Status Report of KENS

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1. JHF and the new Research Organization

Japan Hadron Facility (JHF) project is an interdisciplinary project among particle physics, nuclear science and material science, which utilizes world-most-intensive proton beam produced by synchrotron accelerators. The Institute of Nuclear Study of University of Tokyo (INS), which has been devoting to realize JHF for a long time, was merged to KEK in April 1997, and KEK was re-organized to be a new Research Institute, i.e. the High Energy Accelerator Research Organization (new KEK). The neutron science facility, so called Neutron-arena (N-arena) for material research and other related science will produce intensive pulsed neutron beam by 3GeV, 200μA proton synchrotron.

The formal Committee for discussing about the future of accelerator science in Japan, which was organized in April 1995 in MONBUSHO (Ministry of Education, Science, Sports and Culture), reported the decision of establishment of new organization, mentioned above, in 30th of April 1996. It says, " Under considering the evolution of accelerator science and scientific importance in particle physics, nuclear science, meson science, synchrotron radiation science and neutron science, it is decided to have a comprehensive research institute by combining the three laboratories, i.e. KEK, INS and the Meson Science Laboratory of University of Tokyo (UT-MSL), and reform them to make continuous development of the accelerator science and lead international initiative in the related scientific field." Hence two new institutes, i.e. the Institute of Particle and Nuclear Studies and the Institute of Materials Structure Science, were formed in the new KEK. These institutes share the backbone accelerators in collaborative fashion with keeping independent research scheme.

The budget proposal for the new organization was sent off to the Ministry of Finance from MONBUSHO in August 1996 and approved by the government in December 1996. Under the new KEK, the Neutron Science Laboratory is composed from four units for the neutron scattering research division and three units for the neutron target development division. (One unit contains three research staffs and one or two technical staffs.) The outline of the new organization is shown below. Total staffing at new KEK amounts to about 750 full-time permanent positions.

High Energy Accelerator Research Organization (new KEK)

- Institute of Particle and Nuclear Studies
- Institute of Materials Structure Science
  - Synchrotron Radiation Laboratory
  - Neutron Science Laboratory
  - Meson Science Laboratory
- Accelerator Laboratory
- Applied Research Laboratory
  - Radiation Science Center
  - Computer Science Center
  - Low Temperature Technology Center
  - Manufacturing Center

The one of the aims of the new organization is to realize JHF, which has been a long time dream of researchers in the related scientific fields, especially neutron scientists. The accelerator complex is composed from the 200MeV proton linac, the 3GeV proton booster synchrotron and the 50GeV synchrotron. 3GeV protons of 200μA (0.6MW, 25Hz) will be supplied for N-arena (neutron arena), M-arena (meson arena) and E-arena (exotic-nuclei science arena). 50GeV protons of 10μA will be supplied for K-arena (K-on, pi-meson, anti-protons, neutrino science arena). In order to reduce the construction costs, the existing tunnel for the present 12GeV proton synchrotron and infrastructure, such as the electric power facility, the cooling water facility and so on, will be refurbished and used for JHF. Figure 1 shows the outline of the JHF.

