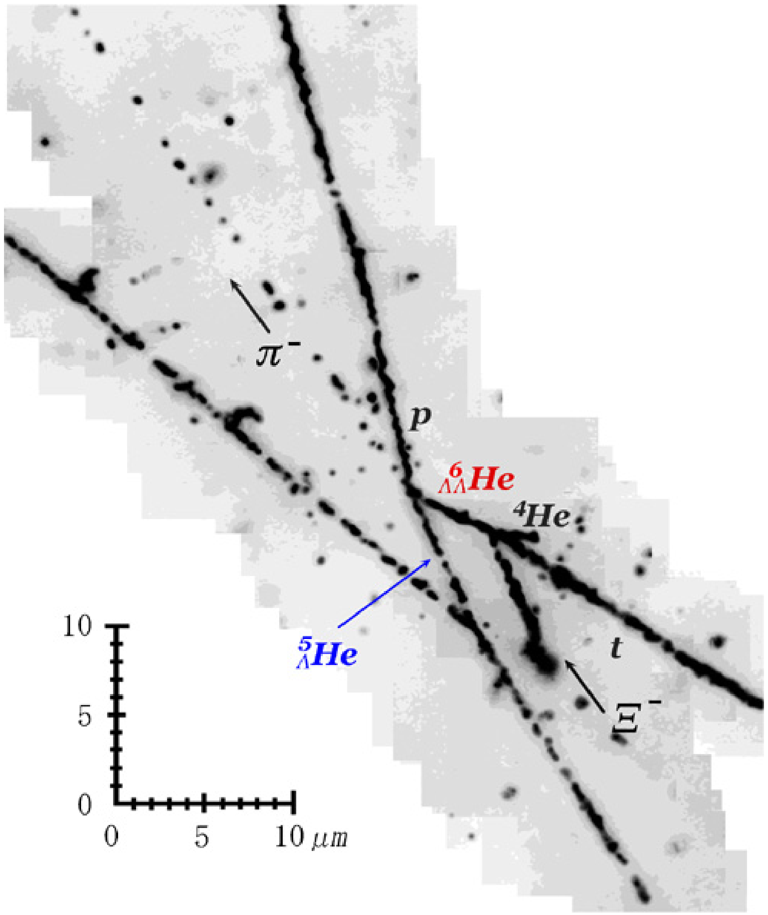
# Experimental Production of S=-2 systems




Double-Λ Hypernucleus
***Nagara event***

Kazuma Nakazawa
Phys. Dept., Gifu Univ.
October 15, 2003

## Outline

- Introduction
- H-dibaryon search
  KEK-E522
- Double-hypernuclei
  KEK-E373
  BNL-E964
  BNL-E961
- Summary

n p Λ

# *Double Strangeness Systems I*

## Experimental motivation

Making a nuclear chart of double-hypernuclei

=> Information Λ-Λ force,

for understanding B-B int. in SU(3)*f*

investigating Multi-strangeness system, “strange matter”

$$\Delta B_{\Lambda\Lambda}({}^{A}_{\Lambda\Lambda}Z) = B_{\Lambda\Lambda}({}^{A}_{\Lambda\Lambda}Z) - 2B_{\Lambda}({}^{A-1}_{\Lambda}Z) = 2M({}^{A-1}_{\Lambda}Z) - M({}^{A-2}Z) - M({}^{A}_{\Lambda\Lambda}Z)$$

Existence of the H-dibaryon

$$M_H \geq 2m_\Lambda - B_{\Lambda\Lambda}$$

Coupling effect

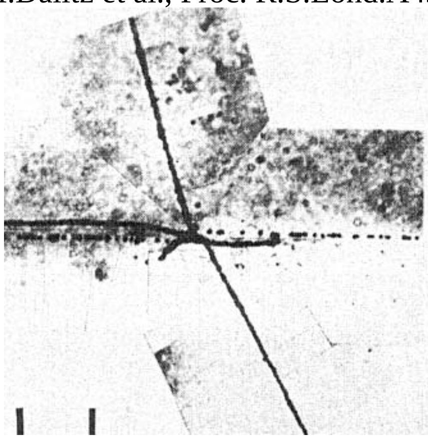
$$|H>= \sqrt{\frac{1}{8}}|\Lambda\Lambda> + \sqrt{\frac{4}{8}}|N\Xi> - \sqrt{\frac{3}{8}}|\Sigma\Sigma>$$

# *Double Strangeness Systems II*

## Experimental status

Only **3** candidate events in the 20th century.

M.Danysz et al., PRL.11(1963)29;
R.H.Dalitz et al., Proc. R.S.Lond.A436(1989)1



**$^{10}_{\Lambda\Lambda}$Be** in ~4 Ξstops

$\Delta B_{\Lambda\Lambda} = 4.3 \pm 0.4$ MeV

if a doughter $^{9}_{\Lambda}$Be is in excited

$\Delta B_{\Lambda\Lambda}$ ・ ~1.3 MeV

D.J.Prowse, PRL.17(1966)782

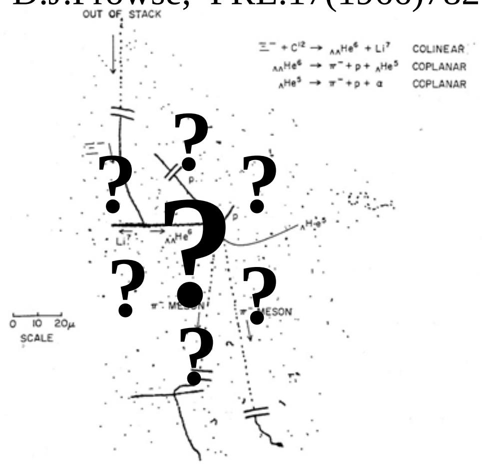
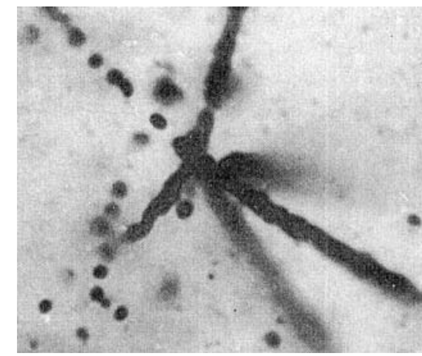



FIG. 1. Drawing of the event.

**$^{6}_{\Lambda\Lambda}$He**

$\Delta B_{\Lambda\Lambda} = 4.6 \pm 0.5$ MeV

S.Aoki et al, PTP.85(1991)1287



**KEK-E176**

**$^{13}_{\Lambda\Lambda}$B** in ~80 Ξstops

$\Delta B_{\Lambda\Lambda} = 4.9 \pm^{0.7}_{0.8}$ MeV

if a doughter $^{13}_{\Lambda}$C is in excited

$\Delta B_{\Lambda\Lambda}$ ・ ~0 MeV

or

**$^{10}_{\Lambda\Lambda}$Be**

$\Delta B_{\Lambda\Lambda} = -4.8 \pm^{0.7}_{0.8}$ MeV

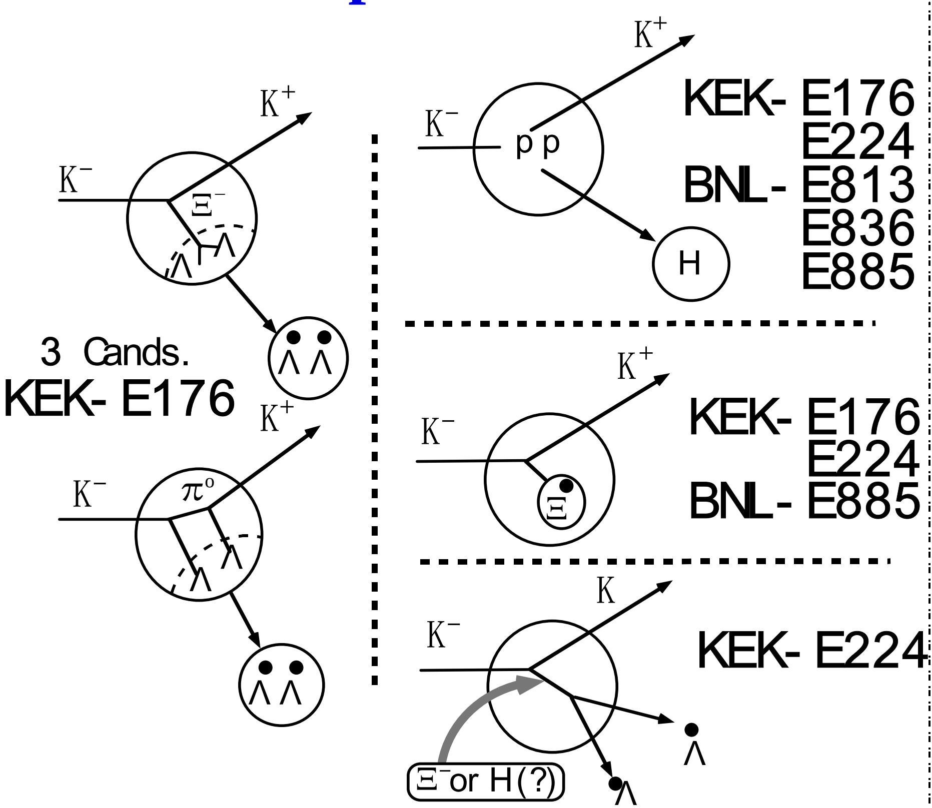
Why $V_{\Lambda\Lambda}$ so strong?

"interesting theoretical problem"

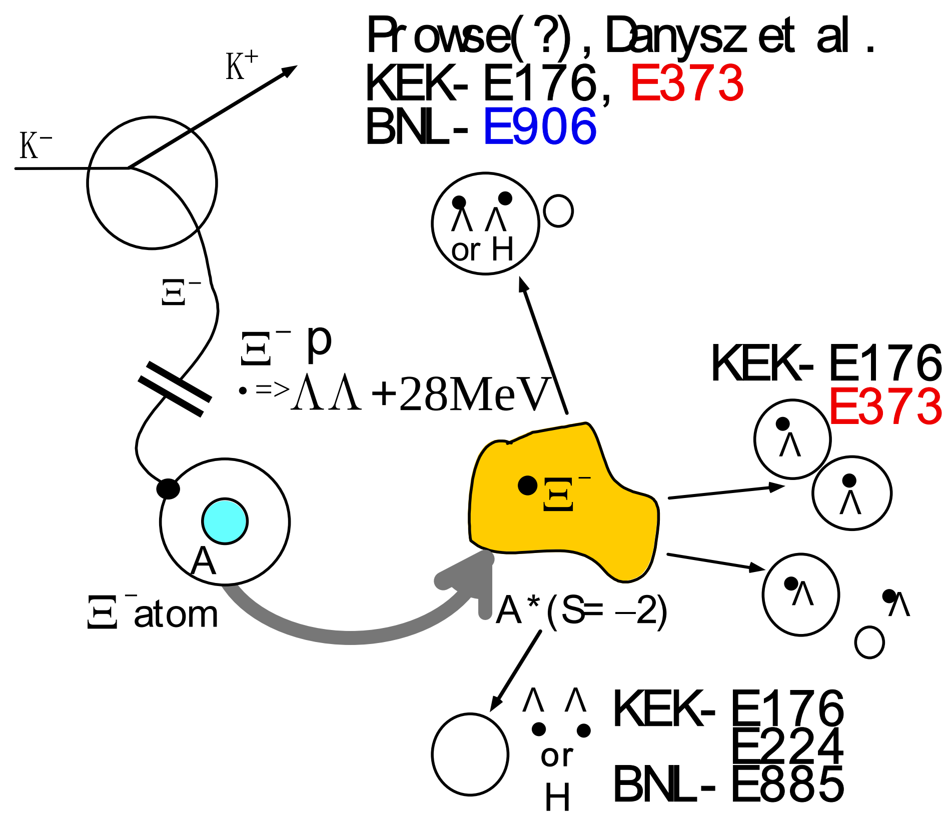
C.B.Dover, Proc. HYP91, NP.A547(1992)27c

