Collimator handling in LHC tunnel

K Kershaw, 5 March 2007

Scope / content

- Introduction – section

Phases of work

1. Coordination with collimator / plug-in design
2. Design and build special equipment for collimator tunnel transport and initial installation
3. Study and test work for collimator remote handling
4. Design and build equipment for remote handling

Introduction / section

- Section TS-IC-IS
- Heavy handling studies for LHC machine and experiments
- Specialised overhead travelling cranes
- Cryomagnet transport and handling –surface and tunnel installation
- Remote handling

AEA TECHNOLOGY

Combining Technology and Applications for Value

ARTISAN ™ HEAVY DUTY TELEROBOTIC MANIPULATOR SYSTEM

AEA Technology's ARTISAN™ telerobotic heavy-duty hydraulic manipulators and control systems are specifically for hazardous environment/material handling applications. It is regularly used for tasks such as:

- Hot cell decommissioning
- Volume reduction of facilities
- Waste retrieval

The ARTISAN™ is a robust, reliable, modular workhorse that can be easily maintained and operated. It has achieved very high levels of availability, even in the most demanding of applications with over 100,000 operating hours of service at 97% reliability in harsh and radioactive environments.

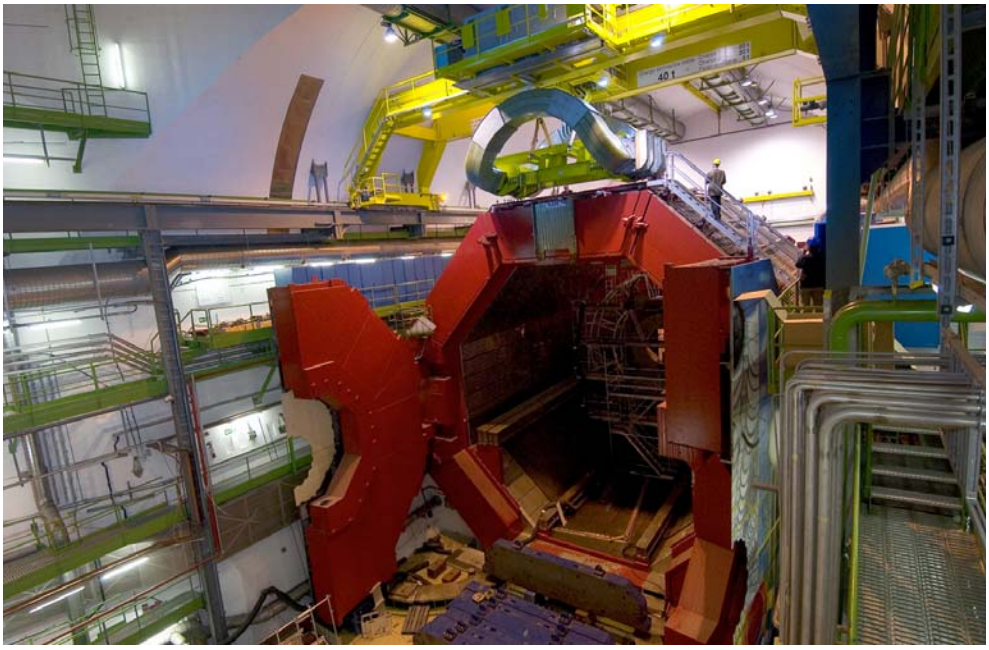
Key features of the ARTISAN™

- Manipulator
  - Heavy duty payload
  - Radiation Hardened
  - Modular component design
  - Variable mounting configurations
  - Harsh environment/nuclear applications
- Control system
  - Joystick controls
  - Teach/repeat functionality
  - Joint / world / tool modes of operation
- Tooling
  - Standard industrial tooling interface
  - Uses a variety of tools (saws, drills, grinders, etc.)

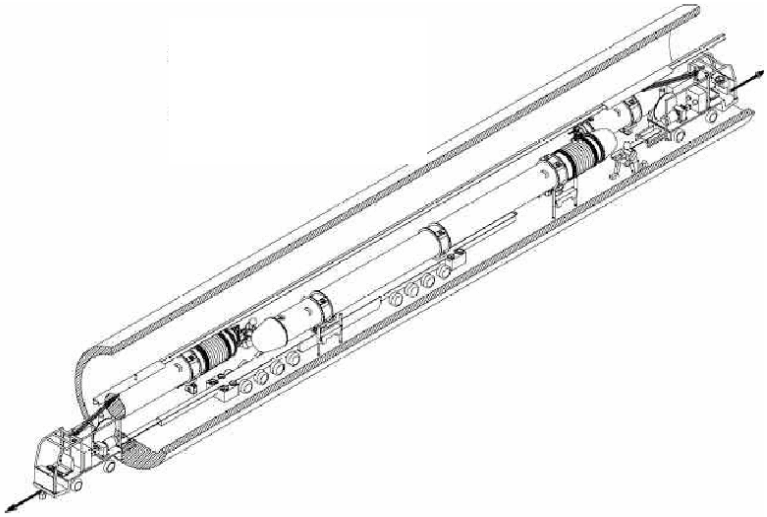
ATLAS surface crane

ATLAS cavern cranes

Alice Crane



Cryomagnet installation - concept



Cryomagnet tunnel transport

Cryomagnet transfer and installation

1) Coordination with collimator / plug-in design

Basic principles agreed with R Perret:

Guidance pins on plug in allow coarse positioning by handling equipment

Design collimator lifting points so that they can be lifted by a spreader beam suspended from a single crane hook – C of G.

Vertical guidance rails guide collimator in zone above conical pins – protect beam pipe

2) Design and build special equipment for collimator tunnel transport and initial installation

Use trailer crane to take collimator from tunnel access point to installation point, and then transfer collimator onto supports

- Needs to fit in space available for towing and for lifting and transfer.

Mock up tests (1)

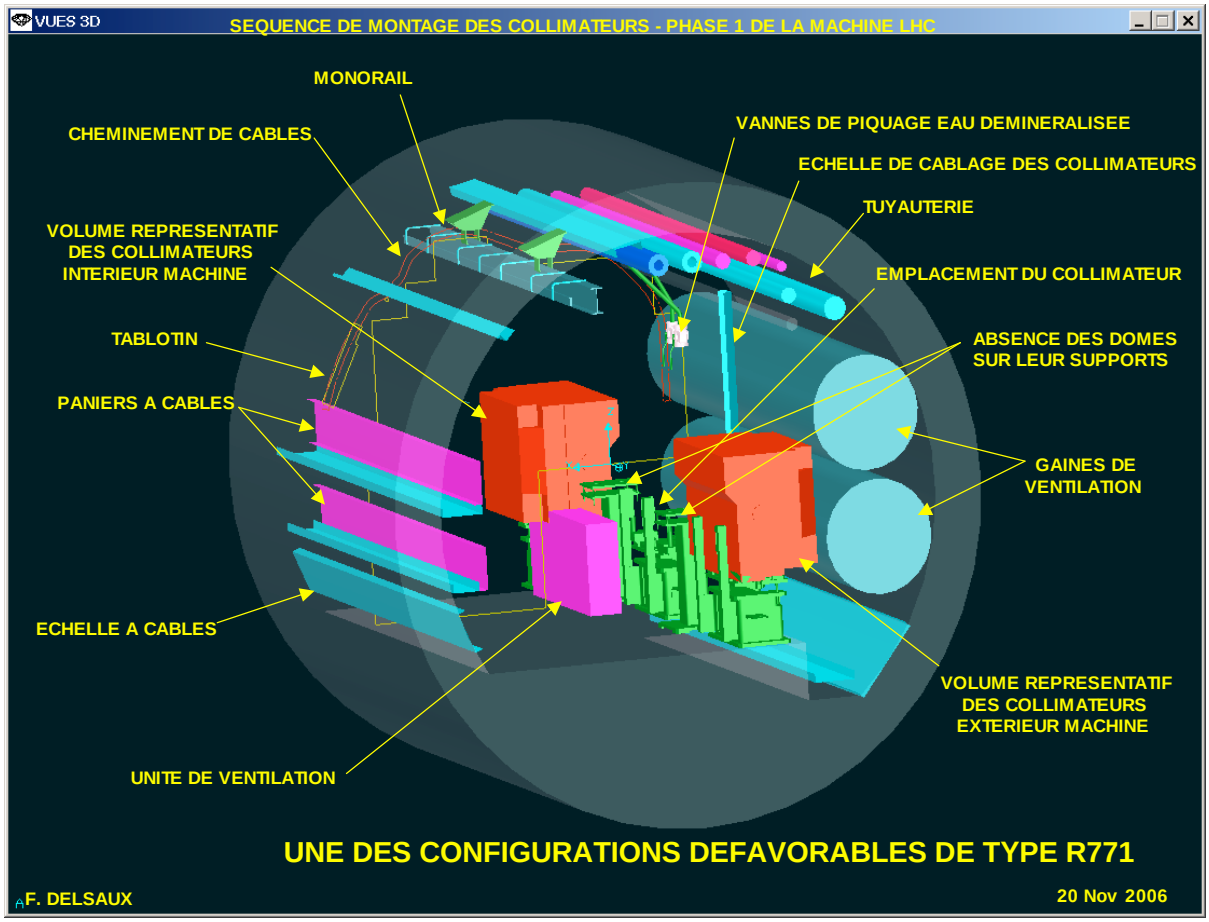
Mock –up tests (2)

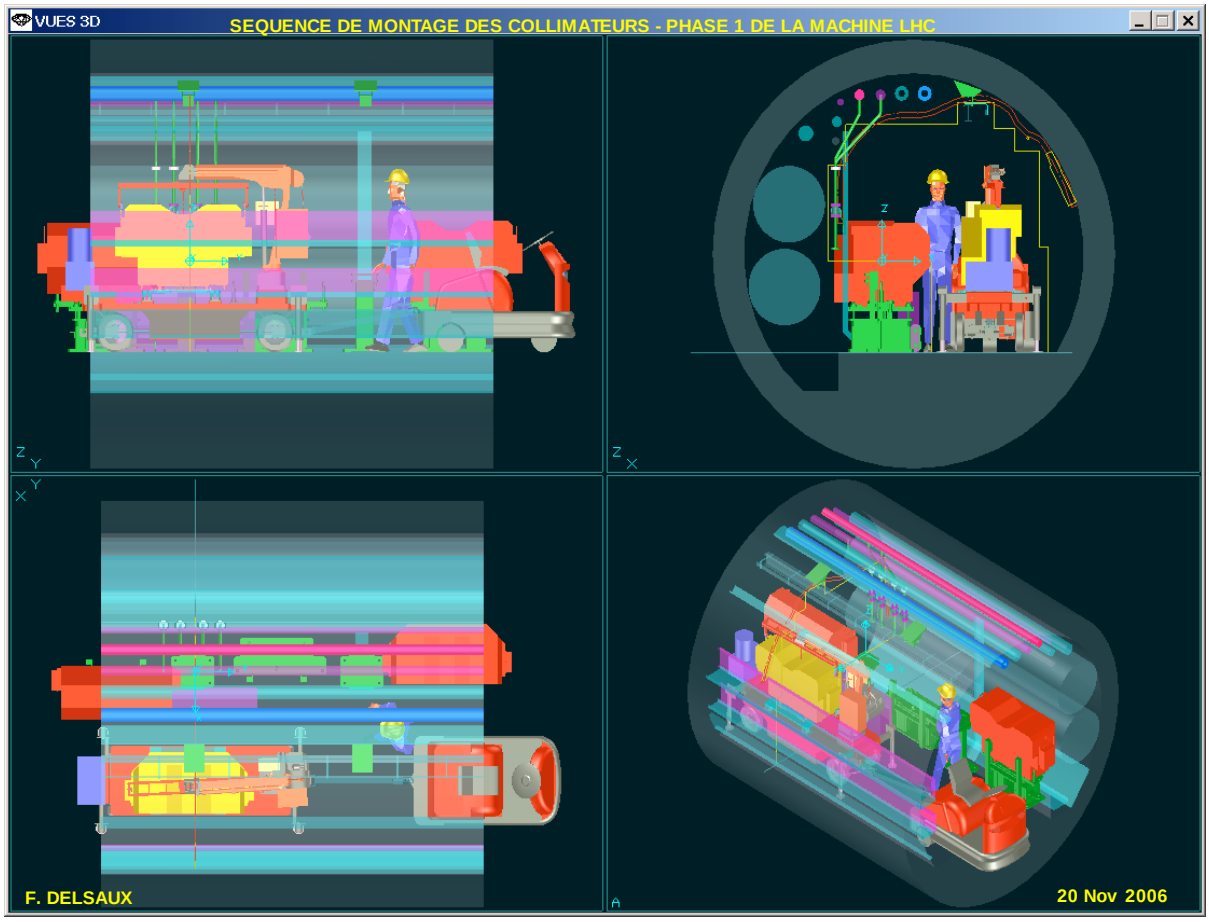
Outcomes of tests

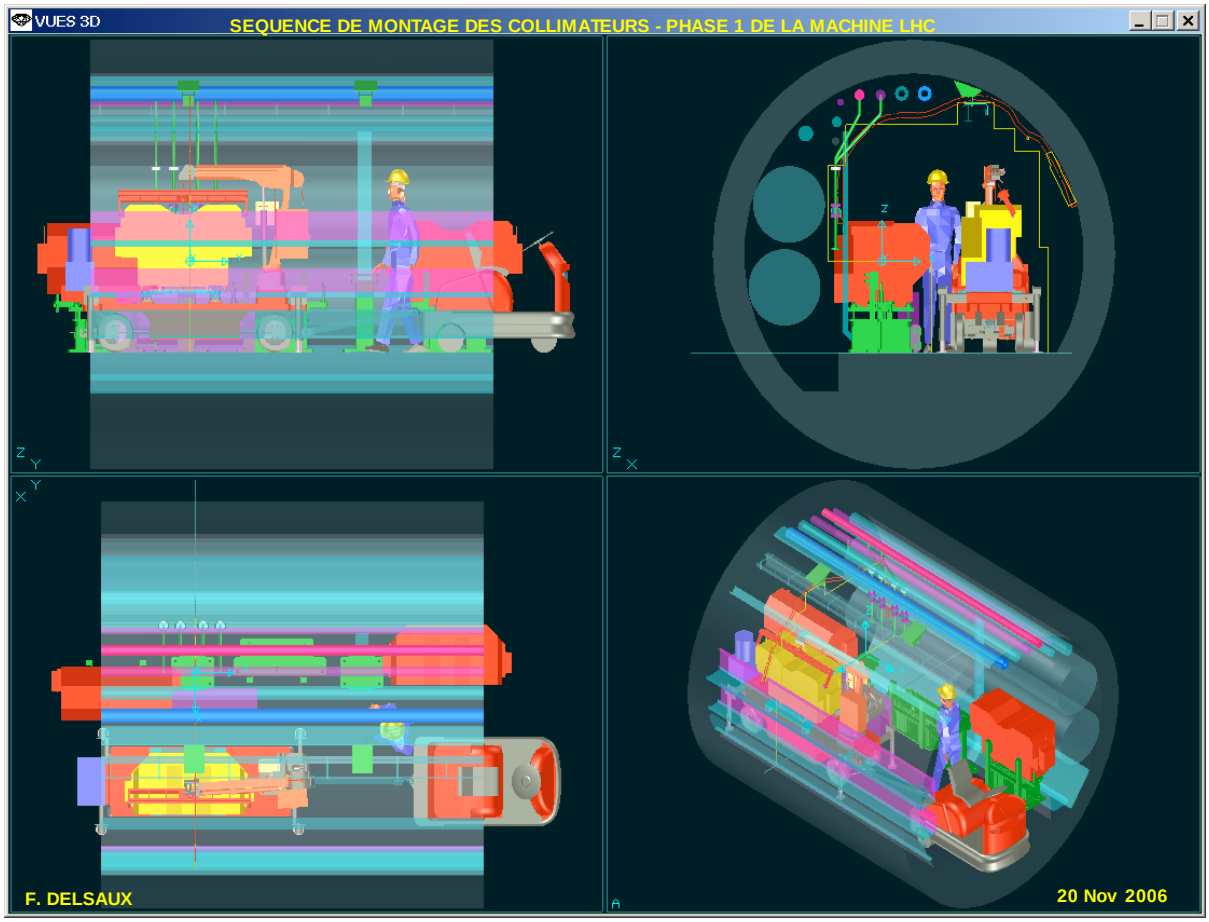
- Collimator supported on cable can be guided and lowered onto pins without unwanted side forces.
- Two-stage guidance works
- Powered rotation of the spreader requires a lot of height

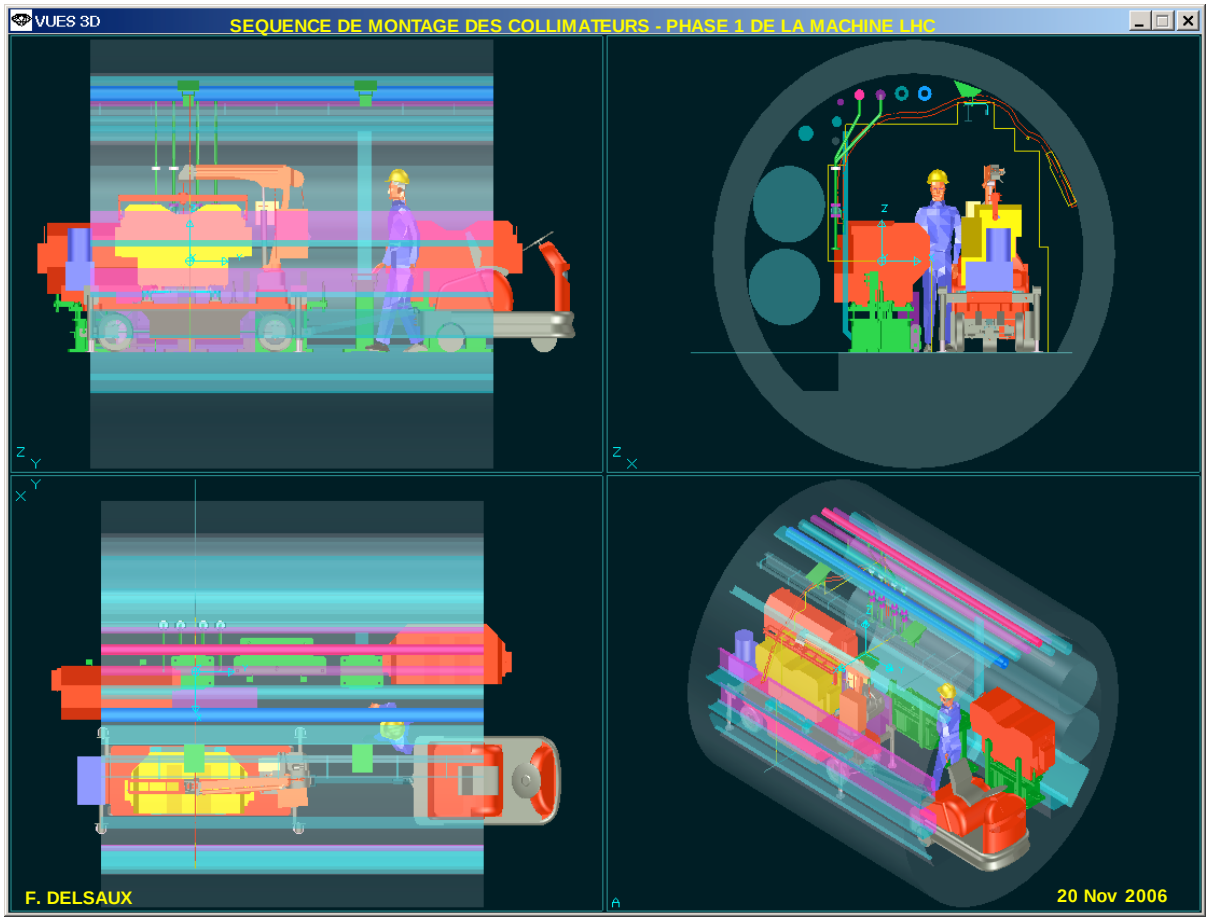
SEQUENCE DE MONTAGE
DES COLLIMATEURS
A L'AIDE DE LA
REMORQUE/GRUE "PALFINGER"

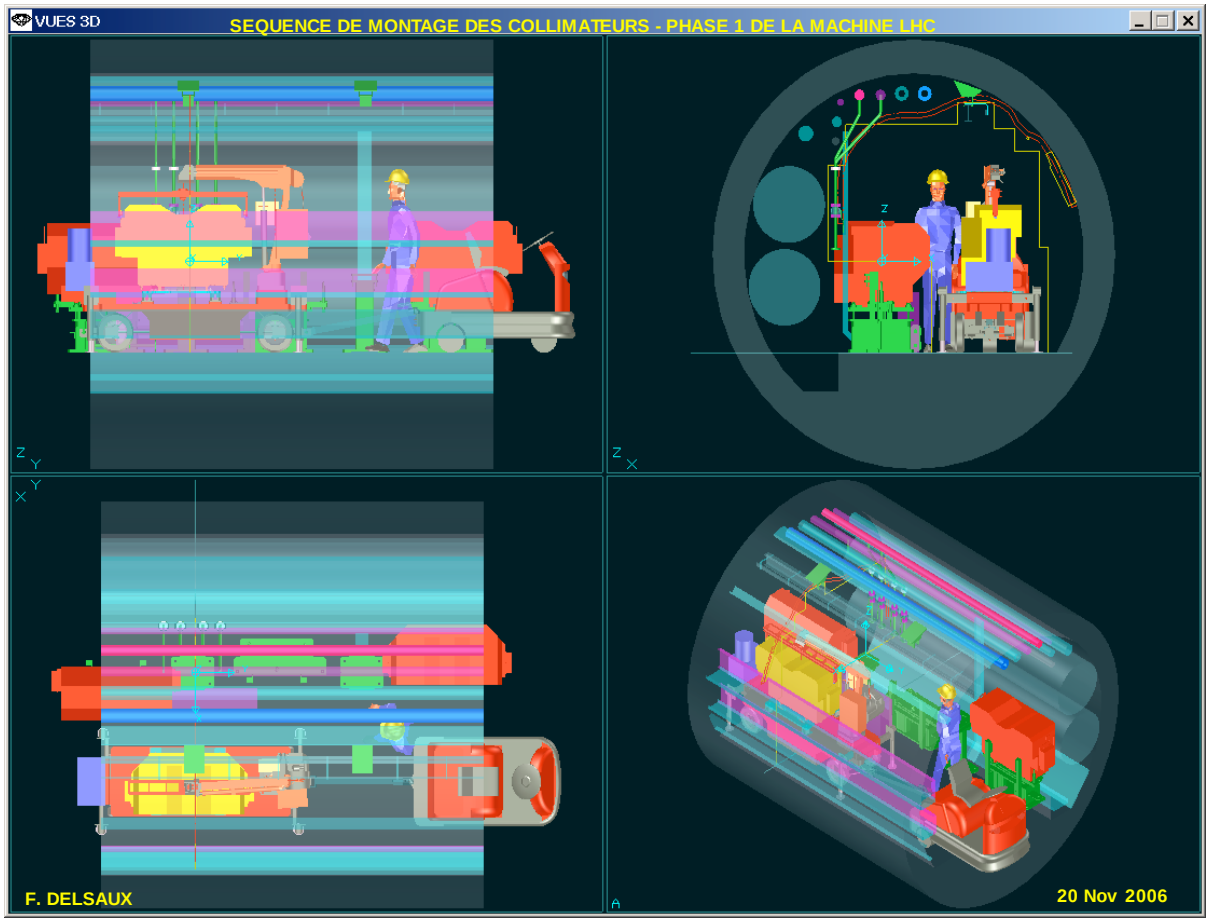
VALABLE POUR LA PHASE 1 DE LA MACHINE LHC

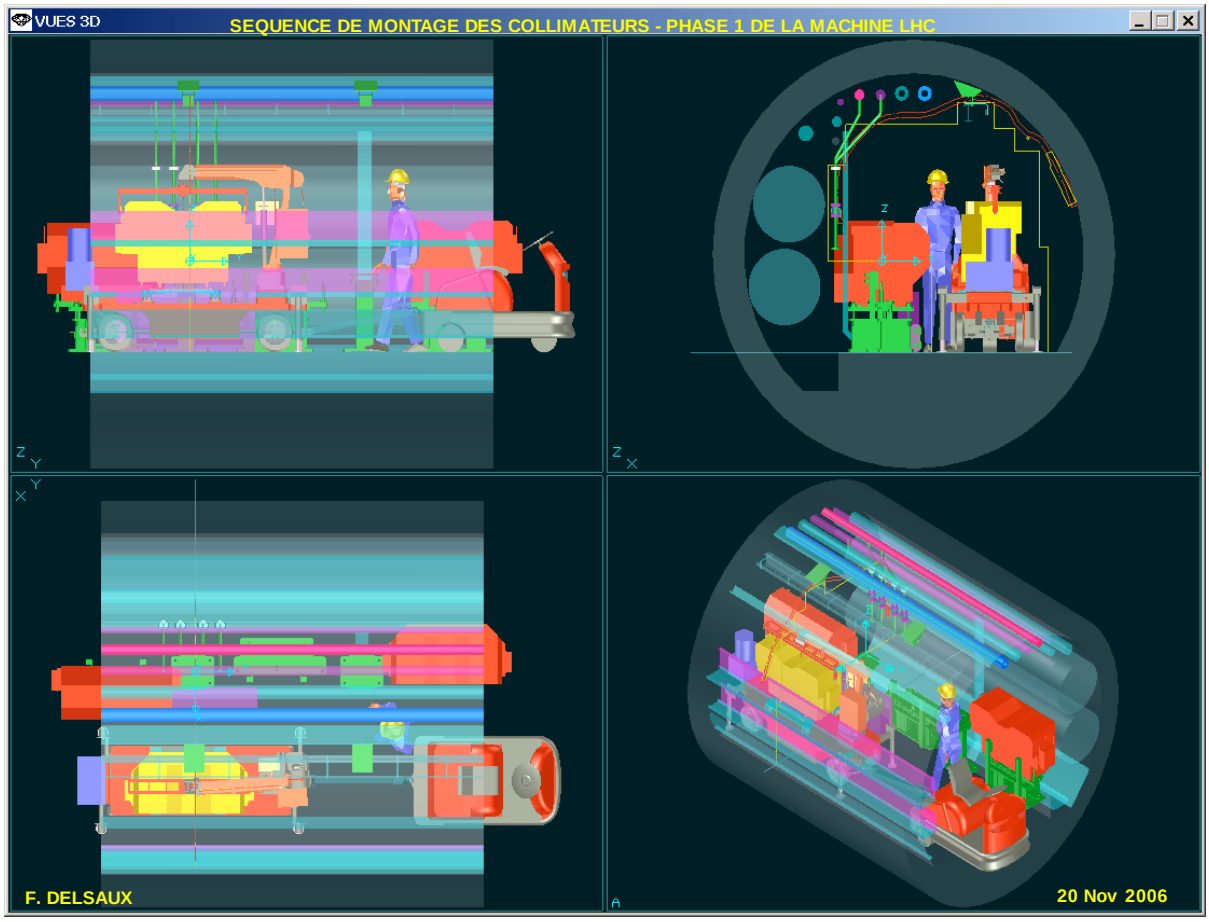

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
MONORAIL
CHEMINEMENT DE CABLES
VANNES DE PIQUAGE EAU DEMINERALISEE
ECHELLE DE CABLAGE DES COLLIMATEURS
TUYAUTERIE
VOLUME REPRESENTATIF DES COLLIMATEURS INTERIEUR MACHINE
EMPLACEMENT DU COLLIMATEUR
TABLOTIN
ABSENCE DES DOMES SUR LEUR SUPPORTS
PANIERS A CABLES
GAINES DE VENTILATION
ECHELLE A CABLES
VOLUME REPRESENTATIF DES COLLIMATEURS EXTERIEUR MACHINE
UNITE DE VENTILATION
UNE DES CONFIGURATIONS DEFAVORABLES DE TYPE R771
F. DELSAUX
20 Nov 2006

