BEER INSTRUMENT

SHUTTER – Design Description

Nuclear Physics Institute, CAS
BEER instrument

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List of abbreviations:

APTE	Application aux Techniques d'Entreprise
BEER	Beamline for European Materials Engineering Research
BD	Basic design
DD	Detail design
FAST	Function Analysis System Technique
FAT	Factory Acceptance Test
ESS	European Spallation Source
PUR	Poly-urethane rubber
NBR	Nitrile butadiene rubber
EDPM	Ethylene Propylene Diene M-class
FPM, FKM, PTFE	Fluoropolymers
POM	Polyoxymethylen
I&C	Instrumentation and Control
NPI	Nuclear Physics Institute
PSS	Personnel Safety System
SAT	Site Acceptance Test
TCS	Target Coordinate System

1 INTRODUCTION

The BEER instrument is one of the instruments build at ESS dedicated to engineering related research. One of the key components which serve safety purposes to block the neutron beam is a Instrument shutter. The purpose of this document is to summarise the technical specification of the Instrument shutter based on the detailed design provided in accordance and agreement with ESS standards, technical policies and radiological calculations, which were approved by ESS authorities.

2 SHUTTER DESIGN

2.1 GENERAL DESCRIPTION

The Instrument shutter is part of the BEER instrument. It is located just after the bunker wall at a distance of about 18 m from the source. The body of the shutter is placed in the so-called shutter pit in building D03. In Figure 1 is shown a schematic layout of the BEER instrument, and the Instrument shutter is represented by the black rectangle with arrows.

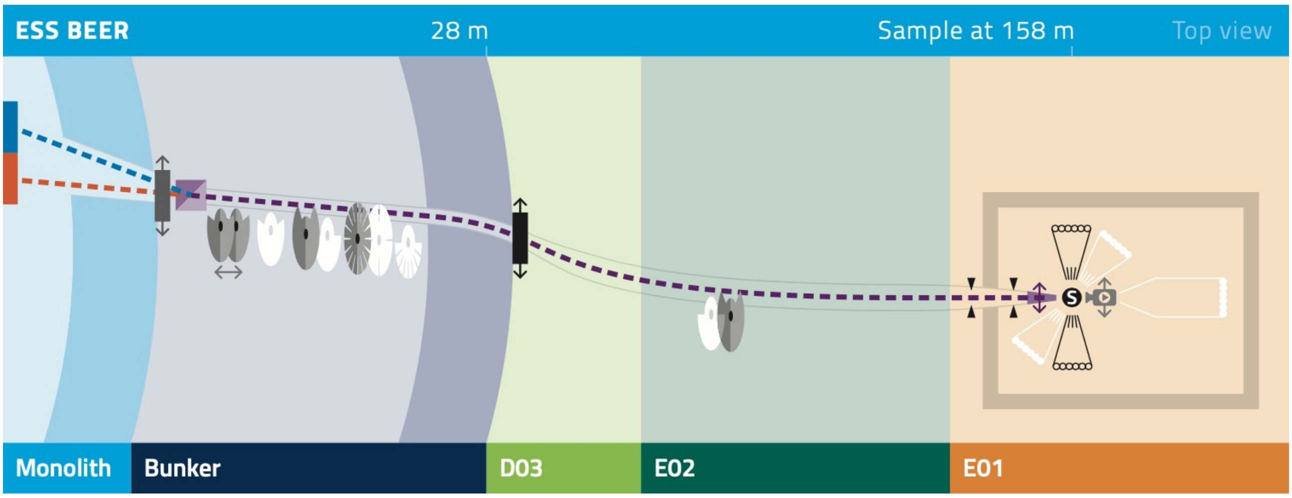


Figure 1: The BEER instrument schematic layout

The main functions of the shutter are:

- Shield the neutron beam to allow safe personnel access in the required areas down-stream from the shutter (hall D03, hall E02, experimental hall E01, shutter pit in D03, chopper pit in E02, experimental cave, shielding tunnel, …),
- Guide the neutron beam between the end window of bunker-wall insert assembly and the start window of the E02 neutron transport guide,

3D views of the shutter in the shutter pit and its surrounding is shown in Figure 2 and Figure 3.

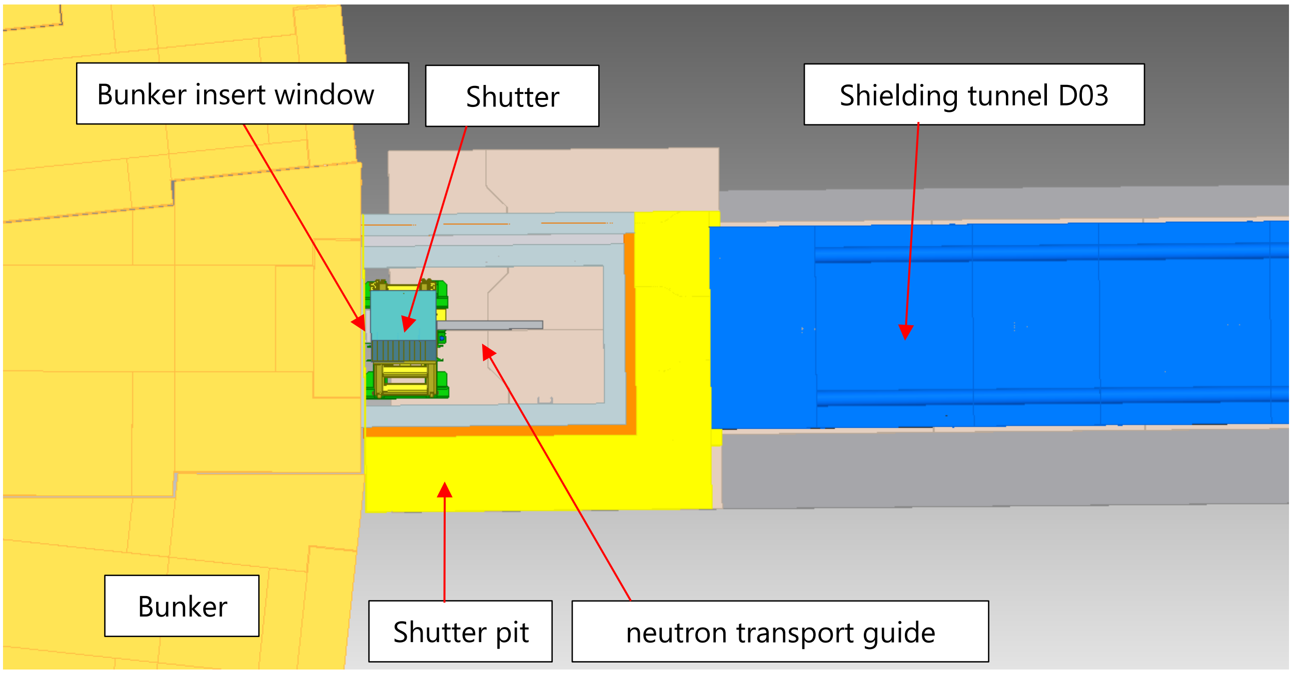


Figure 2: 3D view of the shutter inside the shutter pit

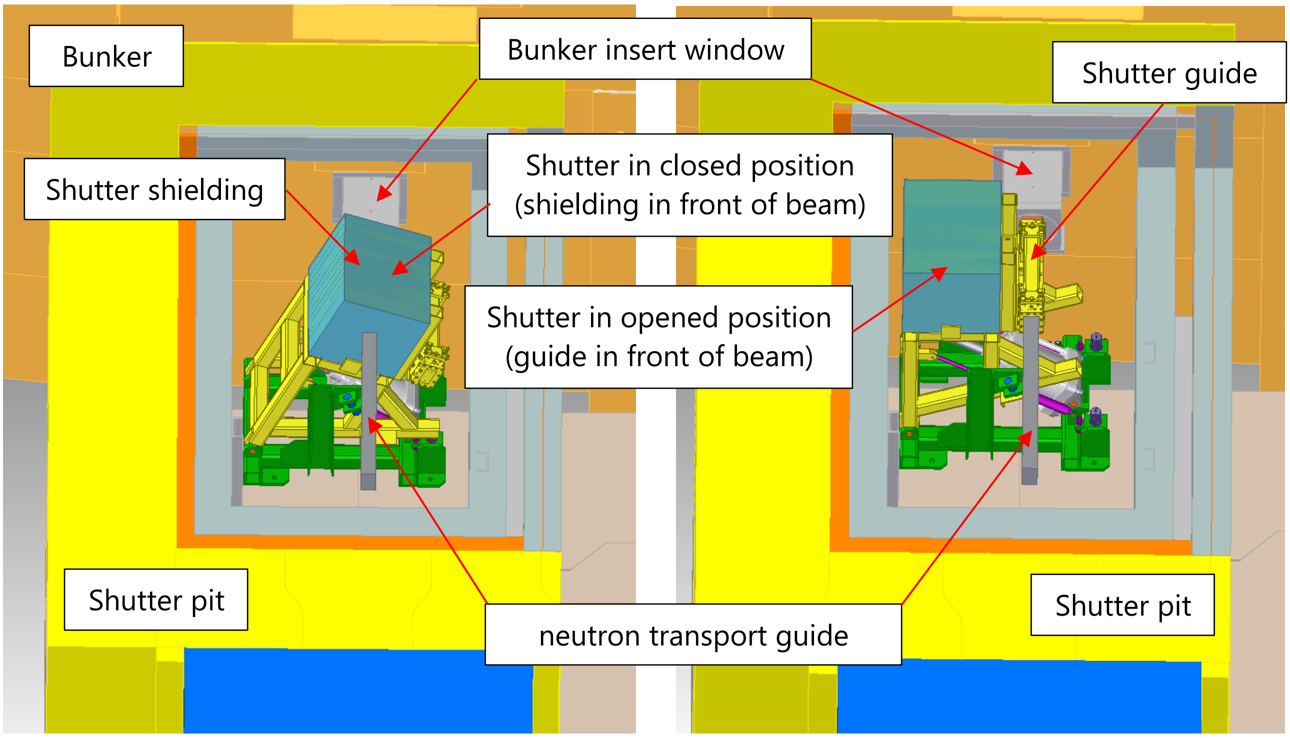


Figure 3: 3D view of the shutter in the shutter pit in the closed position (left) and opened position (right)

2.2 INTERFACES

The main interfaces of the shutter with other systems are described below.

Interface	To component
End-switch system	Personal safety system
Utility connections	Bunker cable tray

Interface	To component
Moving mechanism	Instrument control
Shutter frame	Elevating blocks in D03 hall
Shutter body	End-windows of bunker-wall insert
Shutter body	Start-window of the transport guide
Shutter frame	Support for guide assembly

Table 1: Shutter - interfaces

The shutter sub-system has three external interfaces to ESS or another in-kind partner:

1. Personal safety system (PSS) end switches integration (ESS)
2. Utility connection of power and compressed air (ESS)
3. Instrument control system (in-kind partner)

The internal interfaces of the shutter sub-system are:

4. Elevating blocks in the D03 hall (ESS)
5. End window of bunker-wall insert assembly (in-kind partner)
6. Start window of the E02 neutron transport guide (in-kind partner)
7. Support for shutter neutron guide assembly and its alignment (in-kind partner)

An interface between the shutter neutron guide and ESS vacuum supply shall also be considered.

2.3 BATTERY LIMITS

A 3D view of the shutter assembly design is shown in Figure 4.

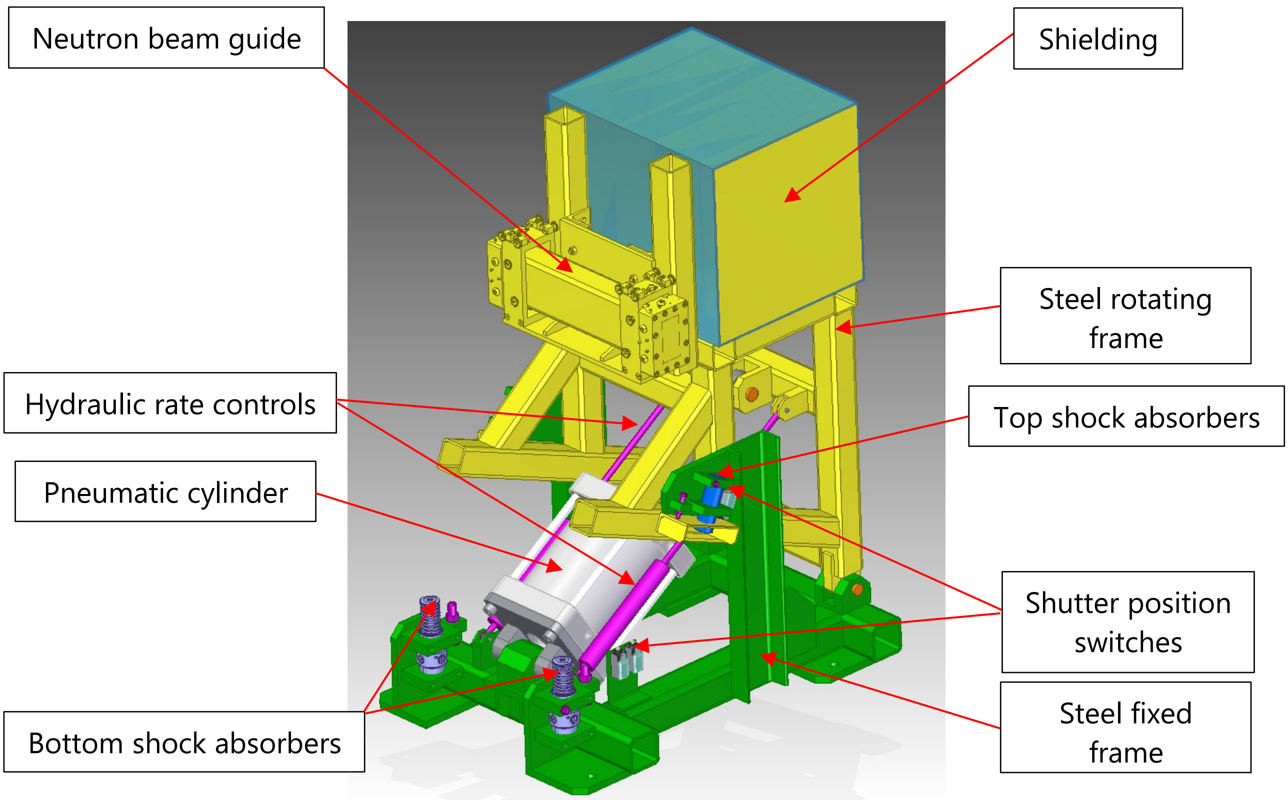


Figure 4: 3D view of the shutter assembly design

The shutter includes the following parts:

- Shielding
- Neutron beam guide (delivered by in-kind partner)
- Steel frame fixed to the elevated concrete blocks of the shutter pit (green colour)
- Steel rotating frame that holds the shielding and the neutron beam guide (yellow colour)
- Pneumatic cylinder including control unit and piping to ESS compressed air supply
- 2 x hydraulic rate controls
- 4 x shock absorbers
- 2 x position switch for shutter operation (close and open position)
- 2 x safety switch for PSS (one magnetic and one mechanical)
- Electric cables for switches
- Anchorage to the shutter pit floor
- Vacuum pipes/hoses to connect neutron guides to ESS vacuum supply

2.4 ASSUMPTIONS

- Shutter pit inner dimensions are: 2730 (L) x 1740 (W) x 1950 (H). The neutron beam axis is at 1137 mm above the pit floor. However, the shutter pit width and height should not be reduced without careful check of the impact on the shutter design.
- The shutter is not classified as a safety component. There are two position switches (magnetic and mechanical) that detect when the shutter is closed position, and they are connected to PSS to permit interlocking of the shutter control unit. Those switches are classified as safety components.
- Dose rates calculated in [1] shows that when the beam is off, personnel access in the shutter pit to perform maintenance of the shutter or adjustment of the neutron guide shall be possible.
- Considering the small compressed air consumption of the shutter (pneumatic cylinder volume for one movement + leaks), it is supposed that 6 bars of compressed air can be supplied during the opening of the shutter. The compressed air supply shall be stable since it includes a buffer tank. When the shutter is closed, no pressure is required in the pneumatic cylinder to hold the shutter position since it will lay on mechanical stops. When the shutter is opened, a minimum pressure of 1.5 bars is required in the pneumatic cylinder to hold the shutter position.

2.5 FUNCTIONAL ANALYSIS

Functional analysis of the shutter has been performed using the APTE method. An octopus diagram of the system is shown in Figure 5. The associated main functions “FP” and constraint functions “FC” are listed in Table 2.

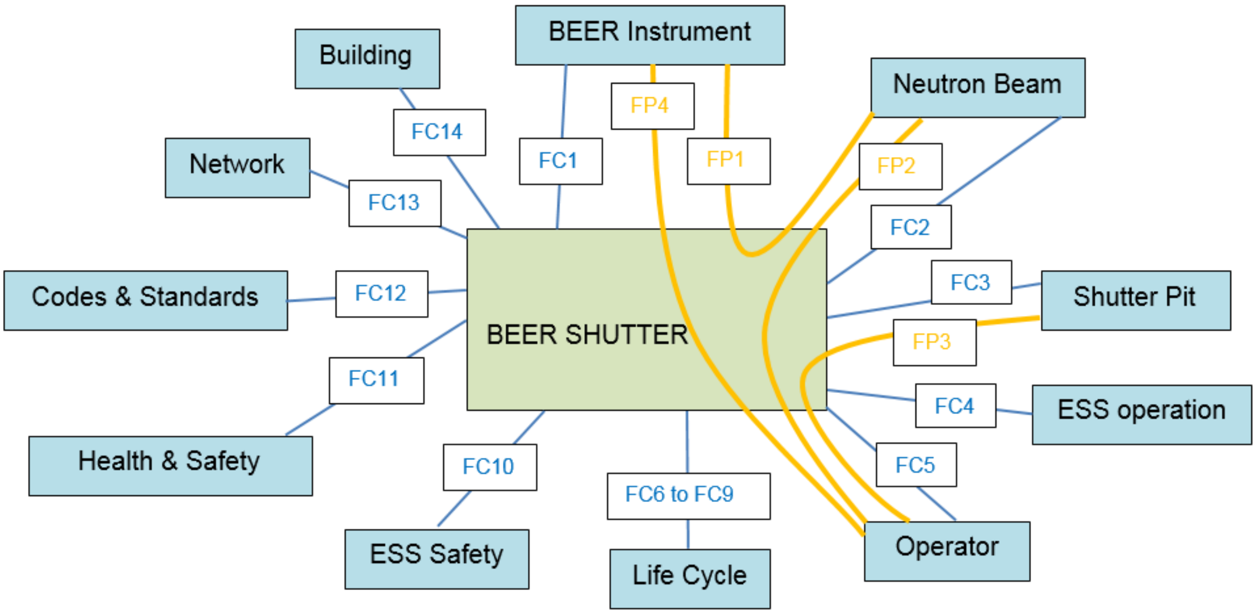
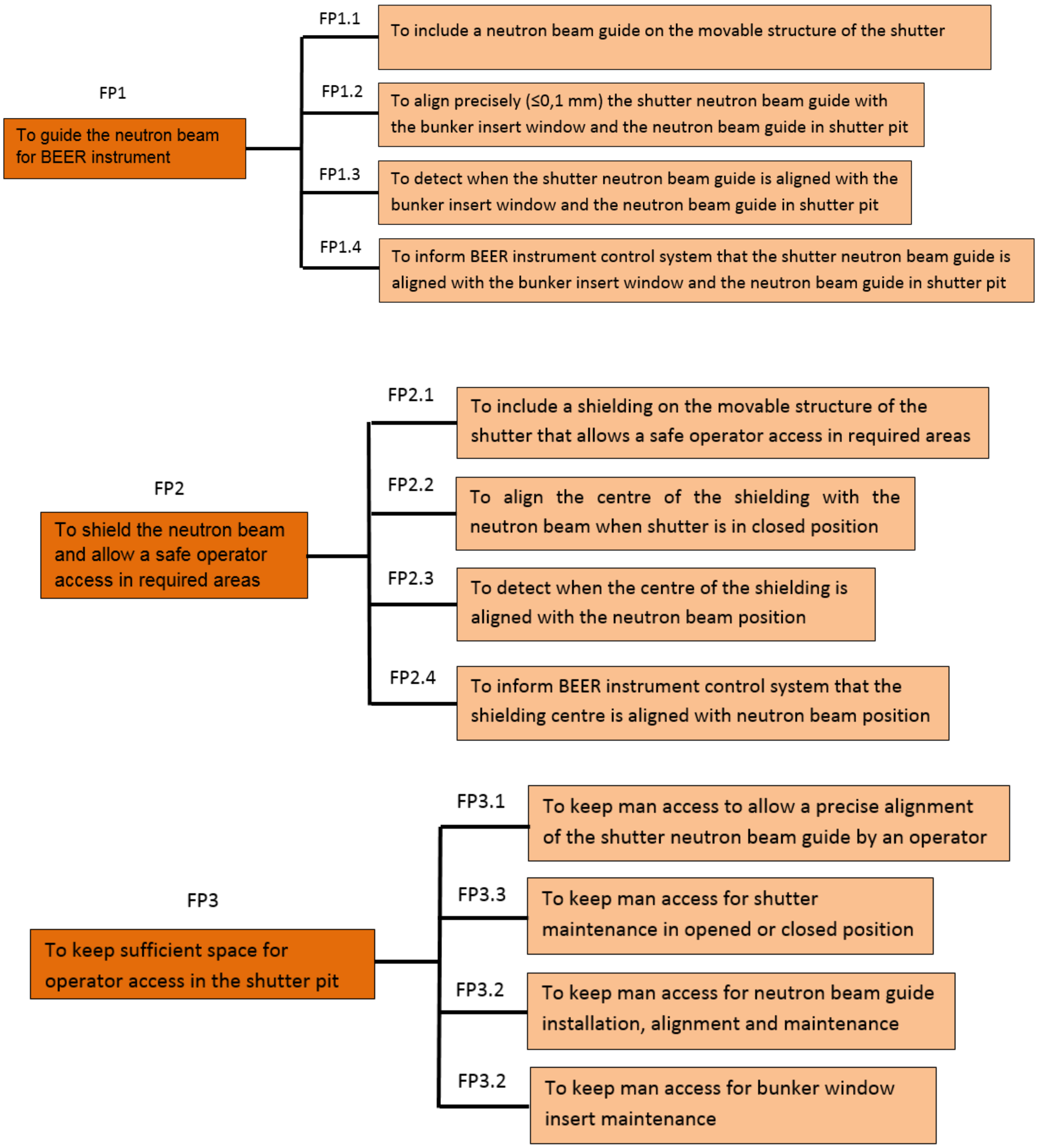


Figure 5: Octopus diagram of the shutter

ID.	Function
FP1	To guide the neutron beam for the BEER instrument
FP2	To shield the neutron beam and allow a safe operator access in required areas
FP3	To keep sufficient space for operator access in the shutter pit
FP4	To be operated according to the operation and maintenance plan of the BEER instrument
FC1	To be compatible with the BEER instrument design
FC2	To be compatible with a neutron beam
FC3	To be compatible with shutter pit design
FC4	To be compatible with ESS operation and maintenance plan
FC5	To be controlled by operators
FC6	To be maintainable
FC7	To allow inspection
FC8	To allow adjustment of the neutron guide
FC9	To have a lifetime of at least 20 years
FC10	To be compatible with ESS safety requirements
FC11	To comply with health and safety rules
FC12	To comply with codes and standards
FC13	To connect with Network
FC14	To be compatible with Building design

Table 2: List of functions of the shutter

FAST diagrams of the above functions are shown below in Figure 6 and Figure 7.


