$\Lambda(1405)$ production in the $\pi p \to K^0 \pi\Sigma$ reaction

Tetsuo Hyodo[a]

A. Hosaka[a], E. Oset[b], A. Ramos[c] and M. J. Vicente Vacas[b]

[a] RCNP, Osaka [b] IFIC, Valencia [c] Barcelona Univ.

2003, July 31st

Contents

MB scattering

1. Motivation
2. Chiral unitary model
3. $\Lambda(1405)$ in the chiral unitary model
4. Model for $\pi^- p \to K^0 \pi \Sigma$
5. Results
6. Conclusions
7. Experiments + α

T. Hyodo, *et al.*, nucl-th/0307005

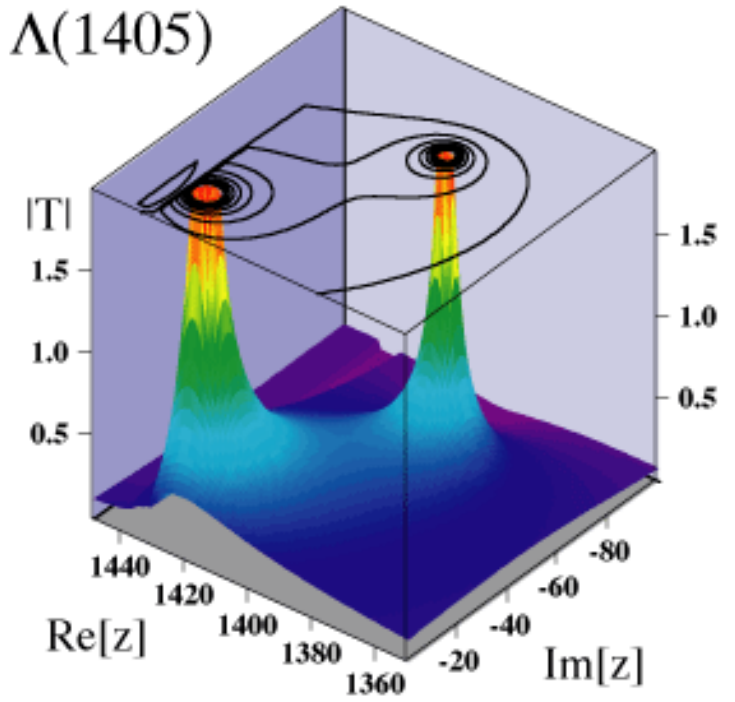
Motivations : Two poles?

There are two poles of the scattering amplitude around nominal Λ(1405) energy region.

- **Cloudy bag model**
  (1990)
  Fink *et al.* PRC41, 2720

- **Chiral unitary model**
  (2001~)
  Oller *et al.* PLB500, 263
  Oset *et al.* PLB527, 99
  Jido *et al.* PRC66, 025203
  Hyodo *et al.* PRC68, 018201

Λ(1405) : $J^P=1/2^-$, I=0



Chiral unitary model

Flavor SU(3) meson-baryon scatterings (s-wave)

Chiral symmetry

Low energy behavior

+

Unitarity of S-matrix

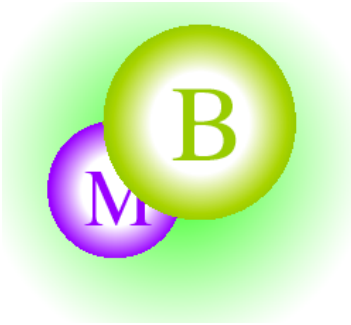
Non-perturbative resummation

Dynamical generation

$$J^P = 1/2^-$$

Resonances

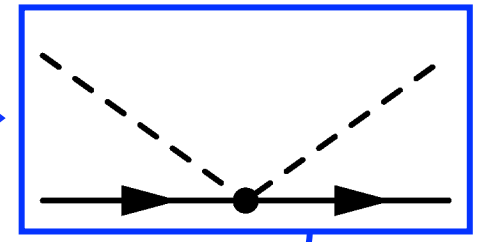
$\Lambda(1405), \Lambda(1670), N(1535), \Sigma(1620), \Xi(1620)$



