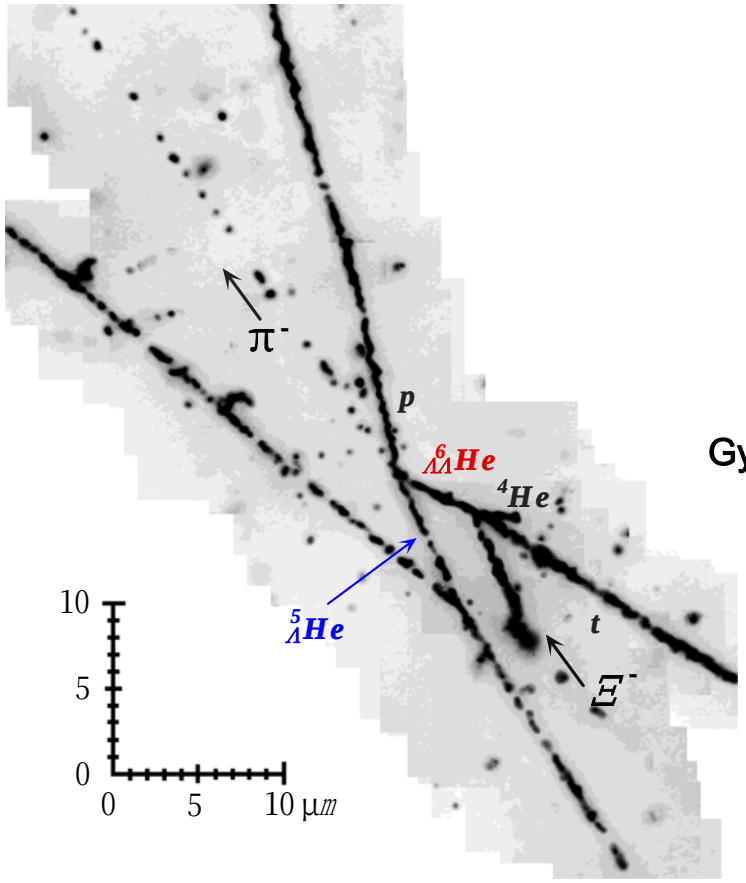
progress report on the E07 experiment

Jan.08,2008
J-PARC.PAC

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

NAGARA event (KEK-E373)



Kyoto:	E.Hayata, M.Hayata, M.Hirose, K.Imai, S.Kamigaito, A.Okamura, K.Tanida, M.Togawa, T.Tsunemi
Gifu:	M.Kawasaki, K.Nakazawa, K.T.Tint, M.Ukai, T.Watanabe
Tohoku:	K.Hosomi, T.Koike, Y.Ma, K.Shirotori, H.Tamura
AMU:	R.Hasan
BNL:	R.E.Chrien
CIAE:	Y.Y.Fu, C.P.Li, Z.M.Li, J.Zhou, S.H.Zhou, L.H.Zhu
Chonnam:	J.Y.Kim
Dongshin:	M.Y.Pac
Fukui:	T.Yoshida
Gyeongsang:	K.S.Chung, S.H.Kim, J.S.Song, C.S.Yoon
KEK:	M.Ieiri, H.Noumi, N.Saito, M.Sekimoto, H.Takahashi
Nagoya:	K.Hoshino, T.Kawai, B.D.Park, T.Sato, T.Watabe
NIRS:	N.Yasuda
OsakaCity:	K.Yamamoto
Pusan:	J.K.Ahn, S.Y.Ryu
Shanxi:	D.H.Zhang
Toho:	C.Fukushima, M.Kimura, S.Ogawa, H.Shibuya
UCL:	D.H.Davis, D.Tovee
U.Houston:	Ed.Hungerfold
U.New-Mexico:	B.Bassalleck

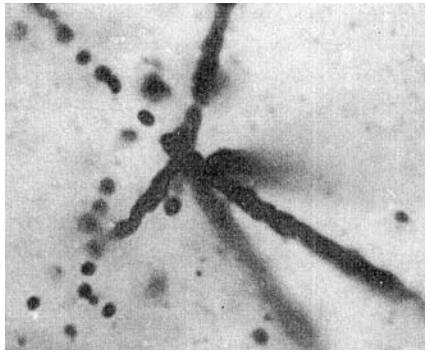
Systematic Study of Double Strangeness System with an Emulsion-Counter Hybrid Method

J-PARC E07

K.NAKAZAWA
(Gifu Univ.)

PS-E176

in ~80 Ξ stops

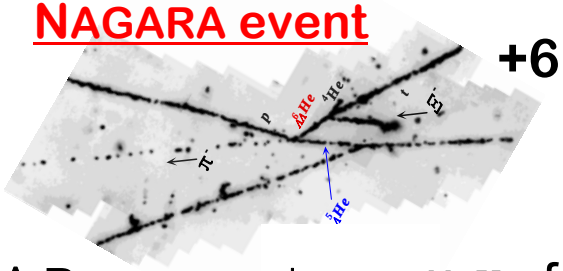


Double-Hypernucleus with sequential decay surely exists.

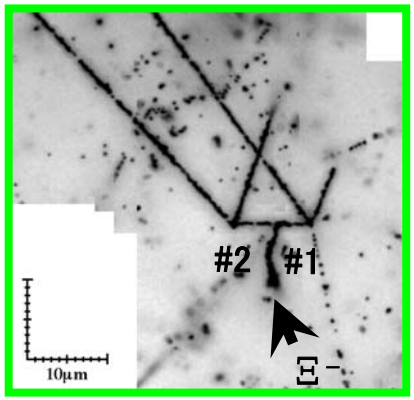
PS-E373

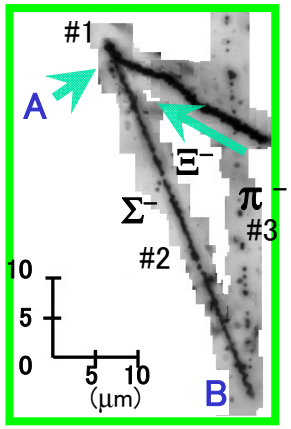
in ~700 Ξ stops

NAGARA event **+6 cand.**



$\Delta B_{\Lambda\Lambda} = 1.01 \pm 0.20$ MeV for ${}^{6}_{\Lambda\Lambda}$He

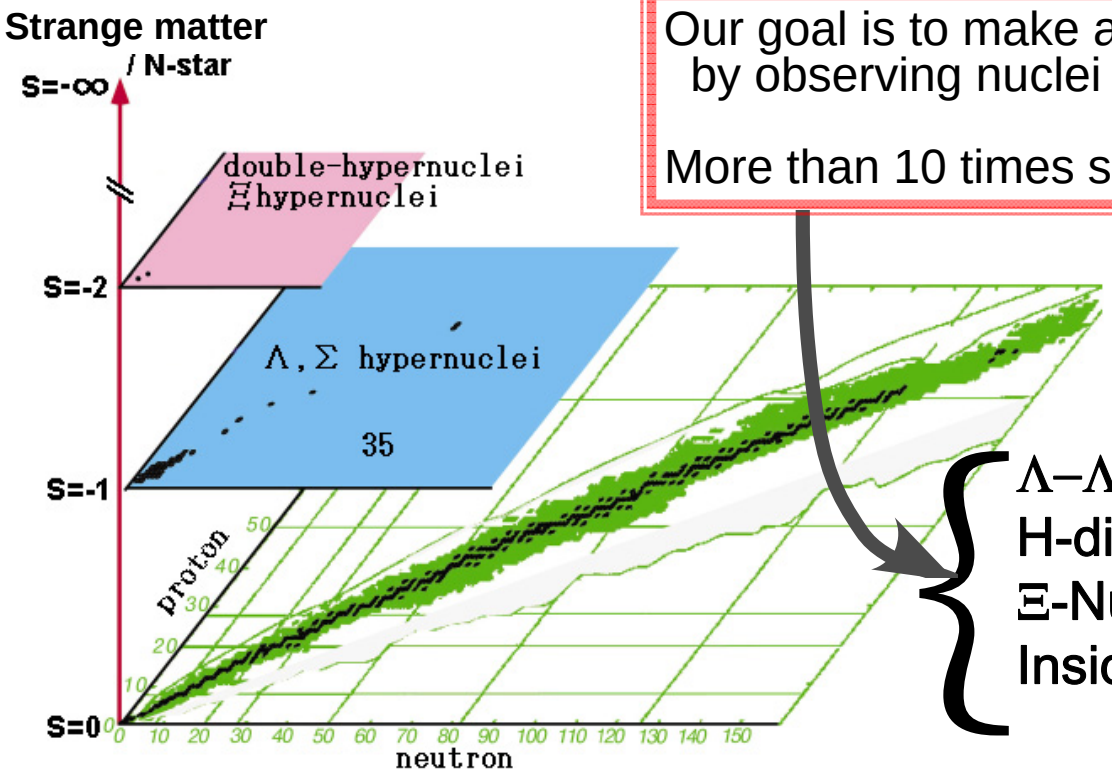




Motivation of the E07 experiment

n p Λ*

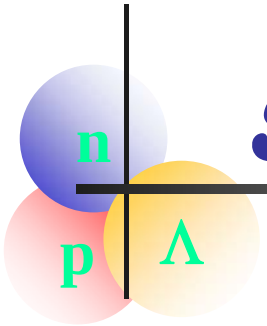
* detection of 10^2 or more candidate events with S = –2,
→ Discovery of 10 or more nuclear species.



Our goal is to make a S=-2 nuclear chart,
by observing nuclei with S=-2 as many as possible.

More than 10 times statistics than previous E373.

Λ–Λ Interaction,
H-dibaryon,
Ξ-Nucleus Interaction,
Inside Neutron Stars (Quark-star?)



