HiRadMat at CERN SPS:

A dedicated in-beam test facility

http://cern.ch/hiradmat

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5th High Power Targetry Workshop
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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-Radiation to Materials**

- 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)
  - ...

21/5/2014 A. Fabich
SPS beam parameters to HiRadMat

• LHC injection like beam

<table>
<thead>
<tr>
<th></th>
<th>Protons</th>
<th>Heavy ions (Pb(^{82+}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam energy</td>
<td>440 GeV</td>
<td>173 GeV/u</td>
</tr>
<tr>
<td>Bunches/pulse (max)</td>
<td>288</td>
<td>52</td>
</tr>
<tr>
<td>Pulse intensity (max)</td>
<td>(5 \times 10^{13})</td>
<td>(4 \times 10^{9})</td>
</tr>
<tr>
<td>Bunch spacing</td>
<td>25, 50, 75 or 150 ns</td>
<td>100 ns</td>
</tr>
<tr>
<td>Pulse length (max)</td>
<td>7.2 (\mu)s</td>
<td>5.2 (\mu)s</td>
</tr>
<tr>
<td>Beam spot</td>
<td>variable around 1 mm(^2)</td>
<td></td>
</tr>
<tr>
<td>Pulse energy (max)</td>
<td>3.4 MJ</td>
<td>21 kJ</td>
</tr>
</tbody>
</table>

• 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)

TJ7 + TNC

Old T9 target (modified to beam dump)

Irradiation Area

TT66

TNC

TJ7

HiRadMat
High-Radiation to Materials
Layout Experimental Area (2)

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

- Equipped with automatic connections
  - Signals
  - Power
  - Water

21/5/2014
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
    - $1.4 \times 10^{16}$ 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

See [http://cern.ch/hiradmat](http://cern.ch/hiradmat) for links

Powder target (HRMT10)

RAL
C. Densham
Material/collimator tests

Beam tunnelling (HRMT12)
TE/MPE
R. Schmidt

Collimator Materials (HRMT14)
EN/MME
A. Bertarelli

See http://cern.ch/hiradmat for links
Robustness test of a beam septum protection collimator; 9 m long experimental installation

J. Borburgh, CERN TE
HRMT16-U9CRY experiment

Simone Montesano (CERN – EN/STI)

Reporting on the work by many people including:
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.
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

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

SLAC
Beryllium specimen

Multiple samples exploiting long interaction length in beryllium. Samples include:
• Different commercial grades of Be
• Thick & thin windows
**Powder target**

**Sample #1**
Small grains
Open Trough

- Vacuum $2 \times 10^{11}$ ppp
- Eruption?
- N
- Vacuum $2 \times 10^{12}$ ppp
- Eruption?
- N
- Helium $2 \times 10^{11}$ ppp

**Sample #2**
Large grains
Open Trough

- Vacuum $2 \times 10^{11}$ ppp
- Y
- Vacuum Same beam
- Y
- Helium $2 \times 10^{11}$ ppp

**Sample #3**
Small grains
Open Trough

- Helium $2 \times 10^{11}$ ppp
- Option ‘A’
  - Higher Intensity
- Option ‘B’
  - Vary the Beam Posn.

**Sample #4**
Large grains
Closed Tube

- Vary intensity and monitor container wall with LDV

C. Densham (RAL) et al.
pbar target

- Pulse intensity \( \sim 1.5 \times 10^{12} \) p/pulse
- Spot size: \( 1 \times 1 \text{ mm}^2 \rightarrow 1.5 \times 1.5 \text{ mm}^2 \)
- Total number of medium-high intensity pulses: \( \sim 300-400 \)
  - Ramp-up approach
  - Other \( \sim 200 \) low intensity pulses could be anticipated
- Integral intensity \( \sim 2 \times 10^{15} \) POT
- Beam alignment/stability:
  - Maximum shift pulse-by-pulse \( \sim 100 \mu\text{m} \)
    - Important to have it guaranteed, not only monitor
  - Monitor beam asymmetry \( \sim 100 \mu\text{m} \)
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

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.