Perspectives of the superheavy element chemistry at RIKEN GARIS

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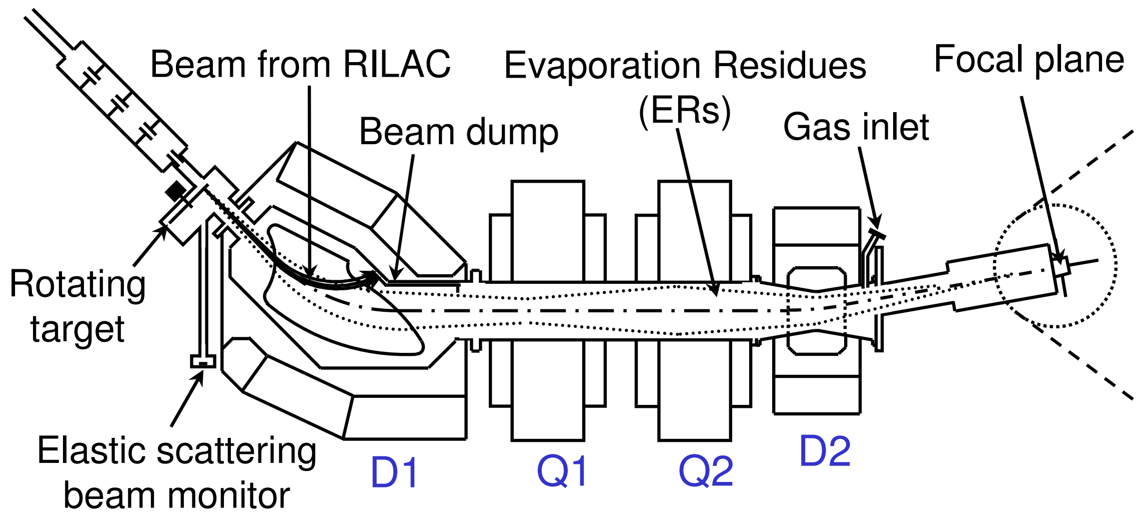
1. Present status of SHE chemistry at RIKEN GARIS

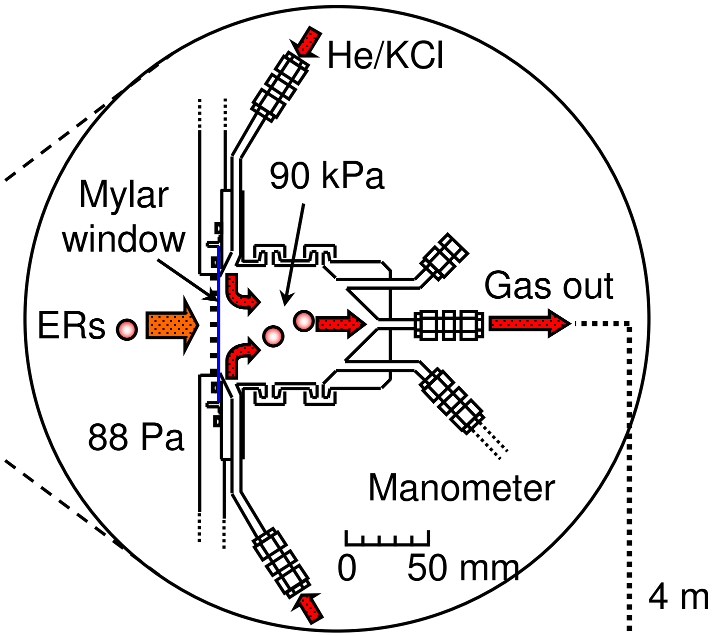
Development of the gas-jet transport system coupled to GARIS

Startup of the SHE chemistry in RIKEN

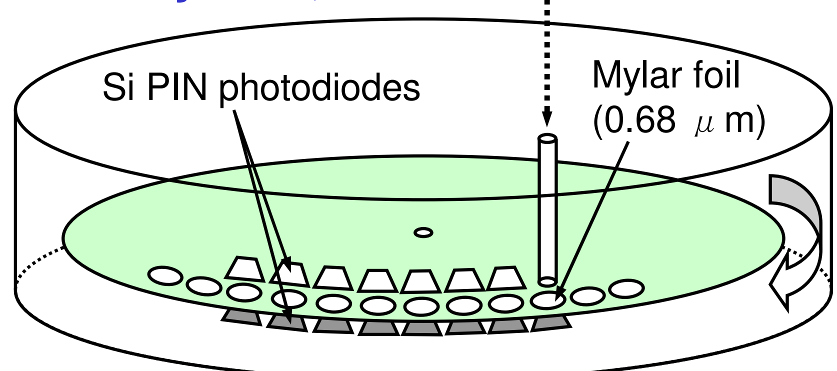
RIKEN GARIS



Gas-jet transport system



Rotating wheel system, MANON



Model experiments

^{169}Tm(^{40}Ar,3n)^{206}Fr (15.9 s)

