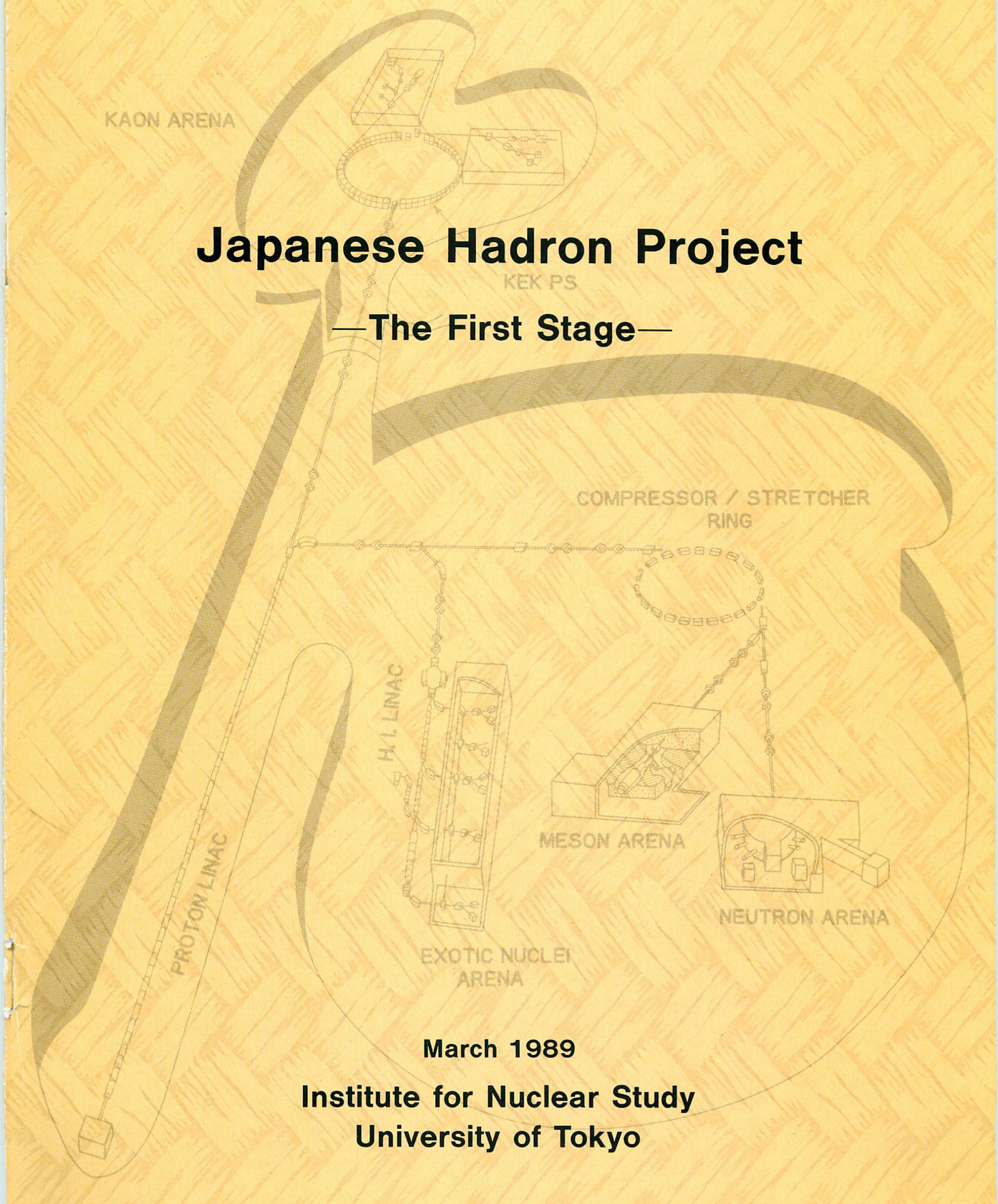


Japanese Hadron Project

—The First Stage—

March 1989

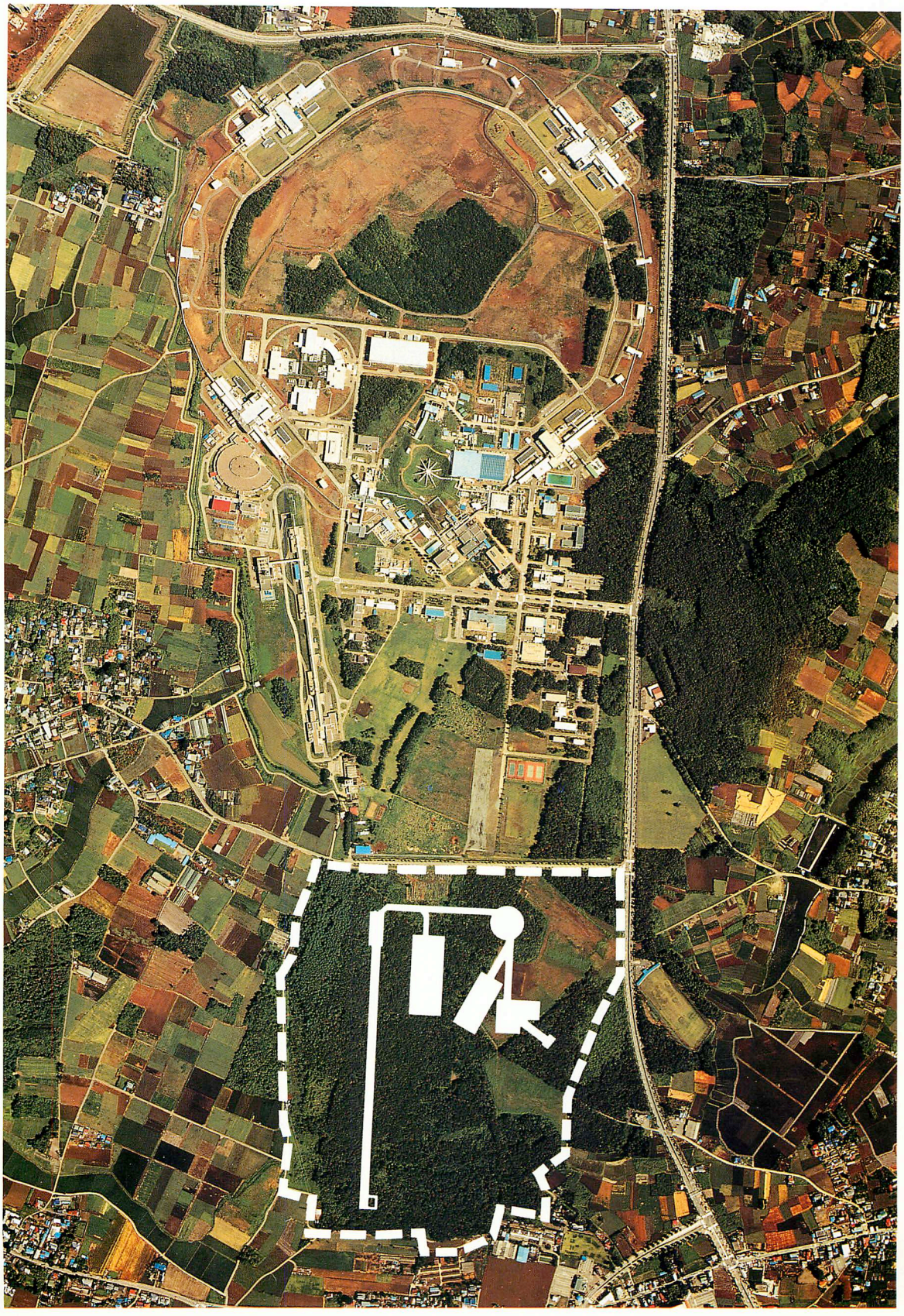
Institute for Nuclear Study
University of Tokyo

CONTENTS

The Japanese Hadron Project (JHP) has been proposed in order to promote the progress of new research fields in nuclear physics and related science. Much effort has been put forth by the JHP working group organized under the auspices of the Institute for Nuclear Study, University of Tokyo. In June 1987, the first draft of "The Japanese Hadron Project" was published. Since this project is closely related to particle and nuclear physics as well as other sciences presently under way at the National Laboratory for High Energy Physics (KEK), its concept has been fully deliberated in collaboration with KEK. From