Preventing hUman intervention
for incrREased SAfety
in inFrastructures Emitting
ionizing radiation

PURESAFE@CERN

European Organisation
for Nuclear Research
European Laboratory
for Particle Physics

RP13: Interactive visual intervention planning in particle accelerator environments with ionizing radiation

Work conducted by ESR Thomas FABRY
and presented by CERN Supervisor Bruno FERAL

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PhD Support

Laboratoire SYMME, Système et Matériaux pour la Mécatronique (Annecy):

Laurent TABOUROT & Christian BRAESCH

CERN, European Organization for Nuclear Research:

Chris THEIS & Bruno FERAL

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Purpose of the study

The purpose of this project is to deliver a set of software tools and a methodology for:

-3D simulation for interventions in radioactive environment

-**On screen visualization of dose rates to which workers are exposed and individual and collective doses received**

-Merging radiation maps (from *Fluka* & data from measurements) with CATIA 3D models

The deliverables:

The resulting software and methodology will be focused on *complex interventions in radioactive environment*, in order *to work out an optimal intervention plan in the spirit of an ALARA approach*.

General Principles of Radiation Protection

1) **Justification:**
   any exposure of persons to ionizing radiation has to be justified

2) **Limitation**
   the personal doses have to be kept below the legal limits

3) **Optimization**
   the personal doses and collective doses have to be kept as low as reasonable achievable (ALARA)

ALARA
As Low As Reasonably Achievable

Starts already during at the ***design phase:***

- Design the components for optimised maintenance and repair (imagine yourself maintaining a radioactive component)
- Design the whole facility for optimised maintenance and repair (optimised lay-out, space, cranes, easy access to equipment, etc.)
- Consider remote handling as an option

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“complex interventions in radioactive environment”

Why ?

At CERN we work in tunnels and caverns…

- Access for people and equipments can be complicated

- Due to lack of space, we work very closely to the radioactive equipments

- Storing and transport is very often difficult

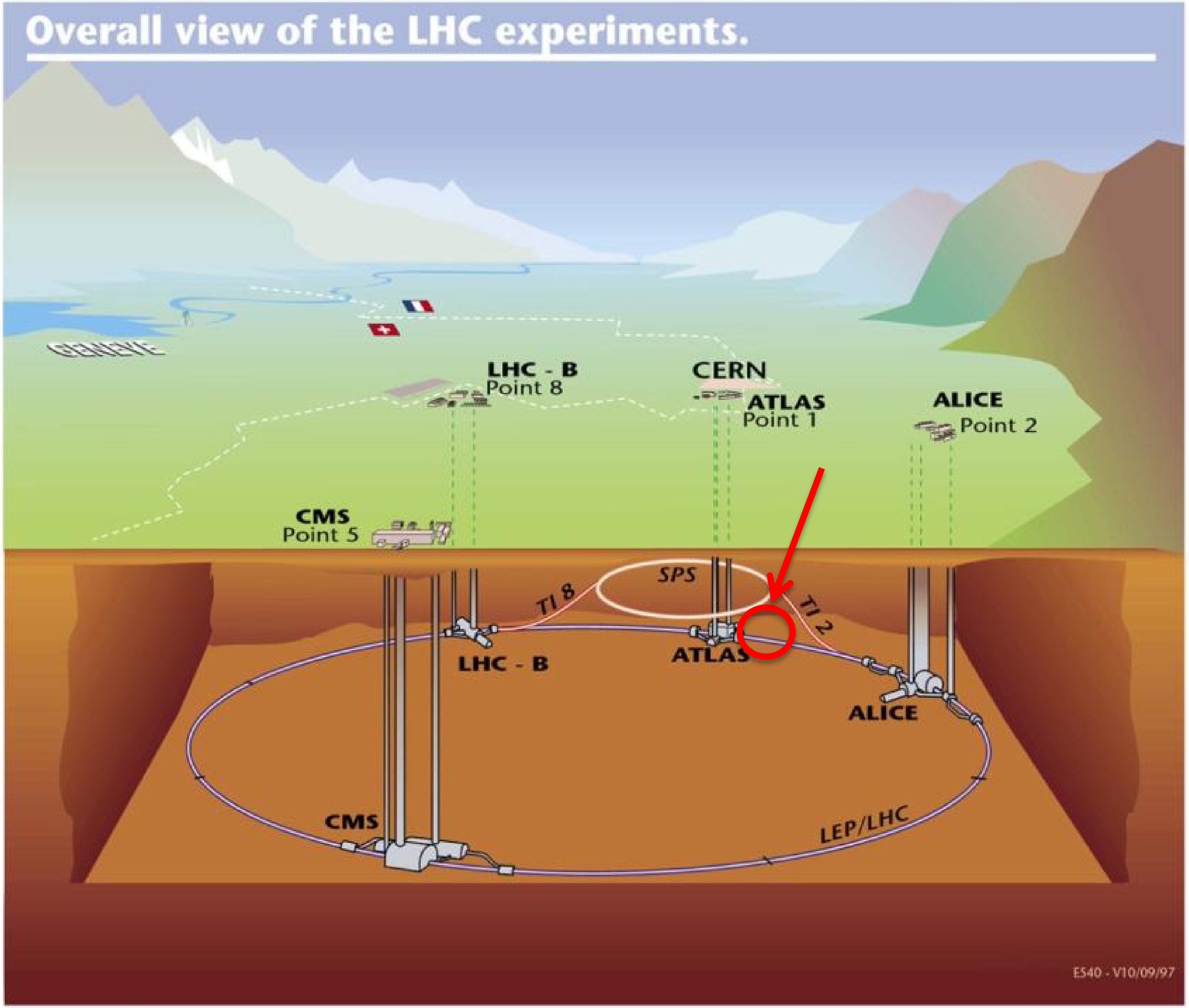
→ We need careful preparation and training

3 examples of real situations @ CERN

- Collimator exchange
- TAN mini crane
- ISOLDE Robots

Example 1:
TAN mini crane

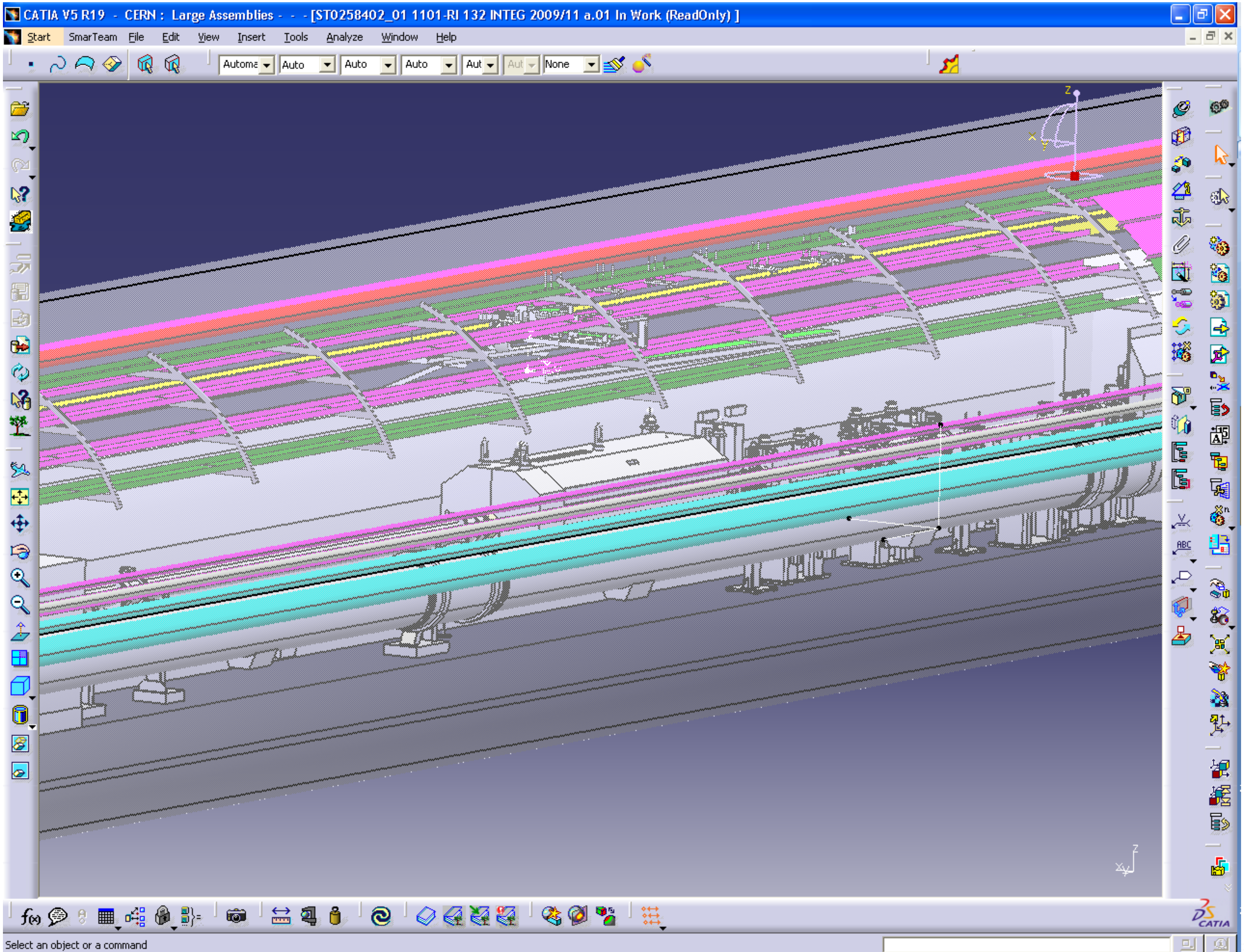
The need: - Recovery scenarios



Overall view of the LHC experiments.
GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
ES40 - V10/09/97