Summary

The 1st PAC on Jun.30,2006

Physics

1) S=-2 nuclear chart by **~10^2 $_{\Lambda\Lambda}^{\ \ \ \ A}Z$** via **$10^4$ Ξ^--stopping events.**

=> **$\Delta B_{\Lambda\Lambda}$ of several nuclides** will provide definitive information on ΛΛ interaction and structure of S=-2 nuclei.

2) H-dibaryon state in S=-2 system ?

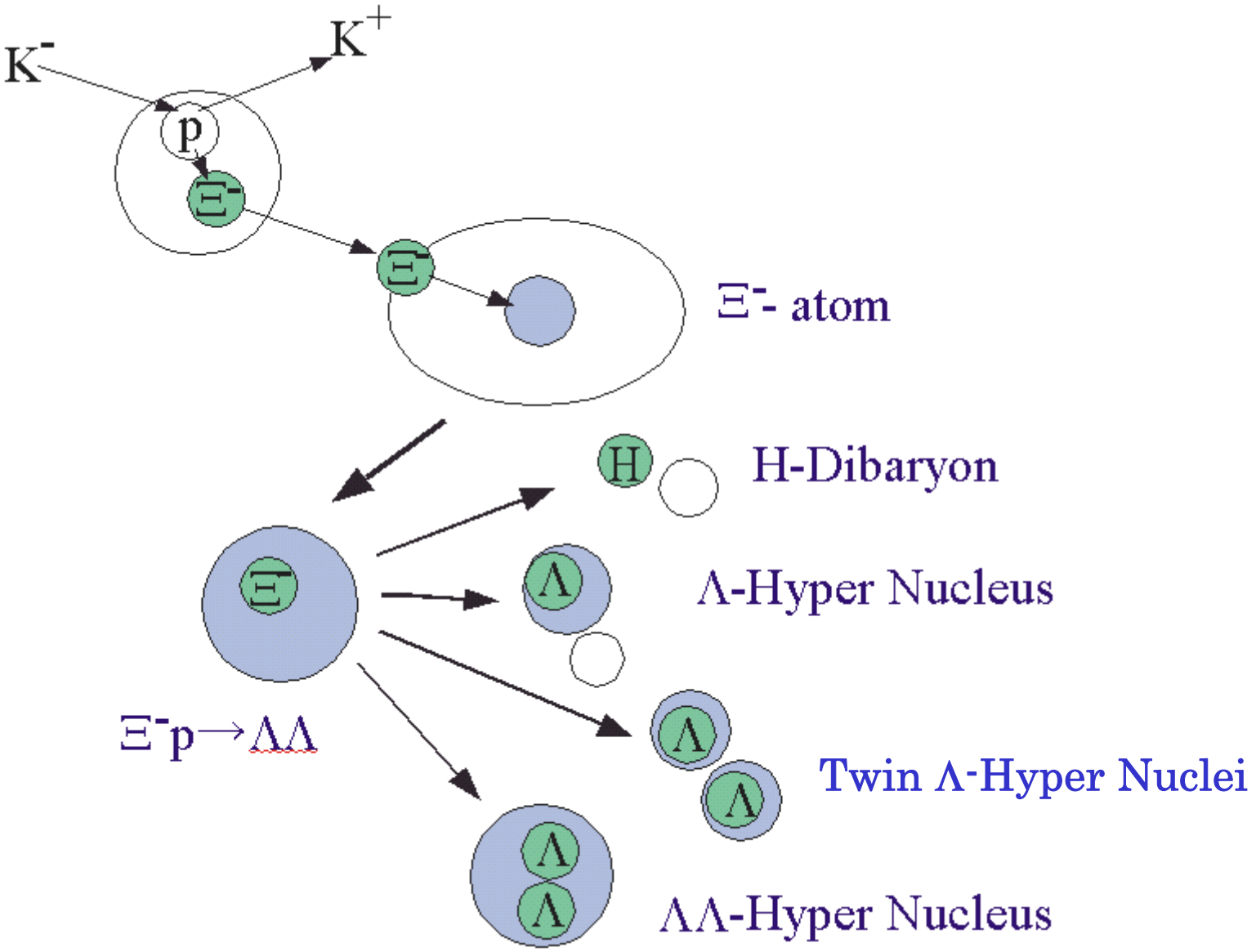
=> measure **A-dependence of $\Delta B_{\Lambda\Lambda}$** & **Σ⁻decay mode of $_{\Lambda\Lambda}^{\ \ \ \ A}Z$.**

3) Ξ^--nucleus potential

=> detection of **twin hypernuclei**

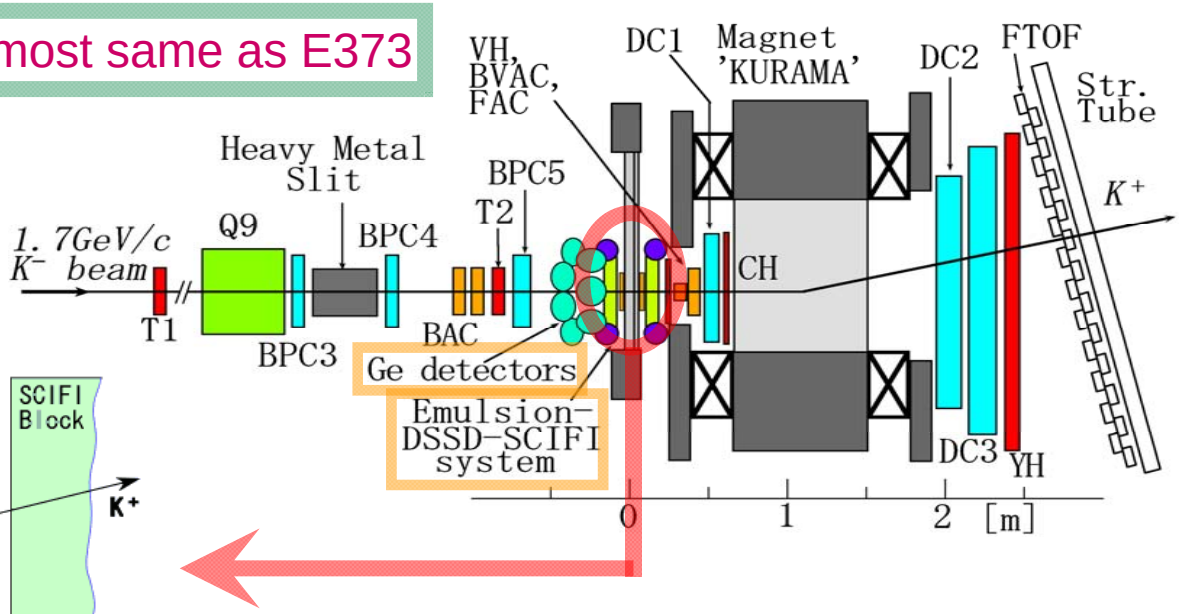
=> First measurement of **X-ray** of **Ξ^-atom**

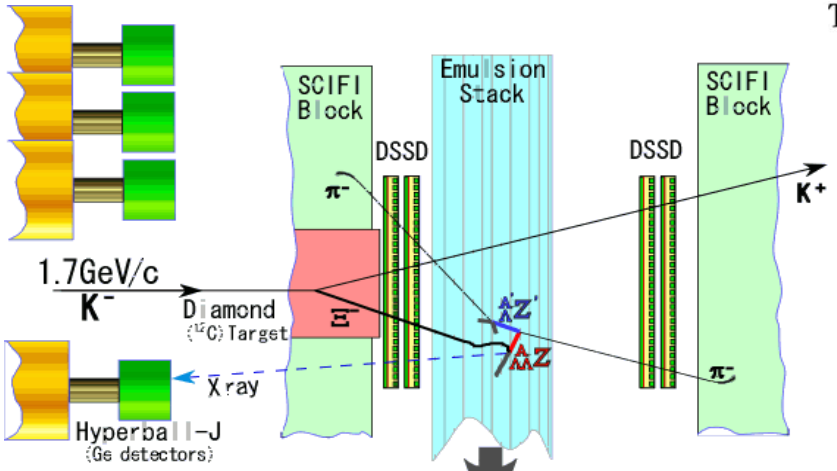
Production of S=-2 Nuclei

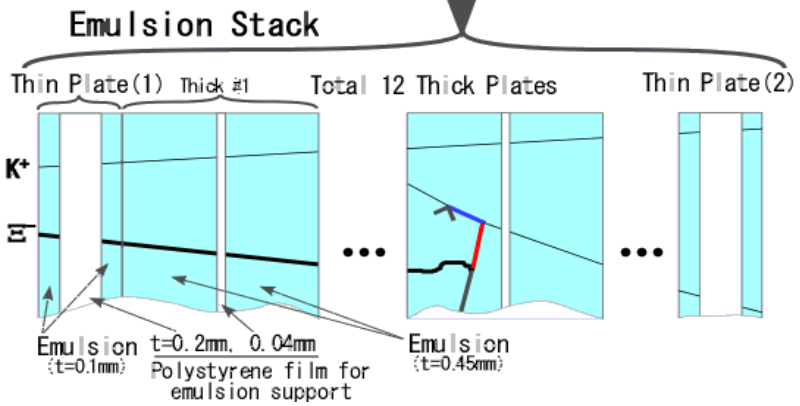


Setup of the proposed experiment

Almost same as E373







Beam : K^- (1.7GeV/c),

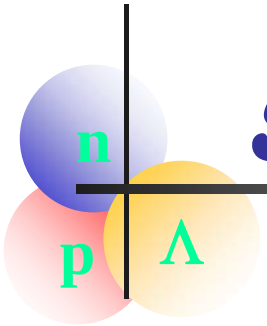
3×10^5 K^-/spill with **$K^-/\pi^- > 6$**

at **K1.8 beam-line** **(~20% of 9μA)**

Trigger : **(K-, K+)**

=> 10^4 Ξ^- stopping events

(more than 10 times higher stat. than E373)



Summary

The 1st PAC on Jun.30,2006

Readiness of the Experiment ('Kakenhi / Tokubetsu-Suishin' : $3M)

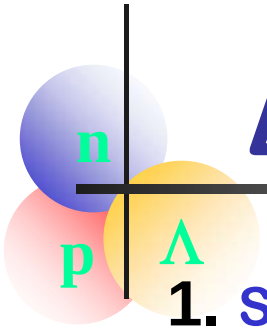
+ **DSSD** (**D**ouble-sided **Si** **S**trip **D**etector)
+ **Scanning system** (**6**=>**10** systems : high speed and better efficiency)
+ **Emulsion** (50%)
+ **Hyperball-J** (other budgets)

Requested **Beam and Time** (K-, K+) trigger

3 x 10^5 K^-/spill with $K^-/\pi^- > 6$ at **K1.8 beam-line** (**~20%** of 9μA)
150 hours for detector tuning and **600 hours** for beam exposure

Detector : DSSD, Emulsion, Hyperball, KURAMA spectrometer, etc.