the viewpoint of physics in general, the Japanese National Committee on Physics of Japan Science Council positively reviewed this proposal and has resolved to see its realization as soon as possible.

In 1988, the working group decided to emphasize, as the first stage, the facilities designated for early construction among the ones proposed in the first draft proposal. Under an interim promoting organization of the JHP, further design work for accelerators and experimental facilities has started according to this plan.

This document summarizes the present proposal for the first stage of the JHP.



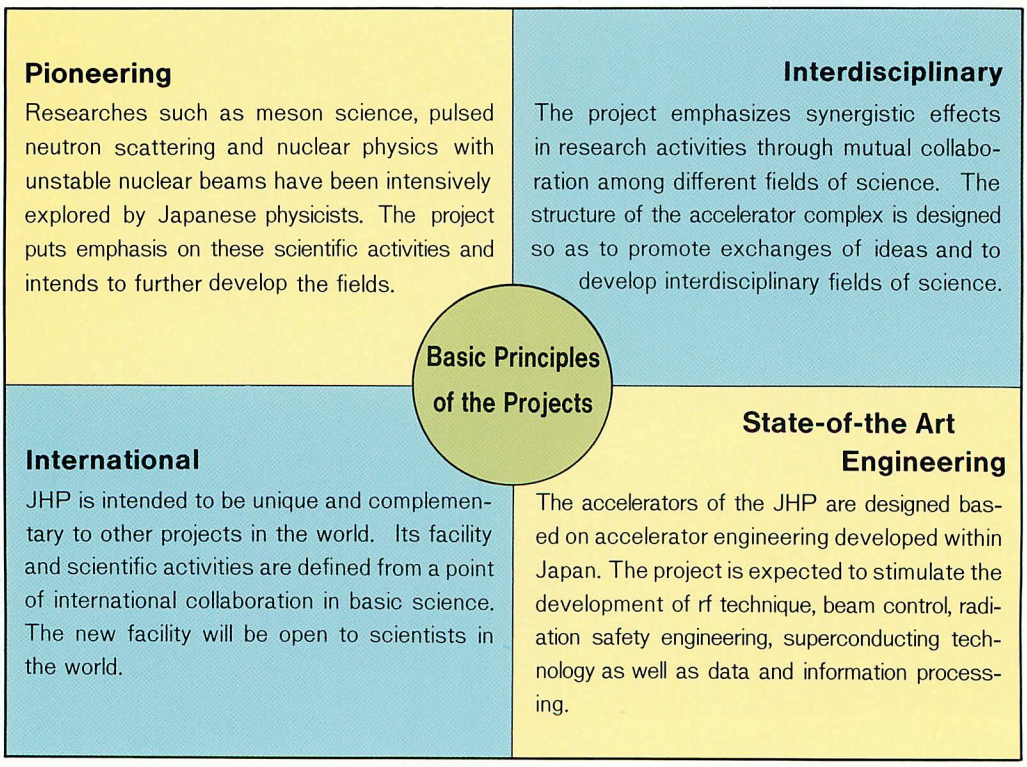
A proposed site for the Japanese Hadron Project is shown with a white dashed line in the picture, which is located at the southern part of the present KEK site.