The CERN PDM: ENOVIA SMARTEAM

The CERN CAD system: CATIA V5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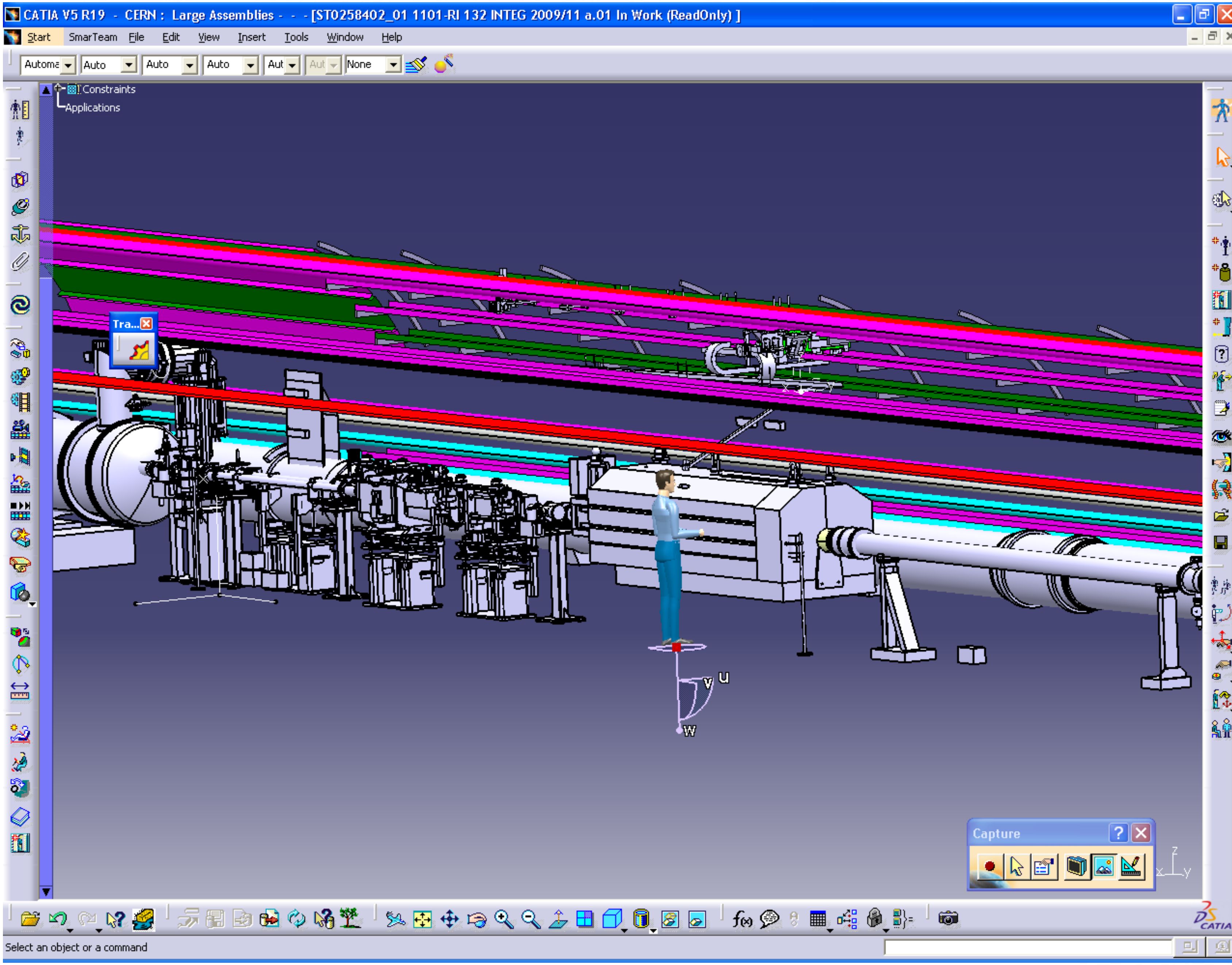
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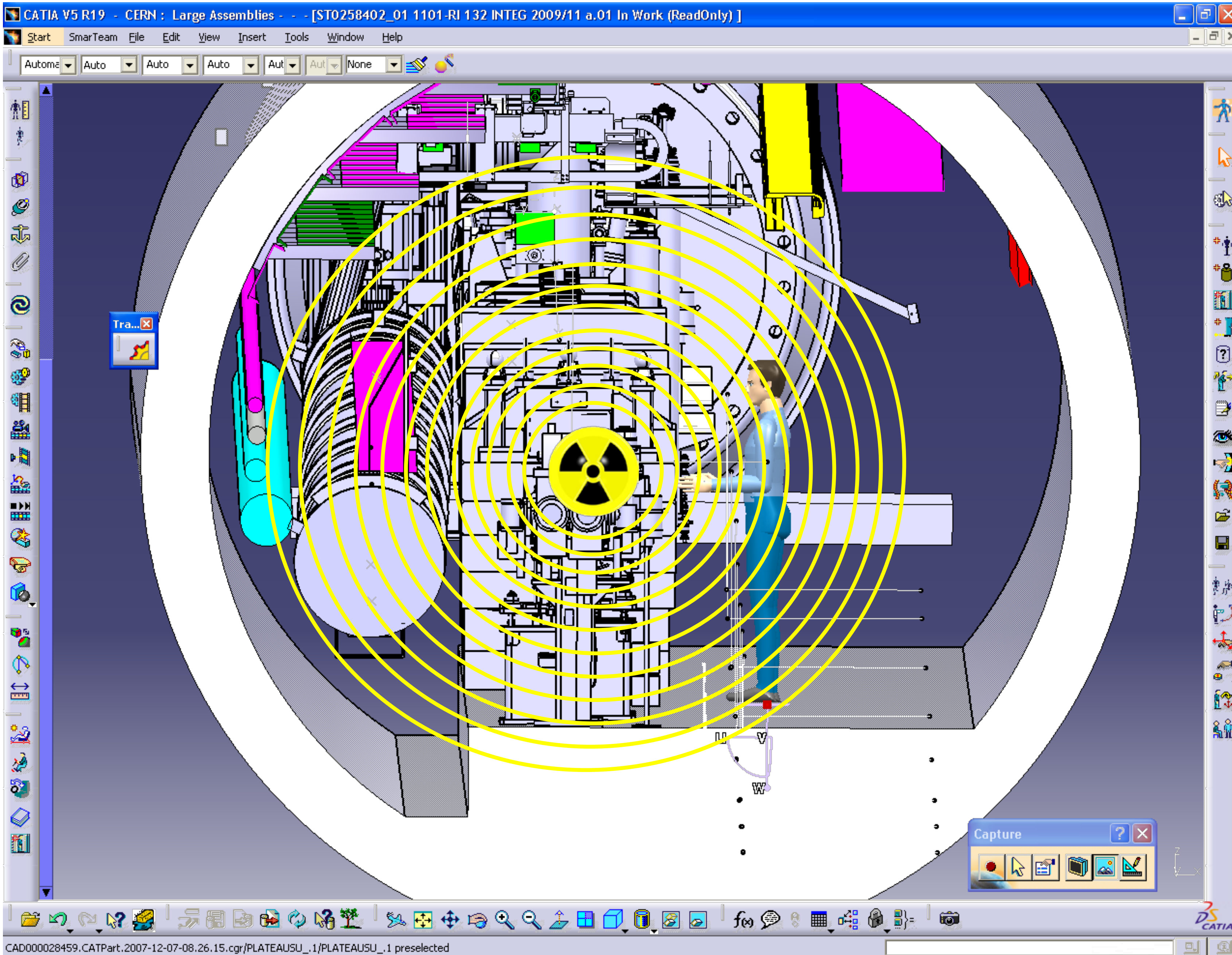
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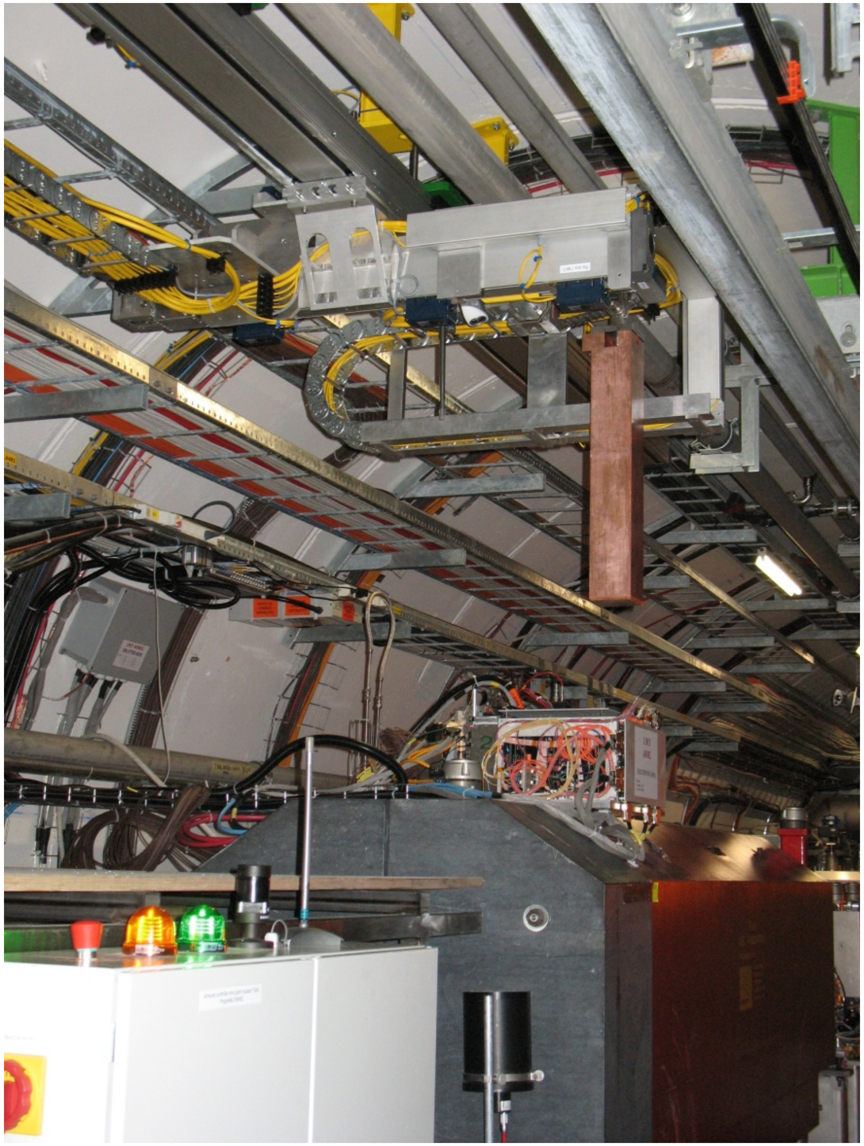
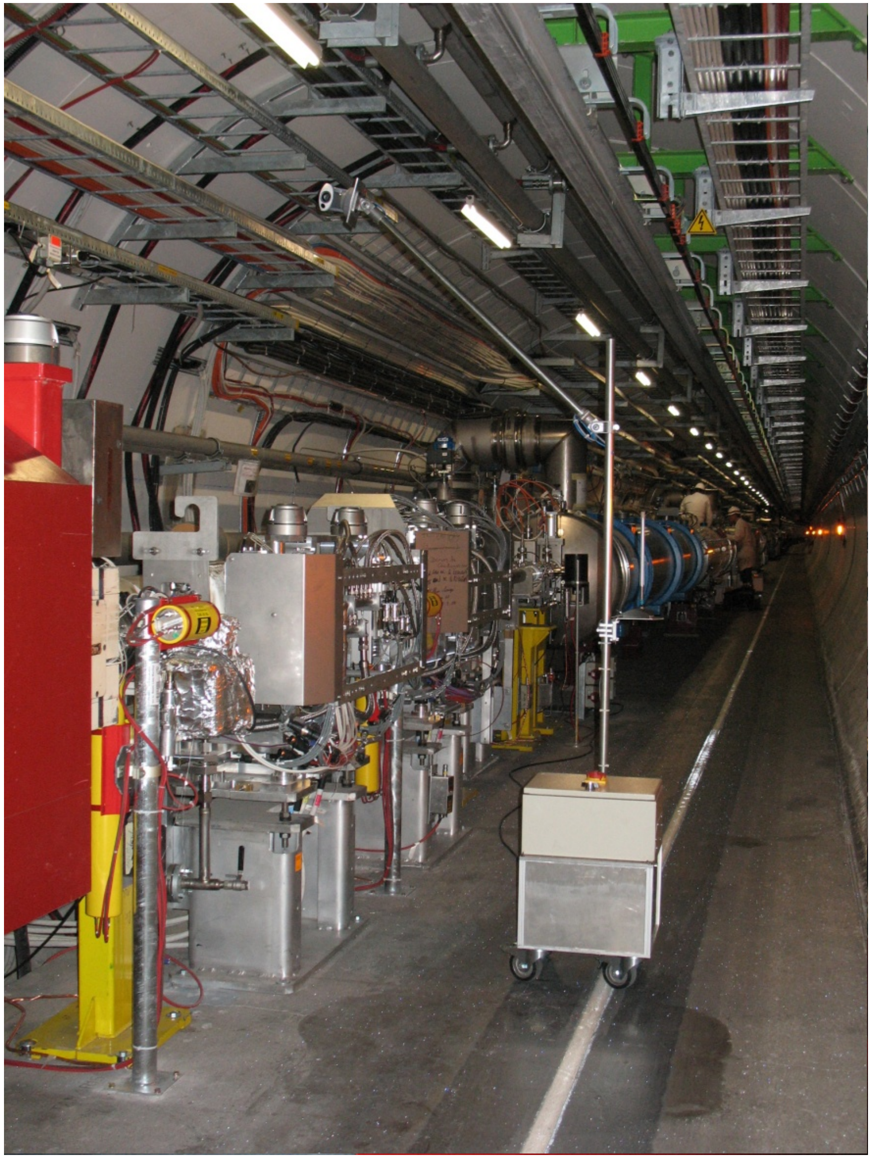
TAN Mini Crane copper bar handling



