EN Engineering Department

EN STI

PSB Upgrade
LIU Project

ALARA COMMITTEE
Level III

REPLACEMENT OF PSB DUMP

Alba Sarrió on behalf of EN-STI-TCD section

Thanks to: Antonio Perillo-Marcone, Frédéric Loprete, Caterina Bertone, Frédéric Delsaux, Robert Froeschl and Gérald Dumont.

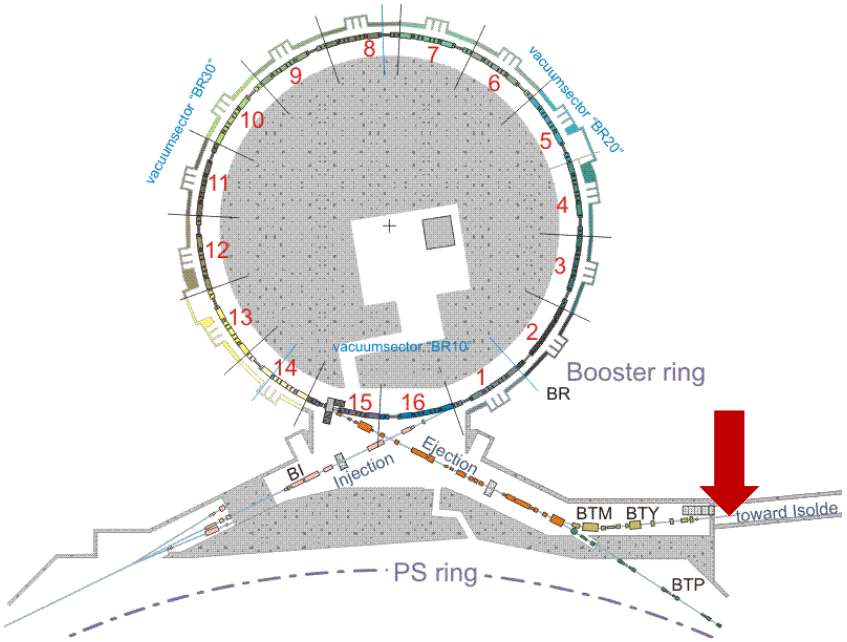
EN-STI

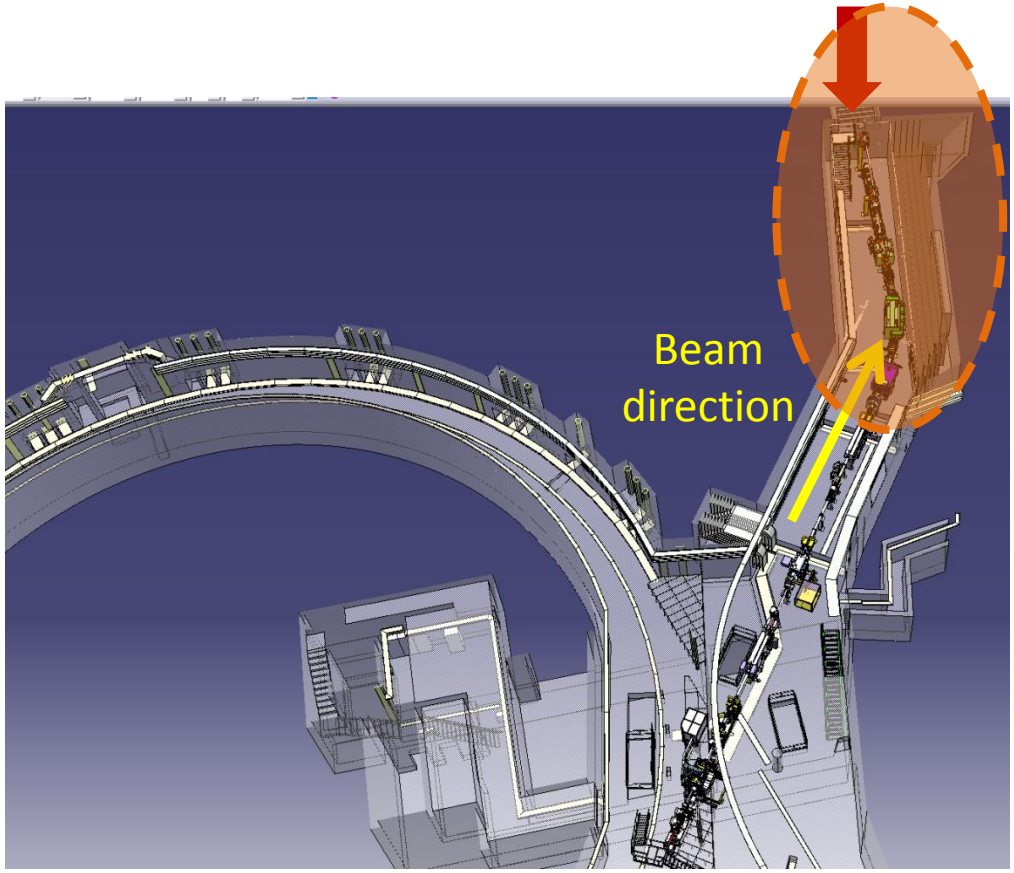
21 May 2013

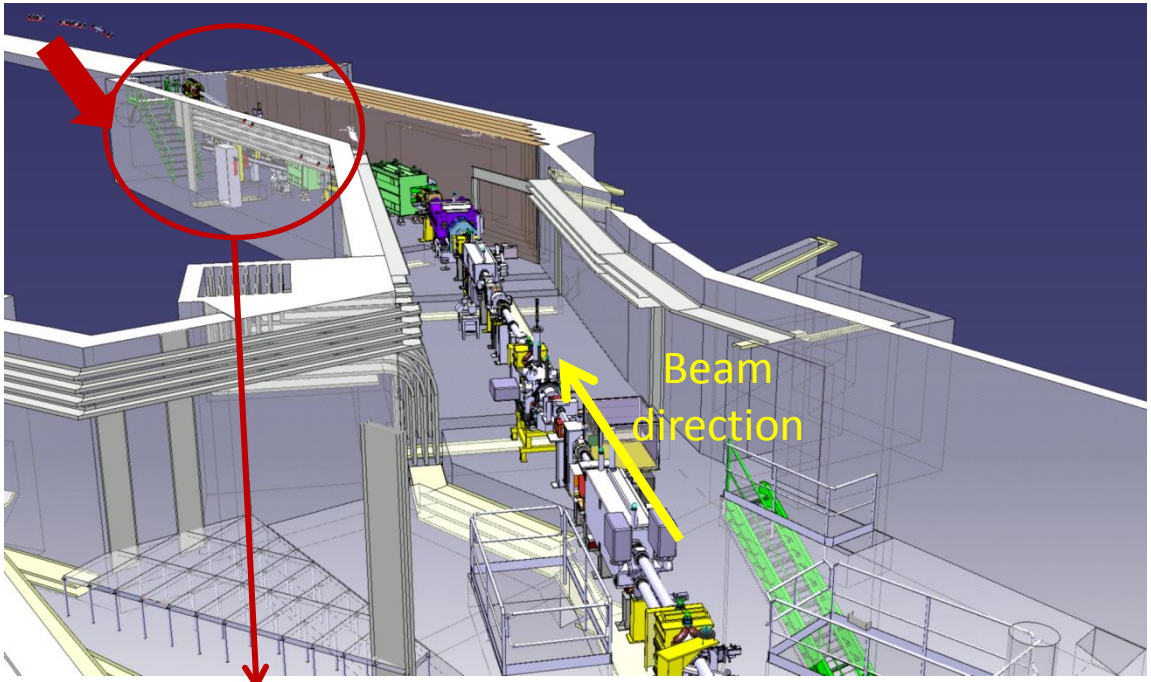
PRESENTATION OUTLINE

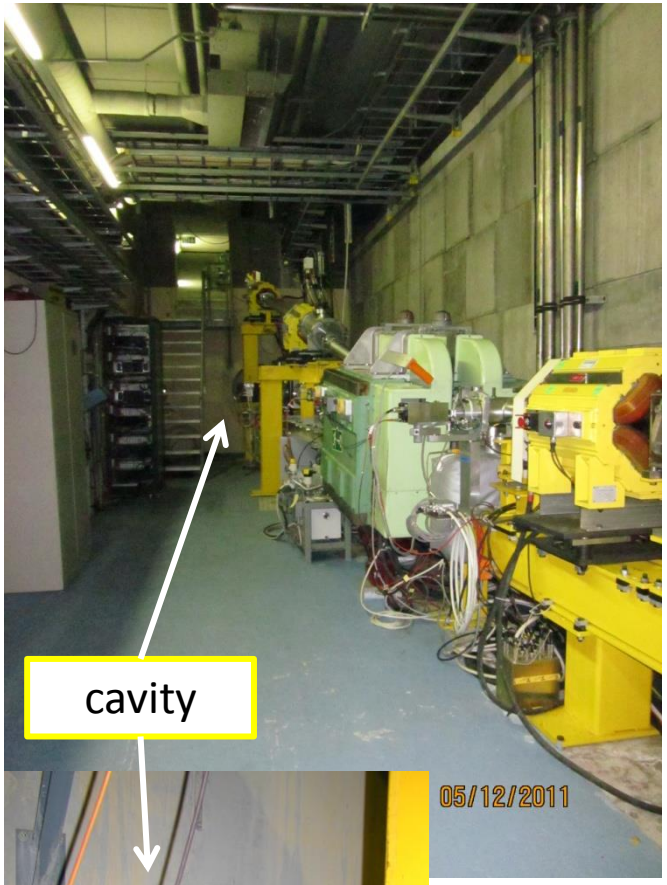
- Type of intervention
- History and justification
- Work description
- Summary of dose optimization measures

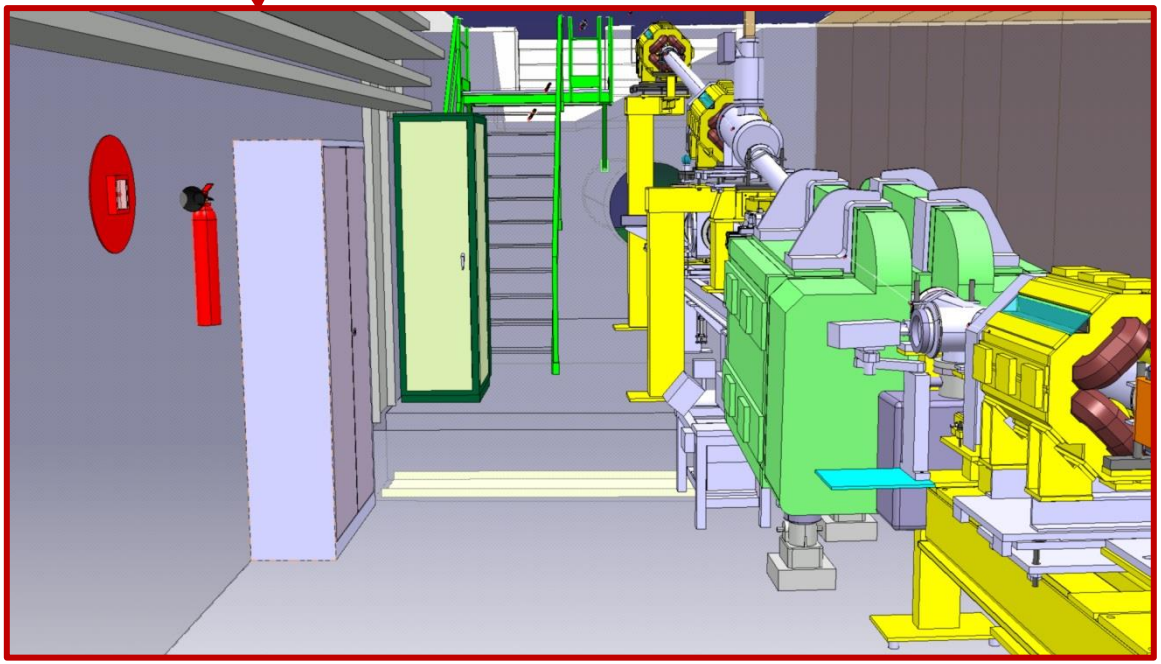
TYPE OF INTERVENTION






Beam
direction


cavity
05/12/2011



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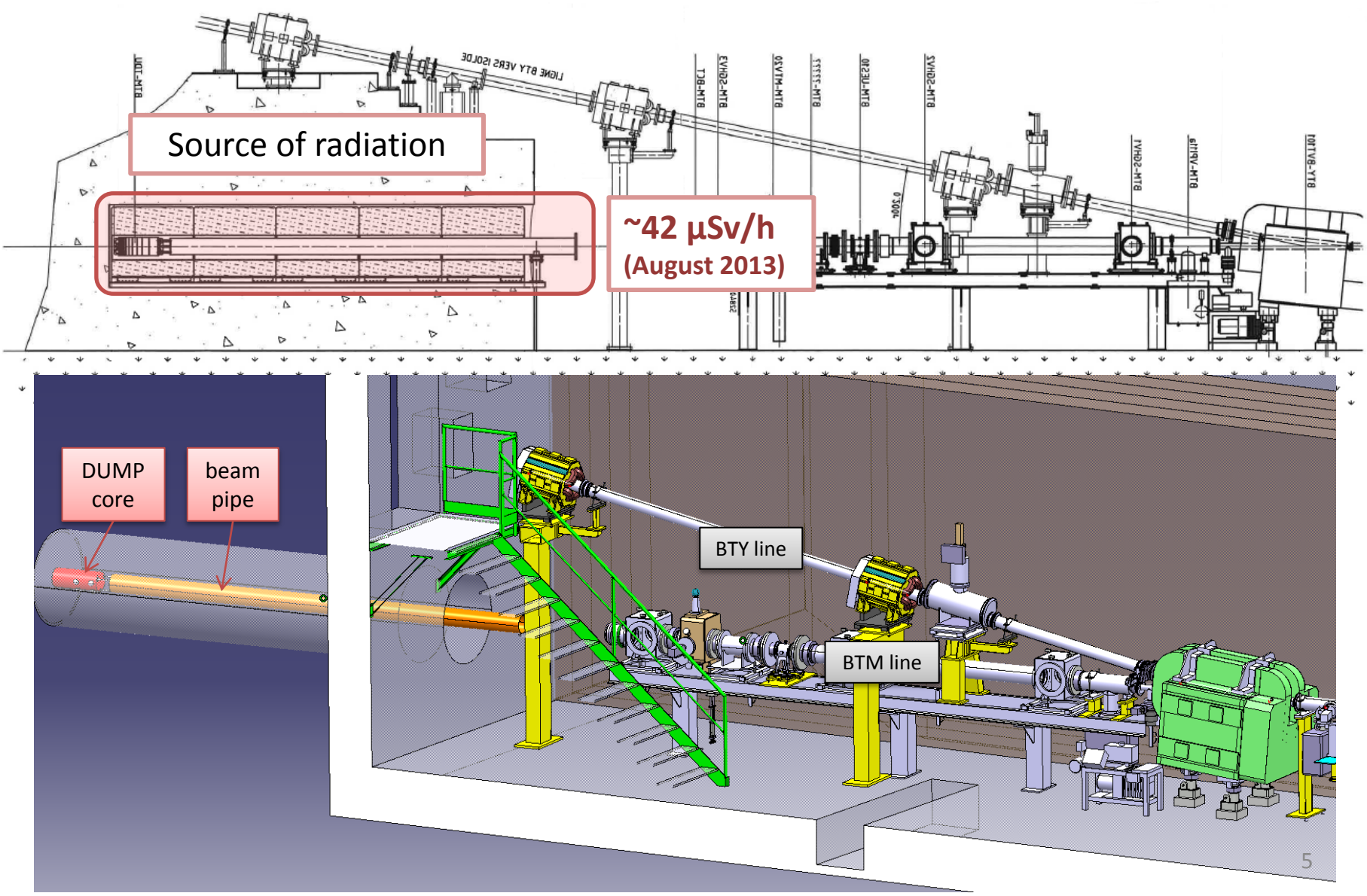

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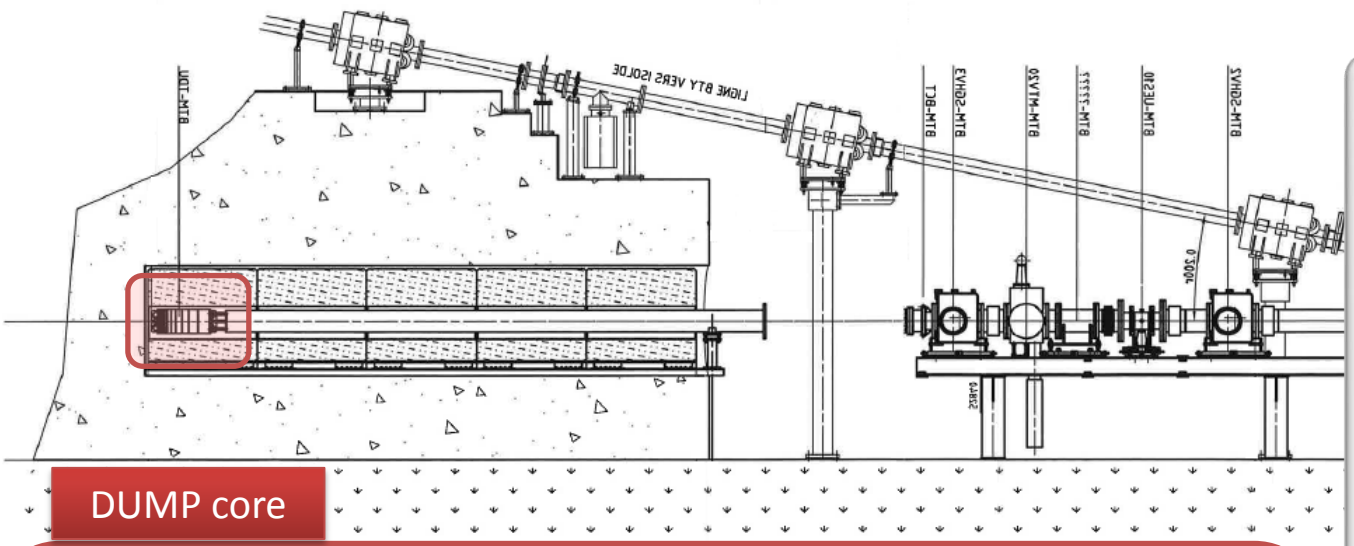
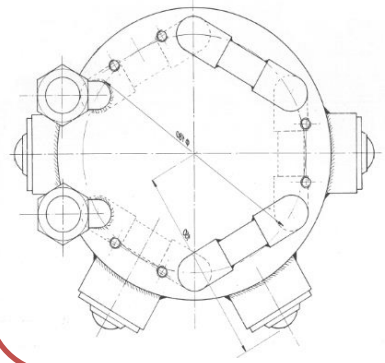
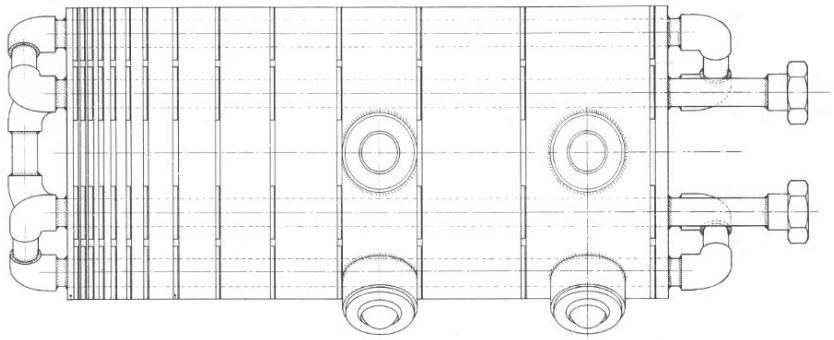


DUMP core

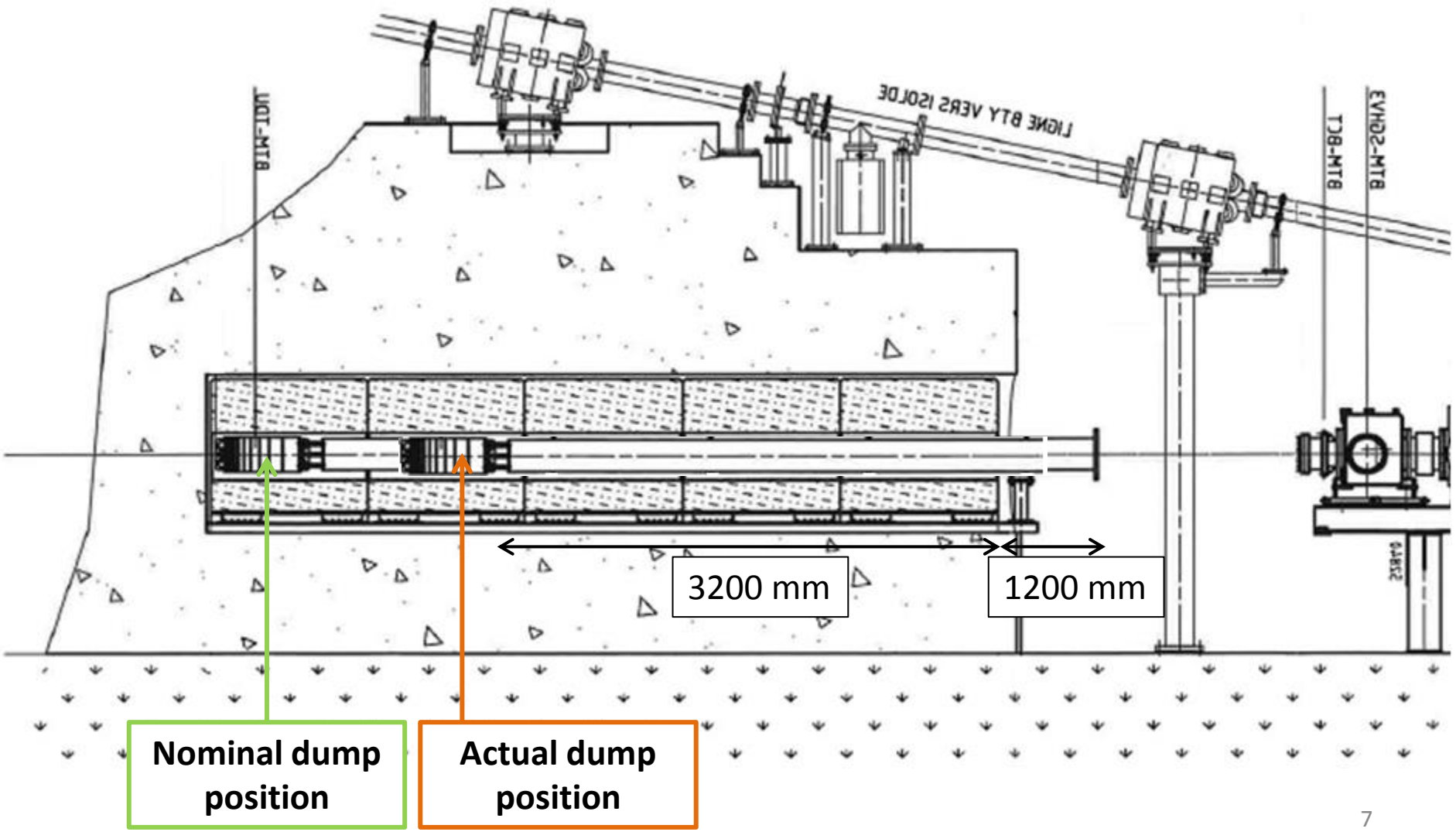




Present PSB dump mock-up

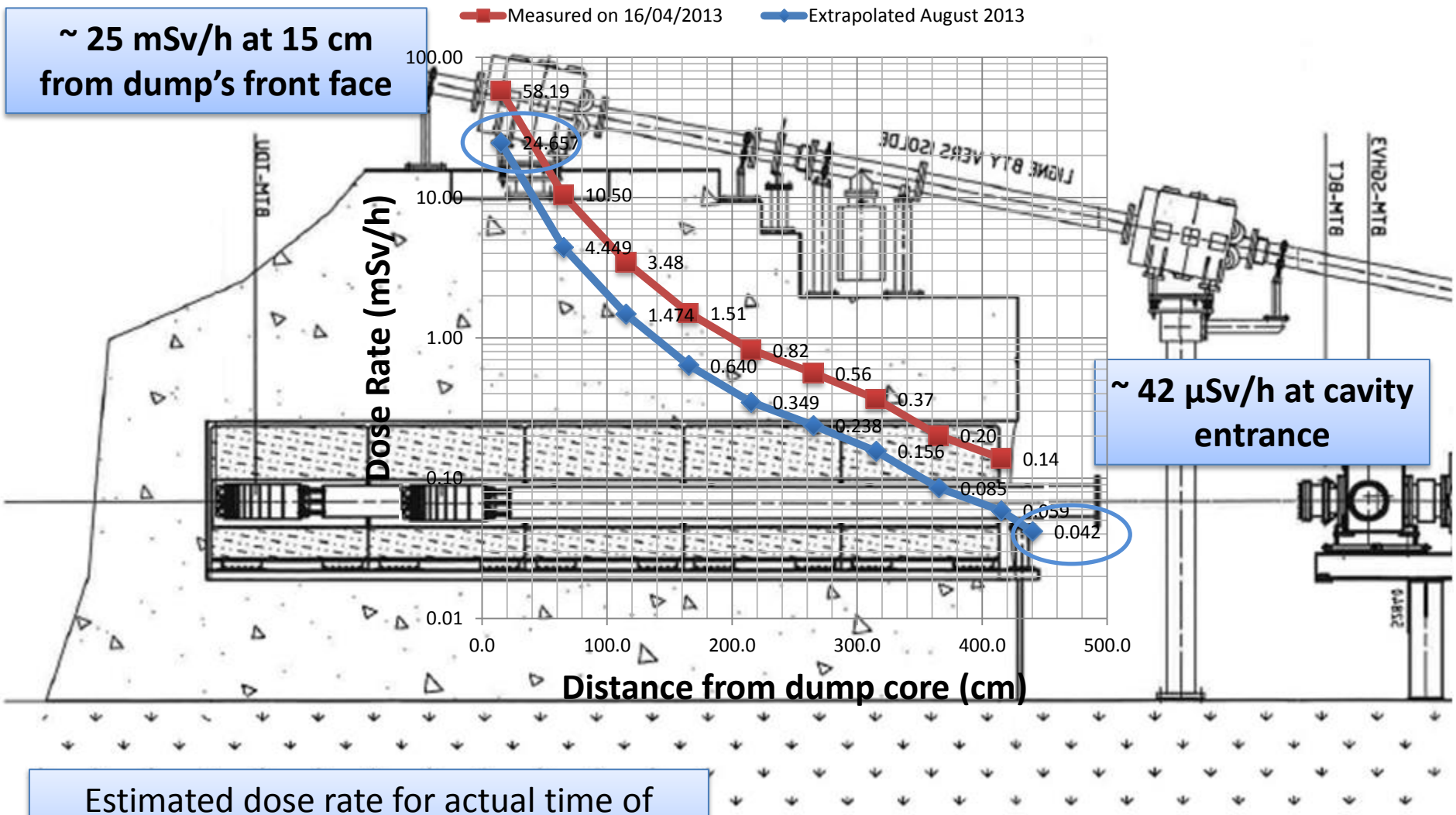
Thanks to F. Loprete

TYPE OF INTERVENTION



TYPE OF INTERVENTION

~ 25 mSv/h at 15 cm from dump's front face



~ 42 µSv/h at cavity entrance

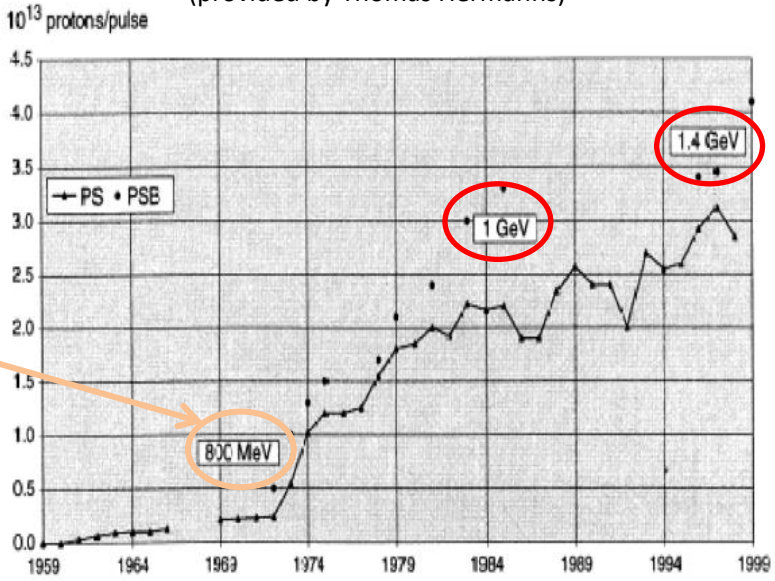
Estimated dose rate for actual time of intervention – August 2013

HISTORY

1. The PSB dump was designed in the early 1970's to cope with beam energies reaching 800 MeV and intensities of 10^{13} protons per pulse in each ring*
2. Over the past years, the dump encountered some problems, i.e. vacuum and water leaks
3. Beam energy and intensity have been gradually increased during the last upgrades (1 GeV in 1988 and 1.4 GeV in 1999)

Historical diagram of peak beam intensities

(provided by Thomas Hermanns)

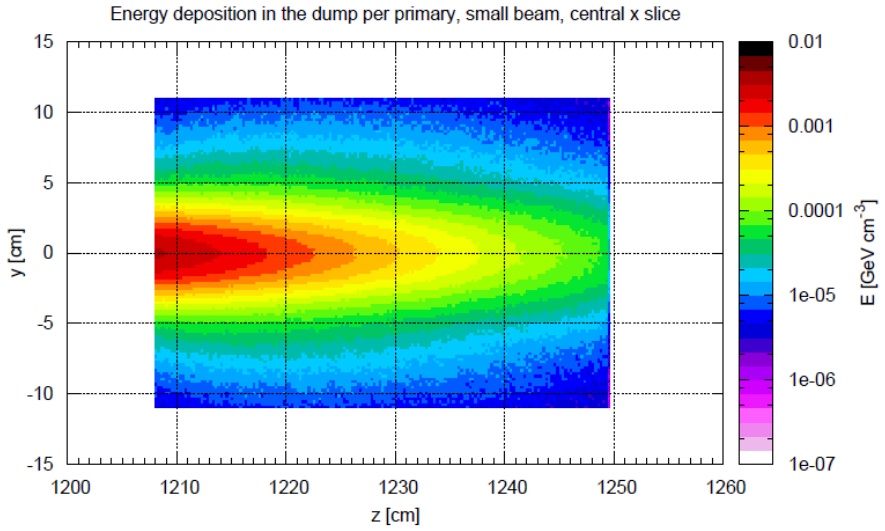


Design energy

* G. Gelato et al., IEEE Particle Accelerator Conference, Washington D.C. 1987

JUSTIFICATION

1. Dump is nowadays under-dimensioned (i.e. energy leaking radially and longitudinally)
2. A new upgrade in beam energy (2 GeV) and beam intensity (10^{14} particles per pulse) is foreseen for LS2: dump core would reach extreme temperatures and stresses
3. Consequently: a new dump is needed to cope with this last upgrade.



Energy Deposition in present PSB Dump – current beam parameters

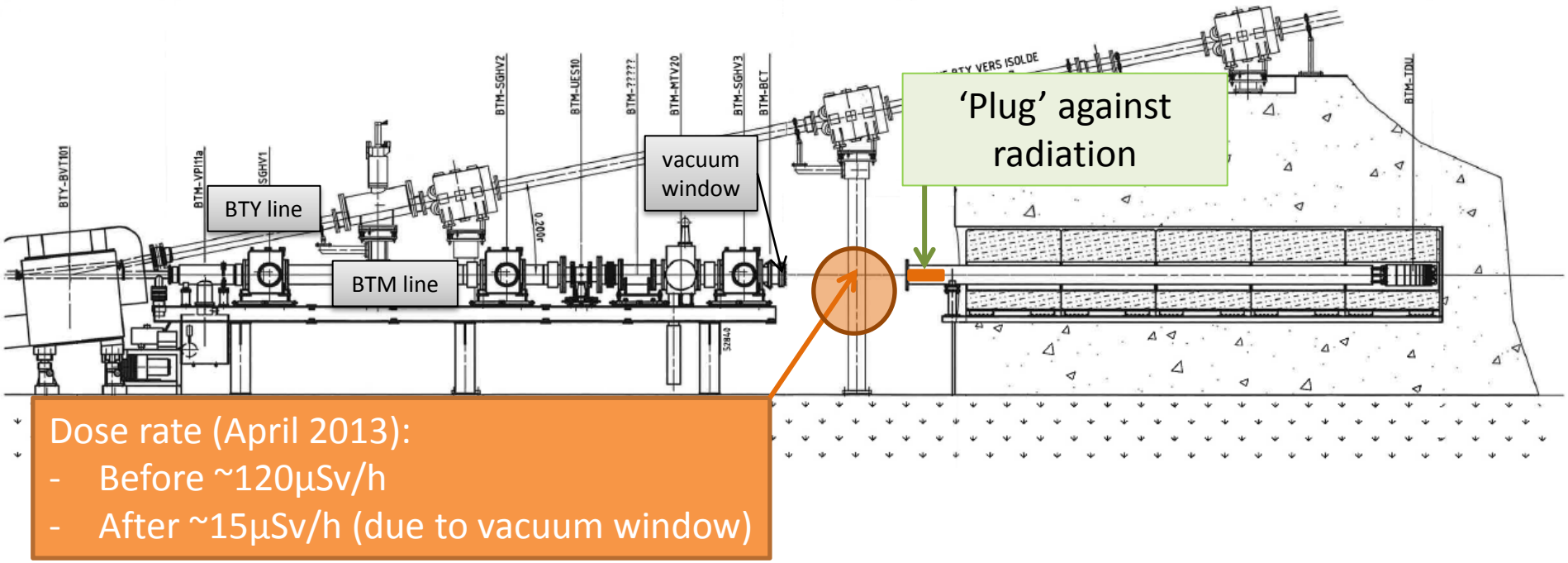
Simulation by FLUKA, thanks to STI-EET

WORK PLANNING

1. Preparatory measures for LS1 – prior intervention
2. Temporary dismantling of equipment in BT, BTM and BTY lines
3. Dismantling and disposal operations of dump and its shielding
4. Installation of new dump
5. Re-assembly of equipment in BT, BTM and BTY lines.
6. Survey
7. Ready for commissioning

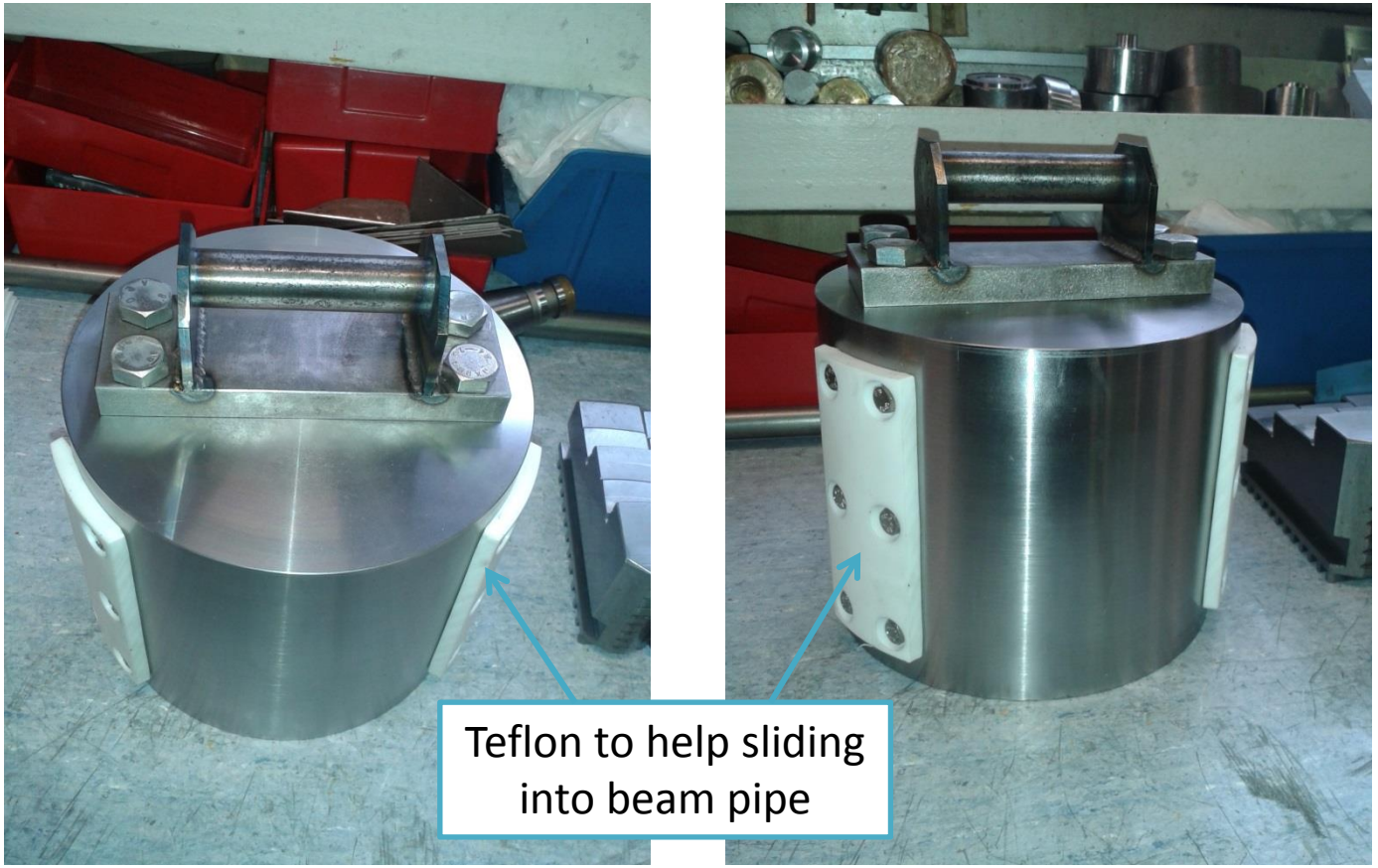
TOTAL COLLECTIVE DOSE 3.11 mSv

1. PRE-SHIELDING: PREPARATORY MEASURE FOR LS1



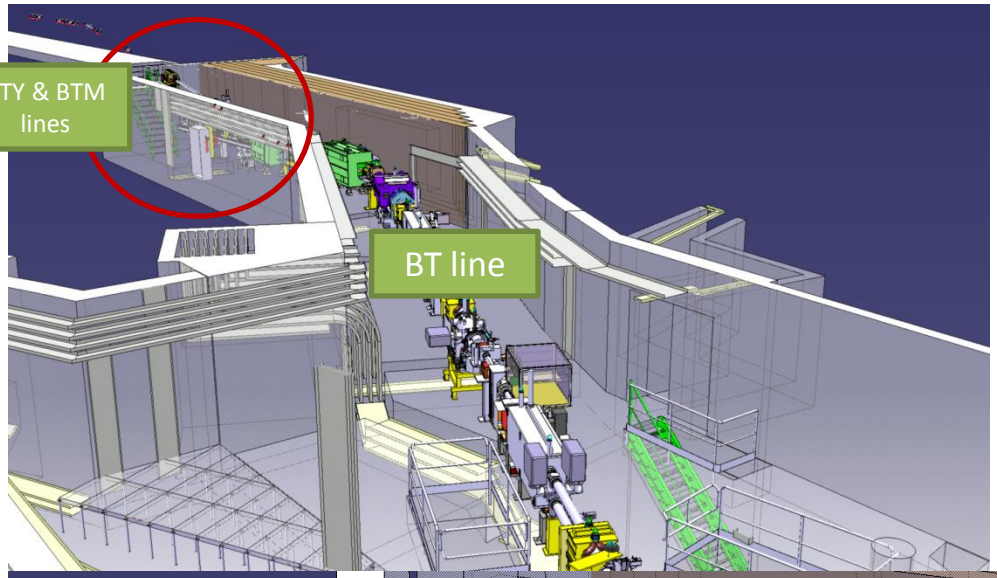
- 'Plug against radiation' installed on 18 April 2013
- This 'plug' is also useful for other activities during LS1, before the dump removal tasks.

