HIGH RADIATION TO MATERIALS

part of the EUCARD FP7 program

Outline

- The HiRadMat facility – Why, What, When, Where
- Status
  - WANF(*) dismantling
  - Primary beam line installation
- Planning: Installation & Commissioning in 2011
- Irradiation Area Layout & Operation
- Summary

(*)West Area Neutrino Facility

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IEFC Workshop, March 22, 2011

The HiRadMat Facility

Why, What & When

Why

- Luminosity increases in particle accelerators → materials of near-beam equipment must be able to withstand the higher beam intensity
- Need for a facility to test materials in an intense pulsed beam to investigate damage effects from heat & radiation with increasing intensity.

  → analyze the threshold of destructive effects to find material limitations

What

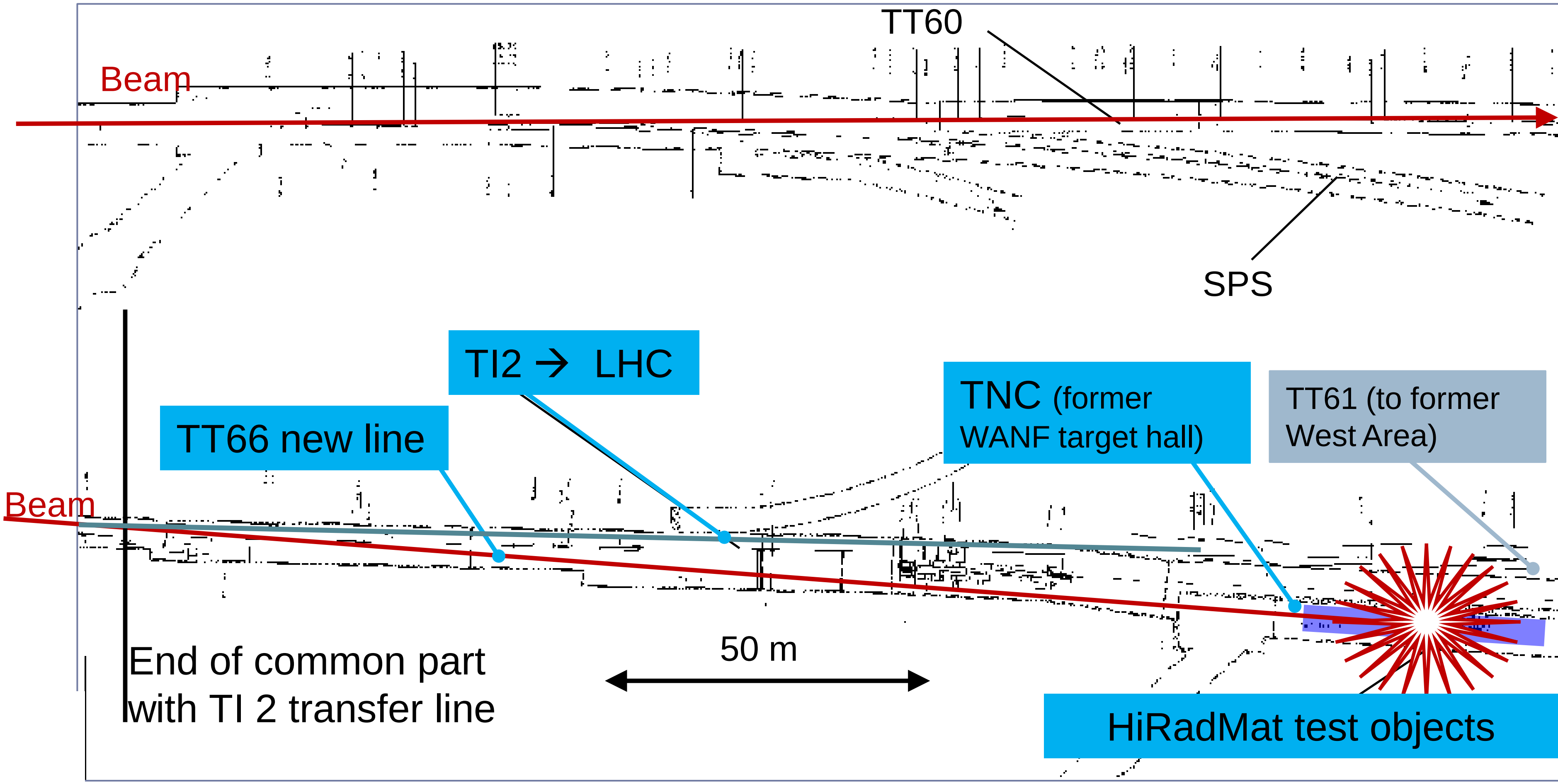
- HiRadMat = Facility to study the impact of **intense pulsed beams** on materials
  - Thermal management (heating) & thermal shock (pressure waves)
  - Radiation damage to materials - change of mechanical properties
- Beam extracted from SPS (450GeV/c): provides 10^{11} protons per bunch, 288 bunches per pulse, 30 pulses per user → 10^{15} protons per user, ~2.4MJ/pulse
- Beam size 0.1-0.5mm (1σ) at impact.

When

- Aim for **2011**: 3 users - LHC phase 2 collimator (jaw materials), tungsten powder (as high-power target for future neutrino beams), beam windows.
- Interest expressed for > 2011: protection devices, machine components, material studies, irradiation tests of electronics.

