



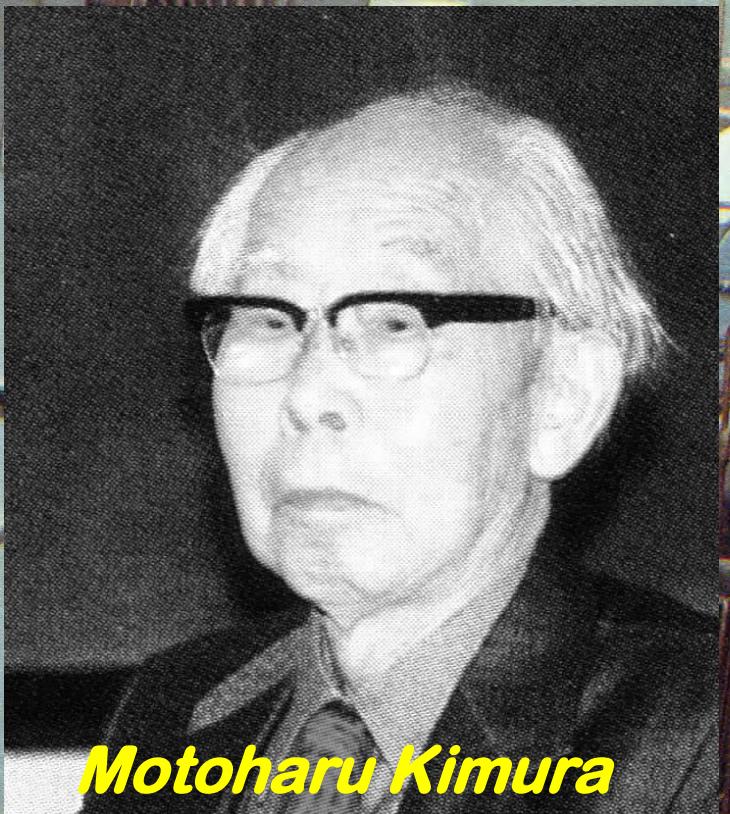
## *Symposium, 2020. 12. 23*

- Start up of KENS & History of Pulsed neutron scattering activities in Japan
- Quick survey of research activity of KENS at KEK/ BSF which was a milestone of J PARC/MLF.

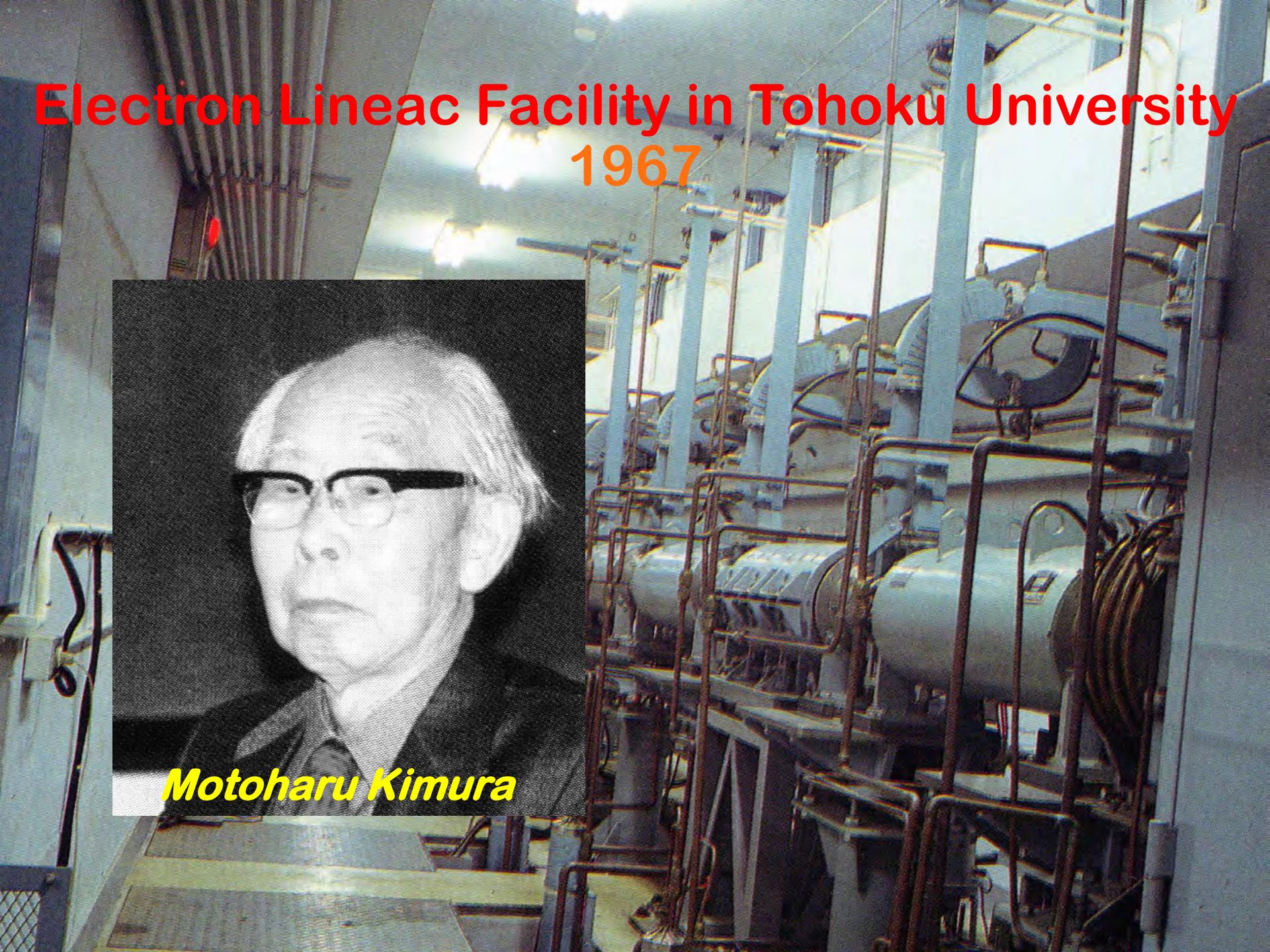
*Yasuo Endoh ( Tohoku University & CEMS.RIKEN)*

The history started from the institute of Nuclear Science Facility,  
Tohoku University located at Mikamine, Sendai