Almost Ready



List of questions from the PAC and our reports on today

1. Spectrometer magnet : KURAMA

1st PAC minutes [Jul. 2, 2006]
==> FIFC [Nov. 2006]
==> 2nd PAC minutes [Jan. 12, 2007]

The PAC received a report from the FIFC committee on the evaluation of the experiment. There is no major technical problem in the experiment. The FIFC judges that the installation of Kurama magnet is both possible and preferable for acquiring more statistics.

TODAY : Setting status of Kurama and SKS magnet at the K1.8 line

2. Alignment between the DSSD and the emulsion

FIFC [Nov. 2006]
==> 2nd PAC minutes [Jan. 12, 2007]

The FIFC considers that good alignment between the two DSSD detectors and the emulsion stack is important for an efficient scanning. The strategy of the alignment procedure is, however, not well documented and reviewed.

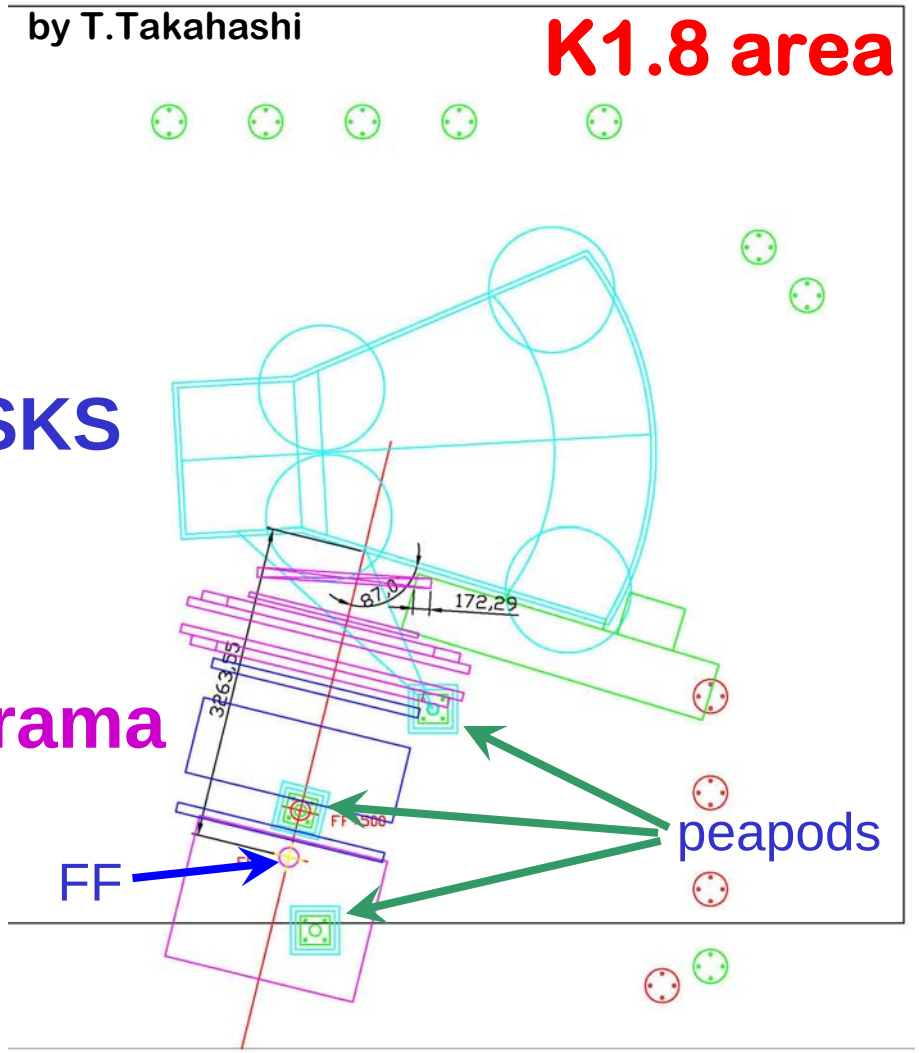
Originally, there was nothing problems [PS-E176(KEK)]

TODAY : 2-1. Review of alignment in PS-E176(KEK)
2-2. test of New alignment method
2-3. Performance of Developed DSSD (**D**ouble-sided **Si** **S**trip **D**etector)

3. Our strategy

budget, preparation schedule

1. *Setting status of Kurama and SKS magnet at the K1.8 area*



Three peapods shall be set in suitable position for each experiments using SKS.

We can locate

Kurama in K1.8

with SKS.

Plan (prof. T.Takahashi)

in FY08 :

transfer SKS from KEK to J-PARC.

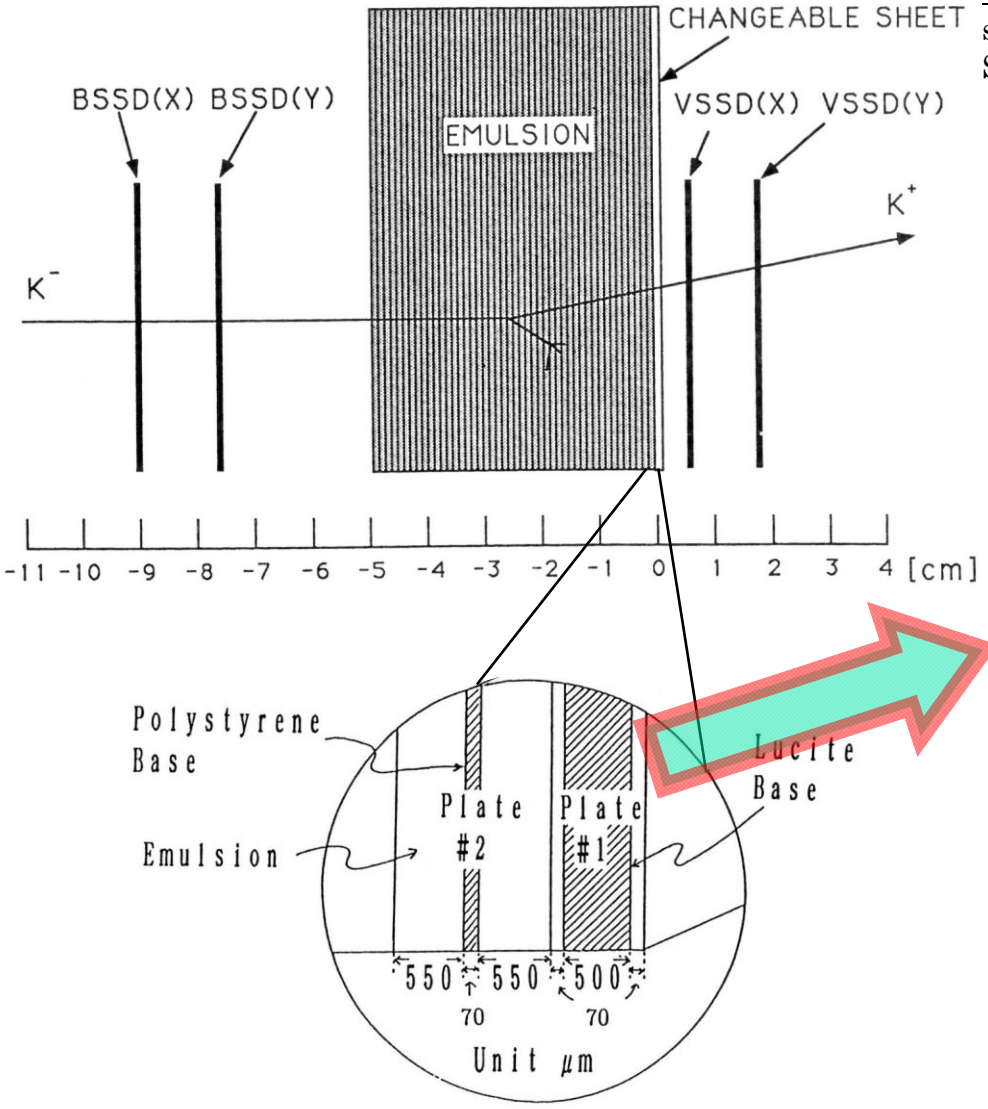
2. Alignment between the DSSD and the emulsion

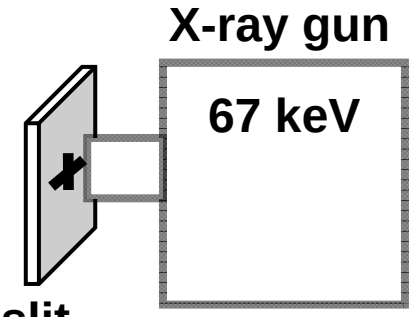
2-1. Review of alignment in PS-E176 (KEK)

