

# HIGH RADIATION TO MATERIALS – HiRADMAT@SPS

## A NEW IRRADIATION FACILITY AT CERN FOR MATERIAL TESTING



The poster for the 4th High Power Targetry Workshop features logos for ESS (European Spallation Source), DTU, and Lund University. It includes a red stamp that reads 'EXTENDED ABSTRACTS SUBMISSION DEADLINE 21ST MARCH'. The text describes the workshop's focus on high-power target facilities and lists proposed topics such as neutron targets, spallation neutron targets, and radioactive ion sources. It also provides important dates for abstract submission and workshop registration.

**4th HIGH POWER TARGETRY WORKSHOP**

Hilton Malmö City Hotel  
Malmö, Sweden  
2nd May - 6th May

**EXTENDED ABSTRACTS SUBMISSION DEADLINE 21ST MARCH**

The High-Power Targetry Workshop provides scientists and engineers from the international community with an opportunity to discuss the major laboratories operating or designing high power targets.

The 4th workshop will focus on high-power targetry issues from the design phase to the operation of the targetry, including the design of the targetry and the targetry facilities.

Through the workshop, participants will be given to discussions and exchanges with a balanced sharing of experiences, questions & answers and discussion & concluding sessions.

**Proposed Topics:**  
Operational experience of high-power target facilities  
Neutron targets  
Spallation-neutron targets  
Radioactive ion sources  
Simulations: Tools and methodology  
Instrumentation/Safety issues  
Ball-cushion damage/material properties  
Design principles for high-power targets

**The Venue:**  
Hilton Malmö City Hotel is in the centre of Malmö only 15 minutes by train from Copenhagen Airport.

**Important Dates:**  
March 16, 2011: Abstracts submission deadline  
March 21, 2011: Extended Abstracts submission deadline  
March 30, 2011: Notification of abstract acceptance  
April 3, 2011: Deadline registration for the workshop  
May 2 – May 6, 2011: 4th HPTW in Malmö, Sweden  
June 1, 2011: Manuscripts submitted

Register on  
<http://ess-scandinavia.eu/hptw>

Ilias Efthymiopoulos, CERN

4th HPTWorkshop - Malmoe , May 6, 2011



# Outline

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



# The HiRadMat Facility - Motivation

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- ▶ 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?

