HIGH RADIATION TO MATERIALS – HIRADMAT@SPS

A NEW IRRADIATION FACILITY AT CERN FOR MATERIAL TESTING

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4th HPTWorkshop - Malmoe , May 6, 2011

Outline

- Motivation for making the facility
- Layout and beam parameters
- Construction challenges
  - WANF Dismantling
- Doing experiments in HiRadMat
- Project Status
- Summary

The HiRadMat Facility - Motivation

- Facility designed, to study the impact of **intense pulsed beams** on materials
  - Thermal management (heating)
    - material damage even below the melting point
    - material vaporization (extreme conditions)
  - Radiation damage to materials
  - Thermal shock - beam induced pressure waves

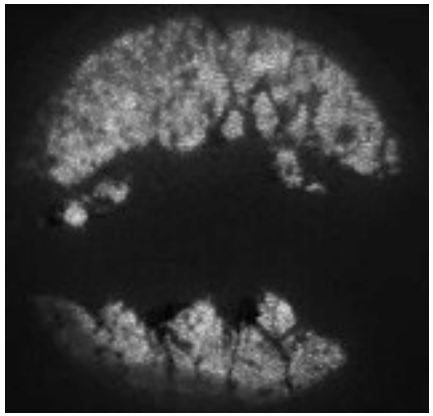
- Test bed, important for the design validation of **LHC near beam components** before installation in the ring
  - An alternative to ad-hoc pirate installations for such tests as done so far

- **Targeted users**: LHC collimators, R&D on materials, high-power targetry, test of vacuum components (beam windows, coating), others?

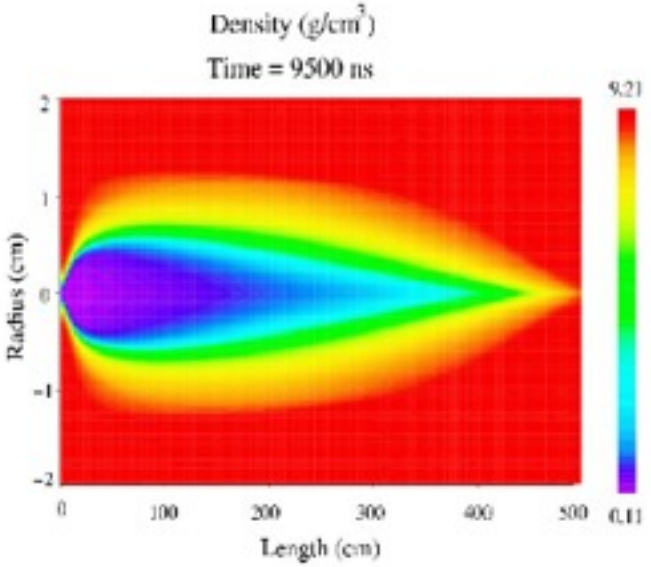
Possible HiRadMat experiments

Courtesy: J. Lettry, CERN

Targetry: High-intensity beam on a solid target (Ta)



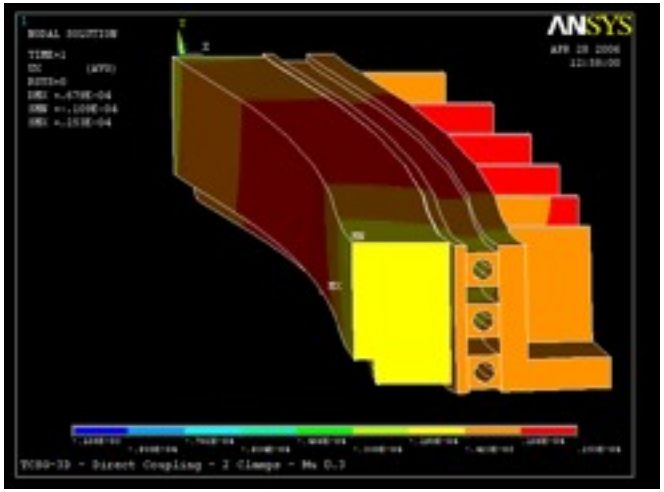
MERIT experiment: High-intensity beam on a liquid Hg-target



Courtesy: N.Tahir, GSI

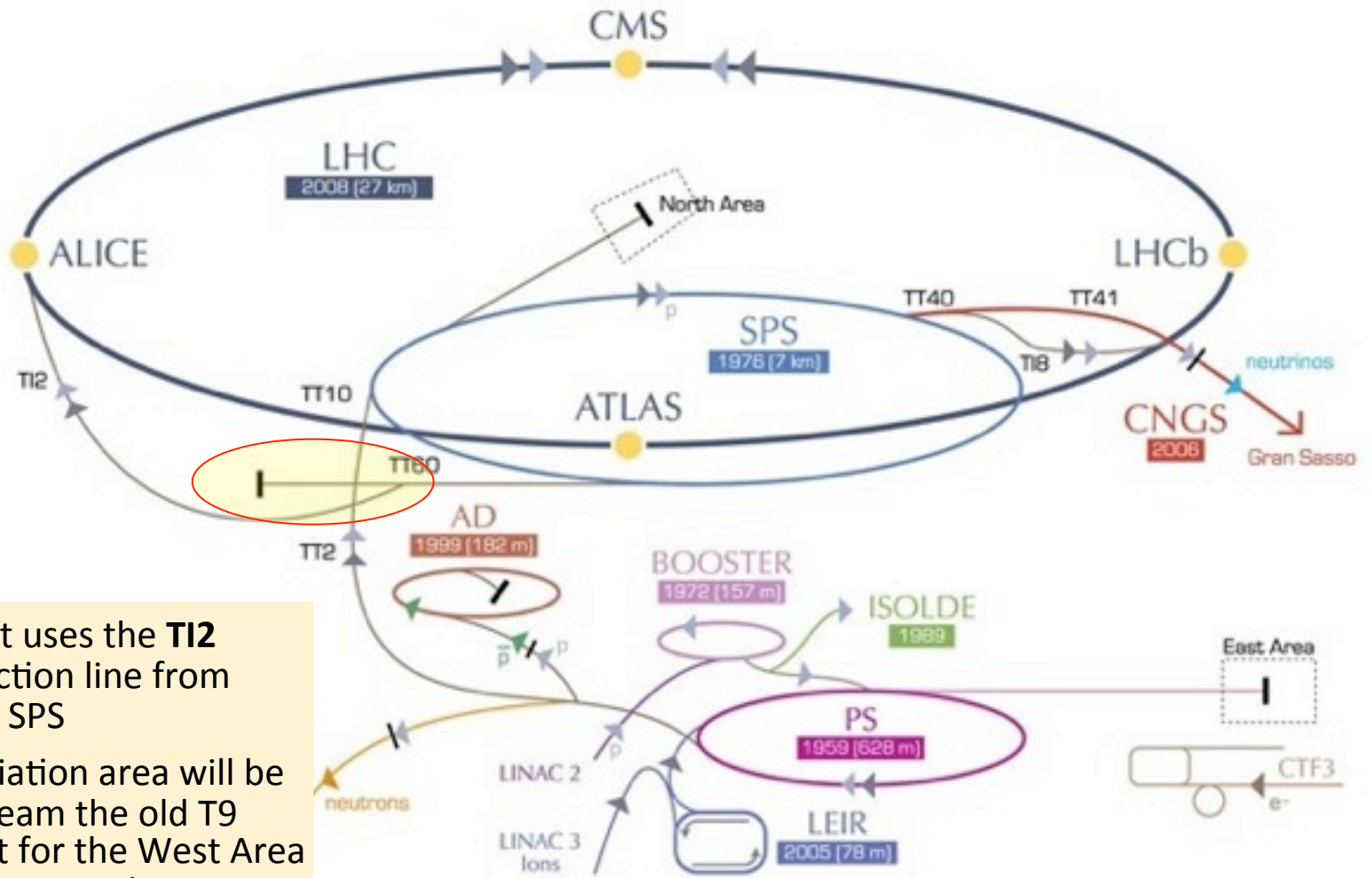
Material studies: High-intensity beam on a bulck material – plasma formation