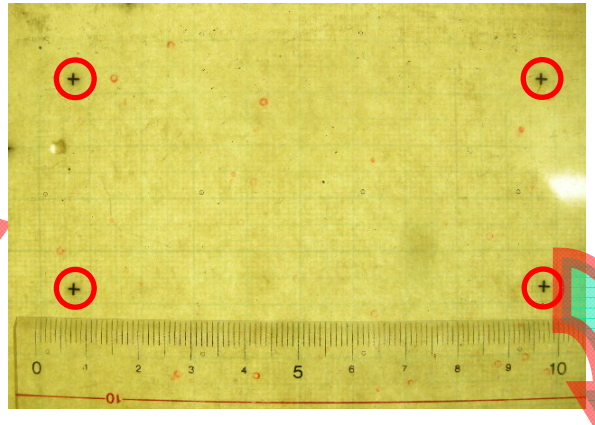
SSD Specification KEK Preprint 94-163

size : 50mm x 50 mm x 0.3mm

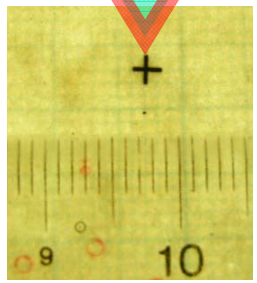
Strip pitch : 42μm







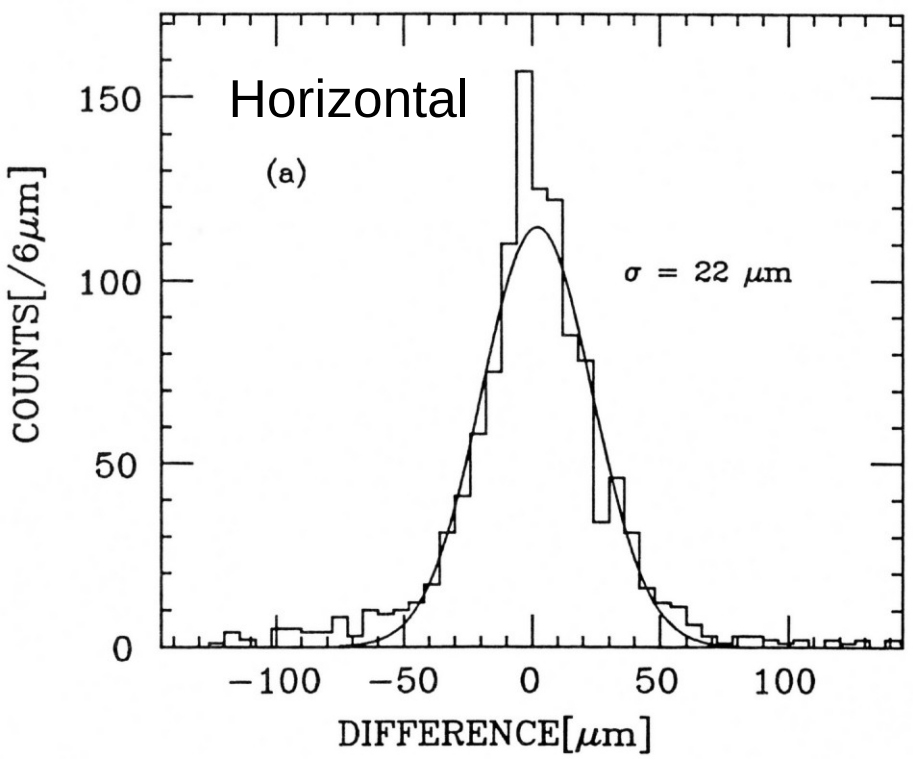
Emulsion Plate #1

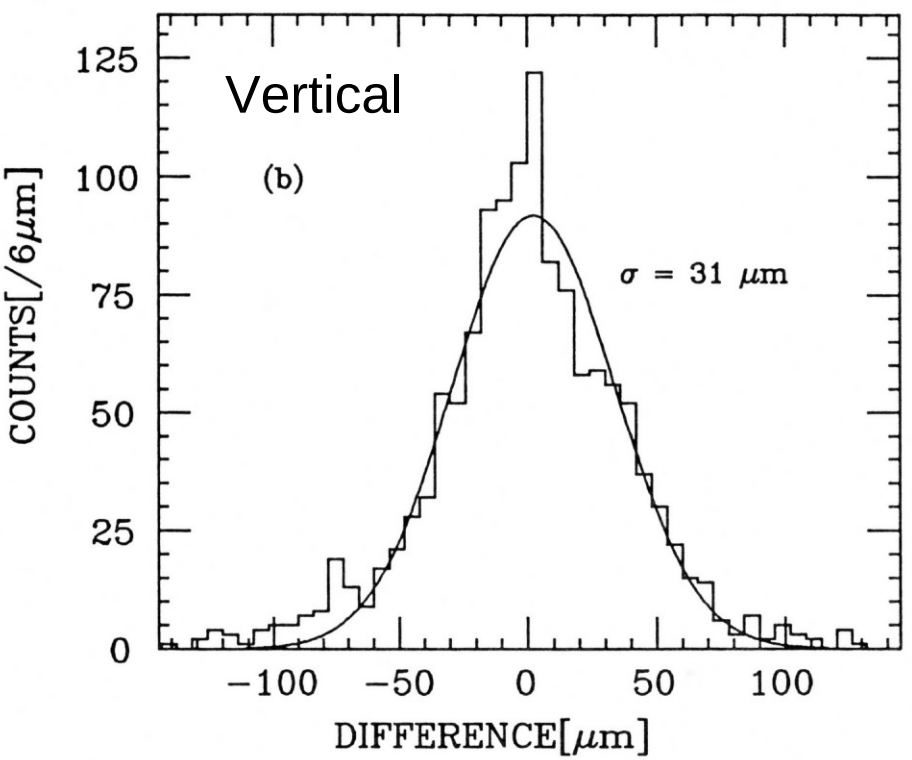


SSD<=>Em.

$\sigma_{x,y}$ ~0.1mm

Position accuracy distribution. [Final]
SSD=> (Em sheet) => Em stack.
after the calibration using a few thousand tracks





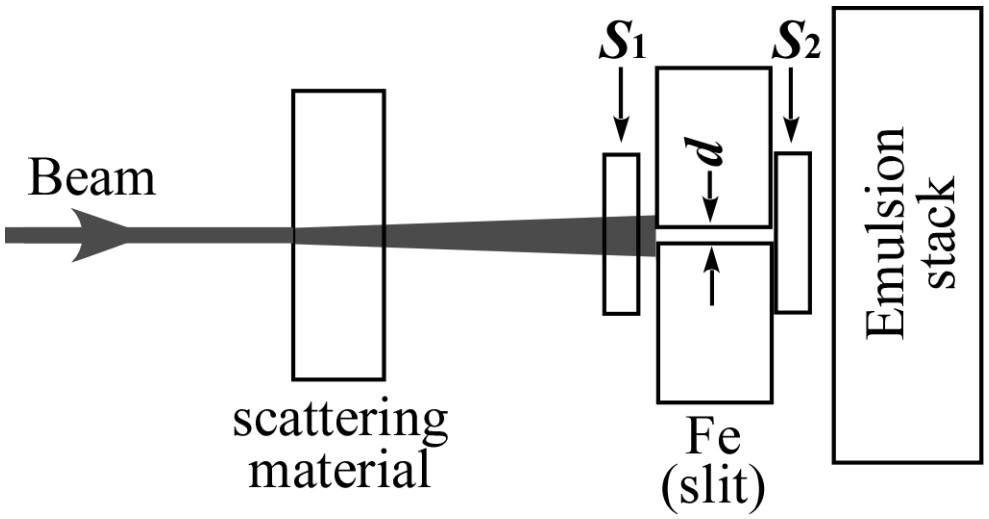
Alignment using X-ray is well applicable for E07 as PS-E176.

2-2. test of New alignment method

1. X-ray generator is so heavy to be installed in beam line.
2. Safety for the exchange of the emulsion stacks.

==> beam spot painting on DSSD and the emulsion

Test exp. of beam spot at RCNP- R80 (Dec.,2007)

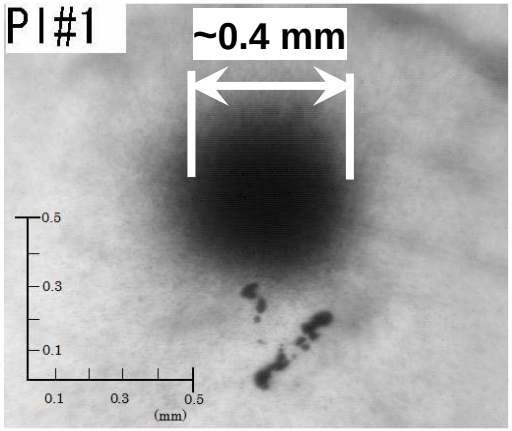


- Beam **Proton**(65 MeV, 355MeV/c)
- slit size
  d = **0.3x0.3, 0.5x0.5, 1.0x1.0 [mm^2]**
- Track density in the Emulsion
  0.5, 1.0, 5.0, 10.0
  x10^5 protons/[mm^2]
- Thickness of Fe slit **10 mm**

