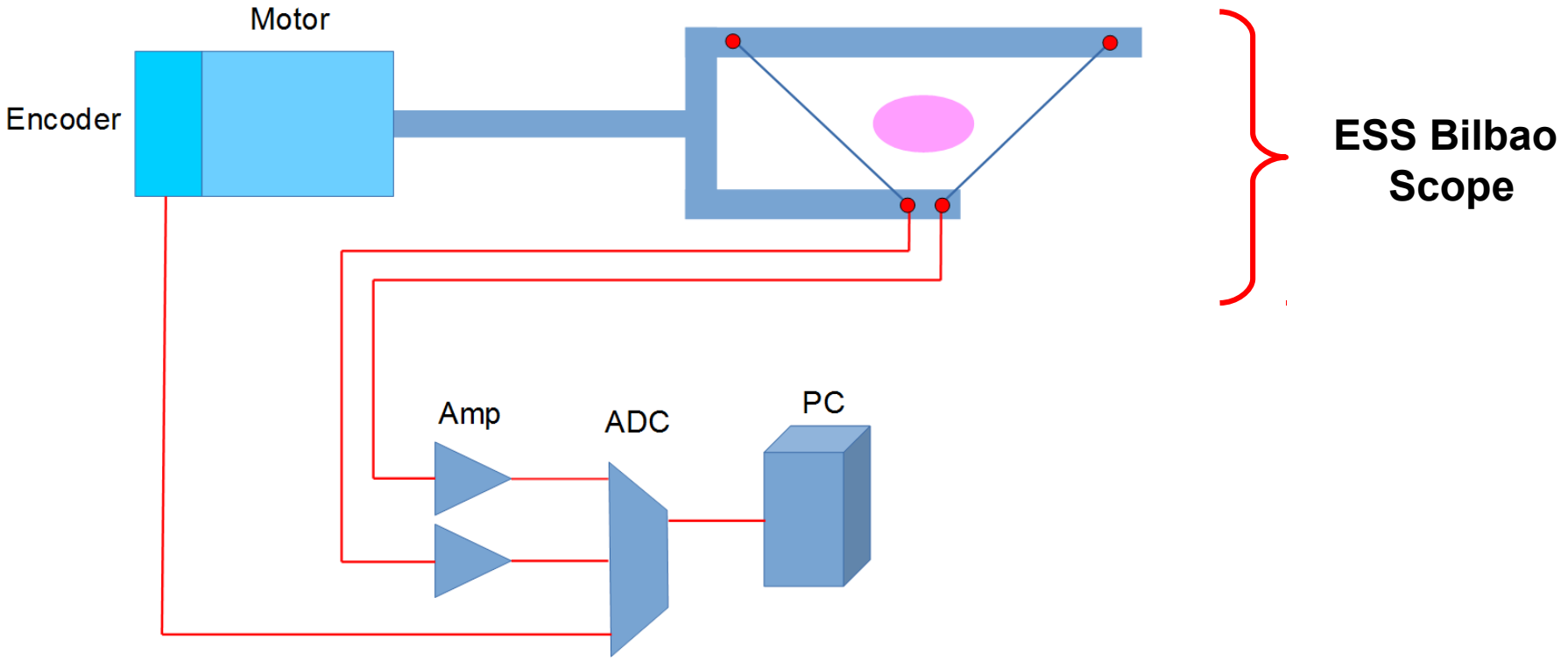
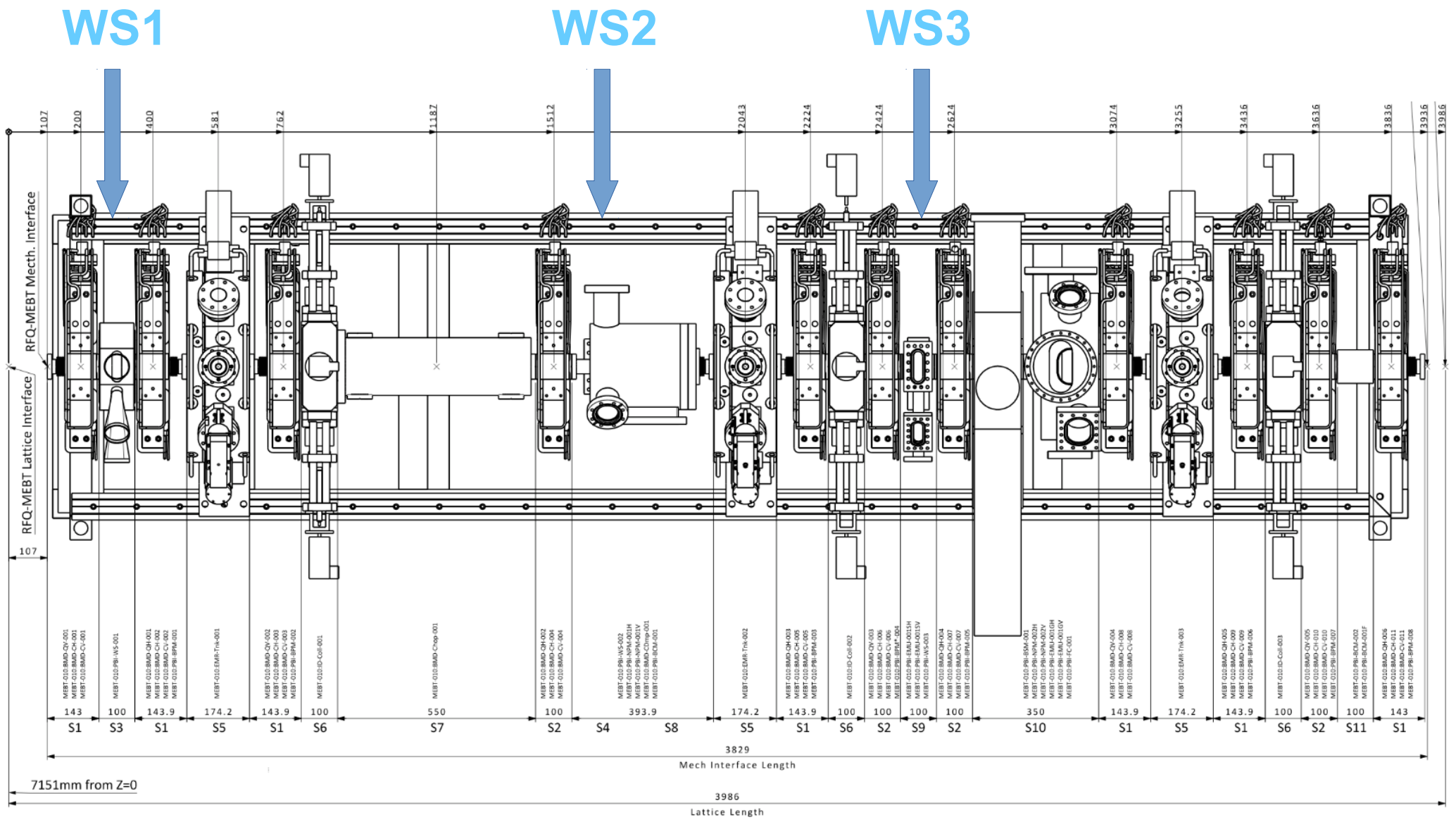
Introduction