Plug against radiation



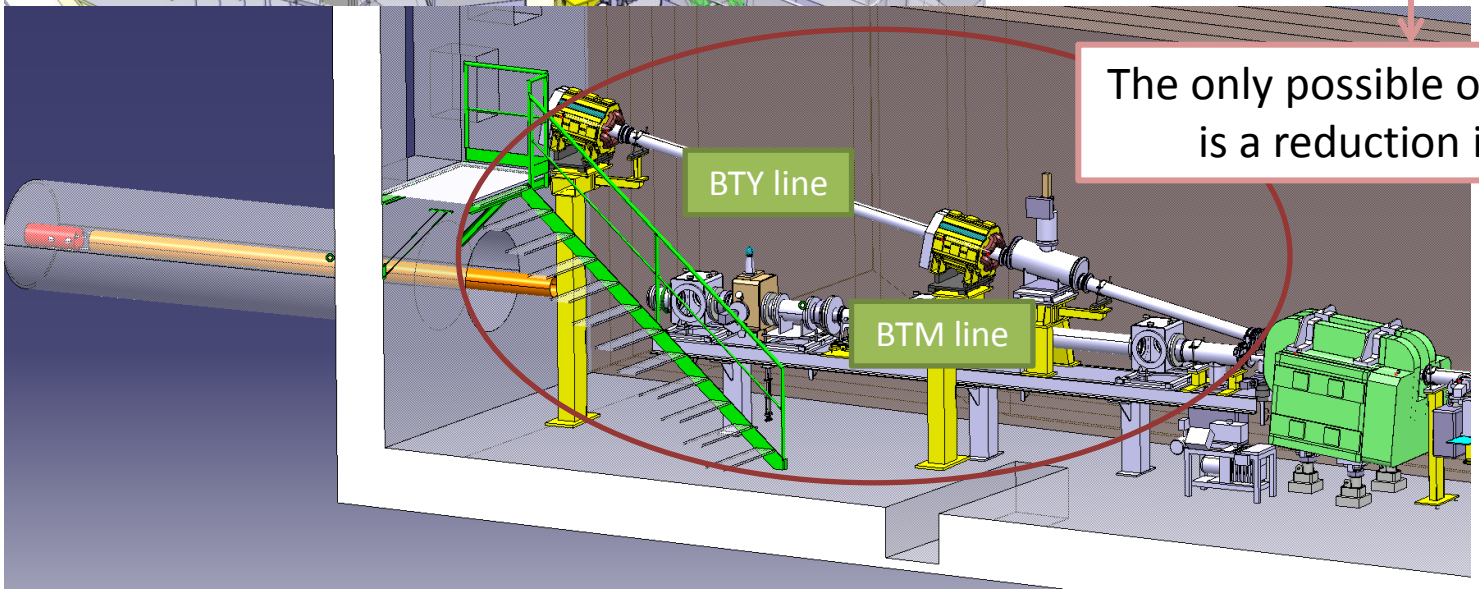
Carbon steel block: ∅ 180 mm x L 150 mm

2. TEMPORARY DISMANTLING OF EQUIPMENT IN BT, BTM AND BTY LINES



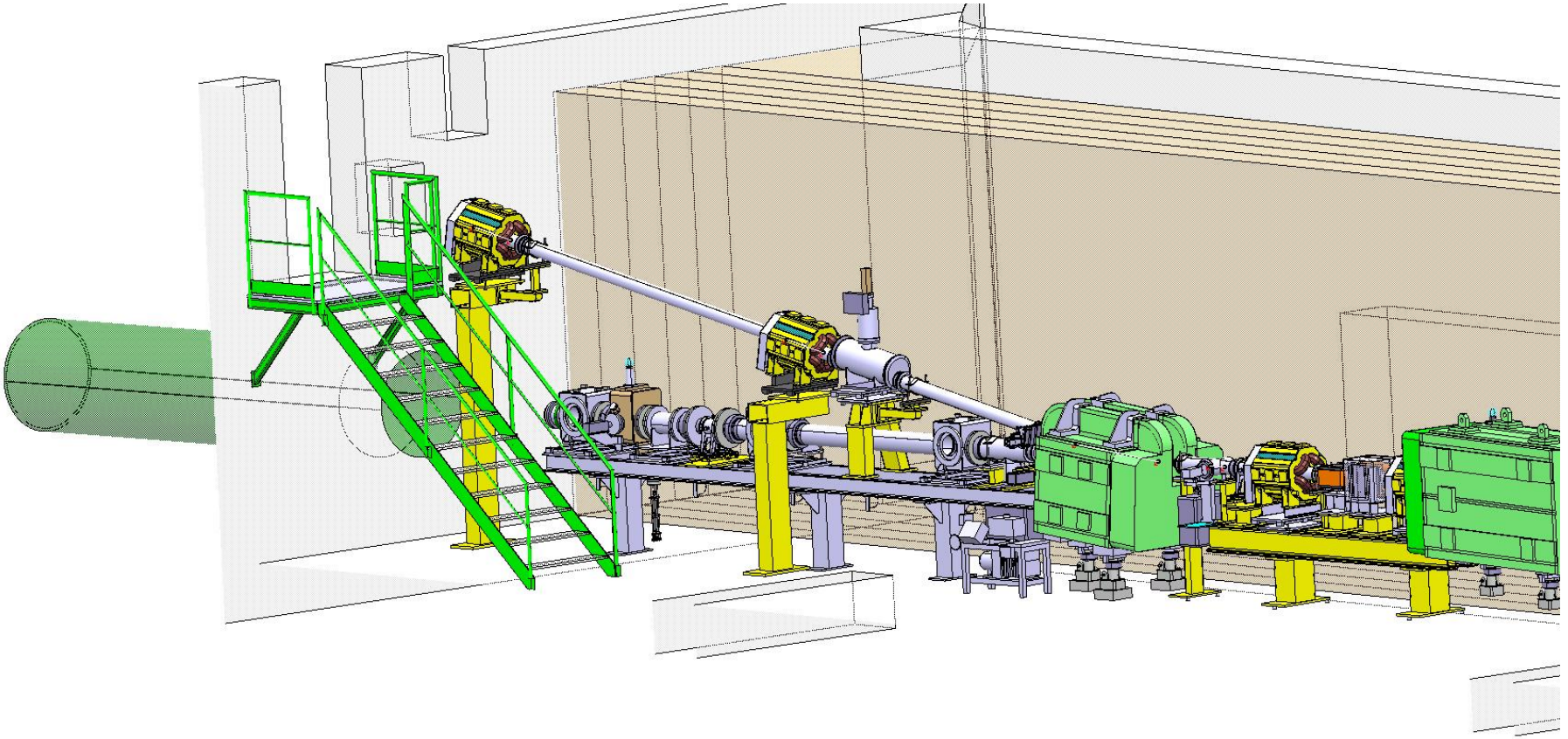
- Dismantling of equipment in BTY line
- Survey of BTM line
- Dismantling of equipment in BTM line

Main source of radiation: beam line elements



The only possible optimization is a reduction in time

2. TEMPORARY DISMANTLING OF EQUIPMENT IN BT, BTM AND BTY LINES



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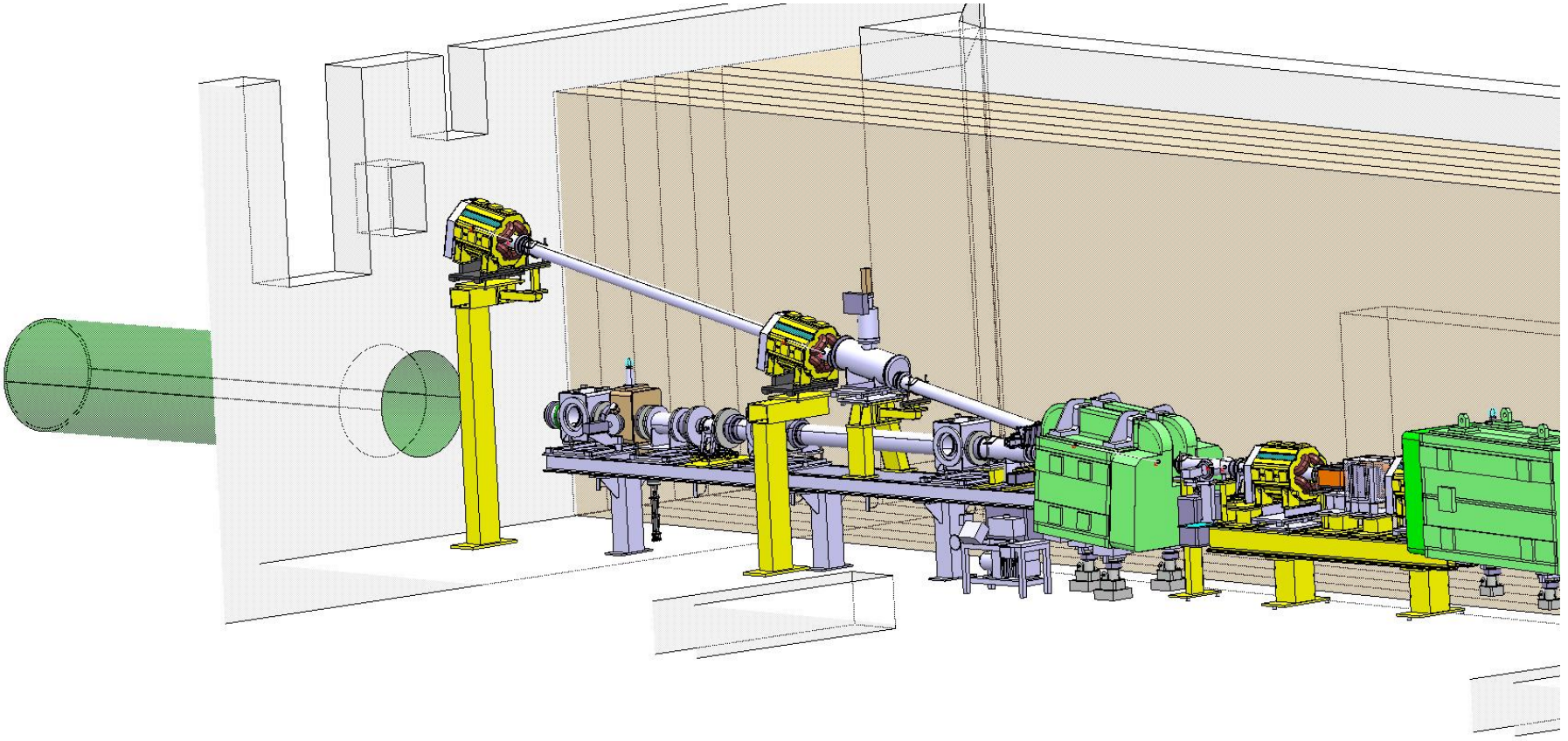

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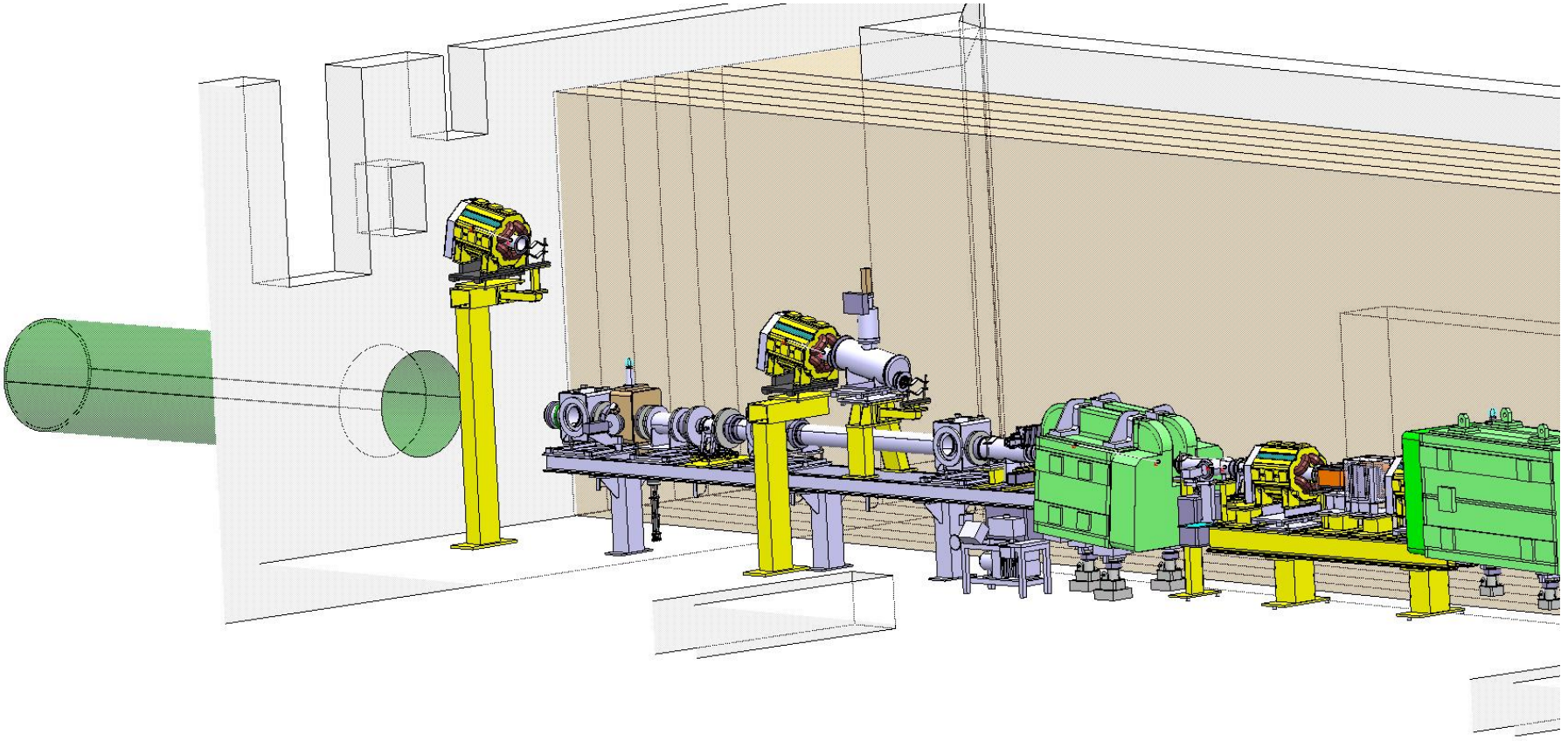

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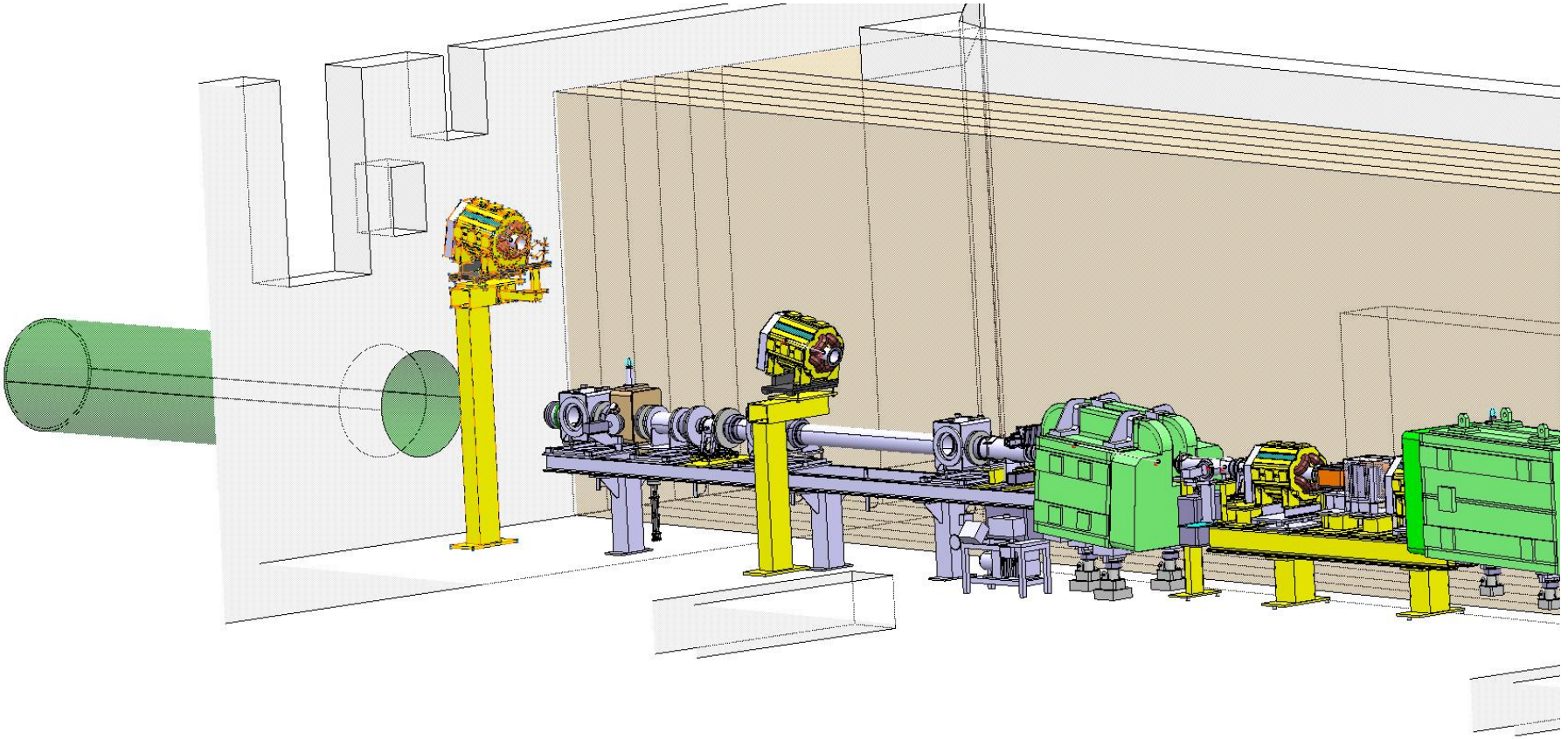

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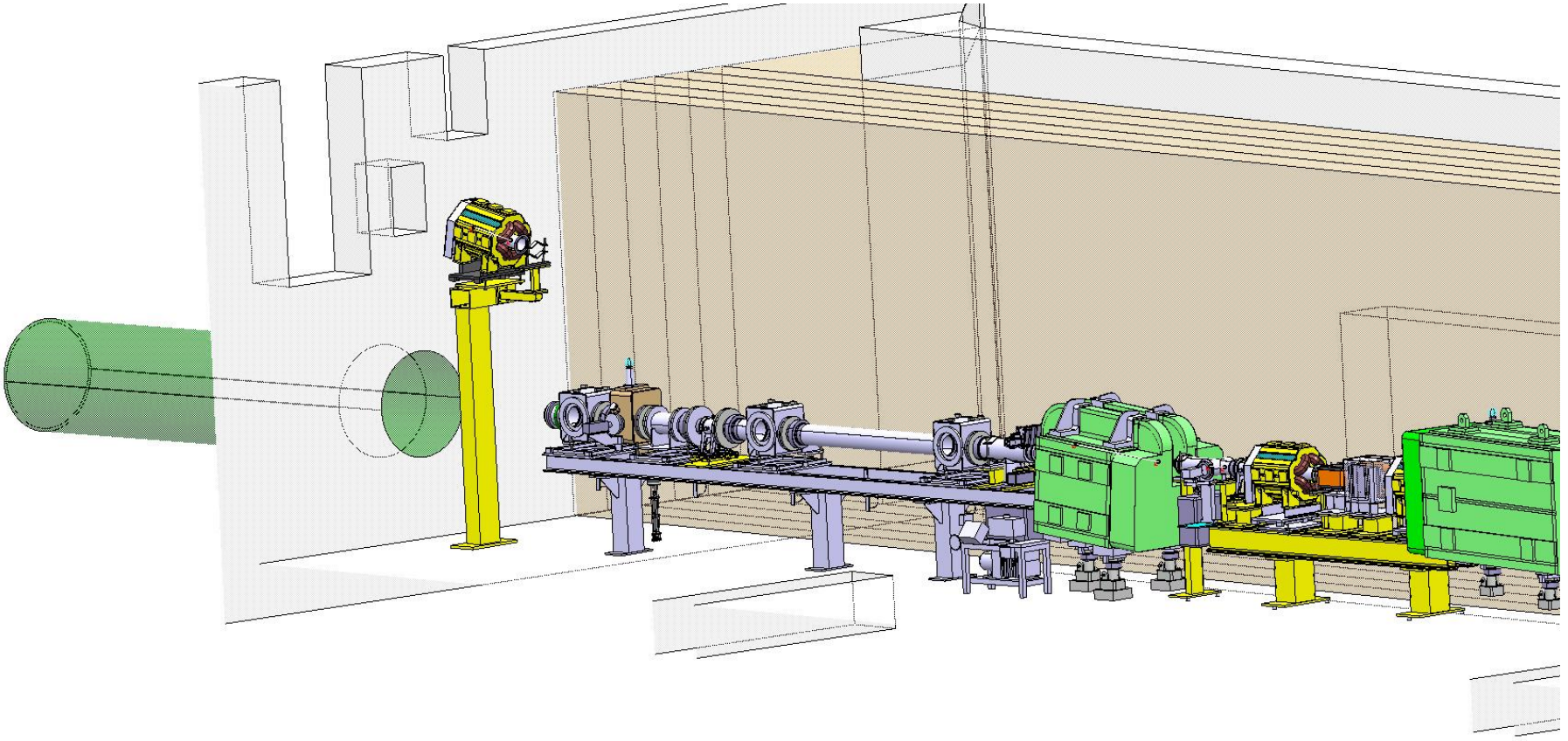

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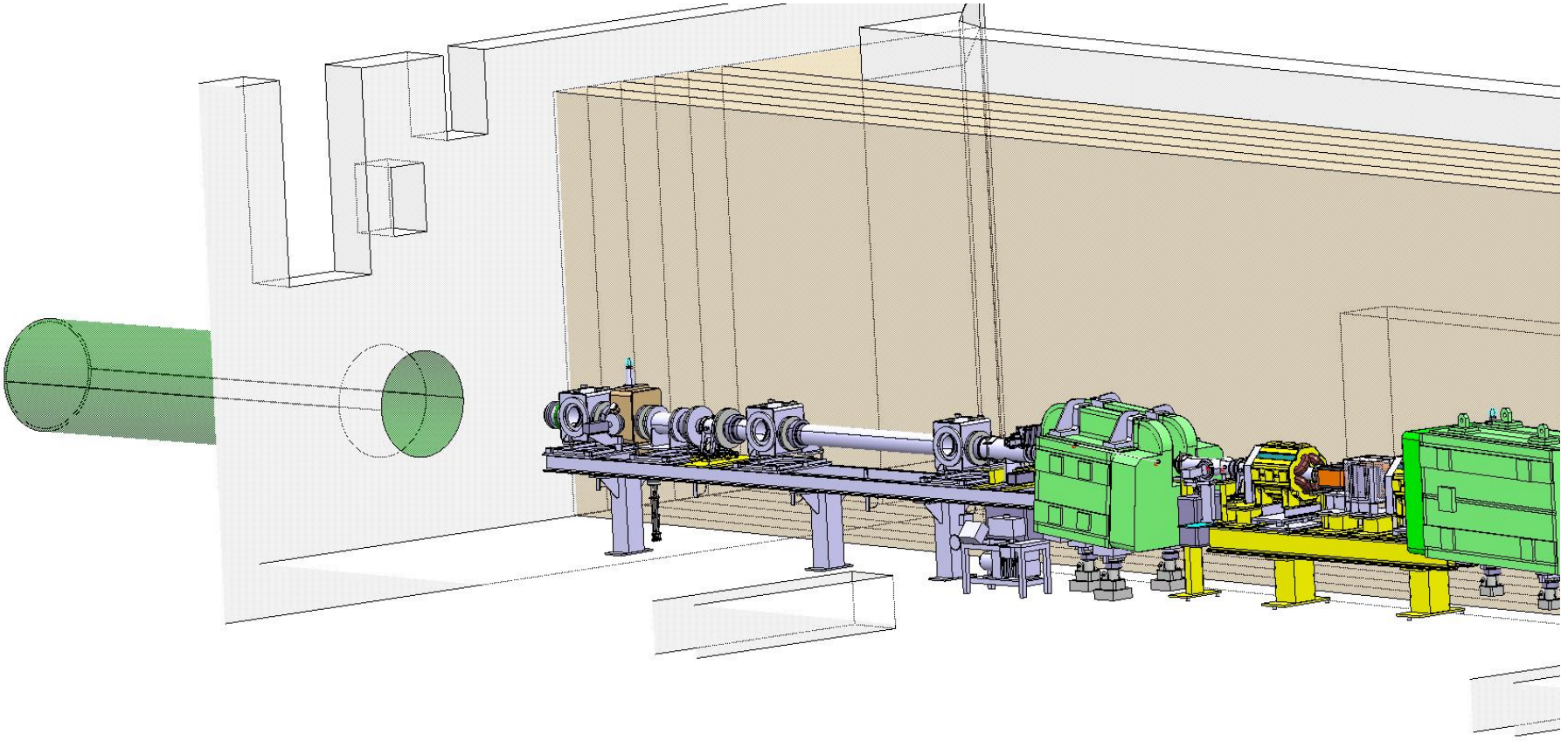

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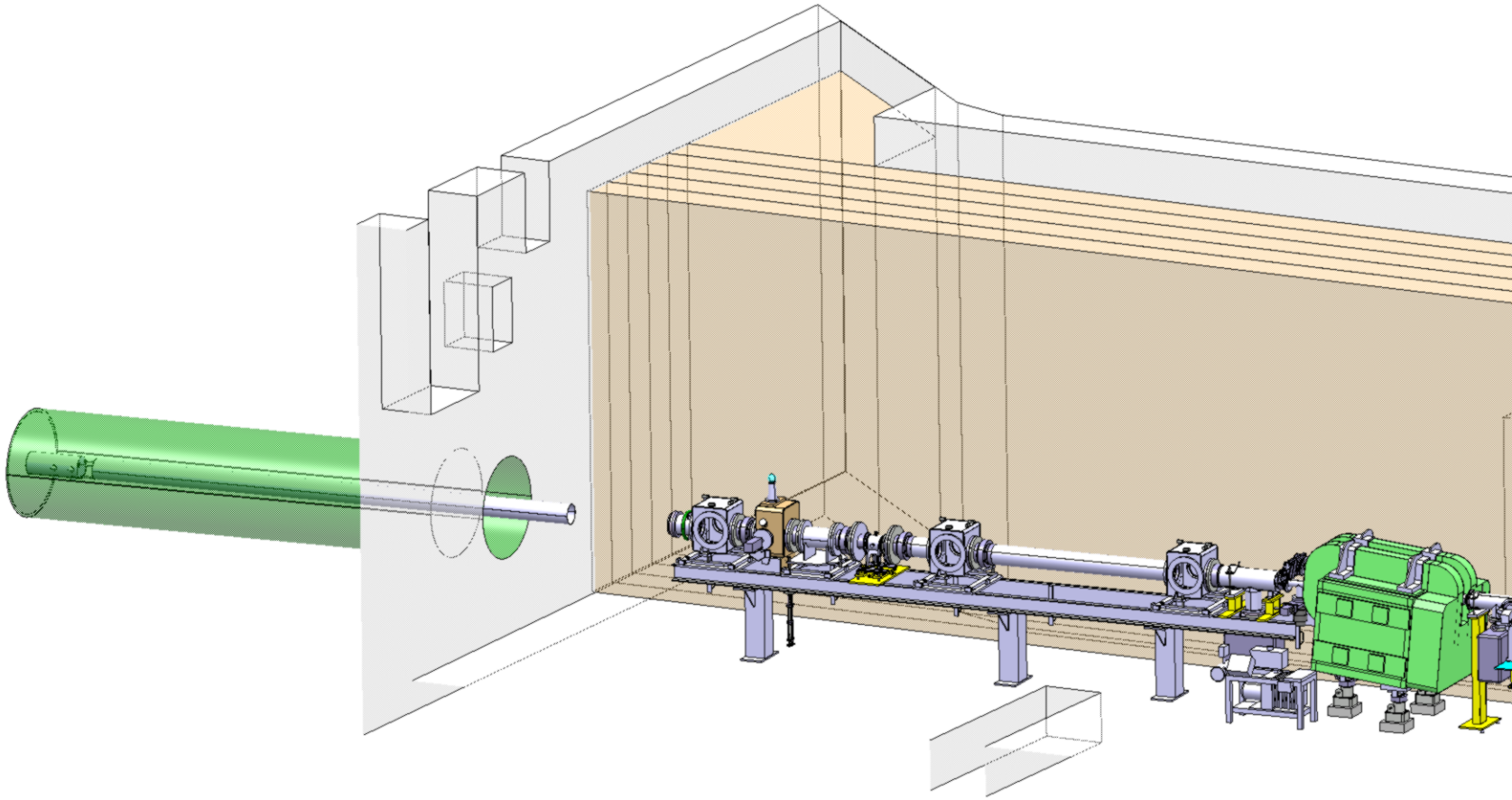

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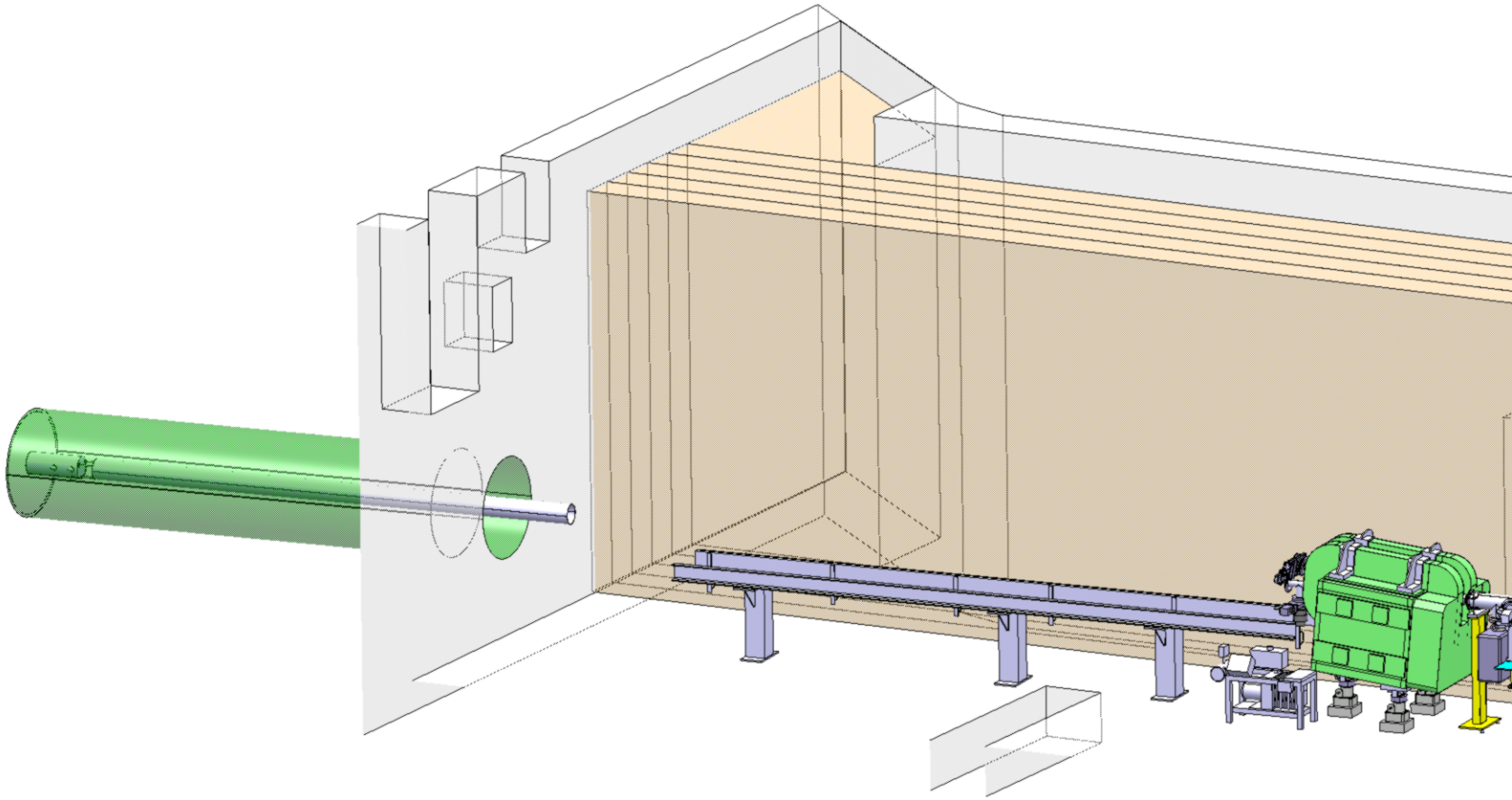
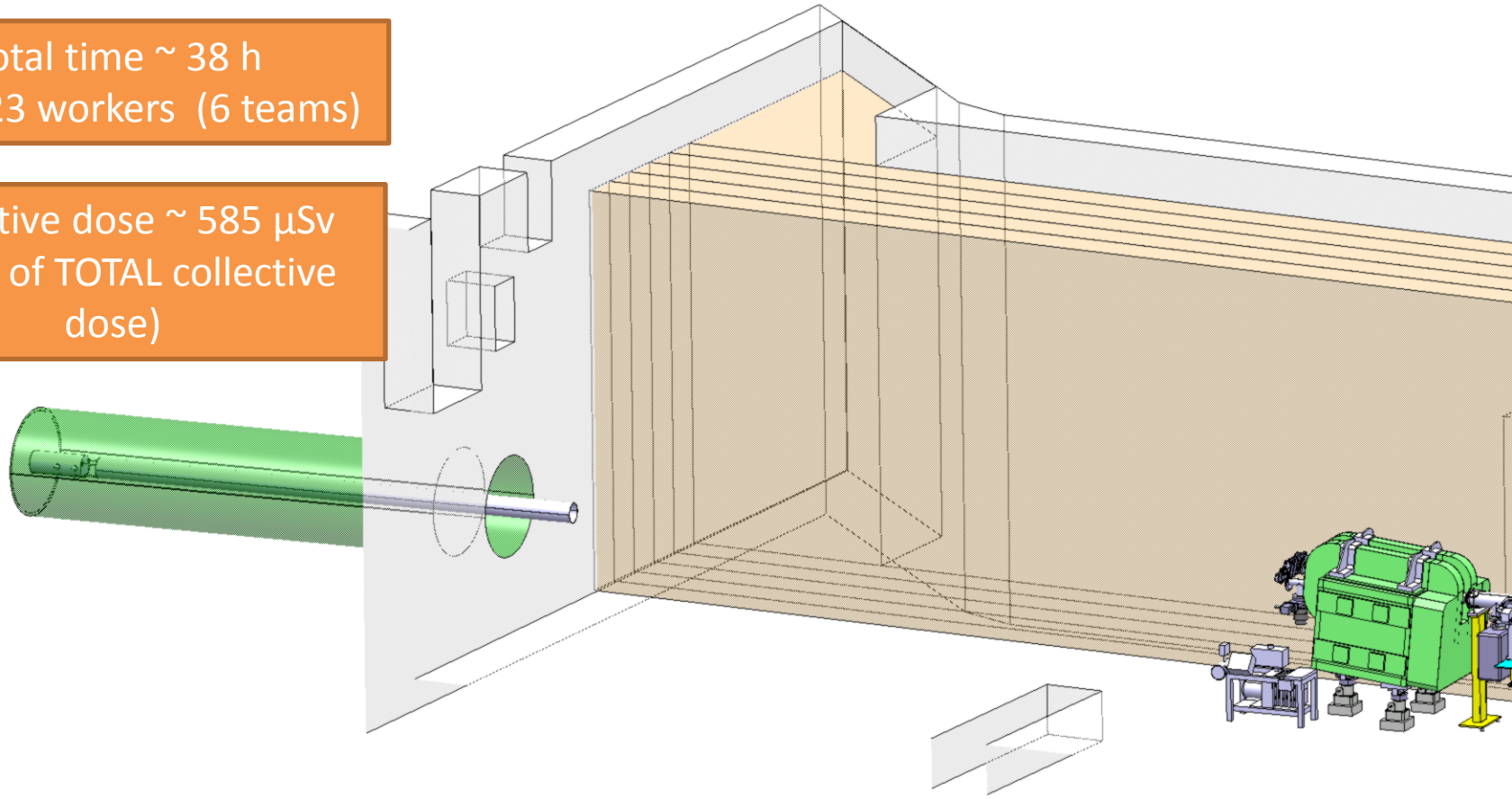


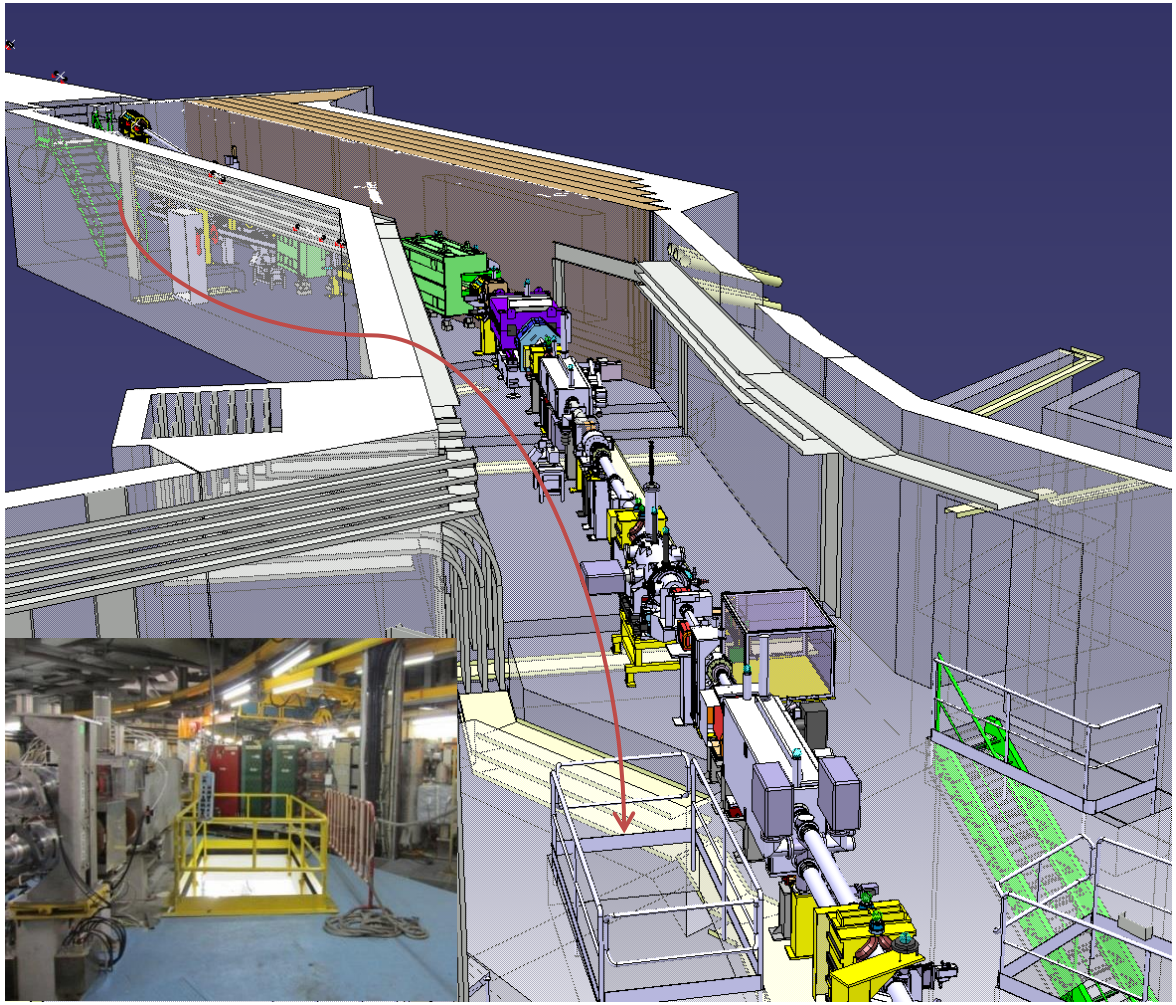
2. TEMPORARY DISMANTLING OF EQUIPMENT IN BT, BTM AND BTY LINES

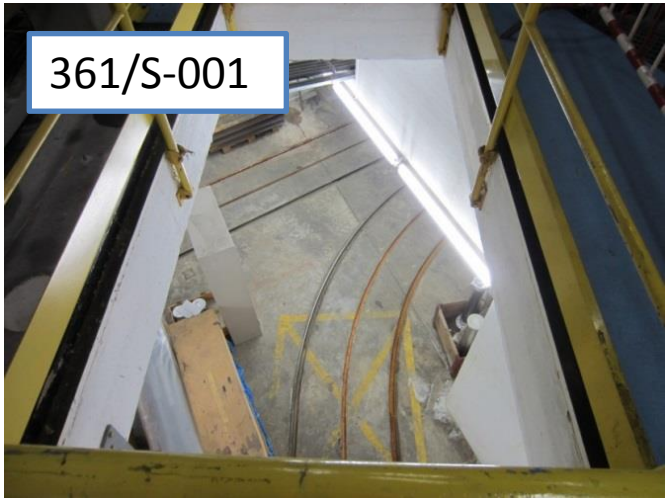
Total time ~ 38 h
Min. ~23 workers (6 teams)

Collective dose ~ 585 µSv
(~19% of TOTAL collective dose)

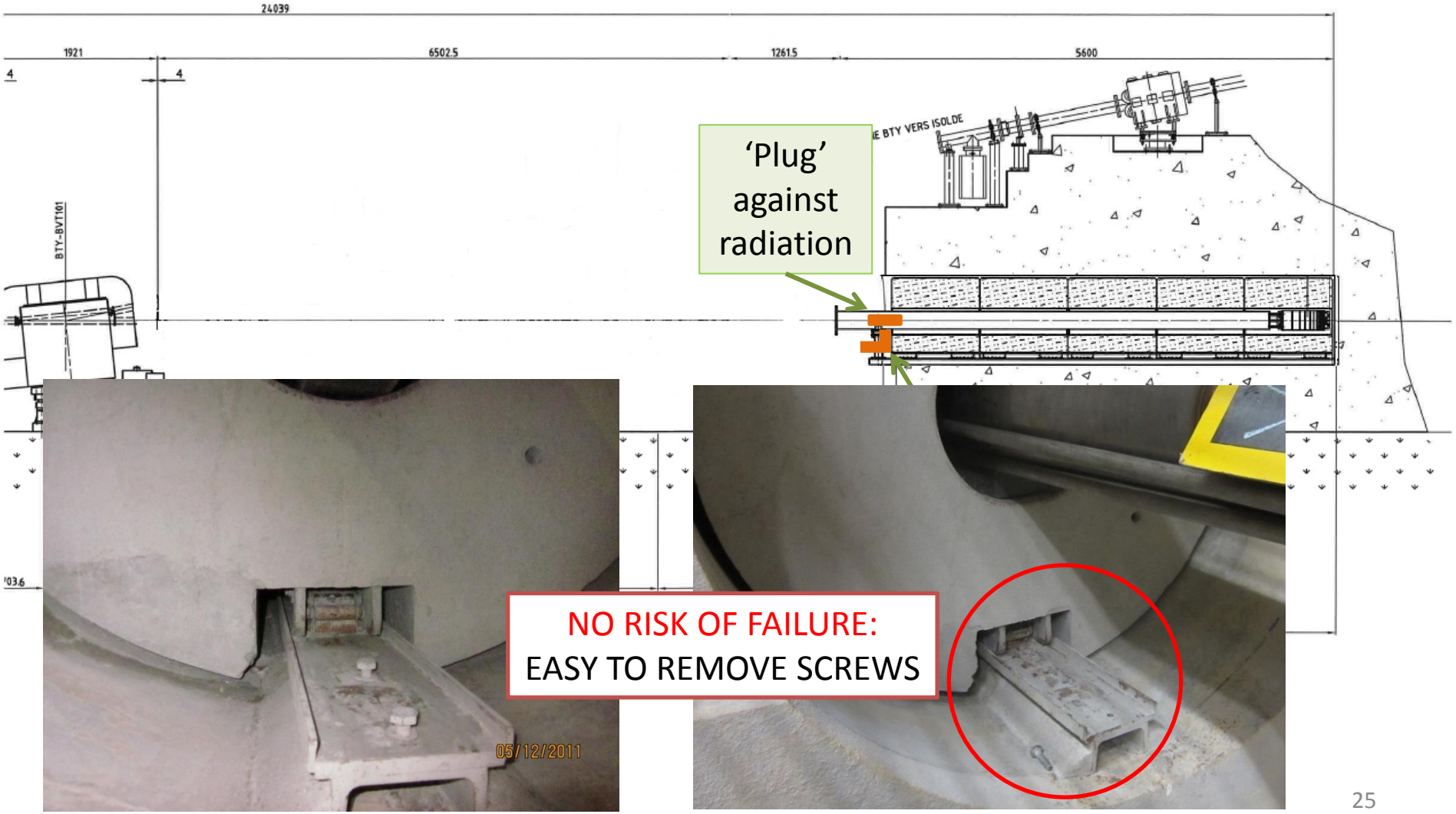


STORAGE OF BEAM LINE ELEMENTS





3. DISMANTLING AND DISPOSAL OPERATIONS



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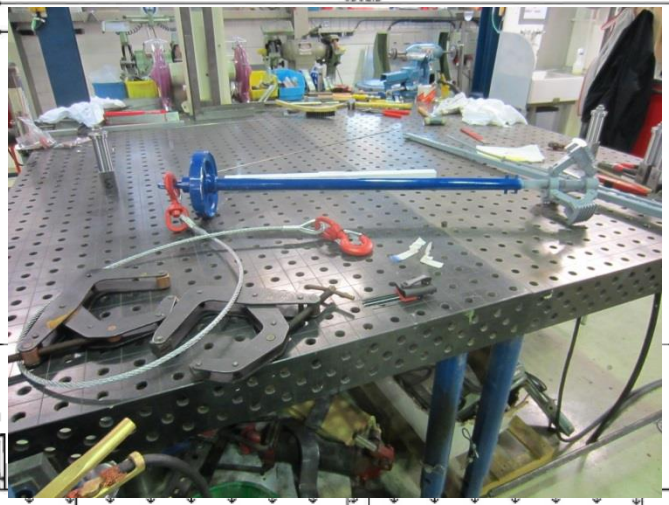

