Experimental targetry at CERN

Adrian Fabich

Transformative Hadron Beamlines Workshop
BNL, 21.-23. July 2014

Overview

- Test objects: TARGET = OBSTACLE

  interacting with the beam resulting in energy deposition:

  material damage, material vaporisation, thermal management, radiation damage, beam induced pressure waves, thermal shock

  - Benchmarking for simulations, material properties
  - Prototyping

    “Thick” targets:
    - Production targets
    - Collimators
    - Accidental exposures of beam elements (e.g. magnets)

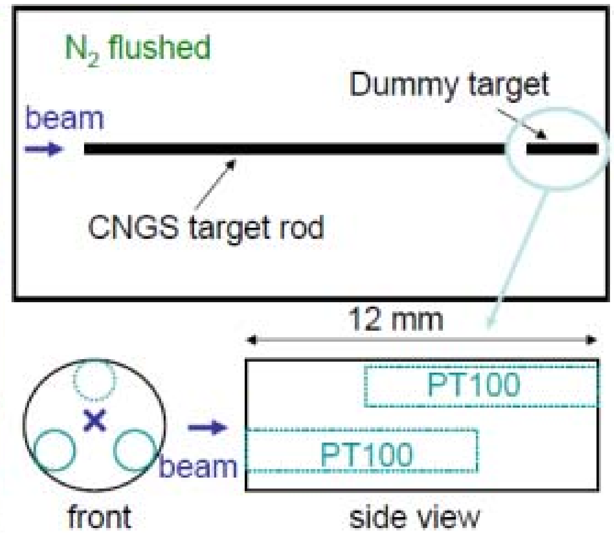
    “Thin” targets
    - Beam measurement – detectors and monitors
      - Also off-beam-axis in parasitic mode (e.g. BLMs)
    - Vacuum windows/pipes
    - Collimators (bending crystals)

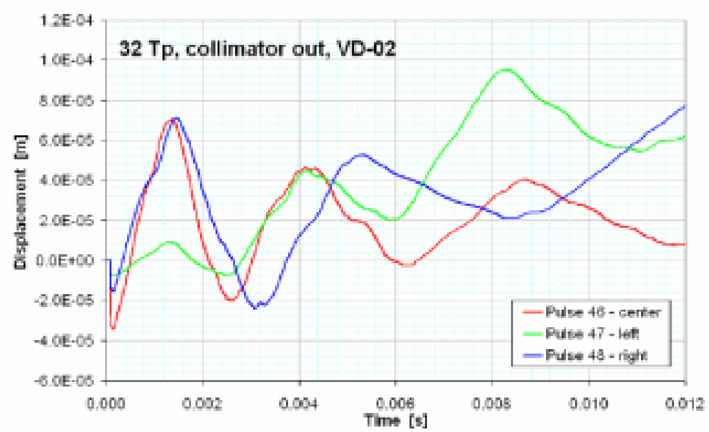
- Location of target tests? Parasitic or dedicated?

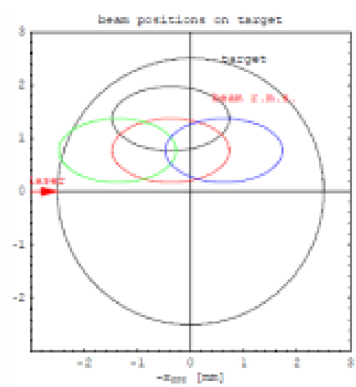
CNGS target

- Ad-hoc setup in LHC transfer line (2004)

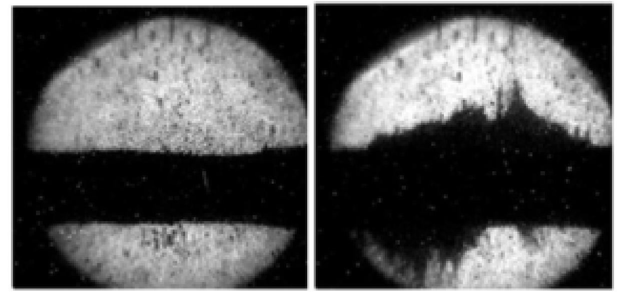
- Laser Doppler-Vibrometer
  - Mechanical deformation of rod







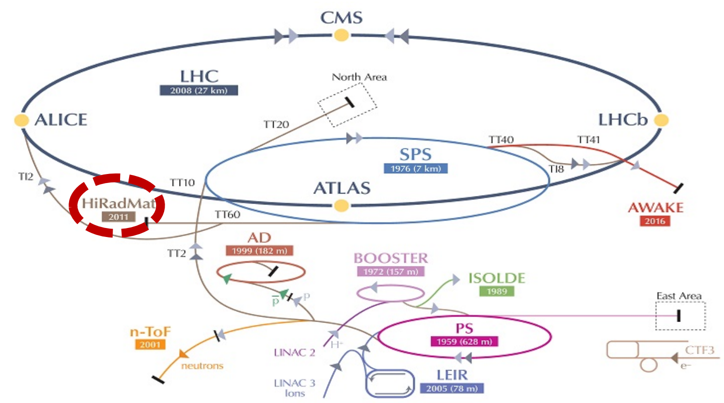
MERIT – mercury target test



- Temporary use of nToF primary line
- Required installation of all infrastructure

