^{8}Li and ^{18}F Diffusion Experiments in Solid -An Application of Accelerated RNB-

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Outline

1. **Why diffusion studies with RNB?**
2. **^{8}Li diffusion in Li inter-metallic compound**
3. **^{18}F diffusion in super-ionic conductor**
4. **Another application of RNB to material science**
   -Polarized RNB; some trials on tilted foil method-
5. **Conclusions**

To be operational in 2004 !

TRIAC (Tokai Radioactive Ion Accelerator Complex)

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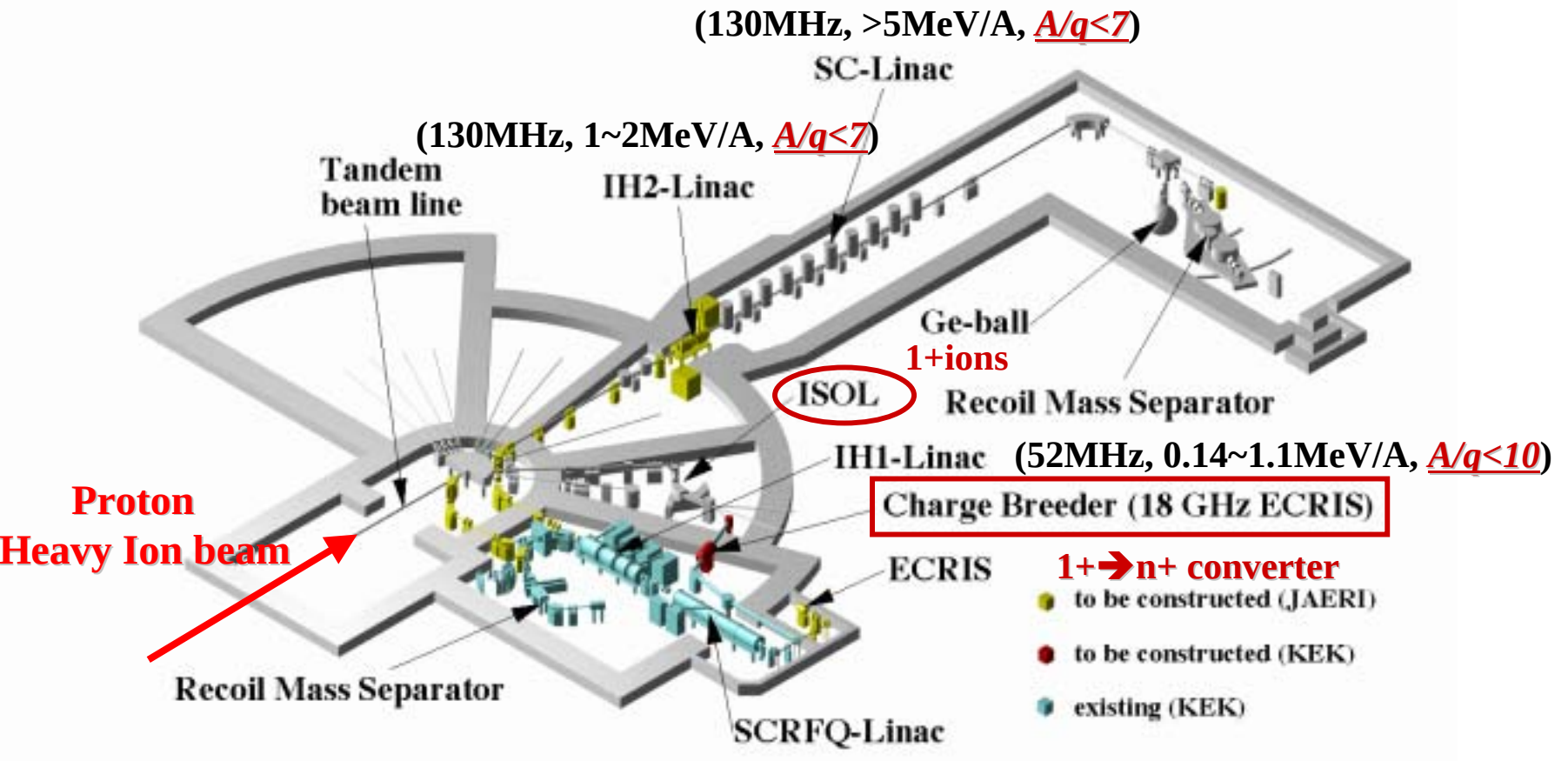
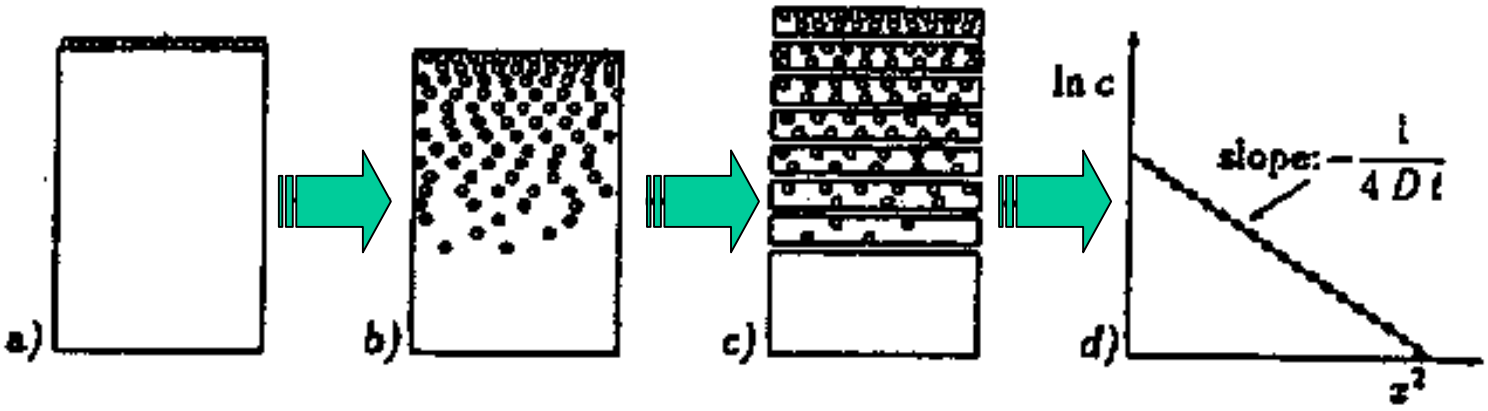


