High Radiation to Materials

A Facility at CERN for Material & Component Testing

- Facility overview
- Doing experiments at HiRadMat
- Highlights of 2012 Experiments

http://cern.ch/hiradmat - hiradmat.sps@cern.ch

Motivation

HiRadMat
High-Radiation to Materials

- Move away from ad-hoc setups, to a facility specially designed to study the impact of **intense pulsed beams** on materials
  - Thermal management (heating)
    - material damage even below the melting point
    - material vaporization (extreme conditions)
  - Radiation damage to materials
  - Thermal shock - beam induced pressure waves

- Search for threshold effects
  - More challenging, but interesting for the understanding of the underlying physics,
  - More interesting for engineering and applications

- Robustness tests of assemblies
  - high-intensity beams, single or multiple pulses

- Test bed, important for the design validation of **LHC near beam components** before installation in the ring

- **Targeted users**: LHC collimators, R&D on materials, high-power targetry, test of vacuum components (beam windows, coating), others?

HiRadMat - Location

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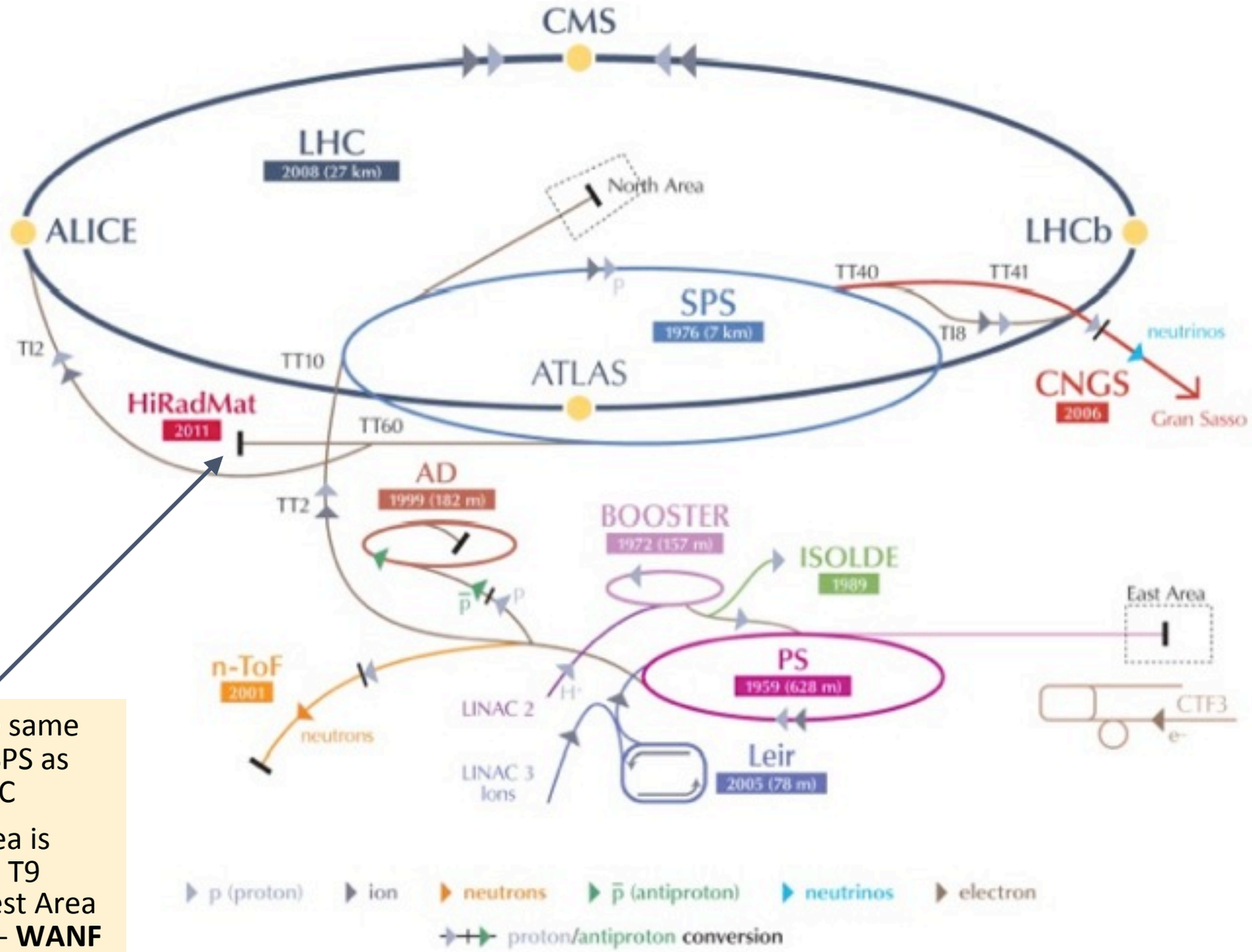
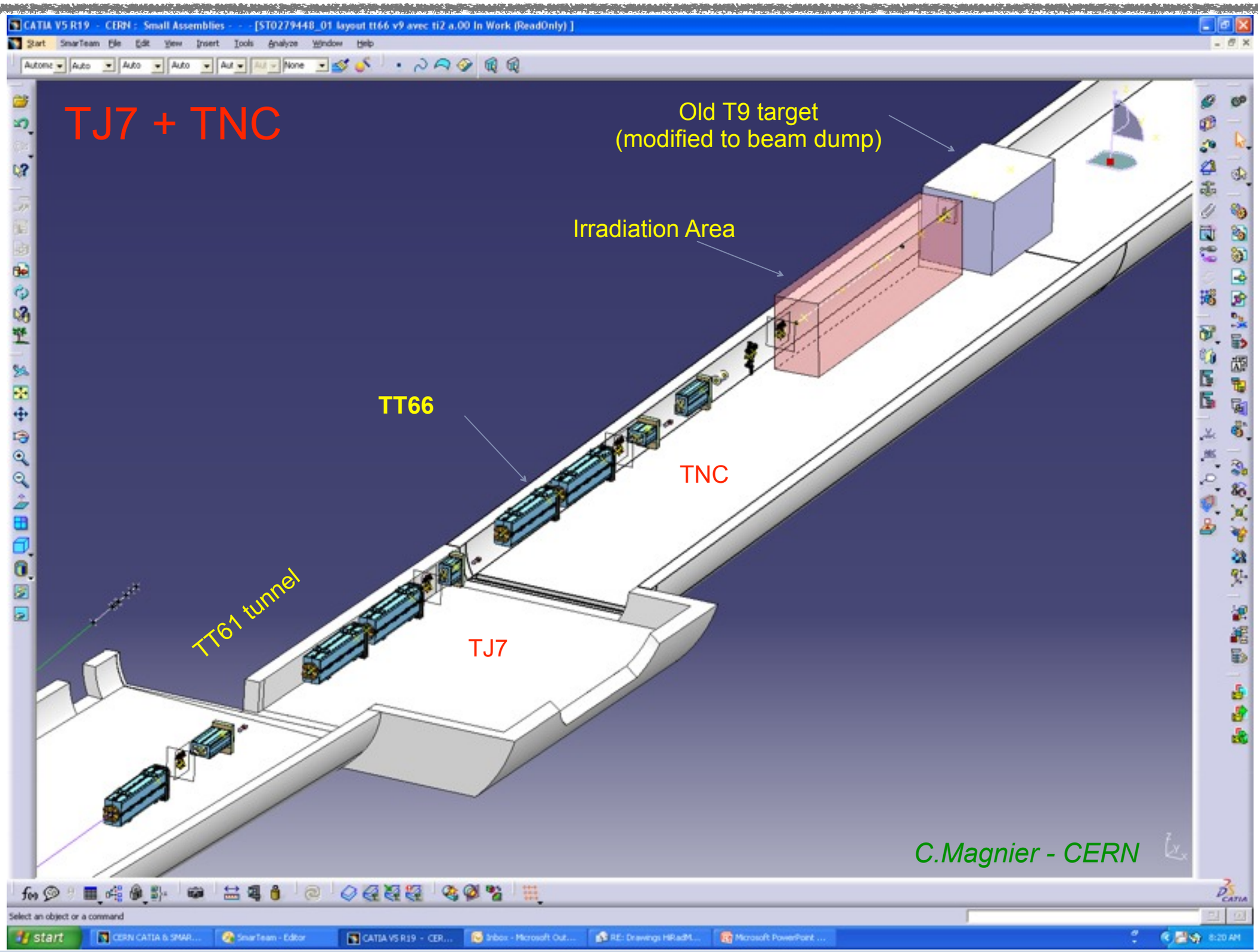


HiRadMat shares the same extraction from SPS as the **TI2** line to LHC

The experimental area is upstream the old T9 target for the West Area Neutrino Facility - **WANF**

