HiRadMat at CERN SPS:

A dedicated in-beam test facility

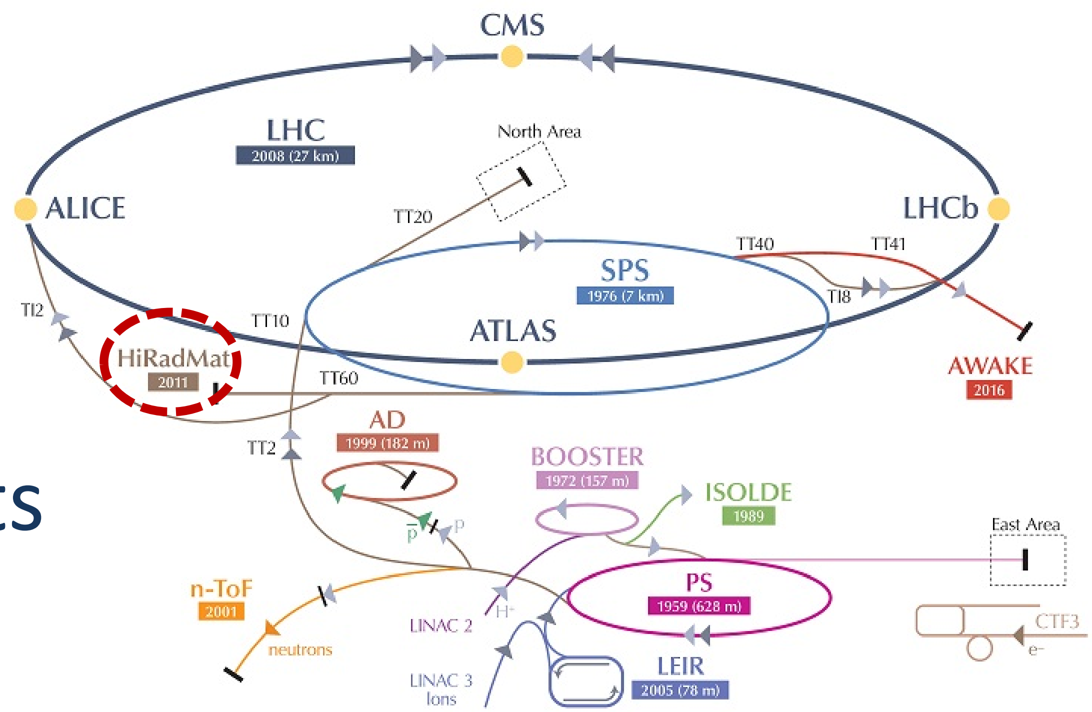
http://cern.ch/hiradmat

Adrian Fabich

5th High Power Targetry Workshop
FNAL, 20th-23rd May 2014

Contents

- Motivation and parameters of HiRadMat
- Facility layout



- Former experiments
- Present upgrade
- Future proposals

Motivation

Initiated for LHC component testing (proposed by R. Assmann), it can also be used for other accelerator studies and applications.

High-**Ra**diation to **Ma**terials

- Dedicated facility
- Moving away from ad-hoc set-ups (e.g. in LHC)

- Studying the impact of intense pulsed beams on materials
  - material damage
  - material vaporization
  - Thermal management
  - Mechanical 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
High-Radiation to Materials

SPS beam parameters to HiRadMat

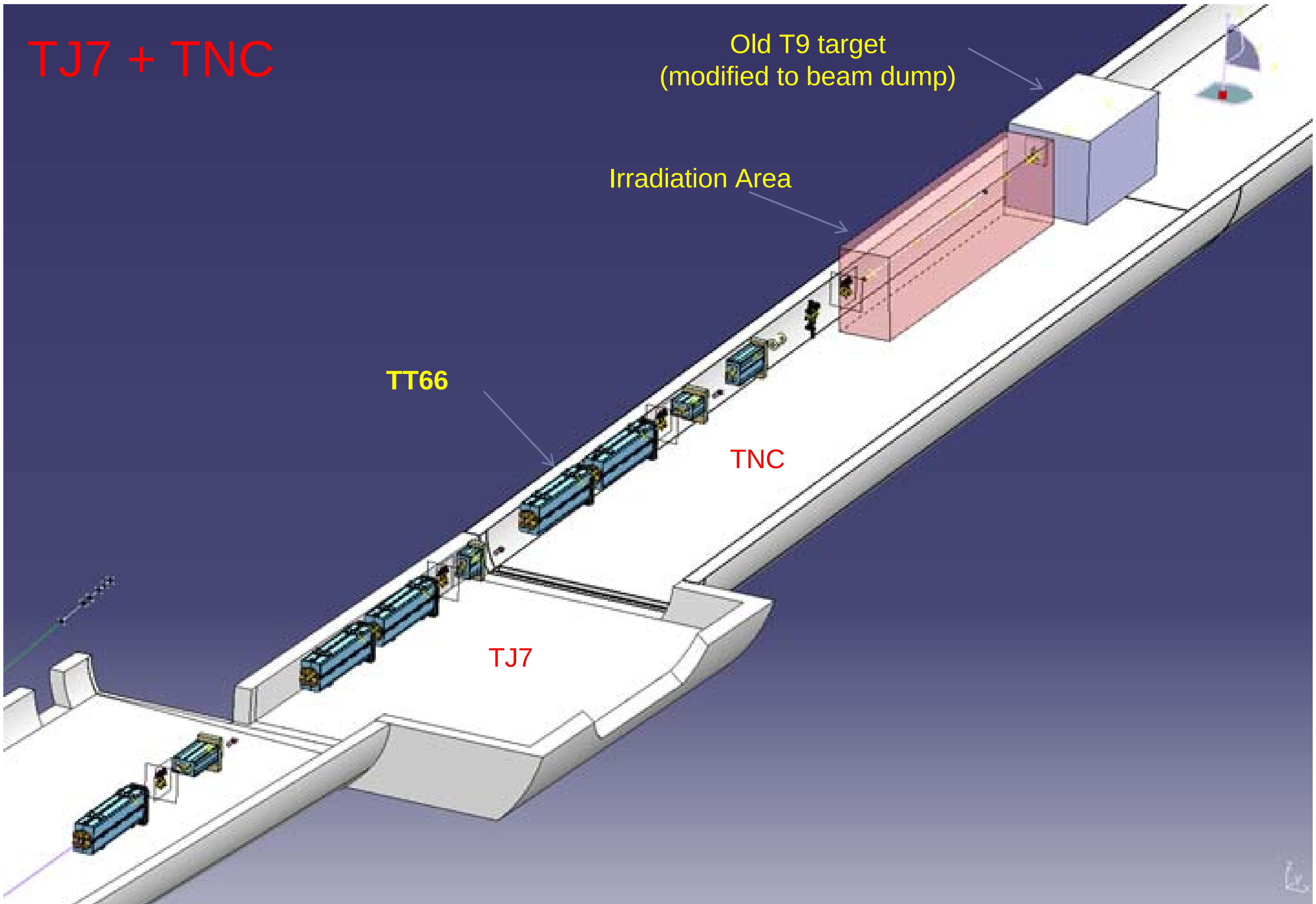
- LHC injection like beam

	Protons	Heavy ions (Pb^{82+})
Beam energy	440 GeV	173 GeV/u
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
Beam spot	variable around 1 mm^2	
Pulse energy (max)	3.4 MJ	21 kJ

- Annual intensity budget limited to ~10^{16} pot.
  - Environmental RP aspects
  - Limited SPS beam time
  - Enabling experimenters' access