OUTLINE OF THE JAPANESE

Quest for a New Science with a Wide Variety of Unstable Particles

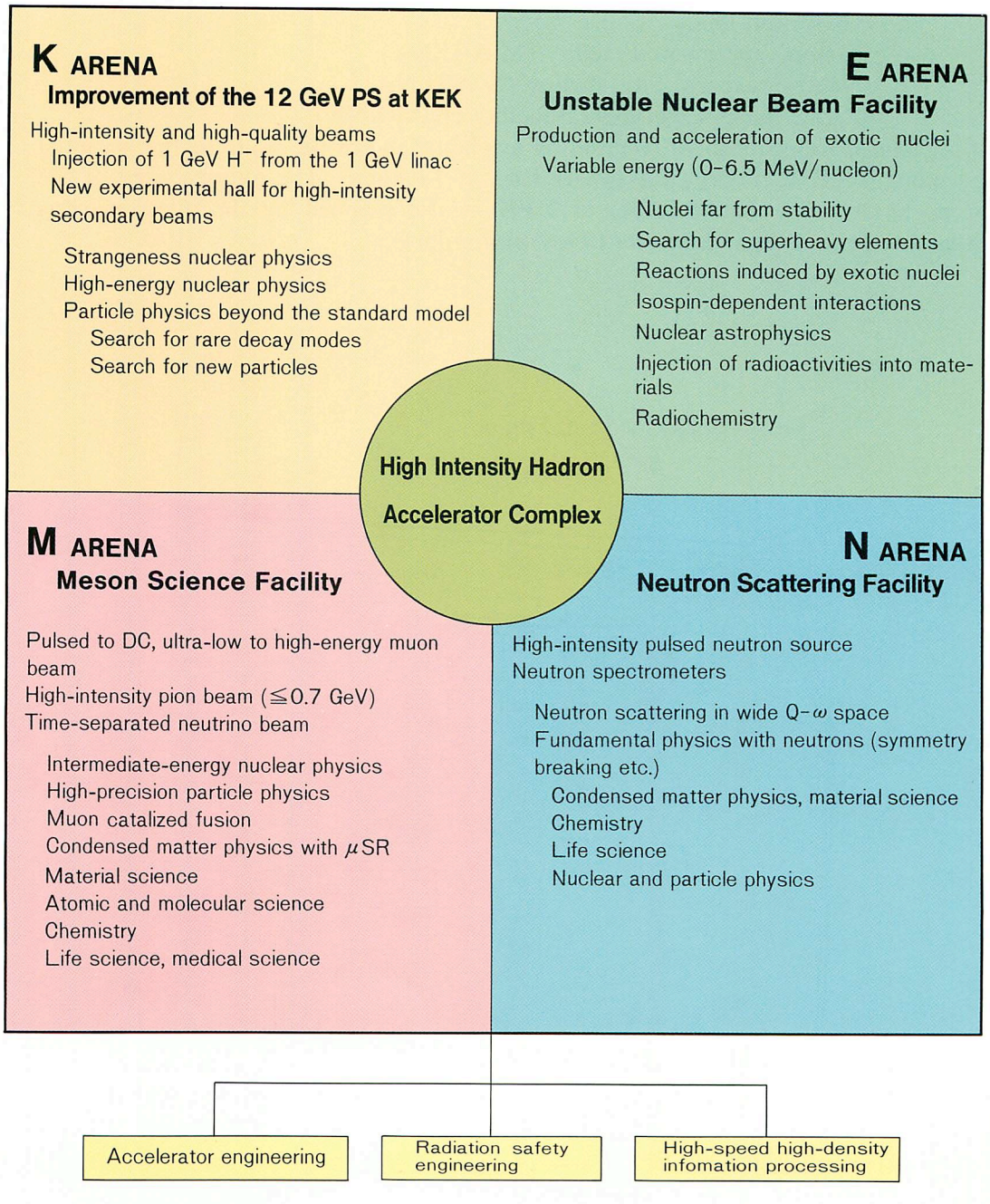
The Japanese Hadron Project aims to investigate many unexplored facets of matter by utilizing various kinds of unstable particle beams such as mesons, muons, neutrons, and short-lived nuclei. Such beams are to be supplied by an accelerator complex of high-intensity hadrons described in this brochure. This project is expected to extensively contribute to the progress of basic sciences, not only nuclear and particle physics but also condensed-matter physics, atomic physics, chemistry, life science and advanced engineering.