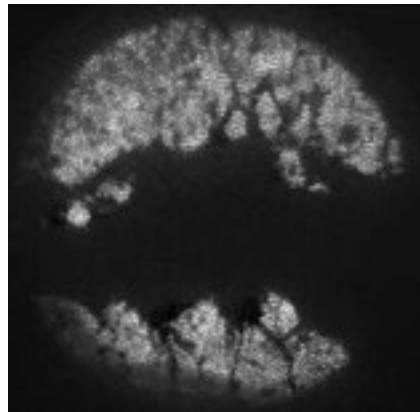


# Possible HiRadMat experiments

Courtesy: J. Lettry, CERN

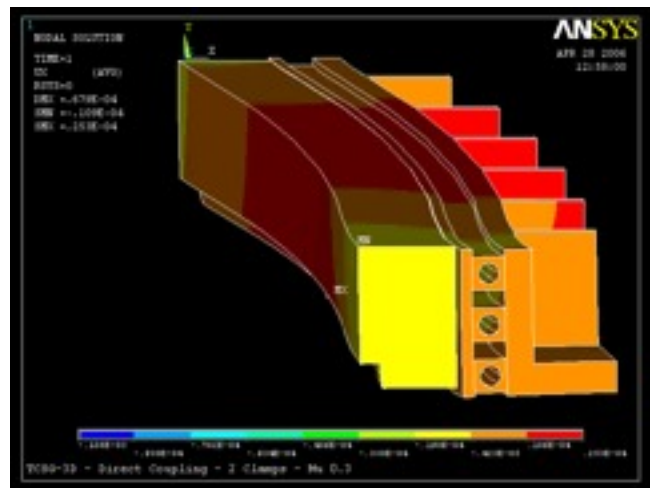


**Targetry:** High-intensity beam on a solid target (Ta)

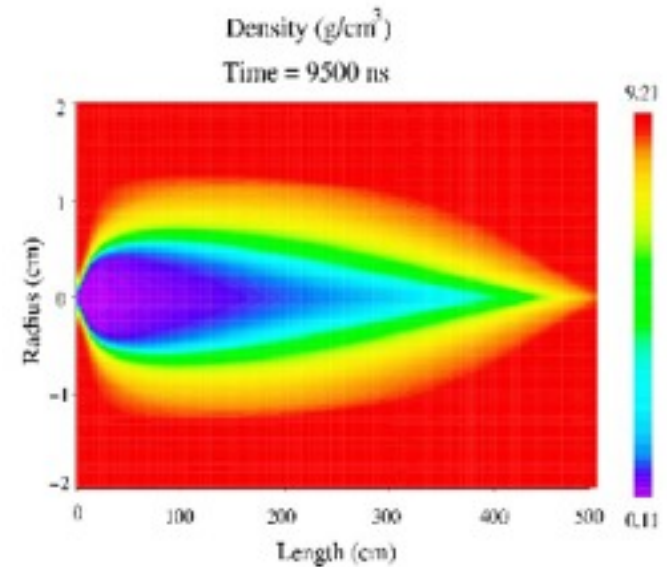


**MERIT experiment:** High-intensity beam on a liquid Hg-target

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



Courtesy: R.Assmann, CERN

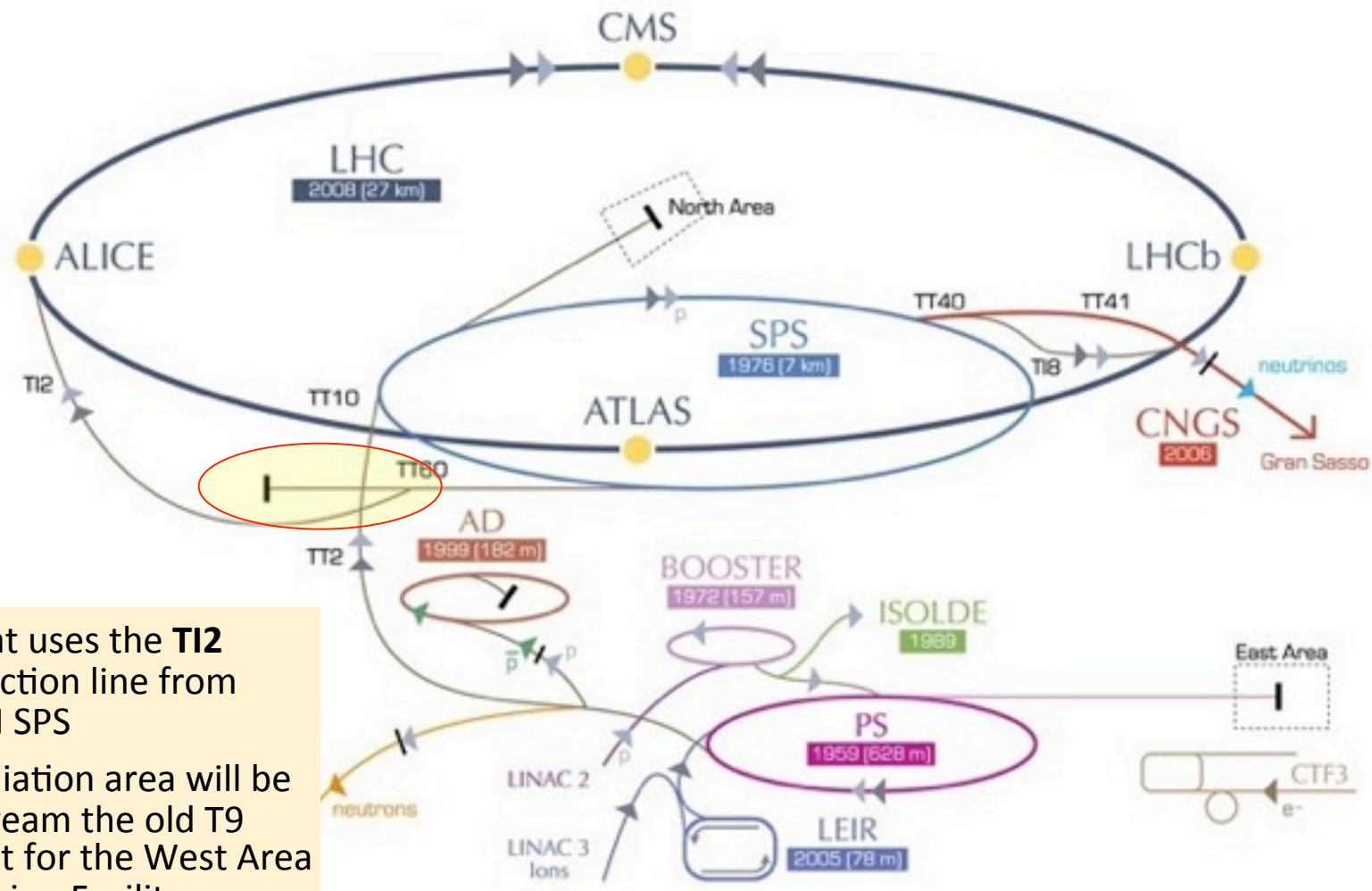