# *How to produce S=-2 Systems*

- **Direct process**



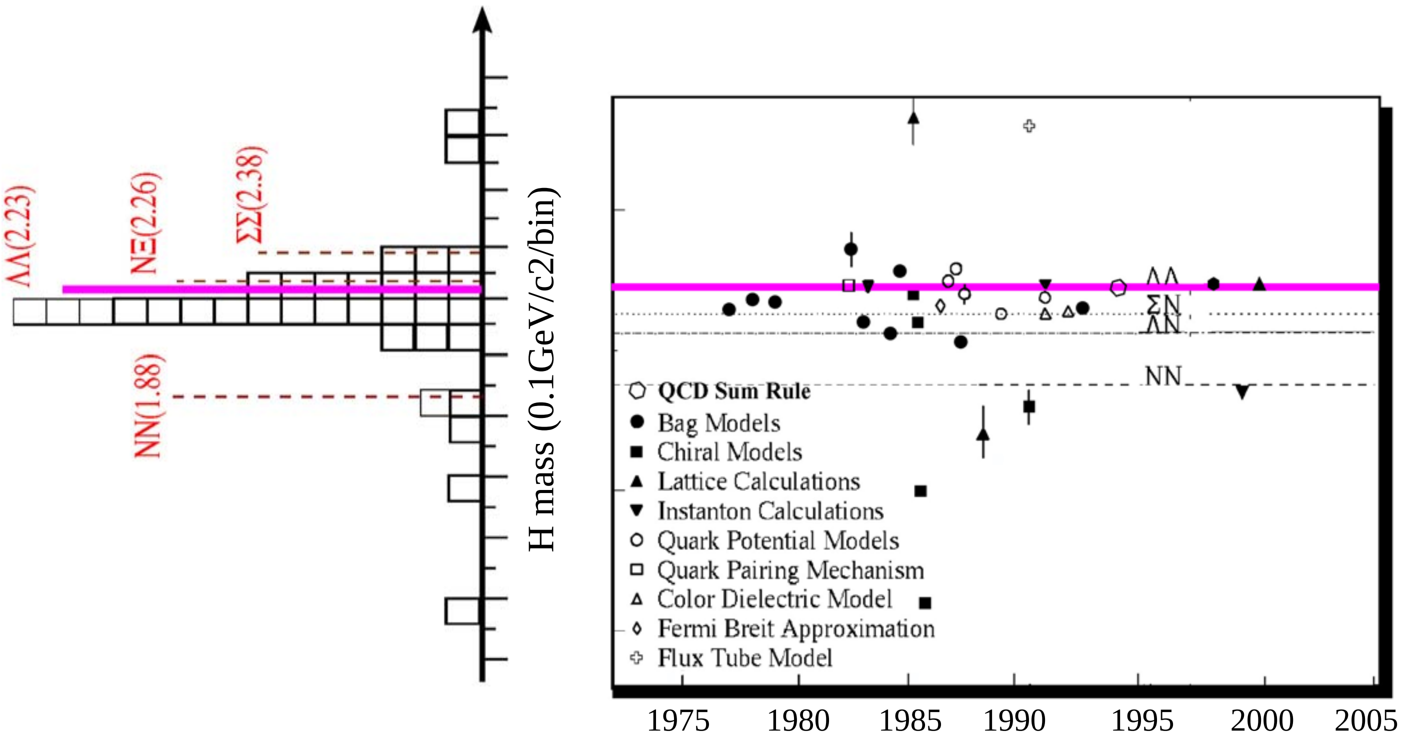

- **via Ξ atom**



# *H-Dibaryon*



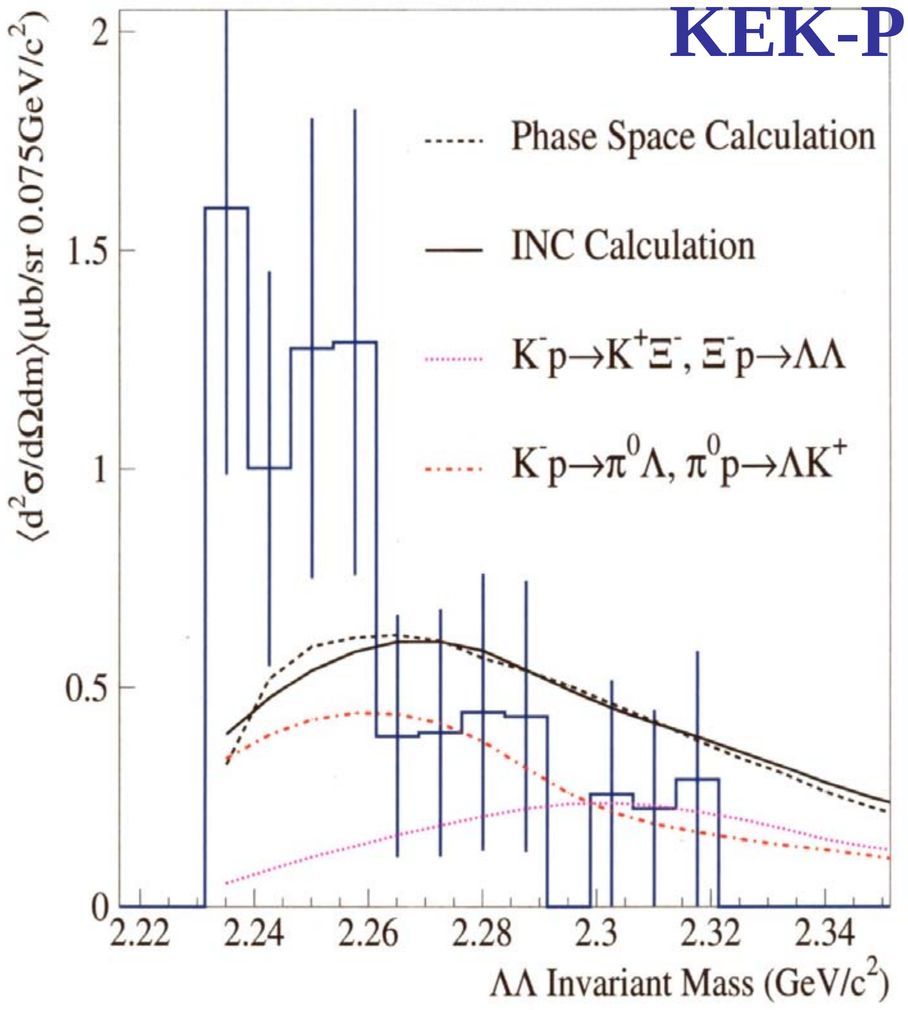
## Predicted masses




**Updated from the year 1995, referred on**
**S.V.Bashinsky, R.L.Jaffe, Nucl. Phys. A625(1997)167,**
**and W.J.Lope, talk given at '12th Winter Workshop on Nuclear Dynamics'**

# *H-Dibaryon near the ΛΛ threshold*

## ΛΛ Invariant mass spectrum
## KEK-PS E224




J.K.Ahn et al., (KEK-E224)
Phys. Lett. B444 (98) 267

# *H-dibaryon resonance : KEK-E522*

**Search for H–dibaryon Resonance via $^{12}C(K^-, K^+\Lambda\Lambda)$ and Study of $\Xi^- N$ interaction**

**KEK E522**

**Participants**

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M.Ieiri, H.Takahashi [c)]
H.N.Kyaw, K. Nakazawa, M.Okuda, T.Wint [d)]
T.Hayakawa, T.Kishimoto, A.Sato, Y.Shimizu [e)]
K.Yamamoto, T.Yoshida [f)]
J.K.Ahn, S.J.Kim [g)]
S.H.Kim, I.G.Park, J.S. Song, C.S.Yoon [h)]
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T.Miura [l)]

**Institutes**

a) Dept. Phys. Kyoto Univ.
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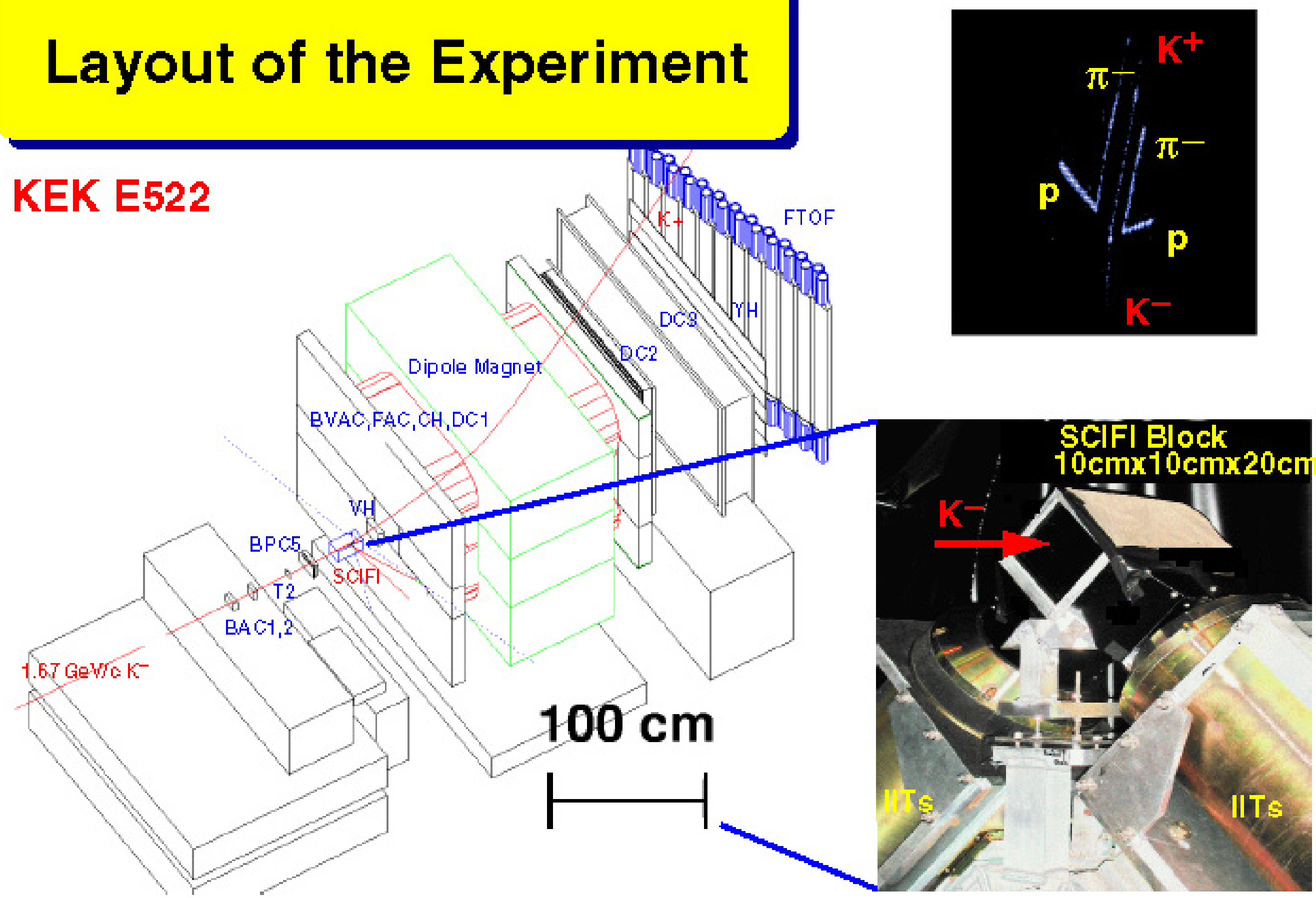
c) IPNS, KEK
d) Phys. Dept. Gifu Univ.
e) Dept. Phys. Osaka Univ
f) Dept. Phys. Osaka City Univ.
g) Dept. Phys. Pusan Nat'l Univ.
h) Dept. Phys. Gyeongsang Nat'l Univ.
i) JAERI, j) Dept. Phys. Nagoya Univ.
k) RIKEN, l) Dept. Phys. Tohoku Univ.

*) spokes person

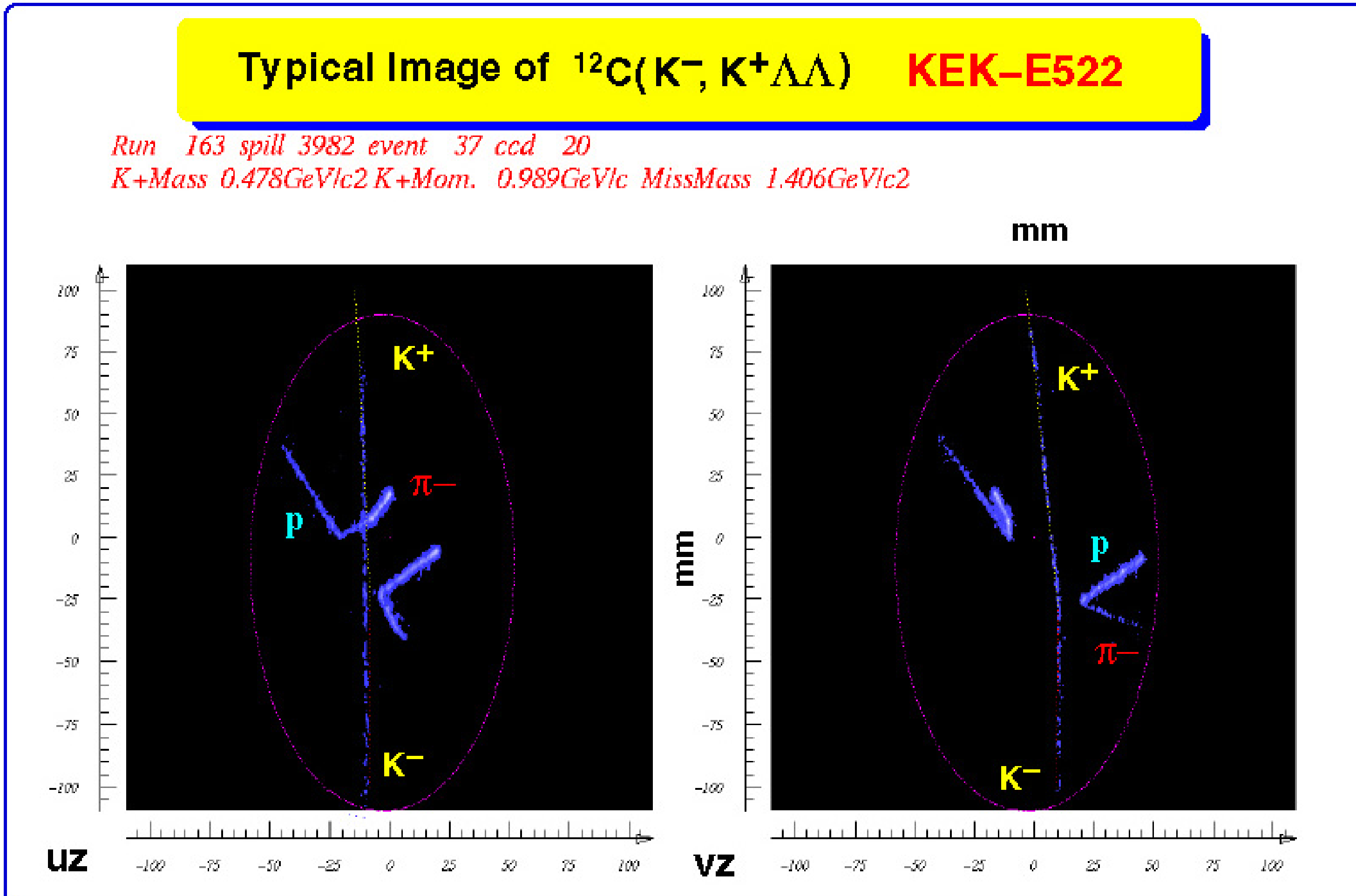
# *H-Dibaryon resonance : KEK-E522*

## Layout of the Experiment




by GEANT Simulation of J.K.Ahn

# H-Dibaryon resonance : KEK-E522




Analyses of 2002 run are ongoing.

Expecting higher statistics with several times as large as E224

# KEK-E373 : *Study of S=-2 nuclear systems*

## Study of *S*=-2 Nuclear System by an Emulsion-Counter Hybrid Method

KEK-E373 collaborators

Japan(16 Univ.・ Inst.)
Aichi-edu, Gifu, Higashi-Nippon-Kokusai, KEK, Kobe, Kyoto, Kyoto-Sangyo, Nagoya, Nat. Inst. Rad. Sci., Osaka-city, Osaka-ele.-comm., Science-center Osaka pref., Toho, Tohoku, Tokyo, Tsuru

Korea(4 Univ.)
Gyeonsang National Univ., Chonnam National Univ., Wonkwang Univ., Konkuk Univ., Korea Univ.

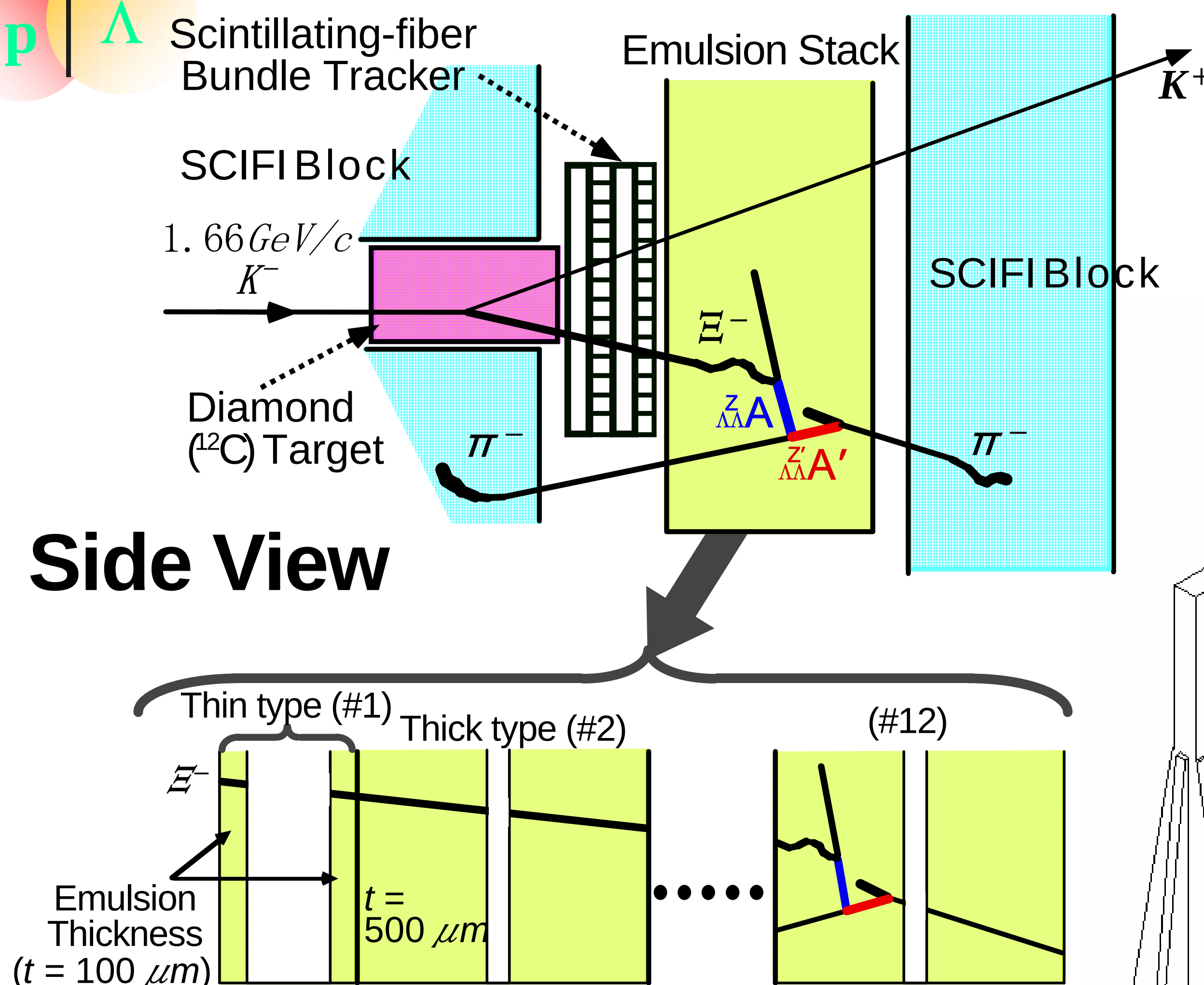
USA(3 Univ.・ Inst.)
BNL, Univ. New Mexico, Carnegie Mellon Univ.

