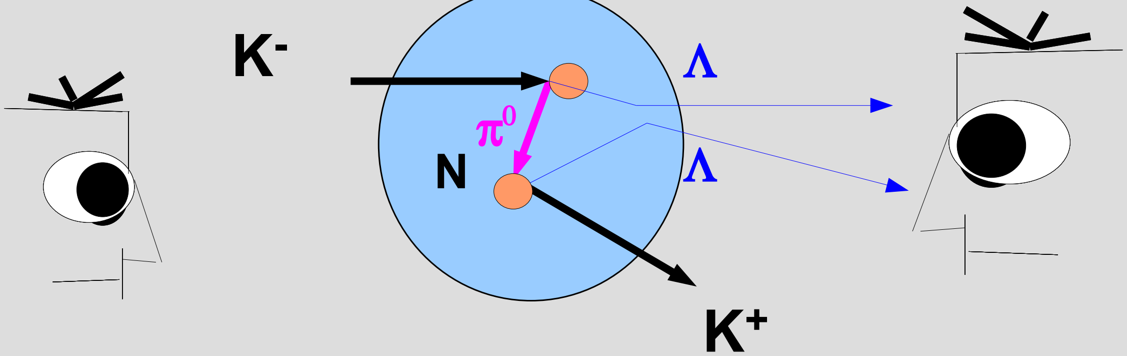
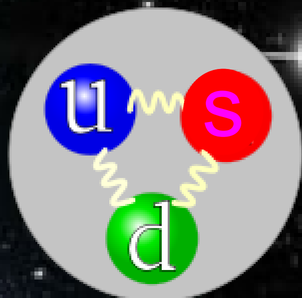
Probing ΛΛ potential

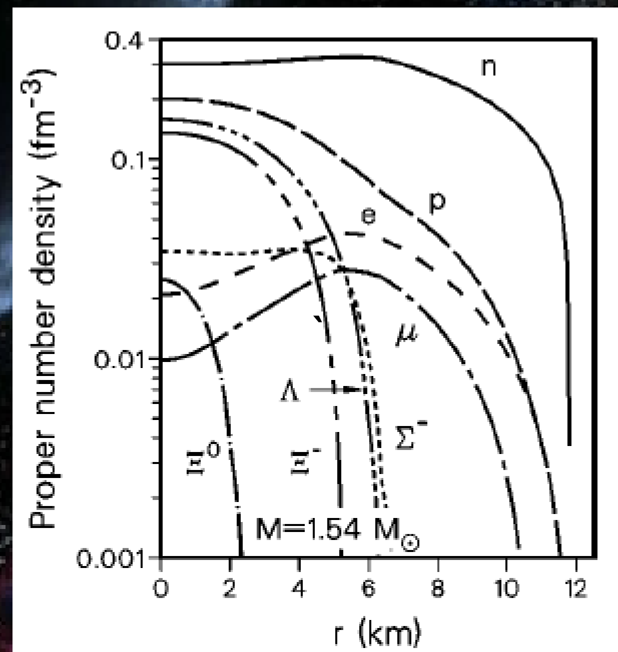
YOON CHOONGJAE,
RCNP, Osaka U

For KEK-PS E522 Collaboration

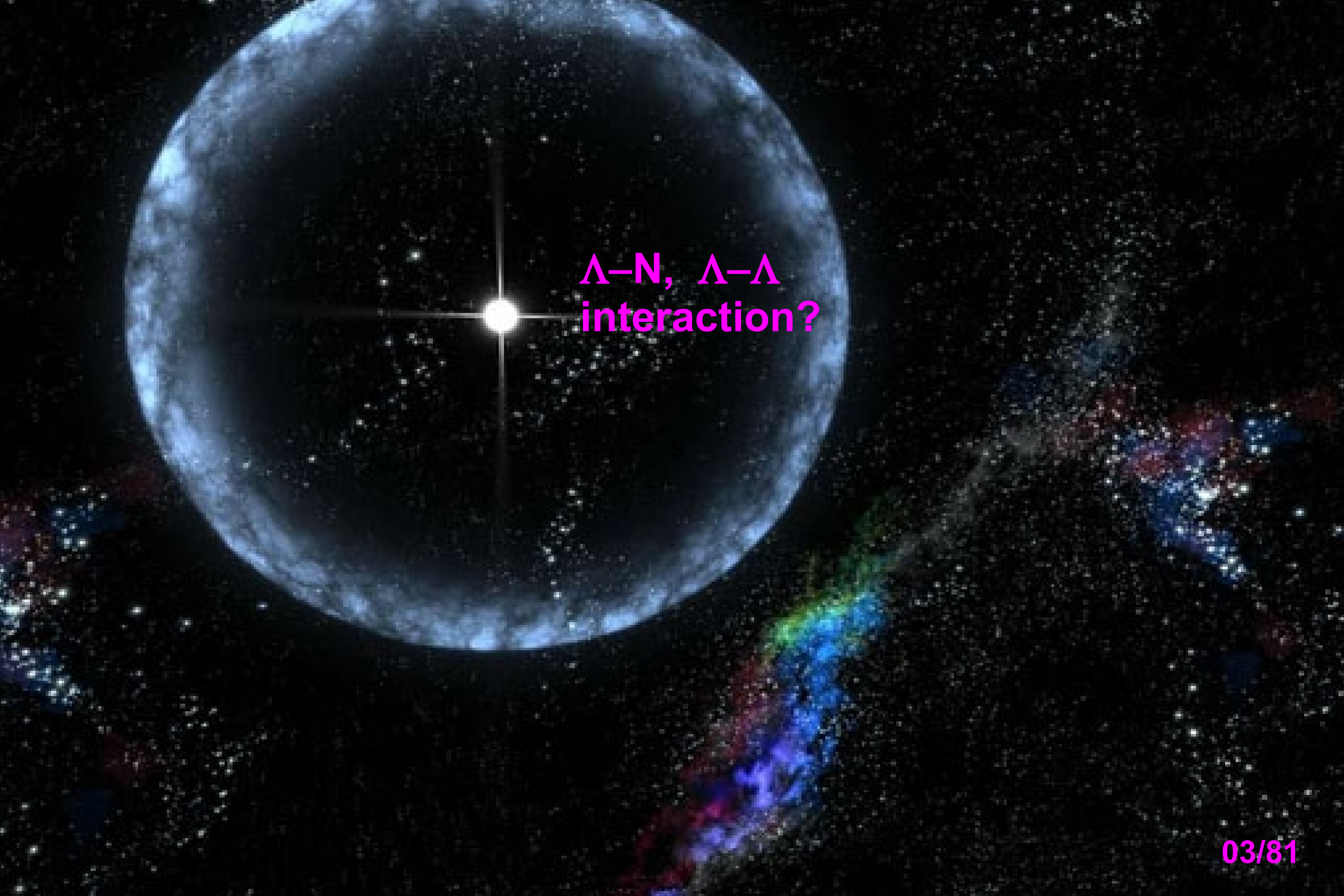


Λ–hyperon?

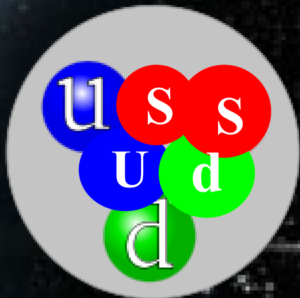




Norman K. Glendenning et al.,
Phys. Rev.C 58(1998)1298


Λ–N, Λ–Λ
interaction?

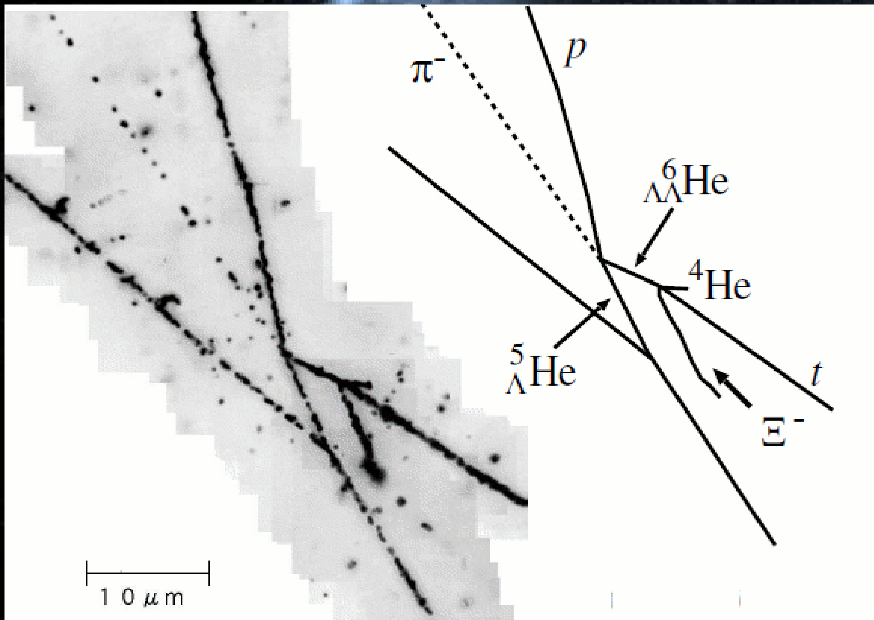
Λ–Λ interaction?



H-dibaryon;
flavor singlet (uuddss),
J=0.

$$H_m = -(\alpha_s / R) \sum \sum (\sigma_i \lambda_i^a)(\sigma_j \lambda_j^a) \bar{M}(m_i R, m_j R)$$

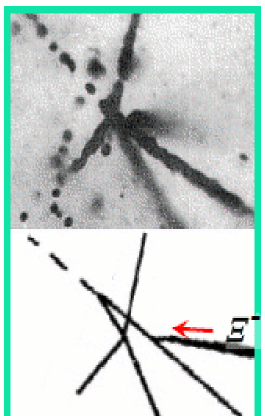
H.Takahashi et al.(KEK-PS E373),
Phys. Rev. Lett. 87, 212502(2002).



$\Delta B_{\Lambda\Lambda}(^{6}_{\Lambda\Lambda}He)$= 1.01± 0.20 MeV
(first publication)

0.55± 0.91 (with new Ξ^- mass),
0.67± 0.17 MeV (Ξ^- atomic-N, 3D)
(recent reanalysis.)

S. Aoki et al. (KEK-PS E176),
Nucl. Phys. A 828, 191(2009).



K.Nakazawa (HYP 2009)

most probable case

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

$^{13}_{\Lambda\Lambda}B \Rightarrow {}^{13}_{\Lambda}C^* + \pi^-$: Ex = 4.9 MeV

$^{13}_{\Lambda\Lambda}$B

$B_{\Lambda\Lambda}$ = 23.3 +/- 0.7 MeV
$\Delta B_{\Lambda\Lambda}$ = 0.6 +/- 0.8 MeV

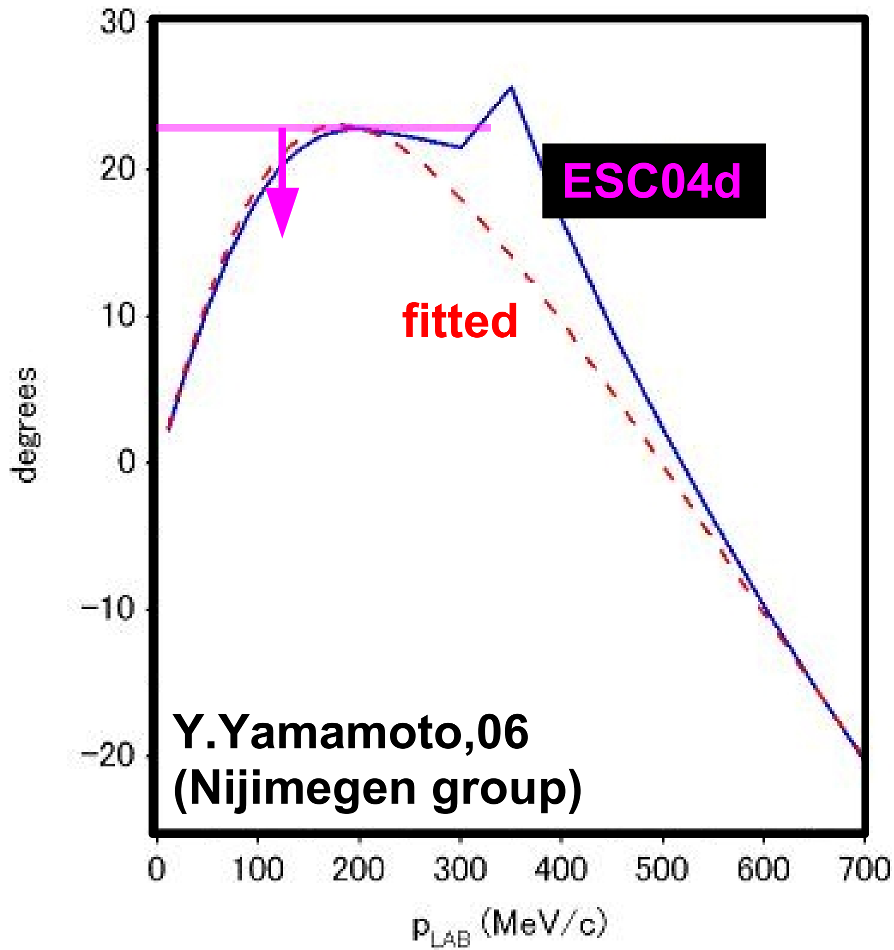
[Assumption]
B_{Ξ^-} = 0.17 MeV (atomic **3D** in $^{14}N-\Xi^-$)

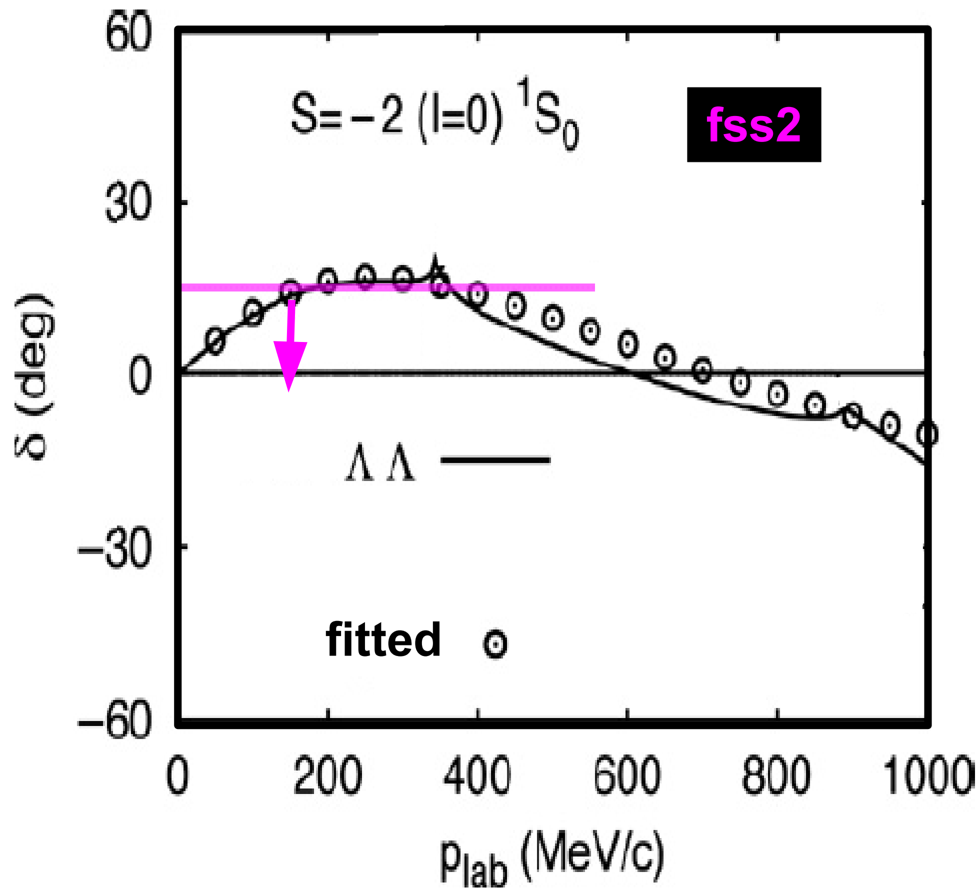
$\Delta B_{\Lambda\Lambda}(^{13}_{\Lambda\Lambda}B)$= 0.6 ± 0.8 MeV
(recent reanalysis.)

Y. Fujiwara et al.,
Prog. Part. Phys. 58, 439(2007)

Phase shifts;

Motivated by result from $\Delta B_{\Lambda\Lambda}({}_{\Lambda\Lambda}^{6}He)$ ~1.01 MeV





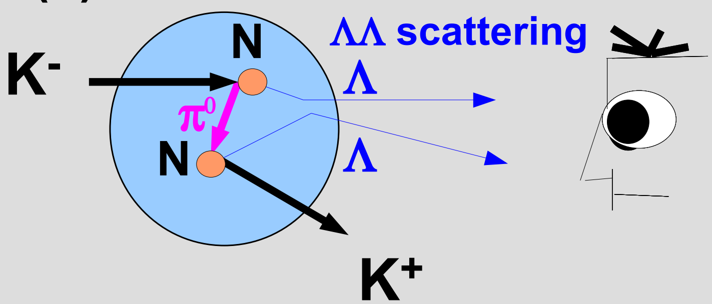
Enhanced ΛΛ production

J.K. Ahn et al. (KEK-PS E224),
Phys. Lett. B444 (1998)267

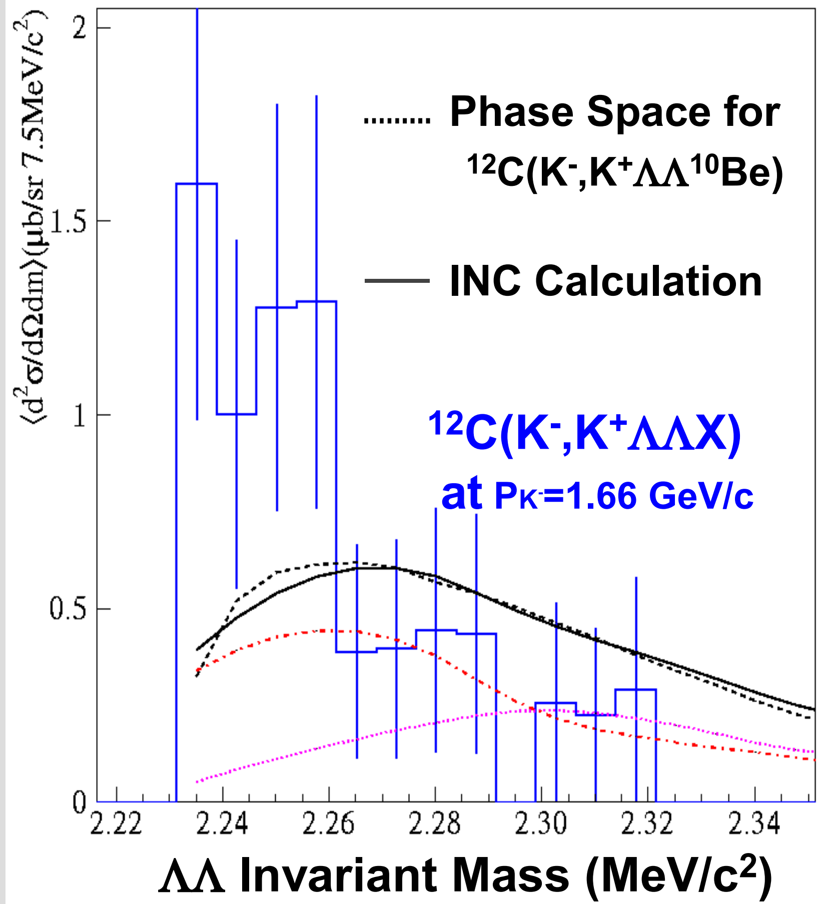
Possible Interpretations

(1) H-dibaryon as ΛΛ resonance;
$K^-p \to \Xi^- K^+$, $\Xi^-(p) \to H$

(2) ΛΛ final state interaction (FSI)



(3) Both ?



ΛΛ Invariant Mass (MeV/c²)

Enhanced ΛΛ production

J.K. Ahn et al. (KEK-PS E224), Phys. Lett. B444 (1998)267

Possible Interpretations

(1) H-dibaryon as ΛΛ resonance;
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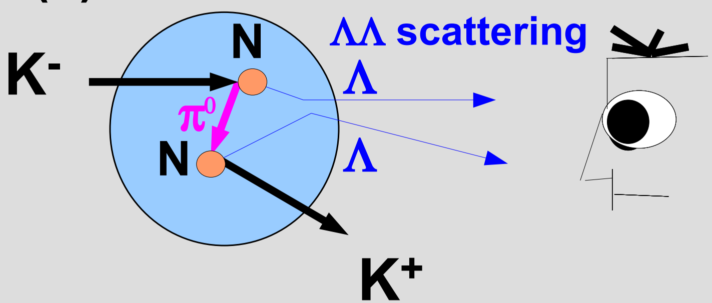
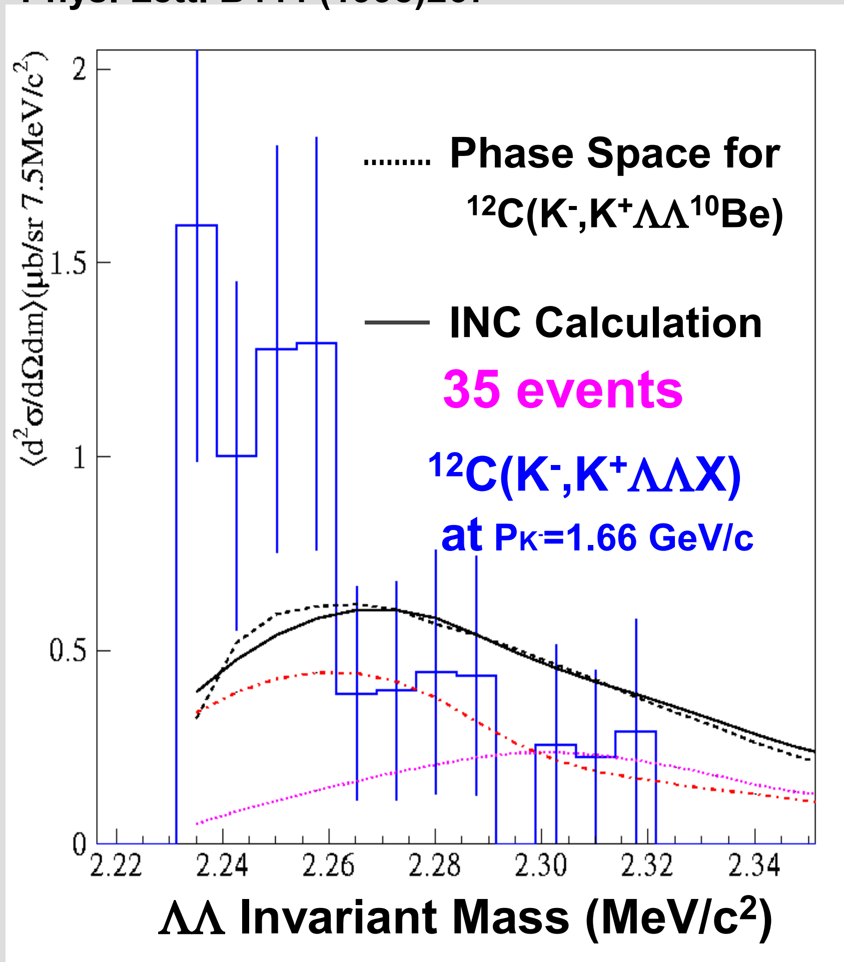


(3) Both ?



This seminar; continued exp./theo. studies on the ΛΛ invariant mass spectrum

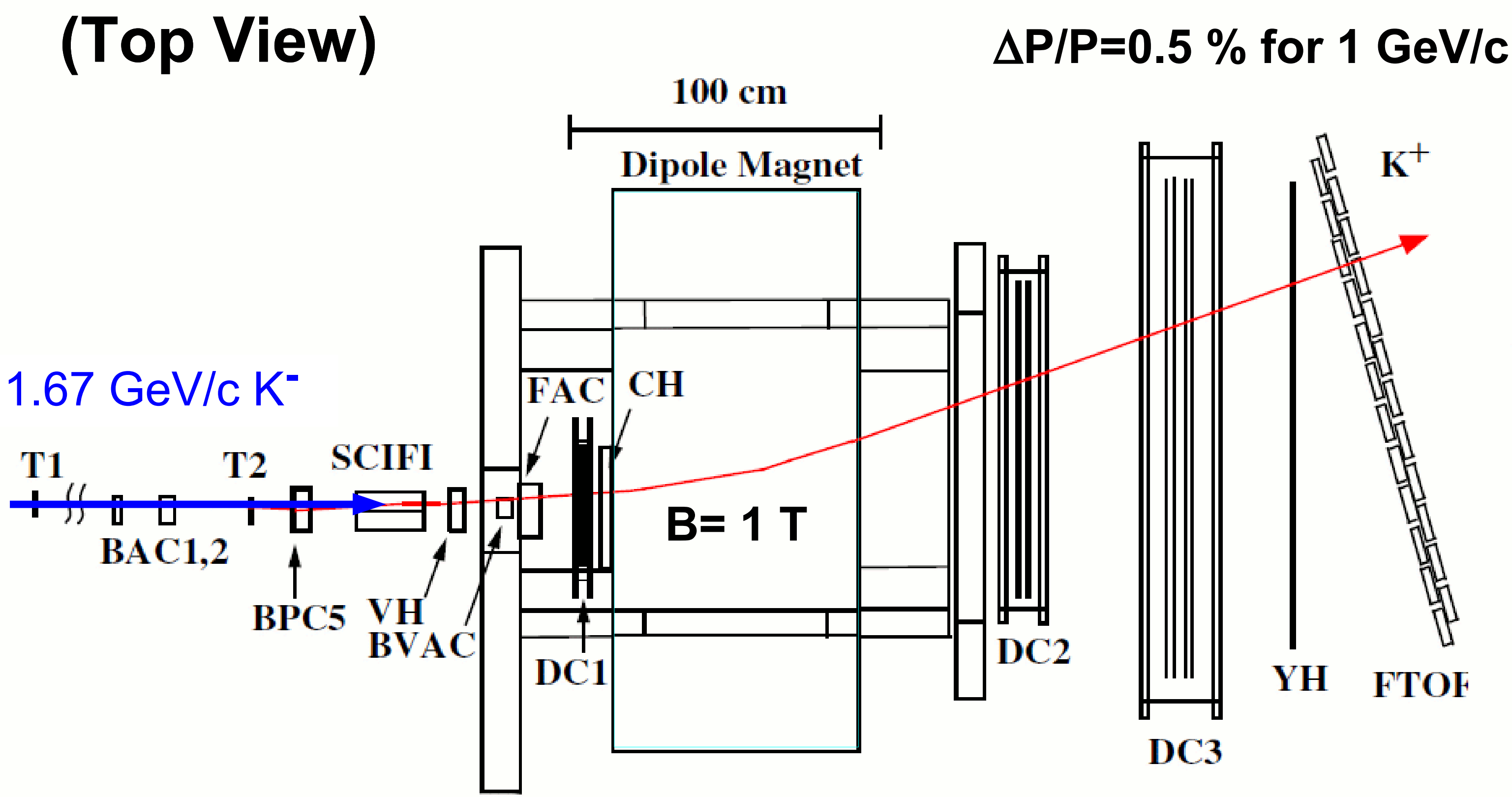
(1) ΛΛ events; Doubled statistics (E522),

(2) ΛΛ mass spectrum will be compared
with model calculations including ΛΛ FSI's,
which are consistent with first published result of $_{\Lambda\Lambda}{}^{6}$He.

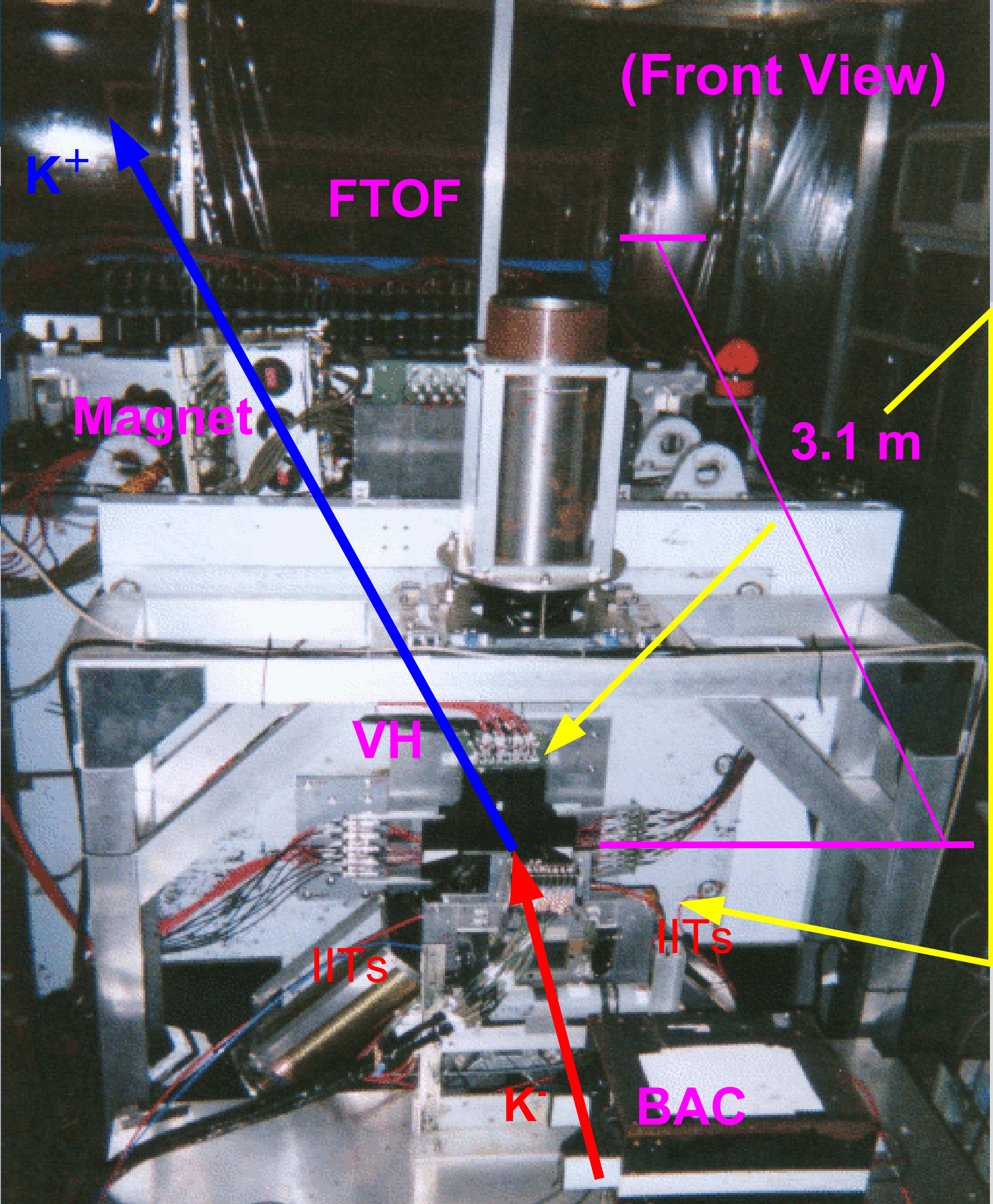
(3) ΛΛ-scattering parameters.

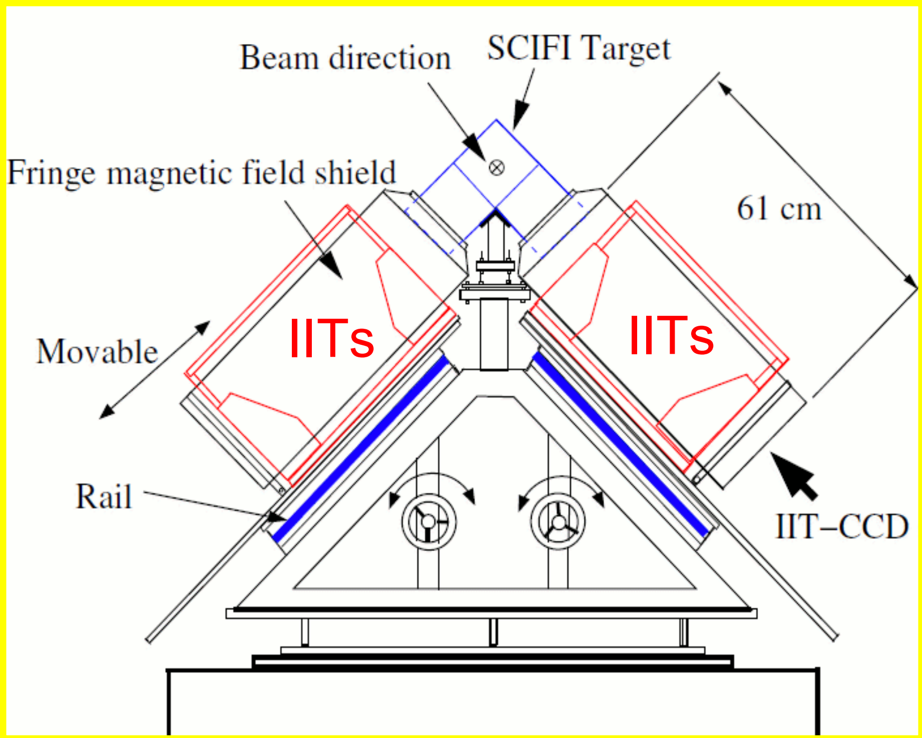
(4) Phenomenological ΛΛ potential.

