γ -ray spectroscopy study of

$^{11}_{\Lambda}\mathrm{B}$ and $^{12}_{\Lambda}\mathrm{C}$

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Collaboration List for KEK-PS E566

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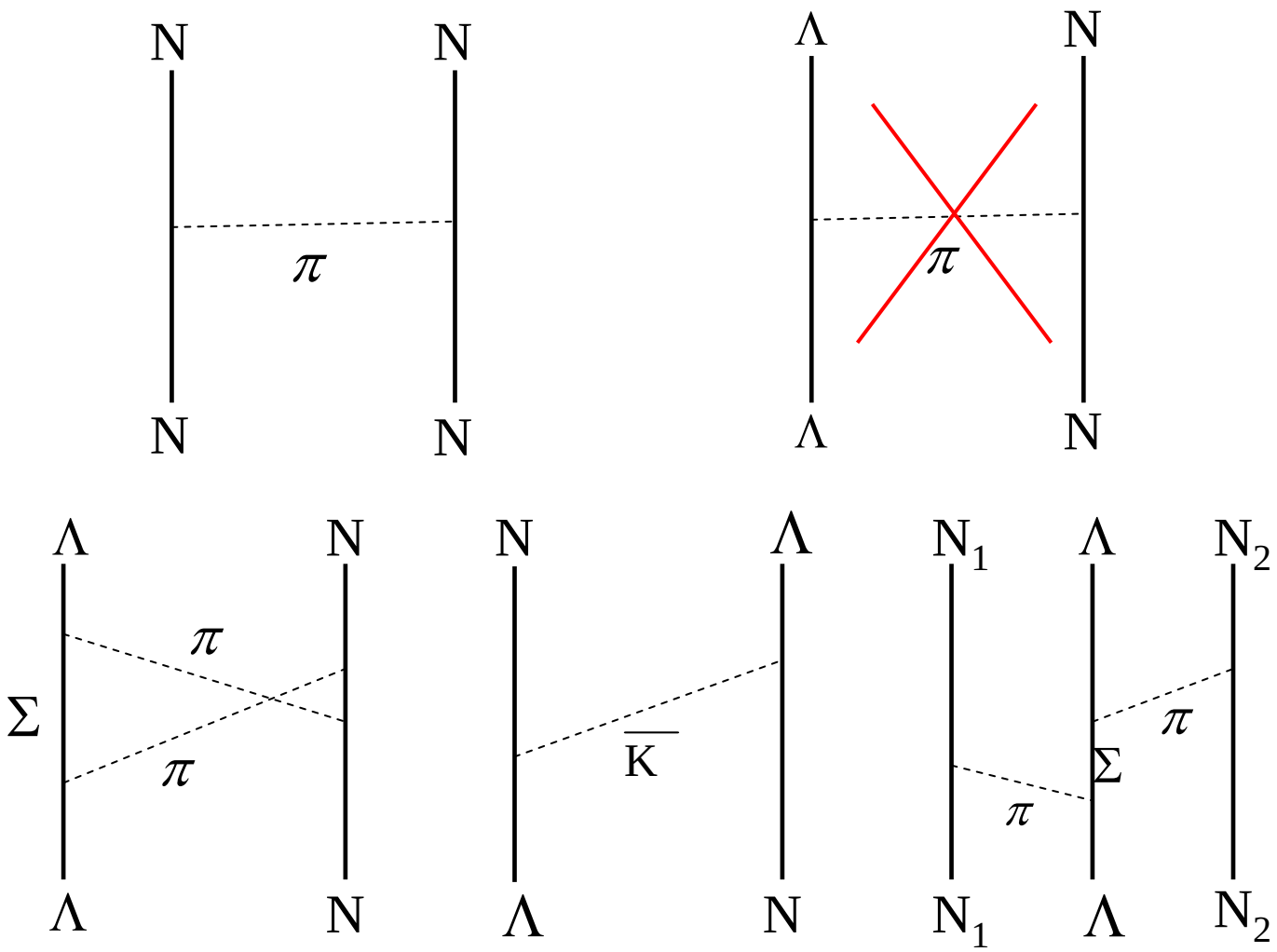
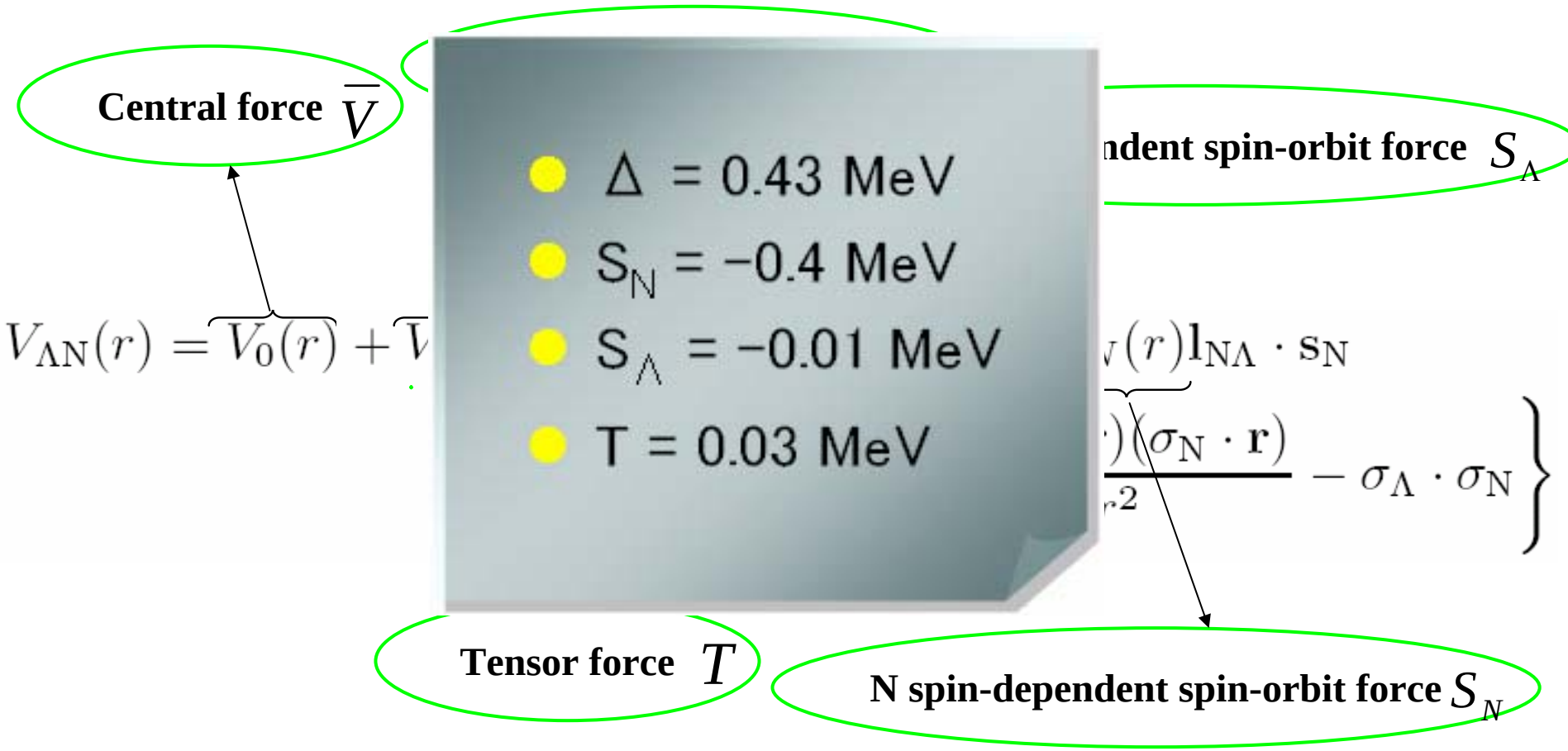
Outline

