

# Neutron Beam Extraction System

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Target Division

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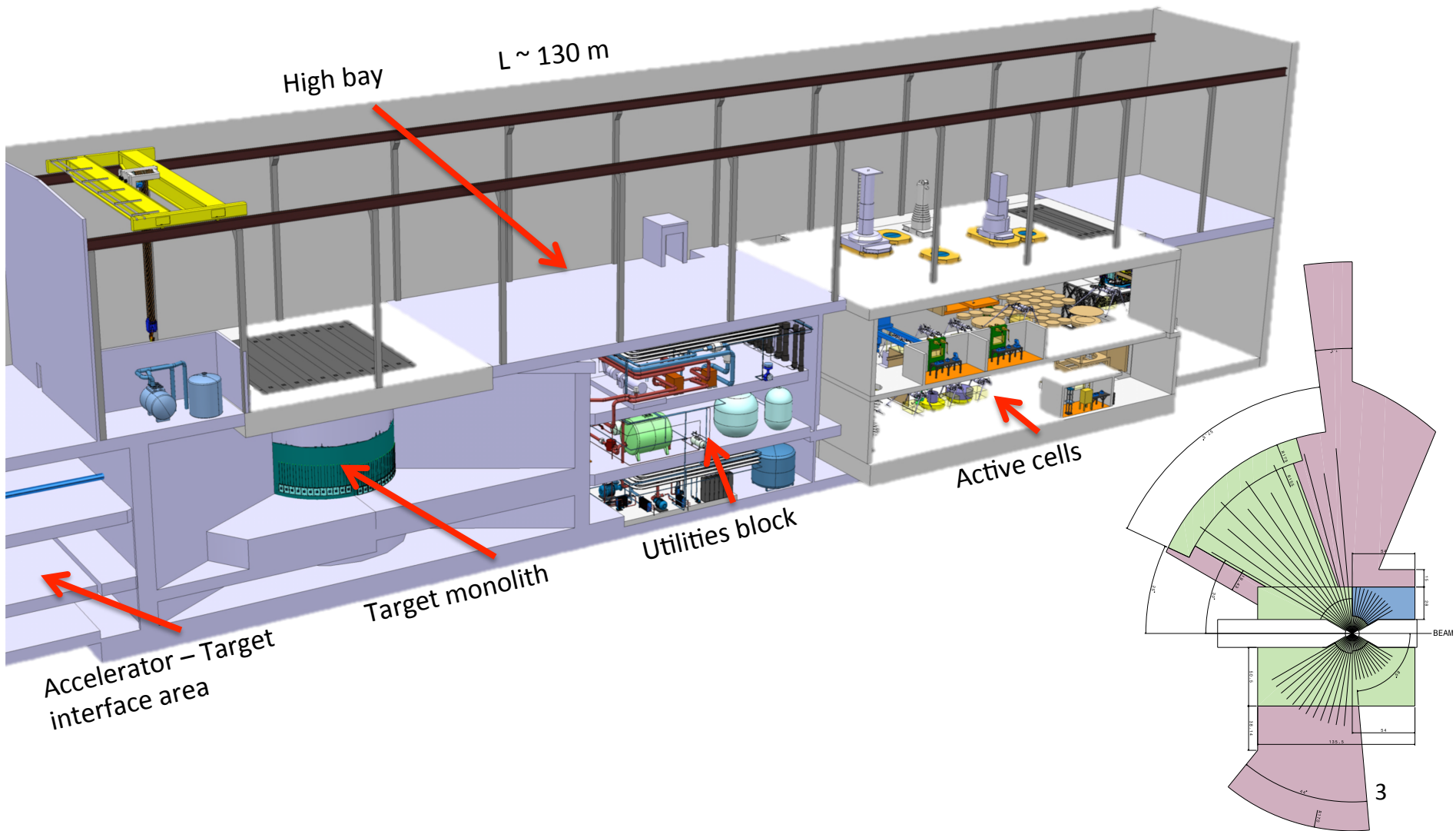
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3 June 2015

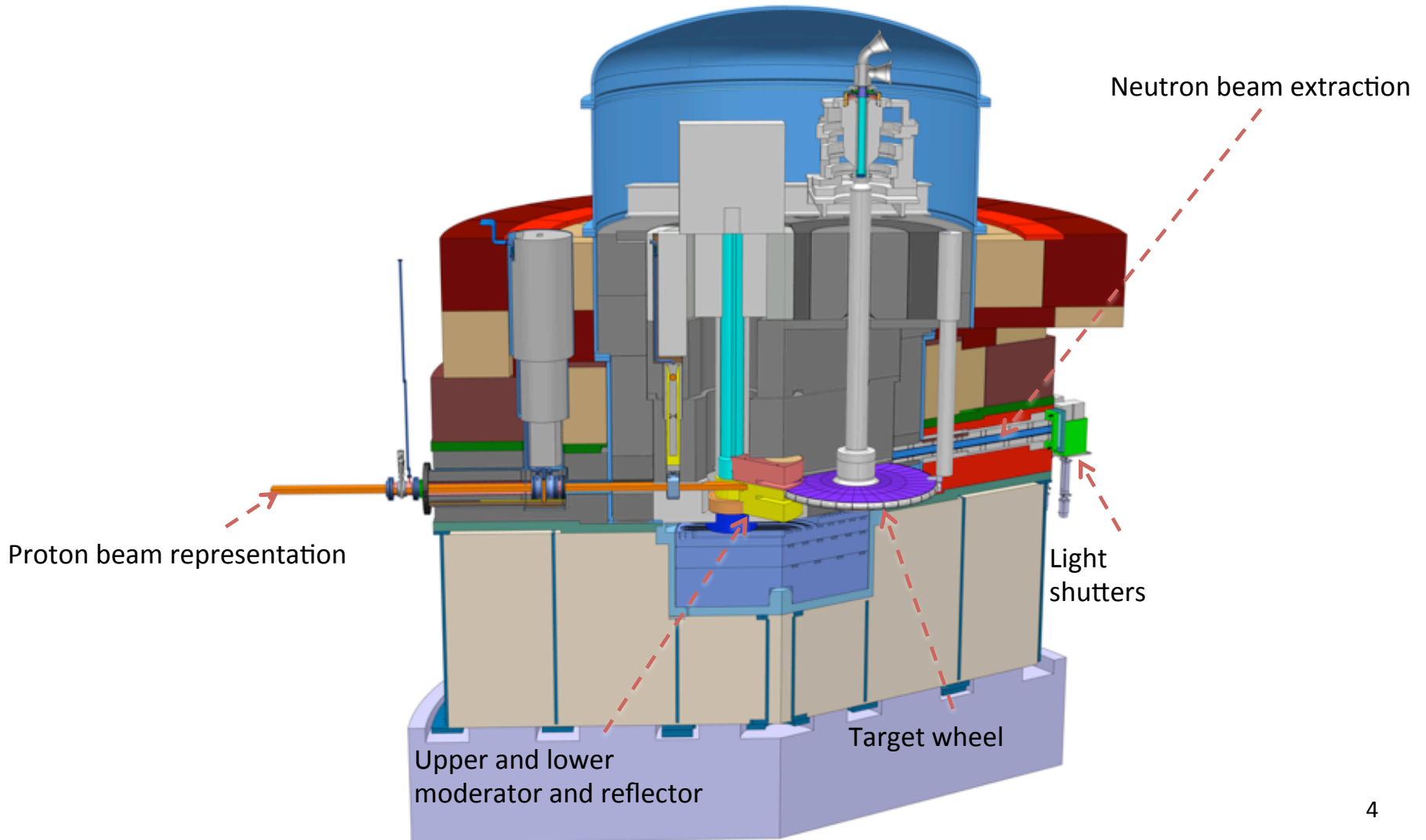
# Outline

- Target station – in brief
  - Target station layout
  - Monolith and target systems
- Beam extraction system parts
  - Neutron beam port blocks
  - Neutron beam port inserts
  - Neutron beam windows
  - Light shutters
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- Provisional alignment concepts
- Exchange procedures
  - Handling tool
  - Neutron beam port inserts
  - Light shutters
- Insert environment
  - Monolith atmosphere
  - Neutron flux map
  - Activation considerations and estimations

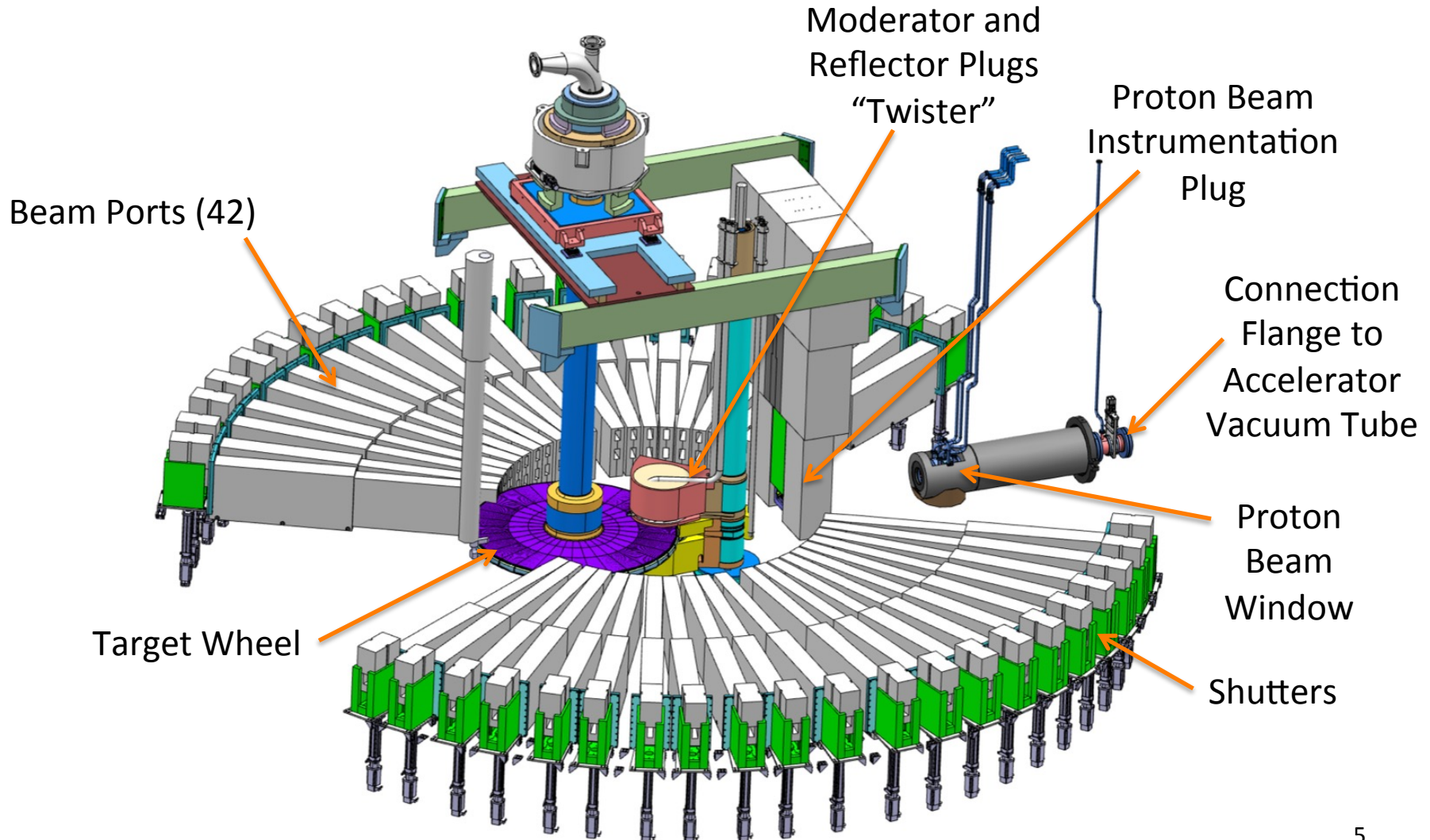
# Target station layout



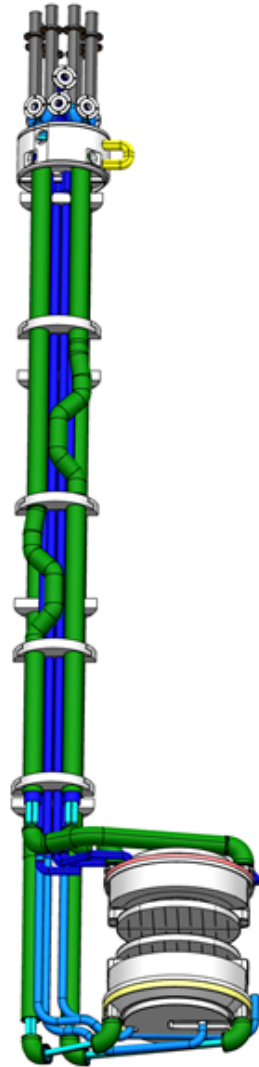
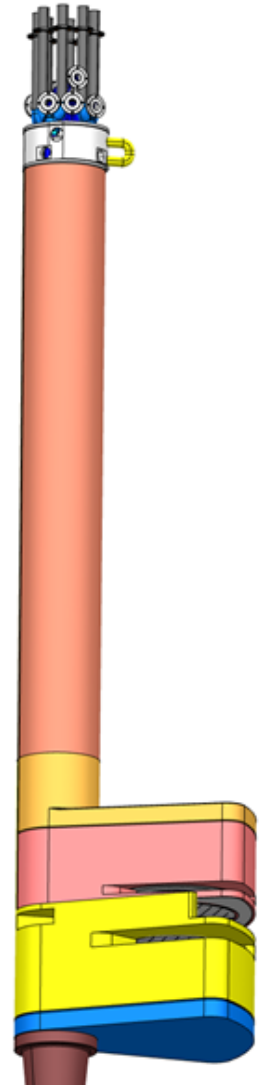
# Monolith and target systems



# Monolith interior seen without surrounding steel shielding

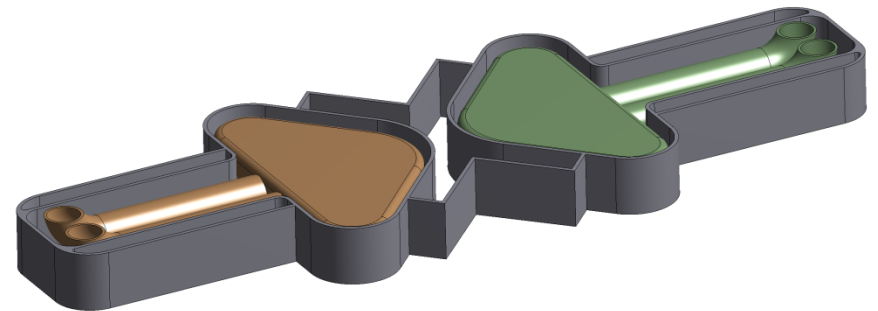
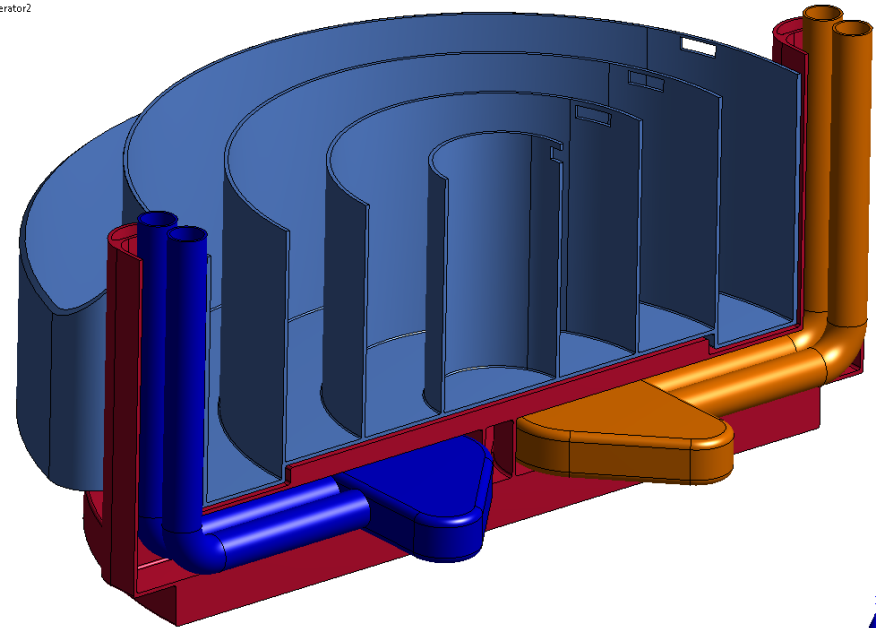


