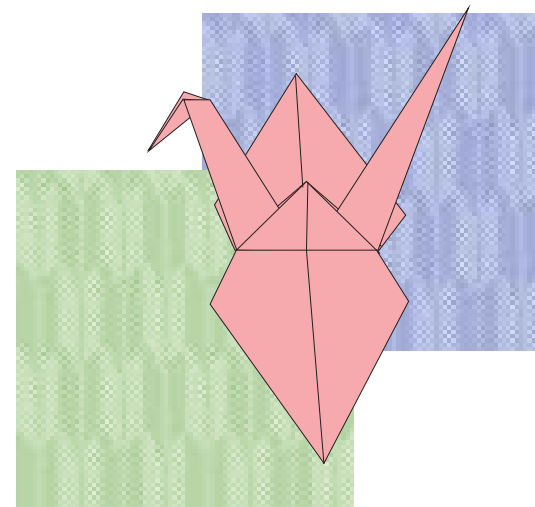# Observation of hypernuclear fine structure in $^{16}_{\Lambda}\text{O}$

Dept. of Phys. Tohoku Univ.

Mifuyu Ukai

E930 '01 collaboration

Tohoku Univ.   H. Tamura, Y. Miura,K. Mizunuma, M. Ukai
                  O. Hashimoto, S. N. Nakamura,
                  Y. Okayasu, T. Miyoshi
Riken   K. Tanida
Kyoto Univ.   H. Akikawa, K. Imai, H. Takahashi
Osaka Univ   S. Ajimura, T. Hayakawa, K. Kishimoto,
                  S. Minami
Gifu Univ.   K. Nakazawa
BNL   H. Hotchi, D. E. Alburger, R. E. Chrien
                  M. May, P. Pile, A. Rusek
CMU   G. B. Franklin, B. P. Quinn
GSI   A. Banu
Hampton Univ   L. Tang, L. Yuan
Univ. Freiburg . J. Franz
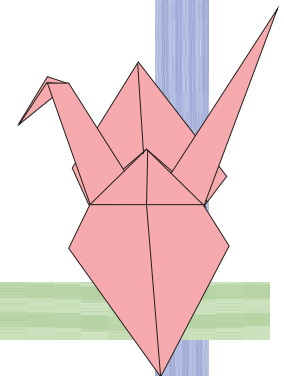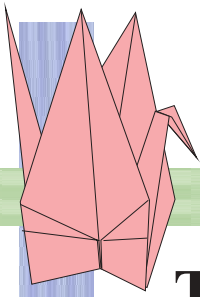
ΛN effective interaction

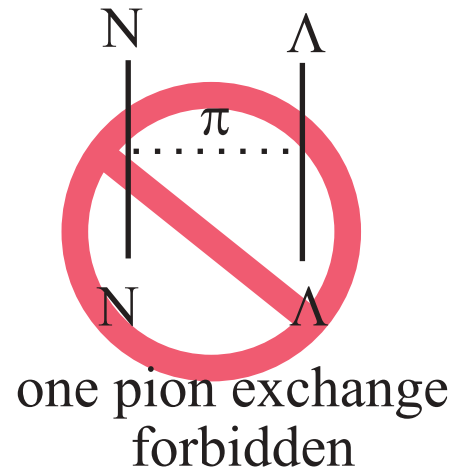|		radial integral w/ shell model w. f.	from exp. data
$V =$ $V_0(r)$			
$+ V_\sigma(r)\,\vec{s}_\Lambda\,\vec{s}_N$	Δ	spin-spin	0.5
$+ V_\Lambda(r)\,\vec{l}_{N\Lambda}\,\vec{s}_\Lambda$	S_Λ	spin-orbit(LS+ALS)	-0.01
$+ V_N(r)\,\vec{l}_{N\Lambda}\,\vec{s}_N$	S_N	spin-orbit(LS−ALS)	-0.4
$+ V_T(r)\,S_{12}$	T	**tensor**	

[MeV]

