

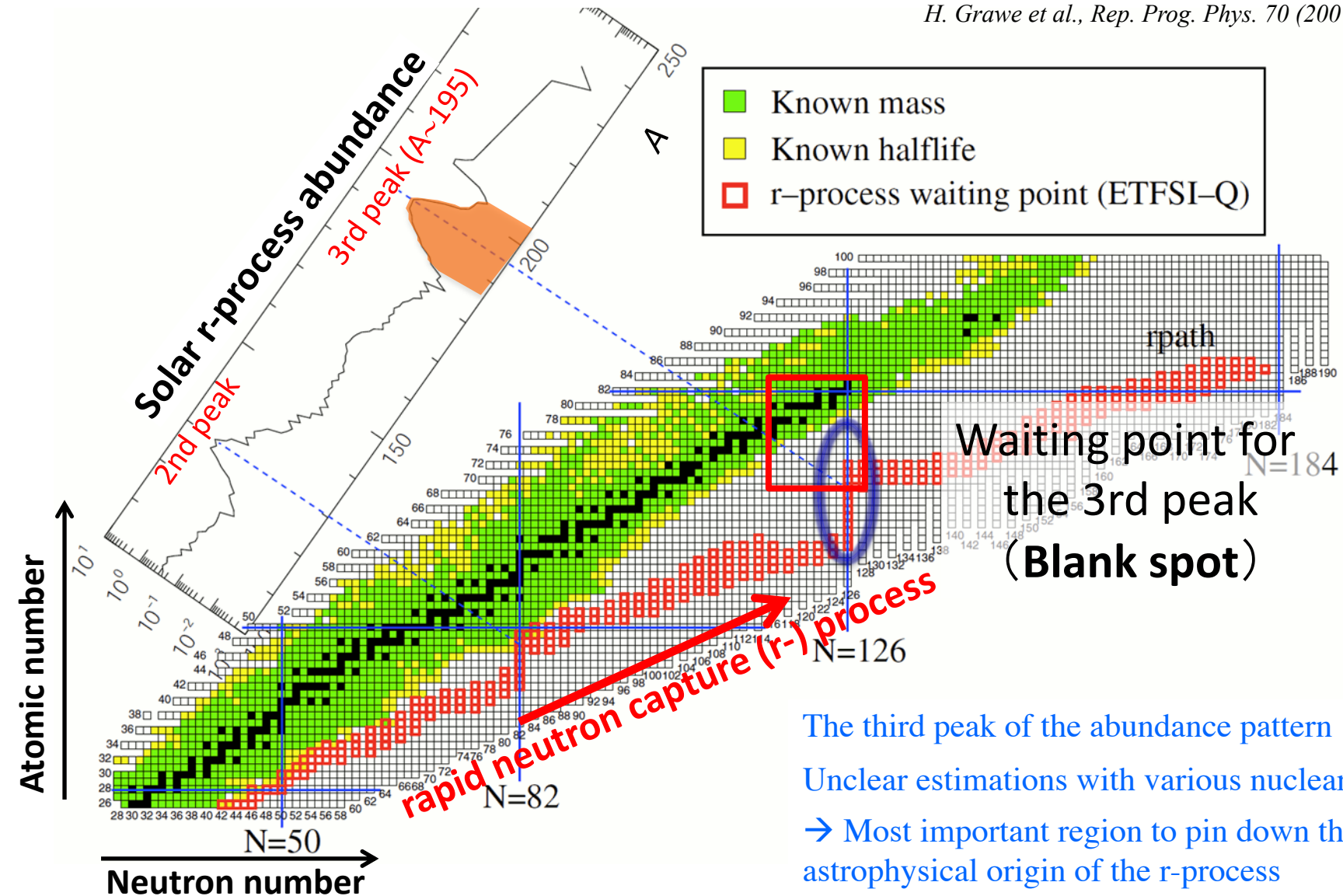
RNB project on the astrophysical element synthesis

- Physics motivation of the KISS project
- Recent activities at KISS stage I
 - > Lifetime and mass measurements
- Summary

What is KISS ?

- How are the gold and platinum synthesized ? -

H. Grawe et al., Rep. Prog. Phys. 70 (2007), 1525-1582.



The third peak of the abundance pattern
 Unclear estimations with various nuclear models
 → Most important region to pin down the astrophysical origin of the r-process

Physics goal

— Lifetime and Mass measurements —



Directly

- (n, γ) - (γ, n) equilibrium:
- r -process path
- lifetimes of waiting nuclei
- duration time to form the third peak
- steady flow approx.:
- correlation between T and N_n



Unique circumstance for r -process ?