FP1
To guide the neutron beam for BEER instrument
FP1.1
To include a neutron beam guide on the movable structure of the shutter
FP1.2
To align precisely (≤0,1 mm) the shutter neutron beam guide with the bunker insert window and the neutron beam guide in shutter pit
FP1.3
To detect when the shutter neutron beam guide is aligned with the bunker insert window and the neutron beam guide in shutter pit
FP1.4
To inform BEER instrument control system that the shutter neutron beam guide is aligned with the bunker insert window and the neutron beam guide in shutter pit
FP2
To shield the neutron beam and allow a safe operator access in required areas
FP2.1
To include a shielding on the movable structure of the shutter that allows a safe operator access in required areas
FP2.2
To align the centre of the shielding with the neutron beam when shutter is in closed position
FP2.3
To detect when the centre of the shielding is aligned with the neutron beam position
FP2.4
To inform BEER instrument control system that the shielding centre is aligned with neutron beam position
FP3
To keep sufficient space for operator access in the shutter pit
FP3.1
To keep man access to allow a precise alignment of the shutter neutron beam guide by an operator
FP3.3
To keep man access for shutter maintenance in opened or closed position
FP3.2
To keep man access for neutron beam guide installation, alignment and maintenance
FP3.2
To keep man access for bunker window insert maintenance

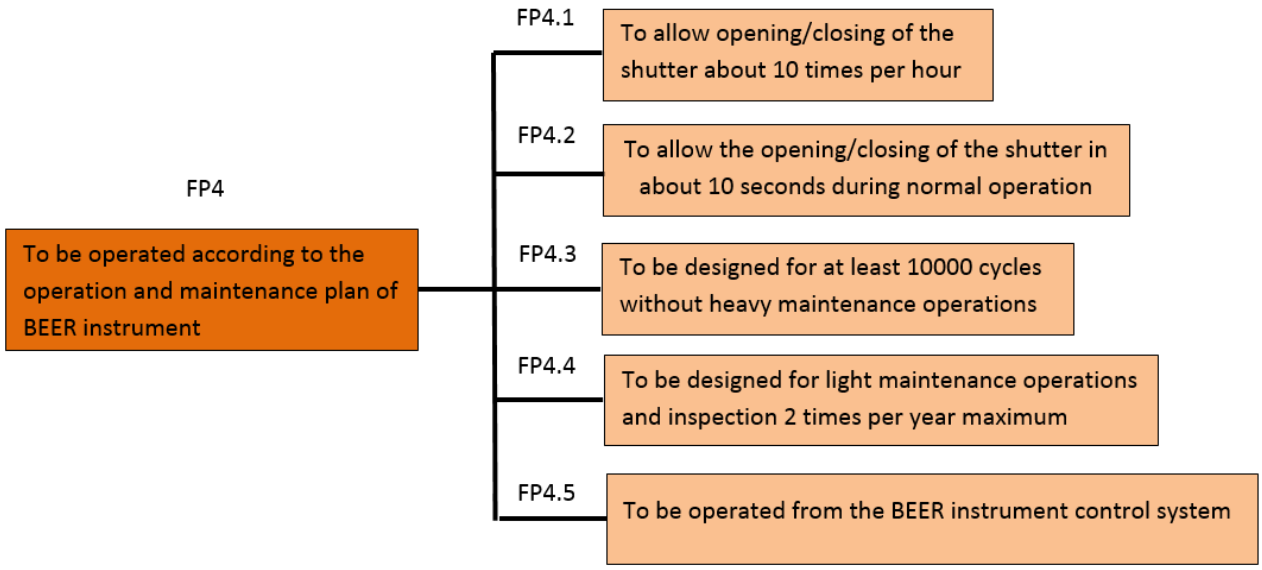
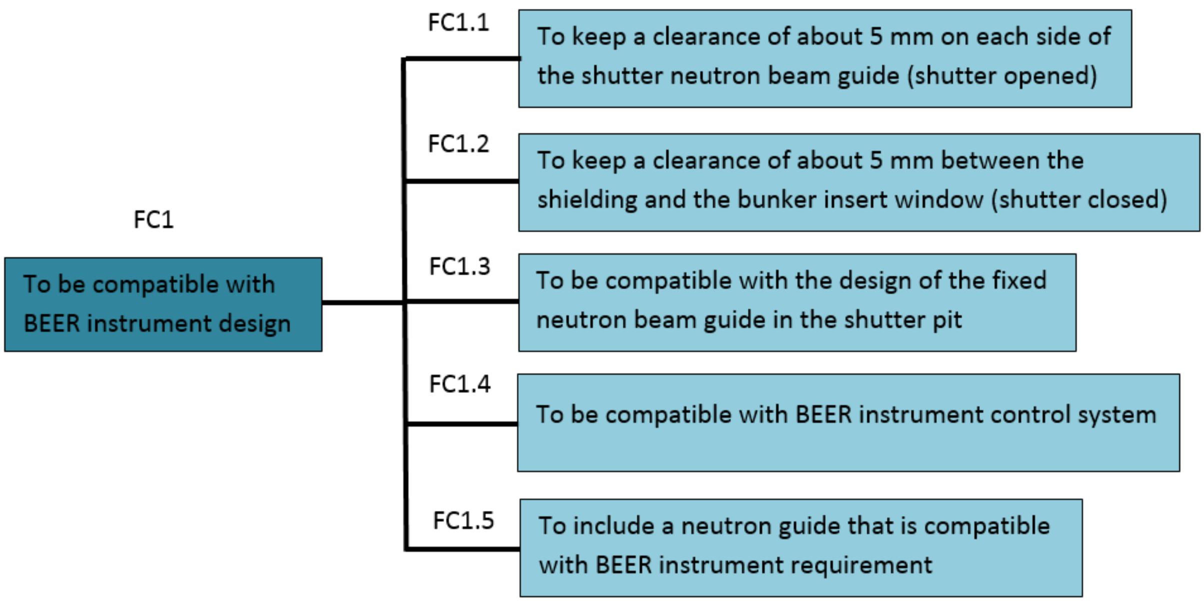
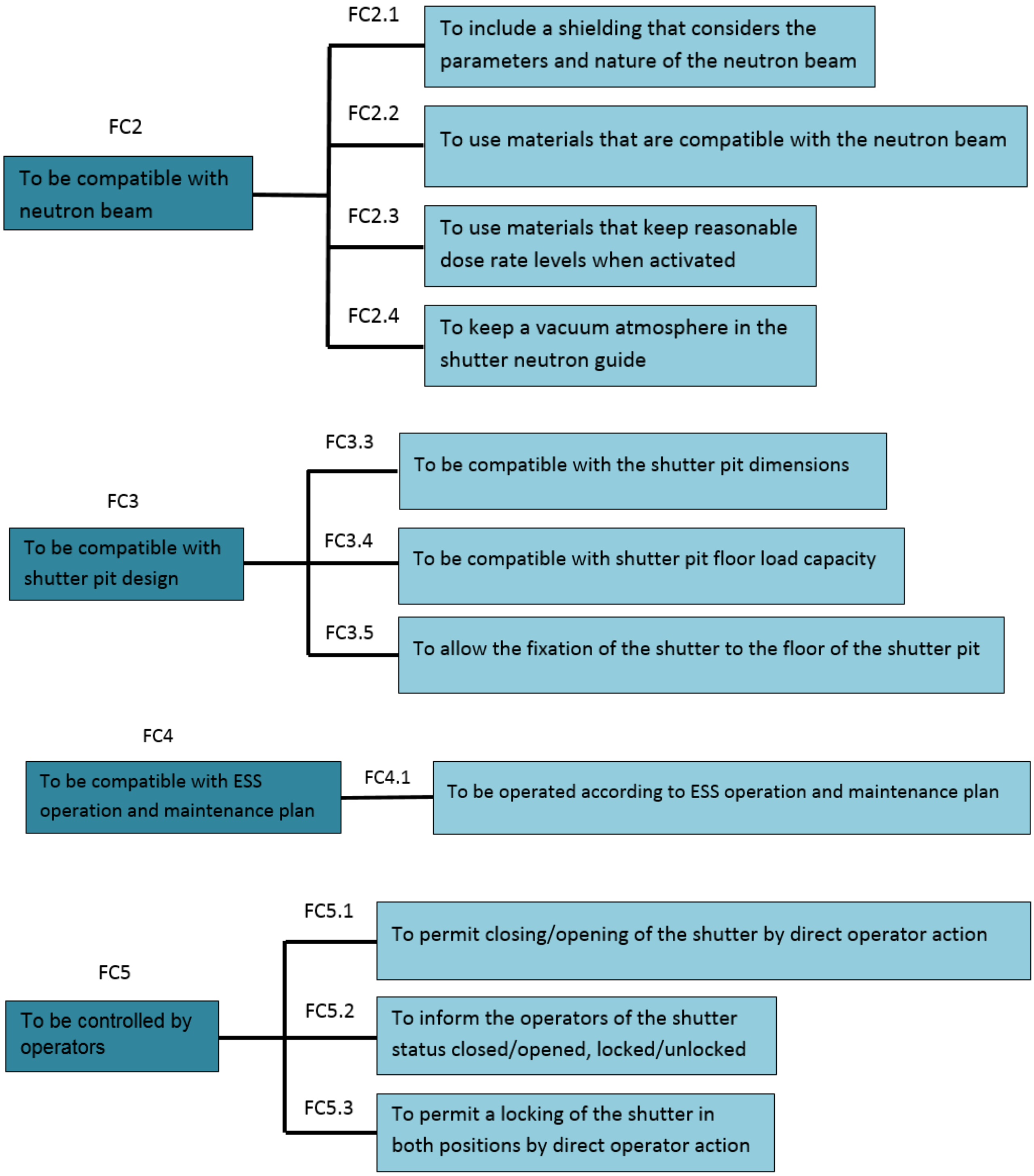
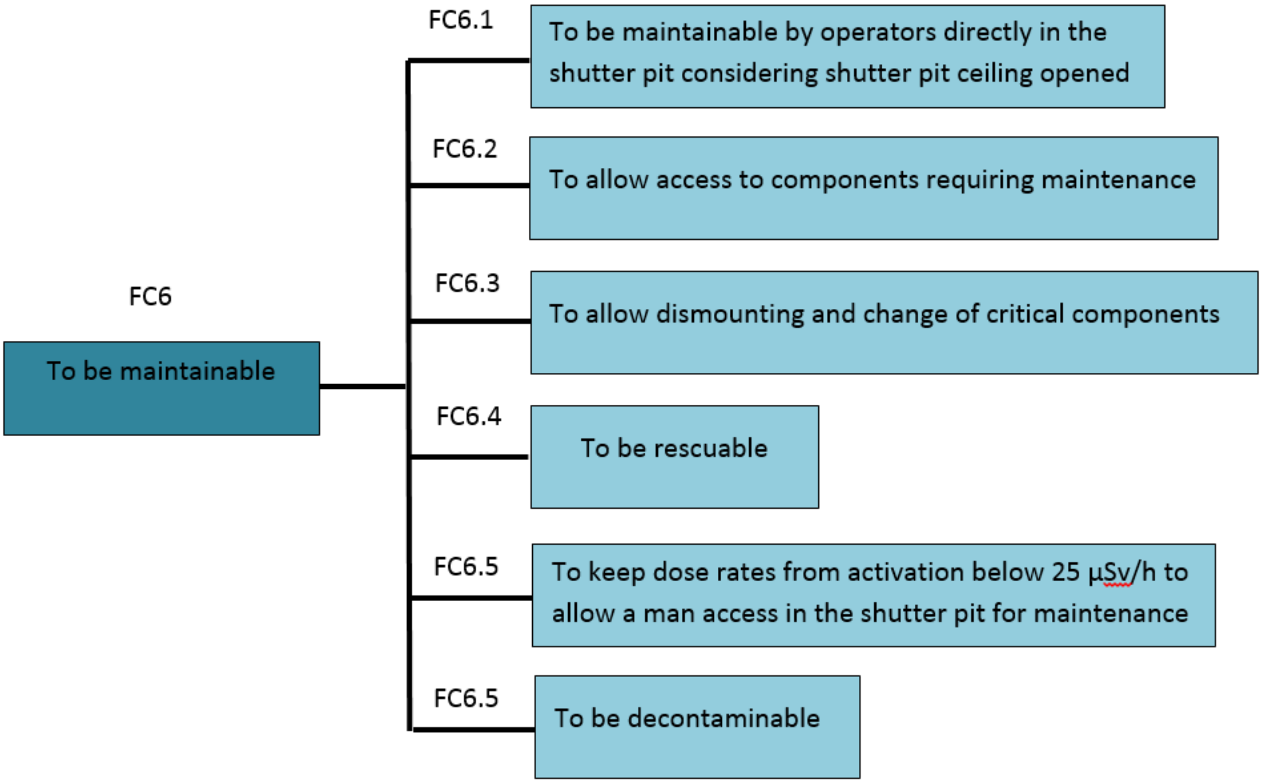
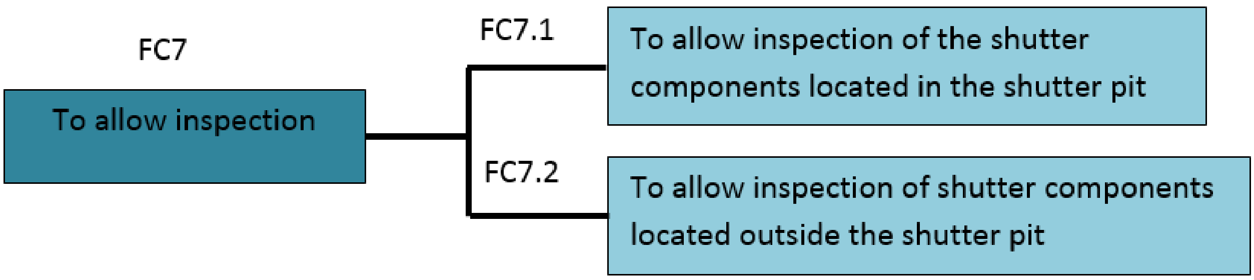


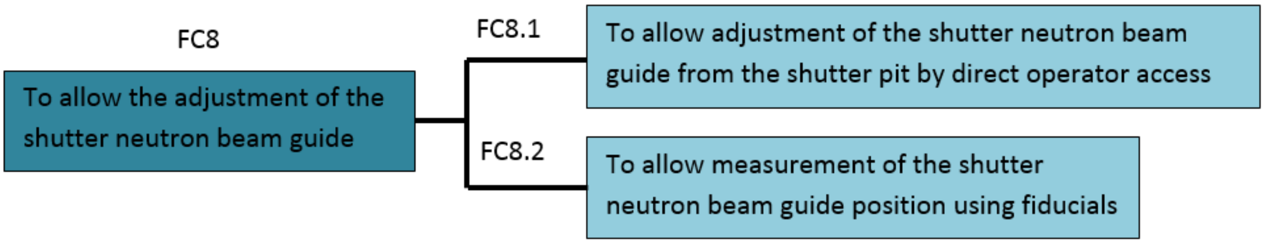
Figure 6: FAST diagram of Main Functions of the shutter

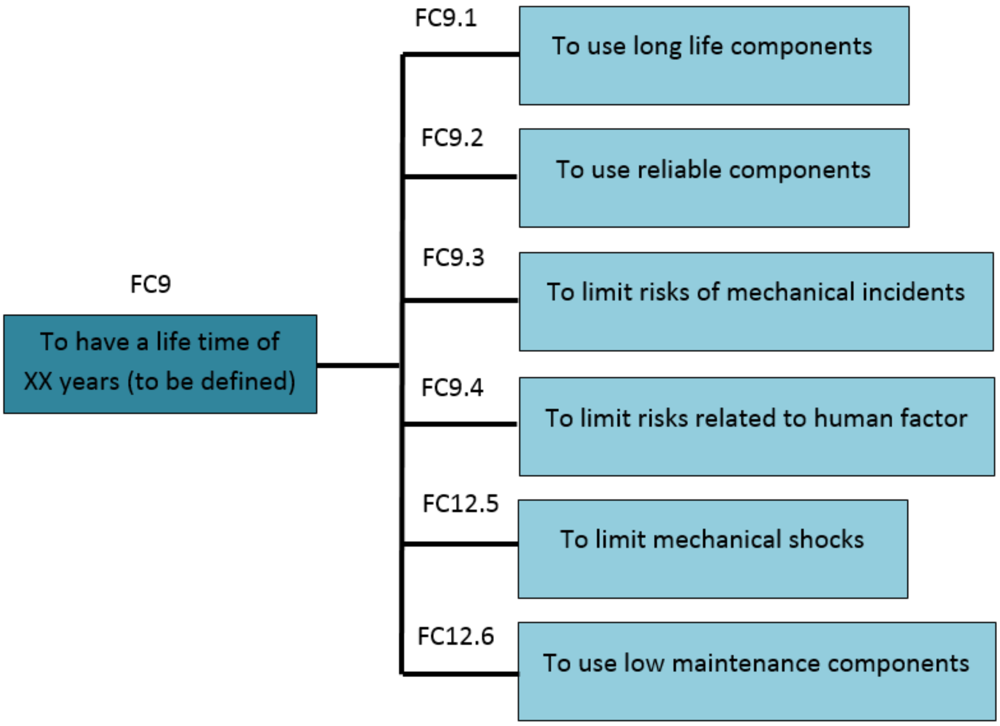


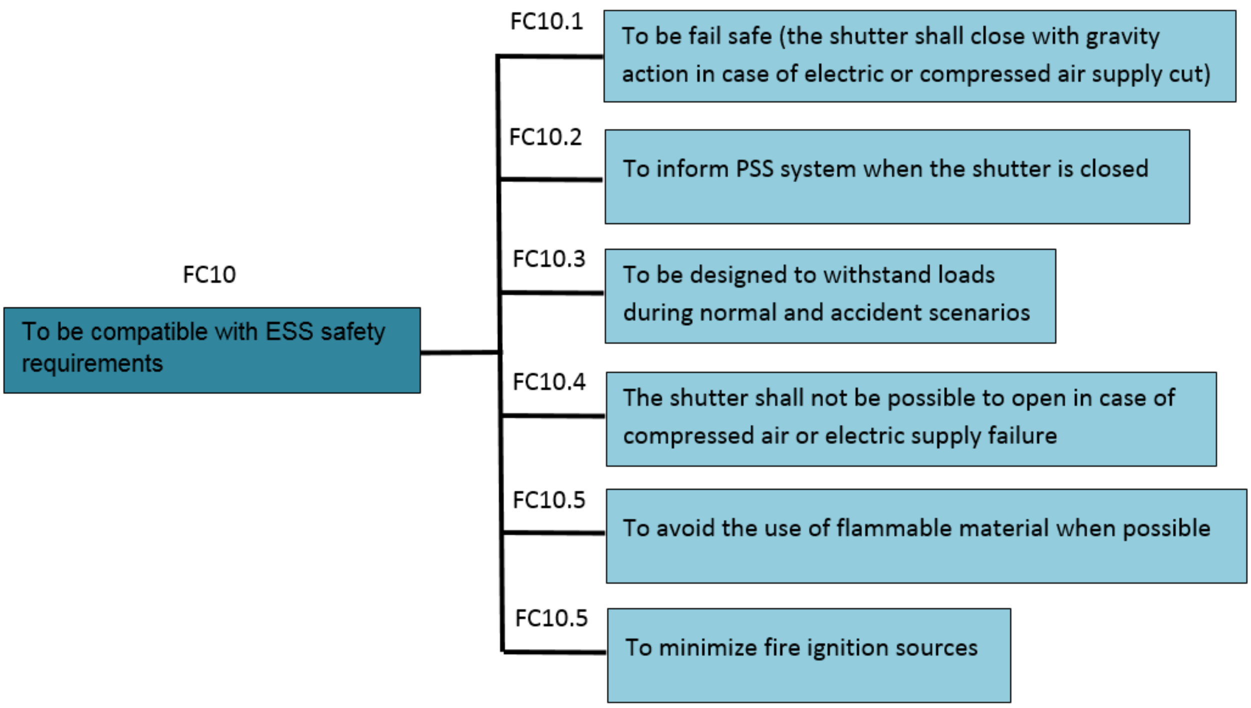

FC2
To be compatible with neutron beam
FC2.1
To include a shielding that considers the parameters and nature of the neutron beam
FC2.2
To use materials that are compatible with the neutron beam
FC2.3
To use materials that keep reasonable dose rate levels when activated
FC2.4
To keep a vacuum atmosphere in the shutter neutron guide
FC3
To be compatible with shutter pit design
FC3.3
To be compatible with the shutter pit dimensions
FC3.4
To be compatible with shutter pit floor load capacity
FC3.5
To allow the fixation of the shutter to the floor of the shutter pit
FC4
To be compatible with ESS operation and maintenance plan
FC4.1
To be operated according to ESS operation and maintenance plan
FC5
To be controlled by operators
FC5.1
To permit closing/opening of the shutter by direct operator action
FC5.2
To inform the operators of the shutter status closed/opened, locked/unlocked
FC5.3
To permit a locking of the shutter in both positions by direct operator action