BNL, Princeton, ORNL, CERN, FNAL, RAL, MIT …

HiRadMat

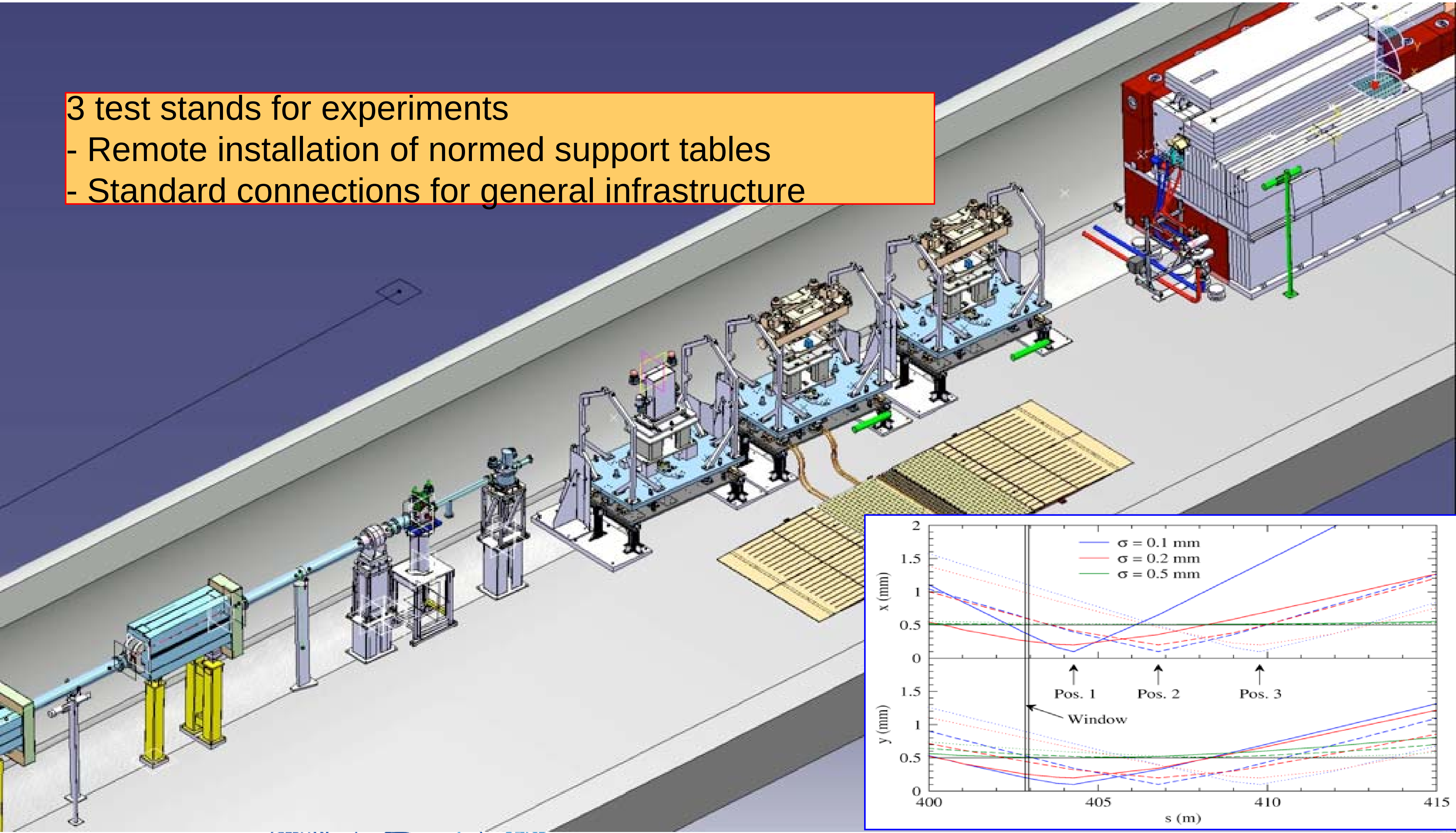


High-Radiation To Materials http://cern.ch/hiradmat

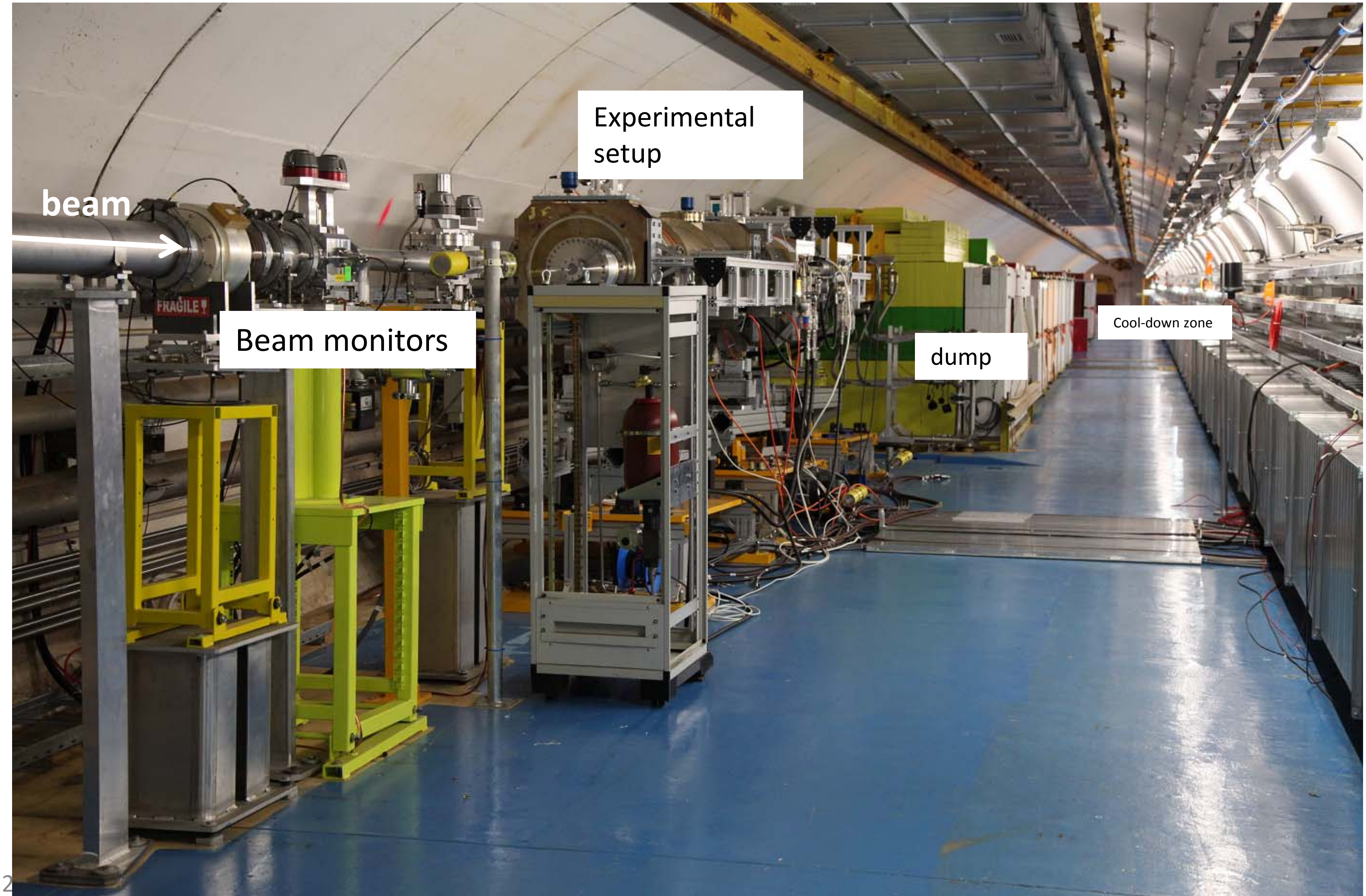
- Dedicated test facility
- Protons 440 GeV, also ions possible
  - In the higher range for production targets
  - With the small focus a higher pulse intensity can be simulated in terms of peak energy deposition.
- Maximum $5*10^{13}$ protons per pulse
- Tests with single pulses; HiRadMat is not an irradiation facility
  - Limited to ~10^{16} protons/year
  - Reduces residual radio-activity for manipulation
- Destructive tests possible as decoupled from accelerator machine/vacuum.

	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

Layout Experimental Area

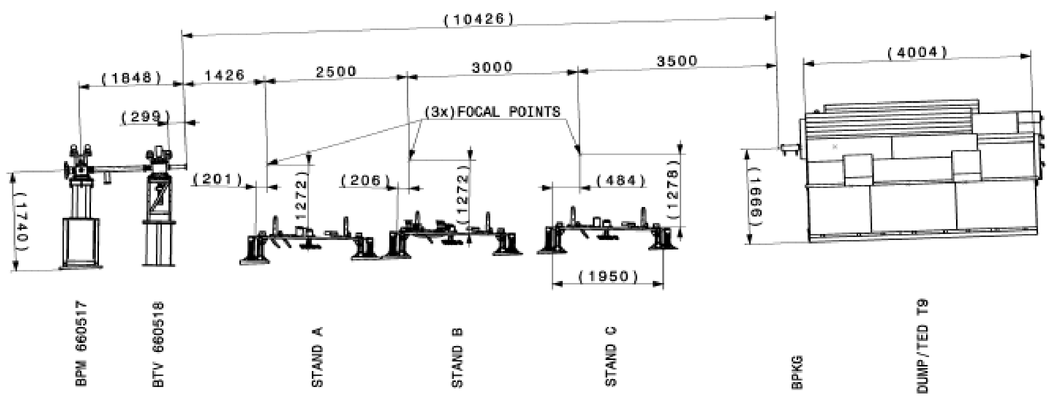


Target area


beam
Experimental setup
Beam monitors
FRAGILE
dump
Cool-down zone

Remote handling

- Equipped with automatic connections
  - Signals
  - Power
  - Water



Facility services

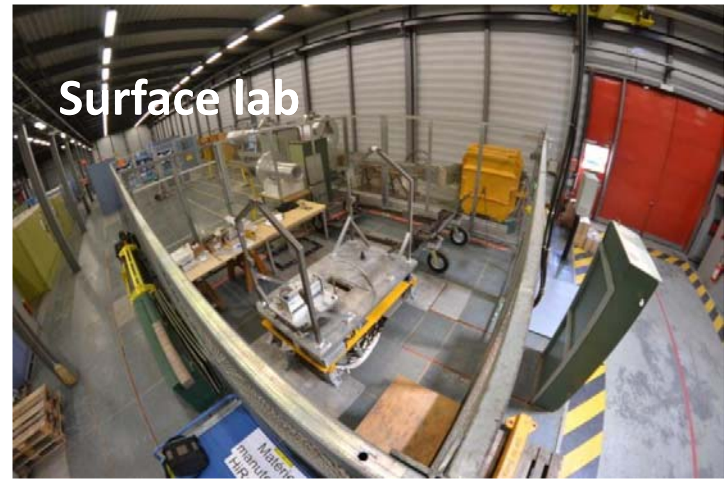
Provision of dedicated irradiation infrastructure