^{208}Pb(^{40}Ar,3n)^{245}Fm (4.2 s)

^{238}U(^{22}Ne,5n)^{255}No (3.1 min)

Model experiments of the GARIS/gas-jet system

	^{206}Fr	^{245}Fm	^{255}No
Reaction	^{169}Tm(^{40}Ar,3n)	^{208}Pb(^{40}Ar,3n)	^{238}U(^{22}Ne,5n)
Cross section	376 μb[1)]	15 nb[2)]	90 nb[3)]
Beam energy (MeV)	170	199	114
Recoil energy (MeV)	32	32	9.6
Beam intensity (pμA)	2	2	4
Target (μg/cm^2)	120 (Tm)	420 (Pb)	310 (U_3O_8)
Target backing (μg/cm^2)	30 (C)	30 (C)	1270 (Ti)
Magnetic rigidity (Tm)	1.64	2.01	1.93
He pressure (Pa)	88	88	38
Mylar window (μm)	3.5	3.5	1.0
Support grid (%)	89	89	72
Gas-jet eff. (%)	88 ± 4	83 ± 9	84 ± 9
GARIS eff. (%)	-	43 ± 4	5 ± 1

1) D. Vermeulen et al.: Z. Phys. A **318**, 157 (1984).
2) J. M. Nitschke et al.: Nucl. Phys. **A313**, 236 (1980).
3) This work

2. Future plans

2.1. Production of SHE nuclides for chemical experiments

(a) ^{238}U target

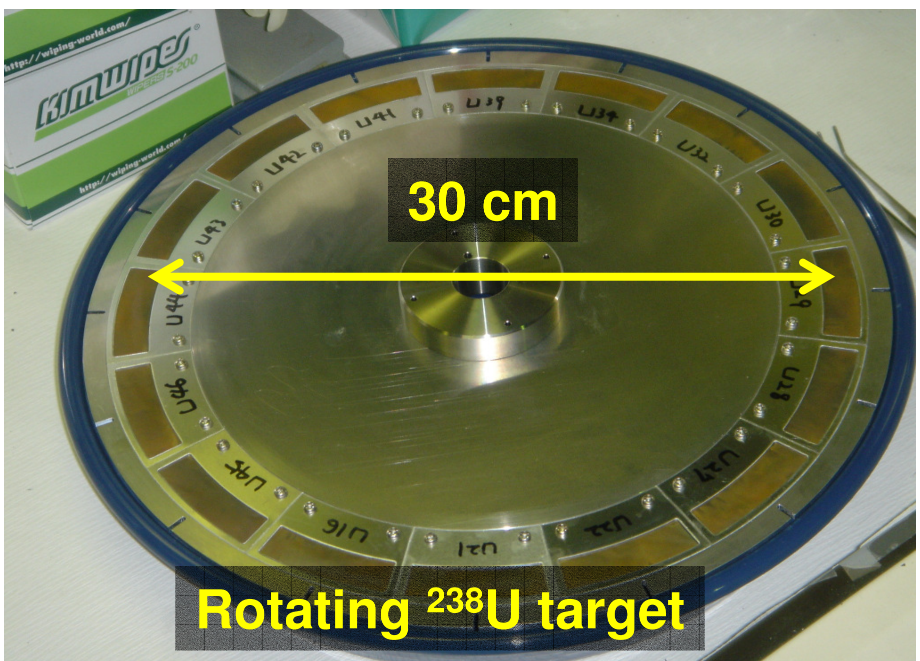
$Z = 104$ $^{238}U + ^{26}Mg \rightarrow ^{259}Rf + 5n$: Oct. 8–10, 2007

