

# 2 $\pi$ - PHOTOPRODUCTION FROM CLAS AND CB-ELSA

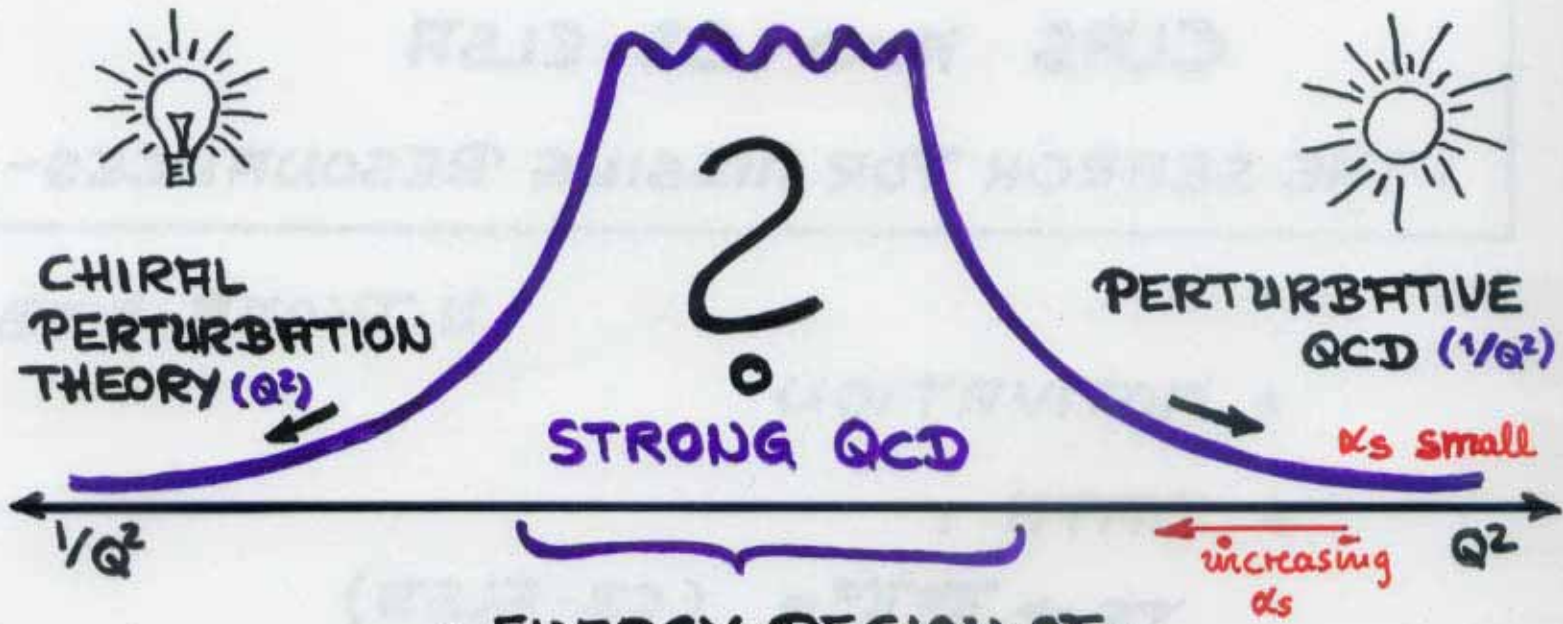
- THE SEARCH FOR MISSING RESONANCES -

U. THOMA, JLAB

- MOTIVATION
- DATA :
  - $\gamma p \rightarrow \pi^0 \pi^0 p$  (CB-ELSA)
  - $\gamma p \rightarrow \pi^+ \pi^- p$  (CLAS)
- PRELIMINARY PARTIAL WAVE ANALYSIS OF  $\gamma p \rightarrow \pi^0 \pi^0 p$  @ 1.4 GeV
- SUMMARY

# MOTIVATION

QCD:



= ENERGY REGION OF:

- BARYONS
- MESONS

↔ WHAT ARE THE RELEVANT DEGREES OF FREEDOM ?  
AND THE FORCES BETWEEN THEM ?