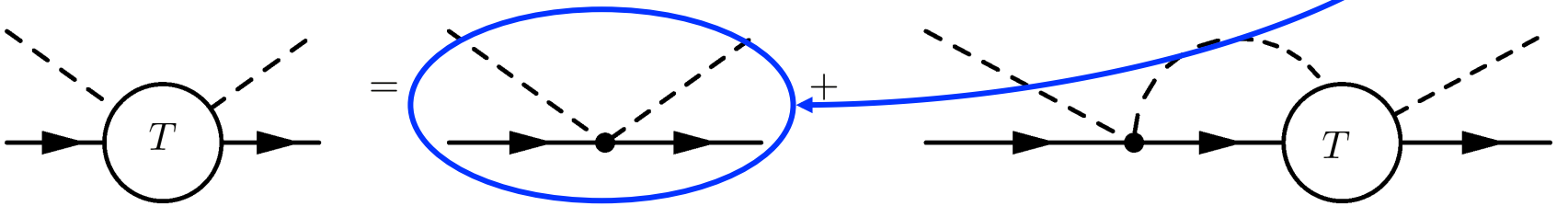
Framework of the chiral unitary model

Chiral perturbation theory

$$\mathcal{L}_{WT} = \frac{1}{4f^2}\mathrm{Tr}(\bar{B}i\gamma^\mu[(\Phi\partial_\mu\Phi - \partial_\mu\Phi\Phi), B])$$



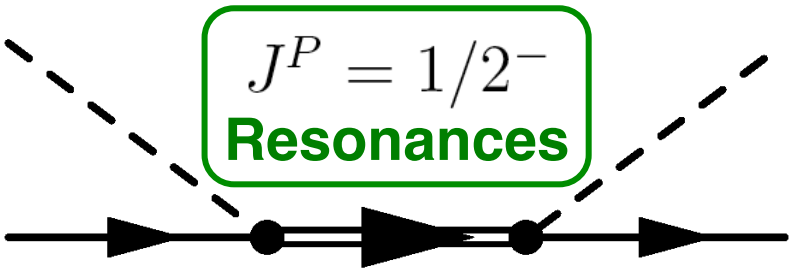
Unitarization



$$T_{ij}(\sqrt{s}) \sim \frac{g_i g_j}{\sqrt{s} - M_R + i\Gamma_R/2} + T_{ij}^{BG}$$

