

THE NEW CERN EAST AREA PRIMARY AND SECONDARY BEAMS

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Abstract

The East Area at the Proton Synchrotron is one of the intensely used facilities at CERN, serving for over 56 years beams nowadays to more than 20 user teams and experiments for about 200 days of running each year. Besides primary proton and ion beams for the irradiation facilities IRRAD and CHARM, mixed secondary beams of hadrons, electrons and muons within a range of 0.5 GeV/c to 12 GeV/c are provided. The CERN Management approved an upgrade and a renovation of the full facility to meet reliably future beam test and physics requirements. We present a new, flexible beam design that will assure better purity of the secondary beams, even with the new possibility of highly pure electron, hadron or muon beams. The upgrade also includes a pulsed powering scheme with energy recovering power supplies and new laminated magnets that will reduce both power and cooling requirements. The renovation phase has started already and first beams in the new facility will be delivered from 2021 on.

INTRODUCTION

Current Facility

The East Area is among the oldest CERN's facilities, in which beam tests, experiments and irradiations are hosted since the 60's. The primary beam is extracted from the Proton Synchrotron by a third-order resonance method. Usually around five extractions per overall PS super-cycle of typically 40 s take place; however, it depends both on users other than PS ones and on schedule constraints, respectively. The primary proton beam, whose momentum is 24 GeV/c, is commonly extracted within 2.4 s cycles during a 400 ms long flat top with a nearly constant rate. Particle beams are then transported by the F61 beam line towards the experimental hall. In order to serve either the North branch, leading to a production target feeding the secondary beams, or the irradiation facilities (namely CHARM and IRRAD), a dedicated magnet can switch the beam. If the whole CERN accelerators complex operates with ion beams, only these two irradiations facilities can be served. Finally, the North branch offers two secondary beam lines for R&D detector tests and calibrations (T9 and T10), and one secondary beam line dedicated to the CLOUD experiment (T11). Their momentum can reach 10 GeV/c, 6 GeV/c and 3.5 GeV/c respectively.

Project Scope

During the last years, operation in the East Area has been slowed down because of technical issues, mainly related to failures and damages of magnets and power supplies. Replacing a magnet in the primary zone requires certain accessibility conditions, *e.g.* the opening of the primary area roof over a length of 6 m. Furthermore, magnets belong to more than 20 different types, *i.e.* having spares available in case of a breakdown would generate additional costs. In addition, the DC supplied magnets imply a high energy consumption in spite of a very low operational duty cycle.

The CERN Management has approved the East Area Renovation Project, for which the reshaping of the whole area is engaged, including beam optics and infrastructure. The redesign of the beam lines will reduce the various magnet families drastically and improve the radiation situation, especially in the primary zone. It will therefore contribute to better maintainability of this experimental area. Furthermore, a new, pulsed powering scheme with laminated magnets and energy recovering power supplies will considerably contribute to energy savings. Finally, the building will be modernised to fulfil the latest safety requirements. This whole study is documented in [1].

NEW BEAM LINE LAYOUT

The East Area renovation starts directly after the extraction from CERN's Proton Synchrotron. The main characteristics of the extraction remain the same as well as the optical elements. Renovation is focused on all beam lines, *i.e.* the transfer line to the secondary targets (now called F61, F62 and F63), the primary beam towards the irradiation facilities (T08), and finally the secondary beam lines (T09, T10 and T11). Optics have been calculated with the help of TRANSPORT [2].

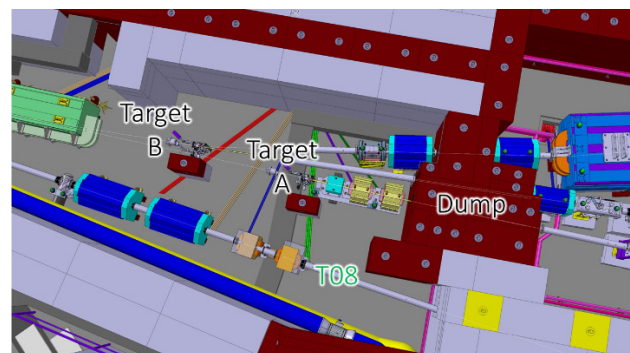


Figure 1: 3D layout of production targets and dump.

