

*Jan/31<sup>st</sup>/2009*  
*Hall-C users meeting*

# **E05-115 (HKS-HES) experiment preparation status**

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On behalf of JLab E05-115 Collaboration



**TOHOKU**  
UNIVERSITY

**Jefferson Lab**  
Thomas Jefferson National Accelerator Facility

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- Introduction
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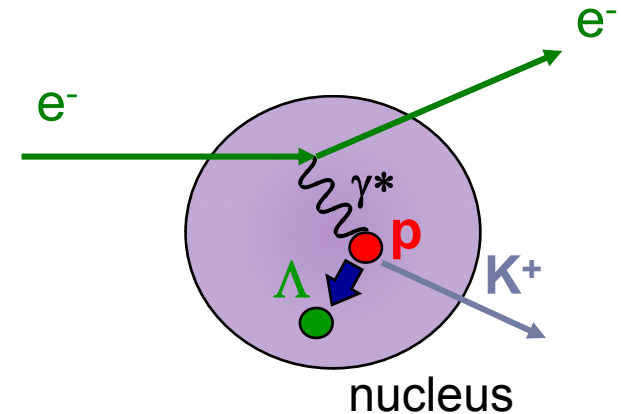
D. Androic, M. Furic, T. Petkovic, T. Seva

- ▶ 78 researchers from 19 institutes
- ▶ 4 Ph.D candidates

# Characteristics of the $(e, e'K^+)$ Reaction

## Physics side

- ▶ Convert p to  $\Lambda$ :  $p(e, e' K^+)\Lambda$ 
  - ▶ mirror hypernuclei produced by  $(\pi^+, K^+)$
  - ▶ neutron-rich hypernuclei
- ▶ Product both spin-flip/ non-flip state in forward angle



## Experimental side

- ▶ Available a high quality electron beam
  - ▶ achievable high energy resolution  
 $\sim 400$  keV (FWHM)  $\Leftrightarrow 2$  MeV (FWHM) by  $(\pi^+, K^+)$
- ▶ missing mass scale calibration by  $p(e, e' K^+)\Lambda/\Sigma^0$ 
  - ▶ absolute  $-B_\Lambda$  measurement

# Progress of Spectroscopic Study by $(e, e'K^+)$ @JLab Hall-C

**E89-009** (2000):  $^{12}_{\Lambda}\text{B}$

- Splitter + SOS + Enge
- Resolution: **750 keV** (FWHM)

**“A proof of principle”**

**E01-011** (2005):  $^7_{\Lambda}\text{He}$ ,  $^{12}_{\Lambda}\text{B}$ ,  $^{28}_{\Lambda}\text{Al}$

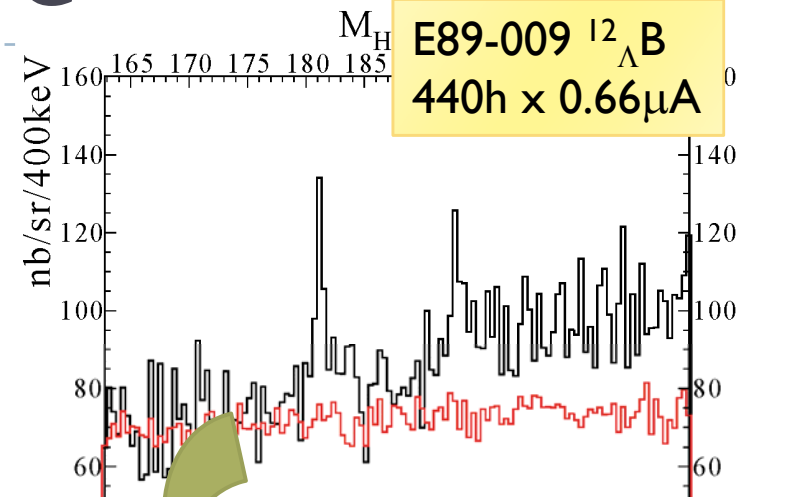
- Splitter + **HKS** + Enge
- Optimization of  $e'$  acceptance (**Tilt method**)
- Resolution:  $\sim$  **400 keV** (FWHM)
- Yield [/hour]: **10** x E89-009

**“Establish the techniques”**

**E05-115** (2009):  $^7_{\Lambda}\text{He}$ ,  $^{10}_{\Lambda}\text{Be}$ ,  $^{40}_{\Lambda}\text{K}$ ,  $^{52}_{\Lambda}\text{V}$

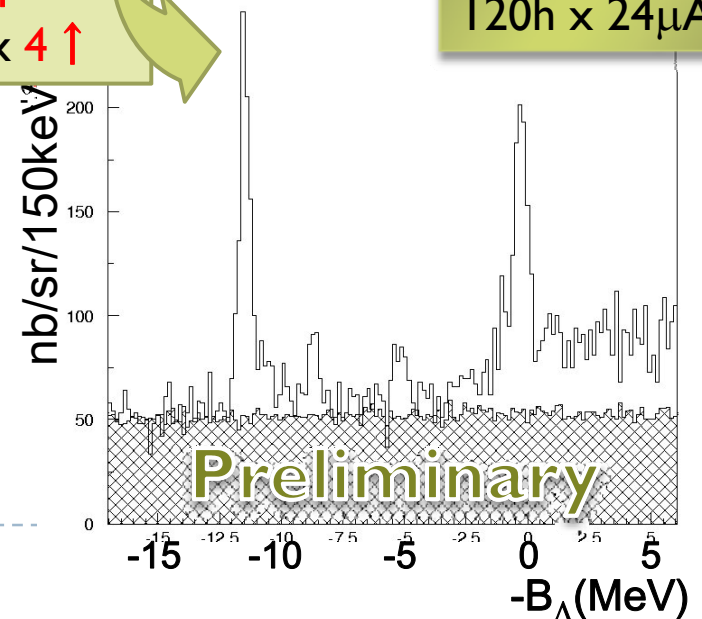
- **New Splitter** + **HKS** + **HES**
- **Tilt method**

