Recent results from LEPS

Takashi NAKANO

(RCNP, Osaka University)

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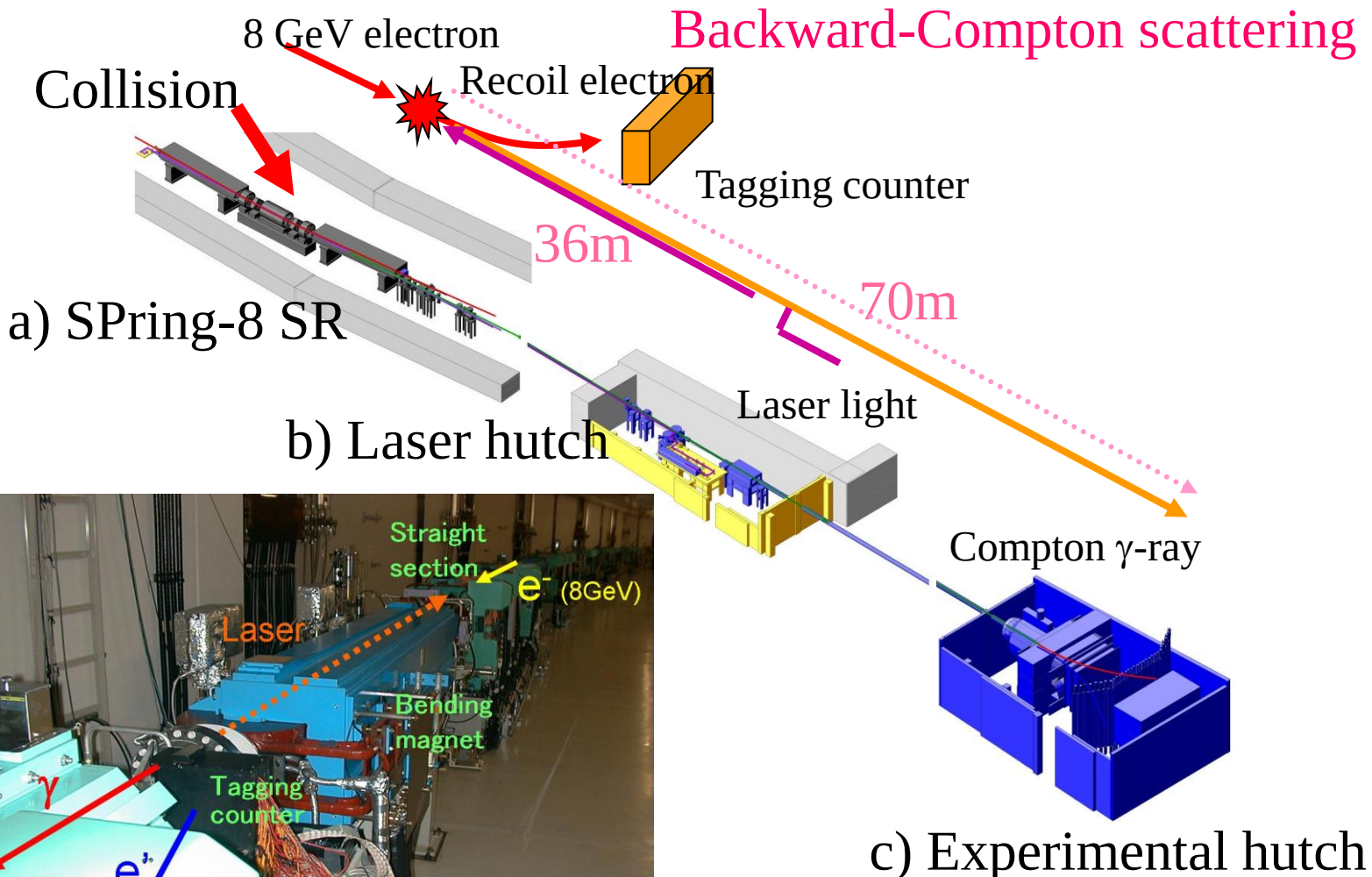
LEPS Collaboration

Research Center for Nuclear Physics, Osaka University : D.S. Ahn, M. Fujiwara, T. Hotta, Y. Kato, K. Kino, H. Kohri, Y. Maeda, T. Mibe, N. Muramatsu, T. Nakano, M. Niiyama, T. Sawada, M. Sumihama, M. Uchida, M. Yosoi, T. Yorita, R.G.T. Zegers
Department of Physics, Pusan National University : J.K. Ahn
School of Physics, Seoul National University : H.C. Bhang
Department of Physics, Konan University : H. Akimune
Japan Atomic Energy Research Institute / SPring-8 : Y. Asano
Institute of Physics, Academia Sinica : W.C. Chang, J.Y. Chen
Japan Synchrotron Radiation Research Institute (JASRI) / SPring-8 : S. Date', H. Ejiri, N. Kumagai, Y. Ohashi, H. Ohkuma, H. Toyokawa
Department of Physics and Astronomy, Ohio University : K. Hicks
Department of Physics, Kyoto University : K. Imai, H. Fujimura, M. Miyabe, Y. Nakatsugawa, T. Tsunemi
Department of Physics, Chiba University : H. Kawai, T. Ooba, Y. Shiino
Wakayama Medical University : S. Makino
Department of Physics and Astrophysics, Nagoya University : S. Fukui
Department of Physics, Yamagata University : T. Iwata
Department of Physics, Osaka University : S. Ajimura, K. Horie, M. Nomachi, A. Sakaguchi, S. Shimizu, Y. Sugaya
Department of Physics and Engineering Physics, University of Saskatchewan : C. Rangacharyulu
Laboratory of Nuclear Science, Tohoku University : T. Ishikawa, H. Shimizu
Department of Applied Physics, Miyazaki University : T. Matsuda, Y. Toi
Institute for Protein Research, Osaka University : M. Yoshimura
National Defense Academy in Japan : T. Matsumura

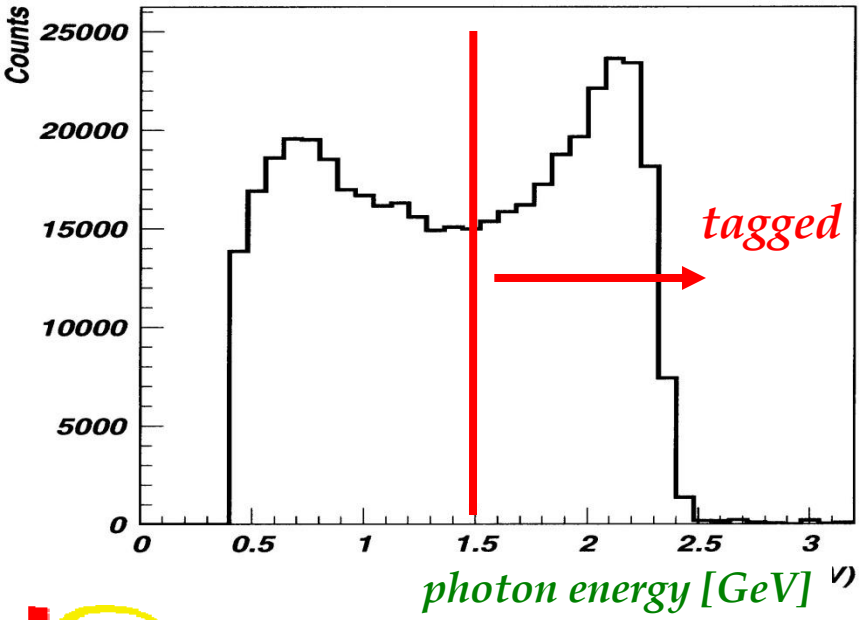
Schematic View of LEPS Facility



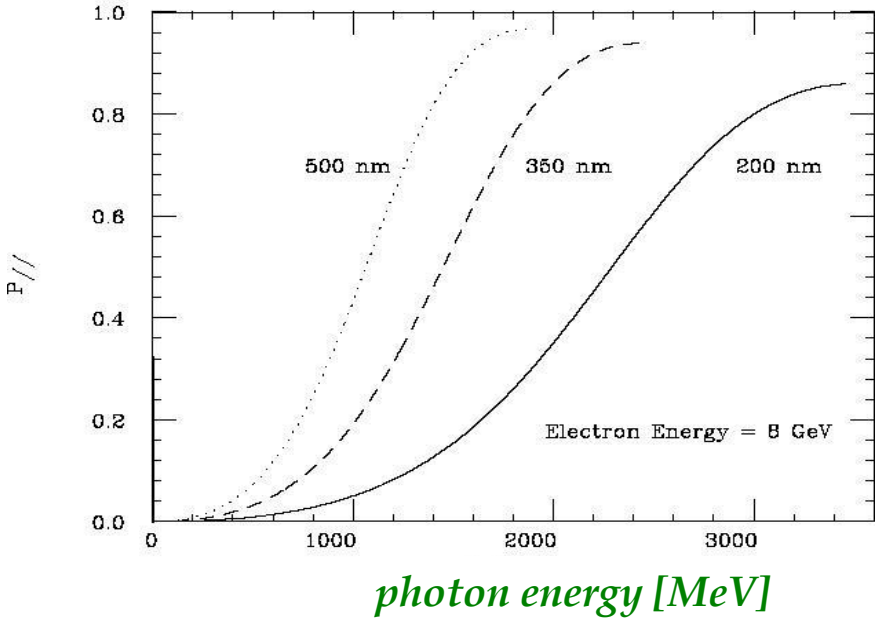
Backward-Compton Scattered Photon

- 8 GeV electrons in SPring-8 + 351nm Ar laser (3.5eV)
  ➔ maximum **2.4 GeV** photon
- Laser Power ~6 W ➔ Photon Flux ~1 Mcps
- Eγ measured by tagging a recoil electron ➔ Eγ>1.5 GeV, **ΔEγ ~10 MeV**
- Laser linear polarization 95-100% ⇒ **Highly polarized γ beam**

