Pion Photoproduction in the Region of the Delta Resonance

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The LEGS-SPIN Collaboration

Goal: Examination of γ D observables in order to develop a means of extracting free neutron observables

Outline:

- Experimental Overview
- Cross Sections
- Beam Asymmetries
- Comparison to Theory
- Conclusions

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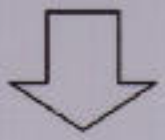
Overview of Experiment:

Linearly Polarized Photons
Laser-Electron Gamma Source (LEGS)
(NSLS, BNL)

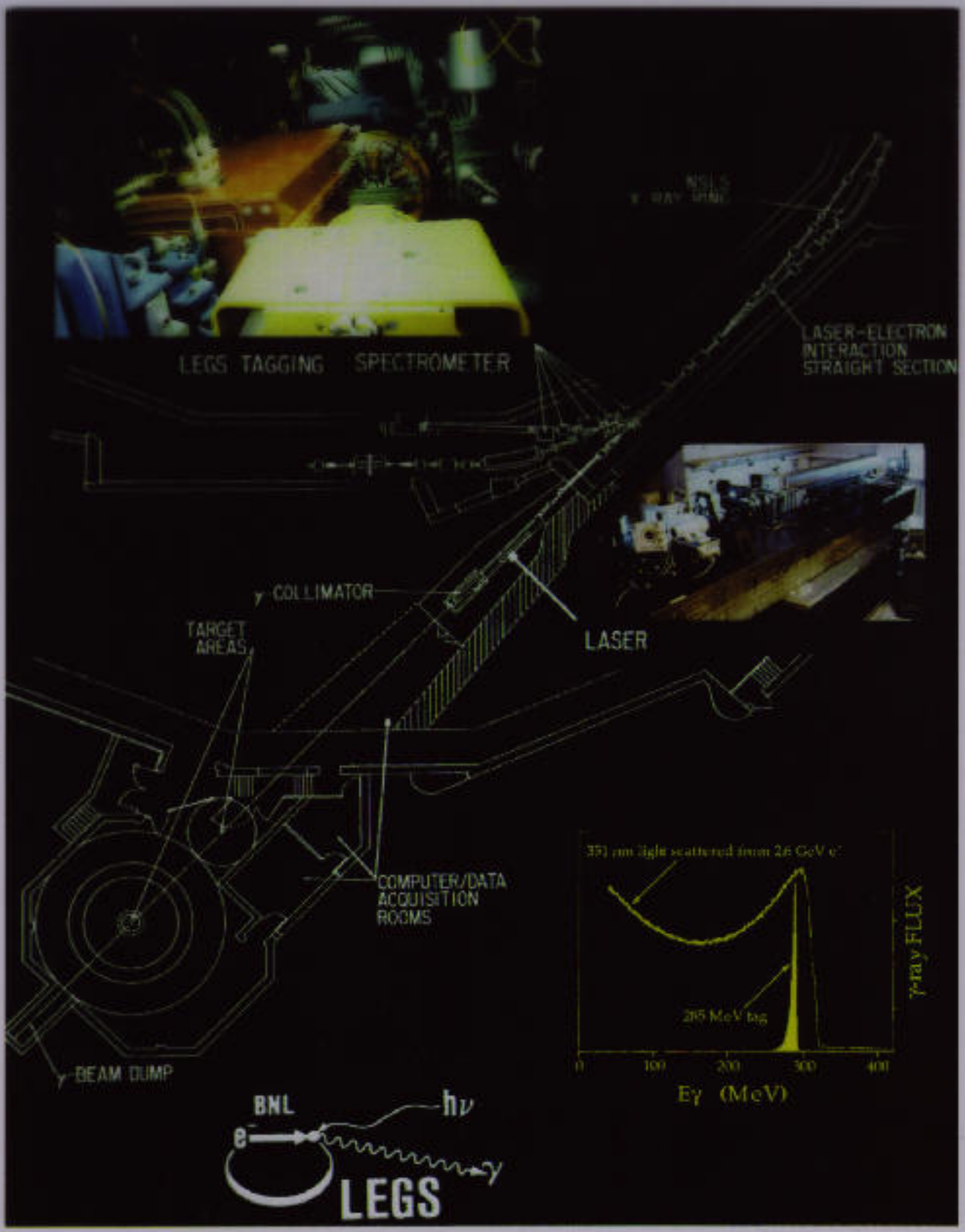
Liquid H2, Liquid D2, Solid HD targets

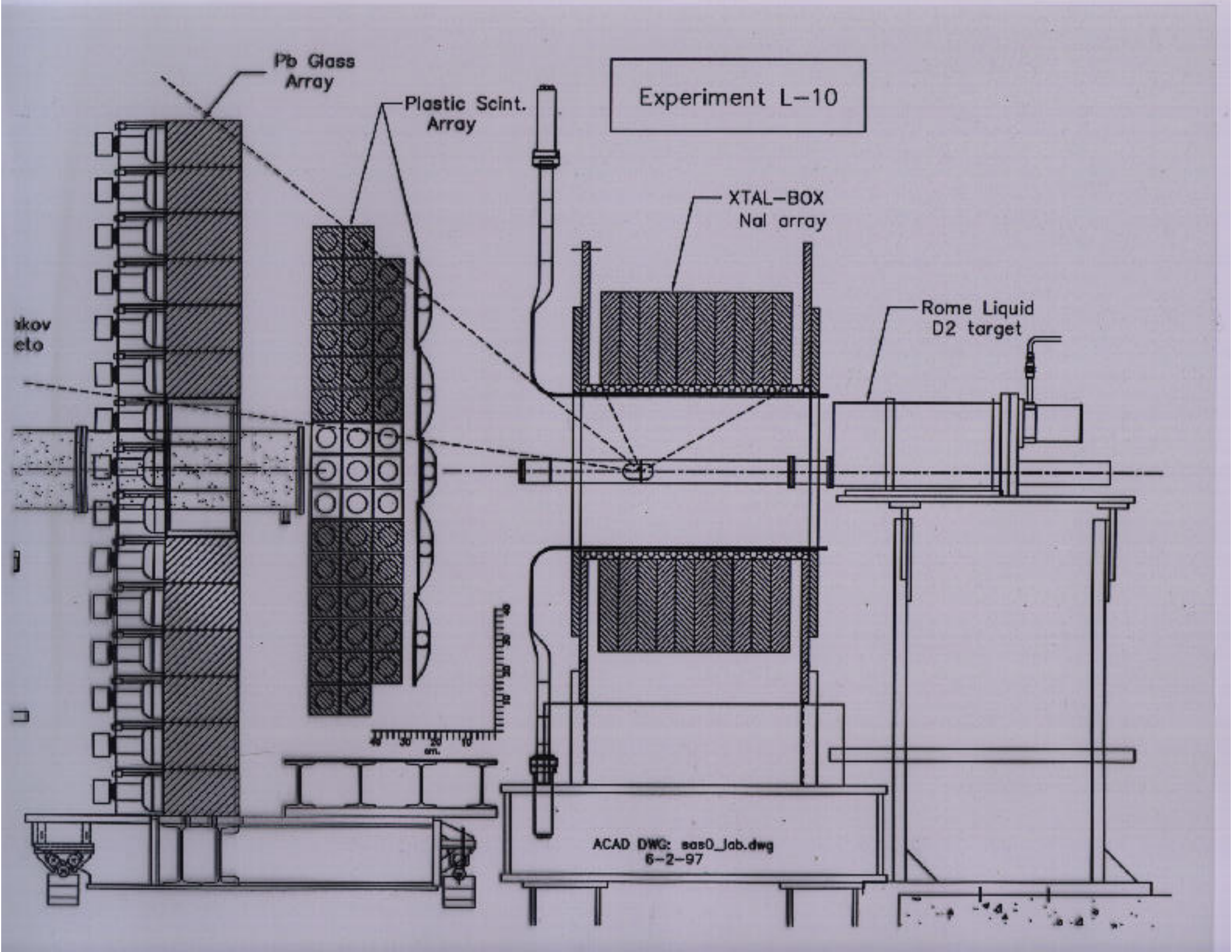


