Hypernuclear spectroscopy at Jefferson Lab. The third generation experiment (E05-115)

A. Matsumura for the E05-115 collaboration

Tohoku Univ.

NP08@Mito, March 6, 2008

JLab E05–115 collaborators in proposal

~ 87 researchers from 19 instituites

Dept. of Phys. Tohoku Univ.
Y. Fujii, O. Hashimoto, H. Kanda, M. Kaneta, D. Kawama, K. Maeda, N. Maruyama, A. Matsumura, S.N. Nakamura, K. Nonaka, Y. Okayasu, M. Sumihama, H. Tamura, K. Tsukada, Y. Miyagi

Dept. of Phys. Hampton Univ.
O.K. Baker, L. Cole, M. Christy, P. Gueye, C. Jayalath, C. Keppel, S. Malace, E.K. Segbefia, L. Tang, V. Tvaskis, L. Yuan

Dept. of Phys. Florida International Univ.
A.Acha, W. Boeglin, L. Kramer, P. Markowitz, N. Perez, B. Raue, J. Reinhold, R. Rivera

Dept. of Phys. Yamagata Univ.
S. Kato

Institute of Particle and Nuclear Physics (KEK)
H. Noumi, Y. Sato, T. Takahashi

Laboratory of Phys, Osaka Electro-Comm. Univ.
T. Motoba

Dept. of Phys. Univ. of Houston
Ed. V. Hungerford, K.J. Lan, Y. Li, N. Elhayari, S. Randeniya, N. Klantrains

Thomas Jefferson National Accelerator Facility
P. Bosted, R. Carlini, V. Dharmawardane, R. Ent, H. Fenker, D. Gaskell, M. Jones, D. Mack, J. Roche, G. Smith, W. Vulcan, S. Wood, C. Yan

Yerevan Physics Institute
R. Asaturyan, H. Mkrtchyan, A. Margaryan, S. Stepanyan, V. Tadevosyan

Nuclear Physics InstituteLanzhou Univ.
X. Chen, B. Hu, S. Hu, Y. Song, W. Luo, B. Wang

Dept. of Physics / Applied Phys. Univ. of Zagreb
D. Androic, M. Furic, T. Petkovic, M. Planinic, T. Seva

Dept. of Phys. North Carolina A&T State Univ.
A. Ahmidouch, S. Danagoulian, A. Gasparian

