FUSION FOR ENERGY

BRINGING THE **POWER** OF THE **SUN** TO **EARTH**

Cassette Toroidal Mover (DAT CTM)

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Remote Handling Engineer

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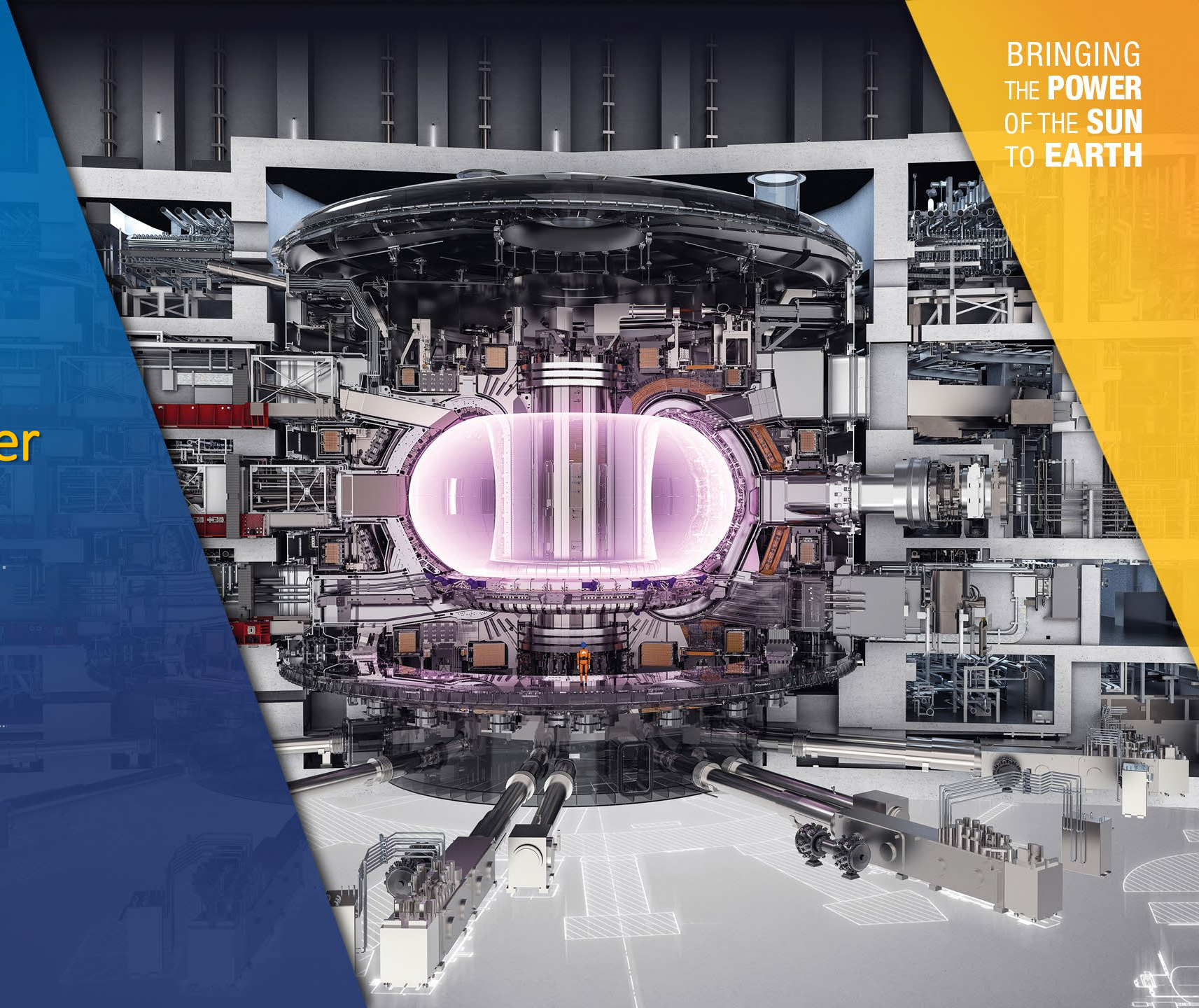


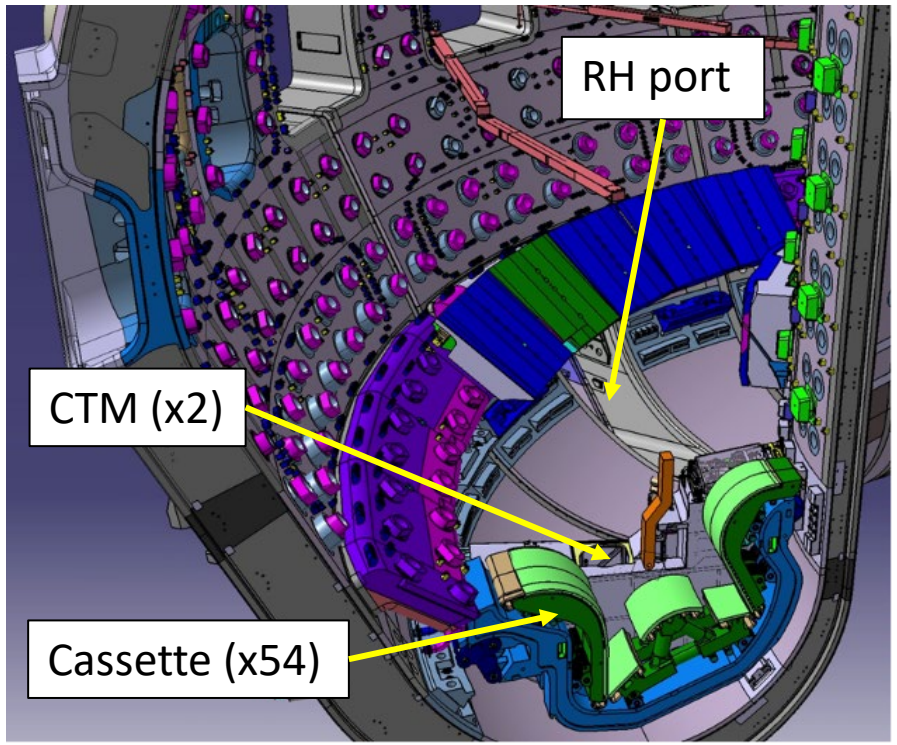
Cassette Toroidal Mover (CTM)

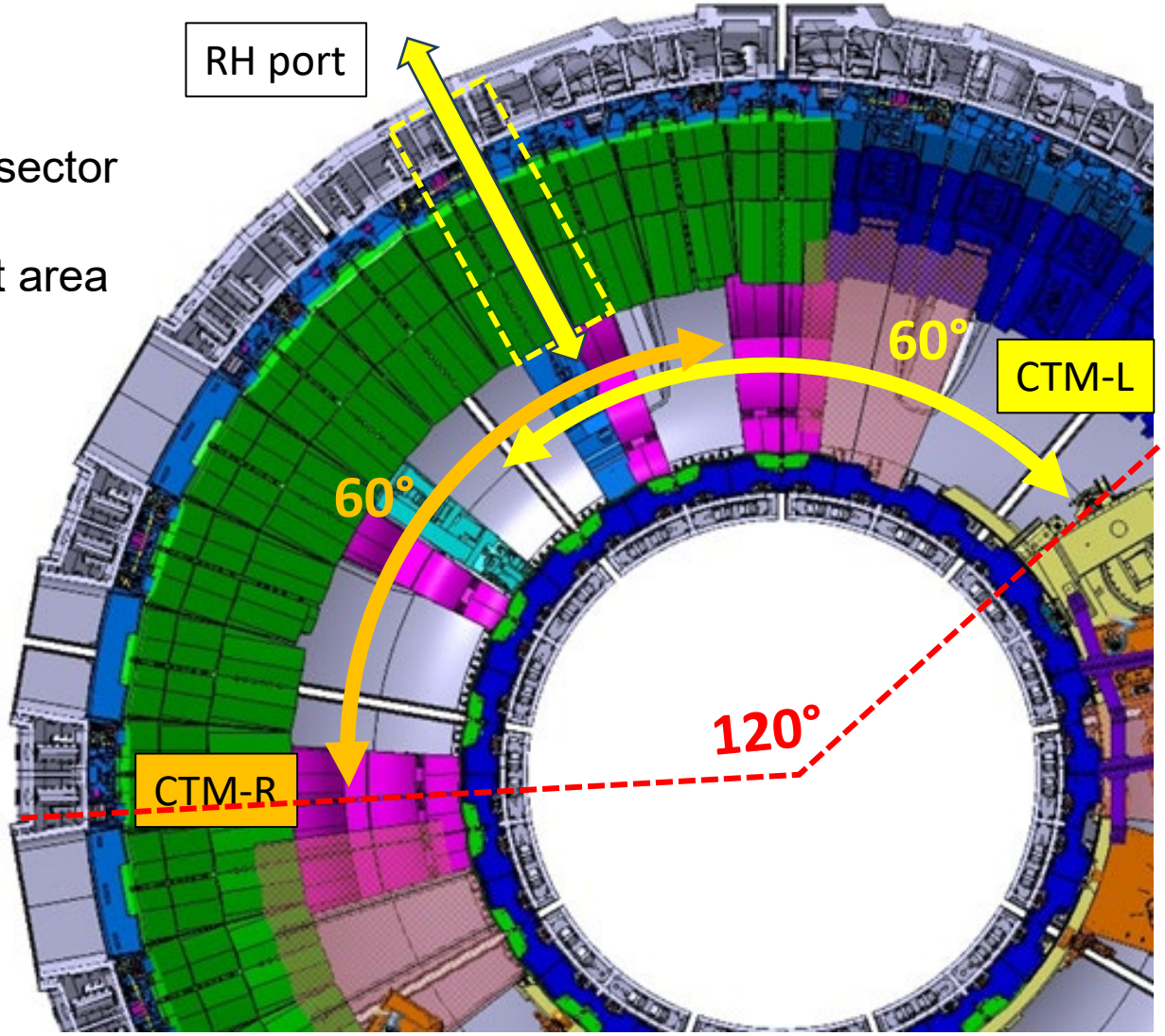
- Introduction
- Functions
- Design drivers and constrains
- Main subsystems:
  - Drive Units: Toroidal movement
  - Lift Units: Cassette lifting and fine positioning
  - Hydraulic system
  - Cable Guide: services connection for CTM

Introduction: two CTMs working from the same port

DAT CTMs

- Two CTMs inserted through RH port
- CTMs supported and running on toroidal rails
- Two CTMs will be present simultaneously on a 120° sector
- Each CTM will be working on a 60° sector
- The trajectories of both CTMs are overlapping at port area

