

First results from SPring-8

T. Nakano(RCNP)
for LEPS collaboration

- Laser-Electron Photon beam
- LEPS Detector
- First physics run and results.
- Summary



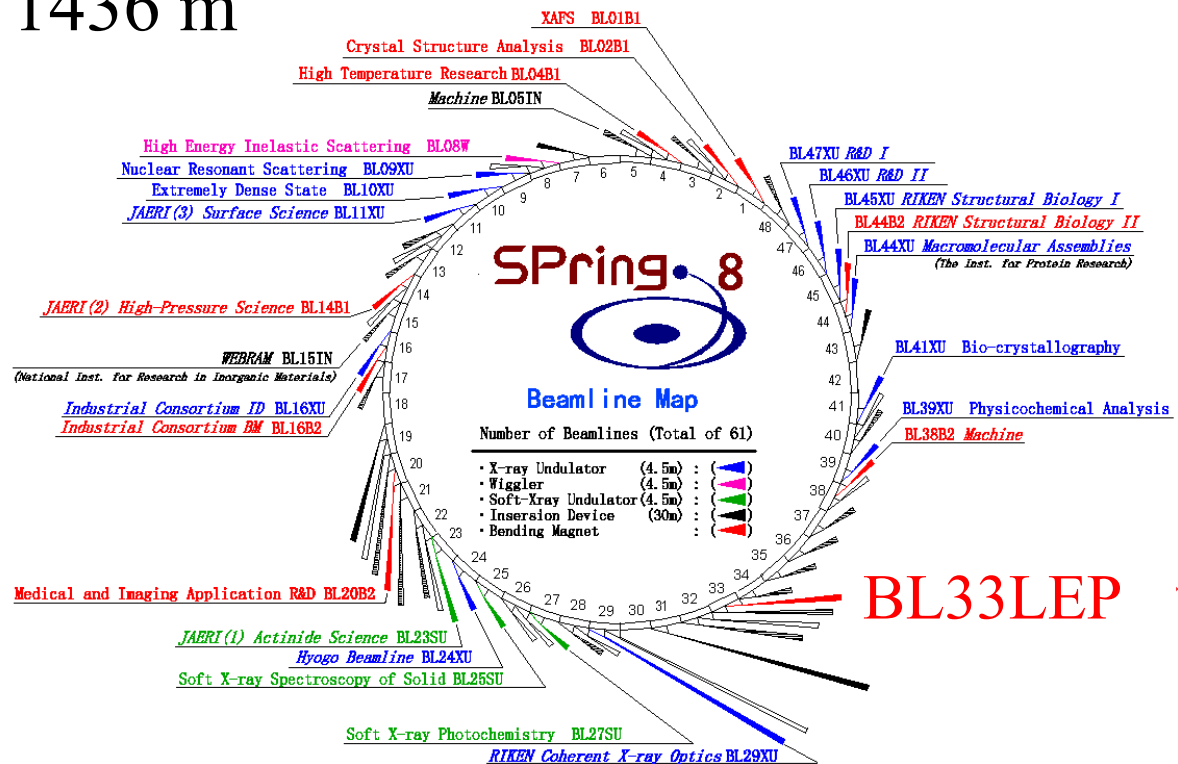
Baryons2002

March 4-8, 2002 @ Jlab

SPring-8

(Super Photon ring-8 GeV)

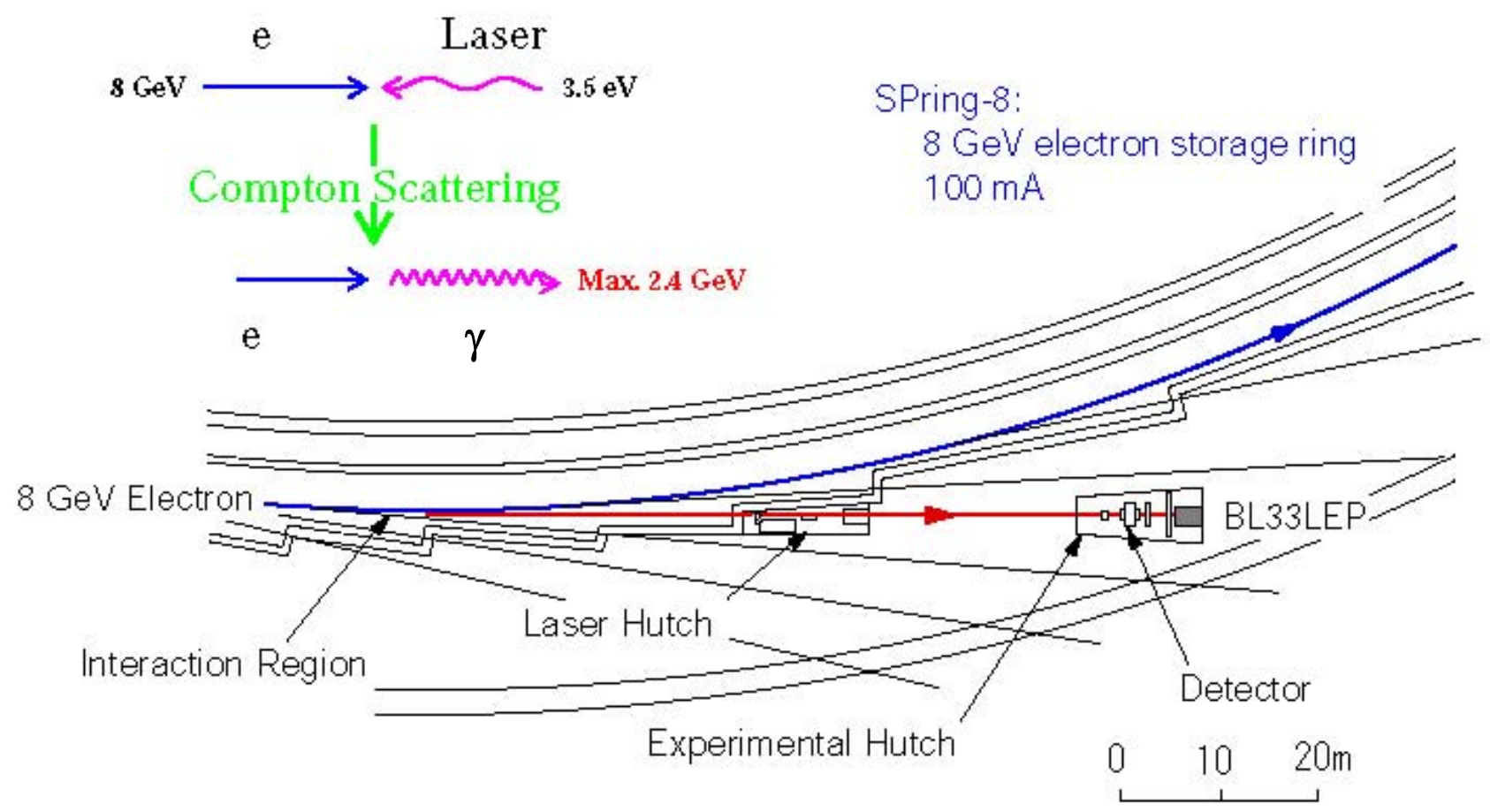
- Third-generation synchrotron radiation facility
- Circumference: 1436 m
- 8 GeV
- 100 mA
- 62 beamlines



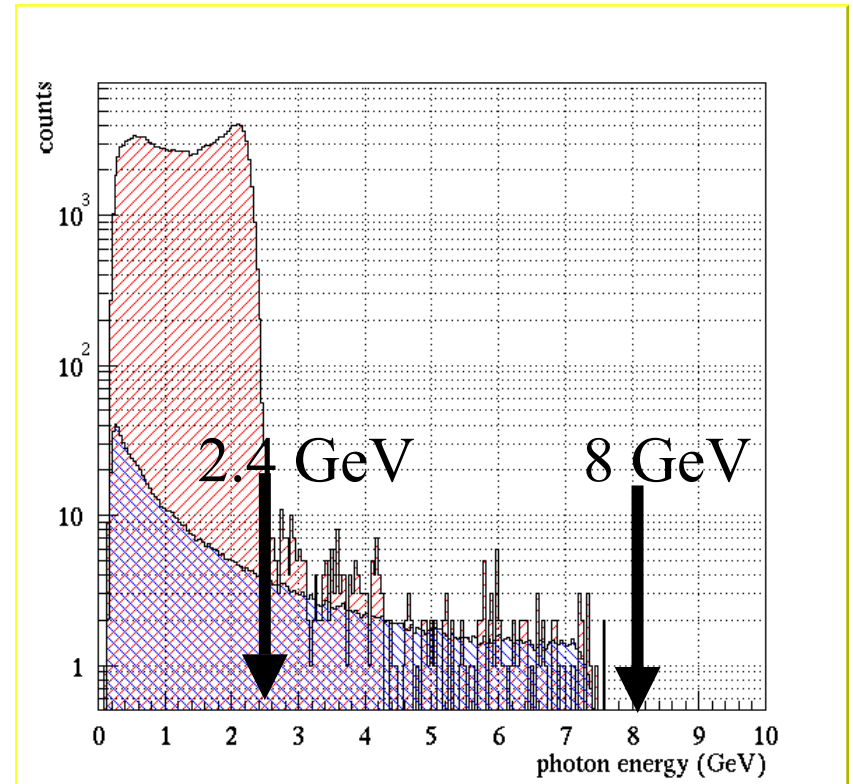
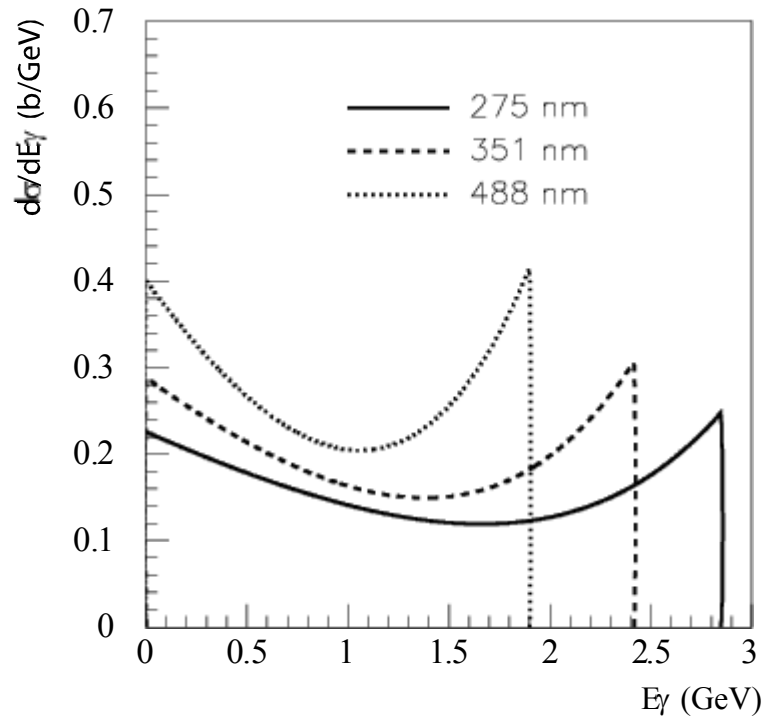
The LEPS Collaboration

