Photoproduction of Strangeness near the Threshold at Tohoku

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for the NKS/NKS2 collaboration

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Outline of this talk

- Introduction
- Experiments
- Further Investigation
- Summary

序

INTRODUCTION

Motivation

Understanding the process of
Strangeness production

Key: Neutral channel
Threshold region

via $\gamma+n$ reaction

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Why Neutral?

Neutral channel is requisite

Theoretical studies were based on

data of $\gamma + p \rightarrow K^+ + Y$

and then there are huge discrepancies
in prediction of neutral channel

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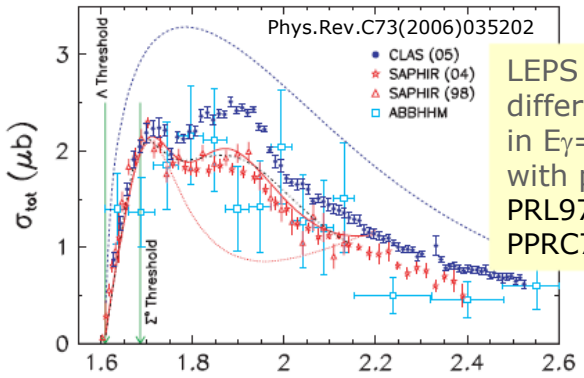
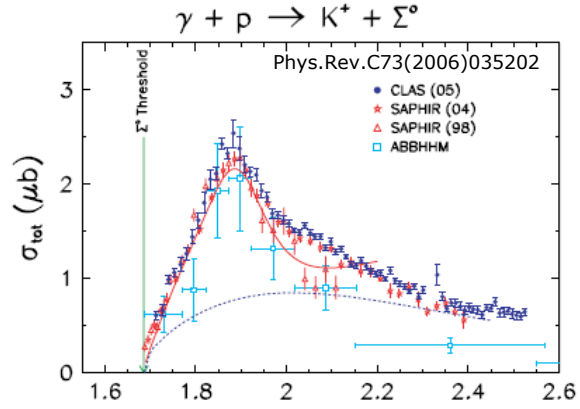
Data

$\gamma + p \rightarrow K^+ + \Lambda$



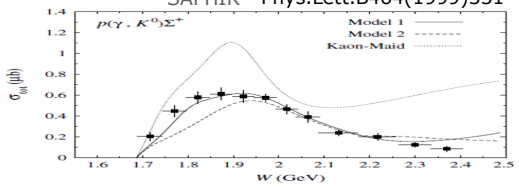
LEPS experiment:
differencial cross section
in Eγ=1.5-2.4 GeV
with polarized photon beam
PRL97 (2006)082003
PPRC76(2007)042201(R)

$\gamma + p \rightarrow K^+ + \Sigma^0$



$\gamma+p\rightarrow K^0+\Sigma^+$

SAPHIR Phys.Lett.B464(1999)331



$\gamma+n\rightarrow K^0+\Lambda$

NKS experiment:
differencial cross section
in Eγ=0.8-1.1 GeV
PRC78(2008)014001

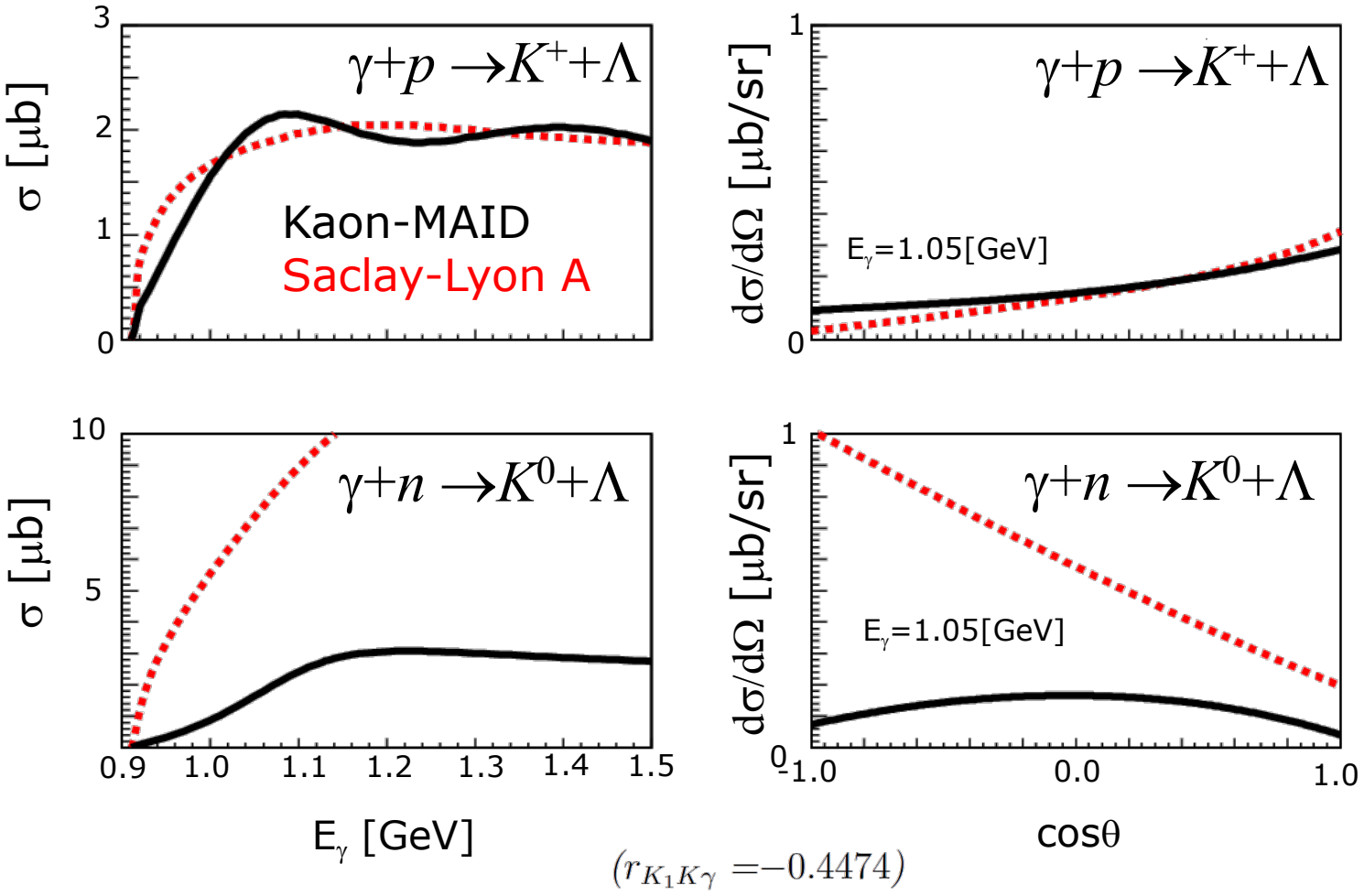
$\gamma+n\rightarrow K^+ +\Sigma^-$

LEPS experiment:
differencial cross section in Eγ=1.5-2.4 GeV
with polarized photon beam
PRL97 (2006)082003

CLAS experiment:
differencial cross section in Eγ=1.1-3.6 GeV
PLB688(2010)289

$\gamma+n\rightarrow K^0+\Sigma^0$

Discrepancy



Why Threshold ?

In the threshold region

Less effect of resonances than higher energy region

Simplicity

to compare the data with a model

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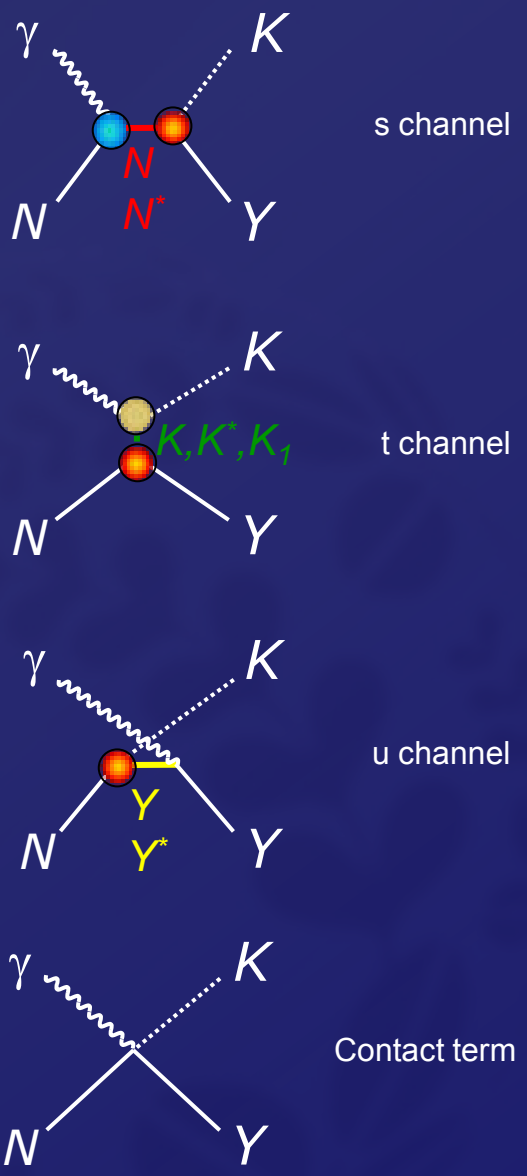
Theoretical Approach

Theoretical Study: Effective Lagrangian Approach

- Hadron coupling
  - Isospin symmetry
- Electromagnetic (photo) coupling
  - Helicity amplitude
    - Charged and neutral nucleon resonances
  - Decay width
    - Charged and neutral Kaon resonances
    - However, the decay width of K_1 resonance is not known

$$r(K^*K\gamma) = \frac{g(K^{*0}K^0\gamma)}{g(K^{*+}K^+\gamma)} = -1.53$$

$$r(K_1K\gamma) = \begin{cases} -0.45 & \text{in Kaon-MAID, estimated from } \gamma p \to K^0\Sigma^+ \text{ data} \\ \text{Free parameter} & \text{in SLA} \end{cases}$$



Characteristics of Two Models

- Kaon-MAID
  - T.Mart, C.Bennhold, PRC61 (2000) 012201(R)
  - Input: $\gamma+p\rightarrow K^{+}+\Lambda$, $\gamma+p\rightarrow K^{+}+\Sigma^{0}$, $\gamma+p\rightarrow K^{0}+\Sigma^{+}$
  - Resonances:
    - $N(1650)\ S_{11}$, $N(1710)\ P_{11}$, $N(1720)\ P_{13}$,
    - $\Delta(1900)\ S_{31}$, $\Delta(1910)\ P_{31}$
    - $K^{*}(892)$, $K_{1}(1270)$
  - Hadronic form factor, contact term
- Saclay-Lyon A
  - T. Mizutani *et al*. PRC58 (1998) 75
  - Input: $\gamma+p\rightarrow K^{+}+\Lambda$
  - Resonances:
    - $N(1720)\ P_{13}$
    - $\Lambda(1405)$, $\Lambda(1670)$, $\Lambda(1810)$, $\Sigma(1660)$
    - $K^{*}(892)$, $K_{1}(1270)$
  - No hadronic form factor

