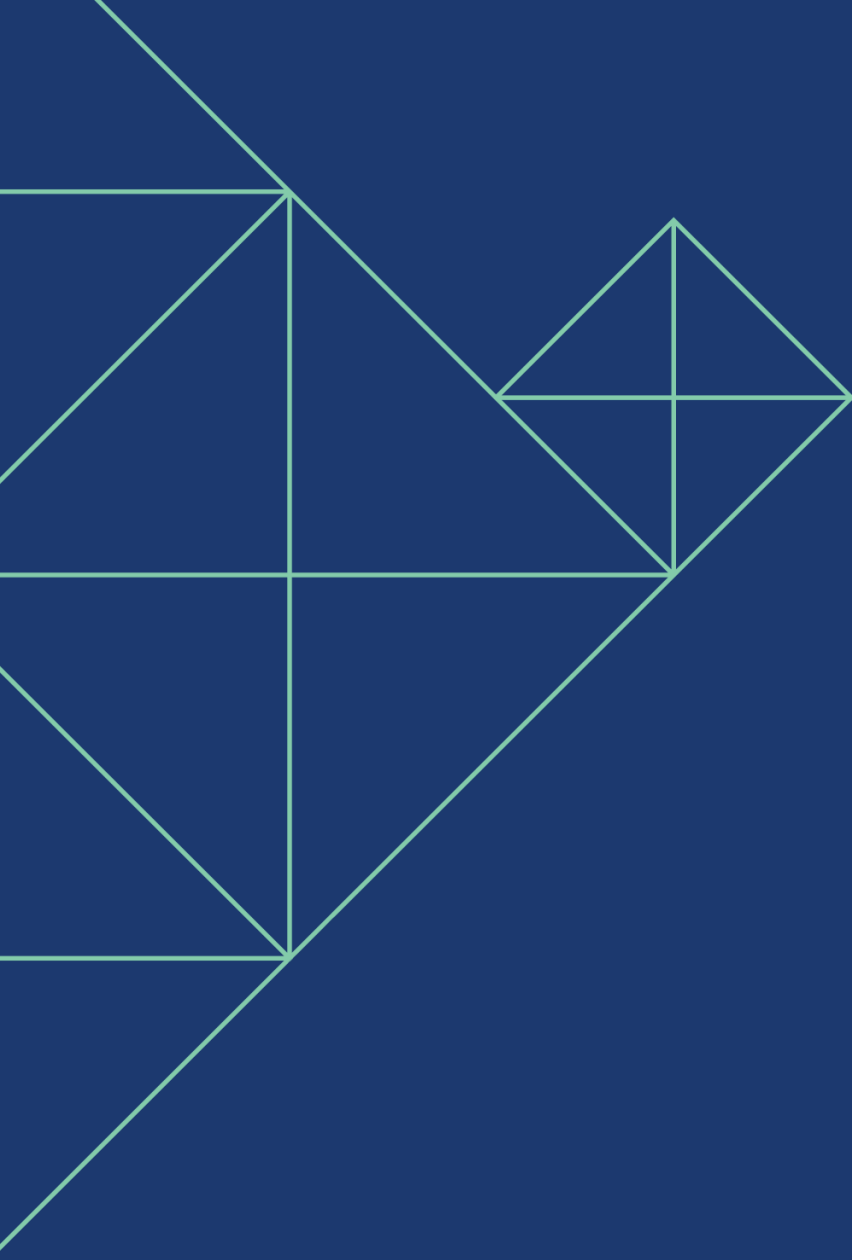




**Brain Power
since 1986**





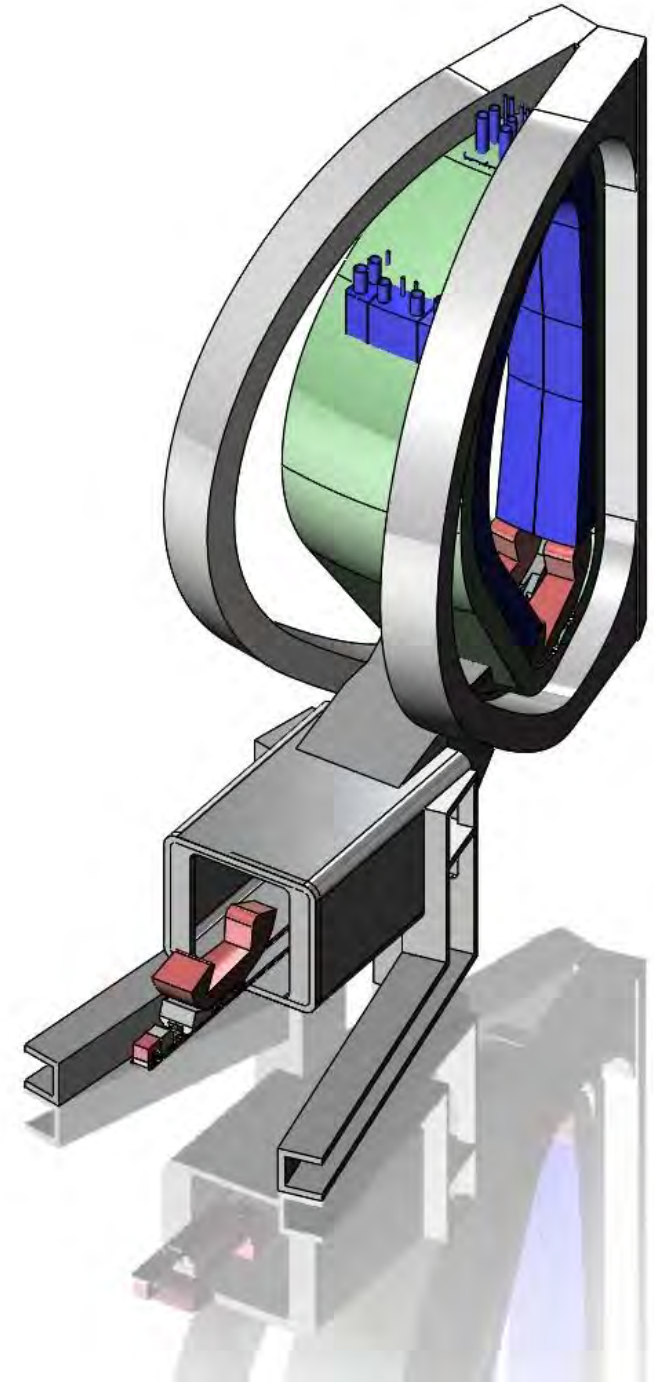
Engineering Design for DEMO

28.05.2024

Stefan Mühlig-Hofmann

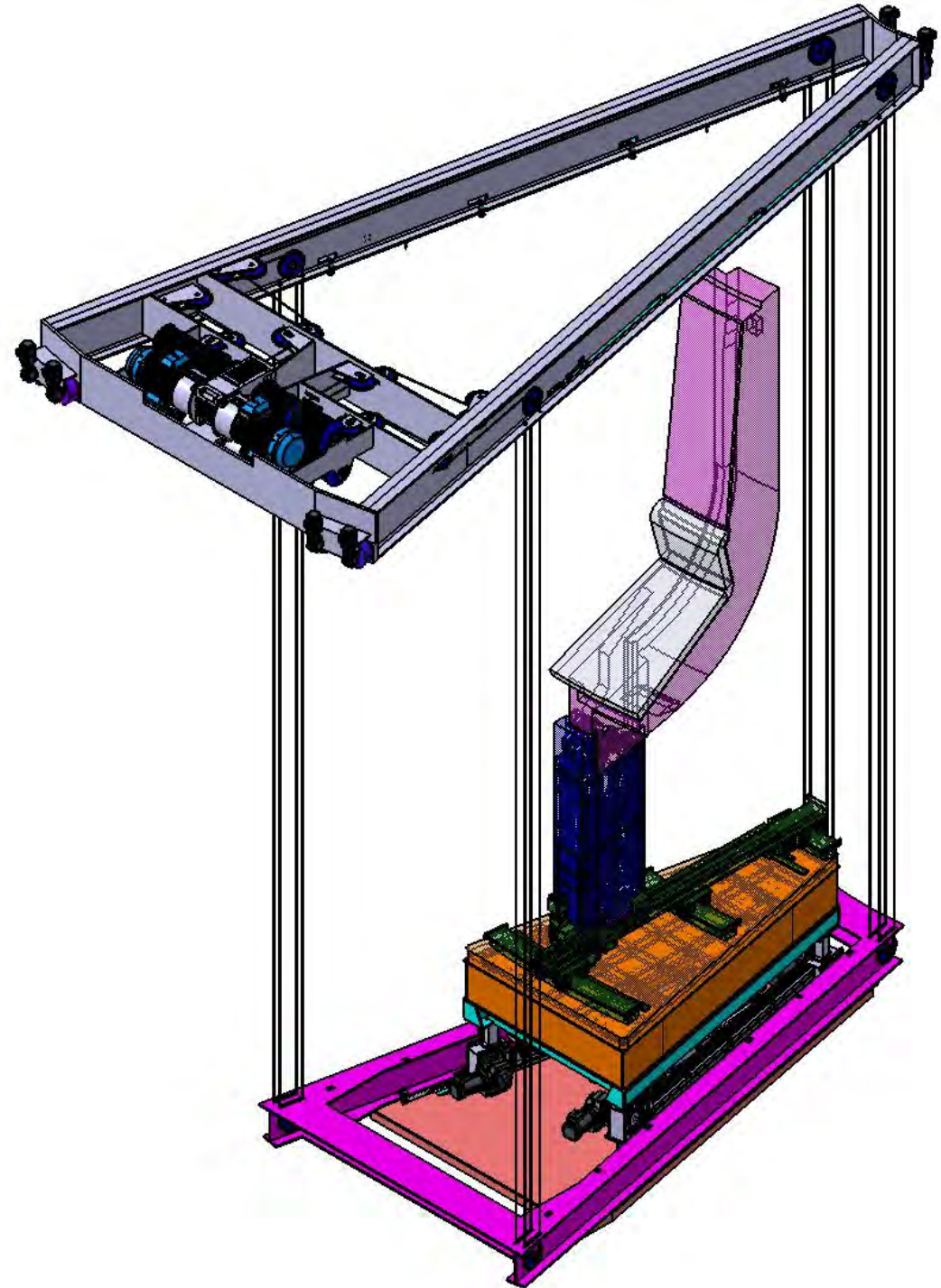
Lower Port RH solutions since 2018

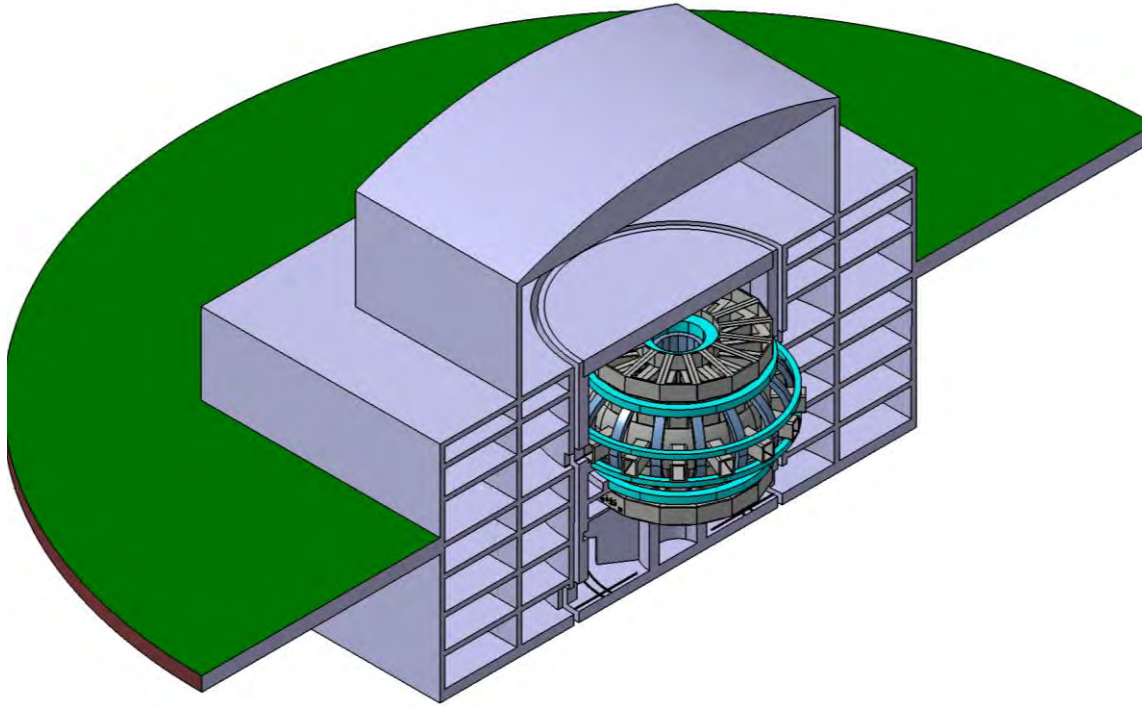
- Engineering studies for RH handling of divertors and lower blankets through different lower ports
- Designs for vertical, horizontal, and inclined lower ports
- Conceptual design of movers and divertor & blanket end effectors



Vertical lower port

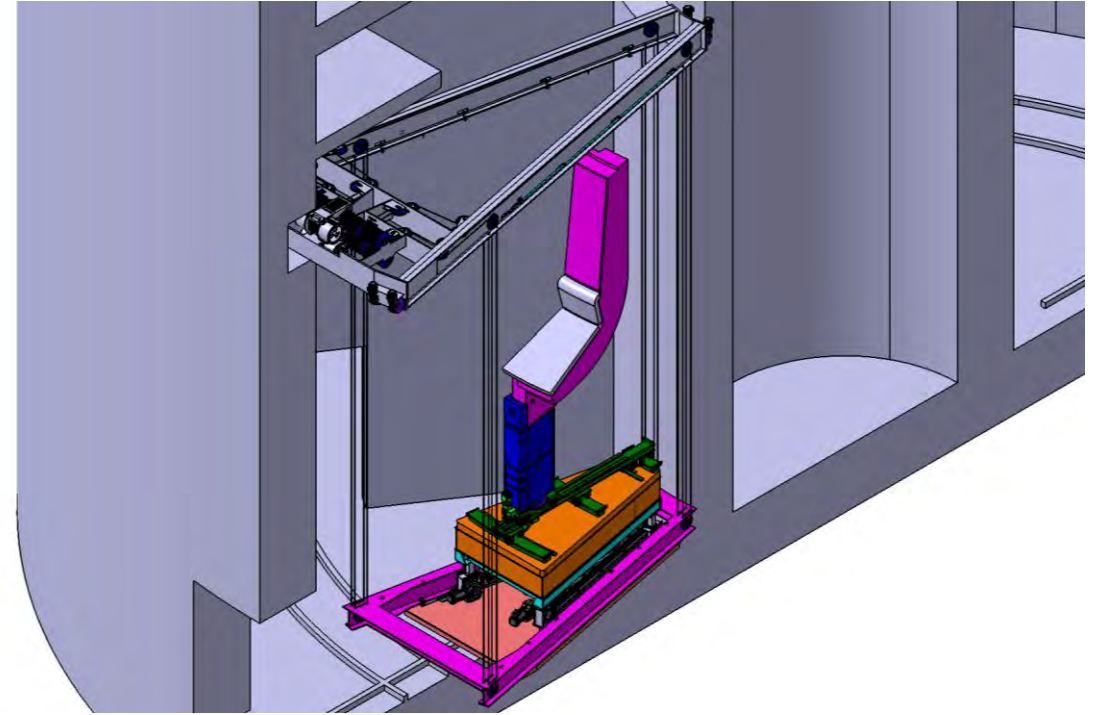
