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AUSTRON Progress Report*

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Abstract

The present status of the AUSTRON project is discussed. Updates are given on the AUSTRON accelerator and target design. A preliminary list of instruments under present discussion is introduced.

1. Background

AUSTRON is the project of a pulsed spallation source, which is foreseen to be built in Austria. At the last ICANS - Meeting a report [1] was given on the successful finalisation of a Feasibility Study [2]. We would now like to report on the progress of the project.

Two major events have added new elements to the project:
In 1996 a Med-AUSTRON Office was created. The city of Wiener Neustadt and the Bundesland Lower Austria are financing since then the elaboration of a Feasibility Study covering the Medical Part of AUSTRON. The Study will be finalised in early fall this year and describes a medical synchrotron aiming at proton and light ion (C) cancer therapy and research. The facility is planned as a stand alone project, which in case of being built at the same site and at the same time as AUSTRON will benefit from considerable

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synergies. The preliminary cost estimate for the Med-AUSTRON project sums up to some 800 million shillings (65 mill $). The light ions have a maximum nominal intensity of $5x10^8$ ions/fill (C) in case of single turn injection and a maximum nominal energy of 400 MeV/nucleon. Med-AUSTRON will be the world's best medical synchrotron enabling the cancer scientists and researchers to compare results of protons and ions under the same conditions.

The second important move was to present the AUSTRON Feasibility Study to the European Science Foundation (ESF) located in Strasbourg late 1996. In October 1997 the ESF returned its Assessment to the Austrian Ministry of Science and acknowledged the technical feasibility of the Study. The Austrian Minister of Science supported the idea to install a project group to enlighten the recommendations of the ESF until early September 1998. Based on the fact the Austrian government is prepared to finance up to a third of the total investment (400 mill $) transnational partners will have to co-finance the facility.

In their summary the ESF - Panel came forward essentially with the following assessment of the AUSTRON project:

* The AUSTRON feasibility study is recognised to be aiming at a high-performance research facility of medium to large scale that could serve science and research with high impact and satisfactory value.

* The R&TD fields served by neutron sources are, and will be in the long term, of high actuality and importance for fundamental and applied research in Europe.

* The users' clientele in the catchment area targeted by AUSTRON is large enough (some 940 users), and the facility's projected size in general appears to be adequate.

* The technical feasibility of the AUSTRON study is acknowledged, but a new cost analysis is needed to update the recommended 0.5 MW facility.

* The policy value and impact which a central facility of excellence like AUSTRON would have for the region and Austria is acknowledged.

According to the recommendations of the ESF the following chapters are elaborated by the AUSTRON - Project - Group (H. Rauch, M. Regler, P. Skalicky, H. Weber):

The positioning of AUSTRON in the landscape of other available neutron sources in Europe (ILL, ISIS, FRM2, SINQ, HMI, BNC).

The development of an instrumentation plan offering the possibility of unique experiments at AUSTRON.

Finalisation of the envisaged accelerator concept, leading to a spallation source of up to 0.5 MW at a pulse rate of 50 Hz. Thus AUSTRON will offer a neutron flux at the world-wide highest level of a pulsed source before the European Spallation Source (ESS) presently under discussion would go into operation.

Since the AUSTRON project is aiming at a new and additional neutron source for transnational use in the context of the existing and future neutron facilities, and as the Austrian parties are aiming at a substantial financial inflow from the targeted transnational region, a diplomatic mission to confirm collaborations with partners is planned in fall 1998. The specific value of the projected AUSTRON facility and its specific features of merit within its regional context are the crucial issues which would be decisive for the projected transnational use.

2. Accelerator

A prominent feature of the AUSTRON project is the well-founded accelerator concept [3]. AUSTRON's power substantially exceeds that of the present world-leading facility. Based on custom-tailored solutions in known technologies, it could be built relatively quickly and with a ratio of cost to scientific and technological potential that is very favorable. Its design has been performed by the AUSTRON accelerator team hosted by CERN, under the leadership of P. Bryant.

With respect to the European Spallation Source (ESS), AUSTRON should be regarded as a second, and ESS as a third, generation facility that will be separated by a decade in time and an order of magnitude in beam power.