- Background
  - ΛN interaction (interaction parameters)
  - Physics interests of the present experiment
- Experimental setup & analysis
  - Magnetic spectrometer & Missing mass analysis
  - Hyperball2 apparatus & gamma-ray spectrum analysis
- Preliminary results & discussion
- Summary

Background: ΛN interaction

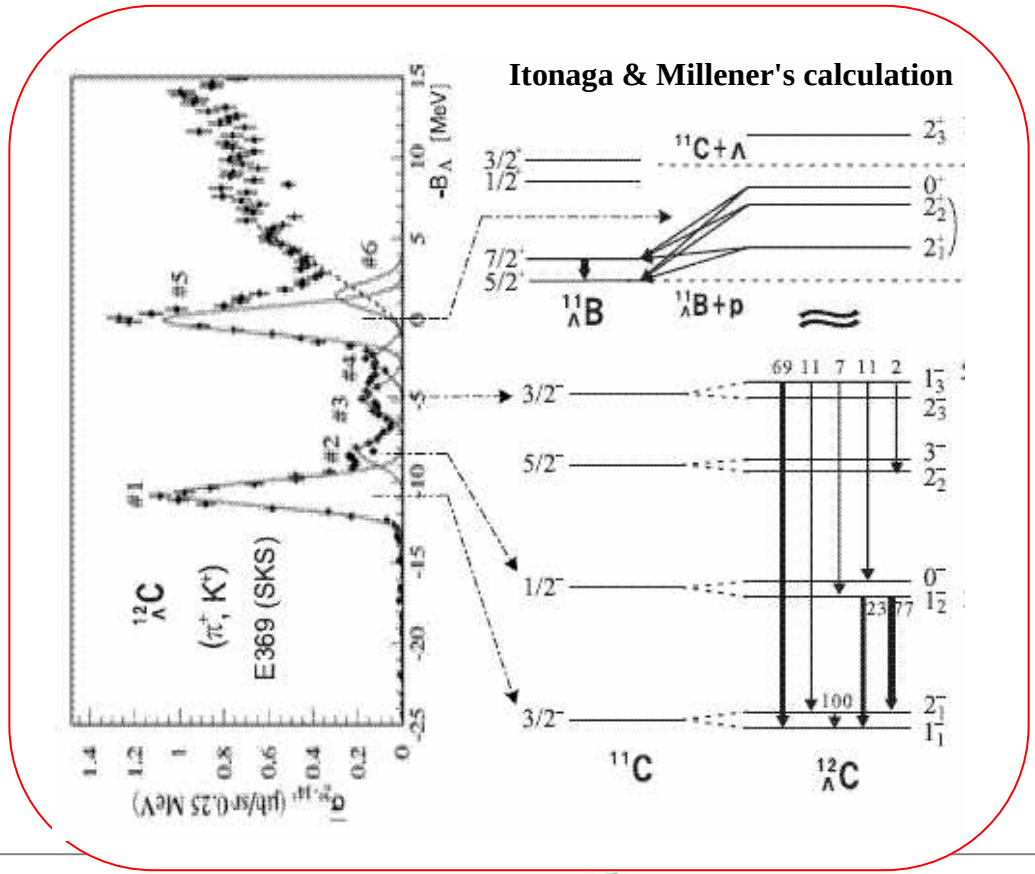


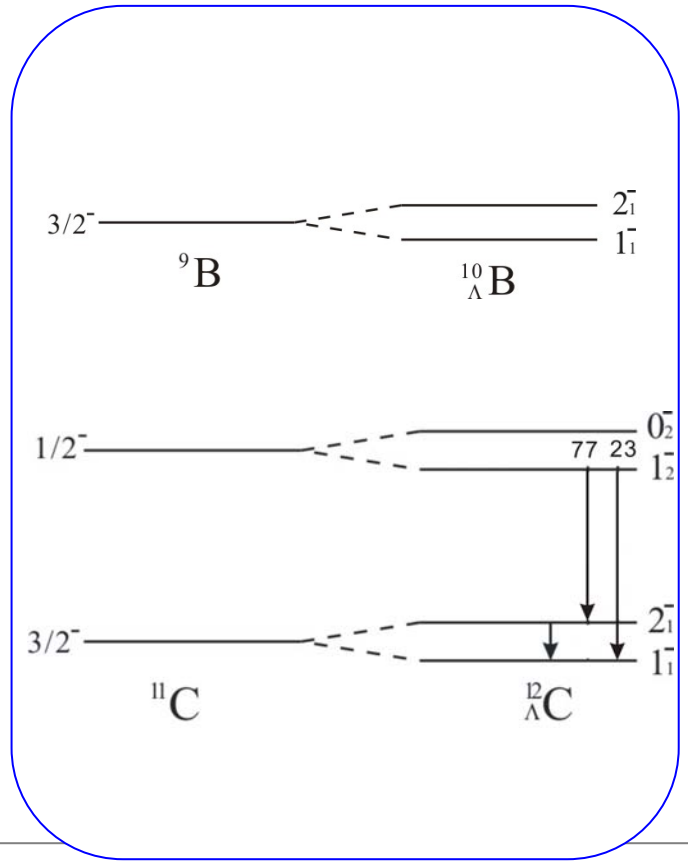
Background: ΛN interaction



Physics interests of the present experiment

$^{12}_{\Lambda}C$ can be employed to cross check the parameters.
can help to solve the $^{10}_{\Lambda}B$ puzzle.



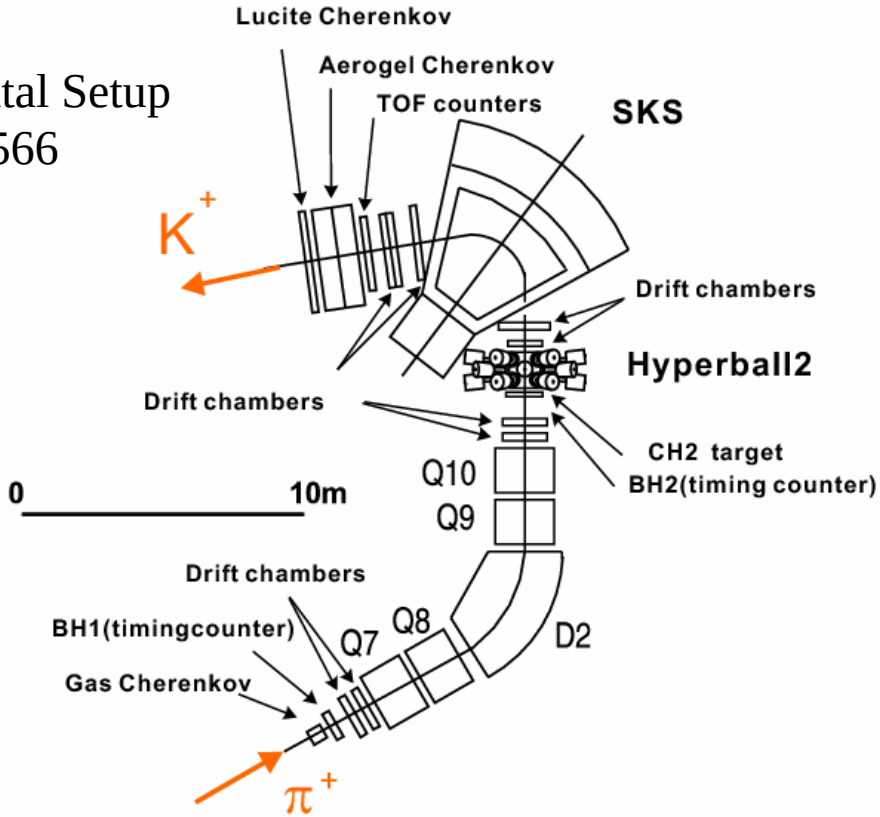


Experimental setup: overview

$$^{12}\mathrm{C}\,(\,\pi^{+}\,,\mathrm{K}^{+}\,)\,{}^{12}_{\Lambda}\mathrm{C}\,/\,{}^{11}_{\Lambda}\mathrm{B}$$

