RECENT RESULTS OF THE COMMISSIONING OF THE DELTA FACILITY

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Abstract

The DELTA storage ring facility, consisting of a 100 MeV LINAC, the booster storage ring BoDo and the 1.5 GeV main storage ring, is under commissioning since fall ´94. All accelerators are in operation. DELTA includes all features of a 3rd generation light source, but in contrast to a user source this facility is mainly devoted to the test and development of components for future accelerators. The second main goal of the facility is to drive short wavelength Free-Electron-Lasers. Furthermore, special beam conditions for single user experiments and local syncrotron radiation users will be provided. This paper presents the recent results of the commissioning of the facility and first measurements of spontaneous synchrotron radiation emitted from the FEL-undulator FELICITA I.

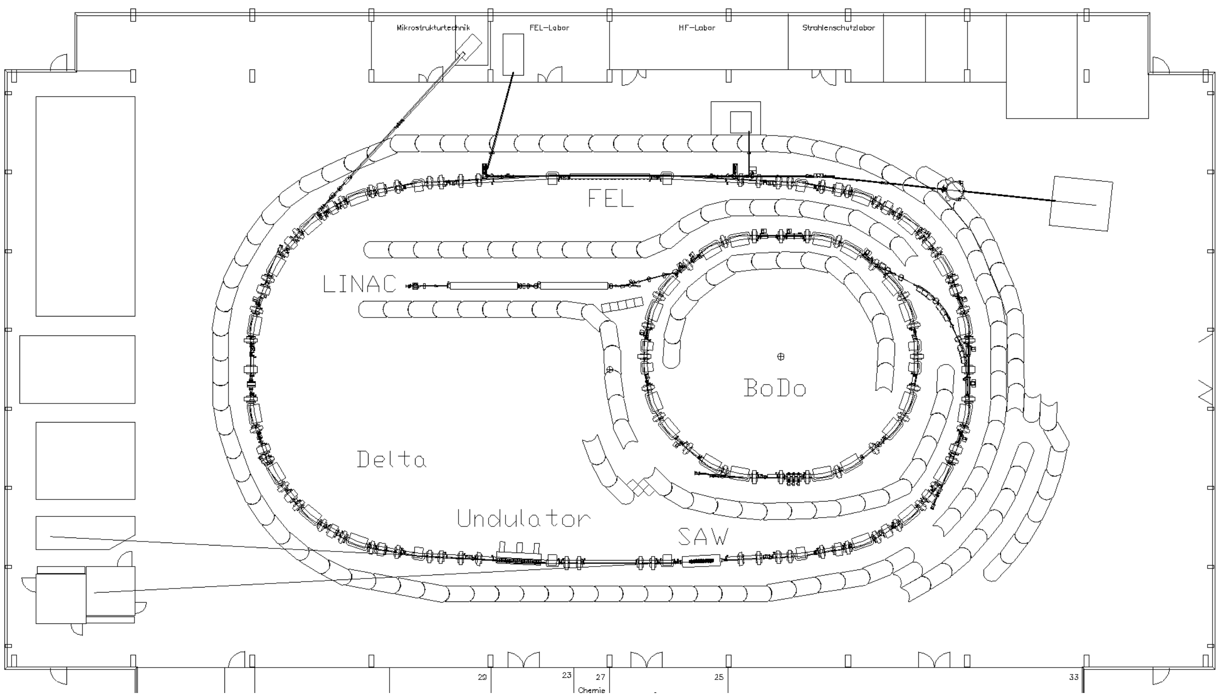

FIG. 1 THE DELTA STORAGE RING FACILITY

1 INTRODUCTION

The **D**ortmund **El**ectron **T**est **A**ccelerator facility DELTA is designed as a 3rd generation light source with beam energies up to 1.5 GeV [1,2]. It consists of a 100 MeV LINAC [3], the full energy booster storage ring BoDo and the main storage ring (Fig. 1). The facility is designed as a test bench for machine components and Free-Electron-Laser (FEL) development. Furthermore, it will also provide local users with synchrotron radiation. Both applications will take 50% of the beam time.