UK(1 Univ.)
Univ. College London

Analysis for $10^3$ stopped $\Xi^-$ events (statistics **10 times** more than KEK-E176)

- Λ-Λ interaction energy
- existence of *H* dibaryon
- ΛΛ weak interaction (ΛΛ → Λ *n*, Σ *N*)
- level energy of Ξ in nucleus

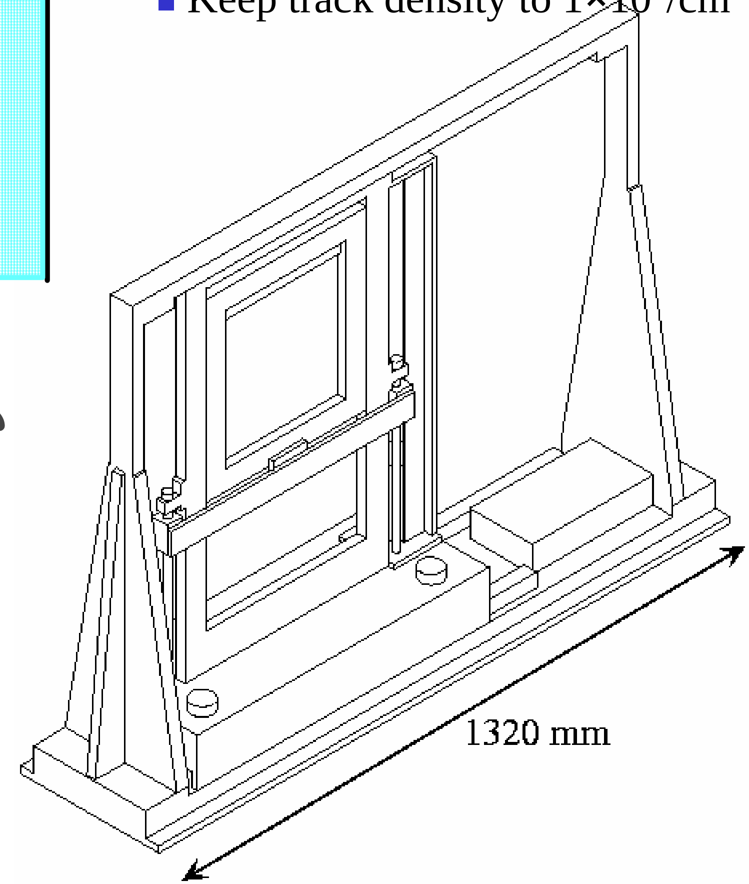
# *Experimental Method* (KEK-E373)




Area : $24.5 \times 25.0\ cm^2$
Packed in vacuum chamber

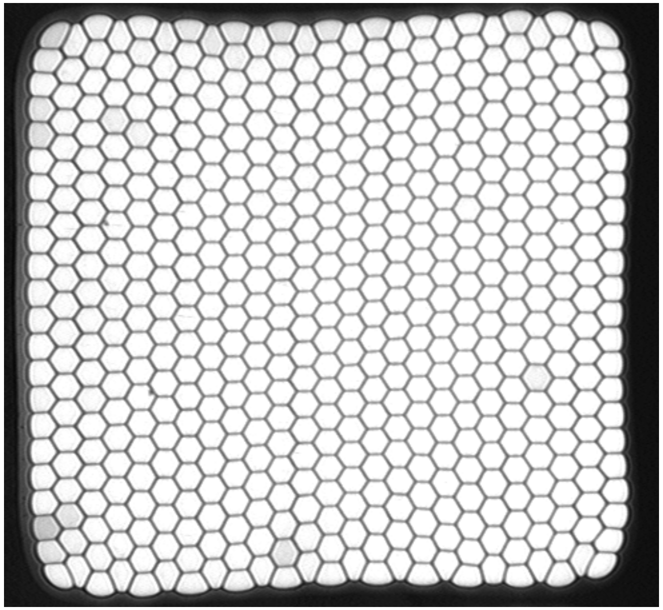
**Emulsion Mover**

- Controlled with PC
- Move emulsion during spills
- Keep track density to $1 \times 10^6/cm^2$



# *Scintillating-fiber bundle* (KEK-E373)





0.7mm

**Readout with Image Intensifier Tube and CCD**

**Diameter of a fiber : 45 μm**

**Cross section of a bundle : 0.7 x 0.7 mm$^2$**

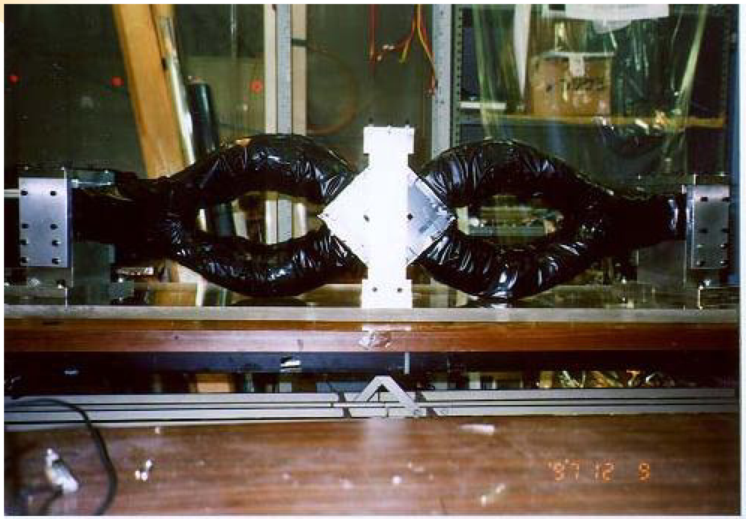
**Width of a sheet : 42 mm**

**Constructed with 4 sheets (u, v, u’, v’)**

**Precision(r.m.s) estimated with proton**

**25 mrad (angle) / 75 μm (position)**

# *Scintillating-fiber blocks I* (KEK-E373)

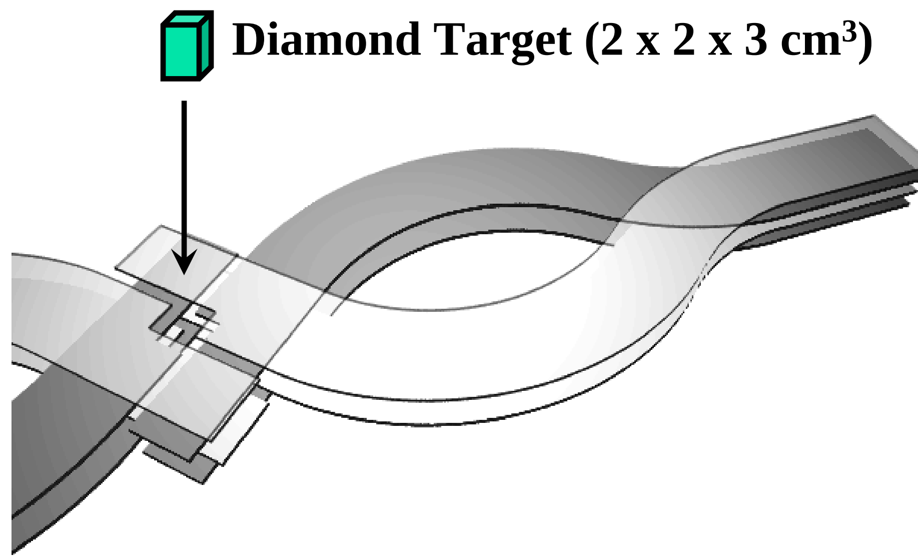


**Readout with Image Intensifier Tube and CCD**

**Cross section of a fiber : 0.3 x 0.3 $mm^2$**

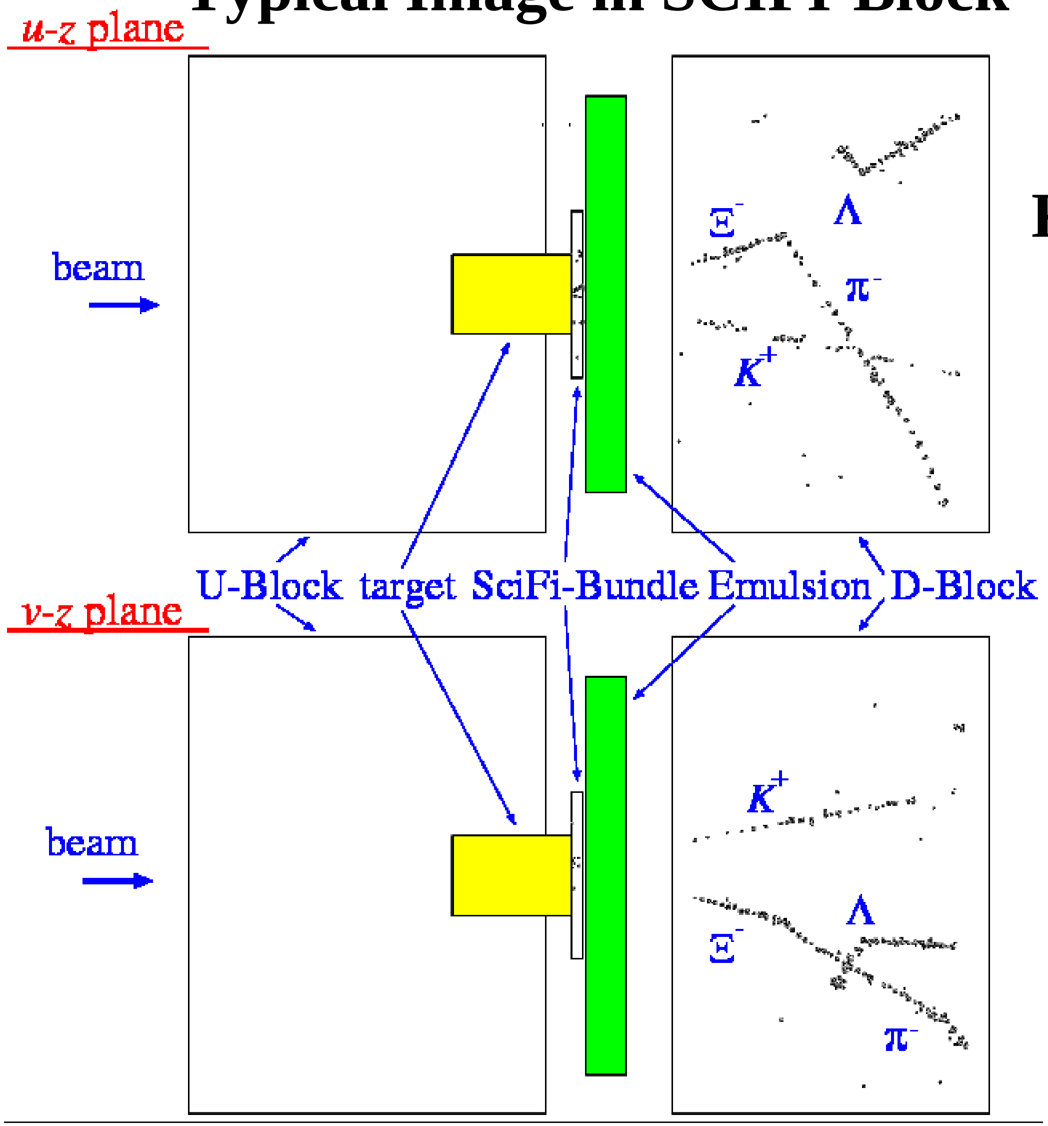
**Cross section of a block : 10 x 10 x 10 $cm^3$**

