



Photoproduction of pion pairs from ${}^7\text{Li}$

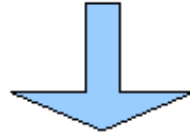
Yasser Maghrbi

Graduertenkolleg - Hallstatt - September 2009

Outline

- Introduction - Motivation - Existing results
- Experimental setup
- Results
- Conclusion

Meson photoproduction off light and heavy nuclei



important tool in hadron physics

Some applications :

- **Investigation of meson-nucleon / meson-nucleus interaction :**
 - meson free mean path in nuclear matter
 - search for meson-nucleon bound state
- **Possible in-medium modifications of hadrons :**
 - predicted effects on the in-medium mass and width of vector mesons and on certain nucleon resonances
 - the investigation of the invariant mass distributions of pion pairs in view of in-medium effects on the much discussed meson : σ
- **Use of coherent pion production for the study of the mass form factors of atomic nuclei**

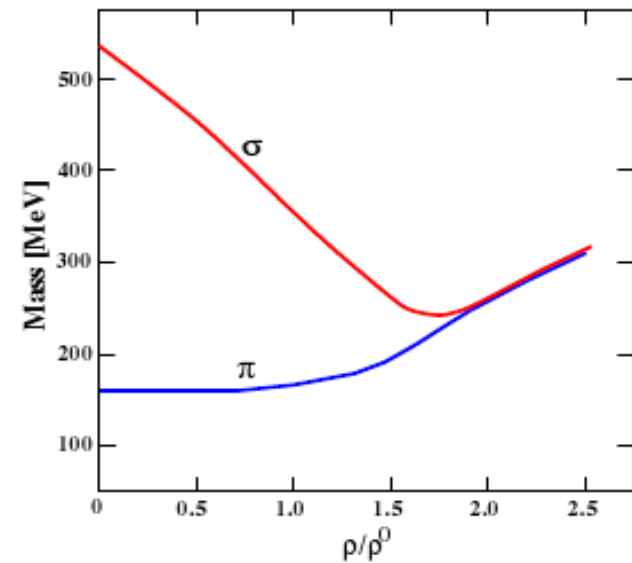
σ Meson ?

In medium modification of σ meson

Models : Mass (σ) \searrow when nuclear density \nearrow and σ becomes degenerate with its chiral partner π at large density

- σ meson decays into $\pi^0\pi^0$ but not $\pi^0\pi^{+/-}$
Expect shift in invariant mass distributions towards small values in $\pi^0\pi^0$

- predicted dependence of σ -mass on density (V.Bernard et al.):



- masses of chiral partners degenerate in chiral limit

$$m_\sigma = m_{\sigma_0}(1 - \alpha\rho/\rho_0)$$

Introduction

Existing results

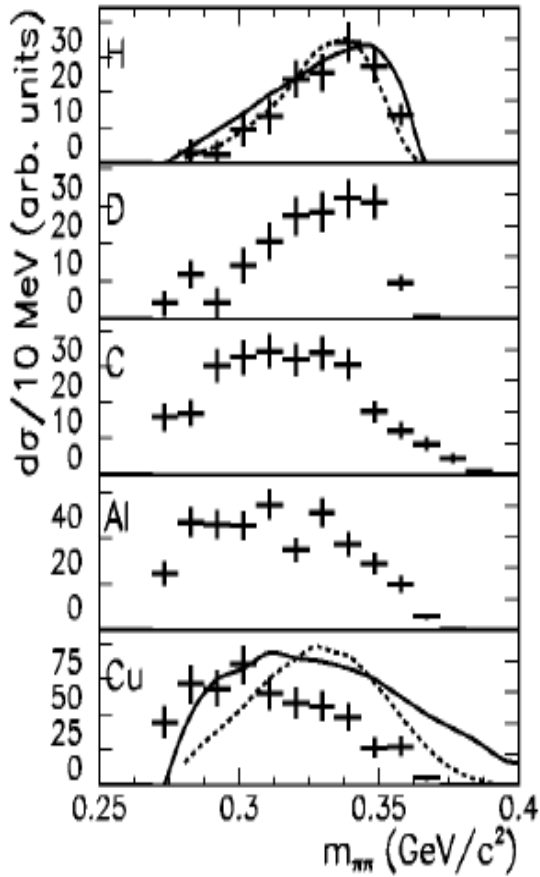
- CHAOS
- CB @ BNL
- TAPS @ MAMI
- ⇒ CB-TAPS @ MAMI

