Scientific pedigree of Chief Scientists of Radiation Laboratory

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Radiation Laboratory and growth of accelerator-based science

When Yoshio Nishina passed away in 1951, his laboratory was split into four laboratories. One of them, headed by Fumio Yamazaki, was soon after renamed as the Radiation Laboratory. Since then, Tastuzo Hamada, Masayasu Ishihara and Hideto En'yo have served as the Chief Scientists of the Radiation Laboratory. The first volume of APR was issued 50 years ago when Yamazaki was in charge.

Figure 1 shows the scientific pedigree of Chief Scientists who are presently engaged in Nishina Center which was inaugurated in year 2006 when the Superconducting Ring Cyclotron was commissioned. One can see the growth of accelerator-based science in RIKEN over 50 years since 1966. Apparently, the name of Radiation Laboratory has persisted for the longest time.

Radiation Laboratory and RIKEN-BNL collaboration

When the author assumed this honorable post in year 2001, the major mission of Radiation Laboratory was and still to understand how the spin of nucleon is formed with ingredients (quarks and gluons) through the RIKEN-BNL collaboration which modified Relativistic Heavy Ion Collider (RHIC) to include a capability to accelerate and collide polarized protons. M. Ishihara summarized the achievements of this project in the article "Pursuit of Spin Physics Program at RHIC" in this volume.[2]

Besides spin physics, RHIC's original mission was to create quark gluon plasma (QGP), the state of the Universe just after the Big Bang. Y. Akiba, the associate chief scientist of Radiation Laboratory, was rewarded by the Nishina Memorial Prize in 2011 for his leading role in the measurement of thermal photons, which showed that the initial temperature reached in the central Au+Au collision at 200 GeV is approximately 350 MeV, far above the expected transition temperature $T_c \sim 170$ MeV, from hadronic phase to quark-gluon plasma.[3] This was an important discovery that assured the creation of QGP at RHIC.

Acceleration of polarized proton at RHIC was an innovative challenge. Protons make precession in magnetic field. Once the ratio of the precession frequency to the ring-revolution frequency becomes integer, the proton spin resonates and the polarization is lost. "Siberian Snake Magnet" is a technology to overcome such resonances by flipping the spin of proton in every turn. The principle methodology is established but the reality was more difficult. The biggest problem was the depolarization that occurred in the AGS ring. M. Okamura, who once contributed to the design of the snake magnets in the RHIC main ring, solved the problem of the AGS depolarization by using a variable-pitch helical snake magnet.[4] Okamura, J. Takano, and others in Radiation Laboratory fabricated such a novel magnet in a year by taking advantage of a special mobility of

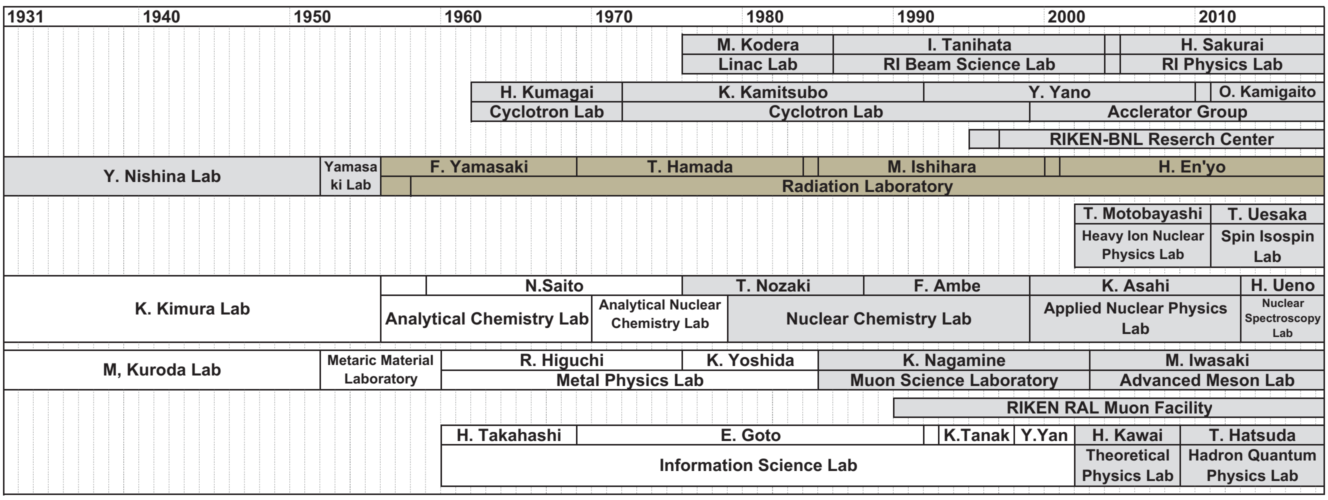

Fig. 1. History of Chief Scientists in Nishina Center. Shaded laboratories are for accelerator-based science.[1]

*1 Chief Scientist of Radiation Laboratory (2001–present)
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RIKEN.

