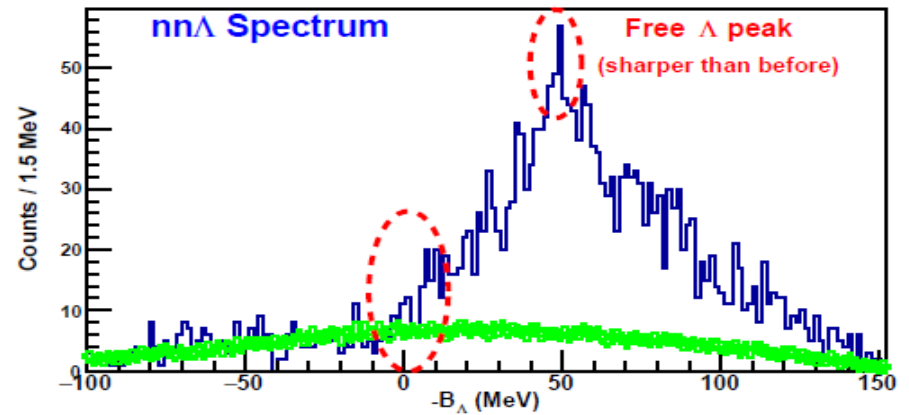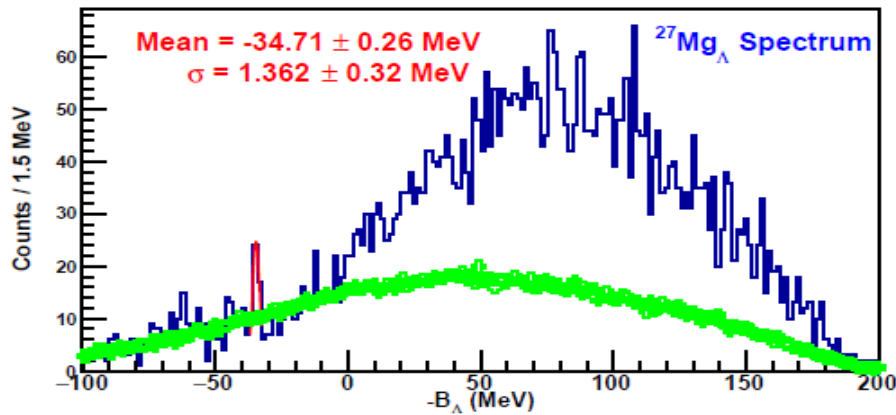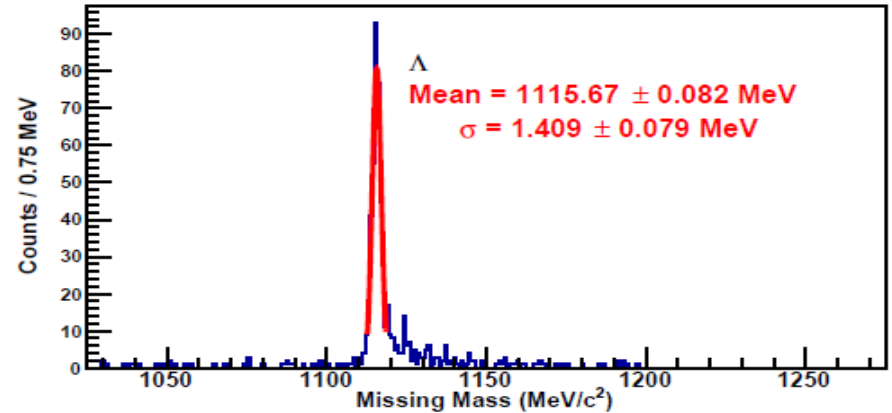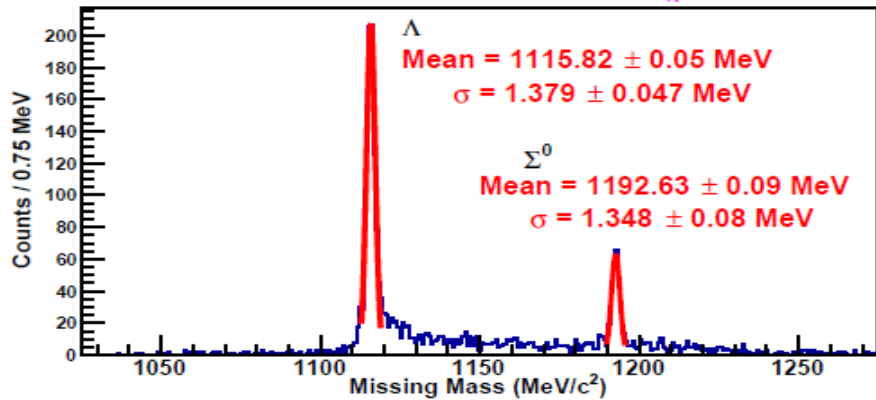# nnL Analysis Meeting
September 9, 2021

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Hampton University

Can a Fake Peak be Produced?

For this tune:
Events gated within -40 to -30 MeV of $^{27}Mg_\Lambda$ (for all 4 peaks)

Λ
Mean = 1115.82 ± 0.05 MeV
σ = 1.379 ± 0.047 MeV

Σ^0
Mean = 1192.63 ± 0.09 MeV
σ = 1.348 ± 0.08 MeV

Λ
Mean = 1115.67 ± 0.082 MeV
σ = 1.409 ± 0.079 MeV

Mean = -34.71 ± 0.26 MeV
σ = 1.362 ± 0.32 MeV

$^{27}Mg_\Lambda$ Spectrum
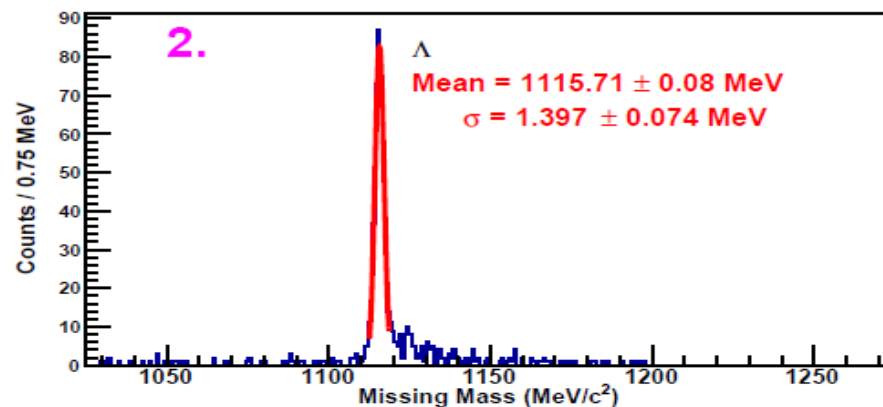

nnΛ Spectrum

Free Λ peak
(sharper than before)

- Events are selected within -40 to -30 MeV which are non-physical.
- The wrong selection of events can deform the matrix.
- The free Λ peak in the nnΛ spectrum becomes much narrower than the actual peak (~6.5 MeV).

