η and η' photoproduction off deuterium

Introduction, Motivation and Previous Results

Experimental setup

η photoproduction:

- Angular distributions
- Photon beam asymmetry

**η' photoproduction: Total cross section**

Conclusion and Outlook
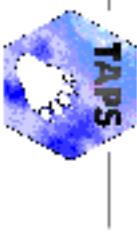
# Resonances in η and η' photoproduction

- broad and overlapping resonances
- characteristic meson decay
- tagging resonances

Photoabsorption on nucleon

N.Bianchi et al. PRC 54 (1996) 1688
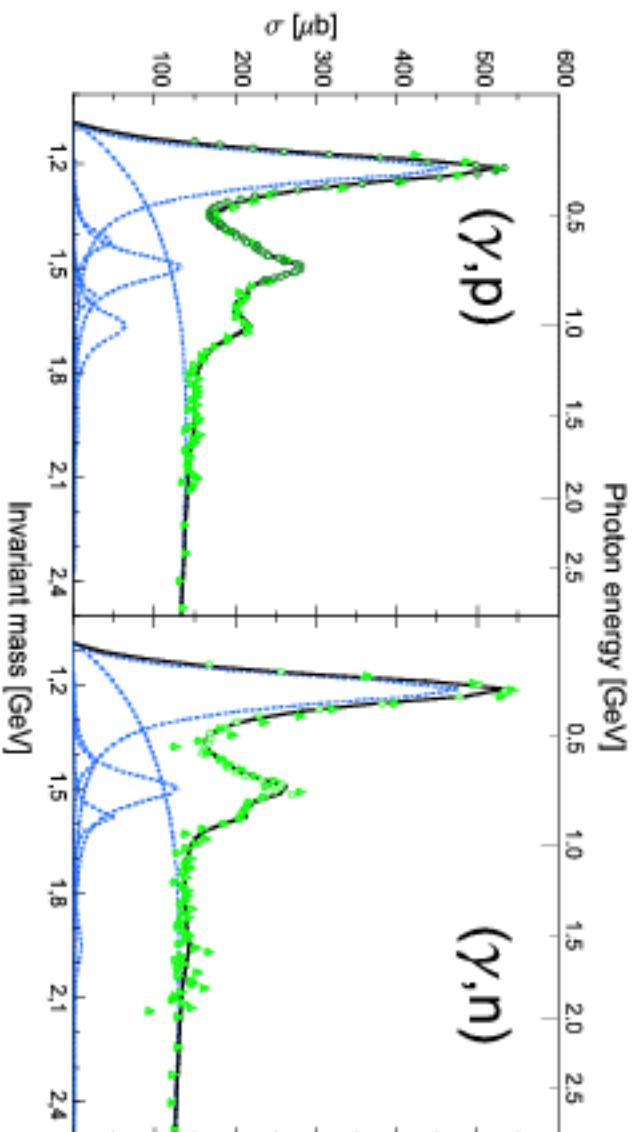

Excited states of the nucleon

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Resonances coupling to η and η' photoproduction off the proton

Branching ratios and elm. couplings:

state	b_η [%]	$A^p_{1/2}$	$A^p_{3/2}$	$A^n_{1/2}$	$A^n_{3/2}$
$D_{13}(1520)$:	0.23±0.04	-24	166	59	139
$S_{11}(1535)$:	30 - 55	90		-46	
$S_{11}(1650)$:	3 - 10	53		-15	
$D_{15}(1675)$:	<1	19	15	-43	-58
$F_{15}(1680)$:	<1	-15	133	29	-33
$D_{13}(1700)$:	<1				
$P_{11}(1710)$:	6.2±1.0				
$P_{13}(1720)$:	4±1				
$P_{13}(1900)$:	*				
$D_{13}(2080)$:	**				
$S_{11}(2090)$:	*				
$P_{11}(2100)$:	*				
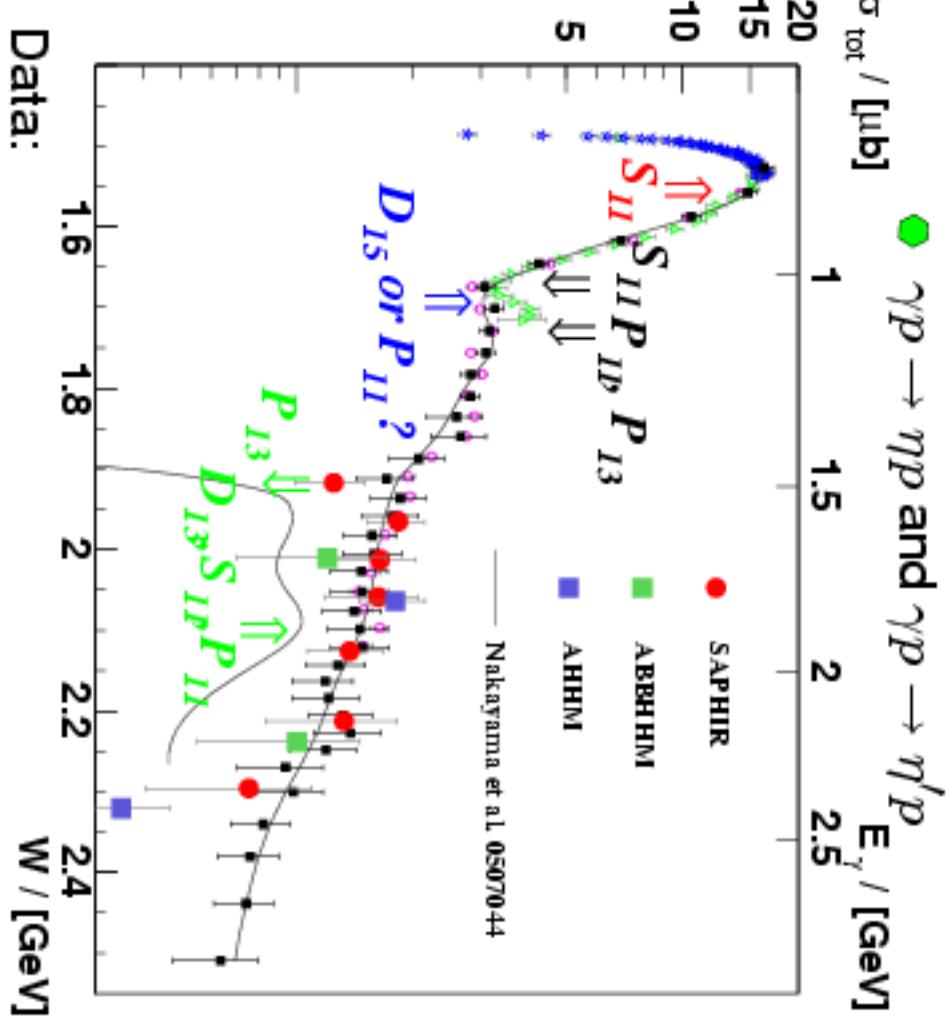
among known resonances $D_{15}(1675)$ is the only with stronger electromagnetic coupling to the neutron

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$\gamma p \rightarrow \eta p$ and $\gamma p \rightarrow \eta' p$
- ● SAPHIR
- ■ ABBHHM
- ■ AHHM
- —— Nakayama et al. 0507044

Data:
- TAPS: B. Krusche et al., PRL74 (195) 3736
- GRAAL: F. Renard et al., PLB528 (2002) 215
- CLAS: M. Dugger et al., PRL89 (2002) 222002
- Crystal Barrel: V. Crede et al., PRL94 (2005) 012004

TAPS
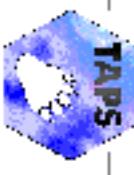
Resonance contributions to $\gamma N \to \eta N$ in the MAID model

● proton

Legend (proton plot):
- full model MAID
- no $D_{13}(1520)$, no $D_{13}(1700)$, no $P_{11}(1710)$, no $P_{13}(1720)$, no $F_{15}(1680)$
- no $S_{11}(1650)$
- no $D_{15}(1675)$
- no D_{15}, no S_{11}