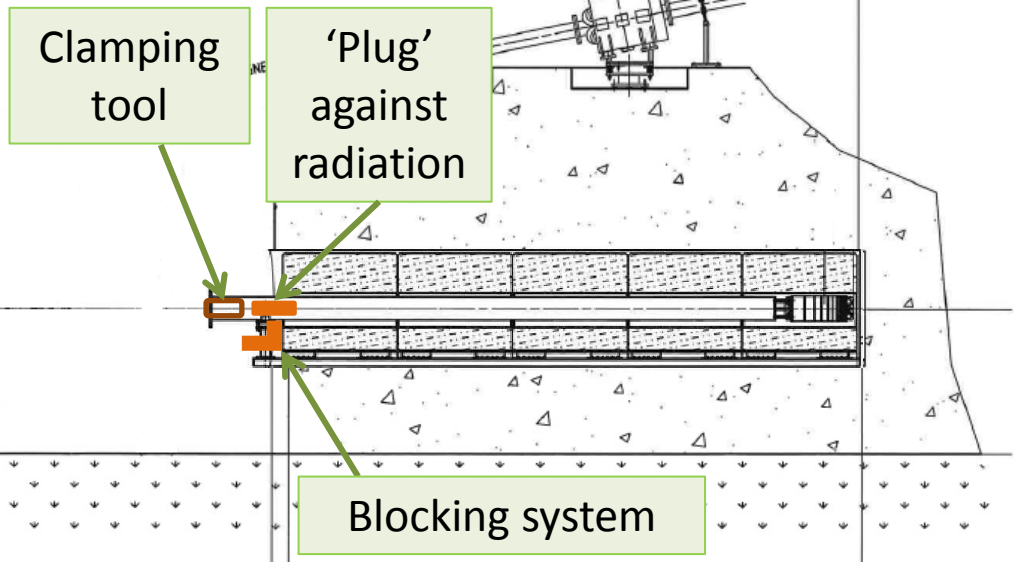

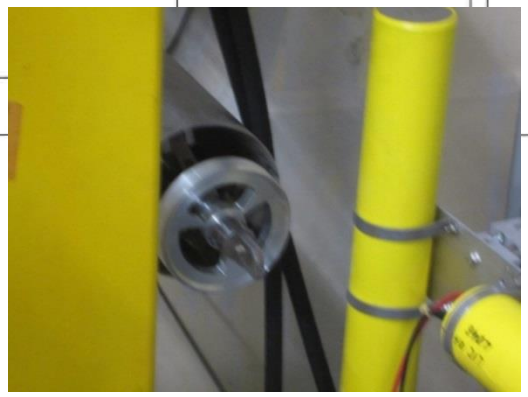

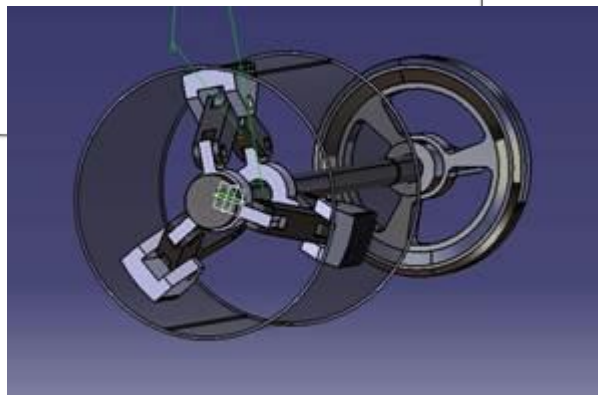

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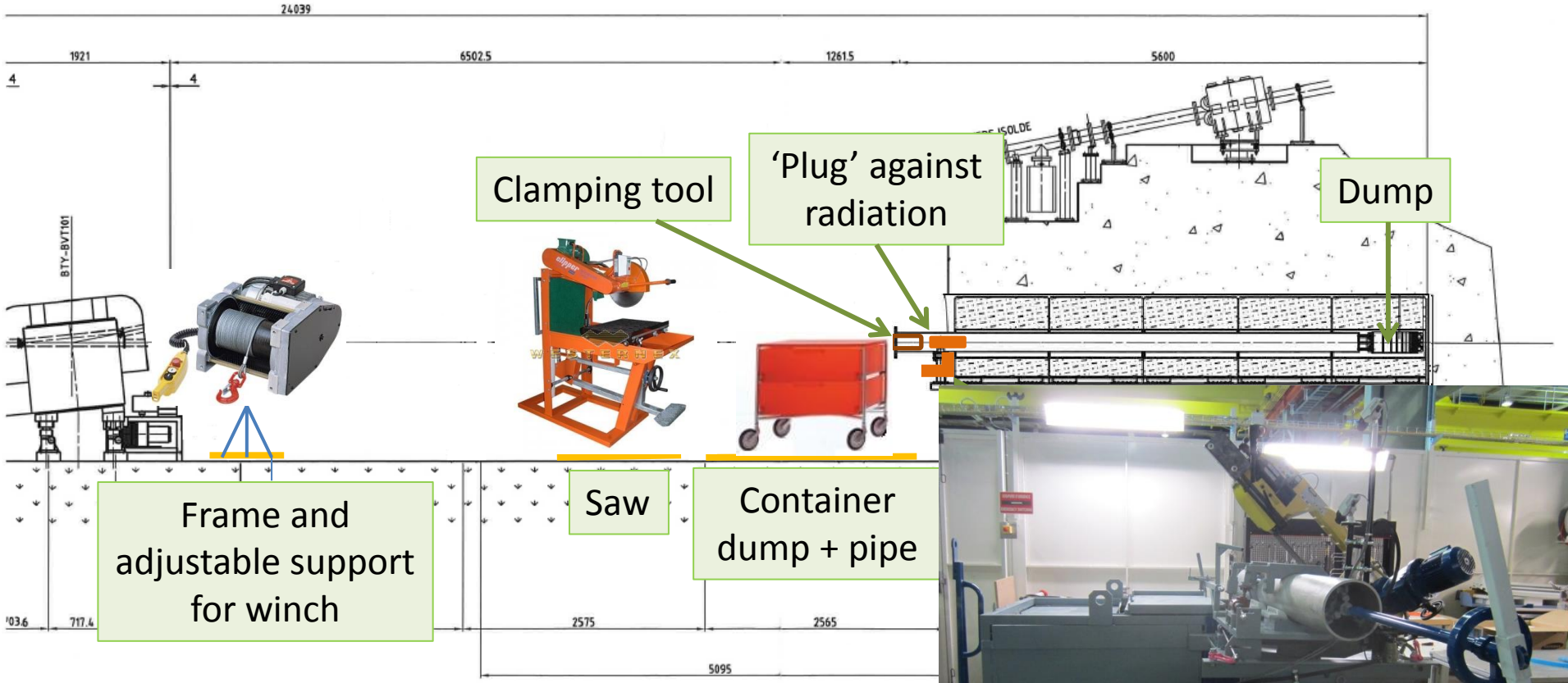
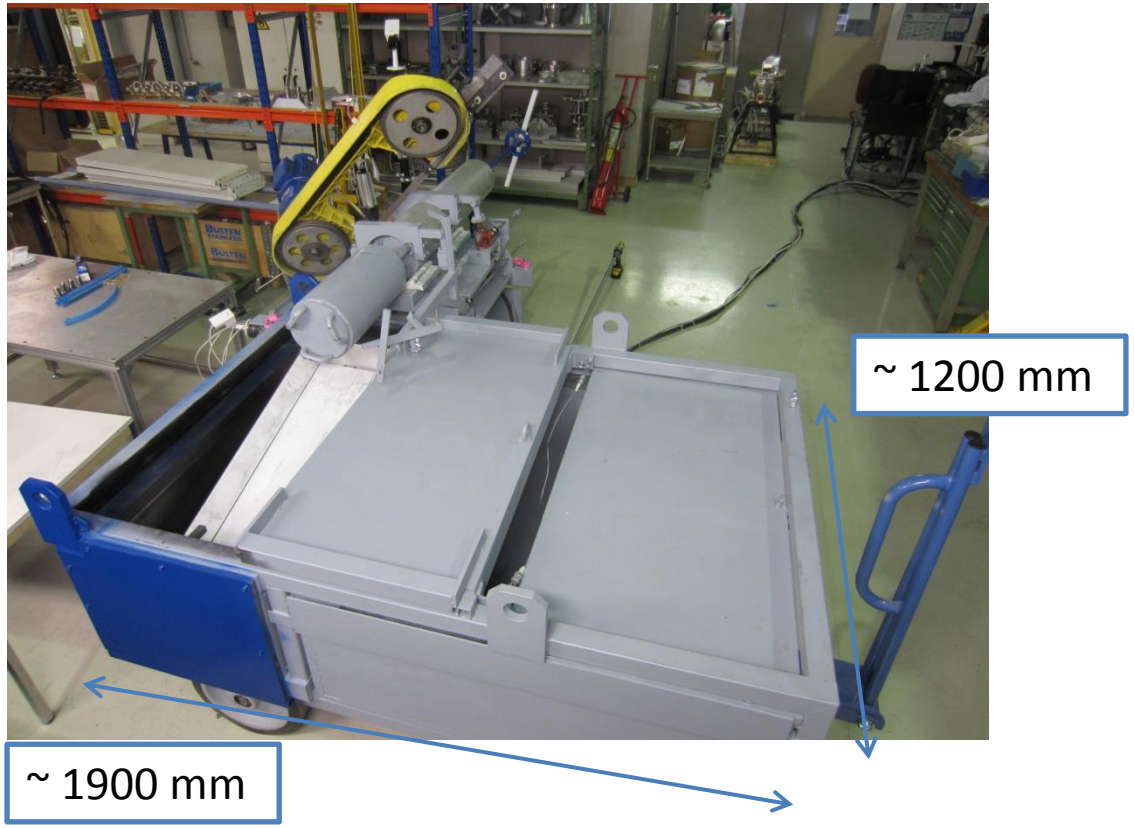


Installation extension of rail

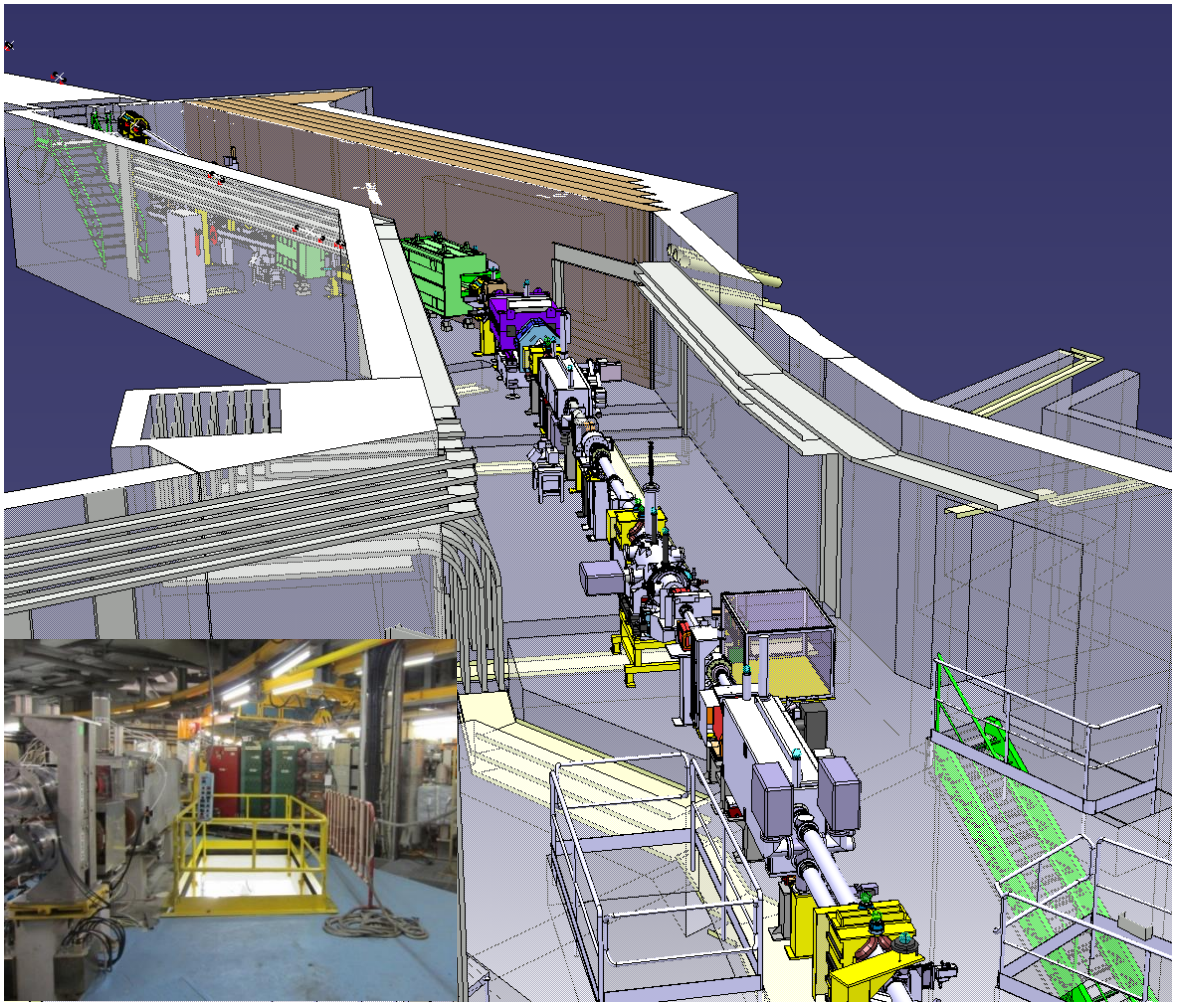
CONTAINER FOR RW



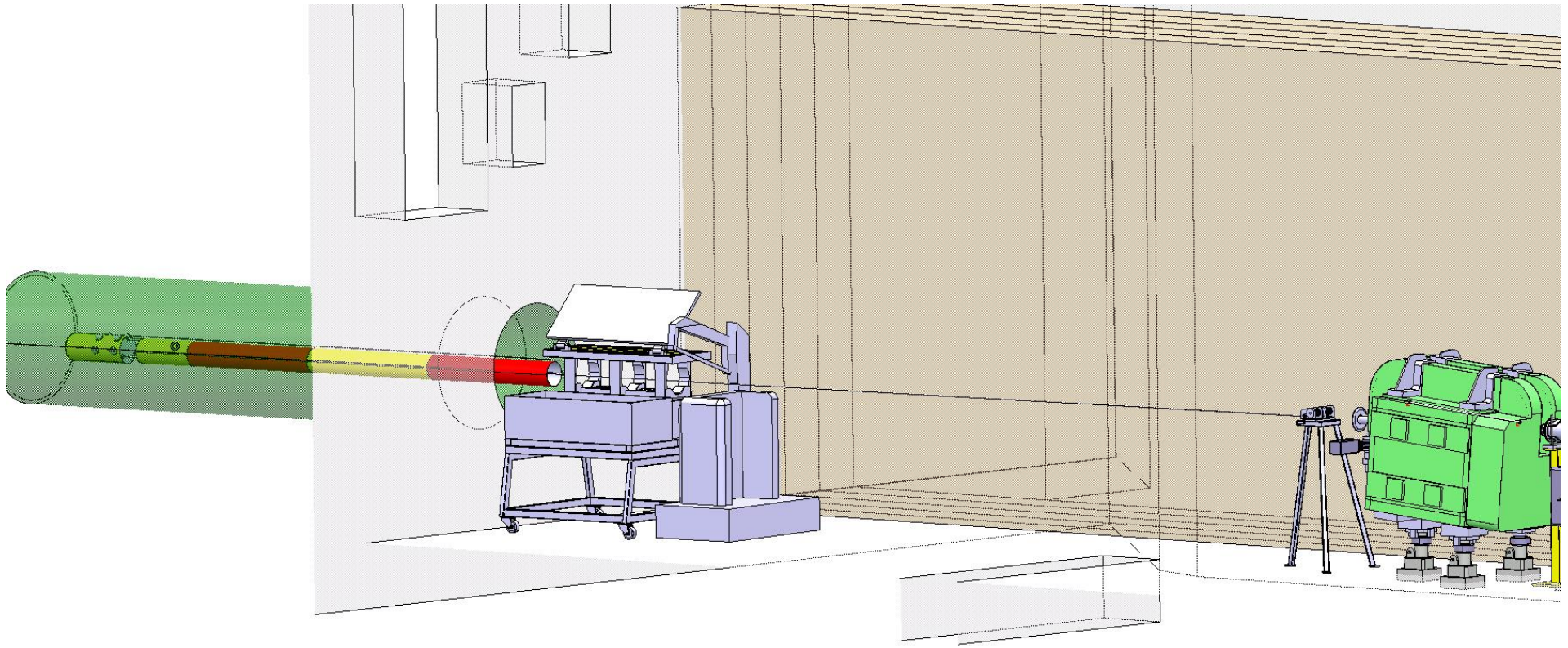
- 5-7 cm of lead on dump side
- 2 cm of steel on pipe side
- weight: ~3000 kg with RW

The necessary equipment will be brought through the shaft by crane

Length: 2.6m to 2.9m
Width: 1.3m
SWL PR: 10t



3. DISMANTLING AND DISPOSAL OPERATIONS: DUMP REMOVAL



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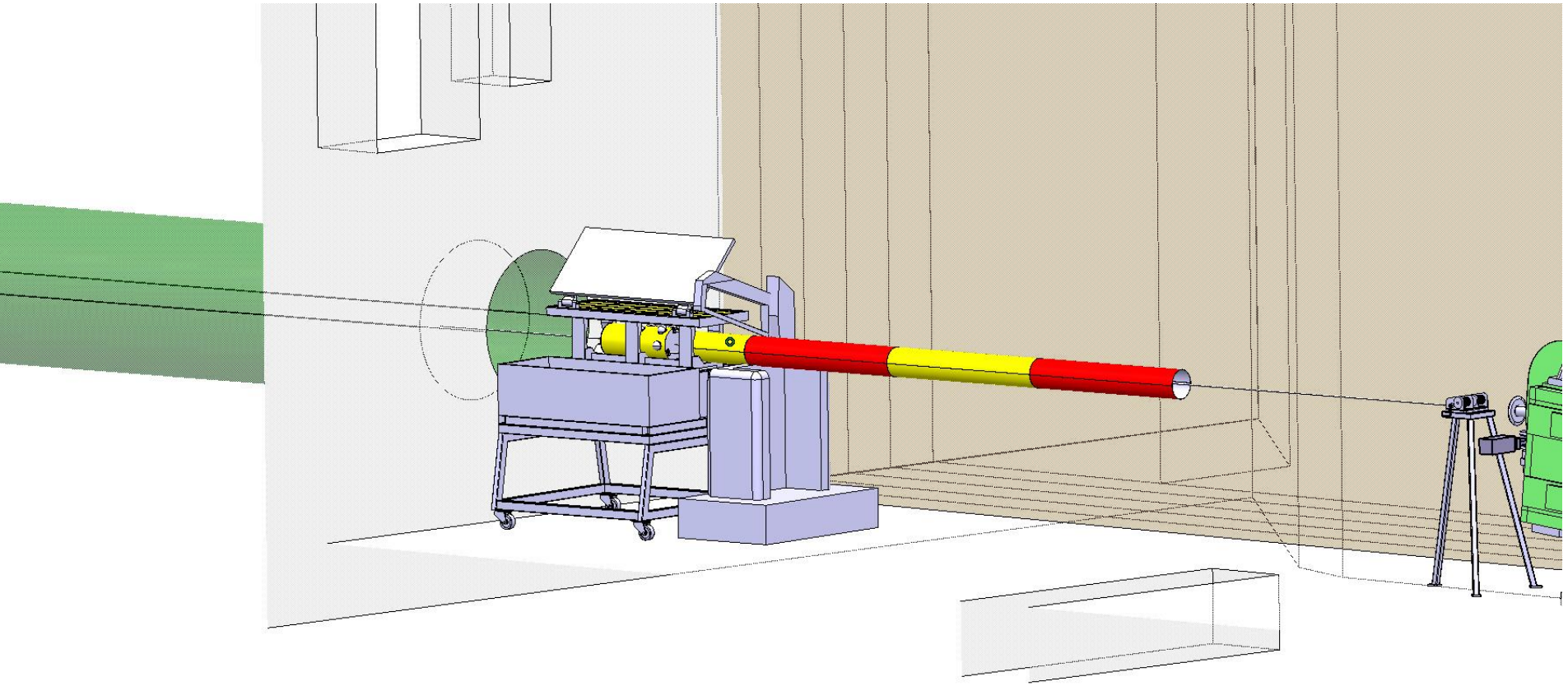

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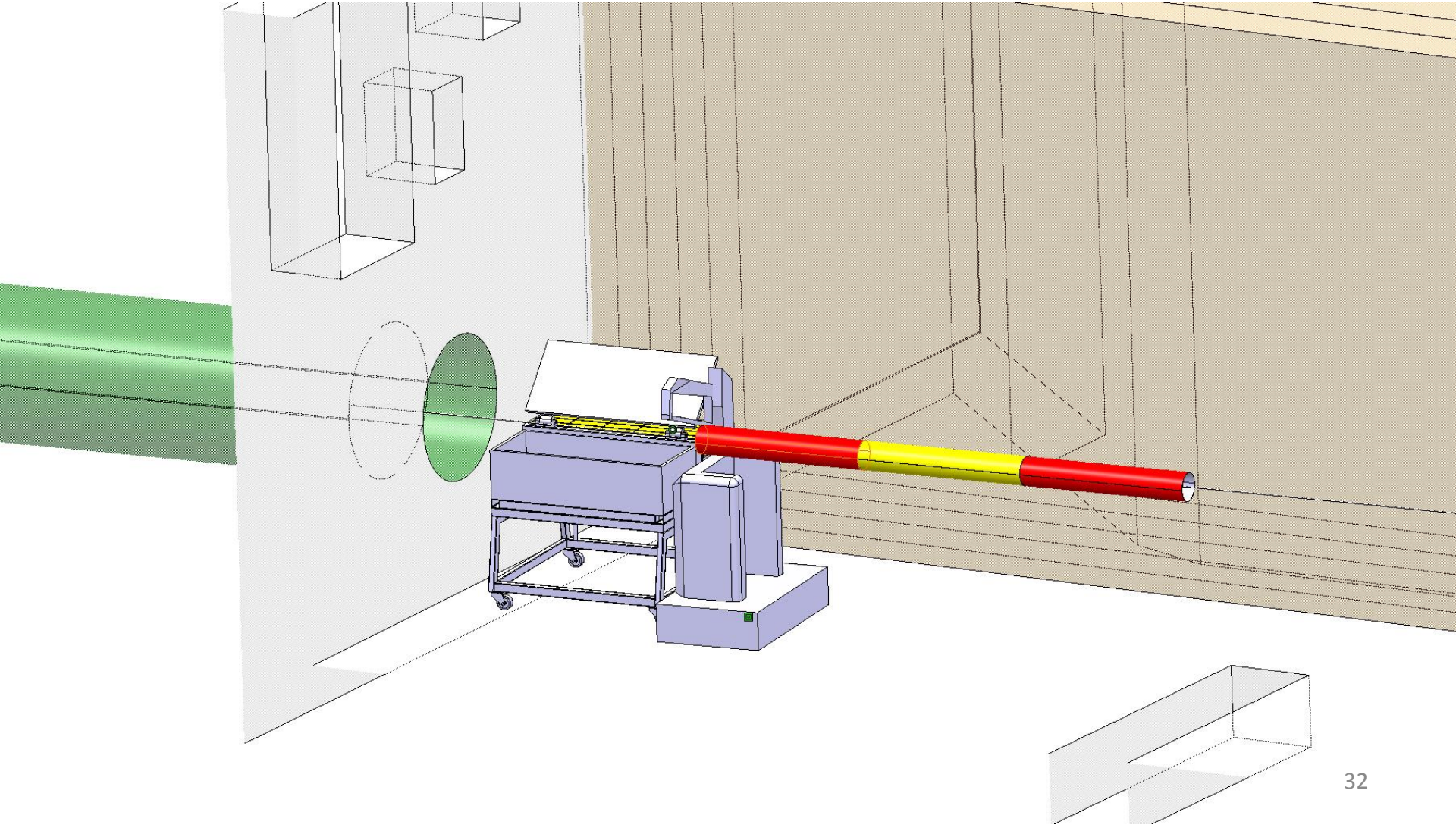

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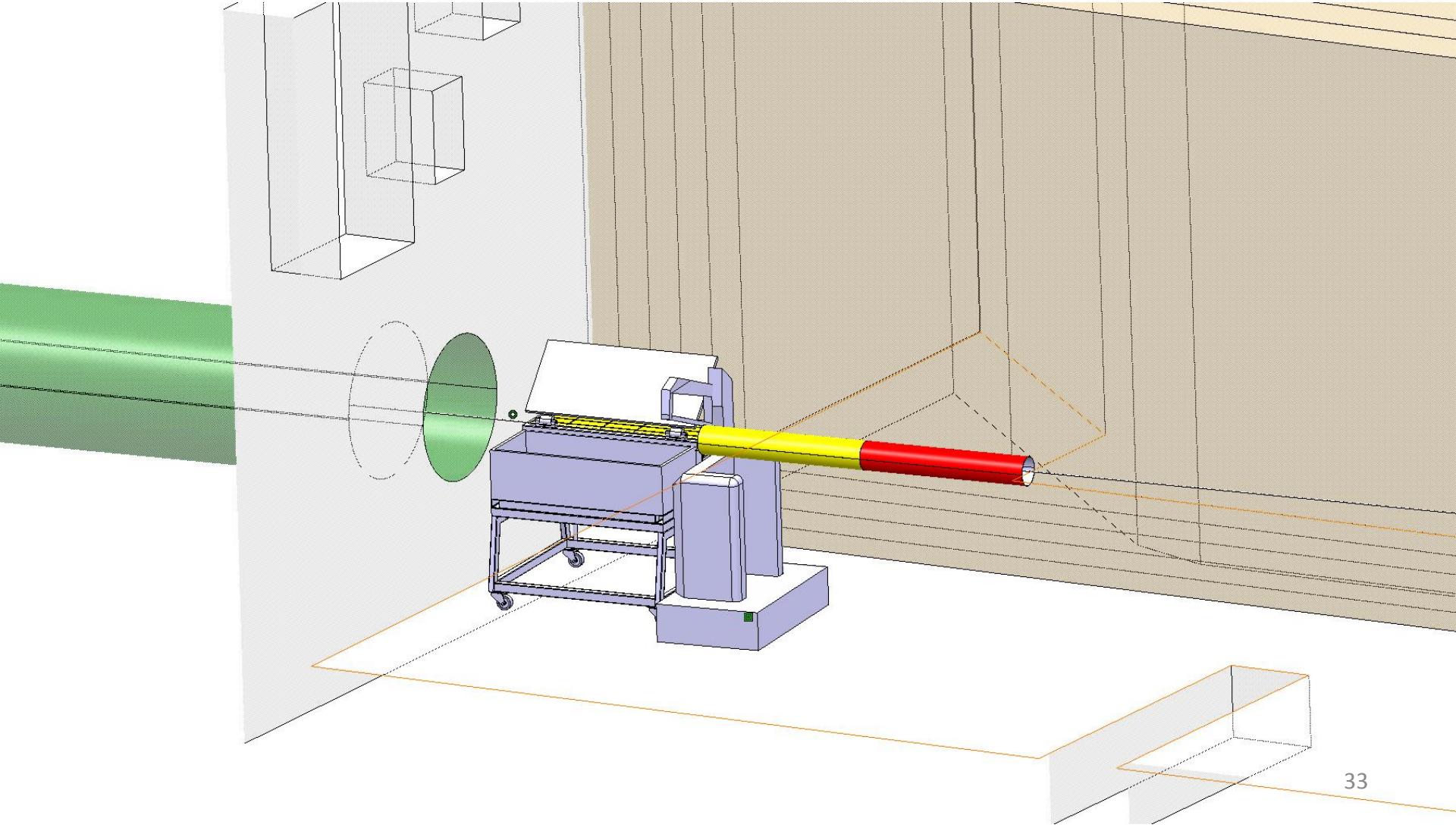

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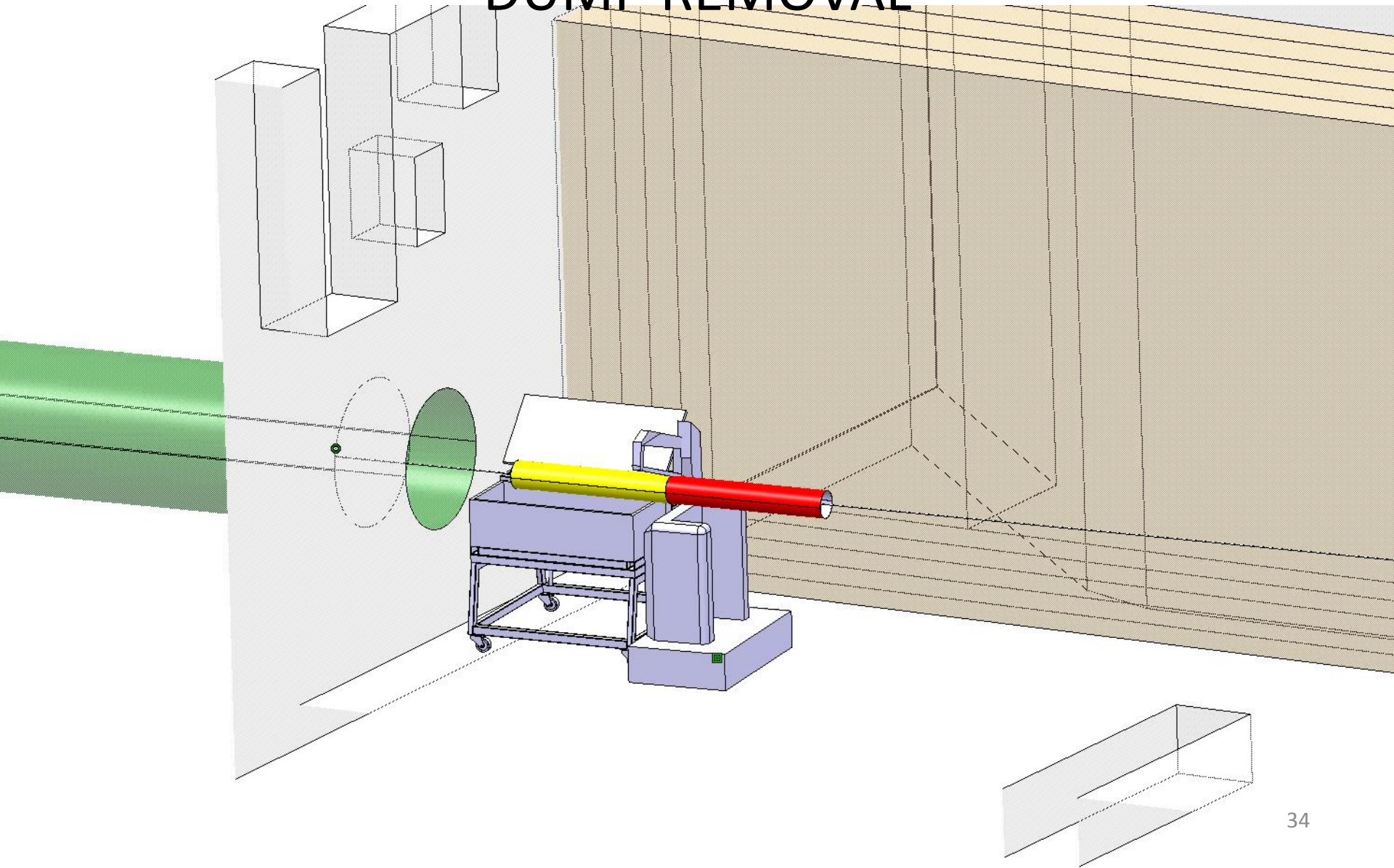

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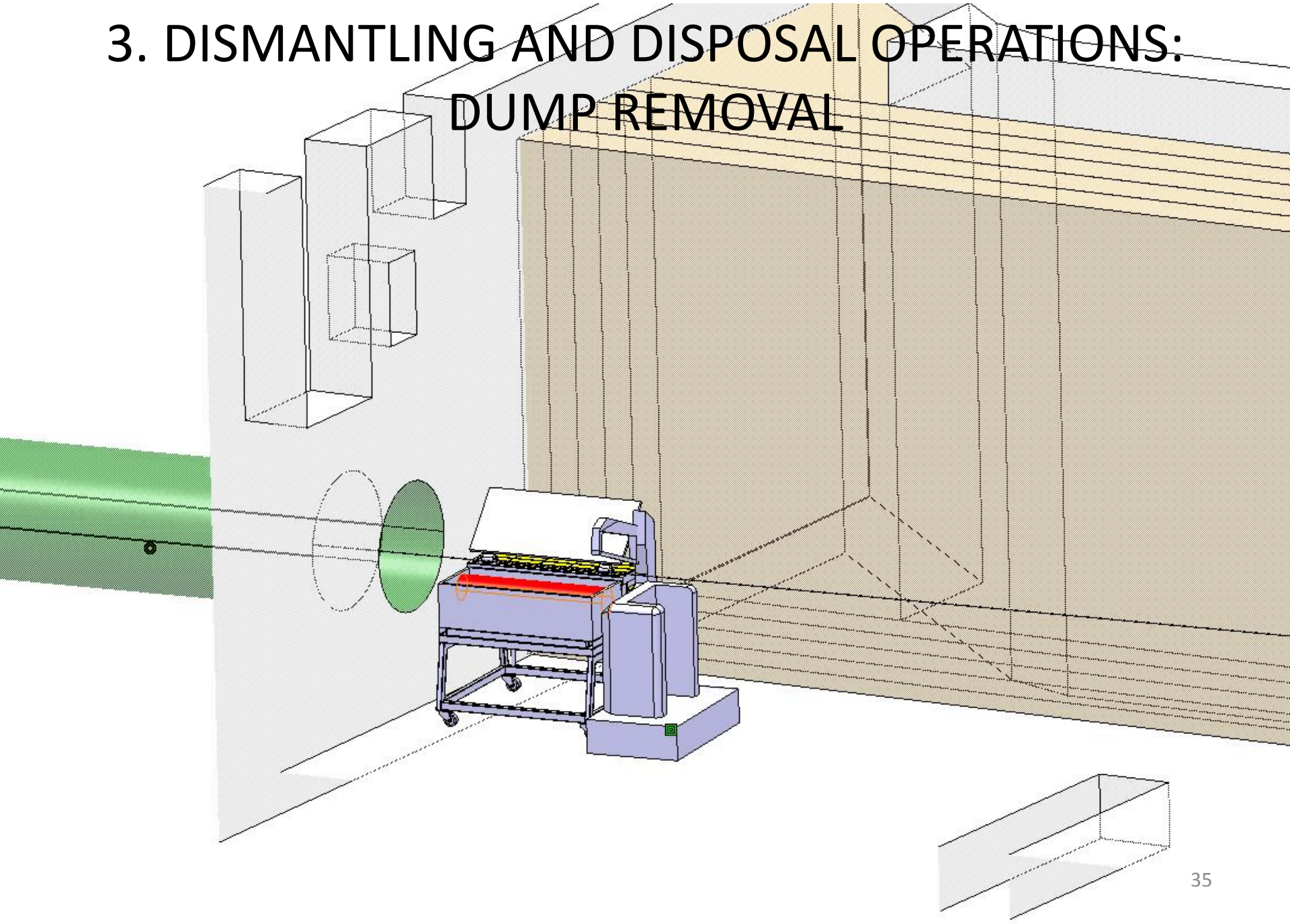

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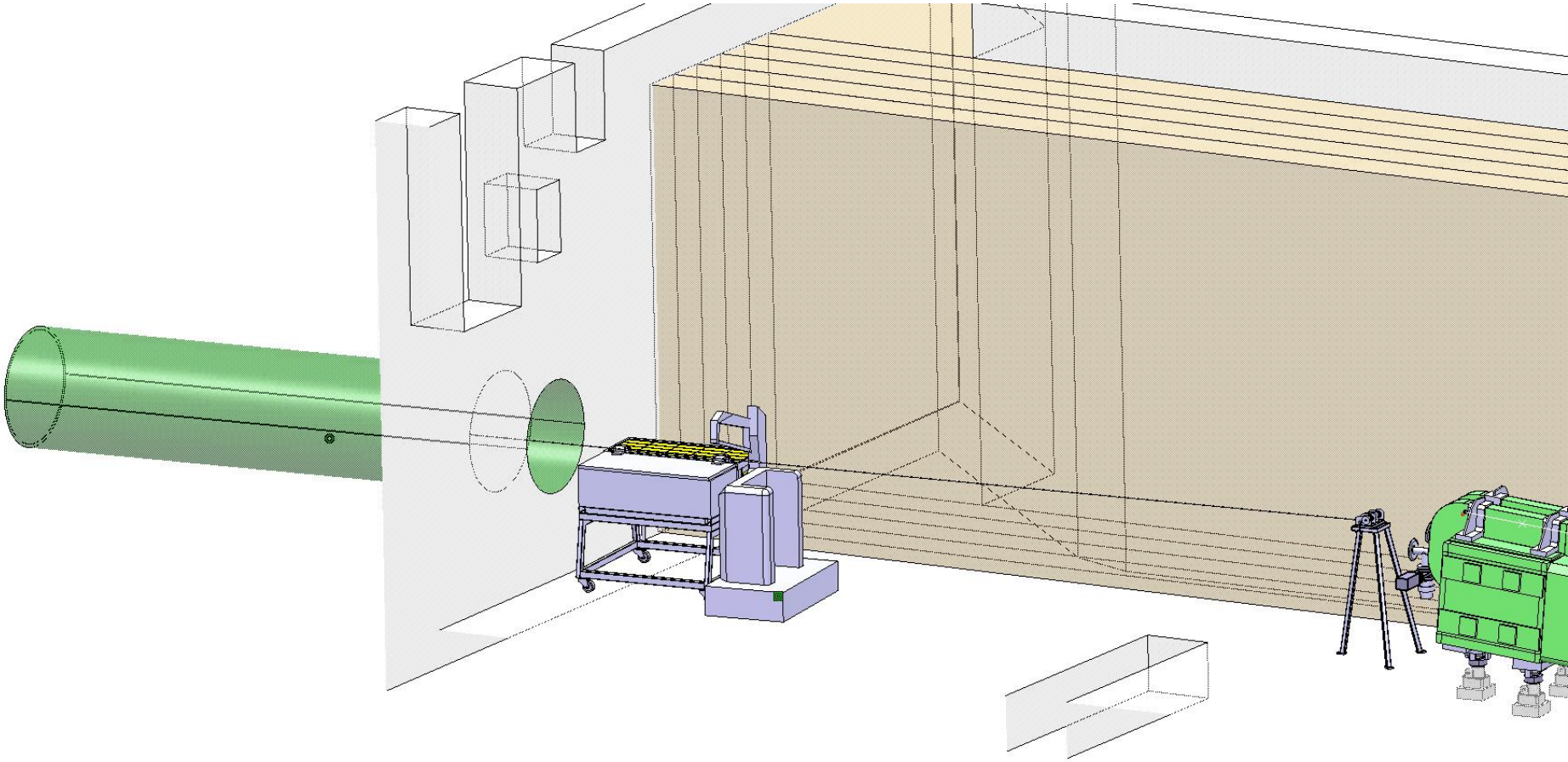

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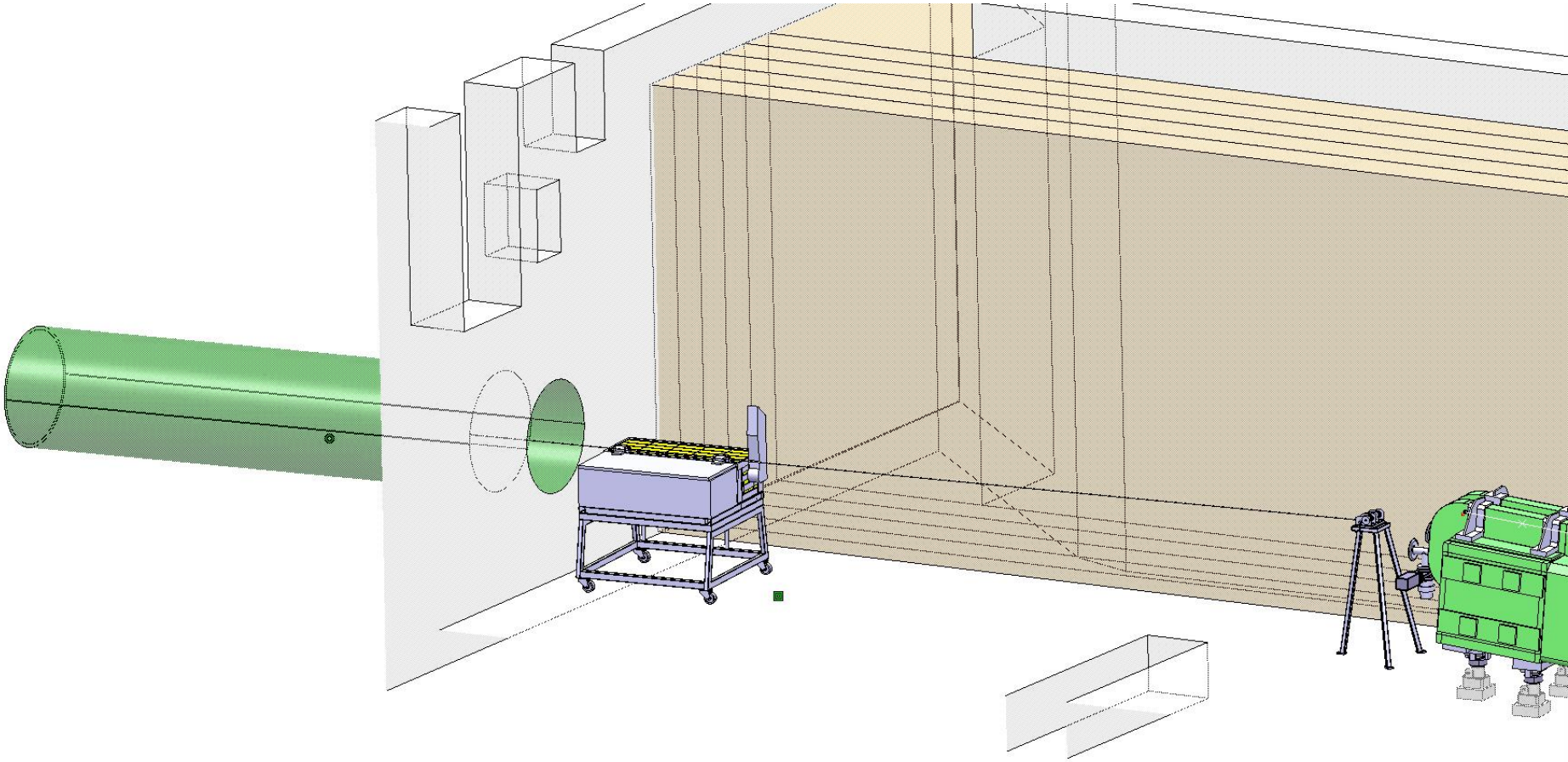
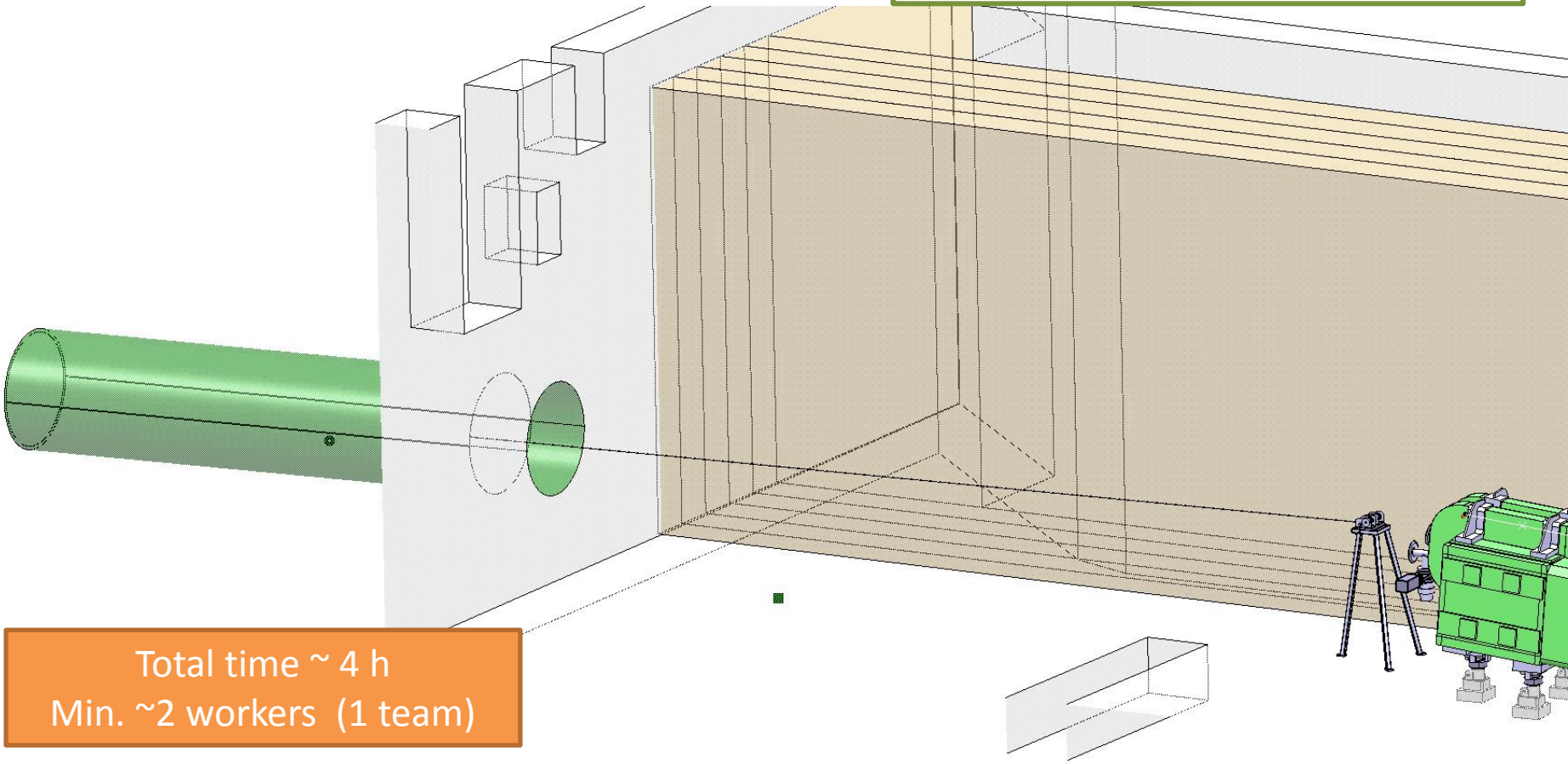


3. DISMANTLING AND DISPOSAL OPERATIONS: DUMP REMOVAL

Vacuum clean floor after cutting



Total time ~ 4 h
Min. ~2 workers (1 team)