Spin ASYmmetry (SASY)
Large Solid-Angle Detector Array

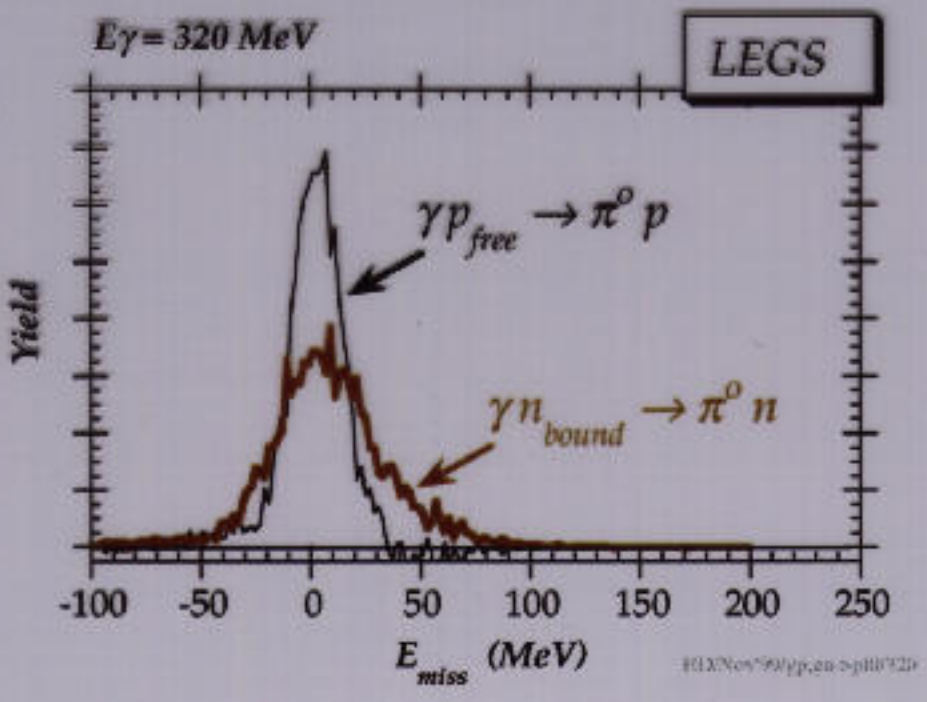
Cross Sections, Beam asymmetries for pion photoproduction in the region of the Delta resonance
*** Preliminary Data ***

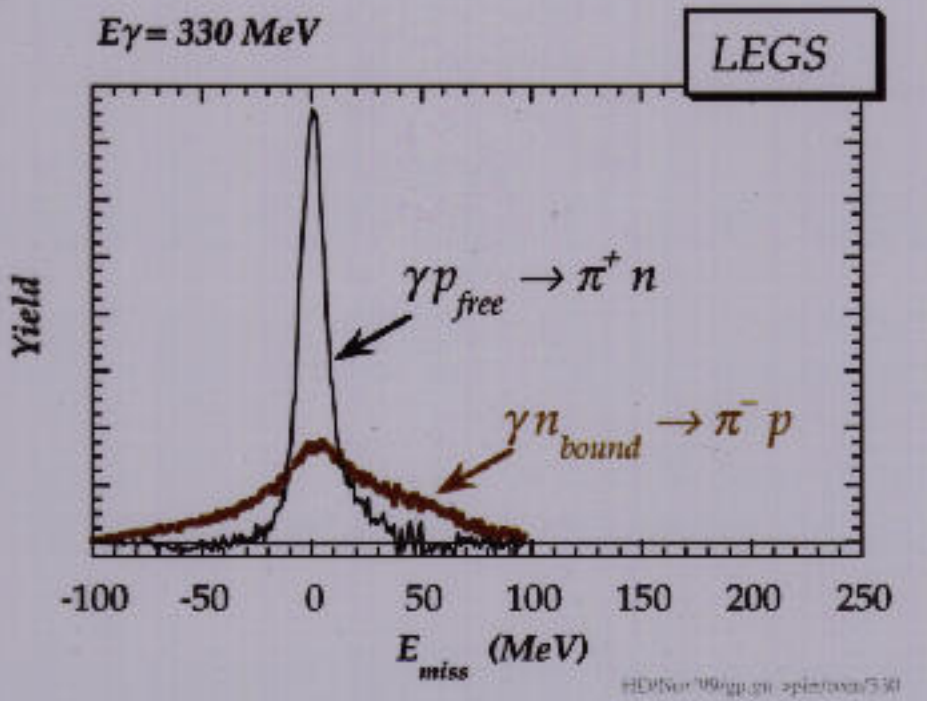
Will focus on $d(\vec{\gamma}, \pi^0)X$


LEGS TAGGING SPECTROMETER
LASER-ELECTRON INTERACTION STRAIGHT SECTION
γ COLLIMATOR
TARGET AREAS
LASER
COMPUTER/DATA ACQUISITION ROOMS
γ BEAM DUMP
351 nm light scattered from 26 GeV e⁻
285 MeV tag
γ-ray FLUX
0
100
200
300
400
Eγ (MeV)
BNL
hν
e⁻
LEGS


Pb Glass
Array
Plastic Scint.
Array
Experiment L–10
XTAL–BOX
NaI array
Rome Liquid
D2 target
ACAD DWG: sas0_lab.dwg
6–2–97

