# Gamow-Teller transitions in $^{37}Cl(^{3}He, t)^{37}Ar$ and $^{37}Ca \rightarrow ^{37}K$ $\beta$-decay

## 鏡映対称な$^{37}Cl(^{3}He, t)^{37}Ar$反応と$^{37}Ca \rightarrow ^{37}K$ $\beta$崩壊におけるGamow-Teller遷移

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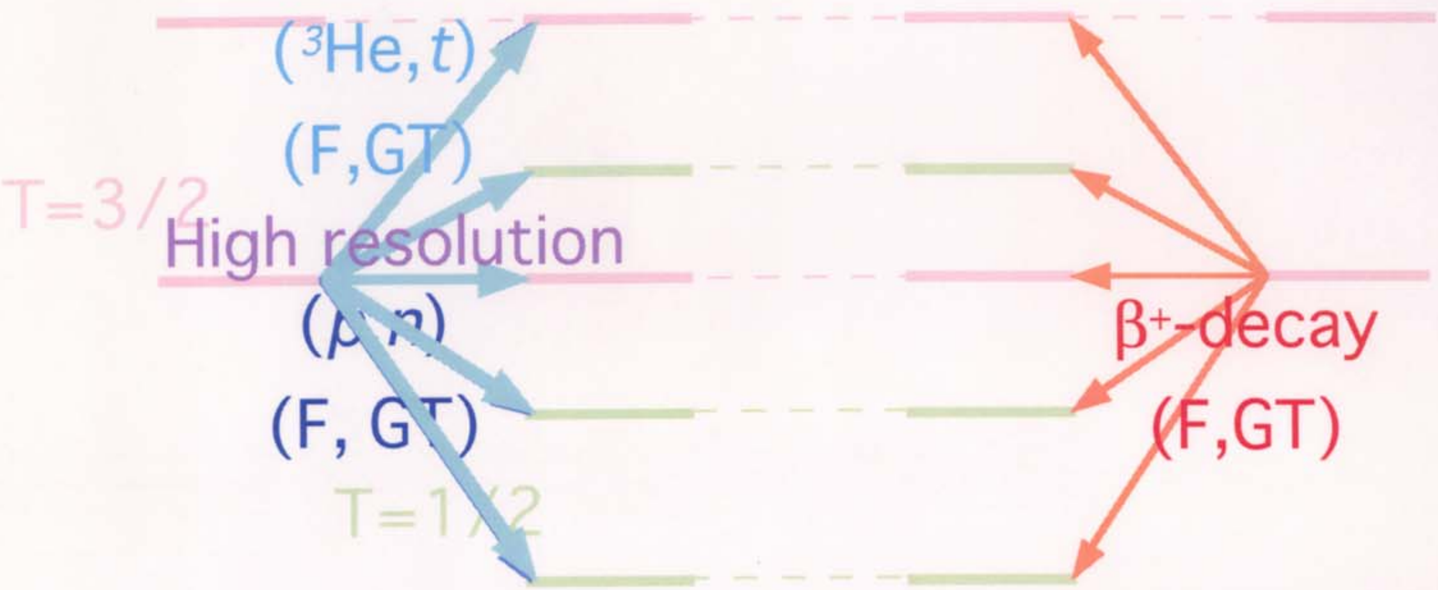
## Abstract

- $^{37}Cl(^{3}He, t)^{37}Ar$ experiment was performed.
- *B*(GT) values of $^{37}Cl \rightarrow ^{37}Ar$ transition were extracted.
- The *B*(GT) were compared with those of $^{37}Ca \rightarrow ^{37}K$ transitions by $\beta$-decay measurements.

⇒ Neutrino detector $^{37}Cl + \nu_e \rightarrow ^{37}Ar + e^-$

# Isospin Symmetry Structure of $T$=1/2 and $T$=3/2 System




$T_z$= 3/2 $T_z$=1/2 $T_z$= -1/2 $T_z$= -3/2

$^{37}_{17}Cl_{20}$ $^{37}_{18}Ar_{19}$ $^{37}_{19}K_{18}$ $^{37}_{20}Ca_{17}$

Stable

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If **Isospin symmetry** is valid,

$^{37}Cl \rightarrow {}^{37}Ar$ ⟷ $^{37}Ca \rightarrow {}^{37}K$

Same $B$(GT) values

**Purpose** $^{37}Cl(^3He, t)^{37}Ar$ (High resolution)

$^{37}Cl \rightarrow {}^{37}Ar$ ◀ Comparison of $B$(GT) values ▶ $^{37}Ca \rightarrow {}^{37}K$

## Simple transition

### β decay

$$B(F)+\left(\frac{g_A}{g_V}\right)^2 B(GT)=\frac{K}{ft}$$

⇒ $B$(GT)

$f$: Phase space factor (calculated)

$t_{1/2}$ : Half life

### ($p$,$n$) type reaction

⇒ $E_{\mathrm{beam}} \geqq 100$ MeV/u

⇓

$\sigma\tau$  $\Delta S=1$, $\Delta T=1$

2-step transition ⇒ Small

Distortion ⇒ Small

⇒ $q \sim 0$  (θ=0° )