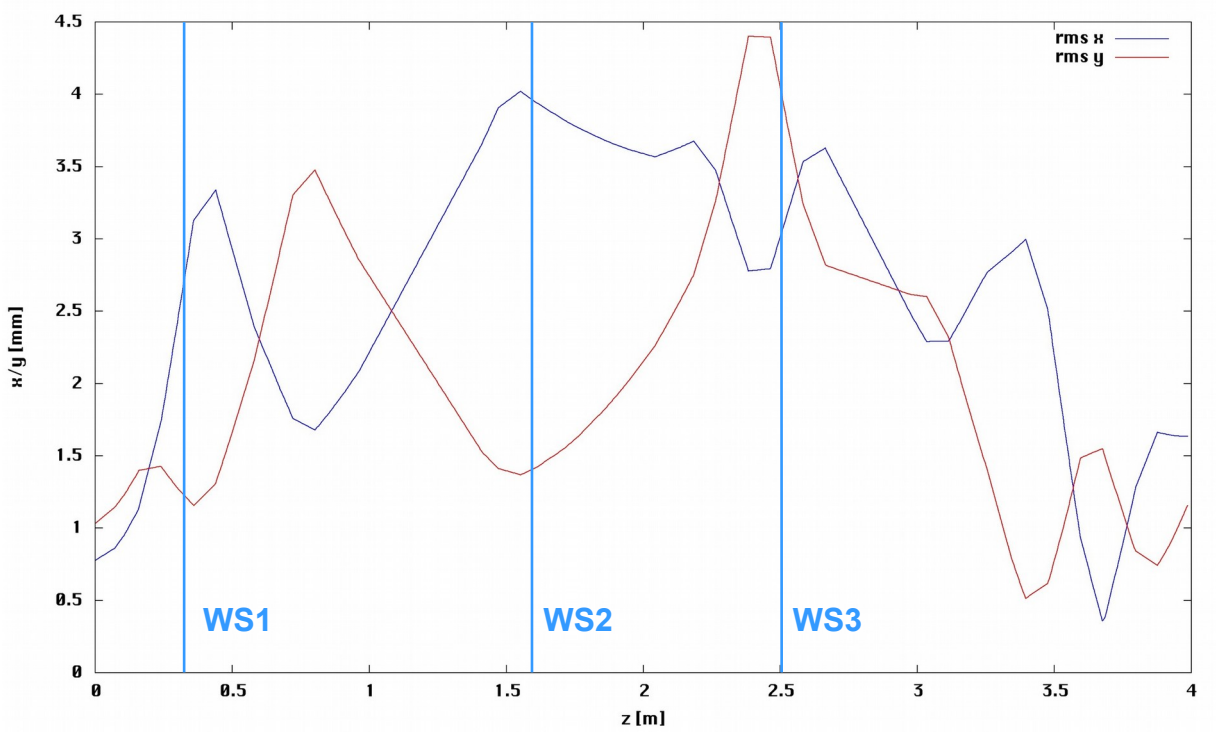


- Preferred solution to beam profile measurements on ESS Medium Energy Beam Transport line (MEBT).
- 3 Wire Scanner will be installed in the line.
- The fork and actuator mechanical design will be identical.

Introduction: WS Positions



Introduction: Expected beam sizes



Expected Beam Sizes (2015.v0c)	Long Location (m)	Sigma_x (mm)	Sigma_y (mm)	Ratio (sigma_x/sigma_y)
WS1	0,3	2,43	1,277	**1,9**
WS2	1,612	3,923	1,432	**2,74**
WS3	2,524	3,157	3,835	**0,82**

Requirements

Name	Definition
Transverse profile measurements: Planes for the measurements.	Transverse profile measurements shall be done in the two transverse planes (**Horizontal and Vertical**) those planes being defined withrespect to the general ESS coordinate system.
Transverse profile measurements: Accuracy.	The RMS transverse extension of the proton beam shall be measured with an accuracy better than **10%**.
Transverse profile measurements: Resolution.	The rms transverse extension of the proton beam shall be measured with a resolution better than **50 micrometers**.

Angular error budget

Cumulative angular errors affect the motion direction and the wire orientation.

Motion axis orientation error

$$\Delta\alpha_m = \Delta\alpha_{vc} + \Delta\alpha_f + \Delta\alpha_{f\downarrow a} + \Delta\alpha_{ag}$$

Shaft & fork orientation error

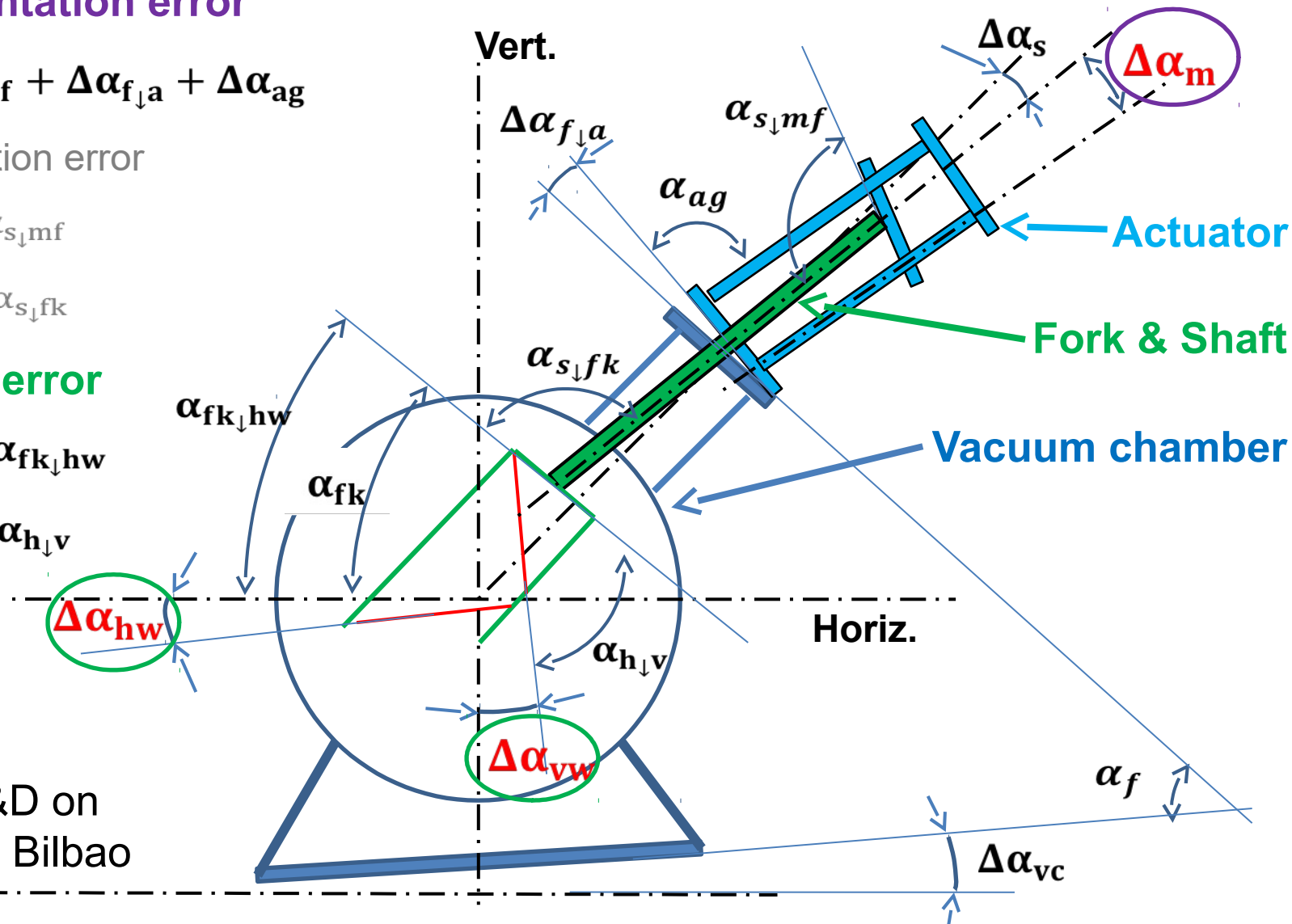
$$\Delta\alpha_s = \Delta\alpha_m + \Delta\alpha_{s\downarrow mf}$$