- ⇒
- MESON - SPECTROSCOPY
  - BARYON - SPECTROSCOPY

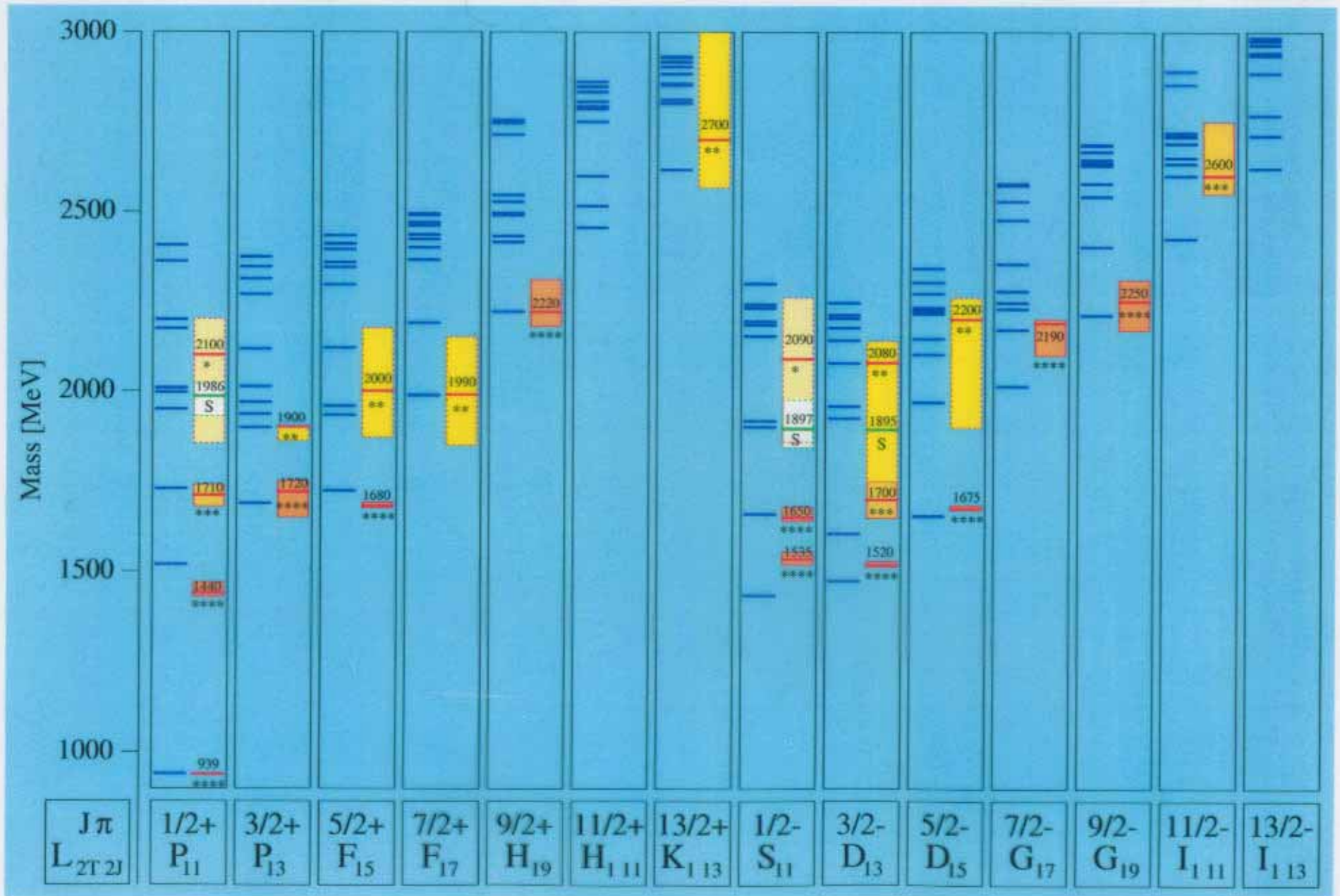
GOOD UNDERSTANDING OF THE EXP. SPECTRUM AND THE PROPERTIES OF THE RESONANCES

↔ COMPARISON WITH MODELS

# $N^*$ - RESONANCES

→ talk by  
B. Metsch

## WITH INSTANTON INDUCED FORCES



# SEARCH FOR MISSING RESONANCES

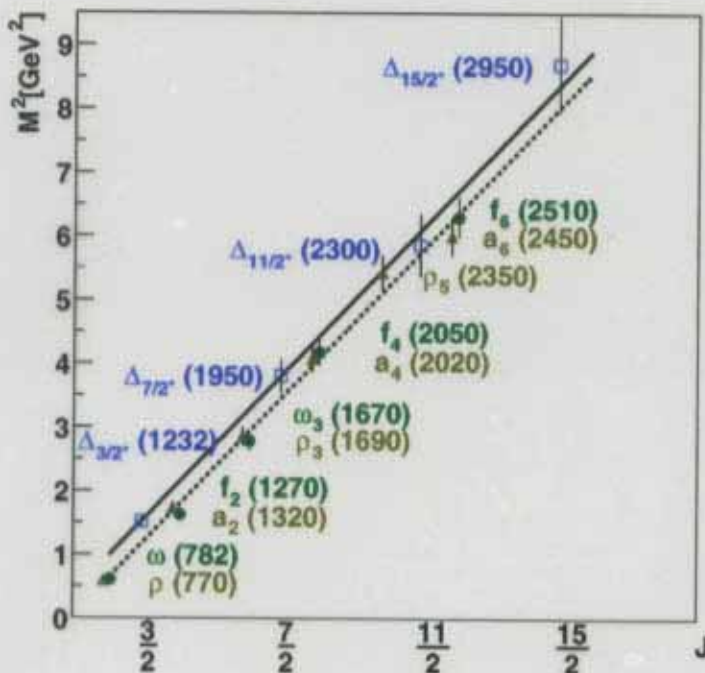
QUARK-MODEL : MORE BARYONS  
PREDICTED THAN  
OBSERVED

## POSSIBLE EXPLANATIONS :

↔ BARYONS HAVE A QUARK-DIQUARK  
STRUCTURE :



ONE OF THE INTERNAL  
DEGREES OF FREEDOM  
IS FROZEN



↔ THEY HAVE NOT BEEN OBSERVED UP TO NOW

NEARLY ALL EXISTING DATA FROM  $\pi N$ -SCATTERING EXPERIMENTS

↔ MISSING STATES DECOUPLE FROM  $\pi N$  (supported by theory)

### MISSING RESONANCES:

→ MANY STATES PREDICTED TO COUPLE SIGNIFICANTLY TO e.g.  $\Delta\pi$ ,  $N\pi$  AND  $\gamma p$

↪ INVESTIGATE  $\gamma p \rightarrow p\pi\pi$

In Addition:

### MEASUREMENT OF RESONANCE PROPERTIES

- PHOTOCOUPPLINGS
- PARTIAL WIDTHS ...

↪ ADDITIONAL INFORMATION

↔ DISCRIMINATION BETWEEN DIFFERENT MODELS

## SEARCH FOR $N^* \rightarrow \Delta\pi$ IN $\gamma p \rightarrow \pi^0\pi^0 p$

### ADVANTAGES:

- NO DIFFRACTIVE S-PRODUCTION
- NO DIRECT  $\Delta^{++}\pi^-$ -PRODUCTION  
(strong in  $\gamma p \rightarrow \pi^+\pi^-p$ )
- FEWER BORN-TERMS, t-CHANNEL EX.

↳  $\gamma p \rightarrow \pi^0\pi^0 p$  WELL SUITED TO INVESTIGATE  $N^* \rightarrow \Delta\pi$