Layout Experimental Area



Layout Experimental Area

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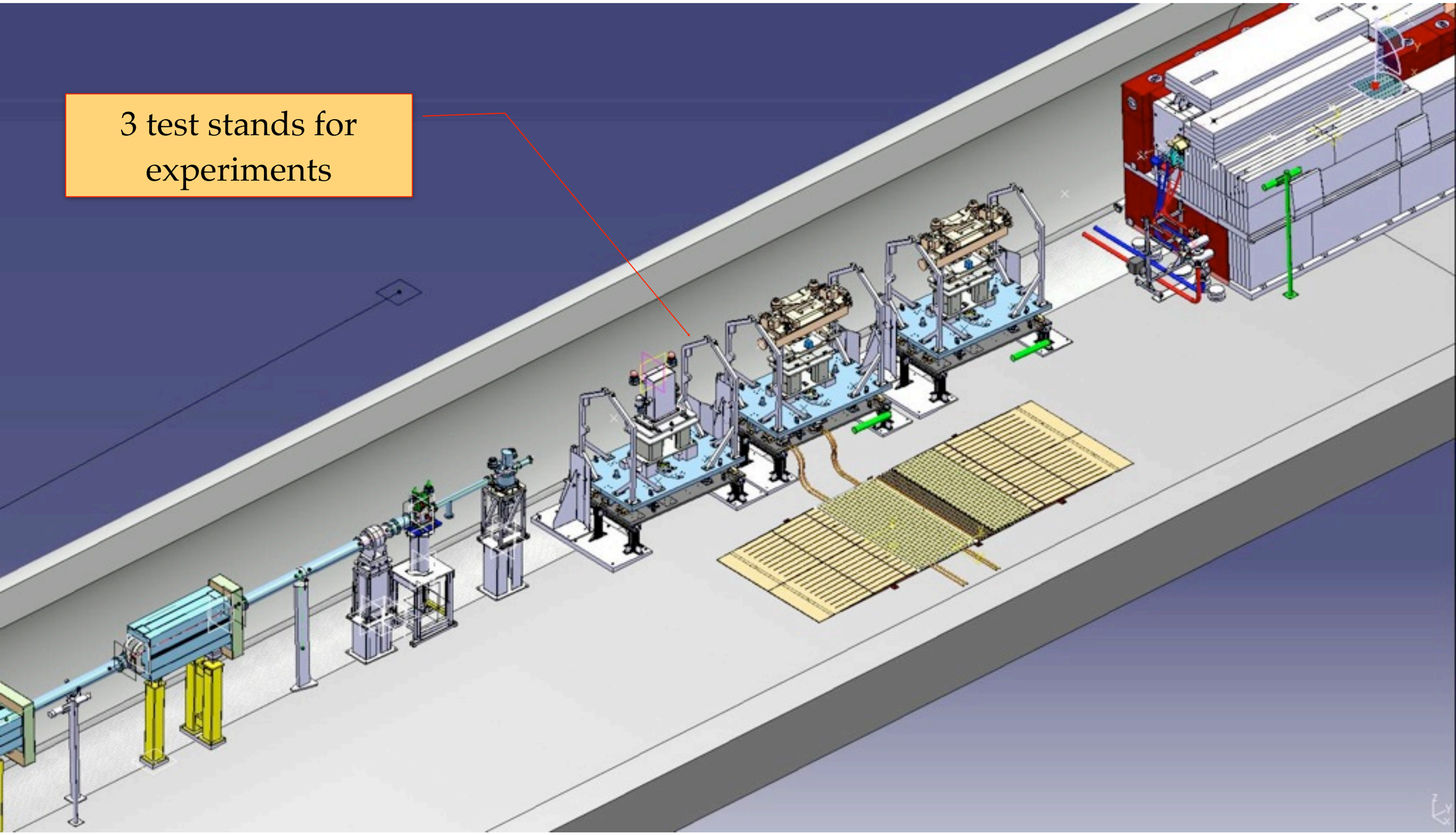
3 test stands for experiments



HiRadMat Beam Parameters

- LHC type beam extracted from SPS, protons or ions

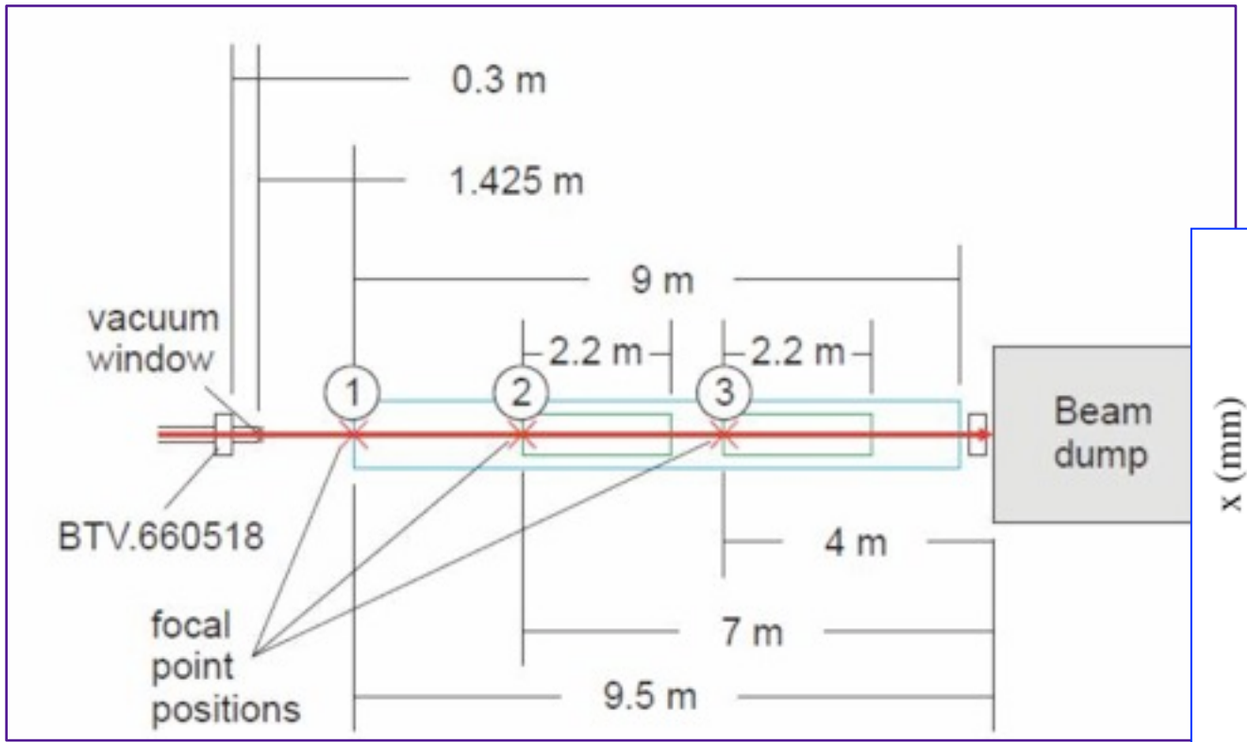
	Protons	Heavy ions ($Pb82^{+}$)
Beam Energy	440 [GeV]	173 [GeV/u], 36.1 [TeV/ions]
Pulse energy	up to 3.4 [MJ]	up to 21 [kJ]
Bunch intensity	3×10^{9} to 1.7×10^{11} [protons]	3×10^{7} to 7×10^{7} [ions]
Number of bunches	1 to 288	52
Max intensity	4.9×10^{11} [protons]	3.64×10^{9} [protons]
Bunch length	11.24 [cm]	11.24 [cm]
Bunch spacing	25, 50, 75 or 150 [ns]	100 [ns]
Pulse length	7.2 [μs]	5.2 [μs]
Cycle length	18 [s]	13.2 [s]
Beam spot at the experiment	variable around 1 [mm^2]	variable around 1 [mm^2]

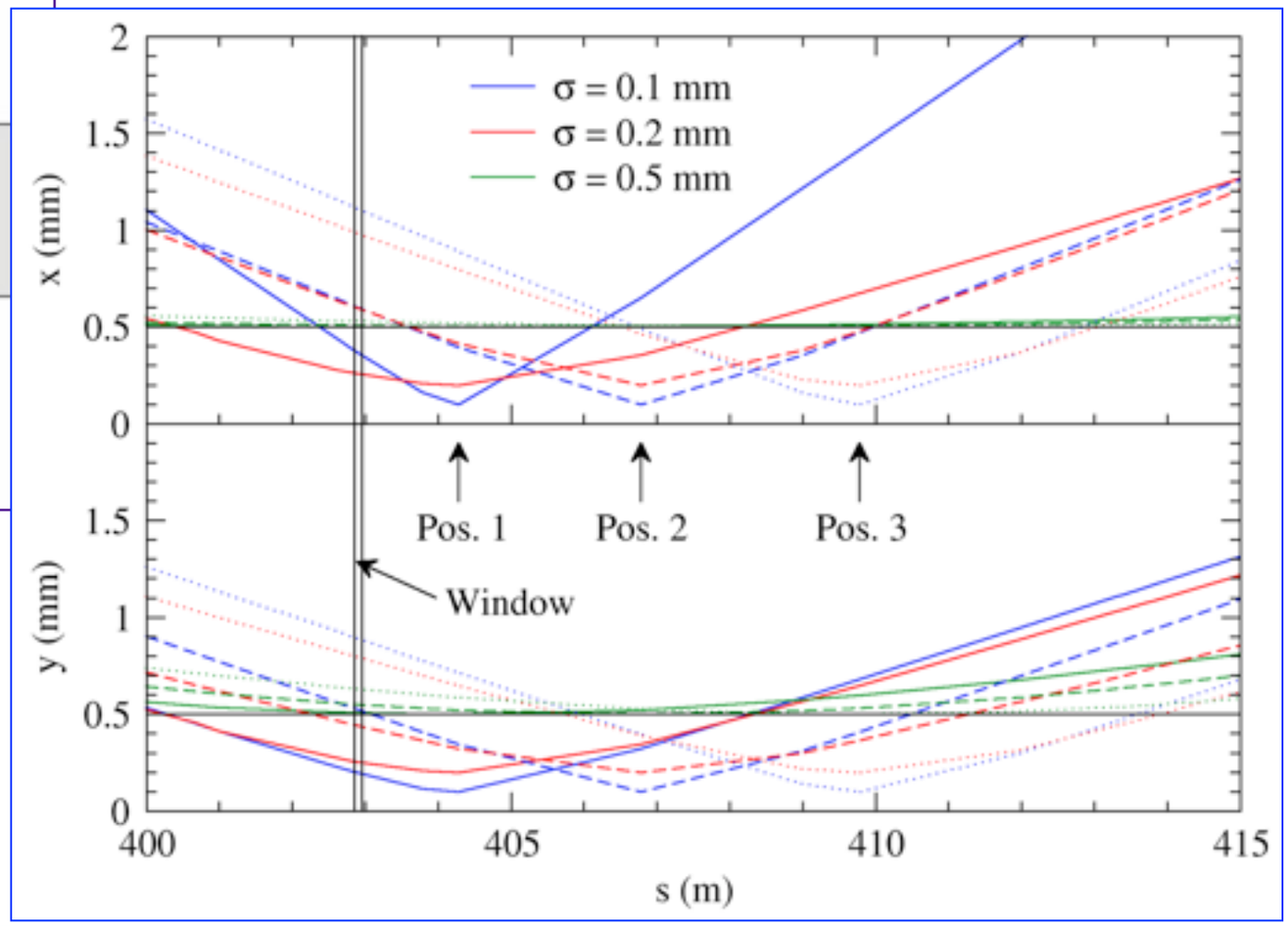
- Intensity:
  - **10^{15} protons/experiment** (max 30 high-intensity pulses)
  - 10 experiments/year - **10^{16} protons in total/year**