Dept. of Phys. Louisiana Tech Univ.
N. Simicevic, S. Wells

Dept. of Phys. James Madison Univ.
G. Niculescu, M.-I. Niculescu

Dept. of Phys. Univ. of North Carolina at Wilmington
L. Gan

Dept. of Phys. Duke Univ.
M.W. Ahmed

Dept. of Phys. Univ. of Maryland
F. Benmokhtar, T. Horn

Dept. of Phys. Southern Univ. at New Orleans
M. Elaasar

Phys. and Astro. Dept. California State Univ.
Ed F. Gibson

Reaction spectroscopy @ JLab and γ-ray spectroscopy @ J-PARC

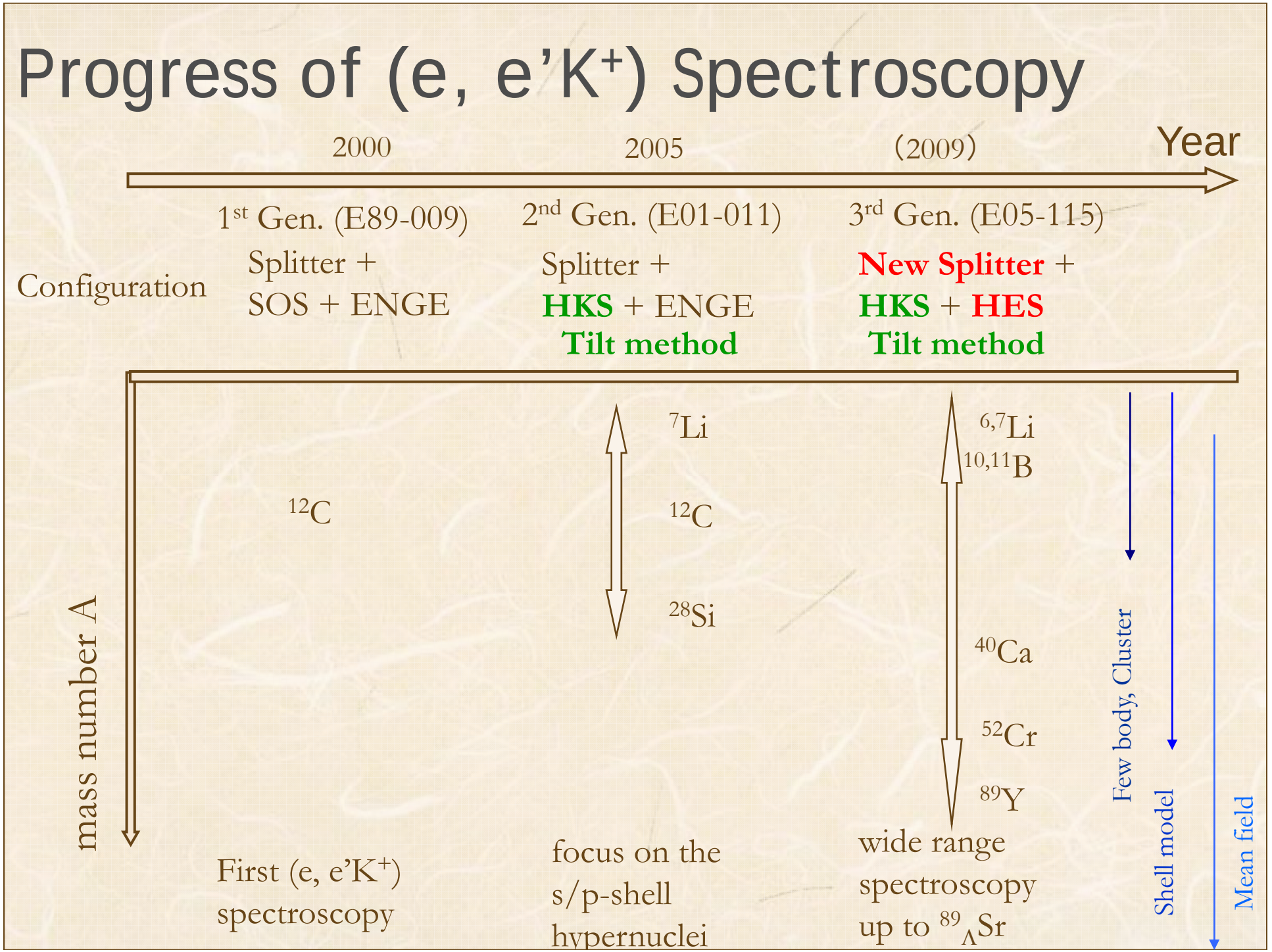
	@JLab	@J-PARC
Reaction	$(e,e'K^+)$	$(K^-,\pi^-\gamma)$
Measurement	Absolute binding energy Cross section	Energy space
Resolution	~ 3-400 keV (FWHM)	a few keV (FWHM)
Difficulty	Yield, Background, …..	

Combine information from complementary experiments

➔ Λ hypernuclear structure

➔ Λ-N interaction

Progress of (e, e'K^+) Spectroscopy



JLab E05-115 Experiment

Physics motivations

- **^{7}Li(e, e' K^{+})$^{7}_{\Lambda}$He**, ^{10}B(e, e' K^{+})$^{10}_{\Lambda}$Be, (H_2O for calibration)
  - Neutron rich hypernuclei
  - Charge symmetry breaking
  - ΛN - ΣN coupling
- **^{40}Ca(e, e' K^{+}) $^{40}_{\Lambda}$K**, ^{52}Cr(e, e' K^{+}) $^{52}_{\Lambda}$V
  - Binding energy of *s-*, *p-*, *d-* orbit, Cross section
  - *ls* splitting
  - Single-particle potential
- ^{89}Y(e, e' K^{+}) $^{89}_{\Lambda}$Sr
  - Feasibility