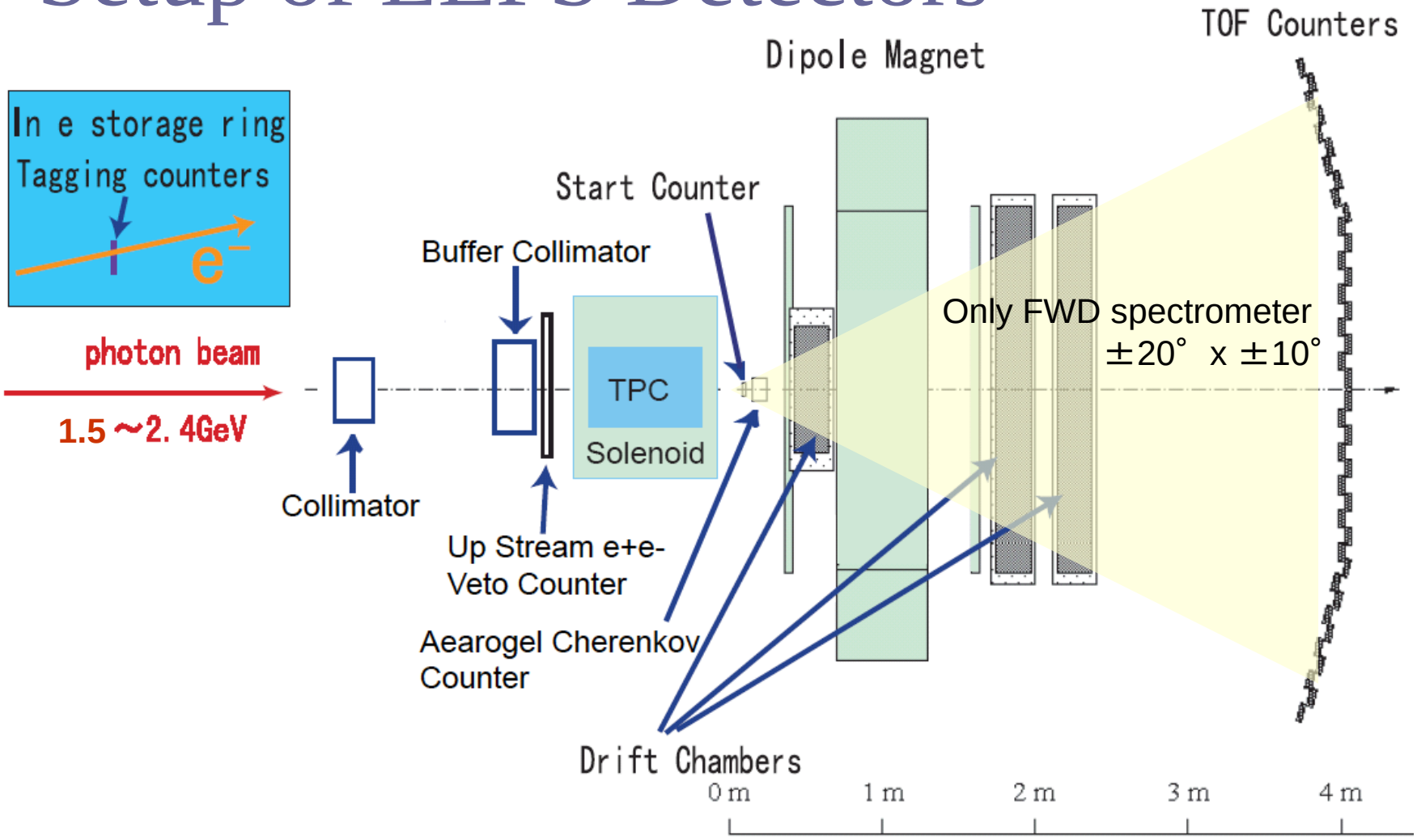
PWO measurement



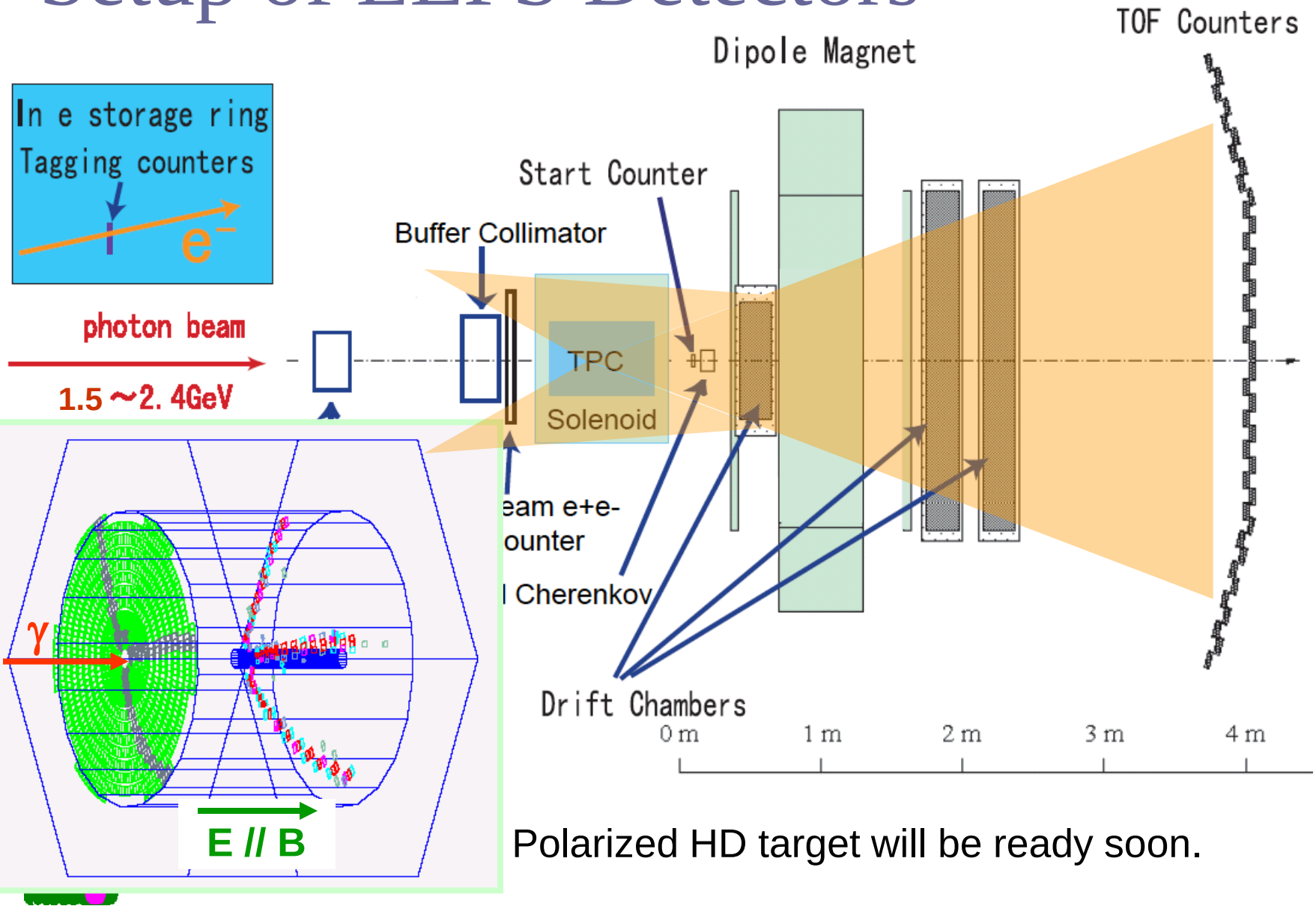
Linear Polarization of γ beam



Setup of LEPS Detectors



Setup of LEPS Detectors



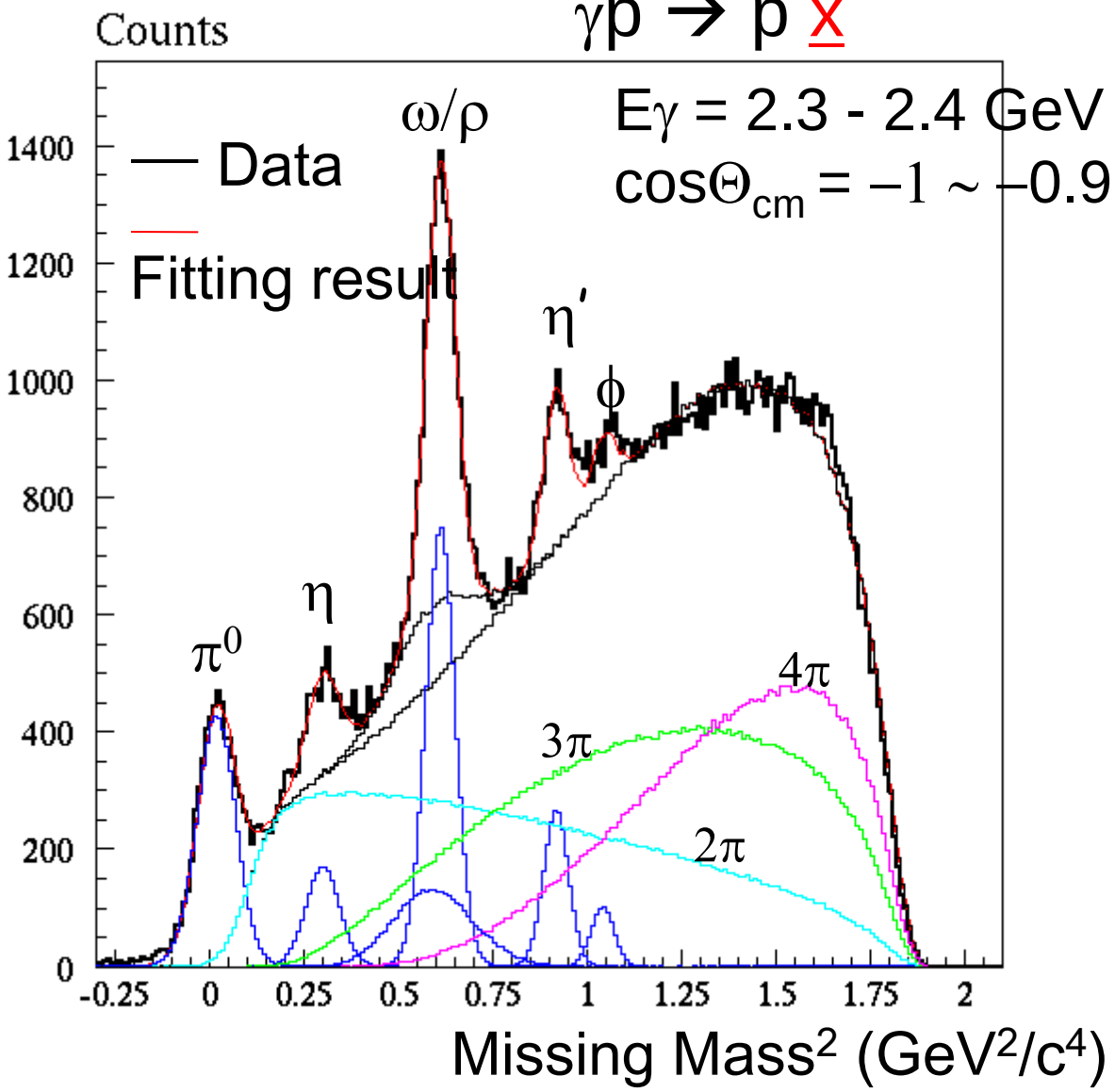
Polarized HD target will be ready soon.