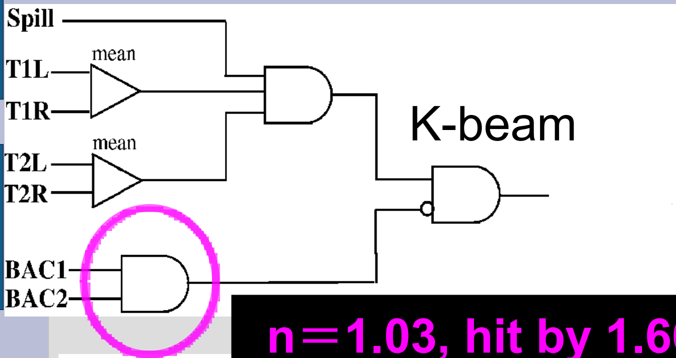
Layout of Experimental Setup at KEK-12 GeV PS (E522)



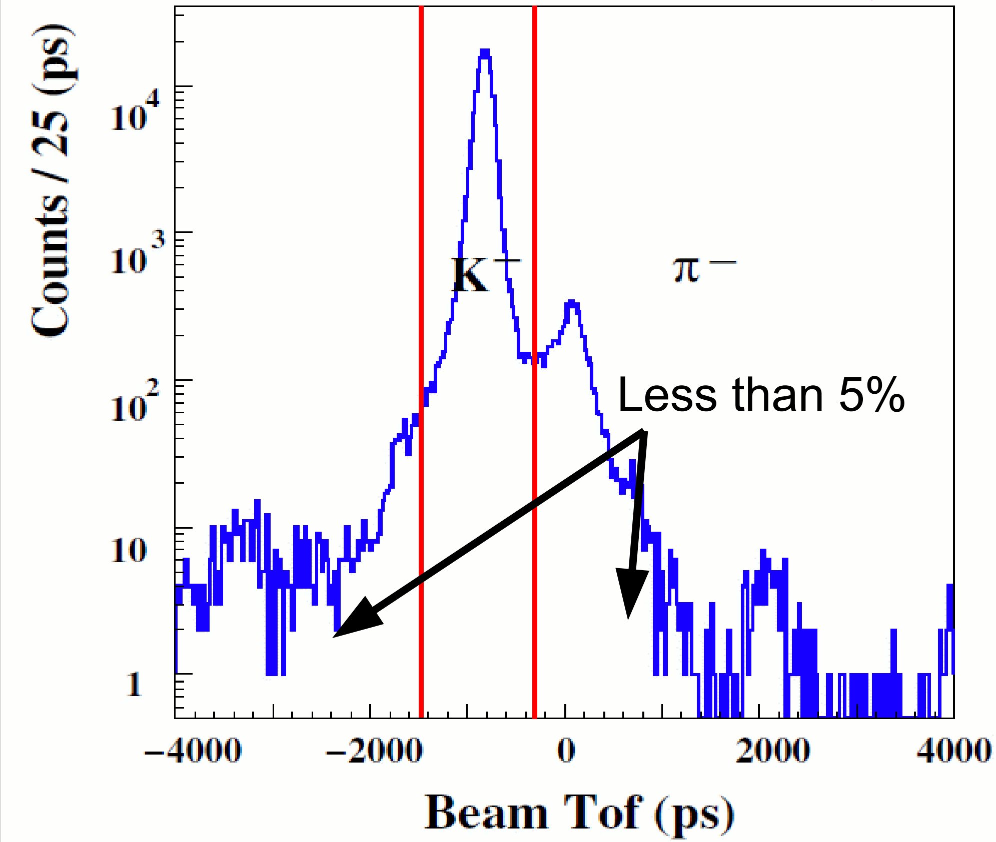
K+ Spectrometer

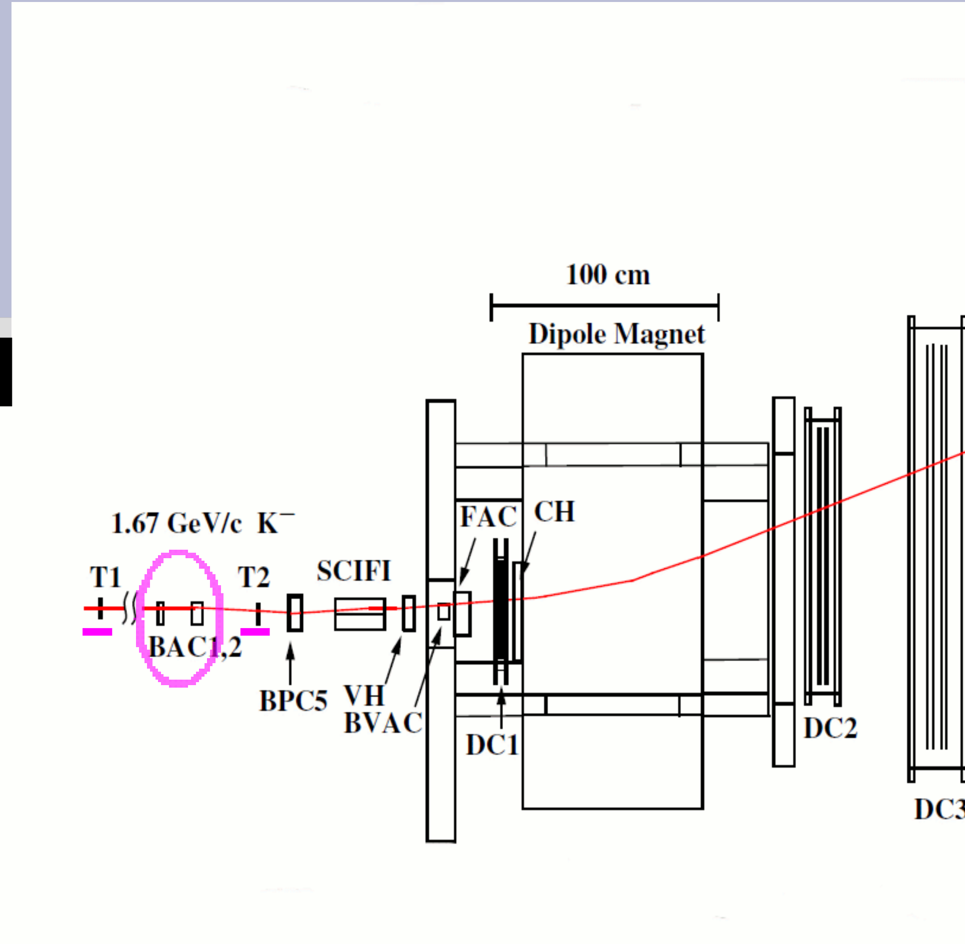

(Front View)
K+
FTOF
Magnet
3.1 m
VH
IITs
IITs
K-
BAC

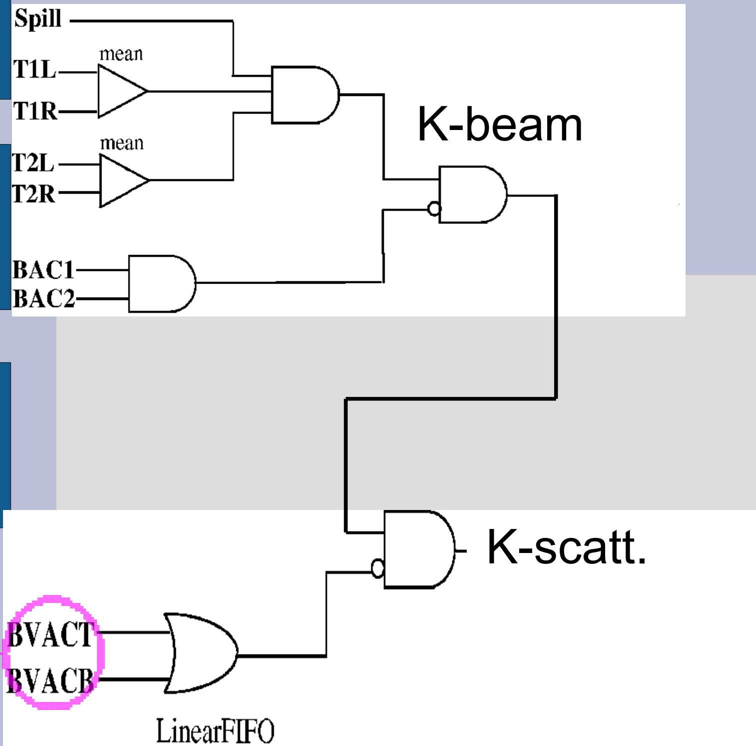

Beam direction
SCIFI Target
Fringe magnetic field shield
61 cm
Movable
IITs
IITs
Rail
IIT−CCD

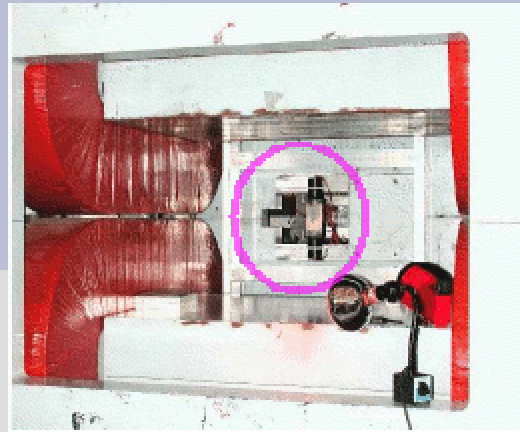


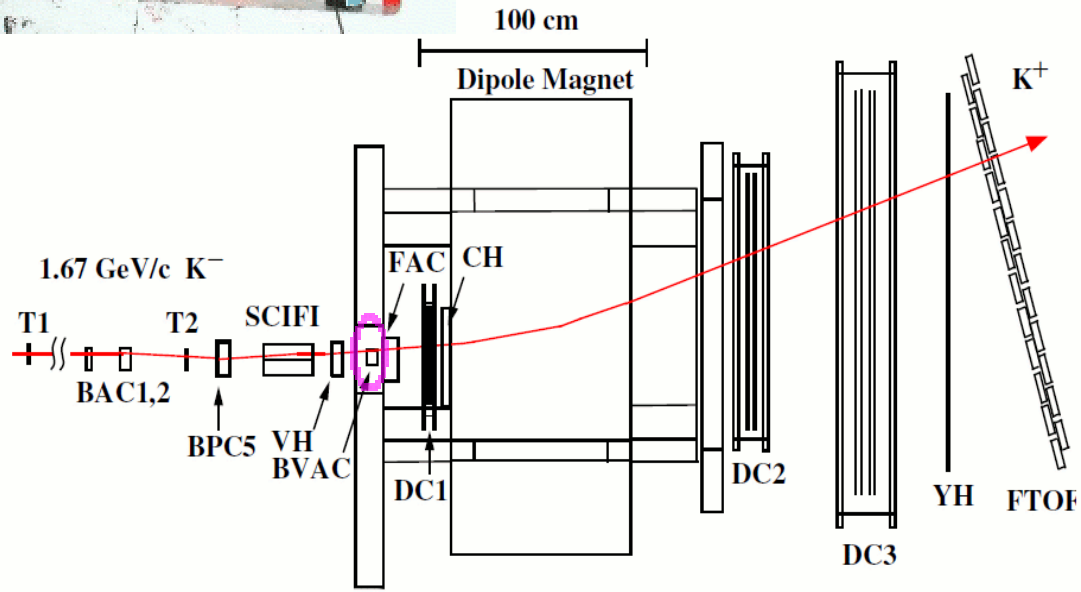
n=1.03, hit by 1.66 GeV/c π , μ, e.



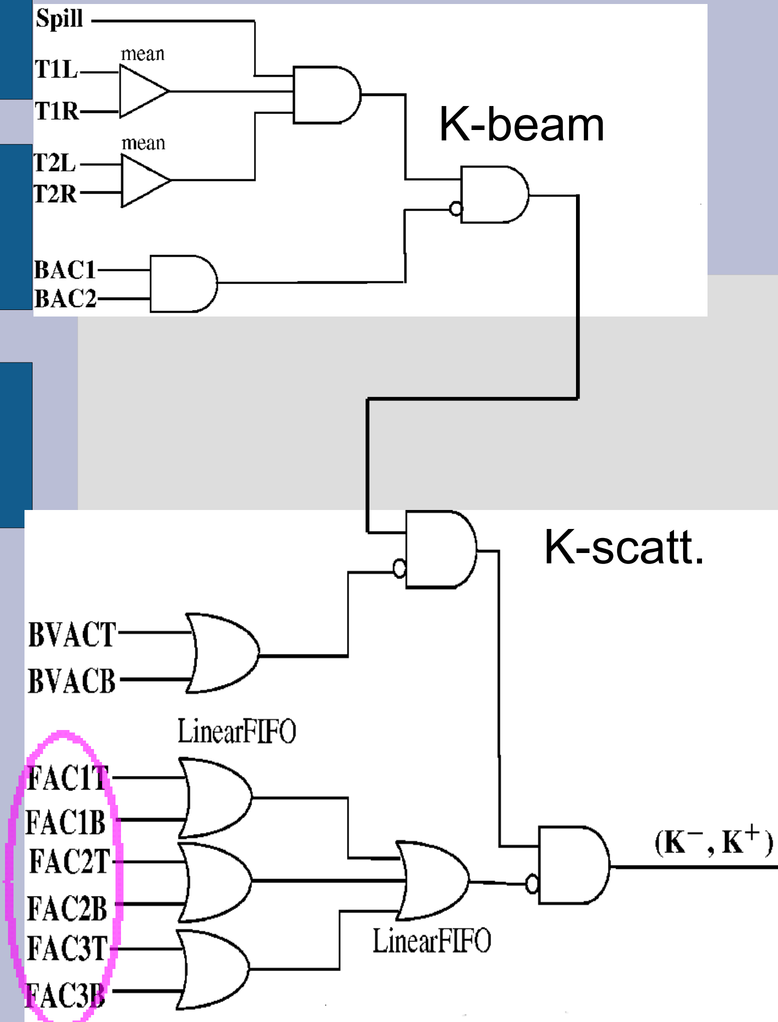




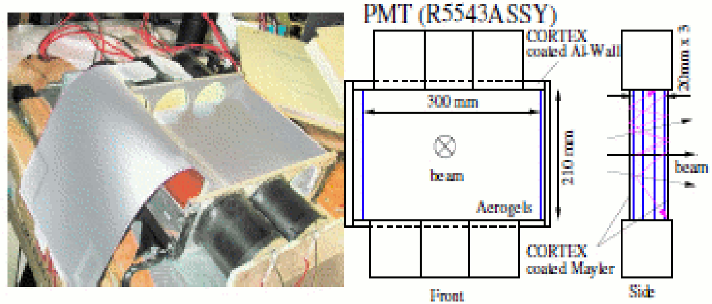


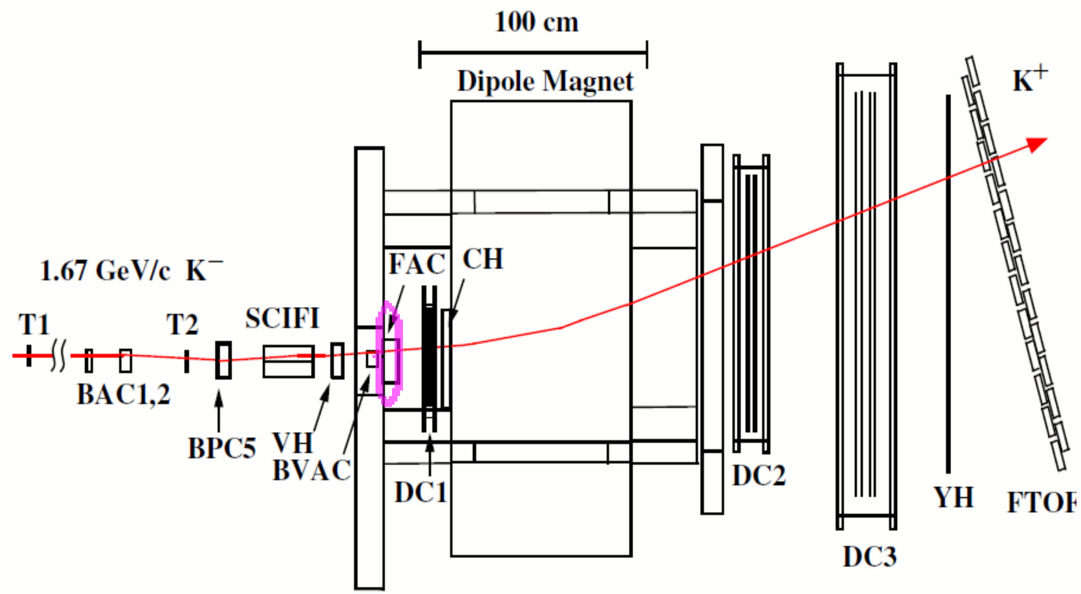


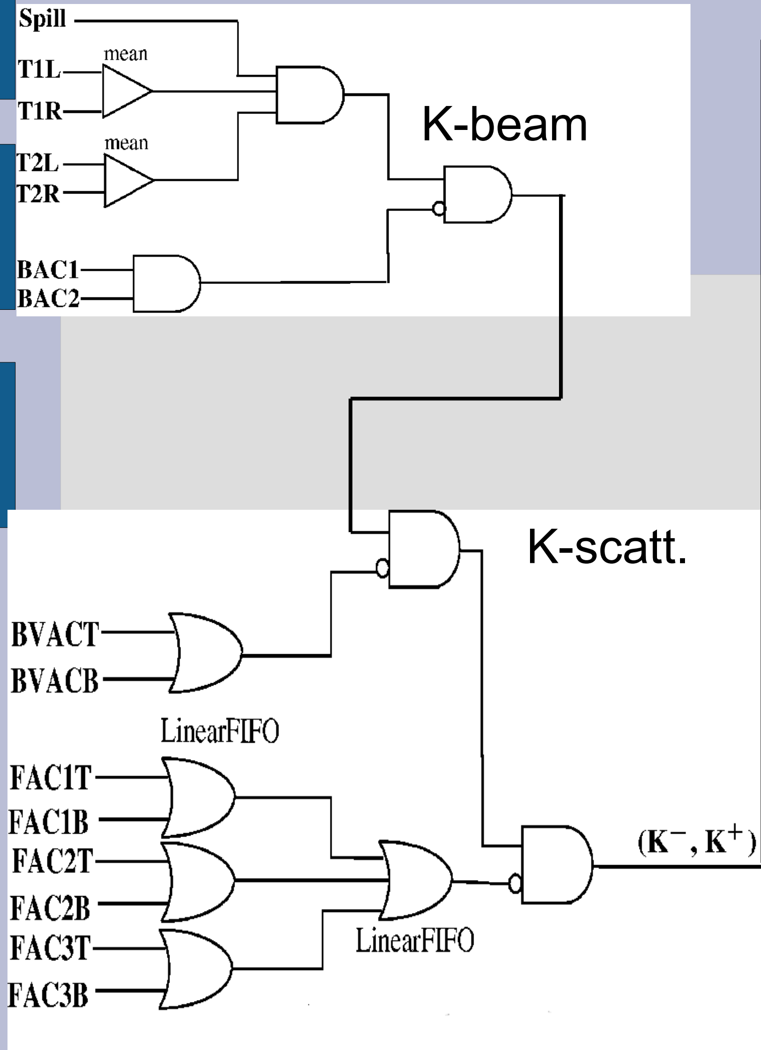
n = 1.05,
hit by 1.66 GeV/c K^-



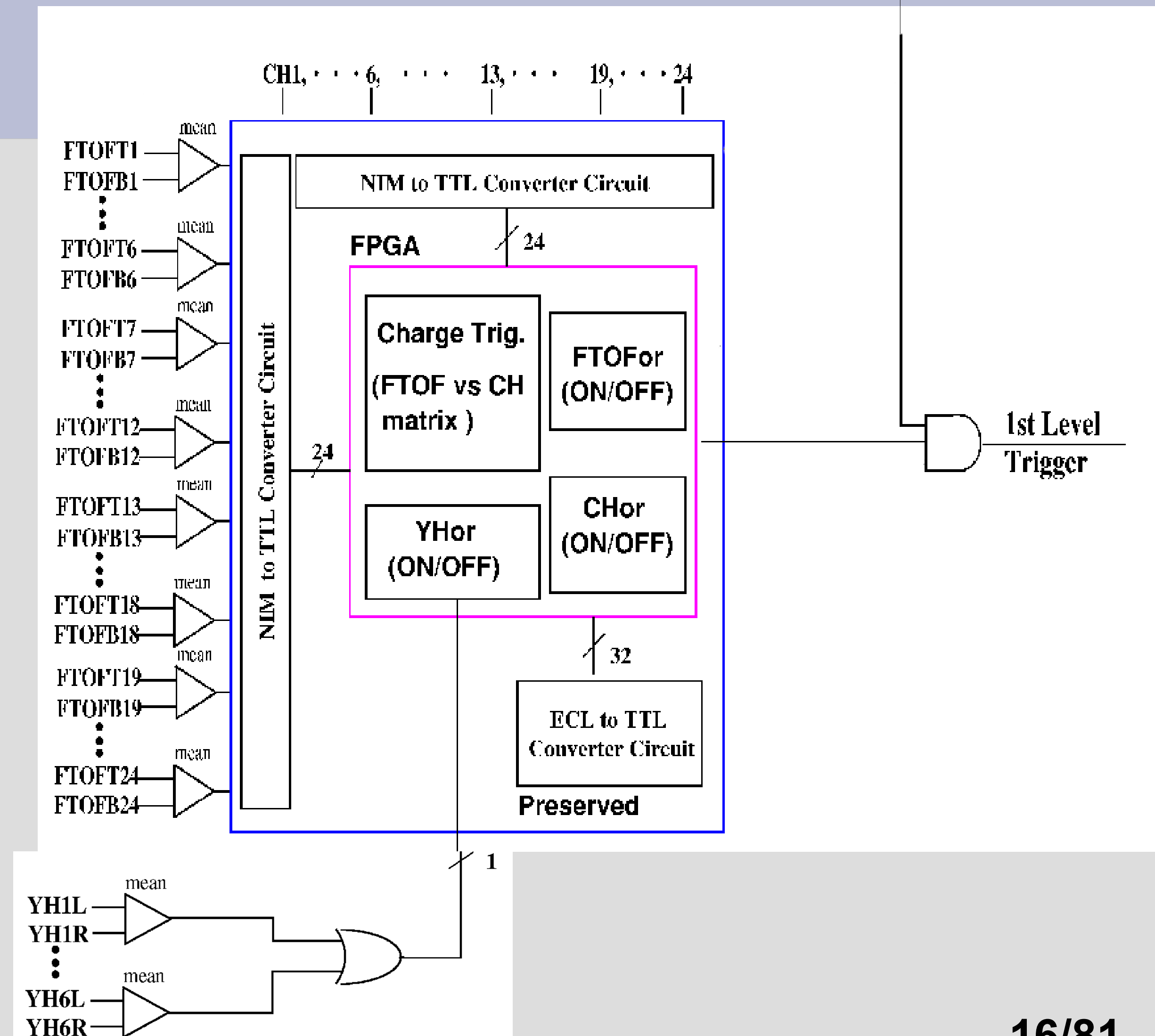
n=1.04,
hit by scattered π

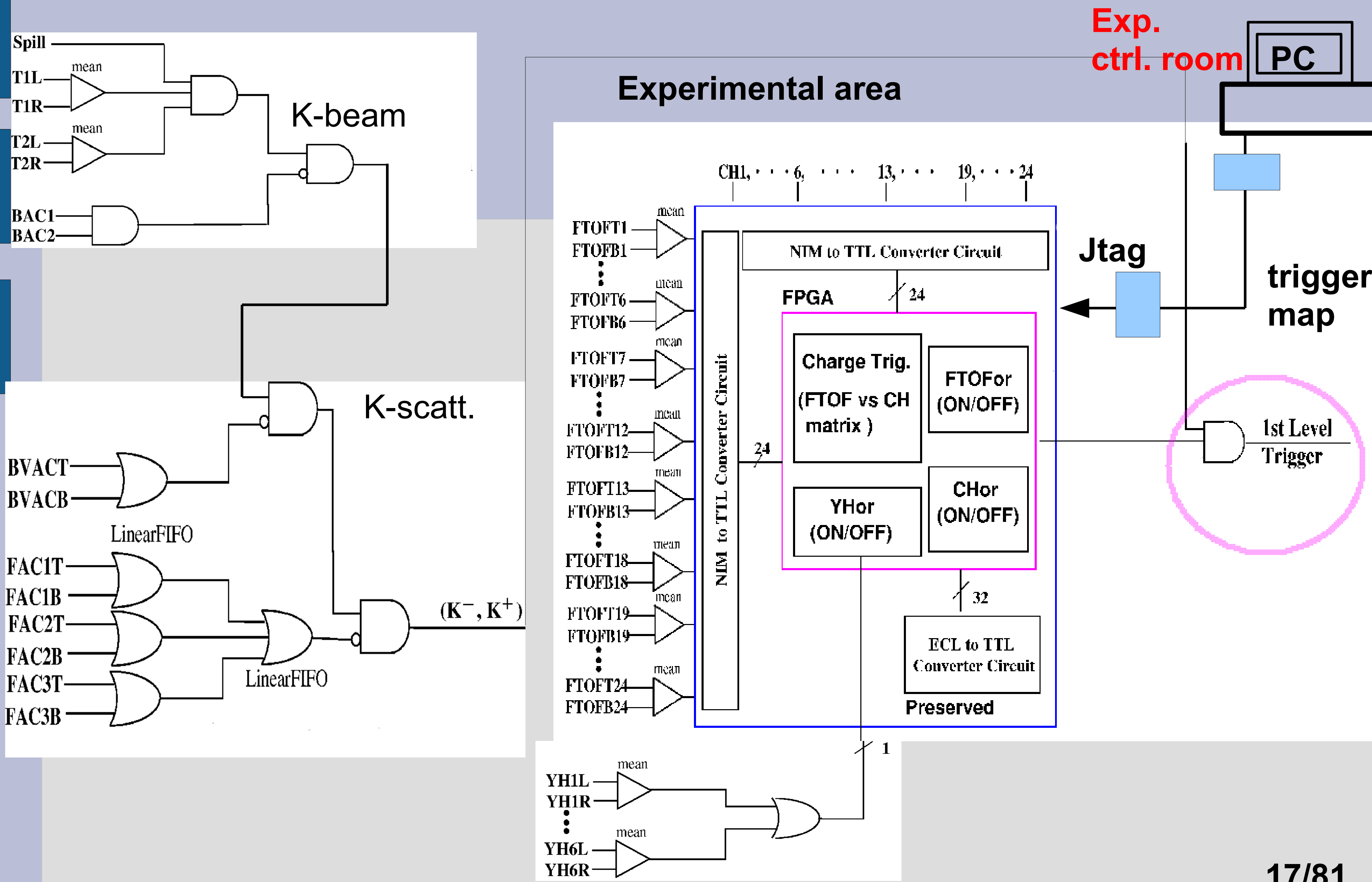


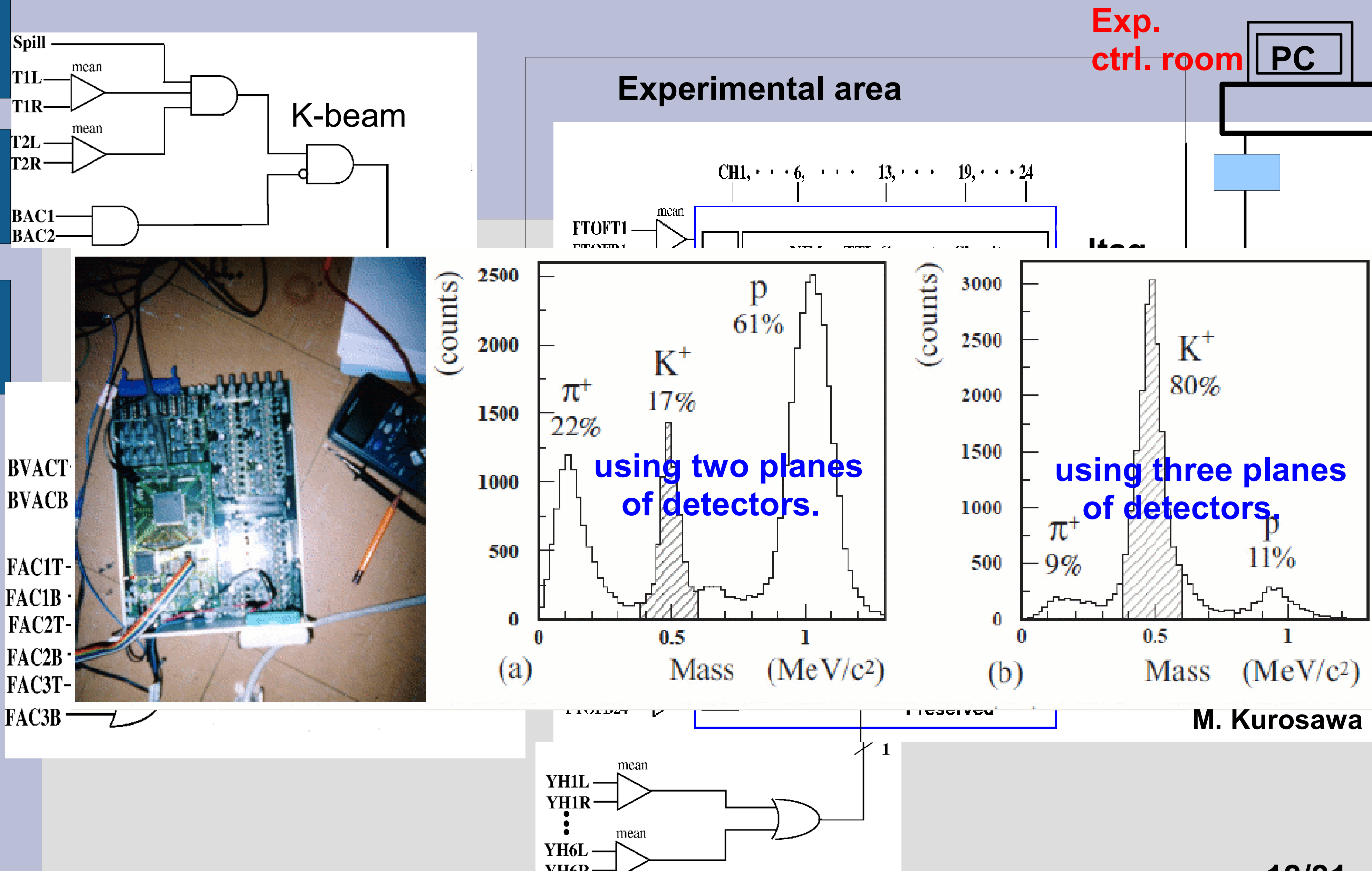




Experimental area



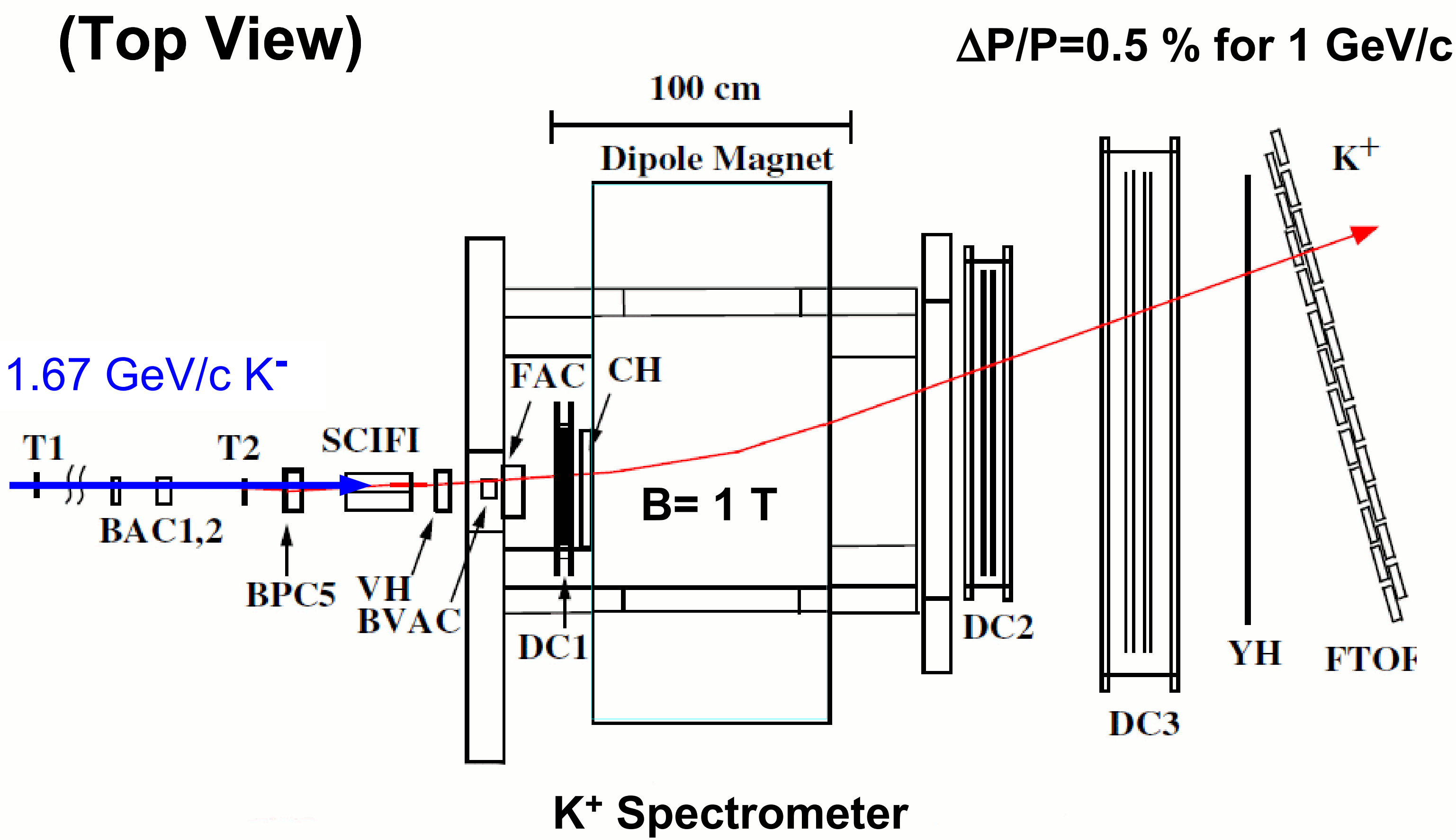

Exp.
ctrl. room
PC
Experimental area
K-beam
Spill
T1L
T1R
mean
T2L
T2R
mean
BAC1
BAC2
K-scatt.
BVACT
BVACB
LinearFIFO
FAC1T
FAC1B
FAC2T
FAC2B
FAC3T
FAC3B
LinearFIFO
(K^-, K^+)
CH1, · · · 6, · · · 13, · · · 19, · · · 24
FTOFT1
FTOFB1
FTOFT6
FTOFB6
FTOFT7
FTOFB7
FTOFT12
FTOFB12
FTOFT13
FTOFB13
FTOFT18
FTOFB18
FTOFT19
FTOFB19
FTOFT24
FTOFB24
NIM to TTL Converter Circuit
NIM to TTL Converter Circuit
24
FPGA
24
Charge Trig.
(FTOF vs CH
matrix)
FTOFor
(ON/OFF)
YHor
(ON/OFF)
CHor
(ON/OFF)
32
ECL to TTL
Converter Circuit
Preserved
Jtag
trigger
map
1st Level
Trigger
1
YH1L
YH1R
mean
YH6L
YH6R
mean



M. Kurosawa

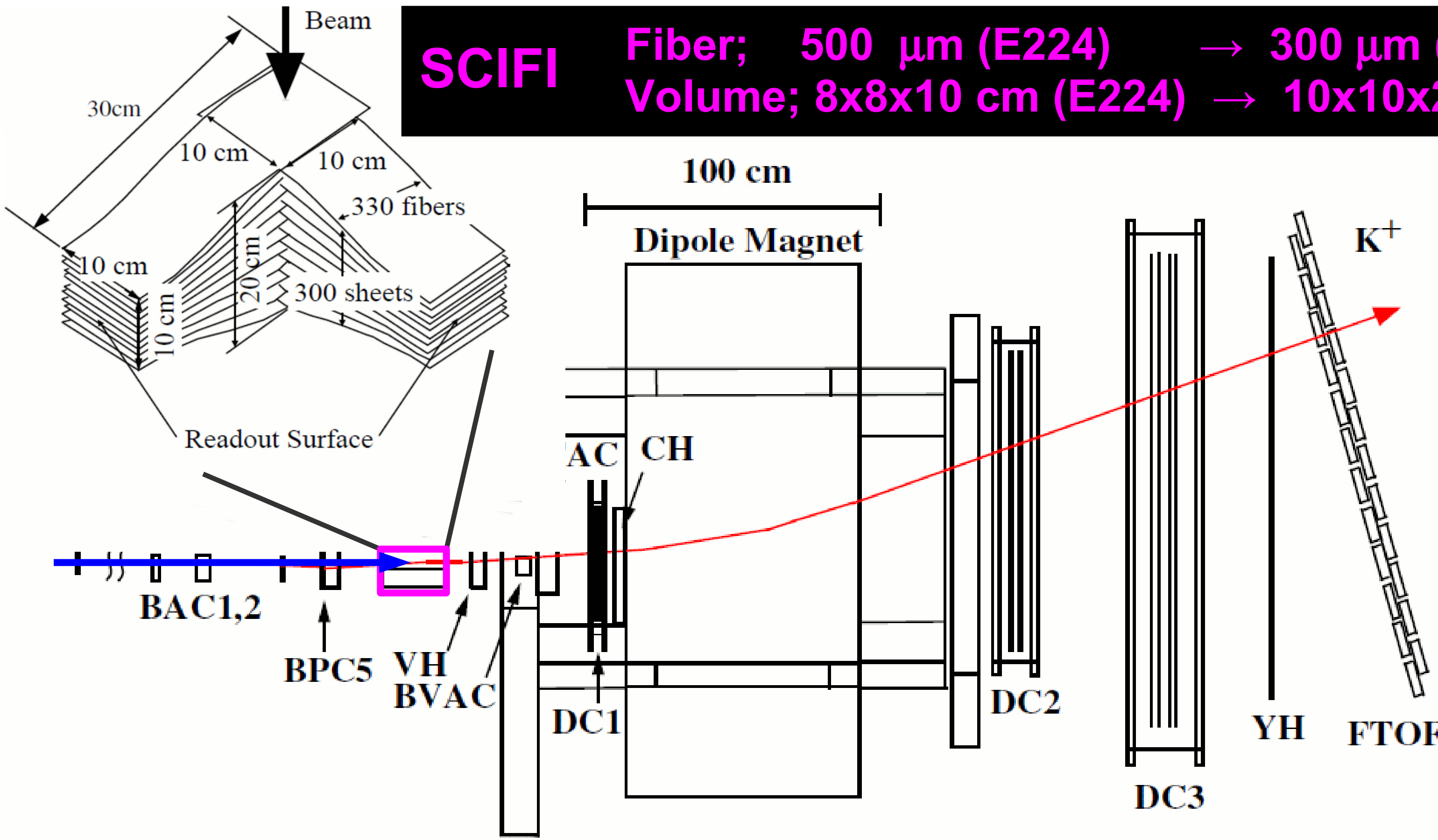
Used in (π^-,K^+) reaction experiment, E452.