- Divertors and lower blankets to be handled through a vertical lower port
- Solution needs a deep pit in the basement under the reactor to accommodate the lifting systems and the components to be removed
- Hot cells located under the reactor
- RH equipment consists of VTS (Vertical Transport System) and ILS (Intermediate Lifting System)





Reactor in underground pit

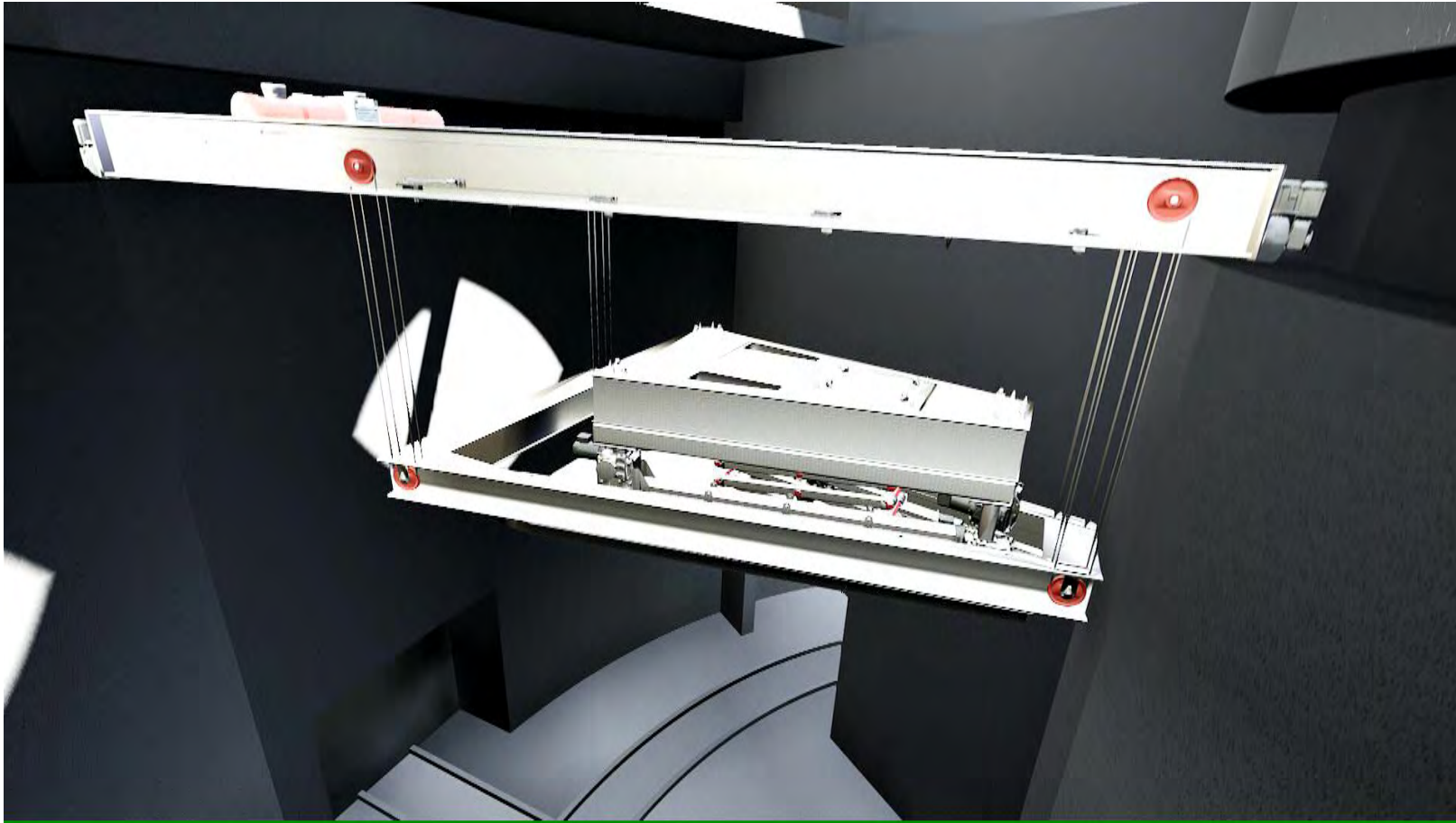
- 15 m of vertical space needed under the lower port
- Circular hot cells connected by rails for access
- Servicing and handling facilities underground
- Upper blankets to be handled by crane via upper ports