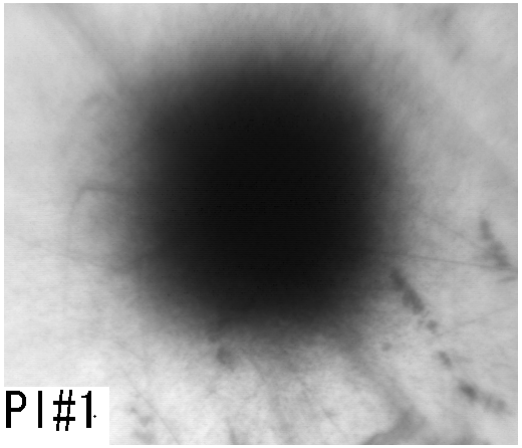
Beam spot (R80 at RCNP)

exposed beam density = 10 x 10^5 [protons/mm^2]

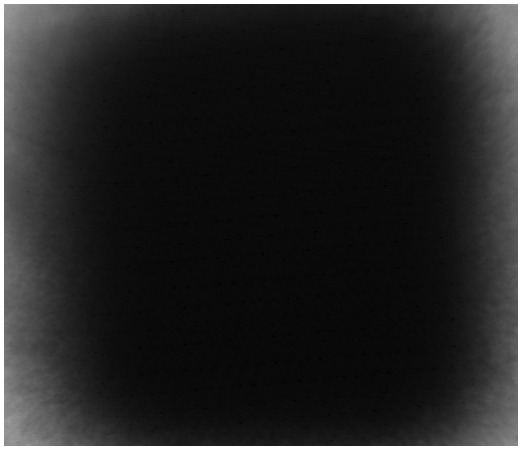
0.3 x 0.3 [mm^2]



0.5 x 0.5 [mm^2]



1.0 x 1.0 [mm^2]



Accuracy
0.4/sqrt(12) ~ 0.1 [mm]

good enough alignment for the experiment

Yield estimation at K1.8 @30GeV 9μA (Sanford-Wang, TRANSPORT & TURTLE)
for 10 x10^5 [protons/mm^2] through **0.3x0.3** [mm^2] **slit**

300 MeV/c : 120 spills
400 MeV/c : 40 spills
500 MeV/c : 20 spills

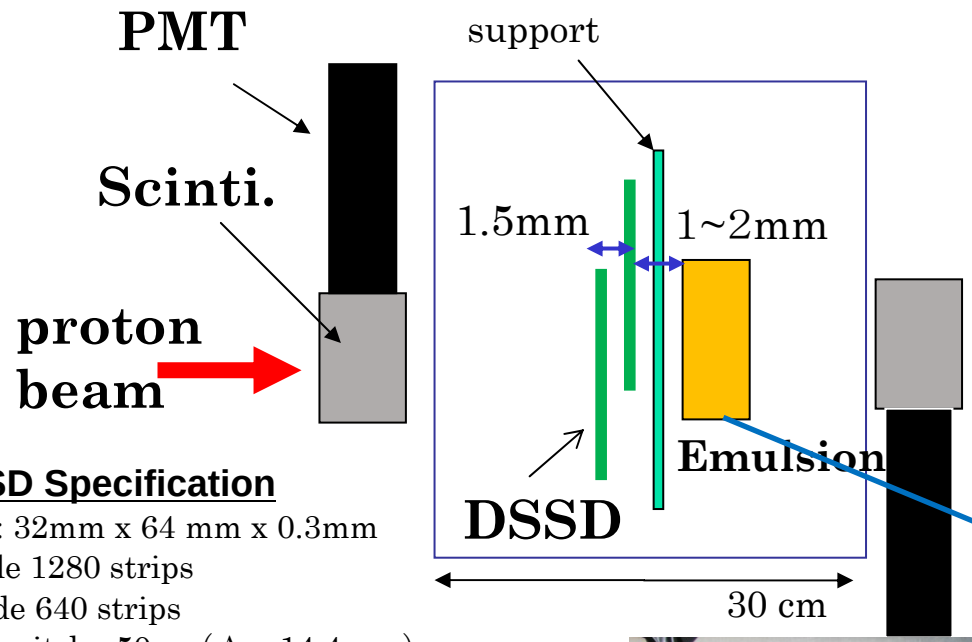
reasonable beam time

preliminary

2-3. performance of developed DSSD

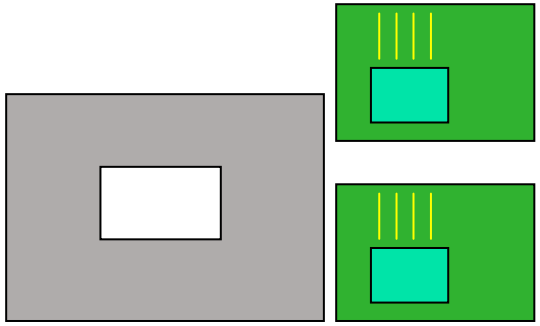
Test exp. of DSSD at RCNP- R78 (Dec.,2006)

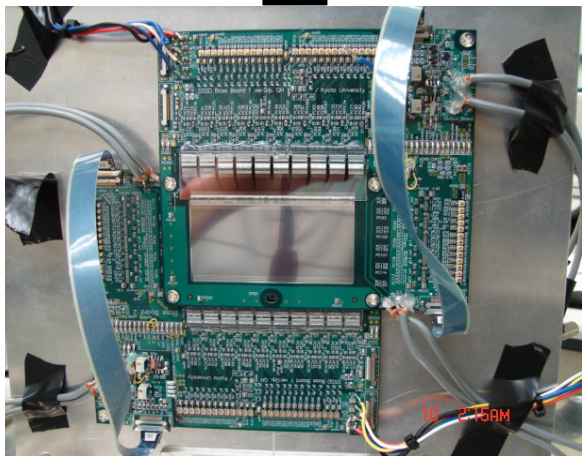
- Beam **Proton**(136.2 MeV)
- Incident angle
  0°, 15°, 20°, 30°, 45°, 50°
- Track density in the Emulsion
  3 protons/[mm²]
- Gap [DSSD <=> DSSD]
  1.5mm
- Gap [DSSD <=> emulsion]
  1~2mm

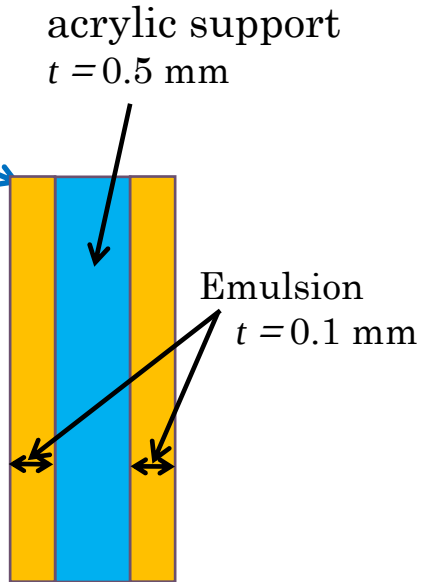


DSSD Specification

size : 32mm x 64 mm x 0.3mm
P-side 1280 strips
N-side 640 strips
Strip pitch : 50μm（Δr=14.4μm）
S/N ration : p-side 31.03±0.16
n-side 24.46±0.13



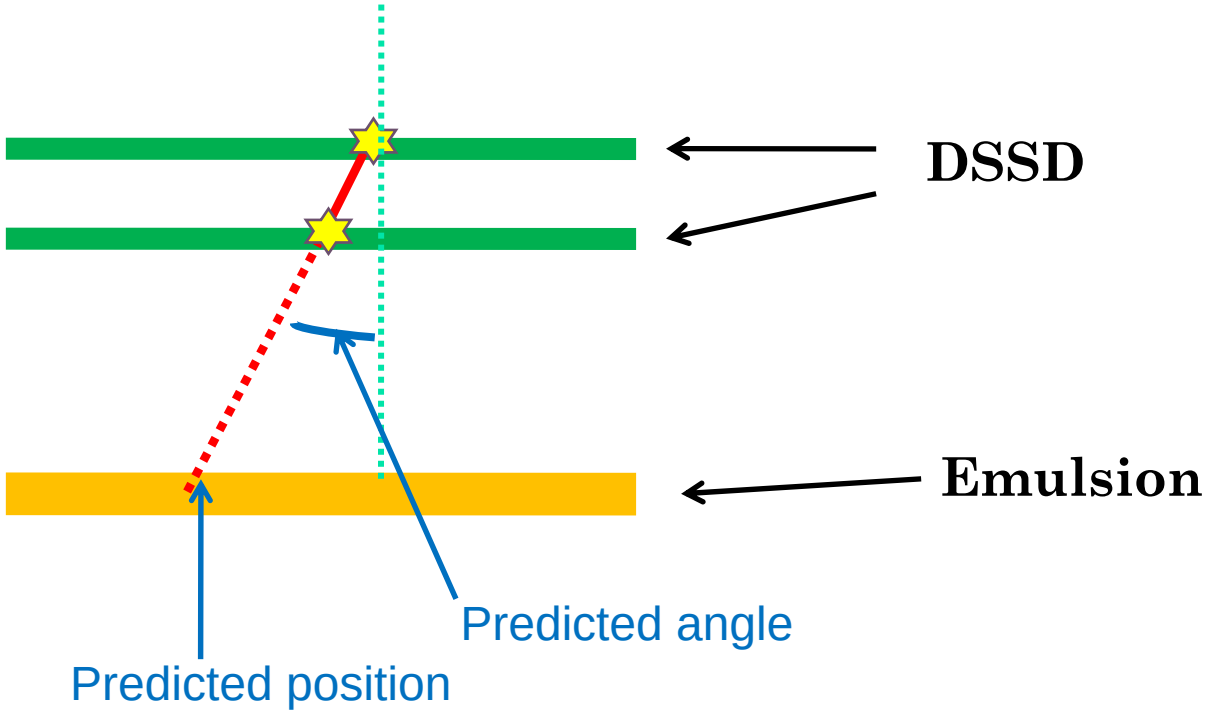




Track reconstruction

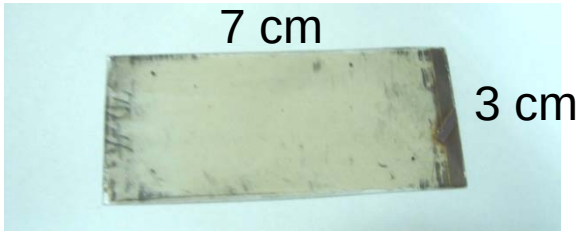
Condition

- Signal ADC > $3\sigma_{noize}$
- Clustering (ADC weighted)