Courtesy: N.Tahir, GSI

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



# HiRadMat - Layout

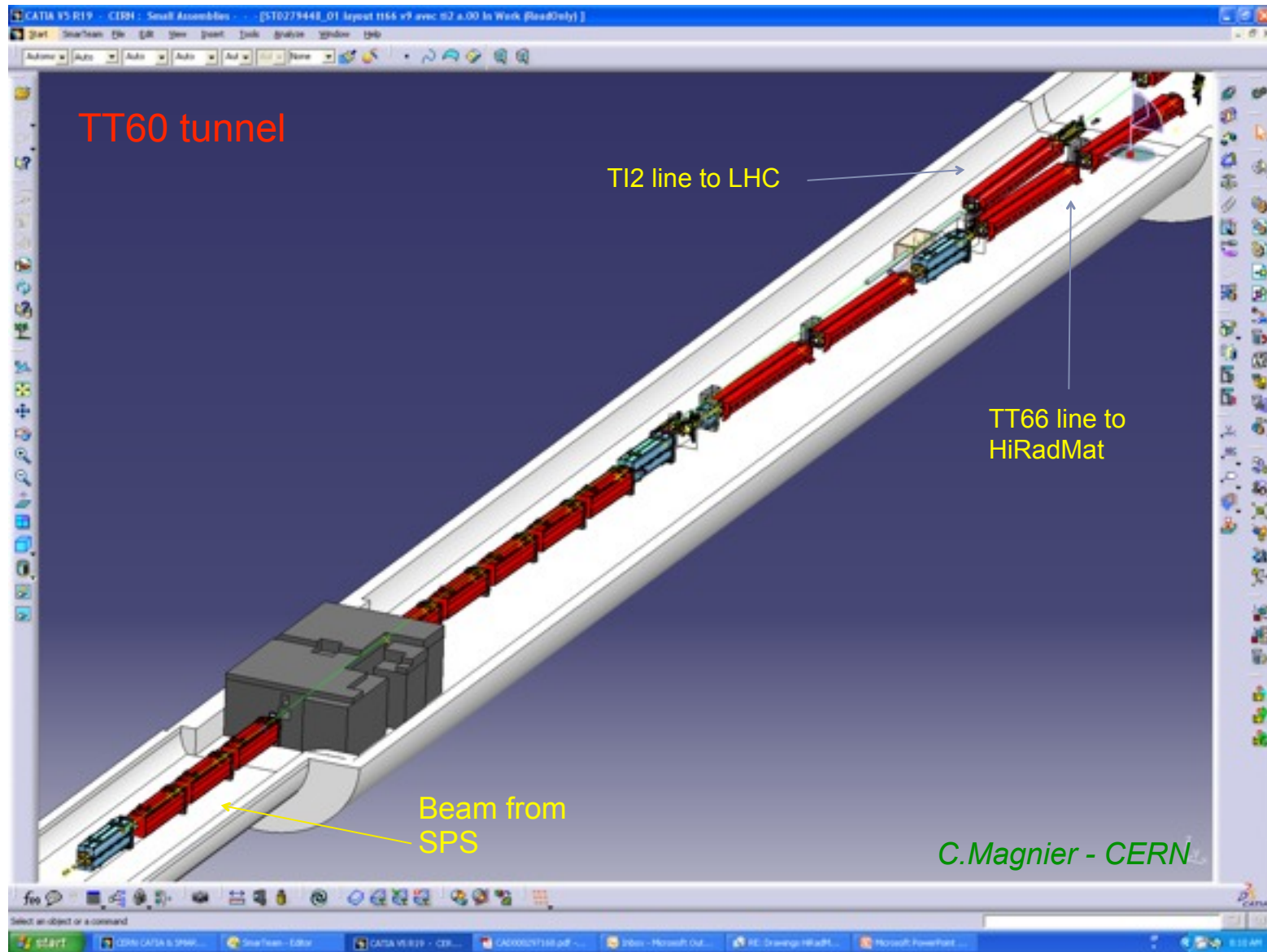


HiRadMat uses the **T12** extraction line from CERN SPS

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



# HiRadMat - Layout TT66 line & TNC



May 6, 2011

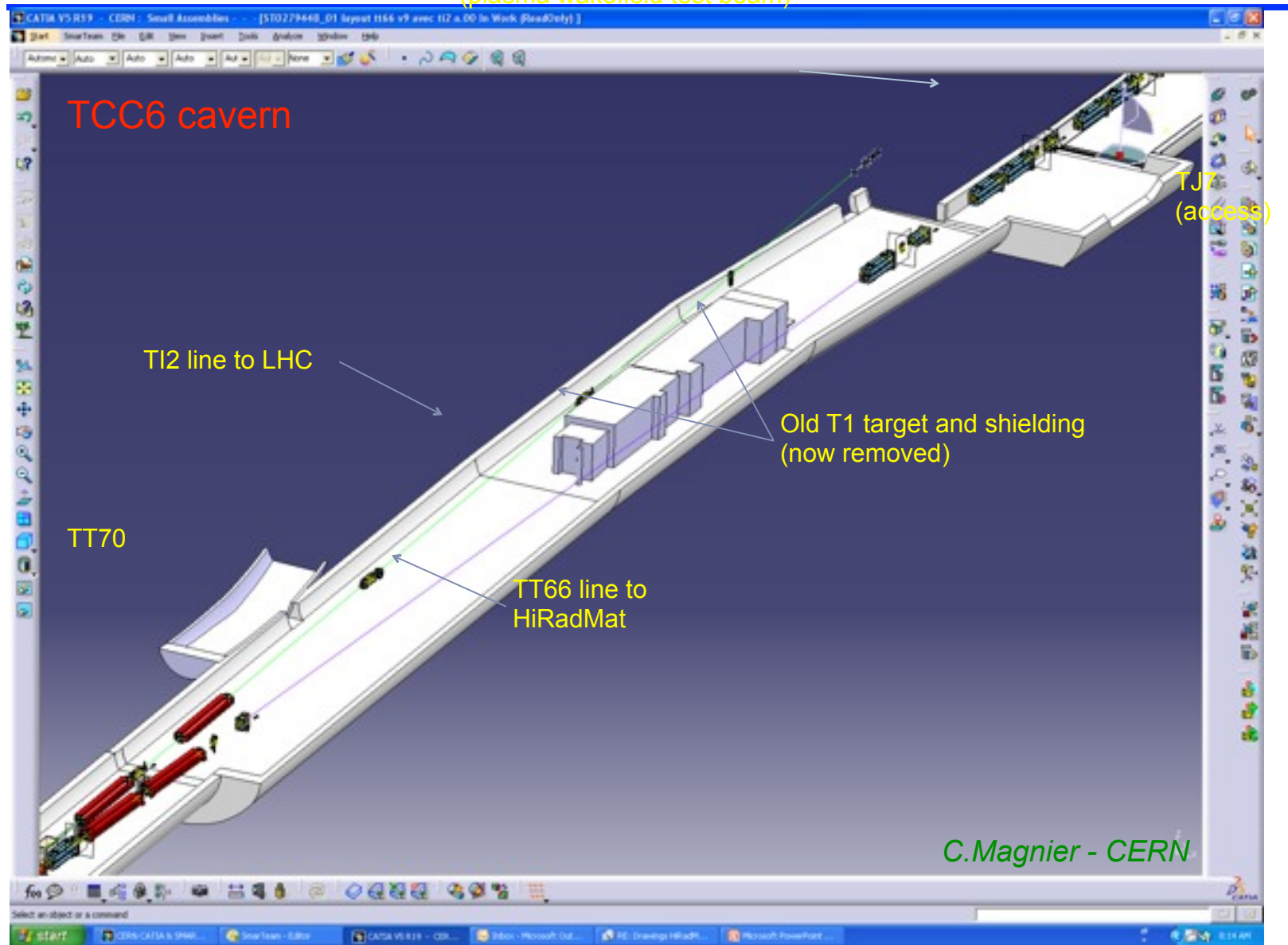
ie-4HPTW, Malmoe





# HiRadMat - Layout TT66 line & TNC

Towards T761  
(plasma wakefield test beam)

