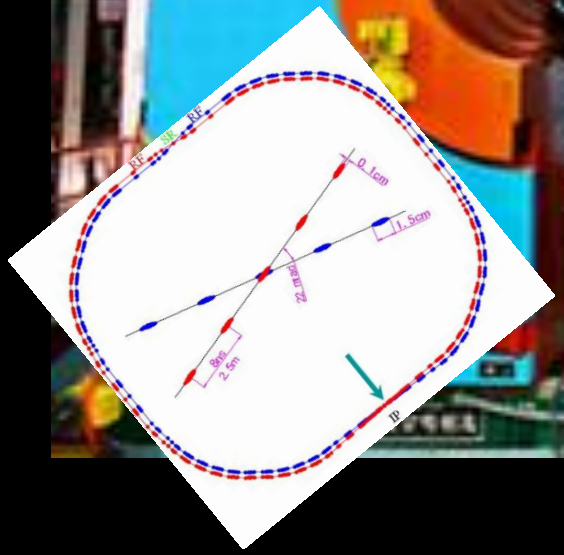
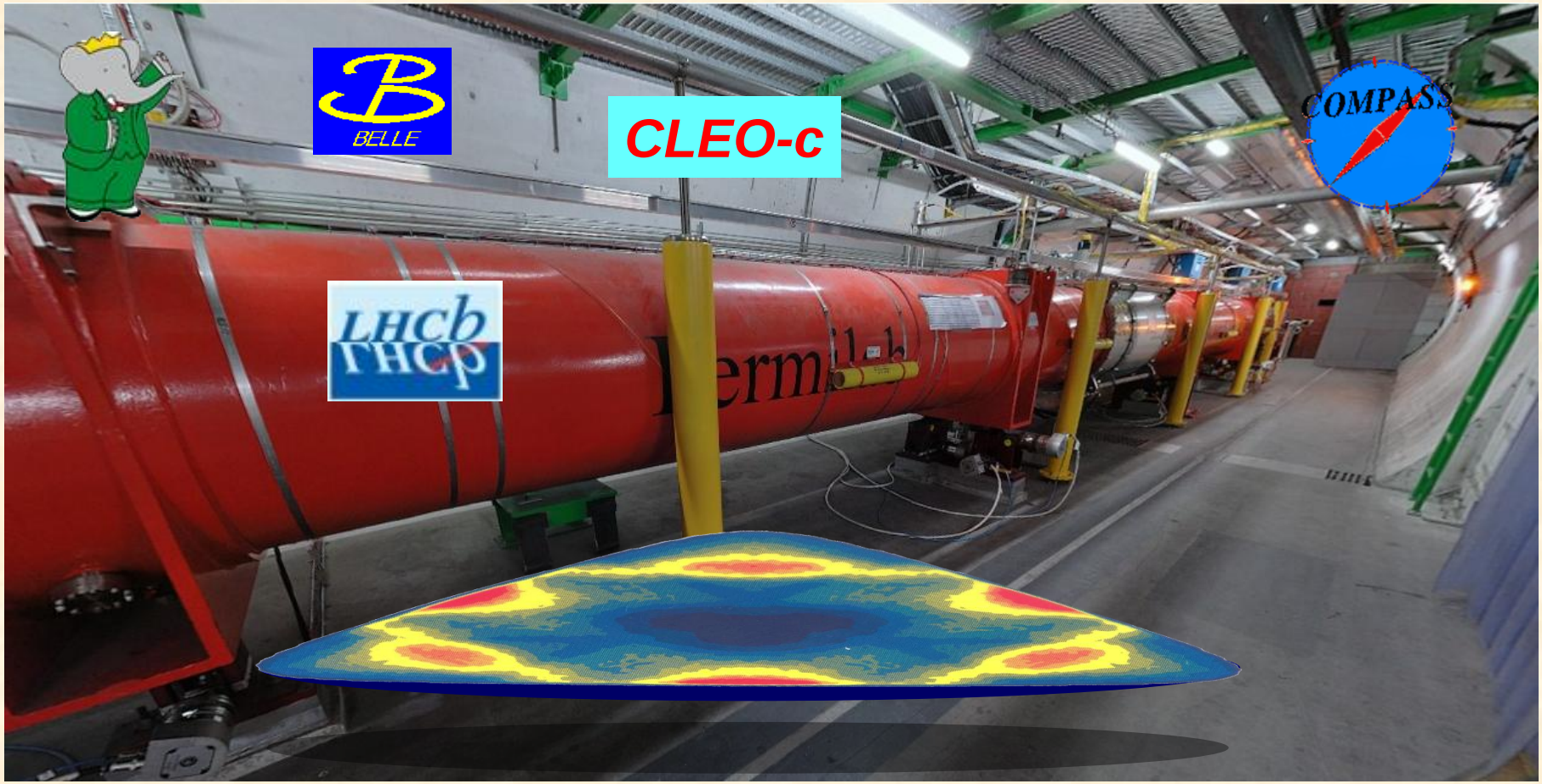
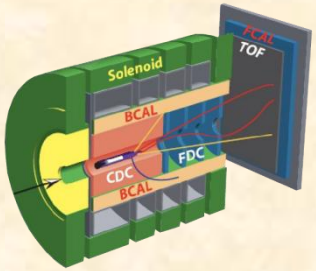
$\pi\pi$, Kπ final state interactions: examples from BES



