CERN

HiRadMat
High-Radiation to Materials

High-**Rad**iation to **Mat**erials

HiRadMat facility at the CERN SPS

More information at http://cern.ch/hiradmat

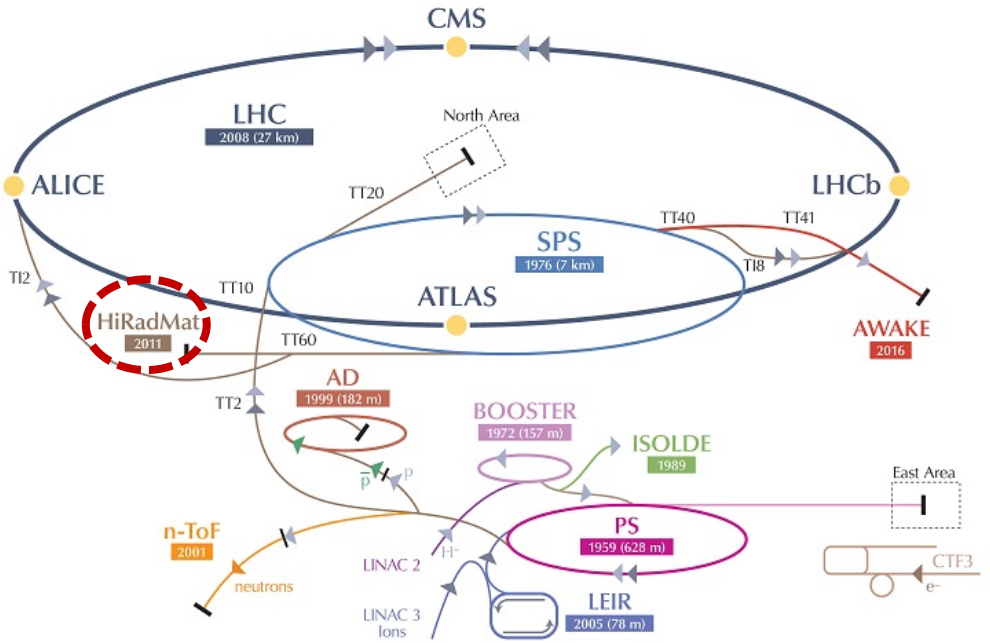
Adrian Fabich

IWSMT-12, Bregenz, 20th October 2014

EN Engineering Department

Motivation of HiRadMat

- **Dedicated facility for studying the impact of intense pulsed beams on materials**
  Move away from ad-hoc setups for material tests
  - material damage
  - material vaporization
  - Thermal management
  - Radiation damage to materials
  - Thermal shock - beam induced pressure waves



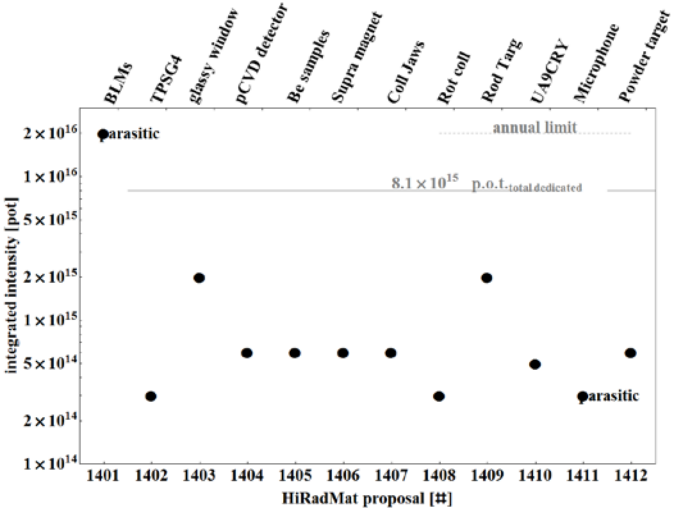
- Application areas:
  - materials R&D
  - high-power targetry
  - benchmark tests
  - (survival of) beam line components (windows, coating, vacuum)
  - …

HiRadMat proposed/realized by 2011:
R. Assmann, I. Efthymiopoulos

SPS beam parameters

- LHC injection like beam

	Protons	Heavy ions (Pb^{82+})
Beam energy	440 GeV	173 GeV/u
Bunch intensity	$3\ 10^9$ to $1.7\ 10^{11}$	3 to $7\ 10^7$ ions
Bunch length	11.24 cm	
Bunches/pulse (max)	288	52
Pulse intensity (max)	$5\ 10^{13}$	$4\ 10^9$
Bunch spacing	25, 50, 75 or 150 ns	100 ns
Pulse length (max)	7.2 µs	5.2 µs
Cycle length	18 s	13.2 s
Beam spot	variable around 1 mm^2	
Pulse energy (max)	3.4 MJ	21 kJ



