Extension Request For E12-17-003:
Determining the Unknown Λ-n Interaction by Investigating The Λnn Resonance

PAC48 Proposal: PR12-20-003

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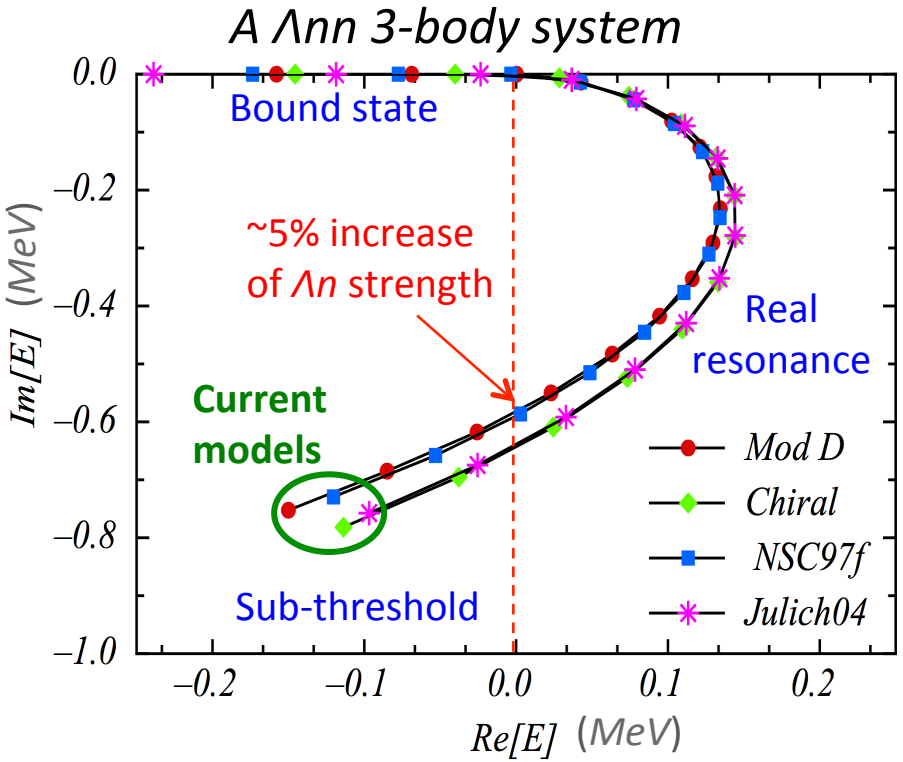
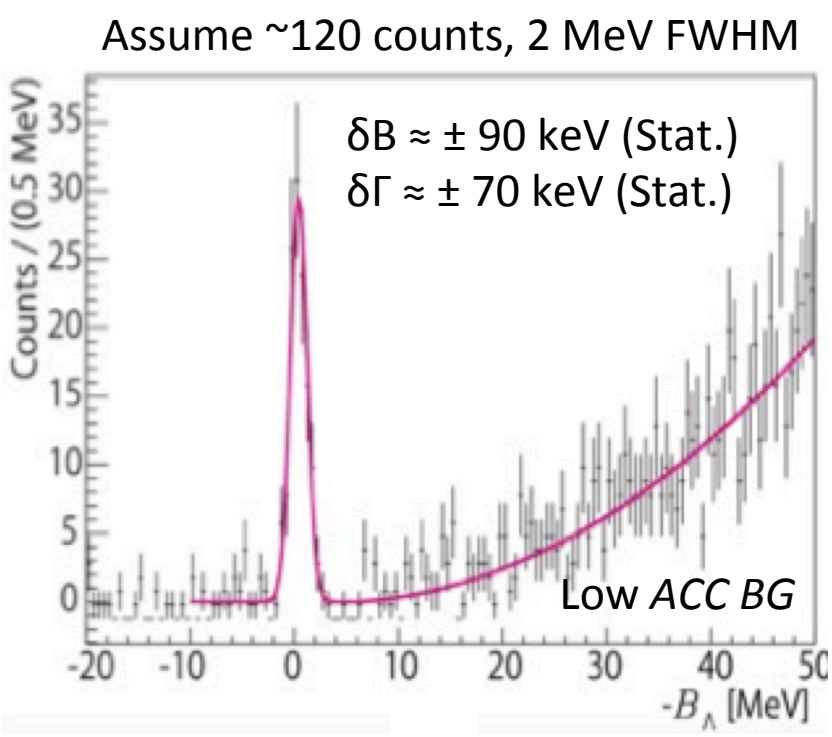
INTRODUCTION