HiRadMat Beam Parameters

- Constraint: the beam must be >0.5mm in [x, y] at the last beam window of the line and at the dump

- Larger beam sizes can be achieved, <2mm





HiRadMat Operations 2012

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- **16** experiment requests received
- **9** experiments completed, interesting variety of tests!

Exp-ID	Title	Description	Contact Person	Status	Beam Period	Mobile Table	Storage (temporary)
HRMT-01	TISD	RIB target R&D	T. Stora - CERN	Completed	w44-2012	Table-01	cool-down #4
HRMT-02	RADTOL	Radiation tolerence of electronics	M. Brugger - CERN	Request			
HRMT-03	SLACRC1	LHC rotating collimator	T. Markewicz - LBL	Request			
HRMT-04	BLM	LHC beam loss monitor	B. Dehning - CERN	Completed	w35-2012	-	departed
HRMT-05	VDWBR	Vacuum Be window	R. Veness - CERN	Request			
HRMT-06	TPSG4	LHC transfer line collimator - TPSG	J. Borburgh - C.Baud CERN	Completed	w47-2012	special support	
HRMT-07	TCDQ	LHC transfer line collimator - TCDQ	W. Weterings - CERN	Request			
HRMT-08	TCDS	LHC transfer line collimator - TCDS	W. Weterings - CERN	Request			
HRMT-09	LCOL	LHC collimator tests	A. Rossi - CERN	Completed	w32,2012	Table-04	departed
HRMT-10	WTHIMBLE	High-power W-thimble experiment	C. Densham - RAL, N.Charitonidis - CERN	Completed	w22, 2012	Table-01 (sample holder removed)	
HRMT-11	DYNVAC	Ion disorption and vacuum	E. Mahner - CERN	Request			
HRMT-12	LPROT	LHC machine protection R&D	R. Schmidt - J.Blanco CERN	Completed	w25,2012	Table-03	cool-down #5
HRMT-14	LCMAT	LHC collimator material R&D	A. Bertarelli - CERN	Completed	w39,w40-2012	Table-02	cool-down #7
HRMT-15	RPINST	RP Instrumentation R&D	M. Silari - CERN	Completed	w41,w24-2012	dismantled	departed
HRMT-16	UA9CRY	UA9 Crystal collimation	W.Scandale LAL, S. Montesano - CERN	Completed	w44-2012	Table-01(sample holder removed)	departed

- The CERN accelerator complex is in long shutdown for 2013 and part of 2014 due to LHC. Beam for HiRadMat would become available as of October'14
- Already some interest for experiments in 2014 more proposals are welcome !!
- Note: HiRadMat is part of EuCARD and EuCARD^2 as **Transnational Access**

HRMT10-WTHIMBLE Experiment

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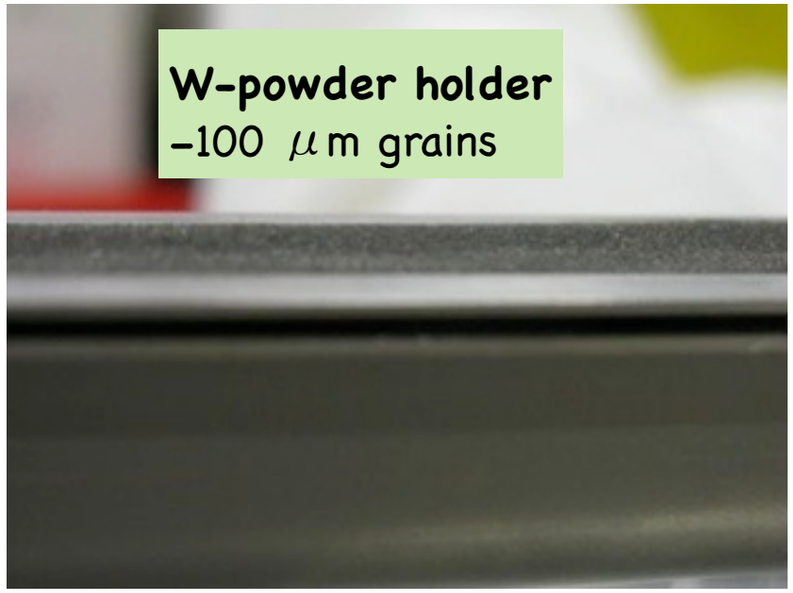
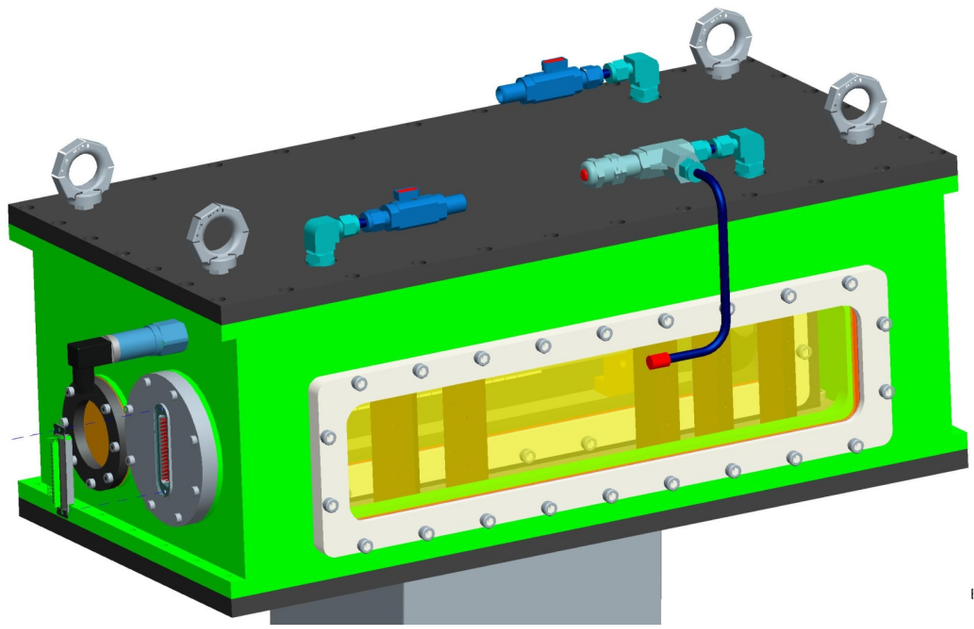
Tungsten Powder Test @ HiRadMat (RAL-CERN Collaboration)

- Proof-of-principle operation of a segmented target as high-power option in future ν-beam facilities (>1 MW range)
- Key questions/observations:
  - would the W-powder splash/erupt?
  - can you propagate a pressure waver through the powder target to its container?