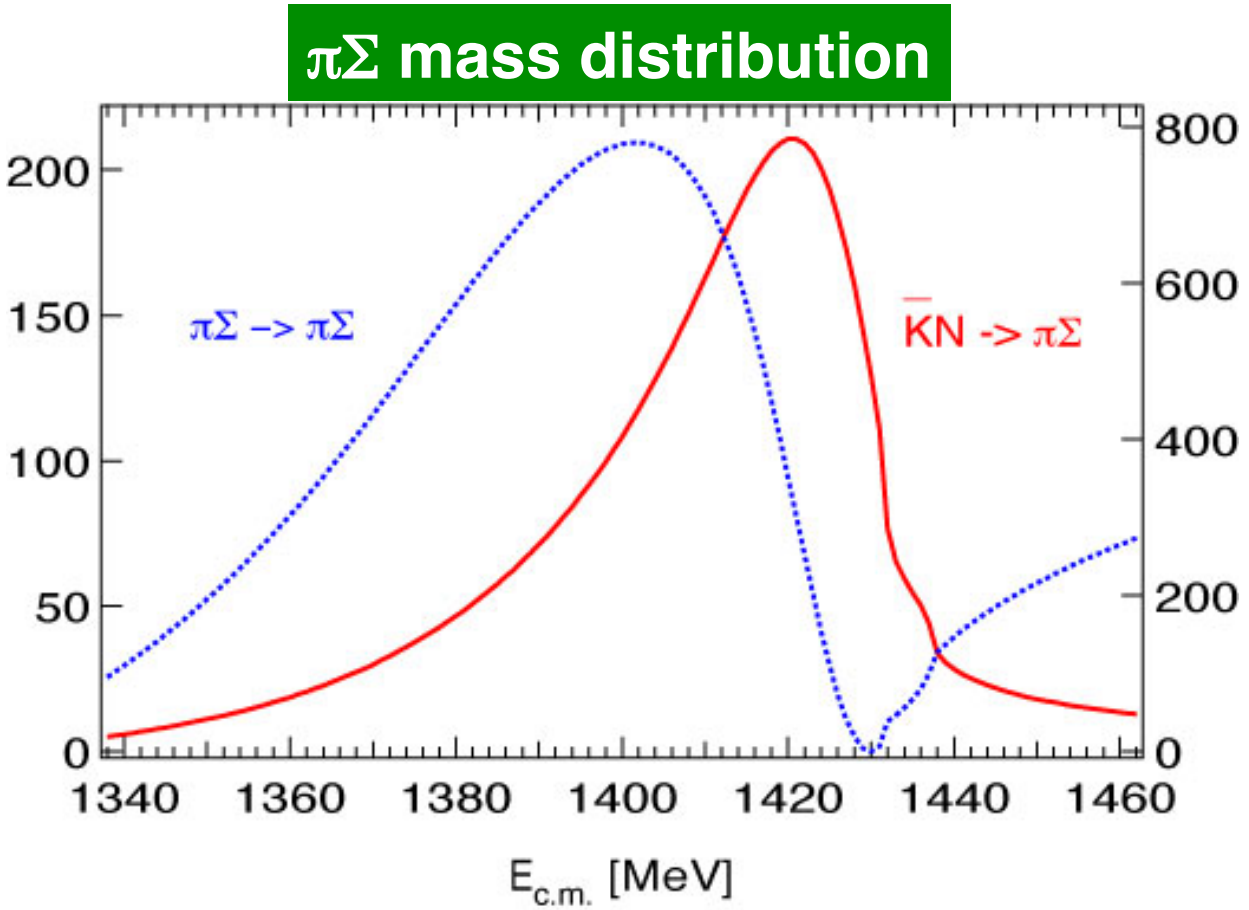
Generated resonances are expressed as poles of the scattering amplitude.

$\sim$



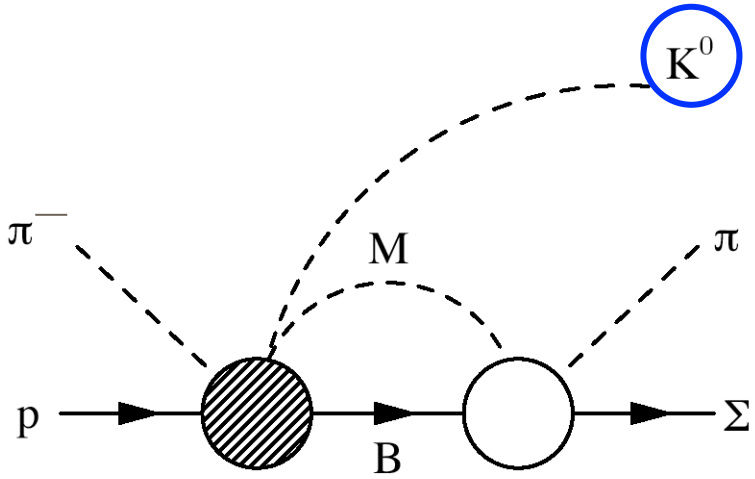
Λ(1405) in the chiral unitary model

Two poles : 1390 + 66i ($\pi\Sigma$), 1426 + 16i ($\bar{K}N$)