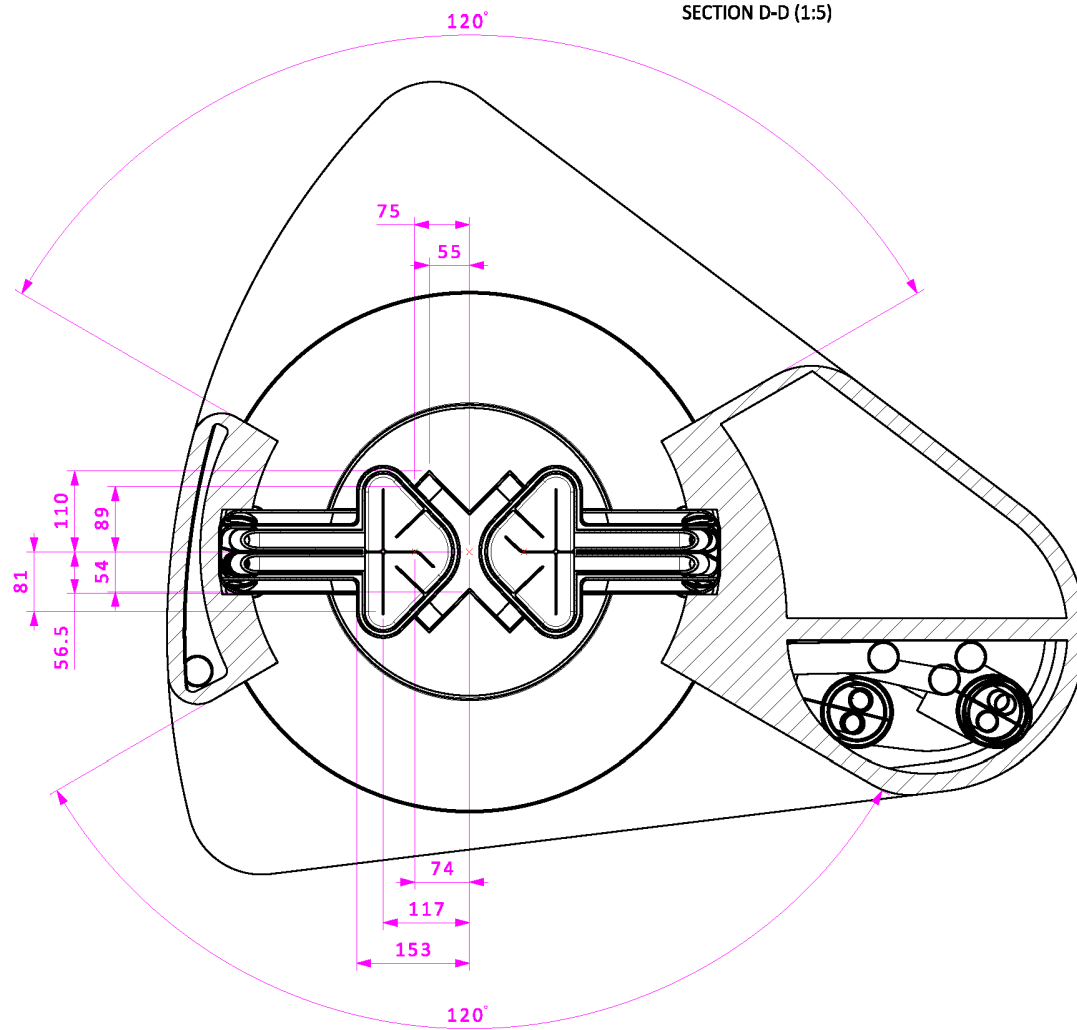
# Moderator and reflector assembly



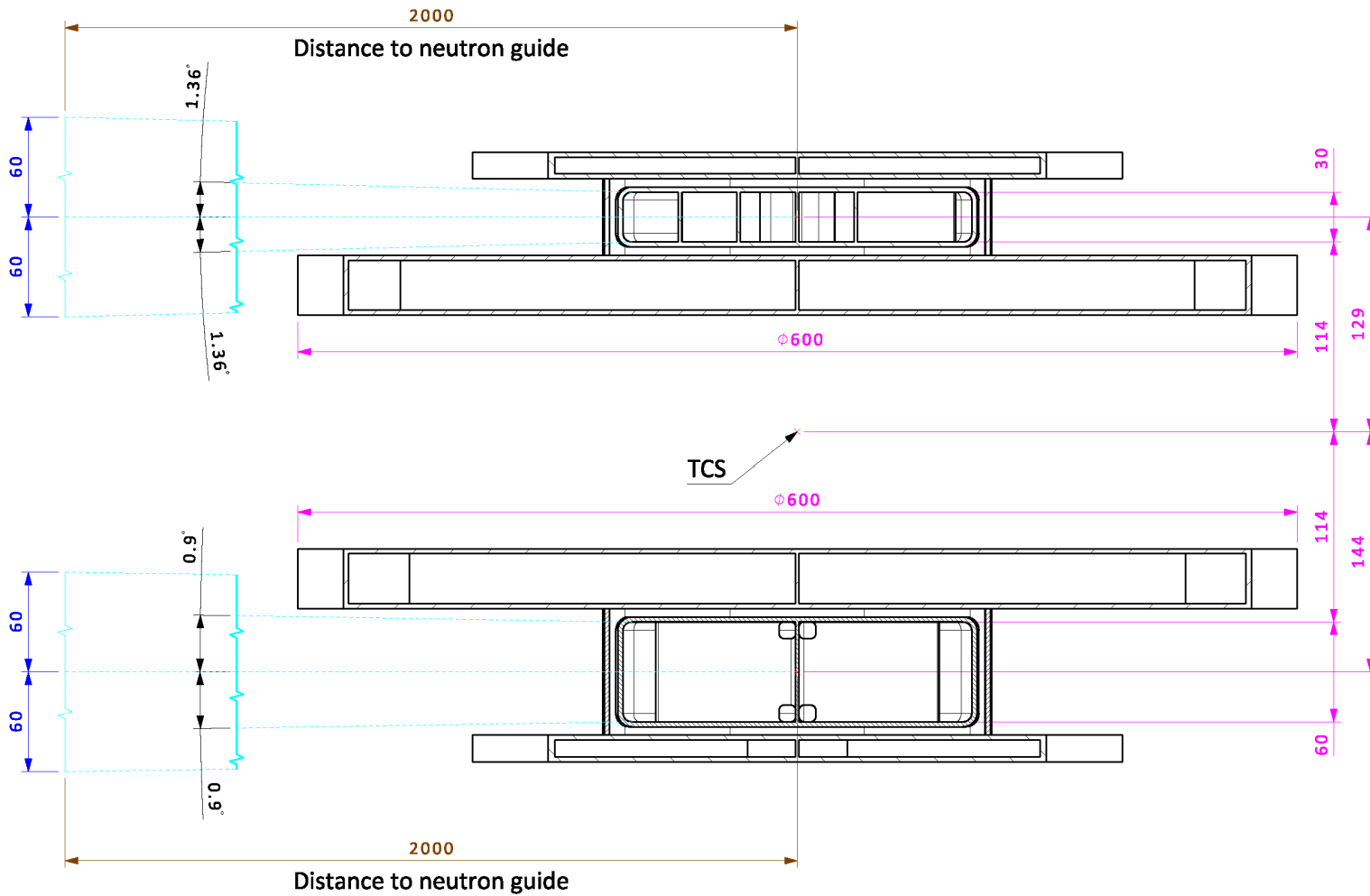
Named Selections  
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- thermalmoderator
- coldmoderator1
- coldmoderator2
- reflector2





SECTION C-C (1:2)

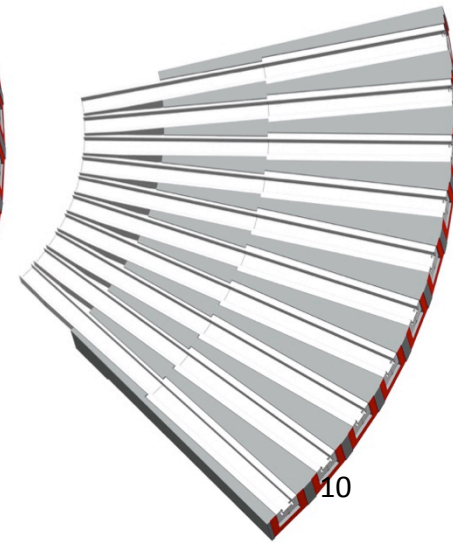
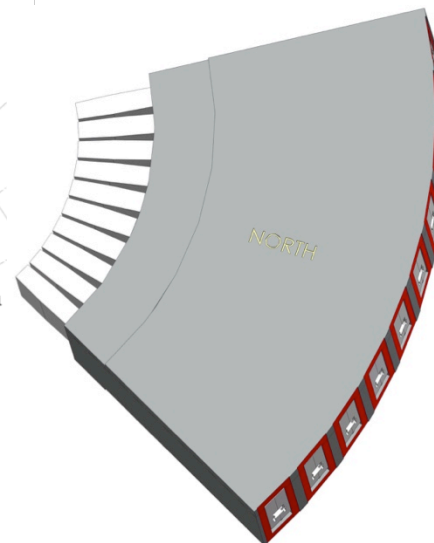
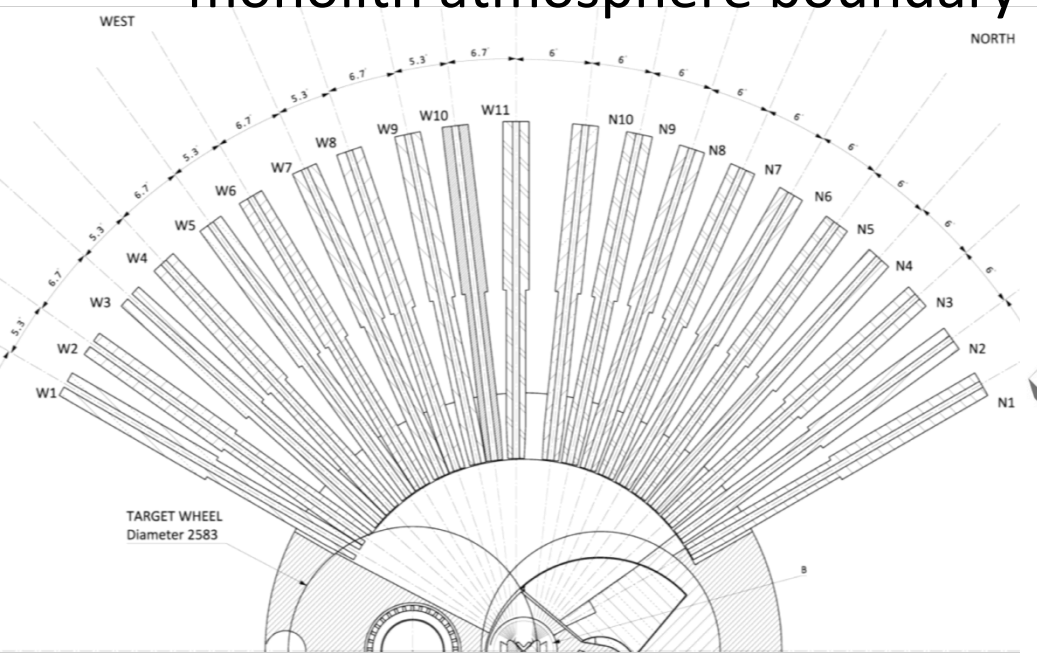
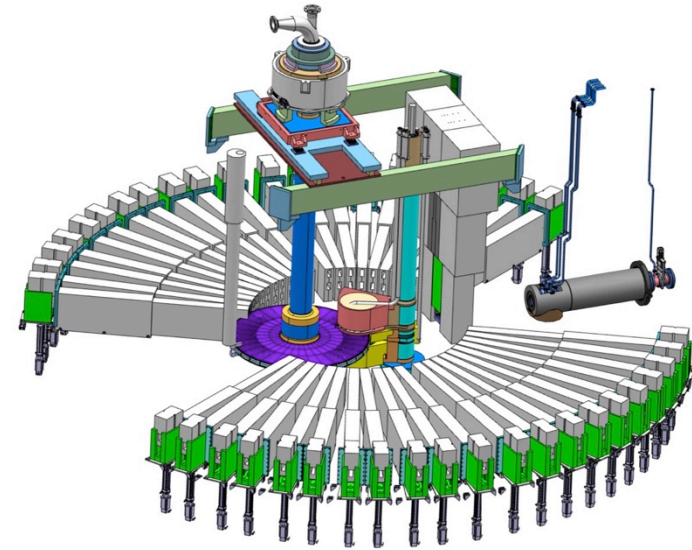


# Beam extraction system parts

- Neutron beam port blocks
- Neutron beam port inserts
- Neutron beam widows
- Light shutters

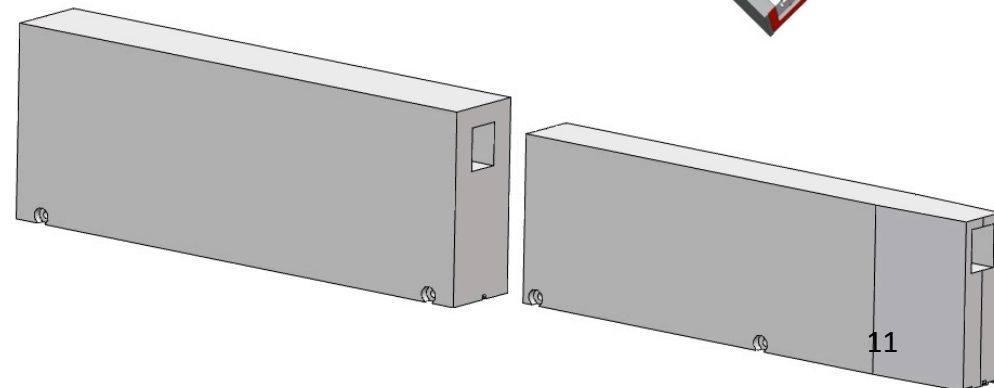
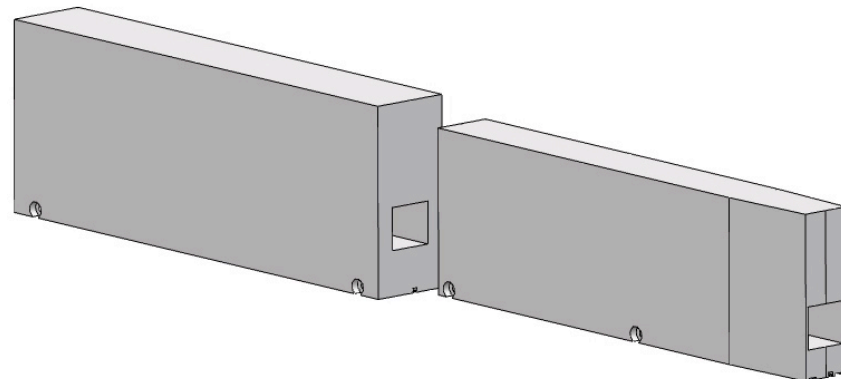
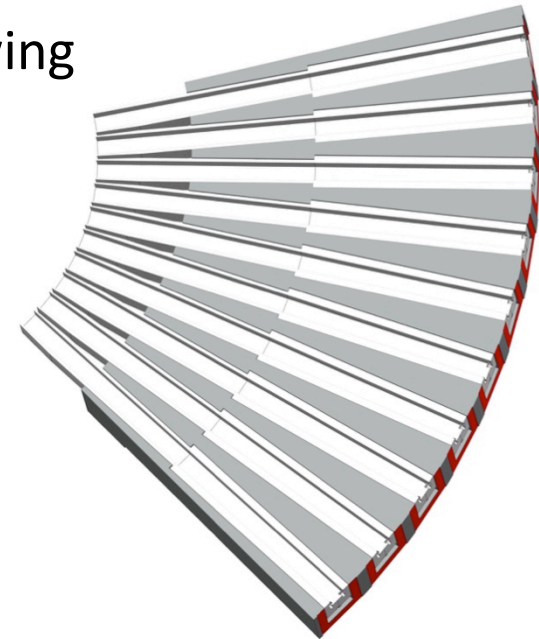
# Neutron beam port blocks

- The geometry of the 42 neutron beam ports are defined by four port blocks
- Outer surfaces (red) are envisaged as the reference plane for each individual beam line
- The port blocks are part of the monolith atmosphere boundary



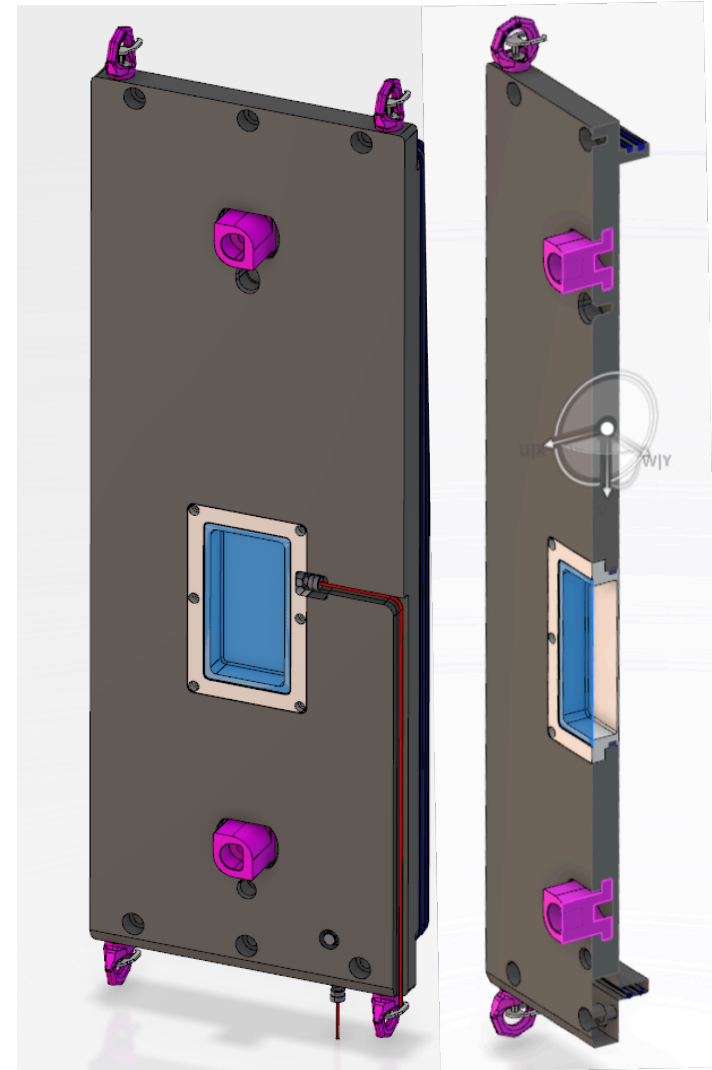
# Neutron beam port inserts

- Double decker inserts
  - Can be equipped with neutron optics for viewing either of the upper or the lower moderators
  - Split in two halves due to weight and replacement space restrictions
    - Inner half 660 mm high, 200 mm wide with tapered front tip
    - Outer half 740 mm high, 270 mm wide
    - Total length 1.5 m