# Electron Lineac Facility in Tohoku University 1967



*Motoharu Kimura*





Drawn by Toyoichi Tanaka

KEK Symposium 5.19.'06

# Construction of Electron Lineac Facility

at Laboratory of Nuclear Science, Tohoku University

**300 MeV EL :**

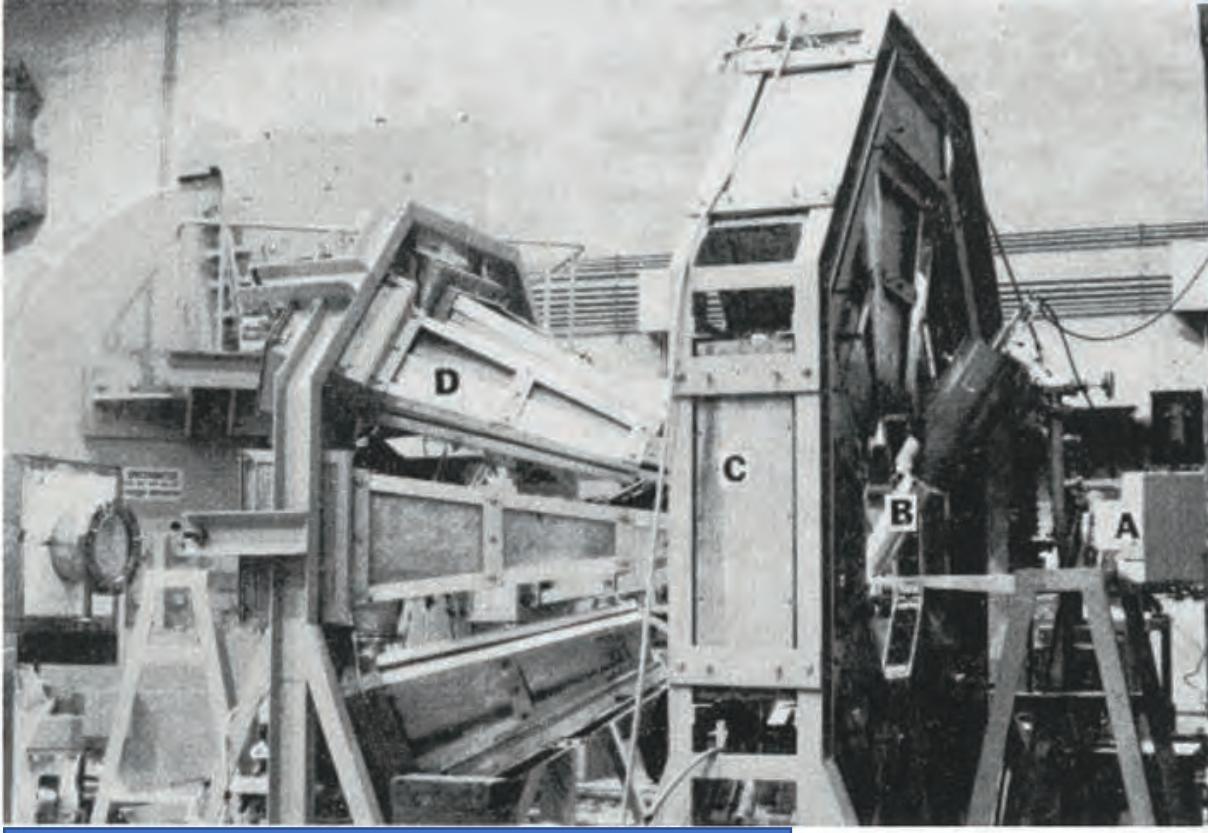
*multi purpose or Interdisciplinary  
research fields*

*Nuclear Physics & Condensed Matters Science*

*( Giant Electron Resonance, Neutron Scattering, Dense exitons etc)*

**Challenge : Novel Way how to utilize the large facility**

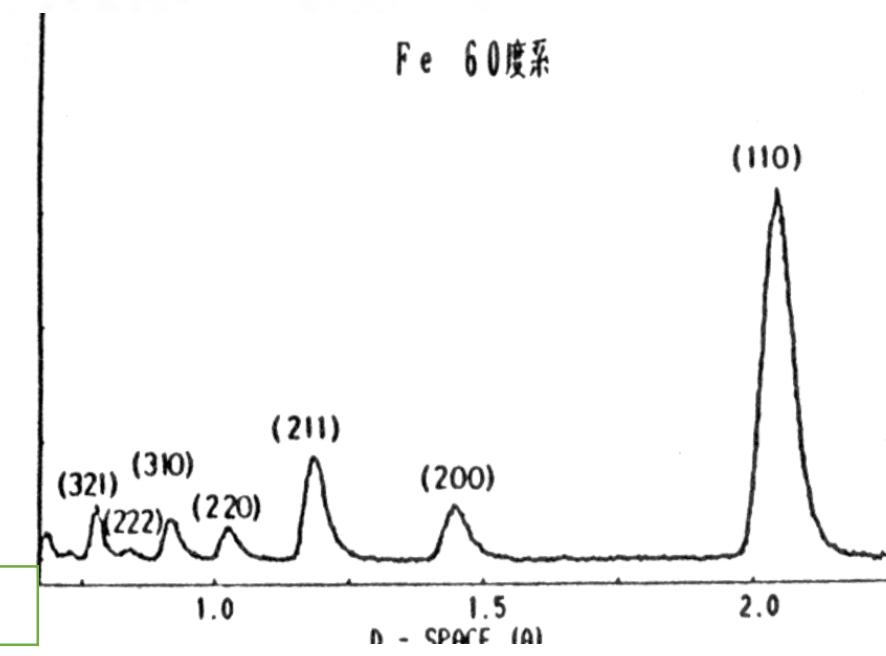
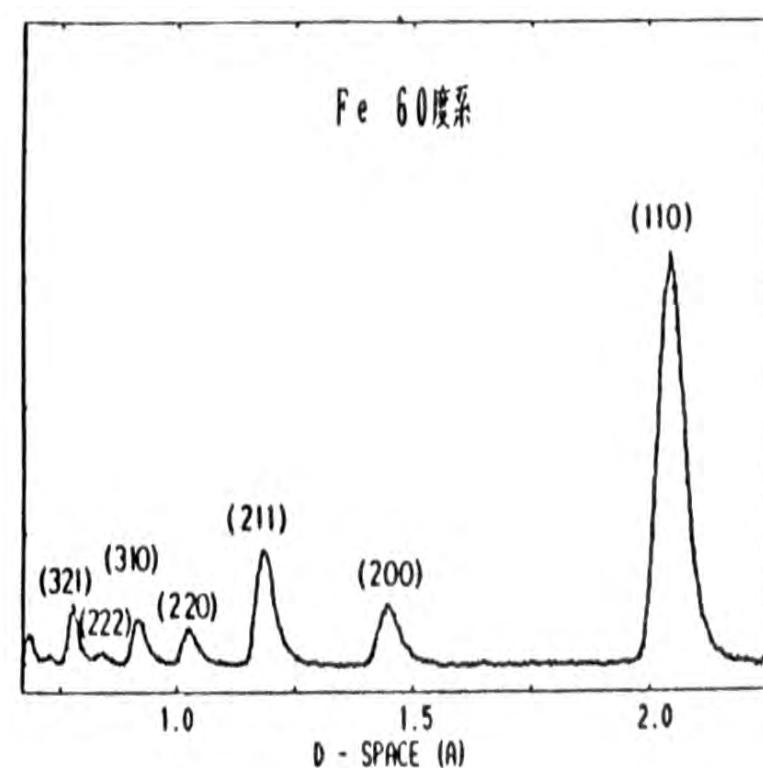