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

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

- Observation tools
  - Camera, LDV, BLMs (diamond)

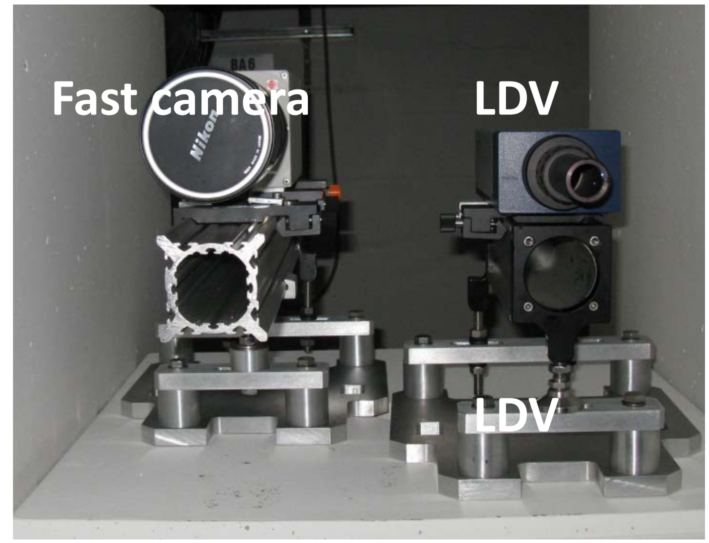
- Application/logistics/installation at CERN
- Safety Advice



Measurement tools

With the expertise of various groups at CERN

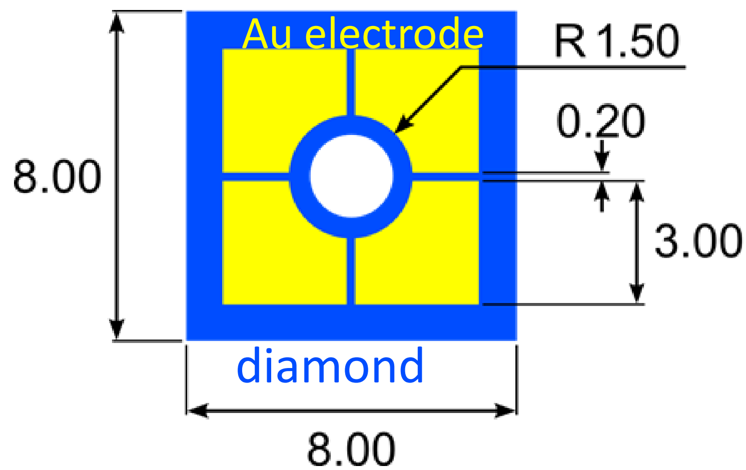
- Laser-Doppler vibrometer
  - Measuring surface velocities of several m/s
  - tens of MHz sampling

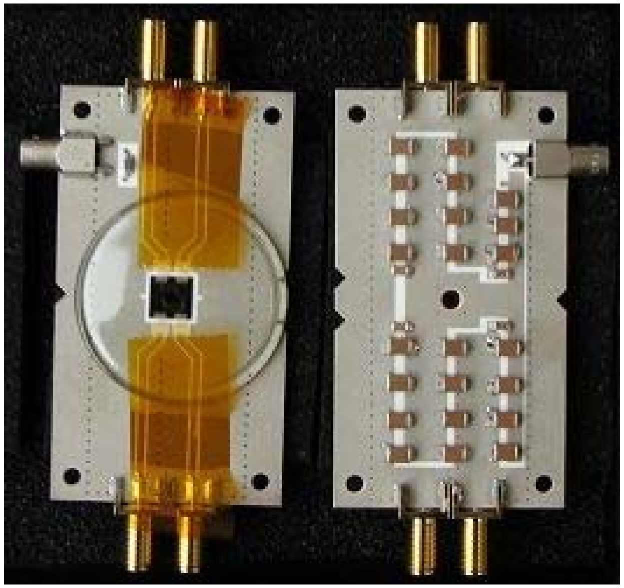


- Optical high-speed recording
  - High-speed camera with several kHz frame rate
- Diamond detectors, strain gauges, temperature sensors, microphones …
- Transverse beam monitoring
  - High precision (< 0.1 mm) alignment to experimental tables
  - Based on pCVD diamond detectors

Beam monitoring

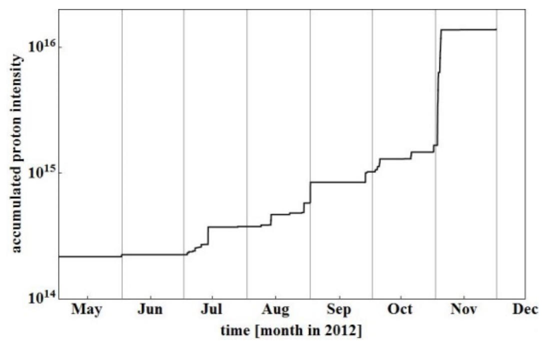
- Beam parameters to be measured **at the test object**
- Using diamond detectors on beam halo
- Requirements:
  - Online measurement
  - Single bunch resolution
  - 0.1 mm transverse beam position
    - precision at experiment
  - Beam sigma measurement
  - Full intensity range (up to 10^{14} p^{+}/pulse)

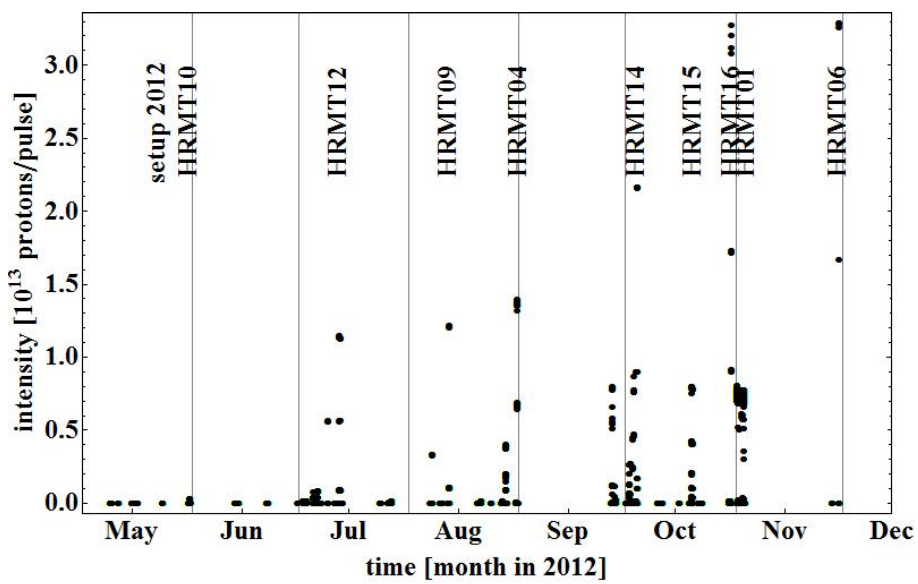




Start-up 2011/2012

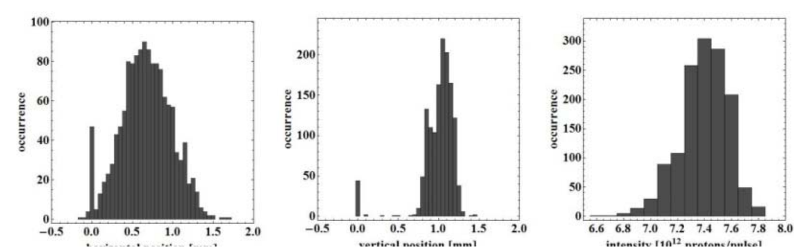
- 2011: commissioning (project leader I. Efthymiopoulos)
- 2012: first year of operations
  - 9 experiments completed successfully
  - On average every 4 weeks