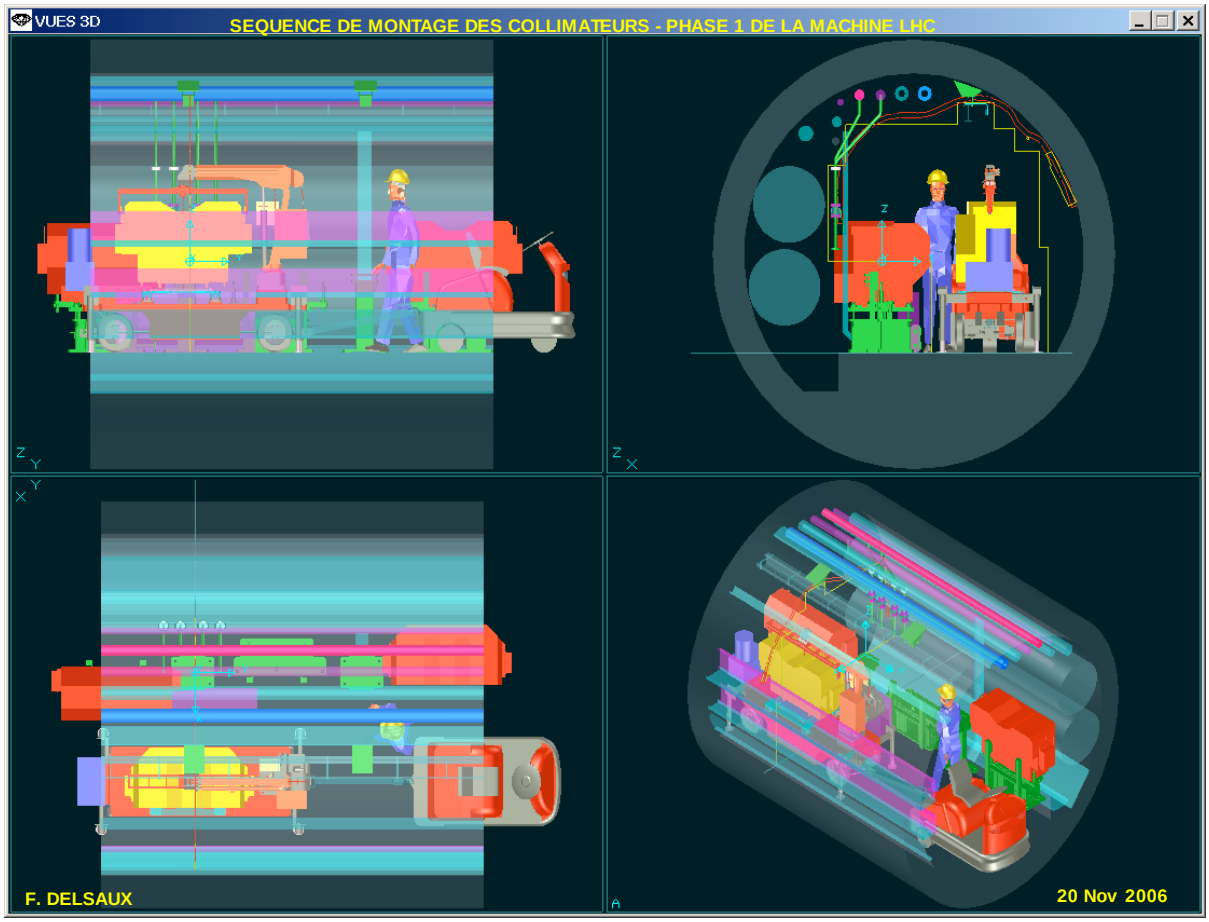

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

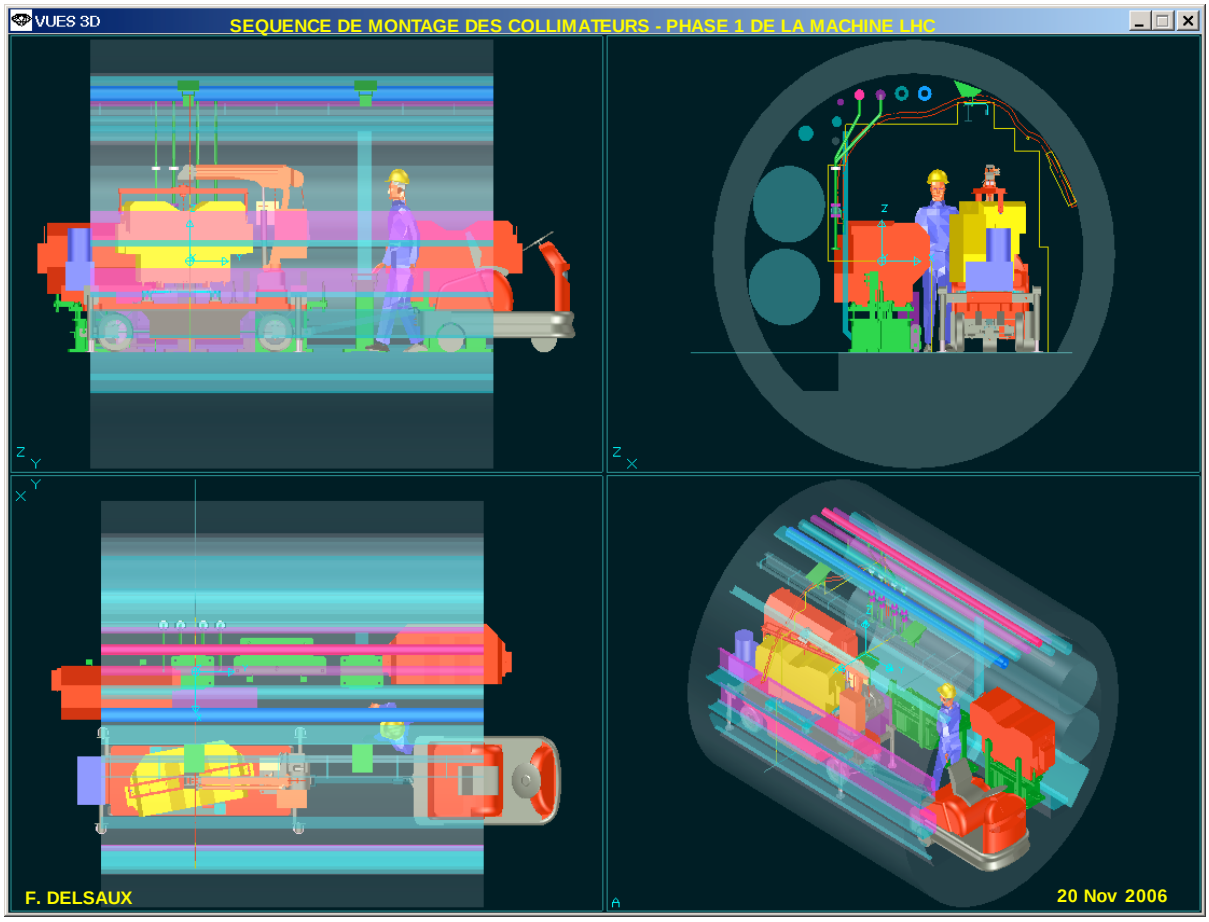

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

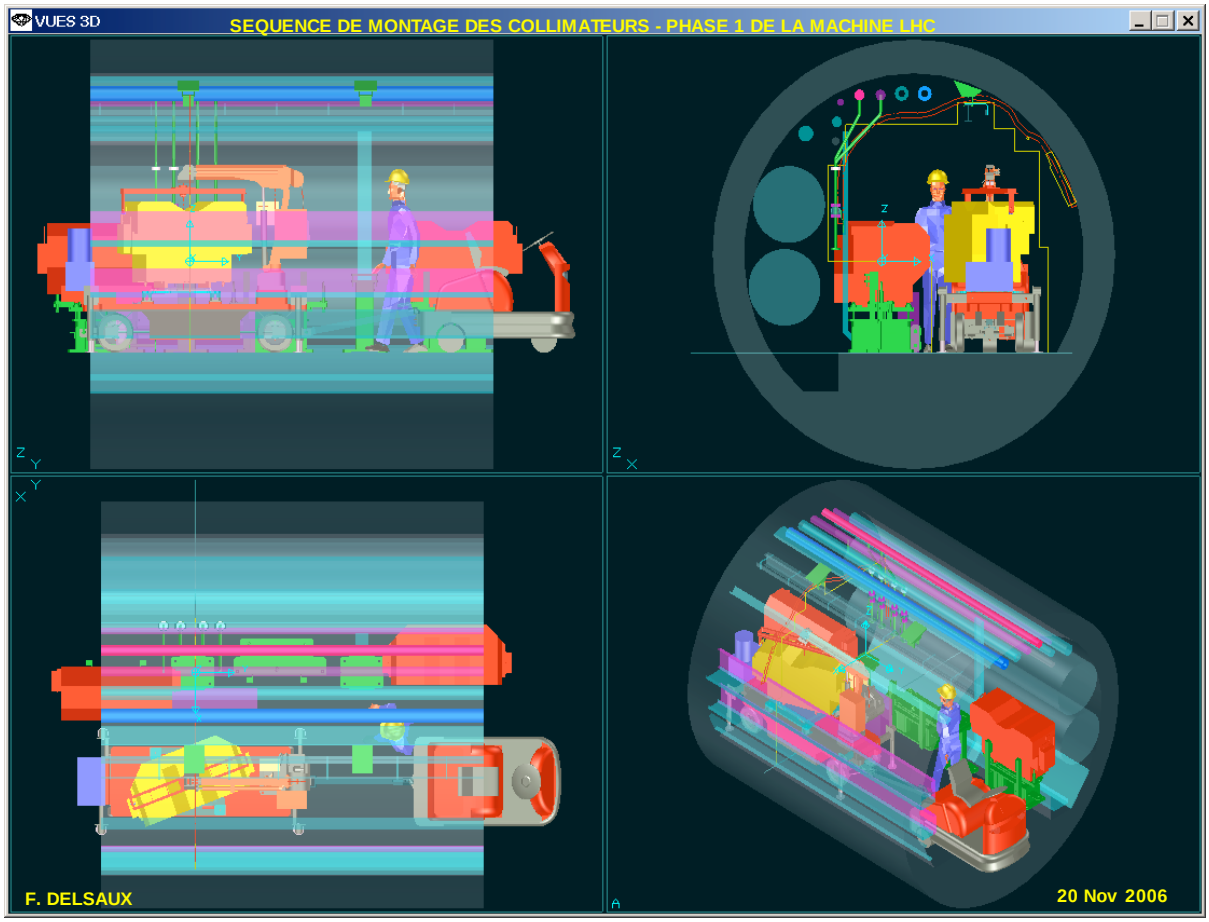

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

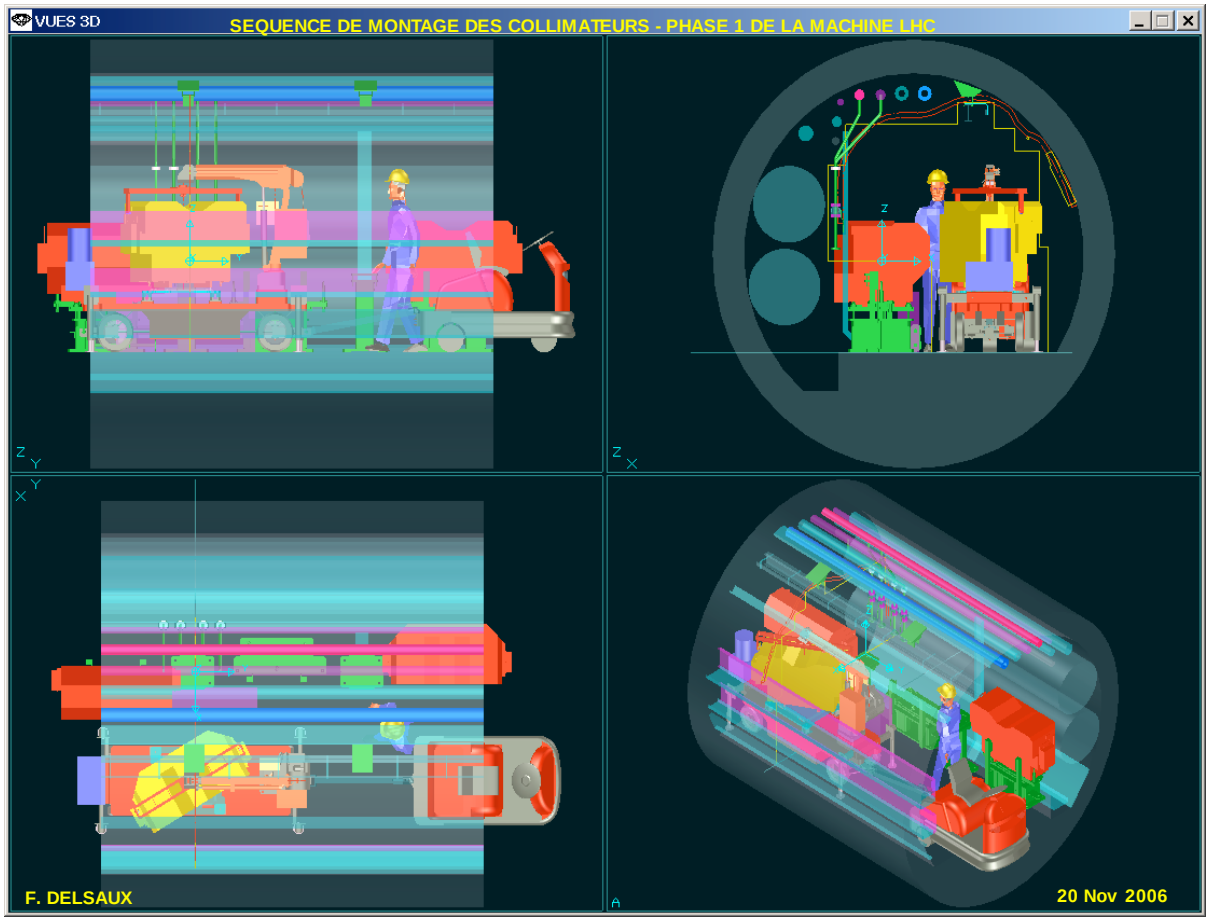

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

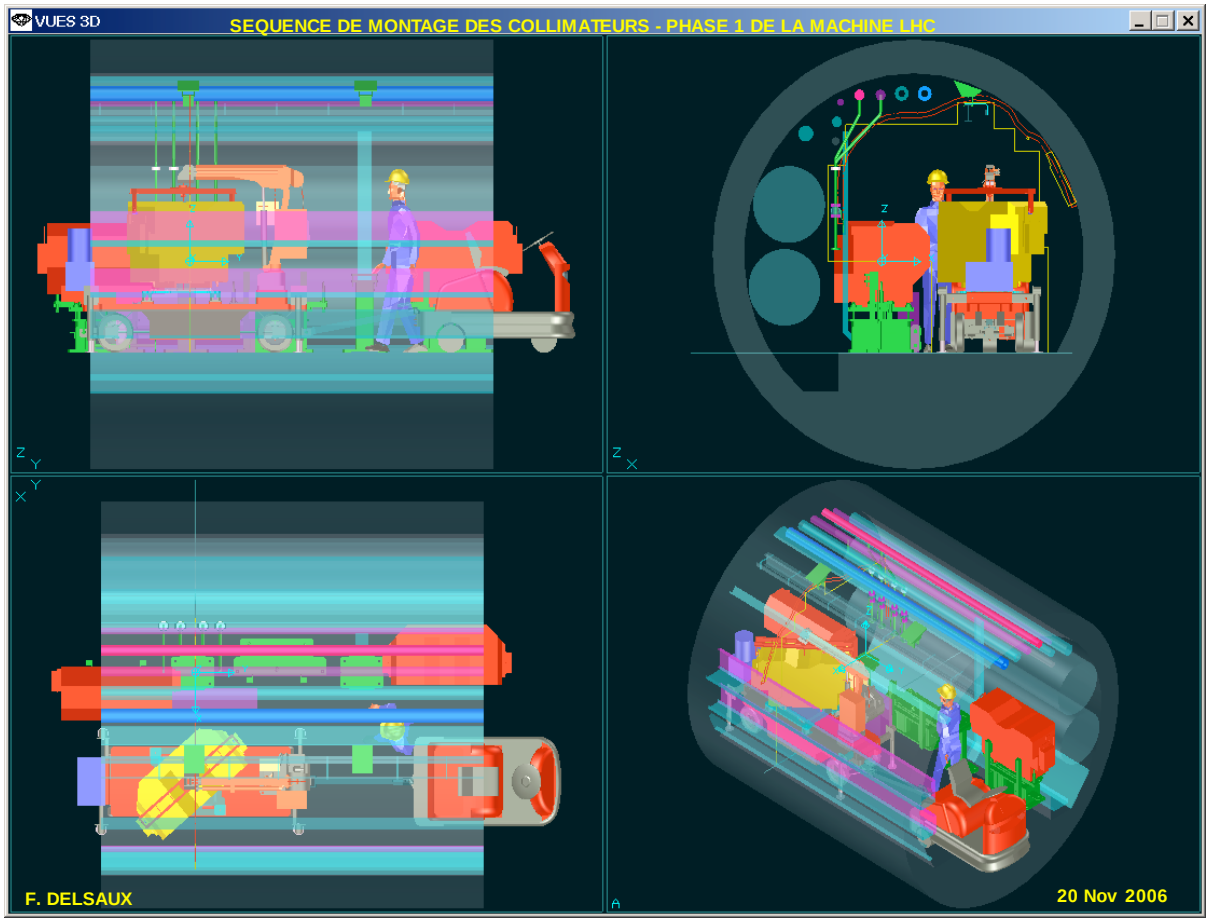

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

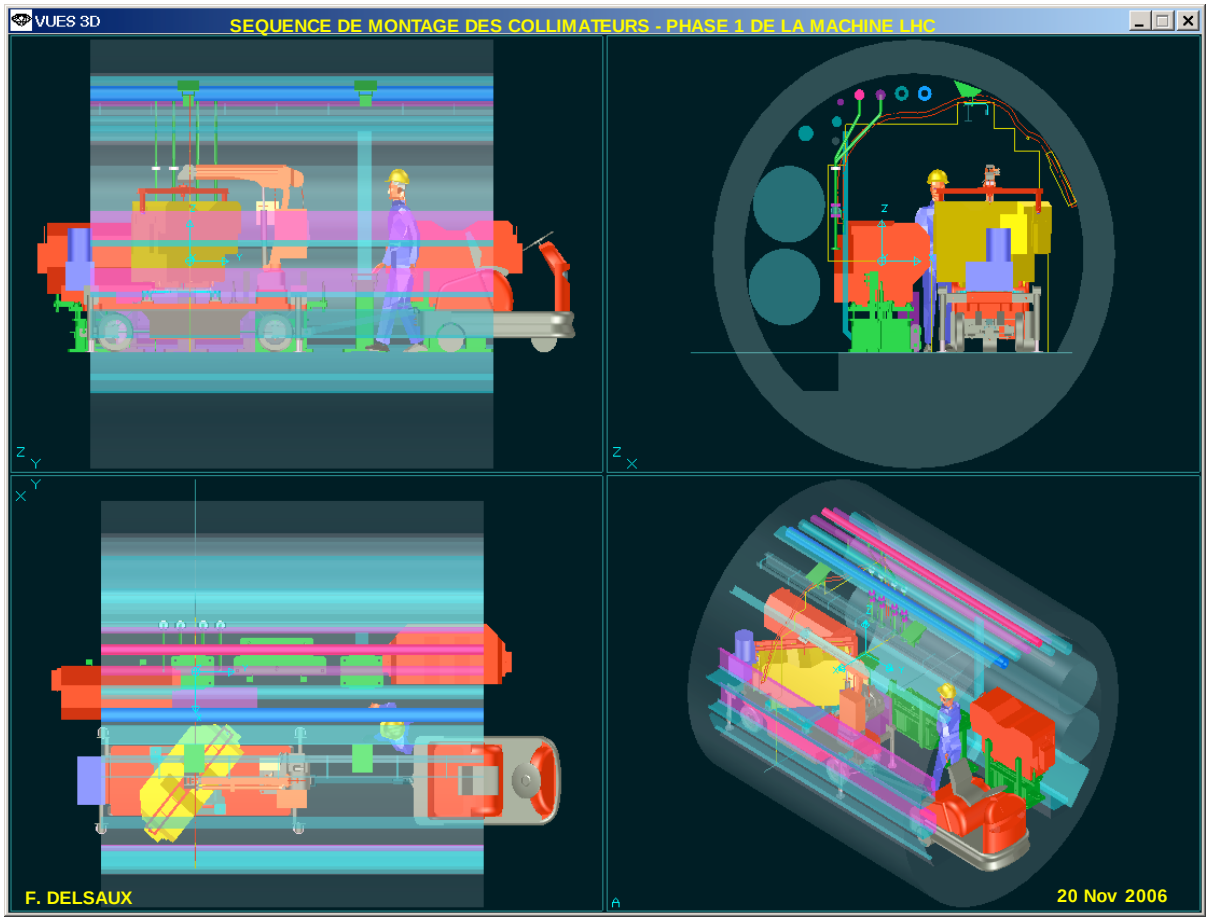

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

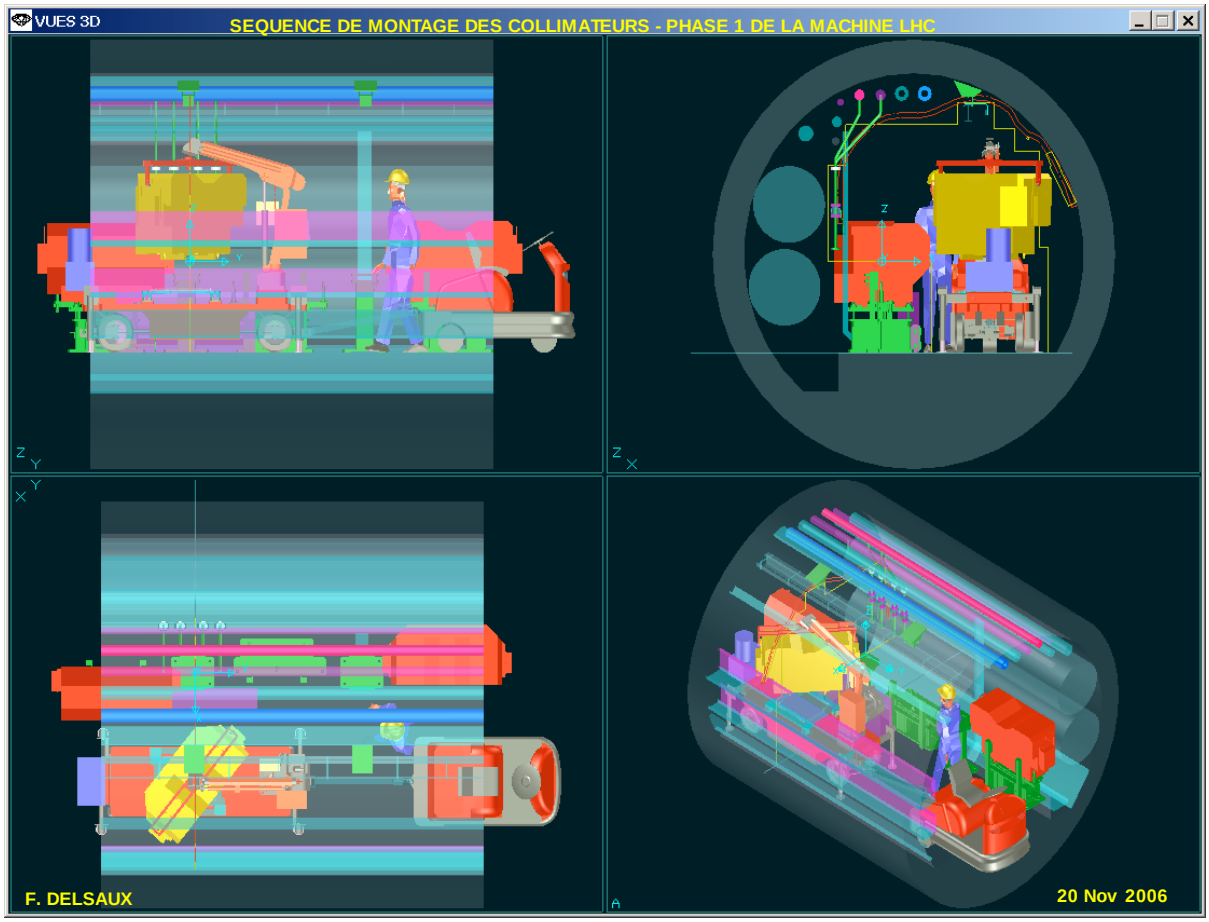

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

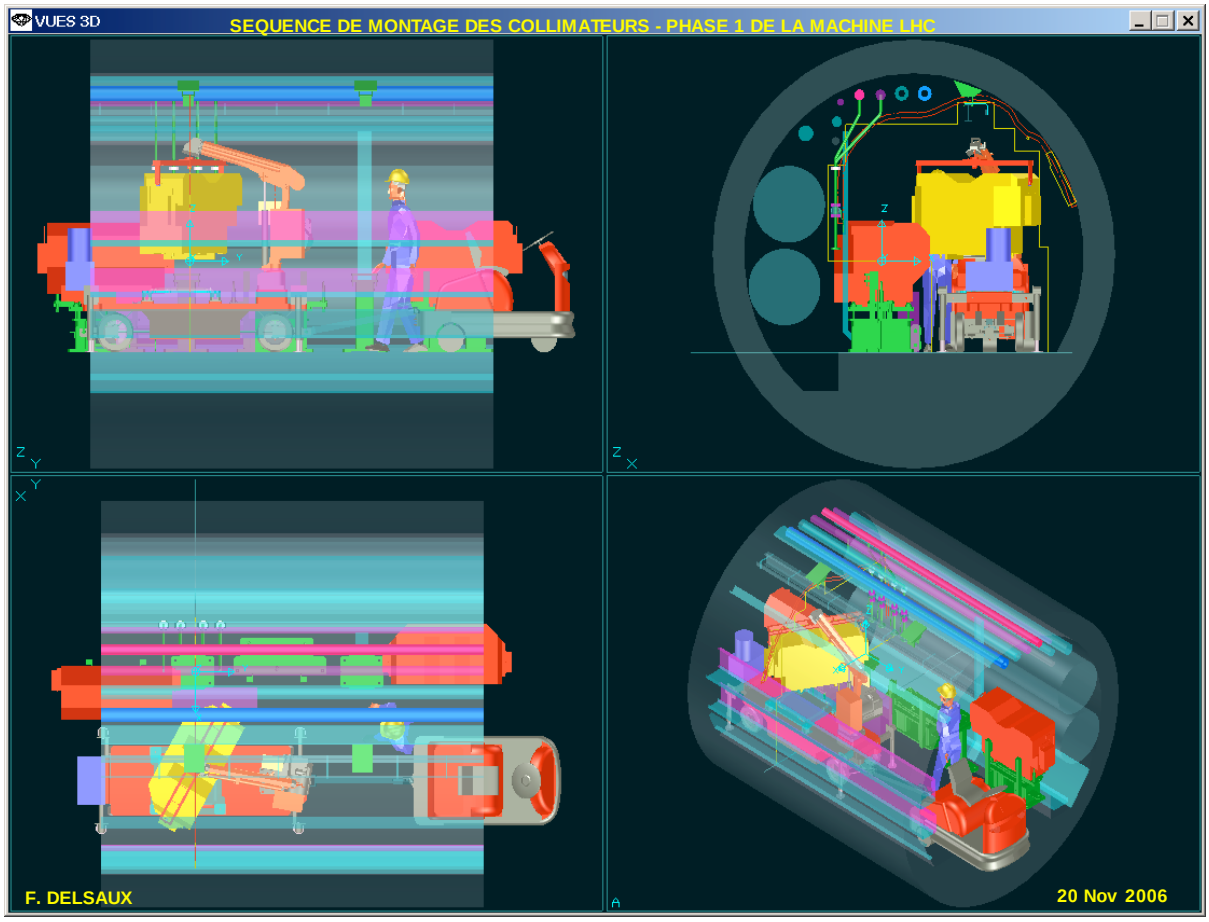

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

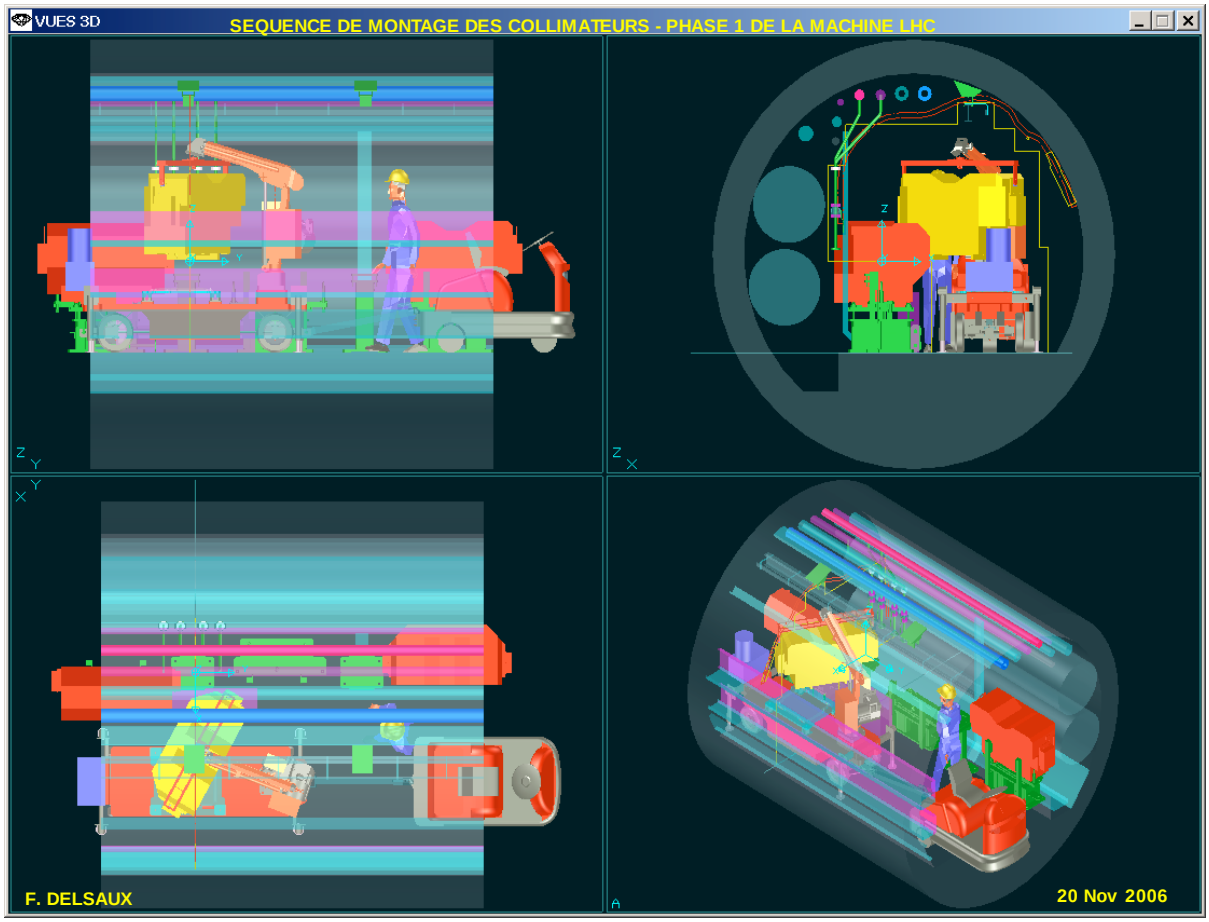

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

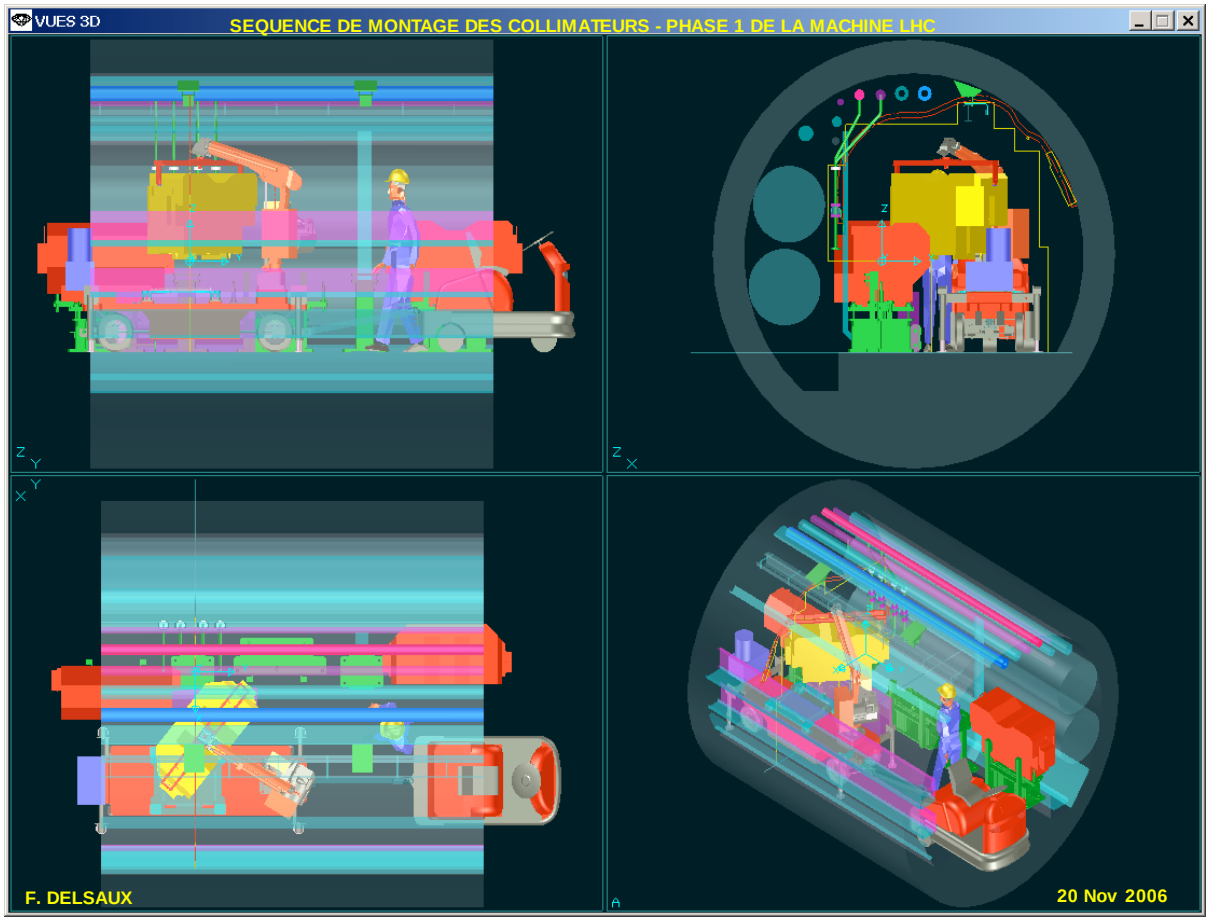

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

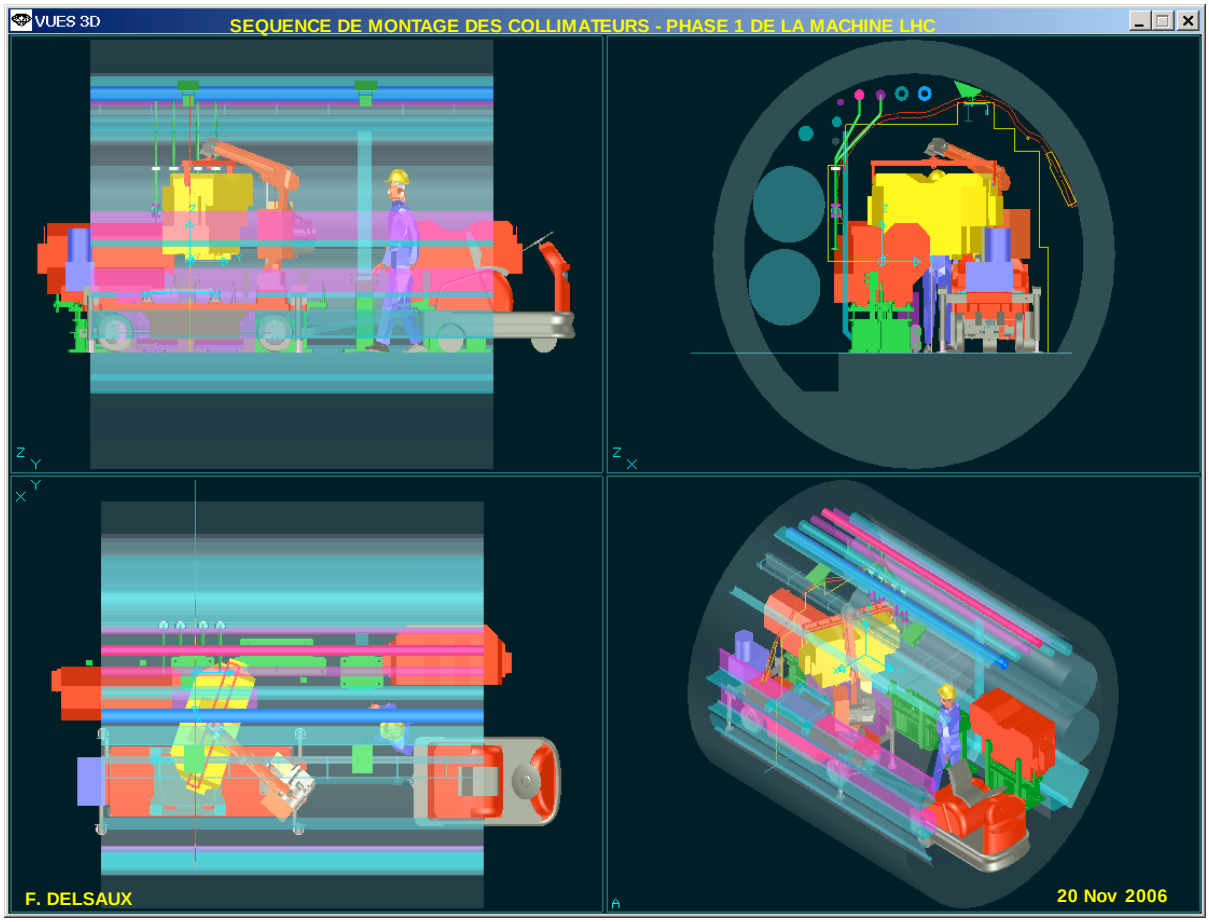

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

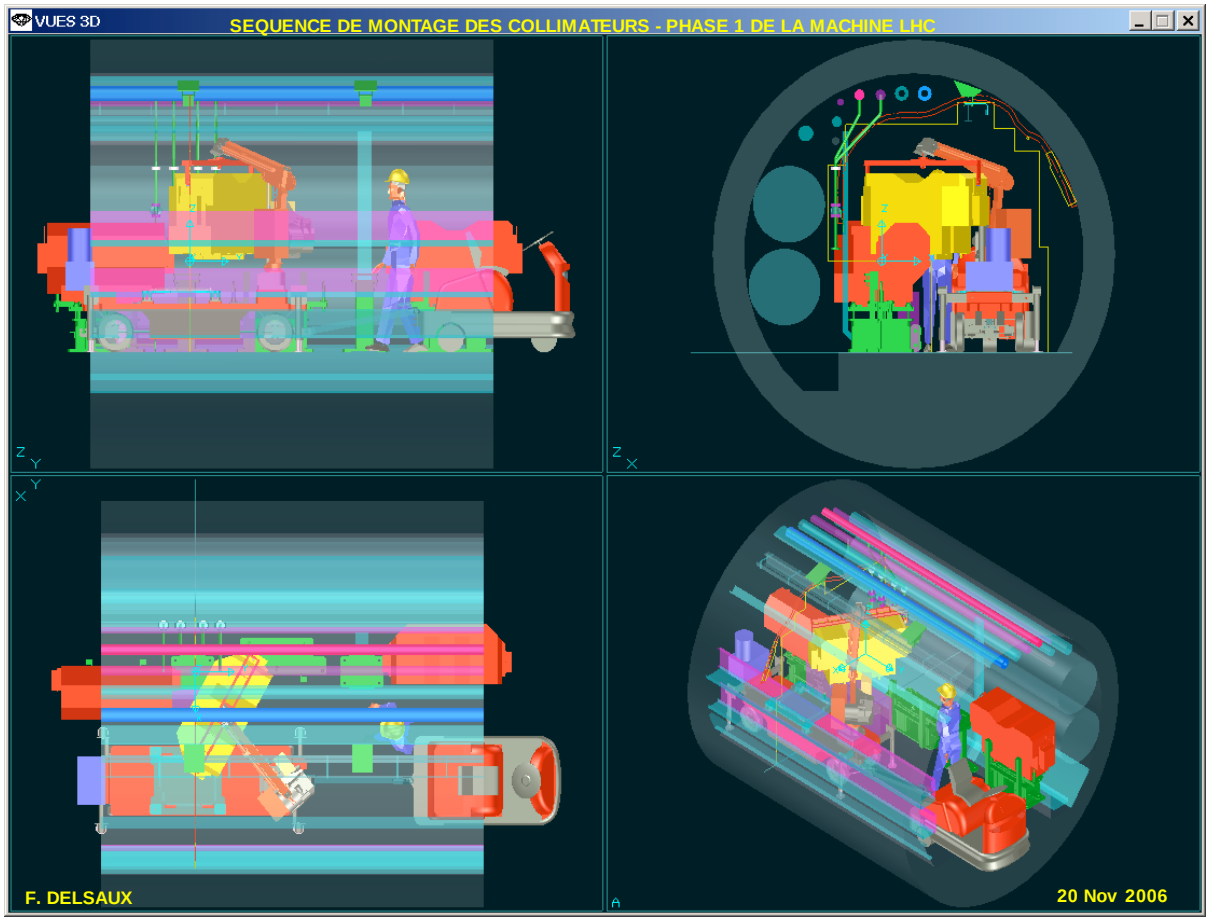

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

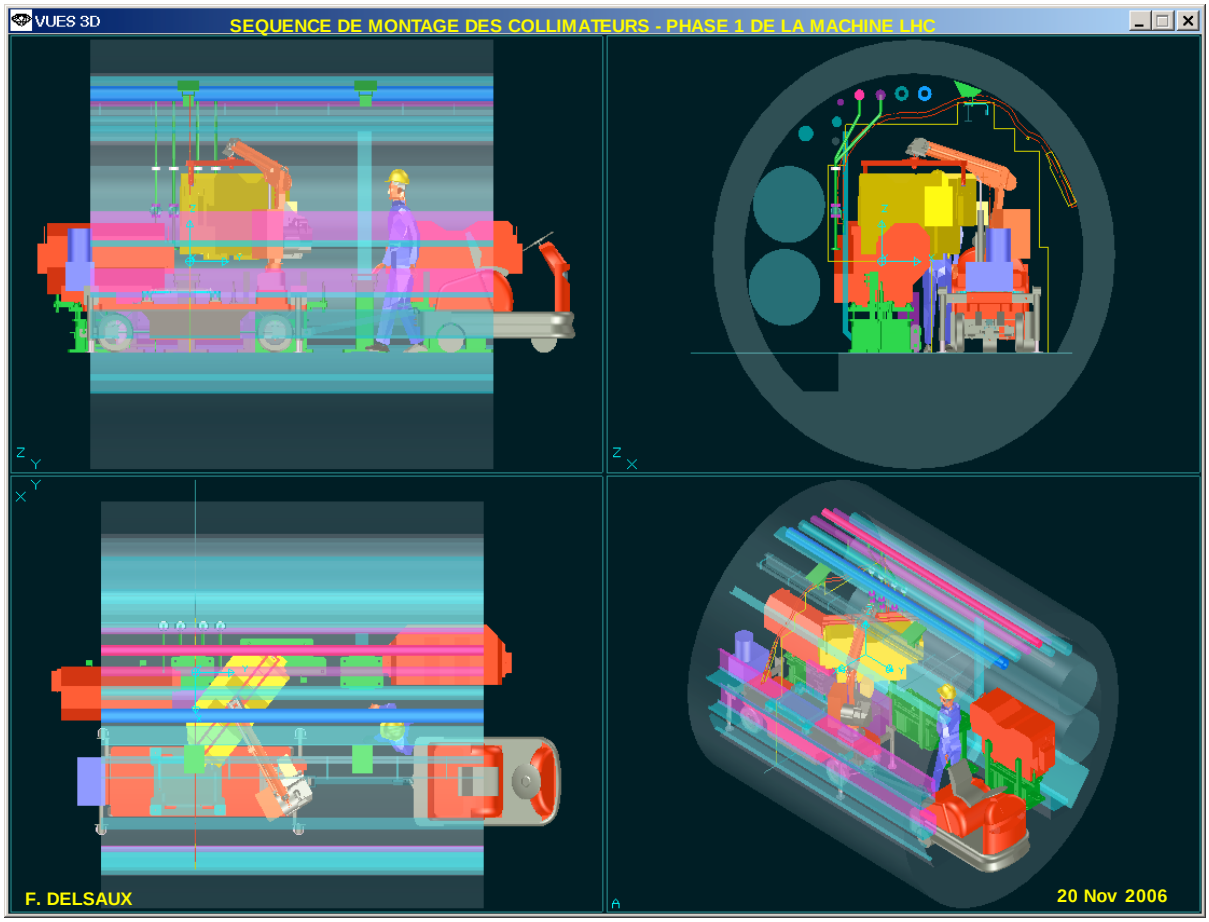

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

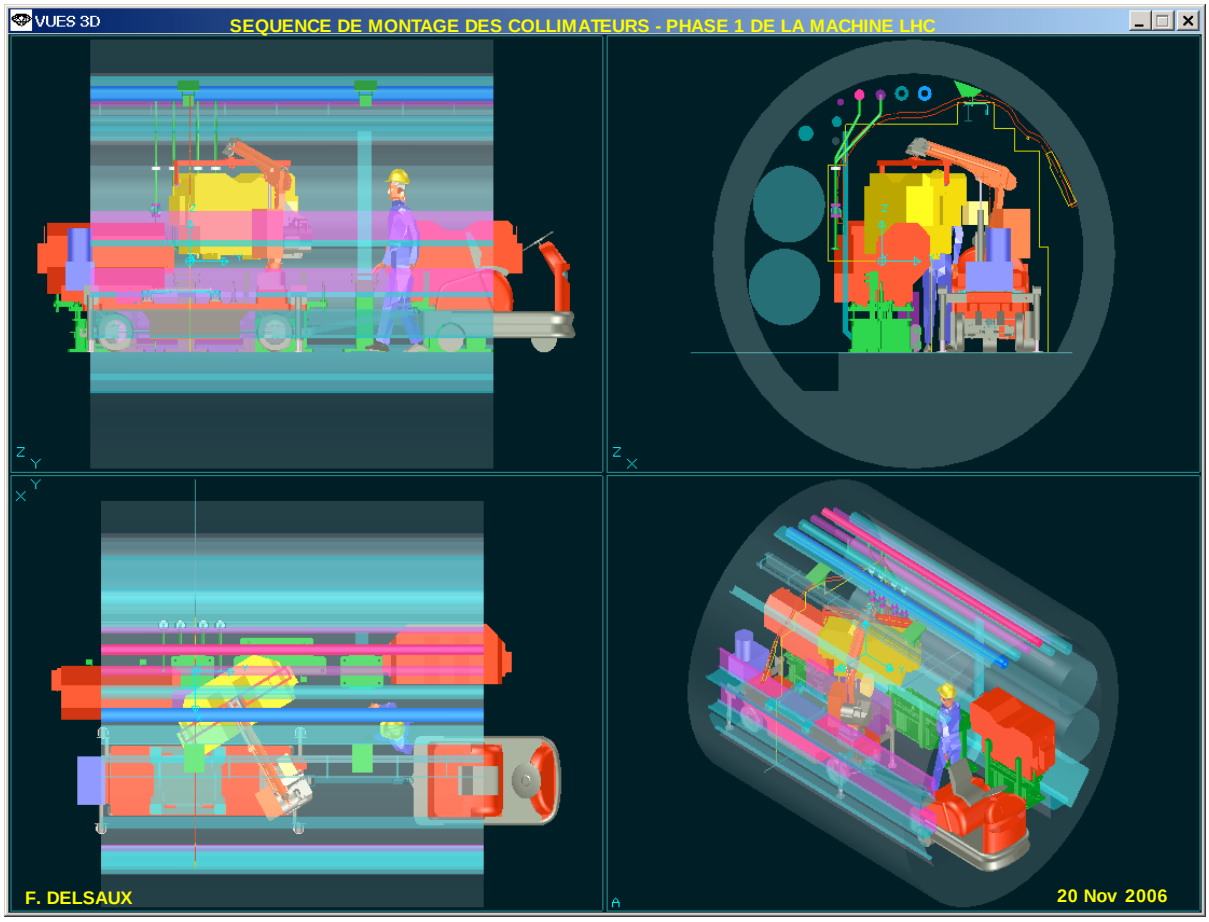

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

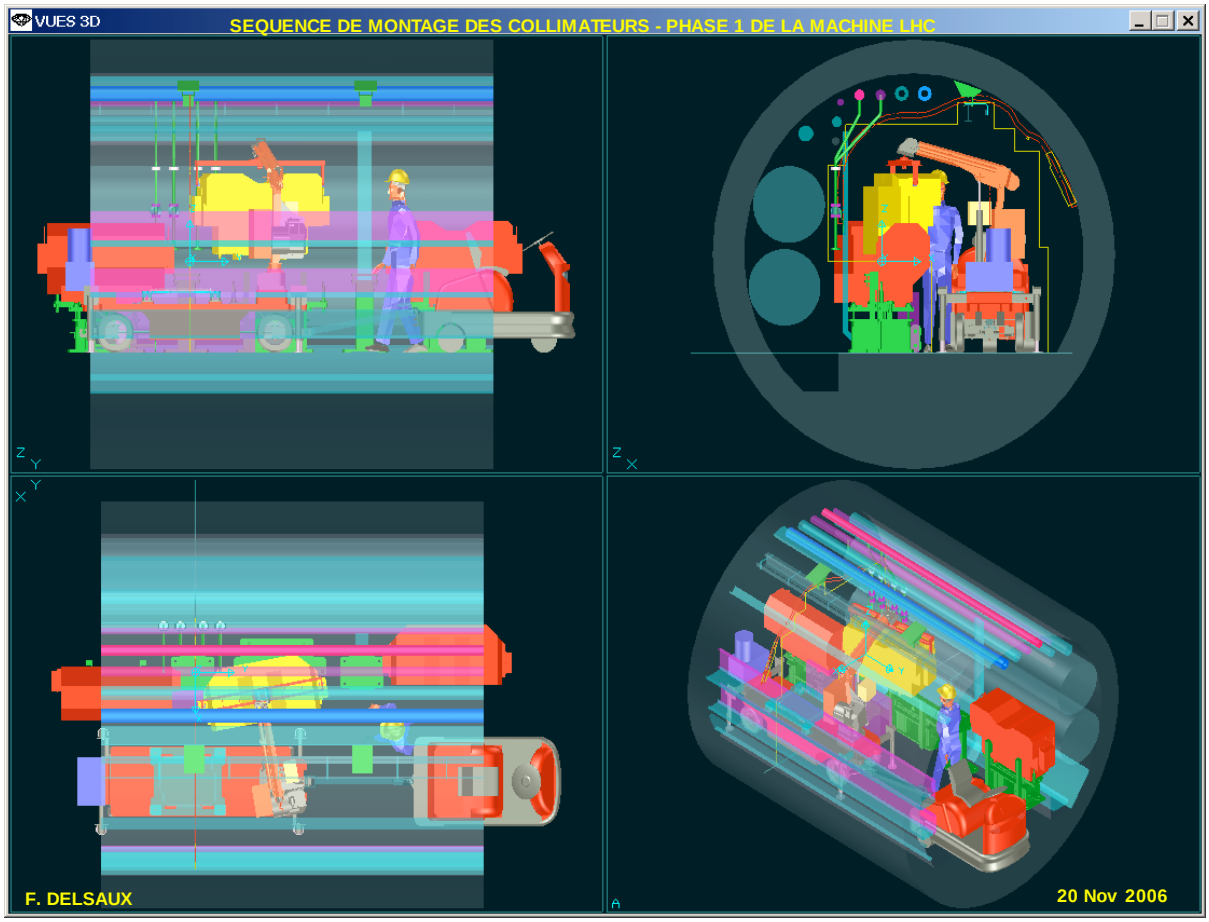

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

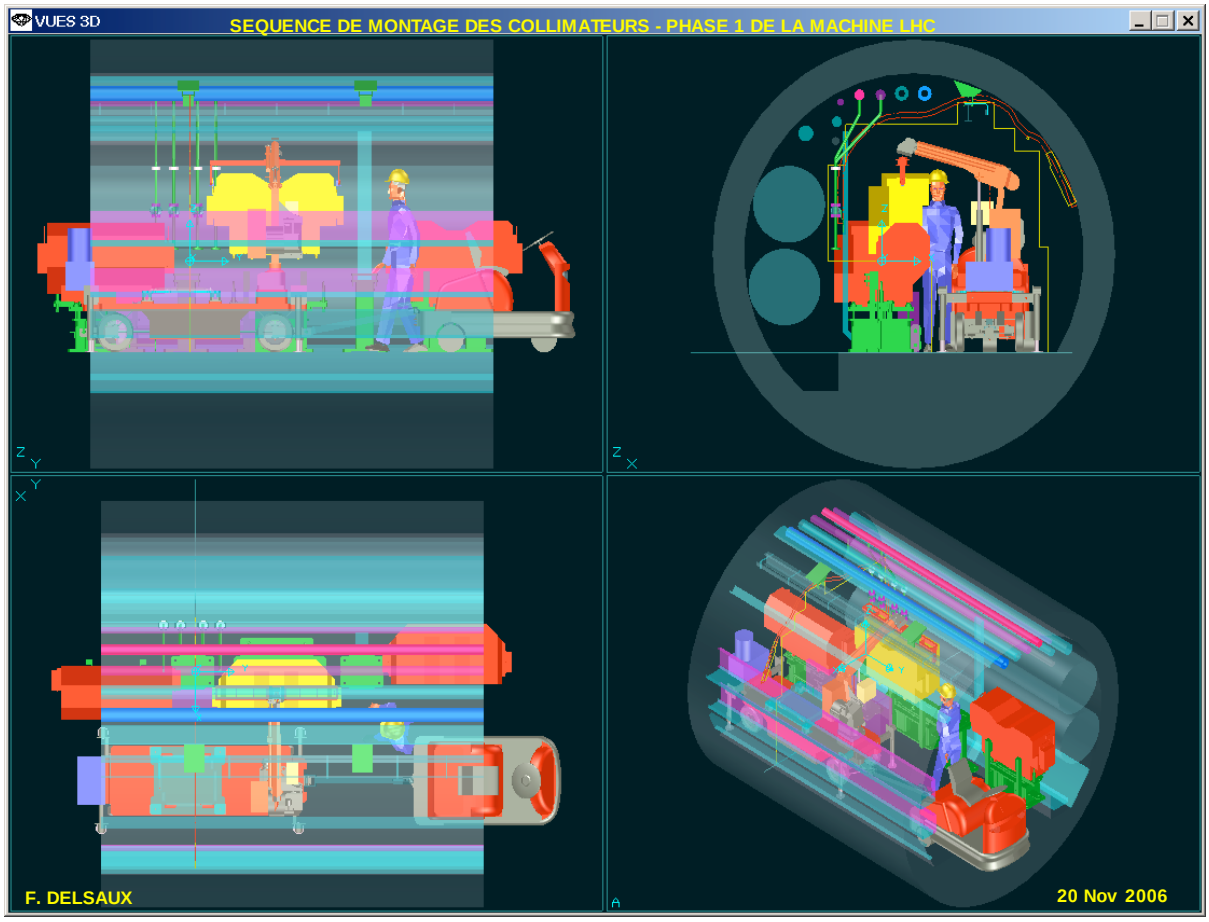

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

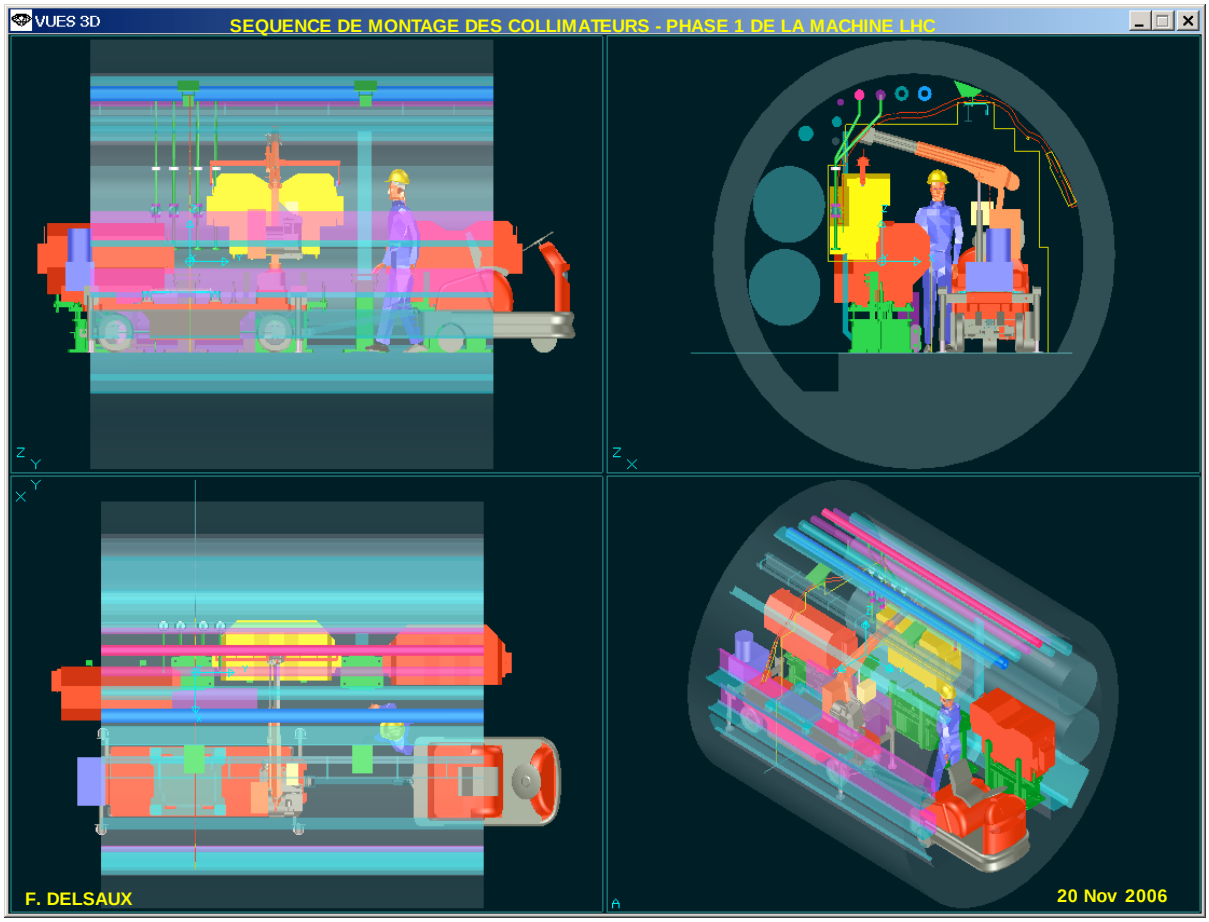

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