**There is almost NOT dead area.**



# *Scintillating-fiber blocks II* (KEK-E373)

## Typical Image in SCIFI-Block

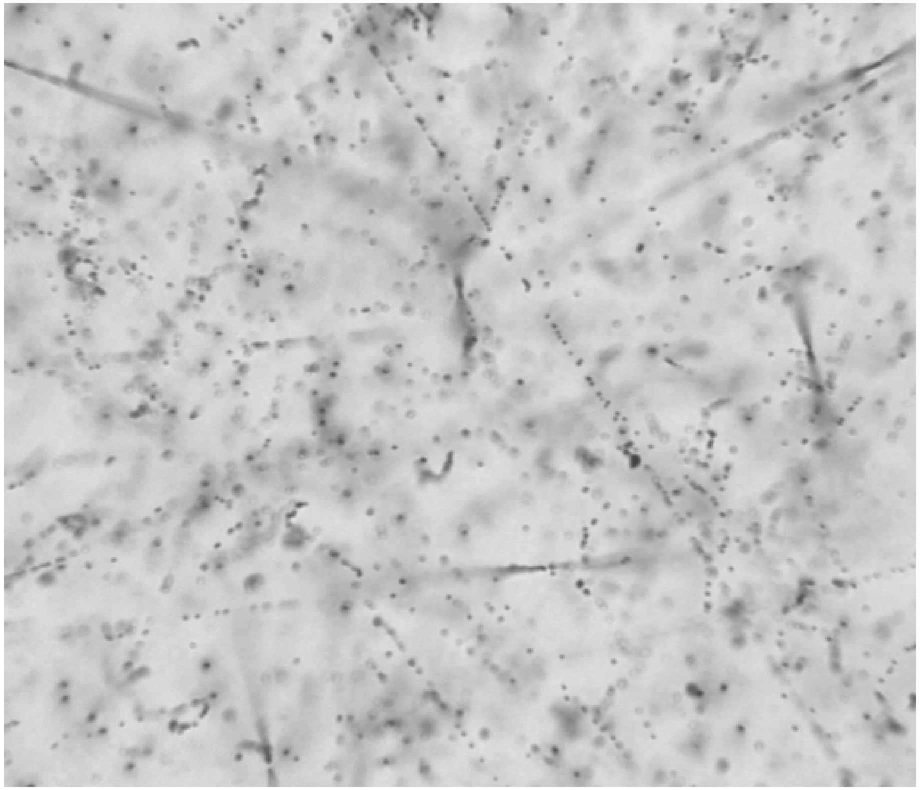



$K^{-}+{}^{12}C \Rightarrow \Xi^{-}+K^{+}$

$\Xi^{-} \Rightarrow \Lambda+\pi^{-}$

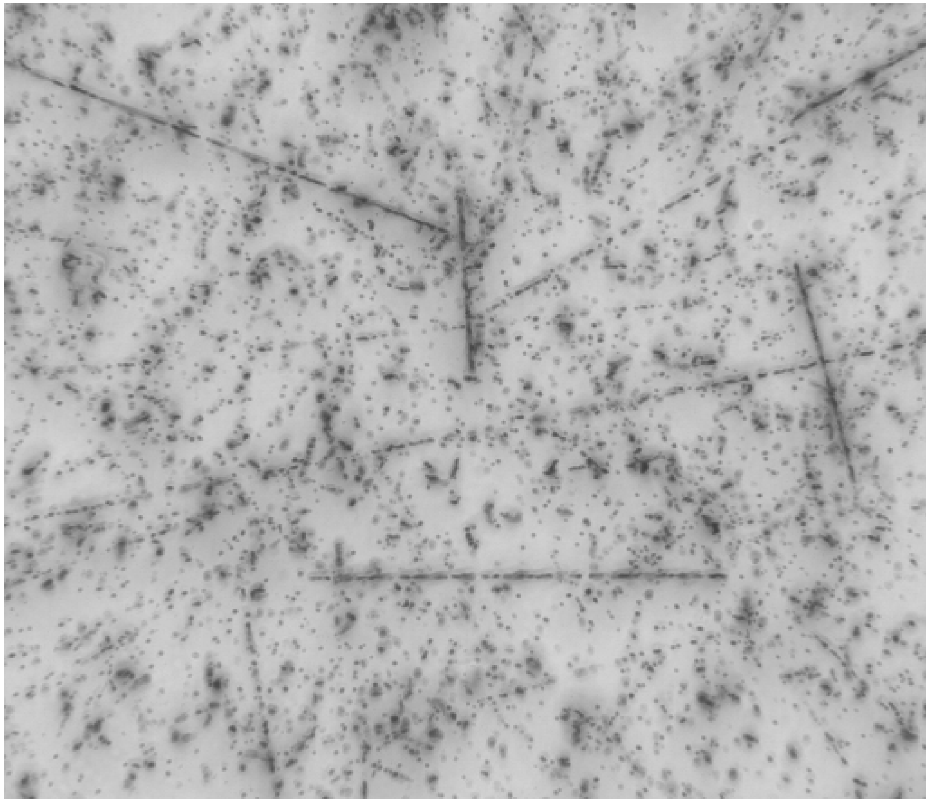
# *Example of Emulsion Image*

Raw Image



~ 100μm

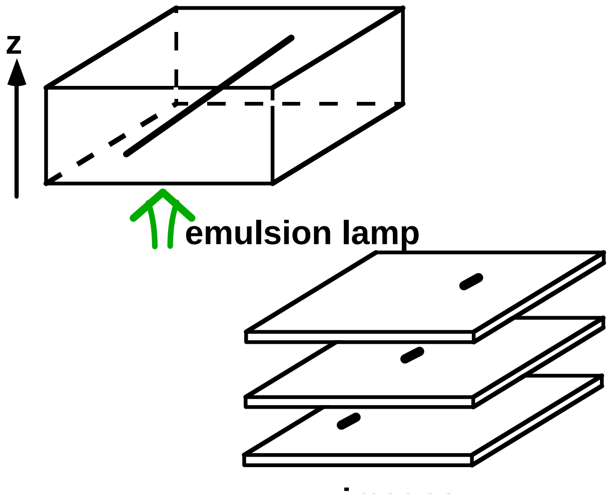
Overlap Image



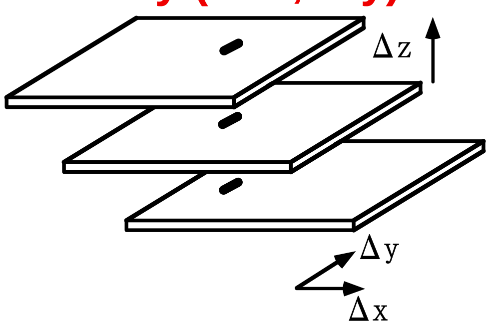
# KEK-E373: *Automatic track finding*

## Algorism

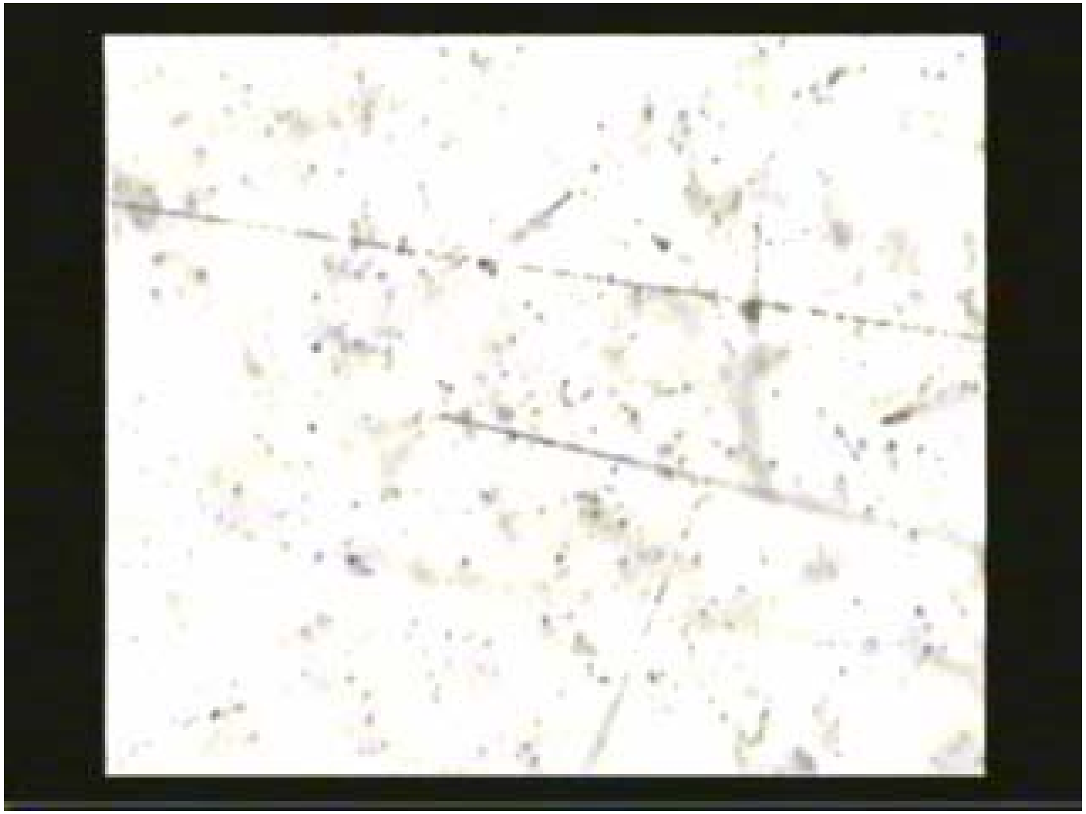
1) Take pictures
at different *z*(focusing)position.




2) Make overllapped image
shift each image
by (- Δx,- Δy)




## Video Image



*HYP2003*
at J-Lab
Oct.14-18,

# Double hypernucleus #1

## *Demachi-yanagi event*

* **two body** case at point A

$\Xi^- + {}^{12}C \rightarrow {}^{10}_{\Lambda\Lambda}Be + t$ or ${}^{10}_{\Lambda\Lambda}Be^* + t$

$\Delta B_{\Lambda\Lambda}$ : $-1.14 \pm 0.19$ or $+1.86 \pm 0.19$ MeV

$B_{\Lambda\Lambda}$ : $12.29 \pm 0.17$ (excited) MeV

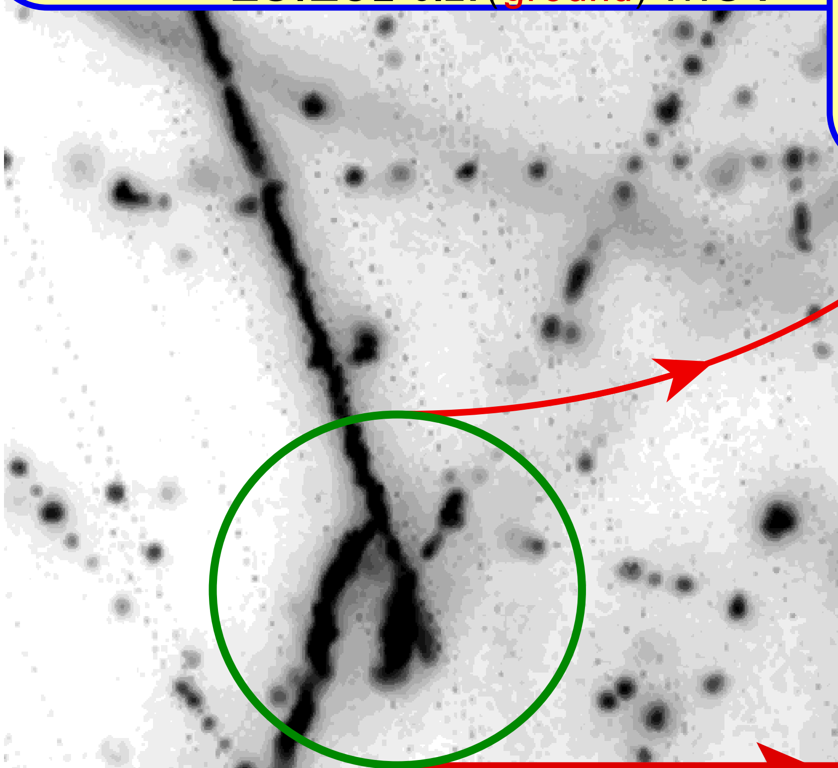
$15.29 \pm 0.17$ (ground) MeV

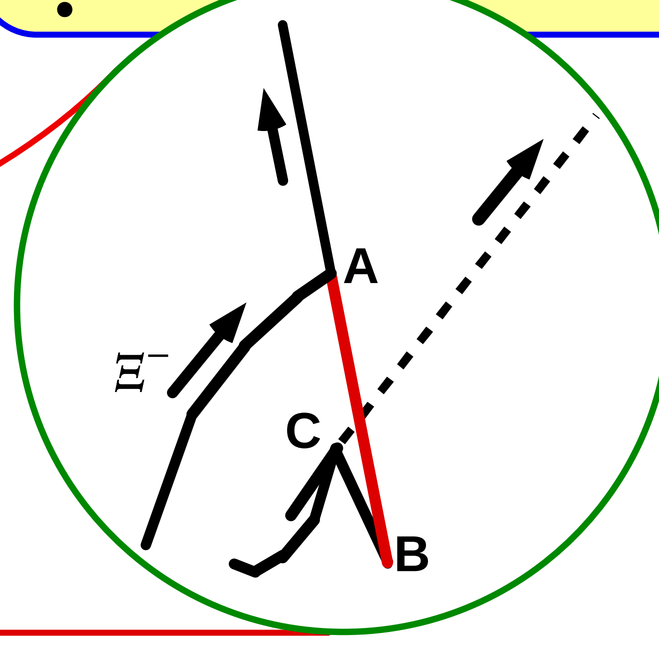
* **three body** case at point A

1) $\Xi^- + {}^{14}N \rightarrow {}^{13}_{\Lambda\Lambda}B + p + n$

$\Delta B_{\Lambda\Lambda}$ : $+1.47^{+2.4}_{-0.7}$ MeV

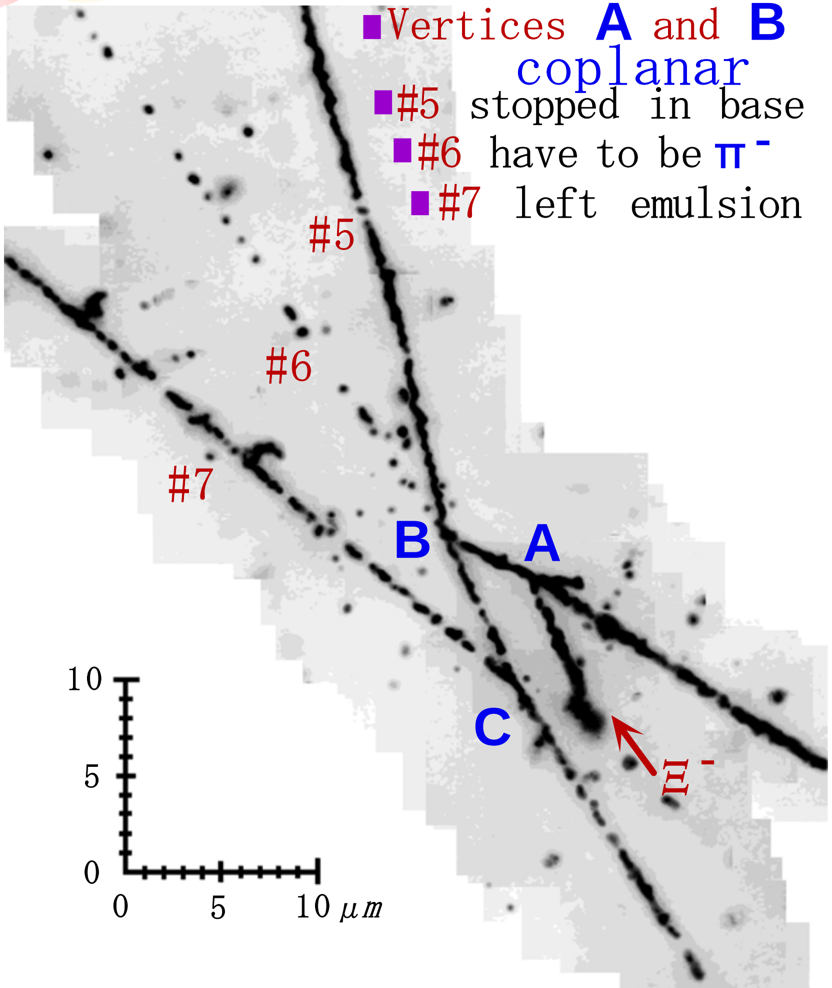
⋮



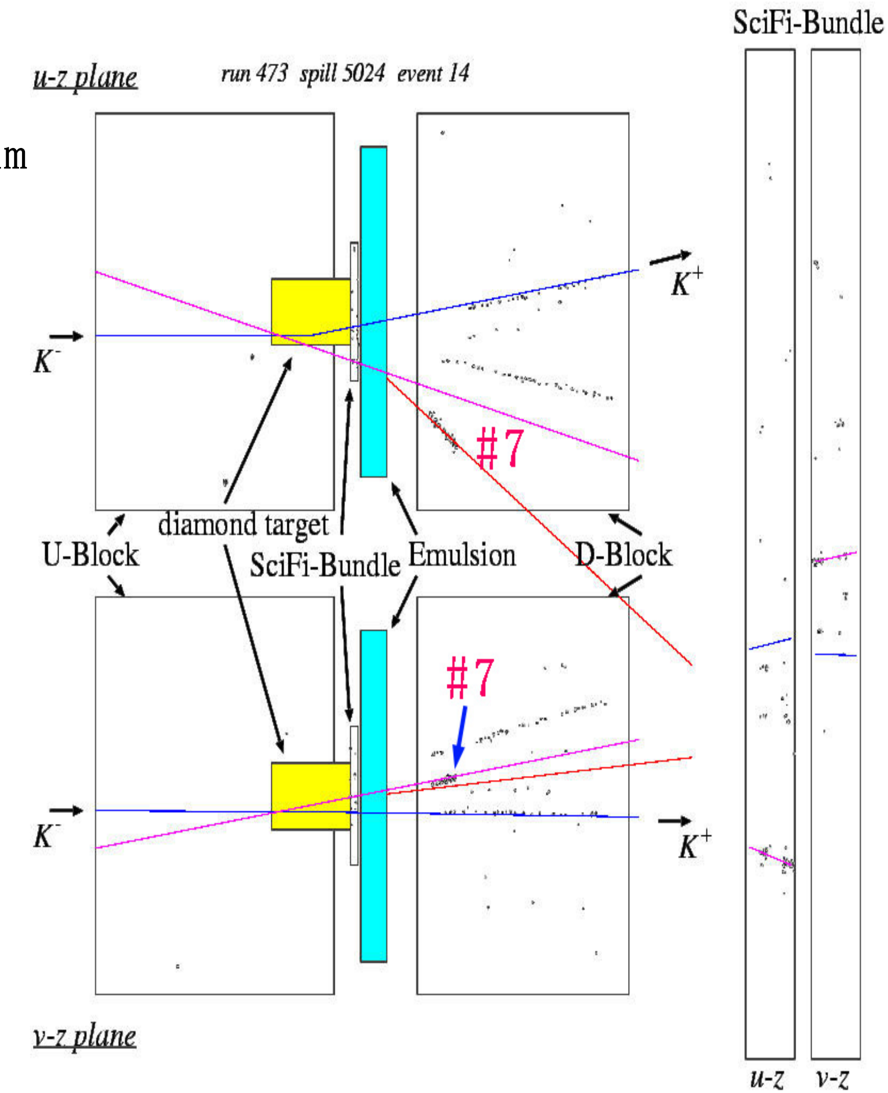


# Double hypernucleus #2






- Vertices **A** and **B** coplanar
- #5 stopped in base film
- #6 have to be $\pi^-$
- #7 left emulsion