● neutron

Legend (neutron plot):
- full model MAID
- no $D_{13}(1520)$, no $D_{13}(1700)$, no $P_{11}(1710)$, no $P_{13}(1720)$, no $F_{15}(1680)$
- no $S_{11}(1650)$
- no $D_{15}(1675)$
- no D_{15}, no S_{11}

Axes: σ[a.u.] vs W[MeV]
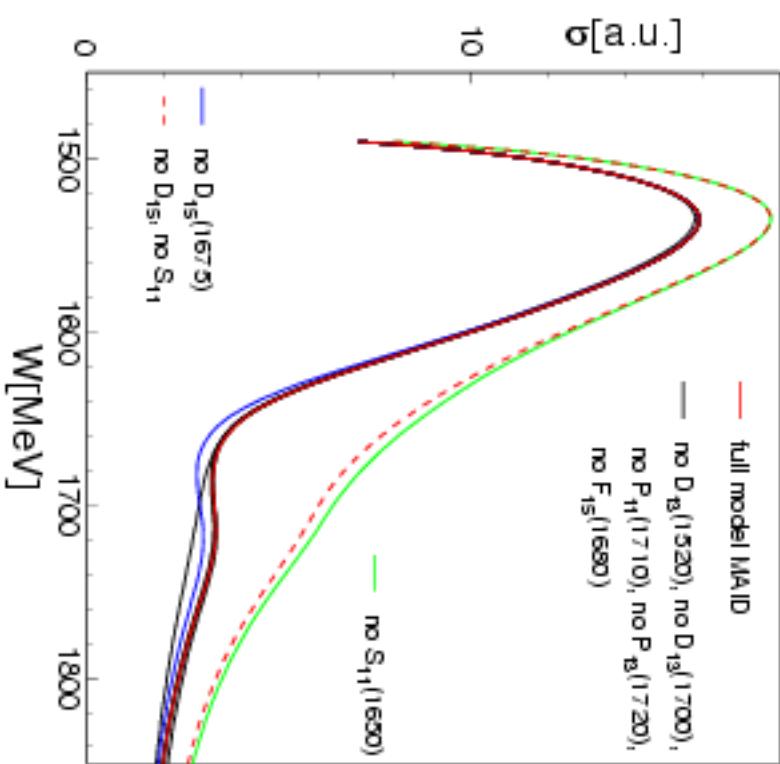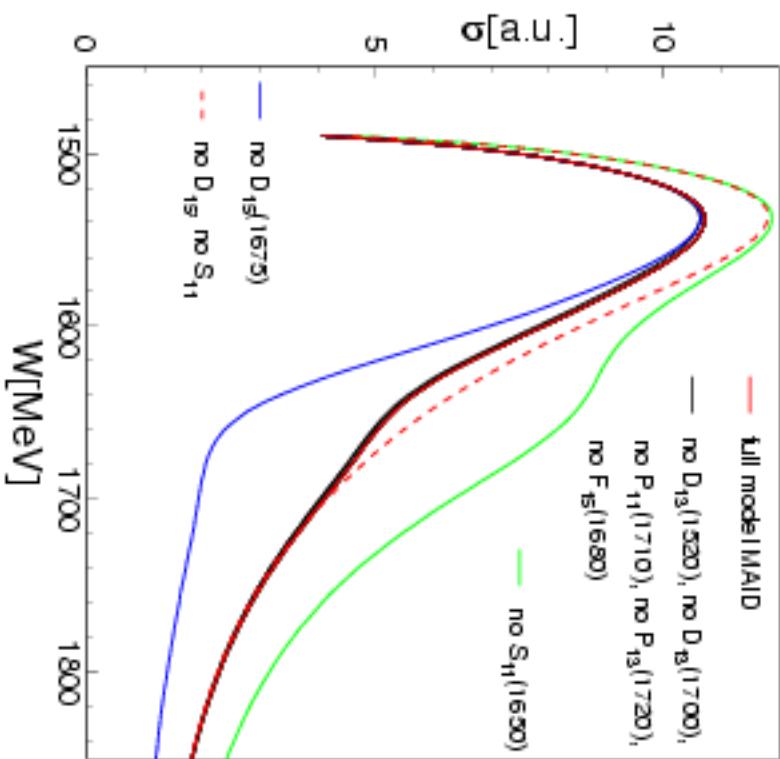
● Dominance of $S_{11}(1535)$

● Strong cancelation between $S_{11}(1535)$ and $S_{11}(1650)$

● Proton: only small contributions from other resonances

● Neutron: strong contribution from $D_{15}(1675)$?

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TAPS

Previous results for the ratio σ_n/σ_p (TAPS@MAMI)

- $d(\gamma,\eta)X$, $\sigma_n/\sigma_p(E_\gamma)$
- $d(\gamma,\eta)X$, $\sigma_n/\sigma_p(E_\gamma^*)$
- $^4He(\gamma,\eta)X$, $\sigma_n/\sigma_p(E_\gamma)$
- $^4He(\gamma,\eta)X$, $\sigma_n/\sigma_p(E_\gamma^*)$

- $\cdots$ Kaiser et al.
- MAID 1
- MAID 2
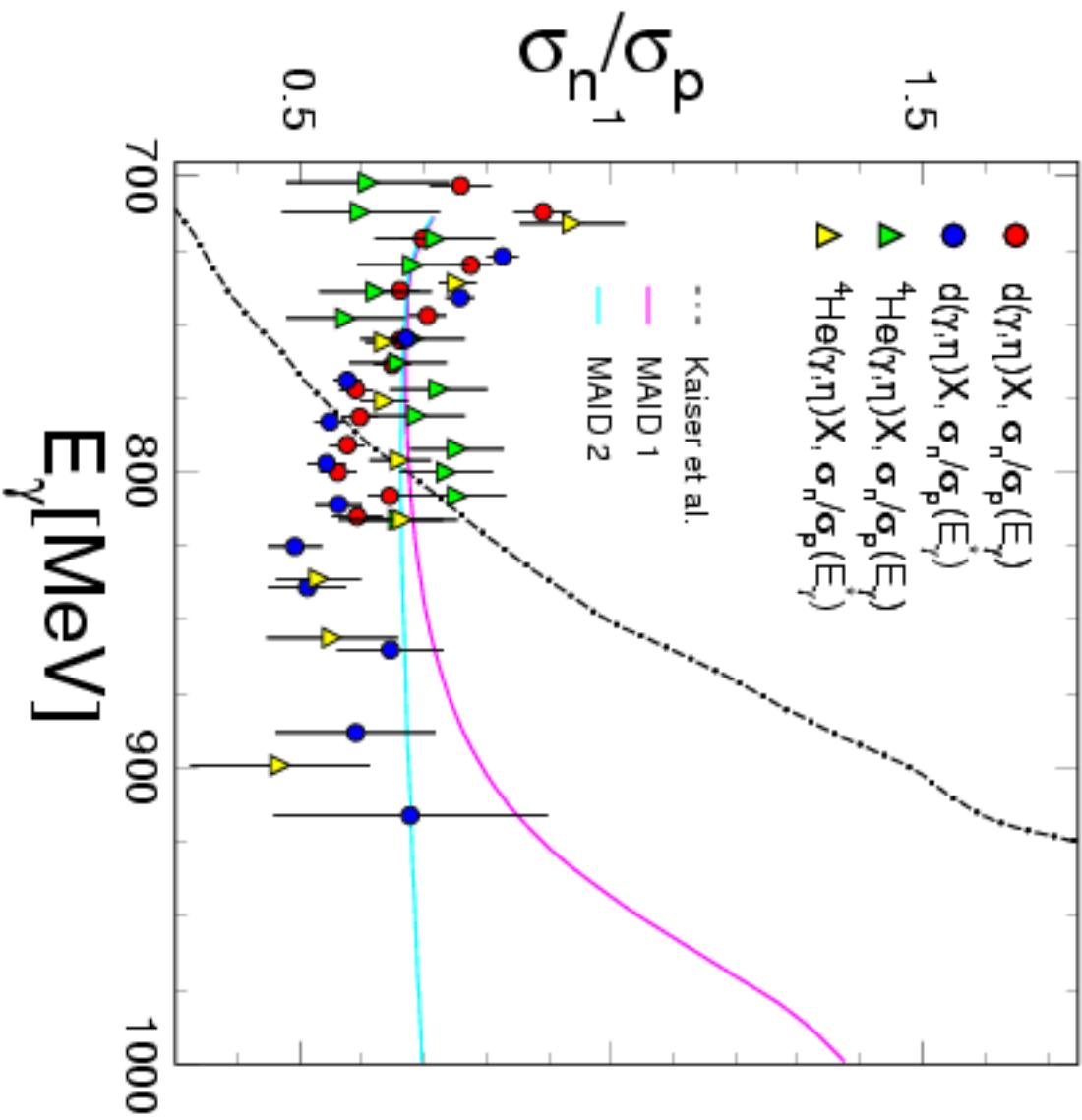
- Ratio in $S_{11}(1535)$ region $\approx 2/3$