Indirectly

- neutron fraction ($1 - Y_e$)
- production rates of fissile isotopes
- nuclear properties in waiting region
-

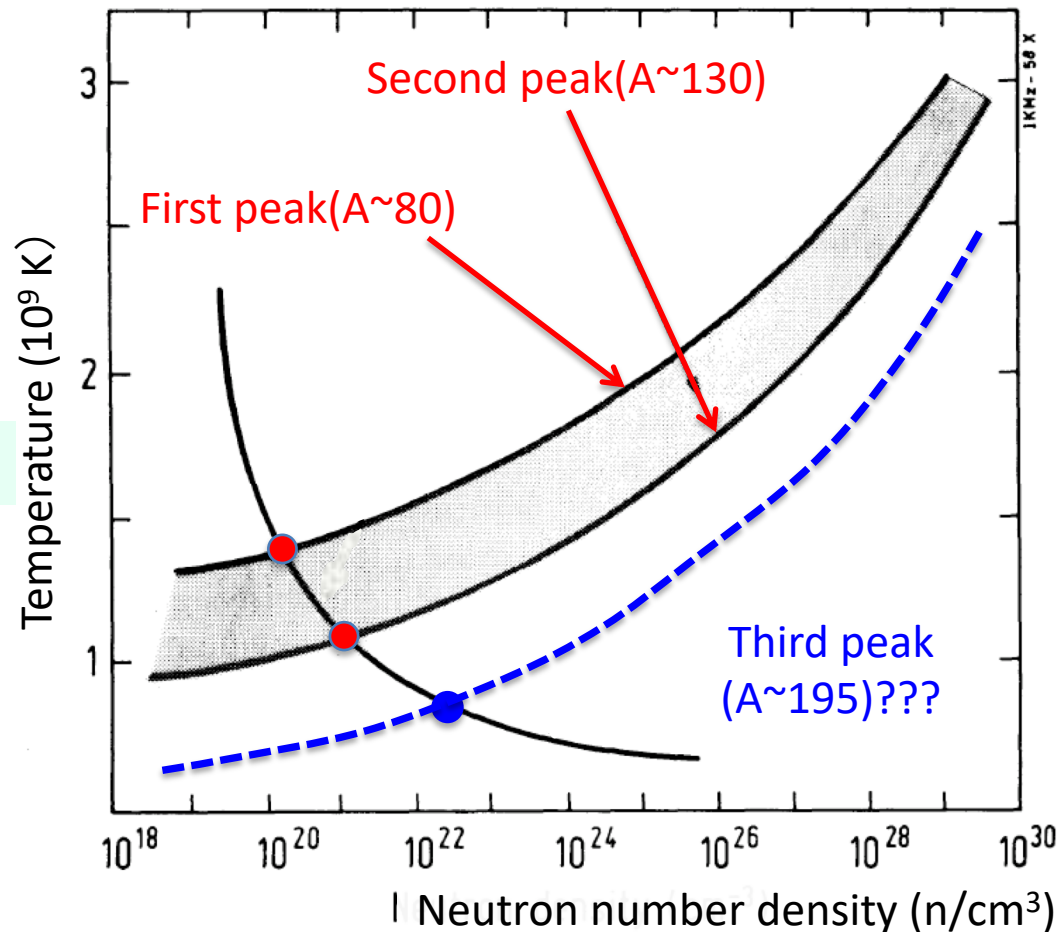


Clarifying origins (CC-SNe, NSM, ..)

GW170817: from optical (UV, IR) observation

- r -process heavy element synthesis is occurred in the NSM event (< Lanthanoid)
- Further questions: heavier element synthesis, fission recycling, termination of the r -process

from K. -L. Kratz, et al., Ap. J. 403('93)216.



KISS: KEK Isotope Separation System

- New research method for waiting nuclei of A=195 peak -



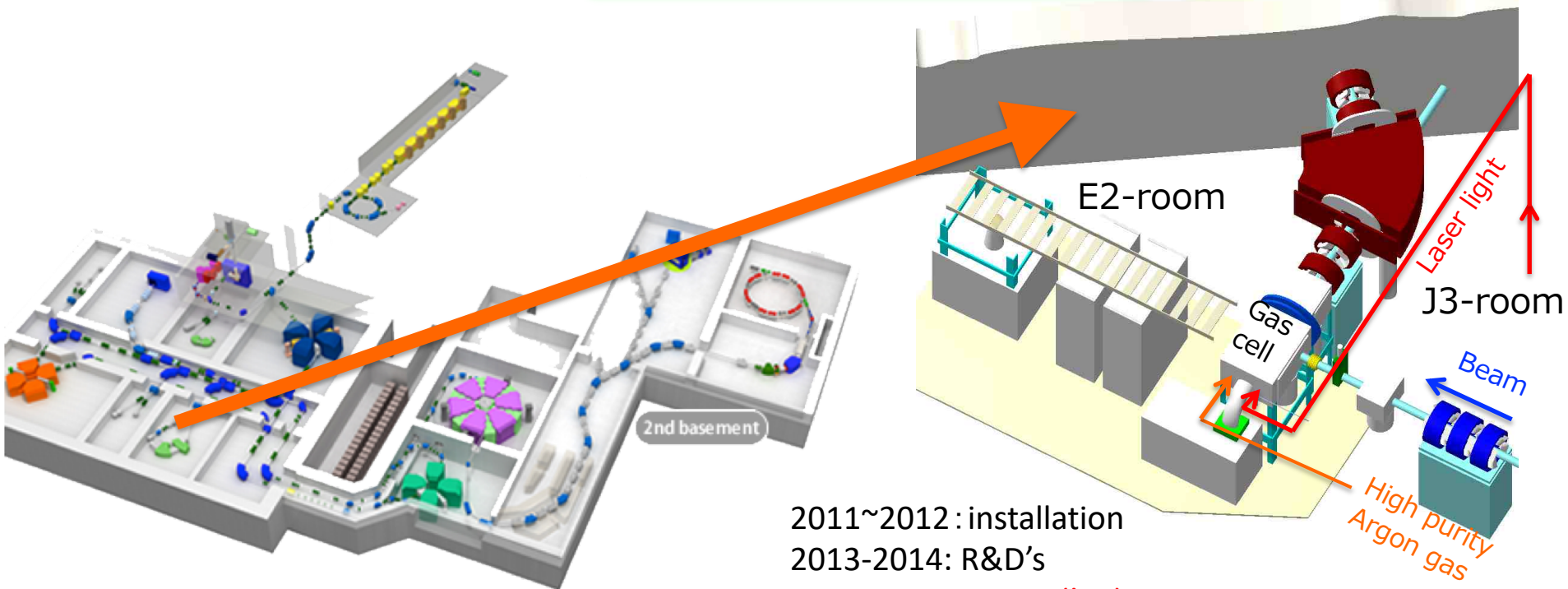
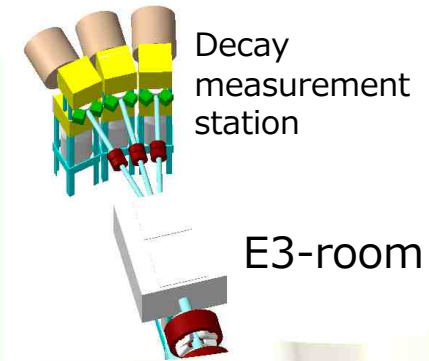
(1) Multi-nucleon transfer reactions

