Search for the H-Dibaryon near ΛΛ threshold at J-PARC

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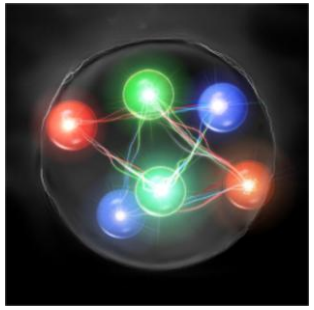
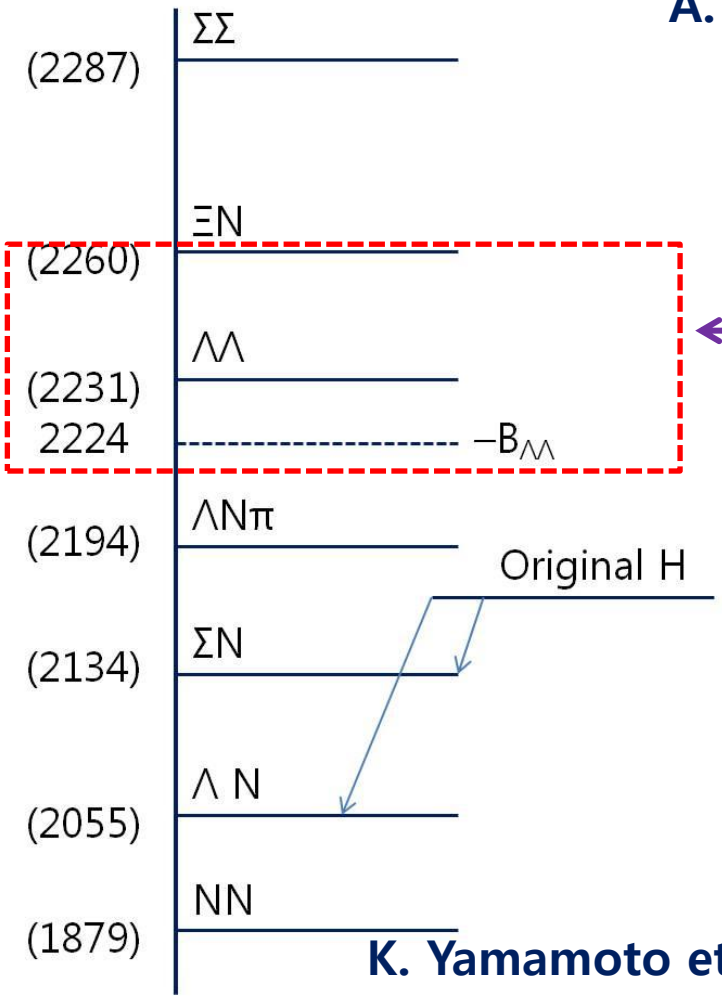
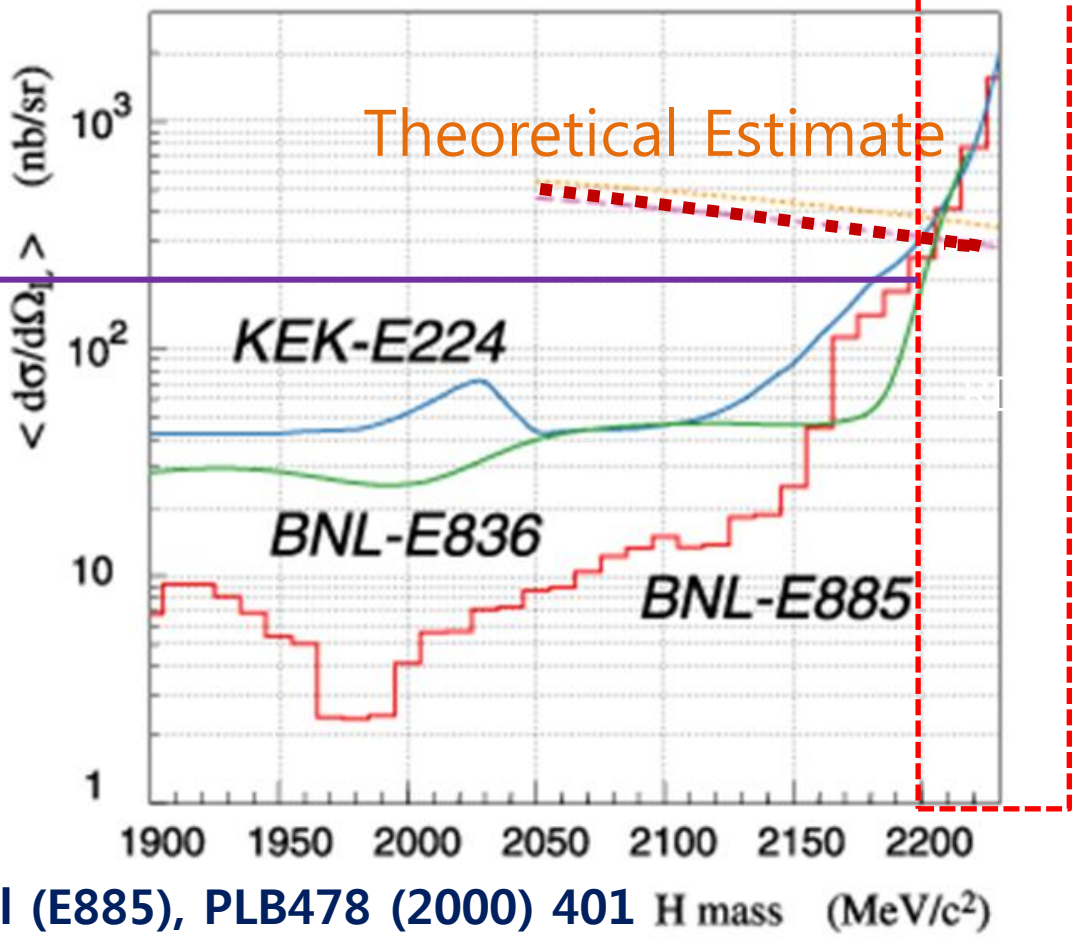


H-Dibaryon



A.T.M. Aerts and C.B. Dover, PRD28 (1983) 450



K. Yamamoto et al (E885), PLB478 (2000) 401

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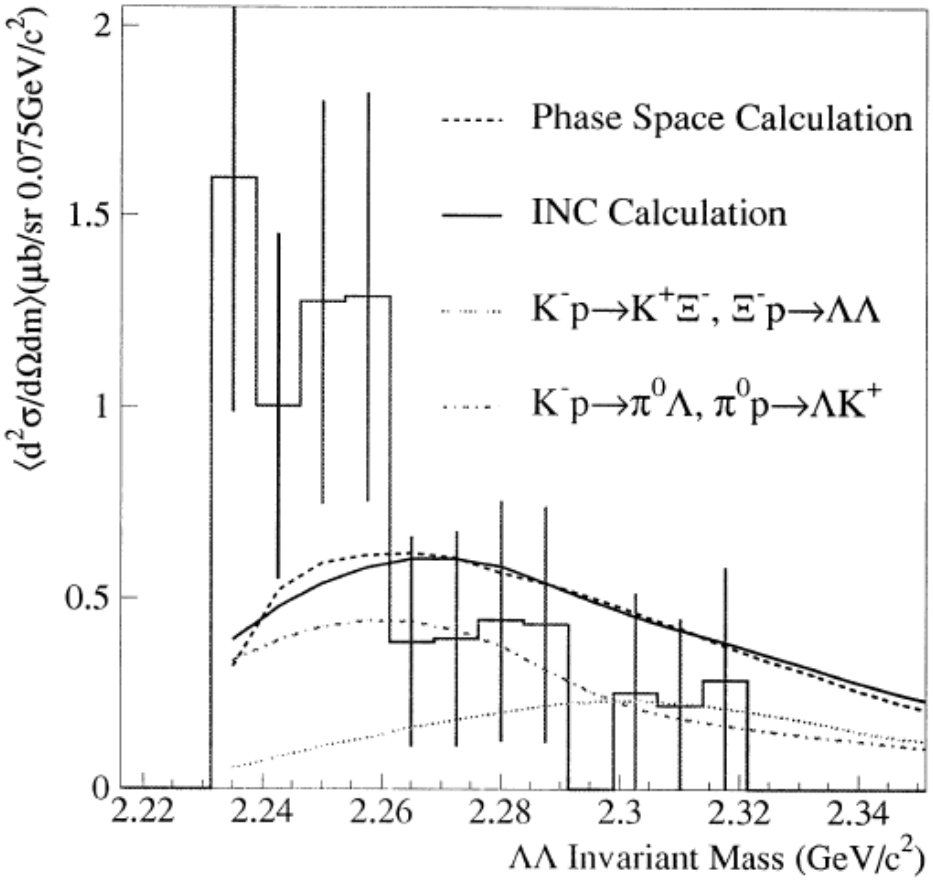
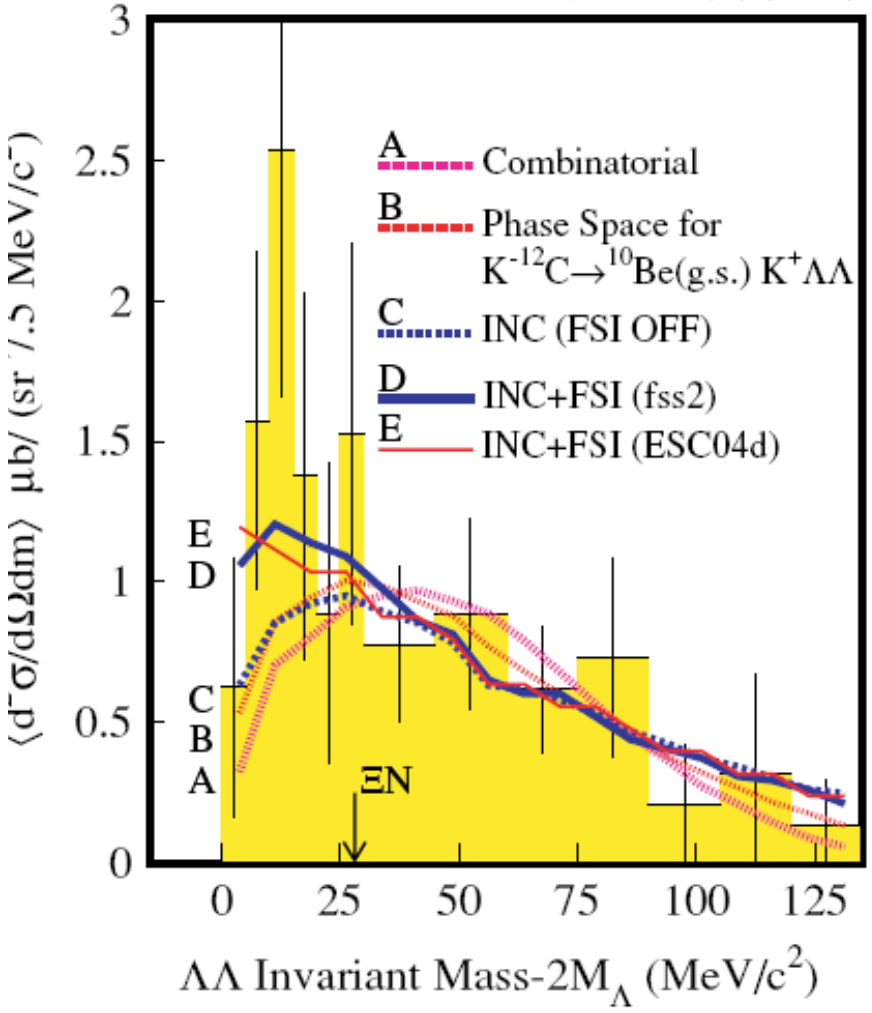
H(2250)

H-Dibaryon as a ΛΛ Resonance?