- The constant ratio shows the dominance of $S_{11}(1535)$

- Predicted to increase at higher incident photon energy due to higher lying resonances

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TAPS

Exclusive measurement

$\gamma N \to N\eta$

Incident γ

$\eta \to \pi^o \pi^o \pi^o \to 6\gamma$
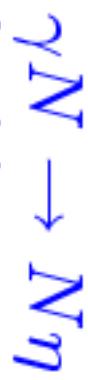
N = (n or p) measured in coincidence

Inclusive measurement

$\gamma N \to \eta X$

Incident γ

$\eta \to \pi^o \pi^o \pi^o \to 6\gamma$

X = whatever

Experimental setup - 4π electromagnetic calorimeter

TAPS front view

Crystal-Barrel (1290 CsI$_2$ Crystals)

$\delta E \sim 2.5\%$

$\delta\vartheta \sim \delta\phi \sim +/- 2°$

linear polarisation

photon flux monitor

ToF-wall

TAPS

Target

scintillating fiber detector

2 m

Tagger
$E_\gamma = 0.22 - 0.95\ E_0$
$N_\gamma \sim 10^7$/s

Goniometer Radiator

e-beam E=3.2GeV

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TAPS
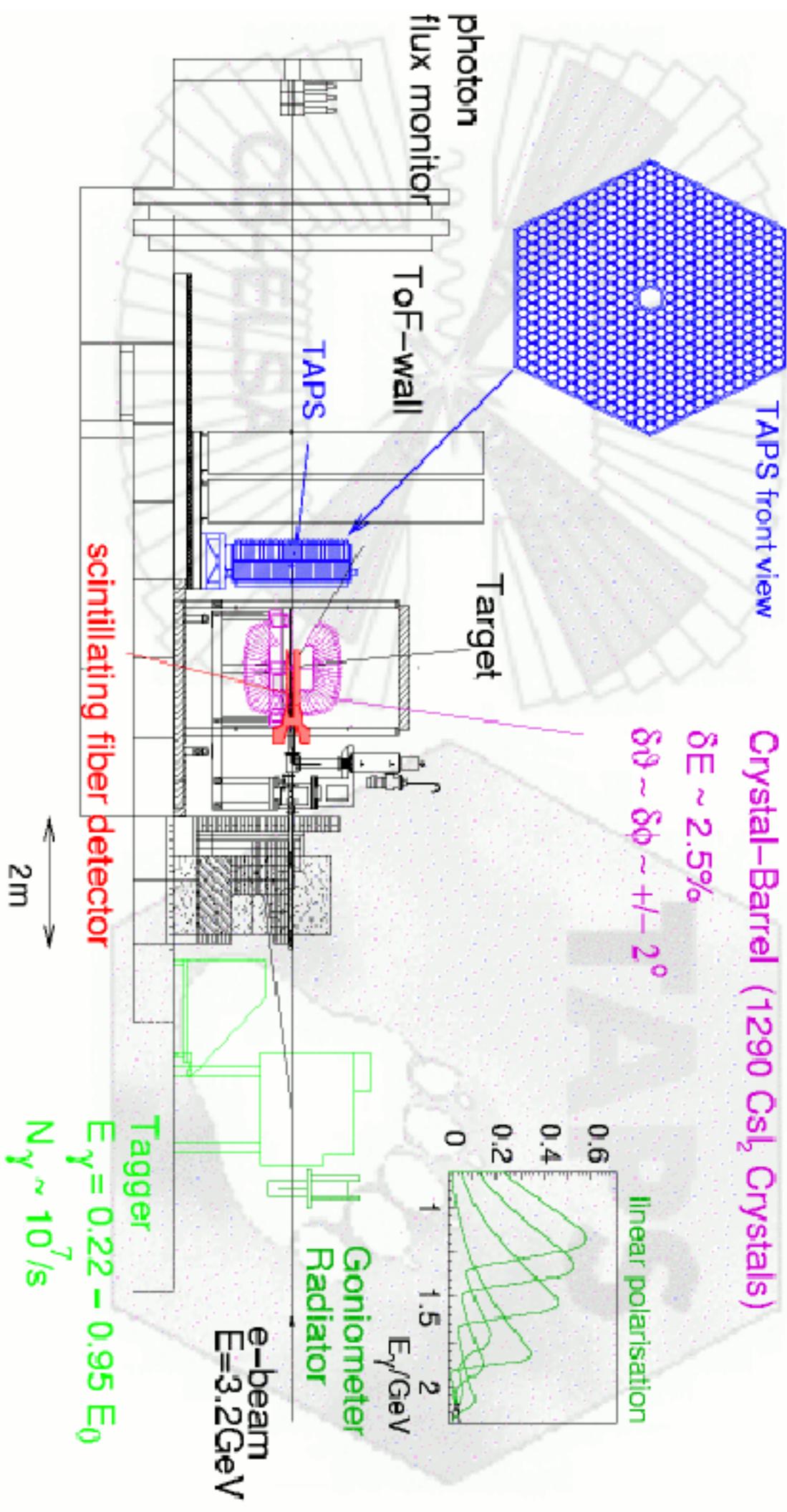
Quasifree $\gamma p \rightarrow p\eta$: angular distributions

$d\sigma/d\Omega$ [μb/sr]

