THE AUSTRALIAN SYNCHROTRON PROJECT - UPDATE

A. Jackson, Technical Director, Australian Synchrotron

Abstract

The Australian Synchrotron – a synchrotron light facility based on a 3-GeV electron storage ring – is under construction at a site in the Metropolitan District of Melbourne. Building preparation started on a "green-field" site in September 2003 and staff moved into their new offices in February 2005. Installation of the technical equipment started in April 2005 with all accelerator contracts expected to be completed before May 2006. Storage Ring commissioning with beam will start in June 2006, and project completion is scheduled for March 2007. In this paper we present an overview of the facility and discuss progress to date in meeting this very aggressive schedule.

FACILITY OVERVIEW

The Australian Synchrotron (AS) is being constructed as one of the current generation of medium-energy synchrotron light source facilities. It 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 injection synchrotron and is housed in a circular building that has a diameter of 112 m, see Figure 1. The building can accommodate insertion device (ID) beamlines of up to 40 m from the centre of the ID to the sample. Figure 2 shows the layout of the facility, 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.

BRIEF HISTORY

Like all such projects, the AS had a life before funding was approved. This "foundation" phase included the development of a concept design of the building, accelerator systems, and beamlines on which a cost estimate was established. In the case of the accelerators the concepts were developed by Boldeman, Einfeld, and Huttel [refs 3, 4] with assistance from members of the International Machine Advisory Committee. The final design of the Storage Ring was completed under the direction of the project's Technical Director by a Task Group that was brought together at Lawrence Berkeley National Laboratory in October 2002. The building concept was developed by the joint team of DesignInc (Architect) and Arup (Engineering Services). The Arup team was maintained as a consultant to the project into the construction phase.

The funding announcement for the AS was made in January 2003 at which time the Project and Technical Directors began recruiting the delivery team. In 2003 this team grew from 3 people to 18, and contracts were awarded for two major systems: the building (July); and the injection system (December). In 2004 the team grew to 32 people, including staff associated with the beamline programme, and contracts were awarded for almost all of the remaining accelerator systems. In February 2005 the new building was completed, and staff (now numbering 43), moved into their new offices. Recruitment in the beamlines area continues, and by March 2007 the total staff is expected to reach 62.

Installation of the technical equipment in the building began in April 2005. The survey monuments were the first system to be installed and surveyed. The uncertainty in the positions of the monuments is modelled to be less than 80 microns in the plane of the accelerators, and less than 30 microns in the vertical plane. This is the foundation to which the accelerator systems (and later beams) are being installed.

CHALLENGES

Australian institutions and industry have very limited experience in building and operating large accelerator based facilities. Therefore a decision was made early in the acquisition stage to develop performance based specifications for large accelerator sub-systems that would be built, installed, and commissioned by industry. This strategy has been carried forward by the small in-house staff, with help from subject expert consultants from accelerator facilities around the globe. A list of the major sub-systems and contractors is given in Table 2.

The in-house staff are responsible for managing these contracts, and in particular for managing the many sub-system interfaces between the contracts.

Examples of the progress to date are given in the following sections.

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

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Figure 1: Aerial view of the Australian Synchrotron, March 2005.

