

Overview on Test Beam Facilities

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ILC detectors are required to haveprecedented precision. Achieving this requires significant investment for detector test beam activities to complete the R&D needed, to test prototypes and (later) to qualify final detector system designs, including integrated system tests. This document describes an overview of current test beam facilities.

1 Introduction

ILC detectors are required to haveprecedented precision. Achieving this requires significant investment for detector test beam activities to complete the R&D needed, to test prototypes and (later) to qualify final detector system designs, including integrated system tests. To this purpose ILC Detector Test Beam Workshop (IDTB07) [2] was held at Fermilab in January 2007, where we started to write the roadmap document for ILC detector R&D test beams [3]. In this talk an overview of current test beam facilities was given based on the information collected at the IDTB07 workshop with some updates.

2 Facilities

Currently seven laboratories in the world provide eight beam test facilities; CERN PS, CERN SPS, DESY, Fermilab MTBF, Frascati, IHEP Protvino, LBNL and SLAC. In addition, three laboratories are planning to provide beam test facilities in the near future; IHEP Beijing starting in 2008, J-PARC in 2009 and KEK-Fuji available in fall 2007. Table 1 summarizes the capabilities of these facilities and their currently known availabilities and plans.

2.1 CERN

There are presently four beam lines at two machines; four in the east area of the PS and four in the north area at the SPS. A variety of targets are possible for the PS beams, including one that enhances electron yield by a factor 5~10, but T9/T10/T11 share the same target. For the SPS beams, H2/H4 and H6/H8 share targets. Up to three user areas are possible per beam, although some areas have been permanently occupied by major LHC users. H4 can be set up to produce a very pure electron beam, with energies up to 300 GeV. Low energy tertiary beams are possible in H2 and H8. In addition to test beams, there are two irradiation facilities at CERN. The Gamma Irradiation Facility (GIF), based on a ^{137}Cs source in the former SPS west area, provides 662 keV photons at up to 720 GBq. While 2007 may be the last year of operation, a new facility is under discussion. A proton and neutron irradiation facility in the PS east hall uses the 24 GeV primary protons from the PS to provide a $2 \times 2 \text{ cm}^2$ beam spot with 2.5×10^{11} protons/spill. Neutrons with a spectrum similar to the LHC can be obtained from a beam dump. With the start of the high-priority LHC program in 2008, there is considerable uncertainty about the future test beam running schedule. Three interleaved operational modes for the PS and SPS are envisioned in the

| Facility | Primary beam energy (GeV) | Particle types | Beam lines | Beam Inst. | Availability and plans |
|---------------|--------------------------------|-----------------------|------------|---|---|
| CERN PS | 1–15 | e, h, μ | 4 | Cherenkov, TOF, MWPC | Available, but reduced services during LHC commissioning |
| CERN SPS | 10–400 | e, h, μ | 4 | Cherenkov, TOF, MWPC | Available, but reduced services during LHC commissioning |
| DESY | 1–6 | e | 3 | Pixels | Available over 3 mo/yr |
| FNAL-MTBF | 0.25–0.75 | p, e, h, μ | 1 | Cherenkov, TOF, MWPC, Si-strips, Pixels | Continuous at 5% duty factor, except for summer shutdowns |
| Frascati | 0.25–0.75 | e | 1 | | Available 6 mo/yr |
| IHEP-Beijing | 1.1–1.5 0.4–1.2 (secondary) | e e, π , μ | 3 3 | Cherenkov, TOF, MWPC | Available in March 2008 or later |
| IHEP-Protvino | 1–45 | e, h, μ | 4 | Cherenkov, TOF, MWPC | Two one-month periods per year |
| KEK-Fuji | 0.35–3.4 | e | 1 | | Available in fall 2007, for 8 mo/yr, as long as KEKB operates |
| LBNL | 1.5; ≤ 0.06 ; ≤ 0.03 | e; p; n | 1 | Pixels | Continuous |
| SLAC | 28.5 1–20 (secondary) | e e, π , p | 1 | | Shutdown in 2008-2009, with certain plans beyond |

Table 1: Summary of test beam facilities along with their beam instrumentation, availability and plans.

LHC era, including LHC injection, LHC setup (with test beams in parallel), and delivery to other programs, e.g., the neutrino program, and fixed target and test beam experiments. The study suggested about a 50% fraction in the delivery mode in 2008, rising to perhaps 85% by 2011, depending on experience. It remains to be seen what the actual availability will be in the coming years. However, operation of the SPS in test beam mode, and therefore the PS as well, is required to serve several fixed target experiments that are part of the core CERN physics program.

2.2 DESY

Three test beam lines are available, based on bremsstrahlung photons generated by a carbon fiber in the circulating beam in the DESY II synchrotron. Photons are converted in an external copper or aluminum target, spread into a horizontal fan by a dipole magnet, and then collimated. There are no external beam diagnostics or instrumentation available. However, the T24 area is being dedicated to EUDET, which will provide significant infrastructure. The facility will be down for the first half of 2008, but is otherwise available on a continuous basis.