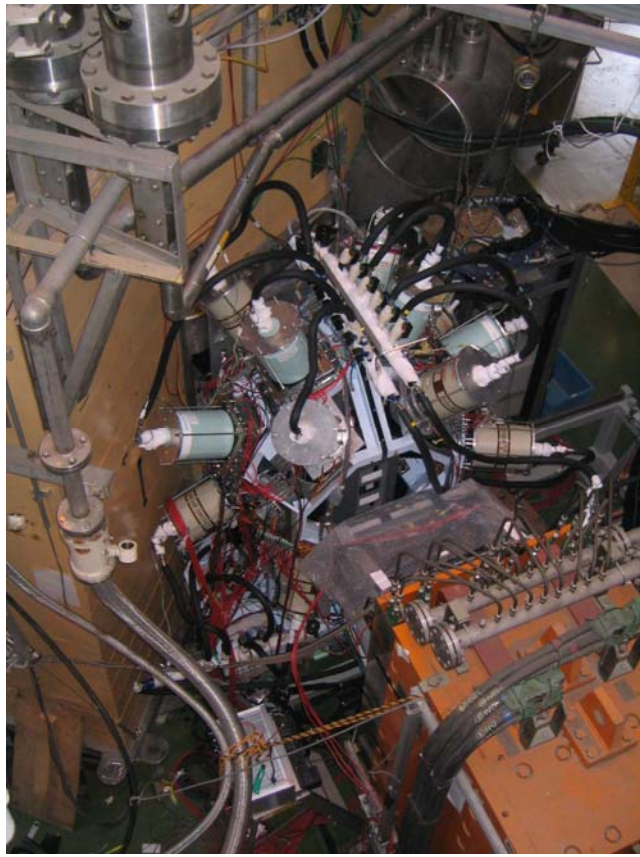
The last hypernuclear experiment @ KEK-PS