HRMT10-WTHIMBLE Experiment

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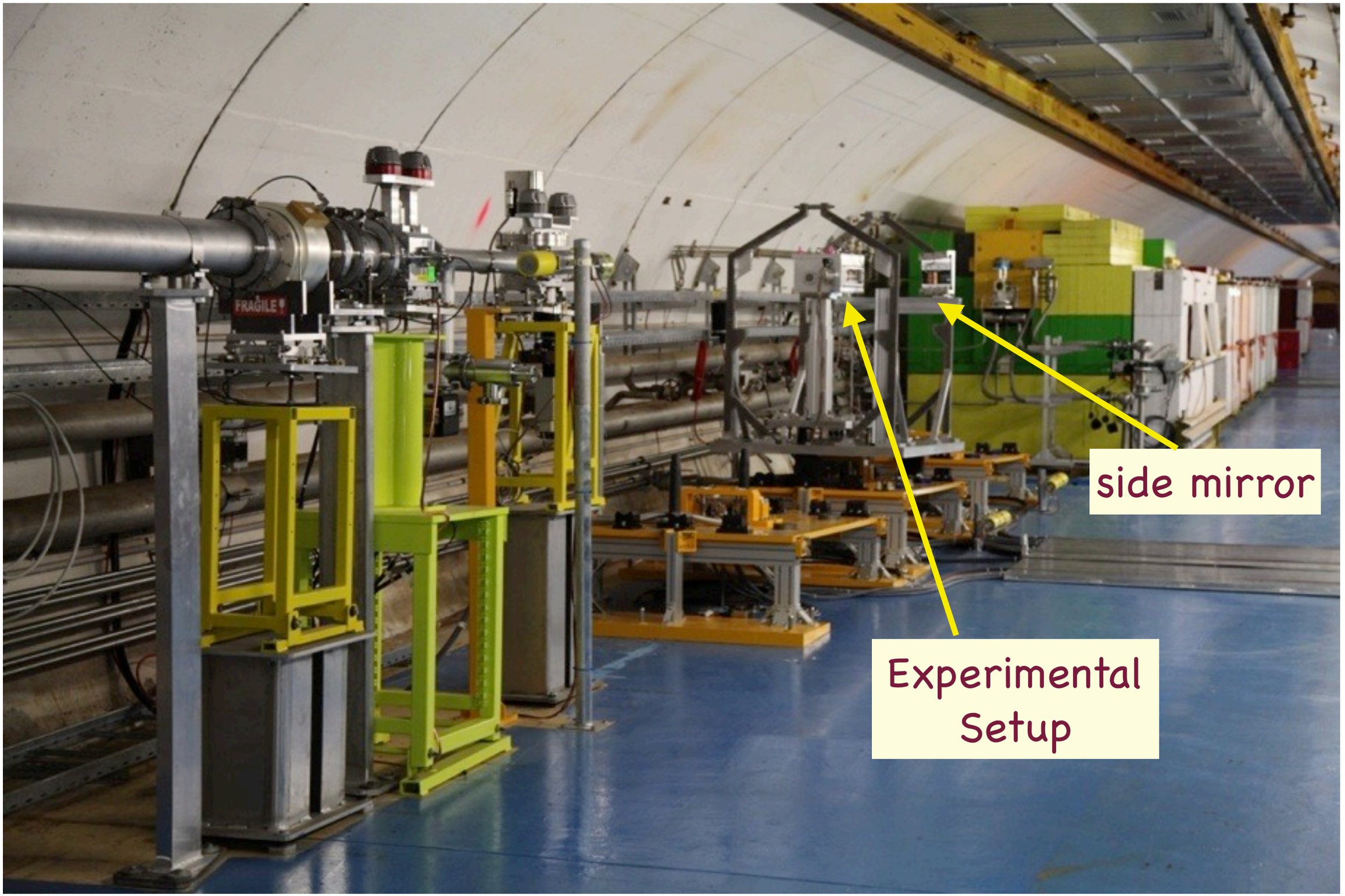
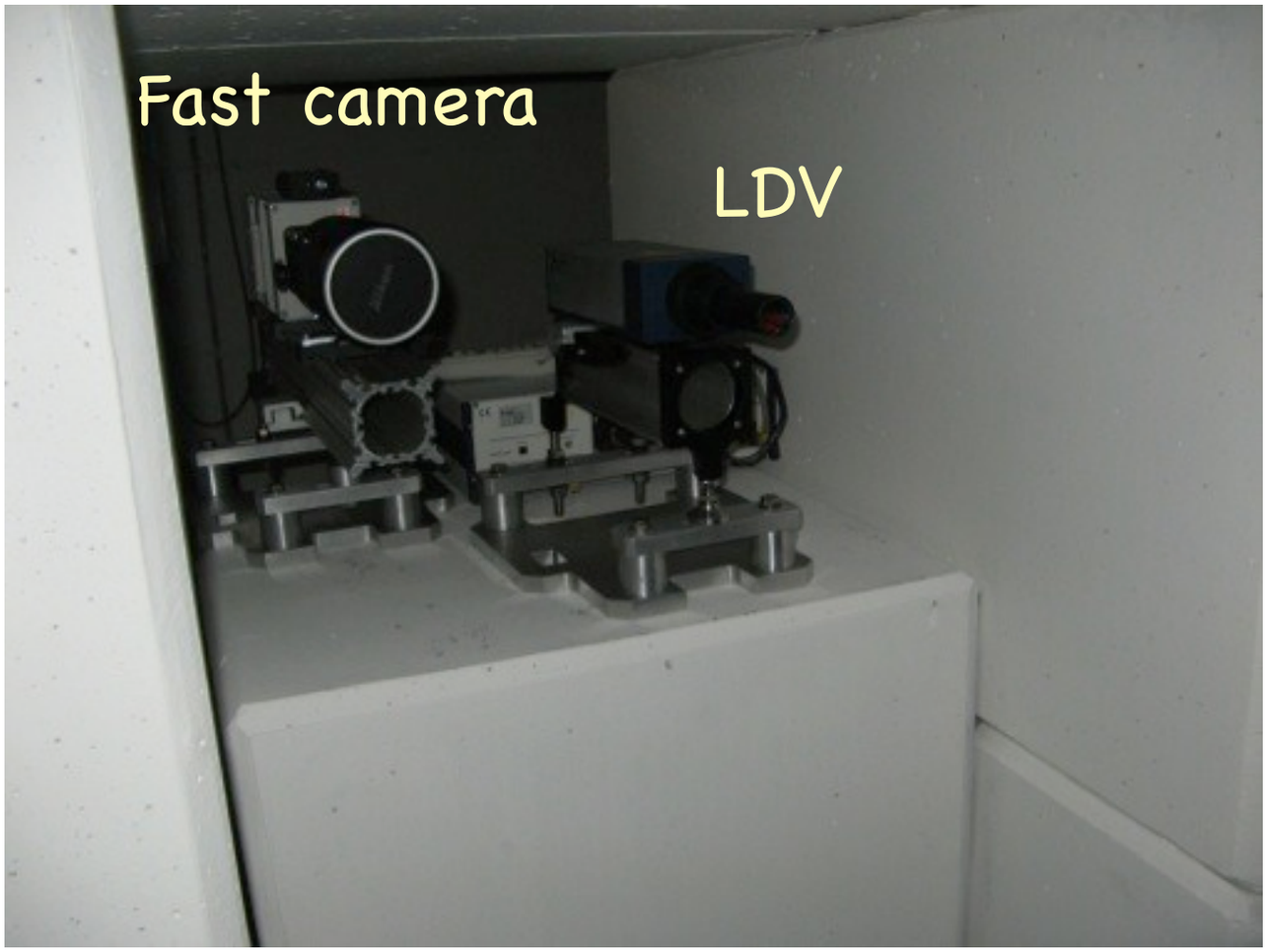


HRMT10-WTHIMBLE Experiment

- Experiment instrumentation:
  - LDV for shock wave measurement (borrowed from EN/STI - thanks!)
  - Fast camera (from BE/BI - thanks!) with special lenses and mirrors to take photos at 40m distance!



HRMT10 W-powder Experiment

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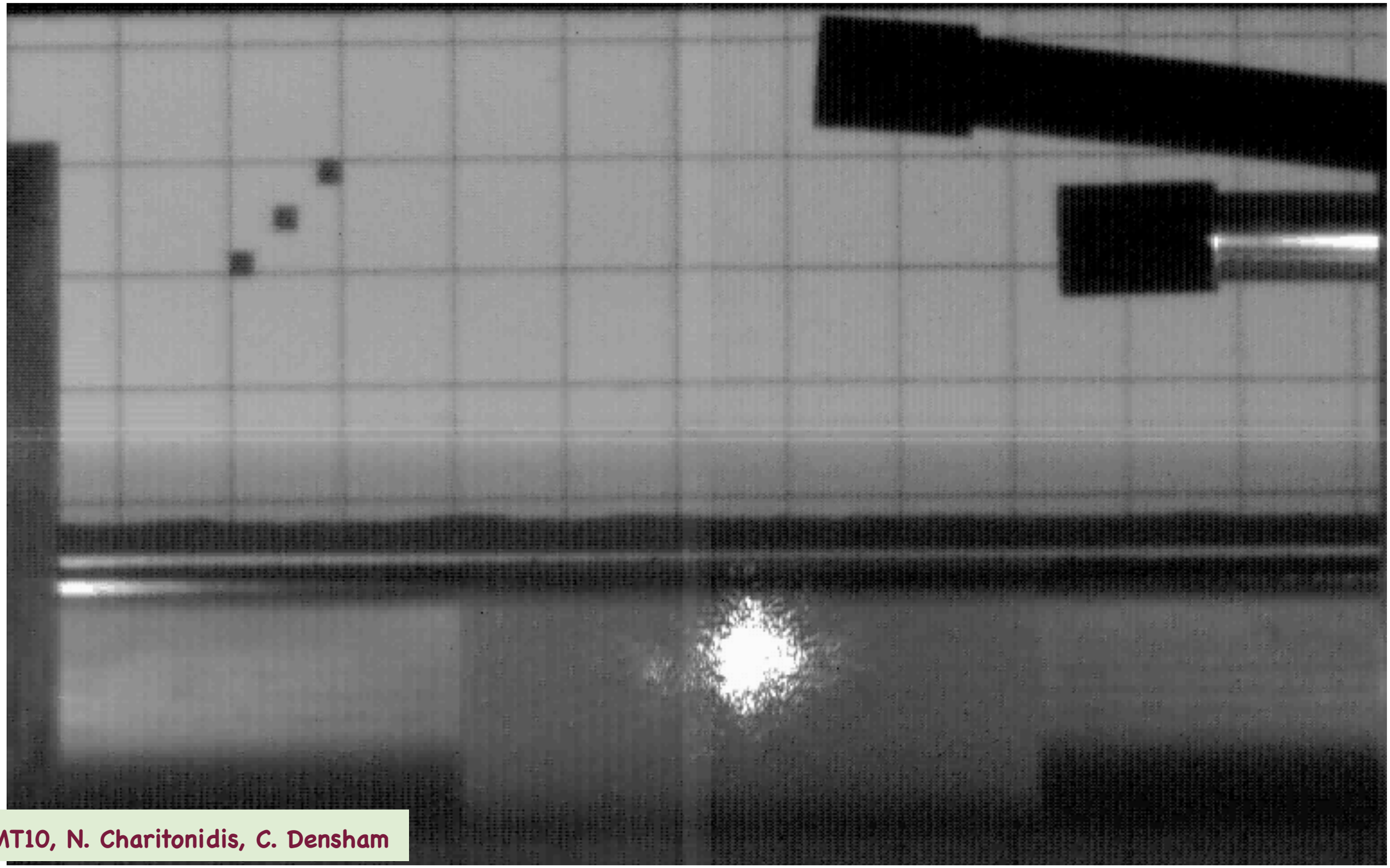
- Beam pulse : 1.58 10^{11} 400 GeV protons