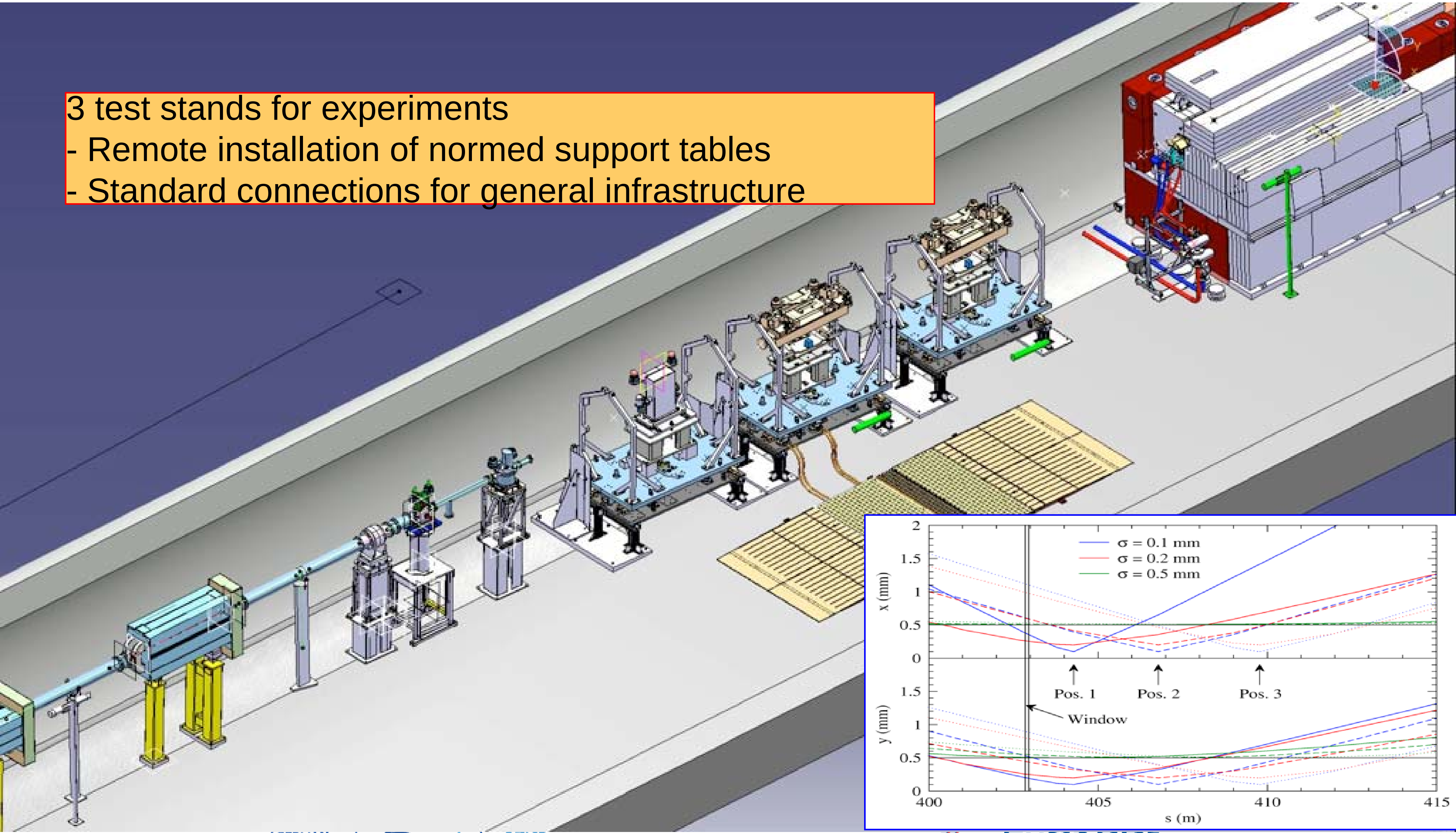
"Single-shot" experiments

Layout Experimental Area (1)

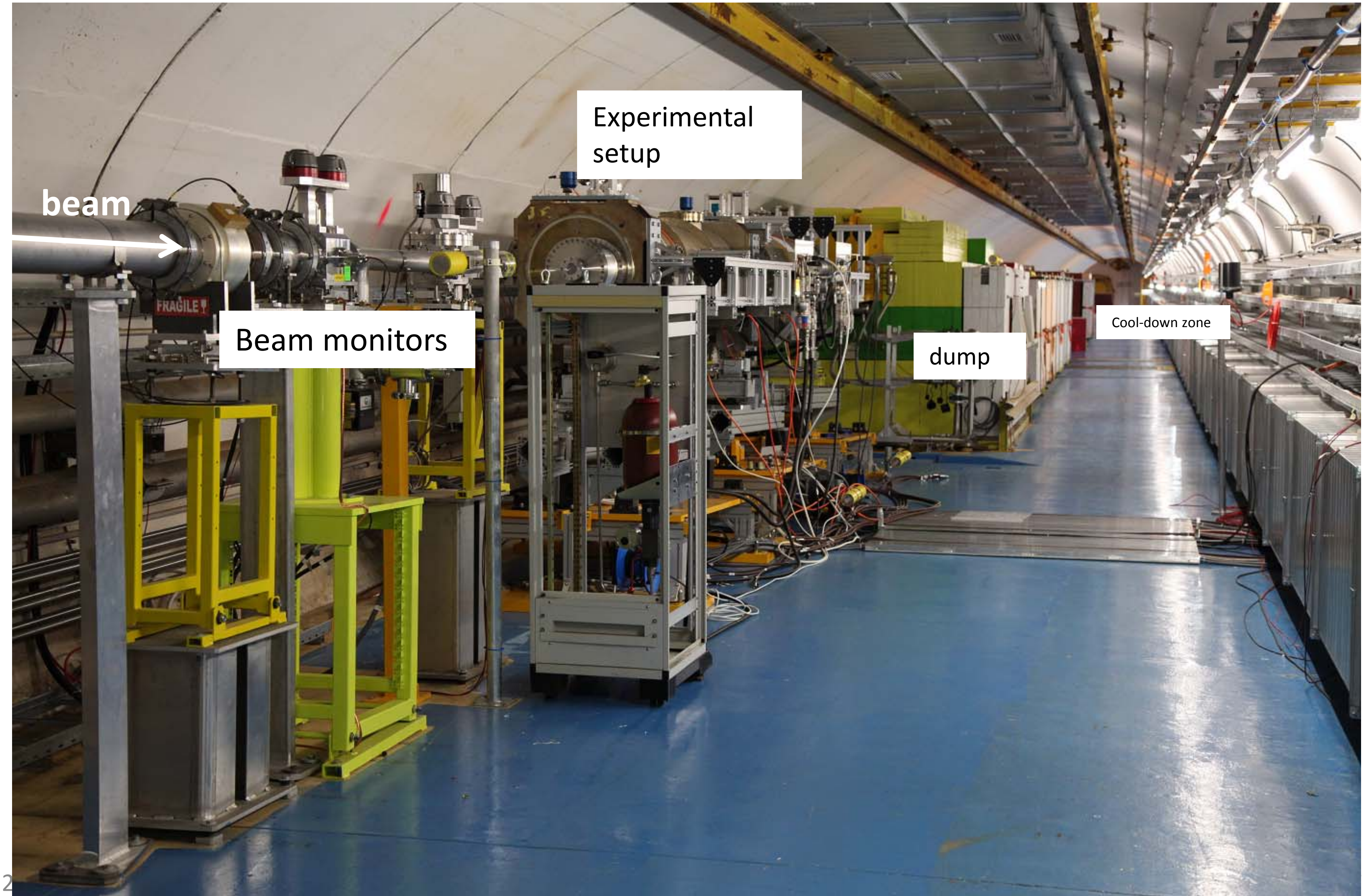


Layout Experimental Area (2)

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

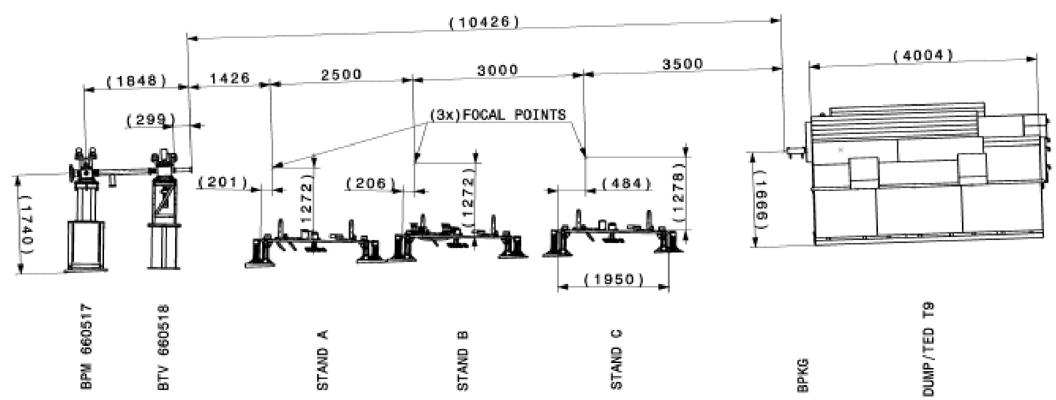


Target area


beam
Experimental setup
Beam monitors
dump
Cool-down zone
FRAGILE

Remote handling

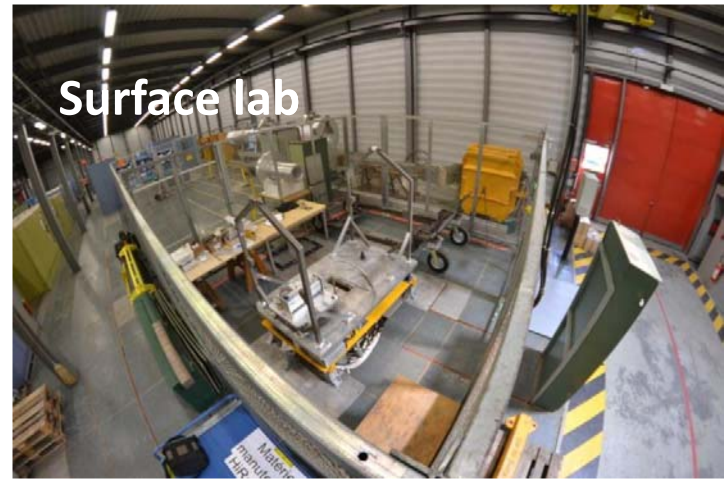
- Equipped with automatic connections
  - Signals
  - Power
  - Water