**“Precise study in the wide mass region”**



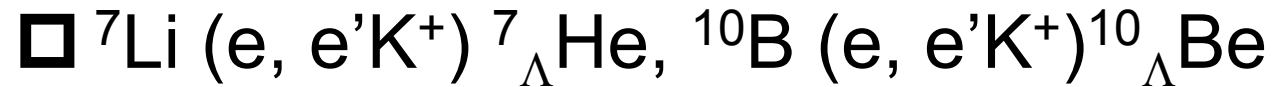
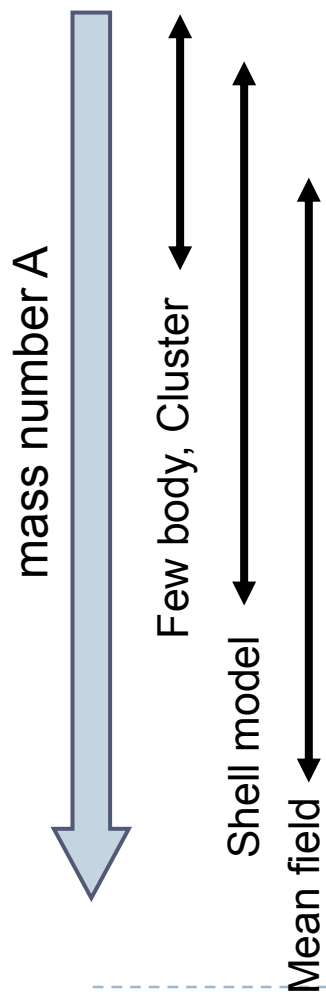
Resolution x **2** ↓  
Yield x **10** ↑  
S/N ratio x **4** ↑

**E01-011**  $^{12}_{\Lambda}\text{B}$   
120h x 24 $\mu\text{A}$



# E05-115 Physics Motivation

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- Neutron rich hypernuclei
- Charge symmetry breaking
- $\Lambda\text{N}-\Sigma\text{N}$  coupling

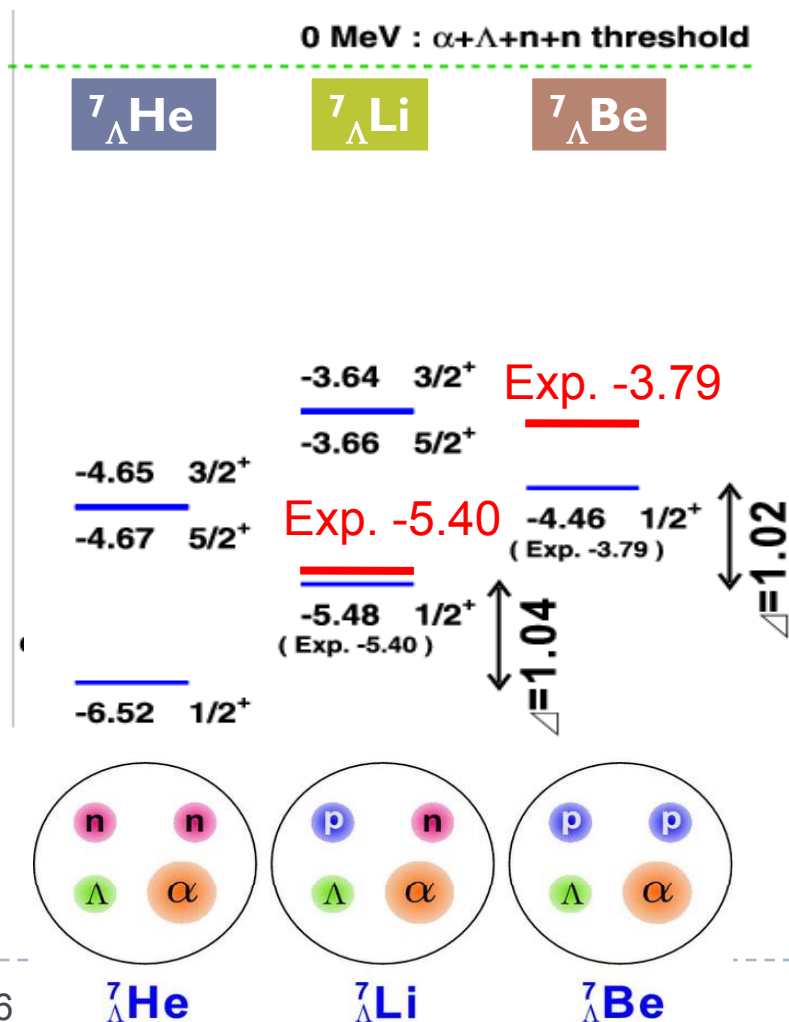


- Binding energy of  $s$ -,  $p$ - and  $d$ - orbit, Cross section
- $l/s$  splitting
- Single-particle potential

# Theoretical calculation of $A=7$ iso-triplet & emulsion data

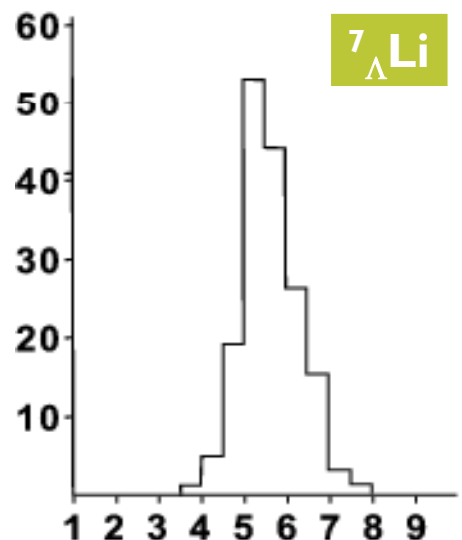
## Cluster model calculation

(E. Hiyama Private Communication)