Experimental Setup of KEK-E566

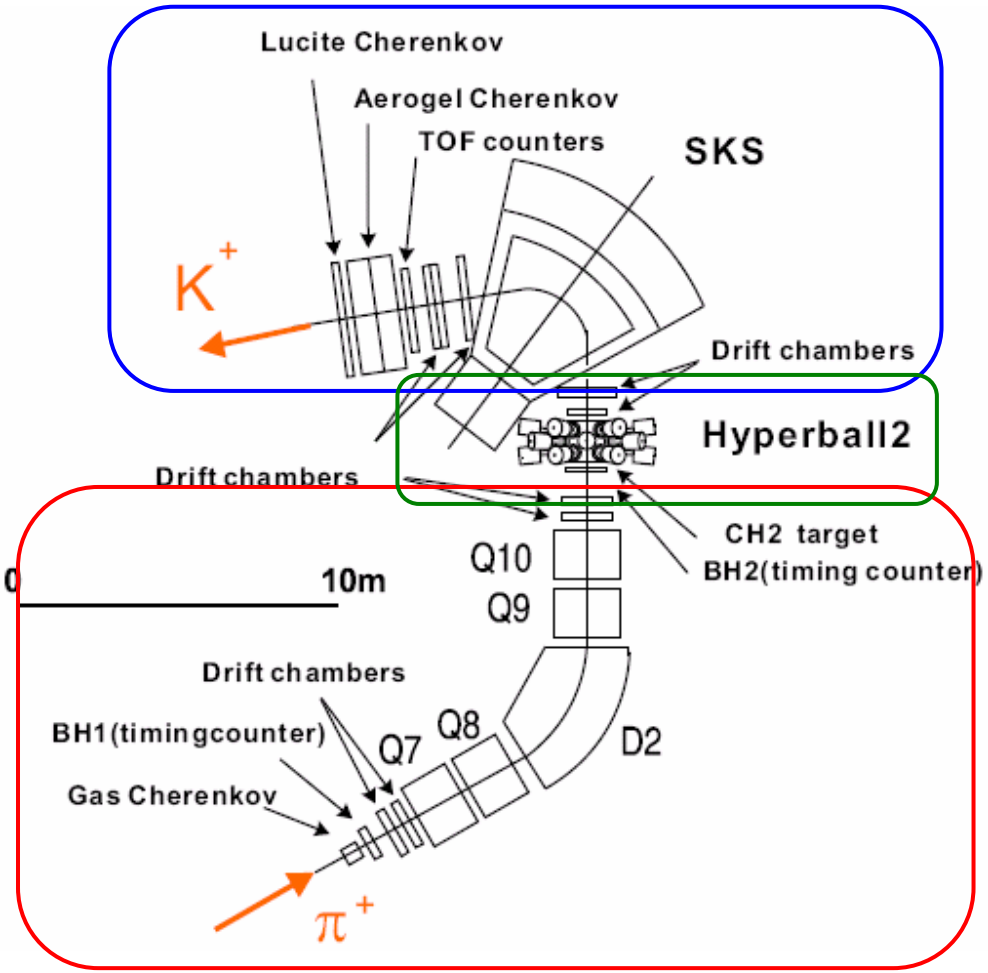


1.05 GeV/c
3×10^{6}/spill

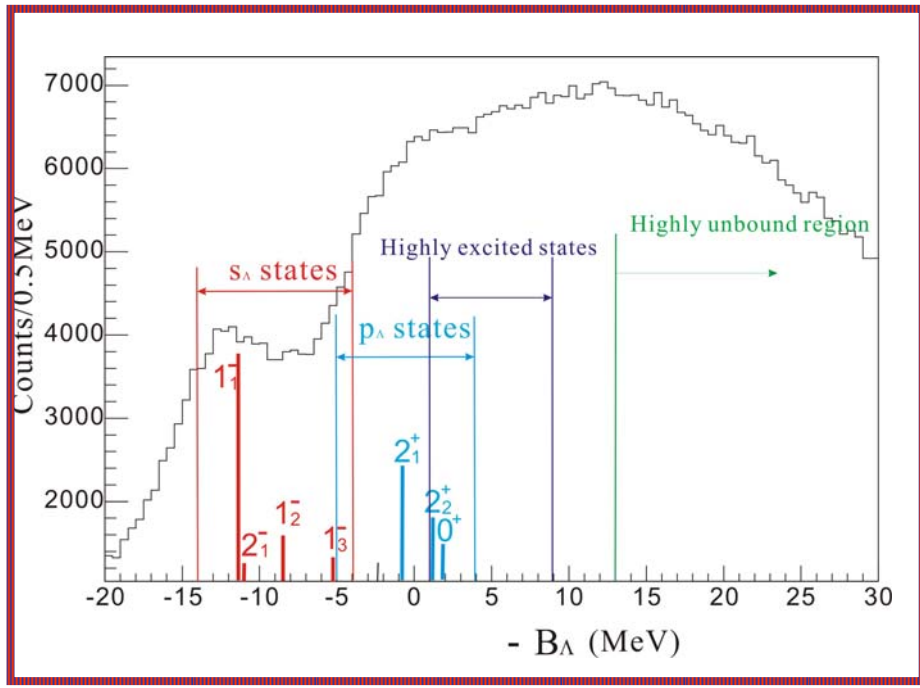
Totally 2×10^{12} π^{+}



Experimental setup & analysis: track reconstruction

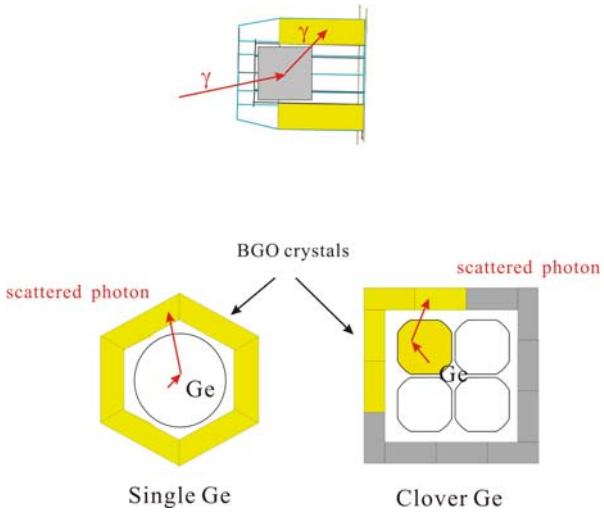


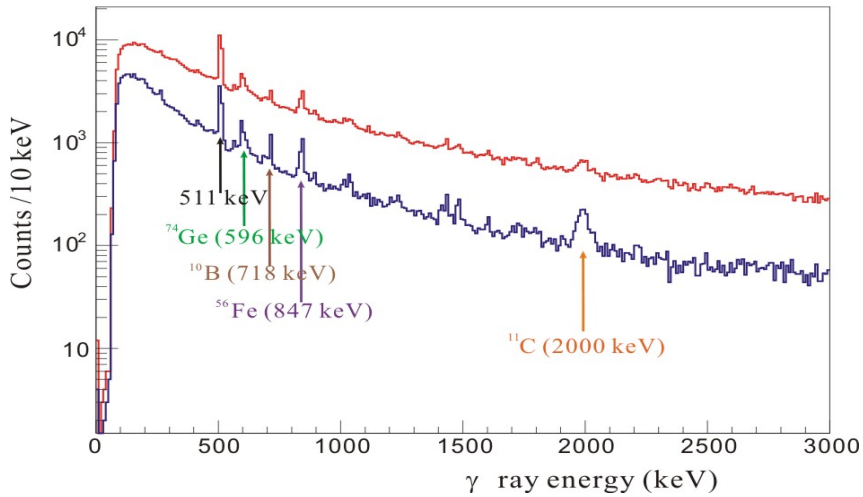
Preliminary



Experimental setup & analysis : Ge detectors

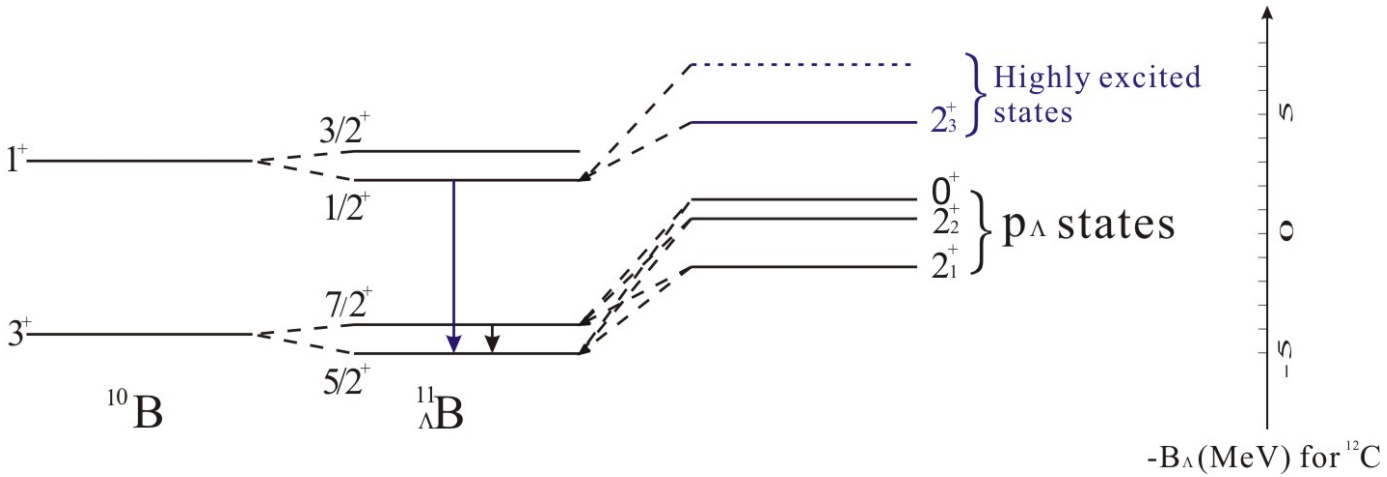
- BGO suppression





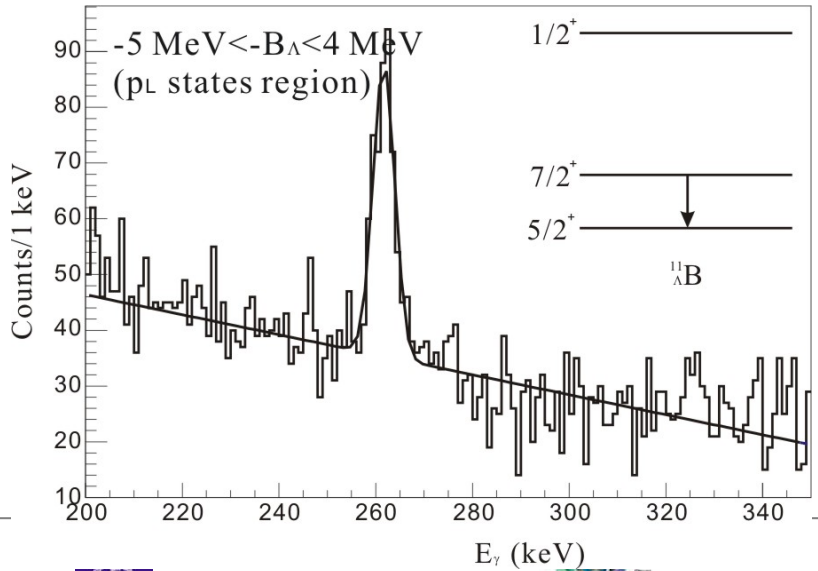
- Photoelectric peak efficiency ~5 % @ 1.33 MeV when beam off
- Energy resolution = 5.3 keV (FWHM) @ 1.33 MeV when beam on
- Time resolution = 18 ns (FWHM) @ 1.33 MeV when beam on

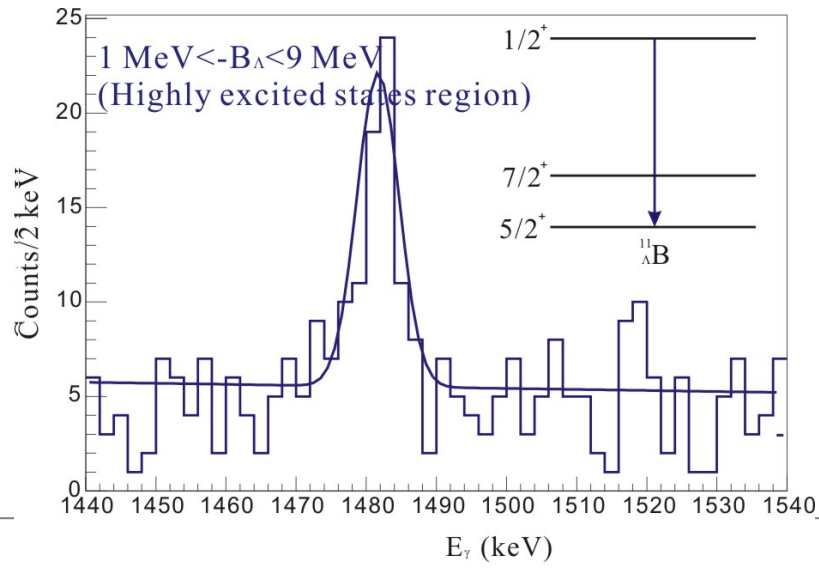
Preliminary results: gamma rays from ${}^{11}_{\Lambda}\mathrm{B}$