Facility services

Provision of dedicated irradiation infrastructure

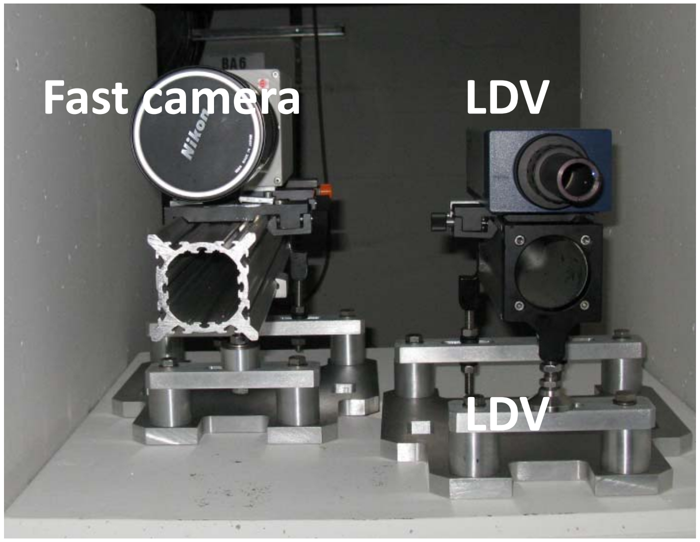
- Preparation lab at surface
  - Same interfaces as in the tunnel
- Control room
- Irradiation position
  - Standardized installation (remote)
  - General supplies (water, electricity, cabling)
  - Beam monitoring
- Observation tools
  - Camera, LDV, BLMs (diamond)
- Application/logistics/installation at CERN



Measurement tools

With the expertise of various groups at CERN

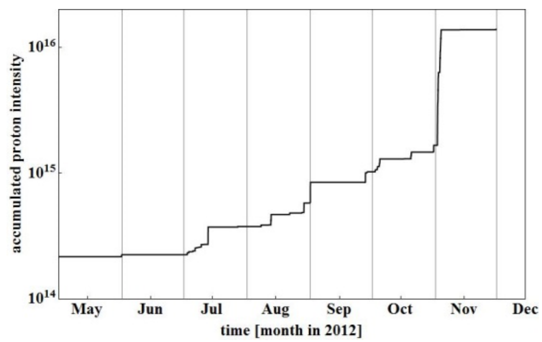
- Laser-Doppler vibrometer
  - Measuring surface velocities of several m/s
  - tens of MHz sampling
- Optical high-speed recording
  - High-speed camera with several kHz frame rate

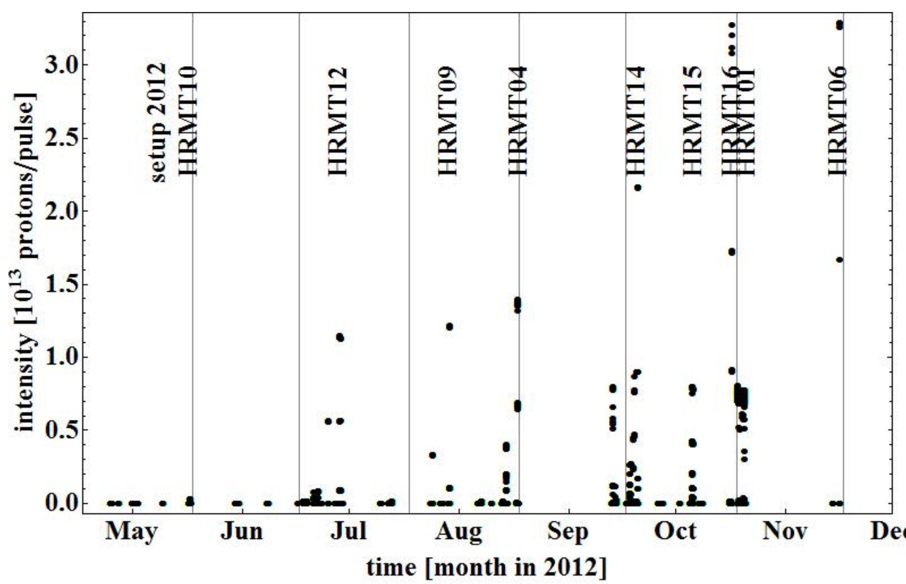


- Diamond detectors, strain gauges, temperature sensors, microphones …
- Transverse beam monitoring
  - High precision (< 0.1 mm) alignment to experimental tables
  - Based on pCVD diamond detectors

Start-up 2011/2012

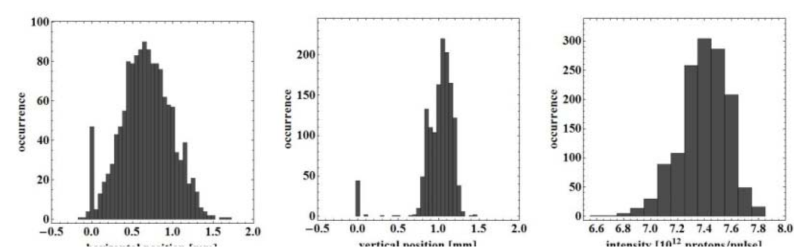
- 2011: commissioning (project leader I. Efthymiopoulos)
- 2012: first year of operations
  - 9 experiments completed successfully
  - On average every 4 weeks





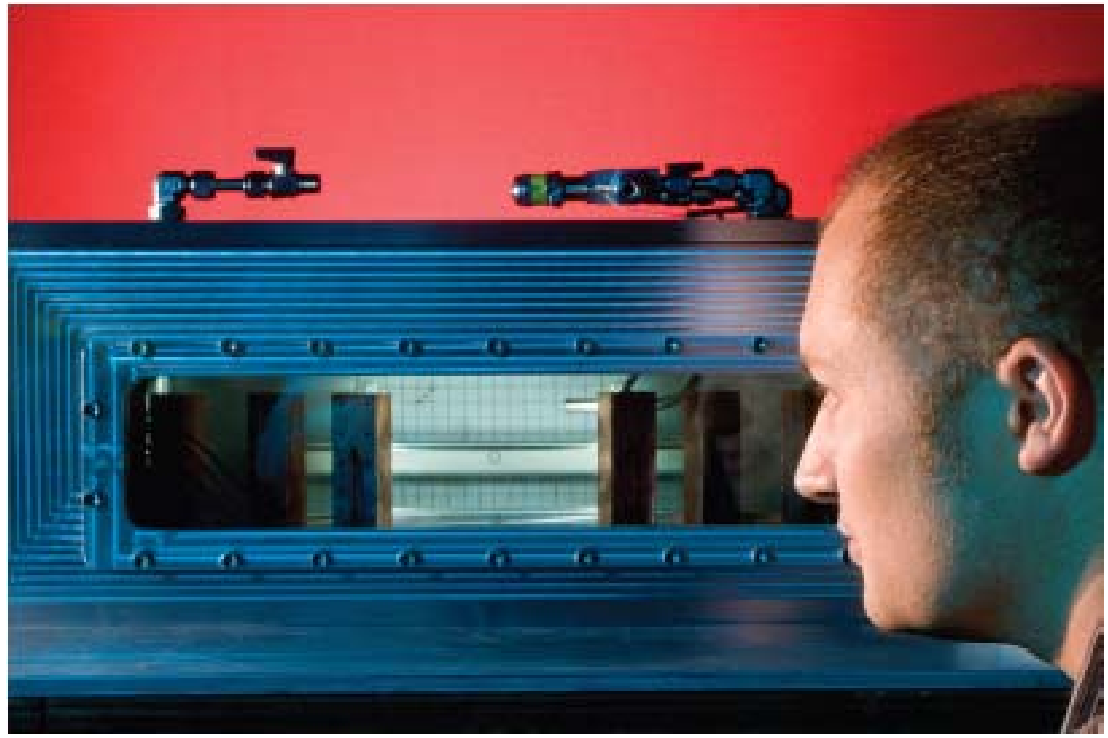
  - $1.4*10^{16}$ pot

2012: only 48 hours of SPS cycling with destination HiRadMat



Experiments in 2012

- RIB target R&D
- LHC transfer collimator (2x)
- BLM validation
- RP benchmarking
- Crystal collimation

