

# Photon Induced Reactions on Nuclei

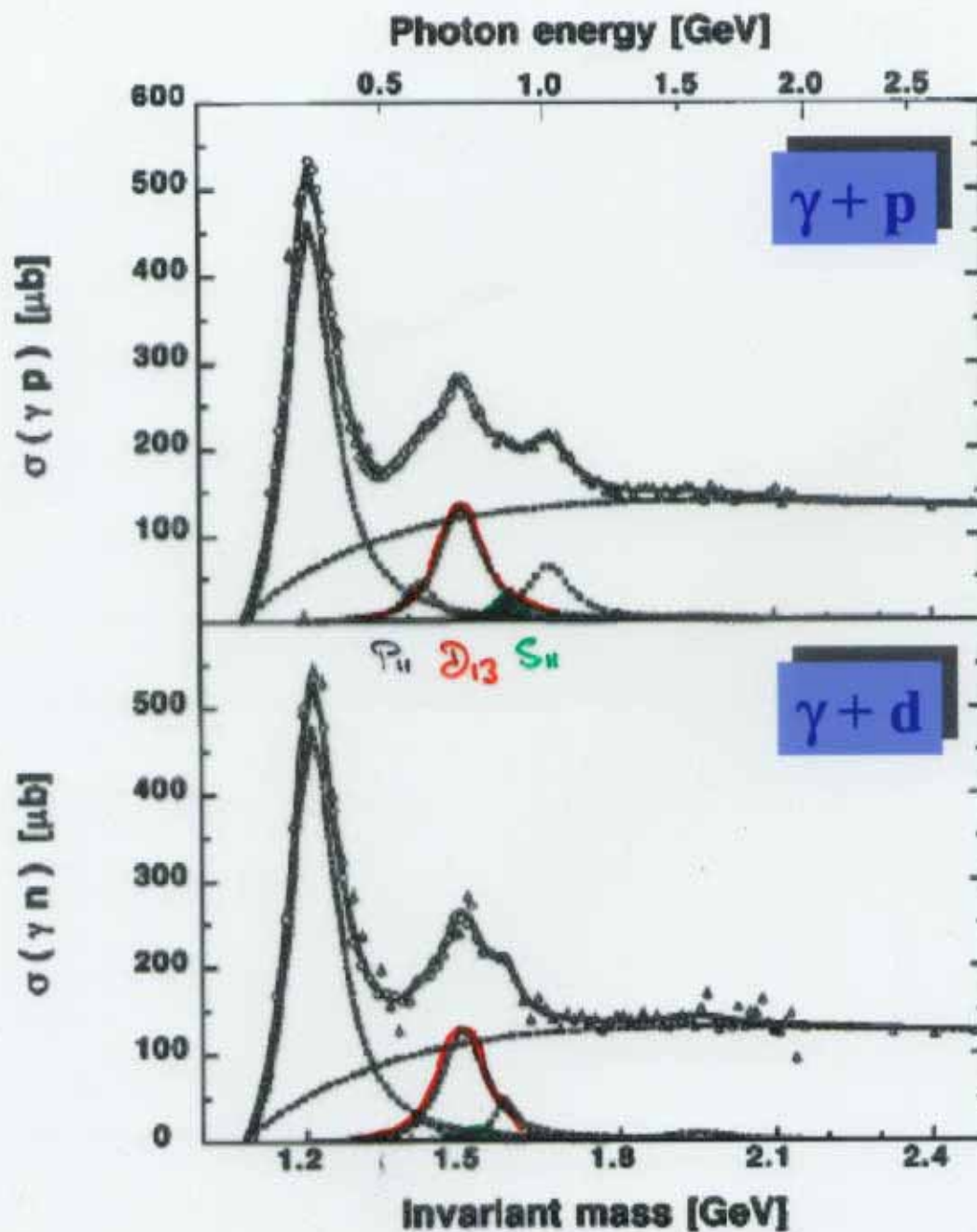
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- **Introduction**
- **Photoabsorption**
- **Meson Photoproduction from the Nucleon**
- **Meson Photoproduction from Nuclei**