- Acceleration of the ^{26}Mg beam at RILAC (~2 pμA)
- Production and gas-jet transport of ^{259}Rf ($T_{1/2} = 3.0$ s)

  Optimization of the setting parameters of GARIS and the gas-jet system

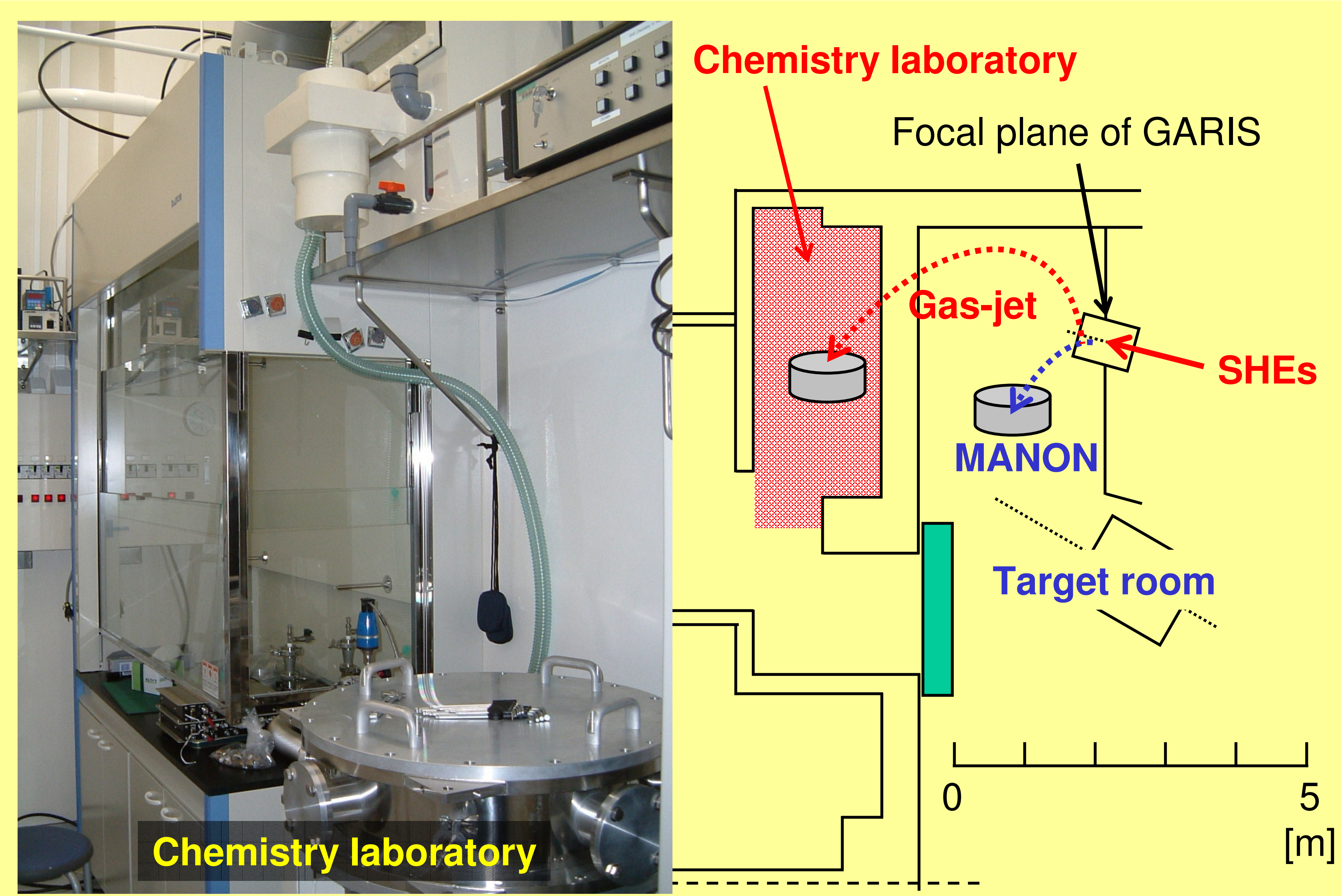
  $^{238}U + ^{26}Mg \rightarrow ^{261}Rf$ ($T_{1/2} = 78$ s) $+ 3n$?