VTS and ILS

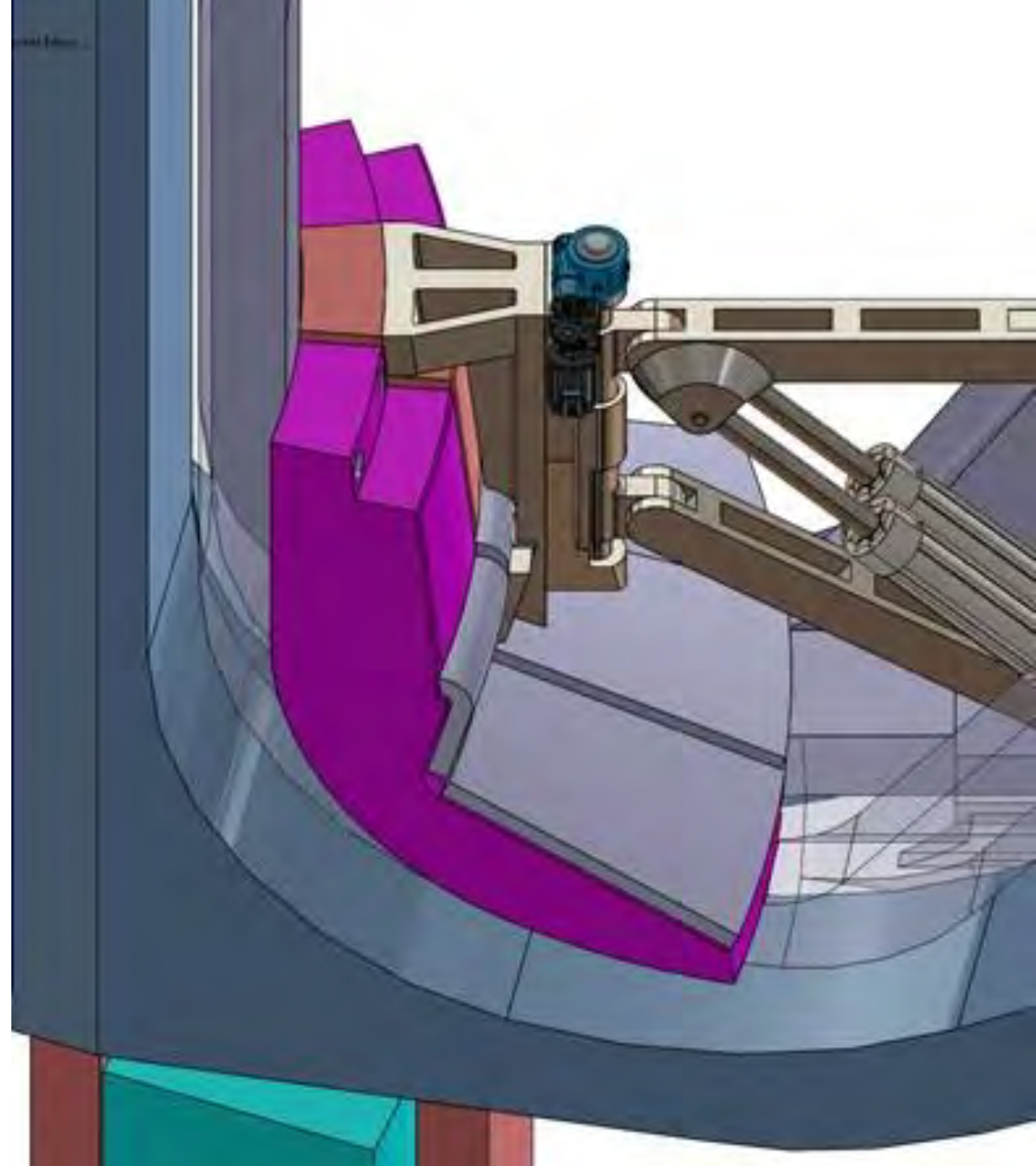
- VTS operated by wire rope, pulleys and winches from above
- ILS installed on top of platform which is picked up by VTS
- ILS includes another separate platform for smaller operations inside the lower port area of the reactor