The main steps of the radiotracer method (conventional)



(a) Deposition of the radiotracer onto the sample surface

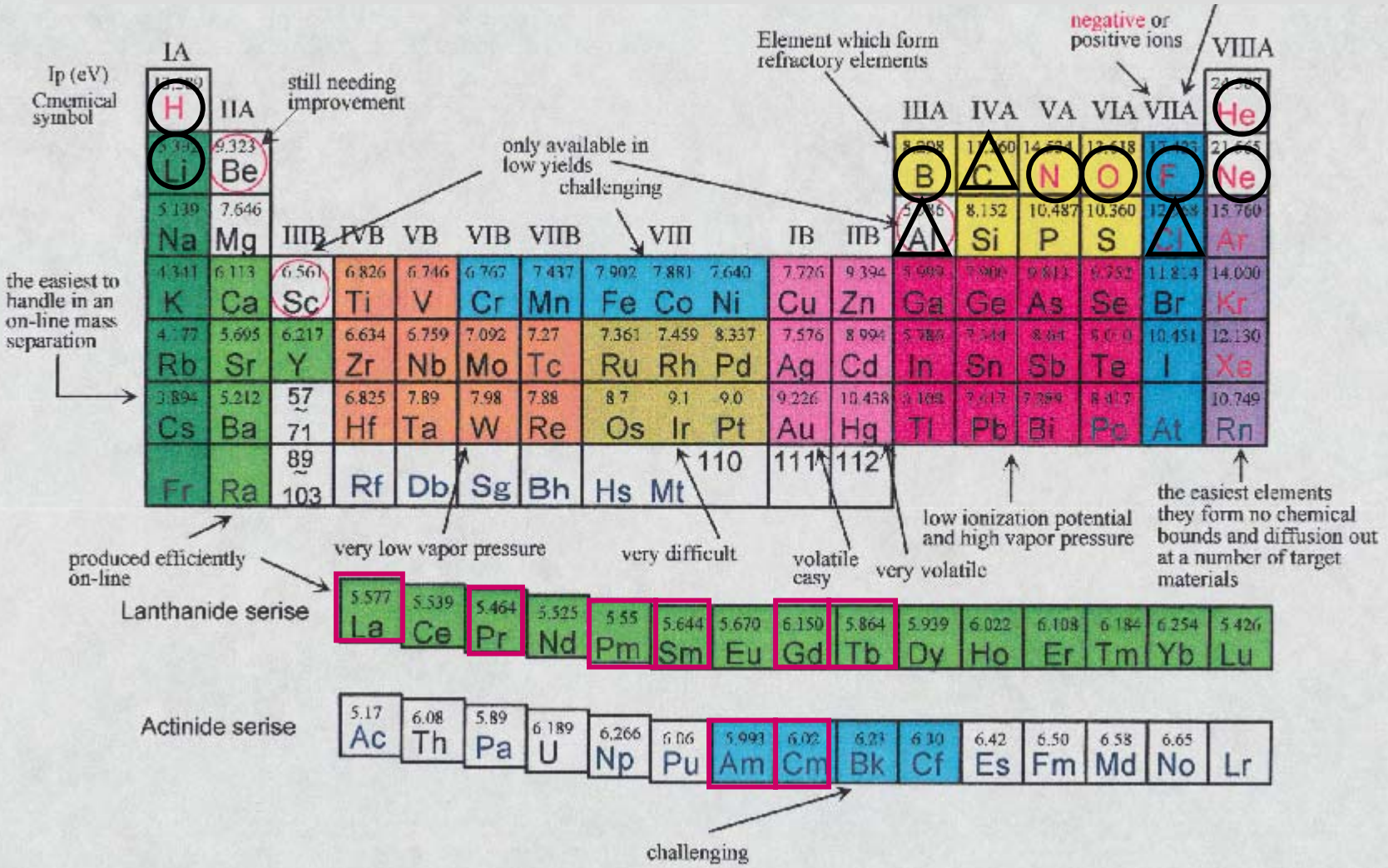
(b) Diffusion annealing for a certain time period ➔ Frozen