- Understanding the baryonic interaction with all flavors is one of the essential goals of nuclear physics.
- One of the important but unresolved puzzles is the "*Charge-symmetry-Breaking*" (CSB):
  - For NN interactions: $\Delta B(^3H - ^3He) \approx 70\text{-}80\ keV$, negligibly small. Good approximation can be made w/o considering CSB
  - For ΛN interactions: $\Delta B(^4_\Lambda H - ^4_\Lambda He) \approx 270\ keV$, significantly large. The origin is not yet known, although $\Lambda N - \Sigma N$ coupling was suggested to be responsible for the A = 4 systems.
- Clearly, direct scattering data are extremely important and needed
  - For *NN* scatterings, there are plenty of data
  - For *Λp* scattering, limited data exist
  - For *Λn* scattering, no data exist at all
- *Λn* and *Λp* interactions have been treated identical

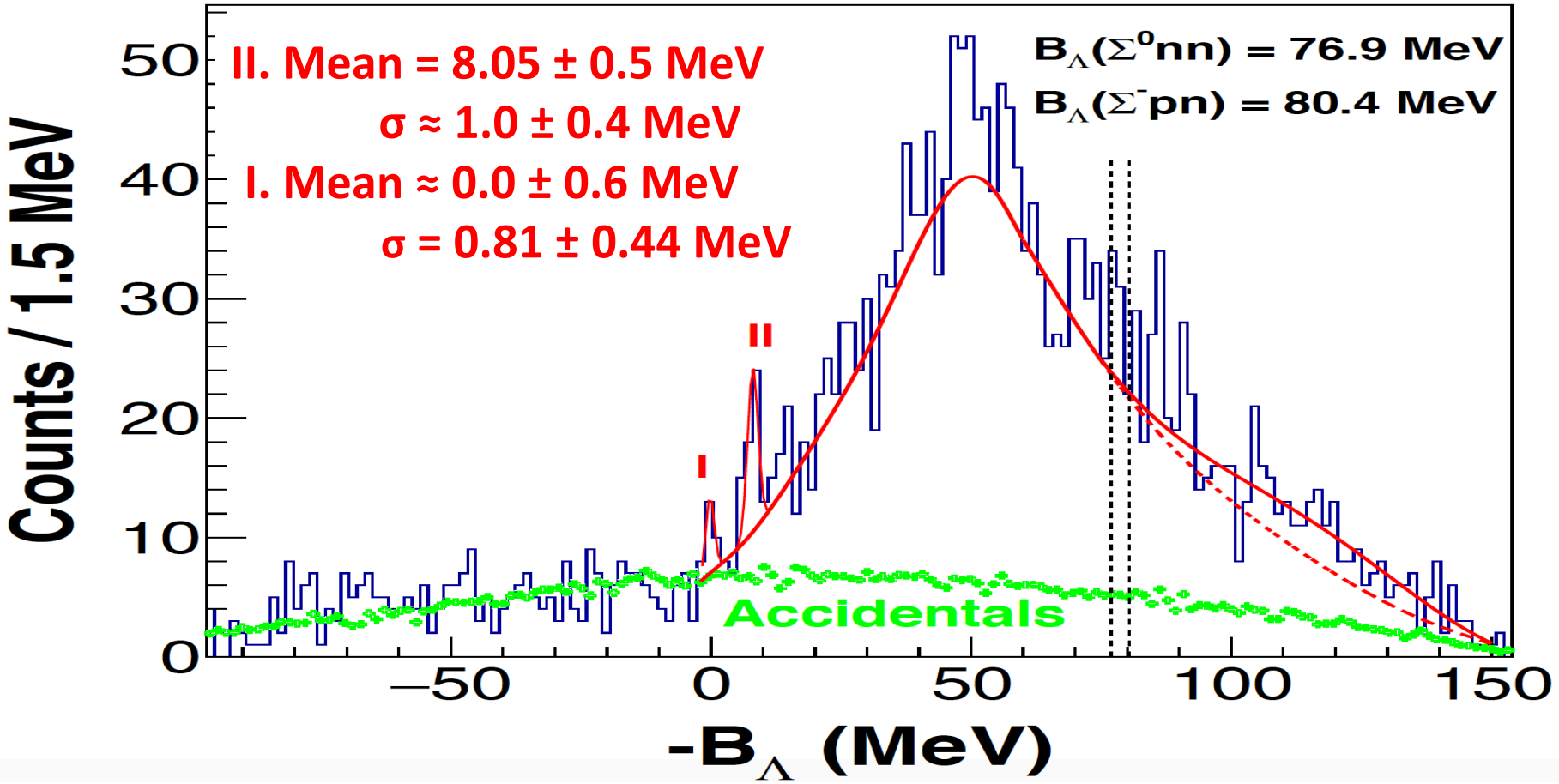
GOAL OF THE COMPLETED E12-17-003

- Using the unique ($e,e'K^+$) reaction and excellent CEBAF beam with the available ^3H target to search for the possible Λnn resonance.
- Make precise measurement on its binding energy and natural width to determine the unknown Λn interaction.
- Experimental conditions: Cross section was unknown; the HRS-HRS system is not optimized for ($e,e'K^+$) reaction.