- Research Center for Nuclear Physics, Osaka University
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- Pusan National University
J.K. Ahn, D.S. Ahn
- Seoul National University
H.C. Bhang
- Konan University
H. Akimune
- Japan Atomic Energy Research Institute / SPring-8
Y. Asano, N. Muramatsu
- Institute of Physics, Academia Sinica, Taiwan
W.C. Chang, D.S. Oshuev, C.W. Wang, S.C. Wang
- Japan Synchrotron Radiation Research Institute (JASRI) / SPring-8
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- Ohio University
K. Hicks
- Kyoto University
K. Imai, T. Ishikawa, M. Miyabe, M. Niiyama, T. Sasaki, D. Seki, M. Yosoi
- Chiba University
H. Kawai, T. Ooba, Y. Shiino
- Catholic University of America
F.J. Klein
- Wakayama Medical University
S. Makino
- Nagoya University
T. Iwata, Y. Miyachi, A. Wakai
- Osaka University
H. Nakamura, M. Nomachi, A. Sakaguchi, Y. Sugaya, M. Sumihama
- University of Saskatchewan
C. Rangacharyulu
- Institute for High Energy Physics (IHEP), Moscow
P. Shagin
- Laboratory of Nuclear Science, Tohoku University
H. Shimizu
- University of Michigan
K. Yonehara
- International Institute for Advanced Studies
H. Ejiri

Laser electron Photon at SPring-8

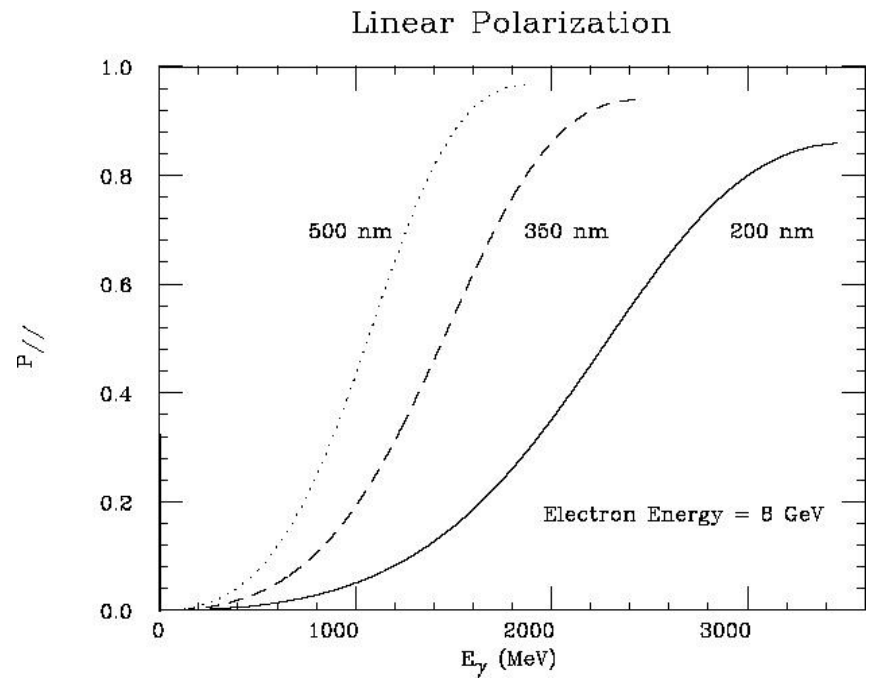
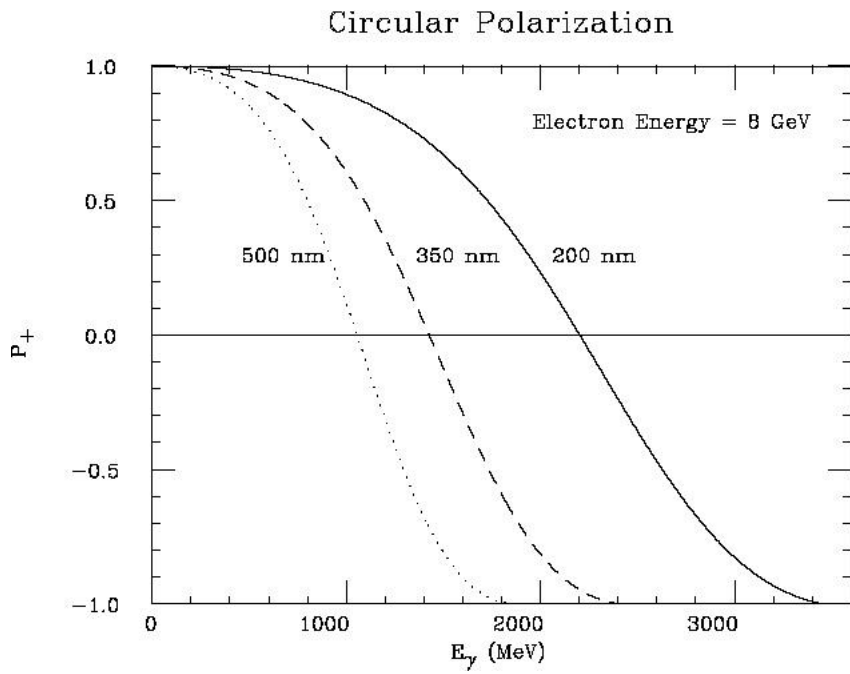


Energy Spectrum



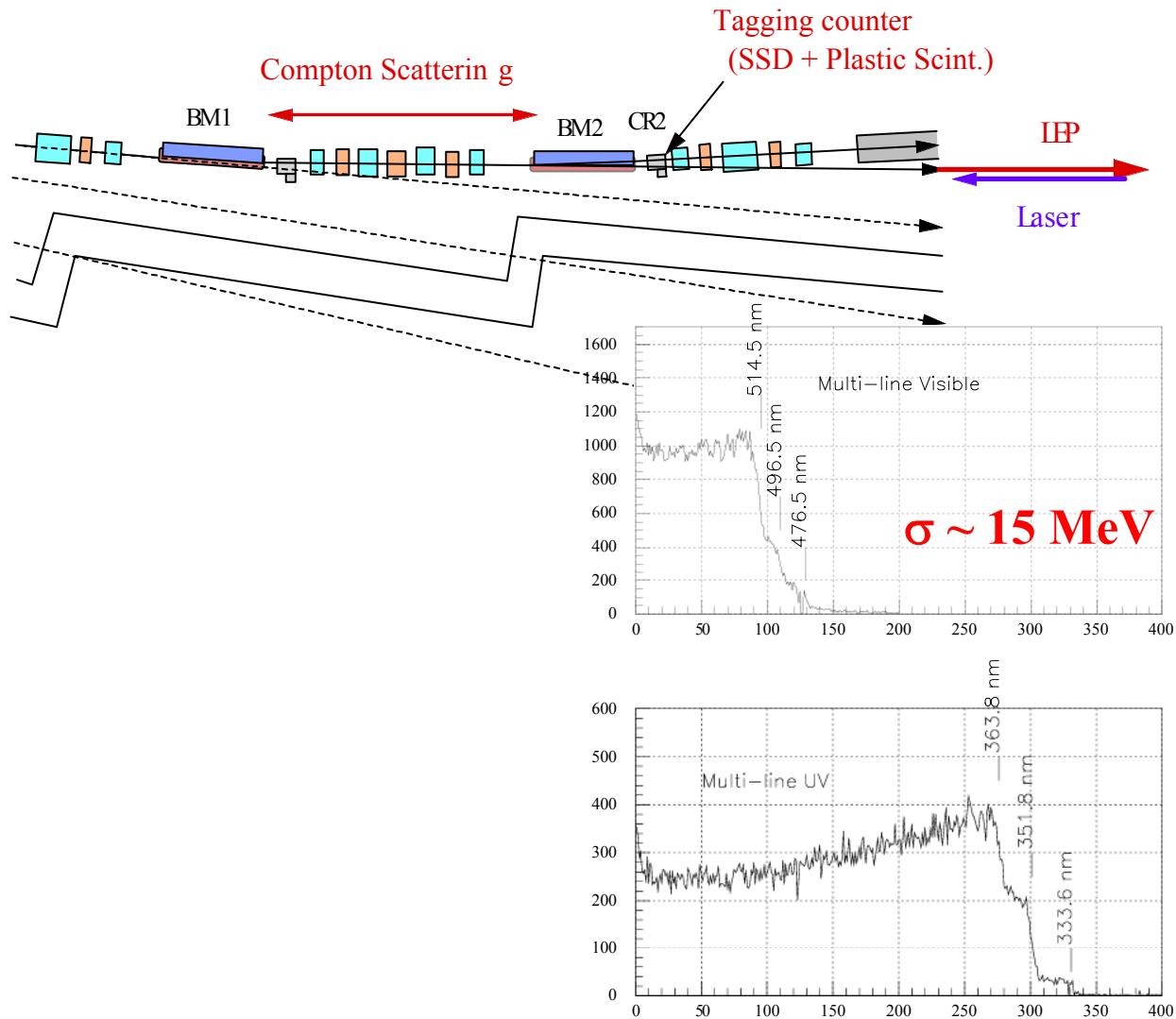
Intensity (Typ.) : $2.5 * 10^6$ photons/sec