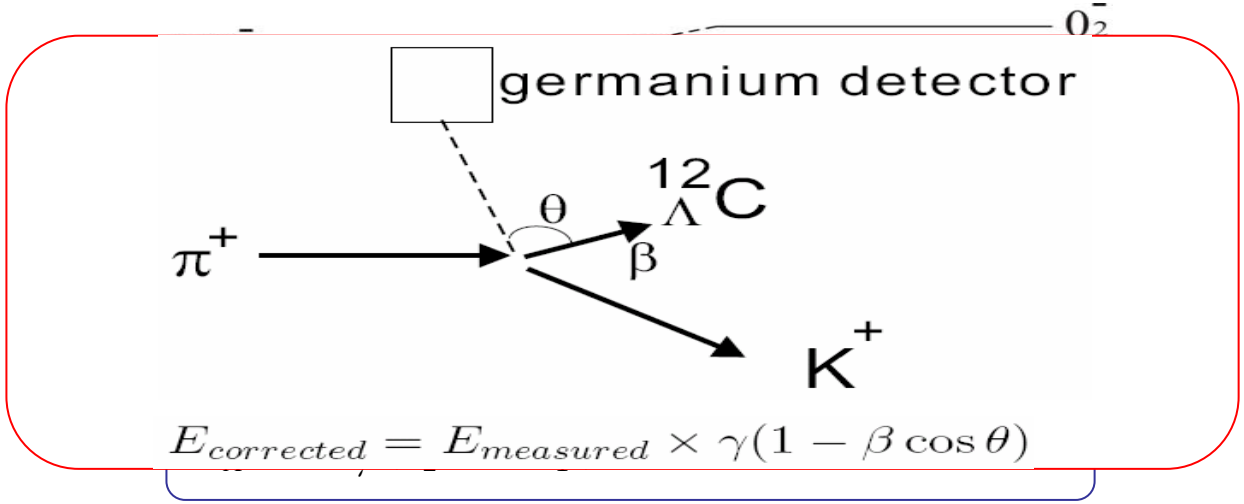
$${}^{11}_{\Lambda}\mathrm{B}: E_\gamma(7/2^+ \rightarrow 5/2^+) = 261.6 \pm 0.2\mathrm{keV}$$

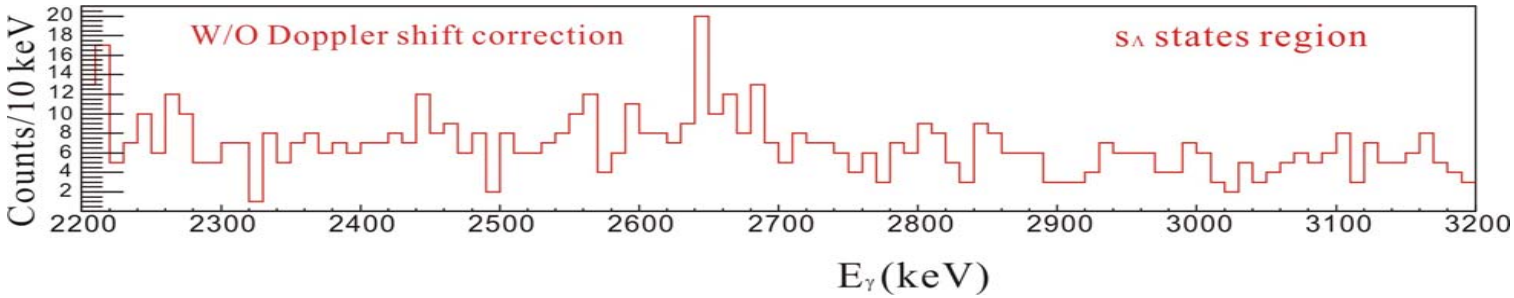
$${}^{11}_{\Lambda}\mathrm{B}: E_\gamma(1/2^+ \rightarrow 5/2^+) = 1481.7 \pm 0.7\mathrm{keV}$$

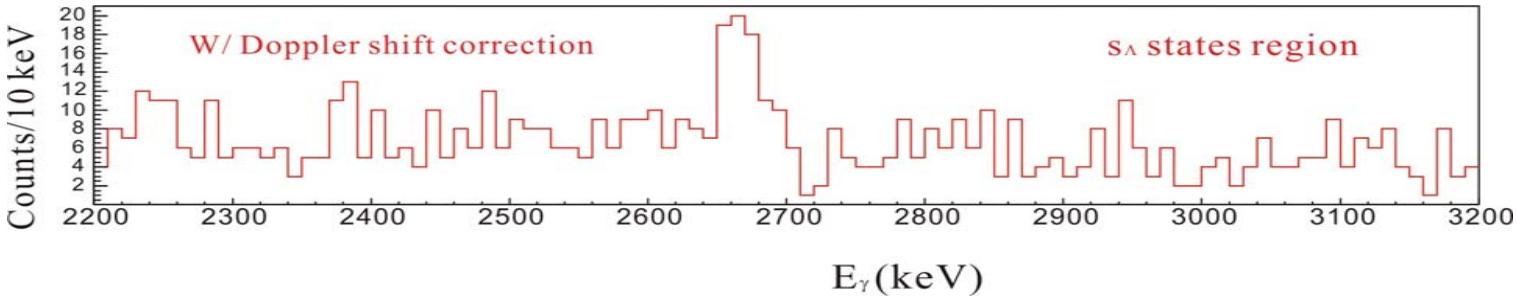




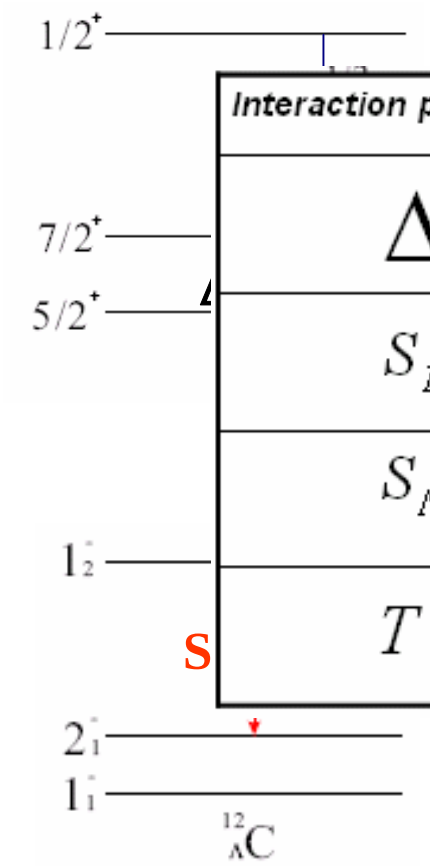
Preliminary results: gamma rays from $^{12}_{\Lambda}C$







Discussion



Interaction parameters	Previous results	Present results
Δ	0.43 MeV	0.33 MeV
S_N	-0.4 MeV	-0.7~-0.9 MeV
S_Λ	-0.01 MeV	
T	0.03 MeV	

$$E_\gamma = \Delta E_{core} - 0.143\Delta - 0.363S_\Lambda - 0.944S_N + 2.762T$$

Summary

- KEK-E566: ^{12}C (pi+, K+) $^{12}_{\Lambda}$C / $^{11}_{\Lambda}$B @ K6 beam line, KEK
- Three hypernuclear gamma-ray peaks were observed.

$$^{11}_{\Lambda}\mathrm{B}: E_{\gamma}(7/2^{+} \rightarrow 5/2^{+}) = 261.6 \pm 0.2\mathrm{keV}$$

$$^{11}_{\Lambda}\mathrm{B}: E_{\gamma}(1/2^{+} \rightarrow 5/2^{+}) = 1481.7 \pm 0.7\mathrm{keV}$$

$$^{12}_{\Lambda}\mathrm{C}: E_{\gamma}(1_2^{-} \rightarrow 2_1^{-}) = 2667.3 \pm 2.8\mathrm{keV}$$

- Two interaction parameters were derived from proper transitions.