$\cos\theta_{cm}$
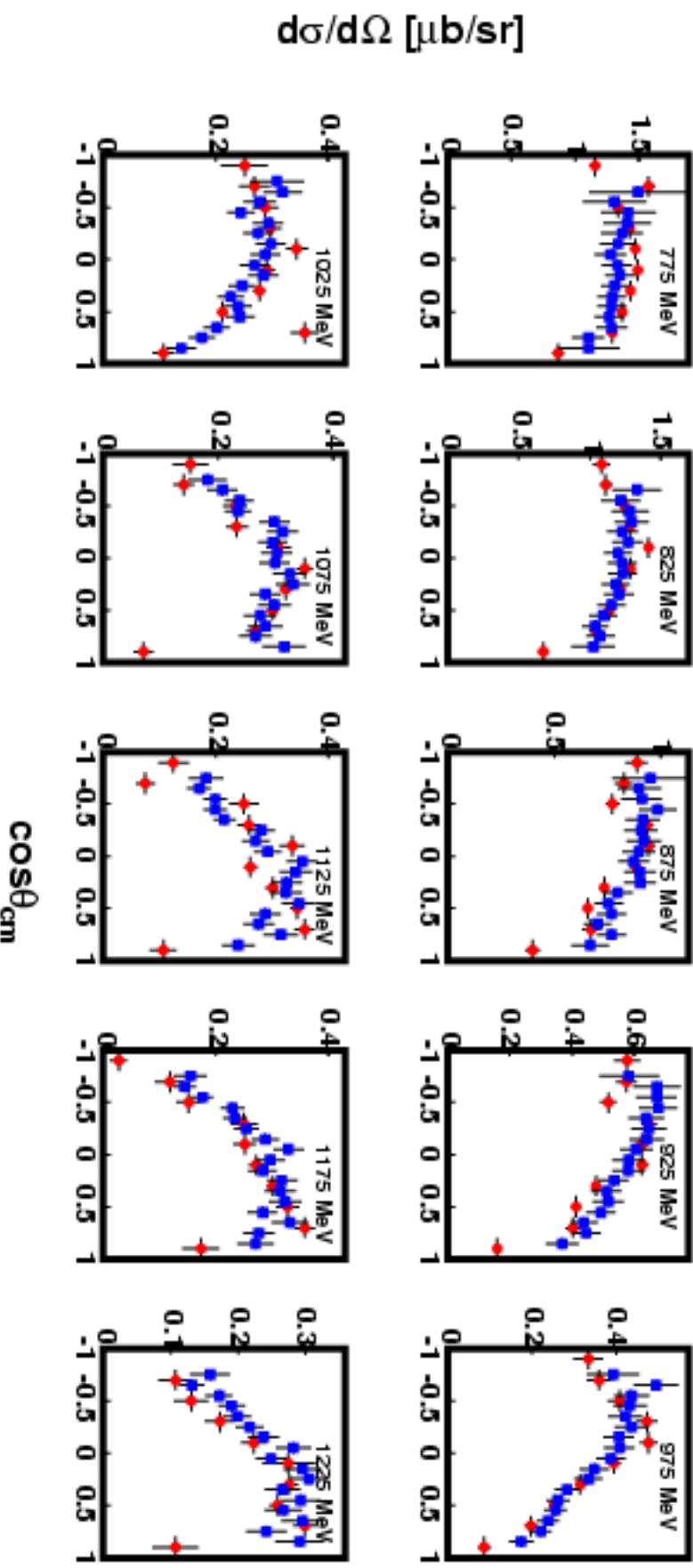
- $\gamma p \rightarrow p\eta$ (Crede et al.)
- $\gamma p \rightarrow p\eta$ (quasifree from d)

normalization arbitrary

preliminary

775 MeV, 825 MeV, 875 MeV, 925 MeV, 975 MeV, 1025 MeV, 1075 MeV, 1125 MeV, 1175 MeV, 1225 MeV

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TAPS

Quasifree $\gamma n \to n\eta$: angular distributions

dσ/dΩ [μb/sr]

cosθ_{cm}
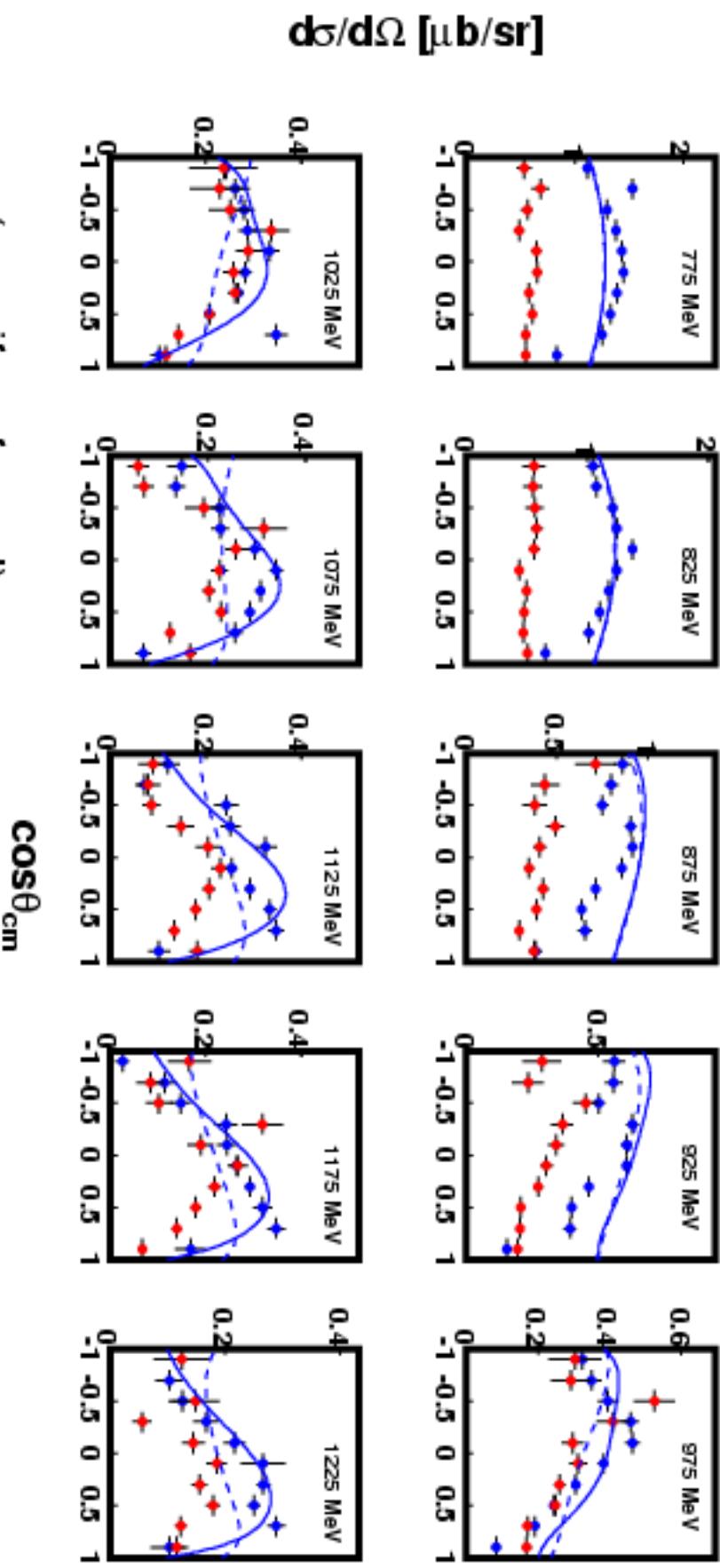
- $\gamma p \to p\eta$ (quasifree from d)
- $\gamma n \to n\eta$ (quasifree from d)

normalization arbitrary

very preliminary!!!