# Reconstruction and $\Delta B_{\Lambda\Lambda}$

by Y.S. Iwata & H. Takahashi

## Production

| Target | #1 | #3 | #4 | | $B_{\Lambda\Lambda}$ [MeV] | $\Delta B_{\Lambda\Lambda}$ [MeV] |
|---|---|---|---|---|---|---|
| $^{12}$C | ${}_{\Lambda\Lambda}^{6}$He | $^{4}$He | $p$ | $2n$ | $> 16.9$ | $> 10.6$ |
| $^{12}$C | ${}_{\Lambda\Lambda}^{6}$He | $^{4}$He | $d$ | $1n$ | $14.5 \pm 0.7$ | $8.2 \pm 0.7$ |
| $^{12}$C | ${}_{\Lambda\Lambda}^{6}$He | $^{4}$He | $t$ | | $7.3 \pm 0.2$ | $1.1 \pm 0.2$ |
| $^{12}$C | ${}_{\Lambda\Lambda}^{7}$He | $^{4}$He | $p$ | $1n$ | $21.6 \pm 1.3$ | $13.3 \pm 1.3$ |
| $^{14}$N | ${}_{\Lambda\Lambda}^{6}$He | $^{7}$Li | $p$ | $1n$ | $24.4 \pm 2.1$ | $18.2 \pm 2.1$ |
| $^{14}$N | ${}_{\Lambda\Lambda}^{6}$He | $^{6}$Li | $d$ | $1n$ | $25.8 \pm 1.3$ | $19.6 \pm 1.3$ |
| $^{14}$N | ${}_{\Lambda\Lambda}^{6}$He | $^{4}$He | $^{4}$He | $1n$ | $17.9 \pm 1.5$ | $11.7 \pm 1.5$ |
| $^{14}$N | ${}_{\Lambda\Lambda}^{7}$Li | $^{4}$He | $t$ | $1n$ | $26.2 \pm 0.9$ | $17.2 \pm 0.9$ |
| $^{14}$N | ${}_{\Lambda\Lambda}^{9}$Li | $p$ | $^{4}$He | $1n$ | $31.5 \pm 1.8$ | $17.9 \pm 1.8$ |
| $^{16}$O | ${}_{\Lambda\Lambda}^{8}$Li | $^{4}$He | $^{4}$He | $1n$ | $31.1 \pm 0.9$ | $19.9 \pm 0.9$ |

($\Delta B_{\Lambda\Lambda} < 20$MeV)

## Decay

| double-hyp. | #2 | #5 | #6 | | $B_{\Lambda\Lambda}$ [MeV] | $\Delta B_{\Lambda\Lambda}$ [MeV] |
|---|---|---|---|---|---|---|
| ${}_{\Lambda\Lambda}^{5}$He | ${}_{\Lambda}^{4}$He | $p$ | $\pi^-$ | | $7.1 \pm 0.5$ | $2.4 \pm 0.5$ |
| ${}_{\Lambda\Lambda}^{6}$He | ${}_{\Lambda}^{5}$He | $p$ | $\pi^-$ | | $6.9 \pm 0.6$ | $0.6 \pm 0.6$ |
| ${}_{\Lambda\Lambda}^{7}$He | ${}_{\Lambda}^{5}$He | $p$ | $\pi^-$ | $1n$ | $< 8.6$ | $< 0.3$ |
| ${}_{\Lambda\Lambda}^{7}$He | ${}_{\Lambda}^{6}$He | $p$ | $\pi^-$ | | $6.3 \pm 0.7$ | $-2.0 \pm 0.7$ |
| ${}_{\Lambda\Lambda}^{8}$He | ${}_{\Lambda}^{5}$He | $p$ | $\pi^-$ | $2n$ | $< 6.8$ | $< -7.2$ |
| ${}_{\Lambda\Lambda}^{8}$He | ${}_{\Lambda}^{5}$He | $d$ | $\pi^-$ | $1n$ | $< 7.4$ | $< -6.6$ |
| ${}_{\Lambda\Lambda}^{8}$He | ${}_{\Lambda}^{6}$He | $p$ | $\pi^-$ | $1n$ | $< 6.6$ | $< -7.4$ |
| ${}_{\Lambda\Lambda}^{8}$He | ${}_{\Lambda}^{7}$He$^{a}$ | $p$ | $\pi^-$ | | $7.7 \pm 0.8$ | $-6.3 \pm 0.8$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{5}$He | $p$ | $\pi^-$ | $3n$ | $< 7.2$ | $< -7.1$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{5}$He | $d$ | $\pi^-$ | $2n$ | $< 8.2$ | $< -6.1$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{5}$He | $t$ | $\pi^-$ | $1n$ | $< 11.2$ | $< -3.1$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{6}$He | $p$ | $\pi^-$ | $2n$ | $< 7.2$ | $< -7.1$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{6}$He | $d$ | $\pi^-$ | $1n$ | $< 8.4$ | $< -5.9$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{7}$He$^{a}$ | $p$ | $\pi^-$ | $1n$ | $< 11.2$ | $< -3.1$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{7}$He$^{a}$ | $d$ | $\pi^-$ | | $13.4 \pm 0.5$ | $-0.9 \pm 0.5$ |
| ${}_{\Lambda\Lambda}^{9}$He | ${}_{\Lambda}^{8}$He | $p$ | $\pi^-$ | | $6.4 \pm 0.8$ | $-7.9 \pm 0.8$ |

($\Delta B_{\Lambda\Lambda} > -20$MeV)

# *Observation of a Lambpha*

## *Success of Emulsion detector with micro-meter accuracy*

***HYP2003***
at J-Lab
Oct.14-18,

## ***NAGARA event***

$^{6}_{\Lambda\Lambda}$**He** ***double-hypernucleus***

***Unique interpretation!!***

$\Xi^- + {}^{12}\mathrm{C} \longrightarrow {}^{6}_{\Lambda\Lambda}\mathrm{He} + {}^{4}\mathrm{He} + t$

${}^{6}_{\Lambda\Lambda}\mathrm{He} \longrightarrow {}^{5}_{\Lambda}\mathrm{He} + p + \pi^-$

*H.Takahashi et al.,*
*P. R. L. 87, 212502(2001)*

***Lambpha***

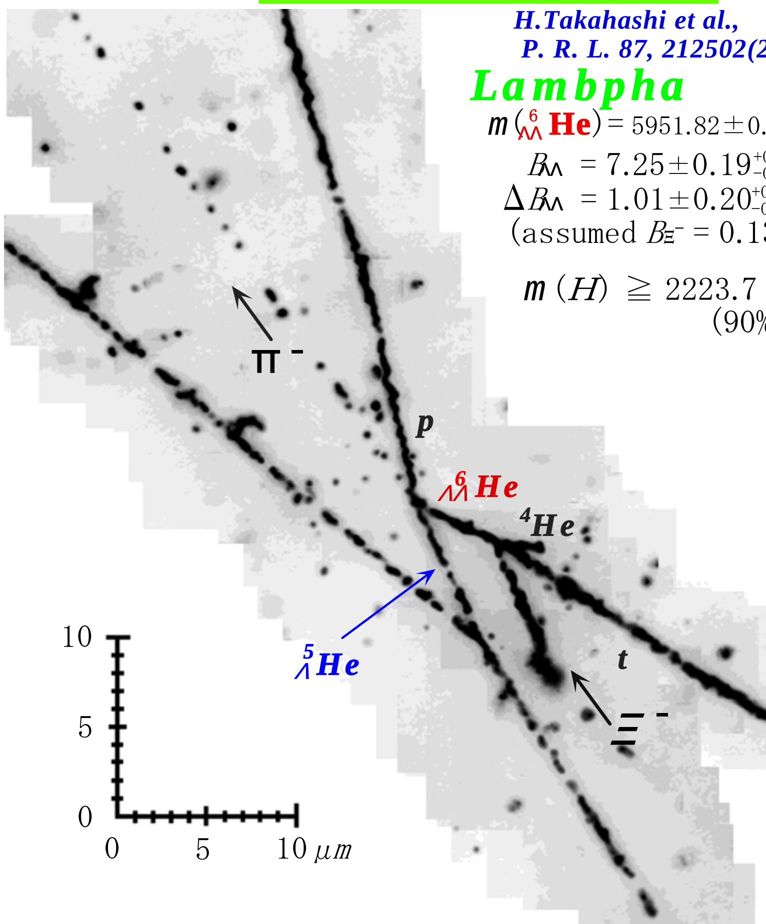
$m({}^{6}_{\Lambda\Lambda}\mathrm{He}) = 5951.82 \pm 0.54\mathrm{MeV}$

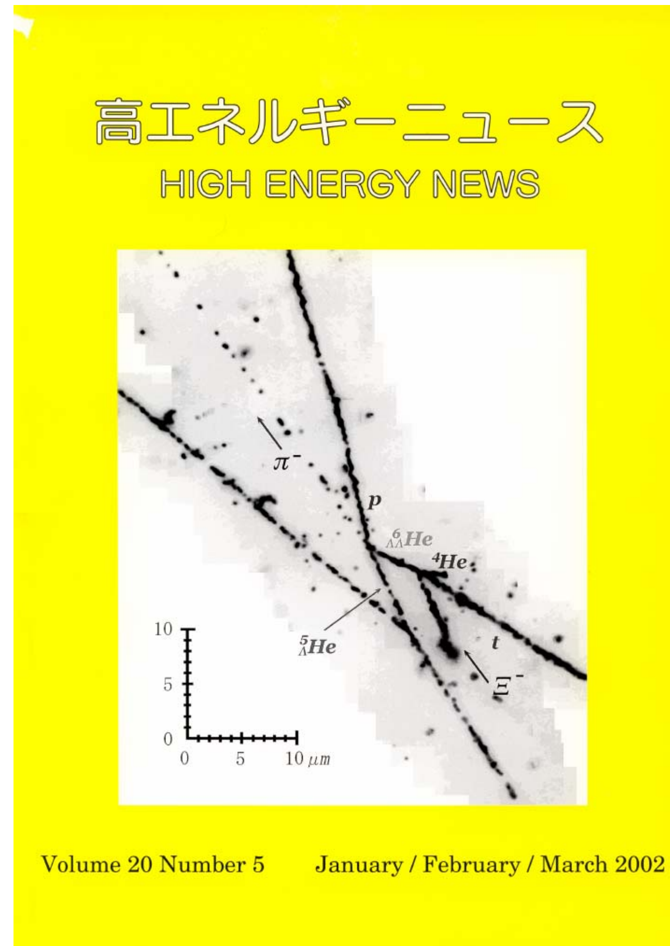
$B_{\Lambda\Lambda} = 7.25 \pm 0.19^{+0.18}_{-0.11}\mathrm{MeV}$

$\Delta B_{\Lambda\Lambda} = 1.01 \pm 0.20^{+0.18}_{-0.11}\mathrm{MeV}$

(assumed $B_{\Xi^-} = 0.13$ MeV)

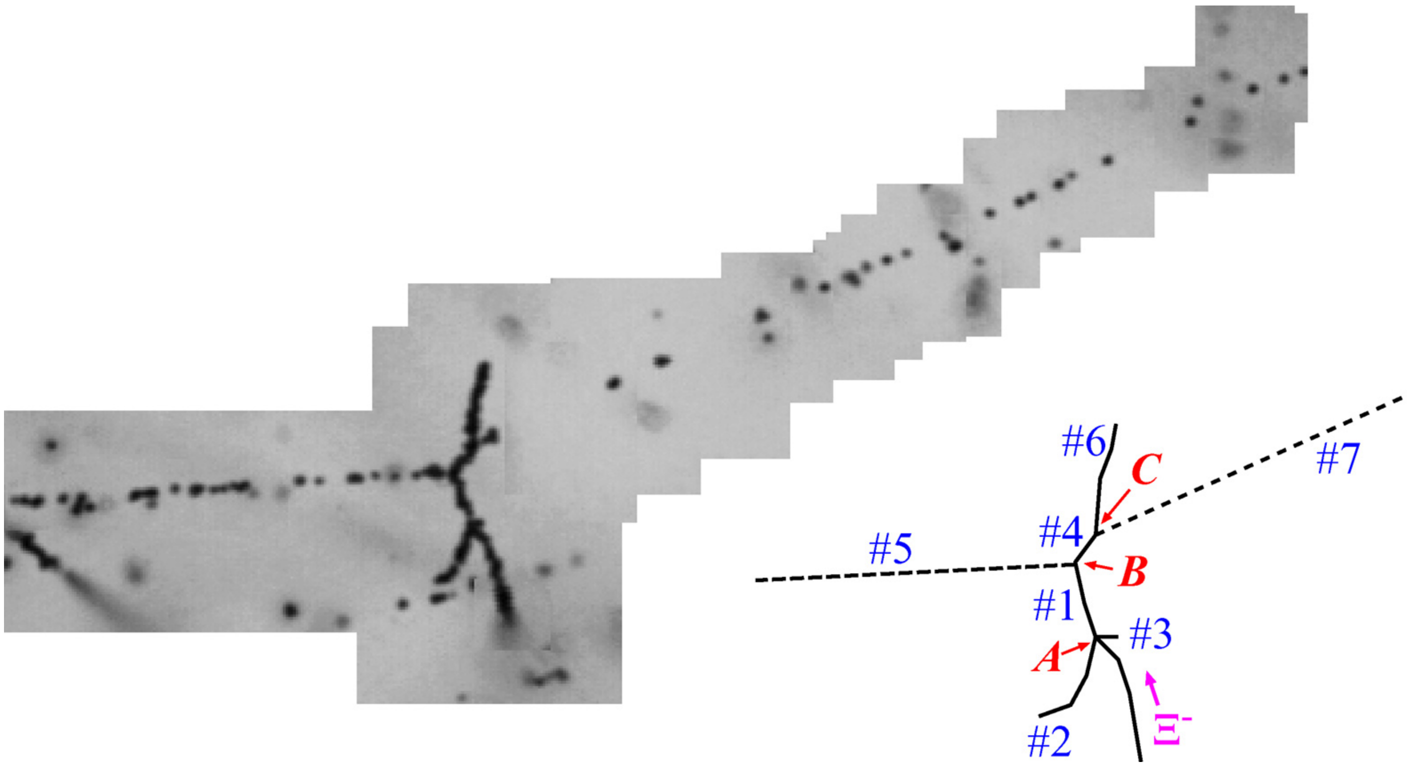
$m(H) \geqq 2223.7\ \mathrm{MeV}/c^2$
(90% C.L.)