Polarization of LEP Beam



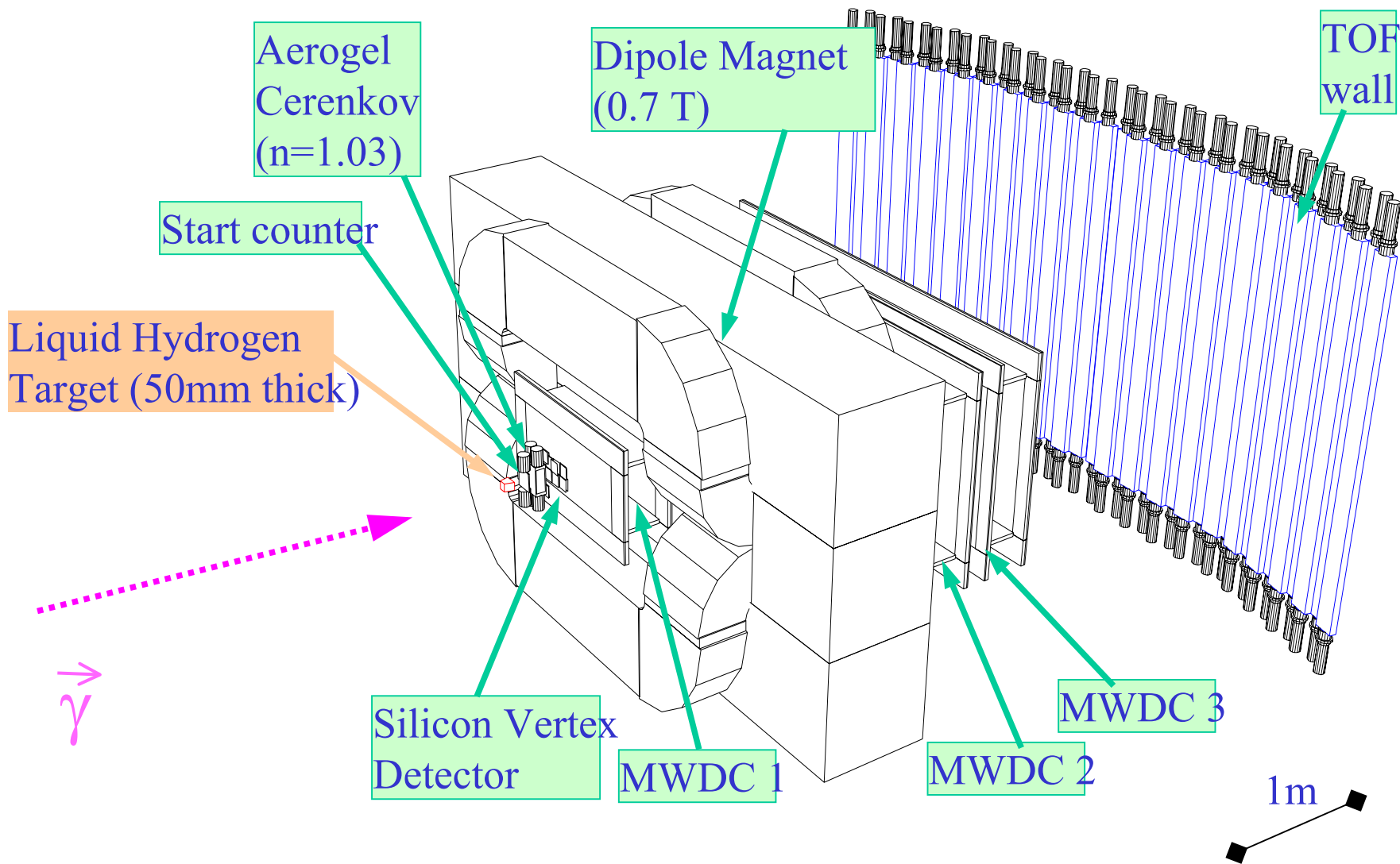
Linear Polarization : 95 % at 2.4 GeV

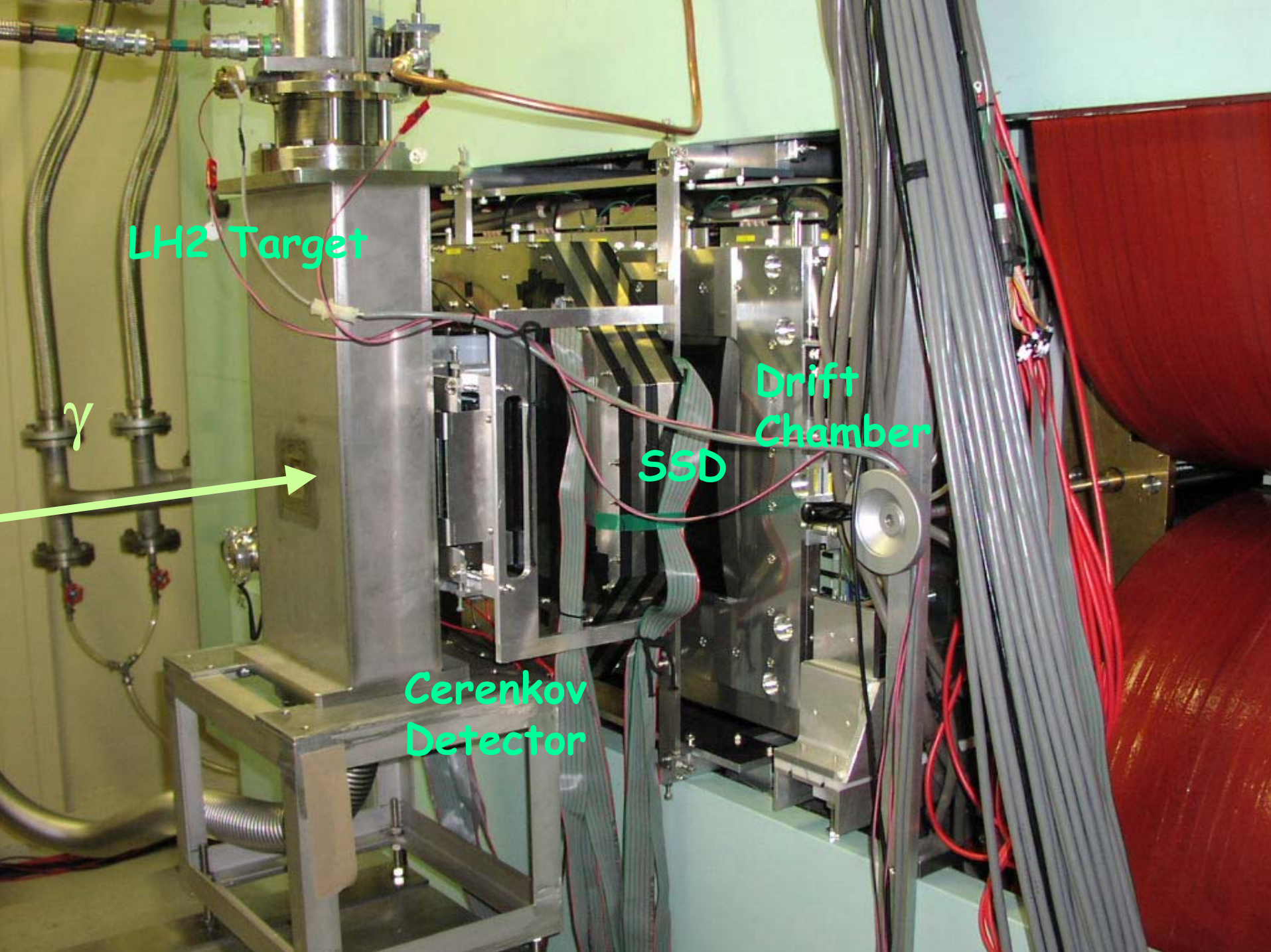
Tagging system



Tagging Region : $1.5 \text{ GeV} < E_{\gamma} < 2.4 \text{ GeV}$

LEPS detector





LH2 Target

γ



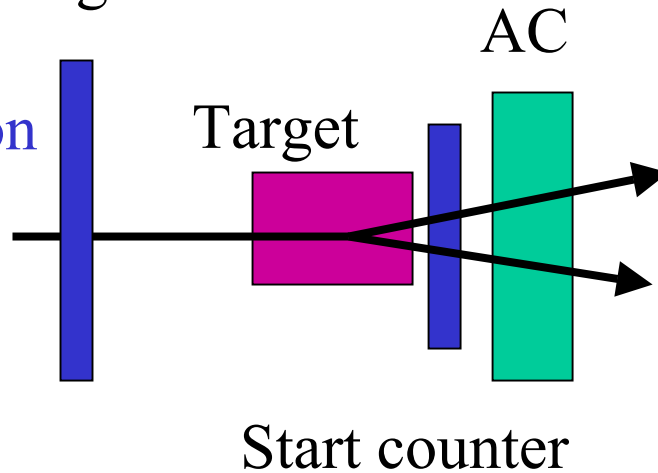
Drift Chamber

SSD

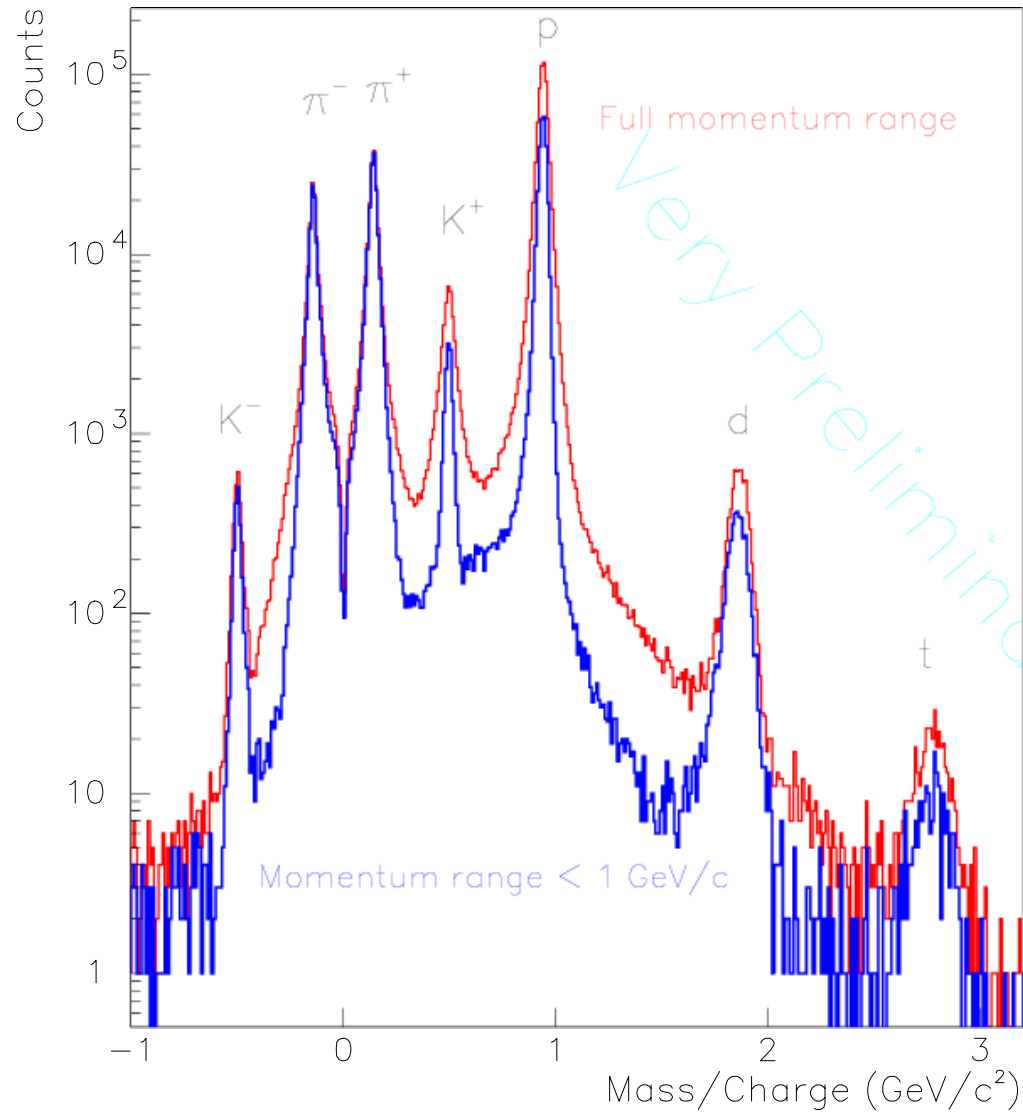
Cerenkov Detector

Trigger

- Photon requirement about 30 Hz for 800 kHz@tagger
 - Tagger hit
 - No signal in charge veto
- Charged particle production
 - Start counter
 - TOF hit
- $e^+ e^-$ veto
 - AC ($n = 1.03$)
 - $p_\pi < 0.6 \text{ GeV}/c$