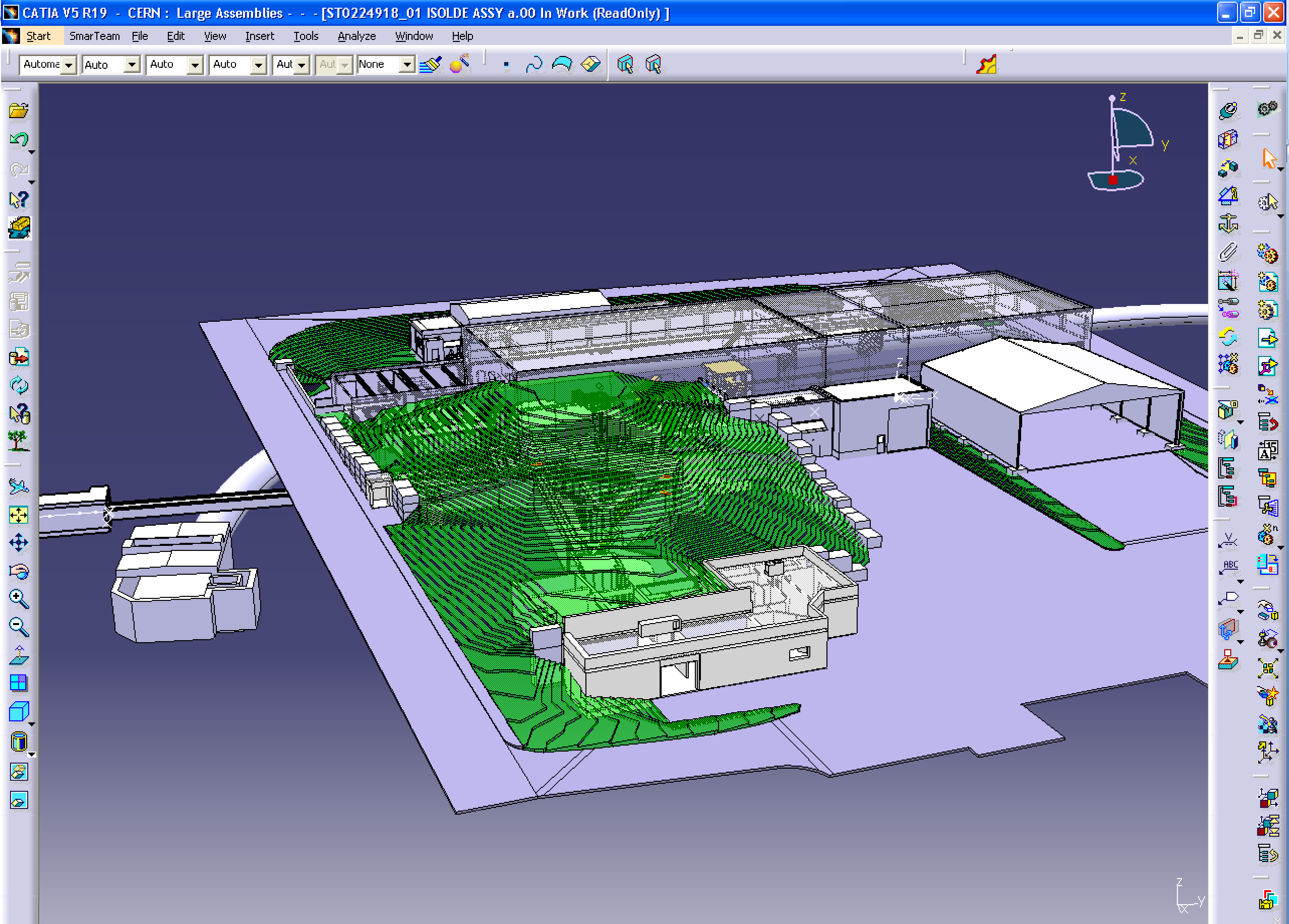


Example 2:
ISOLDE target area

The need: - developing recovery scenarios
- training of operators

ISOLDE robots

Location: Building 179 – ISOLDE Class A Lab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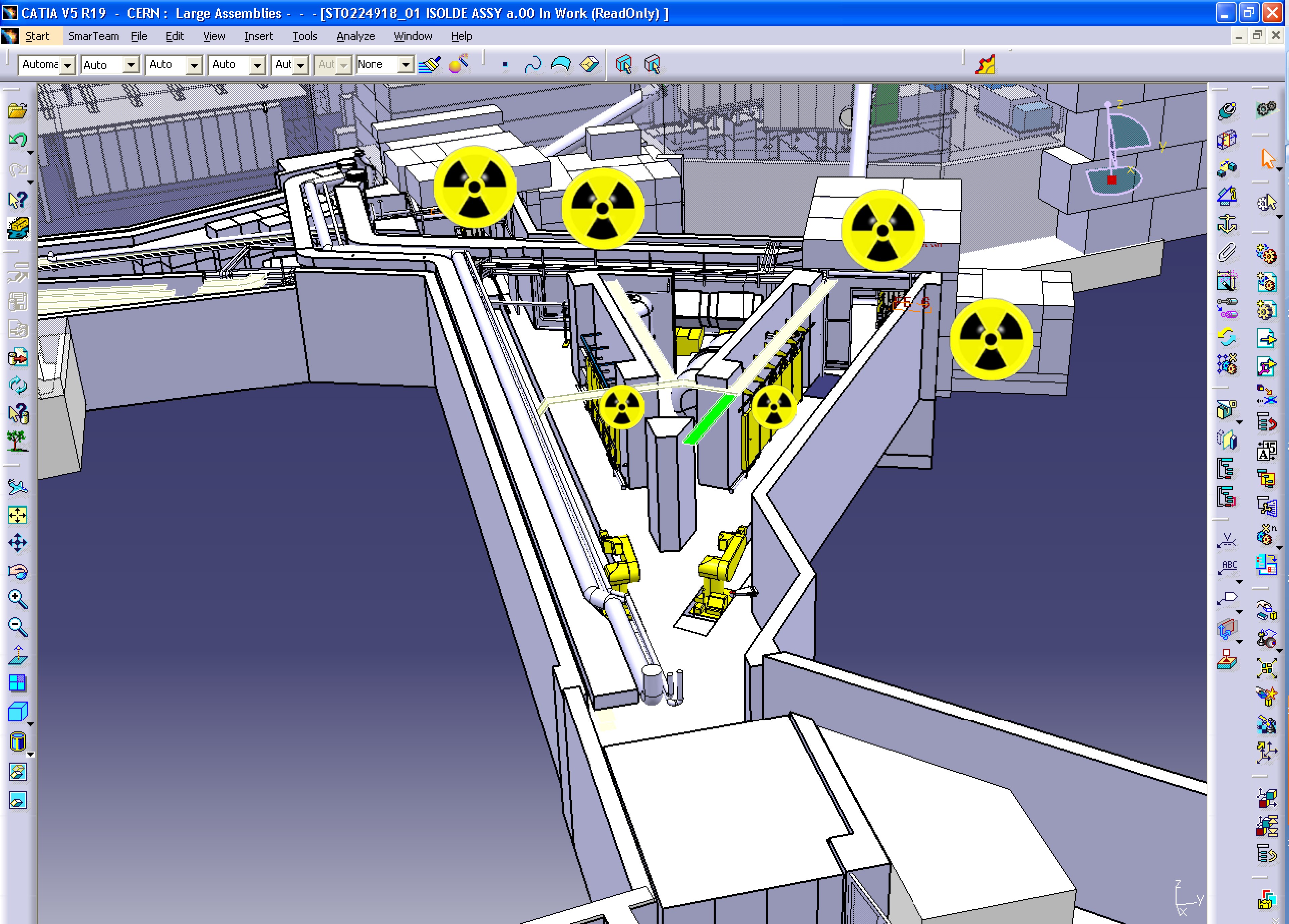