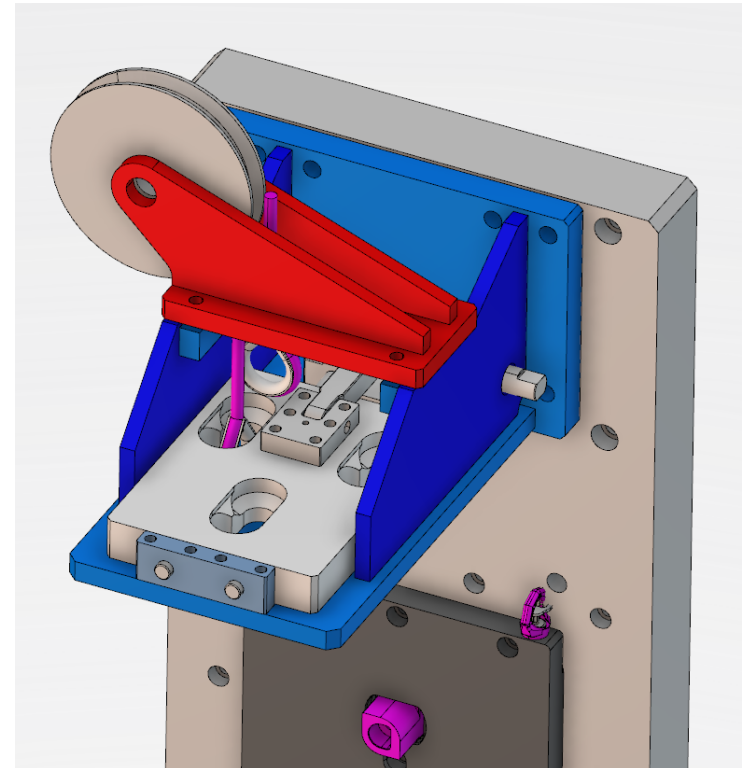
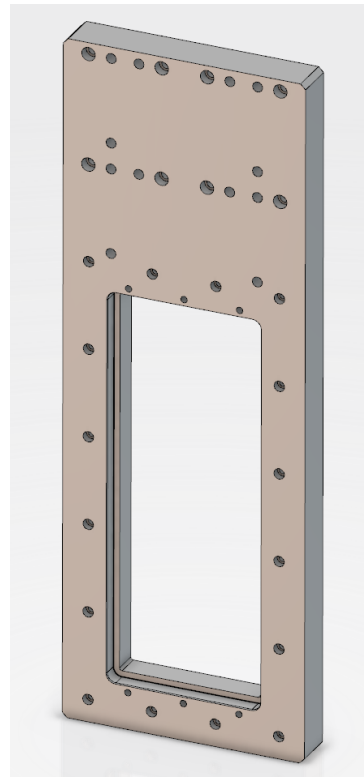
# Monolith neutron beam window with attached components

- Requirements:
  - Sealing the inner monolith atmosphere.
  - Letting the neutrons through.
  - Narrow enough to be removed easily from the front.
  - Easy handling.
- Solution:
  - Outer window made of steel give strength.
  - Inner window of e.g. aluminium.
  - Tube routing on side and front groove.
  - Lifting lugs on ends.
  - Handling slots for mounting tool on front.



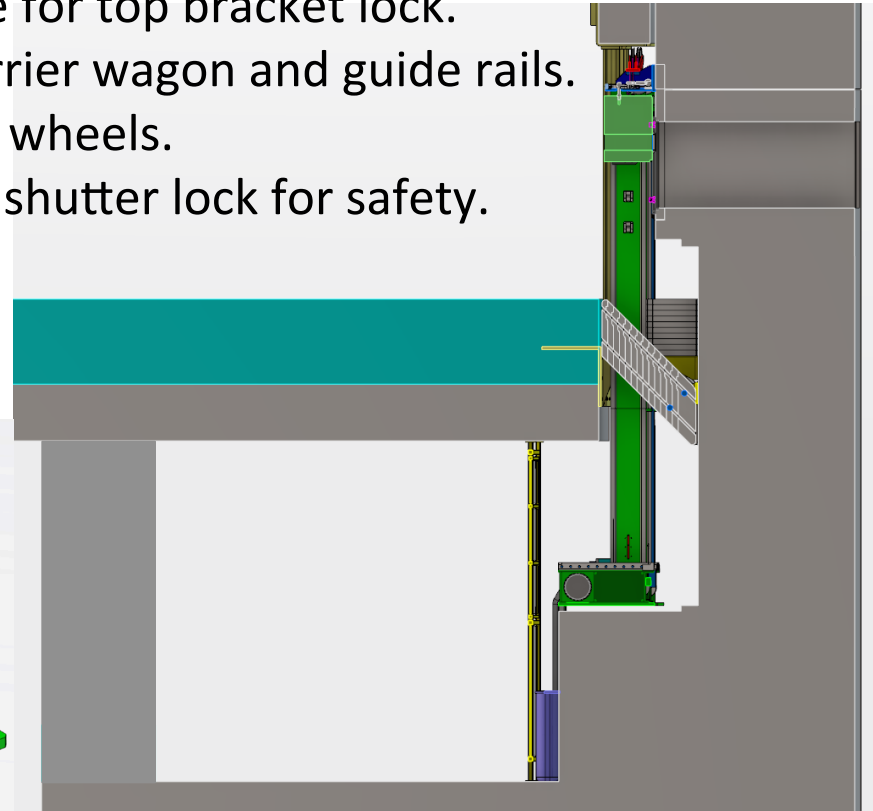
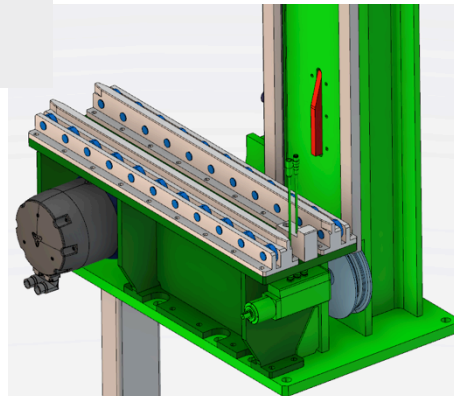
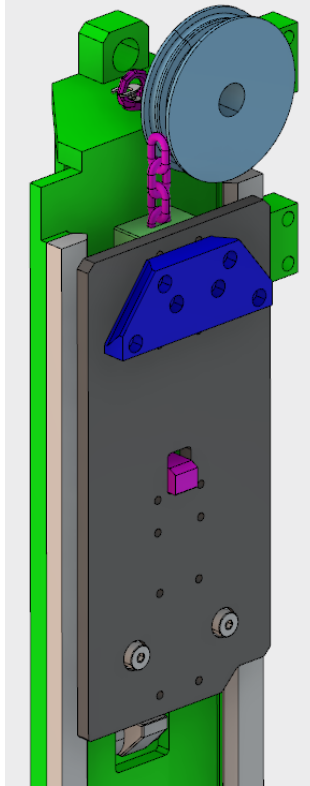
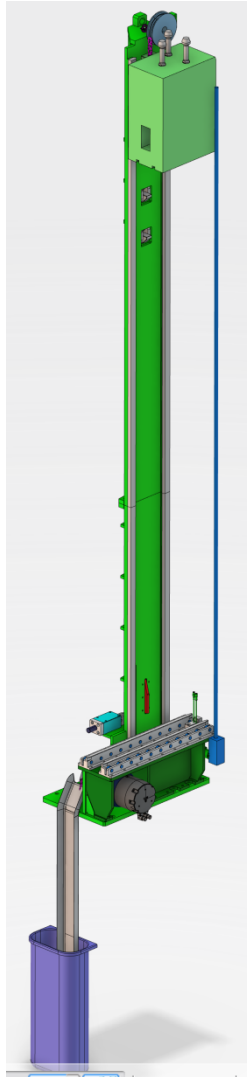
# Monolith neutron beam window with attached components

- Neutron beam window mounting surface needs some holes for the window and light shutter attachment bracket. This will guarantee a correct position for the top bracket in relation to the nominal neutron beam.



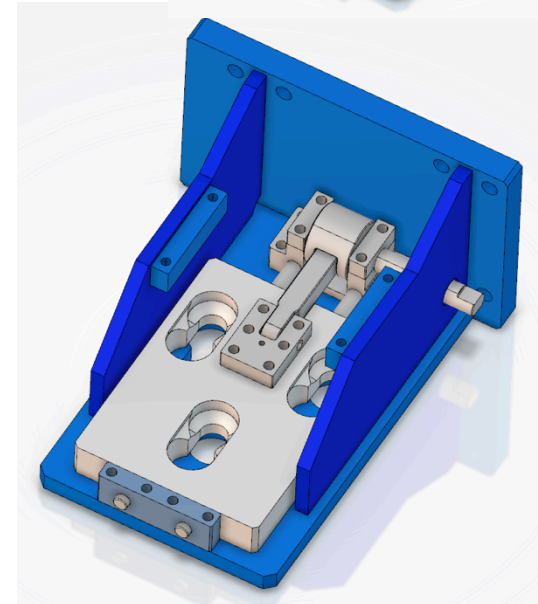
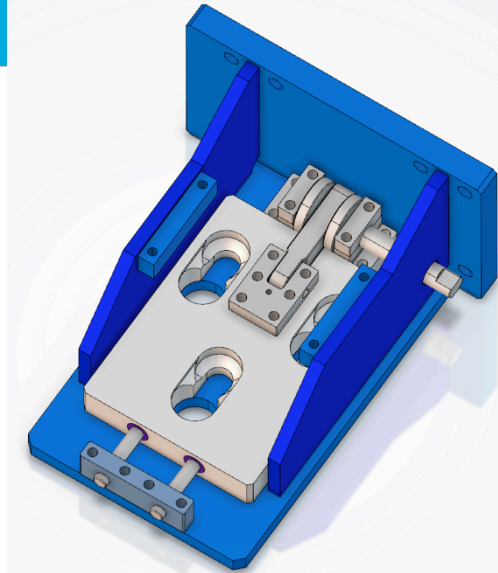
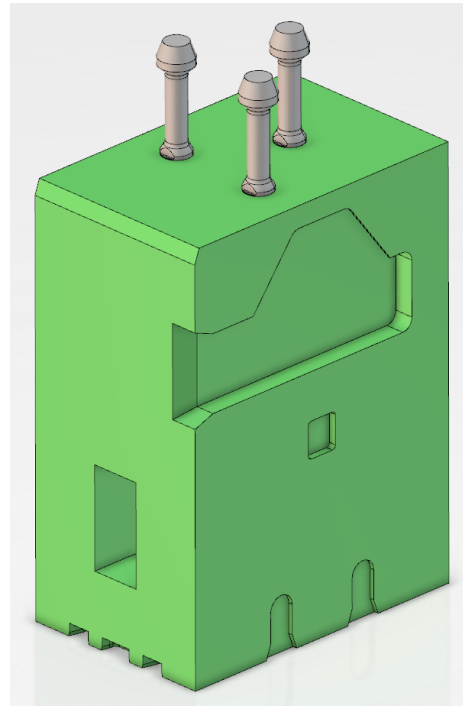
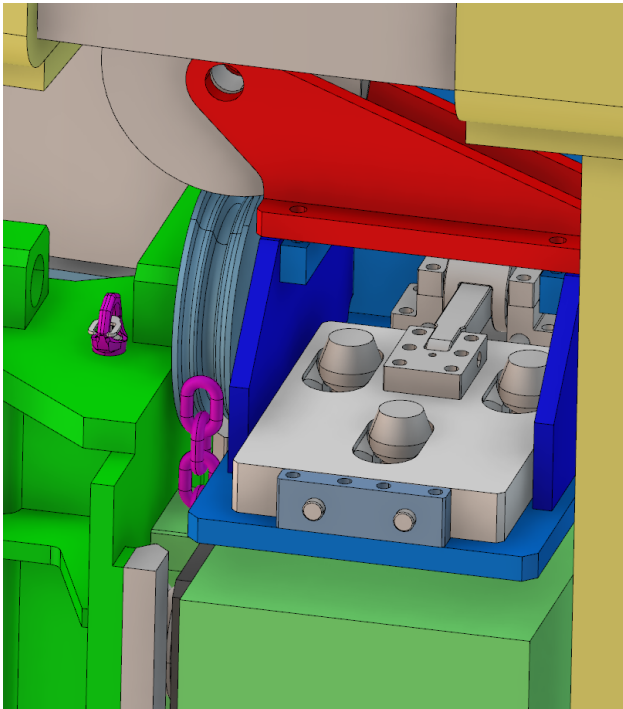
# Light shutter technical solution

- Light shutter lift consist of:
  - Landing pad for shutter weight. Automatic load and unload of shutter.
  - Servo drive for lifting.
  - Servo drive for top bracket lock.
  - Shutter carrier wagon and guide rails.
  - Chain loop wheels.
  - Secondary shutter lock for safety.



# Light shutter solution for single neutron beam.

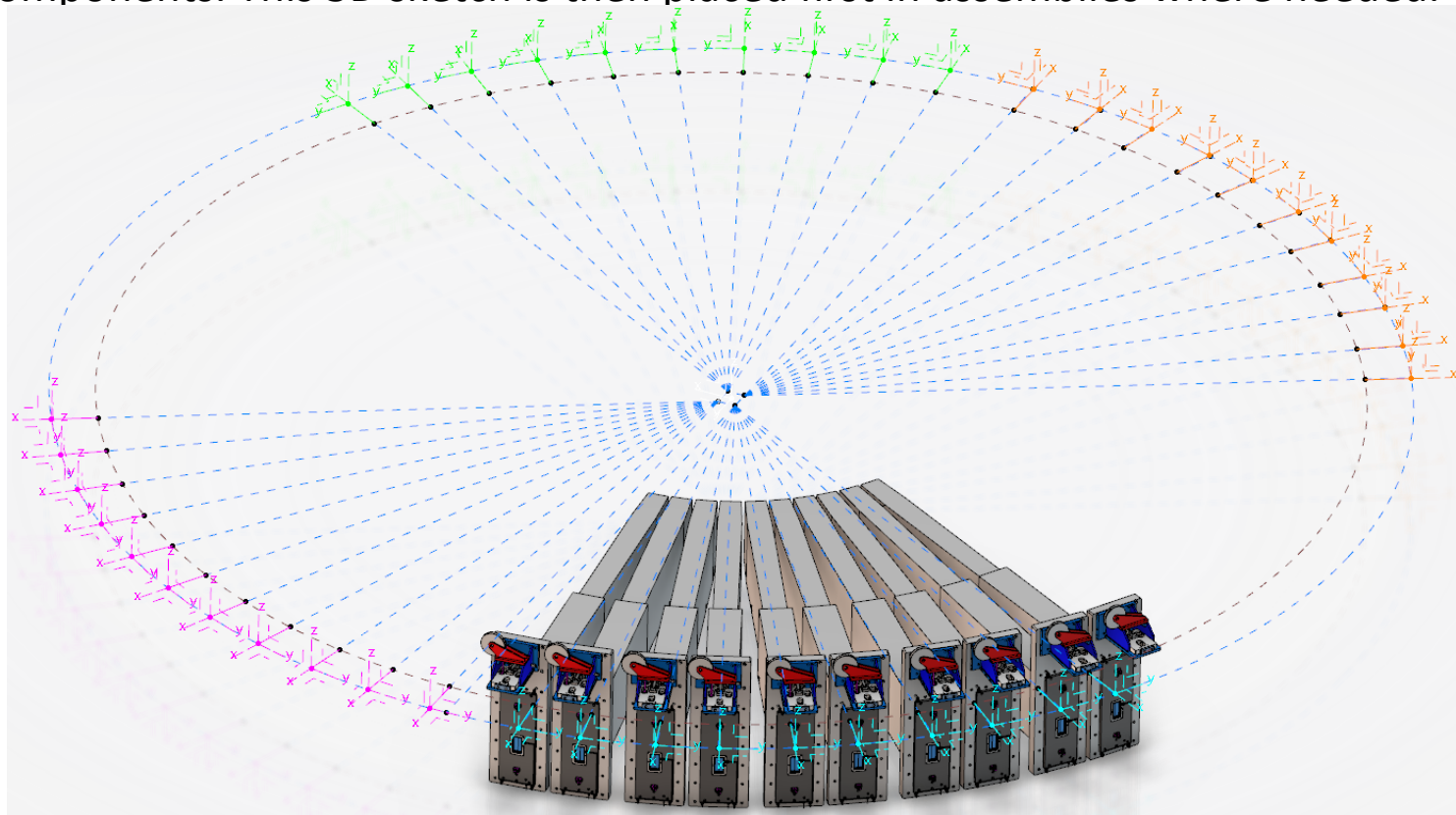
- In open position the top bracket lock plate allows the light shutter studs to penetrate the three holes from below.
- In closed position the shutter stud cones will rest in the seat pockets thus creating a tripod hanging support for the shutter.
- The 3 seat pocket can be machined to compensate for inaccuracy in bracket placement in relation to nominal neutron beam.