Reconstructed mass spectrum

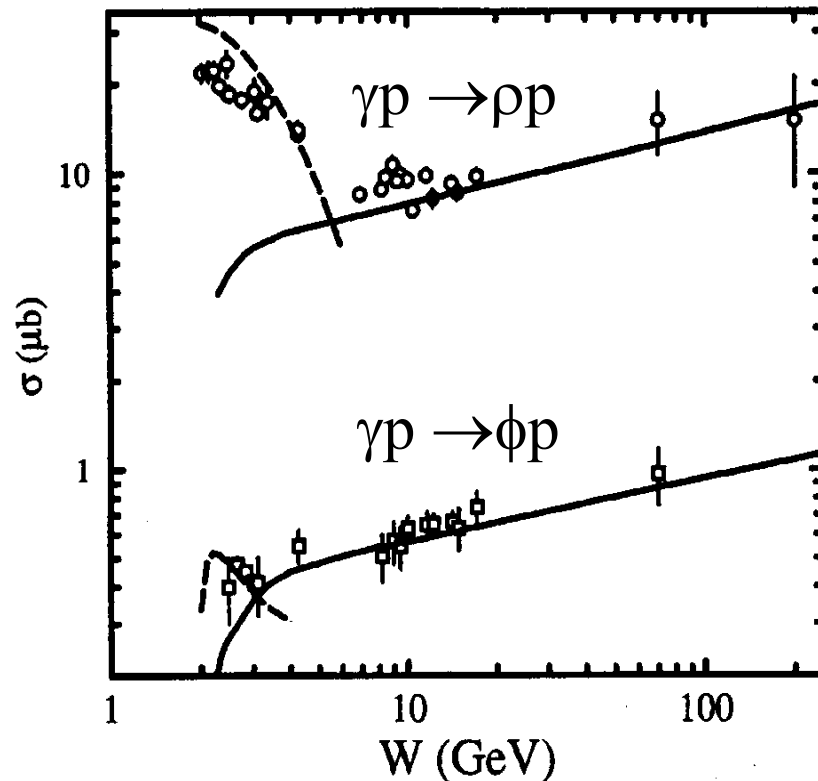


Physics programs

- **Photo-production of ϕ meson near threshold in the forward angles.**
 - **Pomeron (multi-gluon) exchange $>$ meson exchange.**
 - **Search for additional multi-gluon (0^+ glueball) exchange.**
 - **Linearly polarized photons help to decompose natural and un-natural parity exchange contributions.**
 - **Complementary to the SAPHIR and CLAS (Jlab) experiments.**

Cross section of Vector Meson Photoproduction

M. A. Pichowsky and T.-S. H. L
PRD 56, 1644 (1997)



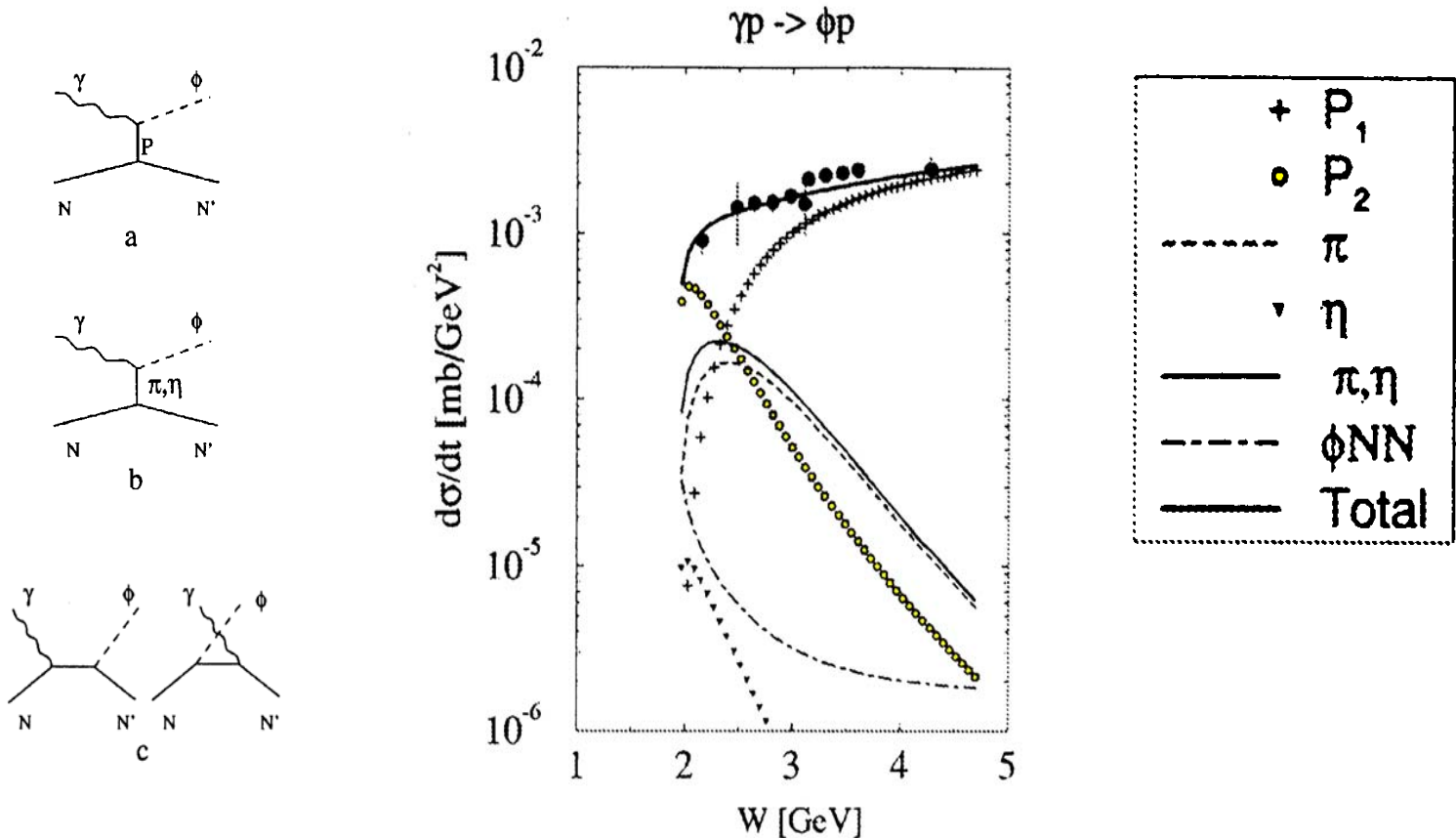
— Prediction from
Pomeron exchange
- - - Prediction
from meson
exchange

FIG. 15. Energy dependence of ρ - (top) and ϕ -meson (bottom) photoproduction cross sections. The solid curves are the predictions from our quark-nucleon Pomeron-exchange interaction. The dashed curves are the predictions of the meson-exchange model discussed in the text. The ρ -meson data (triangles) are from Refs. [35,36,44–47]. The ϕ -meson data (squares) are from Refs. [41,44,46,48].

Data from: LAMP2('83),
DESY('76), SLAC('73),
CERN('82),
FNAL('79,'82), ZEUS('95,'96)

ϕ photoproduction near production threshold

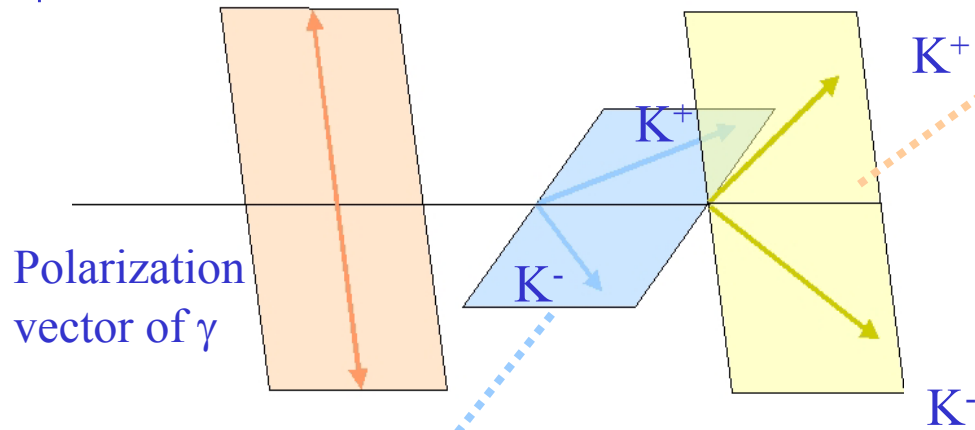
Titov, Lee, Toki Phys. Rev C59 (1999) 2993



P_2 : 2nd pomeron $\sim 0^+$ glueball (Nakano, Toki (1998))

Photoproduction by linearly polarized photon

In ϕ rest frame (Helicity frame)



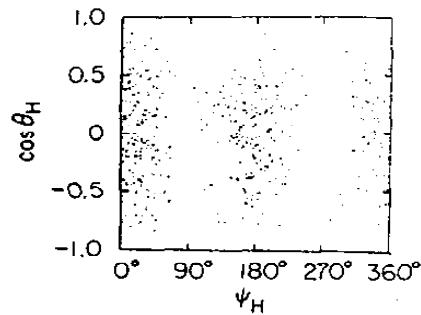
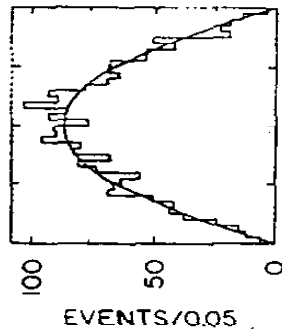
Decay Plane $\parallel \vec{\gamma}$
 γ
 if natural parity exchange $(-1)^J$
 (Pomeron, Scalar mesons)

Decay Plane $\perp \vec{\gamma}$
 γ
 if unnatural parity exchange
 $-(-1)^J$ (Pseudoscalar mesons)

Decay Angular distribution of ϕ
 \downarrow
 Decomposition of

- natural parity exchange
- unnatural parity

At high energies...



$$E_\gamma = 9.3$$

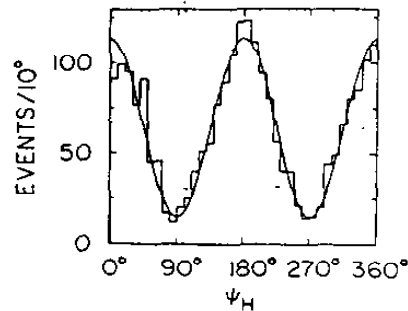
GeV Linear

Pol.

Ballam et.al.

PLD 7(1973)

3150



ρ tends to decay into direction of the photon polarization.

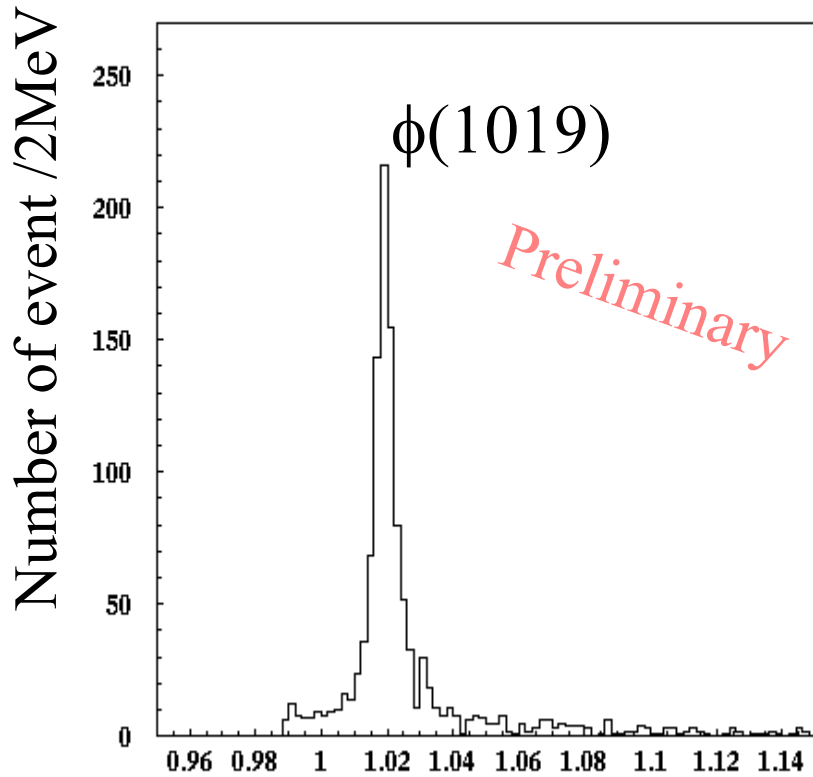
- Natural parity exchange dominate
- s-channel helicity is conserved.