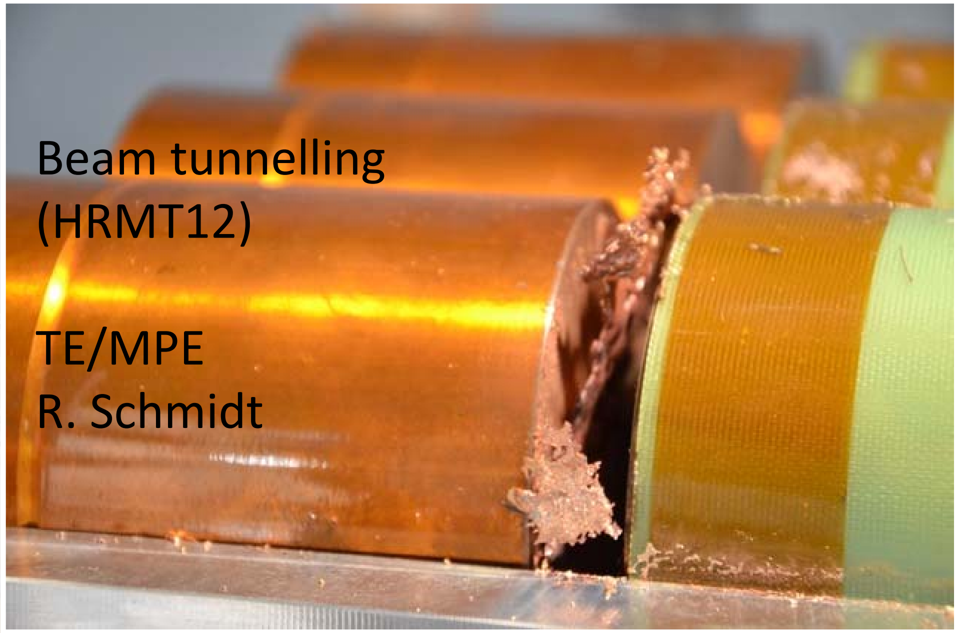


Powder target (HRMT10)

RAL
C. Densham

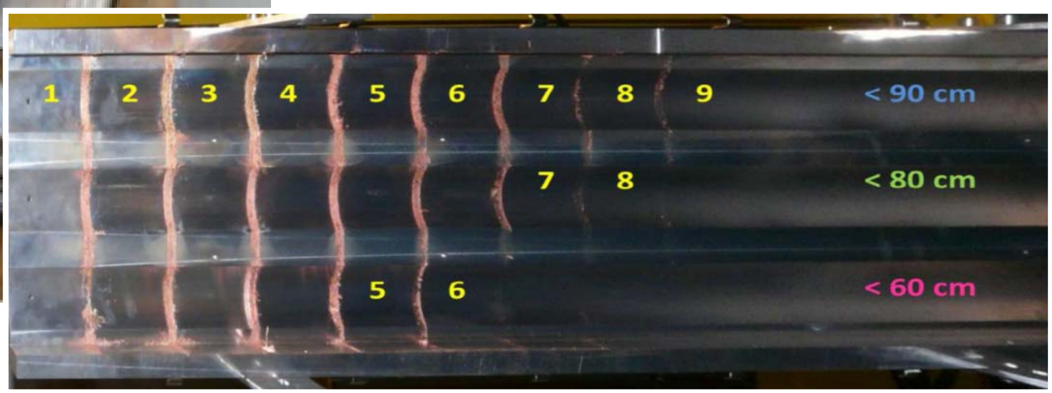
See http://cern.ch/hiradmat for links

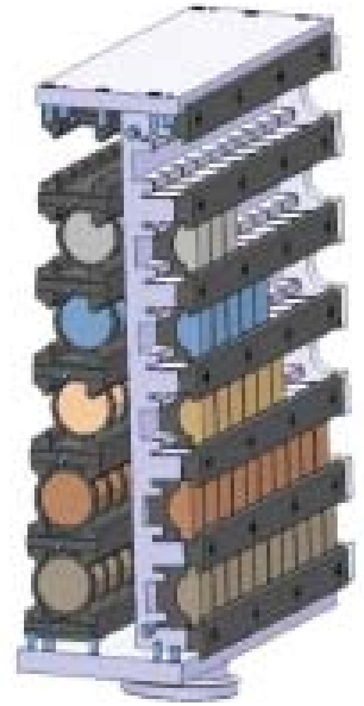
Material/collimator tests



Beam tunnelling
(HRMT12)

TE/MPE
R. Schmidt



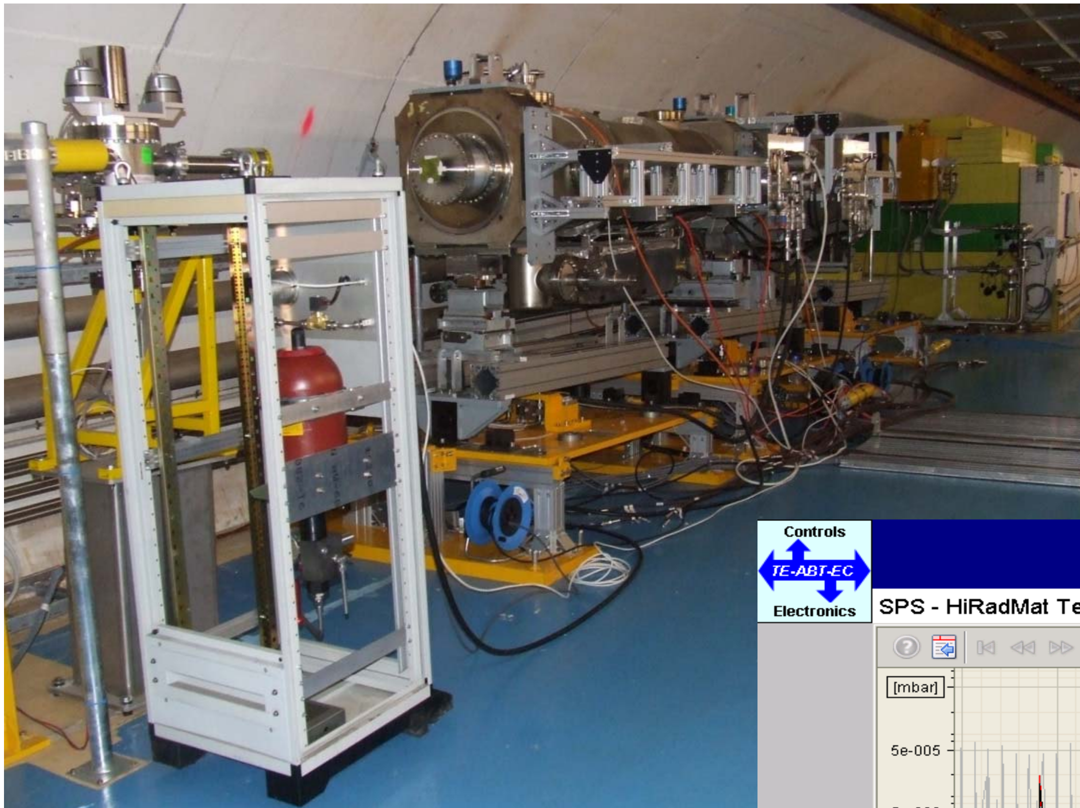


Collimator
Materials
(HRMT14)