No exp. data

Tensor force of ΛN interaction

one pion exchange
forbidden

contribution for ΛN tensor force
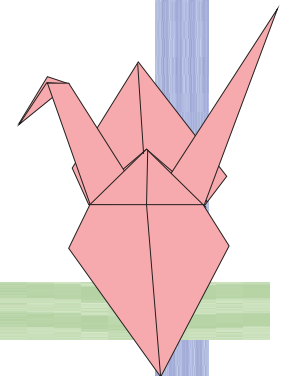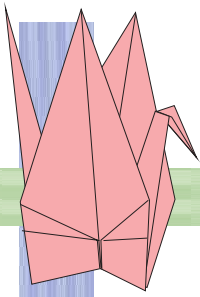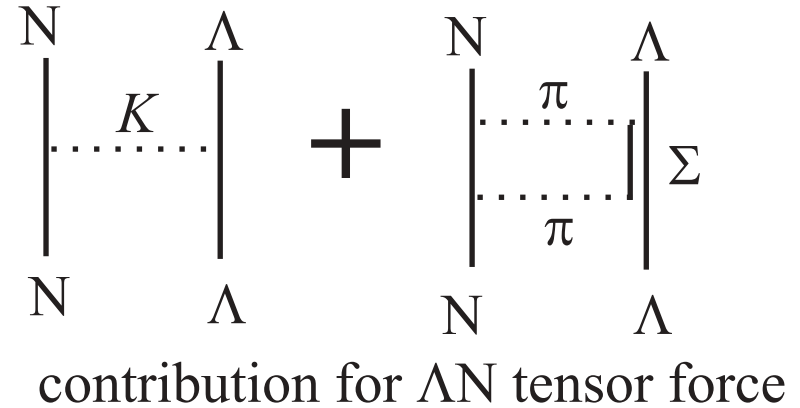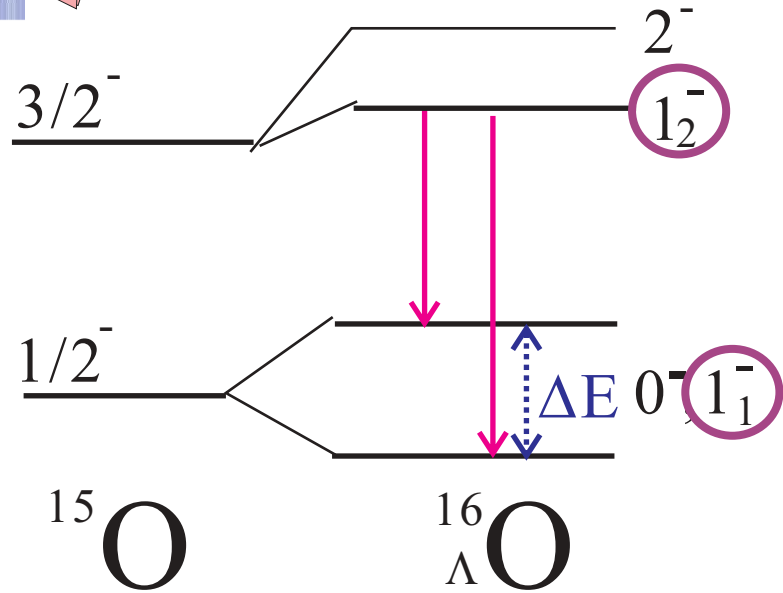
predicted sterngth T

T : 20 keV ~ 60 keV (meson exchange models)

	ND	NF	NSC89	NSC97f
[MeV]	0.018	0.033	0.036	0.054
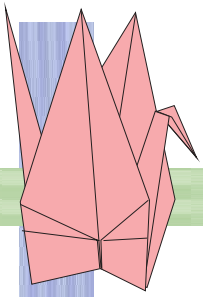
$^{16}_{\Lambda}O$ as a probe of the tensor force

$\Delta E_{doublet}$ ($^{16}_{\Lambda}O_{g.s.}$) is sensitive to the tensor force

$E(1^-) - E(0^-) =$
$-0.38\Delta + 1.38 S_\Lambda - 0.005 S_N + \mathbf{7.8T} + \Lambda\Sigma$
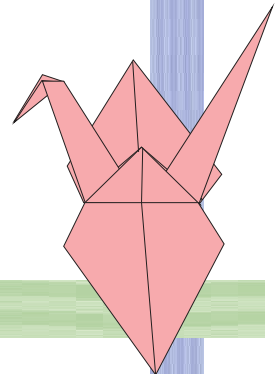
calc. by D. J. Millener