Layout of experimental setup at KEK-12 GeV PS (E522)



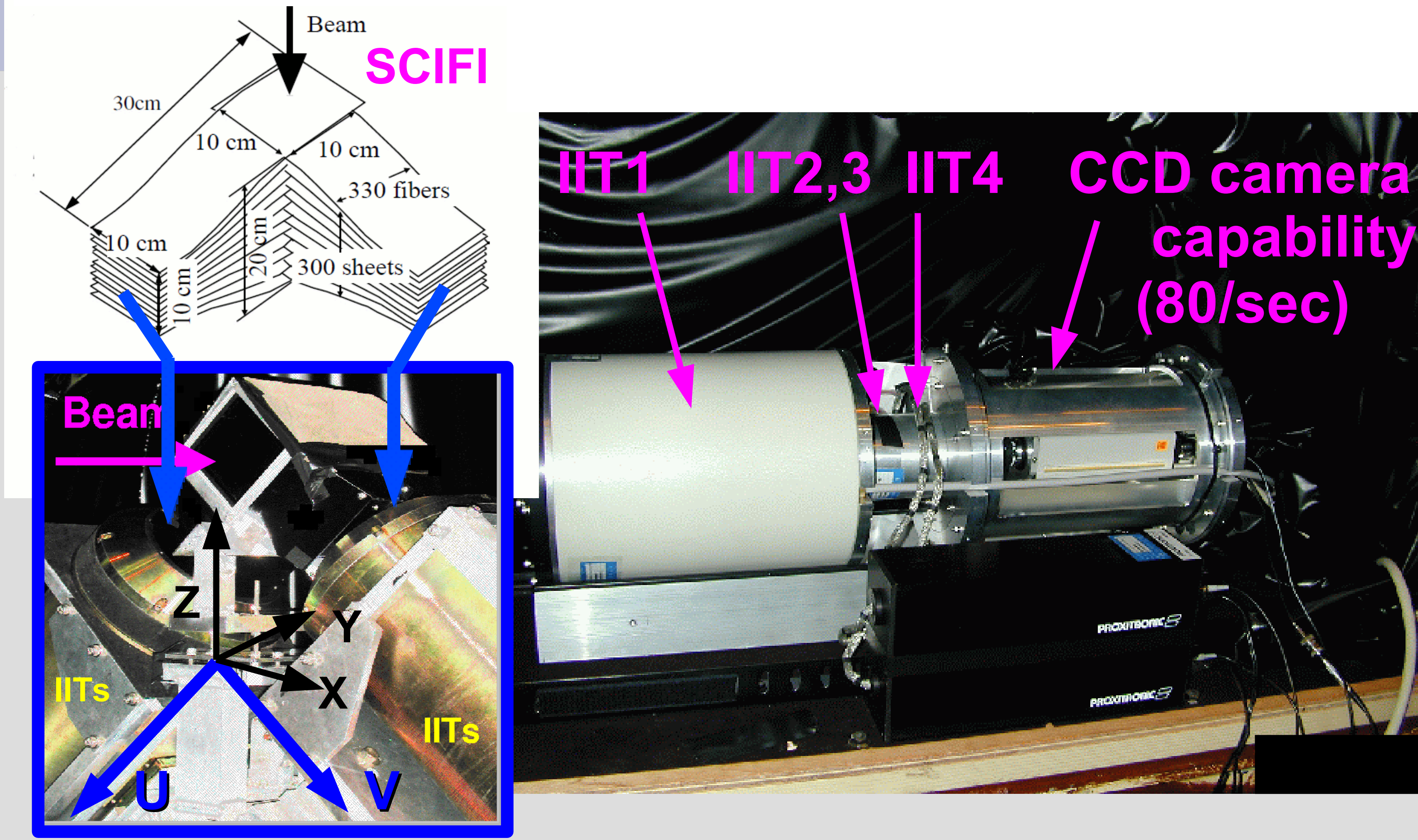
Layout of experimental setup at KEK-12 GeV PS (E522)

SCIFI Fiber; 500 μm (E224) → 300 μm (E522)
Volume; 8x8x10 cm (E224) → 10x10x20cm (E522)

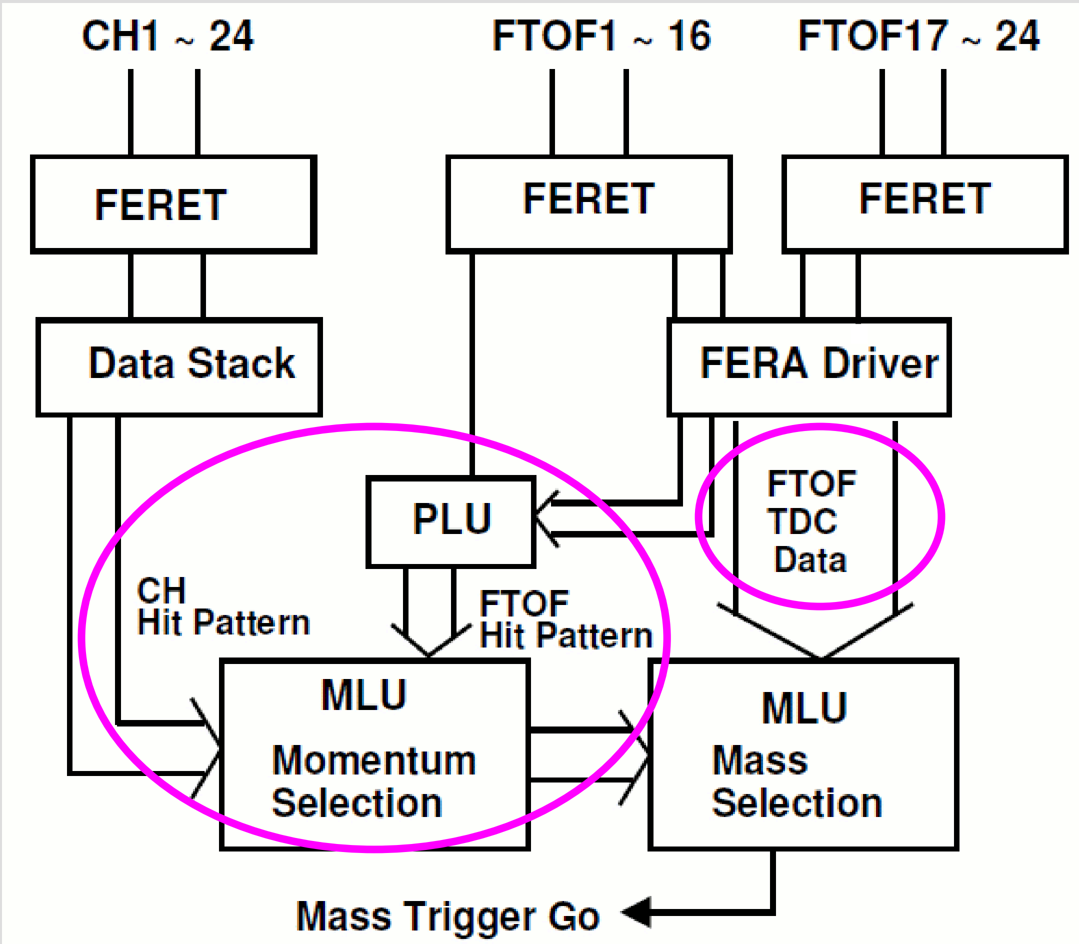


K+ Spectrometer

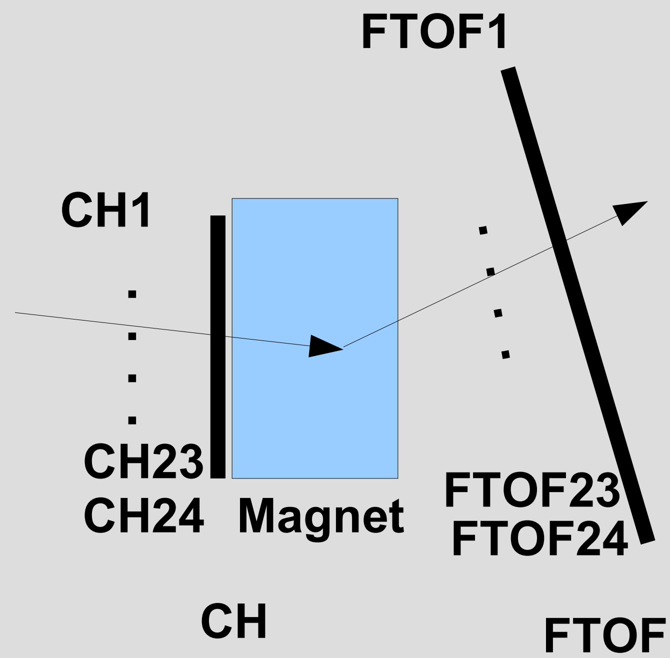
Readout of the SCIFI target



Conceptual drawing of 2nd level trigger (=Mass Trigger)

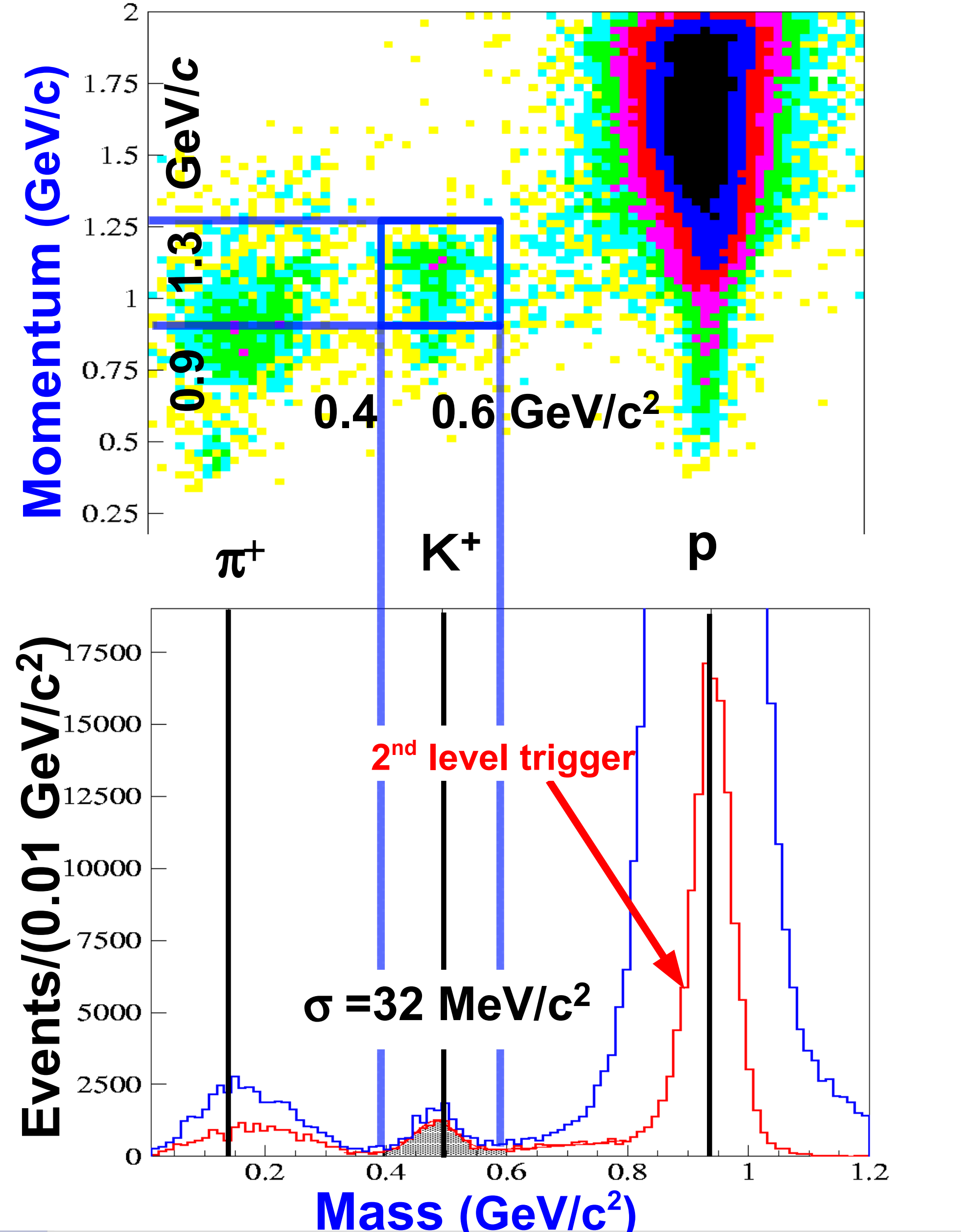


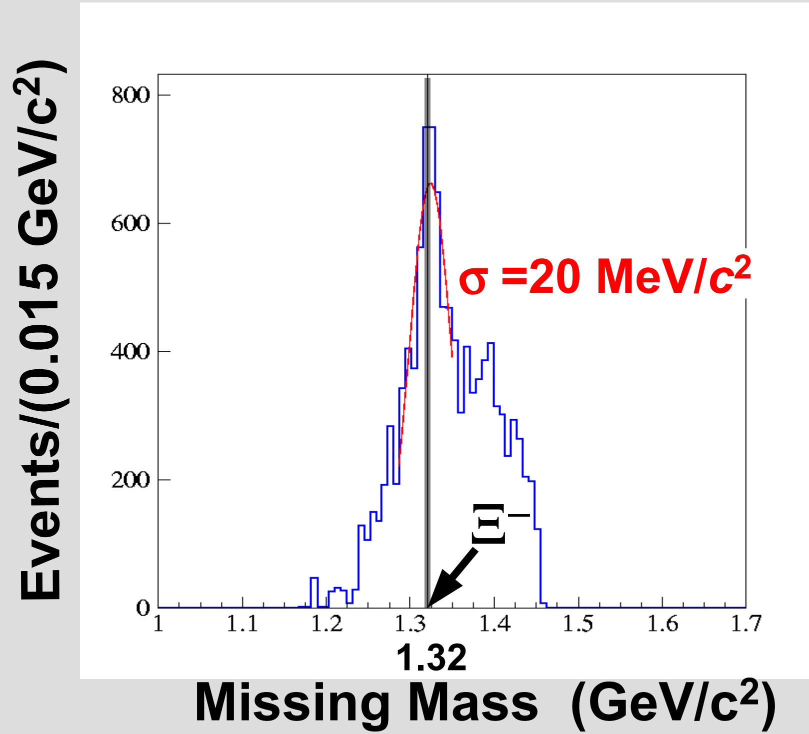
(30 events/sec)

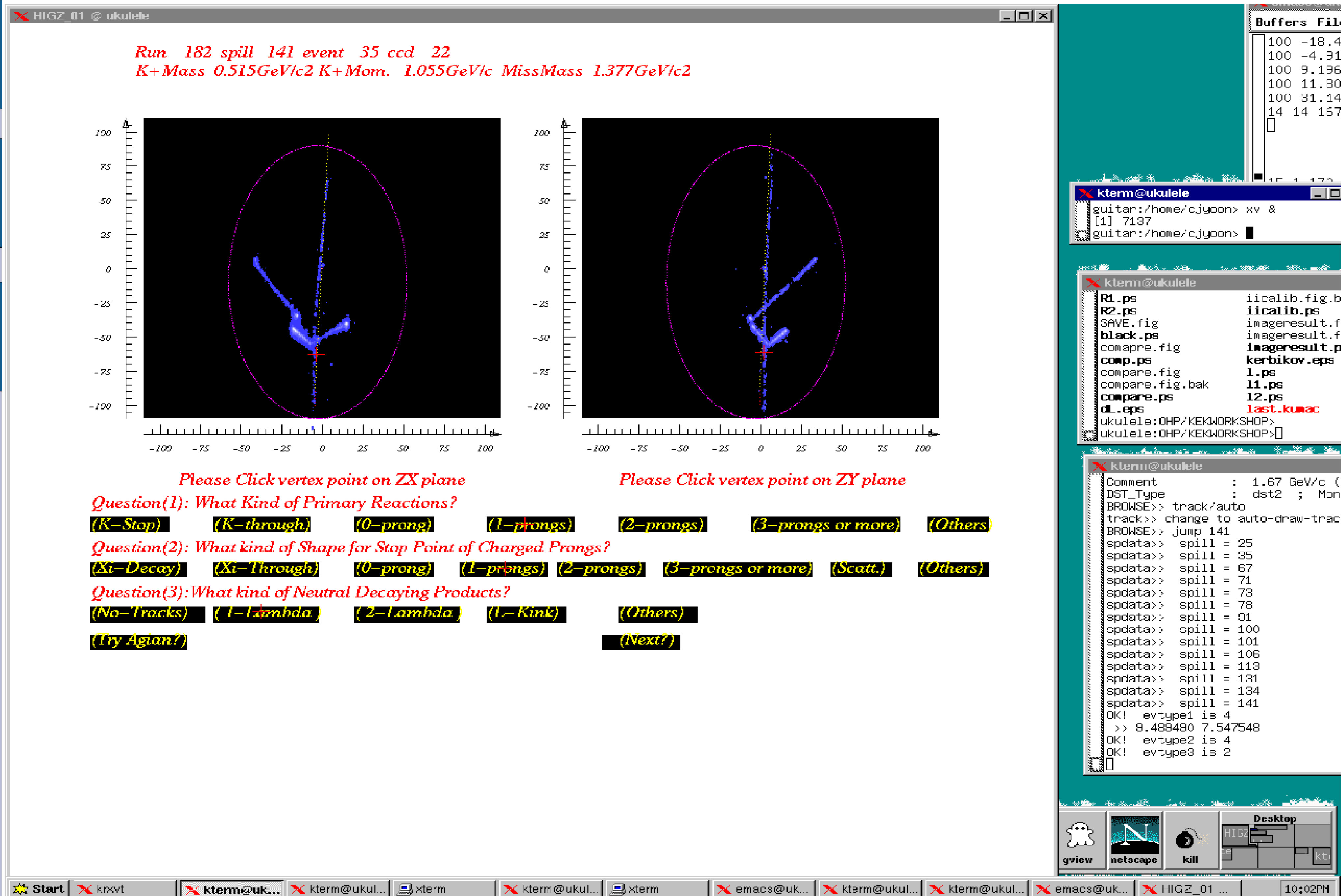


Obtained data

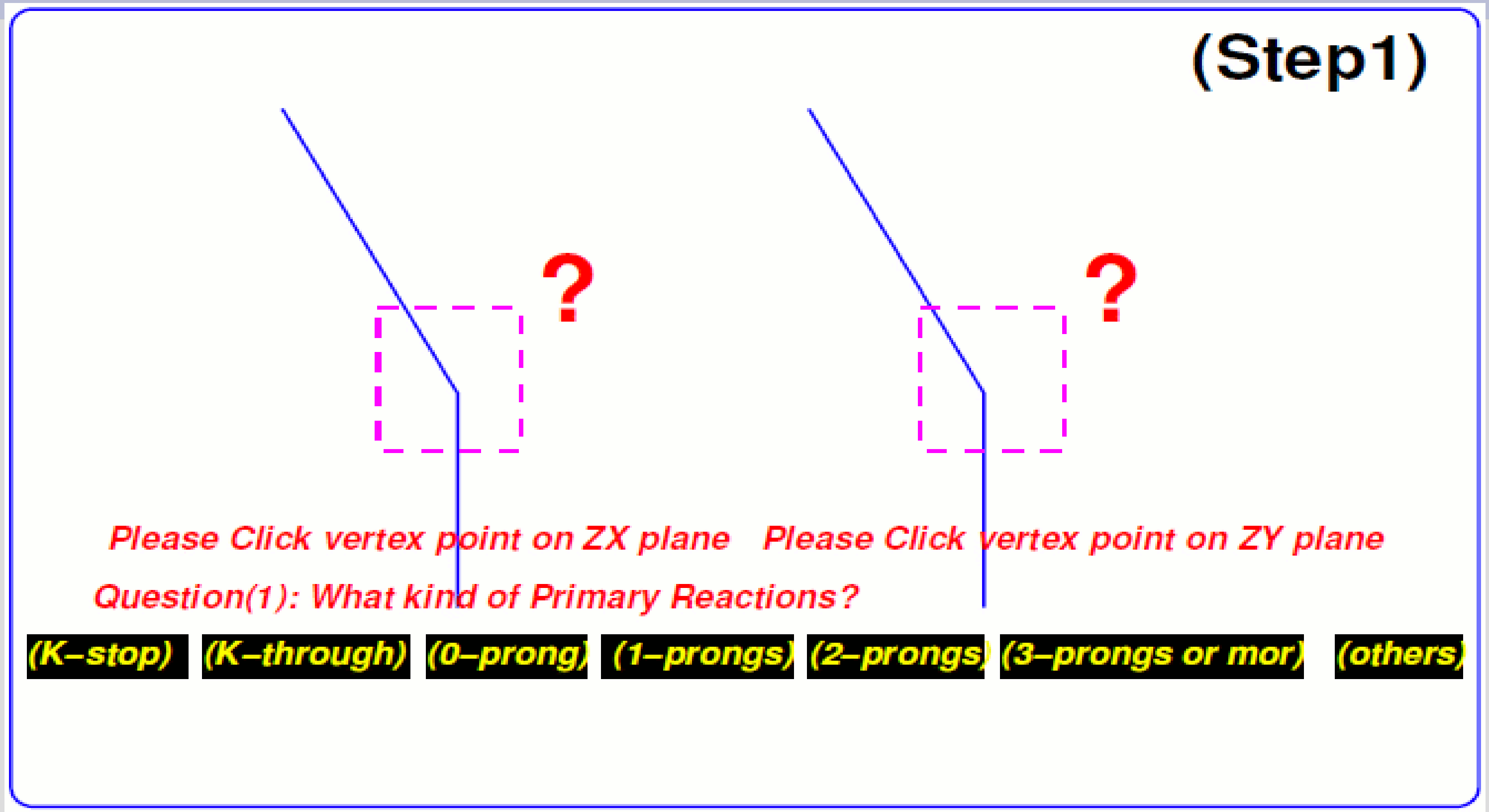
K^- Beam	:	9.0×10^9
(K^-,K^+)	:	4.6×10^4



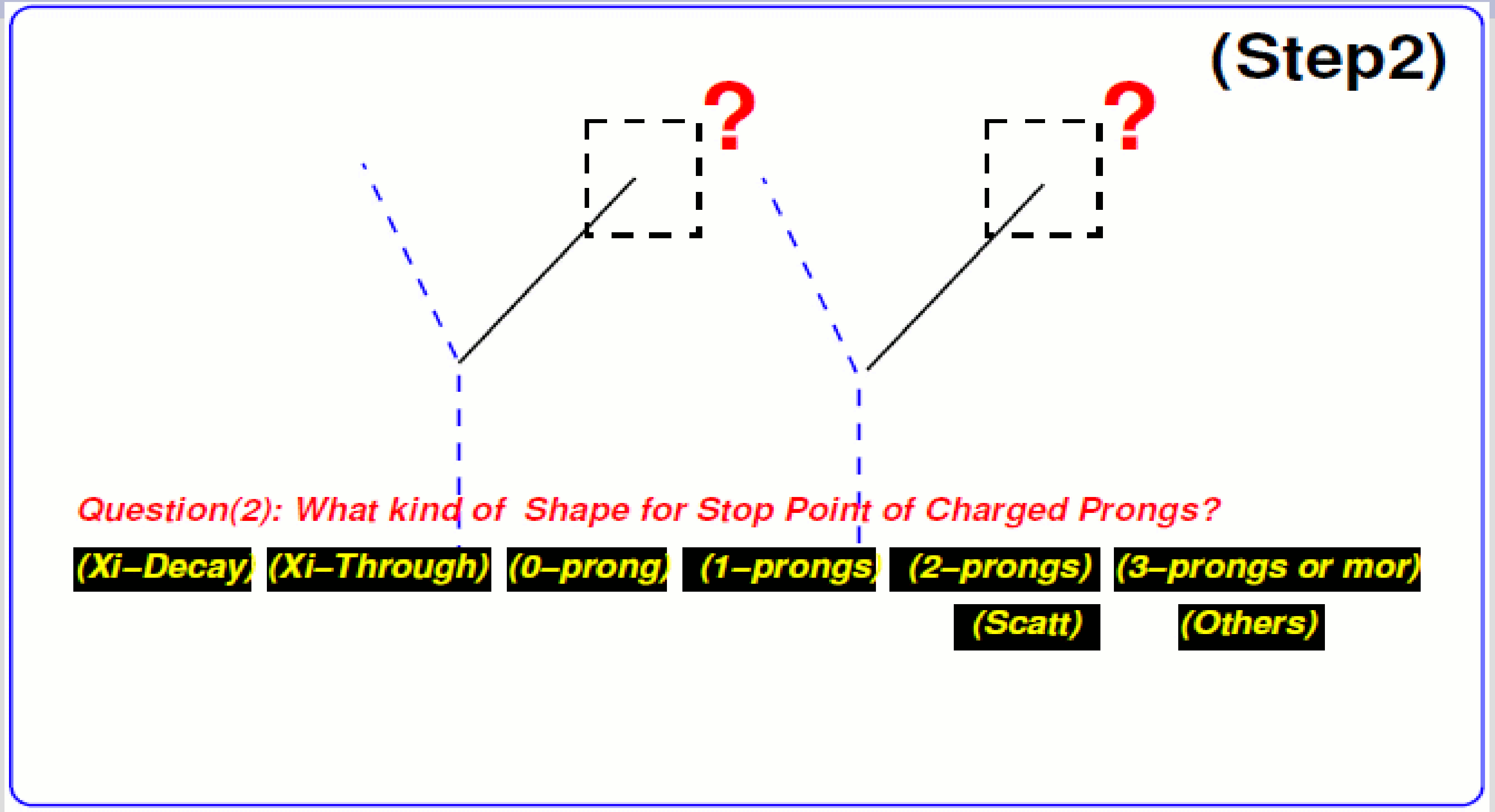



HIGZ_01 @ ukulele
Run 182 spill 141 event 35 ccd 22
K+Mass 0.515GeV/c2 K+Mom. 1.055GeV/c MissMass 1.377GeV/c2
100
75
50
25
0
-25
-50
-75
-100
-100 -75 -50 -25 0 25 50 75 100
Please Click vertex point on ZX plane
Please Click vertex point on ZY plane
Question(1): What Kind of Primary Reactions?
(K-Stop)
(K-through)
(0-prong)
(1-prongs)
(2-prongs)
(3-prongs or more)
(Others)
Question(2): What kind of Shape for Stop Point of Charged Prongs?
(Xi-Decay)
(Xi-Through)
(0-prong)
(1-prongs)
(2-prongs)
(3-prongs or more)
(Scatt.)
(Others)
Question(3):What kind of Neutral Decaying Products?
(No-Tracks)
(1-Lambda)
(2-Lambda)
(L-Kink)
(Others)
(Try Agian?)
(Next?)
kterm@ukulele
guitar:/home/cjyoon> xv &
[1] 7137
guitar:/home/cjyoon>
kterm@ukulele
R1.ps
R2.ps
SAVE.fig
black.ps
comapre.fig
comp.ps
compare.fig
compare.fig.bak
compare.ps
dl.eps
iicalib.ps
kerbikov.eps
l.ps
l1.ps
l2.ps
last.kumac
ukulele:OHP/KEKWORKSHOP>
ukulele:OHP/KEKWORKSHOP>
kterm@ukulele
BROWSE>> track/auto
BROWSE>> jump 141
spdata>> spill = 25
spdata>> spill = 35
spdata>> spill = 67
spdata>> spill = 71
spdata>> spill = 73
spdata>> spill = 78
spdata>> spill = 91
spdata>> spill = 100
spdata>> spill = 101
spdata>> spill = 106
spdata>> spill = 113
spdata>> spill = 131
spdata>> spill = 134
spdata>> spill = 141
OK! evtype1 is 4
>> 8.489480 7.547548
OK! evtype2 is 4
OK! evtype3 is 2
gview
netscape
kill
Desktop
Start
10:02PM