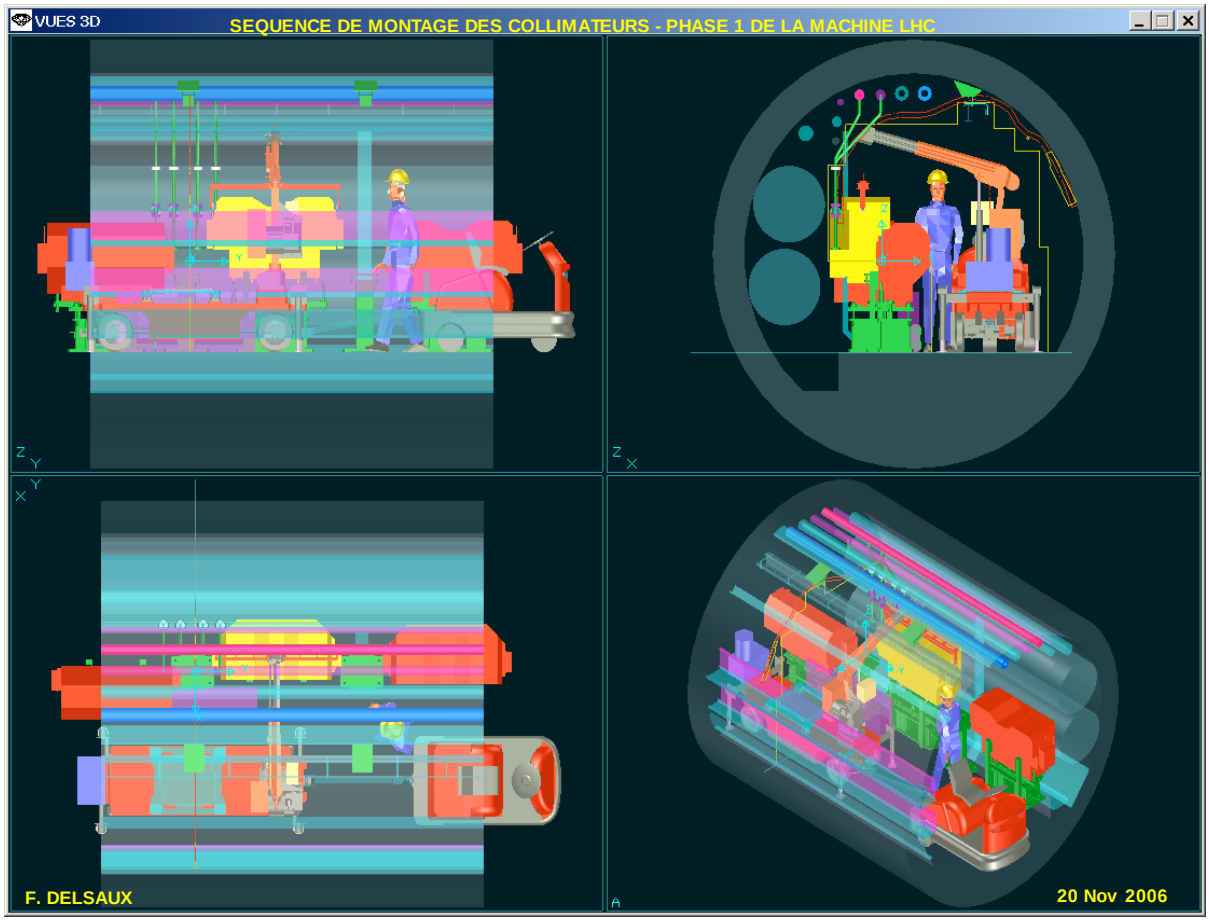

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

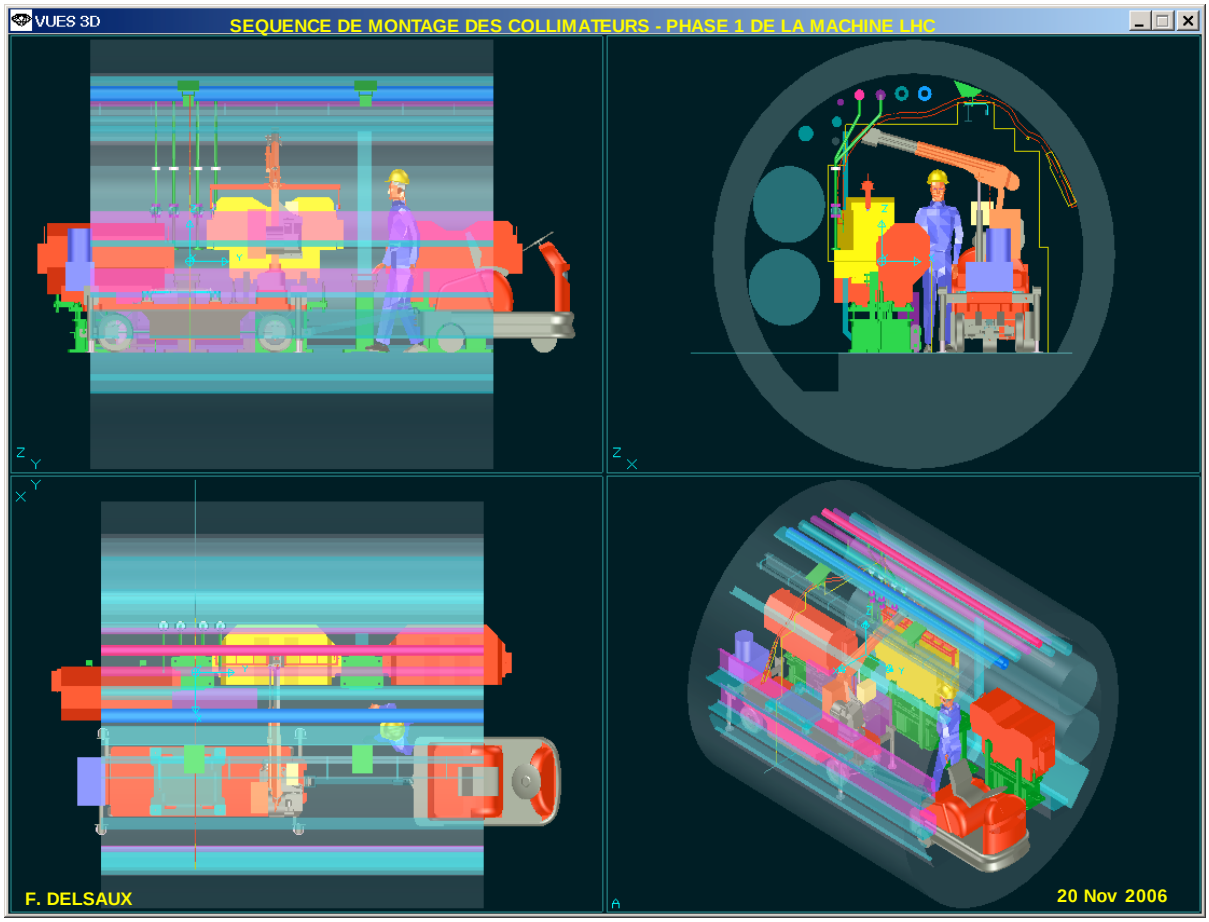

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

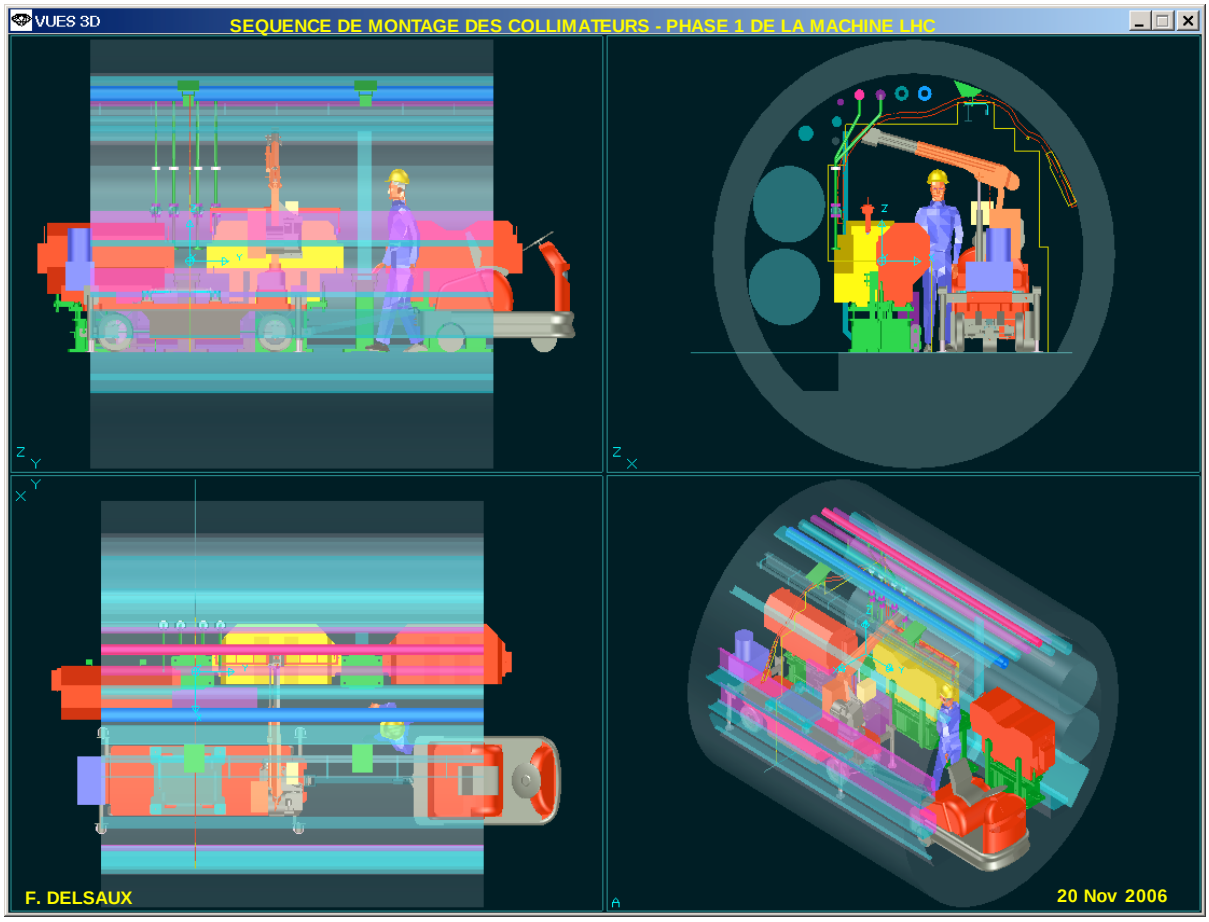

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

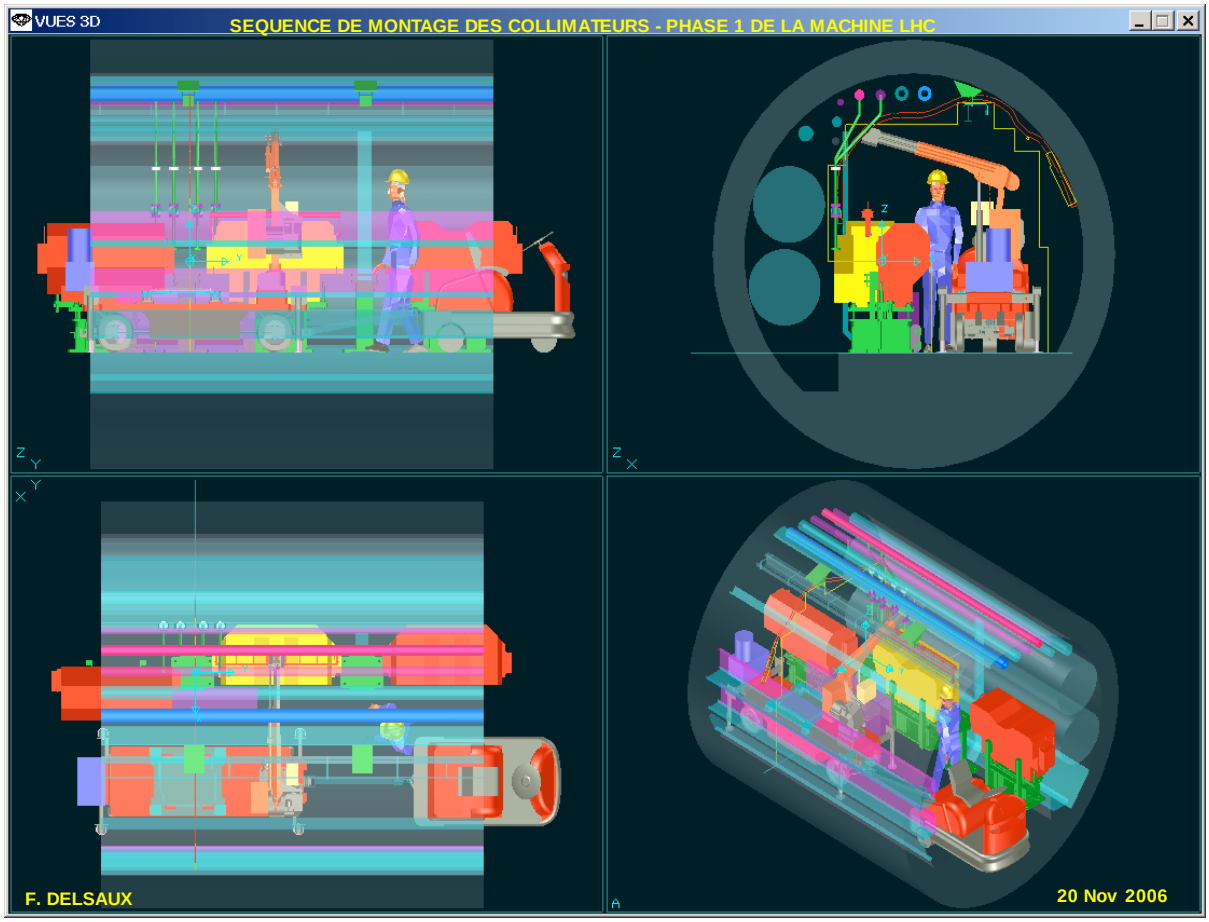

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

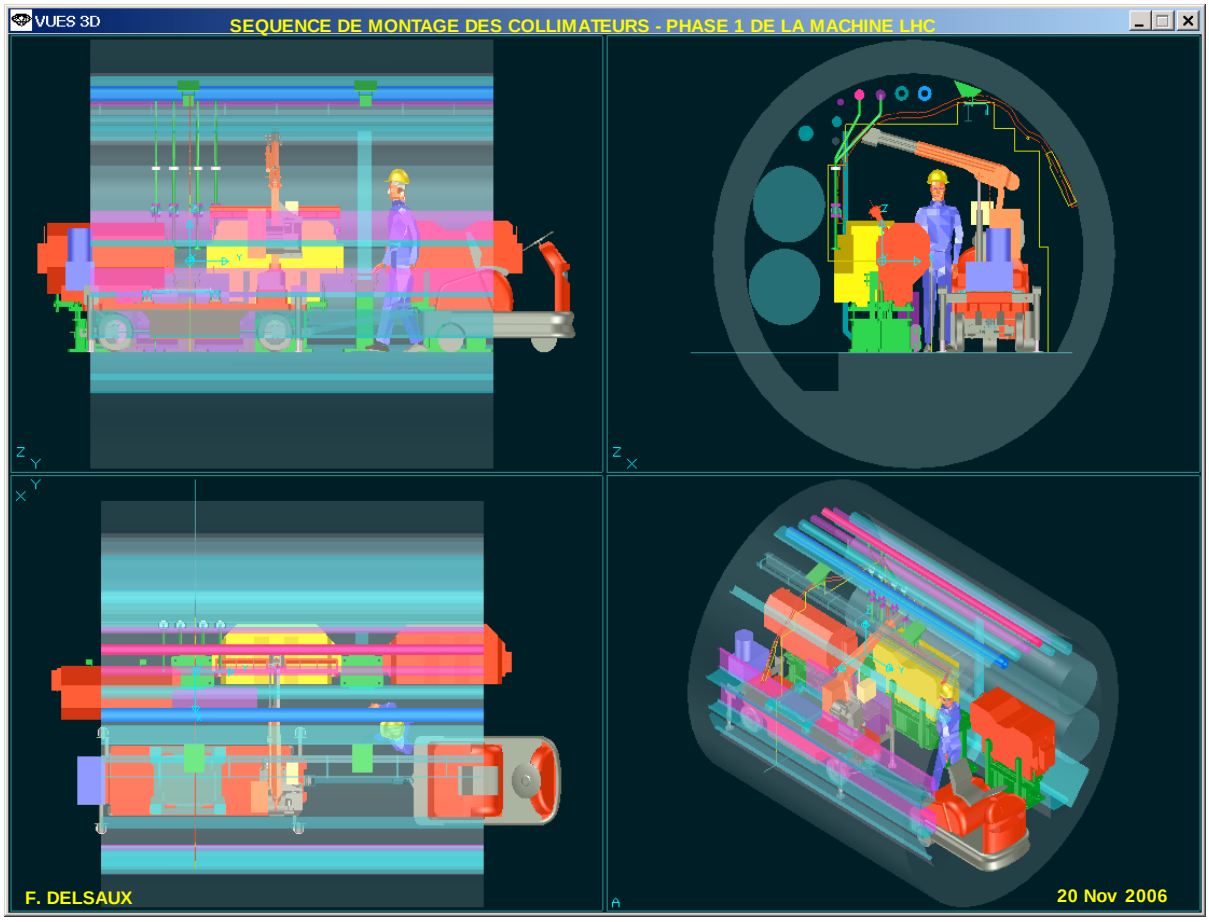

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

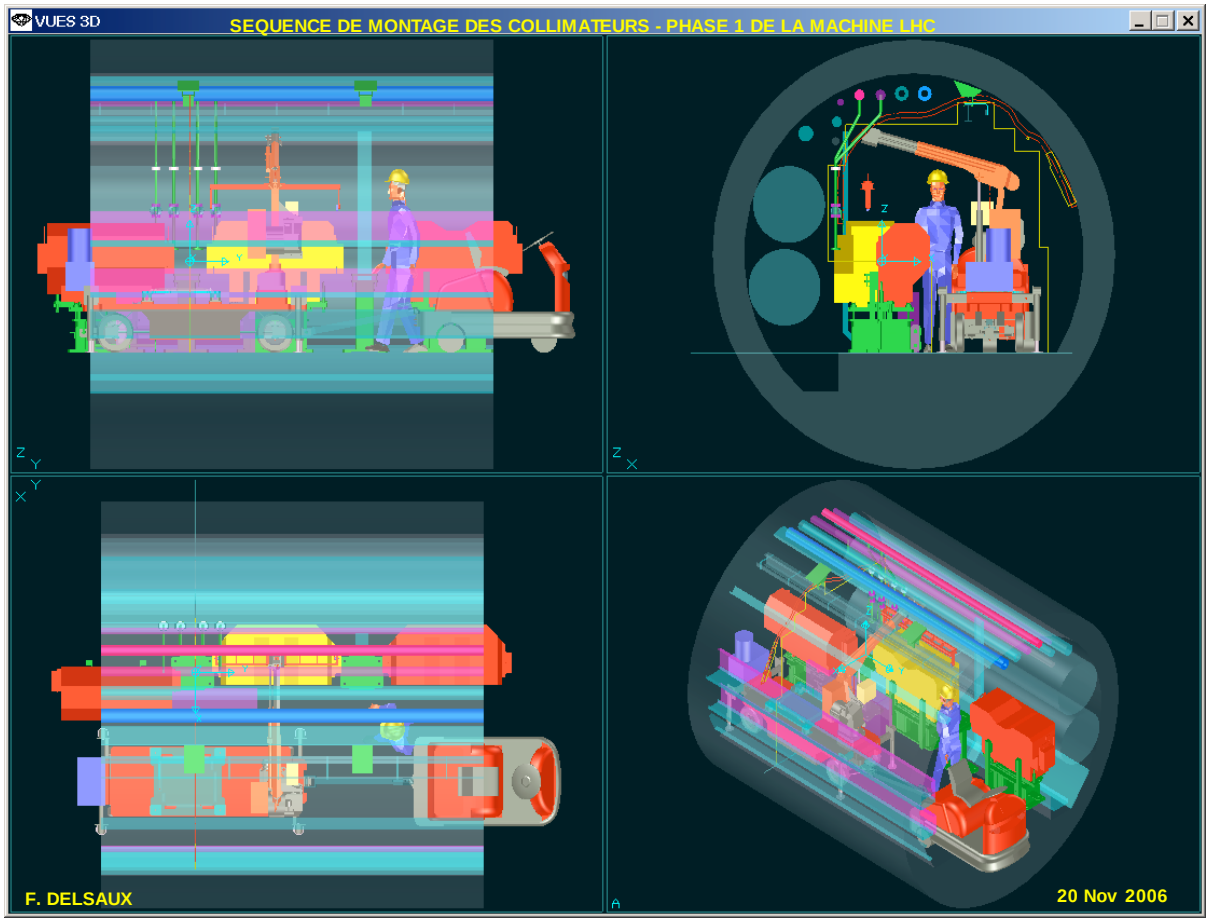

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

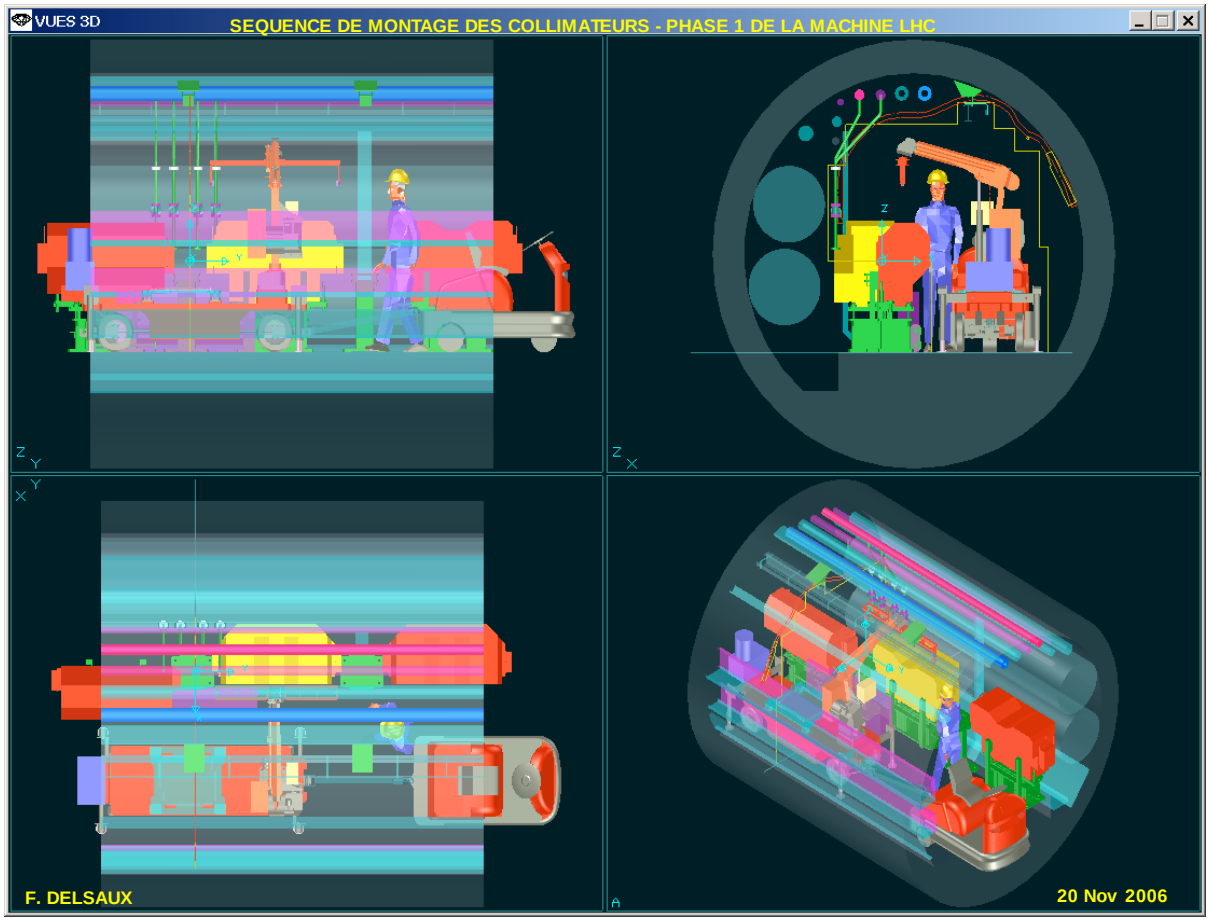

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

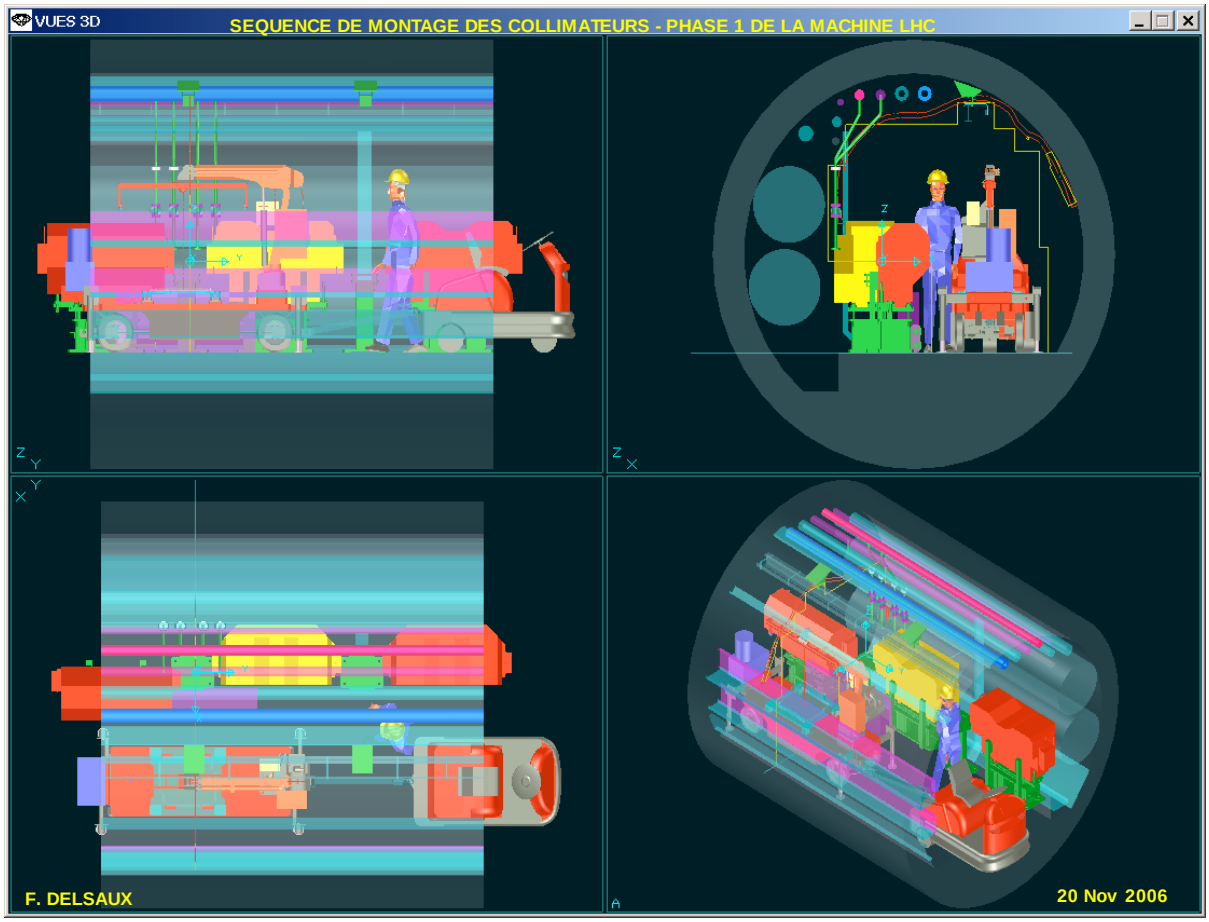

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006


VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006


VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006

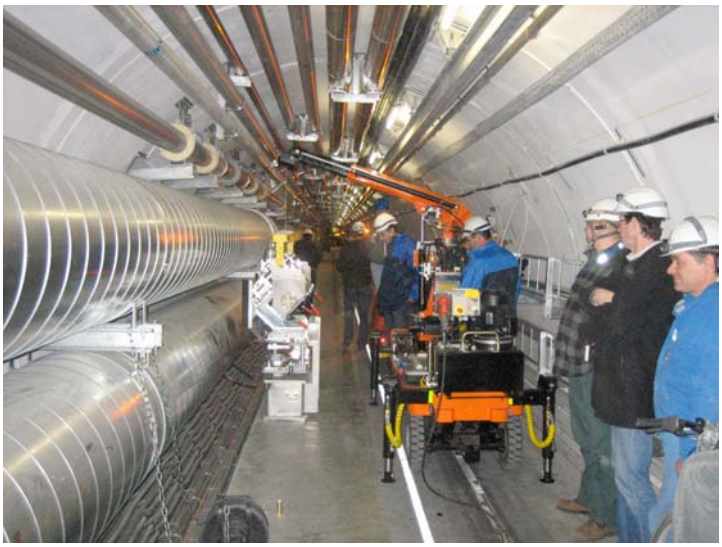

VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006


VUES 3D
SEQUENCE DE MONTAGE DES COLLIMATEURS - PHASE 1 DE LA MACHINE LHC
F. DELSAUX
20 Nov 2006



Photos trailer -crane

- Modified Palfinger crane with hoist, on heavy trailer with stabilisers + special spreader



3) Study and test work for collimator remote handling

Programme of work considers 2 main tasks:

- Collimator removal and replacement
- Geometrical and radiation remote survey

Collimator remote handling - outline

- Remove collimator from supports and transport to handling or storage area (where?)
- Take replacement collimator from access point and install it on supports
- Vacuum (dis)connection

LHC remote survey