The research facilities to be realized in the Japanese Hadron Project are called "ARENA" after the Roman amphitheaters which were used for combat and other performances. In the arena of JHP, scientists are expected to freely perform their research activities with the supplied unstable particle beams. This project intends to establish four arenas (K, M, N, and E), in which particular fields of science will principally be studied. It is also emphasized that the scientific activities of the four arenas are to be related to each other through cross-communication among the different disciplines of science, which should be mutually beneficial.



HADRON PROJECT

Research Areas of JHP

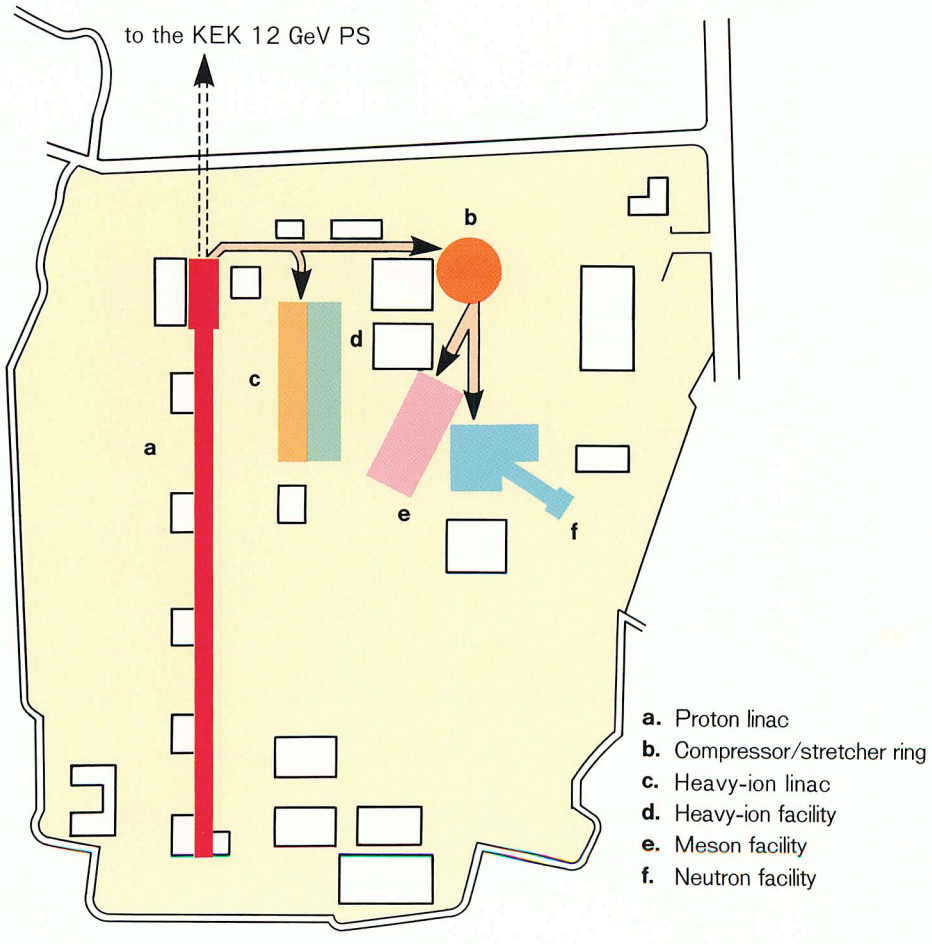


OUTLINE OF THE JAPANESE HADRON PROJECT

The JHP plans to construct the following accelerators and facilities:

a. Proton linac,
b. Compressor/stretcher ring,
c. Heavy-ion linac,
d. Meson experimental facility (M ARENA),
e. Neutron experimental facility (N ARENA),
f. Exotic-nuclei experimental facility (E ARENA).

It is planned to locate these facilities on available land to the south of the National Laboratory for High Energy Physics (KEK) at Tsukuba. The improvement of the existing 12 GeV PS (K ARENA) at KEK is also planned by the injection of a high-quality proton beam from the 1 GeV proton linac.

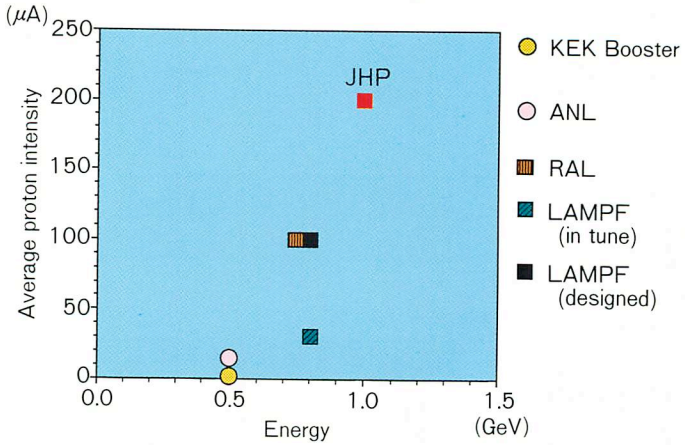


Features of the Accelerators and Arenas

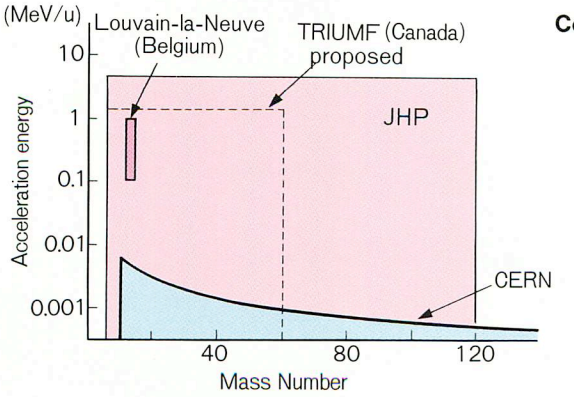
Each facility will have the following unique features compared with other facilities in the world.