A short wavelength FEL [4] in the northern straight section is under commissioning simultaneously with the storage ring. A **S**uperconducting **A**symmetric **W**iggler (SAW- 3 ports) [5] and a hybrid undulator (period length 55 mm; 1.5 keV photon energy; 1 port) for the 2nd long straight section are under construction. Beside the use of the radiation from these insertion devices up to 5 synchrotron radiation beam lines from bending magnets are possible. One of these ports is already equipped with a beamline designed for micromechanics [6].

2 COMMISSIONING STATUS

2.1 The Linear Accelerator

The S-band LINAC is a modified reconstruction of the old LINAC of the University of Mainz, Germany. Its design energy is 100 MeV, but due to limitations of the old hardware, especially of RF components, the maximum energy is presently about 67 MeV. The thermionic 50 keV triode electron gun produces a beam current of 2 A within a 15 ns pulse. To provide effective bunching with an energy of 4.5 MeV the buncher (LAL design) requires about 2 MW of RF power. With the present setup, using a 10 dB coupler to split up 10 MW RF power from the first klystron (one arm of Thomson F2042) to the first accelerating structure and the buncher only 750 kW remains for the buncher, yielding a reduced transmission of 30%. Parmela calculations have shown the ability of 70% transmission within 2% energy spread only by increasing the RF power for the buncher. The short term solution is to use the old klystron, but with a second transmission line providing the design power at the buncher. First results from this modification are expected in July 97. On a longer timescale the change to a new klystron type (Thomson TH2100; 35 MW) is planned to reach the design values for the RF power in all structures, and thus the design energy and transmission.

*2.1 BoDo, The **Bo**oster **Do**rtmund*

The full energy booster BoDo was designed not only as an injector for the DELTA storage ring but also to serve as a test bench for low energy injection and accumulation. Therefore, it is constructed as a ramped storage ring. A 3 kicker system of the slotted pipe type [7] is used to inject into a FODO-lattice. For accumulation studies the kicker PFN can produce a 1 µs flat top current pulse with a fall time smaller than 1 BoDo revolution (168 ns). Currently an on orbit injection scheme with 2 kickers and a sinusoidal half wave pulse (t_p=340ns) is used.

The shortest possible acceleration cycle to reach the maximum energy is 5.6 s. During the acceleration all quadrupoles and dipoles run computer controlled current functions, to compensate for individual hysterises and dynamics. At the present state of commissioning a 960 MeV energy ramp with 6.4 s cycle duration is mainly used. The beam current at the top is about 4 mA and the particle loss is about 50% during the energy ramp. During the cycle the RF power is ramped from 20 W at injection to 2kW for beam energies higher than 400 MeV. Up to now a maximum energy of 1.4 GeV has been achived.

A closed orbit beam bump, produced by additional coils on three main dipoles, is used to prepare the beam for extraction. The extraction kicker is a double kicker of the slotted pipe type with a rise time of less then one BoDo revolution (168 ns).

2.3 Transfer Line Between BoDo and DELTA Main Ring

As the transfer line from BoDo to the DELTA main ring has to be compact, pulsed dipole magnets with a field exitation of 1.5 T for 1.5 GeV energy are used. The pulse length for the 2π pulse is 100 ms. Without special shielding stray fields act on the stored beam of the main ring. Therefore, a magnetic shielding is under construction.

2.4 The Main Storage Ring DELTA

The main storage ring has a racetrack shaped triplett lattice. At 1.5 GeV the design emittance is 1.1 10^{-8} mrad. The ring provides two superstraights of nearly 20 m each. Concerning space for matching insertion devices up to 14 m length are possible. This feature is essential for future FEL development. At present 2 additional dipoles are used to split up each of these sections into 3 straights. This allows for the use of up to 3 insertions per superstraight.