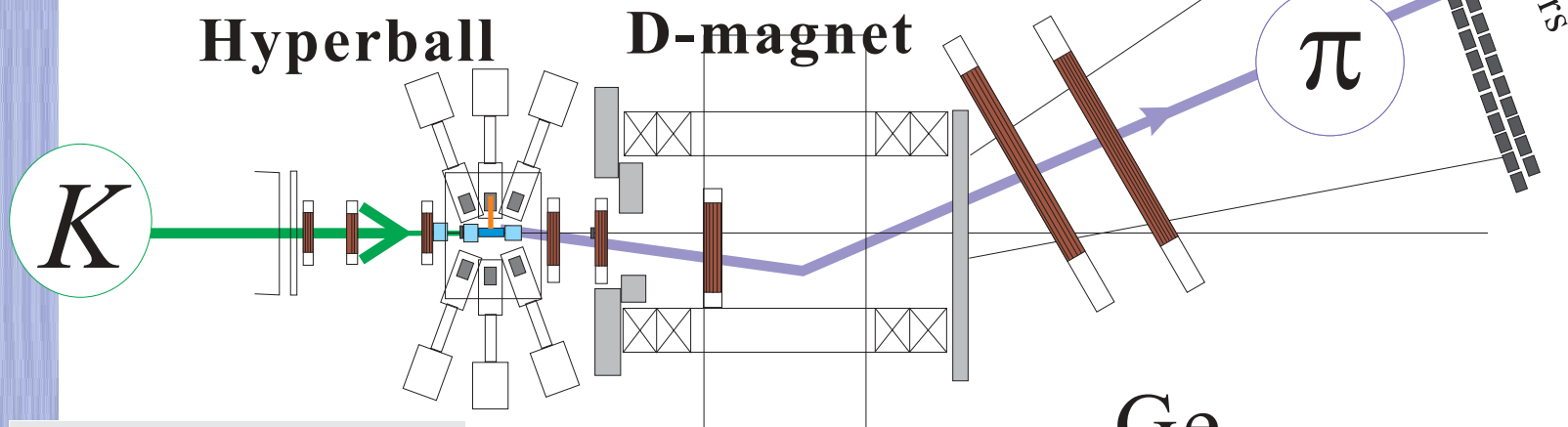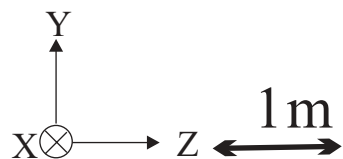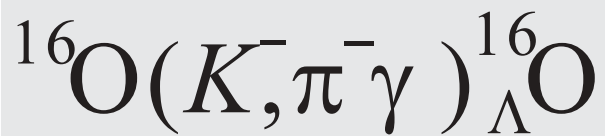$= \mathbf{-50 \sim +150}$ [keV]

T: $+0.02 \sim 0.06$ [MeV]
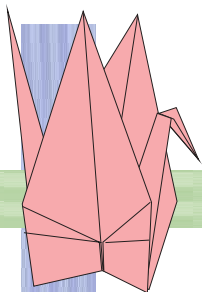(from meson exchange models)

Δ:0.47, S_Λ:-0.01, S_N:-0.44, $\Lambda\Sigma$:0.031

(from experiments)   [MeV]

○ populating state by (K^-, π^-)