**Talk at N\*2002, Pittsburg**  
**October, 2002**

# Photoabsorption

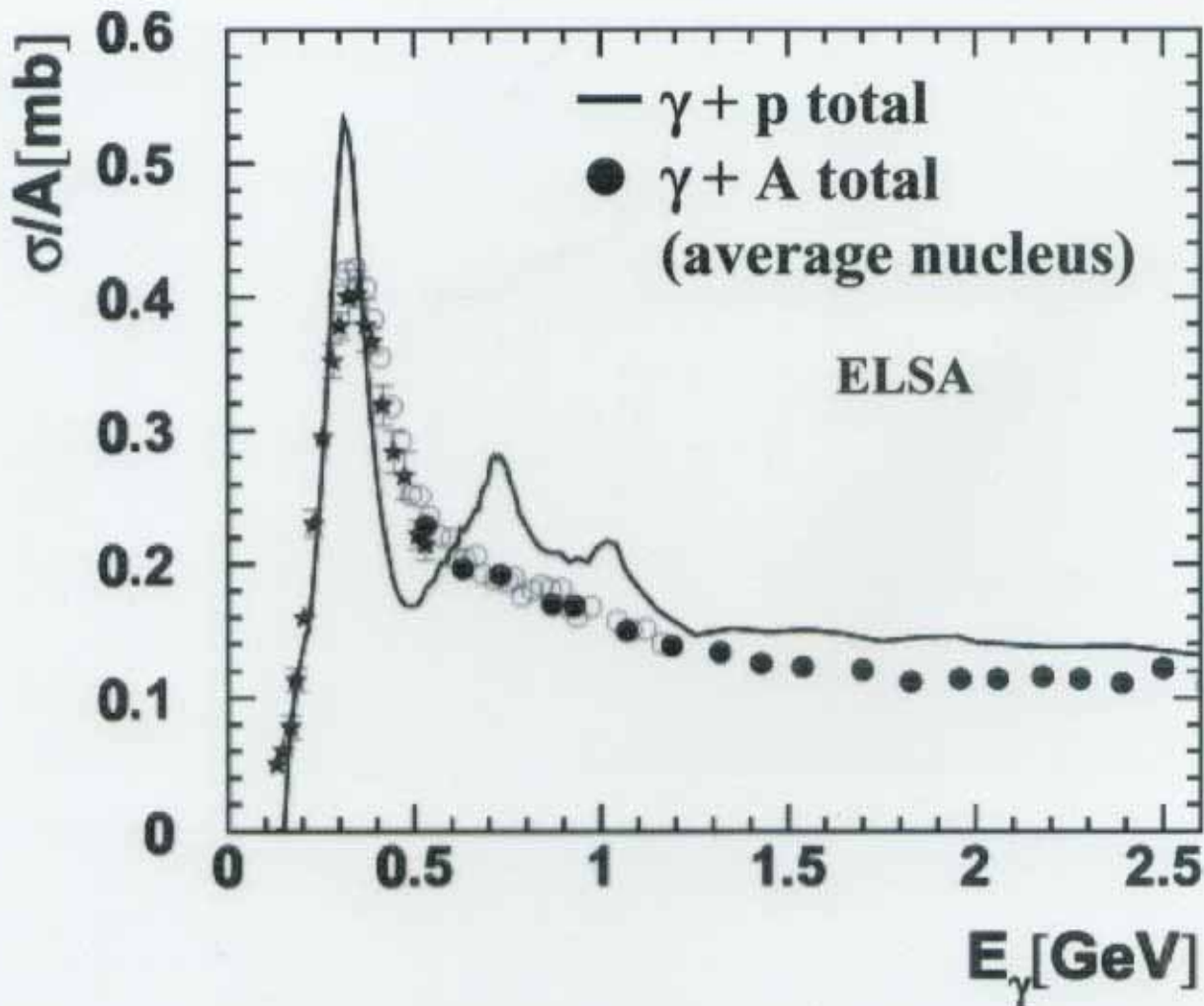
N. Bianchi et al. PRC54(1996)1688



- complex structure of nucleon is reflected in excitation spectrum
- broad overlapping resonance states