$$\Delta\alpha_{fk} = \Delta\alpha_s + \Delta\alpha_{s\downarrow fk}$$

Wire orientation error

$$\Delta\alpha_{hw} = \Delta\alpha_{fk} + \Delta\alpha_{fk\downarrow hw}$$

$$\Delta\alpha_{vw} = \Delta\alpha_{hw} + \Delta\alpha_{h\downarrow v}$$



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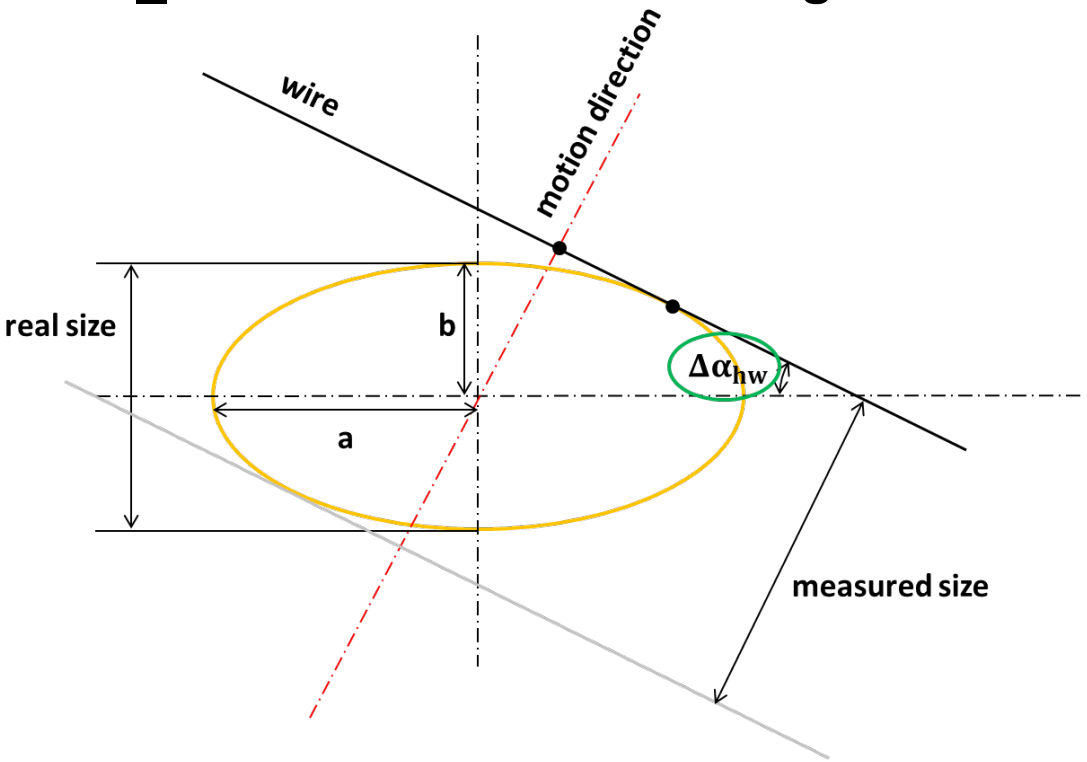
Angular error budget

SYMBOL	ERROR (mrad)	DESCRIPTION / REMARKS
Δα_vc	0.10	Angular error between the vacuum chamber horizontal reference and the horizontal plane. The vacuum chamber reference plane can be machined better than 0.05mm on 500 mm
Δα_f	3.33	Angular error between the flange and the horizontal reference on the Vacuum chamber, it is expected that the full orientation and flatness error on the flange respect to the chamber reference can be better than 0.5 mm on a CF 150 flange (150 mm)
Δα_(f_a)	0.13	Error induced by machining flatness between the flange and the actuator connection, a conservative value is 0.02mm/150mm
Δα_ag	0.25	Angular error between actuator guides and fix actuator flange, it can be better than 0.1 mm on 400 mm
Δα_m	**3.82**	**Motion direction angular error, resulting error**
Δα_(s_mf)	12.50	A conservative value is 5 mm on 400 mm, due to shelf weigh deflection and machining errors
Δα_s	**16.32**	**Shaft orientation error, resulting error**
Δα_(s_fk)	0.40	Perpendicularity can be better than 0.02 mm on 50 mm
Δα_fk	**16.72**	**Angular error between the fork reference and the horizontal plane, resulting error**
Δα_(fk_hw)	5.26	Angular error between the fork reference and the horizontal wire, a conservative value is 0.4 mm on 76 mm
Δα_hw	**21.98**	**Horizontal wire angular error**
Δα_(h_v)	5.26	Angular error between the horizontal and vertical wire, based on 0.4 mm in 76 mm that would be a conservative machining error
Δα_vw	**27.24**	**Vertical wire angular error**

Angular error budget

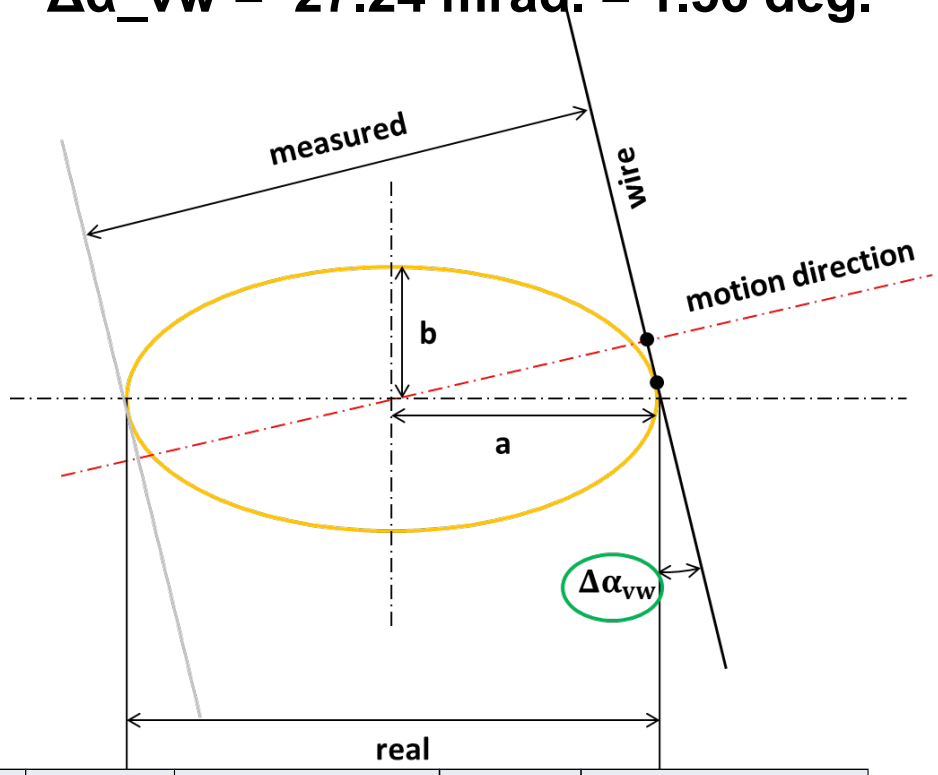
Vertical

Δα_hw = 21.98 rad. = 1.26 deg.



Horizontal

Δα_vw = 27.24 mrad. = 1.56 deg.