  Background in α-spectrometry at the new chemistry laboratory



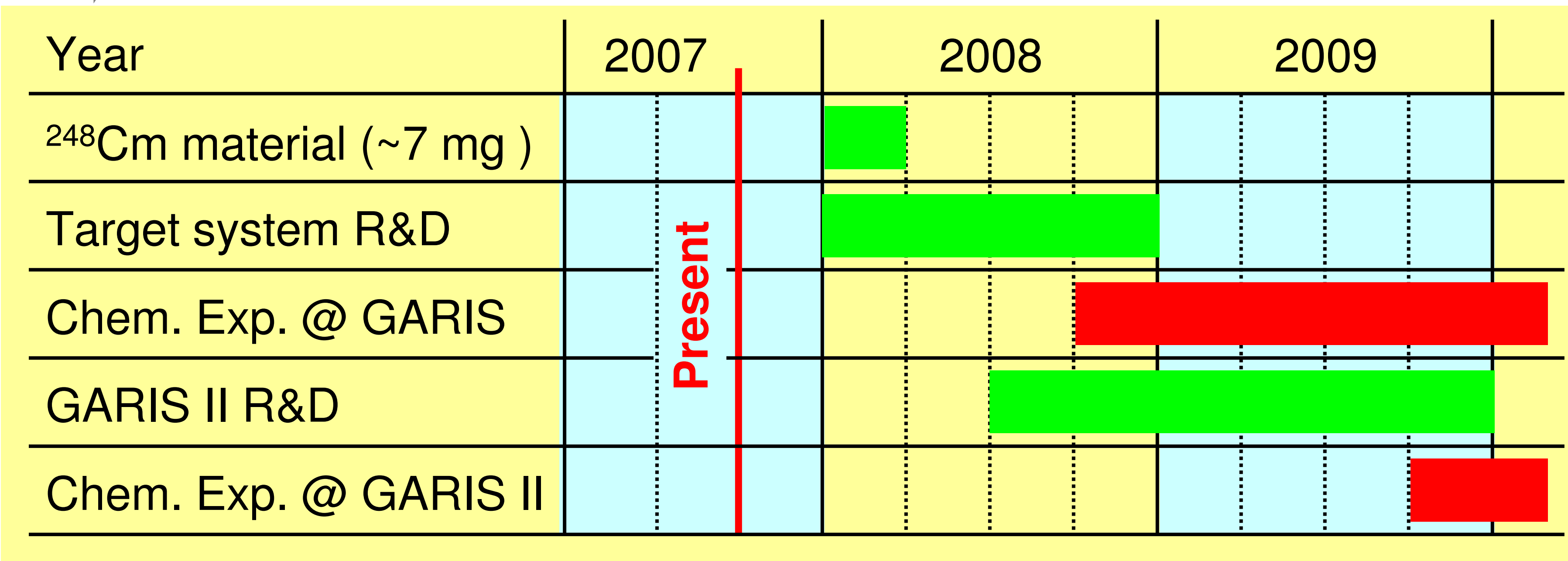
Chemistry laboratory for the SHE chemistry

Background level: ~1/100 of that in the target room



(b) ^{248}Cm target and GARIS II

→ *Great advantage for future SHE chemistry !!*



GARIS/gas-jet setting parameters, decay properties, and excitation functions

$Z = 104$	^{248}Cm + ^{18}O $\longrightarrow$ ^{261}Rf + 5n
$Z = 105$	^{248}Cm + ^{19}F $\longrightarrow$ ^{262,263}Db + 5;4n
$Z = 106$	^{248}Cm + ^{22}Ne $\longrightarrow$ ^{265,266}Sg + 5;4n
$Z = 107$	^{248}Cm + ^{23}Na $\longrightarrow$ ^{266,267}Bh + 5;4n ?
$Z = 108$	^{248}Cm + ^{26}Mg $\longrightarrow$ ^{269,270}Hs + 5;4n
$Z = 109$	^{248}Cm + ^{27}Al $\longrightarrow$ ^{270,271}Mt + 5;4n ?