In the AUSTRON accelerator complex, the particles are accelerated through a series of accelerators of different types that are adapted to the changing energy and intensity. First, negative hydrogen ions (H-) are accelerated in a radio frequency quadrupole (RFQ), followed by a drift tube linac (DTL) which raises the energy to 130 MeV before injection into the rapid cycling synchrotron (RCS). The RCS is a strong focussing separate-function accelerator of 213 m circumference with a double pulse structure (h=2) that is capable of being cycled at 25 Hz (AUSTRON II) and 50 Hz (AUSTRON III, the final choice for AUSTRON). At injection into the RCS, the H- ions are stripped of their electrons by a thin foil (charge exchange injection, allowing a very high-intensity proton beam to be accumulated). After trapping, the proton bunches are accelerated to 1.6 GeV and ejected onto a spallation target, with 200–250 kW and 400-500 kW, respectively. In both cases an energy of about 10 kJ per pulse impinges on the spallation target.

A possible upgrade could be the addition of a storage ring, working as a bunch accumulator, in order to deposit 40-50 kJ with a frequency of 10 or 12.5 Hz on the target. This would, however, require a new RF design in order to operate the RCS at h = 1, a decision which will be taken right from the beginning.

3. Target

In the present concept of the target design a flat target geometry is proposed [1,4]. The target material under consideration is solid W-5%Re according to its excellent thermal and mechanical properties [4]. Dimensions of a target block are 10 x 30 x 60 cm^3 (Heigth x Width x Length) where, due to the edge-cooling concept, cooling channels are only installed within 2 cm from the top and bottom surface. Since the beam power on target was taken to be 250 kW (version AUSTRON II) for the initial target design and for material tests on W-5%Re a target group, coordinated by T. Schmeskal, Austria Research Centre Seibersdorf, has been nominated to clarify the impact of a 0.5 MW beam on a target of the proposed design.

Calculations of the temperature distribution in the target, based on the standard AUSTRON III conditions with source repetition rate 50 Hz, yield a temperature maximum of about 1250 °C. Cooling of a target under these conditions is possible within the edge-cooling concept and an improved cooling system has been designed for this task. Material properties of W-5%Re like ductility, thermal conductivity or self-healing after irradiation damage look favorable for the temperature range of AUSTRON III. However, to obtain reliable data about the properties of W-5%Re under the combined effects of high temperature and high irradiation, further test series will be necessary for the final target design. From the present point of view, metallurgy as well as cooling technology, a 50 Hz/0.5 MW solid W-5%Re target seems feasible.

The final target design will be mainly influenced by the actual neutron instrumentation set for AUSTRON. Even if a 50Hz/0.5 MW solid target is feasible it might be preferable to make the AUSTRON target of two target blocks situated above each other [1]. Moderators can be placed between the two target blocks or above the upper and below the lower block. At 50 Hz operation of the accelerator both target blocks can be operated alternately at 25 Hz or one at 12.5 Hz or 10 Hz and the other at 50 Hz with every fourth or fifth pulse missing. With one target block acting as an effective decoupler from the neutron flux of the other, the upper and lower moderators would eventually represent 50, 25, 12.5 or 10 Hz sources while the moderators in the middle would operate at 50 Hz always. The double target block design offers good flexibility for neutron instrumentation and reduced radiation and thermal load for a single target block. Cold moderators will be needed to fulfil the needs of most instruments.

The final decision on the target design will be made in agreement with the instrument development and after neutron flux calculations for the respective moderator configurations which will take place in the AUSTRON design phase immediately after approval of the AUSTRON project.

4. Instrumentation

The AUSTRON instrumentation is one of the chapters to be elaborated according to the ESF assessment. In a workshop held in Wien, May 1998, a preliminary list of instruments was compiled with the idea of a well-balanced set of instruments comprising state-of-the-art instrument design following concepts already exploited with tremendous success at pulsed neutron sources and new instrument ideas with concepts not yet transferred to actual instrument design. From the first point of view, instruments will gain by sheer increase of neutron flux compared to instruments at existing sources and by using state-of-the-art instrument components, especially advanced detector systems. The second point of view underlines the innovative aspect of instrument development at AUSTRON, also with respect to the instrumentation for future generation sources, like ESS.