FC6
To be maintainable
FC6.1
To be maintainable by operators directly in the shutter pit considering shutter pit ceiling opened
FC6.2
To allow access to components requiring maintenance
FC6.3
To allow dismounting and change of critical components
FC6.4
To be rescuable
FC6.5
To keep dose rates from activation below 25 μSv/h to allow a man access in the shutter pit for maintenance
FC6.5
To be decontaminable


FC7
To allow inspection
FC7.1
To allow inspection of the shutter components located in the shutter pit
FC7.2
To allow inspection of shutter components located outside the shutter pit


FC8
To allow the adjustment of the shutter neutron beam guide
FC8.1
To allow adjustment of the shutter neutron beam guide from the shutter pit by direct operator access
FC8.2
To allow measurement of the shutter neutron beam guide position using fiducials


FC9
To have a life time of XX years (to be defined)
FC9.1
To use long life components
FC9.2
To use reliable components
FC9.3
To limit risks of mechanical incidents
FC9.4
To limit risks related to human factor
FC12.5
To limit mechanical shocks
FC12.6
To use low maintenance components


FC10
To be compatible with ESS safety requirements
FC10.1
To be fail safe (the shutter shall close with gravity action in case of electric or compressed air supply cut)
FC10.2
To inform PSS system when the shutter is closed
FC10.3
To be designed to withstand loads during normal and accident scenarios
FC10.4
The shutter shall not be possible to open in case of compressed air or electric supply failure
FC10.5
To avoid the use of flammable material when possible
FC10.5
To minimize fire ignition sources

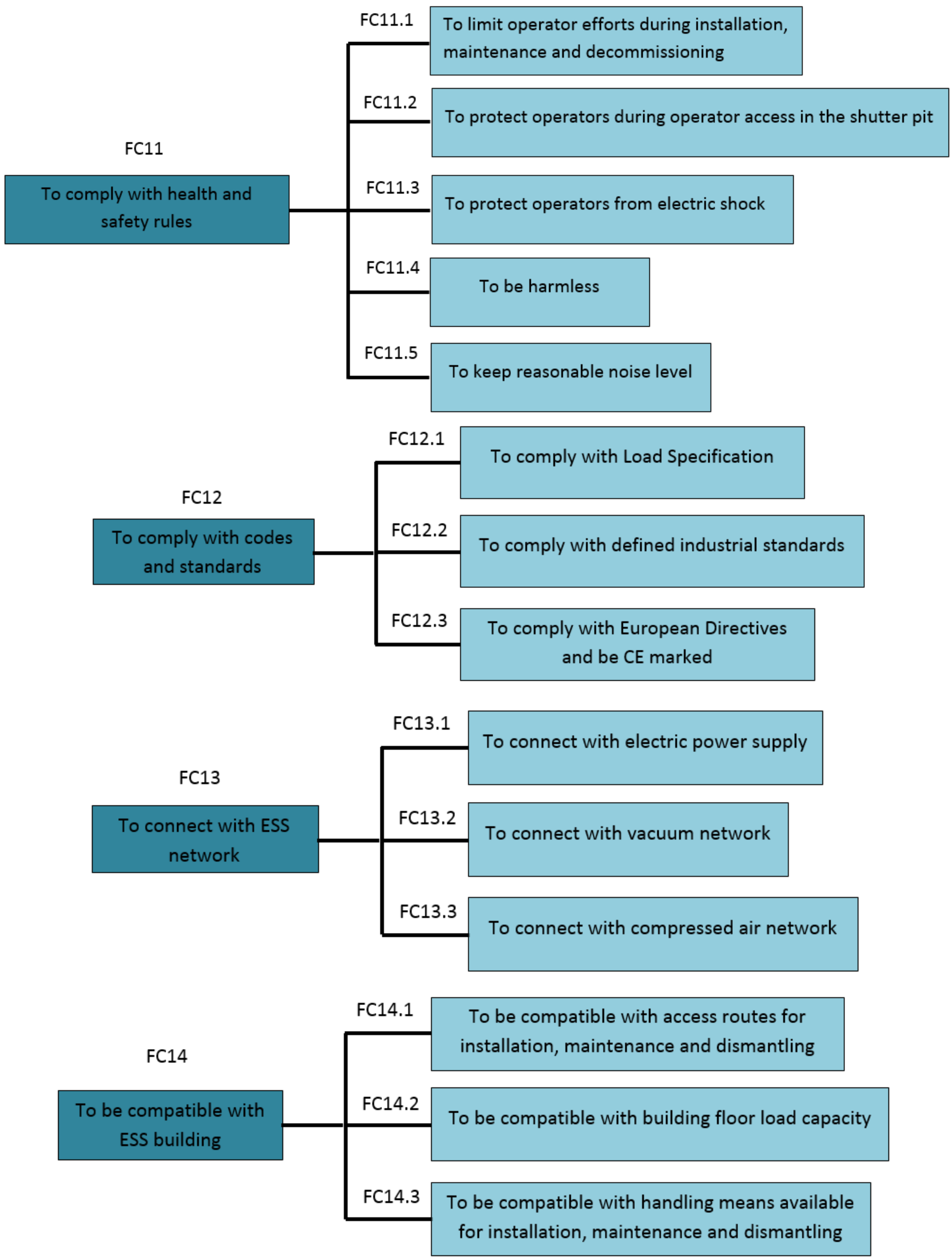


Figure 7: FAST diagram of Constraint Functions of the shutter

2.6 REQUIREMENTS

The requirements that apply to the shutter are listed below in Table 3.

R1	The shutter shall include a neutron beam guide on the movable structure of the shutter
R2	The shutter shall allow a precise alignment (≤0,1 mm) of the shutter neutron beam guide with the bunker insert window and the neutron beam guide in shutter pit
R3	The shutter shall detect when the shutter neutron beam guide is aligned with the bunker insert window and the neutron beam guide in shutter pit
R4	The shutter shall inform BEER instrument control system that the shutter neutron beam guide is aligned with the bunker insert window and the neutron beam guide in shutter pit
R5	The shutter shall include a shielding on the movable structure of the shutter that allows a safe operator access in required areas
R6	The shutter shall allow alignment of the centre of the shielding with the neutron beam when shutter is in closed position
R7	The shutter shall detect when the centre of the shielding is aligned with the neutron beam position
R8	The shutter shall inform BEER instrument control system that the shielding centre is aligned with neutron beam position
R9	The shutter shall keep a man access to allow a precise alignment of the shutter neutron beam guide by an operator
R10	The shutter shall keep a man access for shutter maintenance in opened or closed position
R11	The shutter shall keep man access for neutron beam guide installation, alignment and maintenance
R12	The shutter shall keep man access for bunker window insert maintenance
R13	The shutter shall allow opening/closing of the shutter about 10 times per hour
R14	The shutter shall allow the opening/closing of the shutter in about 10 seconds during normal operation
R15	The shutter shall be designed for at least 10000 cycles without heavy maintenance operations
R16	The shutter shall be designed for light maintenance operations and inspection 2 times per year maximum
R17	The shutter shall be operated from the BEER instrument control system
R18	The shutter shall keep a clearance of about 5 mm on each side of the shutter neutron beam guide (shutter opened)
R19	The shutter shall keep a clearance of about 5 mm between the shielding and the bunker insert window (shutter closed)
R20	The shutter shall be compatible with the design of the fixed neutron beam guide in the shutter pit
R21	The shutter shall be compatible with BEER instrument control system
R22	The shutter shall include a neutron guide that is compatible with BEER instrument requirement
R23	The shutter shall include a shielding that considers the parameters and nature of the neutron beam
R24	The shutter shall use materials that are compatible with the neutron beam
R25	The shutter shall use materials that keep reasonable dose rate levels when activated
R26	The shutter shall keep a vacuum atmosphere in the shutter neutron guide
R27	The shutter shall be compatible with the shutter pit dimensions
R28	The shutter shall be compatible with shutter pit floor load capacity
R29	The shutter shall allow the fixation of the shutter to the floor of the shutter pit
R30	The shutter shall be operated according to ESS operation and maintenance plan
R31	The shutter shall permit closing/opening of the shutter by direct operator action
R32	The shutter shall inform the operators of the shutter status closed/opened, locked/unlocked
R33	The shutter shall permit a locking of the shutter in both positions by direct operator action
R34	The shutter shall be maintainable by operators directly in the shutter pit considering shutter pit ceiling opened
R35	The shutter shall allow access to components requiring maintenance
R36	The shutter shall allow dismounting and change of critical components
R37	The shutter shall be rescuable
R38	The shutter shall keep dose rates from activation below 25 µSv/h to allow a man access in the shutter pit for maintenance
R39	The shutter shall be be decontaminable
R40	The shutter shall allow adjustment of the shutter neutron beam guide from the shutter pit by direct operator access
R41	The shutter shall allow measurement of the shutter neutron beam guide position using fiducials
R42	The shutter shall use long life components
R43	The shutter shall use reliable components
R44	The shutter shall limit risks of mechanical incidents
R45	The shutter shall limit risks related to human factor

R46	The shutter shall limit mechanical shocks
R47	The shutter shall use low maintenance components
R48	The shutter shall be fail safe (the shutter shall close with gravity action in case of electric or compressed air supply cut)
R49	The shutter shall inform PSS system when the shutter is closed
R50	The shutter shall be designed to withstand loads during normal and accident scenarios
R51	The shutter shall not be possible to open in case of compressed air or electric supply failure
R52	The shutter shall avoid the use of flammable material when possible
R53	The shutter shall minimize fire ignition sources
R54	The shutter shall limit operator efforts during installation, maintenance and decommissioning
R55	The shutter shall protect operators during operator access in the shutter pit
R56	The shutter shall protect operators from electric shock
R57	The shutter shall be harmless
R58	The shutter shall keep reasonable noise level
R59	The shutter shall comply with Load Specification
R60	The shutter shall comply with defined industrial standards
R61	The shutter shall comply with European Directives and be CE marked
R62	The shutter shall connect with electric power supply
R63	The shutter shall connect with vacuum network
R64	The shutter shall connect with compressed air network
R65	The shutter shall be compatible with Building access routes for installation, maintenance and dismantling
R66	The shutter shall be compatible with building floor load capacity
R67	The shutter shall be compatible with handling means available for installation, maintenance and dismantling

Table 3: List of requirements applicable to the shutter

2.7 DESCRIPTION

2.7.1 SHUTTER KINEMATIC

The shutter kinematic is shown in Figure 8.
In the left picture, the shutter is shown in the opened position and in the right picture, the shutter is shown in the closed position. When the shutter is in the opened position, the neutron shutter guide should be aligned with the position of the neutron beam. When the shutter is in the closed position, the centre of the shutter shielding should be aligned with the position of the neutron beam. To perform this, the shielding and the shutter neutron guide are fixed to a rotating part that rotates by an angle of 22.5°. Positions of the shielding, shutter neutron beam guide and rotation axis have been defined to fulfil the above requirements. The rotating part is actuated by a pneumatic cylinder. The stroke of the pneumatic cylinder is 200 mm.
In the opened position, the gravity centre of the rotating part has an offset of 235 mm with the rotation axis to ensure an efficient closing of the shutter with gravity.
3D views of the shutter in the open and close positions are shown in Figure 9, Figure 10 and Figure 11.
The movement of the shutter between the closed and opened position shall last about 10 s. The shutter is foreseen to be used about 10 times per hour in average during an experiment setup.
A 5 mm gap is foreseen between the shutter neutron guide and the bunker-insert window. A 5 mm gap is foreseen between the shutter neutron guide and the following neutron transport guide.

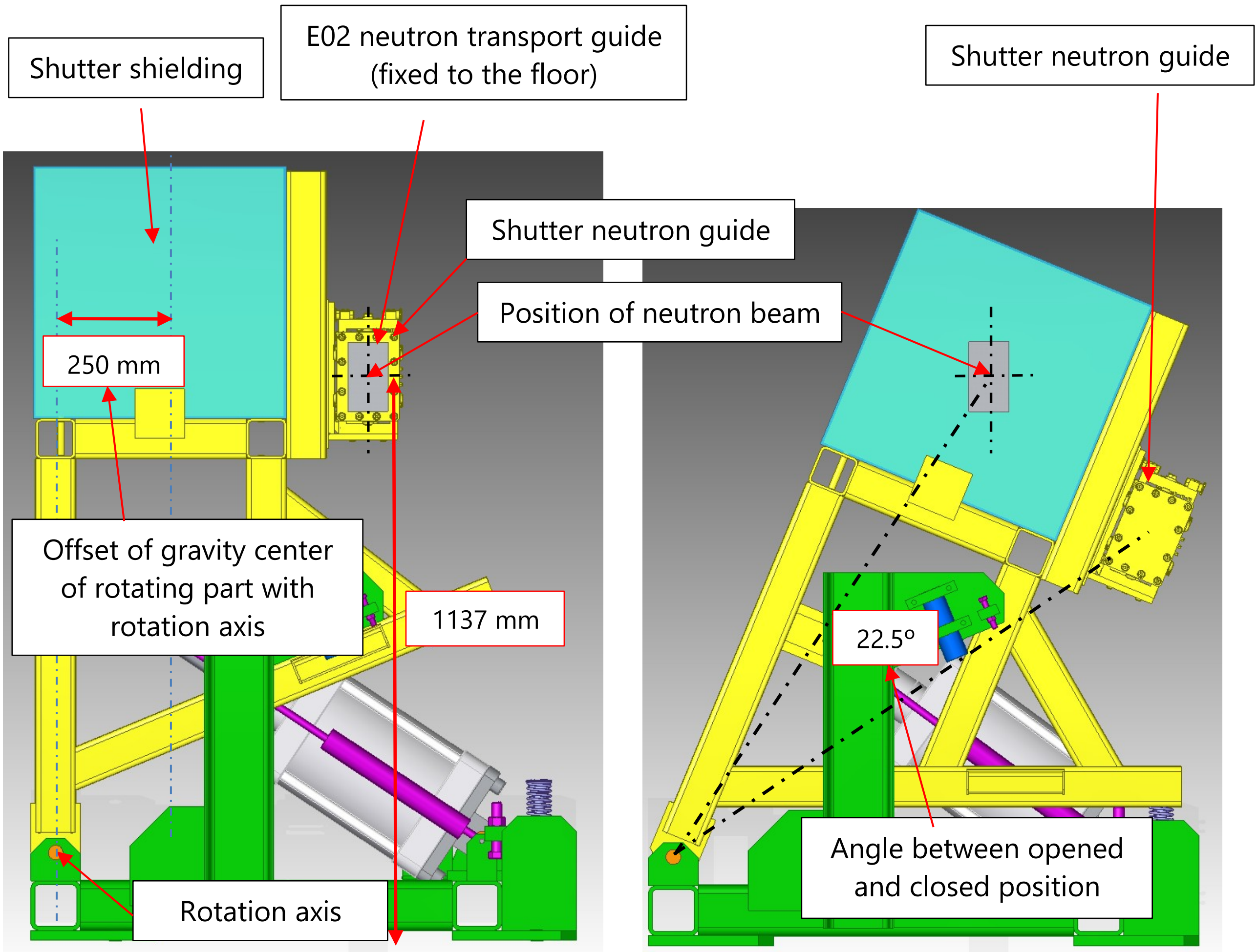


Figure 8: Kinematic of the shutter. Left – the shutter opened. Right – the shutter closed.

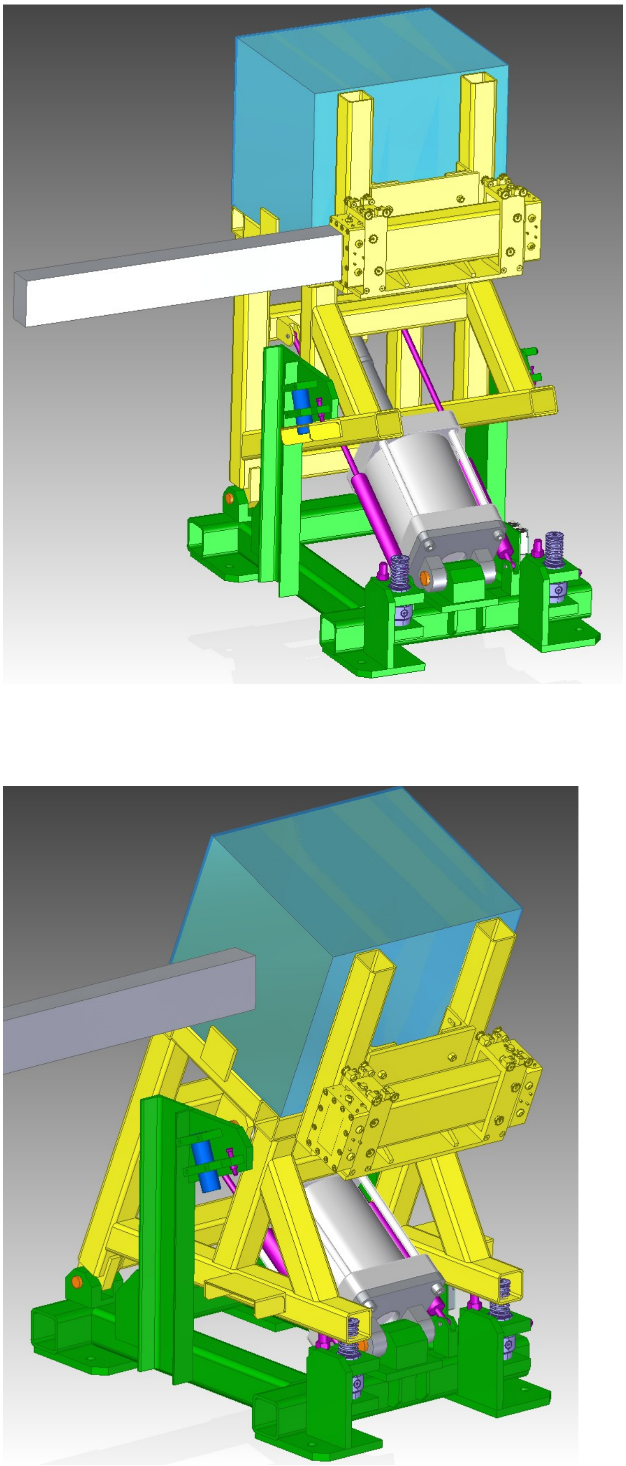


Figure 9: Kinematic of the shutter. Left – the shutter opened. Right – the shutter closed.

