A WIDE RANGE ELECTRONS, PHOTONS, NEUTRONS BEAM FACILITY

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Abstract

The DAFNE Beam Test Facility (BTF) is in operation since the 2003 and has been continuously improved and upgraded in order to take into account the many different requests coming from the high energy and accelerator community. The facility was initially optimized to produce single electron and positron in the 25-750 MeV energy rage, manly for high energy detector calibration and testing; it can now provide beam in a wider range of intensity, up to 10^10 electrons/sec, typically needed for accelerator diagnostic tests. In the last two years the facility has also been modified in order to produce tagged photons, and the possibility to deliver tagged neutrons in the MeV energy range is under study. The main results obtained, the performance and the most significant characteristics of the facility diagnostics and operation are presented, as well as the users experience collected during these years of operation.

INTRODUCTION

The BTF is part of the DAFNE collider devoted to the production of very high rate Φ meson. It consist of a high current electron-positron LINAC and 510 MeV, a dumping ring and two 100 m Main Rings (MR).

The e+/e- beam from the LINAC is stacked and damped in the accumulator ring for being subsequently extracted and injected into the MR. When the injector is not delivering beam to the accumulator, the LINAC beam can be transported into the Beam Test area by a dedicated transfer line (BTF line). The main components of the line are described in the following [1].

The main parameters of the S-band LINAC (length 60 m) are listed in the table below:

Table 1: LINAC parameters

Particle	Electron	Positron
Energy	800 MeV	510 MeV
Max. Current	500 mA/pulse	100 mA /pulse
Transverse Emmittance	≤ 1 mm mrad at 510 MeV	≤ 10 mm mrad at 510 MeV
Energy spread	~1% at 510 MeV	~2.5 % at 510 MeV
Pulse duration	1 or 10 ns	
Repetition rate	1-50 Hz	

Electron (positron) beams in that energy range are suitable for many purposes: high energy detector calibration, low energy calorimetry, low energy electromagnetic interaction studies, detector efficiency and aging measurements, test of beam diagnostic devices etc. Since the end of 2005 a photon tagging system has been installed and started operation with the first users.

THE BTF TRANSFER LINE

The layout of the BTF transfer line is shown in Fig.1. The transfer line is about 21 m long, from the outlet of DHPTB101 (the pulsed dipole extracting the beam to the BTF line) to the bending magnet DHSTB002 in the BTF hall that is one of the two beam exits, and has an inner diameter of about 5 cm. All the line is kept under high vacuum (10-10 bar) with the exception of the final part (from the DHSTB002 inlet to the 2 beam exits in the experimental hall), that is working, at present time, at 10-4 bar. The part under high vacuum ends with a Be window of 0.5 mm thick. The 10 cm air gap between the Be window and the inlet of the DHSTB002 bending allows the insertion of the silicon micro-strip chambers needed for tagged photon production.

The injector system provides beam both to the DAFNE damping ring and to the test beam area. The DHPTB101 allows driving each of 49 pulses per second either to accumulator or to the BTF line, thus permitting a quasi-continuous operation, limited only by electron/positron LINAC switch (30-40 sec). Indeed, even when beams are injected into the DAFNE main rings, not all the bunches are needed for machine filling, so that beam can still be delivered to the BTF, but with a lower repetition rate [2]. Obviously, in this operation scheme the pulse duration and the primary beam energy must be the same of DAFNE (10 ns). This is not a strong limitation, since the facility is mainly operated in single particle mode (electrons/positrons), which is the ideal configuration for detectors calibration and testing.

The intensity and the spot of the beam at the begging of BTF line can be measured by a beam current monitor (BCM1 beam charge to charge output ratio 50:1) and a fluorescent screen of beryllium-oxide type (FLAG01).

The intensity of the beam can be tuned by means of a vertical collimator (SLTB01), located upstream respect to FLAG01 in the BTF transfer line. In the high multiplicity (107 up to 1010 particles/bunches) range, the diagnostic elements of the line are completed by another beam charge monitor BCM2 (high sensivity, beam charge to output charge ratio 5:1) and two fluorescent screens FLAG02 (beryllium oxide), FLAG03(YAG:CE) mounted at the two exits of the line. In the following, the number of particles per bunch is also referred as "multiplicity of the beam".