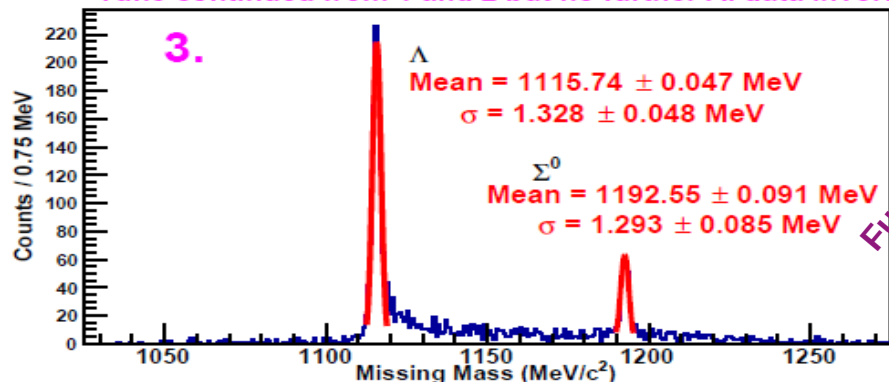# What would be the resolution of a heavy system (A>1) if no Al data involved in tune?

For 1. and 2.
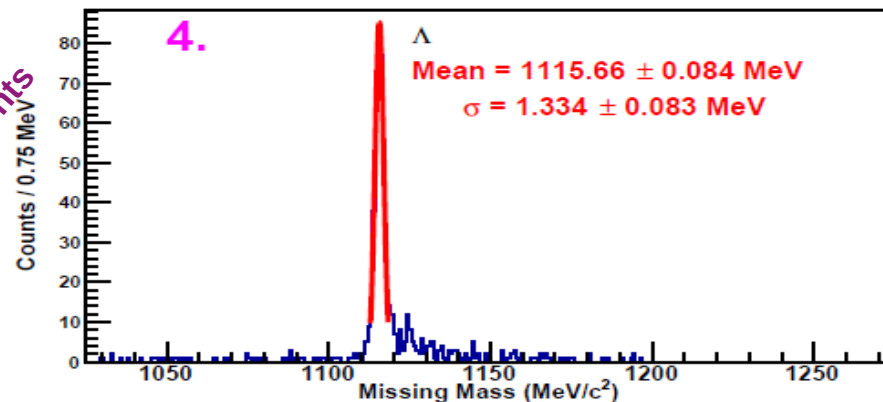Al data (-20 to -10, -10 to 0 and 0 to 10 MeV) involved in tune

1.
Λ
Mean = 1115.67 ± 0.05 MeV
σ = 1.395 ± 0.047 MeV

Σ^0
Mean = 1192.61 ± 0.099 MeV
σ = 1.371 ± 0.11 MeV

2.
Λ
Mean = 1115.71 ± 0.08 MeV
σ = 1.397 ± 0.074 MeV
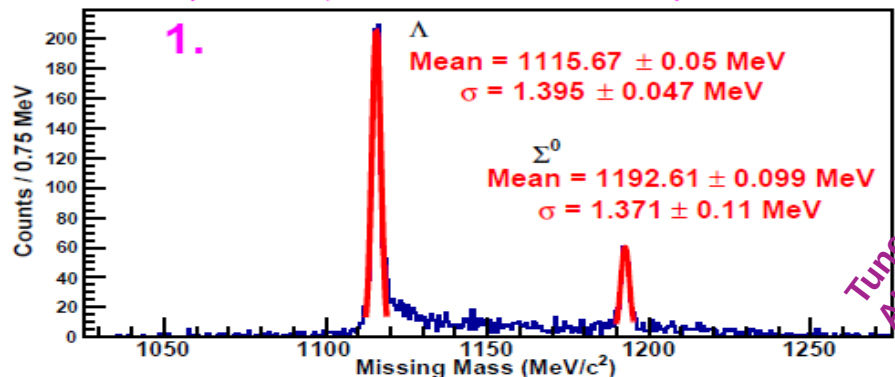
Tuned by involving Al events

For 3. and 4.
Tune continued from 1 and 2 but no further Al data involved

3.
Λ
Mean = 1115.74 ± 0.047 MeV
σ = 1.328 ± 0.048 MeV

Σ^0
Mean = 1192.55 ± 0.091 MeV
σ = 1.293 ± 0.085 MeV
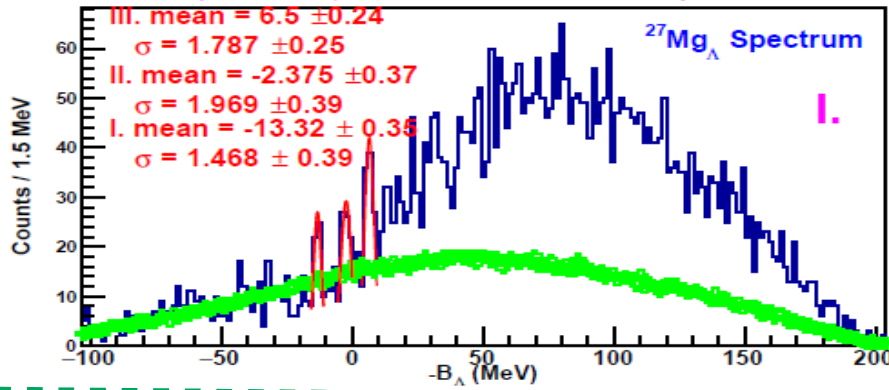
4.
Λ
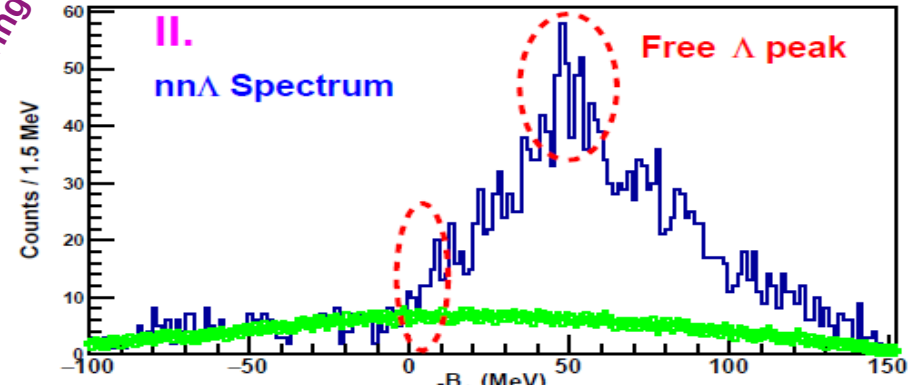Mean = 1115.66 ± 0.084 MeV
σ = 1.334 ± 0.083 MeV

Further tuned without Al events

- Initially, the momentum matrices are tuned by selecting the events from the 3 different regions of 27Mg_L.
- When the peak width of Λ/Σ reached ~ 1.4 MeV, the matrices are further tuned without involving Al data.

Continue..