Kimura Sputnik  
(Debye Scherrer camera)



100m Flight path with short pulses (high resolution) :  $\Delta d/d \geq 0.035\%$



# Production & extraction of pulsed cold neutrons besides development of high resolution spectroscopic methods

- Neutron production by developing of solid methane neutron moderator installed at the side of neutron production solid target and neutron guide tubes with new supermirrors.
- Contribution of KENS facility
- New proposal scheme of collaboration programs has been established in the research field of condensed matter science which had been well organized among the accelerator based large sciences of high energy physics.
- Under the established collaboration program, the construction of BSF facility has been completed.
- Rapid growth of neutron users in Japan which has been also applied to reactor based neutron science collaboration at JRR3.
- International collaborations such as UK –Japan, US – Japan, ICANS have been organized.

*Every Neutron is Good Neutron !*

1980 **KENS 完成**

Completion of KENS

世界初のスパレーションパルス中性子施設

The first spallation pulsed  
neutron facility in the world

初めての冷中性子  
The first cold neutrons



*Every Neutron is Good Neutron !*

1980 **KENS 完成**

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世界初のスパレーションパルス中性子施設

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1986 石川義和教授・逝去

Prof. Yoshikazu Ishikawa's decease

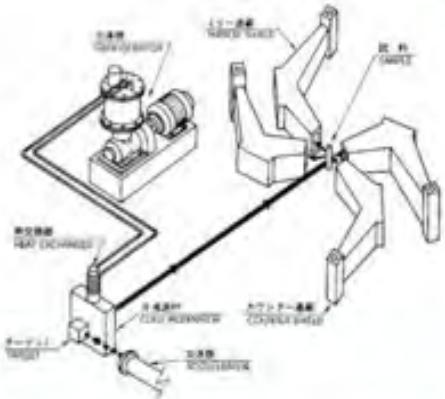


The late Prof. Yoshikazu Ishikawa, discussing with Dr. Grey  
in attendance at ICANS-II (the International Collaboration on  
Advanced Neutron Source) meeting held at Rutherford Laboratory

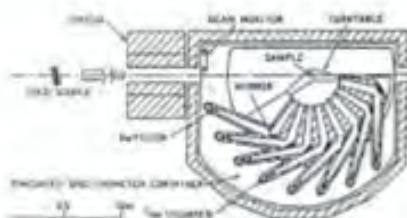
# LAM & Low Energy INS

(using pulsed cold neutrons)