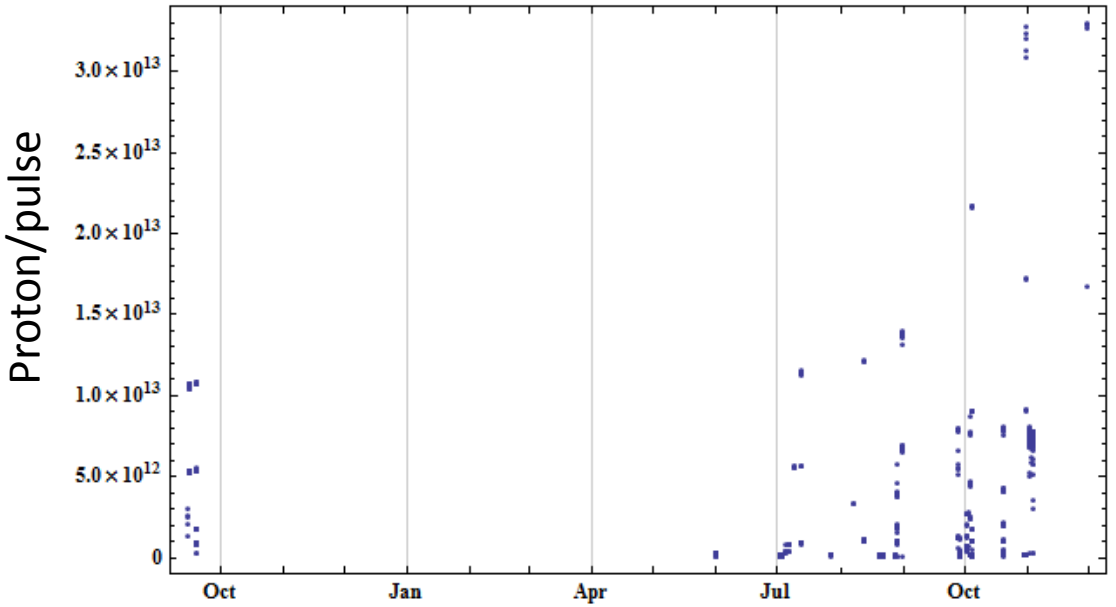
"Single-shot" experiments – no long-term irradiation studies

- Annual budget limited to ~10^{16} proton on target

History

- Commissioned in 2011
- Operational since May 2012
  - 9 experiments/tests completed in 2012