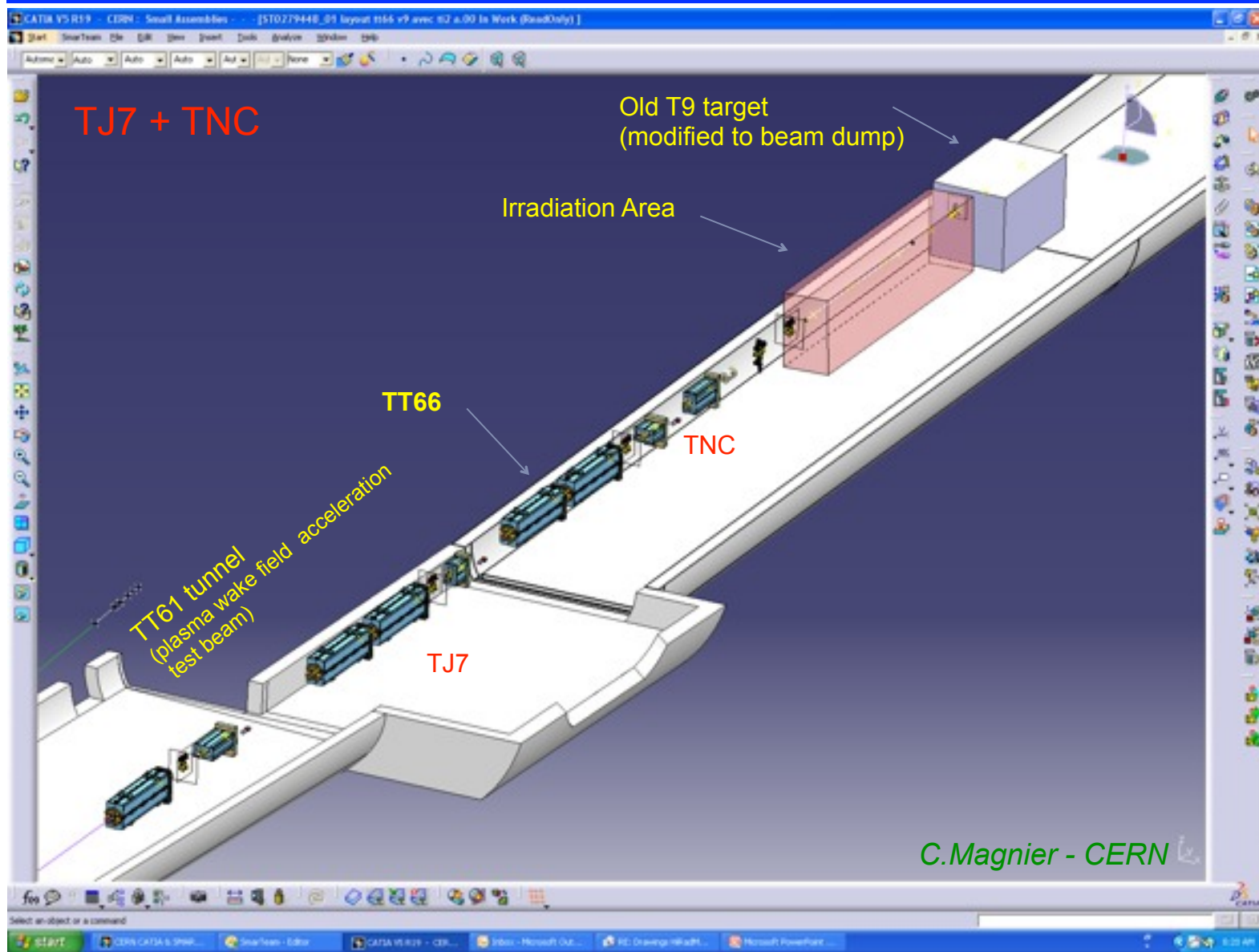


May 6, 2011

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# HiRadMat - Layout TT66 line & TNC



May 6, 2011

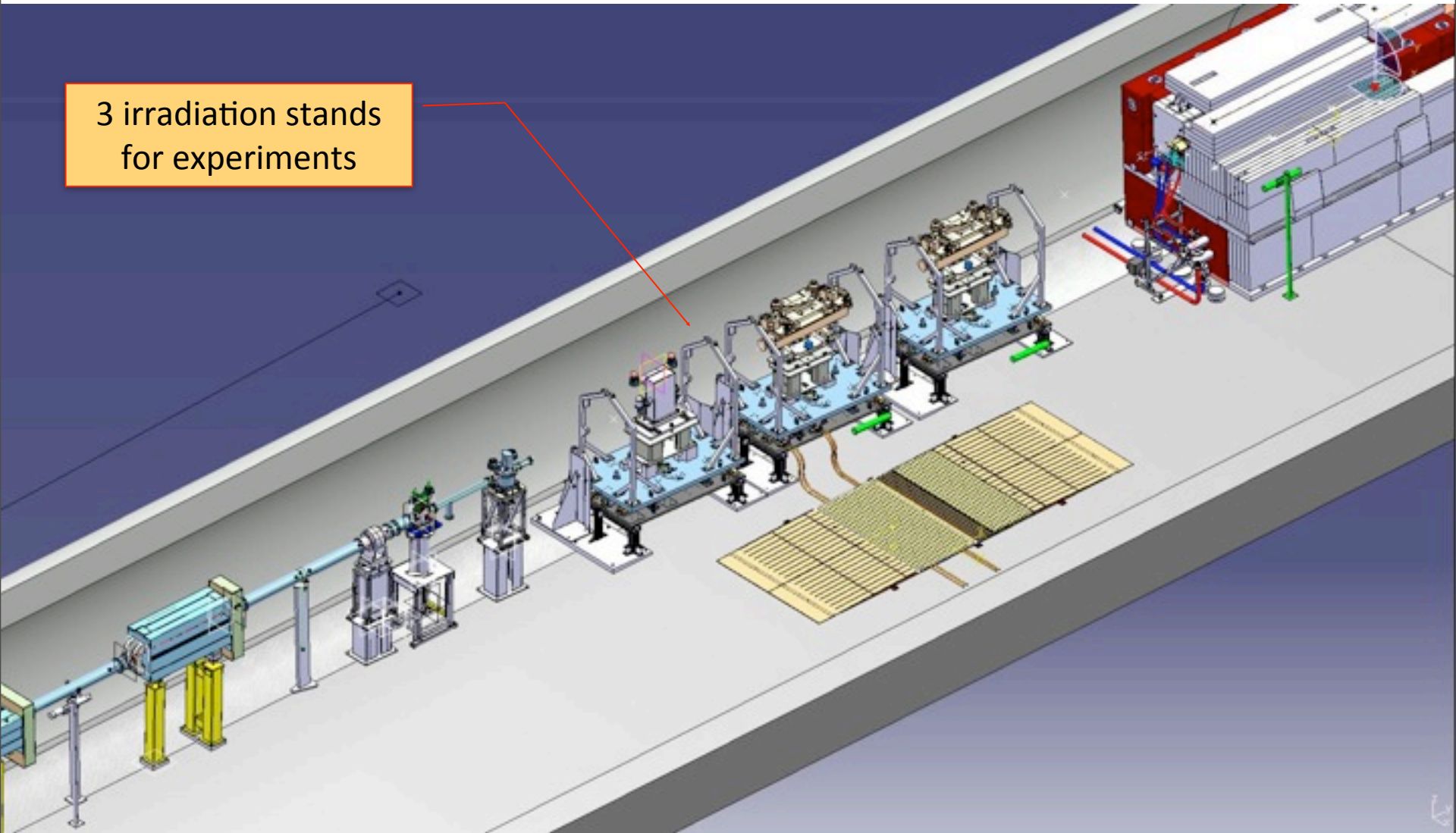
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# HiRadMat - Layout TT66 line & TNC

