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Current status of JHP N-arena

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ABSTRACT

Japanese Hadron Project (JHP) consisted of four facilities, namely, N-arena (a high power pulsed spallation neutron source), M-arena (meson science), E-arena (unstable nuclear beam) and K-arena (nuclear and particle physics). JHP is based on a 200 MeV, 400 μA linac, a 3 GeV, 200 μA, 0.6 (1.2) MW rapid cycle synchrotron and a 50 GeV, 5 (10) μA synchrotron. Conceptual design of N-arena, for example, a target station, a target-moderator-refletor-assembly (TMRA) and instruments is underway now. Systematic research and development of high efficiency TMRA is also underway.

1. Outline of JHP

1.1 History of JHP

In 1983, soon after the successful startup of KENS-I, we already had a project KENS-II, aimed to be a 0.4 MW pulsed spallation neutron source (SNS). In 1986, KENS-II was merged into the original Japanese Hadron Project (JHP), which comprised a 1 GeV, 400 μA linac and a 200 μA compressor/stretcher ring. JHP consisted of four facilities, namely, N-arena (neutron scattering), M-arena (meson science), E-arena (unstable nuclear beam) and K-arena (nuclear and particle physics). It was a phased program and K-arena was for second phase.

The site for the project had not been decided at that stage, but a site south to the KEK was a strong candidate. Since we do not have any buildings, tunnels, and infrastructures like roads, electricity, water supply and so on at that site, the total cost of the project was considered to be rather expensive.

1.2 Updated JHP

In June, this year, all the parameters were reconsidered, taking into account that there were several plans to build megawatt class SNSs in Europe and in USA. After the discussions, the requirements for N-arena were summarized as follows: i) proton beam power: 1-MW class, ii) energy: between 1 and 3 GeV, iii) repetition rate: between 10 and 50 Hz, and iv) harmonics number: do not care.

We also decided to build the whole array of accelerators and facilities at the current KEK site, using tunnels for the current proton accelerators and experimental halls for nuclear and particle physics as shown in Fig. 1. By using existing tunnels and facilities, it was shown that

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we could build the whole facilities including a 50 GeV accelerator and the K-arena with almost the same budget as the previous plan.

Some compromises were made among the requirements for M-arena, E-arena, K-arena and the accelerators. Eventually, the energy has been decided to be 3 GeV (Injection to the 50 GeV ring and M-arena prefer higher energy.), the repetition rate to be 25 Hz and the harmonic number to be four. The parameters for the accelerators have been decided to be 200 MeV and 400 μA for the linac, 3 GeV, 200 μA and 25 Hz for the rapid cycle synchrotron, i.e. 0.6 MW, and a 50 GeV, 5 μA synchrotron for the K-arena. By adding RF cavities to the 3 GeV synchrotron in the future, we could increase the frequency to 50 Hz and hence upgrade to 1.2 MW. An alternative idea is to extend the linac to 400 MeV and increase the current to 400 μA to upgrade to 1 MW, keeping the long repetition rate.