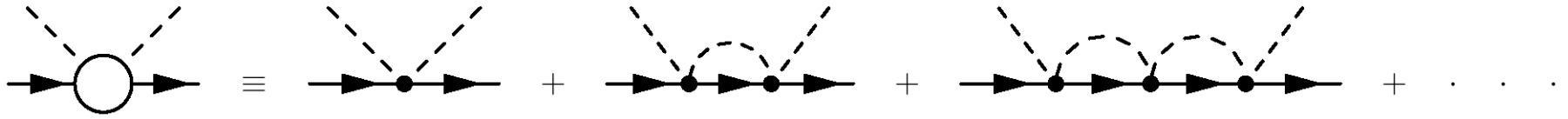
D. Jido, *et al.*, nucl-th/0303062

Mechanism of $\pi^- p \to K^0 \pi\Sigma$



K^0 ~ at rest

$\pi^- p$ c.m. frame ~ $\pi\Sigma$ c.m. frame



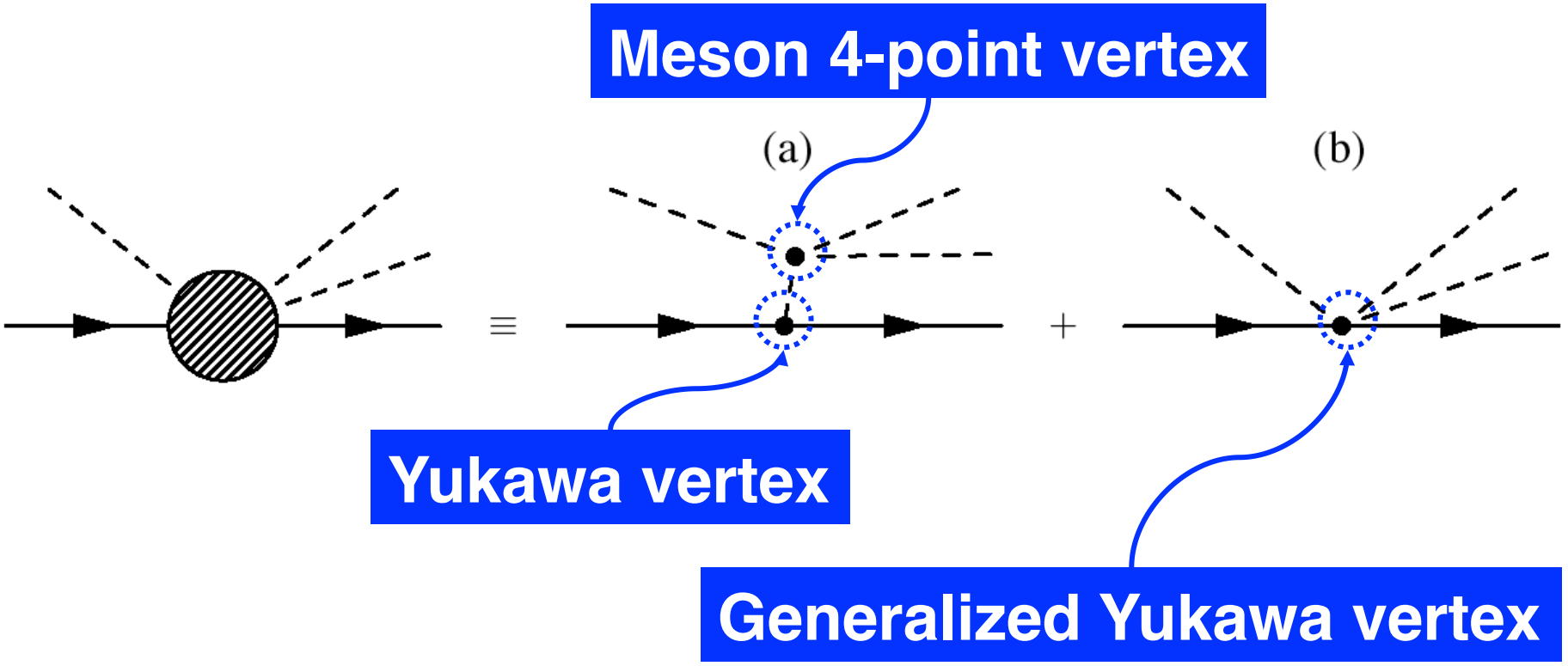
Channel MB = $\bar{K}N, \pi\Sigma, \pi\Lambda, \eta\Lambda, \eta\Sigma, K\Xi$