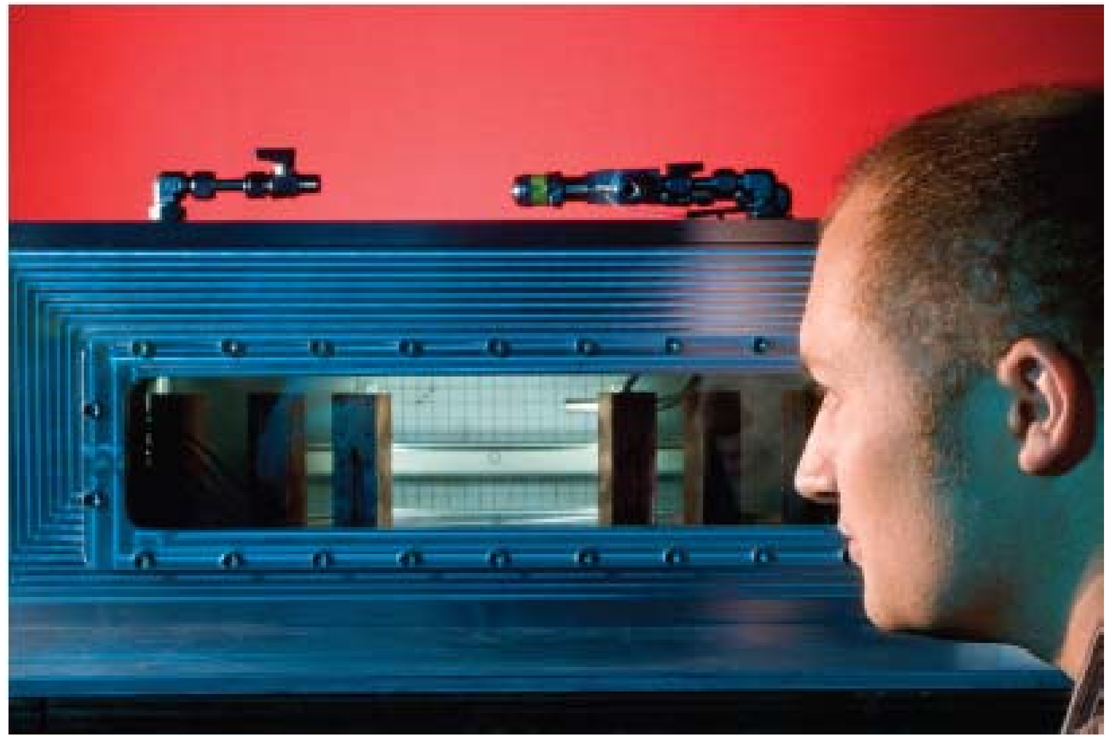
  - $1.4*10^{16}$ pot

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

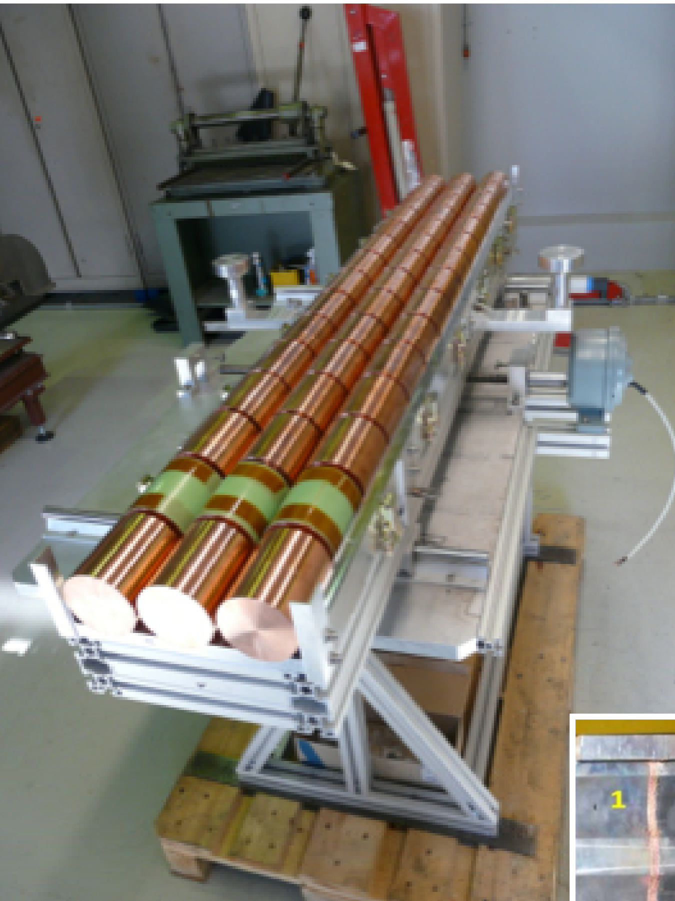


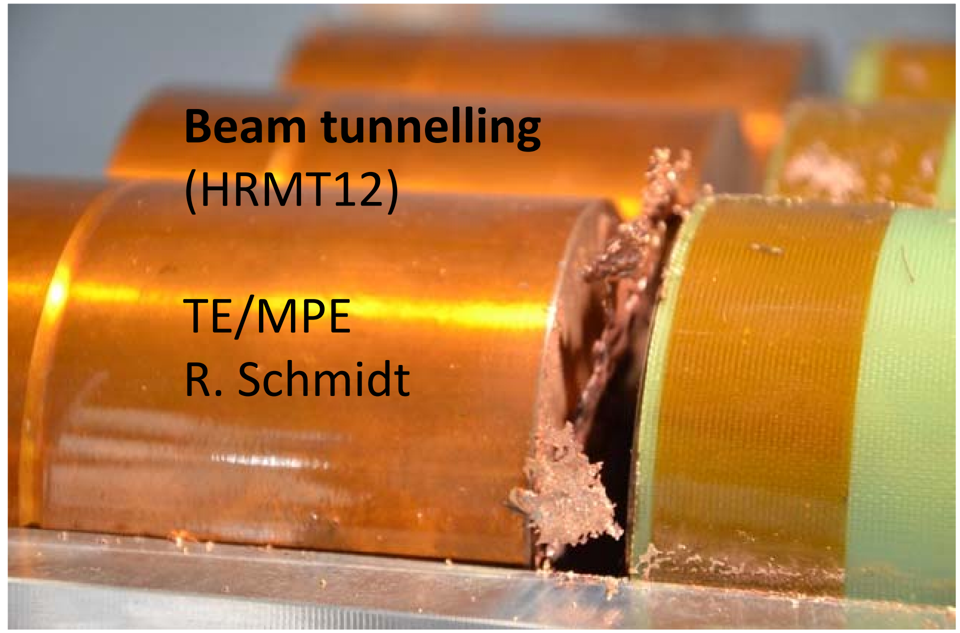
Powder target
(HRMT10)