Accelerator · Arena	Characteristic features
Proton linac	Highest energy (1 GeV) in the world Largest acceleration gradient per unit length
Compressor/stretcher ring	Highest beam intensity ($\gtrsim$200 μA) Various time structures
Heavy-Ion linac	Ultra-low energy (1 keV/u) injection Acceleration of unstable nuclei
MESON arena	Short-pulsed beam (20 ns) to DC π, μ beam Very low-energy μ beam; pulsed ν beam
NEUTRON arena	High-intensity and pulsed neutron scattering facility
EXOTIC NUCLEI arena	Acceleration of unstable nuclear beam up to 6.5 MeV/u; unique in the world

A high-intensity proton beam is supplied to the M and N arenas by the 1 GeV proton linac and the compressor/stretcher ring. The intensity of the beam is planned to exceed those of existing accelerators, as shown in the figure. JHP emphasizes supplying low-emittance beams with various time structures which meet various experimental requirements.



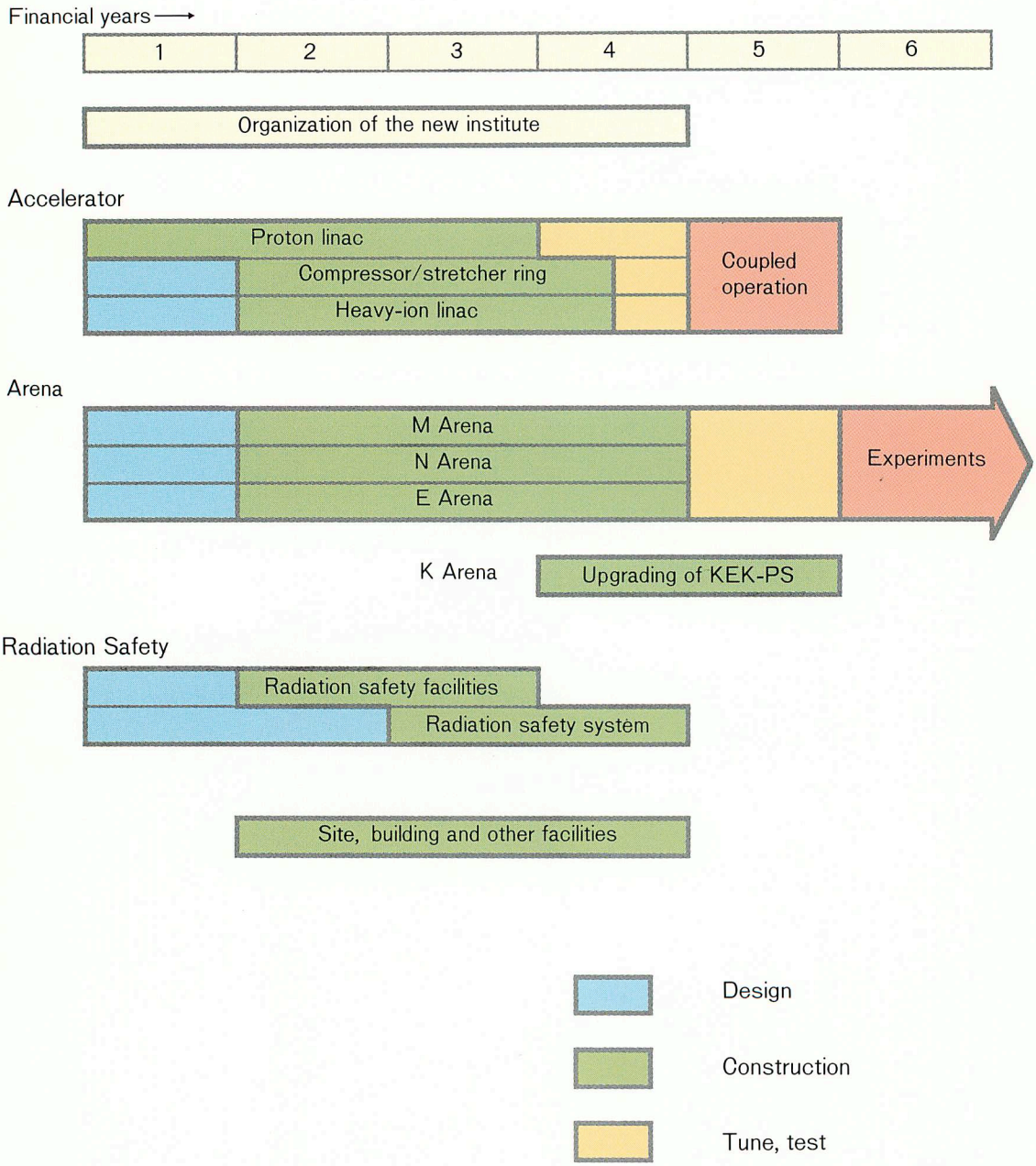
Comparison of Pulsed Proton Beam



Comparison of Radioactive Ion Beam

A unique feature of the E arena is that a wide variety of short-lived exotic nuclei with A$\leq$60 produced by 1 GeV protons are accelerated by the heavy-ion linacs up to 6.5 MeV/nucleon, so that nuclear reactions can be induced by unstable nuclear beams.