but: NO INFORMATION ON  $N^* \rightarrow N\pi$

### ↳ ANALYSIS OF $\gamma p \rightarrow p\pi^+\pi^-$

→ CONTAINS MORE INFORMATION

- $N^* \rightarrow N\pi$
- $N^* \rightarrow \Delta\pi$

but: MORE "BACKGROUND"-AMPLITUDES

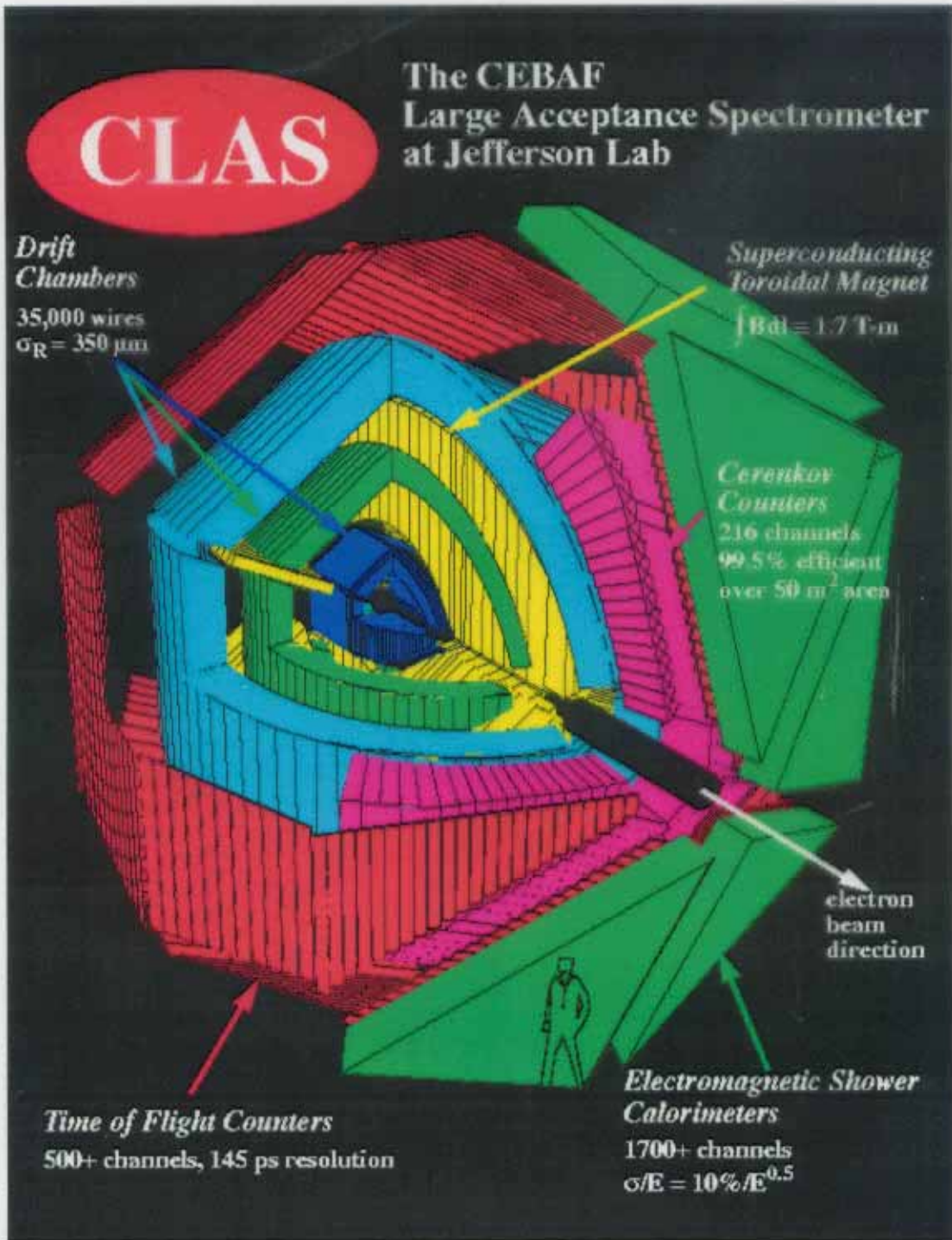
↳ MORE DIFFICULT TO ANALYSE

⇒ INFORMATION CONTAINED IN BOTH DATA SETS CAN BE COMBINED

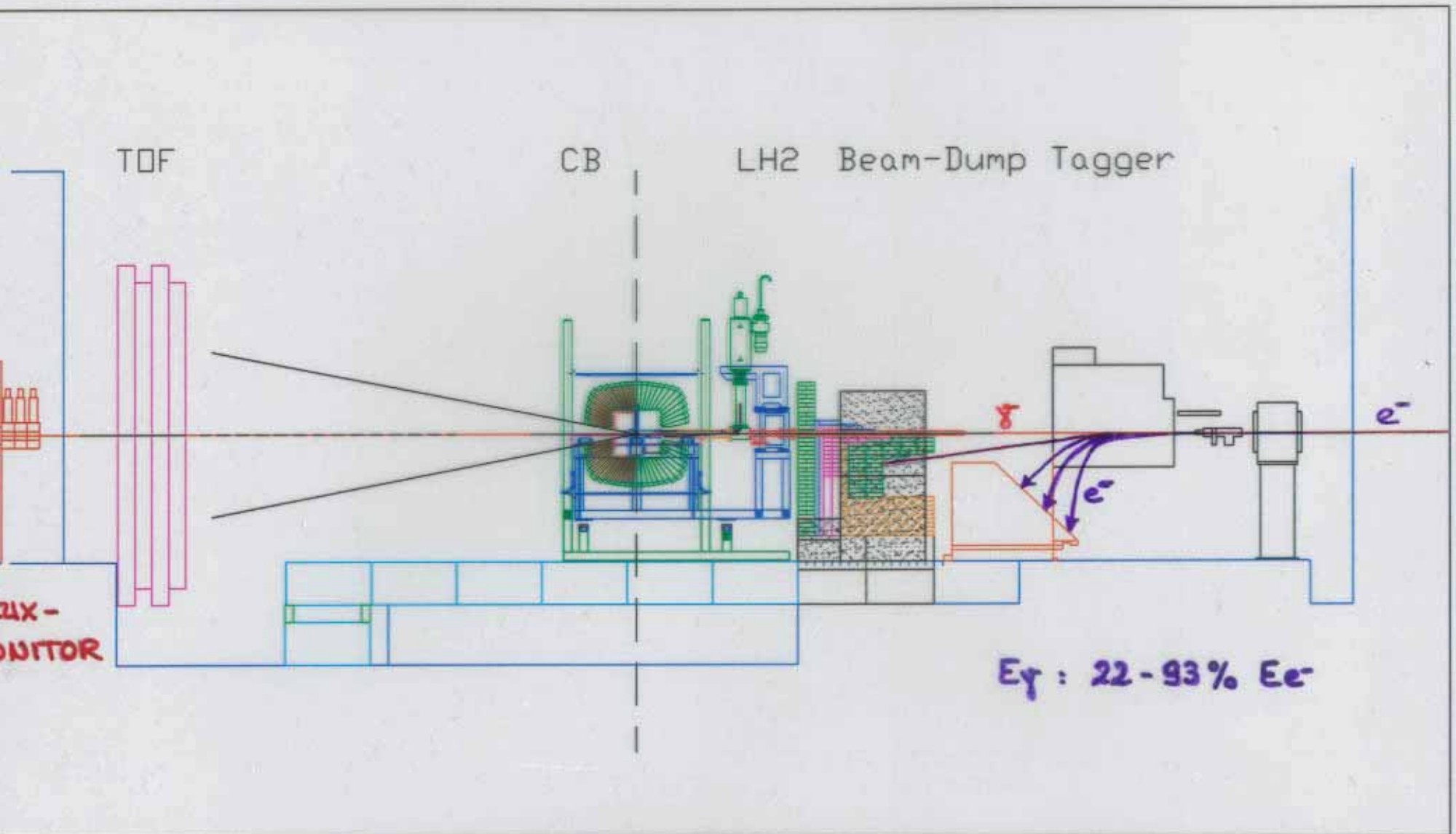
↔ ALL COMMON AMPLITUDES ARE RELATED BY ISOSPIN

# MEASUREMENT OF $\gamma p \rightarrow p \pi^+ \pi^-$ WITH CLAS

- VERY WELL SUITED TO MEASURE  
CHARGED PARTICLES



# CRYSTAL BARREL @ ELSA



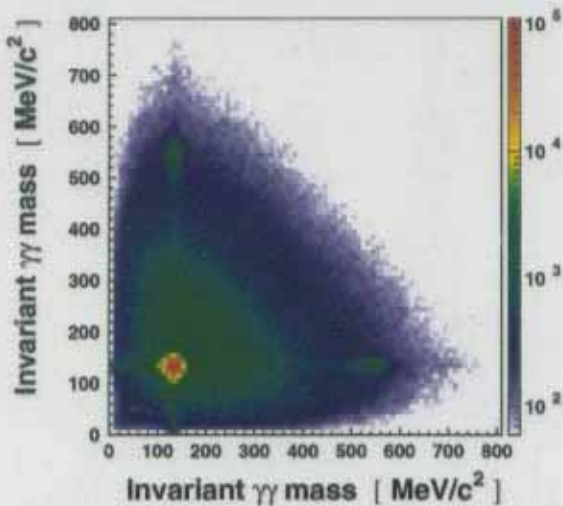
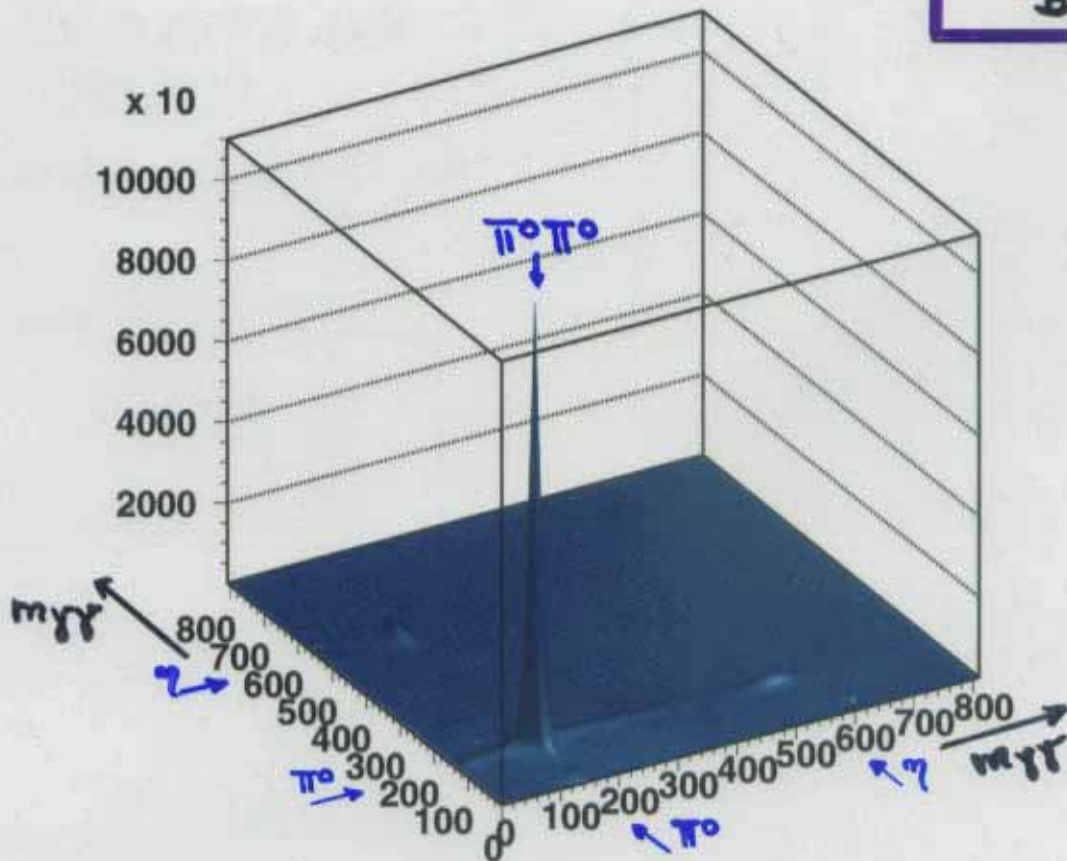
↪  $\gamma p \rightarrow \pi^0 \pi^0 p$  with  $E_{\text{beam}} = 1.4 \text{ GeV}, 2.6 \text{ GeV}, 3.2 \text{ GeV}$