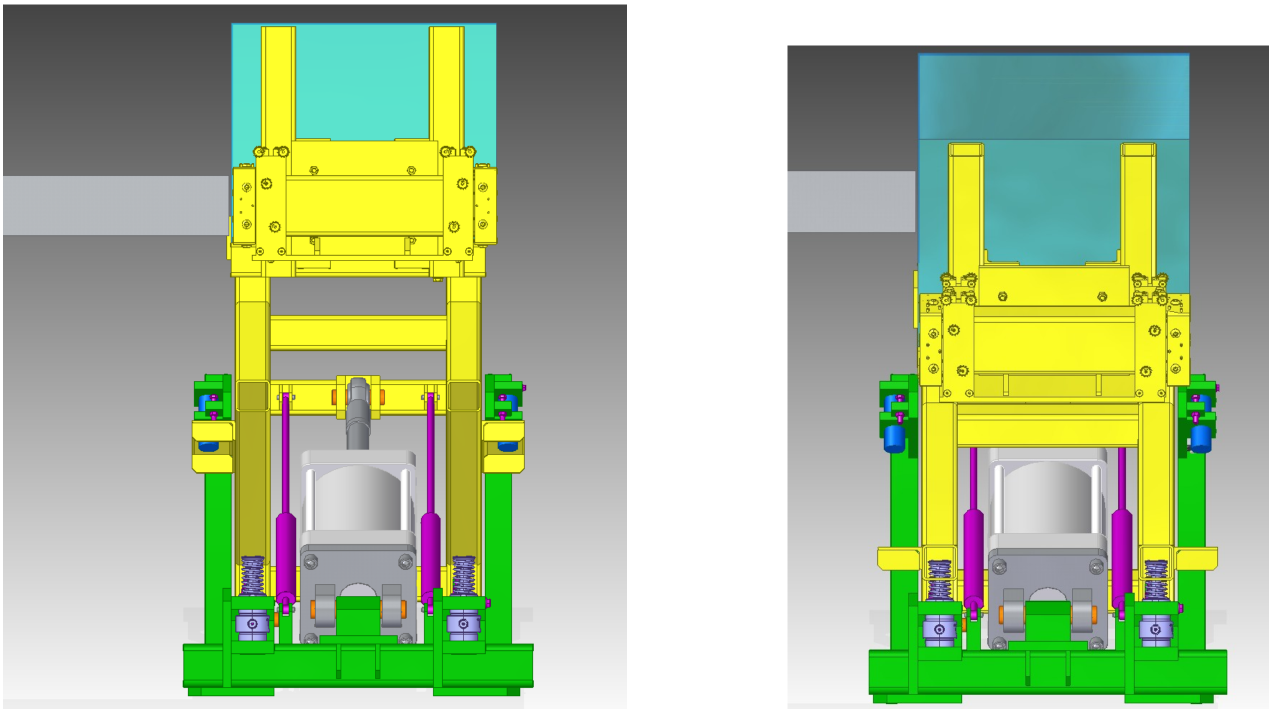


Figure 10: Side view of shutter in opened position (left) and closed position (right)

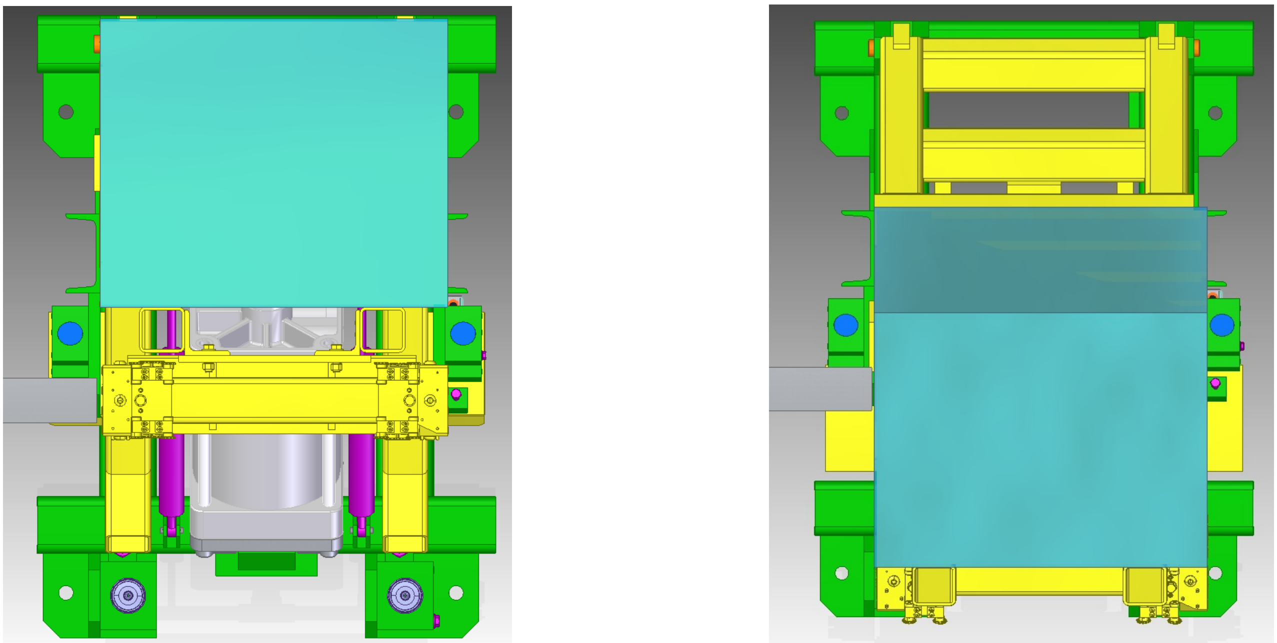


Figure 11: Top view of shutter in opened position (left) and closed position (right)

2.7.2 SHUTTER MAIN PARTS

A 3D view of the shutter assembly is shown in Figure 12. Each part is described below

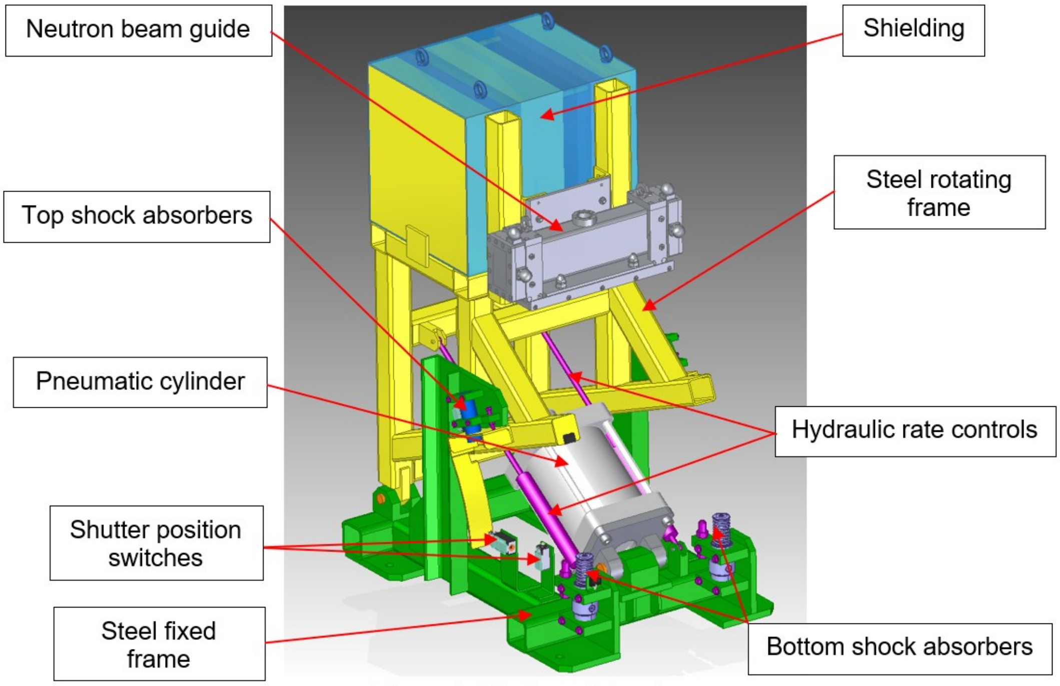


Figure 12: 3D view of the shutter assembly

2.7.2.1 SHIELDING

The shielding composition and dimensions have been defined based on radiological calculations performed in [1]. The shutter shielding can be seen in Figure 13 to Figure 15. The shielding dimensions are 510 x 510 x 610 mm, its weight is 1148 kg. The shielding includes:

- A 10 mm thick layer with at last 80% of B_4C on the front face (towards the bunker)
- 10 x copper plates of 50 mm thickness (material Cu-OF, EN CW008A, DIN 2.0040)
- A 100 mm thick polyethylene plate with 5% boron,
- A 5 mm additional layer with at last 80% of B_4C to limit activation of other shutter parts

The copper plates are screwed together by 4 long screws located on each corner. On the top, the copper plates shall include 4 tapered holes for lifting eyes and thus allow manipulation with a crane. The shielding is positioned and fixed on a rotating steel welded supporting frame. Mechanical stops in two directions allow the positioning of the shielding on its frame. The shielding is held on the supporting frame by 4 screws screwed in the bottom of the copper plates.
The B_4C containing layer and polyethylene plate shall be mechanically fixed to copper plates. Glue can only be used if its long term stability and sufficient adhesivity in radiation environment can be guaranteed.

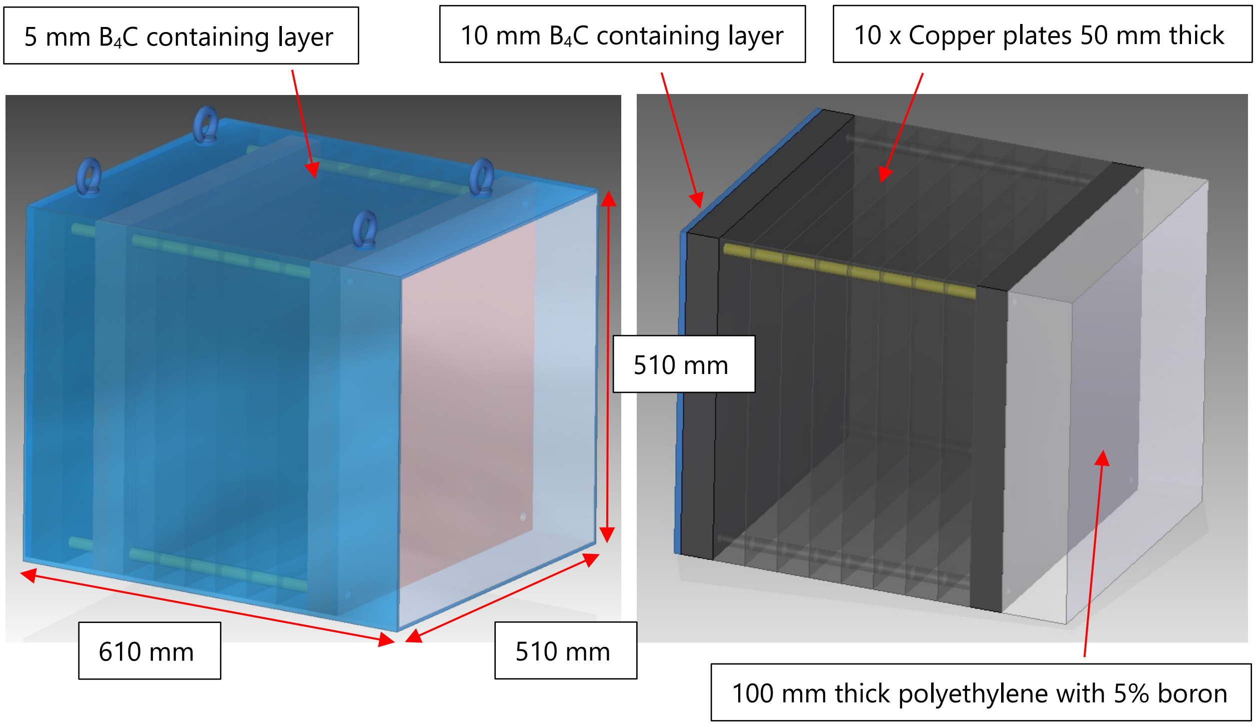


Figure 13: 3D view of the shutter shielding. Left – shutter with B_4C containing layer. Right – shutter without B_4C containing layer

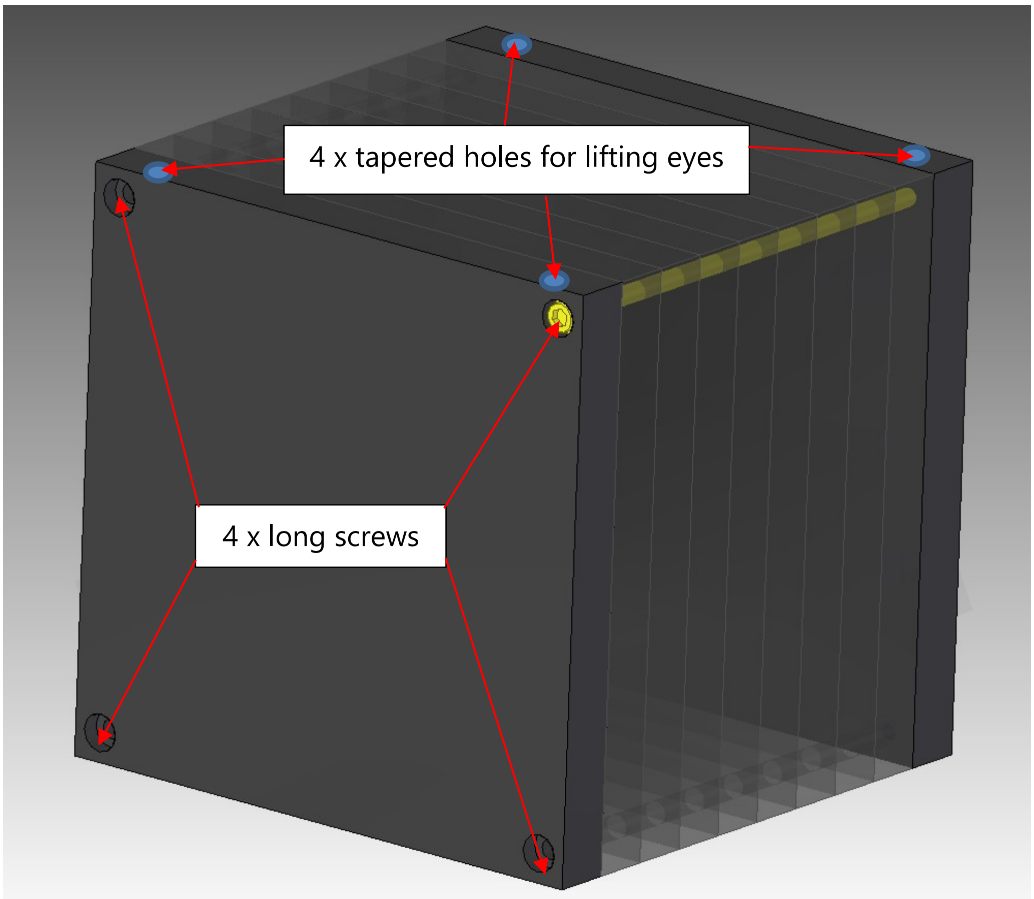


Figure 14: 3D view of the shutter shielding copper plates

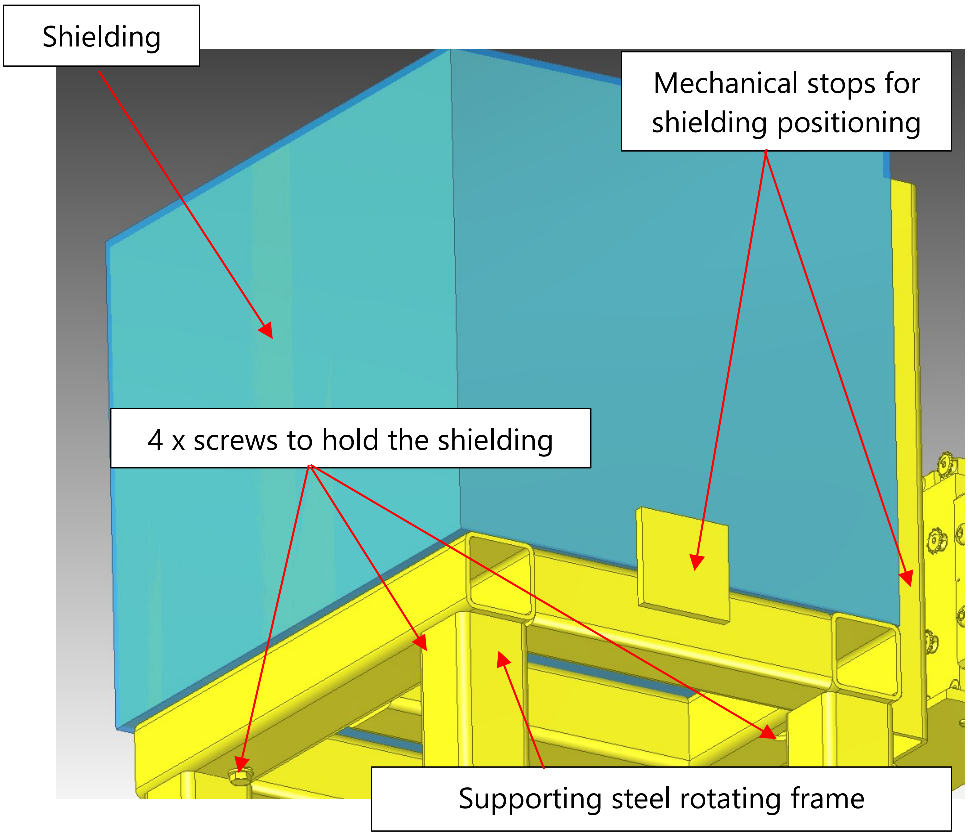


Figure 15: 3D view of the interface between the shielding and its supporting frame

2.7.2.2 NEUTRON BEAM GUIDE

The shutter neutron beam guide is shown in Figure 16 in grey colour. This component is delivered by the in-kind partner (MIRROTRON) and is not a part of the shutter design. The neutron beam guide includes a mechanical system that allows adjustment of the guide in three directions. The neutron beam guide is fixed to the rotating shutter frame by 4 screws.

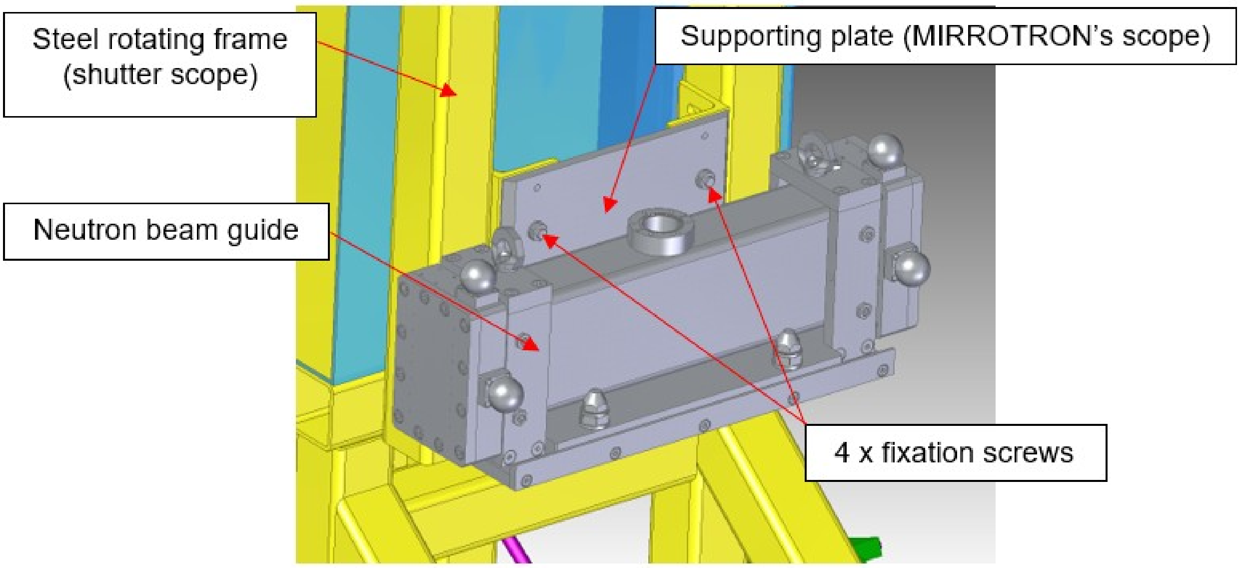


Figure 16: 3D view of the shutter neutron beam guide fixed to the rotating steel supporting frame

2.7.2.3 STEEL ROTATING FRAME

Details of the rotating steel frame are shown in Figure 17. It includes the following features:

- A robust welded beam structure made of square hollow sections 80 x 80 x 5 mm to withstand the mechanical loads
- Mechanical stops to position the shielding
- Lateral mechanical features to interface with switches, shock absorbers and mechanical stops when the shutter is in the opened position
- Additional beams to interface with switches, shock absorbers and mechanical stops when the shutter is in the closed position
- Mechanical interface to fix the neutron guide
- Pivot connections to the fixed frame
- Pivot connections with pneumatic cylinder and hydraulic rate controls

The frame is made of S235 steel. Epoxy paint is applied to the external surfaces of the frame. Plugs shall be installed on the ends of the frame to prevent loss of parts and limit contamination risks inside the frame.

For maintenance and to make easier the removal of the pneumatic cylinder, the beam that includes pivot connections with cylinder and hydraulic control rates could be screwed and be thus dismountable. The beam could thus be lifted together with the pneumatic cylinder.