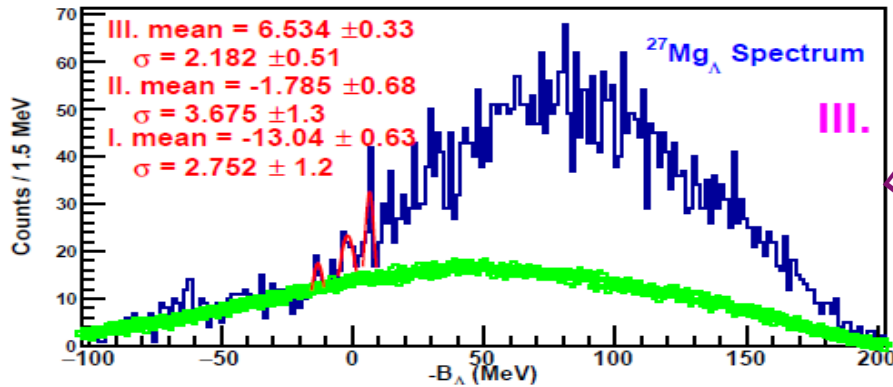For I and II:
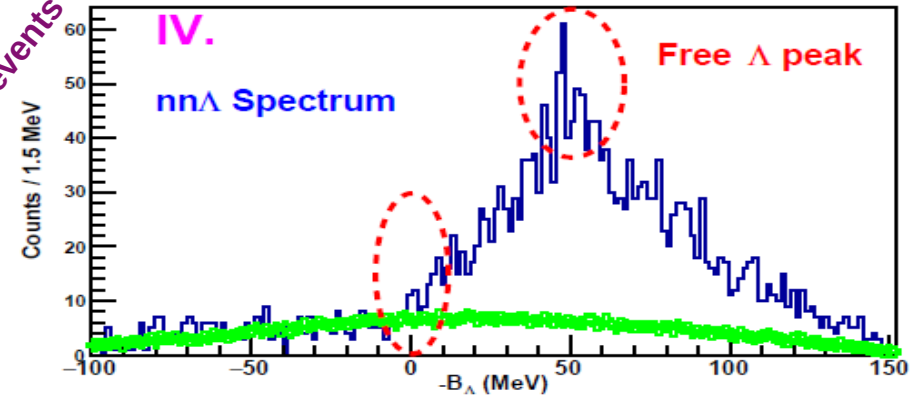Al data (-20 to -10, -10 to 0 and 0 to 10 MeV) involved in tune

III. mean = 6.5 ±0.24
σ = 1.787 ±0.25
II. mean = -2.375 ±0.37
σ = 1.969 ±0.39
I. mean = -13.32 ± 0.35
σ = 1.468 ± 0.39

$^{27}Mg_\Lambda$ Spectrum

I.

Tuned by involving Al events

II.

nnΛ Spectrum

Free Λ peak

For III and IV:
Tune continued from I and II but no further Al data involved

III. mean = 6.534 ±0.33
σ = 2.182 ±0.51
II. mean = -1.785 ±0.68
σ = 3.675 ±1.3
I. mean = -13.04 ± 0.63
σ = 2.752 ± 1.2

$^{27}Mg_\Lambda$ Spectrum

III.

Further tuned without Al events

IV.

nnΛ Spectrum
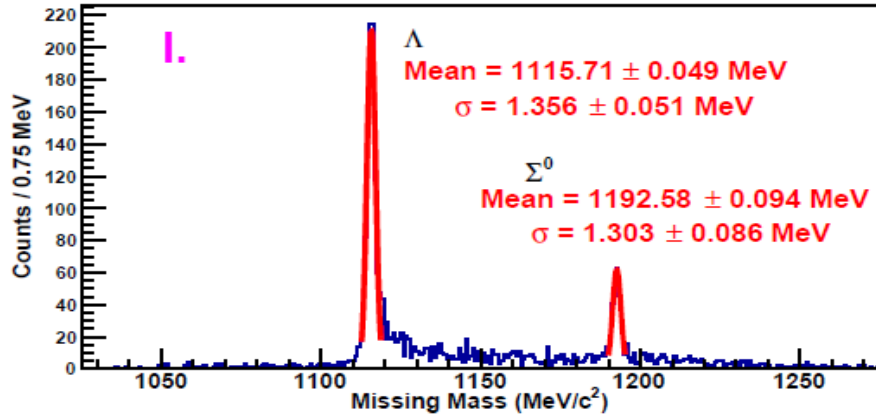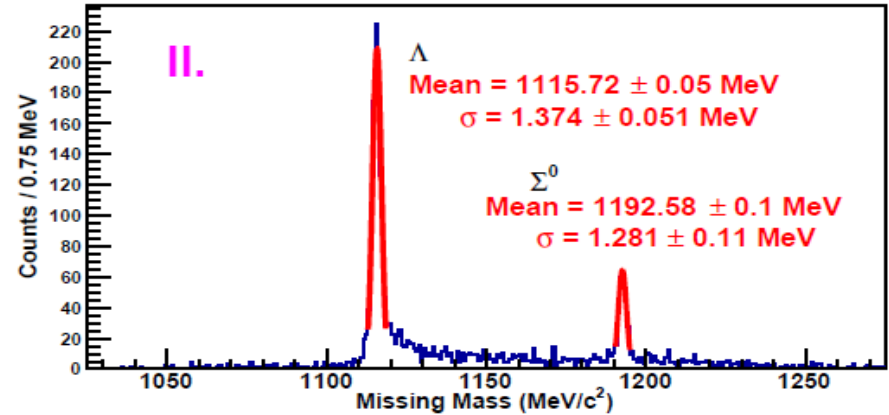
Free Λ peak

- While the matrices are tuned further without involving the Al data, the preexisted peaks blow up.
- The phenomena is significant as the ground state of 27Mg_L widen from 1.46 to 2.75 MeV.
- If no Al data is involved in tune, we don't know the exact resolution of the heavy system (A>1).
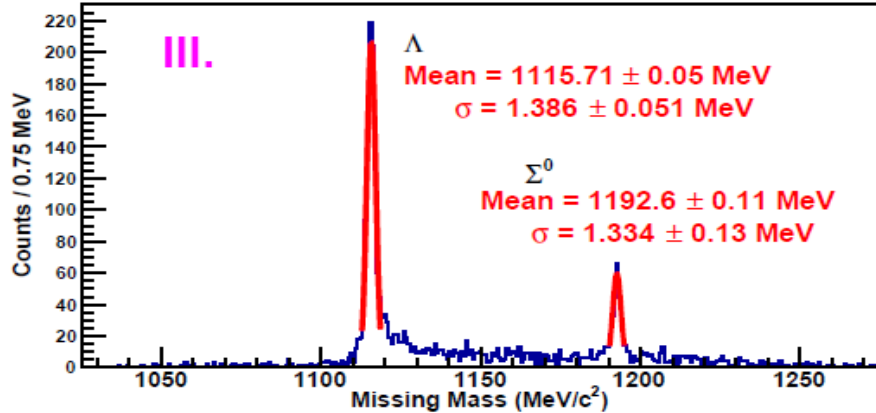
Consistency Test by Moving the Events Selection Gates

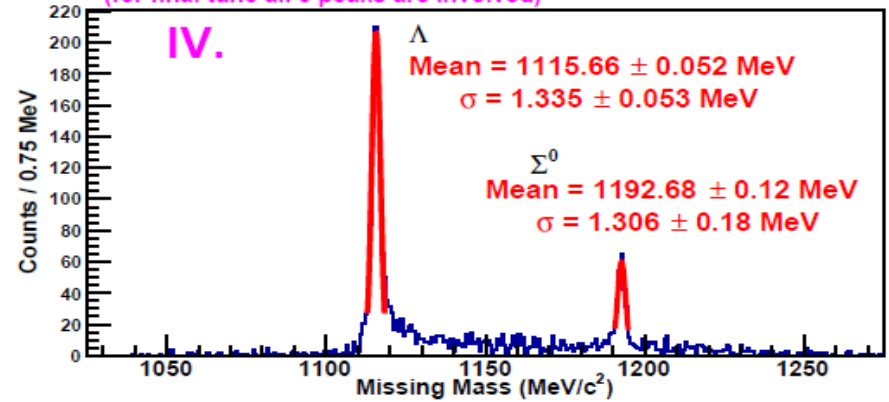**I. Peak search tune (-20 to -10, -10 to 0 and 0 to 10 MeV) of $^{27}Mg_\Lambda$**

I.

Λ
Mean = 1115.71 $\pm$ 0.049 MeV
σ = 1.356 $\pm$ 0.051 MeV

Σ^0
Mean = 1192.58 $\pm$ 0.094 MeV
σ = 1.303 $\pm$ 0.086 MeV

II. Peak search tune (-18 to -8, -8 to +2 and 2 to 12 MeV) of $^{27}Mg_\Lambda$

II.