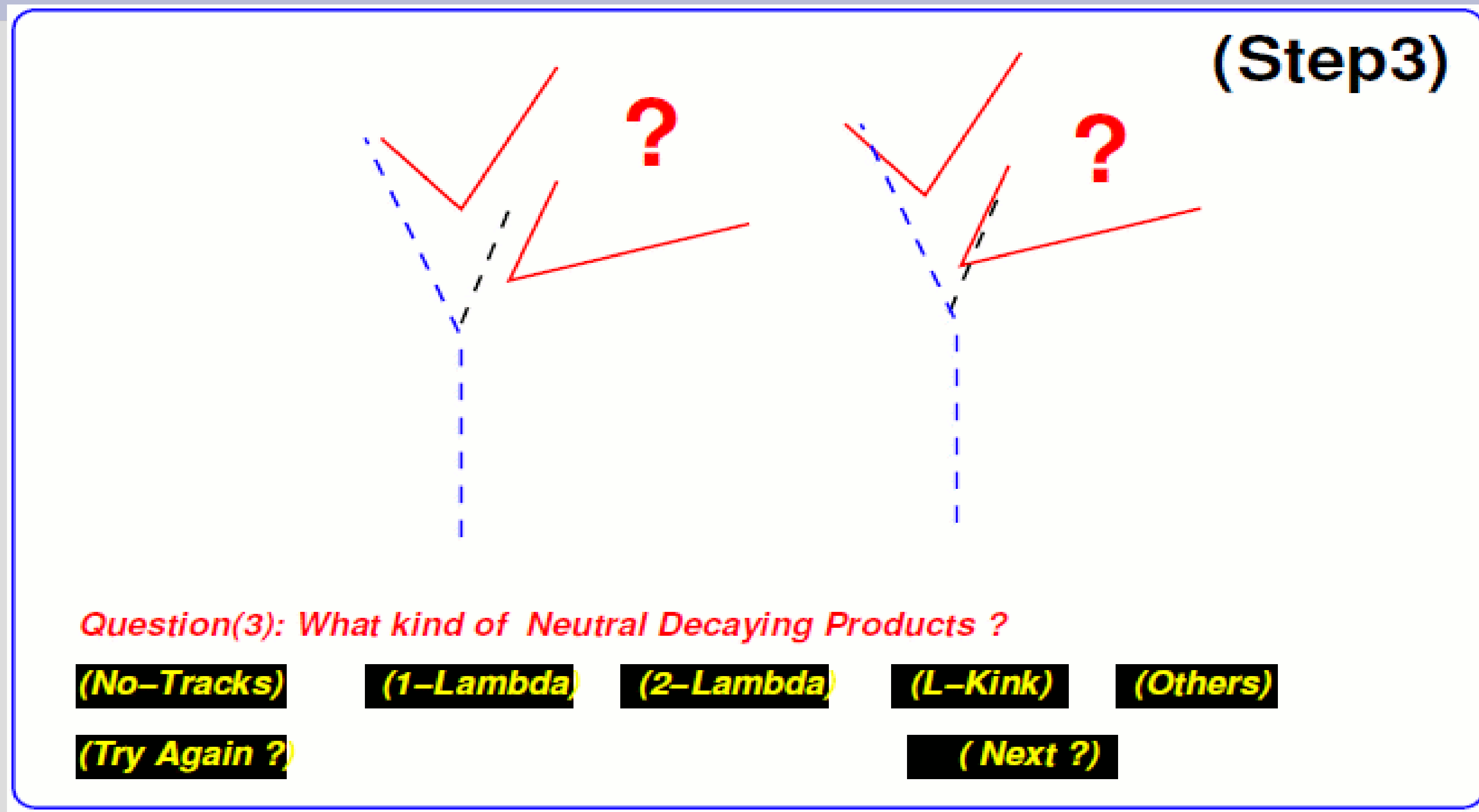
Event categorization



Event categorization

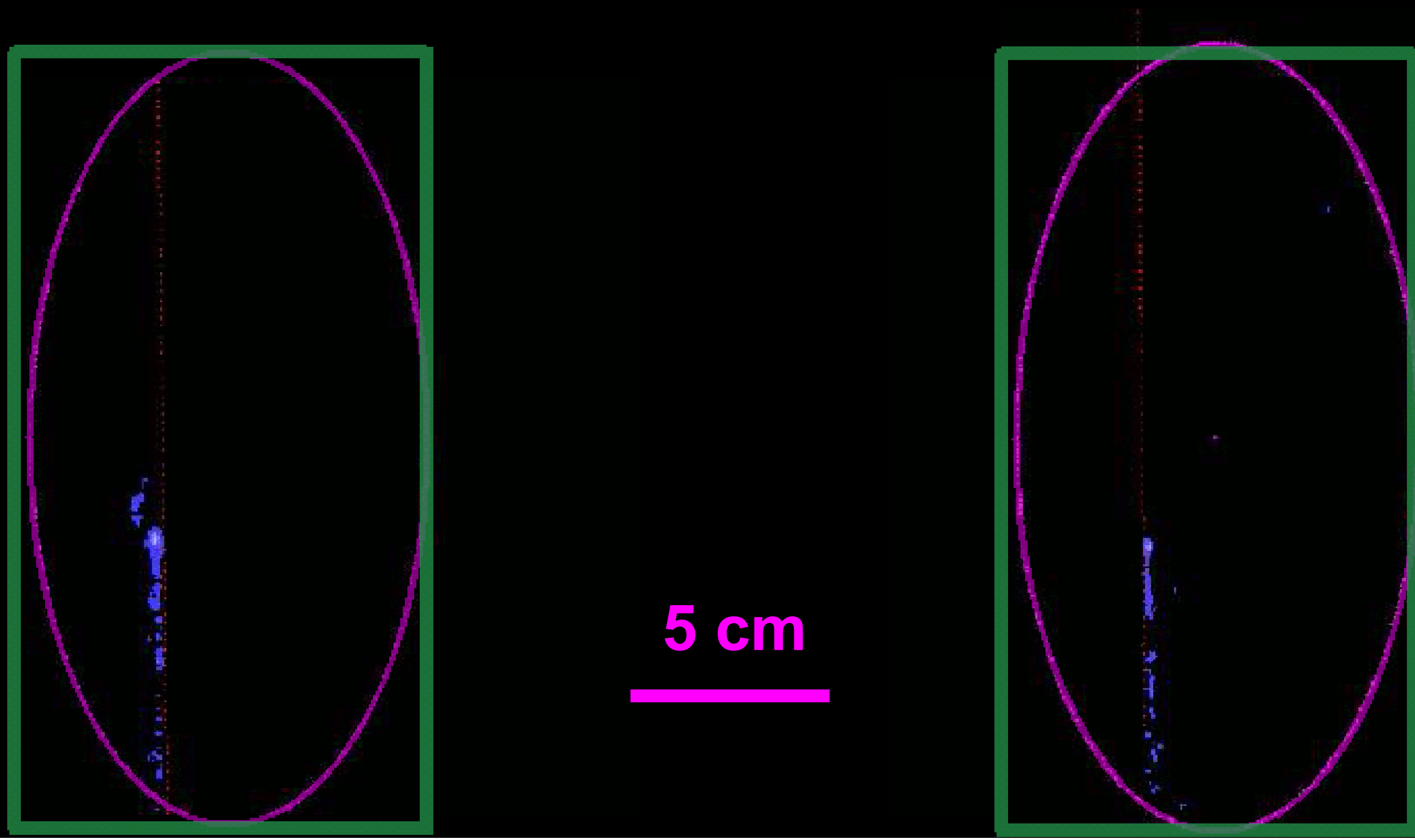


Event categorization

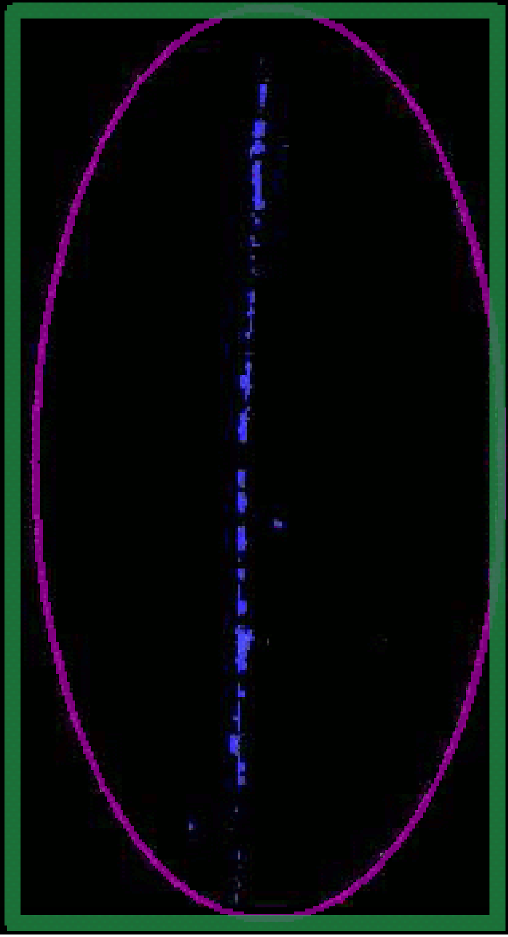


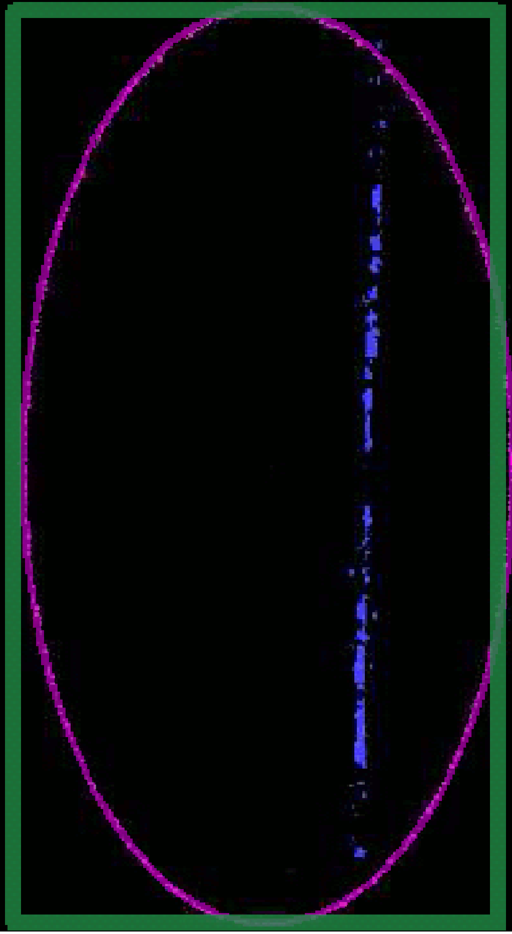
Result of event categorization

Event type	Numbers	Fraction(%)	Tagging method
K^- stop	1928	5.9	step1=1
K^- through	4892	14.9	step1=2
$\Xi^- \rightarrow \Lambda\pi^-; \Lambda \rightarrow \pi^- p$	4425	13.5	step1=4, step2=1, step3=2
$\Xi^- \rightarrow \Lambda\pi^-; \Lambda \rightarrow \pi^0 n$	3967	12.1	step1=4, step2=1, step3=1
1-Λ production	9158	28.0	step3=2
2-Λ production	1184	3.6	step3=3
$\Lambda\Lambda$+one prong	28	0.06	step2=4 or 7, step3=2

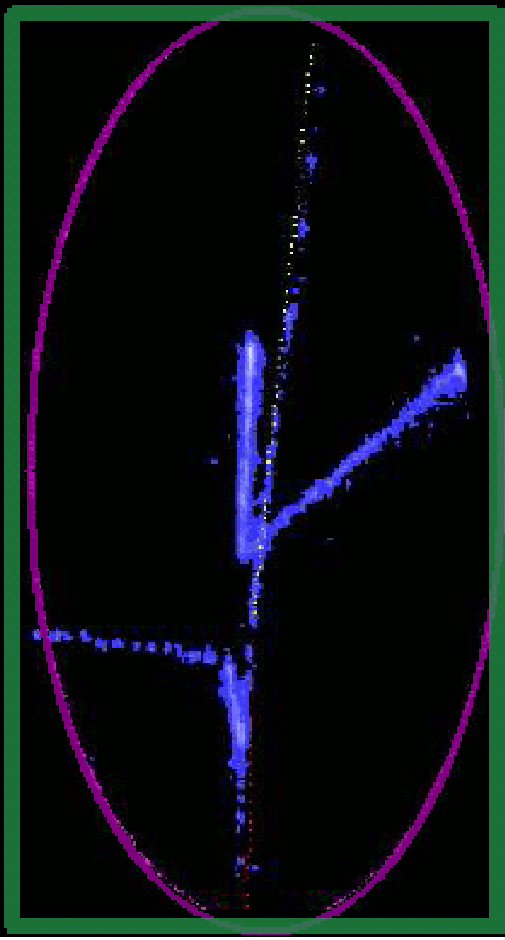


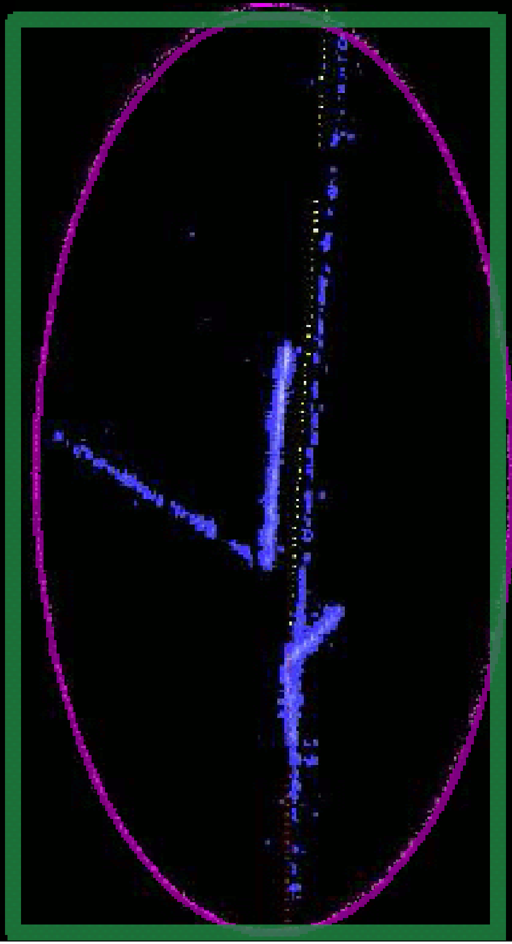
Event type	Numbers	Fraction(%)	Tagging method
K^- stop	1928	5.9	step1=1



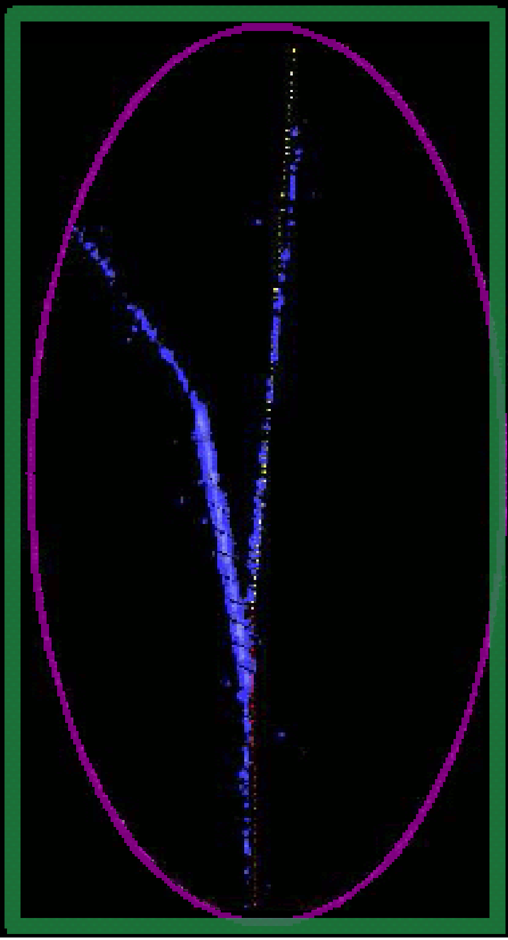


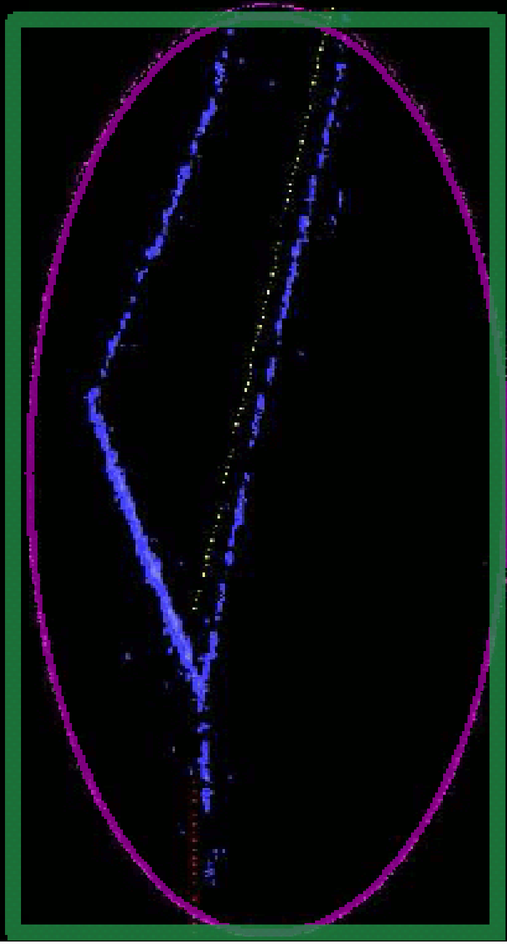
Event type	Numbers	Fraction(%)	Tagging method
K^- through	4892	14.9	step1=2



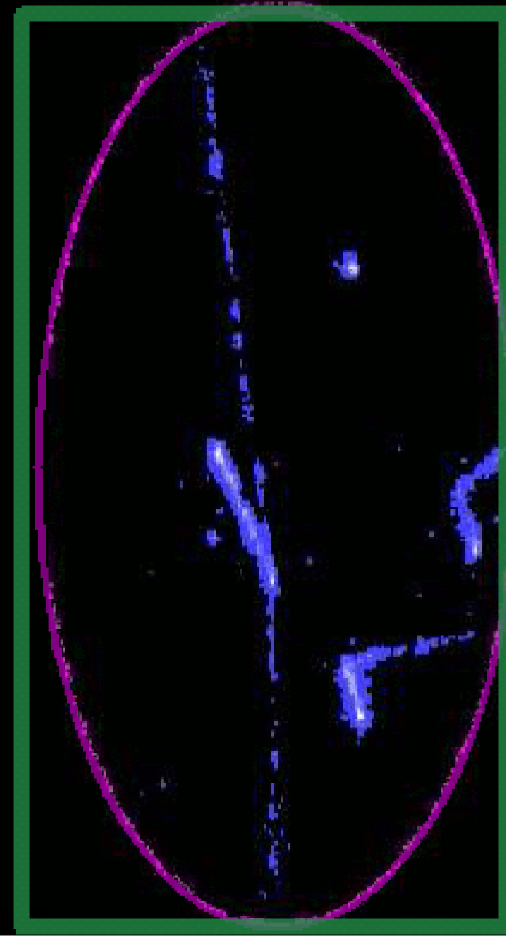


Event type	Numbers	Fraction(%)	Tagging method
$\Xi^- \to \Lambda\pi^-; \Lambda \to \pi^- p$	4425	13.5	step1=4, step2=1, step3=2

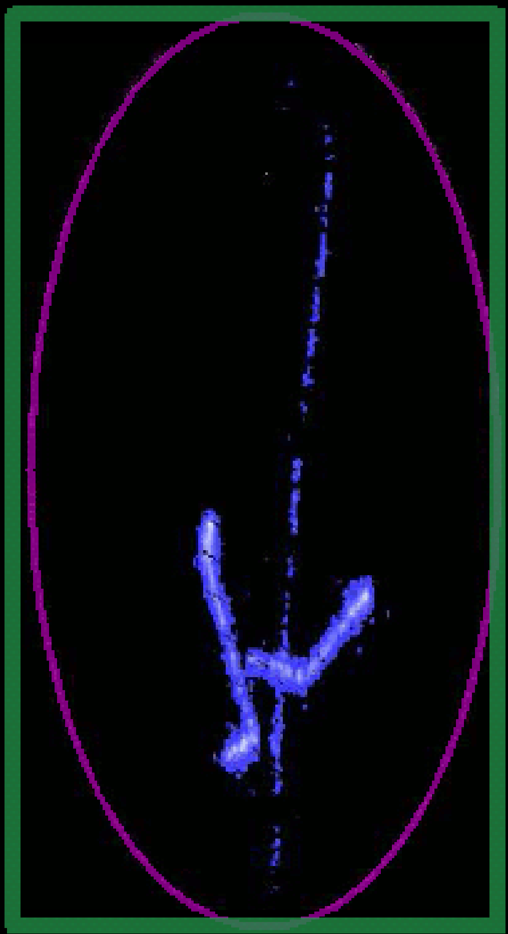


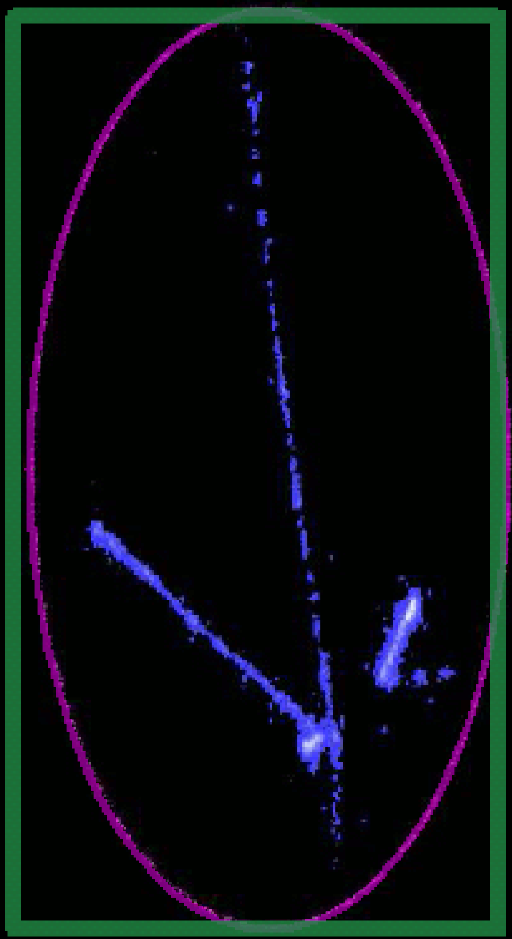


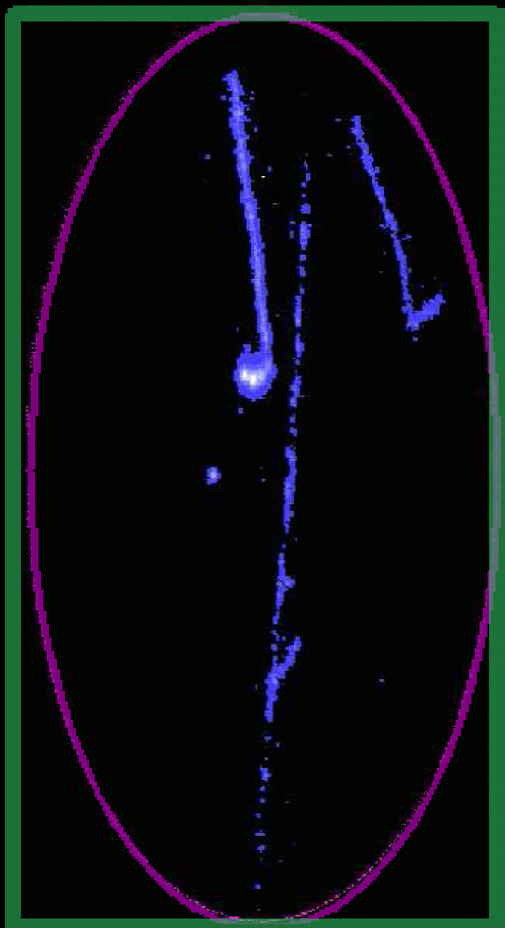
Event type	Numbers	Fraction(%)	Tagging method
$\Xi^- \to \Lambda\pi^-; \Lambda \to \pi^0 n$	3967	12.1	step1=4, step2=1, step3=1

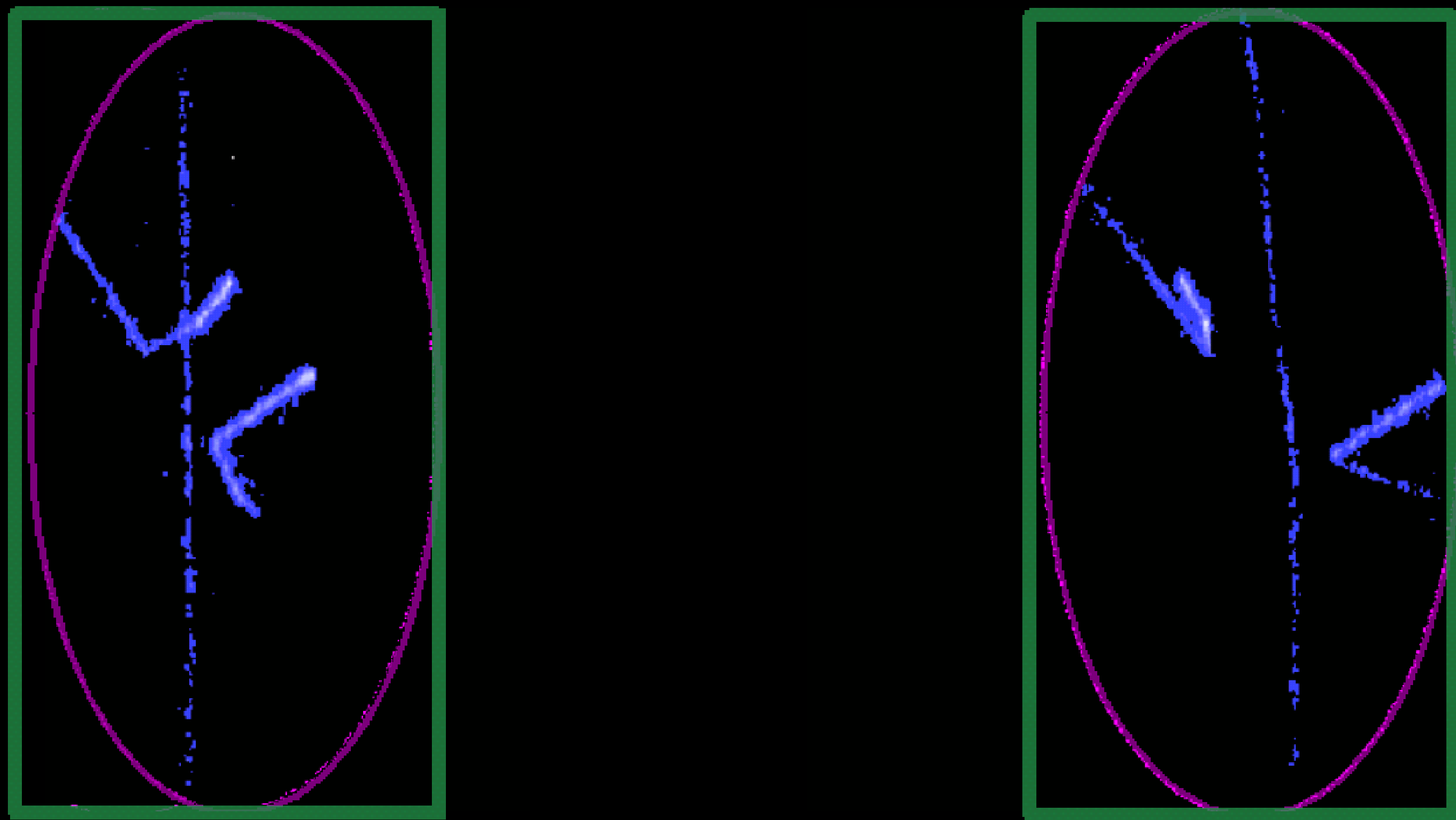


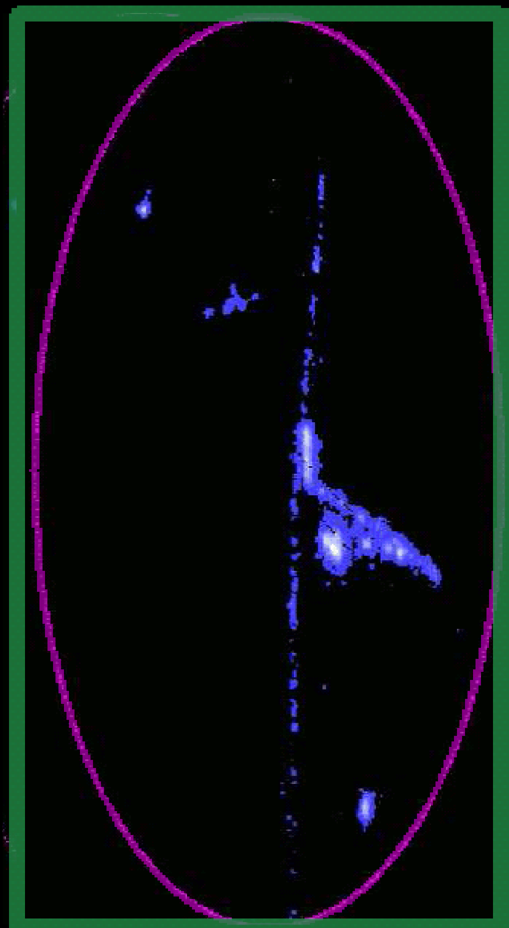
Event type	Numbers	Fraction(%)	Tagging method
ΛΛ+one prong	28	0.06	step2=4 or 7, step3=2