EN/MME
A. Bertarelli

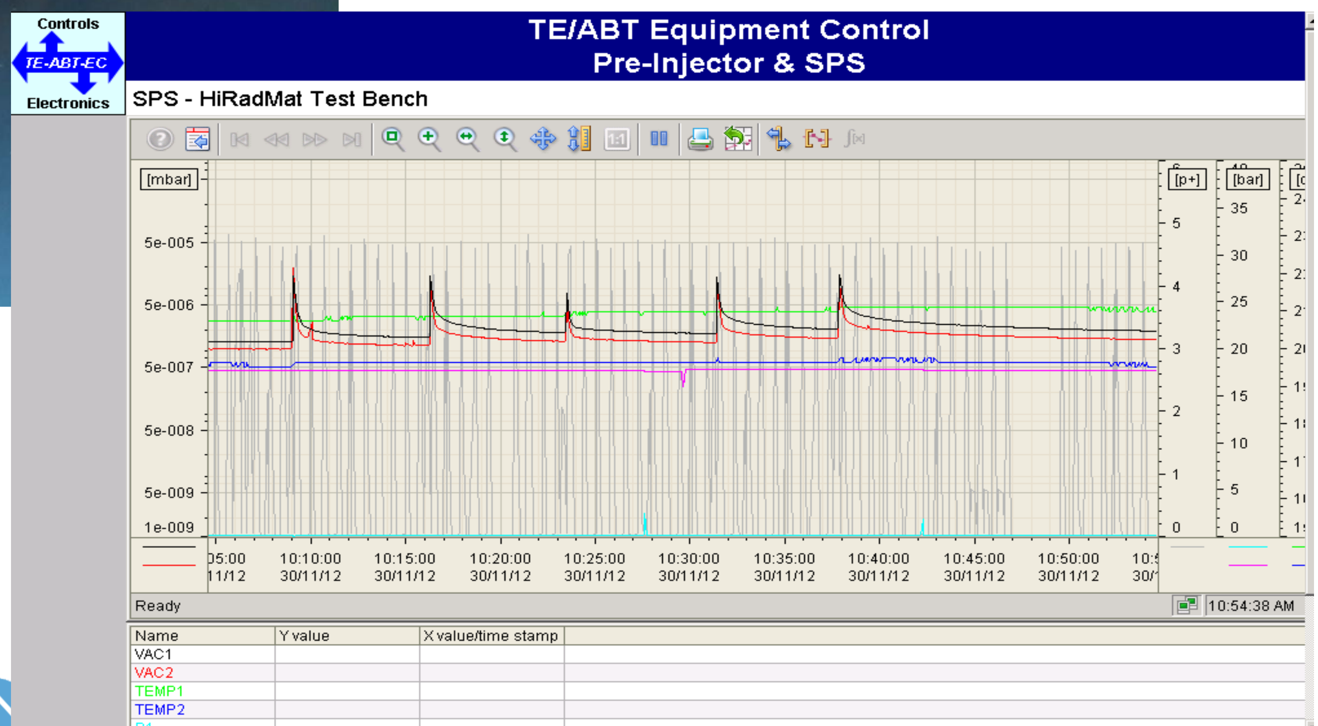
See http://cern.ch/hiradmat for links

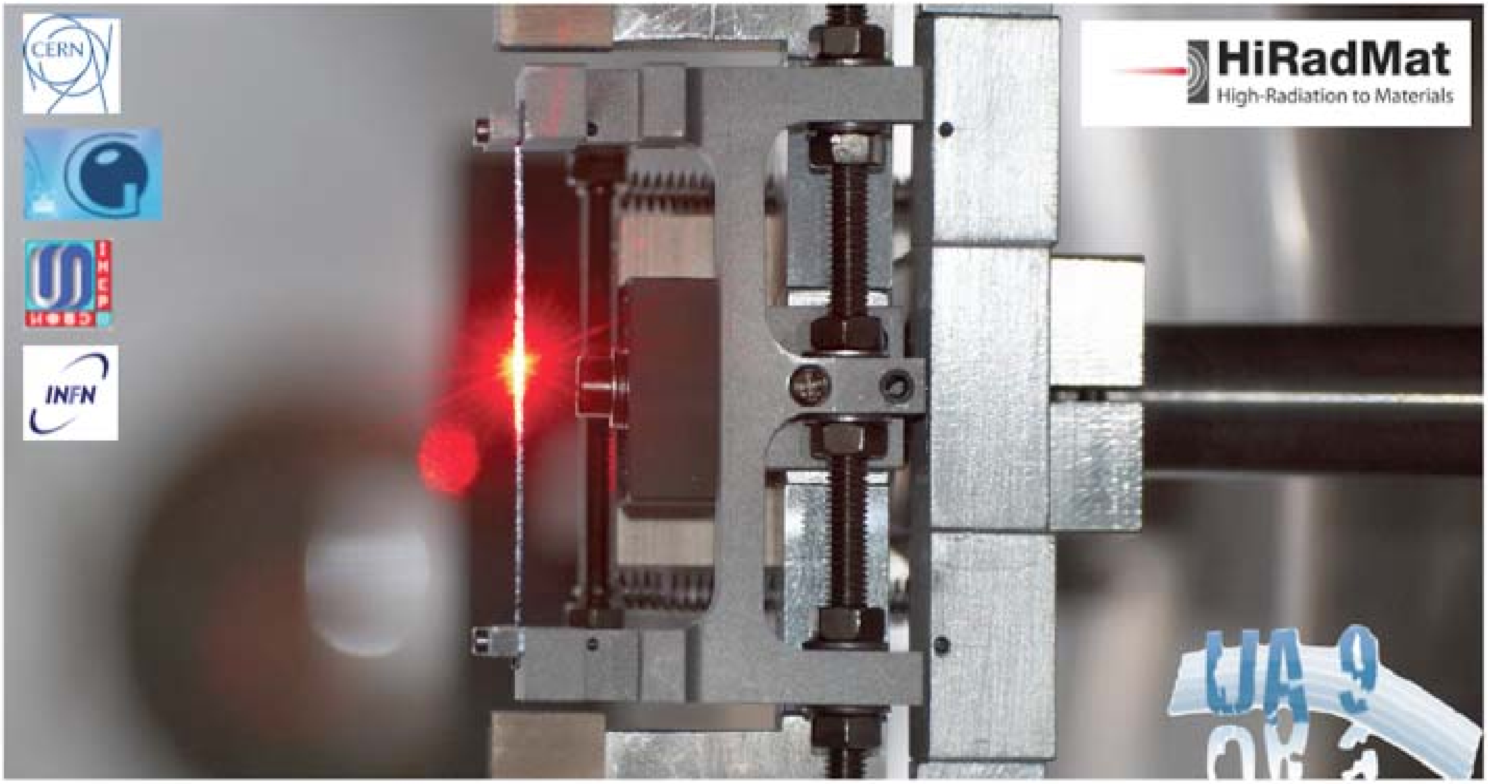
TPSG4 - 2012



Robustness test of a beam septum protection collimator; 9 m long experimental installation

J. Borburgh, CERN TE





HiRadMat Scientific and Technical board - 18 October 2012

HRMT16-UA9CRY experiment

Simone Montesano (CERN – EN/STI)

Reporting on the work by many people including:
A. Lechner, M. Di Castro, C. Maglioni, A. Perillo
Marcone, J. Lendaro, F. Loprete, M. Calviani, G.
Smirnov, R. Losito and W. Scandale

A feasibility experiment of a W-powder target (HRMT-10)

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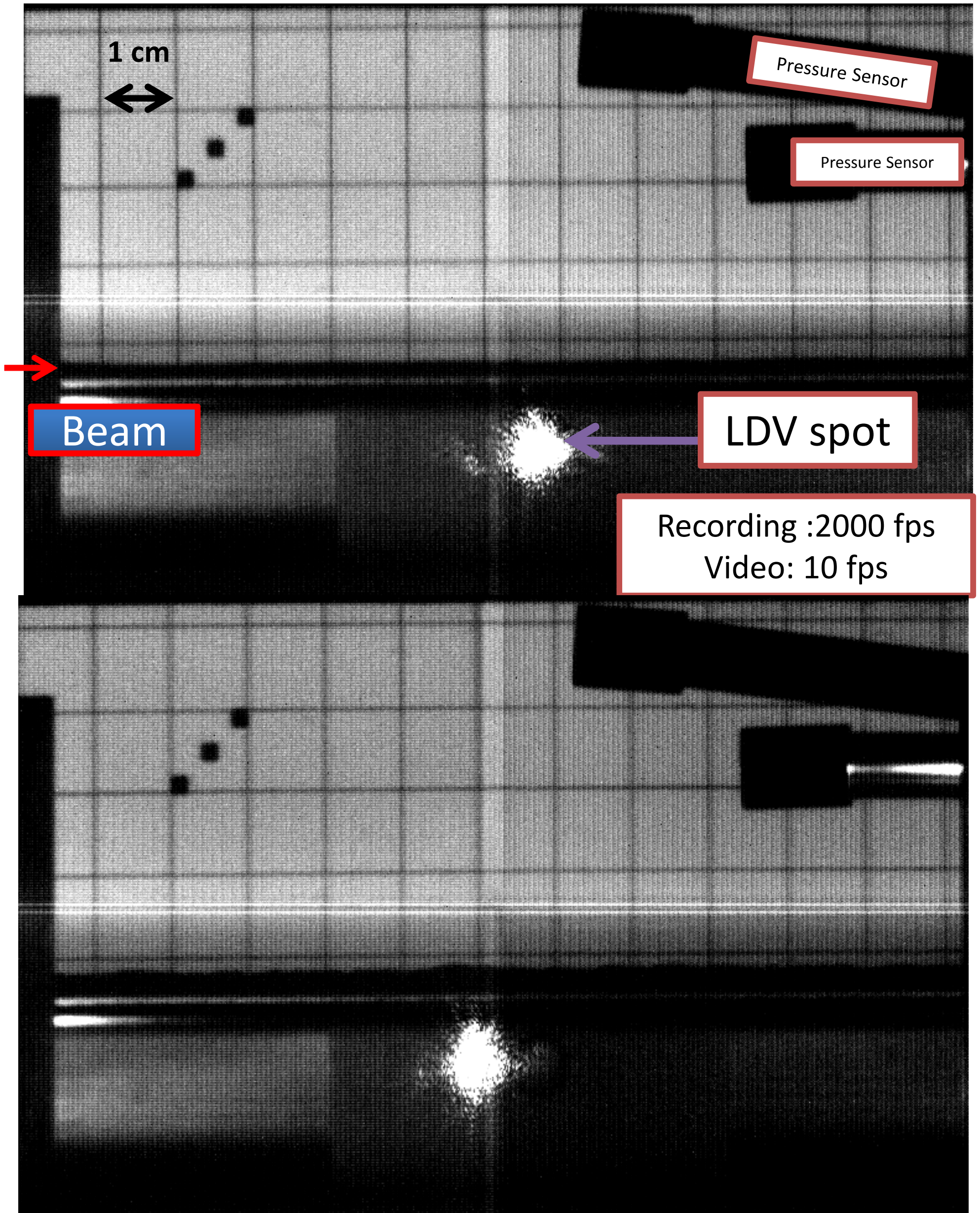
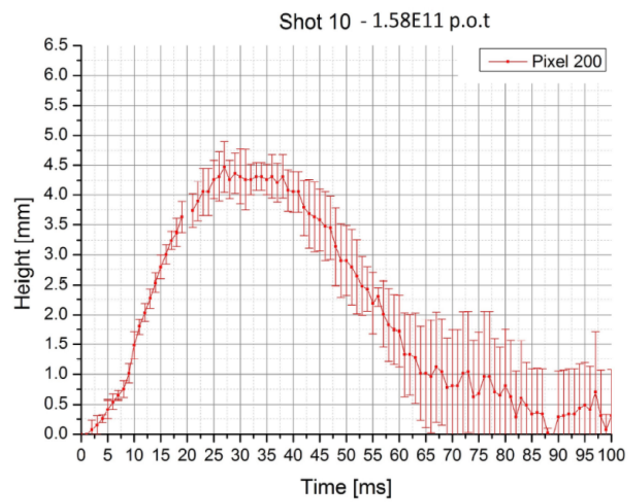