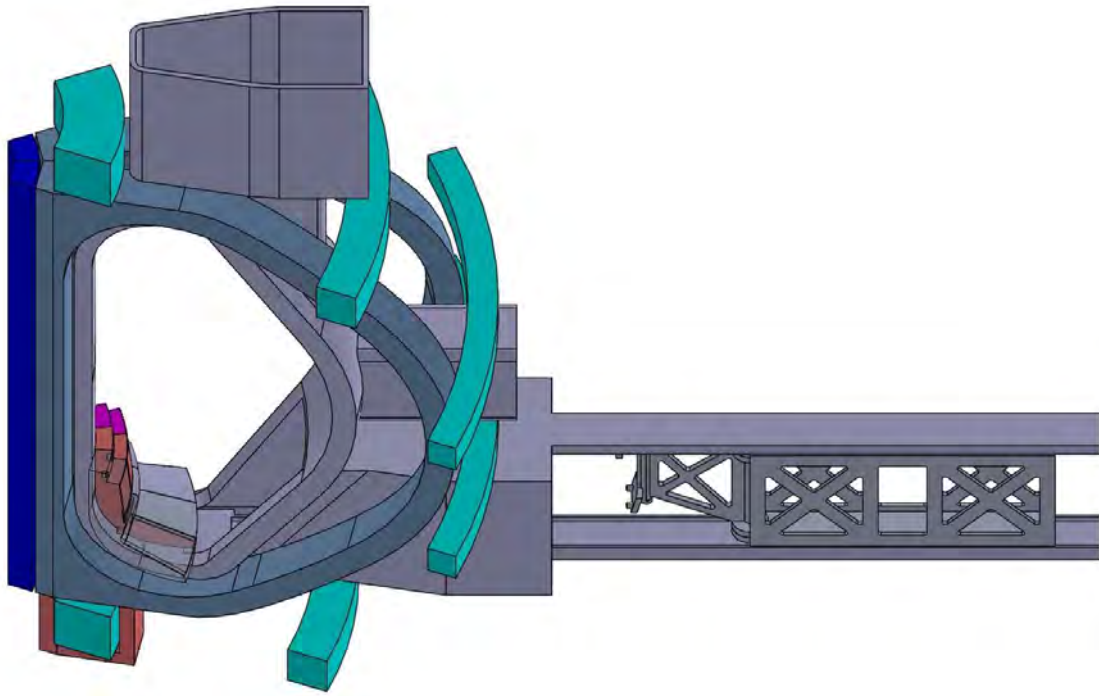
Vertical lower port: video



Horizontal lower port

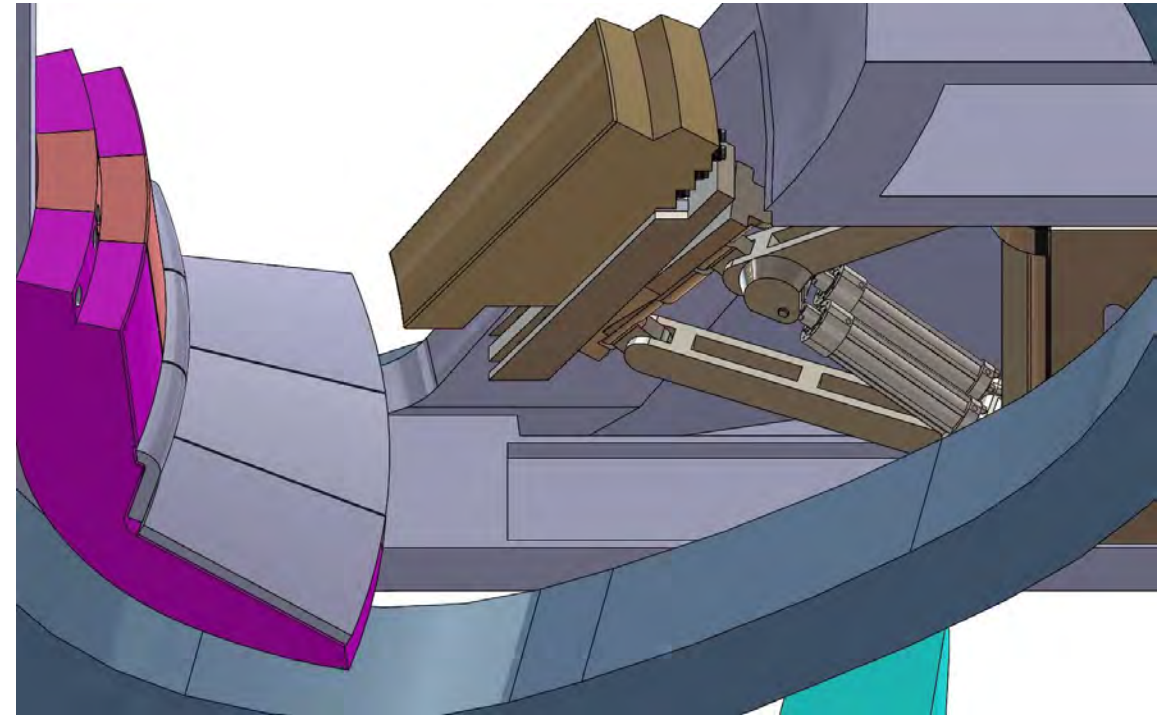
- Divertors and lower blankets to be handled through a horizontal lower port
- Hot cells located around the reactor
- RH equipment includes a wagon that moves radially in and out, and different end effector tools





One radial mover per horizontal port

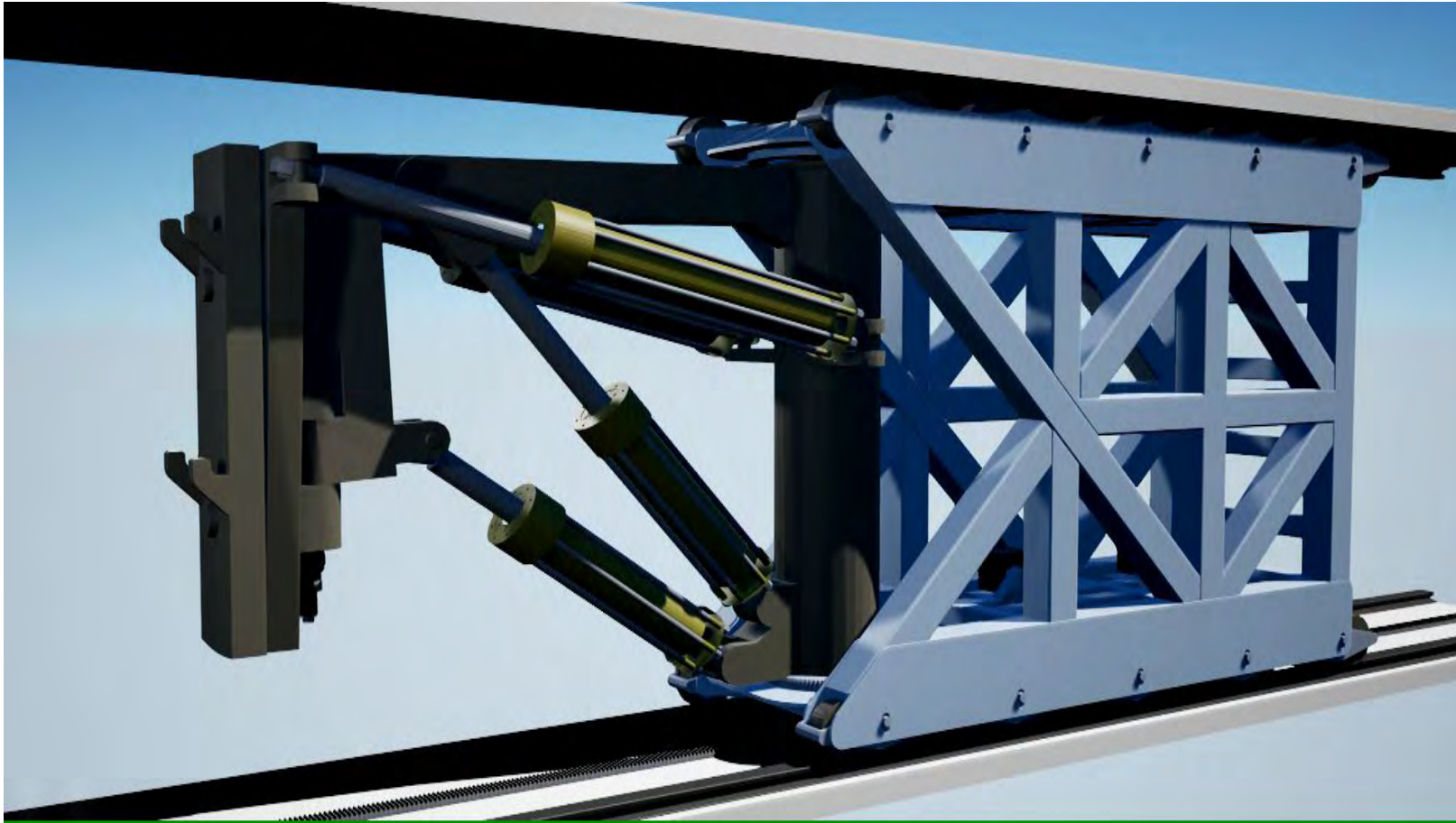
- Mover is supported by rails and powered by rack-and-pinion drives
- Lower inboard and outboard blankets have been shortened in height to fit through the lower port
- Upper inboard and outboard blankets have to be longer



Different end effectors

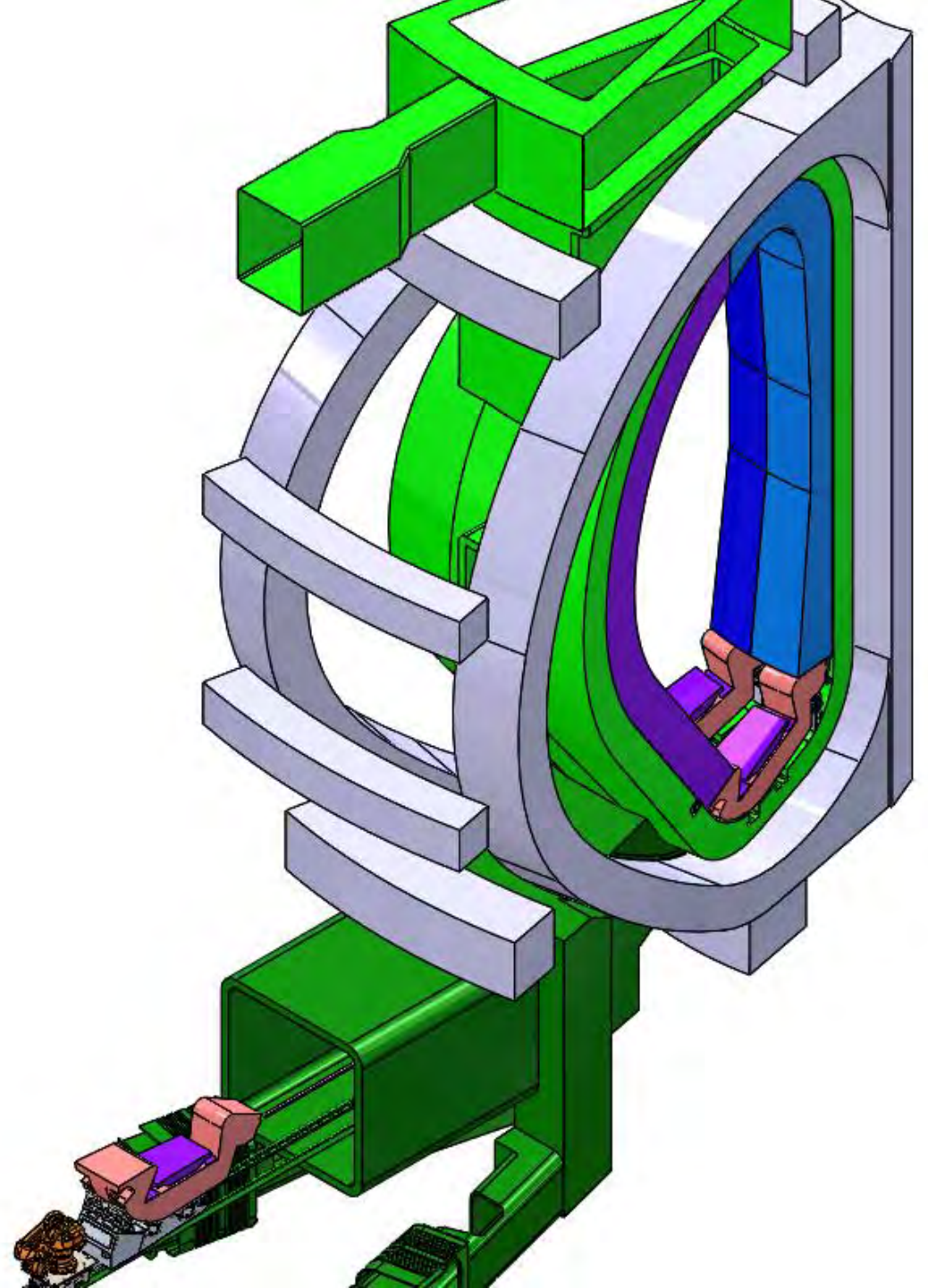
- 2 different end effectors to be attached to the mover: one for the lower divertors and the lower outboard blankets, and one for the lower inboard blankets
- End effectors to be stored and changed in the hot cell
- Articulation of the end effector by water hydraulic cylinders