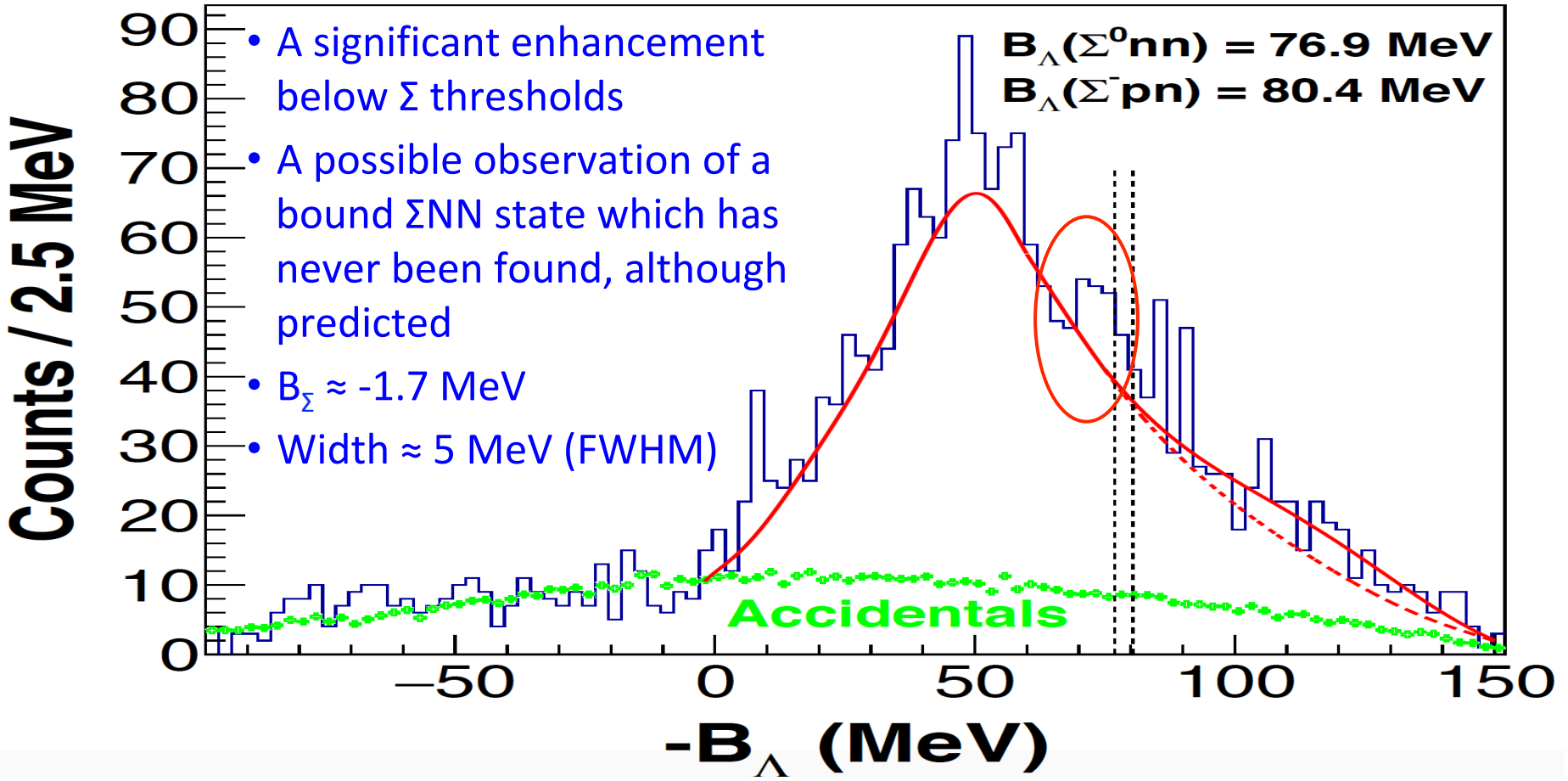


E12-17-003 RESULTS – *Λnn Resonance*



- The 1st peak: The possible *Λnn* resonance (Γ/2 ≈ 0.55 MeV)
- The 2nd peak: Unexpected, the nature is not clear
- Statistics is not sufficient to make definitive identification
- Statistical uncertainty is large at ~ ± 0.5 MeV

E12-17-003 RESULTS – *Bound ΣNN State*

