Development of a gas-jet transport system coupled to GARIS for heavy element chemistry

5th Workshop on
Recoil Separator for Superheavy Element Chemistry

September 29, 2006
Garching, Germany

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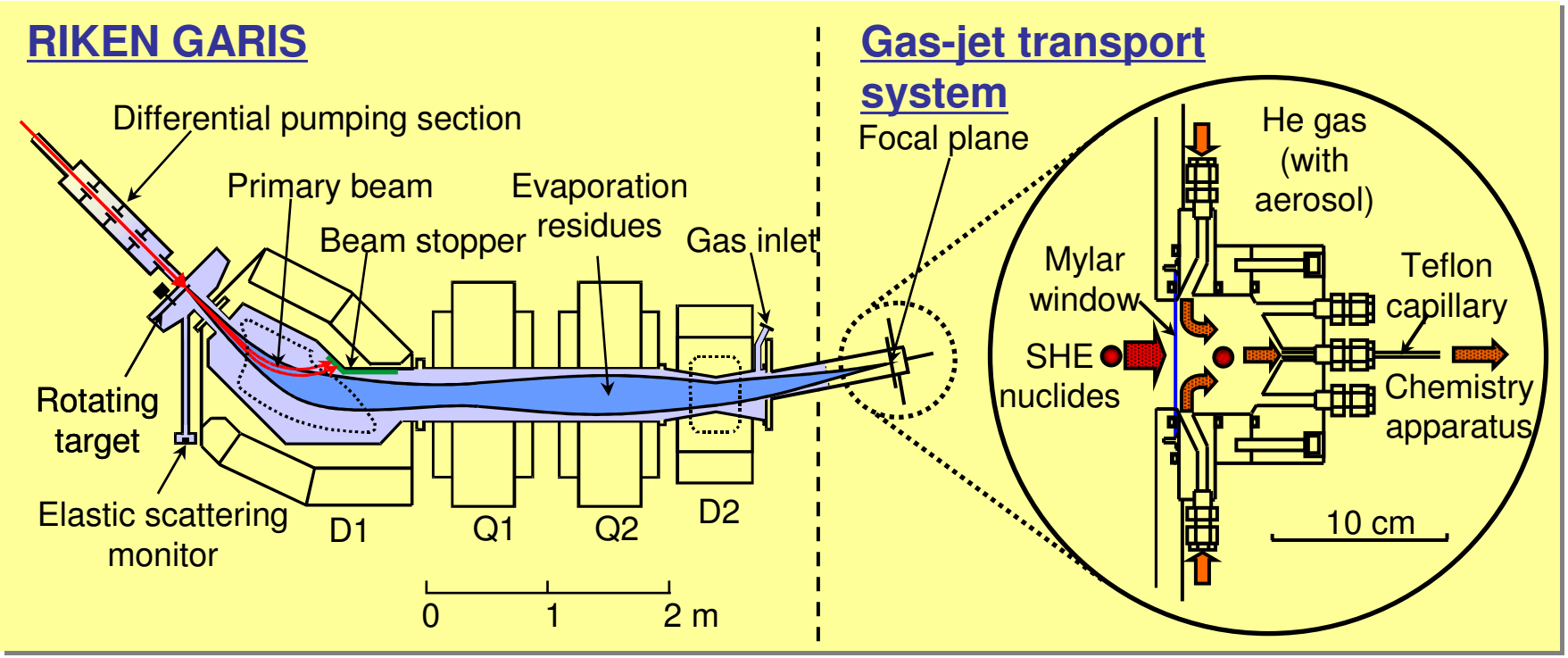
RIKEN (The Institute of Physical and Chemical Research)
JAPAN

Introduction

Development of GARIS - Gas-jet System

⇒ TASCA05 by Haba (RIKEN)