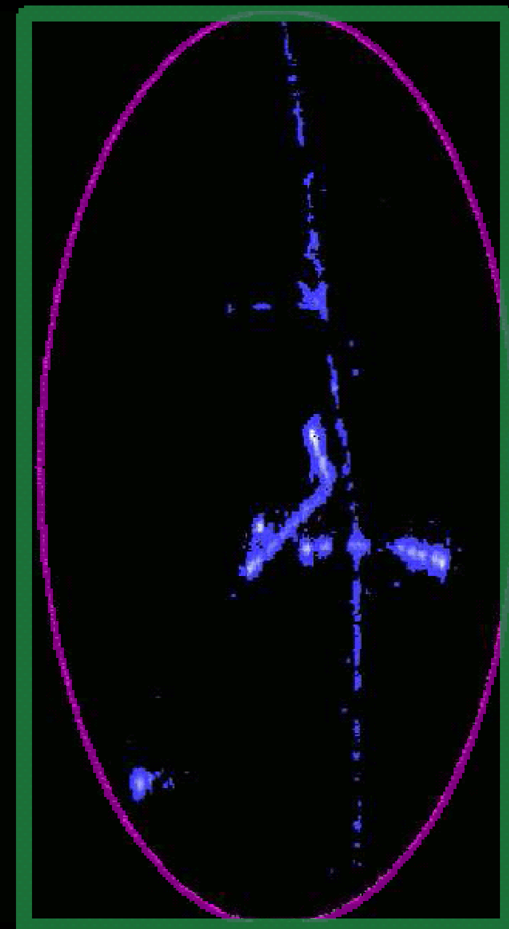


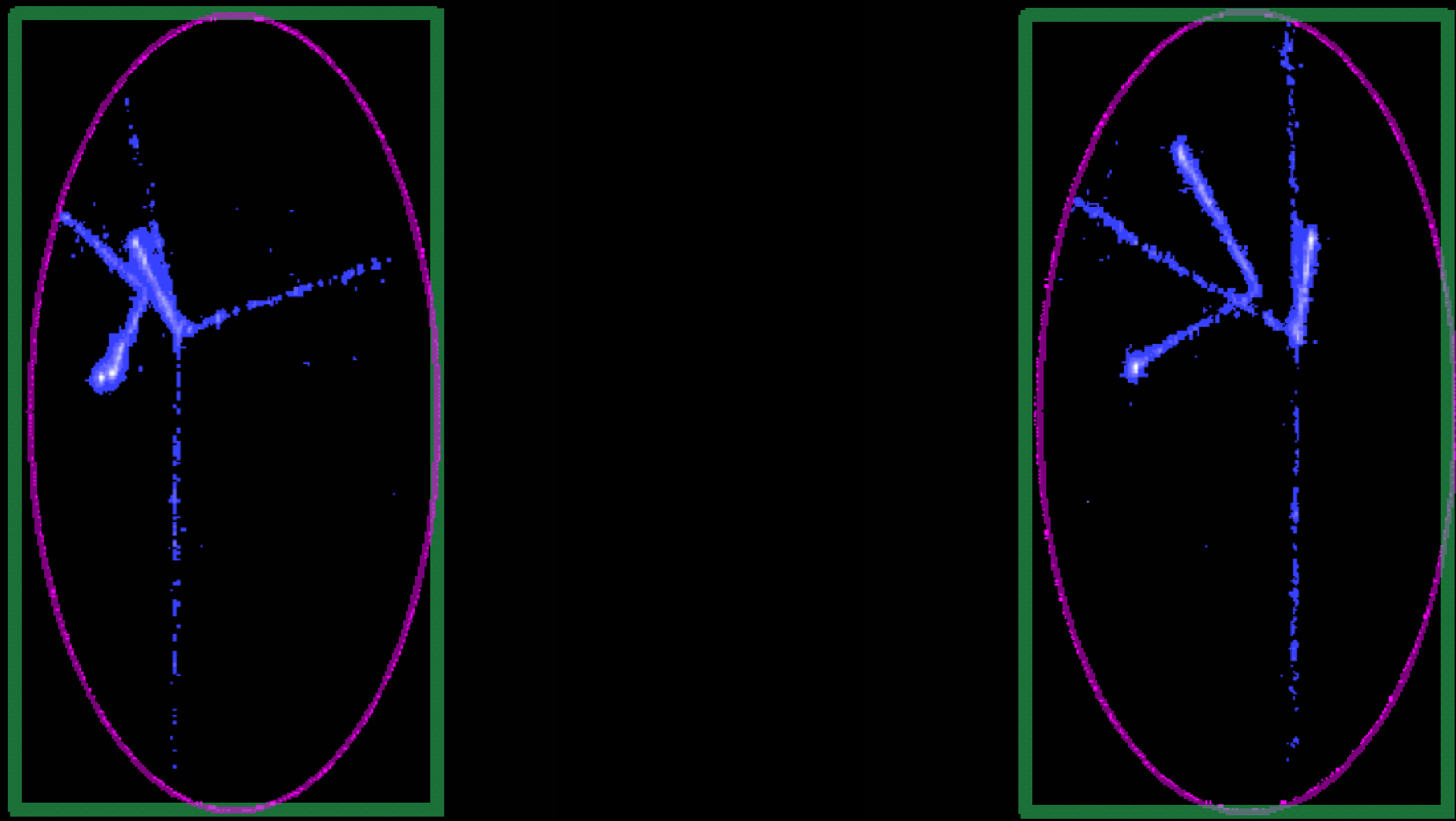




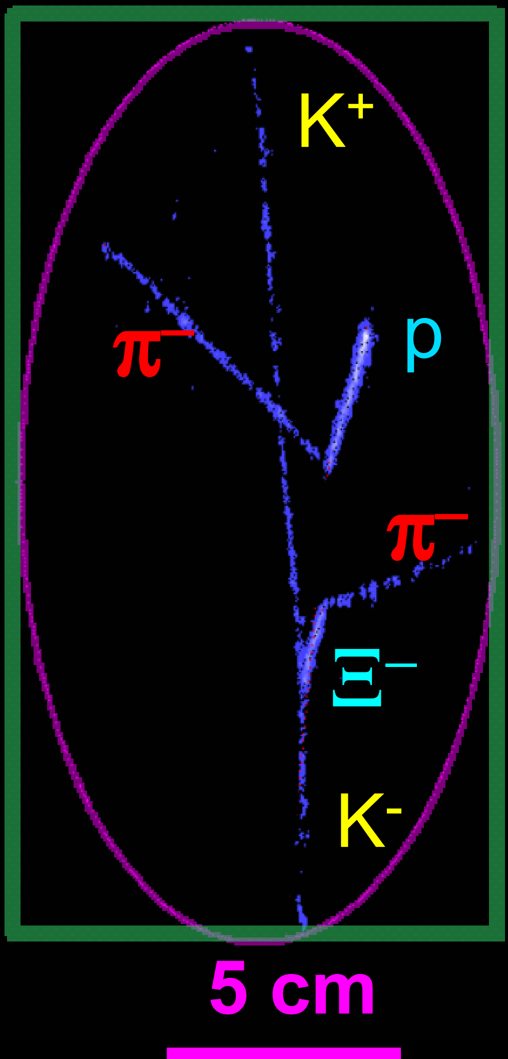






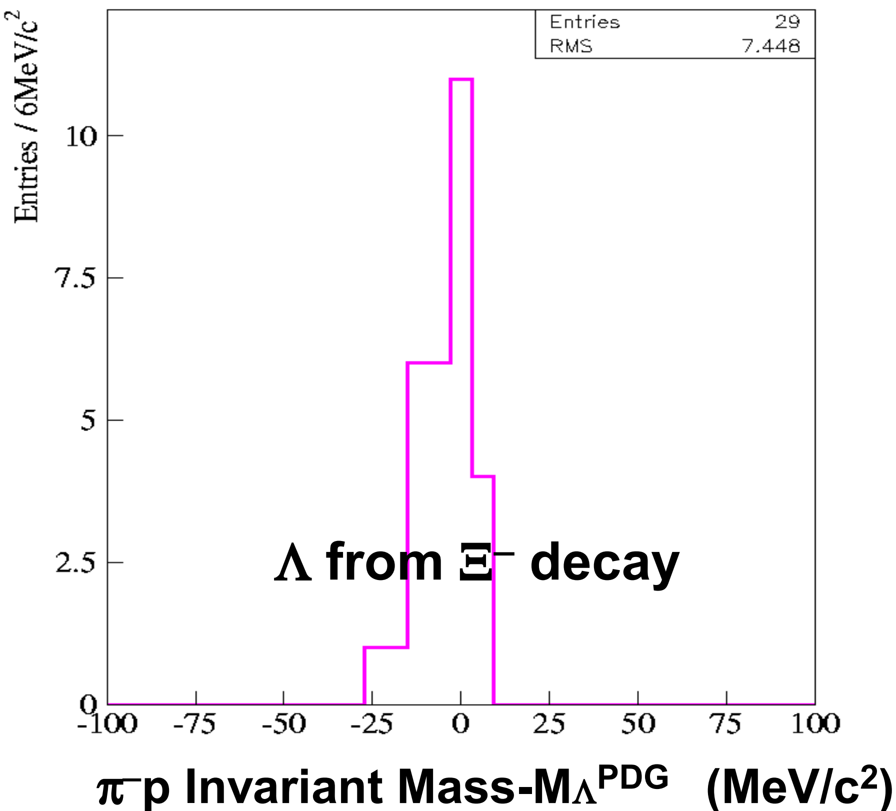


Range-energy calibration



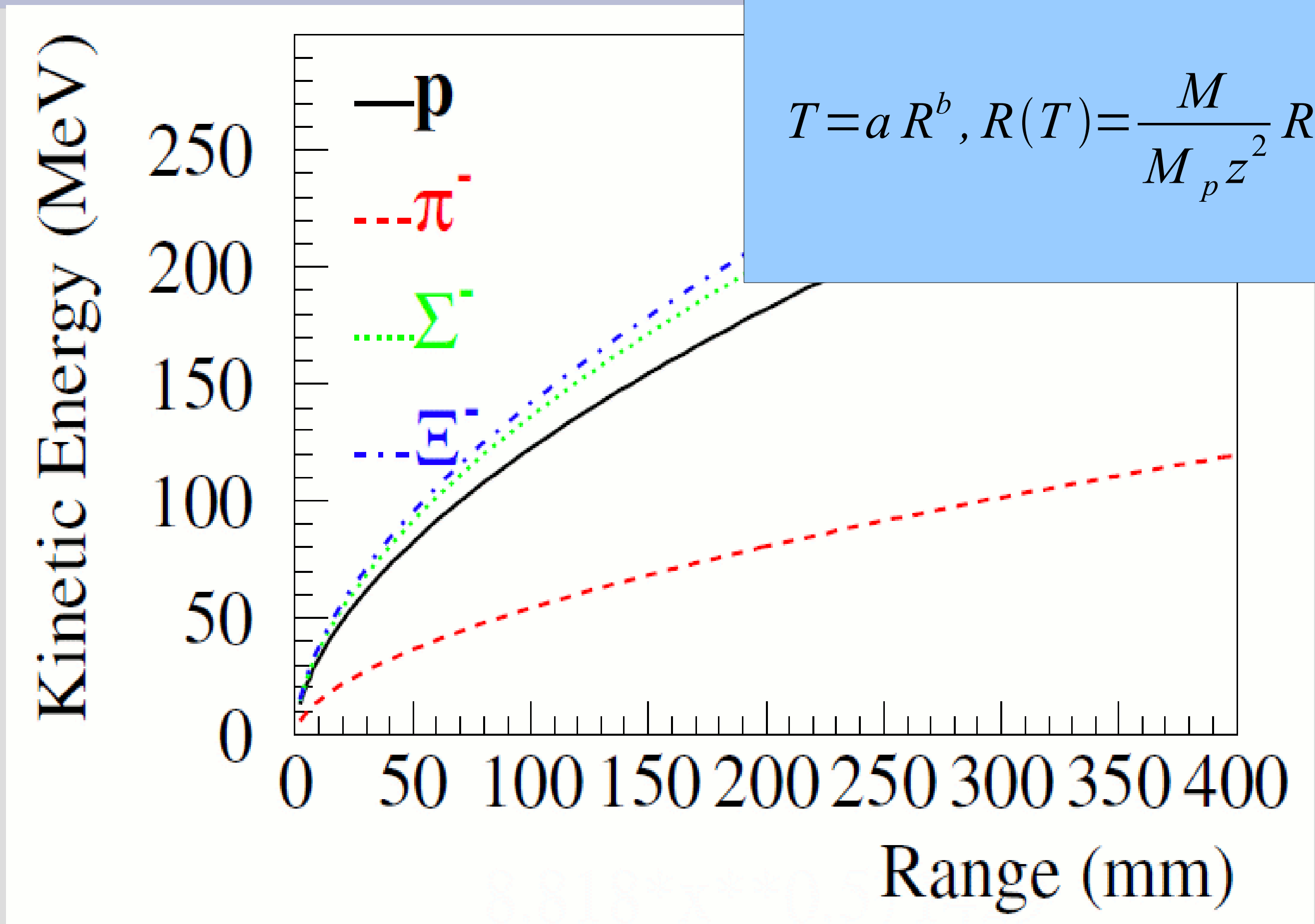
PID	p	π^-	Σ^-	Ξ^-
a (in mm, MeV)	8.818	3.897	9.790	10.212

$$E\,(\text{MeV}) = \mathbf{a}\, R\,(\text{mm})^{4/7}$$



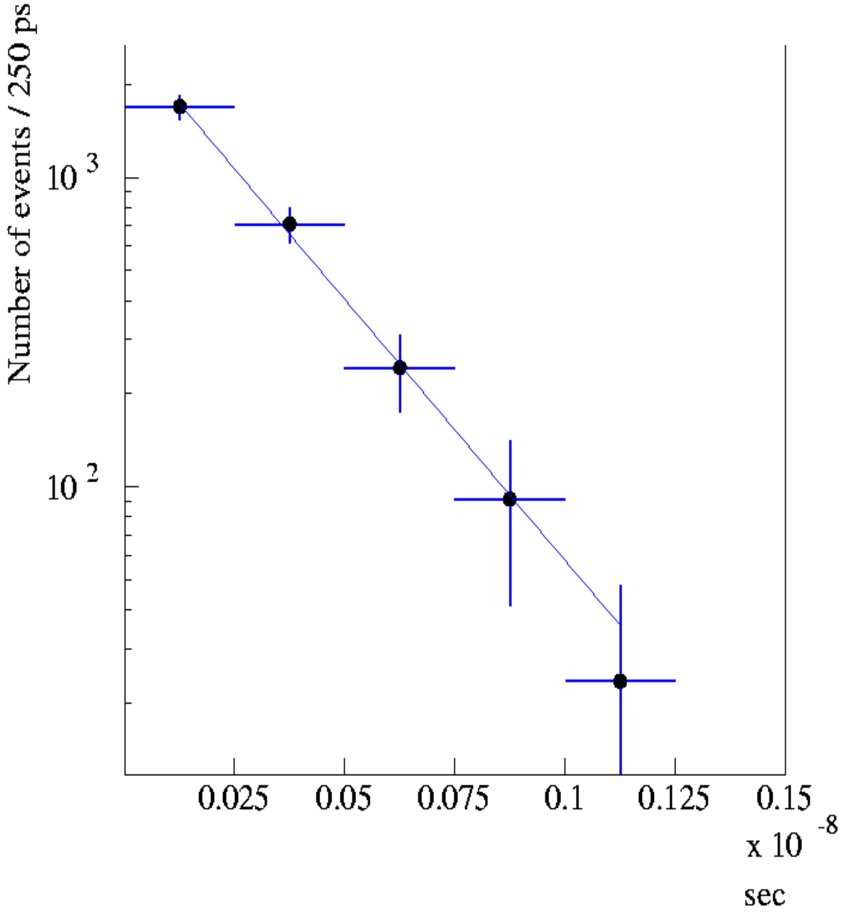
Relation of K.E. vs Range for the tracks were determined by $a = M^{1-b} M_p^{b-1} a_p z^{2b}$