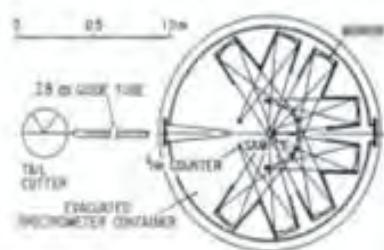
*Original Idea & Device*



Prof. Kazuhiko Inoue



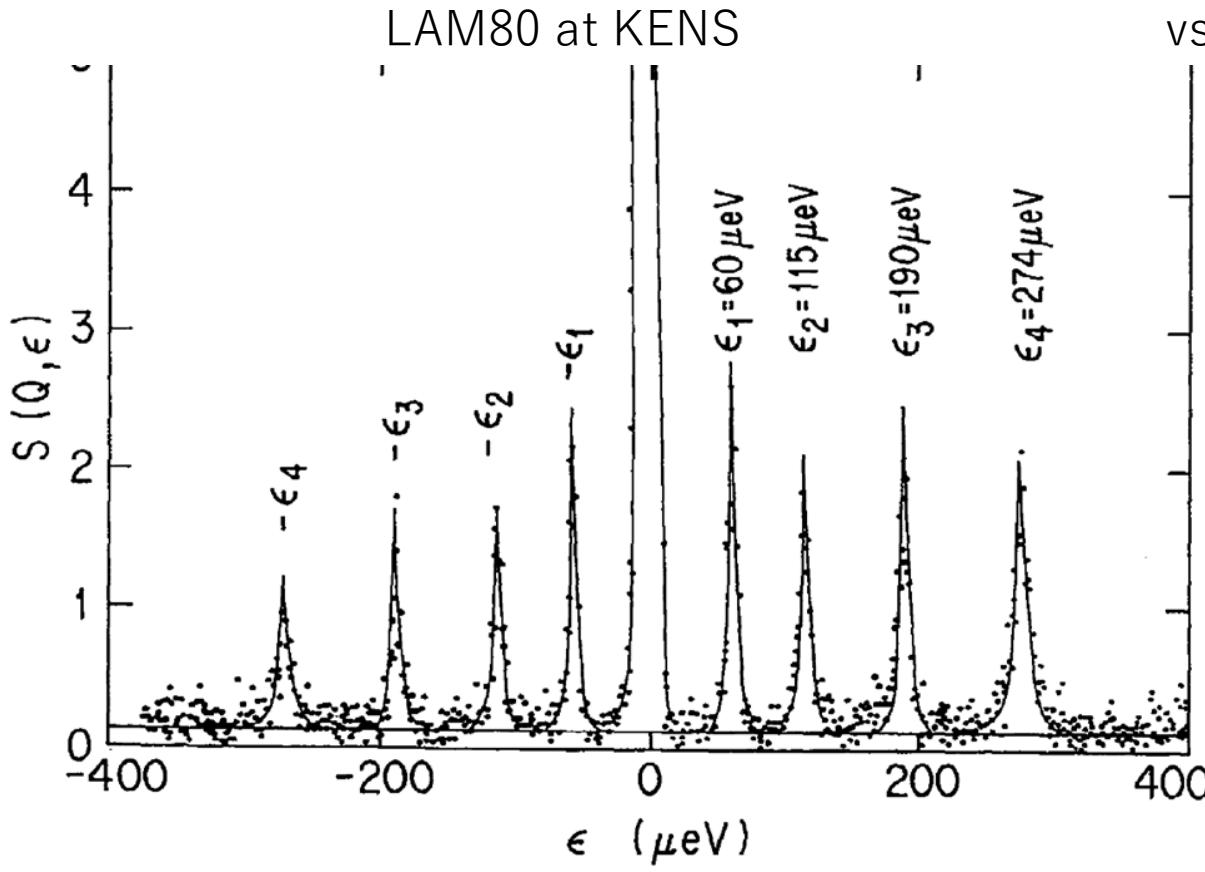
Mica Analyser Xstal  
Back Scattering



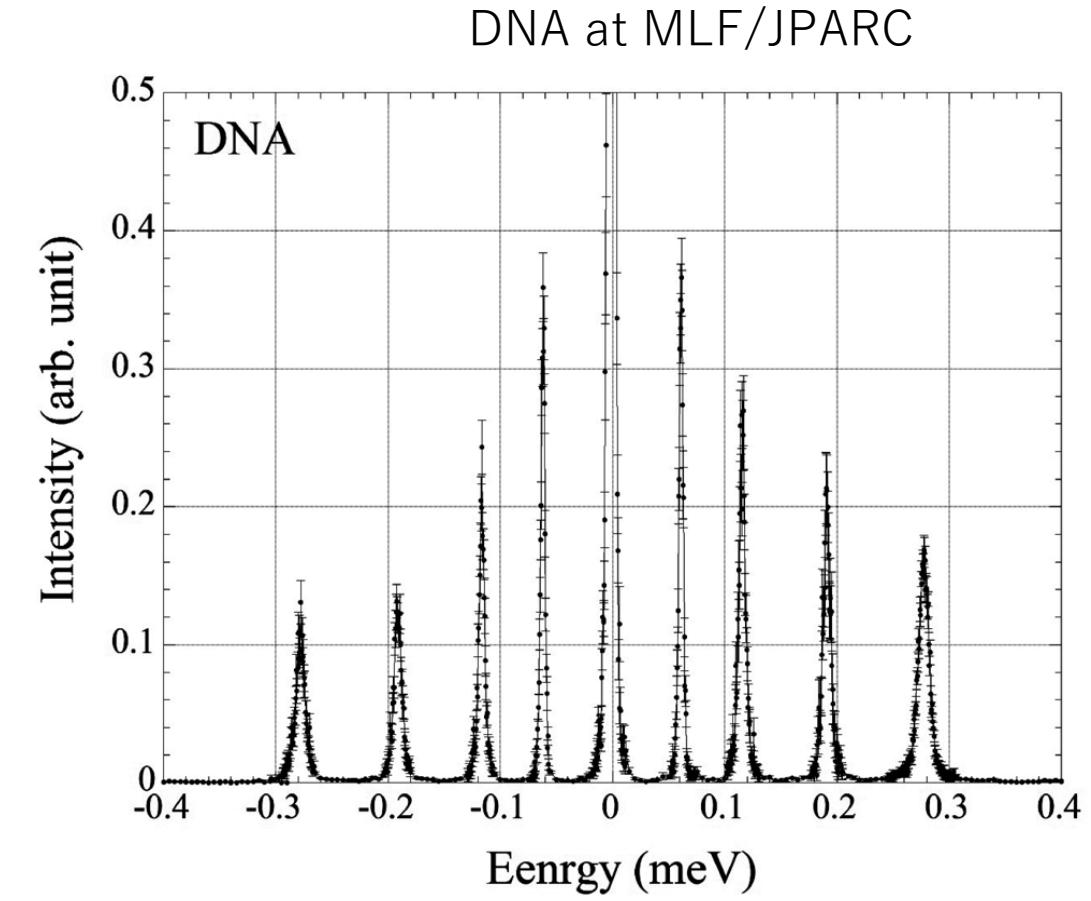
→ IRIS at ISIS

# Quantum Rotational Tunneling spectroscopy

(CH<sub>3</sub> molecule in  $\gamma$  picoline)



vs



# Analysis of Quantum tunneling Spectrum

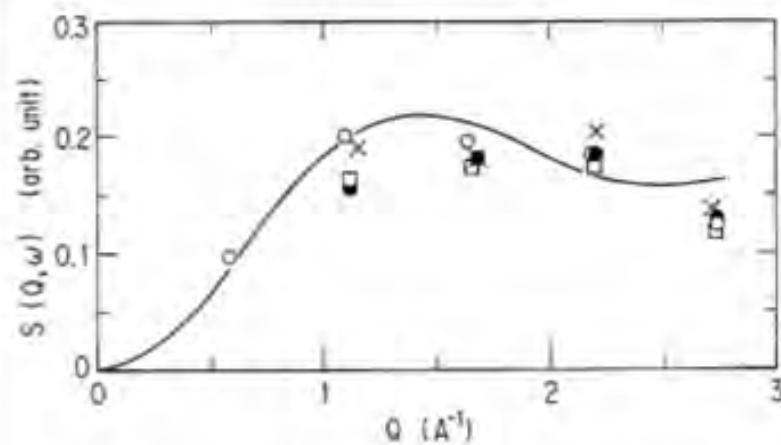


Fig. 11.  $Q$ -dependencies of inelastic scattering from N-oxy  $\gamma$ -picoline at  $\varepsilon_i$  ( $i=1 \cdots 4$ ). (○), (×), (●) and (□) denote peak intensities observed at  $\varepsilon_i$  ( $i=1 \cdots 4$ ), respectively. Calculated values are shown by a solid line.