Chiral unitary model

$\pi\Sigma$ invariant mass distribution -> $\Lambda(1405)$

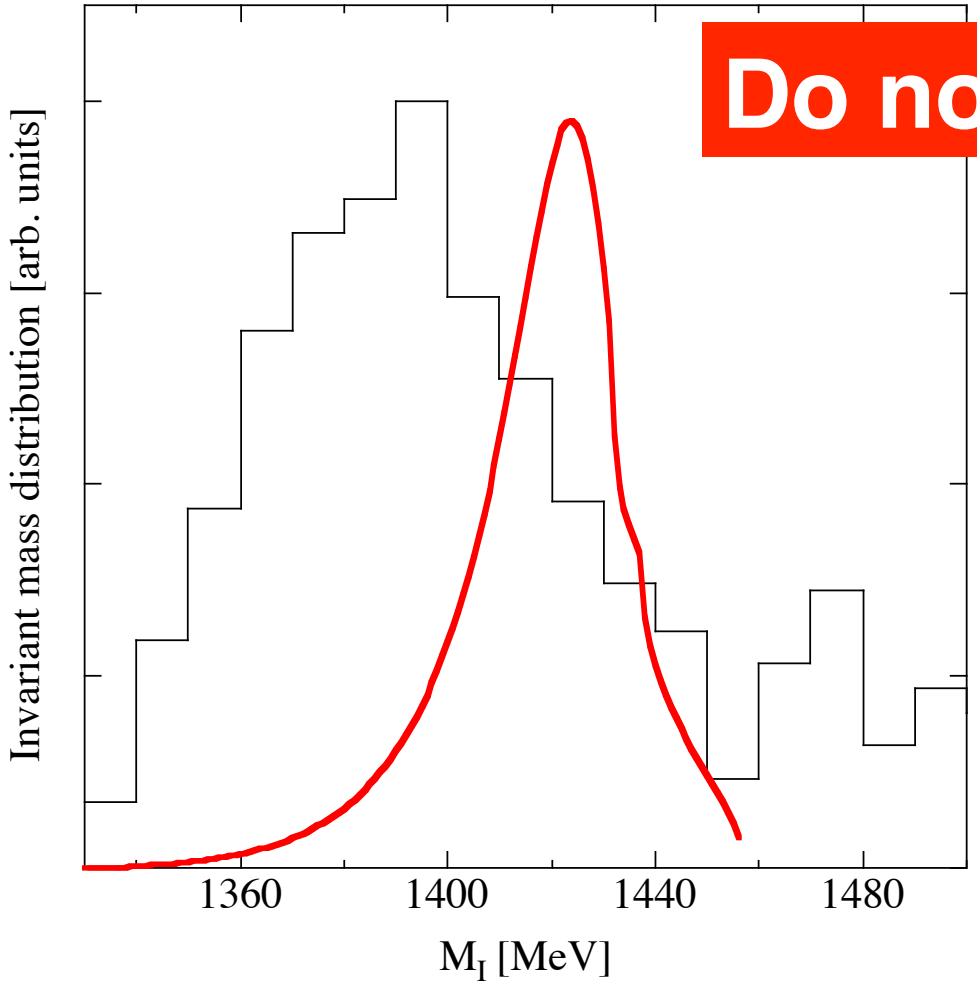
Chiral amplitude for $\pi^- p \to K^0 \pi \Sigma$

Construct the initial stage interaction from ChPT.



At low energies, these two diagrams are relevant.

Chiral amplitude for $\pi^- p \to K^0 \pi \Sigma$: results



Do not agree!!