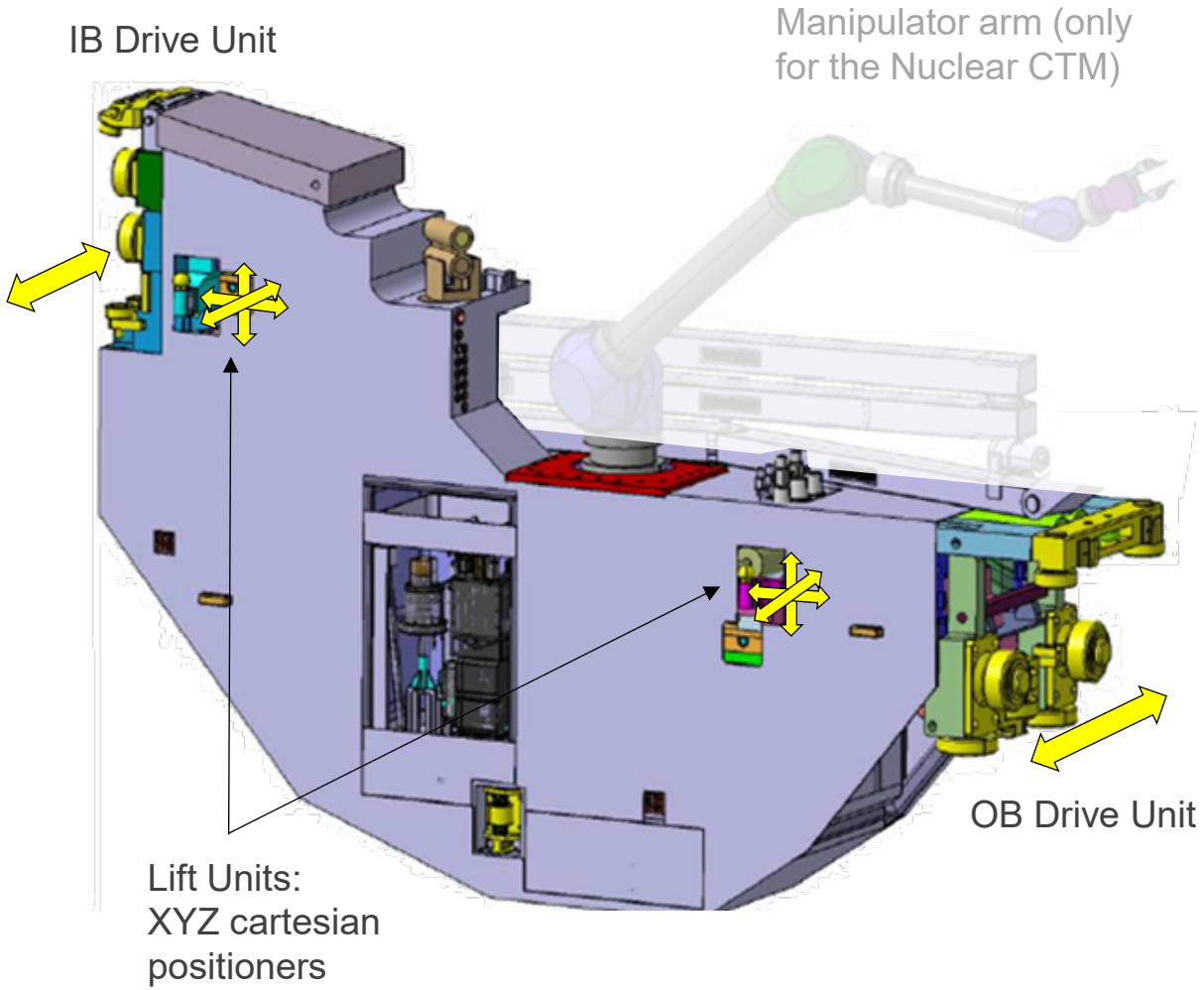




DAT CTM: Functions (1/2)

The DAT CTM is a simplified version of the Nuclear CTM, with limited functions:

1. Cassette Lifting & positioning function: Equipped with two small XYZ cartesian positioners to lift the cassette through two hooks (Lift Units)
2. Cassette Transport function: Is a mover running toroidally along circular rails (Drive Units)



DAT CTM functions (2/2): DAT compared to Nuclear CTM

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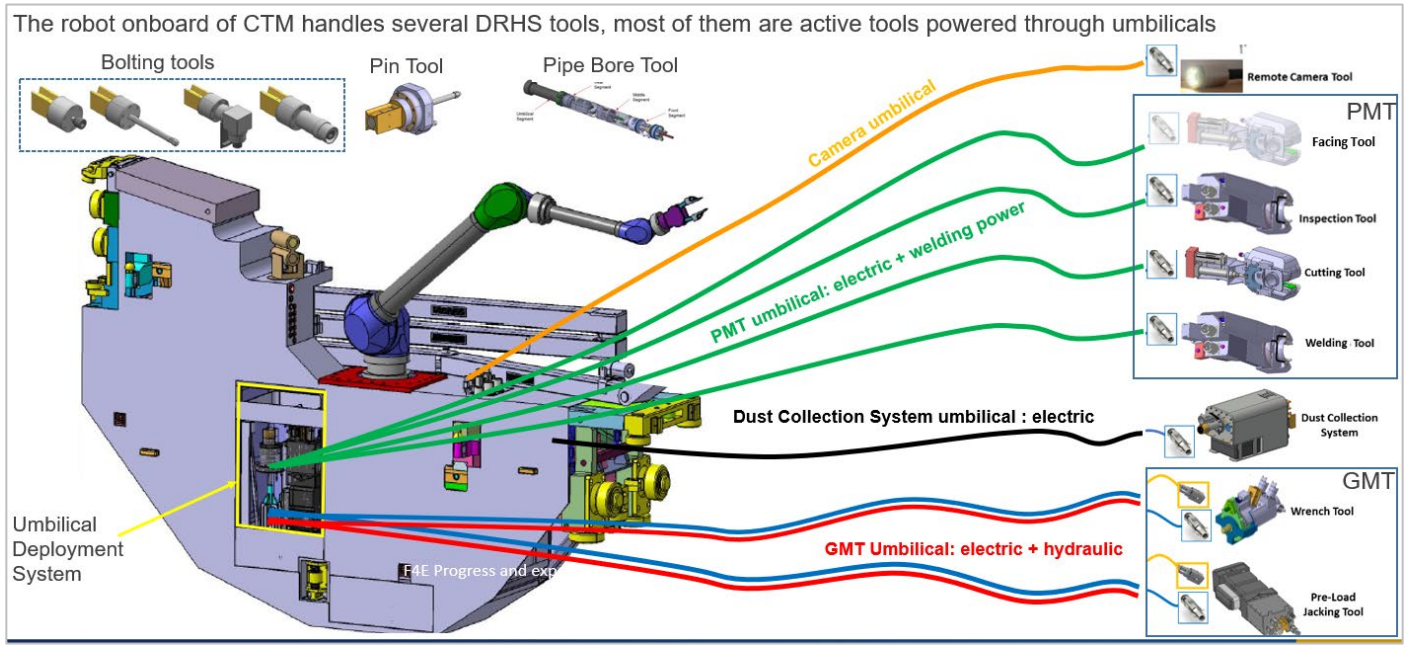
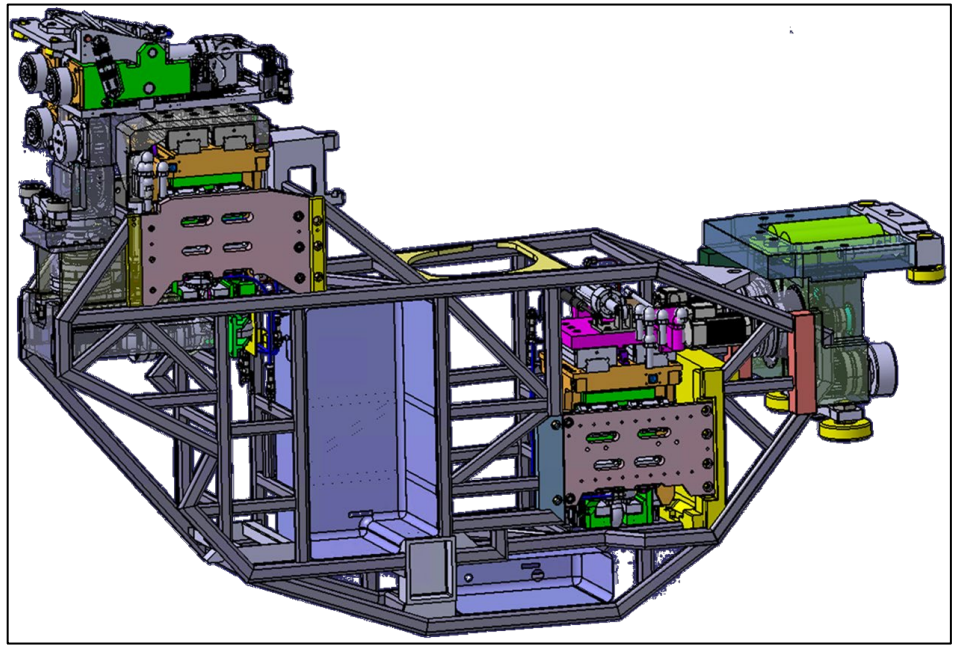
Nuclear CTM (future machine)

- Radiation hardened machine
- Radhard components (electronics, cameras, etc.)
- Functions: multiple complex functions
- Manipulator onboard
- Several active tools and umbilicals
- Operation: fully remote from control room

DAT CTM for 1st Assembly (current project)

- **Functions: only lifting and transporting cassettes**
- No radiation hardened machine
- Mainly Industrial components
- No manipulator onboard, no tools, no umbilicals
- Operation: remote + local control (pendant)