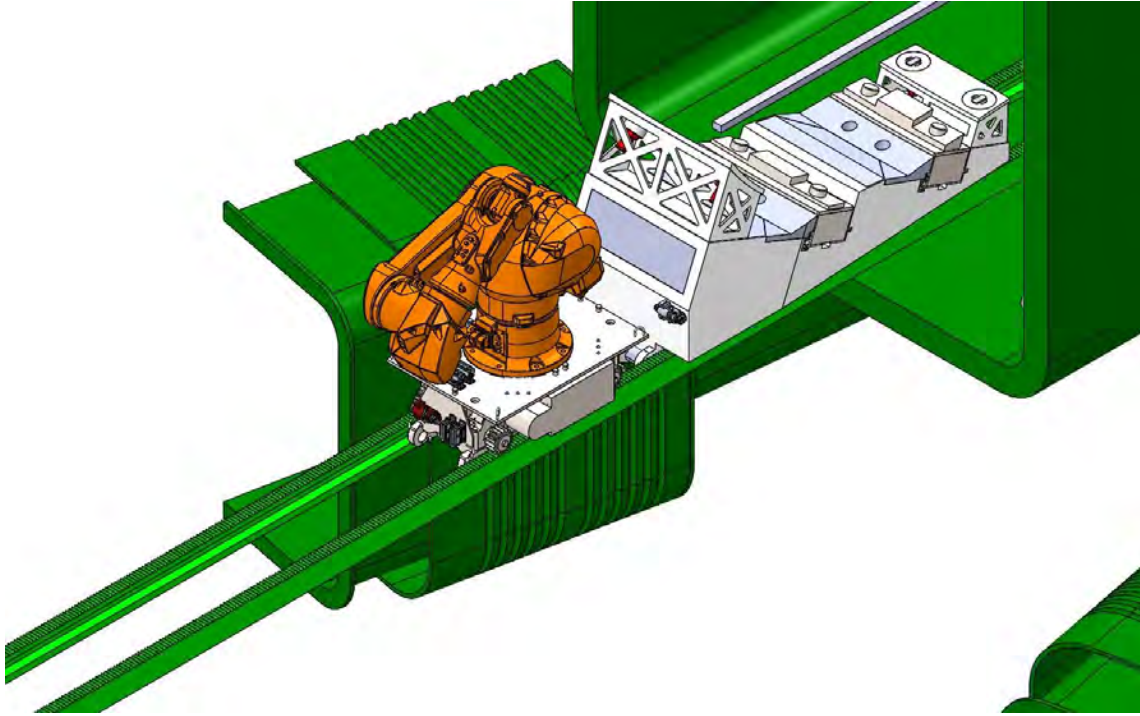
Horizontal lower port: video



Inclined lower port

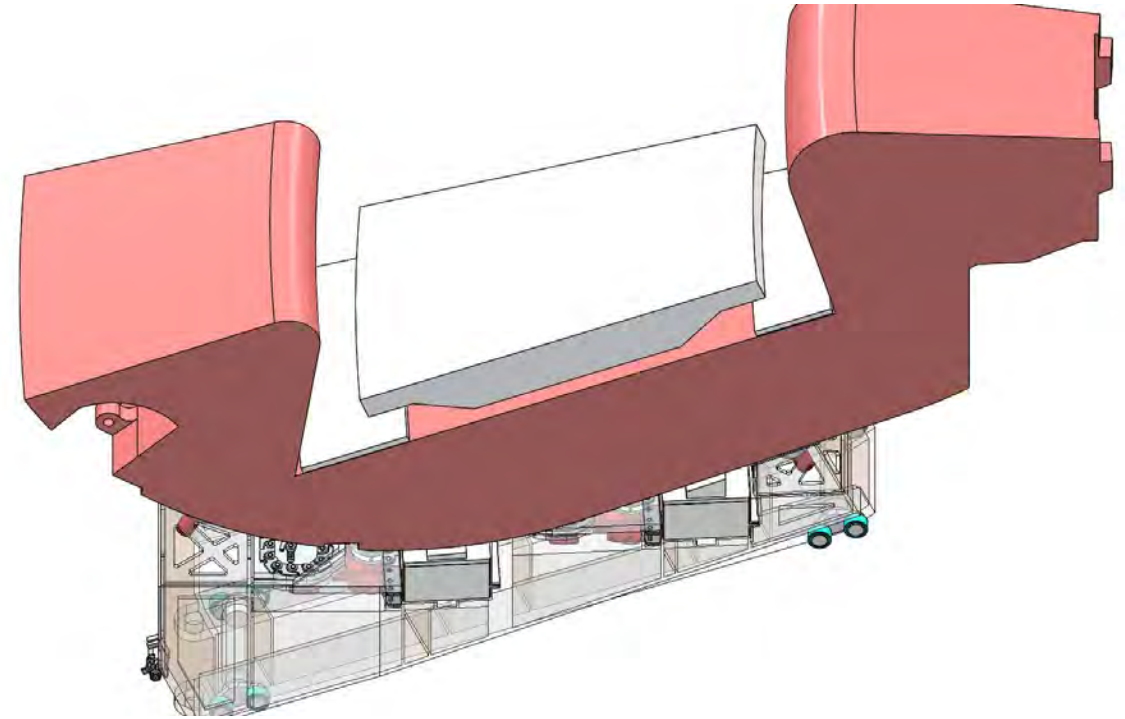
- Lower port tracks are inclined
- Rack-and-pinion mover (VTT)
- Mover pushes end effectors
- Divertor end effector has trolleys and lifters to position and hold lateral and center divertors





One mover for different end effectors

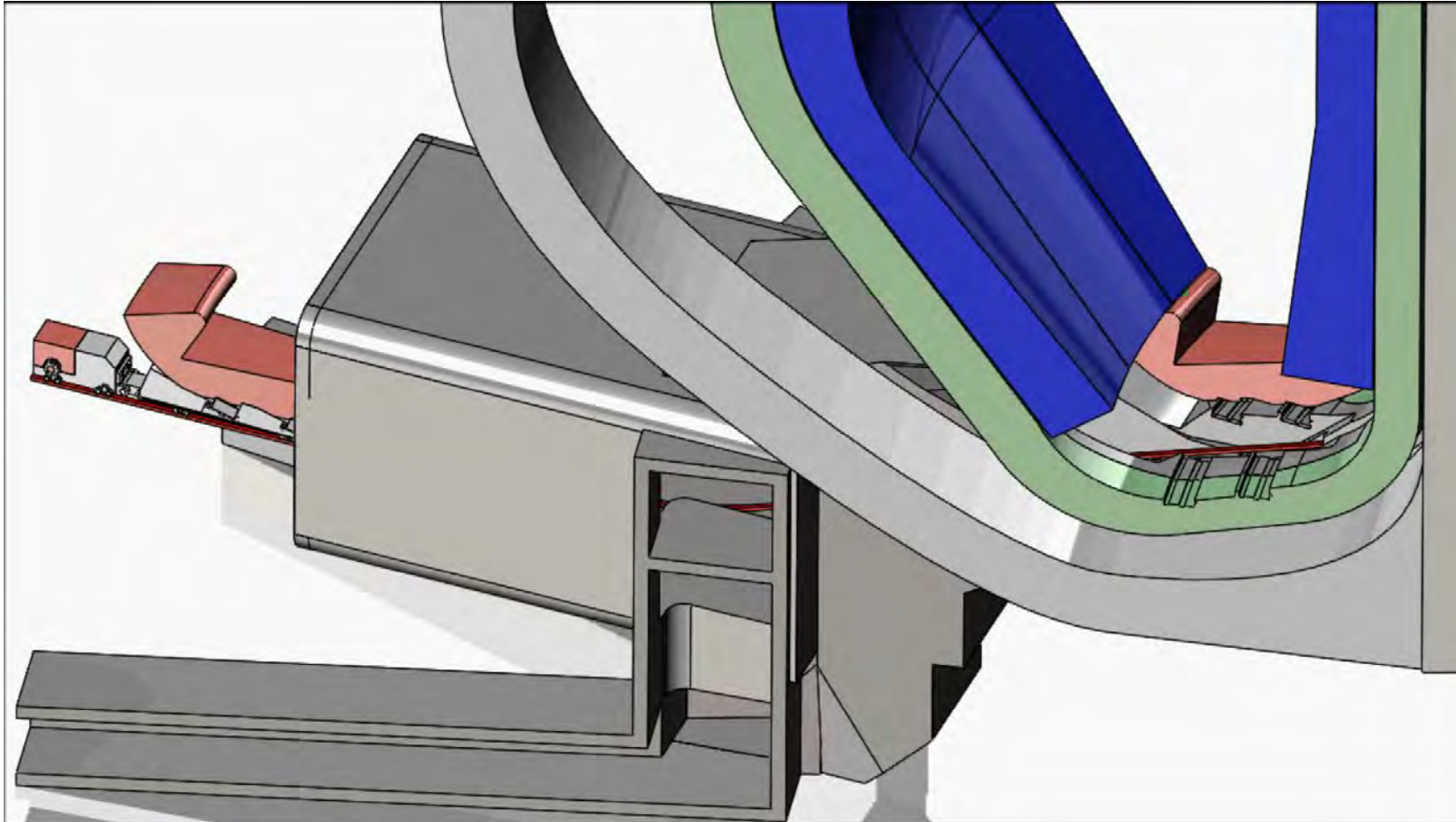
- The end effector for divertors is shown here
- Other end effectors are needed for e.g. vacuum closure plate, vacuum pump, pipe bundles, and ramps
- Possibility to install industrial robot on the mover