J.K. Ahn et al. / Physics Letters B 444 (1998) 267–272



PHYSICAL REVIEW C 75, 022201(R) (2007)



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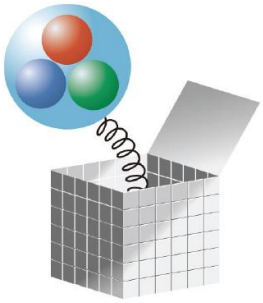
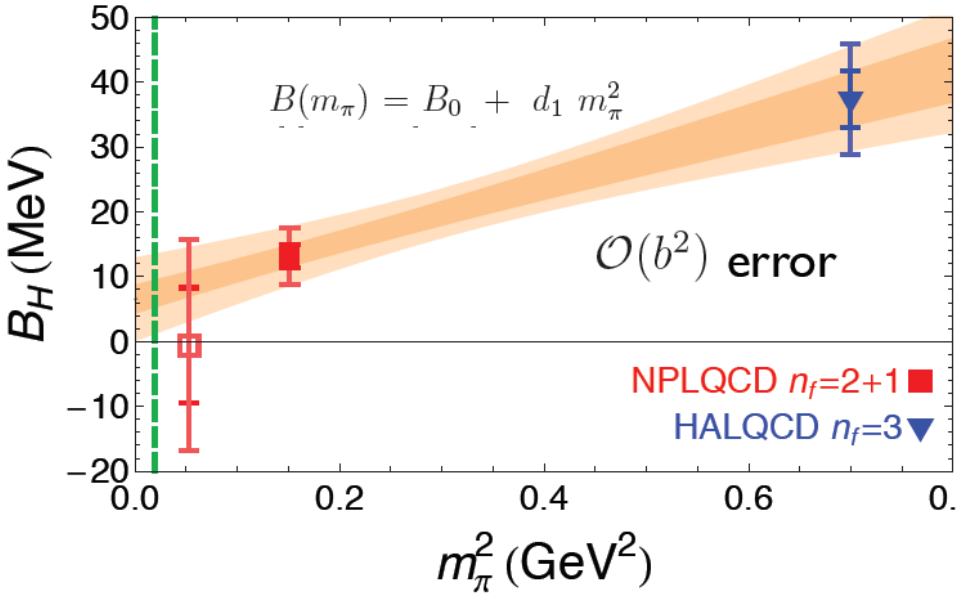
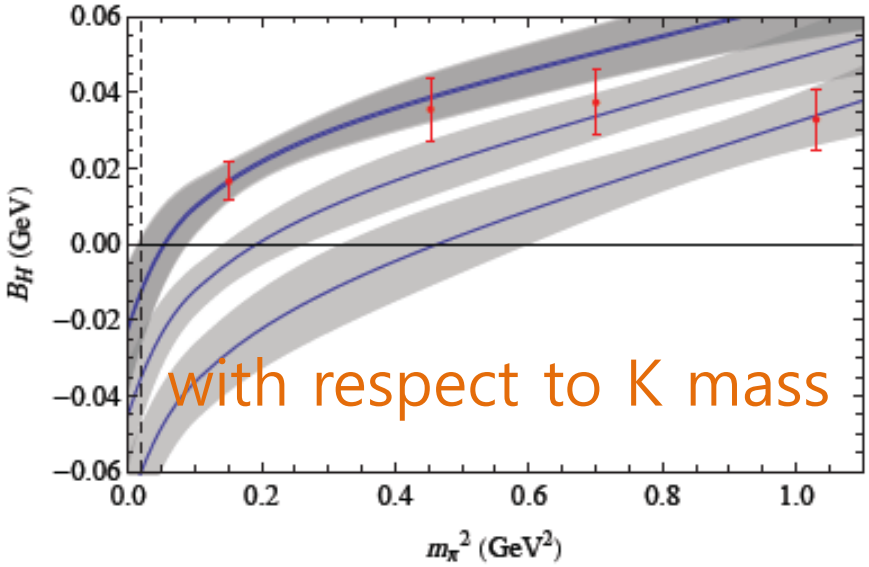


H-Dibaryon from Lattice QCD

- Recent LQCD calculations seem to point to a weekly bound H or resonant state although we have got to wait for definite results with physical quark masses.





HAL Collab., PRL 106 (2011) / NP LQCD Collab. PRL 106 (2011)
Shanahan, Thomas, Young, PRL 107 (2011)

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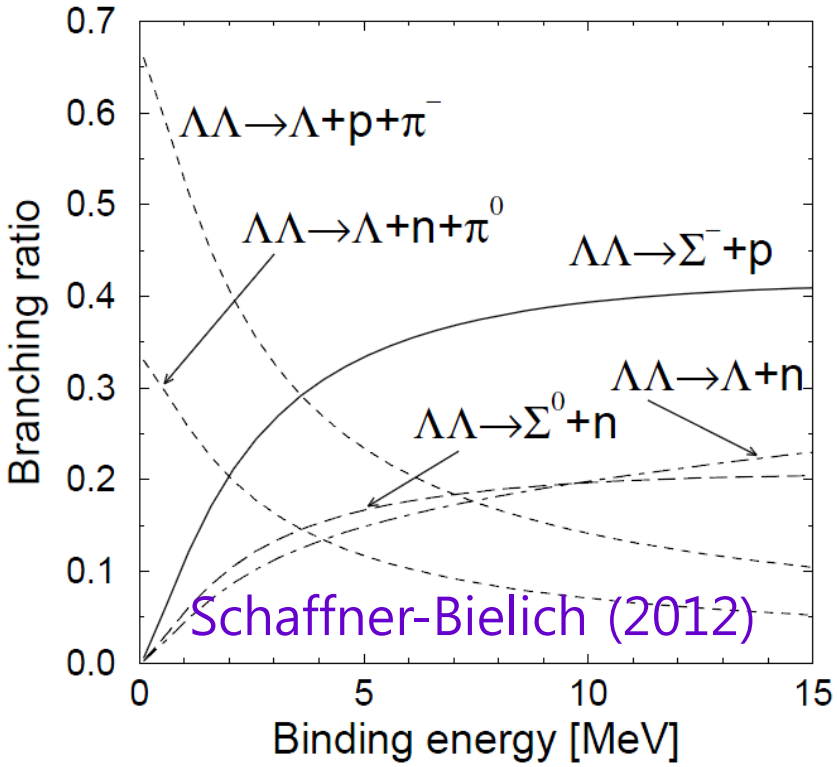
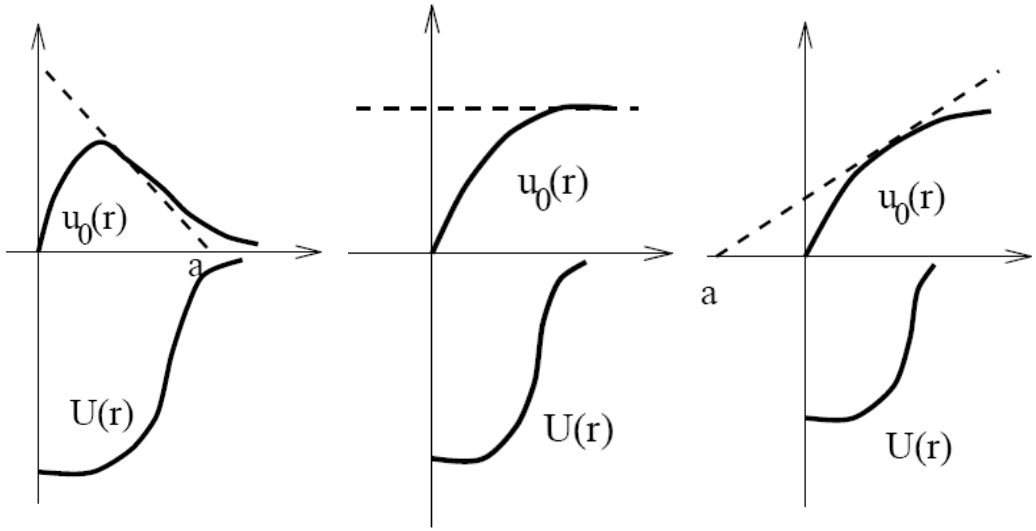
Bound, Virtual State (a=∞), or Resonance?





- Weakly-bound : H → Λpπ weak decay
- Virtual state : ΛΛ threshold effect
- Resonance : Breit-Wigner peak in the ΛΛ mass spectrum.

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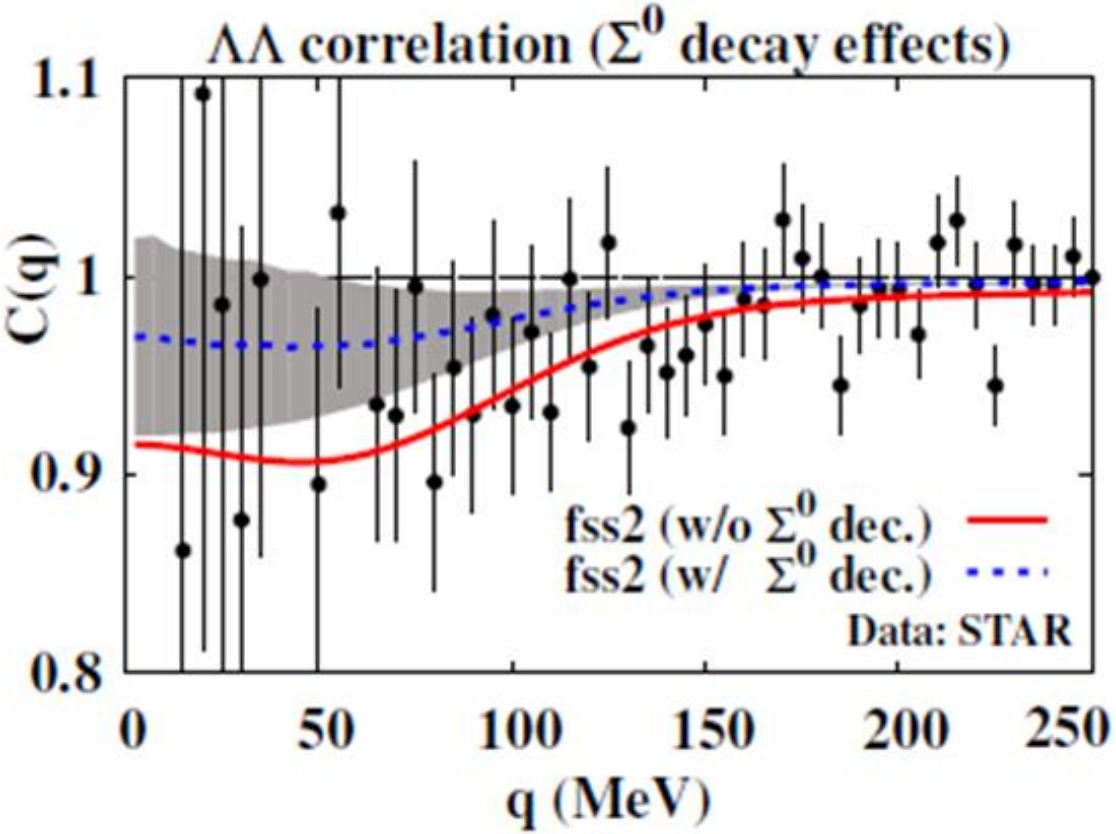
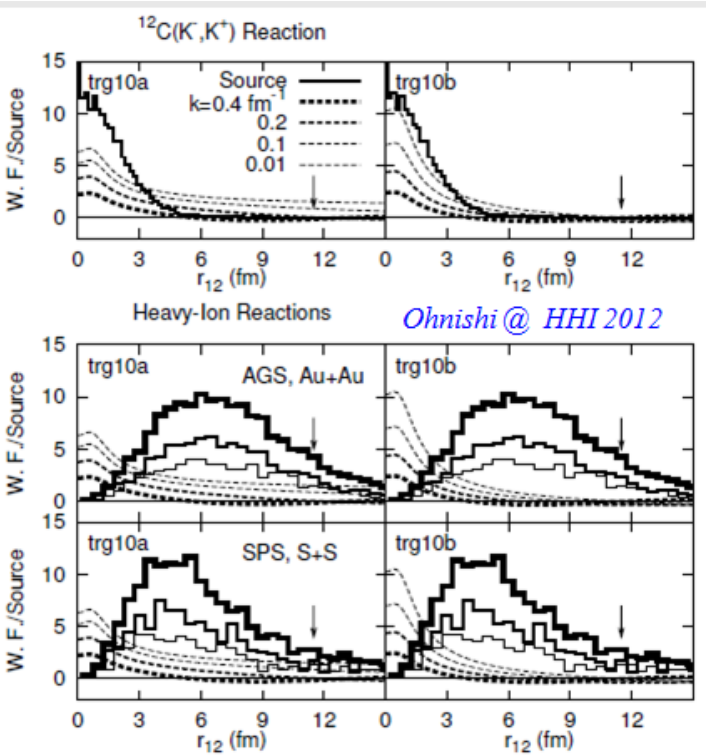
Recent Results from STAR





- Only small fraction of ΛΛ or ΞN pairs will be produced close enough in space and with their relative momenta small enough to interact via H-formation.