Introduction

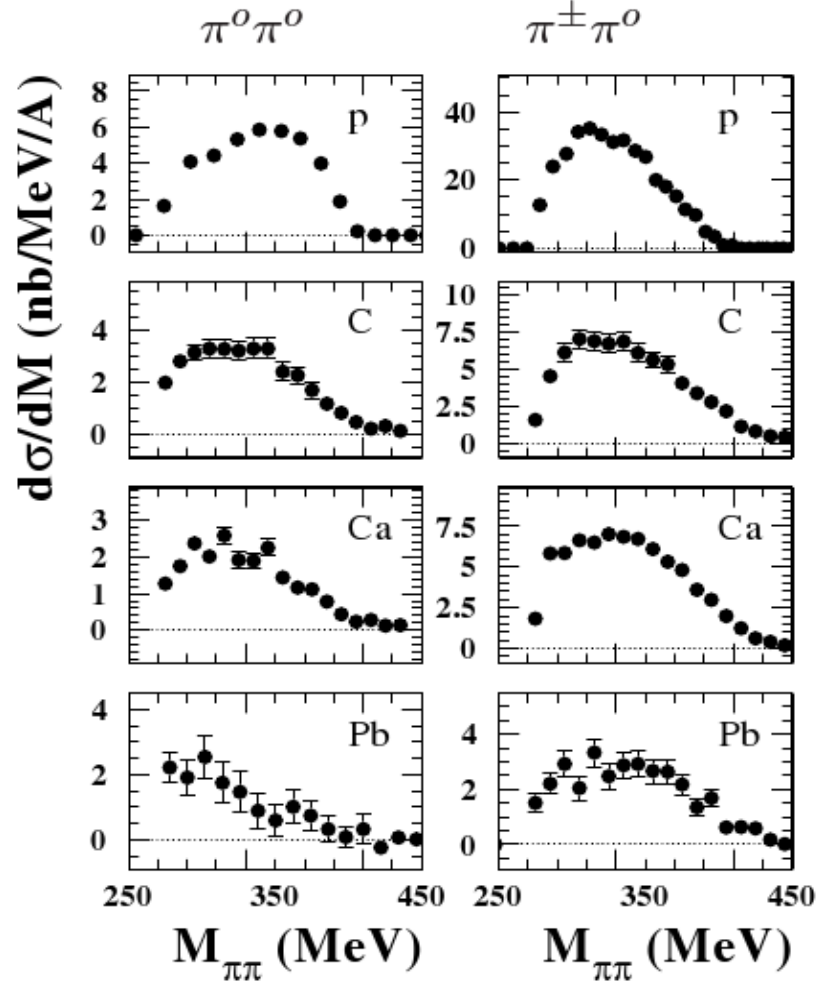
Existing results

Crystal Ball@BNL: (S. Starostin et al.)

$\pi^- A \rightarrow A' \pi^0 \pi^0$ reaction

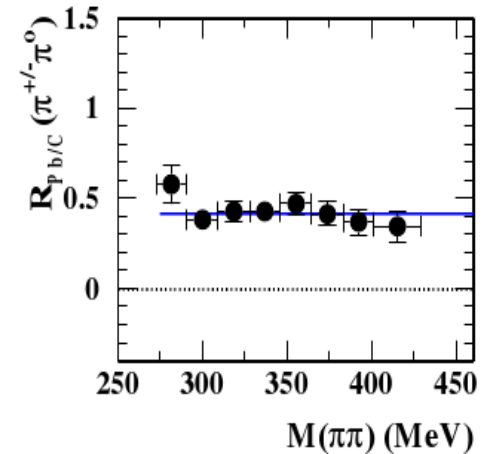
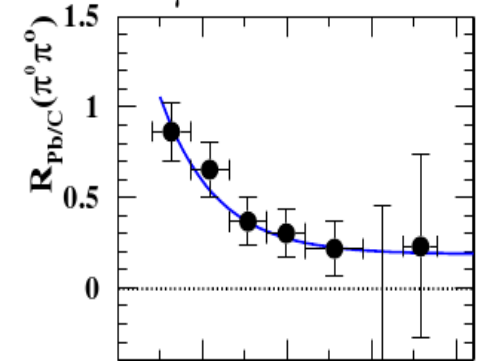


TAPS@MAMI



$$R_{Pb/C} \equiv \left(12 \frac{d\sigma}{dm}\right)_{Pb} / \left(208 \frac{d\sigma}{dm}\right)_C$$

$E_\gamma = 400-500$ MeV

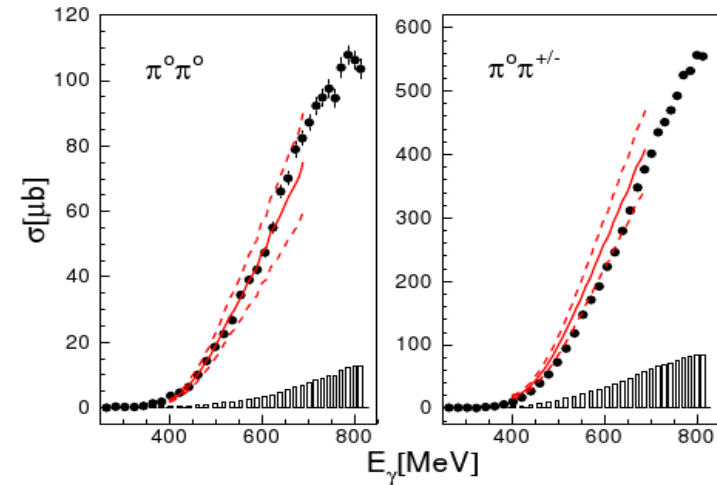
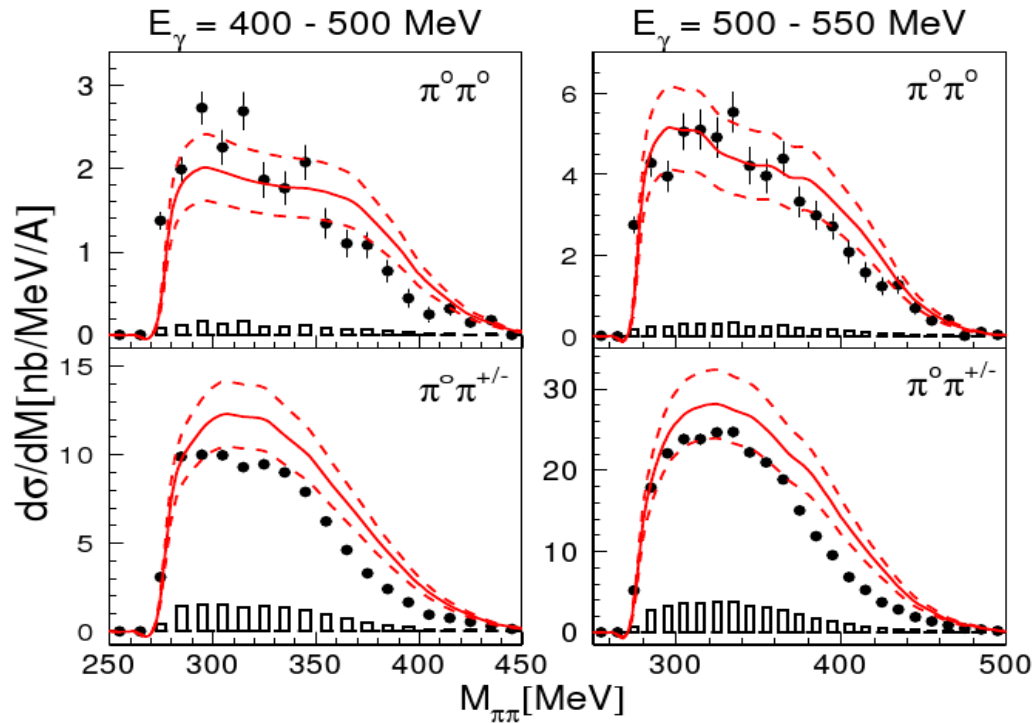


Introduction

FSI or in-medium effect?