⇓

$\sigma\tau$  $\Delta S=1$, $\Delta T=1$

$\Delta L \neq 0$ ⇒ Small

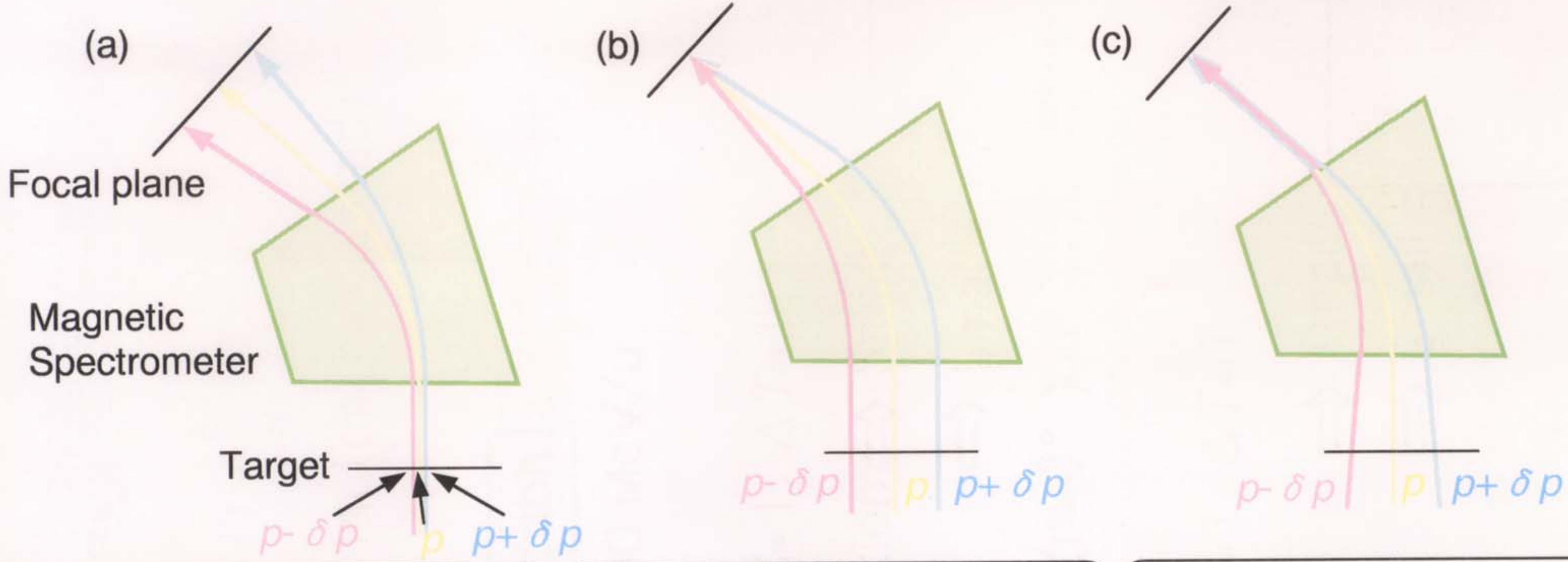
Tensor term ⇒ Small ⇒ (depend on shell model configuration)

$$\frac{d\sigma}{d\Omega}=\hat{\sigma}\cdot B(GT)$$

# Dispersion matching technique

Y. Fujita et al.,
Nucl. Inst. and Meth. in Phys. Res. B 126 (1997) 274.

H. Fujita et al.,
Nucl. Inst. and Meth. in Phys. Res. A Accepted for publication




**Achromatic beam transportation**

$\Delta E \sim$ 200keV
for 140MeV/u $^3$He beam

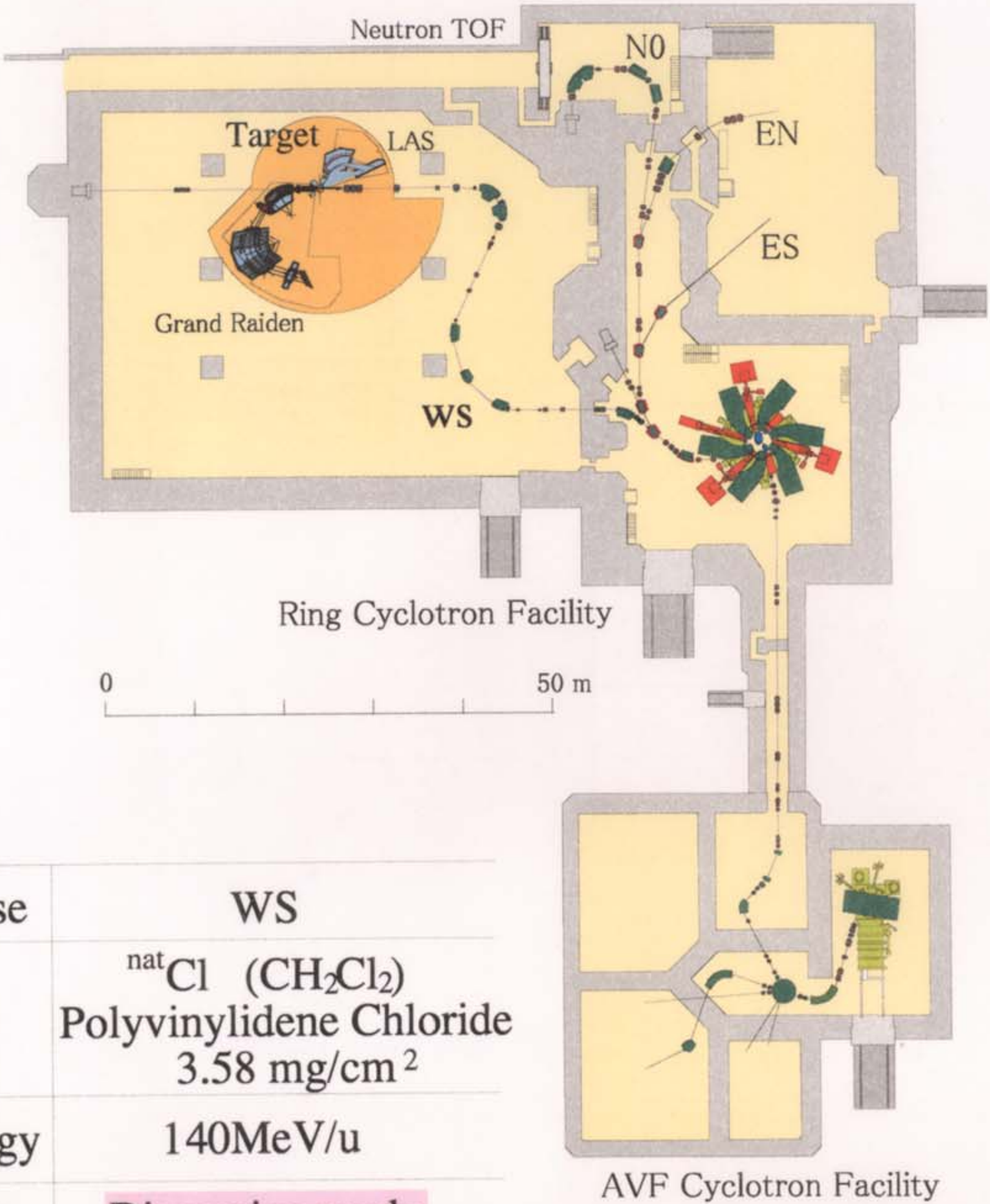
**Lateral dispersion matching**

$\Delta E \sim$ 25keV (resolving power)
$\Delta E \sim$ 55keV (target effect)
Horiz. angle resolution
$\Delta\theta_{SC} >$ 15mrad