LHC collimator: Displacement analysis – 500kW load case for 10s
Loss rate 4×10^{11} p/s (Beam Lifetime 12min)



Courtesy: R.Assmann, CERN

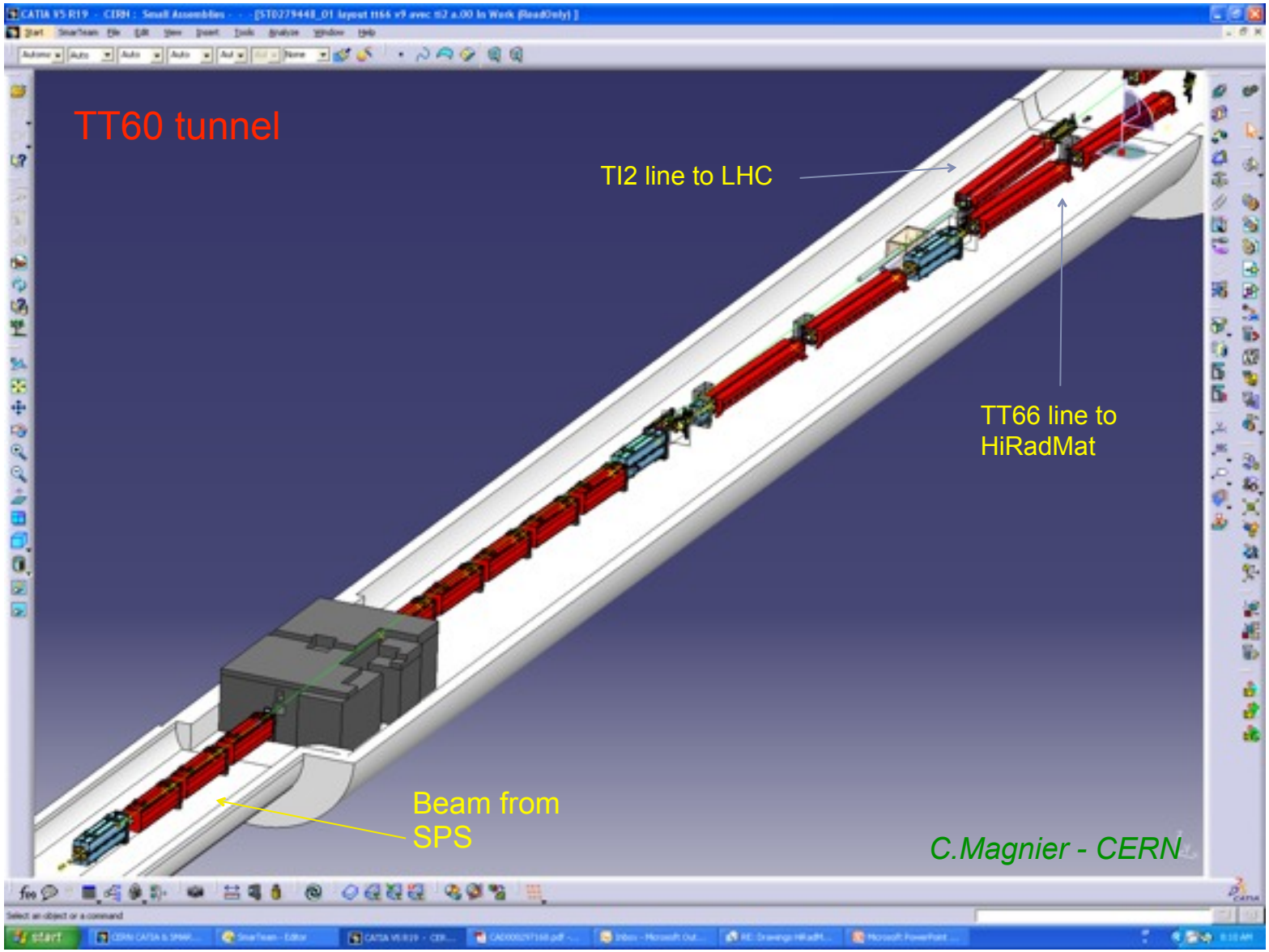
HiRadMat - Layout



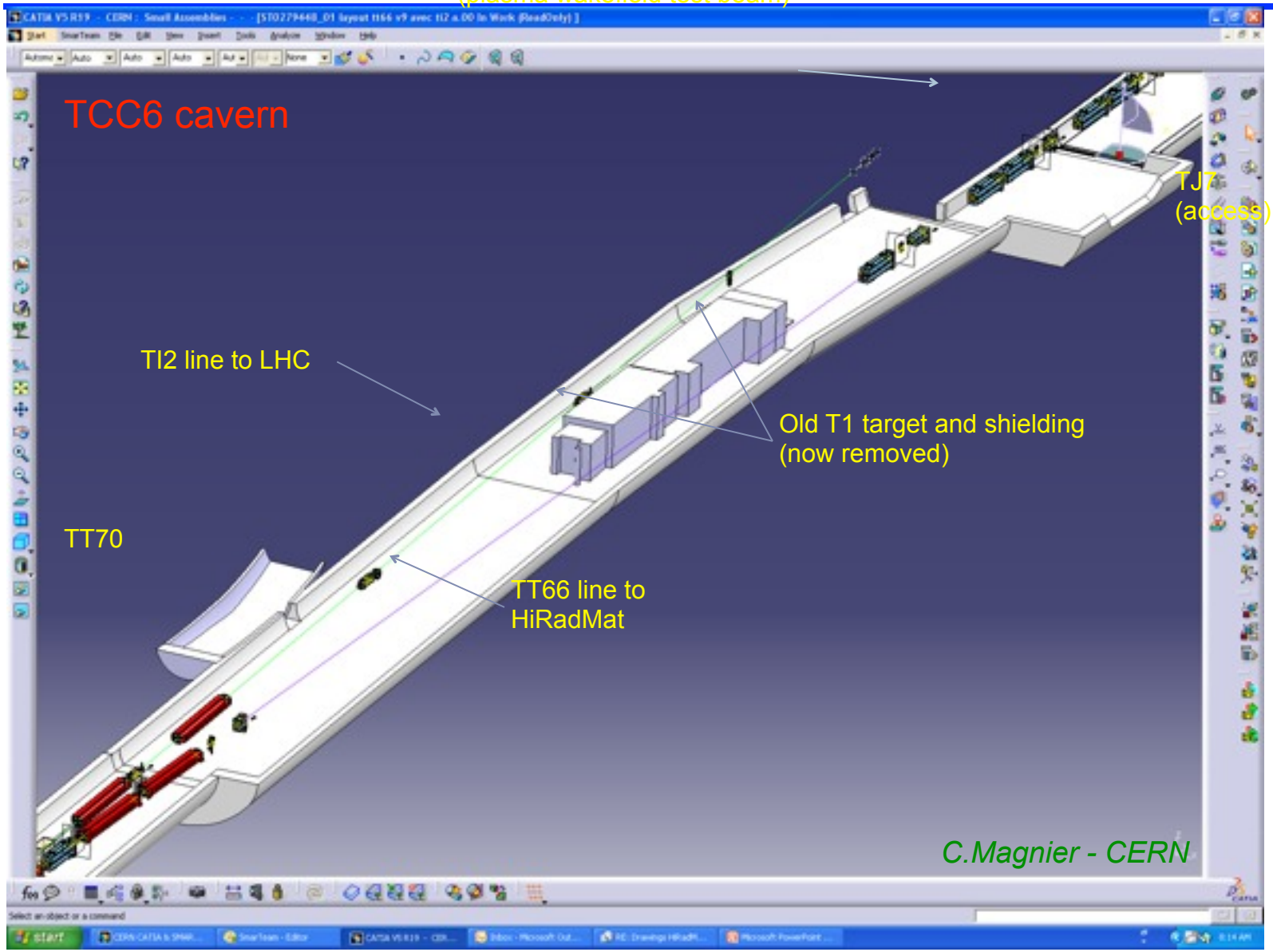
HiRadMat uses the **TI2** extraction line from CERN SPS