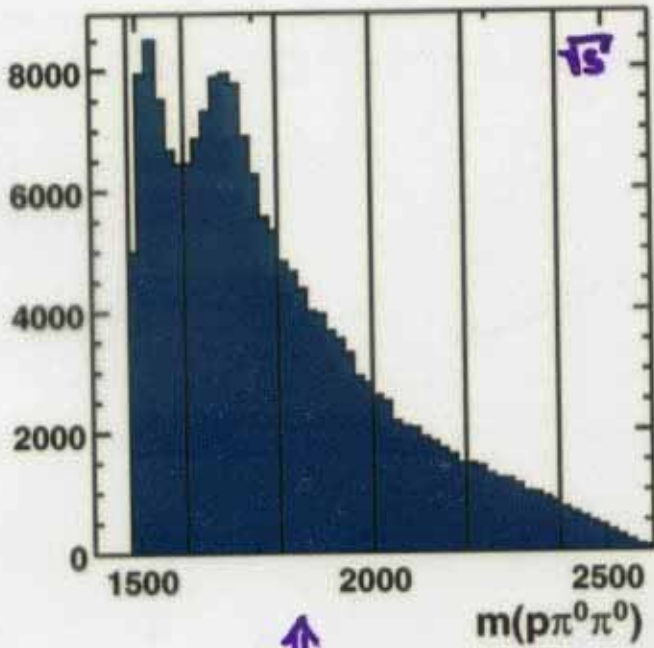
$\rightarrow p 4\gamma$ -EVENTS

CB-ELSA  
Bonn

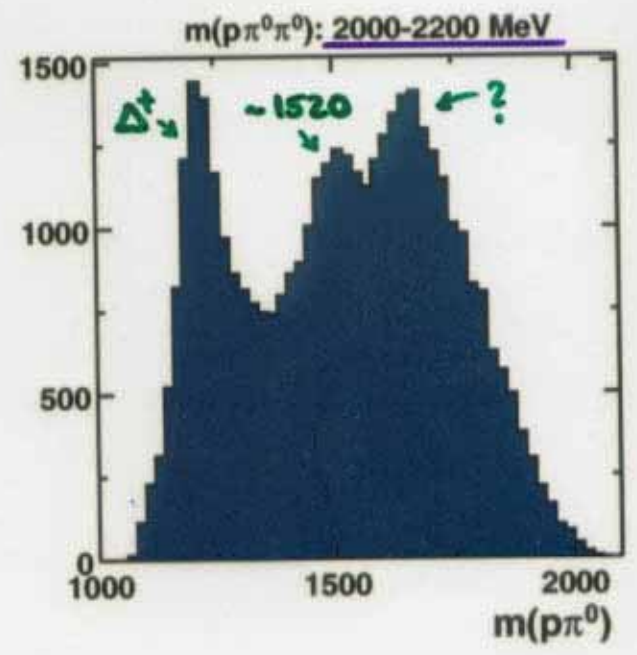
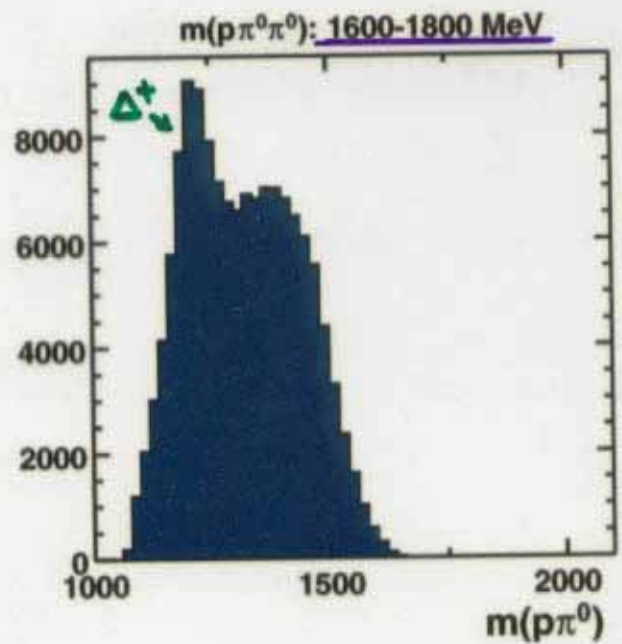
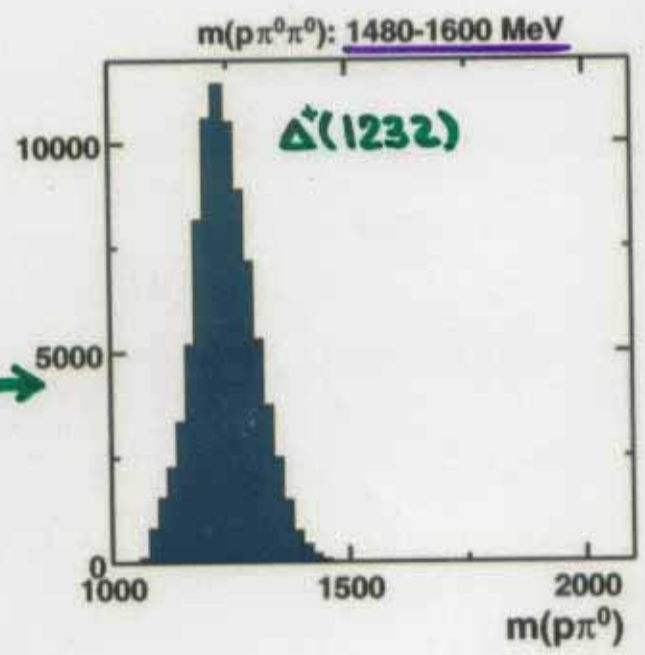
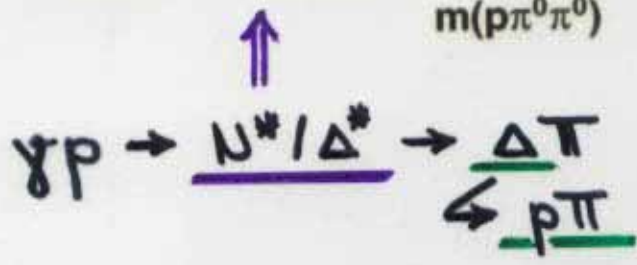


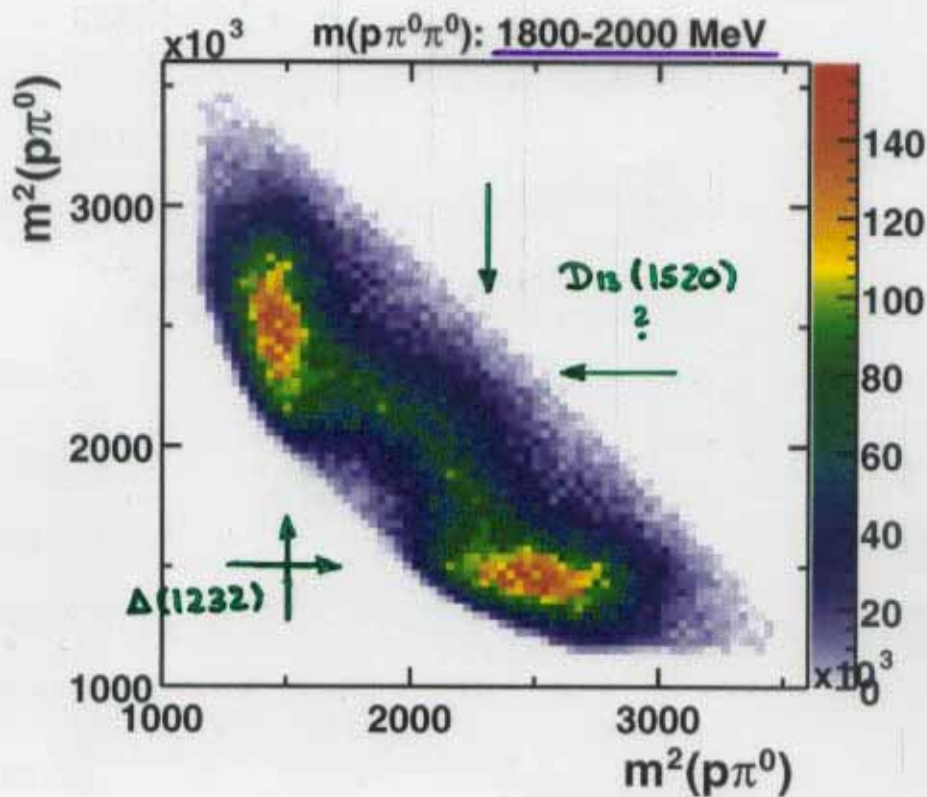
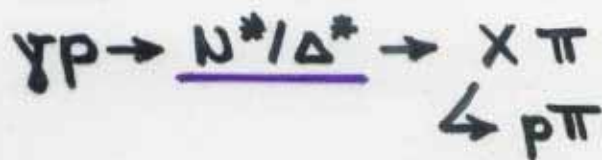
$\Rightarrow$   $\chi p \rightarrow p \pi^0 \pi^0$   
CLEARLY  
OBSERVED