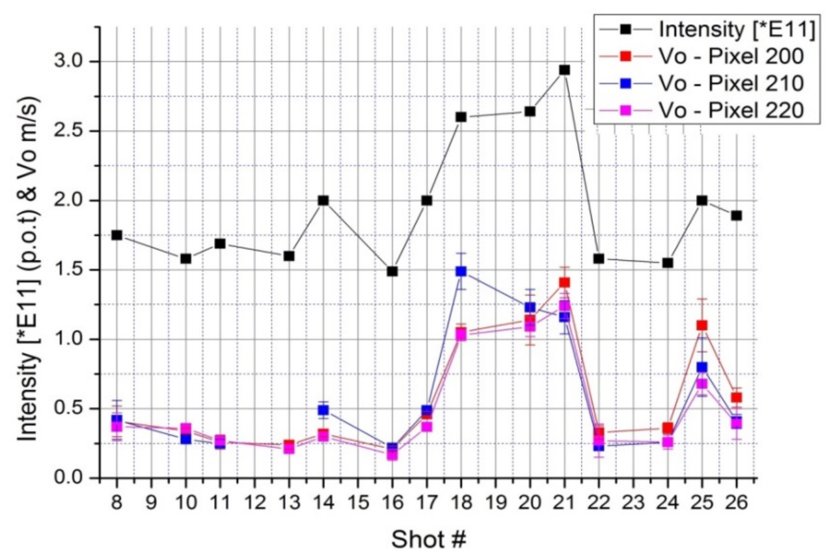
1.75E11 p.o.t: First significant disruption



ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Science & Technology Facilities Council
Rutherford Appleton Laboratory

1.85E11 p.o.t: Different reaction of the powder. Due to the increased surface roughness.



Facility upgrades

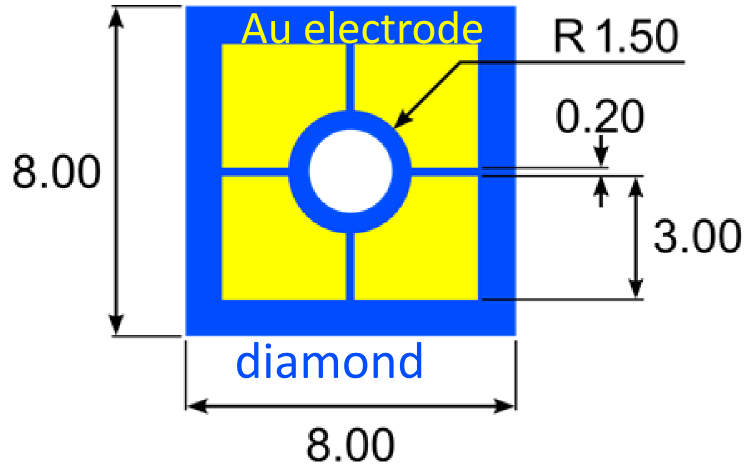
Based on experience gained during 2012:

- Extending the general infrastructure
  - Additional cabling for signals, vacuum and 220V; to be installed in autumn 2013
- Adding a beam position monitor
  - High precision alignment to experimental tables
  - Based on pCVD diamond detectors
- Removal of remaining experiments from tunnel

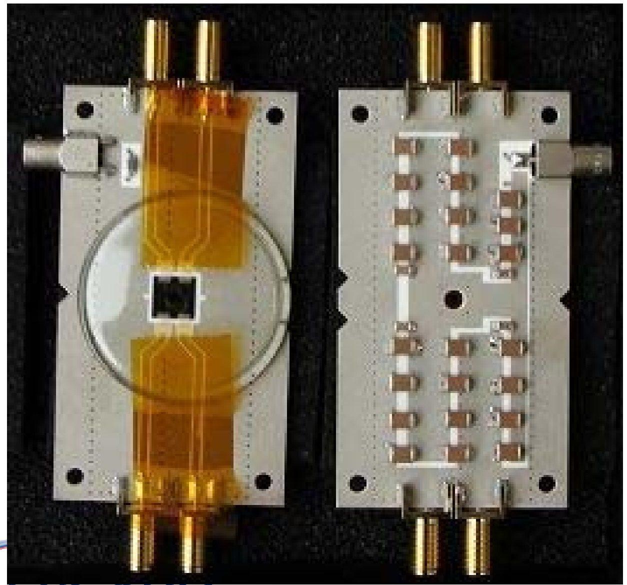
Beam position

- Present BPM at about 5 m upstream of experiment provides limited position precision

- Requirements:
  - Online measurement
  - Single bunch resolution
  - 0.1 mm transverse beam position
    - precision at experiment
  - Beam sigma measurement
  - Full intensity range (up to 10^{14} p^{+}/pulse)