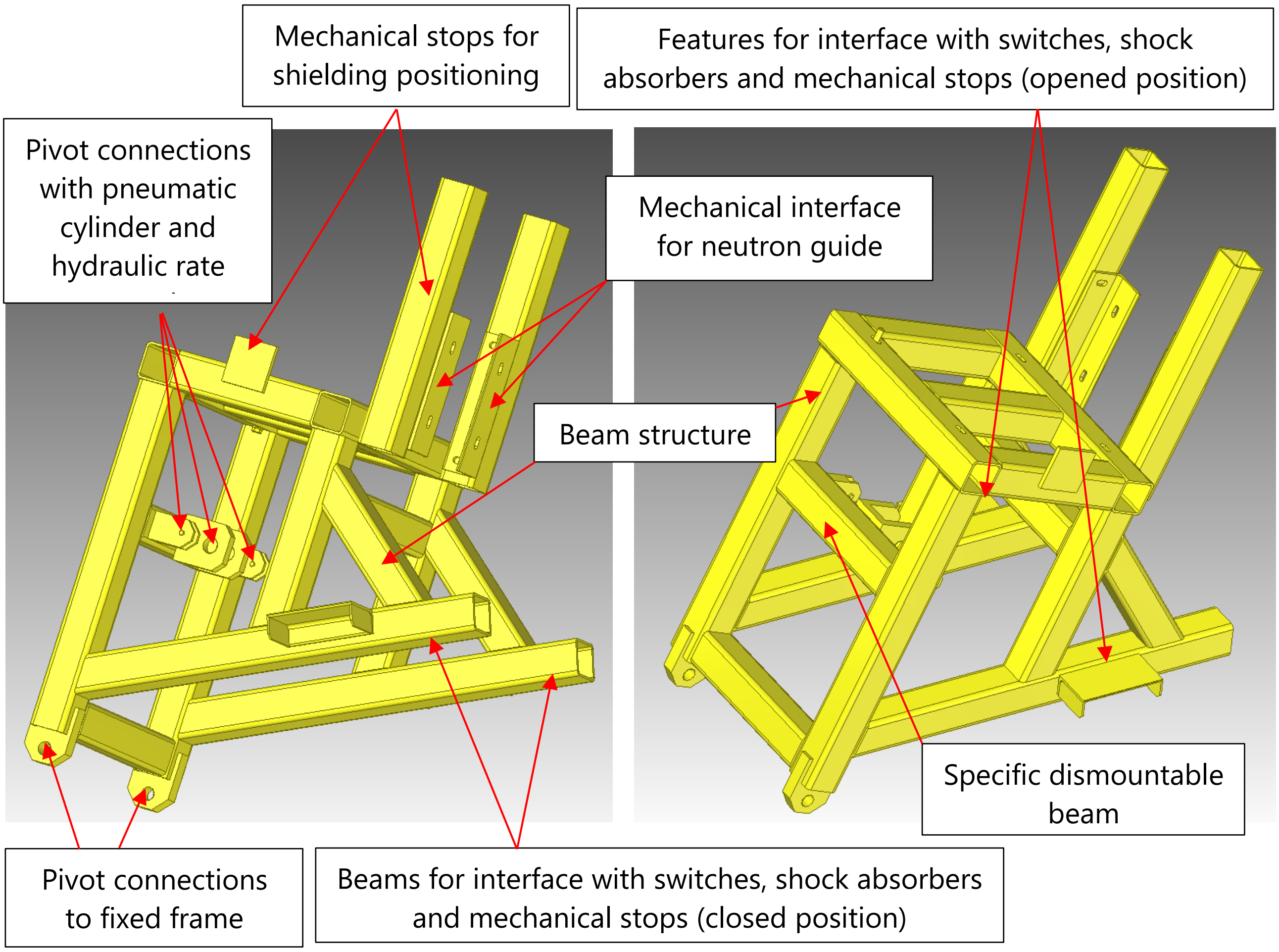


Figure 17: 3D view of the rotating steel frame

2.7.2.4 STEEL FIXED FRAME

The fixed steel frame is shown in Figure 18. It includes the following features:

- A robust welded beam structure made of square hollow sections 100 x 100 x 8 mm to withstand the mechanical loads,
- Supports to fix switches, shock absorbers and mechanical stops,
- Pivot connections to the rotating frame,
- Pivot connections with pneumatic cylinder and hydraulic rate controls,
- 4 x plates with holes to anchor the shutter to the shutter pit floor,

The frame is made of S235 steel. Epoxy paint is applied to the external surfaces of the frame. Plugs shall be installed on the ends of the frame to prevent loss of parts and limit contamination risks inside the frame.

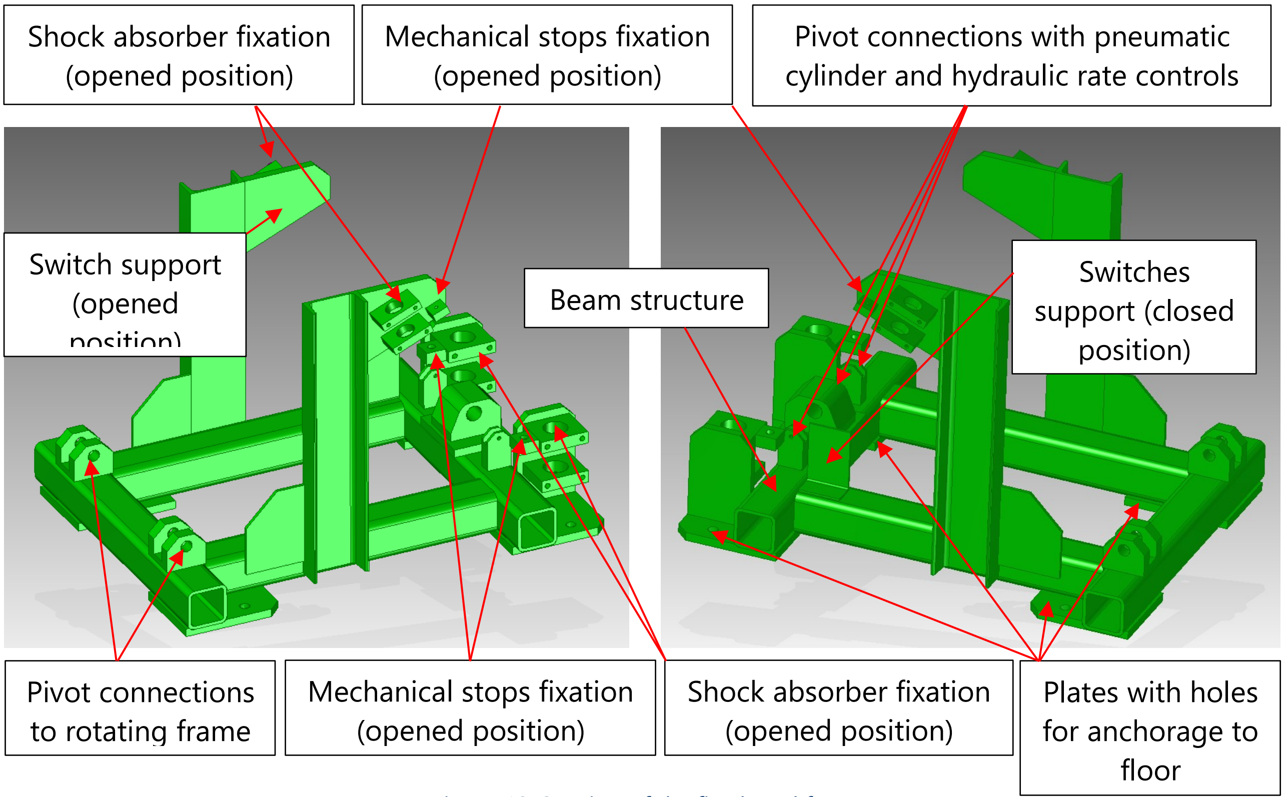


Figure 18: 3D view of the fixed steel frame

2.7.2.5 PNEUMATIC CYLINDER WITH CONTROL UNIT

A pneumatic cylinder is used to actuate the shutter. Needed stroke is 200 mm as it is shown in Figure 19. The requirements of the pneumatic cylinder considered during the design are listed in Table 4. Moreover, the used cylinder should satisfy the standard of ISO 15552 or ISO 6431 for Pneumatic Cylinders. An articulated self-lubricated fork is considered to connect to the rotating shutter frame, and a female rear hinge with a pin is considered to connect to the shutter fixed frame.

To prevent any interaction between air hoses and the rotating frame, the compressed air supply connection shall be ideally located on the bottom face of the pneumatic cylinder, as shown in Figure 19.

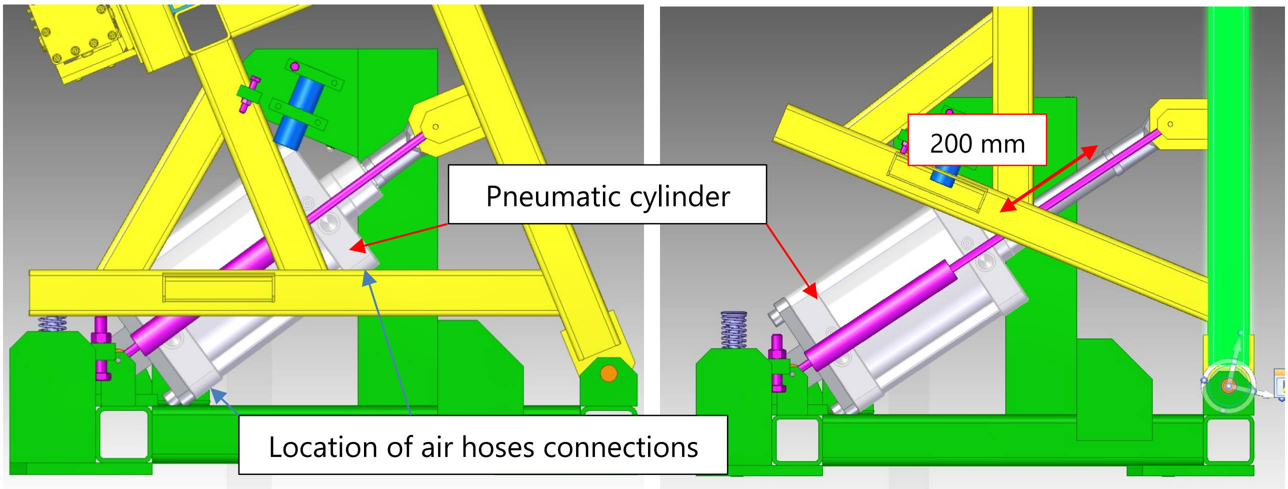


Figure 19: 3D view of the pneumatic cylinder when the shutter is closed (left) and when the shutter is opened (right)

Property	**Value**
Stroke	200 mm
Working temperature	-20 – 80°C
Fluid	Filtered air without lubrication
Working pressure	1.5 – 10 bar
Barrel material	aluminium
Piston rod	Carbon/high-alloy steel
Cushioning	Pneumatic adjustable or external cushioning elements
Material sealing	PUR, NBR or EPDM
Not allowed structural plastics	FPM, FKM, PTFE or POM
Bore	≤ 250 mm
Version	Double acting one side piston rod
Weight	< 45 kg

Table 4: Pneumatic cylinder required properties

Several pneumatic components are required between the ESS compressed air supply and the pneumatic cylinder to ensure a correct working of the system. In Figure 20 is shown a preliminary scheme of the pneumatic control unit.
However, the pneumatic and control unit depicted in the green rectangle in Figure 20 are not a part of the shutter design. Only the parts in the red rectangle (pneumatic actuator and flow control valves) should be provided and they create the interface with ESS/in-kind partner.
The control scheme will be designed to support a passively safe system. When electric or air supplied are interrupted, the gravity action compressed the pneumatic cylinder and the shutter closes. Speed of the cylinders shall be controlled since the required force on the pneumatic cylinder decreases when the shutter is opening – offset between shielding gravity centre and rotation axis is decreasing.
Compressed air supply as described in [2] is compatible with the shutter design (pressure, stability, cleanliness, air consumption).

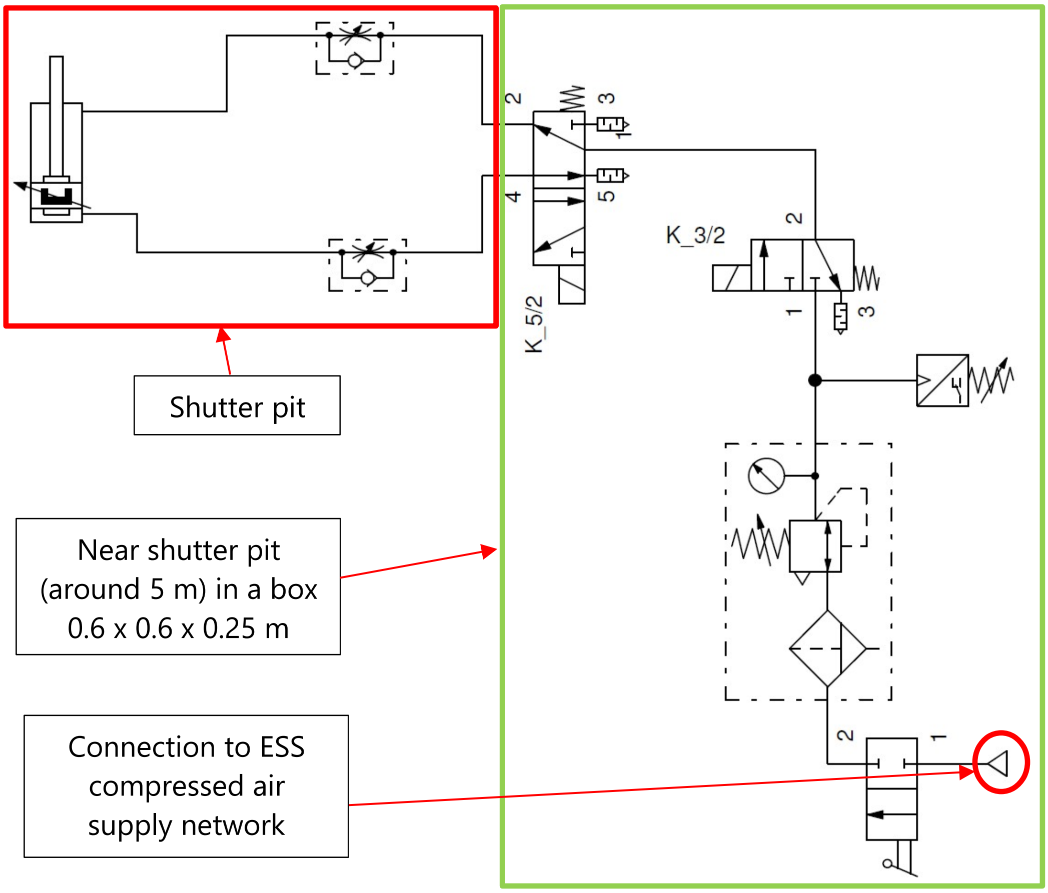


Figure 20: Preliminary scheme of compressed air distribution to the pneumatic cylinder

The location of the shutter compressed air to the ESS network is shown in Figure 21.

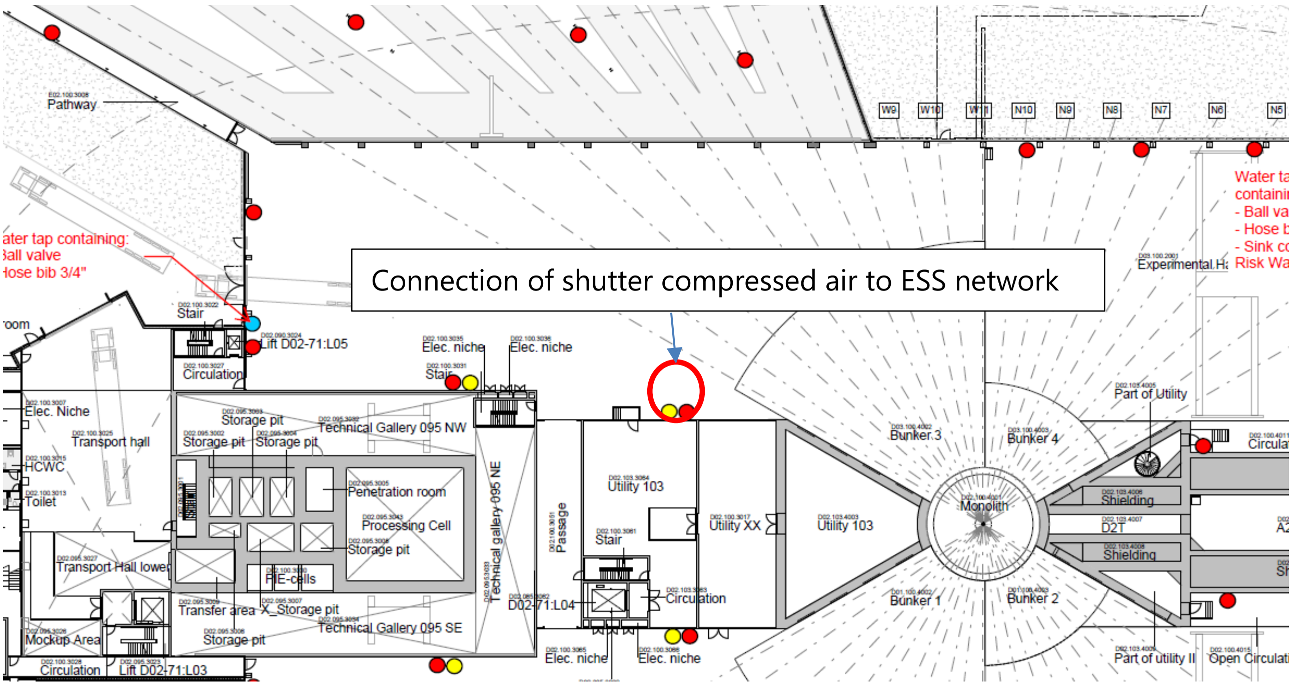


Figure 21: Location of shutter compressed air connection to the ESS network

2.7.2.6 HYDRAULIC RATE CONTROLS

As mentioned above, the force Fm (see Figure 22) changes during the shutter movement since the offset between the shielding gravity centre and rotation axis is changing. As a result, the pressure P_2 is also changing. These pressure changes can generate jerking problems, and consequently, hydraulic rate controls have been added on each side of the pneumatic cylinders to damp the change of pressures and ensure smooth working of the system. Hydraulic rate controls location is shown in Figure 23. The required properties of the hydraulic rate controls are listed in Table 5.

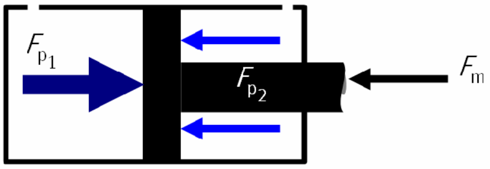


Figure 22: Equilibrium of acting forces in pneumatic cylinders

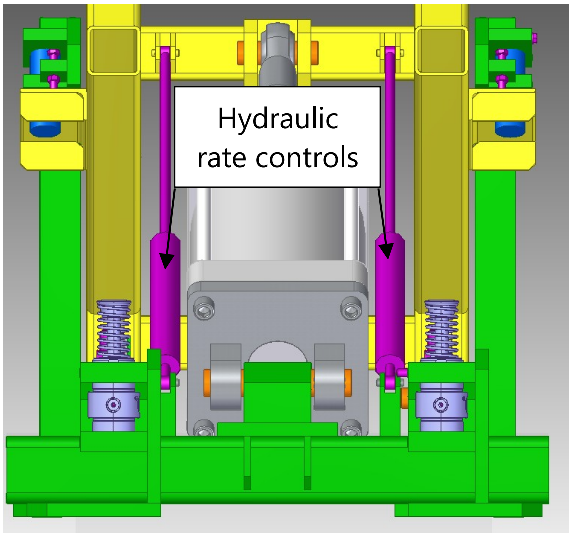


Figure 23: Side view of hydraulic rate controls installation on each side of the pneumatic cylinder

Property	Value
Dumping direction	Compression and tension
Bore size	25 mm
Stroke	200 mm
Max. propelling force in tension	11 kN
Max. propelling force in compression	11 kN
Piston length	<350 mm

Table 5: Required properties of the hydraulic rate controls

2.7.2.7 SHOCK ABSORBERS

Shock absorbers are required to avoid impacts of the shutter rotating frame on the shutter fixed frame at the end of the motion during the closing/opening of the shutter. These shock absorbers shall increase the lifetime of the shutter during normal operation. Shock absorbers can also absorb energy and limit damage in case of accident scenario (rupture of compressed air supply and fall of the shutter under gravity action, rupture of air compressed hose at the pneumatic cylinder exhaust resulting in an increased speed of the shutter opening).

In Figure 24 can be seen the location of the shock absorbers. The shock absorbers for the opened shutter position are sized based on the shutter opening speed in normal conditions. The shock absorbers for the closed position are sized considering a free fall of the shutter around its rotation axis. The required properties of the shock absorbers for the closed position are listed in Table 6. The required properties of the shock absorbers for opened position are listed in Table 7. The strokes of the shock absorbers are respectively 50 mm and 25 mm.