実験

EXPERIMENTS

Experiments to Investigate Strangeness Photo-Production at LNS/ELPH

NKS and NKS2

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2000-2004:

Using TAGX spectrometer (INS, U. Tokyo)
Reconstruct K^0_S from $\pi^+\pi^-$ decay
The first measurement of K^0 cross section from $n(\gamma,K^0)\Lambda$ reaction [Phys.Rev.C78(2008)014001]

NKS

Neutral Kaon Spectrometer

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2005-2007:

Completely new spectrometer to cover full kinematical region

2008-: Upgrade project

2010-: Taking physics data

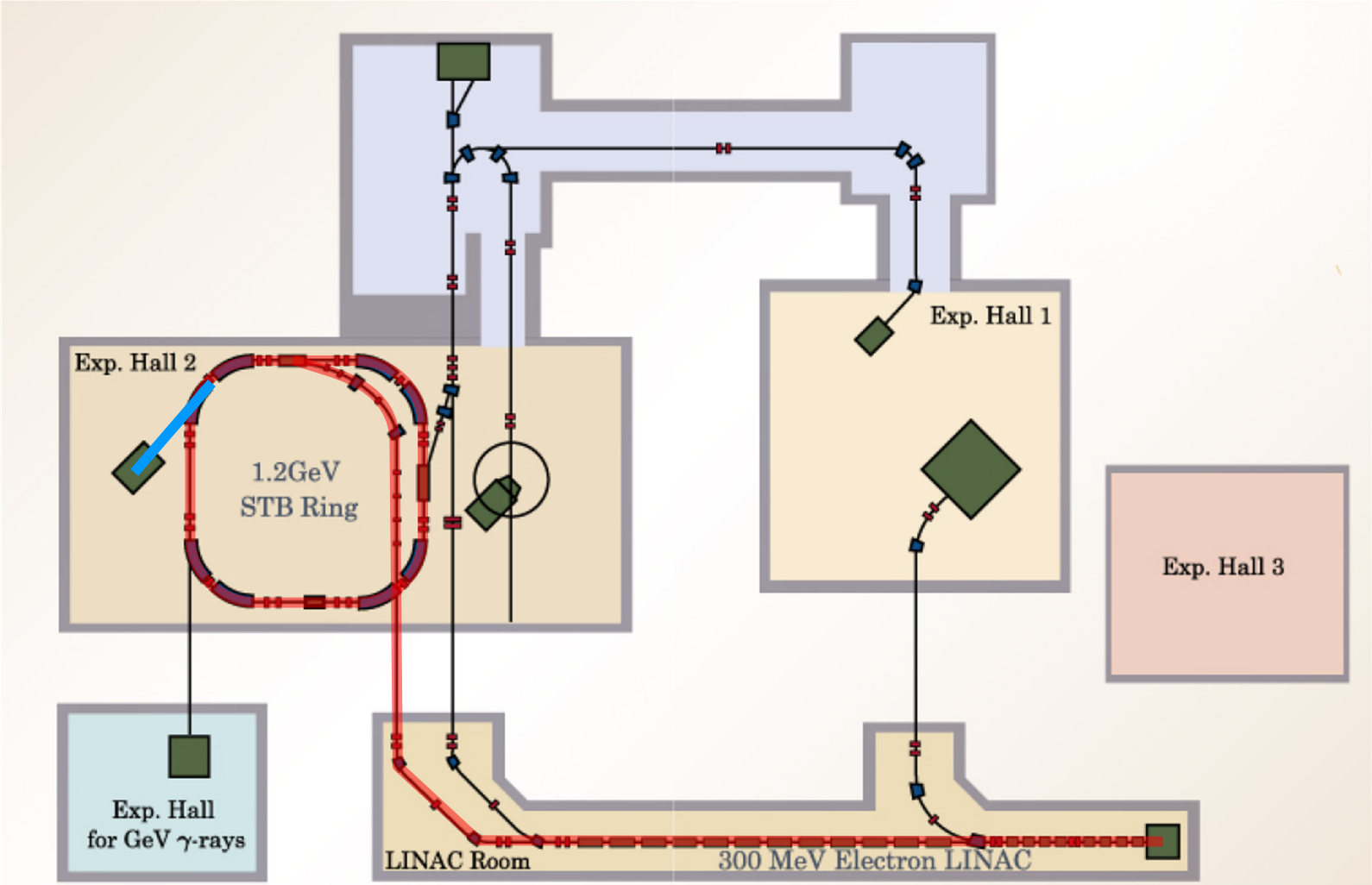
Neutral Kaon Spectrometer 2

Place of the Experiment

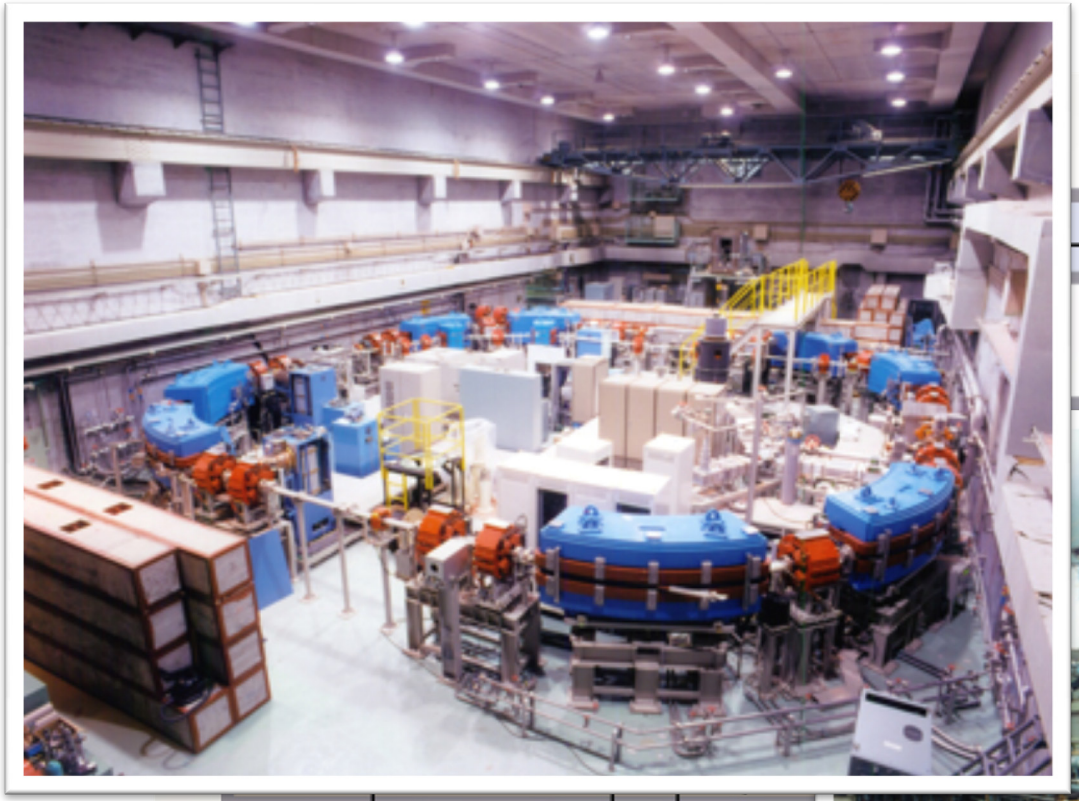
Laboratory of Nuclear Science
(LNS)

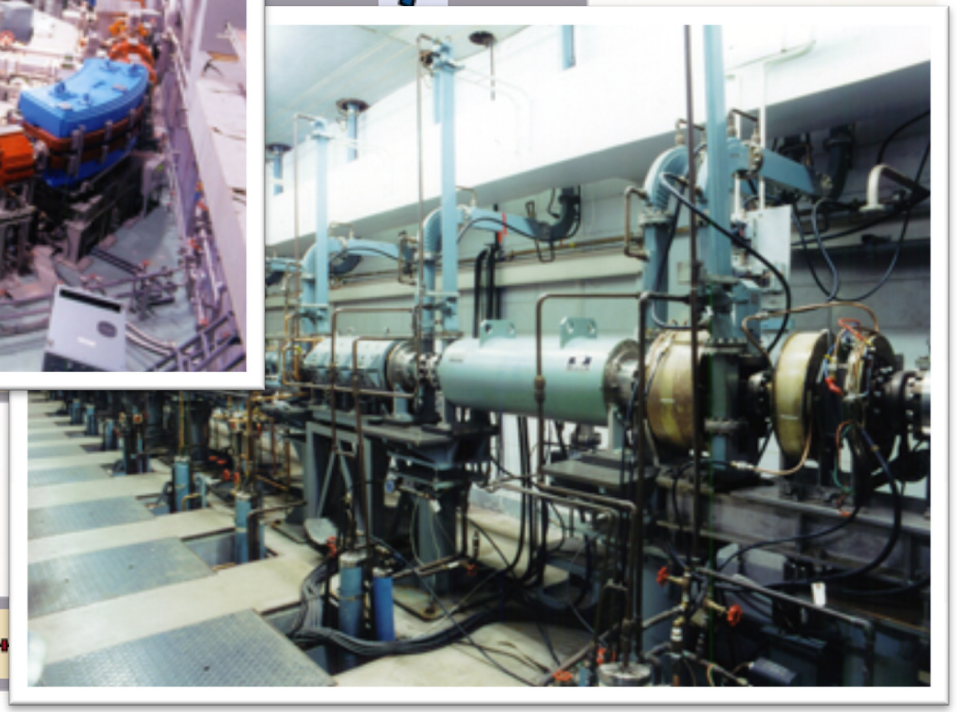
Research Center for
Electron Photon Science
(ELPH)

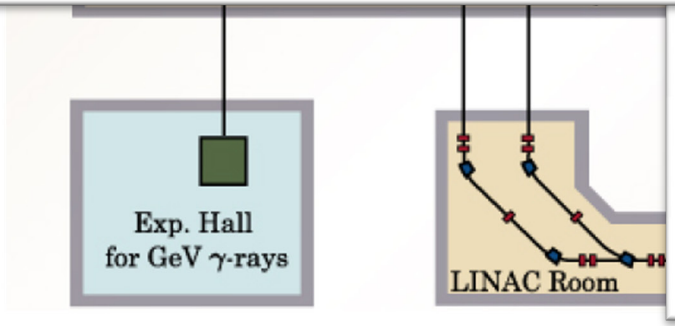
Accelerator of LNS/ELPH, Tohoku University