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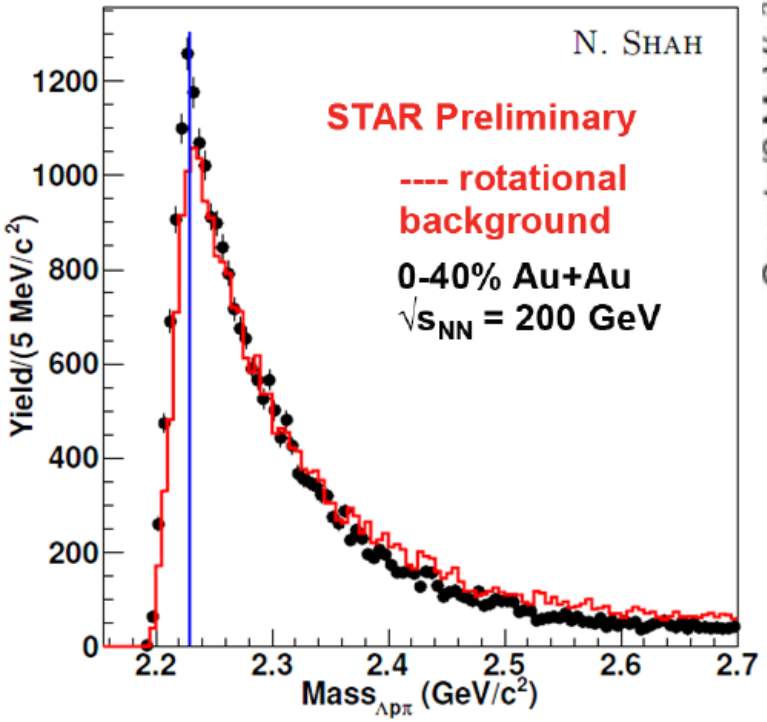
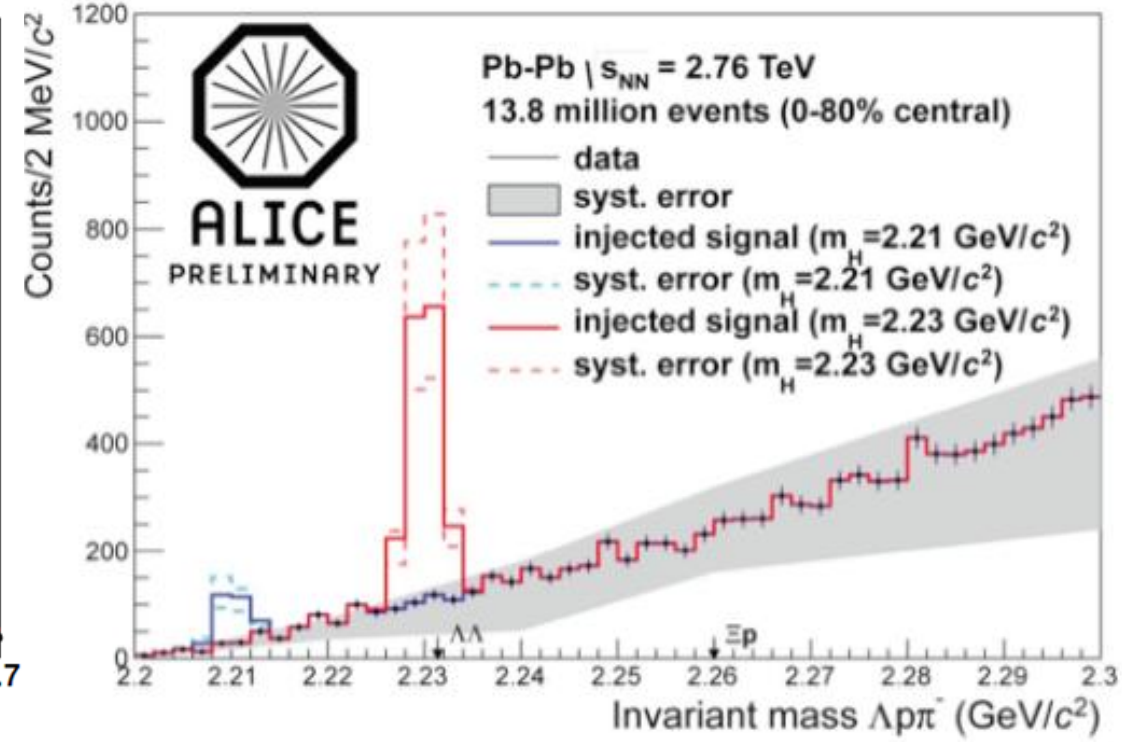
$\Lambda p\pi$

Recent Results from STAR and ALICE





- Rotational background?

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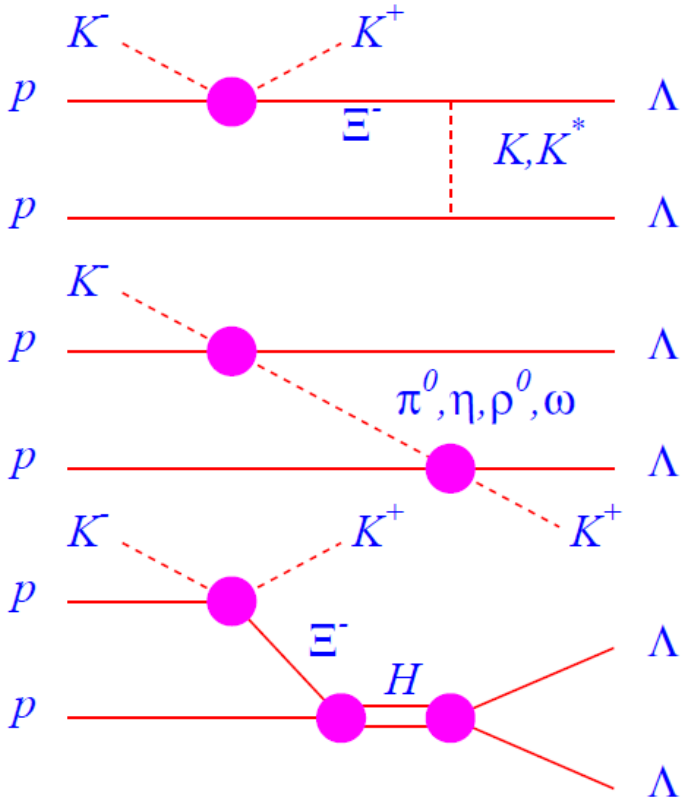
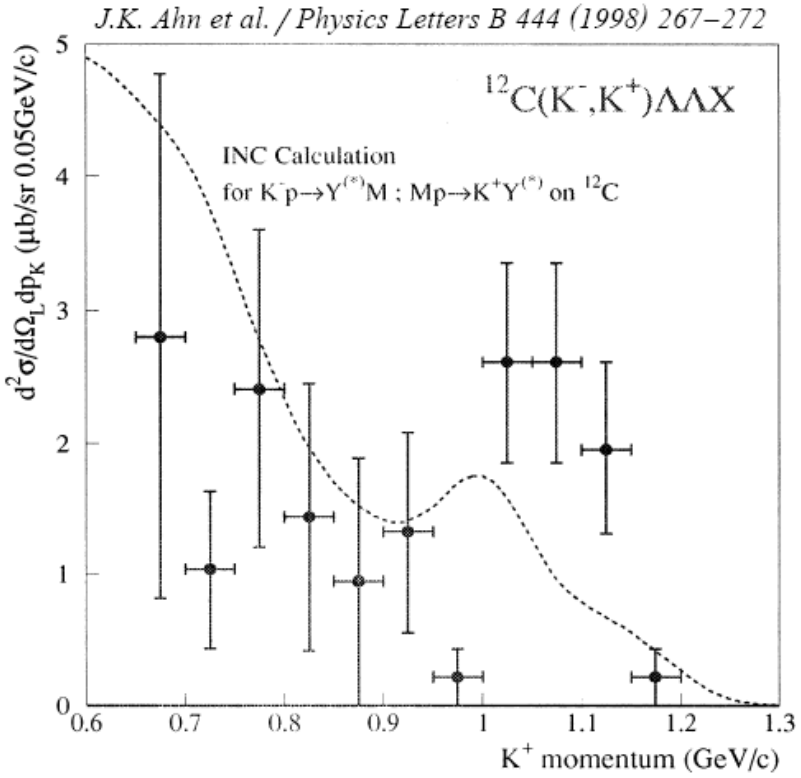
ΛΛ Production in (K-,K+) Reaction





- Theoretical prediction by Aerts and Dover for K-(pp) → K+H on ^{3}He (~0.2 μb/sr)
- KEK-E224 measurement for ^{12}C(K-,K+)ΛΛX (7.6 μb/sr and 3 μb/sr for the H)

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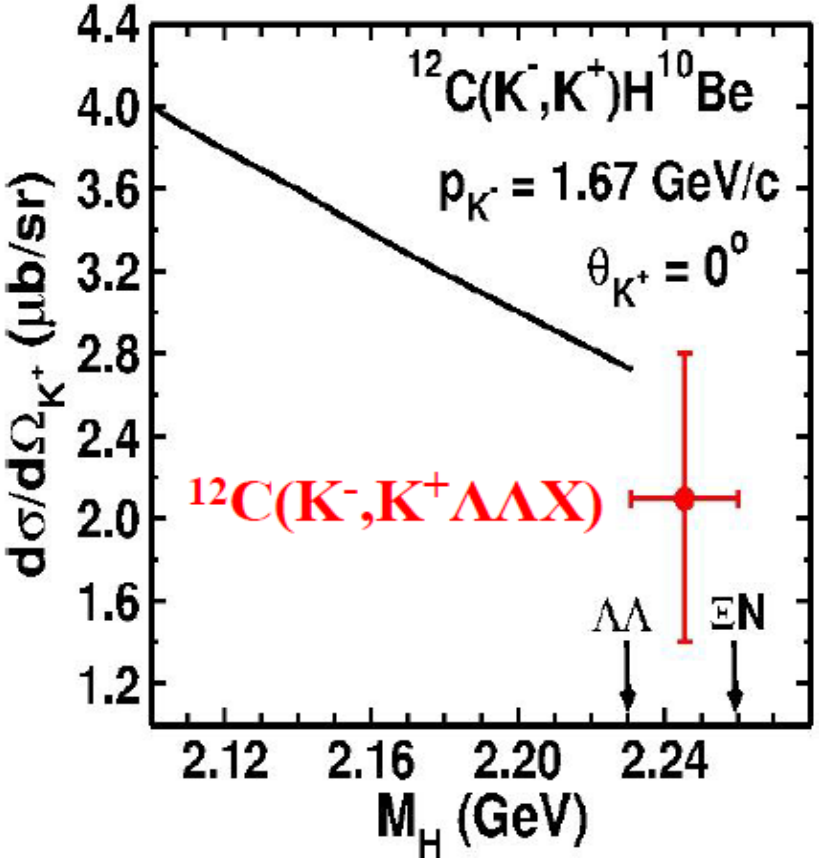
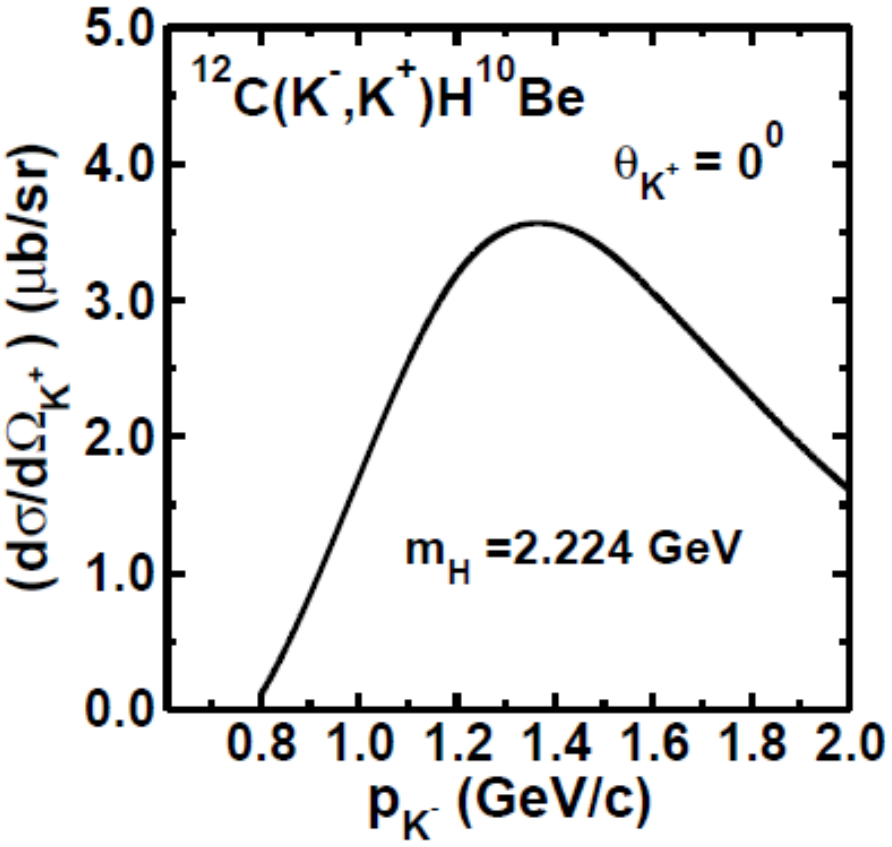
Recent effective-lagrangian model calculation