List of Publications on Hyperon

Reaction	Detection Method & Measurements	Major Authors	Reference
$p(\vec{\gamma},K^+)\Lambda$ $p(\vec{\gamma},K^+)\Sigma$	K+ missing; beam asymmetry (Σ)	R.G.T. Zegers, M. Sumihama	PRL 91, 092001 (2003)
$p(\vec{\gamma},K^+)\Lambda$ $p(\vec{\gamma},K^+)\Sigma$	K+ missing; beam asymmetry (Σ), differential cross section (dσ/dcosθ)	M. Sumihama	PRC 73, 035214 (2006)
$n(\vec{\gamma},K^+)\Sigma$	K+ missing; Σ, dσ/dcosθ	H. Kohri	PRL 97, 082003 (2006)
$p(\vec{\gamma},K^+)\Lambda$	pπ-; Σ, dσ/dcosθ	K. Hicks, T. Mibe, M. Sumihama	PRC 76, 042201(R) (2007)
$p(\vec{\gamma},K^+)\Lambda(1405)$ $p(\vec{\gamma},K^+)\Sigma(1385)$	Σπ; dσ/dcosθ	M. Niiyama, H. Fujimura	PRC 78, 035202 (2008)
$n(\vec{\gamma},K^+)\Sigma(1385)$	K+ missing; Σ, dσ/dcosθ	K. Hicks, D. Keller, H. Kohri	PRL 102, 012501 (2009)
$p(\vec{\gamma},K^+)\Lambda(1520)$ $n(\vec{\gamma},K^0)\Lambda(1520)$	pK, KK; Σ, dσ/dcosθ decay asymmetry	N. Muramatsu, J. Y. Chen, W.C. Chang	PRL 103, 012001 (2009)
$p(\vec{\gamma},K^+)\Lambda(1520)$	K+ missing; Σ, dσ/dcosθ	H. Kohri	PRL 104, 172001 (2010)

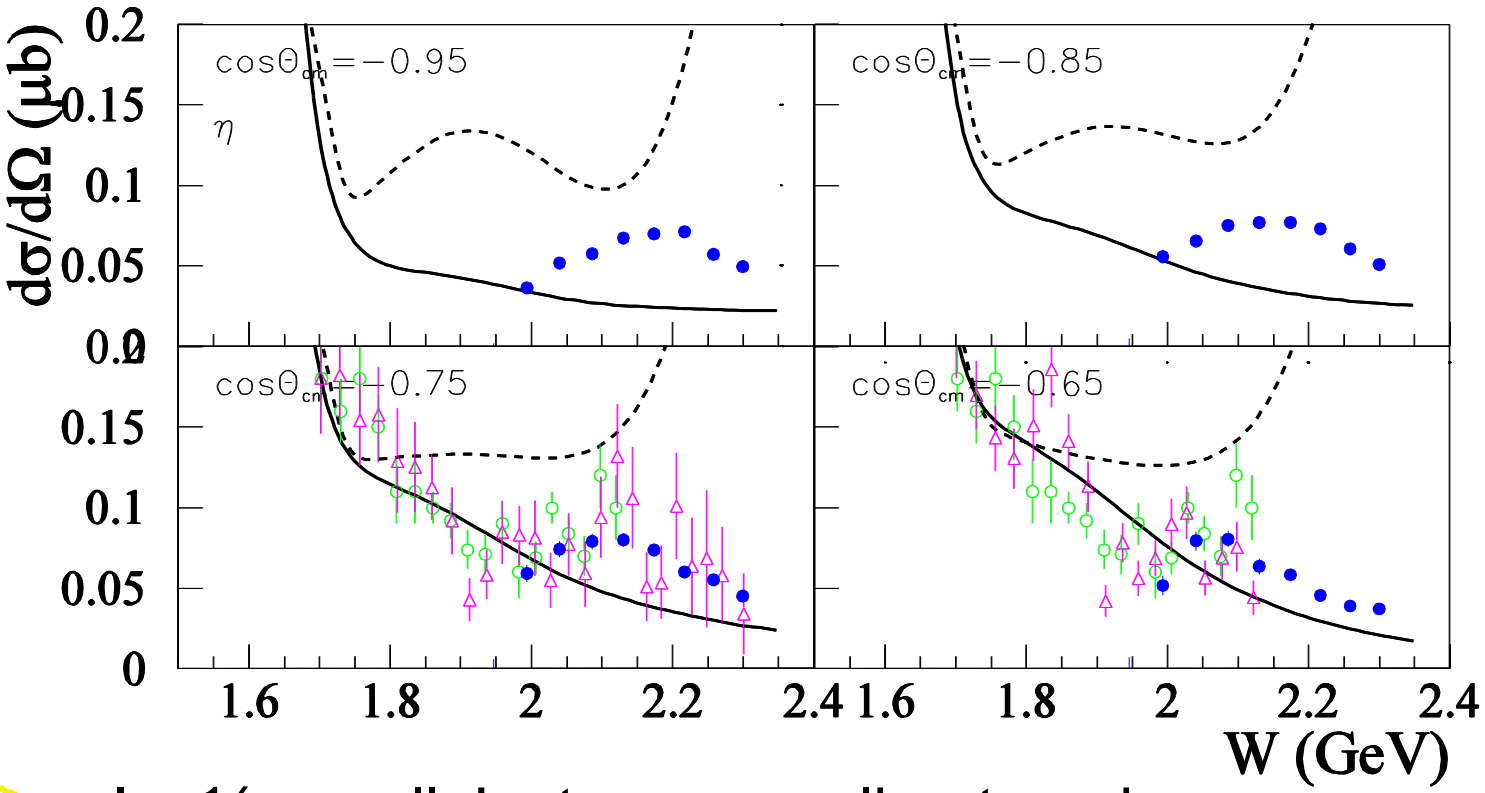
Backward π^0, η, ω, η', ϕ productions

Missing mass spectra



Differential cross sections for η photoproduction

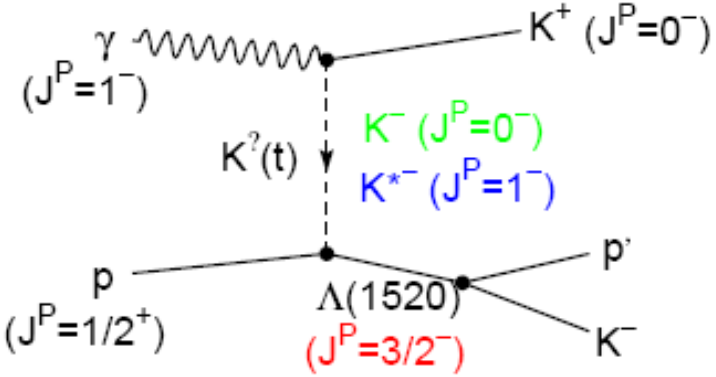
- LEPS data
- ○ Jlab/CLAS data
- △ Bonn/ELSA data
- —— SAID -partial-wave analysis
- ---- Eta-MAID - isobar model

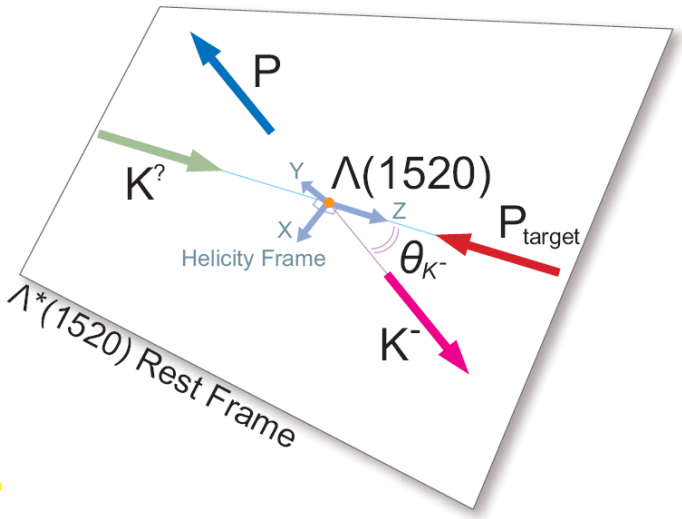


I = ½, small J, strong coupling to η, heavy
→ may contain large $s\bar{s}$ component