Courtesy HRMT10, N. Charitonidis, C. Densham

HRMT10-WTHIMBLE Experiment

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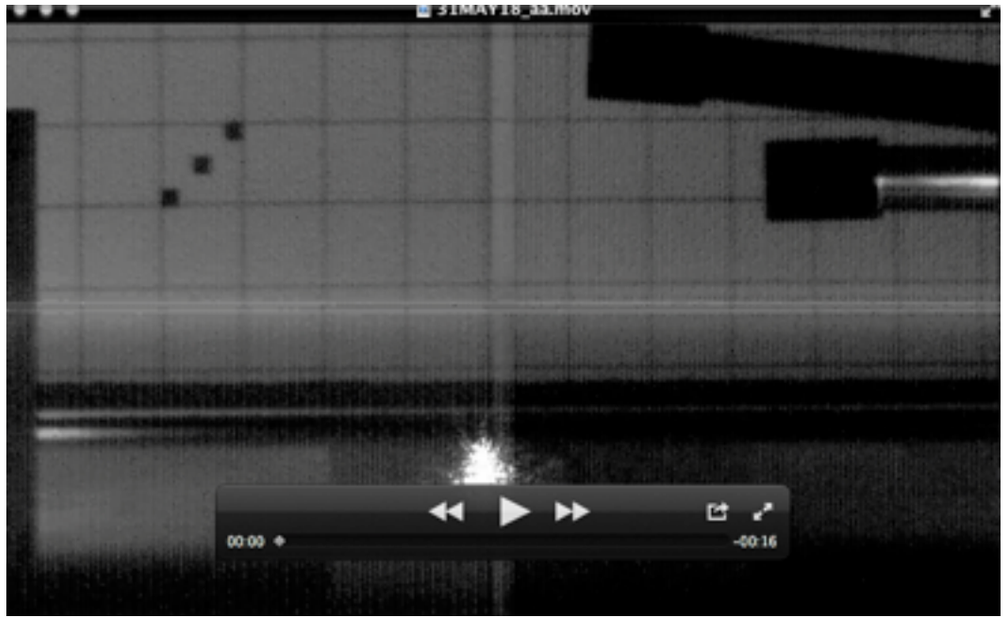
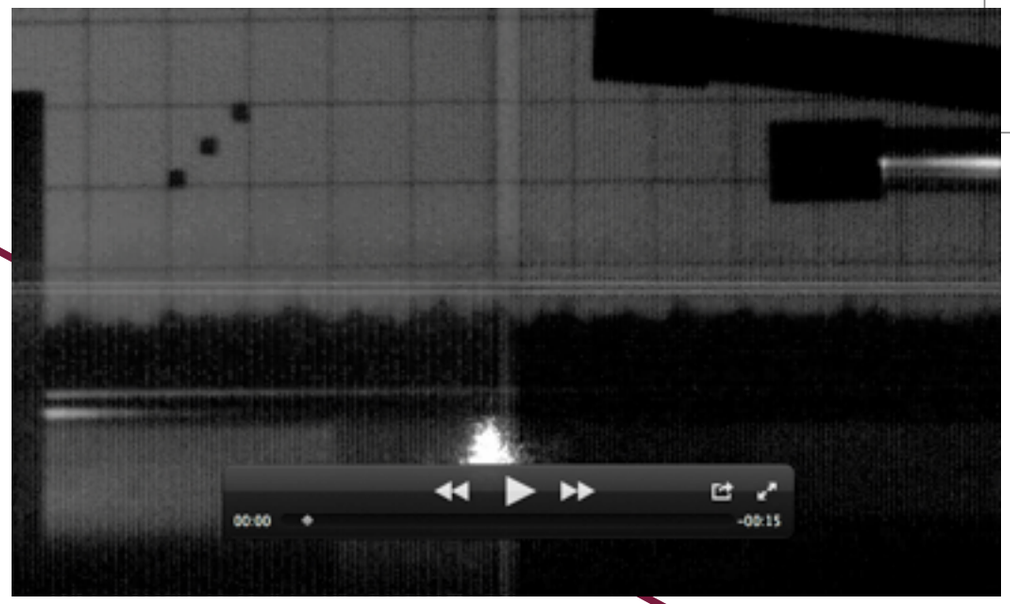
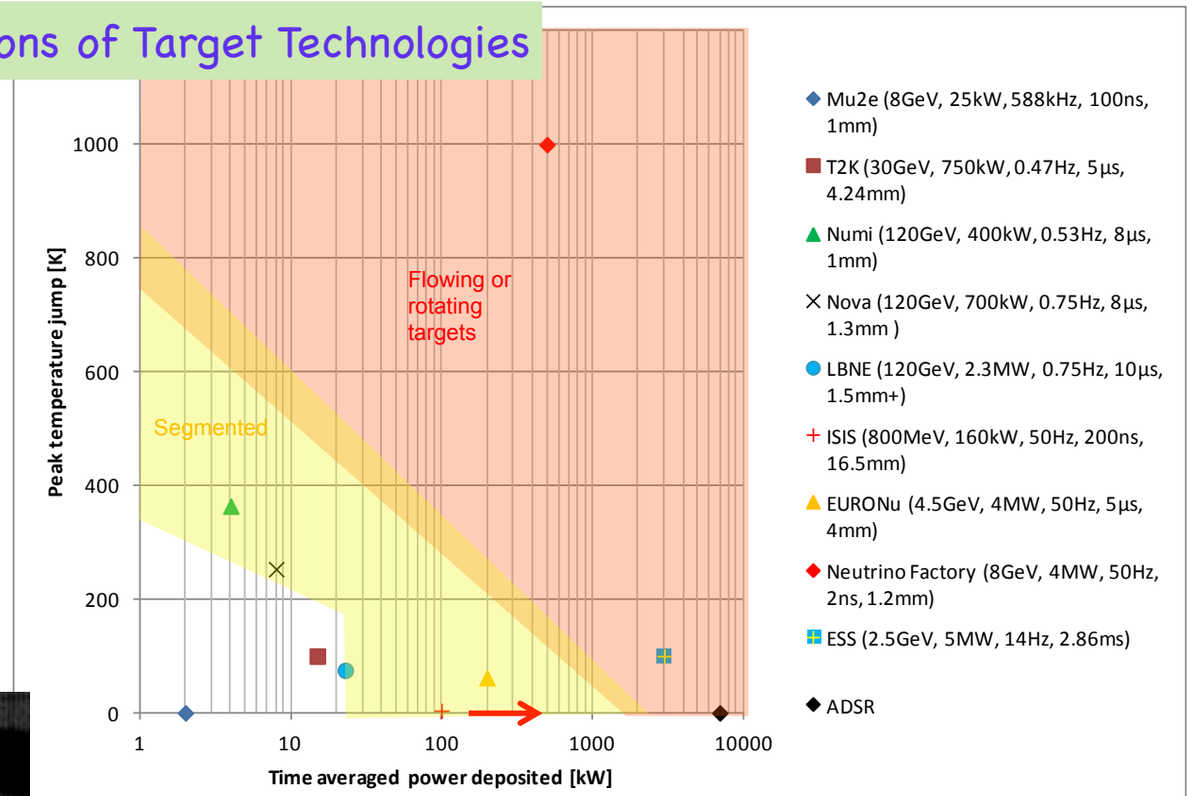
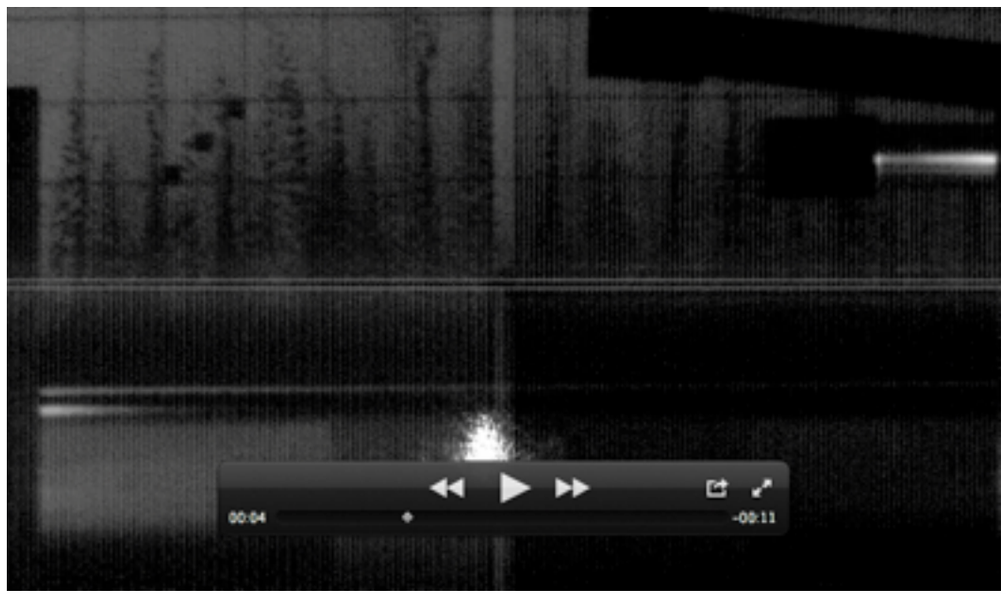