n-rich beams (~ 10 MeV/u)

i.e. $(^{136-144}\text{Xe} + ^{198}\text{Pt})$

(2) In-gas laser ionization

Neutralization of RI by argon gas
+ Laser resonance ionization (Z)
+ mass separation (A)
+ Det. system at low-background



Radioactive Isotope Beam Factory (RIBF)

2011~2012 : installation

2013-2014: R&D's

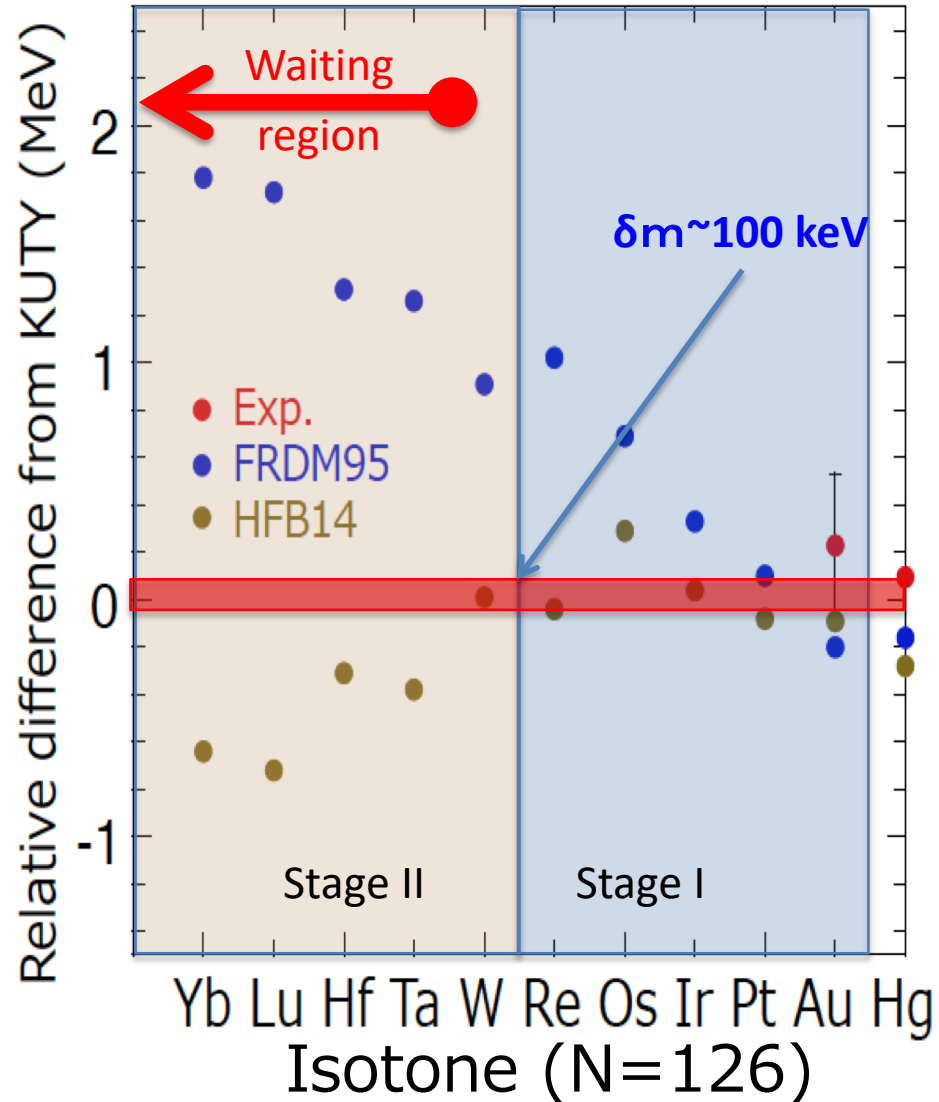
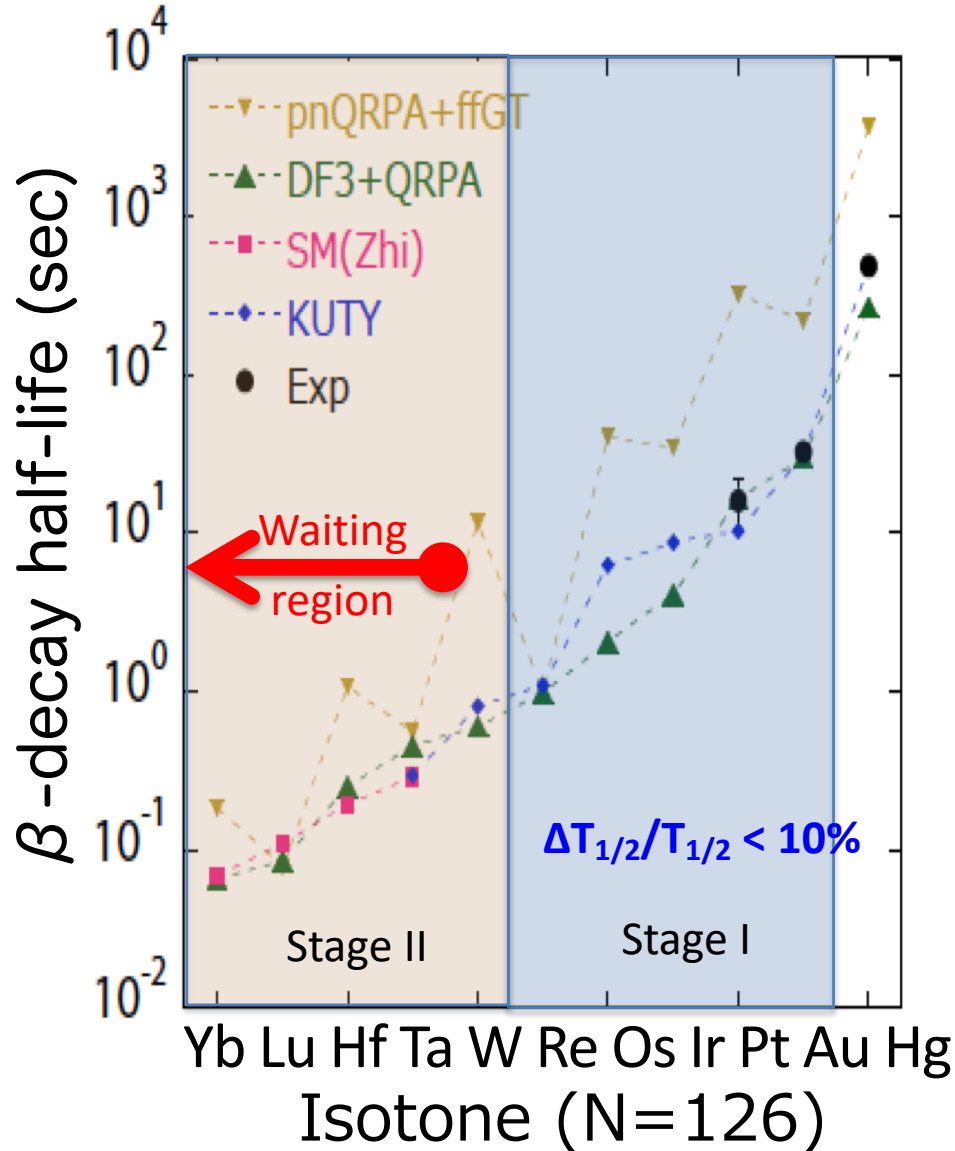
Y. Hirayama, EPJ 66('14)11017.

Y.X. Watanabe, P.R.L. 115('15)172503.