(c) Sample sectioning (lathes,microtomes,grinding machines,IBS)

(d) The *concentration-depth profile* for a fixed Dt

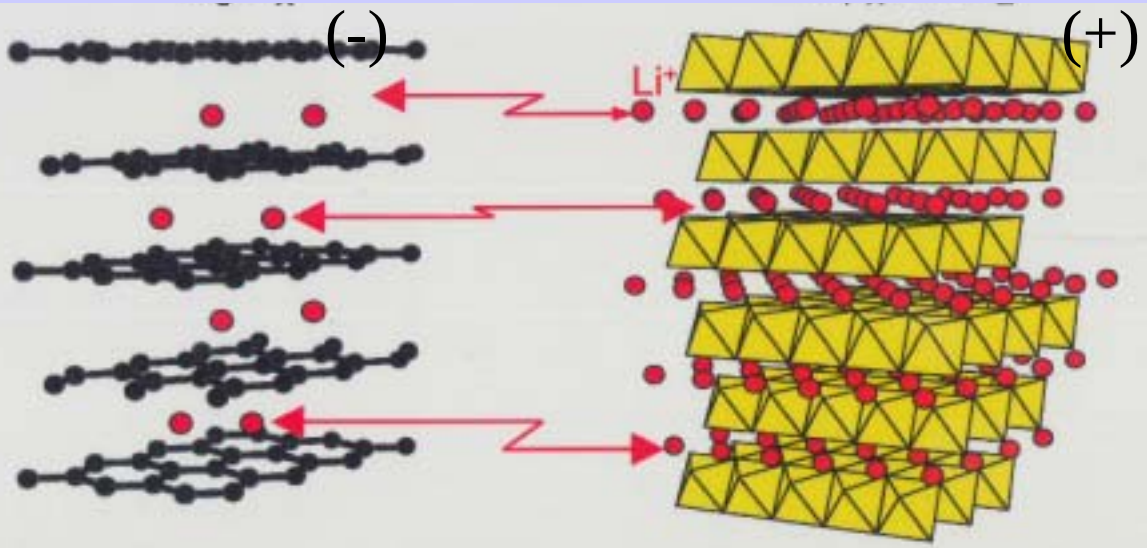
(for a thin film solution of Fick's 2nd law)

There are no radioisotopes with lifetimes (indicated by ○ △) adequate for conventional radiotracer diffusion experiments.