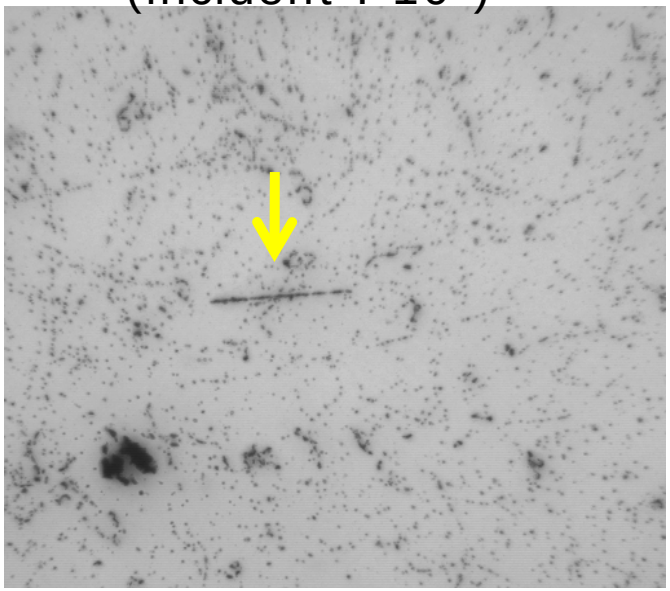


Scanning of protons in the emulsion

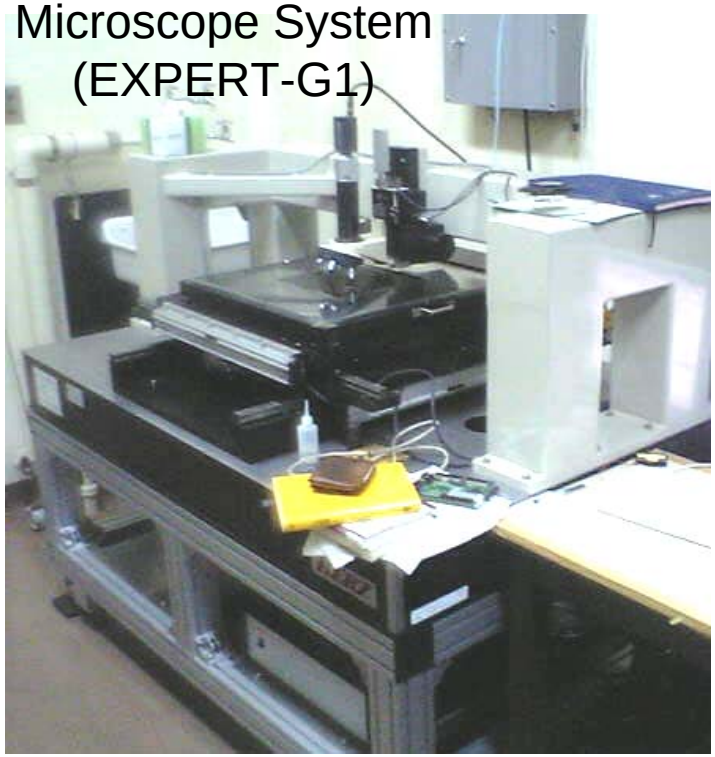
Emulsion Plate



Microscope image
of proton track
(incident : 10°)

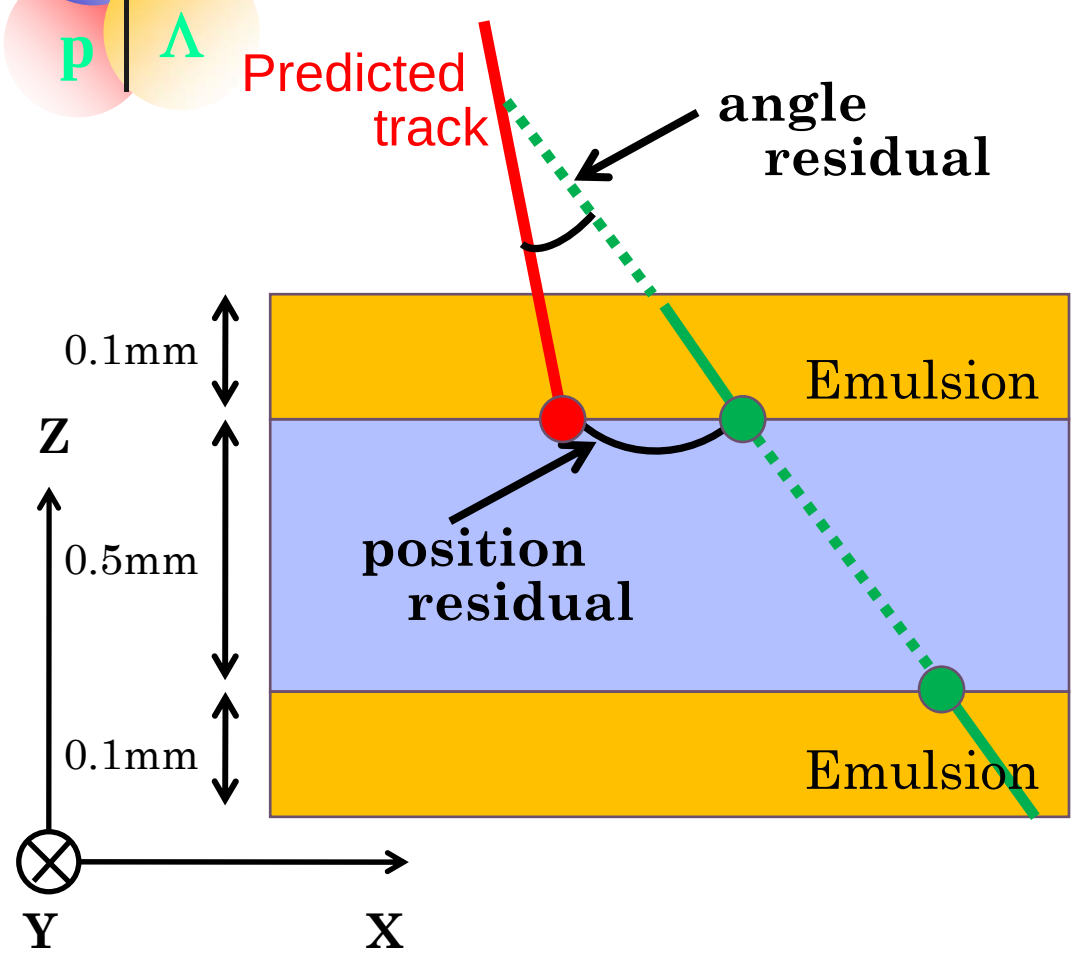


Microscope System
(EXPERT-G1)

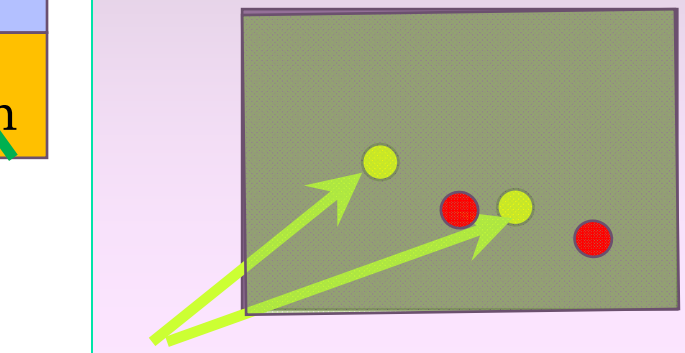


Scanned ~100 tracks
/ each angle exposure

Measurement of residuals (position, angle)



Aligned the Emulsion with DSSD so as to minimize the sum of the residual by iteration.



Result of residuals (position, angle)

		Position (μm)		Angle (mrad)		
		x	*y*	*x*	*y*	
E07	0º	19.9 +/- 1.8	19.5 +/- 1.9	19.1 +/- 1.8	11.5 +/- 1.0	
	15º	16.4 +/- 1.4	25.6 +/- 0.8	8.9 +/- 0.8	11.4 +/- 0.7	
	25º	45.3 +/- 6.8	26.0 +/- 2.3	10.6 +/- 0.8	13.8 +/- 1.2	
	30º	42.3 +/- 6.6	15.7 +/- 1.6	12.3 +/- 3.7	11.8 +/- 1.7	
	45º	41.3 +/- 5.0	21.0 +/- 2.2	7.6 +/- 0.8	15.3 +/- 1.4	
		20 ~ 45	**DSSD**	**10 ~ 20**		**X-ray ?**
E373 N.I.M. A 417 (1998) 220-229		194 (163)	113 (137)	**Fiber-bundle** 44 (-)	25 (-)	**X-ray**
E176 KEK Preprint 94-163		~ 100 (22)	(31)	**SSD** -	-	**X-ray**

for Ξ-tracking S/N ~ 1/3 → **S/N ~ 3**

good enough!!