3 irradiation stands for experiments





# HiRadMat Beam Parameters

- ▶ LHC type beam extracted from SPS, protons or ions

	Protons	Heavy ions (Pb82 <sup>+</sup> )
Beam Energy	440 [GeV]	173 [GeV/u], 36.1 [TeV/ions]
Pulse energy	up to 3.4 [MJ]	up to 21 kJ
Bunch intensity	$3 \times 10^9$ to $1.7 \times 10^{11}$ ions	$3 \times 10^7$ to $7 \times 10^7$ [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 [ $\mu$ s]	5.2 [ $\mu$ s]
Beam spot at the experiment	variable around 1 [mm <sup>2</sup> ]	variable around 1 [mm <sup>2</sup> ]

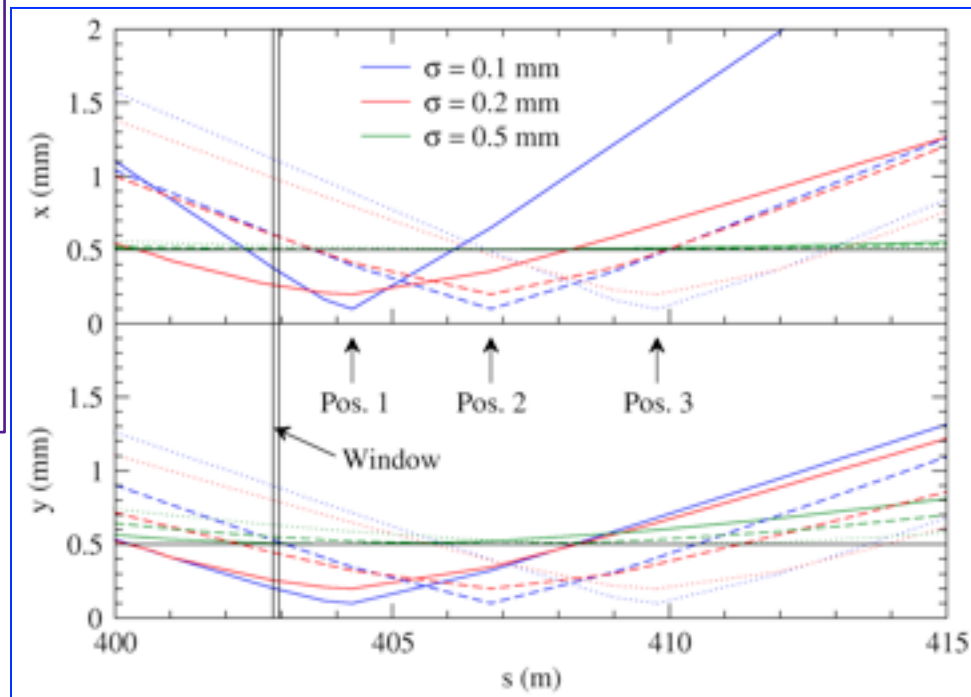
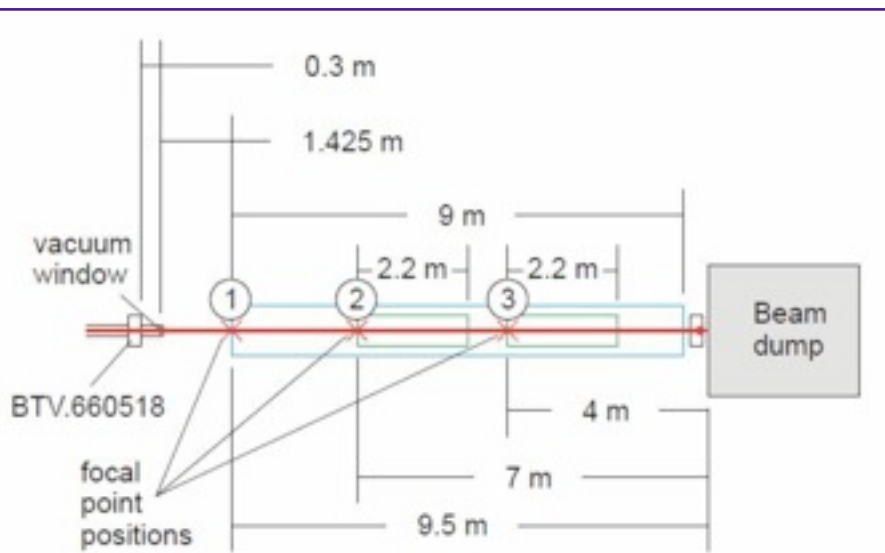
- ▶ Intensity:

