THE AUSTRALIAN SYNCHROTRON PROJECT

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Abstract

Funding for the Australian Synchrotron, a 3 GeV synchrotron light source, was announced by the Victorian State Government in January 2003, and six months later bulldozers moved onto the green-field site in the South-East suburbs of Melbourne. After a remarkably fast construction and installation period the accelerators, which form the heart of the facility, were commissioned in 2006. Installation of the first five beamlines commenced in January 2007, and the first experiments were carried out in April. In this presentation we give an update on the status of the facility and present highlights of the commissioning activities.

FACILITY OVERVIEW

The Australian Synchrotron (AS) was constructed as one of the current generation of medium-energy third-generation synchrotron light source facilities. Funding (AUD157.2M) for the building, infrastructure, and accelerators was provided by the Victorian State Government. The facility is based on a 3 GeV double-bend achromat lattice that has a periodicity of 14, a circumference of 216.0 m, and an emittance that can be varied (by changing the dispersion function) between 7 nm-rad and 16 nm-rad. The storage ring (SR) is served by a full-energy injector synchrotron and is housed in a circular building that has a diameter of 112 m. The building can accommodate insertion device (ID) beamlines of up to 40 m from the centre of the ID to the sample. Also included in the first traunch of nine beamlines is one that extends 150 m from the source point. Figure 1 shows the layout of the facility (excluding the 150 m long line), and table 1 lists the basic parameters of the storage ring; more details regarding the storage ring can be found in references 1 and 2.

ACCELERATOR COMMISSIONING

The Injection System (IS) was designed, installed, and commissioned by Danfysik, with significant help in commissioning provided by facility staff, thereby satisfying part of the "technology transfer" aspect of the contract. The 100 MeV linac was sub-contracted to ACCEL Instruments. The 3 GeV booster synchrotron is a novel strong-focusing design that has bend magnets that incorporate a large quadrupole component, and a sextupole component to correct the lattices' chromaticity. Auxiliary quadrupoles provide "tuning" over a half-integer square in the tune diagram. This strong-focusing booster produces a beam with a horizontal emittance of just 33 nm-rad, in a circumference of 130.2 m. Beam was first accelerated to 3 GeV in April 2006. More details regarding the design and commissioning of the IS can be found in references 3.

The Storage Ring (SR) lattice was designed by Boldeman, Einfeld and Huttel [1], and refined by the "Lattice Task Group" that was brought together at LBNL in October 2002. Separate contracts for the SR components (magnets, RF, vacuum, power supplies, etc) were let to companies world-wide (see Table 2), with interfaces and installation coordination managed in-house. Installation was completed in March 2006 with the commissioning of the SR RF cavities; first turns in the SR were obtained on June 8; and the first beam was stored, and stacked to 1 mA on July 14. Since that date the stored current has been brought up to the nominal operating current of 200 mA. In January 2007 a water-to-vacuum leak occurred in one of the four RF cavities. The cause has been identified (low flow on a cooling circuit) and remedial action taken on all RF systems. In the meantime the SR current has been restricted to 100 mA, where the beam lifetime has increased to over 20 hours. Details of the current SR performance can be found in reference 4.

It should be noted that the above SR commissioning activities were being carried out at the same time that the first five beamlines were being installed. This severely restricted available time for commissioning to late evening and overnight.

At the beginning of April 2007 the facility began running on a scheduled basis, with installation and maintenance, and accelerator studies scheduled for four eight-hour shifts starting on Monday mornings, with beam available for Users for the following twelve shifts – finishing on Saturday afternoon. Full 24/7 operations is expected to begin in January 2008.

Table 1: Storage Ring – Basic Parameters

Energy	3.0	GeV
Circumference	216.0	m
Periodicity	14	
Natural emittance (η^* = 0.0 m) (η^* = 0.24 m)	16 7	nm-rad
Betatron tunes, ν_x / ν_y	13.3 / 5.2	
Natural chromaticities, x/y	-28 / -27	
Relative energy spread, $\Delta E/E$	0.001	
RF frequency	500	MHz
RF Voltage	3.0	MeV
Energy loss/turn (bends only)	932	keV
Injection energy	3.0	GeV

