A 0.5 TO 50 MEV ELECTRON LINEAR ACCELERATOR SYSTEM

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Abstract

Since 1998 ACCEL delivers turn key accelerator for scientific applications. After three injector systems for synchrotron light sources have been successfully commissioned, ACCEL is currently producing a 0.5 to 50 MeV system for the German metrological institute in Braunschweig (PTB). Beside excellent beam energy qualities the accelerator has to operate in a wide energy range, delivering 1 to 100 W average beam power to the target. The paper will give a description of the system layout and related technical parameters. The status of the project and results of the factory acceptance test of some of the major components will be presented as well.

ACCELERATOR LAYOUT

The PTB accelerator shall deliver electron beams in a wide energy range from 0.5 to 50 MeV to two different experiment halls. Therefore the system is built up out of two 3 GHz accelerating sections, where the beam can be decoupled after the first low energy section to experiment hall 1. Accelerating section 2, which is of the DESY S Band Linear Collider Type II design, increases the energy up to 50 MeV, a high energy beam transport leads the beam to the experiment hall 2.

In Tab1e 1 the requirements for electron beam in the different experiment halls are summarized.

Table 1: Requirements for the PTB accelerator system

Parameter	Experiment hall 1	Experiment hall 2
Energy	0.5 - 10 MeV	6 - 50 MeV
Energy spread	0.2 % (rms)	0.2 % (rms)
Beam power	1 W	100 W
Pulse length	2μs	2μs
Repetition rate	1 - 100 Hz	1 - 100 Hz
Beam size	< 1.24 mm (rms)	< 1.24 mm (rms)
Position stability	+/- 0.3 mm	+/- 0.3 mm

MAIN COMPONENTS

The complete layout of the accelerator system is illustrated in Figure 1 (for clearness the building is not shown). Main components of the system are:

- Electron source and 10 MeV accelerator (including a prebuncher and a buncher)
- 50 MeV accelerator
- 85° dipole and energy slit for hall 1
- Spectrometer in hall 1
- Low energy scanning system in hall 1
- 50° dipole and energy filter for hall 2
- Medium energy scanning system in hall 2

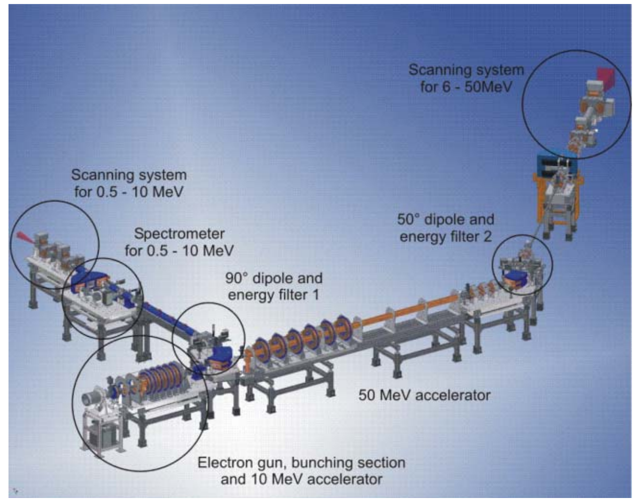

Figure 1: 3D model of the PTB accelerator layout.

Electron source and 10 MeV accelerator

The electron source can deliver a pulsed electron beam of up to 400 mA with an output energy of 90 keV. This design is well proven and already used at three injector systems build by ACCEL [1].

