

Nuclear Spectroscopy at KISS/KISS-1.5

KEK Isotope Separation System (KISS)

to study nuclear properties from astrophysical interest

- Multi-nucleon transfer reactions to produce neutron-rich nuclei
- Ar gas-cell combined with laser ionization
- Mass separator (ISOL)

Yoshikazu HIRAYAMA (Wako Nuclear Science Center, IPNS, KEK)

Ph.D. exp. at ISAC, 2002

Nuclear structure of ^{11}Be

from beta-decay spectroscopy with polarized ^{11}Li



Contents :

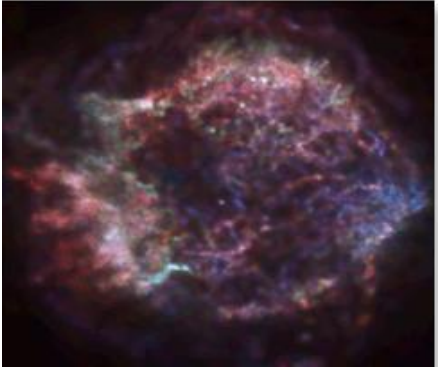
1. Introduction : Physics motivation and KISS/KISS-1.5
2. Laser Spectroscopy
3. Summary

2026 TRIUMF-KEK Symposium
28-29th September 2026, Vancouver, Canada

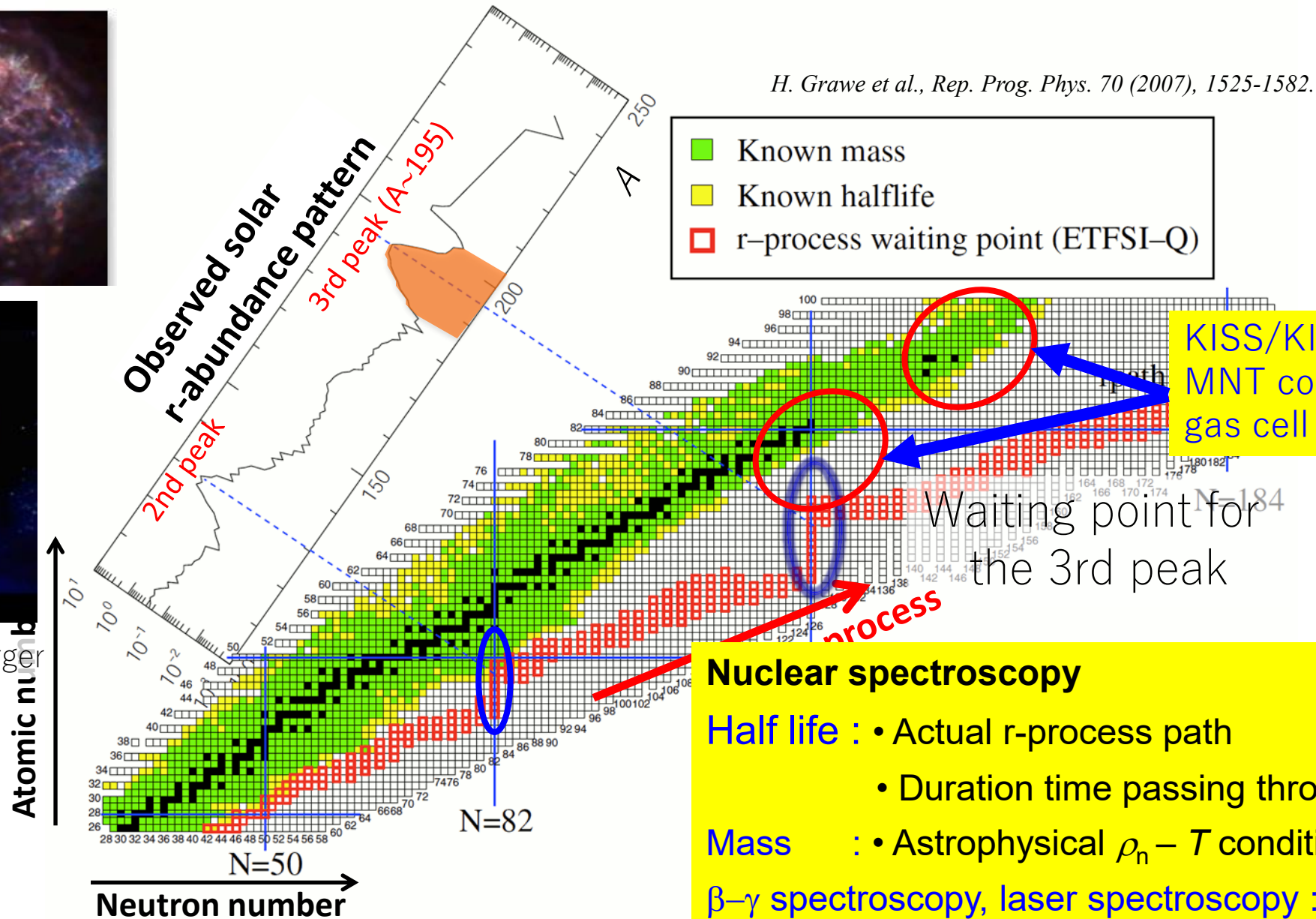
Physics motivation and KISS/KISS-1.5

Identification of astrophysical site for r-process and study the origin of uranium