**Angular dispersion matching**

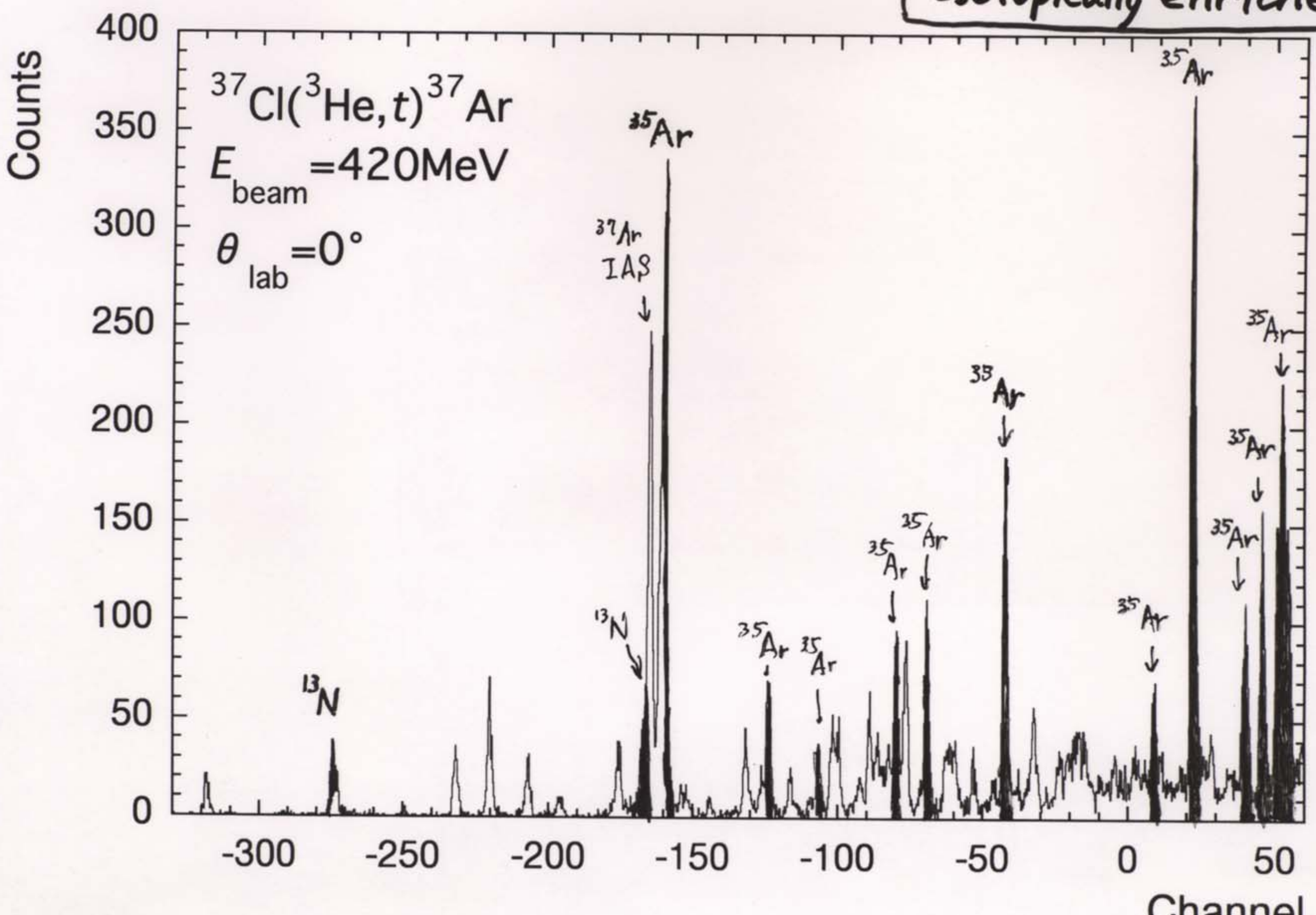
$\Delta\theta_{SC} \sim$ 5mrad

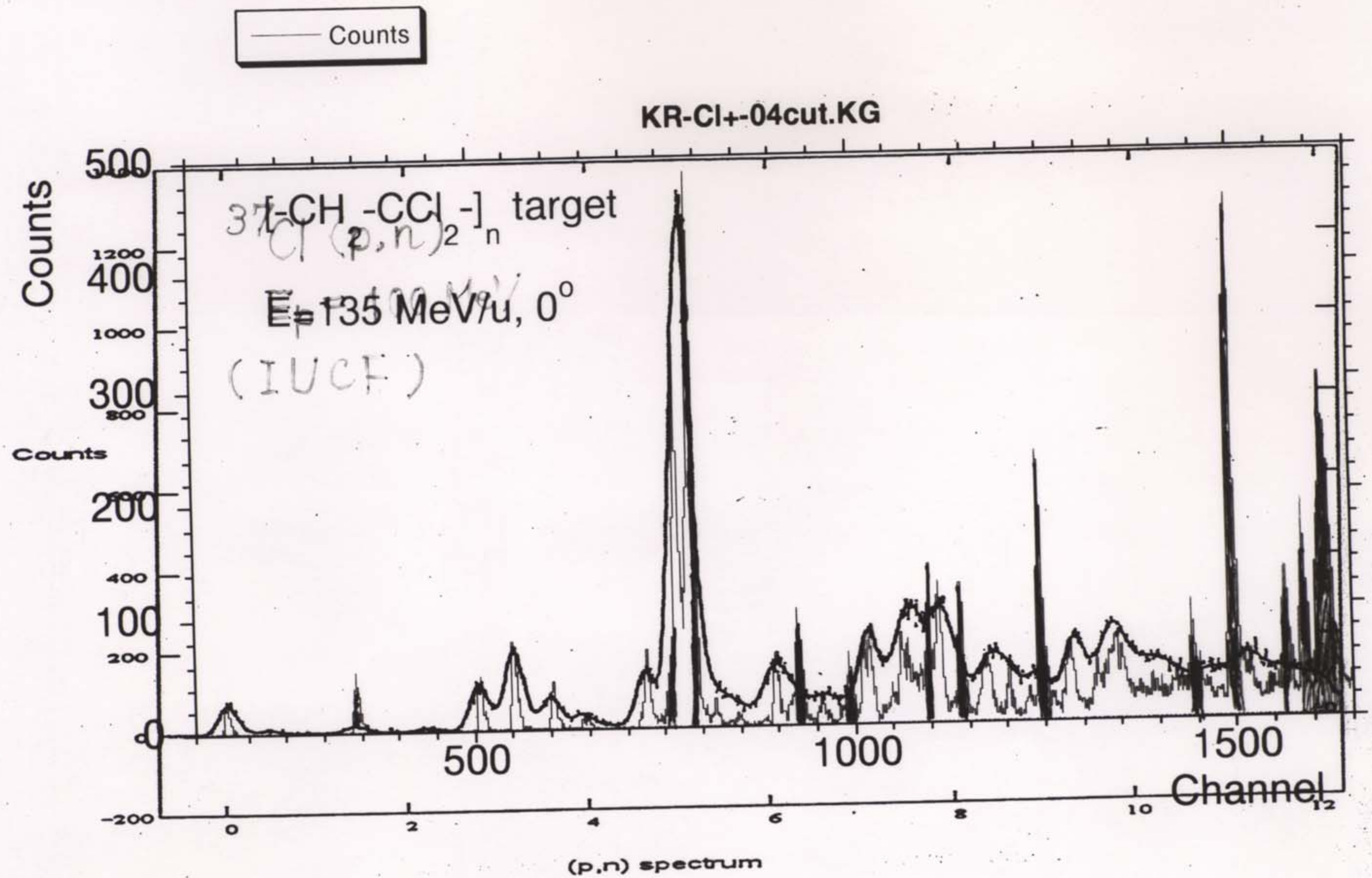
# Osaka University
# Reserch Center for Nuclear Physics
# (RCNP)




| | |
|---|---|
| Beam course | WS |
| Target | $^{nat}Cl$ ($CH_2Cl_2$)<br>Polyvinylidene Chloride<br>3.58 mg/cm $^2$ |
| Incident energy | 140MeV/u |
| Beam tune | Dispersive mode |
| Scattering angle | $\sim 0^{\circ}$ |
| Spectrometer | Grand Raiden |
| Resolution | 55keV High resolution |

