Report on the session "Test Beams & Irradiation facilities" at the workshop "New Opportunities in the Physics Landscape at CERN".

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Summary

CERN provides unique facilities for test beams and irradiations with excellent technical support. There will be other possibilities for tests with high-energy particle test beams in the coming decades.
The number of users of these facilities is expected to increase, as tests of the LHC detectors will continue at least until 2012. More communities (sLHC, future detectors for a linear collider, heavy ion and neutrino physics) will increase their R&D program with the need for test beams even longer than 2020.
The communities stress the need for permanent installation of their equipment within a test beam zone and see the need for additional infrastructure (magnets, beam instrumentation).
The number of users from smaller communities (e.g. satellite experiments, astroparticle physics detectors) is expected to remain constant.
With this large need for test beams and irradiation facilities it is feared that with the stop of the CERN PS the East Area will not be available for the communities any more resulting in a defile for tests and detector R&D. It was suggested to study the possibility to keep the East Area operational using beam from the future PS2. New test beam and irradiation facilities at the PS2 would be very welcome and possibilities should be studied.
Irradiation facilities to study behaviour of detectors and materials for LHC machine and experiments and their upgrades in a very harsh radiation environment are seen to be mandatory. The diverse requirements make four facilities necessary.
The users ask for an opportunity for a regular forum to express their wishes, synchronise requests and exchange information and technology.
It was stressed that the test beams provide an excellent opportunity for education: for students they are very often the only possibility to get hands-on experience with detectors and to learn about experimental techniques.

Detailed Report

The session received contributions from many user groups of the CERN test beams with different focus and needs. Thus the session was organised in three categories to present and to summarise the future needs: (1) plans for test beams for non-collider experiments - contributions were sent by the heavy ion community and the neutrino community; (2) plans for test beams for collider experiments - the LHC, sLHC communities and communities working on detectors for a future linear collider contributed; (3) plans for future irradiation facilities at the CERN test beams - supported by the LHC and sLHC detector communities but also needed by accelerators for material studies.

For test beams the following infrastructure is currently available at CERN:

- two beam lines at the PS East Area providing secondary electron, muon and hadron beams with momenta between 1 GeV/c to 15 GeV/c. Typically there is one user per beam line and beam lines are used in about 90% of the available beam time (n.b. three more beam lines in the East Area have permanent installations by the DIRAC and CLOUD experiments and host a proton and neutron irradiation facility);
- four beam lines at the SPS North Area providing primary proton beam at 400 (450) GeV/c or secondary electron, muon and hadron beams with momenta between 10 GeV/c and 400 GeV/c. There is one user per beam line and beam lines are always fully booked.

As an example, the number of users each year in the SPS test beam area has steadily increased since 2001 from 22 users to 29 users in 2009.

It was stressed by all communities that the test beams at CERN are a unique opportunity for detector and physics tests. This will remain true also in the coming decades. In addition, the technical support at CERN for the users was described as superb and is vital for successful tests also in the future.

(1) Plans for test beams for non-collider experiments

For the communities interested in heavy ions, additional possibilities for test (and physics) beams with different ion species were proposed. A high-energy secondary beam of ion fragments can be produced by bringing the lead ion beam used for the LHC to a target. Different species can be selected and transported to the experimental areas by a set of magnets for momentum selection plus degraders to select the required ion species. For the community, carbon, sulphur and indium ions would be of interest. Some first test have been done to study this method, but without particular attention to purity. Further studies are required [Abstract 61]

A contribution from the heavy ion community was a proposal to use the ion beam in the test beam area to study bremsstrahlung emission from relativistic heavy ions which gives a serious background for the ALICE experiment [Abstract 21].

The test beam needs for neutrino detector R&D will start to increase from 2010 onwards. It was summarised that the design of future neutrino long baseline experiments will face the challenges to build very large scale-detectors with increased resolution and increased ability to reduce background signals. A large range of magnetic and non-magnetic detectors either with improved or very new technology needs to be tested and optimised [Abstract 15]. Especially because of the size and complexity of the detectors to be tested, installations which will remain in a test beam zone for a couple of years are important for the neutrino community, e.g. for a liquid Argon TPC detector with an instrumented mass of about 4 tons [Abstract 82].