In this presentation

➡ Performance of the GARIS / Gas-jet System

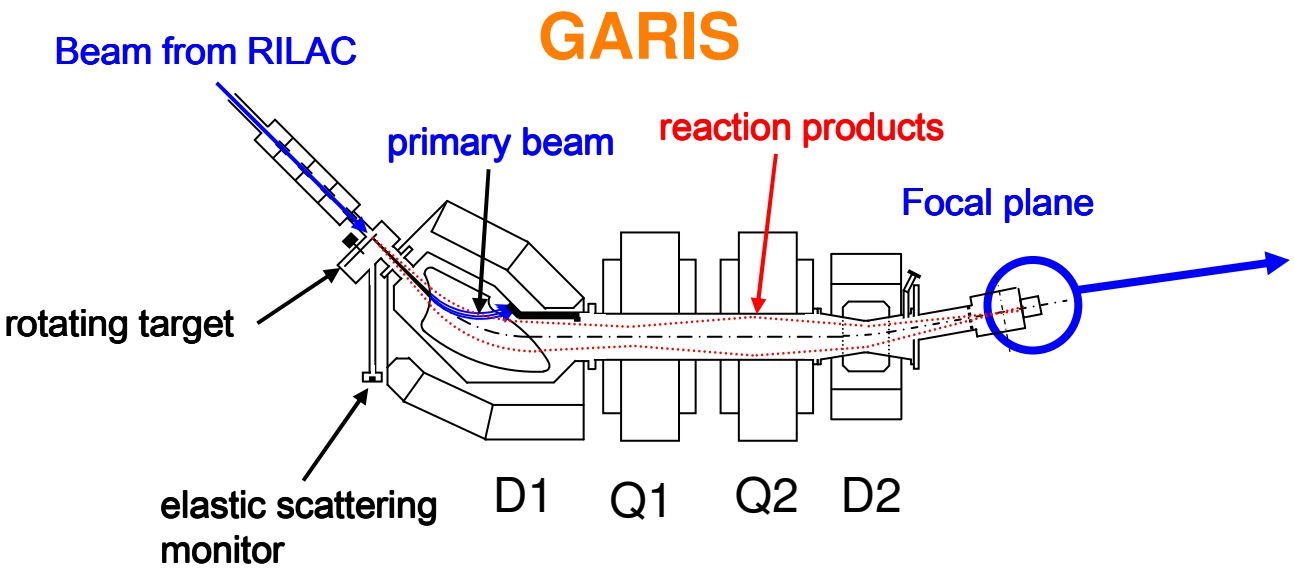
Reactions

^{169}Tm(^{40}Ar,3*n*)^{206}Fr ($T_{1/2}$ = 15.9 s) , 376 μb

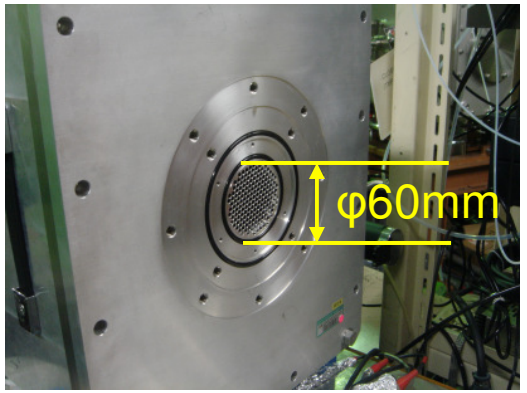
^{208}Pb(^{40}Ar,3*n*)^{245}Fm ($T_{1/2}$ = 4.2 s) , 15 nb

^{238}U(^{22}Ne,5*n*)^{255}No ($T_{1/2}$ = 3.1 m) , 90 nb

Experimental setup



Focal plane window



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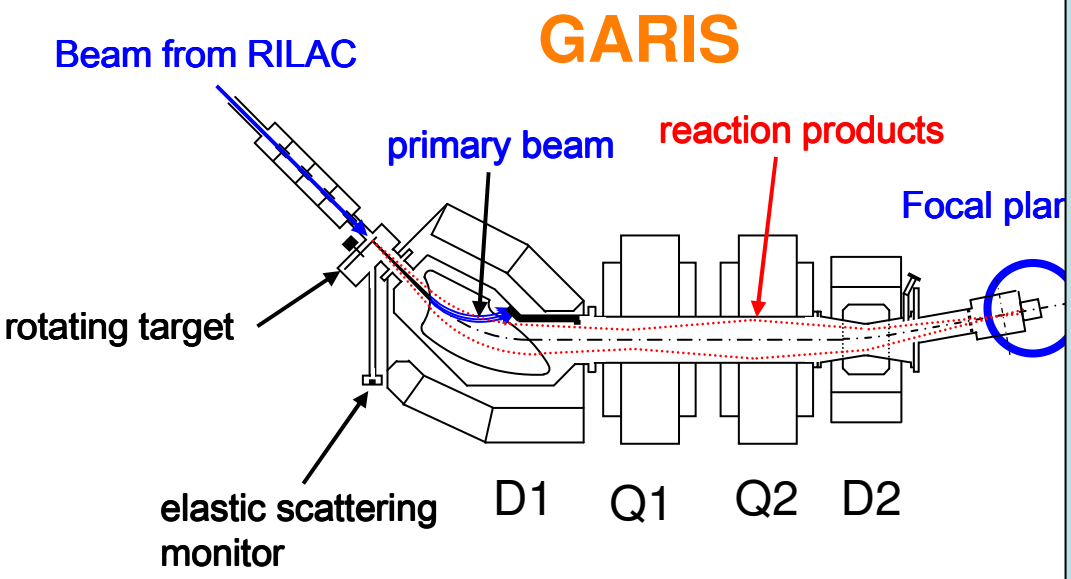
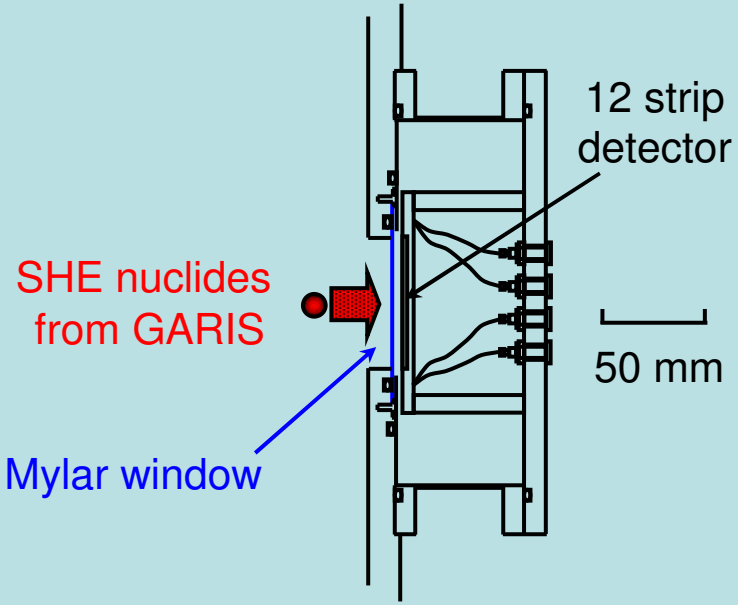