Λ
Mean = 1115.72 $\pm$ 0.05 MeV
σ = 1.374 $\pm$ 0.051 MeV

Σ^0
Mean = 1192.58 $\pm$ 0.1 MeV
σ = 1.281 $\pm$ 0.11 MeV

III. Peak search tune (-16 to -6, -6 to +4 and 4 to 14 MeV) of $^{27}Mg_\Lambda$

III.

Λ
Mean = 1115.71 $\pm$ 0.05 MeV
σ = 1.386 $\pm$ 0.051 MeV

Σ^0
Mean = 1192.6 $\pm$ 0.11 MeV
σ = 1.334 $\pm$ 0.13 MeV

IV. Peak search tune (-6 to +4 MeV) of $^{27}Mg_\Lambda$
(for final tune all 3 peaks are involved)

IV.

Λ
Mean = 1115.66 $\pm$ 0.052 MeV
σ = 1.335 $\pm$ 0.053 MeV

Σ^0
Mean = 1192.68 $\pm$ 0.12 MeV
σ = 1.306 $\pm$ 0.18 MeV

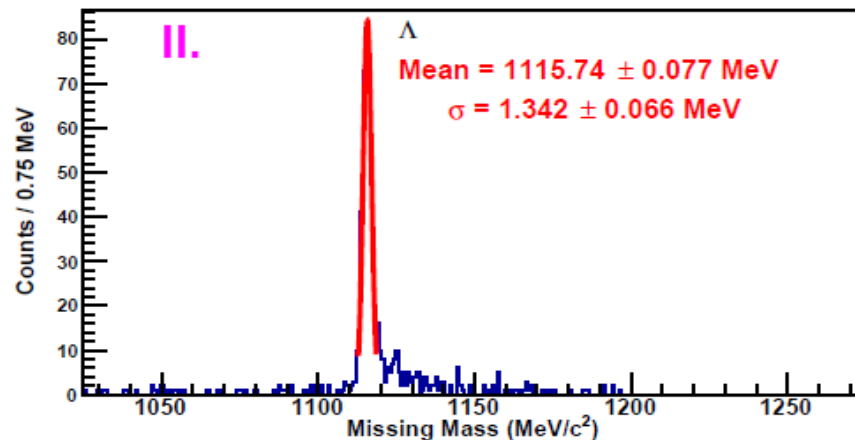Axis labels: Counts / 0.75 MeV (y-axis), Missing Mass (MeV/c^2) (x-axis)

- The events selection gates are chosen by considering the previous measurements on A=28 hypernuclei.
- To check the consistency, the gates are artificially shifted by 2 MeV and then further by 2 MeV.
- For each case, the matrices are tuned until the width of Λ reached ~ 1.35 MeV (Σ~1.3 MeV).
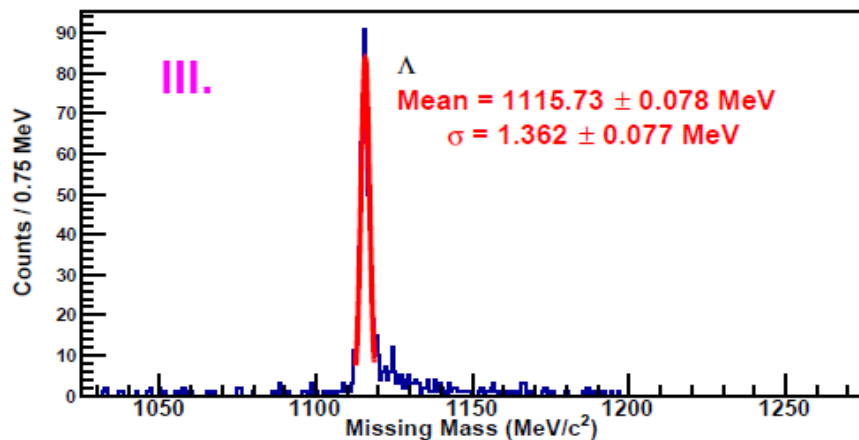
Consistency Test Continue..

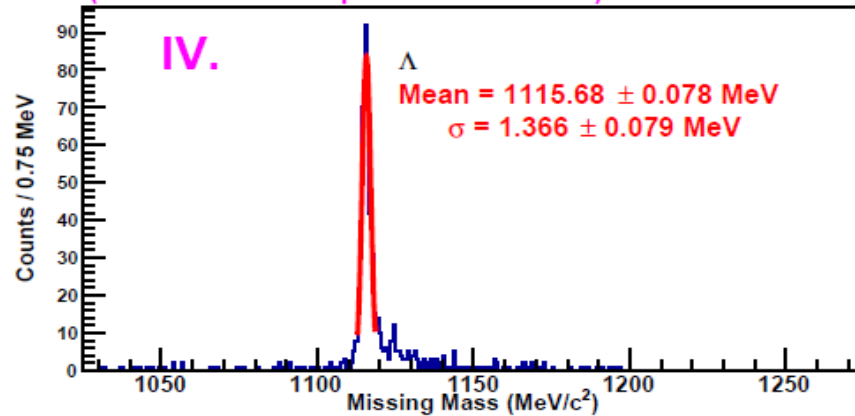I. Peak search tune (-20 to -10, -10 to 0 and 0 to 10 MeV) of $^{27}Mg_\Lambda$

I.
Λ
Mean = 1115.74 ± 0.076 MeV
σ = 1.341 ± 0.069 MeV

II. Peak search tune (-18 to -8, -8 to +2 and 2 to 12 MeV) of $^{27}Mg_\Lambda$

II.
Λ
Mean = 1115.74 ± 0.077 MeV
σ = 1.342 ± 0.066 MeV

III. Peak search tune (-16 to -6, -6 to +4 and 4 to 14 MeV) of $^{27}Mg_\Lambda$

III.
Λ
Mean = 1115.73 ± 0.078 MeV
σ = 1.362 ± 0.077 MeV

IV. Peak search tune (-6 to +4 MeV) of $^{27}Mg_\Lambda$
(for final tune all 3 peaks are involved)

IV.
Λ
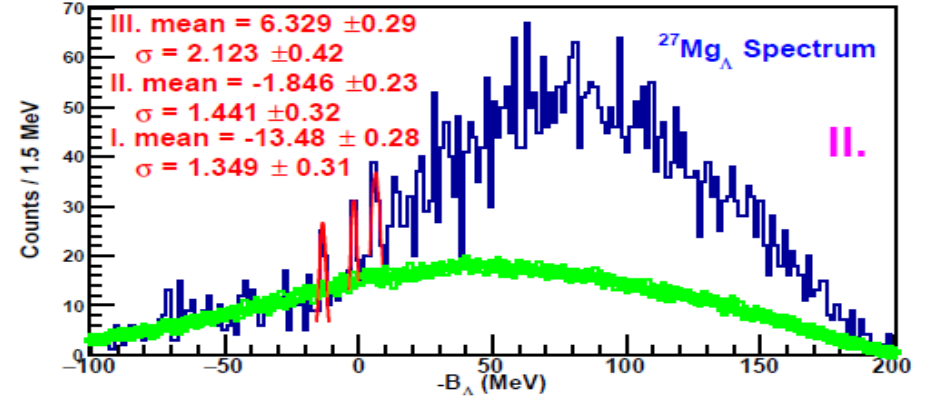Mean = 1115.68 ± 0.078 MeV
σ = 1.366 ± 0.079 MeV

- For each tune, the peak width of Λ (H/T) agreed within 50 KeV.