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Quasifree $\gamma N \to N\eta$ total and ratio cross sections
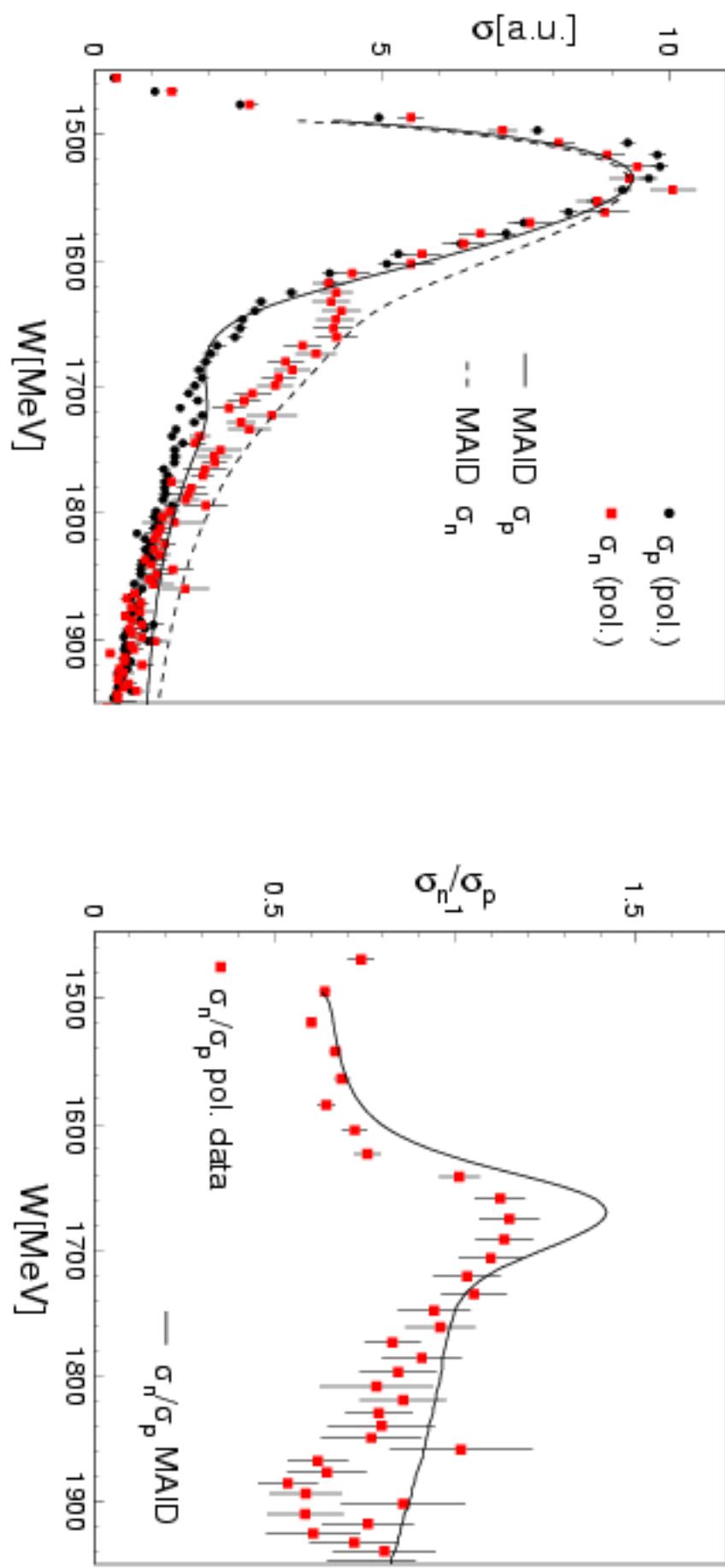
Preliminary results for photon beam asymmetry Σ

quasifree proton
Θ=90°

Σ

— MAID all
— MAID w/o D₁₅

W[MeV]

quasifree neutron
Θ=90°

Σ

— MAID all
— MAID w/o D₁₅
— MAID w/o S₁₁
— MAID w/o D₁₅, S₁₁

W[MeV]
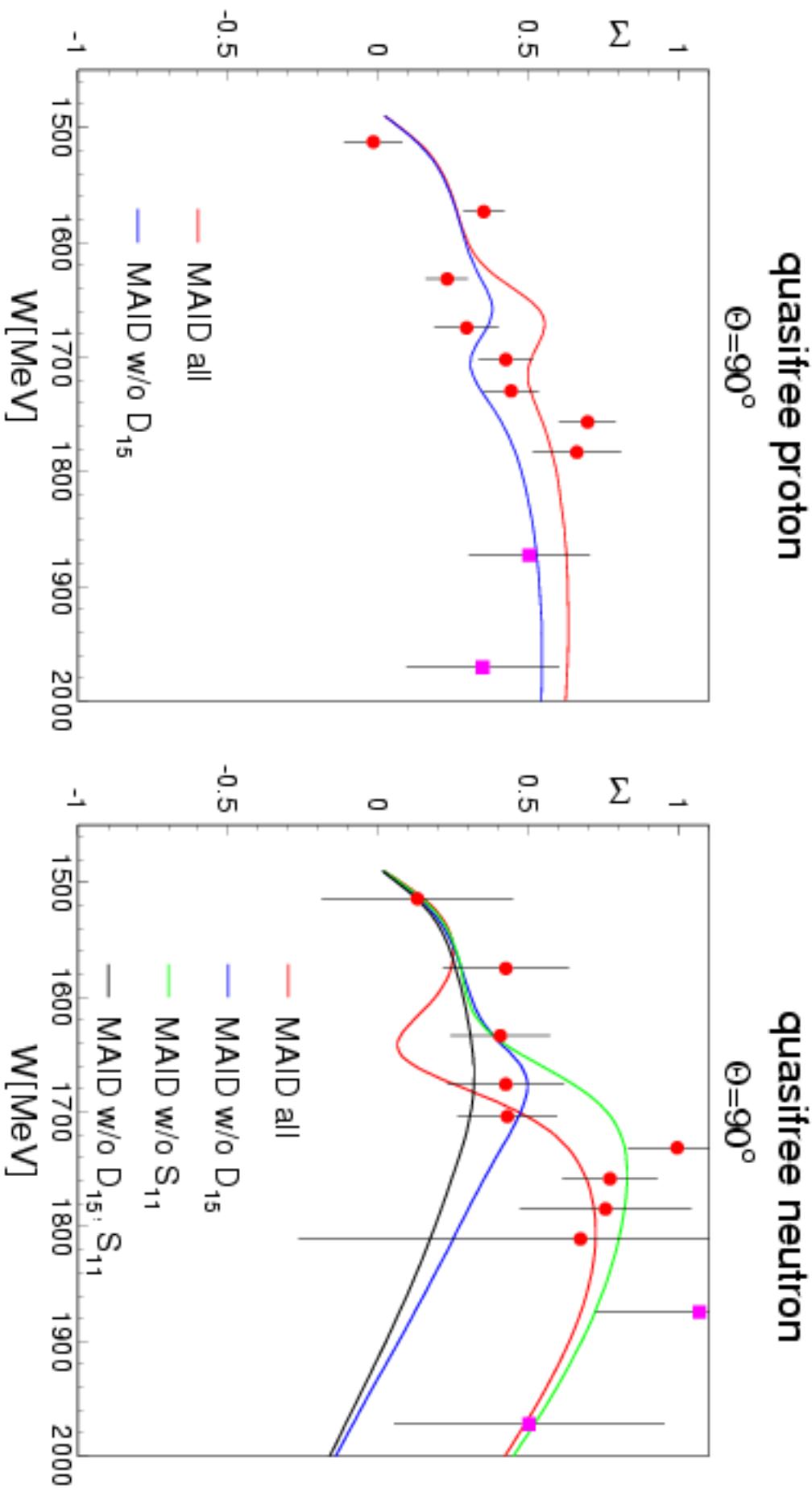
● Very preliminary analysis, but full available statistics!

● Some indication for D_{15} contribution
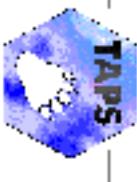
Comparison with $\eta - MAID$ model

- Angular distribution for $\gamma n \to \eta n$
- Sensitivity of Σ to $D_{15}(1675)$ at neutron