↓ γ transition

Experimental setup @BNL D6

$^{16}O(K^-, \pi^- \gamma)^{16}_\Lambda O$

Hyperball

D-magnet

TOF counters

drift chamber

AC

K

π

$p_K \sim 0.93$ GeV

γ

Ge

Target

H2O: 20 g/cm^2

K

π
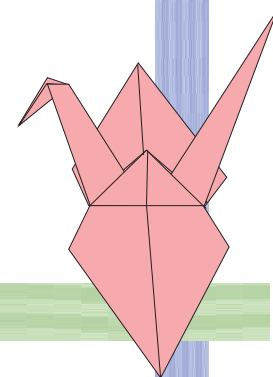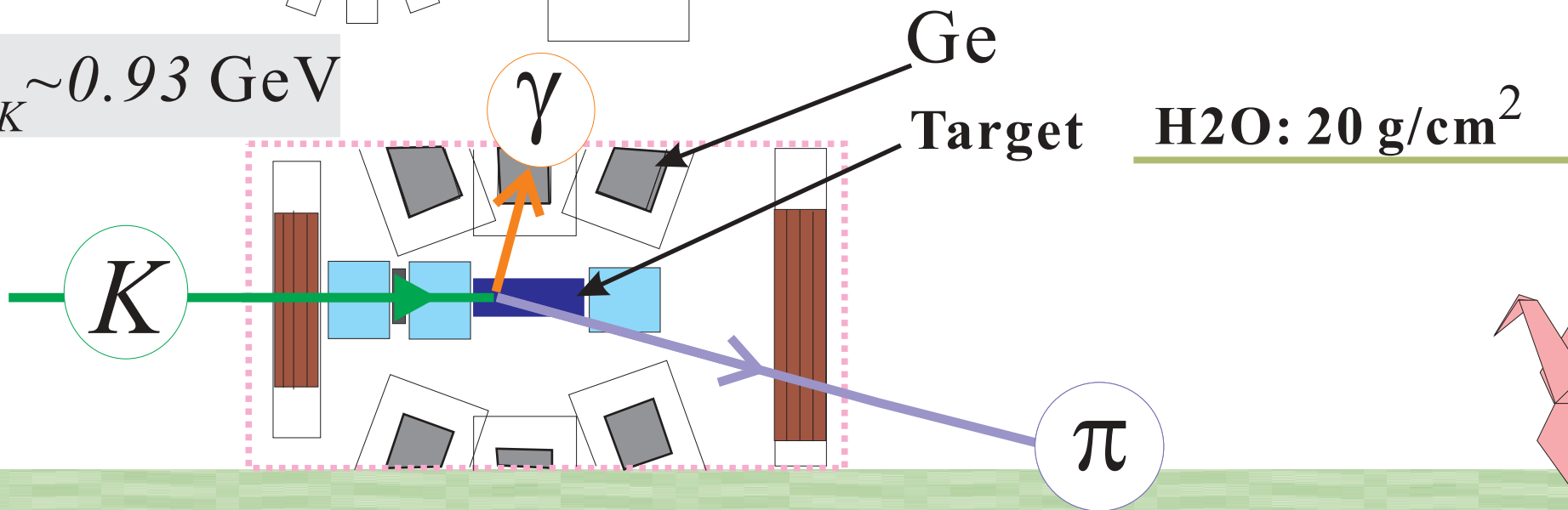
Gamma energy calibration