Experiment : D. W. Tomas, *et al.*, NPB56, 15(1973)

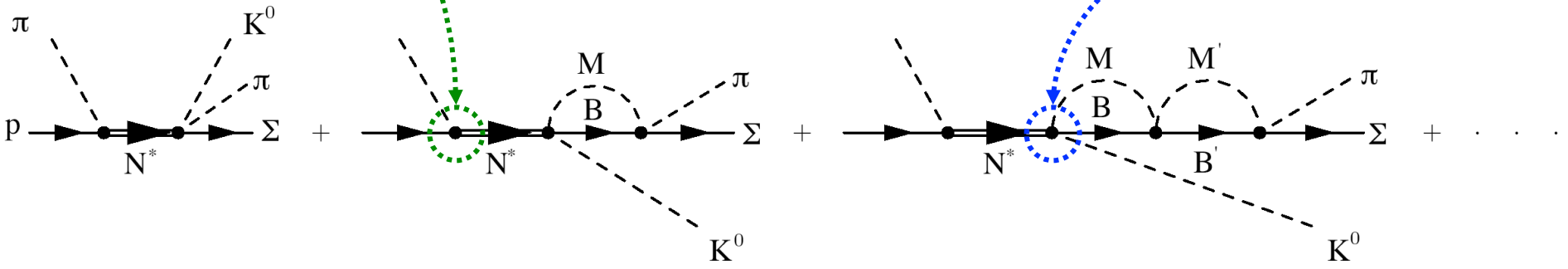
N(1710) contribution for $\pi^- p \to K^0 \pi \Sigma$

Initial c.m. energy of $\pi^- p$ system $\sim$ 1.9GeV
-> resonance excitation in the initial stage
P_{11} resonance : s-wave coupling to MMB

N(1710) -> π N (10-20 %)
-> $\pi\pi$ N (40-90 %)
-> $\eta\pi$ N (no)