The HiRadMat Facility

Where

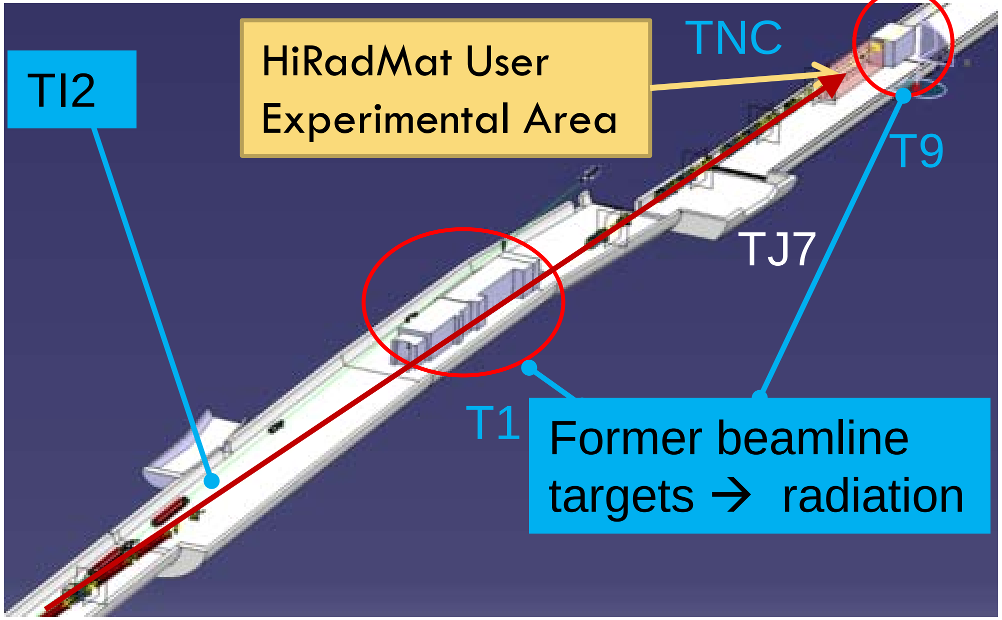


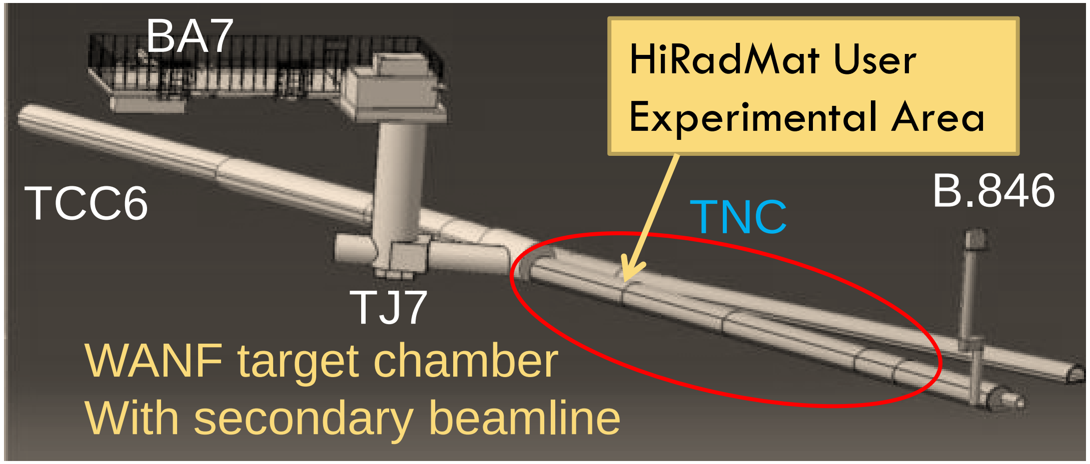
➡ Access to HiRadMat intrinsically linked to LHC (injection)

The HiRadMat Facility

Where & Location of main dismantling activities

- T1 - former West Area primary target & shielding & MTR magnets: **dismount**
- TNC - former neutrino target hall with secondary beam elements: **replace** services, **dismount** beam elements & **complete** HRM beam dump





- T9: former neutrino beam target: **dismount** target & collimators and **install** HRM beam dump in and behind former T9 shielding castle

Status – WANF dismantling

General dismantling

Hot objects & high remnant radiation dose

→ Remote handling tools

- Cameras on renovated crane and in TNC
- Automatic hook for standard blocks
- Shielded fork lift
- Several custom-made hooks & lifting beams

→ Shielding during intervention & transport





Status - WANF dismantling

Example 1: WANF Horn & collimator removal

- Horn and support manually dismounted from TNC and sent to waste storage in ISR(*)
- Collimator and support 80% remotely dismounted and sent to waste storage in ISR

(*) Intersecting Storage Rings

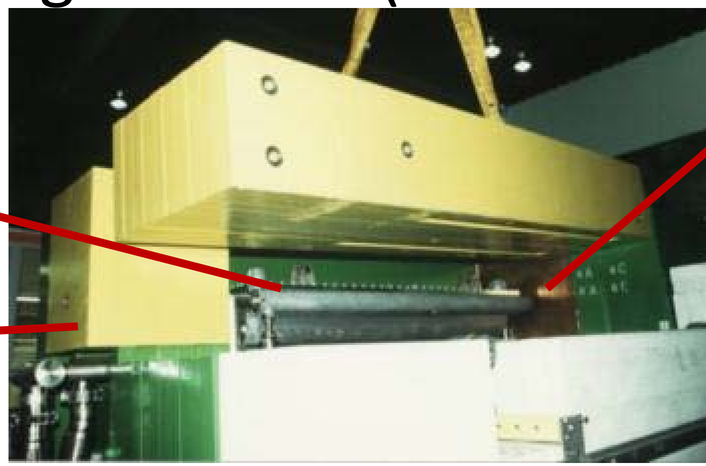
Status - WANF dismantling

Example 2: T9 dismantling (transformation)