Reconstruction of exclusive π^0 / $\pi^\pm$ channels



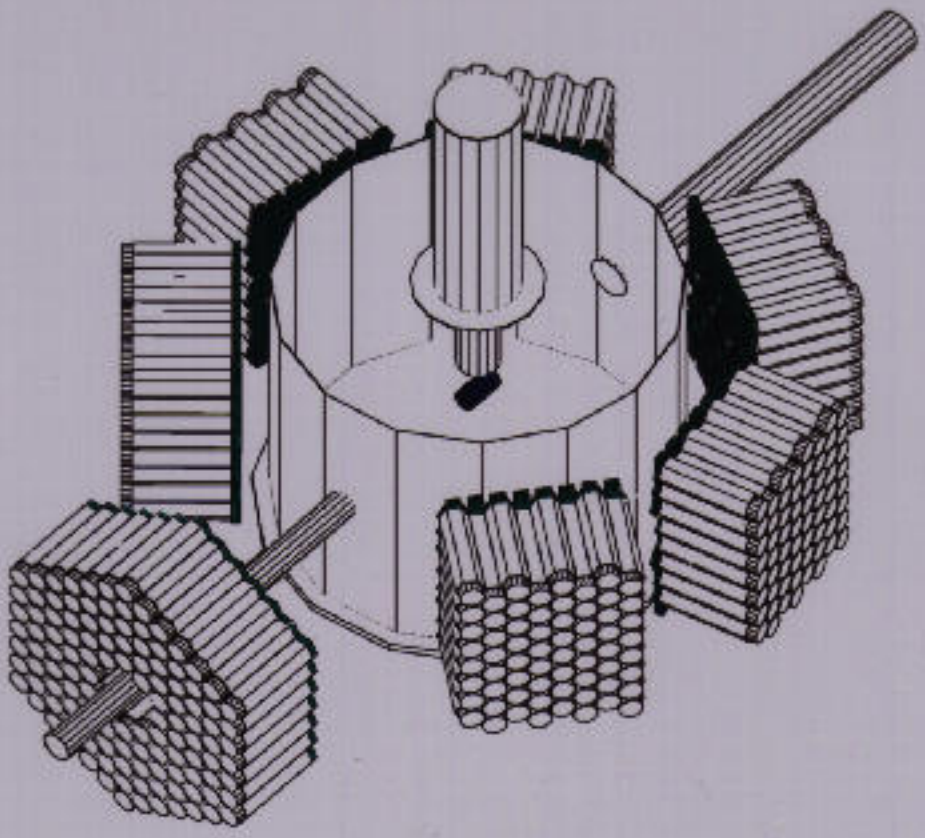


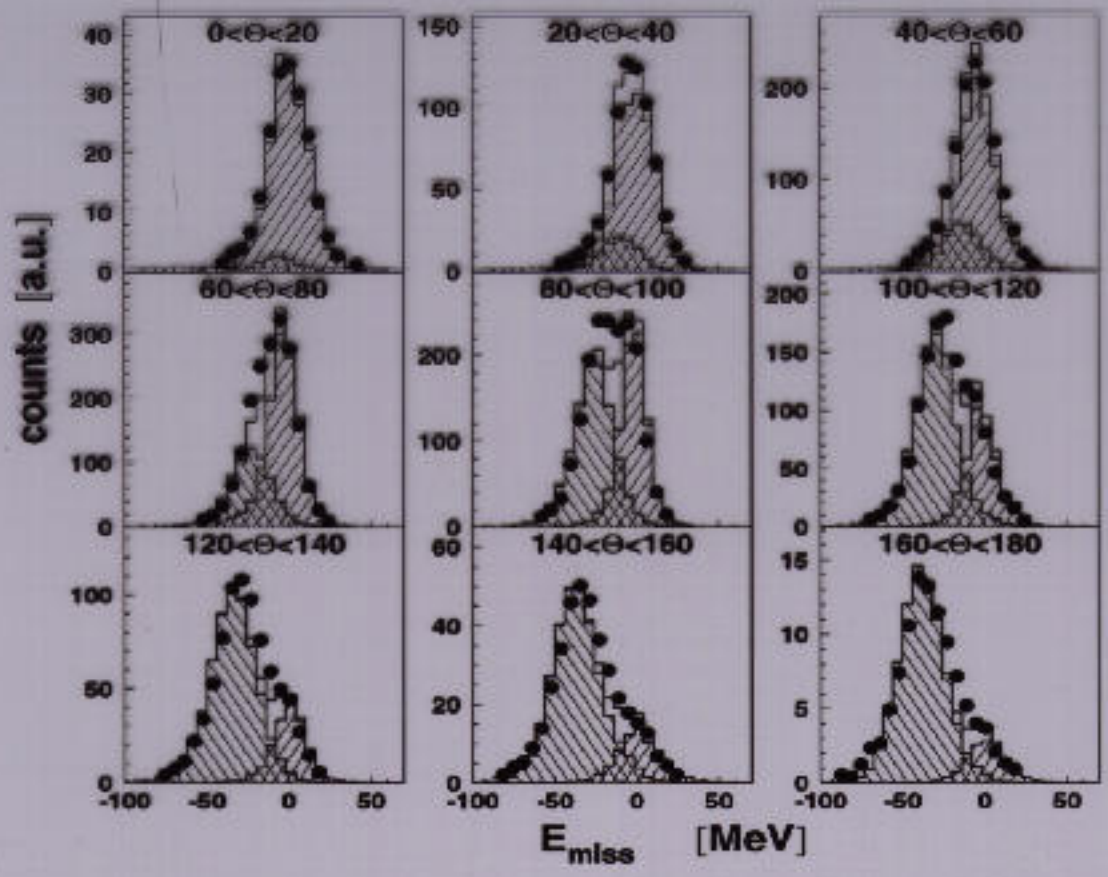
Mainz Inclusive $d(\gamma, \pi^0)X$

Coherent and Incoherent pi0 Photoproduction from the Deuteron
Eur. Phys. J. A10(2001), 365-371