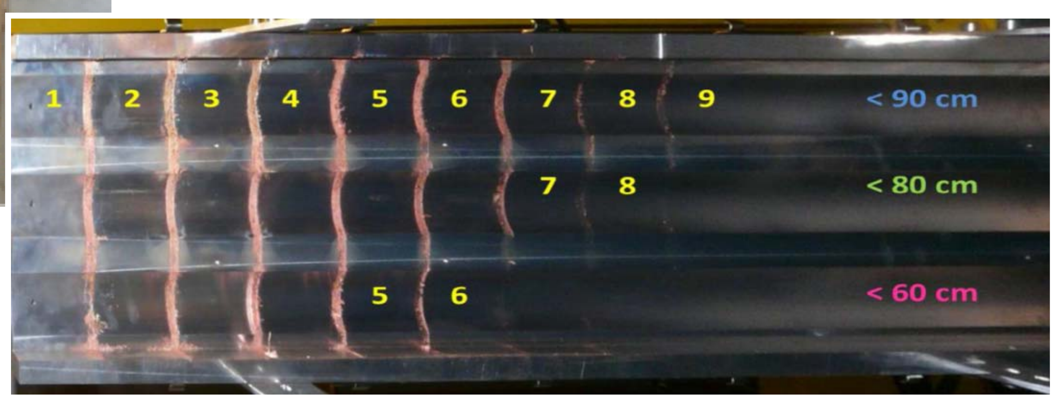
RAL
C. Densham

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

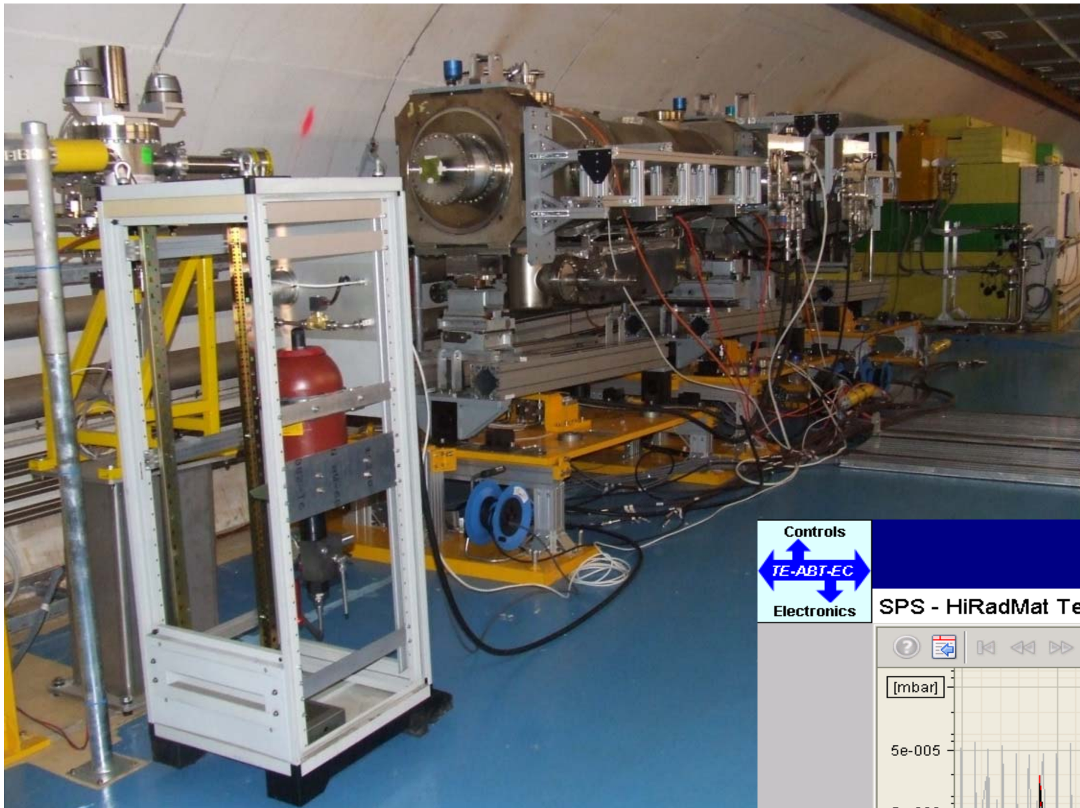
Material tests





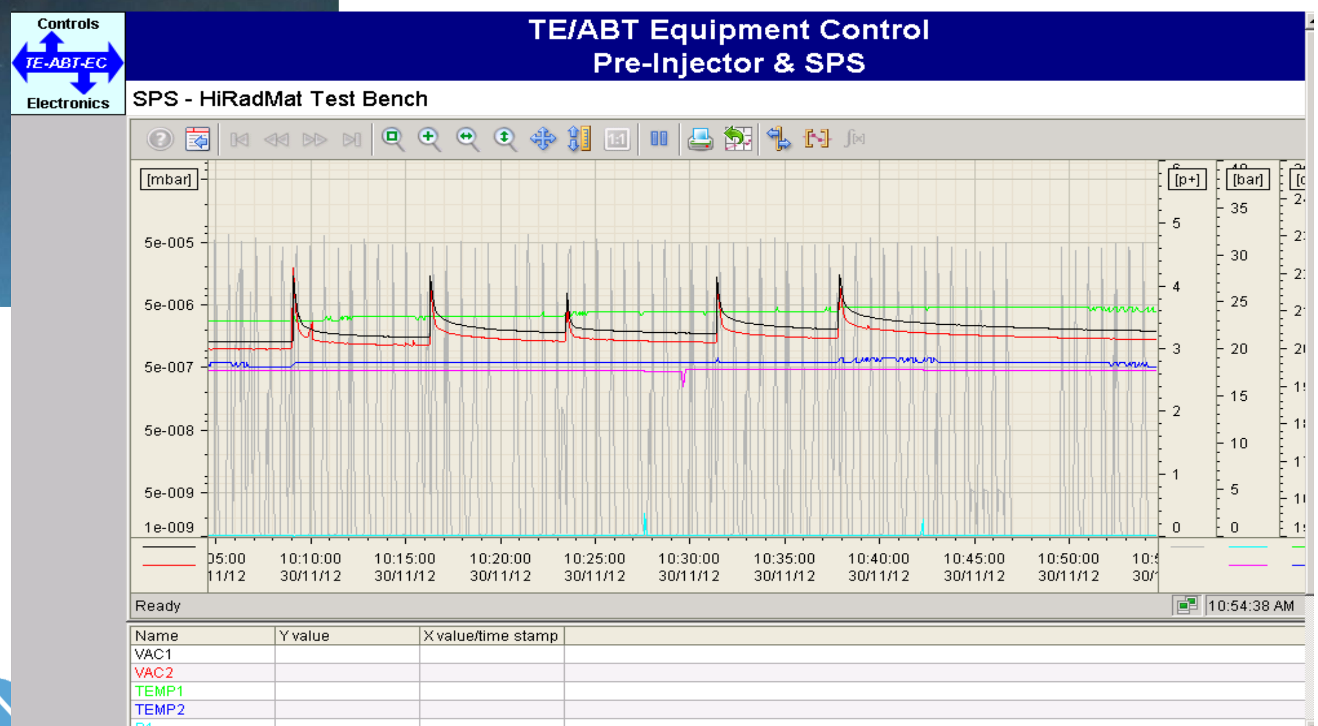


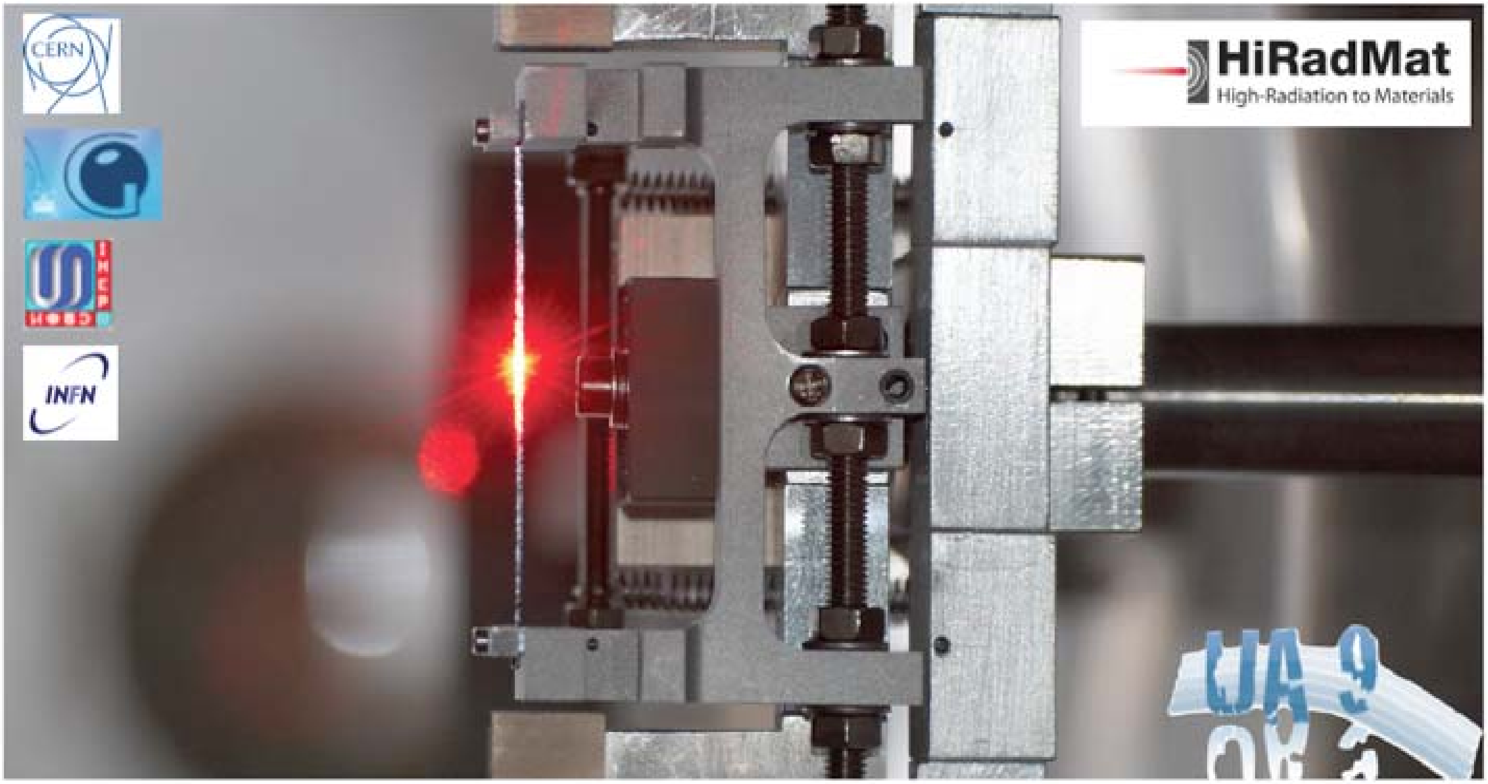
TPSG4 - 2012



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

J. Borburgh, CERN TE