$\Lambda(1520)$

K^- Decay Asymmetry



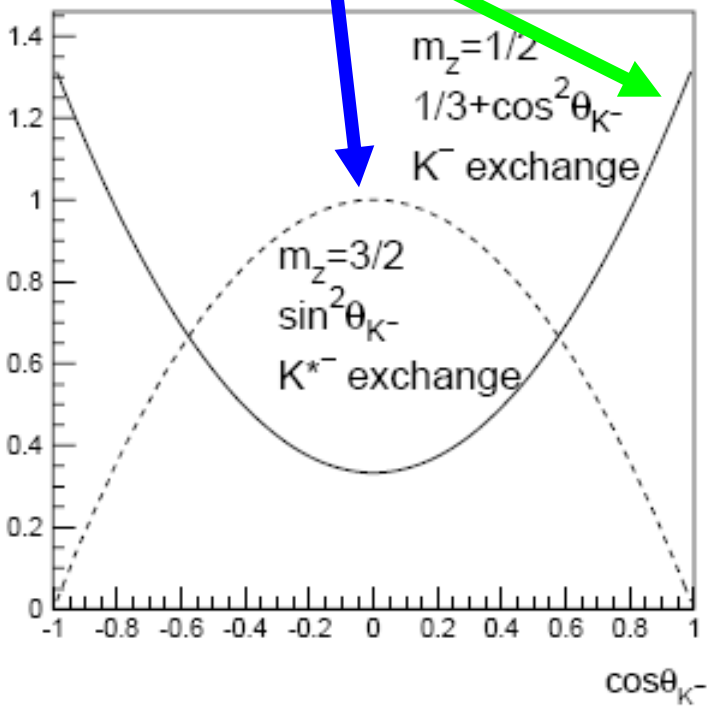


$$m_z = \pm\tfrac{3}{2}$$

$$\Rightarrow K^{*-}\text{exchange}$$

$$m_z = \pm\tfrac{1}{2}$$

$$\Rightarrow K^{-}\text{exchange}$$



K^- Decay Asymmetry

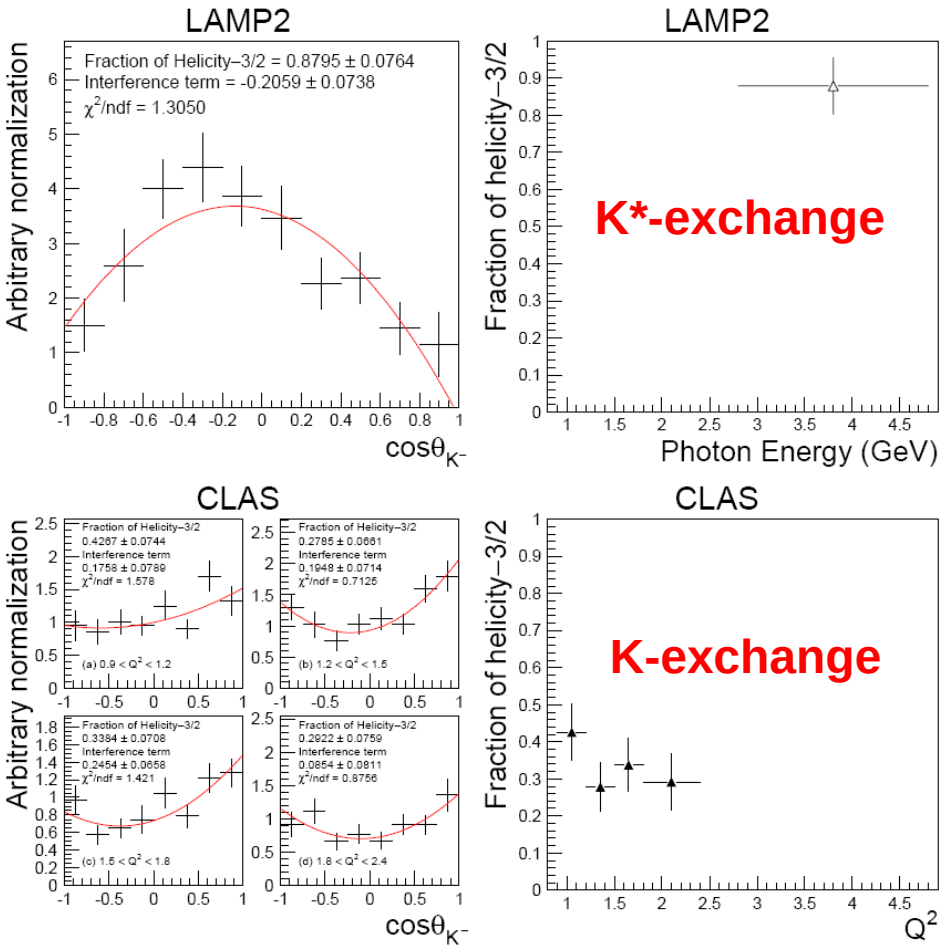
Spin Density Matrix

$$I(\cos\theta,\phi)=\frac{3}{4\pi}\{\rho_{33}\sin^2\theta+\rho_{11}(\frac{1}{3}+\cos^2\theta)-\frac{2}{\sqrt{3}}Re\rho_{31}\sin 2\theta\cos\phi-\frac{2}{\sqrt{3}}Re\rho_{3-1}\sin^2\theta\cos 2\phi\}$$

Parameterization

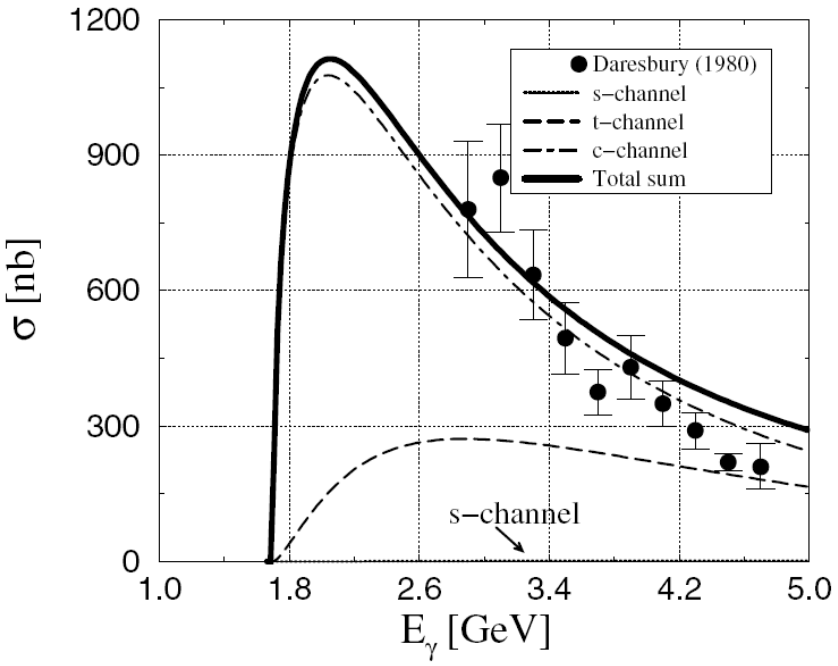
$$f(\theta_{K^-})=N((1-a)\cdot\left(\frac{1}{3}+\cos^2\theta_{K^-}\right)+a\cdot\sin^2\theta_{K^-}+b\cdot\cos\theta_{K^-})$$

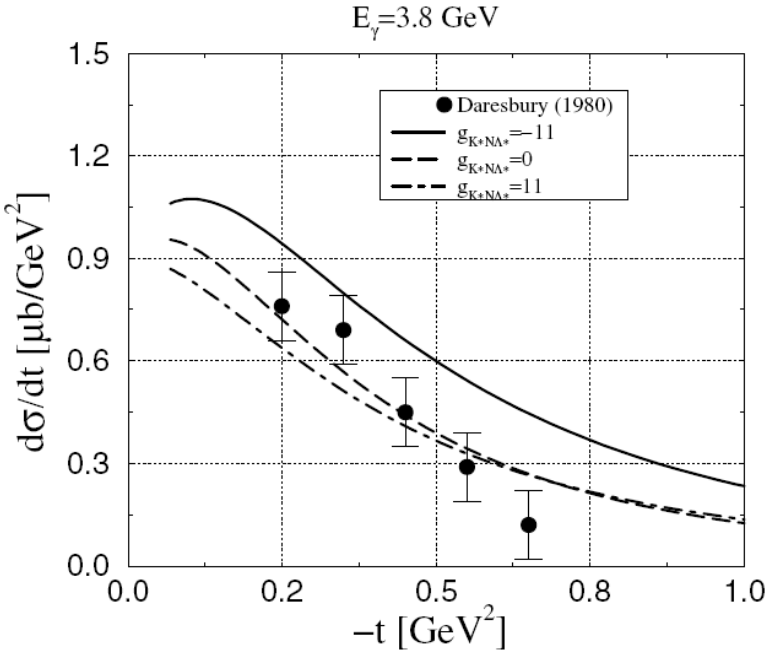
a: fraction of mz=3/2 component.



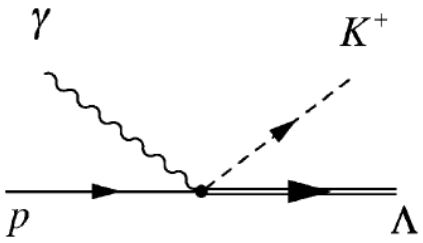
Is the difference mainly caused by the energy dependence or photon-virtuality?

S.i. Nam, A. Hosaka, and H.-Ch. Kim, Phys. Rev. D, 71, 114012 (2005)



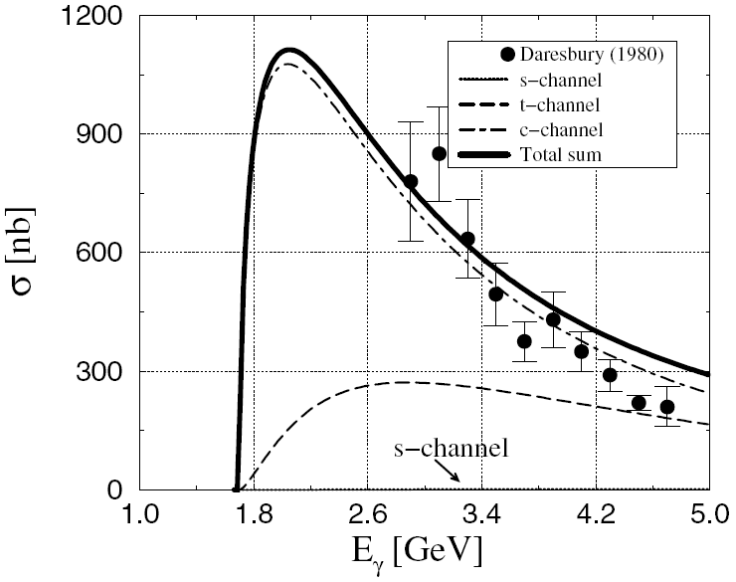


Dominance of contact term

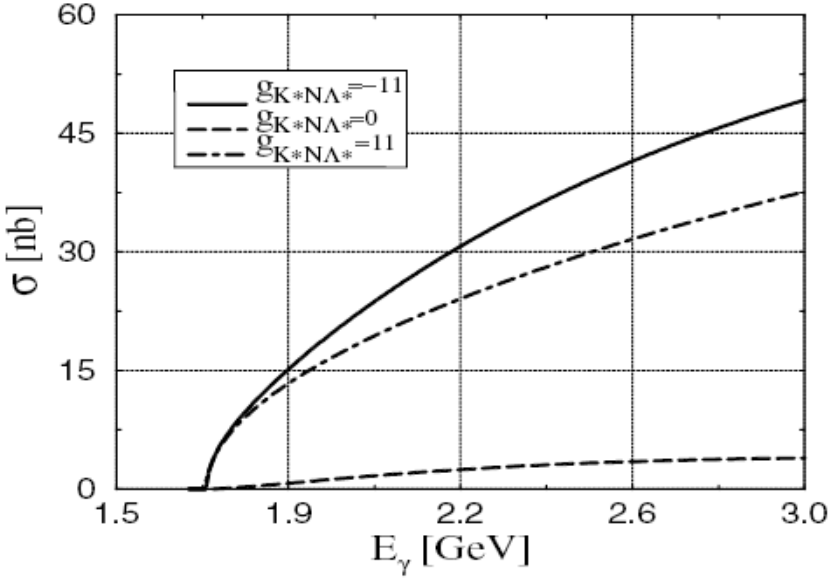


S.i. Nam, A. Hosaka, and H.-Ch. Kim, Phys. Rev. D, 71, 114012 (2005)

