THE AUSTRON SPALLATION SOURCE PROJECT

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The organization scheme as well as the accelerator, target and instrumentation concepts of the planned 0.5 MW/10 Hz neutron spallation source AUSTRON are presented. Its relation to existing and planned pulsed sources is discussed.

1 Introduction

The project of an interdisciplinary International Research Centre is proposed for the fine analysis of matter by neutron scattering in the basic and applied fields of materials science, biology, engineering, biotechnology, life sciences, chemistry and physics. This Centre will serve the purpose of supporting the growth of the overall Central European research infrastructure (universities, industrial and academic laboratories), through an internationally competitive access and use, also inducing a quality benchmarking in the existing research programs. The fine analysis of the structure of matter is essential for the development of new materials, products and processes, and the scientific support for products ranging from microelectronics to new materials and new pharmaceutical compounds. It has, therefore, contributed to the most extensive and continuous growth of new industries in this century. The Centre emerges from the AUSTRON project developed by a large international team on the basis of indications from all interested users from the Central European countries.

The AUSTRON project is based on a pulsed high-flux neutron spallation source providing one of the world-best research-service facilities for neutron scattering experiments for the next two decades. On an international scale the project AUSTRON was incorporated in the global plans to counteract the occurring "neutron gap" by the OECD-Megascience Forum. The major
projects of neutron sources of the next generation are the ESS in Europe, the SNS in USA and JJP in Japan (Fig. 1). New sources in Europe are the projects of the reactor FRM II (under construction) in Munich, a second target station at ISIS, UK and AUSTRON. AUSTRON is proposed as a regional neutron source to catalyze science in Central Europe across the borders of present and future EU countries. It can be built with existing techniques and will provide features not available at existing sources. The 10 Hz repetition rate favours high resolution condensed matter spectroscopy and new instruments will broaden the scope of neutron spectroscopy in general.

2 Accelerator and Target Concept

The AUSTRON project is based on a well-founded accelerator concept using available state-of-the-art technologies to allow for a relatively short construction period and to create a favourable ratio of cost to scientific and technological potential. Several successive accelerator stages of different types will be used to generate a proton beam with 1.6 GeV energy per particle, an average beam current of 0.311 mA and a total beam power of 500 kW. The accelerator chain comprises an $^1\text{H}^-$-ion source, a radio frequency quadrupole and a drift tube LINAC, providing a final ion energy of 130 MeV, from which the ions enter a rapid cycling synchrotron (RCS) passing a stripper foil which removes their electrons to enable the acceleration of a high-intensity proton beam to 1.6 GeV final energy. Using a dual frequency magnetic cycle, losses should be kept at about 0.5% occurring at lowest energies during trapping only. This is of particular importance with respect to the question of induced activity.
which can be answered positively under these circumstances. The operation frequency of this acceleration process has been determined with 50 Hz. However, since there is strong demand for cold neutrons, a preference for a lower operation frequency of 10 Hz without reduction of beam power was expressed in order to avoid frame overlap problems of successive neutron pulses in the long wavelength regime. This can be achieved by adding an additional storage ring to the accelerator complex which works as a bunch accumulator for the proton bunches leaving the RCS (see Fig. 2). Employing such an installation, the stacking of up to 4 proton bunches is feasible. Extracting these bunches together with the bunch which has just reached the final energy in the RCS, a 10 Hz source is realized with 1.6 GeV protons ($\sim 2 \times 10^{14}$ protons in total), which deposit 50 kJ per pulse on the spallation target. The average thermal neutron flux is expected to be about $7 \times 10^{12}$ neutrons/cm$^2$s with a peak flux of $\sim 3.7 \times 10^{19}$ neutrons/cm$^2$s. This configuration will make AUSTRON a truly unique facility among present neutron sources. The effective flux for certain classes of neutron instruments will be increased by a factor of 15 - 20 compared to the present standard. With more than an order of magnitude higher performance, the exploration of completely new fields of research can be envisaged. Furthermore, the 10 Hz option takes the increasing demand for cold neutron scattering into account and no flux penalty will be experienced by those instruments which would usually be operated at higher frequencies. Concerning AUSTRON’s relation to the European Spallation Source (ESS) in this respect, it should be noted that these facilities will belong to two different generations of neutron sources which will be separated by a decade in time and an order of magnitude in beam power. In the present concept of the target design a flat target geometry is proposed. The target material under consideration is solid W-5%Re according to its excellent thermal and mechanical properties. Dimensions of a target block are $10\times30\times60$ cm$^3$ (height x width x length) where, due to the edge-cooling concept, cooling channels are only installed within 2 cm from the top and bottom surfaces. Calculations of the temperature distribution in the target, based on a 0.5 MW version of AUSTRON running at 50 Hz, yield a temperature maximum of 1200-1300 °C. Edge-cooling of a target is possible under these conditions and an advanced cooling system has been designed. Material properties of W-5%Re like ductility, thermal conductivity or self-healing after irradiation damage look favourable for this temperature range and reveal that such a target is indeed feasible. The operation of AUSTRON with 10 Hz/0.5 MW leads to a marginal temperature increase of less than 10 °C only. It is also suggested to operate the AUSTRON target at even higher temperatures, above 2000 °C, and to cool by radiation cooling alone, which would help to avoid thermally induced stress inside the target.
block. The final decision on the target design will be made immediately after approval of the AUSTRON project.