● invariant mass distributions

● total cross sections



● Data: F. Bloch et al. (Basel), Eur. Phys. J. A32 (2007) 219

● Model: O. Buss et al. (Giessen), nucl-th/0502031

- Shift observed on Ca (latest results)
- BUU (FSI ONLY) shift in the same way

Let's summarize!

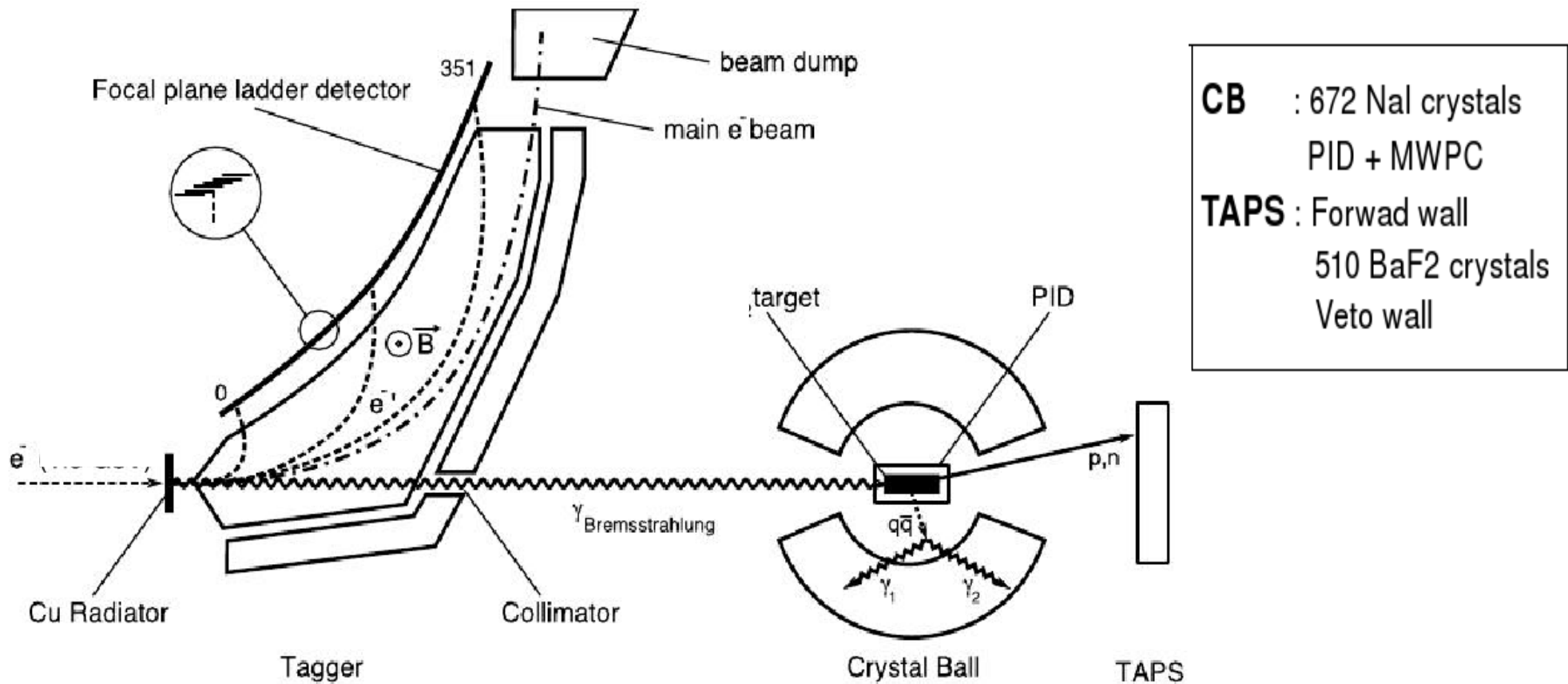
- Shift observation confirmed @ different experiments.
- Only model : BUU on Ca, *includes only FSI but no in-medium modifications!*
 - ⇒ Need to go much lower on energy and finer bins
 - ⇒ New data with high statistics and better detection