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



# HiRadMat Beam Parameters

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







# HiRadMat Construction - T1 target dismantling

September 2009



January 2011



February 2011

May 6, 2011

ie-4HPTW, Malmoe



# 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

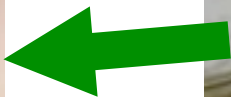
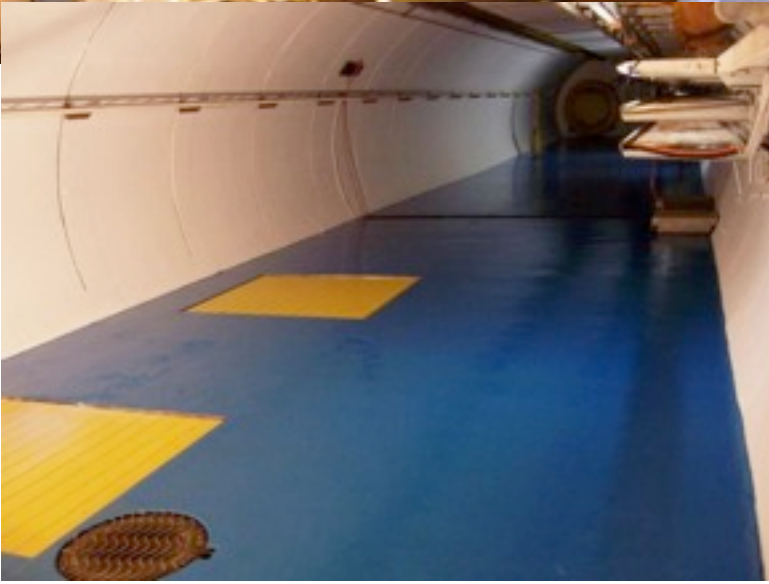
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# HiRadMat Construction - WANF dismantling



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# HiRadMat Construction - WANF dismantling

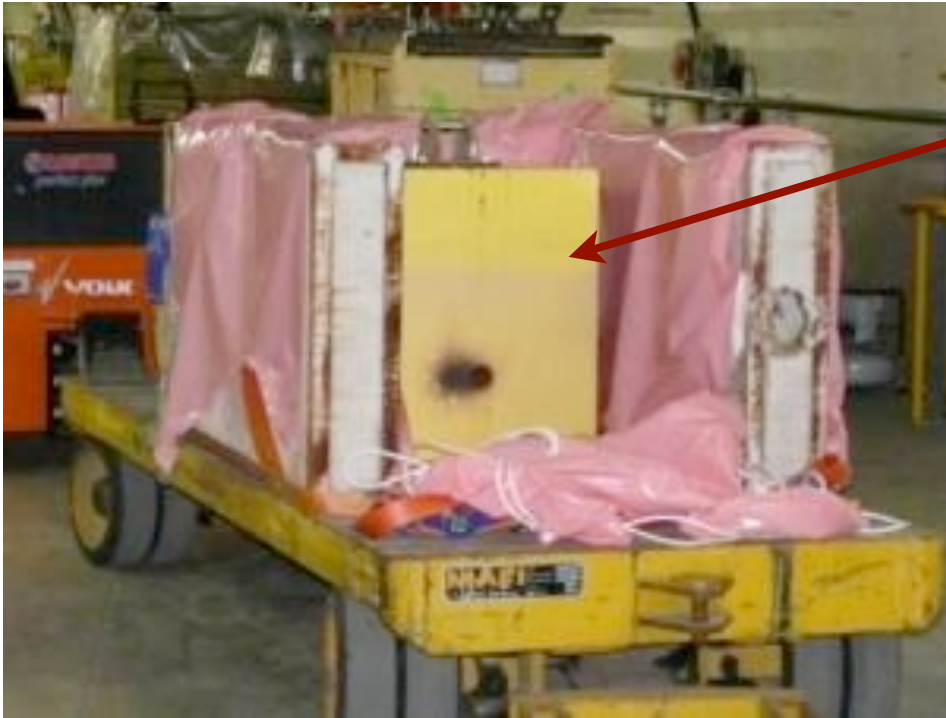


▶ Remote manipulation with the overhead crane

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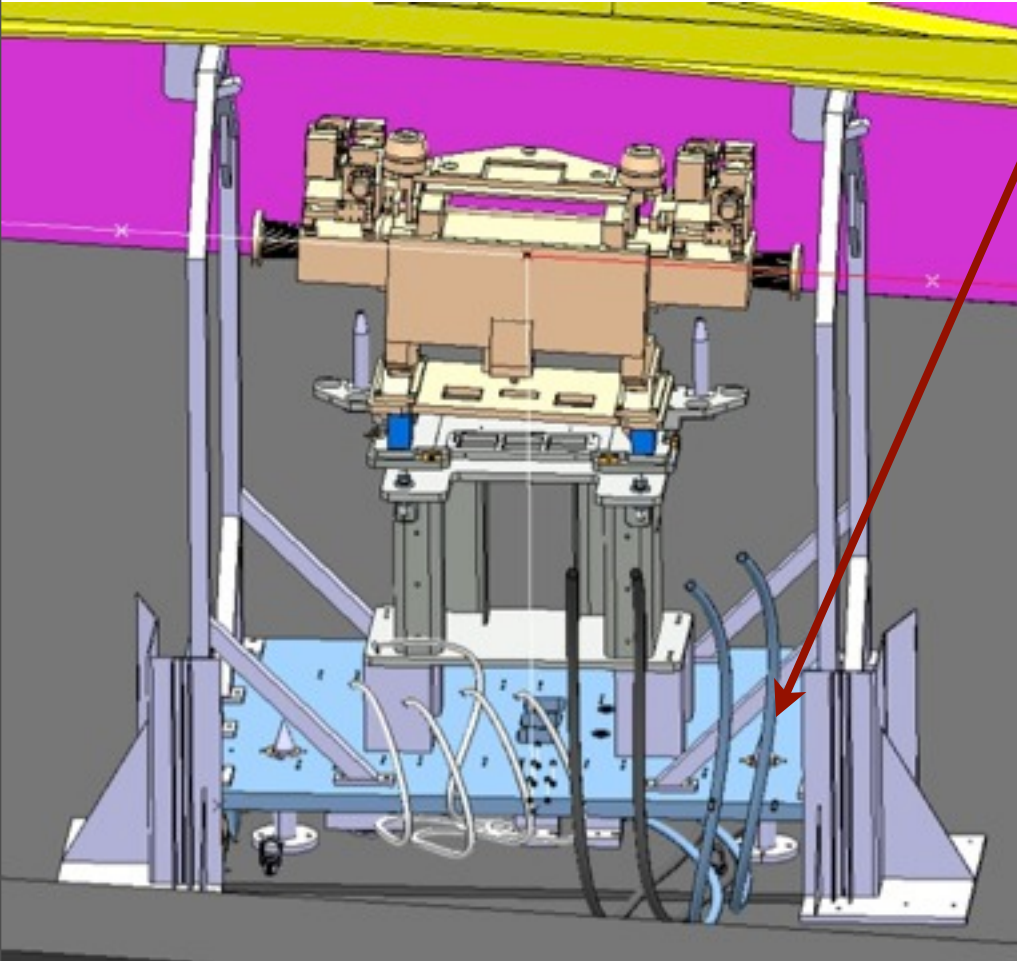