$\gamma p \rightarrow p \pi^0 \pi^0$  @ 3.2 GeV

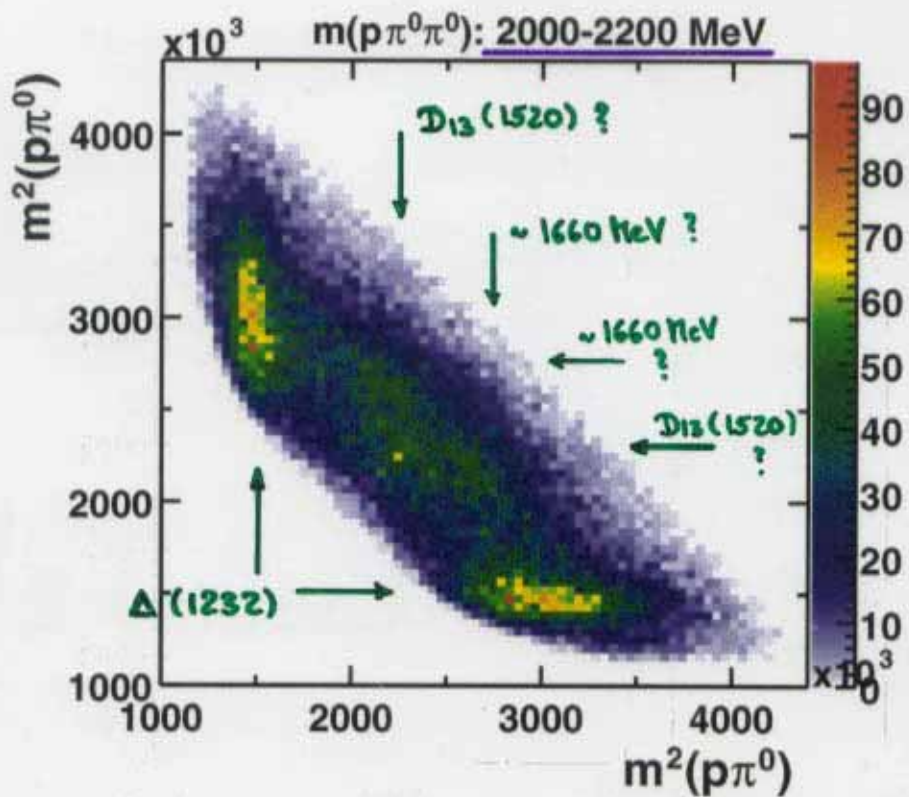
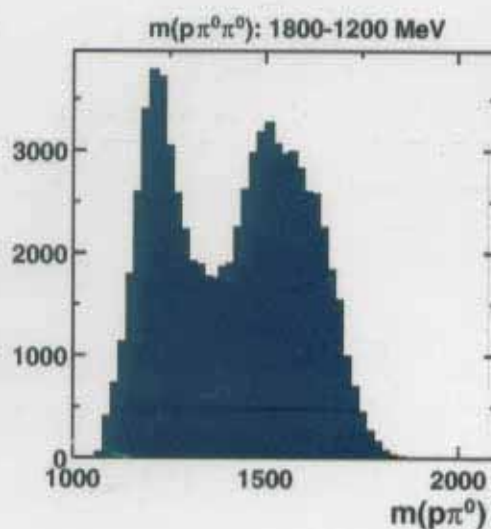


- NO FLUX NORMALISATION
  - NO EFFICIENCY CORRECTION
- ← PRELIMINARY

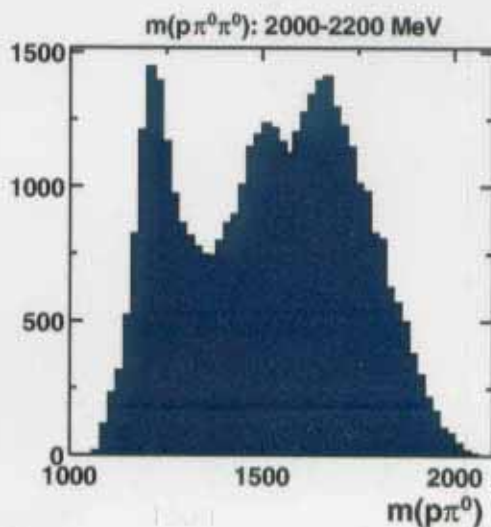




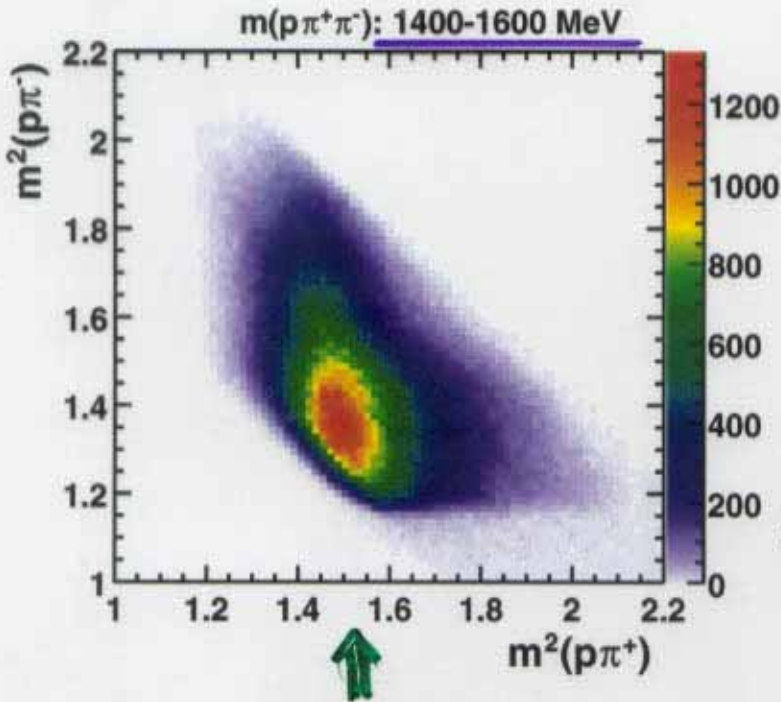
X :  $\Delta(1232)$   
 :  $D_{13}(1520) ?$



