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History of Nuclear Fusion Research in Japan

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The atomic energy research was declassified worldwide at the International Conference on the Peaceful Uses of Atomic Energy in 1955. In the late 1950s there was a lively discussion among scientists on the strategy of nuclear fusion research in Japan, leading to the conclusion that fusion research should be started from the basic, namely, research on plasma physics and from cultivation of human resources at universities under the Ministry of Education, Science and Culture (MOE). However, an endorsement was given that construction of an experimental device for fusion research would be approved sooner or later. Meanwhile, confinement studies were conducted specifically in USSR and USA with tokamaks and multipoles, respectively. In Japan, studies on toroidal plasma confinement started at Japan Atomic Energy Research Institute (JAERI) under the Science and Technology Agency (STA) in the mid-1960s. Successful results from tokamak researches in USSR encouraged scientists worldwide, which resulted in construction rush of tokamaks in Japan, too. However, dualistic fusion research framework established in 1960s has lasted until now; MOE for science and STA for development.

World Trend in Early Days as a Background

***Extracted from "Presidential Address at the 1st International Conference on the Peaceful Uses of Atomic Energy" by* Mr. Homi J. Bhabha (India) on 8 August 1955 (at Geneva)**

Presiding over the opening session of the Conference. Left to right: Mr. Max Petitpierre, President of the Swiss Confederation; Mr. Dag Hammarskjold, Secretary-General of the United Nations; Mr. Homi J. Bhabha, President of the Conference; Mr. Walter G. Whitman, Conference Secretary-General

It is well known that atomic energy can be obtained by a fusion process as in the H-bomb, and there is no basic scientific knowledge in our possession today to show that it is impossible for us to obtain this energy from the fusion process in a controlled manner. The technical problems are formidable, but one should remember that it is not yet fifteen years since atomic energy was released in an atomic pile for the first time by Fermi. **I venture to predict that a method will be found for liberating fusion energy in a controlled manner within the next two decades.**

2nd International Conference on the Peaceful Uses of Atomic Energy (ICPUAE) held at Geneva in September 1958

REVIEW OF EXPERIMENTAL RESULTS by ARTSIMOVICH at 1st IAEA Conf., 1961 (Nuclear Fusion: 1962 Supplement, Part 1 p.9-14)

L. A. ARTSIMOVICH (Kurchatov Inst. , USSR)

It is now clear to all that our original beliefs that the doors into the desired region of ultra-high temperatures would open smoothly at the first powerful exerted by the creative energy of physicists, have proved as unfounded as the sinner's hope entering Paradise without passing through Purgatory. And yet there can be scarcely any doubt that the problem of controlled fusion will eventually be solved. **Only we do not know how long we shall have to remain in Purgatory.** We shall have to leave it with an ideal vacuum technology, with the magnetic configurations worked out, with an accurate geometry for the lines of force and with programmed conditions for the electrical contours, bearing in our hands the high temperature plasma, stable and in repose, pure as a concept in theoretical physics when it is still unsullied by contact with experimental fact.

The 3rd IAEA Conf. on Nuclear Fusion at Novosibirsk, 1968

Successful experimental results on Tokamak T-3 (Kurchatov Inst.) were reported. They were: T_e ~ 100-2000 eV, T_i ~ 300 eV, n_e ~ 10^{12}-5x10^{13} cm^{-3}, τ_E ~ 10 ms.
These results were confirmed by Thomson Scattering measurements performed by researchers from Culham Lab. UK in 1969, which opened the age of Tokamak in fusion research.

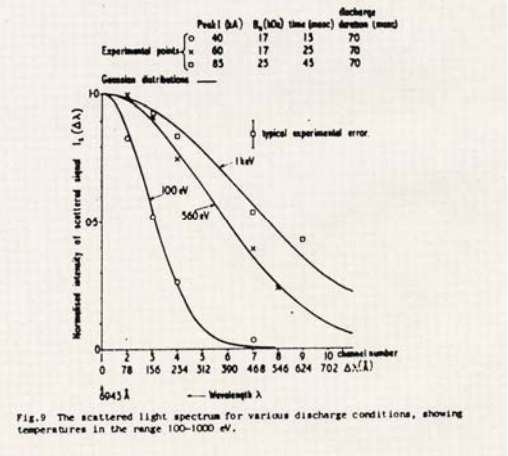
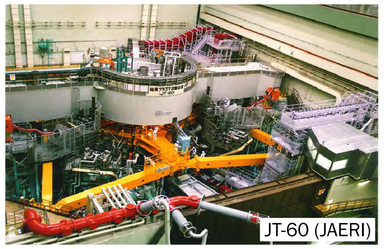


Fig.9 The scattered light spectrum for various discharge conditions, showing temperatures in the range 100-1000 eV.



