INSTALLATION OF THE ASTRID2 SYNCHROTRON LIGHT SOURCE

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Abstract

ASTRID2 is the new 10 nm UV and soft x-ray light source currently being built at Aarhus University, to replace the aging source ASTRID. ASTRID2 is now in the middle of its installation phase. Almost all components have been received. Several choices and solutions for hardware will be described, together with the present status. Commissioning of the ASTRID2 ring is expected to start early 2012.

INTRODUCTION

ASTRID2[1] is the new synchrotron light source, presently being built in Aarhus, Denmark to replace the 20 year old storage ring ASTRID [2]. Figure 1 gives an overview of the new facility, showing the two rings ASTRID and ASTRID2, the transfer beam line between the two rings, and the injection beam line coming from the 100 MeV racetrack microtron, serving as injector for ASTRID. ASTRID will in the future be used as a full energy injector for ASTRID2. The main reasons for the upgrade are a more than ten-fold reduction in emittance, more straight sections for insertions device, and the possibility of running in top-up mode (full energy injections), to give an effective infinite lifetime of the stored beam.

THE ASTRID2 STORAGE RING

Table 1 shows the main parameters of ASTRID2. The ring has six-fold symmetry, consisting of 6 arcs and 6 long (2.7m) straight sections. One straight section is reserved for injection, and one straight section is reserved for RF and diagnostic, leaving 4 straight sections for insertion devices. Three of the straight sections will be filled initially. In section 2 (marked S2 in Figure 1) there will be a new 0.7 m long 2 T multipole wiggler. Section 3 will house the existing ASTRID undulator, and finally there will be a new 2.4 m long undulator in section 5.

The lattice, which is a double-bend achromat is shown in figure 2. Each arc consist of two combined function dipole magnets, 4 quadrupole magnets (two families), 3 sextupole magnets (two families) and 2 combined horizontal and vertical correctors. The two sextupoles closest to the dipole magnets have integrated horizontal correctors. All magnets in an arc are mounted on one girder. For more details on the magnets see ref [1].

An overview of the diagnostics for ASTRID2 is given in ref [3]. For improved beam positioning the number of BPMs have been increased to 24 (4 per arc), and the read-out electronics have been changed to an all-digital system including first turn capabilities (Libera Electron).

Table 1: ASTRID2 specifications

Quantity	Value
Energy	580 MeV
Betatron tunes	5.185; 2.14
Horizontal emittance	~10 nm
Natural chromaticity	-6; -11
Current	200 mA
RF frequency	105 MHz
Circumference	45.7 m
Dynamical aperture	25-30 mm