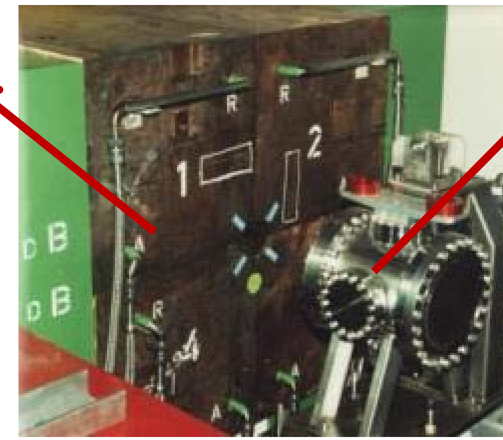
- T9 target station (installed 1993, 5 years of beam)

Steel upstream collimator

ν-production target



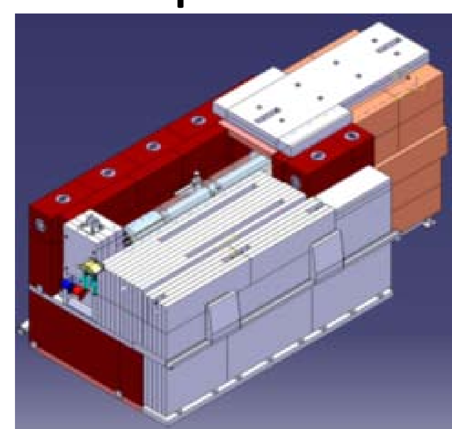
Copper downstream collimator blocks



Downstream monitor

- T9: transformation to HiRadMat beam dump:

1. Remove target, all collimators & monitor
2. Replace upstream collimator with new collimator
3. Replace other items with TED(*)-type beam dump
4. Close shielding and complete HRM beam dump



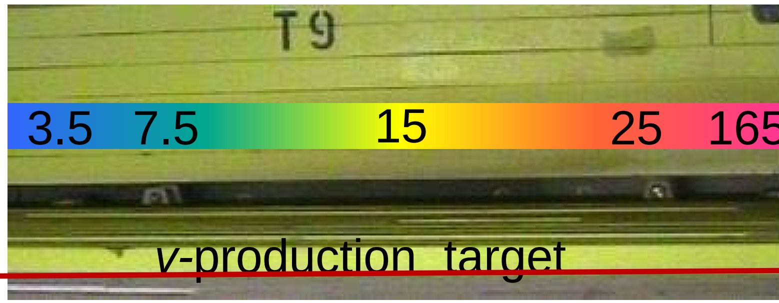
(*) Target External Dump

Status - WANF dismantling

Target & upstream collimator

- Dose rate near target and upstream collimator

Upstream collimator



Downstream collimator

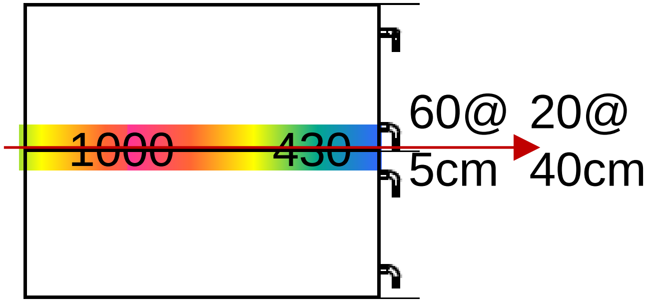
Dose rate (**mSv/h**) measured at contact with target container and cradles (12.01.11)

- Items designed in 1993 for remote removal!
- Remote removal, transport to ISR in shielded containers or on shielded trailers

Status - WANF dismantling

9 Downstream collimator blocks dismantling: Challenges

- Dose rate in & near copper collimator blocks



Dose rate (**mSv/h**) measured inside and near the collimator (12.01.11)

Reminder: forbidden area if dose rate > 100mSv/h

- The collimator blocks' geometry brings several challenges
  - Each block (2.7t) has hot outer surface
  - Axis of 2 blocks is outside range of overhead crane
  - Items not designed for remote handling!!!
    - 4 threaded holes per block
    - 1993: installed manually with forklift, lifting rings and straps

Status - WANF dismantling

ALARA Level 3 committee

Following > 100mSv/h dose rate measurement, the case of T9 dismantling was presented to the ALARA L3 committee

Results & consequences:

- Review took place of detailed dismantling procedure by CERN safety specialists from outside the project (M. Tavlet & P. Bonnal)
- Detailed risk analysis established
- Decision taken to NOT remove the copper blocks out of TNC (yet)
  - Blocks with handling plates will be placed in custom-build containers in a 40cm thick iron sarcophagus downstream TNC
  - The evacuation of the blocks from TNC will be carefully planned by EN/MEF & DGS/RP and executed in the "near" future (e.g. shut-down 2013)
- Green light from reviewers and hierarchy obtained to start T9 dismantling on 2/2.

→ Dismantling work took ~10 days, collective dose of ~1.2mSv

Status –WANF dismantling

Downstream collimator blocks dismantling: Solutions

- Lifting & shielding plates fixed manually on copper blocks
- Custom-made lifting beam takes 2 blocks at the time
- Shielding in place for all manual interventions
- Extensive tests on mock-up
  - Optimise tools
  - Define camera positions for handling
  - Training interveners