Type II Supernova

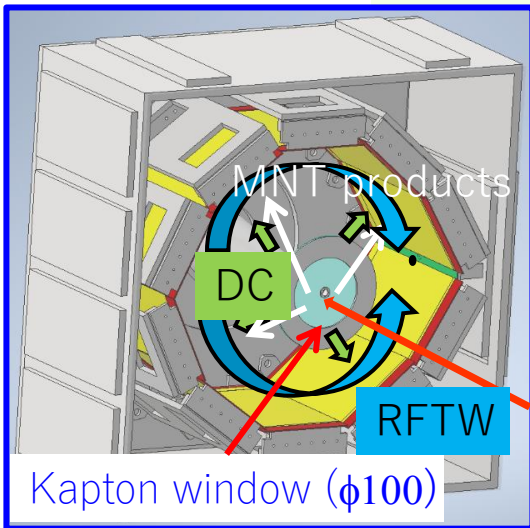


Neutron star merger



KISS/KISS-1.5

Helium gas cell
Ion beam
w/o laser



KISS-1.5

He gas cell
Actinide elements

Gas cell system

KISS

Ar or He gas cell
Heavy refractory elements

Wall

$\beta\gamma$ detectors :
 $T_{1/2}$

MRTOF-MS :
mass & PI

CLARIS beam line:
Precise laser spectroscopy

Laser Spectroscopy at KISS

- Neutron-rich Re isotopes
- Neutron-deficient Ir isotopes
- CLARIS

Laser spectroscopy of unstable nuclei

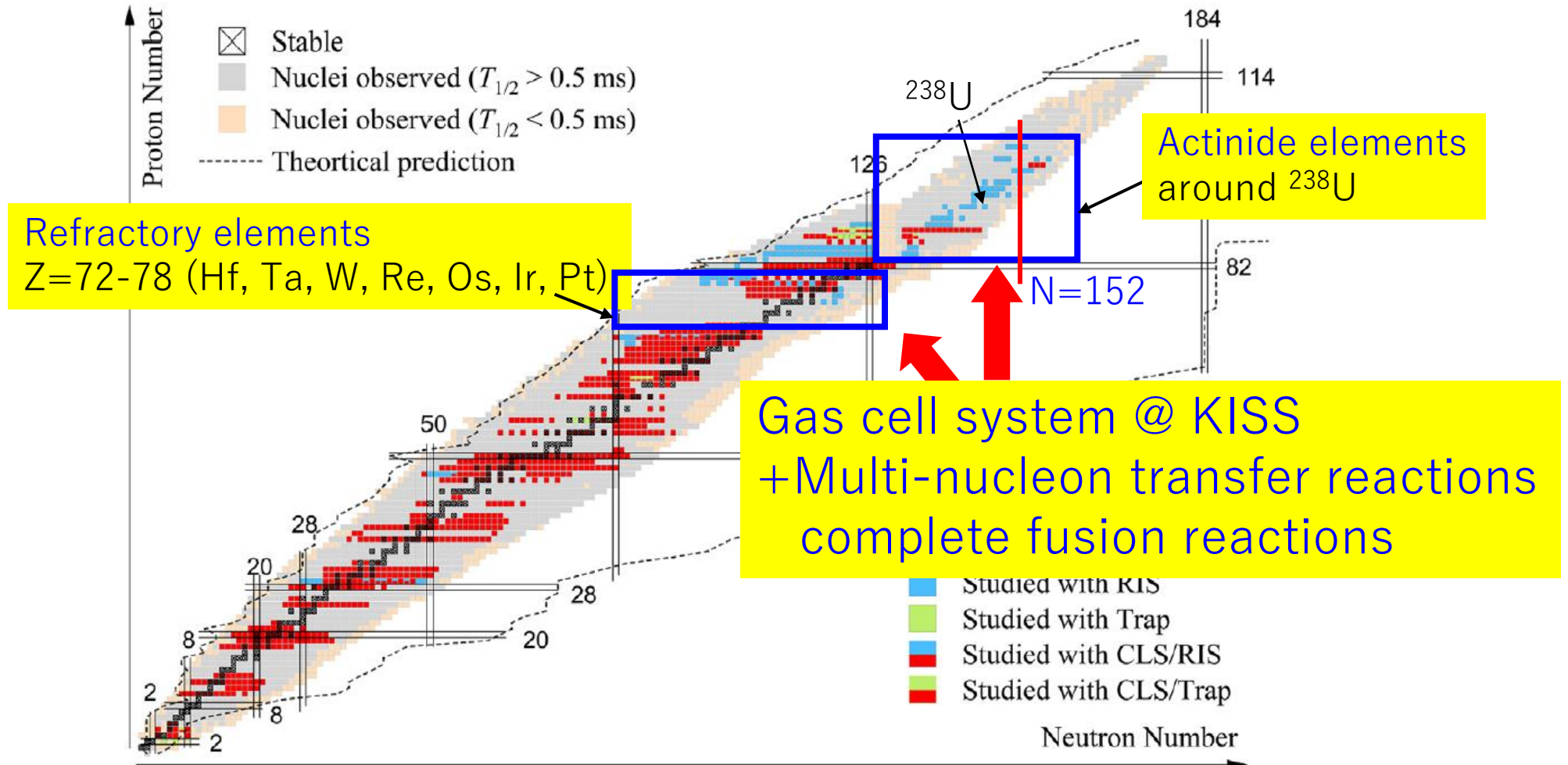
Hyperfine splitting (HFS) measurements

Nuclear electro-magnetic moments : μ_I, Q
→ Nuclear structure (wave function, deformation)

Isotope shift : $\delta\nu$

→ $\delta\langle r^2 \rangle$

→ nuclear deformation parameter $|\beta_2^2|^{1/2}$
for the nuclei with $I = 0, 1/2$