The main ring operation started in June ‘96 with a high emittance commissioning optics shown in Fig.2. Small values of the chromaticity allowed to start without sextupoles.

Currently beam currents up to 52 mA have been stored in a train of 6 bunches at 0.96 GeV. The typical lifetime is about 1 hour at 20 mA. The chromaticity is corrected to +2 using two families of sextupoles. With the integrated NEG and ion getter pumps [8] the beam loaded average vacuum pressure is about 10^{-7} Pa.

Table:1 lists the actual and design performance of the comissioning for BoDo and the main storage ring

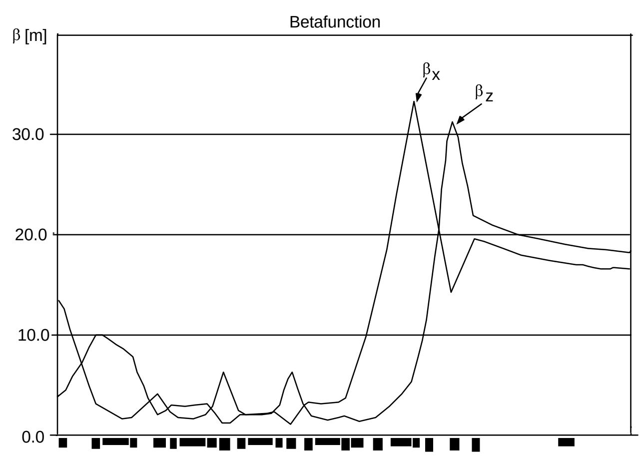

Fig. 2 β-functions of the commissioning optics for the DELTA storage ring

3 THE STORAGE RING FEL FELICITA I

Simultanously with the commissioning of DELTA first tests of the FELICITA I FEL hardware have started [9]. The electromagnetic undulator with 25 cm period and 4.875 m total length was tested with beam in both possible operation modes. By changing the excitation of 2 central periods it is possible to switch online between the undulator mode and the optical klystron mode and vice versa without loosing the stored electron beam. The distance between the FEL-cavity mirrors is 14.4 m providing operation with 1, 2 and 4 bunches in DELTA. With energies ranging from 300 MeV to 1 GeV wavelengths from 2 µm down to 200 nm should be available. First tests of the magnet at 650 MeV and at maximum undulator K-value produced a spontanous spectrum shown in Fig.3. Maximum excitation of the dispersive section yields the spectrum of the fundamental of the optical klystron shown in Fig.4 [10]. Besides small changes of the vertical tune the influence on the stored beam was neglectable. The energy spread of the electron beam calculated from these measurements is in a good agreement with the theoretical values.

BoDo	*Actual*	*Design*
Optics	FoDo	FoDo
RF Power [kW]	0.01 - 4	30 (max)
Energy [MeV]	67 - 1400	50-1500
hor. Emittance [mrad]	< $3x10^{-7}$@1GeV	$1.6x10^{-7}$@1GeV
Av. Current [mA]	3-5	5
Cycle Time [s]	6.4 (<1 GeV)	5.4 (<1.5GeV)
Lifetime [h]	>3	1.5
Main Storage Ring		
Optics	Triplet	Triplet
RF Power [kW]	10	60
Energy [MeV]	960	300-1500
hor. Emittance [mrad]	$7.5x10^{-8}$ **	$5.3x10^{-8}$
Av. Current [mA]	52	100
Lifetime [h]	1 (@20 mA)	10
Bunchlength [ps] P_{RF}=3.5kW	65 (0 A extrapolated)	60 (@ 960 MeV)

**: optical measurement

Tab. 1 Some parameters of BoDo and the main storage ring with the commissioning optics.