CB-TAPS @ MAMI

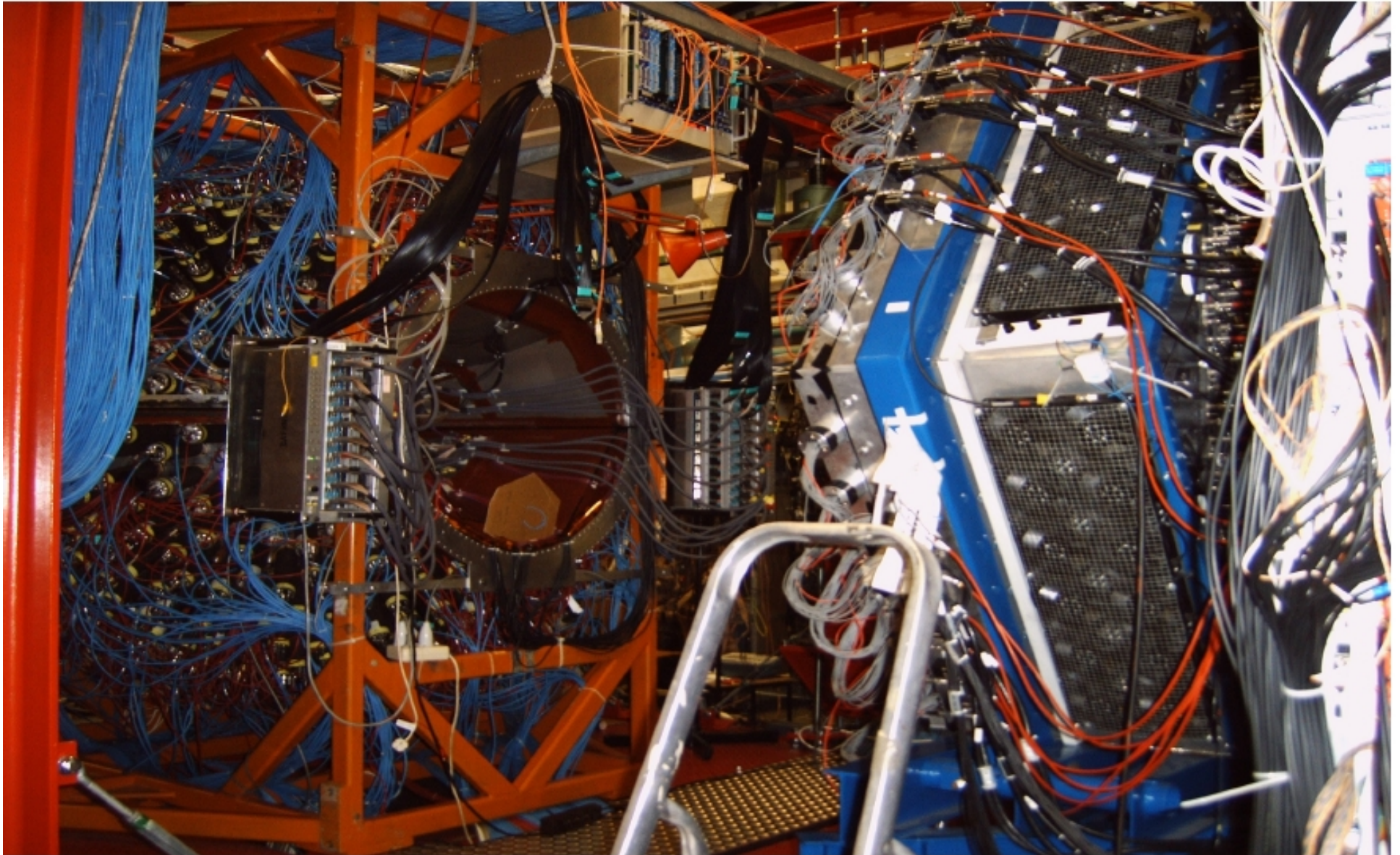
- Nuclei comparison : p, C, Ca, Pb
 - ⇒ Need new reference light nucleus : Li
 - ⇒ New series of data in 2005

Experimental setup

- Experiment performed in 2005 within the MAMI B (883 MeV), $I = 6$ nA
180 hours of beam \Rightarrow acceptable statistics to study $\pi\pi$ in medium effects
and coherent η production (2200 η/h)



Experimental setup



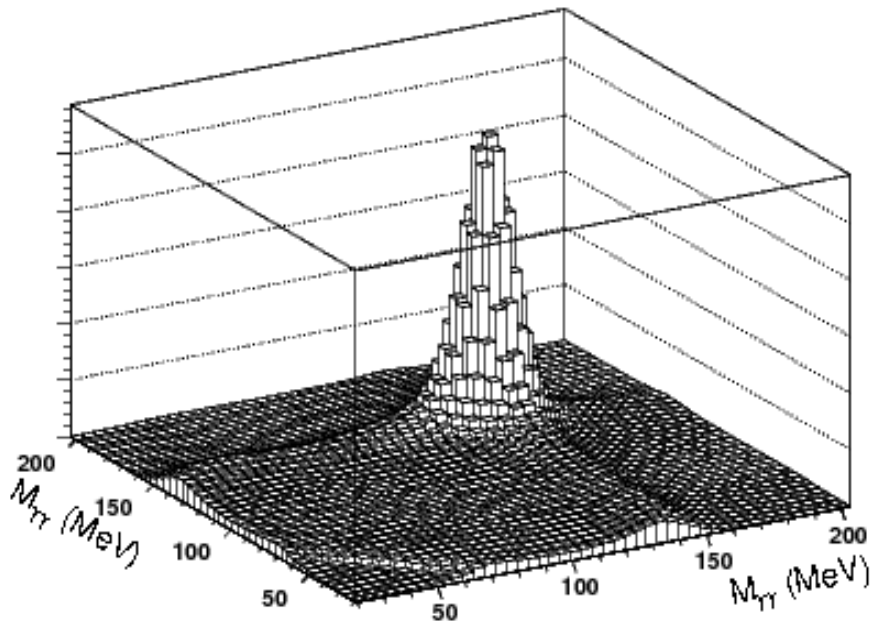
Results

Shift towards small invariant mass :