Next measurements
Isotopically enriched $^{37}Cl$

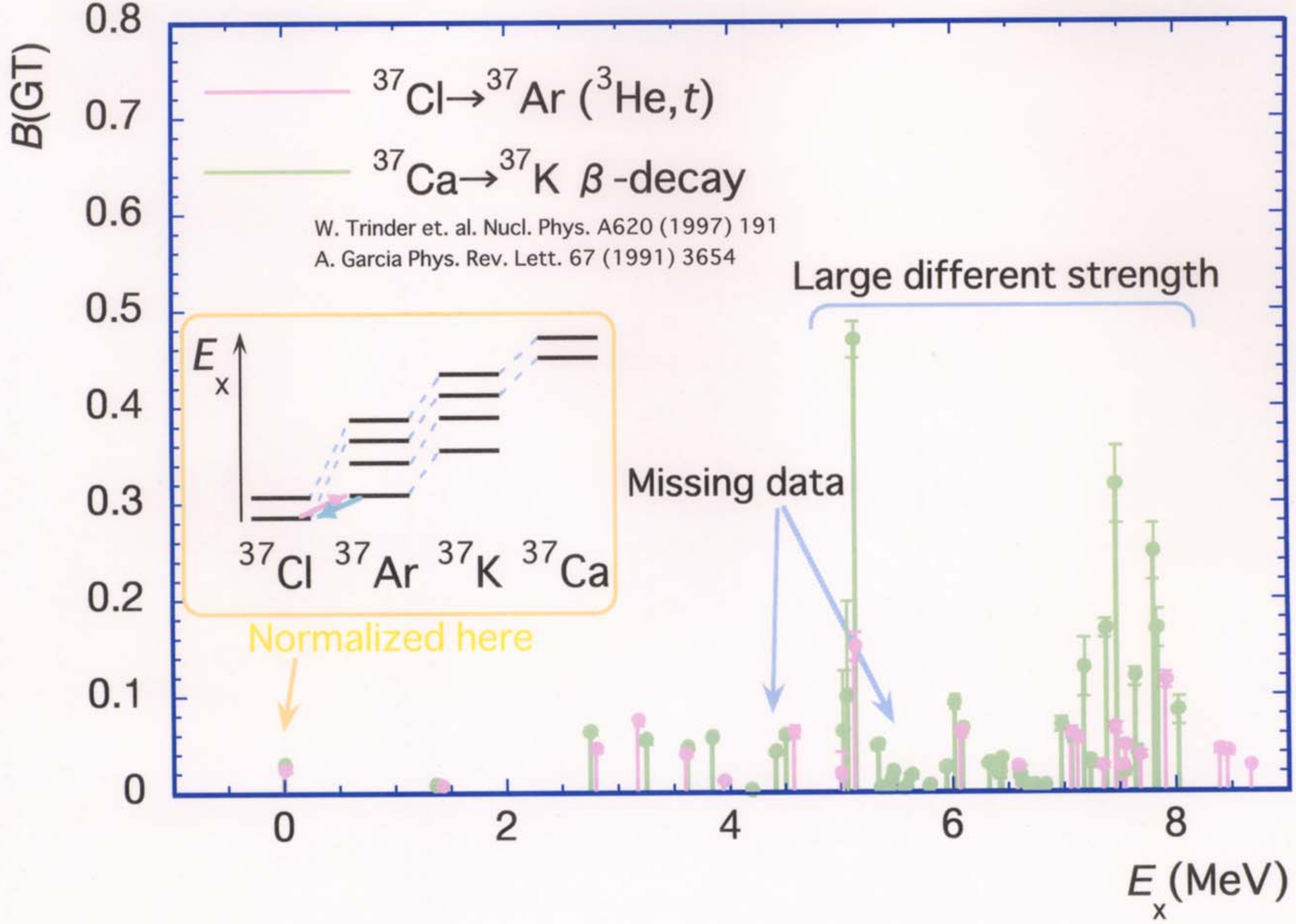




① ②
Counts
KR-Cl+-04cut.KG
[-CH2-CCl2-]n target
37Cl (p,n)
E=135 MeV/u, 0°
(IUCF)
Counts
Channel
(p,n) spectrum

# Comparison of $B$(GT) values

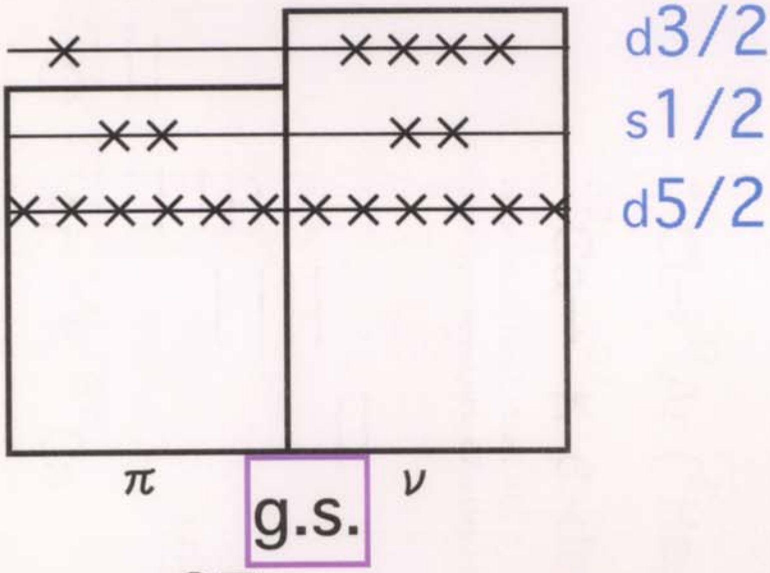
( $B$(GT)'s of $^{37}Cl \rightarrow ^{37}Ar$ are normalized by g.s. in $^{37}Cl$ from $^{37}Ar$ $\beta$-decay )



Assumption of proportionality in $(p, n)$ or $({}^3\mathrm{He}, t)$ experiment?

$$\frac{d\sigma}{d\Omega}(q=0) = \hat{\sigma} \cdot B(GT) \quad (E_{\mathrm{beam}} > 100\mathrm{MeV/u})$$