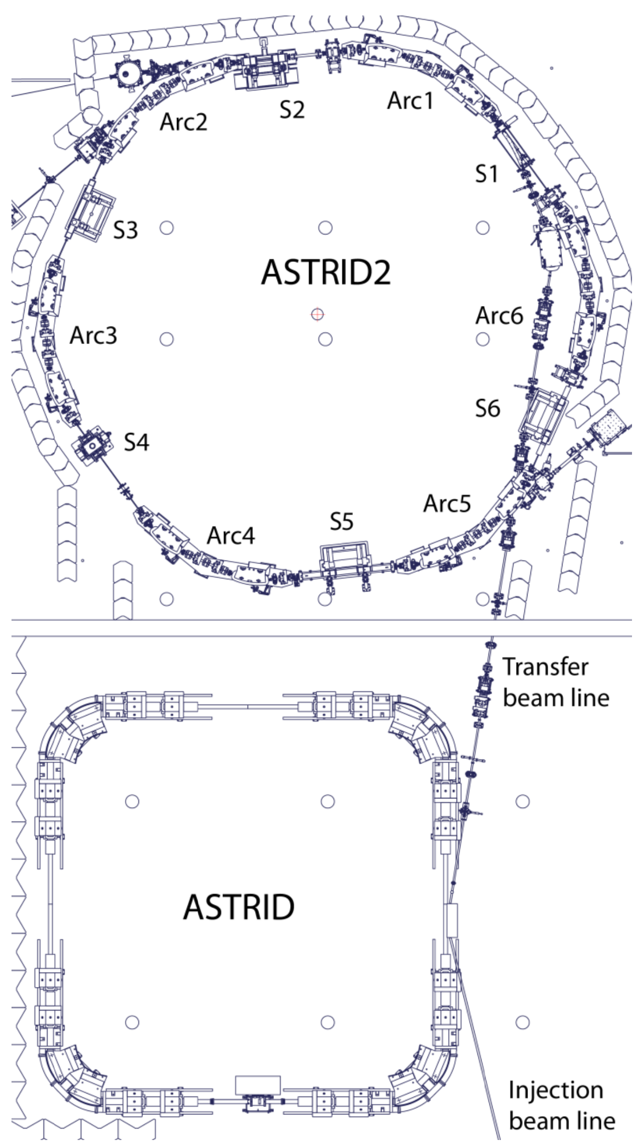

Figure 1: Overview of the ASTRID and ASTRID facility.

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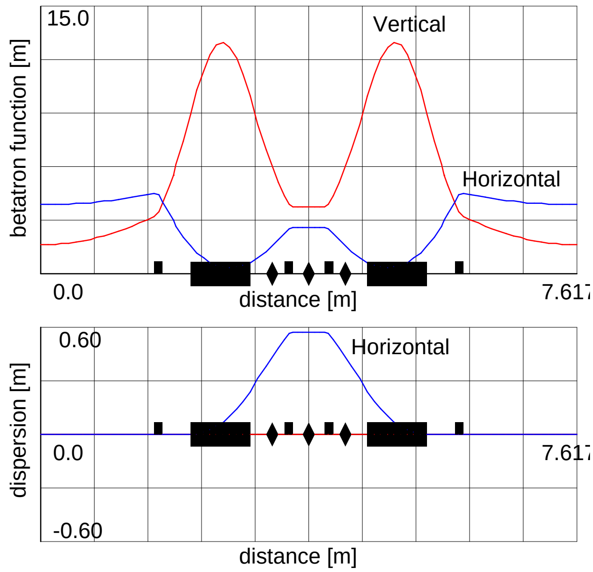

Figure 2: Lattice functions of ASTRID2.

PRESENT STATUS

All magnets are in place and cabling for the magnets is progressing well. Most vacuum components are ready, and installation of the vacuum system has begun. The RF cavity, which has been designed by MAX-Lab and is manufactured by RI Research Instruments GmbH, is well under way and is expected to be finished this year.

Installation is expected to be completed by the end of 2011, so commissioning can start early 2012. After successful commissioning of ASTRID2, beam lines will be transferred one by one to ASTRID2. It is planned that ASTRID will continue to operate part-time as a light source until all beam lines have been relocated. Figure 3 shows a photo of the ASTRID2 ring hall as of Aug. 2011.

Figure 3: Photo of ASTRID2 in its present state (Aug. 2011).

COMMISSIONING OF TRANSFER BEAMLINE

The first part of the transfer beam line, (the part which is inside the ASTRID hall) has been installed and first commissioning tests have been performed. The installed parts include the first vertical bending magnet, allowing tests of the proposal of using the synchrotron radiation (SR) emitted as a position diagnostic. To allow for better diagnostics of the extracted beam and of the beam line, a fast current transformer and a viewer from a little further along the transfer beam line have temporarily been moved closer to ASTRID, and are now at the end of the beam line.

Figure 4 shows the signal from the first fast current transformer just after the ASTRID septum magnet. 13 of the possible 14 bunches from ASTRID are clearly visible. Since the rise time of the kicker is ~50 ns, we do not expect the horizontal position of all bunches to be the same. Further down the transfer beam line, two horizontal scrapers are planned to remove beam which cannot be stored in ASTRID2.