delayed γ back ground

$$^{16}N \, (7.3 \text{ s}) \rightarrow {}^{16}O^* + \beta^-$$

$$\rightarrow {}^{16}O + \gamma(6.13 \text{ MeV}) \; 67\%$$

$$\rightarrow {}^{16}O + \gamma(7.11 \text{ MeV}) \; 5\%$$

5107(DE) 5618(SE) 6129

6604(SE) 7115
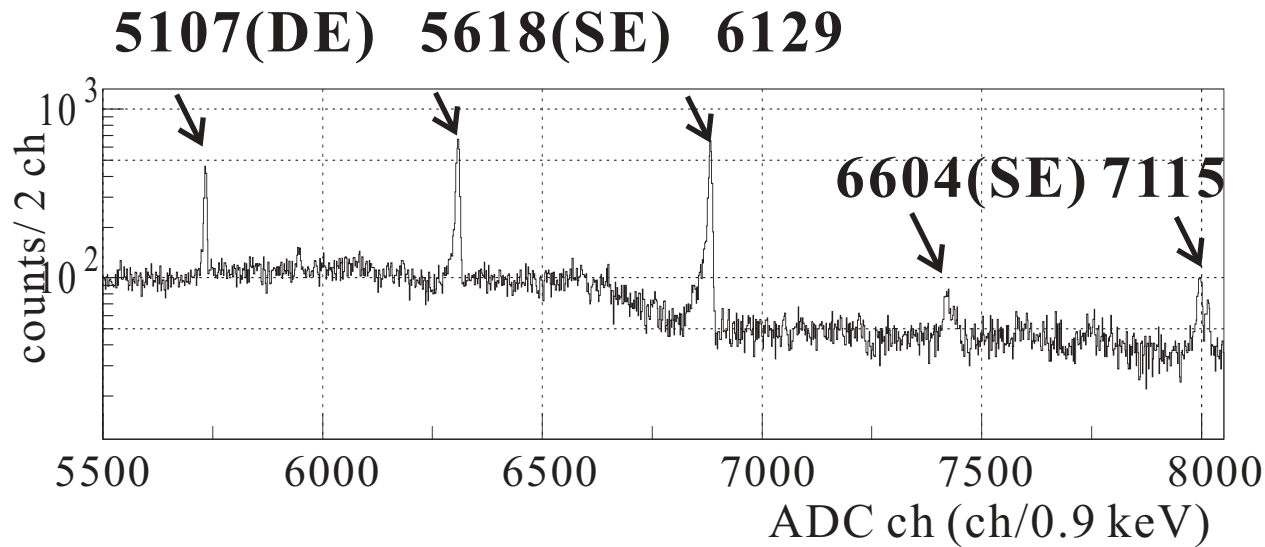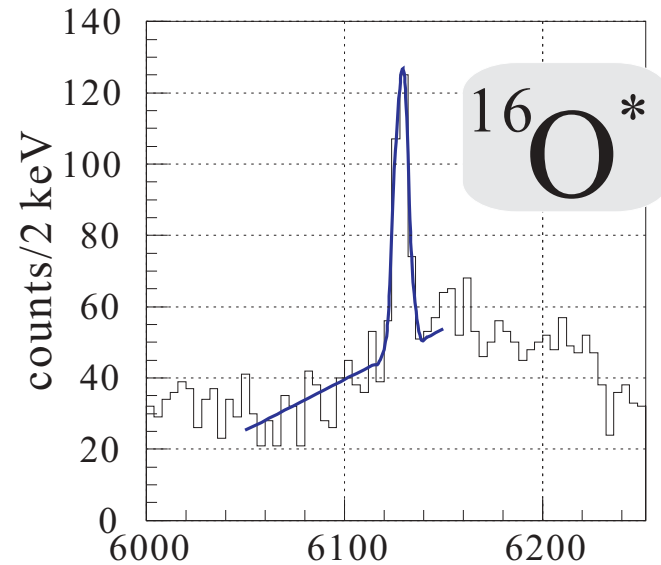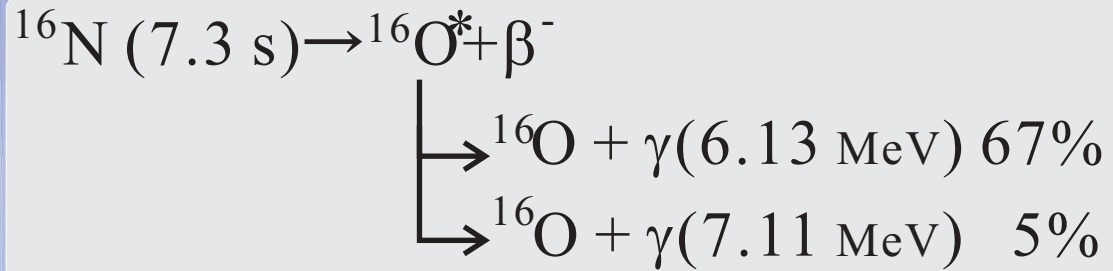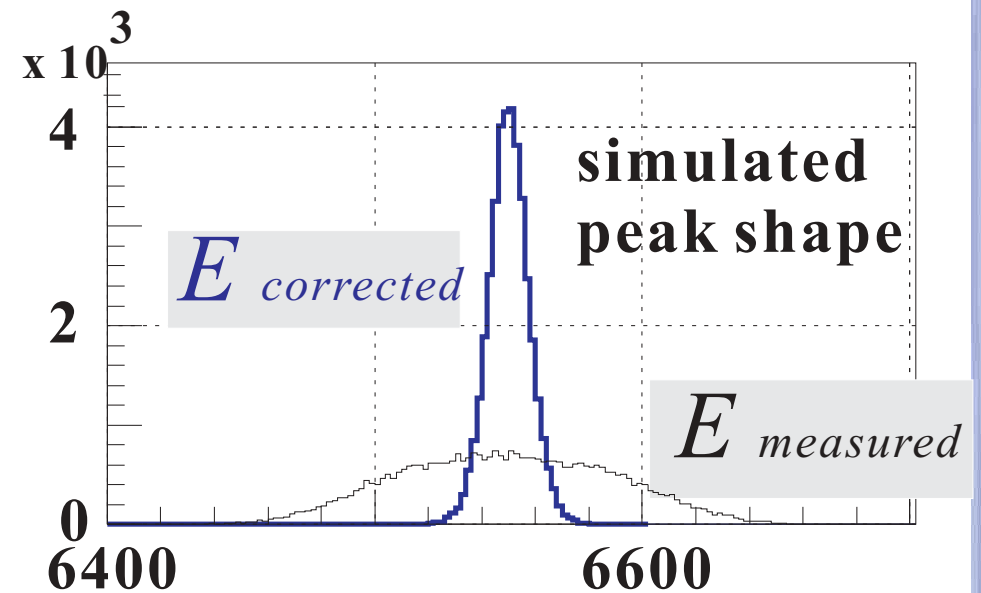