# Nuclear Photoabsorption

total cross sections **per nucleon**

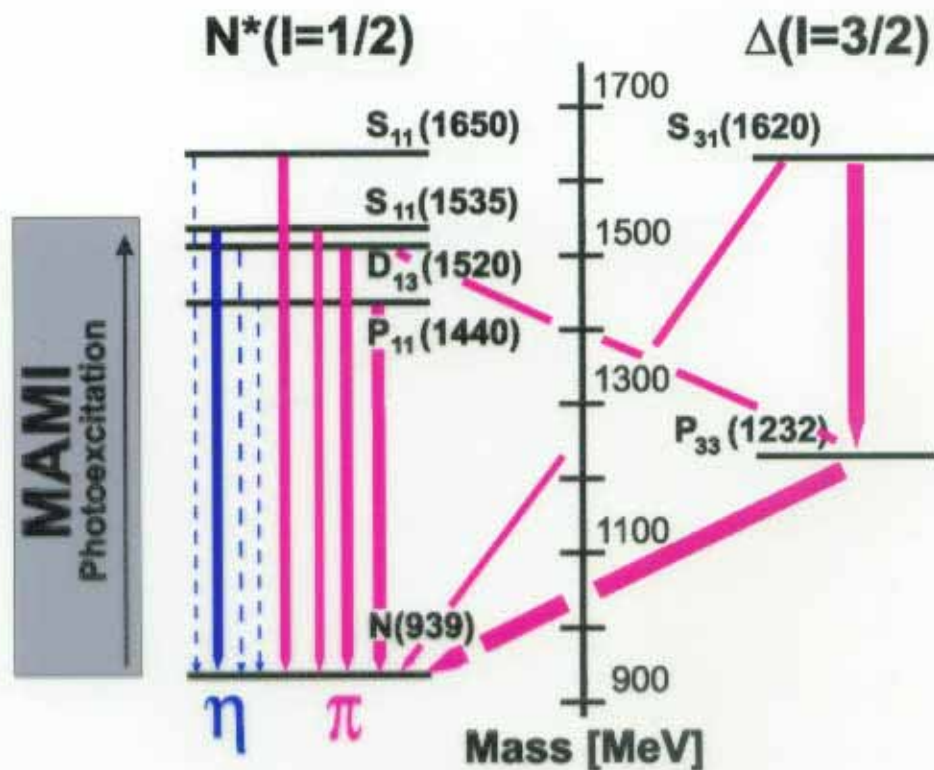


- universal behavior  $\sigma \propto A$
- $\Delta$  resonance broadened + shifted
- higher resonance regions ?

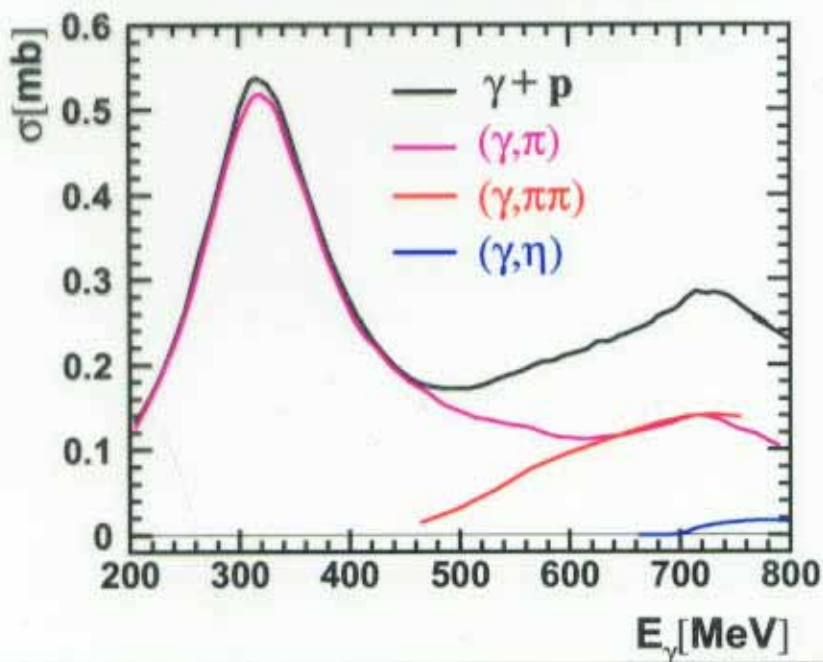
*"disappearance of  $\Delta_{13}$  resonance"*