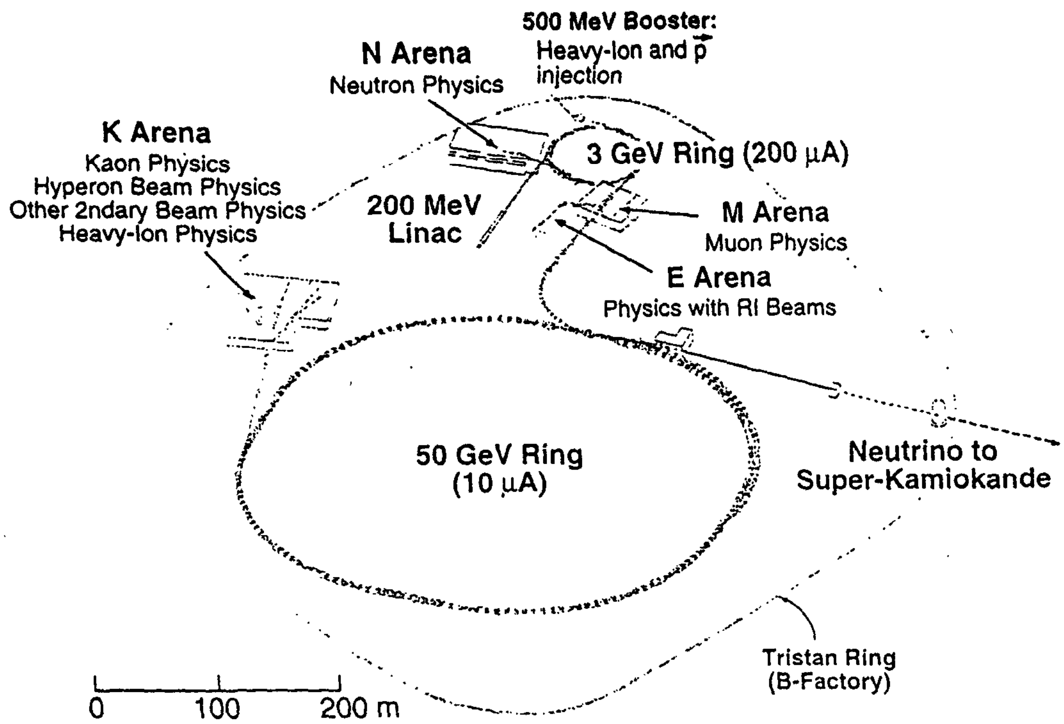

Fig.1 Proposed accelerator complex and experimantal areas for JHF

The N-arena is aimed at producing the world highest neutron flux by utilizing newly developed moderators. It is six times for thermal neutrons and 36 times for cold neutrons compared to those of the ISIS facility of the Rutherford Appleton Laboratory. Hence it is over 200 times of the present flux of the KENS facility, and a large number of fruitful scientific outputs are highly expected. In addition, for endowing further uniqueness to JHP, a possible research scheme of multi-beam experiment with using neutron, muon and synchrotron radiation, and development of high performance spectrometer are under consideration. In the N-arena more than twenty spectrometers will be installed. Those are small-angle scattering instrument, diffractometers, inelastic spectrometers, polarization analysis instruments, reflectometer and so on, which will be served for studying static and dynamic structure of materials including biological substances and basic nuclear science.

After realizing the performance of 0.6MW in the neutron source, there will be possible upgrading to 1.2MW by increasing the operational frequency of the accelerator to 50Hz. Further increase of the proton power can be achieved by improving the 200MeV lineac, which will reserve available site for this purpose. It is, however, indispensable to develop a component for high power accelerator and a new type of neutron target for high power neutron source, because even liquid metal target is not proved yet to be usable above a few MW. Those issues should be solved in the future by the related working force. Working for N-arena program is underway by the power users. The working group for target station is lead by Dr. M.Furusaka (KEK) and for spectrometers by Dr. M.Arai (KEK). The cost estimation for the target station of N-arena was already made and the gloss budget proposal was submitted to the government in July 1997, but the project was not officially approved because the Japanese Government started the reform of the Japanese financial systems.

The N-arena will be opened for the outside users after completion of the construction, and it will be also opened for international community. Hence it is important to consider the strategy of the management of the facility. KEK has been making collaboration with any foreign countries without collateral beam costs.

The development of target station, spectrometers, sample environments and data analysis software, the decision of the strategy of the management of the facility for achieving high performance, establishing the relation between foreign countries in competing way and collaborative way and improving research environment for in-house staff, those all should be well discussed and considered among neutron community to realize JHF, which will be really an important project for continuous development of the neutron science in the next century.

2. Activities at KENS

2.1 Facility Operation

At present, the high-energy pulsed neutrons are produced by the spallation reaction with the proton beam of 500MeV and 6μA, and are moderated by two moderators of the circulating water at ambient temperature and the solid methane at 20 K to the thermal and cold neutrons, respectively. These moderated neutrons are delivered to 17 neutron spectrometers through 11 neutron beam holes in the biological shield (see Fig.2).

In 1997, the construction of new spectrometers (SIRIUS: high-resolution powder diffractometer, TOP: polarized cold-neutron spectrometer, SWAN: small- and wide-angle scattering instrument) was completed and installed in the new cold-neutron experimental hall, which was built in 1996, and the instruments are now open for the use of external users. In 1998, the beam-time of about 70 days is allocated to the neutron scattering facility.