1. Focal Plane Chamber



Measurement of total number of atoms transported to the vacuum window

Reactions

$^{169}Tm(^{40}Ar,3n)^{206}Fr$ ($T_{1/2}$ = 15.9 s) , 376 μb

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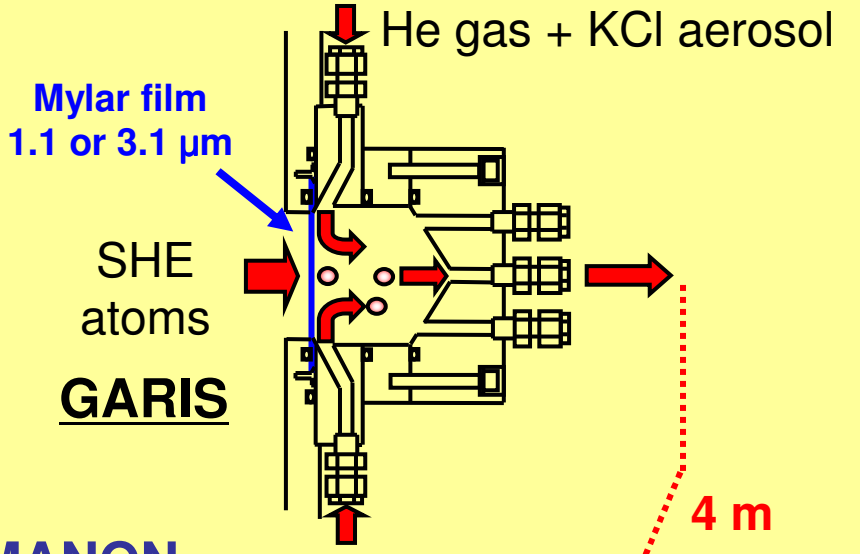
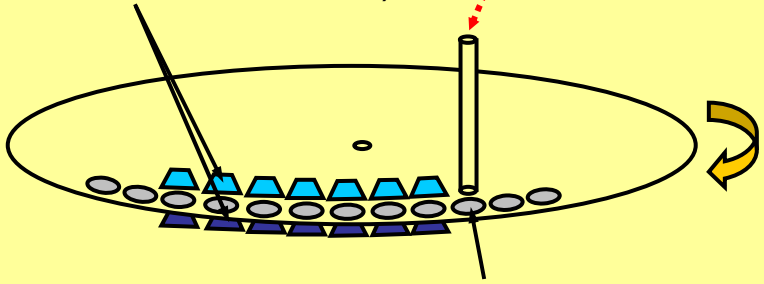
Setup of GARIS - Gas-jet system