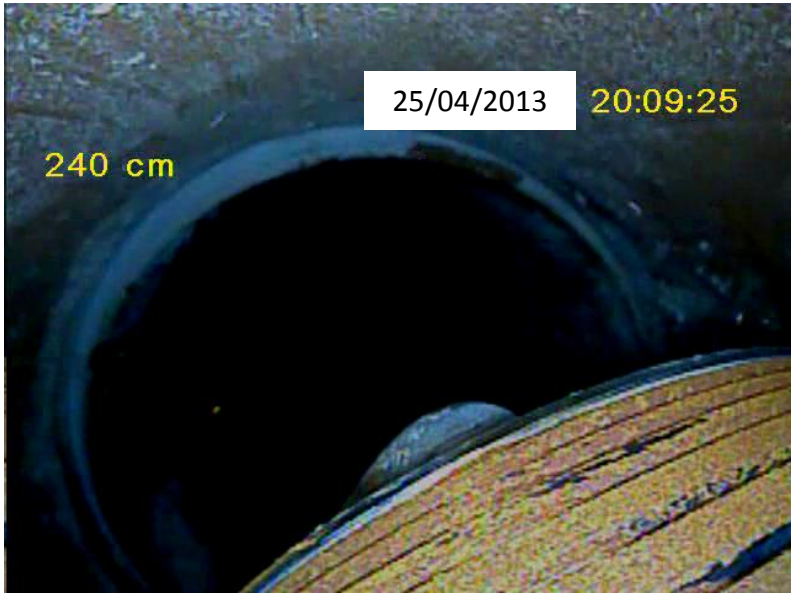
Collective dose ~ 450 µSv (15% of TOTAL collective dose)

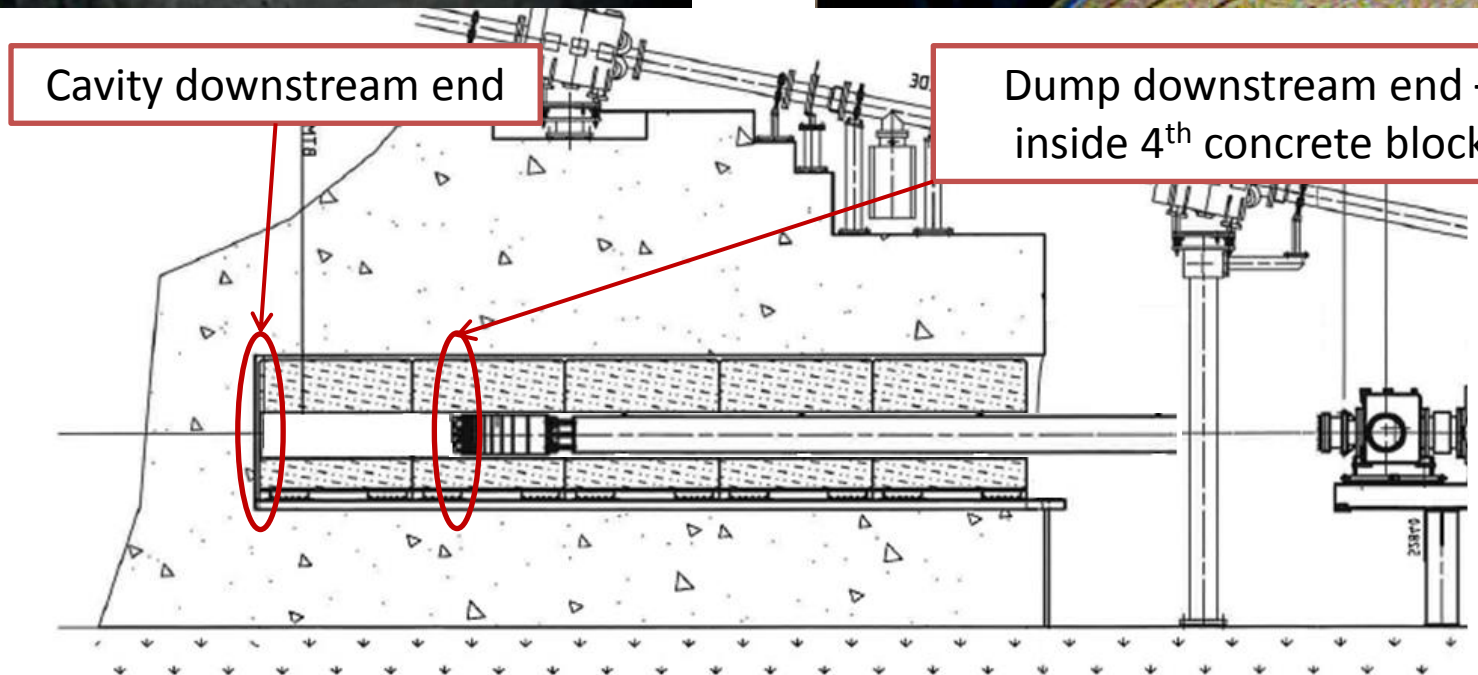
MAIN RISK OF DISMANTLING DUMP:
it is adhered to the shielding and it does not come out

- A test was performed on the 25th of April and the dump was successfully pulled out – manually – by about 15 cm

  $\rightarrow$ NO LONGER A RISK
- Inspection by means of an endoscope the same day, the dump seems to be in one piece
- The operator who performed the operation took 6 µSv

ENDOSCOPY 25TH April 2013





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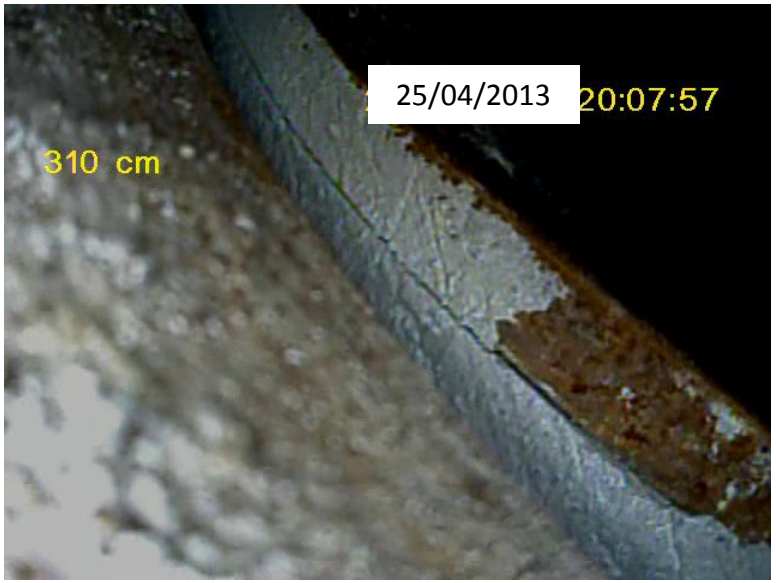
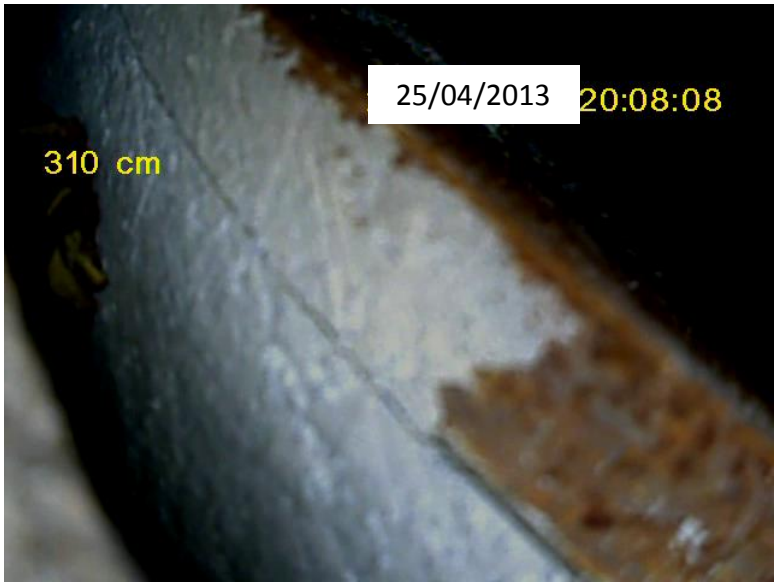
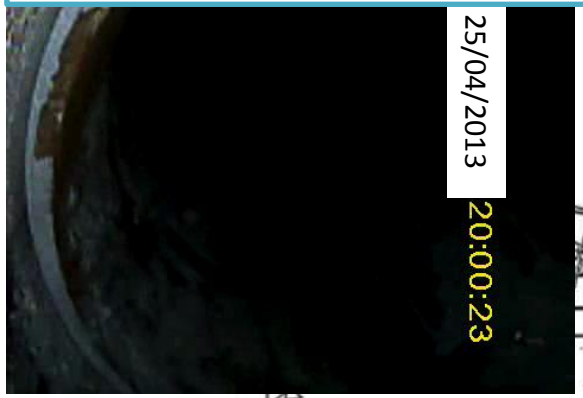
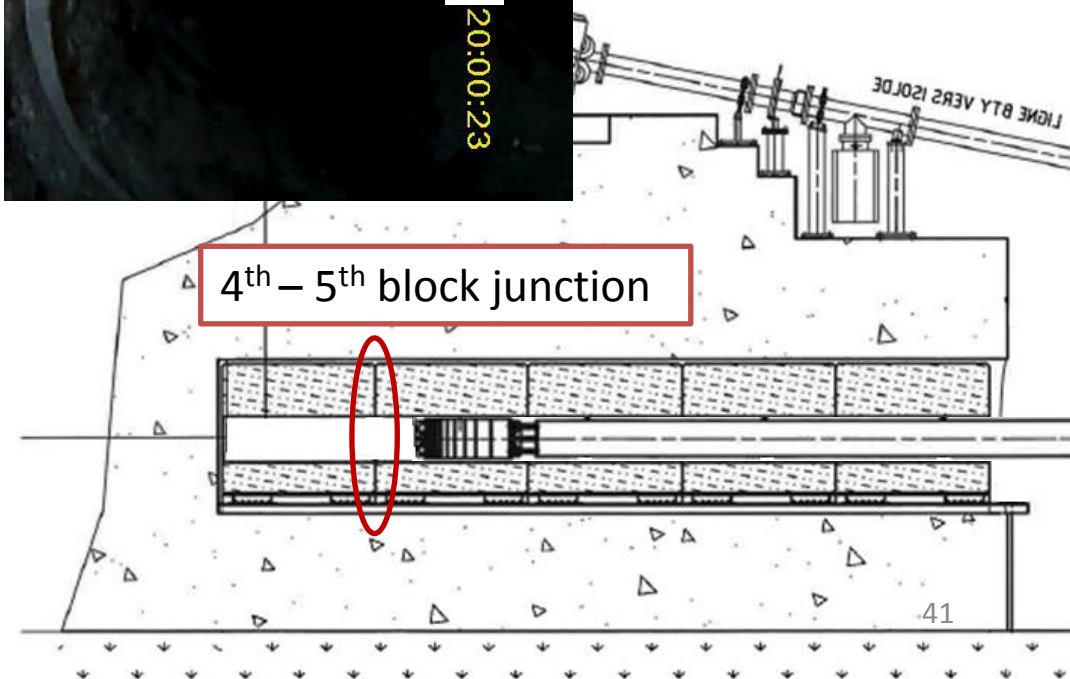




Another endoscopy planned for June 2013, to investigate further:

- State of Rail
- Junction between 4th and 5th block
- State and position of dump
- Upper part of concrete blocks: lifting point?





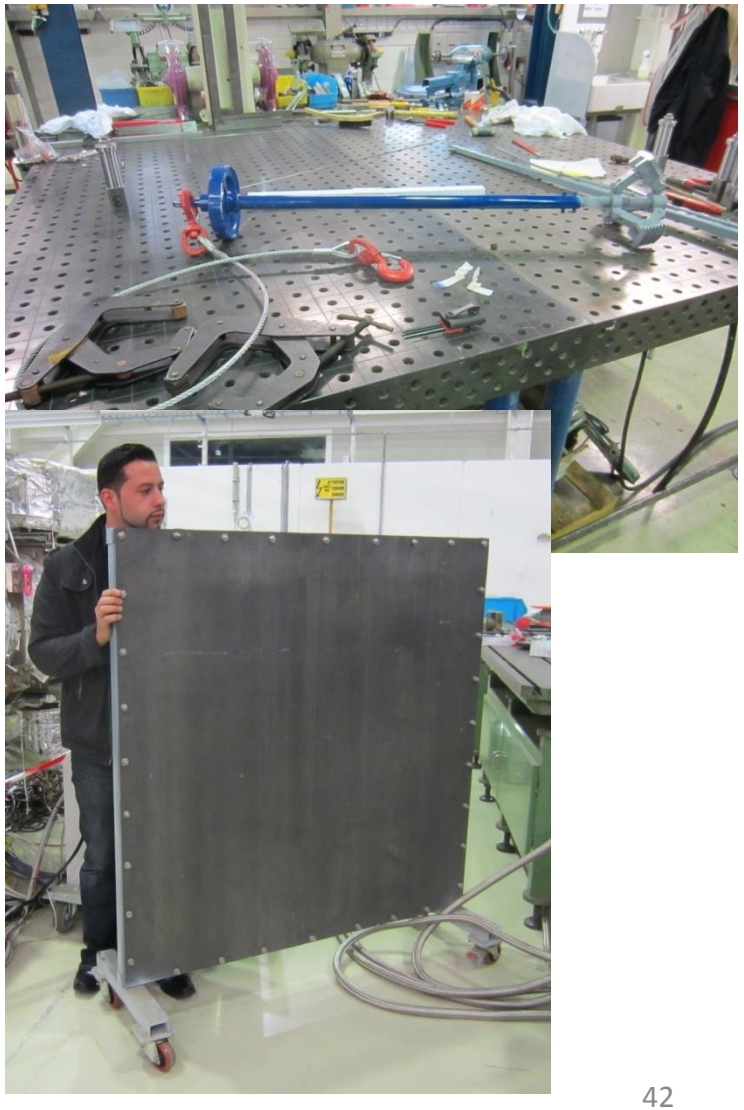
RISK: FAILURE OF PULLING SYSTEM

- **A) Risk of CABLE breaking**
  - Cable certified to withstand 1200 kg.
  - Winch max. force 900 kg.
  - Estimated force required to pull dump ~ 100-200 kg.
  - Very high safety margin

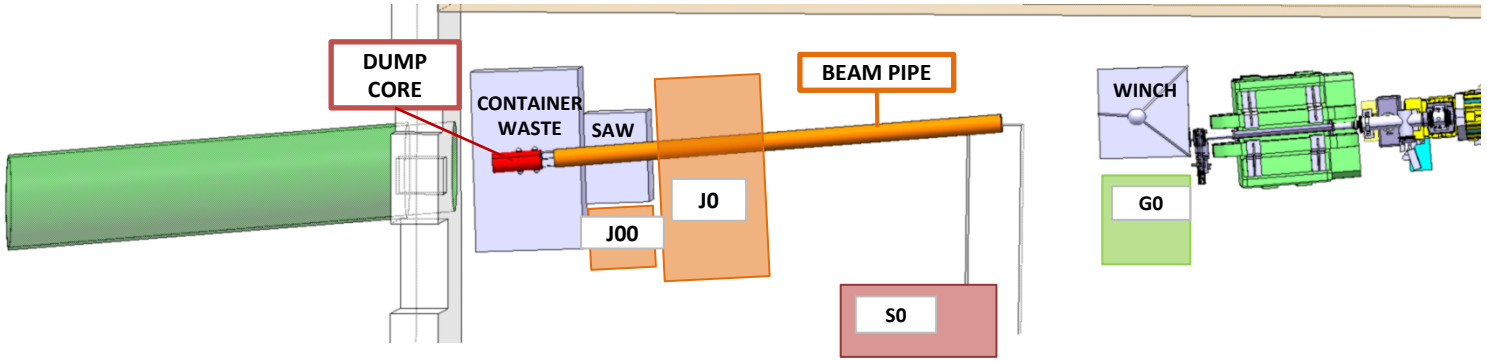
    → NO LONGER A RISK
- **B) Risk of tool slipping: TOOL HURTING OPERATOR**
  - Very unlikely to happen: high friction between tool and pipe → slow motion
  - Operator far away and protected by a lead screen

    → NO LONGER A RISK
- **C) Risk of PIPE breaking**
  - FE simulations show stresses well below the limit

    → NO LONGER A RISK

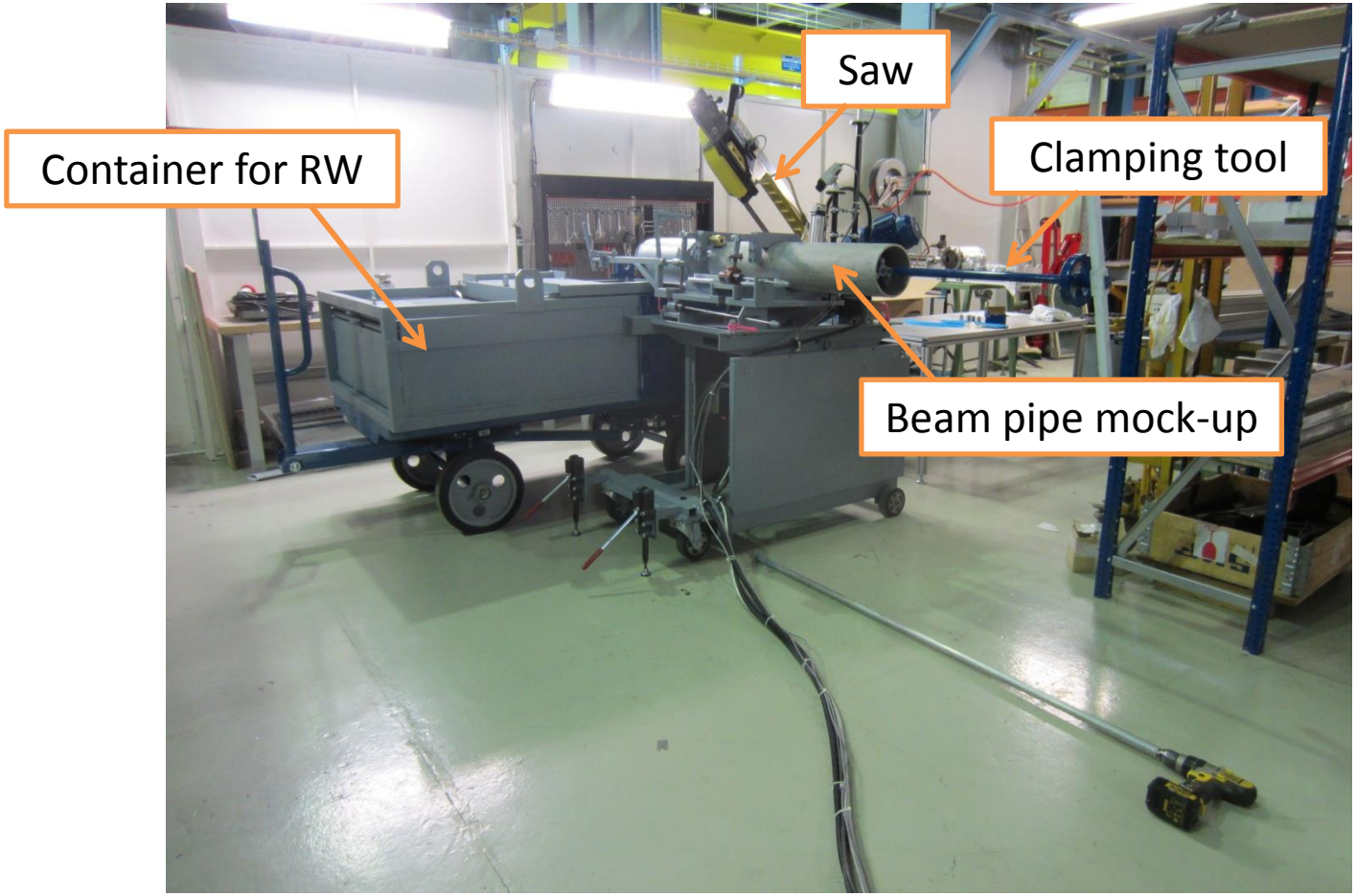


MAIN RISK OF DISMANTLING DUMP: the saw blade breaks while cutting

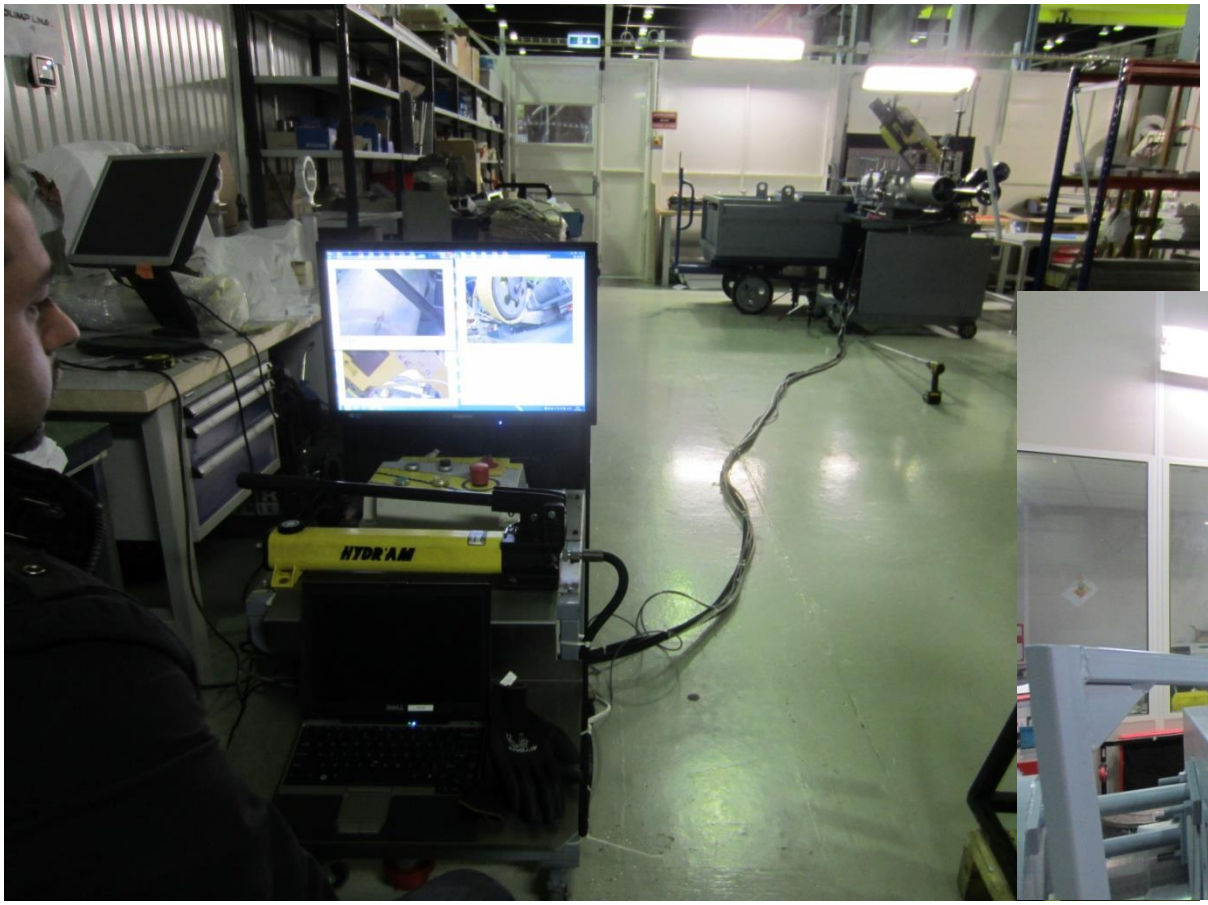


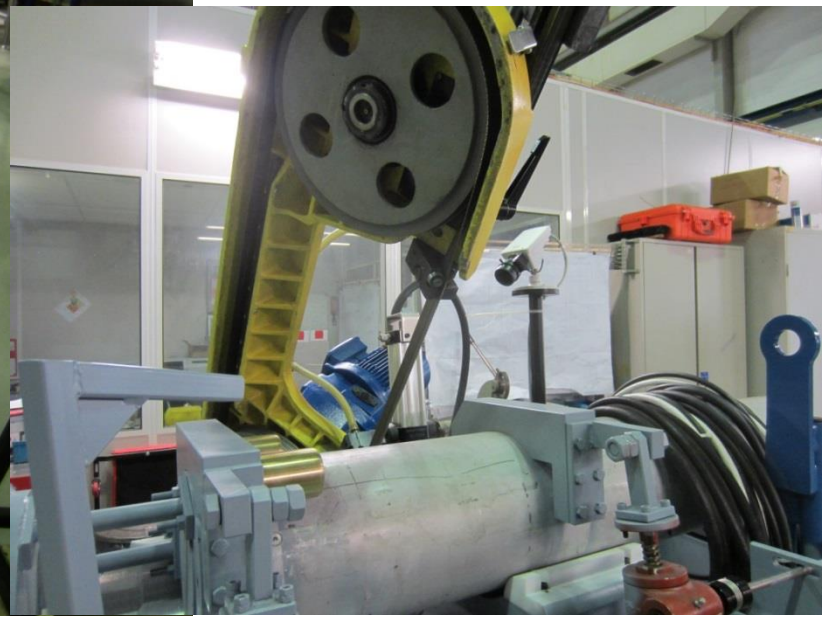
- The experience shows that this is very unlikely to happen. The cut is done very slowly, it is lubricated and cooled.
- Some modifications have been done in the saw, so that the exchange of its blade (if needed in case of accident) is as fast as possible.
- It would take max 5 min. to replace the blade: 4 min. in 'J0' and 1 min. in 'J00'
- It would mean 1 mSv (if blade breaks while cutting dump – 1st cut)
- It would mean 112 µSv (if blade breaks while cutting pipe)

3. DISMANTLING AND DISPOSAL OPERATIONS: DUMP REMOVAL



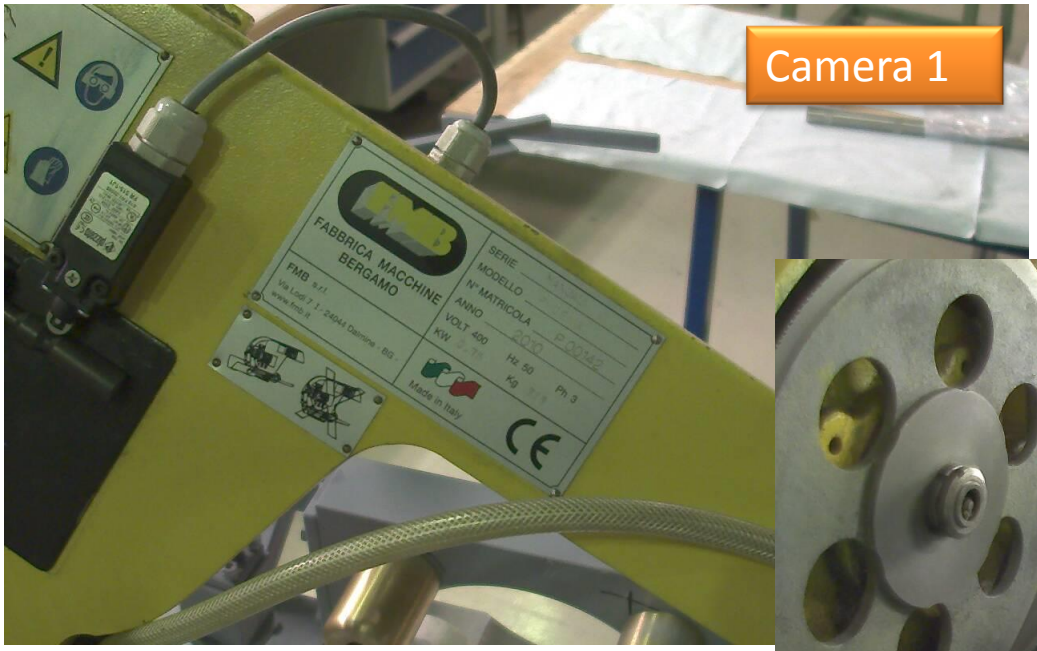
DUMP EXTRACTION CONTROLLED REMOTELY BY CAMERAS

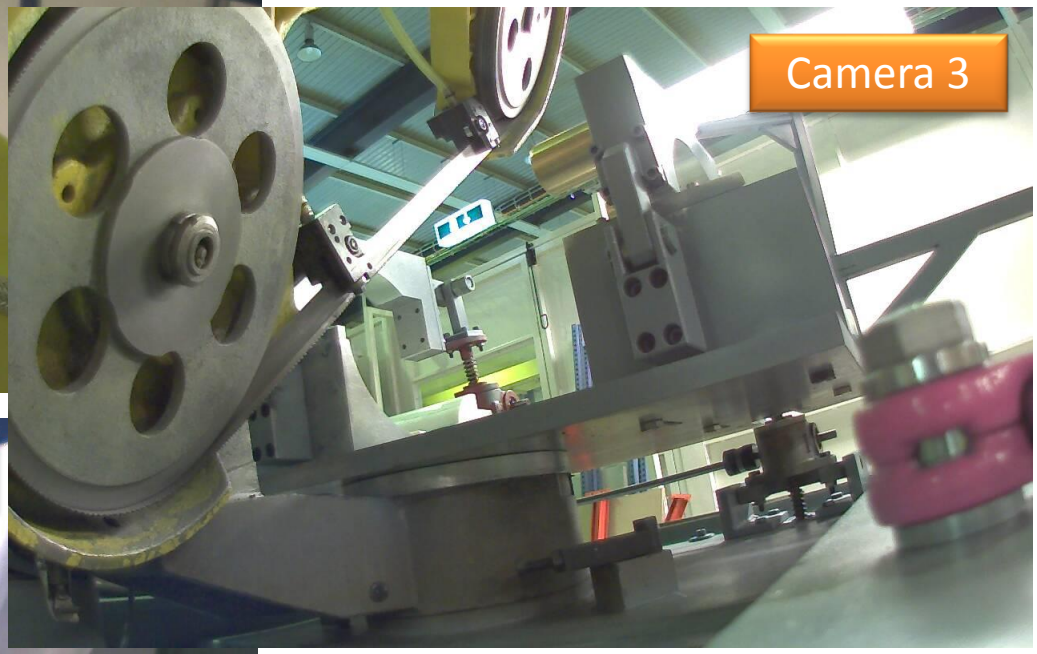


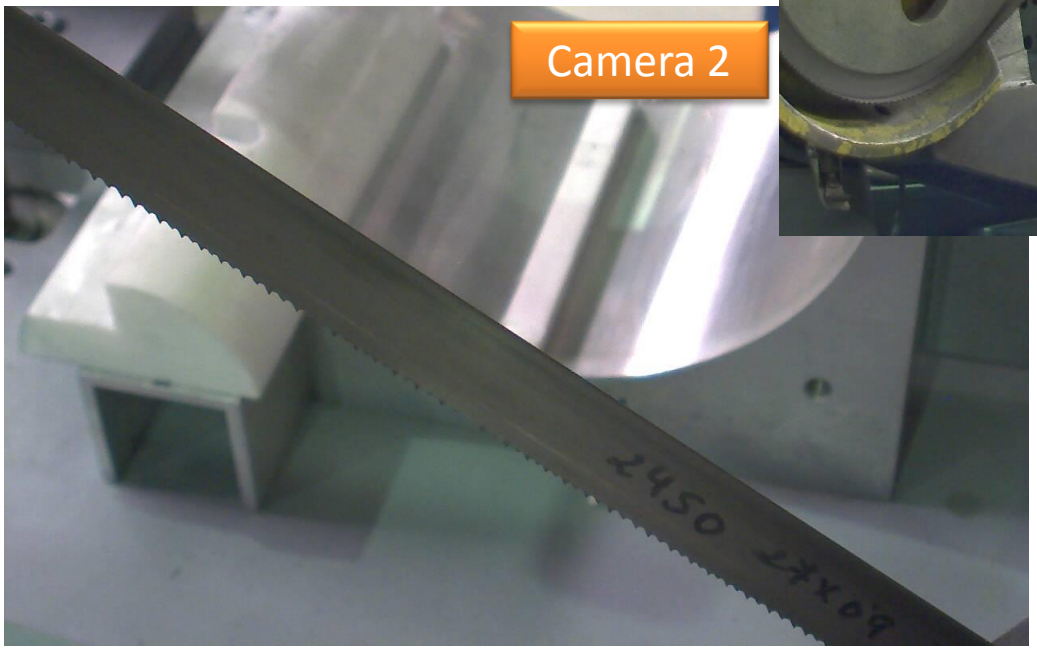


There will be 3 cameras, focused on:

1) The saw's mechanism
2) The cut (pipe and dump)
3) The container for RW


Camera 1
FABBRICA MACCHINE
BERGAMO
SERIE
MODELLO
N° MATRICOLA
ANNO
VOLT 400
Hz 50
Ph 3
Made in Italy
CE


Camera 3

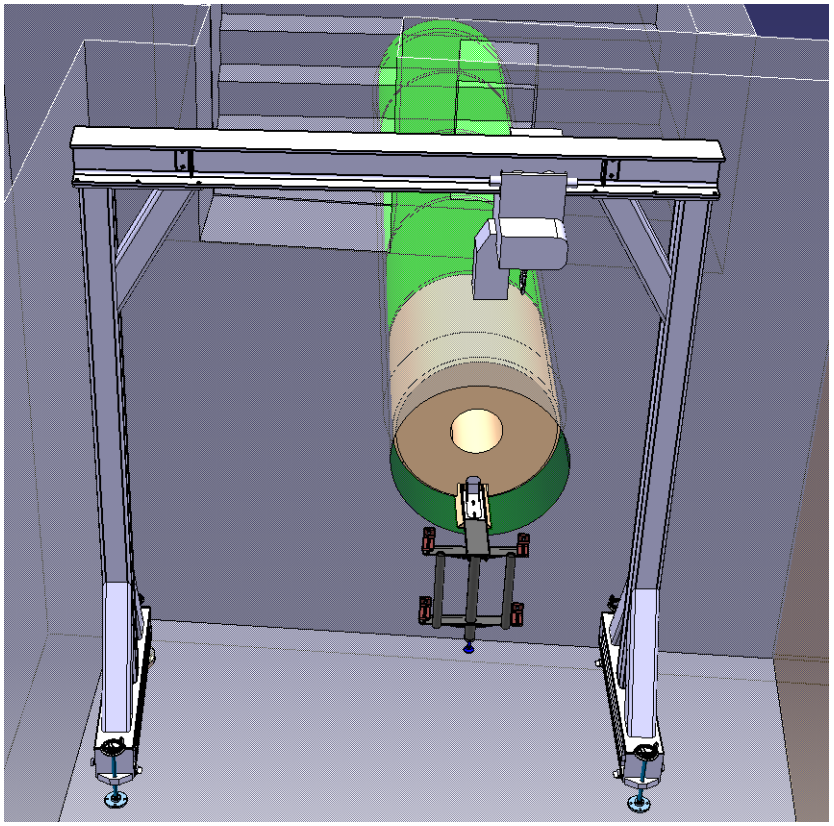

Camera 2
2450

3. DISMANTLING AND DISPOSAL OPERATIONS: TRANSPORT TO ISR

Total time ~ 2 h
1-2 teams

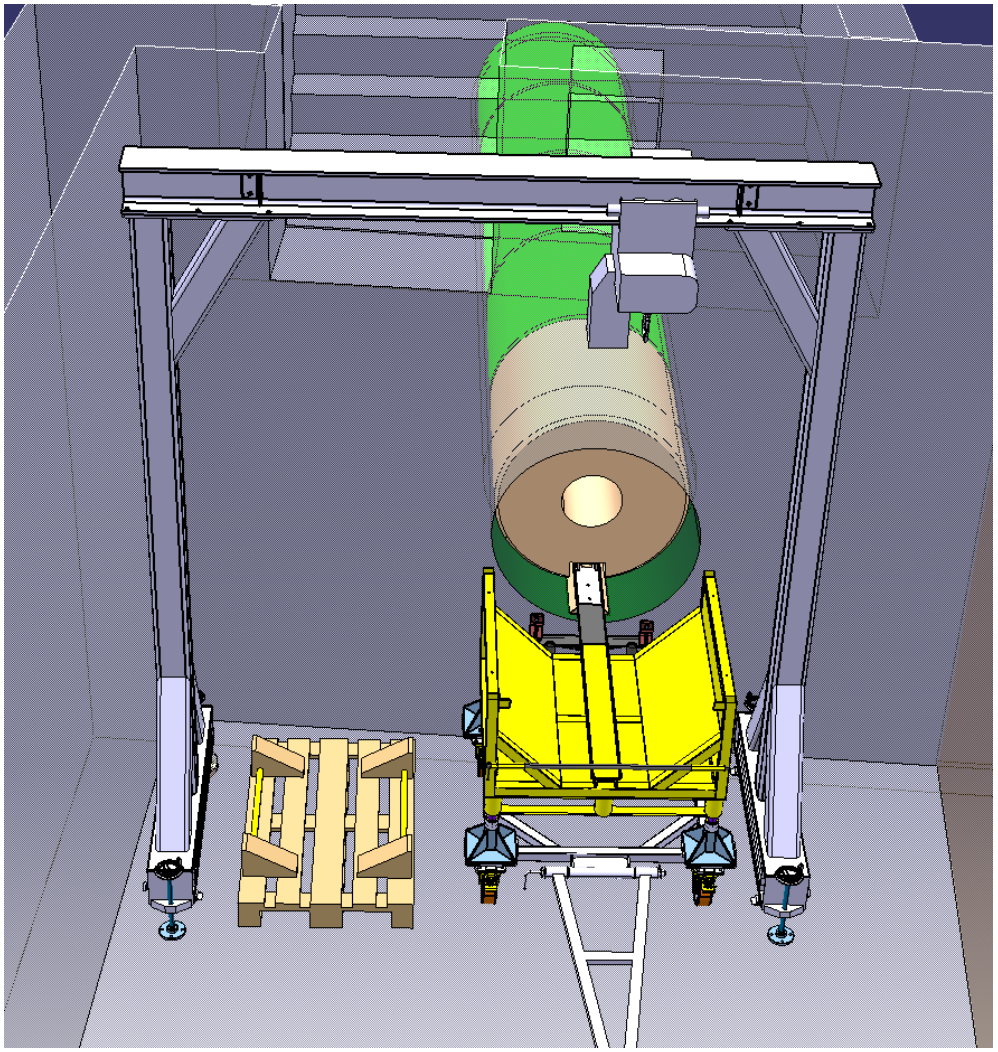
Collective dose ~ 141 µSv (~5% of TOTAL collective dose)

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



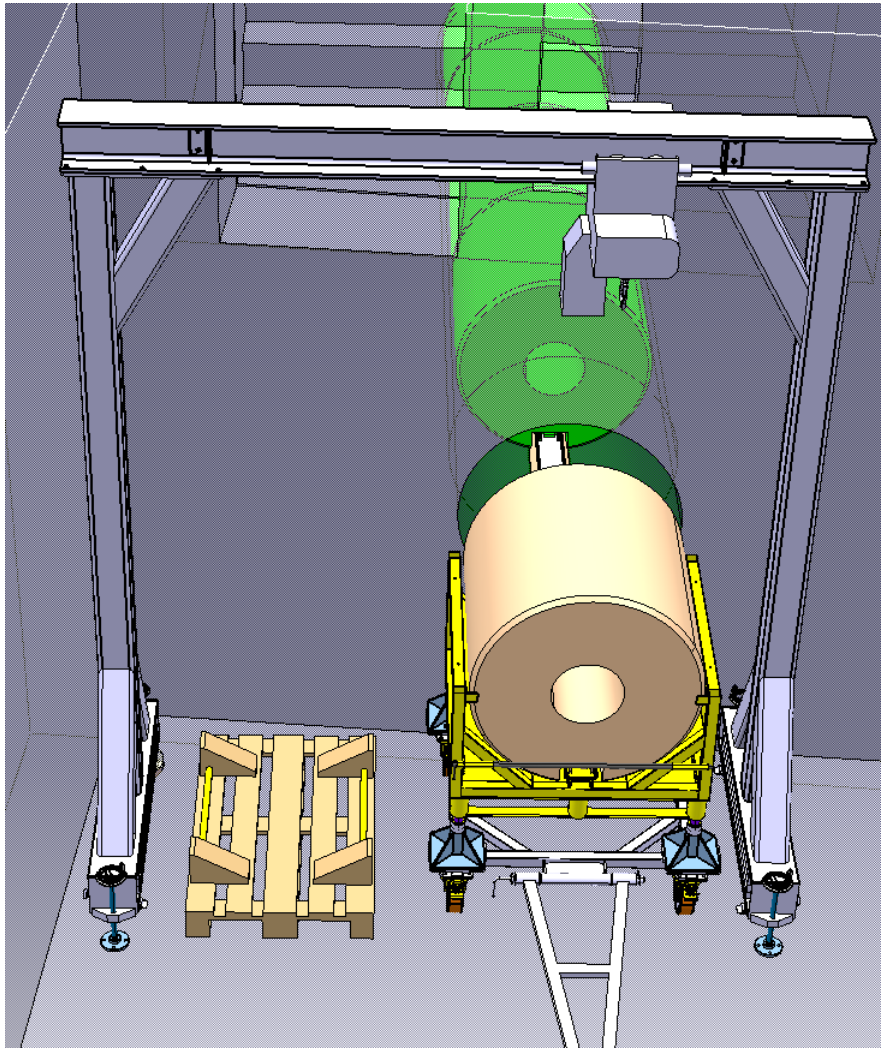
- Extension of rail
- Erection of a movable crane on site (custom made for this operation)

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



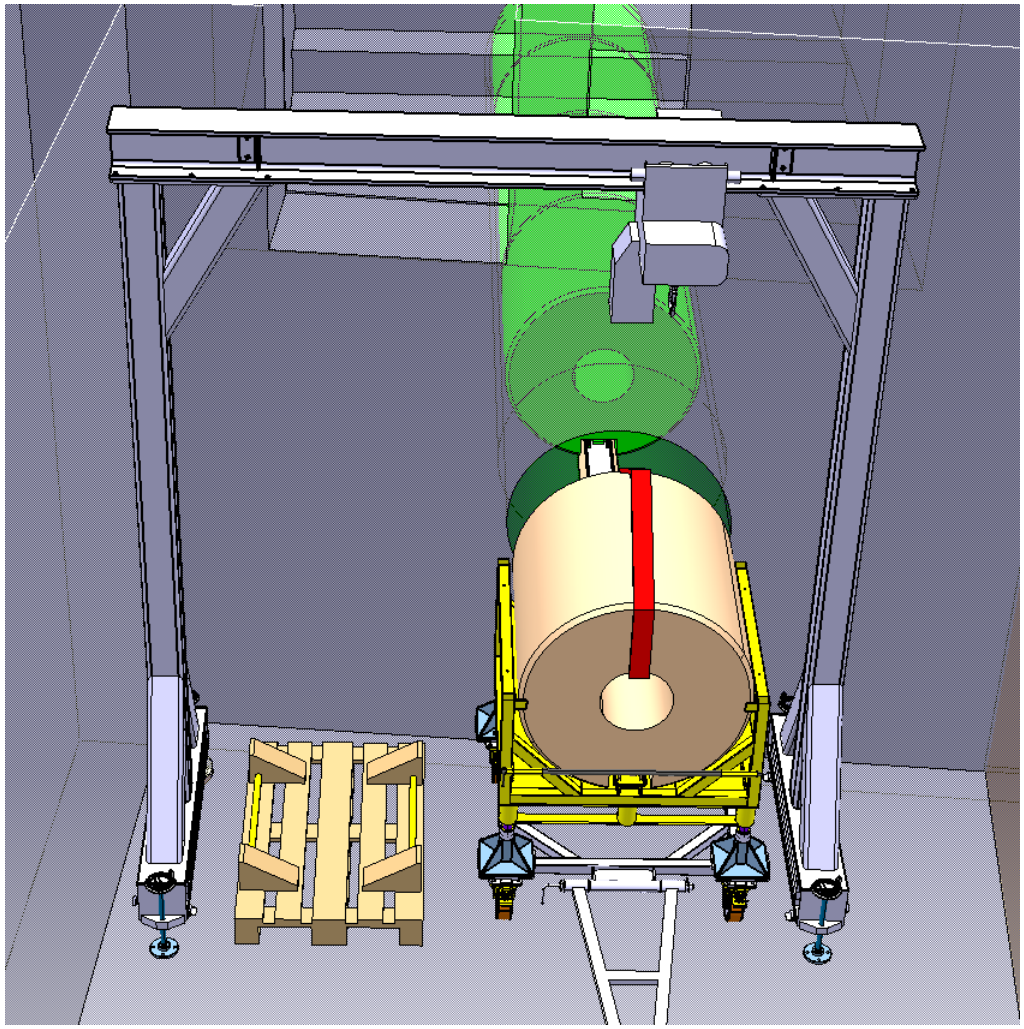
- Positioning of trailer in front of cavity
- Alignment and fixation to the rail extension
- Installation of a pallet beside the trailer to receive the block