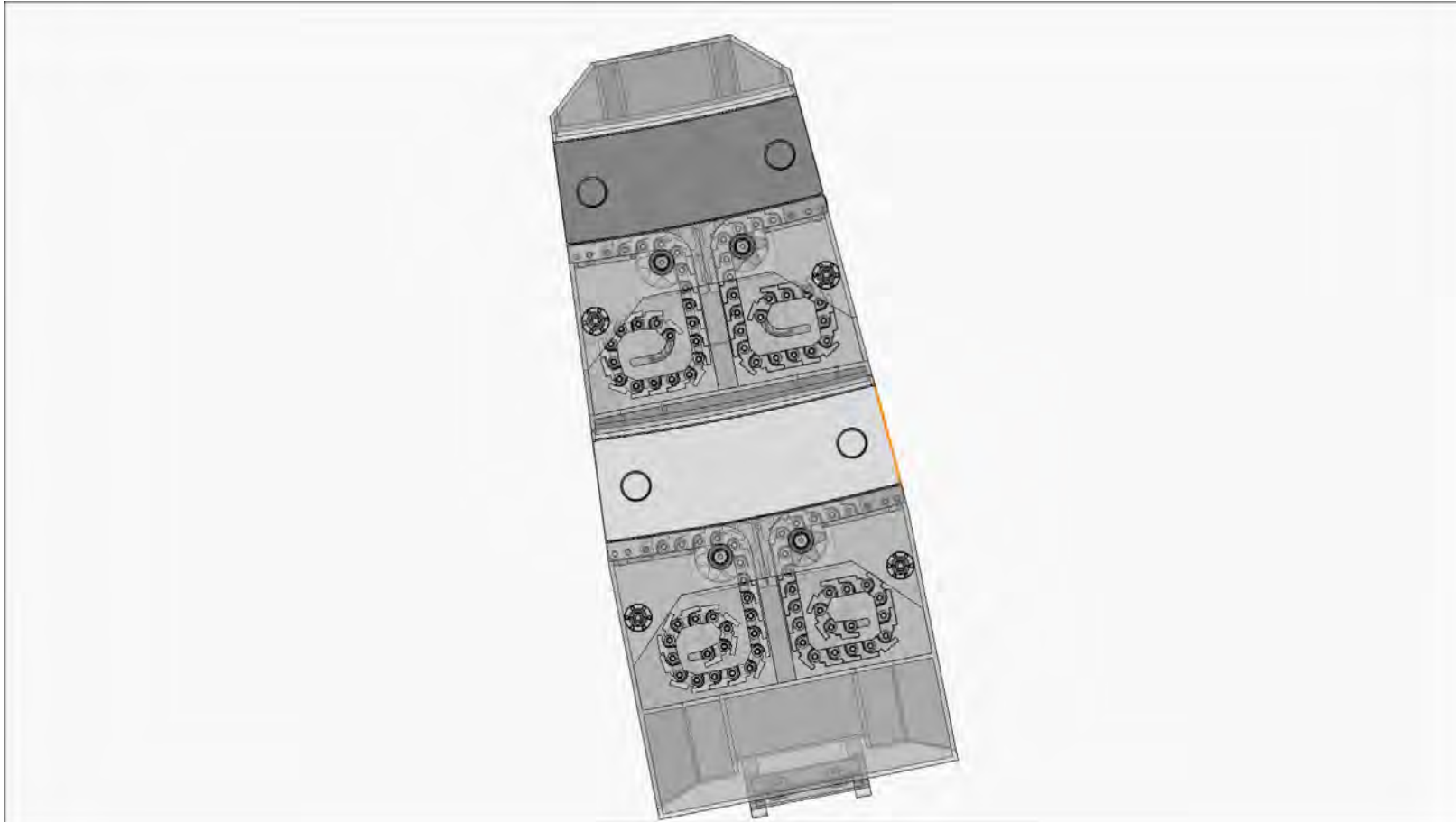
Divertor end effector

- 2 trolleys for toroidal movement of the divertor cassette
- Trolleys actuated by Serapid rigid chains
- Water-hydraulic lifters in the trolleys
- Locking devices for divertor on the end effector