The irradiation area will be upstream the old T9 target for the West Area Neutrino Facility - **WANF**

HiRadMat - Layout TT66 line & TNC



HiRadMat - Layout TT66 line & TNC



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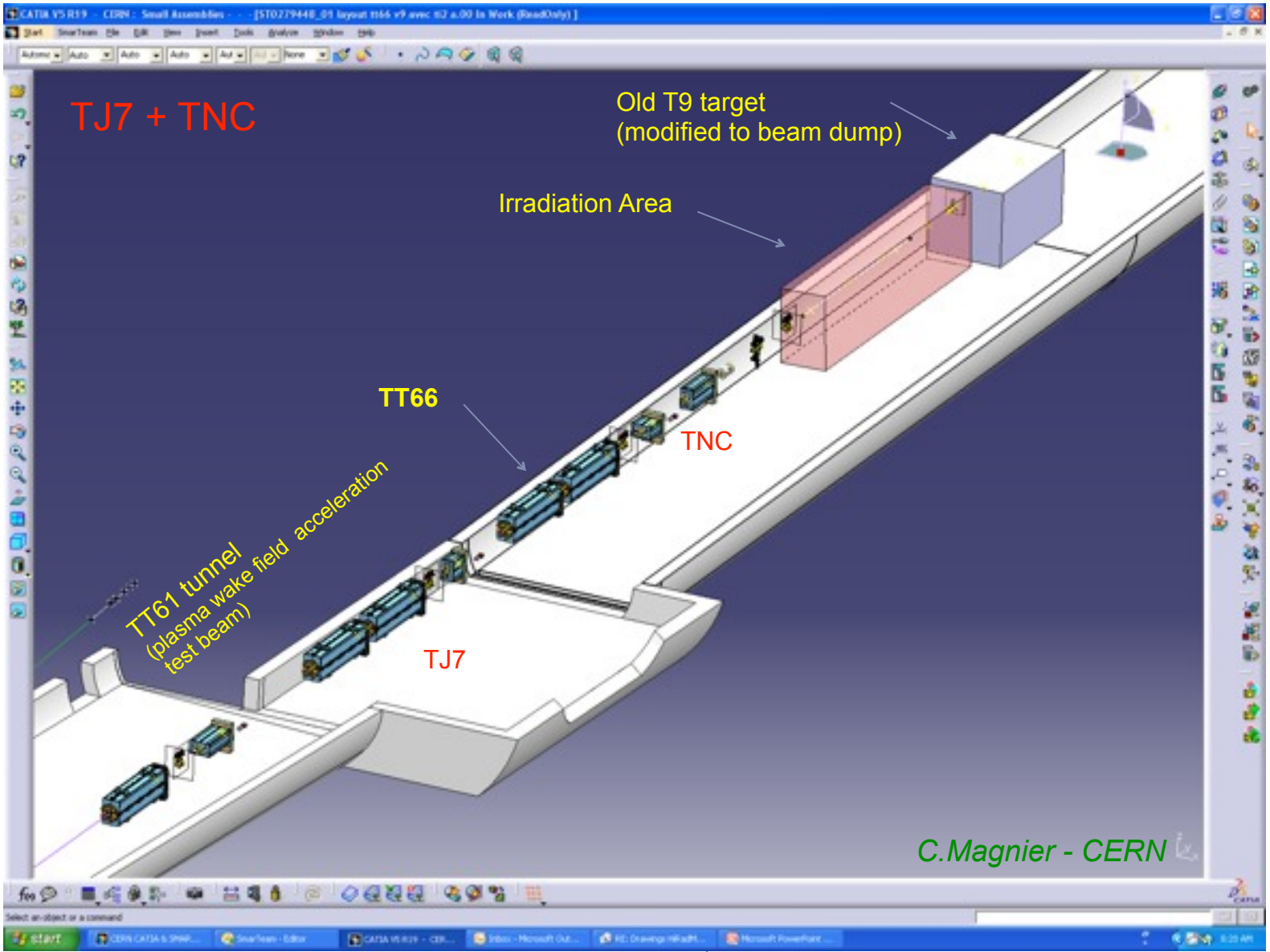