Yields of SHE nuclides for chemistry experiments (rough estimation)

Z	Reaction	σ (pb)	GARIS I Eff. (%)	GARIS I Yield (1/d)	GARIS II Eff. (%)	GARIS II Yield (1/d)
104	$^{248}Cm(^{18}O,5n)^{261}Rf$	13000	3.4	**700**	11.1	**2300**
105	$^{248}Cm(^{19}F,5n)^{262}Db$	1500	4.2	**98**	13.4	**320**
106	$^{248}Cm(^{22}Ne,5n)^{265}Sg$	240	6.9	**26**	21.6	**82**
107	$^{248}Cm(^{23}Na,5n)^{266}Bh$	37*	8.2	**4.8**	25.1	**15**
108	$^{248}Cm(^{26}Mg,5n)^{269}Hs$	6	12.5	**1.2**	36.4	**3.4**
109	$^{248}Cm(^{27}Al,5n)^{270}Mt$	0.71*	14.4	**0.16**	40.8	**0.46**

Preliminary!

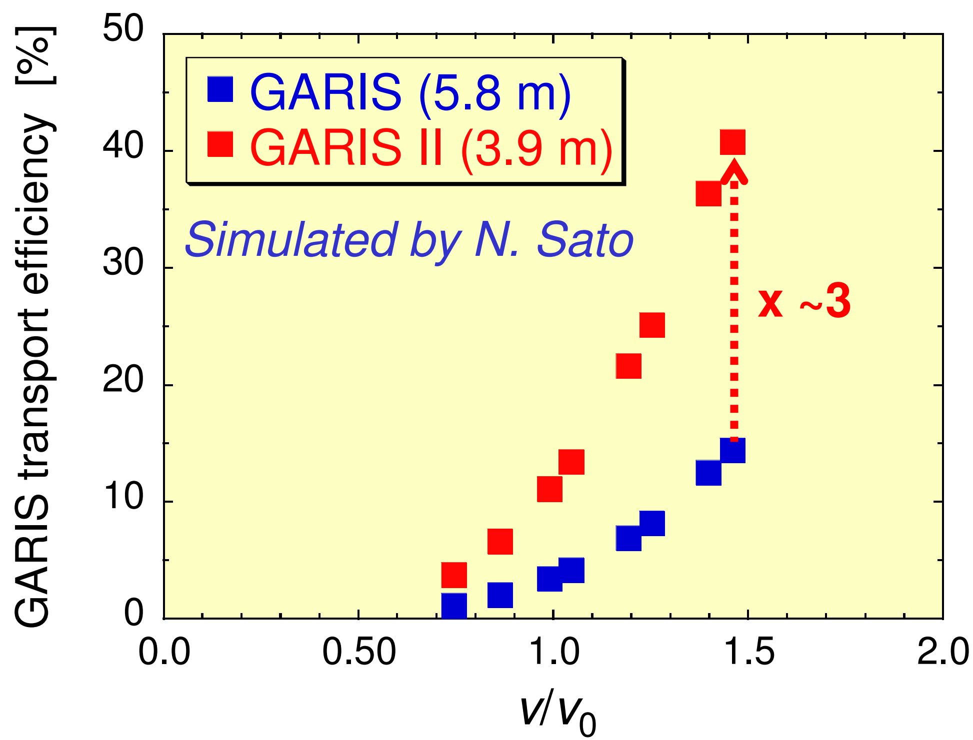
Assumptions

- Target thickness: 300 μg/cm^2
- Beam intensity: 5 pμA
- Gas-jet transport efficiency: 80%
- * from the σ vs. Z systematics
- Transport efficiency of GARIS