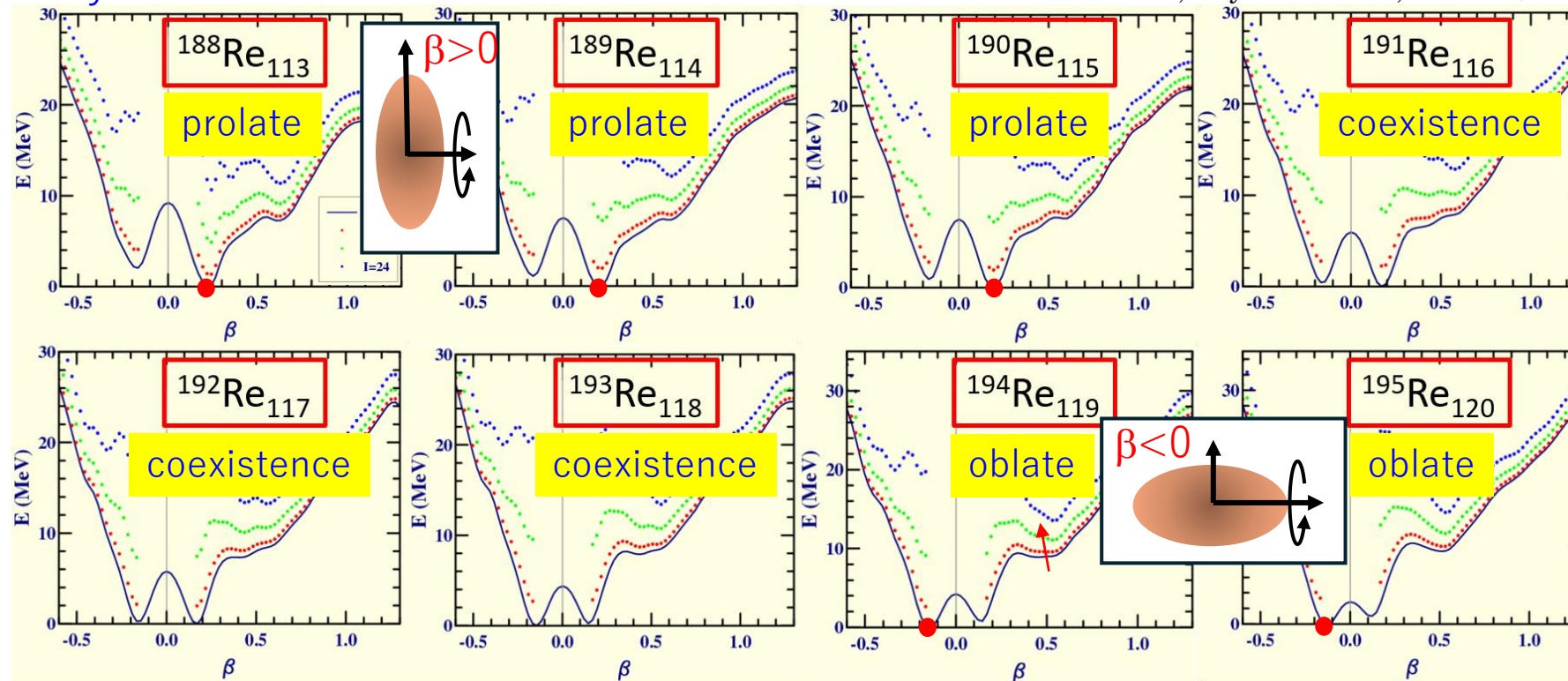


In-gas-cell laser spectroscopy of $^{188-193}\text{Re}$

Shape transition at $N = 116 - 118$, $Z = 72 \sim 76$

- PES calculated by CHFB+5DCH

J.-P. Delaroche et al., Phys. Rev. C 81, 014303 (2010).



- Change of the proton orbit from $[402]5/2^+$ to $[411]1/2^+$ at $N = 116$ from the β -decay study of ^{192}Re at KISS H. Watanabe et al., Phys. Lett. B 814, 136088 (2021).

➡ Suggested $\pi = 1/2^+$ for ^{191}Re , 0^- for ^{192}Re , and $1/2^+$ for ^{193}Re