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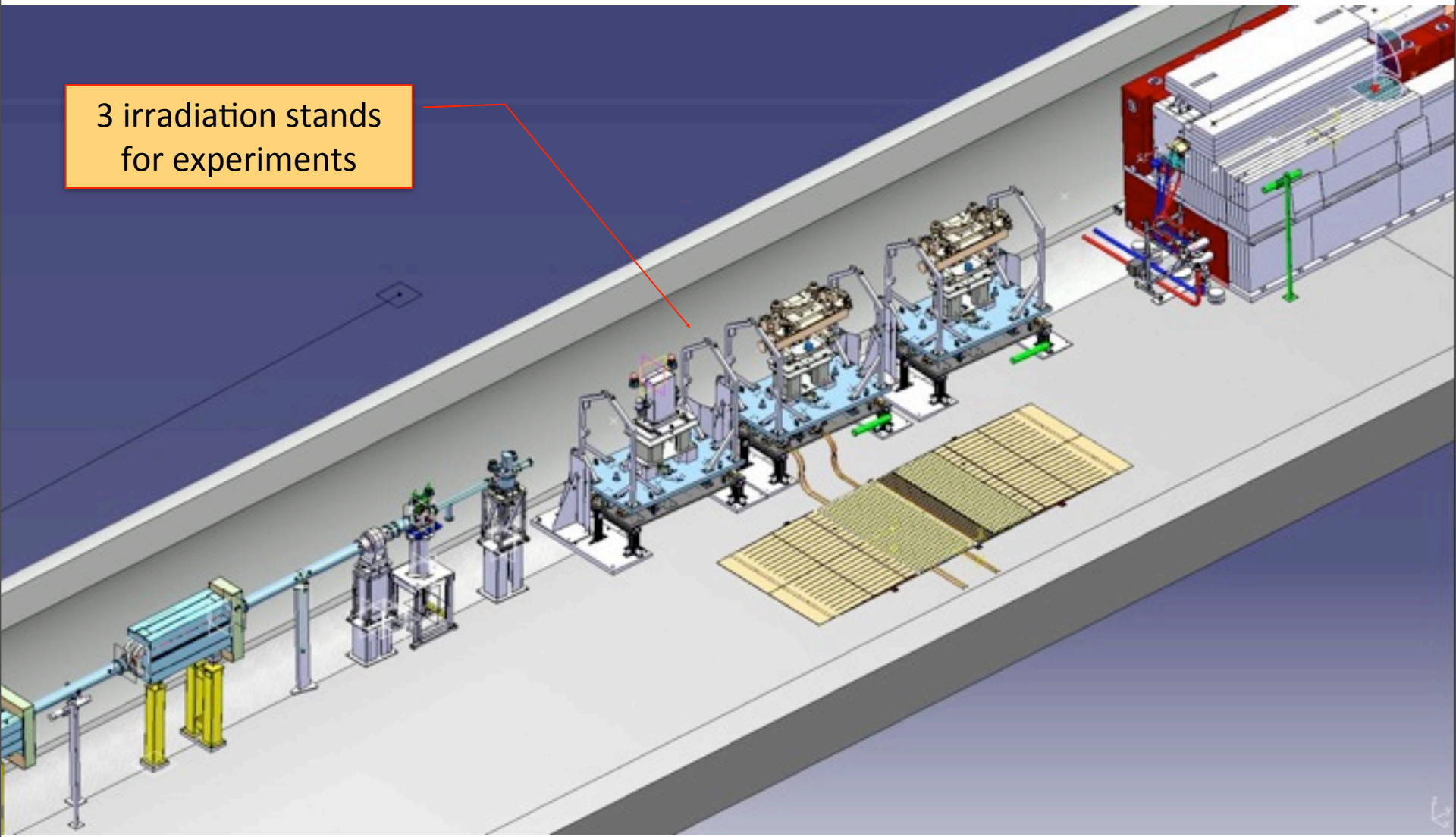