Transport measurement equipment to known position and take readings (measurement equipment provided by others)

- Radiation survey – autonomous package also used on CNGS crane – go in before personnel access
- Geometrical survey – LSS initially , future possibility of measurements in arc during operation

Remote handling study and test work - background

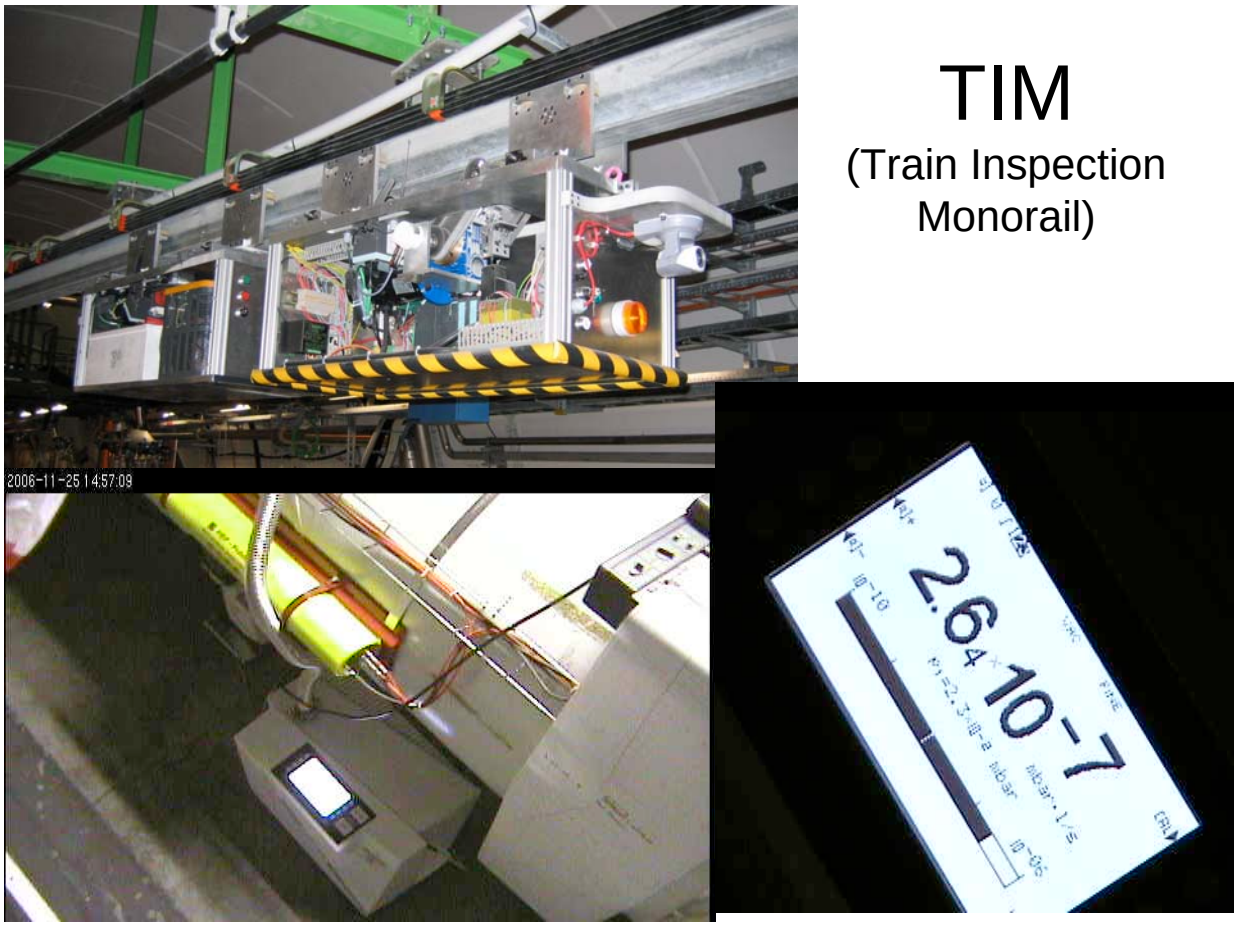
- Change from “hands-on” to remote handling
- Operator control at a distance
- Need to drive/control all degrees of movement
- Need control communication
- Need good vision equipment and vision communication

Remote handling study and test work – main tasks

- Develop and demonstrate communication, control, vision - TIM
- Mock up tests and studies for mechanical handling and transport

TIM (Train Inspection Monorail)

- Proves feasibility of communication in LHC tunnel with existing infrastructure
- Used for visual inspection during pressure testing and cool-down of sector 7-8



TIM

(Train Inspection Monorail)

Collimator mechanical handling

Two main requirements

- Transport along tunnel
- Transfer from vehicle onto supports and vice versa

Collimator remote transport along tunnel

- Passage is narrow with low clearances
- Aim to avoid need for driver
- To simplify guidance of transport vehicle try to suspend from monorail
- Alternative is floor-running automatically guided vehicle

Collimator remote installation handling

1) Need to be able to:

- position collimator in 3 axes
- orient collimator in two axes

(third axis is guaranteed by support points)

2) Ensure

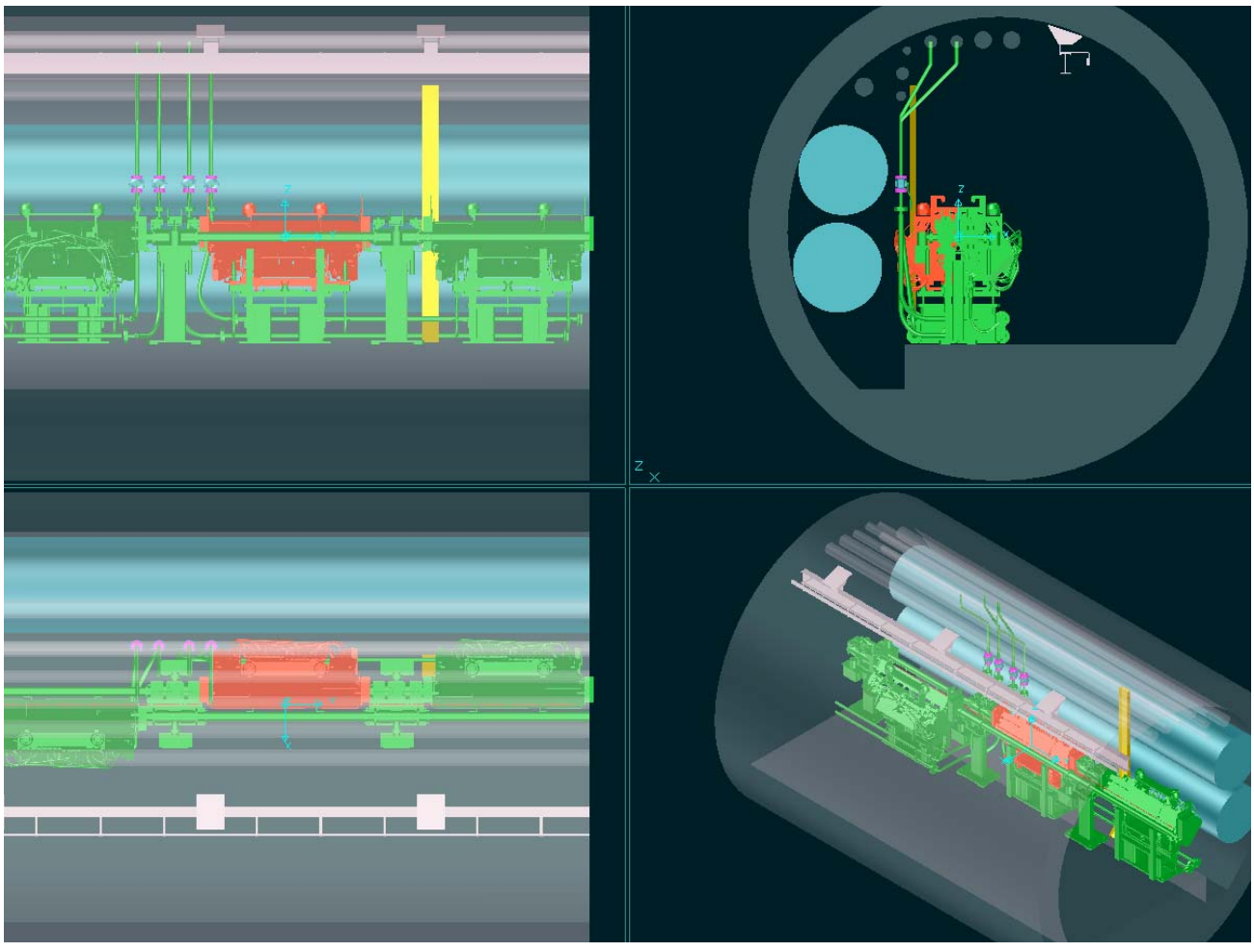
- Sufficient travel
- Fit in space available