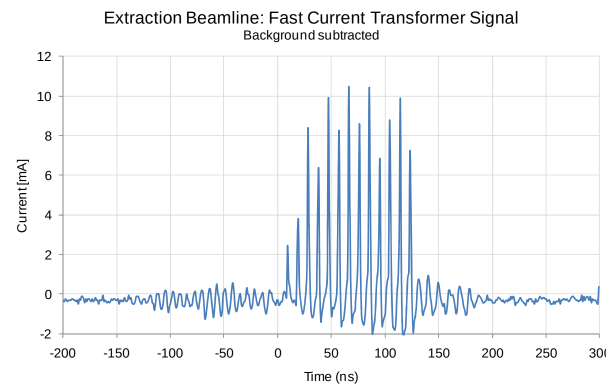

Figure 4: Signal from first fast current transformer in the transfer beam line.

EXTRACTION FROM ASTRID

Extraction from ASTRID is achieved using a single kicker, placed ¼ turn before the thick (11 mm), DC extraction septum (which is also used for injection). The beam passes the kicker twice, effectively giving a 1¼ turn extraction. To relax the kicker strength the beam is slowly bumped close to the septum. Figure 5 shows the position of the bumped beam, compared with a one or two times kicked beam. The bump, centered around corner 4 (at a position of 35 m), is realized using 4 BackLeg windings on 4 of the main dipoles (marked with an arrow labeled BL in the figure) and 4 of the regular correctors (labeled C in the figure). The kicker (labeled with a K) is located at a position of 30 m.

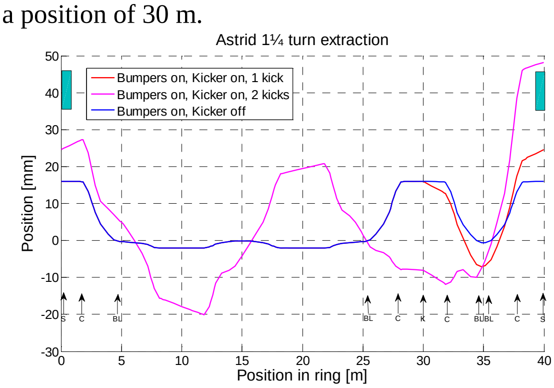

Figure 5: Beam position during extraction from ASTRID.

POLE-FACE WINDINGS

All of the ASTRID2 dipoles are equipped with a pair of pole-face windings. The pole-face windings are thin (<0.3

mm) flexible prints with 14 strips (wires) of copper, placed directly on the top and bottom of the vacuum chamber, see figure 6. The central 7 strips carry current in the same direction and thus generate a quadrupole field. The outer 3+4 strips are used for the return current. The thickness of the copper strips is 0.15 mm and the width of the strips varies between 4.4 and 7.4 mm. The variation in width is necessary to compensate for the varying pole gap, due to the integrated quadrupole gradient in the dipole magnets, and give a constant quadrupole gradient across the pole face. With a current of 10 A, we get a quadrupole gradient of 0.12 T/m.

Since the ratio of the vertical to the horizontal beta function in the dipoles is very large (>25), the effect of the quadrupole field from the pole-face windings is mostly in the vertical plane (i.e. the vertical tune). This gives the possibility of a complete correction of the lattice distortions from an insertion device. The two pole-face windings closest to the insertion device are used to compensate the (global) changes in the (vertical) beta function, and using all pole-face windings the tune can be corrected. It turns out that this correction scheme also restores the dynamical aperture [1].