# Reference coordinate systems

## Catia 3D assembly setup

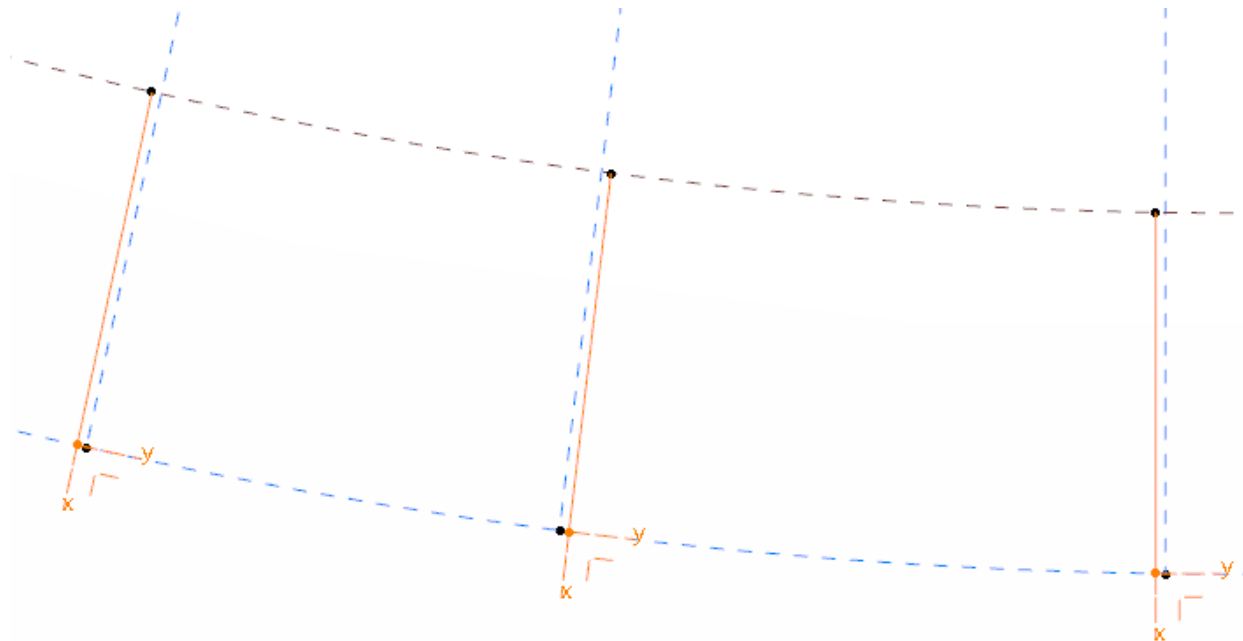
- Issue: We need to be able to easily position and move components in relation to TCS and moderator focal points.
- Solution: Master modelling technique. We create a 3D sketch with all important dimensions and place CSYS at point where we want to attach the components. This 3D sketch is then placed first in assemblies where needed.



# Reference coordinate systems

## 3D assembly setup

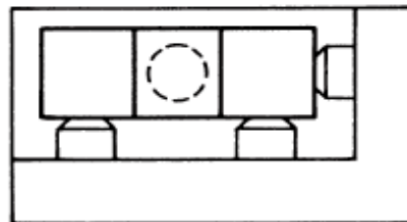
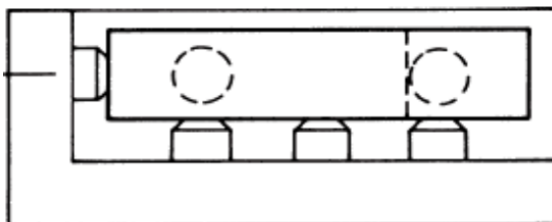
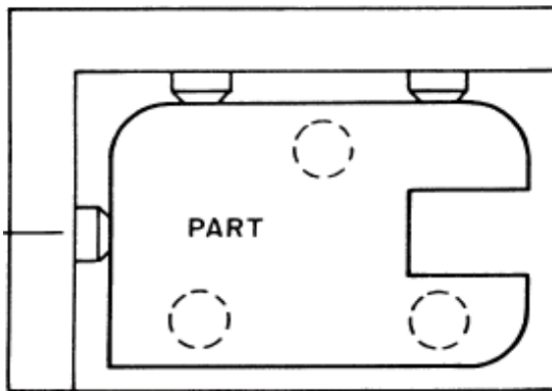
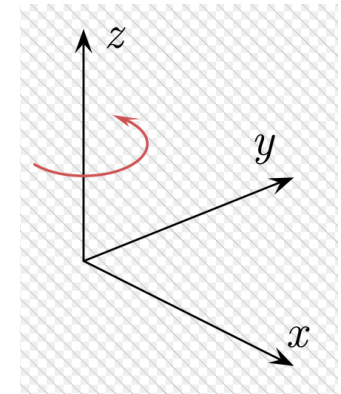
- Component location can be adjusted by changing dimensions in the sketch which will automatically update positions of components locked to CSYS



# Provisional alignment concepts

## Precision positioning with the 3-2-1 method

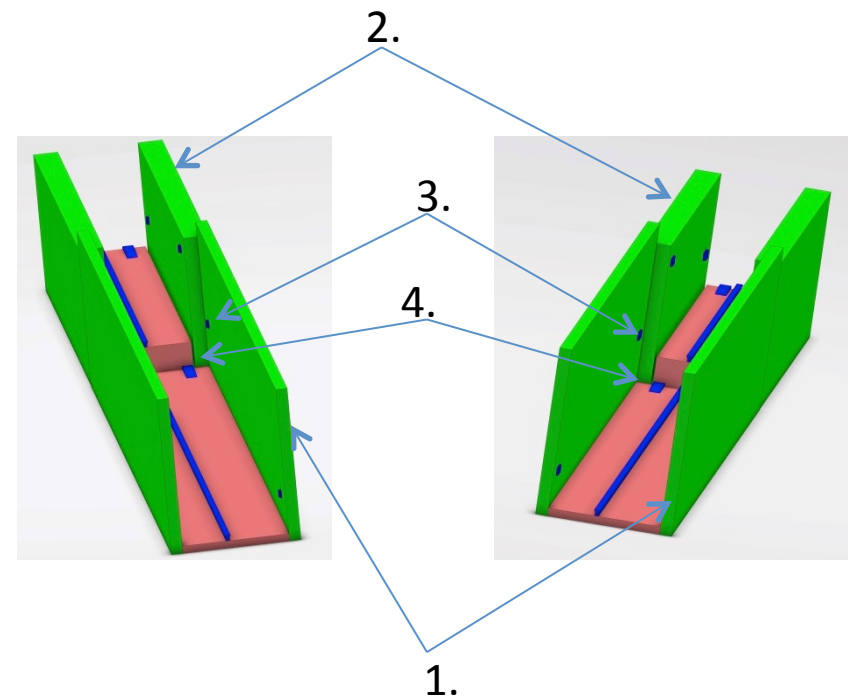
- Method used to fix work-pieces for machining.
- 3 fixture points to lock in the Z-direction.
- 2 fixture points to lock in the Y-direction.
- 1 fixture point to lock in the X-direction.



- 6 DoF fully constrained
- Coordinate system definition
  - Z: Vertical
  - X: Along beamline
  - Y: Horizontal
  - Angles
    - X-rot
    - Y-rot
    - Z-rot

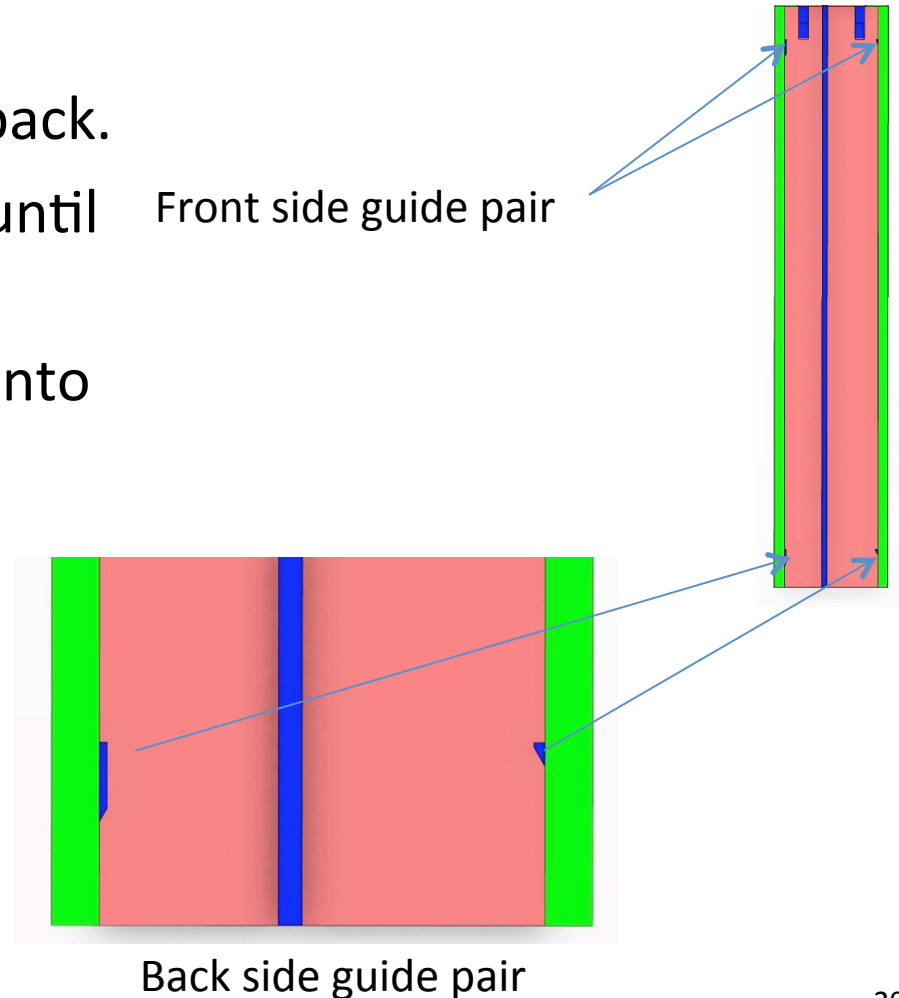
# Positioning and alignment features in monolith

1. Surfaces for outer Insert
  - R3.75 to R5.5
2. Surfaces for inner insert
  - R2 to R3.75
3. Side guides
  - 2 pairs per insert
4. Horizontal lift plates for inserts
  - 2 per insert



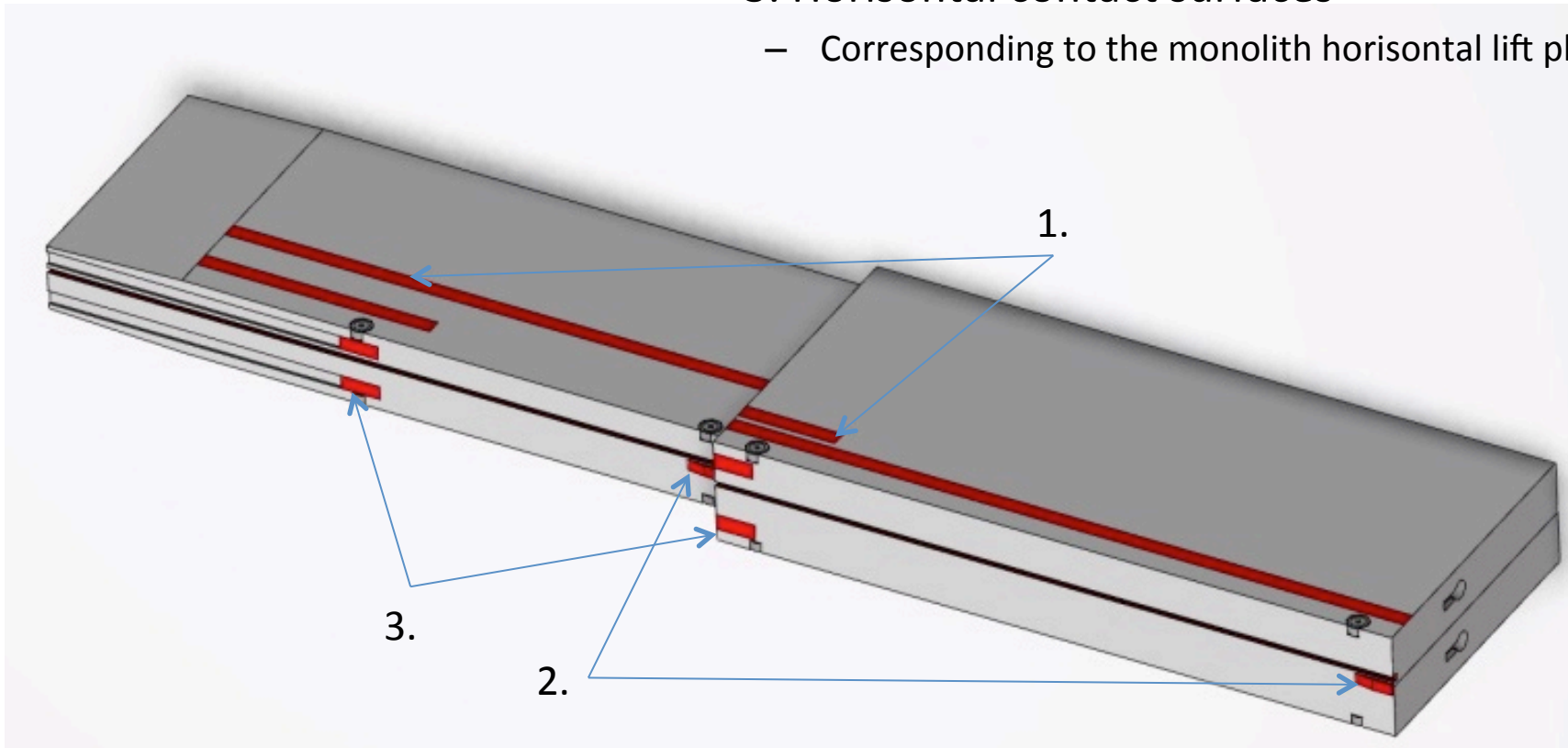
# Positioning and alignment features in monolith

- Side guides
  - Works in pairs, front & back.
  - Pushes insert sideways until it stops
  - Front and back pair get into contact with insert simultaneously.