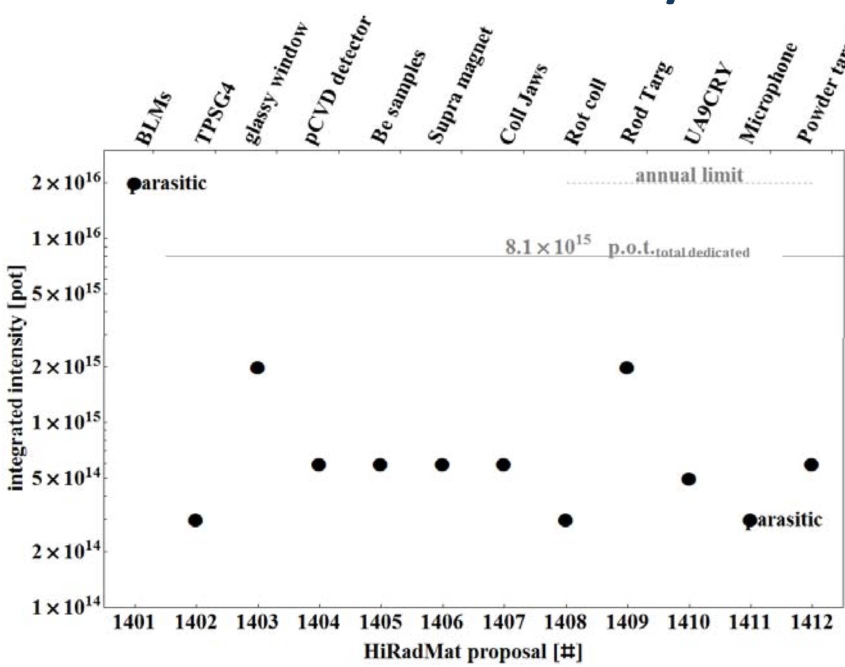


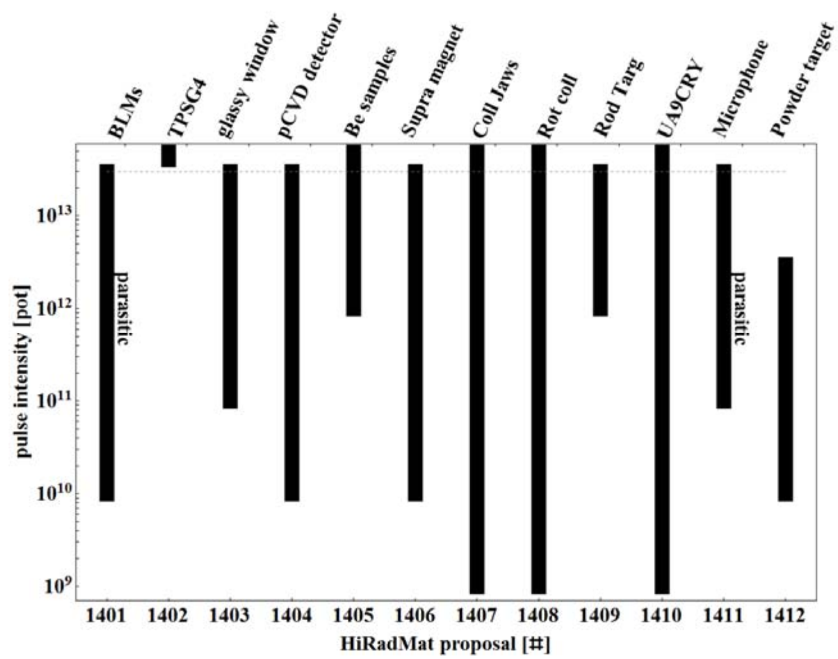
- Using diamond detectors
- Placed just upstream of experiment
- Measuring beam halo



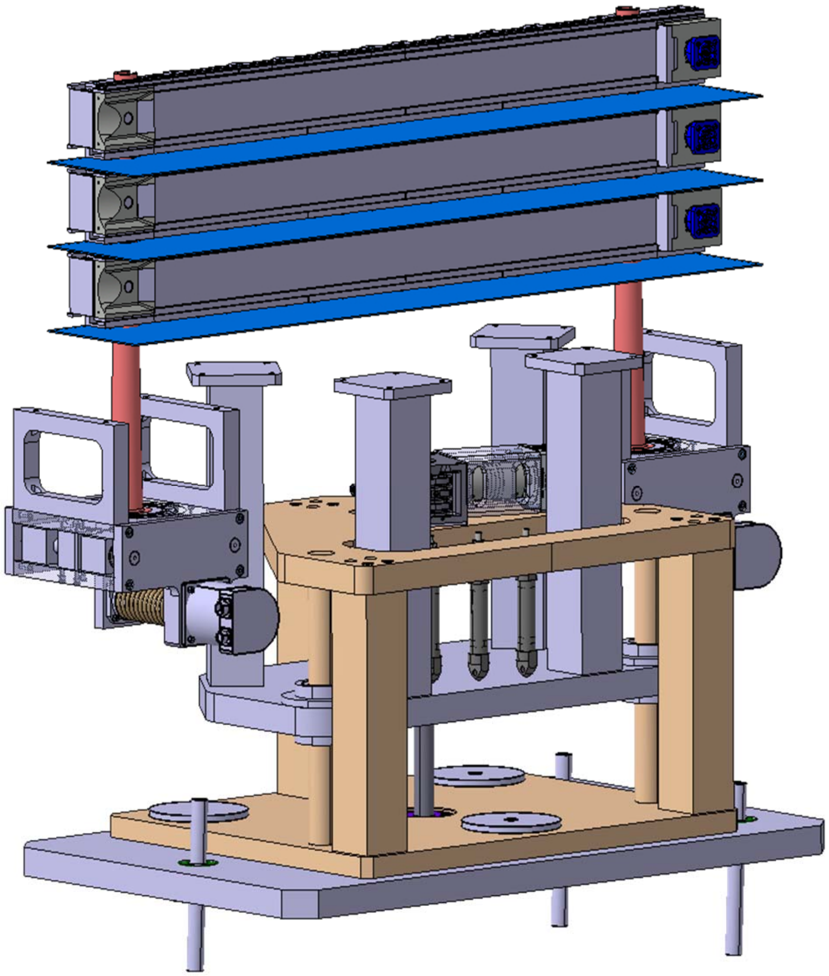
Proposals 2014/2015

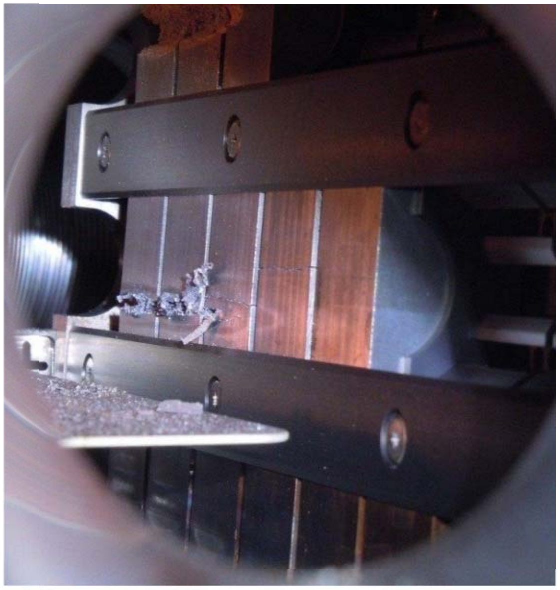
- Call for proposals in spring 2014
  - 12 applications
- Beam run 2014/15 allows about 12 beam slots



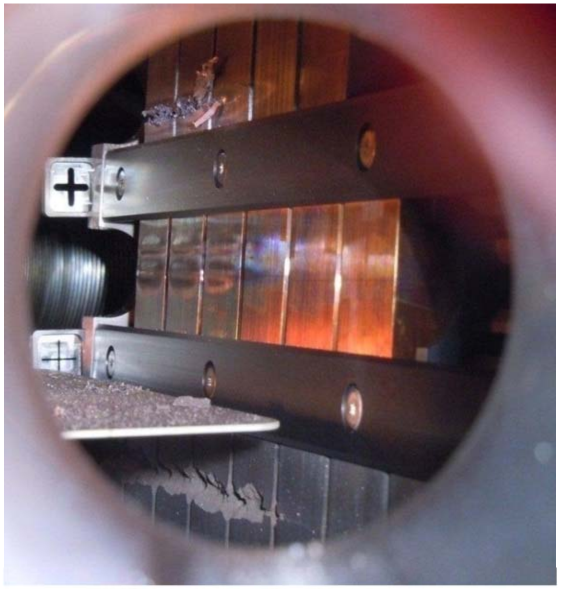


Collimators



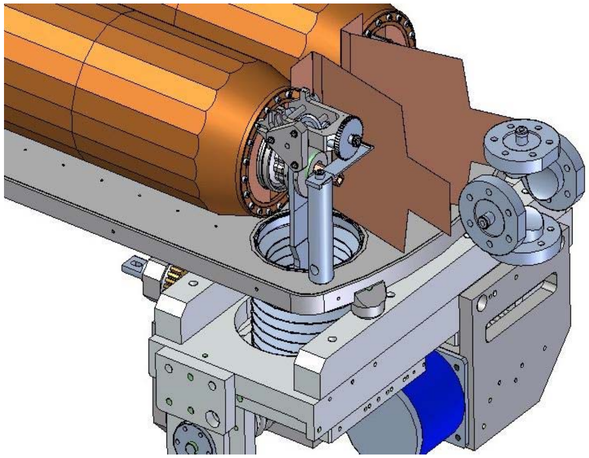


Molybdenum, 72 & 144 bunches



Glidcop, 72 bunches (2 x)