What is the situation in

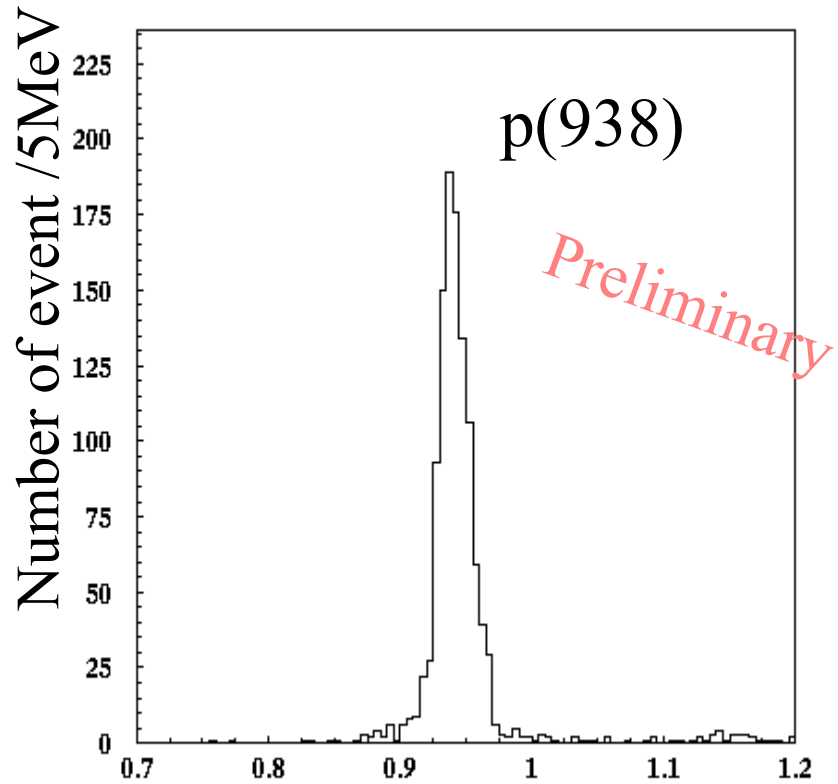
$\gamma p \rightarrow \phi p$ near threshold ?

$\phi \rightarrow K^+K^-$ events

Reconstructed mass distributions from K^+K^- tracks

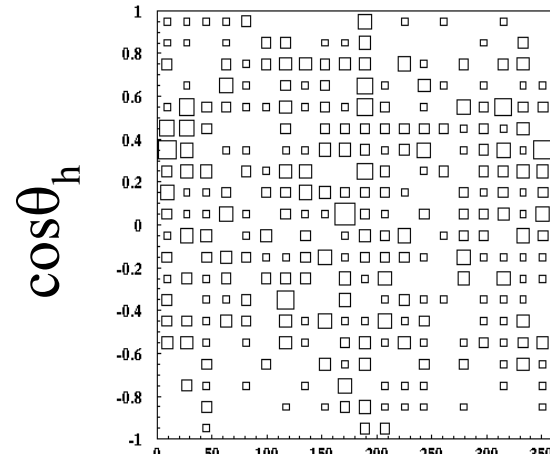
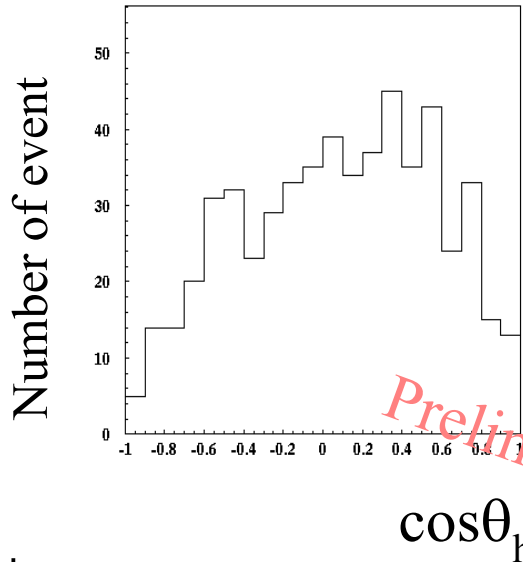


invariant mass (GeV)



missing mass (GeV)

Decay angular distribution of K^+ in Helicity frame



$$\gamma p \rightarrow \phi p$$

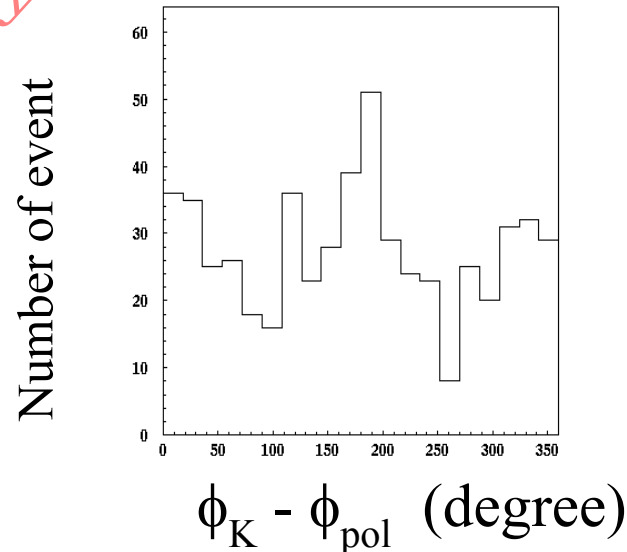
554 events (Vert +Hori)