$\Theta = 90°$
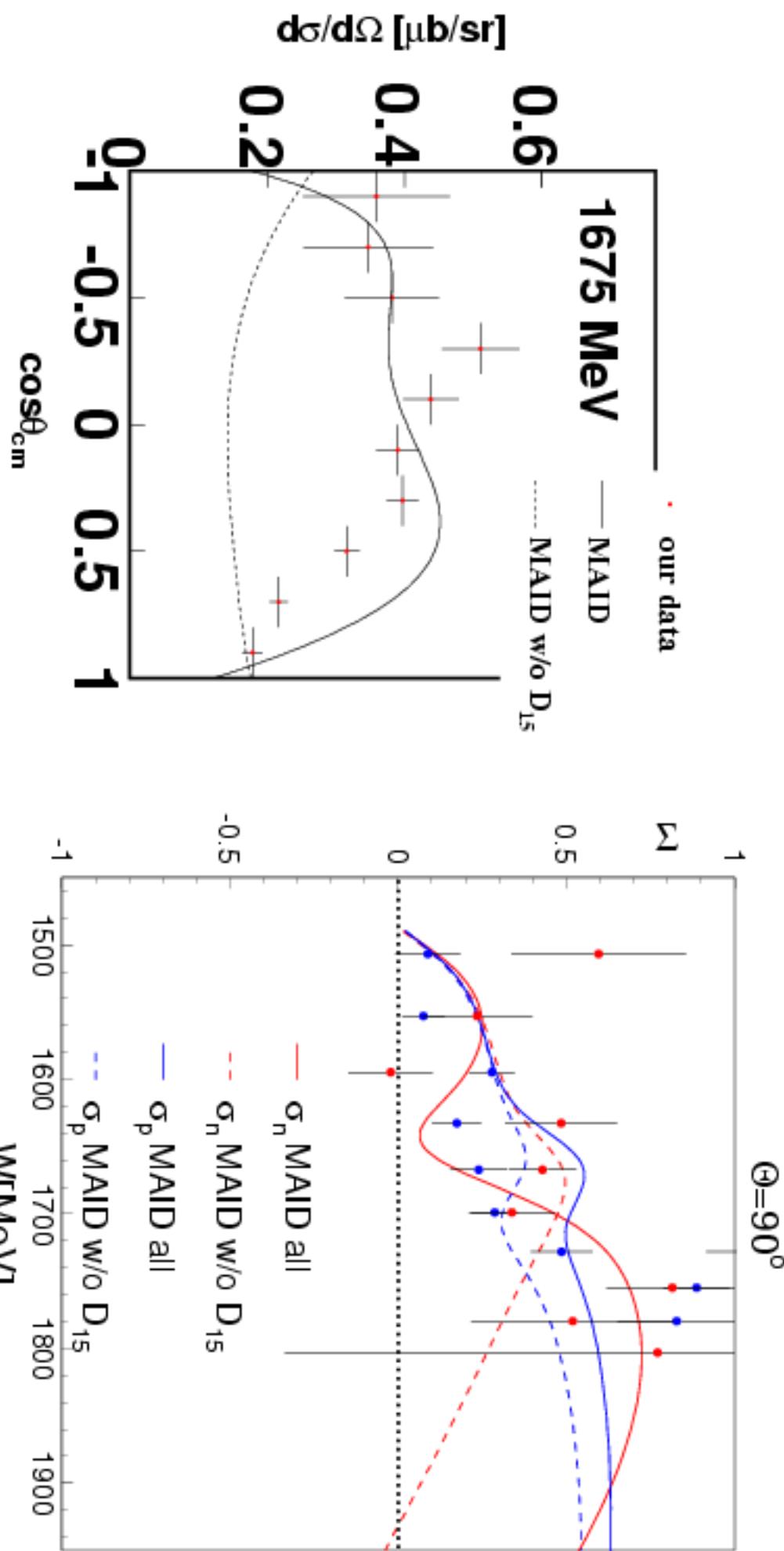
- Agreement with $\eta - MAID$ model for angular distribution !!!
- Agreement with the sensitivity of Σ to $D_{15}(1675)$!!!

η' results: Very Preliminary
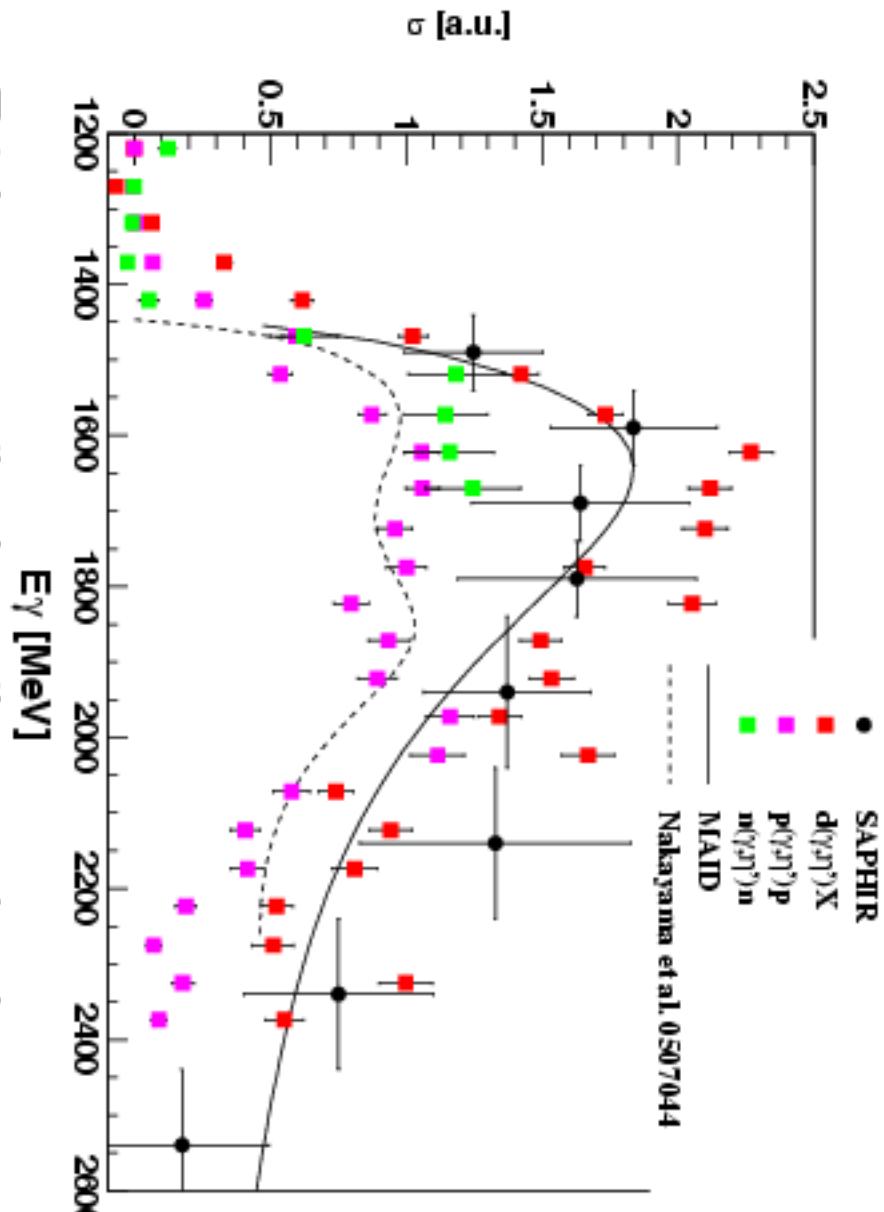
- Total cross section lower than previously measured
- Neutron and proton cross sections have the same size