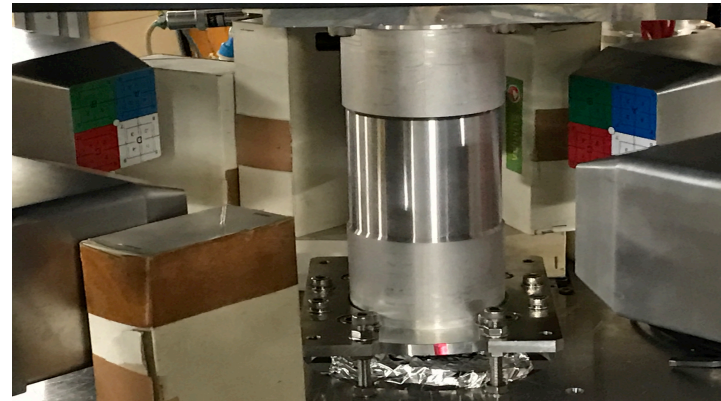
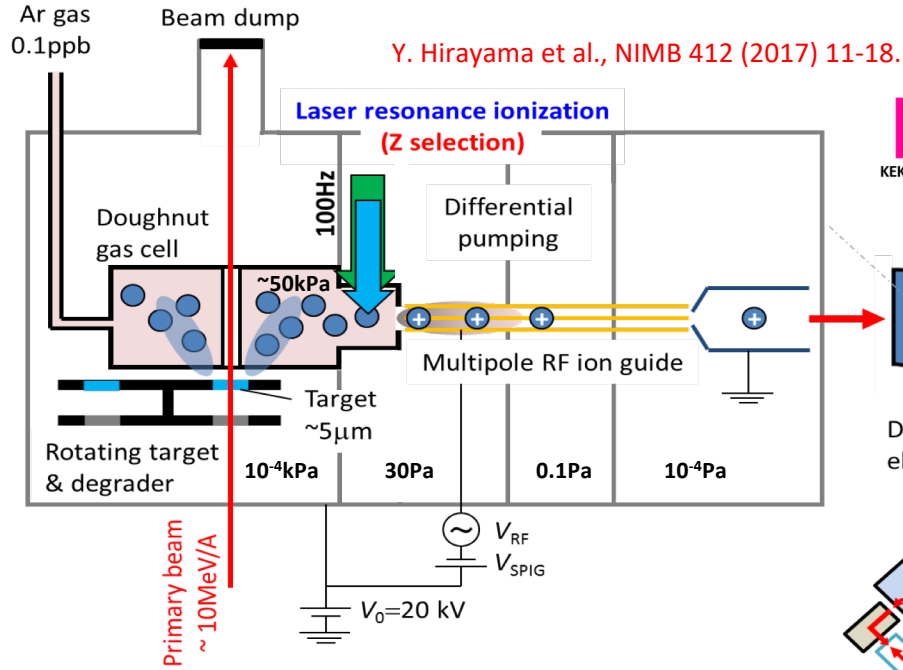
Uncertainty of lifetime & mass predictions in N=126 isotones



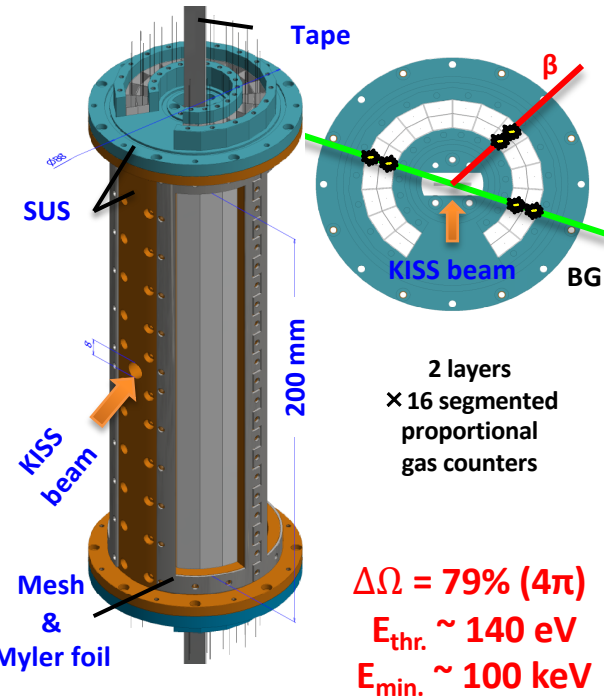
Stage I (~2020, ^{136}Xe , 250 pA) to Stage II (2021~, ^{238}U , up to 10 μA)



KISS (KEK Isotope Separation System)

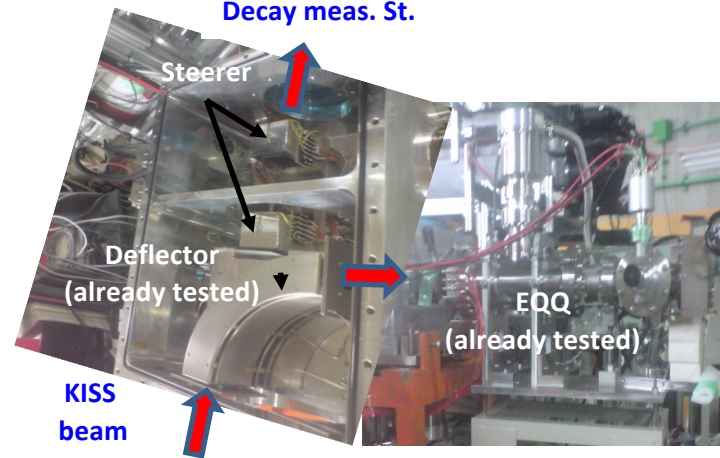


M. Mukai et al., NIM A884(2018)1.



IBS-KEK collaboration

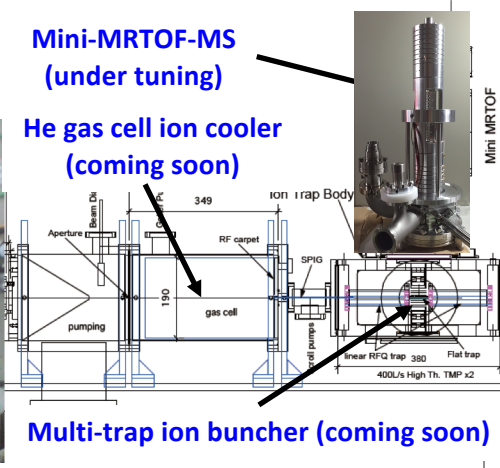
Decay meas. St.