**evidence for medium modifications**

## Nucleon Level Scheme



## Characteristic Meson Decay



# The Second Resonance Region

Resonance N*(M)	width	decay mode	decay probability
P <sub>11</sub> (1440) Roper	350 MeV	Nπ Nππ Δπ Nρ N(ππ) <sub>s-wave</sub> <sup>l=0</sup>	60-70% 30-40% 20-30% <8% 5-10%
D <sub>13</sub> (1520)	120 MeV	Nπ Nππ Δπ Nρ N(ππ) <sub>s-wave</sub> <sup>l=0</sup>	50-60% 40-50% 15-25% 15-25% <8%
S <sub>11</sub> (1535)	150 MeV	Nπ Nη Nππ	35-55% 30-55% 1-10%

**D<sub>13</sub> → Nρ decay branch**

free nucleon: TAPS PRL 87 (2001) 052001  
responsible for D<sub>13</sub> broadening in medium?  
Mosel et al.

**modification of ππ interaction**

responsible for 'disappearance' of D<sub>13</sub> ?  
Hirata et al.

# Medium Effects

on baryon resonance parameters ( $m_R, \Gamma$ )

Fermi-motion

$\Gamma \nearrow$

meson decay



$\Gamma \searrow$   
(Pauli blocking)

collisional broadening



$\Gamma \nearrow$

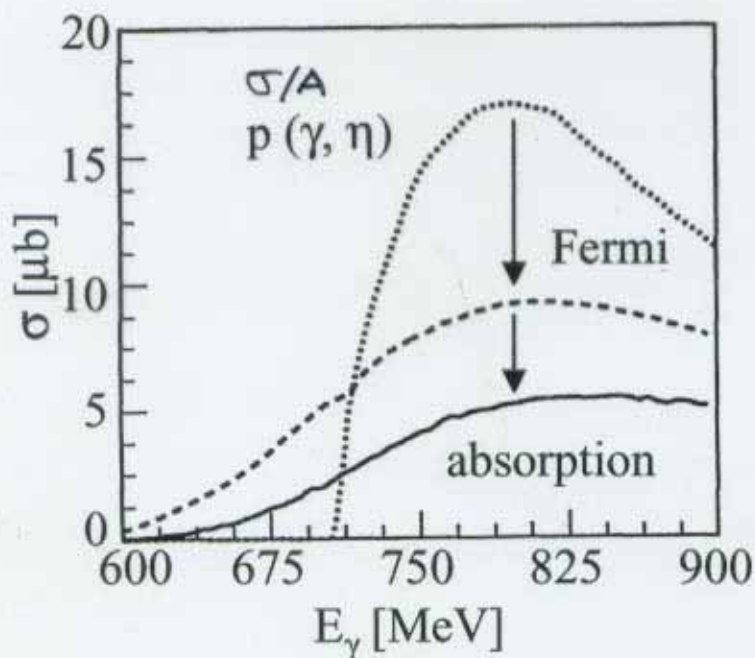
quenching



reduction of  
meson yield

$N^*$ -propagation  
self energy

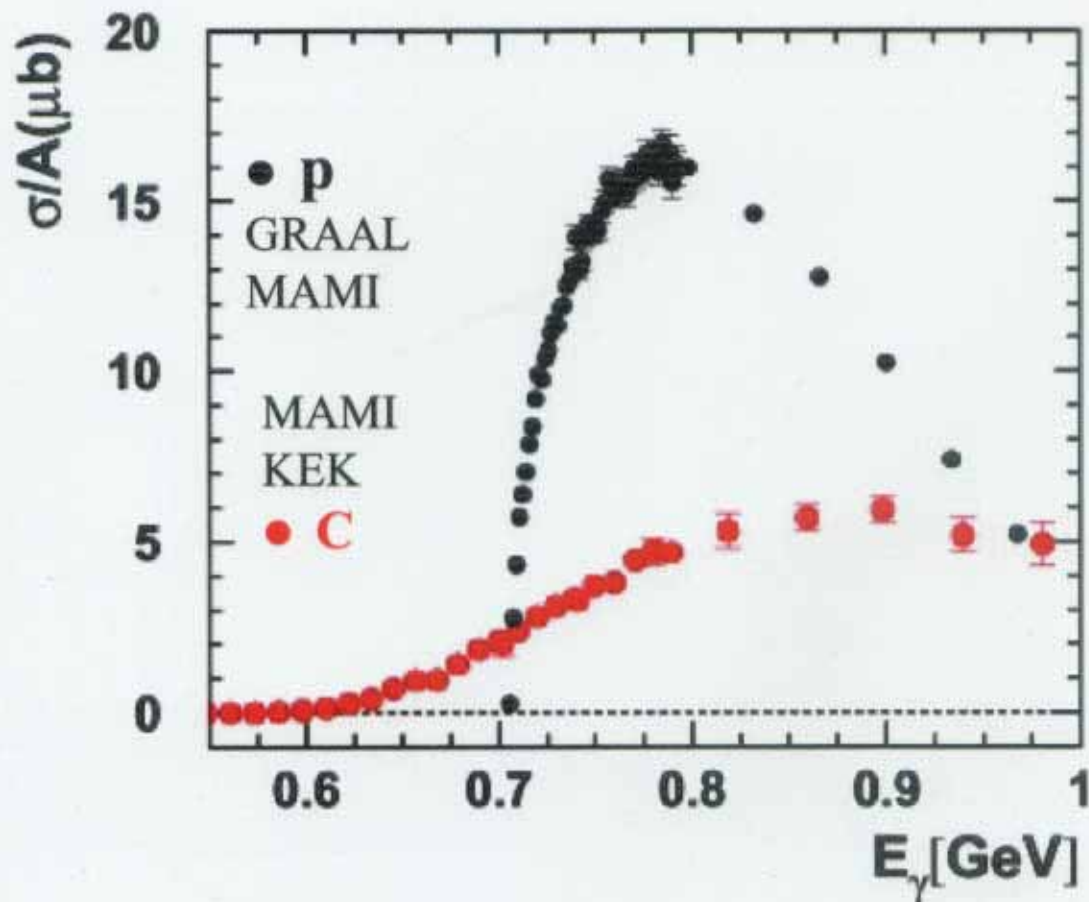
mass / width



theoretical prediction  
 $^{12}\text{C}(\gamma, \eta) X$

Carrasco et al.  
U. Mosel et al.

# $\eta$ Photoproduction



**$S_{11}(1535)$  is modified in medium:**

- Fermi motion
- Pauli principle
- $\eta$  absorption
- N-  $S_{11}$  collisions

- no sign of depletion of  $S_{11}(1535)$
- influence on total cross section small