R. Shyam et al, arXiv 12110775

- s- and u-channels via Y* for Ξ production
- Ξp→H fusion (Aerts and Dover PRD28 (1983) 450)

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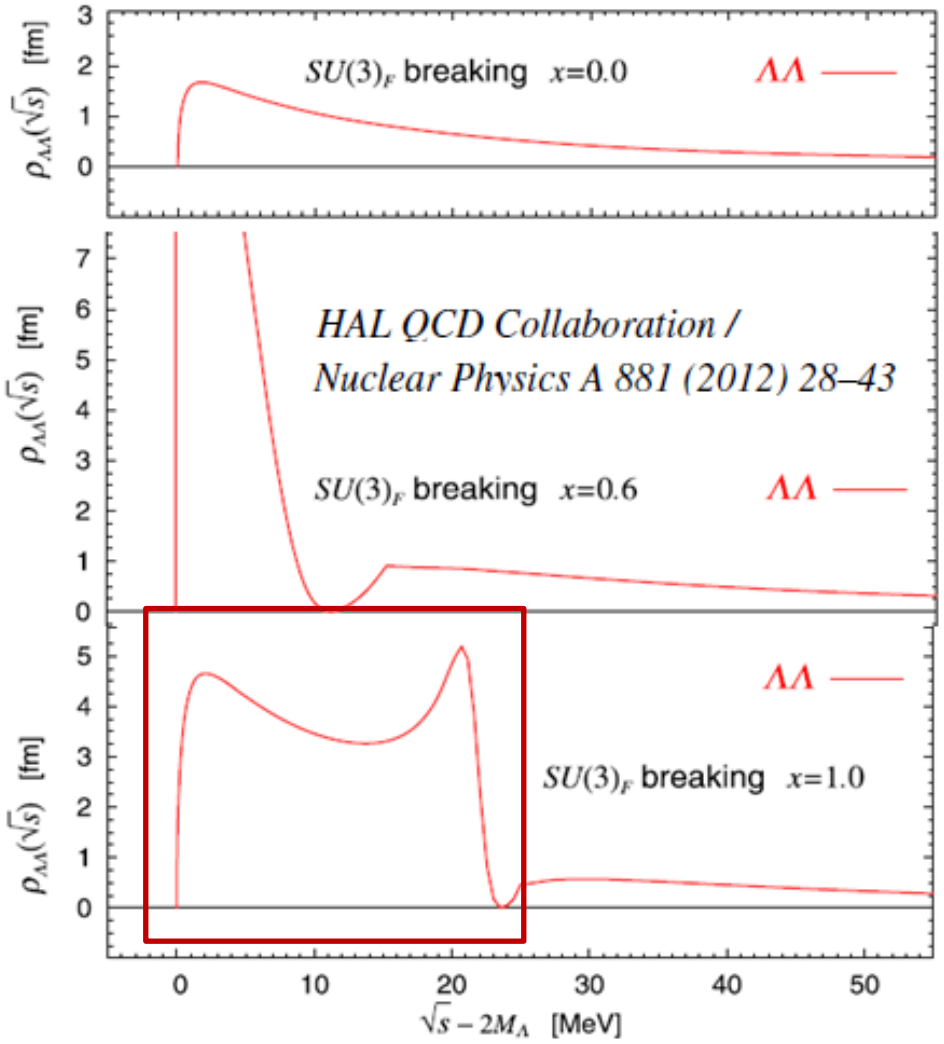
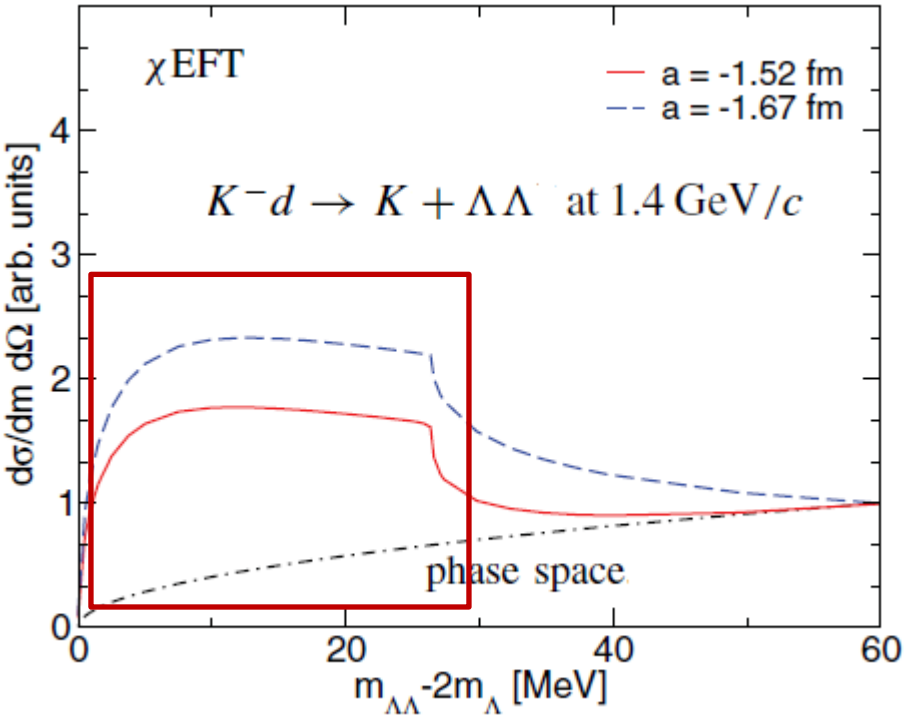
- Lineshape of ΛΛ mass spectrum and ΛΛ scattering length.





A. M. GASPARYAN, J. HAIDENBAUER, C. HANHART
PHYSICAL REVIEW C 85, 015204 (2012)

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The H-dibaryon Search at J-PARC (E42)

- To confirm whether or not the previously observed enhancement is due to the H-dibaryon with much higher statistics and much precise mass resolution.
- (K-,K+) reaction on a C(diamond) target with p=1.8 GeV/c K- beam at J-PARC.
- Large acceptance for ΛΛ detection near the target (a Helmholtz-type dipole magnet with a TPC and trigger counters).
- Detecting Σ-p, Λpπ, ΛΛ, and Ξ-p systems.

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The E42 Collaboration

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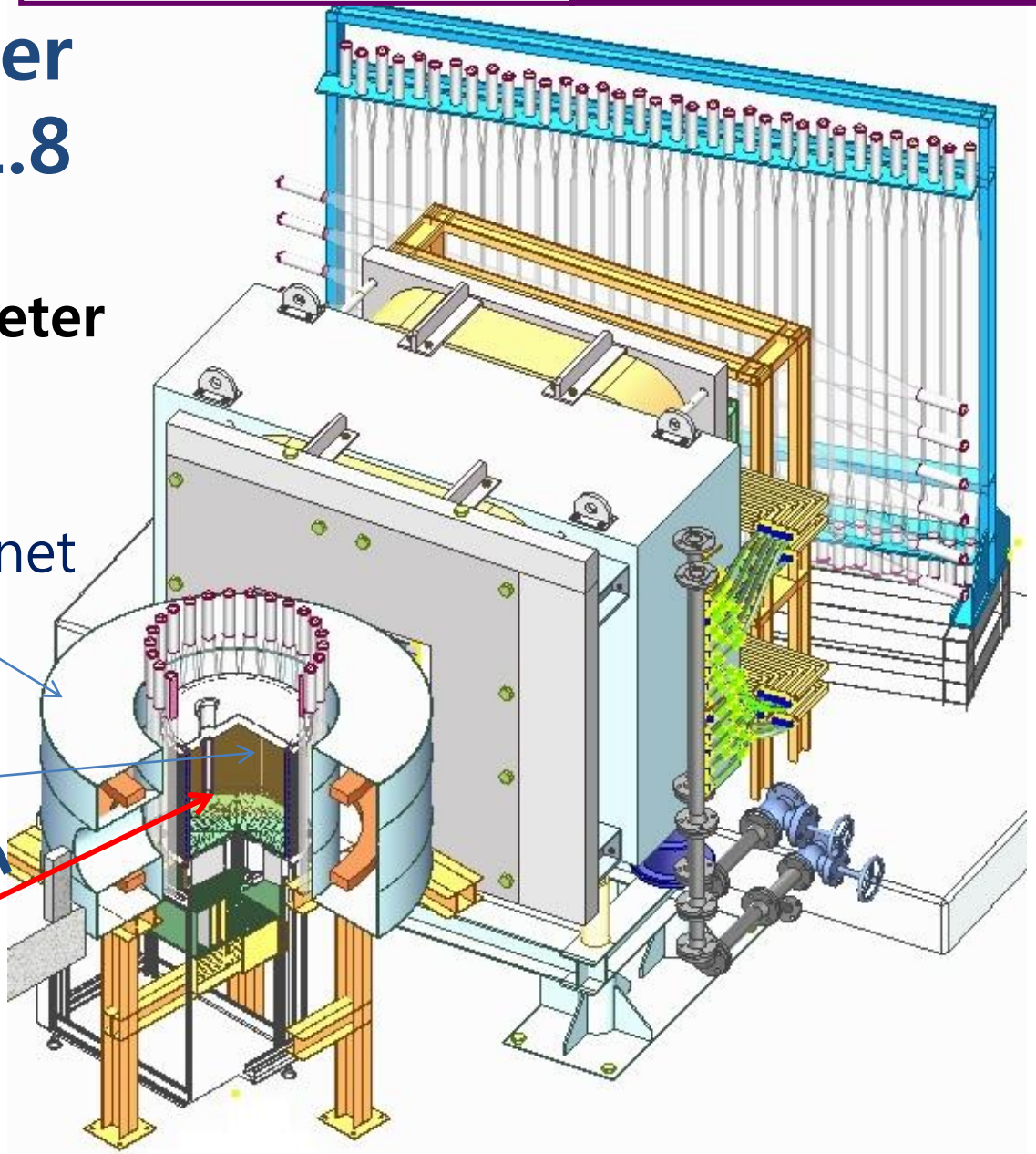
Florida International University, USA