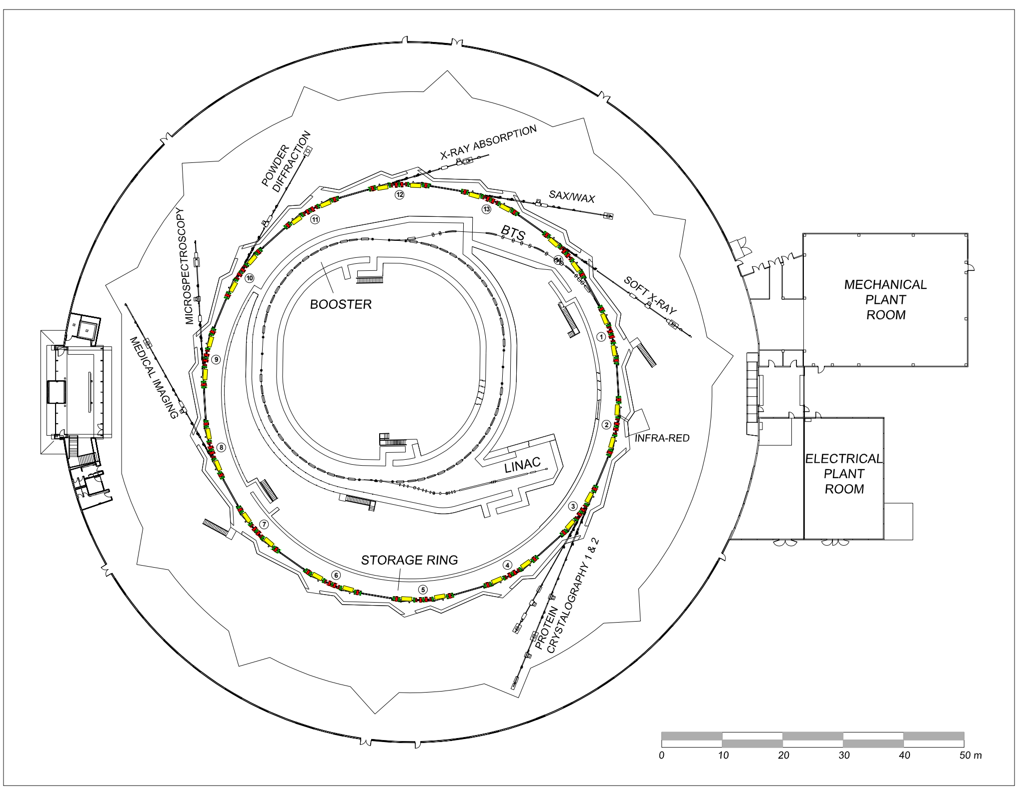

Figure 2: Layout of the Australian Synchrotron Facility.

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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

STATUS OF MAJOR CONTRACTS

Many of the accelerator contracts have moved from the design phase into the fabrication phase. In almost all cases some parts of the fabrication are behind schedule, and some are ahead. In no case have delays impinged on the critical path for that contract, or on the overall installation schedule. In the storage ring many contracts have contingent requirements on others. For example, girder installation (with the magnets being installed at the Metaltec factory) is contingent on the phased deliveryof magnets; and the vacuum chamber installation is contingent on the girder/magnet assemblies being in place in the storage ring tunnel; and this is contingent on the survey network being complete. All such interface issues are managed by the AS staff, who keep themselves informed on progress on the different contracts through weekly telephone conference calls, formal monthly updates from the contractor, and visits to the factories to validate these communications.

In the following sections we give an update on the current status of the major contracts.

Injection System – The Injection System (IS) for the AS comprises a 100 MeV linac, a 3 GeV 1 Hz booster synchrotron, the two transport lines to take the beam from the linac to the booster and booster to storage ring, and the injection elements in the storage ring. The contract is let to Danfysik, and they have sub-contracted the linac and booster RF cavity to Accel. With the exception of issues associated with later than expected completion of the linac, this contract is progressing on schedule, and installation has started on site.

SR Girders and Pedestals – This contract, let to a local manufacturer, Metaltec, includes the production of the pedestals, which support the fully kinematic (6 degrees of freedom) girder adjusters, on which rest the magnet girders. There are five such systems per achromat. The SR magnets are mounted directly onto the precision ground girder surfaces. This contract also includes provision of the SR low conductivity water (LCW) distribution system in the storage ring tunnel; and installation and alignment of the pedestal/girder/magnet system in the tunnel. A full-scale mock-up of one sector of the system, using real pedestals, adjusters, girders and magnets, has been built at Metaltec to test out all system prior to the start of installation on site. Figure 3 shows this mock-up.

SR Magnets – The storage ring magnet contract was let to CMS Alphatech working with Buckley Systems an engineering company in Auckland, New Zealand. Design of the major profiles of the magnets were made in house, with the assistance of a consultant. The total contract comprises 28 dipole magnets (+ 1 spare), 84 quadrupoles of two lengths (+ 2 spares), and 98 sextupoles (+ 2 spares). The sextupoles also have coils to provide horizontal and vertical orbit correction, and skew quadrupole fields. To date two sectors worth of magnets has been delivered to Metaltec for mounting on the girders (see Figure 3); the third sector will be shipped on 11th May.

Figure 3: Mock-up of a complete sector at Metaltec.

Magnet Power Supplies – The SR dipole magnet power supply (all dipoles connected in series) is being constructed by Alpha Scientific, California USA. The supply has undergone its final design review, and some modifications were made … mainly as a result of findings from an electrical incident at SLAC. Delivery is expected at the end of September 2005 – ahead of the date when the supply can be connected to the magnet string.

The remaining magnets all have individual supplies, which are being manufactured by Danfysik, Denmark. These supplies have a phased delivery starting at the beginning of September. In this case the supplies will be assembled into their racks and connected to the magnets when they arrive on site. They will be connected and commissioned in a phased manner.

SR Vacuum Vessels – The vacuum vessels are being supplied by FMB, Berlin. Successful acceptance tests on the first article arc chamber were made in April. Figure 4 shows this 10.5 m long section fully assembled at the FMB factory. Delivery of the first arc sectors worth of chambers to the AS site is expected, on schedule, on 8th June 2005. The chambers will then be assembled, baked, and installed onto the SR girders.

Figure 4: The first arc-vacuum vessel at FMB.