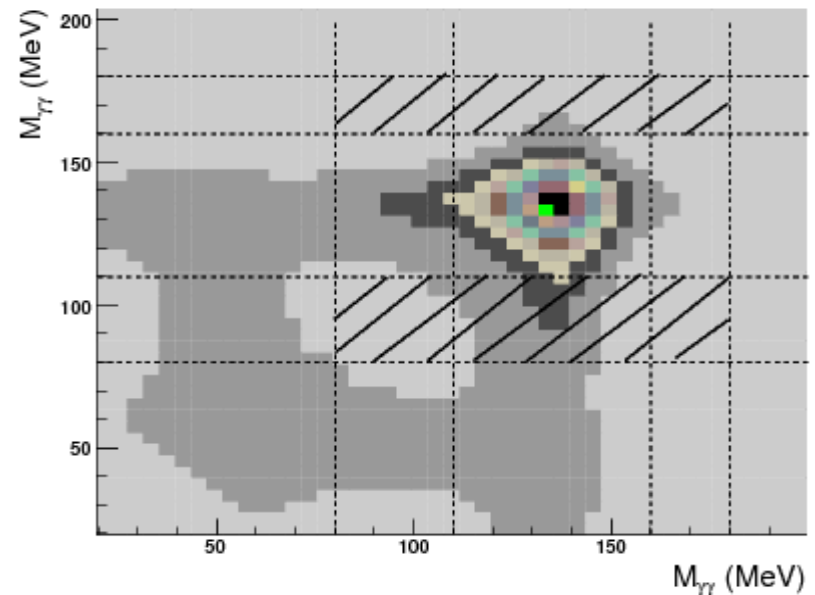
- Observed with increasing A
 - Observed for neutral channel but not for charged
- ⇒ comparison Li / other nuclei
- ⇒ comparison charged and neutral distributions of Li
-
- *Channel identification*
 - *Cross sections*
 - *Mass distributions - comparison*

Results Neutral channel

- select events with 4/5 neutral hits + invariant mass of all photon pairs
- select best combination of 4γ by χ^2 test
- True signal = Signal [110-160] – (Signal [80-110] + Signal [160-180])



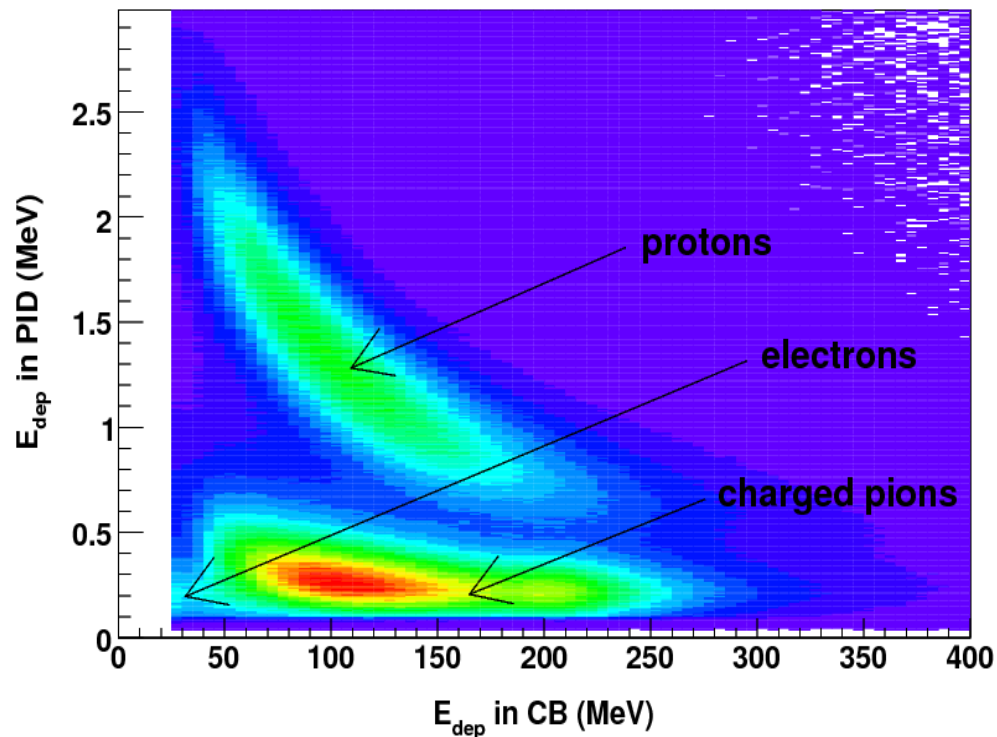
Invariant mass system of 2 pions



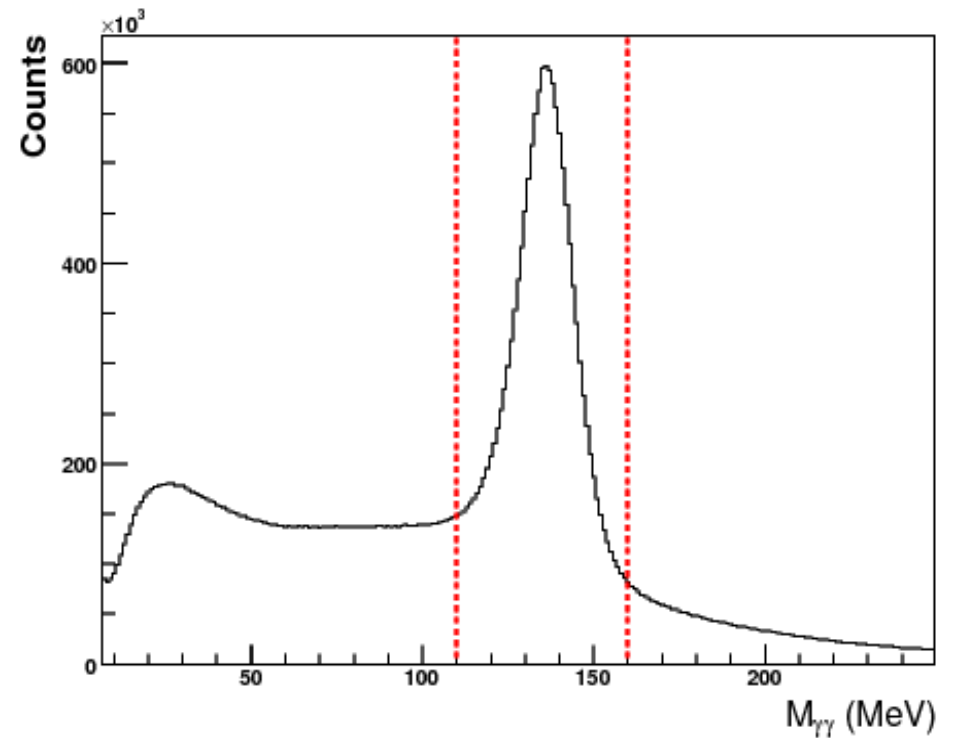
additional background removed
from hatched areas