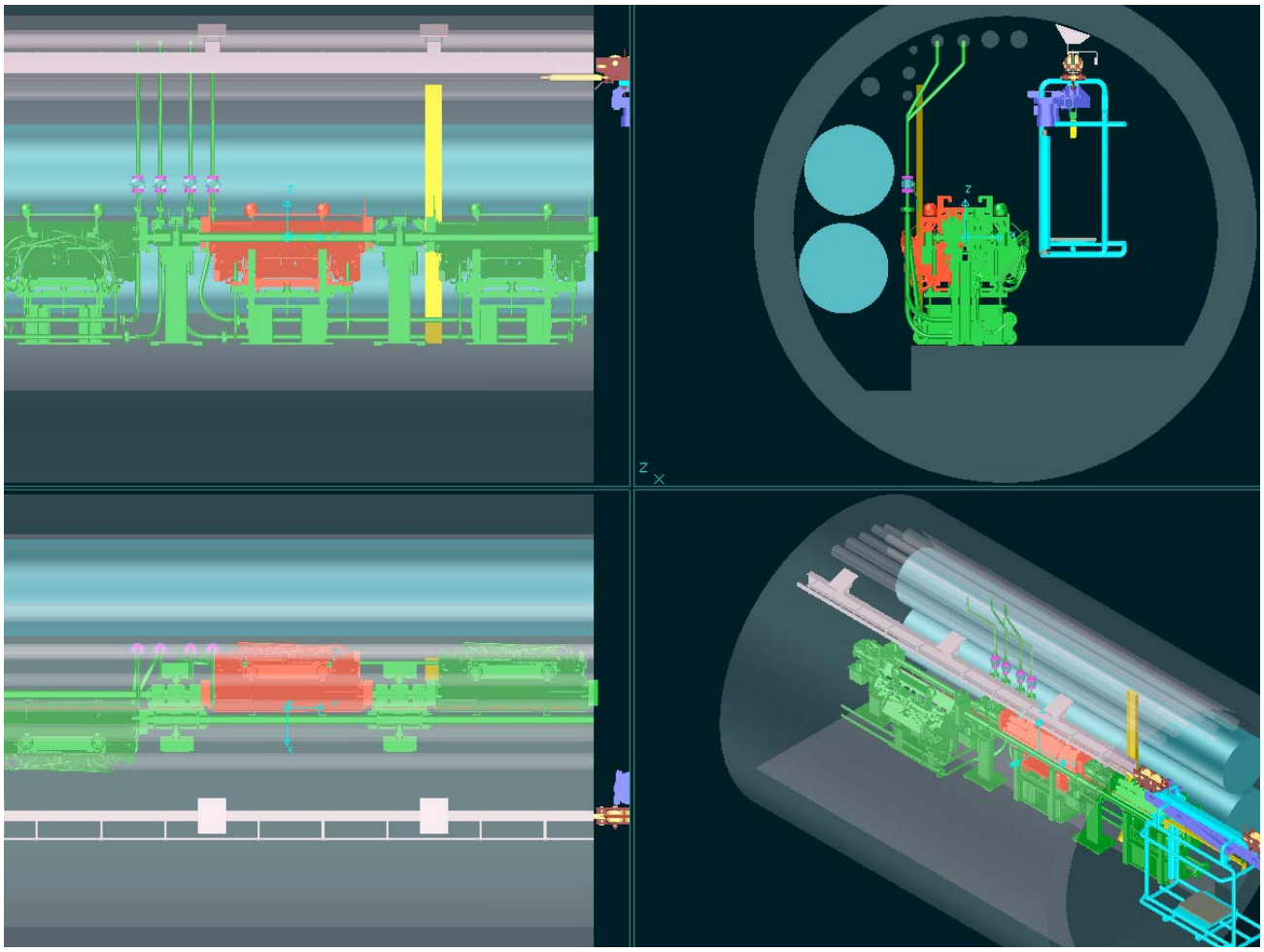
3) Avoid jamming forces – cable support

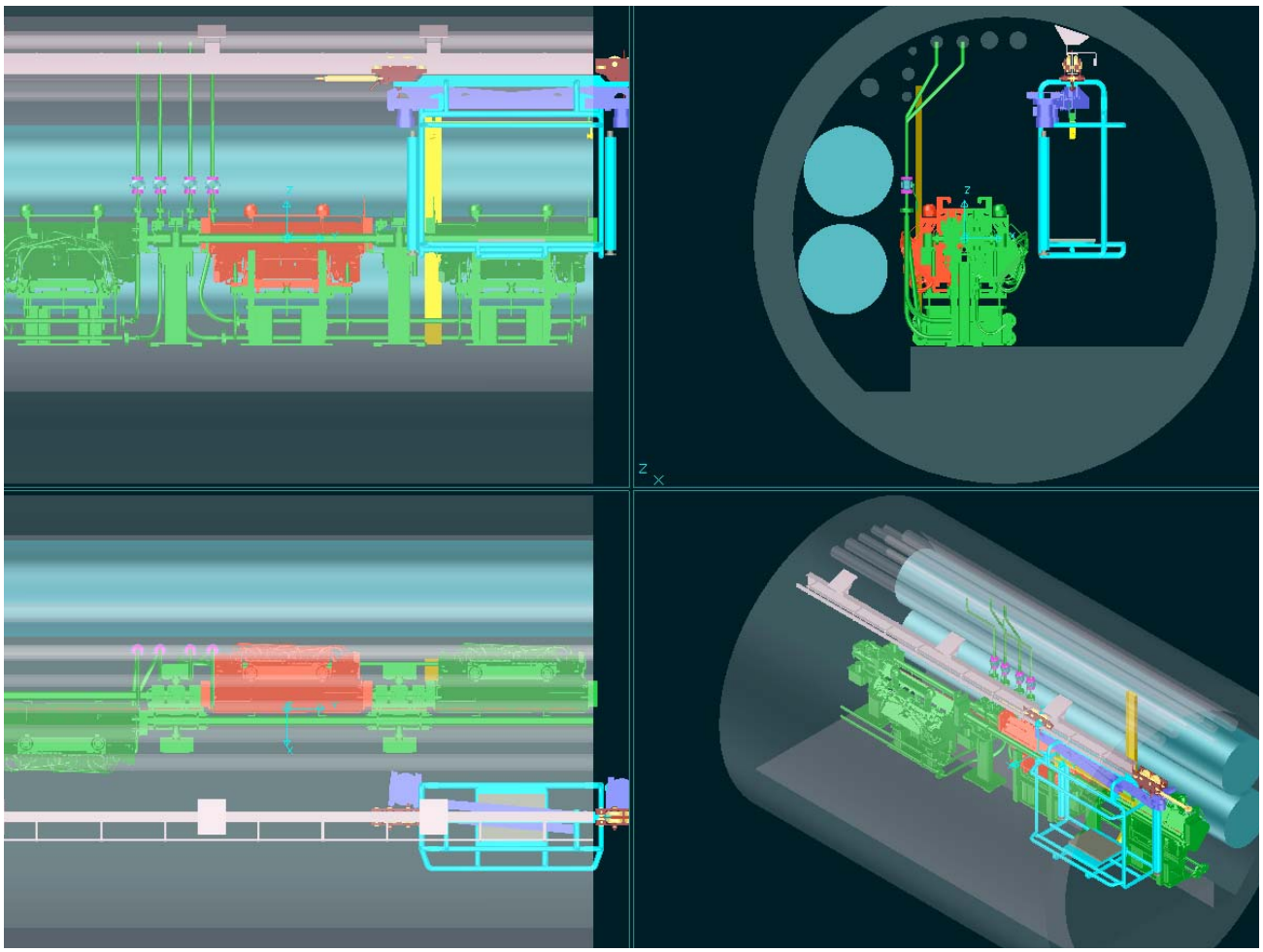
CHANGEMENT D'UN COLLIMATEUR

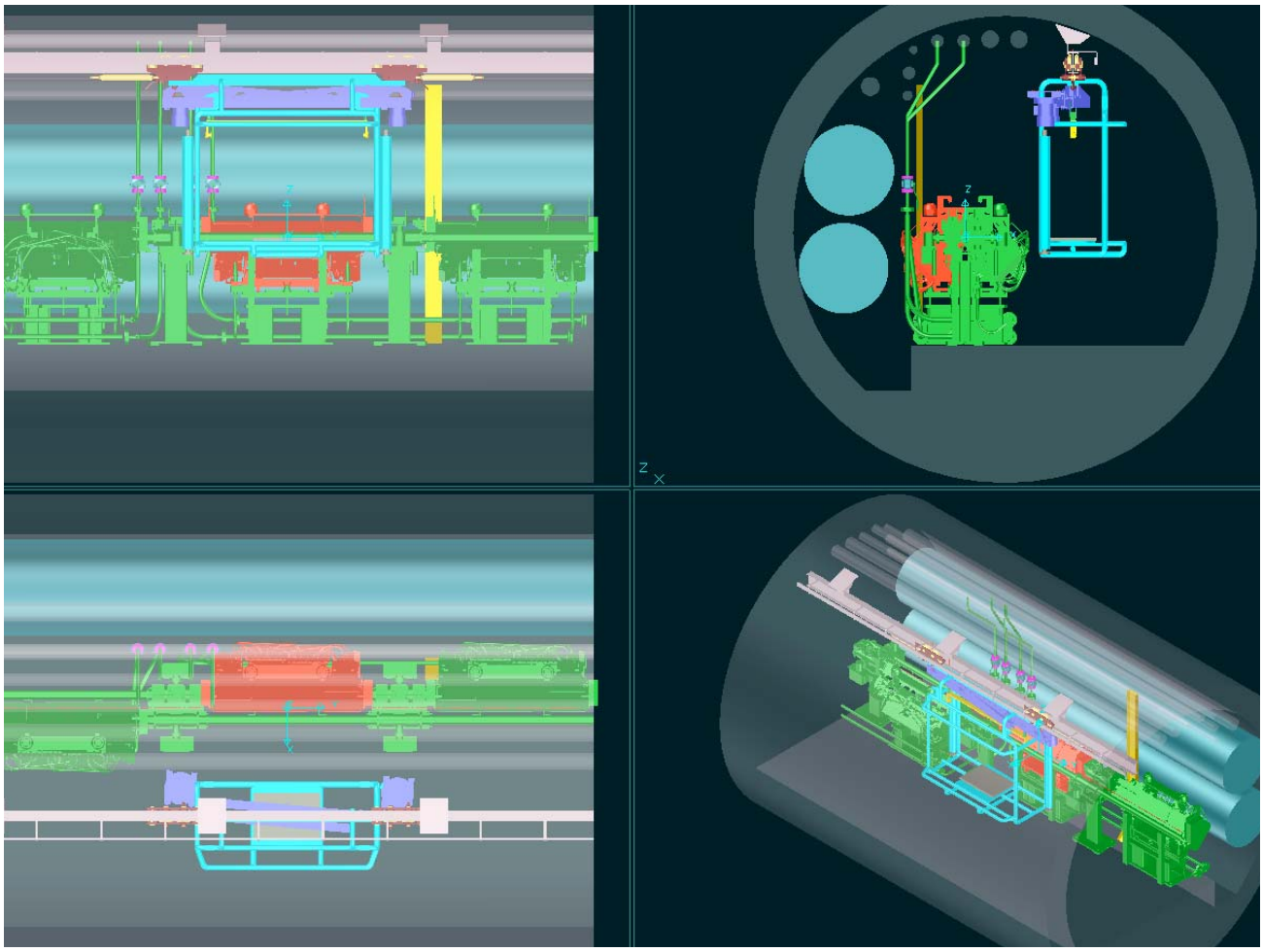
MANIPULATION A DISTANCE

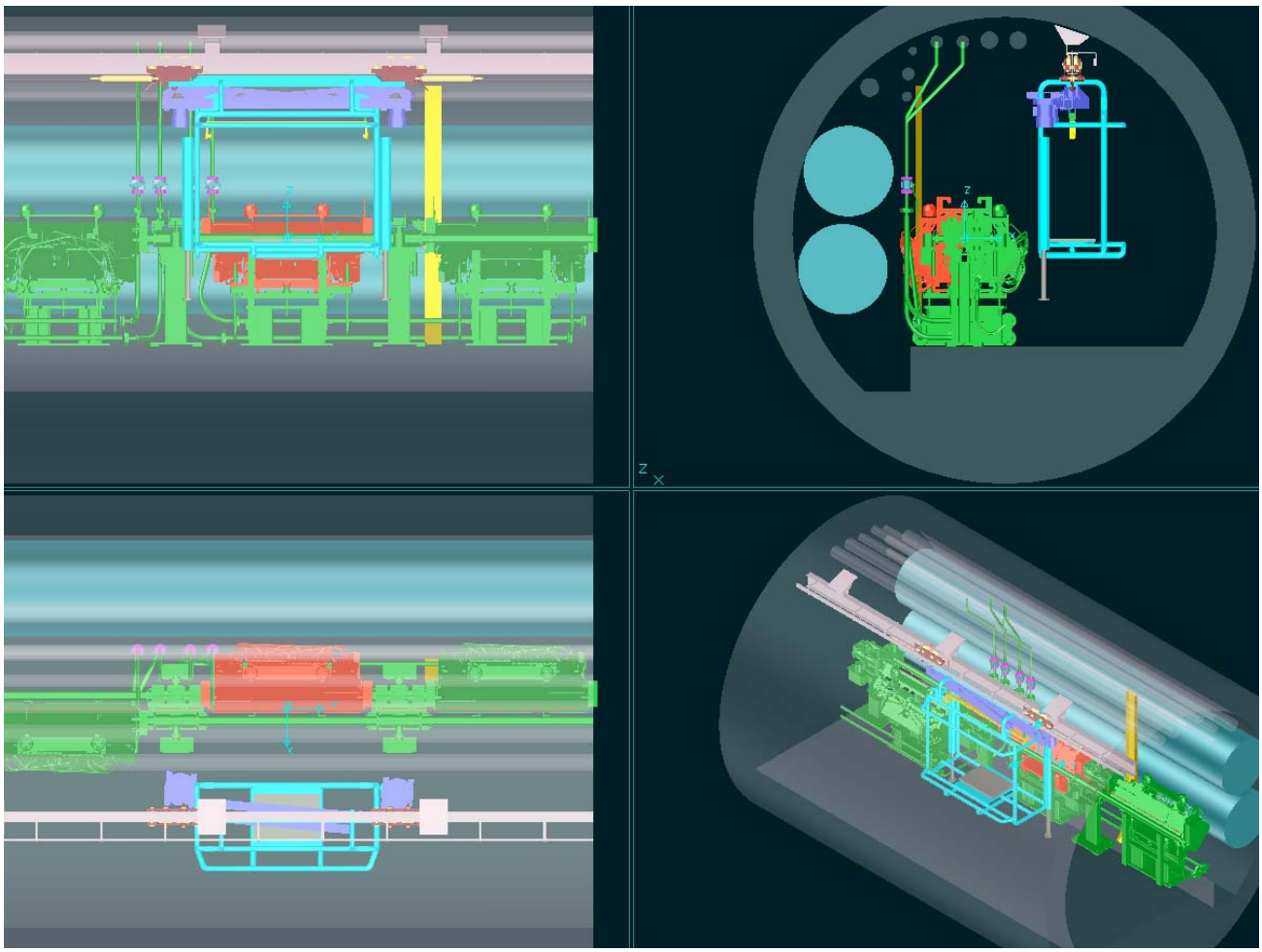
FREDERIC DELSAUX
FEVRIER 2007

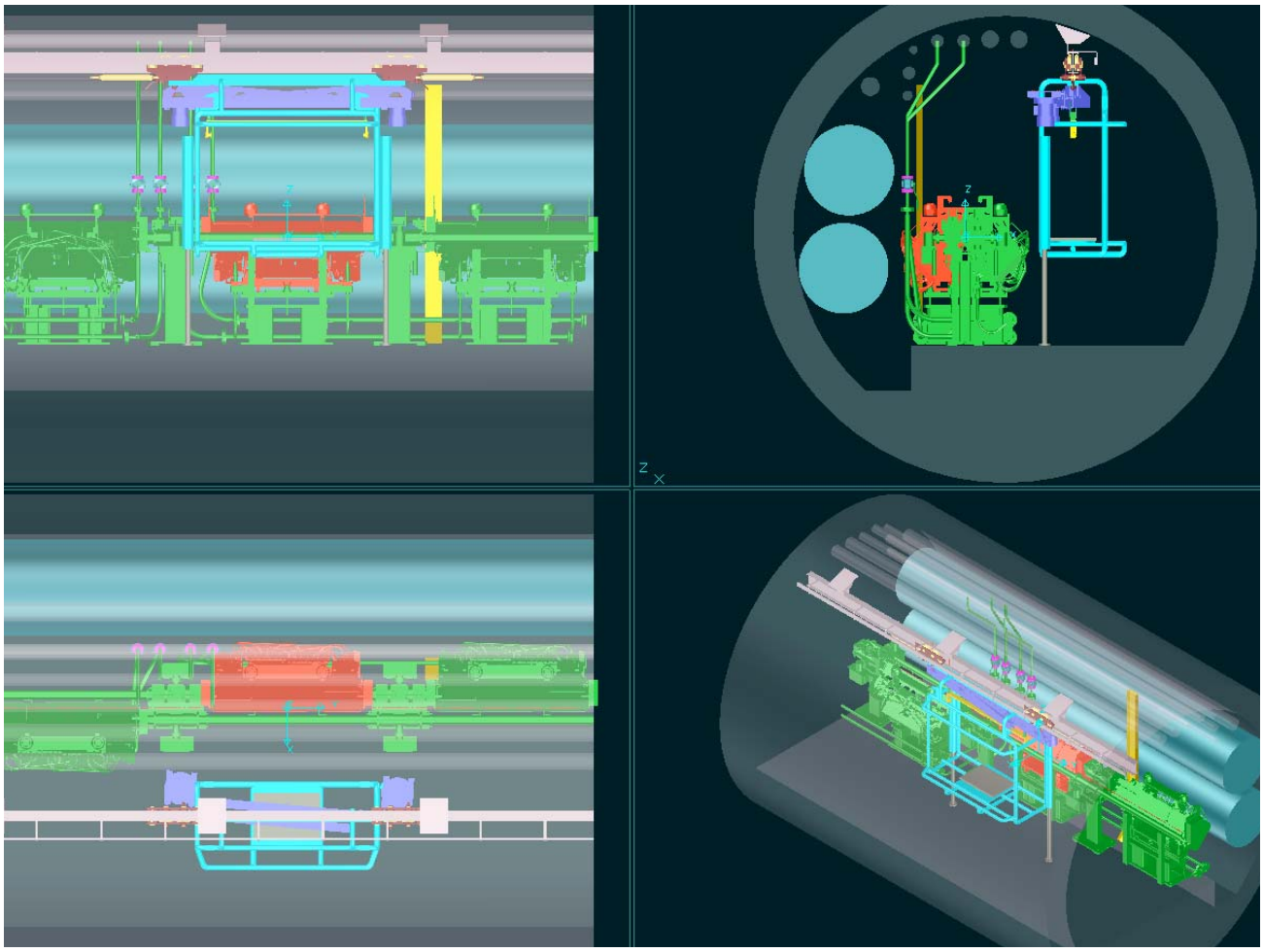


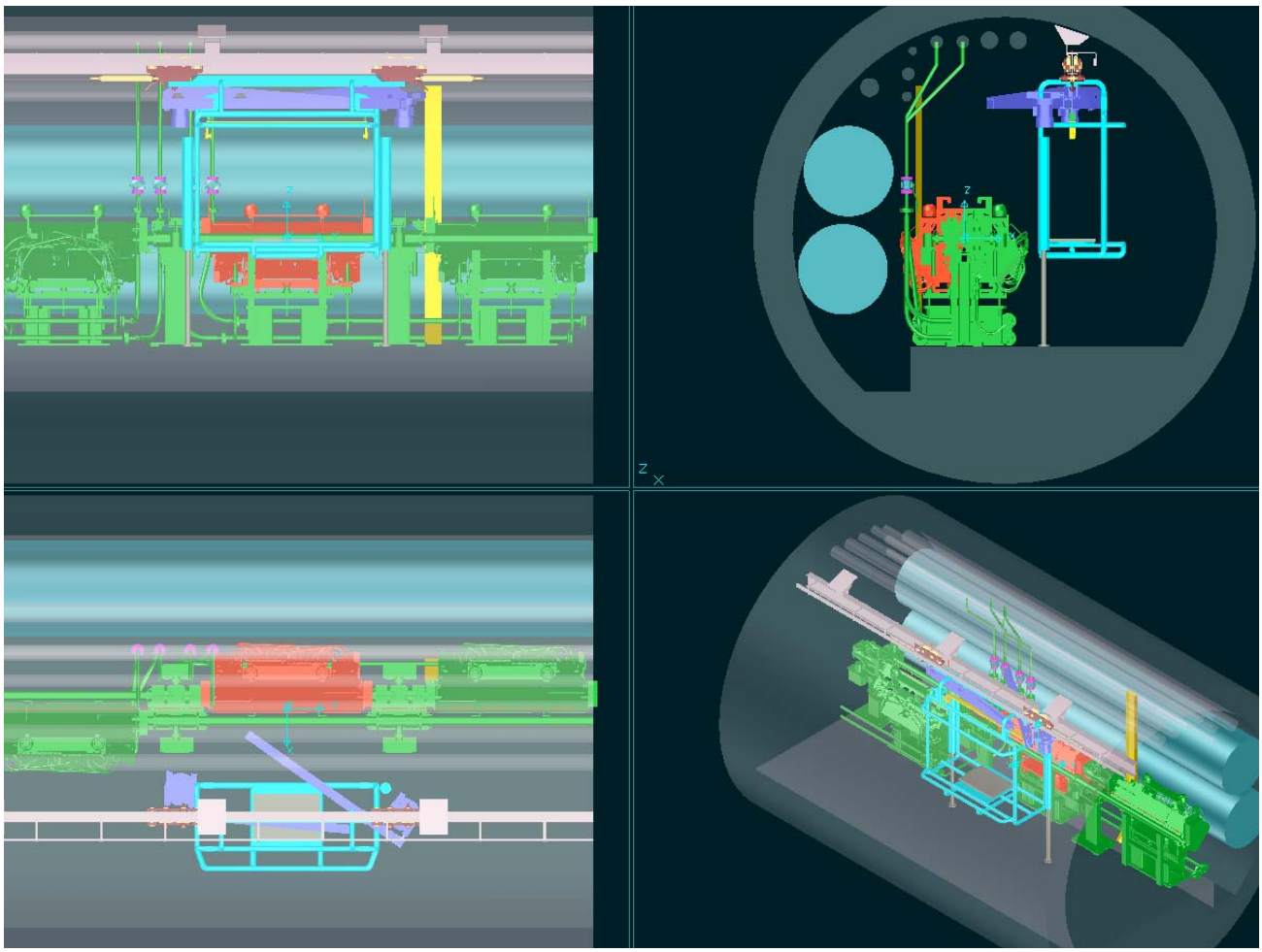


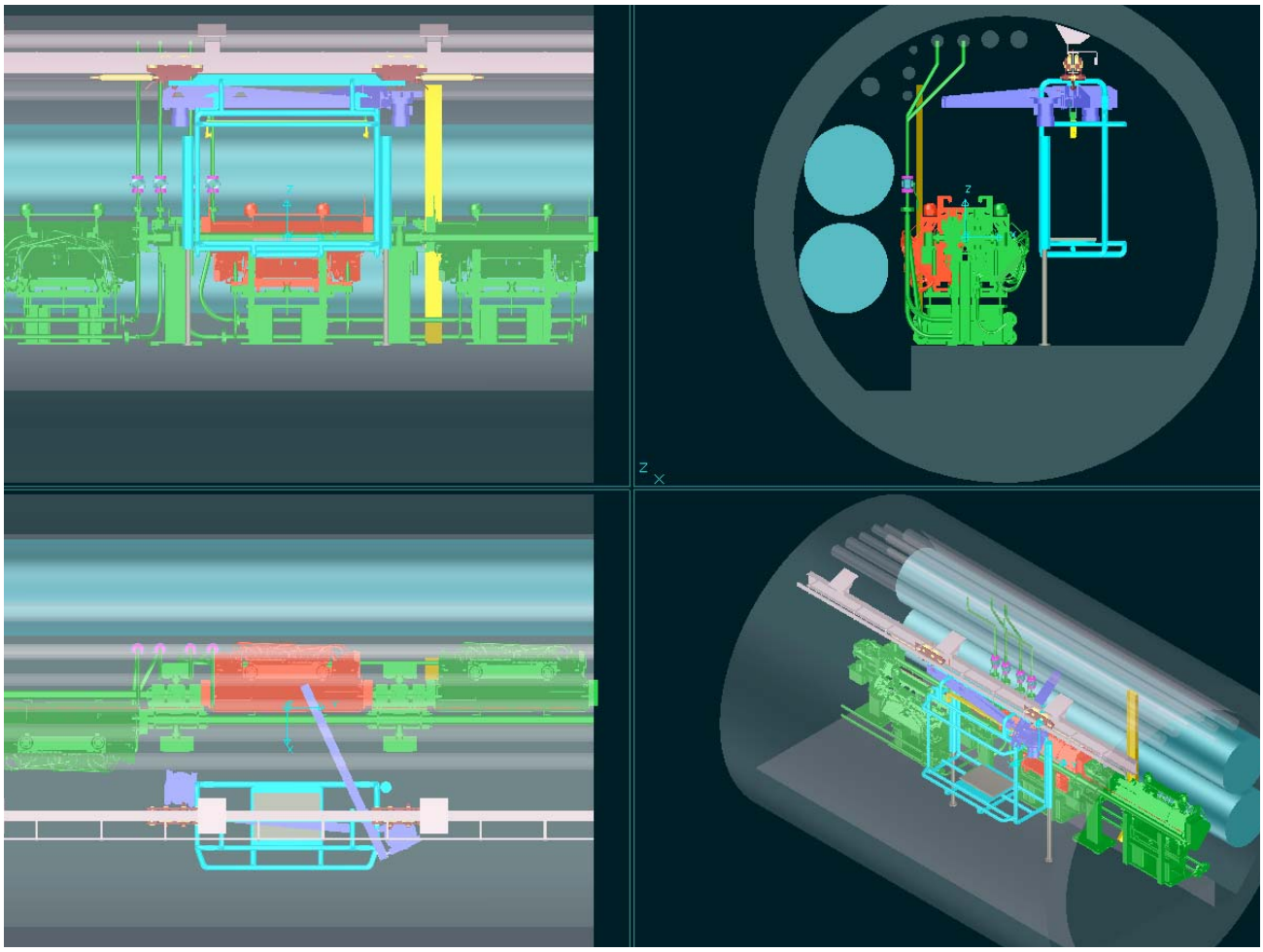


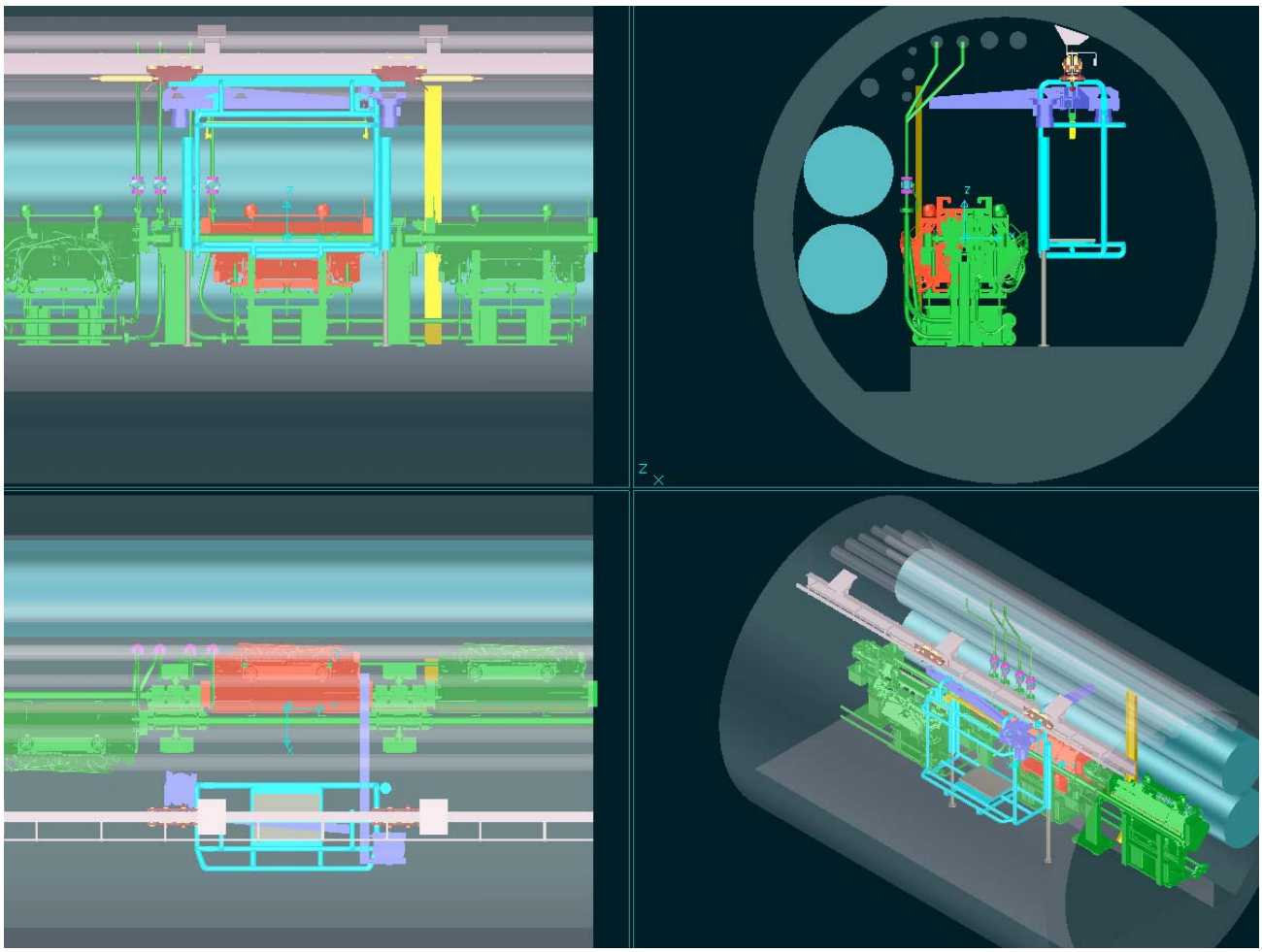


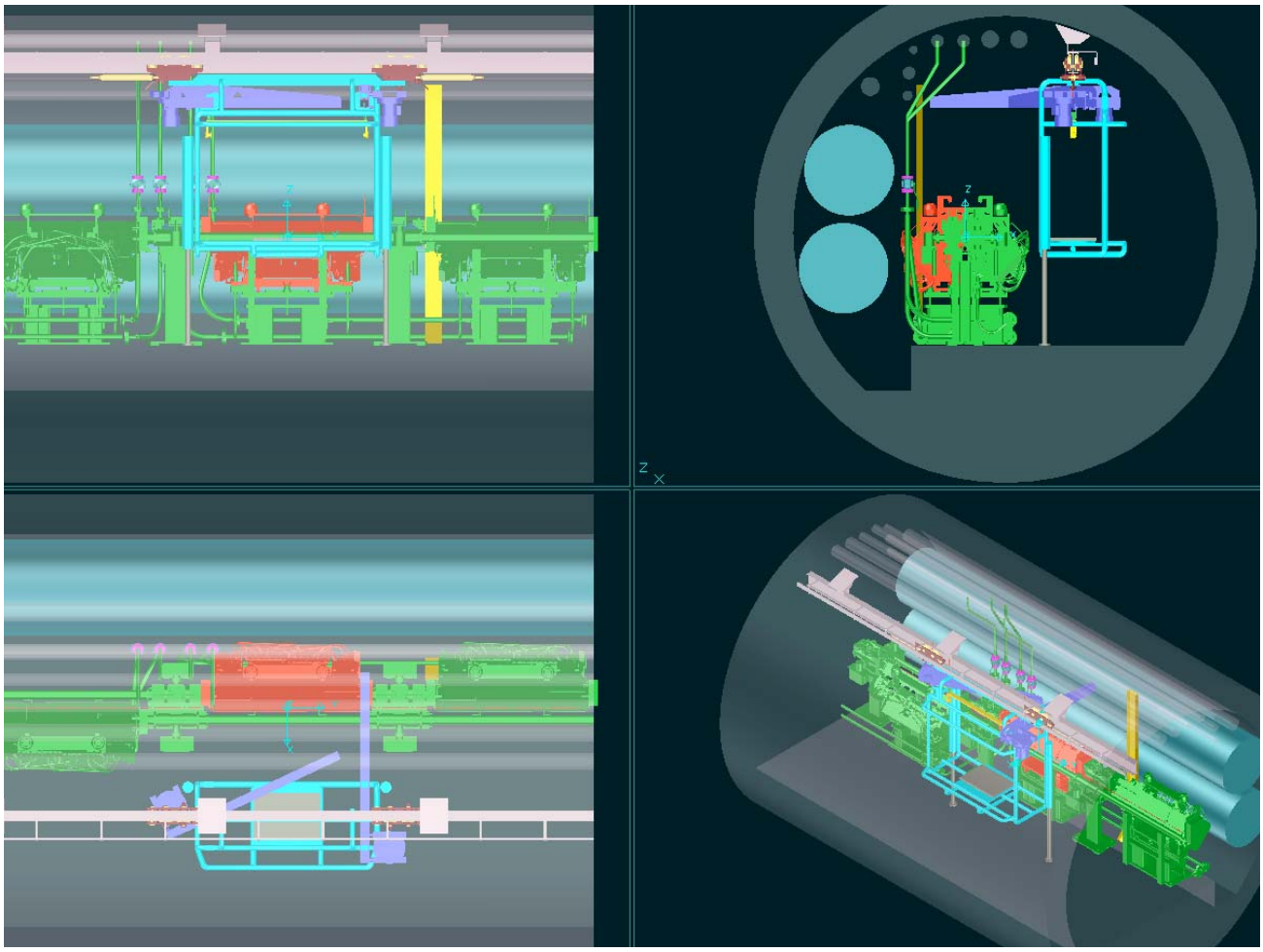


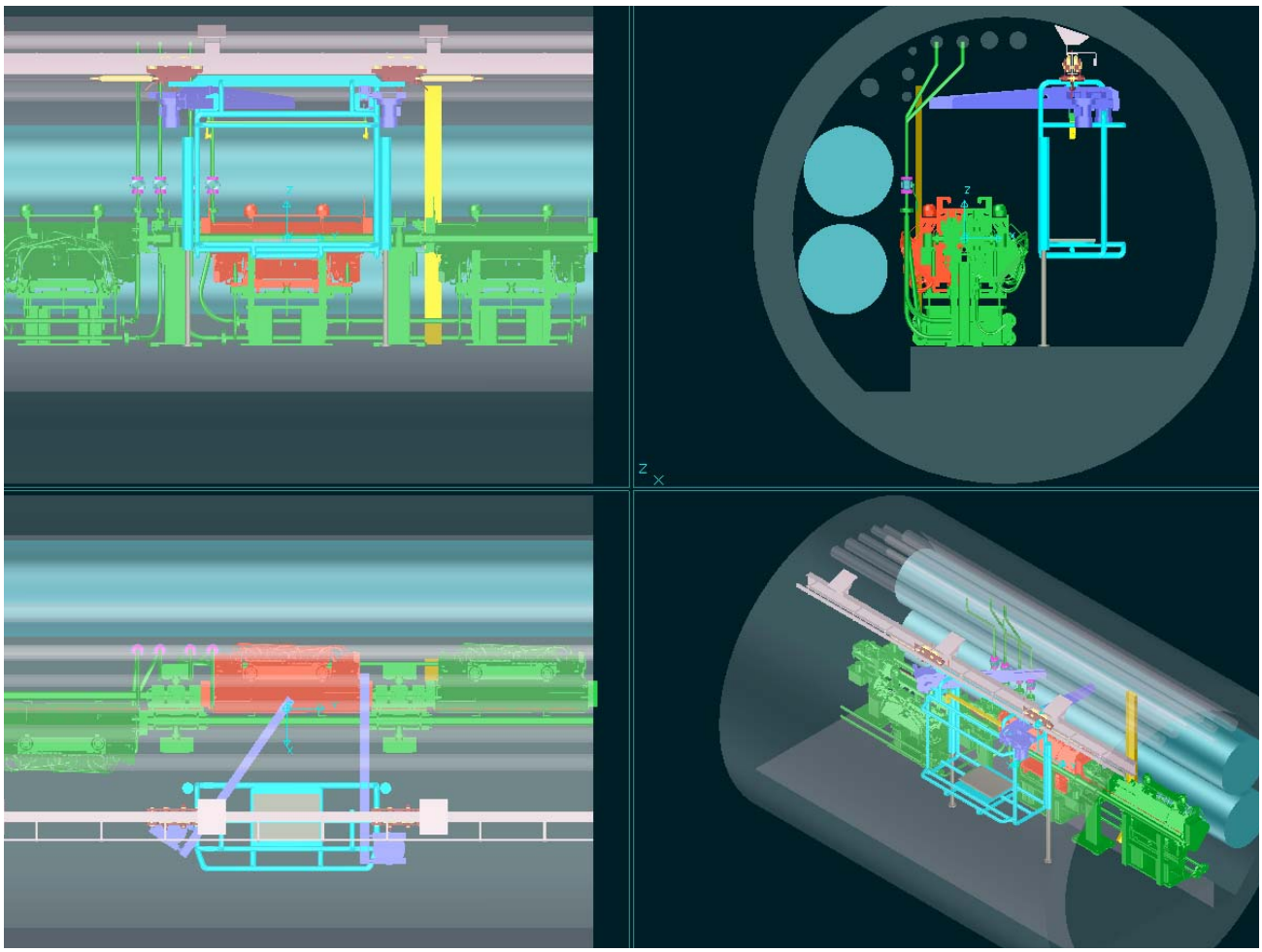


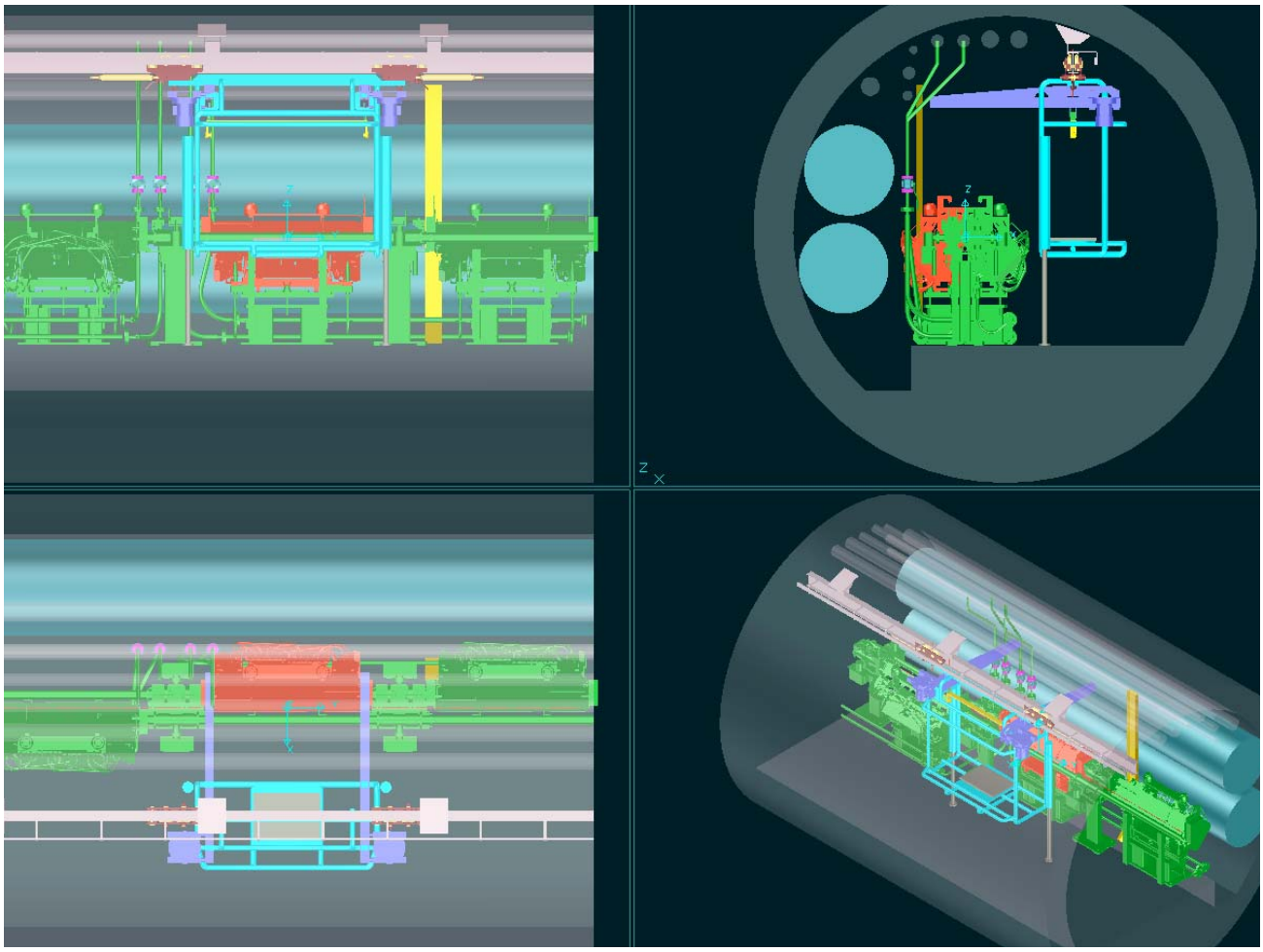


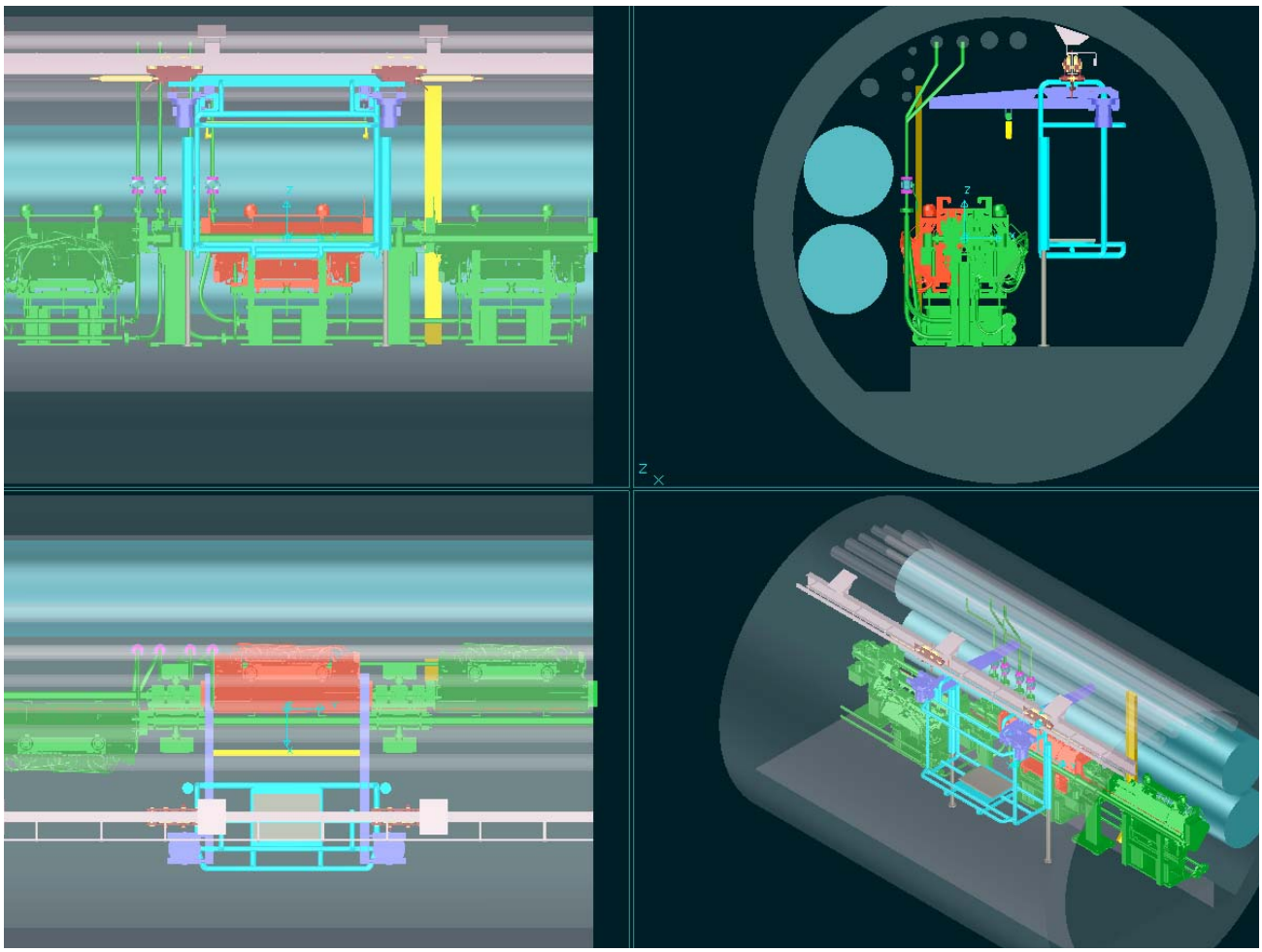


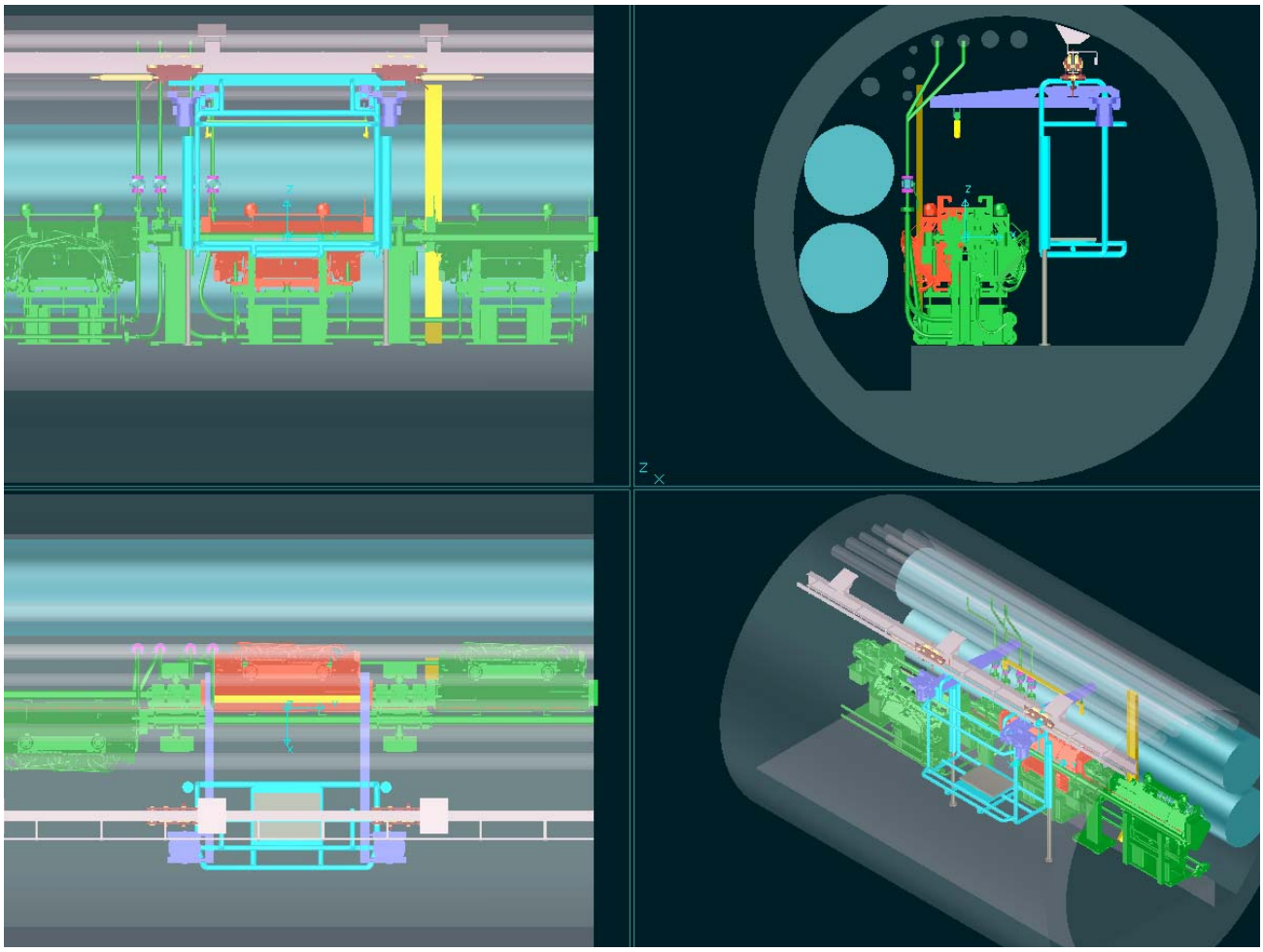


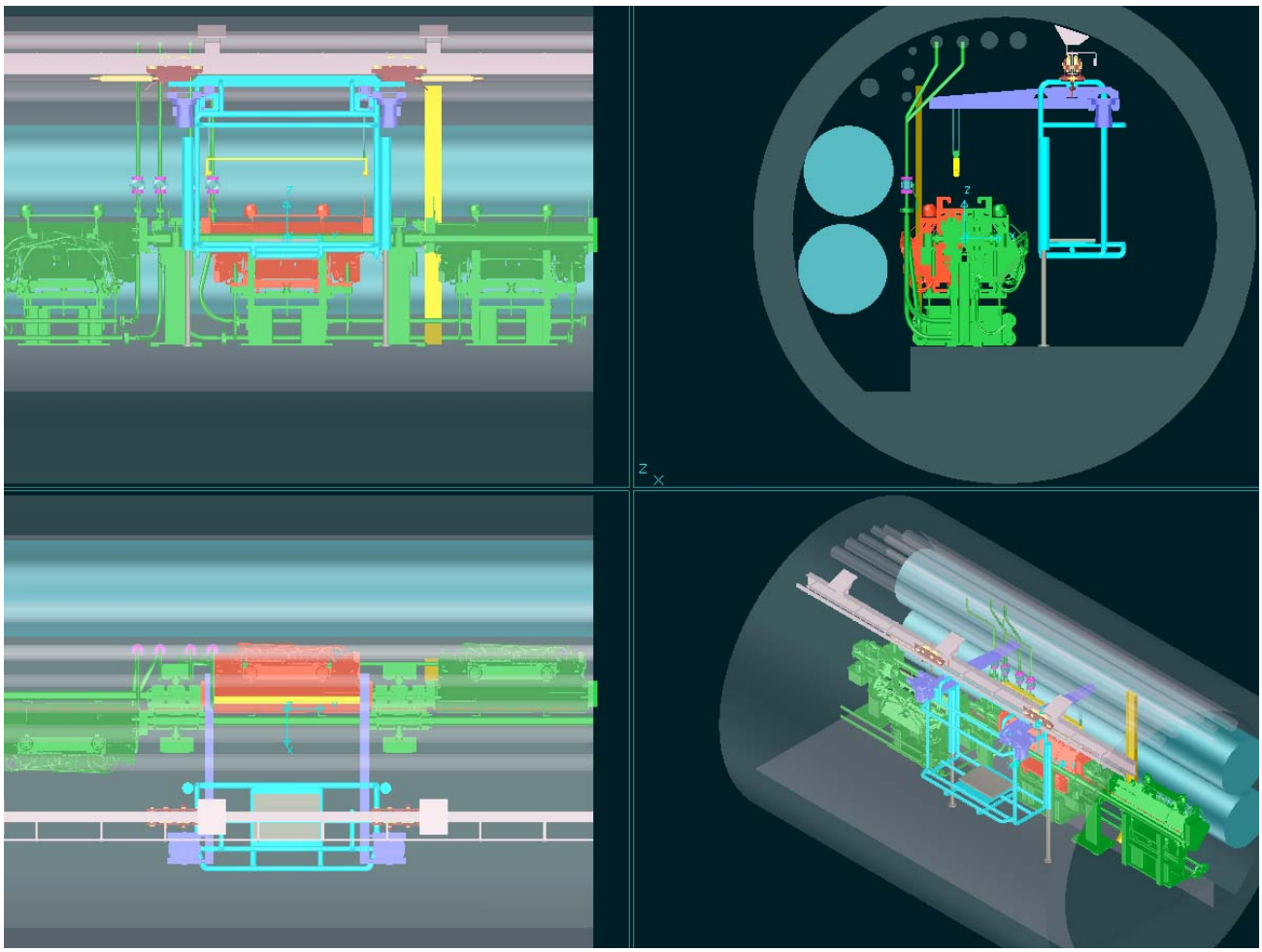