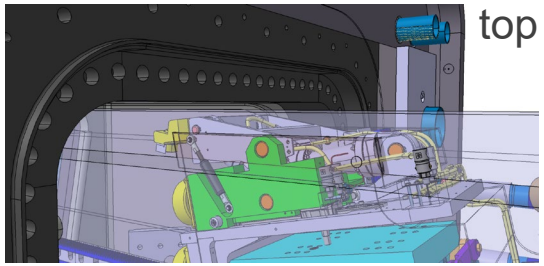


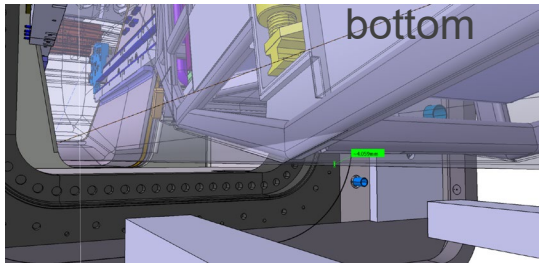


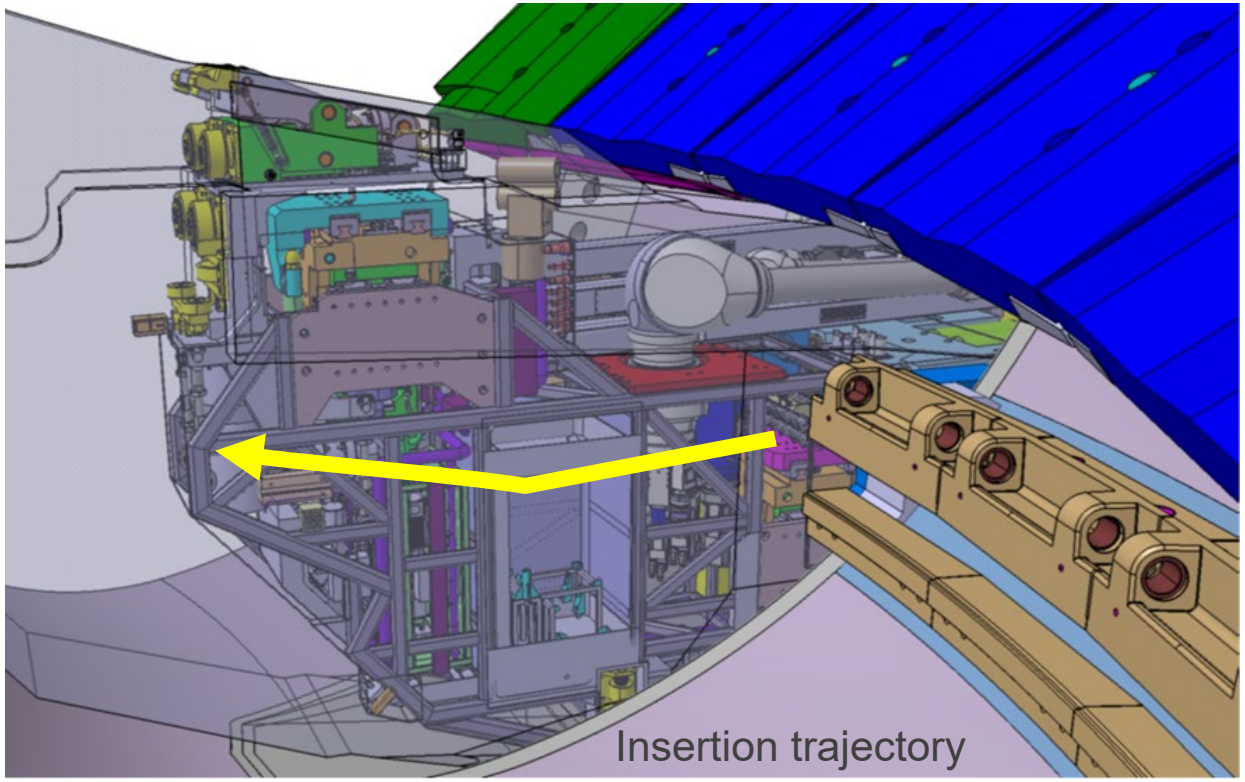
DAT CTM main constrains (1/3)

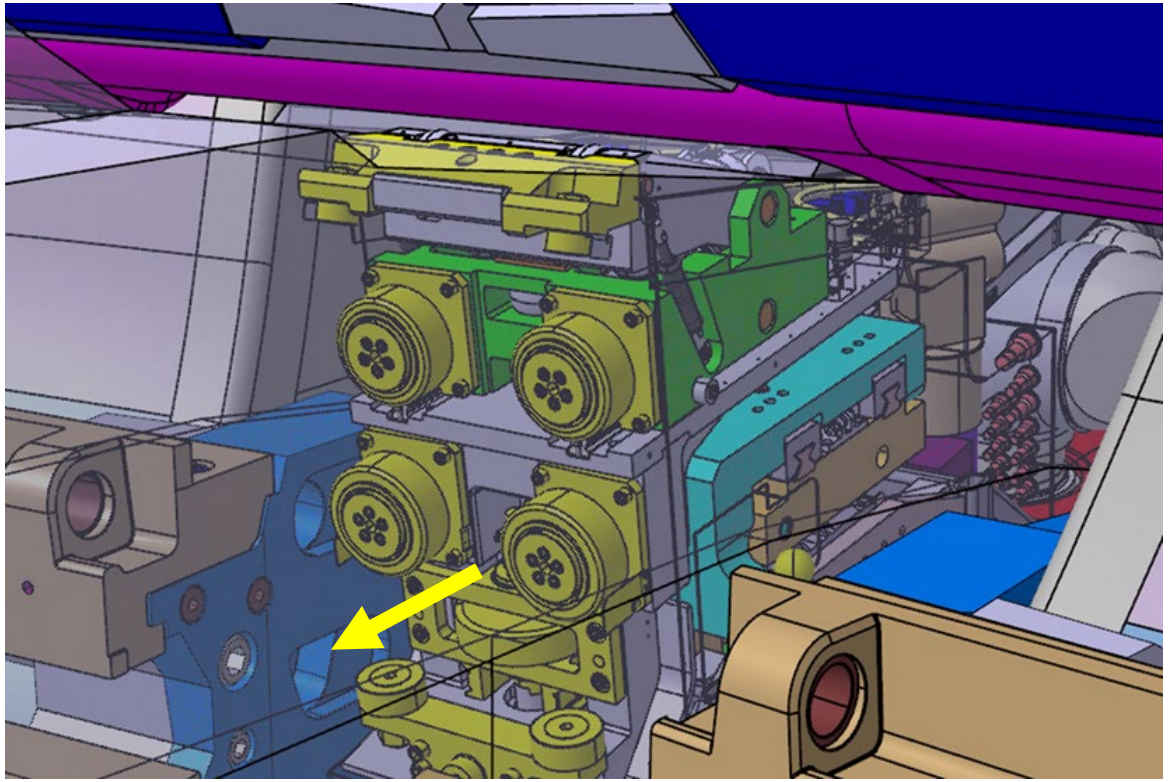
External volume strictly limited as a cassette

- CTM design uses the maximum volume available compatible with the insertion through the port duct.
- Not possible increasing external dimensions





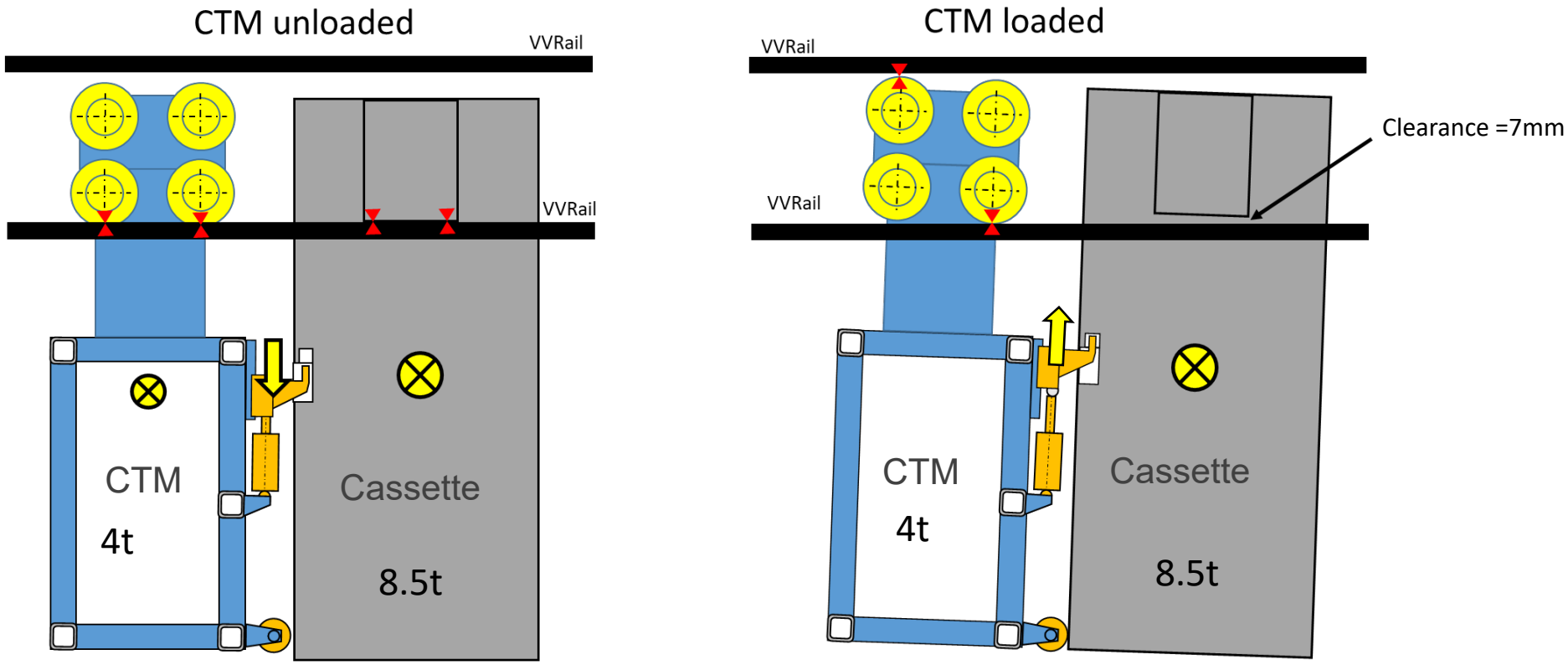




DAT CTM main constrains (2/3)

Offset Lifting Function

- The cassette is lifted cantilevered at one side of the CTM
- The lifting stroke is short, only required 7mm clearance from cassette to rail for transport



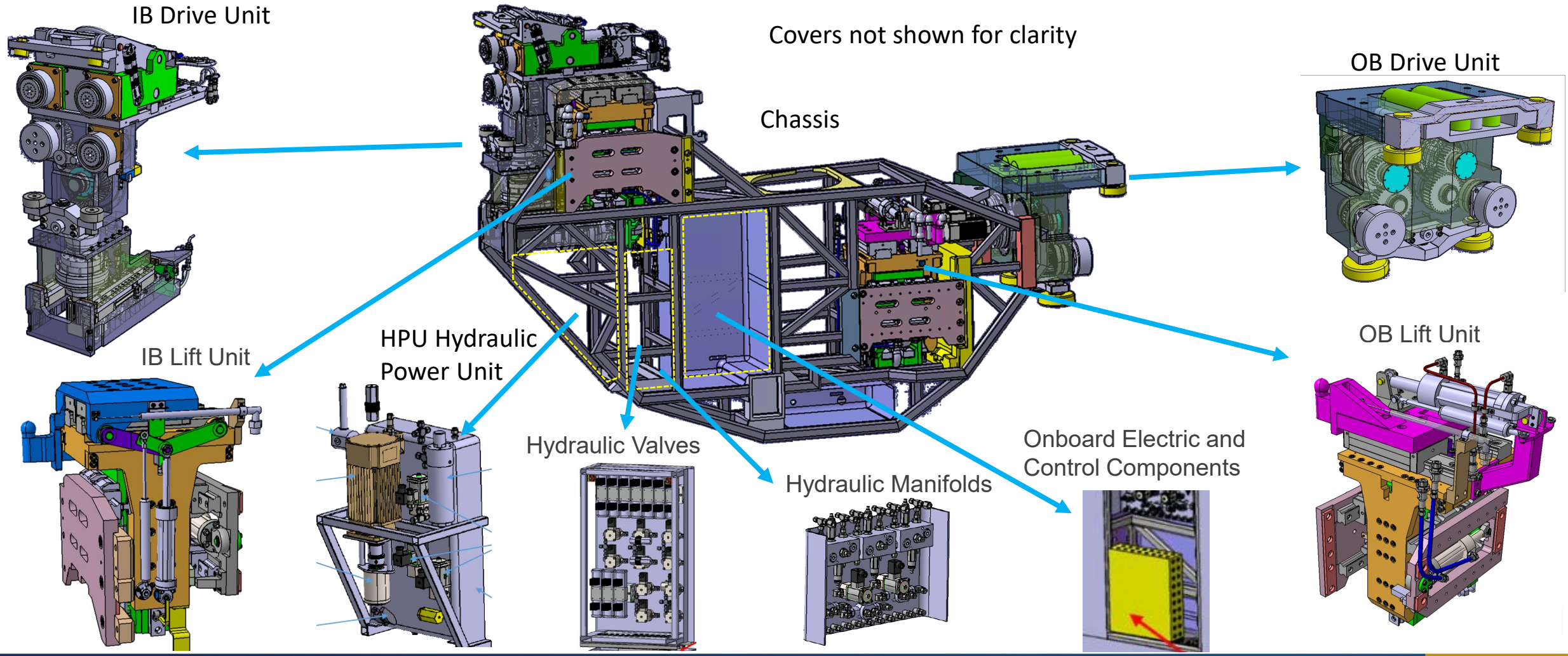
DAT CTM main constrains (3/3)