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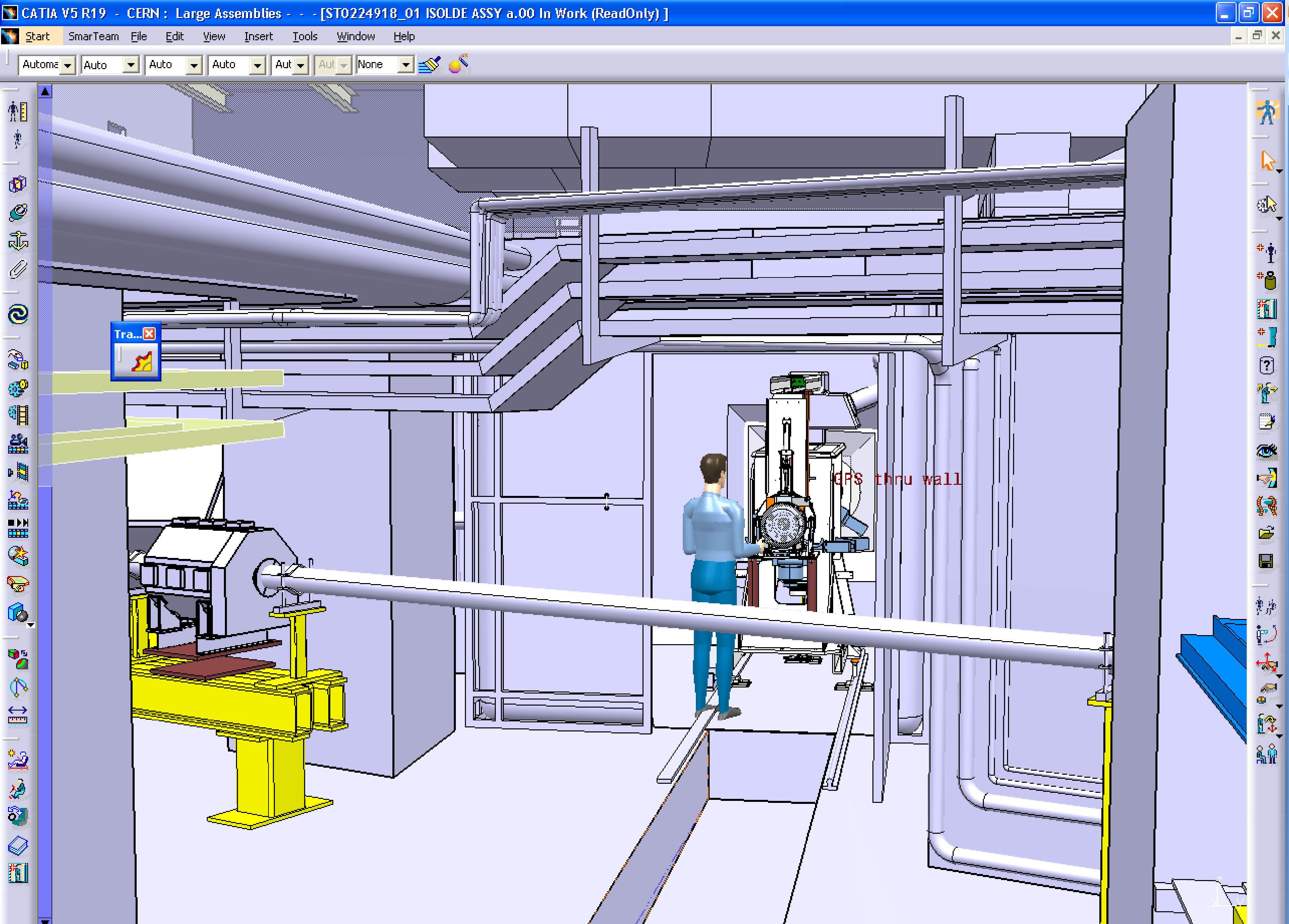
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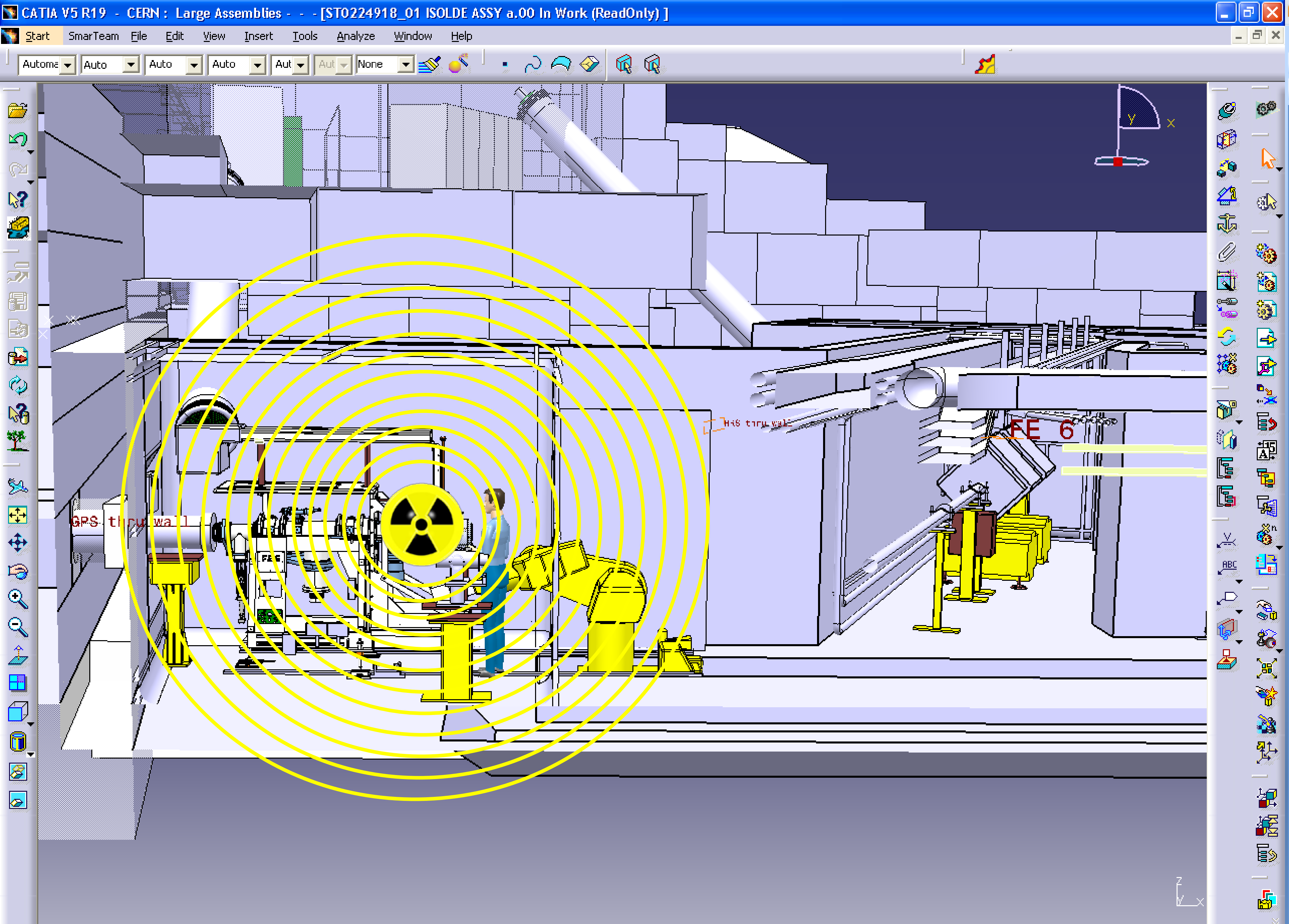
GPS thru wall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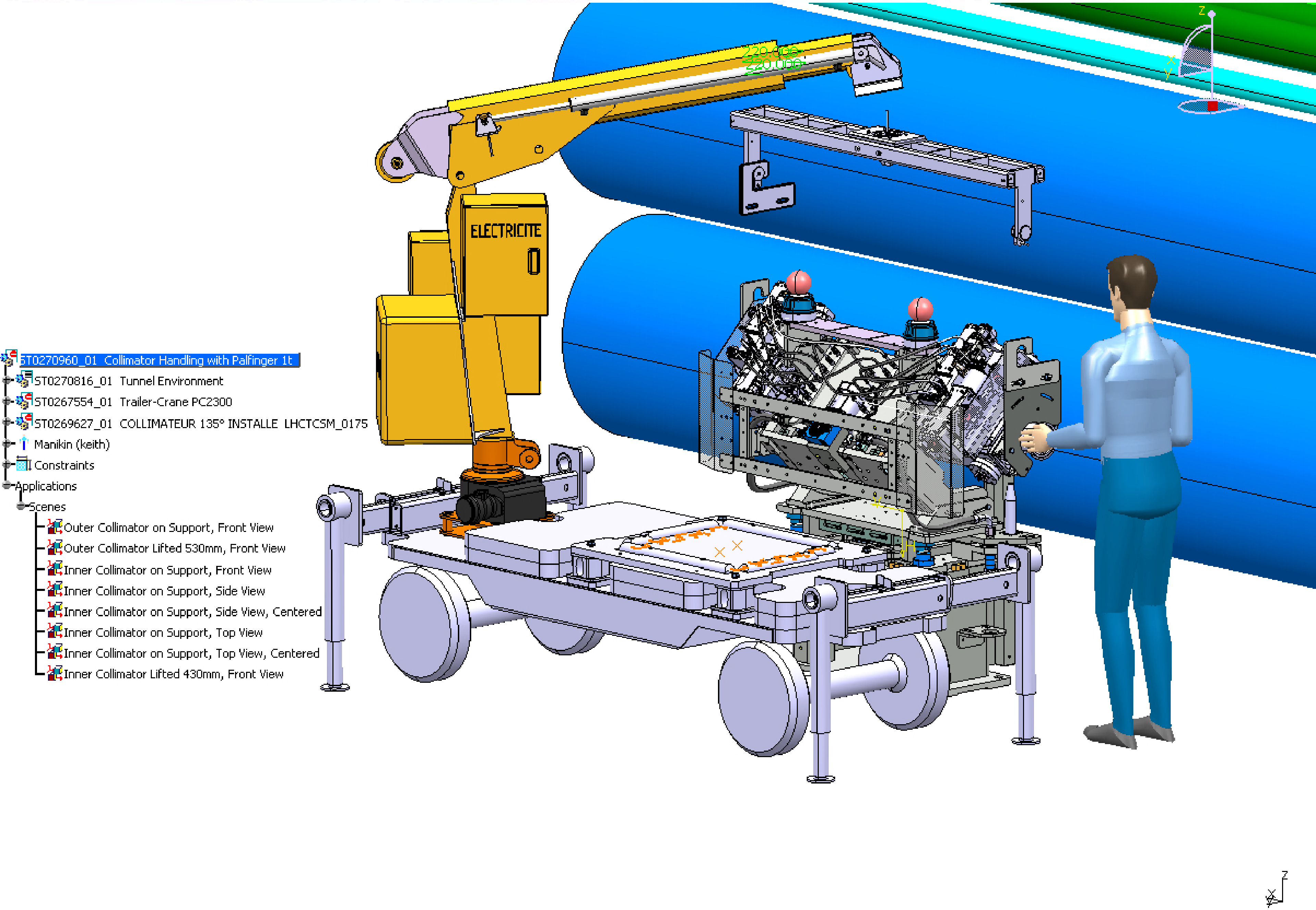
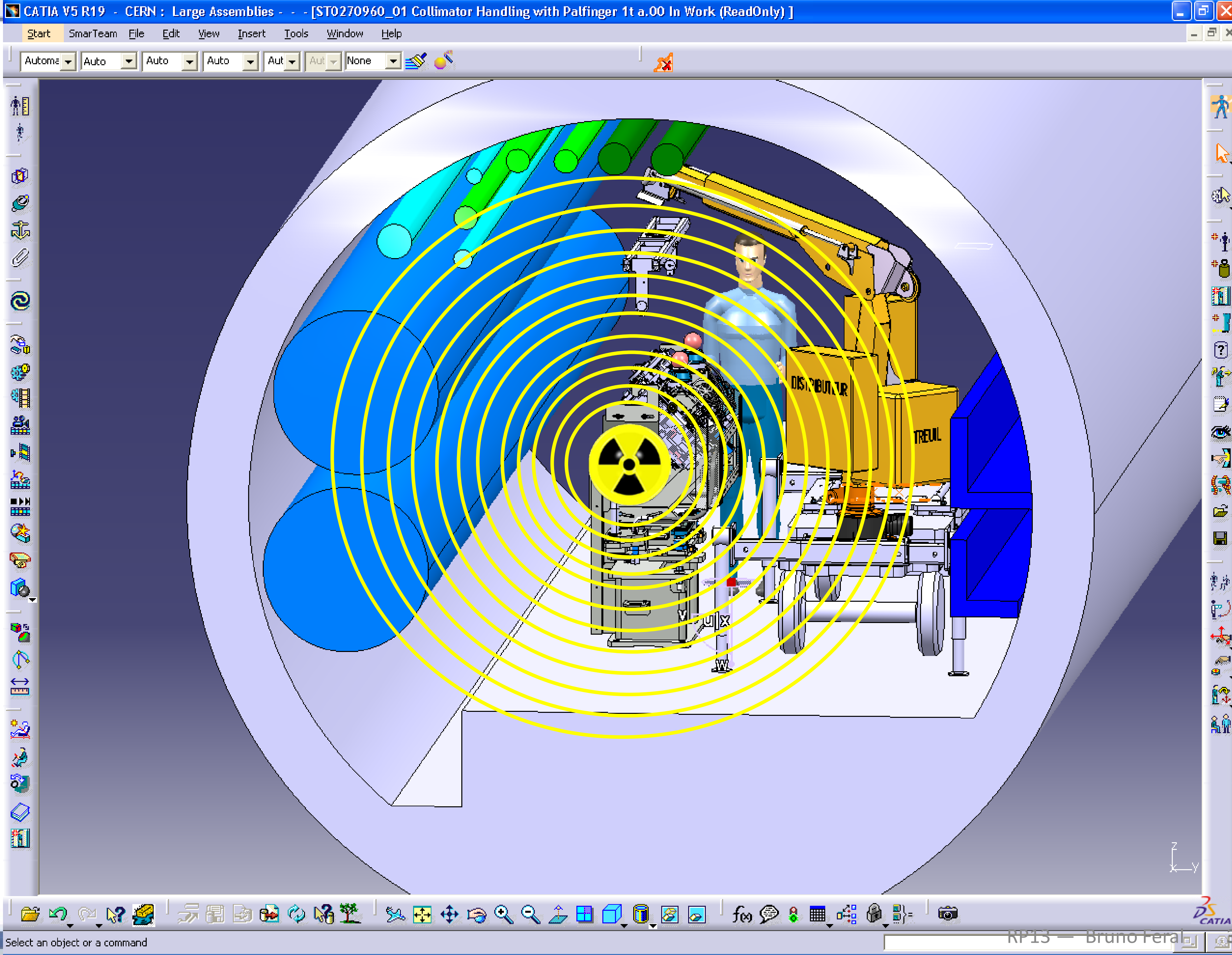
R. CATHERALL