ISOL Ion Sources : *Surface Ionization, FEBIAD, Resonant Ionization* (laser)

Charge-discharge in Secondary Li ion battery



- Charge carrier : Only Li^+ ions **Electrodes**

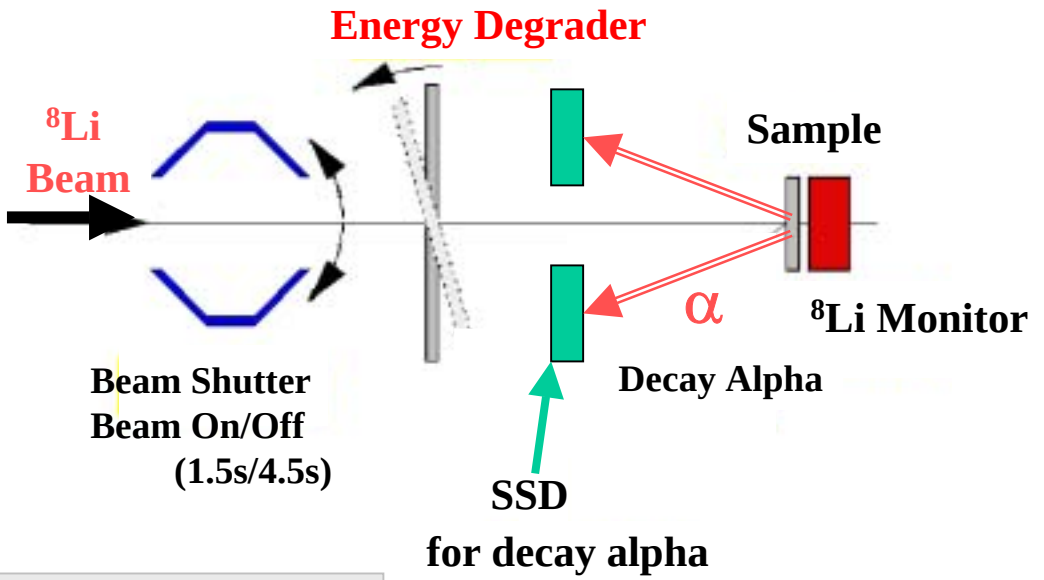
$$C_6 + LiCoO_2 \leftrightarrow C_6Li_x + Li_{1-x}CoO_2$$

- Solid Electrolyte ← **Super Solid Ion Conductors**

  -High ion conductivity & high dielectric constants

  -Solid battery / Interface (micro-battery)

Diffusion studies with ^{8}Li(half-life: 0.83s)



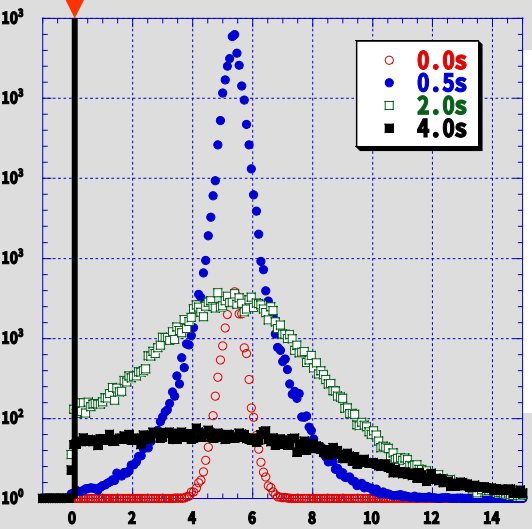
- Beam energy : 14.6MeV (4% FWHM)
  (JAERI-RMS: ^{9}Be(^{7}Li,^{8}Li) :2.5kpps/30nA
- Beam On/Off : 1.5s / 4.5s
- Optimize the implantation depth by an energy degrader (Al foil)
- Measure decay-alpha

→ < 8MeV (2% FWHM)
~1x10^{7}pps
@KEK-JAERI RNB Facility

Time spectra of alpha yields (E_a>400keV)

Diffusing ^{8}Li:
Corrected for trivial time-dependence
(growth and decay of the radioactivity)

ample surface



Expected profile
in the sample

In LiAl @~20°C

Alpha

^{8}Li

Yields/40ms

Ratio(Y_{alpha}/Y_{8Li})