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



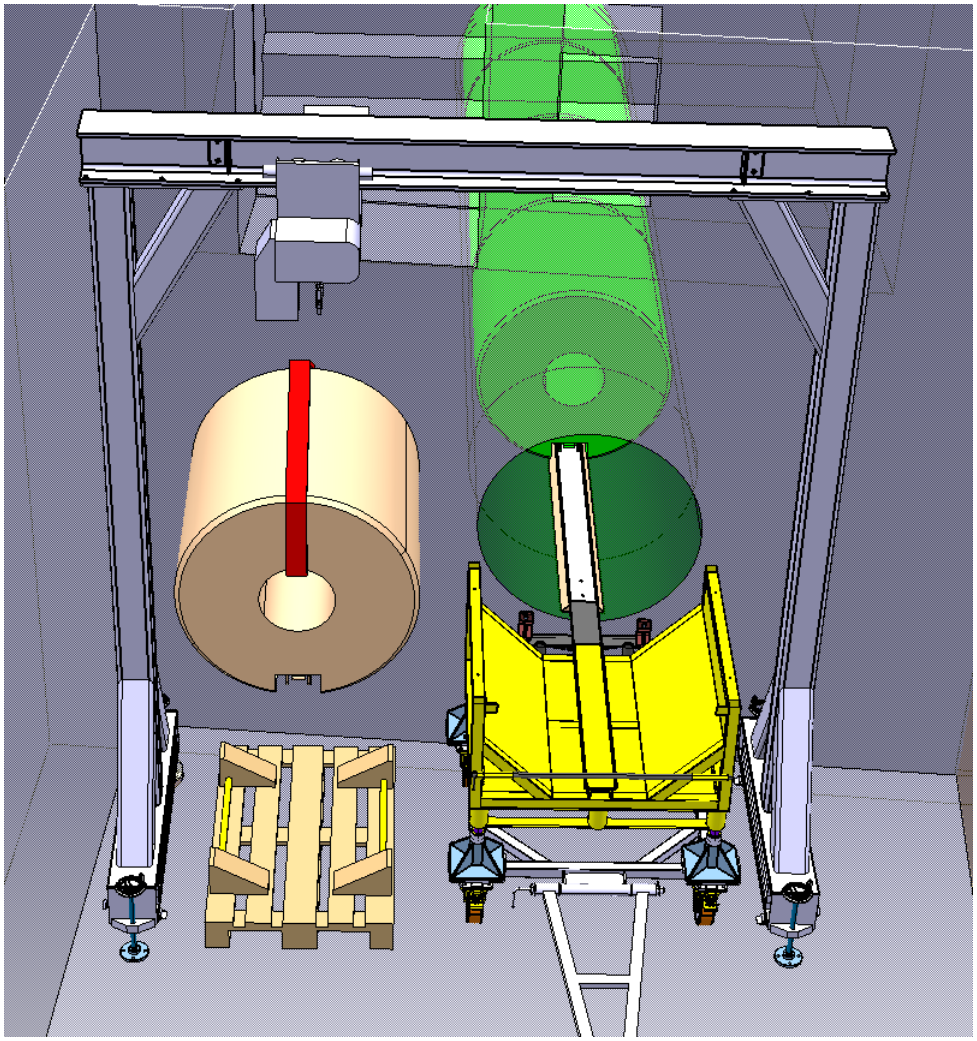
- Hoist pre-aligned
- Hook lowered prior to extraction
- Extraction of block

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



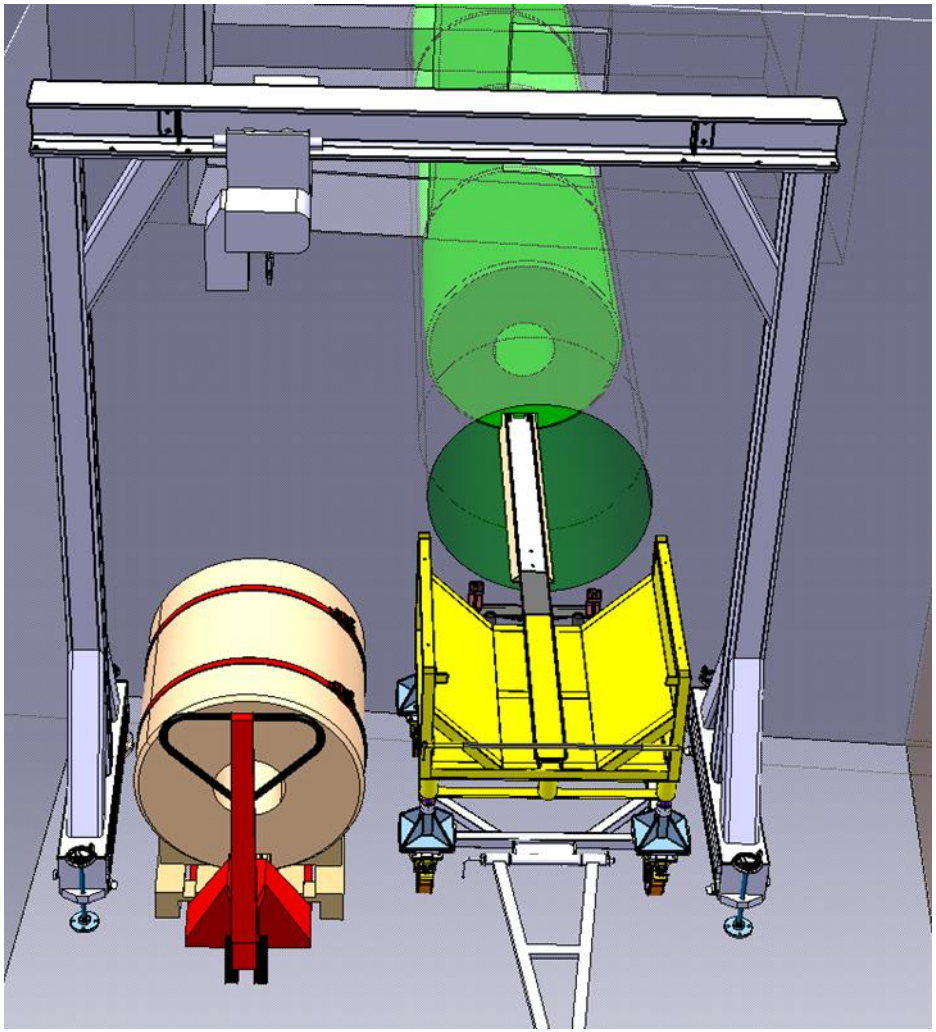
- Place sling around block (previously prepared on a bar)

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



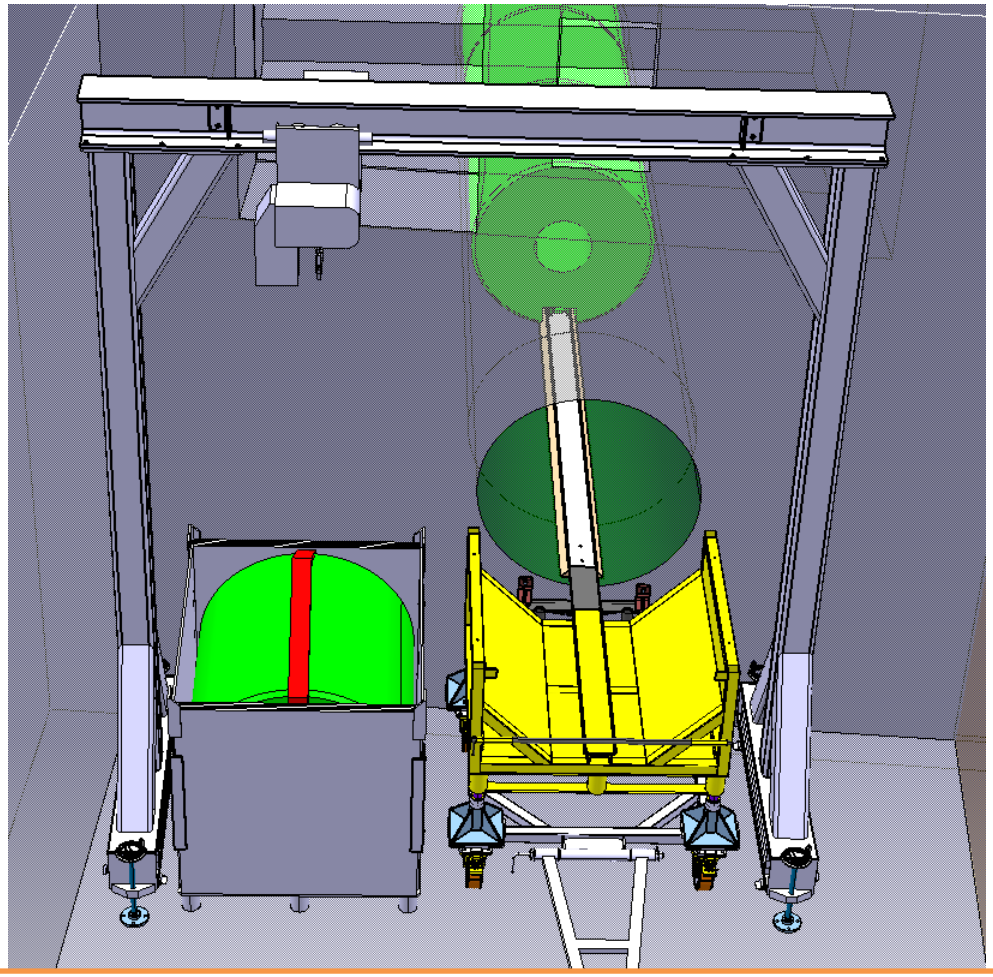
- The operator steps back and with the radio command (5m away) lifts the block and transfers it on the pallet

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



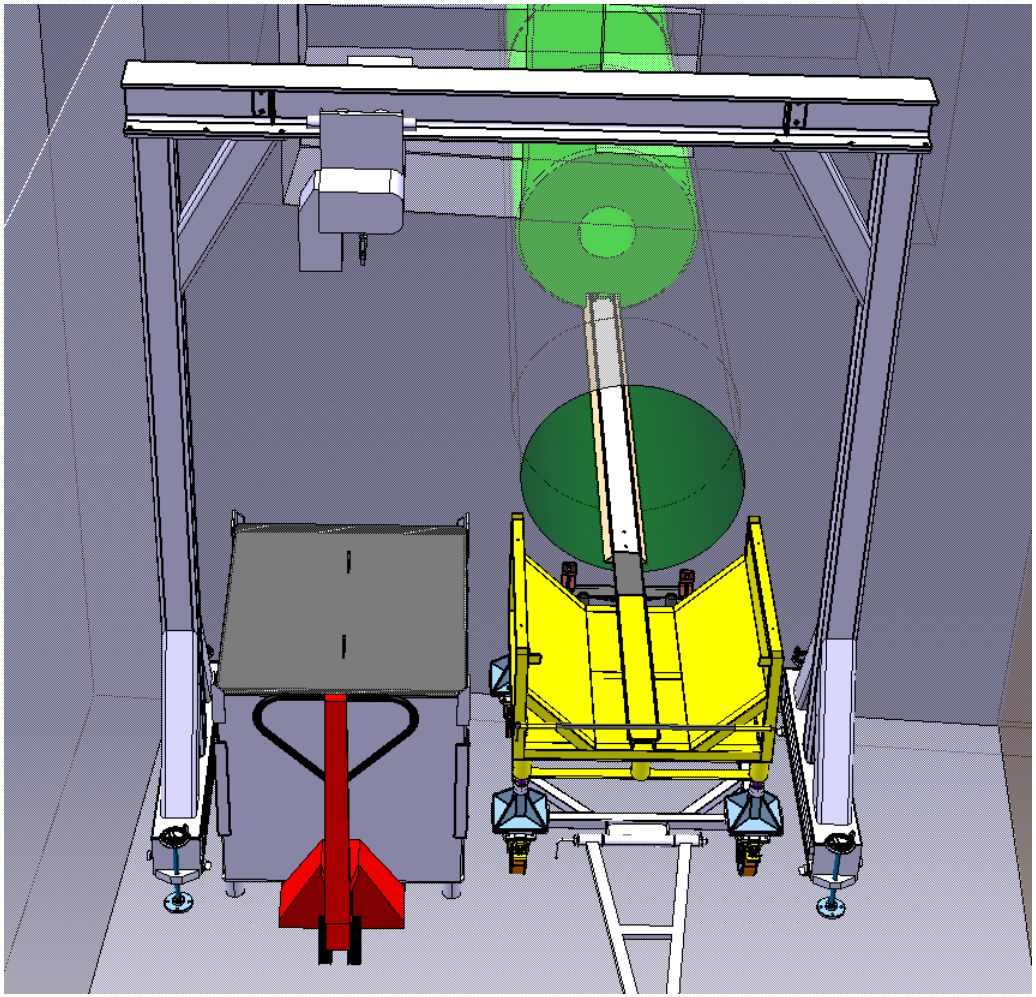
- Hook removed
- Block fixed to the pallet by 2 straps that were already in place
- The lifting slings are left in place for further transfer

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



The containers will be marked, since not all of them will be equally radioactive

3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL



3. DISMANTLING AND DISPOSAL OPERATIONS: SHIELDING REMOVAL + TRANSPORT TO ISR

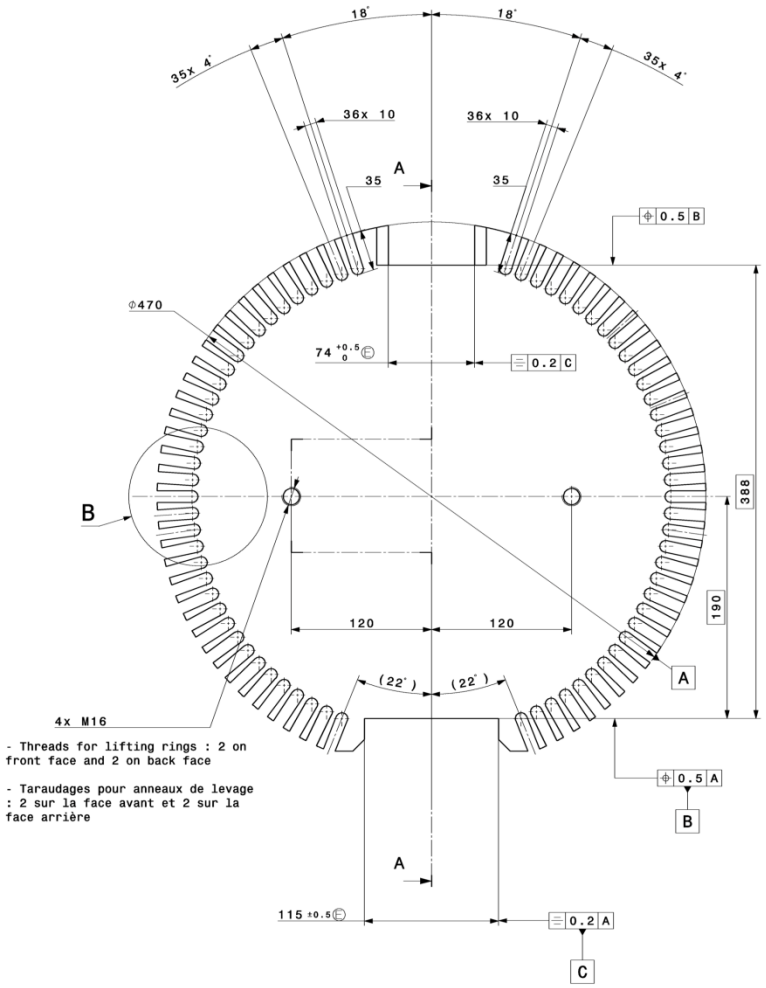
Total time ~ 11 h
1-2 teams

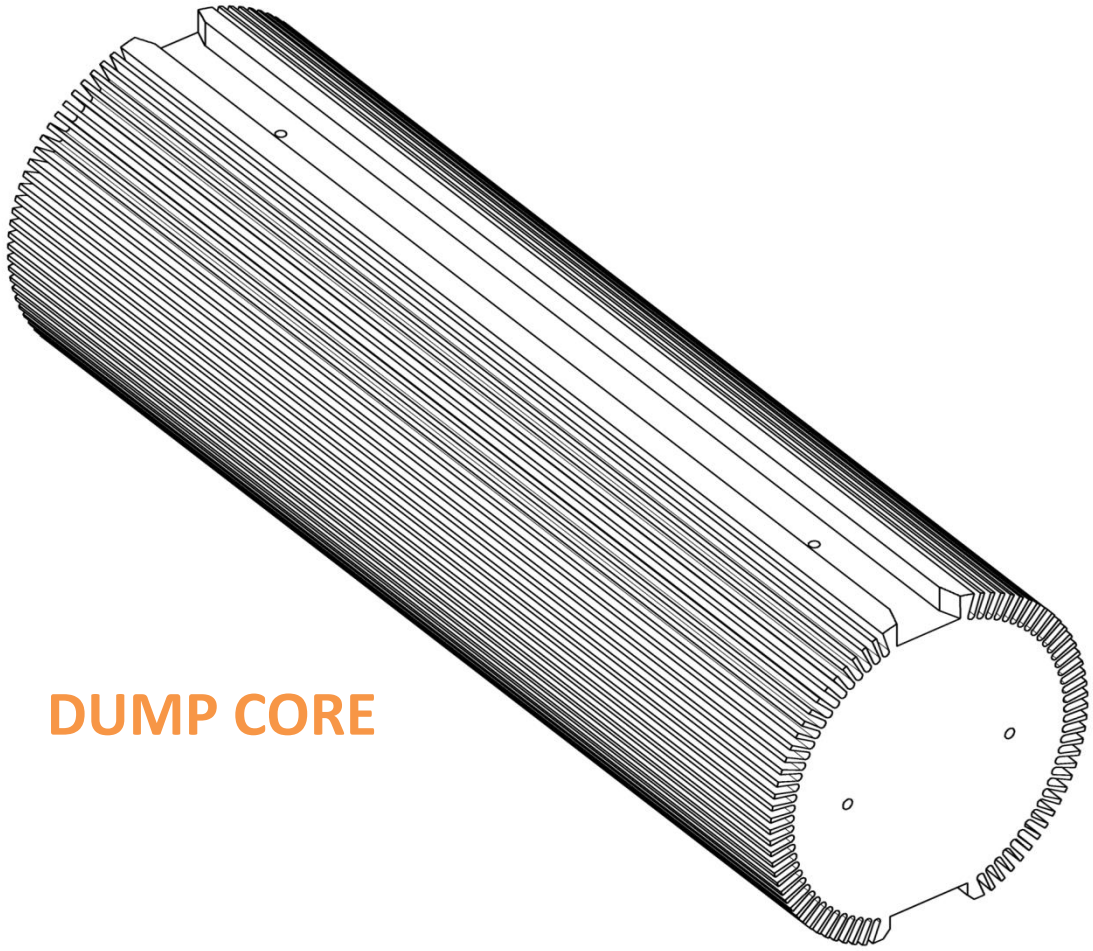
Collective dose ~ 746 µSv
(24% of TOTAL collective dose)

3. DISMANTLING AND DISPOSAL OPERATIONS:

	Total Time [h]	Collective Dose [µSv]	(% of TOTAL collective dose)
Dump removal	4	450	15
Transport to ISR	2	141	5
Shielding removal + Transport to ISR	11	746	24
TOTAL	**17**	**1337**	**43 %**

4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

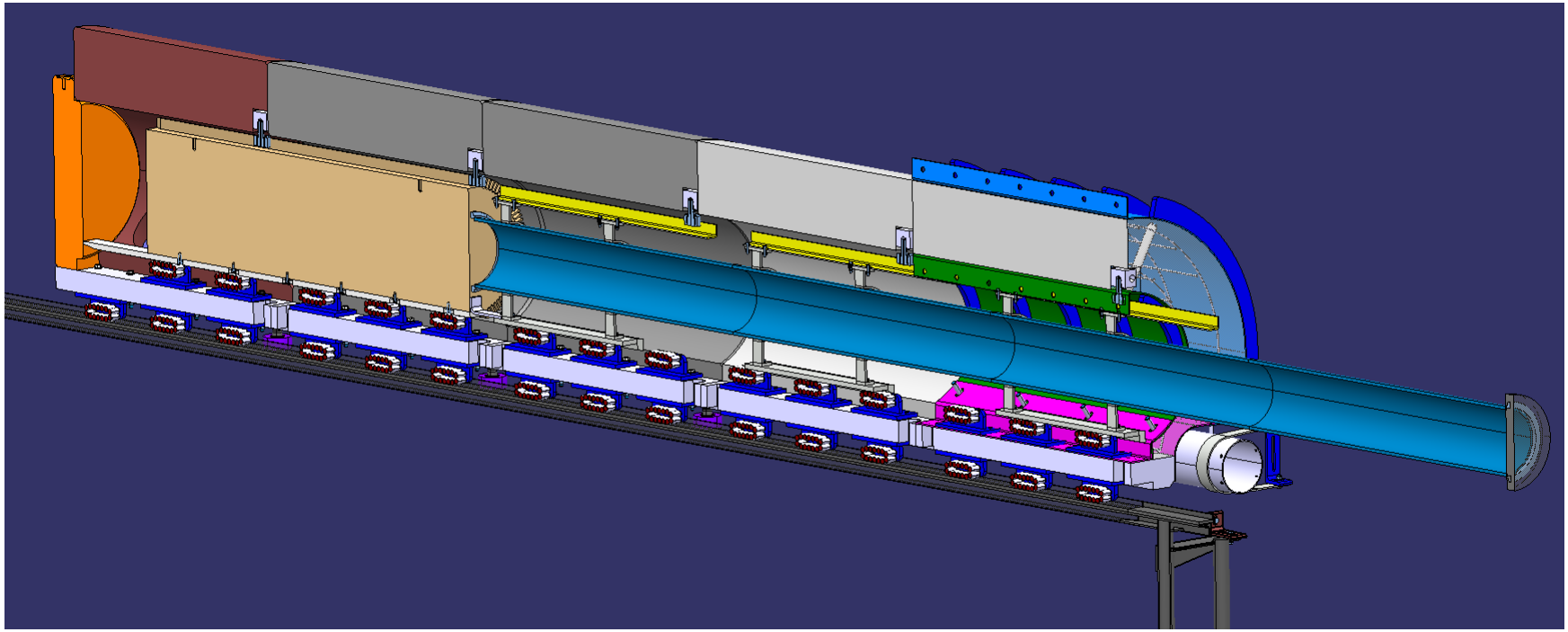




DUMP CORE

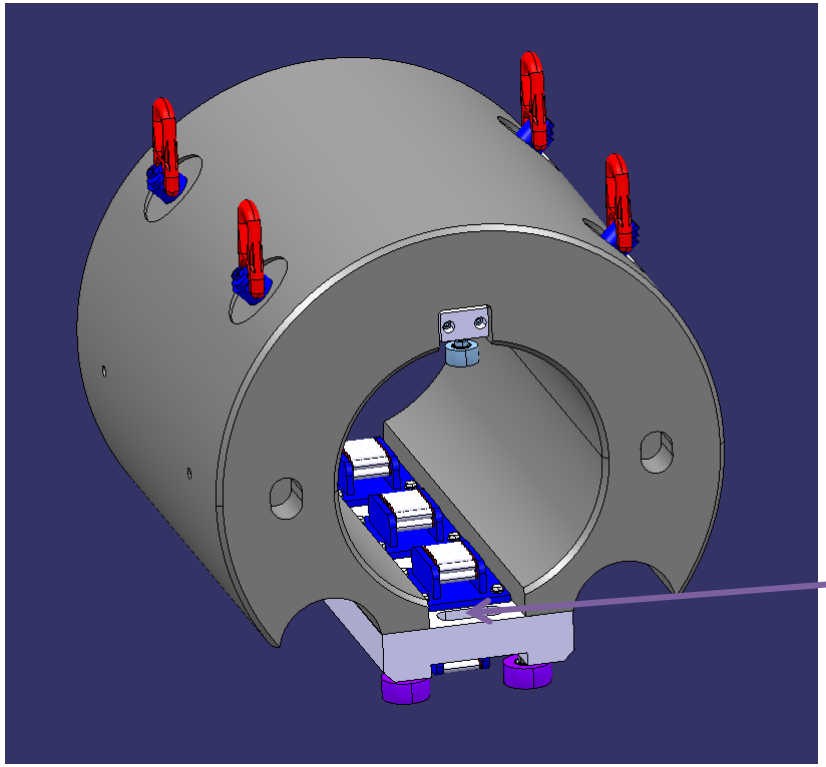
4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

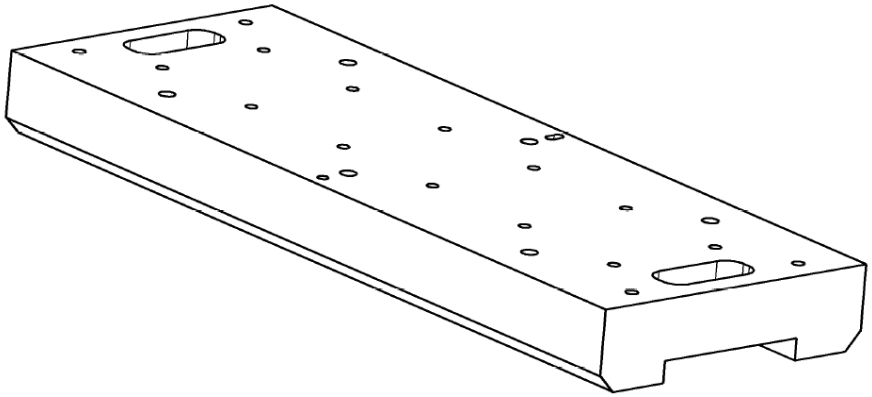
- Installation of new dump



4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

– Installation of new shielding

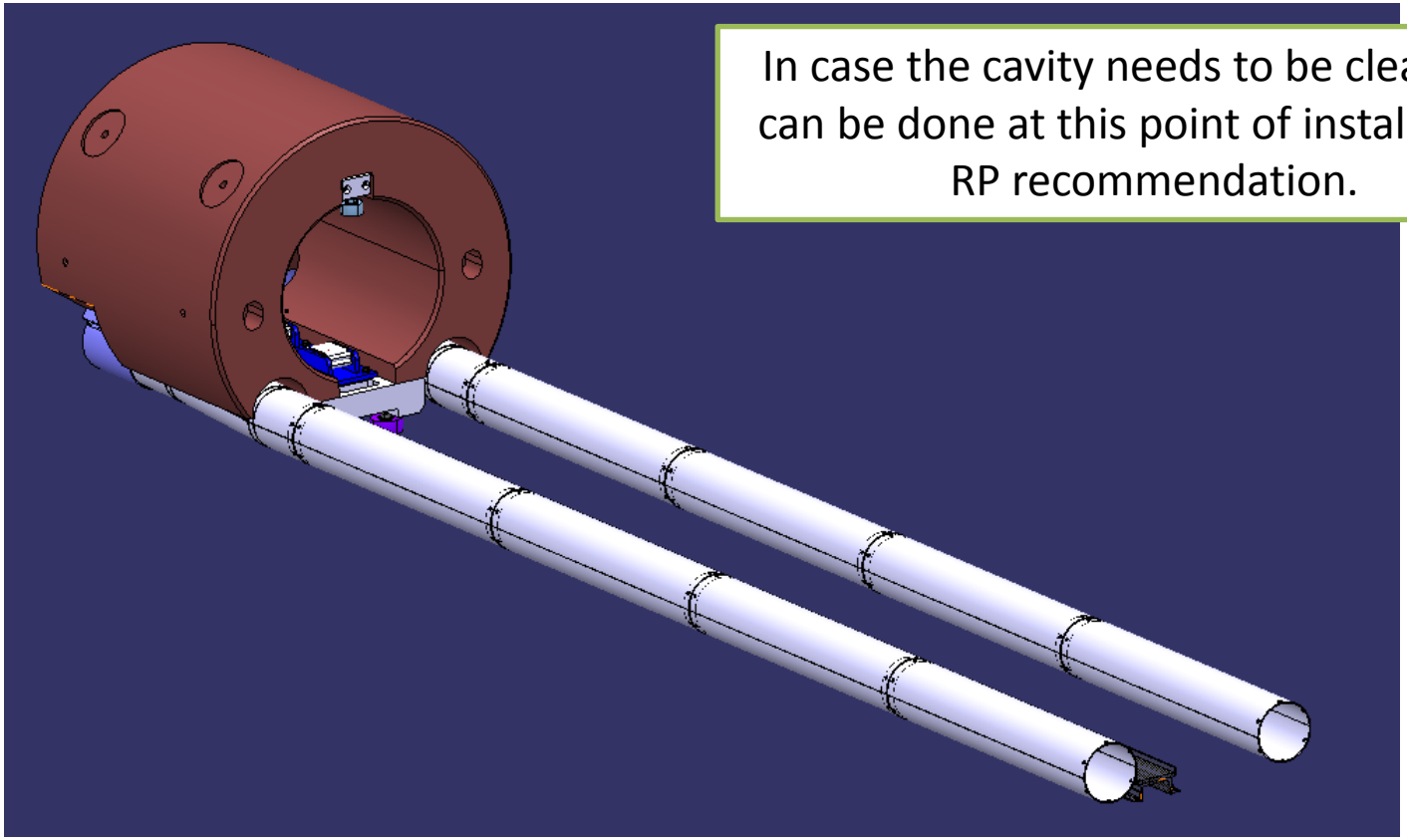




Handle to be used for future extraction

4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

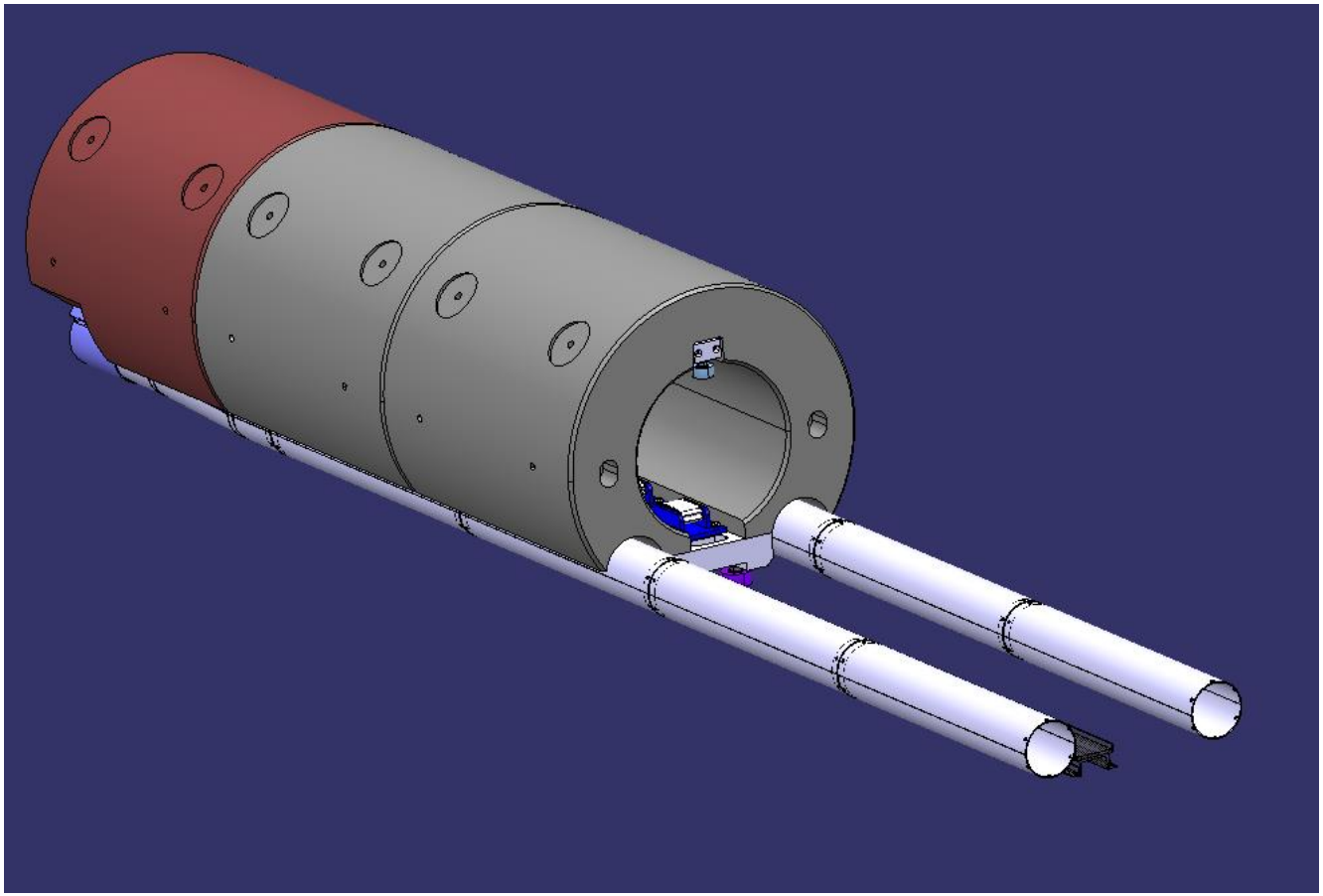
– Installation of new shielding



In case the cavity needs to be cleaned, it can be done at this point of installation – RP recommendation.

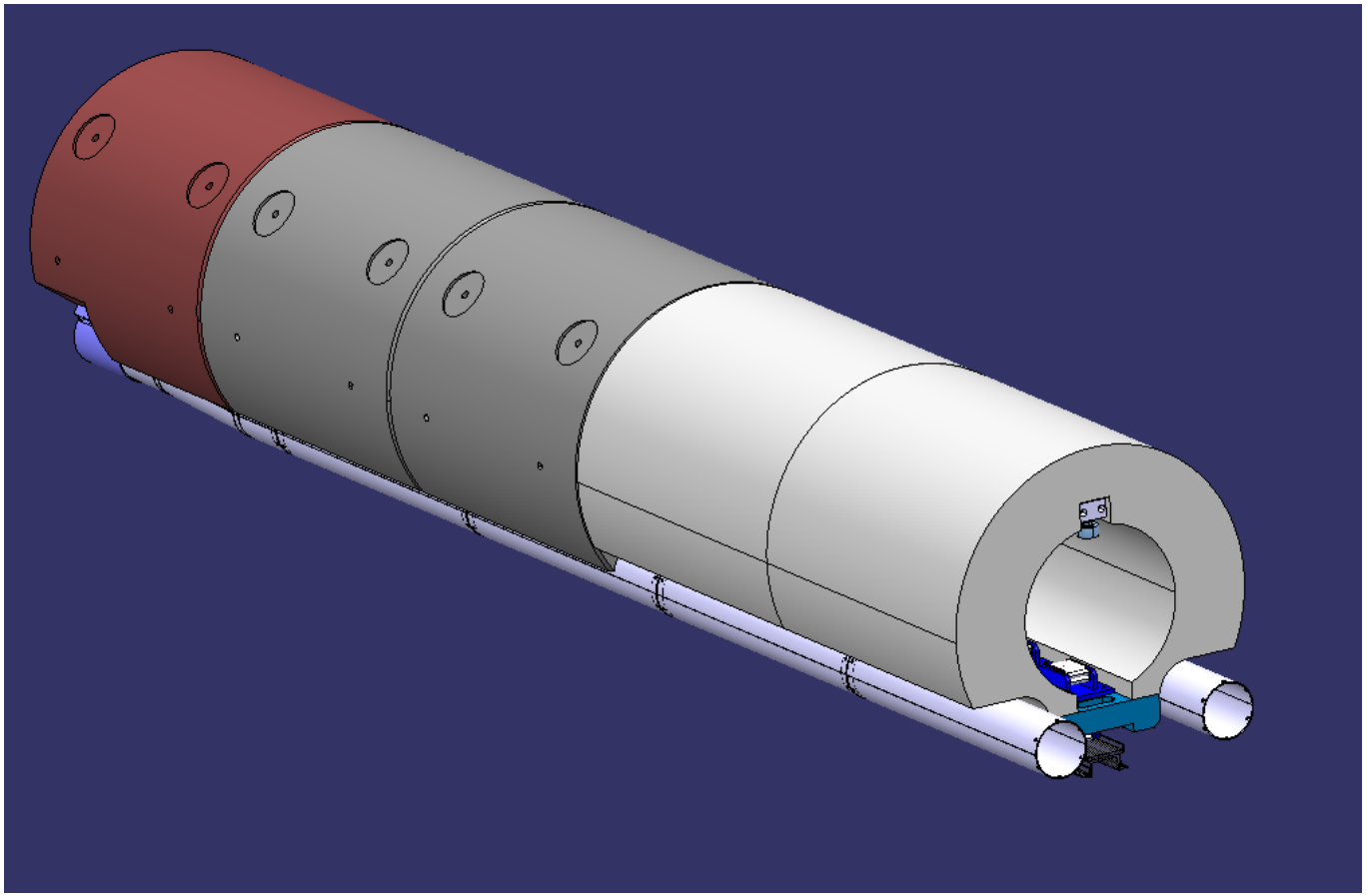
4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

– Installation of new shielding



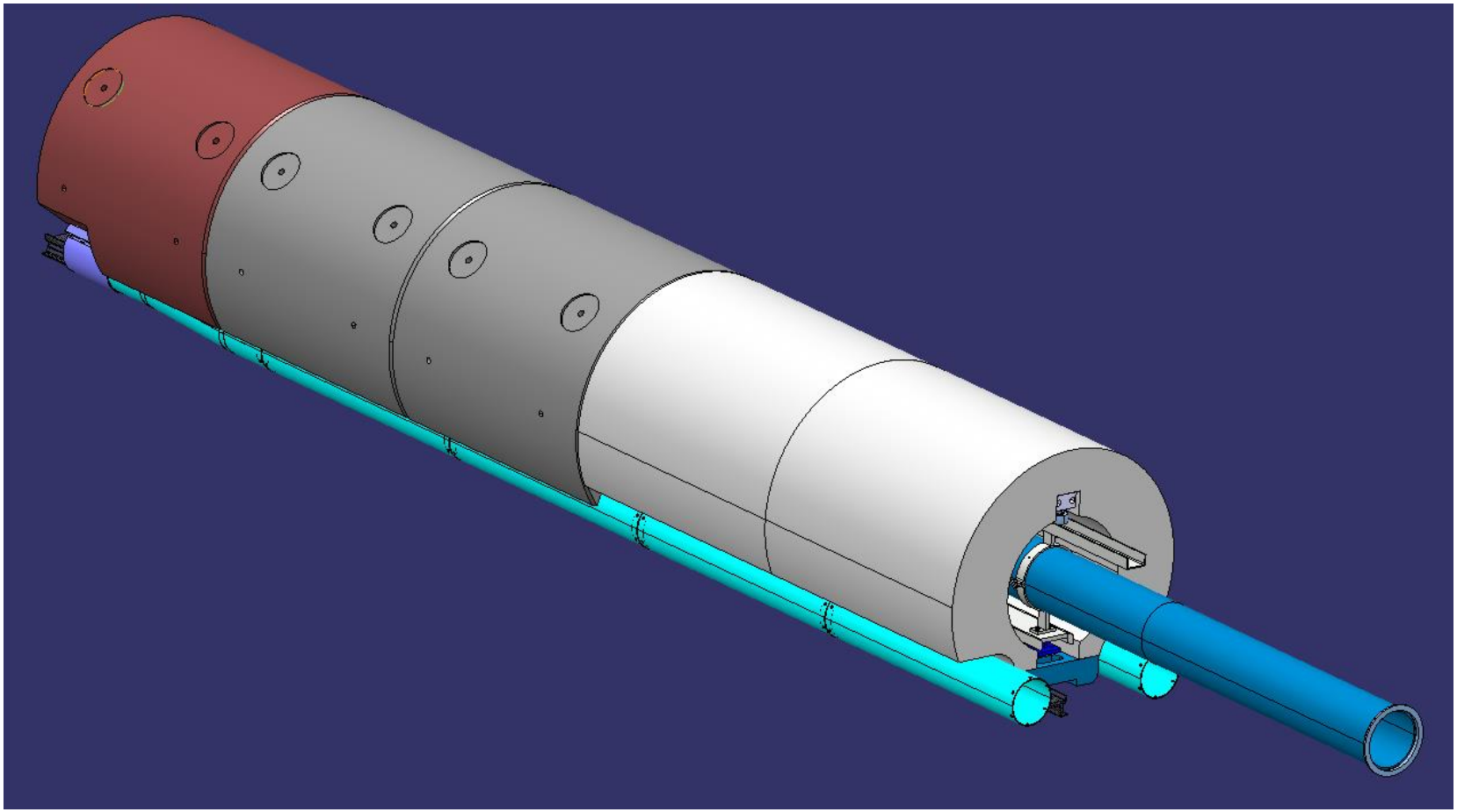
4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

– Installation of new shielding



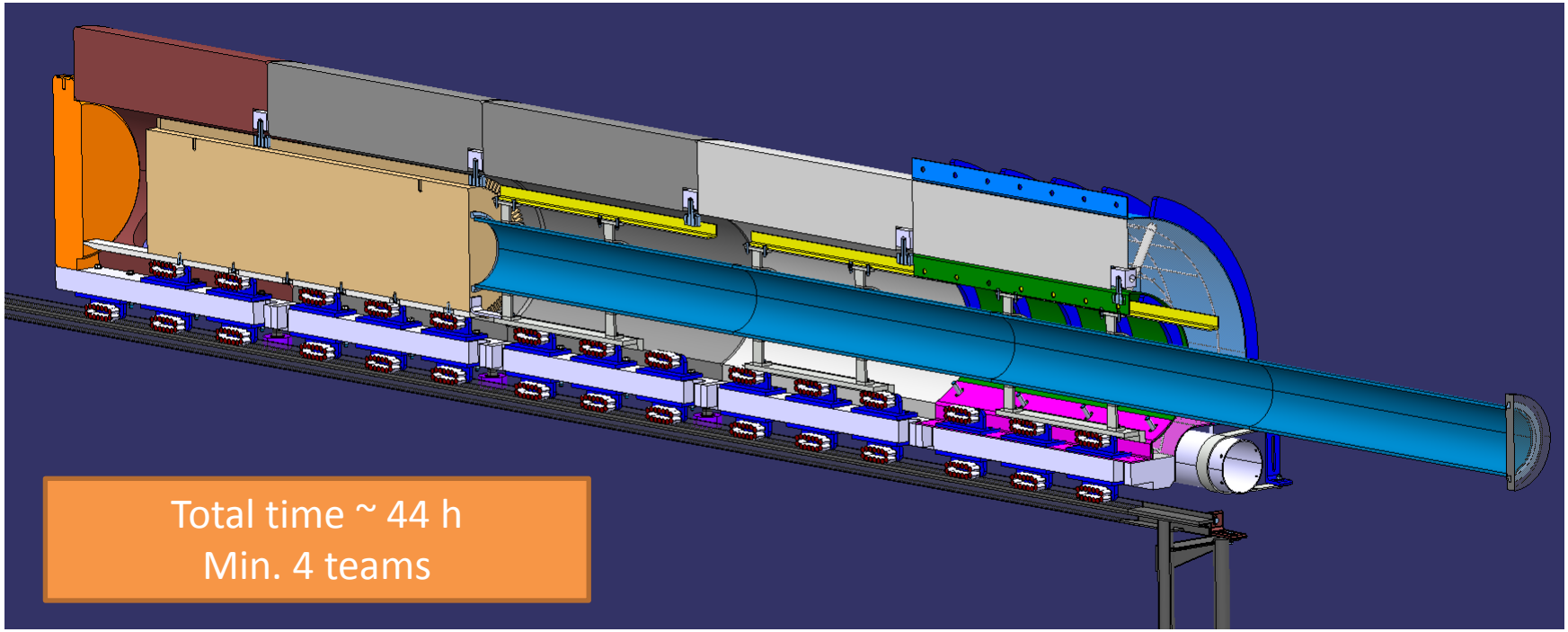
4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

- Installation of new shielding



4. ASSEMBLY AND PLACEMENT OF THE NEW DUMP

– Installation of new dump



Total time ~ 44 h
Min. 4 teams

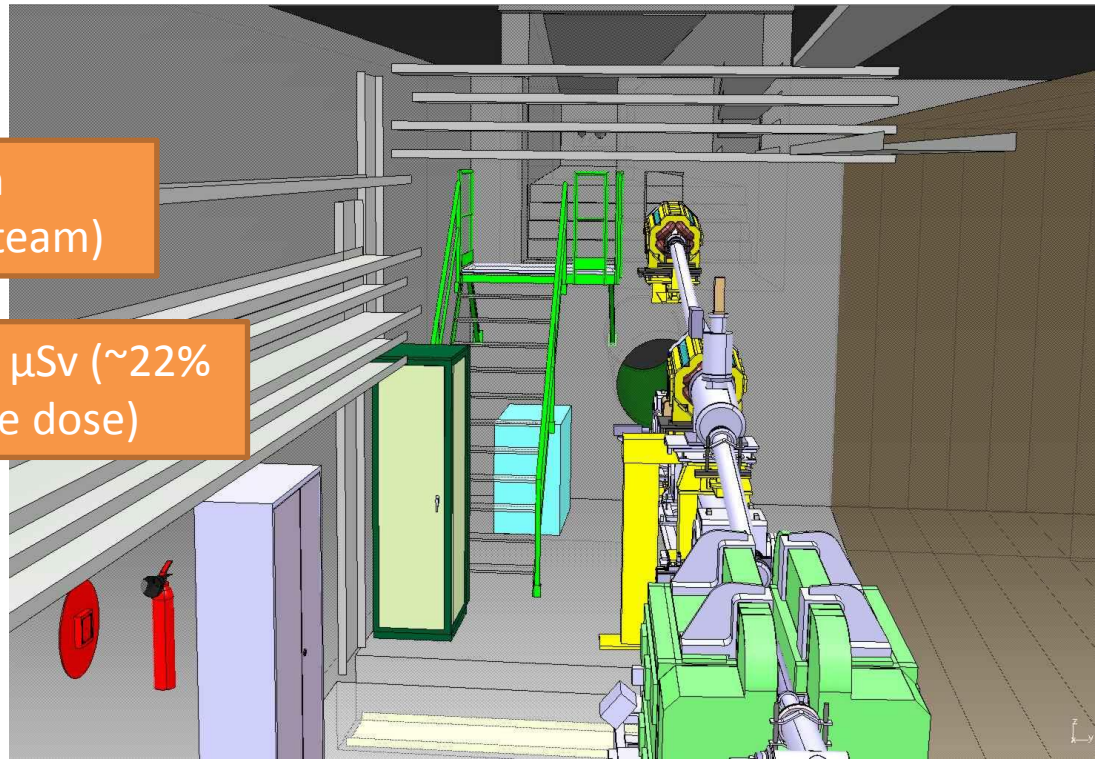
Collective dose ~ 205 µSv (~7% of TOTAL collective dose)

5. RE-ASSEMBLY OF EQUIPMENT IN BT, BTM AND BTY LINES. CONNECT SERVICES

- Re-assembly of equipment in BTM line
- Re-assembly of equipment in BTY line
- Final reconstruction and Connect Services

Total time ~ 4 h
Min. ~2 workers (1 team)

Collective dose ~ 666 µSv (~22% of TOTAL collective dose)



WORK PLANNING

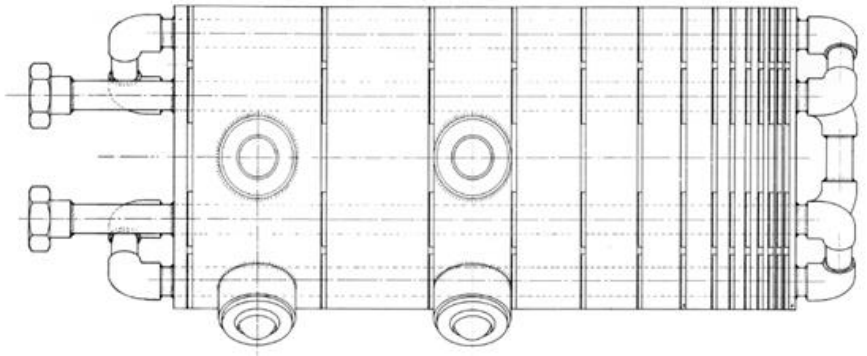
6. Survey
7. Ready for commissioning

TOTAL collective dose ~ 3.11mSv

Operation breakdown	Total Time [h]	Collective Dose [µSv]	(% of TOTAL collective dose)
Dismantling equipment	38	585	19
Extraction and disposal of dump + shielding	17	1337	43
Installation new dump	44	205	7
Re-assembly equipment	4	666	22
TOTAL	**103**	**2793**	**91 %**

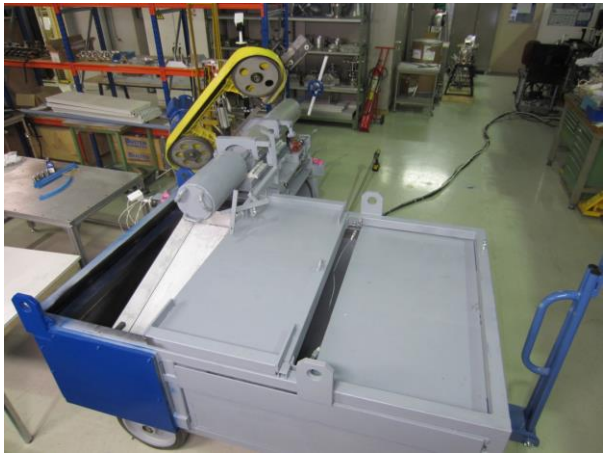
SUMMARY OF DOSE OPTIMIZATION MEASURES

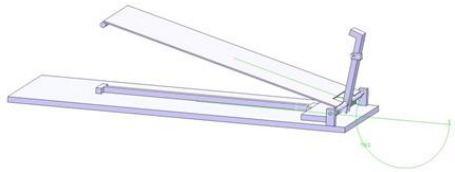
1. Plug against radiation: installed at the beginning of LS1, in order to protect any worker in the area.
2. Winch used to extract radioactive elements placed far (~7 m)
3. Mock-up in Building EHN1: to get familiar with the operations to perform, learn from the mistakes made, improve the strategy and last but not least reduce the time spent.

