HiRadMat: The new High Irradiation of Materials facility of CERN/SPS

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HiRadMat (High Irradiation to Materials) facility is a new facility under construction at CERN designed to provide high-intensity pulsed beams to an irradiation area where raw materials as well as accelerator component assemblies can be tested. The facility uses a 440 GeV proton beam extracted from the CERN SPS with a pulse length of 7.2 μs, to a maximum pulse power of 3.4MJ. Ion beams can be used as well with an energy of 173.5 GeV/nucleon and a total pulse power of 21 kJ. The facility is expected to become operational in autumn 2011. The first tests will include candidate materials and prototype assemblies of LHC collimators foreseen to operate at the ultimate LHC beam powers. Beam windows and high-power target material options, such as tungsten powder, will be tested as well. The poster describes the layout and design parameters for the facility as well as results from simulation studies to address the radiation protection issues involved with its operation.

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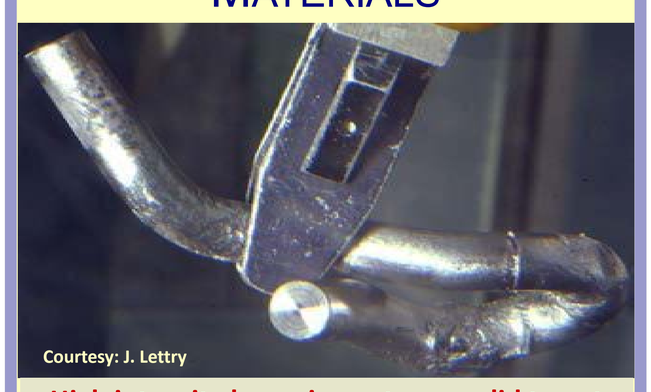
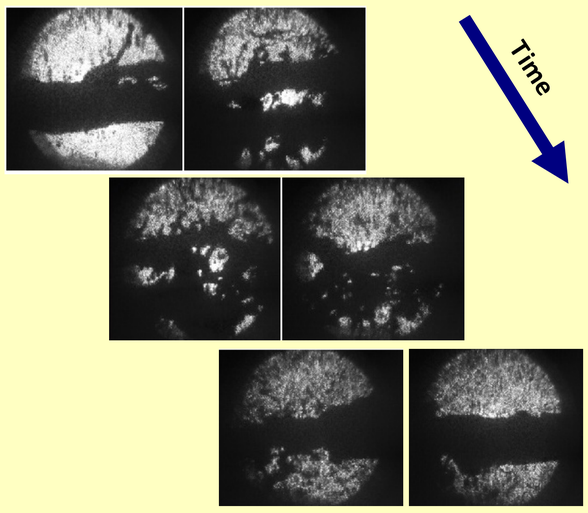
BEAM IMPACT EXAMPLES ON MATERIALS