Michael Pennington
Jefferson Lab



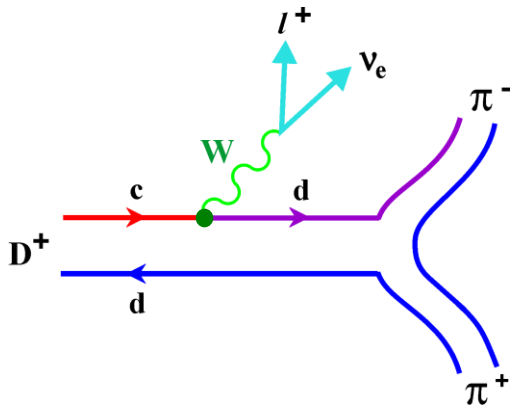
GLUEX CITATIONS PERIMENT
Hall D@JLab

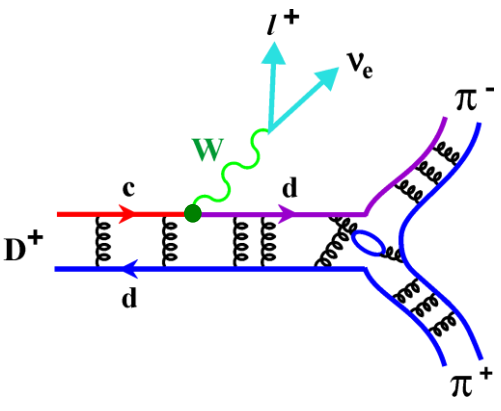