Ge self trigger data
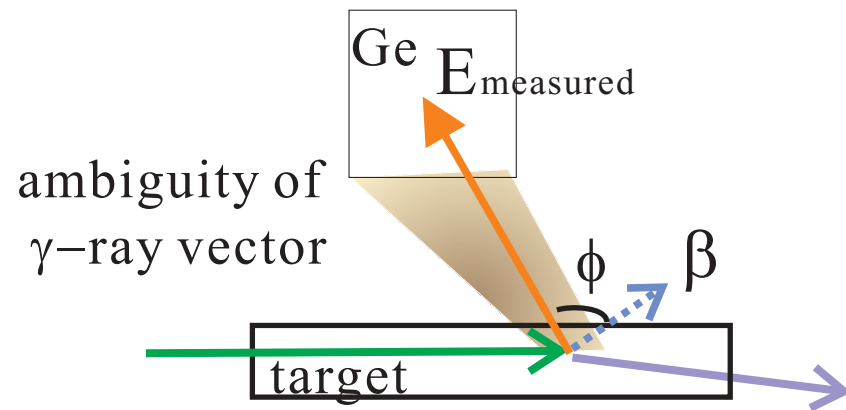
$^{16}O^*$

Eγ (keV)

14 Ge sum spectrum

3.4 keV(σ)

@6129keV

in beam
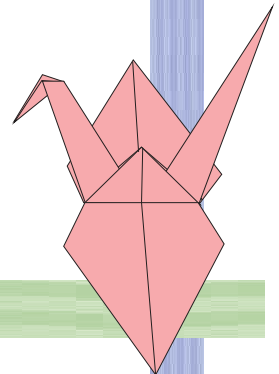
Doppler shift correction

$^{16}_{\Lambda}O^*(\Gamma)$ life time $<<$ stopping time
~fs order   ~ps order

$$E_{corrected} = \gamma(1-\beta.\cos\phi)\, E_{measured}$$

γ-ray and mass spectrum of $^{16}_{\Lambda}$O

γ-ray spectrum with mass region cut
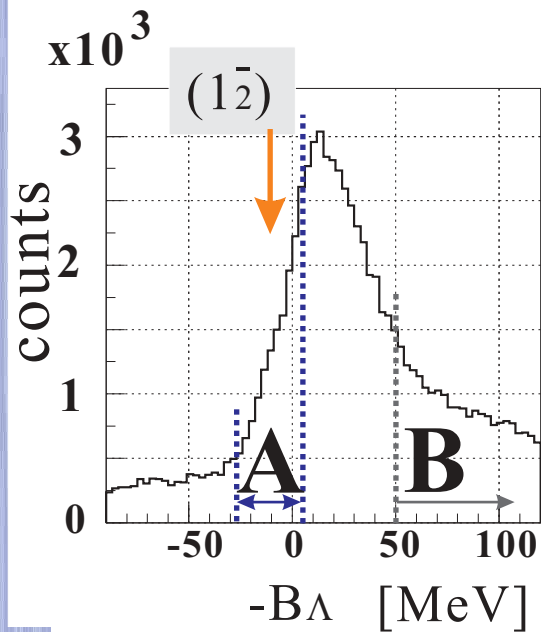
A : bound region
B : unbound region