# $\pi^+\pi^-$ Photoproduction

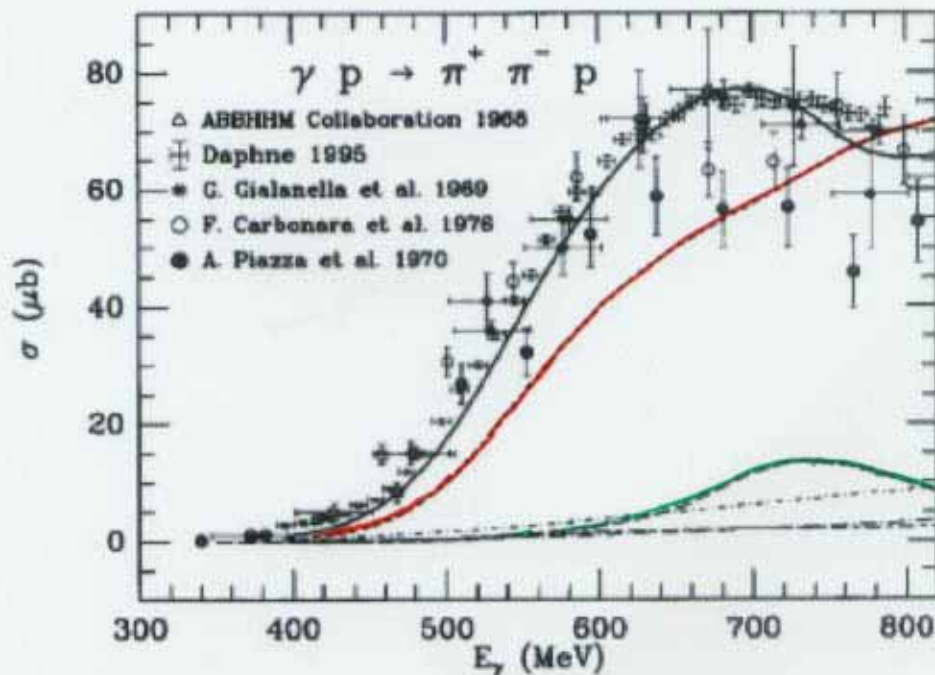
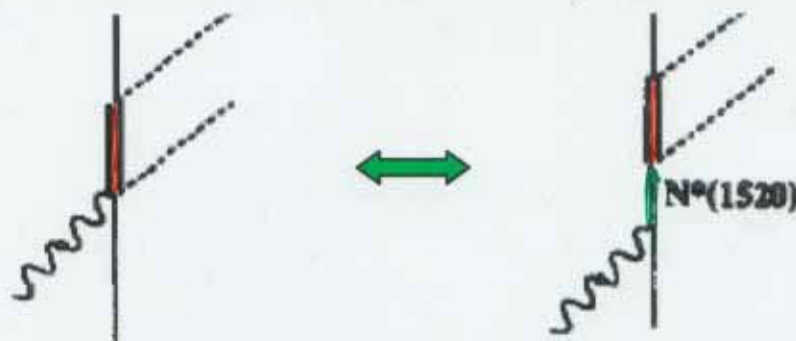


Fig. 5. Total cross section for the  $\gamma p \rightarrow \pi^+ \pi^- p$  reaction. Continuous line: total cross section. Short-dashed line: contribution of  $\Delta(1232)$  intermediate states. Long-dashed line: contribution of  $N^*(1520)$  intermediate state. Short-dash-dotted line: contribution of  $N$  intermediate states. Long-dash-dotted line: contribution of  $\rho$  intermediate states. Short-dash-long-dashed line: rest of the diagrams. Experimental data from Refs. [1-4,8].