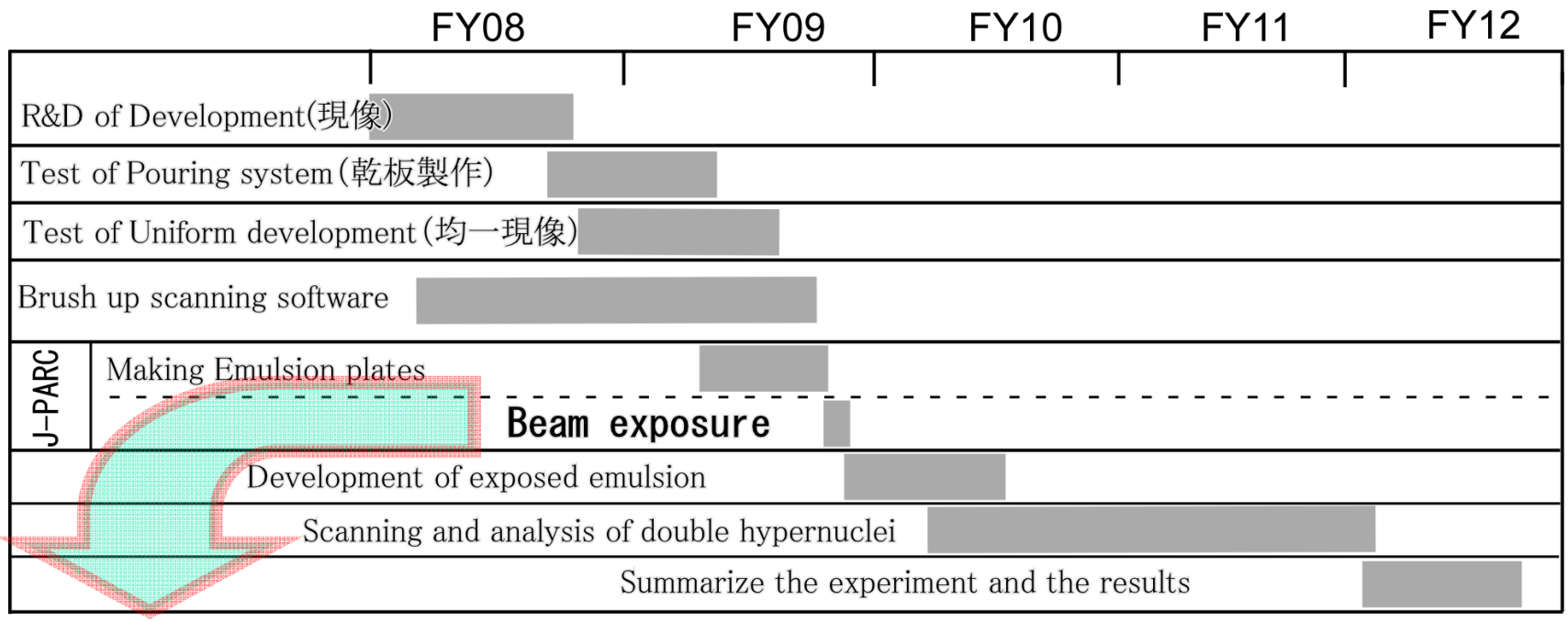
3. *Strategy*

3-1. Budget application for FY08-12

	x10^{6}yen	Funding Category [JSPS : Kakenhi]
Emulsion	35	Basic S ¥180M (including ¥30M for Counters, Chambers, etc. ¥50M for Microscope)
Post Doc.	12	Basic A ¥46M
Tank for development	8	
chiller	7	
Chemicals for development	10	
Waste liquid treatment	7	
Expendable supplies	2	

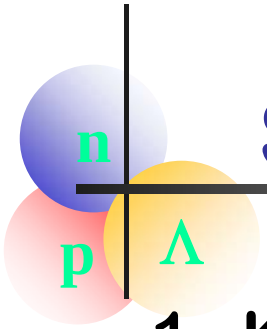
3-2. Our preparation schedule

(related part to the Emulsion work)



our beam request …… 20% of 9μA

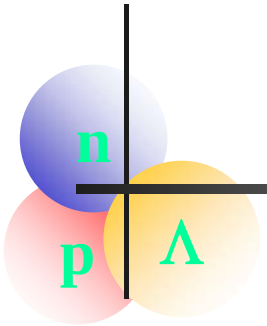
Kurama use …… E07 & E03 (K1.8)

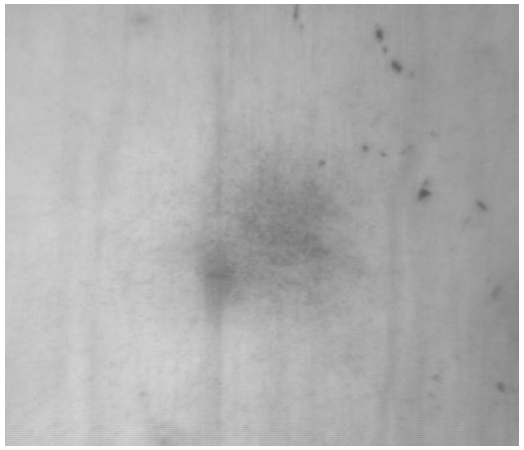
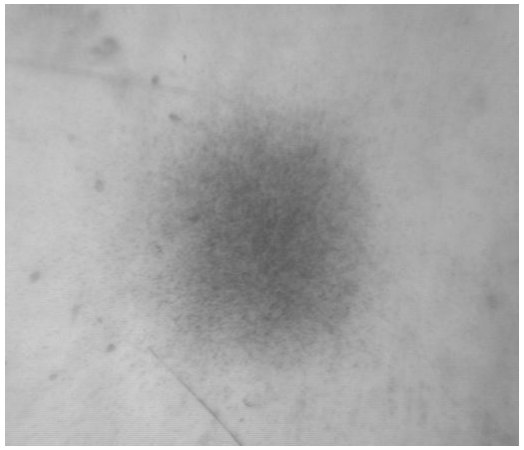
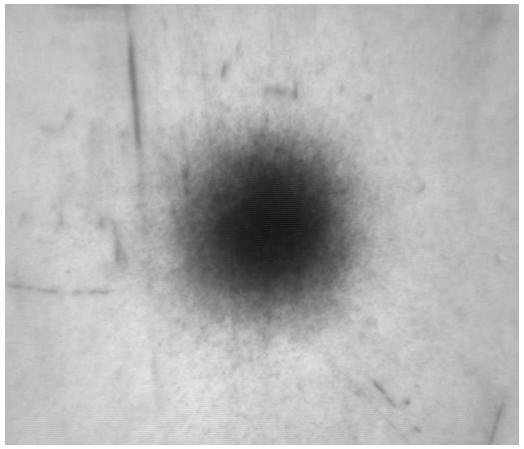
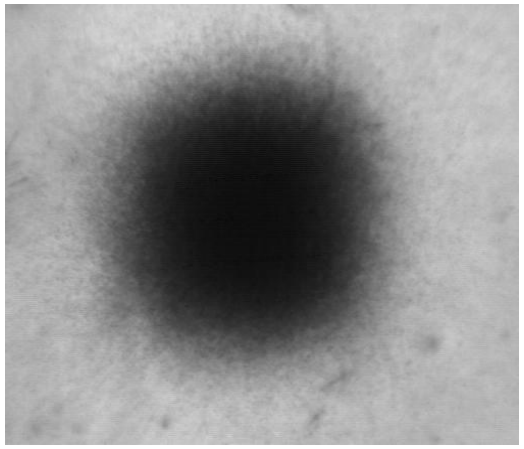


Summary

1. Kurama magnet shall be located in K1.8 area without disturbance.
2. Alignment between DSSD and Emulsion has no problem.
   - 2-1. It is reliable using X-ray as PS-E176.
   - 2-2. Beam spot method can be effective.
   - 2-3. DSSD detectors are well working.
3. Budgetary application has been done for FY08-12. Our preparation is going for the beam exposure on FY09.

- Extra slides



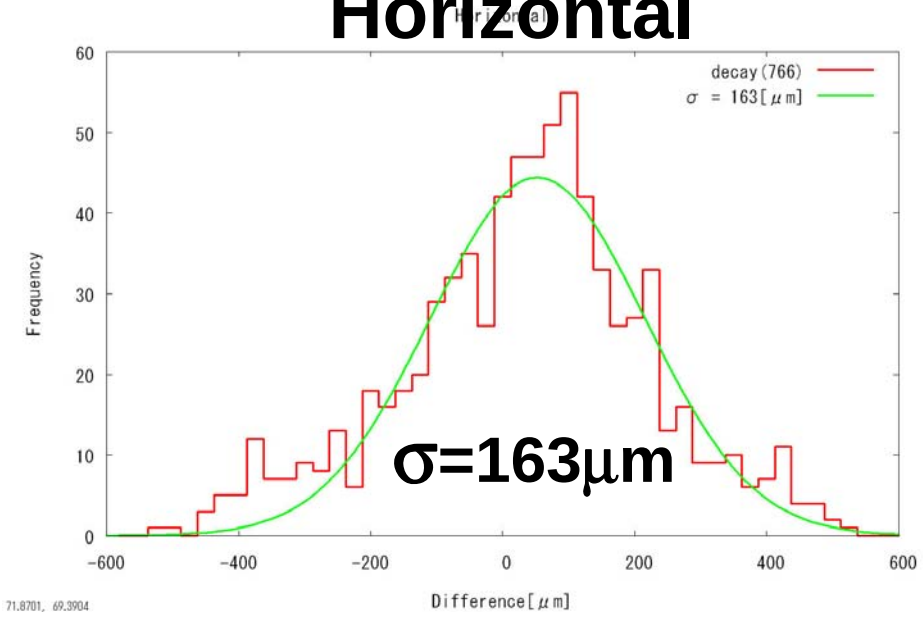
proton density [/mm^2]	0.3 x 0.3 [mm^2]	0.5 x 0.5 [mm^2]
1.0 x 10^5		
5.0 x 10^5		

Fiber-Em position accuracy
E373 Ξ cands.