Production from Proton



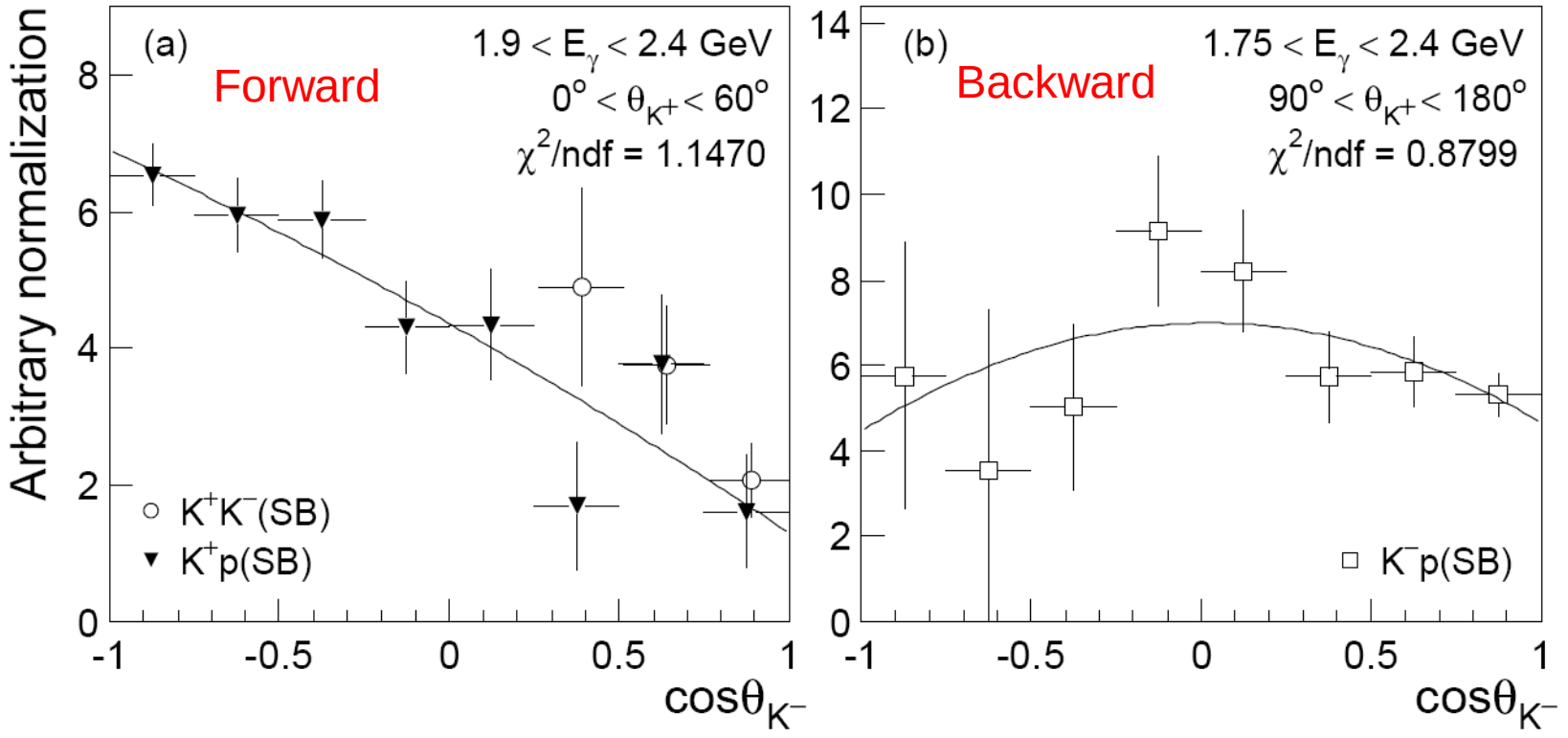
Production from Neutron



Reactions	$\gamma p \to K^+ \Lambda^*$	$\gamma n \to K^0 \Lambda^*$
σ	~900 *nb*	~30 *nb*
$d\sigma/d(\cos\theta)$	Forward peak	Peak at ~45°
$d\sigma/dt$	Good	No data

Large isospin asymmetry is expected.

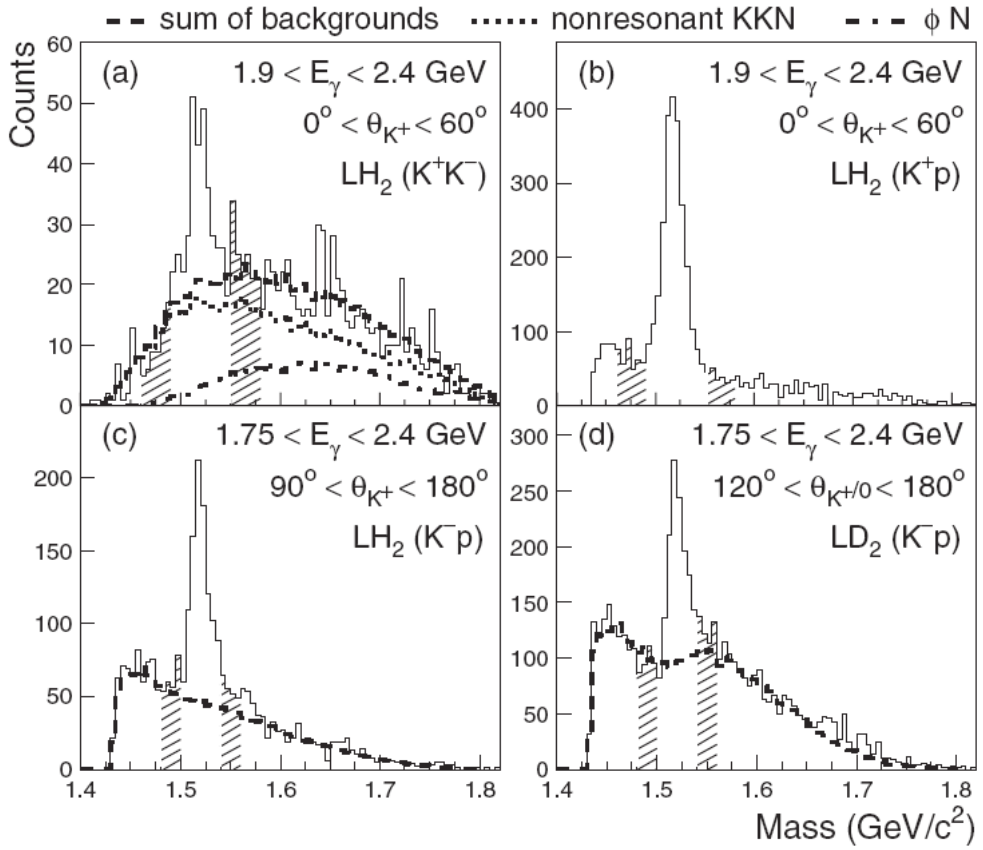
Decay Asymmetry



- In K^+p mode, an asymmetric distribution suggests an interference effect. The fraction of helicity-3/2 component was about 0.5.
- In K^-p mode, the helicity-3/2 fraction was around 0.6.

Photoproduction of Λ(1520) from p/d

$$\gamma + p \rightarrow K^+ + \Lambda(1520) \rightarrow K^+ + p + K^-$$
$$\gamma + n \rightarrow K^0 + \Lambda(1520) \rightarrow \pi^+ + \pi^- + p + K^-$$



$$\sigma(d) \approx \sigma(p)$$
$$\sigma(n) \approx \sigma(p)$$

N. Muramatsu et al. (LEPS Collaboration), PRL 103, 012001 (2009)

A Large Isospin Asymmetry in Θ^+ Production

$\Lambda(1520)\ J^P = 3/2^-$

Reactions	$\gamma p \to K^+\Lambda^*$	$\gamma n \to K^0\Lambda^*$
σ	$\sim 900\,nb$	$\sim 30\,nb$
$d\sigma/d(\cos\theta)$	Forward peak	Peak at $\sim 45°$