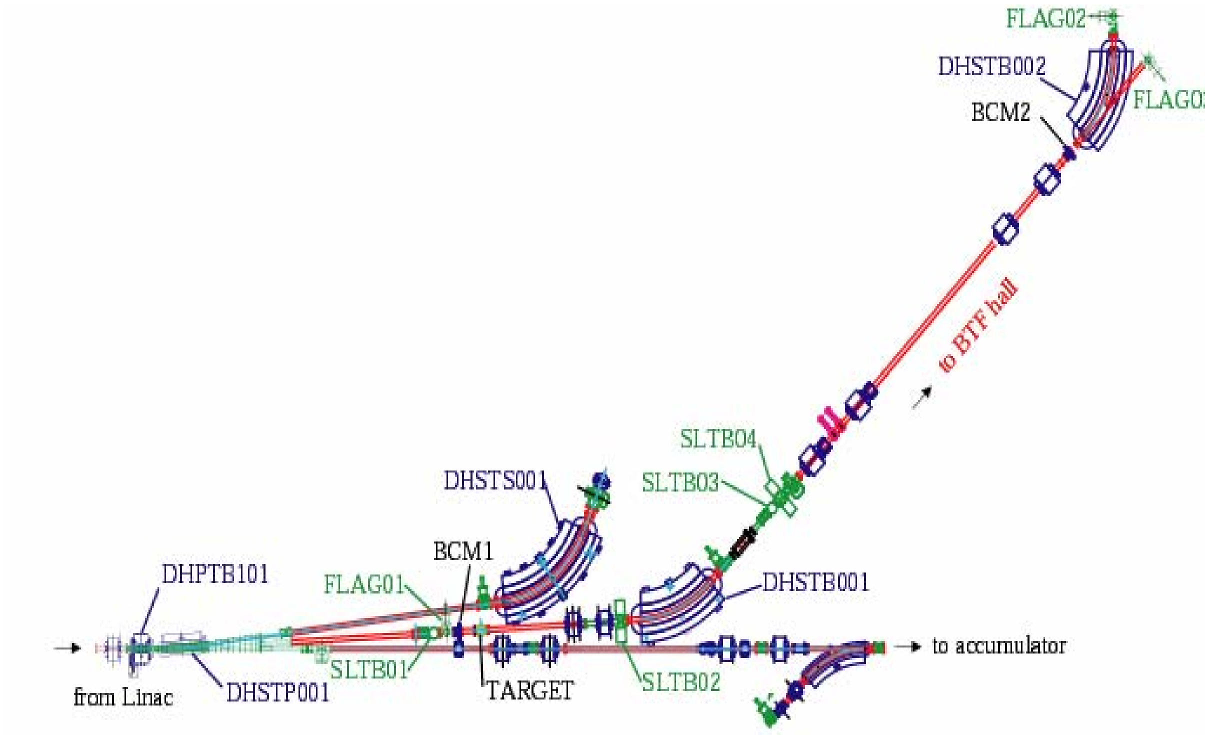

Figure 1: The BTF transfer line. In figure are shown the diagnostic elements mounting on the line, and the position of the target and the four collimator which is necessary to produce a beam with a variable number of particles.

When the facility operates in low multiplicity range, it is necessary to strongly reduce the primary beam of the LINAC. The minimum beam current that can be detected by the BCM2 current monitors is I≈1 mA, and the corresponding number of electrons (positrons) is 107/pulse. It is thus necessary to strongly reduce the number of particles to reach the few particles range. The reduction of the particle multiplicity can be achieved with different methods; the one chosen for the BTF operation is the following: first the LINAC beam is intercepted by a variable thickness TARGET, in order to strongly increase the energy spread of the primary beam; then the out coming particles are energy selected by means of a bending magnet DHSTB001 and two horizontal collimators (SLTB02 and SLTB04).

This energy selector accepts a small fraction of the resulting energy distribution of particles, thus reducing the number of electron/positron by a large and tunable factor. The TARGET is shaped in such way that three different values of radiation length can be selected (1.7, 2.0, 2.3 X0) by inserting it at different depths into the beam-pipe. The momentum of the selected particles has a resolution better than 1%.

After the energy selector, the beam is driven by a 12 m transfer line into the experimental hall by means of a focusing system of four quadrupoles. At the end of the BTF line a second bending magnet allows to use two separate beam-lines alternatively: a straight line is used when the magnet is off, while particles exit from a 45 degrees curved line when the magnetic field is properly set. In table 2 the beam parameters of the facility operated at different multiplicity are reported.

Table 2: BTF parameters for electron/positron beam; A) time-sharing with the DAFNE collider operation, B) continuous operation.