U. Siodlaczek, doctoral thesis, University of Tuebingen, 2000
http://www.w210.ub.uni-tuebingen.de/dbt/volltexte/2001/213

140 MeV < E_γ < 306 MeV





Fit of missing mass using π^0

Inclusive $d(\gamma, \pi^0)X$

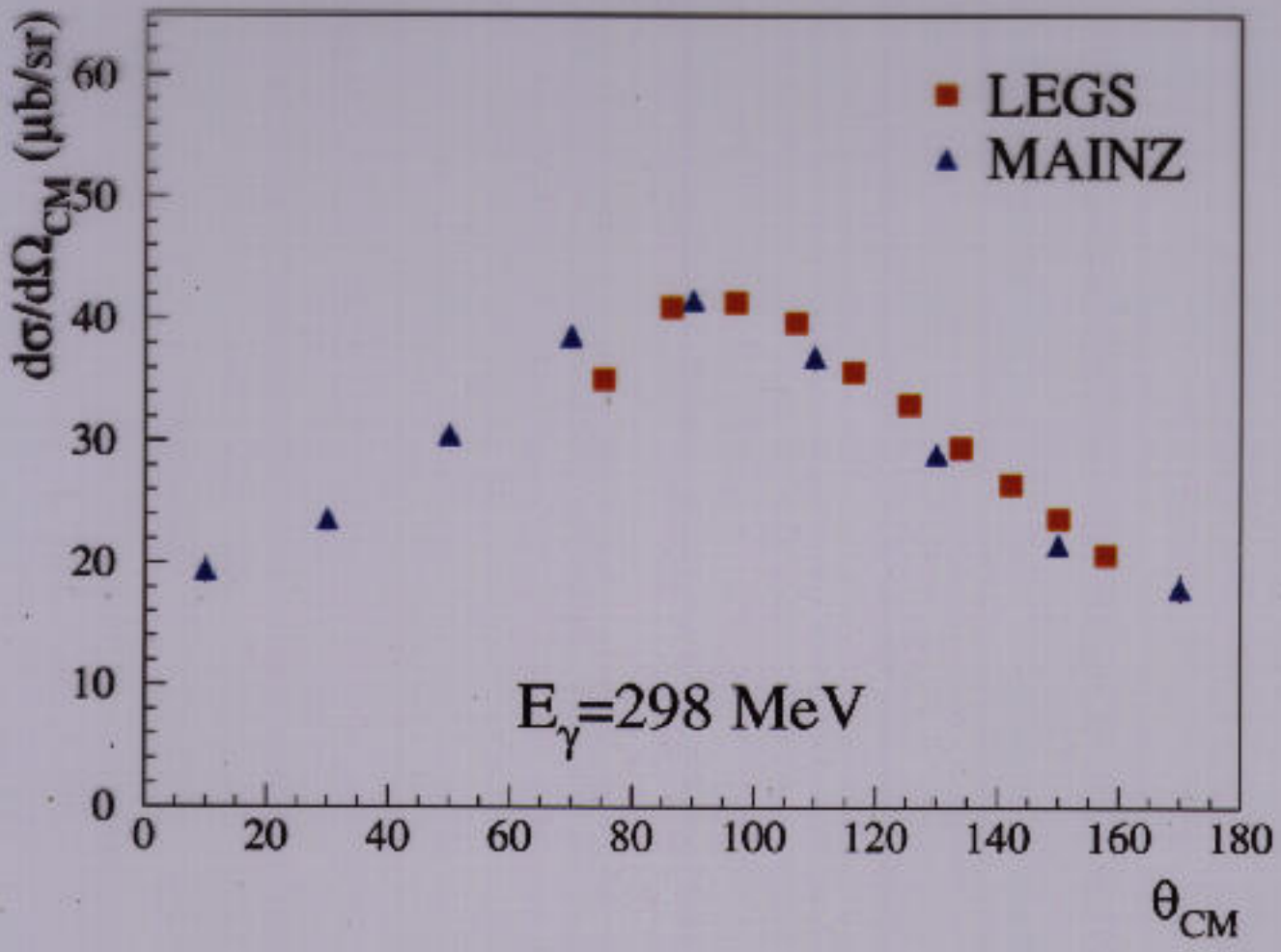
Coherent

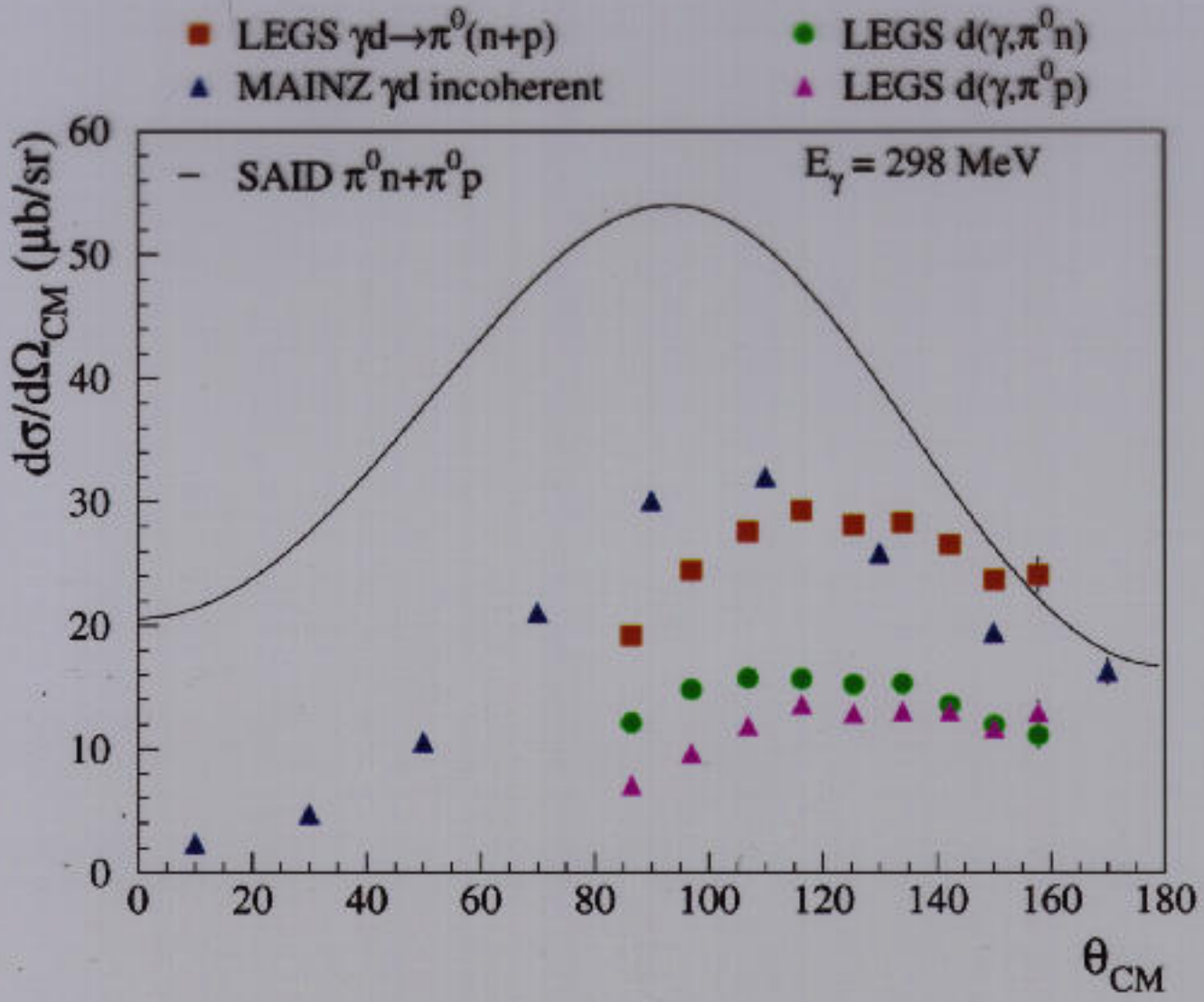
$d(\gamma, \pi^0)d$

Incoherent

$d(\gamma, \pi^0)pn$

Inclusive Reaction - $d(\vec{\gamma},\pi^0)X$




LEGS γd→π⁰(n+p)
MAINZ γd incoherent
LEGS d(γ,π⁰n)
LEGS d(γ,π⁰p)
SAID π⁰n+π⁰p
E_γ = 298 MeV
dσ/dΩ_CM (μb/sr)
θ_CM
0
10
20
30
40
50
60
0
20
40
60
80
100
120
140
160
180

Differential Cross sections (C.S.):

LEGS Preliminary and Mainz 2001

Inclusive C.S. very consistent

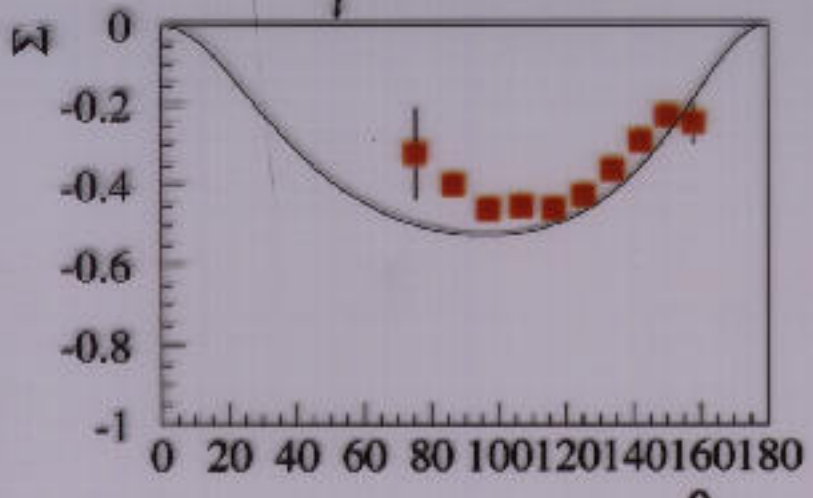
Sum of LEGS exclusive channels confirms incoherent results from Mainz

Both support large deviations from free behavior in incoherent C.S.