Total
$2*10^{16}$ pot



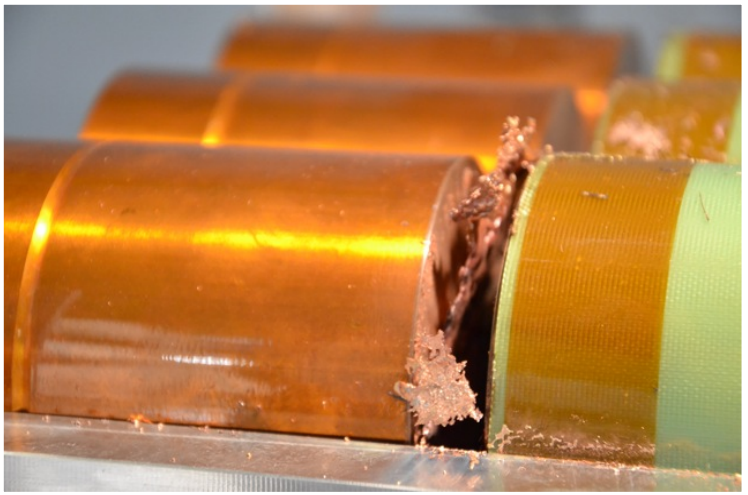
- Restart operation in Autumn 2014

Completed experiments in 2012

9 experiments in total

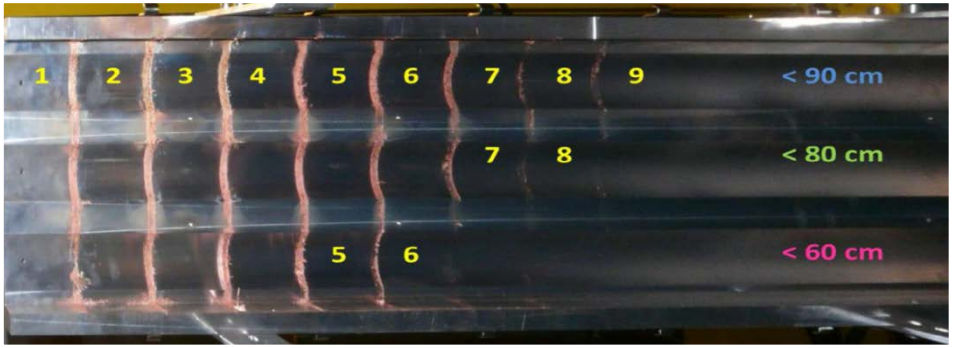
- Material studies
  - Benchmarking
- Testing of accelerator components
  - Collimators, vacuum windows, targets
- Performance of detector technologies

Absorber material tests



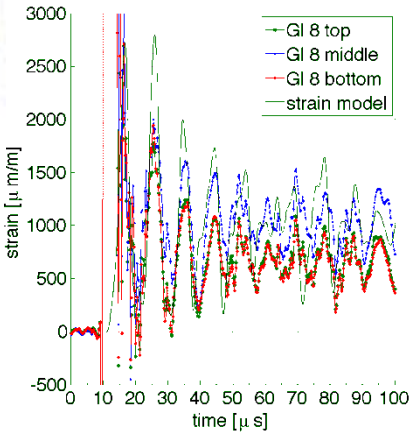
Beam tunnelling (HRMT12)

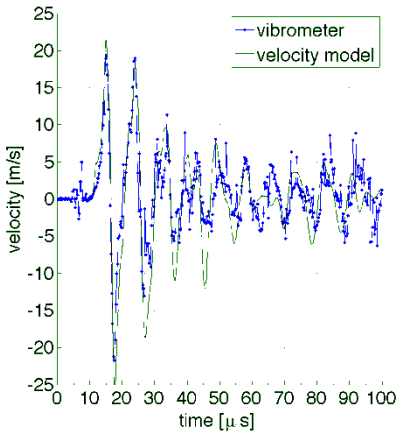
TE/MPE
R. Schmidt



Collimator materials

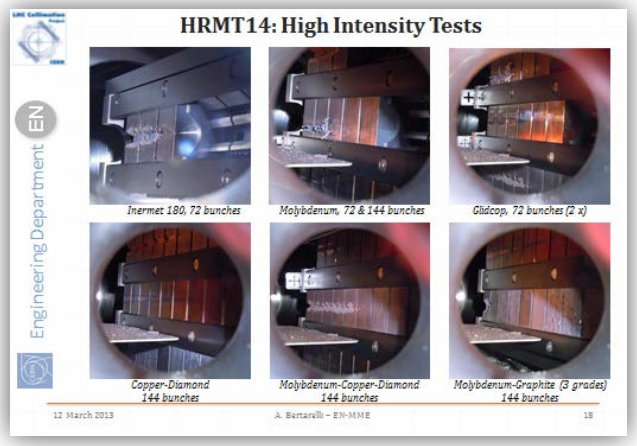
- Inermet180, Molybdenum, Glidcop, Mo-CD, Cu-CD …
- Measured material stresses compared with hydro-code



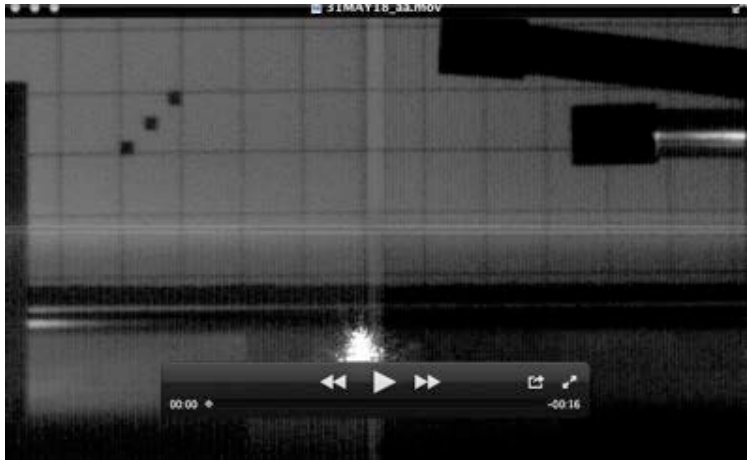


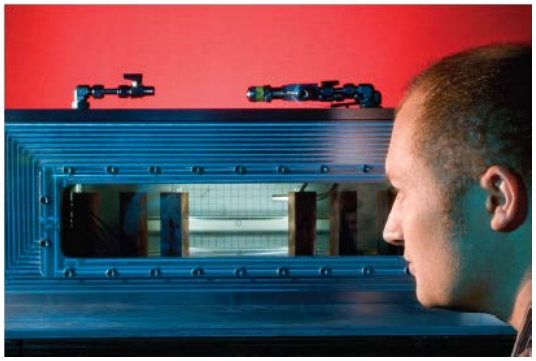
Collimator Materials (HRMT14)