50-year History of Nuclear Fusion Research in Japan

Fusion Science Archives, National Institute for Fusion Science / Oct. 2008

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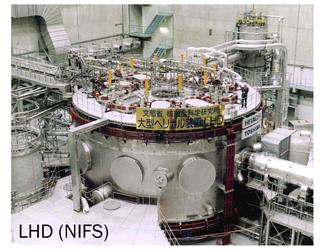
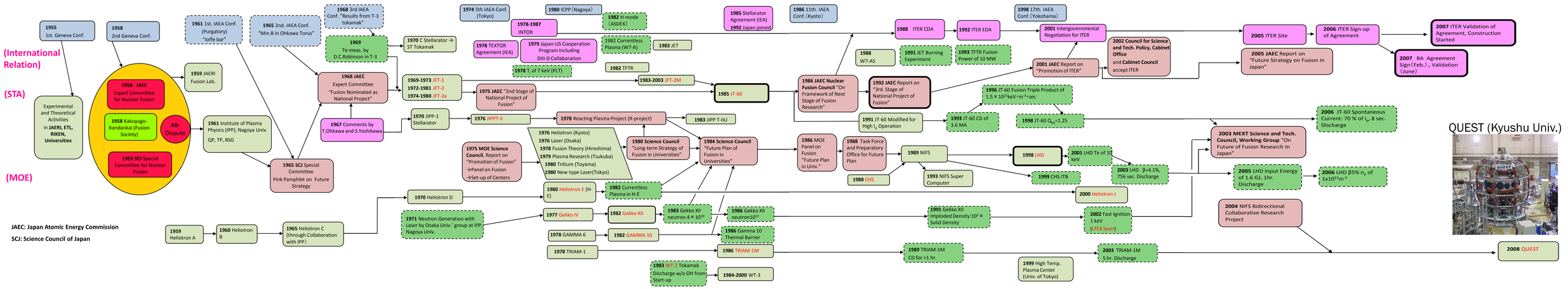


CONFINEMENT



Brief description of early phase of fusion research in Japan

In 1950s information on nuclear fusion research in the world was rather widely spread among nuclear physicists, astrophysicists, researchers of electric engineering and others in Japan. Experimental and theoretical studies started at JAERI, ETL (Electrotechnical Laboratory, former AIST), RIKEN and universities nationwide.

These activities made industry-government-academia aware of importance of nuclear fusion. As a result, Japan Atomic Energy Commission (JAEC) that is under Cabinet Office, and Science Council of Japan (SCJ) organized "expert committee on fusion" in April 1958 and "special committee on fusion" in April 1959, respectively. Scientists who gathered from various fields established Kakuyugo Kondankai nominating Nobel Prize winner Hideki Yukawa as a chairman in Feb. 1958. Kakuyugo Kondankai was the voluntary association of fusion community and was reorganized to establish The Japan Society of Plasma Science and Nuclear Fusion Research in 1983.