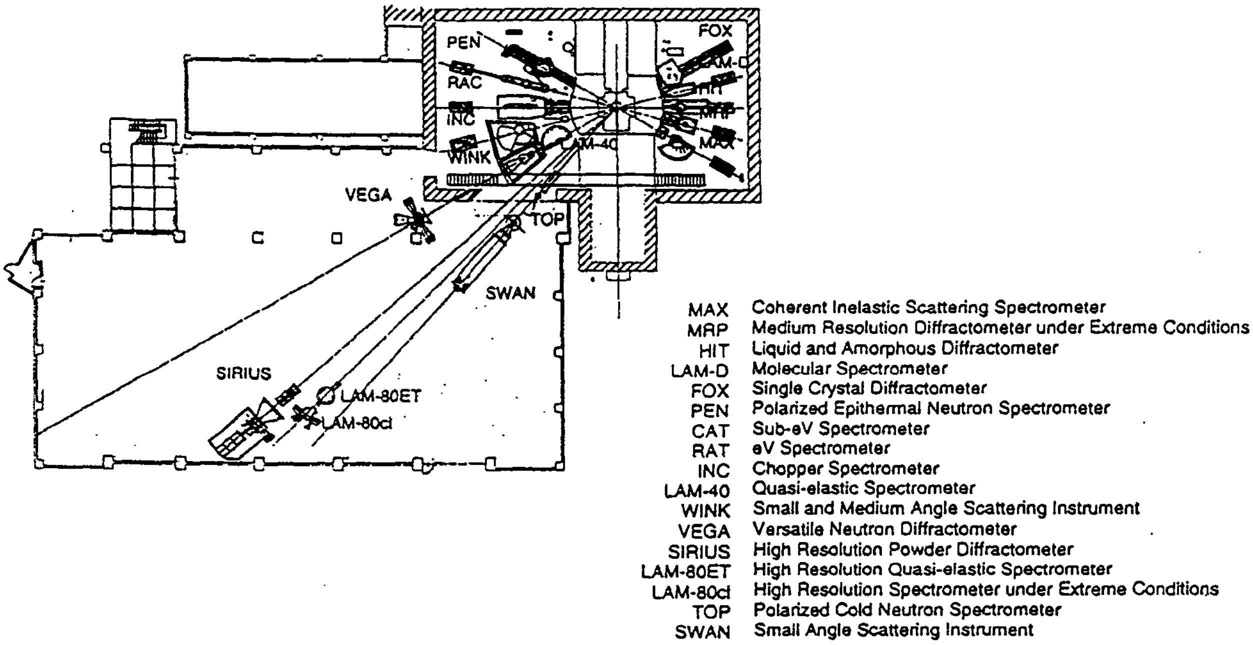

Fig.2 Layout of KENS instruments

2.2 Inter-University Program

99 scientific proposals have been submitted as the Inter-University Research Program at KENS for the year 1998. Among them, 80 proposals were accepted through peer review. About 400 researchers were registered as a radiation worker at KENS. About 60% of proposals are concerned with studies of crystal structure and excitations of materials including liquids and glasses.

2.3 Recent Progress of Scattering Experiments

There are increasing demands for higher resolution neutron powder-diffraction experiments at KENS. In order to satisfy the demands, a new high-resolution powder diffractometer (SIRIUS) was installed in the guide hall. Figure 3 shows a layout of SIRIUS. Because of the pulse width through the solid methane moderator at KENS, a flight path of about 40m is required to achieve a high resolution of $\Delta d/d=1\times10^{-3}$. A long flight path demands the use of a neutron guide tube to avoid a loss of intensity. If natural nickel is used for the coating materials of the guide tube, the intensity is very small at wavelengths shorter than 4Å. In order to gain more intensity at shorter wavelengths on SIRIUS, it was decided to use a guide tube comprising supermirrors with a beam cross section of 4cm × 5cm. In the case of a NiC/Ti-supermirror with a critical angle three-times larger than that of natural nickel, the intensity around 1Å is large. The guide tube started at 5.5m from the moderator, and the total length of the guide tube (28.5m) was chosen to meet the geometrical limitation. A collimator is installed between the end of the guide tube and the diffractometer chamber, and the resolution and intensity can be selected by changing its slit. An overall flight path of 39.5m enables a wavelength window of 5Å, which corresponds to the d-range of 2.5Å. Figure 3 illustrates the layout of SIRIUS with a large backward bank and a 90-degree bank comprising one-dimensional position sensitive detectors (PSD). Each PSD has a diameter of 1.27cm and an effective length of 60cm. The PSD-VME data-acquisition system, which has been developed at KENS, was adopted. The position encoding, data transfer and histograming are carried out by a Macintosh. The calculated ratio of the intensity of SIRIUS to that of

VEGA, the existing powder diffractometer at KENS, has been expected to be almost 15. It was confirmed in a recent experiment. Furthermore, it was found that SIRIUS realized the best resolution of $\Delta d/d=1\times10^{-3}$ by a measurement of the Bragg reflection from a single crystal of silicon.