Materials allowed and contamination avoidance

- The Vacuum Vessel is a clean area with high cleaning requirements
- Materials allowed: mainly stainless steel, no carbon steel, in general no plastics, no rubber
- High requirements to avoid spreading contamination:
  - CTM equipped with external covers to prevent spreading contamination from CTM to Vacuum Vessel
  - No paints, no stickers, smooth external surface to allow careful cleaning
  - The DAT CTM cannot use oil
  - Hydraulics based on water instead of oil
  - Grease requires double confinement

DAT CTM main subsystems

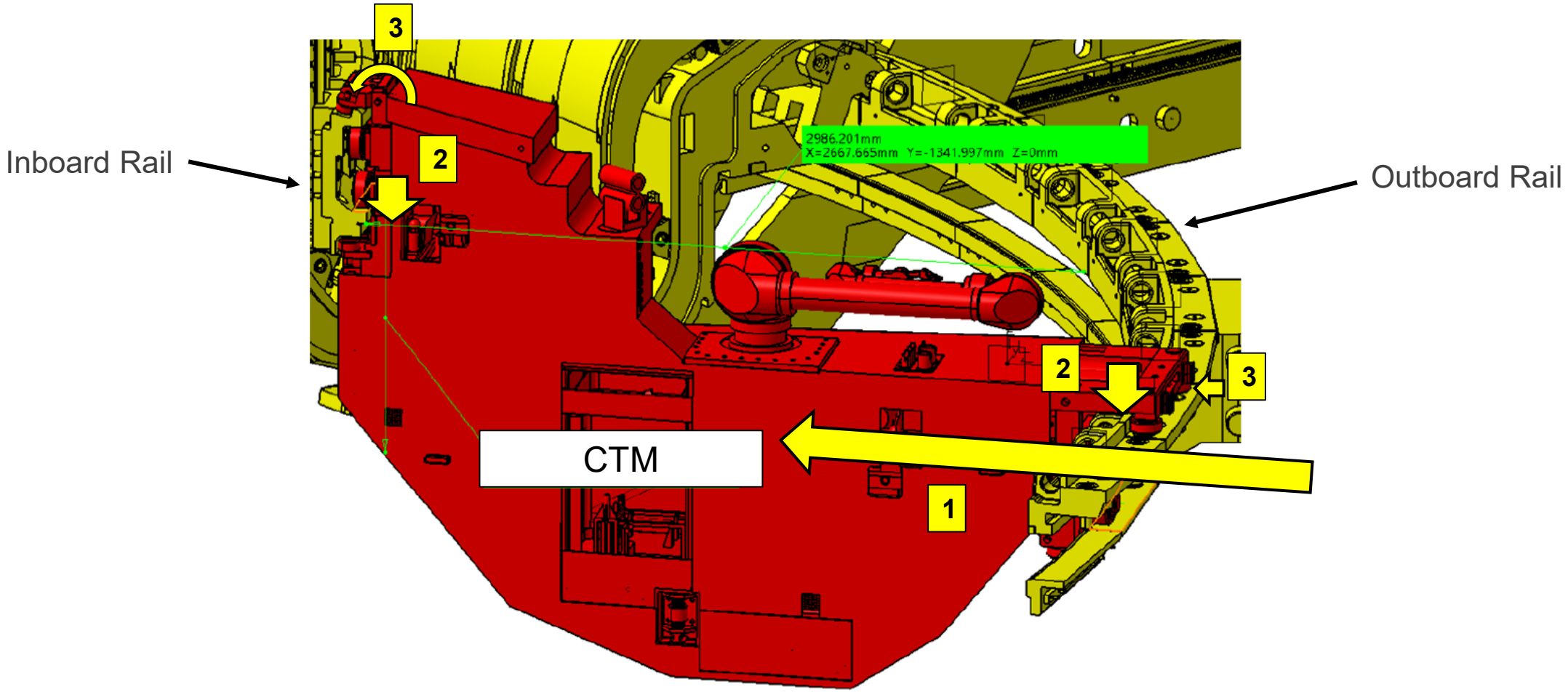
Each individual subsystem is a compact unit, replaceable independently of the other ones



Toroidal Movement (1/7): Installation on rails

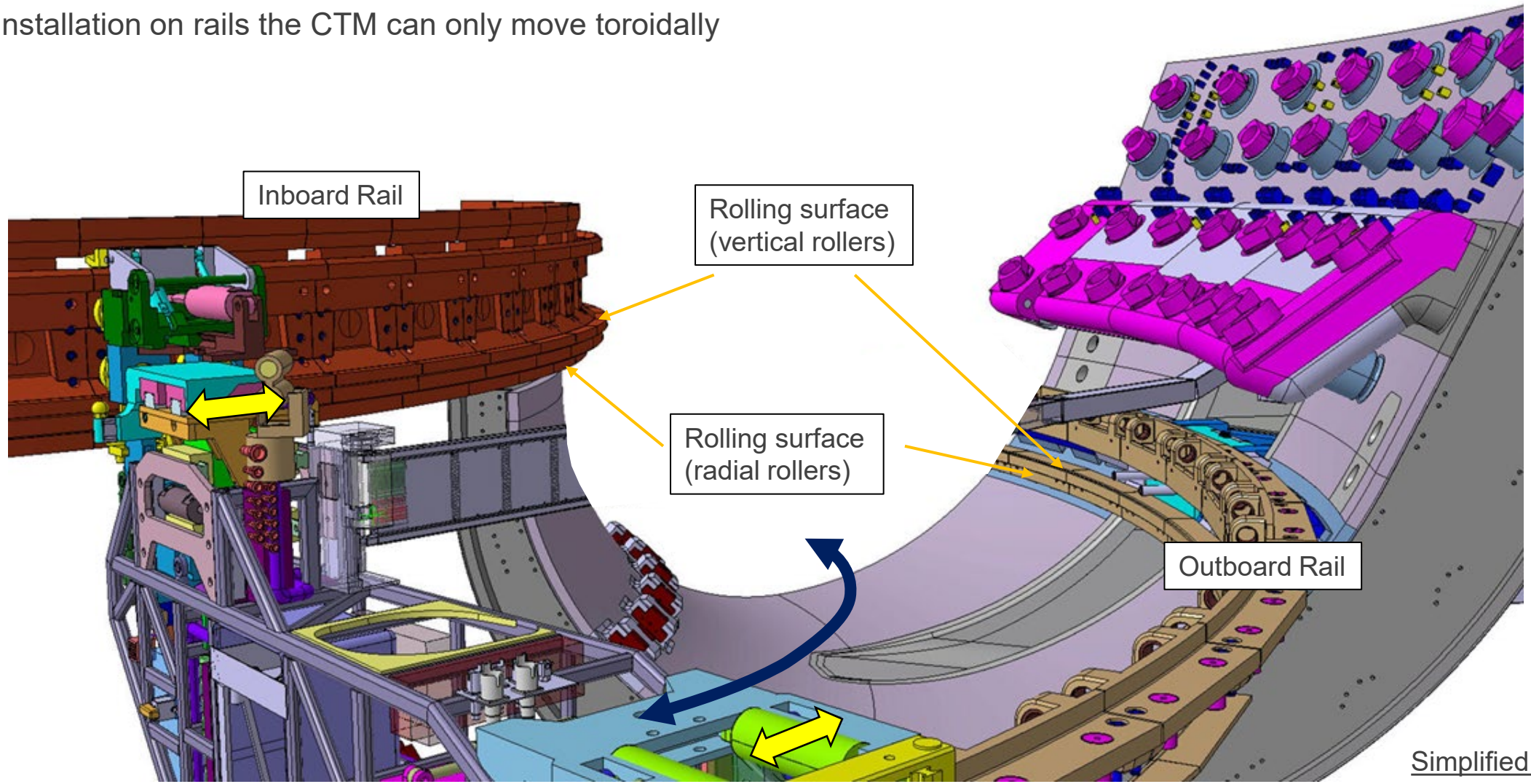
CTM installation on Vacuum Vessel rails

- The CTM is inserted by the CMM (1), released on rails (2), and secured to the rails thanks to clamps (3).