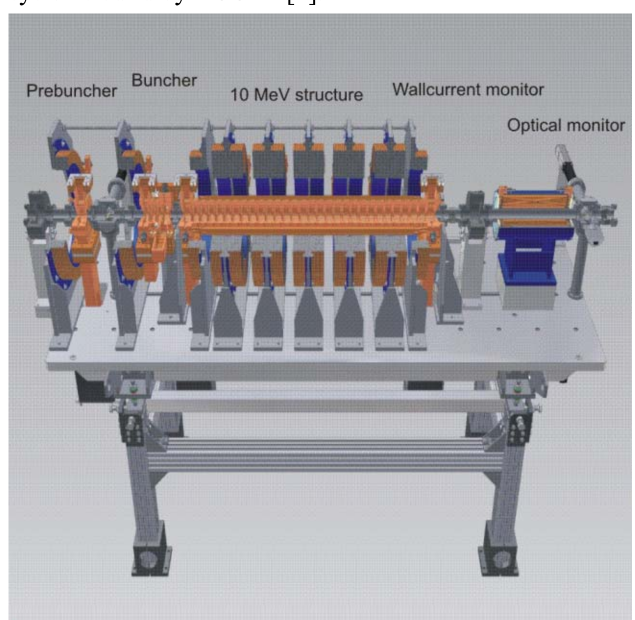

Figure 2: 3D model of the 10 MeV structure including the bunching system.

The 10 MeV structure as well as the bunching section can be seen in Figure 2. The accelerating structure is of a travelling wave typ ($2\pi/3$ mode) with a length of about 1 m. To achieve a low energy spread and also high transmission to experiment hall 2 both the buncher and the 10 MeV structure are β matched. The layout of the 10 MeV accelerating structure as well as of the buncher and pre-buncher was done by ACCEL.

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50 MeV accelerator

This constant gradient travelling wave structure accelerates the beam from 6 MeV up to 50 MeV. It has a length of 5.2 m and is already used at three injector systems build by ACCEL [1]. A quadrupole triplet and three quadrupole doublets make the medium energy beam transport to experiment hall 2.

85° dipole and energy filter for hall 1

After the first accelerating section the beam can be decoupled to experiment hall 1 with a 85° dipole. The low energy spread of 0.2 % (rms) for electron energies from 0.5 to 10 MeV in hall 1 can only be achieved by use of a variable energy slit. A 3D model of its design is shown in Figure 3.

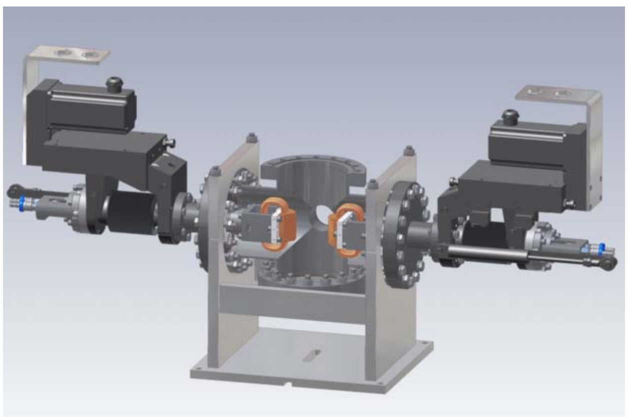

Figure 3: 3D model of the energy slit.

As this design is also used in the beam transport to hall 2 where a beam power of 100 W is required, the copper blocks which build the slit are water cooled.

Spectrometer in hall 1

The specifications of the low energy spectrometer are given in Table 2, a 3D model can be seen in Figure 4.

Table 2: Specifications of the spectrometer

Energy	0.5 to 10 MeV
Energy resolution	1 keV
Deflection angle	180°
Deflection radius	250 mm
Max. current	200 A
Magnetic field	0.012 - 0.14 T

A variable slit in front of the 180° bending magnet and an optical monitor after the magnet allow to measure the energy distribution over the beam size. The intensity distribution on the monitor screen will be measured by a camera and be analysed afterwards.

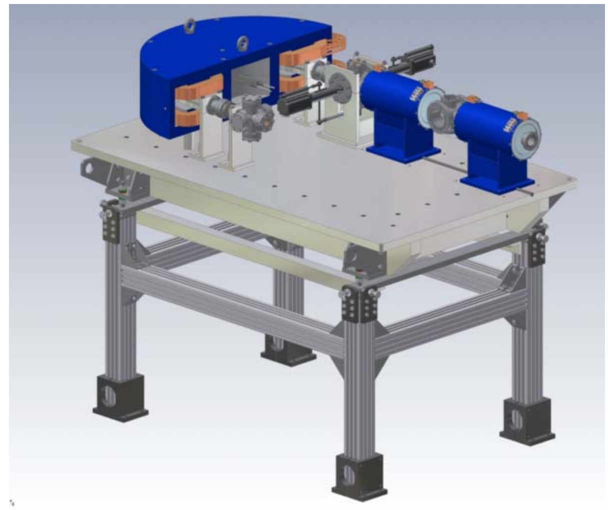

Figure 4: 3D model of the spectrometer.