Consistency Test Continue.. (27Mg_L spectrum)

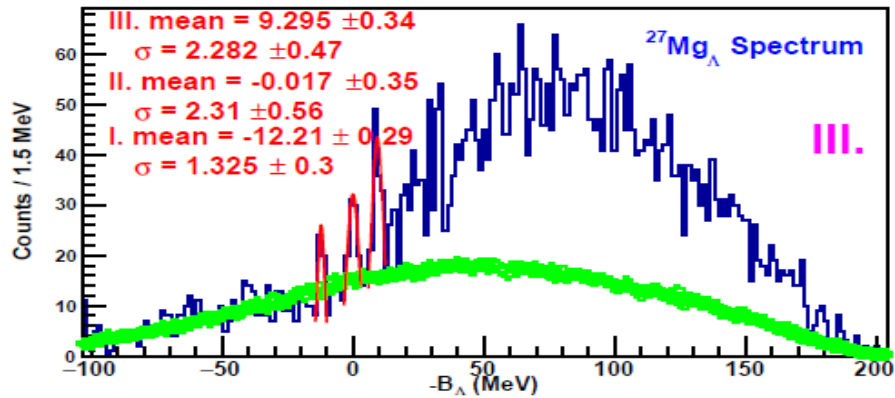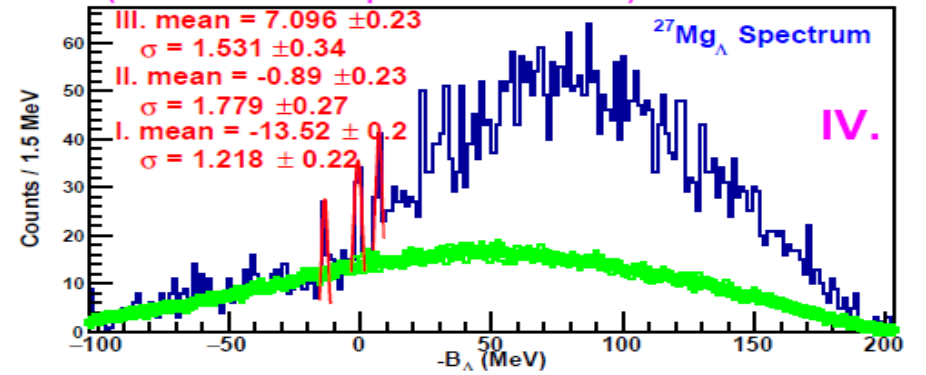I. Peak search tune (-20 to -10, -10 to 0 and 0 to 10 MeV) of $^{27}Mg_\Lambda$
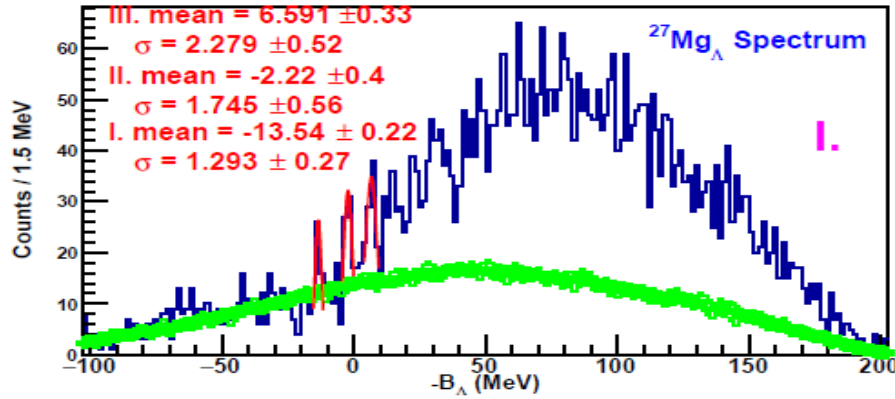
III. mean = 6.591 ±0.33
σ = 2.279 ±0.52
II. mean = -2.22 ±0.4
σ = 1.745 ±0.56
I. mean = -13.54 ± 0.22
σ = 1.293 ± 0.27

$^{27}Mg_\Lambda$ Spectrum

I.

II. Peak search tune (-18 to -8, -8 to +2 and 2 to 12 MeV) of $^{27}Mg_\Lambda$

III. mean = 6.329 ±0.29
σ = 2.123 ±0.42
II. mean = -1.846 ±0.23
σ = 1.441 ±0.32
I. mean = -13.48 ± 0.28
σ = 1.349 ± 0.31

$^{27}Mg_\Lambda$ Spectrum

II.

III. Peak search tune (-16 to -6, -6 to +4 and 4 to 14 MeV) of $^{27}Mg_\Lambda$

III. mean = 9.295 ±0.34
σ = 2.282 ±0.47
II. mean = -0.017 ±0.35
σ = 2.31 ±0.56
I. mean = -12.21 ± 0.29
σ = 1.325 ± 0.3

$^{27}Mg_\Lambda$ Spectrum

III.

IV. Peak search tune (-6 to +4 MeV) of $^{27}Mg_\Lambda$
(for final tune all 3 peaks are involved)

III. mean = 7.096 ±0.23
σ = 1.531 ±0.34
II. mean = -0.89 ±0.23
σ = 1.779 ±0.27
I. mean = -13.52 ± 0.2
σ = 1.218 ± 0.22

$^{27}Mg_\Lambda$ Spectrum

IV.

- For the ground state there is a good agreement (consistency is less than 1 MeV level).
- For the 2nd and 3rd peak the disagreement is because the selected region was close to gate boundary.

Closer View of 27Mg_L hypernuclei

- For this study events gated within -20 to -10, -10 to 0 and 0 to 10 MeV of 27Mg_L.
- The statistical significance for first, second, and 3rd peak is calculated as 2.75, 3.42 and 2.42 respectively.

Consistency Test Continue.. (nnΛ Spectrum)