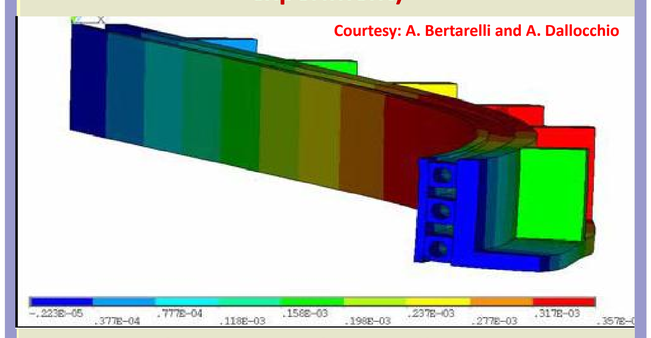


Courtesy: J. Lettry

High intensity beam impact on a solid target

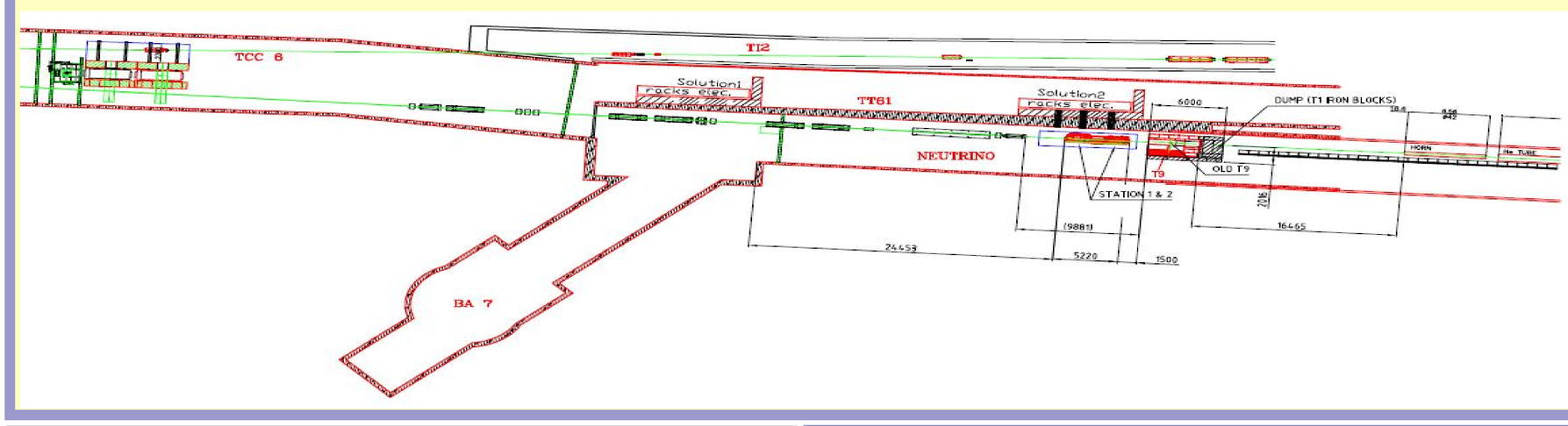


High intensity beam on a liquid target (MERIT experiment)



Deformation of LHC collimators

THE IRRADIATION AREA

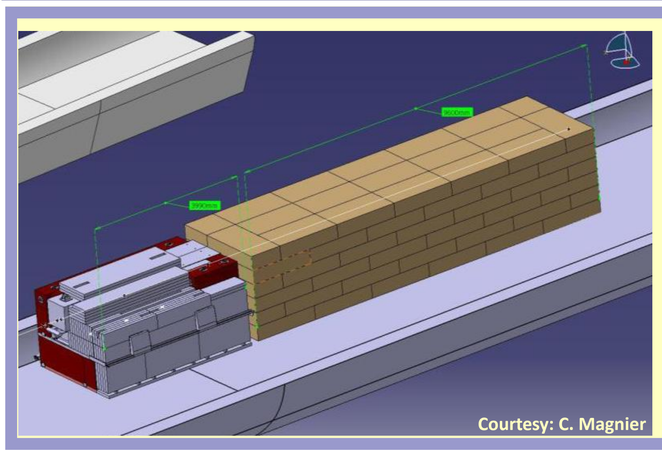


PROTON BEAM PARAMETERS

Beam parameter	Value
Nominal energy [GeV]	440
Pulse Energy	up to 3.4 MJ
Bunch length [cm]	11.24
Bunch Intensity [protons]	$5.0 \cdot 10^9$ - $1.7 \cdot 10^{11}$
Number of bunches per pulse	1— 288
Bunch spacing [ns]	25
Pulse length [μs]	7.2
Beam size at target	Variable around 1 mm^2

HEAVY ION BEAM PARAMETRES

Beam parameter	Value
Nominal energy [GeV/nucleon]	173.5
Pulse Energy	up to 21 kJ
Bunch length [cm]	11.24
Bunch Intensity [ions]	$3 \cdot 10^7$ to $7 \cdot 10^7$
Number of bunches per pulse	52
Bunch spacing [ns]	100
Pulse length [μs]	5.2
Beam size at target	Variable around 1 mm^2