→ Minimise risk & dose personnel




Status –WANF dismantling

T9 downstream collimator dismantling in pictures

Moving upper blocks with fixed lifting plates

Blocks in temporary storage location

Sarcophagus with containers ready

Fixing plates on lower blocks

Separating blocks 2→1

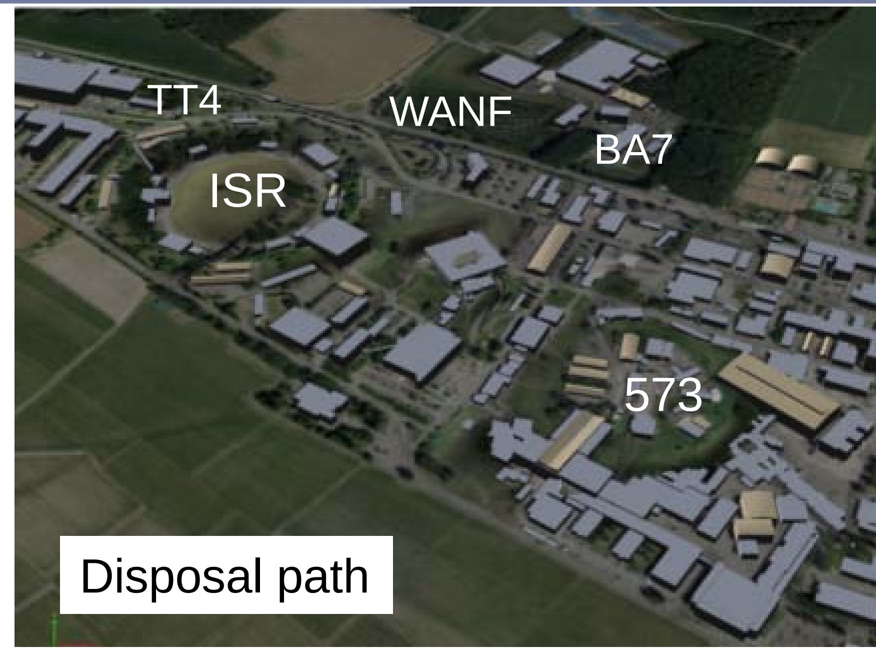
Placing block in container

Lifting test before closing roof

Status - WANF Dismantling

Waste management

- Radioactive waste is treated in several steps:
  1. Rough cleaning in WANF (specialized company ENDEL Nucléaire)
  2. Removal from WANF → TT61 → TT4
  3. In TT4: thorough decontamination and disassembling
  4. Volume reduction in RP waste workshop in building 573
  5. Convenient conditioning for long term storage
  6. Long term storage in ISR



Status - Primary beamline installation

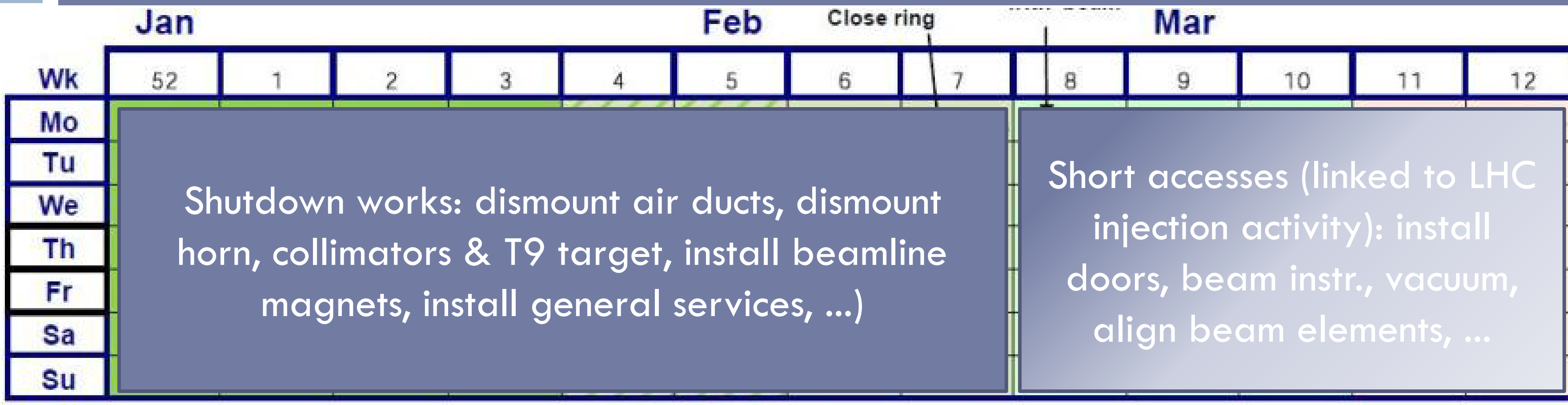
Installation progress of TT66 beamline

Equipment	Status	Comments
Magnets	25/25 installed	
Vacuum system	88% installed	77% leak tested
Electrical feeds	95%	
Cooling connections	85%	
Power converters	7/13 installed	Last one: End of March
Beam instrumentation & Control	15/17 installed	BPKG, 1 BTV to install weeks 13/19
Machine interlocks	almost ready	Link to power converters not yet commissioned
Survey	90%	Remaining work during week 13 or short accesses

Summary table status mid March 2011 (upstream line TT60/TI2 is 100% installed)