Example 3:
Collimator exchange

The need: - optimizing work scenarios
- developing methodologies
- training of operators


ST0270960_01 Collimator Handling with Palfinger 1t
ST0270816_01 Tunnel Environment
ST0267554_01 Trailer-Crane PC2300
ST0269627_01 COLLIMATEUR 135° INSTALLE LHCTCSM_0175
Manikin (keith)
Constraints
Applications
Scenes
Outer Collimator on Support, Front View
Outer Collimator Lifted 530mm, Front View
Inner Collimator on Support, Front View
Inner Collimator on Support, Side View
Inner Collimator on Support, Side View, Centered
Inner Collimator on Support, Top View
Inner Collimator on Support, Top View, Centered
Inner Collimator Lifted 430mm, Front View
ELECTRICITE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Collimator exchange: doing it for real…

Optimized collimator handling

Mock-up feasibility trials

“Merging radiation maps (from Fluka) with CATIA 3D models”

What is Fluka?

FLUKA Description

FLUKA is a general purpose tool for calculations of particle transport and interactions at CERN.

- Maintained and developed under CERN-INFN* agreement and copyright 1989-2011
- More than 4000 users all over the world

http://www.fluka.org

* Istituo Nazionale per la Fisica della Materia

Example of FLUKA application

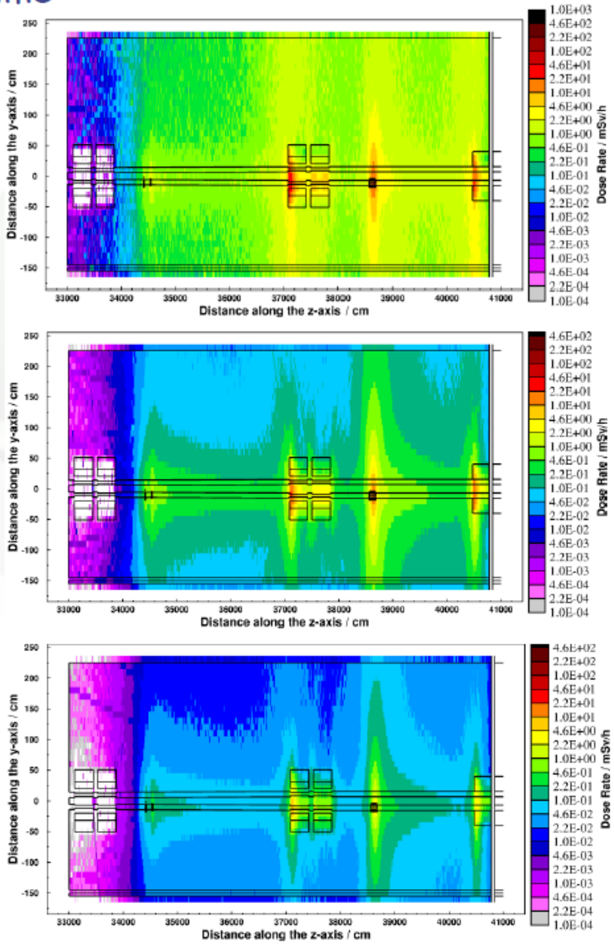
Applications – *LHC collimation region*

Cooling time

8 hours

1 week

4 months



Residual dose rate (mSv/h)
after one year of operation

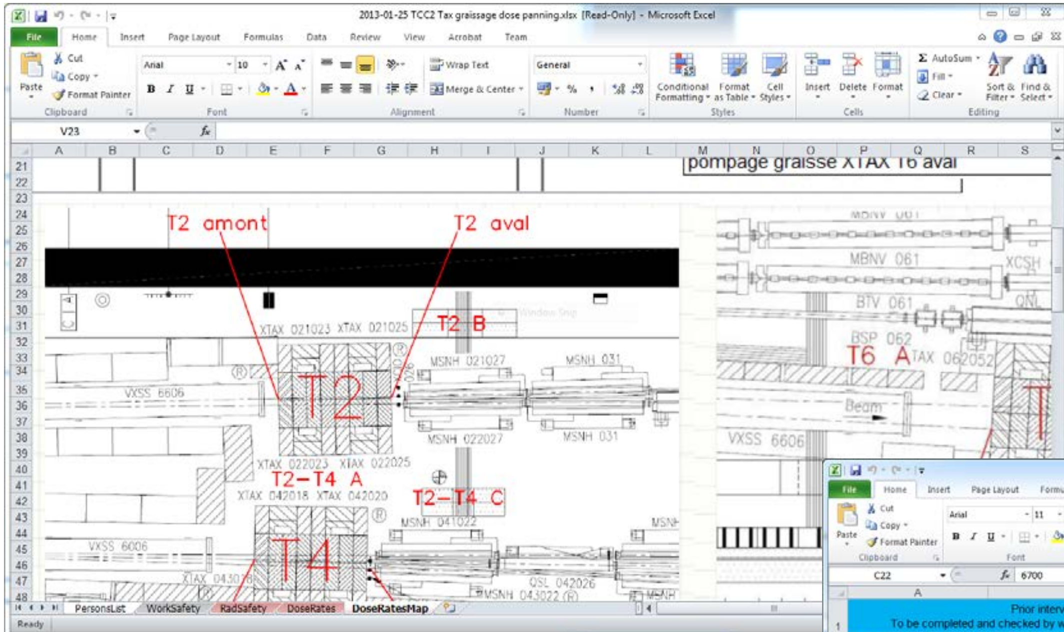
LHC tunnel

CERN-SC-2005-092-RP-TN

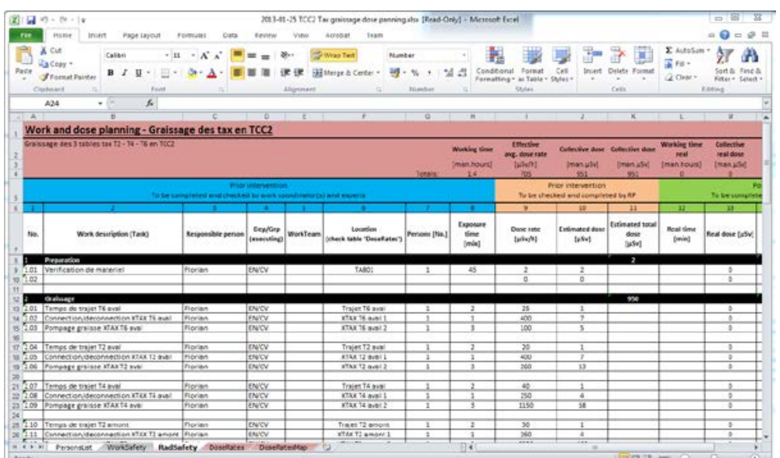
REMANENT DOSE RATE MAPS
OF THE LHC BETATRON CLEANING INSERTION (IR7)