HiRadMat Beam Parameters

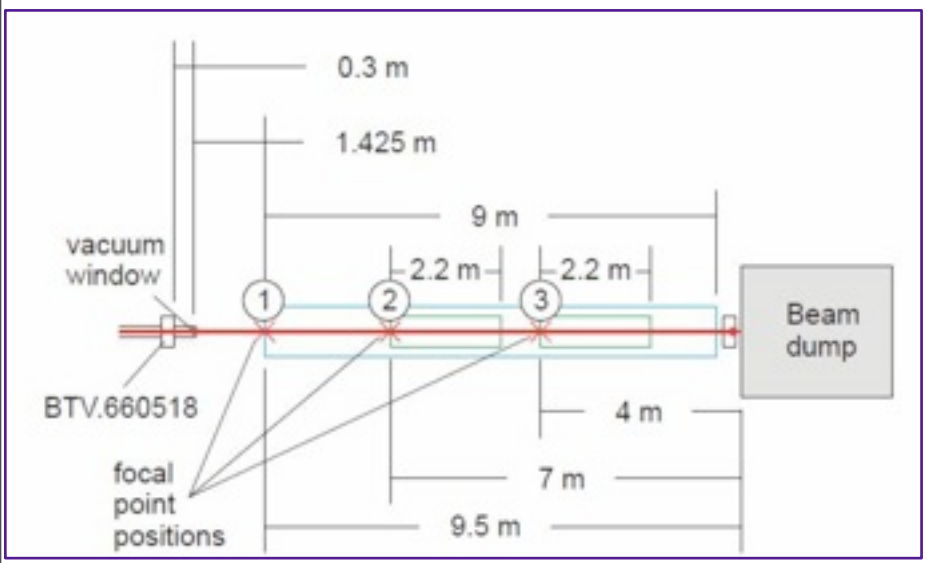
- LHC type beam extracted from SPS, protons or ions

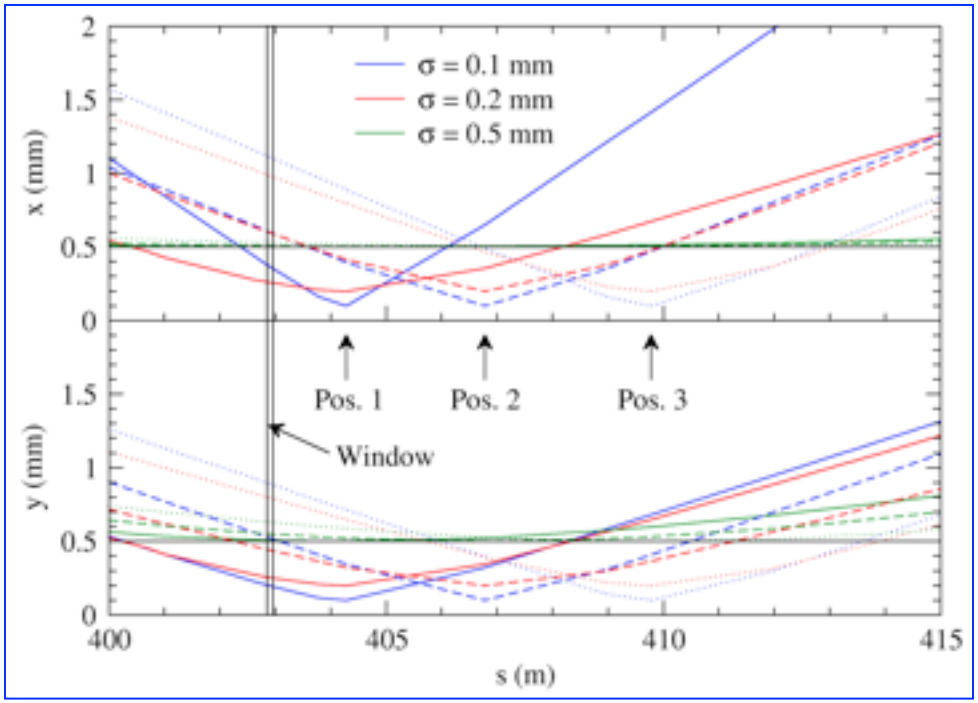
	Protons	Heavy ions ($Pb82^{+}$)
Beam Energy	440 [GeV]	173 [GeV/u], 36.1 [TeV/ions]
Pulse energy	up to 3.4 [MJ]	up to 21 kJ
Bunch intensity	3×10^{9} to 1.7×10^{11} ions	3×10^{7} to 7×10^{7} [ions]
Number of bunches	1 to 288	52
Bunch length	11.24 [cm]	11.24 [cm]
Bunch spacing	25, 50, 75 or 150 [ns]	100 [ns]
Pulse length	7.2 [μs]	5.2 [μs]
Beam spot at the experiment	variable around 1 [mm^2]	variable around 1 [mm^2]

- Intensity:
  - **10^{15}** protons/experiment (max 100 high-intensity pulses)
  - 10 experiments/year - **10^{16}** protons in total/year

HiRadMat Beam Parameters

- **Constraint**: the beam must be >0.5mm in [x, y] at the last beam window of the line and at the dump
- Larger beam sizes can be achieved, **<2mm**





HiRadMat Construction - T1 target dismantling

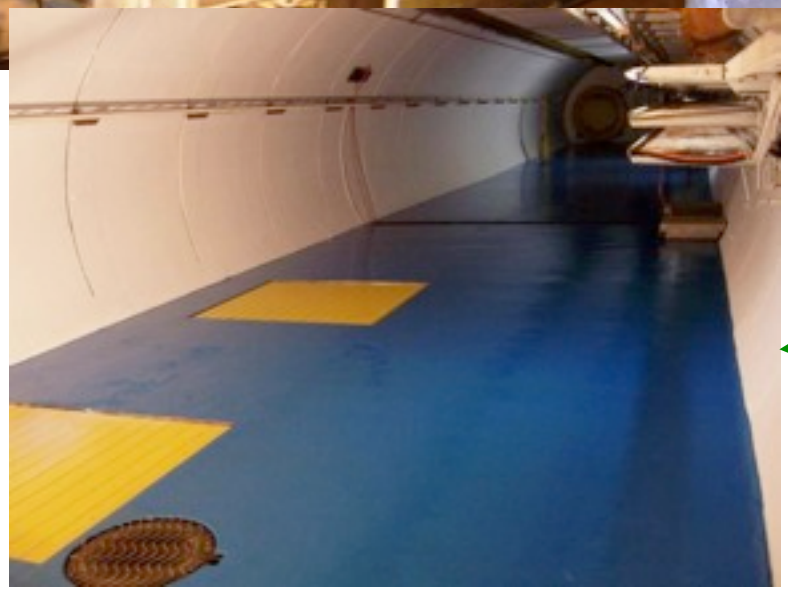
HiRadMat Construction - WANF dismantling

Challenges:

- Work in radioactive environment
  - careful dose planning, protection measures
- Contamination risk (dust, radioactive water, rust)
  - help of specialized external company

- The WANF beam was stopped in **1998**
- Then the tunnel was closed and the ventilation stopped