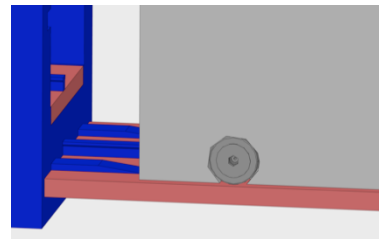
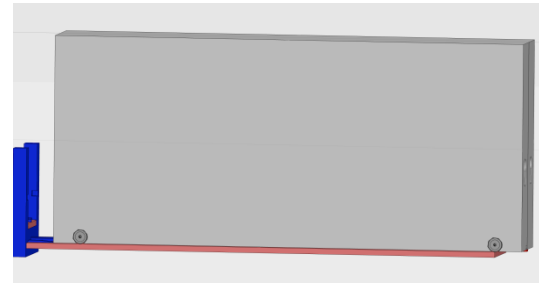
# Positioning and alignment features on insert

- 1. Contact surfaces for side guides
- 2. Horizontal lift plates
  - 1 at insert end
- 3. Horizontal contact surfaces
  - Corresponding to the monolith horizontal lift plates

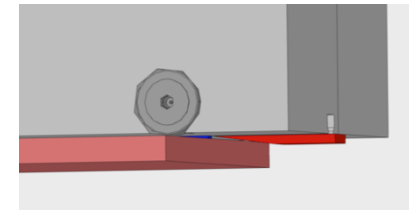


# Horizontal lift plates Insert $\Delta x$ -100mm from final position

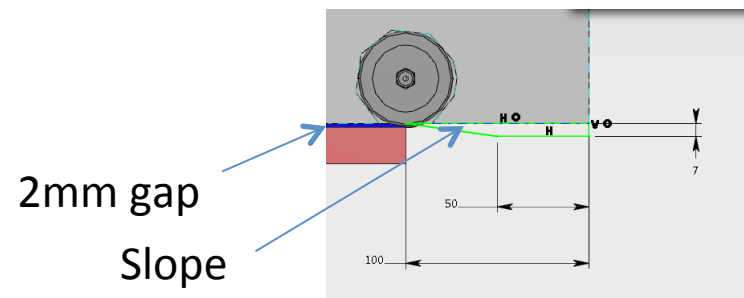
- 2mm gap between Insert bottom & monolith surface
- 5mm lift of insert when in position
  - By moving up slope
    - $s=50\text{mm}$
    - $h=5\text{mm}$



Inner horizontal plates



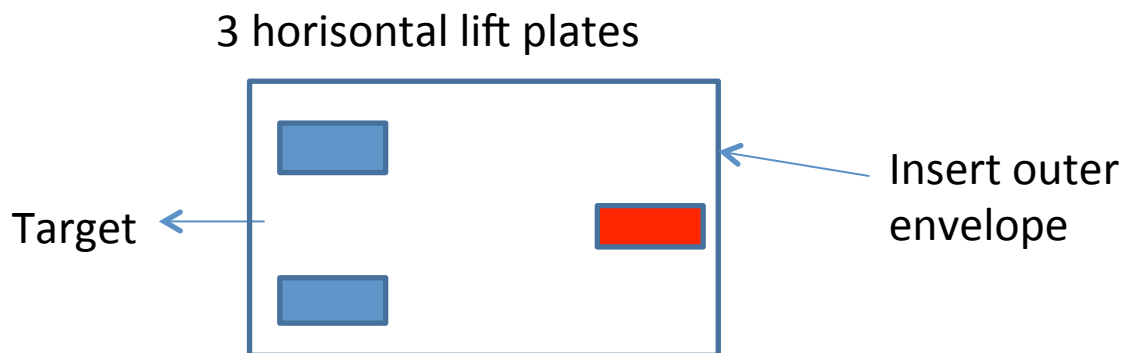
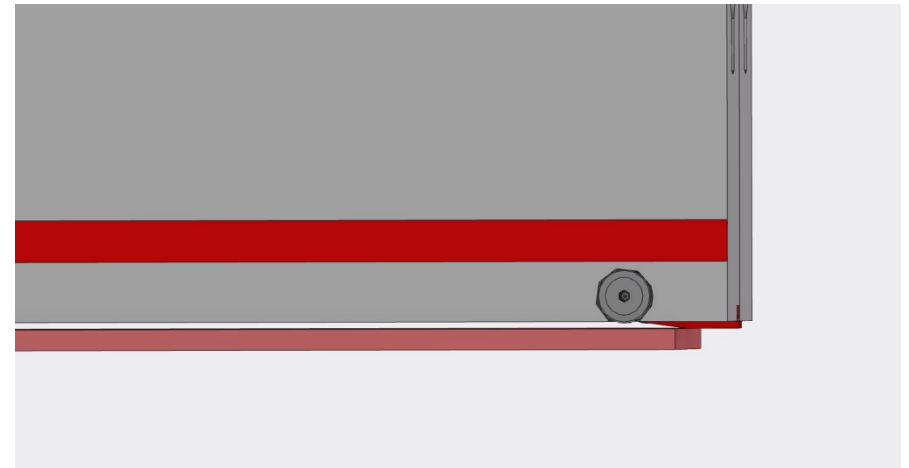
Outer horizontal plates



Horizontal plate dimensions

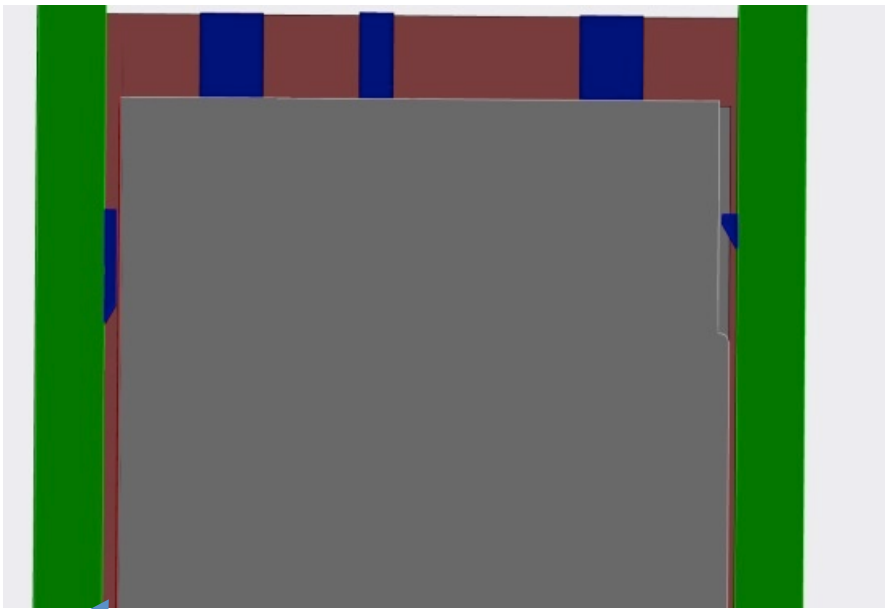
# Horizontal lift plates Insert $\Delta x$ -50mm from final position

- Insert standing on 3 horizontal lift plates  $\Delta x$  -50mm from final position
  - 2 in monolith & 1 on insert
  - Defines z-pos, x-rot, y-rot
  - Cam rollers not in contact with monolith

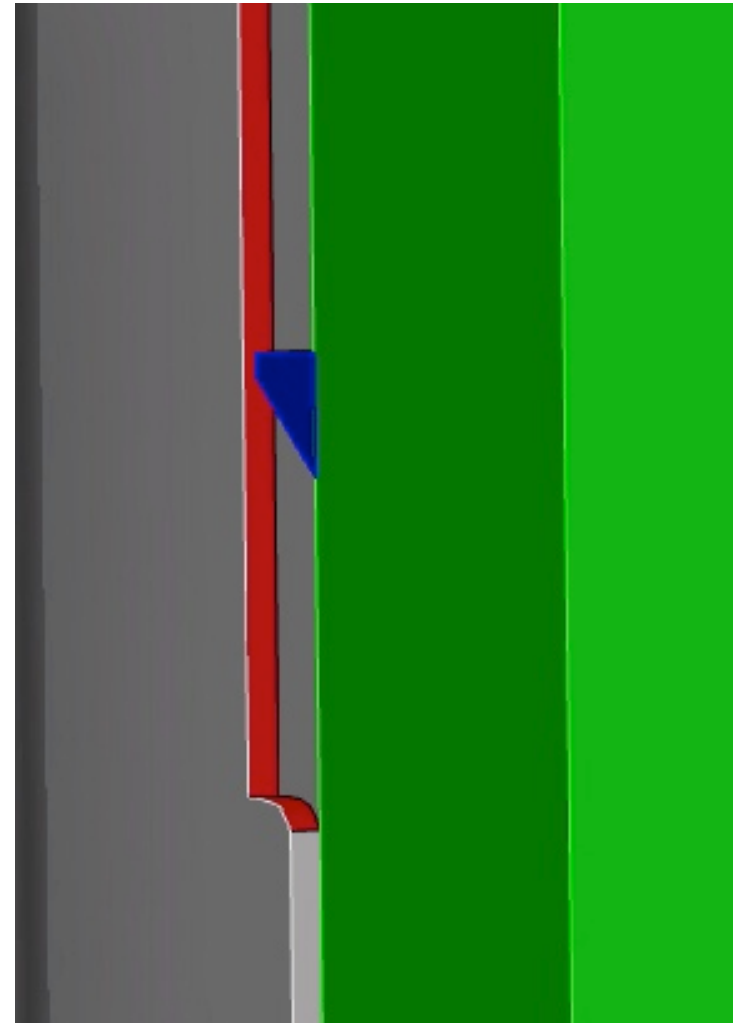


# Side guides at $\Delta x$ -50mm

- Insert being pushed forward sliding on horizontal lift plates

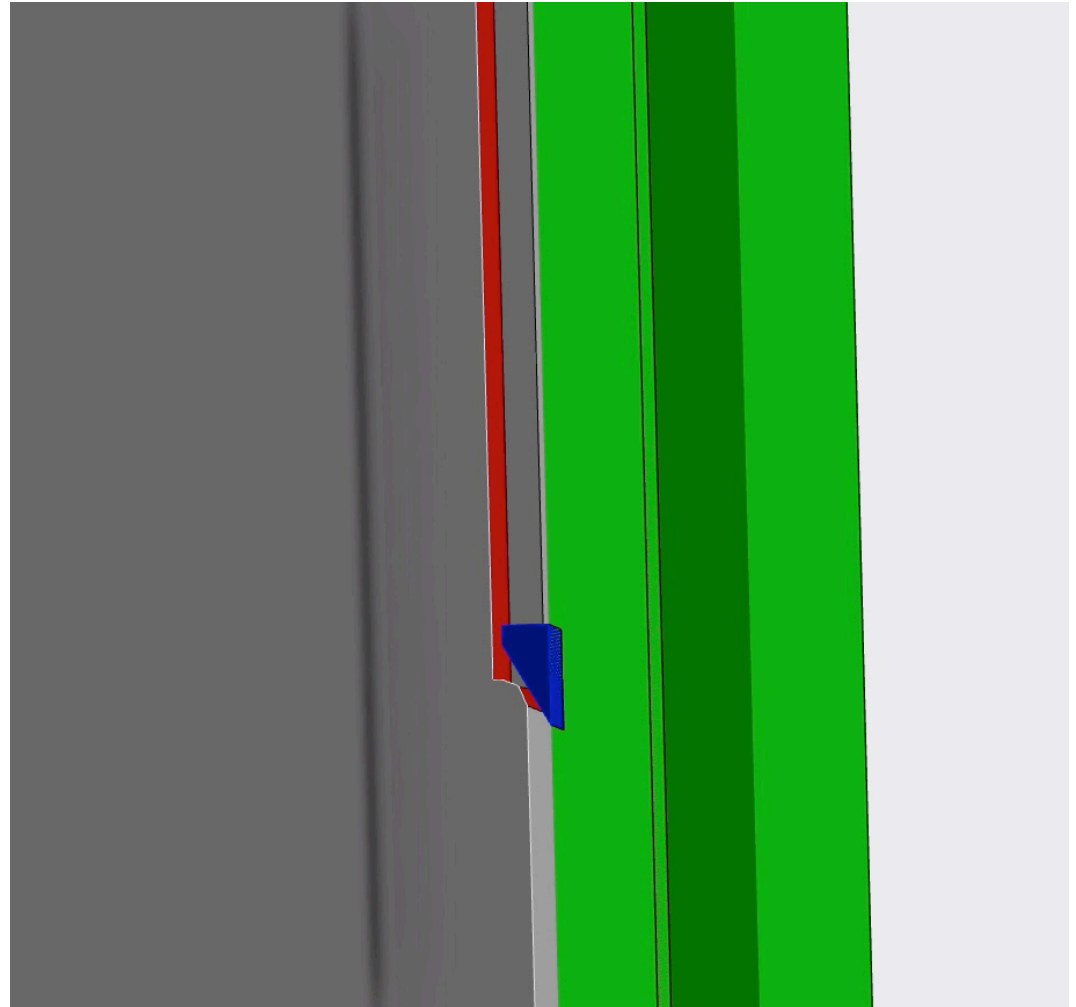


Insert 1.5mm wrong in  
y-direction



# Side guides at $\Delta x$ -5 mm

- Side guides about to get in contact

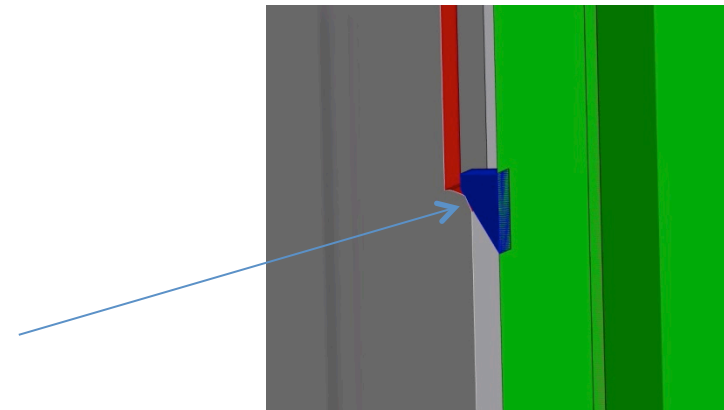


# Side guides at final position

- Defines position in y & x direction.
  - Distance between guides in y-direction is insert width -2mm



Side guide  
defines insert  
in x & y-  
direction

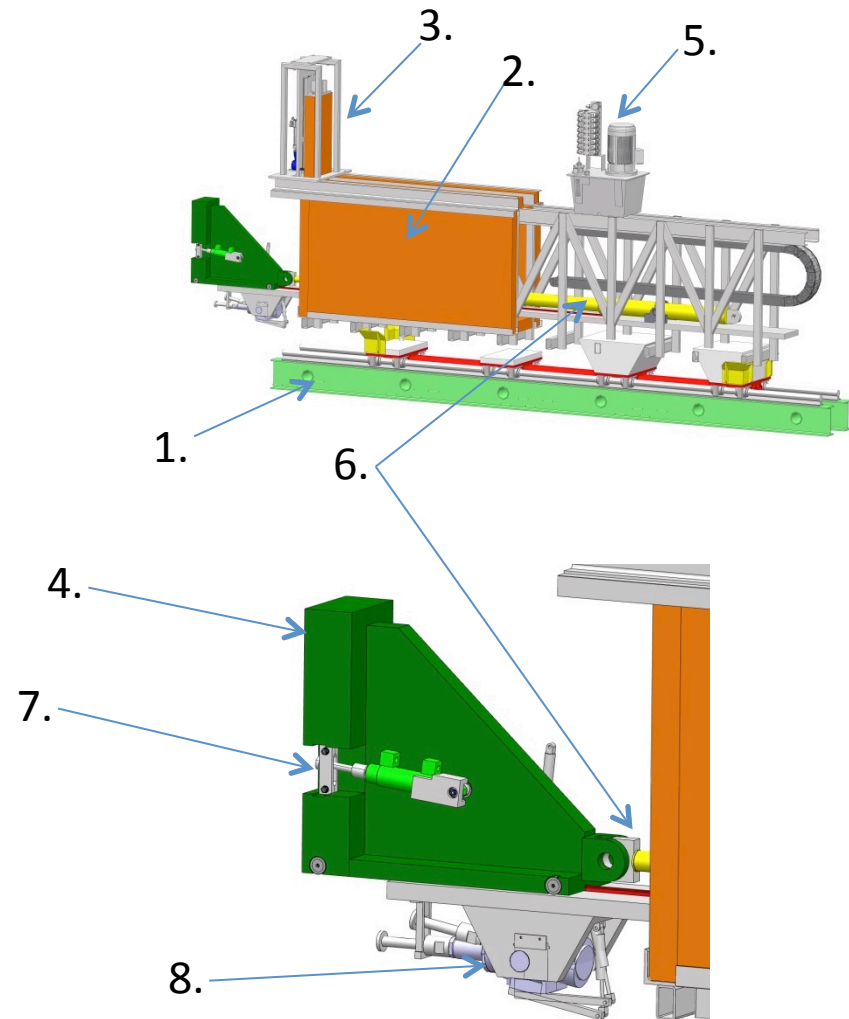


# Exchange procedures

- Handling tool
- Neutron beam port inserts
- Light shutters

# Neutron beam insert handling tool

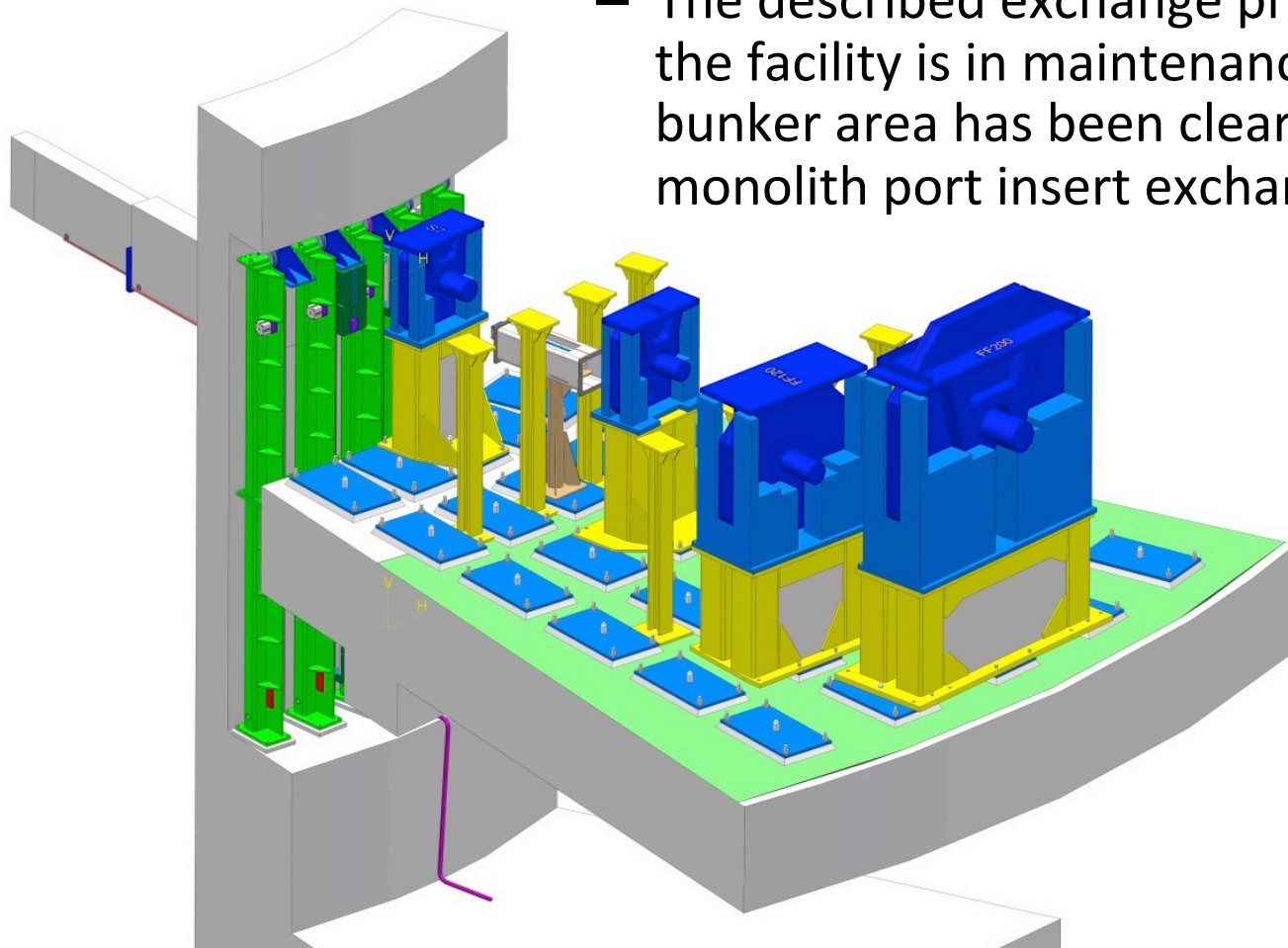
1. Wagon
2. Lead shield protection
3. Insert tip protection
4. Carrier
5. Hydraulic power unit
6. Telescopic hydraulic cylinder
7. Insert connector
8. Monolith connector