Grand state configuration in s-d shell

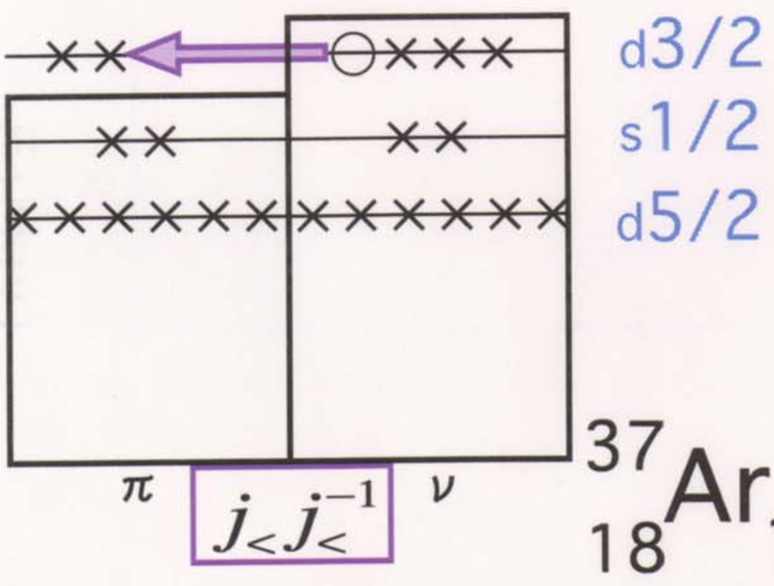



$^{37}_{17}\mathrm{Cl}_{20}$

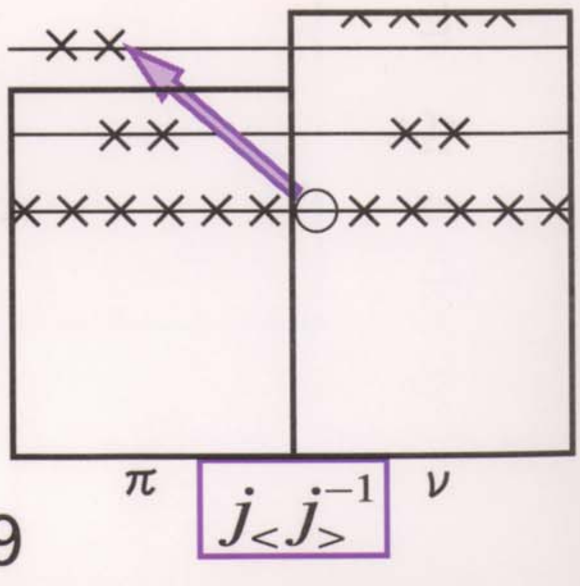
Large tensor effect

Small tensor effect

1p-1h configuration in s-d shell

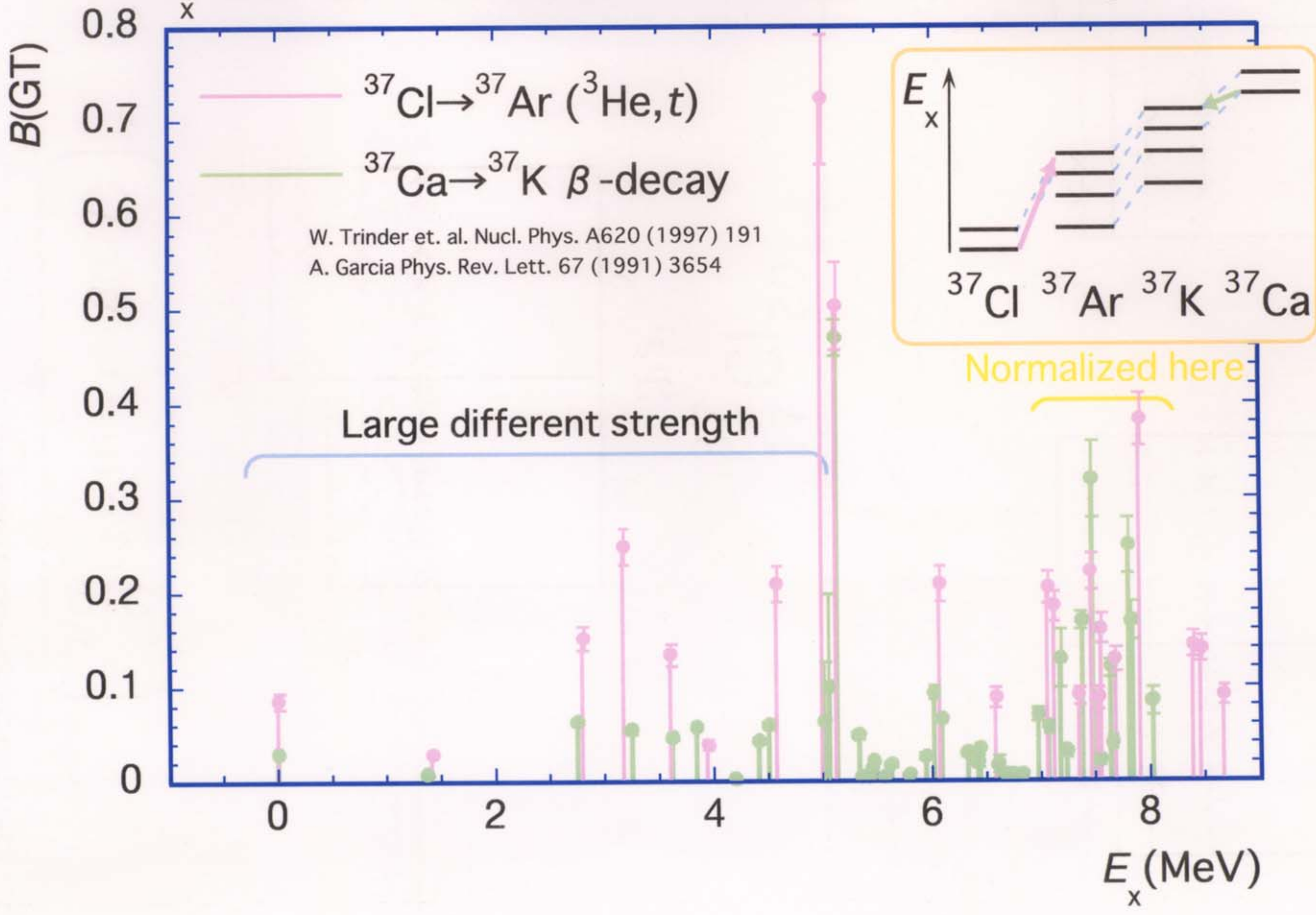



$^{37}_{18}\mathrm{Ar}_{19}$



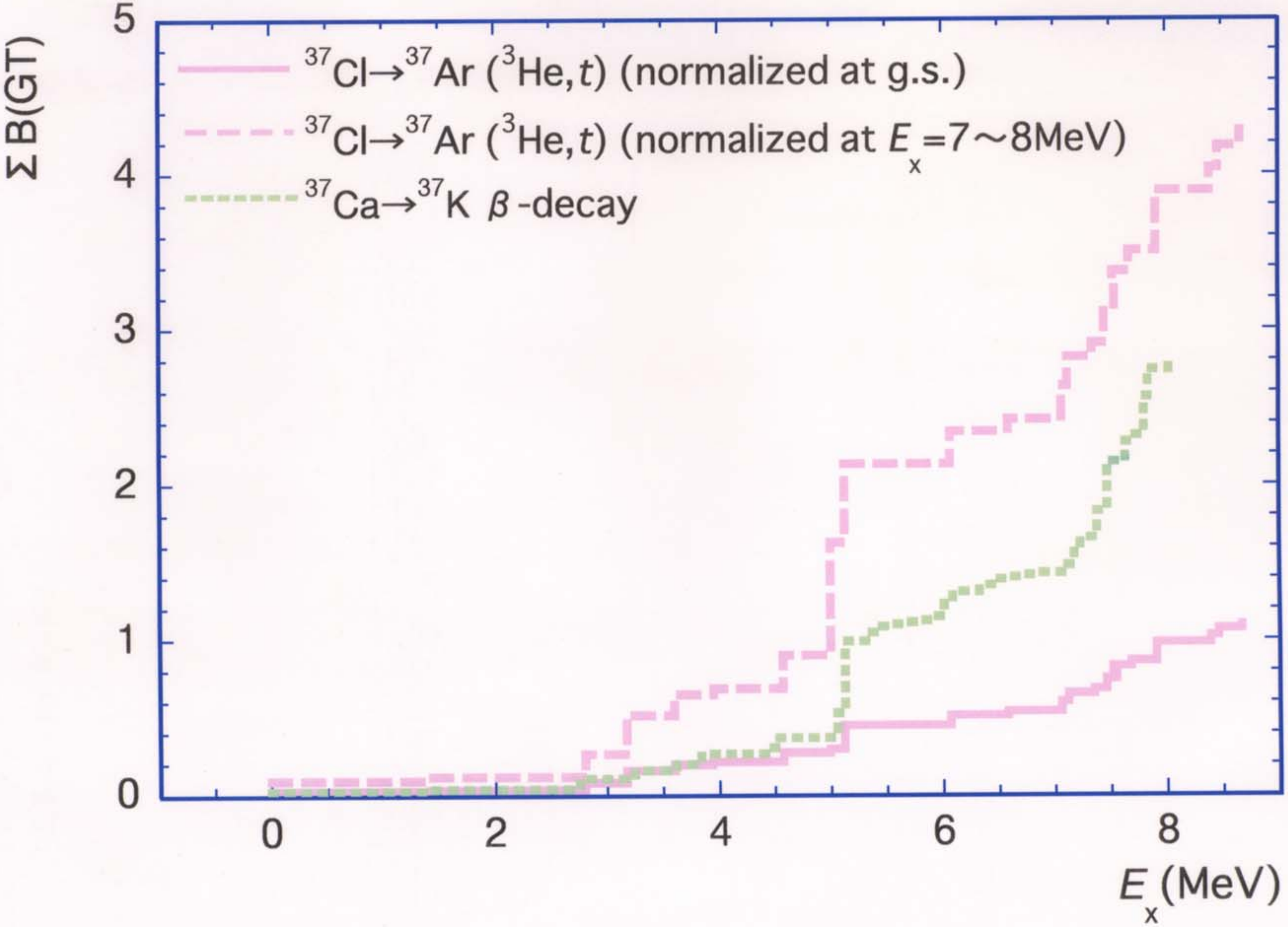
## Comparison of $B$(GT) values

( $B$(GT)'s of $^{37}Cl \rightarrow ^{37}Ar$ are normalized by $E_x$=6.9~8.1 MeV states in $^{37}K$ from $^{37}Ca$ $\beta$-decay )



## Possible explanations

1) Bad proportionality between $d\sigma/d\Omega$ and $B(GT)$ for tensor interaction in $(p, n)$ and $(^3He, t)$ experiments?
2) Different isospin mixing between $^{37}Cl \rightarrow ^{37}Ar$ and $^{37}Ca \rightarrow ^{37}K$?
3) Large ambiguity of $\beta$-decay measurements?



Σ B(GT)
5
4
3
2
1
0
0
2
4
6
8
$E_x$ (MeV)
$^{37}Cl \rightarrow ^{37}Ar$ ($^3He$,$t$) (normalized at g.s.)
$^{37}Cl \rightarrow ^{37}Ar$ ($^3He$,$t$) (normalized at $E_x$=7～8MeV)
$^{37}Ca \rightarrow ^{37}K$ $\beta$-decay

## Summary

| Experiment | $^{37}Cl(^{3}He, t)^{37}Ar$ |
|---|---|
| | $E_{beam}$=140 MeV/u, $\theta_{scat}\sim 0°$ |

*Energy spectra* → ***High Resolution*** ***Low Background***

**Analysis**: $^{37}Cl \rightarrow ^{37}Ar$ ($^{3}He$, $t$) ⟷ Compared $B$(GT) values ⟷ $^{37}Ca \rightarrow ^{37}K$ $\beta$-decay

**Results**

1) ($^{3}He$, $t$) and ($p$,$n$) have the same strength distributions.
2) ($p$,$n$)-type reactions and $\beta$-decay have different $B$(GT) distributions.

# Versatile target formation method for water soluble compound

## Problem of Cl target

Pure chroline is gas.