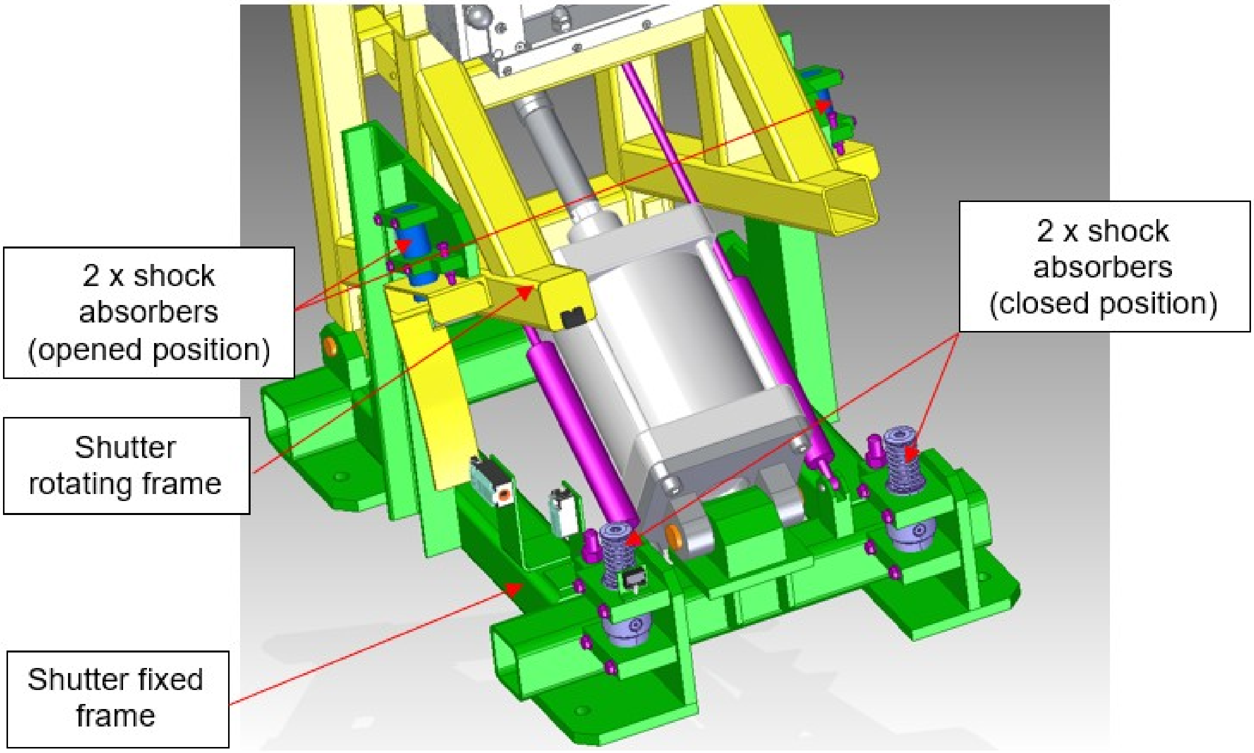


Figure 24: 3D view of the shock absorbers installation on the shutter fixed frame

Property	**Value**
Type	Hydraulic, multiple orifices, adjustable
Stroke	50 mm
Optimal velocity range	0.3-3.5 m/s
Max. Nm/cycle	>2000
Max. Nm/hour	>250000
Max. Reaction force	51 kN
Max. propelling force	>6000 N

Table 6: Required properties for the close position shock absorbers

Property	**Value**
Type	Hydraulic, single orifice
Stroke	25 mm
Optimal velocity range	0.8-2.0 m/s
Max. Nm/cycle	>200
Max. Nm/hour	>100000
Max. Reaction force	11 kN

Property	Value
Max. propelling force	>3000 N

Table 7: Required properties for the open position shock absorbers

2.7.2.8 MECHANICAL PIVOT CONNECTIONS

Mechanical pivot connections include:

- 2 x Pivot connections between rotating shutter frame and shutter fixed frame
- 1 x Pivot connection between the pneumatic cylinder and shutter fixed frame
- 1 x Pivot connection between the pneumatic cylinder and rotating shutter frame
- 2 x Pivot connections between hydraulic rates control and shutter fixed frame
- 2 x Pivot connection between hydraulic rates control and shutter fixed frame

In regards to the system requirements (long life, minimum maintenance, reliability, resistance to radiation), the small rotating angle of the rotating part (22.5°) and the low-frequency pivot connection are solved with hard steel pins without lubrication.
In order to ensure a precise alignment (≤0.1 mm) of the shutter neutron beam guide with the bunker insert window and the neutron beam guide in the shutter pit, the clearance in the pivot connection between the shutter rotating frame and shutter fixed frame shall be limited (0.1 mm maximum value as the first estimation).
Clearances in other pivot connections shall be wider (0.2 to 0.5 mm as the first estimation)

2.7.2.9 ADJUSTABLE MECHANICAL STOPS

One of the key requirements of the shutter is to allow a precise alignment (≤0.1 mm) of the shutter neutron beam guide with the bunker insert window and the neutron beam guide in the shutter pit. Consequently, adjustable mechanical stops with fine settings are required for the opened position of the shutter. In Figure 25 is shown the adjustable mechanical stop for the shutter opened position. The mechanical stop includes two screws and two nuts located on each side of the shutter. This allows to set and lock the final opened position. The distance between the mechanical stop and the shutter rotating frame rotation axis is about 750 mm, which should be sufficient to fulfil the above requirement.

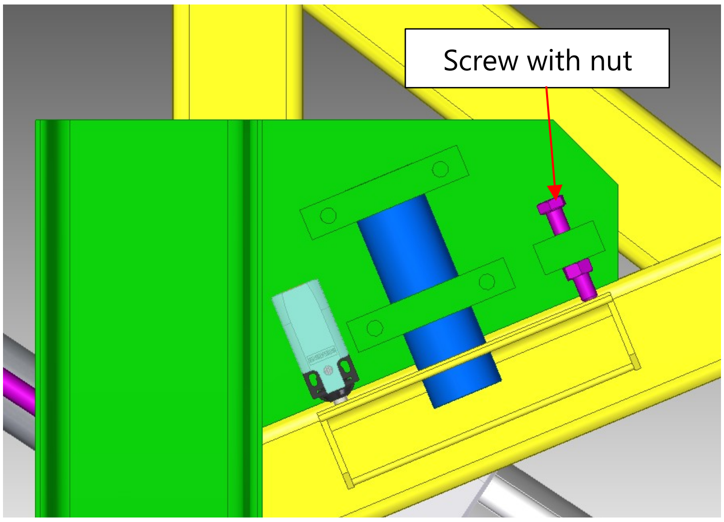


Figure 25: Side view of the adjustable mechanical stop for the shutter opened position

When the shutter is closed, the centre of the shielding should be roughly aligned with the neutron beam, but the tolerance can be a few millimetres (5 mm should not have any impact on the calculated doses in [1]). However, the rotating shutter frame cannot lay only on the shock absorbers. Mechanical stops are also required for the closed shutter position. The technical solutions are the same as for the opened position and are shown in Figure 26. Stronger screws are used since half the weight of the shutter will act on the mechanical stops in the closed position.

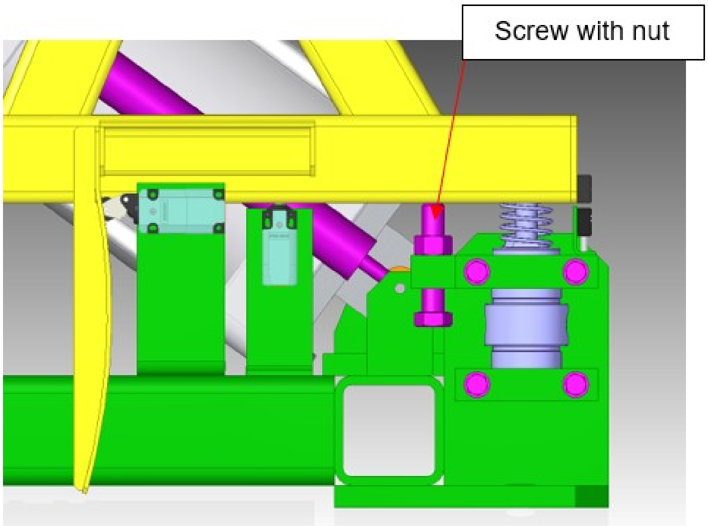


Figure 26: Side view of the adjustable mechanical stop for the shutter closed position

2.7.2.10 POSITION SWITCHES

4 position switches are included in the shutter design:

- Two switches to detect both the end positions of the shutter (opened, closed). Due to the standardisation, these **must be fully compatible** with the type ESS has selected for the use in radiation environment, CROUZET SP4863-12[1]. Guidelines for actuation, travel range and adjustment of the switches are available from ESS MCA group [3].
- One safety classified mechanical switch will be connected to the PSS system and will detect the closed position. Due to the ESS safety requirements, this device **must be fully compatible** with the switch SIEMENS 3SE5212-0KC05[2] with the actuator head 3SE5000-0AD04[3]. The actuator head shall be extended only when the shutter is in the closed position. When the shutter is in the opened position and during the shutter rotation, the actuator head shall be retracted. The actuator head orientation shall take into account the location of the chamfer on the switch activation cam. Guidelines for actuation, travel range and adjustment of the switches are available from ESS PSS group.
- One safety classified magnetic switch will be connected to the PSS system and will detect the closed position. Due to the ESS safety requirements, this device **must be fully compatible** with the switch SIEMENS 3SE6604-2BA[4] with solenoid 3SE6704-2BA[5] to detect the closed position of the shutter.

[1] Switch – CROUZET SP4863-12
[2] Switch body – SIEMENS 3SE5212-0KC05
[3] Head part – SIEMENS 3SE5000-0AD04
[4] Switch body – SIEMENS 3SE6604-2BA
[5] Solenoid – SIEMENS 3SE6704-2BA

The integration of switches are shown in Figure 27

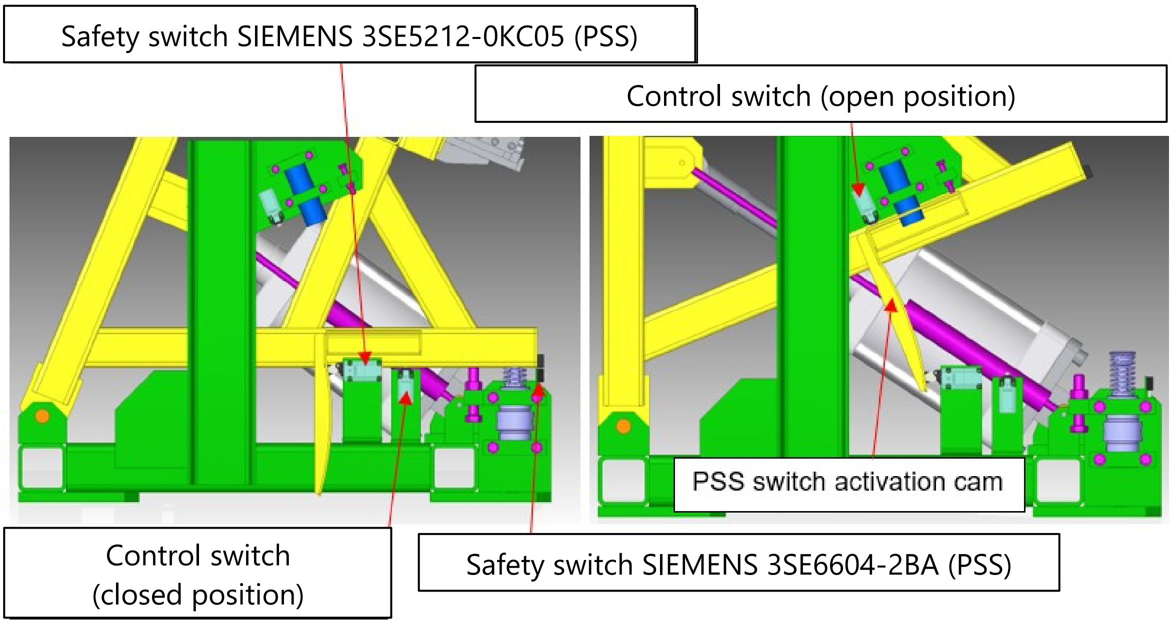


Figure 27: Side view of the switches integration in the shutter (left – shutter in the closed position, right – shutter in opened position).

2.7.2.11 ELECTRIC CABLES

This electric control is not part of the supply scope, but the shutter shall include two connection boxes as interfaces between the shutter and the electric & pneumatic control. One box connects to the cables from the end position switches and pipe connection to the pneumatic input/output (see Figure 20). The second box connects to the two PSS switches. The connection boxes will be aluminium boxes roughly of the size 120x120x80 mm with connection terminals inside, suitable for use in radiation environment, and equipped with standardized [3] connectors which **must be fully compatible** with receptacle Lemo EEJ.3B.306.CYB to connect to the ESS motion control system and PSS. A detailed design is currently being finalized at ESS and will be provided during manufacturing.
The exact position of the boxes also with respect to a connection point in the bunker needs to be defined during the design update process.

2.7.2.12 INTERFACE WITH SHUTTER PIT FLOOR

Anchorage of the whole shutter assembly to the shutter pit floor is ensured by four M20 screws (see Figure 28). During the shutter movement, the gravity centre of the assembly is always located between the screws and no rocking of the whole shutter is expected. There shall be only compression loads on the shutter pit floor and no tension loads in the anchors.
The only case that can create tension loads in the anchors is when the rotating shutter frame gets in contact with the shock absorbers in the opened position. The estimated reaction force of the shock absorber is 14200 N, which would generate maximum tension loads of 11000 N in two screws (see Figure 29). This value is conservative since it does not consider other forces like the weight of the fixed frame, the weight of the rotating shutter part and the force of the pneumatic cylinder on the fixed frame. All these forces tend to reduce the tension loads in screws. 11000/2 = 5500 N tension load is acceptable for an M20 screw with a lot of margins.
The design of the anchorage shall be compatible with the design of the shutter pit floor.

The total estimated weight of the shutter is 1850 kg.

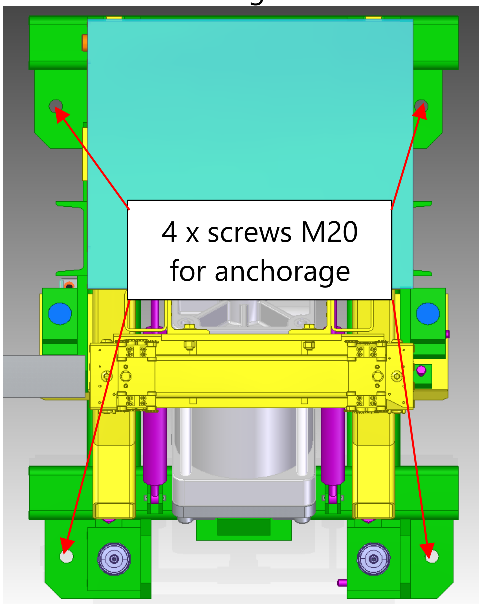


Figure 28: Location of shutter anchorage to the shutter pit floor

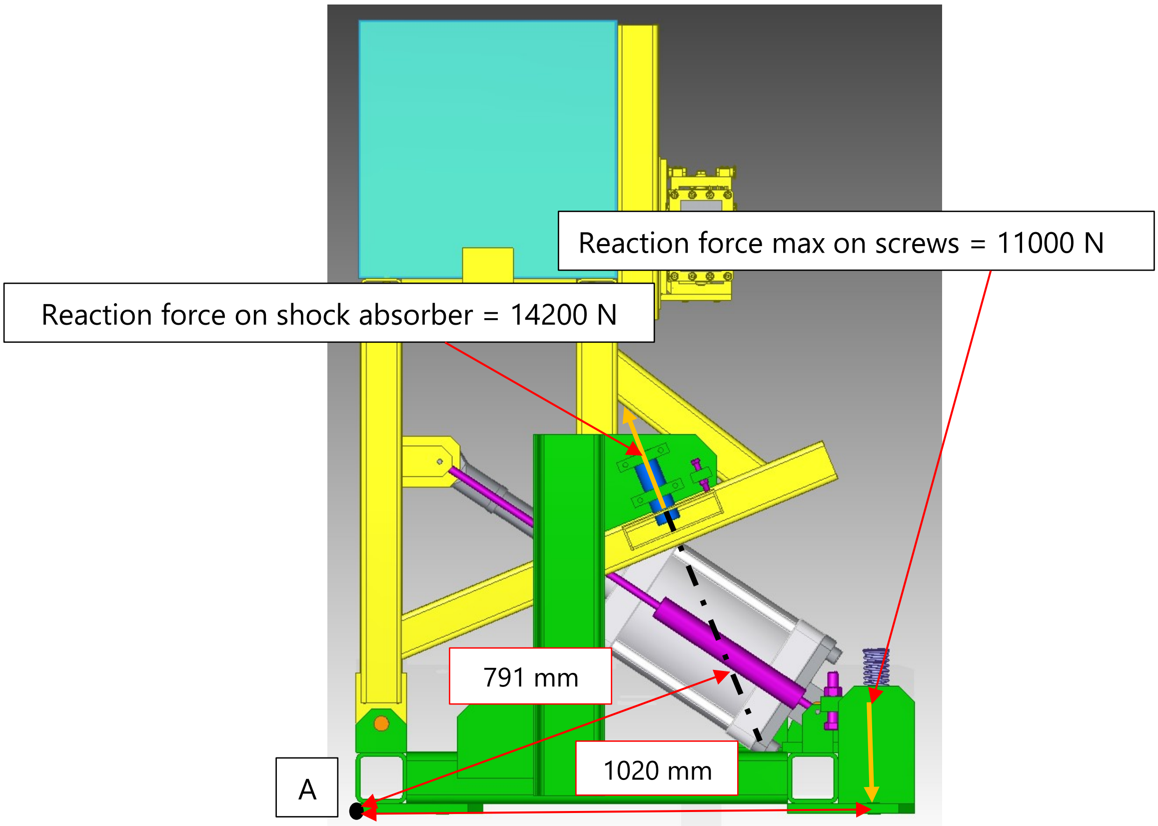


Figure 29: Forces acting in shutter in the opened position

2.7.2.13 VACUUM PIPES AND COMPRESSED AIR CONNECTIONS

Flexible hoses for the connection of the compressed air between the actuator/flow control valve and a connection point under the bunker roof shall be included in the shutter design. The hoses

shall be suitable for use in radiation environment. Again, more details of the exact positions and lengths will be available during the final design phase.
Connection routing of the vacuum pipes for the guide system on the shutter shall be considered during cabling and compressed air housing design.

2.8 CALCULATIONS

2.8.1 MAXIMUM REQUIRED FORCE OF THE PNEUMATIC CYLINDER

In order to calculate the maximum force to be delivered by the pneumatic cylinder, it is important to estimate the position of the gravity centre of the assembly shielding + rotating frame + neutron beam guide. The maximum force to be delivered by the cylinder is at the beginning of the shutter opening. Then the force decreases and is minimum when the shutter is opened. For this reason, only the shutter in the closed position is shown below. The position of the gravity centre in the closed position is shown in Figure 30.
The weight of the shielding is 1148 kg, the weight of the rotating frame is 120 kg, and the weight of the neutron guide is 110 kg (first assumption to be confirmed by supplier MIRROTRON) which gives a total weight of 1378 kg of the rotating part of the shutter.
The maximum force F of the pneumatic cylinder is then (neglecting friction forces):
F = (1378 * 9.81 * 644)/493 = 17659 N
The maximum force that can be delivered by a 250 mm bore diameter pneumatic cylinder at 6 bars is: F = P * S = 0.6 * 3.14 * 125 * 125 = 29438 N. A pneumatic cylinder with a 250 mm bore diameter is sufficient to open the shutter.