Results Charged channel

- 3 cases : - $\pi^0\pi^{+/-}$
- $\pi^0\pi^+n$
- $\pi^0\pi^-p$



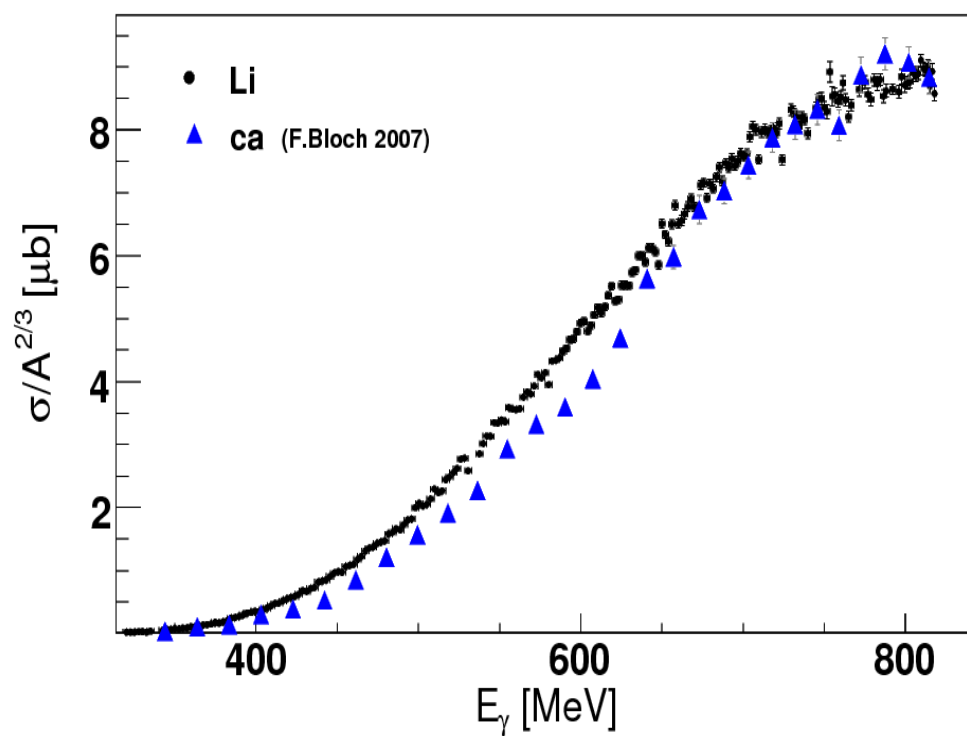
CB/PID charged particles identification