Operation mode	Time sharing	Dedicated
Energy range	25-500 MeV	25 – 750 MeV
Repetition rate	20-49 Hz	49 Hz
Pulse duration	10 ns	1 or 10 ns
Multiplicity	1 up to 10^5	1 up to 10^{10}
Duty cycle	80%	96 %
Spot size (σ_x*σ_y)	~ 2×2 mm (low multliplicity) ~ 10x10 mm (high multiplicity)	
Divergence	~2mrad- 10mrad	
Energy resolution	< 1%	

BTF PERFORMANCE.

Since November 2002, the facility has hosted many users that have worked in different conditions of beam parameters (wide range of energy and multiplicity) running typically more then 250 days/year.

Many different diagnostic devices for spot size, position, multiplicity measurements have been developed and are available for user in the wide rage of energy and multiplicity. Since 2005, the tagged photon source has been designed, built and tested. The photons are produced by bremsstrahlung of electrons, on a pair of x-y silicon micro-strip chambers, placed at the inlet of the last bending magnet DHSTB002. The photons are tagged in energy using the same bending dipole: the walls of the curved beam-pipe inside the magnet are covered by 10 modules of silicon micro-strip detectors [3].

An example of calorimeter spectrum acquired with charge ADC is shown in Fig2. The individual peaks corresponding to the number of electrons can be easily identified. The total number of events in each peak should represent the probability of producing n particles: by fitting the distribution of the number of events in each peak with the Poisson function, the average number of particles can be determinated.

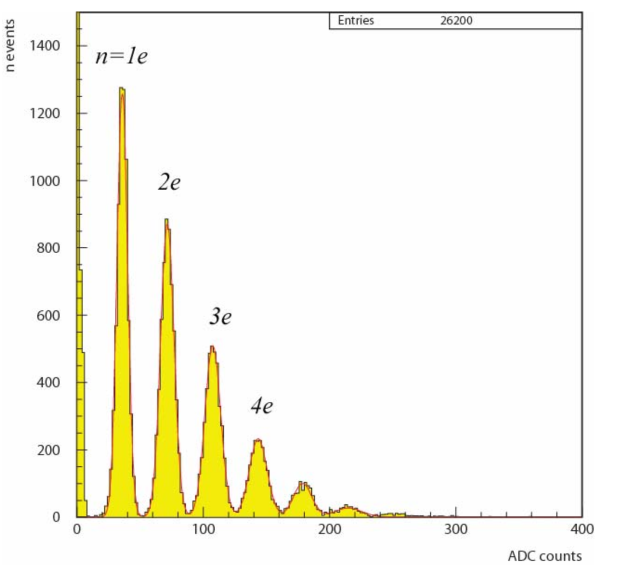

Figure 2: Calorimeter spectrum of BTF beam at low multiplicity.

The beam spot profile and position are measured by a x-y scintillating fiber system with millimetric resolution and multi-anode PMT readout, in the range from single particle up to 10^3 particles/pulse [4].

In the low multiplicity range a silicon micro-strip chamber (the active target of the photon tagged source) can be used to measure the beam spot profile and position with ≈ 200 micron resolution (Fig 3).

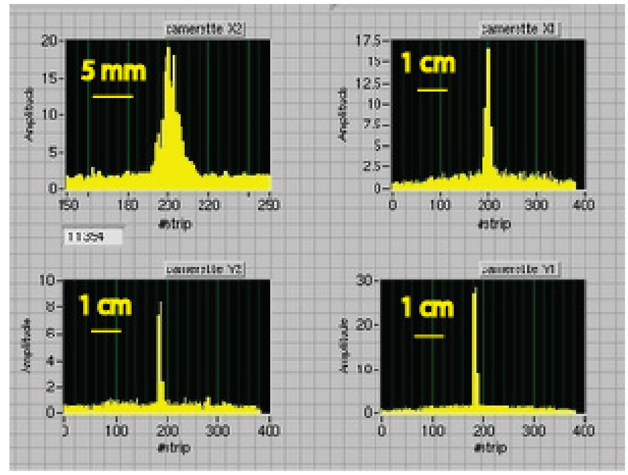

Figure 3: Beam spot profile acquisited with a silicon microstrip chamber.

CONCLUSIONS

The DAFNE Beam Test Facility showed very good performance, both from the point of view of operation reliability and the flexibility in order to cope with very different experimental needs. The diagnostic devices, data acquisition system and tools available for experiments are continuously improving.

In the last upgrade, the duty-factor of the facility has been greatly improved (up to 90%) thanks to the installation of a new dedicated pulsed dipole magnet (DHPTB101), capable of driving any of the 50 Linac pulses either to the accumulator ring or to the BTF transfer line.

First preliminary study has been done in order to develop a neutron source at the Beam Test Facility.

ACKNOWLEDGEMENTS

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