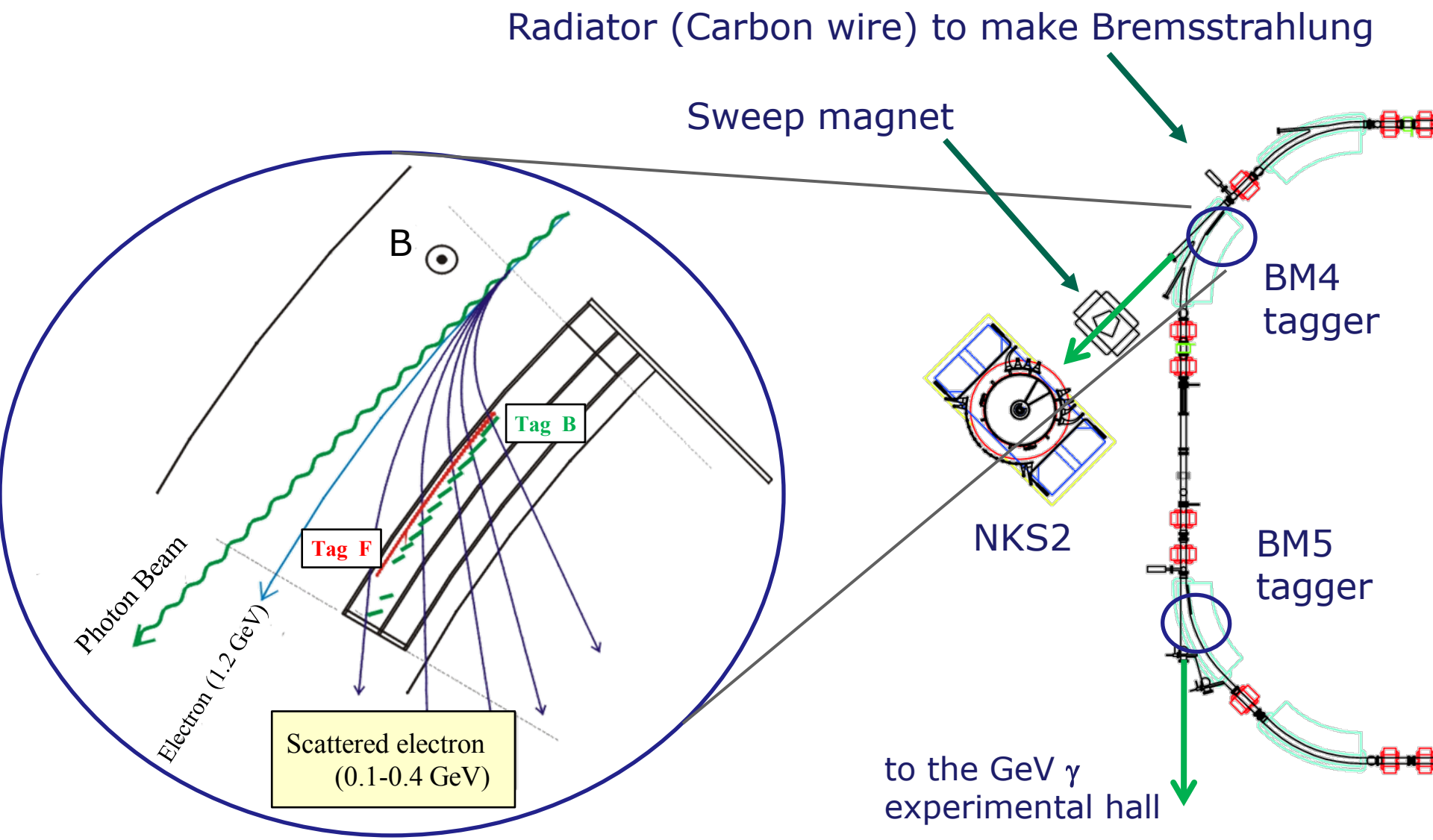
Accelerator of LNS/ELPH, Tohoku University