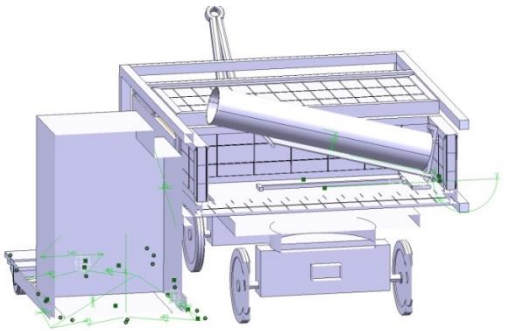


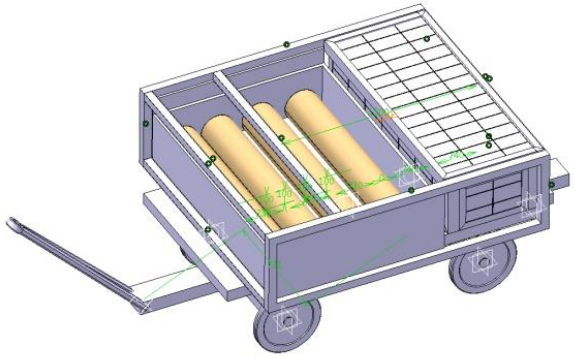
SUMMARY OF DOSE OPTIMIZATION MEASURES

4. Custom made shielded container for dump core and beam pipe: 5-7 cm lead on beam side, 2 cm steel on pipe side
5. Controlled fall of dump safely inside shielded container (no need for manipulation)



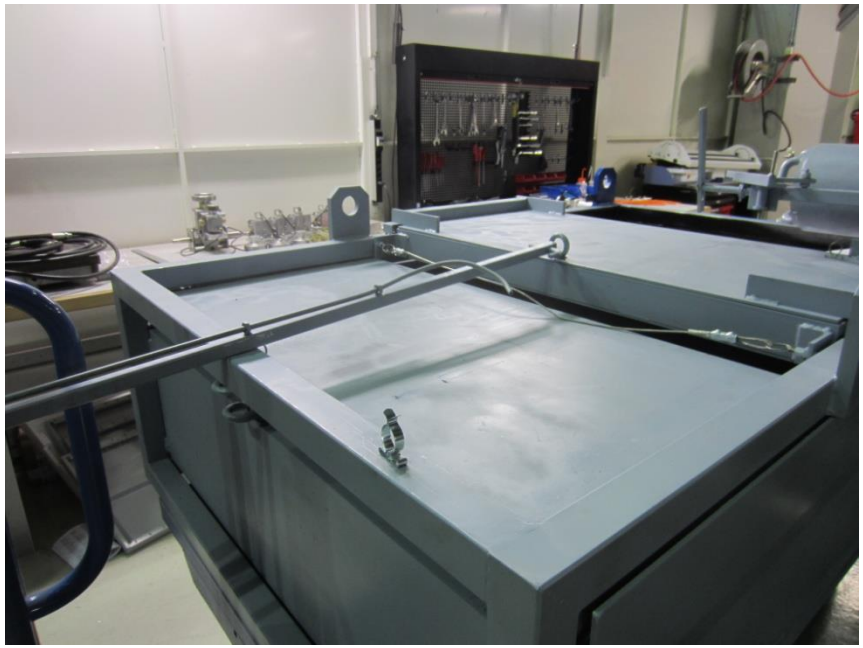






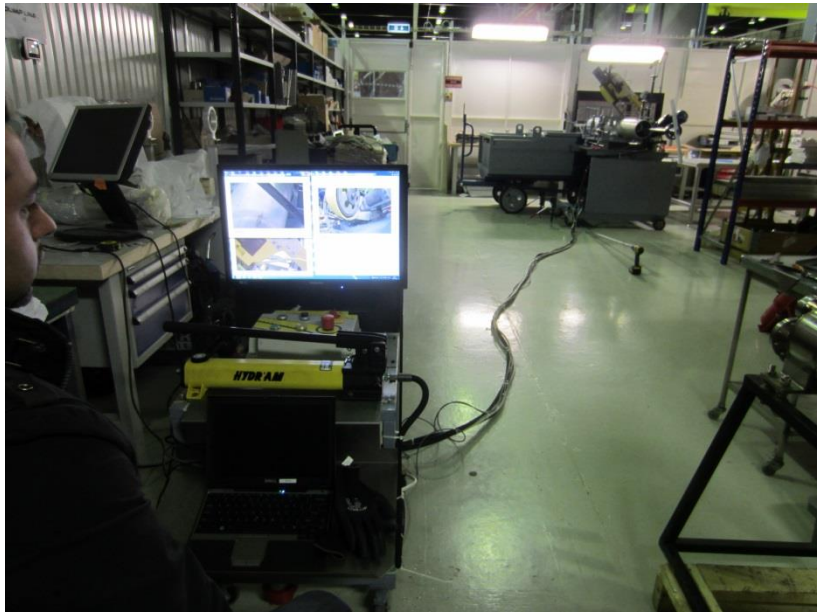
SUMMARY OF DOSE OPTIMIZATION MEASURES

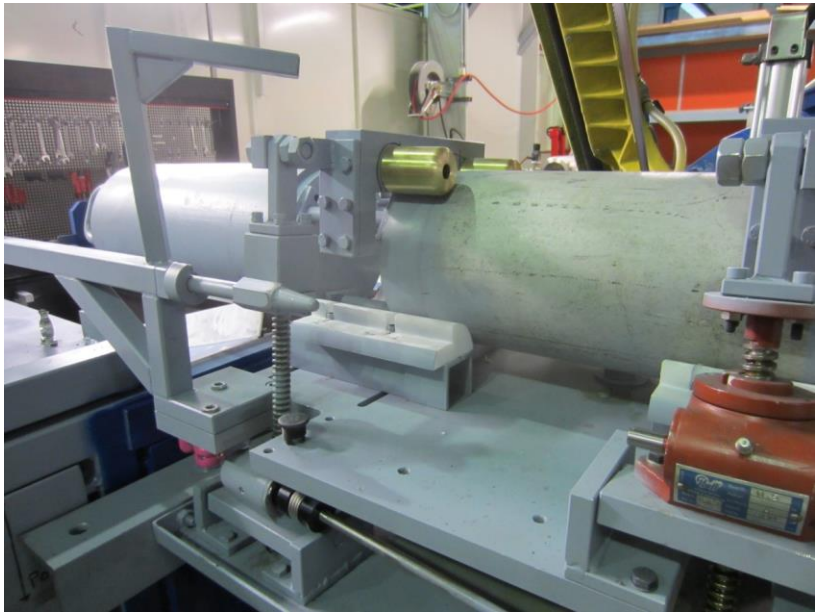
6. Container closed at distance



SUMMARY OF DOSE OPTIMIZATION MEASURES

7. Cutting of beam pipe-dump core assembly done remotely (workers exposure reduced). Use of cameras.





SUMMARY OF DOSE OPTIMIZATION MEASURES

8. Displacement mock-up from dump area to the lorry outside on the street, done by EN-HE-HH

SUPPORT DOCUMENTS

- EDMS document 1265118 (detailed procedure)
  https://edms.cern.ch/document/1265118/1

- WDP: '2013_PSB_Dump_exchange' on Sharepoint

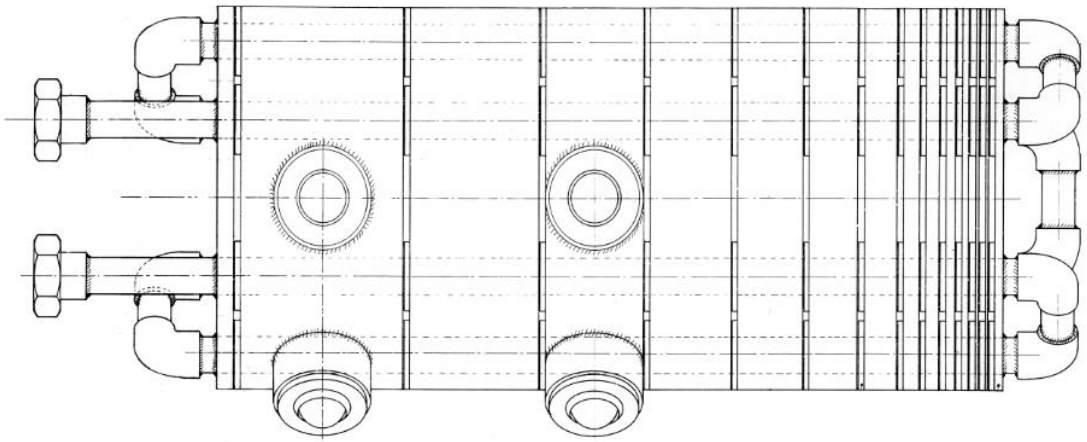
  https://espace.cern.ch/rpps/wdp/docs/PS%20Complex/Booster/2013-2014_LS1/2013_PSB_Dump_exchange.xlsx

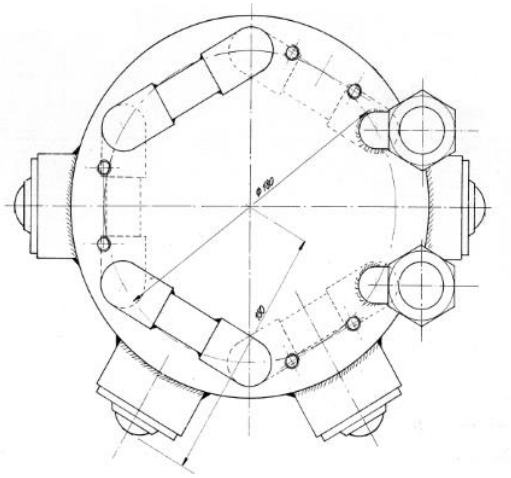
Thanks for your attention

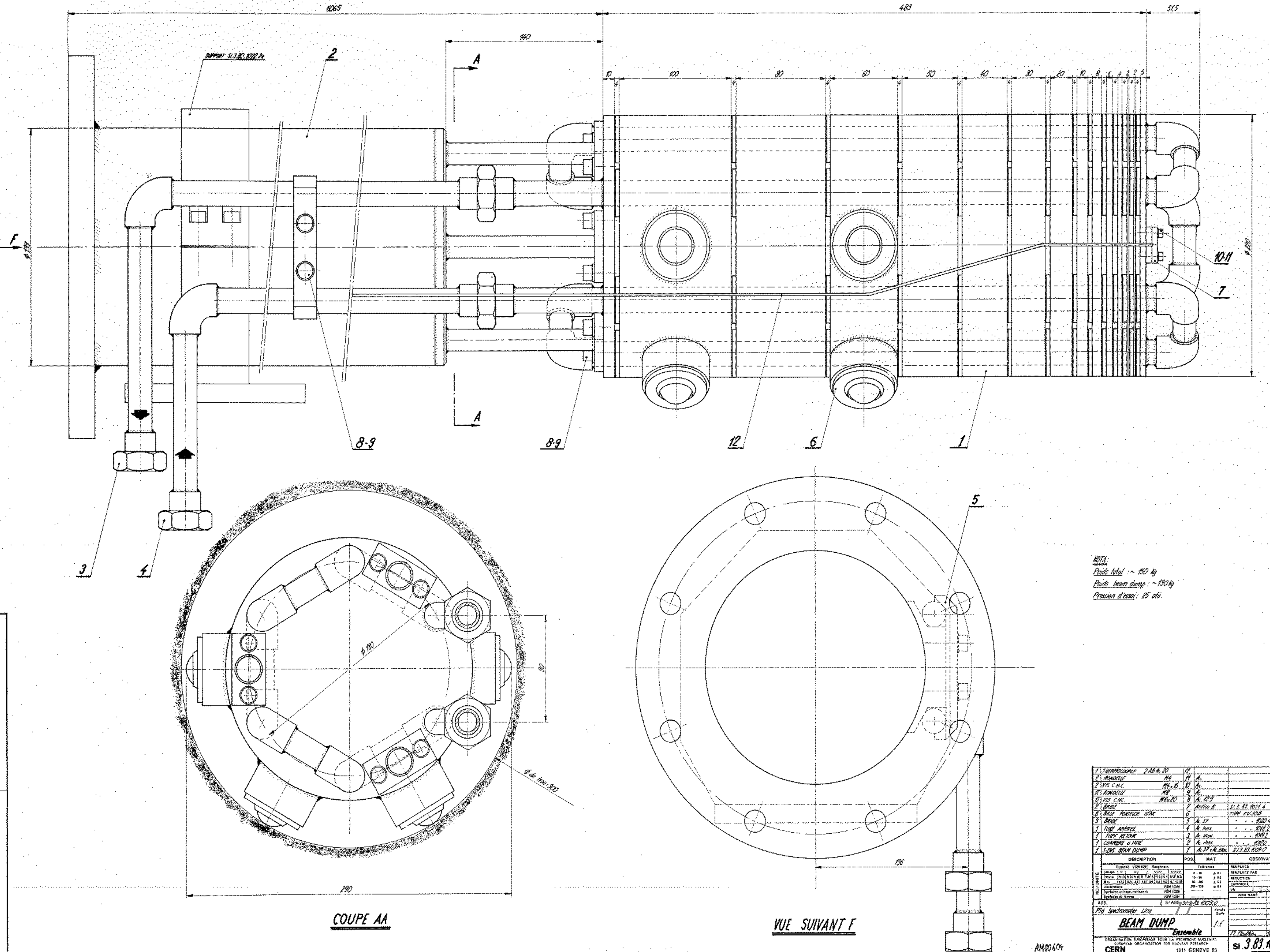
Q & A?

BACK-UP

PRESENT PSB DUMP CORE







NOTA:
Poids total : ~ 150 kg
Poids beam dump : ~ 130 kg
Pression d'essai : 25 atü.

		POS.	MAT.	OBSERVATIONS
1	THERMOCOUPLE 2 AB Ac 30	12		
2	RONDELLE M4	11	Ac.	
2	VIS C.H.C. M4 x 15	10	Ac.	
12	RONDELLE M8	9	Ac.	
12	VIS C.H.C. M8 x 20	8	Ac. 12.9	
2	BRIDE	7	Antico B	SI.3.83.1021.4
8	BILLE PORTEUSE STAR	6		TYPE KU 30B
9	BRIDE	5	Ac. 37	" " .1020.4
1	TUBE ARRIVEE	4	Ac. inox.	" " .1018.2
1	TUBE RETOUR	3	Ac. inox.	" " .1019.2
1	CHAMBRE à VIDE	2	Ac. inox.	" " .1017.0
1	S.ENS. BEAM DUMP	1	Ac. 37 + Ac. inox.	SI.3.83.1029.0
NO/UNITE	DESCRIPTION	POS.	MAT.	OBSERVAT

ASS. S/ ASS. SI.3.83.1005.0

PSB Spectrometer Line

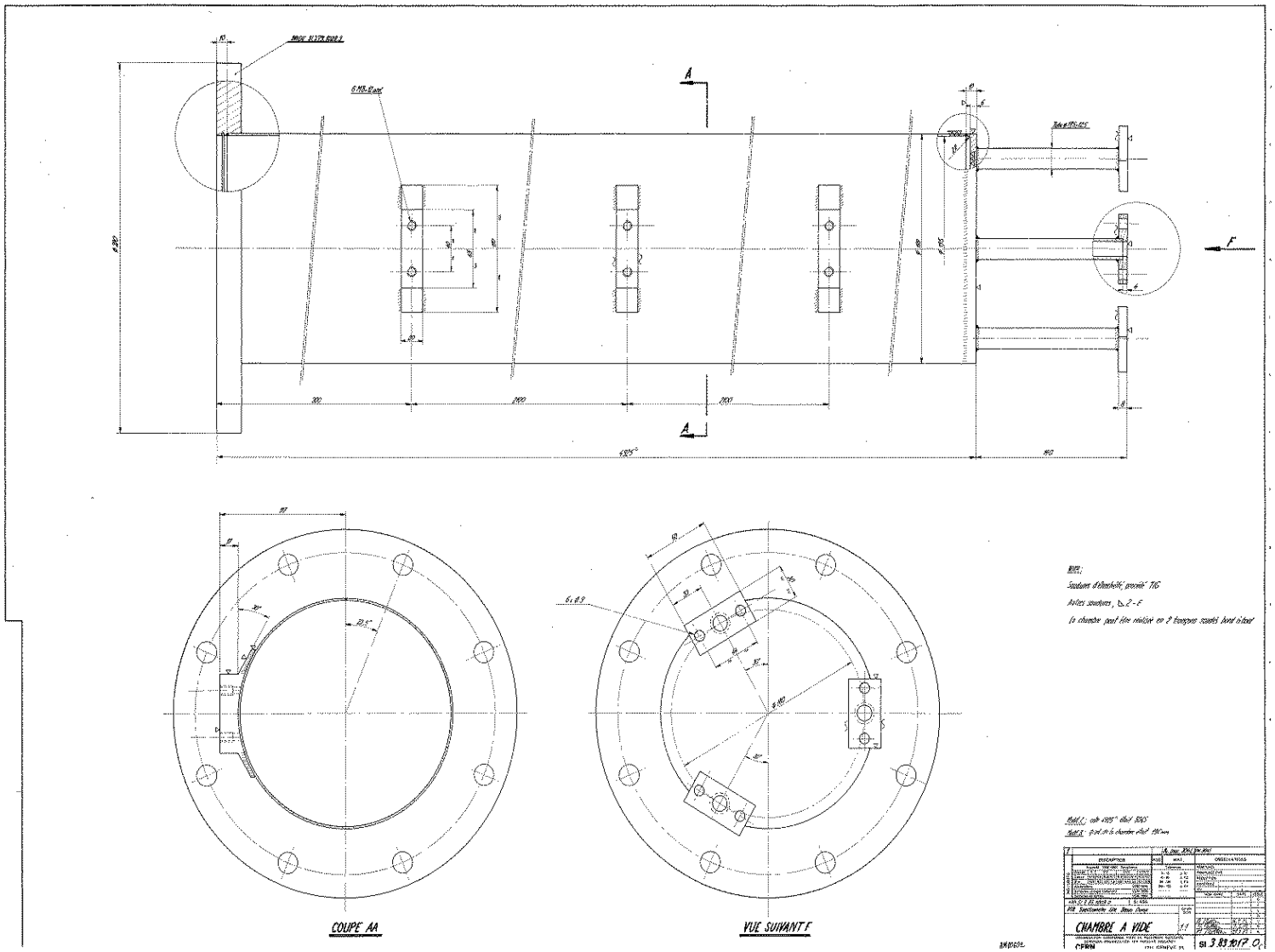
BEAM DUMP Ensemble

Echelle Scale 1:1

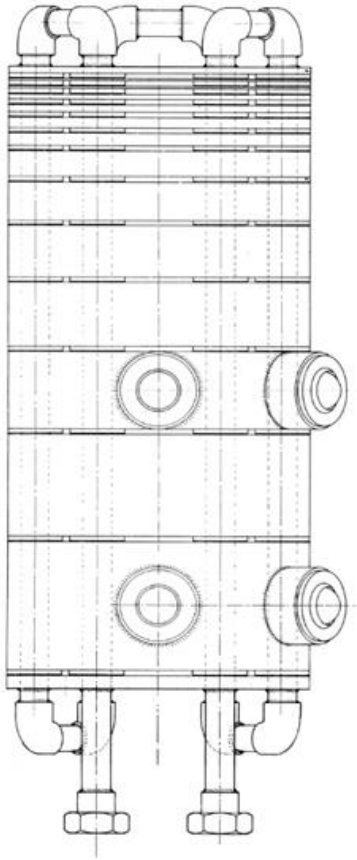
ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
CERN 1211 GENEVE 23