time

Limitations of Target Technologies





Courtesy HRMT10, N. Charitonidis, C. Densham

HRMT12-LPROT Experiment

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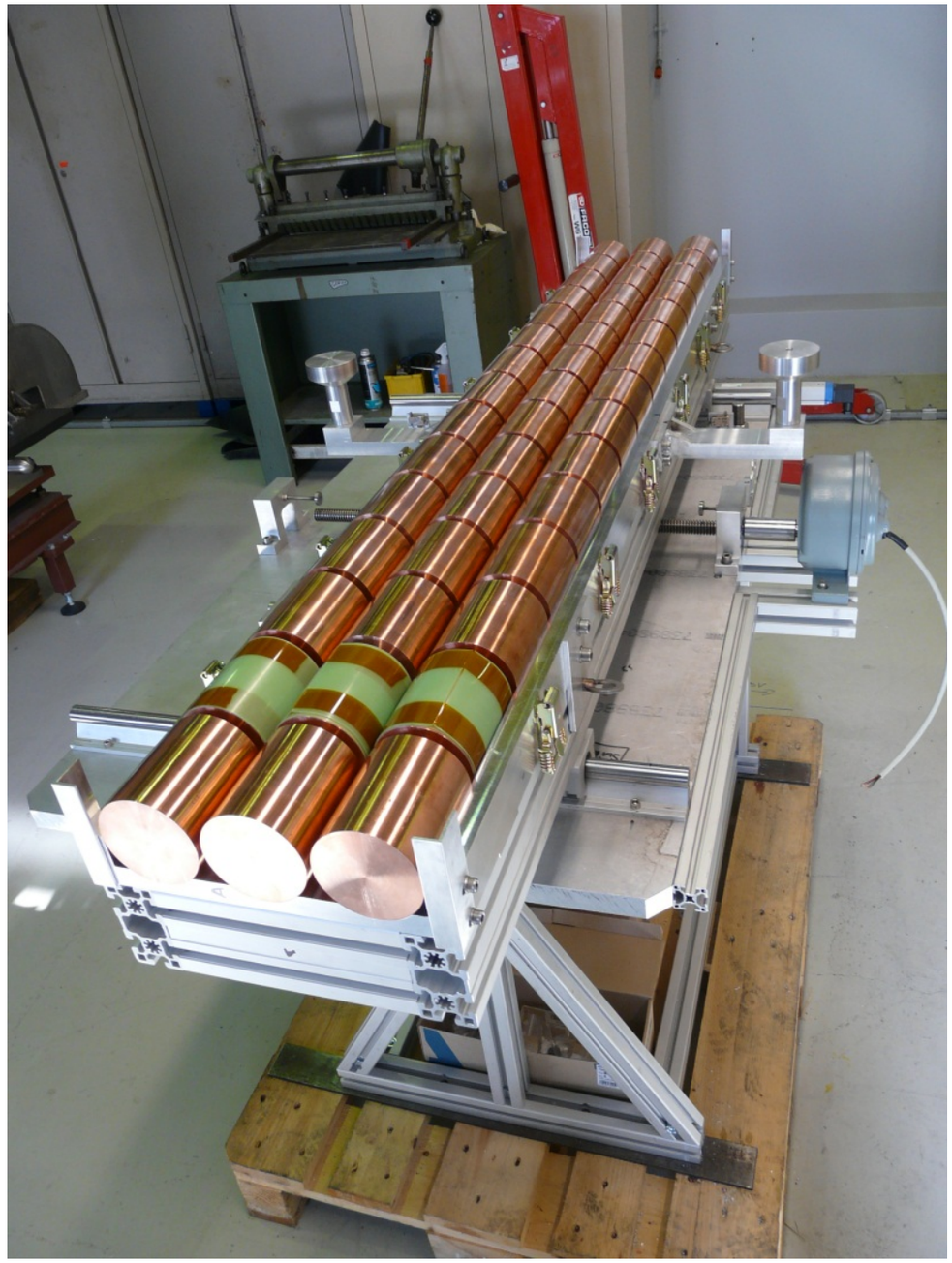
- Experiment to study the **beam tunneling in matter**

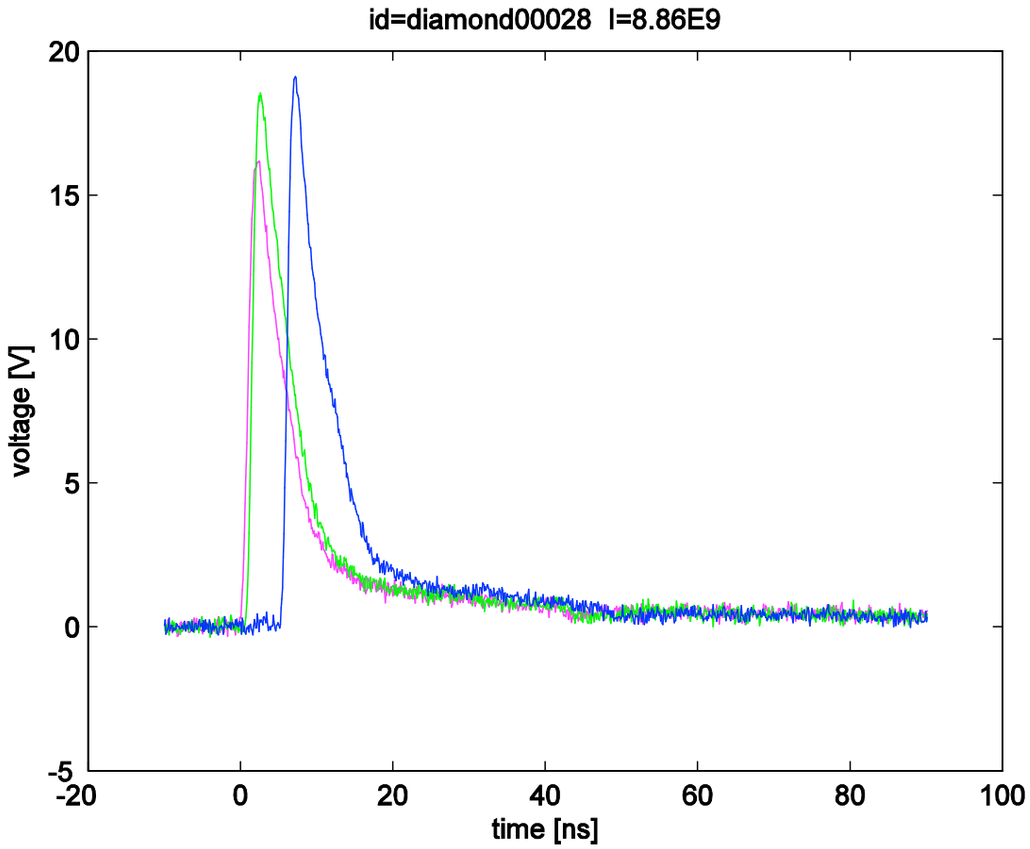
- First "open" experiment - **not to repeat!!!**
- Beam taken:
  - 71 low intensity single bunch shots (2E9 - 1.0E10)
  - 85 high-intensity single bunch shots (1.0E11 - 2.0E11)
  - 8 high-intensity multi-bunch shots (1.5E11 ppb)

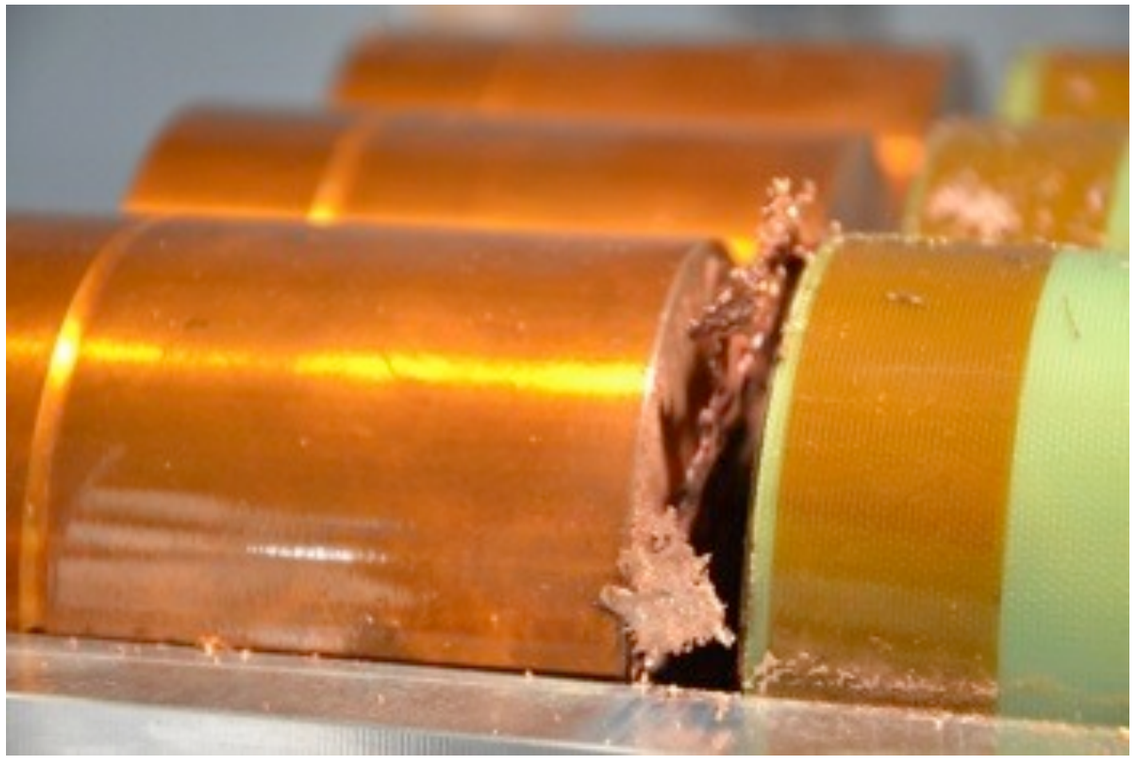
target sample - Cu rods:

- 3 Cu rods, 15 cylinders, 8cm diam, 10cm long



pCVD diamond detectors





Courtesy HRMT12, D. Wollman, J.Sancho

HRMT09-LCOL Experiment

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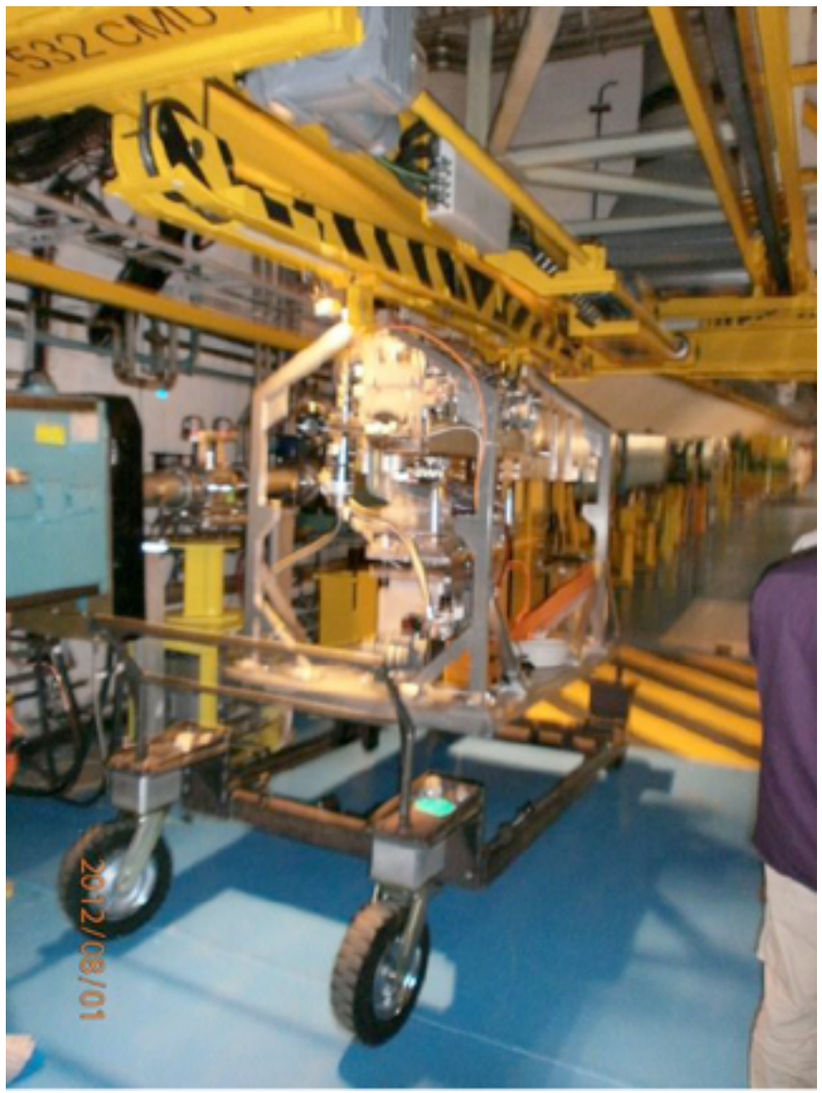
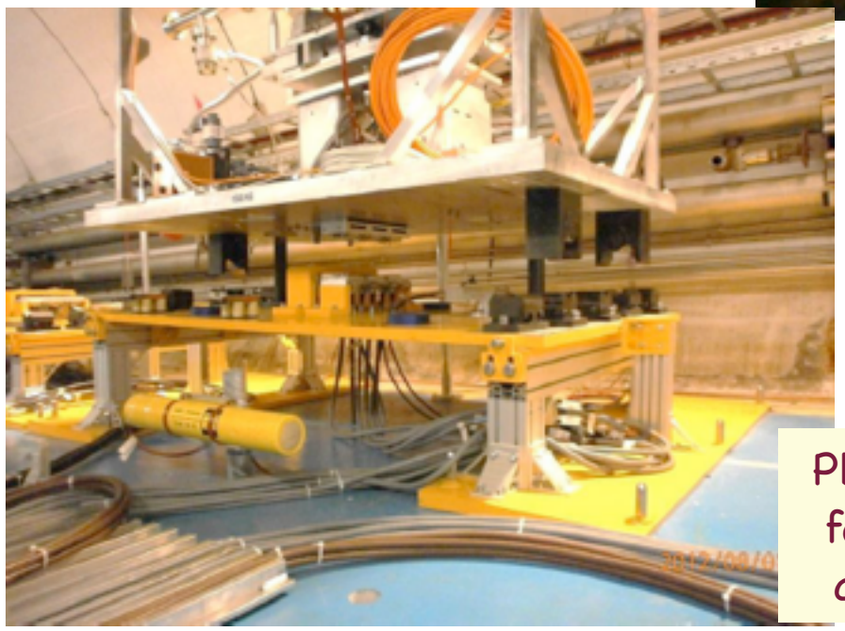
- Impact of high-intensity beam to LHC collimator
- Remote handling (almost) for installation and removal



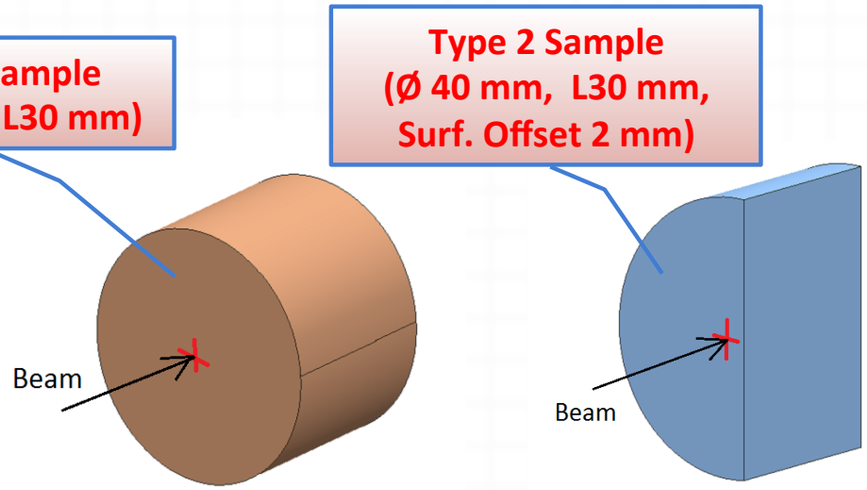


Plug-in system for all cables and services

HRMT14-LCMAT Experiment

LCMAT Experiment: Specifications

- Characterize **six different materials** (Inermet 180, Glidcop, Molybdenum, Copper-Diamond, Molybdenum-Diamond, Molybdenum-Graphite)
- **Medium intensity** and **High intensity** tests, with different material samples for each material (Type 1, Type2)
- Each sample holder tier can host up to **10 specimens**
- Extensive **real time data acquisition**
- **Post-irradiation** analysis