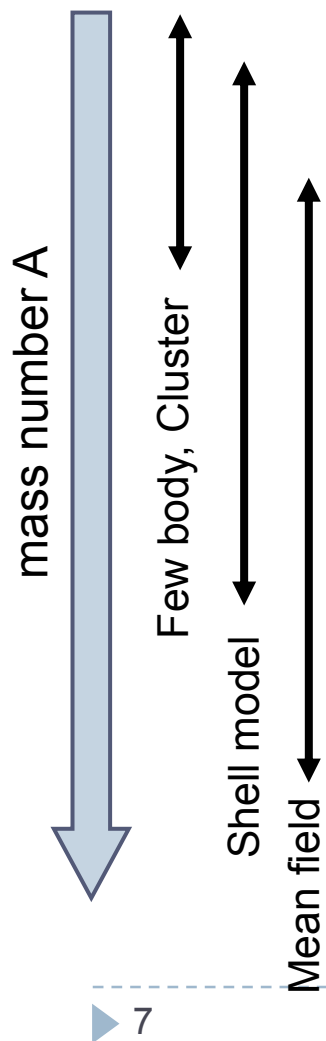
## Emulsion data

Nucl. Phys. B52 (1973) 1



# E05-115 Physics Motivation

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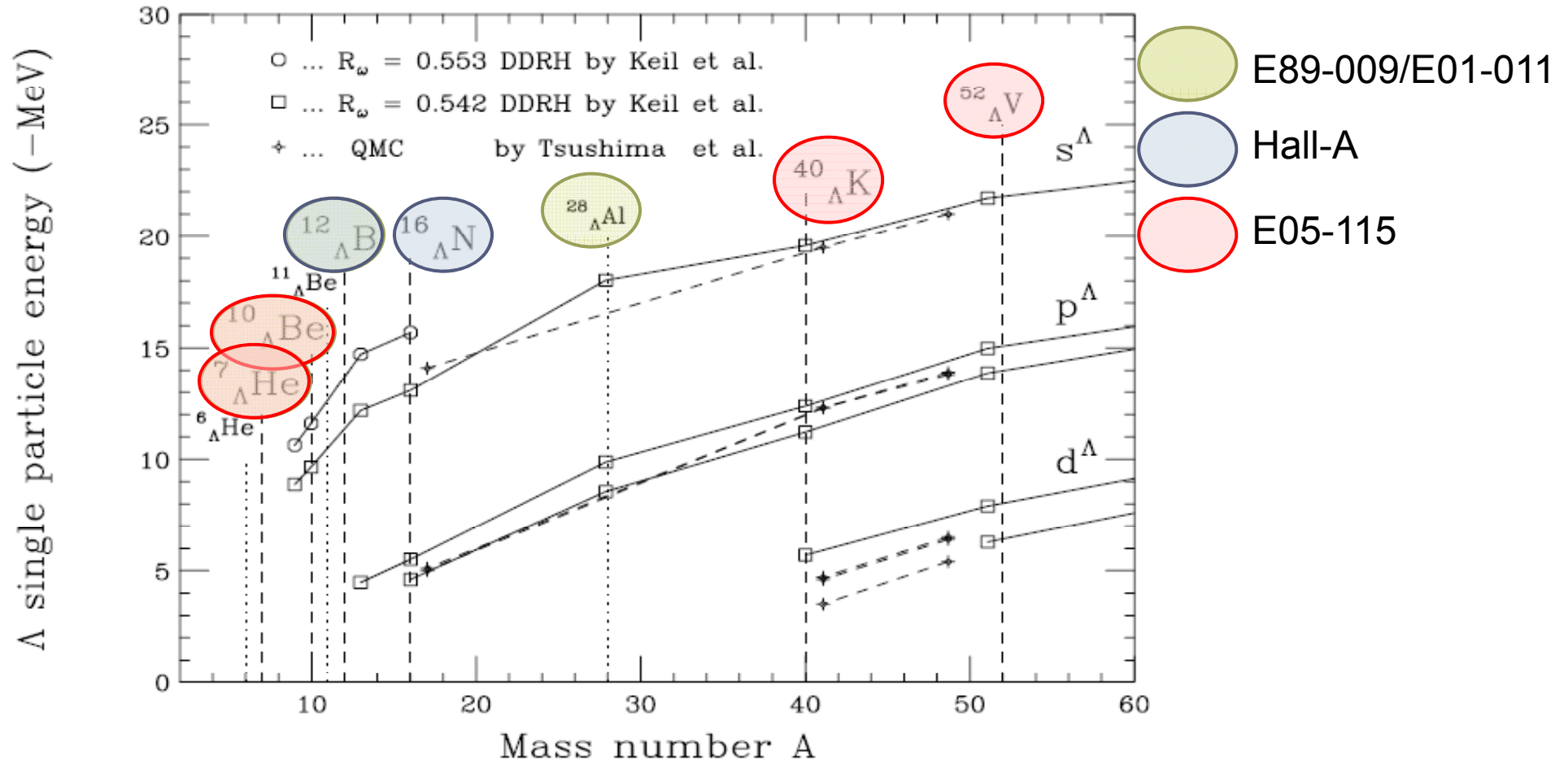
- Neutron rich hypernuclei
- Charge symmetry breaking
- $\Lambda\text{N}-\Sigma\text{N}$  coupling



- Binding energy of  $s$ -,  $p$ - and  $d$ - orbit, Cross section
- $1s$  splitting
- Single-particle potential