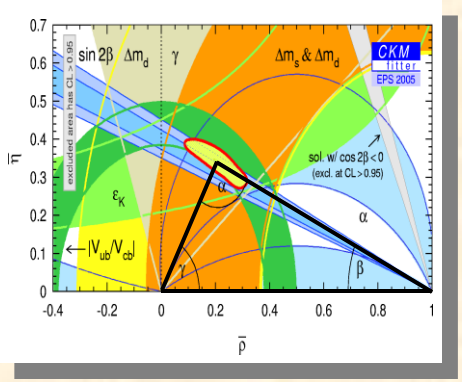
FAIR

PANDA
© GSI

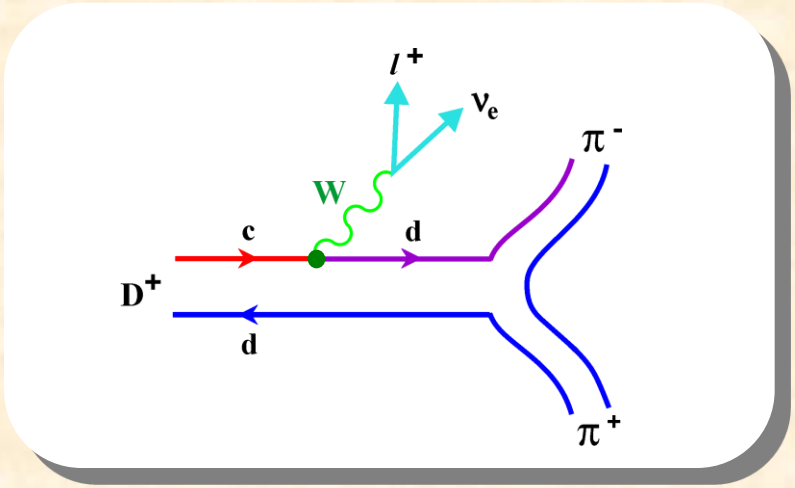
CKM matrix elements