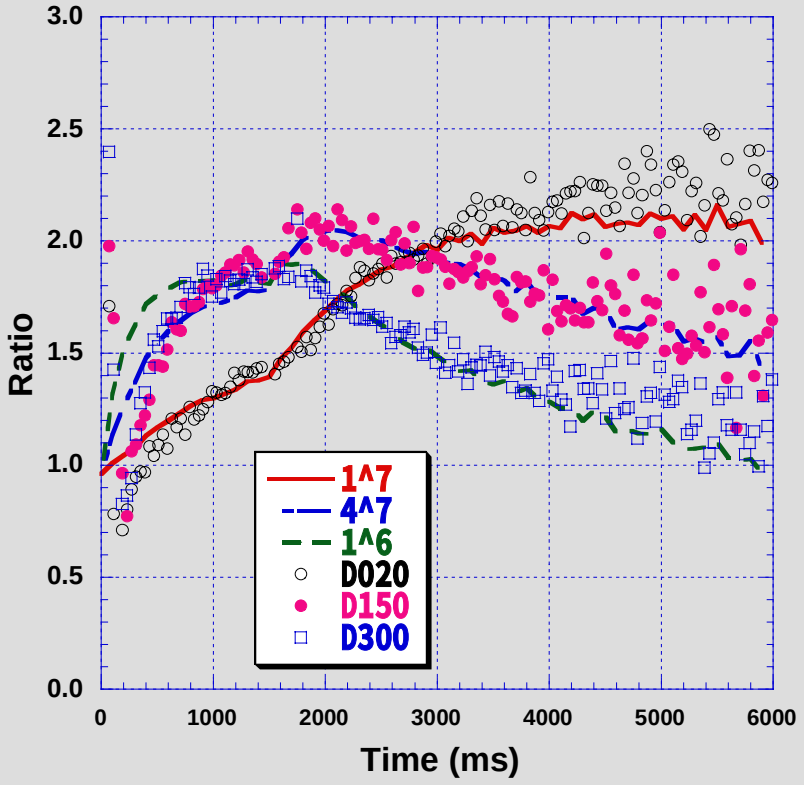
Irradiation & Diffusion (growth)

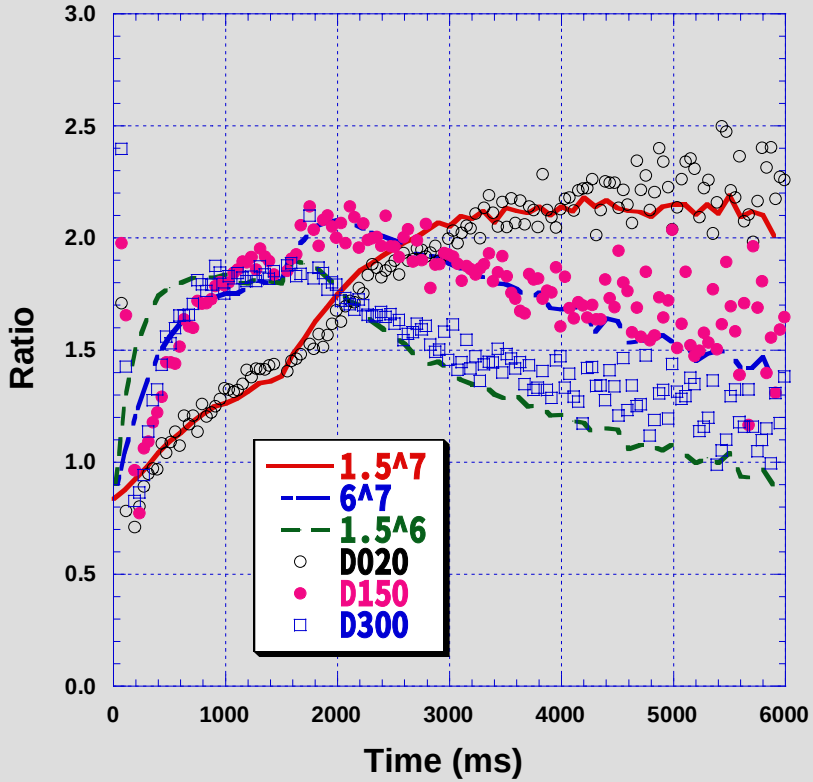
Only Diffusion (decay)

Time (40ms/channel)

Simulation
v.s. Data (@20°C (○), 150°C (●) and 300°C (□))