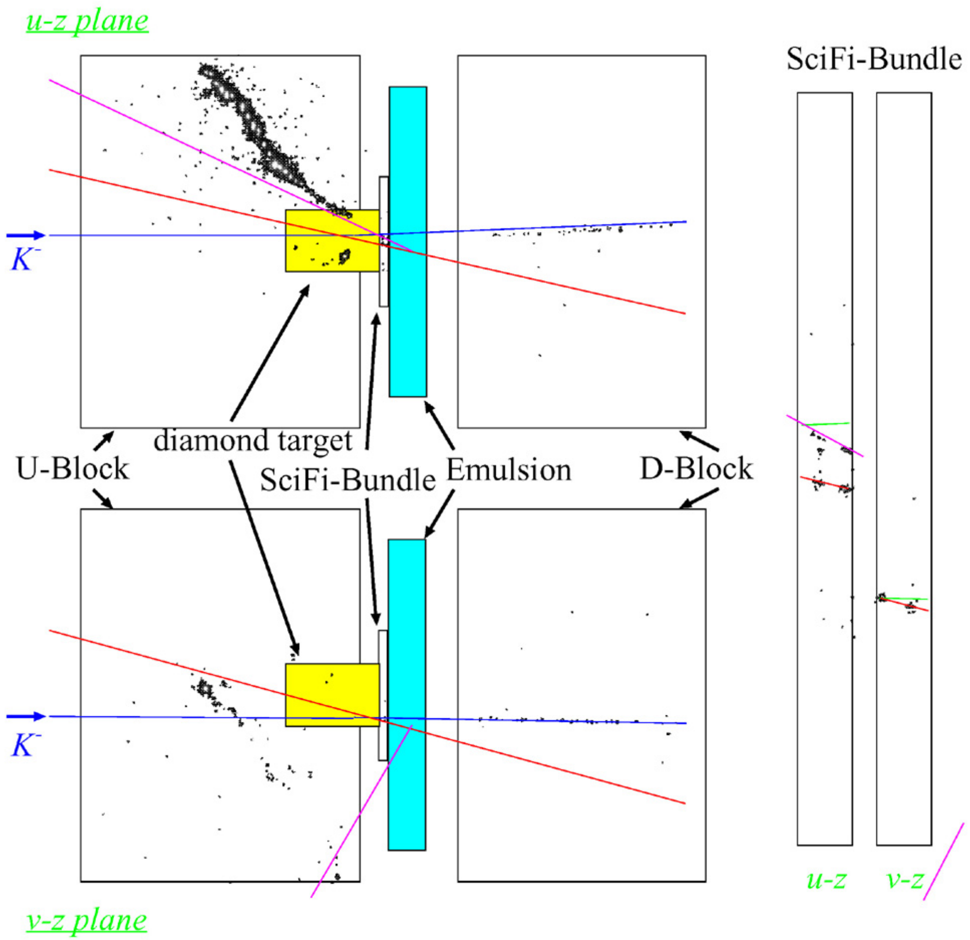




http://www.phys.ed.gifu-u.ac.jp/Topics/NAGARA-e.htm

# *Double hypernucleus #3*



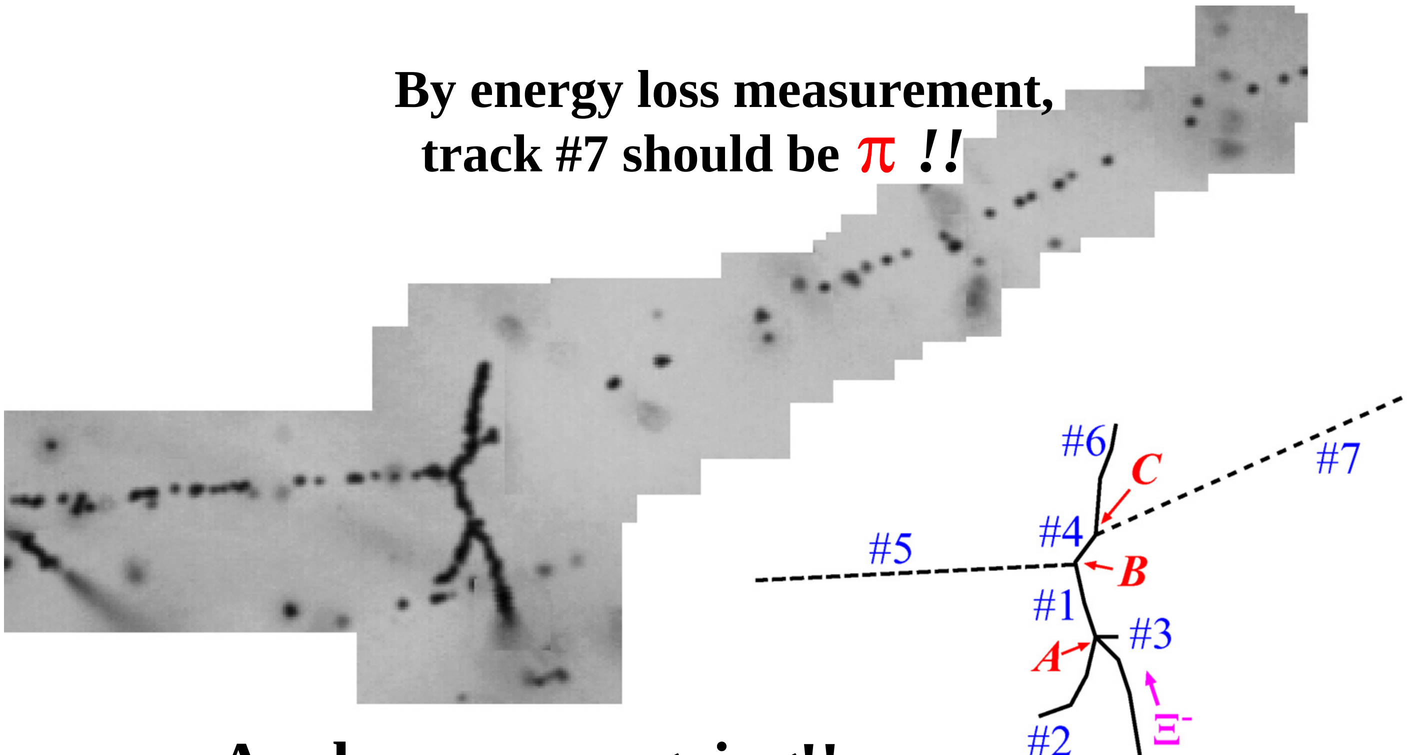
# *Double hypernucleus #3*




$K^-$, $K^+$ tracks measured by the spectrometer system
$\Xi^-$ track measured by the SciFi-Bundle detector
extrapolated line using the position and angle informations of track#7 in the emulsion stack

# *Double hypernucleus #3*

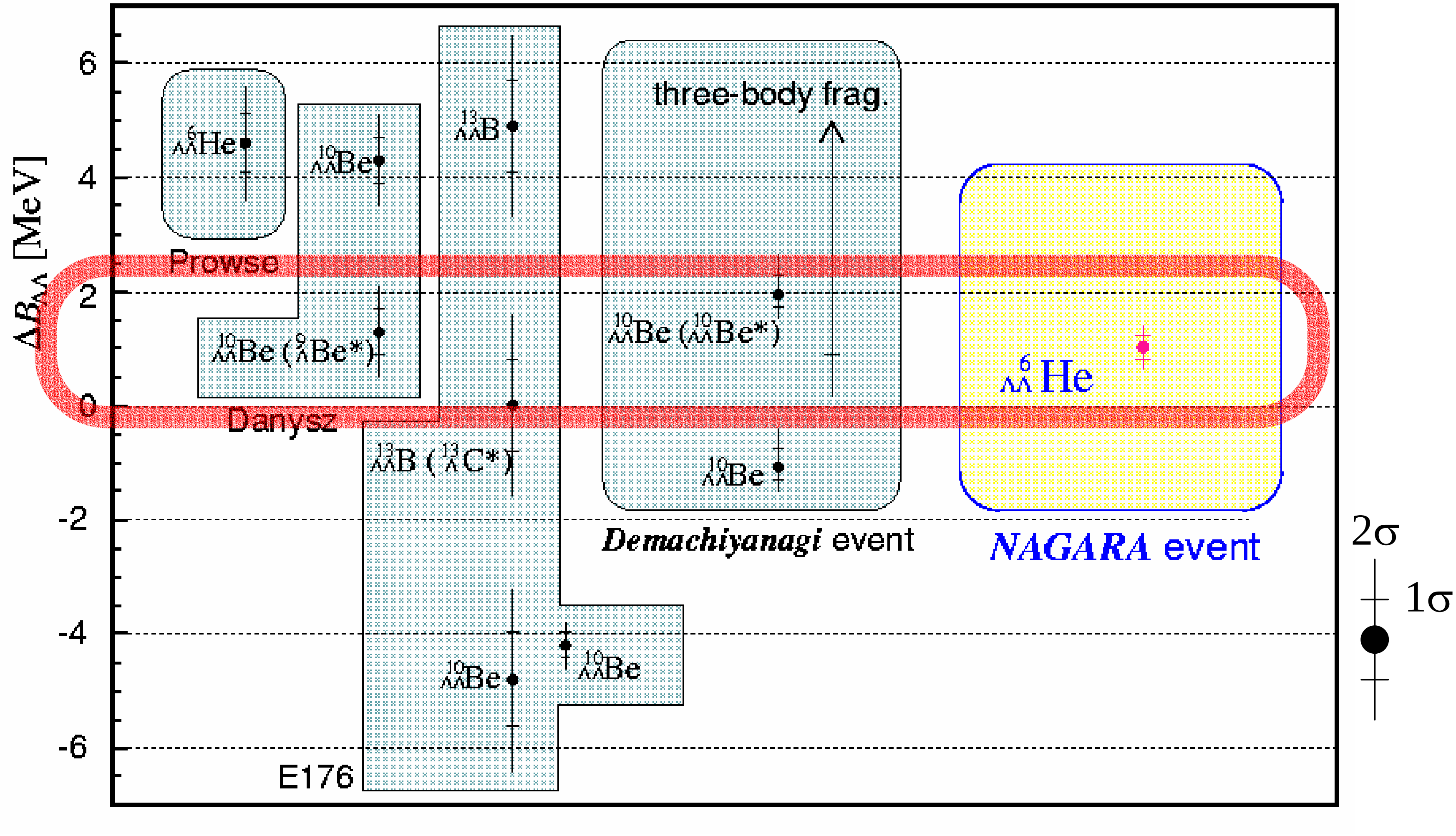
**By energy loss measurement,**
**track #7 should be** $\pi$ ***!!***




**Analyses are ongoing!!**

# *Comparison with past results*

**ΛΛ interaction is attractive but weak**



# BNL-E964: *More S= -2 systems*

## International collaboration

### AGS-E964(BNL)

**Systematic Study
of
Double Strangeness System
by
an Emulsion-Counter Hybrid Method**

AGS-E964 **collaborators** (now)

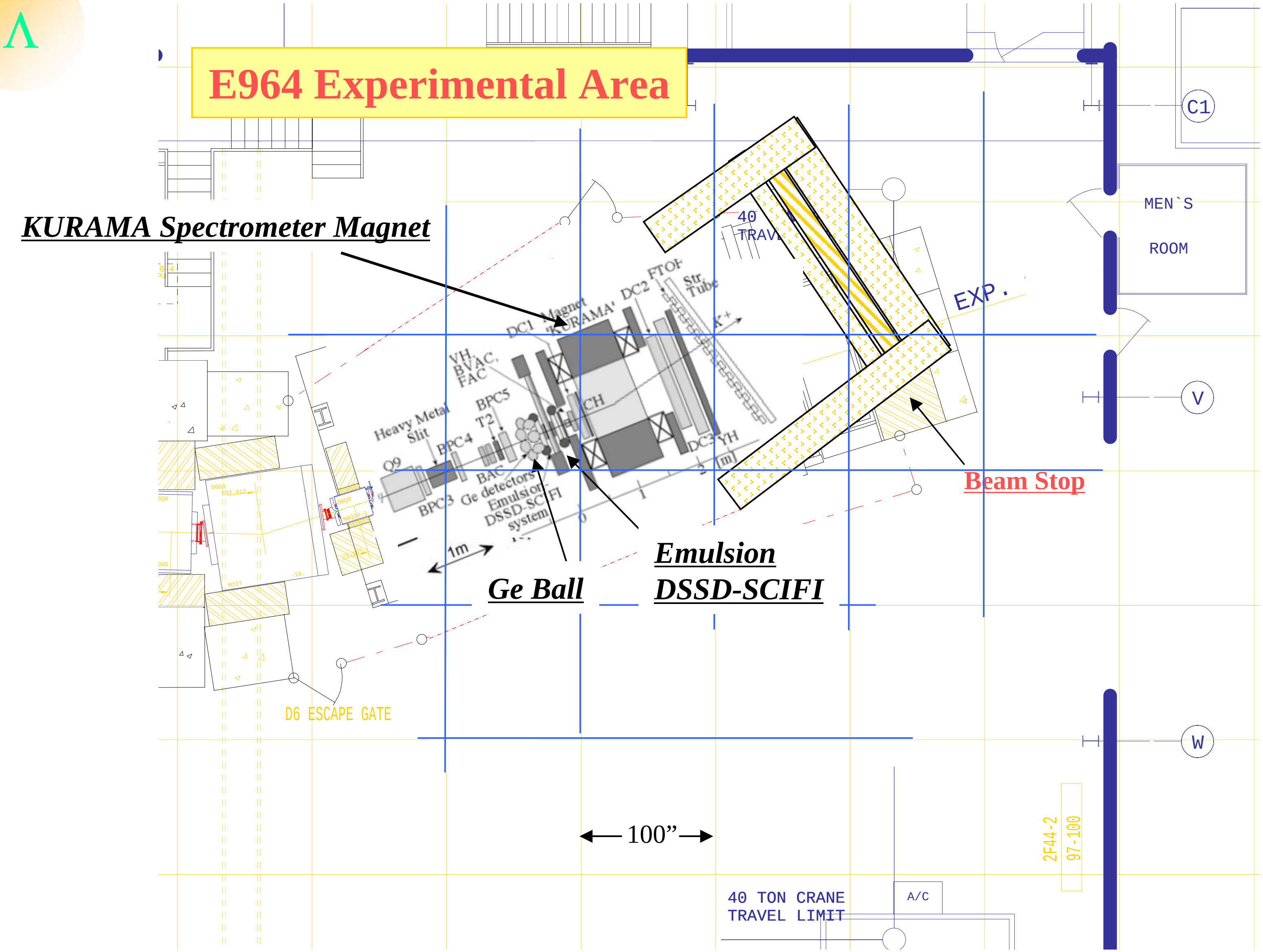
R. E. Chrien, H. Hotchi, M. May, P. Pile, A. Rusek (***BNL***, **USA**),
H. Guo, Z. Liu, S. Lu, J. Zhou (***CIAE***, **China**),
G. B. Franklin (***CMU***, **USA**), K. Nakazawa, M. Mitsuhara (***Gifu***, **JPN**),
J. S. Song, C. S. Yoon (***GNU***, **Korea**),
Ed. Hungerfold, K. J. Lan, Y. Cui, Song (***Houston***, **USA**),
H. Funahashi, K. Imai, M. Nakamura, N. Saito, M. Yosoi (***Kyoto***, **JPN**),
B. Bassalleck (***New MX***, **USA**), K. Yamamoto, T. Yoshida (***OCU***, **JPN**),
P. K. Saha (***Osaka E-C***, **JPN**), J. K. Ahn, S. J. Kim (***Pusan***, **Korea**),
K. Tanida (***Riken***, **JPN**), S. Ogawa, H. Shibuya (***Toho***, **JPN**),
Y. Miura, K. Mizunuma, H. Tamura, M. Ukai (***Tohoku***, **JPN**),
and
Graduate Students