# A-dependence of $\Lambda$ single particle energies

Precise input parameters are required for mean-field theories

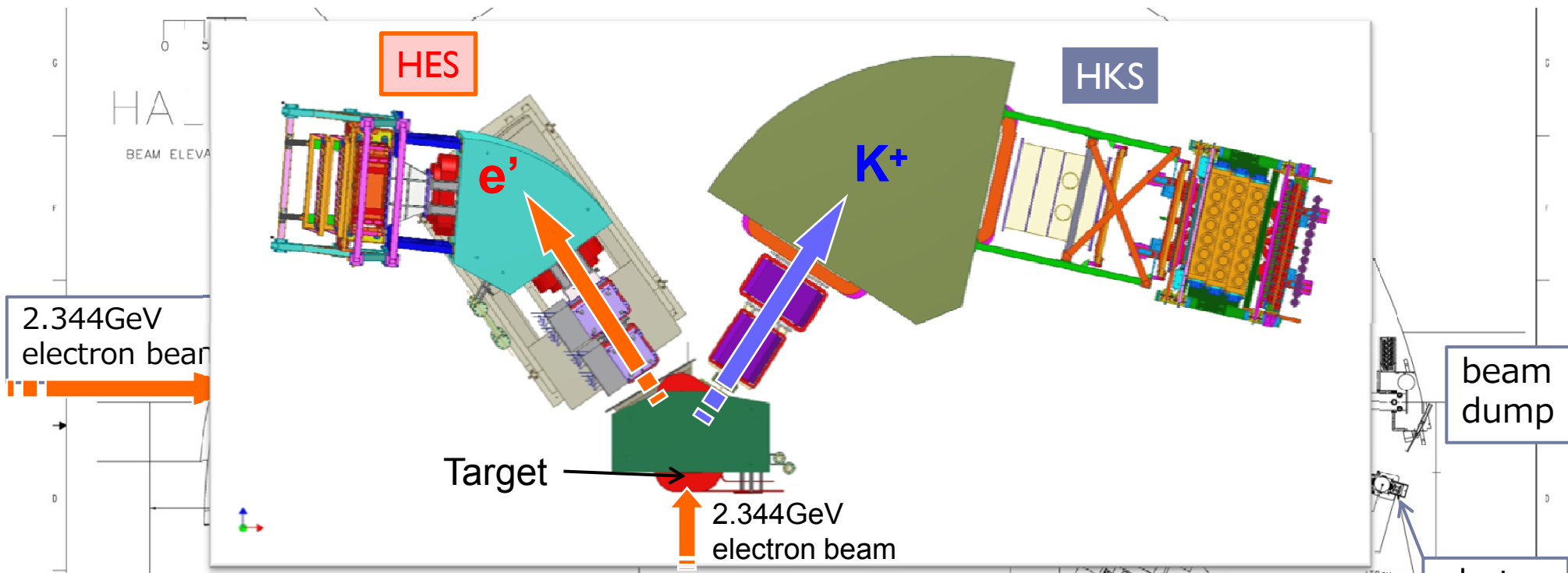


K. Tsushima, K. Saito, J. Haidenbauer, A.W. Thomas, *Nucl. Phys. A* 630 (1998) 691.  
 C.M. Keil, F. Hofmann, H. Lenske, *Phys. Rev. C* 61 (2000) 064309; H. Lenske,  
*presentation at HYP2006 (2006) Mainz.*





# E05-115 Entire Setup

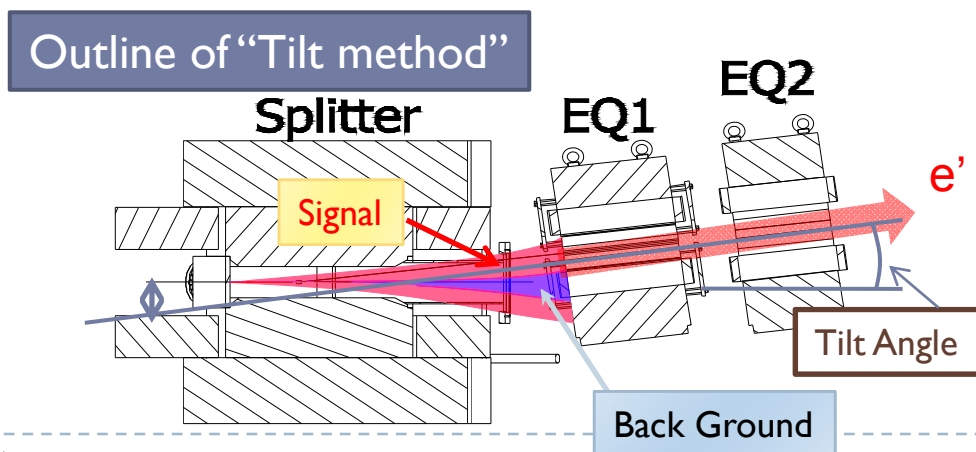


|                     | HES ( $e'$ )         | HKS ( $K^+$ )        | CEBAF ( $e$ )      |
|---------------------|----------------------|----------------------|--------------------|
| Configuration       | Q-Q-D (50deg)        | Q-Q-D (70deg)        | -                  |
| Central Momentum    | 0.844 GeV/c          | 1.2 GeV/c            | 2.344 GeV          |
| Momentum Acceptance | $\pm 0.15$ GeV/c     | $\pm 0.15$ GeV/c     | -                  |
| Solid Angle         | $\sim 8$ msr         | $> 10$ msr           | -                  |
| $\Delta p/p$        | $2.0 \times 10^{-4}$ | $2.0 \times 10^{-4}$ | $7 \times 10^{-5}$ |