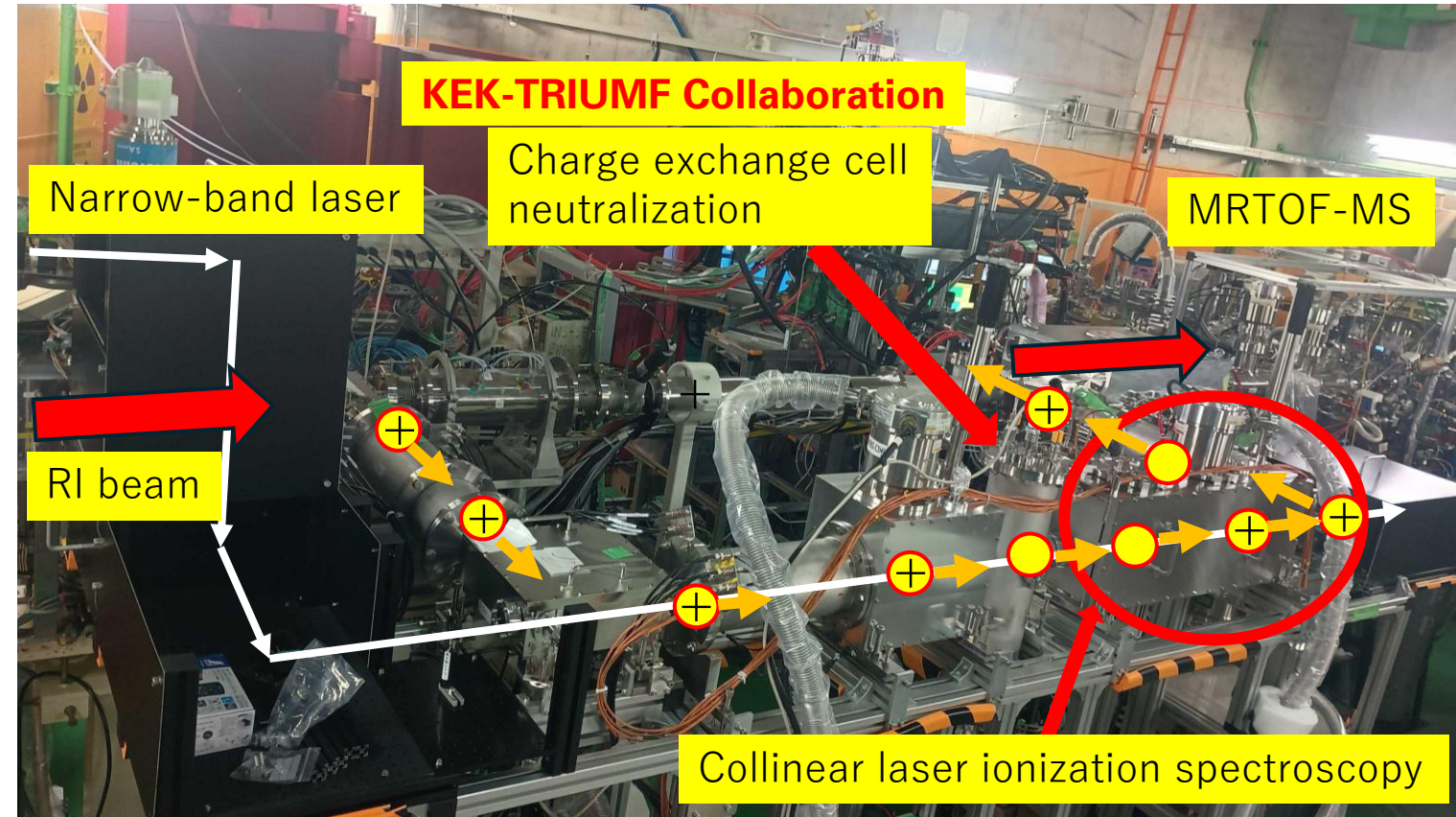