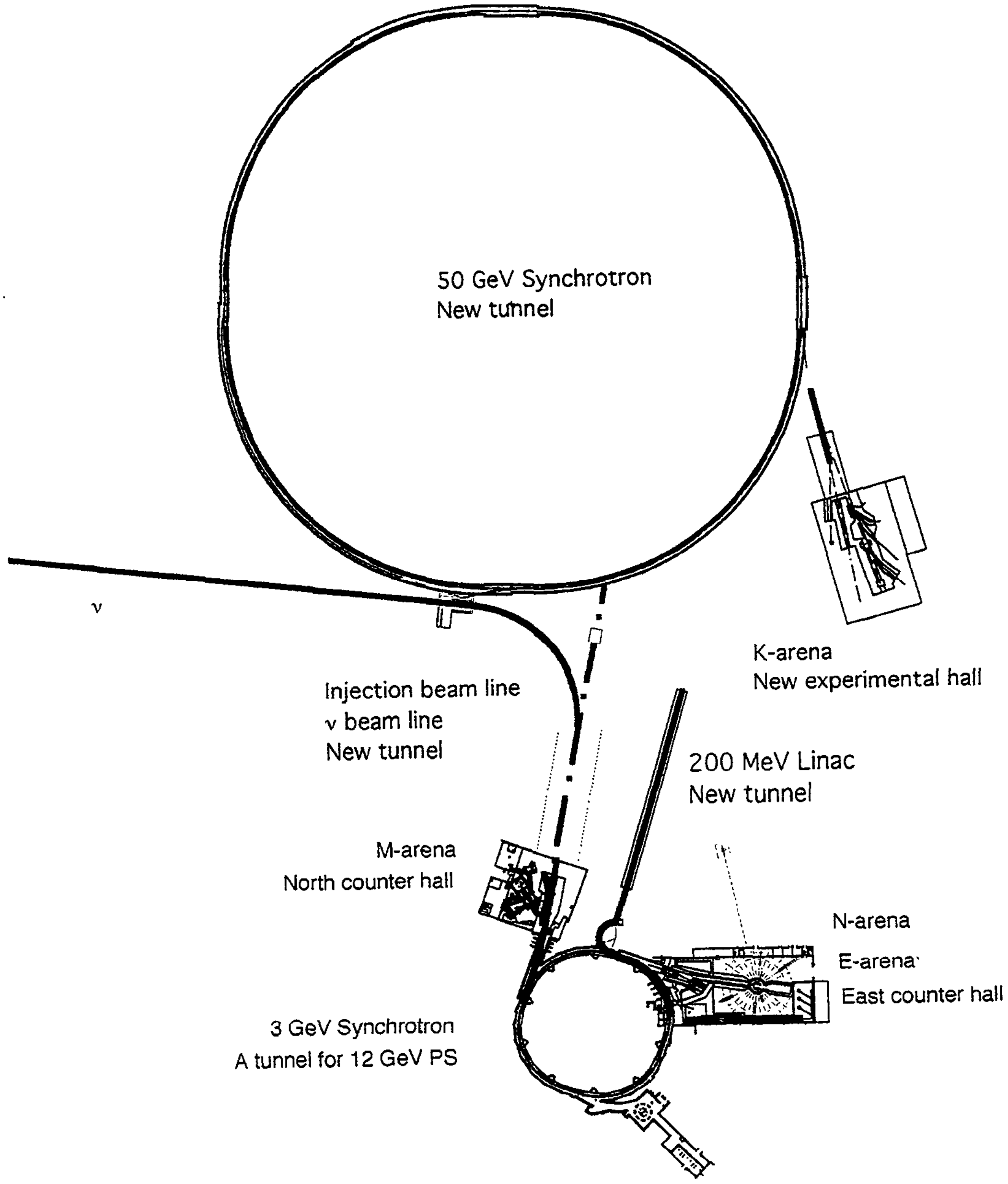

Fig. 1. Layout of the JHP accelerators and experimental facilities.

The updated parameters for the accelerators are summarized in table 1-3.

Table 1. Parameters of proton linac (updated JHP)

Energy	200 MeV
Repetition rate	25 Hz (50 MHz in future)
Beam Pulse Length	400 μs
Chopping Rate	70 %
RFQ, DTL Frequency	324 MHz
Peak Current	30 mA
Linac Average Current	300 μA (600 μA in future)
Average Current after chopping	200 μA (400 μA in future)
Total Length	150 m
H- Ion Source	
Type	Volume-Production Type
Peak Current	32 mA
Normalized Emittance	1.5 π mm·mrad
Extraction Energy	50 kV
RFQ	
Energy	3 MeV
Frequency	324 MHz
DTL	
Energy	200 MeV
Frequency	324 MHz
Focusing Quadrupole Magnet	Electromagnet
(After a few 10 MeV, the quadrupole magnets are located outside tanks-"Separated DTL (SDTL)")	
Total Tank Length	135 m
The Number of Tanks	16
RF Sources	
The Number of Klystrons	17
Total RF Power	26 MW

Table 2. Parameters of 3 GeV Synchrotron (updated JHP)

Energy	3 GeV
Beam Intensity	5×10^{13} ppp
Repetition rate	25 Hz (50 Hz in future)
Average Beam Current	200 μA (400 μA in future)
Beam Power	0.6 MW (1.2 MW in future)
Circumference	339.36 m
Magnetic Rigidity	2.15 ~ 12.76 Tm
Lattice Cell Structure	FODO

Tune	(7.3, 4.3)
Natural Chromaticity	-8.4, -6.3
Transition energy :γ_t	7 (no transition below 3 GeV)
Total Number of Cells	24
Number of Bending Magnets	48
Length of Bending Magnets	1.75 m
Magnetic Field	0.161 ~ 0.954 T
Number of Quadrupoles	48
Length of Quadrupole Magnets	0.5 m
Maximum Field Gradient	5.4 T/m
Revolution Frequency	0.50 ~ 0.86 MHz
Harmonic Number	4
RF Frequency	1.99 ~ 3.43 MHz
Bunch Length	88 ns (B = 0.3)
Average Circulating Beam Current	3.98 ~ 6.83 A
RF Voltage	389 kV
RF Voltage per Cavity	40 kV (20 kV/gap)
The Number of RF Cavities	10
RF Power	5 MW
Beam Emittance at Injection	320 π mm·mrad
Beam Emittance at Ejection	53.9 π mm·mrad