η' results: Very Preliminary
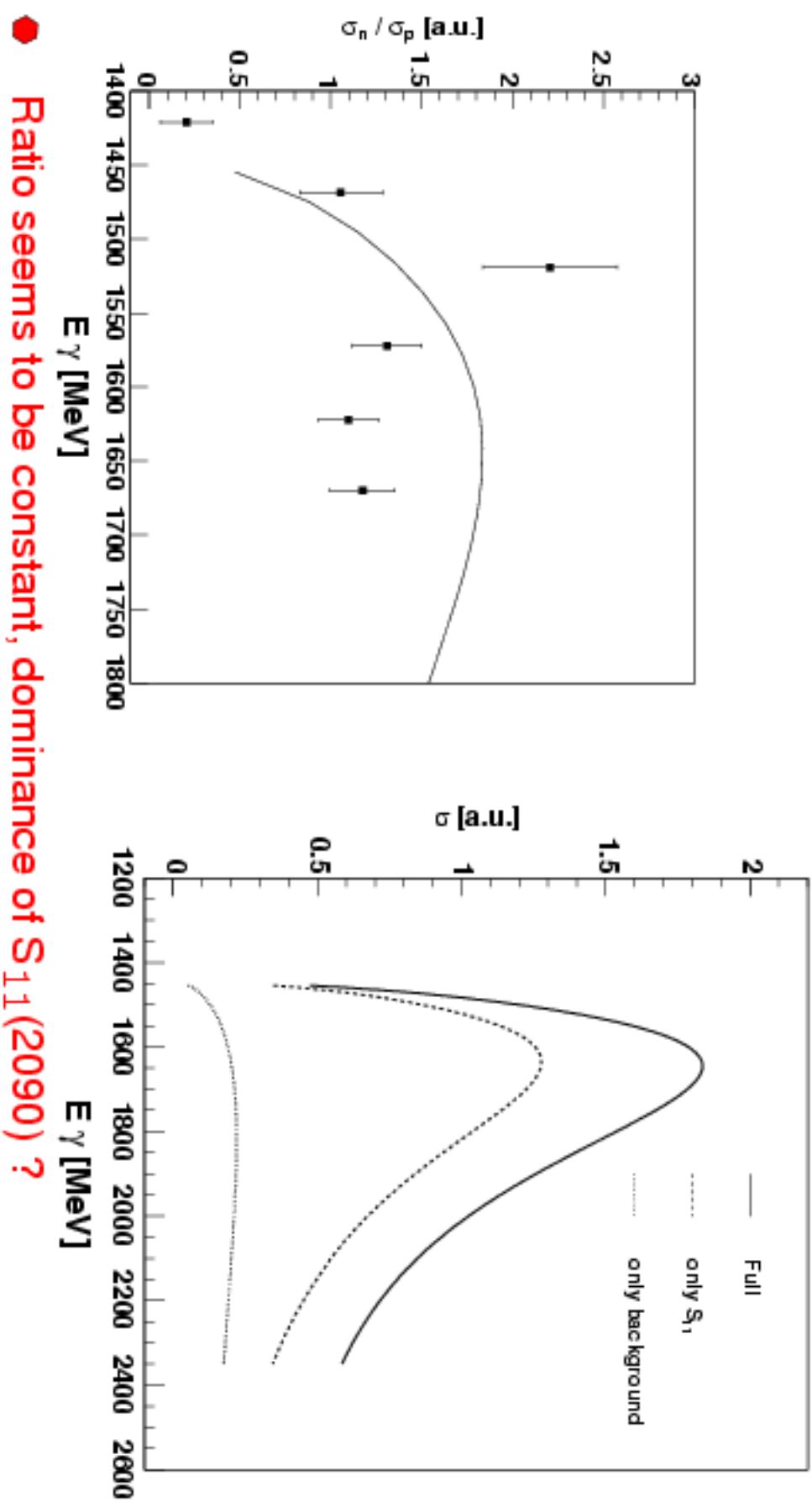
● Ratio seems to be constant, dominance of $S_{11}(2090)$?

Conclusion and Outlook

η-production

⬢ A clear enhancement due
to the neutron-photon coupling

⬢ Some agreement with MAID model

η′-production

⬢ Resonance-like structures
more prononced on the proton
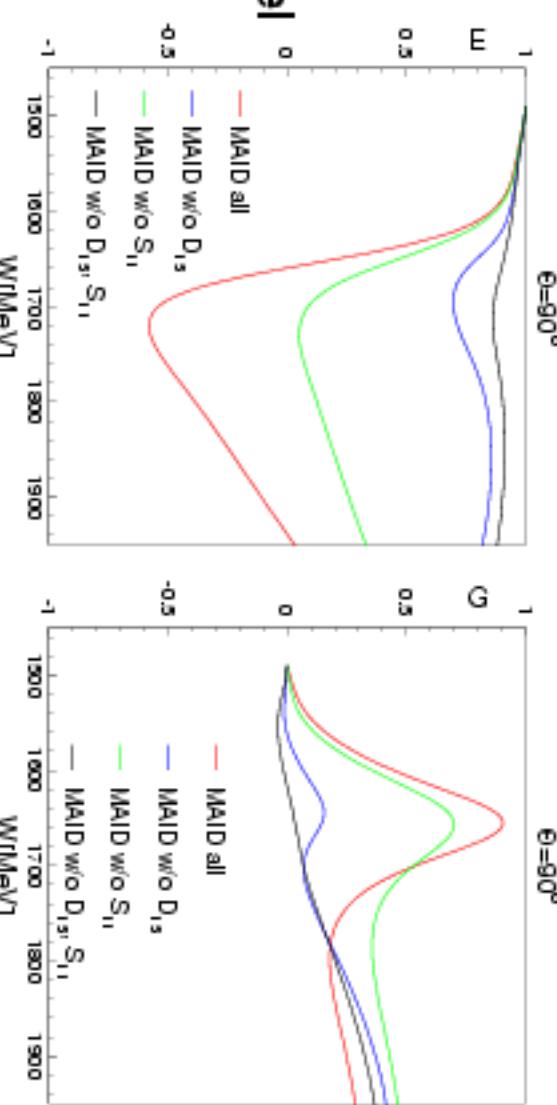
⬢ σ_n/σ_p constant around 1.95GeV !

Still to be done

⬢ Diff. cross section

⬢ η′ in 10γ

2nd generation measurements

⬢ Crystal Barrel / mini-TAPS @ ELSA

  – Better statistics for Σ

  – Double polarization: circularly pol.
   photon and longitudinally pol. target

⬢ to measure the sensivity of G to $D_{15}(1675)$
 to measure the sensivity of E to $D_{13}(2080)$ (for η′)

⬢ Crystal Ball / big-TAPS @ MAINZ

  – Better trigger and both neutral
    $\eta-channel$ are measurables

  – Better statistics for angular distribution

  – Double polarization: circularly pol. photon
    and longitudinally pol. target
    to measure the sensivity of E to $D_{15}(1675)$
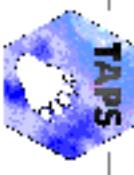
Inclusive η-photoproduction from deuterium