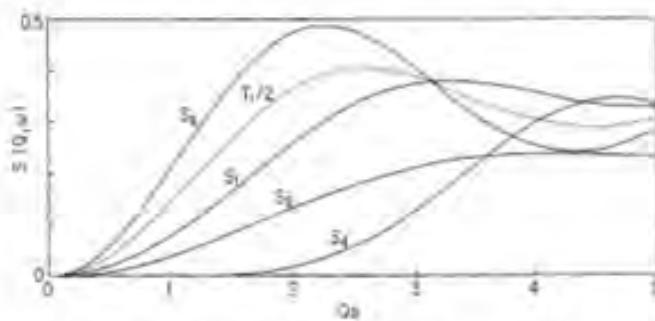
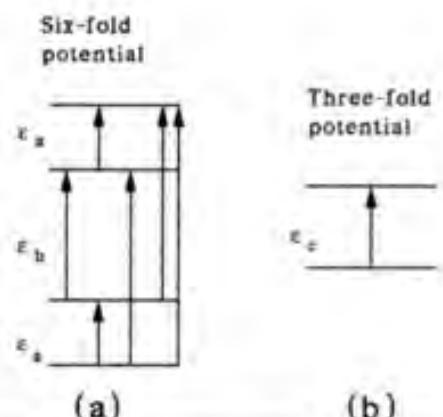
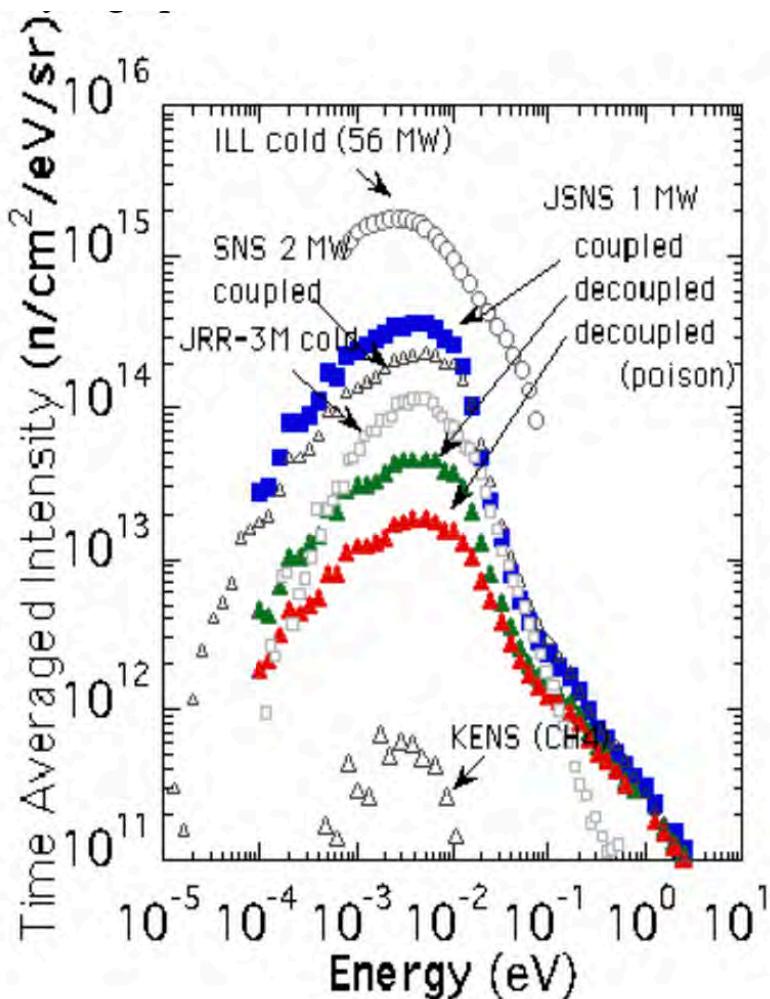


Fig. 13.  $Q$ -dependencies of  $S_i$  ( $i=1 \cdots 4$ ) and  $T_1/2$ .  $S_i$  and  $T_1/2$  are displayed by solid lines and a dotted line, respectively.



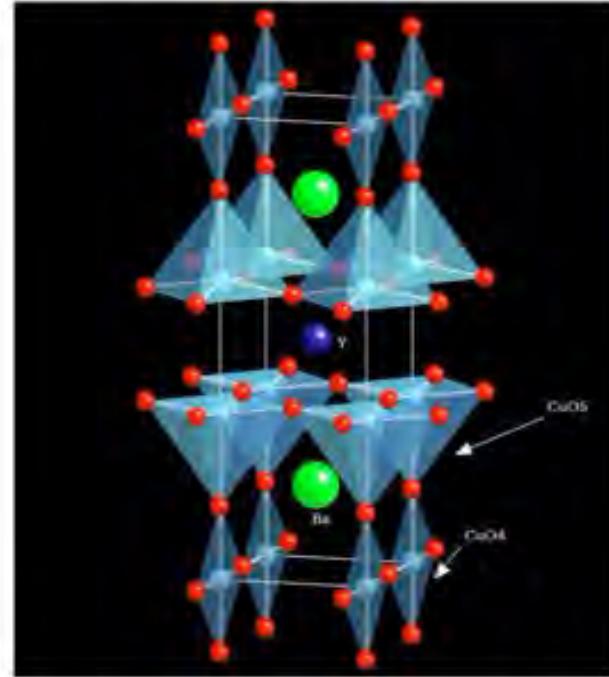
# SUPER INTENSE PULSED NEUTRON (100/ KENS) PROJECT PLANNED AT 1985 UNDER THE LEADERSHIP BY PROF. ISHIKAWA

- GEMINI(KENS-II) proposal



Expansion of Q- $\omega$  space  
 $10^2 > \omega > 10^{-3}$  meV,  $10^2 > Q > 10^{-4}$  Å<sup>-1</sup>  
New research field  
materials engineering and sciences  
bioscience and engineering  
polymer and chemical sciences  
Contributions of interdisciplinary fields  
Radiation protection engineering  
Safety analytical engineering  
Accelerator physics and engineering