2.3 Fermilab

The Meson Test Beam Facility (MTBF) has recently completed a major upgrade in anticipation of the needs of the ILC community. By moving the target to shorten the decay path from about 1300 to 450 ft, reducing material in the beam line from 17.8 to 3.4% X_0 , and increasing the aperture and the momentum acceptance from .75 to 2%, the overall rate has been substantially improved in the new design and the momentum range has been extended below 4 GeV. In addition, the fraction of electrons in the beam has been enhanced. The Switchyard 120 (SY120) delivers main injector beams to the Meson Detector Building. It must run in conjunction with proton delivery to the pbar source and the neutrino programs. For the purposes of program planning, the MTBF is administratively limited to no more than a 5% impact on these other programs. The Accelerator Division has implemented both 1 second and 4 second spills. Possible configurations are one 4-second spill every minute, 12 hours/day; two 1-second spills every minute, 12 hours/day; and one 4-second spill every two minutes, 24 hours/day. It may also be possible to simulate the ILC beam structure of 1 ms beam followed by 199 ms gap. The MTBF test beam area is divided into two beam enclosures, although these cannot be operated independently. These enclosures are divided into six user stations and are supported by installed cables, gas lines, offices, and two climate controlled huts. Experiments are also supported by a tracking station, a new TOF system and differential Cherenkov detector, motion tables and video system, and a laser alignment system. Further enhancements to the Fermilab test beam capability are under consideration. The MCenter beam line, which houses the MIPP experiment, is currently not scheduled. The beam line has very attractive characteristics. Six beam species are available from 1~85 GeV, with excellent particle identification capabilities. The MIPP experimental setup could allow for a better understanding of hadron-nucleus interactions, thereby benefiting our understanding of hadronic shower development.

2.4 IHEP-Beijing

Three test beam lines are available at BES: two are to deliver primary electrons or positrons at 25 Hz to the E1 and E2 experimental areas, while secondary beams at 1.5 Hz are available in E3. The facility is already booked for all of 2007. It will undergo significant upgrade through March 2008, at which point the facility will be available on a continuous basis.

2.5 IHEP-Protvino

At least four high intensity and low intensity beam lines are available at IHEP-Protvino. Beam lines in the BV hall are produced from internal targets in proton synchrotron and have limited intensity. The extracted proton beam is also used to produce high-intensity primary and secondary test beams in the experimental gallery. Test beams are available in two period (April and November-December) for a total of about 2 months/year.

2.6 KEK and J-PARC

There are currently no test beam facilities at KEK. However, the Fuji test beam line is being implemented for fall 2007. This is based on bremsstrahlung photons from 8 GeV high-energy beam particle collisions with residual gas in the KEKB Fuji straight section vacuum chamber. Photons are converted in a tungsten target and the conversion electrons

are extracted to an experimental area outside the KEKB tunnel. The expected particle rate is continuously more than 100 electrons/s over a momentum range from 0.5 to 3.4 GeV. The facility will operate parasitically to KEKB, with availability about 240 days/year. Plans are developing for test beam facilities at J-PARC, which would be realized no earlier than 2009.

2.7 LBNL

Two test beam opportunities are offered, as well as dedicated beam lines for proton and neutron irradiation from the 88 inch cyclotron. A 1.5 GeV electron beam with tunable flux is available at 1 Hz from the injection booster for the ALS. This test area is equipped with a 4-plane beam telescope based on thinned CMOS pixel sensors. In addition, LOASIS is able to supply electron beams via TW laser wakefield acceleration. At present, it is possible to tune beam energies from 50 MeV to 1 GeV. There are also plans to extend the beam line for decreased intensity and to allow testing at different incident angles.

2.8 SLAC

A single beam line brings primary electrons from the main linac to End Station A (ESA), with energies up to 28.5 GeV and fluxes varying from 1.0×10^6 to 3.5×10^{10} /pulse. A secondary beam can be produced by putting the primary beam on a Be target in the beam-switchyard and accepting hadrons into the A-line, which makes a 0.5 degree angle with respect to the linac. Secondary electron or positron beams can also be created using collimators at the end of the linac, with fluxes adjustable down to one particle per pulse. The End Station A facility is well equipped with a shielded area for work with primary beam, and an open experimental region beyond for secondary beams. The beams are well instrumented.

Anticipating the end of the B Factory running in September 2008, the user-based test beam program in End Station A (ESA) will complete in Summer 2007, though some ILC tests will continue in ESA until September 2008. In 2009, the downstream 1/3rd of the linac will be used for the LCLS project with no plans for delivering test beams to ESA. The South Arc Beam Experiment Region (SABER) has been proposed as a follow-up to the Final Focus Test Beam Facility (FFTB). SABER would use the first 2/3 of the linac to deliver compressed, focused, primary electrons and positrons at 28.5 GeV to the south arc experimental region. This space may be suitable for smaller scale R&D experiments. SLAC is also considering an extension of the SABER proposal that would provide 28.5 GeV primary beams to the A-line, thereby restoring capability for both primary and secondary beams into End Station A. SABER is scheduled for operation in 2010, so a user test area could be restored in either the south arc or End Station A shortly afterward.

References

- [1] Slides:
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- [2] URL: <https://conferences.fnal.gov/idth07/>
- [3] *Roadmap for ILC Detector R&D Test Beams*, KEK Report 2007-3, FERMILAB-TM-2392-AD-DO-E, Unpublished (2007).