Molybdenum-Copper-Diamond 144 bunches

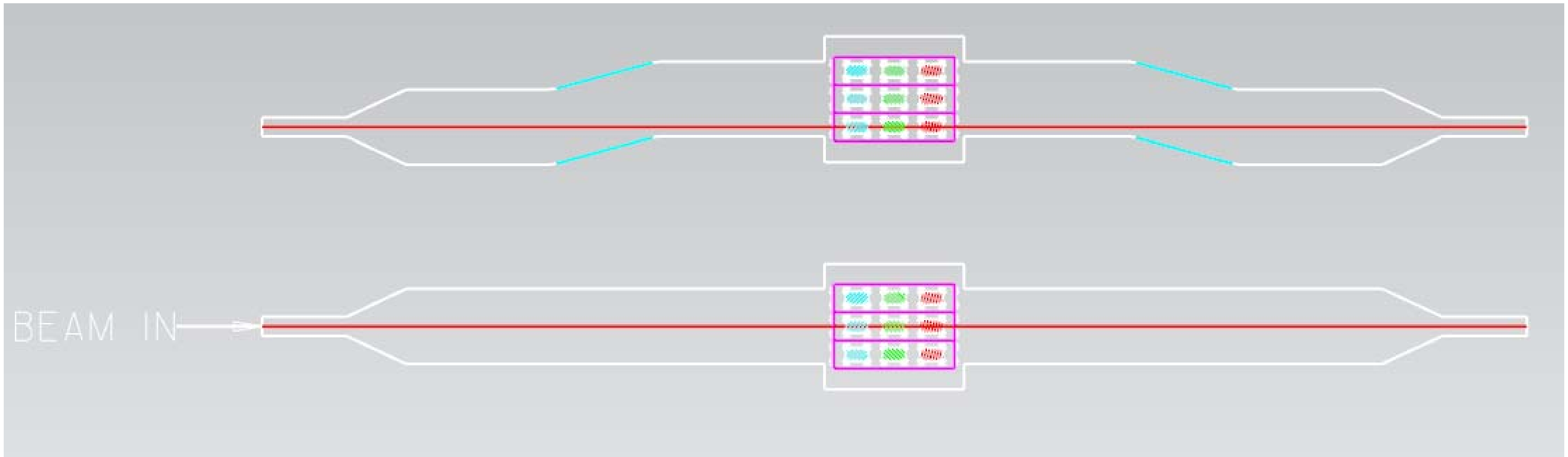


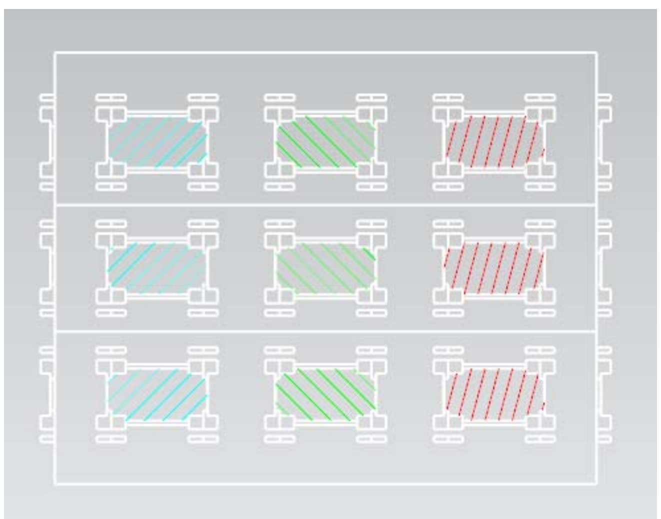
SLAC

A. Bertarelli CERN MME
S. Redaelli CERN ABP
et al.

Beryllium specimen

P. Hurh (FNAL), C. Densham (RAL) et al.



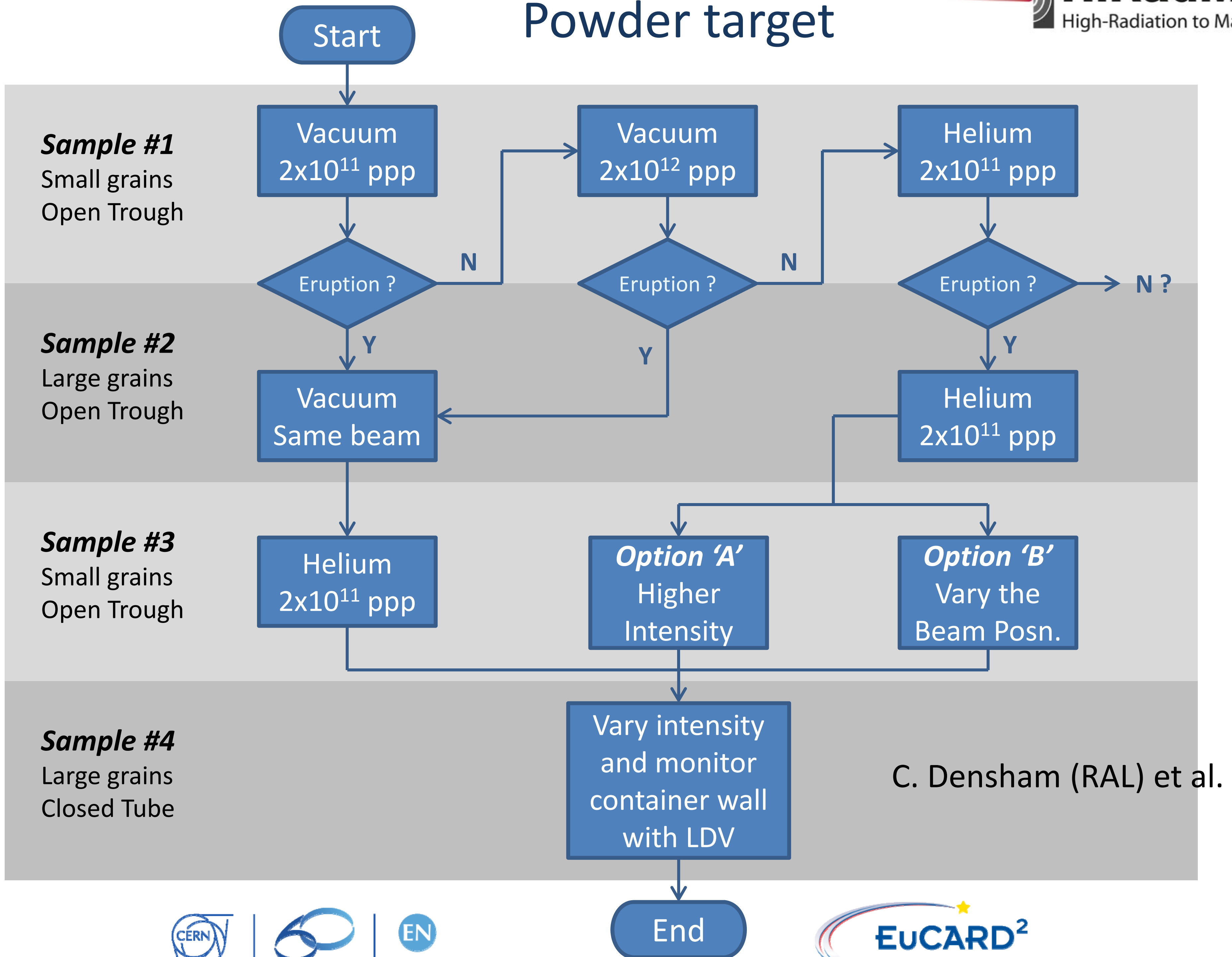


Multiple samples exploiting long interaction length in beryllium.

Samples include:

- Different commercial grades of Be
- Thick & thin windows

Powder target



pbar target

- Pulse intensity ~1-5*10^{12} p/pulse
- Spot size: 1x1 mm^2 → 1.5x1.5 mm^2
- Total number of medium-high intensity pulses: ~300-400
  - Ramp-up approach
  - Other ~200 low intensity pulses could be anticipated
- Integral intensity ~2*10^{15} POT
- Beam alignment/stability:
  - Maximum shift pulse-by-pulse **~100 μm**
    - Important to have it guaranteed, not only monitor
  - Monitor beam asymmetry **~100 μm**

HiRadMat
High-Radiation to Materials

Procedure for Experiments

1. Submit application for HiRadMat beam time
   - Application = scientific interest (1-2 pages), pulse list, installation sketch, preliminary safety documents

2. Initial discussion with Facility Management
   - feasibility of installation, compatibility with existing infrastructure

3. Review by HiRadMat Scientific Board
   - Evaluates the scientific merit of the proposed experiments, the proposed online measurements during beam time, the post-irradiation analysis plans and the expected results to the interest of the scientific community.
   - Distribute the financial support granted from the European community within EuCARD2-TransnationalAccess travel and accommodation subsistence to HiRadMat users

EuCARD²

4. From beam slot to scheduled beam time - HiRadMat Technical Board
   - safety review : interview with safety officials, analysis of the submitted safety file (includes dismantling!)
   - beam review : interview with beam operations and CCC
   - technical review : interview with HiRadMat technical coordination

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

- Beam time
- Dismantling - analysis of results - publications

Summary

- HiRadMat is a young facility with growing interest due to its uniqueness from various fields in Accelerator R&D and beyond.
- First year (2012) of operations: 9 experiments successfully completed
- Beam returns in October 2014

The facility is available to the world-wide community.