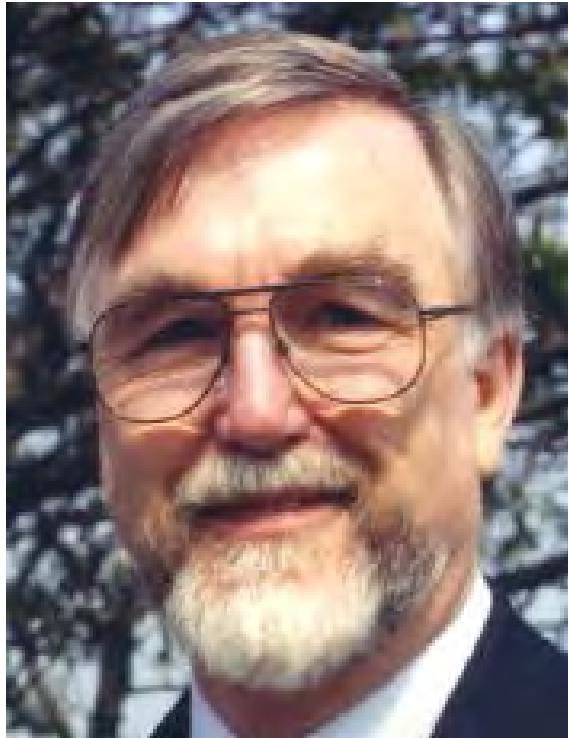
# Structure Determination at KENS



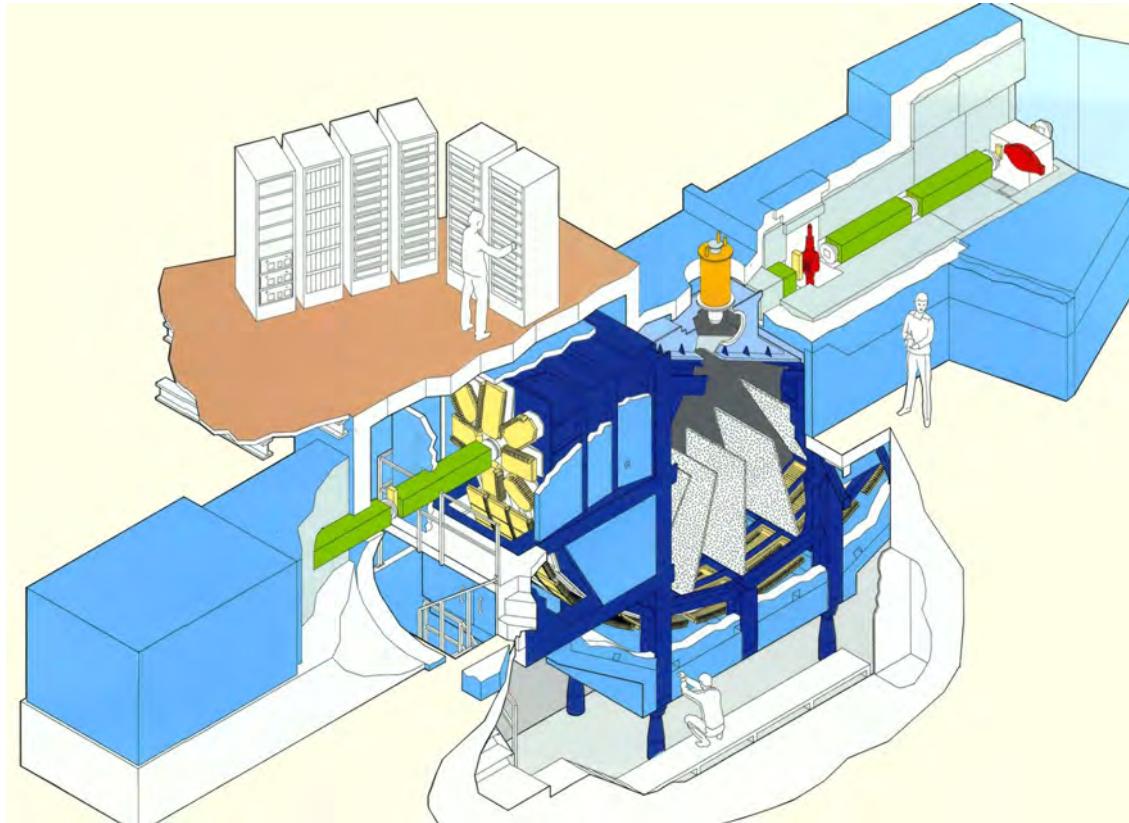
Determined Crystal Structure of YBCO  
&  
'Hot News' in the Paper

Japan-UK international collaboration & installation of  
nearly developed the chopper spectrometer **MARI**

Japanese participation of research activities at ISIS

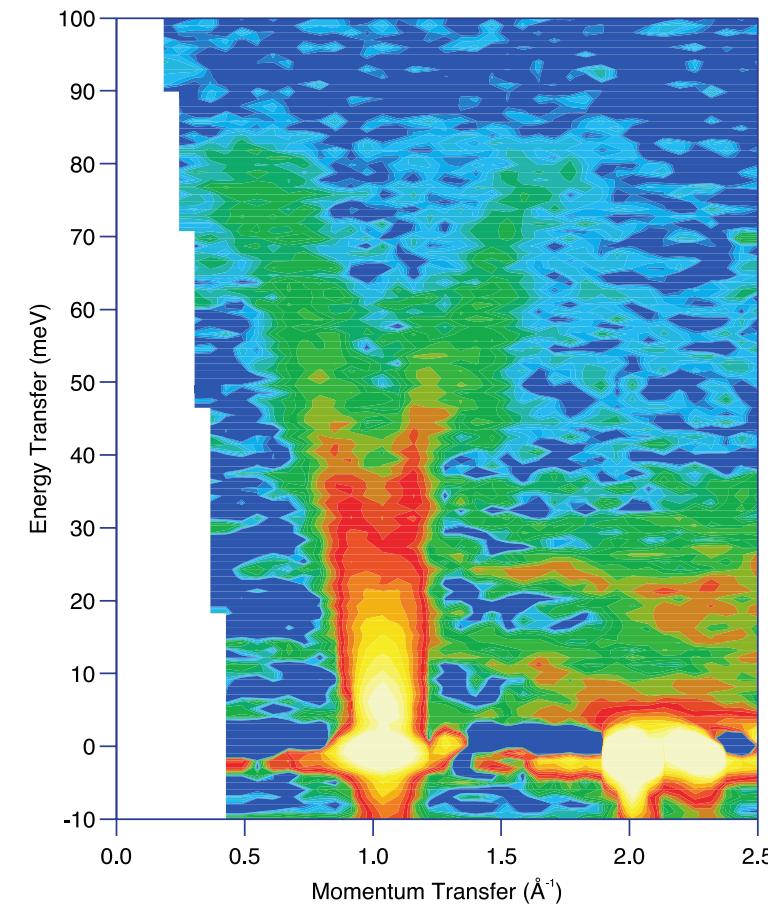


Alan Leadbetter  
(1934 – 2019)