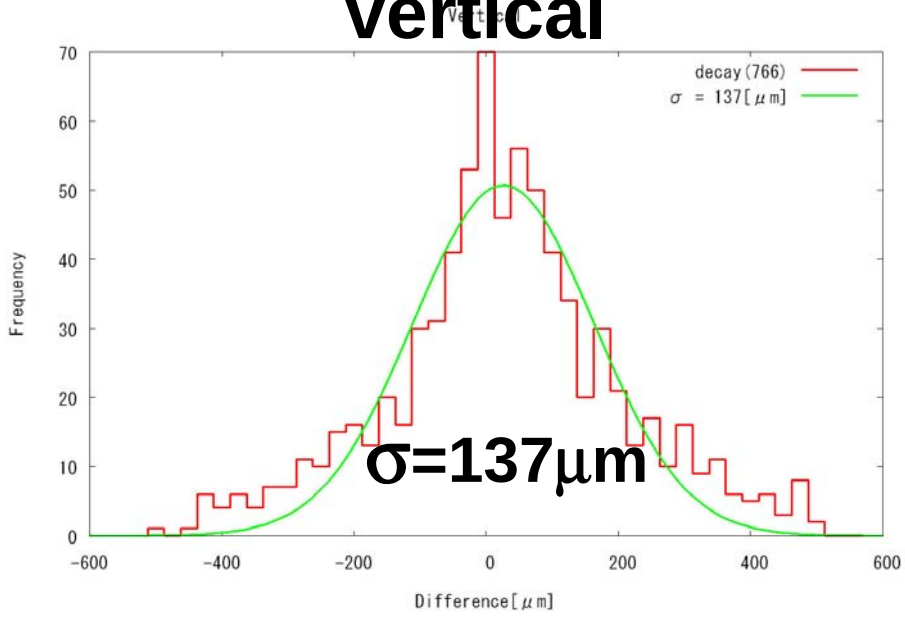
n p Λ

Decay events (all 766)

Horizontal

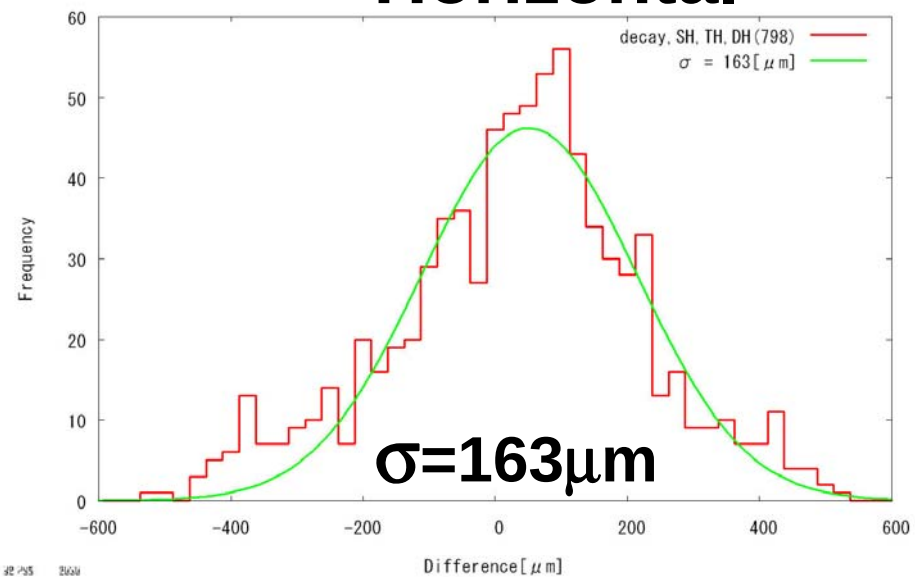


vertical

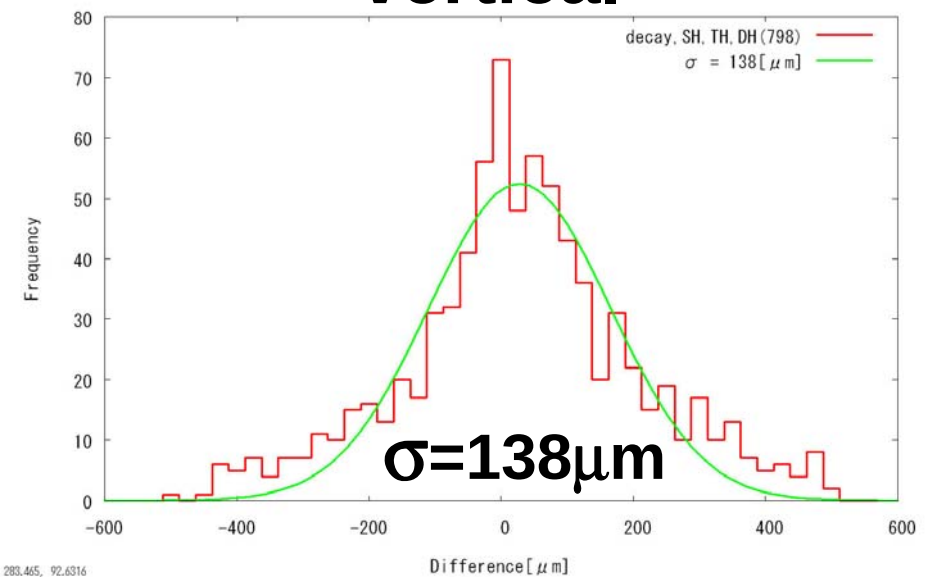


Decay events (766) / SH+TH+DH(32)

Horizontal



vertical



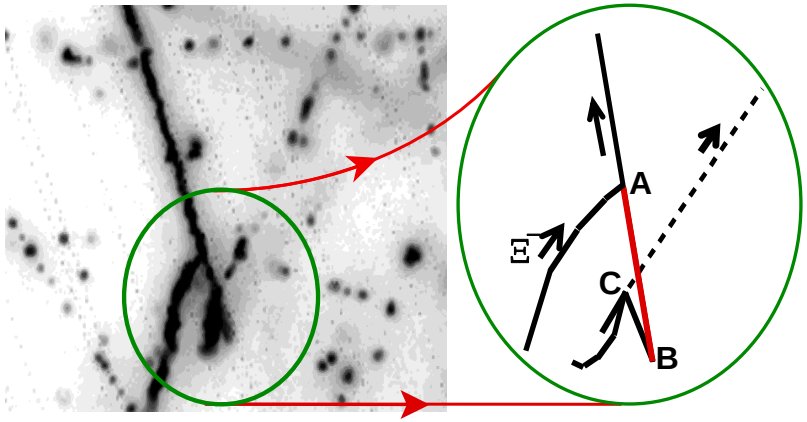
Double-Hypernuclei found by KEK-E373

- **47** single-hypernuclear events
  - ➔ ~ **600** events Ξ^- capture at rest
- 6 double-hypernuclei
- 2 twin-hypernuclei
- 1 Σ^-emission

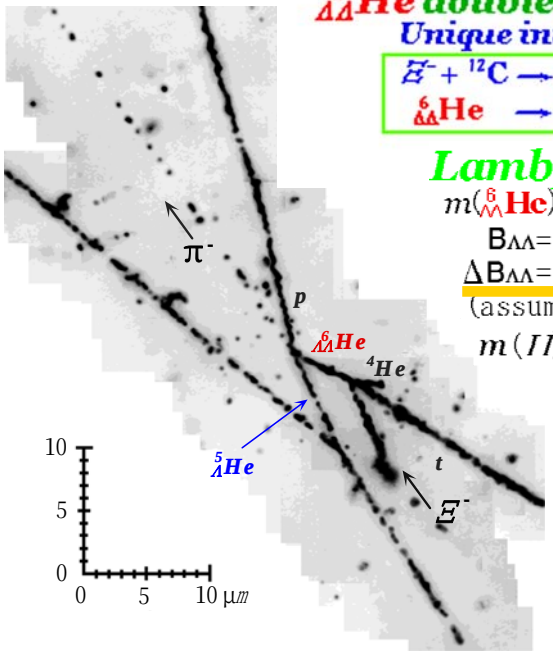
Demachi-yanagi event

* two body case at point A
$\Xi^- + {}^{12}C \rightarrow {}^{10}_{\Lambda\Lambda}Be + t$ or ${}^{10}_{\Lambda\Lambda}Be^* + t$

* three body case at point A
$\Xi^- + {}^{14}N \rightarrow {}^{13}_{\Lambda\Lambda}B + p + n$



NAGARA event



${}^{6}_{\Lambda\Lambda}He$ double-hypernucleus
Unique interpretation!!

$\Xi^- + {}^{12}C \rightarrow {}^{6}_{\Lambda\Lambda}He + {}^{4}He + t$
${}^{6}_{\Lambda\Lambda}He \rightarrow {}^{5}_{\Lambda}He + p + \pi^-$

Lambpha 87, 212502(2001)

$m({}^{6}_{\Lambda\Lambda}He) = 5951.82 \pm 0.54$MeV
$B_{\Lambda\Lambda} = 7.25 \pm 0.19^{+0.18}_{-0.11}$MeV
$\Delta B_{\Lambda\Lambda} = 1.01 \pm 0.20^{+0.18}_{-0.11}$MeV
(assumed $B_{\Xi^-} = 0.13$ MeV)
$m(H) \geq 2223.7$ MeV/c^2
(90% C.L.)

$\Delta B_{\Lambda\Lambda}$: $\Lambda\Lambda$ Interaction Energy

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

Found

Weakly attractive $\Lambda\Lambda$ Interaction *!*

Hybrid Method ==> Reliable