Construction Schedule



JHP ACCELERATOR SYSTEM

The accelerator complex of the JHP consists of a 1 GeV proton linac, a compressor/strecher ring and a heavy-ion linac, which supplies:

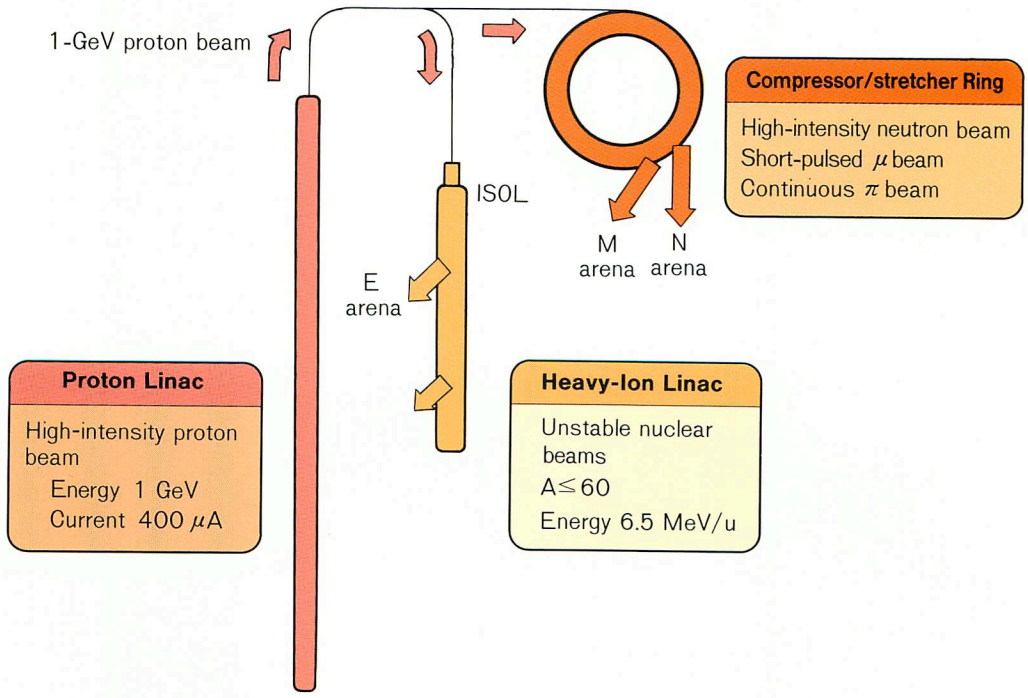
Short-pulsed μ and ν beams,
Continuous π and μ beams,
High-intensity pulsed neutron beam,
Exotic nuclear beams.

The compressor/stretcher ring is a versatile tool for shaping the time structure of beam produced by the high-intensity proton linac. The pulse-structure of 400 μs from the proton linac is compressed to a micro-pulse of 200 ns, resulting in a peak intensity that is more than one thousand times higher.

The acceleration of exotic nuclei is another specific feature of the present project. Nuclei far from the stability line produced by 1 GeV protons and mass-analyzed with an ISOL are to be accelerated by the heavy-ion linac.

The improvement of the existing 12 GeV PS is also planned as stated in p. 4.