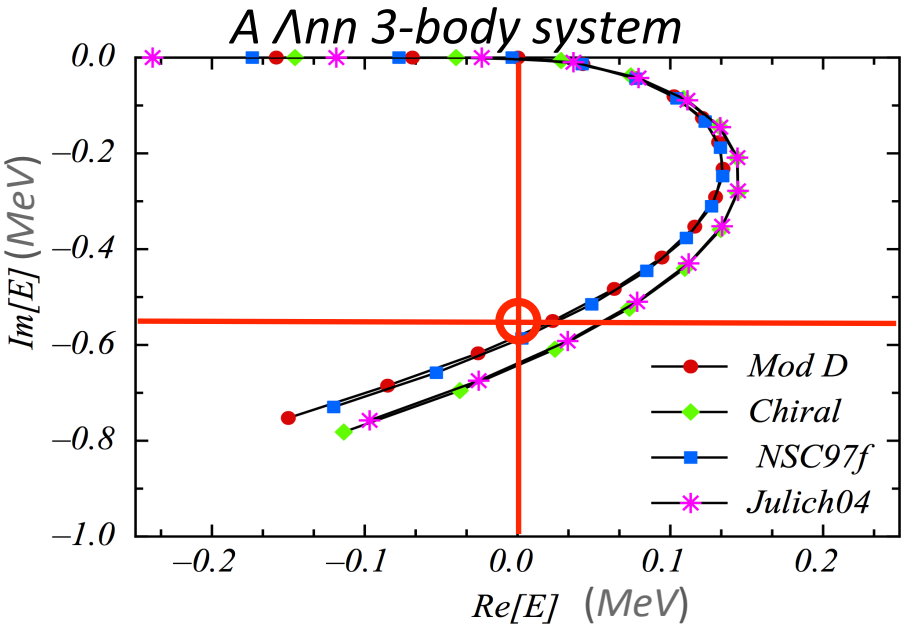


- $^3He(K^-,\pi^-)(\Sigma^+ d)$, $(\Sigma^+ pn)$, or $(\Sigma^0 pp)$, not found!
- $^3He(e,e'K^+)(\Sigma^0 d)$, $(\Sigma^0 pn)$, or $(\Sigma^- pp)$, Hall C E91-016, not found!
- $^3H(e,e'K^+)(\Sigma^0 nn)$, $(\Sigma^- d)$, or $(\Sigma^- pn)$, it is possible $(\Sigma^0 nn)$!