Planning 2011

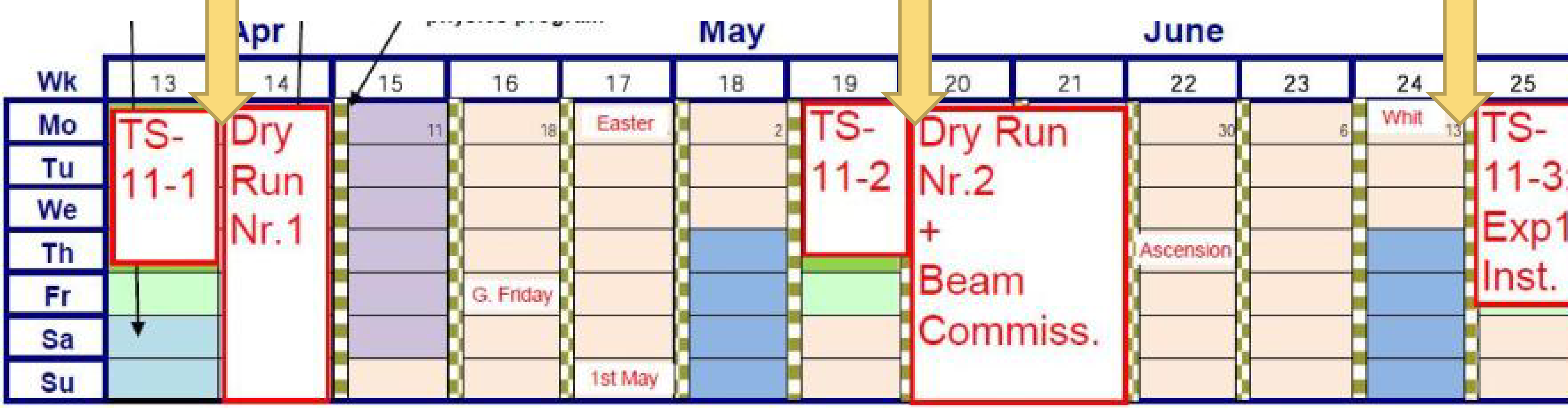
Installation & commissioning



- T9 transformed (no TED)
- Beam line installed & elements connected (incl. beam instrumentation)

- TED dump core and downstream muon dumps installed
- Ventilation operational (challenge!)
- Beam line under beam vacuum

- Exp area in TNC installed & operational (cabling, services, …)
- Surface preparation lab & control room ready

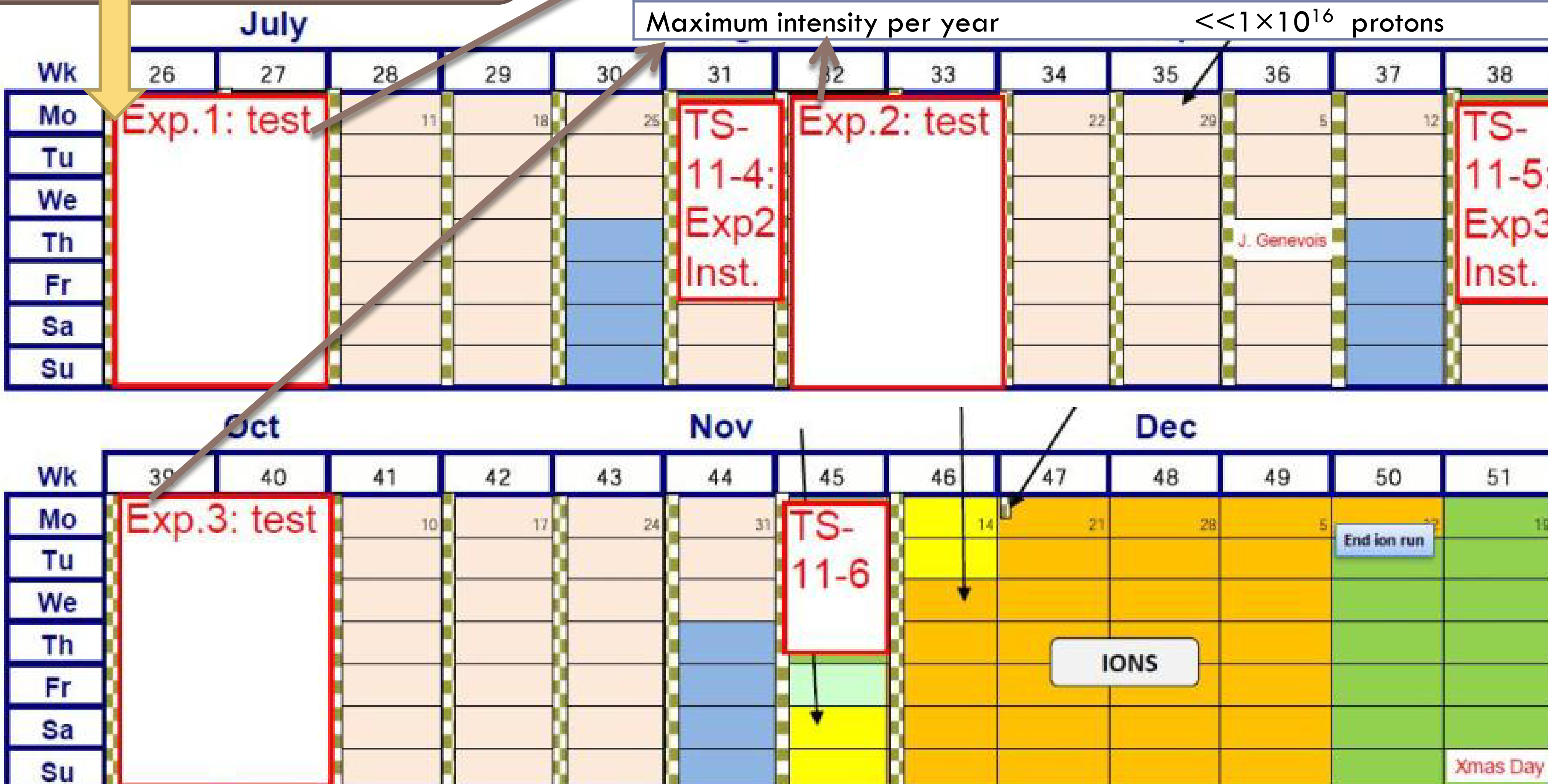


Planning 2011

Installation & commissioning

- Installation & handling equipment & procedures ready, tested & approved
- Downstream cool-down area ready

Parameter	Value
Experiments in 2011	~3
Maximum intensity per experiment	1×10^{15} protons <30 full intensity pulses
Waiting time after experiment for de-installation	≥ 2 weeks
Access during experiment (except urgent interventions)	no
Control of experiment and data taking	remote
Maximum intensity per year	<<1×10^{16} protons



Commissioning plans

- Hardware commissioning on-going: powering tests, etc.
- Dry runs to check the overall beam equipment functionality without beam (week 14):
  Control applications, interlock, magnets/power converters, beam instrumentation.
- Commissioning of the facility with beam (weeks 20 and 21):
  - Tests with **probe beams**:
    Aperture checks, beam parameter checks, steering, beam size / focal point position adjustment, position / intensity stability, BI (calibration, etc.), controls, logging, interlocking tests, etc.
  - **Some** high intensity shots to check the consistency with the nominal beam intensity.