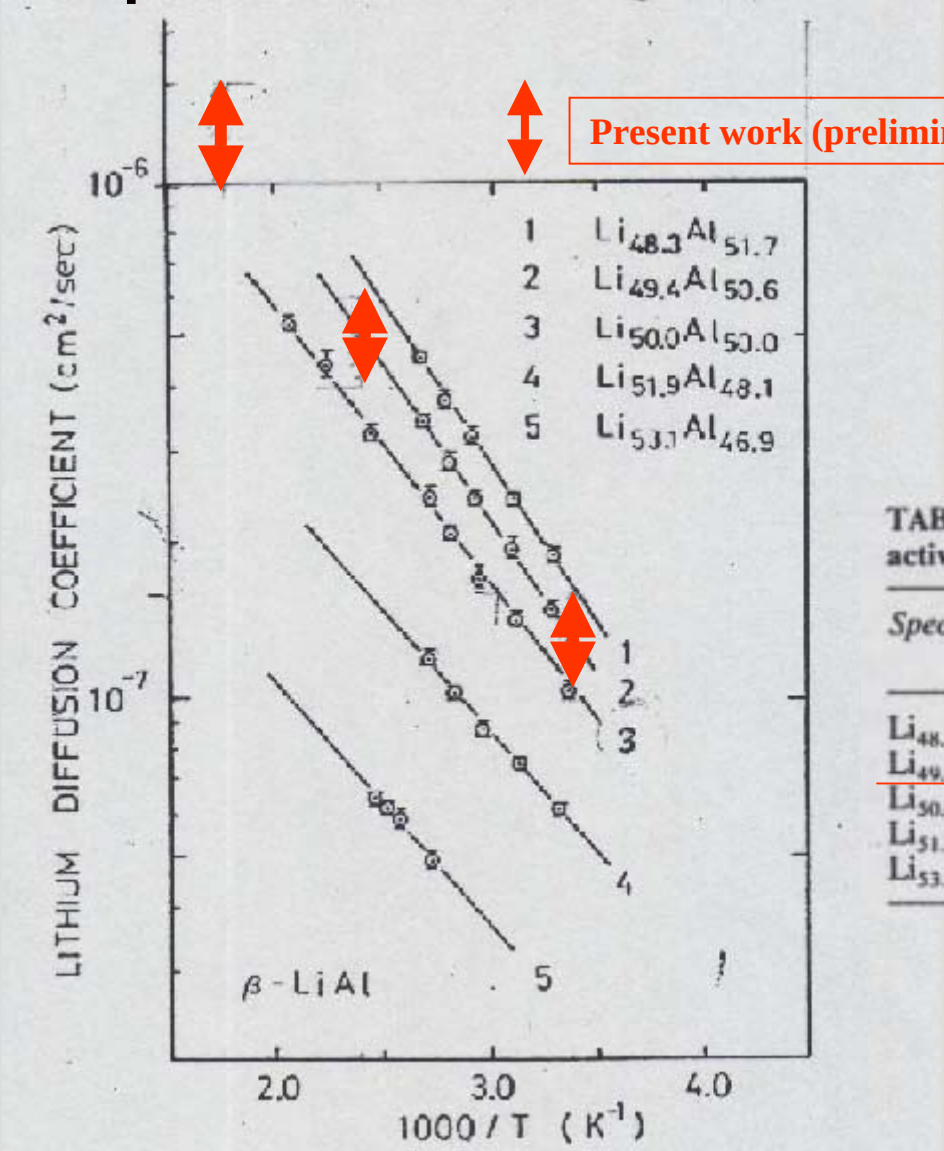
Mean depth → 10μm 11μm





c.f. TRIM : 12.3μm (3.2μm FWHM) in LiAl
Total ~40μm (14.6MeV ^{8}Li)