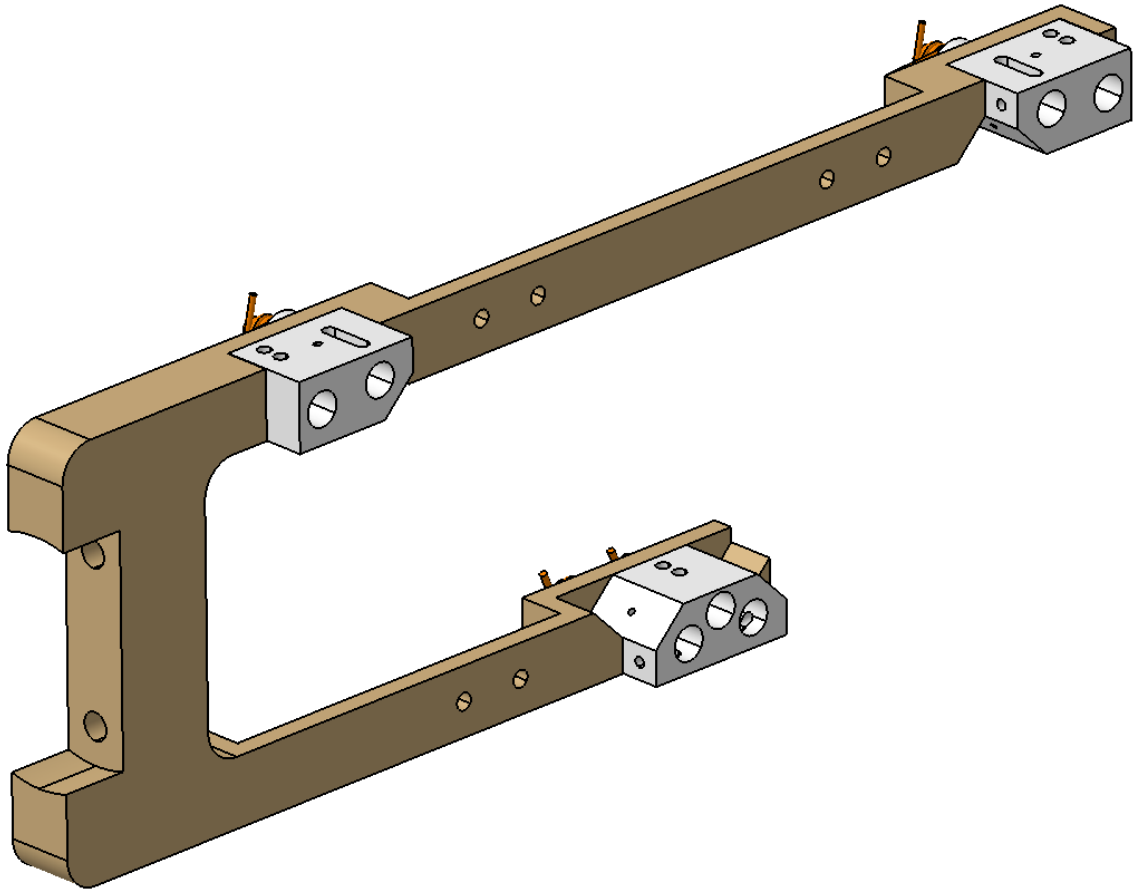


2015.v0c	Long. Location* (mm)	Sigma_x (mm)	Sigma_y (mm)	Sig._x/Sig._y (a/b)	Δα_hw [deg.]	Relative size error Vert. [%]	Δα_vw [deg.]	Relative size error Horiz. [%]
WS1	300	2.43	1.277	1.903	1.26	**<2%**	1.56	**<2%**
WS2	1612	3.923	1.432	2.740	1.26	**<2%**	1.56	**<2%**
WS3/Slit	2524	3.157	3.835	0.823	1.26	**<2%**	1.56	**<2%**

Design Concept

- The principal restrictions of the design are the followings.
  - The recommended material for the wires is Carbon. The fragility of this material need to be taken into account in the fixation system design.
  - Due to the ESS Vacuum Handbook limitations and forbidden materials a mechanical fixation system should be implemented.
  - A minimum accuracy on the wires fixation should be reached in order to achieve the Level 4 requirements of transverse profile measurement.

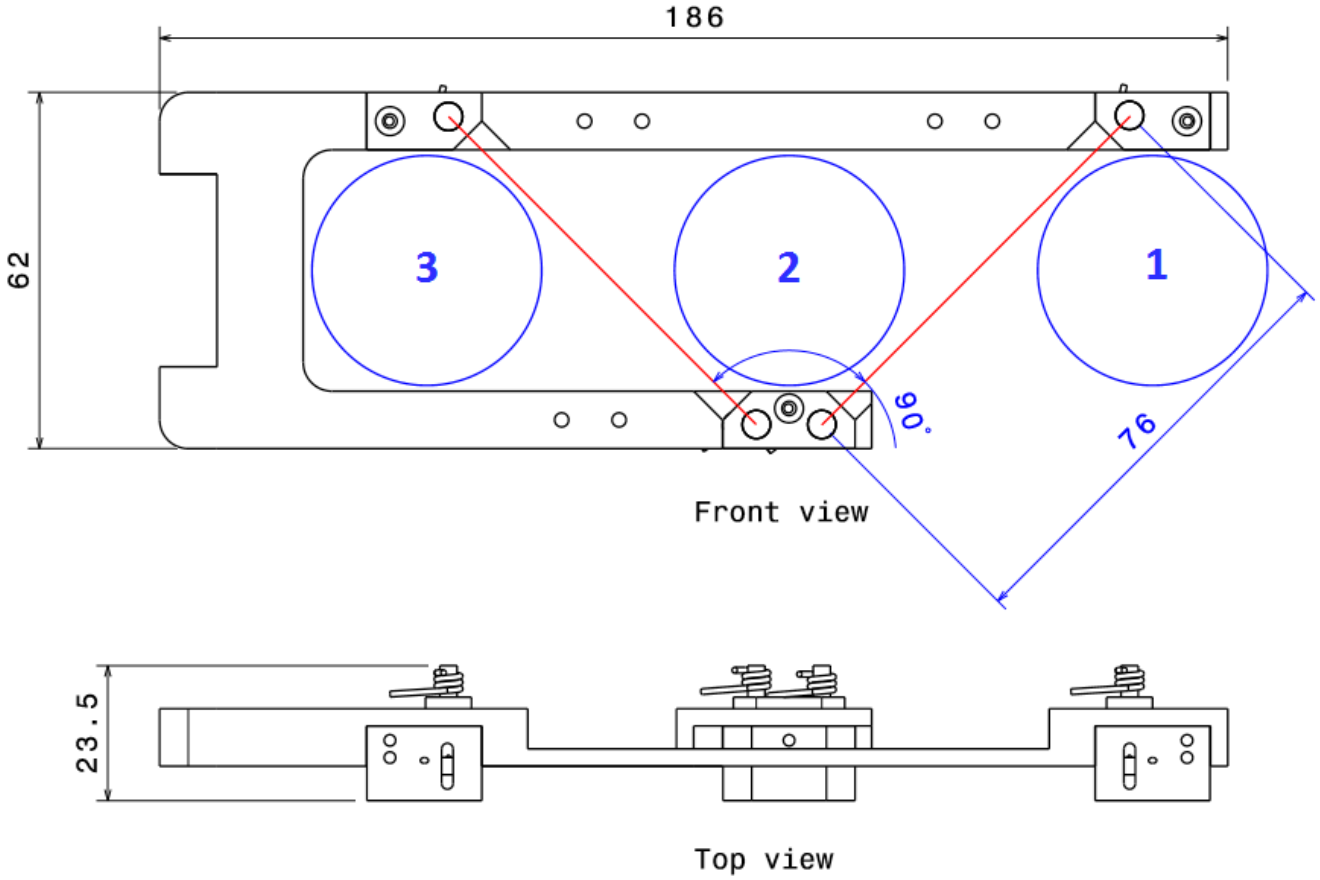
Design Concept



- Main characteristic of the conceptual design:

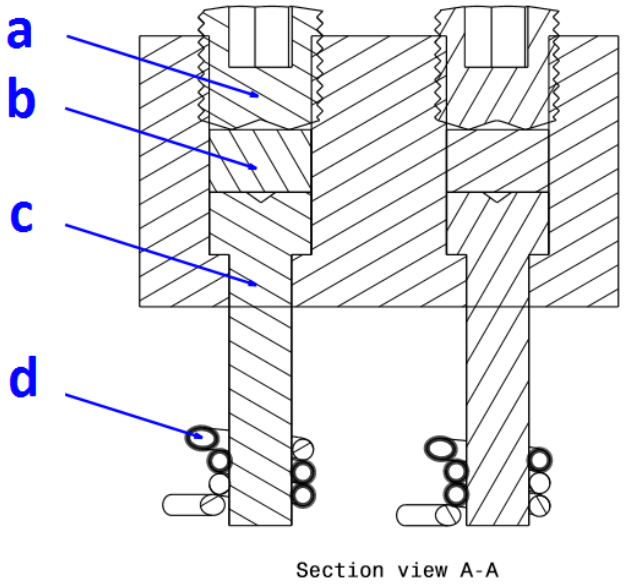
- The two wires are placed with an angle of 90º to avoid cross talk between wires.
- Three insulator pieces are placed on a frame to fix the wires with the desired angle.
- The fixation system is based in pressing both ends of the wires between two pieces of a soft metal like copper.
- The copper plated of the wires ends is highly recommended.