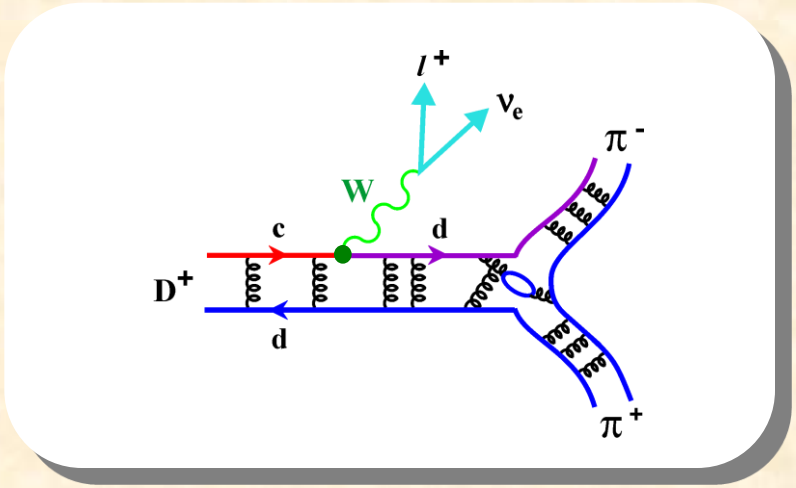


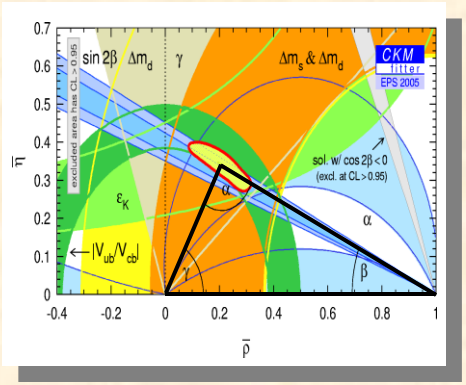


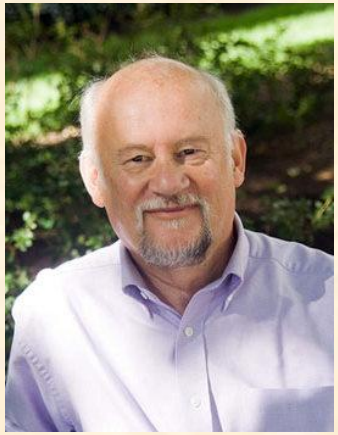