Inclined lower port: video 1

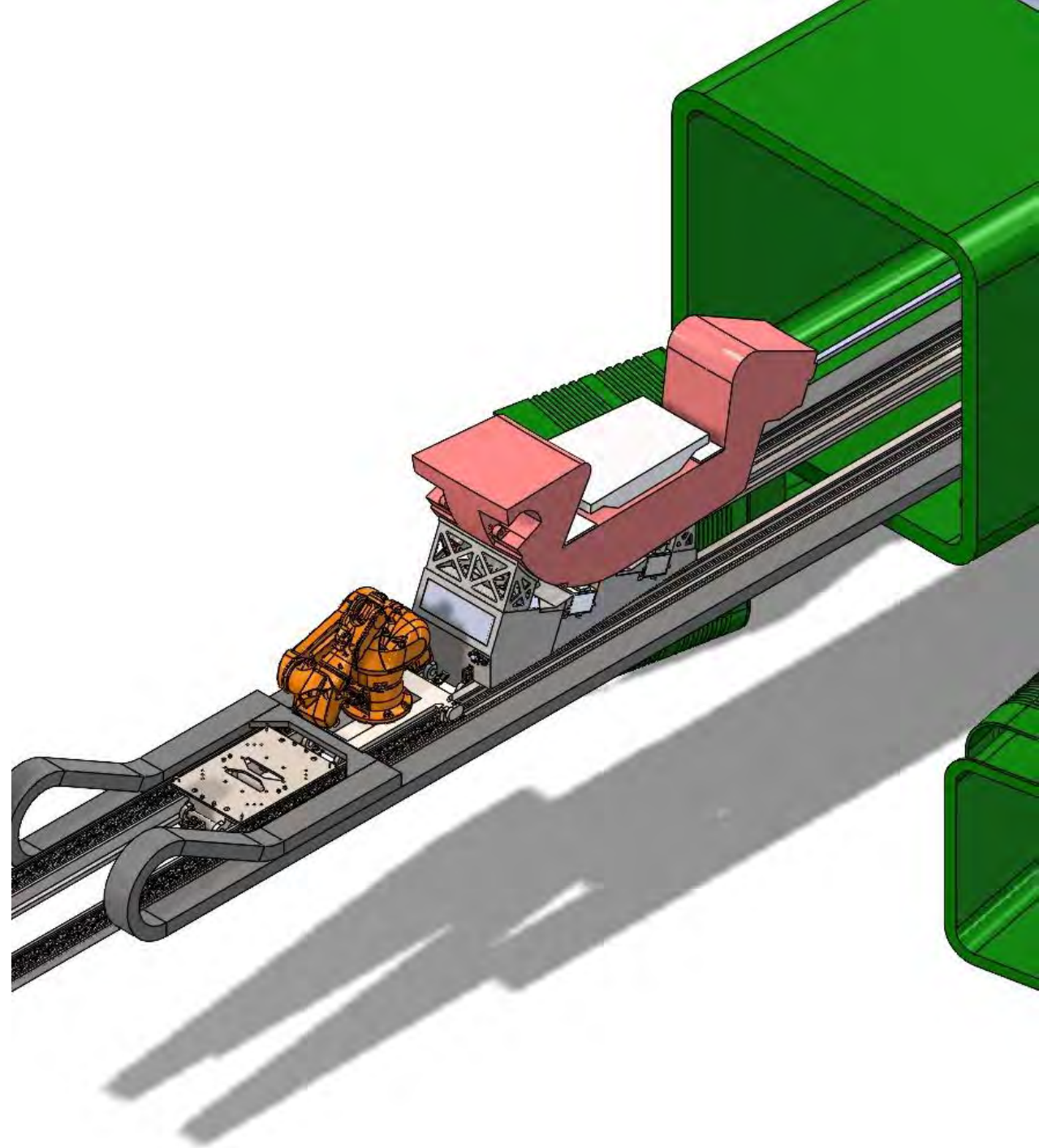


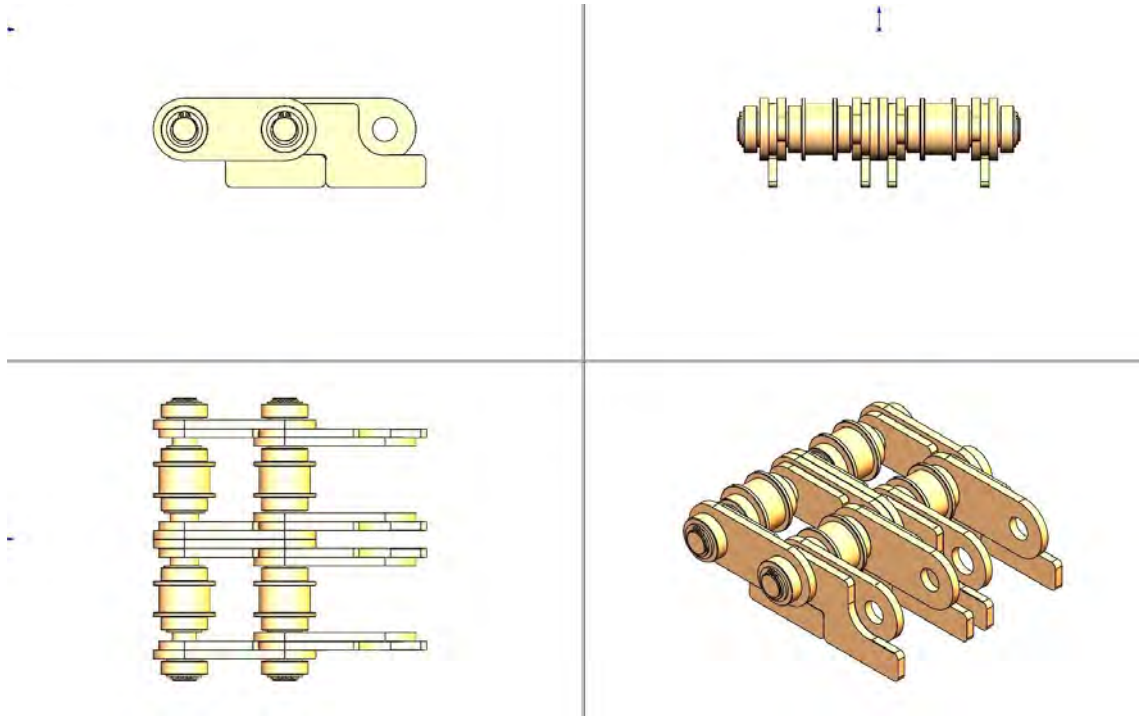
Inclined lower port: video 2



Inclined lower port

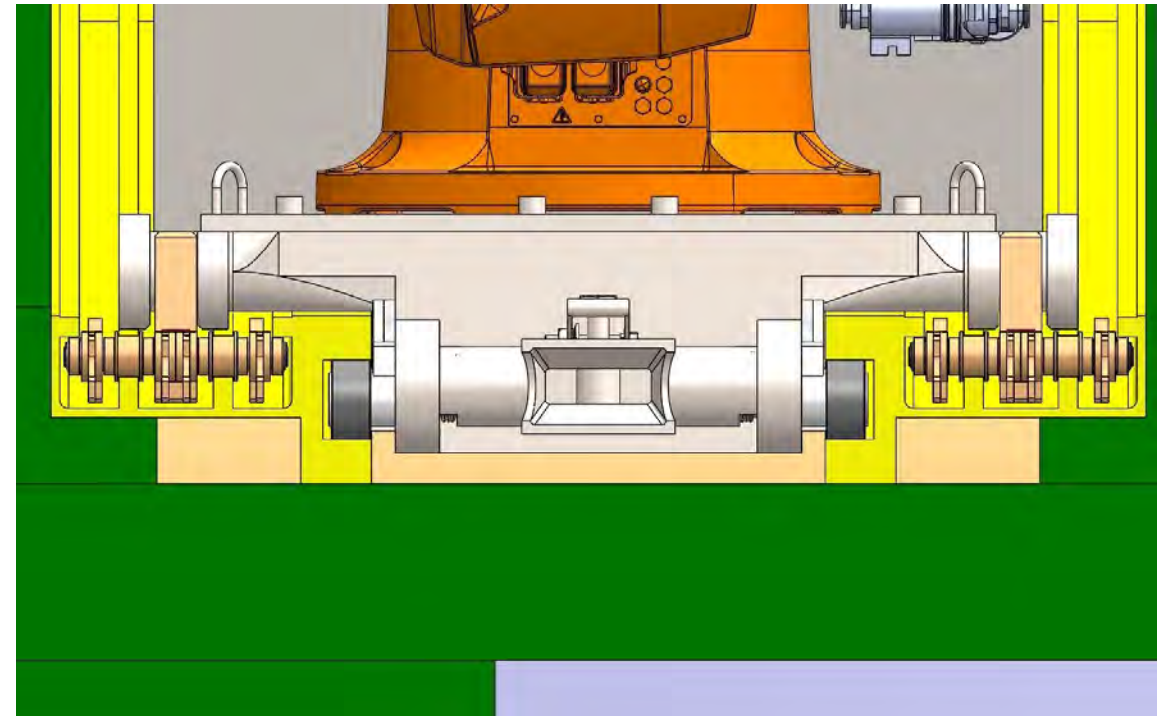
- Lower port tracks are inclined
- Serapid chain mover
- Alternative mover concept for inclined lower port





Serapid rigid chain

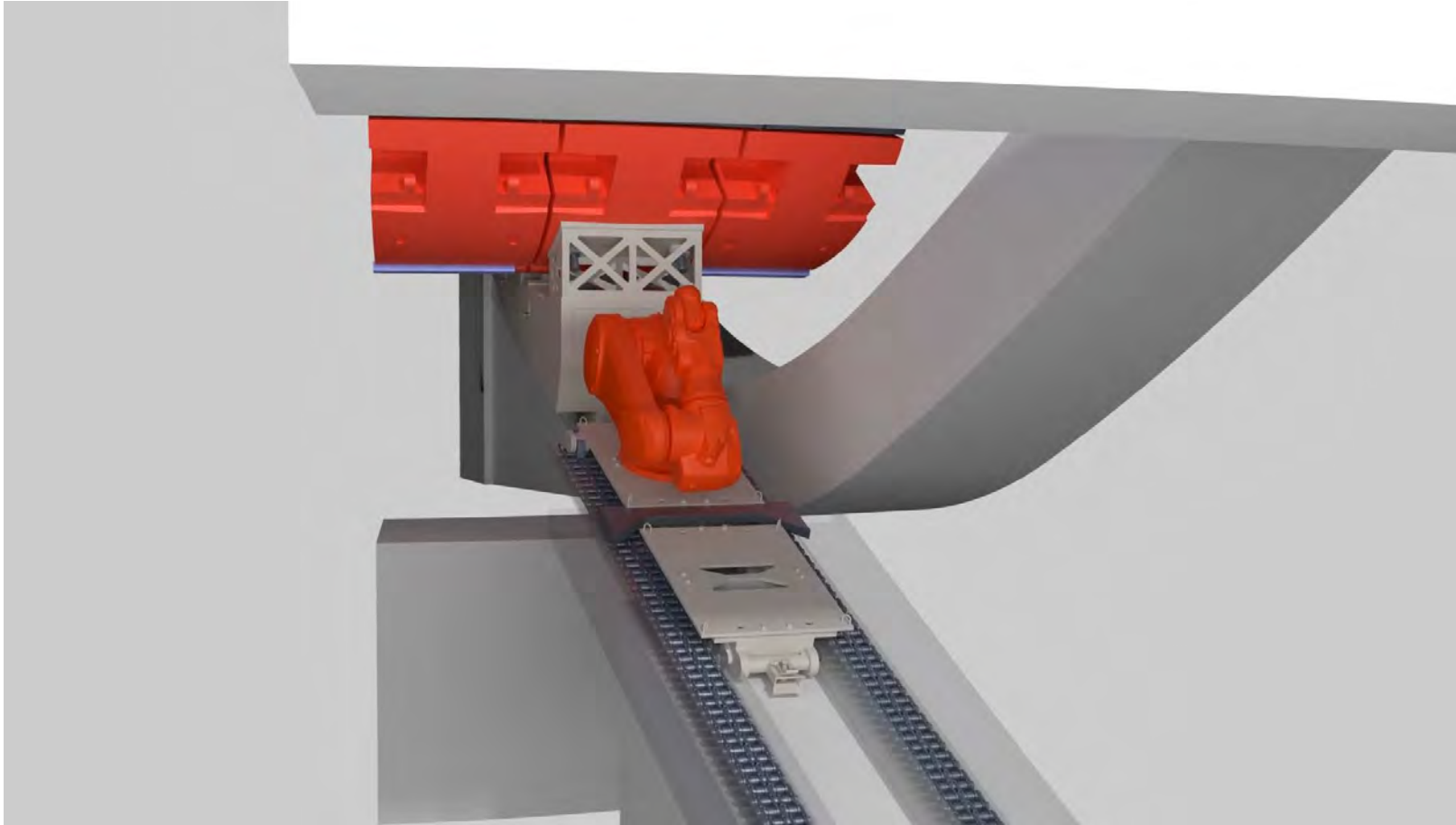
- Rigid chain folds in only one direction
- Almost stiff in other direction
- Can be used to push and pull high loads
- Lubrication-free (dry) for certain material choices