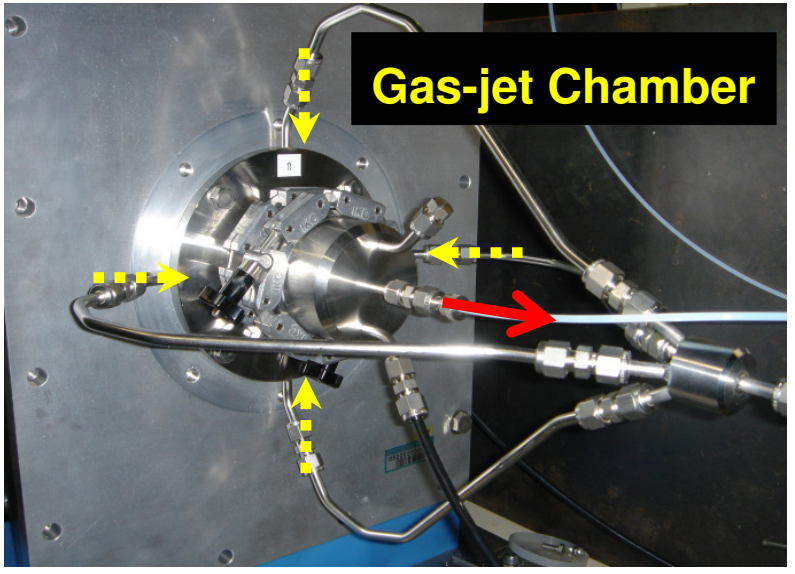
2. Gas-jet chamber

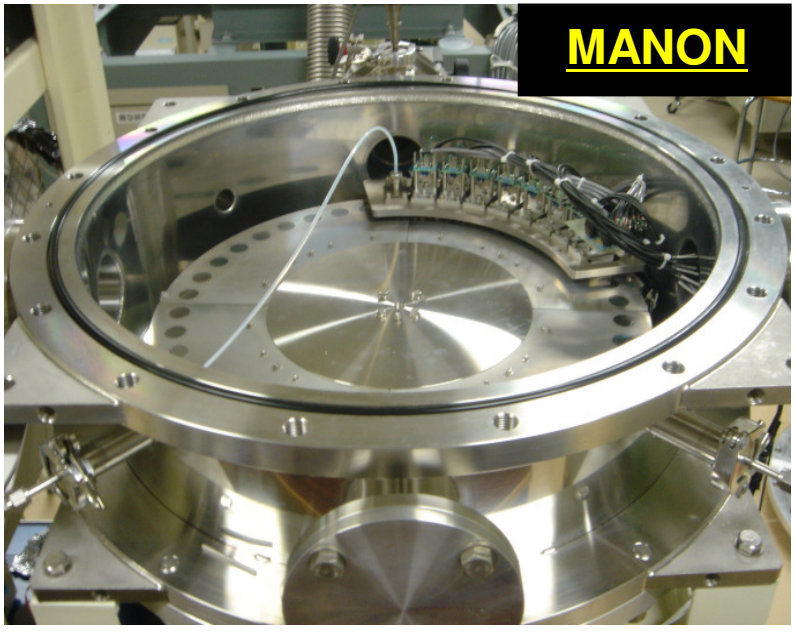


MANON

7 pairs of Si PIN Photodiodes
(18×18 mm^2, EFF: 76%)





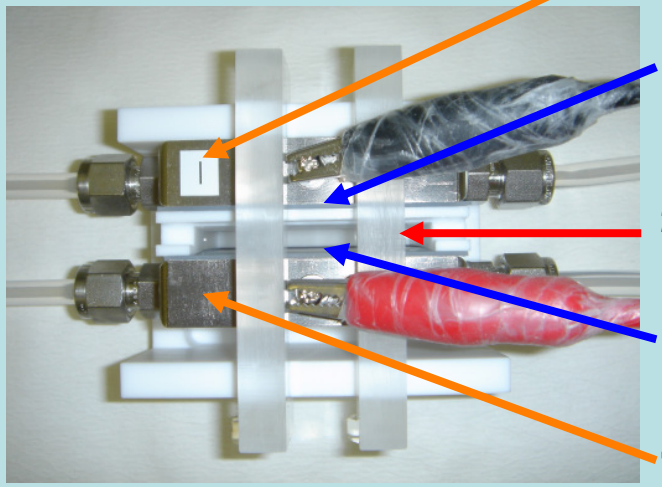


Experimental Condition

	^{206}Fr	^{245}Fm	^{255}No
Reaction	^{169}Tm(^{40}Ar,3n)^{206}Fr	^{208}Pb(^{40}Ar,3n)^{245}Fm	^{238}U(^{22}Ne,5n)^{255}No
Cross section	376 μb	15 nb	90 nb
Beam energy (MeV)	169.7	197.6	113.8
Recoil energy (MeV)	32.5	31.9	9.6
Beam intensity (pμA)	2	2	4
Target (μg/cm^2)	120	460	312
Target backing (μg/cm^2)	30 (C)	30 (C)	1270 (Ti)
Magnetic rigidity (Tm)	1.64	2.05	1.93
GARIS He pressure (Pa)	88	88	38
Mylar window (μm)	3.1	3.1	1.0
Support grid (%)	89	89	72
Chamber pressure (kPa)	89.4	91.3	38.2
He flow rate (L/min)	5.0	5.0	1.0
T_{KCl} (^{o}C)	618	620	622