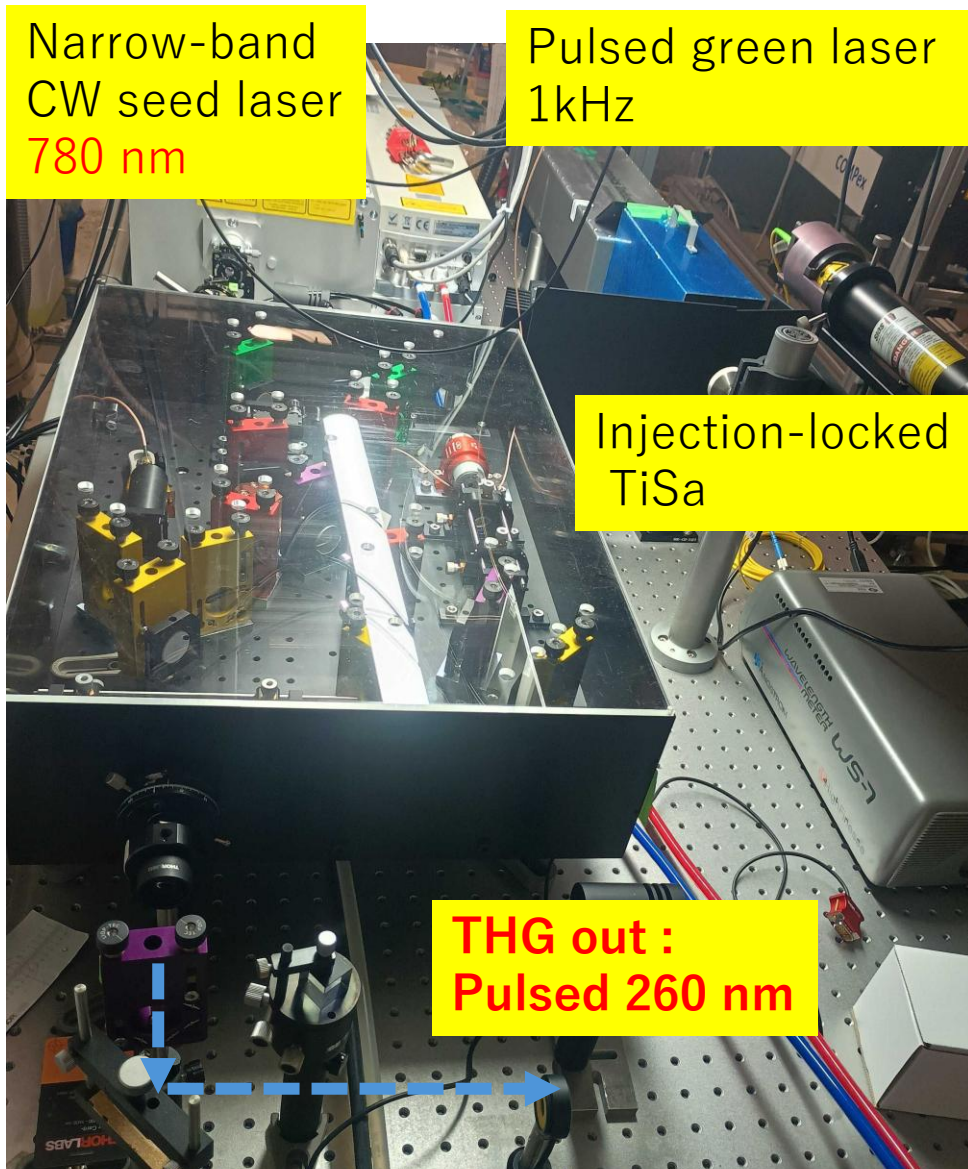