Chain guide profiles

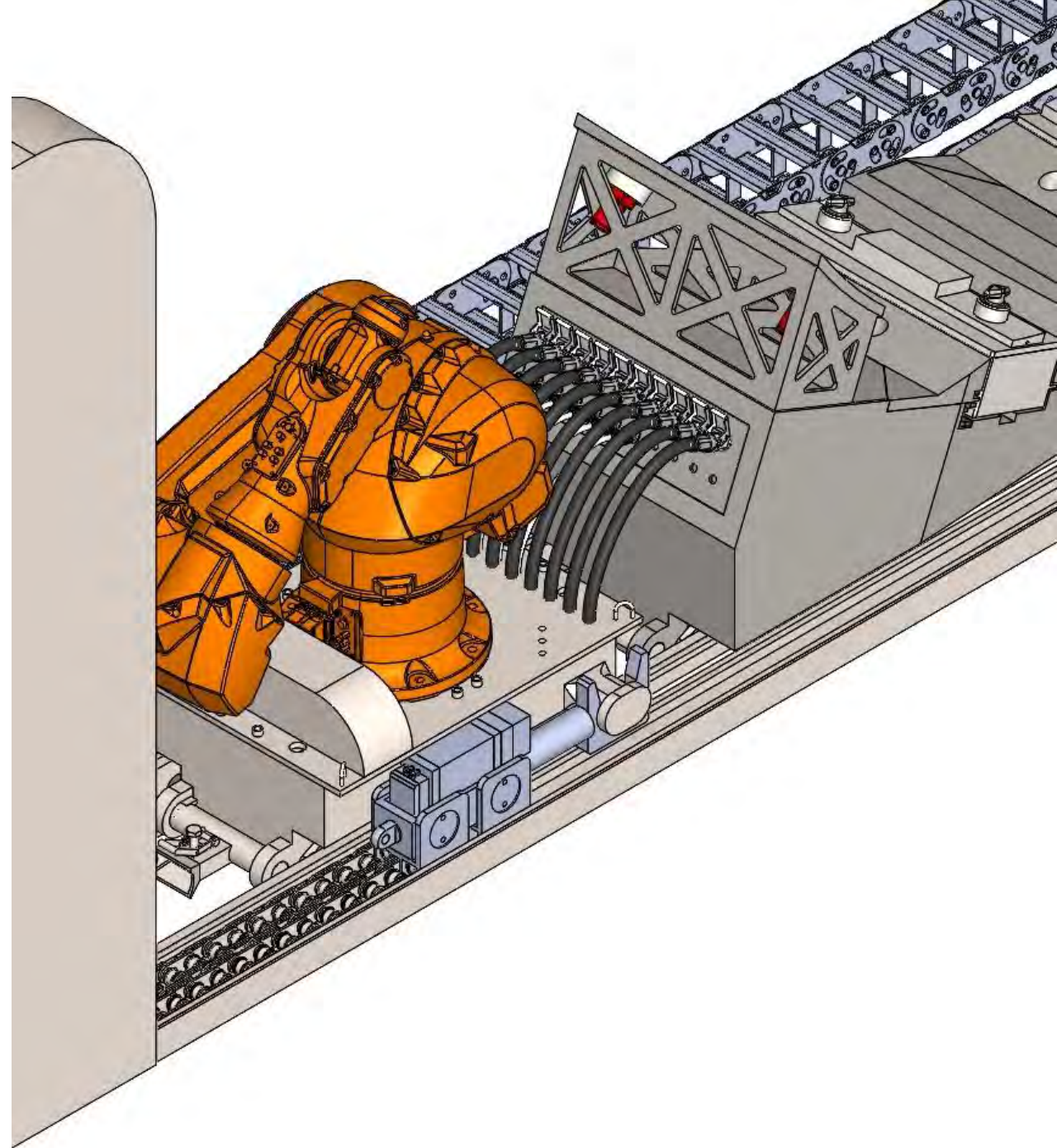
- This type of rigid chain has to be guided along its way
- Guide profiles integrated in lower port floor
- 2 rigid chains add for redundancy in case of failure
- External drive motors and chain magazines in hot cell

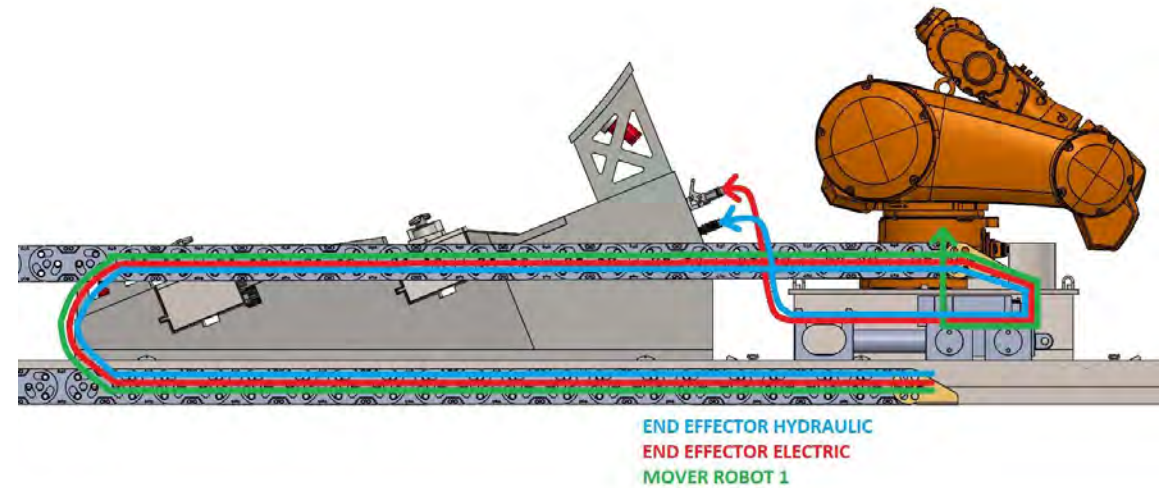
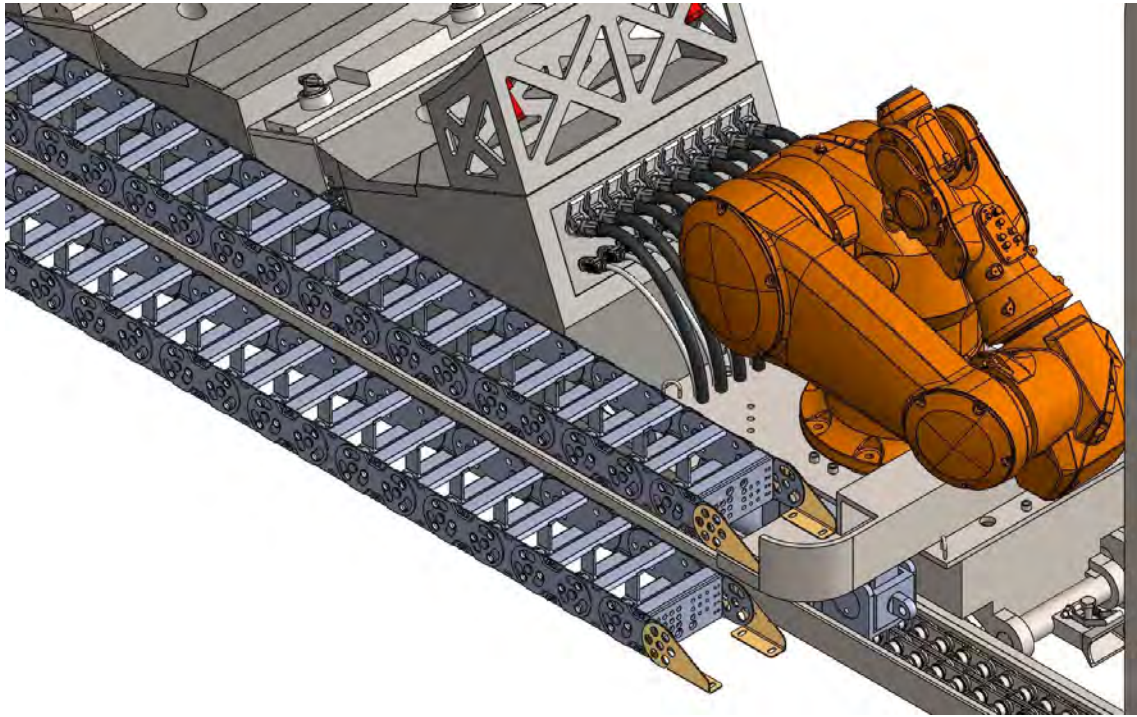
Serapid chain mover: video



Inclined lower port

- Lower port tracks are inclined
- Serapid chain mover
- Further development of previous design for inclined lower port





Refinement of mover design

- More realistic modeling of cable carrier
- Presentation of cable and water hydraulic connections
- Increasing of mover position accuracy by electric actuators
- Studies of brake systems for end effector

Energy for end effector and robot

- Supply of electric energy, data and hydraulic power to the mover via one (or two) lateral cable carrier(s)
- Distribution inside mover body to end effector and possible additional devices, for example robot installed on mover
- Cable carrier made of stainless steel to withstand radiation



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