CKM matrix elements

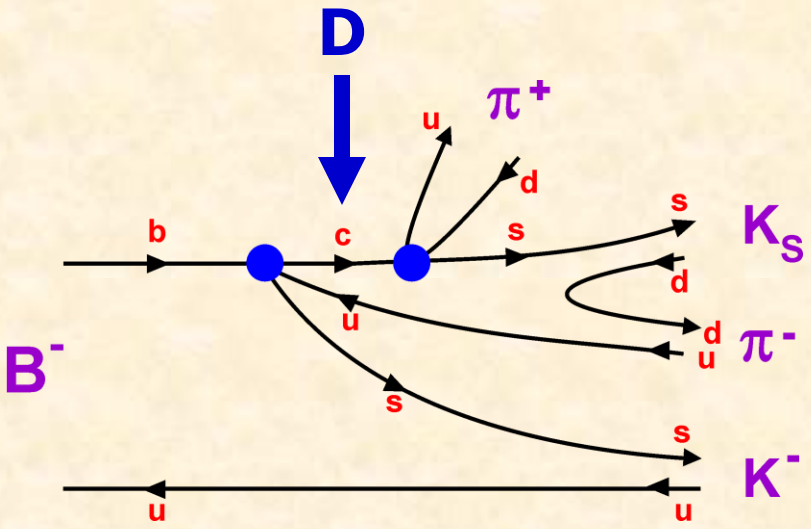




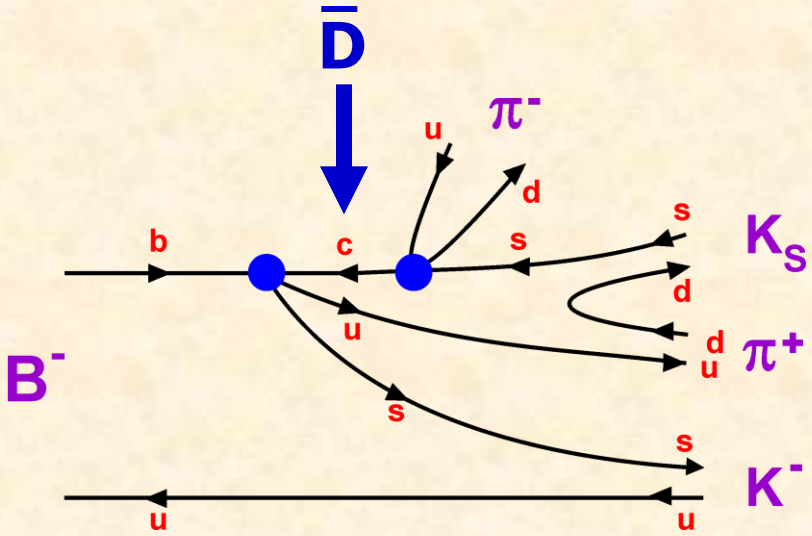




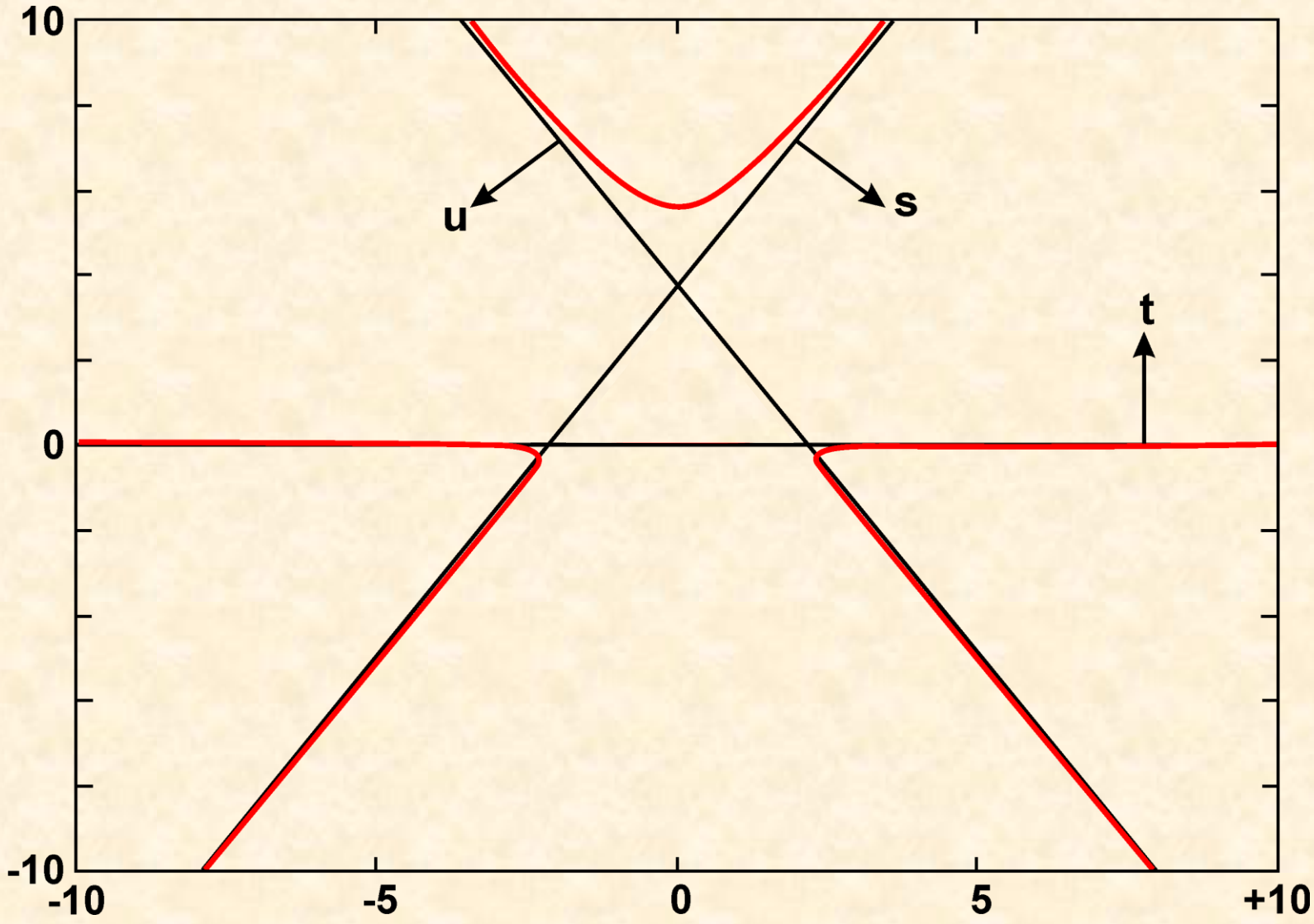