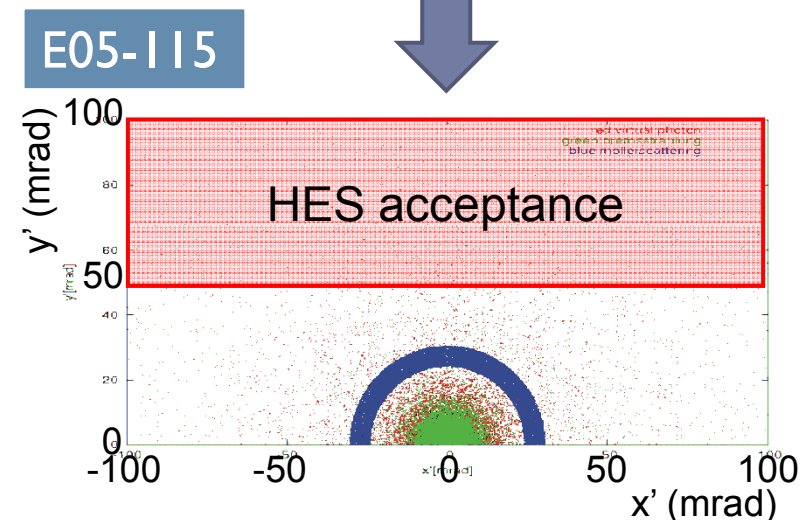
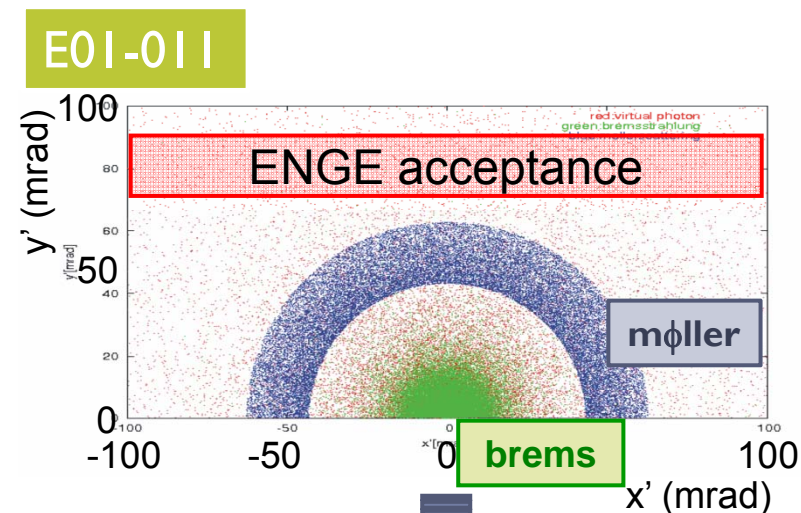
missing mass resolution:  $\sim 400$  keV

# Advantage of the E05-115 Experiment

- ▶ Beam momentum: 1.8→2.344GeV
  - Background electrons go more forward angle.
  - ▣ beam current ↑
  - ▣ S/N ratio ↑
- ▶ e' spectrometer: HES
  - Enlarge acceptance
  - ▣ Virtual Photon Yield ↑
  - Vertical acceptance optimization (Tilt method)
  - ▣ S/N ratio ↑