X :  $\Delta(1232)$   
 :  $D_{13}(1520) ?$   
 :  $\sim 1660 \text{ MeV} ?$

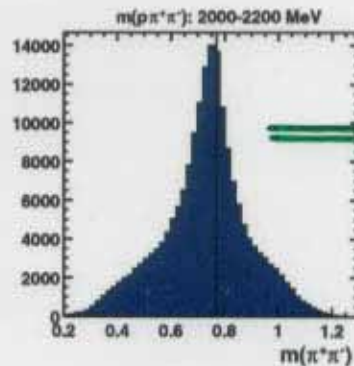
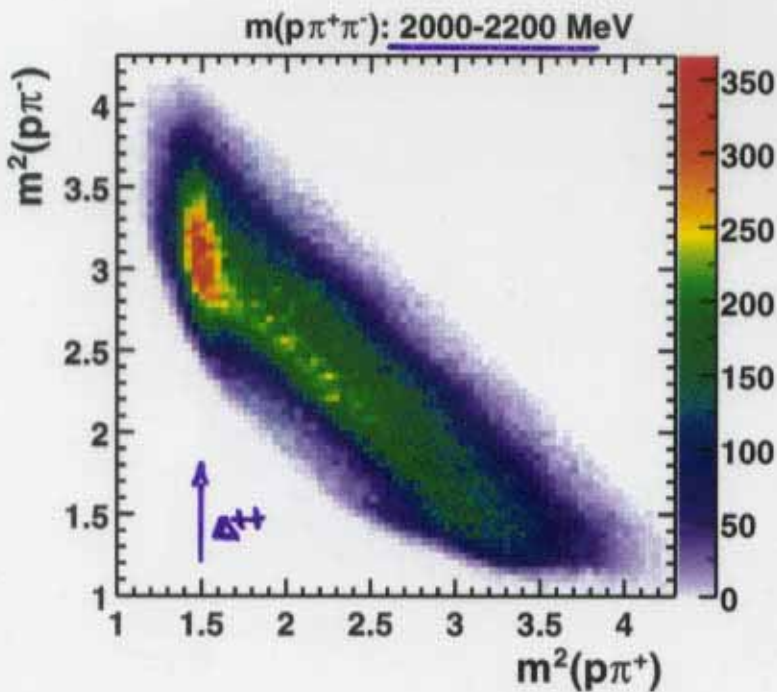
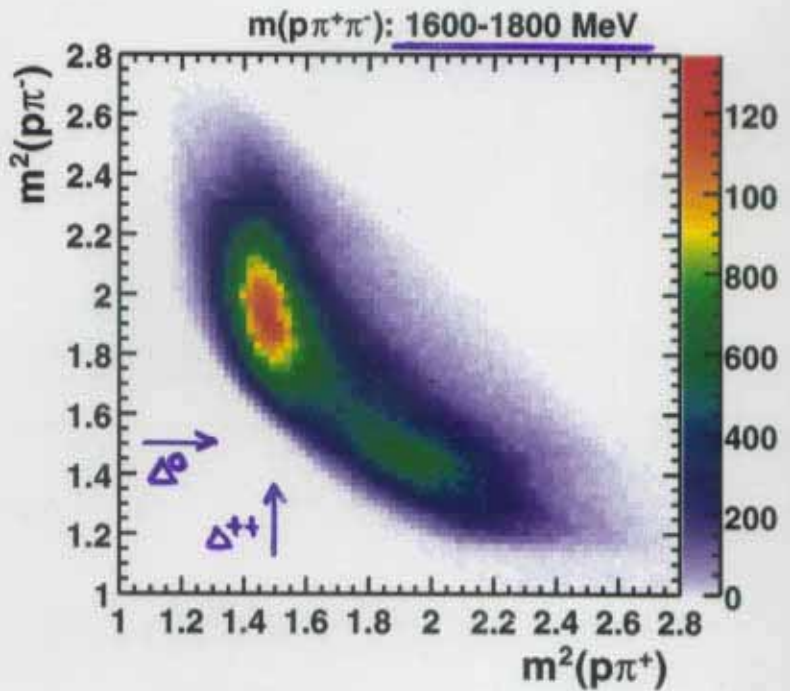


# CLAS : $\gamma p \rightarrow \pi^+ \pi^- p$



DIRECT  $\Delta^{++}\pi^-$   
PRODUCTION  
DOMINANT

- NO FLUX NORMALISATION
  - NO EFFICIENCY CORRECTION
- ↳ PRELIMINARY

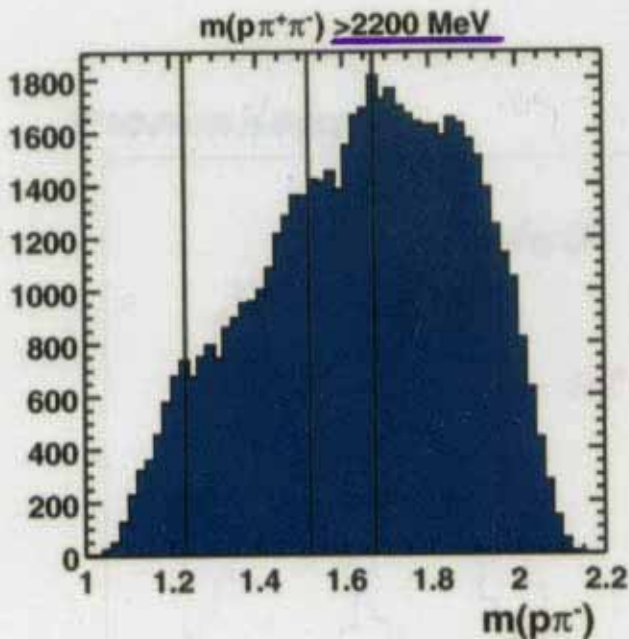
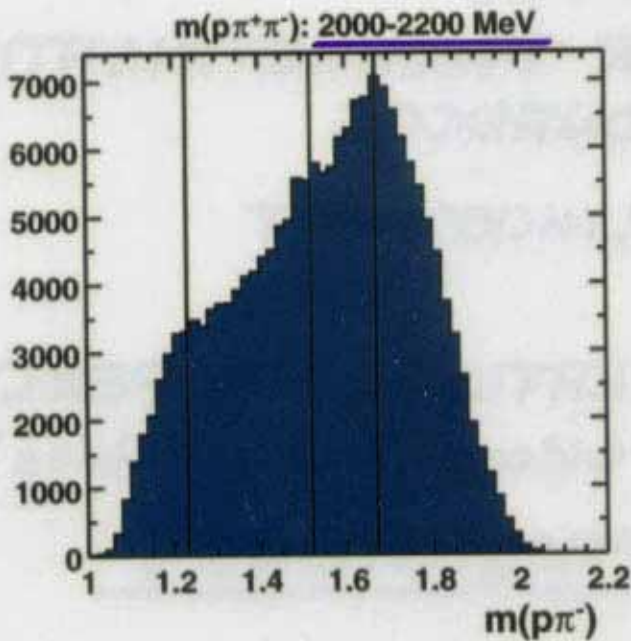


STRONG  $\rho(770)$

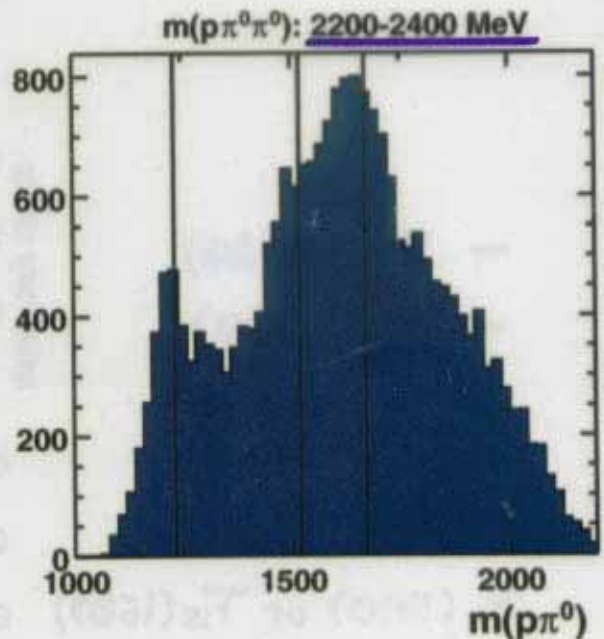
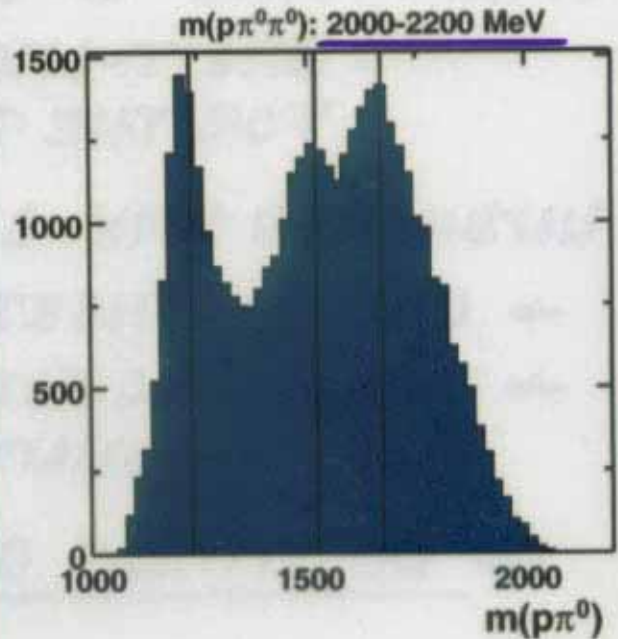
⇒  $\gamma p \rightarrow \underline{N^* / \Delta^*} \rightarrow N \underline{\rho}$  ?



CLAS:  $\gamma p \rightarrow \pi^+ \pi^- p$



CB-ELSA:  $\gamma p \rightarrow \pi^0 \pi^0 p$



↙ X :  $\Delta(1232)$   
 :  $D_{13}(1520)$  ?  
 :  $\sim 1660$  MeV ?