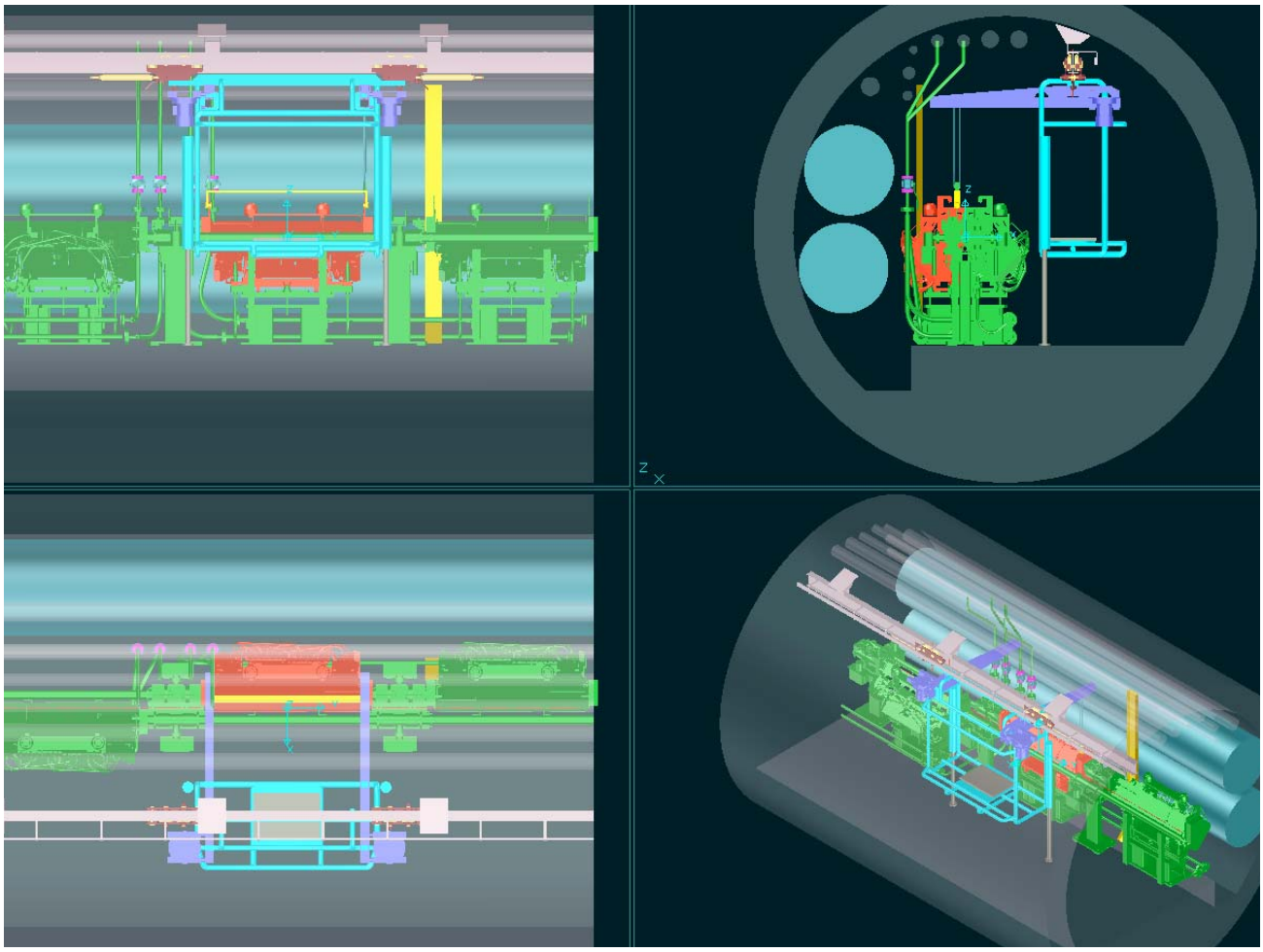


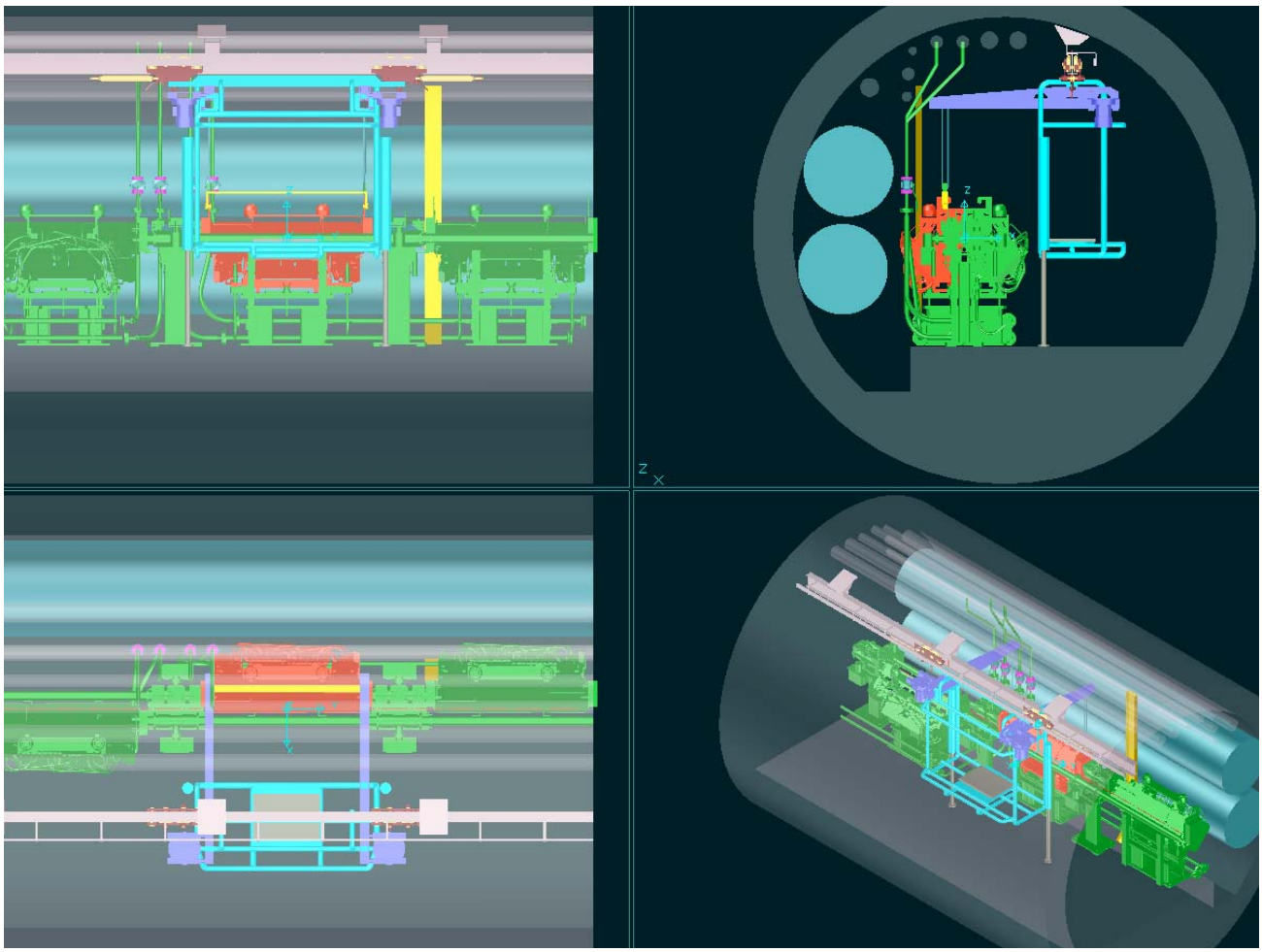


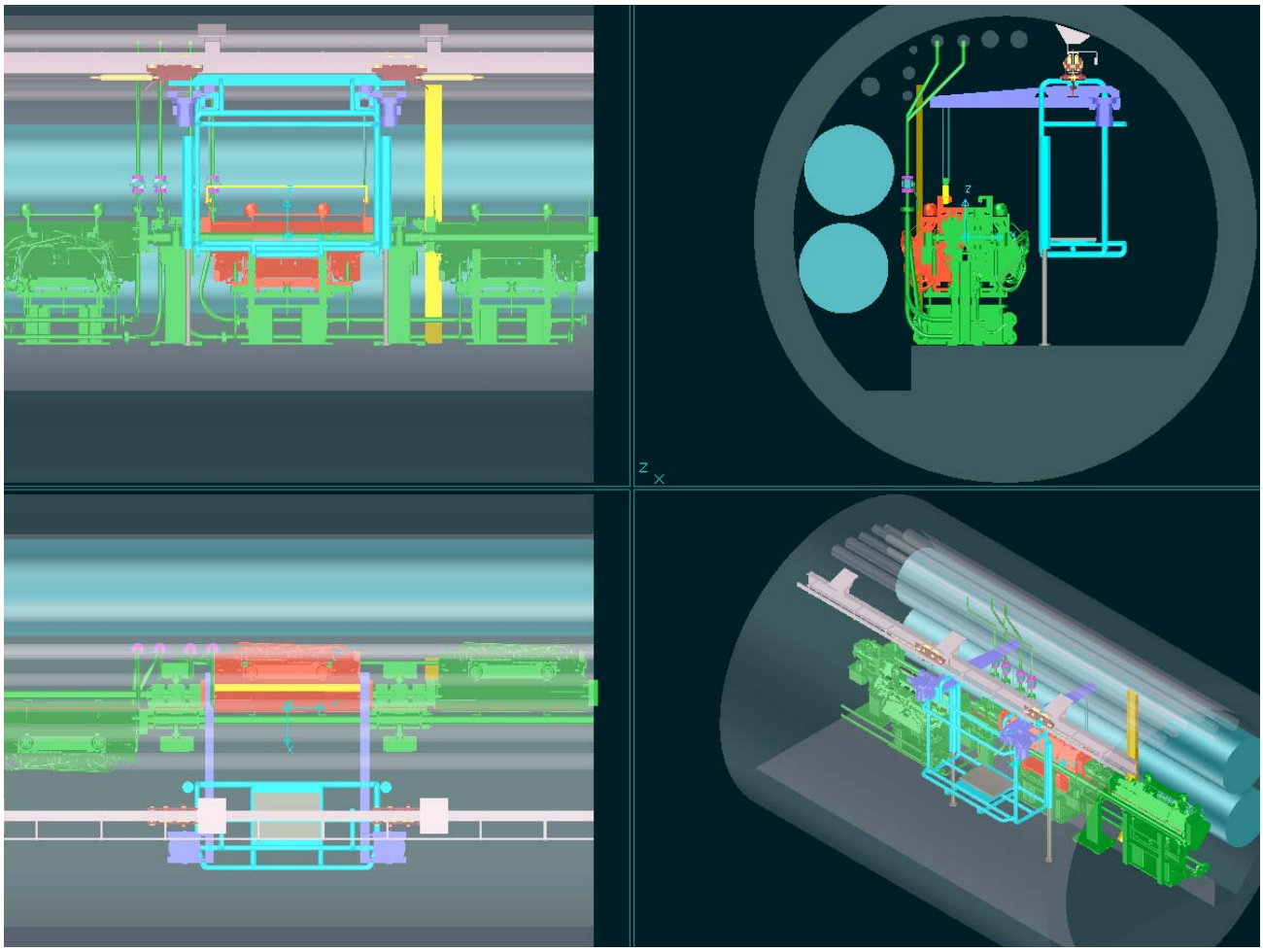


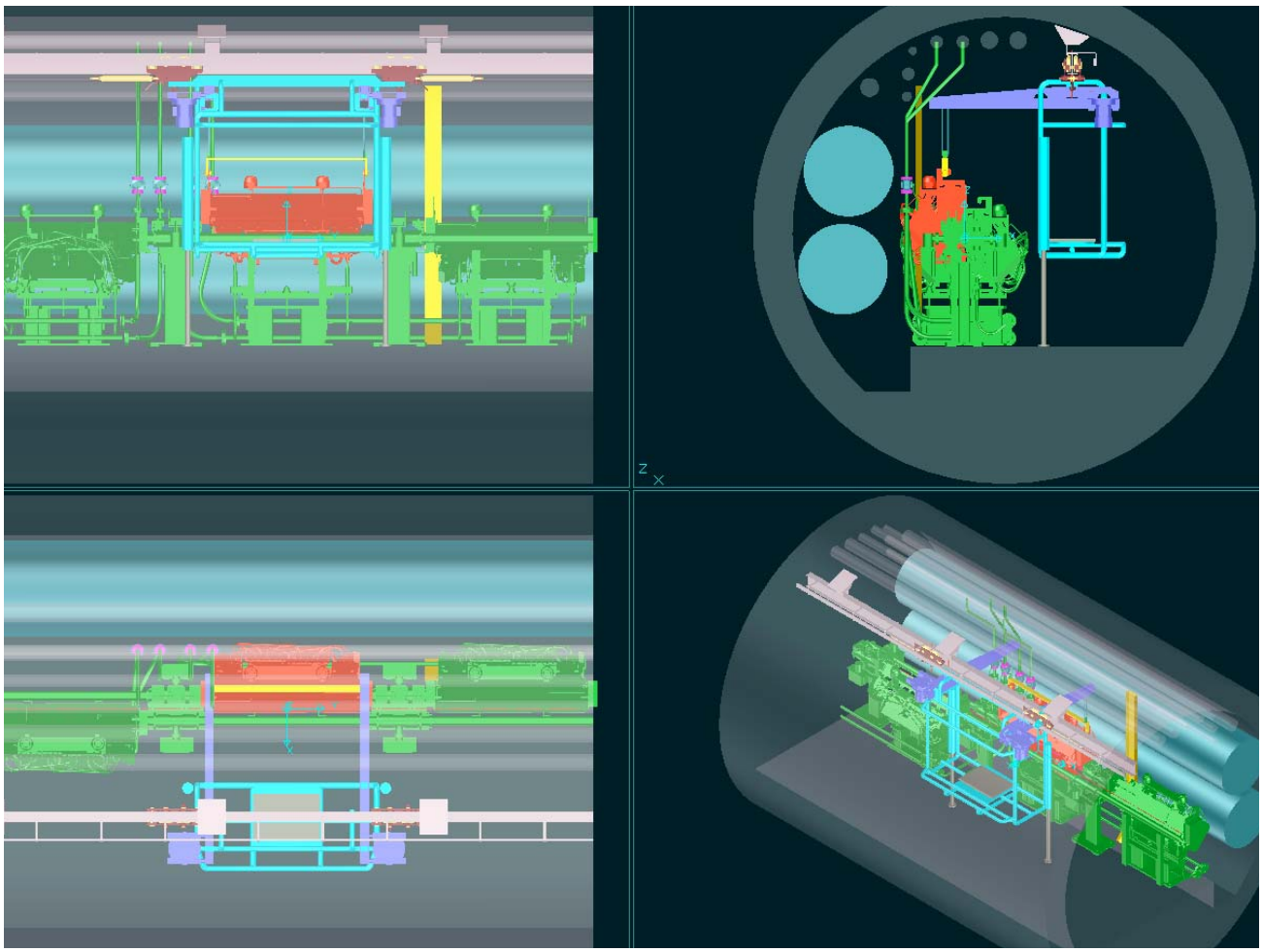


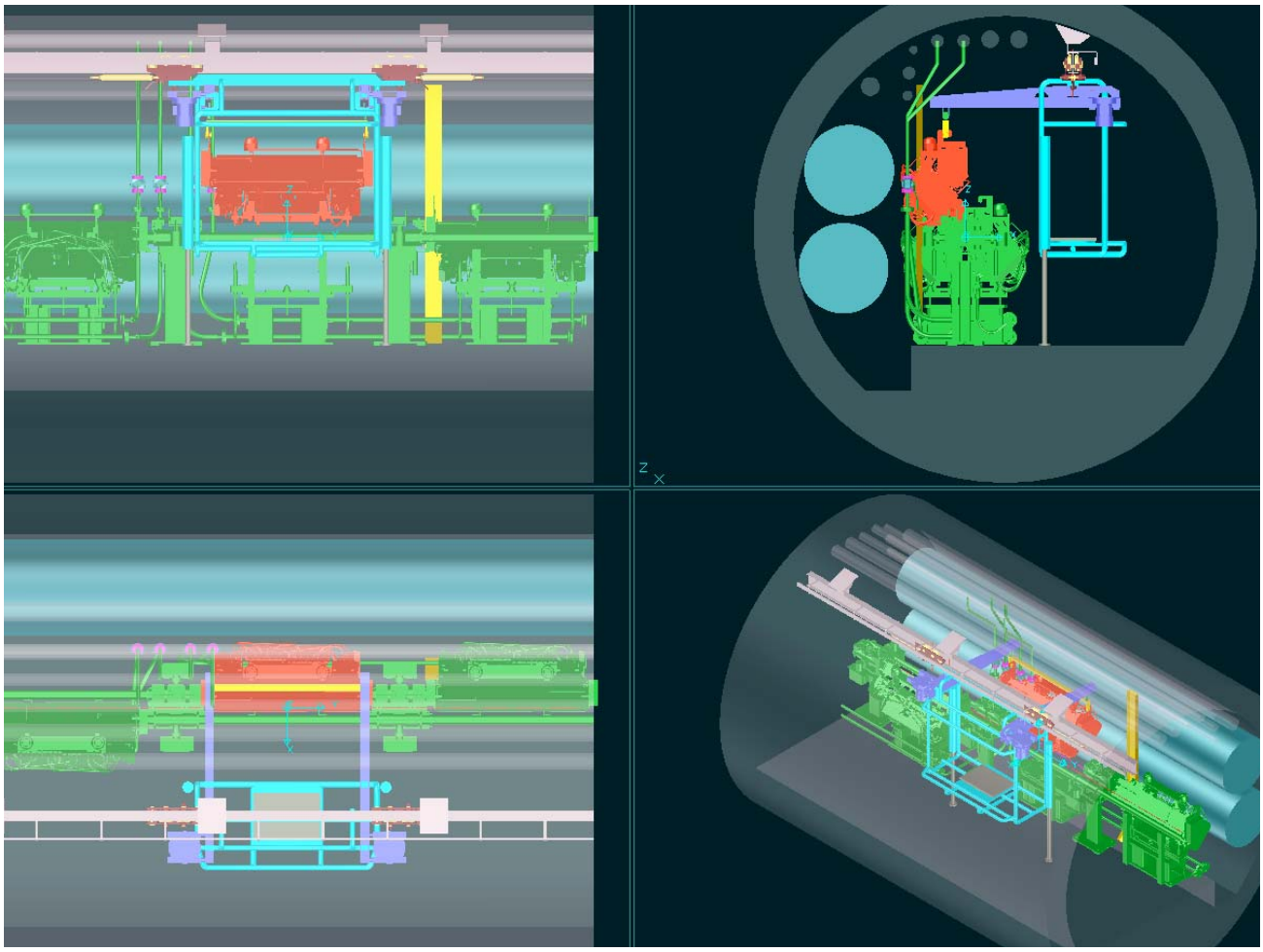


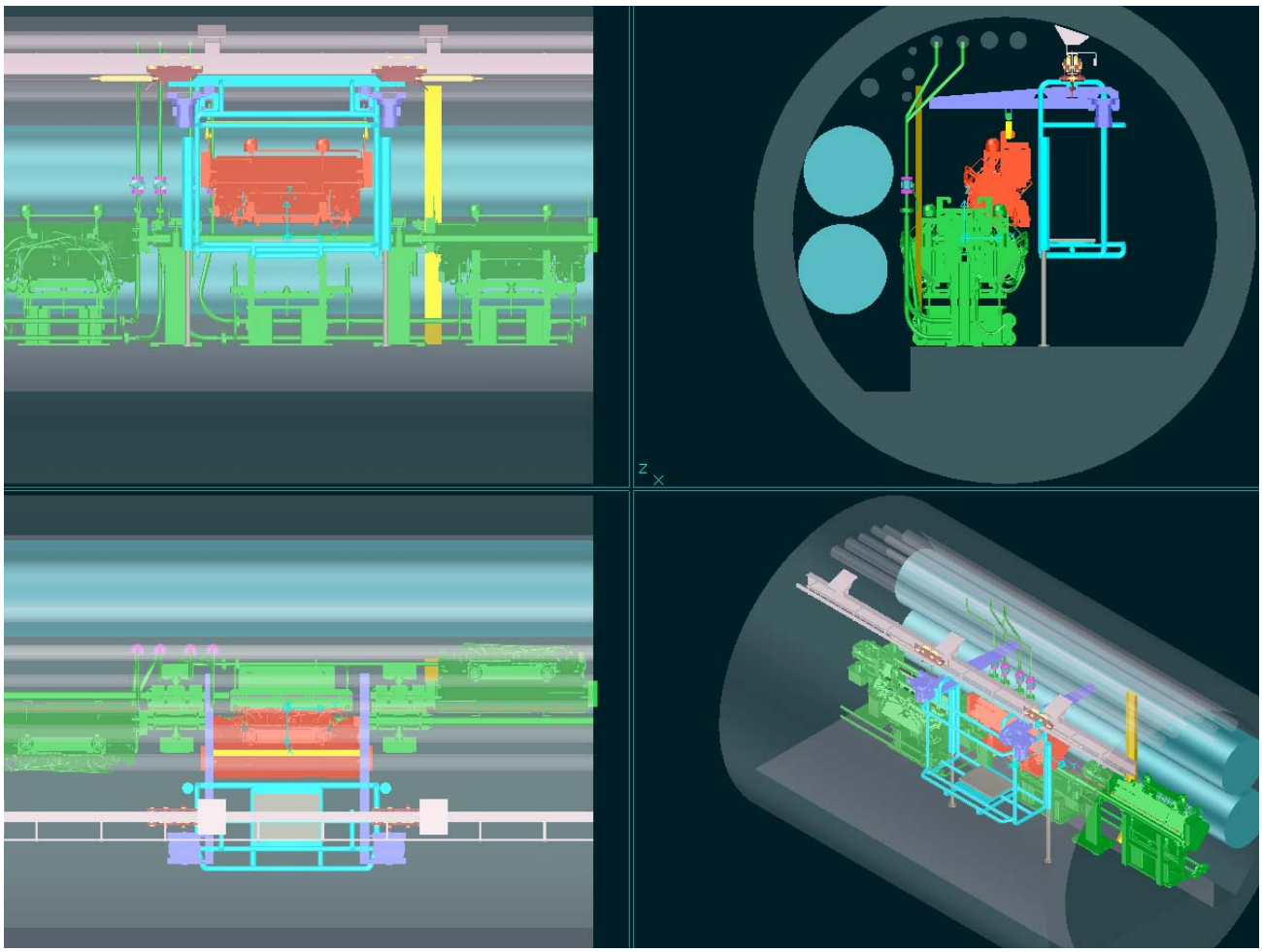


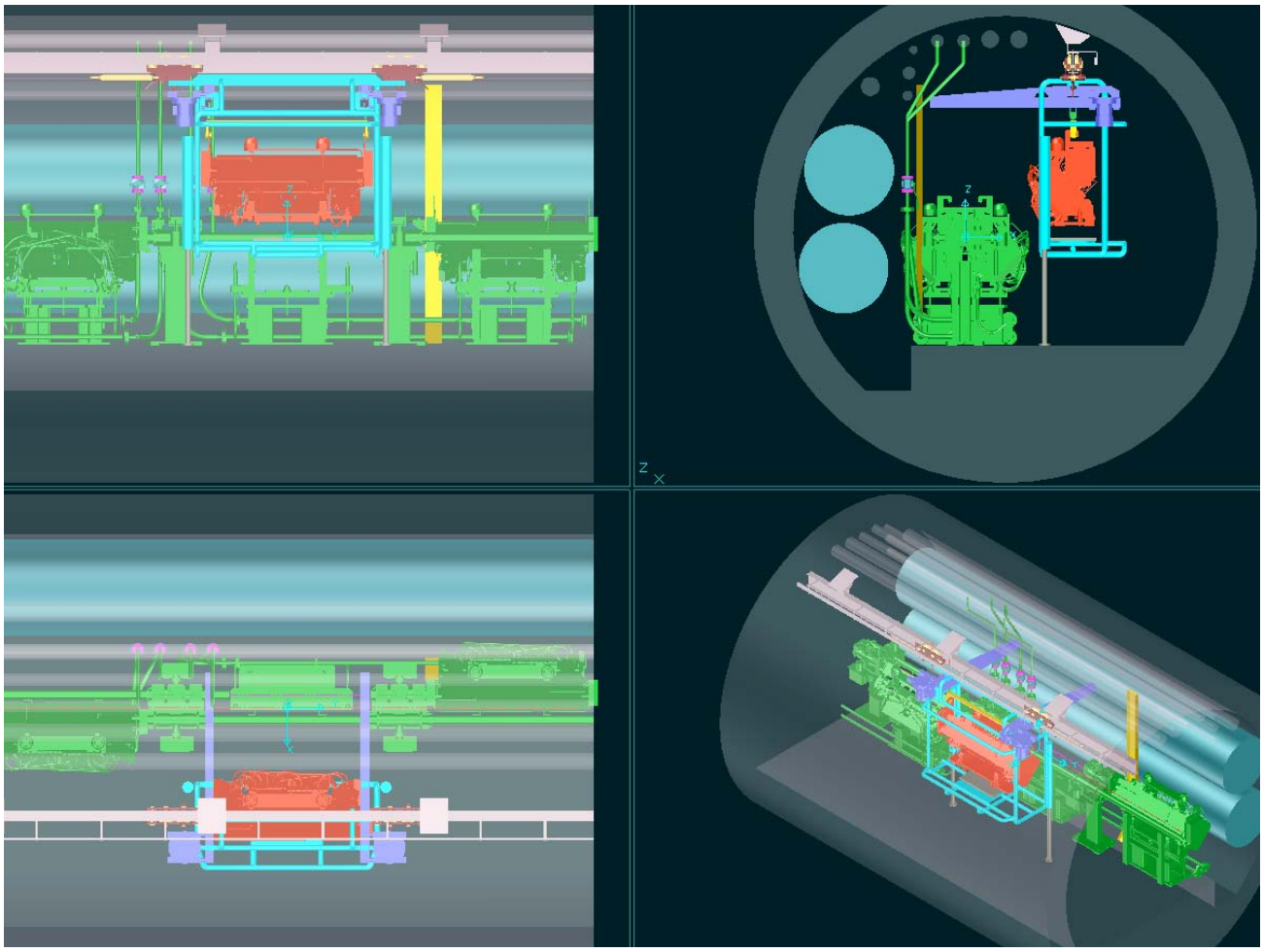


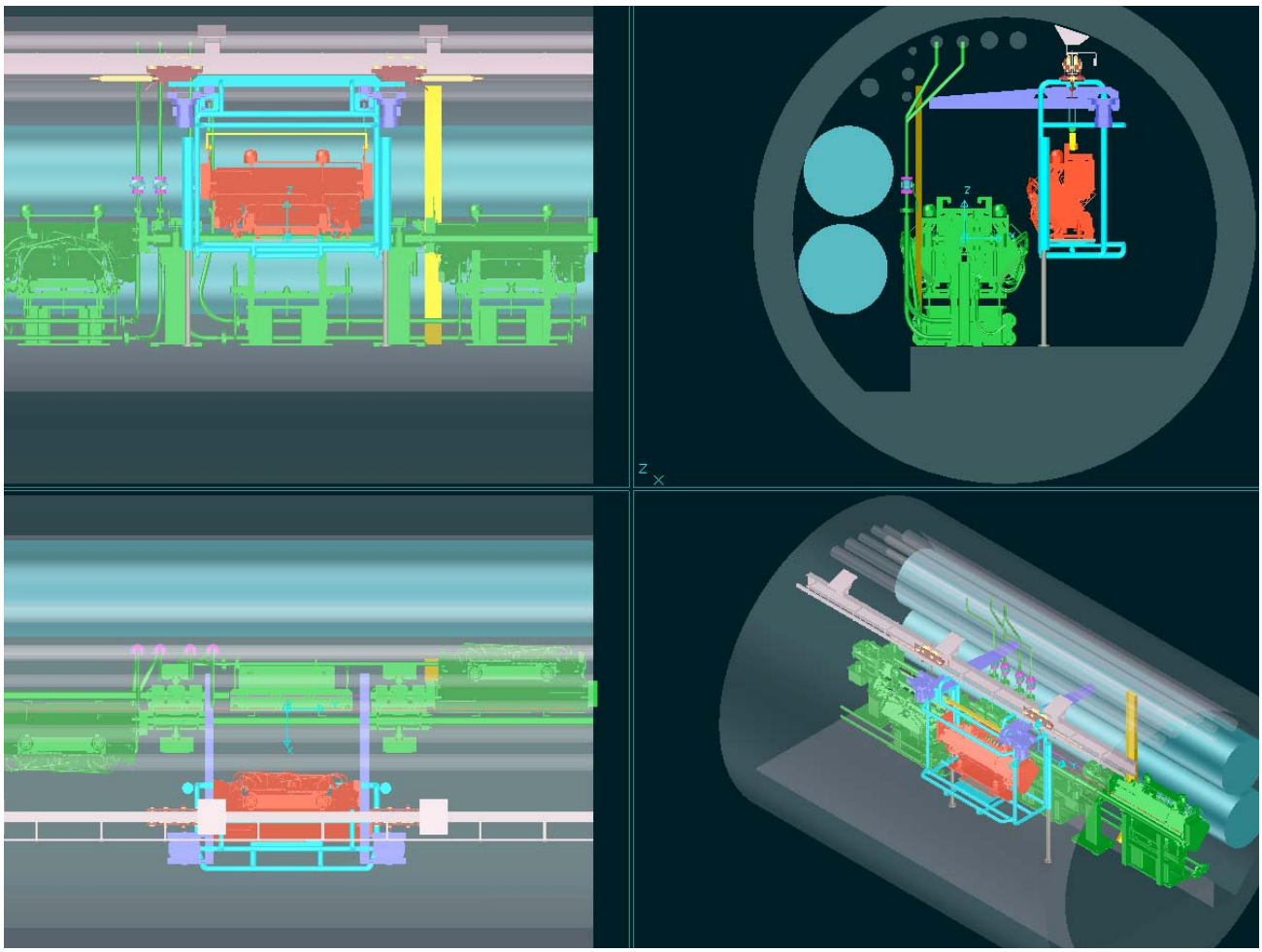


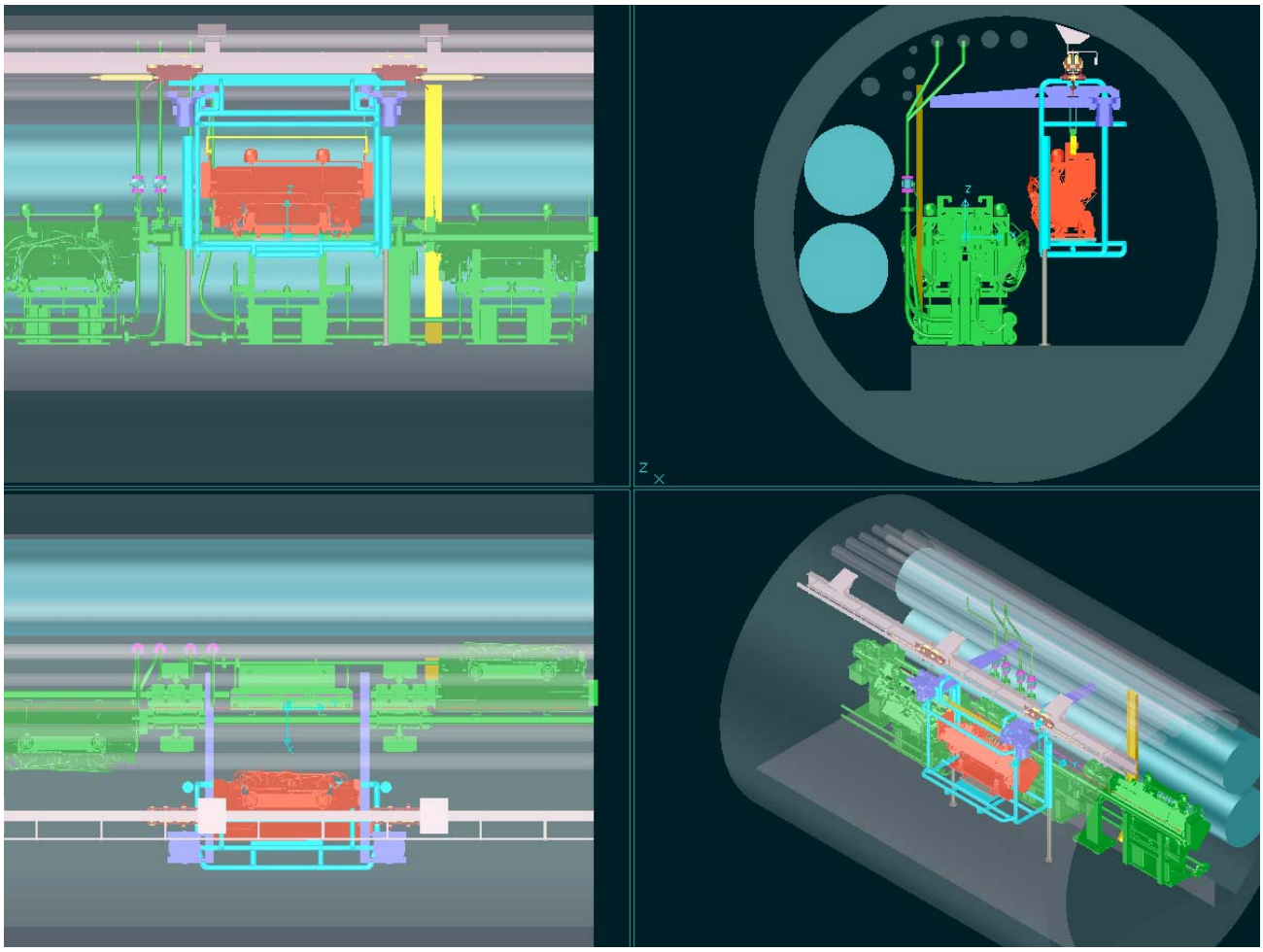


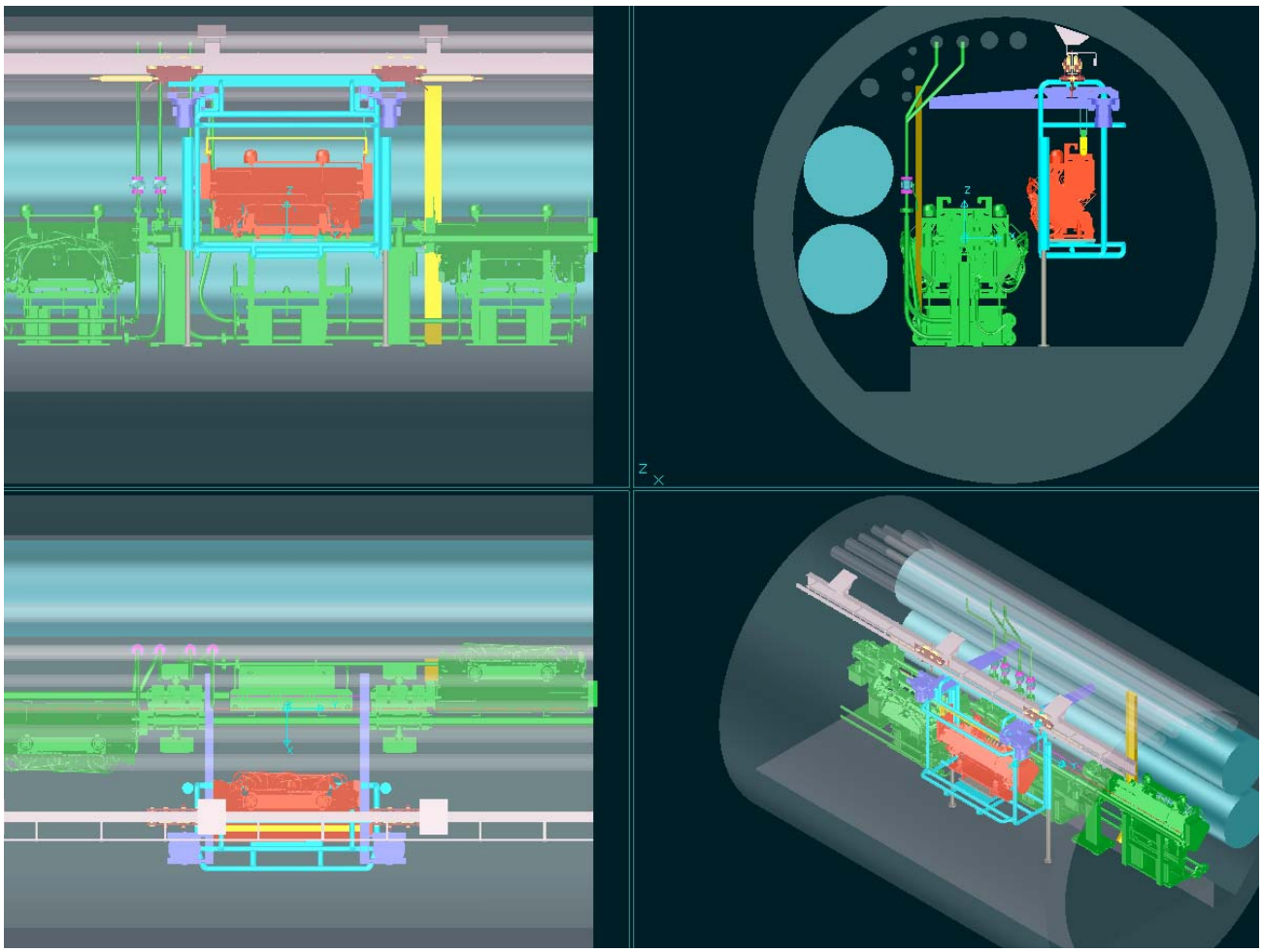


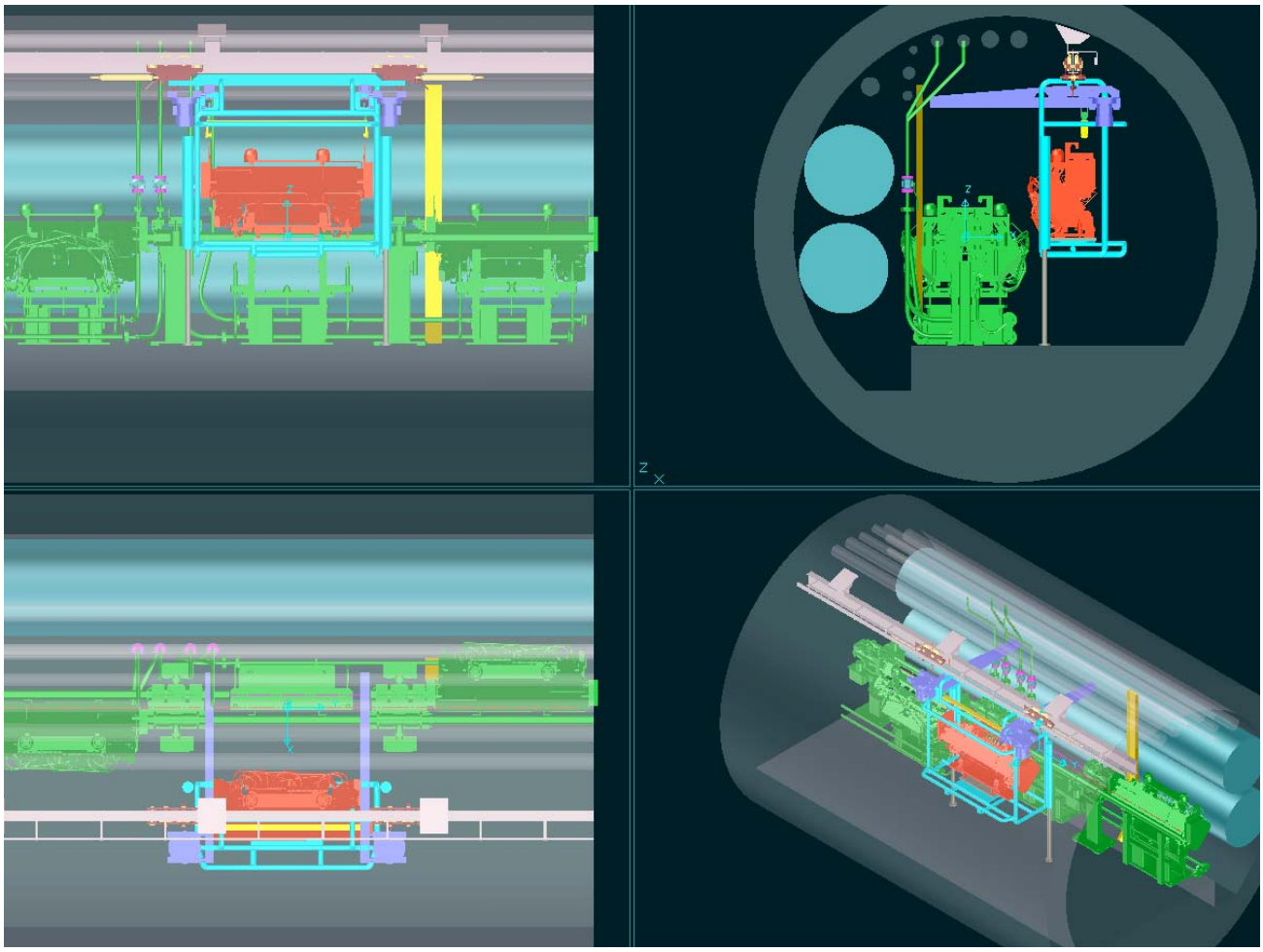


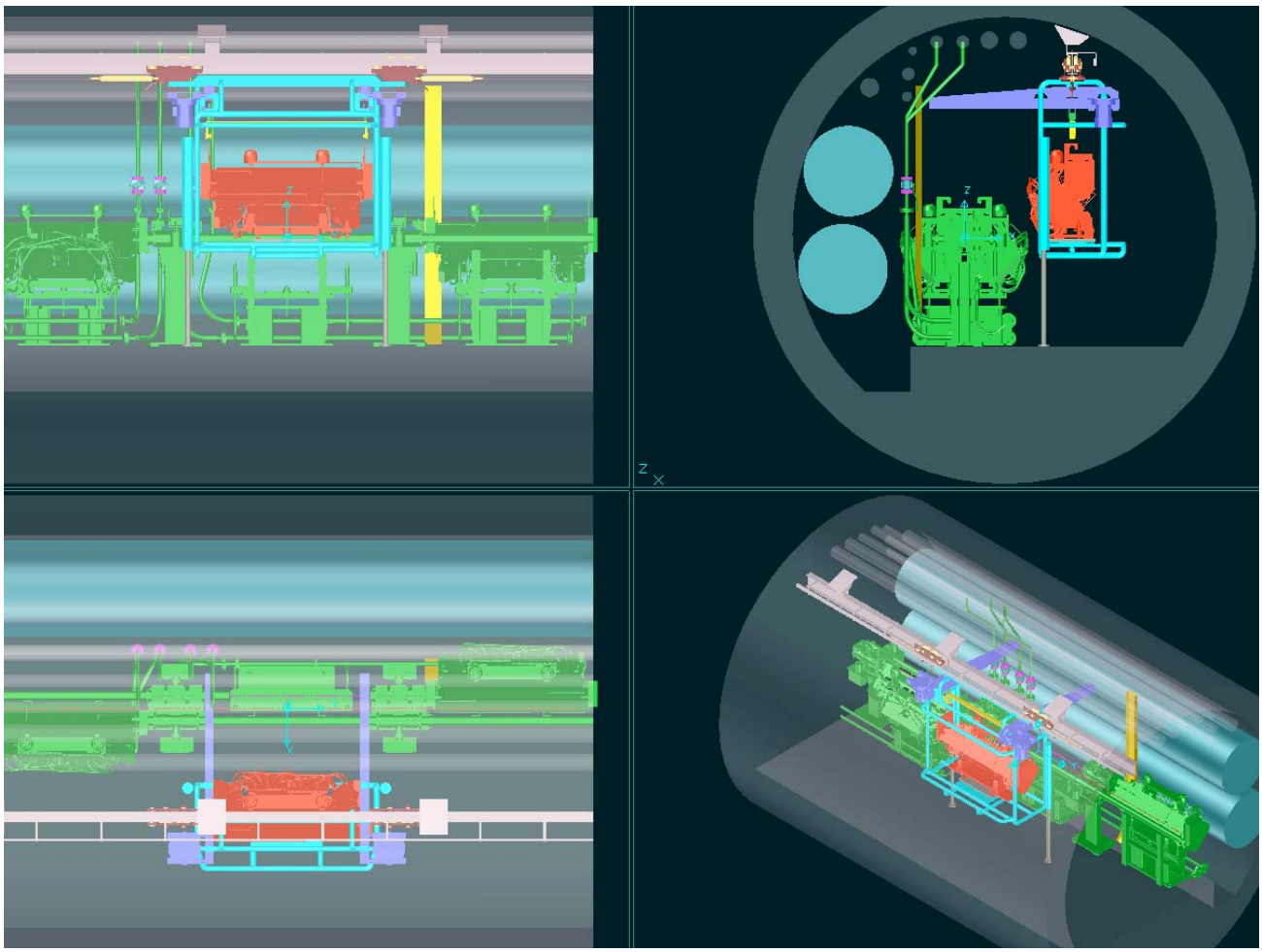


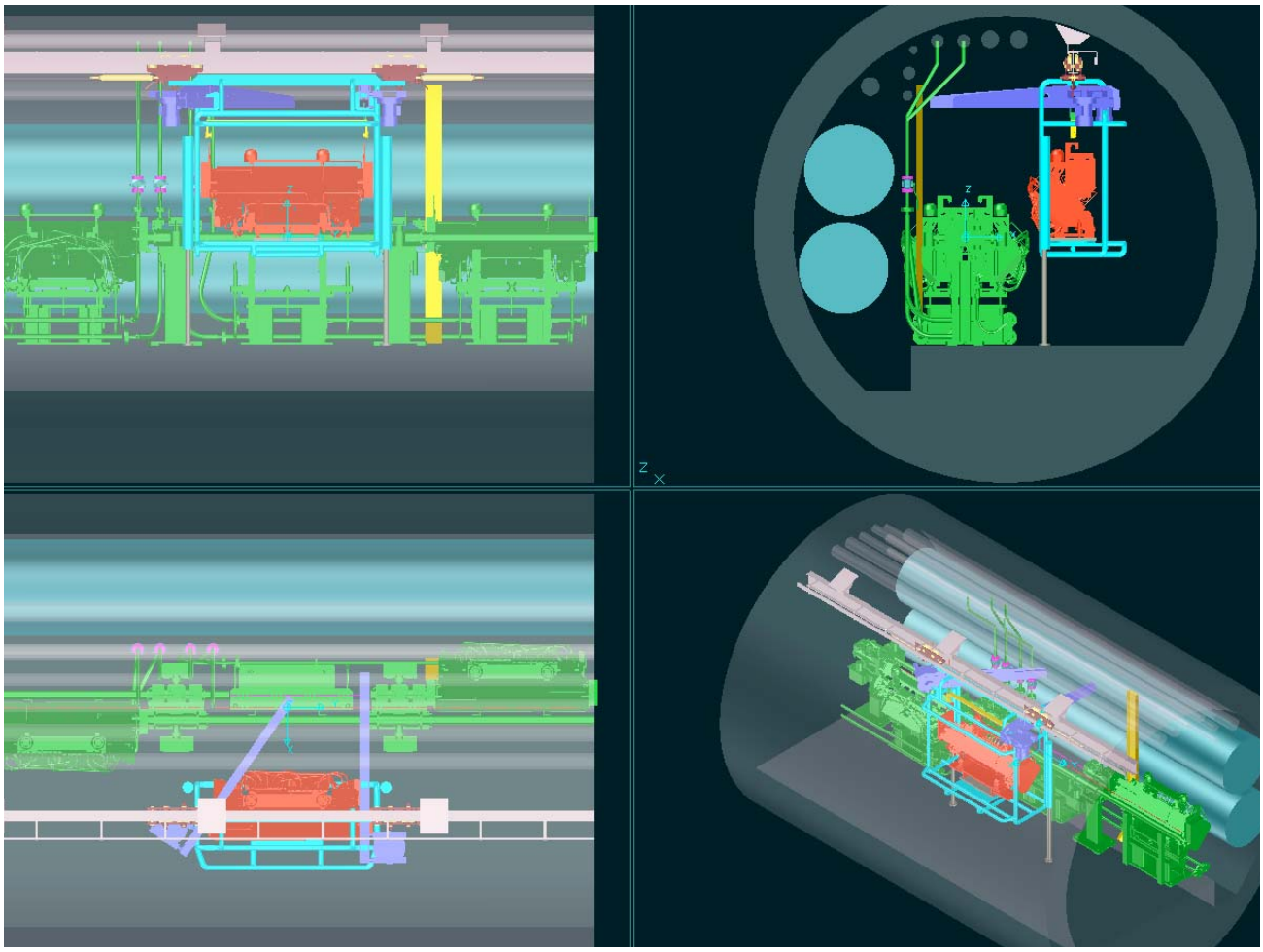


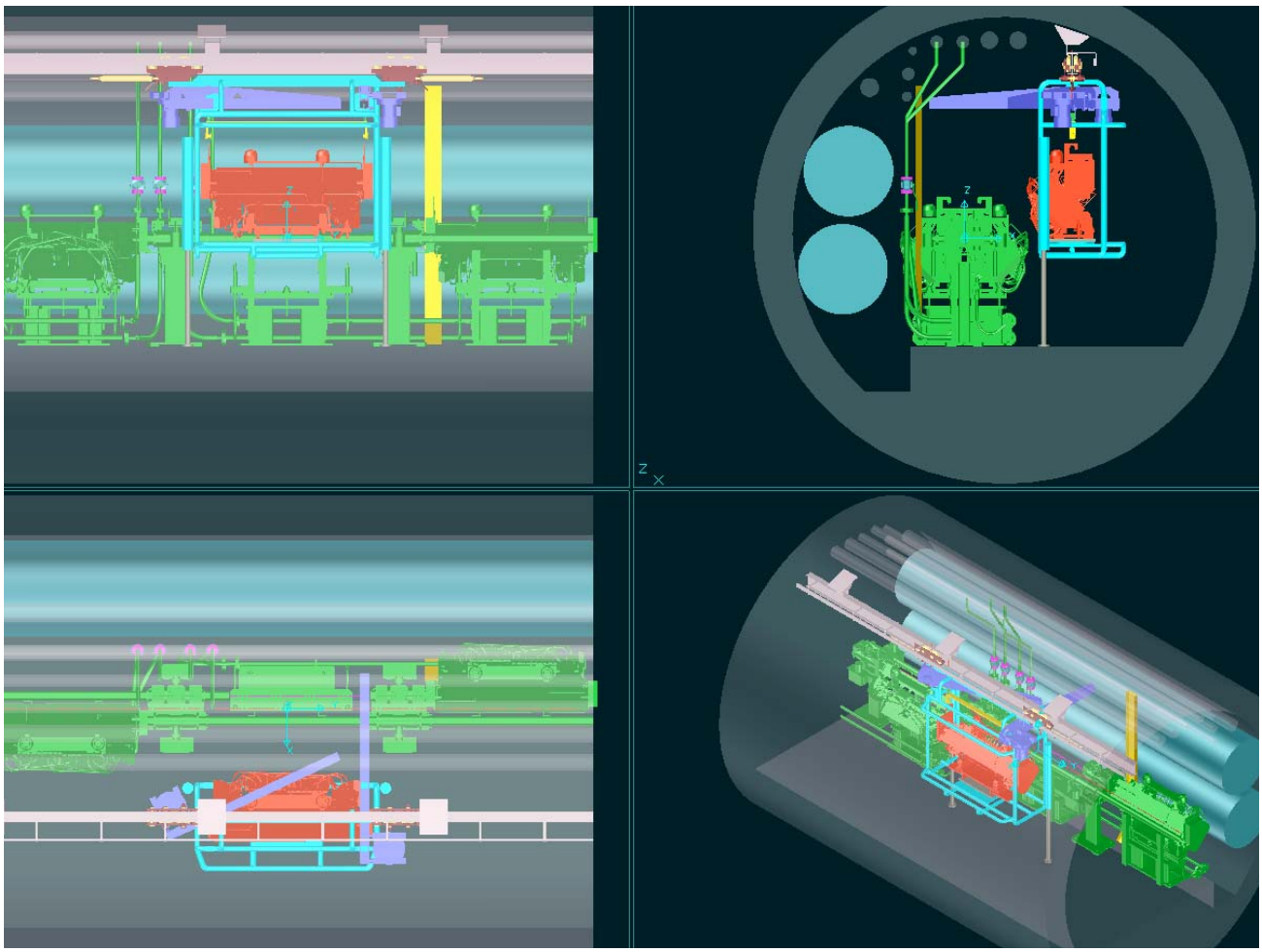


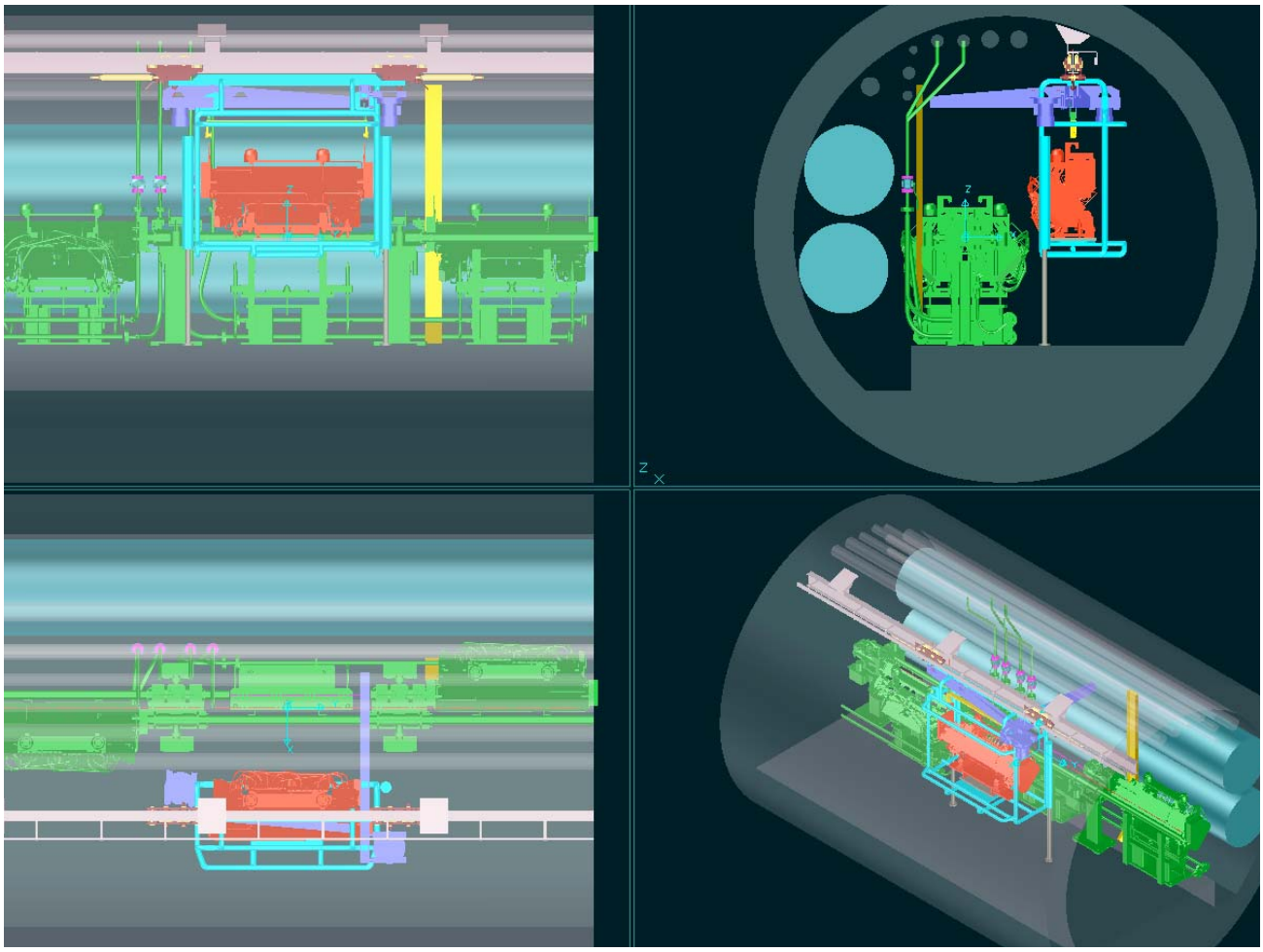


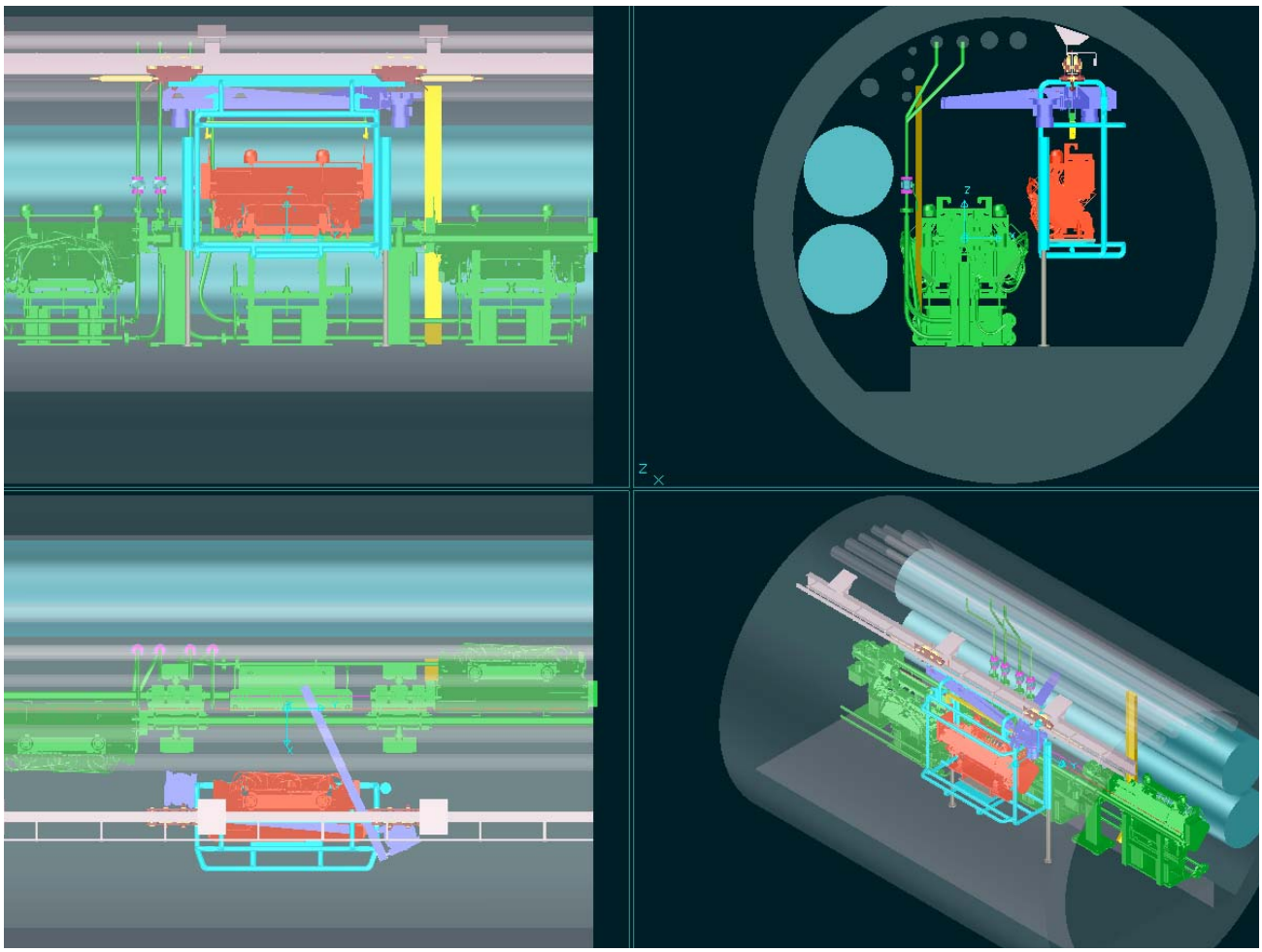