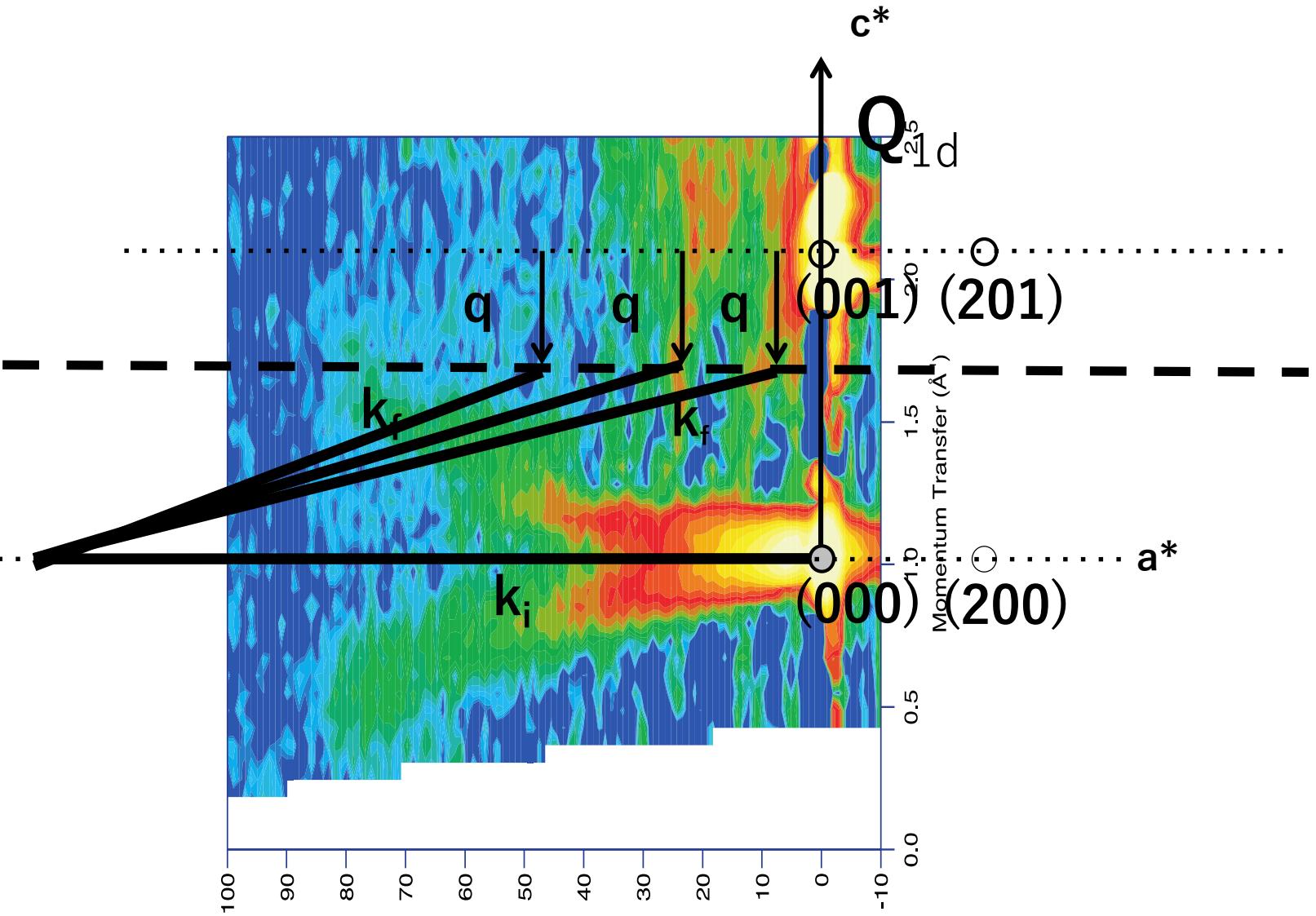


# spin wave spectrum of 1D AF

= outcomes of researches at MARI =



$\text{CsVCl}_3$   
one-dimensional antiferromagnet

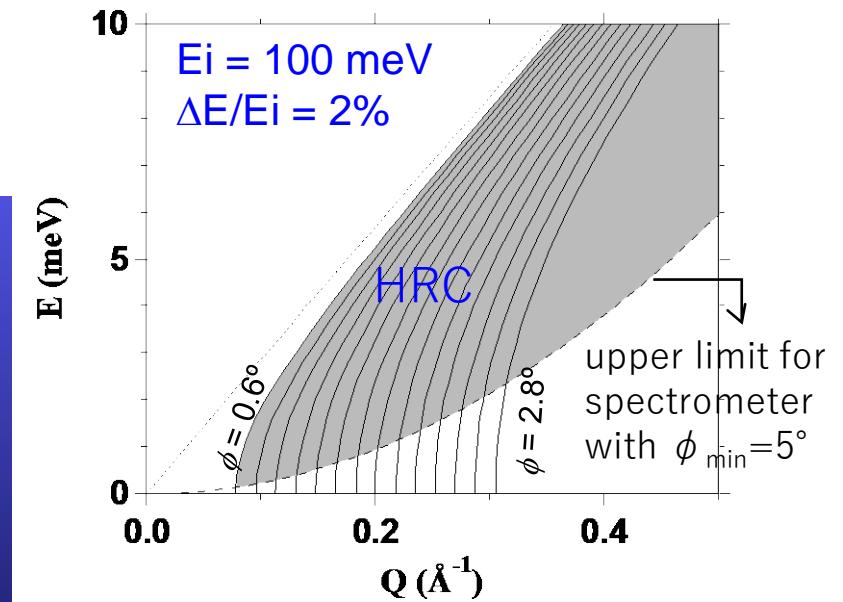
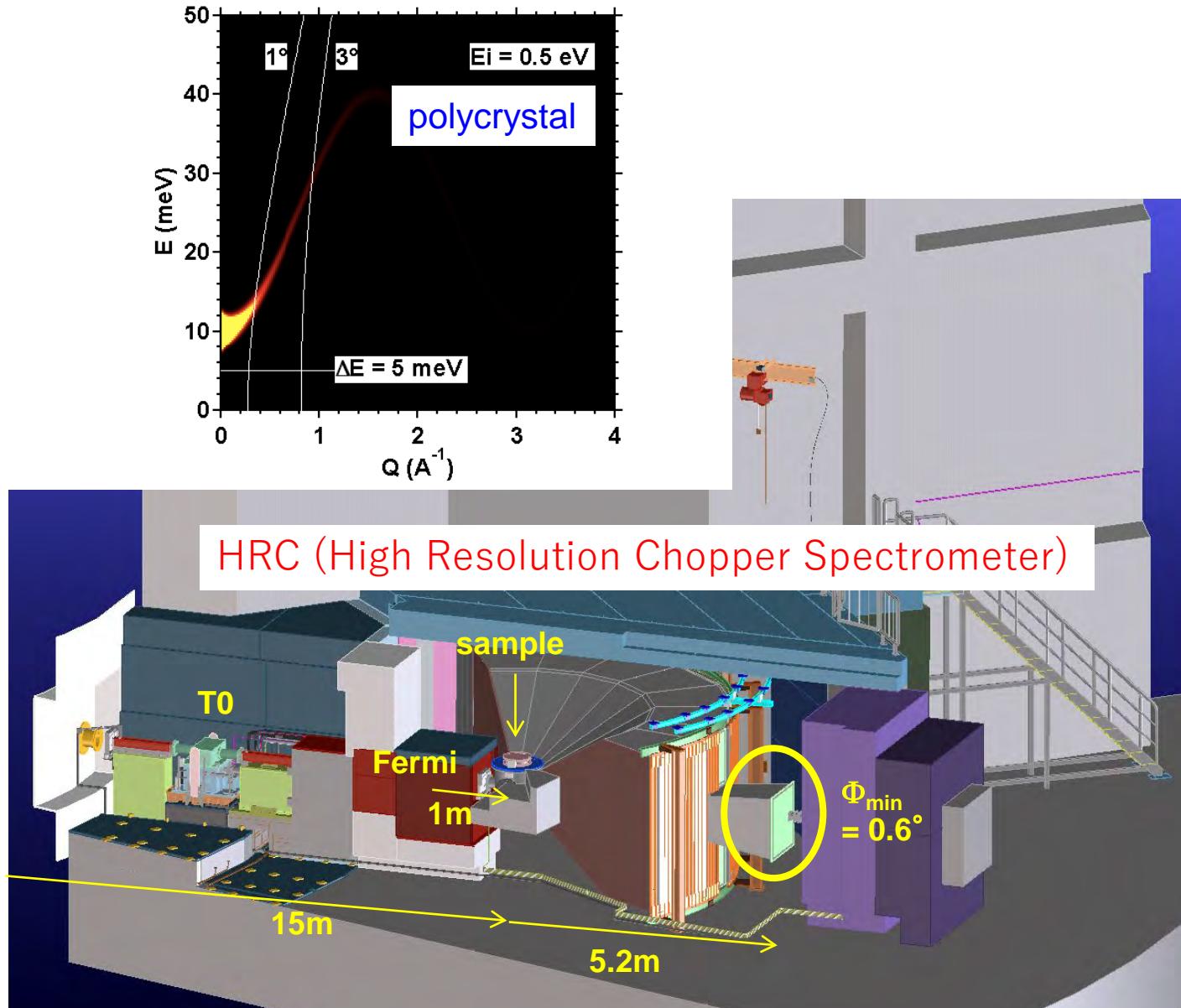