Mini-MRTOF-MS (under tuning)

He gas cell ion cooler (coming soon)

Multi-trap ion buncher (coming soon)



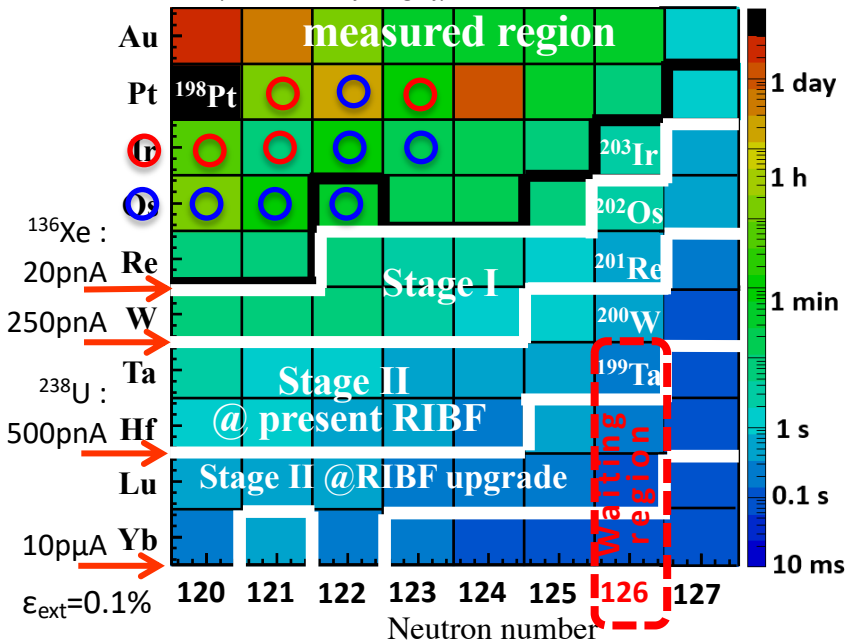
Lifetime confirmation and decay spectroscopy



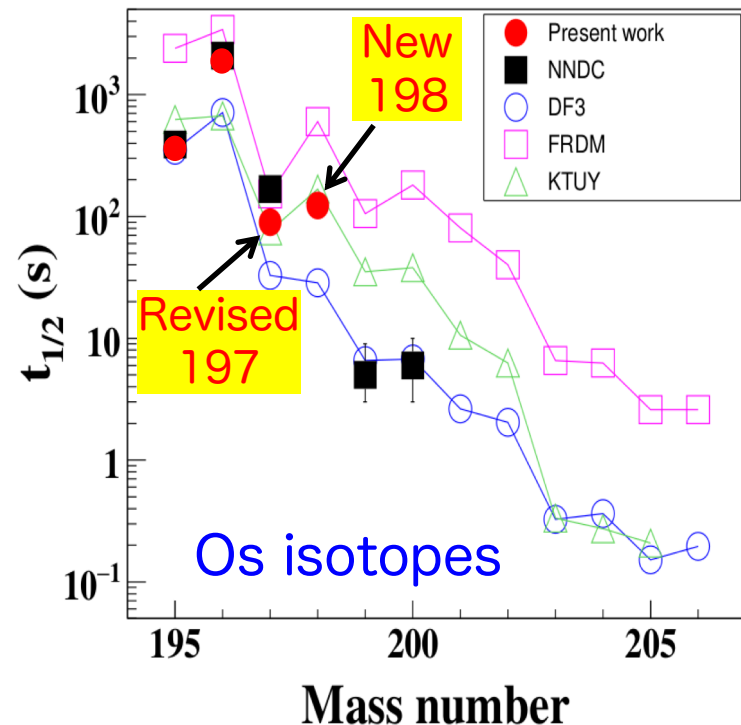
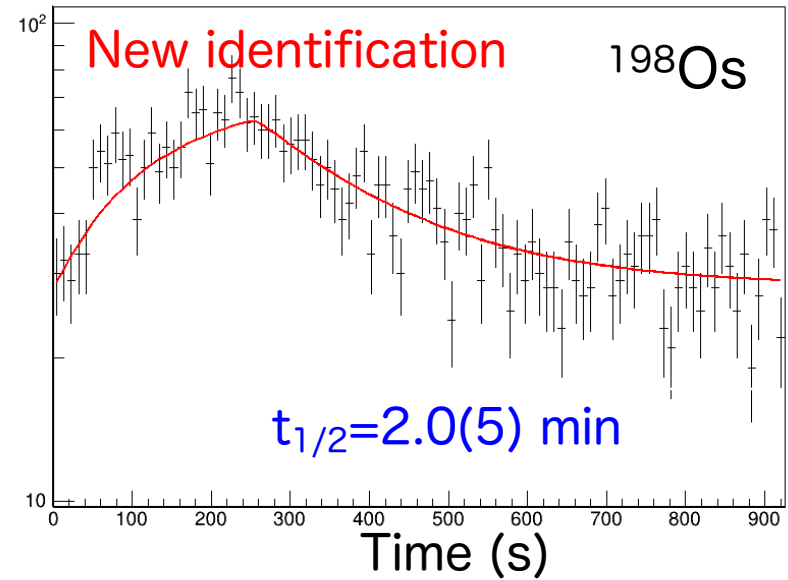
in FY2016 to 2017