  Focal plane size: Φ60mm

  He pressure: 0.28 torr

  Length of GARIS II: 3.9 m



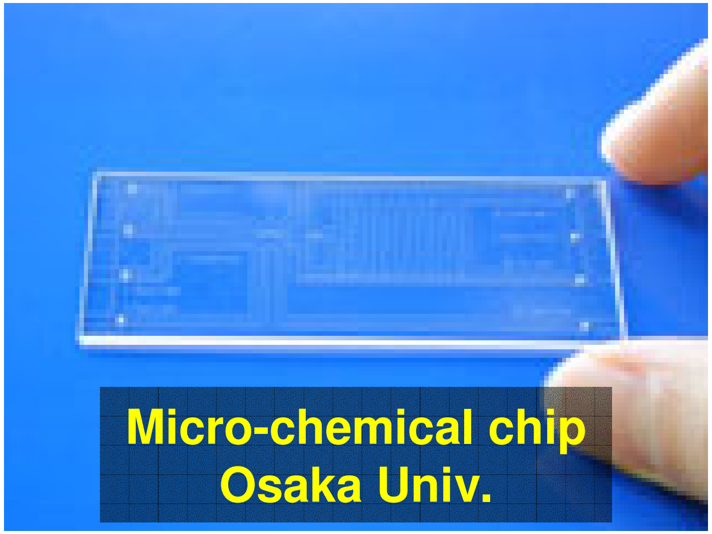
2.2. Chemistry apparatus

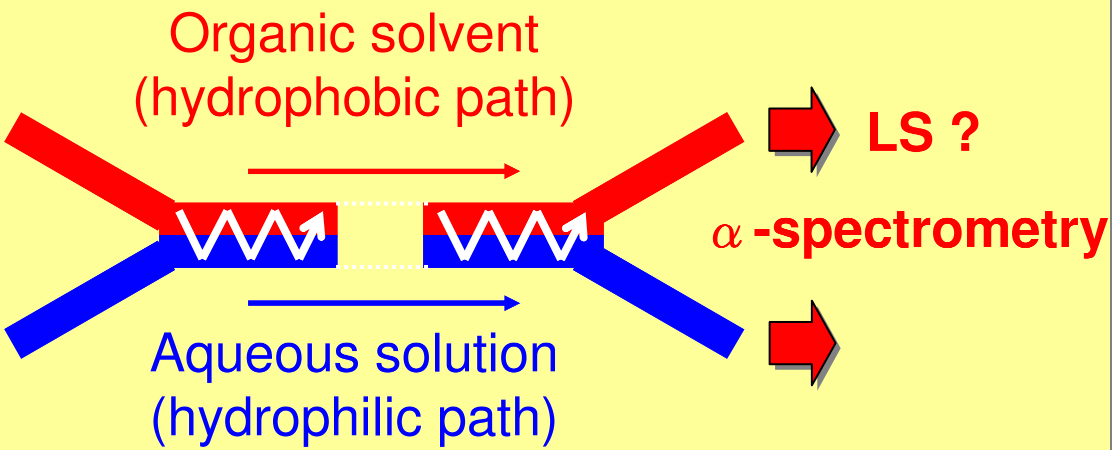
(a) Micro-chemical chip for ion exchange and solvent extraction

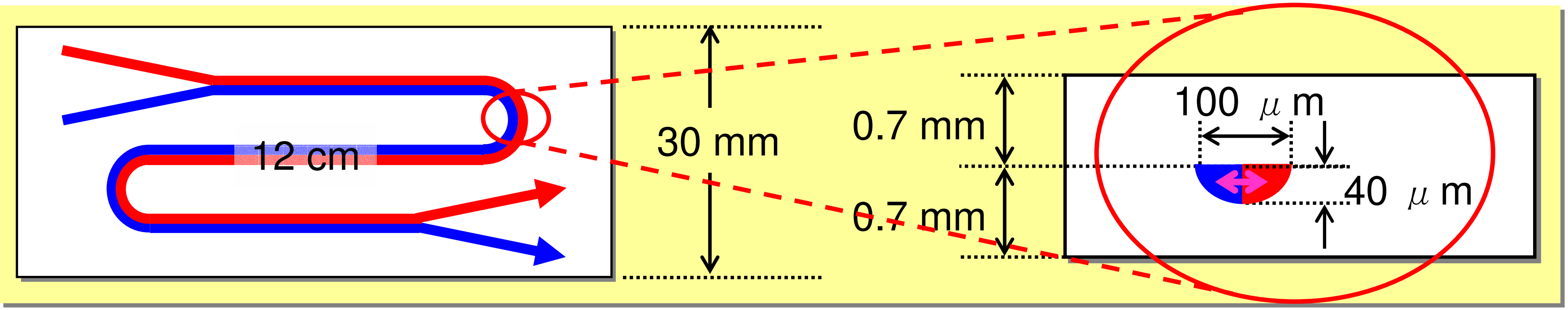
Micro flow path on glass or plastic surface

Laminar flow of aq. solution and org. solvent
Large relative interaction area
Short diffusion length