**Observations of  
spin excitations in  
high T<sub>c</sub> Cu  
superconductors  
Robust two-  
dimensional  
(incommensurate)  
spin fluctuations  
exist in  
superconducting  
phase**



**Visual image  
Charge and spin  
separation  
developed in  
superconducting  
phase for Cu oxides  
probed by neutron  
scattering and X-ray  
photo emission  
measurements**

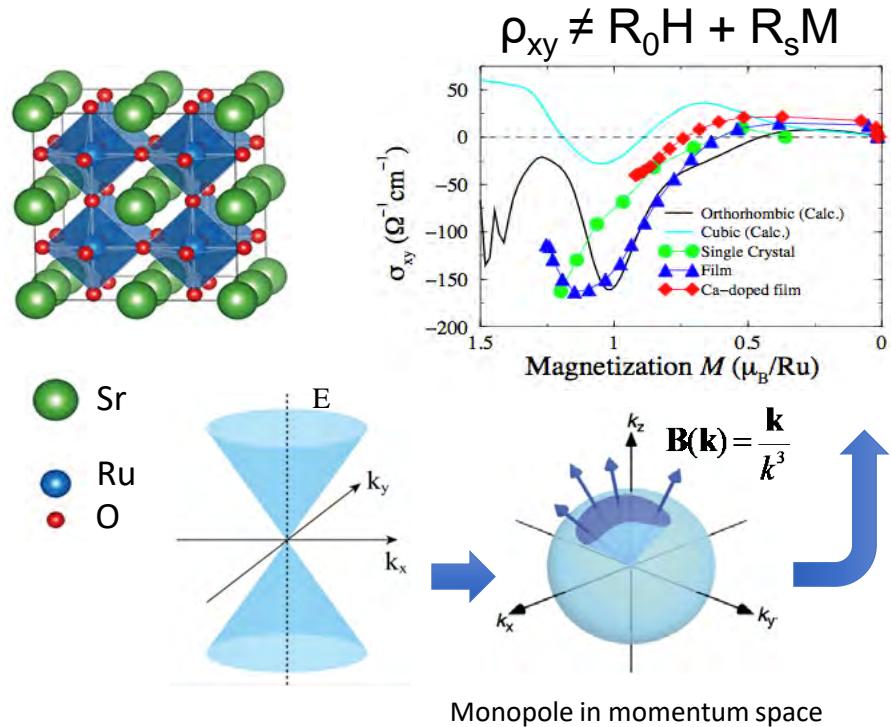
# Development of Neutron Brillouin Scattering Method & Installation of HRC at MLF in JPARC



HRC :  
Low angle down to  $0.6^\circ$   
High energy  $E_i = 0.1 - 0.3 \text{ eV}$   
High resolution  $\Delta E/E_i = 2\%$

spin waves and phonons  
near (000) in polycrystals,  
amorphous materials, liquids

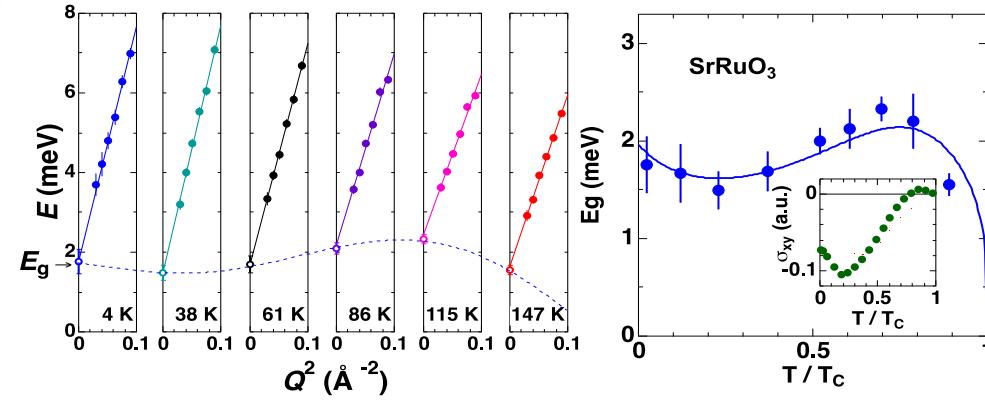
# Spin dynamics of Weyl Fermions in Metallic Ferromagnet of SrRuO<sub>3</sub>



Anomalous Hall Effect (N.Nagaosa et al., Science 2003)

NBS (Neutron Brillouin Scattering)  
with high energy neutrons

Ferromagnetic spin wave  $E(Q) = DQ^2 + E_g$



$$E_g(T) = \frac{a(M(T)/M_0)}{1+b(M(T)/M_0)(\underline{\sigma_{xy}(T)}/\sigma_0)}$$

$$\underline{\sigma_{xy}} = \frac{e^2}{\hbar L^2} \sum_{\mathbf{k},n} f(E_{n\mathbf{k}}) B_{n,z}(\mathbf{k})$$

Magnetic Field produced by Berry phase (Berry curvature) is shown to be an observable of inelastic neutron scattering : magnetic field acting to spin fluctuations is proportional to local anisotropic spin wave energy

## *TO CONCLUDE*

- KENS HAS CONTRIBUTED AS THE BASIS OF MLF/J-PARC: which constitutes the realization of the dream of KENS-II  
**mandatory in future activities in MLF/J-PARC**
- Simplify by change of organization from Troika (KEK, JAEA, CROSS) system to a new single one
- Introduce multiple user programs (long term, short term projects) to separate casual users and acted users
- A new system to train young researchers, engineers and to educate PhD students (Change current SOKENDAI to new program)
- Constant activities for instrumentations, engineering, and search for new comers to expand users
- Relation of PF and MLF in KEK research organization (Revolutionary change of BUKKOKEN)

**MLF user program will be reconsidered to more flexible utilization of the facility**

# End of presentation as an introductory talk

- Thank you all for listening *Yasuo Endoh*