3 Instrumentation

The key part of the AUSTRON facility is naturally represented by the neutron instrumentation which is illustrated in Fig. 3. A set of 21 instruments has been proposed by an international working group. When taking up service 6-8 of them will be ready for operation\(^2\). For optimal instrument performance 4 moderators will be required, one at ambient or intermediate temperature and three cold moderators.

- Instruments at the ambient/intermediate moderator: high resolution powder diffractometer (covering a very large detector solid angle), diffractometer for liquids and amorphous materials (emphasis on low- and small-angle scattering), direct chopper time-of-flight spectrometer (magnetic excitations and vibrational spectroscopy), crystal analyzer spectrometer for molecular excitations, radiography and tomography facility (providing the option of time-gated energy selection), engineering research beam line.

- Instruments at the high resolution cold moderator: general purpose powder diffractometer (following the recommendations in the Austrans report for new developments in this field), two single crystal diffractometers (one en-
abbling protein crystallography, the other dedicated for the investigation of samples with polarized nuclei), phase reflectometer (allowing a model-independent and unique reconstruction of the investigated surface profiles), high resolution crystal analyzer spectrometer (with several diffraction options), neutron resonance spin-echo spectrometer optimized for a pulsed neutron source and two development beam lines for general and for neutron optics developments, respectively.

- Proposed instruments at coupled cold moderators: general purpose reflectometer, instrument for combined small and wide angle scattering, high resolution SANS instrument with neutron spin echo option, SANS project based on spin echo technique, multi-chopper TOF spectrometer with variable energy resolution, TOF spectrometer based on phase space transformation for high-resolution spectroscopy studies, neutron optics research station.

This set of instruments seems to be well balanced with respect to the variety of instrumental and scientific possibilities. There is an adequate mixture of established and partly absolutely novel concepts and techniques. Most instruments are particularly suited to be installed at a pulsed neutron source and a majority of them will profit considerably from the 10 Hz operation of the source. Detailed consideration was given to an optimized sample environment. The proposed installation of a clean-room area (including temperature stabilization) combined with vibration isolation conditions represents a novel concept of sample environment for neutron sources. It will eventually contain about one quarter of the AUSTRON instruments such as reflectometers and single crystal diffractometers, which will gain from these possibilities for the investigation and development of advanced materials. The clean room area will also offer high stability conditions for neutron optics experiments of extreme sensitivity. Another special environment facility is the proposed engineering research area which allows heavy or large industrial samples to be delivered and investigated under full operating conditions on dedicated instrumentation.

4 Summary

As a summary AUSTRON is planned timely to counteract the foreseeable neutron gap. The impact on education and the possibility to train students will also contribute to avert the existing brain-drain in the region. The investment cost of AUSTRON was carefully estimated to be 340 Mil€ over a construction period of seven years, the operative cost will be some 37 Mil€. The creation of this international research centre will need a workforce of about 280 newly employed. It's multidisciplinary character, ranging from
Figure 3. Layout of the proposed AUSTRON instrument set.

materials and solid state physics to biology, polymers, chemistry, liquids, magnetism and superconductivity, will stimulate research in new fields bridging natural and life science.

References