$1.004 < M_\phi < 1.034$ GeV

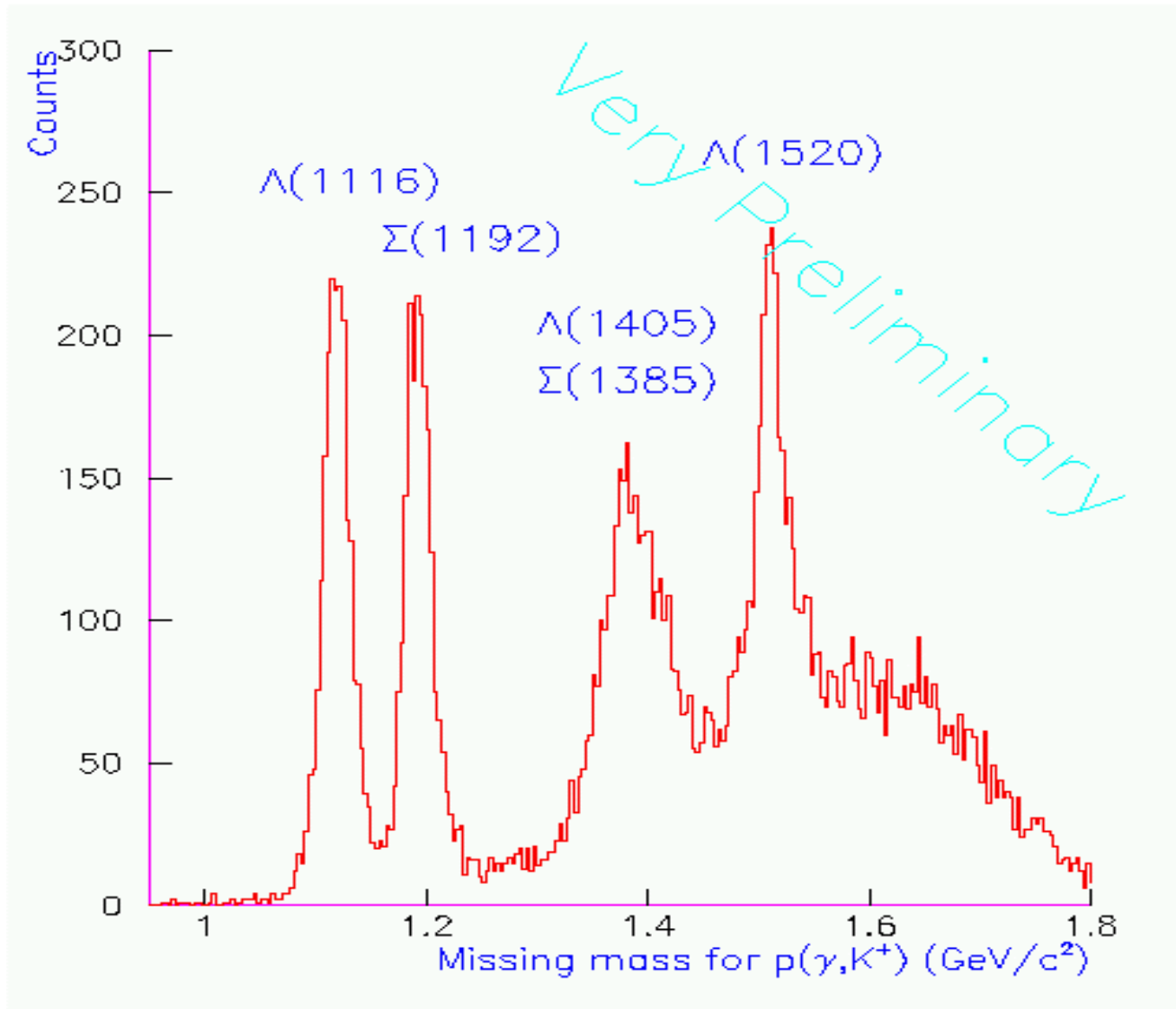
$0.88 < \text{Missing mass} < 1.00$
GeV

$-0.2 < t < t_{\min}$ GeV²

w/o Acceptance Correction



K^+ Photo-production

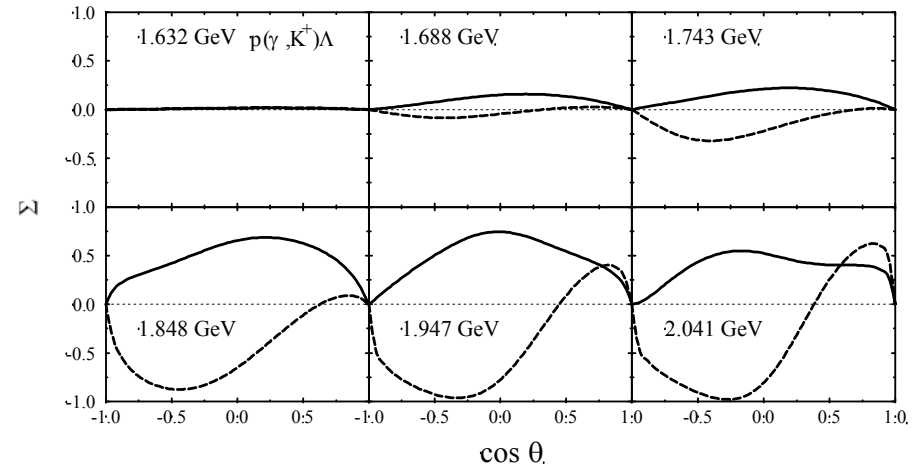
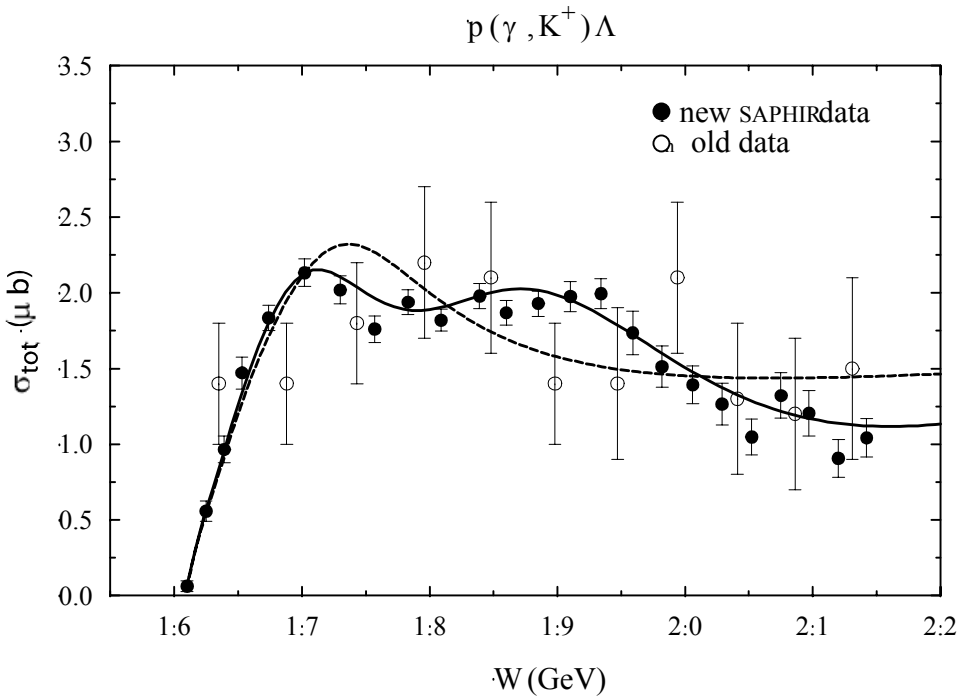


Λ Photo-production with linearly polarized photons.

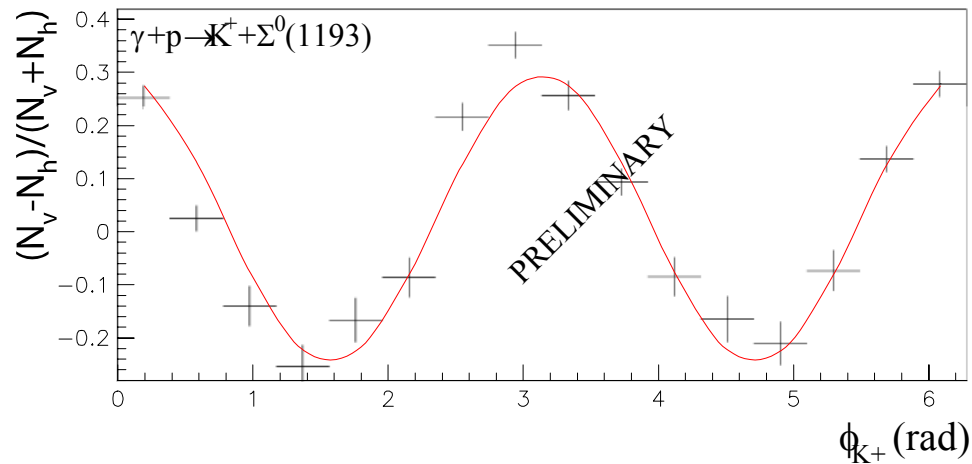
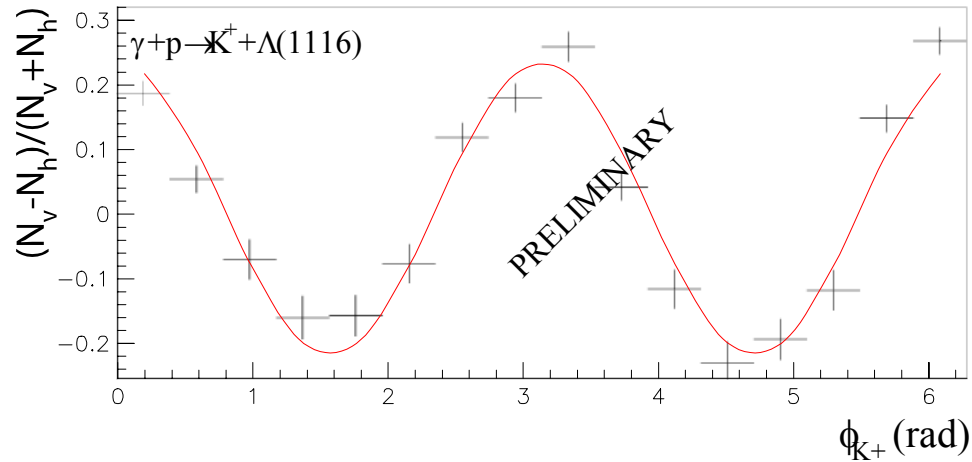
- **SAPHIR and Jlab data indicate a structure in the $p(\gamma^{(*)}, K^+) \Lambda$ cross-section around $W=1.9$ GeV.**
- **Search for missing baryon resonances.**
- **Photon-beam asymmetry is sensitive to the existence of the baryon resonance.**
- **Complementary to the experiment at GRAAL.**

K^+ Photo-production and Missing resonance

T. Mart and C. Bennhold, Phys. Rev. C61, (R)012201 (2000)



Photon-beam asymmetry



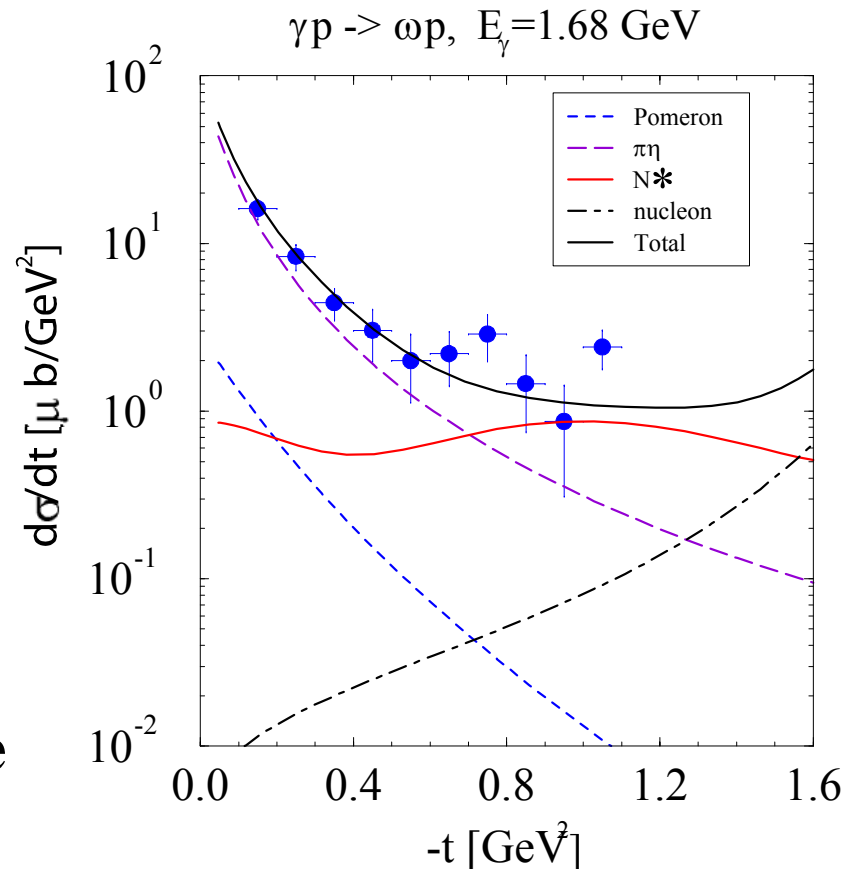
K⁺ Photoproduction at LEPS at SPring-8

R.G.T. Zegers

This afternoon!

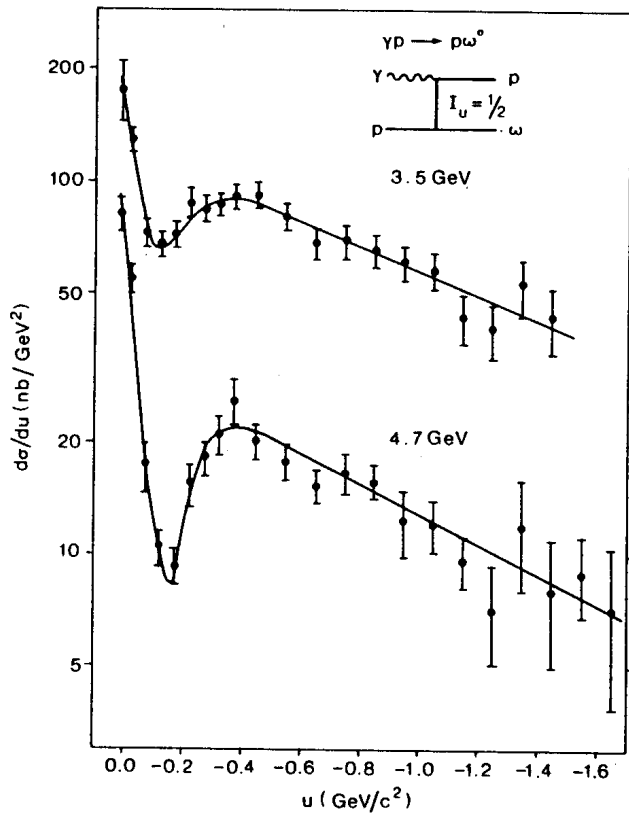
Photo-production of ω meson in u-channel.

- Detect p in the forward angle and identify ω in the missing mass spectrum.
- Very sensitive to the $g_{\omega NN}$ coupling.
- Sensitive to the missing baryon resonances.
- Old data shows a structure around $u=-0.2$ GeV.