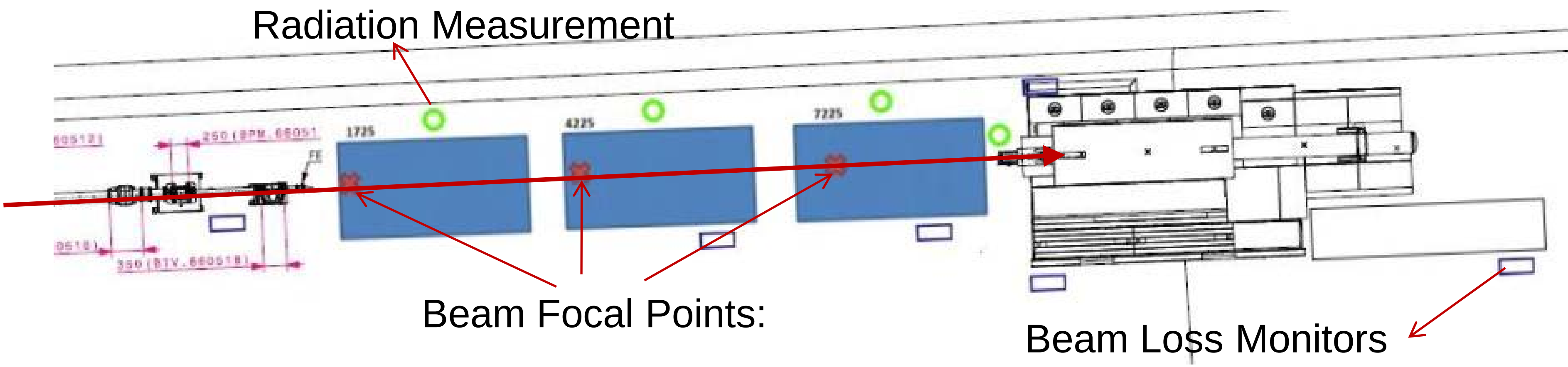
Readiness 2011

Remaining work

- **Dismantling 99% finished**
- **Beamline 90% installed**, remaining part planned for **week 13**
- **Beam dump** will be **completed** in **week 19**
- **Ventilation system will be ready for first user**. Installation before week 20 unsure. **Discussion on-going** to allow limited amount of test pulses/protons without ventilation.
- **Experimental area test tables** designed & tested, production under way, will be **ready for first user**
- **Cabling for test tables** remains to be done during the next technical stops (weeks 13, 19&25). Installation sequence will be done such that the **needs** for 2011 **will be met before installation first user**.

Irradiation area layout

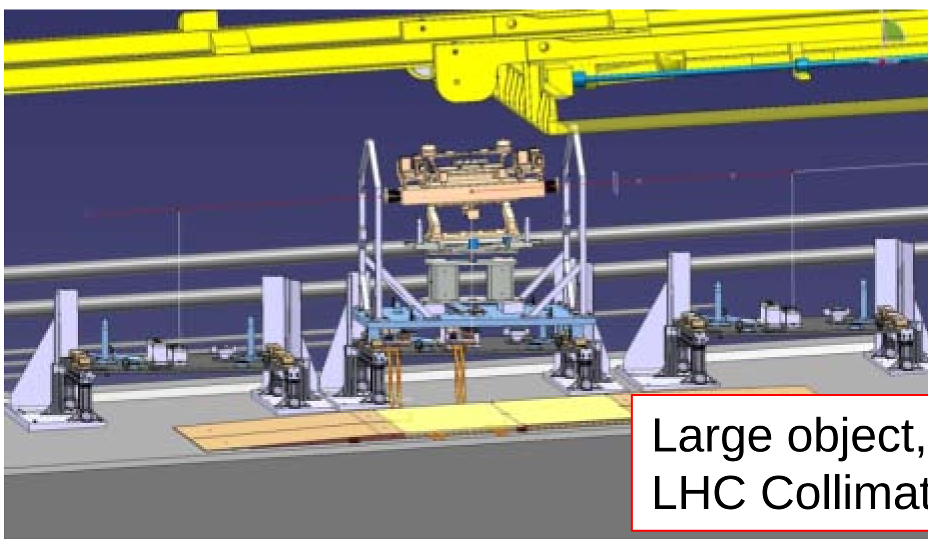
Layout & concept



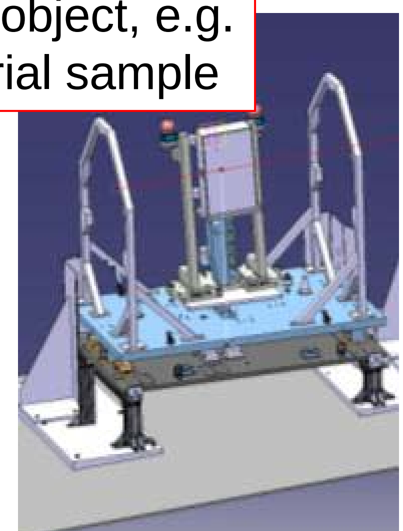
- 3 possible focal points for beam → 3 positions for test stand
- Geometry & services available to users on test stand:
  - Volume ~1.5x0.7x0.7 m^3, weight up to 4 tons
  - Cooling circuit, electricity, neutral gas available
  - Signal connectors (e.g. for camera, motorization, beam instrumentation, vibration measurement, …)
  - ~25m upstream: Patch panel to test signals/services before beam
  - ~100m downstream: cool-down storage area for test objects