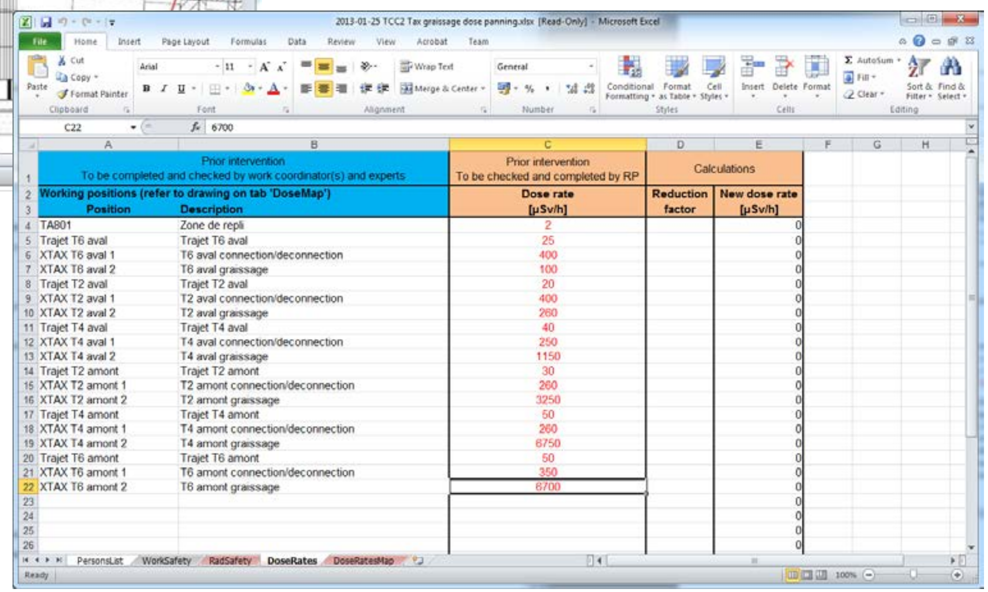
M. Brugger, D. Forkel-Wirth, S. Roesler

Work and dose planning



- \+ optimize work scenarios
- \+ accurate
- \- time consuming
- \- lack of interactivity



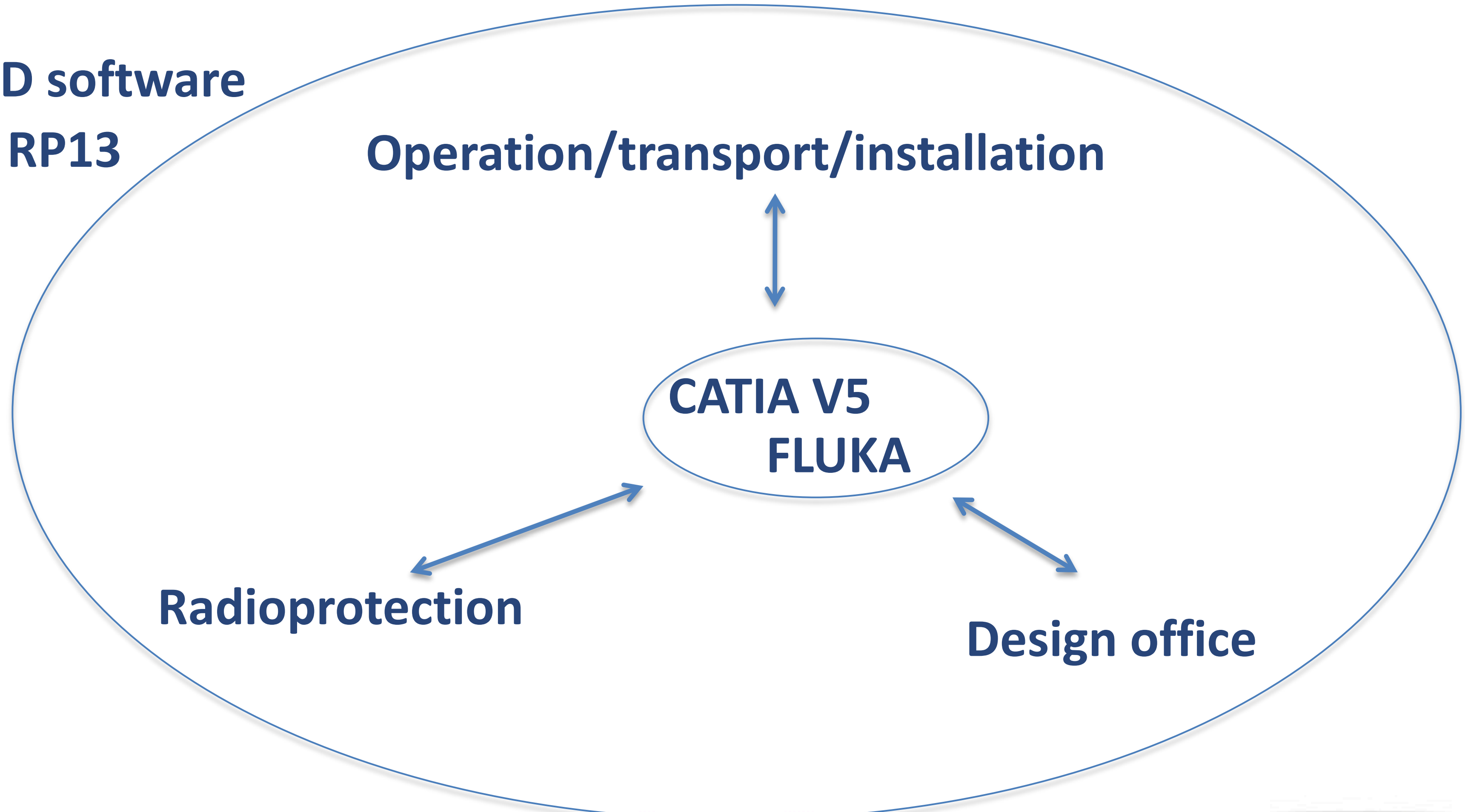


	Prior intervention — To be completed and checked by work coordinator(s) and experts		Prior intervention — To be checked and completed by RP	Calculations	
	Working positions (refer to drawing on tab 'DoseMap')		Dose rate	Reduction	New dose rate
	Position	Description	[µSv/h]	factor	[µSv/h]
4	TA801	Zone de repli	2		0
5	Trajet T6 aval	Trajet T6 aval	25		0
6	XTAX T6 aval 1	T6 aval connection/deconnection	400		0
7	XTAX T6 aval 2	T6 aval graissage	100		0
8	Trajet T2 aval	Trajet T2 aval	20		0
9	XTAX T2 aval 1	T2 aval connection/deconnection	400		0
10	XTAX T2 aval 2	T2 aval graissage	260		0
11	Trajet T4 aval	Trajet T4 aval	40		0
12	XTAX T4 aval 1	T4 aval connection/deconnection	250		0
13	XTAX T4 aval 2	T4 aval graissage	1150		0
14	Trajet T2 amont	Trajet T2 amont	30		0
15	XTAX T2 amont 1	T2 amont connection/deconnection	260		0
16	XTAX T2 amont 2	T2 amont graissage	3250		0
17	Trajet T4 amont	Trajet T4 amont	50		0
18	XTAX T4 amont 1	T4 amont connection/deconnection	260		0
19	XTAX T4 amont 2	T4 amont graissage	6750		0
20	Trajet T6 amont	Trajet T6 amont	50		0
21	XTAX T6 amont 1	T6 amont connection/deconnection	350		0
22	XTAX T6 amont 2	T6 amont graissage	6700		0

RP13: a new approach?

An integrated approach:
An aid to communication…

3D software
RP13



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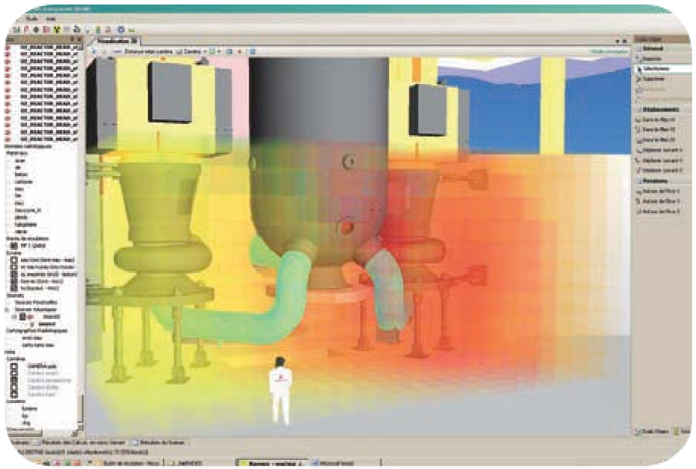
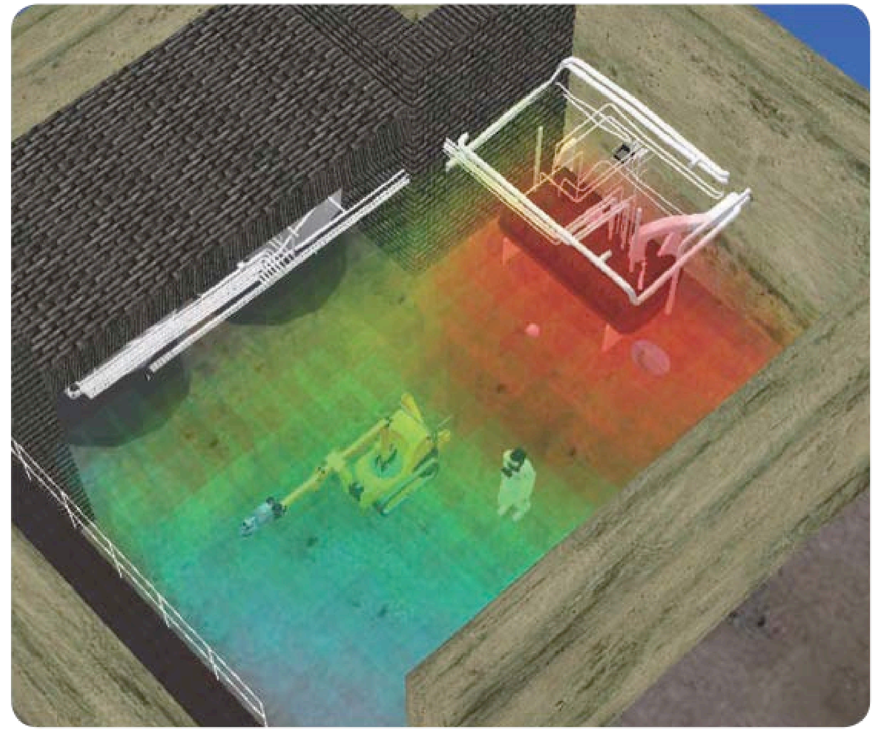
- *Development*
- Software and demo
- Conclusions