$\Delta$  KR

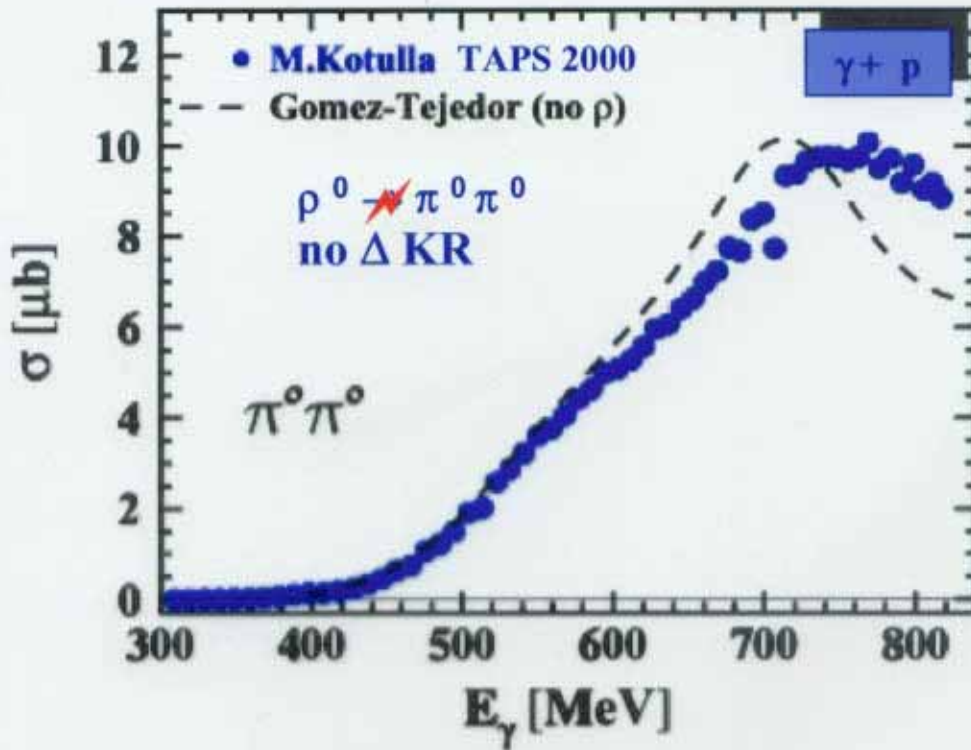
D13 decays sequential via  $\Delta$

- $\Delta$  intermediate terms dominate
- $\rho$  not important
- $D_{13}$  contribution by itself small
- interference terms with  $\Delta$  important

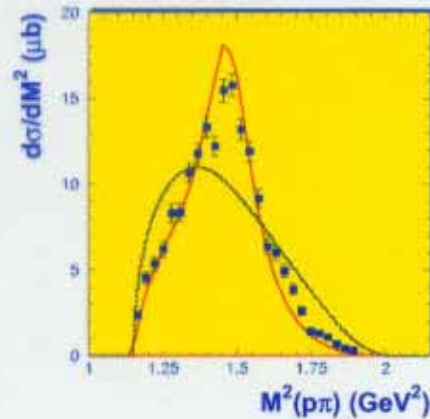