$\Sigma\ \vec{\gamma}d$ - Beam Asymmetries

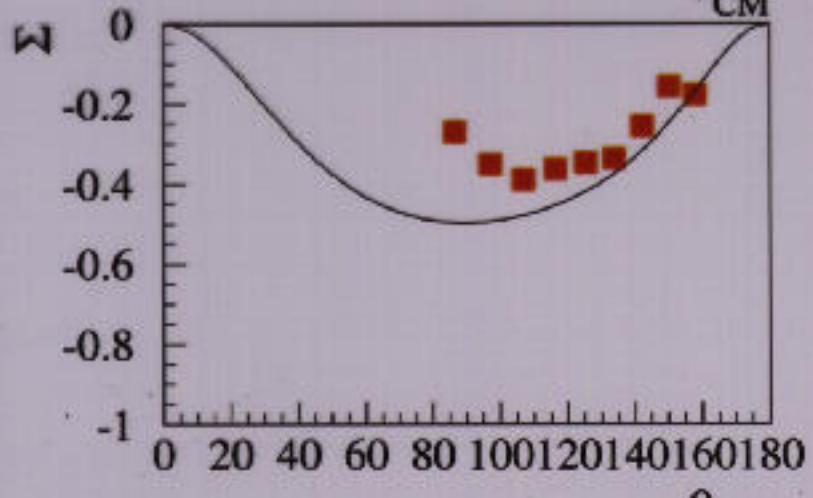
E_γ=298 MeV

$$\Sigma \equiv \frac{\sigma_{par} - \sigma_{per}}{\sigma_{par} + \sigma_{per}}$$