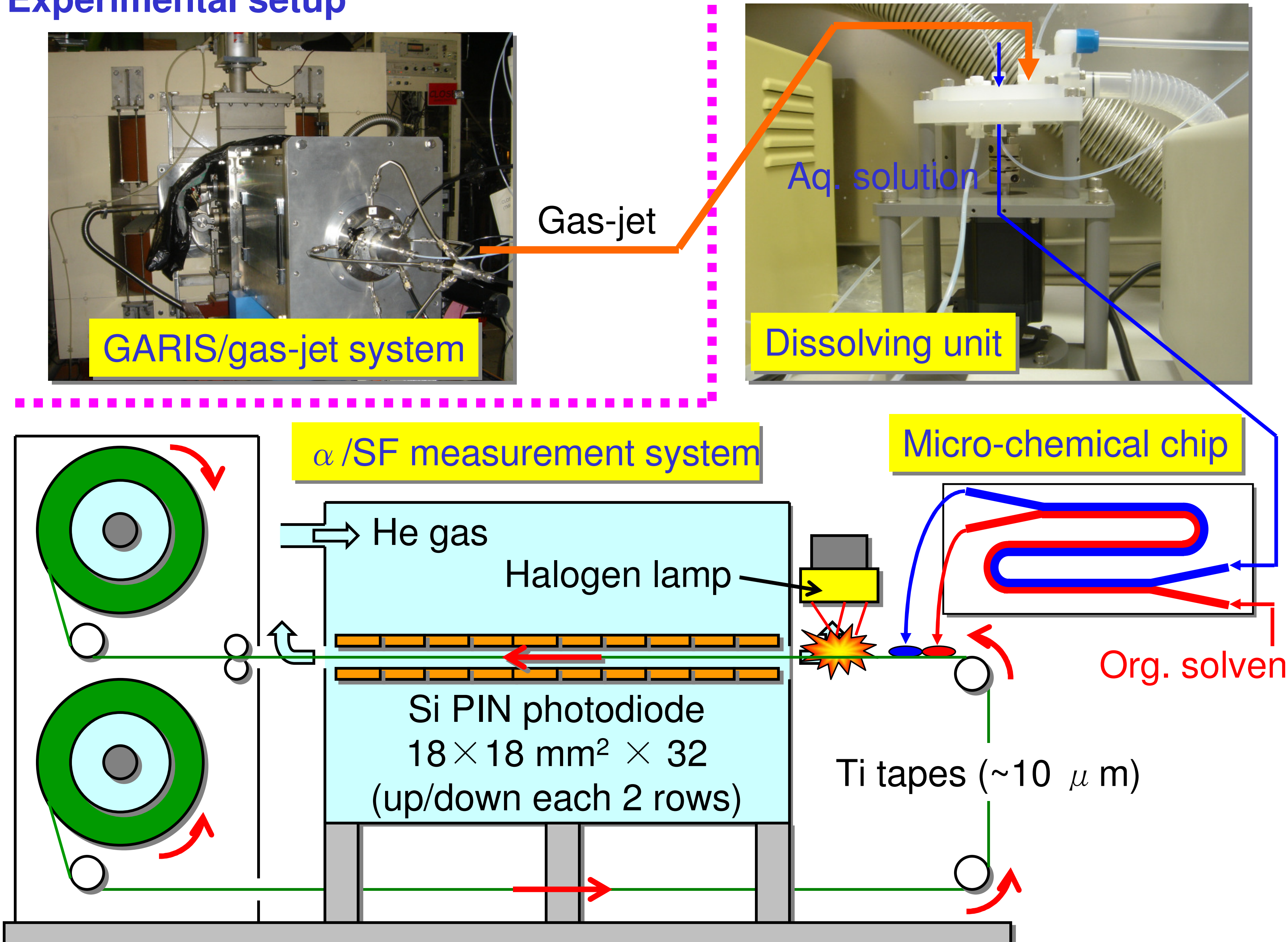
Rapid ion exchange and solvent extraction
Determination of distribution coefficient