Contact term

- $\sigma(p) >> \sigma(n)$
- Strong forward peak

⇒ To be checked by experiments

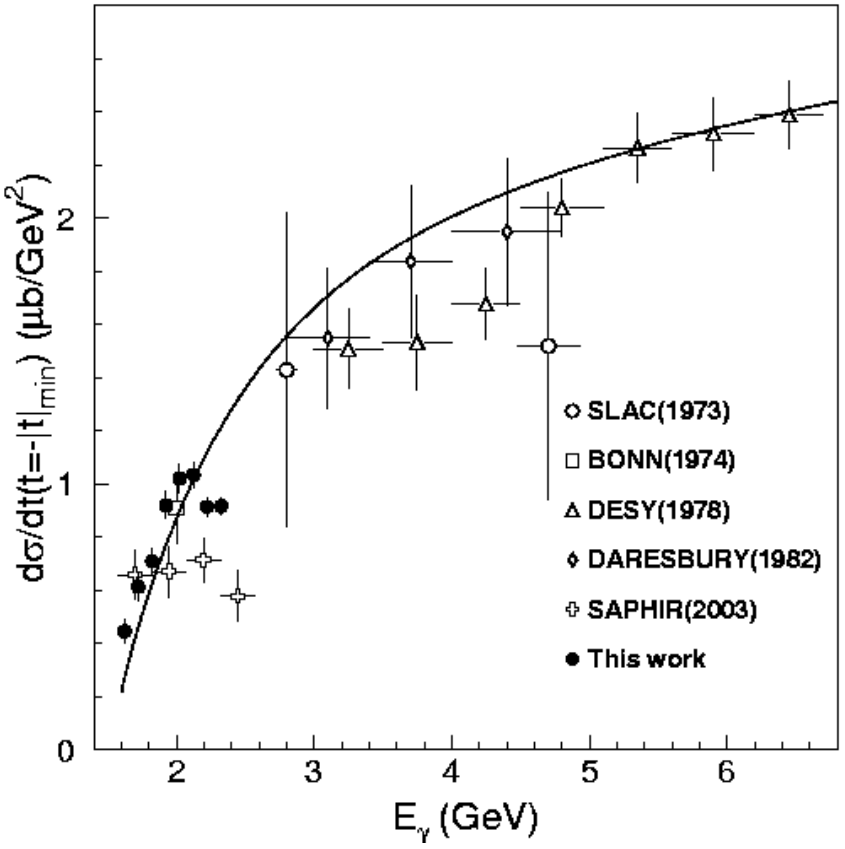
For Θ: we expect $\sigma(p) << \sigma(n)$

A. Hosaka, Workshop of "Challenge to New Exotic Hadrons with Heavy Quarks".

Bump structures around 2 GeV in some reactions

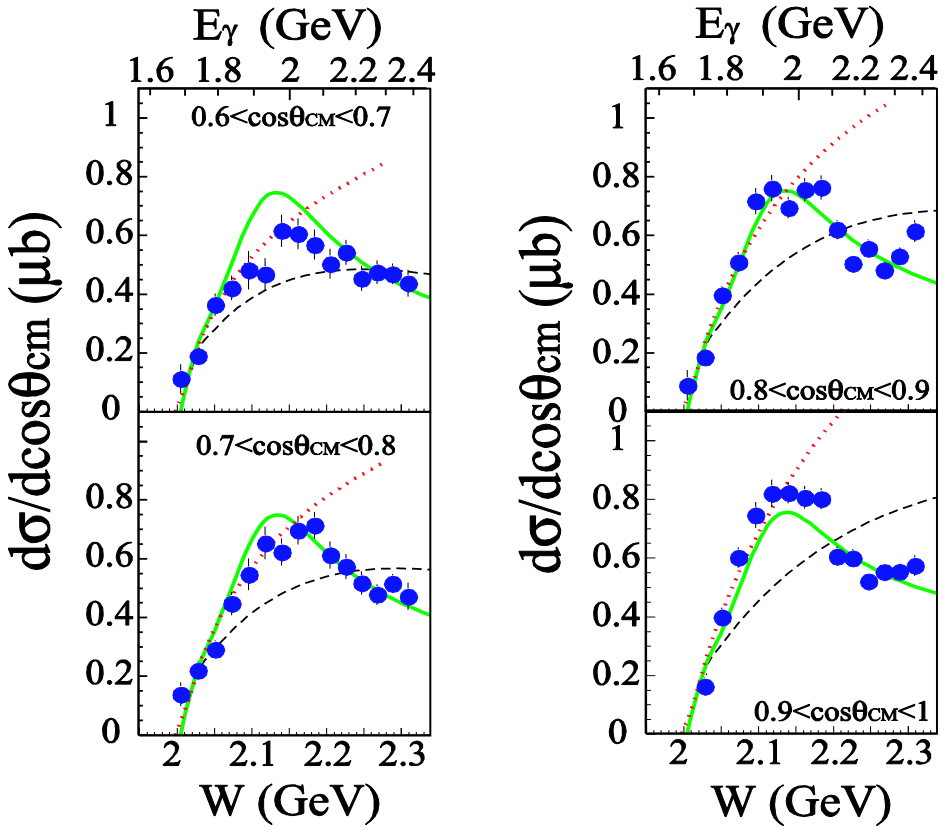
$\gamma\ p \to \phi\ p$

PRL95,182001 (2005)

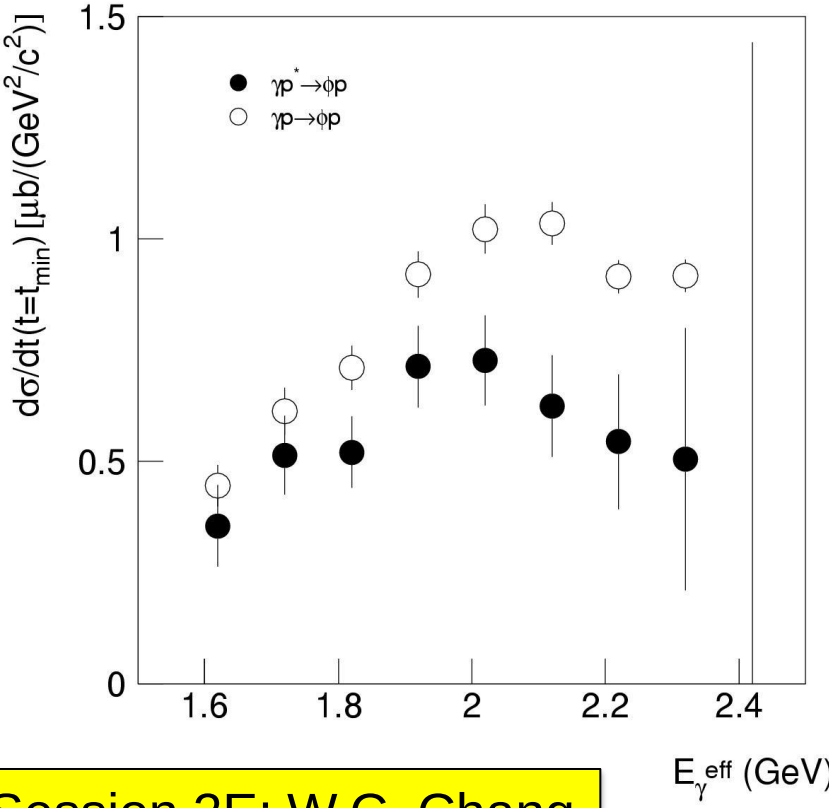


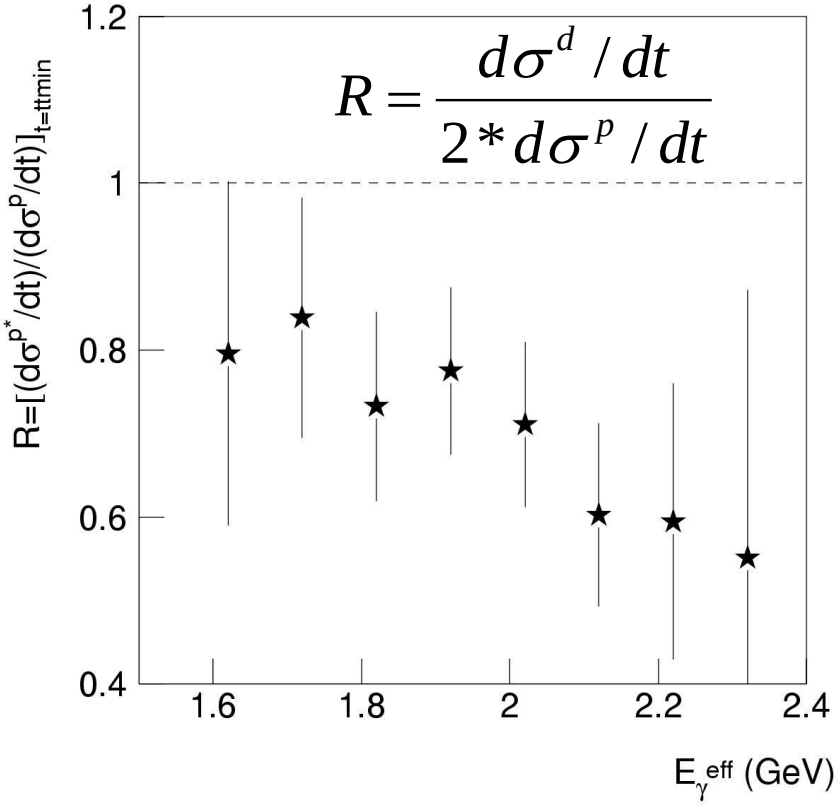
$\gamma\ p \to K^{+}\Lambda(1520)$

PRL104,172001 (2010)



Differential Cross Sections of Incoherent Production $\gamma p^* \rightarrow \phi p$





Session 2E: W.C. Chang

Suppression is common for production from either proton or neutron.

$\Theta^{+}(1530)$

Experimental status

- Not seen in the most of the high energy experiments: The production rate of $\Theta^+/\Lambda(1520)$ is less than 1%.
  - Production rate depends on reaction mechanism.
- No signal observation in CLAS γp, KEK-PS (π^-,K^-), (K^+,π^+) experiments.
  - K* coupling should be VERY small.
- The width must be less than 1 MeV. (DIANA and KEK-B) reverse reaction of the Θ^+ decay: $\Theta^+ \rightarrow n K^+$
  - K coupling should be small.
- LEPS could be inconsistent with CLAS γd experiment (CLAS-g10).
  - Strong angle or energy dependence.