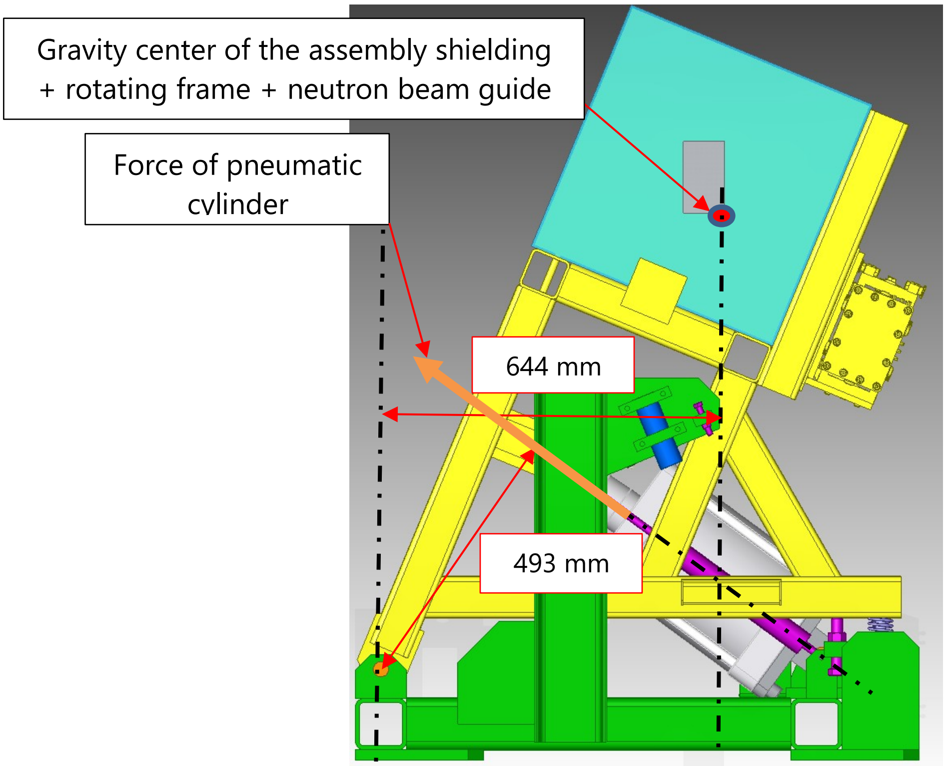


Figure 30: Location of gravity centre of the shielding, the rotating frame and the neutron beam guide

2.8.2 ROTATING FRAME RESISTANCE TO FREE FALL

The fixed and rotating shutter frames are oversized for normal operating conditions.
In an accidental scenario, it is expected that structures can be locally damaged but should not collapse. The worse accident scenario for the steel structures is a rupture of compressed air equipment at the inlet of the pneumatic cylinder. As a consequence, the shutter shall close with a gravity load. This could generate high dynamic loads if the pneumatic cylinder and the hydraulic control rates offer lower resistance to the fall.
The maximum reaction force on one shock absorber in the closed position is 58500 N.
Using the static equivalent method, the strain and stresses in the rotating shutter frame have been assessed with the software RDM Le Mans. The model can be seen in Figure 31 to Figure 33.
Friction forces and resistance of the pneumatic cylinder are neglected, which is conservative. Steel is considered for the calculation.
Boundary conditions are shown in Figure 33. At the location of the shock absorbers, displacement along the z-axis is blocked. At the location of the pivot connections, only the rotation along the y-axis is allowed. Two vertical forces of 60300 N are applied at the contact between the shielding and the rotating frame (in the corner to be conservative) in order to get reaction forces of 58500 on each shock absorber.
Results are shown in Figure 34 to Figure 36. The maximum displacement obtained is less than 1 mm. The maximum Von Mises stresses obtained is 221 MPa.
The conclusion is that the rotating frame structure could be locally damaged but will not collapse. Also, the resistance of the pneumatic cylinder to the fall shall greatly reduce the mechanical loads.
The rotating shutter frame mechanical behaviour is satisfying. During purchasing of the shutter, more detailed calculations shall be required:

- Verification of the fixed frame, especially at the location of the shock absorbers
- Verification of the mechanical interface between the rotating frame and the shutter neutron guide
- Verification of pivot connections

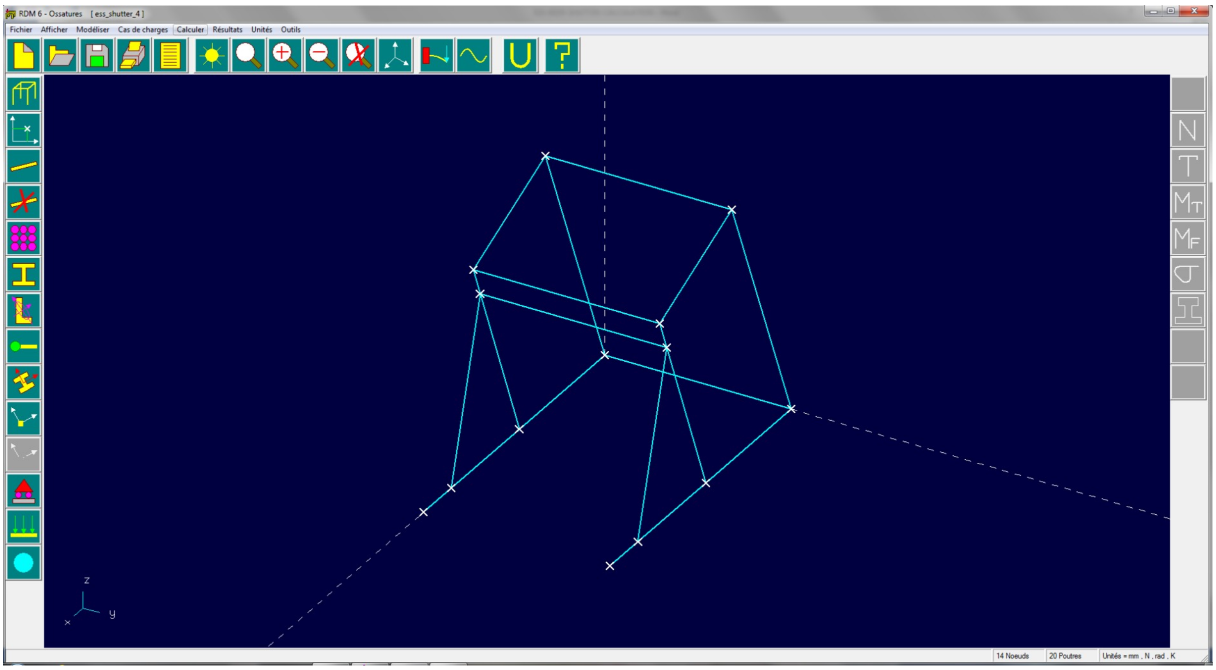


Figure 31: Beam model of the rotating shutter frame

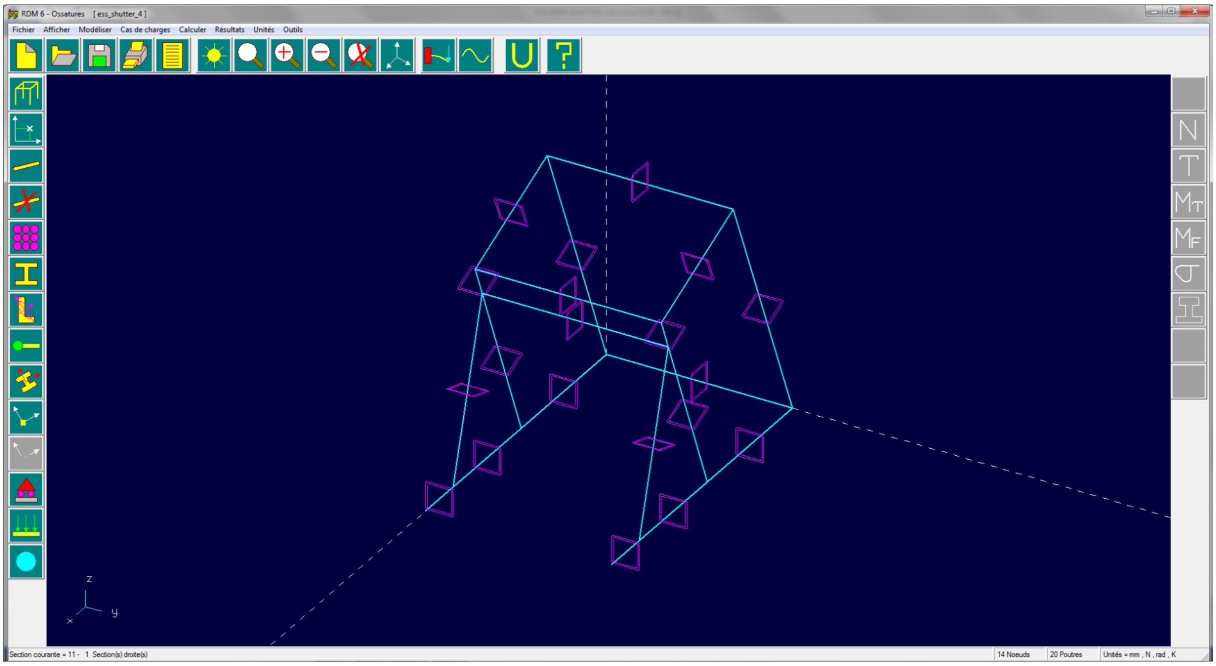


Figure 32: Beam model of the rotating shutter frame

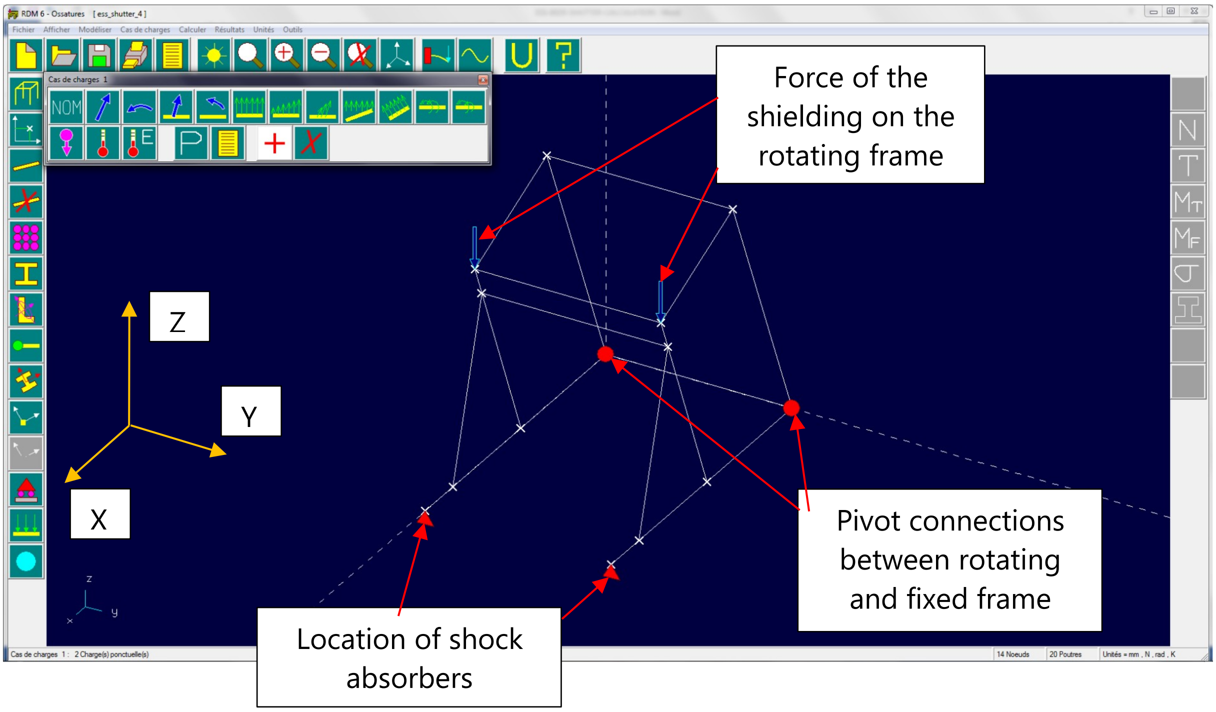


Figure 33: Boundary conditions

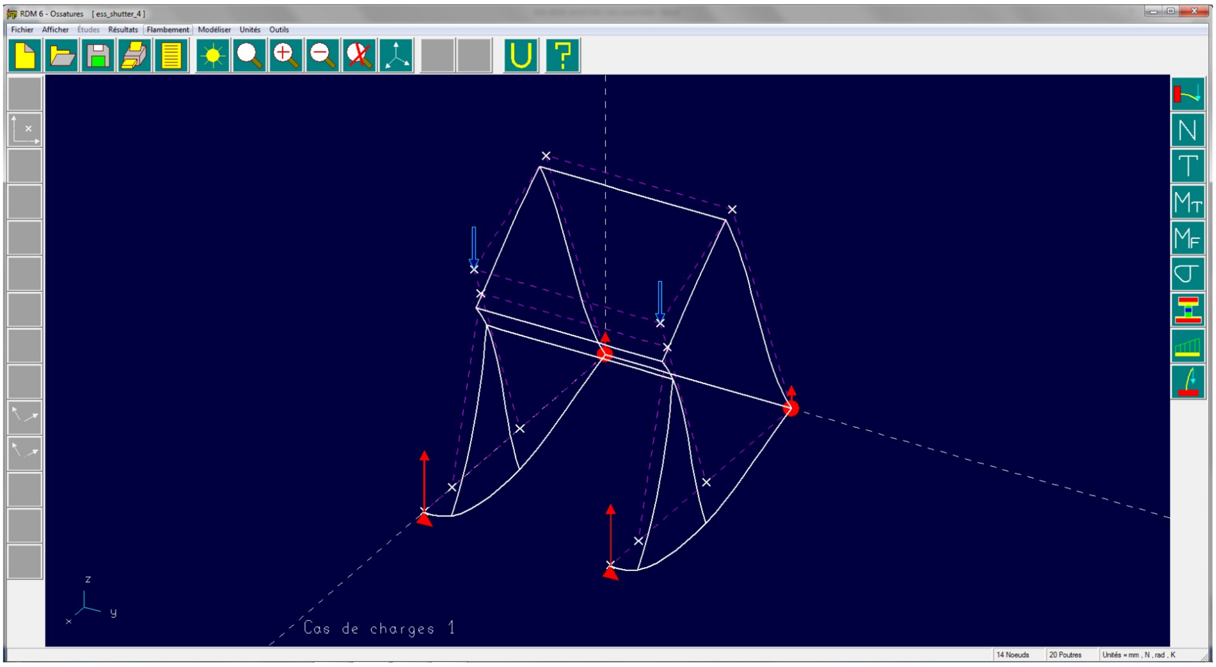


Figure 34: Deformation of the rotating shutter frame

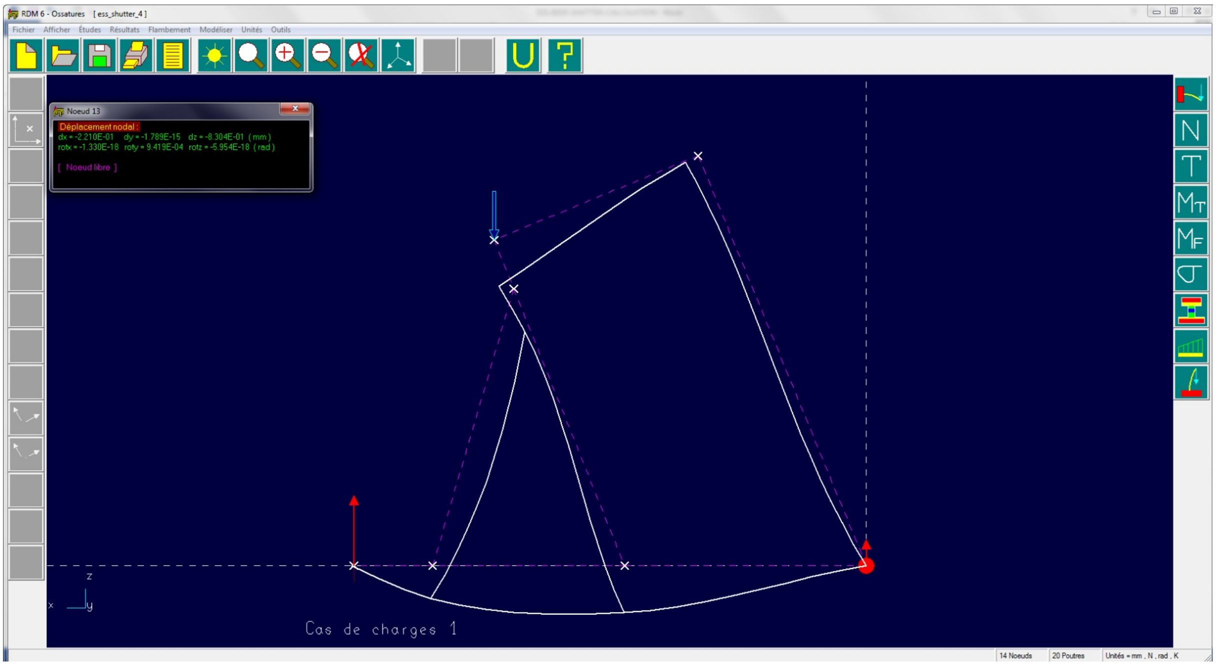


Figure 35: Deformation of the rotating shutter frame

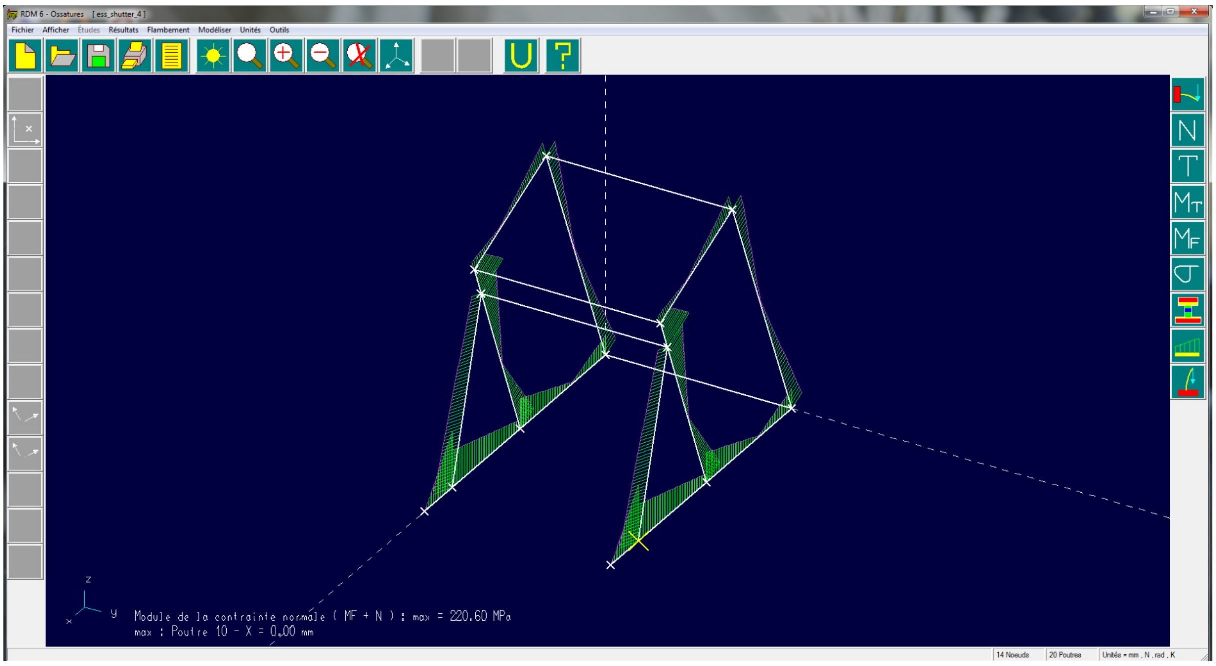


Figure 36: Von Mises stresses in the rotating shutter frame

3 TRANSPORT, ASSEMBLY AND COMMISSIONING

There are no specific requirements regarding the transport of the shutter. The equipment shall be packed and transported to the ESS site without any damage.

FAT and SAT shall be included in the shutter scope of supply. During FAT and SAT, all the functions of the shutter shall be tested. A mock-up of the shutter neutron guide could be required to test the functions and avoid too much transport of the neutron guide.

The time schedule shall be studied so that it is compatible with the installation of the bunker insert and the E02 neutron transport guide.

The assembly of the shutter shall consider the bunker insert and the E02 neutron transport guide carefully.

For SAT, the bunker insert window and the E02 neutron transport guide should be in place to test the correct alignment.

Special attention shall be paid during the positioning of the shutter during installation so that the clearance shutter/bunker insert and shutter/E02 neutron transport guide are about 5 mm and that no collision with these components occurs during the opening/closing of the shutter.

4 SURFACE TREATMENT

Epoxy paint shall be applied to the steel frames.

5 OPERATION AND MAINTENANCE

The shutter has been designed to require minimum preventive maintenance. Check of the pneumatic system once or twice a year is recommended. Also, the alignment of the neutron guide

shall be checked regularly. As mentioned above, operator access in the pit is supposed to be possible for hands-on maintenance operations.
Corrective maintenance in case of component failure could include:

- Change of the pneumatic cylinder,
- Change of other pneumatic components,
- Change of hydraulic rate controls,
- Change of shock absorbers,
- Change of switches,

Change of the pneumatic cylinder is the most complicated operation in regards to the weight of the cylinder. In Figure 37 is shown a solution how to change the pneumatic cylinder and the hydraulic rate controls when the shutter is closed by using a dismountable beam (modification shall be included in the manufacturing drawings). Change of the pneumatic cylinder when the shutter is opened is also possible but would require pins to secure the rotating frame in the opened position (otherwise, it will fall when the pneumatic cylinder is removed).
Top shock absorbers should also be possible to change when the shutter is closed. As seen in Figure 38, access to the top shock absorber and mechanical stop located on the bunker side is limited. A solution could be to place these two components on the other side of the support, offering thus better access through the shutter rotating frame (see Figure 39).
The shutter in the opened position allows good access to lower shock absorbers, lower mechanical stops, pneumatic cylinder, hydraulic rate controls and shutter neutron guide (see Figure 40).
Operator Health and Safety should be carefully looked at while purchasing the shutter.