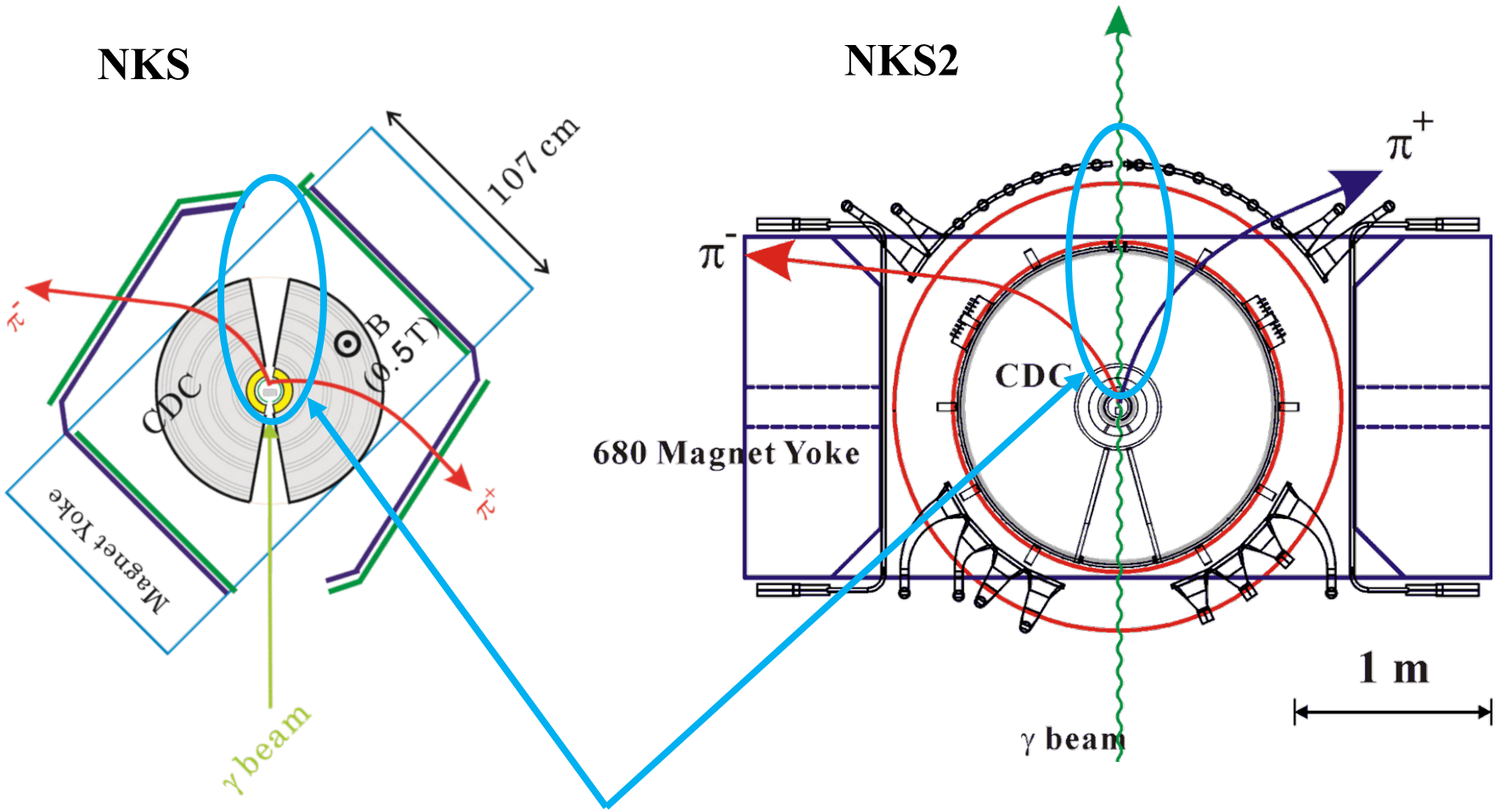




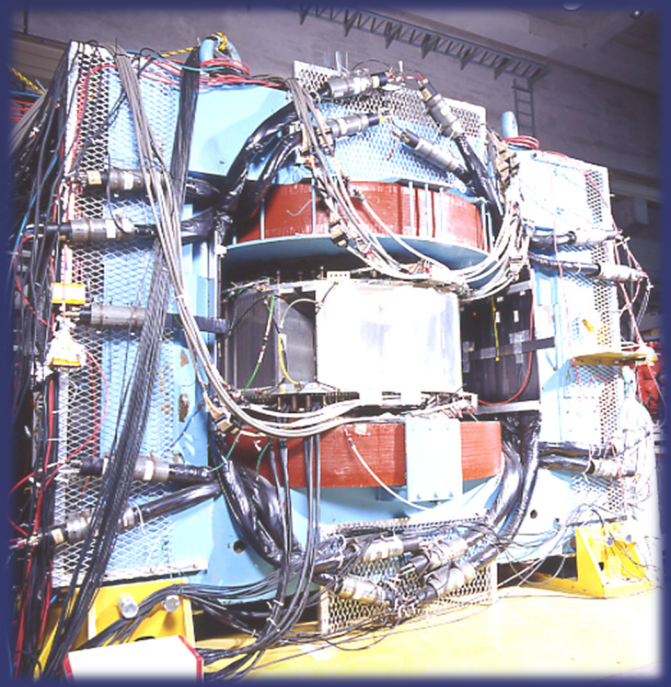
Photon Beam Line



NKS to NKS2



Improved Acceptance
by covering forward region



NKS

NKS2

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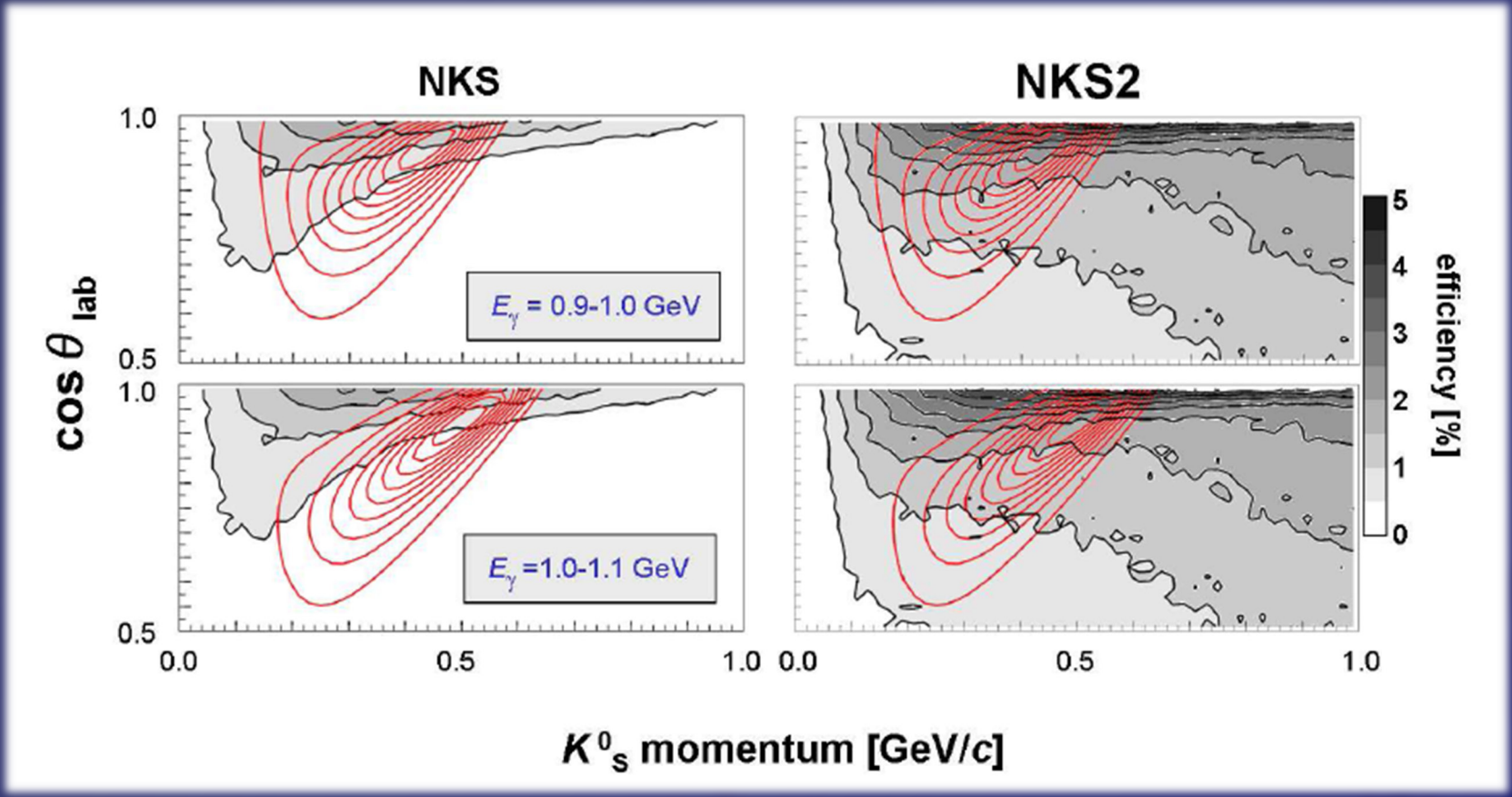
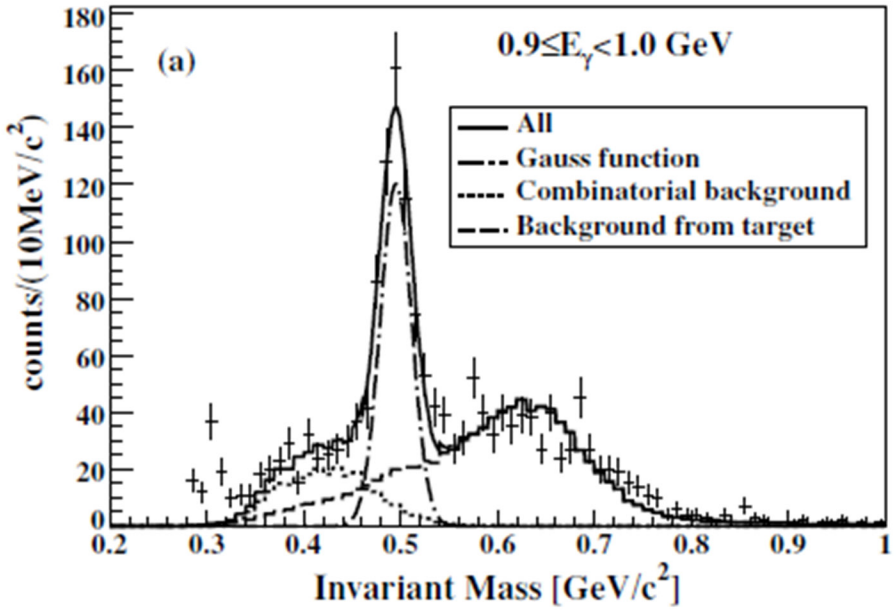
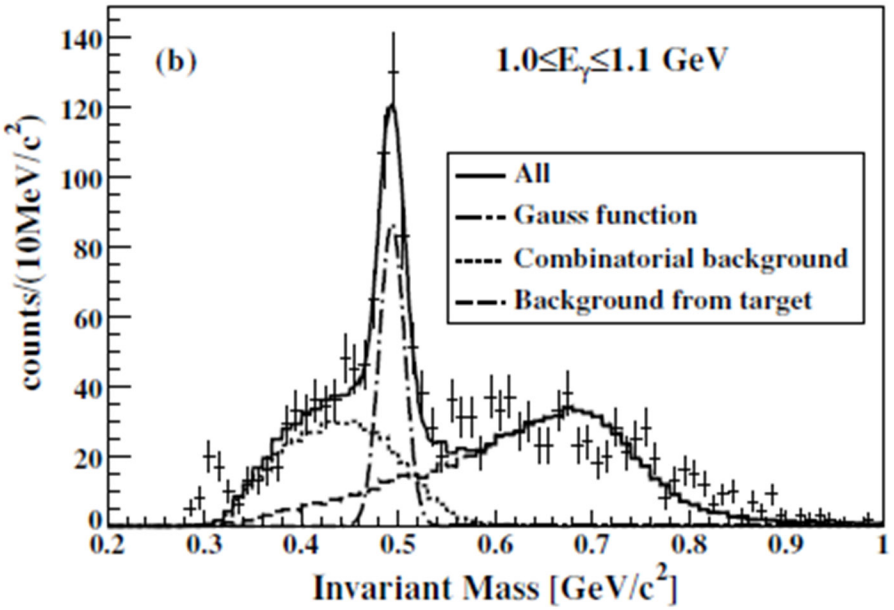
Acceptance of NKS and NKS2(-2007)

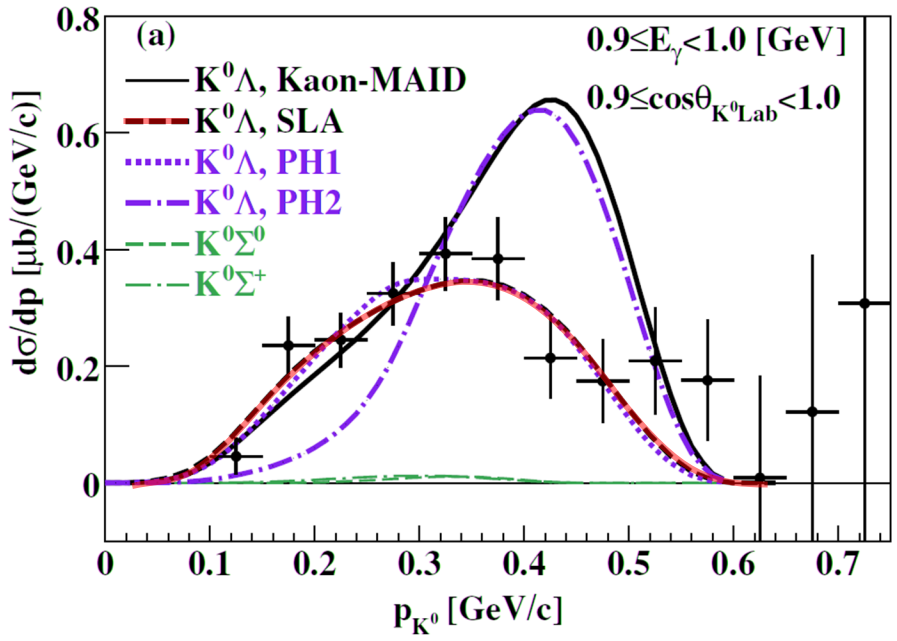


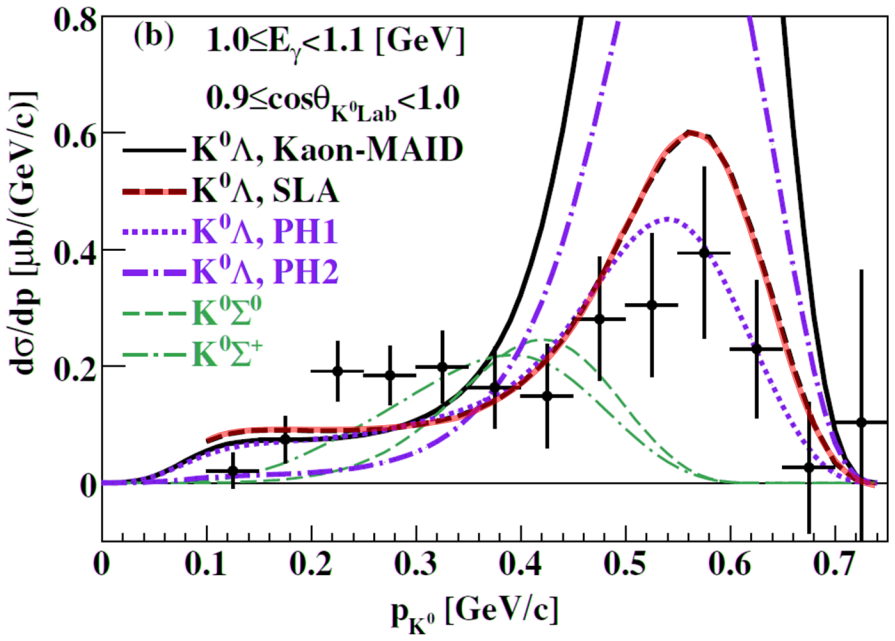




K. Tsukada *et. al*, Phys.Rev.C78(2008)014001

Results of NKS





K. Tsukada *et. al*, Phys.Rev.C78(2008)014001

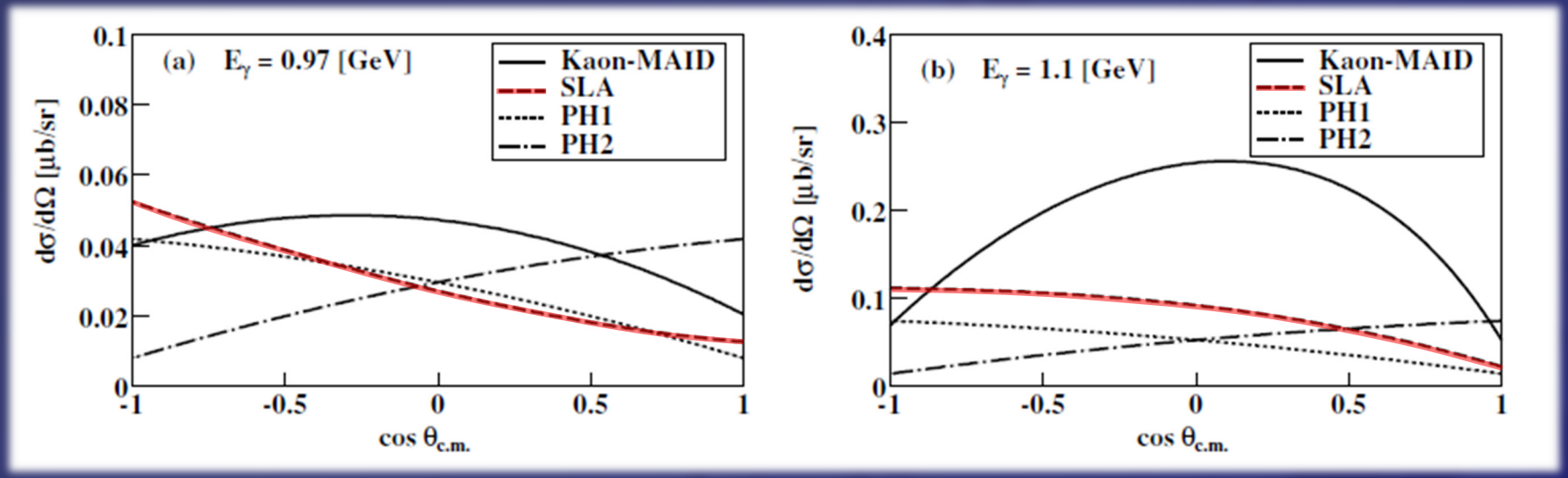
Results of NKS

$r_{K1K\gamma}$=-2.09 for SLA

(Kaon-MAID's value:-0.4474)