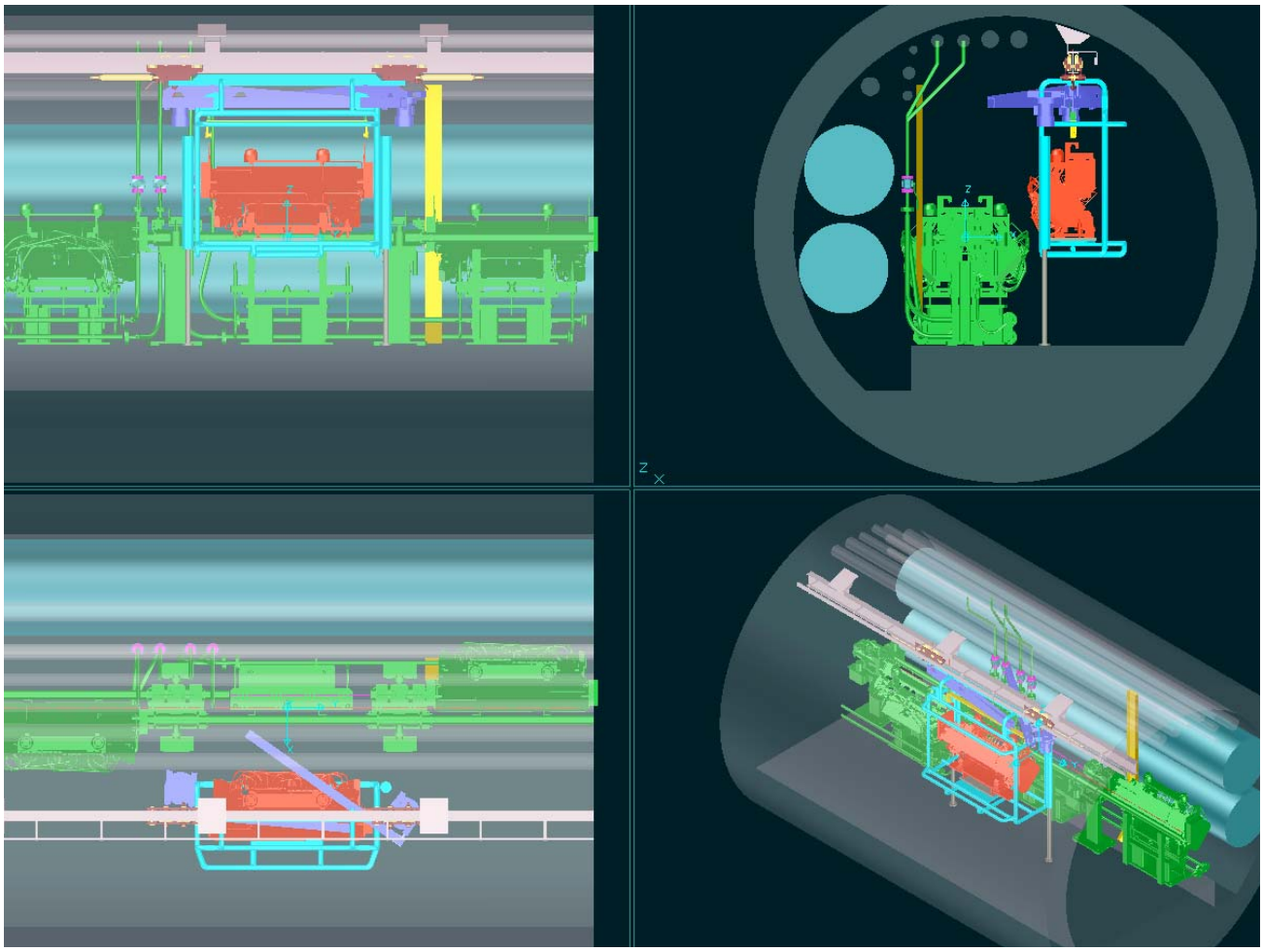


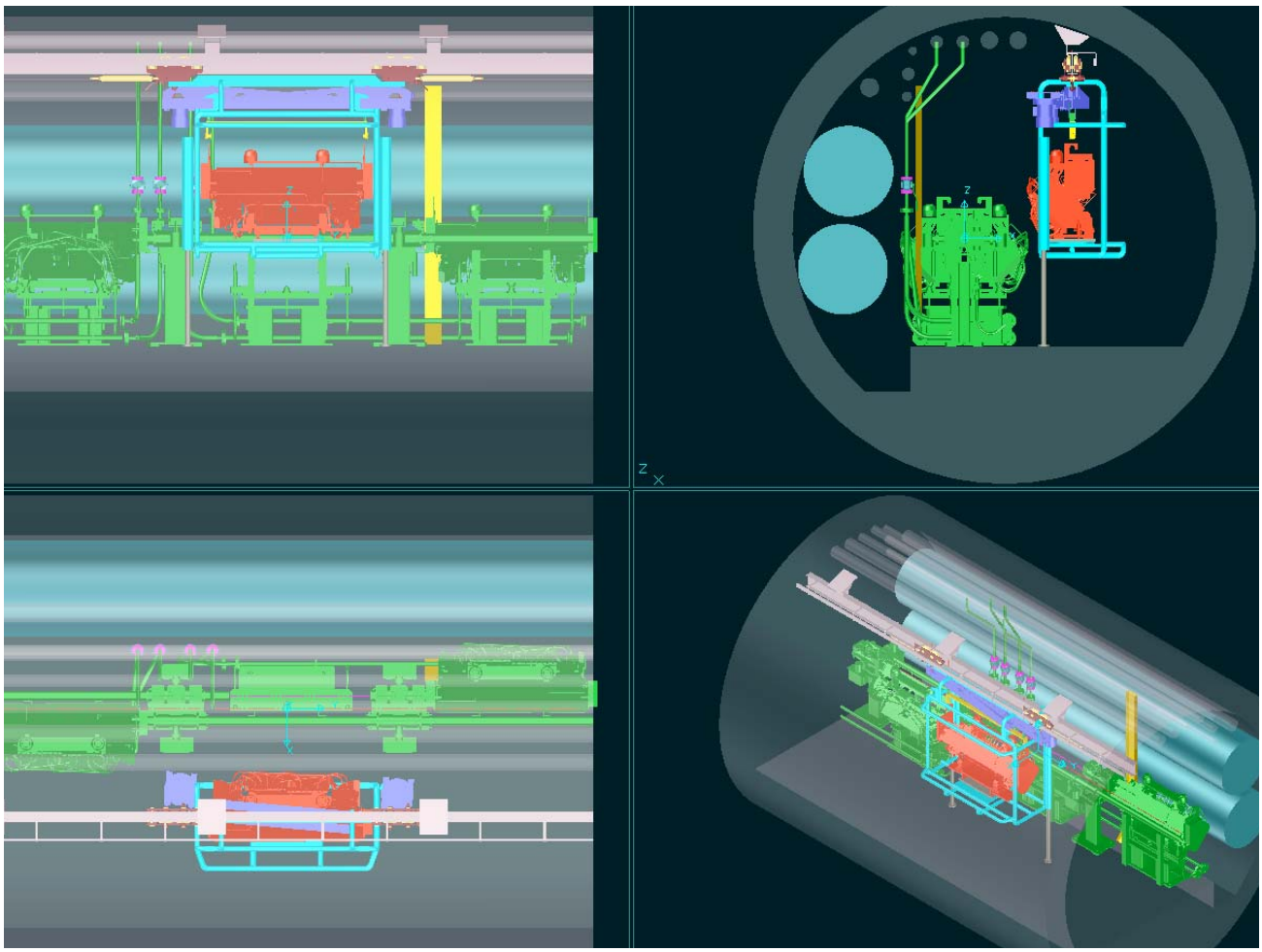


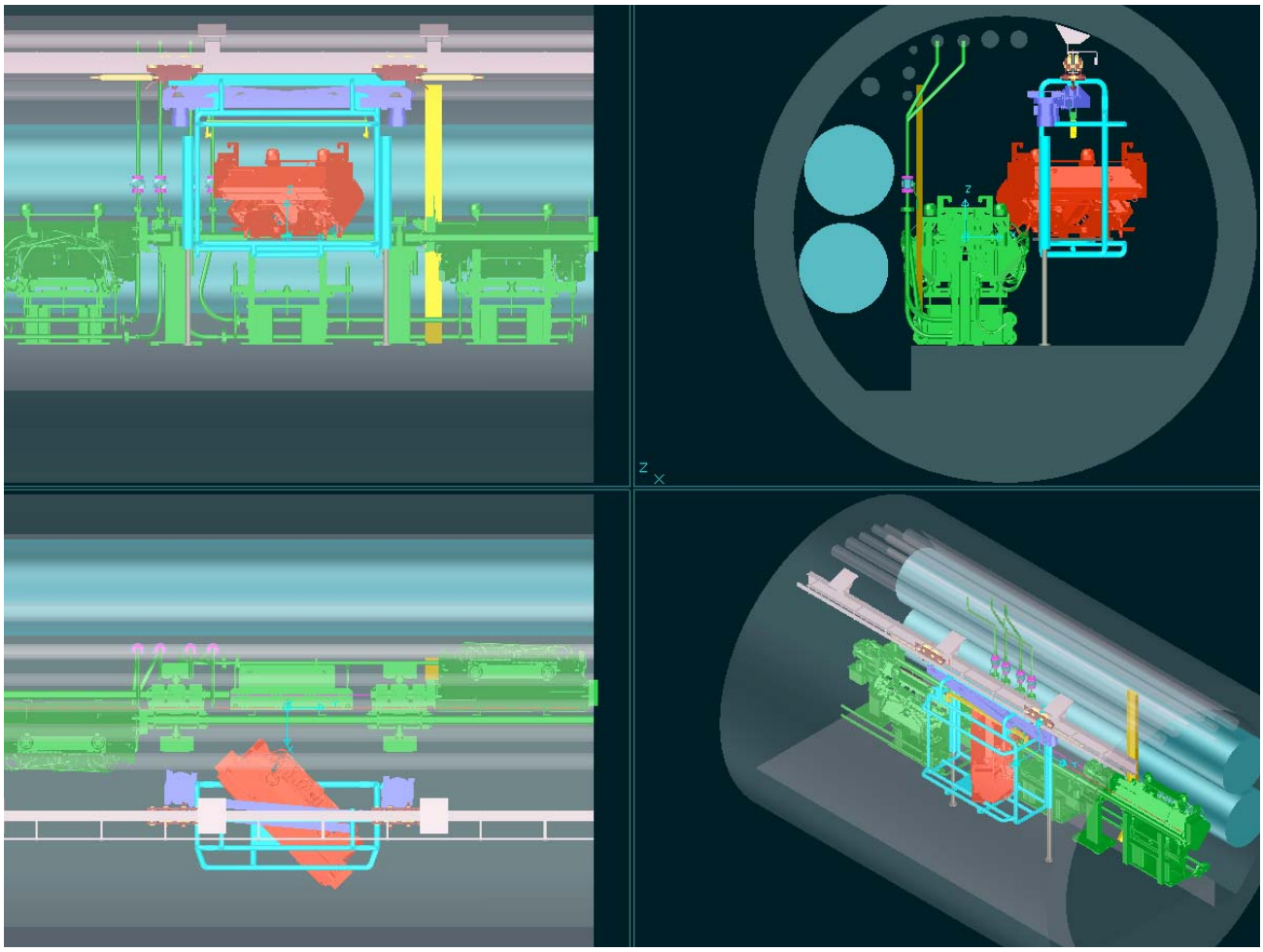


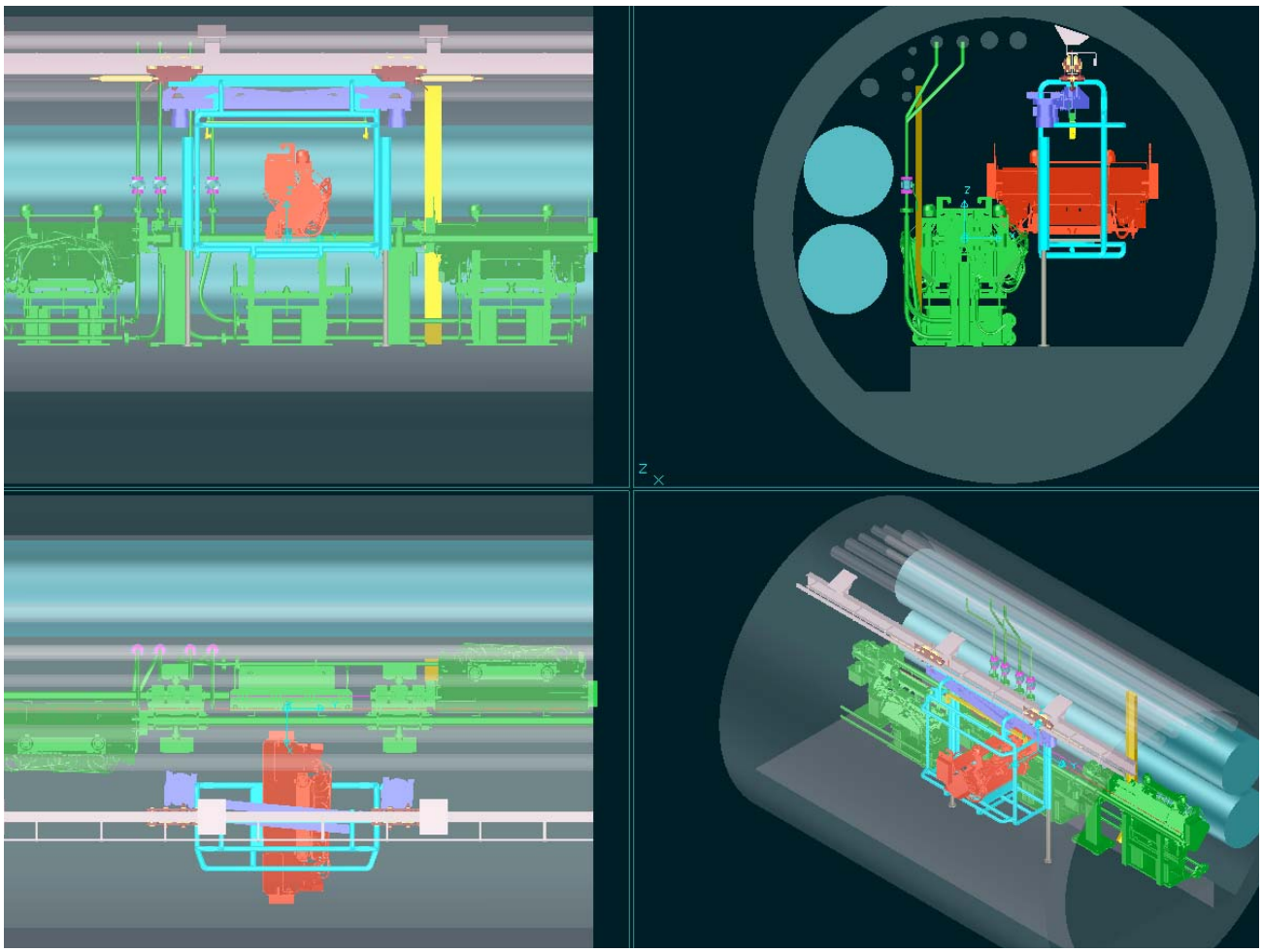


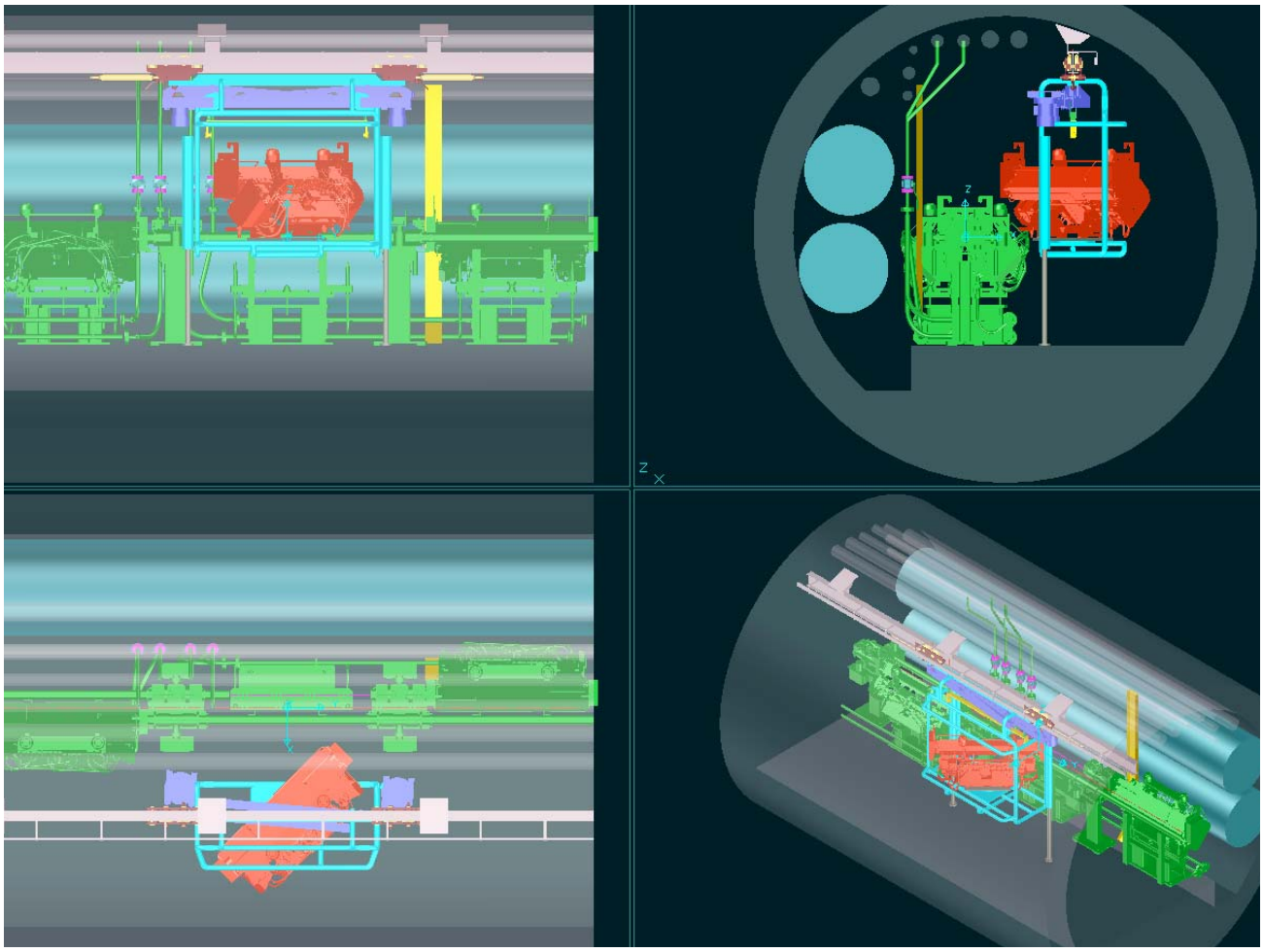


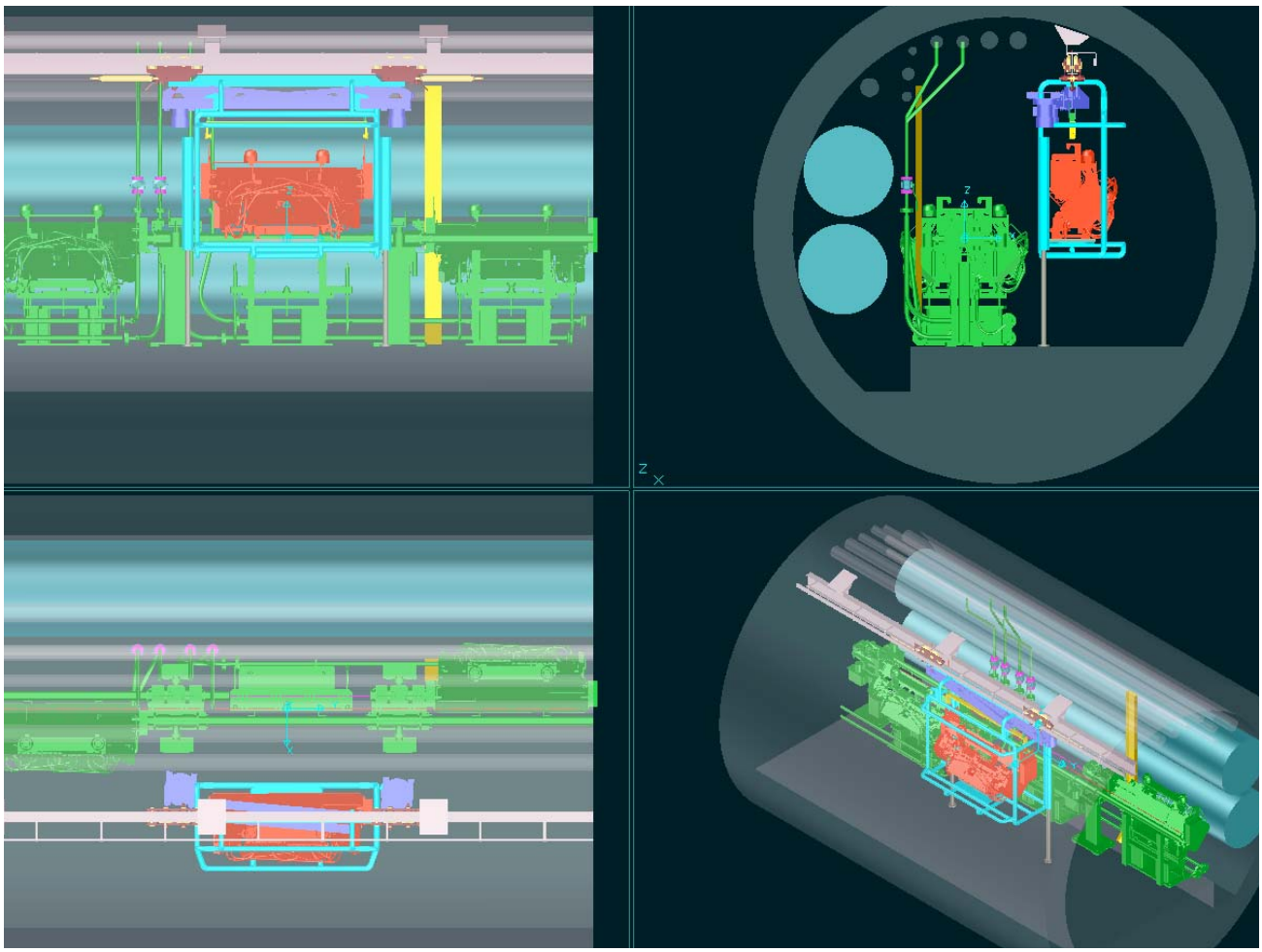


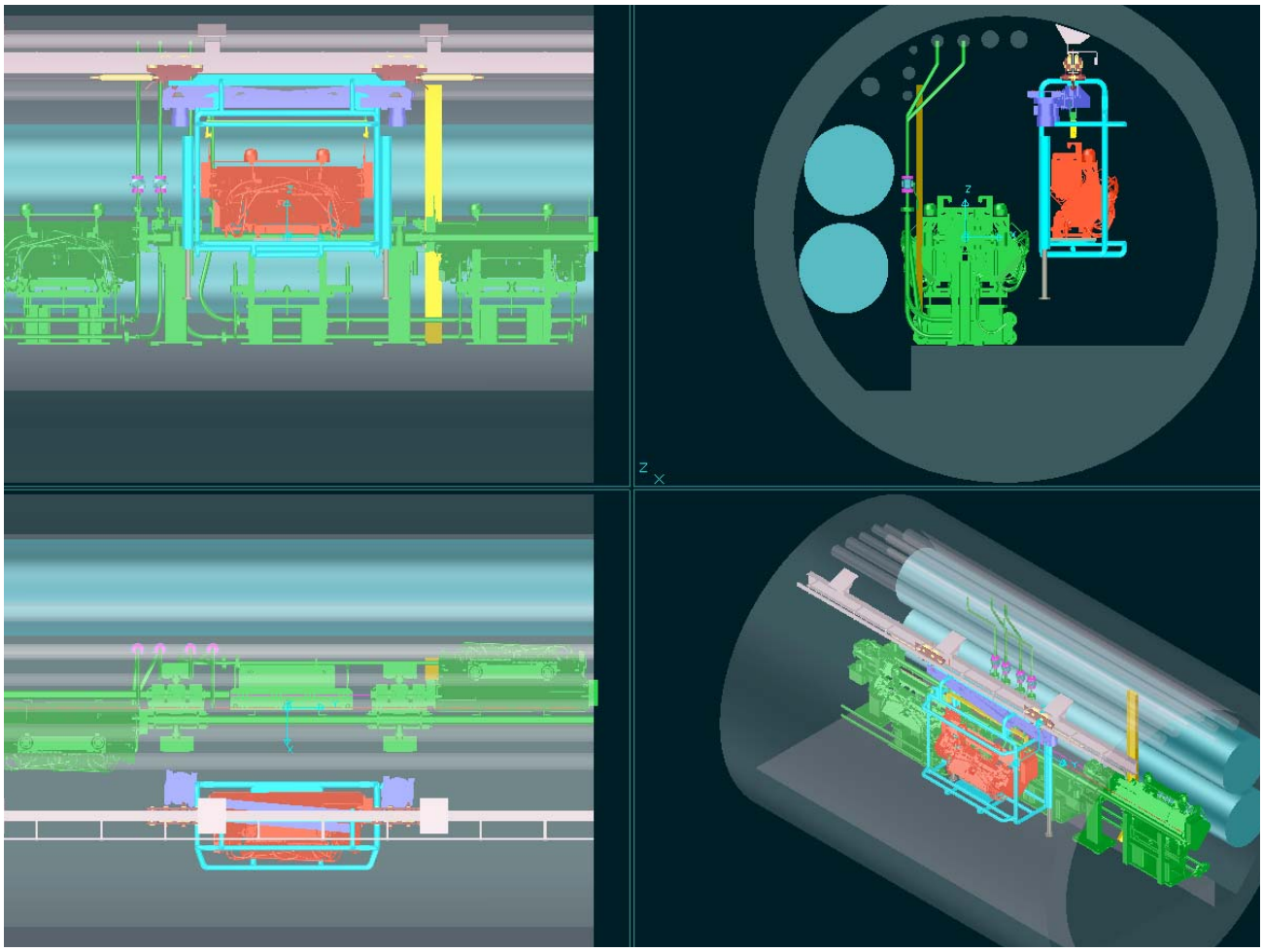


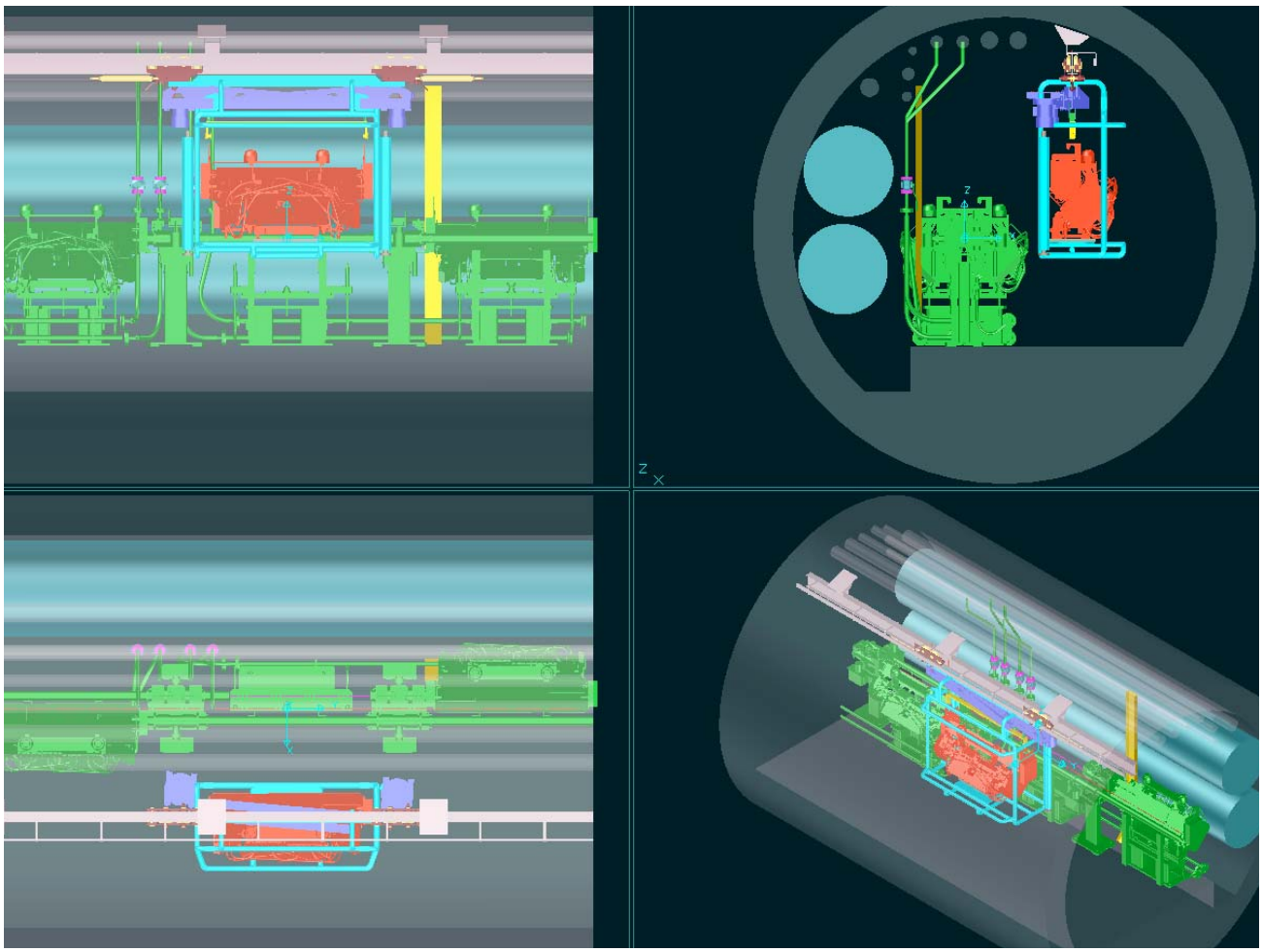


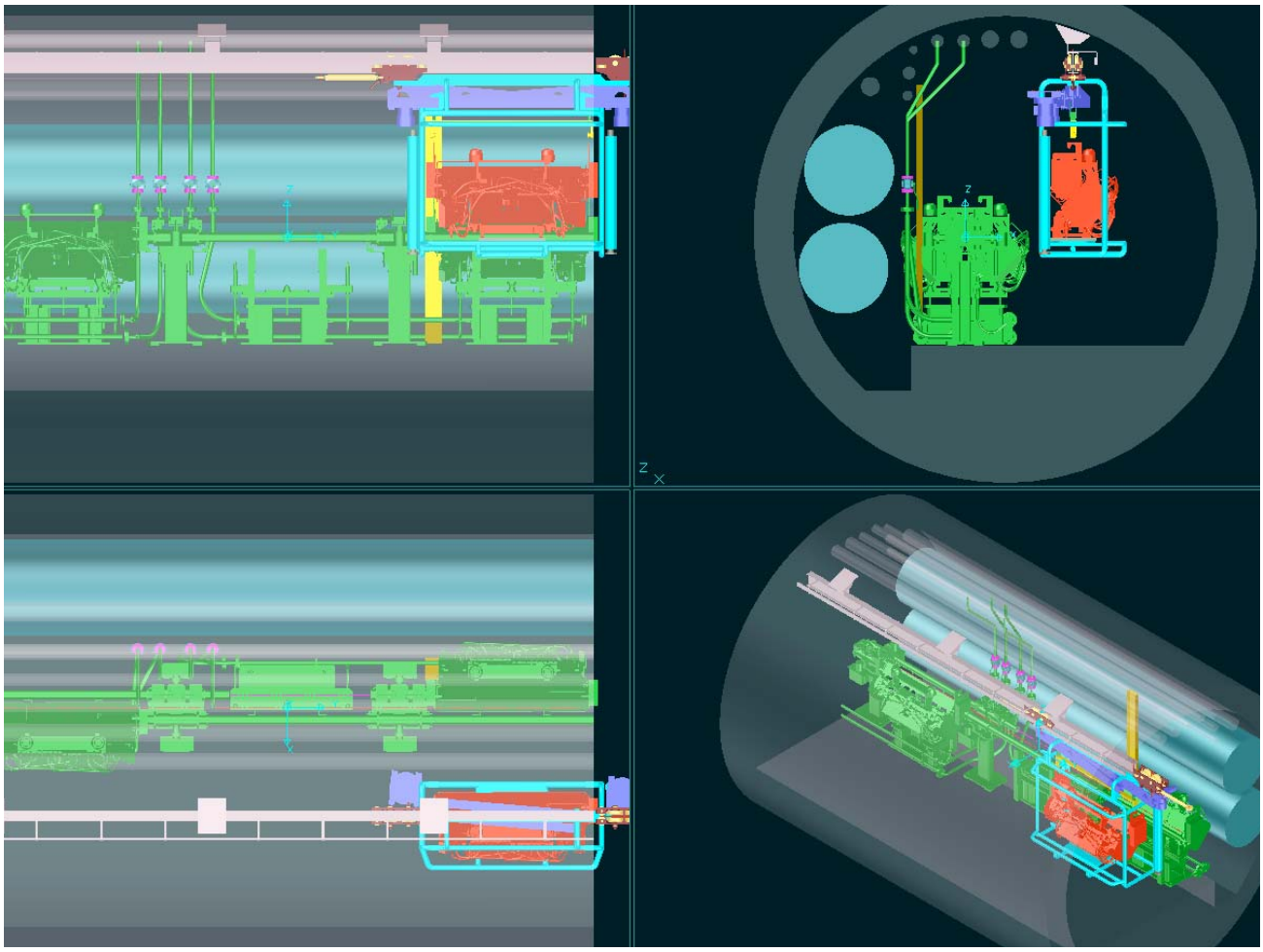


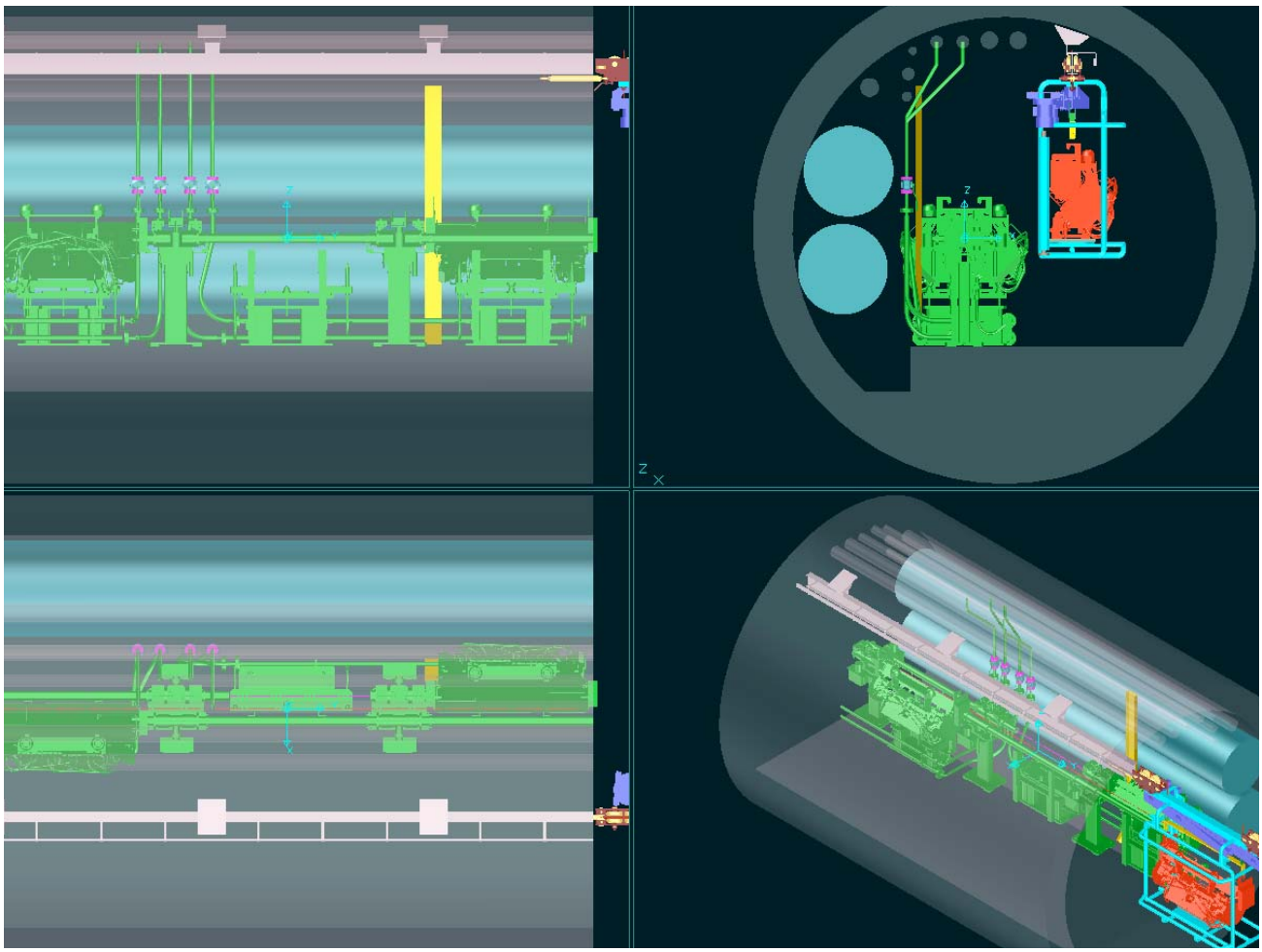












Conclusions from studies and tests to-date

- Remote control/communication demonstrated by TIM
- Remote installation and removal of collimators appears feasible (more detailed design study to be carried out for higher confidence)
- Integration checks including survey scans needed
- Monorail-based solution for remote transport of collimators looks promising

4) Design and build equipment for remote handling

- Work to-date has aimed at proving feasibility, influencing design and infrastructure while still possible.
- This is still underway, but need to consider next steps…

Next stages

- Prepare mock-up area to allow development of remote survey and remote handling equipment
- Design and build handling / transport equipment according to industrial standards, consider radiation implications
- Develop modules to cover:
  - Transport and handling
  - Viewing
  - Communication etc
- Prepare complete scenario for collimator exchange including storage (repair?) area.