Oh, Titov, and Lee, nucl-th/0012012, Data from: SAPHIR('96)

Photo-production of ω



Phys. Lett. 72B (1977) 144

Missing mass for $p(\gamma,p)X$

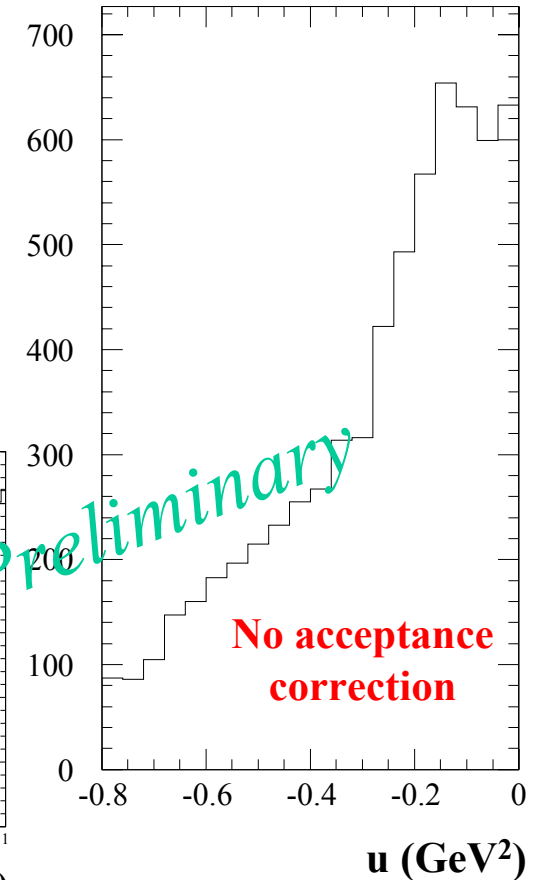
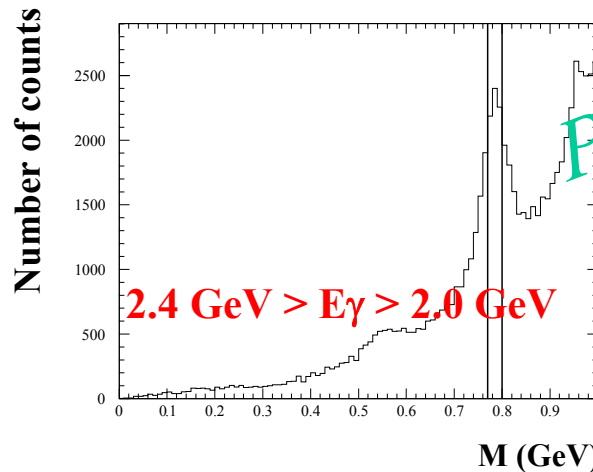
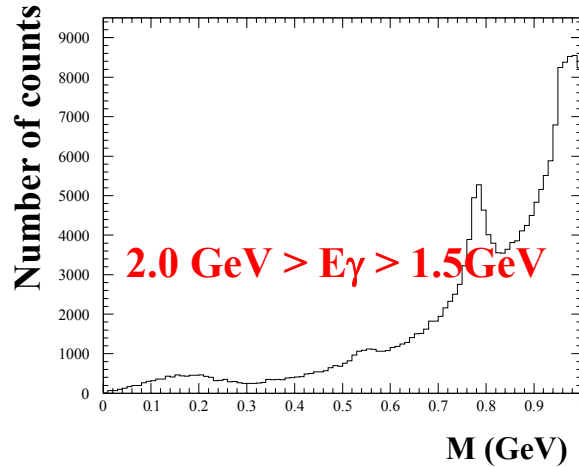


Photo-production of $\Lambda(1405)$

- **qqq state vs. meson-baryon resonance.**
- **Big change of the decay width in nuclear medium for the meson-baryon case.**
 - Chiral unitary model .
- **Need to identify the decay products ($\Sigma\pi$) to study the medium effect.**
- **Time Projection Chamber is newly constructed.**

Nacher, Oset, Toki, Ramos, **PLB455(1999)55**

Chiral Unitary Model

$K^-\pi, K^0n, \pi^0\Lambda, \pi^0\Sigma^0, \eta\Lambda, \eta\Sigma^0, \pi^+\Sigma^-, \pi^-\Sigma^+, K^+\Xi^-, K^0\Xi^0$

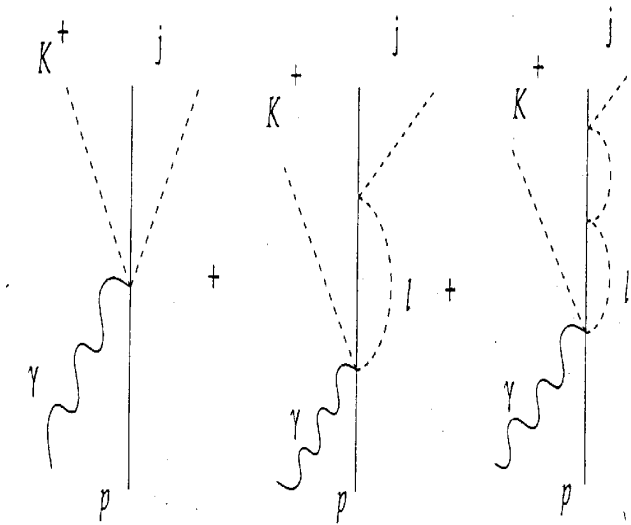
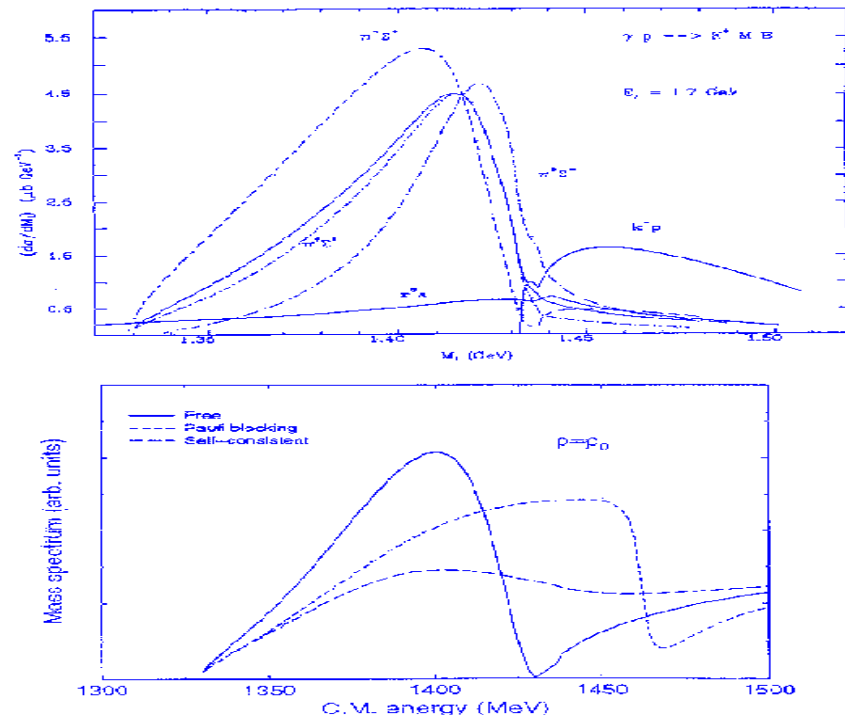
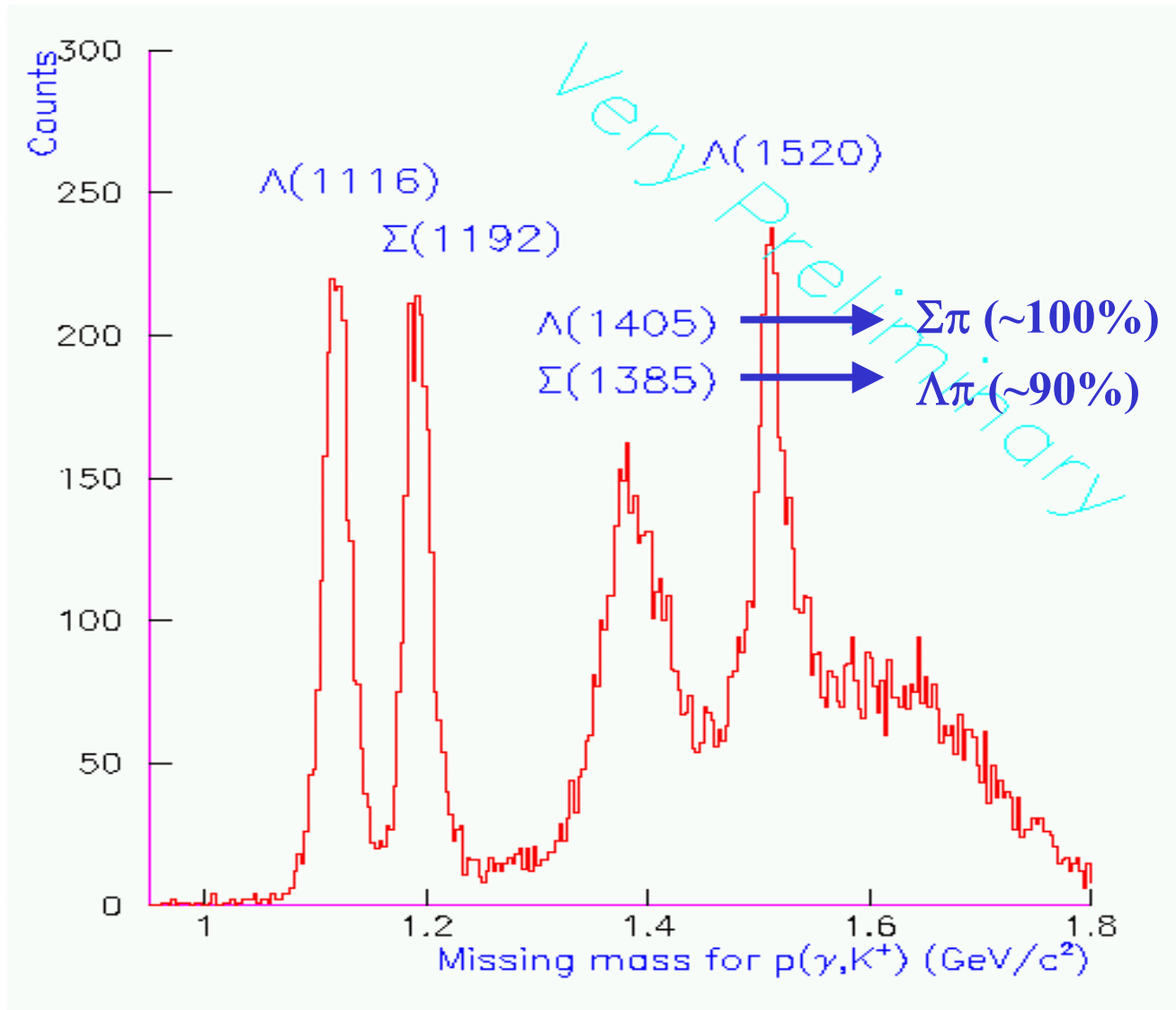


Fig. 2. Diagrammatic representation of the meson-baryon state interaction in the $\gamma p \rightarrow K^+ \Lambda(1405)$ process.