# Exchange procedures

## Monolith beam port inserts

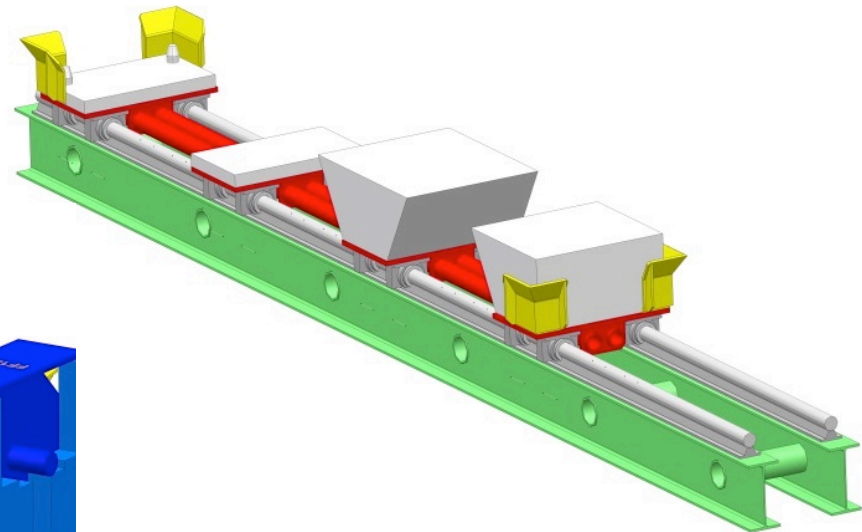
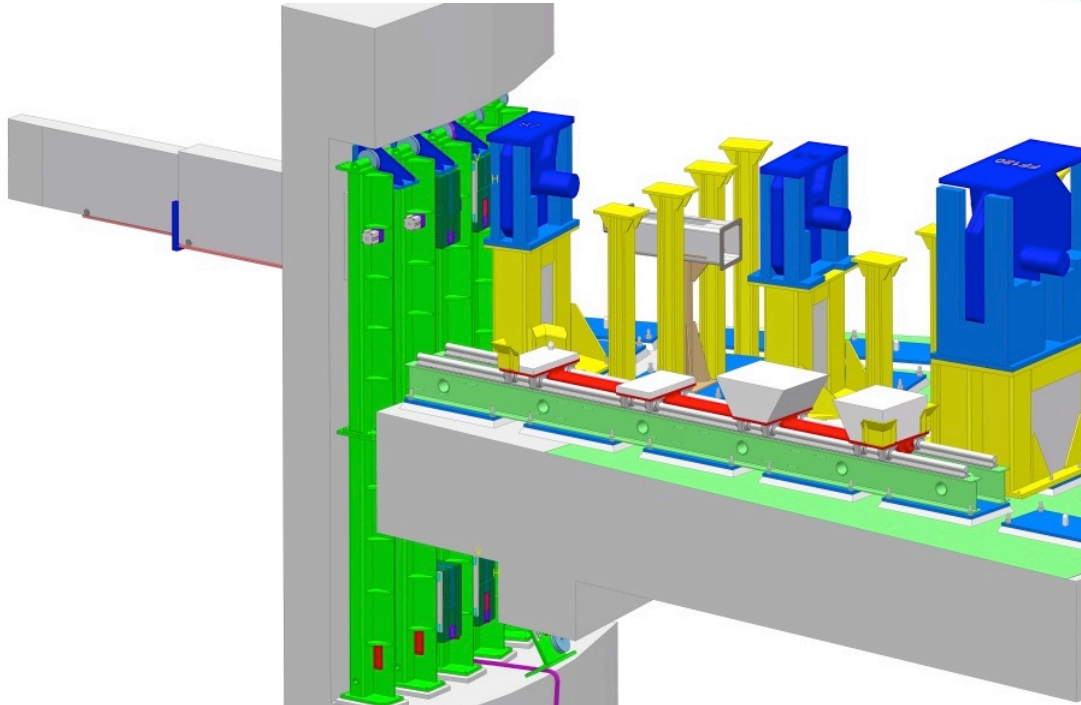
- Preparations
  - The described exchange procedure assumes that the facility is in maintenance mode and that the bunker area has been cleared sufficiently for the monolith port insert exchange



# Exchange procedures

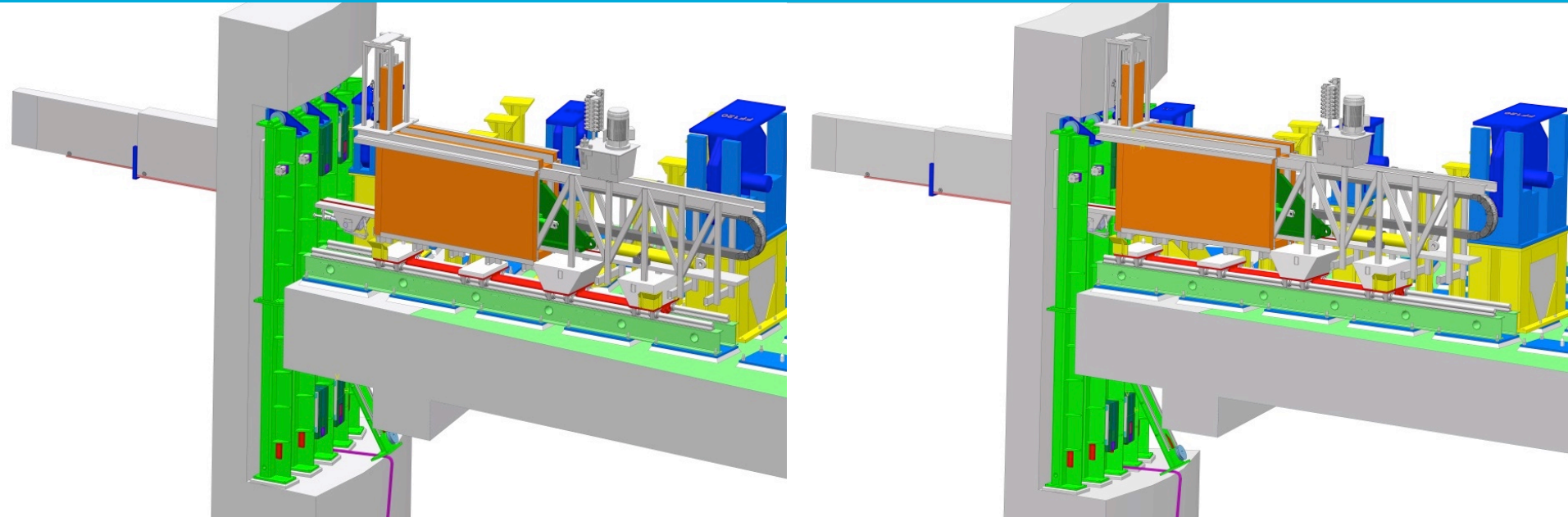
## Monolith beam port inserts

- Removing neutron beam window
- Setting down a tool wagon into position by crane and installing it on existing mounting plates in the experimental hall floor



# Exchange procedures

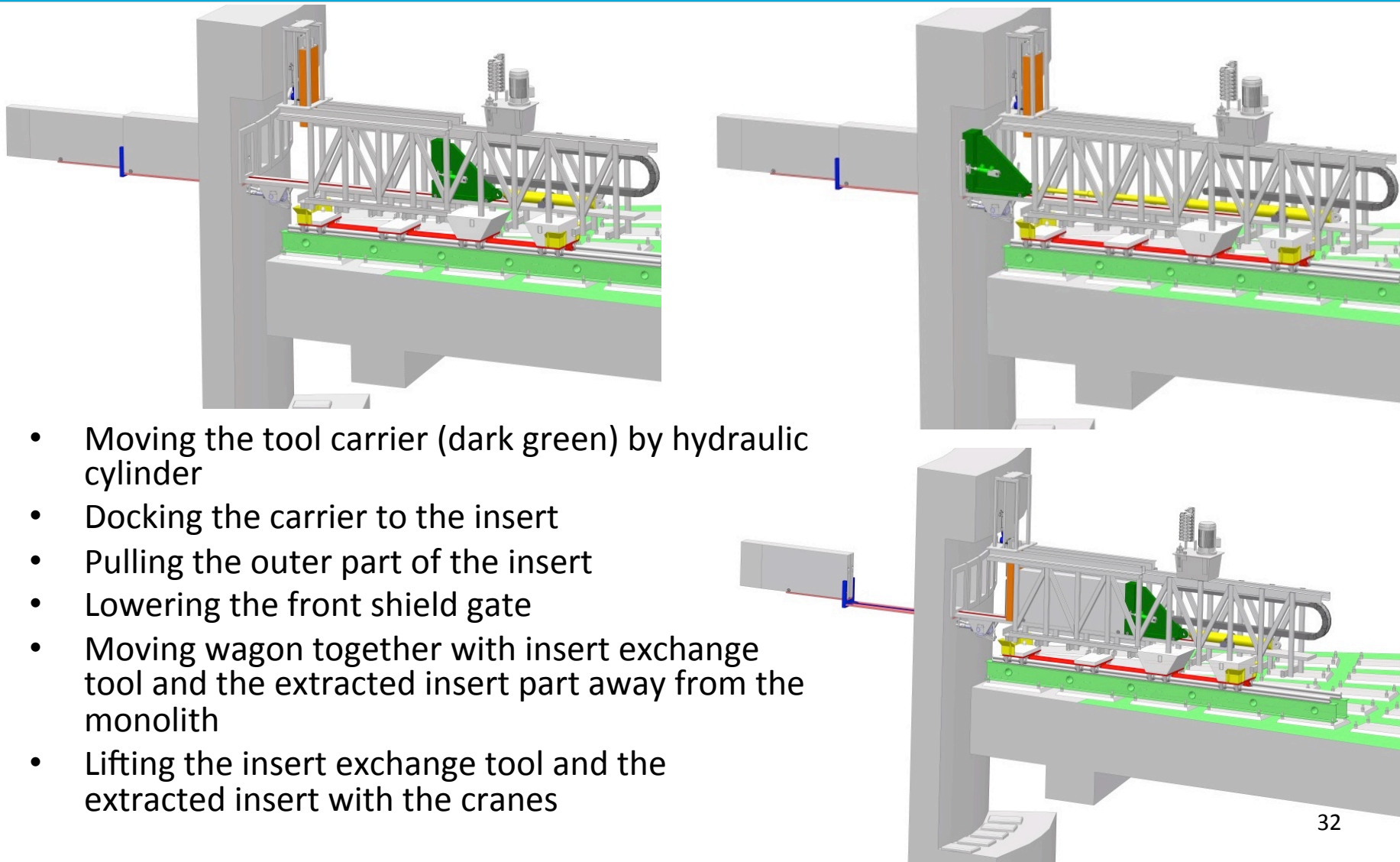
## Monolith beam port inserts



- Setting down an insert exchange tool onto the wagon
- Moving wagon together with insert exchange tool towards monolith
- Docking the insert exchange tool to the monolith structures

# Exchange procedures

## Monolith beam port inserts

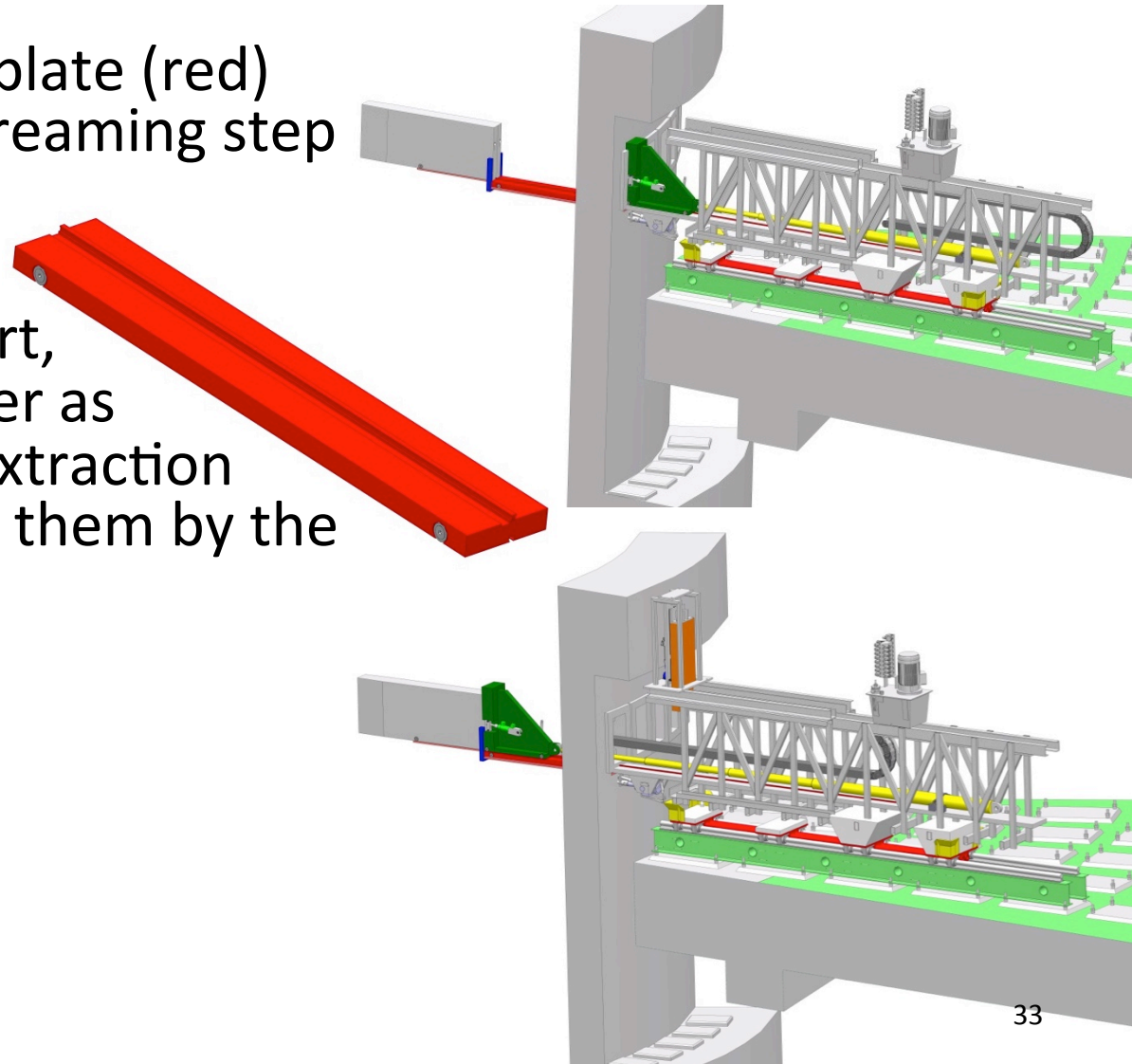


- Moving the tool carrier (dark green) by hydraulic cylinder
- Docking the carrier to the insert
- Pulling the outer part of the insert
- Lowering the front shield gate
- Moving wagon together with insert exchange tool and the extracted insert part away from the monolith
- Lifting the insert exchange tool and the extracted insert with the cranes

# Exchange procedures

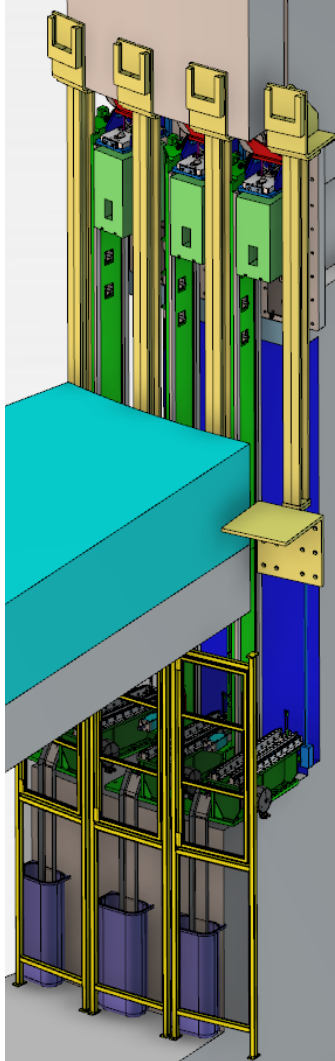
## Monolith beam port inserts

- Installing adapter plate (red) for bridging the streaming step
- Extracting the inner part of the insert from the port, in the same manner as before, onto the extraction tool and removing them by the crane