$$T = a R^b, \; R(T) = \frac{M}{M_p z^2} R_p, \; T_p = T \frac{M_p}{M}.$$



Life time of the Lambda's from ΛΛ events

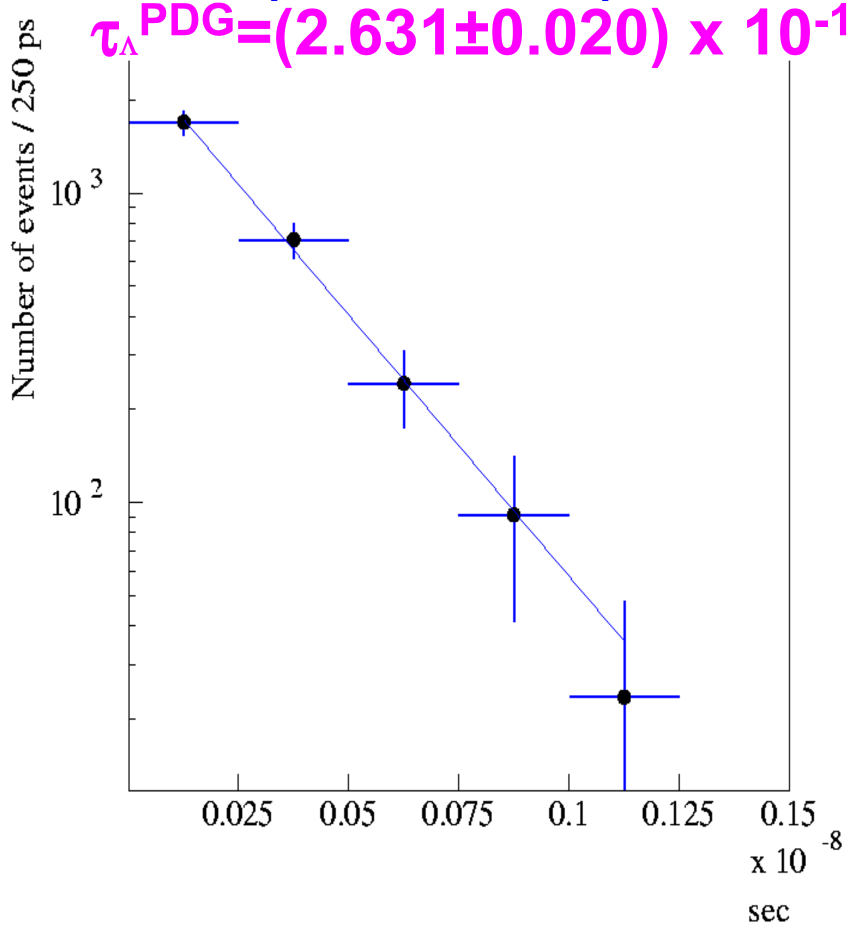
τ_{Λ}^{Exp}=(2.57 ± 0.24) x 10^{-10}s



Life time of the Lambda's from ΛΛ events

τ_Λ^{Exp}=(2.57 ± 0.24) x 10^{-10}s

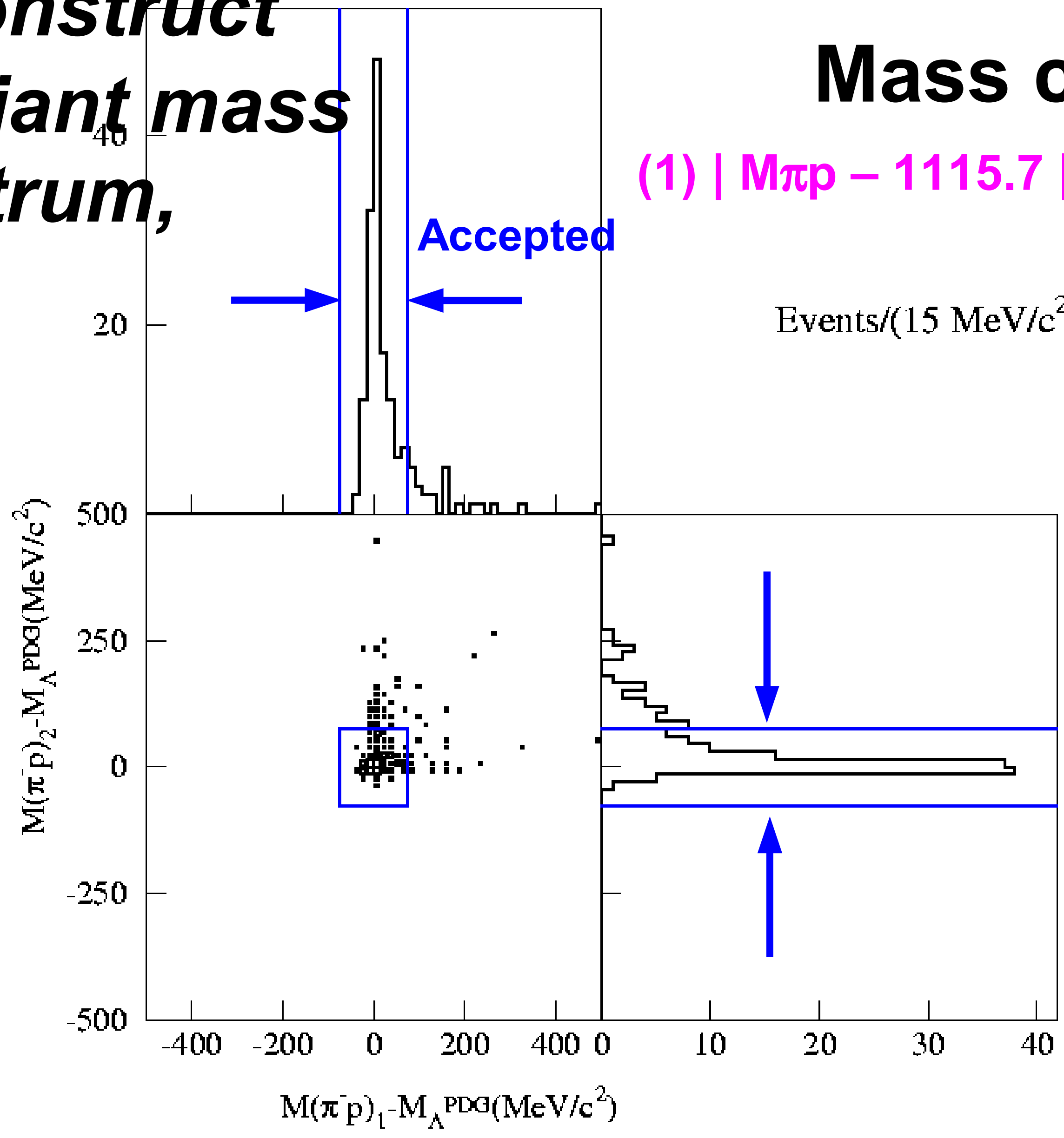
τ_Λ^{PDG}=(2.631±0.020) x 10^{-10}s

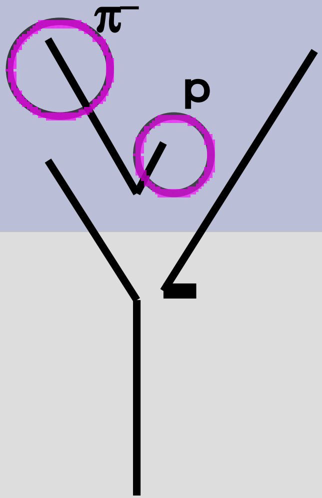


To reconstruct ΛΛ invariant mass spectrum,

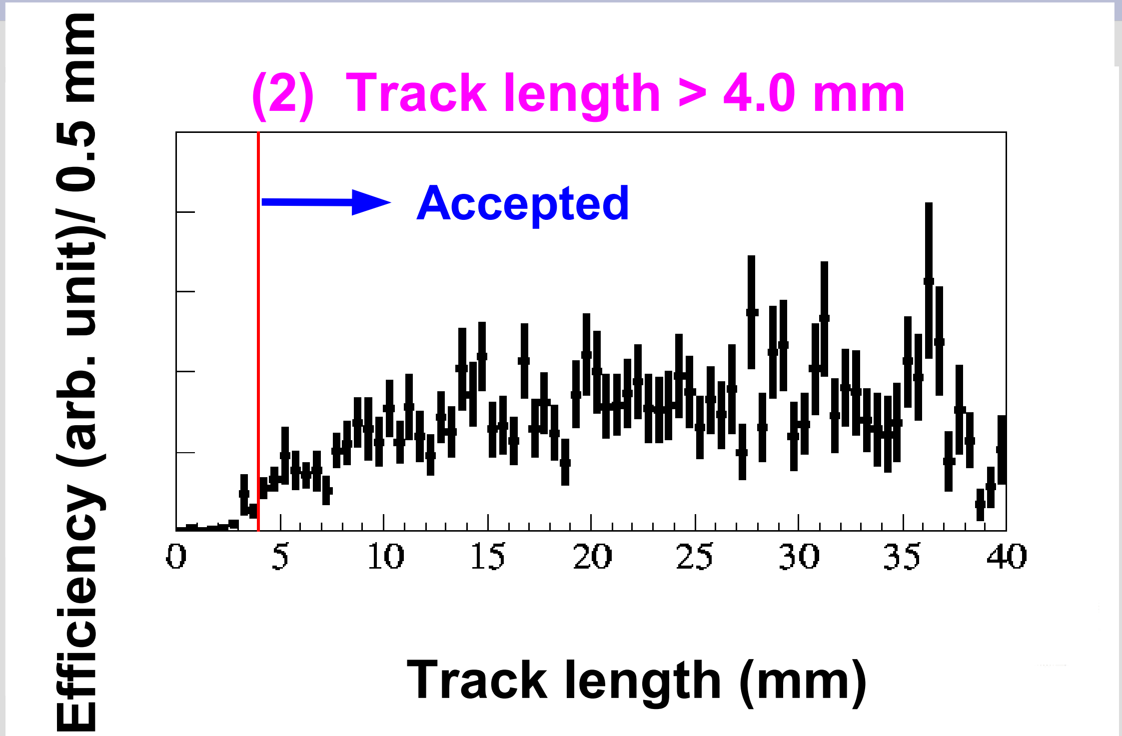
Mass cut

(1) | Mπp – 1115.7 |< 75 MeV/c^2 = 5 $\sigma_{m\Lambda}$

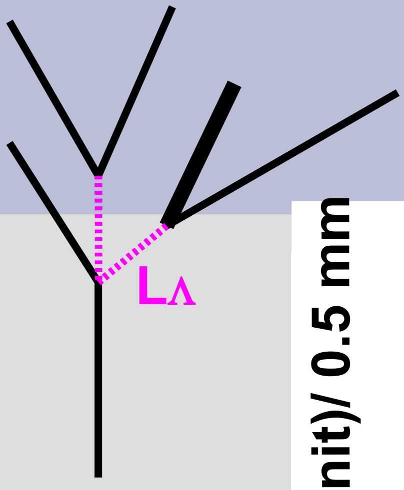


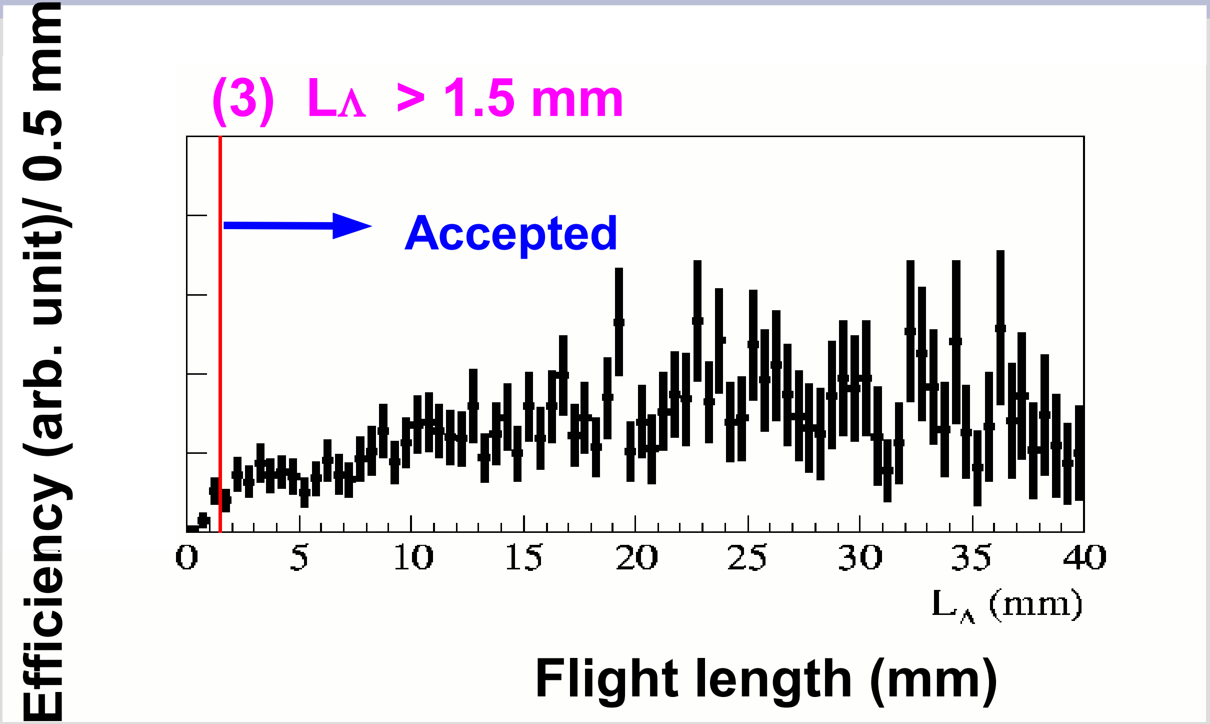


Track length cut

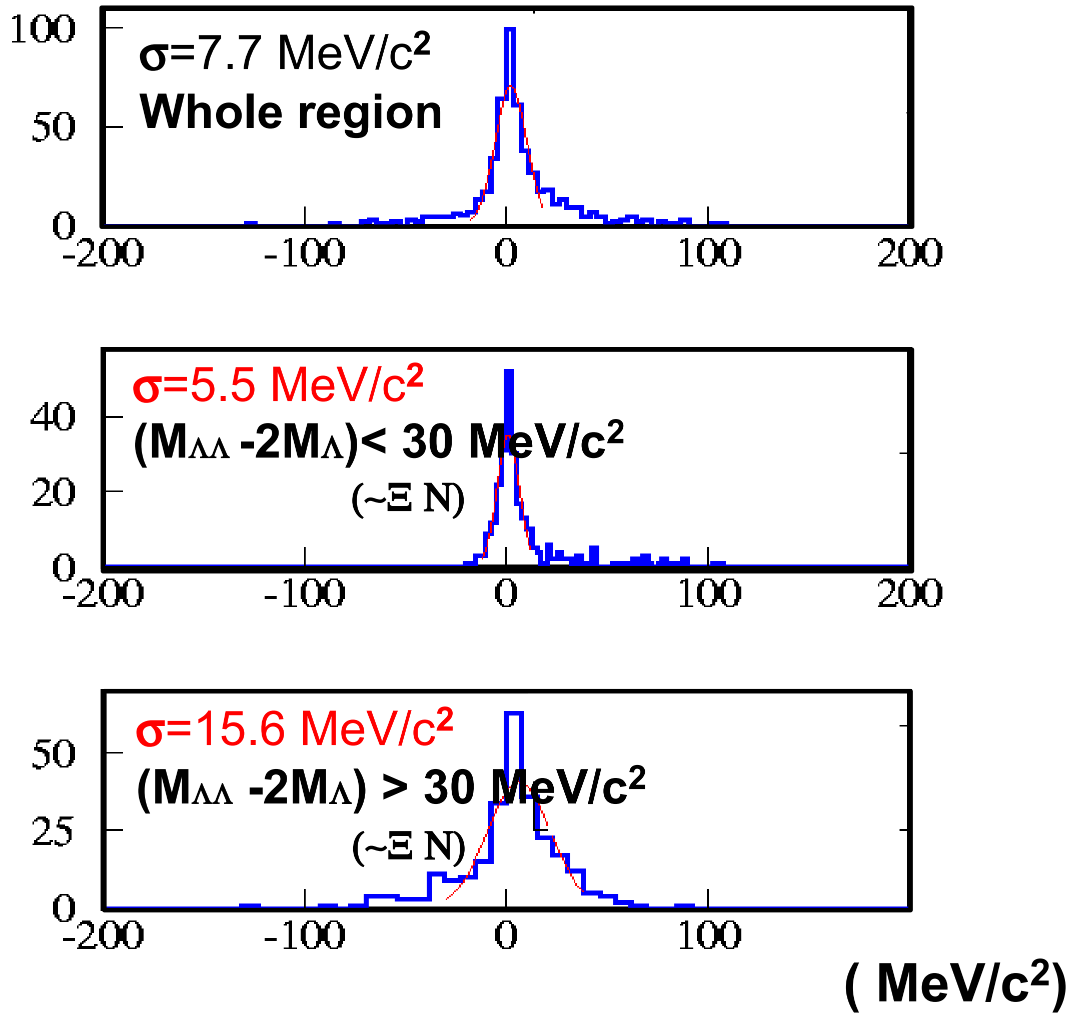


Flight length cut

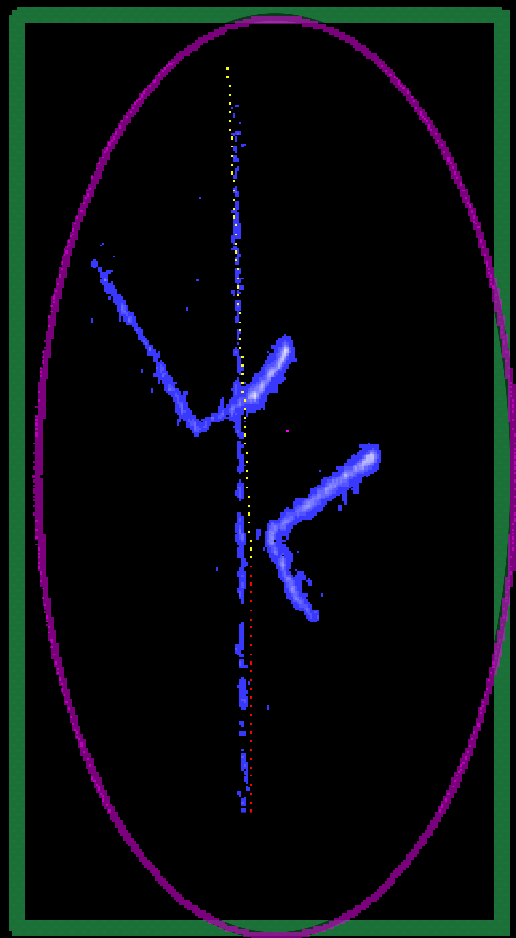


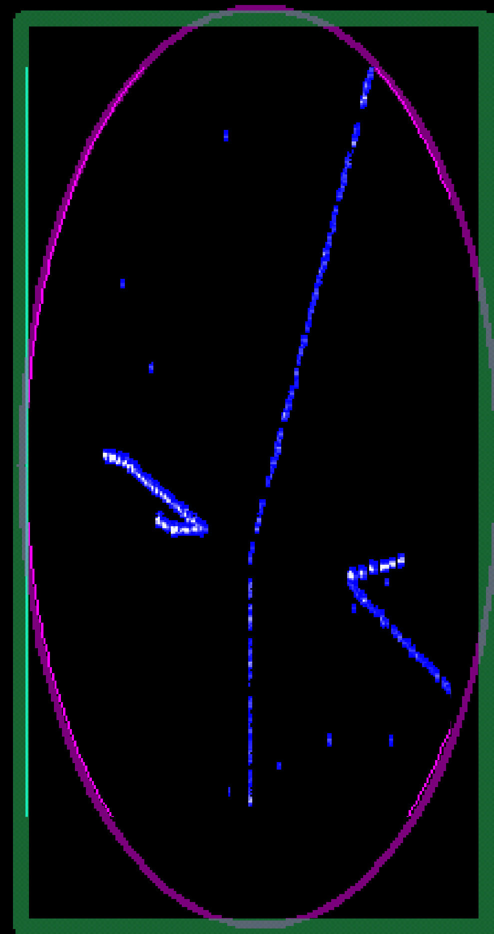


ΛΛ-Inv. mass resolutions



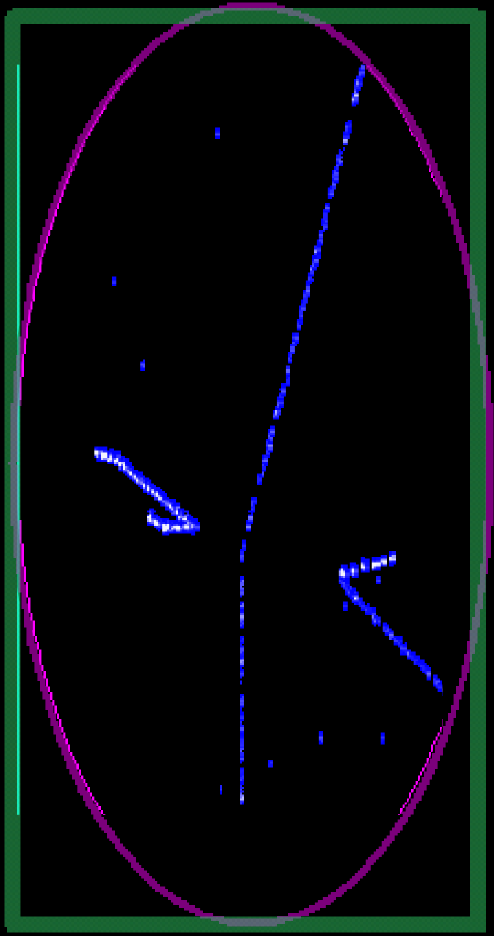
Simulated ΛΛ Inv. Mass– Measured values

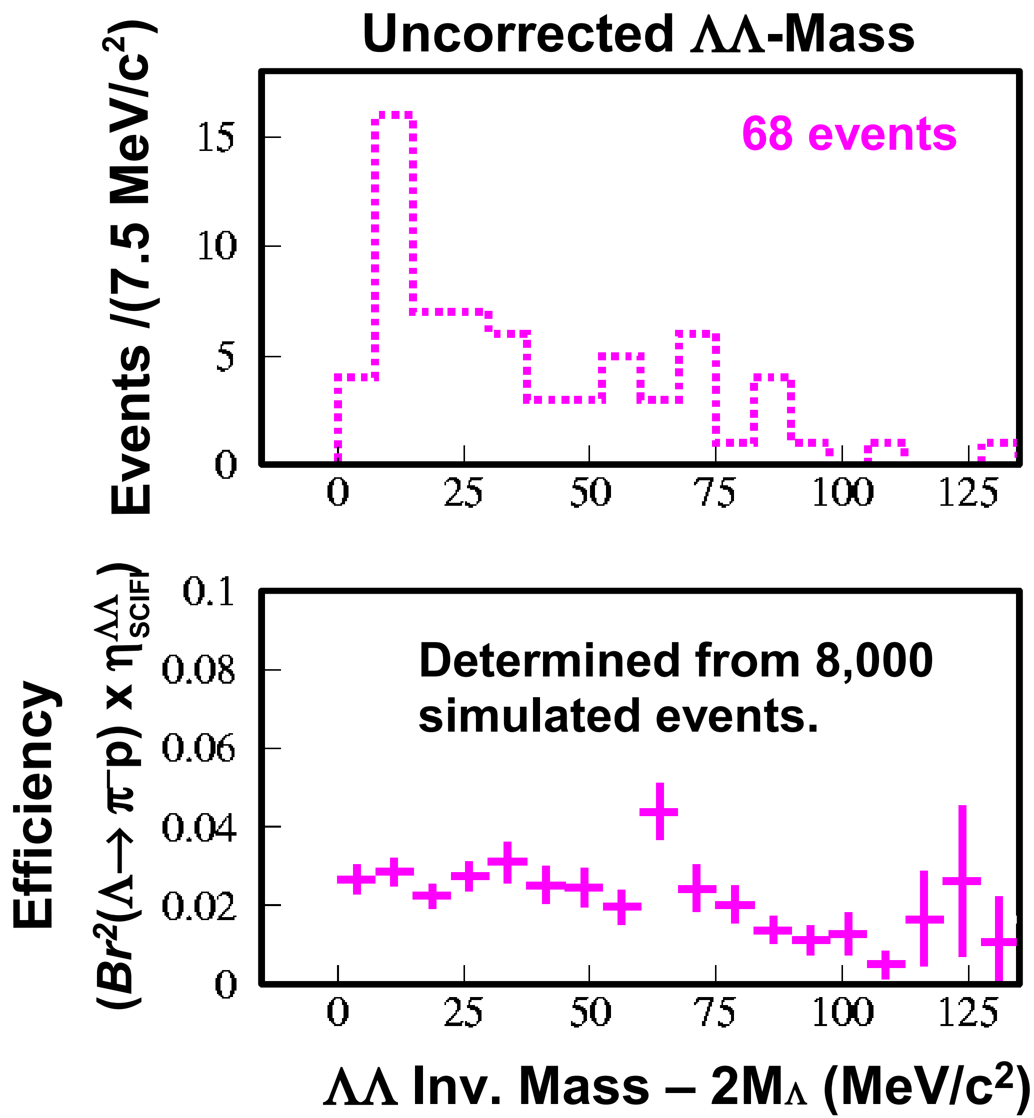




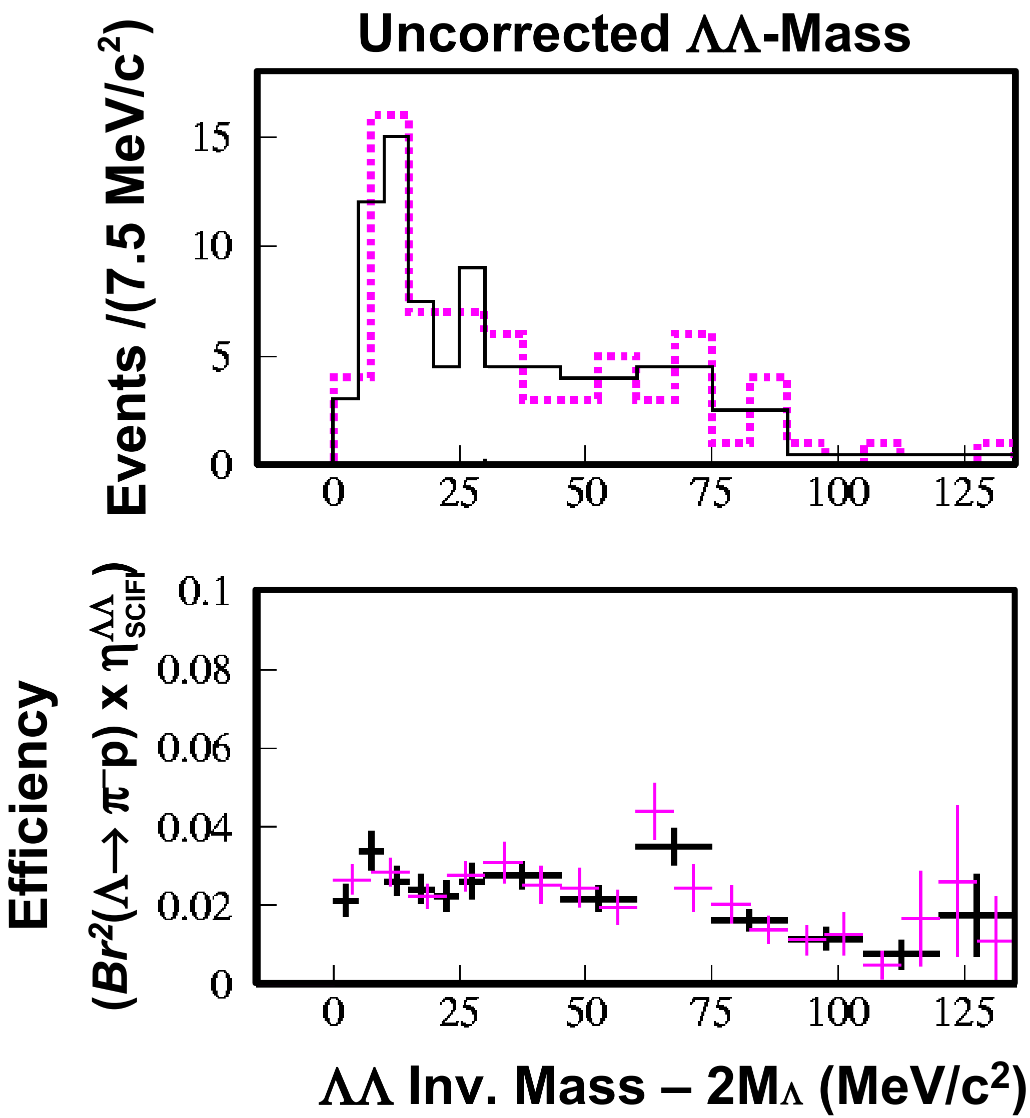
Simulation Data

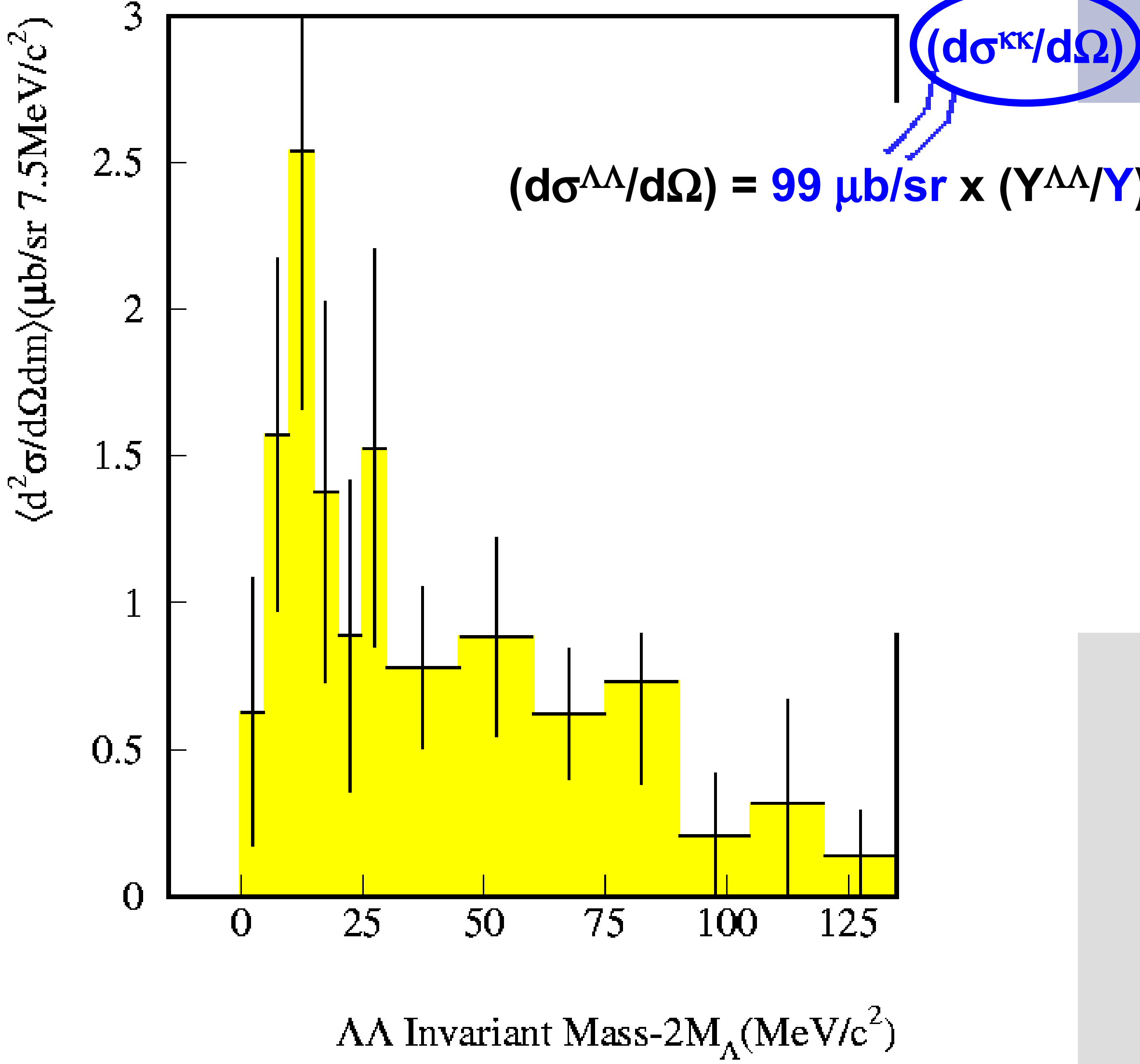
1. **GEANT3** package
2. SCIFI;
   stacked 600 fiber sheets.
   The fiber sheets were **made by single fibers.**
3. Hit information was **digitized following to cluster size.**
4. **Energy loss**,
   multiple scattering,
   π^- absorption on carbon nuclei,
   thermal noises of the IITs
   were taken into account.
5. Vertex **distribution of (K^-,K^+)**, emission angles, **momentum** of Λ were **taken from real data.**



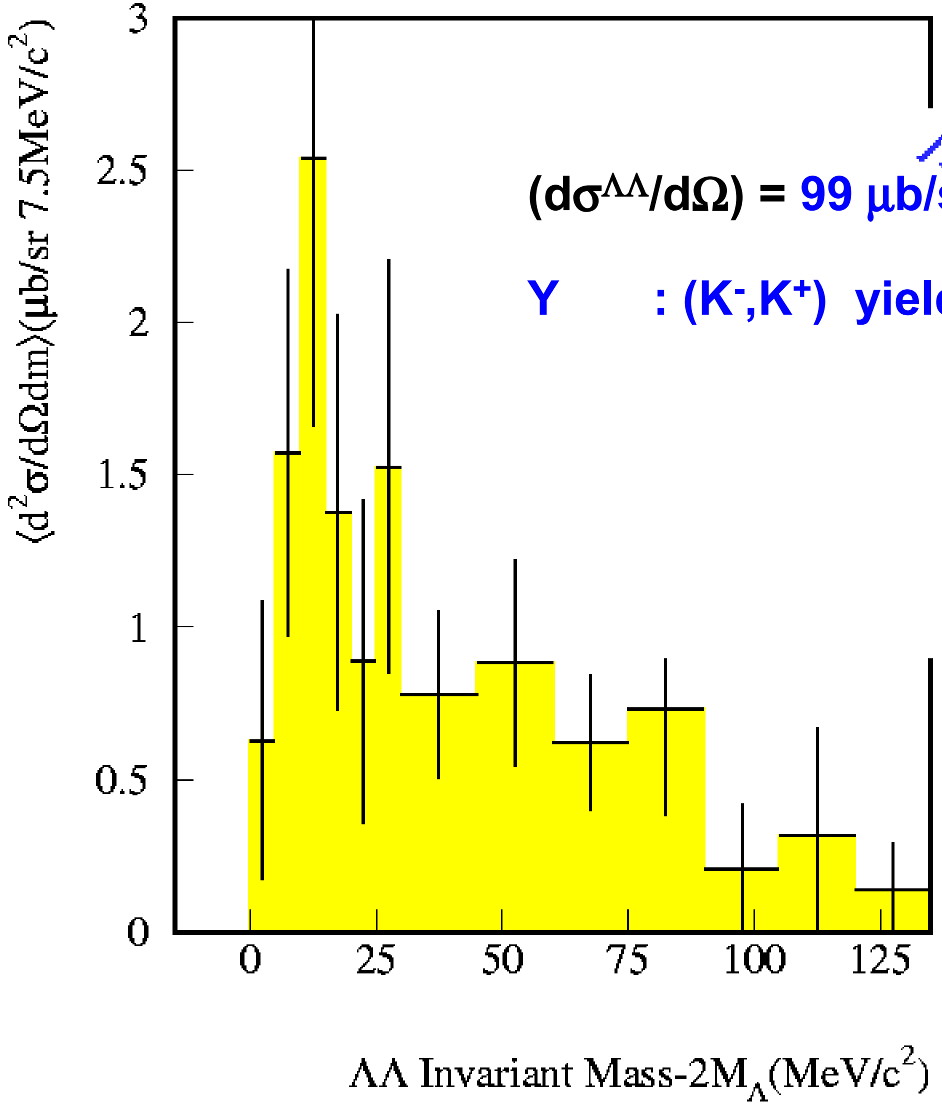


Uncorrected ΛΛ-Mass
68 events
Events /(7.5 MeV/c²)
0
5
10
15
0
25
50
75
100
125
Efficiency
(Br²(Λ→π⁻p) x η^ΛΛ_SCIFI)
Determined from 8,000
simulated events.
0
0.02
0.04
0.06
0.08
0.1
ΛΛ Inv. Mass – 2MΛ (MeV/c²)


Uncorrected ΛΛ-Mass
Events /(7.5 MeV/c²)
15
10
5
0
0
25
50
75
100
125
Efficiency
(Br²(Λ→π⁻p) x η_SCIFI^ΛΛ)
0.1
0.08
0.06
0.04
0.02
0
0
25
50
75
100
125
ΛΛ Inv. Mass – 2M_Λ (MeV/c²)



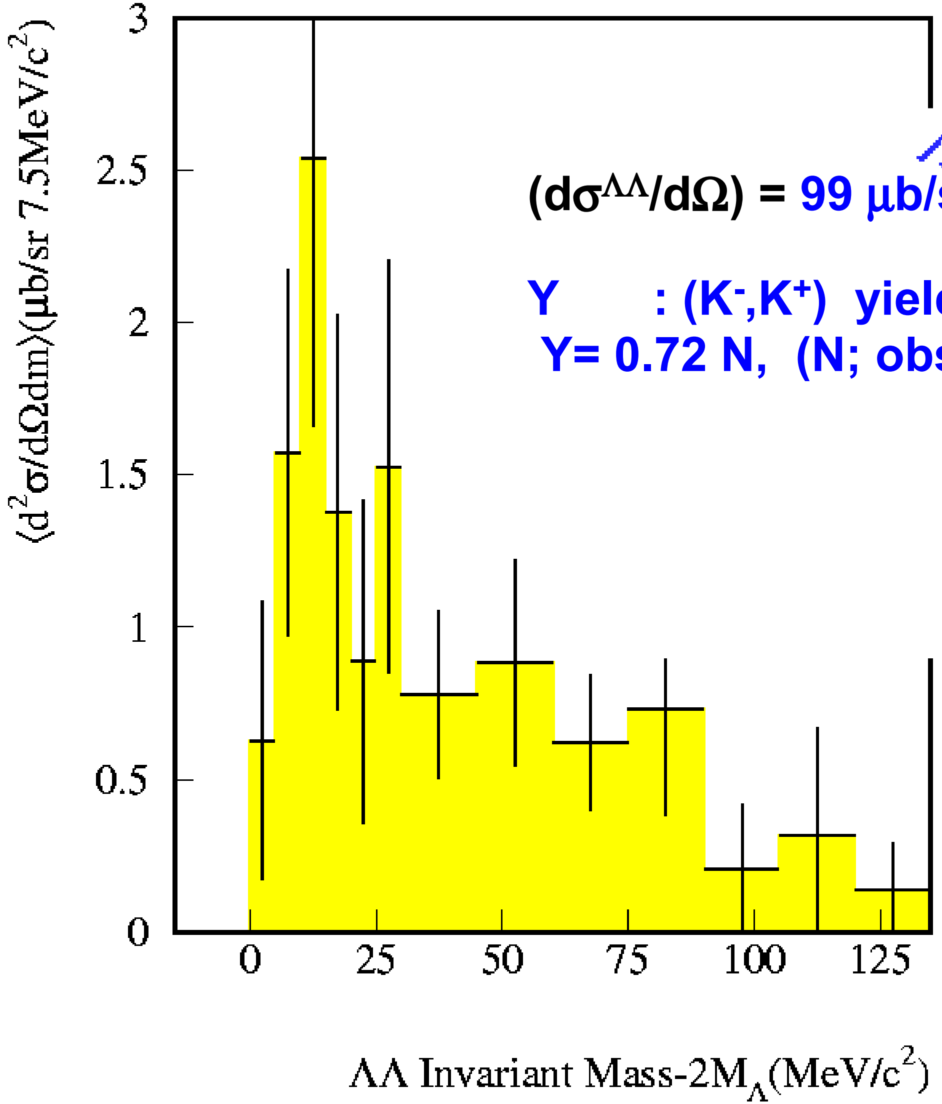
$(d\sigma^{\Lambda\Lambda}/d\Omega)$ = **99 μb/sr** x $(Y^{\Lambda\Lambda}/Y)$,



$(d\sigma^{\kappa\kappa}/d\Omega)$

$(d\sigma^{\Lambda\Lambda}/d\Omega)$ = 99 μb/sr x $(Y^{\Lambda\Lambda}/Y)$,

Y : (K^-,K^+) yield on carbon nuclei,

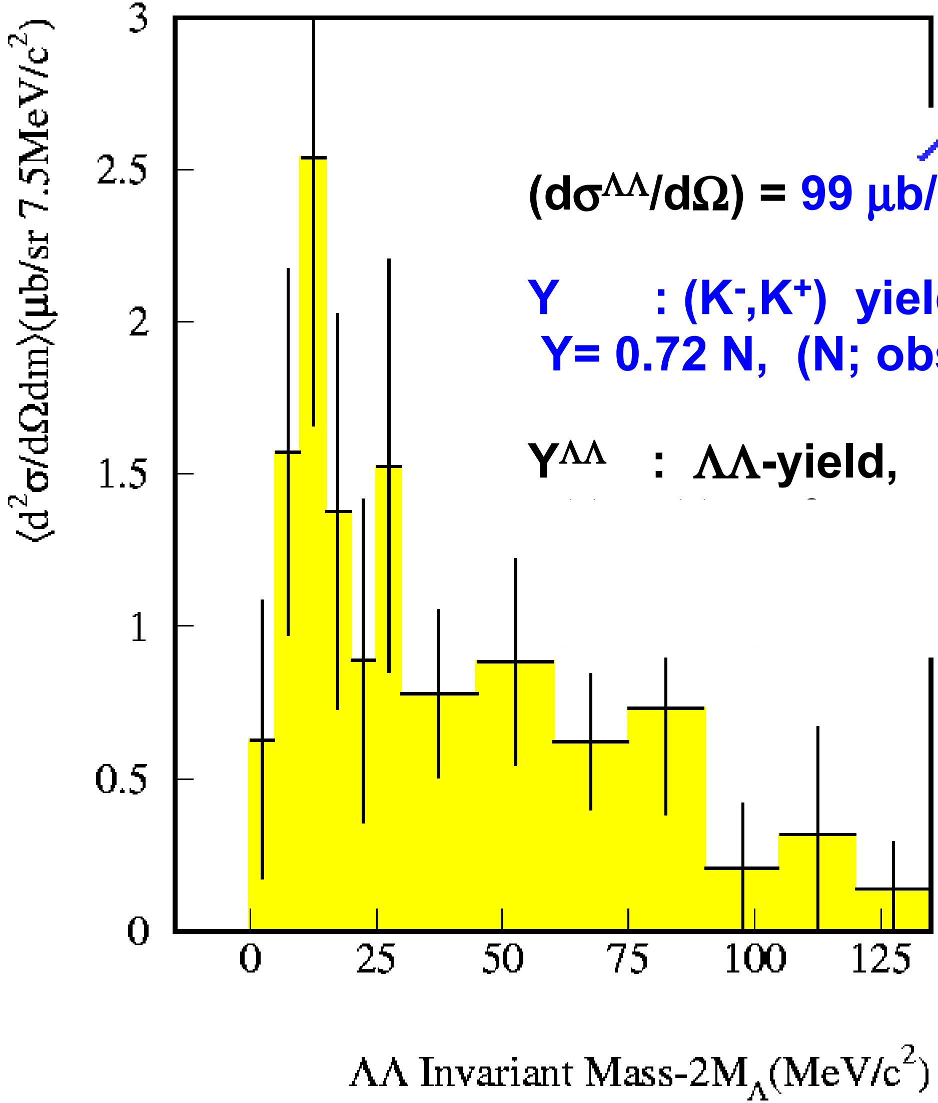


$(d\sigma^{KK}/d\Omega)$

$(d\sigma^{\Lambda\Lambda}/d\Omega)$ = 99 μb/sr x $(Y^{\Lambda\Lambda}/Y)$,

Y : (K^-,K^+) yield on carbon nuclei,

Y= 0.72 N, (N; observed (K^-,K^+) events.)



$(d\sigma^{\kappa\kappa}/d\Omega)$

$(d\sigma^{\Lambda\Lambda}/d\Omega)$ = 99 μb/sr x $(Y^{\Lambda\Lambda}/Y)$,

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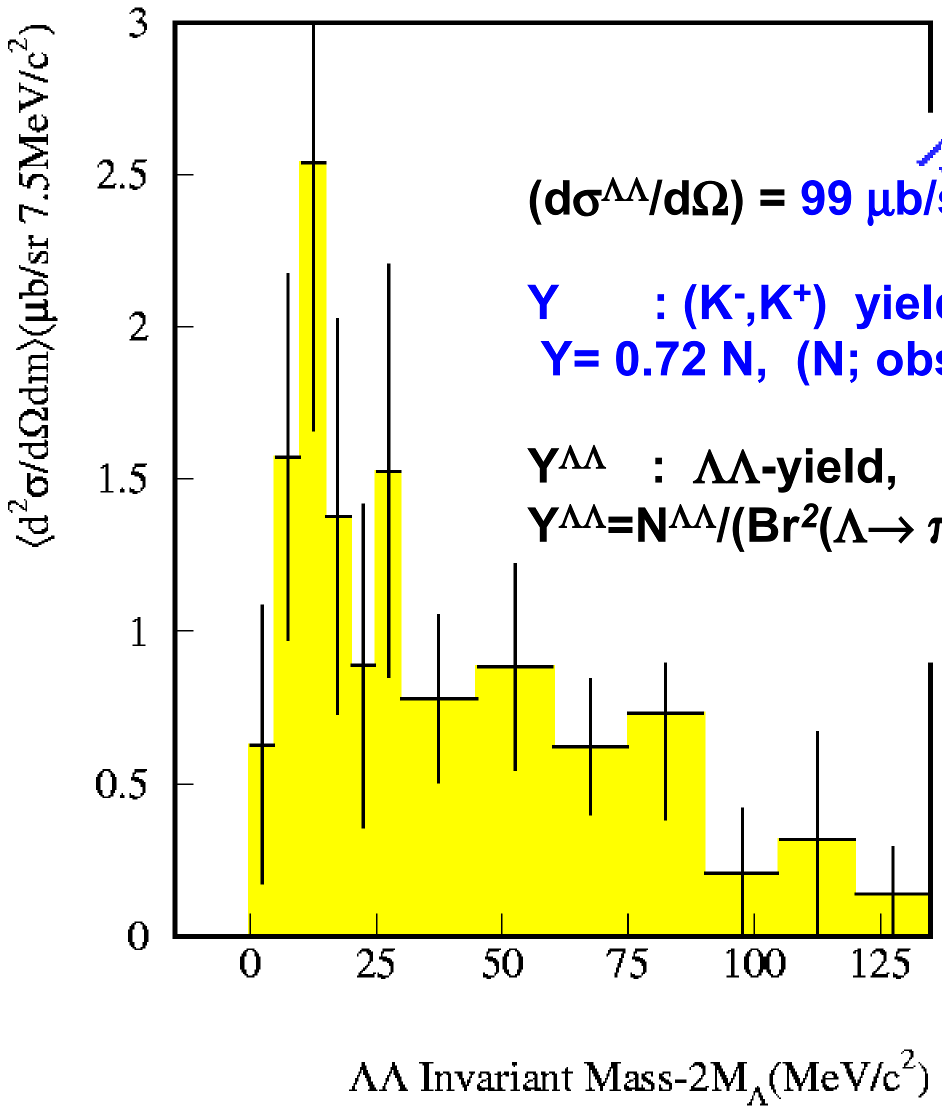
Y= 0.72 N, (N; observed (K^-,K^+) events.)

$Y^{\Lambda\Lambda}$: ΛΛ-yield,

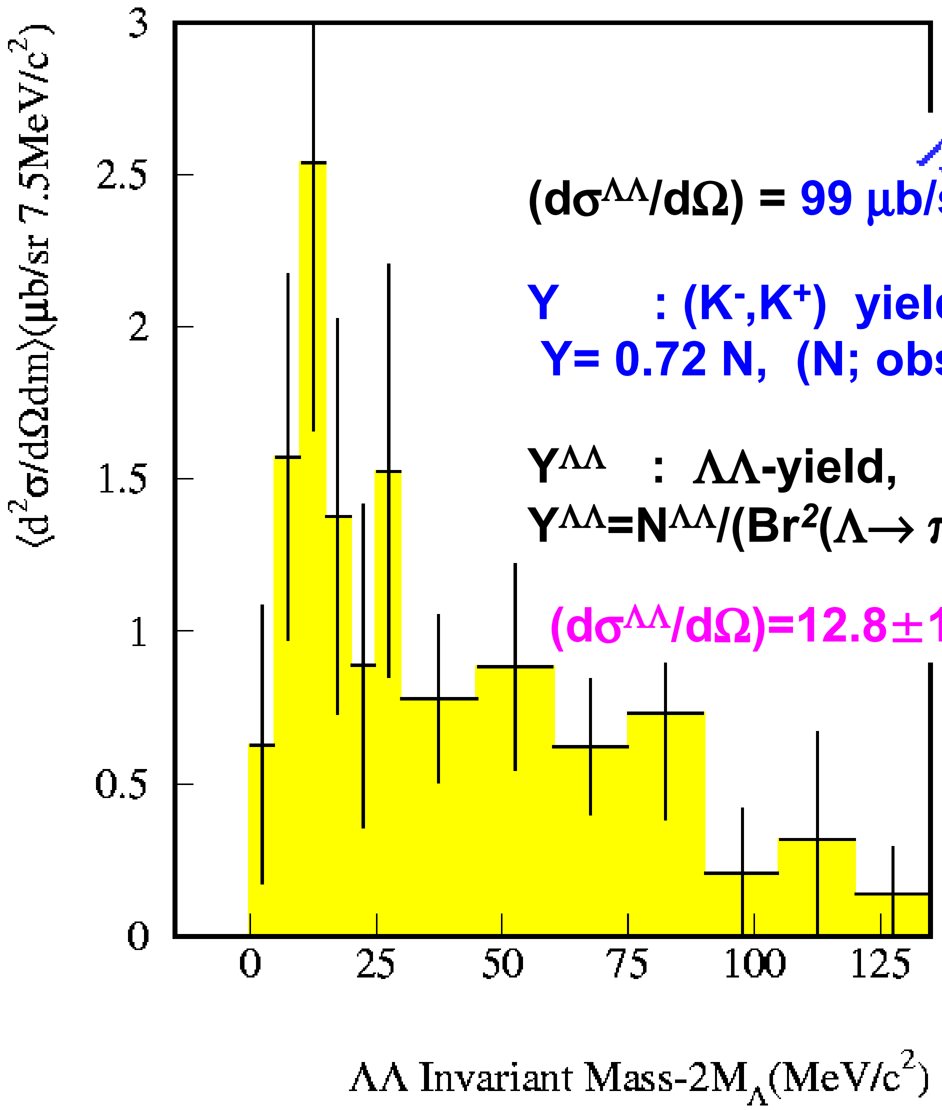


$(d\sigma^{KK}/d\Omega)$

$(d\sigma^{\Lambda\Lambda}/d\Omega)$ = 99 μb/sr x $(Y^{\Lambda\Lambda}/Y)$,

Y : (K^-,K^+) yield on carbon nuclei,
Y= 0.72 N, (N; observed (K^-,K^+) events.)

$Y^{\Lambda\Lambda}$: ΛΛ-yield,
$Y^{\Lambda\Lambda} = N^{\Lambda\Lambda}/(Br^2(\Lambda \rightarrow \pi^- p) \times \eta^{\Lambda\Lambda}_{SCIFI})$.



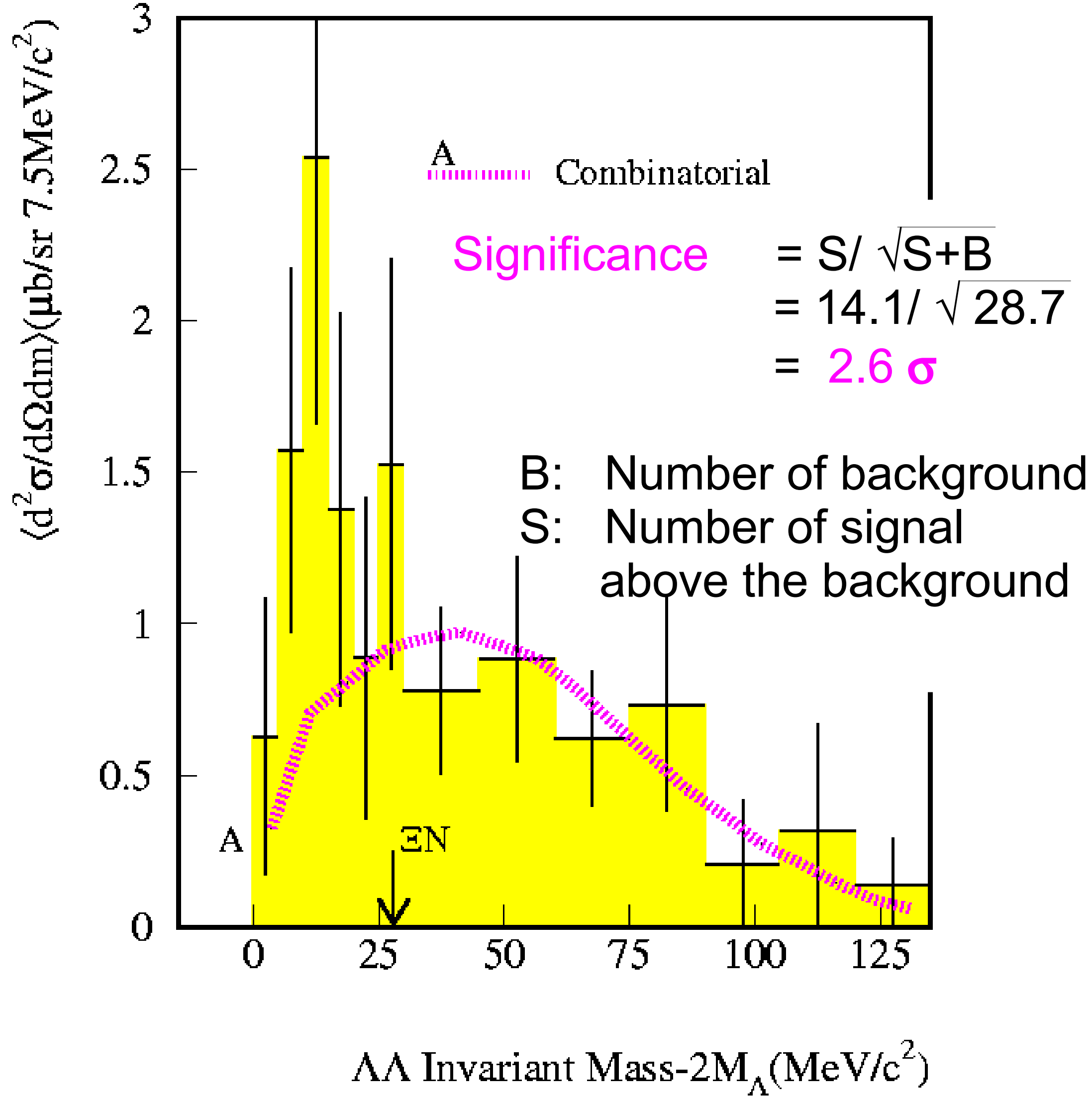
$(d\sigma^{KK}/d\Omega)$

$(d\sigma^{\Lambda\Lambda}/d\Omega)$ = 99 μb/sr x $(Y^{\Lambda\Lambda}/Y)$,

Y : (K^-,K^+) yield on carbon nuclei,
Y= 0.72 N, (N; observed (K^-,K^+) events.)

$Y^{\Lambda\Lambda}$: ΛΛ-yield,
$Y^{\Lambda\Lambda}=N^{\Lambda\Lambda}/(Br^2(\Lambda\rightarrow \pi^- p) \times \eta^{\Lambda\Lambda}_{SCIFI})$.

$(d\sigma^{\Lambda\Lambda}/d\Omega)=12.8\pm1.5(stat.)\pm0.5(syst.)$ μb/sr.