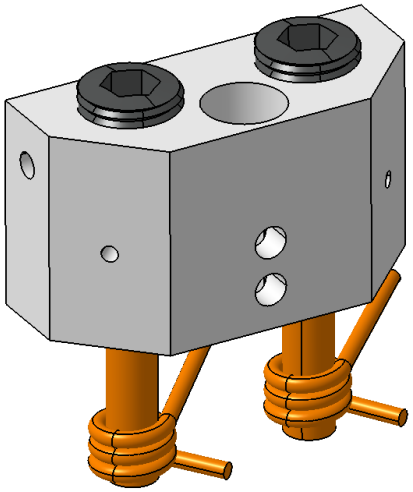
Design Concept

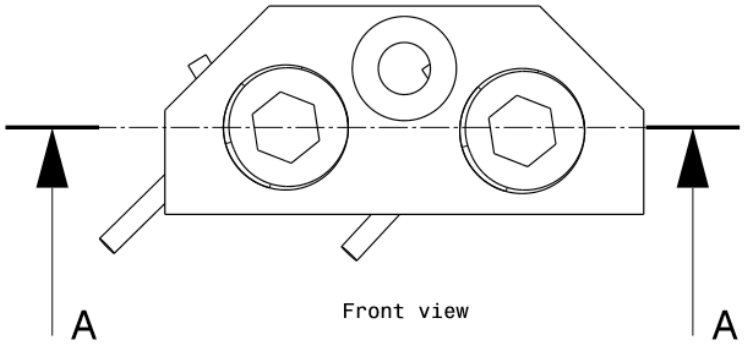


- Main characteristic of the conceptual design:
- The fork dimensions have been design to cover the total beam pipe with both wires during the scan displacement.
- The beam pipe is illustrated in blue with circles of 40mm diameter.
- In order to protect the insulators from the beam a metallic cover sill be placed above them.

Design Concept



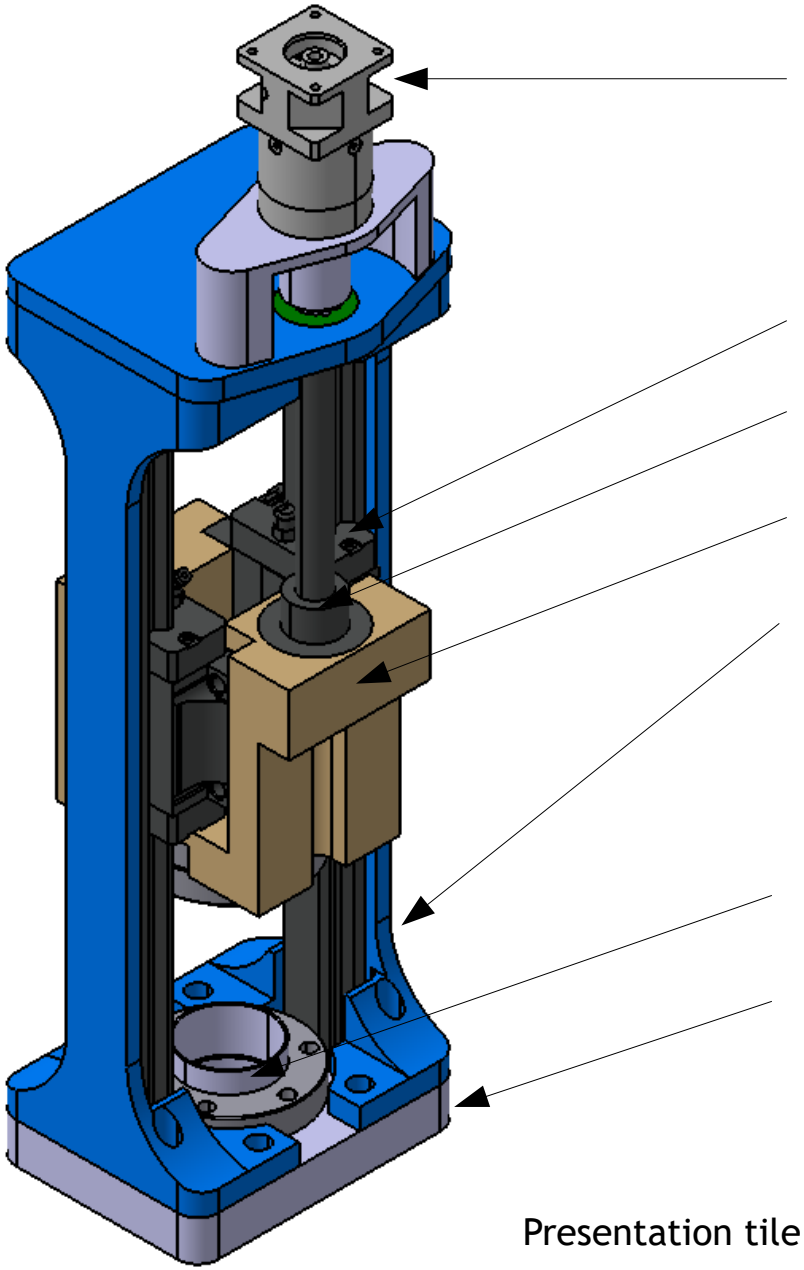




- Main characteristic of the conceptual design:

- The wires are clamped between pieces **b** and **c**. This two cylindrical pieces in a copper alloy like Cu-Be, with better mechanical properties than normal Cu.
- The signal induced on the wires will be measured across piece **c**.
- A spring, piece **d**, could be a solution to do the union between the piece c and the signal vacuum cable.
- The piece **a** is a screw to keep the wires fixed.