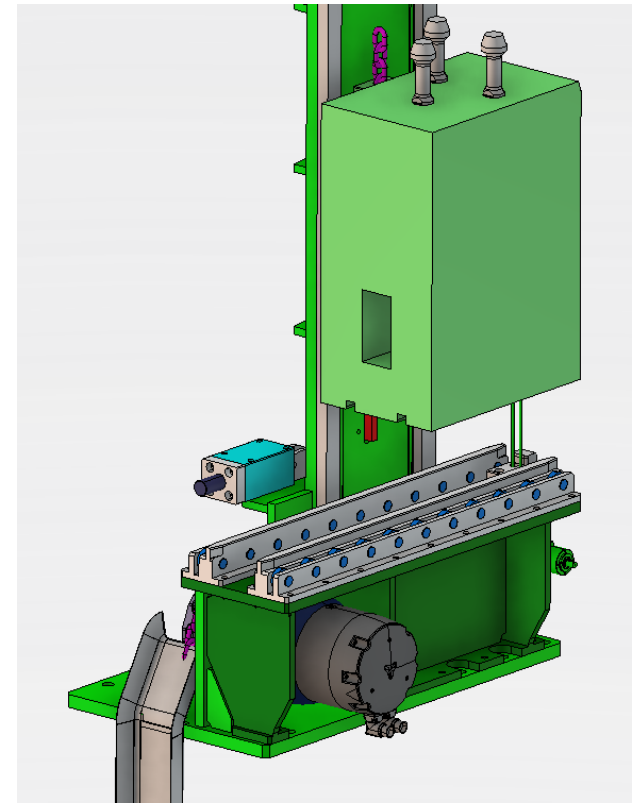
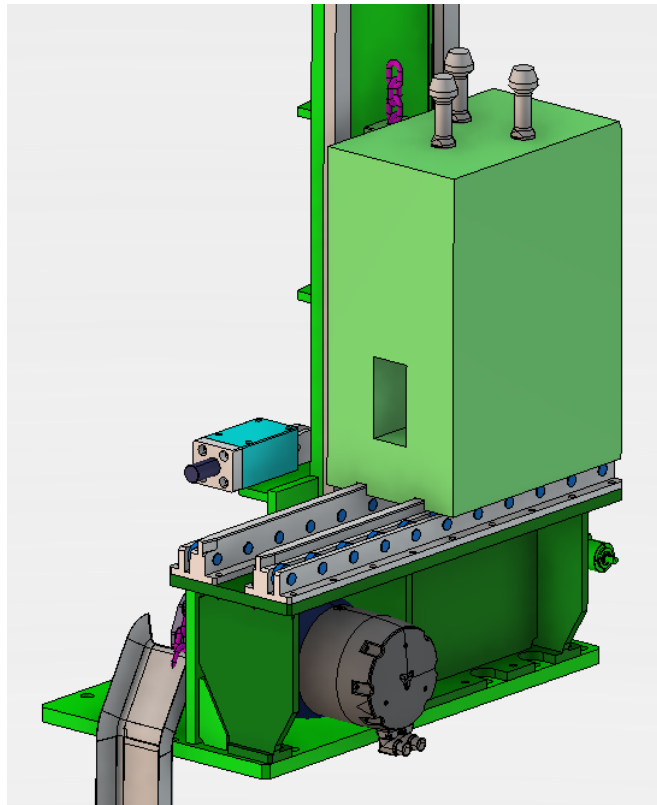


# Light shutter installation sequence

## Loading and lift start.



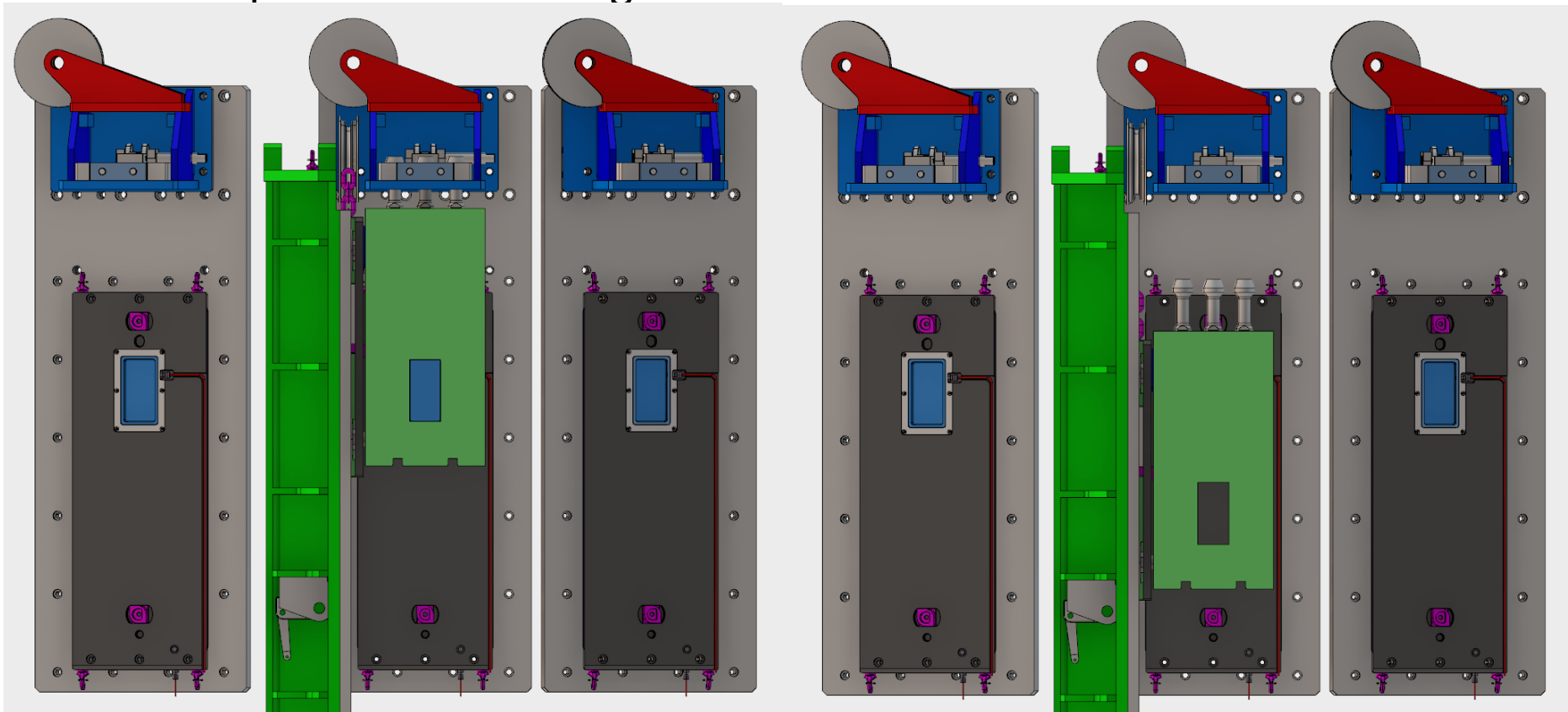
- After the Light Shutter has been loaded onto the landing pad by the autonomous truck, it is being lifted up.



# Light shutter sequence

## Operation locations

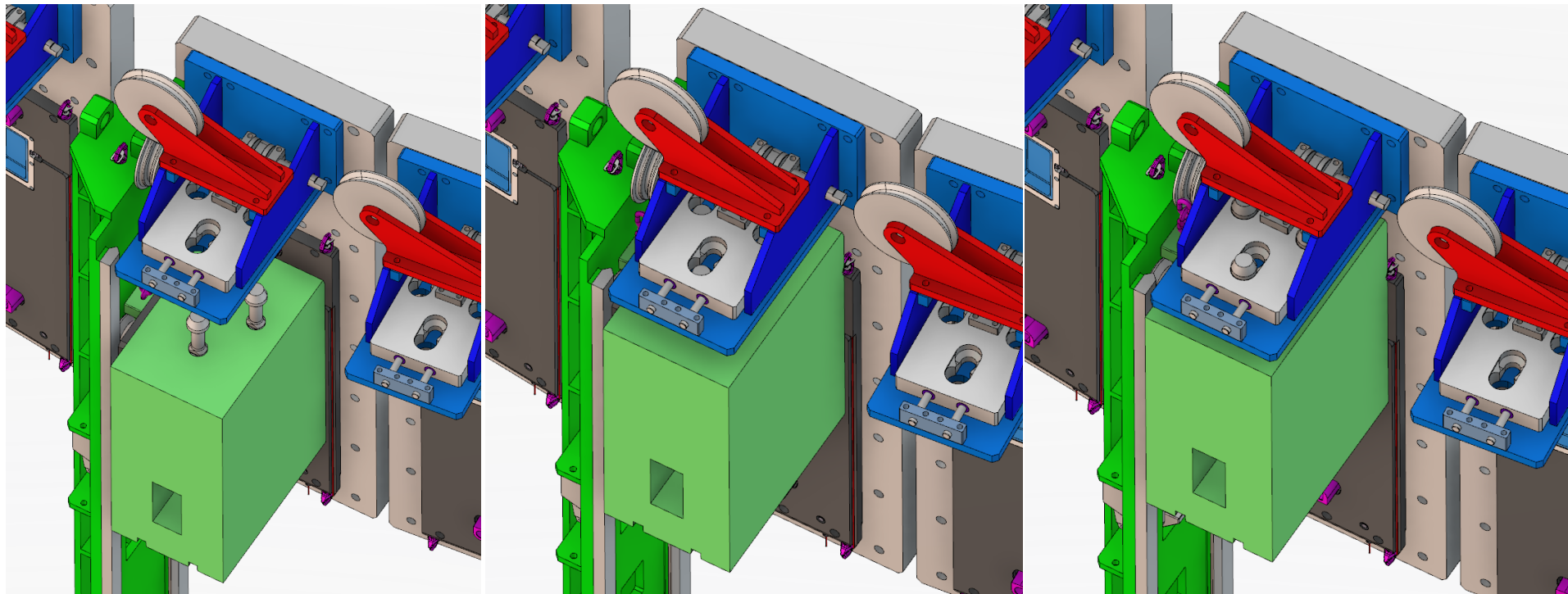
- On top the light shutter can be located in the open or closed position.
- In the open position it hangs in the 3 studs.
- In the closed position it rests on the lower lock.
- In both positions the lifting chain is unloaded.



# Light shutter sequence

## Lifted into open position

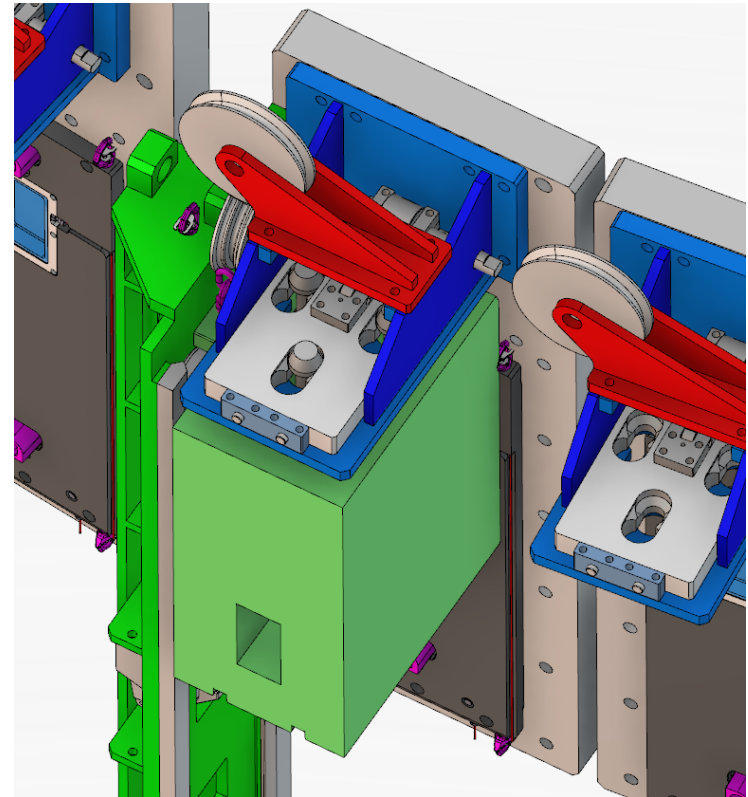
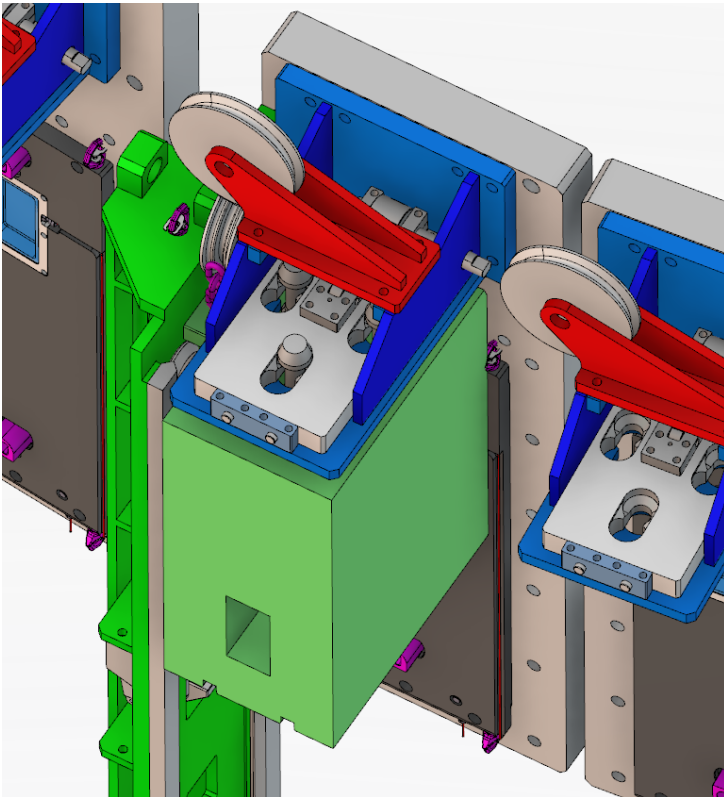
- When being lifted up from the landing pad the upper lock is open and the 3 studs can be pushed through the openings in the top bracket.



# Light shutter sequence

## Locking the shutter into open position

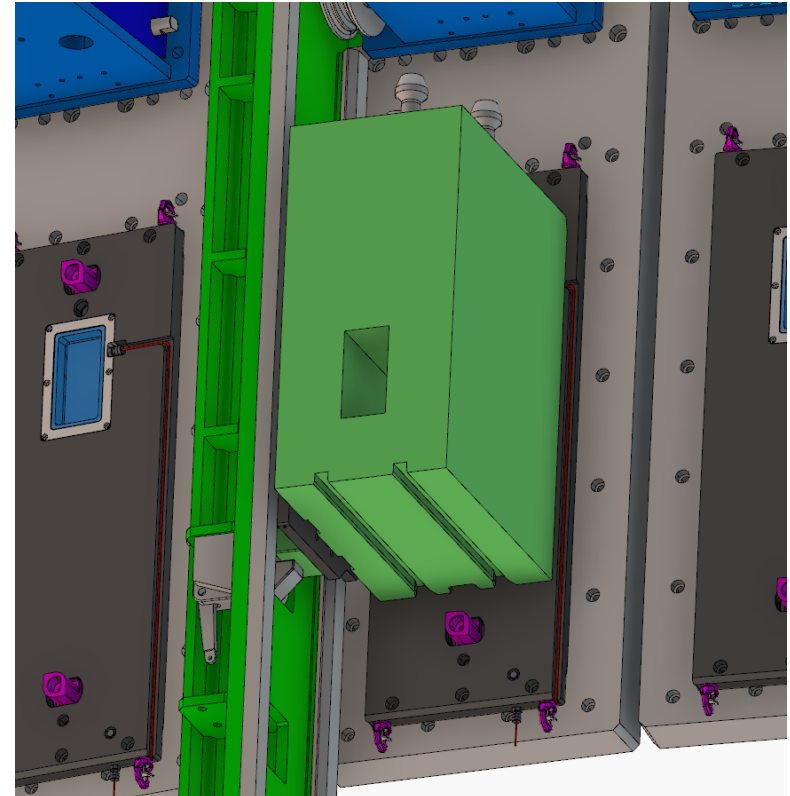
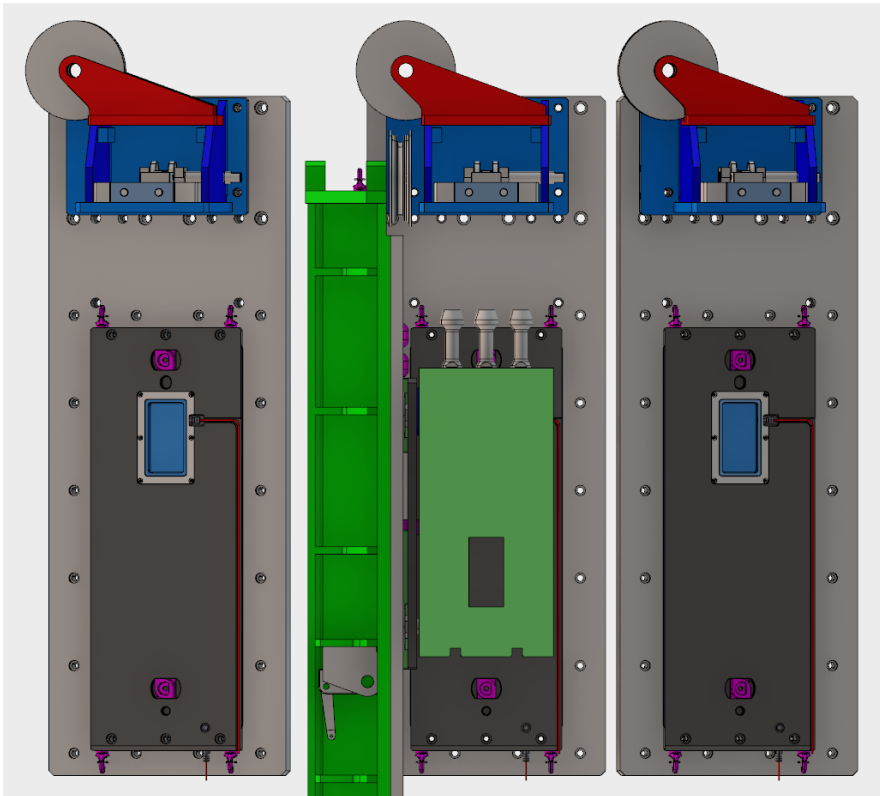
- The lock plate is pushed into locked position.
- The light shutter is lowered 15 mm allowing the 3 studs to be placed into the locking plate seats.
- The top bracket now carries the full load of the light shutter.