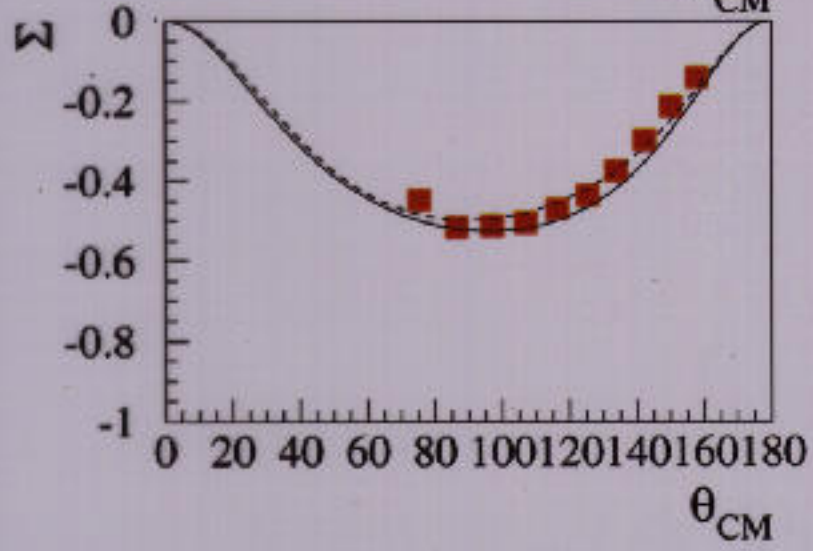
$\Sigma\ d(\vec{\gamma},\pi^0 n)$

- LEGS
- SAID(SM01K) $\pi^0 n$



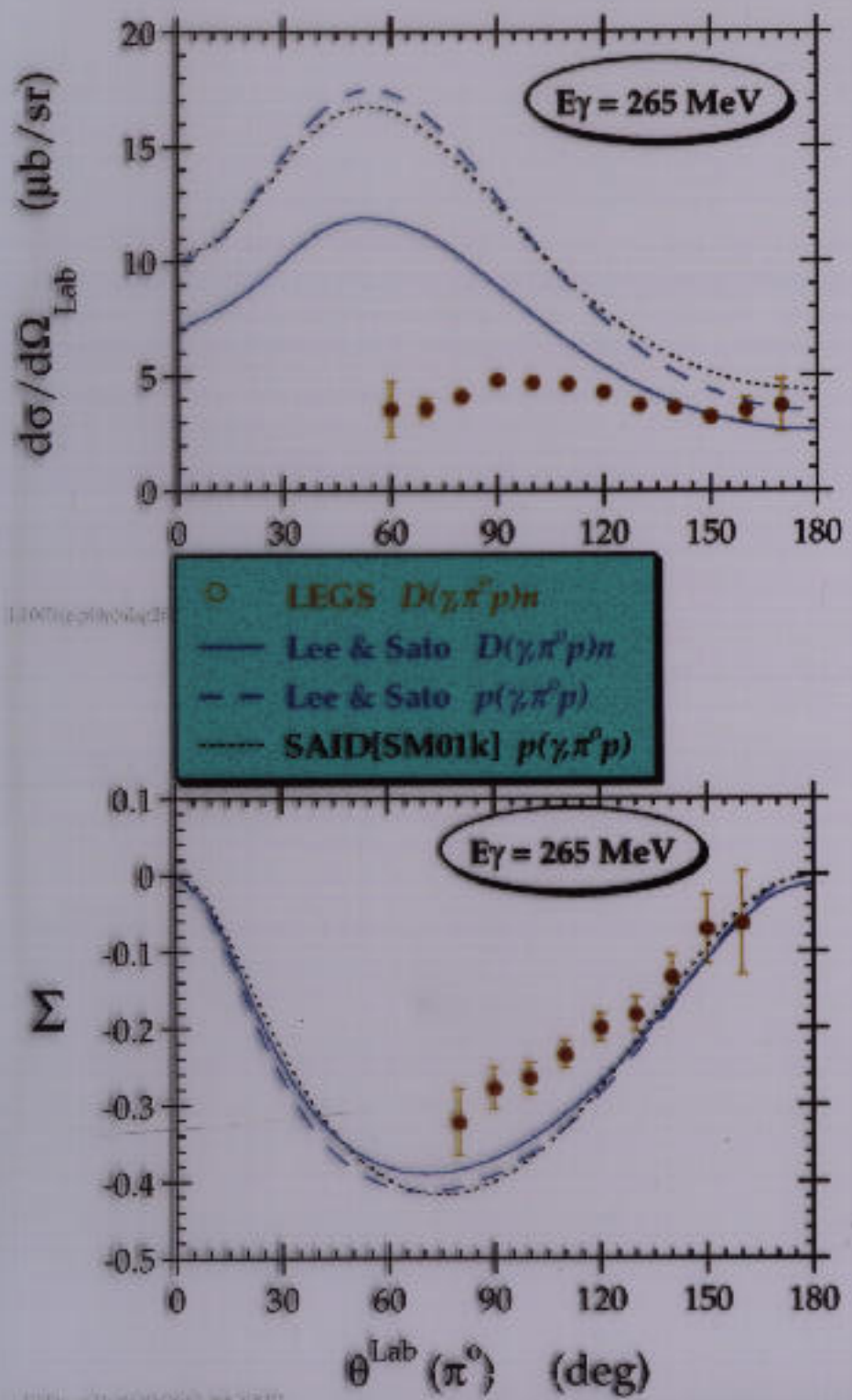
$\Sigma\ d(\vec{\gamma},\pi^0 p)$

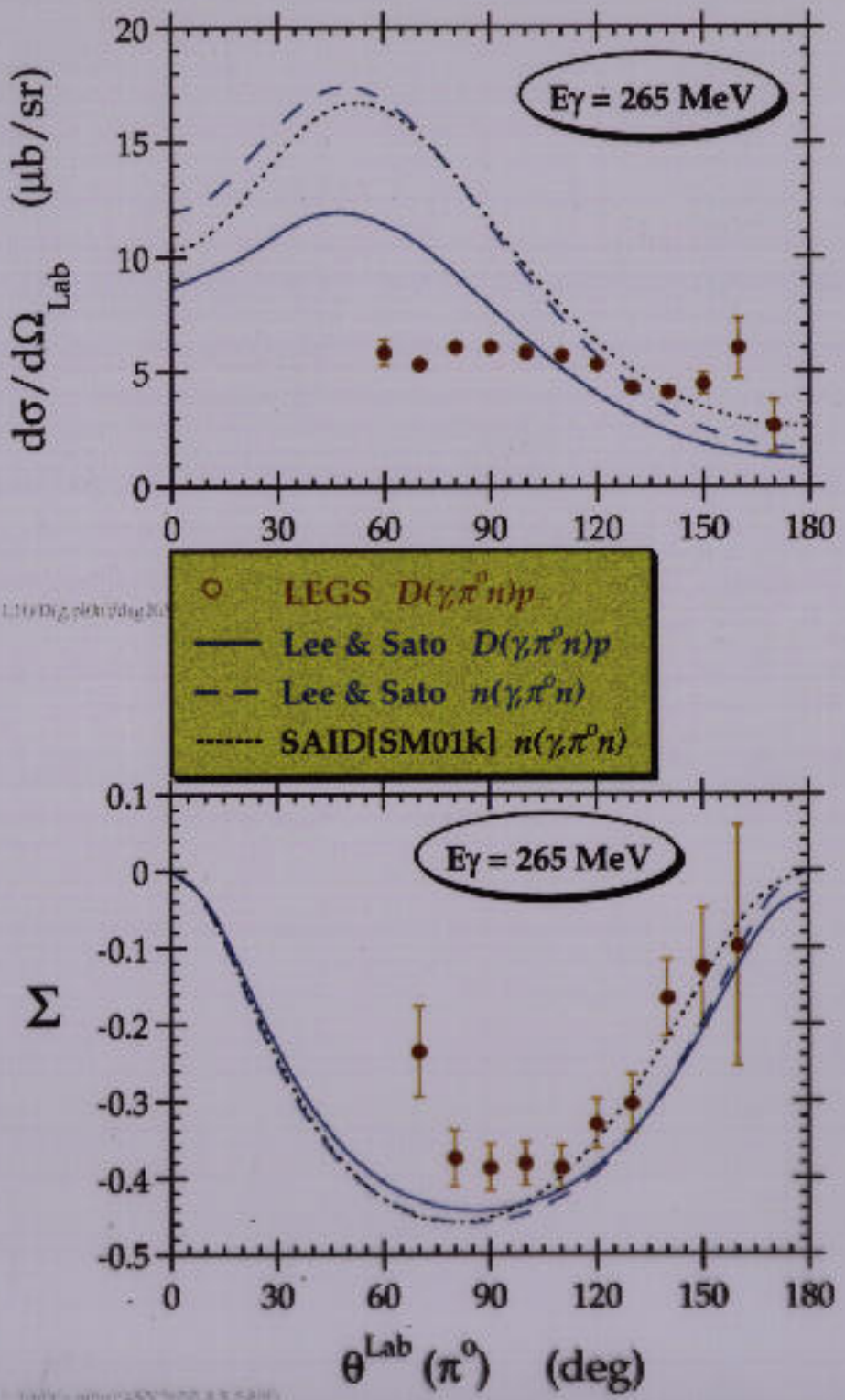
- LEGS