Fitting result

$\chi^2/\text{ndf}=1.31$

preliminary

simulated peak shape → fitting function
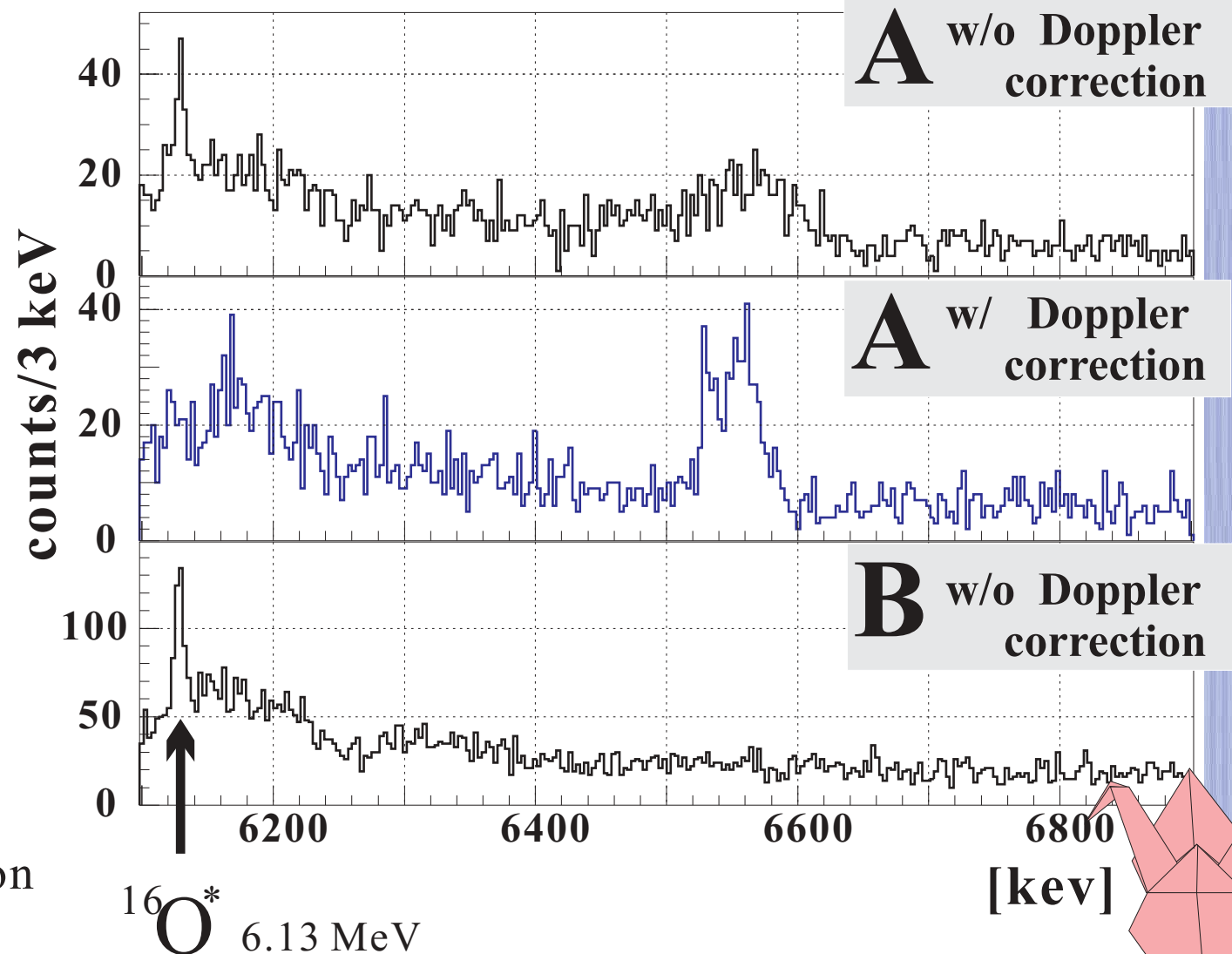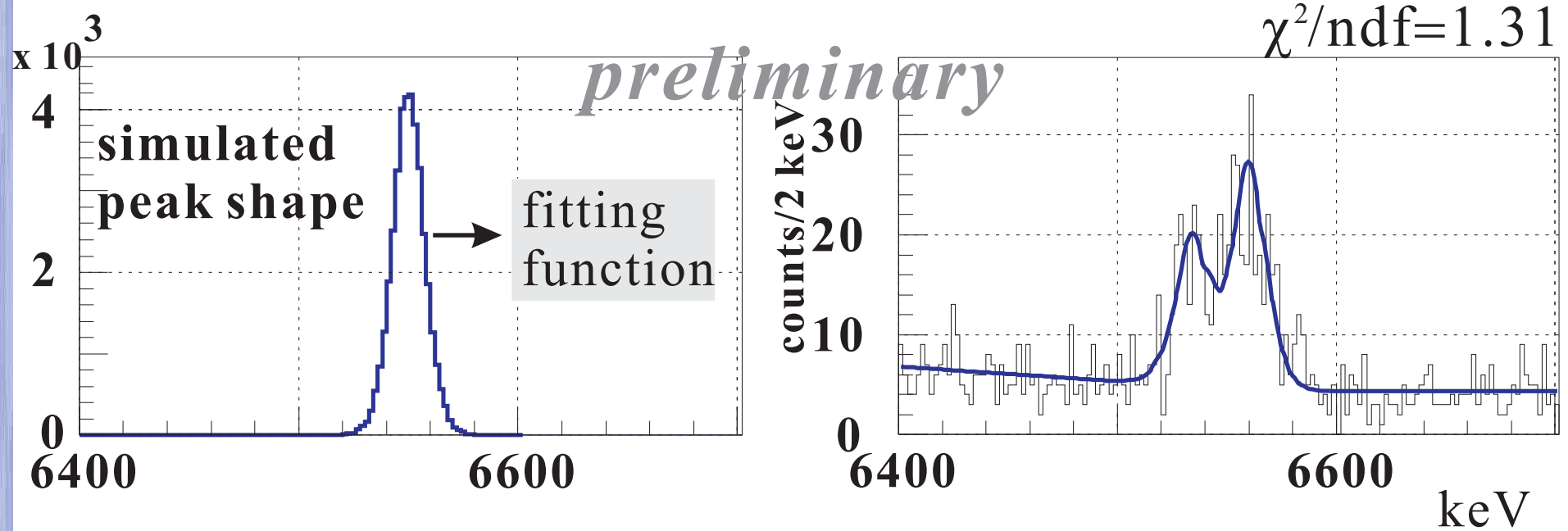
peak energy [keV]	ΔE	counts	ratio
6534.1 ± 1.5 6560.2 ± 1.3	26.1 ±2.0	149 ±18 226 ±30	0.66 ±0.11