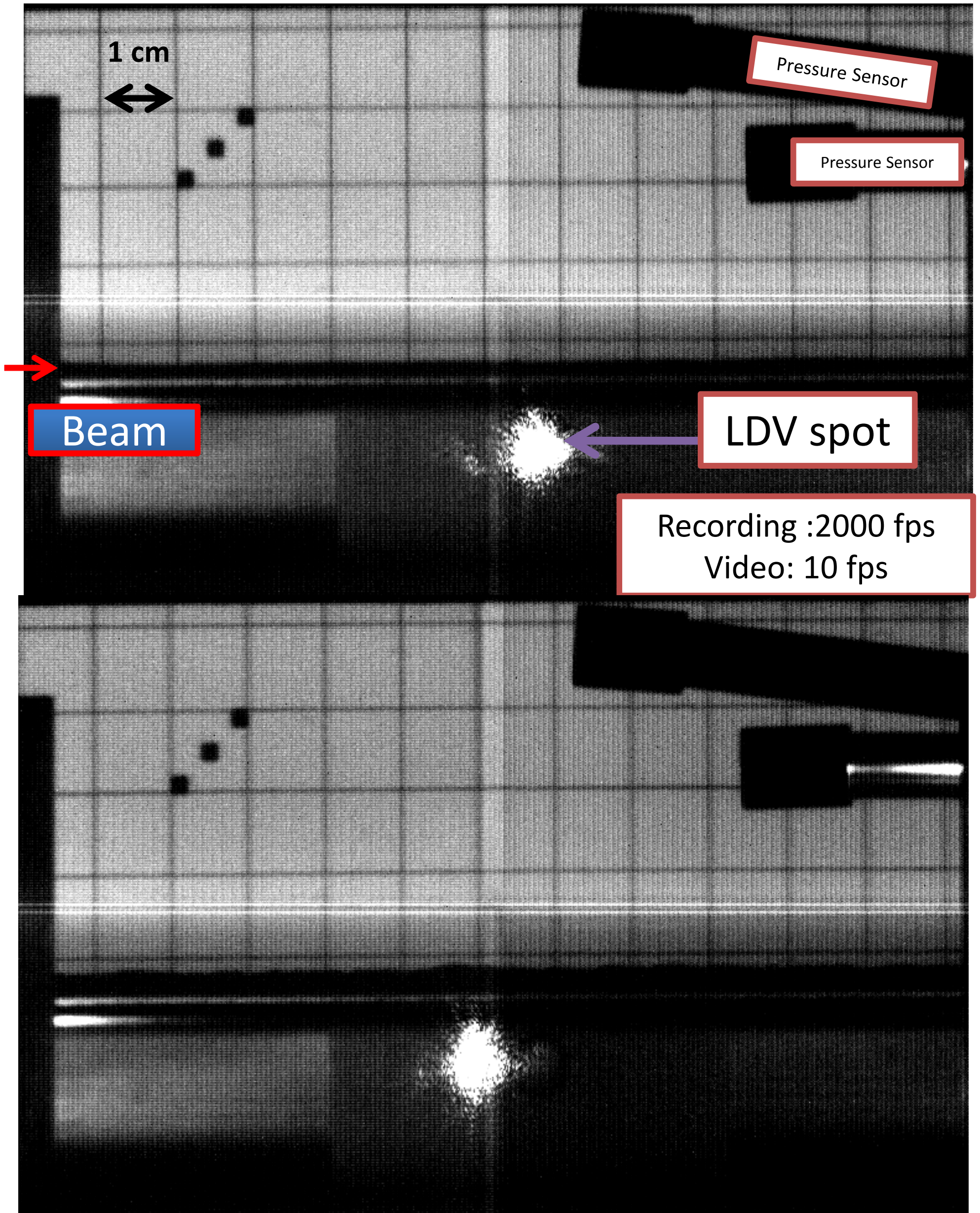
HiRadMat Scientific and Technical board - 18 October 2012

HRMT16-UA9CRY experiment

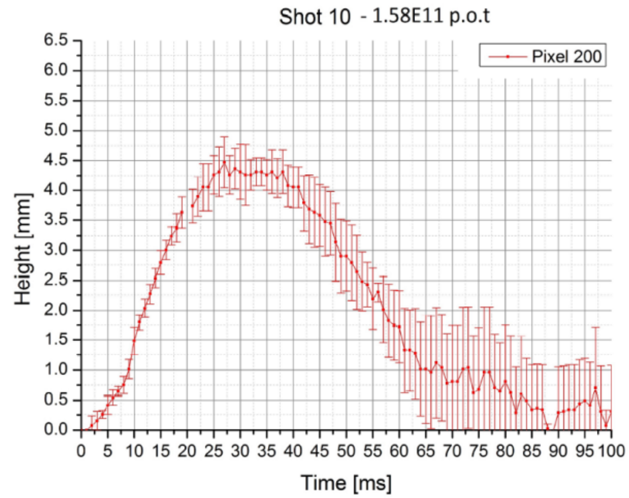
Simone Montesano (CERN – EN/STI)

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

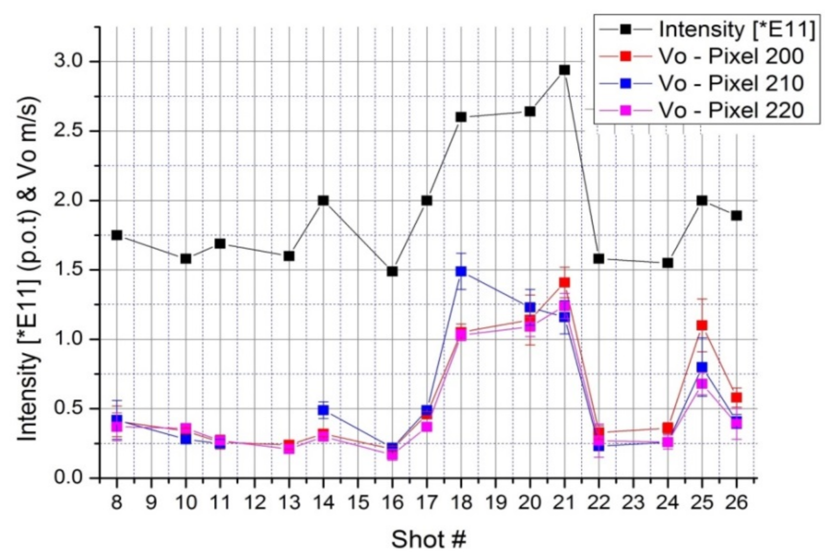
A feasibility experiment of a W-powder target (HRMT-10)