Toroidal Movement (2/7): guidance by rollers & rails

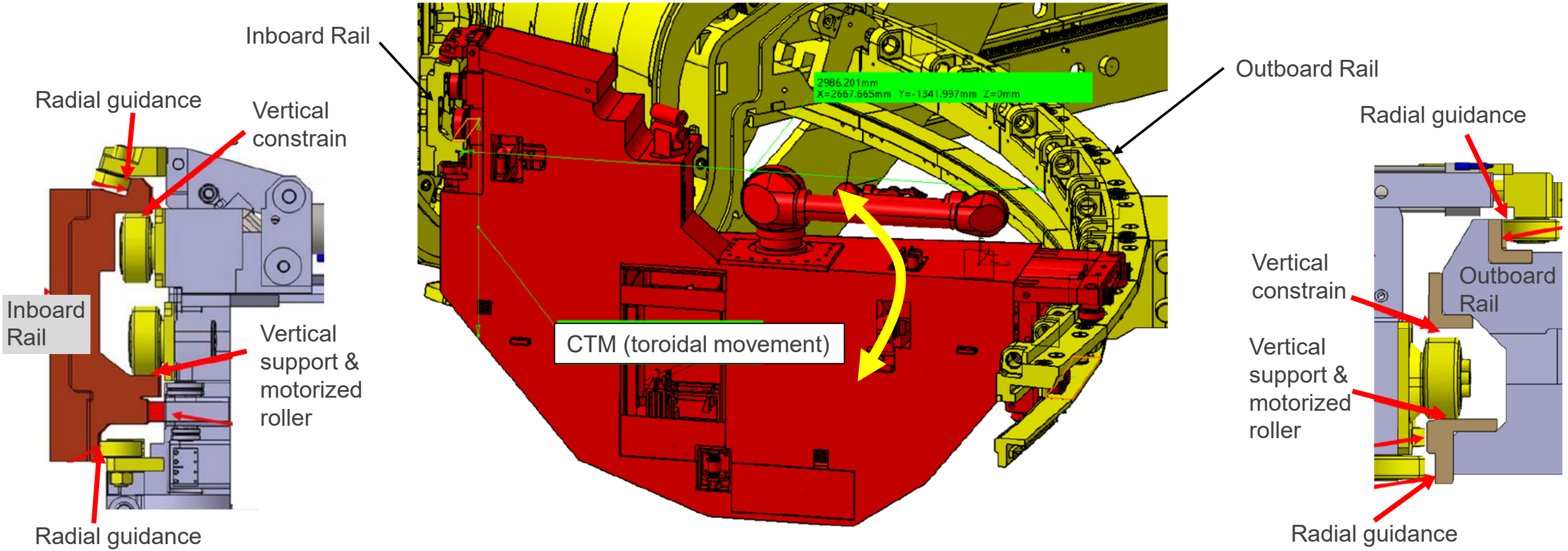
- After installation on rails the CTM can only move toroidally



Simplified view

Toroidal Movement (3/7): guidance by rollers & rails

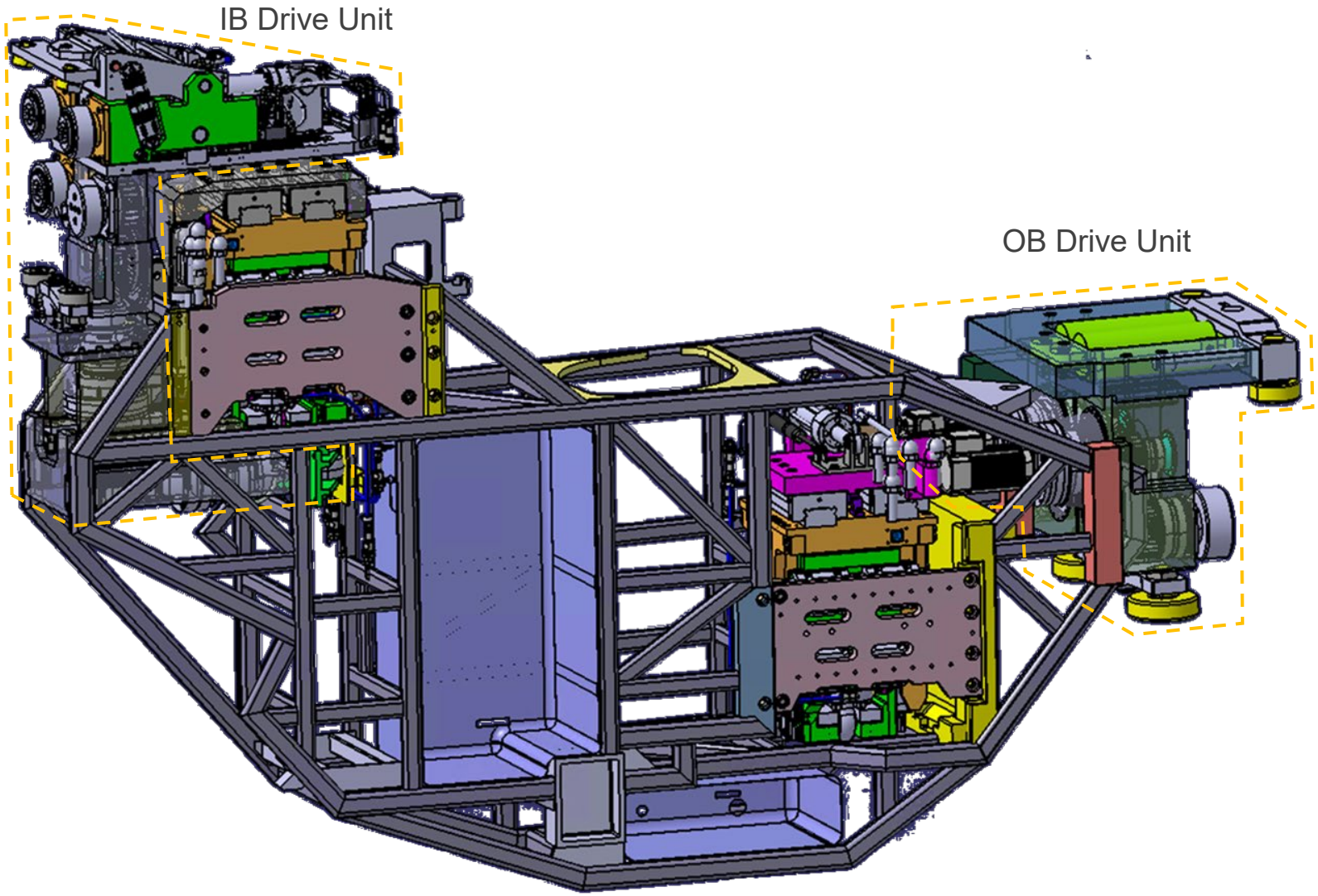
- Travel along toroidal direction: supported and guided to toroidal rails (IB and OB)
- Guidance based on vertical and radial rollers
- Driven by motorized vertical rollers



Toroidal Movement (4/7): Drive Units

Main requirements for Drive Unit

- Vertical loads: 12.5ton approx.
  - Cassette weight =8.5 ton approx.
  - CTM weight = 4ton approx.
- Travel speed:
  - 0-80mm/s unloaded
  - 0-30mm/s loaded
- Positioning accuracy: ±2mm



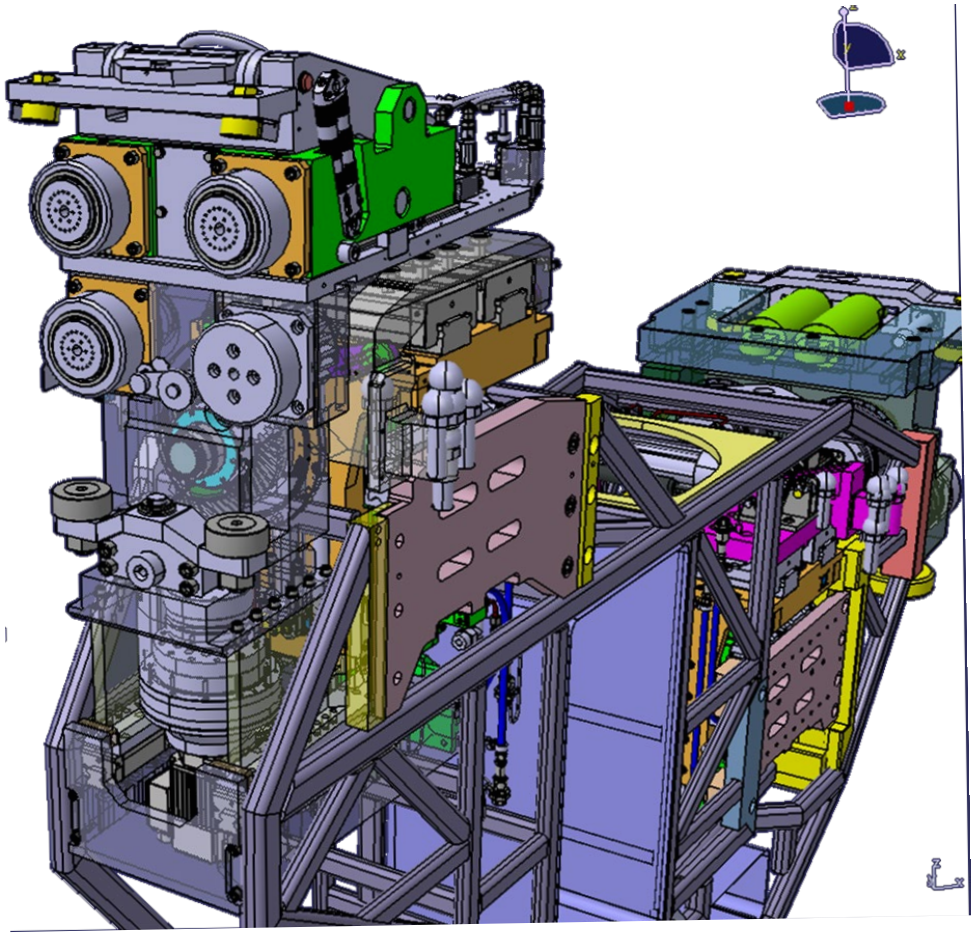
Toroidal Movement (5/7): Drive Units

Inboard Drive Unit

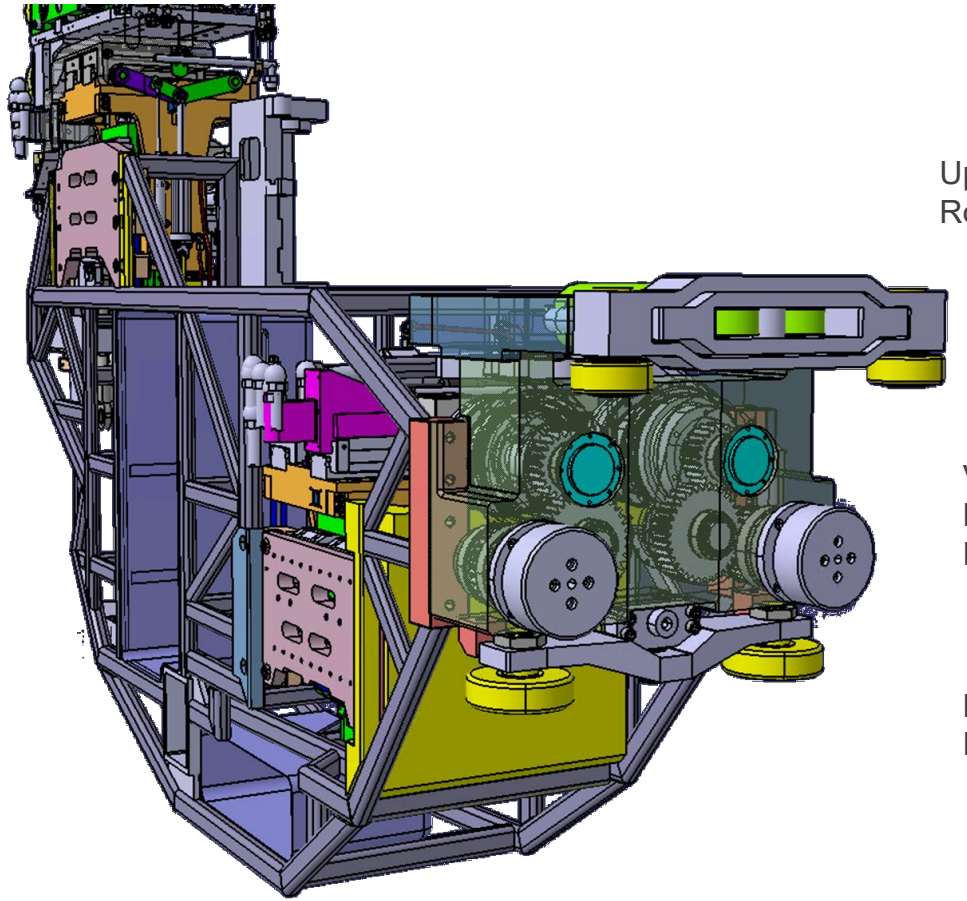
Upper Radial Rollers (x2)