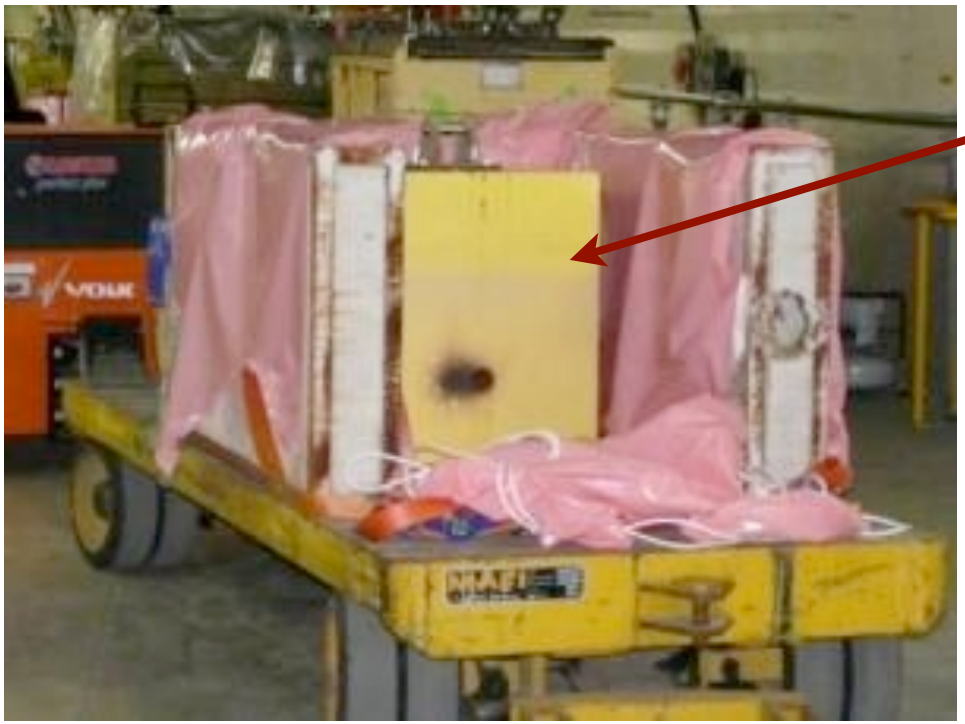
HiRadMat Construction - WANF dismantling



HiRadMat Construction - WANF dismantling

- Remote manipulation with the overhead crane

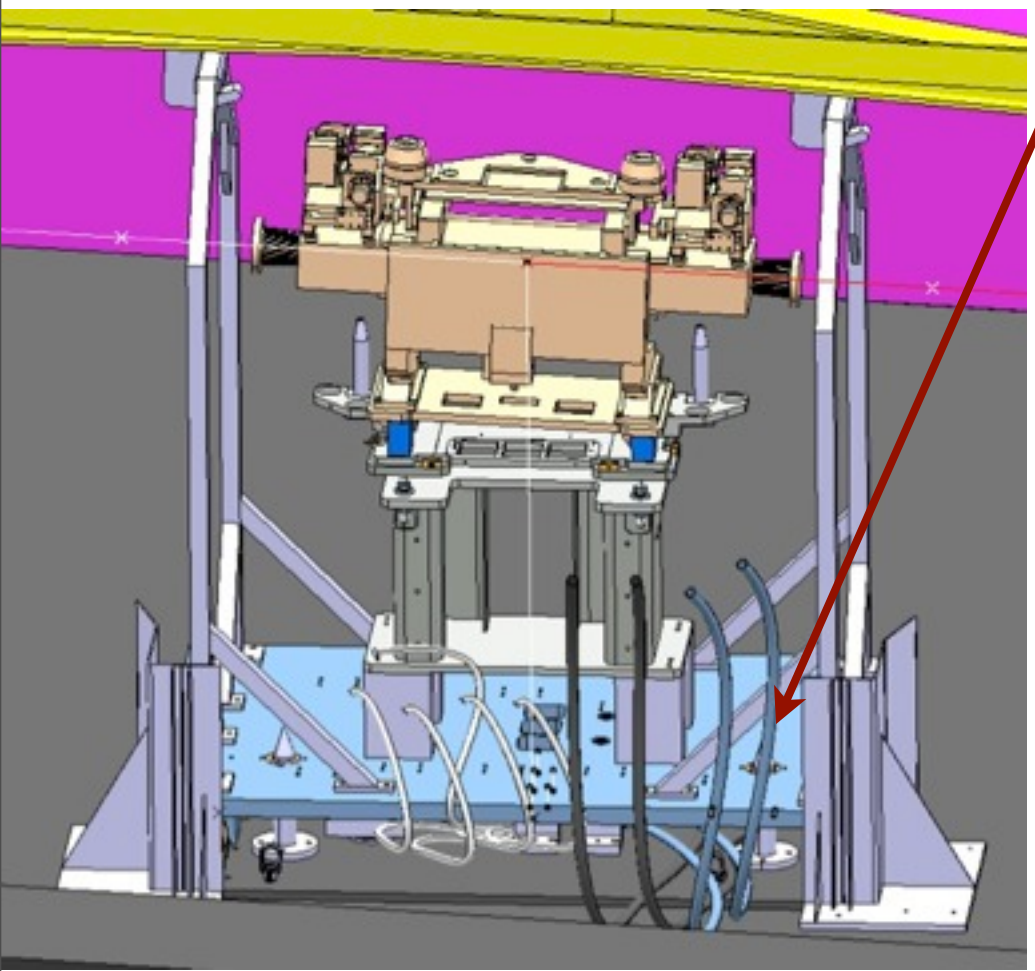
HiRadMat Construction - WANF dismantling



Upstream and downstream collimators

- The removal of the downstream collimator was the most challenging part of the whole project
  - Very radioactive element (**~1Sv/h !!!**)
  - 4 Cu blocks, no remote handling