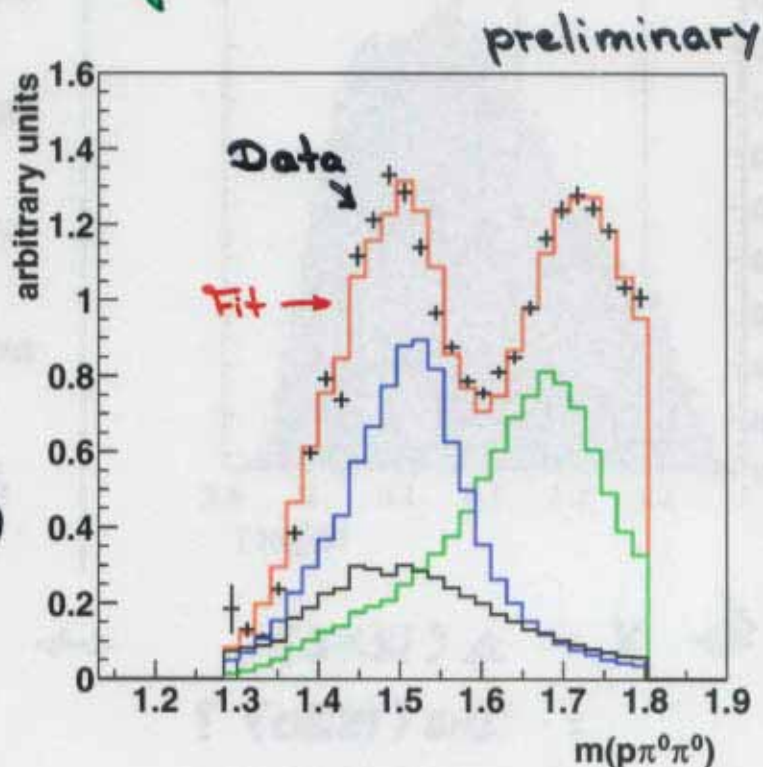
↔ SIMILAR RESONANCE STRUCTURES IN BOTH DATA SETS

# PRELIMINARY PARTIAL WAVE ANALYSIS

$$\underline{\underline{\gamma p \rightarrow p \pi^0 \pi^0 @ 1.4 \text{ GeV}}}$$

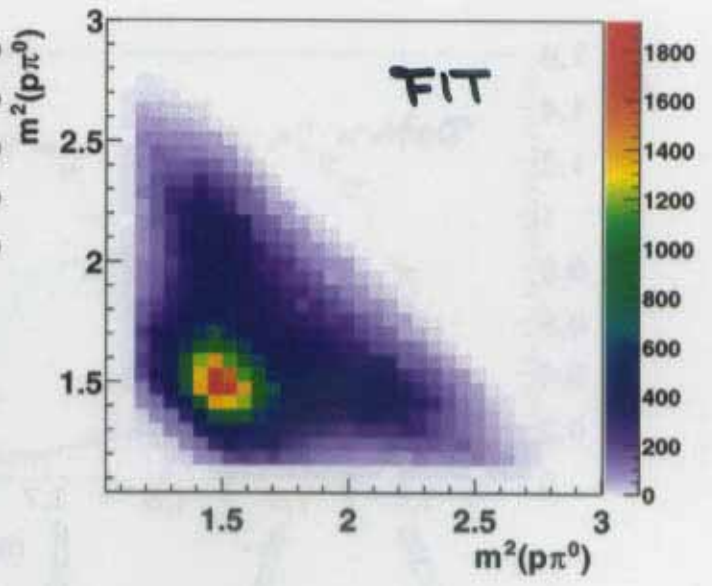
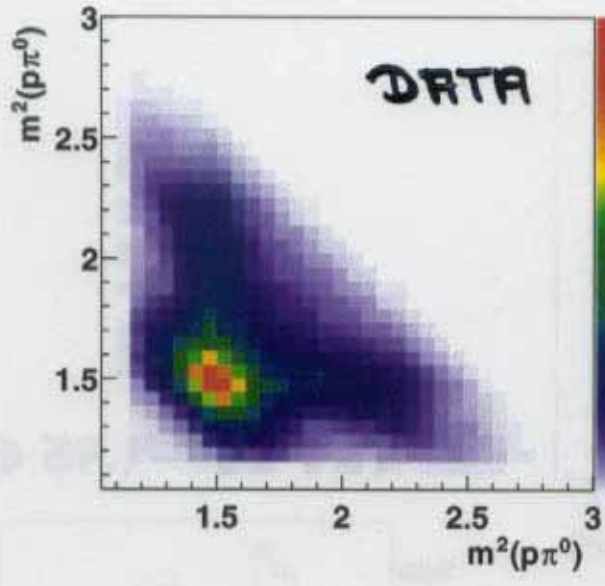
- ISOBAR MODEL
- so far : . ONLY s-CHANNEL
  - . BREIT-WIGNER PARAMETRISATION FOR THE RESONANCES
- UNBINNED MAX. LIKELIHOOD-FIT
  - EVENT BASED
  - TAKES ALL CORRELATIONS PROPERLY INTO ACCOUNT (5 independent variables)
  - ↳ NO FITTING OF PROJECTIONS!

- $D_{13}(1520)$
- $P_{11}(1440)$
- $D_{13}(1700)$
- $P_{13}(1720) +$   
 $P_{11}(1710) \text{ or } F_{15}(1680)$

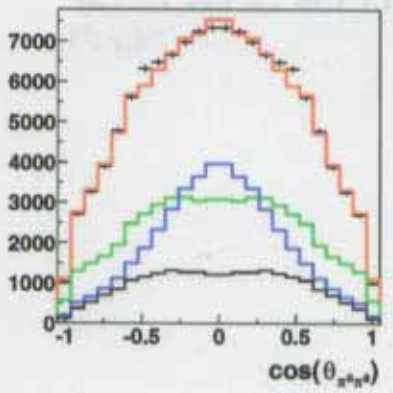
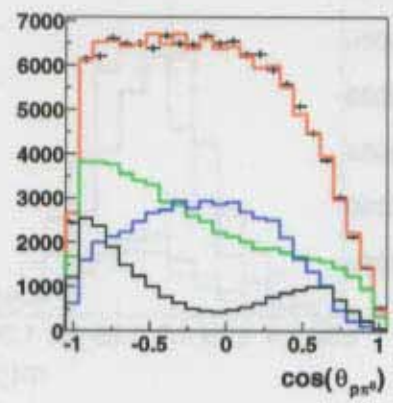
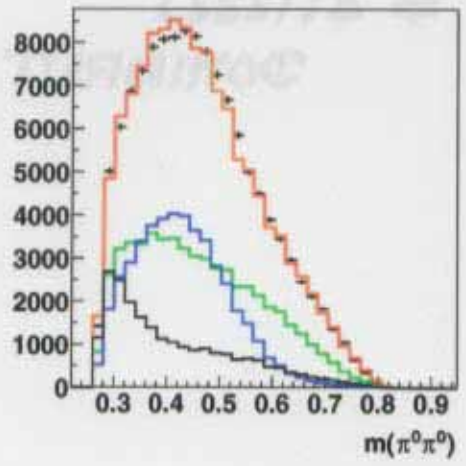
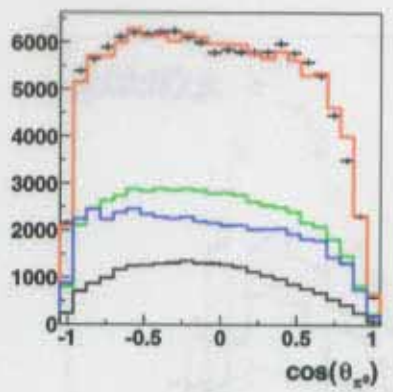
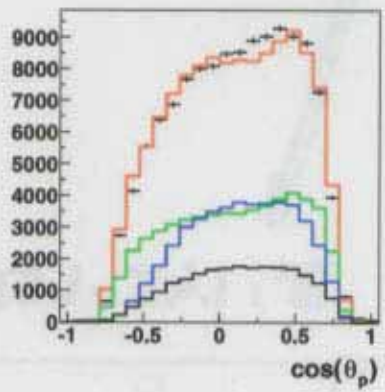
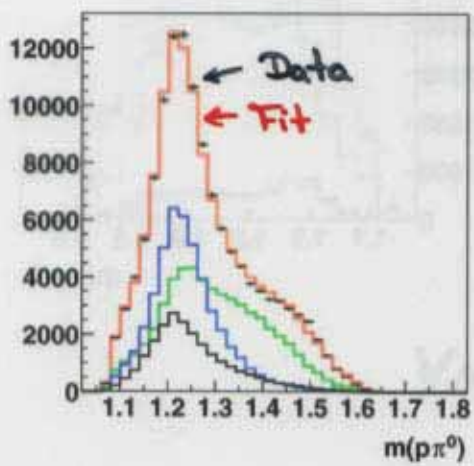