Vertical Rollers (x4) (1 motorized)

Lower Radial Rollers (x2)



Outboard Drive Unit



Upper Radial Rollers (x2)

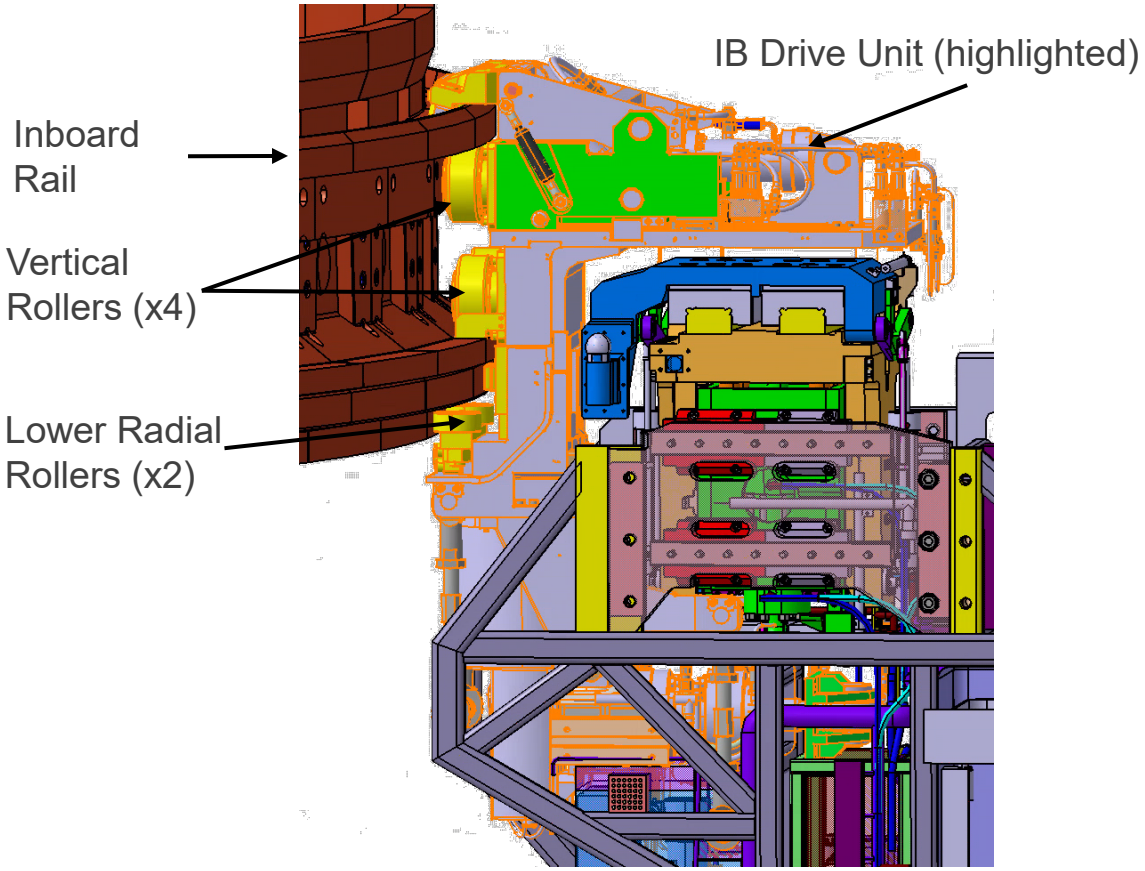
Vertical & Motorized Rollers (x2)

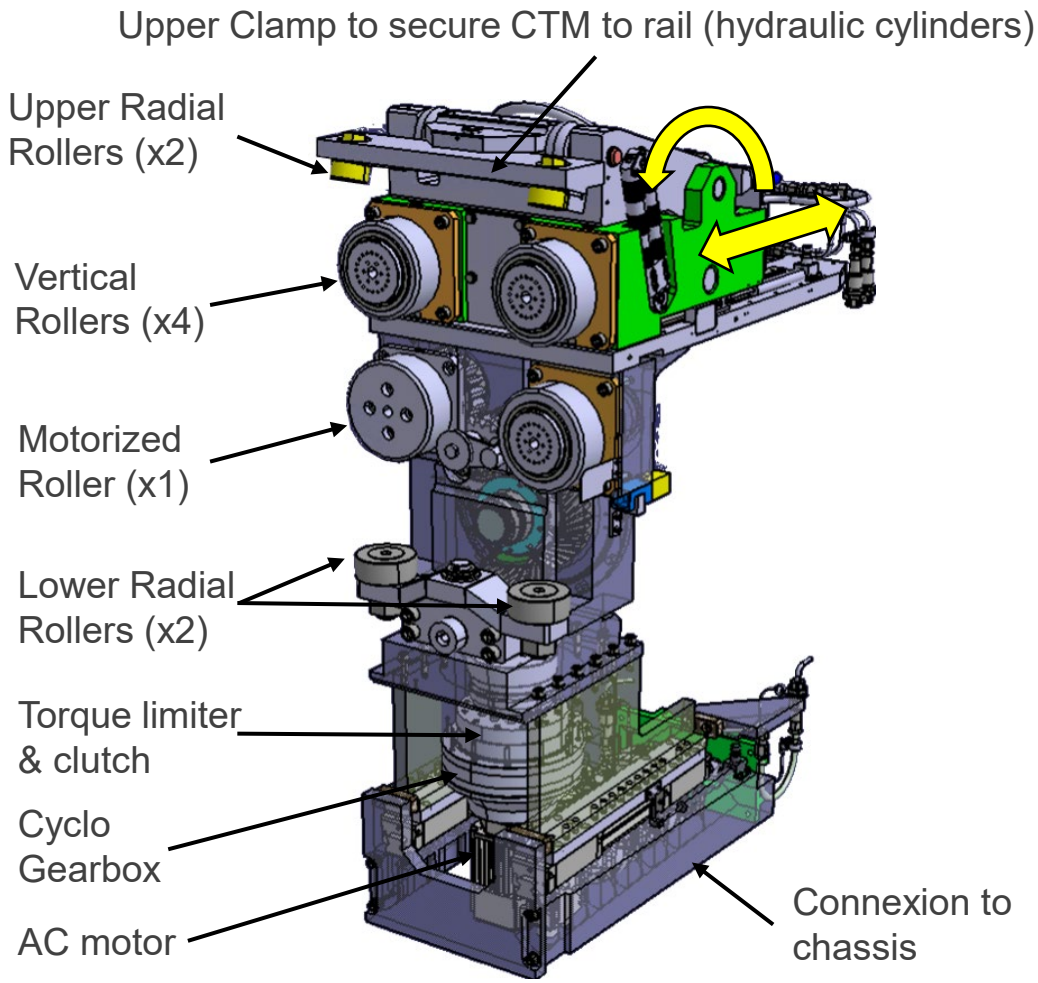
Lower Radial Rollers (x2)

Toroidal Movement (6/7): Drive Units

Inboard Drive Unit

- Shape constrained by other systems around
- Upper clamp driven by hydraulic cylinders





Toroidal Movement (7/7): Drive Units

Outboard Drive Unit

- Different configuration compared to IB Drive Unit
- Two symmetrical drive trains and twin motorized rollers

Upper Clamp to secure CTM to rail (hydraulic cylinders)

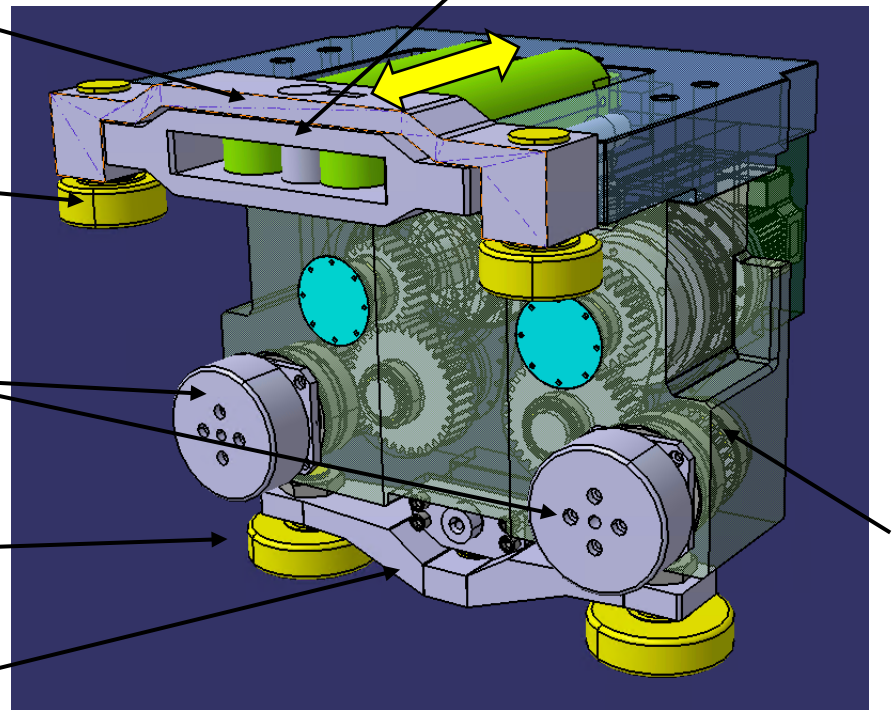
Upper Bogie

Upper Radial Rollers (x2)

Motorized Vertical Rollers (x2)

Lower Radial Rollers (x2)

Lower Bogie



Drive train (x2)