Extrapolation of $\pi\pi$N decay

πN decay

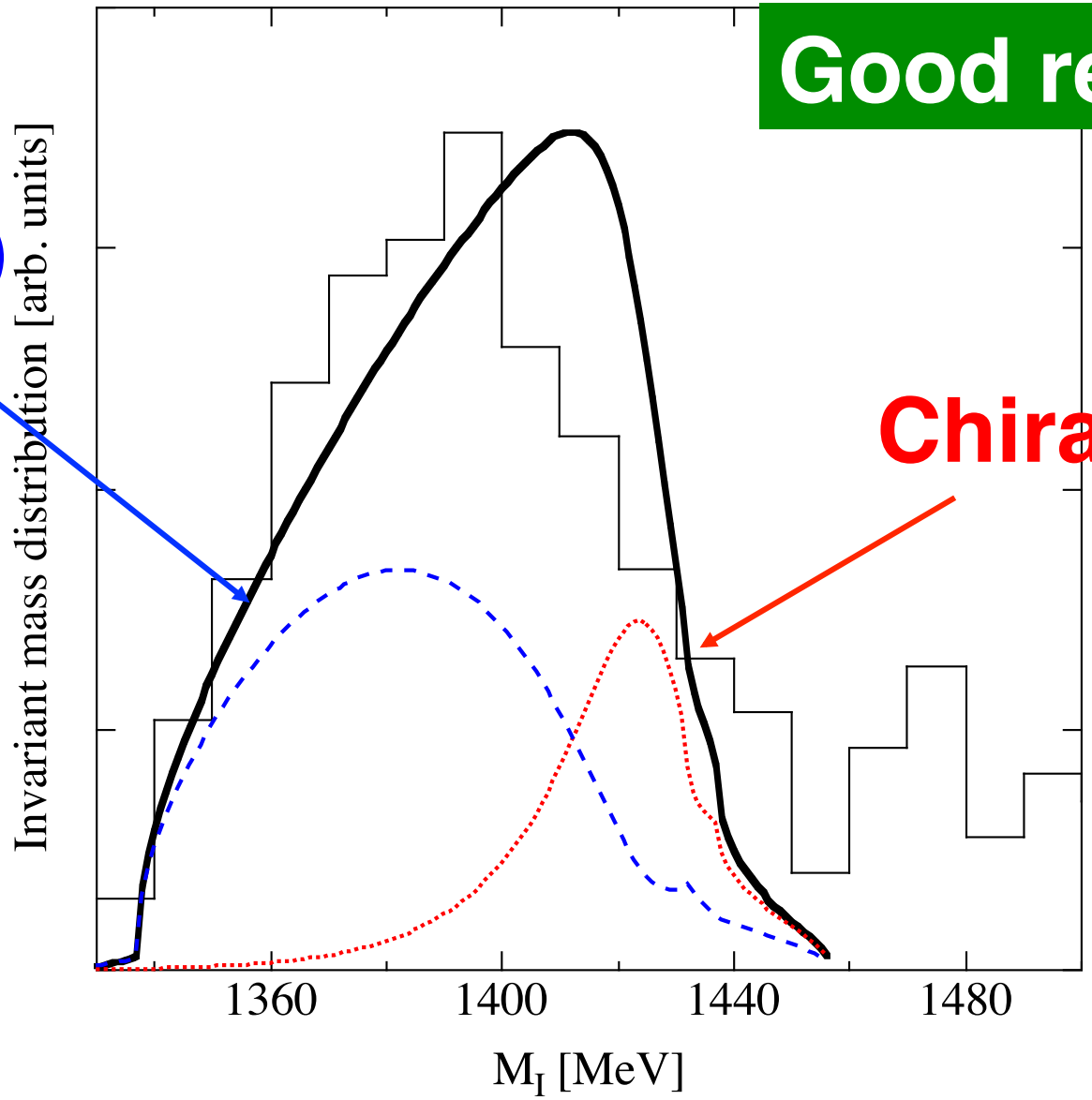


Final results for $\pi^- p \rightarrow K^0 \pi \Sigma$

Good retult!!

N(1710)

Chiral terms



Conclusions

We calculate the $\pi^- p \to K^0 \pi \Sigma$ reaction using the chiral unitary model.

- There are two mechanisms in the initial stage interaction.
- They filter each one of the resonances.

chiral term : higher pole (1426+16i)
N(1710) contribution : lower pole (1390+66i)

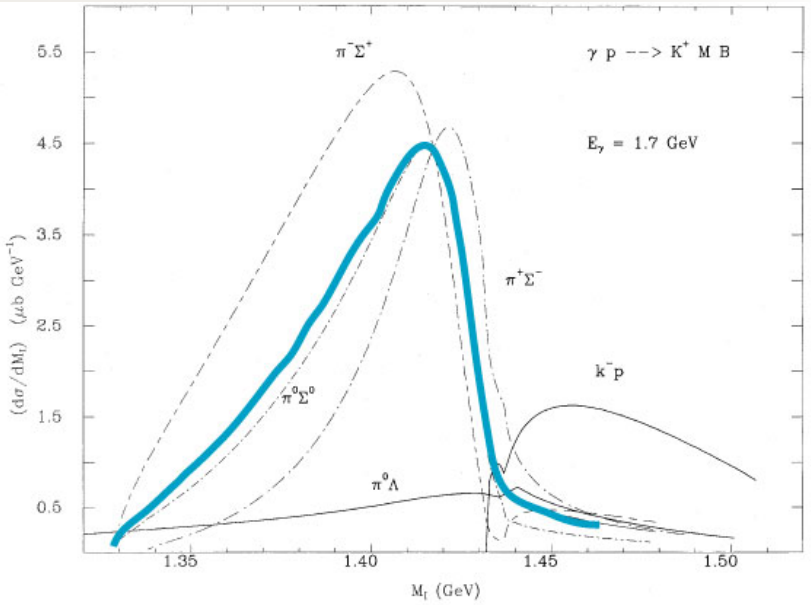
- Combination of the two mechanisms gives a good description of data.