S_N : -0.7~-0.9 MeV

Δ : 0.3 MeV

S_N : ~-0.4 MeV

Δ : ~0.43 MeV

Present problems & future task

- Production rate of the ground state ${}^{12}_{\Lambda}\mathrm{C}$ hypernucleus is rather different from previous data.
  - Other experiments show that the production rate of the ground state ${}^{12}_{\Lambda}\mathrm{C}$ is about 7 counts/(g/cm^2)(10^{9}pion)
  - In our current analysis this value is ~ 2.3 counts/(g/cm^2)(10^{9}pion)

Background: Physics interests of the present experiment

- To measure the g-factor of a Λhyperon inside nuclear medium.

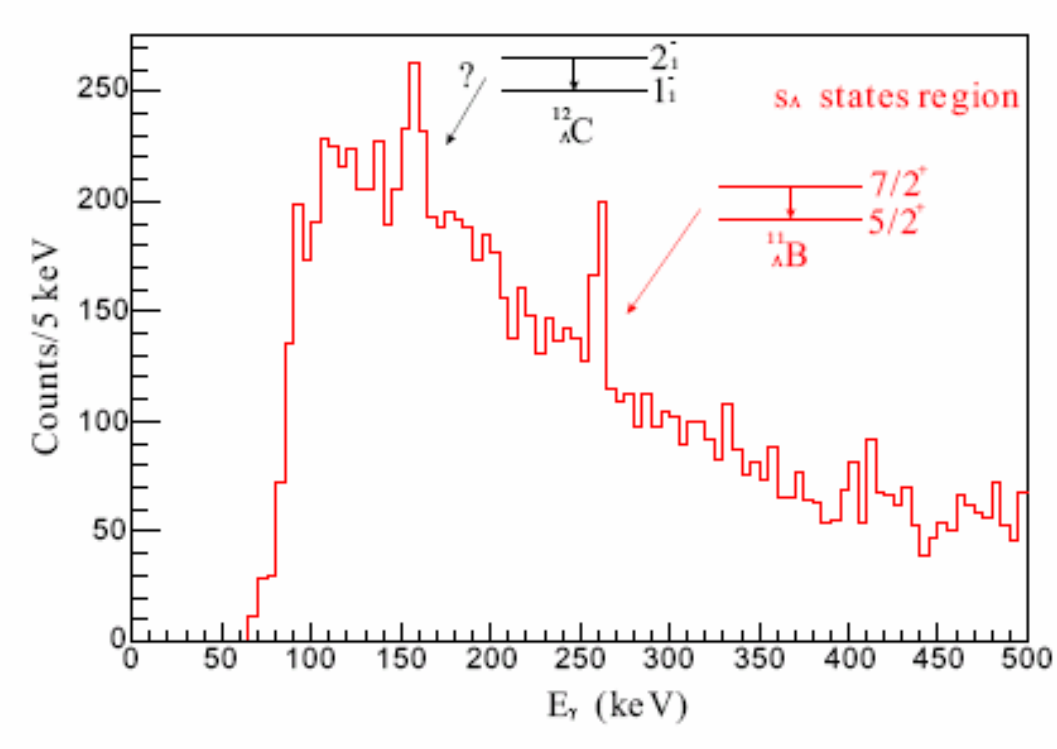
$$
\begin{aligned}
B(M1) &= (2J_{up}+1)^{-1}|<\phi_{low}|\mu|\phi_{up}>|^2 \\
&= (2J_{up}+1)^{-1}|<\phi_{low}|g_{core}J_{core}+g_{\Lambda}J_{\Lambda}|\phi_{up}>|^2 \\
&= (2J_{up}+1)^{-1}|<\phi_{low}|g_{core}J+(g_{\Lambda}-g_{core})J_{\Lambda}|\phi_{up}>|^2 \\
&= \frac{3}{8\pi}(2J_{low}+1)(2J_{core}+1)^{-1}(g_{core}-g_{\Lambda})^2 \quad [\mu_N^2],
\end{aligned}
$$

$$
\frac{1}{\tau} = 1.76\times 10^{13}\cdot B(M1)\cdot E_{\gamma}^3
$$

Doppler Shift Attenuation Method (DSAM)

Present problems & future task

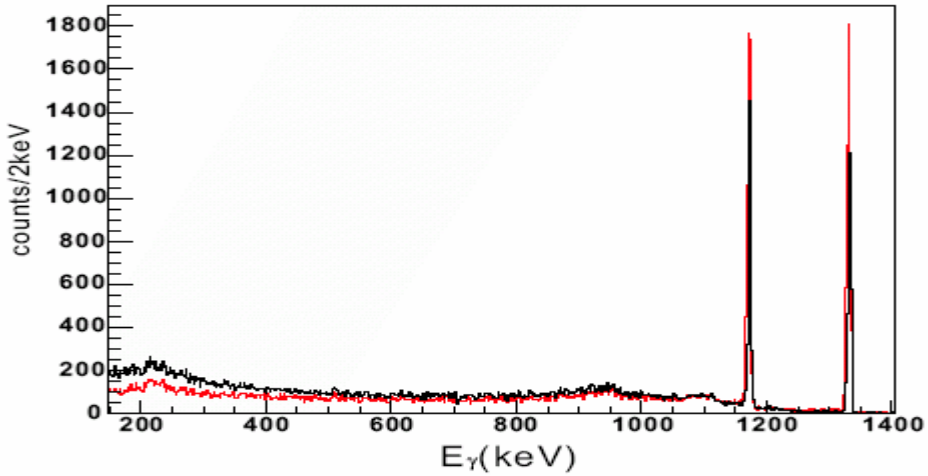
- Candidate for ground state doublet transition of $^{12}_{\Lambda}\mathrm{C}(1^-_2 \rightarrow 2^-_1)$
  - Gamma-ray energy is around 150 keV
  - Number of counts is consistent with rough estimated value



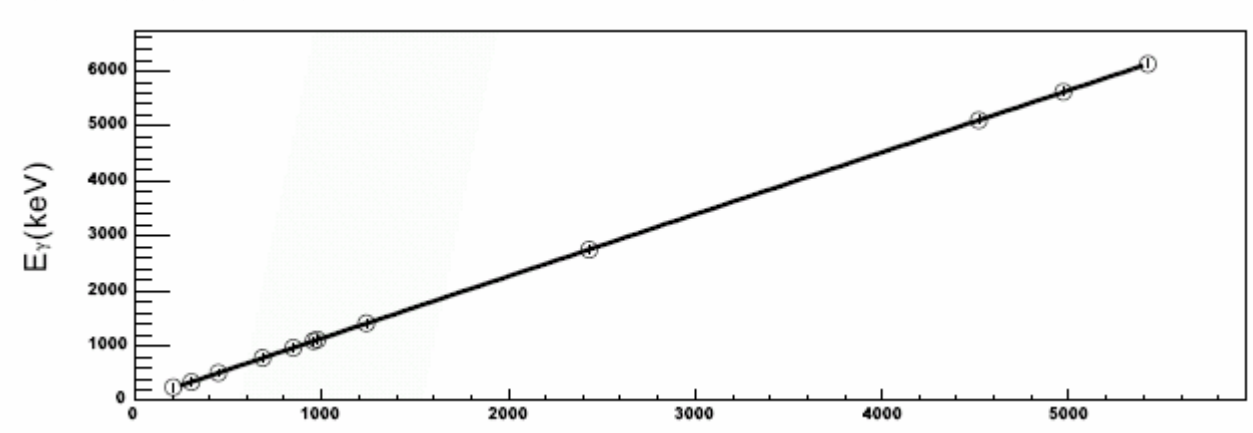
Experimental setup & analysis : Ge detectors