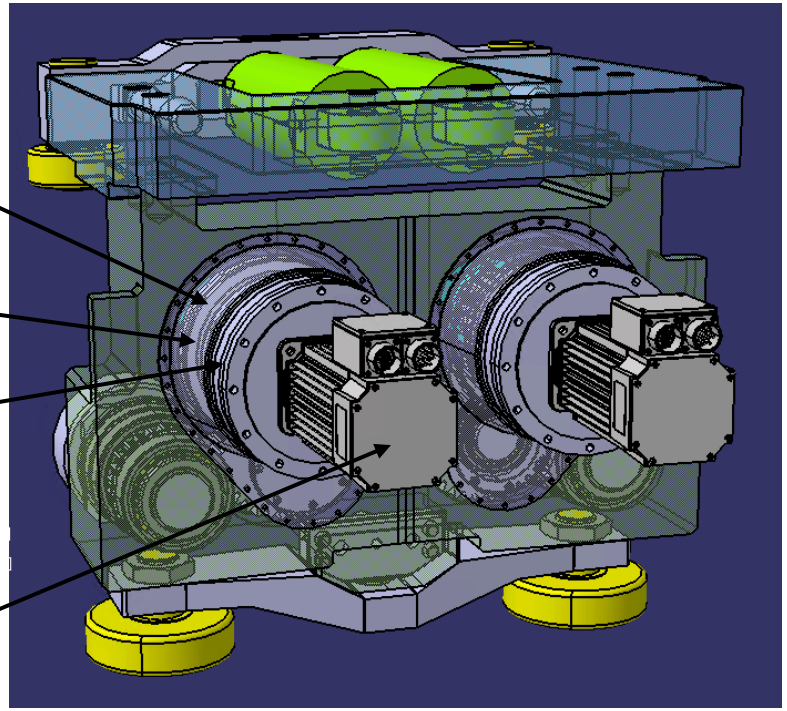
Components for each drive train:

Torque limiter

Decoupling clutch

Cyclo Gearbox

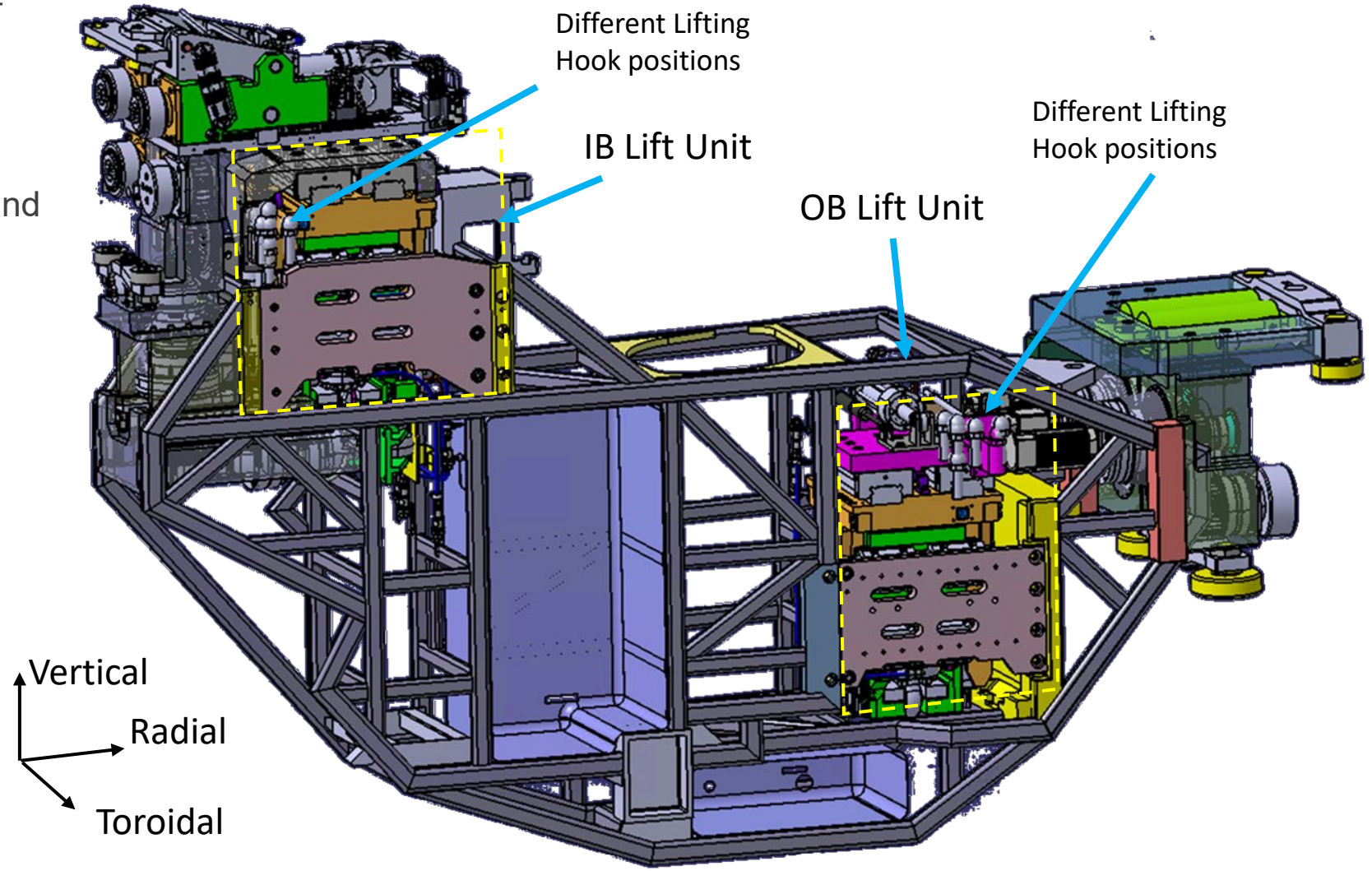
AC motor



Cassette lifting: Lift Units (1/2)

Lift Units are cartesian XYZ positioners with short movements of the hook

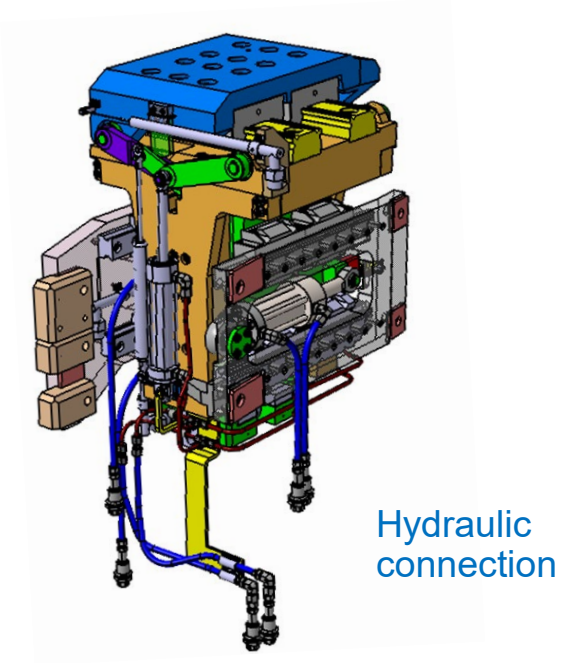
- Two independent Lift Units
- Load: 5 tons approx. load per Lift Unit
- 3 cartesian movements: radial, vertical and toroidal (<100mm each)
- Functions:
  - Lifting the cassette from rails
  - Supporting the cassette during transport along toroidal direction
  - Adjusting the cassette position with accuracy

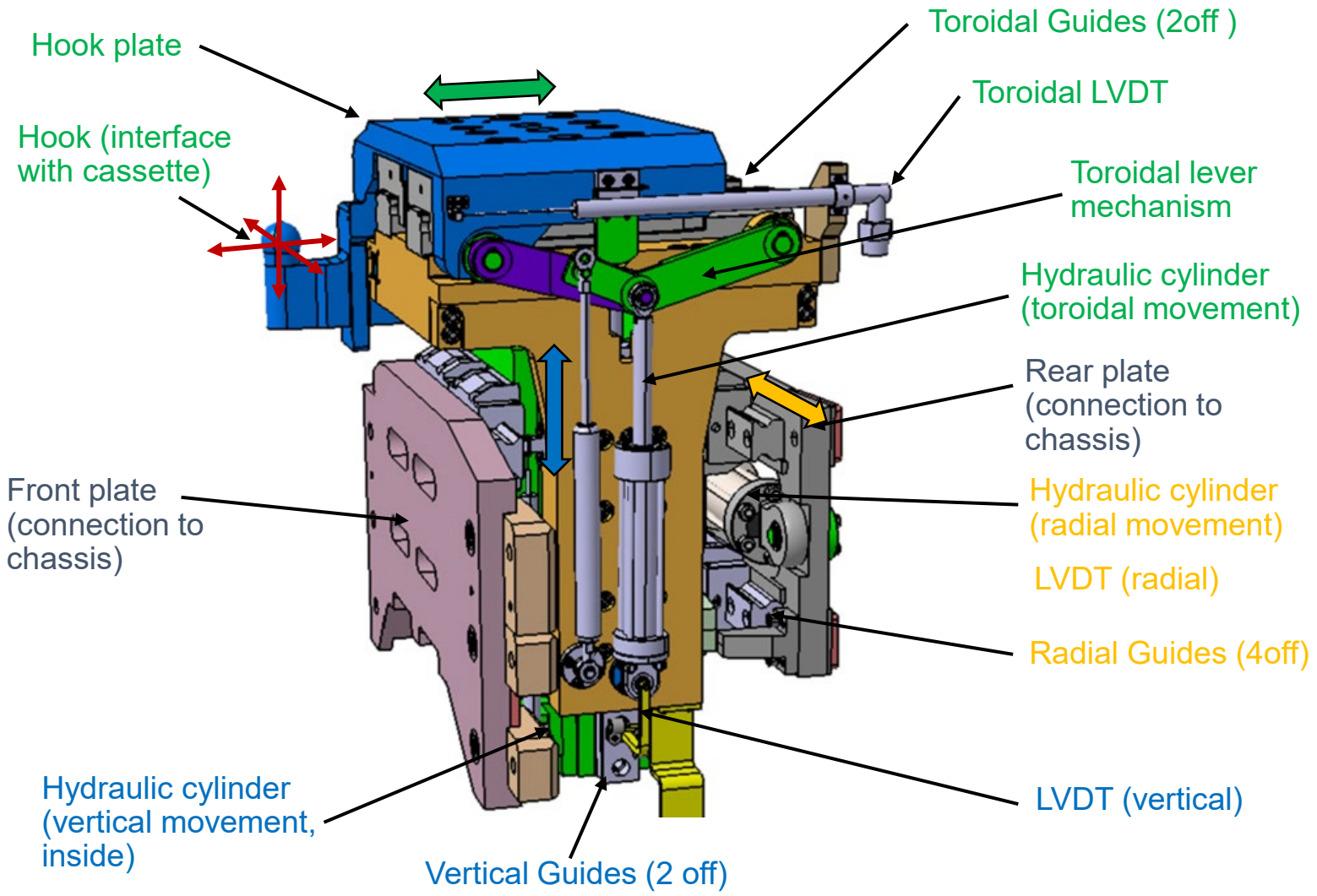


Cassette lifting: Lift Units (2/2)

Main solutions (Inboard Lift Unit shown):

- Mechanical guidance: linear guides
- Actuators: Hydraulic (Water based to prevent contamination)
- Hydraulic connection: pipes / flexible hoses
- Position sensors: LVDTs





CTM Hydraulic System and Power Unit (HPU) (1/2)