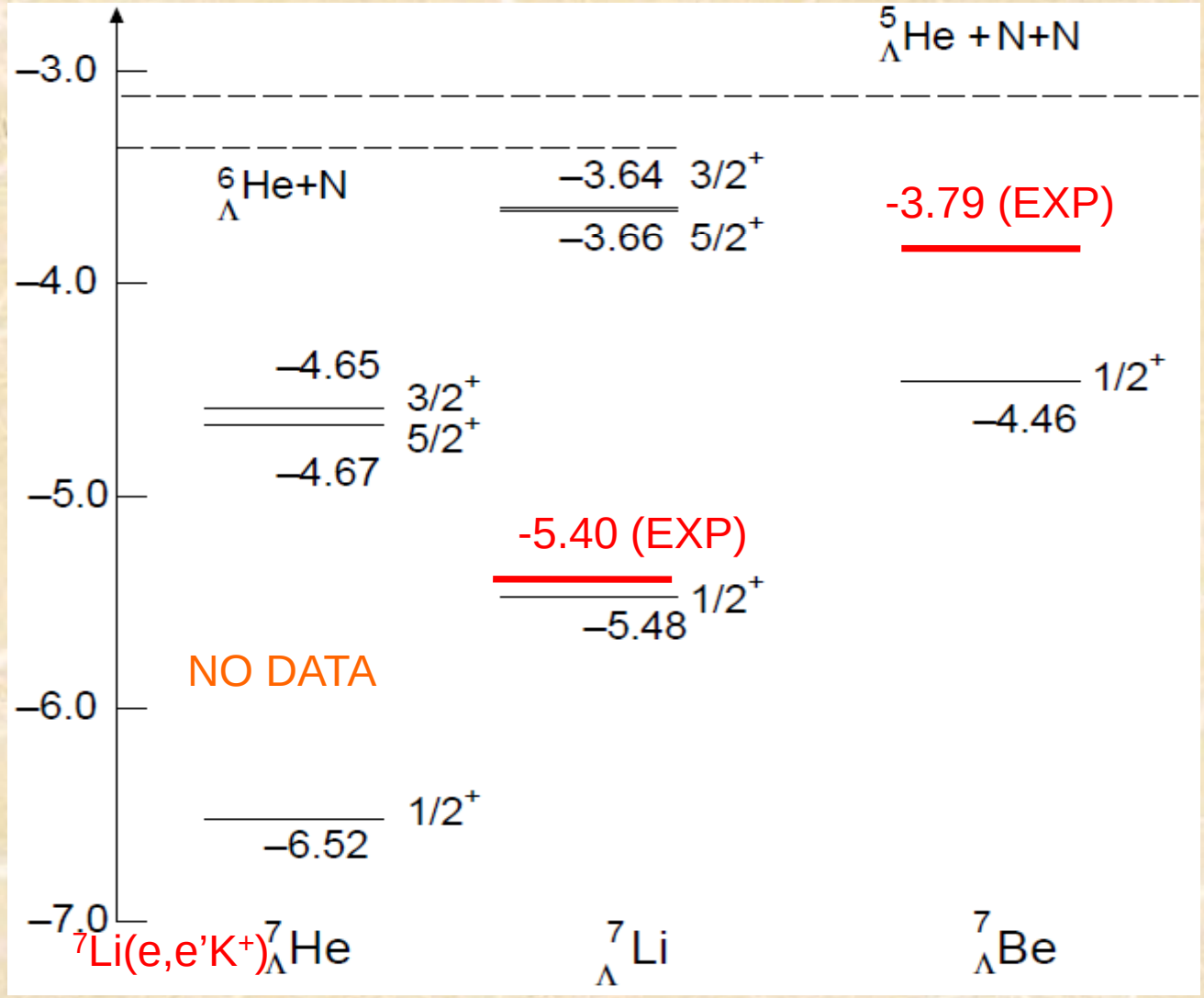
Requirement : more hypernuclear yield

^{7}Li target

E. Hiyama
Private Comm.

- Convert *p* into Λ
- Absolute binding

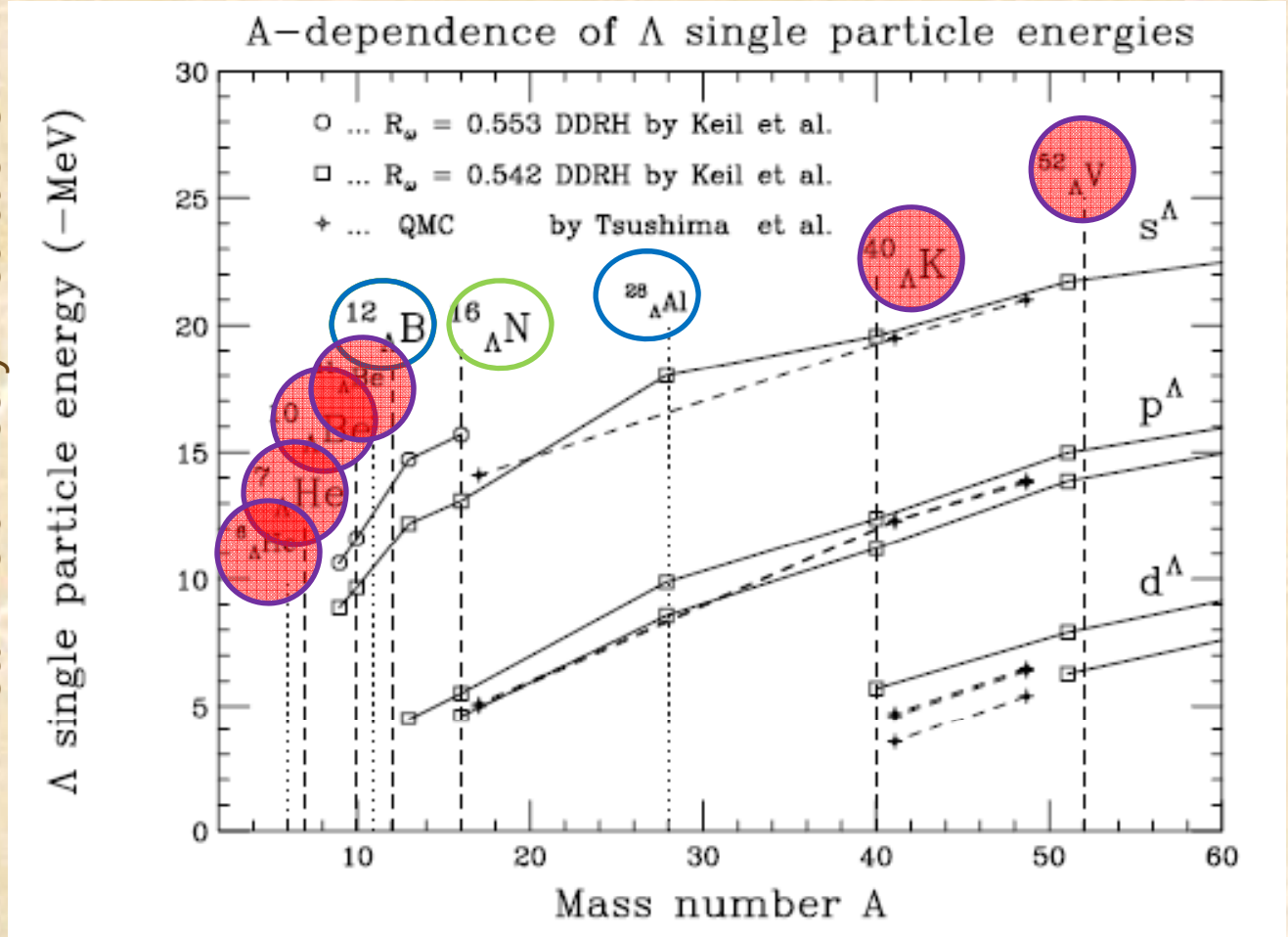
energy
→Possible Charge Sym. Breaking?
→ΛN – ΣN coupling