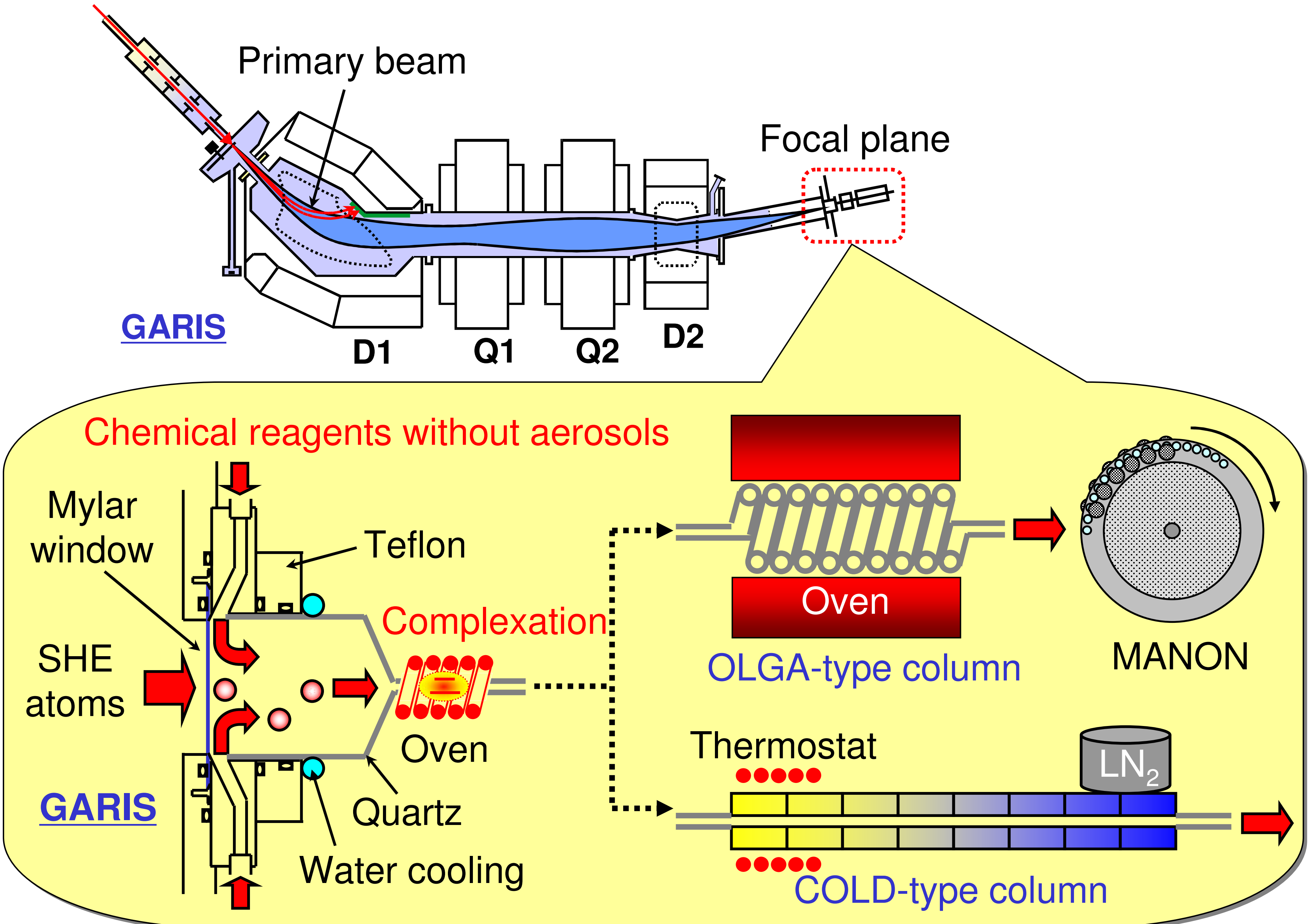




Experimental setup



(b) Gas chromatograph column coupled to GARIS



3. Summary

Present status of SHE chemistry at RIKEN GARIS

- Development of a gas-jet transport system coupled to GARIS
- Model experiments

^{169}Tm(^{40}Ar,3n)^{206}Fr, ^{208}Pb(^{40}Ar,3n)^{245}Fm, and ^{238}U(^{22}Ne,5n)^{255}No

Future plans

(a) Production of SHE nuclides for chemical experiments

- ^{238}U(^{26}Mg,5n)^{259}Rf on Oct. 8–10, 2007
- ^{248}Cm target (end of 2008) and GARIS II (end of 2009)

(b) New chemistry apparatus

- Micro-chemical chip for ion exchange and solvent extraction
- Gas chromatograph column coupled to GARIS

The 2nd Workshop on SHE chemistry @ RIKEN in the end of 2007

What chemistries should be studied at RIKEN GARIS ?

Collaborators

RIKEN

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Thank you very much!

Participants in the 1st Workshop on SHE chemistry @ RIKEN (27 Aug. 2007)