Table 3. Parameters of 50 GeV Synchrotron (updated JHP)

Energy	50 GeV
Beam Intensity	2×10^{14} ppp (4×10^{14} ppp in future)
Repetition period	6 s
Average Beam Current	5 μA (10 μA in future)
Circumference	1442 m
Average Radius	229.5 m
Magnetic Rigidity	12.76 ~ 170 Tm
Lattice Cell Structure	3-Cell DOFO x 6 module + 4-Straight Cell
Tune	(24.25, 20.7)
Transition energy :γ_t	27 i (imaginary)
Total Number of Cells	88
The Number of Bending Magnets	96 (6.2 m)
Maximum Bending Magnetic Field	1.8 T
The Number of Quadrupoles	176 (1.5 m and 2 m)
Maximum Field Gradient	25 T/m
Revolution Frequency	0.21334 ~ 0.21966 MHz
Harmonic Number	16 (32)
RF Frequency	3.42 ~ 3.52 MHz (6.83 ~ 7.03 MHz)
Bunch Length	95 ns (47 ns) (B = 0.3)
Average Circulating Beam Current	6.83 (13.70) A
RF Voltage	200 kV
RF Voltage per Cavity	40 kV (20 kV/gap)
The Number of RF Cavities	5

RF Power	3(6) MW
Beam Emittance at Injection	53.9 π mm·mrad
Beam Emittance at Ejection	4.1 π mm·mrad

1.3 Schedule

We already have a panel in the Ministry of Education, Science, Sports and Culture (Monbusho) established this fiscal year which is now discussing a unification of National Laboratory for High Energy Physics, KEK and Institute for Nuclear Study, University of Tokyo to form a new research institute organization. The reorganization will very likely be happening in 1997. JHP is planned to start in either 1997 or 1998 and finish construction in five years, expecting first beam around 2003.

2. Current status of N-arena

2.1 N-arena basic schemes

Since we use an existing experimental hall for the target station, basic concepts have to be modified. In the original plan, a vertical injection scheme was employed, in preference for a larger number of neutron beam lines. That scheme had to be abandoned and a horizontal scheme employed because the beam line from the accelerator is now above ground level.

The concept of two TMRA's in one target station was also abandoned, mainly because of the horizontal injection. It was also shown that the gain of having two TMRA's compared with only one is only 10 to 20 %. The gain depends on a repetition rate and a harmonic number of the synchrotron and a pulse delivering scheme. If each TMRA has a separate target station, the number of neutron beamlines is doubled, result in a big gain, but with only one target station, we can not increase the number of beamlines. The effect of cross talk between the TMRS's is also a drawback.

2.2 N-arena experimental hall

A preliminary layout of the N-arena is shown in Fig. 2, together with a schematic layout of instruments and a possible moderator arrangement in the inset. The experimental hall which already exists is called "East counter hall", and is now used for nuclear and particle physics experiments. It has a dimension of 108 m by 50 m with three story high attached rooms. The E-arena target is shown at the middle of the left hand side of the figure. Unstable nuclei produced there will be mass-separated, and accelerated by a heavy ion linac which is shown at the bottom of the figure.

2.3 TMRA R&D

Although the proton power for the JHP is only 0.6 MW for the first stage, the N-arena would become a very powerful SNS, because of the improved performance in TMRA, because of the results of the recent research and development. Continuing efforts searching for better TMRA arrangements are still continuing, by mockup experiments using an electron linac facility in Hokkaido University and by computer simulation.

The first big improvement was achieved in 1990 by a coupled hydrogen moderator with a premoderator[1]: Six times higher flux has been achieved compared with a conventional decoupled hydrogen moderator. The moderator is best for the instruments which are not affected by a neutron pulse width, like small-angle scattering instruments and reflectometers. For these instruments, the size of moderator surface viewed from the sample should be small, due to the requirement of the incident beam collimation. The recent study showed that a gain