Various targets

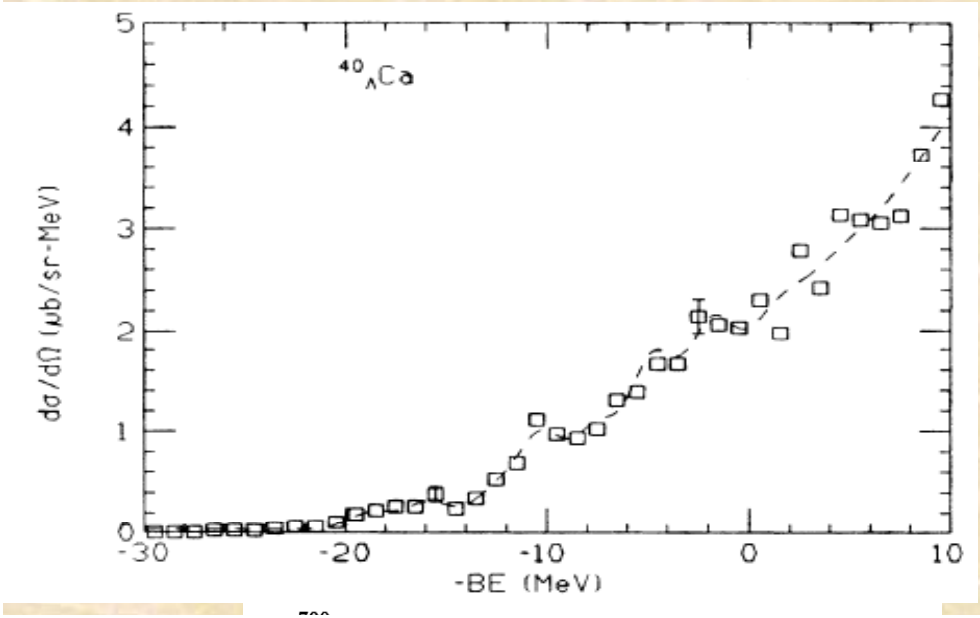
E89-009 First Generation
E94-107 Hall A Experiment
E01-011 Second Generation
E05-115 Third Generation

Mean Field Theory Predictions



^{40}Ca target

P.H.Pile et al. PRL 66 (1991) 2585



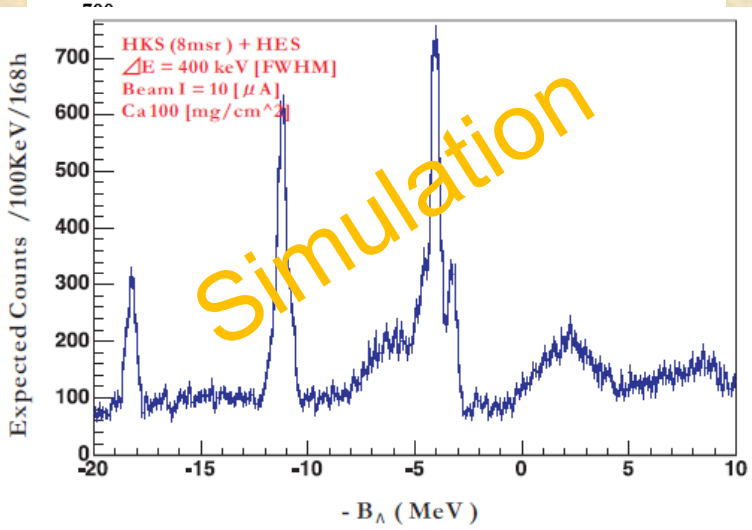


Figure 9: An expected ^{40}Ca(e,e′K$^+$)$^{40}_{\Lambda}$K spectrum. The HKS-HES acceptance was taken into accout in the GEANT simulation. Quasi-free events expected in $-B_\Lambda > 0$ are not included.