^{238}U Target preparation

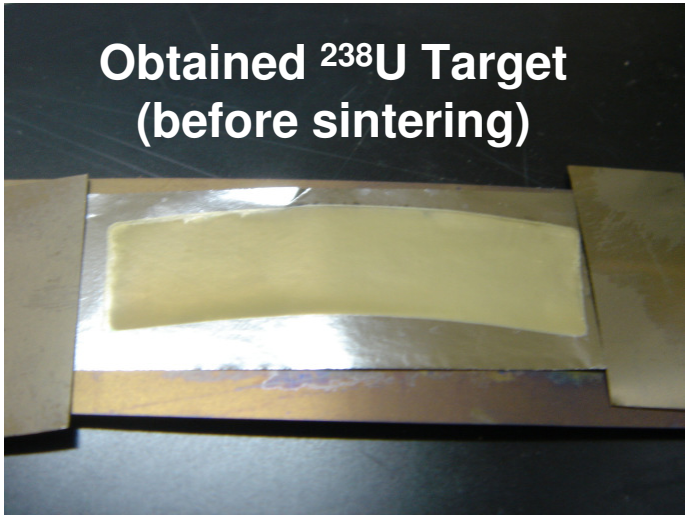
Electrodeposition PTFE Cell



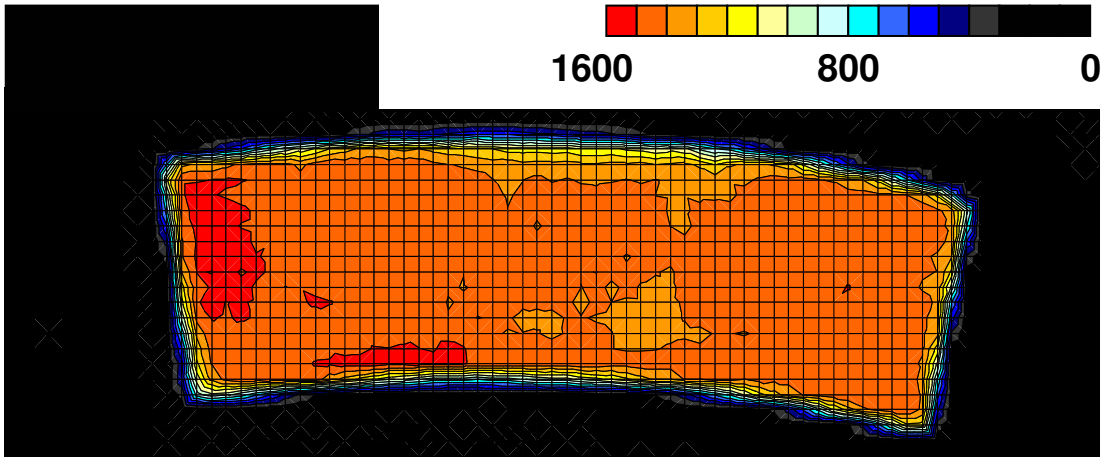
Condition for electrodeposition

Backing: 3 μm Ti foil
Solution: 2.6 mg of U in 5.5 μL of 0.01M HNO_3 + 12 mL of 2-propanol
Voltage × Current × Time: 800 V × 50 mA × 20 min
Deposition area: 7.85 cm^2

^{238}U Target preparation



Photographic image taken by an imaging plate



○Results of electrodeposition

Yield: 95 ± 4%
RSD: 3%
Thickness: 312 ± 15 μg/cm^2

○After Irrad. with 8.7×10^{17} particles of ^{22}Ne

Thickness: 309 ± 17 μg/cm^2

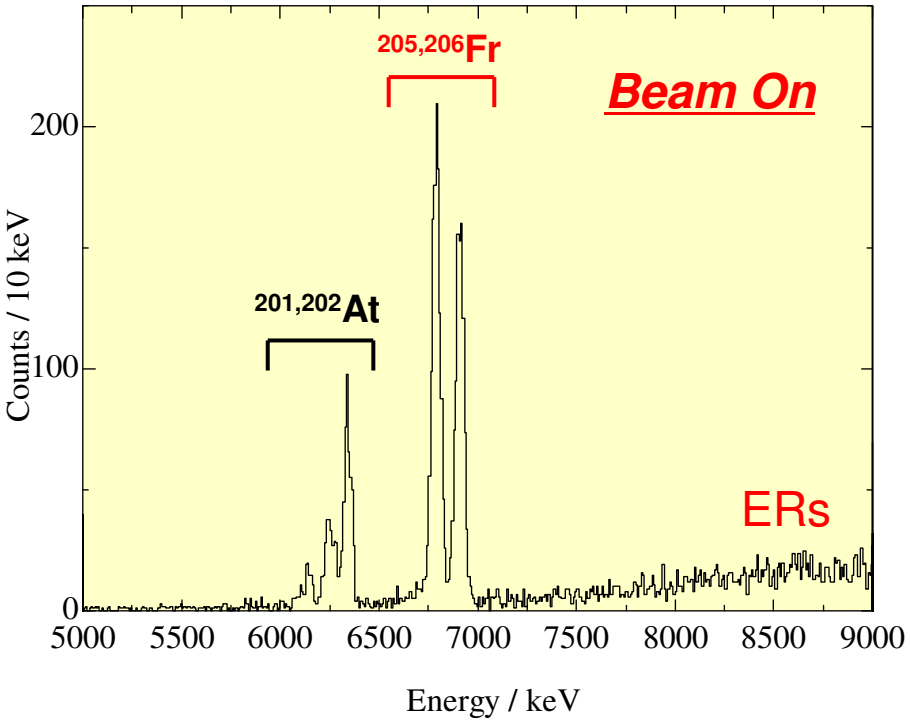
Not decrease !!

Results

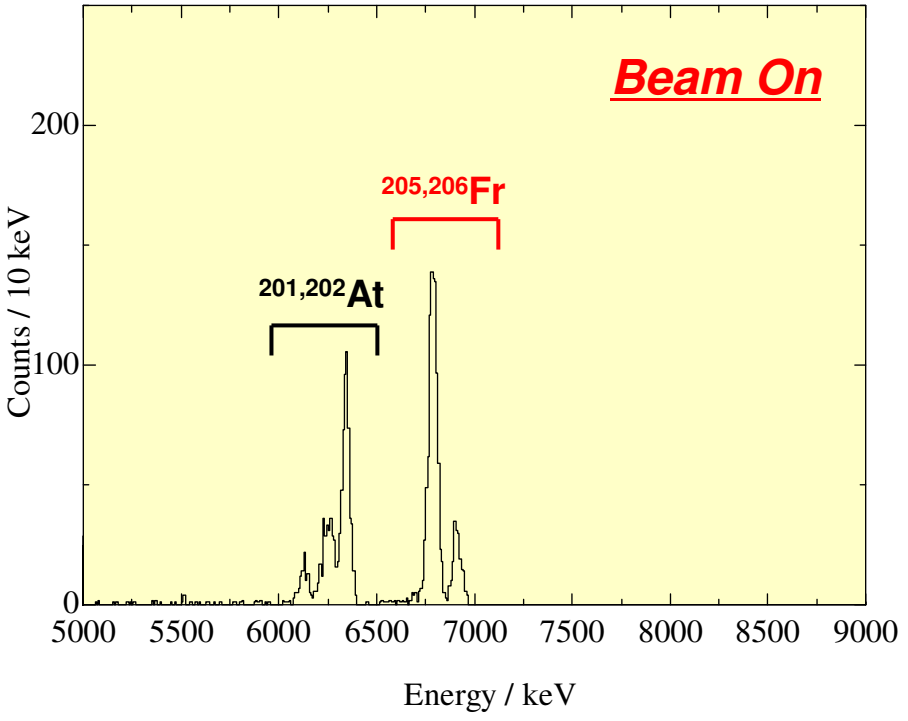
$^{169}Tm(^{40}Ar,3n)^{206}Fr$ (15.9 s, E_α = 6.79 MeV)
$^{208}Pb(^{40}Ar,3n)\ ^{245}Fm$ (4.2 s, E_α = 8.15 MeV)
^{238}U $(^{22}Ne,5n)^{255}No$ (3.1 min, E_α = 7.620–8.312 MeV)