EN Engineering Department

HRMT15-RPINST Experiment

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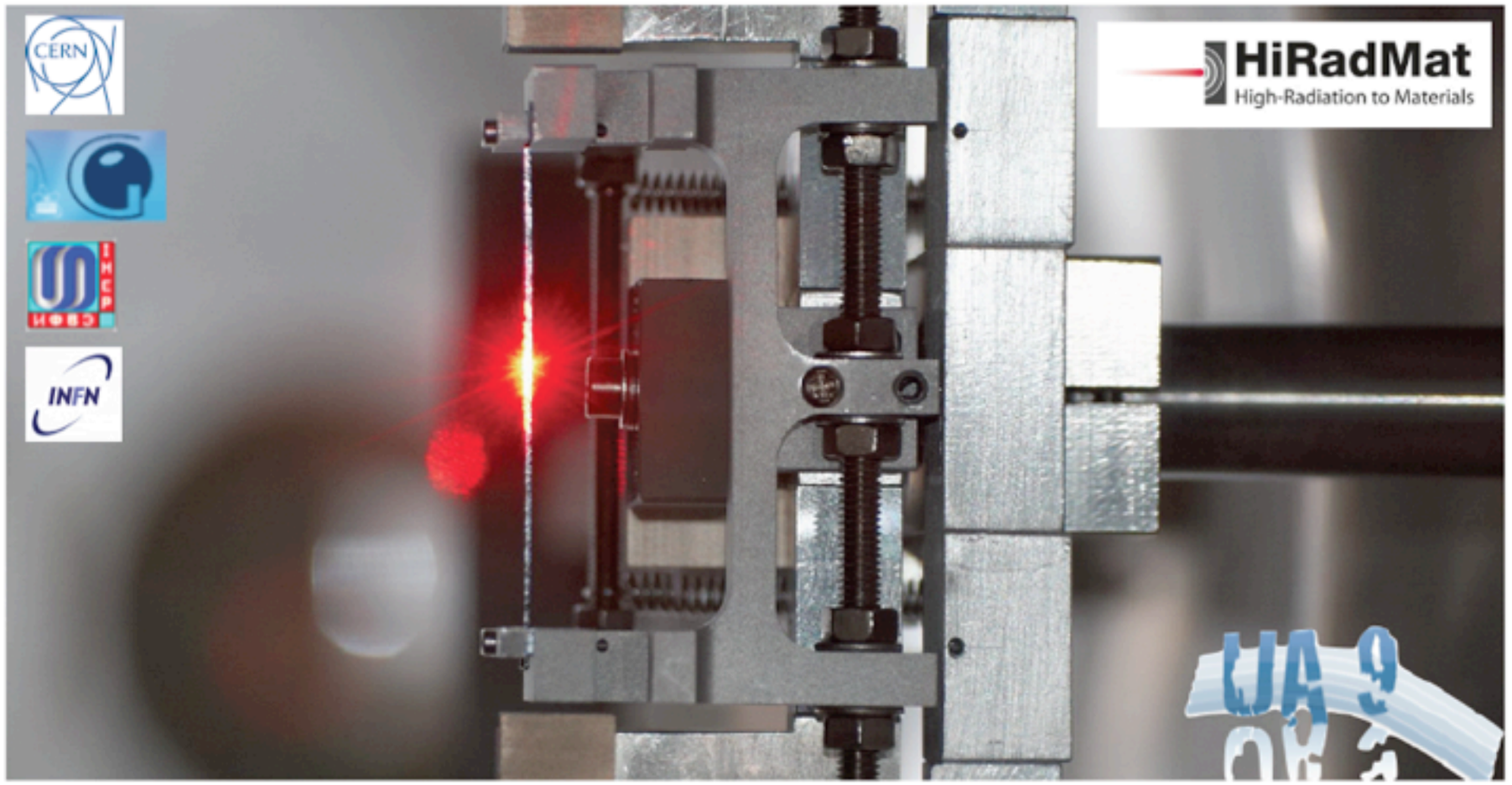
- Test and inter-comparison of RP detectors to neutron and mixed radiation field

HRMT16-UA9CRY Experiment



HiRadMat Scientific and Technical board - 18 October 2012

Proposal of the 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

HRMT01-TISD Experiment

Experiment

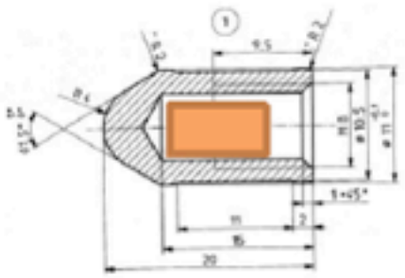
8 samples: (pellets Ø 2 cm x 2 cm) – 4 SiC & 4 Al_2O_3

ISOLDE

beam: NORMGPS – 1.4 GeV, 3.2x10^{13}/pulse (2.4 μs/1.2s, 3-4 bunches), σ = 2.3

RaBIT setup

(Rapid p-beam Irradiation Transport – a pneaumatic system; shuttles sent in front of HRS front-end)



Previous experience – irradiation of SiC and Al_2O_3 at PSI
TARPIPE exp. (INJECTOR 2) – good agreement with experimental results

Fernandes, S., Thèse 4813 (2010), CERN

Cooling down period – 1 year

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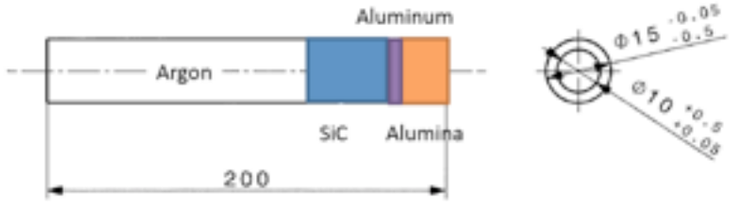
beam: SPS – 450 GeV, 4.9x10^{13}/pulse (7.2 μs/18s, 1 – 288 bunches), σ = 2.0

Max. cycles = 100 (desirable 10x more)

Setup - 8 samples in a row



HRMT06-TPSG Experiment

- Robustness test of a beam septum protection collimator
  - Very large installation (~9m setup) in vacuum!

HRMT06-TPSG Experiment

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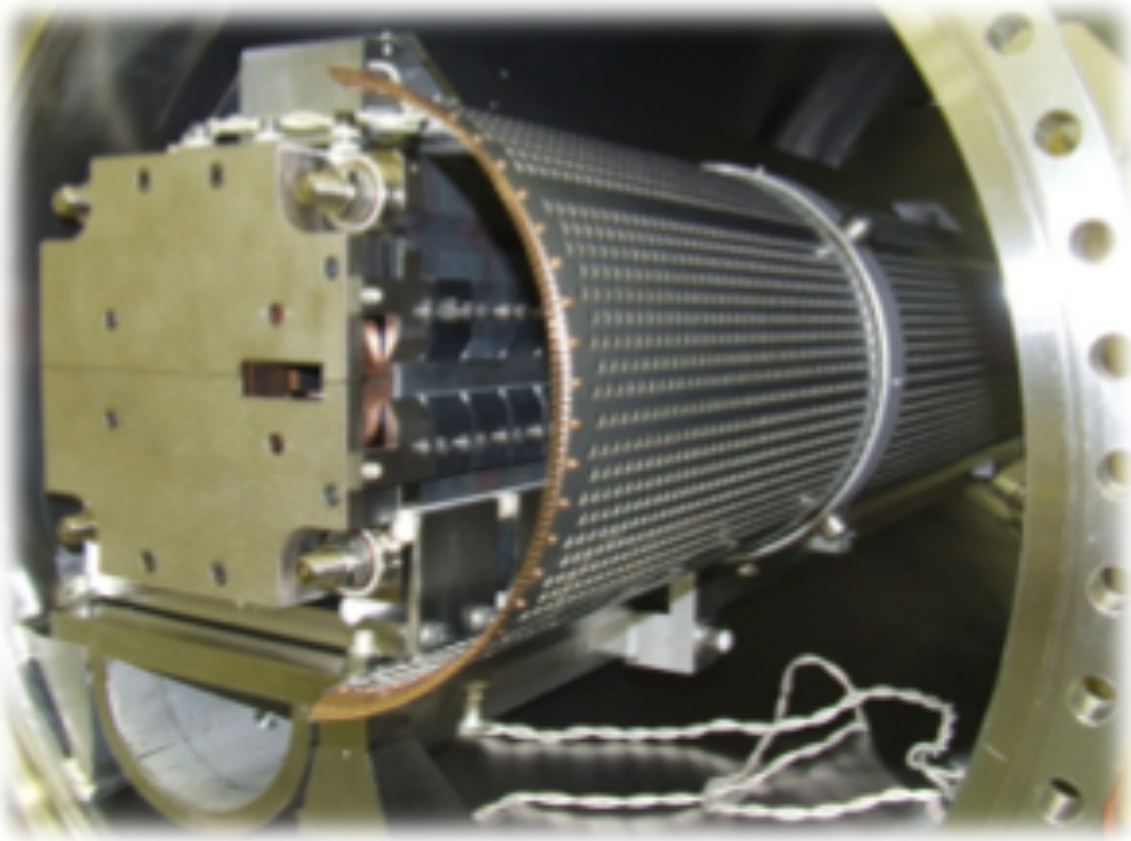
- TPSG: protective device in SPS LSS4 extraction for MSE septum (beam mis-steering, kicker fault)

3100 mm long diluter, with graphite CZ5, CfC, Titanium alloy (TA6V), and a Nickel based alloy (Inconel).

Designed to protect MSE against impact of 450 GeV beam (total intensity: 4.9 10^{13}, time structure: 25ns x 72 x 4)



Courtesy HRMT06, J. Borburgh

The Future

- Experiments in the pipeline and what I would like to see in HiRadMat:
  - 2nd generation of **collimator materials**
  - **Beam windows** (Be, Ti?) used in all machines upstream of targets, beam dumps
  - High-power **targetry** for Neutrino Factory and SuperBeams (pebble beds, ~2MW beam power, others?)
  - **Quench limit** of superconducting magnets
- Possibilities for collaboration ?
  - Instrumentation for experiments : optics, thermal measurements,...
  - Analysis of test samples : techniques and laboratory (RP issues to resolve !)
  - ... and of course Experiments you can propose!!

Future plans

- HiRadMat will be in shutdown mode during the CERN technical stop in 2013-2014

- Restart is expected as of **October 2014**, call for applications in **Summer'13**

- EUCARD/EUCARD2 Transnational Access program will start in **May'13**, also available to support experiments in the facility

Looking forward for more experiments !!

Neutrino Beam Horns – Continue collaboration?

- Conventional (up to 2MW) ν - beam from CERN to Pyhasalmi (Finland)
  - same as CNGS and EUROnu Super beam design --> lot of commonalities with the Horn studies already bone
  - **but** at **18%** slope !!! --> water cooling scheme must basically redone
  - also target embedded in the horn, high-current (300kAms), 1Hz pulsing