- Y. Hirayama et al., Phys. Rev. C96(2017)014307.
Phys. Rev. C98(2018)014321

KUTY : H. Koura, et al.,
<http://www.wndc.jaea.go.jp/CN14/index.html> Expected : $T_{1/2}$

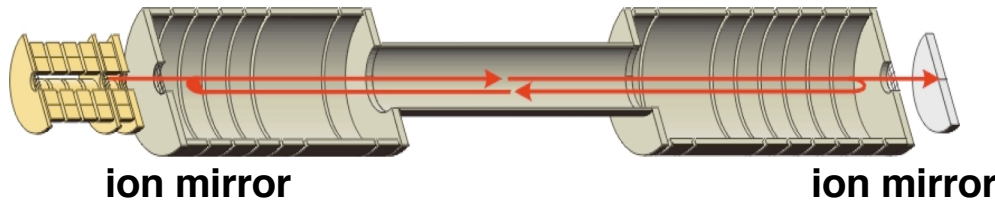


- 12 n-rich isotopes (Pt, Ir, and Os) have been measured.
- ^{198}Os has been newly identified with half-life of 2 min..
- Some discrepancies between the reported and present data
- Some isomeric states would be newly assigned

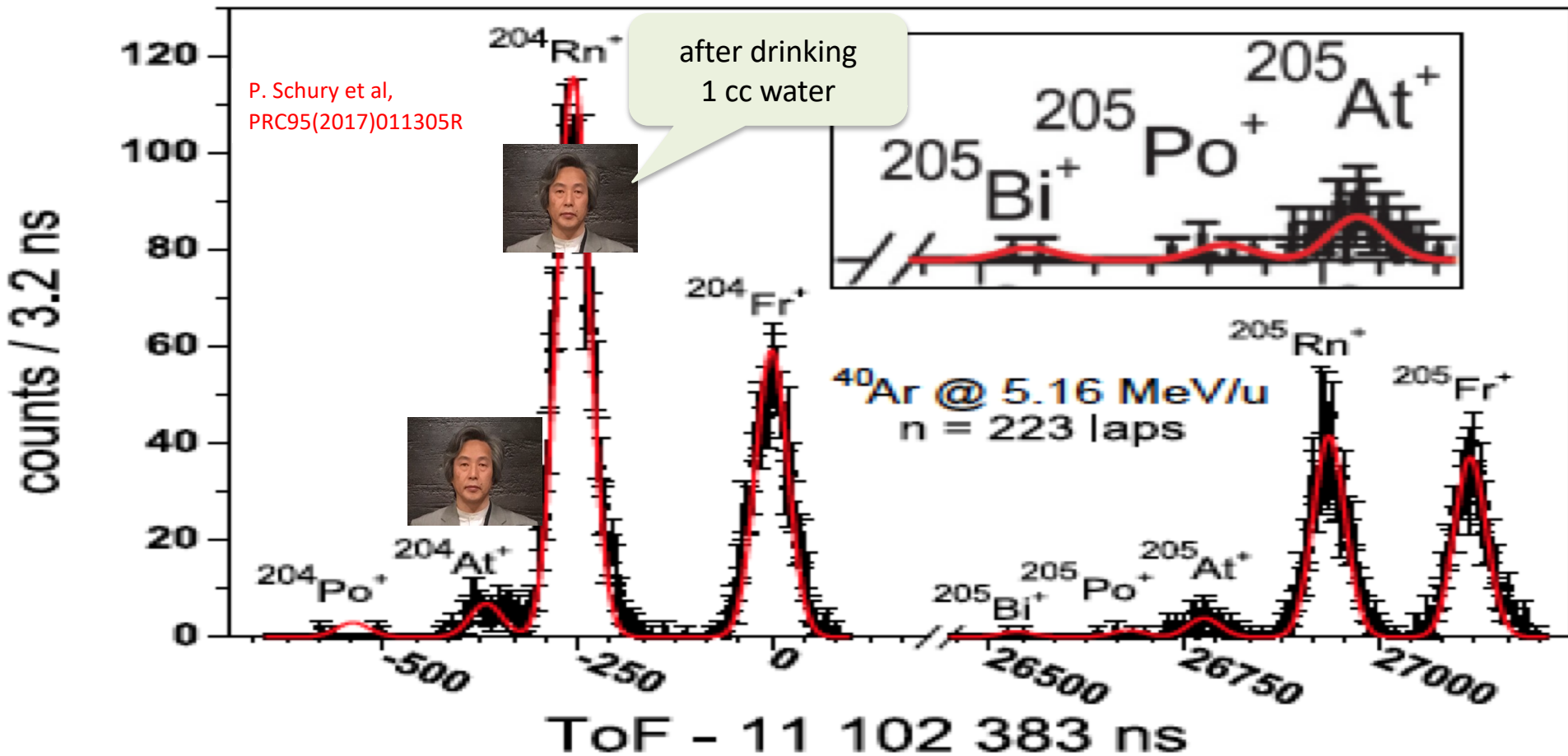


Direct mass measurement

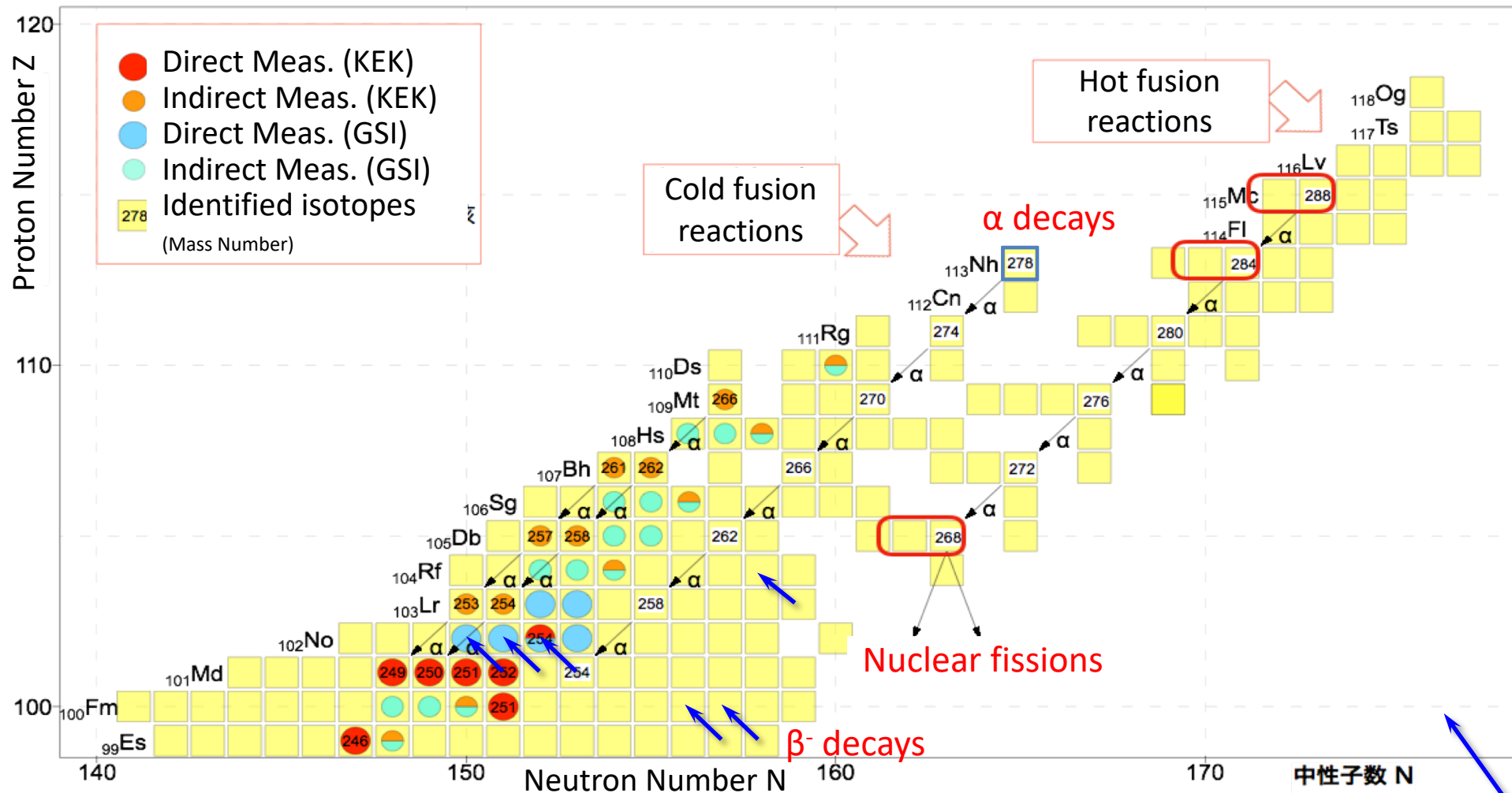
with Multi-Reflection Time-Of-Flight Mass Spectrograph (MRTOF-MS)



→ Comprehensive mass determination of radioactive isotopes available at RIBF



Termination properties of the r-process proved by nuclear mass measurements



P. Schury et al, Phys. Rev. C95(2017)011305R

NIM B407(2017)160

Y. Ito et al., Phys. Rev. Lett. 120(2018)152501.

β^- decays from the r-path

Summary

- **KISS project** has been launched since FY2015 to determine astrophysical conditions of the third abundance peak synthesized in the r-process.
- **Decay measurements in the vicinity of N=126 waiting region** has already been started using KISS at Riken.
- Decay properties of **n-rich 12 isotopes** has been investigated to contribute nuclear model improvements.
- **Newly developed MRTOF-MS** has revealed its high performance in heavy element region.
- **Mass measurements at KISS will be ready** within this year not only for the N=126 waiting region but also for the r-process termination region.

fin