Compared to NMR measurements



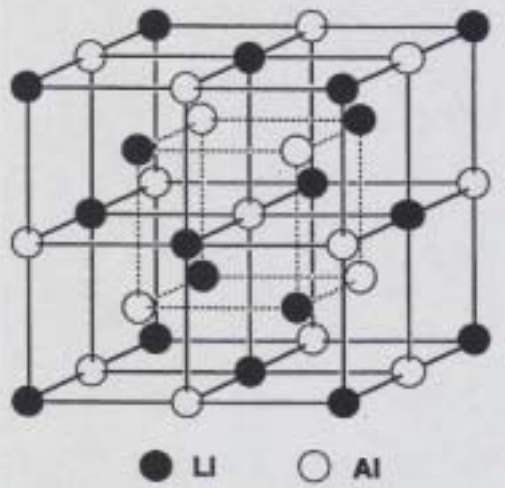
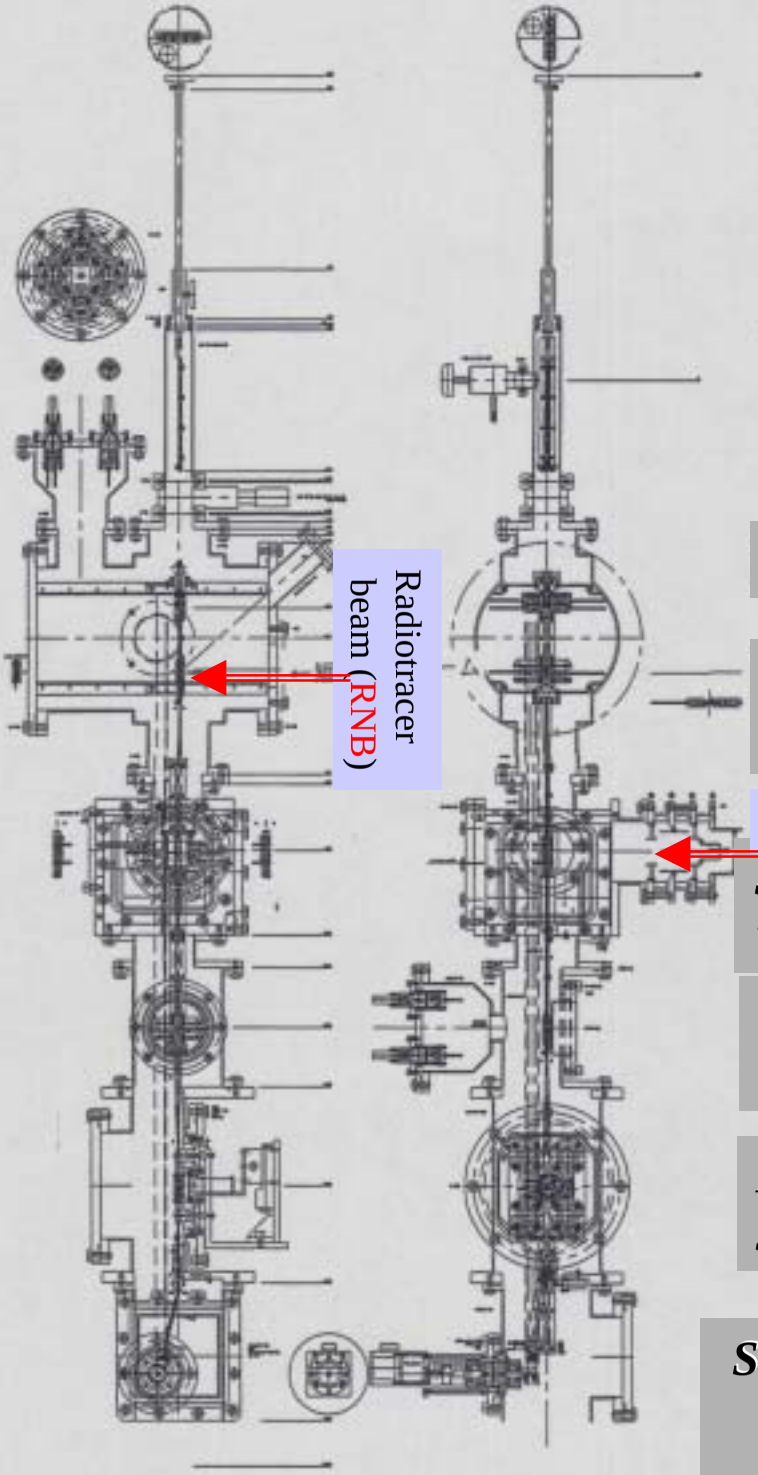


TABLE 2 Values of observed diffusion constant D_0(Li) and activation energy $\langle E \rangle$ in β-LiAl

Specimen	D_0(Li) ($cm^2 s^{-1}$)	$\langle E \rangle$ (eV)
$Li_{48.3}Al_{51.7}$	$(2.54 \pm 0.09) \times 10^{-5}$	0.128 ± 0.003
$Li_{49.4}Al_{50.6}$	$(1.56 \pm 0.08) \times 10^{-5}$	0.121 ± 0.002
$Li_{50.0}Al_{50.0}$	$(8.34 \pm 0.50) \times 10^{-6}$	0.113 ± 0.002
$Li_{51.9}Al_{48.1}$	$(2.34 \pm 0.34) \times 10^{-6}$	0.095 ± 0.003
$Li_{53.1}Al_{46.9}$	$(7.58 \pm 0.03) \times 10^{-7}$	0.087 ± 0.004