in-gas-cell laser spectroscopy of $^{188-193}\text{Re}$ ➡ μ_1 sensitive to π

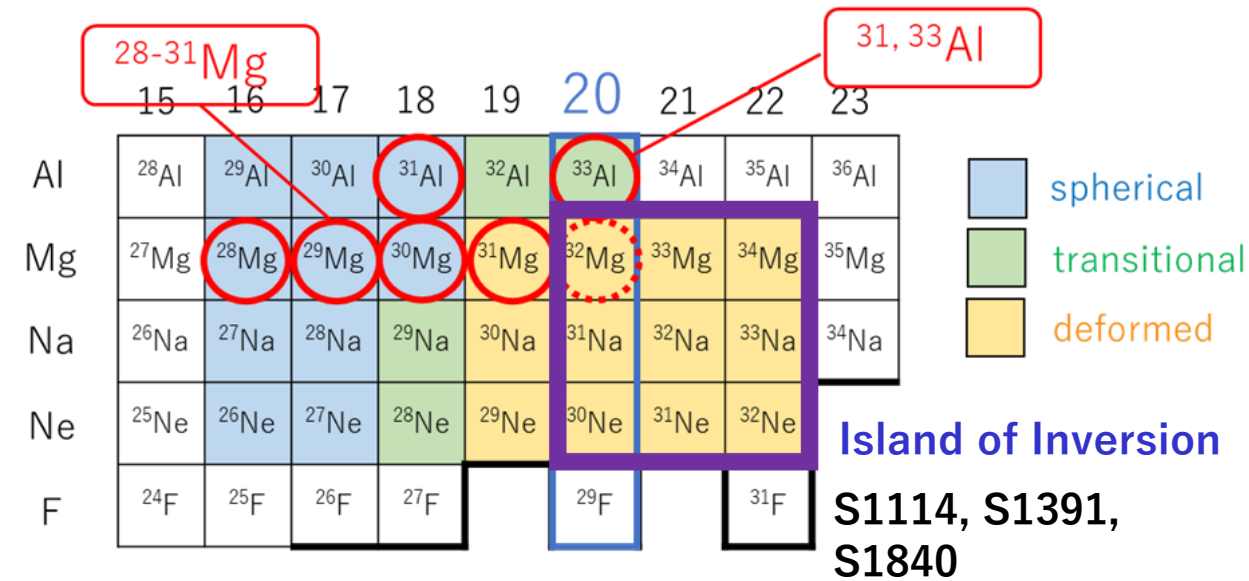
Collinear LAsER Resonance Ionization Spectroscopy (CLARIS)