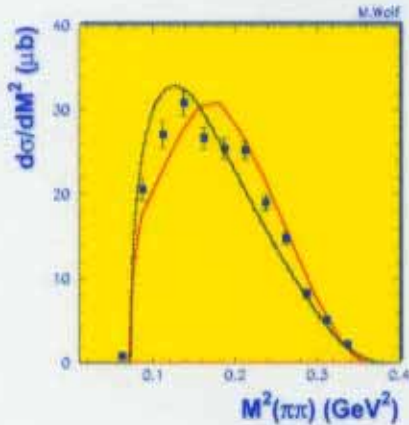
"shifted  $\Delta$  strengths"



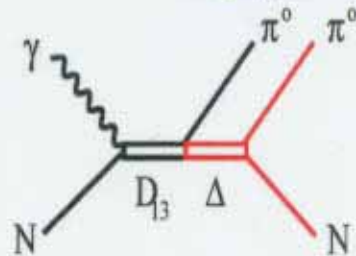
# $\pi^0\pi^0$ Photoproduction



M.Wolf et al., TAPS EPJ A 9 (2000) 5



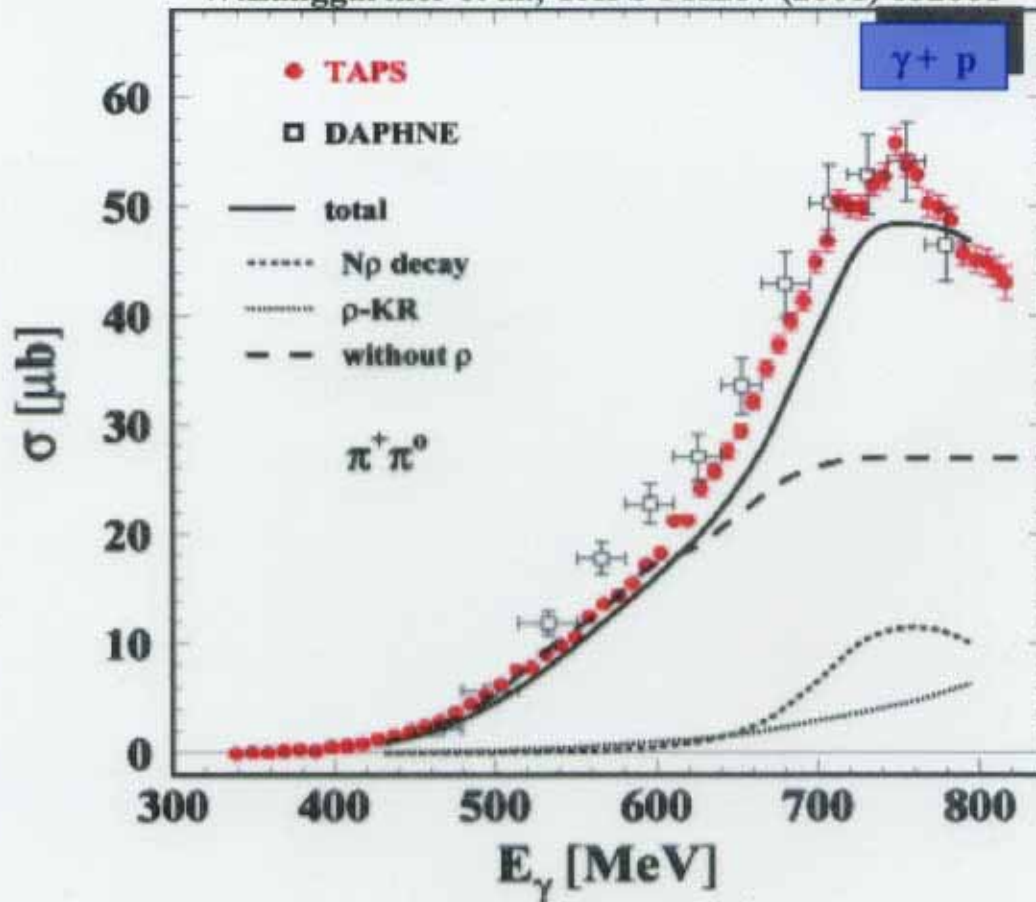
Gomez Tejedor et al.,  
NPA 600 (1996) 413