Upstream and downstream collimators



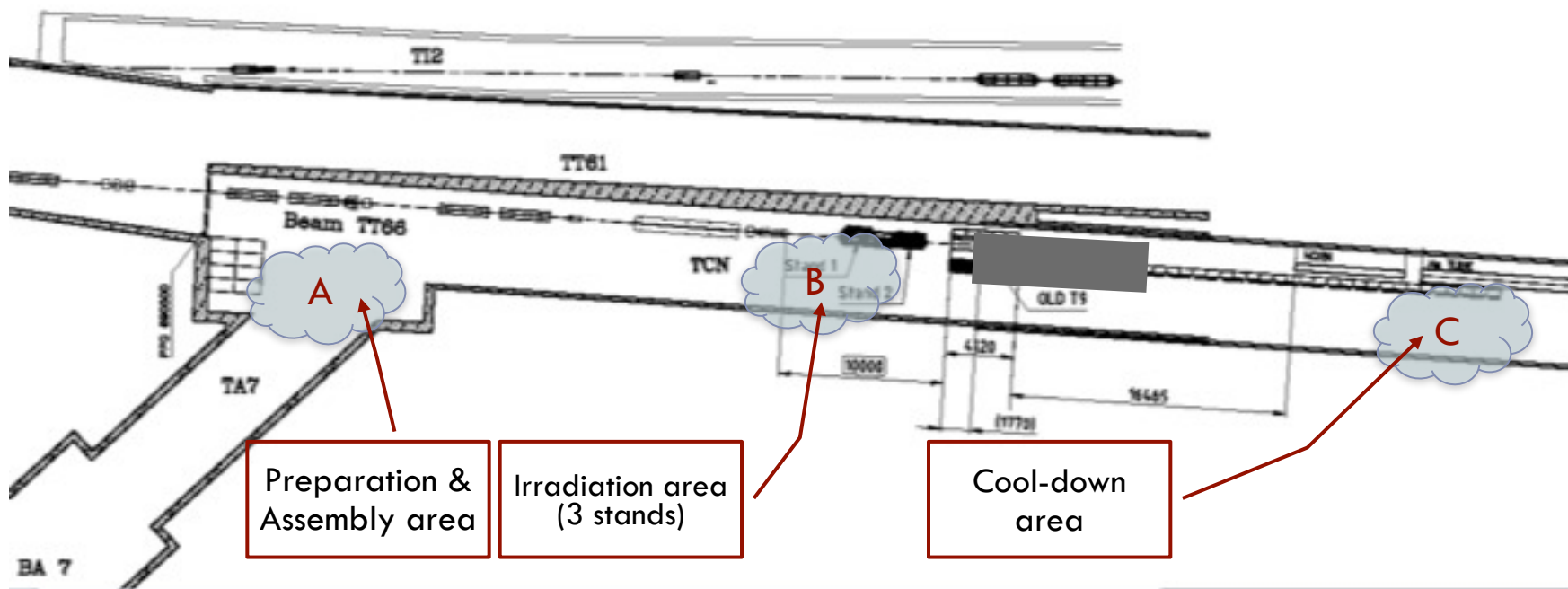
- ▶ The removal of the downstream collimator was the most challenging part of the whole project
  - ▶ Very radioactive element (~1Sv/h !!!)
  - ▶ 4 Cu blocks, no remote handling