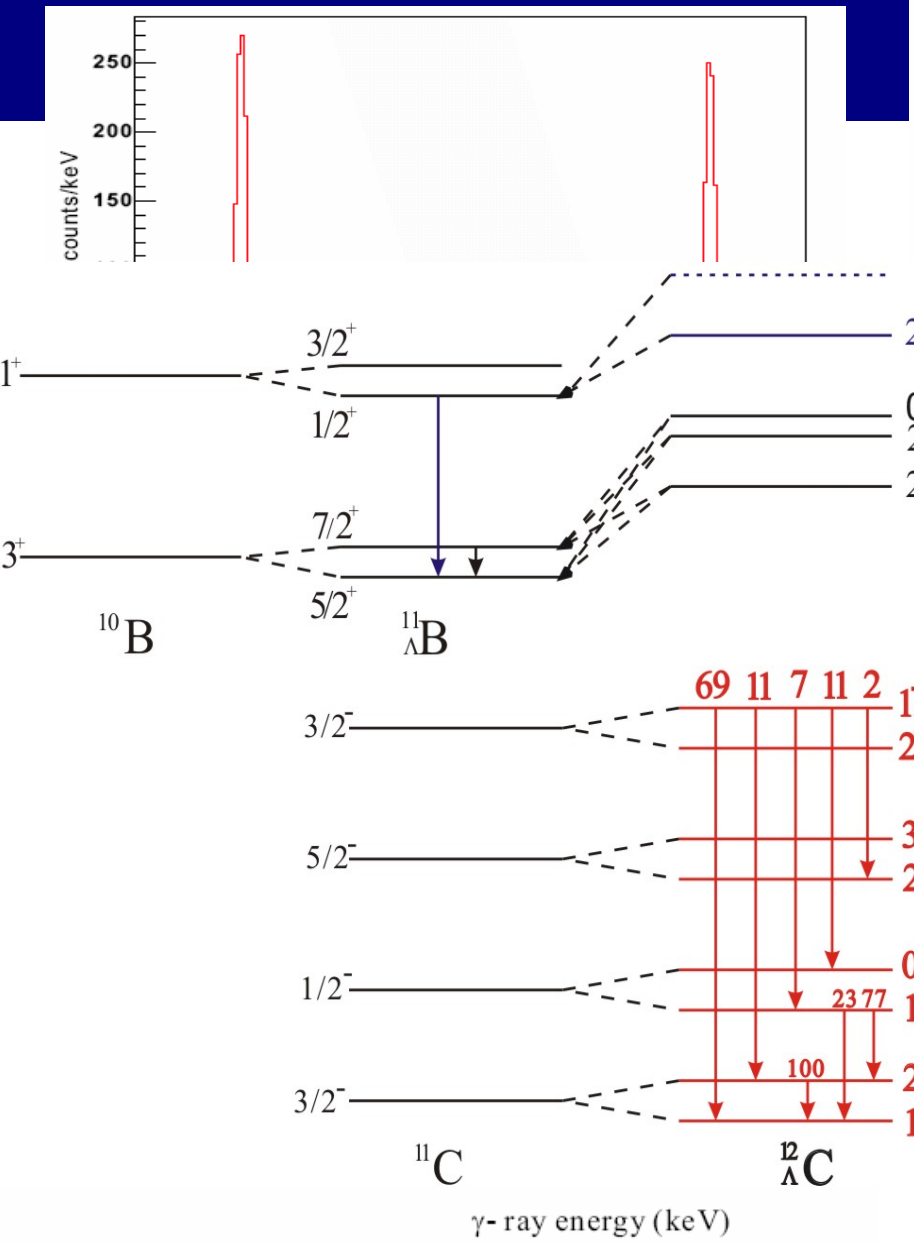
- Clover Ge add back

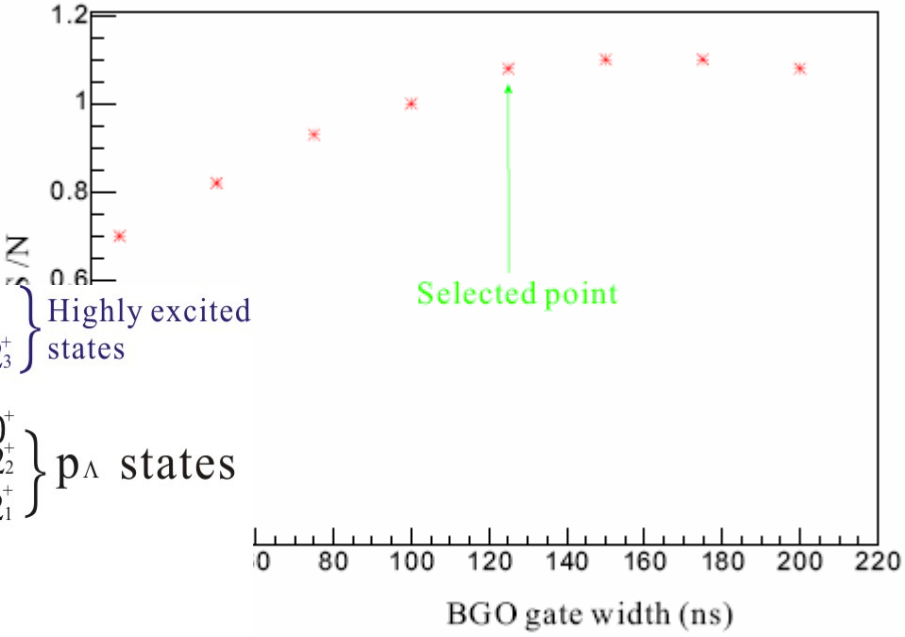
Photo-peak efficiency increased by 1.5 times