Actuator Mechanical Concept



Motor

Linear Guides

Spindle

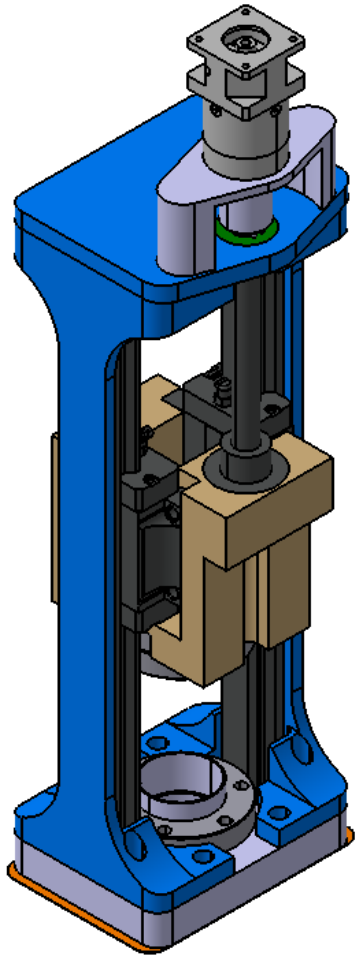
Bellow clamping system

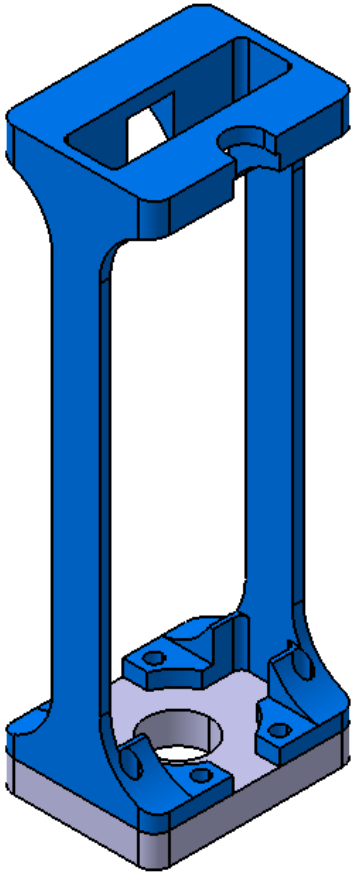
Guides frame

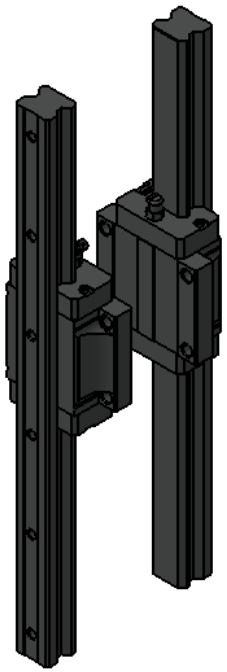
Bellow CF40

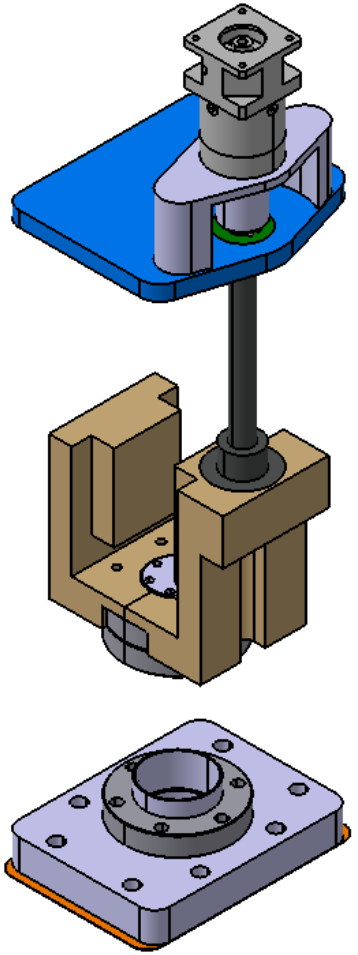
Rectangular Flange 100x130mm

Actuator Mechanical Concept





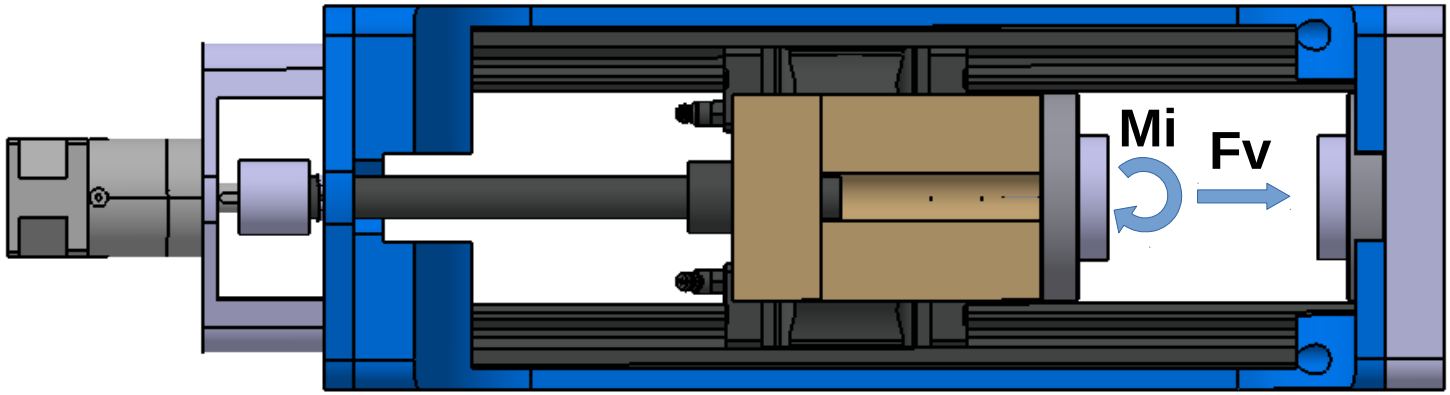




Actuator Forces

The forces applied to the movement system are:

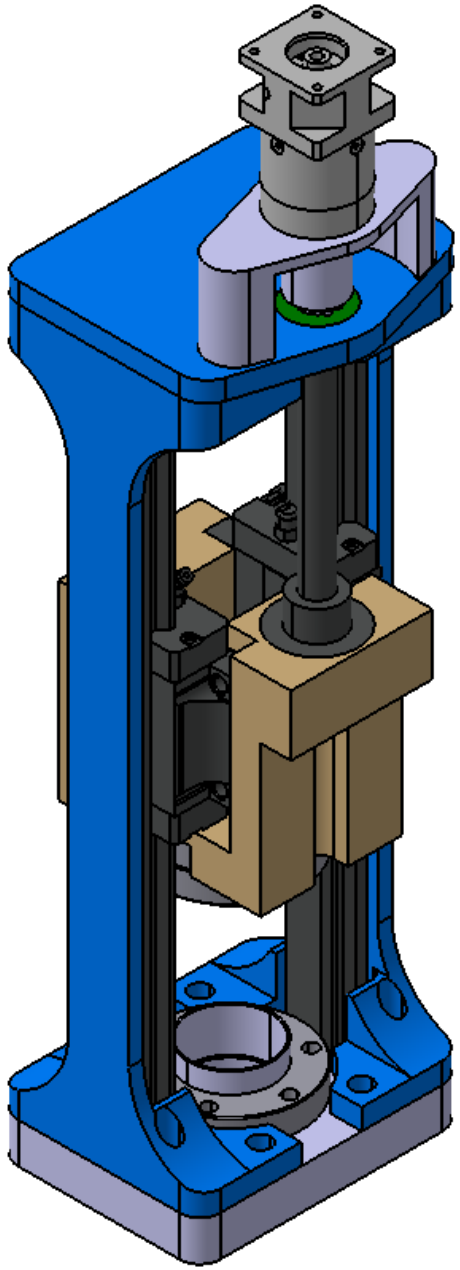
Fv = **176,62 N**
Mi = **4 Nm**



Actuator main characteristics

- The actuator shall be placed over a 100x130mm rectangular flange. The external dimensions of the flange are fixed but the screws position could be changed.
- The total volume of the actuator shall be inside the projection of the rectangular flange surface.
- The total stroke of the actuator shall be 230mm.
- The actuator bellow shall be CF40.
- The conceptual design is based in the idea of using two linear guides to move the instrument with precision and rigidity.
- The actuator shall be irreversible.
- The resolution of the travel shall be better than 50um.

Actuator Mechanical Concept



Mechanical concept under evaluation by:

SCHNEEBERGER LINEAR TECHNOLOGY

IKO Innovation, Know-how & Originality

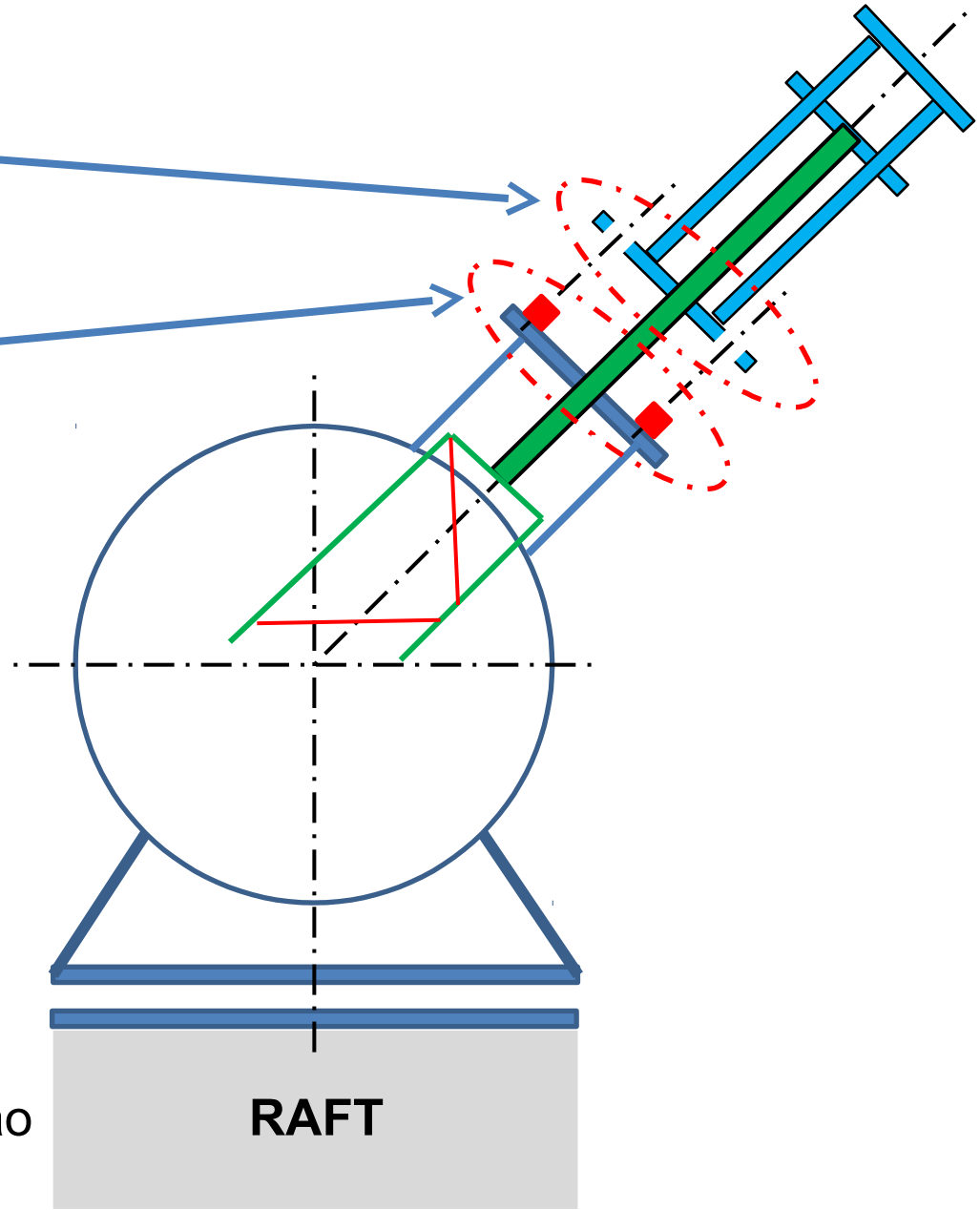
THK The Mark of Linear Motion

Wire replacement

2 precision holes on the actuator flange

2 precision pins on the vacuum chamber flange

Allow to replace the wire and other maintenance tasks ensuring repeatability



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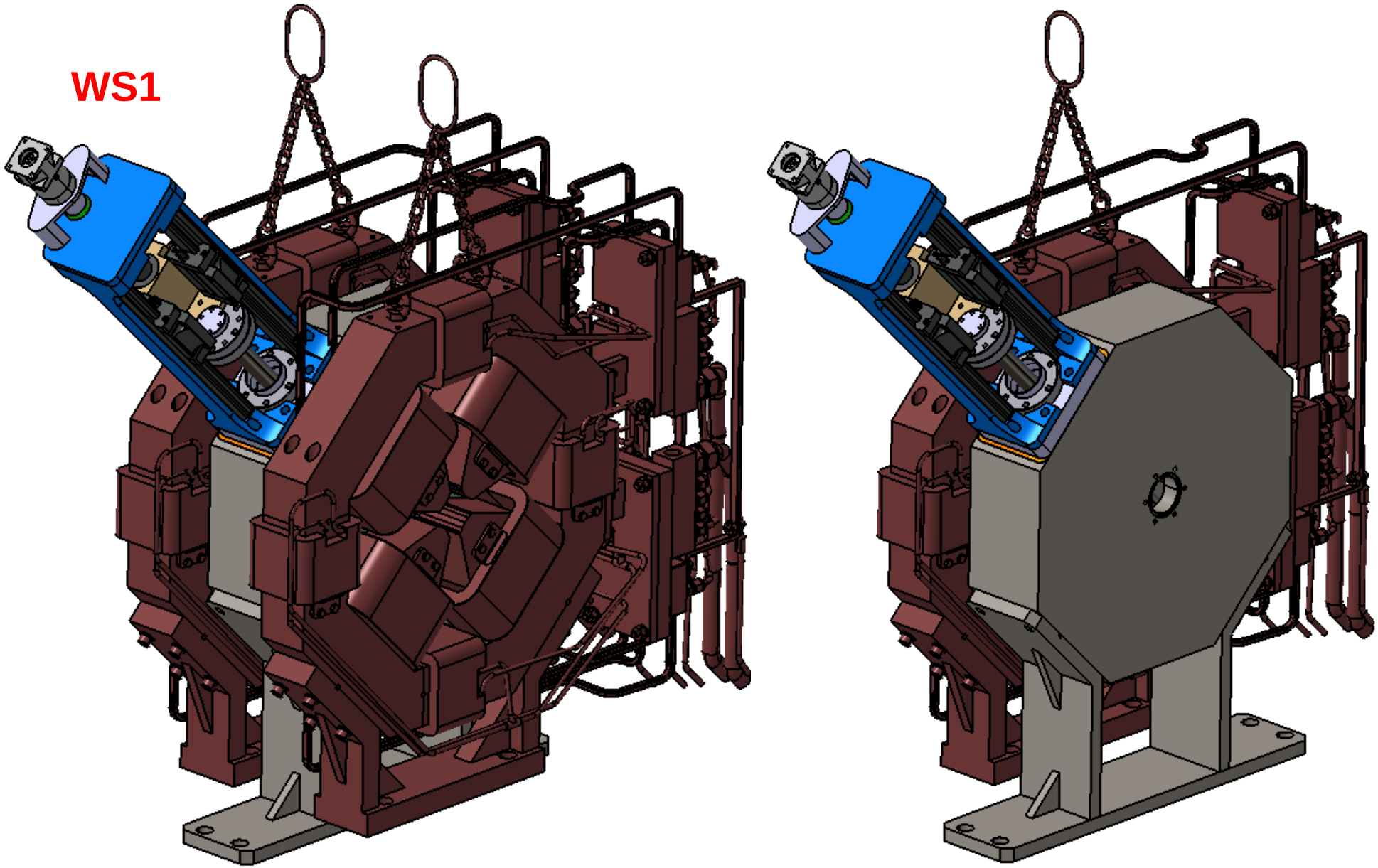
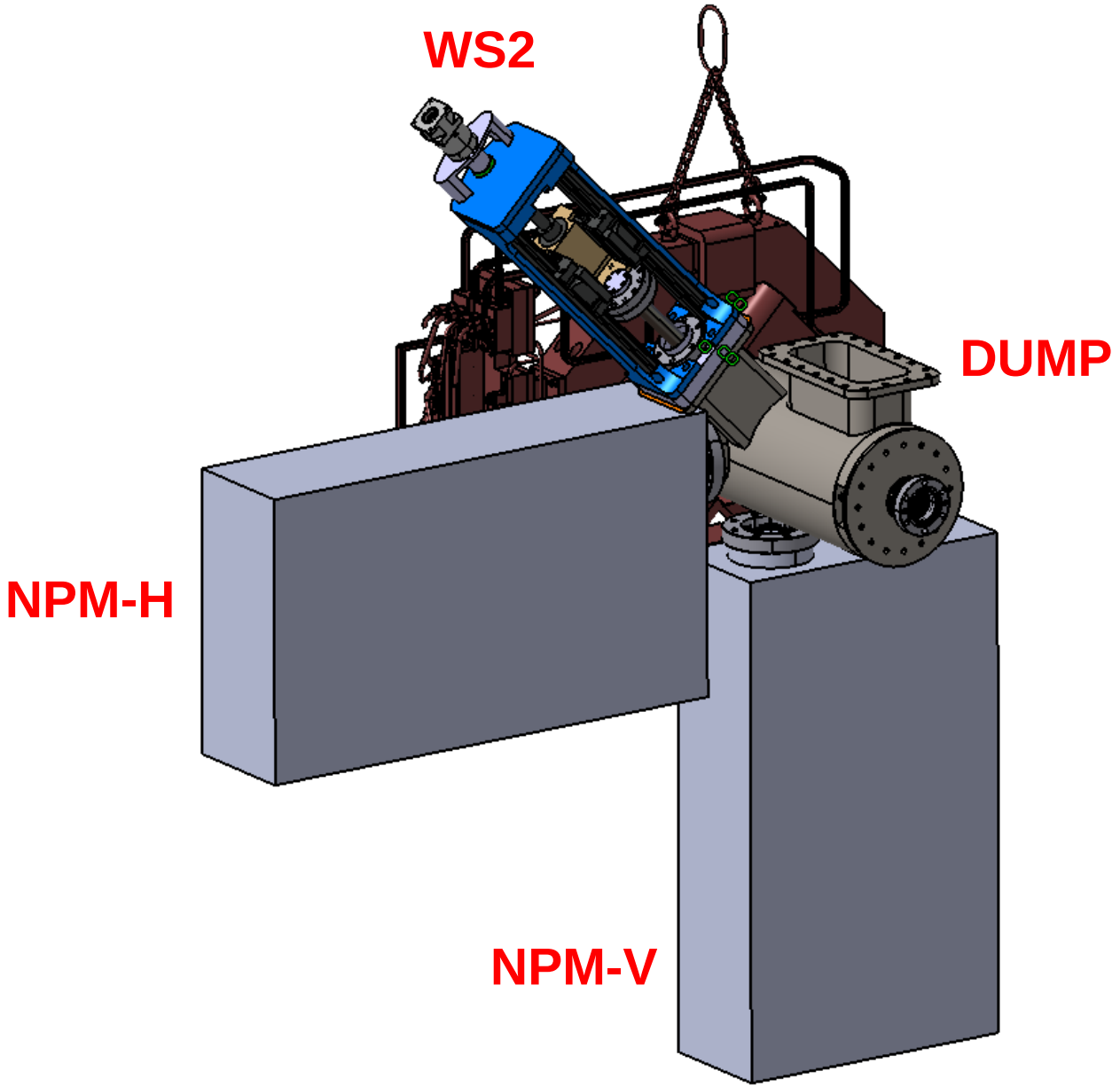
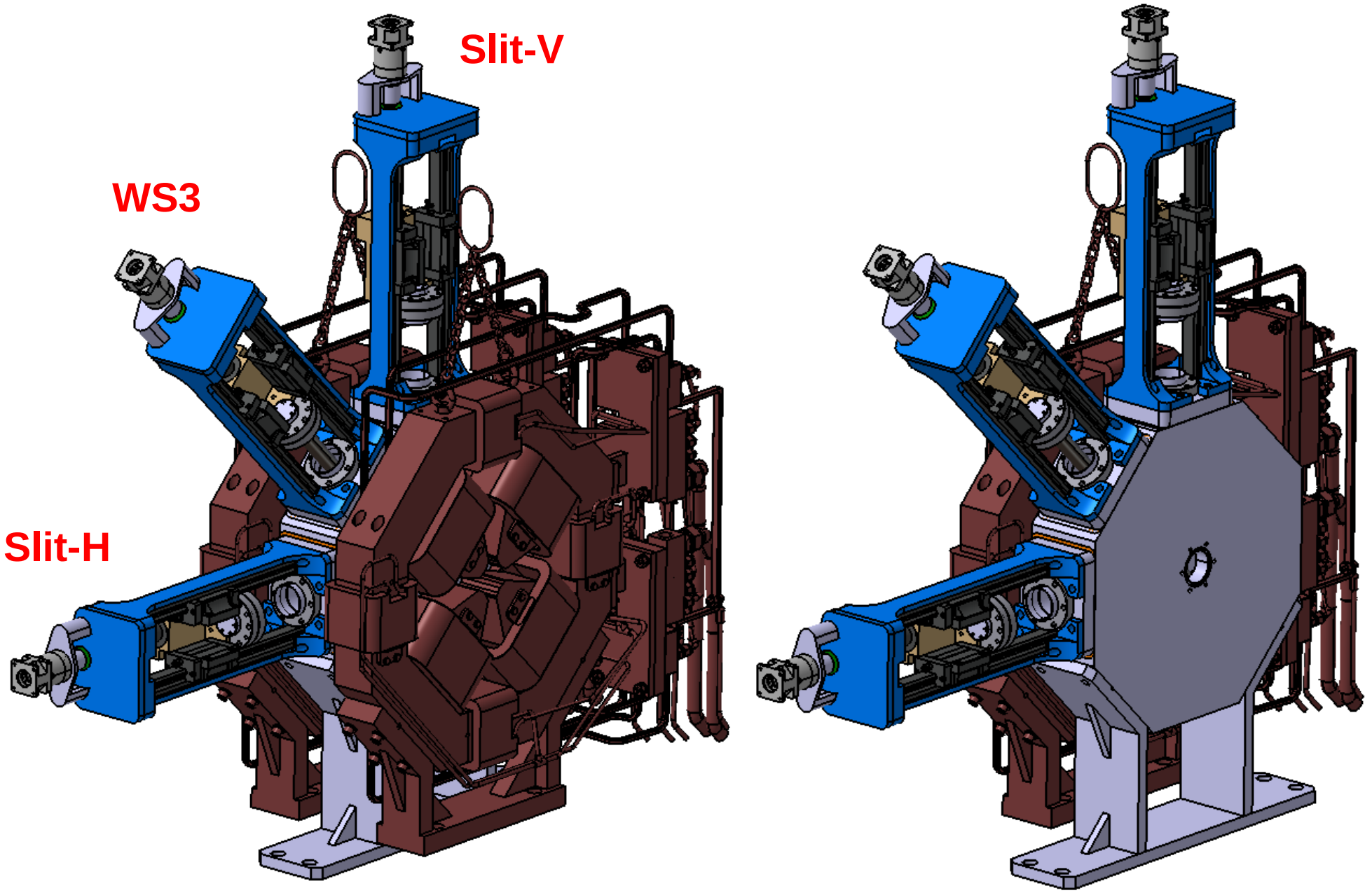
Vessel Integration - S03