- SAID(BNL) $\pi^0 p$

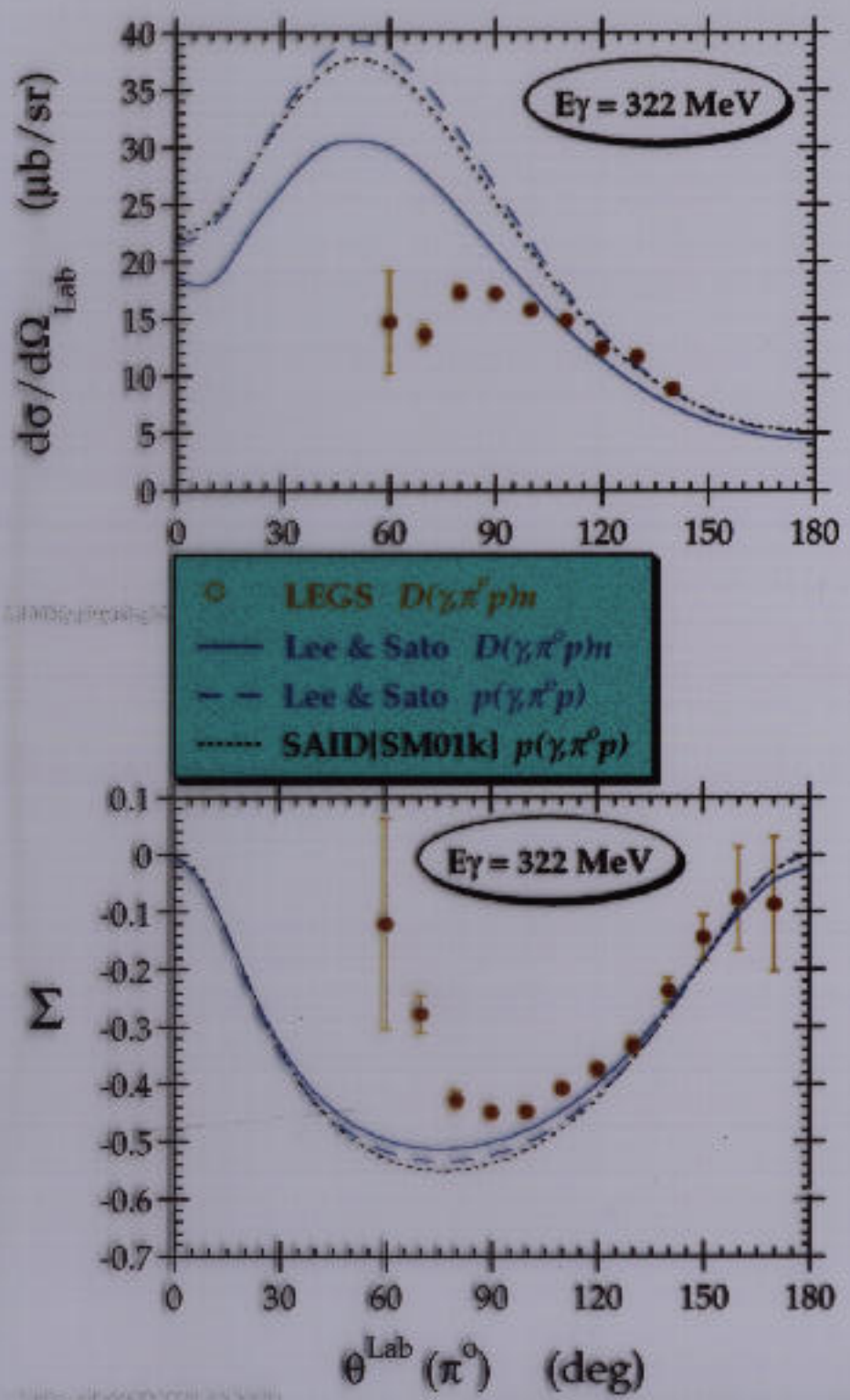


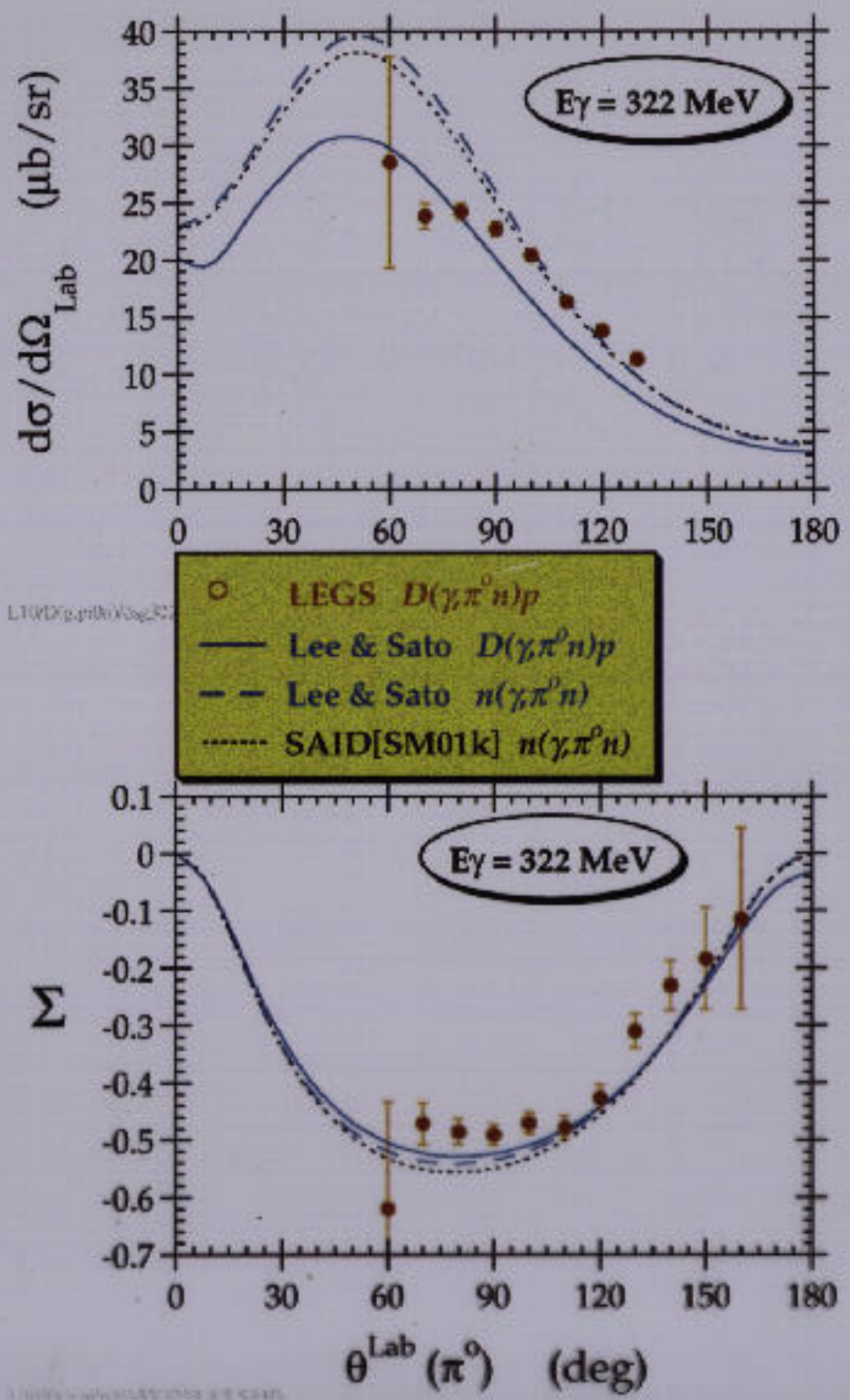
$\Sigma\ d(\vec{\gamma},\pi^0)X$

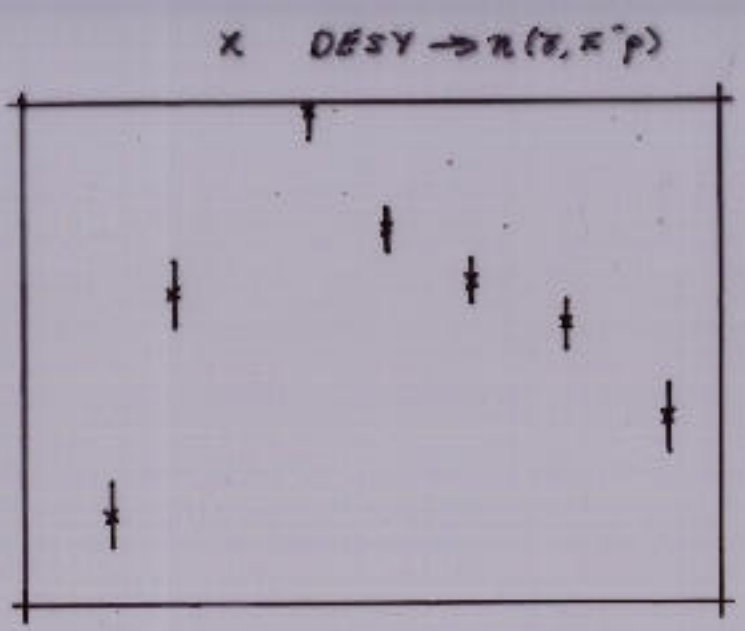
- LEGS
- SAID(SM01K) $\pi^0 n$
- SAID(BNL) $\pi^0 p$