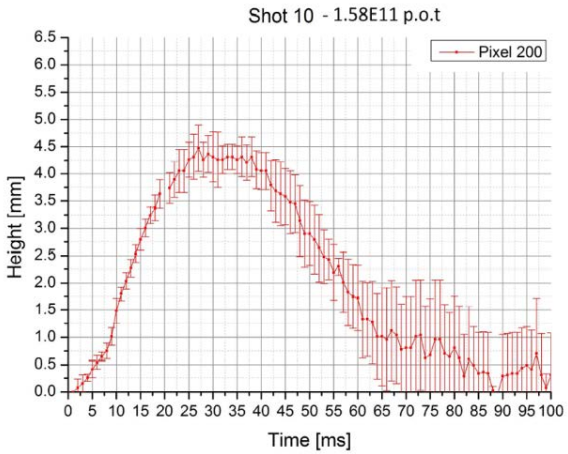
EN/MME
A. Bertarelli

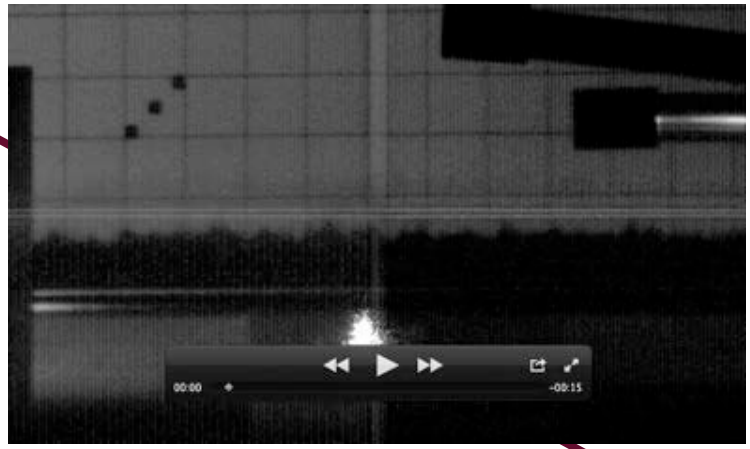


W-Powder Target for high power proton beams



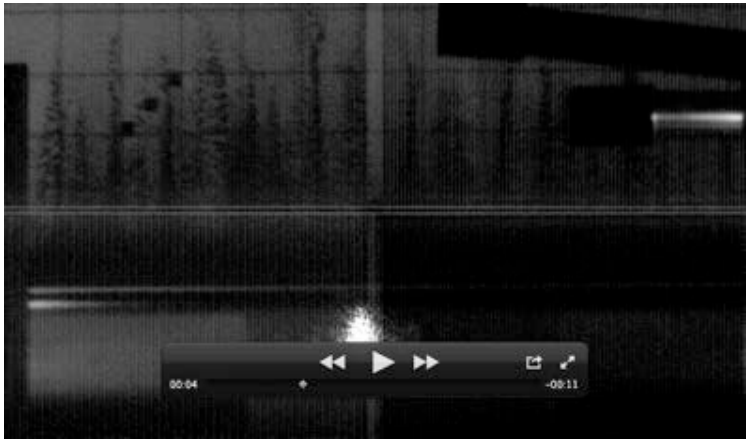




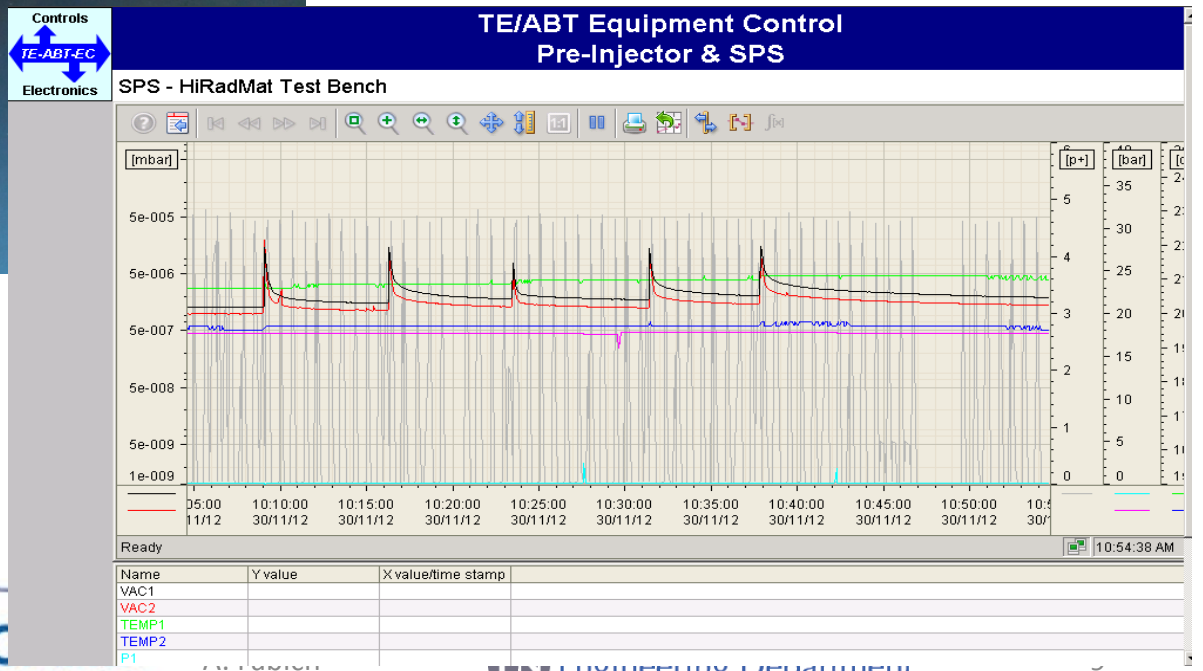


time

Courtesy HRMT10, N. Charitonidis, C. Densham



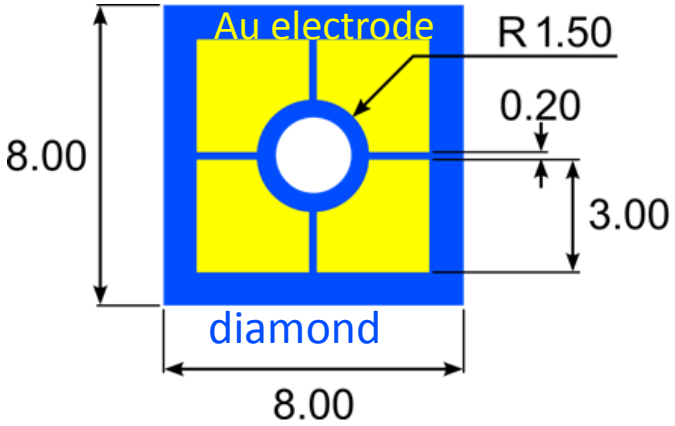
TPSG4 - 2012

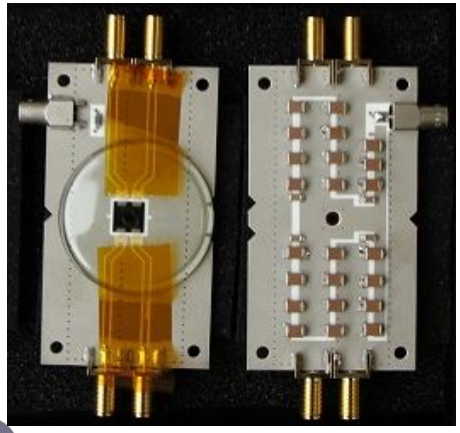

Controls
TE-ABT-EC
Electronics
TE/ABT Equipment Control
Pre-Injector & SPS
SPS - HiRadMat Test Bench
[mbar]
5e-005
5e-006
5e-007
5e-008
5e-009
1e-009
[p+]
[bar]
10:10:00 30/11/12
10:15:00 30/11/12
10:20:00 30/11/12
10:25:00 30/11/12
10:30:00 30/11/12
10:35:00 30/11/12
10:40:00 30/11/12
10:45:00 30/11/12
10:50:00 30/11/12
Ready
10:54:38 AM
Name
Y value
X value/time stamp
VAC1
VAC2
TEMP1
TEMP2
P1