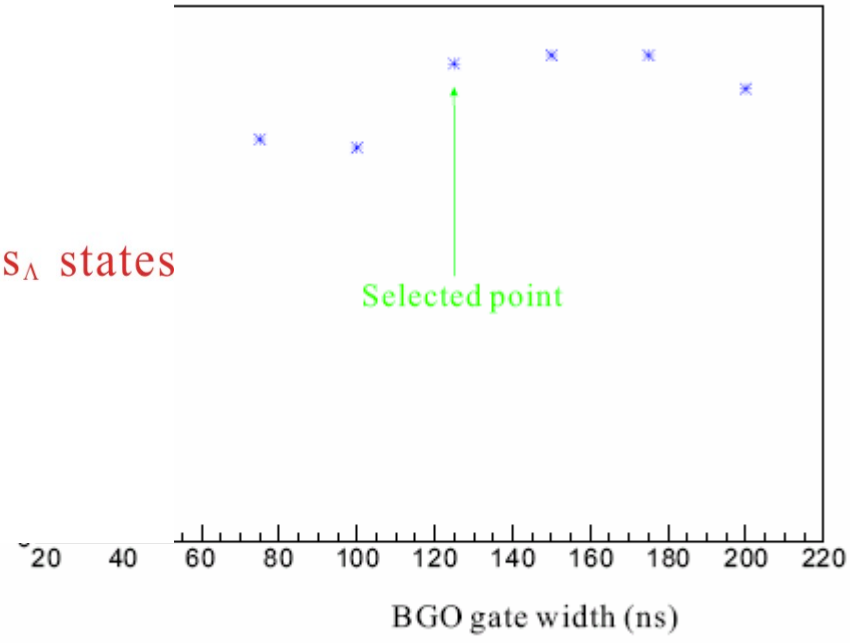


- Ge calibration

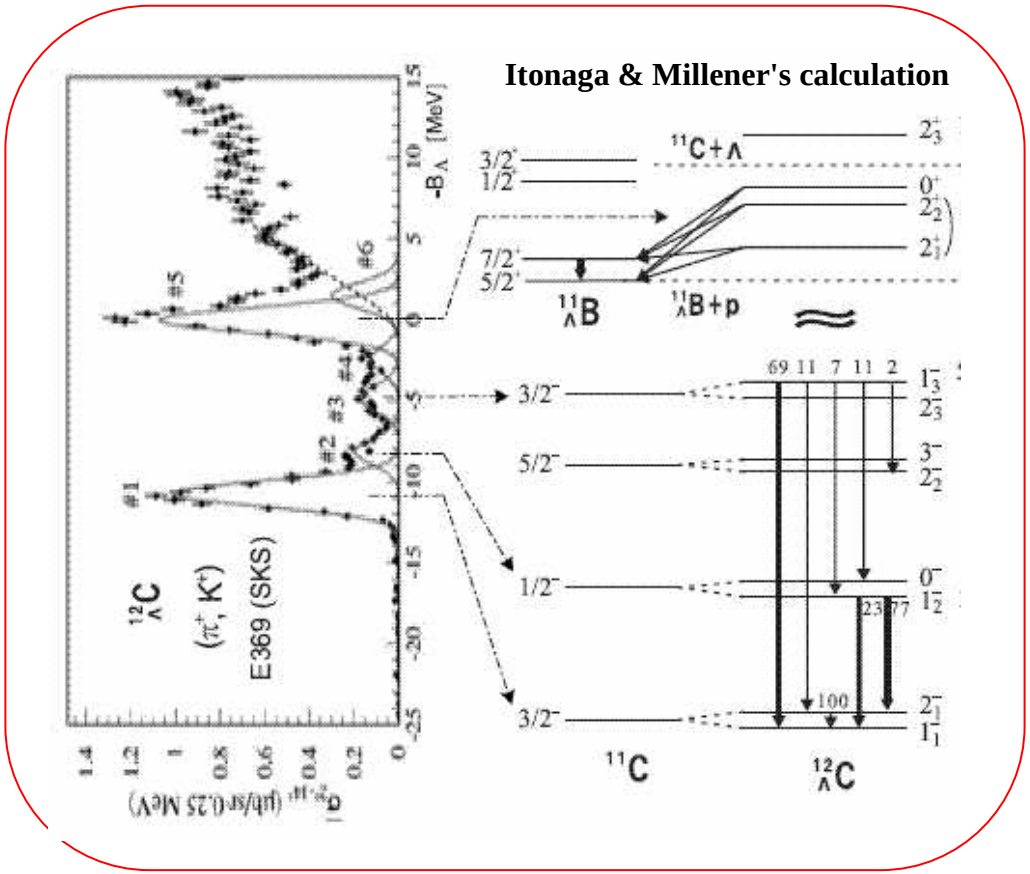


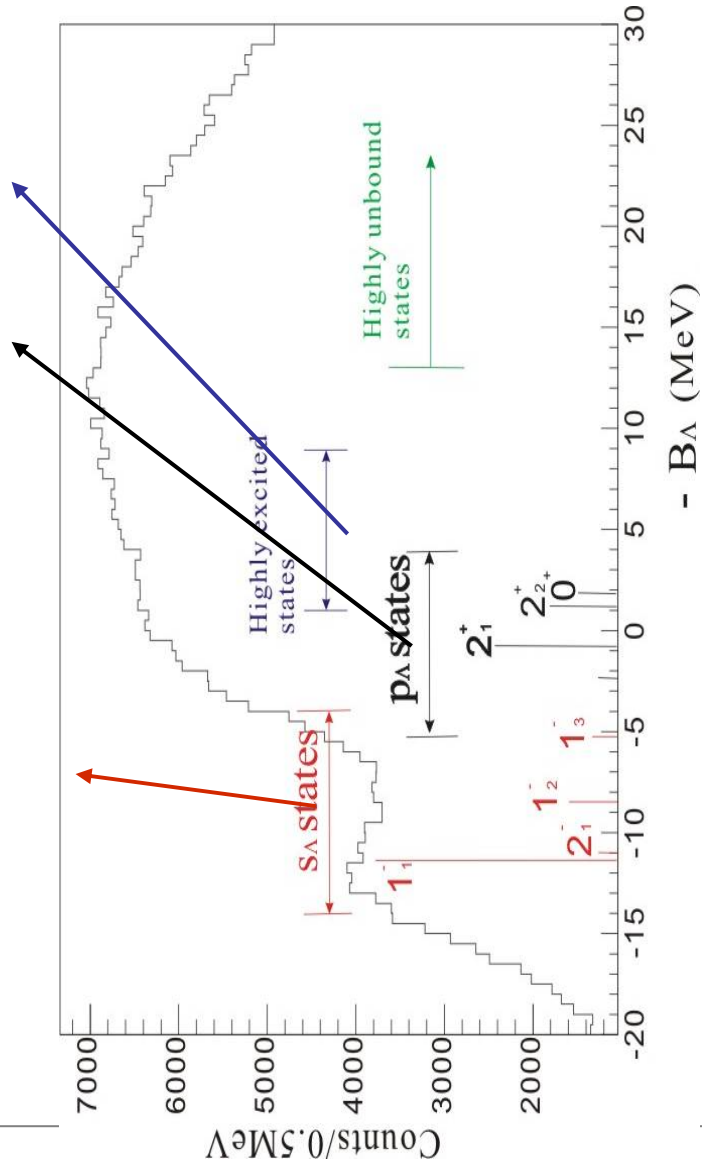

counts/keV
250
200
150
Highly excited states
2^+_3
$3/2^+$
1^+
$1/2^+$
0^+
2^+_2
2^+_1
p_Λ states
$7/2^+$
3^+
$5/2^+$
^{10}B
$^{11}_{\Lambda}B$
69 11 7 11 2
1^-_3
$3/2^-$
2^-_3
3^-_2
$5/2^-$
2^-_2
s_Λ states
0^-_2
$1/2^-$
23 77
1^-_2
100
2^-_1
$3/2^-$
1^-_1
^{11}C
$^{12}_{\Lambda}C$
γ- ray energy (keV)


1.2
1
0.8
0.6
Selected point
0
80
100
120
140
160
180
200
220
BGO gate width (ns)

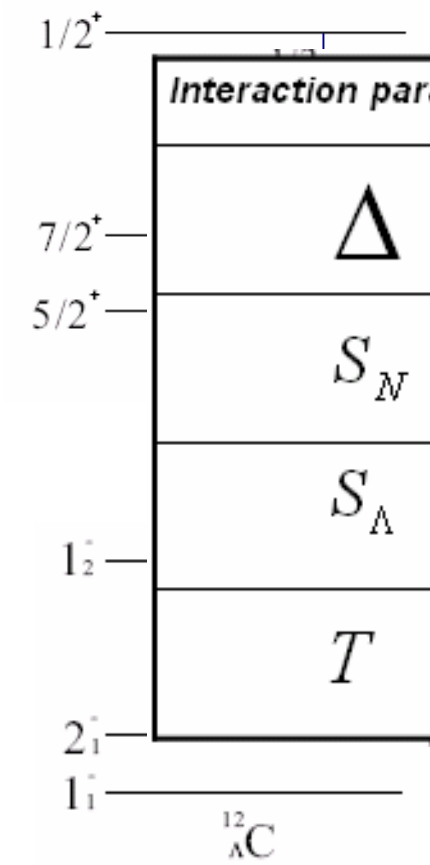

Selected point
20
40
60
80
100
120
140
160
180
200
220
BGO gate width (ns)

Preliminary results: states selection





Discussion



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