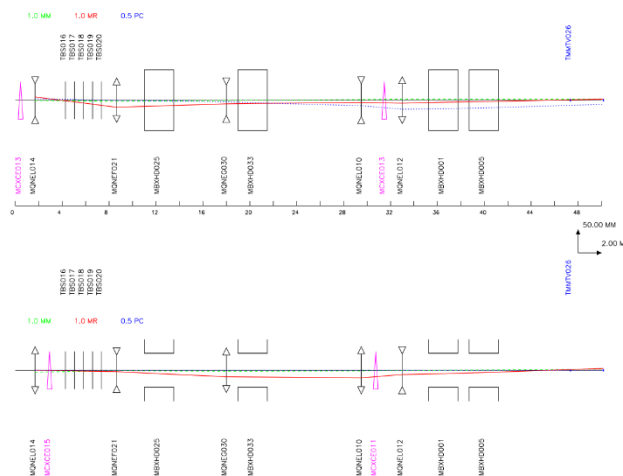
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Primary Beam Transfer Lines

First, a primary dump beam line (F6D) is included in the future East Area layout: it will exclusively be used to set up the PS extraction. The transfer line layout has undergone minor changes. In fact, laminated magnets will replace solid yoke ones. In addition, two corrector magnets will be added in the F62 line, allowing steering of the beam in both horizontal and vertical planes. C-shaped switching dipoles will replace the obsolete splitter and lead the beam on one or the other production target. Indeed, two North primary targets will be installed to produce three secondary beam lines named T09, T10 and T11. As shown in Figure 1, a dump placed after both targets is designed to cleanly discard primary protons, thus reducing high level radiation doses in the primary area. The beam spot size at both targets has been evaluated using TURTLE simulations [3]. The currents of the two last quadrupoles of the F62 beam line will be tuned such that the beam spot size fits within the target diameter (specified in Table 1). This optics of F61 and F62 transfer lines is depicted in Figure 2. Finally, instrumentation along all these primary lines will be upgraded and a dedicated ventilation will be installed for the primary area.

Table 1: Specification of the Multi-target Heads

Head n°	Material	Length (mm)	Diameter (mm)	Comment
1	Be	200	10 + Al casing	Electron enriched
	W	3		
2	Al	100	10	Electron enriched
	Be	3		
3	Al	200	10	Hadron
4	Air	200	10	Empty
5	Al	20	10	Hadron



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The T11 beam line optics is equivalent to the one of T10 but with reduced lengths due to space restrictions. The last two quadrupoles of T11 are set to over-focus the beam in order to irradiate fully the CLOUD chamber [4]. Therefore, the beam spot size at CLOUD is $1.3 \times 1.3 \text{ m}^2$.

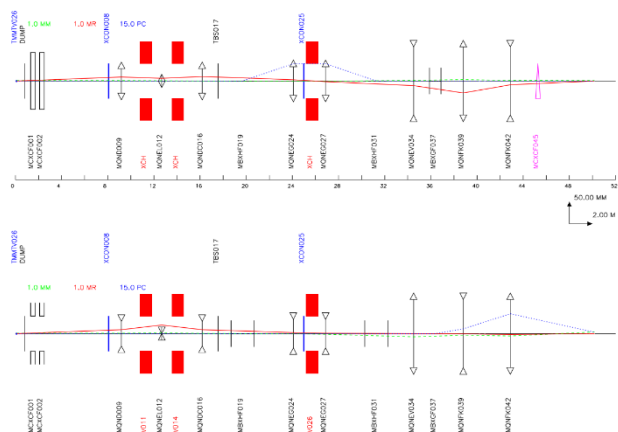


Figure 3: Optics layout of T09 beam line. The red line corresponds to the sine-like ray, the green like represents the magnification and the dotted-blue line is the dispersive term.

MAGNETS AND POWER SUPPLIES

The new powering scheme is based on pulsed operation of laminated magnets and energy-recovering power supplies. The number of magnet types is drastically decreased in order to get more flexibility for spare magnets as well as for easier and faster maintenance. The alignment supports of the magnets will also be improved [5]. The new

SIRIUS power supplies are modular and allow for energy recovery by capacitor banks after each cycle. The annual power consumption will then be reduced from 7 to 1.1 GWh.

INFRASTRUCTURE RENOVATION

Infrastructure renovation concentrates on thermal insulation and on safety aspects that are considered as a priority in this project. The asbestos removal and the renovation of the building façade will allow decreasing the annual power consumption from 3 to 1 GWh [6]. Furthermore, works will be performed on the electrical network, the gas distribution to the experiments, and the cooling and ventilation of equipment and experimental zones.

CONCLUSION AND OUTLOOK

This paper presents the full redesign of the CERN's East Area, which is depicted in Figure 4. This implies a new flexible beam optics, a significant reduction of power consumption and safety improvements.