E42 Spectrometer @ J-PARC K1.8

- **Hyperon Spectrometer + K^+ Spectrometer**

Superconducting Helmholtz-type magnet

Time Projection Chamber



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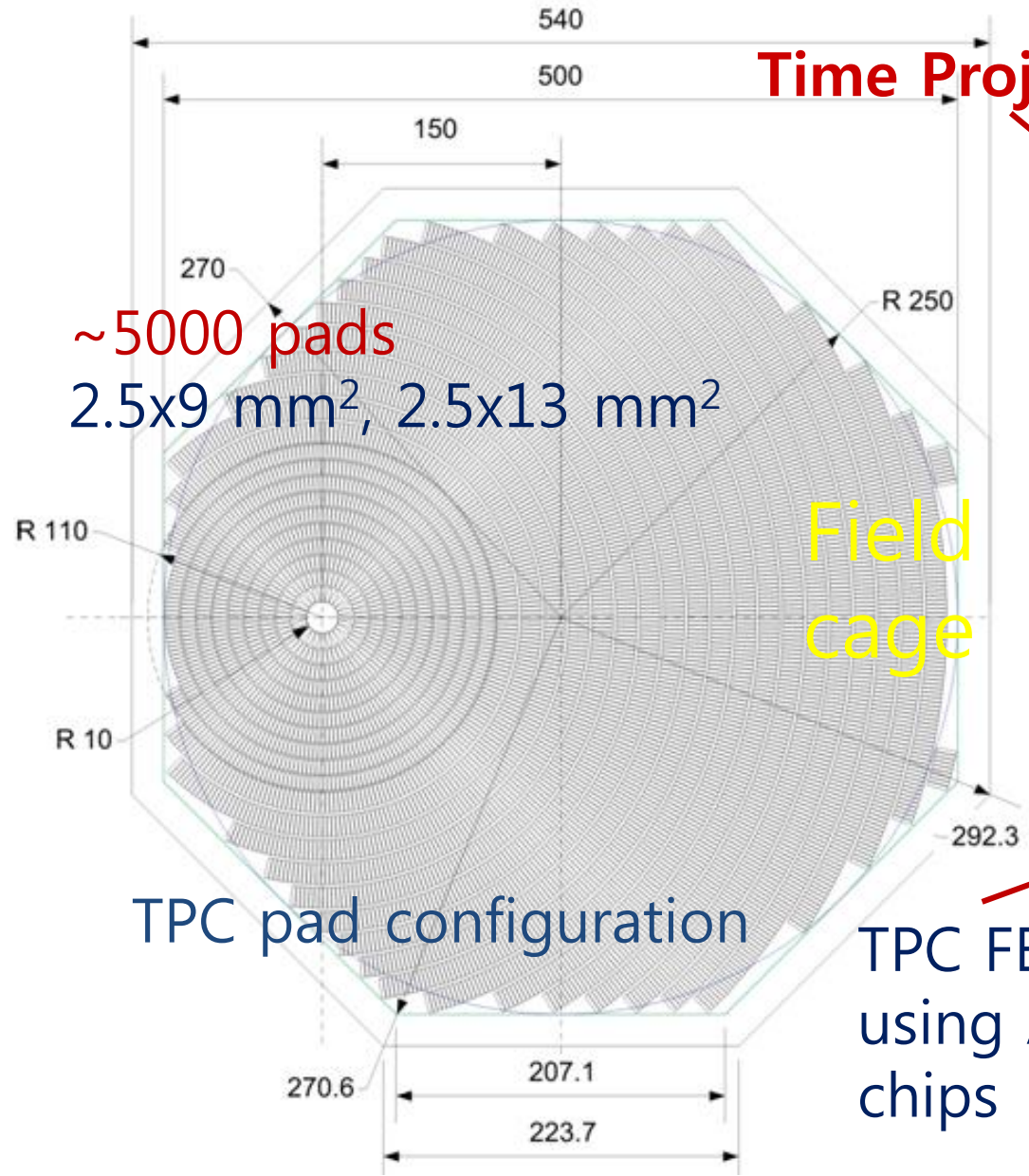


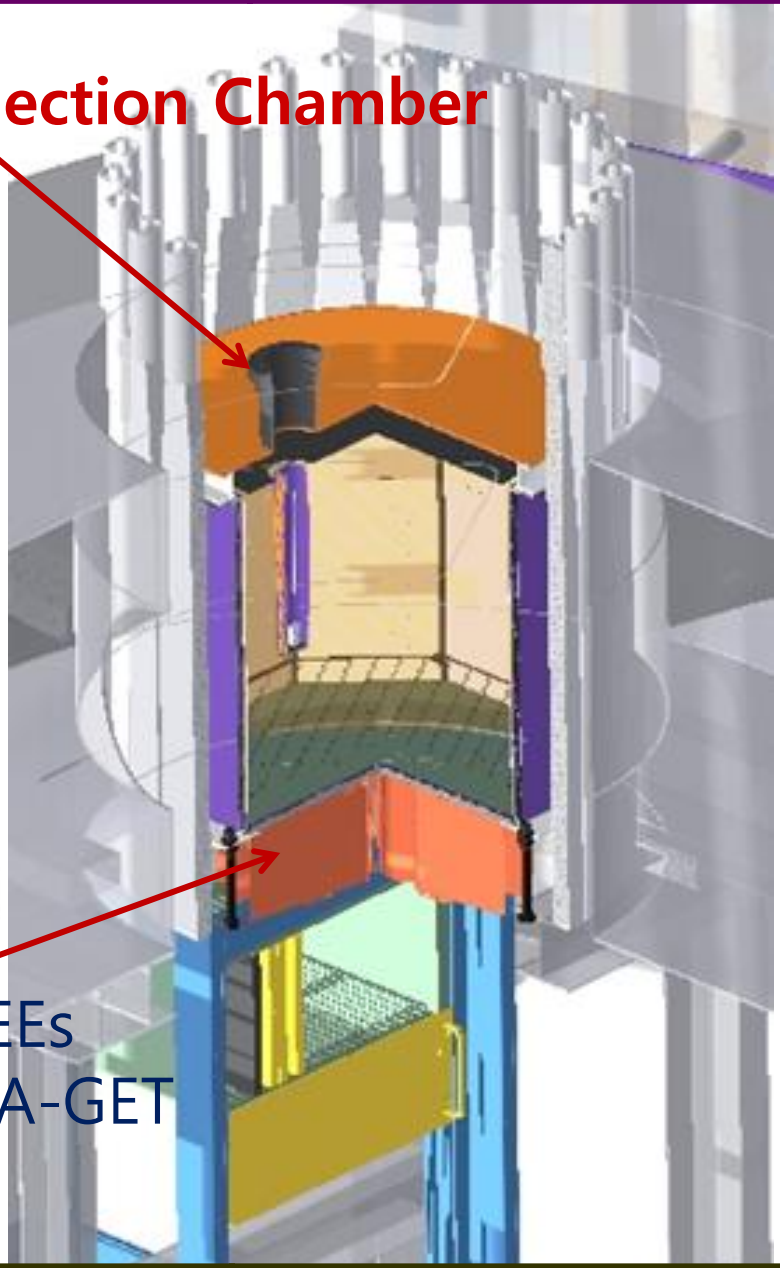
~5000 pads
2.5x9 mm^2, 2.5x13 mm^2

TPC pad configuration

Time Projection Chamber

Field cage

TPC FEEs using A-GET chips



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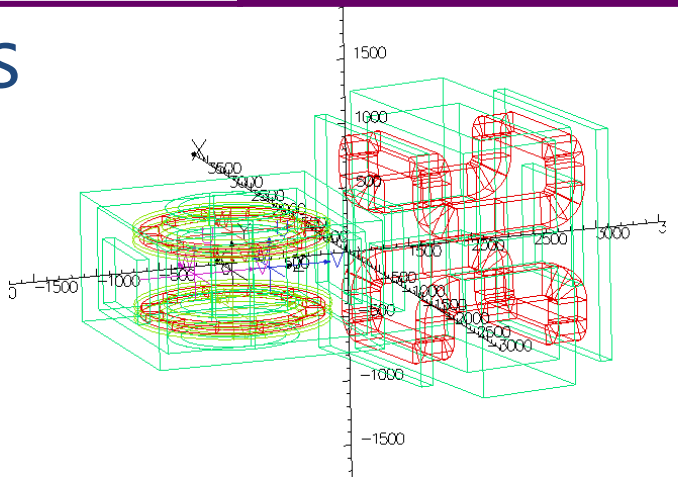
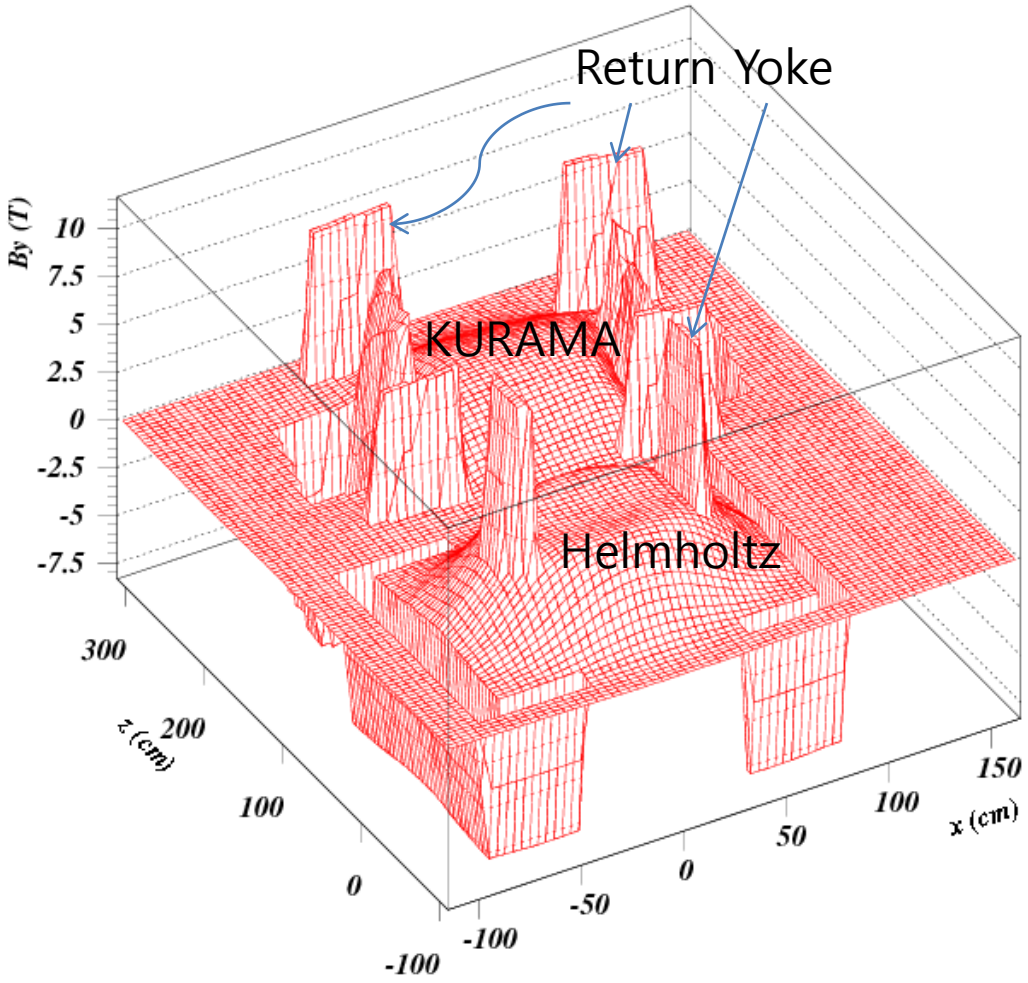
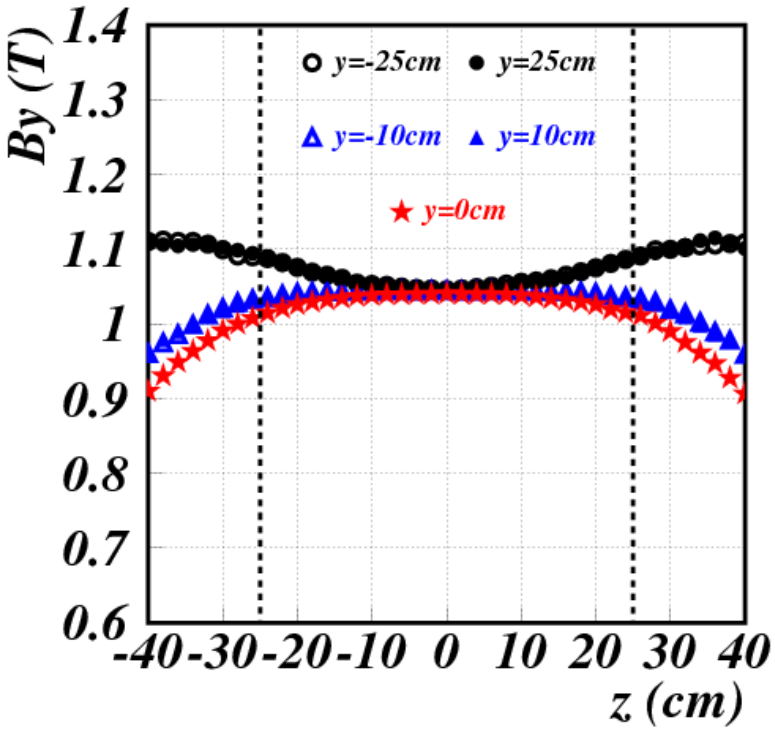
Magnetic Field Strengths
calculated using OPERA-3D







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Yield Estimation

Parameters	Diamond target
K^- beam	$10^6 K^-$ per spill (6 s)
Target length	15 mm
Number of nuclei	$2.65 \times 10^{23}/\mathrm{cm}^2$
$d\sigma/d\Omega_L^C(\Lambda\Lambda)$	7.6 μb/sr
$\Delta\Omega(K^+)$	0.11 sr
Br $(\Lambda \to p\pi^-)^2$	0.41
KURAMA for K^+	0.5
HypTPC for $\Lambda\Lambda$	0.4-0.6 (0.4 for H(2250))
Yield	0.023 event / spill

from E224 data (PLB444 (1998))

- 11000 ΛΛ events for 100 shifts and 1440 H(2250) events for 1.0 μb/sr with a 15-mm thick diamond target.