With the proposals for the AUSTRON instrumentation it is also tried to find a balance in scientific coverage of the research fields which are expected to be served at a source like AUSTRON. A set of 18 instruments has been proposed and associated with the chapters of the report on scientific prospects for future neutron sources [5]. To each topic, a couple of representative instruments from the AUSTRON instrument list is assigned. This assignment is, of course, by no means exclusive and most of the instruments will find use in the fields of almost all cited subjects.

Clean room conditions and vibration isolated areas will cover about one quarter of the experimental hall. Neutron optics instruments, reflectometers and in-situ crystal growth inspection spectrometers will gain most from these advanced environmental conditions. In the field of neutron quantum optics a novel neutron optics research station is proposed under special environmental conditions. A neutron optics development beam line, e.g. for the development of an NMR guide tube resonator for travelling magnetic wave focusing is added. Within a perfect crystal resonator system a stationary flux equivalent to the peak flux of the pulsed source can be produced which can be used for advanced beam tailoring devices.

With the, now for neutron studies, traditional area of magnetism and superconductivity in condensed matter research we associated a chopper spectrometer for magnetic excitations and vibrational spectroscopy (with respectively extensive low and wide angle detector banks) and the development project of an instrument for spin-polarized neutron specular reflection (for model independent determination of layer and interface structures; to be situated in the specially controlled environment area).

For science on liquids and amorphous materials we propose a dedicated diffractometer with emphasis on low- and small-angle scattering but also sufficient high angle coverage and the development of a spin echo small-angle neutron scattering instrument.

An important instrument for polymers and soft matter research is a general purpose reflectometer (with flexible position and orientation of the sample and extensive sample environment; also located in the environmentally controled area). For soft matter dynamics, a neutron spin echo spectrometer project, emphasizing its use on a pulsed source, is under discussion.

For biological studies, a general purpose small-angle instrument (optimised for pulsed source operation) is of general importance. Also assigned to this topic is a high resolution crystal analyzer spectrometer with an option for long d-spacing diffraction suited for large volume unit cells.

With the studies of new materials (especially, regarding their structural properties) in materials science we associated a general materials diffractometer (with large detector coverage and various possibilities for extreme sample environment conditions) and a general purpose single crystal diffractometer (also suited for large unit cell structures).

For dynamical studies in the area of chemical reactions, catalysis and electrochemistry we added a dedicated crystal analyzer molecular spectrometer (with large analyzer and detector area) and a multi-chopper TOF spectrometer with variable energy resolution.

In the upcoming fields, regarding neutron sources, of earth science and engineering a high resolution diffractometer (a flexible set-up to measure also textures, internal residual stress and phase analysis; which includes also a variety of extreme sample environment) and a radiography/tomography facility (exploiting the technique of time-gated energy selection) are listed.

Underlining the aspect of developing new instrumentation at AUSTRON, a phase-space transformation instrument project (aiming at high resolution spectroscopy studies) and a general development beam line (with various beam formation, manipulation and detection possibilities) are included in the AUSTRON instrumentation proposal.

This list of instruments is by all means preliminary. Scientific and technical goals and parameters for the AUSTRON instrumentation are worked out at present. Technical details and evaluation of performance and resolution by Monte Carlo techniques will be part of the above-mentioned AUSTRON design phase. All instruments are chosen due to their special performance on a pulsed neutron source, and there is yet no preference for an initial set of instruments.

5. Conclusion

The AUSTRON project represents now a short pulsed neutron spallation source with 0.5 MW design beam power. Two target configurations seem feasible for the initial target station. A second target station is planned as an option when the number of instruments is accordingly increased. Upgrading to a 1 MW spallation source is possible. A number of instruments has been defined for AUSTRON from which the initial set of instruments will be selected.

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References

[1] M. Schuster, P.J. Bryant, ICANS-XIII, PSI-Proc. 95-02, Villigen (1995), p. 831

[2] P.J. Bryant, M. Regler, M. Schuster eds., AUSTRON Feasibilty Study, Wien (1994)

[3] P.J. Bryant, M. Schuster, M. Regler, Physica B 234-236 (1997) 1220

[4] M. Schuster, I. Smid, G. Leichtfried, Physica B 234-236 (1997) 1224

[5] ESF Framework Studies into Large Research Facilities, Scientific prospects for neutron scattering with present and future sources, Autrans (1996)