Detector testing

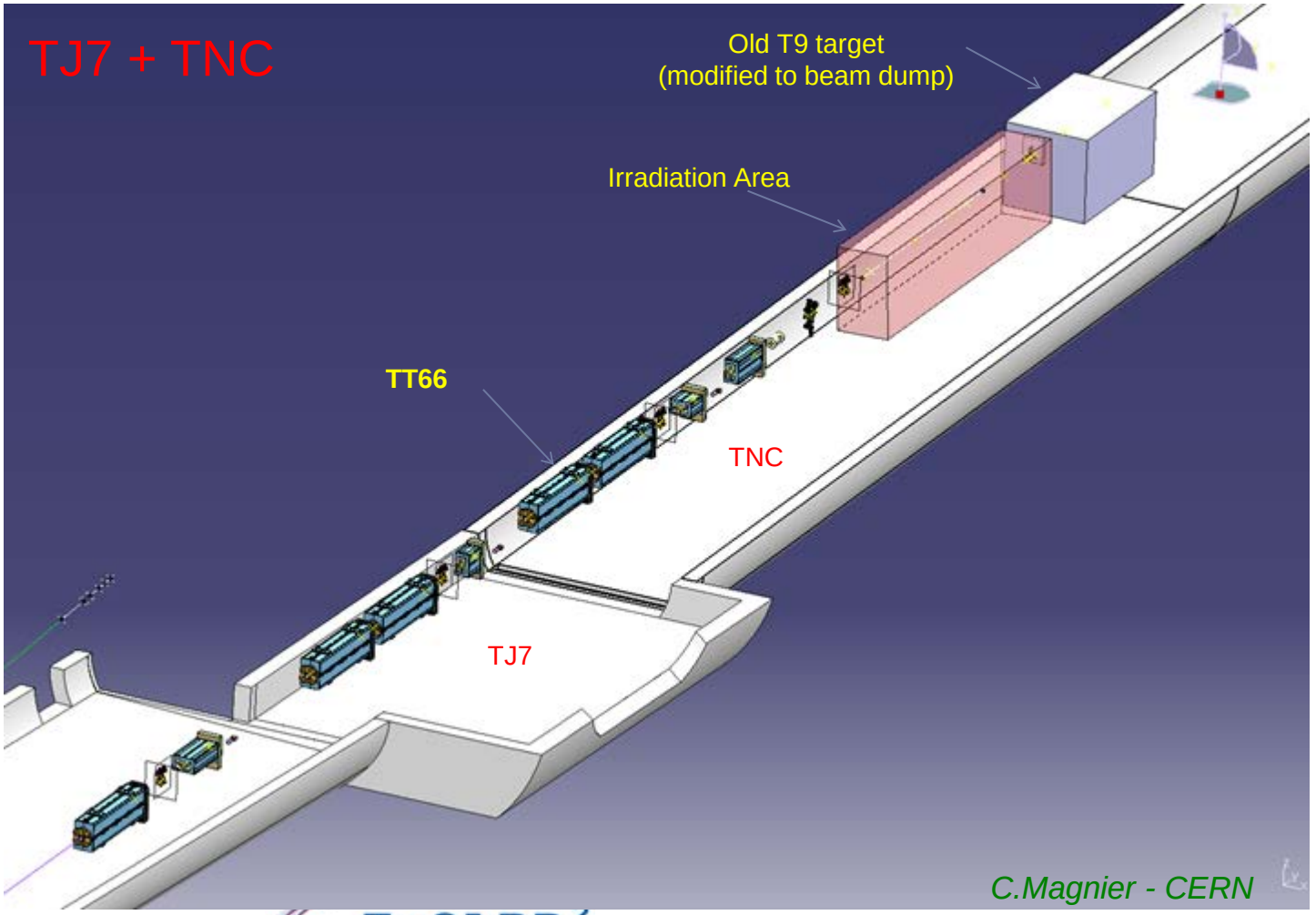
Radiation-protection detectors in neutron and mixed radiation field