Response to Theory Gr. comment

- *LS* spilitting or core config. mixing
- Compare spectrum with Shell model Calc.
- Reliable E(Λ_s), E(Λ_p), E(Λ_d) inputs for Mean Field Theories
- Cross sections of various states constraint ΛN interaction models

How to improve yield?

➔ Increase beam energy !

Bremsstrahlung, Møller : more forward peak

Associated with virtual photon : almost the same angular distribution

Virtual Photon Energy 1.5 GeV

2nd gen. (E01-011)

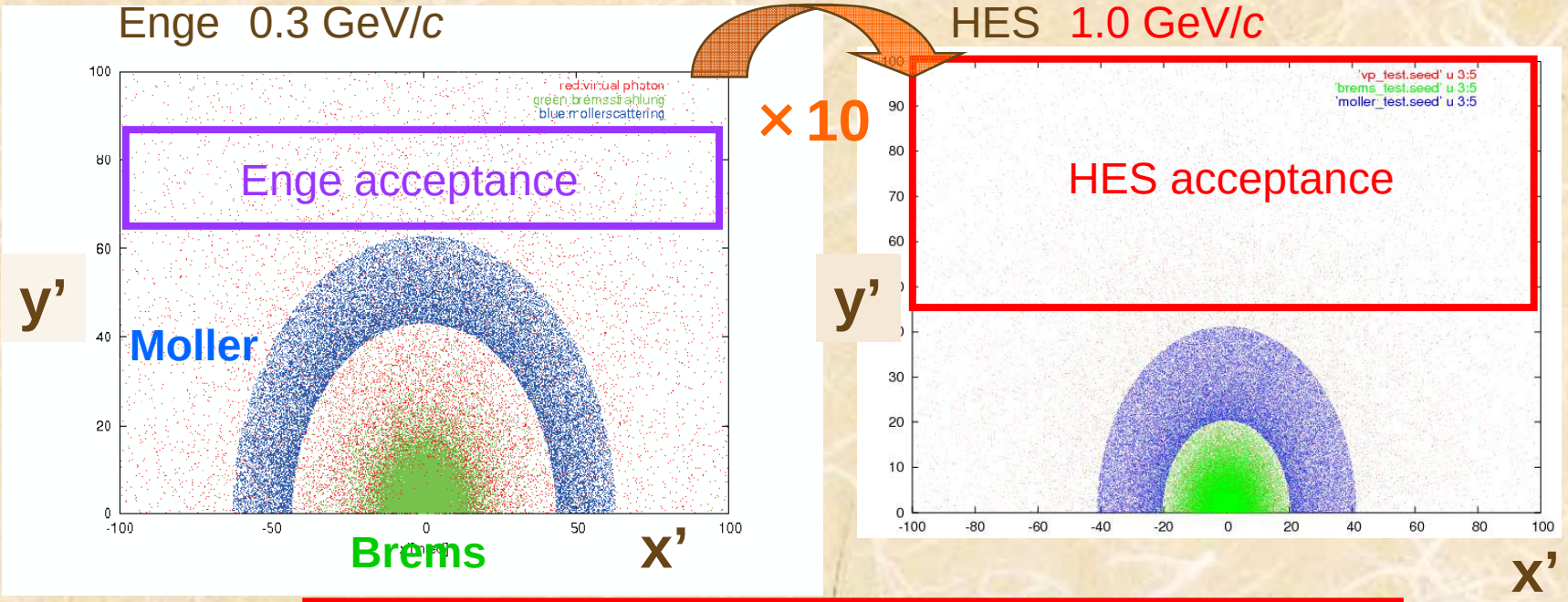
Beam Energy 1.8 GeV

Enge 0.3 GeV/*c*

3rd gen. (E05-115)