$B \to D\bar{K} \to \bar{K}K\pi\pi$



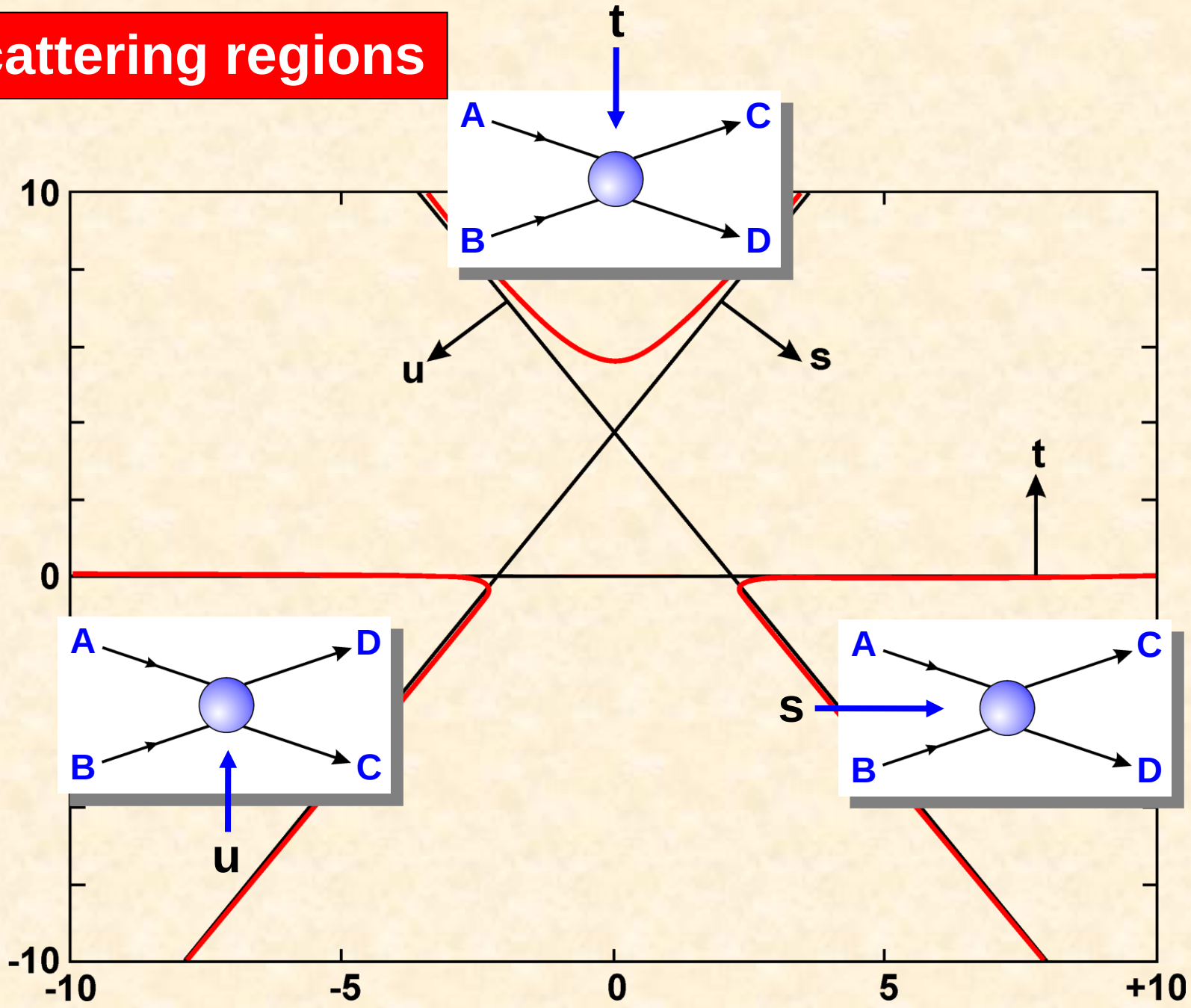
$B \to \bar{D}K \to \bar{K}K\pi\pi$