SI.3.83.1

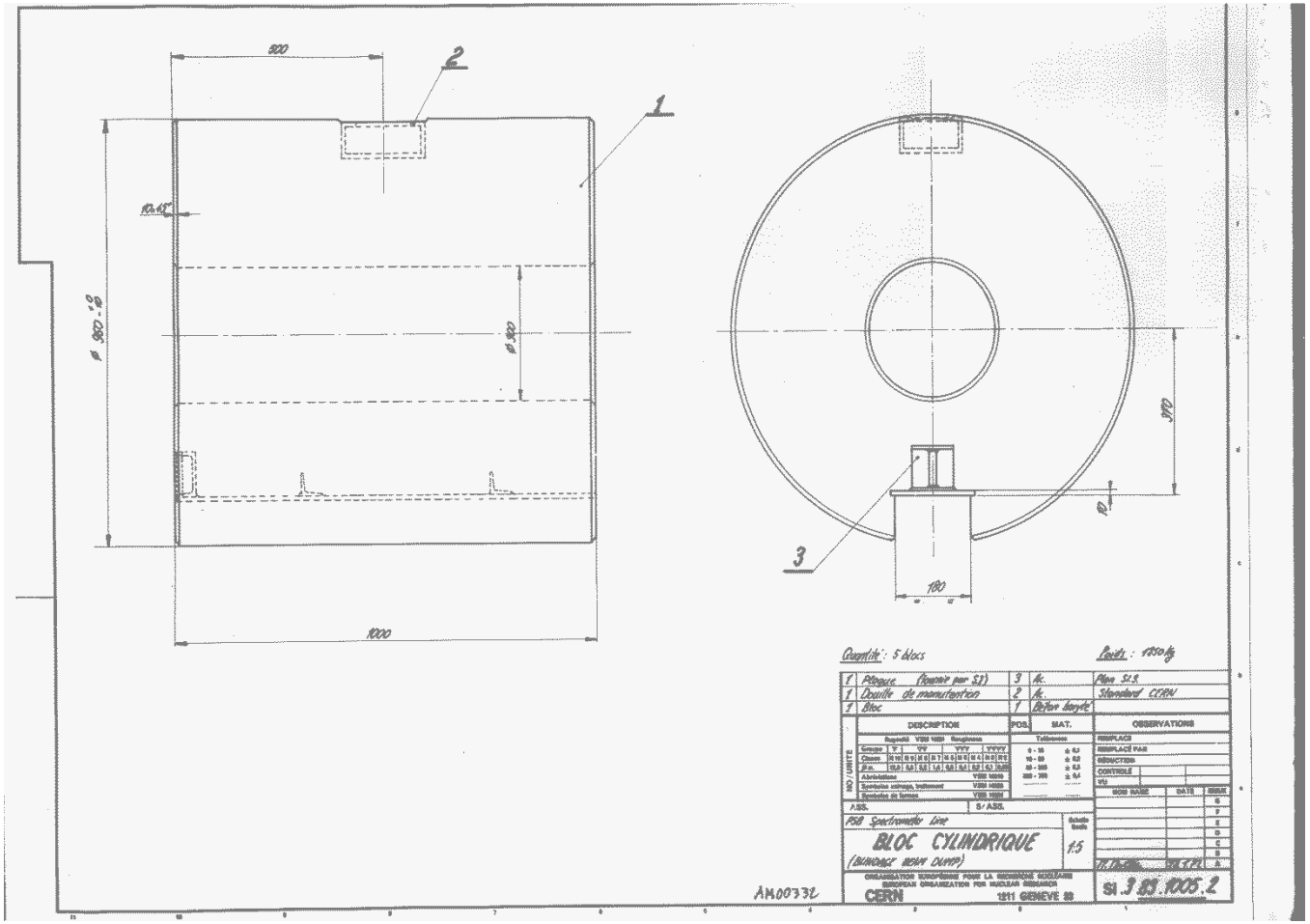
Vacuum Pipe



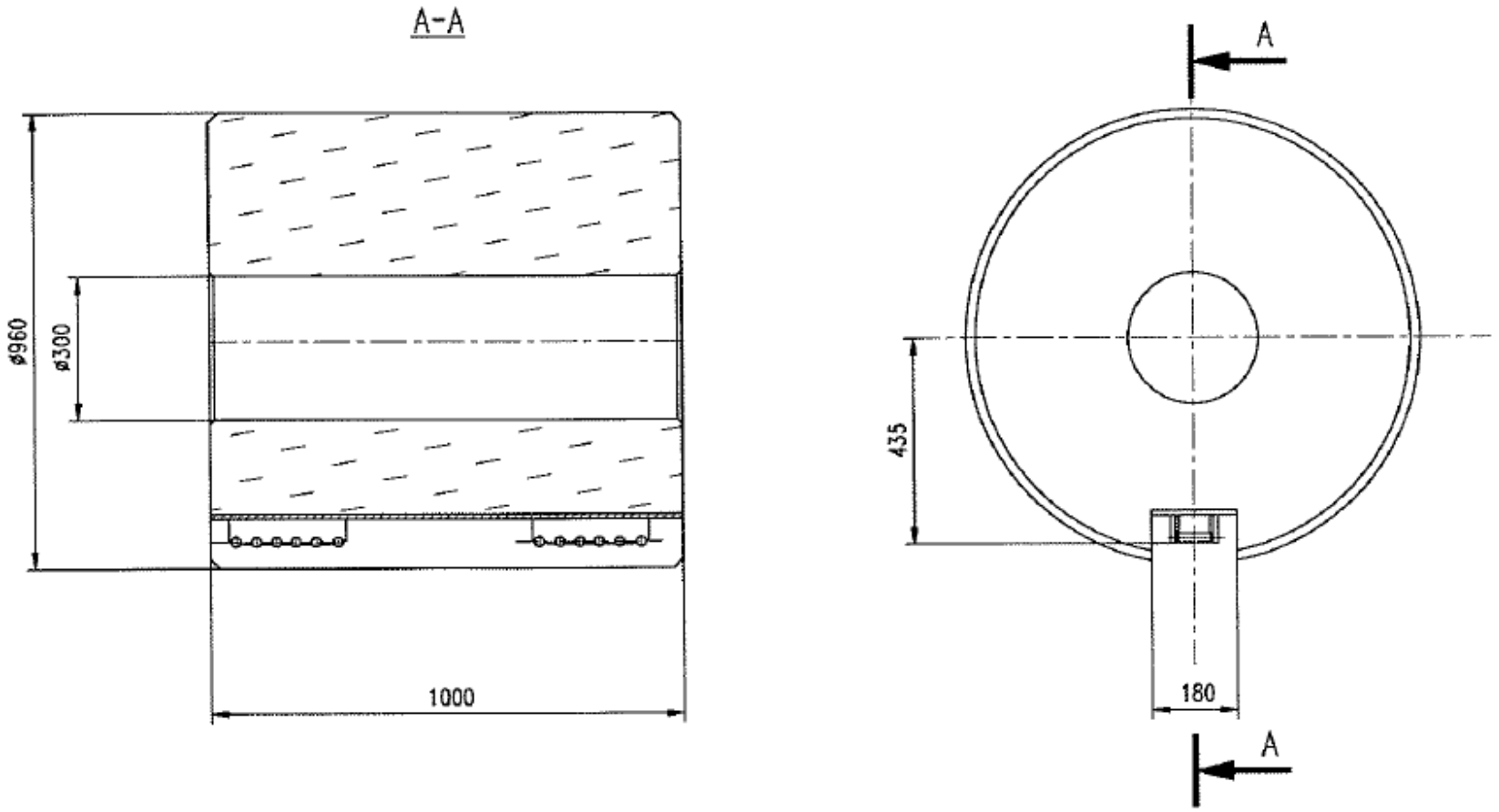
DUMP MOCK-UP



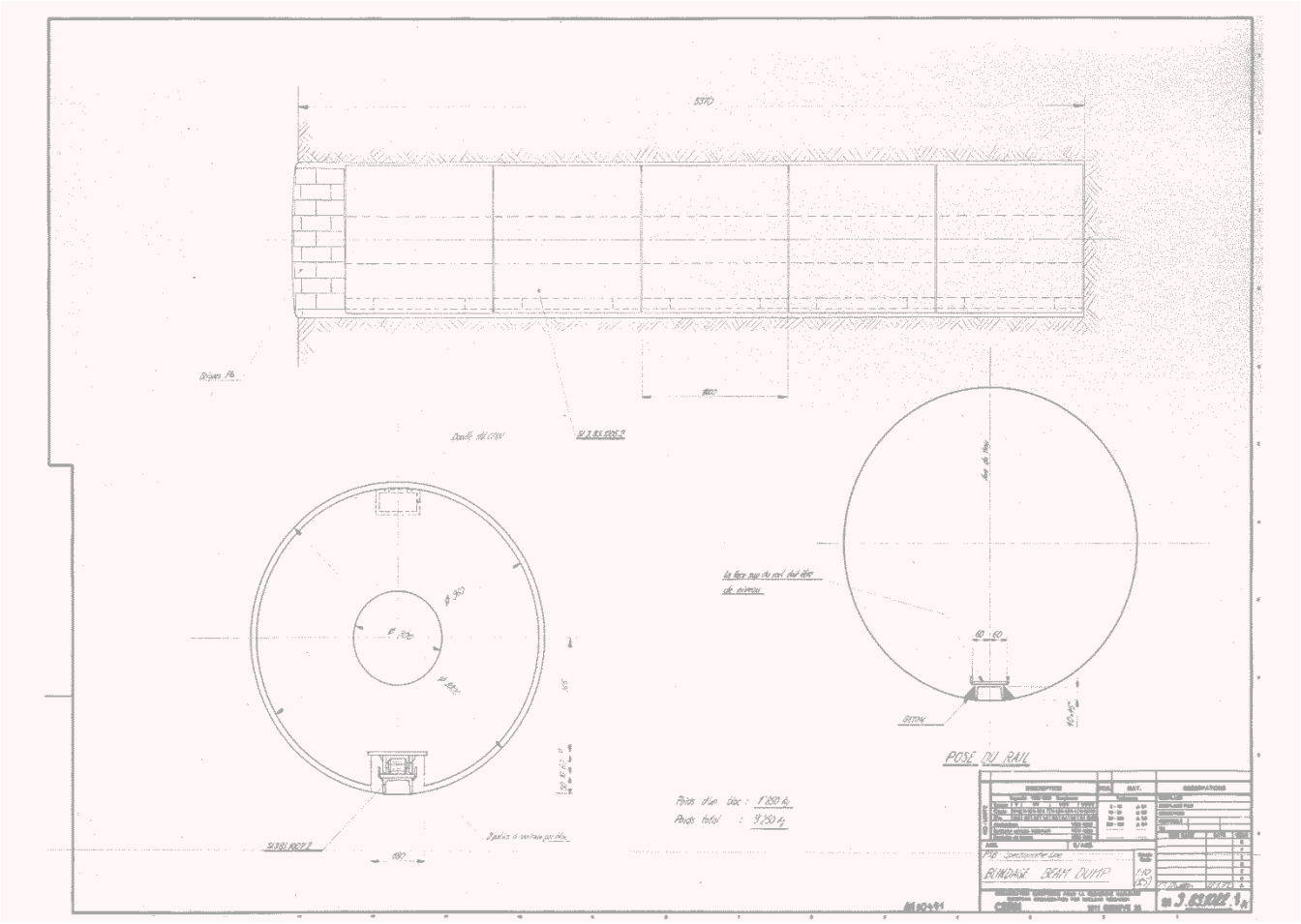
CONCRETE BLOCKS



CONCRETE BLOCKS



CONCRETE BLOCKS



Outermost shielding block must be blocked

ENDOSCOPY

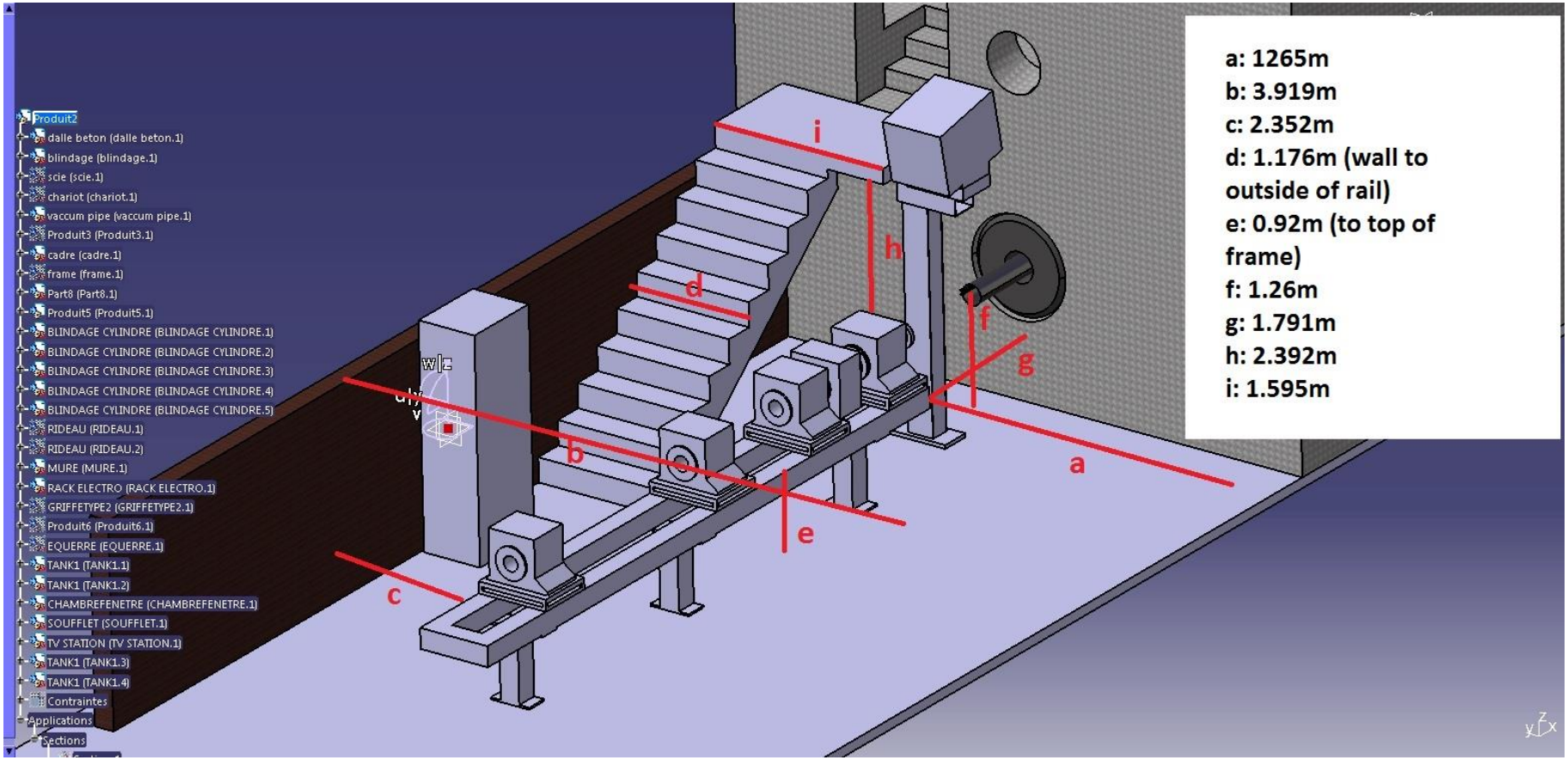

05/12/2011


15/12/2011

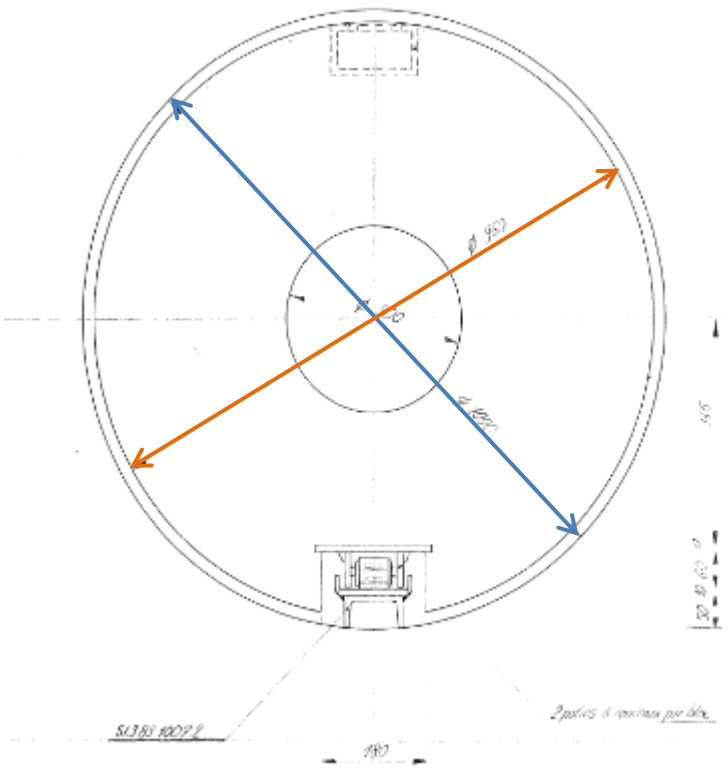

15/12/2011


05/12/2011

MEASUREMENTS

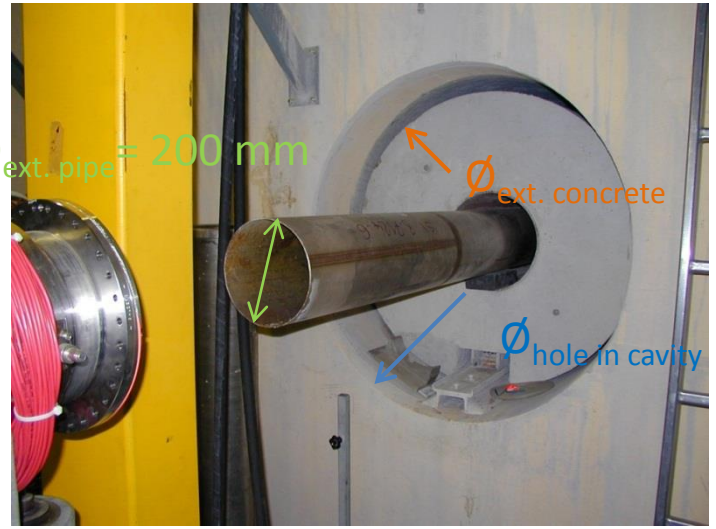


CONCRETE BLOCKS



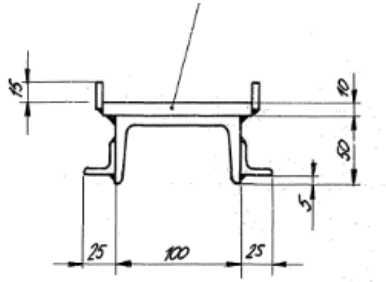
$Ø_{hole\ in\ cavity}$ = ~1000 mm

$Ø_{ext.\ concrete}$ = ~960 mm



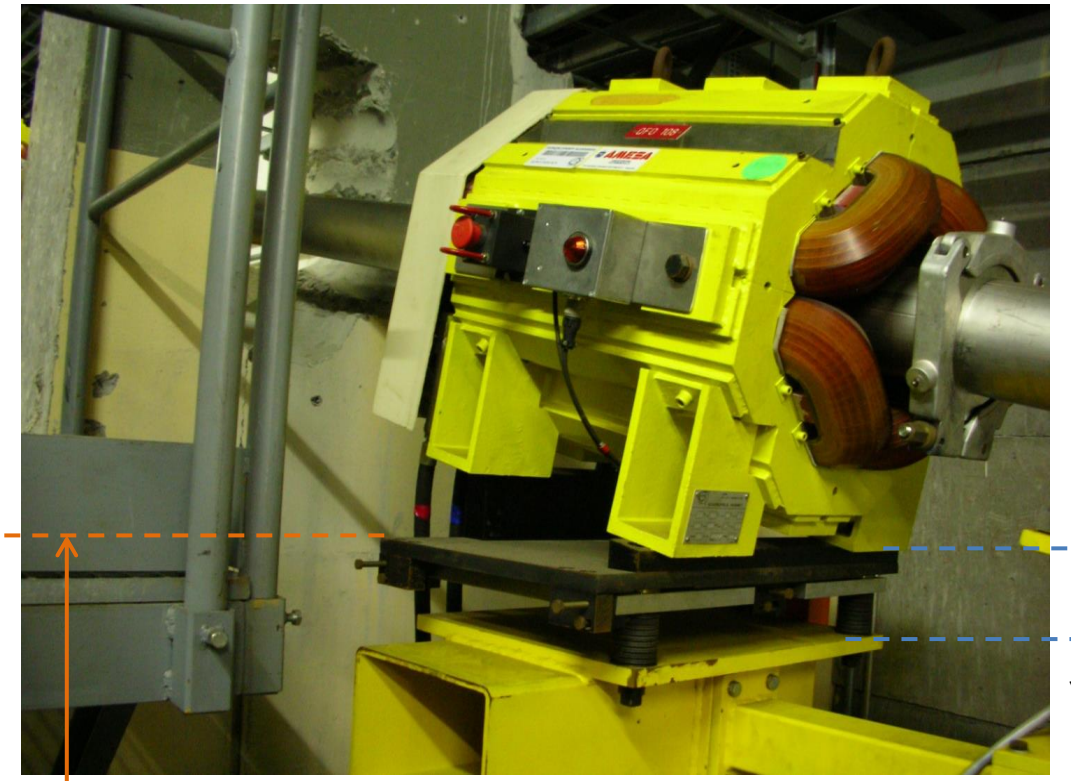
RAIL IN CAVITY

d = 62 mm *(60 mm according to old drawings)*



Old drawings

MAGNET BTY-QFO 108



Black plate's top surface

Black plate's top surface

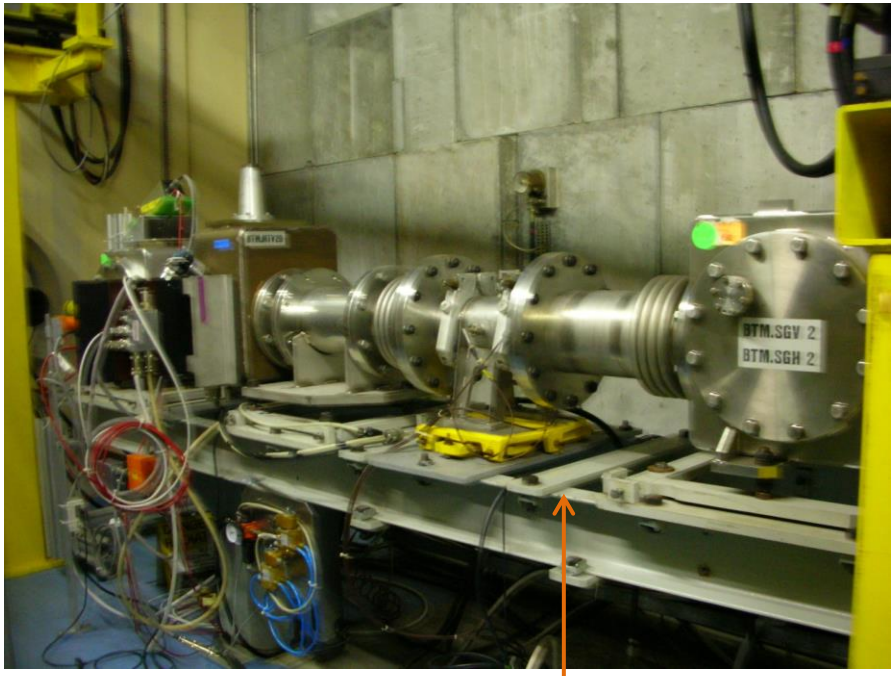
d ~ 100 mm

Yellow plate's top surface

d = 2560 mm

floor

GIRDER vs RAIL INSIDE CAVITY



Girder's top surface

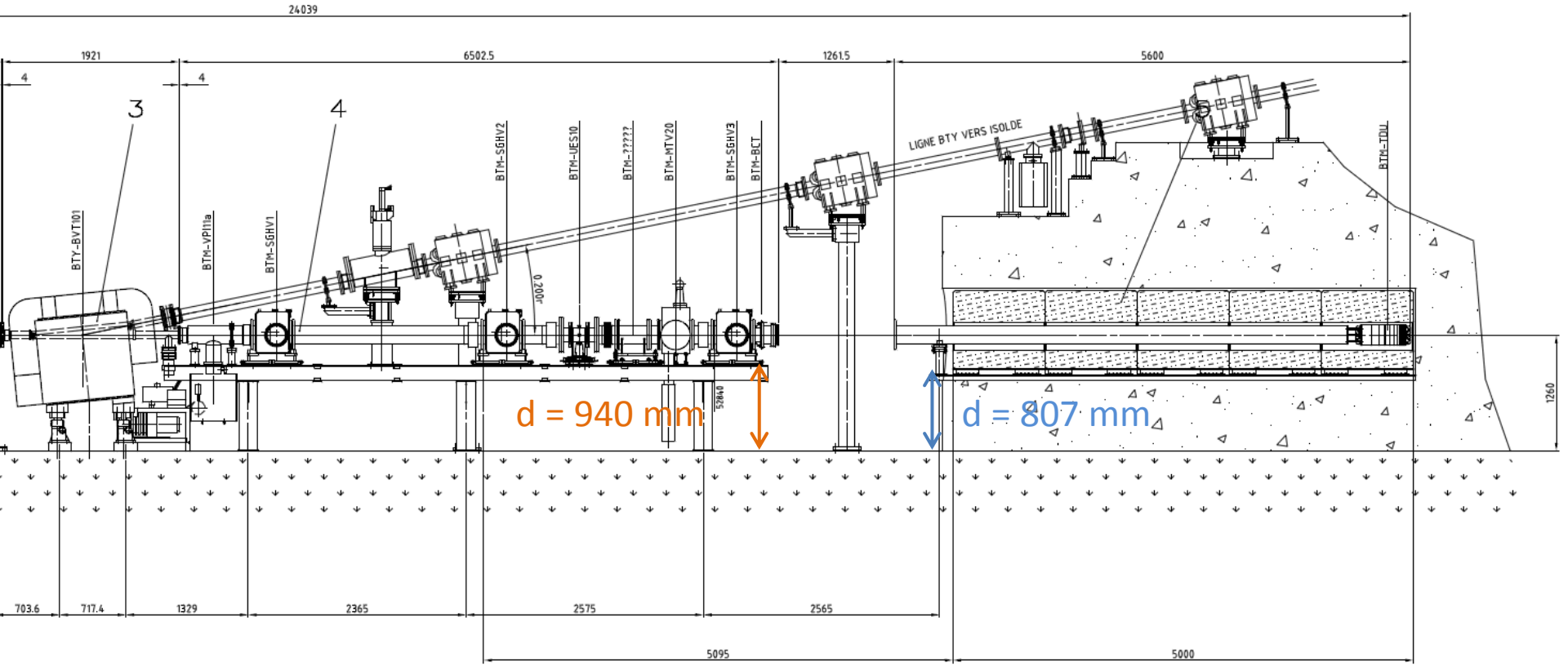
d = 940 mm

Rail's surface where the concrete blocks roll

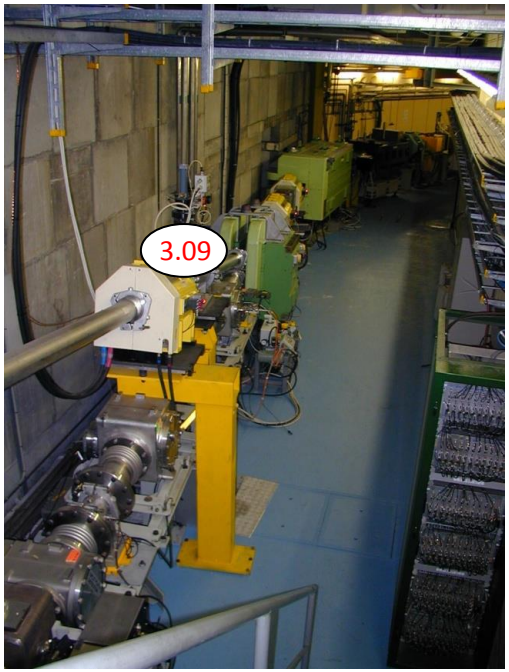
d = 807 mm

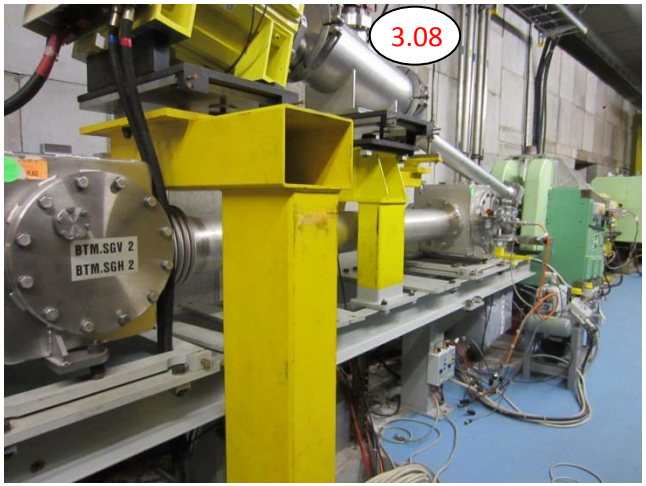
floor

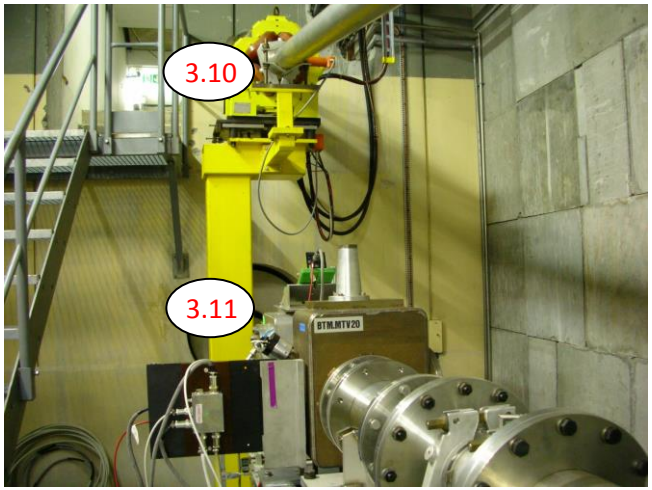
GIRDER vs RAIL INSIDE CAVITY

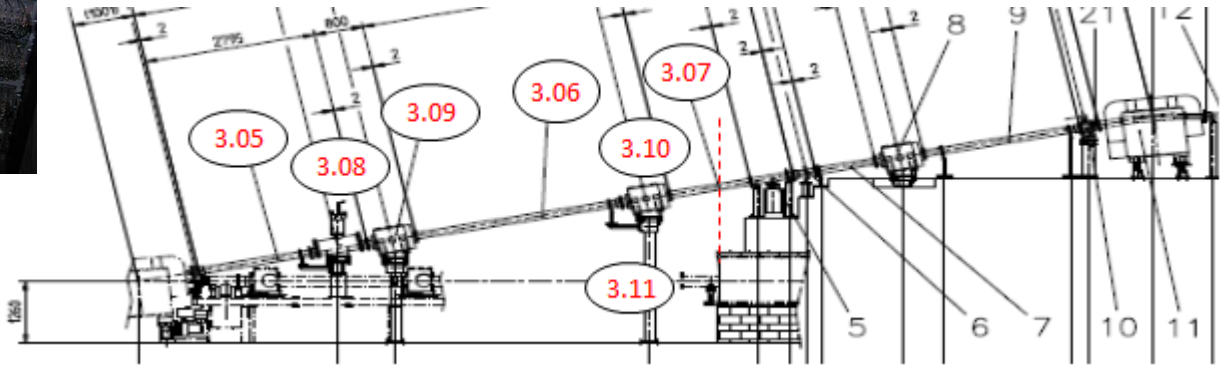


3. TEMPORARY DISMANTLING OF EQUIPMENT IN BT, BTM AND BTY LINES

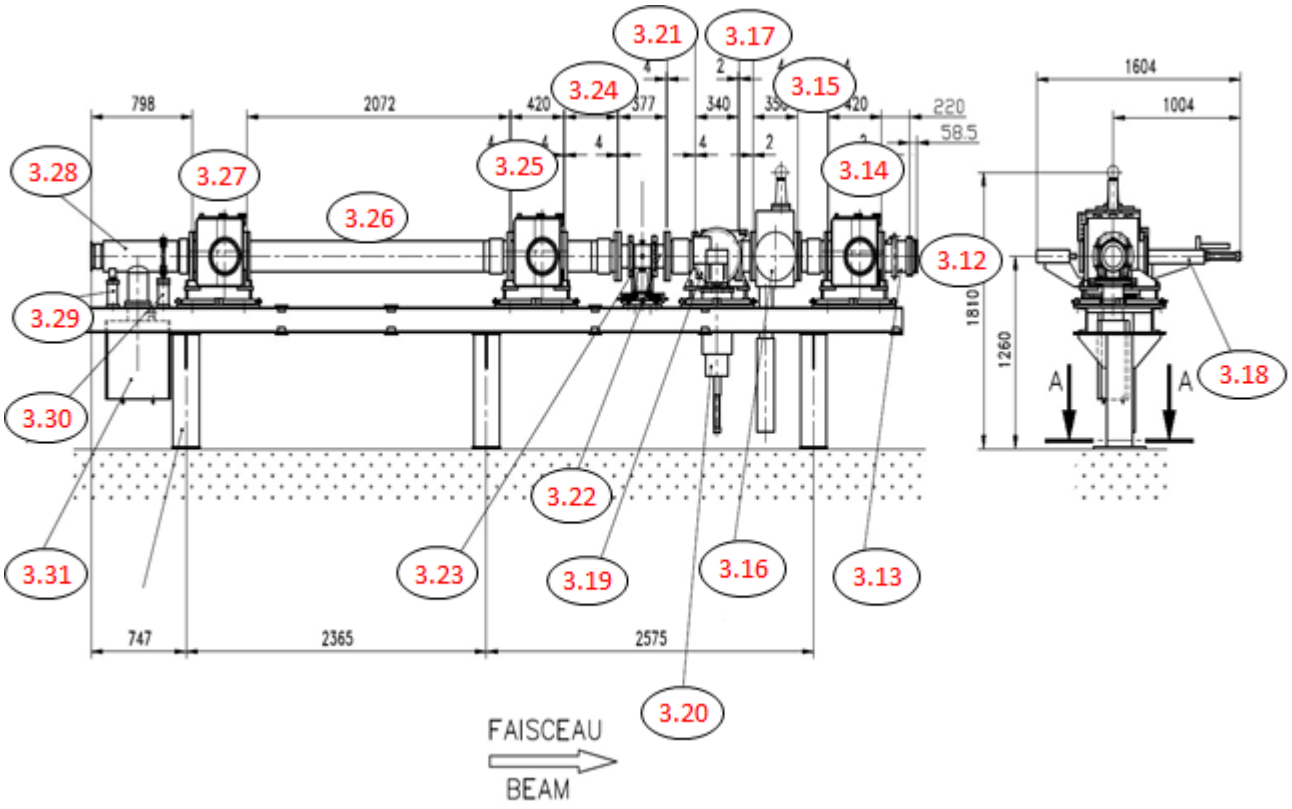








3. TEMPORARY DISMANTLING OF EQUIPMENT IN BT, BTM AND BTY LINES



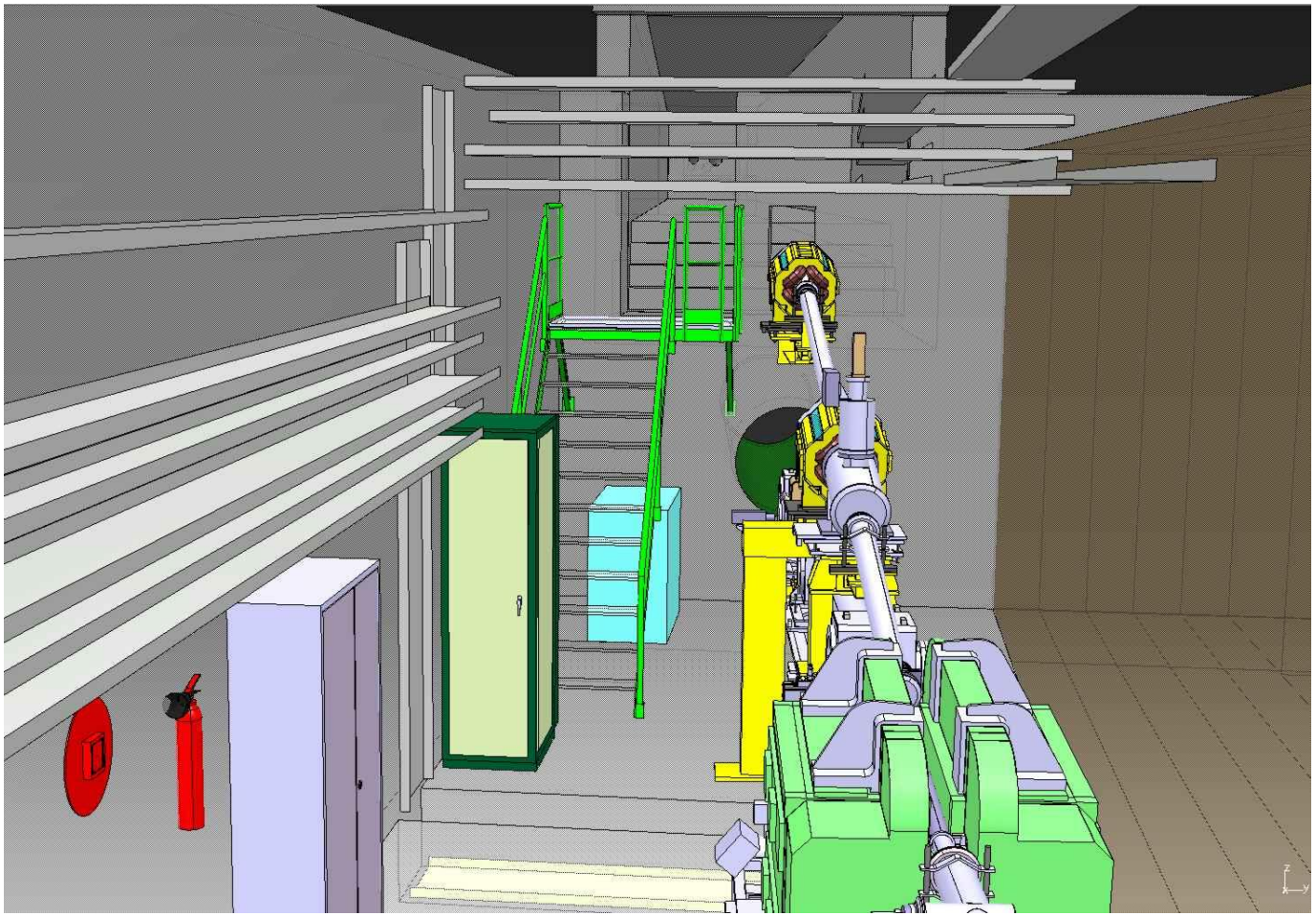
BTM beam line equipment

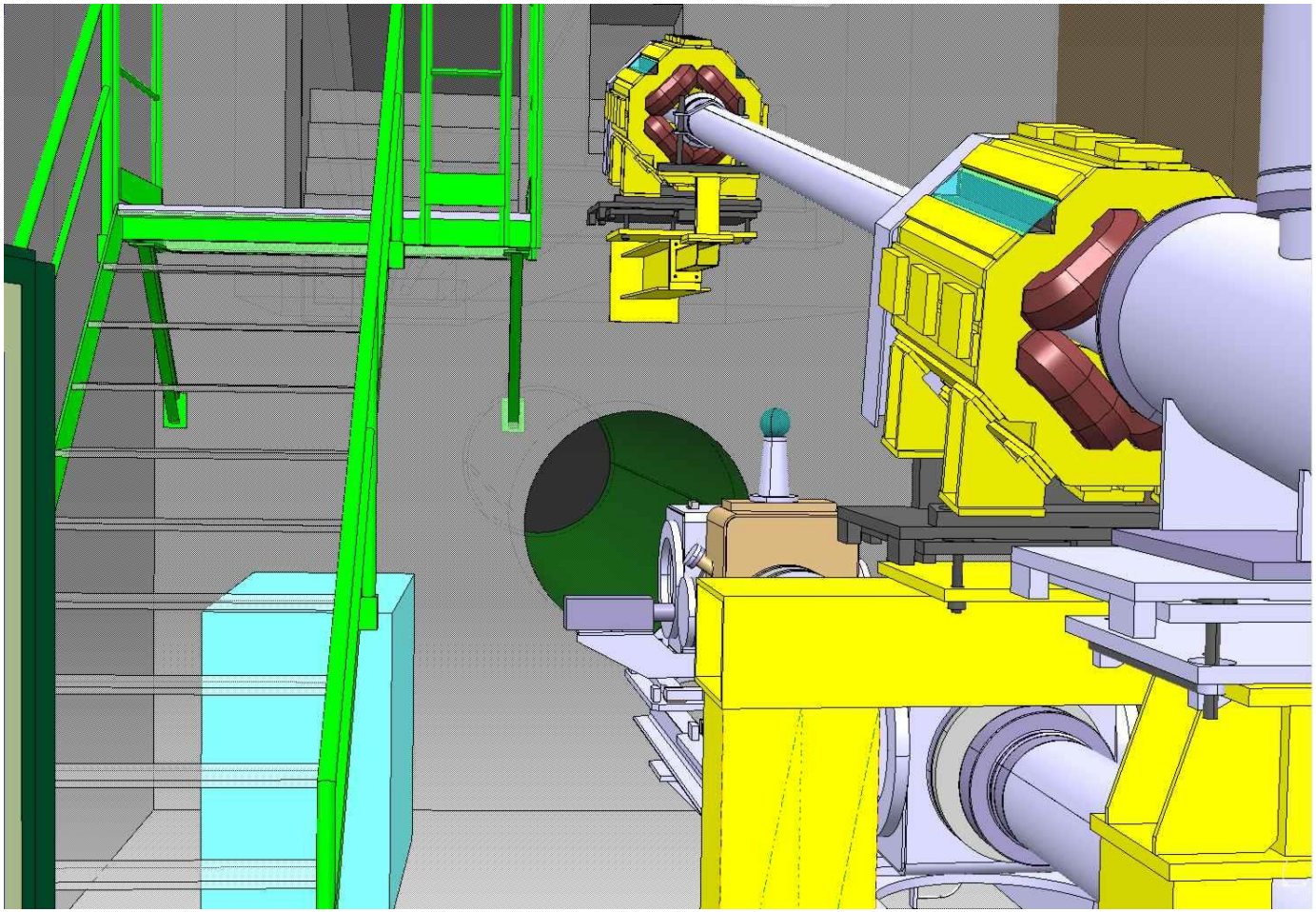
3.12	Window BTM-SGHV3
3.13	BTM-BCT
3.14	Semfil Tank
3.15	Vacuum Tube
3.16	TV Station
3.17	Vacuum Tube
3.18	Big Split Plate
3.19	Tank Split Plates
3.20	Split Plate
3.21	Vacuum Tube
3.22	Vacuum Chamber
3.23	Pick-Up
3.24	Vacuum Tube
3.25	Semfil Tank
3.26	Vacuum Tube
3.27	Semfil Tank
3.28	Vacuum Chamber
3.29	Upper Chamber support
3.30	Lower Chamber support
3.31	Varian Ion Pump

RADIOACTIVE WASTE ESTIMATED

- DUMP CORE + BEAM PIPE + ‘PLUG AGAINST RADIATION’
  - Weight: ~190 kg (~130 kg dump + ~25 kg pipe + ~35 kg plug)
  - Container:
    - Frame made of steel, walls made of lead.
    - weight: ~2 t
    - Size: 1300 x 1000 x 350 mm
    - 5 cm lead for dump, 2.5 cm steel for pipe
  - Total weight: ~ 2.2 t
- CONCRETE BLOCKS (X5)
  - Weight: 1850 kg each block
  - 5 containers made of steel
  - Every block has different levels of activation, being the last one the most active one.

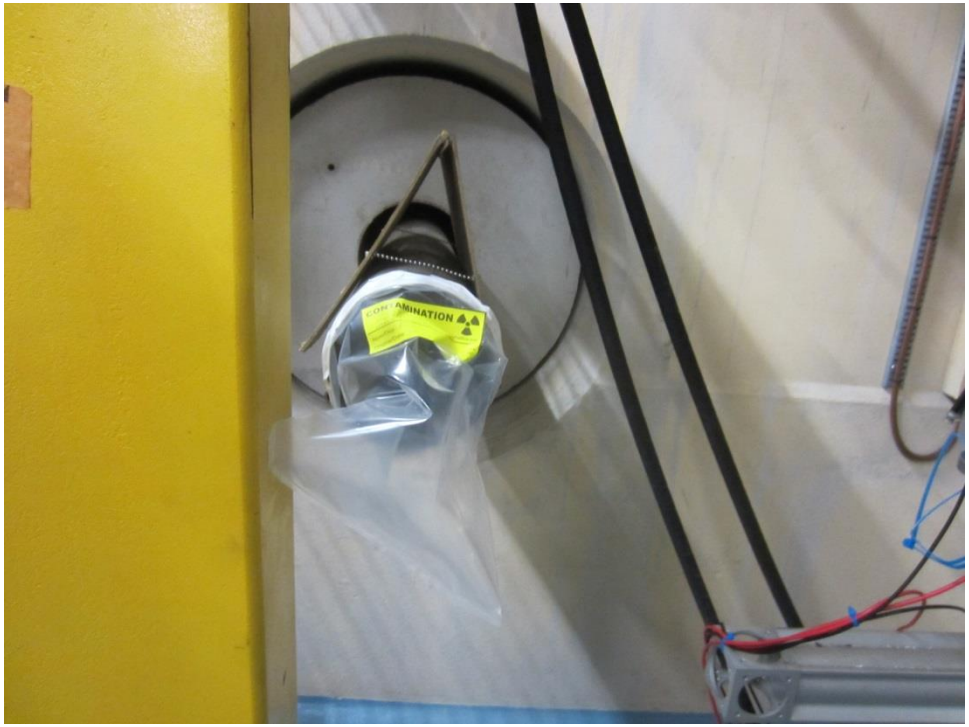
NEW INTEGRATION MODEL



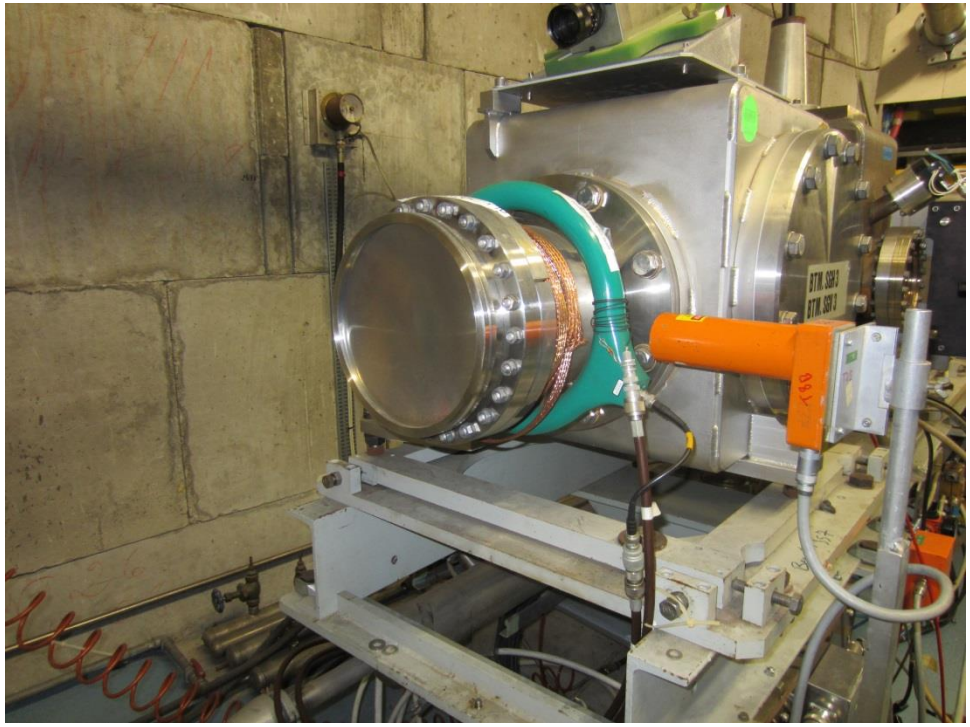


Plug against radiation – before & after

Plug against radiation – before & after

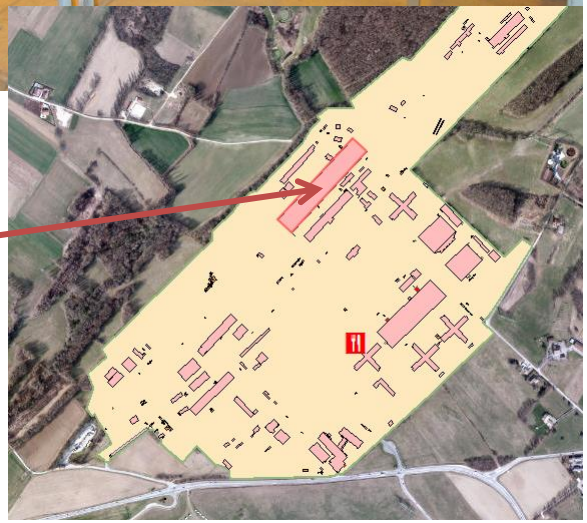


Vacuum window – very active: 1 mSv/h in contact (April 2013)



The screws can be removed – have been removed

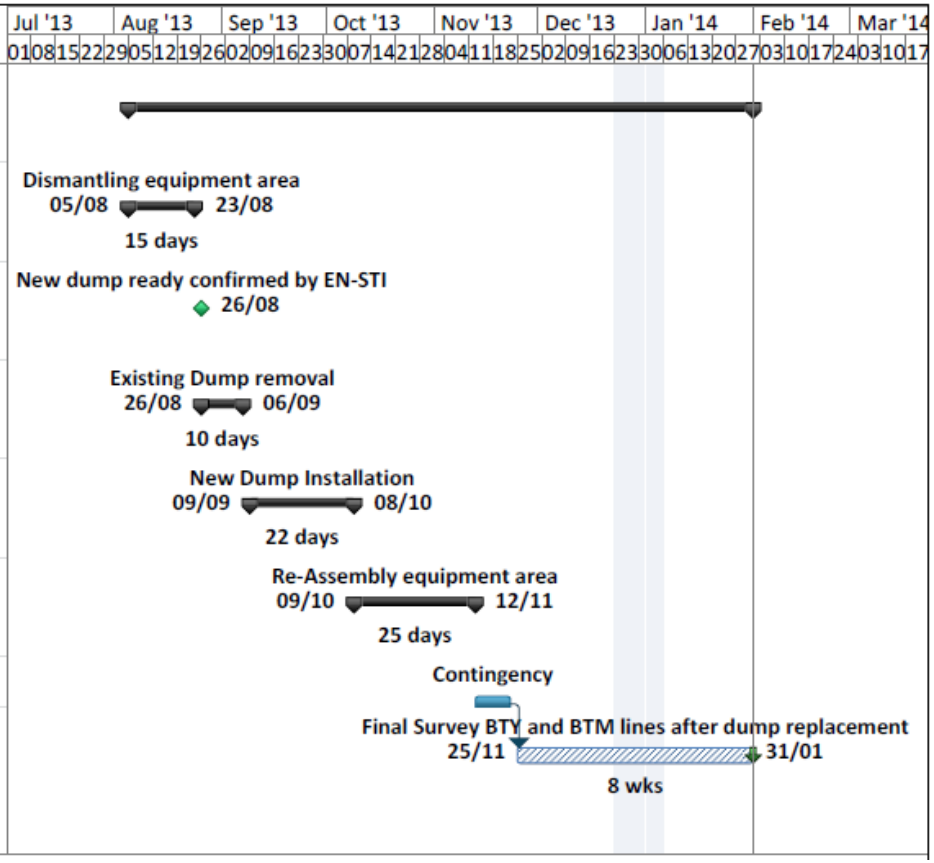
Area for mock-up operations



Building EHN1 (Prevessin site)

PLANNING INTERVENTION

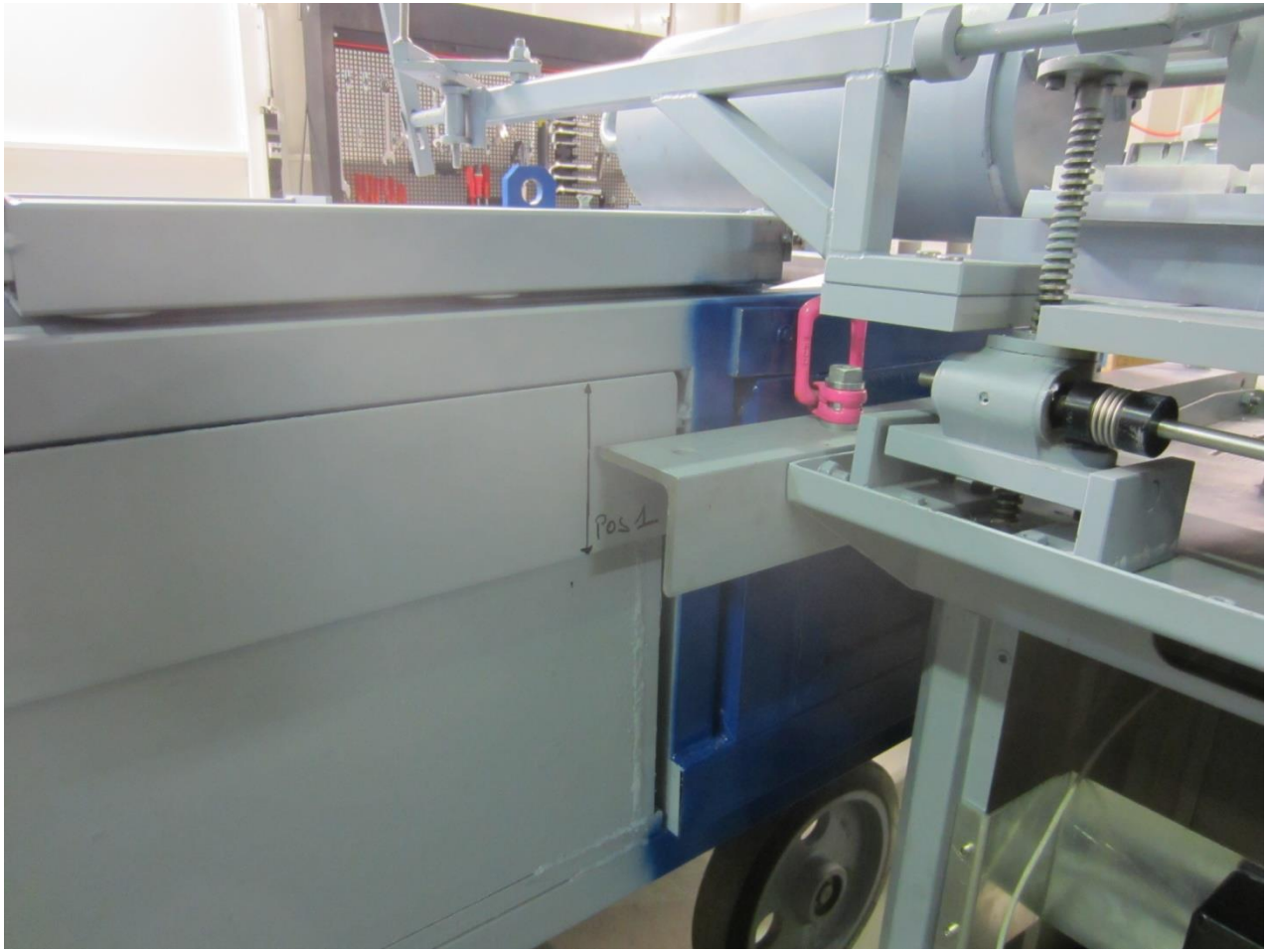
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Beam dump replacement**	**120 days**	**Mon 05/08/13**	**Fri 31/01/14**
2		**Dismantling equipment area**	**15 days**	**Mon 05/08/13**	**Fri 23/08/13**
7		**New dump ready confirmed by EN-STI**	**0 days**	**Mon 26/08/13**	**Mon 26/08/13**
8		**Existing Dump removal**	**10 days**	**Mon 26/08/13**	**Fri 06/09/13**
11		**New Dump Installation**	**22 days**	**Mon 09/09/13**	**Tue 08/10/13**
16		**Re-Assembly equipment area**	**25 days**	**Wed 09/10/13**	**Tue 12/11/13**
20		Contingency	8 days	Wed 13/11/13	Fri 22/11/13
21		**Final Survey BTY and BTM lines after dump replacement**	8 wks	Mon 25/11/13	Fri 31/01/14



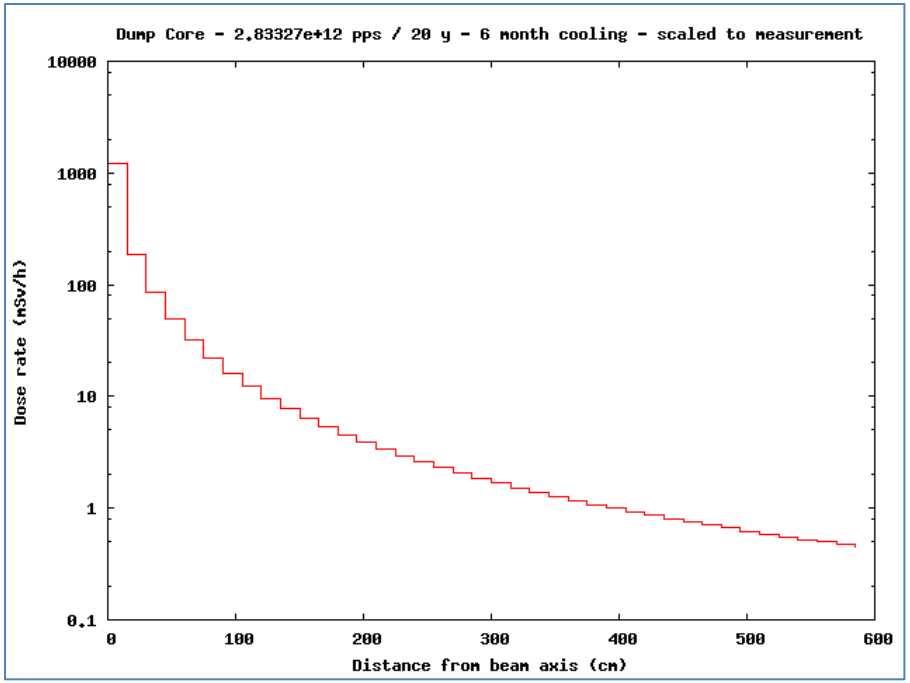
Task Name	Duration	Start	Finish
Beam dump replacement	**120 days**	**Mon 05/08/13**	**Fri 31/01/14**
Dismantling equipment area	**15 days**	**Mon 05/08/13**	**Mon 26/08/13**
Dismantling equipment next to beam line	3 days	Mon 05/08/13	Wed 07/08/13
Dismantling equipment BTY line	1 wk	Thu 08/08/13	Wed 14/08/13
Survey BTM line	2 days	Thu 15/08/13	Fri 16/08/13
Dismantling equipment BTM line	1 wk	Mon 19/08/13	Fri 23/08/13
New dump ready confirmed by EN-STI	**0 days**	**Mon 26/08/13**	**Mon 26/08/13**
Existing Dump removal	**10 days**	**Mon 26/08/13**	**Fri 06/09/13**
Extraction&Disposal of dump core+beam pipe	1 wk	Mon 26/08/13	Fri 30/08/13
Extraction&Disposal of shielding	1 wk	Mon 02/09/13	Fri 06/09/13
New Dump Installation	**22 days**	**Mon 09/09/13**	**Tue 08/10/13**
New shielding Installation	1 wk	Mon 09/09/13	Fri 13/09/13
New Dump Installation	1 wk	Mon 16/09/13	Fri 20/09/13
BTY-QFO108's new support installation	2 days	Mon 23/09/13	Tue 24/09/13
New cooling equipment installation	2 wks	Wed 25/09/13	Tue 08/10/13
Re-Assembly equipment area	**25 days**	**Wed 09/10/13**	**Tue 12/11/13**
Re-Assembly equipment BTM line	2 wks	Wed 09/10/13	Tue 22/10/13
Re-Assembly equipment BTY line	2 wks	Wed 23/10/13	Tue 05/11/13
Re-Assembly equipment next to beam line	1 wk	Wed 06/11/13	Tue 12/11/13
Contingency	8 days	Wed 13/11/13	Fri 22/11/13
Final Survey BTY and BTM lines after dump replacement	8 wks	Mon 25/11/13	Fri 31/01/14

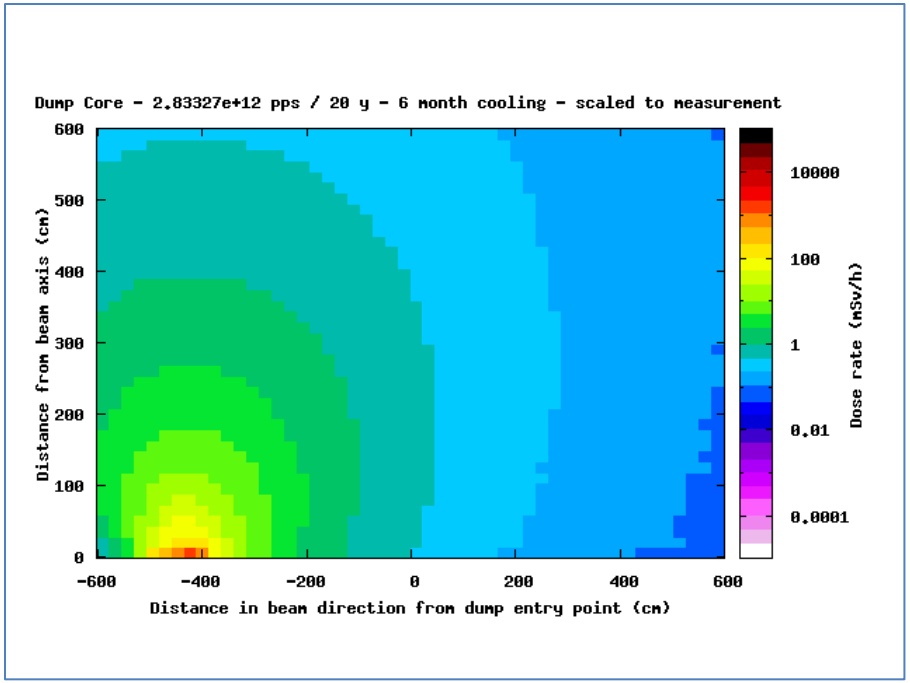
STORAGE OF BEAM LINE ELEMENTS: 361/S-001