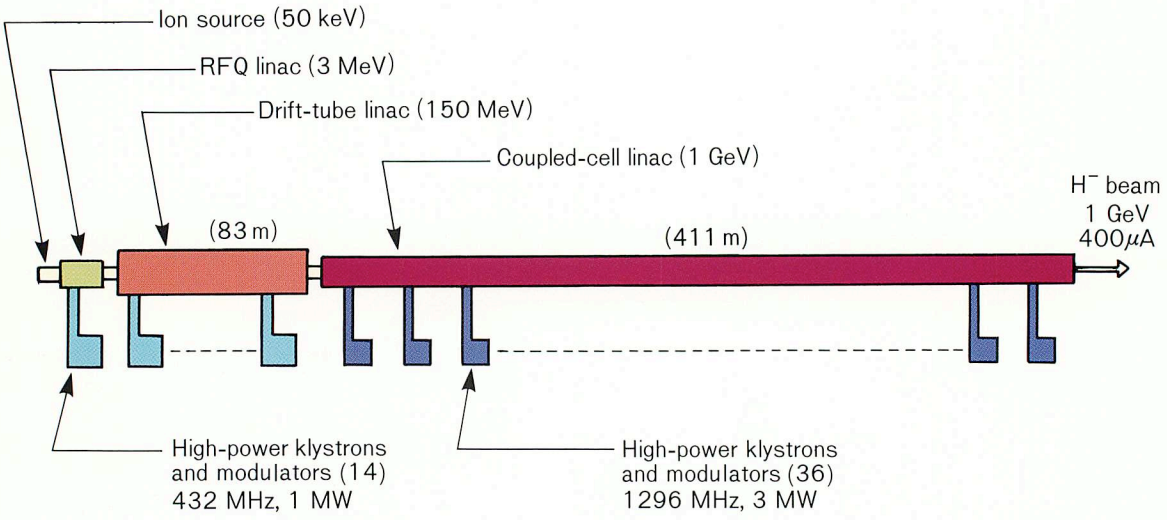
JHP Accelerator Scheme



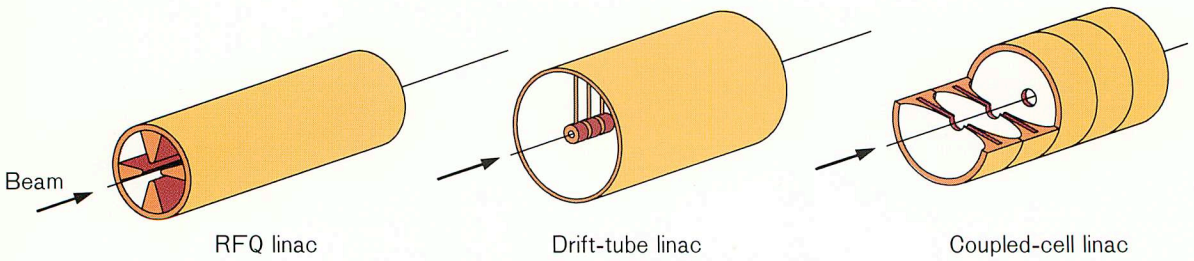
PROTON LINAC

The proton linac comprises an ion source, an RFQ linac, a drift-tube linac and a coupled-cell linac. The present design chooses the acceleration frequency higher than the conventional value, resulting in the smaller cavity size and lower construction cost.

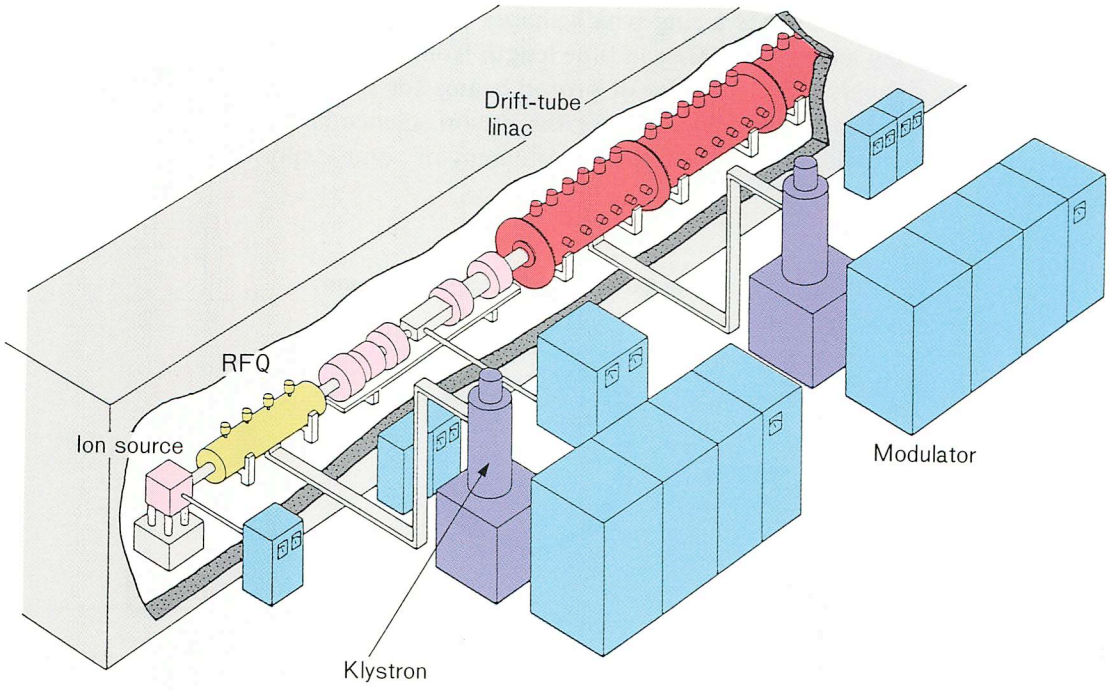
Principal parameters	
Energy	1 GeV
Average current	400 μA
Repetition rate	50 Hz
Peak current	20 mA
Pulse width	400 μs
Total length	500 m