Energy scanning system in hall 1 and hall 2

The scanning system in hall 1 shall deflect the electron beam over an area of 100x100 mm with a scan frequency of 10 Hz. 4 magnets are used in order to achieve deflection of the electron beam through a fixed origin. A schematic of the necessary configuration of the scanning magnets is shown in Figure 5.

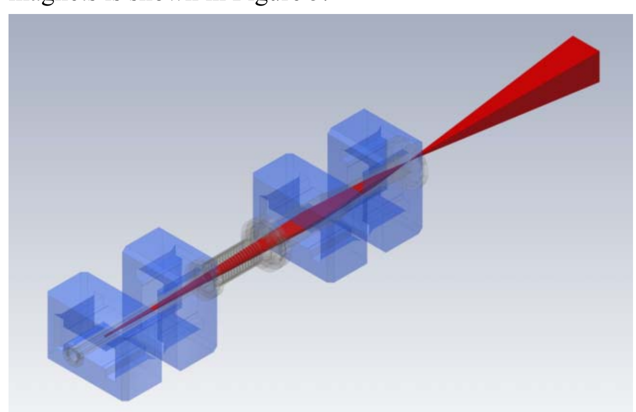

Figure 5: Schematic of the low energy scanning system.

In hall 2 the requirements on the scanning system are stricter, because the beam energy is higher and the scan area is larger with 350 x 350 mm. Therefore the distance between the magnet doublets is enlarged.

50° dipole and energy filter for hall 2

Behind the 50 MeV accelerator and the quadrupole triplet a 50° dipole leads the electron beam to experiment hall 2. As the average beam power at the following energy slit for hall 2 is in the range of 200 to 300 W, ANSYS simulations were made to verify the design of the energy slit (see Figure 3).

STATUS OF THE PROJECT

The accelerator components will be delivered to PTB in September 2007. Then an installation period of 3 months will start. Commissioning of the system will begin in

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January 2008 and is planned to be finished in summer 2008. The actual status of the main components is given in the following:

- The electron source has successfully been tested in May 2007.
- The pre-buncher is ready for power tests, while buncher and 10 MeV structure are currently being RF-tuned. Fig 6 shows the brazed 10 MeV structure before the cooling channels were fixed.
- The 50 MeV structure was built at ACCEL and RF tuning has successfully been finished recently. A result of the RF measurement is shown in Figure 7.
- All other systems as energy slits, spectrometer and scanning magnets are currently during final assembly or manufacturing.

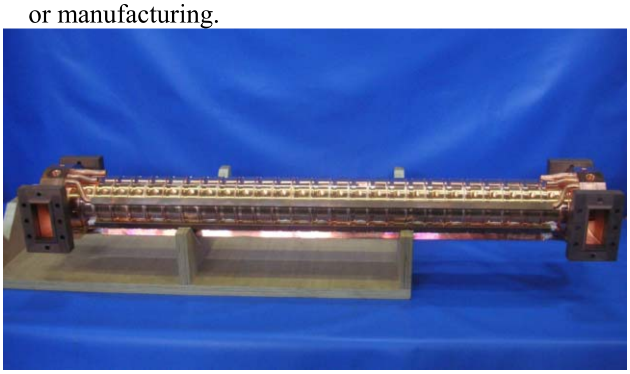

Figure 6: 10 MeV structure after brazing.

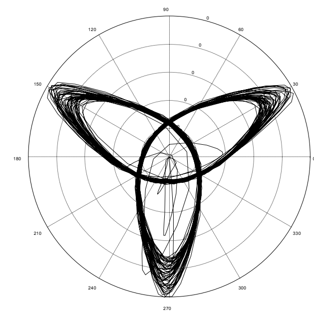

Figure 7: Beadpull measurement at the 50 MeV structure after tuning.

REFERENCES

[1] C. Piel et al., “Design and construction of a turn-key 100 MeV LINAC for the swiss light source”, EPAC’00, Vienna, 2000.

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