Save time placing equipment

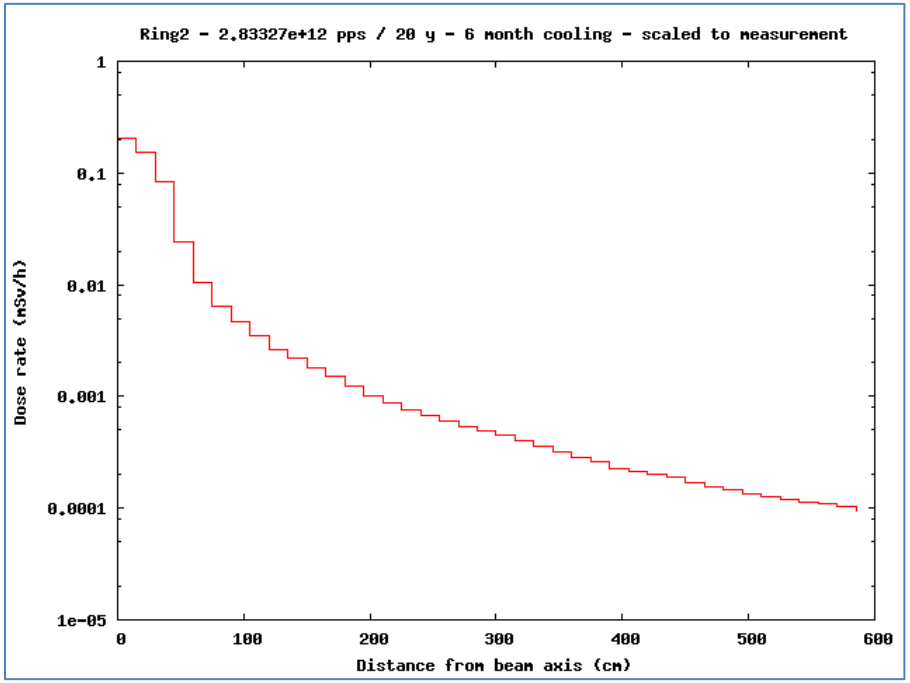


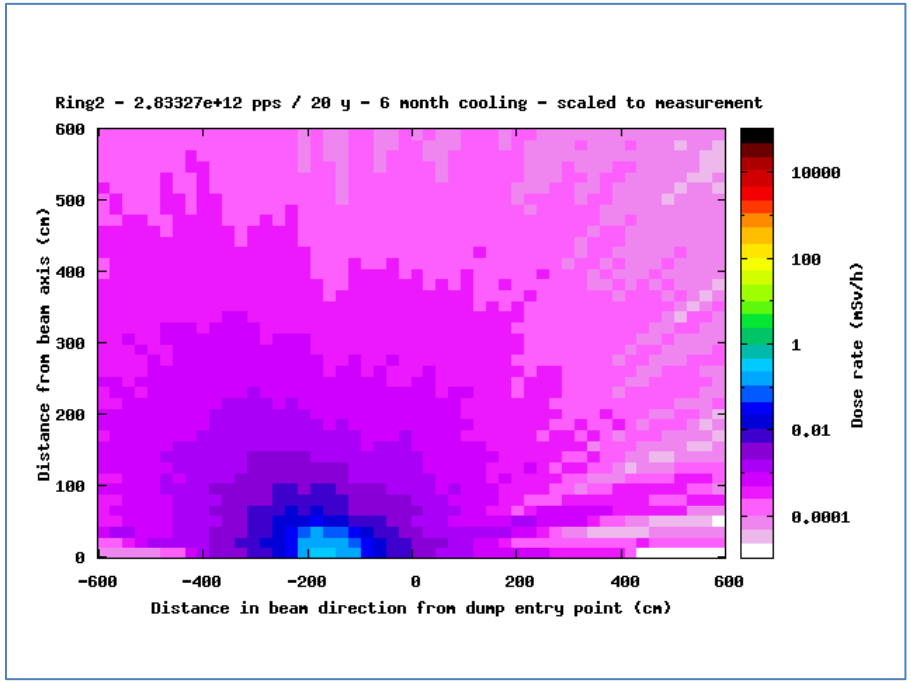
SIMULATIONS ACTIVATION DUMP CORE



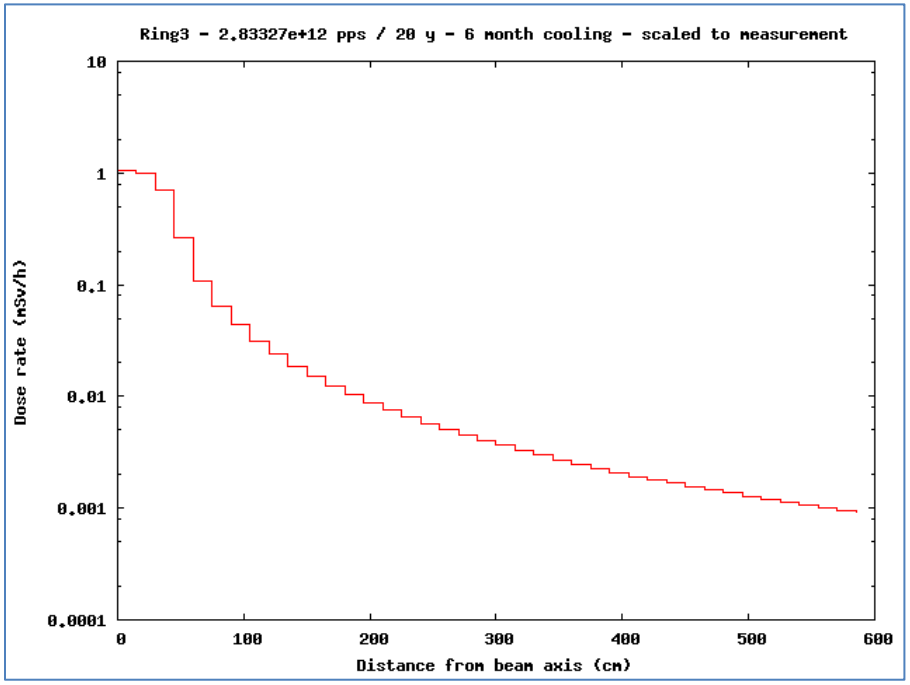


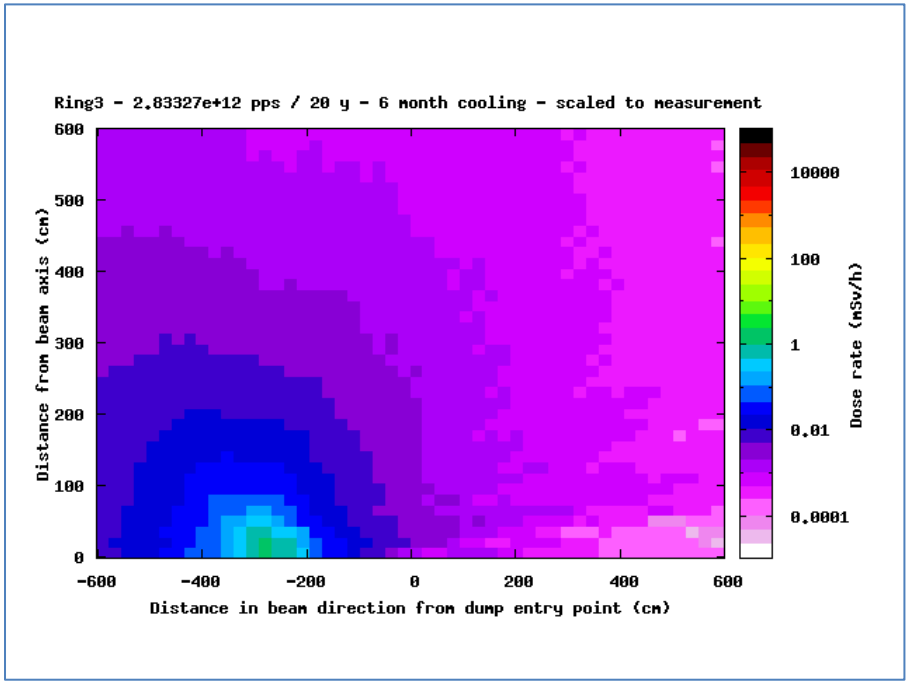
SIMULATIONS ACTIVATION BLOCK 1



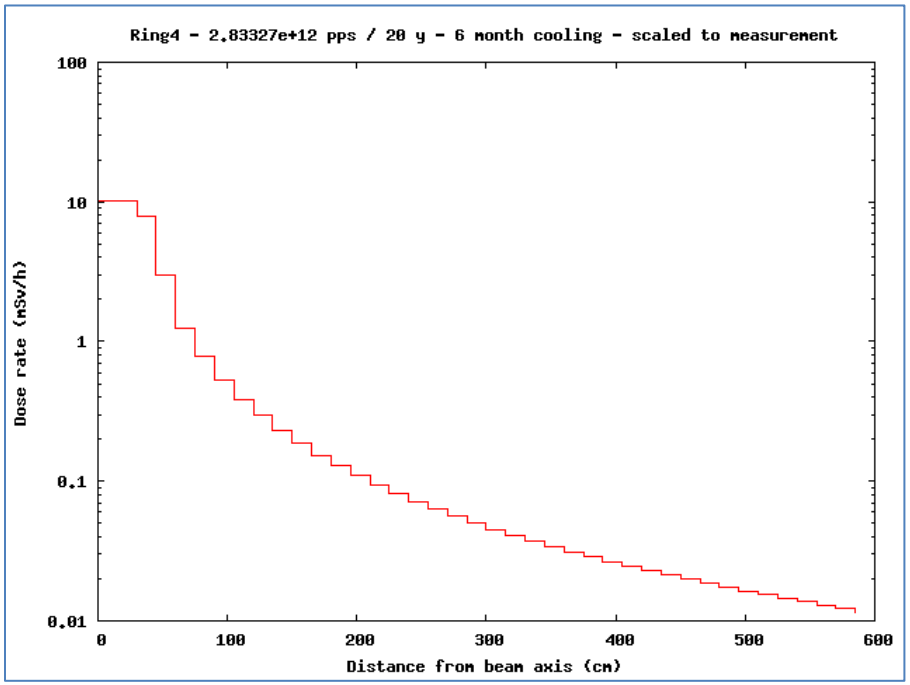


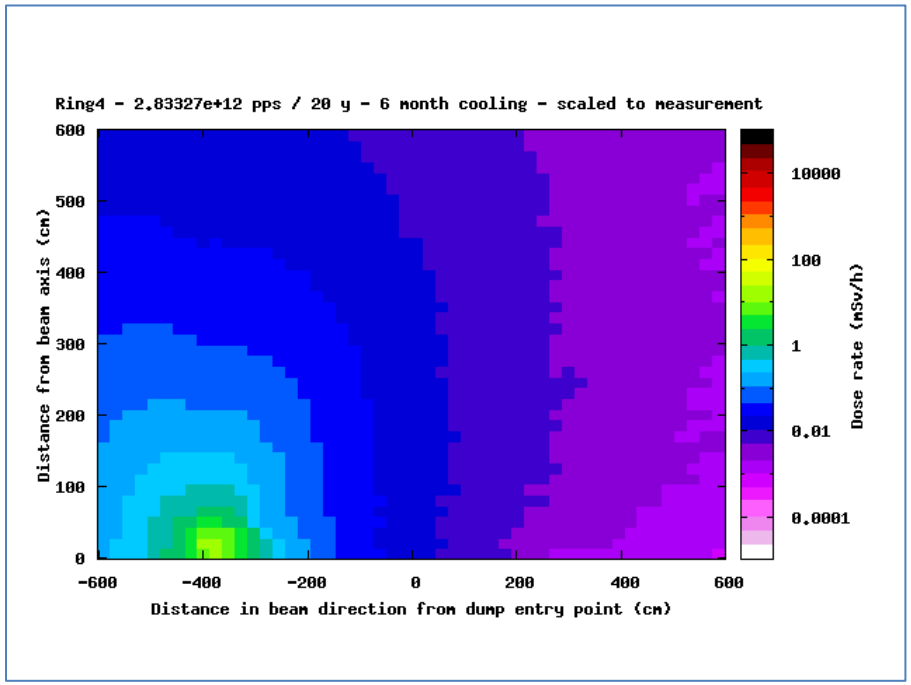
SIMULATIONS ACTIVATION BLOCK 2



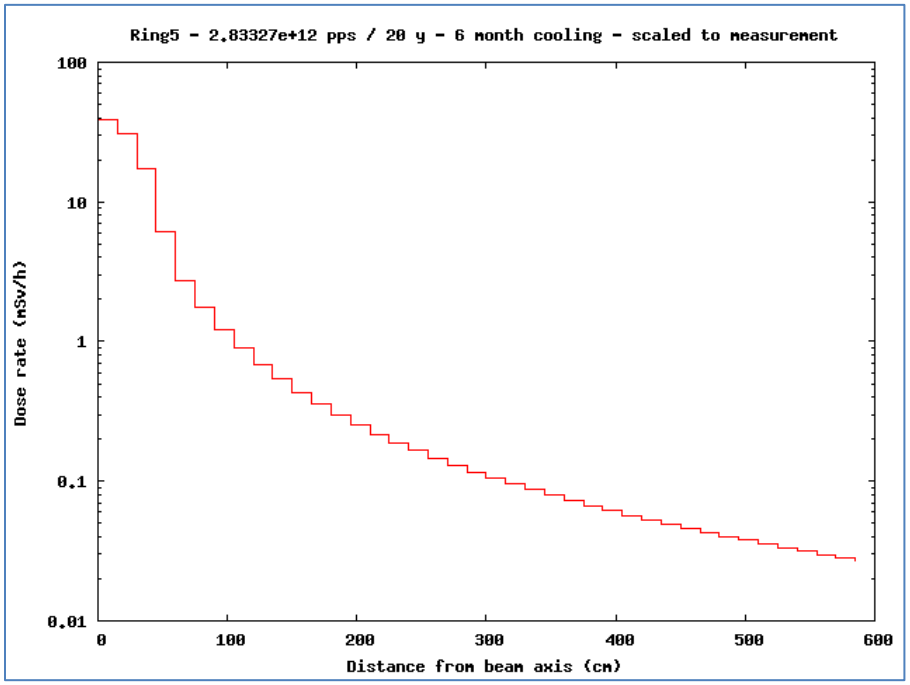


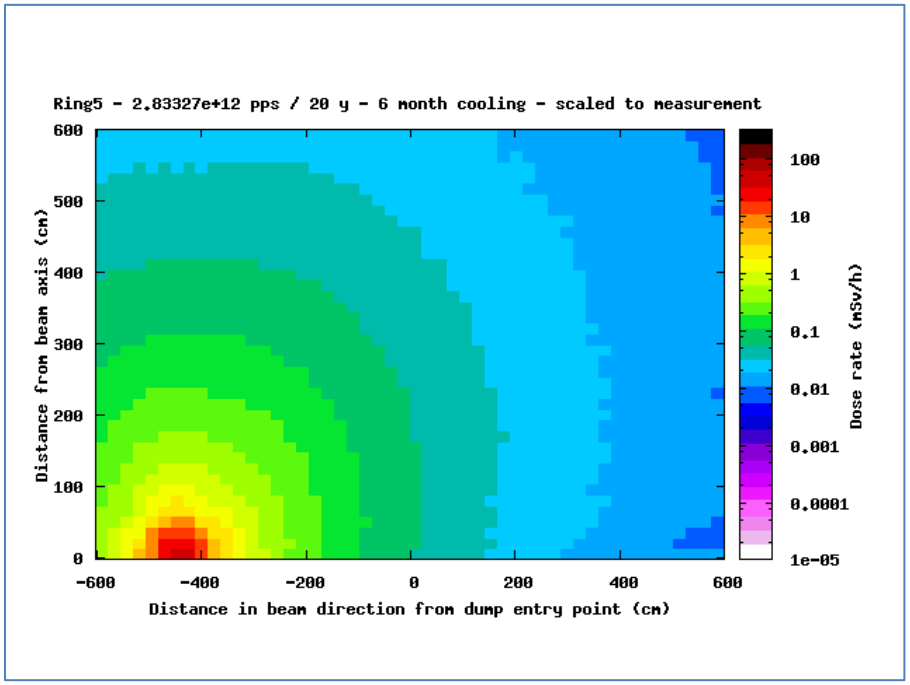
SIMULATIONS ACTIVATION BLOCKS 3 & 5



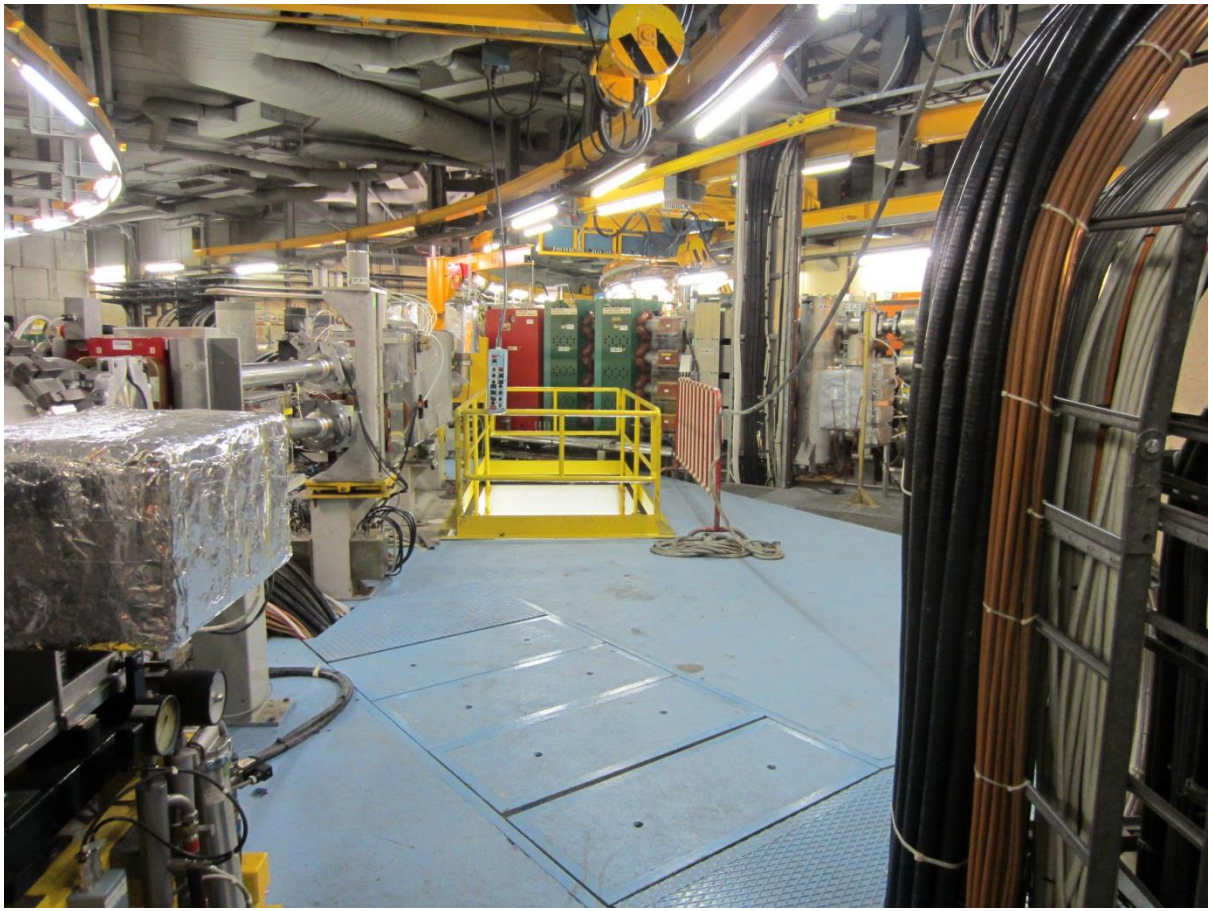


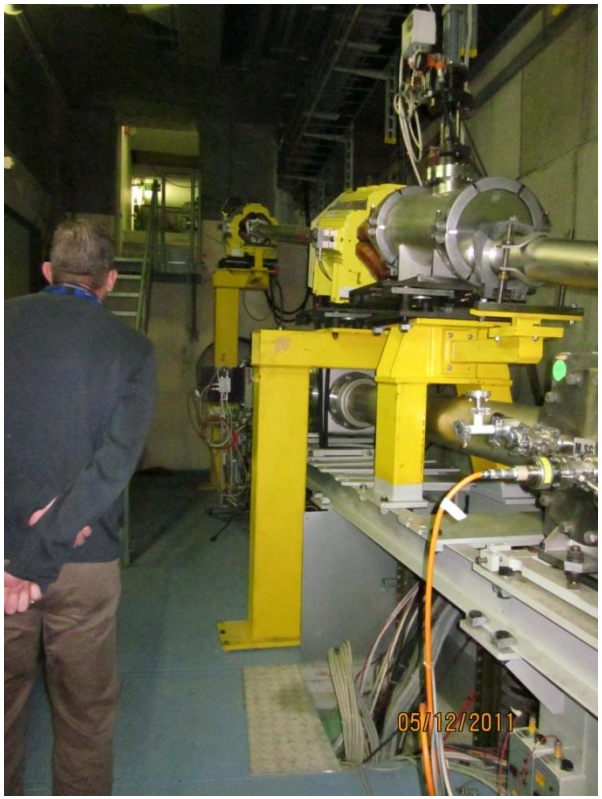
SIMULATIONS ACTIVATION BLOCK 4

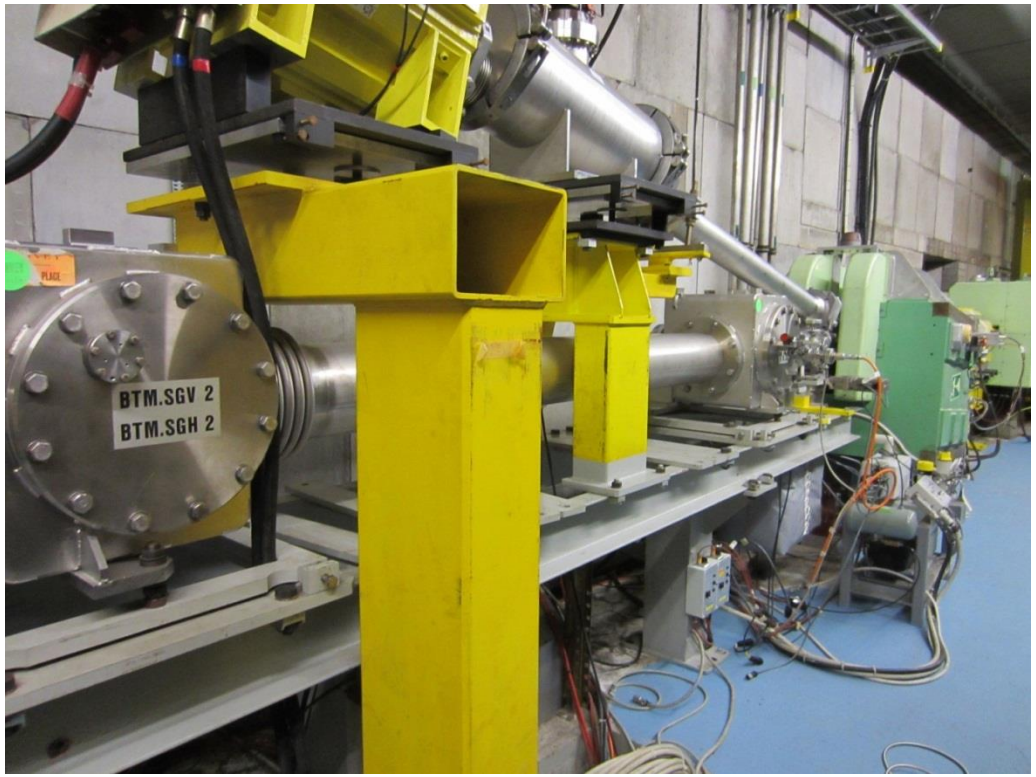


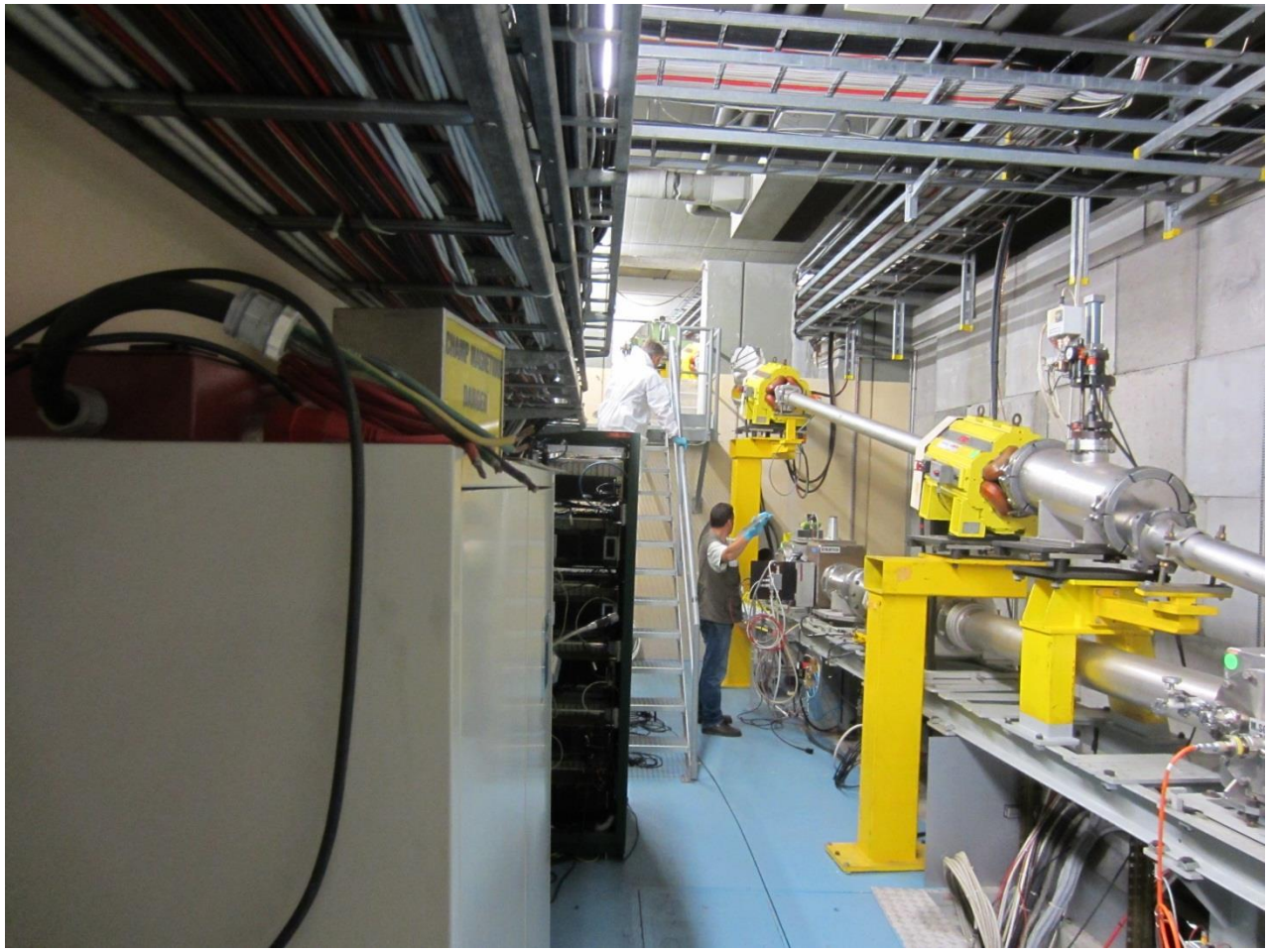


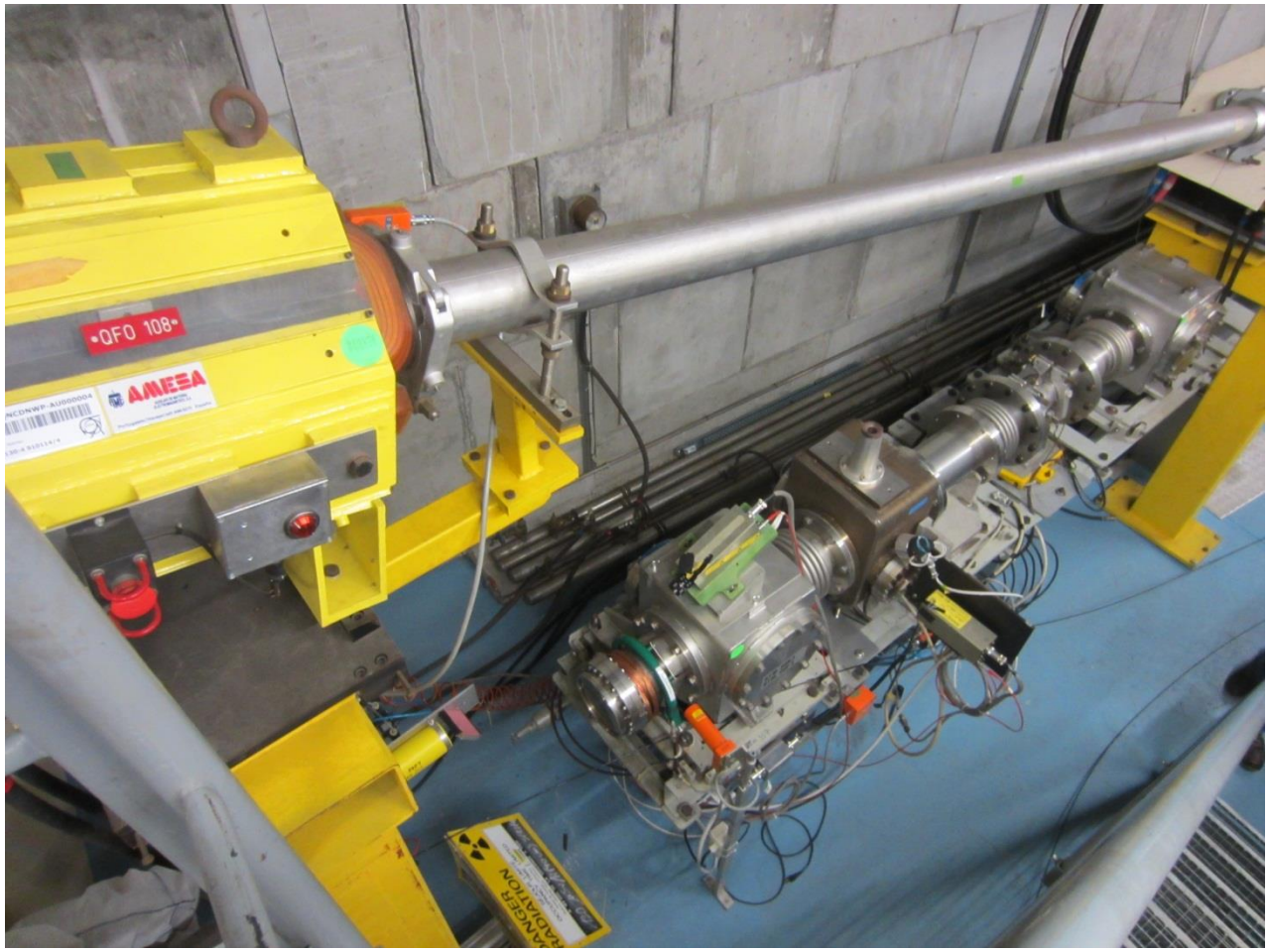
PICTURES OF THE AREA

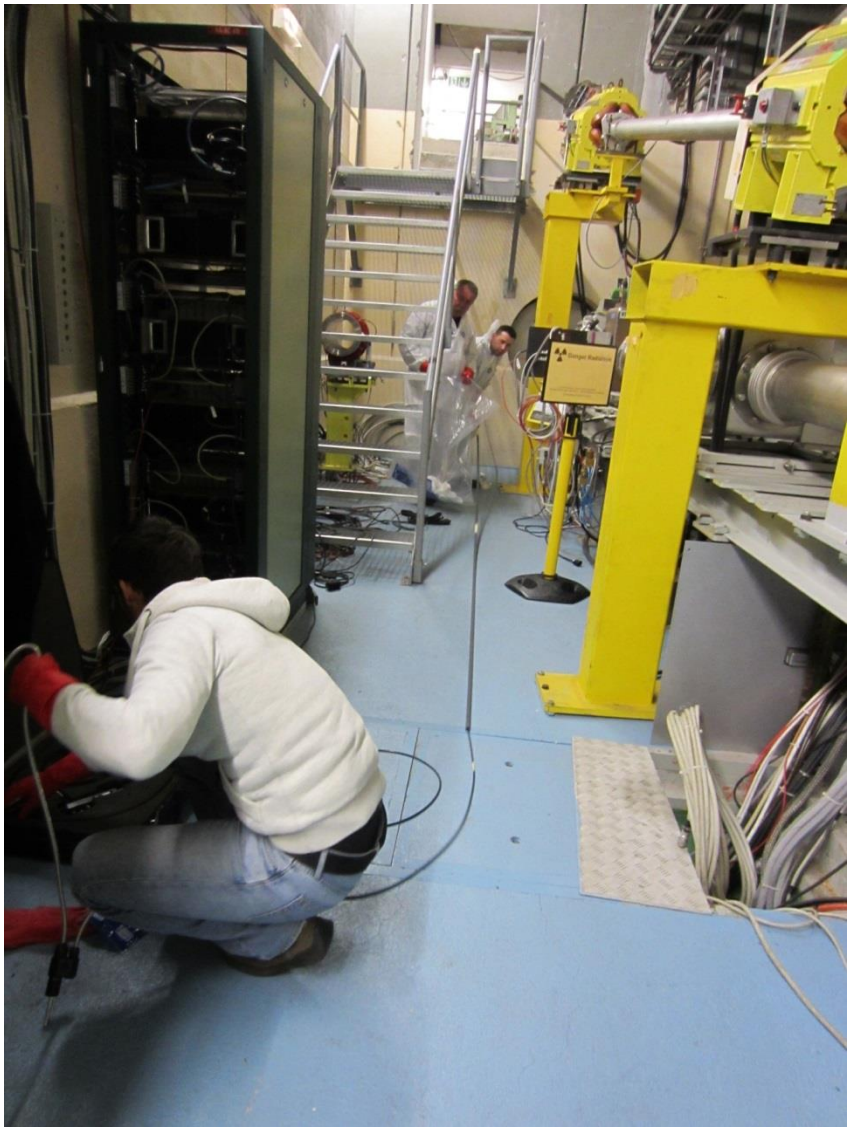



05/12/2011


BTM.SGV 2
BTM.SGH 2



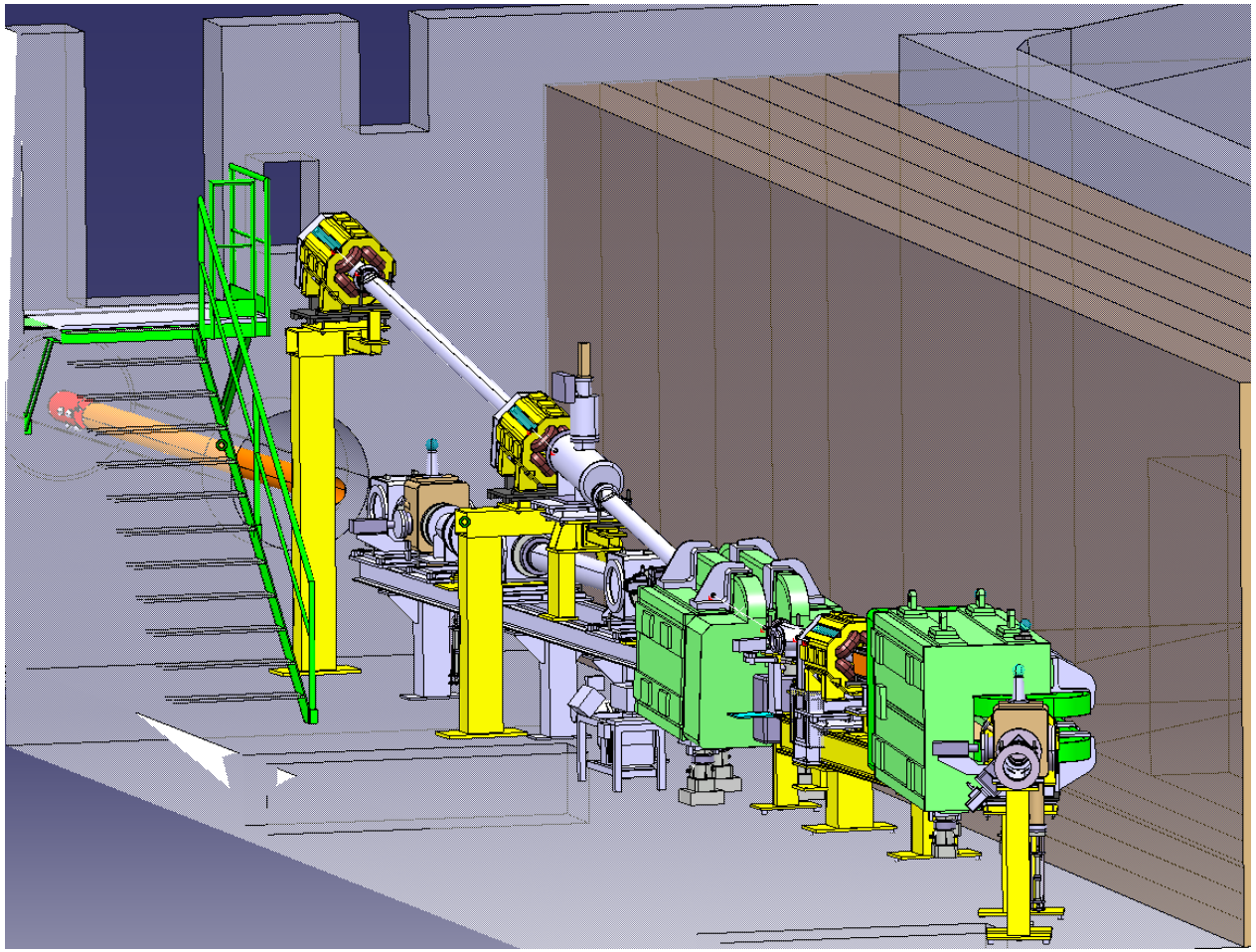

•QFO 108•
AMESA

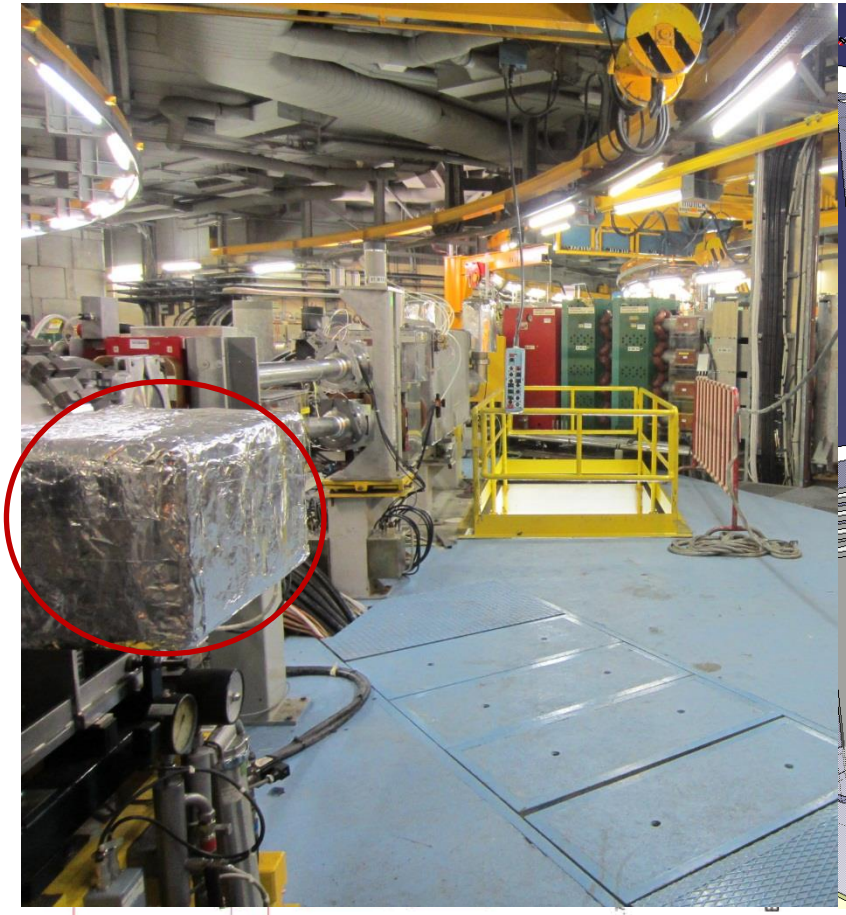


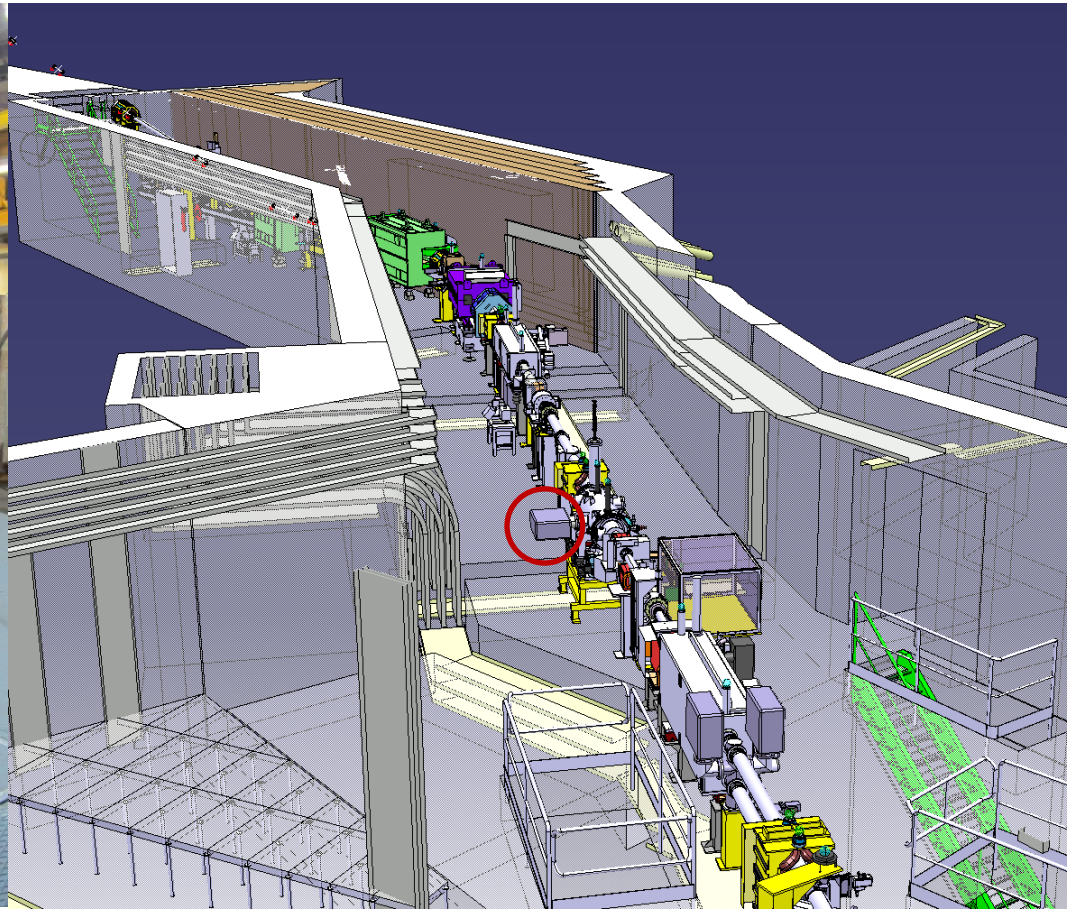

Danger Radiation

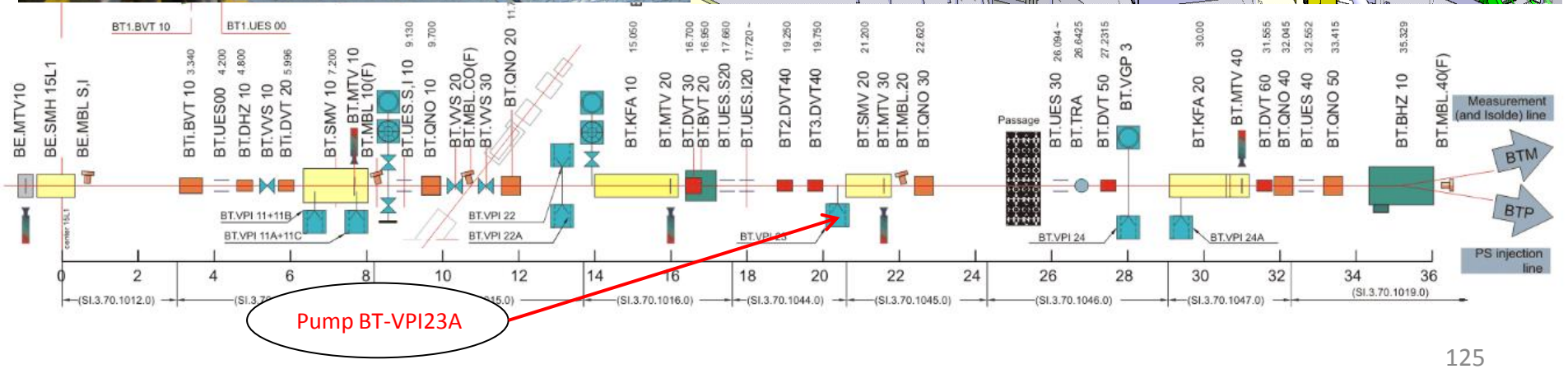

BTM.MTV20


BTM.MTV20
15/12/2011





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BE.SMH 15L1
BE.MBL S,I
BT1.BVT 10
BT1.UES 00
BTi.BVT 10
BT.UES00
BT.DHZ 10
BT.VVS 10
BTi.DVT 20
BT.SMV 10
BT.MTV 10
BT.MBL 10(F)
BT.UES.S,I 10
BT.QNO 10
BT.VVS 20
BT.MBL.CO(F)
BT.VVS 30
BT.QNO 20
BT.KFA 10
BT.MTV 20
BT.DVT 30
BT.BVT 20
BT.UES.S20
BT.UES.I20
BT2.DVT40
BT3.DVT40
BT.SMV 20
BT.MTV 30
BT.MBL.20
BT.QNO 30
Passage
BT.UES 30
BT.TRA
BT.DVT 50
BT.VGP 3
BT.KFA 20
BT.MTV 40
BT.DVT 60
BT.QNO 40
BT.UES 40
BT.QNO 50
BT.BHZ 10
BT.MBL.40(F)
Measurement (and Isolde) line
BTM
BTP
PS injection line
BT.VPI 11+11B
BT.VPI 11A+11C
BT.VPI 22
BT.VPI 22A
BT.VPI 24
BT.VPI 24A
0
2
4
6
8
10
12
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16
18
20
22
24
26
28
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32
34
36
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(SI.3.70.1019.0)
Pump BT-VPI23A