Spectra of ^{205,206}Fr

Focal plane detector



MANON

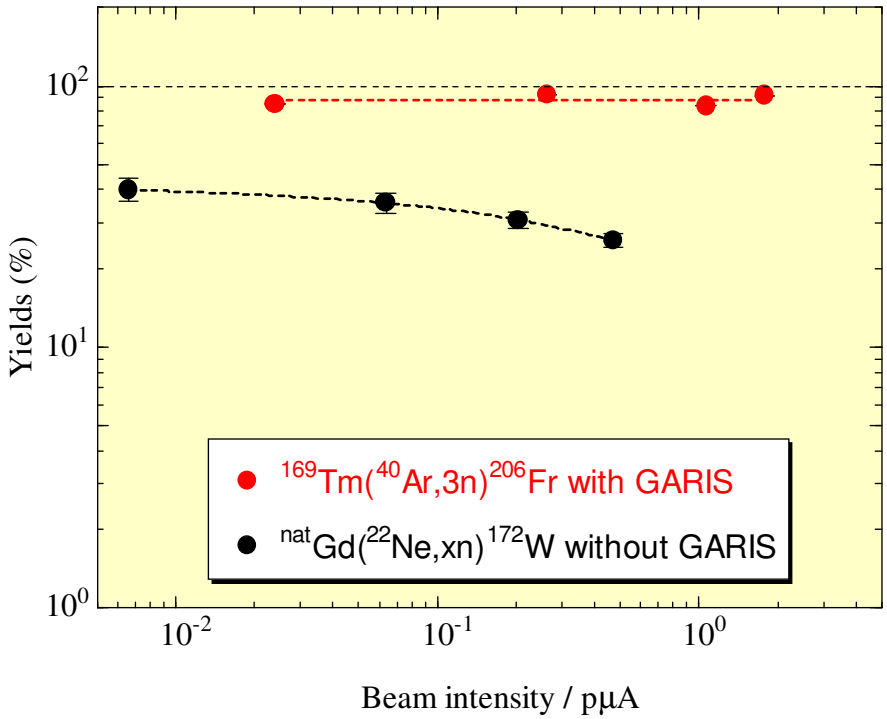


The alpha-peaks of Fr isotopes and their daughters are clearly identified.

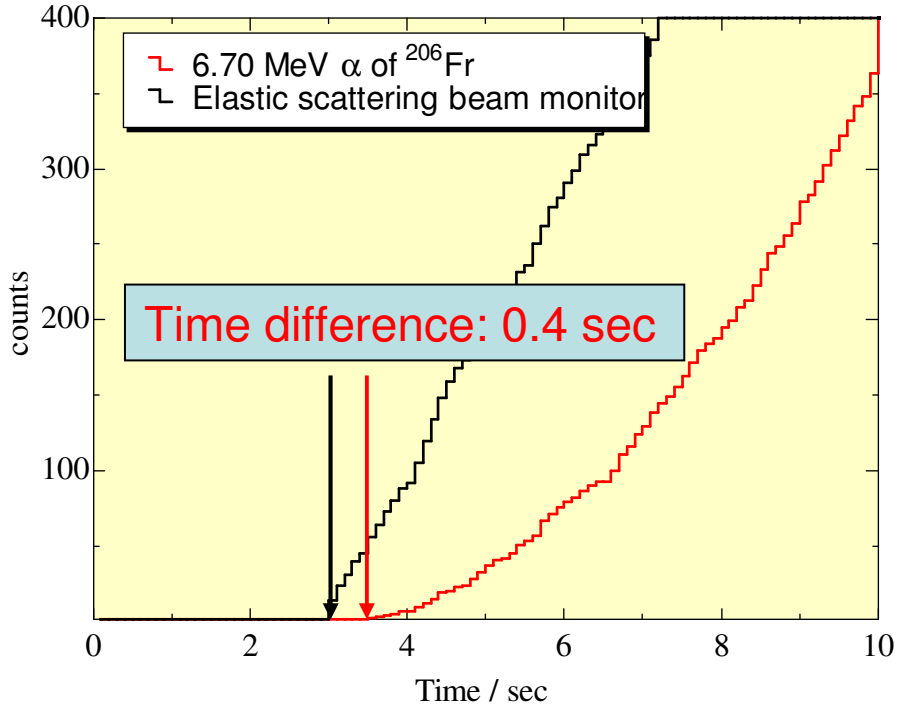
In particular, MANON spectrum was measured under low background condition.