# $\gamma p \rightarrow p \pi^0 \pi^0$ : PRELIMINARY PARTIAL WAVE ANALYSIS

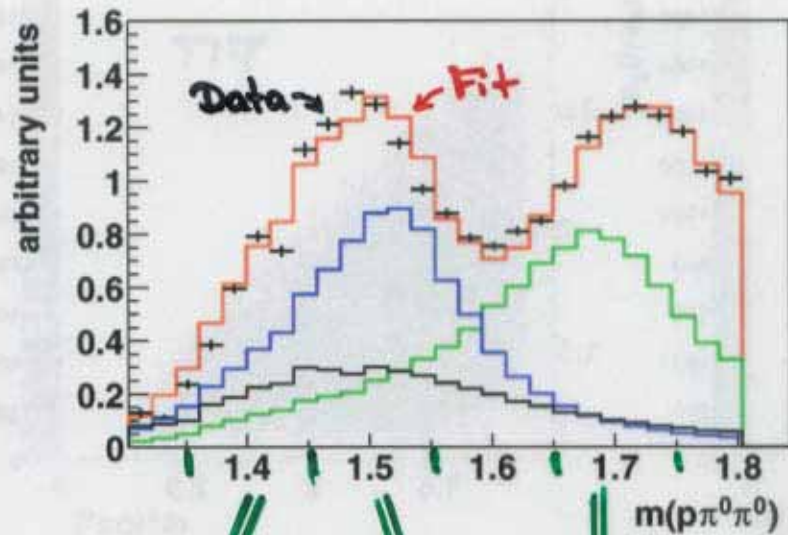
•  $E_{\text{beam}} = 1.4 \text{ GeV}$



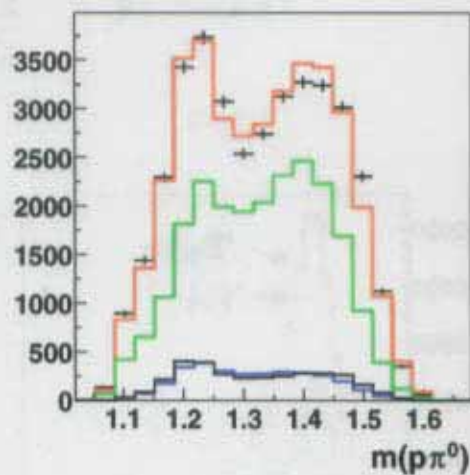
## ANGULAR DISTRIBUTIONS



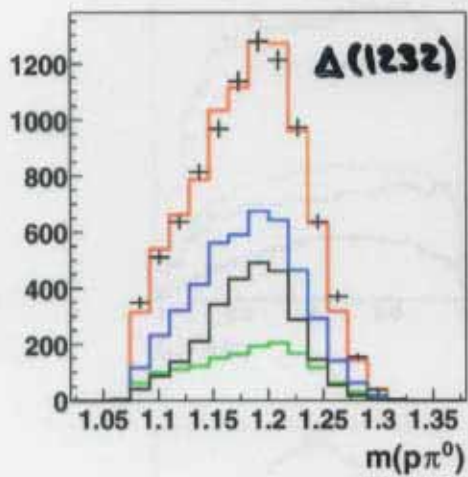
# $\Upsilon P \rightarrow p \pi^0 \pi^0$ : PREL. PARTIAL WAVE ANALYSIS



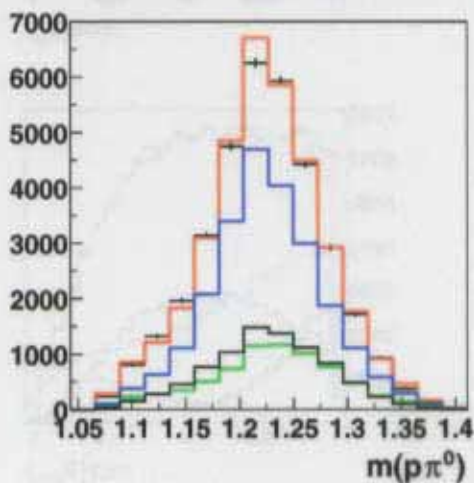
$\sqrt{s} = 1.65 - 1.75 \text{ GeV}$



$\sqrt{s} = 1.35 - 1.45 \text{ GeV}$



$\sqrt{s} = 1.45 - 1.55 \text{ GeV}$



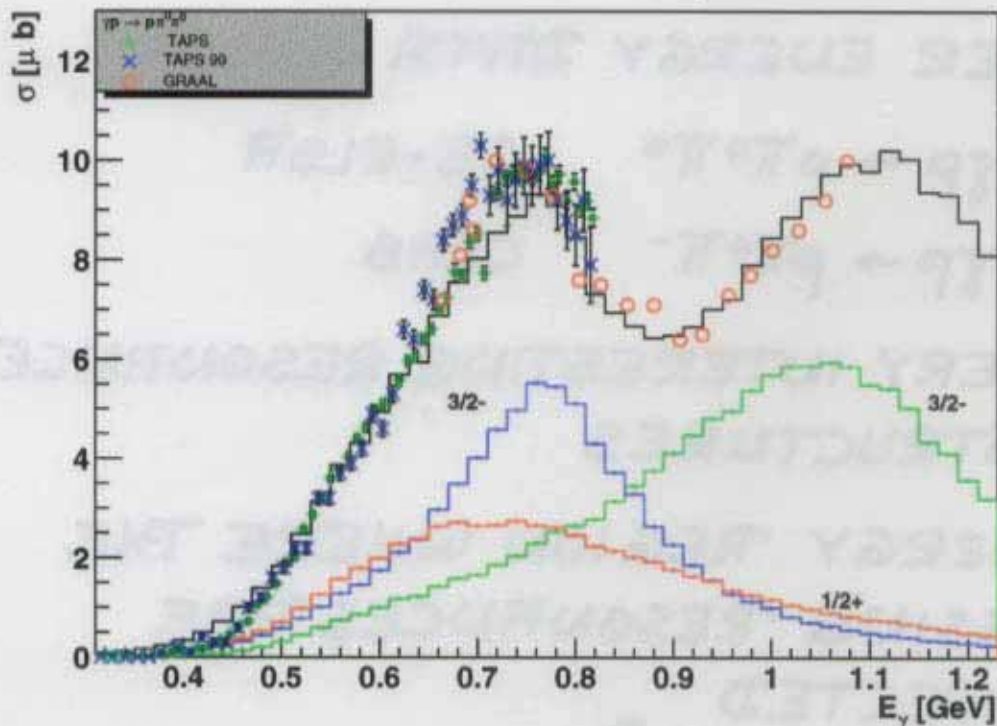
$\Rightarrow \Delta(1232)$   
DOMINANT



# TOTAL $\gamma p \rightarrow p\pi^0\pi^0$ - CROSS SECTION

→ DETERMINED FROM THE PWA

preliminary



## SOME RESULTS ON THE $D_{13}(1520)$ :

- $m, \Gamma$  CONSISTENT WITH PDG
- $A_{3/2} > A_{1/2}$
- $D_{13} \rightarrow \Delta\pi$  DOMINANT DECAY MODE IN  $\gamma p \rightarrow p\pi^0\pi^0$
- $\Delta\pi$ -S-WAVE >  $\Delta\pi$ -D-WAVE

# SUMMARY

→ FIRST PWA OF  $\gamma p \rightarrow p \pi^0 \pi^0$  @ 1.4 GeV  
LOOKS VERY PROMISING

to do : • ADD +- CHANNEL ...

→ HIGHER ENERGY DATA

$\gamma p \rightarrow p \pi^0 \pi^0$       CB-ELSA

$\gamma p \rightarrow p \pi^+ \pi^-$       CLAS

↳ VERY INTERESTING RESONANCE  
STRUCTURES

= ENERGY REGION WHERE THE  
MISSING RESONANCES ARE  
EXPECTED



PWA

**MISSING RESONANCES ?**

↳  $\Delta \pi$

↳  $N \pi$

↳  $N^* \pi$

↳  $N \sigma$