System Layout of the 1-GeV Proton Linac

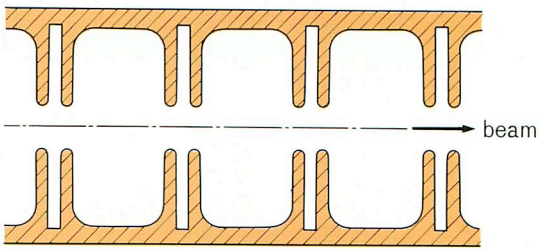


Sketch of the Accelerating Structures

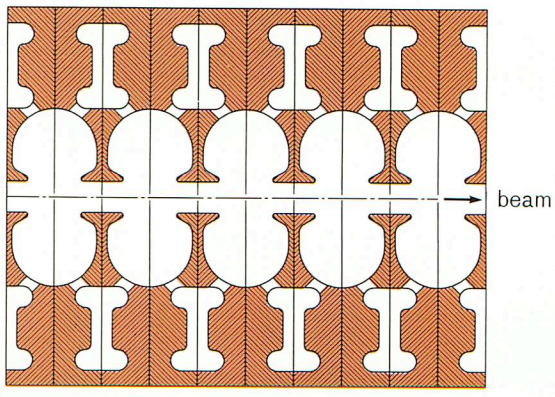


Sketch of the Upstream End of the Linac

In the R & D program presently under way, stress has been laid on studying the technical feasibility of a 3-MeV RFQ linac which is 2.7 m long for 432 MHz frequency, the fabrication technique of a drift-tube linac with permanent magnets and the new accelerating structures for the coupled-cell linac. Specifically, the accelerating structure, which has a high shunt impedance and a high geometrical symmetry to maintain high current, has been developed for the coupled-cell linac.



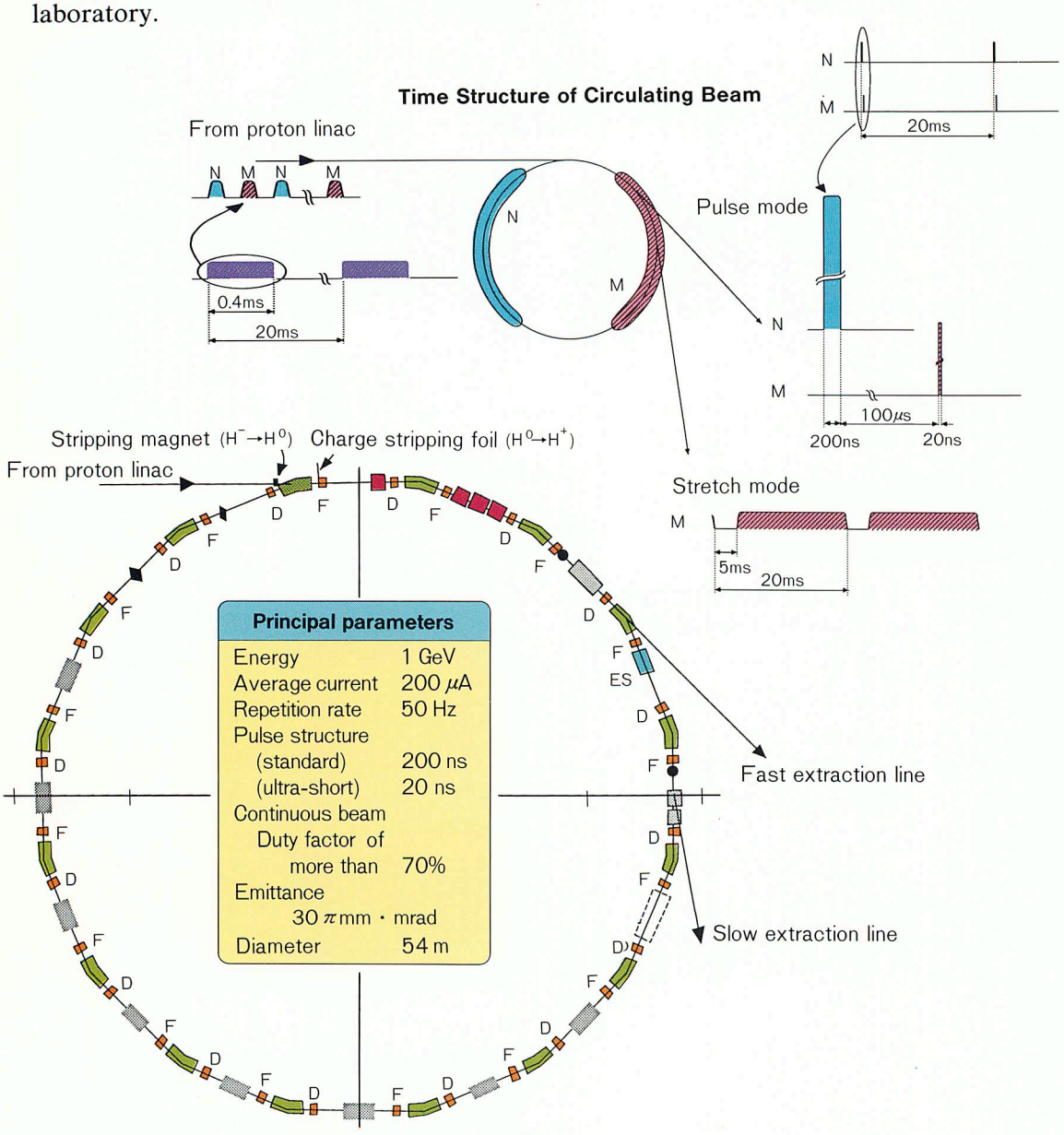
APS-type Cavity Used for TRISTAN



Accelerator Structure under Developement

COMPRESSOR / STRETCHER RING

The compressor/stretcher is a ring which shapes time structure of the beam in various manners. Receiving a beam of 400 μs in time length from the proton linac, the compressor /stretcher ring delivers a 200 ns pulse of proton beams for the neutron scattering facility and a short pulsed beam down to 20 ns for the meson science laboratory. A continuous beam will also be available to meet the requirement of some experiments in the meson laboratory.



Plan of the Compressor/stretcher Ring