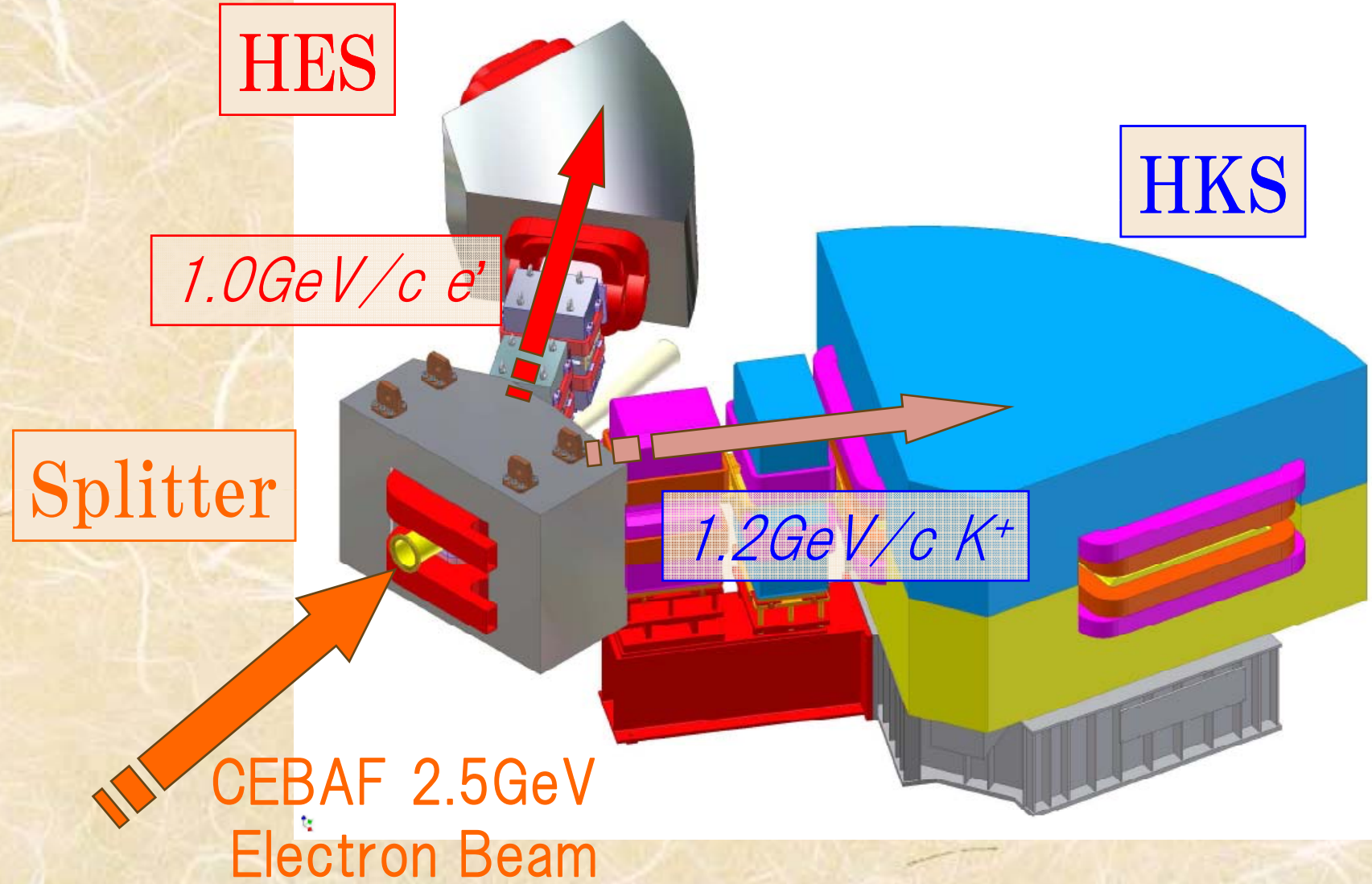
Beam Energy 2.5 GeV

HES 1.0 GeV/*c*

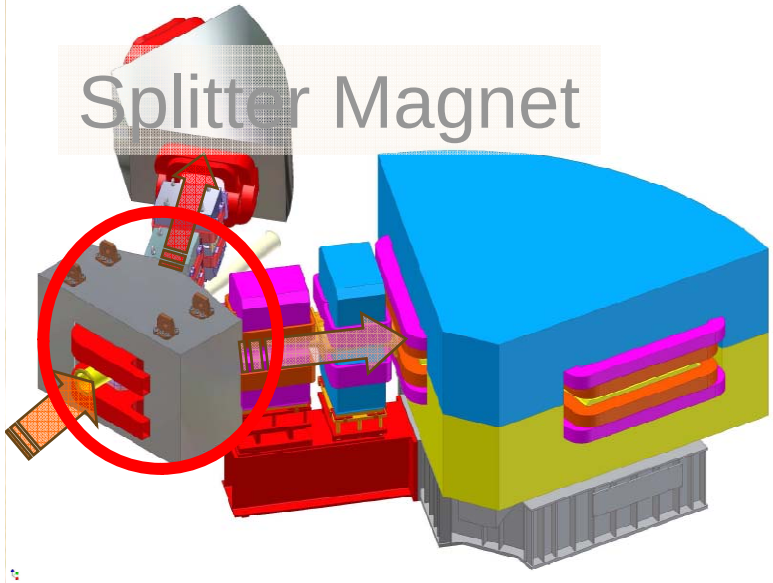


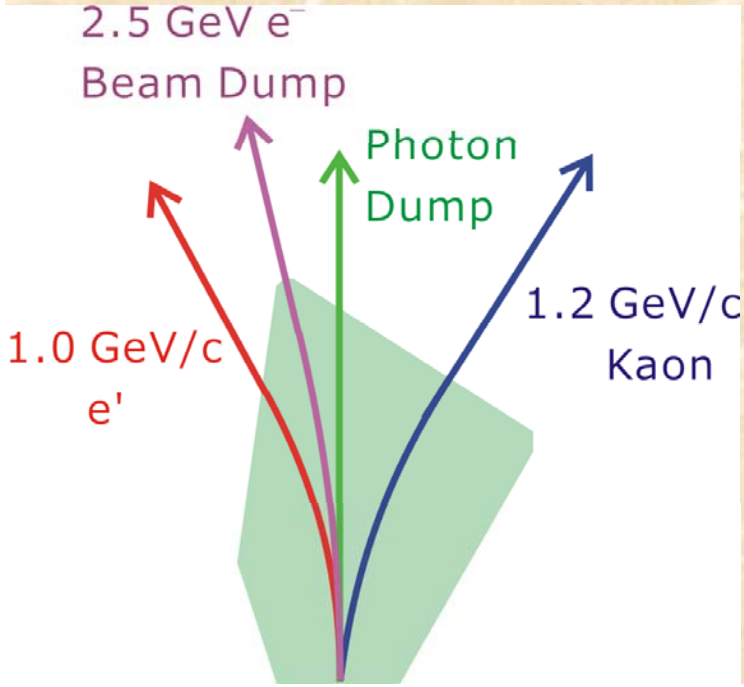
10 times virtual photon tagging efficiency