J.C. Tarczon et al.
Mat. Sci. and Eng. A101 (1988) 99



Radiotracer beam (RNB)

Sample stack

Irradiation & Diffusion

Ion Beam from ECRIS

Sputtering & Tape-collection

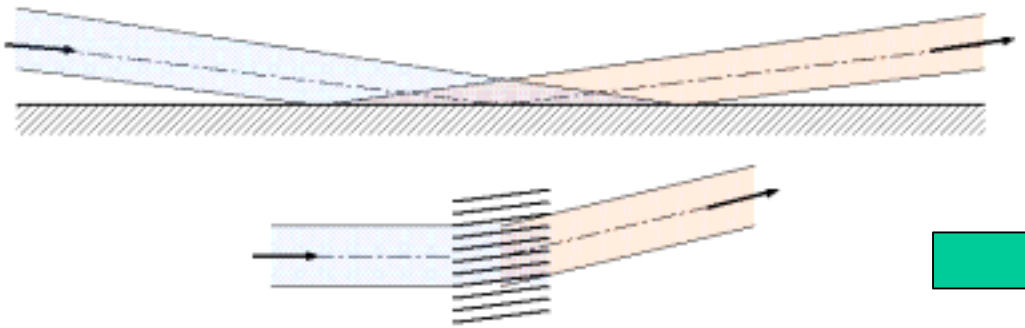
Measuring residual activity

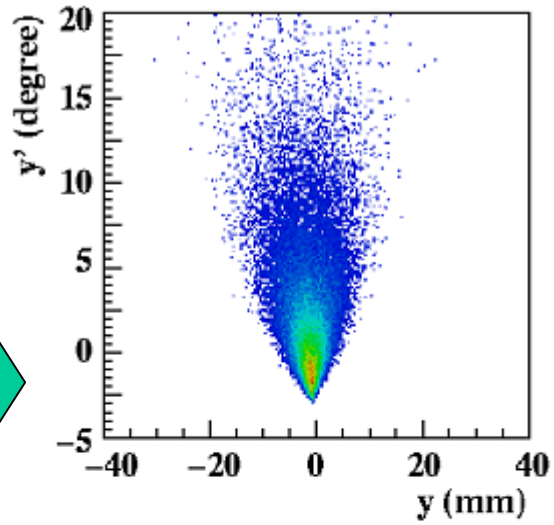
Measuring sputtered depth

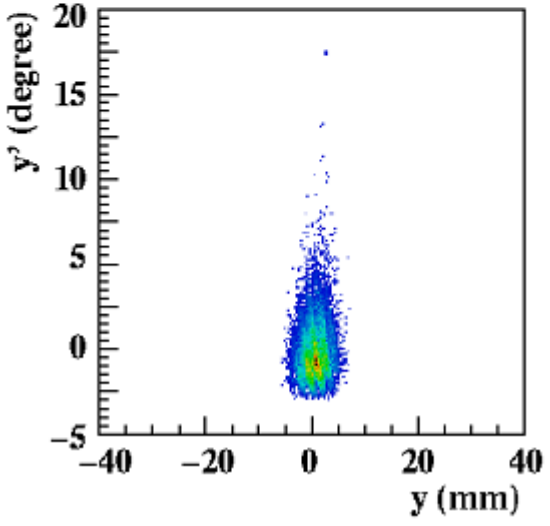
Sample conveyor (switchback or collection)

Experimental equipment for diffusion studies using RNB

Polarized RNB:
-folded tilted foil scatter method-







Schematic view of foil geometries with large tilted angle.
Typical (upper) and **folded**(Lower) **geometries** are compared.

Expected beam emmitance of ions scattered by the respective geometry.

Conclusions

1. **RNBs of 1MeV/u, soon available at JAERI-Tokai, are useful as a probe for materials science.**
2. **^{8}Li and ^{18}F will be used as radiotracers for diffusion studies in Li and F compounds**
3. **A prototype experiment with ^{8}Li ($T_{1/2}$=0.83s) has shown its effectiveness for diffusion studies of LiAl compounds.**
4. **We will also develop a tilted foil method further for the polarization of RNB.**