I. Peak search tune (-20 to -10, -10 to 0 and 0 to 10 MeV) of $^{27}Mg_\Lambda$

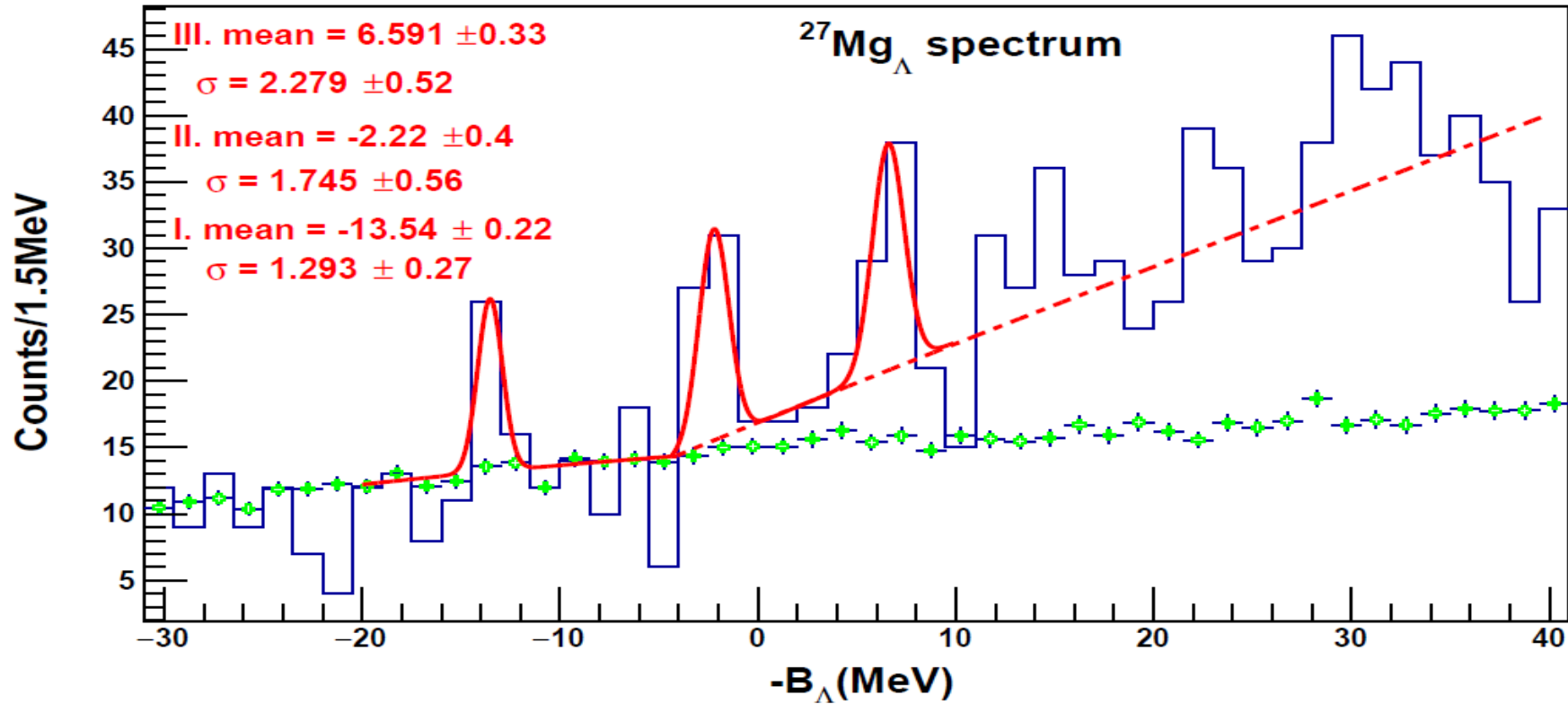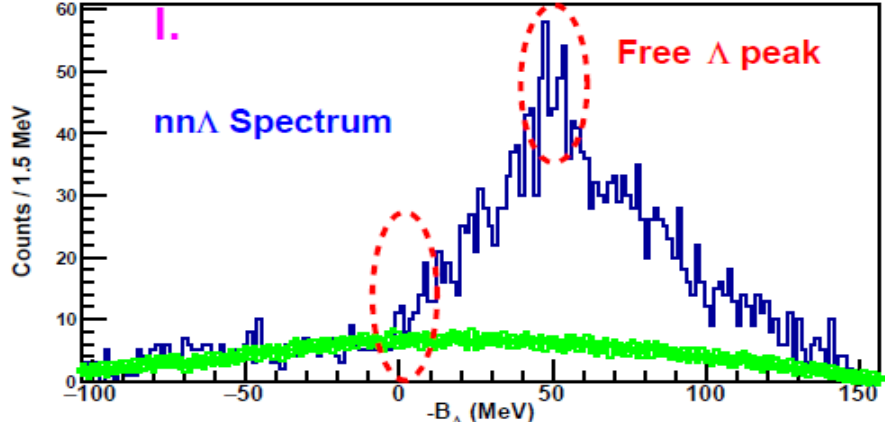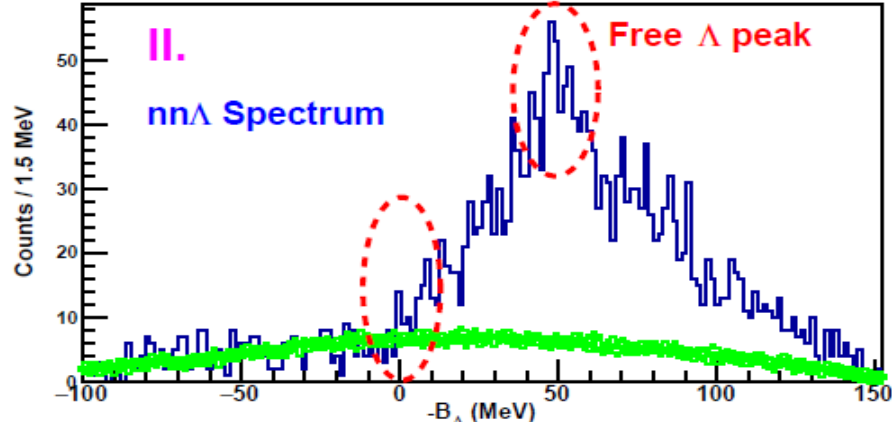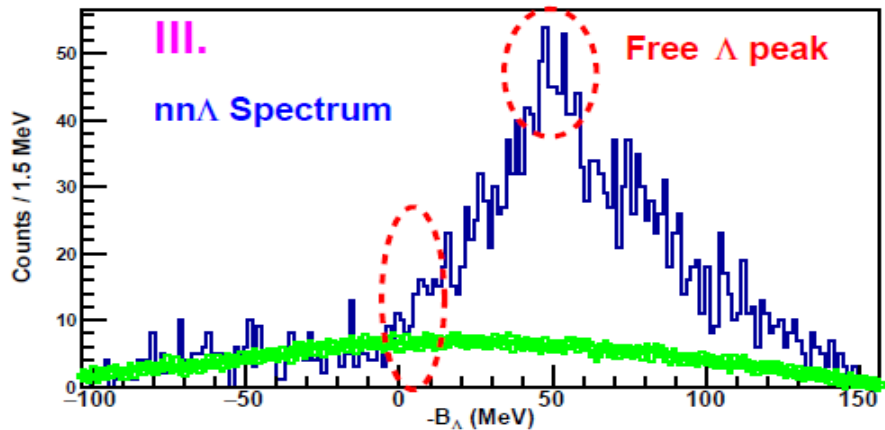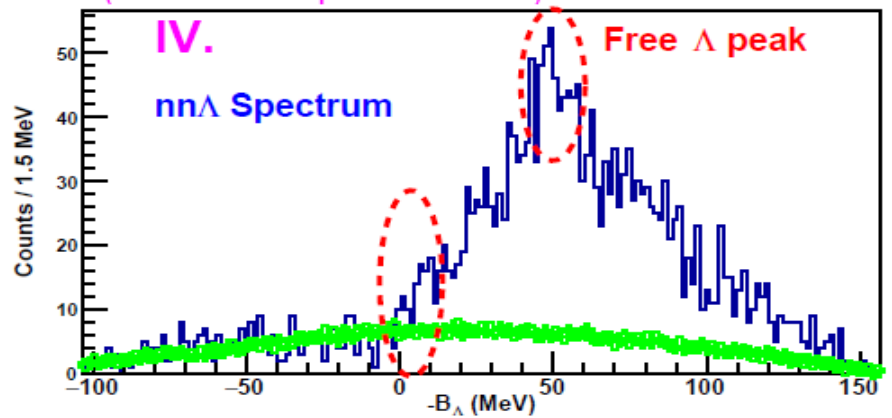II. Peak search tune (-18 to -8, -8 to +2 and 2 to 12 MeV) of $^{27}Mg_\Lambda$