Experiments : πΣ mass distribution

γp -> K⁻πΣ

J.C. Nacher, *et al.*, PLB445, 55(1999)

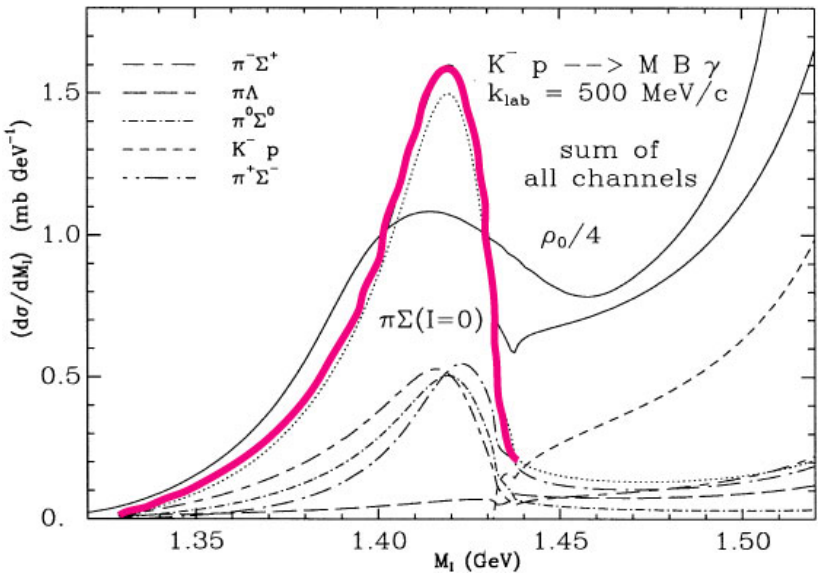
Spring-8



K⁻p -> γπΣ

J.C. Nacher, *et al.*, PLB461, 299(1999)

J-PARC?



+ α : Θ production in $K^+p \to \pi^+K^+n$

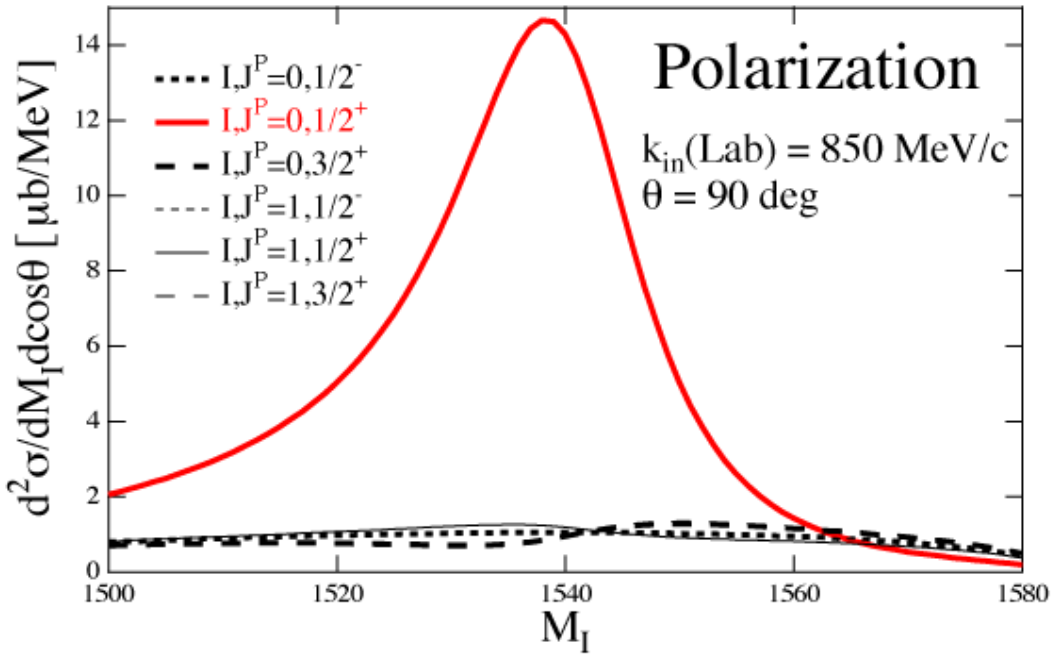
Θ^+ : 5-quark (4 quark + 1 anti-quark)

LEPS, T. Nakano *et al.*, Phys. Rev. Lett. 91 (2003) 012002

Parity : $1/2^+$? $1/2^-$? …

$K^+p \to \pi^+K^+n$

Polarization test



T. Hyodo, A. Hosaka, and E. Oset, nucl-th/0307105