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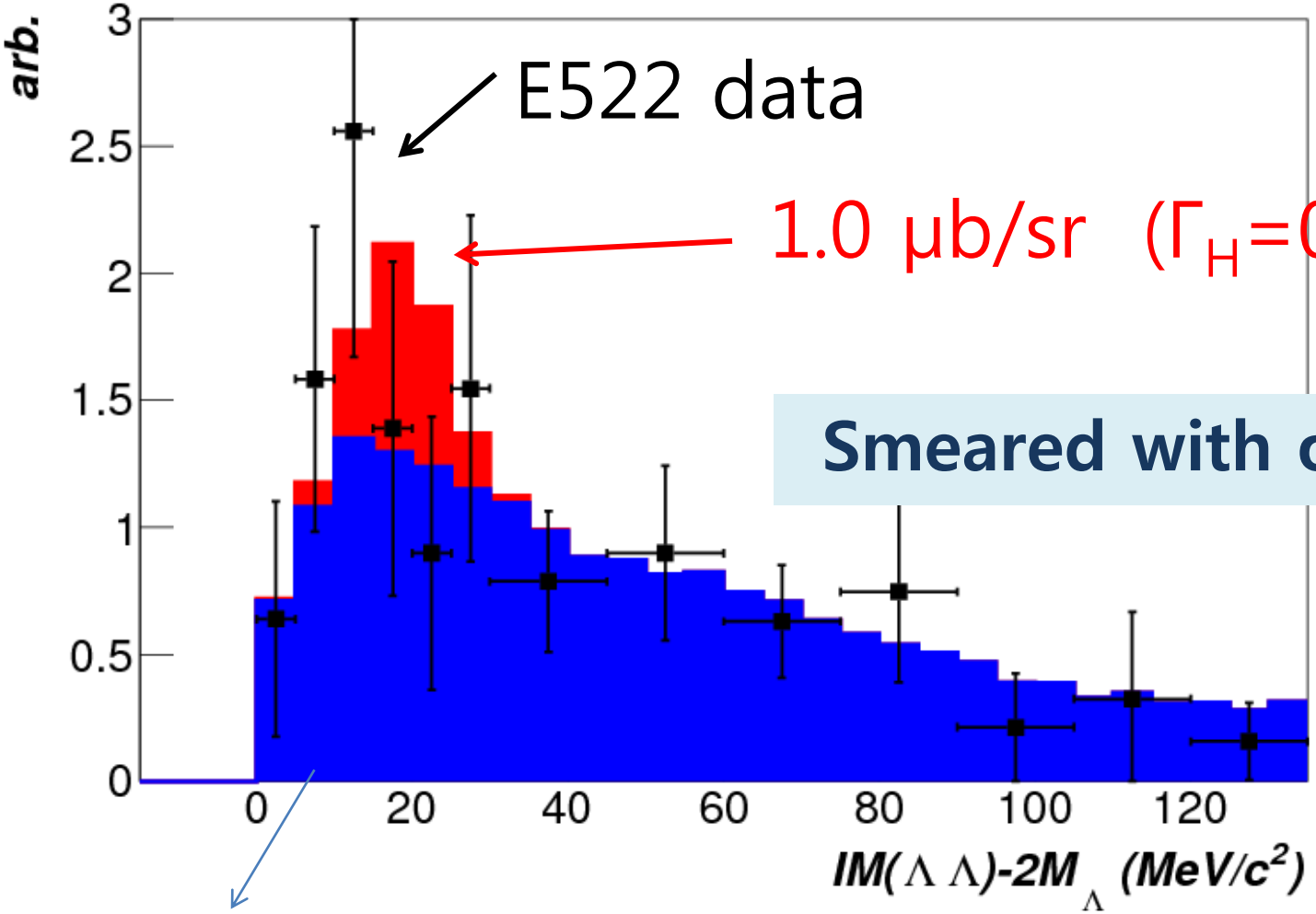
Relative Yields for H to Non-resonant ΛΛ



INC calculation results based on Ref (Y. Nara et al, NPA 614 (1997) 433)

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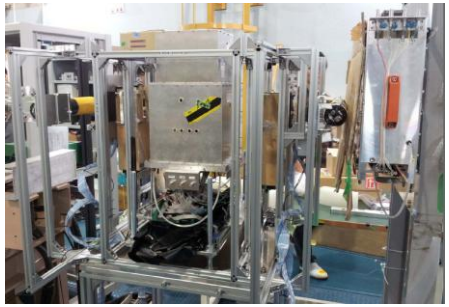
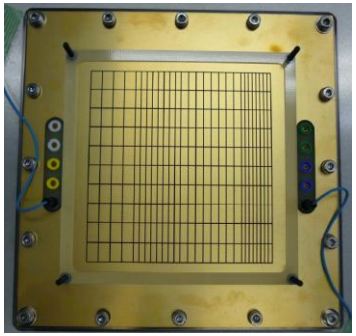
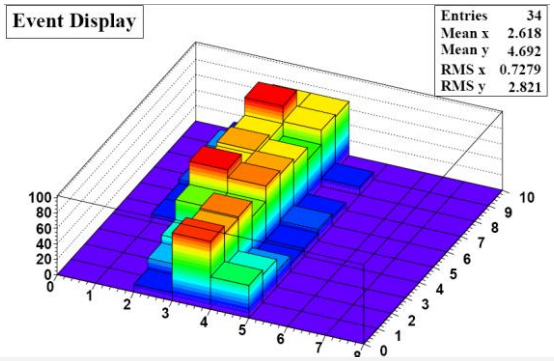
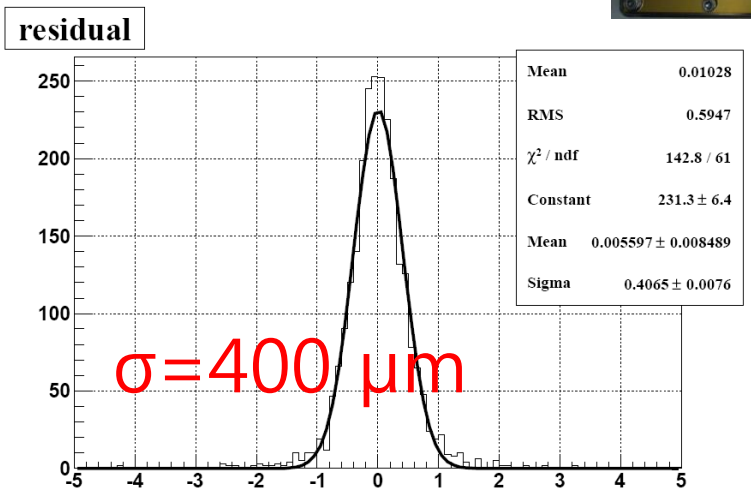
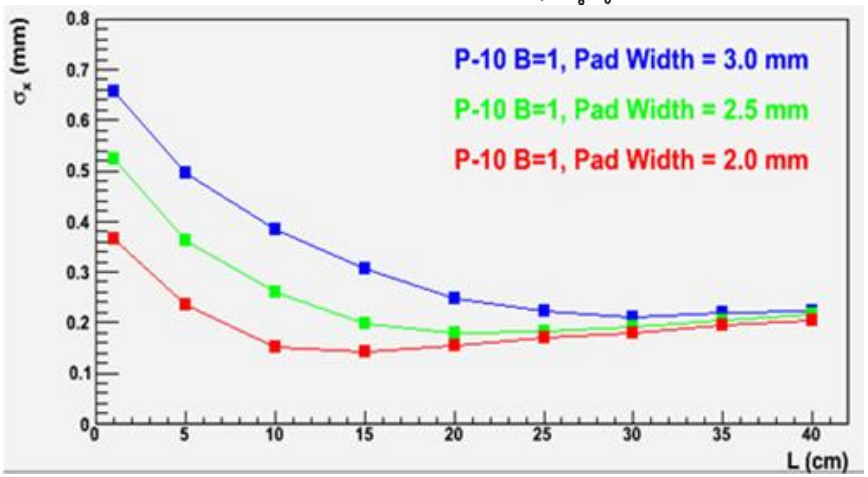
TPC prototype test (RCNP-E384)











- Tolerable with 10^7Hz beam intensity.
- σ=400 μm obtained from the hits on 4-mm wide pads up to 10^6Hz beam intensity.