Irradiation area layout

- Test stand : base table in TNC and mobile table with test object (remote handling) comes from surface
- Interface between tables : remote / automatic plug-in connectors (water, power, signal)
- Check user system (motors, camera, laser, ...) before beam in TJ7, during beam only from surface control room



Large object, e.g. LHC Collimator



Small object, e.g. material sample

Operation

- Guidelines
  - (up to) 10 users/year, (up to) 10^{15} protons/user
  - This quota includes several pilot pulses during setup
- Pilot pulses can be done in an almost transparent way to present operations
- High-intensity pulses will be done in dedicated HiRadMat cycles → impact on other SPS physics users
- User selection panel will:
  (panel with experts from: radiation protection, safety, beam, physics goals, engineering, PS&SPS operation as well as external experts)
  - Review the beam requests, establish criteria for acceptance/rejection (e.g. scientific value, beam feasibility, safety concerns, impact to the facility,…)
  - Establish priority list of experiments with respect to the available beam time
  - Distribute beam time and schedule experiments

Operation

Operating procedure: **first ideas**

A HiRadMat "brochure" will show what HiRadMat offers in services, signal, alignment, control room, observation equipment, beam type, ...

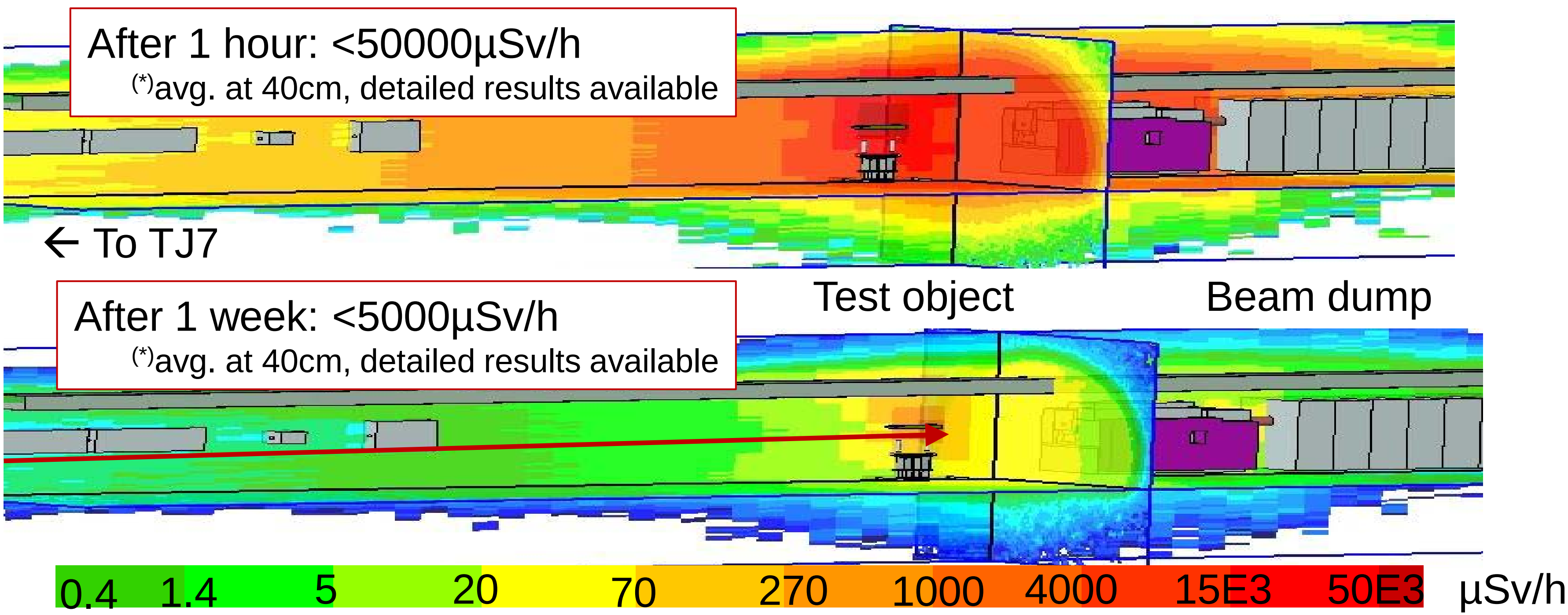
- Approval of user's proposal by user selection panel
- Preparation of interface parts (windows, containers, observation equipment, motorised tables etc.) in collaboration with area engineers & designers
- Arrival at CERN of users ~2 weeks before beam: mounting test object on mobile table, alignment and test connectors in surface lab and control room
- During the week before beam (LHC technical stop): remote installation, remote test of signals, motorization, observation equipment, etc.
- Beam start. Observation and data taking from control room on surface.
- After beam tests: remote moving of mobile test table to cool-down area
- Later, possibly only during end-of-year shut-down: bringing test object back to surface (RP lab)

→ A detailed and official "operating procedure" document will be written & released by the project team in due time