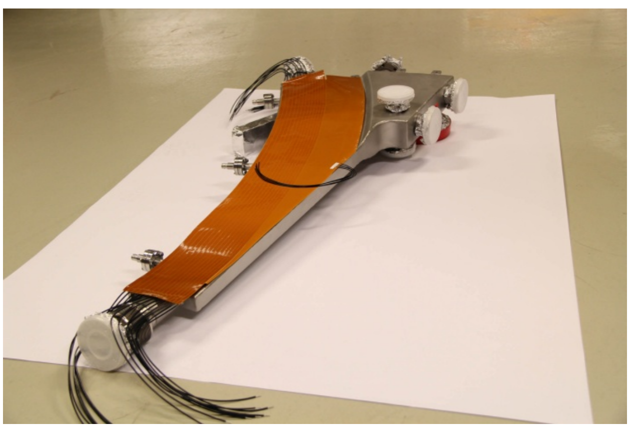

Figure 6: Picture of the pole-face winding placed on the dipole chamber, before fixation with kapton tape, and wrapping with insulation and aluminum foil.

BAKE-OUT

Glued together with the pole-face windings are another thin flexible print for heating. The circuit is designed for 230 V giving a heating power of 600 W. The 230 V is turned on and off every few seconds, and the duty cycle determines the effective power. To reduce heat loss to the dipole magnets a thin (~1mm), insulating ceramic “paper” is placed around the vacuum chamber. The bake-out temperature will be 150°C.

All straight vacuum chambers in the arcs are NEG coated for better pumping, and an in-situ bake-out is also mounted here. These vacuum chambers are also wrapped with a thin heating foil (flexible print), and with the thin insulating ceramic “paper”. Outermost is a layer of aluminum foil to reduce the heat loss due to thermal radiation. Bake-out temperature is planned to be ~200°C in these sections.

NEW LOW LEVEL RF

The Low Level RF (LLRF) system for ASTRID was a quite old analogue system, which needed an upgrade. A new LLRF was therefore developed in-house for use both at ASTRID and ASTRID2. The system (see figure 7) is a digitally controlled analogue system. It consists of a standard PC running LabVIEW Real-Time with a commercial FPGA equipped multifunction card (8-channel 750 kS/s ADC, and 8-channel 1 MS/s DAC). To measure the cavity and forward signals (amplitude and phase) two analogue IQ demodulators are used, and for controlling the cavity amplitude and phase, a voltage controlled attenuator and a voltage controlled phase shifter are used. The amplitude loop is implemented in the FPGA and has a bandwidth of ~50 kHz. The phase loop, which is significantly slower, is implemented in the Real Time program. Cavity tuning is also implemented in the Real Time program. For ASTRID the cavity tuning is done with plungers moved by DC motors. For ASTRID2 the cavity tuning will be achieved by moving the cavity end plate. This movement will be done using a stepper motor. The new LLRF system has now been in operation at ASTRID for more than half a year.

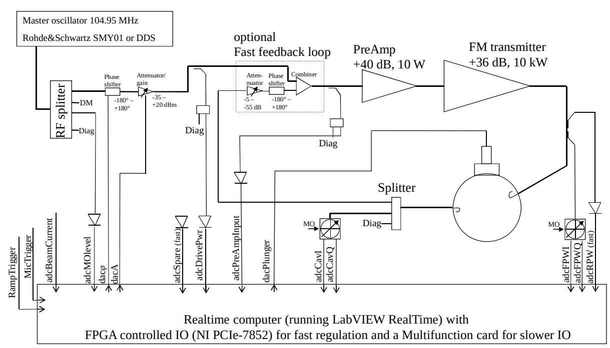

Figure 7: Block diagram of the new ASTRID LLRF.

CONCLUSION

The installation of ASTRID2 is well under way. Extraction from ASTRID is working well, and first tests of the transfer beam line have been performed. Commissioning of ASTRID2 is expected to start early 2012.

REFERENCES

[1] S.P. Møller, N. Hertel, and J.S. Nielsen, IPAC’10, Kyoto, 2010, WEPEA008, p. 2487.
[2] J.S. Nielsen and S.P. Møller, EPAC’98, Stockholm, 1998, WEP05F, p. 406.
[3] J.S. Nielsen, N. Hertel and S.P. Møller, DIPAC’09, Basel, 2009, MOPD24, p. 101.