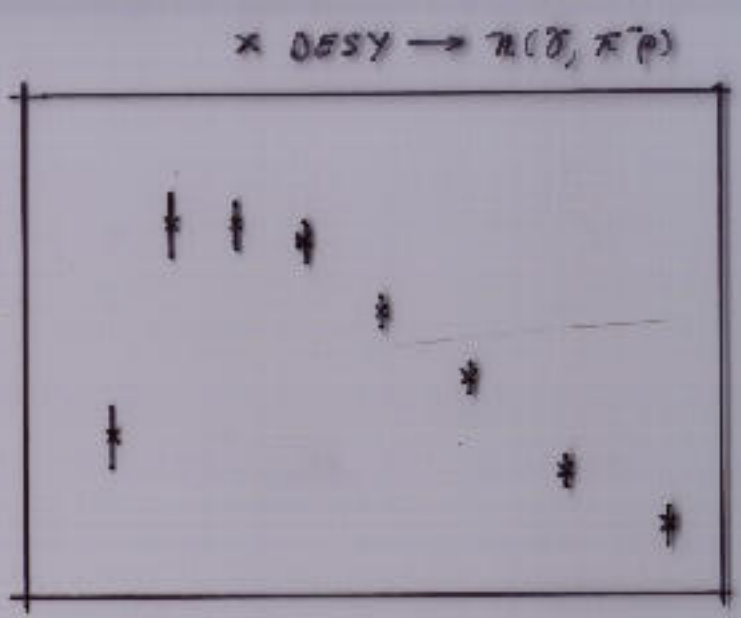

Eγ = 265 MeV
dσ/dΩ Lab (μb/sr)
LEGS D(γ,π°p)n
Lee & Sato D(γ,π°p)n
Lee & Sato p(γ,π°p)
SAID[SM01k] p(γ,π°p)
Σ
θ Lab (π°) (deg)

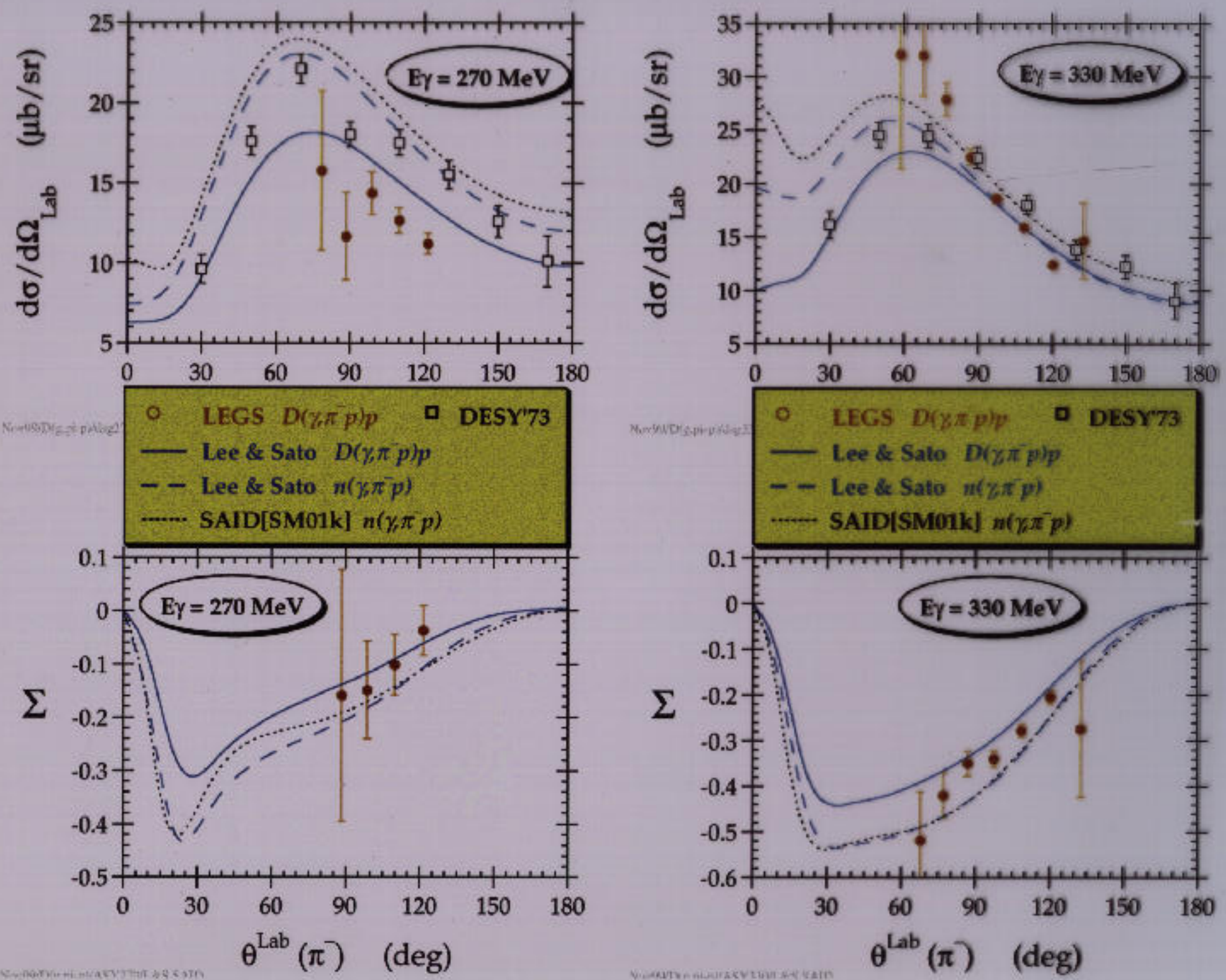

Eγ = 265 MeV
dσ/dΩ Lab (μb/sr)
LEGS D(γ,π°n)p
Lee & Sato D(γ,π°n)p
Lee & Sato n(γ,π°n)
SAID[SM01k] n(γ,π°n)
Σ
θ Lab (π°) (deg)


Eγ = 322 MeV
dσ/dΩ Lab (μb/sr)
LEGS D(γ,π°p)n
Lee & Sato D(γ,π°p)n
Lee & Sato p(γ,π°p)
SAID[SM01k] p(γ,π°p)
Σ
θ Lab (π°) (deg)


Eγ = 322 MeV
dσ/dΩ Lab (μb/sr)
LEGS D(γ,π°n)p
Lee & Sato D(γ,π°n)p
Lee & Sato n(γ,π°n)
SAID[SM01k] n(γ,π°n)
Σ
θ Lab (π°) (deg)


DESY → π(π, π⁻p)


DESY → π(π, π⁻p)


dσ/dΩ Lab (μb/sr)
Eγ = 270 MeV
Eγ = 330 MeV
LEGS D(γ,π⁻p)p
DESY'73
Lee & Sato D(γ,π⁻p)p
Lee & Sato n(γ,π⁻p)
SAID[SM01k] n(γ,π⁻p)
Σ
θ Lab (π⁻) (deg)

Conclusions:

$d(\gamma,\pi^0)X$ LEGS and $d(\gamma,\pi^0)X$ Mainz consistent

Sum of LEGS exclusive (Preliminary) and Mainz incoherent consistent

Exclusive π^0 channels:

$d(\vec{\gamma},\pi^0 p)$ and $d(\vec{\gamma},\pi^0 n)$ are dramatically different than free $p(\vec{\gamma},\pi^0 p)$ and $n(\vec{\gamma},\pi^0 n)$ and still different from full 3-body calculations

Smaller but significant deviations in Asymmetries between $p\ \pi^0$ data and both the full 3-body calculation and the free asymmetry

Exclusive $p\pi^-$ channels:

Difference from free calculations

Better agreement w/full 3-body

POTENTIAL SIGNIFICANT IMPACT ON NEUTRON MULTIPOLES

Extraction of free-neutron observables will require strong theoretical support

Wonderful opportunity for intense collaboration between theory and experiment!