SR RF System – The head contractor for the RF system is Toshiba International Corporation (TIC). The 500 MHz HOM damped cavities (4 off + 1 spare) [Ref. 5], klystrons (4 + 1 spare), low level electronics (4 off), and HV power supplies (4) are all being built by Toshiba, Japan. The waveguide components, control system, and installation and testing are the responsibility of TIC. All aspects of this contract are on schedule. The first article klystron (a modified version of an existing product), was recently tested at full power and shown an efficiency of 66%; to be compared with the contracted target value of 62%. The remaning klystrons are now in full production. Figure 5 shows the focussing coils being lowered over the klystron body. The first cavity will be power conditioned at KEK in May, with the others following along in approximately 3 week intervals. The full integration of the 4 separate RF systems will start on the AS site in September 2005.

Figure 5: Klystron assembly prior to full power tests.

SR Front ends – The front ends contract was awarded to FMB, Berlin in April 2005. This is for the supply of nine front ends for the initial suite of nine beamline (see below). The final design review for the contract is expected at the end of June 2005. There will be a phased delivery starting at the end of October 2005; with completion scheduled for the end of March 2006.

BEAMLINES

There are nine beamlines supported by initial funding for the Project. They are detailed in the "National Science Case for the Initial Suite of Beamlines", that can be accessed at: http://www.synchrotron.vic.gov.au/content.asp?Document_ID=1265. Of these beamlines it is expected that at least four, and possibly five, will be at an advanced stage of commissioning at the hand over to operations in 2007.

These beamlines will serve:

- Protein Crystallography (PX) from a bend-magnet source
- Powder Diffraction (PD) from a bend-magnet source
- X-ray absorption spectroscopy (XAS) from a wiggler source
- Infra-red spectroscopy
- Soft X-ray spectroscopy (SoXS) from an undulator, most likely an Apple-II type EPU

The design objectives for each of the beamlines are developed by the user community. Their concept designs are then reviewed by subject-expert panels prior to finalisation of design/performance specifications. The contract activities are all the responsibility of the MPV delivery team.

The PX was the first beamline that was subjected to this process. We have decided on a procurement strategy based on three work packages: the photon delivery system (the optics) that takes the x-ray beam

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from the storage ring to the experimental station; hutches that house the optical elements and the experimental equipment; and the experimental equipment itself. The proposed layout of the PX beamline is shown in Figure 6.

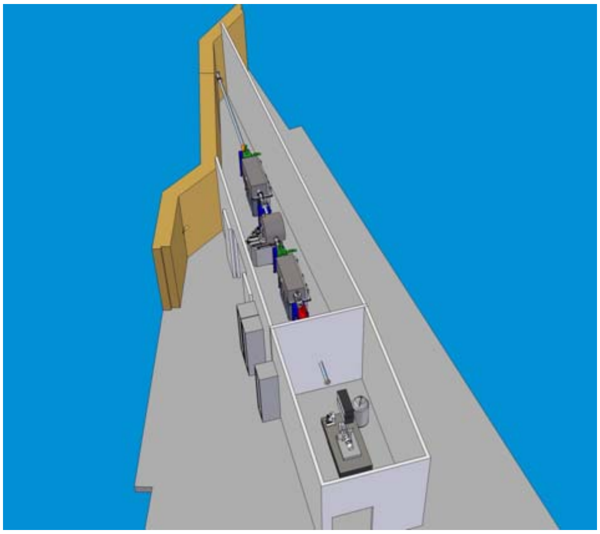

Figure 6: Isometric View of the PX Beamline.

A similar set of three work packages has been developed for the PD beamline and the IR beamline. For the XAS and SoXS beamlines there is an additional work package that covers the insertion device.

Requests for Tender (RFT) for the PX and PD photon delivery systems, and the EPU for SoXS will be issued in May 2005. The RFTs for the IR, XAS and SoXS beamlines, and the XAS wiggler will follow in June and July.

SUMMARY

The Australian Synchrotron is an ambitious technical project being undertaken with a relatively small staff (currently 43 people total), being built in a short (four year) time frame from first funding to project completion. In order to achieve this we are making extensive use of specialist subject-area consultants, and design / supply / installation / design performance demonstration contracts for all major subsystems. Progress to date sees the synchrotron building and staff offices complete, and installation of the accelerators under way. Commissioning of the injection system should start in August 2005. All contracts for the major storage ring subsystems have been awarded and are on track for injecting first beam into the storage ring in June 2006. Contracts for the first five beamlines are in the early stages of development, but it is expected that they will be at an advanced state of commissioning by the end of March 2007.

ACKNOWLEDGEMENTS

It is with great pleasure that I acknowledge the contributions to the Project, not only of our small in-house staff, but also to our consultants to the Project:
Paul Bellamo (SLAC) – SR dipole power supply;
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Steven Hunt (SLS) – control systems;
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Jack Tanabe (SSRL) – design of the SR magnets;
Tony Warwick (ALS) – design of the SoXS beamline;
Harry Watson – leader of the Arup team of engineers in the design of building services (HVAC, LCW, etc).

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