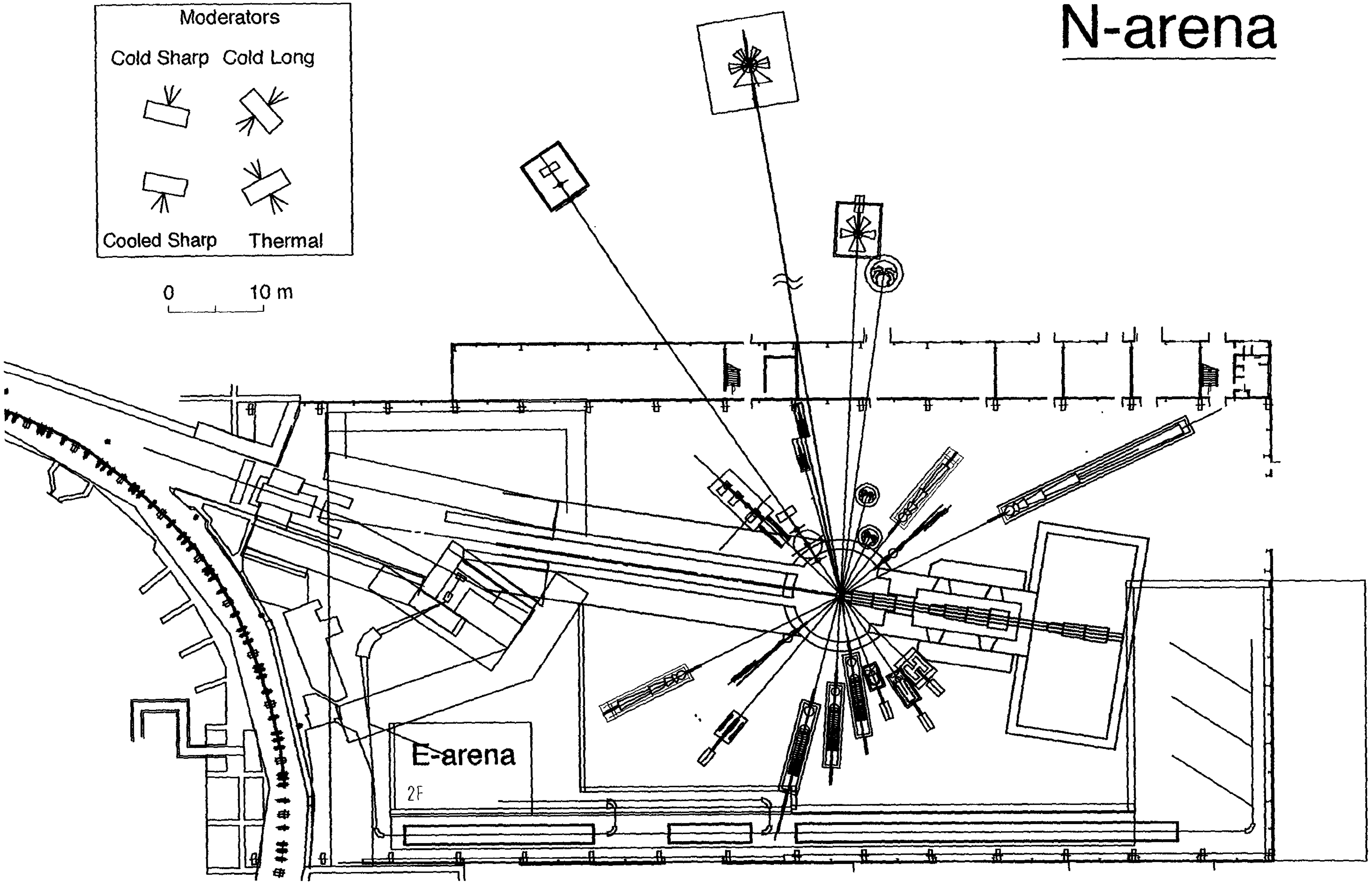

Fig. 2. Preliminary layout of the N-arena experimental hall.

of about 12 % could be achieved, by narrowing a neutron beam extraction hole [2].

A decoupled hydrogen moderator with a premoderator has been developed for instruments which require higher time resolution, hence narrower pulse width. It is intended for instruments like μeV spectrometers and high resolution powder diffractometers. Recently, a poisoned premoderator instead of the decoupled premoderator has been tested, and it showed slightly narrower pulse width than simple premoderators [3].

A decoupled hydrogen moderator with cooled zirconium hydride premoderator was developed [4] as a replacement for a liquid methane moderator, but further research and development is needed for such a moderator. Development of this kind of moderator is crucial for the high power SNS like N-arena, because methane can not be used for the moderator material because of radiation damage problem.

A systematic study of the effect of poisoning especially for room temperature water moderator is also underway.

3. References

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