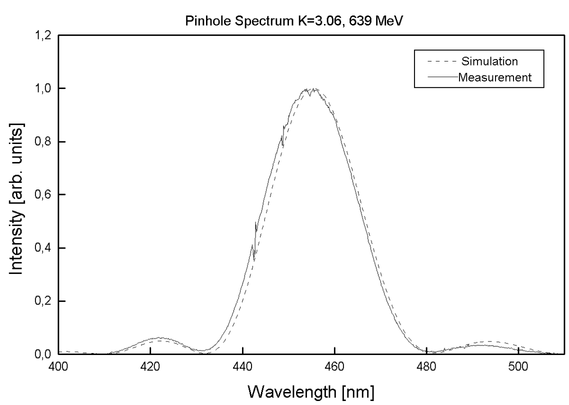

Fig. 3 Comparison of the spectrum of the undulator at 639 MeV and maximum excitation of the undulator section. The Simulation is based on a Hall-Probe Measurement.

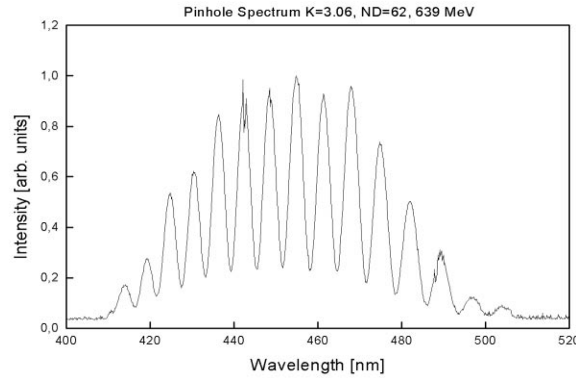

Fig. 4 Measurement of the OK-spectrum at 639 MeV and maximum excitation of the undulator section and the dispersive section.

4 CONCLUSION

During the ongoing commissioning process, DELTA is heading for the design current of 100 mA. As soon as this goal has been reached with the commissioning optics, the machine will be switched to its design low emittance optics with $\varepsilon_x = 5x10^{-9}$ mrad (1GeV). After the commissioning of the optics at 1 GeV, the machine will be run at 1.5 GeV. Simultaneously to the progress of the facility, the first experiments are starting. At the end of 1997 it is expected, that DELTA has reached its main design goals.

REFERENCES

[1] DELTA Group, ‘Status Report’, University of Dortmund, 1990 (unpublished).

[2] K. Wille et al, ‘*Initial Experience with DELTA*’, Proc. 1996, EPAC, Vol. 1, 95, 1996.

[3] G. Blokesch et al, ‘*The Injector LINAC of the DELTA-Facility*’, Proc. 1996 EPAC, Vol. 1, 834, 1996

[4] D. Nölle et al, ‘*DELTA, A New Storage-Ring-FEL Facility At The University of Dortmund*’, NIM, A296, (1990), 263-269.

[5] M. Negrazus et al, ‘*SAW - A Superconducting Asymmetric Multipole Wiggler at the DELTA Storage Ring*’, Proc. 1996 EPAC, Vol. 3, 2576, 1996.

[6] M. Körfer, ‘*Aufbau einer Bestrahlungsapparatur für die Röntgentiefenlithographie*’, PHD-Thesis, Dep. Physics of the University of Dortmund (in preparation)

[7] G. Blokesch et al, ‘*A Slotted Pipe Kicker For High-Current Storage Rings*’, NIM, A338, (1994), 151 - 155.

[8] B. Hippert et al, ‘*The DELTA Vacuum System*’, Proc. 1996 EPAC, Vol. 1, 364, 1996.

[9] A. Geisler et al, ‘*Experience On The Operatoin Of The 2-in-1 Electromagnetic Undulator Of FELICITA-I*’, NIM, A375, (1996), 445-447.

[10] T. Schmidt, ‘*Aufbau des FEL Experiments FELICITA-I im sichtbaren und ultravioletten Spektralbereich am Speicherring DELTA*’, PHD-Thesis, Dep. Physics of the University of Dortmund Apr. 1997 (unpublished).