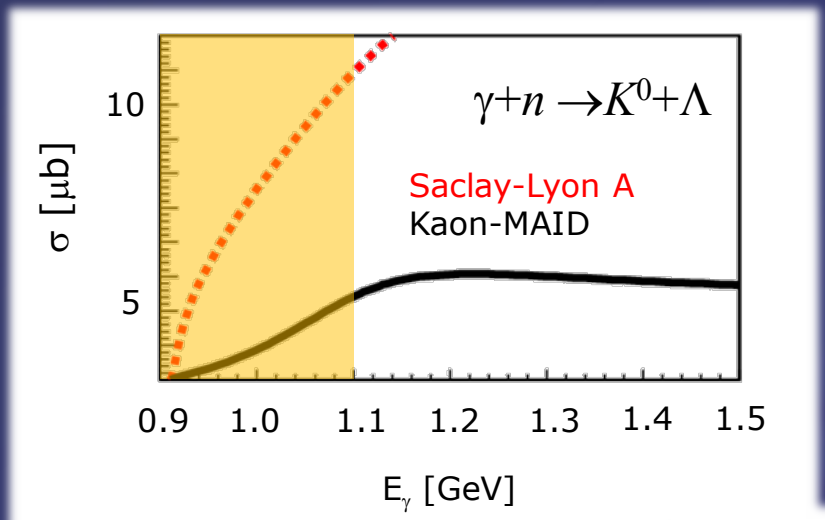
Suggestion from NKS Results

backward angular distribution in CM



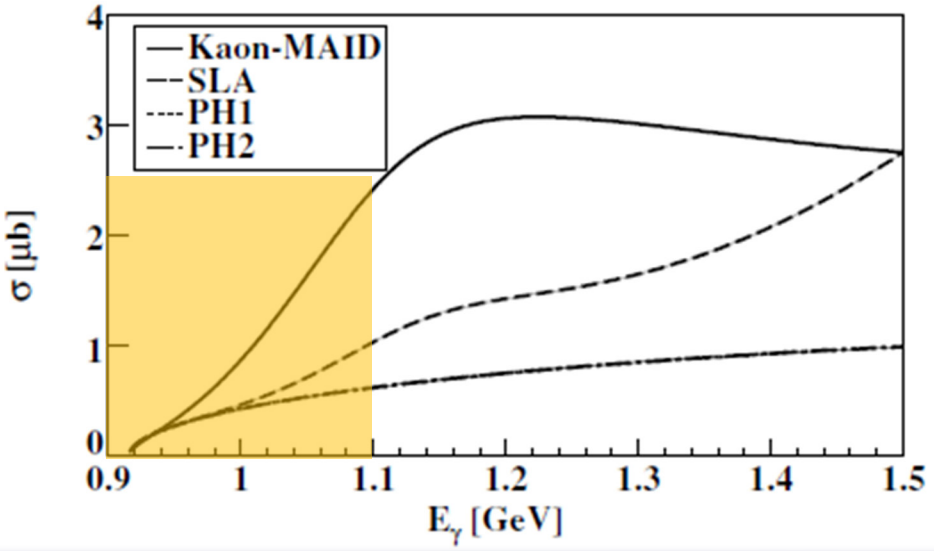
K. Tsukada *et. al*, Phys.Rev.C78(2008)014001

Suggestion from NKS Results



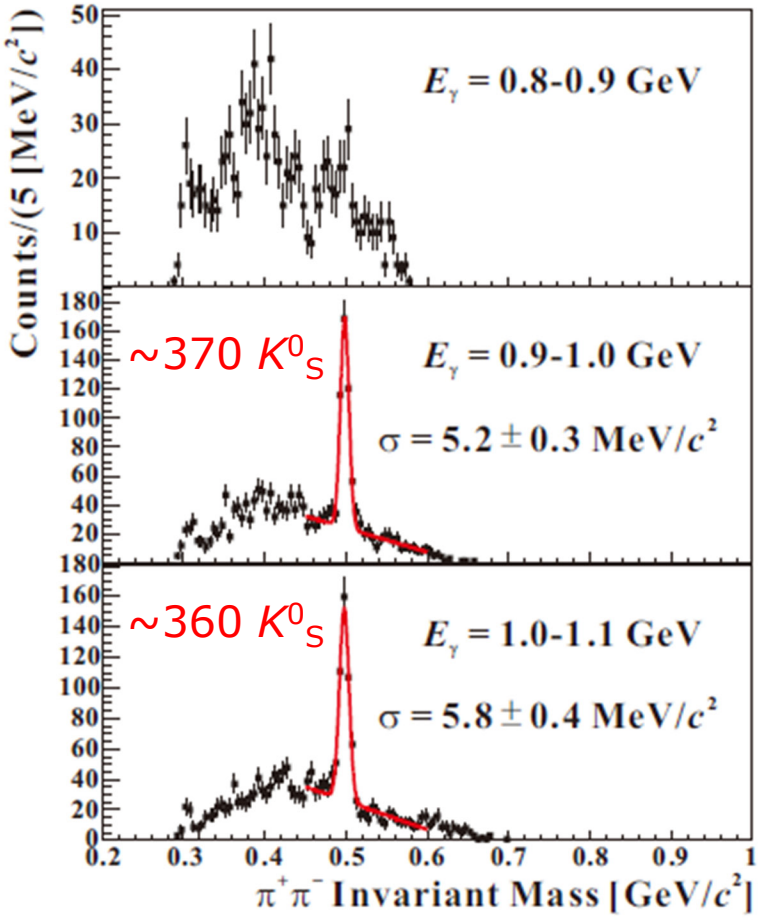
before

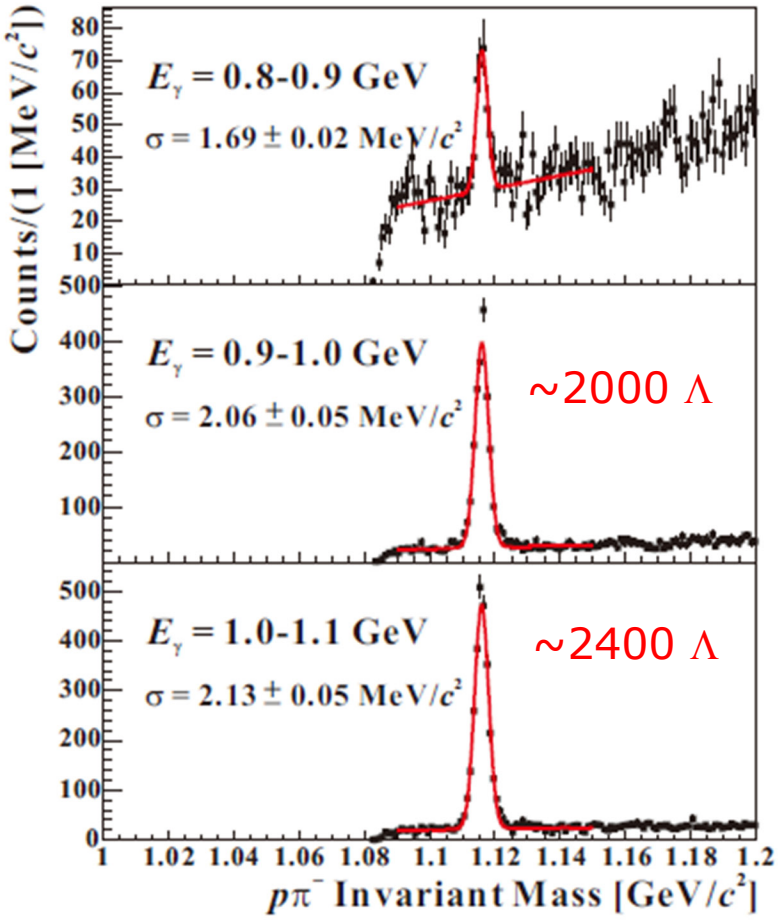
after



K. Tsukada *et. al*, Phys.Rev.C78(2008)014001

Results of NKS2

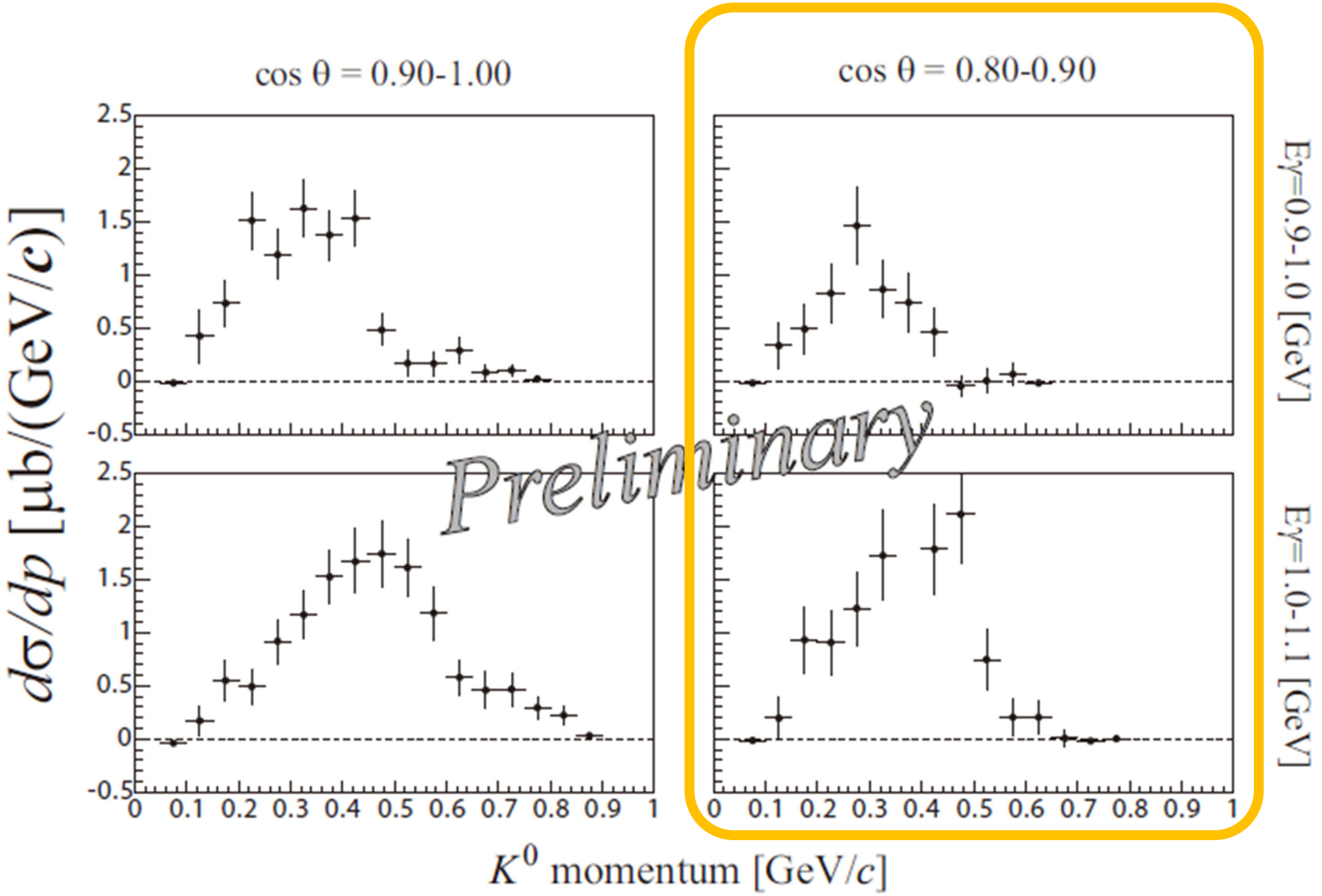




Analyzed by K. Futatsukawa (Ph.D student)