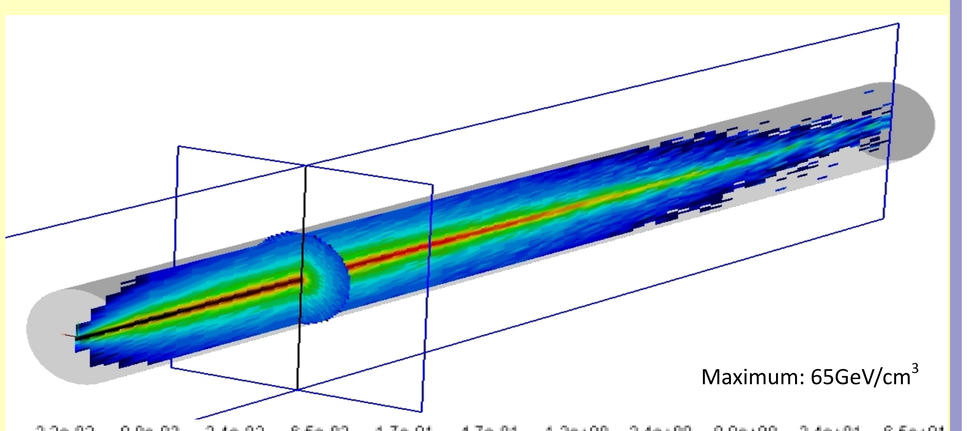
Courtesy: C. Magnier

BEAM LINE AND DUMP

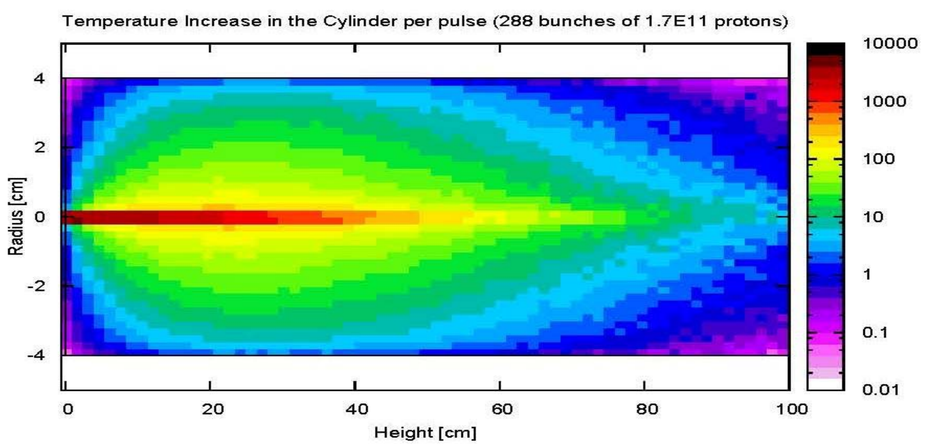
- Flexible design of the beam line to cover a wide range of beam sizes
- Optimized beam line design in order to use recuperated equipment wherever possible
- Water-cooled core dump (based on TED technology— core graphite block)
- Secondary dump made of cast iron blocks

SIMULATIONS AND EXPERIMENTS

The impact of intense high-power pulsed beams on materials is a topic of great interest for the choice of the materials to be used in future accelerators,, as well as for other targetry studies. A special experiment of the impact of the beam in tungsten is being planned, in order to extensively study the material properties and behavior under these extreme conditions of heat and radiation.



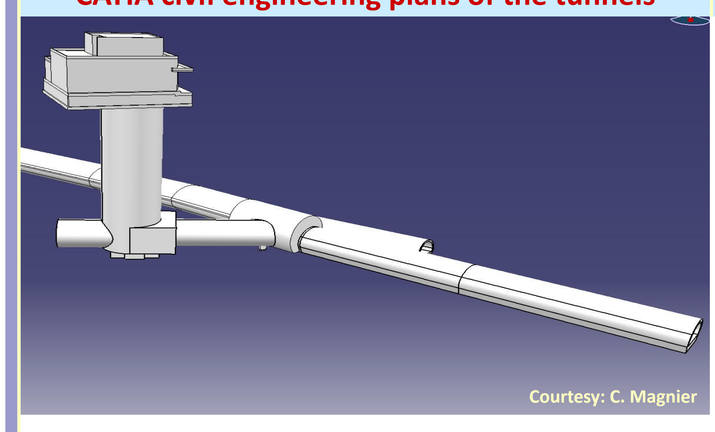
Energy Deposition in Tungsten Cylinder [GeV/cm^3 /primary], after irradiation with a beam of momentum 450GeV/c, beam size 0.1 x 0.1 mm^2