Beam position monitors based on diamond technology



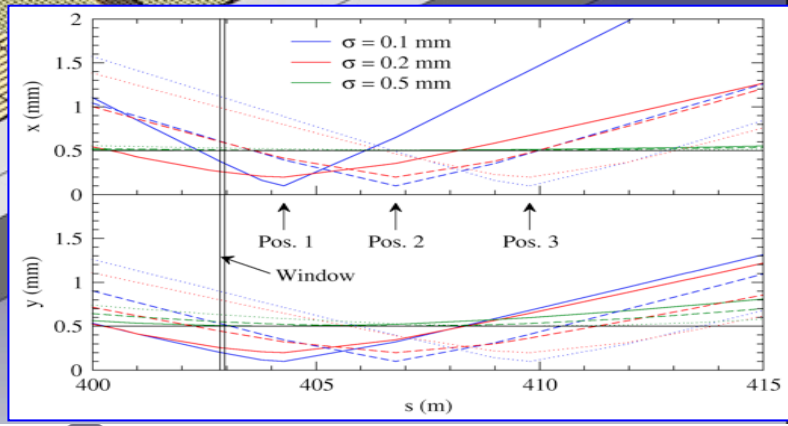


Layout Experimental Area

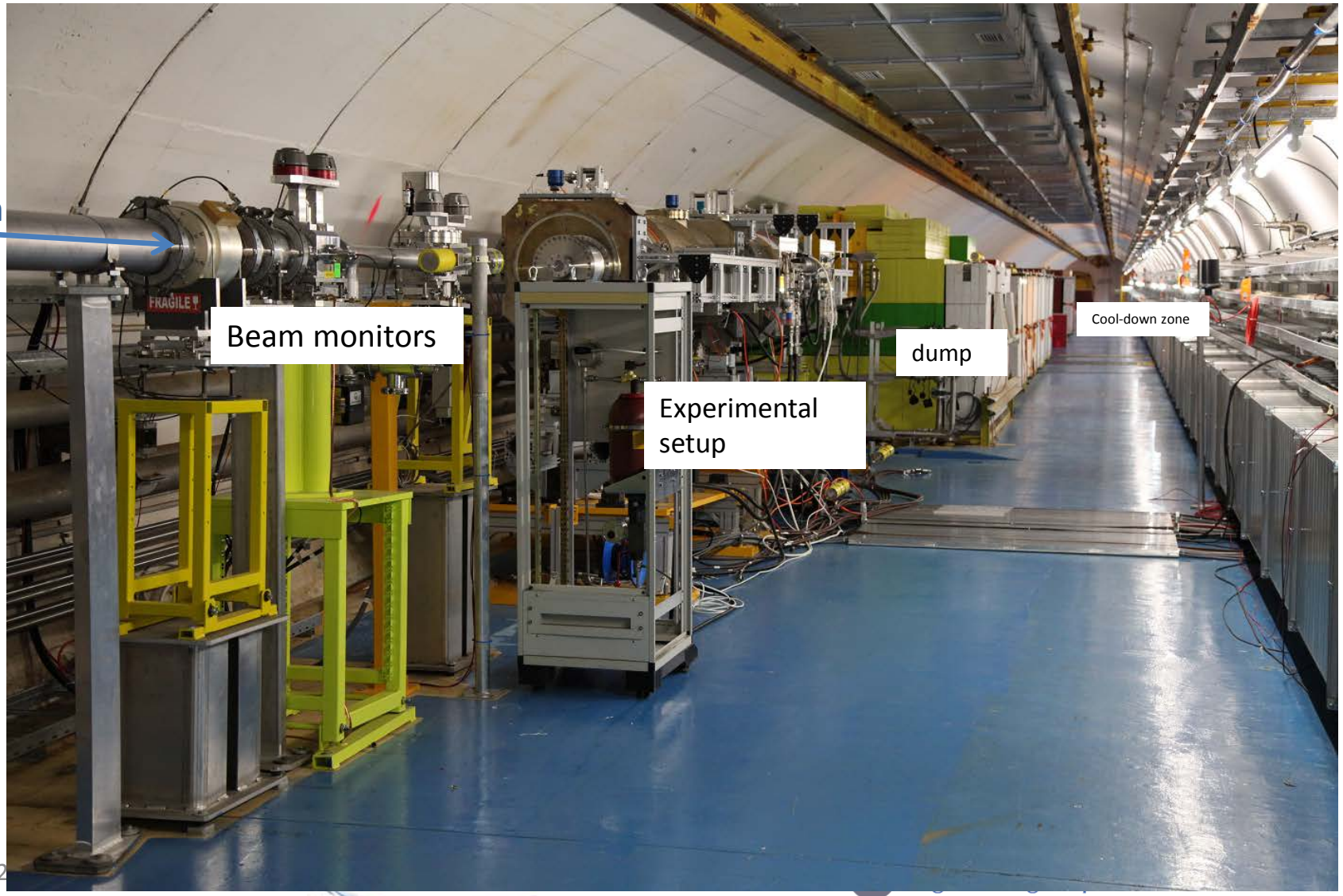


Layout Experimental Area

3 test stands for experiments
- Remote installation of normed support tables
- Standard connections for general infrastructure