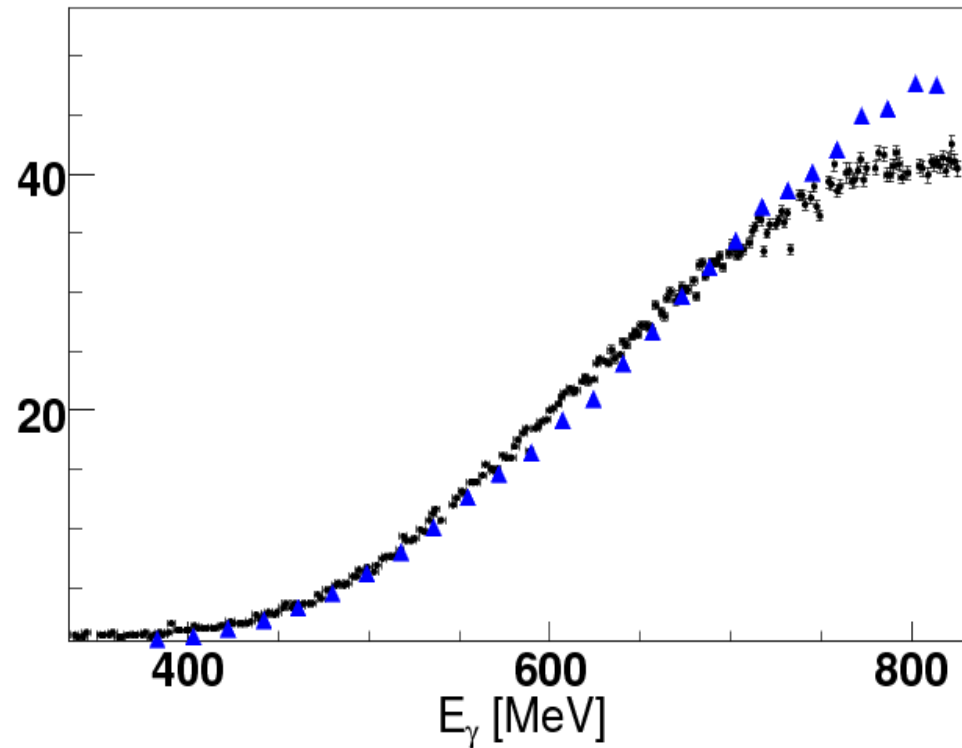
neutral pion invariant mass

Results

Cross sections

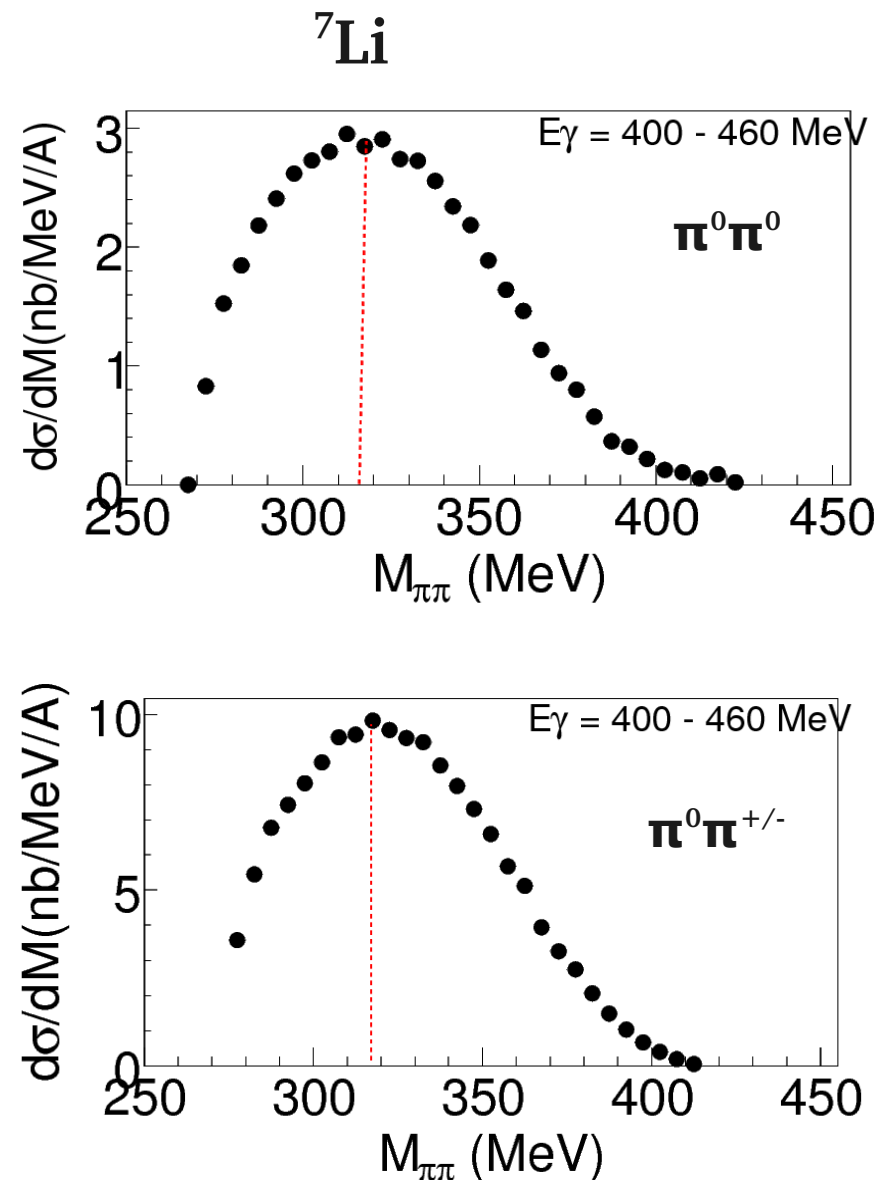
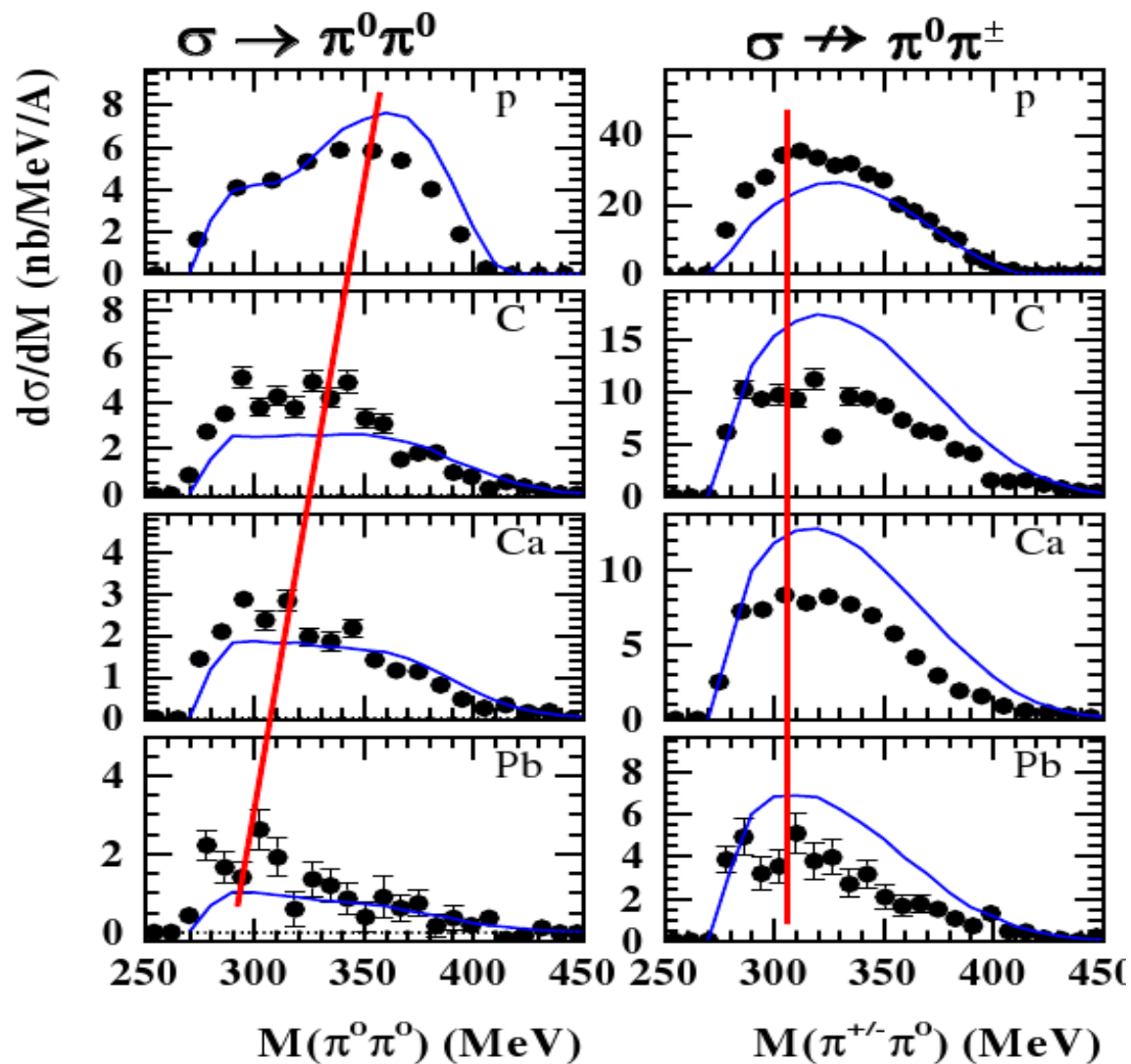