Performance of Gas-jet system

Variation of Gas-jet yields of ^{205,206}Fr



The transport time from the chamber to MANON



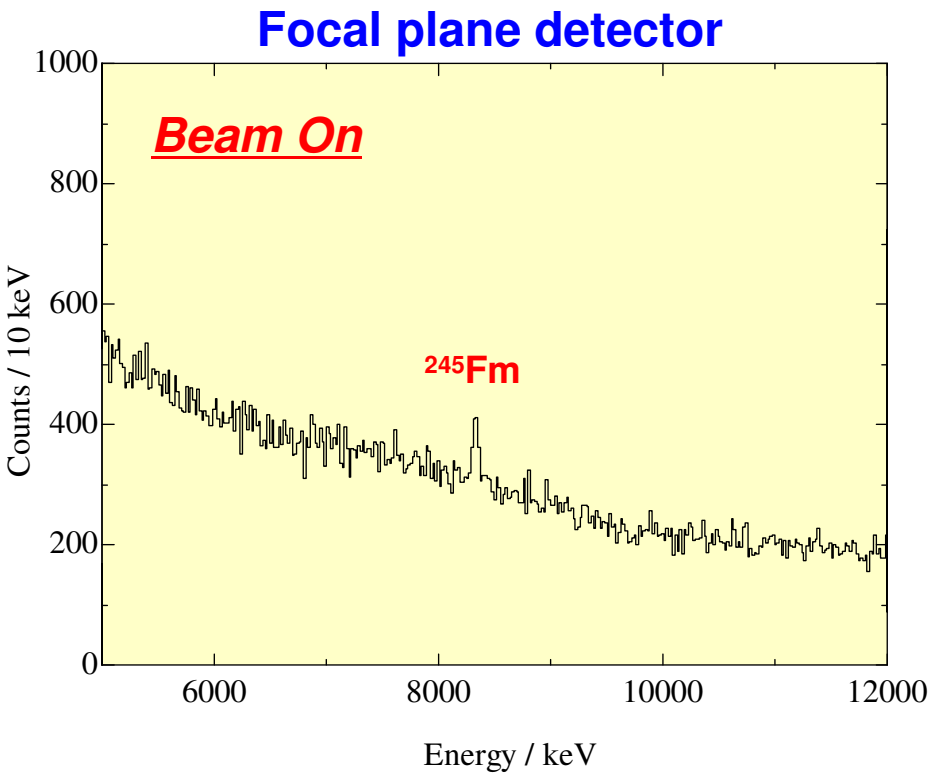
High gas-jet efficiency over 90% are obtained

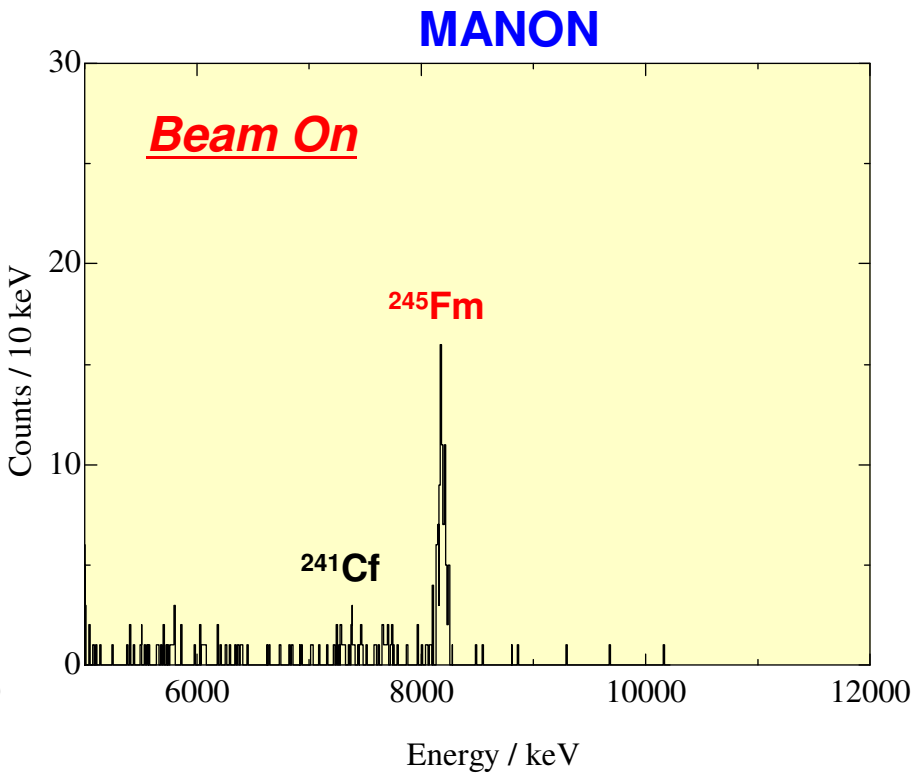
and

these are independent of the beam intensity (~2 pμA).

The transport time from the chamber to MANON is 0.4 s through 4-m capillary.