Target area



Facility services

Provision of dedicated irradiation infrastructure

- Preparation lab at surface
  - Same interfaces as in the tunnel
- Control room

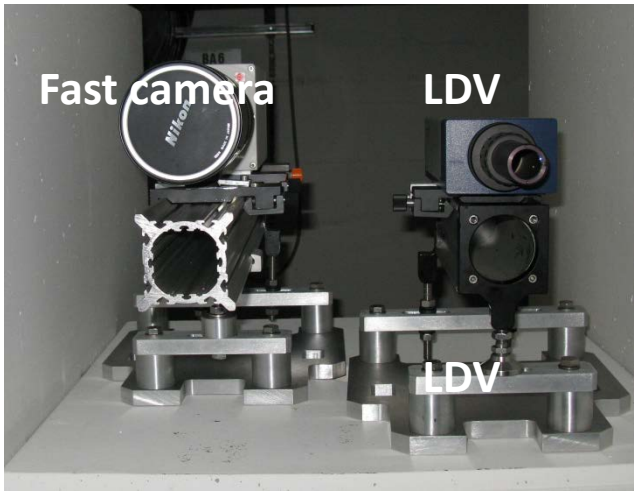
- Irradiation position
  - Standardized installation (remote)
  - General supplies (water, electricity, cabling)
  - Beam monitoring

- Observation tools
  - Camera, LDV (EN/STI), BLMs (diamond)

- Application/logistics/installation at CERN

Measurement tools

With the expertise of various groups at CERN

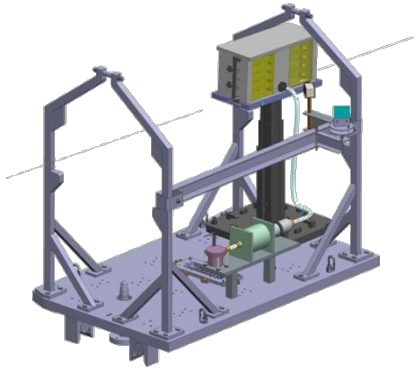


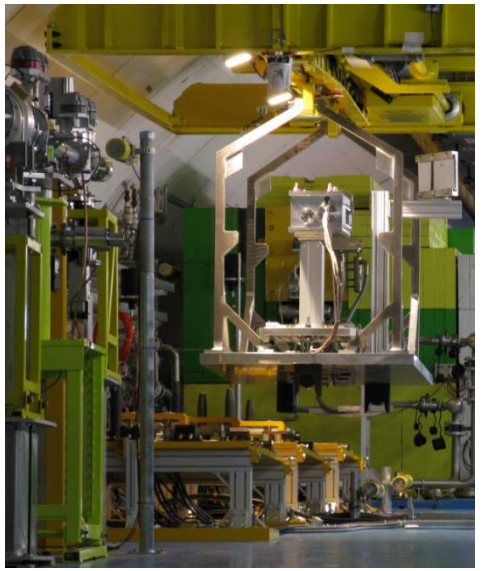
- Laser-Doppler vibrometer
  - Measuring surface velocities of several m/s
  - tens of MHz sampling
- Optical high-speed recording
  - High-speed camera with several kHz frame rate
- Diamond detectors, strain gauges, temperature sensors, microphones …
- Transverse beam monitoring
  - High precision (< 0.1 mm) alignment to experimental tables
  - Based on pCVD diamond detectors

Remote handling

Standardized mobile table

- Testing setup independent of beam line availability
  - dummy target setup in cold area
- Minimising intervention time in RP area





- Equipped with auto-plugs
  - Signals
  - Power
  - Water

From a proposal to beam time

- Submit application for HiRadMat beam time
  - Application = scientific interest (1-2 pages), pulse list, installation sketch, preliminary safety documents
- Initial discussion with Facility Management
  - feasibility of installation, compatibility with existing infrastructure
- Review by HiRadMat Scientific Board
  - Committee assesses the scientific value and the feasibility of the presented experiment
- From beam slot to scheduled beam time - HiRadMat Technical Board
  - safety review: interview with safety officials, analysis of the submitted safety file (includes dismantling!)
  - technical review: interview with beam operations

positive recommendation of all above, validates the beam slot allocation to the schedule

- Beam time
- Dismantling - analysis of results - feedback on publications to HiRadMat Scientific Board

Outlook

- HiRadMat is a young facility with growing interest due to its uniqueness from various fields in Accelerator R&D and beyond.
- specifically designed to perform experiments with high energy beams impacting on materials.

- First year (2012) of operations: 9 experiments successfully completed

- Beam returns in November 2014

The facility is available to the world-wide community.