1.75E11 p.o.t: First significant disruption

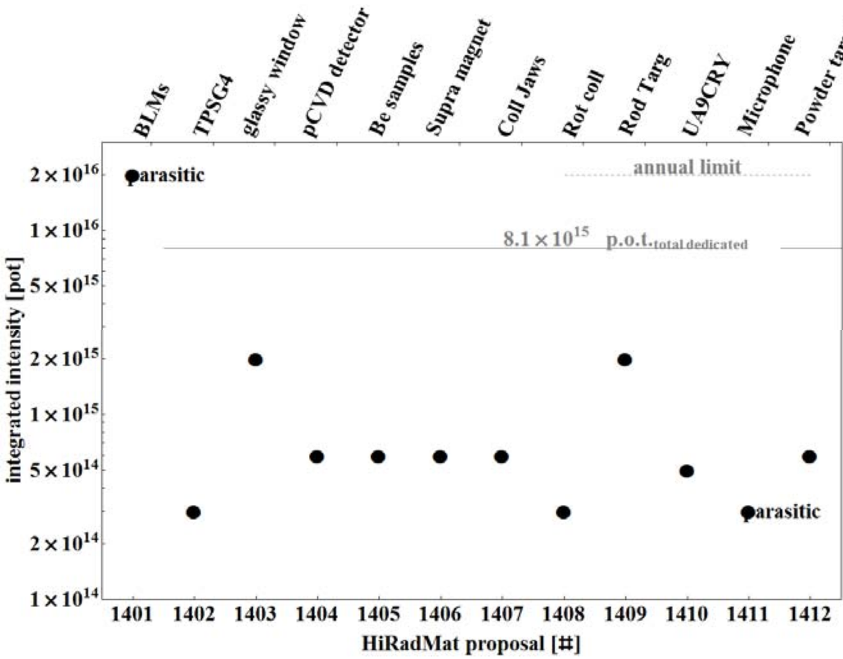


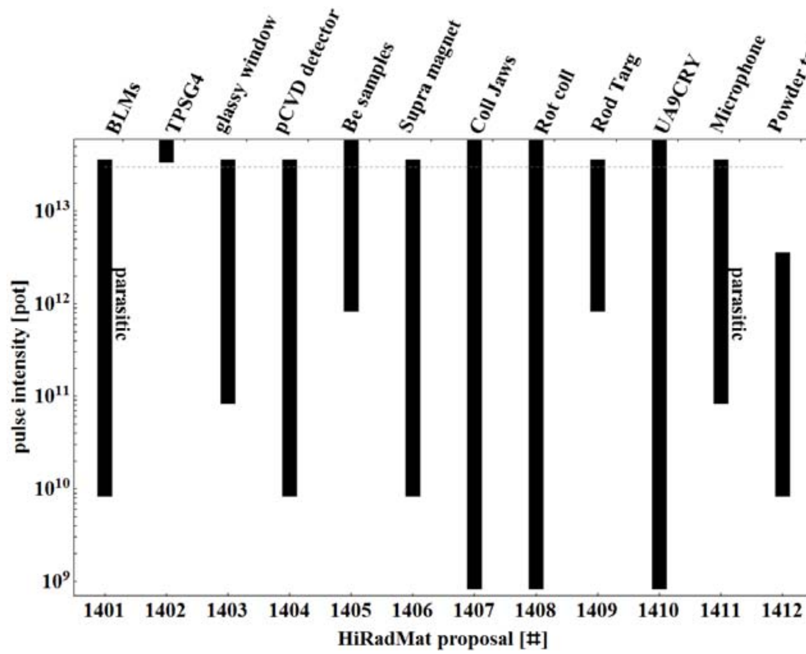
1.85E11 p.o.t: Different reaction of the powder.
Due to the increased surface roughness.



Proposals 2014/2015

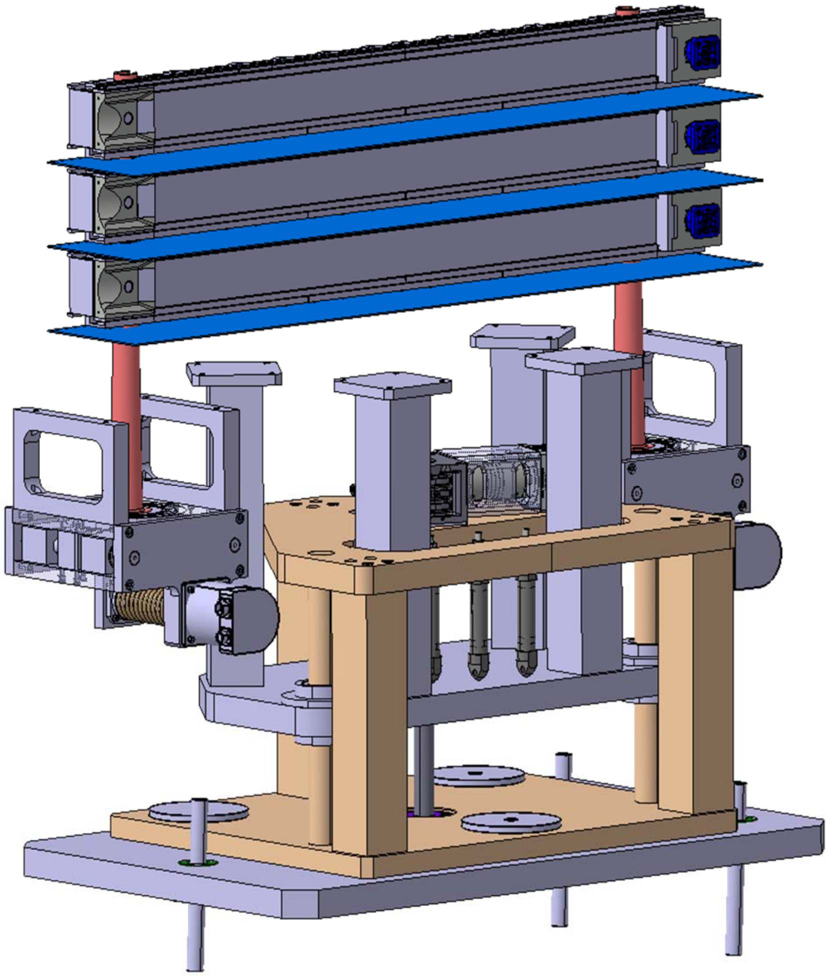
- Call for proposals in spring 2014
  – 12 applications
- Beam run 2014/15 allows about 12 beam slots