Narrow-band pulsed UV laser :
Injection-locked TiSa

CLARIS beamline
ion and laser transports were done.



Studies of nuclear structure of neutron-rich Mg isotopes by using spin-polarized Na isotopes (Odahara@Osaka Univ.) @TRIUMF-ISAC



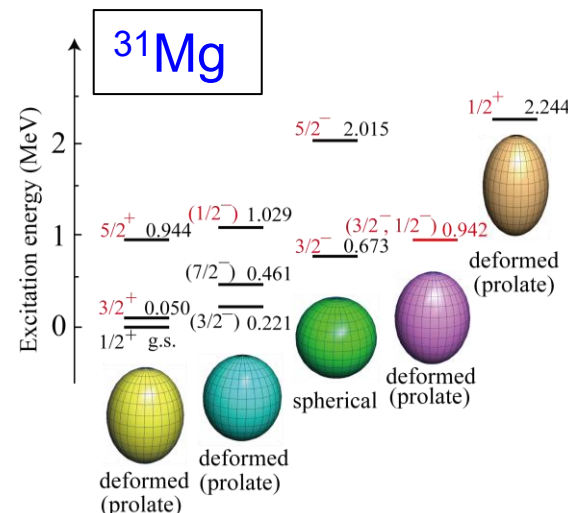
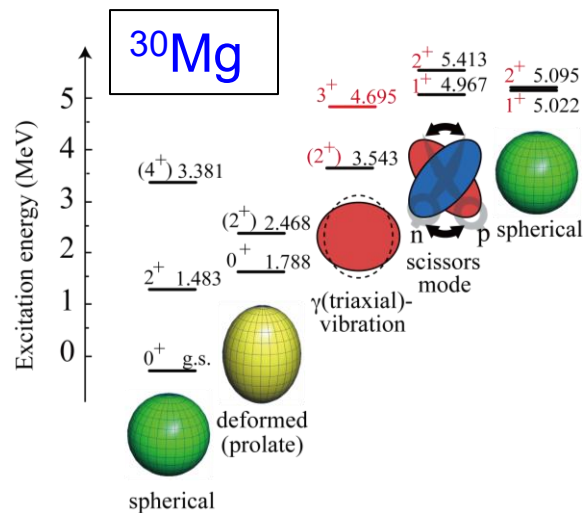
- Systematic studies have been performed for neutron-rich nuclei near and inside the $N = 20$ island of inversion. ($N=20$ magic number disappears.)
- By using spin-polarized nuclei, we can determine the nuclear-spin values of excited states of daughter nuclei



Next step : $^{32}\text{Na} \rightarrow ^{32}\text{Mg}$

To produce spin-polarized ^{32}Na , we need to determine nuclear spin of ^{32}Na at first.

→ **HFS measurement**
by laser ionization spectroscopy
in the collaboration with Jens and Ruohong.



Summary

KISS/KISS-1.5 : MNT reactions + Gas cell system

⇒ Access blank spots on the nuclear chart and
Perform laser ionization spectroscopy
for the studies of nuclear structure

- In-gas-cell laser ionization spectroscopy of heavy refractory nuclei
 - ⇒ Systematic studies of Pt, Ir, Os, Re, W, Ta, and Hf isotopes
- Precise laser ionization spectroscopy for actinide nuclei
 - ⇒ Collinear resonant ionization spectroscopy beam line at KISS
Offline studies will start soon.

TRIUMF-KEK Collaboration
for Complementary Laser Spectroscopy Across the Nuclear Chart