The renovation already started since the end of 2018 by civil engineering works. It will continue through the Long Shutdown 2 and will finish in 2021, when the first beams will be sent to users after a beam commissioning phase.

ACKNOWLEDGEMENTS

The authors acknowledge the continuing help and support of all involved groups at CERN and the involved companies.

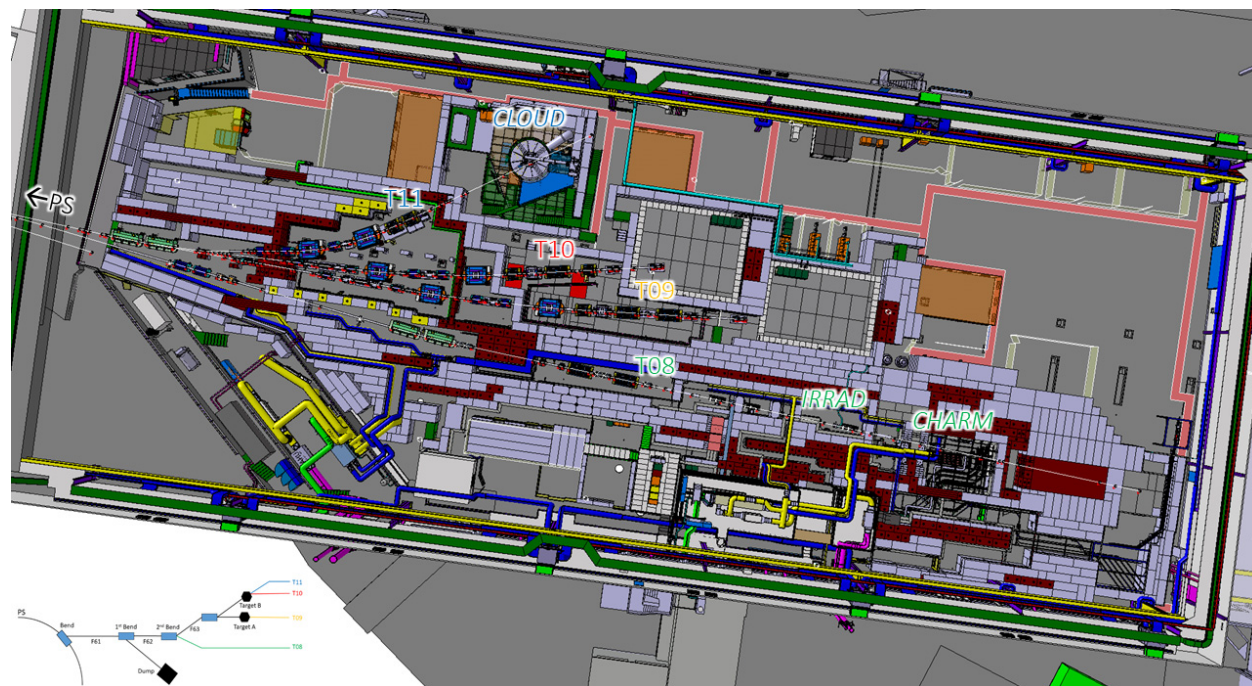


Figure 4: 3D layout of the future East Area, associated with a synoptic of the beam lines. The primary proton beam is extracted from the CERN PS (coming from the left side). It is then transferred thanks to the transfer beam lines either towards the two irradiation facilities IRRAD and CHARM (via the T08 beam line) or towards the production targets that are followed by the T09, T10 and T11 beam lines.

REFERENCES

- [1] L. Gatignon *et al.*, “The East Area Upgrade”, CERN internal note, EDMS 1471844, 2015, unpublished.
- [2] K.L. Brown *et al.*, CERN, pp. 80-04, 1980.
- [3] K.L. Brown, *et al.*, CERN, pp. 74-2, 1974.
- [4] B. Fastrup *et al.*, “CLOUD: An atmospheric research facility at CERN”, CERN physics/0104076, CERN-SPSC-2000-041, 2001.
- [5] R. Vanhoutte *et al.*, “Design & Optimization of the Alignment Supports for the New Laminated Magnets for the CERN East Area Consolidation Project”, presented at the 10th Int. Particle Accelerator Conf. (IPAC'19), Melbourne, Australia, May 2019, paper THPRB086, this conference.
- [6] B. LM. Lamaille *et al.*, “Study of the Energy Savings Resulting from the East Area Renovation”, presented at the 10th Int. Particle Accelerator Conf. (IPAC'19), Melbourne, Australia, May 2019, paper THPRB087, this conference.