α spectra of ^{245}Fm





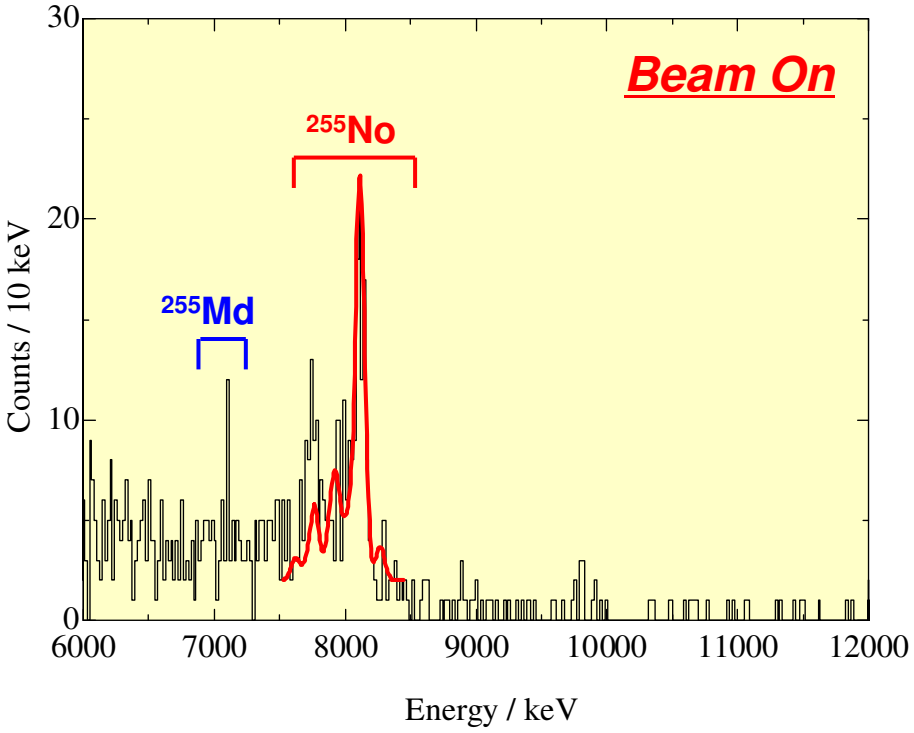
The α-peak of ^{245}Fm is clearly identified.

The transfer reaction products from ^{208}Pb target such as Po isotopes are completely removed.

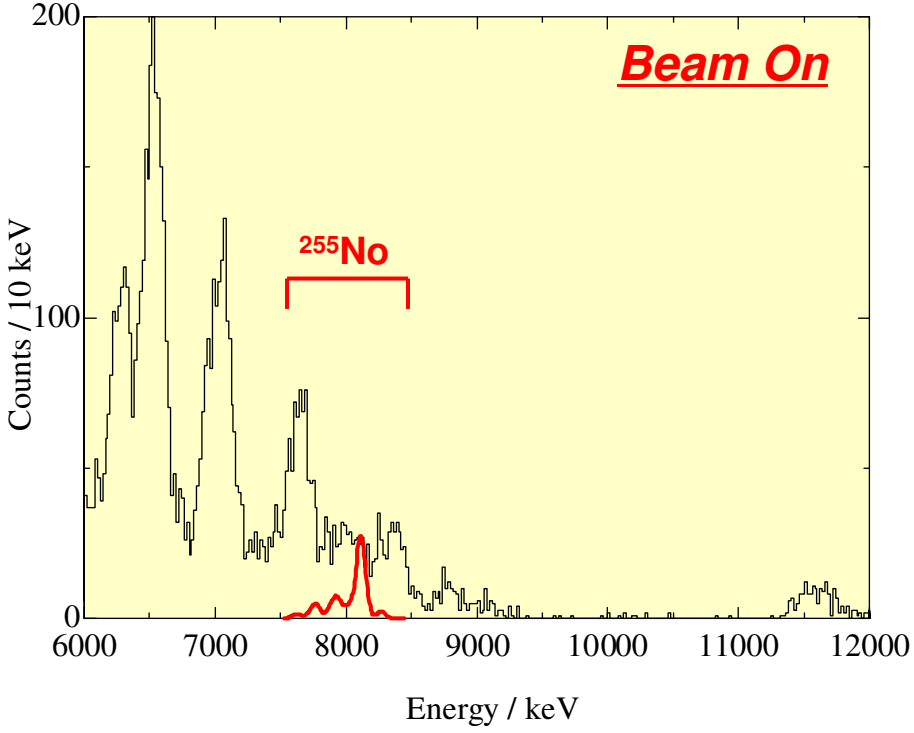
Performance of GARIS system

α-spectrum of $^{238}U(^{22}Ne, 5n)^{255}No$

GARIS / Gas-jet system



Without GARIS



The α spectrum is very complicated.

The α-peaks of ^{255}No are clearly identified.

Chemistry laboratory for the future SHE chemistry

Chemistry laboratory under construction
(1750 x 4280 x 3500 mm^3)

Background level: ~1/100 of that in the irradiation room
Chemistry experiments under low background condition

Summary

- We measured transport efficiency of GARIS and Gas-jet yields.

	GARIS eff.	Gas-jet yield
^{169}Tm(^{40}Ar,3n)^{206}Fr	Not measured	>90%
^{208}Pb(^{40}Ar,3n) ^{245}Fm	45%	75%
^{238}U (^{22}Ne,5n)^{255}No	5.7%	87%

- The transport time from the chamber to MANON is 0.4 s through 4-m capillary 1.6 mm i.d.

GARIS/Gas-jet system expected to be very powerful for the SHE chemistry!!