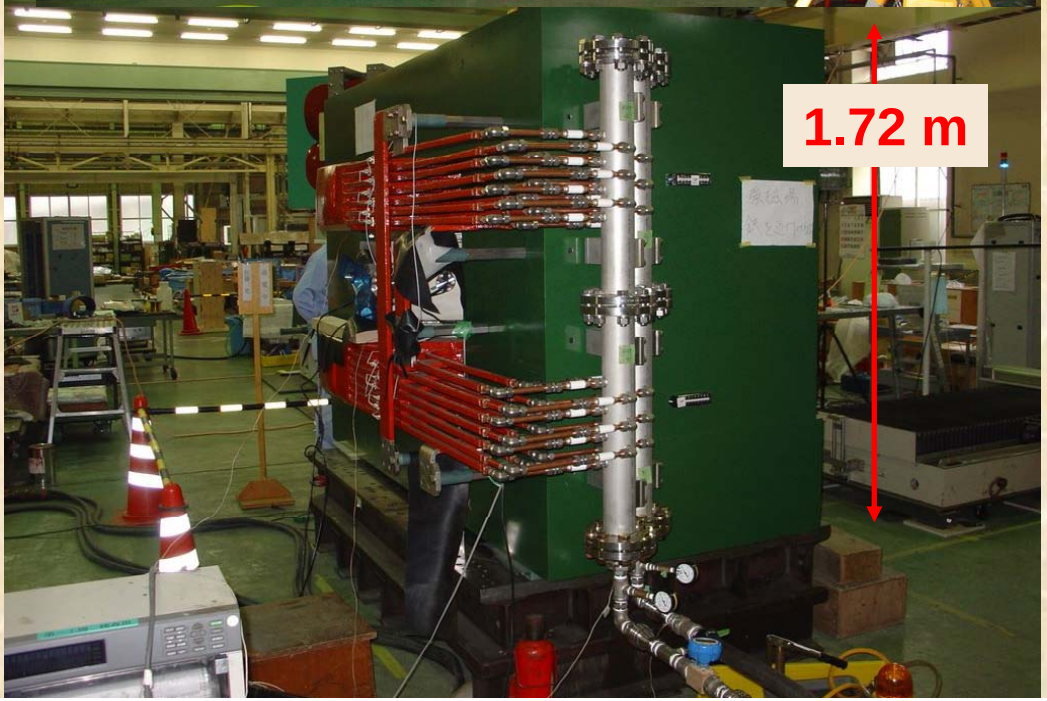
E05-115 Setup



Splitter Magnet



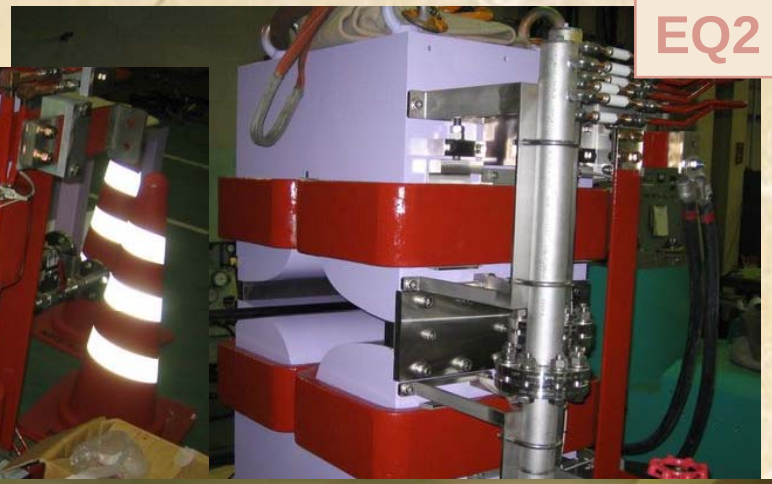


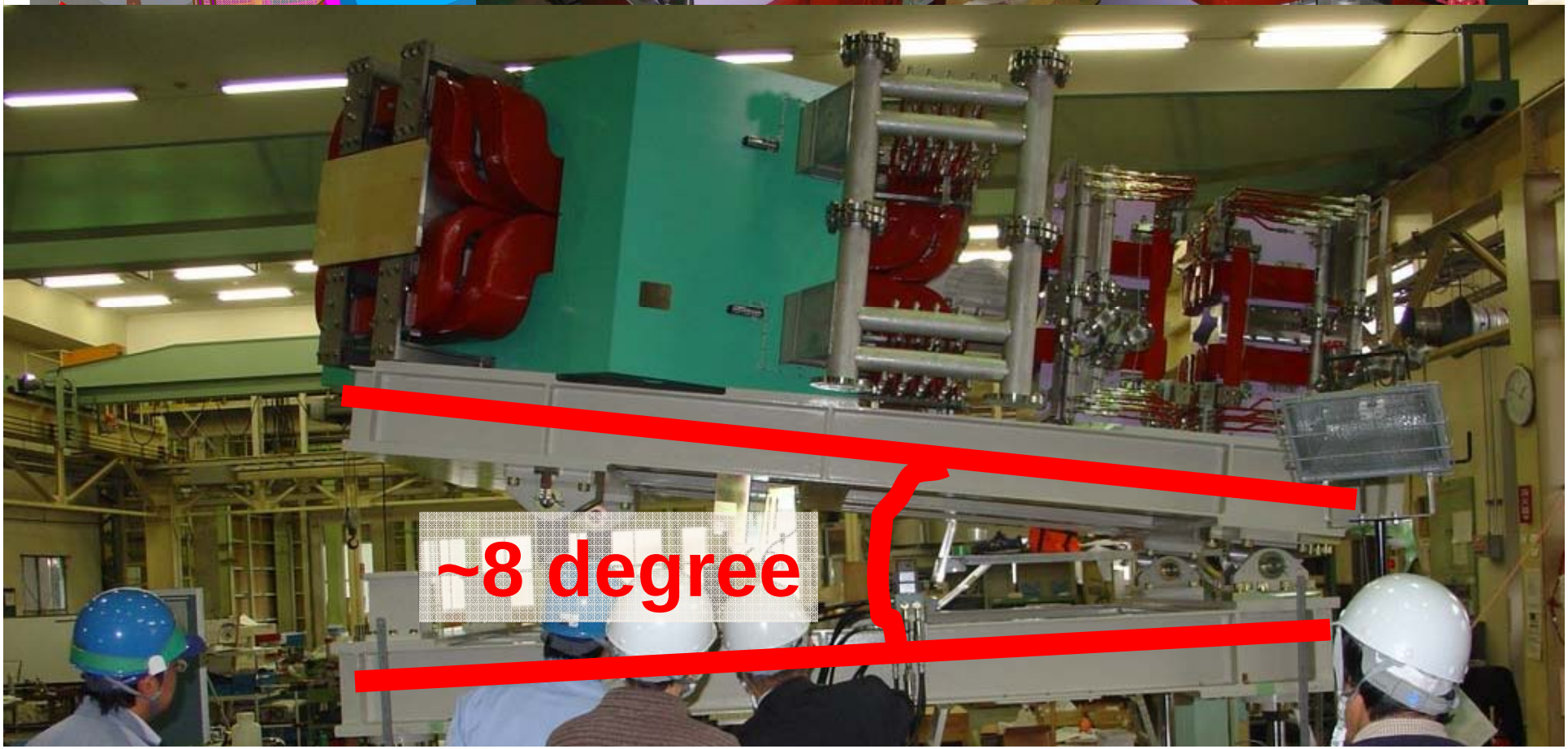


Q-Q-D Magnet

EQ1

EQ2





Summary

- The 3rd generation (e,e'K^+) hypernuclear spectroscopy
  - Wide mass region (A=6~89)
  - High resolution of 300-400 keV(FWHM)
  - Larger yield : 5 times larger than the 2nd generation exp
- HES magnets were arrived at JLab
- HES detectors are under construction

Schedule

- Mar 2008 : Test experiment of detectors at Tohoku Univ. (LNS)
- By the end of 2008 : Ready to install HES in Hall C
- (2009~ : J-PARC)
- 2009 summer : Beamtime