RADIATION PROTECTION STUDIES

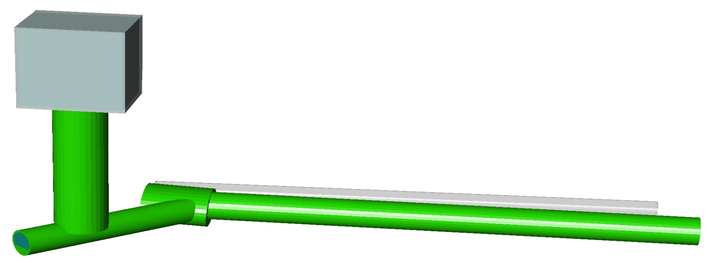
The HiRadMat facility is being carefully designed (choice of materials, redundancy, safety issues) to cope with the high radiation levels foreseen. Extensive Monte-Carlo simulations, using the FLUKA [1,2] code are performed, into a detailed geometry model. Detailed studies of the air, the soil as well as the various elements of he beam line are being carried out, in order the radiation levels to be predicted with the maximum accuracy.

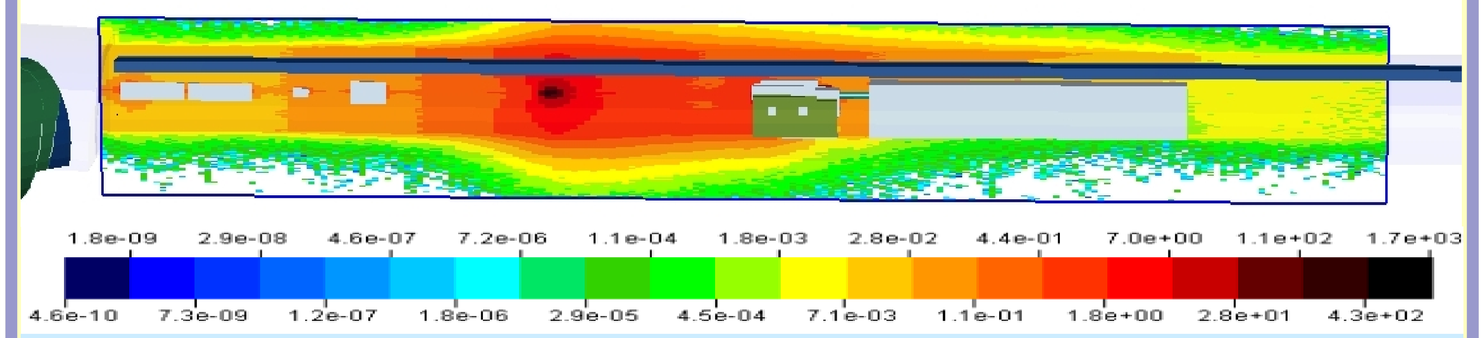
CATIA civil engineering plans of the tunnels



Courtesy: C. Magnier

Fluka model of the tunnels structure





The values of the above figure are expressed in [pSv/impinging proton]. The radiation for a whole experiment (~10^{15} protons over 1320 s) corresponds to a prompt dose equivalent rate of several Sv/h in the irradiation area.

REFERENCES

[1] "The FLUKA code: Description and benchmarking", G. Battistoni, S. Muraro, P.R. Sala, F. Cerutti, A. Ferrari, S. Roesler, A. Fasso`, J. Ranft, Proceedings of the Hadronic Shower Simulation Workshop 2006, Fermilab 6-8 September 2006, M. Albrow, R. Raja eds., AIP Conference Proceeding 896, 31-49, (2007)

[2] "FLUKA: a multi-particle transport code", A. Fasso`, A. Ferrari, J. Ranft, and P.R. Sala, CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773