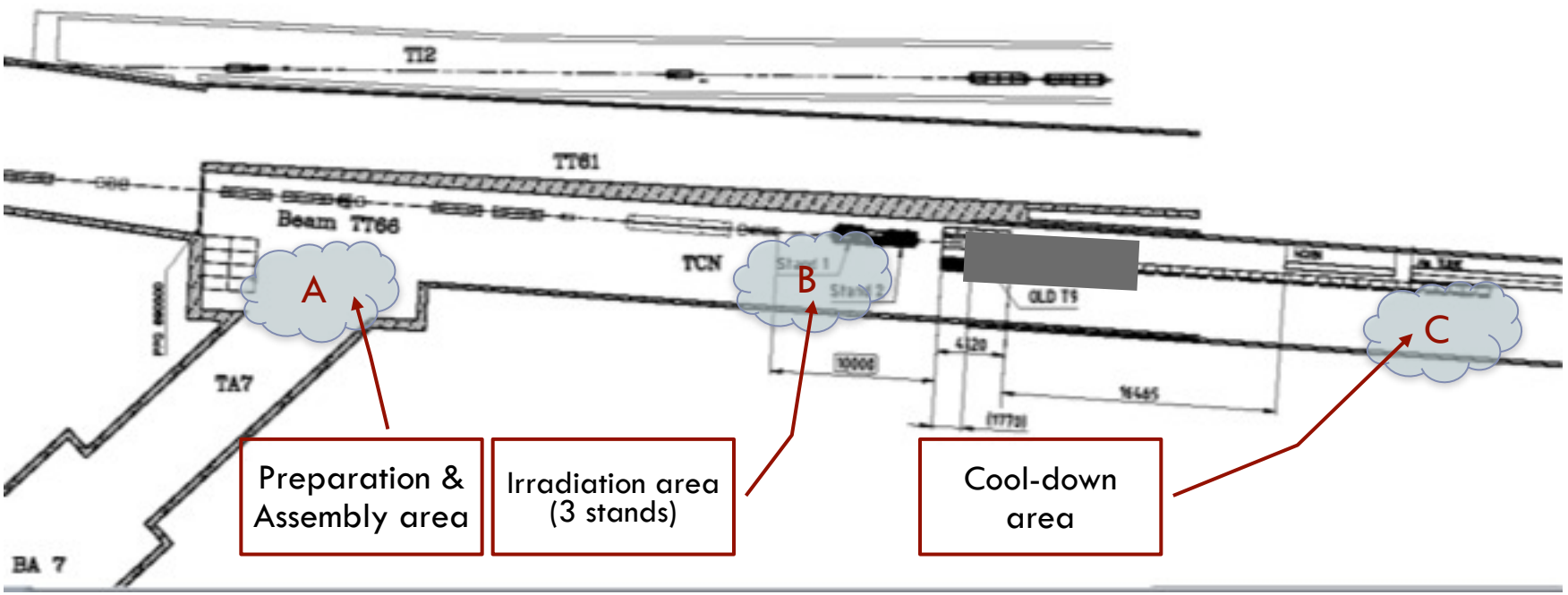
Experiments in HiRadMat



- Interface platform allows experiment assembly outside the irradiation area
  - Access (time) limitations due to LHC operation
  - Access limitations due to radiation
- **First step: surface lab**
  - Experiment assembly on the interface platform
  - Alignment using reference installation
    - copy of the installation in the tunnel → 0.1mm precision
  - Readout / movement tests

Experiments in HiRadMat

- Life cycle of an experiment:
  1. Prepare 1(2) test setups each on is platform in the lab or assembly area
  2. Move them to the irradiation area – do the irradiations ; swap between the two remotely (either base platform movement or object)
  3. Move them to the cool-down area
  4. Recuperate them later for post-irradiation inspection/analysis in the lab