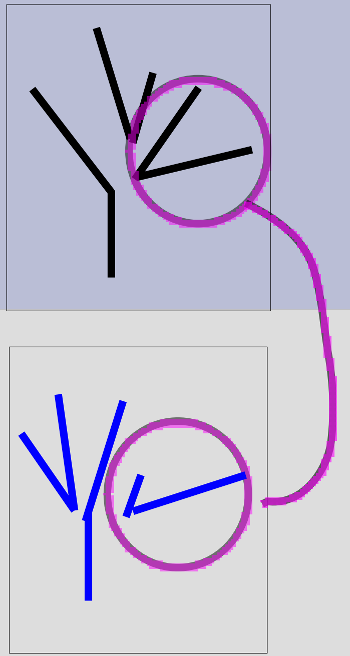
Significance $= S/\sqrt{S+B}$

$= 14.1/\sqrt{28.7}$

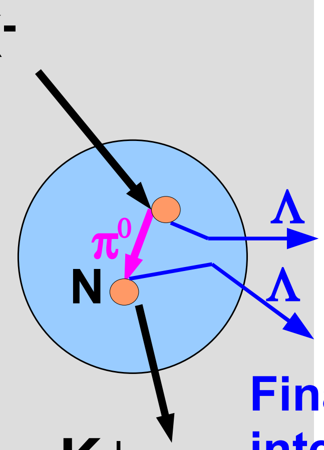
$= 2.6\,\sigma$

B: Number of background

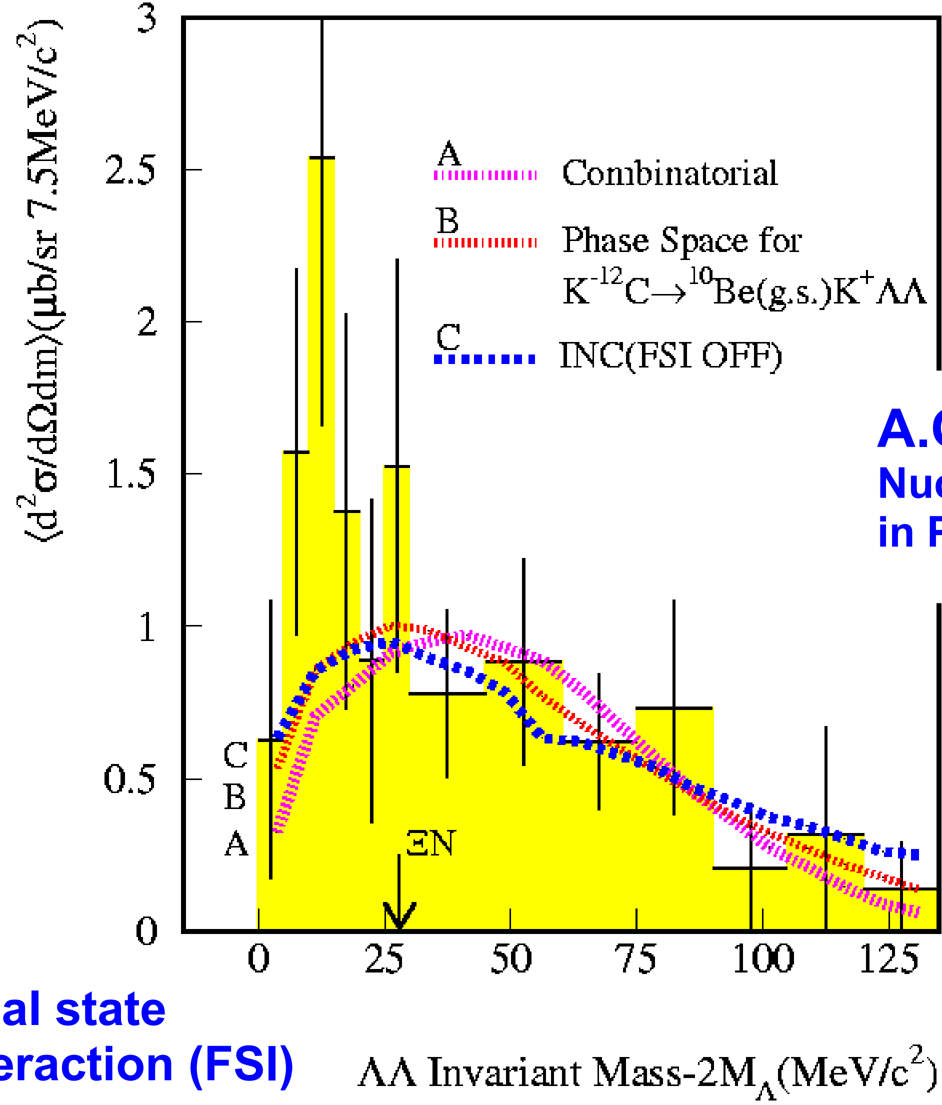
S: Number of signal above the background



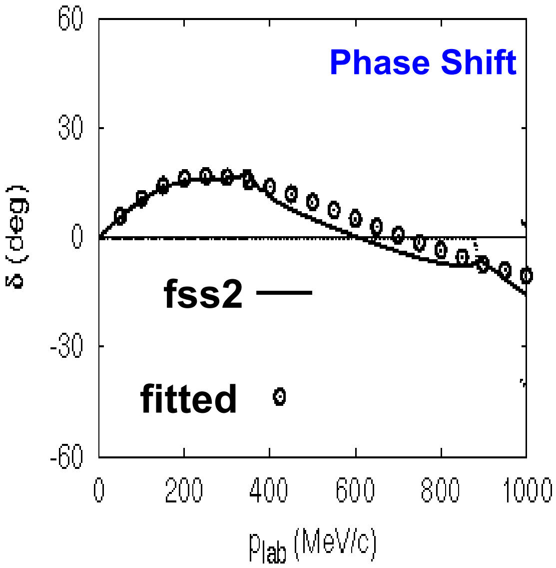
Intranuclear cascade model (INC)



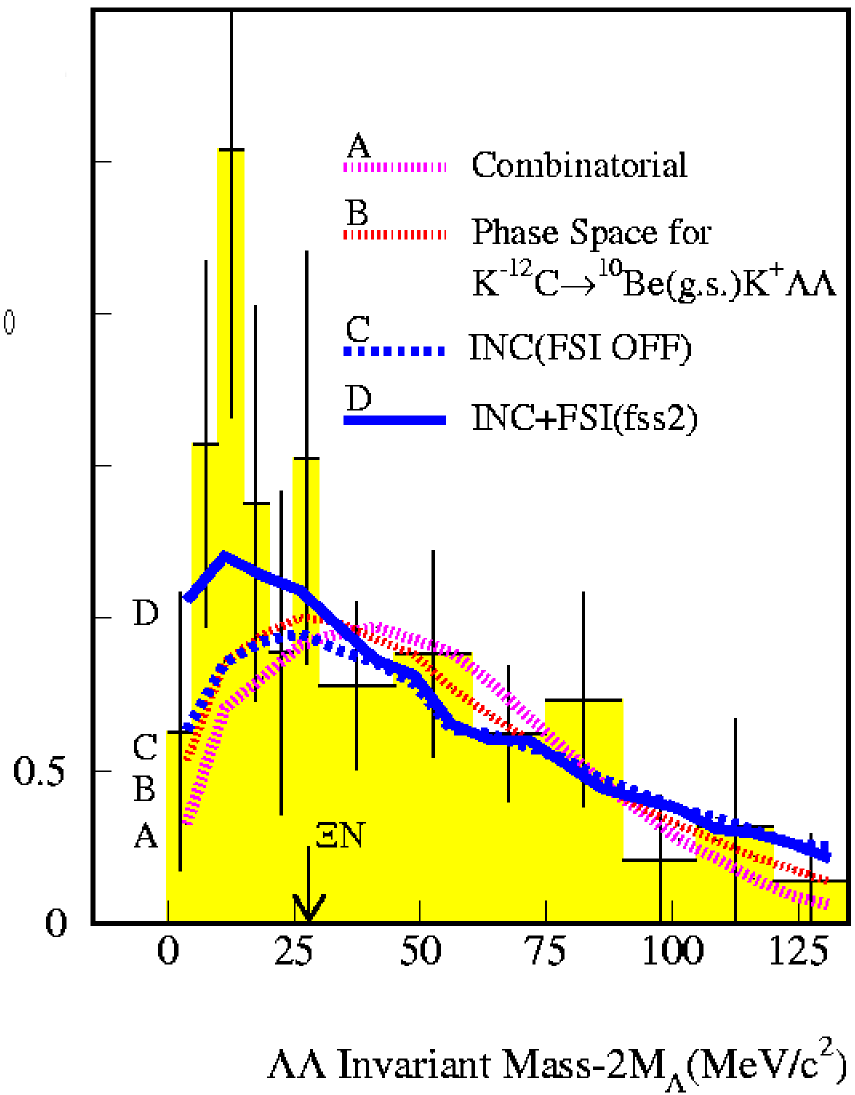
Final state interaction (FSI)

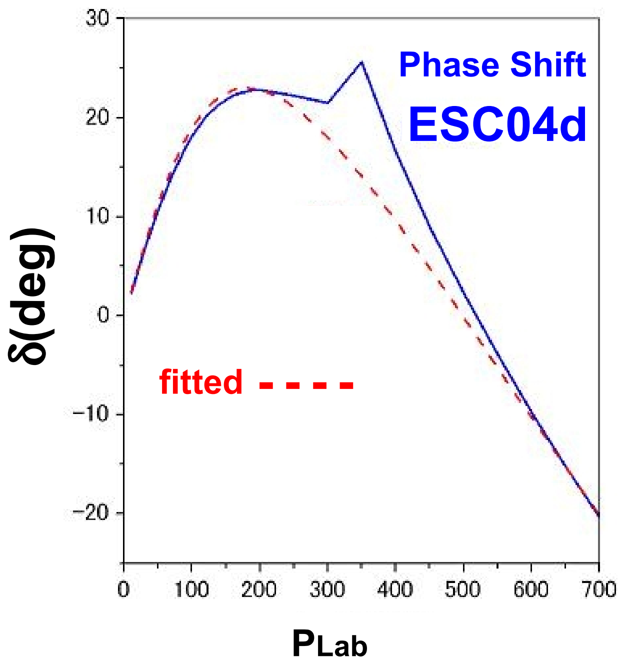


A.Ohnishi et al.,
Nucl. Phys. A691, 242c (2001); in Proc. of HYP2000

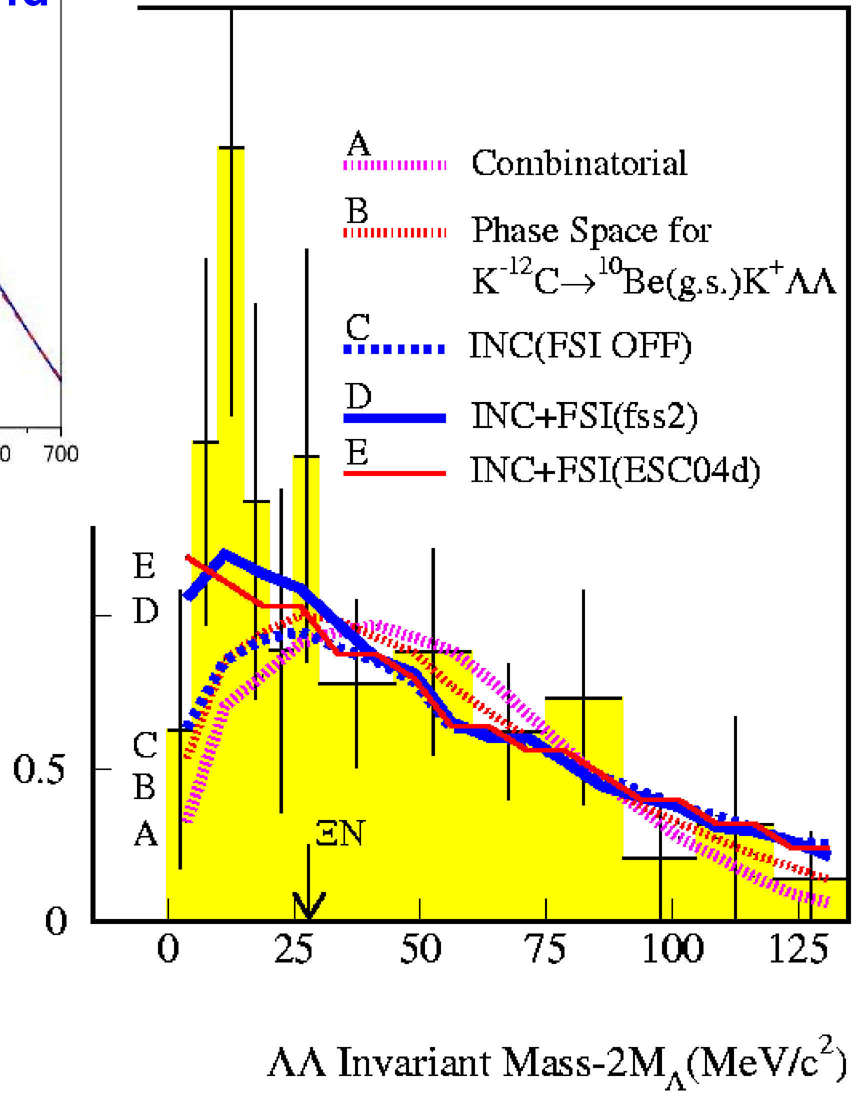


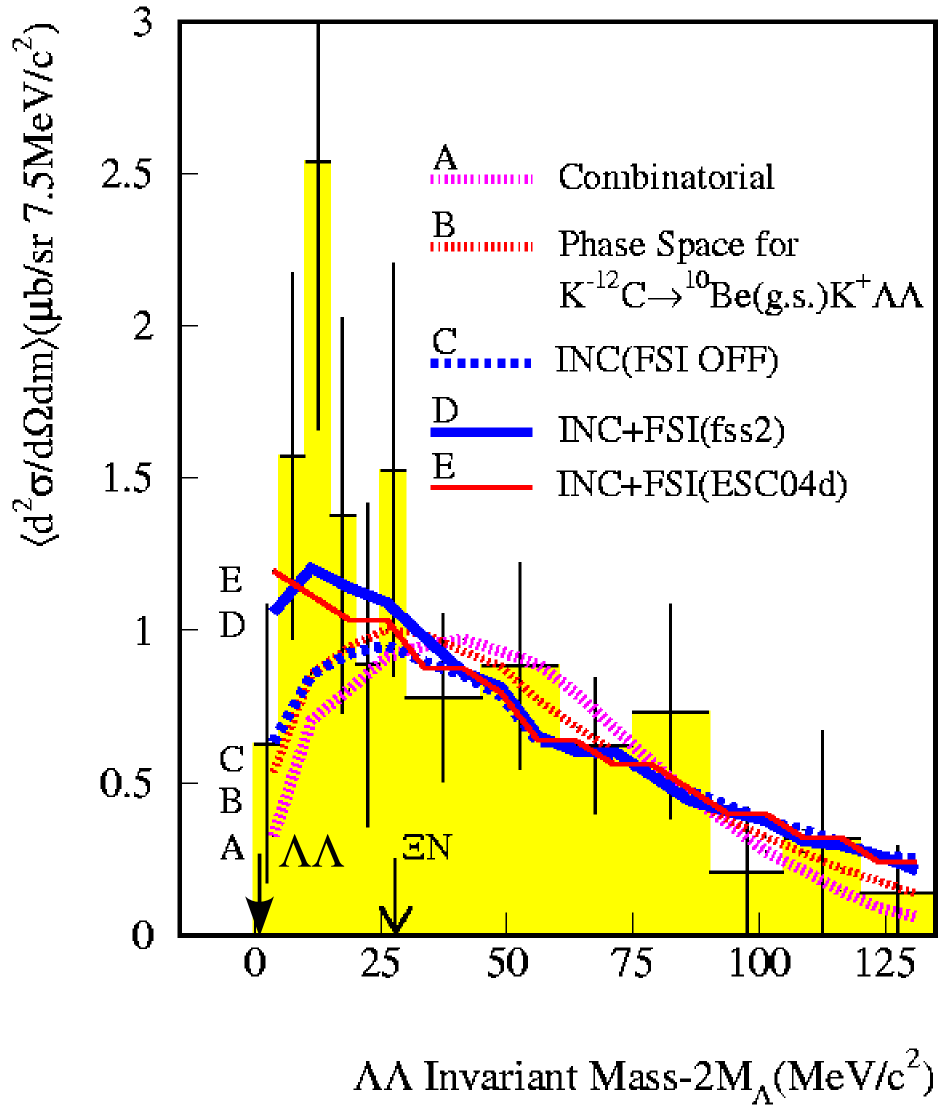
Y.Fujiwara et al.,
Phys. Rev. C70(2004)037001





Y.Yamamoto
(Private Communication)





Significance = $S/\sqrt{S+B}$

= $4.8/\sqrt{28.7}$

= 0.9 σ

(above the fss2)

Excess: **0.9 μb/sr** (4.8 events)

Upper limit (90% C.L.) on
the production cross section of
the H-dibaryon
between the ΛΛ and ΞN region;
2.1 μb/sr

RAPID COMMUNICATIONS

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

Search for the *H*-dibaryon resonance in $^{12}C(K^-, K^+\Lambda\Lambda X)$

C. J. Yoon,[1,*] H. Akikawa,[1,†] K. Aoki,[1] Y. Fukao,[1,‡] H. Funahashi,[1,§] M. Hayata,[1] K. Imai,[1] K. Miwa,[1,‖] H. Okada,[1,‡] N. Saito,[1,†] H. D. Sato,[1] K. Shoji,[1] H. Takahashi,[1,†] K. Taketani,[1] J. Asai,[2,‡] M. Kurosawa,[2,‡] M. Ieiri,[3] T. Hayakawa,[4] T. Kishimoto,[4] A. Sato,[4] Y. Shimizu,[4] K. Yamamoto,[5] T. Yoshida,[5,¶] T. Hibi,[6] K. Nakazawa,[6] J. K. Ahn,[7] B. H. Choi,[7] S. J. Kim,[7] S. H. Kim,[8,**] B. D. Park,[8,††] I. G. Park,[8] J. S. Song,[8] C. S. Yoon,[8] K. Tanida,[9,‡‡] and A. Ohnishi[10]

(KEK-PS E522 Collaboration)

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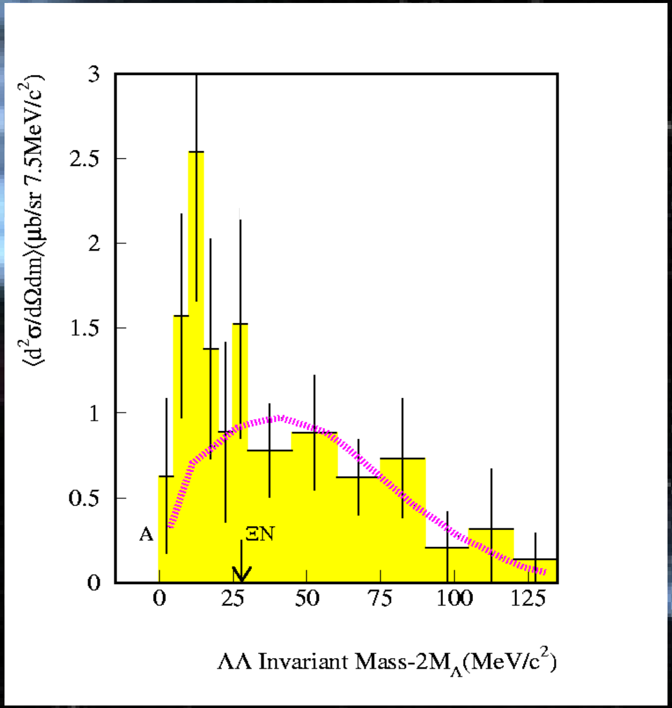
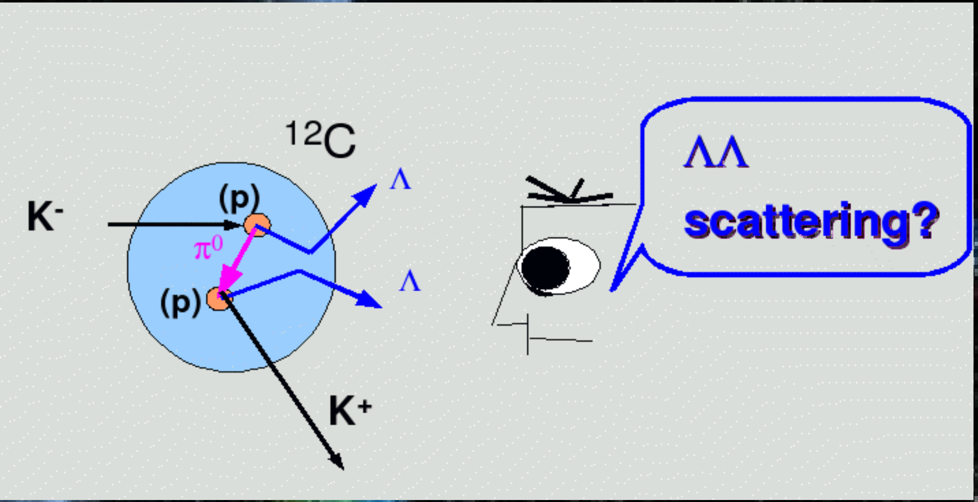
(Received 20 September 2006; published 7 February 2007)

Exp.data=ΛΛ FSI+Combinatorial B.G ?



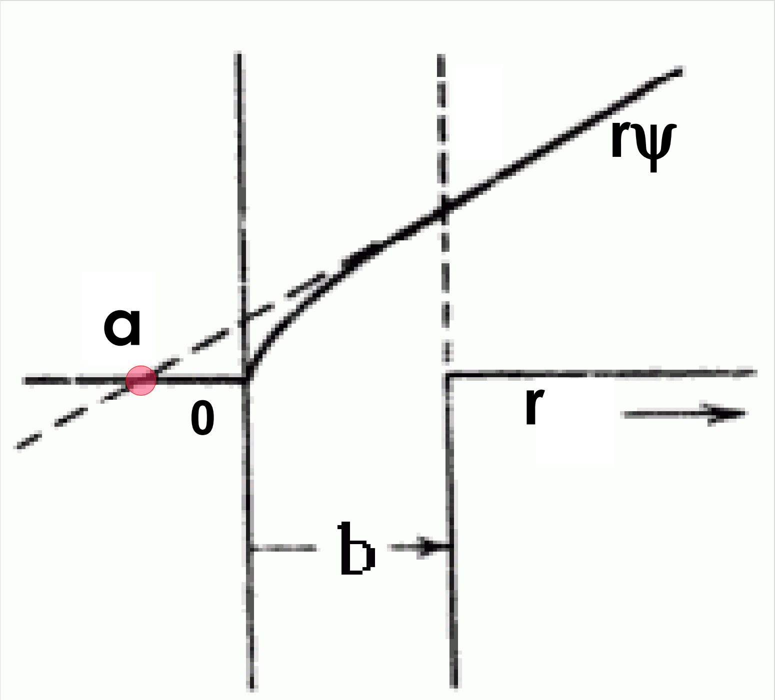


ΛΛ enhancement factor

ψ (s-wave)~$\sin(kr+\delta)/kr$

$F = |\sin(kb+\delta)/k|^2$ Watson (1952)

$k\cot(\delta) = -1/a + (1/2)\, rk^2$ Bethe (1949)



a : scattering length,

r : effective range,

δ : phase shift,

b : intrinsic range,

k : $E_{\Lambda\Lambda} = (\hbar k)^2/2\mu$,

$\mu = m_\Lambda^2/(m_\Lambda + m_\Lambda)$.

ΛΛ enhancement factor

ψ (s-wave)~$\sin(kr+\delta)/kr$

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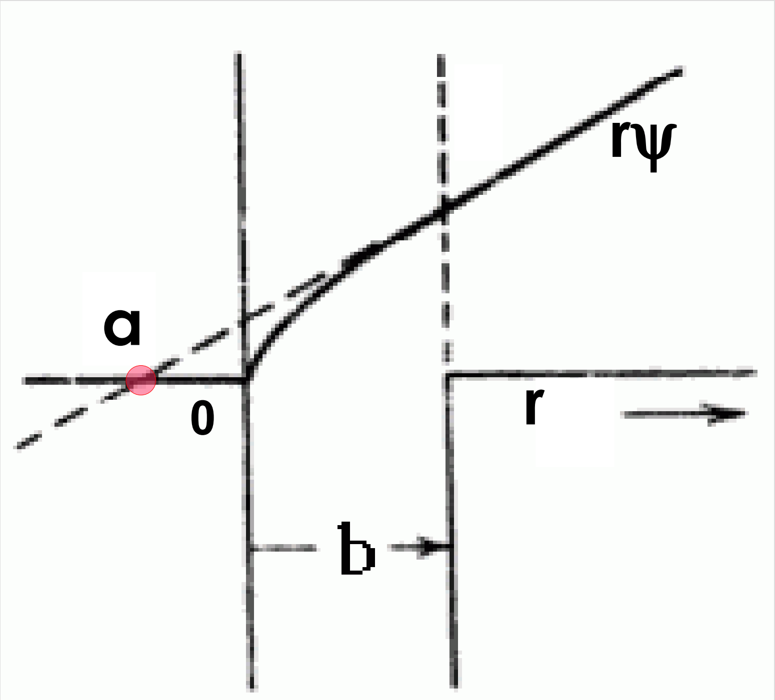

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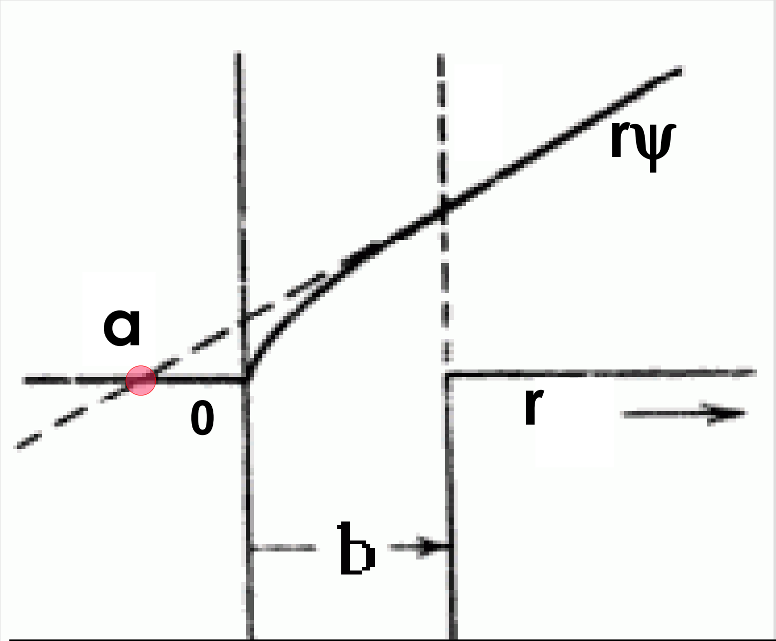


Weakly attractive, and there is no bound state; $a < 0$

ΛΛ enhancement factor

ψ (s-wave)~$\sin(kr+\delta)/kr$

$F=|\sin(kb+\delta)/k|^2$ Watson (1952)

$k\cot(\delta)=-1/a + (1/2)\, rk^2$ Bethe (1949)

a : scattering length,

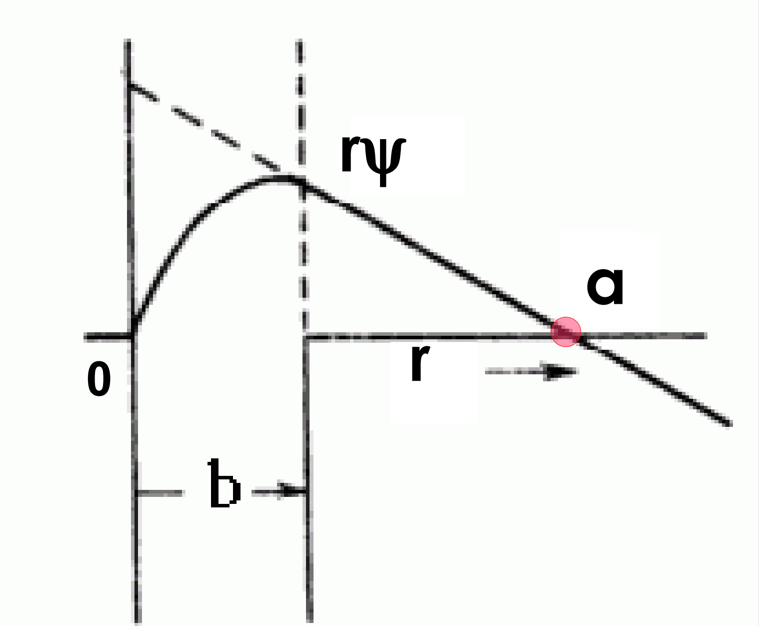
r : effective range,

δ : phase shift,

b : intrinsic range,

k : $E_{\Lambda\Lambda}=(\hbar k)^2/2\mu$,

$\mu=m_\Lambda^2/(m_\Lambda+m_\Lambda)$.



Repulsive, or a bound state (with strongly attractive potential);

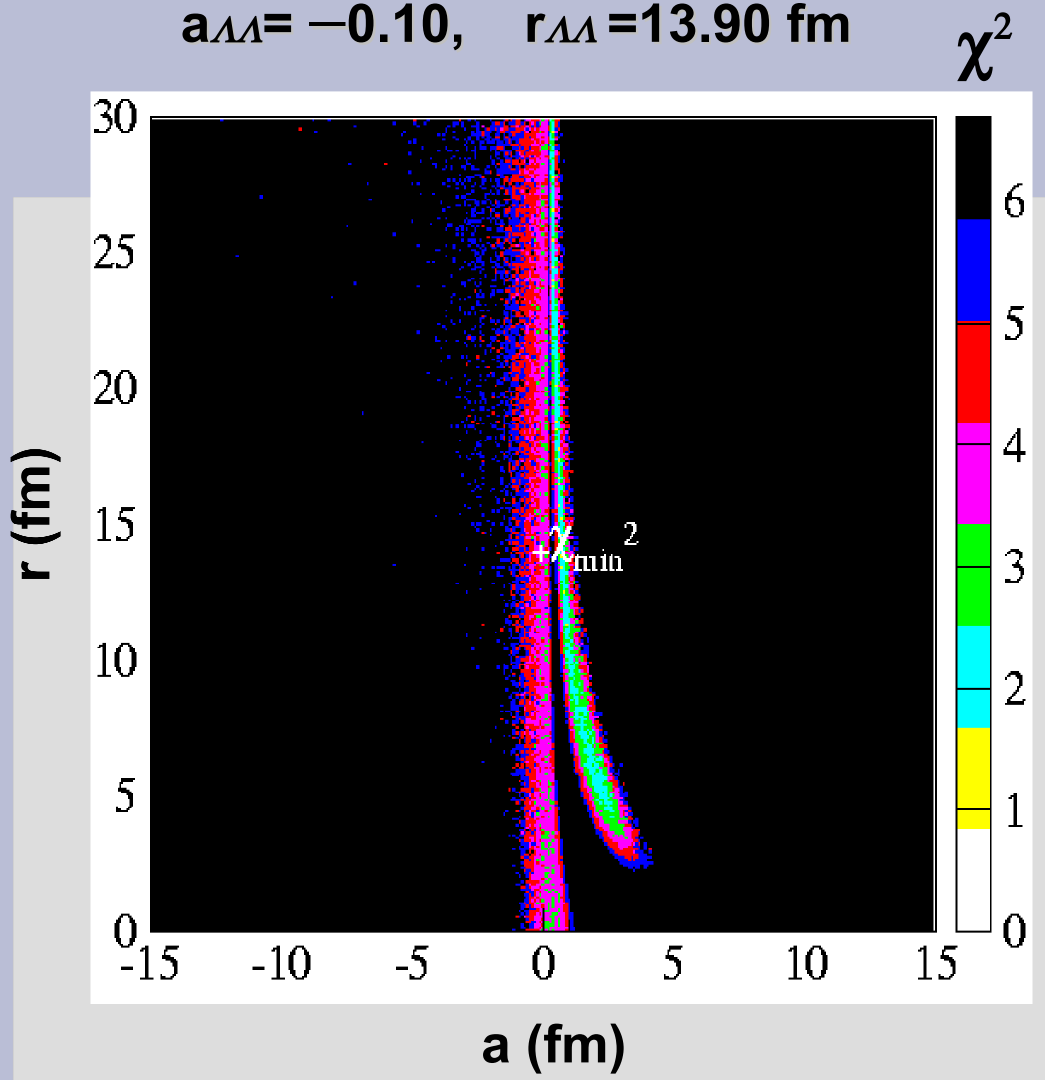
$a > 0$

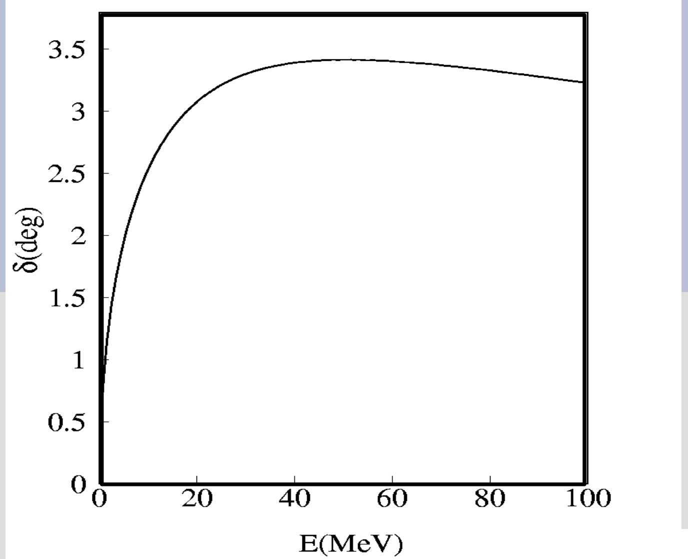
How to extract a and r ?

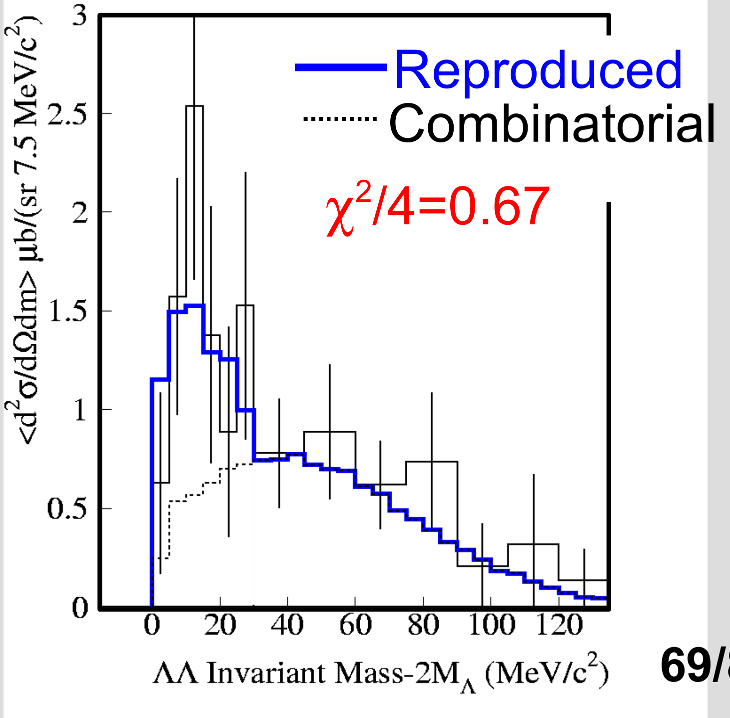
$$\chi^2 = \sum_i^N (C_{adj} \times F_i(a,r;k) + B.G_i - Data_i)^2 / \sigma_i^2$$

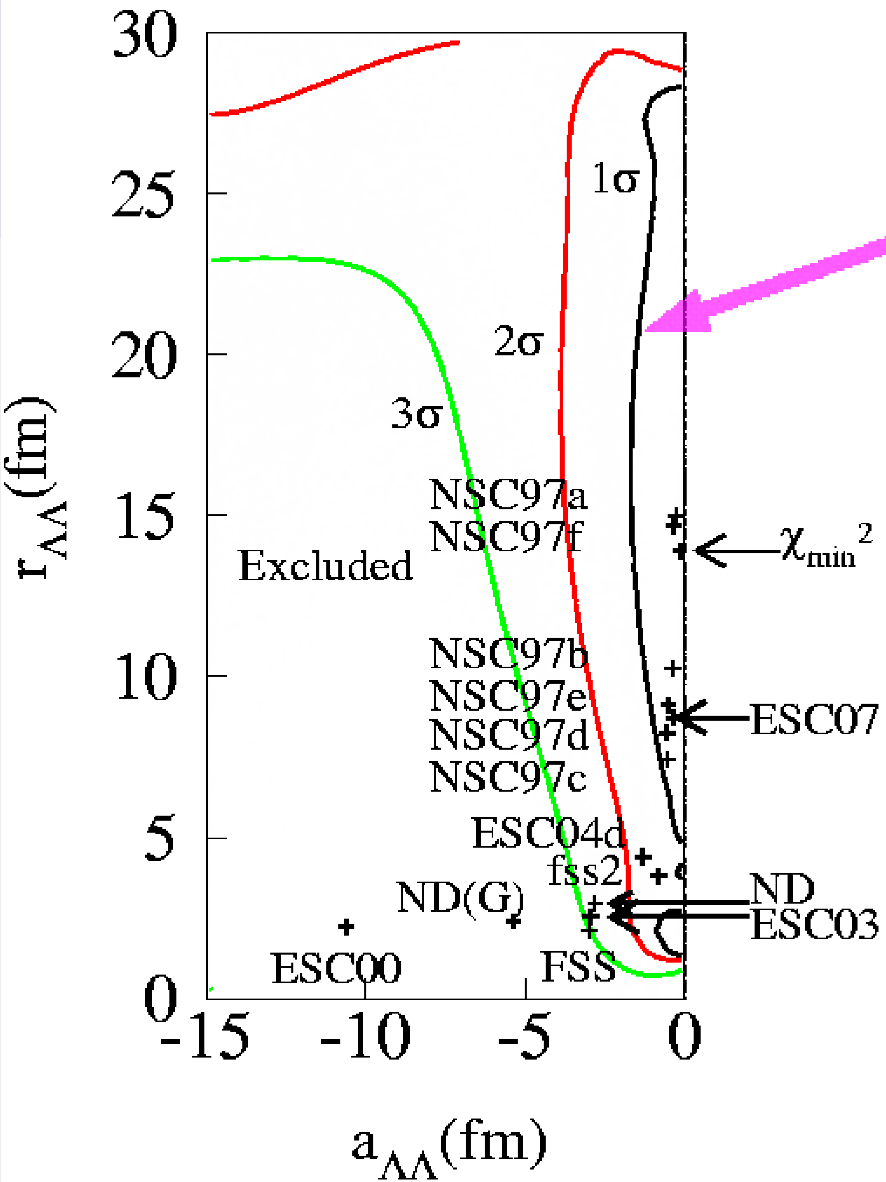
C_{adj} : Adjusting parameter between M.C. & real data,
F(a,r;k) : Enhancement factor, $|\sin(kb+\delta)/k|^2$,
B.G : Background taken from combinatorial b.g.,
Data : $\Lambda\Lambda$ invariant masses,
σ_i : Uncertainty at i-th bin.