NARVEOS by EURIWARE

La solution NARVEOS : optimiser les interventions sur les chantiers ionisants (2010). http://euriware.areva.com/FR/euriware-399/la-solution-narveos.html



Moving around steam generator within dose cartography



Commercial tools not suited for CERN facilities

Narveos and Visiplan: point-kernel methods to calculate gamma dose-rates based on user-inputted information in terms of radionuclide composition as well as spatial distribution.

This approach cannot be applied directly to radiation environments encountered at high energy accelerators.

VINCKE, HELMUT AND THEIS, CHRIS AND ROESLER, STEFAN (2011). Induced radioactivity in and around high-energy particle accelerators. *Radiation Protection Dosimetry*, **146-4**, 434-439.

→ CERN uses FLUKA calculation tool

Develop RADIJS Software tool

python

vtk Visualization Toolkit

matplotlib

wxPython

NumPy

ReportLab

How does the tool work?

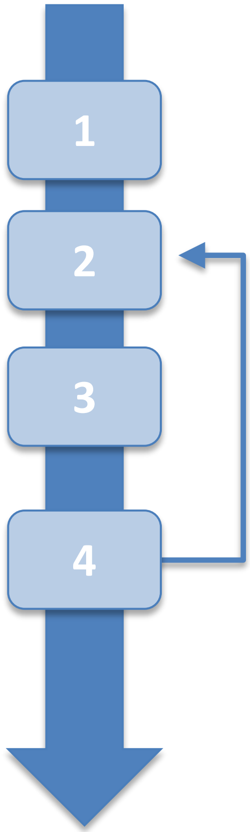
1. Import geometry and import Fluka data

2. Map operator trajectory and build operation tasks

3. Compute radiation doses

4. Optimization of the intervention
   * Work condition : location, radiation dose
   * Paths followed between tasks

To be repeated…



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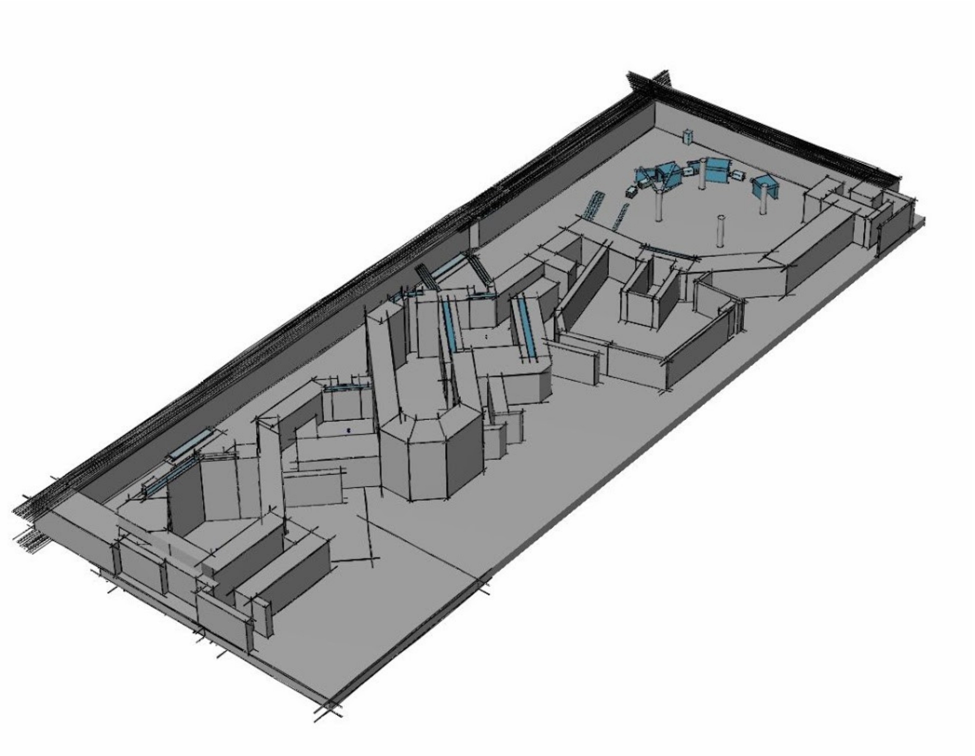
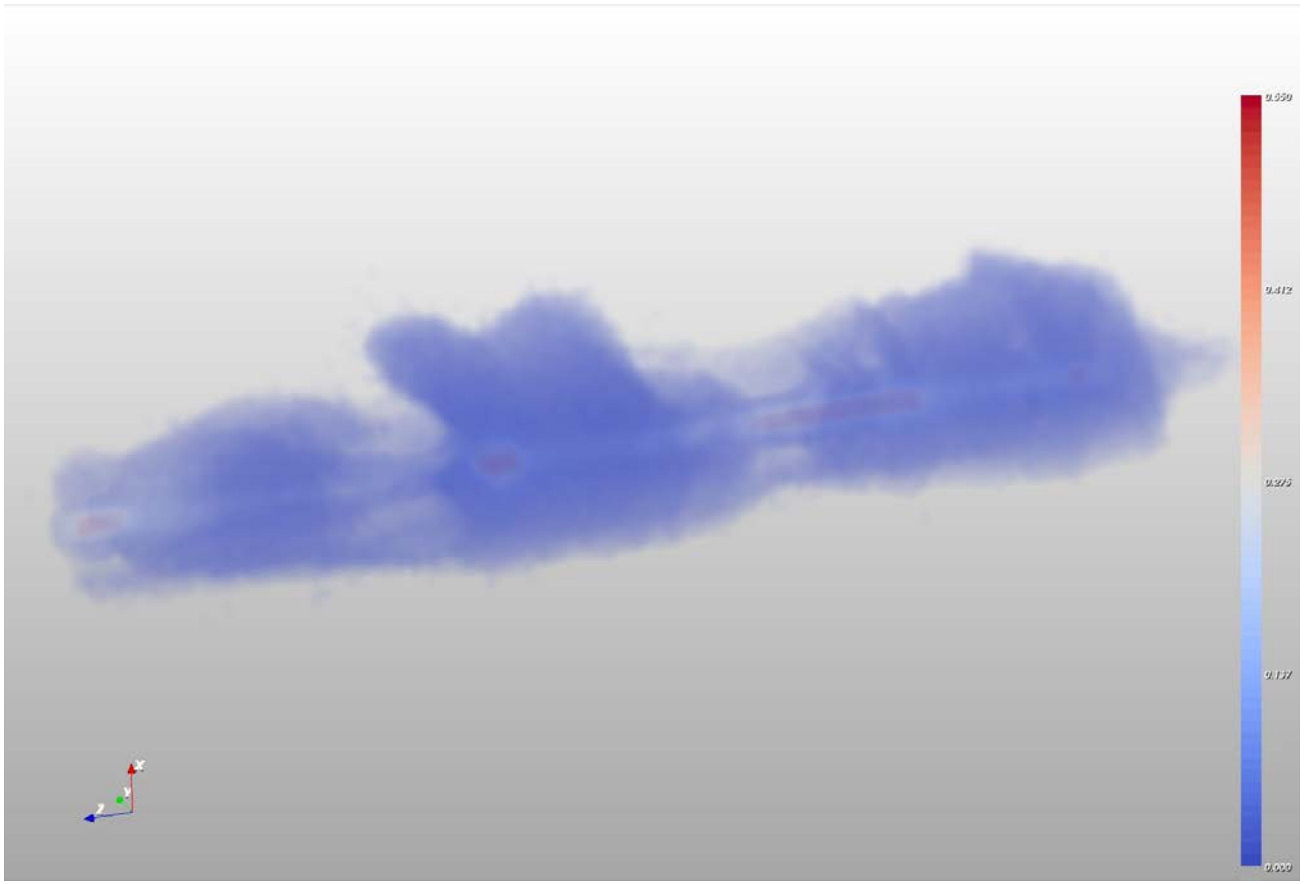
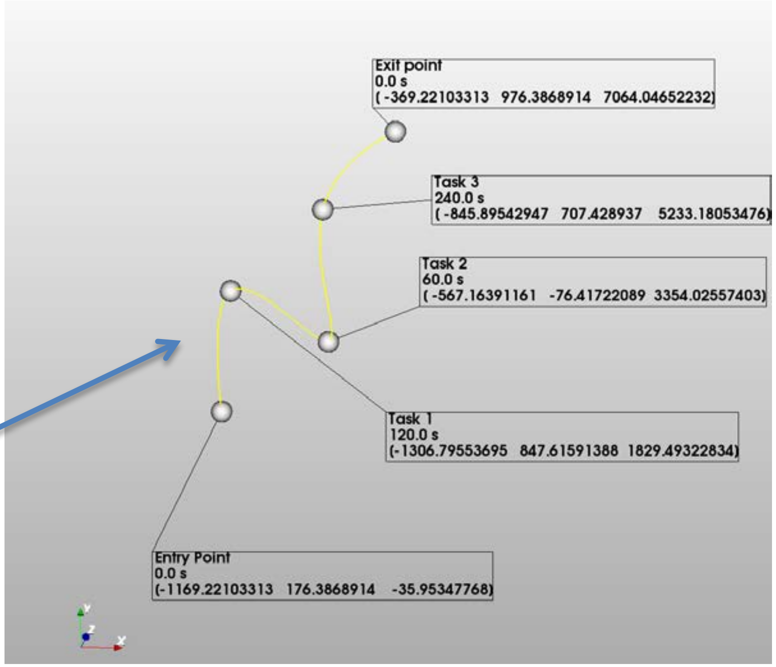
1- Import the 3D geometry of the facility to assess