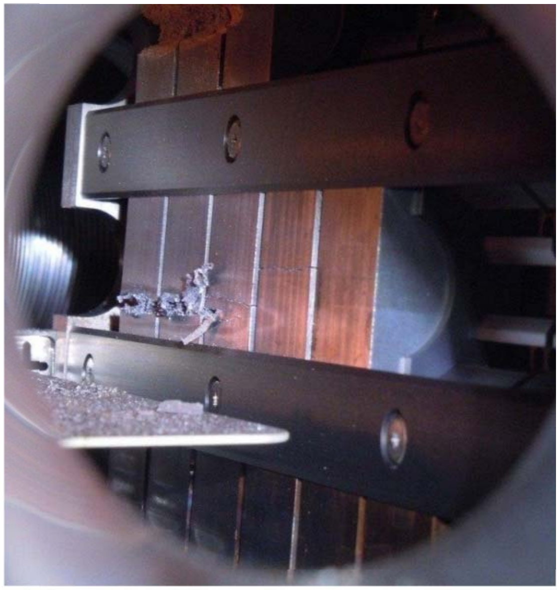




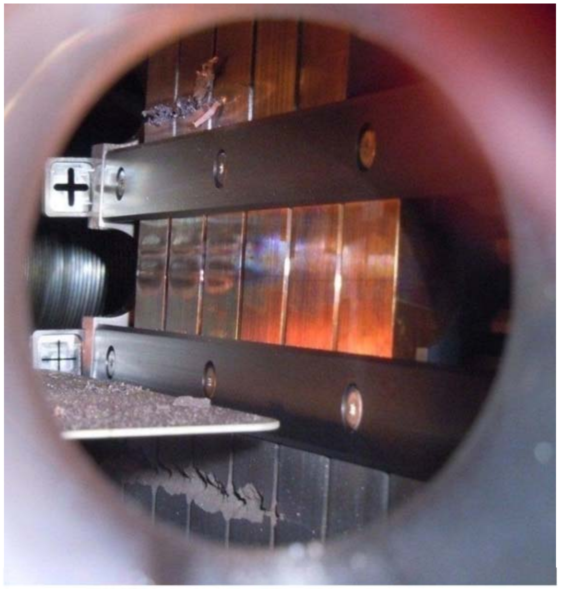
HiRadMat receives support from the EU FP7 grant EuCARD2 within the activity "Transnational Access".

Collimators



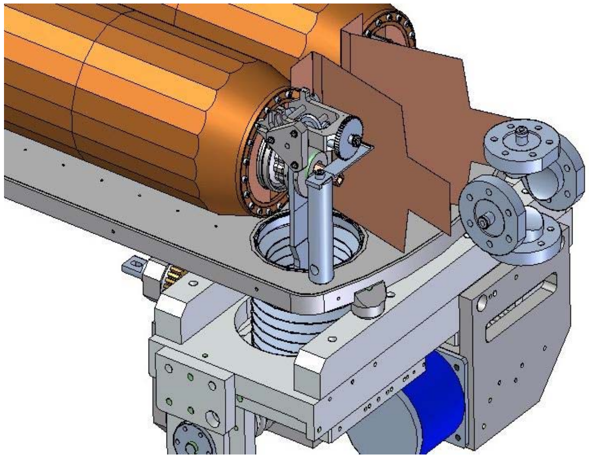


Molybdenum, 72 & 144 bunches



Glidcop, 72 bunches (2 x)

Molybdenum-Copper-Diamond 144 bunches

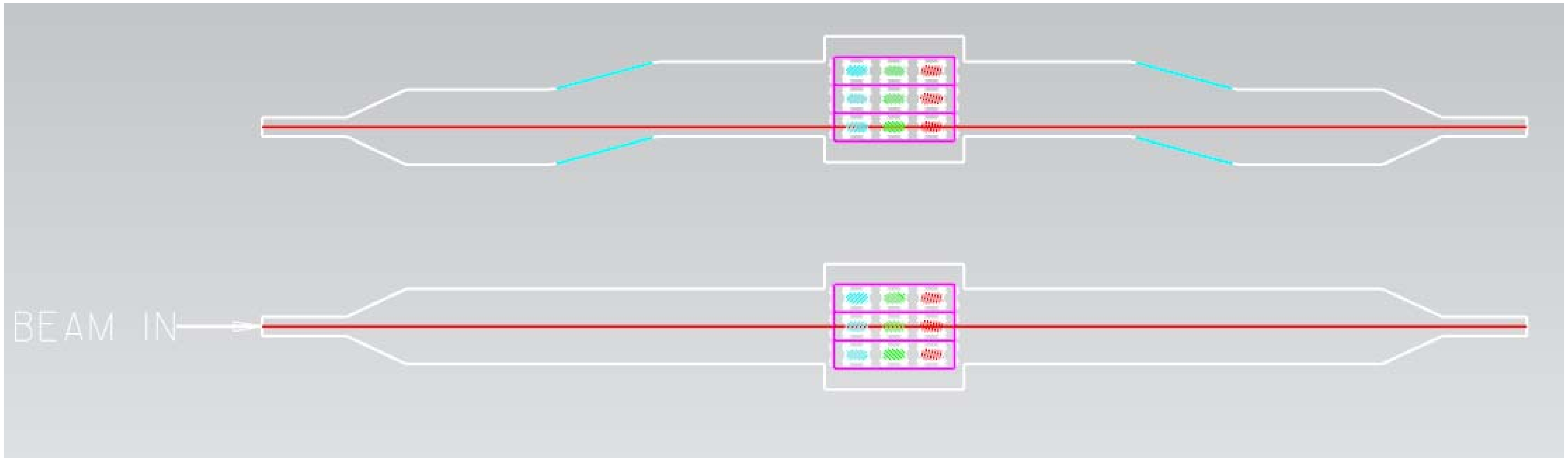


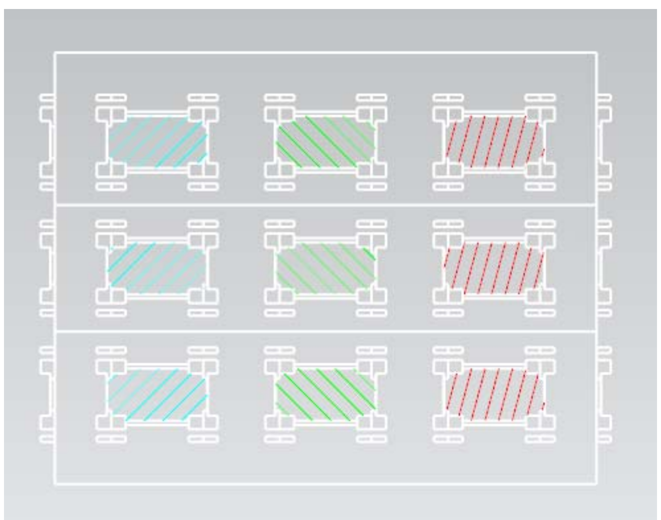
SLAC

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:

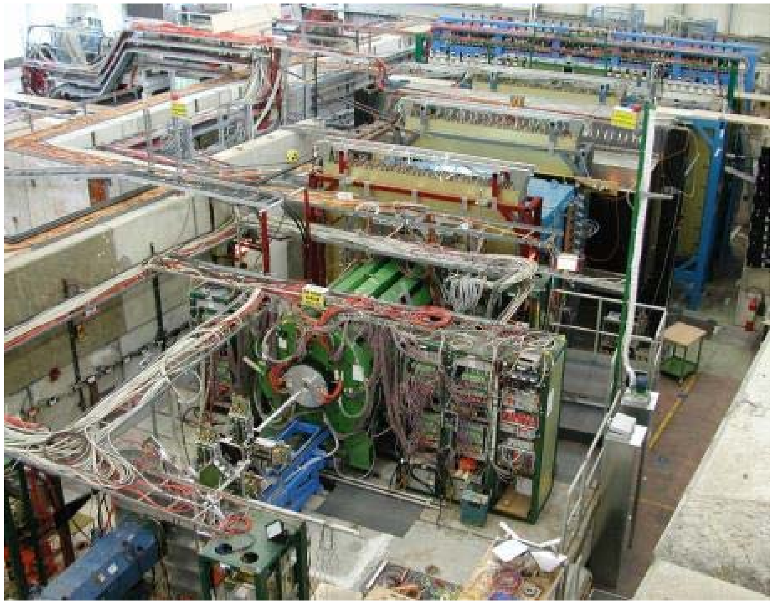
- Different commercial grades of Be
- Thick & thin windows

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**

Secondary beamlines

- In East (T7, T9, T10) and North Area (H2, H4, H6 …)
- E.g. HARP in East Area



- See also FNAL sec. beamlines by Erik

Summary

- HiRadMat is a dedicated in-beam test facility for single-pulse experiments.
  – Avoiding parasitic beam time and operation conflicts

- Such a test facility is useful for a large variety of beam obstacles.

- Dedicated CERN irradiation facilities exist as well.