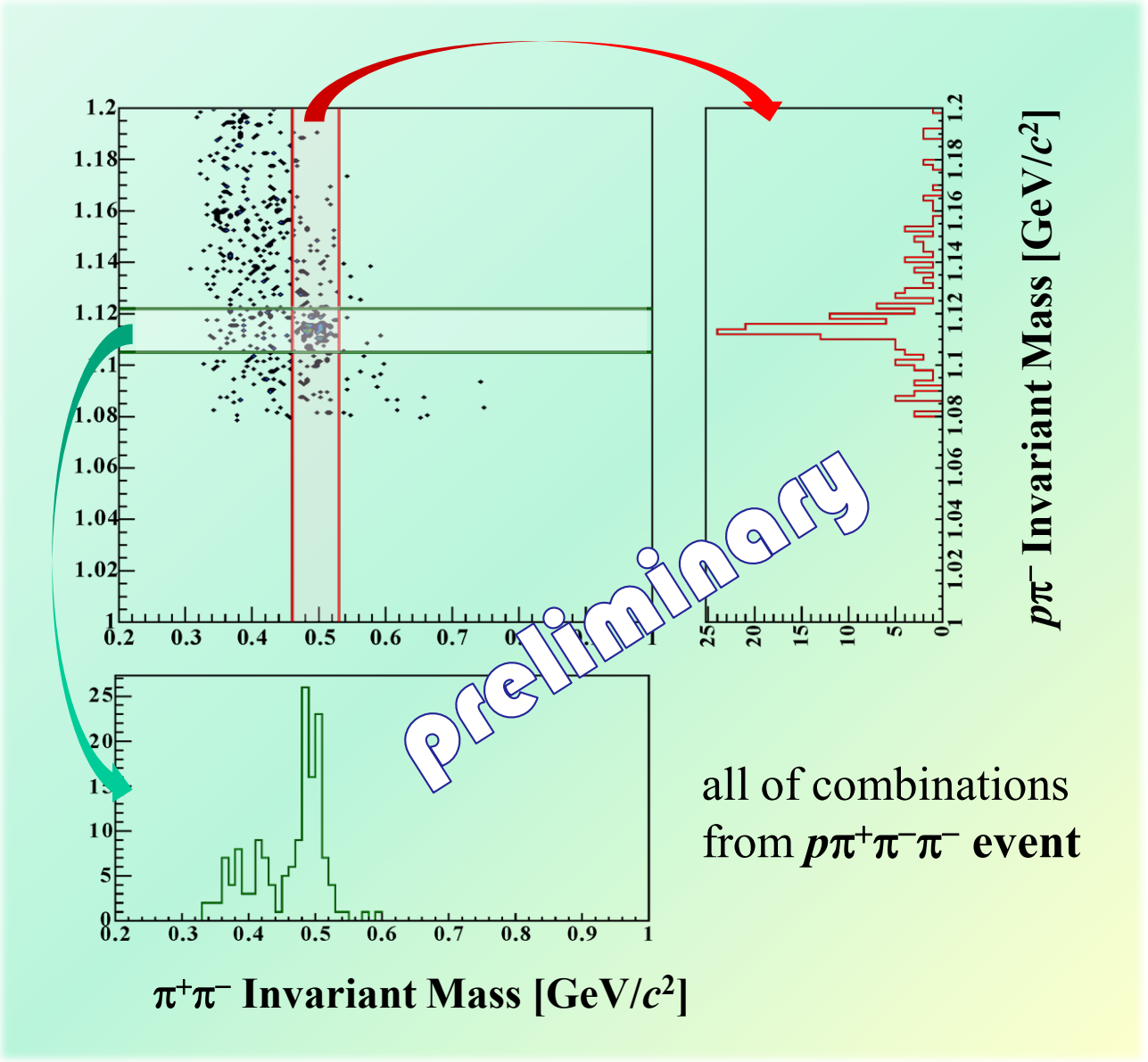
Results of NKS2

New region



Analyzed by K. Futatsukawa (Ph.D student)

Results of NKS2



~90 events
in the peak

Analyzed by
K. Futatsukawa
(Ph.D student)

推進

FURTHER INVESTIGATION

The next targets

$K^0_S+\Lambda$ coincidence events

with reasonable statistics,

and

Determine the sign of

Λ recoil polarization

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K^0_S+Λ coincidence events

Advantage: No.1

Less background

in the invariant mass distribution

(Remember p.28)

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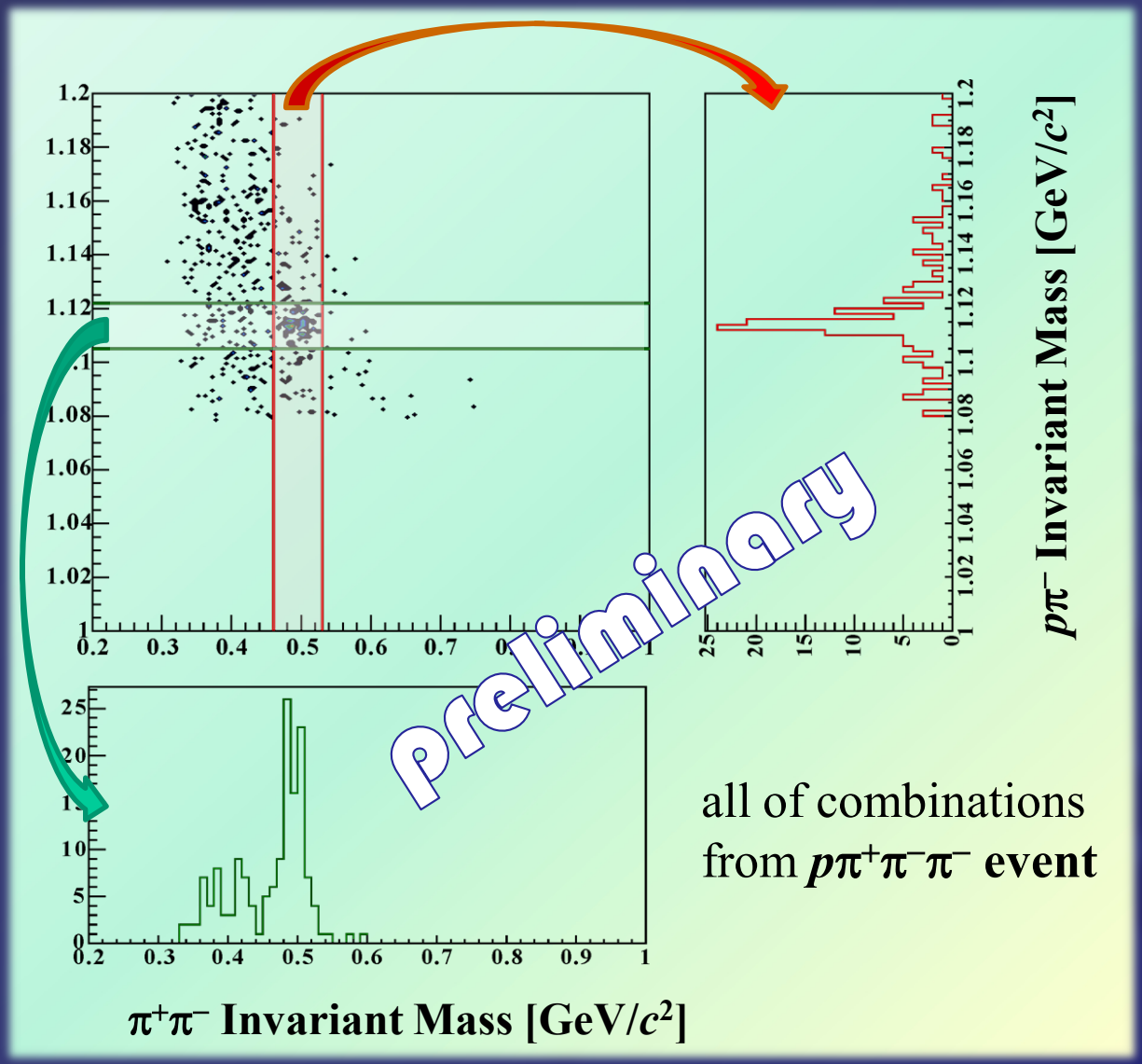
Preliminary
all of combinations
from $p\pi^+\pi^-\pi^-$ event
$\pi^+\pi^-$ Invariant Mass [GeV/c^2]
$p\pi^-$ Invariant Mass [GeV/c^2]