## New target

Compound (e.g. $CaCl_2$) + PVA

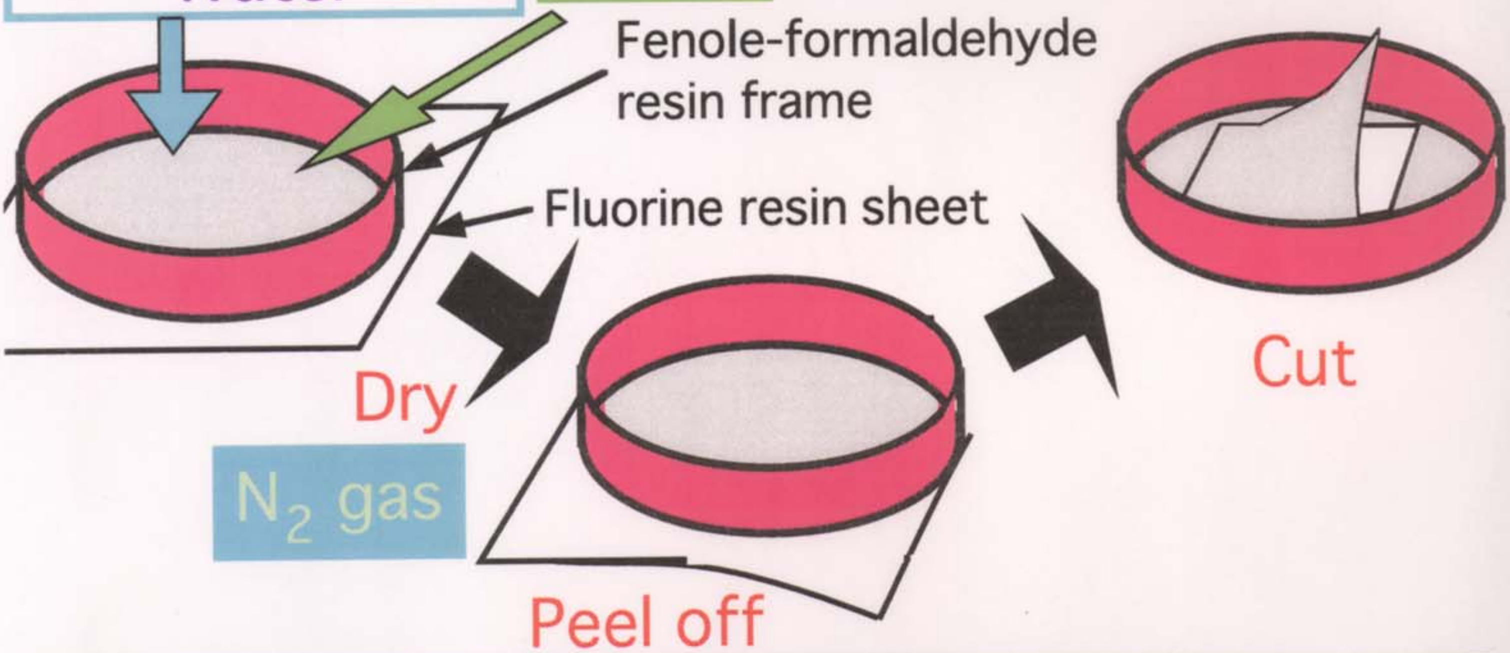
## Feature

1) Thin and self-supporting.
2) $^{12}C$ and $^{16}O$ in PVA have large *Q*-value for ($^3He$, *t*) reaction.

## Way of making

Polyvinylalcohol (PVA) + Water

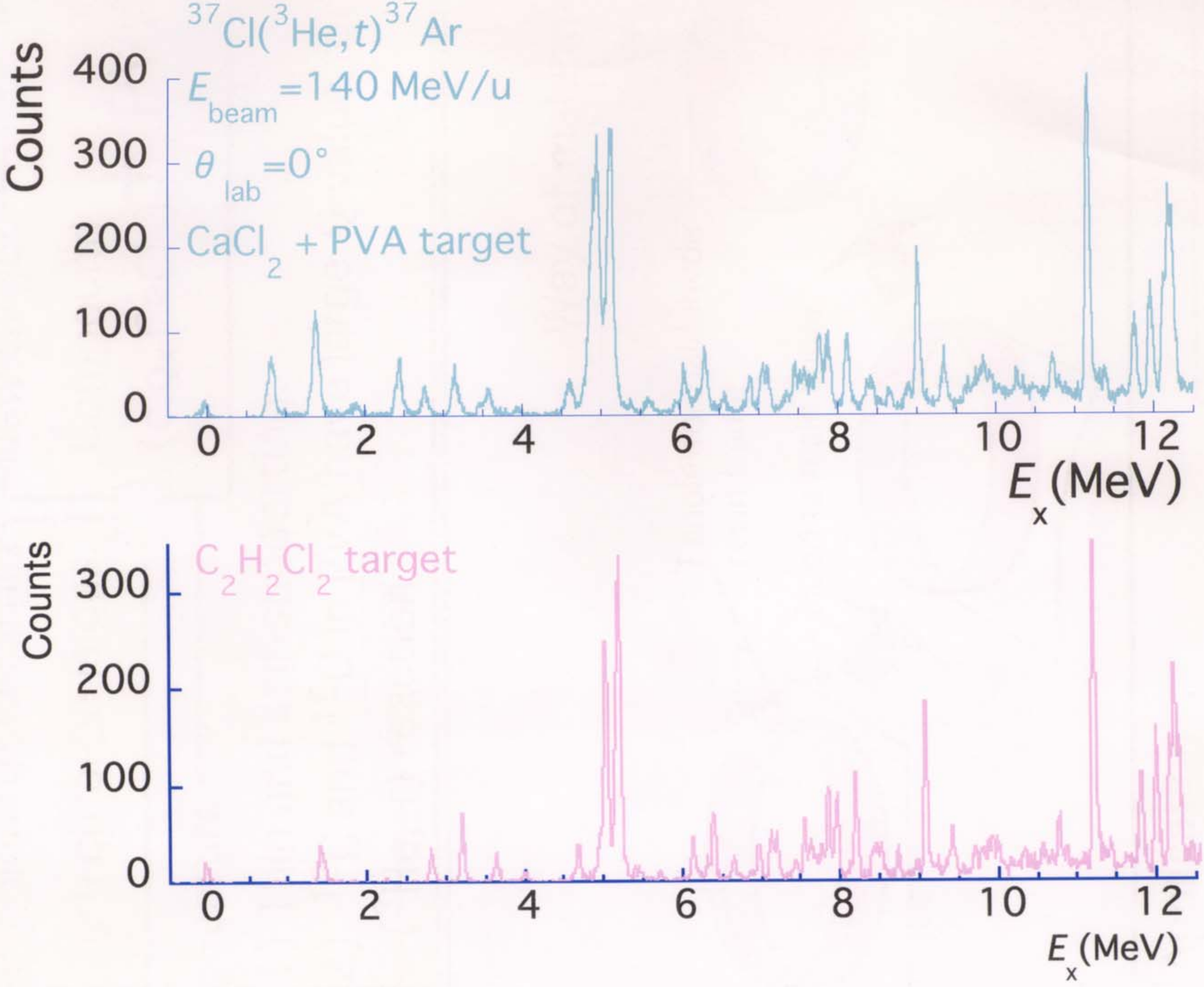
$CaCl_2$ + Water




## Application

Alkaline metals which are chemically reactive and malleable.

e.g. $Na_2CO_3$, $K_2CO_3$ + PVA



Counts
400
300
200
100
0
37Cl(3He,t)37Ar
Ebeam=140 MeV/u
θlab=0°
CaCl2 + PVA target
0
2
4
6
8
10
12
Ex (MeV)
Counts
300
200
100
0
C2H2Cl2 target
0
2
4
6
8
10
12
Ex (MeV)