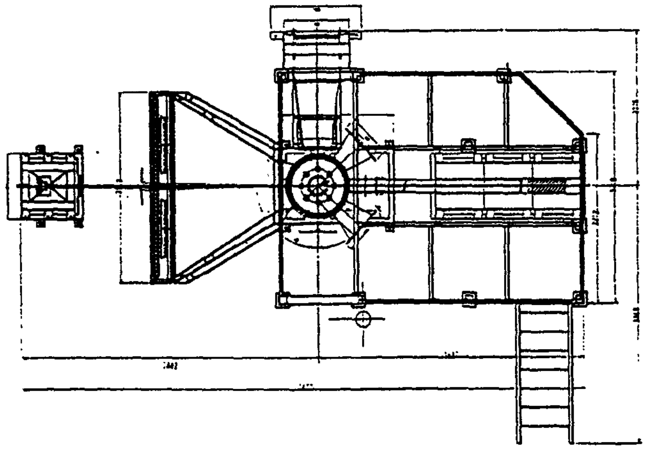

Fig.3 Layout of SIRIUS

SWAN has been designated as a small/wide-angle diffractometer to observe the structural changes in a wide momentum space. Figure 4 shows a layout of the SWAN. The SWAN has 48 3He position-sensitive detectors (PSD) in the small-angle detector bank, 48 conventional 3He detectors in the medium-angle detector bank, and 160 PSDs in the high-angle detector bank. It makes it possible to measure the structure in the very wide momentum transfer range 0.004-20 Å-1. The investigation of both microscopic and semi-macroscopic atomic structures can be performed simultaneously using the SWAN.

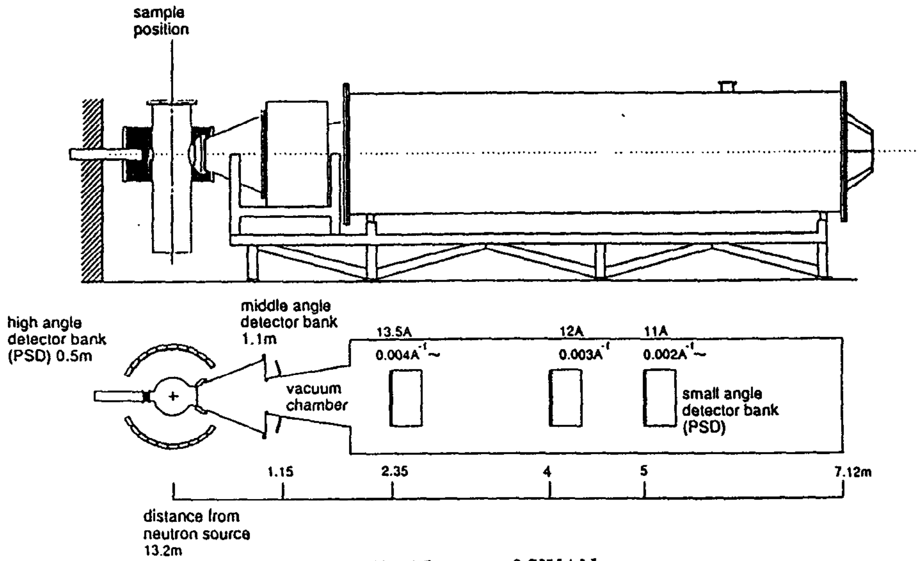

Fig.4 Layout of SWAN

Polarized neutron reflectometer, TOP, has been newly designed for the investigation of surface and interfacial magnetism in magnetic thin films and multilayers. The polarized neutron is much more sensitive to minute magnetic moments than unpolarized one. The advantage makes the polarized neutron reflectometer a very powerful tool for the investigation of such magnetism. Figure shows the reflectivities of a natural Ni mirror which is used for C2 cold neutron guide tube at KENS under a magnetic field of 300 Oe. The interference between reflected beam from the surface and the Ni - substrate interface makes many fringes of reflectivities. The reflectivities depend on the magnitude of magnetic moments of Ni and a relative angle between neutron spin and magnetization of Ni in the mirror. Figure 5 shows the parallel case (solid circles) and the antiparallel case (open circles). From the data Ni in the mirror was revealed to have very small magnetic moments of 0.06 (Bohr magneton / atom) which is only 10% of saturation magnetization. In other words, such small magnetic moments makes very clear difference of the reflectivities. This shows that the polarized neutron reflectometry is a very promising tools for the investigation of surface and interfacial magnetism.

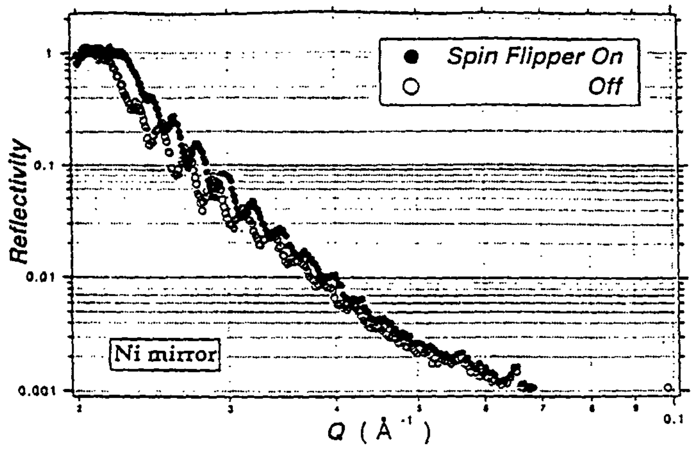

Fig.5 Reflectivities from the Ni mirror