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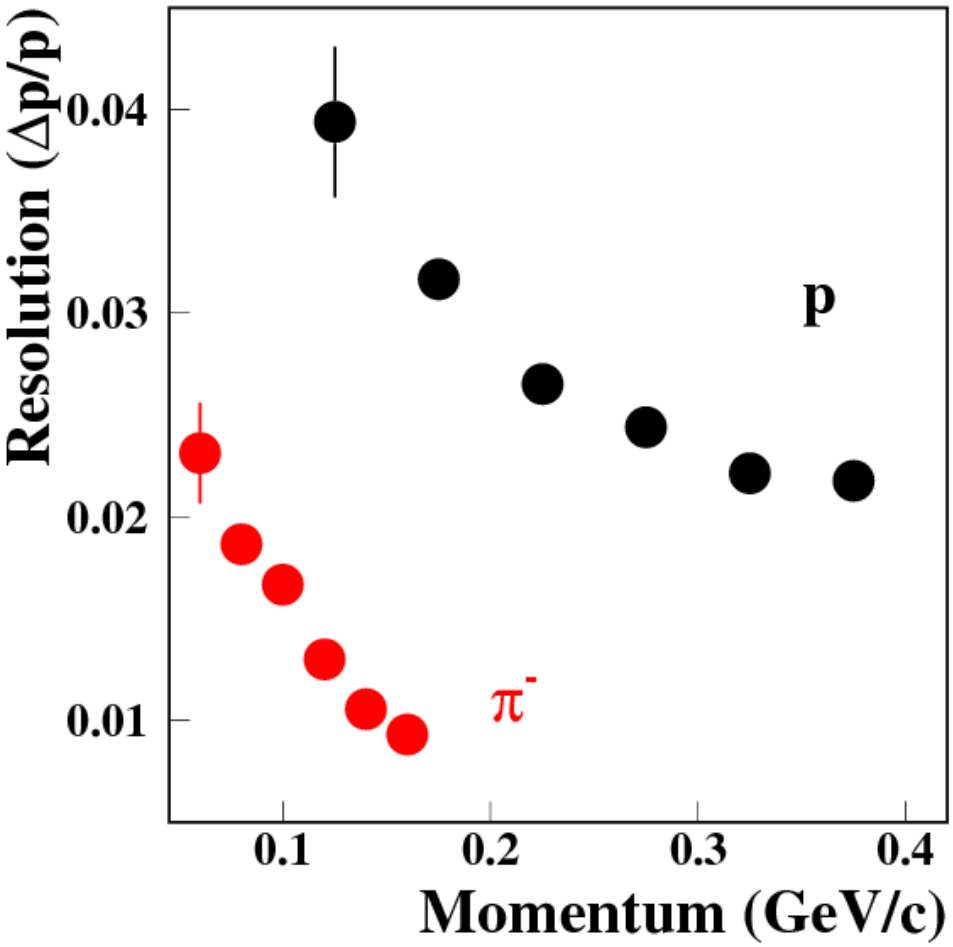
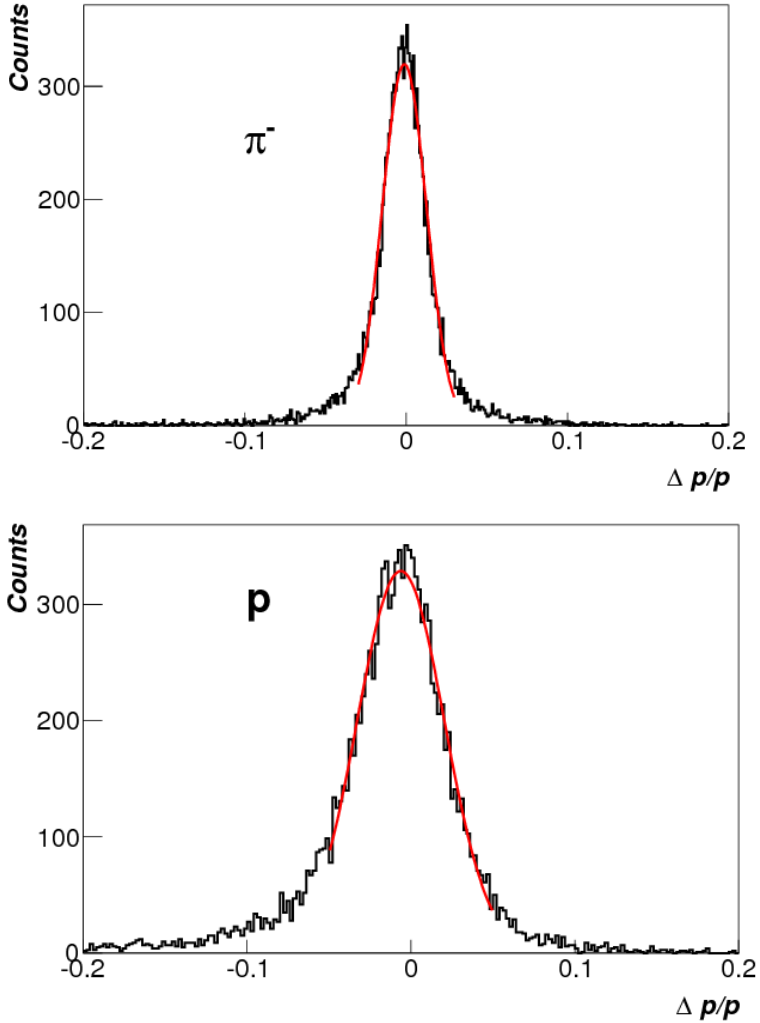
Expected Momentum Resolutions





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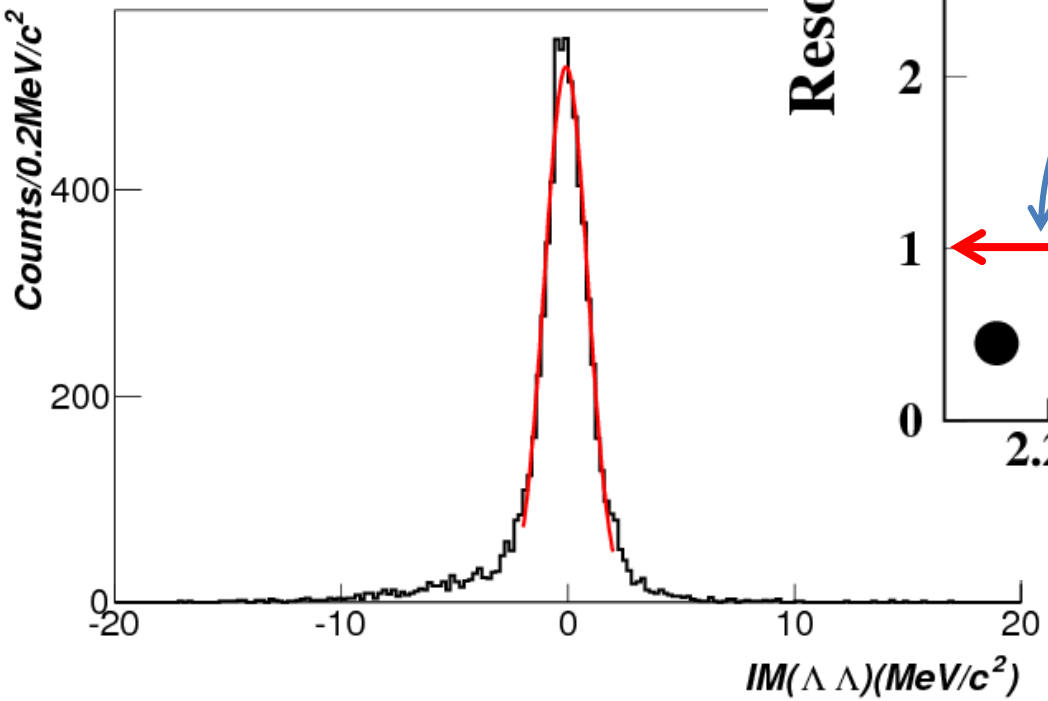
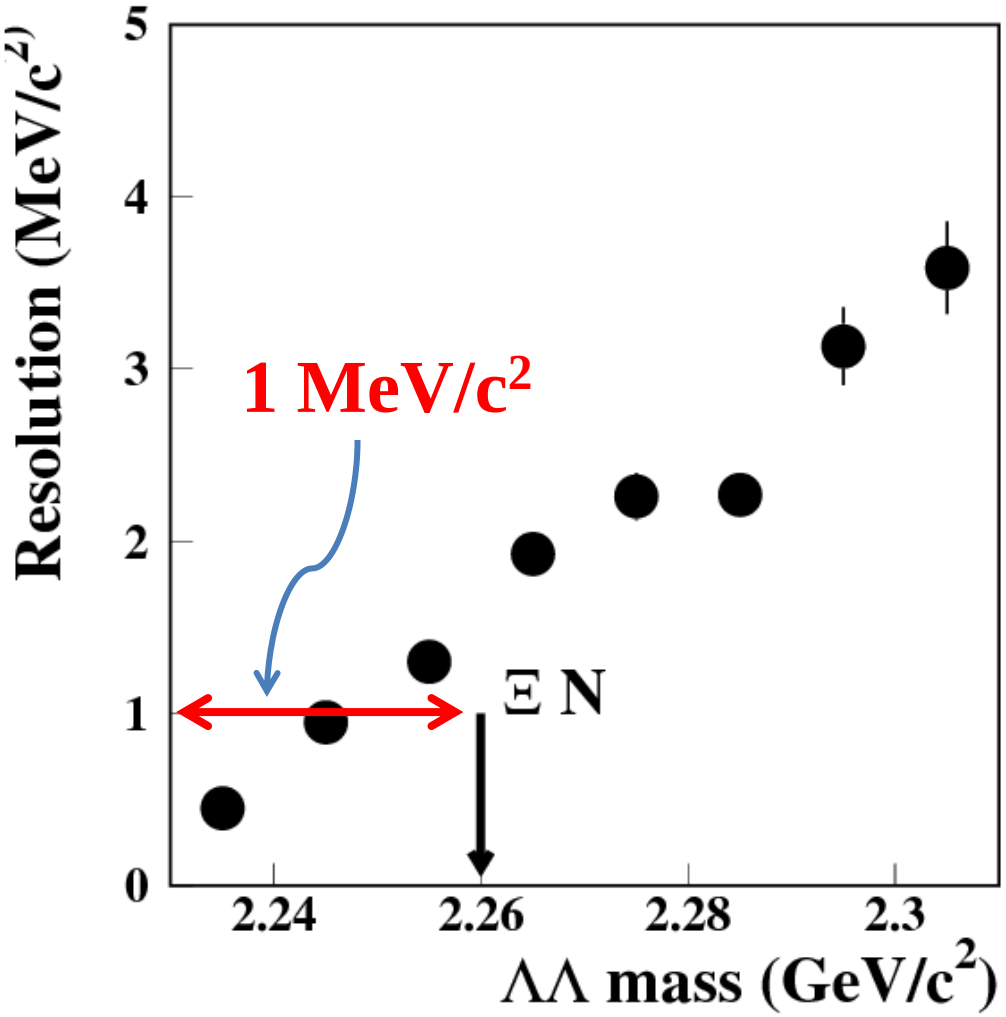
Mass Resolutions





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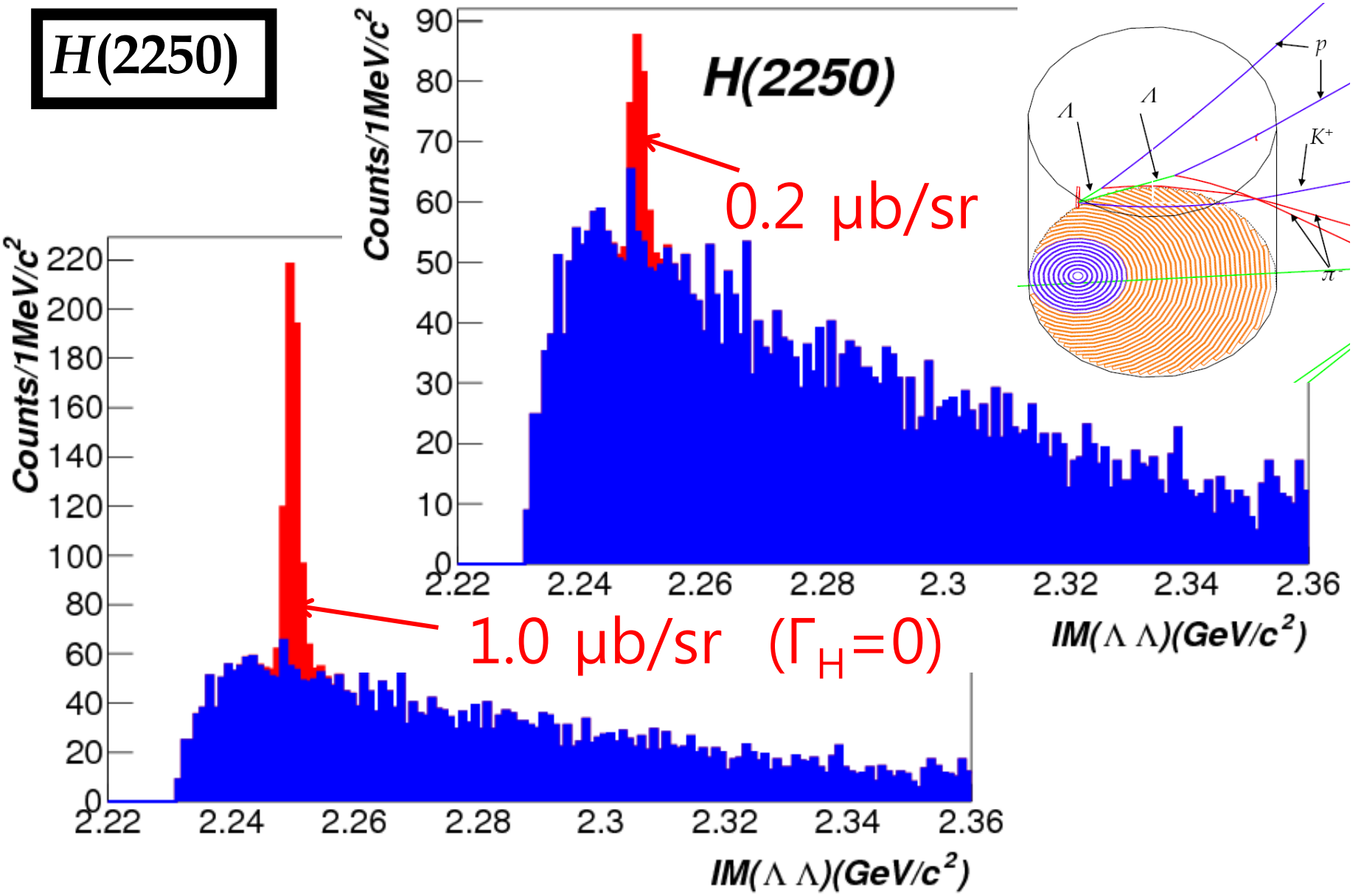
$H(2250)$