# Light shutter sequence

## Placing the light shutter onto the lower lock

- To place the shutter onto the lower lock the top bracket lock is opened allowing the shutter to be lowered (reversing step 3 and 4).
- When resting on the lower lock the lifting chain is unloaded.
- The lower lock can be opened by activating a mechanism from below thus allowing the light shutter to pass the lower lock and reaching the landing pad.

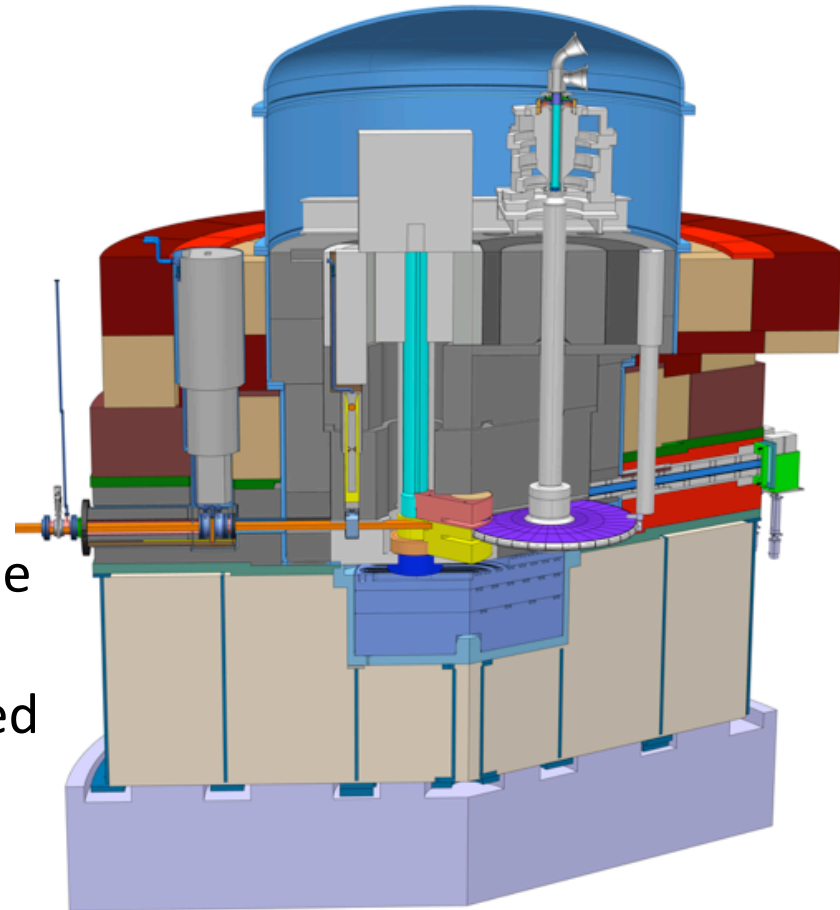


# Insert environment

- Monolith atmosphere
- Neutron flux map
- Activation considerations and estimations

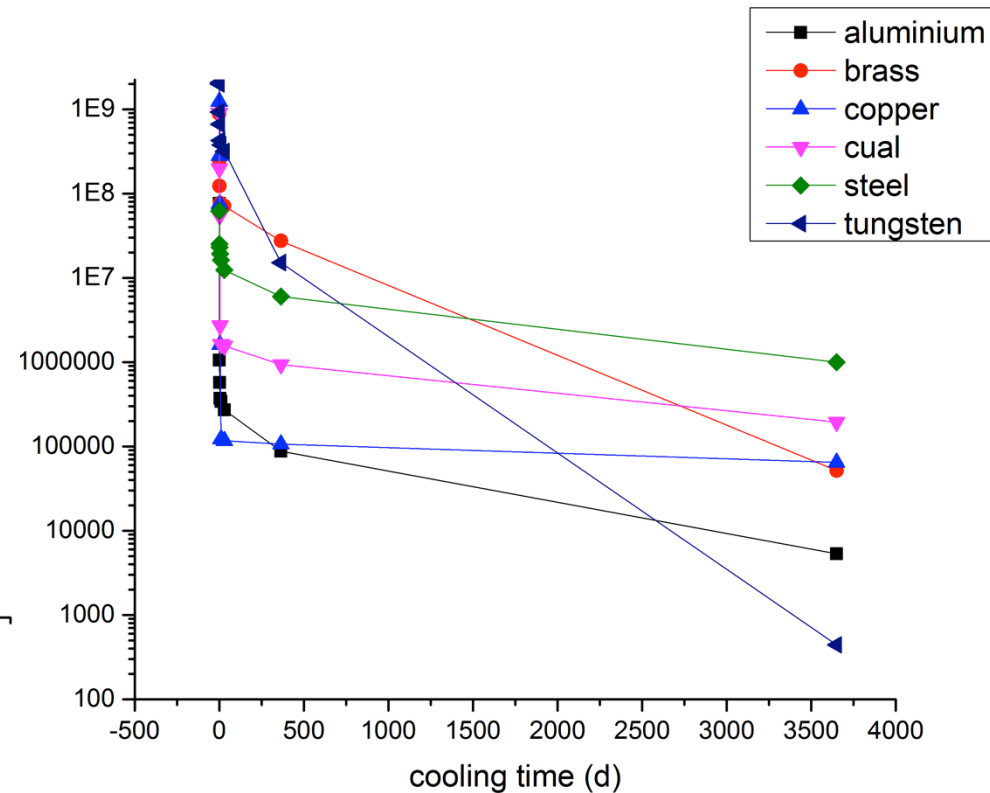
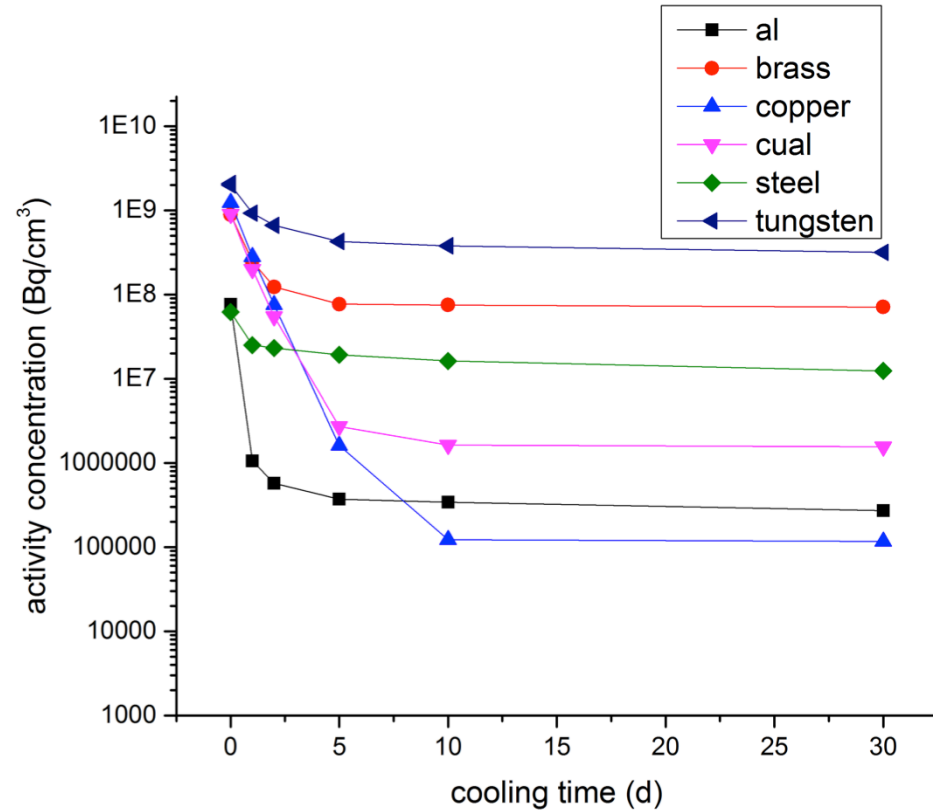
# Monolith atmosphere

- The baseline concept for the ESS monolith atmosphere
  - Helium at slight under-pressure relative the surroundings
  - Gas circulated via a purification system to remove gases and volatiles
- Optional solution for the ESS monolith atmosphere
  - Evacuated monolith vessel volume
  - Removed proton beam window
  - Monolith vessel volume connected to the accelerator vacuum tube volume

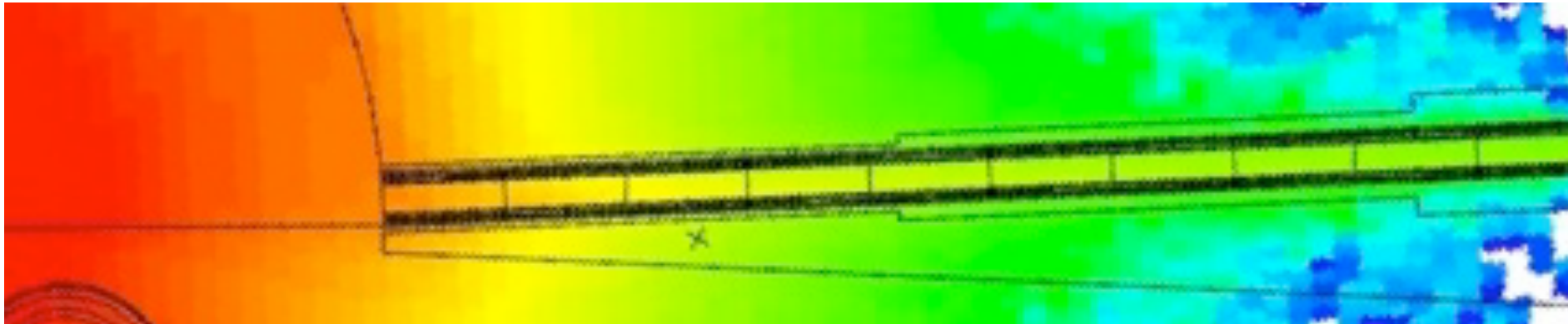


# Early study of activity concentration

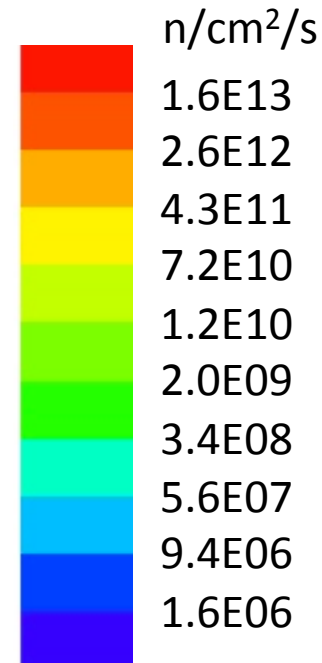
- Five years of irradiation
- Different materials for the insert structure



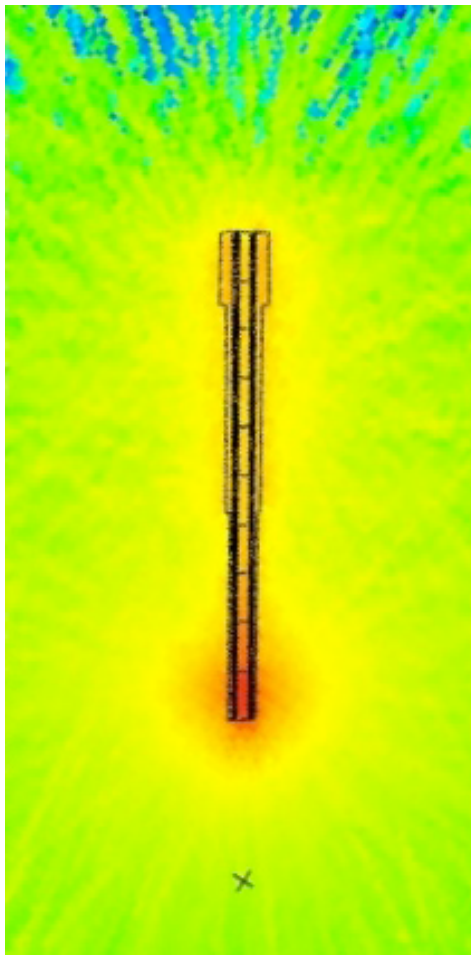
# Neutron flux map of monolith interior



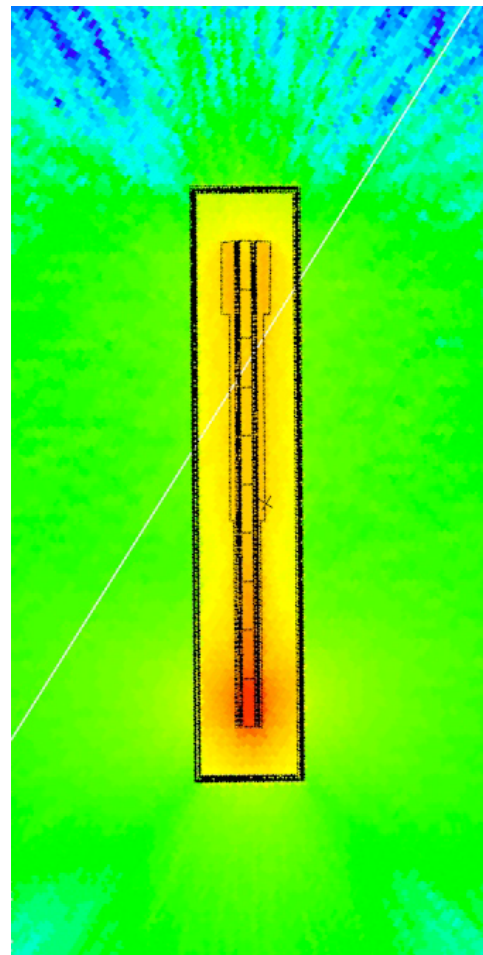
- Integrated neutron flux all energies
- Guide transport ability not included in the code



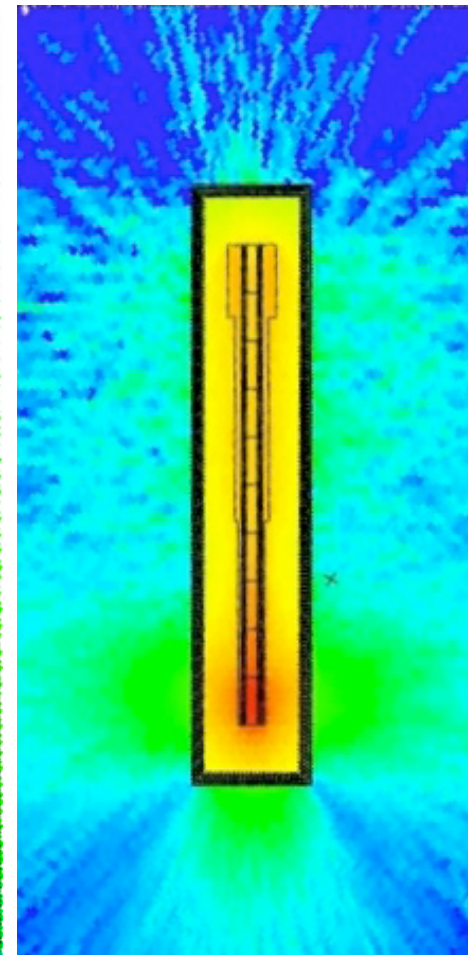
# Gamma dose rate from a removed steel insert after five years of irradiation and one day of cooling time



Without shielding



50 mm Pb



100 mm Pb