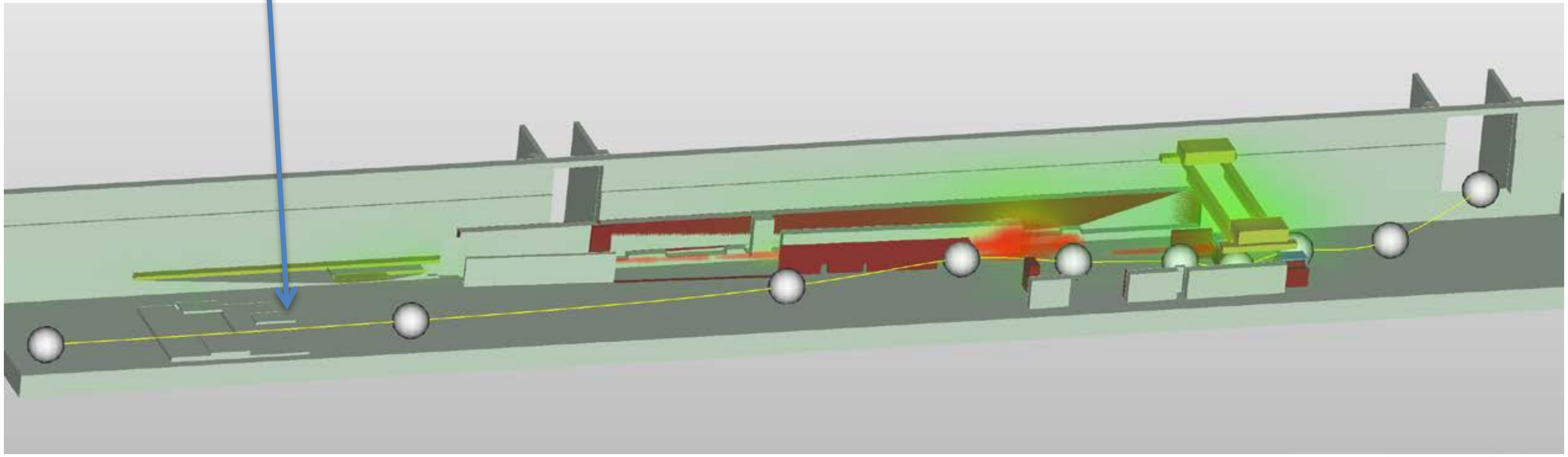
1- Import the data from FLUKA



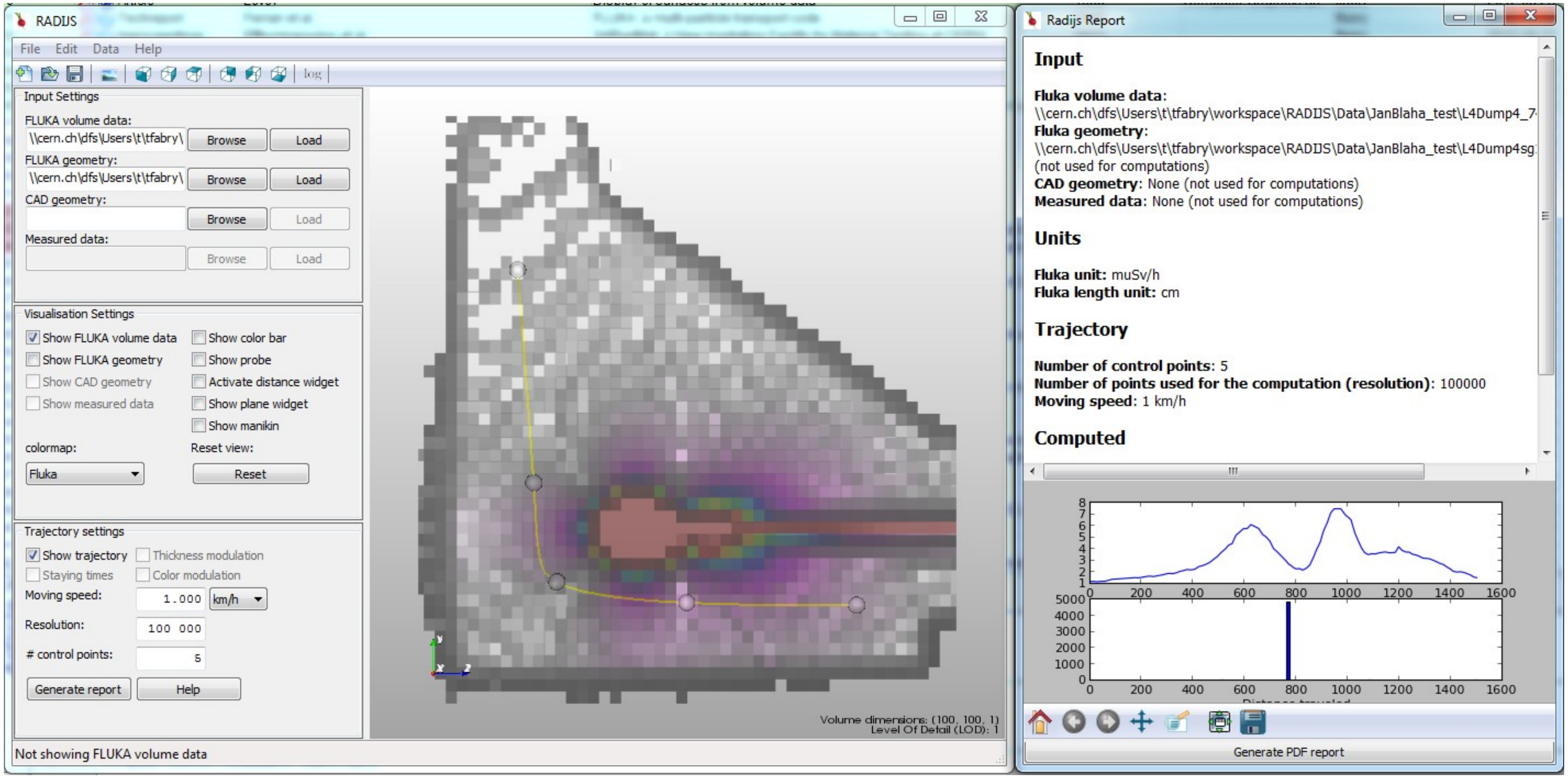
2- Build a trajectory



The trajectory of an intervention

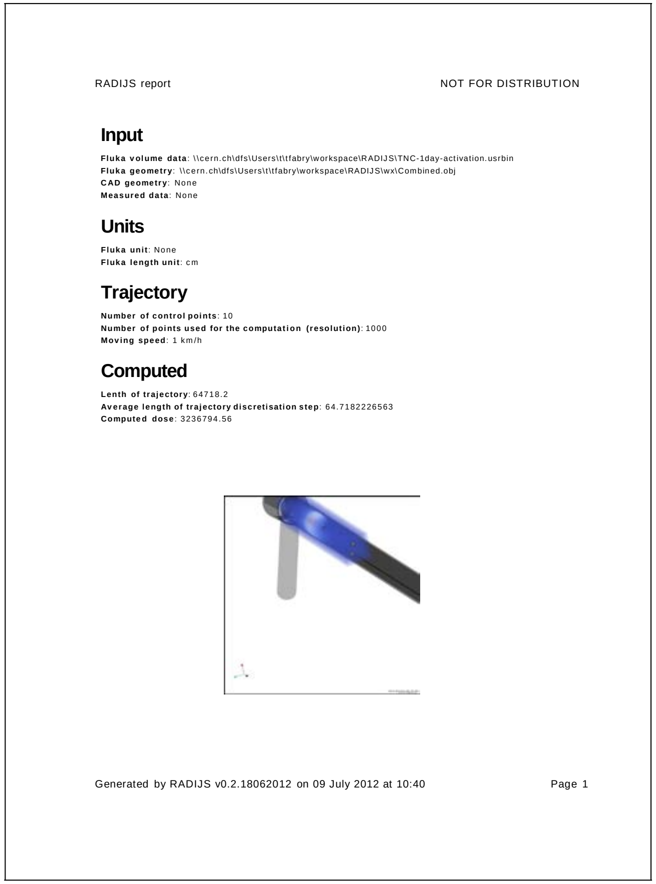


3- Compute doses



4- Generate report

- the **sources**: the names of the input files containing the geometry of the facility and the radiation levels, the applicable units, . . .
- the **trajectory** information: locations, discretisation information, . . .
- the **results**: the computed received dose to be expected during the intervention, the length of the trajectory, . . .



RADIJS report NOT FOR DISTRIBUTION

Input

Fluka volume data: \\cern.ch\dfs\Users\t\tfabry\workspace\RADIJS\TNC-1day-activation.usrbin
Fluka geometry: \\cern.ch\dfs\Users\t\tfabry\workspace\RADIJS\wx\Combined.obj
CAD geometry: None
Measured data: None

Units

Fluka unit: None
Fluka length unit: cm

Trajectory

Number of control points: 10
Number of points used for the computation (resolution): 1000
Moving speed: 1 km/h

Computed

Lenth of trajectory: 64718.2
Average length of trajectory discretisation step: 64.7182226563
Computed dose: 3236794.56

Generated by RADIJS v0.2.18062012 on 09 July 2012 at 10:40 Page 1

DEMO

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Conclusions

- A fully operational software is available at CERN and for Puresafe partners.
- A new approach to integrate constraints of intervention in radioactive facilities (starting from design phase).
- A new communication and training tool for team involved in maintenance of radiation and design facilities.
- Interactive, dynamic and 3D, benefit from today state of the arts visualisation technics.
- This task-level optimization can be combined with schedule-level intervention optimization as studied in Puresafe RP 2 from Mathieu Baudin.

Possible very interesting developments

- A good base for testing augmented reality applications.
- Instantaneous visualisation of radiation - Integration of measured data from gamma ray cameras?

Acknowledgments:

- **Pierre Bonnal** – CERN
- Doris Forkel-Wirth – CERN
- Laurent Tabourot - Laboratoire SYMME
- Christian Braesch – Laboratoire SYMME
- Keith Kershaw - CERN
- Mathieu Baudin - CERN
- Chris Theis - CERN
- CERN colleagues
- PURESAFE Colleagues & organizers

References:

- Fluka: http://www.fluka.org
- CATIAV5 from Dassault System: http://www.3ds.com
- Thomas Fabry publications

cern.ch/puresafe