Gamma yield ratio and level assignment

Branching ratio

$$I\gamma(1^- \to 1^-)/I\gamma(1^- \to 0^-) \; = \;$$
$$0.5 \quad \text{weak coupling}$$
$$0.41 \quad \text{Millener}$$

effective efficiency from $\pi\gamma$ angular correlation

$$\varepsilon(1^- \to 1^-)/\varepsilon(1^- \to 0^-) \; = 0.80 \pm 0.02 \, (\text{sys.})$$

estimation

$$Y(1^- \to 1^-)/Y(1^- \to 0^-) \; = 0.42 \, , \, 0.34$$

exp. data

$$N(6532)/N(6559) = 0.66 \pm 0.11$$

[keV]

6560 1^-

26 1^-

0 0^-
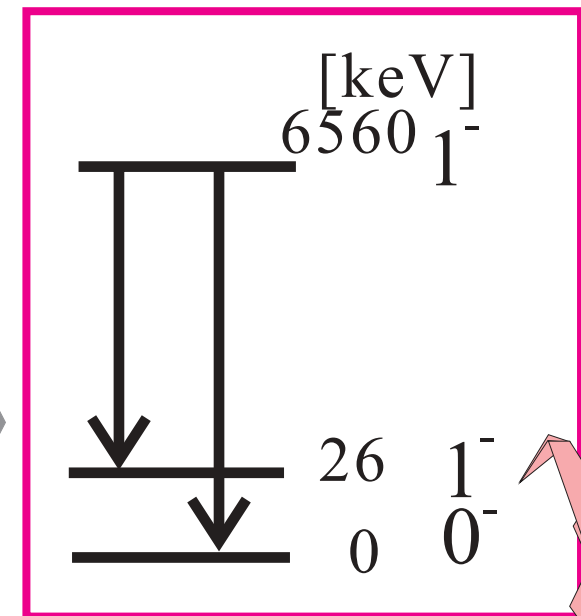
Strength of the tensor force

$^{16}_{\Lambda}O$ g.s. doublet ——— 1^-
——— 0^- $\Delta E_{\text{g.s doublet}} = 26.1 \pm 2.0 \text{ keV}$

$E(1^-) - E(0^-)$
$= -0.38\Delta + 1.38 S_\Lambda - 0.005 S_N + \mathbf{7.8T} + \Lambda\Sigma$
$= +26$ [keV]

$\Delta : 0.47, S_\Lambda : -0.01, S_N : -0.44, \Lambda\Sigma : 0.031$ [MeV]

$T \sim +30 \text{ keV}$ *preliminary*

meson exchange model prediction $+20 \sim 60 \text{ keV}$

Summary

We performed the γ ray spectroscopy experiment of $^{16}_{\Lambda}$O ,BNL E930.
The purpose of the experiment is investigation of
the tensor force of ΛN interaction.

We measured γ -ray of $^{16}_{\Lambda}$O produced by (K^-,π^-) reaction
using Hyperball.

We observed both γ-rays ($1^- - 1^-$, $1^- - 0^-$), and obtained the energies
6534 and 6560 keV and its spacing energy $\sim$ 26 keV.
We succeeded spin assignment of the g.s. doublet
from γ-ray yield ratio .
We derived T $\sim$ 30 keV. (preliminary)

This is the first result on the ΛN tensor force.