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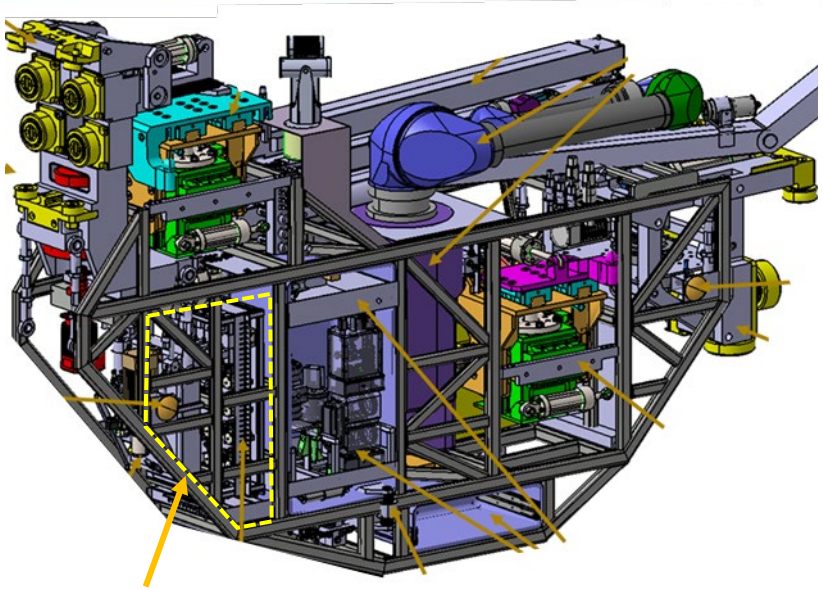
Key requirements

- Water hydraulics to avoid contaminating VV
- 10 hydraulic-actuated mechanisms
- Slow speed for all movements, small flow
- Each mechanism recoverable in case of hydraulic failure

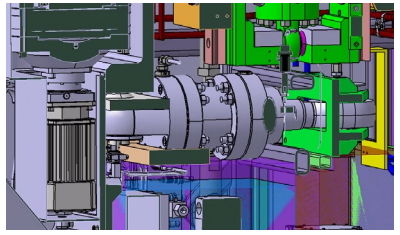


Space reserved for HPU and main valves

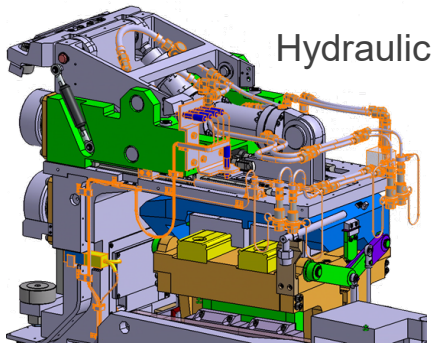
Water hydraulic components

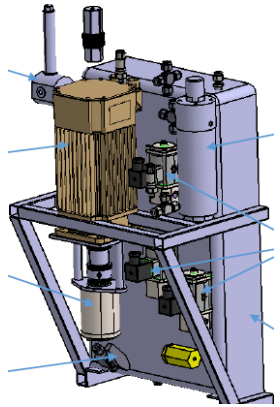
- Hydraulic circuit providing intrinsic redundancy for the application
- Digital valves already developed and tested for water hydraulics
- Hydraulic system prototype currently under design, to be built and tested during 2025

Water hydraulic cylinders



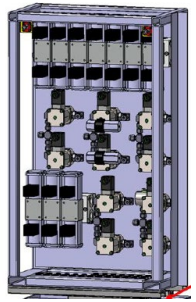
Hydraulic routing



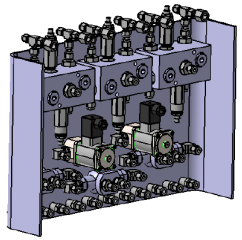


HPU Hydraulic Power Unit

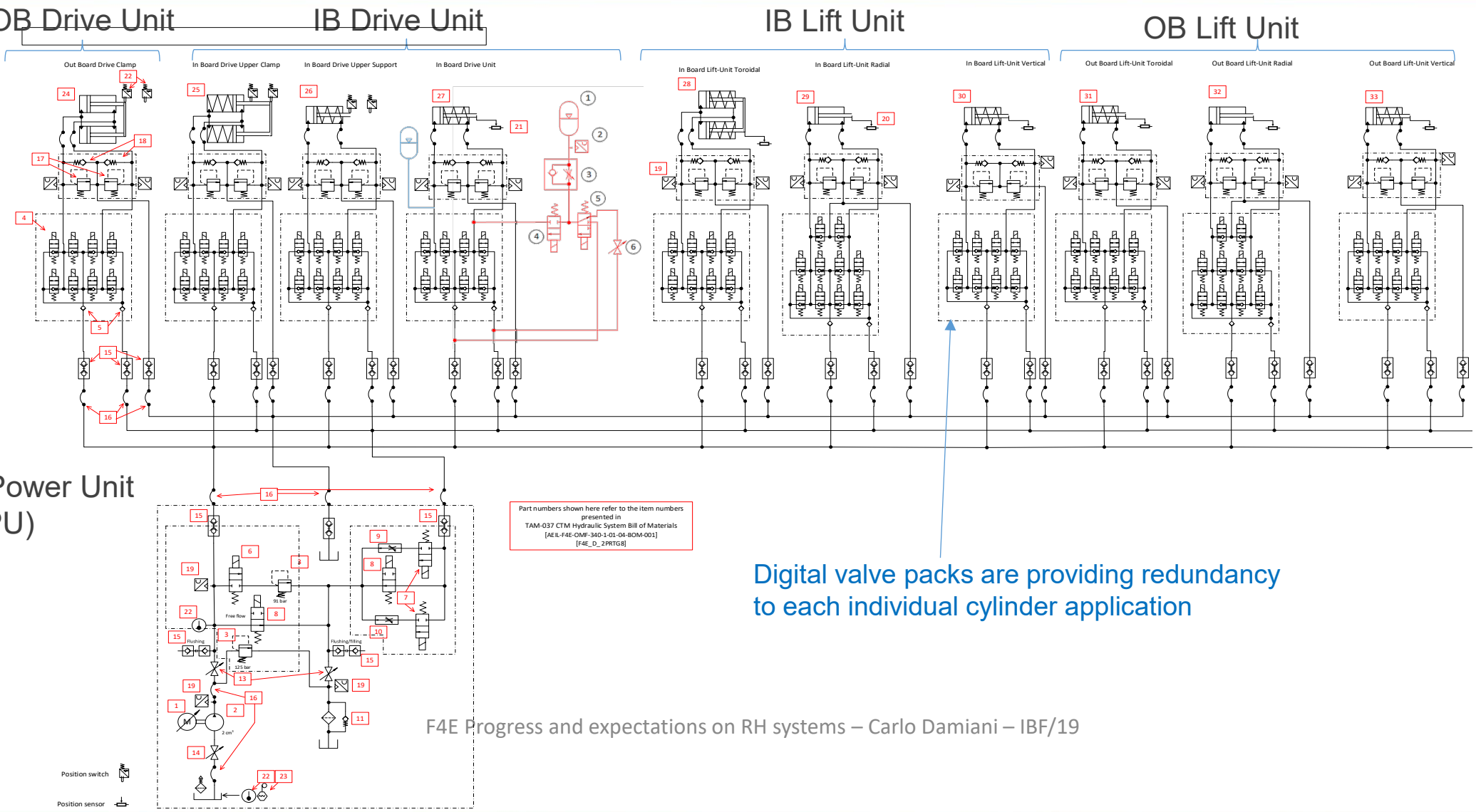
Main Valves



Manifolds



CTM Hydraulic System and Power Unit (HPU) (2/2)



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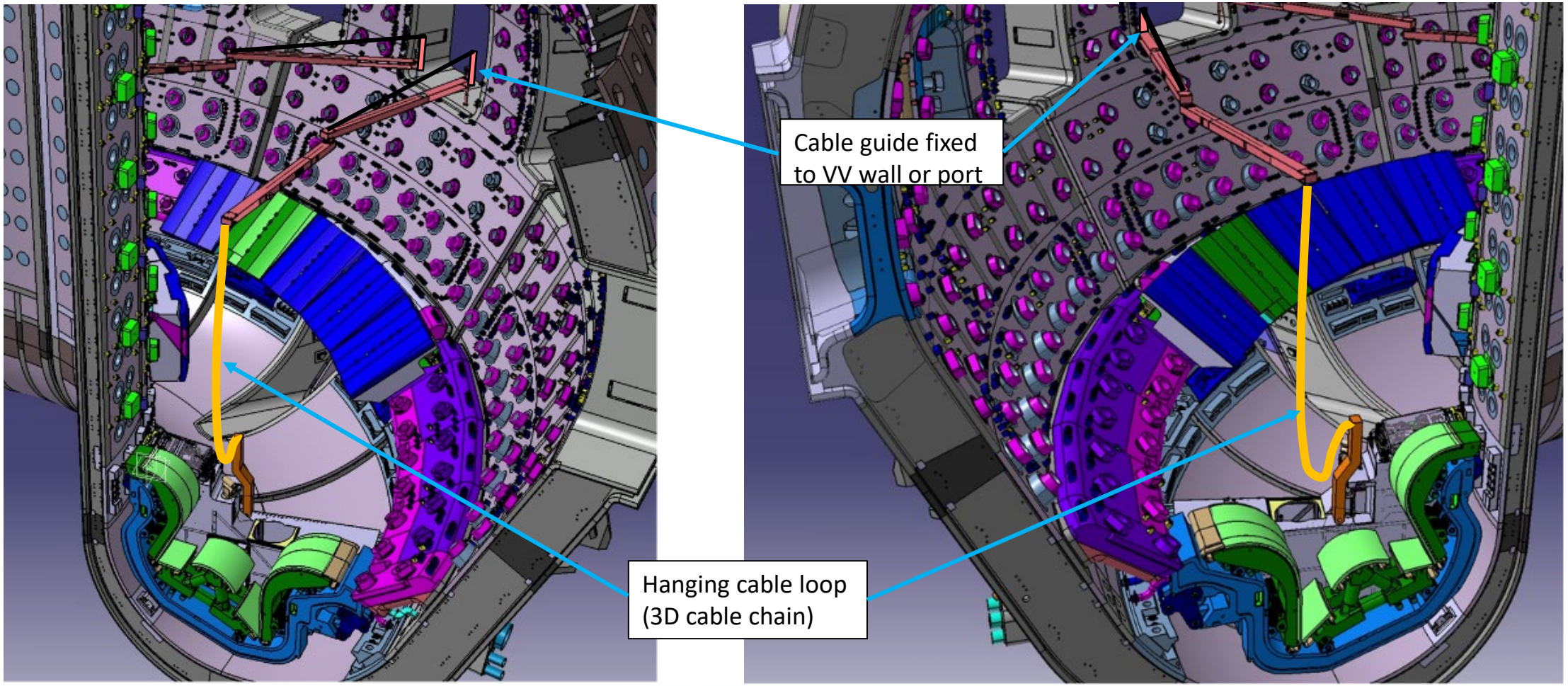
CTM services connection: Cable Guide

Key requirements

- Providing services to CTMs while moving independently inside the Vacuum Vessel
- Services: signal, power, camera signals



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