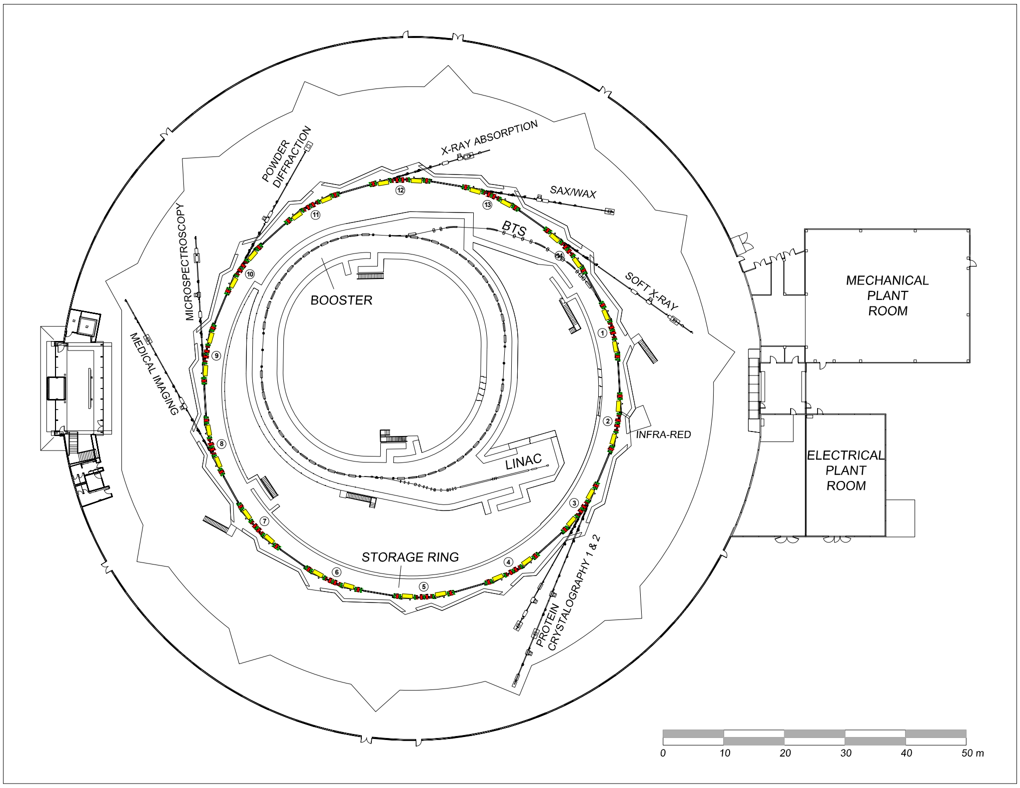

Figure 1. Layout of the Australian Synchrotron Facility

Table 2: Major Subsystems for the Australian Synchrotron

Sub-system	**Contractor**	**Award Date**	**Completion Date**
Injection System	Danfysik	16 December '03	1 April '06
SR Magnets	CMS Alphatech/ Buckley Systems	25 March '04	30 November '05
SR Dipole Magnet Power Supply	Alpha Scientific	17 December '04	15 December '05
SR Quadrupole, Sextupole and Corrector P.S.	Danfysik	20 December '04	15 December '05
SR Vacuum Vessels	FMB	26 April '04	25 January '06
SR RF System	Toshiba International	28 June '04	31 March '06
SR Girders and Pedestals	Metaltec	17 September '04	15 February '06
SR Front-ends	FMB	26 April '05	1 February '06

BEAMLINES

Thirteen beamlines were proposed as the initial suite for the AS, as described in reference 5. Of these, nine were chosen as part of the initial funding package; see table 3, and five of those were chosen for completion by March 2007. The remaining four are scheduled for installation at the beginning of 2008.

Funding for the first nine beamline has been provided through a consortium that includes the Federal Government, all State Governments, the New Zealand Government, most major research Universities, and the Association of Australian Medical Research Institutes.

Each beamlines "photon delivery system" PDS – the optics – were contracted as turn-key packages to European companies (see table 3). The front-ends for the beamlines (containing the safety photon and bremsstrahlung shutters) were constructed as part of the SR, terminating in a vacuum valve outside the shield wall. In this way it was possible to install the PDSs without breaking into the SR vacuum system, or the SR shielding.

Installation of the PDSs started at the end of January 2007 and by the end of March each beamline had seen beam at the sample position and energy calibration carried out. The experimental apparatus in the end-stations has been defined by the user representatives in collaboration with in-house Beamline Scientists, and implemented by the Beamline Scientists. In the case of two of the beamlines, PX and IR, actual experiments had been performed.

The facility is now being used by experienced users, who are ensuring that the quality of the beam and the end-station equipment meets the expectations of the broader user community. A call for proposals to this broader community will go out in July 2007. The proposals will be peer-reviewed with the expectation of beam time for the successful proposals starting in September.

SUMMARY

The construction and commissioning of the Australian Synchrotron on a green-field site, on time and within budget, has been a remarkable success. The procurement strategy to trust industry to design, manufacture, install and commission major subsystems, has allowed the facility to be built with a relatively small number of staff – never exceeding 55. This success is a testament to the skill base that has been built up in industry, and to the skill and dedication of the Project staff.

REFERENCES

[1] J.W. Boldeman and D. Einfeld, Shanghai Symposium on Synchrotron Light Sources, Shanghai, September 2001, page 32.

[2] G.S. LeBlanc, "The Status of the Australian Synchrotron Project", proc. of APAC 2007.

[3] S.W. Friis-Nielsen et al., "Commissioning Results for the Injection System for the Australian Synchrotron Project", Proc. EPAC 2006, Scotland.

[4] G.S. LeBlanc "Performance of the Australian Synchrotron", this Conference.

[5] The National Science Case for the Initial Suite of Beamlines, download as "National Science Case" at www.synchrotron.vic.gov.au.

Table 3. The initial suite of funded beamlines and the photon beam delivery system suppliers

Beamline #	Technique	Source	PDS Supplier
2 IR	Infrared Spectroscopy	Bend Magnet	FMB (Germany)
3 BM	Protein Crystallography	Bend Magnet	Oxford-Danfysik (UK)
10 BM	Powder Diffraction	Bend Magnet	Oxford-Danfysik (UK)
12 ID	X-ray Absorption Spectroscopy	Wiggler	ACCEL (Germany)
14 ID	Soft X-ray Spectroscopy	Apple Undulator	FMB (Germany)
3 ID	Protein Crystallography	IV Undulator*	Oxford-Danfysik (UK)
8 ID	Imaging and Therapy	SC Wiggler**	Design and Engineered in-house
9 ID	Microspectroscopy	IV Undulator*	IDT (UK)
13 ID	Small & Wide Angle X-ray Scattering	IV Undulator*	Oxford-Danfysik (UK)

* IV = In-Vacuum; **SC = Superconducting

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