Vessel Integration - S48

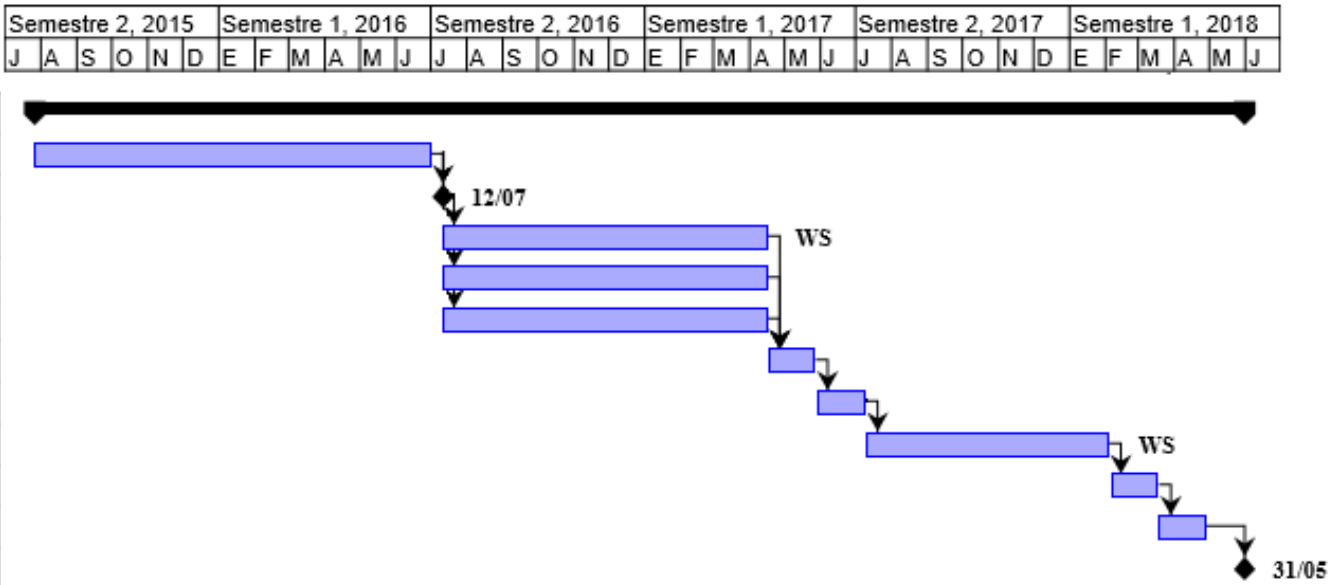


Vessel Integration - S09



Planning

WS	744 days?
WS: Conceptual Design	245 days?
WS: PDR	0 days
WS: Fork Detailed Design and prototyping	200 days
WS: Actuator Detailed Design and prototyping	200 days
WS: Metrology Test Bench Design	200 days
WS: Actuator Metrology Campaign	30 days
WS: Technical Drawings	30 days
WS: Fabrication	150 days
WS: Mechanica and vacuum Tests	30 days
WS: Integration	30 days
WS: Delivery	0 days



Planning after PDR:

- Detailed Design – 200 days
- Metrology Campaign – 30 days
- Technical Drawings – 30 days
- Fabrication – 150 days
- Mechanical and vacuum tests – 30 days
- Integration – 30 days