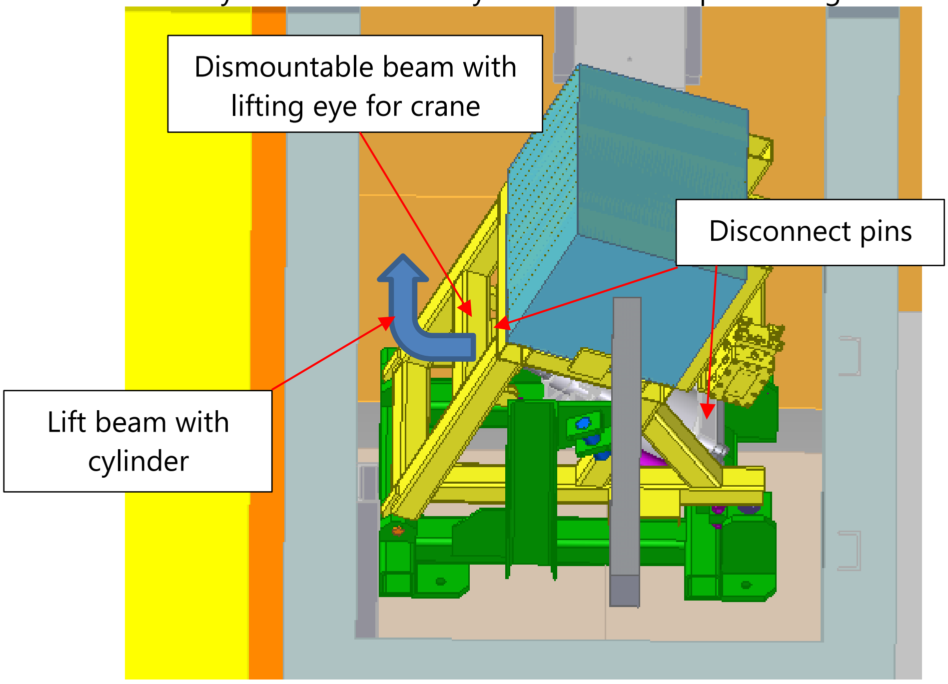


Figure 37: Maintenance operations to change the pneumatic cylinder (shutter closed)

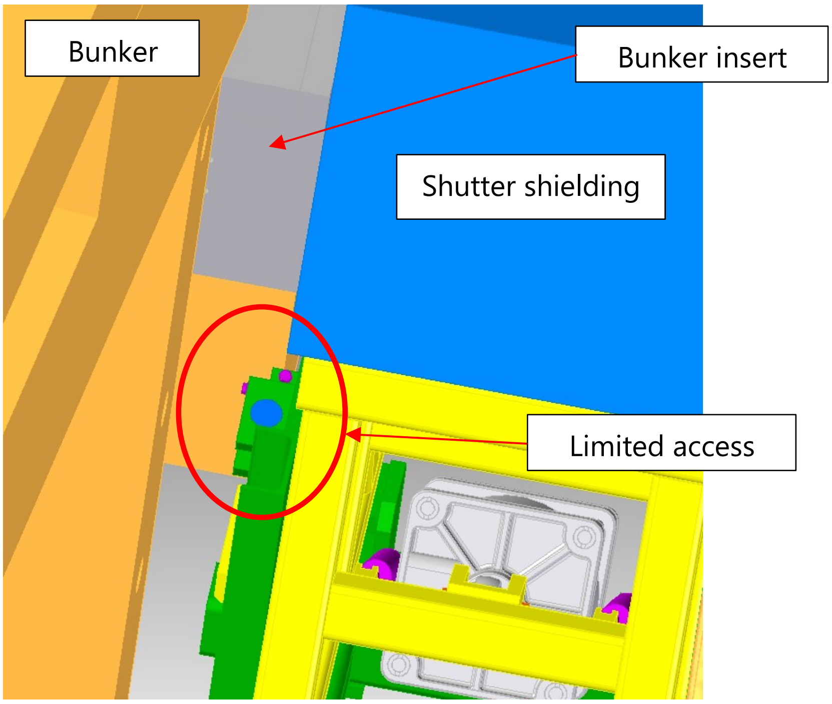


Figure 38: Access to the top shock absorber and mechanical stop on bunker side when the shutter is opened

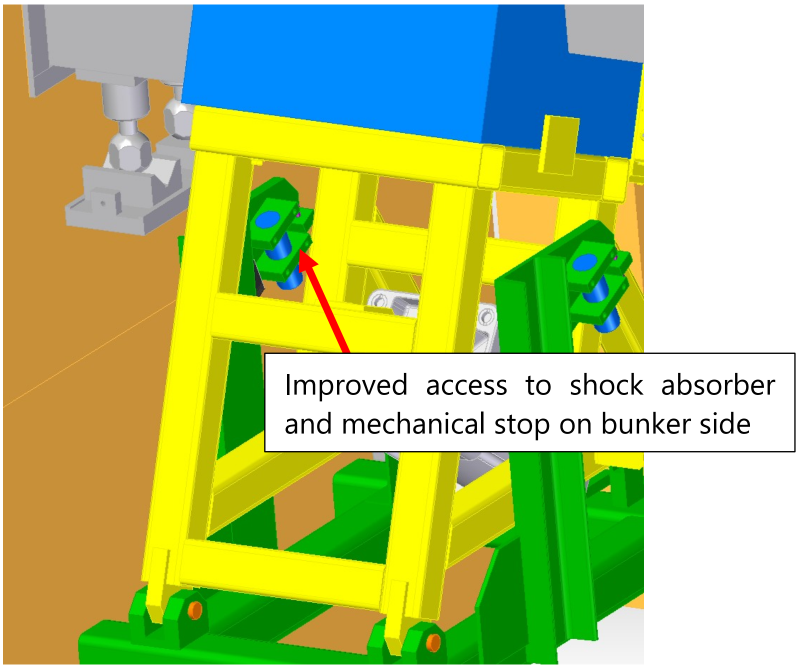


Figure 39: Improved access to the top shock absorber and mechanical stop when the shutter is opened

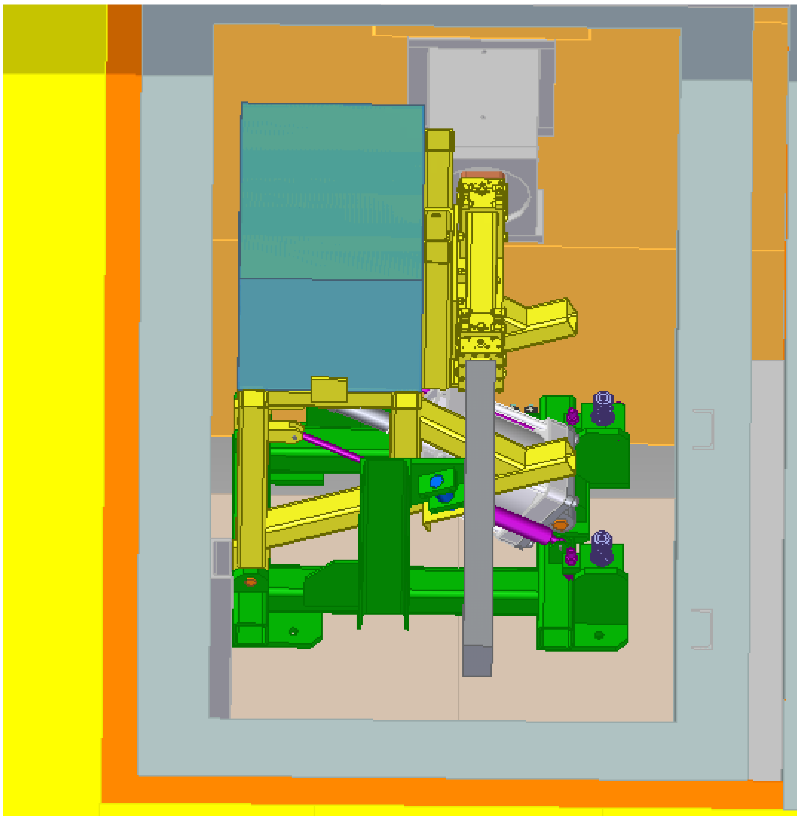


Figure 40: Shutter in the opened position

6 MOUNTING

For installation and mounting on site will be used crane in hall D03.

6.1 ASSUMPTIONS BEFORE MOUNTING

- Bunker is done
- Interface with shutter is done (window in the bunker)
- Shutter pit floor is done
- Shutter pit walls are done
- For shutter installation, at least a mock-up representing the shutter neutron guide should be used

6.2 ANTICIPATED INSTALLATION PROCEDURE – STEP BY STEP

a) STEP 1

   Marking of theoretical shutter position at floor

b) STEP 2

   Insert of mounted assembly = green frame + yellow frame + block represented shielding (just envelope) + engine (pneumatic piston) – using crane

c) STEP 3

Control of correct position in shutter pit (several times close and open shutter; no collision with the wall, bunker, ...)

d) STEP 4

Final marking of the hole for connection of shutter

e) STEP 5

Demounting mounted assembly (using crane)

f) STEP 6

Holes drilling + mounting of anchorages

g) STEP 7

Final insert of shutter + control of position + mounting (using crane)

h) STEP 8

Insert and mount of shielding block (using a crane)

i) STEP 9

Mounting of Neutron beam guide connected to the shutter

j) STEP 10

Final justification neutron beam guide

7 COMPLIANCE MATRIX

Id	Requirement description	Status	Justification/Comment
R1	The shutter shall include a neutron beam guide on the movable structure of the shutter	A	See Technical report
R2	The shutter shall allow a precise alignment (≤0,1 mm) of the shutter neutron beam guide with the bunker insert window and the neutron beam guide in shutter pit	A	See Technical report section 2.7
R3	The shutter shall detect when the shutter neutron beam guide is aligned with the bunker insert window and the neutron beam guide in shutter pit	A	See Technical report section 2.7
R4	The shutter shall inform BEER instrument control system that the shutter neutron beam guide is aligned with the bunker insert window and the neutron beam guide in shutter pit	C	Electric connection between shutter and BEER I&C not performed yet
R5	The shutter shall include a shielding on the movable structure of the shutter that allows a safe operator access in required areas	A	See Technical report section 2.7
R6	The shutter shall allow alignment of the centre of the shielding with the neutron beam when shutter is in closed position	A	See Technical report section 2.7
R7	The shutter shall detect when the centre of the shielding is aligned with the neutron beam position	A	See Technical report section 2.7
R8	The shutter shall inform BEER instrument control system that the shielding centre is aligned with neutron beam position	A	Electric connection between shutter and BEER I&C not performed yet
R9	The shutter shall keep a man access to allow a precise alignment of the shutter neutron beam guide by an operator	A	See Technical report section 5
R10	The shutter shall keep a man access for shutter maintenance in opened or closed position	A	See Technical report section 5
R11	The shutter shall keep man access for neutron beam guide installation, alignment and maintenance	A	See Technical report section 5
R12	The shutter shall keep man access for bunker window insert maintenance	A	See Technical report section 5
R13	The shutter shall allow opening/closing of the shutter about 10 times per hour	A	See Technical report section 2.7
R14	The shutter shall allow the opening/closing of the shutter in about 10 seconds during normal operation	A	See Technical report section 2.7
R15	The shutter shall be designed for at least 10000 cycles without heavy maintenance operations	A	See Technical report section 2.7
R16	The shutter shall be designed for light maintenance operations and inspection 2 times per year maximum	A	See Technical report section 5
R17	The shutter shall be operated from the BEER instrument control system	C	Electric connection between shutter and BEER I&C not
R18	The shutter shall keep a clearance of about 5 mm on each side of the shutter neutron beam guide (shutter opened)	A	See Technical report section 2.7
R19	The shutter shall keep a clearance of about 5 mm between the shielding and the bunker insert window (shutter closed)	A	See Technical report section 2.7
R20	The shutter shall be compatible with the design of the fixed neutron beam guide in the shutter pit	B	To be checked when the E02 neutron transport guide will be available
R21	The shutter shall be compatible with BEER instrument control system	C	To be studied during design of BEER I&C
R22	The shutter shall include a neutron guide that is compatible with BEER instrument requirement	A	Both guides are in the scope of MIRROTRON and should be compatible
R23	The shutter shall include a shielding that considers the parameters and nature of the neutron beam	A	See radiological calculation report.
R24	The shutter shall use materials that are compatible with the neutron beam	A	See Technical report section 2.7
R25	The shutter shall use materials that keep reasonable dose rate levels when activated	A	See radiological calculation report. Activation levels allow operator access in shutter pit
R26	The shutter shall keep a vacuum atmosphere in the shutter neutron guide	A	Included by MIRROTRON in the shutter neutron guide design
R27	The shutter shall be compatible with the shutter pit dimensions	A	Rails and top beams are described in [3]
R28	The shutter shall be compatible with shutter pit floor load capacity	A	No issue foreseen
R29	The shutter shall allow the fixation of the shutter to the floor of the shutter pit	A	See Technical report section 2.7
R30	The shutter shall be operated according to ESS operation and maintenance plan	C	To be checked with ESS
R31	The shutter shall permit closing/opening of the shutter by direct operator action	C	To be implemented during purchasing of the shutter
R32	The shutter shall inform the operators of the shutter status closed/opened, locked/unlocked	C	To be implemented during purchasing of the shutter
R33	The shutter shall permit a locking of the shutter in both positions by direct operator action	C	To be implemented during purchasing of the shutter
R34	The shutter shall be maintainable by operators directly in the shutter pit considering shutter pit ceiling opened	A	See Technical report section 5
R35	The shutter shall allow access to components requiring maintenance	A	See Technical report section 5
R36	The shutter shall allow dismounting and change of critical components	A	See Technical report section 5
R37	The shutter shall be rescuable	B	It should be possible to rescue the shutter using a crane
R38	The shutter shall keep dose rates from activation below 25 µSv/h to allow a man access in the shutter pit for maintenance	A	See radiological calculation report.
R39	The shutter shall be be decontaminable	A	See Technical report section 2.7
R40	The shutter shall allow adjustment of the shutter neutron beam guide from the shutter pit by direct operator access	A	See Technical report section 5

R41	The shutter shall allow measurement of the shutter neutron beam guide position using fiducials	A	See Technical report section 5
R42	The shutter shall use long life components	A	See Technical report section 2.7
R43	The shutter shall use reliable components	A	See Technical report section 2.7
R44	The shutter shall limit risks of mechanical incidents	C	To be implemented during purchasing of the shutter
R45	The shutter shall limit risks related to human factor	C	To be implemented during purchasing of the shutter
R46	The shutter shall limit mechanical shocks	A	See Technical report section 2.7
R47	The shutter shall use low maintenance components	A	See Technical report section 2.7
R48	The shutter shall be fail safe (the shutter shall close with gravity action in case of electric or compressed air supply cut)	A	See Technical report section 2.7
R49	The shutter shall inform PSS system when the shutter is closed	C	To be implemented during purchasing of the shutter
R50	The shutter shall be designed to withstand loads during normal and accident scenarios	A	See Technical report section 2.8
R51	The shutter shall not be possible to open in case of compressed air or electric supply failure	A	See Technical report section 2.7
R52	The shutter shall avoid the use of flammable material when possible	A	See Technical report section 2.7
R53	The shutter shall minimize fire ignition sources	A	See Technical report section 2.7
R54	The shutter shall limit operator efforts during installation, maintenance and decommissioning	B	Should be studied more in detail
R55	The shutter shall protect operators during operator access in the shutter pit	C	To be implemented during purchasing of the shutter
R56	The shutter shall protect operators from electric shock	C	To be implemented during purchasing of the shutter
R57	The shutter shall be harmless	C	To be implemented during purchasing of the shutter
R58	The shutter shall keep reasonable noise level	C	To be implemented during purchasing of the shutter
R59	The shutter shall comply with Load Specification	A	See Technical report section 2.7
R60	The shutter shall comply with defined industrial standards	C	To be implemented during purchasing of the shutter
R61	The shutter shall comply with European Directives and be CE marked	C	To be implemented during purchasing of the shutter
R62	The shutter shall connect with electric power supply	C	To be implemented during purchasing of the shutter
R63	The shutter shall connect with vacuum network	C	To be implemented during purchasing of the shutter
R64	The shutter shall connect with compressed air network	B	Should be studied more in detail
R65	The shutter shall be compatible with Building access routes for installation, maintenance and dismantling	A	No issue foreseen
R66	The shutter shall be compatible with building floor load capacity	A	No issue foreseen
R67	The shutter shall be compatible with handling means available for installation, maintenance and dismantling	A	No issue foreseen

A	Fully implemented in the design
B	Partially implemented in the design and complete implementation shall not be a problem
C	Not implemented in the design but future implementation shall not be a problem
D	Not implemented in the design and future implementation could be a problem

Table 8: Compliance Matrix of the shutter

8 RISKS ASSESSMENTS

Description of Risk			
[Cause] As a result of:	[Event] There is a risk that:	[Consequence] Which would result in:	Mitigation
Bad shutter design	The shutter does not work properly	Redesign of the shutter, delay, increase of costs	Design reviews, communication with suppliers, include margin in the design, FAT and SAT,
Wrong radiological calculations	Higher dose rates than calculated	Increase of shielding size, redesign of the shutter, delay, increase of costs	Include margin in radiological calculations, verify calculations
New requirements added, too high cost	Change of the shutter design	Redesign of the shutter, delay, increase of costs	Check requirements with ESS and UJF, cost estimation of the shutter, communication with suppliers
Design not adapted, difficulty to procure required, materials	Difficult to find suppliers	Redesign of the shutter, delay, increase of costs	Design reviews, communication with suppliers, use simple and robust design
Bad coordination with Bunker insert installation and E02 neutron transport guide. Delay with the delivery ofthe shutter pit, the bunker insert and E02 neutron transport guide	Installation on site not possible	Delays, increase of costs	Coordinate the installation sequences, look after suppliers to get components on time, choose reliable suppliers
Complexity of requirements underestimated, capacity of the design overestimated	Shutter does not fulfil all the requirements	Redesign of the shutter, delay, increase of costs	Design reviews (including requirements review), define realistic requirements, communication with suppliers, include margin in the design, FAT and SAT,
Delay during shutter supply, delay of other components supply, delay during installation of shutter	Shutter is not installed on time	Delays, increase of costs	Coordinate the installation sequences, look after suppliers to get components on time, choose reliable suppliers
Complex design, low number of suppliers	Shutter cost is higher than expected	Increased project budget	Anticipate an increase of shutter cost in the project budget, Try to get as many tenderers as possible during the purchase of the storage racks, Investigate options to reduce the system cost

Table 9: Risks assessments of the shutter

9 CONFORMITY WITH EU REGULATIONS

The shutter must be manufactured according to all requirements and, in the end, must be confirmed by CE marking.
Devices, including accessories, delivered to ESS shall be designed in compliance with:

- European directives
- Swedish laws and standards
- Relevant Europeans and ISO standards
- ESS standards and regulation

The documentation shall be issued in English.

10 APPLICABLE DIRECTIVES, STANDARDS AND REGULATIONS

ČSN EN 287-1 Welding. Testing of Welders. Fusion welding. Part 1: Steel
ISO 9712 Qualification and certification of employees NDT – General principles

ČSN EN ISO 9001:2008 Quality Management Systems – Requirements
ČSN ISO 10005:2006 Quality Management Systems - Regulations for the Quality Plan
ČSN EN ISO 14731 Welding Supervision Tasks and Responsibilities
ČSN EN 1090-2 A1 (732601) Execution of Steel Structures and Aluminum Structures - Part 2: Technical Requirements for Steel Structures.
ČSN EN 10029 09/91 Heat-processed Rolled Steel Sheet in Thickness of 3 mm or Higher - Dimensional Tolerances
ČSN EN ISO 898-1 12/99 Mechanical Characteristics of Fixation Elements made from Carbon Steel and Alloy Steel - Part 1: Screws and Pins
ČSN EN 10204 01/05 Metal Products – Types of Control Documents
ČSN EN 10025-1 03/05 Structural Steel Heat-processed Products - Part 1: General Technical Supply Conditions
ČSN EN 10025-2 03/05 Structural Steel Heat-processed Rolled Products - Part 2: General Technical Supply Conditions for Structural Non-alloy Steel
ČSN EN 10025-3 03/05 Structural Steel Heat-processed Rolled Products - Part 3: General Technical Supply Conditions for Weldable Fine-grain Structural Steel in Normalized Condition/Normalized rolling
ČSN EN 10025-4 03/05 Structural Steel Heat-processed Rolled Products - Part 4: General Technical Supply Conditions for Weldable Fine-grain Structural Steel Obtained by Thermo-[4mechanical Rolling
ČSN EN 10025-6 03/05 Structural Steel Heat-processed Rolled Products - Part 4: General Technical Supply Conditions for Flat Steel Products with High Limit of Flexibility in Hardened and Tempered Condition
ČSN EN 10163-1 05/05 Supply Conditions Regarding Condition of the Surface of Sheets, Wide Steel and Molded Heat-processed Rolled Steel Sheets - Part 1: General Data
ČSN EN 10163-2 05/05 Supply Conditions Regarding Condition of the Surface of Sheets, Wide Steel and Molded Heat-processed Rolled Steel Sheets - Part 2: Sheets and Wide Steel
ČSN EN 10163-3 05/05 Supply Conditions Regarding Condition of the Surface of Sheets, Wide Steel and Molded Heat-processed Rolled Steel Sheets - Part 3: Molded Steel
ČSN EN 10021 03/07 General Technical Conditions of Supply of Steel Products

EN 1993 EUROCODE 3

Machine Directive 2006/42/EC

Standards for electric and pneumatic equipment are still to be defined.

11 REFERENCES

[1] ESS-0464148 Radiation safety Analysis
[2] ESS-0403282 ESS - Instrument Technical Interfaces
[3] ESS-0439471 MCA Components Standard