Neutral channel



charged channel

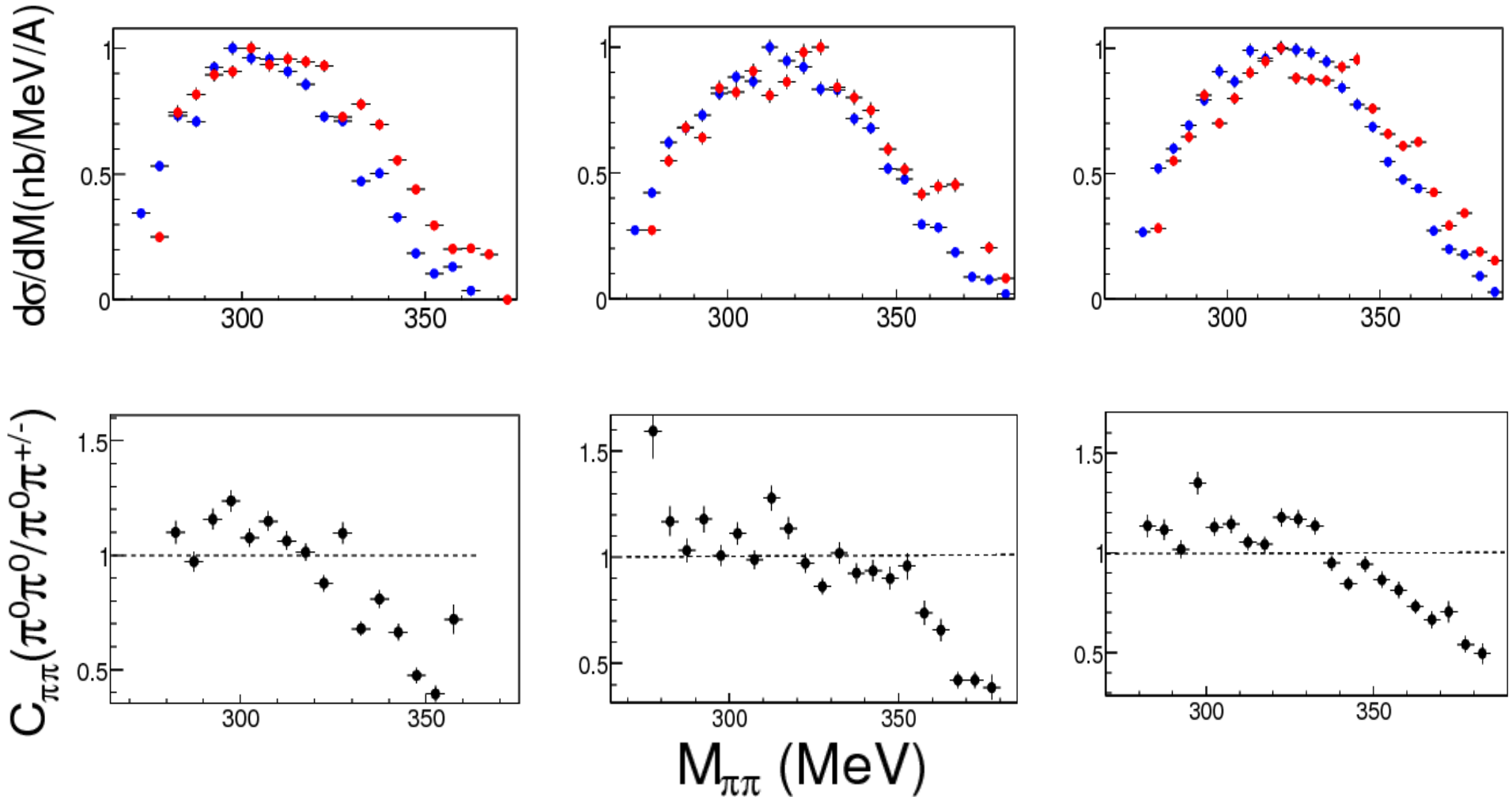
Results comp. TAPS data [400-460] MeV



Results

Finer energy bins

- ${}^7\text{Li}(\gamma, \pi^0 \pi^0) X$
- ${}^7\text{Li}(\gamma, \pi^0 \pi^{\pm}) X$



300–350 MeV

400–420 MeV

420–440 MeV

To sum up..

- High statistics experiment \Rightarrow small and close to threshold bins
- Charged channel very sensitive to the analysis parameters
- Mass distributions in agreement with the different nuclei for [400-460] MeV (predicted effect seen on neutral channel, charged channel unchanged)
- Ratio neutral/charged on ${}^7\text{Li}$ for fine bins \Rightarrow small shift towards small invariant mass seen

Coming up :

- finish analysis of high statistics data (Ca, C, Pb), compare to Li

Guten Appetit