$a_{\Lambda\Lambda} = -0.10, \quad r_{\Lambda\Lambda} = 13.90$ fm









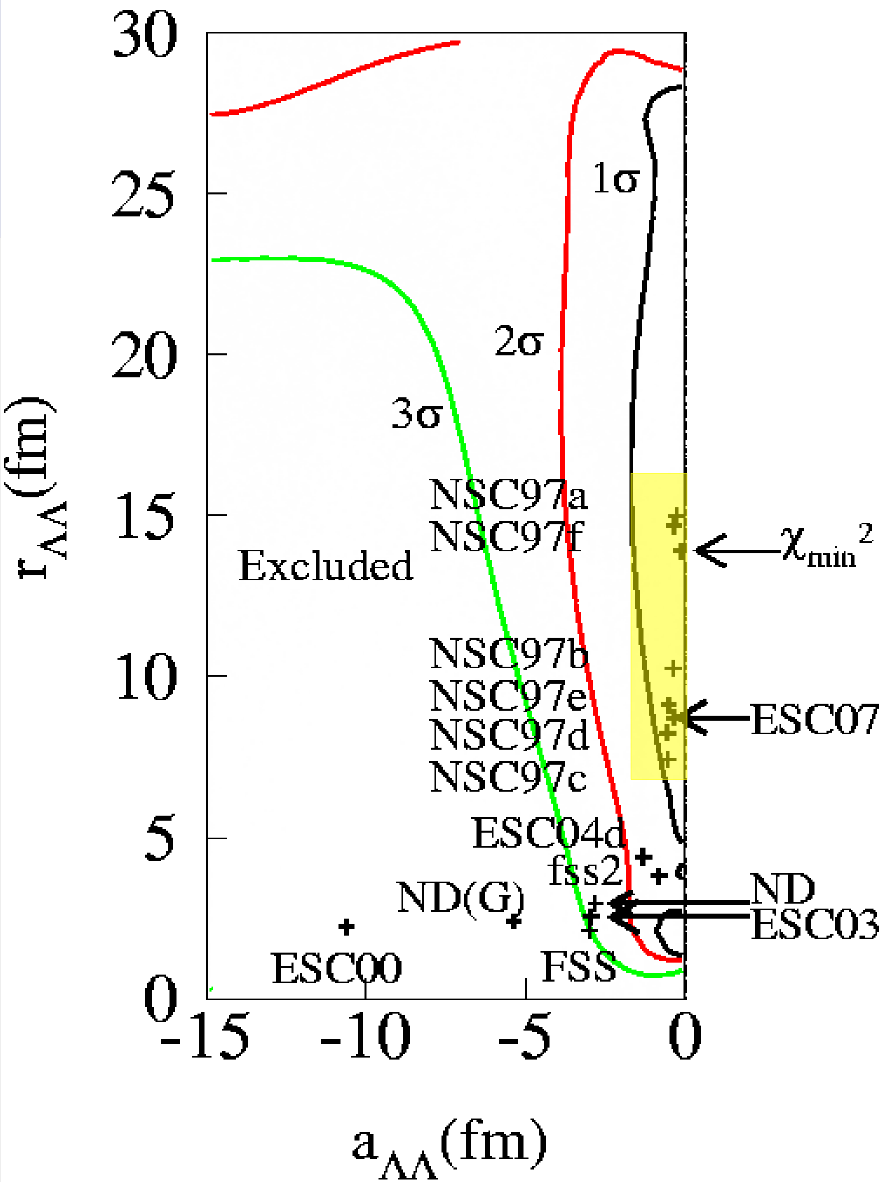
$a_{\Lambda\Lambda} = -0.10 \, {}^{+0.37}_{-1.56} \pm 0.28,$

$r_{\Lambda\Lambda} = \; 13.90 \, {}^{+14.35}_{-9.13} \pm 10.53$ fm.

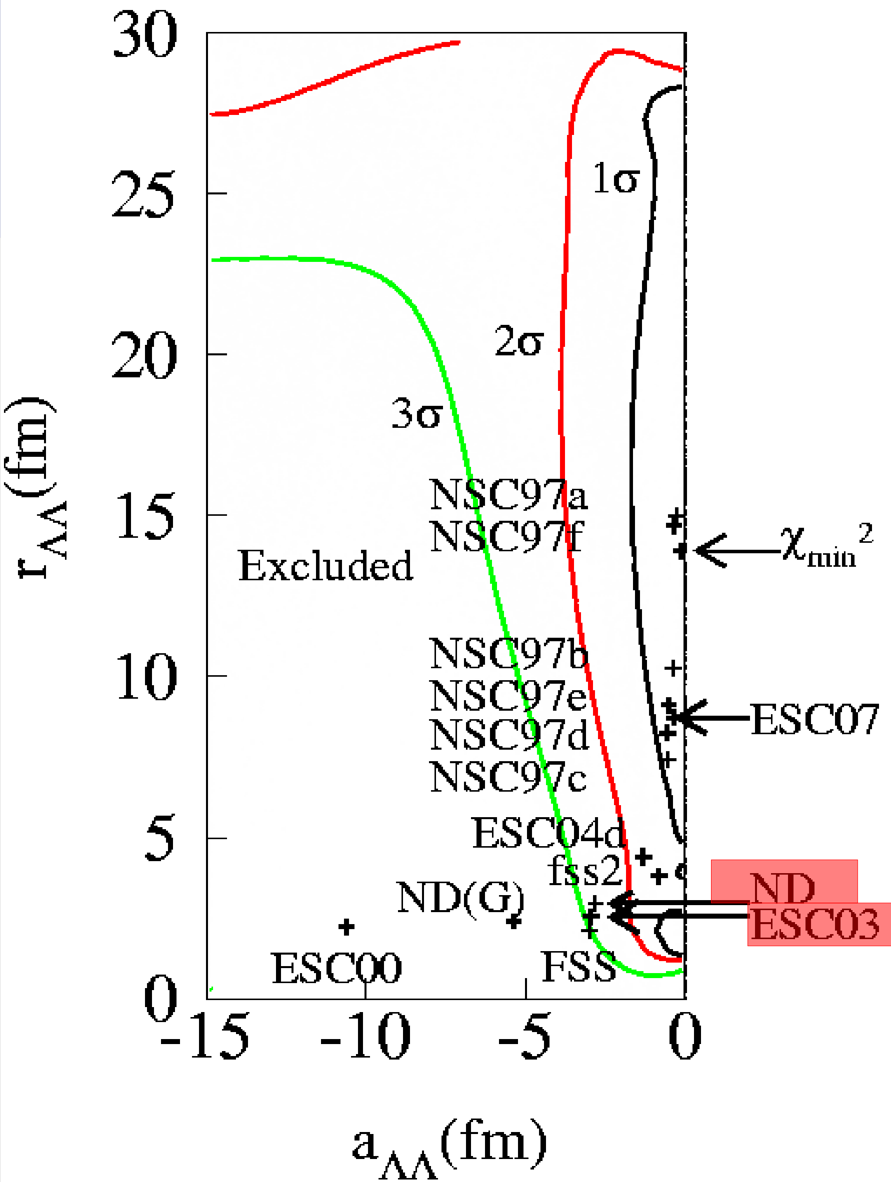
Systematic uncertainties were determined by considering

1. **change of b; 2 ~ 2.5 fm, and bin size in a-r plane,**
2. **uncertainty arise from smoothing procedure of contour plot,**
3. **uncertainty arise from different analysis methods,**

$$k \cot \delta = -\frac{1}{a_{\Lambda\Lambda}} + \frac{1}{2} r_{\Lambda\Lambda} k^2 - P r_{\Lambda\Lambda}^3 k^4,$$



Model	$a_{\Lambda\Lambda}$ (fm)	$r_{\Lambda\Lambda}$ (fm)
Nijmegen hard-core		
ND	−2.81⋆⋆	2.95
ND(G-matrix)	−5.37⋆⋆⋆	2.40
Nijmegen soft-core		
NSC97a	−0.27	15.00
NSC97b	−0.38	10.24
NSC97c	−0.53	7.43
NSC97d	−0.53	8.24
NSC97e	−0.50	9.11
NSC97f	−0.35	14.68
Nijmegen extended soft-core		
ESC00	−10.60⋆⋆⋆	2.23
ESC03	−2.94⋆⋆	2.53
ESC04a	−1.15⋆	4.48
ESC04b	−1.25⋆	4.45
ESC04c	−1.08⋆	4.46
ESC04d	−1.32⋆	4.40
ESC07d	−0.34	8.73
ESC08d	−0.47	8.19
Kyoto-Niigata		
FSS	−3.01⋆⋆⋆	2.14
fss2	−0.81⋆	3.80
Jülich-Bonn		
Chiral effective-field	−1.52⋆	0.82
This work	−0.10	13.90



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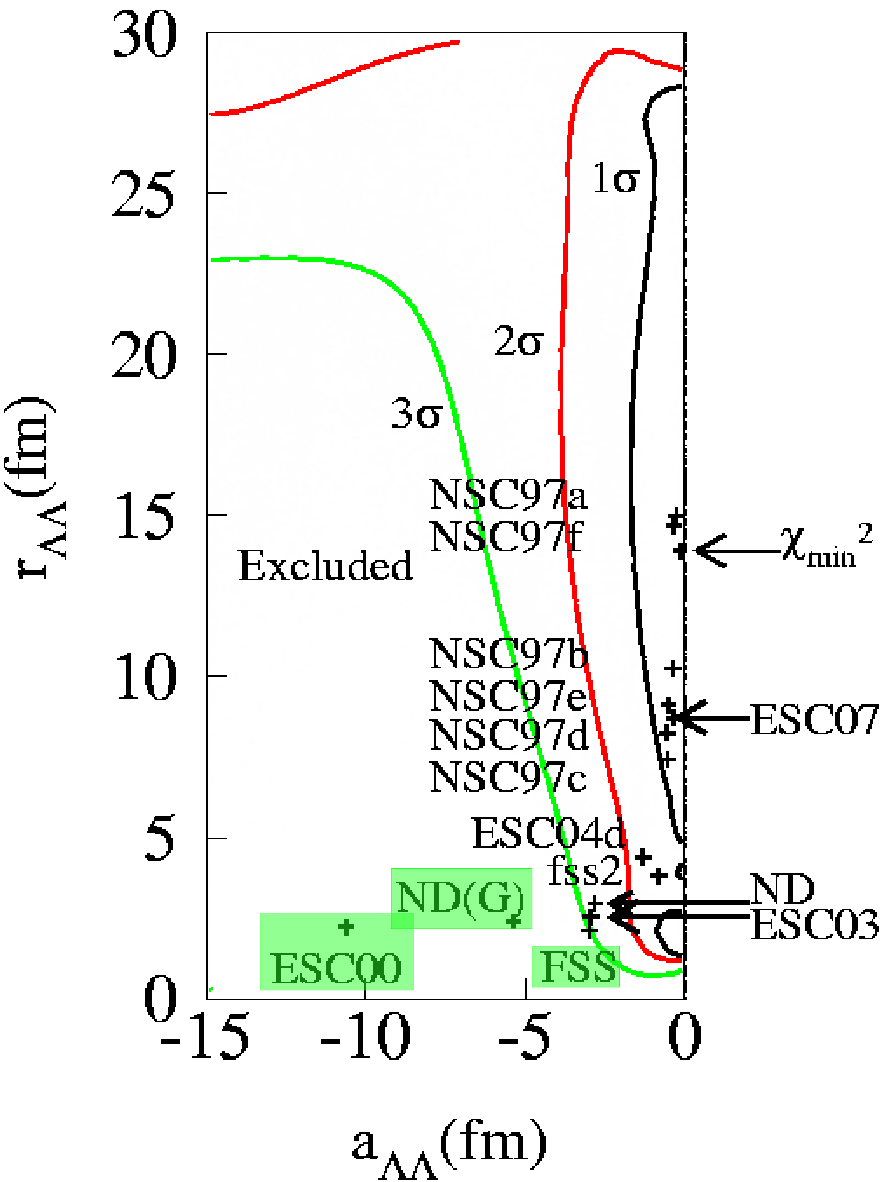

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Extracting a and r by determining wave function with assumed potential wells

$$\chi^2 = \sum_{i}^{N} (C_{adj}\, x F_i\, (a, r; k) + B.G_i - Data_i)^2 / \sigma_i^2$$

C_{adj} : Adjusting parameter between M.C. & real data,

$F(a,r;k)$ $= \psi^2$; Determined by solving wave equation by using $\Lambda\Lambda$ potential described by

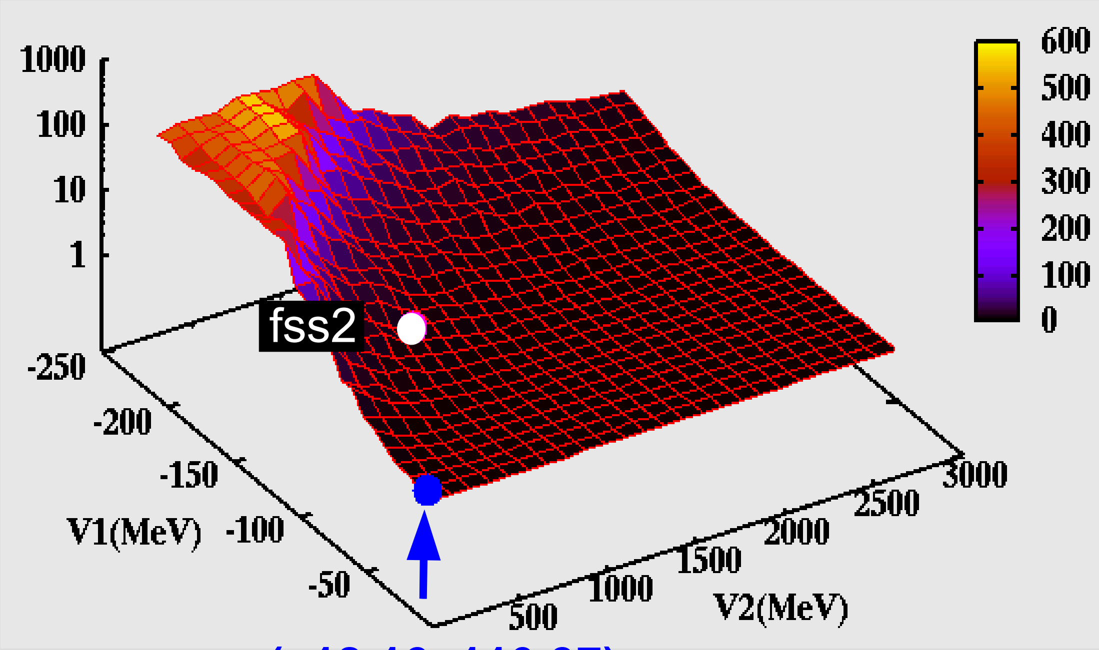
$$V(r) = V_1 \exp(-(r/\mu_1)^2) + V_2 \exp(-(r/\mu_2)^2)$$

V_1=-9.9 ~-197.9, V_2=61.4 ~1251.8 at μ_1=0.922, μ_2= 0.410

(On the basis of the fss2)

Potential parameters determined by fitting the ΛΛ mass spectrum

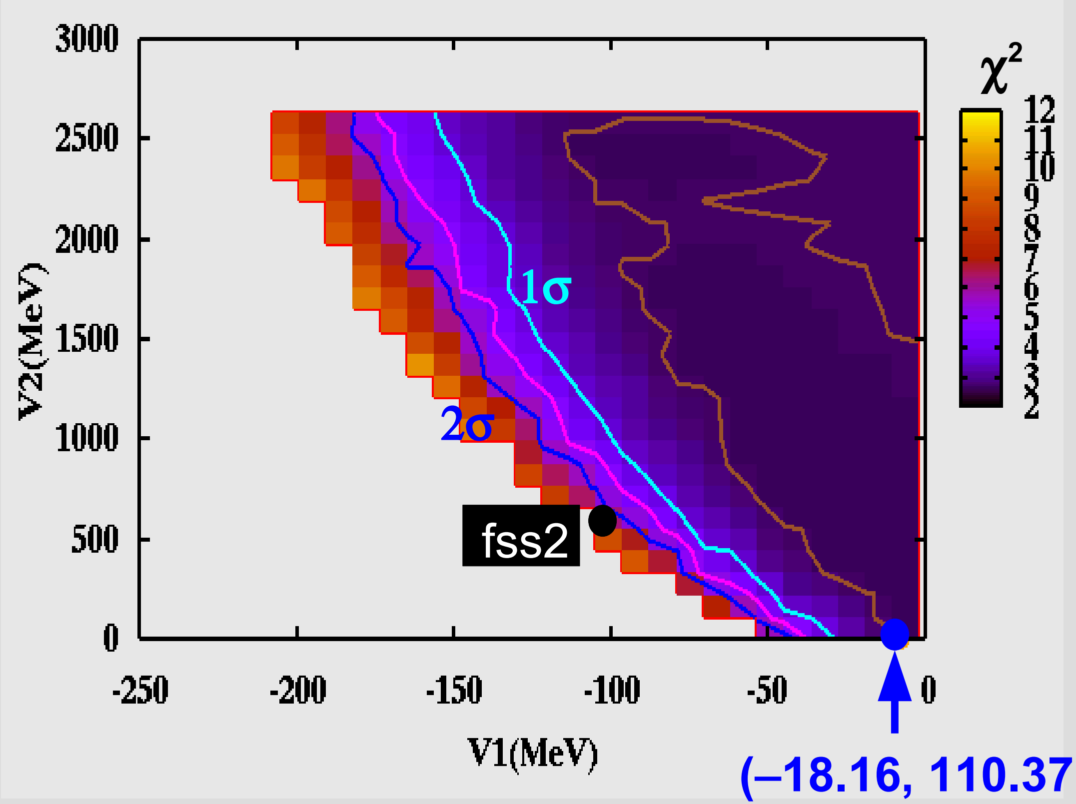
log(χ^2)



(–18.16, 110.37)

$a_{\Lambda\Lambda} < 0$, and $0 < r_{\Lambda\Lambda} < 30$ fm region only considered in order to give attractive ΛΛ-potential.

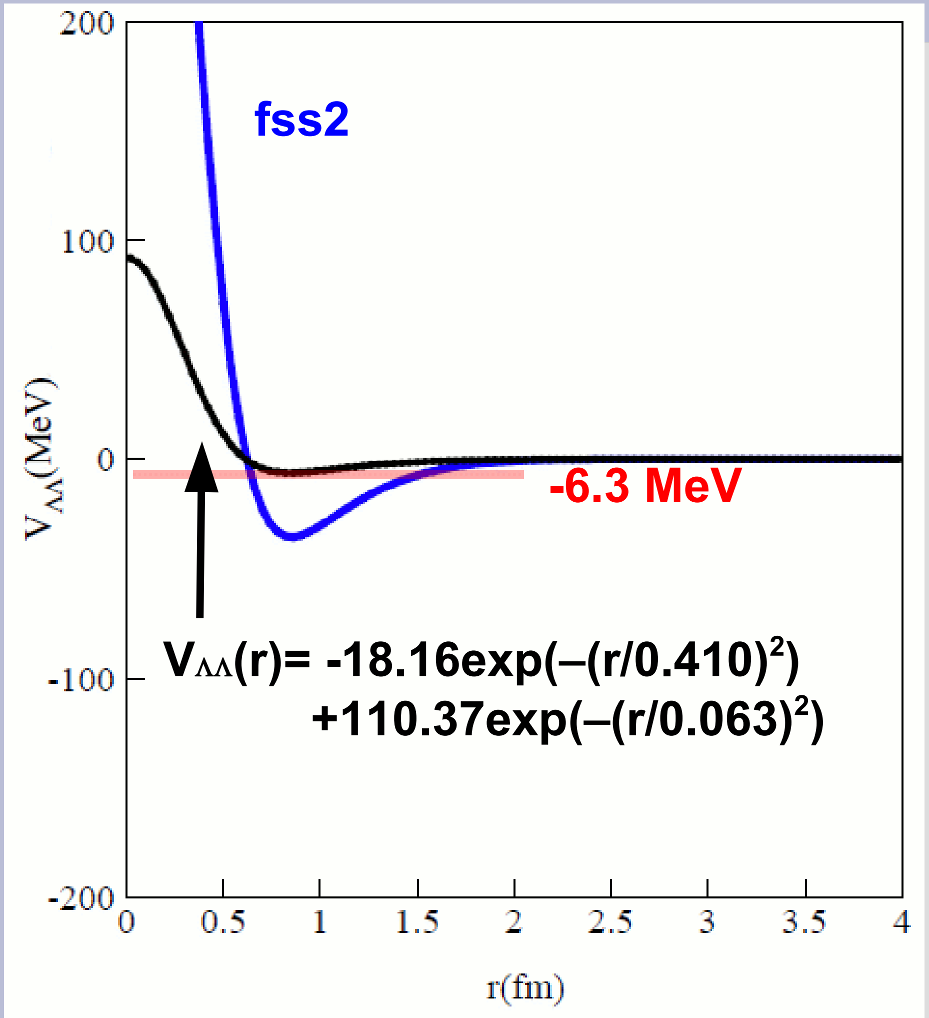
Potential parameters determined by fitting the ΛΛ mass spectrum

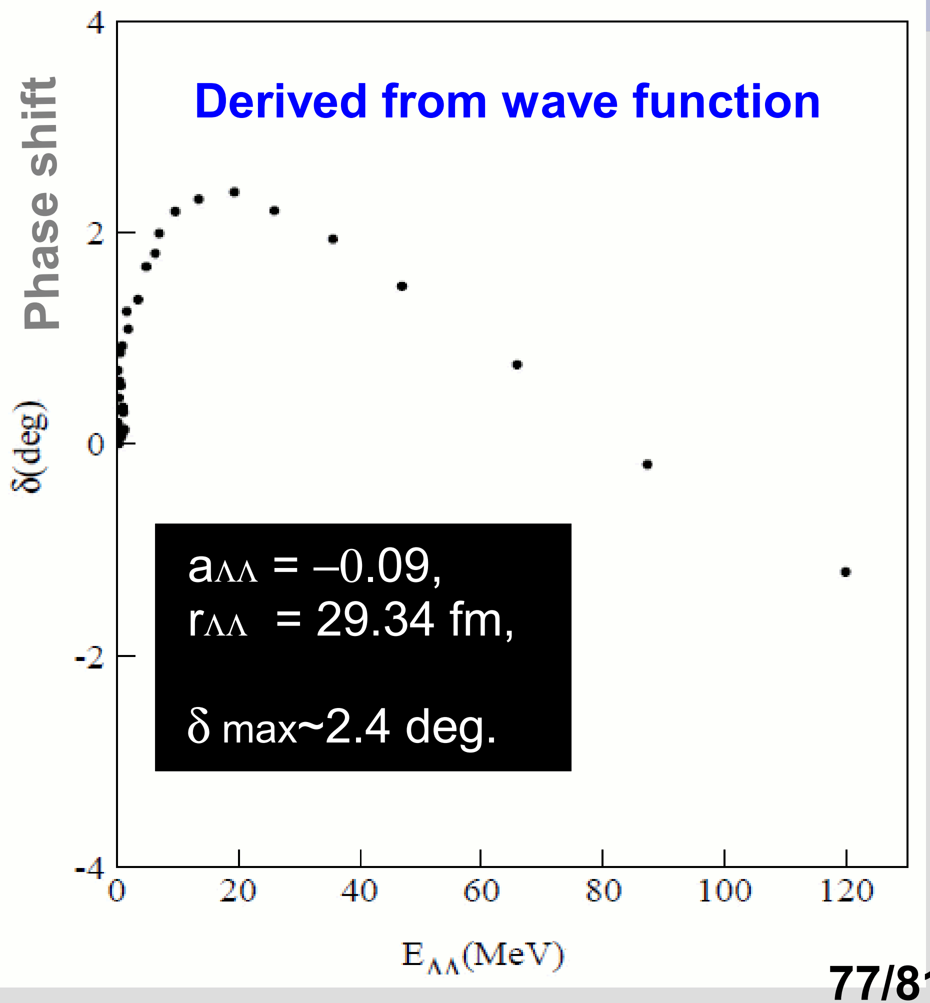


(–18.16, 110.37, 2.57/(dof=6-2))

$a_{\Lambda\Lambda} < 0$, and $0 < r_{\Lambda\Lambda} < 30$ fm region only considered in order to give attractive ΛΛ-potential.

Determined ΛΛ potential, wave function, phase shift, and scattering length





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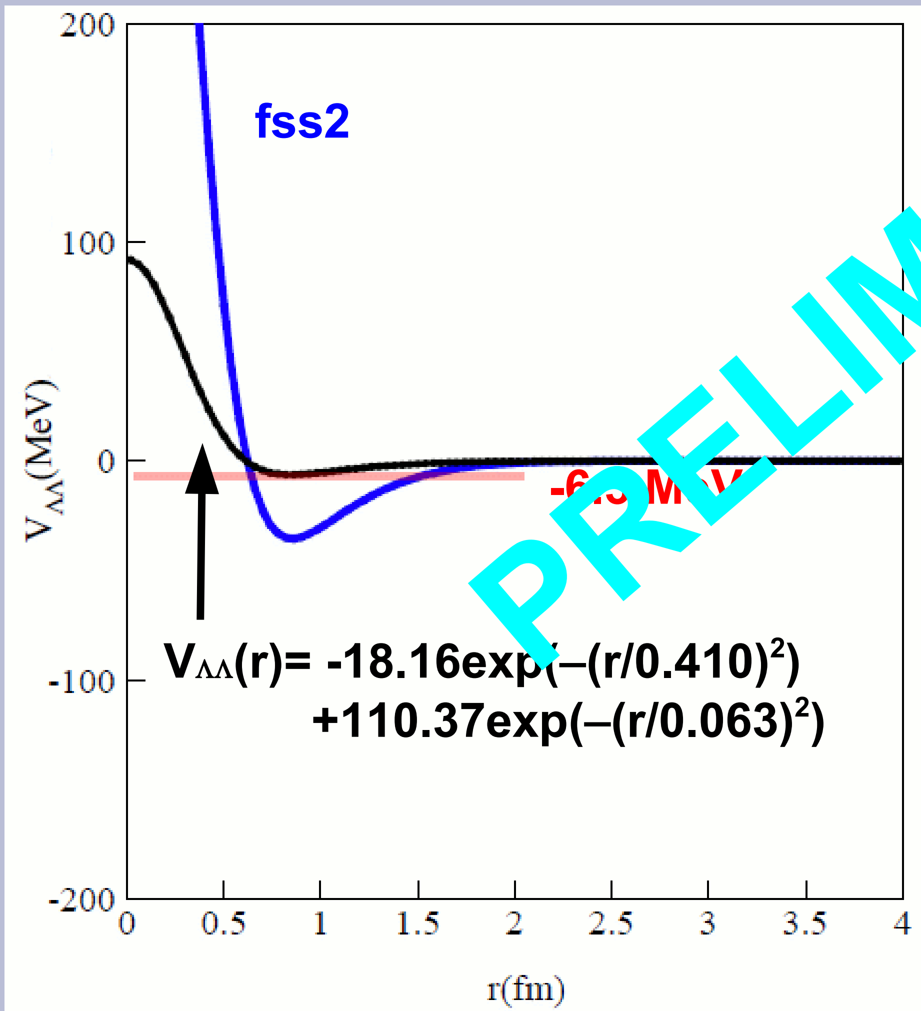

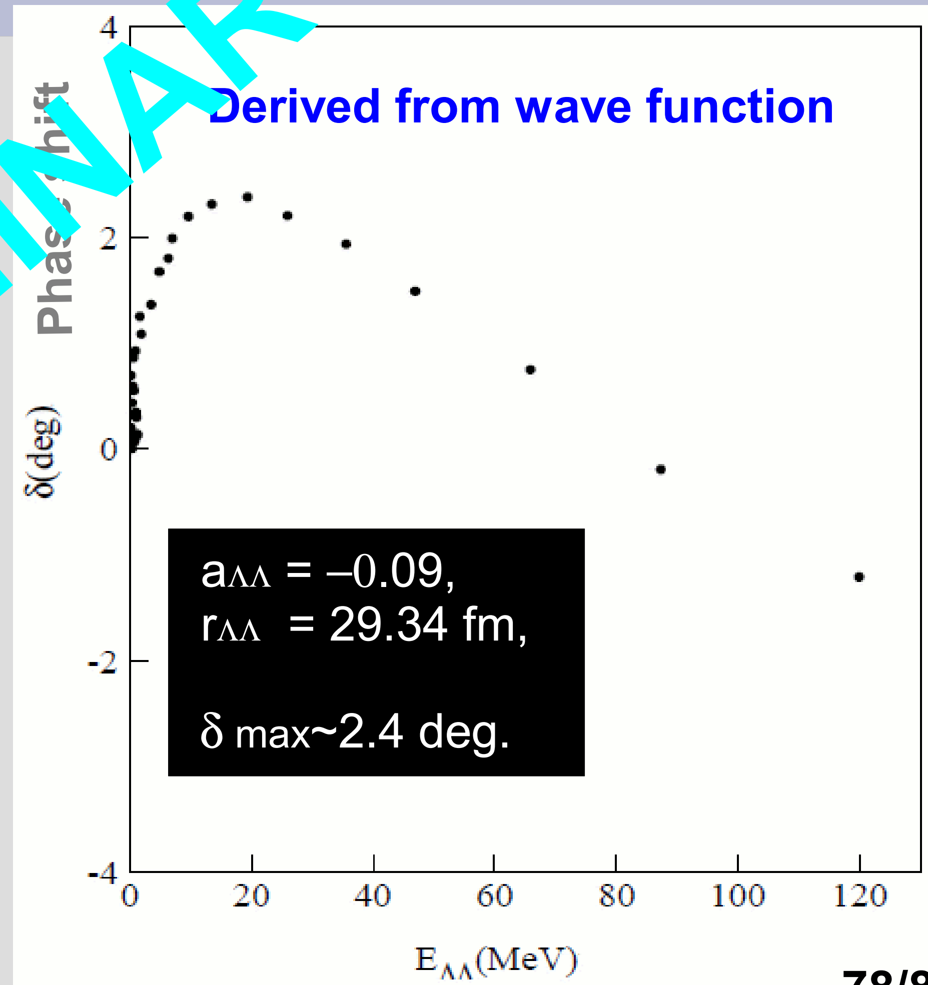

Summary

- We studied $\Lambda\Lambda$ invariant mass spectrum in the $^{12}C(K^-, K^+\Lambda\Lambda)$ reaction to search for a possible $\Lambda\Lambda$ resonance as H-dibaryon.
- The experiment was performed at the KEK-Proton Synchrotron by injecting 1.6 GeV/c K^- beam into the scintillating fiber active target. The (K^-,K^+) events were obtained by using image intensifiers and CCD cameras together with a Kaon-spectrometer.
- For the production run in 2002, we obtained 45,000 (K^-,K^+) events and we analyzed it, and observed a similar enhancement in the $\Lambda\Lambda$ invariant mass spectrum as reported in the previous KEK experiment (E224).

Summary

- Data were compared with combinatorial background, and Internuclear cascade (INC) model calc. without/with Λ–Λ interaction consistent with the first published double-Λ hypernucleus data(Phys. Rev. Lett. 87, 212502(2002).). The experimental result exhibited **no significant enhancement above level of the predicted by INC with FSI calc.**

- By fitting the $\Lambda\Lambda$-mass spectrum, we determined Λ–Λ scattering parameters. The obtained value, $a_{\Lambda\Lambda} = -0.10^{+0.37}_{-1.56} \pm 0.28$, $r_{\Lambda\Lambda} = 13.9^{+14.35}_{-9.13} \pm 10.53$ fm, is the most **consistent with** the values predicted by using the Nijmegen soft core models, **NSC97's.**

- However, the predicted values by using the Nijmegen hard core model **ND (G-matrix),** the extended soft core model **ESC00**, and the Kyoto-Niigata FSS models are **out of three standard deviations** from the determined scattering parameters.

Summary

- Further, we **probing ΛΛ potential** by fitting the obtained ΛΛ invariant mass spectrum **using numerically solved ΛΛ-wave function and combinatorial background** in which ΛΛ potentials were assumed as two Gaussian shaped potential well.
  We have searched amplitudes of the Gaussian potentials fixing the range parameters on basis of the phase shift equivalent potential of the Kyoto-Niigata model, fss2.

- An extremely **shallow (V_{min}=–6.3 MeV) ΛΛ potential well describe experimental ΛΛ-mass spectrum** in which maximum phase shift was ~2.4 deg with a very small ΛΛ scattering length (–0.09 fm), and long effective range (29.34 fm) suggesting consistent result with the values derived from a different method; $a_{\Lambda\Lambda}$=–0.10, $r_{\Lambda\Lambda}$=13.90 fm and δ_{max}~3.5 deg.