Difference between LEPS and CLAS for $\gamma n \rightarrow K^- \Theta^+$ study

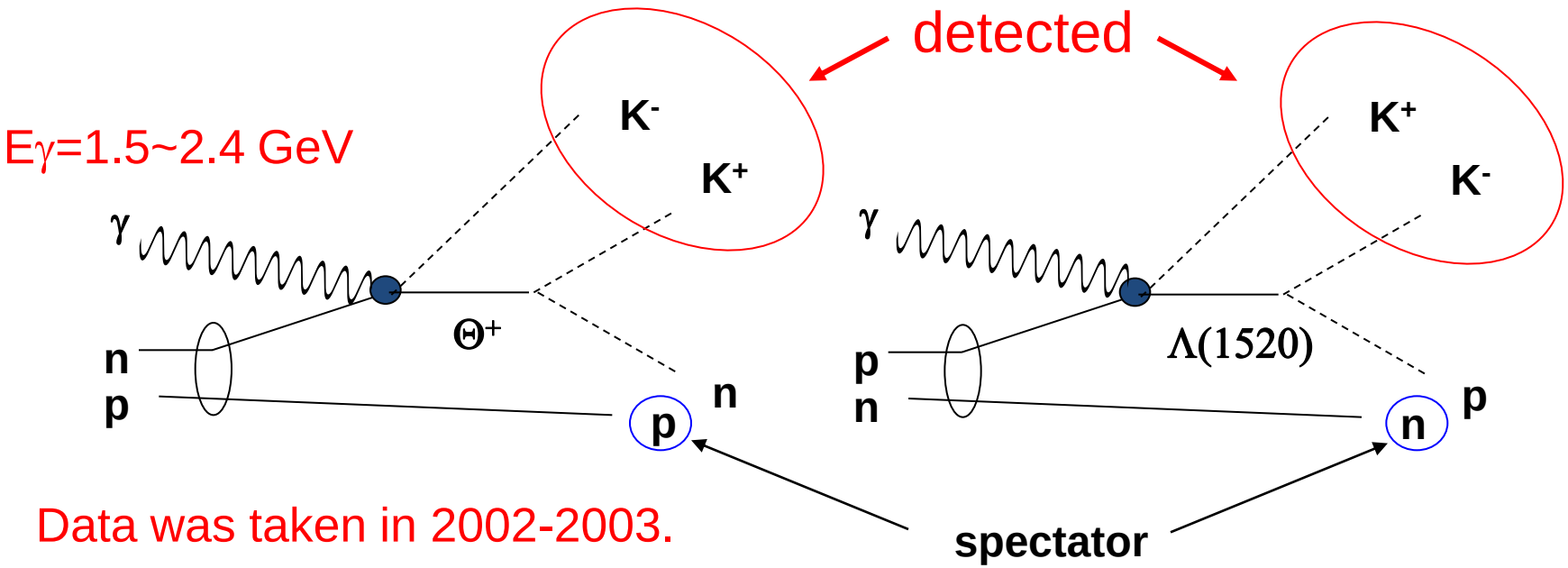
LEPS		CLAS
Good forward angle coverage	⟷	Poor forward angle coverage
Poor wide angle coverage	⟷	Good wide angle coverage
Low energy	⟷	Medium energy
Symmetric acceptance for K^+ and K^-	⟷	Asymmetric acceptance
$M_{KK} \gtrsim 1.04$ GeV/c^2	⟷	$M_{KK} > 1.07$ GeV/c^2
Select quasi-free process	⟷	Require re-scattering or large Fermi momentum of a spectator

K^- coverage:

LEPS: $\theta_{LAB} < 20$ degree

CLAS: $\theta_{LAB} > 20$ degree

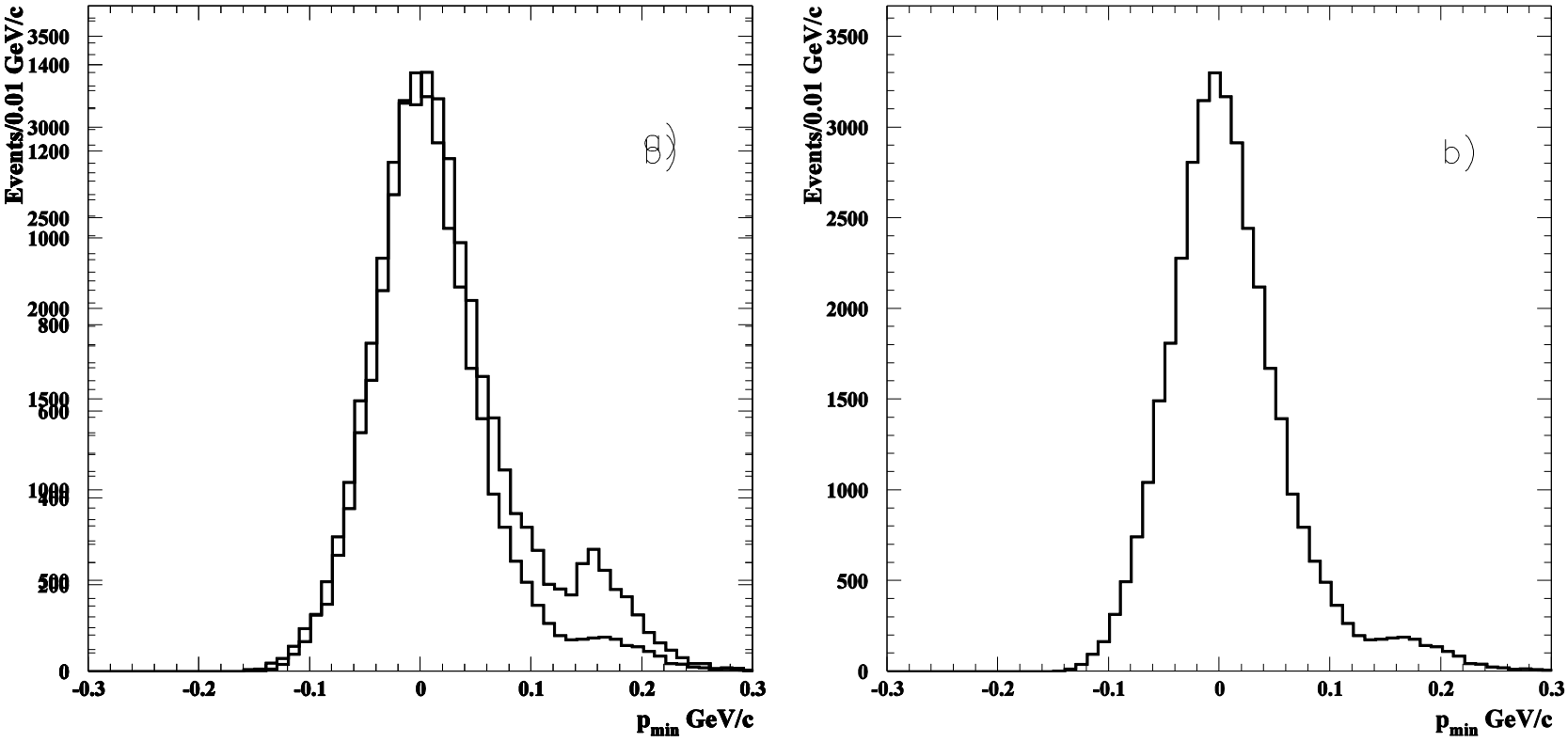
Quasi-free production of Θ^+ and $\Lambda(1520)$



Data was taken in 2002-2003.

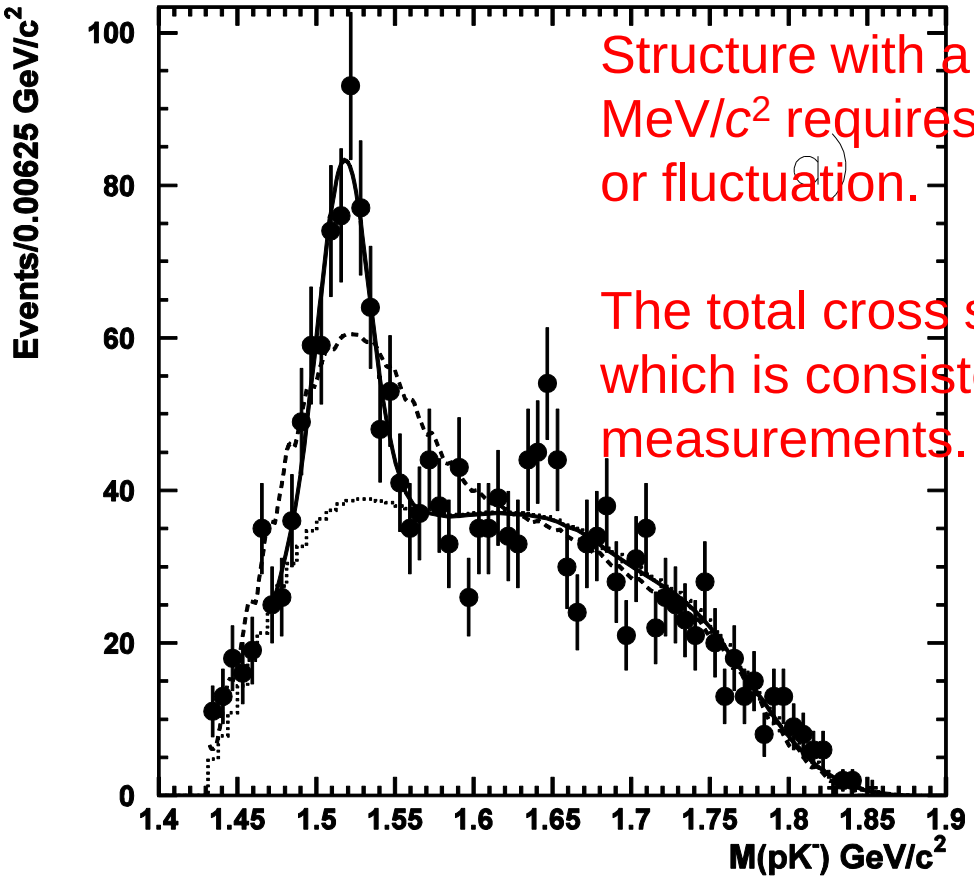
- Both reactions are quasi-free processes.
- Fermi-motion should be corrected.
- Existence of a spectator nucleon characterize both reactions.

Comparison of Real and MC p_{min} distributions



Results of $\Lambda(1520)$ analysis

pK^- invariant mass with MMSA: Fermi motion effect corrected.



Structure with a width less than 30 MeV/c^2 requires a physics process or fluctuation.