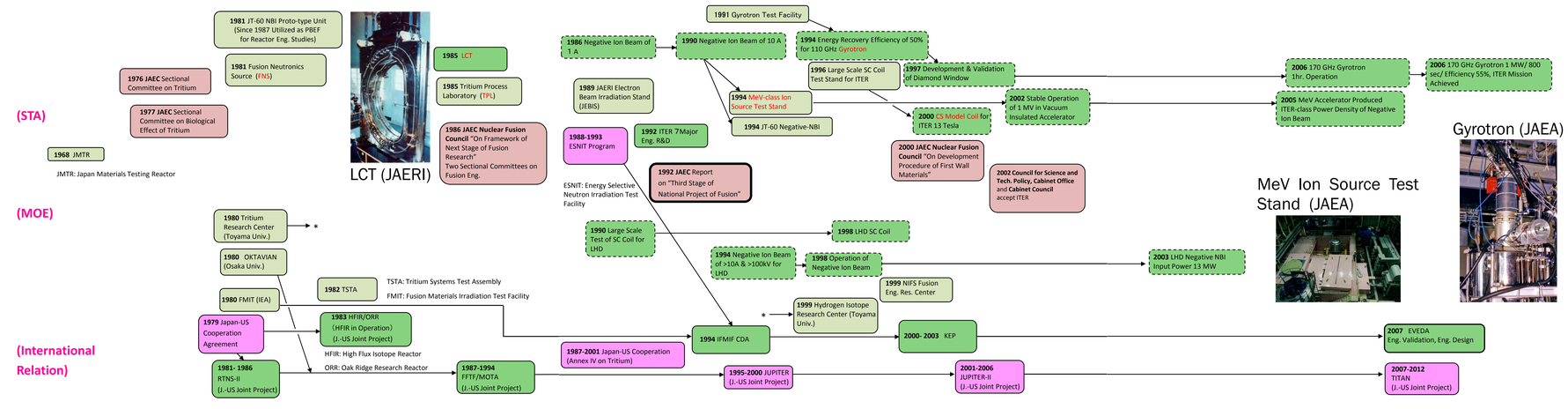
Lively discussion was made between A-plan and B-plan, the so-called AB-dispute. The policy of A-plan is to start fusion research from the basics, putting emphasis on understanding basic plasma physics, finding new ideas and cultivating scientists. B-plan is based on the idea to promote fusion research by constructing the medium-sized machine taking account of the running machines in the world, such as stellarator, mirror, and so on. The expert committee of JAEC finally adopted the A-plan. As a result, Institute of Plasma Physics, Nagoya University was established in 1961. On the other hand, there was agreement among government and scientists that the B-plan should be executed sooner or later.

In the first half of 1960s scientists in Japan had difficulty in finding how they should forward magnetic confinement research and getting rid of Bohm diffusion as was symbolized by "purgatory" by Artsimovich. The special committee of SCJ made an open argument among researchers and outlined the direction of fusion research in Japan, taking consideration of the guiding principle of min. B shown by T. Ohkawa at the second IAEA Conference in 1965. In 1968 JAEC designated fusion research as one of the national projects of Atomic Energy Research. This decision-making was an important step to promote the research in Japan. Tokamak was adopted as the machine of the national project and JFT-2 was constructed at JAERI. In universities JIPP-I stellarator and heliotron D were constructed at that time. It can be said that in 1970 the foundation of magnetic confinement was laid in Japan.

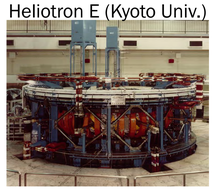
The laser confinement fusion was originated in the neutron generation with laser at IPP, Nagoya University which was done by guest scientists from Osaka University. Major part of fusion engineering studies commenced in 1970s and advanced being inextricably linked with plasma confinement studies.

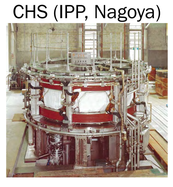
According to the Atomic Energy Law that was effective since 1955, JAEC had been in charge of atomic energy researches of which budget (Atomic Energy Fund) was funded by STA (Science and Technology Agency), while MOE funded the university-based researches of which budget was not Atomic Energy Fund. There were two different funding lines in Japan.

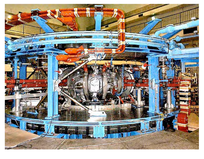
FUSION ENGINEERING




JIPP T-II (IPP, Nagoya)


Heliotron E (Kyoto Univ.)


CHS (IPP, Nagoya)


Heliotron J (Kyoto Univ.)


GAMMA 10 (Univ. Tsukuba)

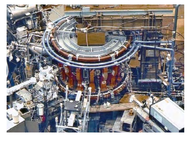

Gekko IV (Osaka Univ.)


Gekko XII (Osaka Univ.)


LFEX (Osaka Univ.)

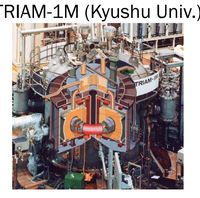
JFT-1 (JAERI)

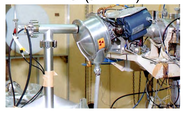

JFT-2 (JAERI)


JFT-2a (JAERI)

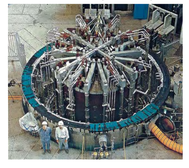

JFT-2M (JAERI)


WT-2 (Kyoto Univ.)


TRIAM-1M (Kyushu Univ.)


FNS (JAERI)


TPL (JAERI)


CS Coil (JAERI)