Operation

Activation dose rate after 1 user test – Fluka calculation results

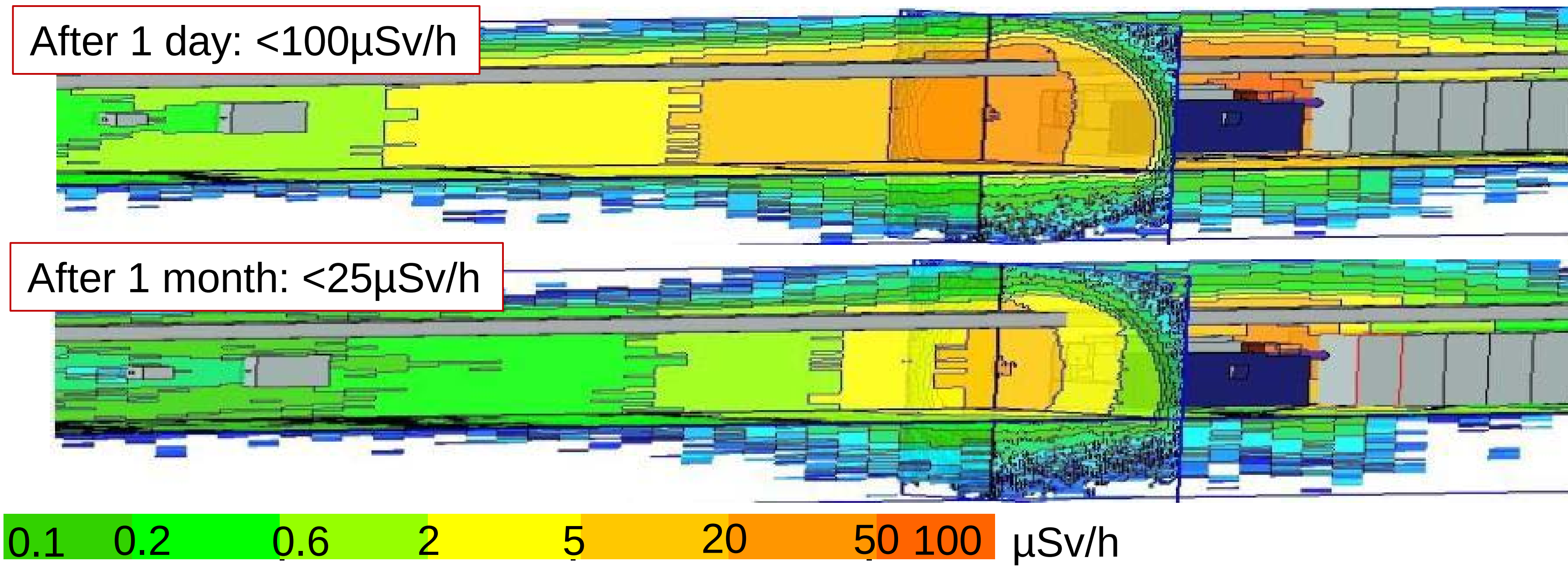
- Assumption:
  - Short SPS cycle, 1.98E12 p/s for 504 s (1e15 protons)
  - The beam hits the carbon jaw of a typical collimator
- Activation dose **near**(*) **test object** after 1 hour/1 week cool-down



Operation

Background dose rate after a full year of operation – test object removed

- Assumption: 10^{16} protons over 1 year on a 15cm long copper test object, followed by **removal of test object**
- Background dose rate **in TNC** after 1 day / 1 month



→ During annual shut-down: possible to intervene near test stands for repair or upgrade

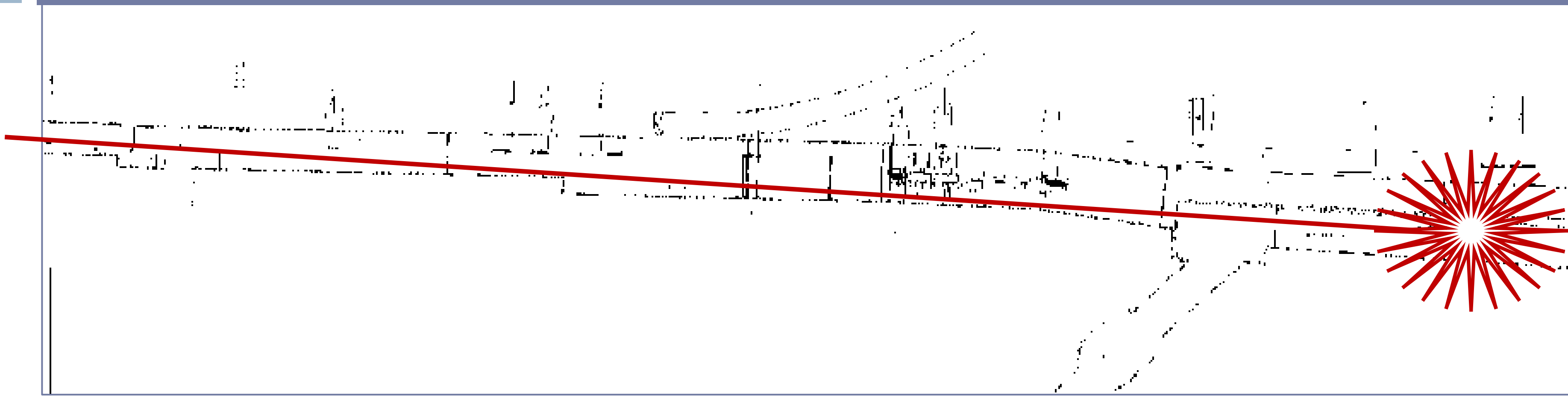
Summary

- Work done in 2010 and early 2011:
  - WANF dismounted
  - Primary beamline installed

95%

- Readiness for 2011:
  - Remaining works for week 13 & 19 well defined, prepared & planned
  - → Ready for dry run week 14, commissioning week 20
  - → Ready for scheduled users from week 26 on
- Planning for 2011: aim for 3 users w26, w32, w39
- "Operating procedure" document under way

HiRadMat knocking at the door



Thank you for listening – Any questions?