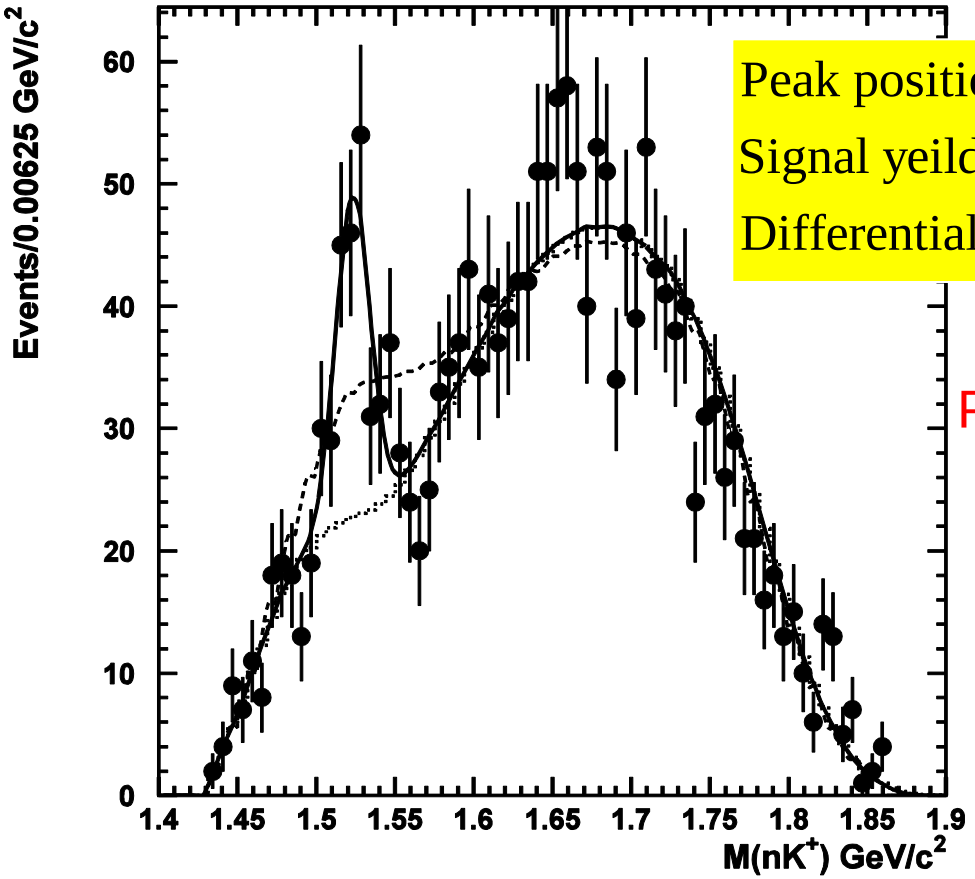
The total cross section is ~1 μb, which is consistent with the LAMP2 measurements.

$\Delta(-2\ln L) = 55.1$ for $\Delta ndf = 2 \longrightarrow 7.1\sigma$

$$\mathrm{Prob}(7.1\sigma) = 1.2\times10^{-10}$$

Results of Θ^+ analysis

nK$^+$ invariant mass with MMSA: Fermi motion effect corrected.



Peak position: 1.527± 0.002 GeV/c^2

Signal yeild: 116± 21 events

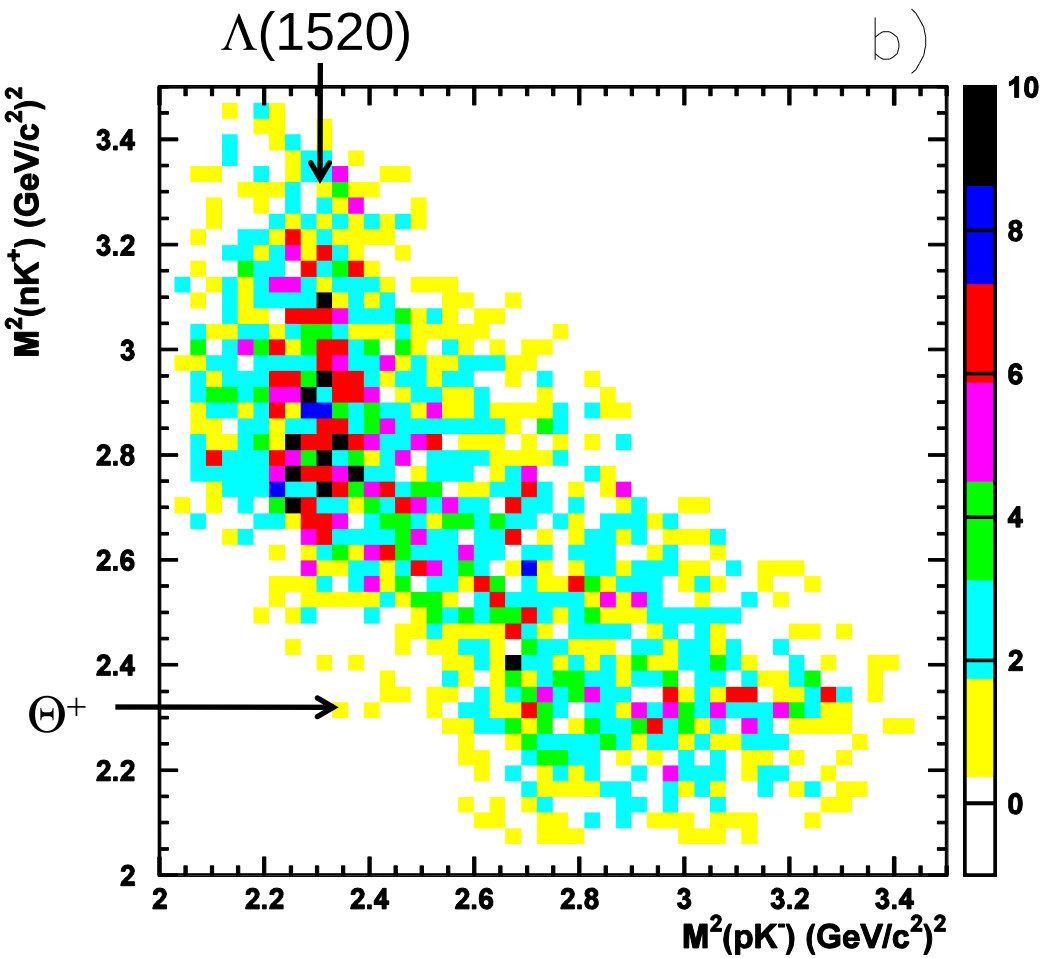
Differential cross-section: 12± 2 nb/sr

PRC **79,** 025210 (2009)

"The narrow peak appears only after Fermi motion correction."

$\Delta(-2\ln L) = 31.1$ for $\Delta ndf = 2 \longrightarrow 5.2\sigma$ $\quad \mathrm{Prob}(5.2\sigma) = 2\times10^{-7}$

$M^2(nK^+)$ *vs.* $M^2(pK^-)$



We assume a proton is a spectator for M(nK^+)
a neutron is a spectator for M(pK^-)

Next step

Probability of 1/5000000 may not be low enough.
"Extraordinary claim requires an extraordinary evidence."

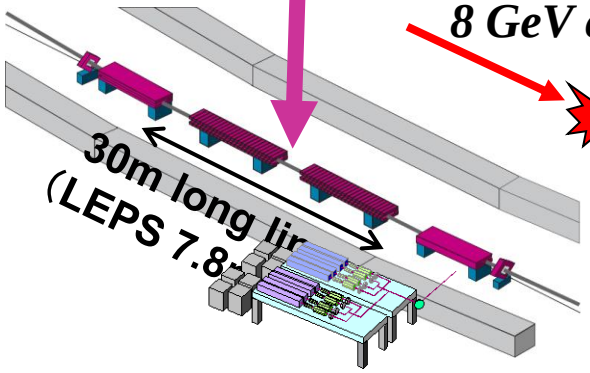
High statistics data was already collected in 2006-2007 with the same experimental setup.

Blind analysis is under way to check the Θ^+ peak

The result will tell if the peak structure is due to statistical fluctuations or not unambiguously.

LEPS2 Project at SPring-8

Backward Compton Scattering



8 GeV electron

Recoil electron (Tagging)

Laser or re-injected X-ray

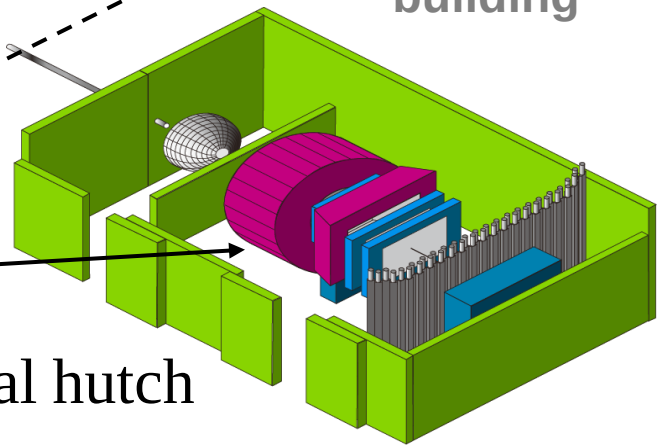
GeV γ-ray

High intensity:
Multi (ex. 4) laser injection w/ large aperture beam-line &
Laser beam shaping
~10 ^{7} photons/s (LEPS ~10 ^{6})
High energy: Re-injection of X-ray from undulator
Eγ < 7.5GeV (LEPS < 3GeV)

Better divergence beam
⇒collimated photon beam
Different focus points for multi CW laser injection

Inside building

Outside building



Experimental hutch

Large 4π spectrometer based on BNL-E949 detector system.
Better resolutions are expected.
New DAQ system will be adopted.

Summary

1. LEPS is a Backward Compton gamma beam facility at SPring-8. GeV γ beam with high polarization is available.
2. LEPS detector has a good forward angle acceptance which is complimentary to the CLAS acceptance.
3. LEPS provides essential information to understand production mechanism of hyperons.
4. A new experiment with a Time Projection Chamber has been started.
5. Strong isospin dependence was observed in $\Lambda(1520)$ photo-production.
6. Evidence for new baryon resonance in η photo-production, which may contain $s\bar{s}$ component.
7. 5-σ Θ^+ peak was observed in the nK^+ invariant mass at 1.53 GeV/c^2. New data set with 3 times more statistics was taken. Blind analysis is under way.

8. LEPS2 project is approved: 10 times stronger beam & 4π coverage.