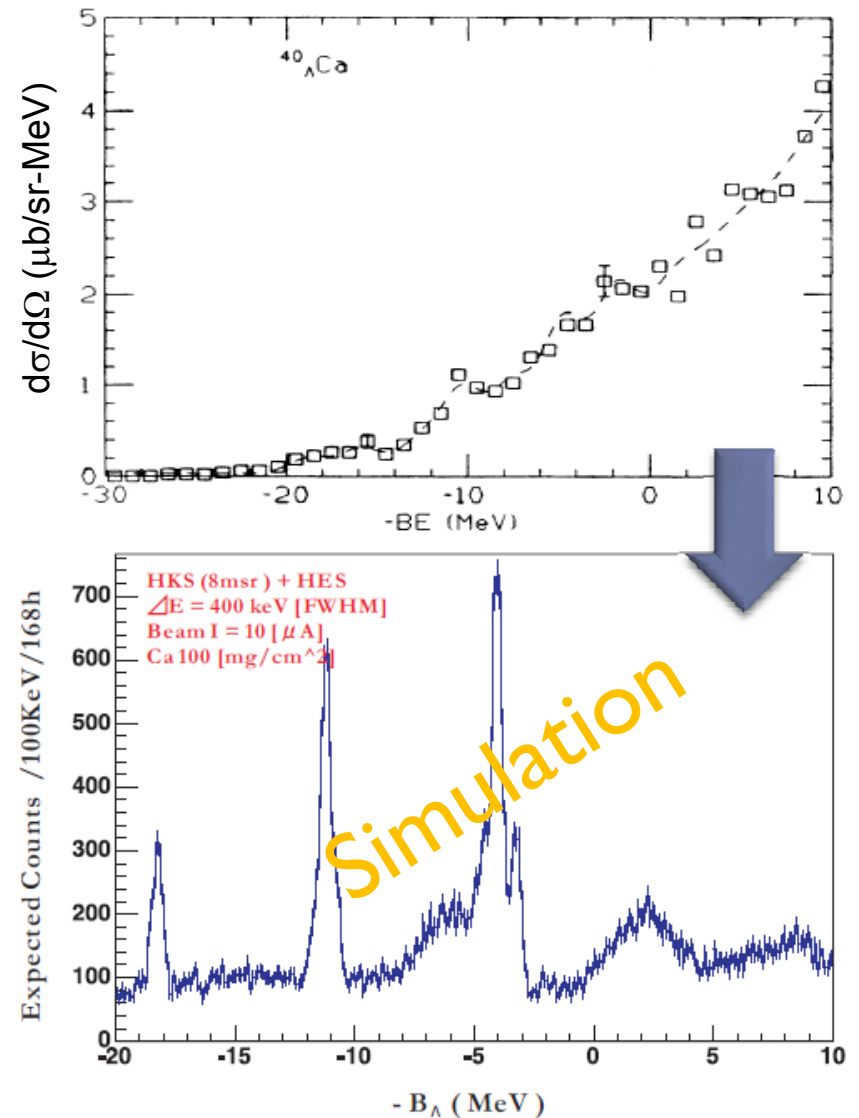
Scattered electron distribution



# Yield Estimation

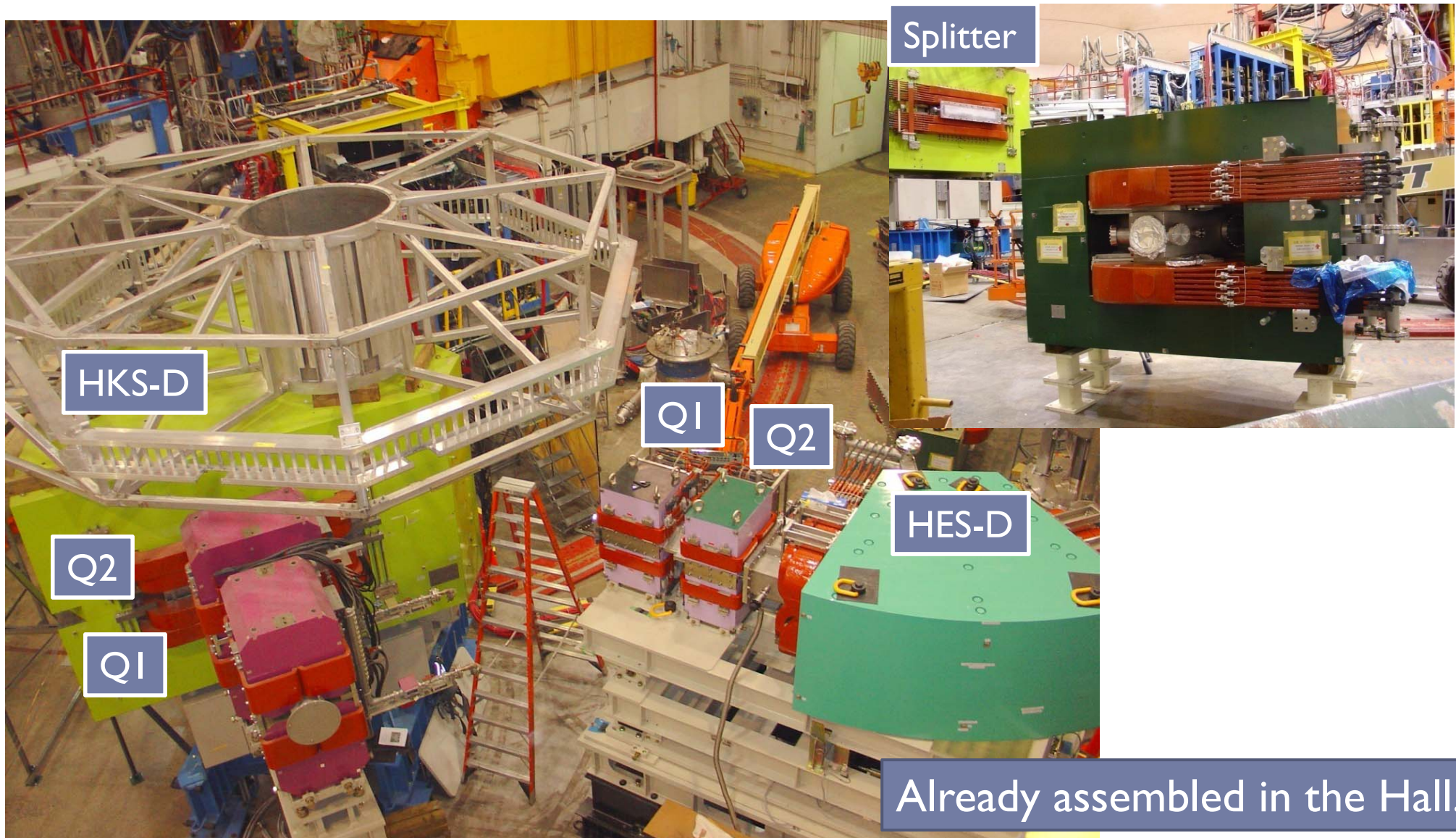
P.H.Pile et al. PRL 66 (1991) 2585

| Target<br>(100mg/cm <sup>2</sup> ) | Yield for 100nb/sr [/hour] |                       |
|------------------------------------|----------------------------|-----------------------|
|                                    | E01-011<br>(1.8GeV)        | E05-115<br>(2.344GeV) |
| Beam Current                       | 24μA                       | 30μA<br>(Max 100μA)   |
| <sup>7</sup> Li (15μA)             | 8.5                        | 32                    |
| <sup>10</sup> B                    | 9.6                        | 44                    |
| <sup>12</sup> C                    | 9.6                        | 37                    |
| <sup>40</sup> Ca                   | —                          | 11                    |
| <sup>52</sup> Cr                   | —                          | 9                     |
| <sup>89</sup> Y                    | —                          | 5                     |