E12-17-003 RESULT SUMMARY

For the Λnn resonance

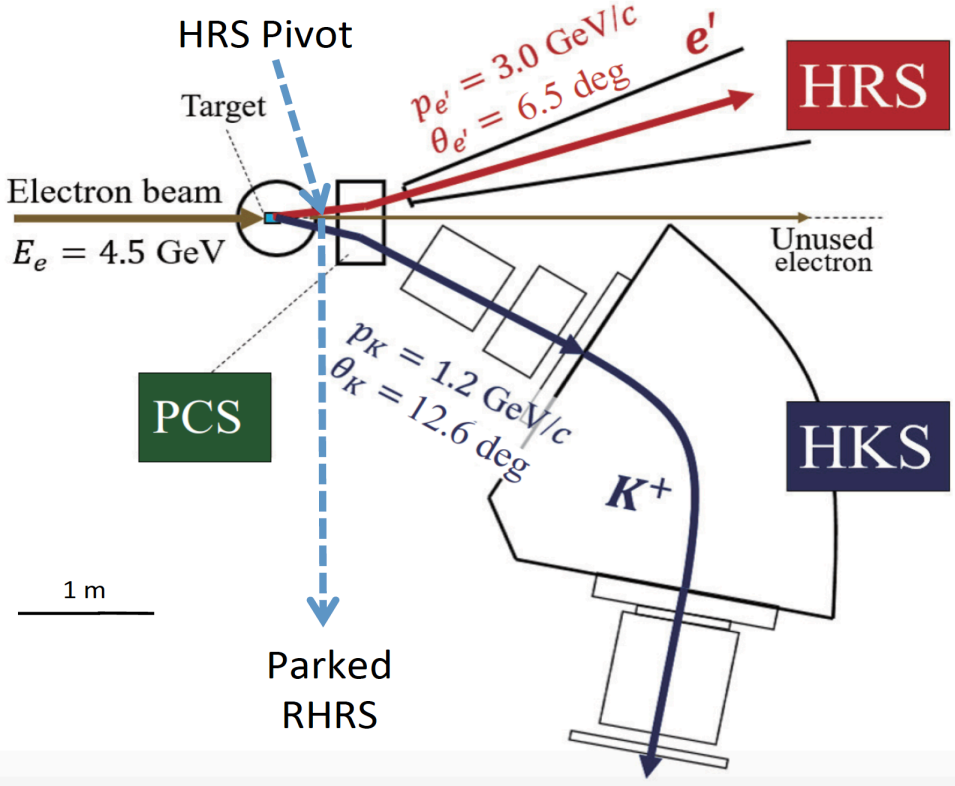
- It is exciting for the observation of the *Λnn* resonance which can provide unique data to determine the unknown *Λn* interaction.
- However, E12-17-003 did not obtain the needed statistics to make definitive identification, nor have the needed precision on its *B* and *Γ/2.*
- It proves the feasibility.



For the bound ΣNN state

- It is exciting for observing the A = 3 bound *ΣNN* state for the first time.
- It can provide important information to investigate the *ΛN − ΣN* coupling potential, as well as the CSB in the *ΛN* interaction.

PR12-20-003 – OPTIMIZED HKS-HRS



- Smaller e' angle, 7 times gain for the integrated virtual photon flux
- Short HKS orbit, 2.9 times gain on K^+ survival rate
- Excellent KID, 1.6 times gain
- Larger kinematics acceptance, 1.4 times gain
- Shorter target, 0.5 times gain
- **Overall gain: 22.7**
- **Yield on the *Λnn* resonance: ~ 270**
- **Yield on the *ΣNN* state: > 750**
- **Statistical uncertainty: < ±50 keV**

Required beam time: 204 hours (8.5 days)

T_2	Production	140 hours
H_2	Calibration by Λ and Σ^0 known masses	8 hours
Multi-foil-C	Calibration by the ground state of $^{12}_{\Lambda}B$	54 hours
Empty cell	Background from the Al end caps	2 hours

SUMMARY

- *E12-17-003 has proven the feasibility and uniqueness of using the (e,e'K^+) reaction with the Tritium gas target.*
- *The experiment had possible observation of the Λnn resonance and a bound (A = 3) ΣNN state.*
- *However, the obtained statistics was too small to allow a definitive identification, nor to provide precise results in order to determine the Λn and ΛN - ΣN interactions.*
- *A newly proposed experiment (PR12-20-003) is to repeat the experiment with the optimized HKS-HRS system in order to achieve the needed precision that is dominated by the statistical uncertainty (≤ 50 keV).*