Okamura also developed a laser ion source named Direct Plasma Injection Scheme. In this, ions are extracted, not by high voltage, but by the initial expansion of plasma diffusion. The plasma stays with neutral charge for a long time; one can get rid of the space charge effect. His ion source recorded the highest peak current many times.[5] His laser ion source technology was adopted first by the NASA Space Radiation Laboratory, and then for the RHIC injector. With those achievements, Okamura was head-hunted by BNL and is now a tenure physicist in the Collider-Accelerator Department.

Radiation Laboratory and chiral symmetry restoration

When the hadronic matter gets hotter or denser, chiral symmetry must be restored as theoretically predicted by Nambu,[6] i.e., hadrons' mass must change when they are in different vacuum. Although QGP is created at RHIC, there are no measurements so far which show a signature of restored symmetry, owing to the difficulty in performing experiments at the very high multiplicity environment of hot QGP. Complementary measurements can be done in dense but cold nuclear matter. Radiation Laboratory performed KEK E325 experiment at 12 GeV-PS and CERN NA60 experiment at SPS, and had challenged to measure mass of vector mesons when they fly in dense nuclear matter. The former used proton nuclear interaction and measured electron pairs, while the latter used indium-indium collision and measured muon pairs.

The E325 experiment produces theses by S. Yokkaichi, K. Ozawa, M. Naruki, R. Muto, F. Sakuma, and T. Tabaru. They succeeded in detecting the mass modification of ρ, ω and ϕ mesons,[7] and concluded that the measured modifications are consistent with the theoretical model by Hatsuda and Lee.[8] On the other hand, NA60 concluded that the measured spectrum modification of ρ meson is explained not by mass shift but by mass broadening.[9] The states of nuclear matter for both experiments are so different that the physics picture can be different, but it can be admitted that the two are not very consistent. To obtain the final conclusion, the E16 experiment is under preparation at J-PARC. Although the E325 experiment was only the experiment that could measure electron pair decays of ϕ mesons with high statistics. E16 is aggressively seeking to go beyond.[10]

Radiation Laboratory and neutron

From 1999 to 2005, the Radiation Laboratory hosted the Image Information Research Unit lead by H. Shimizu. This unit developed a Superconducting Tunnel Junction detector for Tera Hertz light, optical devices for neutron beams, etc. Many of the group's works have been taken over by the RIKEN Center for Advance Photonics. Especially, T. Otake and her Neutron Beam Technology Team constructed RANS, RIKEN Accelerator-driven compact Neutron Source, and developed technology "to make invisible visible." The ultimate goal is to make available a transportable non-destructive neutron inspection system for outdoor use in applications, like a bridge, tunnel, or building. This is a very active offspring from Radiation Laboratory for societal needs.[11]

Radiation Laboratory for future

RHIC was once the largest heavy-ion collider in the world. In 2010, however, the Large Hadron Collider (LHC) at CERN started lead-lead collision with energy that was 14 times higher than that at RHIC. The PHENIX detector, which the Radiation Laboratory was working on, stopped operation in 2016 to metamorphose to the upgraded sPHENIX detector, to accomplish the latest measurements, that cannot be performed by the present PHENIX.

In 2015, the Nuclear Science Advisory Committee (NSAC) was requested by the US Department of Energy (DOE) to update their long range plan; the recommendation was to construct an electron-ion collider.[12] In the past, all the NSAC recommendations were achieved in the US contradictory to recommendations by the Japan Science Council. The physics of proton structure, which was initiated by RIKEN at RHIC, will be the foundation of the future of US nuclear physics.

Selection for a new Chief Scientist in the field of hadron physics is happening currently. He/She will inaugurate a new era in the history of Radiation Laboratory that has produced streams of new scientific flow.

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