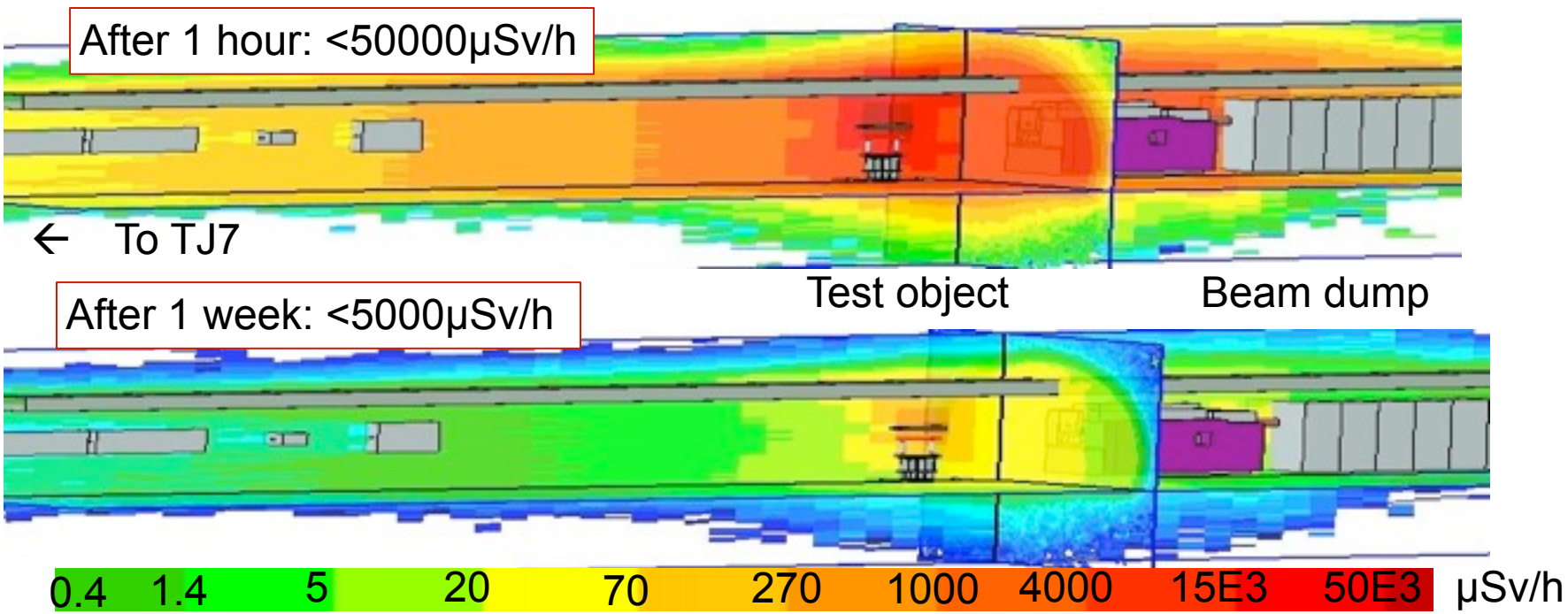


Experiments in HiRadMat

- Beam parameters to vary for the experiments:
  - Bunch intensity: [5×109(pilot) ÷ 1.1(1.7) ×1011] ppb
  - Number of bunches : [1 (pilot) ÷ 288 (bunch trains)]
  - Timing between bunches or bunch trains: [SPS filling modes possibilities]
  - Beam focusing at the experiment : [0.25 ÷ 4.0] mm2
- HiRadMat beam control
  - Each beam pulse will be on request : single (next sc) or multiple (next 5 sc)
- Beam interlock:
  - During extraction to TI2/LHC access to TJ7/TNC will be prohibited
  - During extraction to TI2/HRM access to TJ7/TNC will be prohibited
    - new beam dump in TI2 to allow access to LHC while HRM receives beam
    - during tests/beam setup the beam is dumped in the HRM dump (ex. T9 target) – experiments retracted

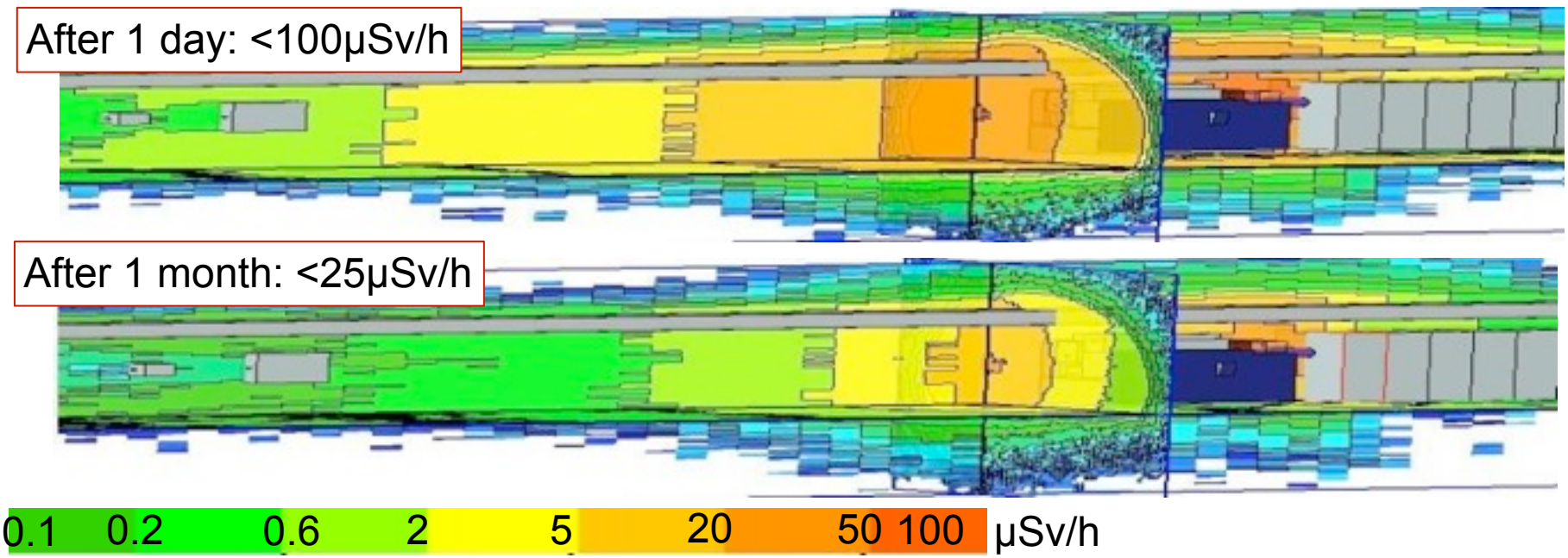
Experiments in HiRadMat

- Activation dose near (average at 40cm) test object after 1 hour/1 week cool-down
  - Short SPS cycle, 1.98E12 p/s for 504 s (1e15 protons)
  - The beam hits the carbon jaw of a typical collimator



Experiments in HiRadMat

- Remnant radiation
  - Assumption: 10^{16} protons over 1 year on a 15cm long copper test sample
  - The sample is removed after irradiation
  - Background dose rate in TNC after 1 day / 1 month



HiRadMat @ SPS - Transnational Access

- HiRadMat is registered as TA within EUCARD

- Funds available to support EU users for the exploitation of the facility
  - Details and application form in : http://eucard.web.cern.ch/EuCARD/activities/access/
    - 12 applications received so far for 2011 !!!

- **User Selection Panel**
  - Mandate:
    - Evaluate the scientific merit of the proposed experiments
    - Discuss safety or other operational issues
    - Distribute the yearly beam time and EU funds

HiRadMat @ SPS - Infrastructure

- We aim at providing to the users:
  - the interface table
  - "standard" cabling from the test area to the surface control room
    - each test stand will be equipped with 5 plug-in connectors
    - signal, power (DC and 220V), HV, cables available
      - others could be added if needed
  - technical support for their installation and operation at CERN

- We are now looking at the possibilities for permanent instrumentation in the facility
  - Buy instruments (cameras, LDV, acoustic installation, etc.) within the available budget
  - Gain experience with the first tests
  - Try to re-use equipment (eg. sample holder) and share knowledge between users
  - We've submitted a request to EC for funding to complete the instrumentation of the facility - in the pipeline....

HiRadMat - Project Status

- The project is well on track
- The proton beam line is completed and tested without beam
- Further tests with low intensity pulses foreseen for w19, 20 (next week!)
- Formal approval for the facility expected in early June'11
- We are now focusing on the experimental area and discussions with the first users
  - Ready for scheduled users from week 26 on
- Possible windows for installation and first tests in 2011 for w26, w32, w39

Summary

- HiRadMat is a new facility to allow testing of materials on beam impact in a scientific manner, going away from ad-hoc installations
- The facility offers a very powerful beam from SPS with sufficient flexibility to adjust it for several applications
- The project is well on track, with the possibility for first users in autumn 2011
- Doing experiments in HiRadMat would be very interesting, lots of physics questions to answer, but also very challenging
- Stay tuned in : **http://cern.ch/hiradmat**