- ▶ 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

## ▶ Life cycle of an experiment:

1. Prepare 1(2) test setups each on its 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





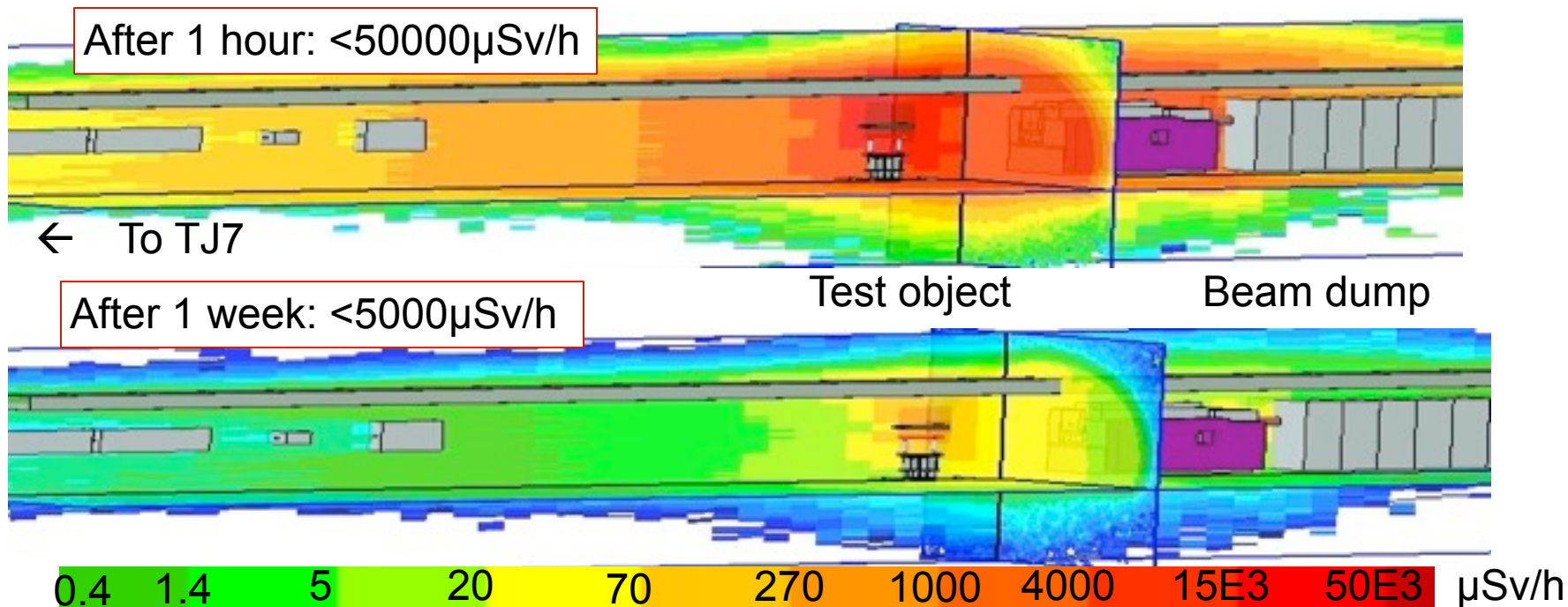


# Experiments in HiRadMat

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- ▶ Beam parameters to vary for the experiments:
  - ▶ Bunch intensity:  $[5 \times 10^9 (\text{pilot}) \div 1.1(1.7) \times 10^{11}]$  ppb
  - ▶ Number of bunches :  $[1 (\text{pilot}) \div 288 (\text{bunch trains})]$
  - ▶ Timing between bunches or bunch trains: [SPS filling modes possibilities]
  - ▶ Beam focusing at the experiment :  $[0.25 \div 4.0 ]$  mm<sup>2</sup>
  
- ▶ 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

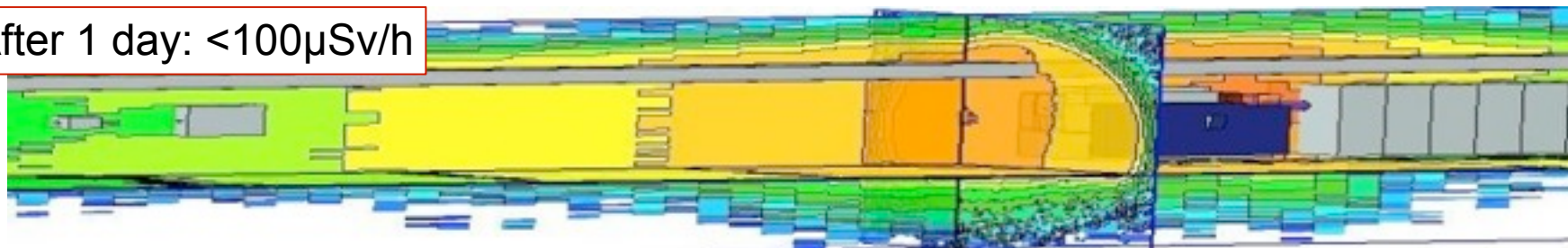
- ▶ Activation dose near (average at 40cm) test object after 1 hour/1 week cool-down
  - ▶ Short SPS cycle,  $1.98E12$  p/s for 504 s ( $1e15$  protons)
  - ▶ The beam hits the carbon jaw of a typical collimator



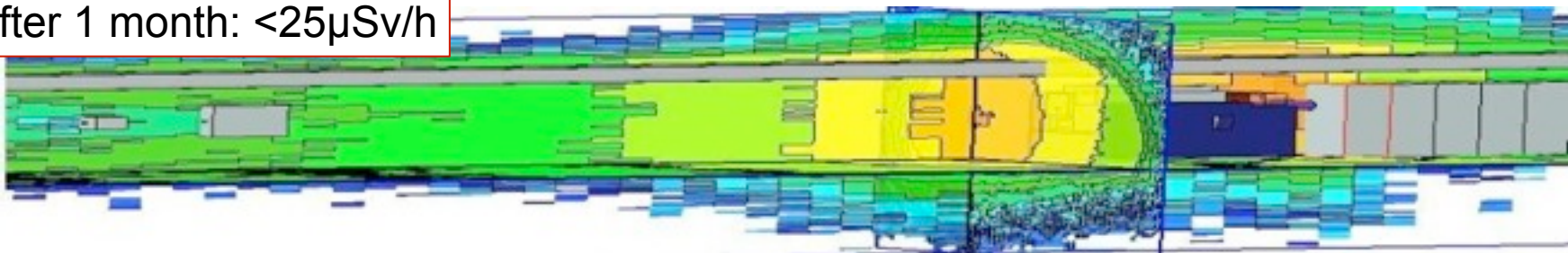
## ▶ Remnant radiation

- ▶ 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

After 1 day:  $<100\mu\text{Sv/h}$



After 1 month:  $<25\mu\text{Sv/h}$



0.1 0.2 0.6 2 5 20 50 100  $\mu\text{Sv/h}$



- ▶ 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

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- ▶ 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

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- ▶ 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

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- ▶ 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>**