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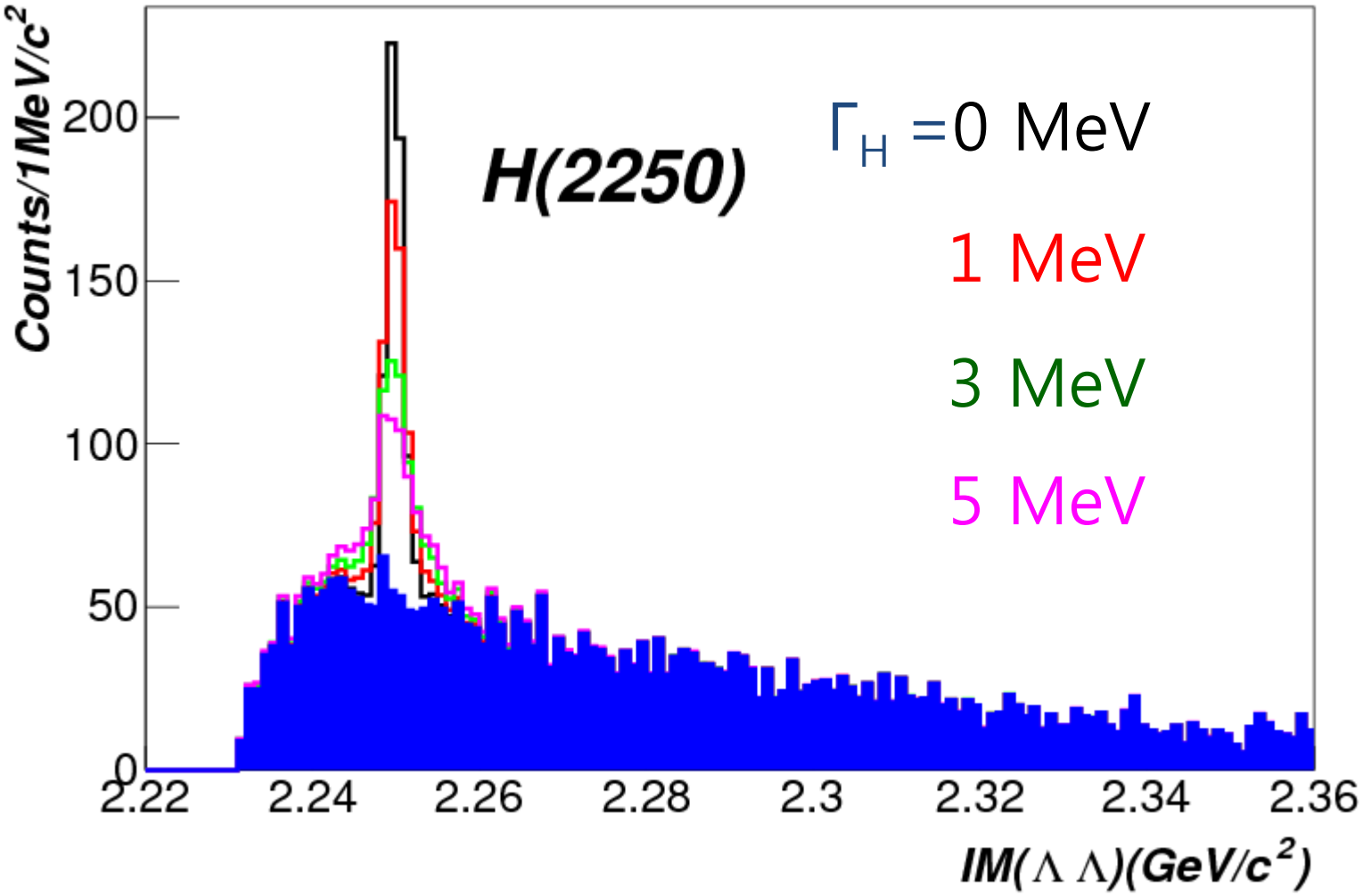
Lineshapes with respect to the H-decay width Γ_H



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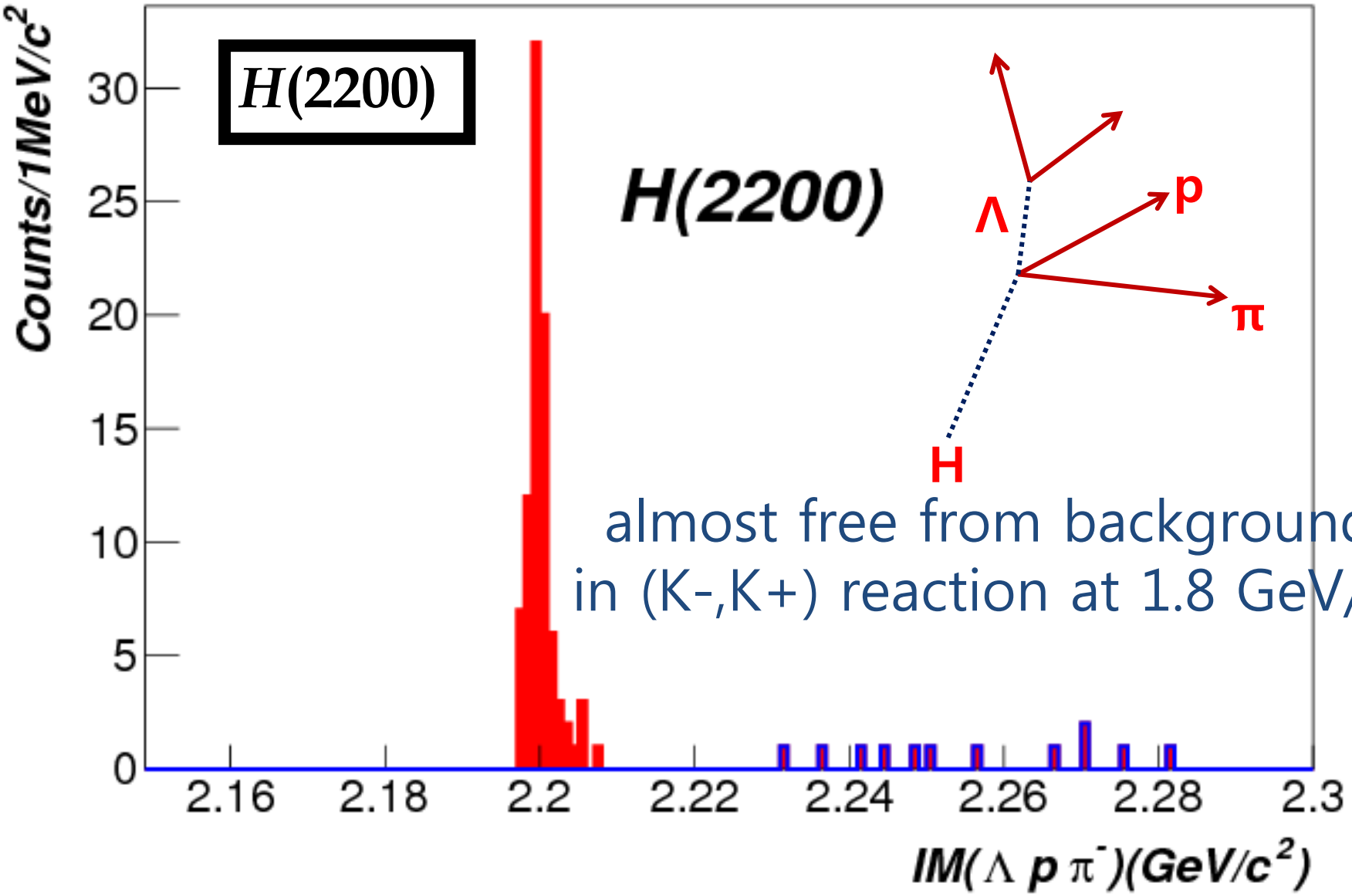

almost free from background
in (K-,K+) reaction at 1.8 GeV/c.

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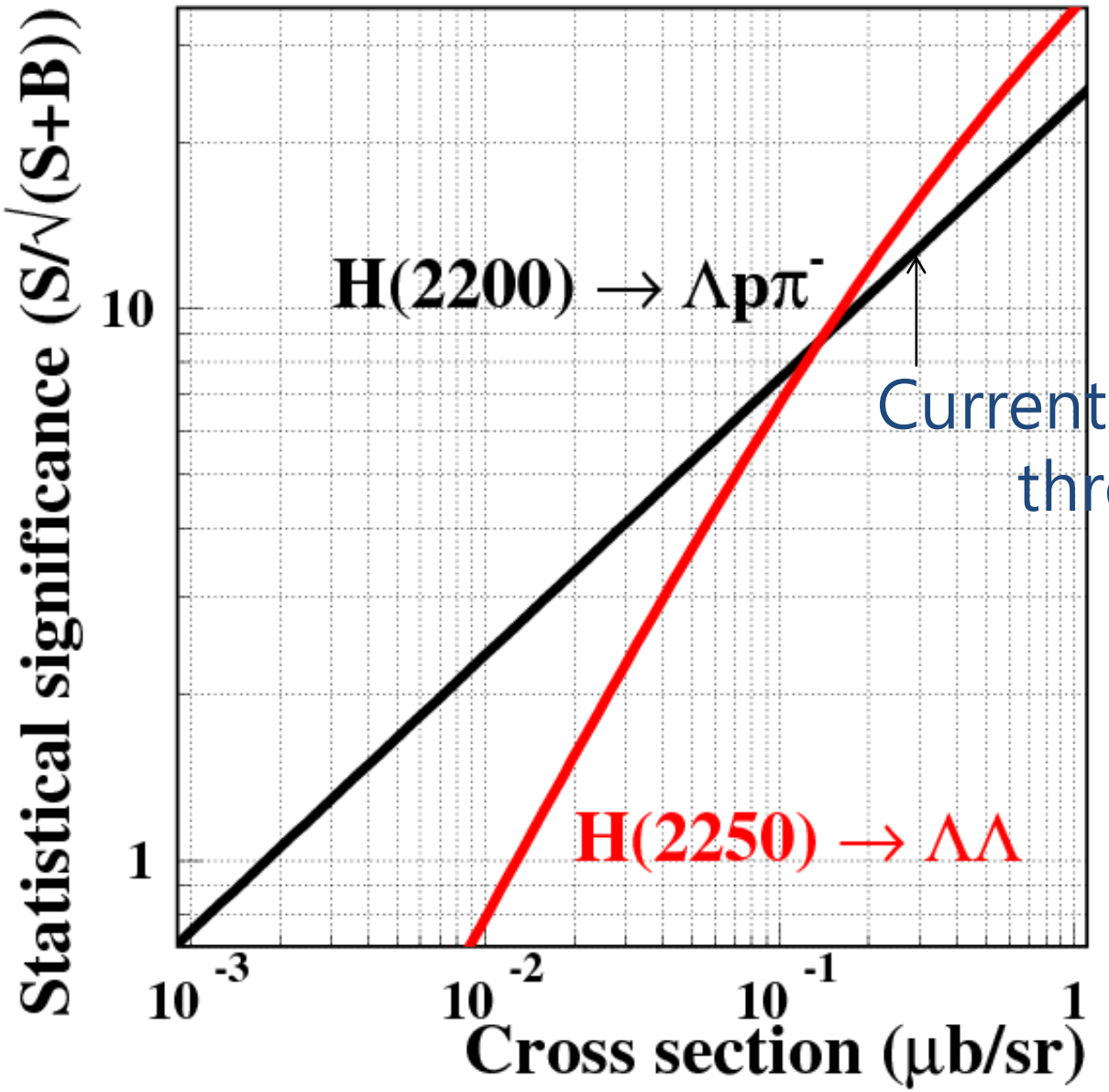
Sensitivity



Current UL at Λpπ threshold

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Summary

- We plan to search for the H-dibaryon resonance in $\Lambda\Lambda$ system and the bound one decaying weakly into $\Lambda p\pi$ system at J-PARC.
- We plan to construct a hyperon spectrometer with a TPC to track Λ decays.
- We expect to collect 11K $\Lambda\Lambda$ events for 100 shifts.
- We are going to get ready for physics runs late in 2014.