- **Approved by PAC Oct. '01**
- **Funding approved in Japan from FY03 to FY07**
- **Preparation '03~**
- **Data taking '05, '06 (??)**
- **Data analysis**
- **Ten times higher statistics than KEK-E373 *!!***
  => $10^4$ $\Xi^-$ stopping events
- **First measurement of X-ray from S=-2 systems.**

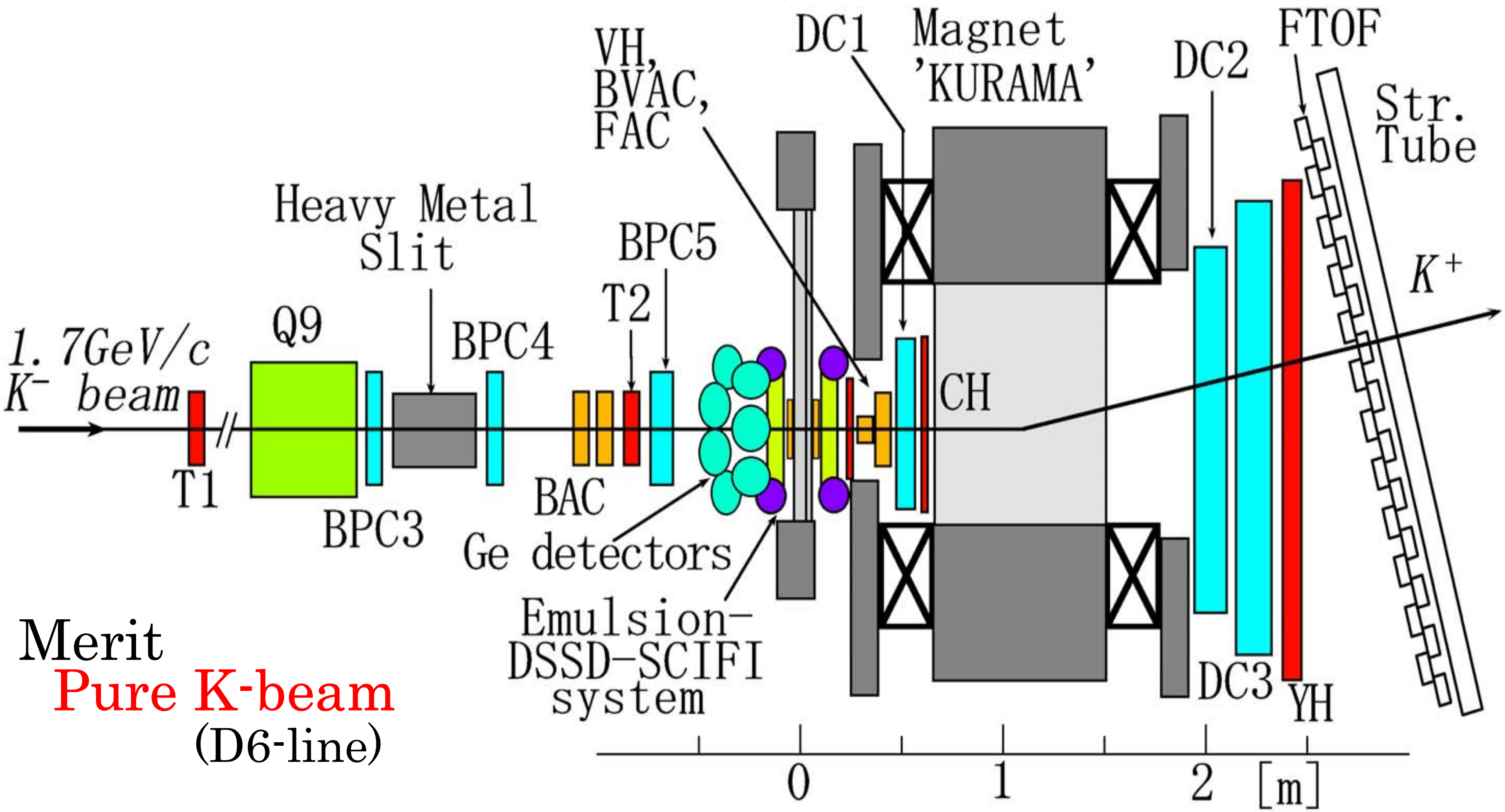
# BNL-E964: *AGS D6 Beam line*

**by Dr. P. Pile**

***HYP2003***
at J-Lab
Oct.14-18,



# *Experiment E964 at BNL-AGS*




Merit
Pure K-beam
(D6-line)

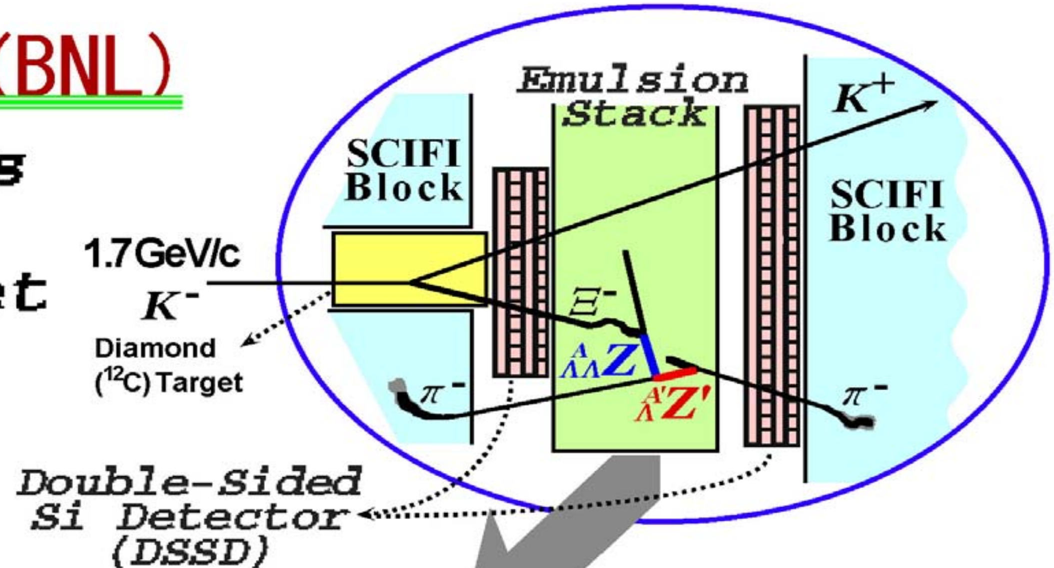
# *E964 near the target*

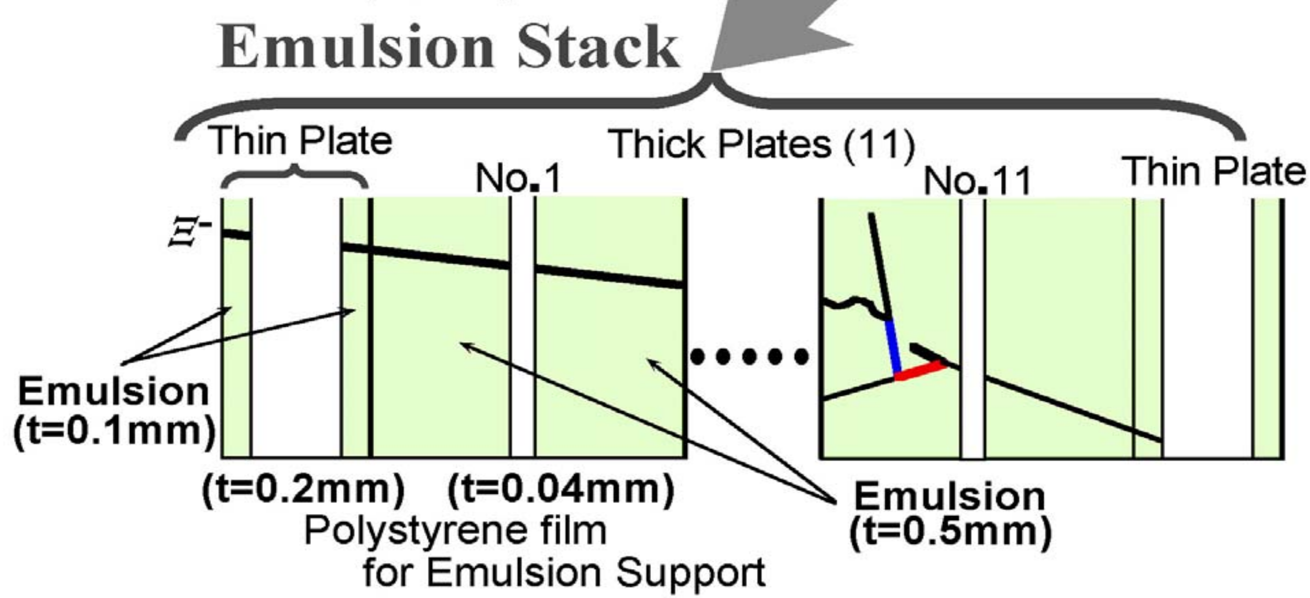
n p Λ

## AGS-E964 (BNL)

**Apparatus around the Target**

Area : 34.0×34.0 cm$^2$
Packed in vacuum chamber
Emulsion mover drives stacks

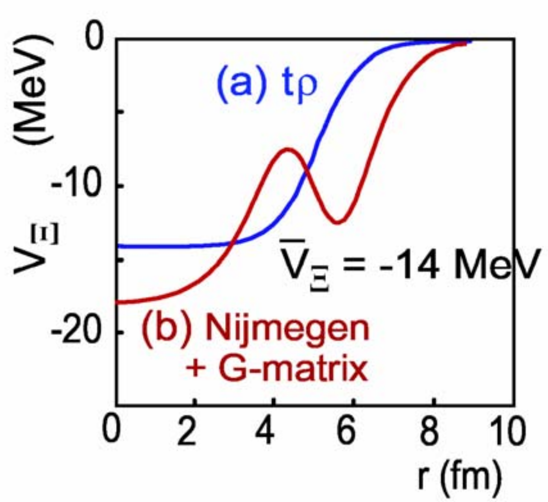


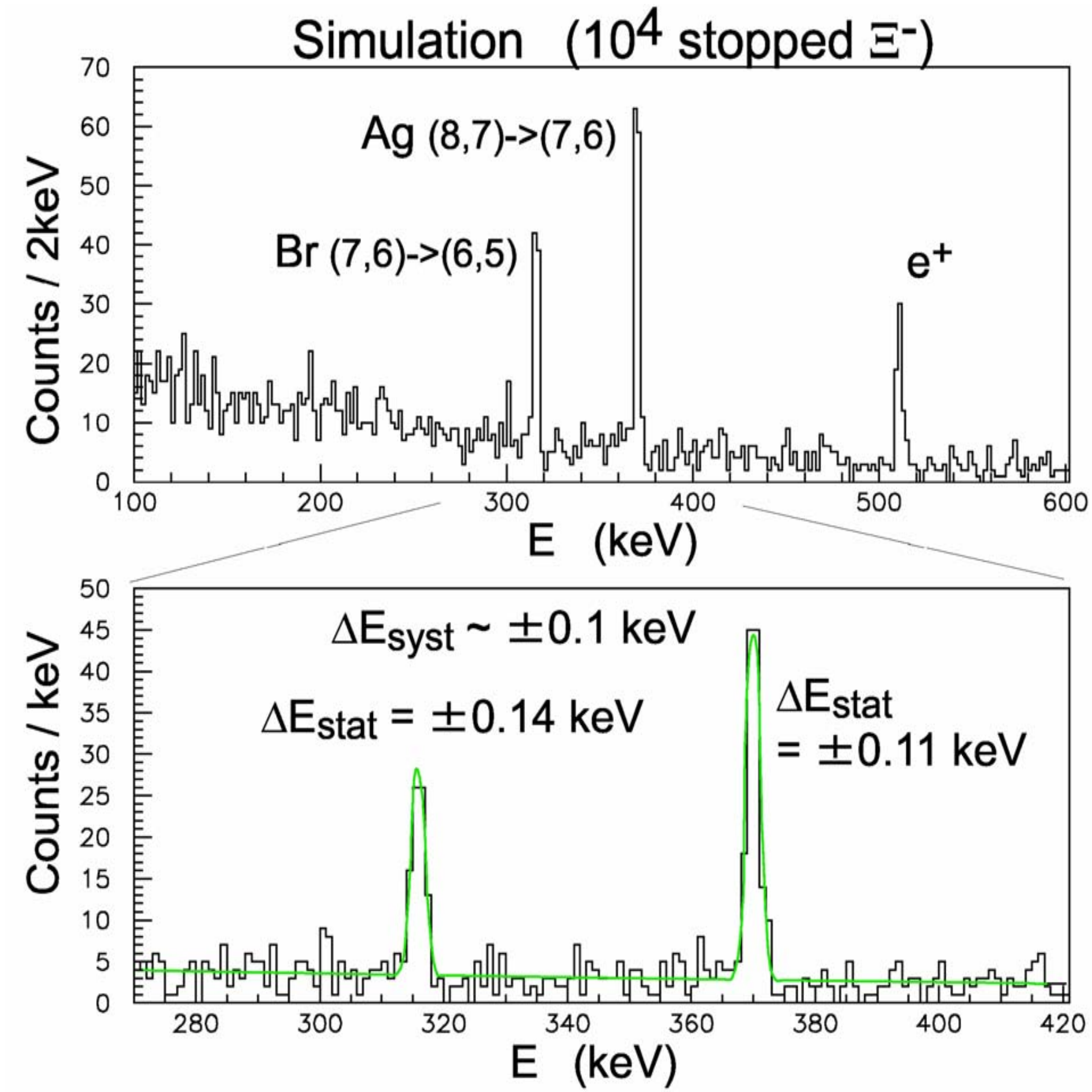



# $\Xi^-$ atomic X rays → $\Xi$N interaction

Expected energy shifts (keV)