- Comparison: inclusive data at low energy
- Total cross sections: η and ηX
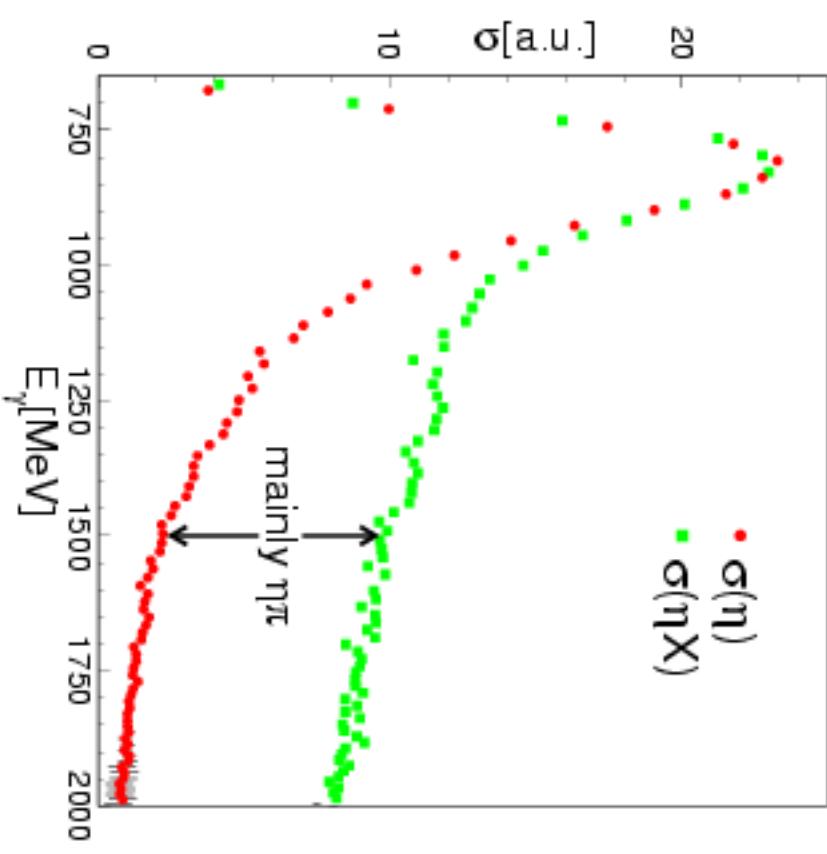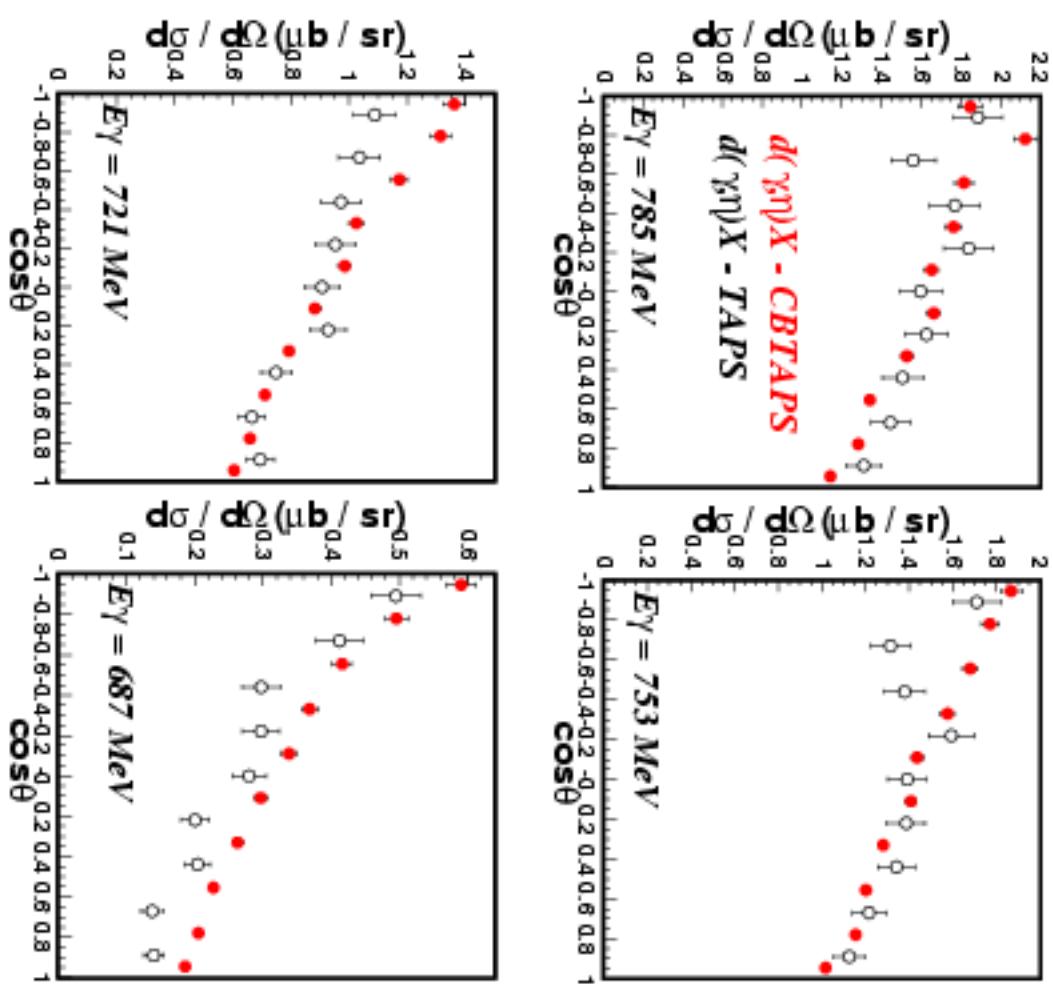
Identification of quasifree η production from $\eta \rightarrow \pi^0 \pi^0 \pi^0$
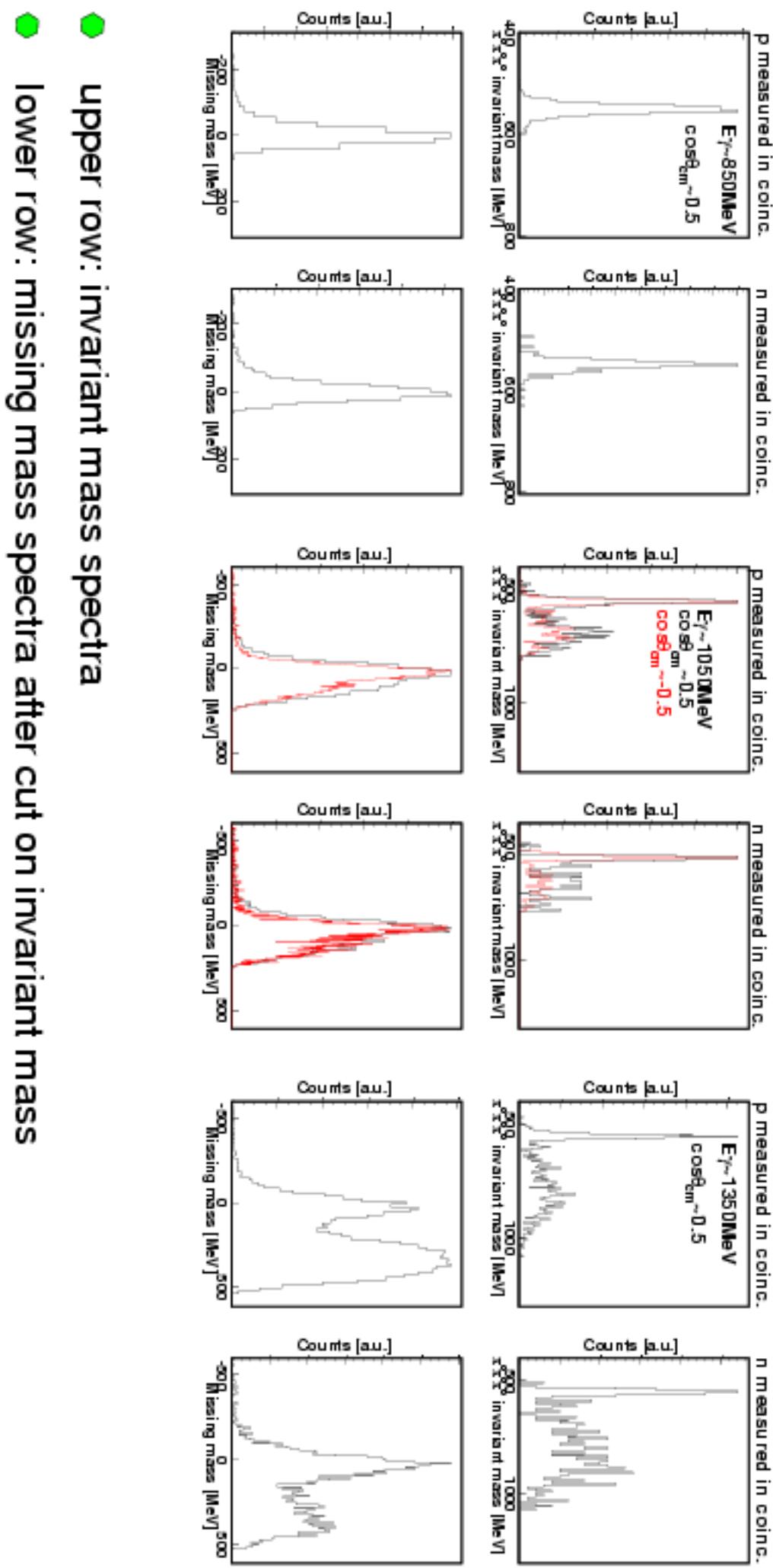
- upper row: invariant mass spectra
- lower row: missing mass spectra after cut on invariant mass