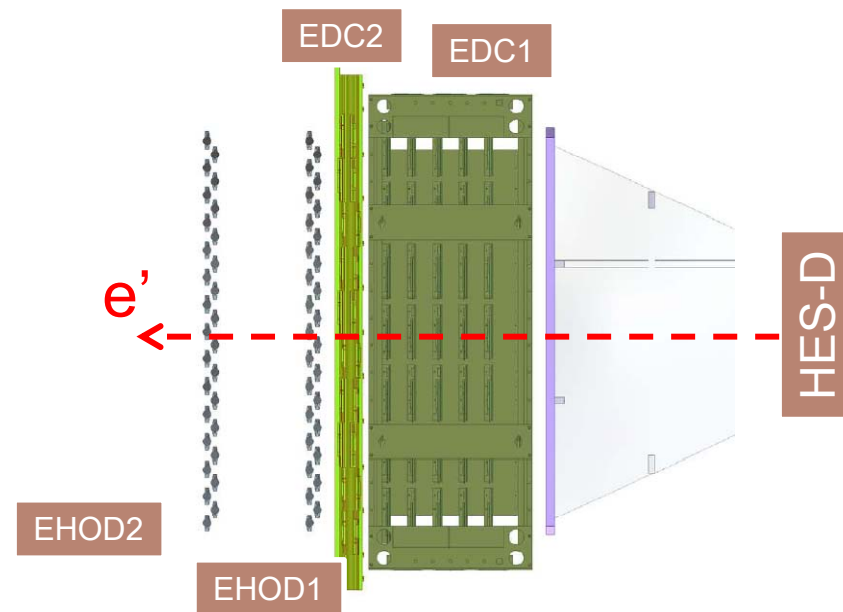
- DWIA + SLA
- $\Delta E = 400$  keV (FWHM)
- 1 week data taking

# Status of HKS HES Magnets



# Status of HES Detector Package

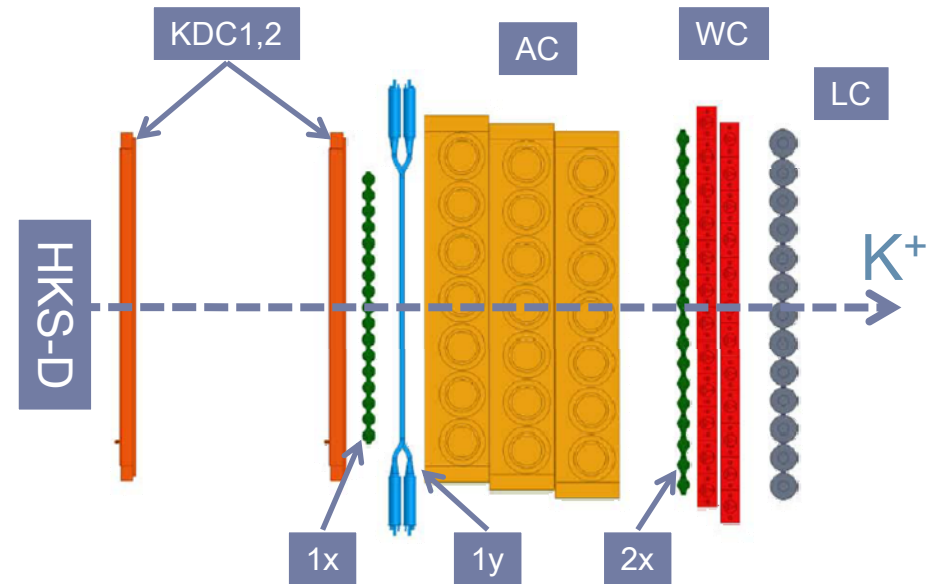
- ▶ Detector Support Frame
  - ▶ Design finished. Fabrication starts soon.
- ▶ EDC1, EDC2
  - ▶ EDC1 arrived from Japan at Jan./23
  - ▶ Under commissioning @ EEL124
- ▶ EHOD1/2
  - ▶ Timing resolution check @ EEL126
  - ▶ Assembling @ EEL126



|                |  |
|----------------|--|
| <b>EDC1</b>    | (used in 2 <sup>nd</sup> Exp., Honeycomb)                                |
| Effective area | 12 <sup>H</sup> x 100 <sup>W</sup> x 32 <sup>T</sup> [cm <sup>3</sup> ]  |
| Layers         | 10 (xx', uu', xx', vv', xx')   |
| <b>EDC2</b>    | (same type as HKS DC, Plane)   |
| Effective area | 30 <sup>H</sup> x 105 <sup>W</sup> x 3.5 <sup>T</sup> [cm <sup>3</sup> ] |
| Layers         | 6 (xx', uu', vv')  |
| <b>EHOD1/2</b> | (29 segments plastic Scinti. array)                                      |
| Effective area | 30 <sup>H</sup> x 117 <sup>W</sup> x 1 <sup>T</sup> [cm <sup>3</sup> ]   |

# Status of HKS Detector Package (1)

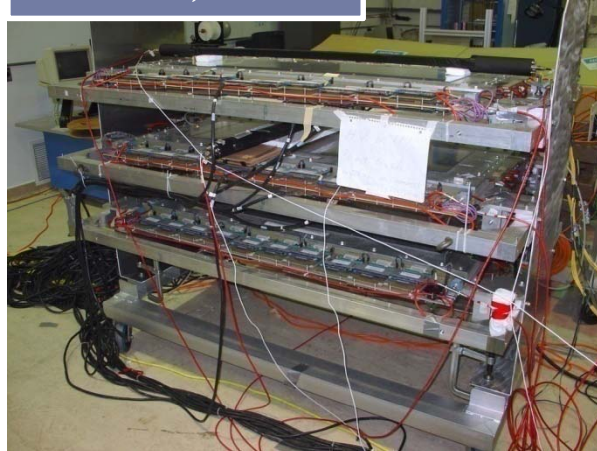
- ▶ Drift Chambers (KDC1/ KDC2)
  - ▶ Commissioning at EEL124.
  - ▶ Cosmic ray test w/ DAQ system starts soon.
- ▶ TOF Counters (1X/1Y/2X)
  - ▶ 1Y: new lightguide for staggered configuration.