K^0_S+Λ coincidence events

Advantage: No.2

Elimination of Fermi motion correction

Direct comparison with model
Separation of K^0+Λ and K^0+Σ^0

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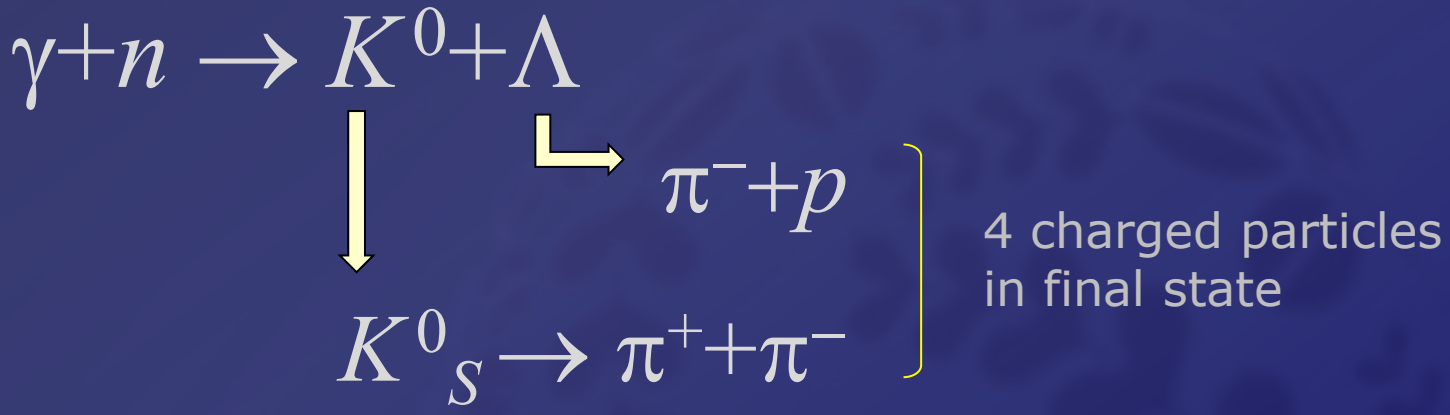
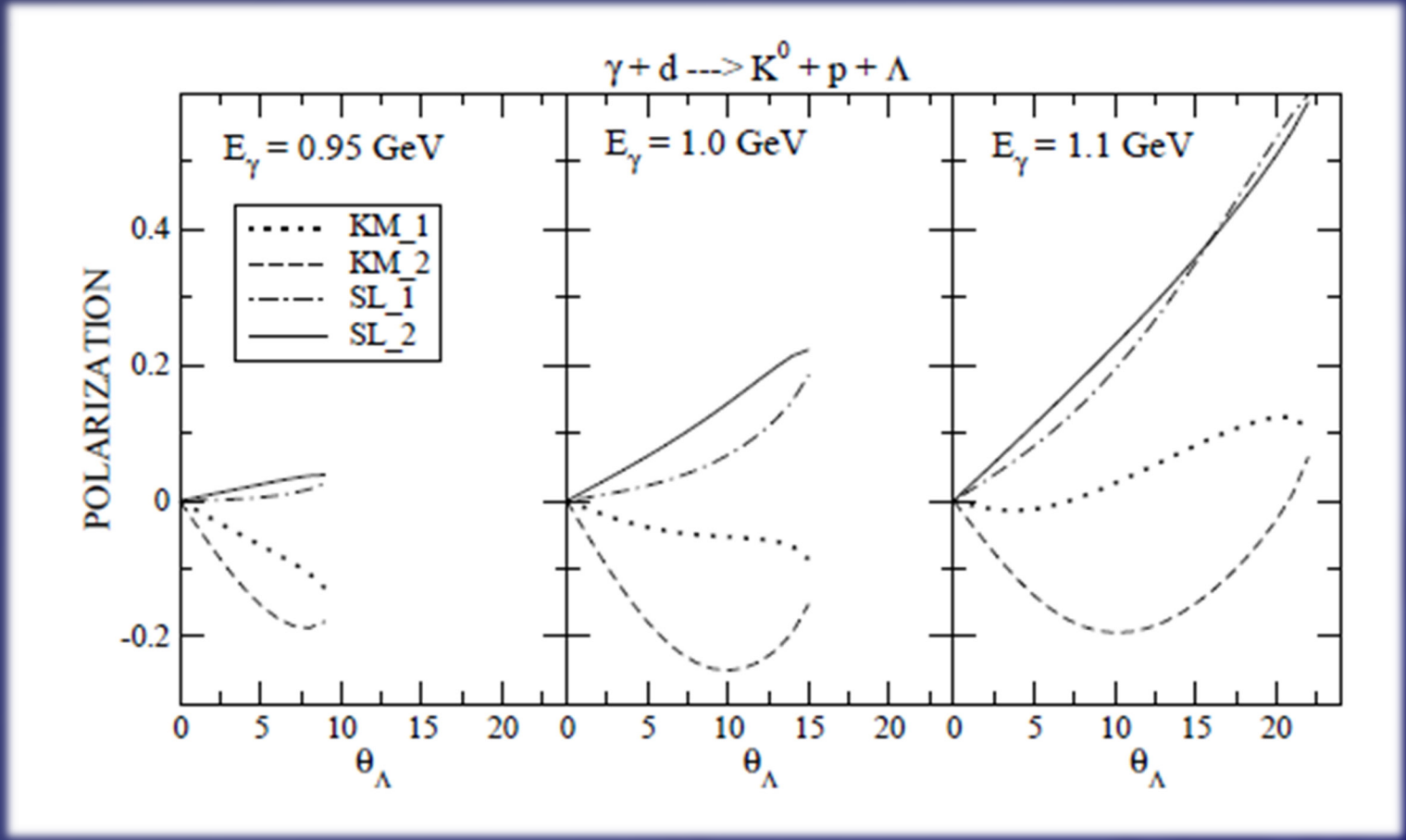
$K^0_S+\Lambda$ coincidence events



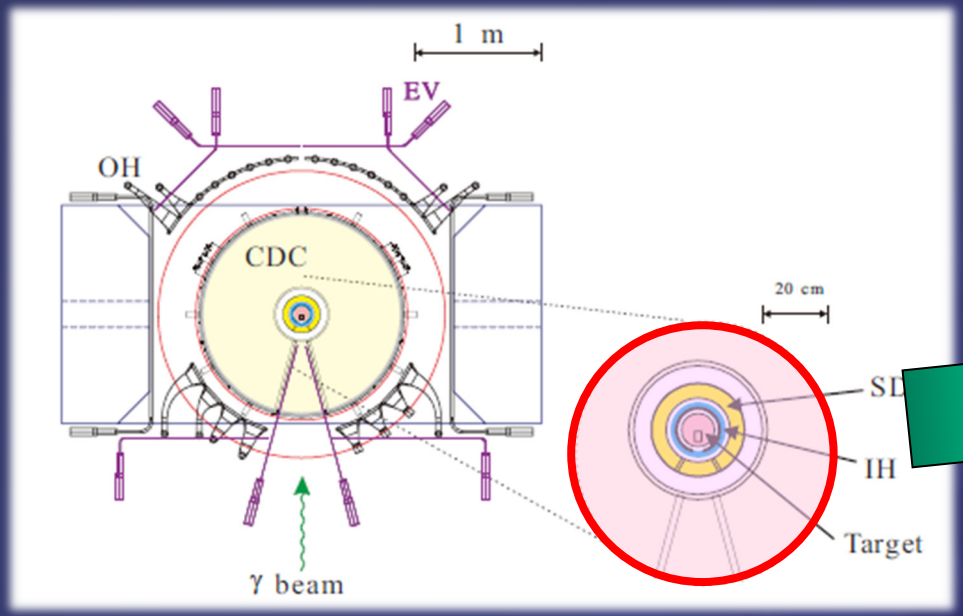
Extending the acceptance is essential

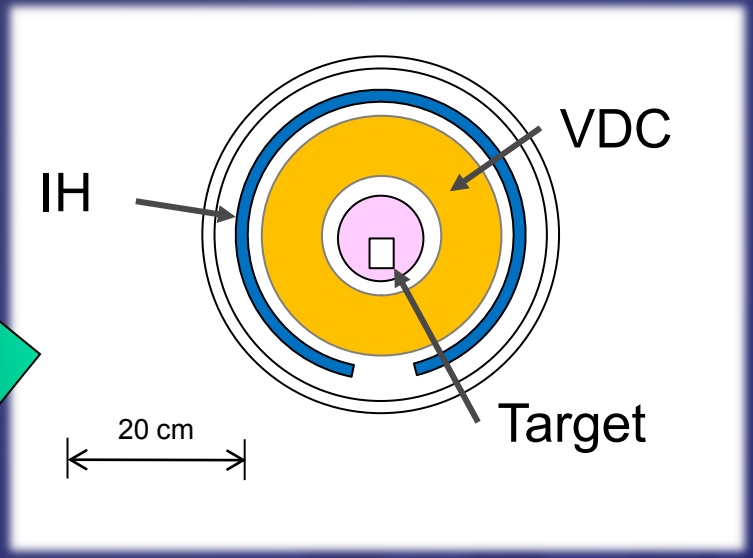
Λ recoil polarization

The information make a restriction to model



Upgrade Project



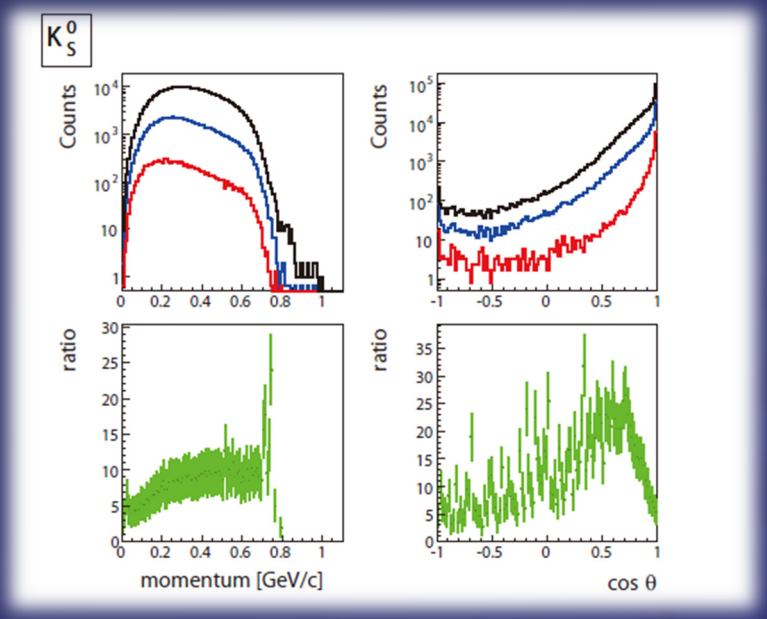


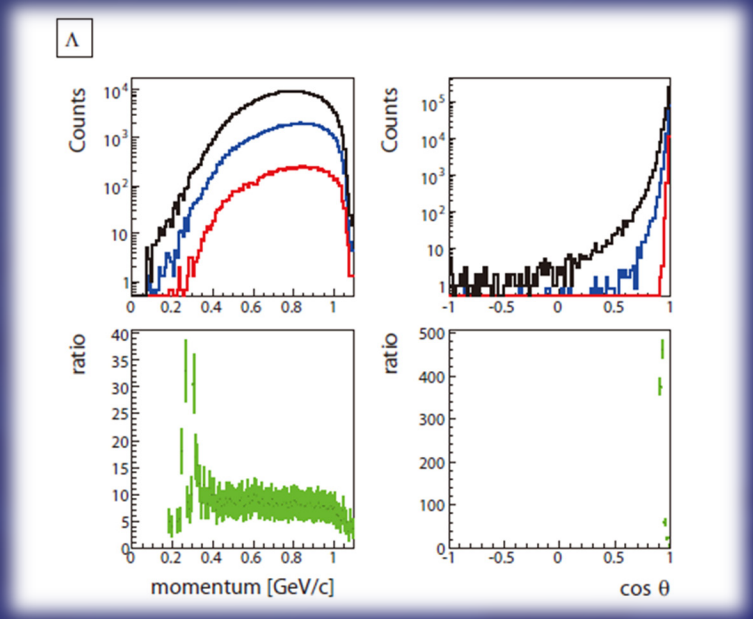
To increase acceptance
Inner detectors are replaced by

Vertex Drift Chamber (VDC)
New Inner Hodoscope (IH)