K^+ Photo-production



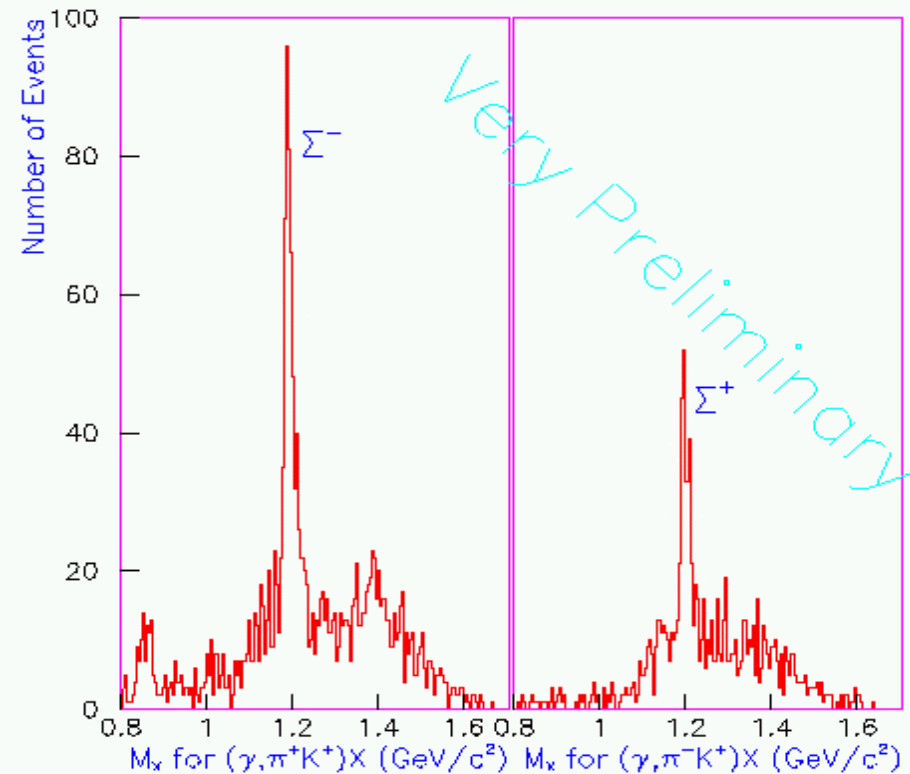
Preliminary Analysis for

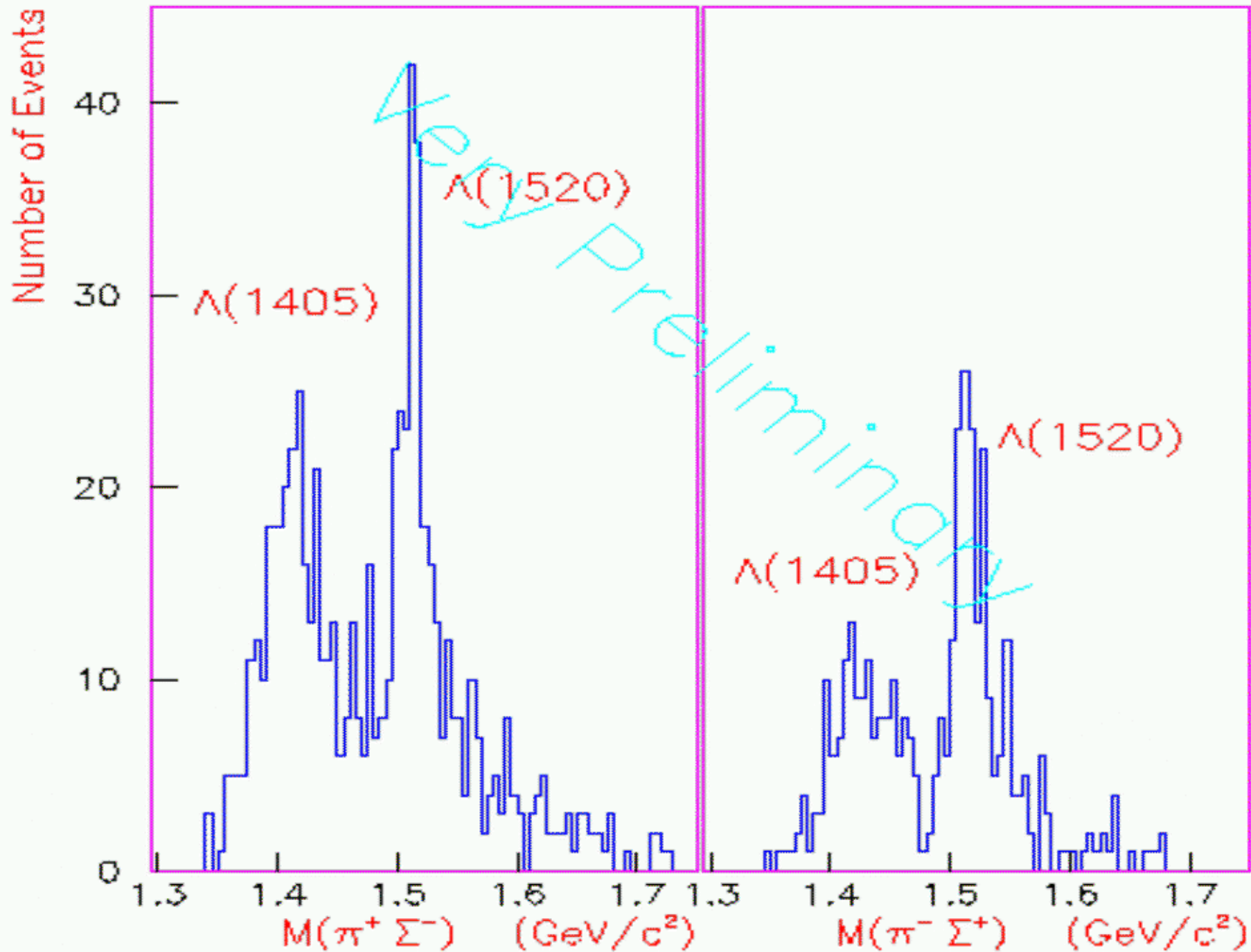


Missing-mass technique
to reconstruct Σ

from $p(\gamma, K^+ \pi) X$

Possible to reconstruct
 $\Lambda(1405)$ from invariant
mass of π and Σ





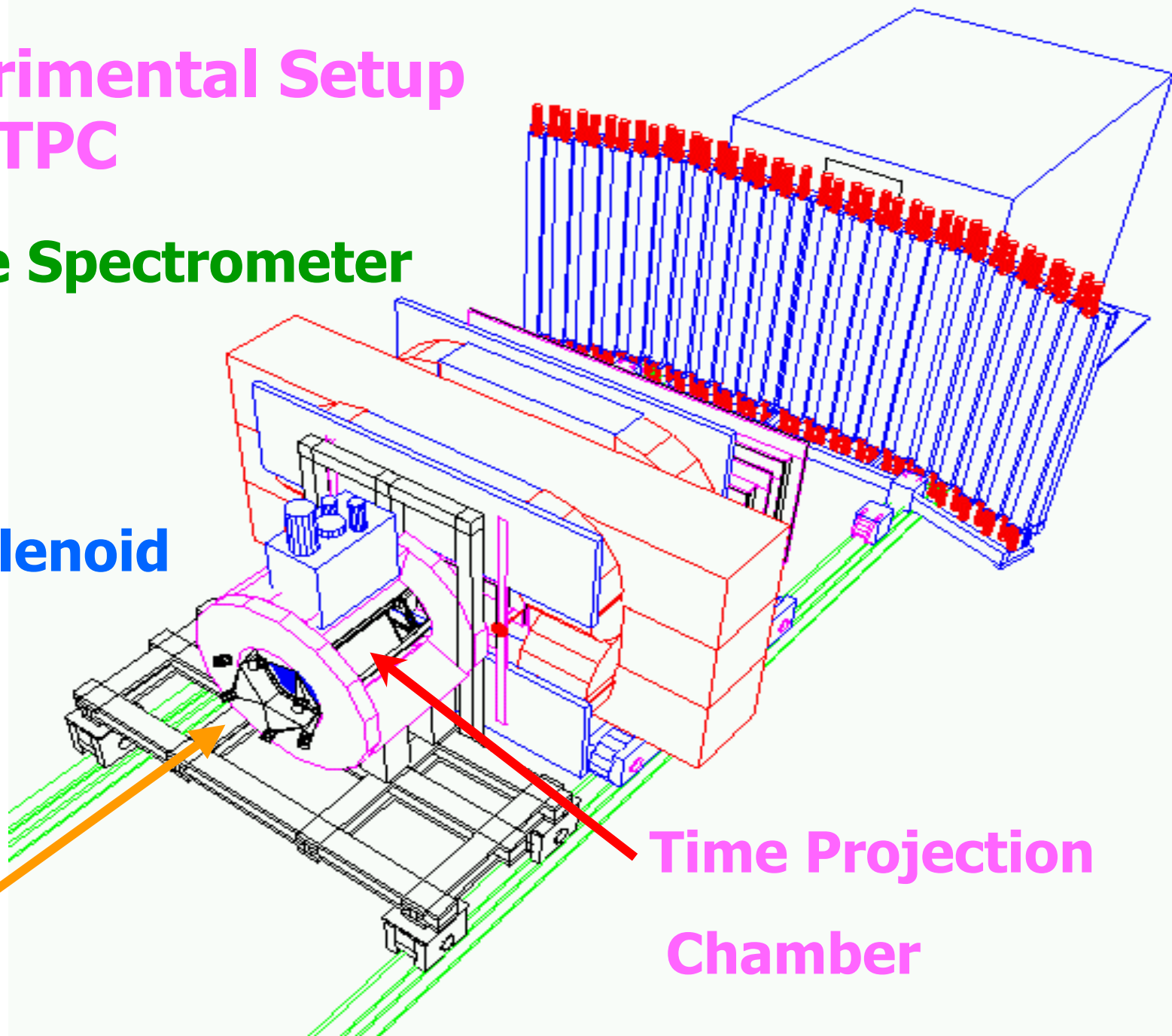
Experimental Setup with TPC

Dipole Spectrometer

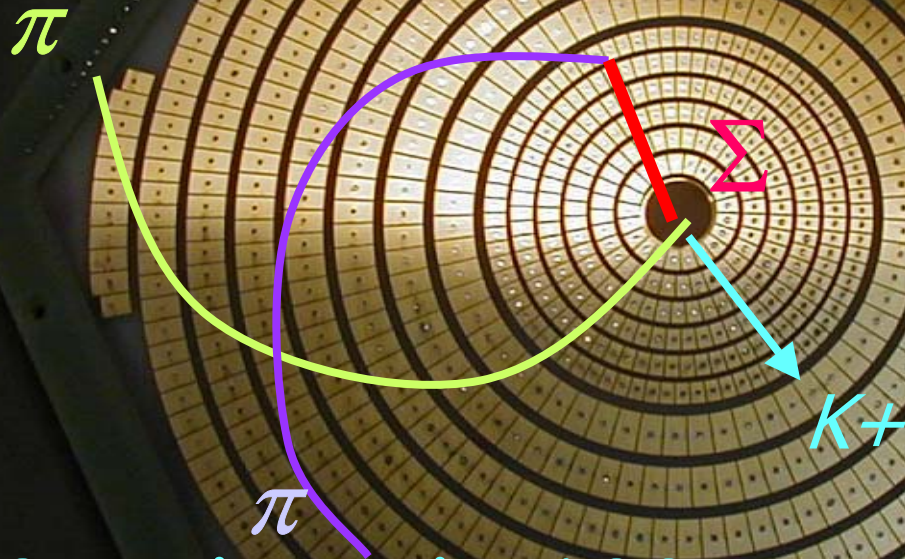
Solenoid

γ

Time Projection
Chamber



TPC Readout Chamber



- ~1000 pads and ~100 wires for readout
- $\sigma_{xy} \sim 350\mu\text{m}$ and $\sigma_z \sim 500\mu\text{m}$
- $B = 1.5 \sim 2.5\text{T}$
- $\Delta M/M \sim 0.5\%$ for $\Lambda(1405)$ mass



Summary

- **New photon beam facility in Japan.**
 - **2.4 GeV linearly polarized photons.**
 - **Forward-angle spectrometer .**
 - **Complementary to Jlab and GRAAL.**
- **Physics programs.**
 - **Photo-production of ϕ meson near threshold.**
 - **Decay asymmetry measurement to separate various contributions.**
 - **K^+ Photo-production.**
 - **Photon beam asymmetry sensitive to N^* contribution.**
 - **Photo-production of ω meson in u-channel.**
 - **sensitive to N^* and $g_{\omega NN}$.**
 - **Photo-production of $\Lambda(1405)$ in nuclei.**
 - **Pin down the nature of $\Lambda(1405)$.**
 - **TPC to study the medium effect.**