Detector Package



KDC1/2, EDC2



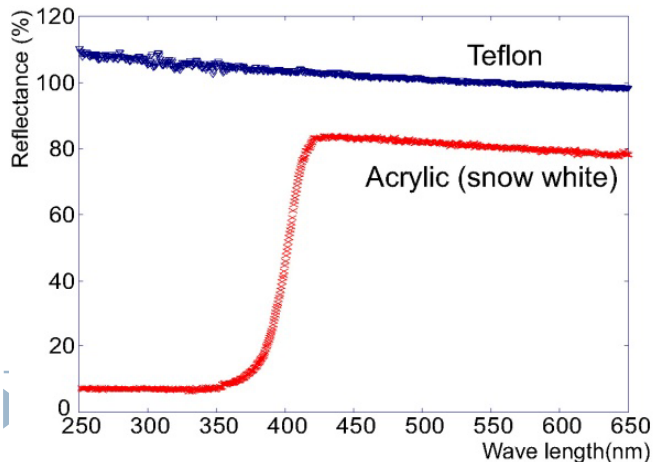
| KDC1 / 2                            |   |
|-------------------------------------|---|
| Effective area                      | $30^H \times 105^W \times 3.5^T$ [cm <sup>3</sup> ] |
| Layers                              | 6 (xx', uu', vv')                                   |
| KTF1X (17 segments plastic Scinti.) |   |
| Effective area                      | $30^H \times 125^H \times 2^T$ [cm <sup>3</sup> ]   |
| KTF1Y (9 segments plastic Scinti.)  |   |
| Effective area                      | $27.5^H \times 125^H \times 2^T$ [cm <sup>3</sup> ] |
| KTF2X (18 segments plastic Scinti.) |   |
| Effective area                      | $35^H \times 170^H \times 2^T$ [cm <sup>3</sup> ]   |

continue...

# Status of HKS Detector Package (2)

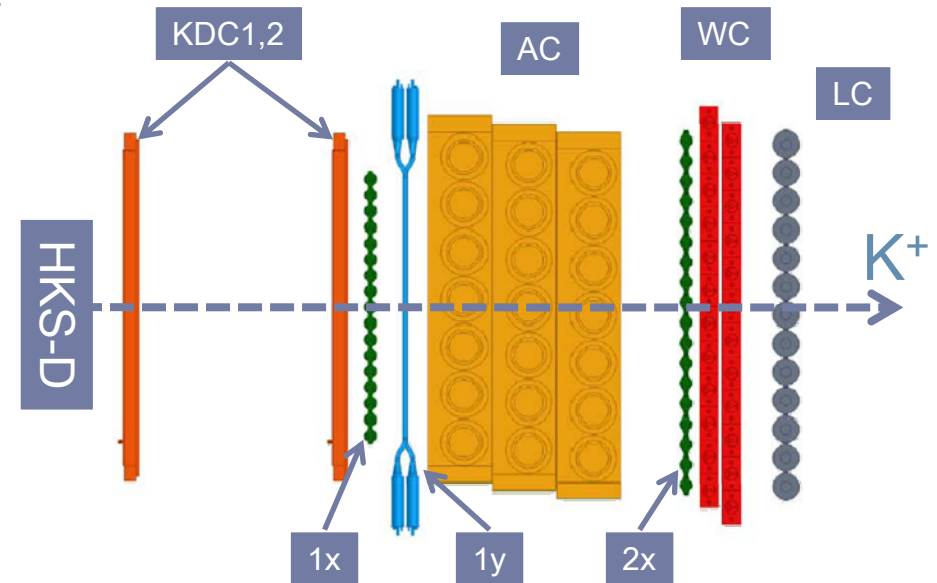
- ▶ Cherenkov Counters (AC/WC/LC)
  - ▶ AC : maintenance @ 2F machine shop
  - ▶ LC : assembling finished and installed in Detector package
  - ▶ WC : Half of E01-011 counters are replaced to new one which is UV sensitive.

|         | radiator             | box                    | window  | PMT              |
|---------|----------------------|------------------------|---------|------------------|
| E01-011 | Pure water + Amino-G | Acrylic                | Acrylic | Hamamatsu H7195  |
| E05-115 | Pure water           | Acrylic + Teflon sheet | Quartz  | H7195 (UV glass) |



Wave length dependence of Reflectance ratio. % is normalized by the reflective ratio of BaSO<sub>4</sub>.

$N_{p.e.}$  (E01-011)  $\sim$  110  
 $N_{p.e.}$  (E05-115)  $\sim$  100



|  |  |
|--|--|
| <b>AC1/2/3</b> (6 segments, index = 1.055)         |  |
| Effective area                                     | 46 <sup>H</sup> x 169 <sup>W</sup> x 31 <sup>T</sup> [cm <sup>3</sup> ]  |
| <b>LC</b> (13 segments Lucite array, index = 1.49) |  |
| Effective area                                     | 42 <sup>H</sup> x 175.5 <sup>H</sup> x 2 <sup>T</sup> [cm <sup>3</sup> ] |
| <b>WC1/2</b> (12 segments, index = 1.33)           |  |
| Effective area                                     | 35 <sup>H</sup> x 184.8 <sup>H</sup> x 8 <sup>T</sup> [cm <sup>3</sup> ] |



# Summary

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The 3<sup>rd</sup> generation (e, e'K<sup>+</sup>) hypernuclear spectroscopy.

Study on the wide mass region up to mid-heavy

- ${}^7_{\Lambda}\text{He}$ ,  ${}^{10}_{\Lambda}\text{Be}$ ,  ${}^{40}_{\Lambda}\text{K}$ ,  ${}^{52}_{\Lambda}\text{V}$

Excellent data expected

- Missing mass resolution of  $\sim 400\text{keV}$  (FWHM)
- 5 times higher yield than 2<sup>nd</sup> Gen.

Preparation status

- HES/ Splitter magnets assembled in the Hall
- Detectors are under preparation

Data taking in Summer 2009