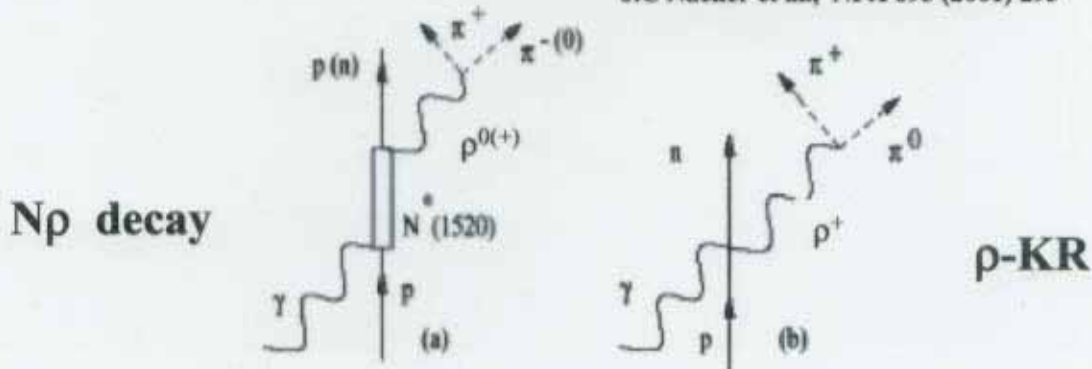
- excitation of  $D_{13}$  (1520) resonance
- sequential decay via  $\Delta$  resonance

# $\pi^+\pi^0$ Photoproduction

W.Langgärtner et al., TAPS PRL87 (2001) 052001



J.C Nacher et al., NPA 695 (2001) 295



- $D_{13}$  sequential decay via  $\Delta$  resonance
- $\Delta$  KR less important
- $D_{13}$  contribution by itself small
- importance of interference terms (with  $\rho$ )



# Double Pion Photoproduction

$\gamma + p$

*important processes  
for comparison*

$\pi^+ \pi^0$

$\pi^+ \pi^-$

$\pi^0 \pi^0$

$\gamma p \rightarrow D_{13} \rightarrow \Delta \pi \rightarrow N \pi \pi$



$\gamma p \rightarrow \Delta \pi \rightarrow N \pi \pi$



$\gamma p \rightarrow D_{13} \rightarrow N \rho \rightarrow N \pi \pi$



$\gamma p \rightarrow N \rho \rightarrow N \pi \pi$



and interferences.

$\pi^+ \pi^0$  production is the process  
where

- $\rho$  meson is important
- $\Delta$  resonance is less important

# $\pi^0\pi^0$ Photoproduction

comparison with BUU calculation

J. Lehr, U. Mosel 'without further modification'