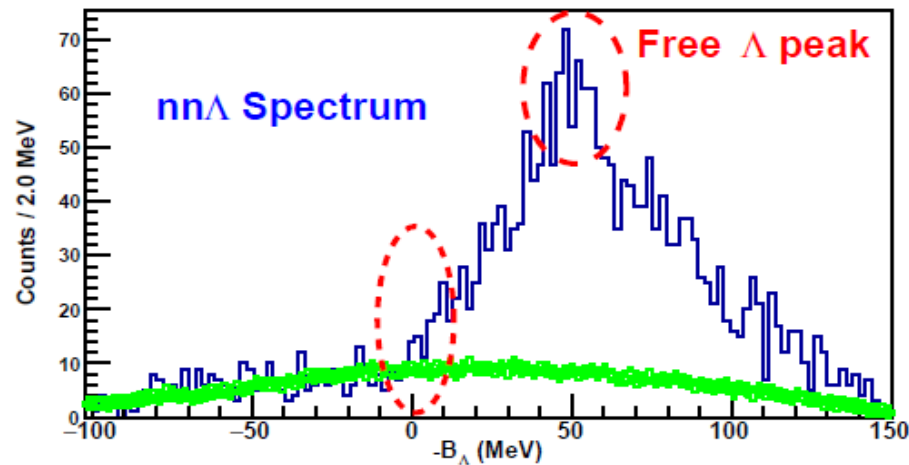III. Peak search tune (-16 to -6, -6 to +4 and 4 to 14 MeV) of $^{27}Mg_\Lambda$
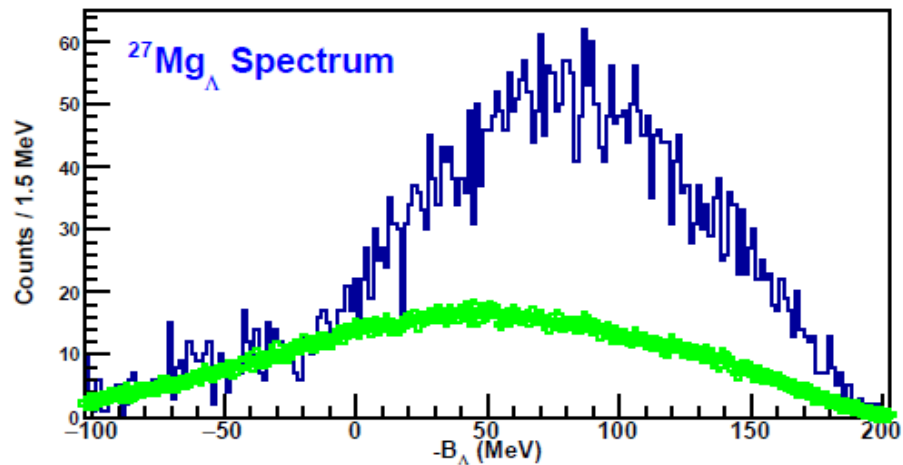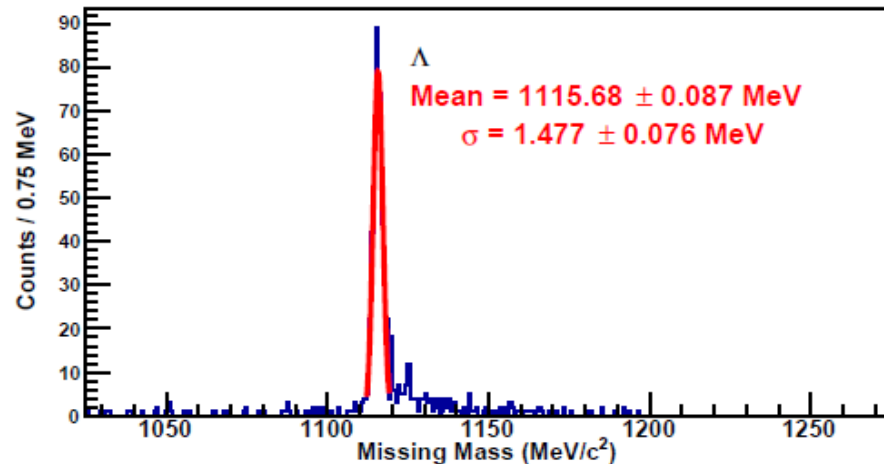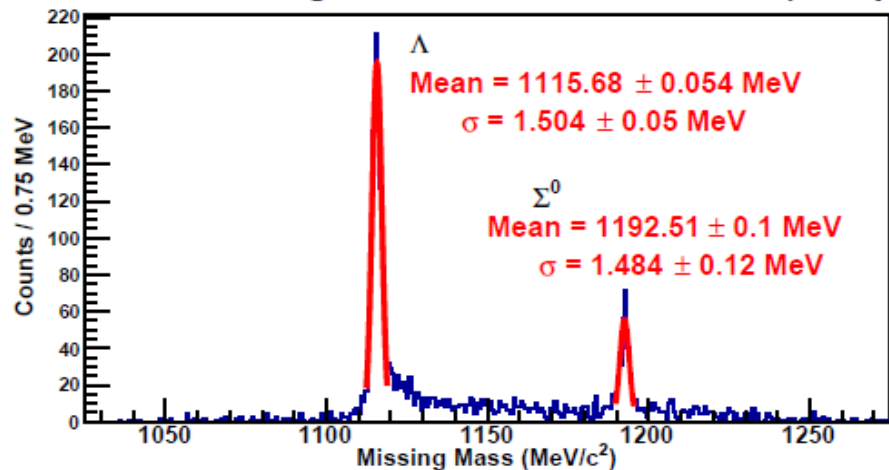
IV. Peak search tune (-6 to +4 MeV) of $^{27}Mg_\Lambda$
(for final tune all 3 peaks are involved)

- For each tune, the nnΛ spectrum is about same with similar free Λ peak width and similar enhancement above the threshold region.

Spectrum Before Al Data Involved in Tune

Before involving the Al data in Matrix Tune (all 4 plots)

Λ
Mean = 1115.68 $\pm$ 0.054 MeV
σ = 1.504 $\pm$ 0.05 MeV

Σ^0
Mean = 1192.51 $\pm$ 0.1 MeV
σ = 1.484 $\pm$ 0.12 MeV

Λ
Mean = 1115.68 $\pm$ 0.087 MeV
σ = 1.477 $\pm$ 0.076 MeV

$^{27}Mg_\Lambda$ Spectrum
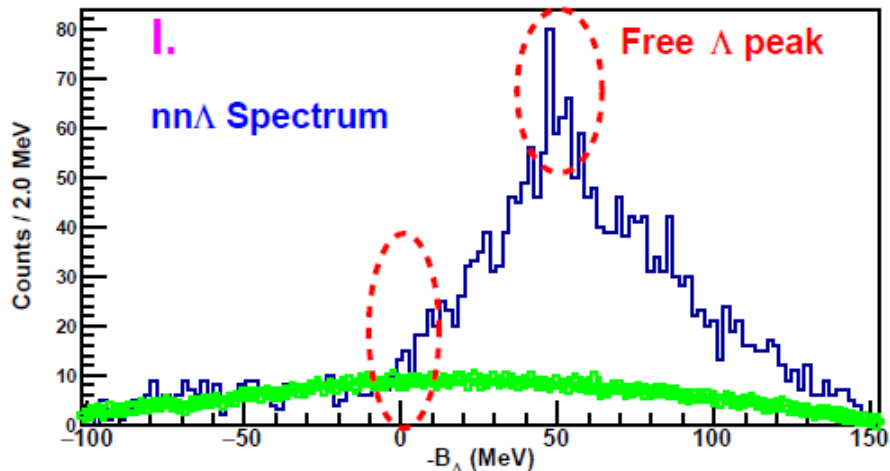
nnΛ Spectrum

Free Λ peak

Summary and Conclusions

- A fake peak can be generated anywhere but it can deform the momentum matrix.