For future neutrino experiments, high power proton beams need to be used to provide the required neutrino flux. New targets for neutrino factories need to be

developed, different possibilities (solid targets, liquid targets) need to be studied. Target tests to simulate the thermal shock need test beams, however options at the CERN Isolde facility or at possible CERN irradiation facilities need to be evaluated [Abstract 49].

It was emphasised that test beam users who are not organised in the communities mentioned above (from astroparticle detectors, satellite experiments or groups from national laboratories and universities working on detector development which e.g. in 2008 used about a quarter of the beam time available at the H4 beam line) did not send any contributions to the session. However for these groups, the CERN test beams are vital to develop, test and calibrate new equipment. It is expected that the utilization of the beam by these groups remains constant over many years from now.

(2) Plans for test beams for collider experiments

For the LHC experiments, with the start of the data taking, it is expected that details and problems about the detector operation will emerge that require exercising a realistic copy of the system in controlled conditions of a test beam. As well a better understanding of the detectors might be necessary. It is expected that there will be test beam needs at least until 2012. It will be necessary to keep the permanent installations e.g. in the H2, H4 beam line until then [Abstract 54].

Research and development for sLHC detectors has started, many new technologies are already being studied, e.g. new pixel technologies, silicon photomultipliers, GEMs, new scintillating crystals, heavy fibres. After a technology decision for the detector will be made, an exhaustive test beam program as for the LHC will be needed using permanent installations. It is expected that for the sLHC experiments test beam activities will continue up to 2020 and beyond.

As future LC-CLIC and ILC detectors have a huge synergy, test beam efforts can cover both detctors. Currently, realistic prototypes of many detector technologies are under way, e.g. for the electromagnetic and hadronic calorimeter. In the future, tests with ILC-like time structure, Bunch trains of 1ms length, a 300ns spacing with a repetition rate of a few hundred ms, would be ideal and should be possible at the PS.
The next step would be to perform integrated system tests combining tracking, magnet and calorimetry which requires permanent installation of the equipment in a test beam line. It is expected that test beam activities will continue up to 2020 and beyond [Abstracts 34 and 56].

With the increasing number of users from the collider experiments it can be expected that it will be required to have a larger number of permanent installations in the SPS North Area, which will require a careful planning and very likely re-organisation, upgrades and extensions of the infrastructure in the area. Also, the communities see the need for additional magnets and beam instrumentation. Here additional studies and investigations are required.

(3) Plans for future irradiation facilities at the CERN test beams

Irradiation facilities are important tools to develop and test prototypes, materials and final assemblies of detectors and equipment before installation in a radiation environment. Monitoring devices can be calibrated and tested, the results of irradiation tests provide feedback to simulation codes. The facilities can provide benchmark measurements and tests in a controlled, standardised environment. A user survey has been carried out, 145 replies were received mainly from LHC (sLHC) experiments and machine as well as from groups involved in radio protection and simulation, details can be found at http;//cern.ch/irradiation facilities.

From the survey possibilities to combine needs and a minimisation of the number of proposed facilities were studied, the diverse requirements make four facilities necessary:

- A proton and ion facility irradiating at high energy and high density using a fast extraction of an LHC-type beam. Thermal management (heating) of materials thermal shocks and beam induced pressure waves need investigations, which are important for validation of LHC near-beam components like collimators and absorbers. The proposed facility is HiRadMat with a possible implementation in the TT60/WANF tunnel;
- A gamma irradiation facility in the presence of a muon beam to study signal performance of detectors in a high background environment, to study detector aging properties and to optimise detector and beam diagnostics equipment operation parameters. This facility is vital for LHC detector upgrades and a heavy use is expected (N.b. the current gamma irradiation facility can not provide a muon beam and the gamma irradiation intensity is more than a factor of ten too low for LHC upgrade detectors). The proposed facility is GIF++ in the North Area;
- A proton irradiation facility providing high intensity using a slow beam extraction from the accelerator to study long-term exposure of equipment, mainly for the inner trackers of the LHC experiments, their upgrades and for detector and accelerator electronic components. The proposed facility is to continue the irradiation at the PS and a future facility at the PS2;
- A mixed field irradiation facility using a slow extraction to study the impact on system components exposed in radiation fields. Primary users would be the LHC accelerator and detector components. The proposed facility is CERF++ in the SPS North Area.

The next steps for the working group are to advance the feasibility studies to the implementation and the technical designs of all four facilities [Abstract 55]