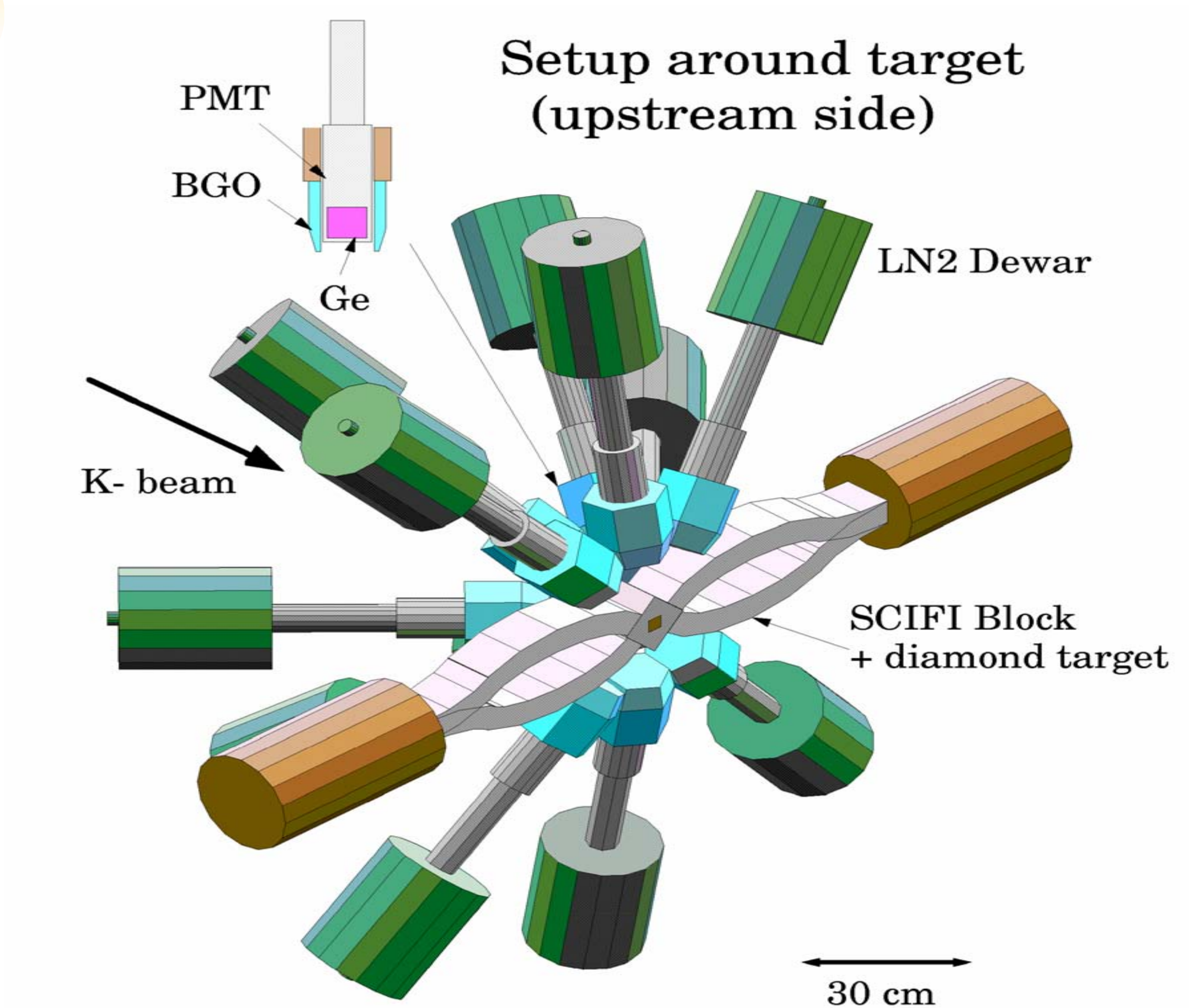
| Transition (n,l) | $E_{Coulomb}$ | (a) | | (b) |
|---|---|---|---|---|
| Ag (8,7)->(7,6) | 370.5 | 0.28 | -- | 3.3 |
| Br (7,6)->(6,5) | 315.5 | 0.73 | -- | 5.5 |



# Ge detector for Ξ-atomic X-ray



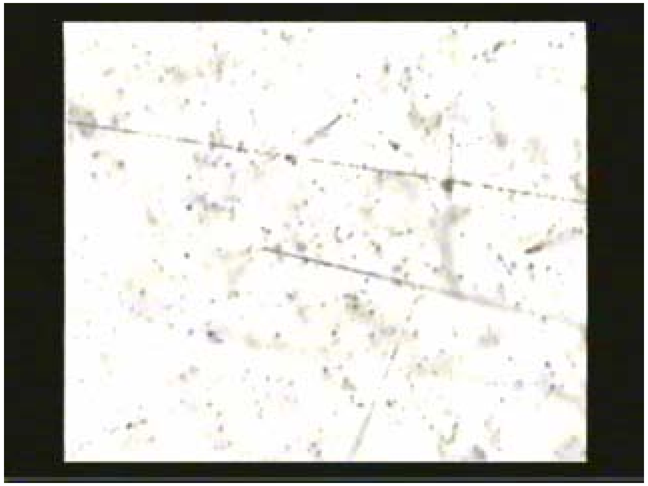


# *Speeding up of Automatic Scanning*

## ○KEK-E373

- **stage drive :** step-by-step
- **image capture :** 30Hz

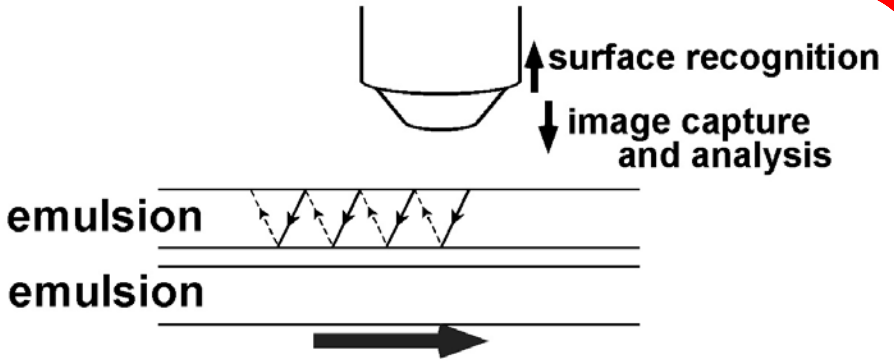
⇨ **1.5~2.0 sec / one view**



## ◎AGS-E964(BNL)

- **stage drive :** Non-Stop
- **image capture :** 100Hz

⇨ **~0.2 sec / one view**
***(designed value)***



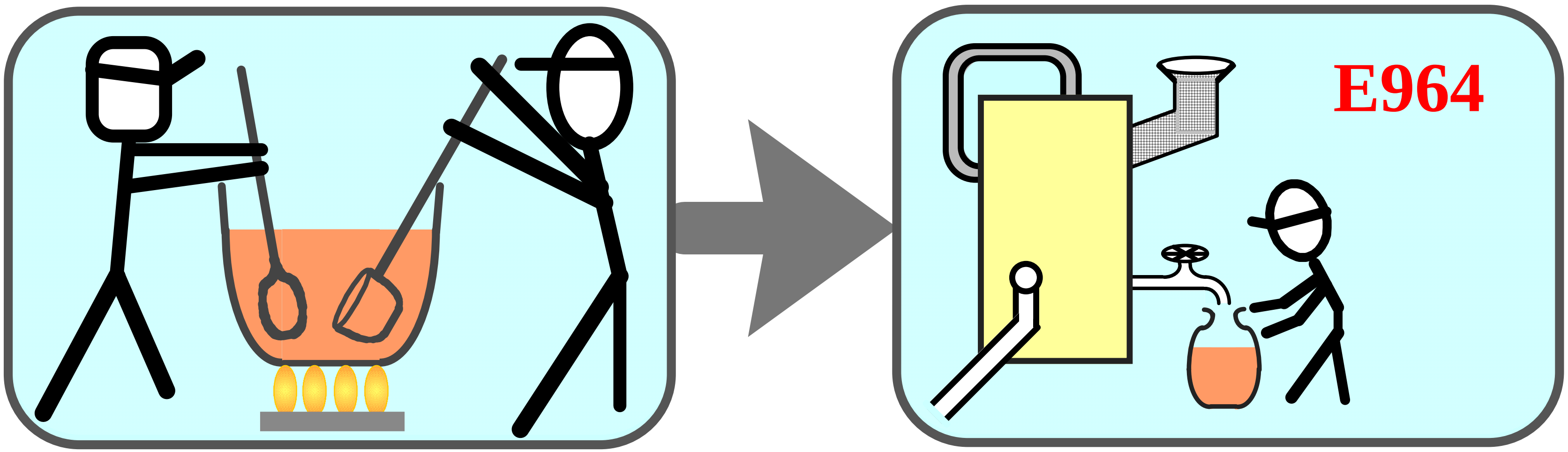

**Non-stop driving : speed~1mm/sec**

# *Development of new-type emulsion*

Production method of Emulsion gel will be changed.
For E964, amount of emulsion gel => 2.4 tons
Fuji-film needs one year or more by conventional way.

conventional coach-built way

by the production lines for commercial films




50% lower the cost of production

**Under inspection of quality**

n p Λ

# *Summary* : More S=-2 systems

- Recently, “Nagara event” opened the door of S=-2 systems, however it is only one event!!
- Future experiments give us more rich information by making a S=-2 nuclear chart, which is quite useful for understanding B-B int. in $SU(3)_f$ and multi-strangeness system.
- This progress is coming from developments of hybrid-emulsion technique, scanning method, Hyperball, High-quality Kaon beam, and so on.

| | | KEK-E176 | KEK-E373 | BNL-E964 |
|---|---|---|---|---|
| Beam Quality : K– / beam | | 0.3 | 0.2 | 0.9 |
| # of K- ( K- / spill ) | | ~ 10^9 (3*10^3) | ~ 10^10 (~10^4) | ~ 10^11 (~10^5) |
| Emulsion Volume ( *liters*) | | 30 | 70 | 210 |
| Ξ– stopping event search | Tracking method | K+(SSD) mannual | Ξ– (SCIFI) auto & mannual | Ξ– (DSSD) automated |
| X- and γ-rays measurement | | NO | NO | YES (Hyper-ball) |

# *Summary* : More S=-2 systems

## *Rough yield estimation*

| | | E176 | E373 (at 70% finished) | E964 |
|---|---|---|---|---|
| # of Ξ– stopping event | | ~80 | ~1*10^3 | ~1*10^4 |
| # of Double-Λ hypernucleus | * Light | 1 ( + 1 ? ) | 3(+a few?) | Several *10 or more? (+α) |
| | * Heavy | 3 | Not yet anal. | 100 or more? |
| | * (K-,K+)point | (3) | We will try | 100 or more? |

# *Summary* : Theoretical Prediction

HIYAMA, KAMIMURA, MOTOBA, YAMADA, AND YAMAMOTO

PHYSICAL REVIEW C 66, 024007 (2002)

**Lightest ΛΛnucleus search**

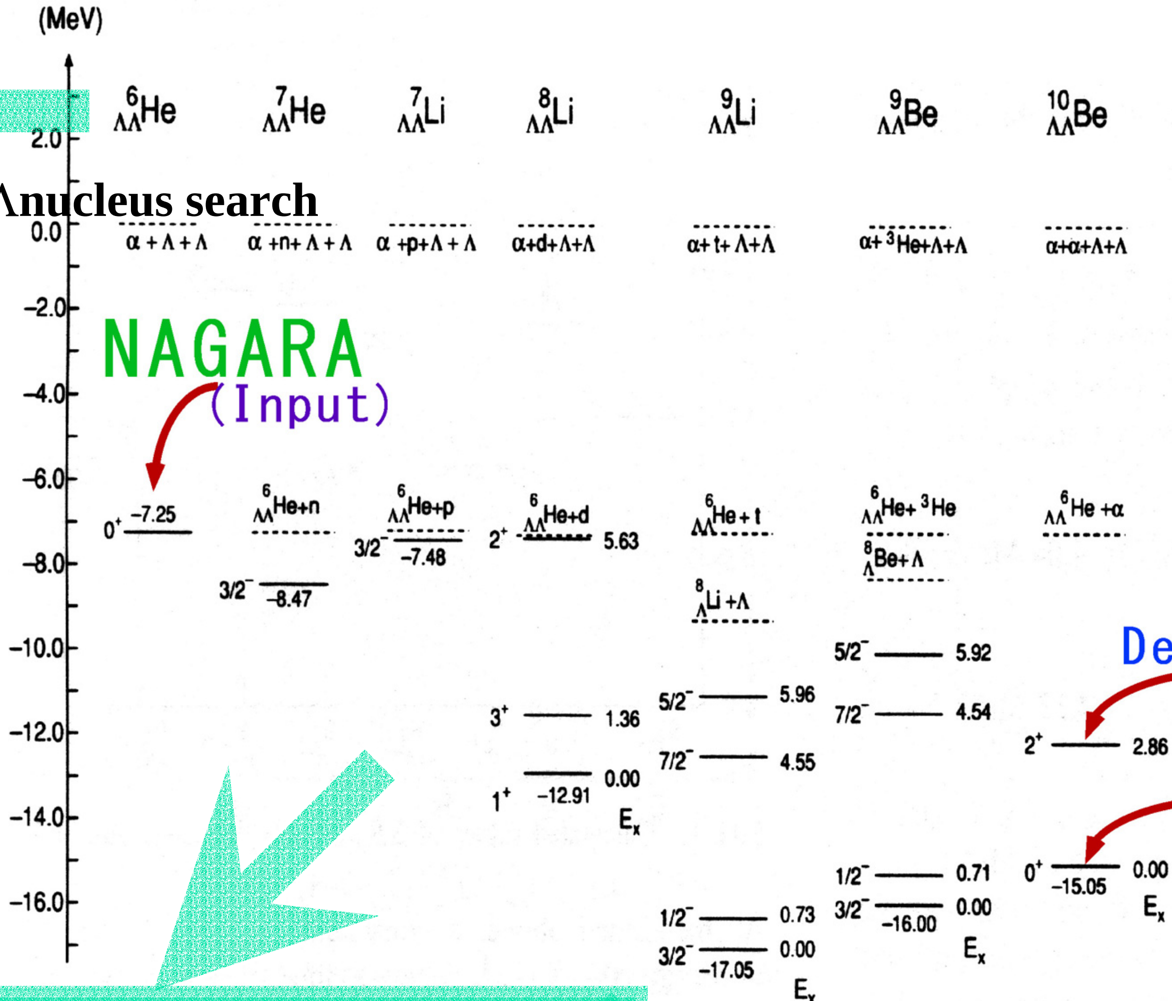



FIG. 12. Summary of the energy levels of the double-Λ hypernuclei $^{6}_{\Lambda\Lambda}$He, $^{7}_{\Lambda\Lambda}$He, $^{7}_{\Lambda\Lambda}$Li, $^{8}_{\Lambda\Lambda}$Li, $^{9}_{\Lambda\Lambda}$Li, $^{9}_{\Lambda\Lambda}$Be, and $^{10}_{\Lambda\Lambda}$Be calculated using the $\alpha+x+\Lambda+\Lambda$ model with $x=0,n,p,d,t,{}^{3}$He, and $\alpha$, respectively.

**E.Hiyama Fri, Oct.17, Prallel #9**

# *E961, An improved search for $\Lambda\Lambda$ hypernuclei*

**(given by Dr. Philip Pile)**

## E961 improvements over E906

| | Improvement | Total |
|---|---|---|
| **Improvement in statistics:** | | |
| Data collection hours | 2.7 | |
| • Protons per AGS spill | 2.1- 3.2 | |
| • $K^+$ Spectrometer Acceptance | 1.9 | 10 – 16 times |

| | | |
|---|---|---|
| **Other improvements** | | |
| CDS momentum resolution (rms MeV/c at 100 MeV/c) | 1.6 | |
| • $\Xi^-$ decay background reduction (S/N at 114 MeV/c) | 4 | |

**Search for**

1) ${}_{\Lambda\Lambda}^{5}\mathrm{H} \rightarrow {}_{\Lambda}^{5}\mathrm{He} + \pi^-$

2) ${}_{\Lambda\Lambda}^{4}\mathrm{H} \rightarrow {}_{\Lambda}^{4}\mathrm{He} + \pi^-$

3) ${}_{\Lambda\Lambda}^{7}\mathrm{He} \rightarrow {}_{\Lambda}^{7}\mathrm{Li} + \pi^-$

**Phil.Pile Fri, Oct.17, Prallel #9**

# Nuclear Chart with Strangeness

*HYP2003*
at J-Lab
Oct.14-18,