- If the heavy system (Al data) is not involved in the tune, the resolution for the heavy system (A>1) cannot reach to the expected level.

- By involving Al data in the matrix tune, we believe that our resolution for A=3 system is around 1.3 MeV (σ) and therefore the Γ can be measured precisely.

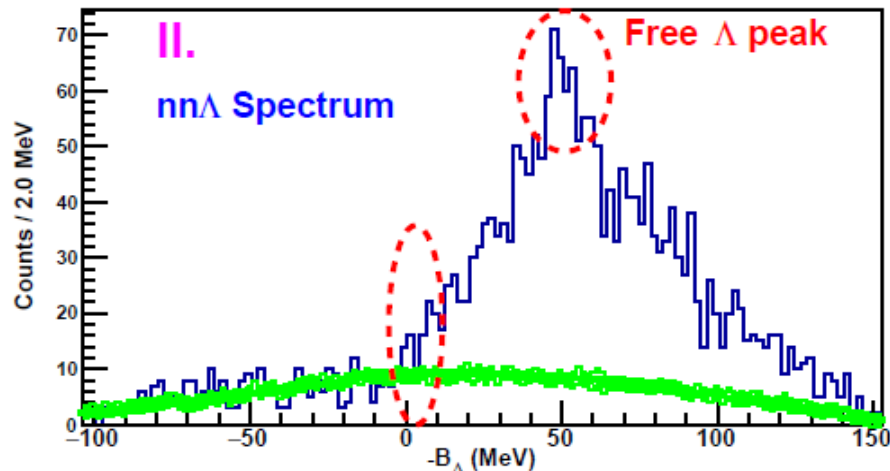- Involving Al is the correct way to achieve the expected resolution.
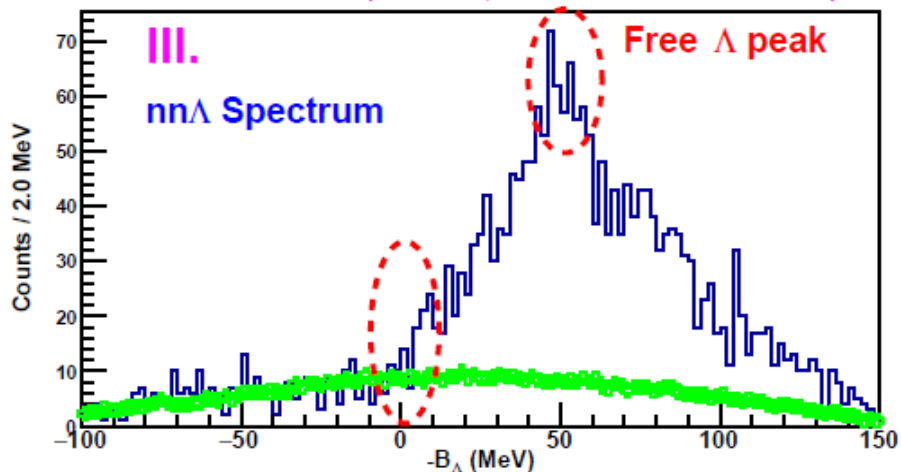
Backup Slides:

Λnn Spectrum With Wider Bins

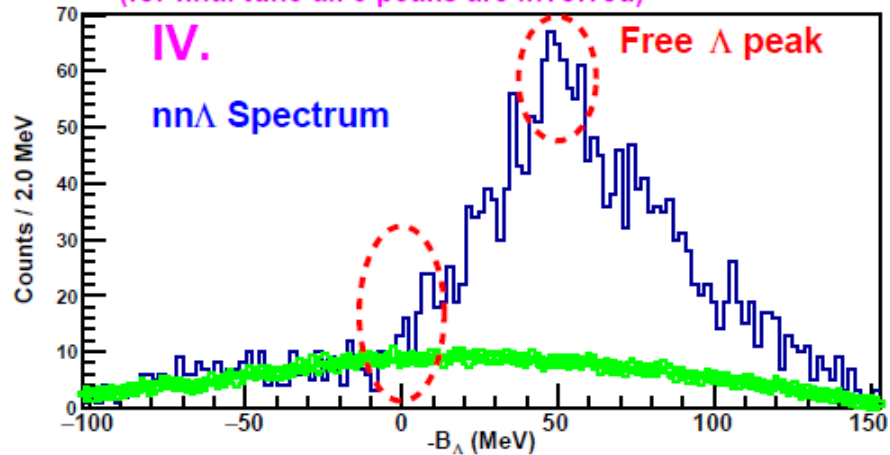I. Peak search tune (-20 to -10, -10 to 0 and 0 to 10 MeV) of $^{27}Mg_\Lambda$

II. Peak search tune (-18 to -8, -8 to +2 and 2 to 12 MeV) of $^{27}Mg_\Lambda$

III. Peak search tune (-16 to -6, -6 to +4 and 4 to 14 MeV) of $^{27}Mg_\Lambda$

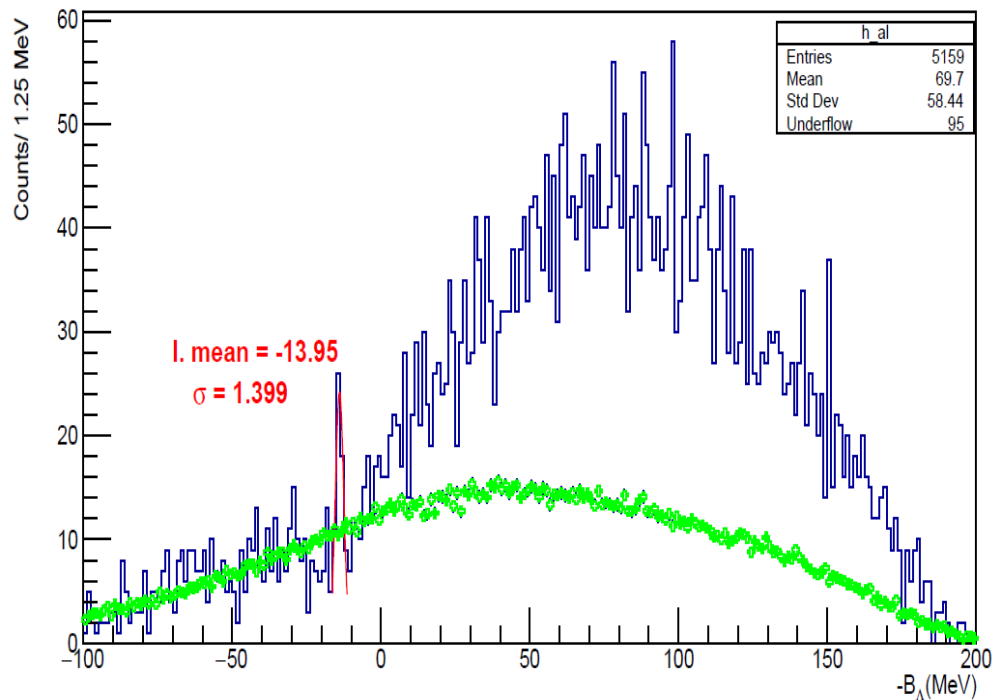IV. Peak search tune (-6 to +4 MeV) of $^{27}Mg_\Lambda$
(for final tune all 3 peaks are involved)

When the events are gated within -20 to -10 MeV of 27Mg_L

Al Spectrum, H/T data

h_al	
Entries	5159
Mean	69.7
Std Dev	58.44
Underflow	95

l. mean = -13.95
σ = 1.399

nnL Spectrum, T/T data

h1_may	
Entries	2490
Mean	47.88
Std Dev	46.92
Underflow	39
Overflow	18