Gain of Acceptance

for K^0_S+Λ coincidence events

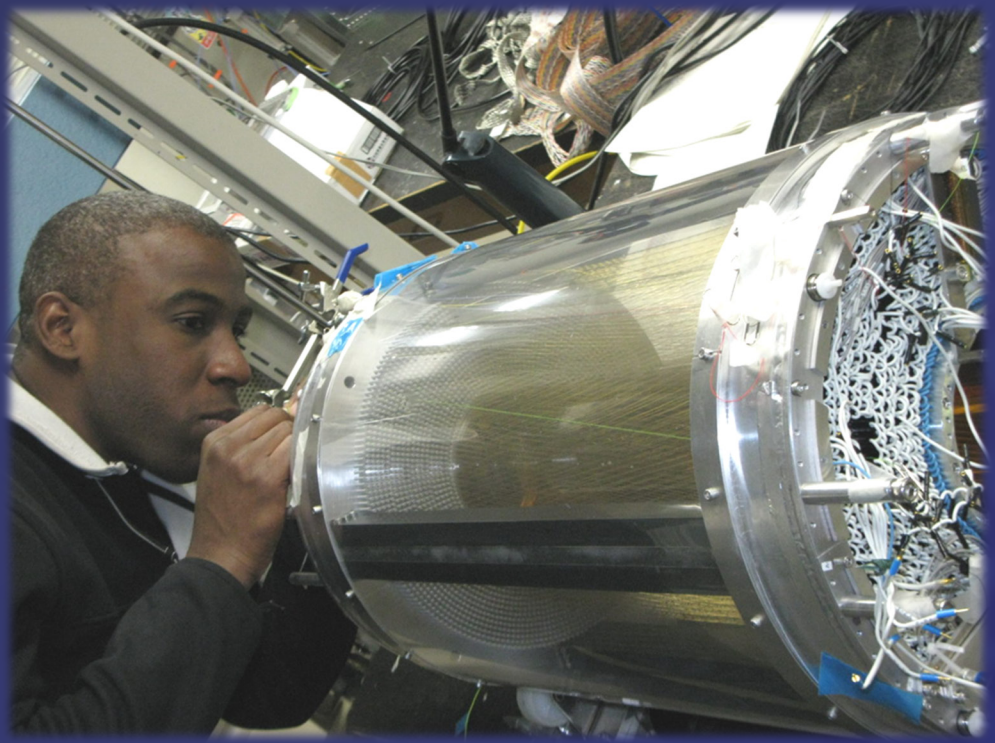




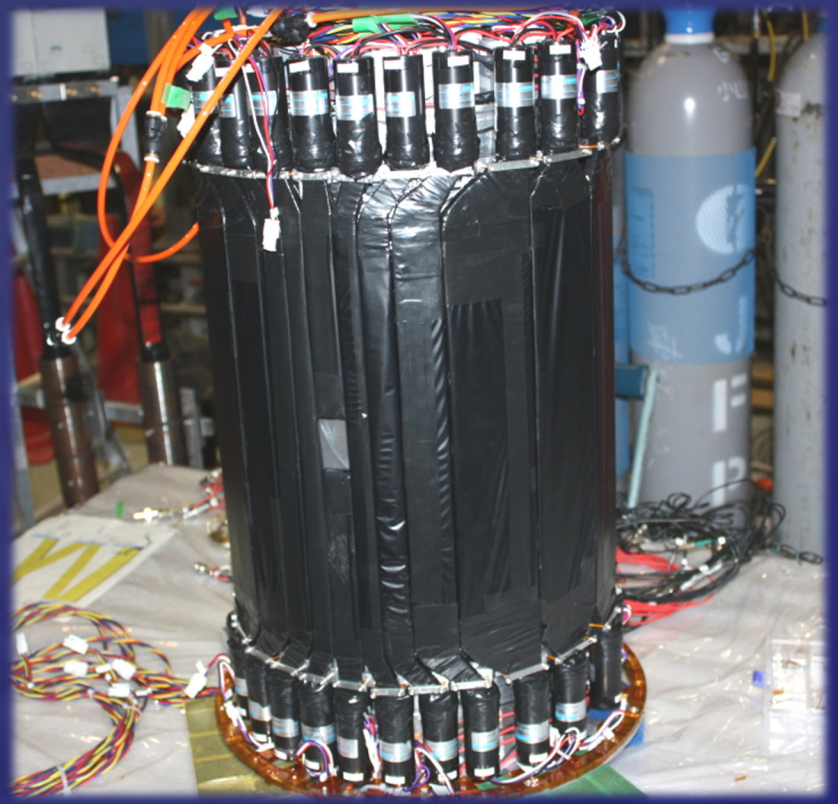
(1) Produced
(2) NKS2 with new detectors
(3) NKS2 prior
(4) ratio of (2)/(3)

about 7 times after upgrade

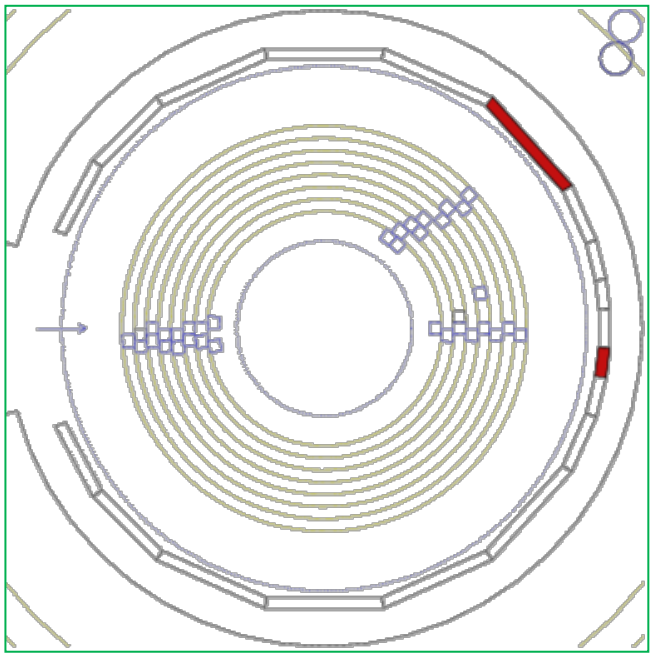
VDC

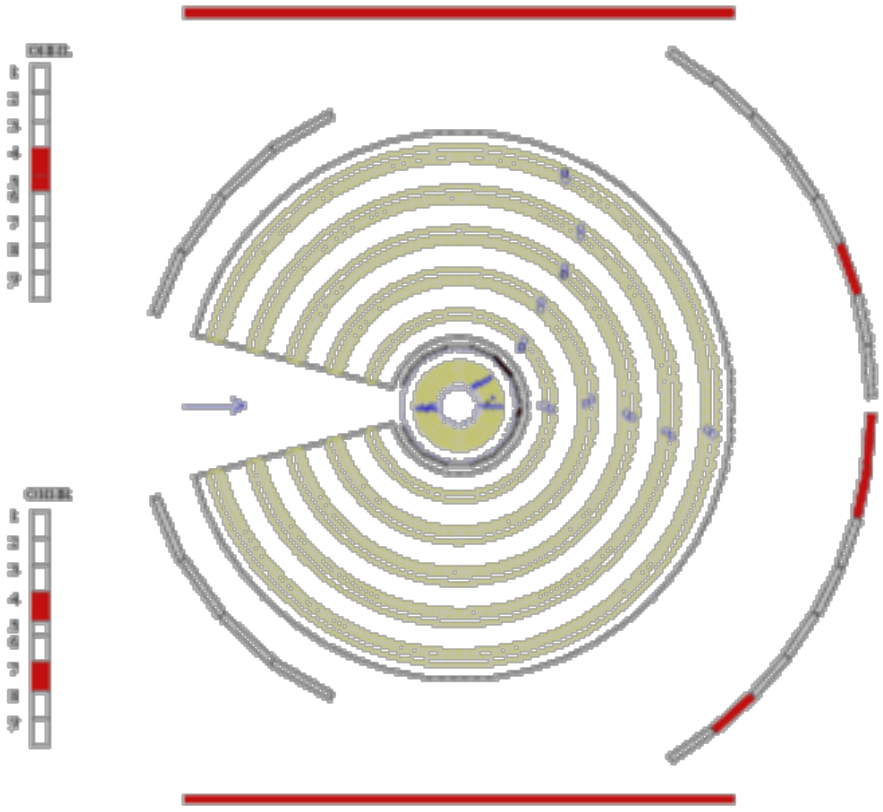


IH

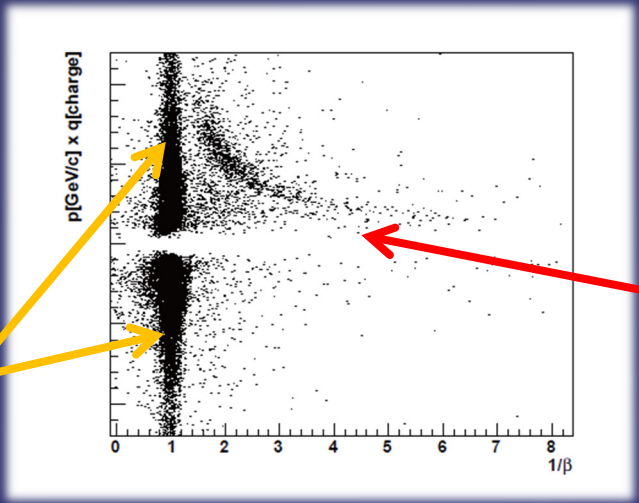


An Event Display from the Last Run





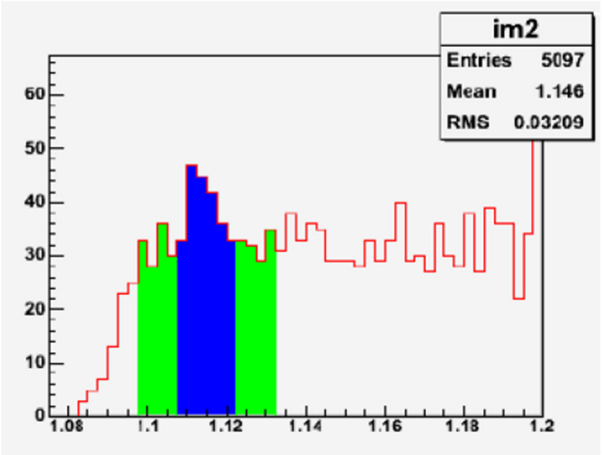
Preliminary results from the last run (2010/June-July)



PID plot: Momentum vs. 1/β with rough counter calibration for two track event

proton

pion



About 40 counts as Lambda above the background

要点

SUMMARY

- Investigation of strangeness photoproduction at ELPH, Tohoku Univ. in Sendai
  - NKS/NKS2 is an unique experiment
    - Focusing neutral channel
    - In the threshold region (E_γ=0.9-1.1 GeV)
  - NKS
    - The first measurement of $n(\gamma, K^0)X$ cross section
      - $\cos\theta_{K0}$ = 0.9-1.0 in CM
  - NKS2
    - Covering forward region
      - $\cos\theta_{K0}$ = 0.8-1.0 in CM
  - NKS2 upgraded
    - New detectors are added to increase the acceptance
    - Detector and the system is ready
    - Physics data taking is going to start soon
      - Sep/6–26 and Oct/1-31
      - ~2.0×10^{12} photon will be achieved
        - » ~400 $K^0_s+\Lambda$ coincidence events is expected


感謝
THANKS FOR LISTENING