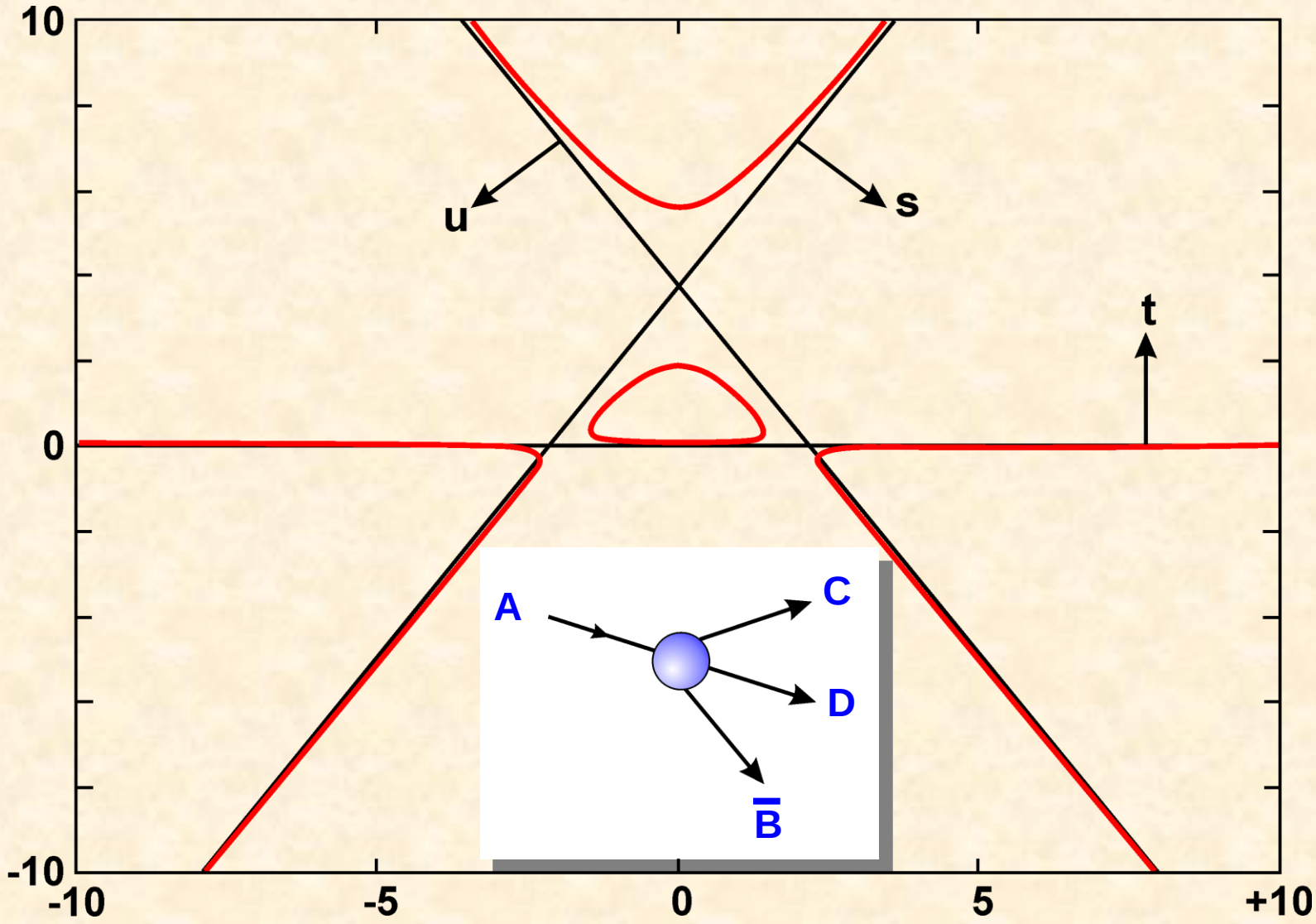
scattering & decay regions



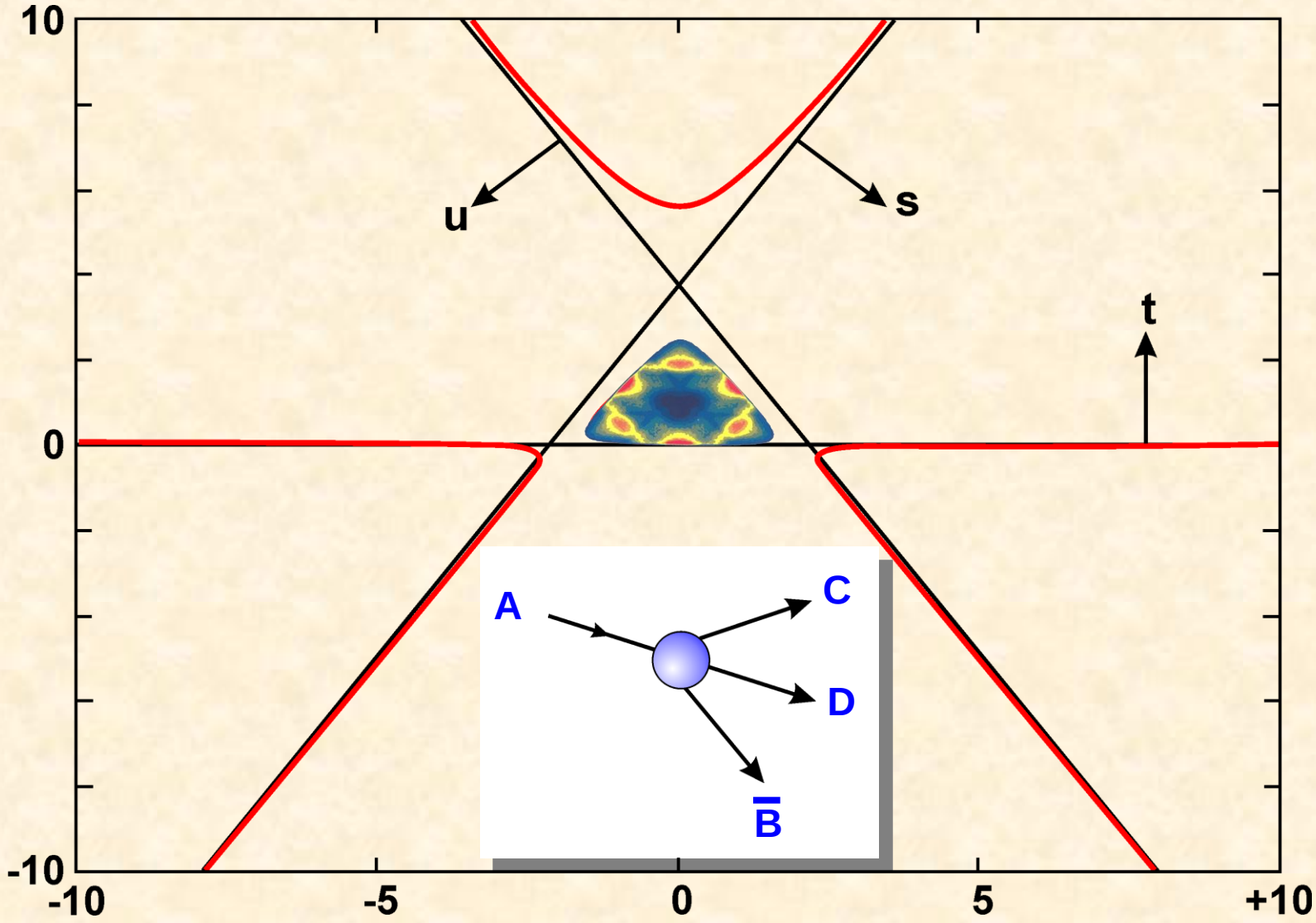
scattering regions



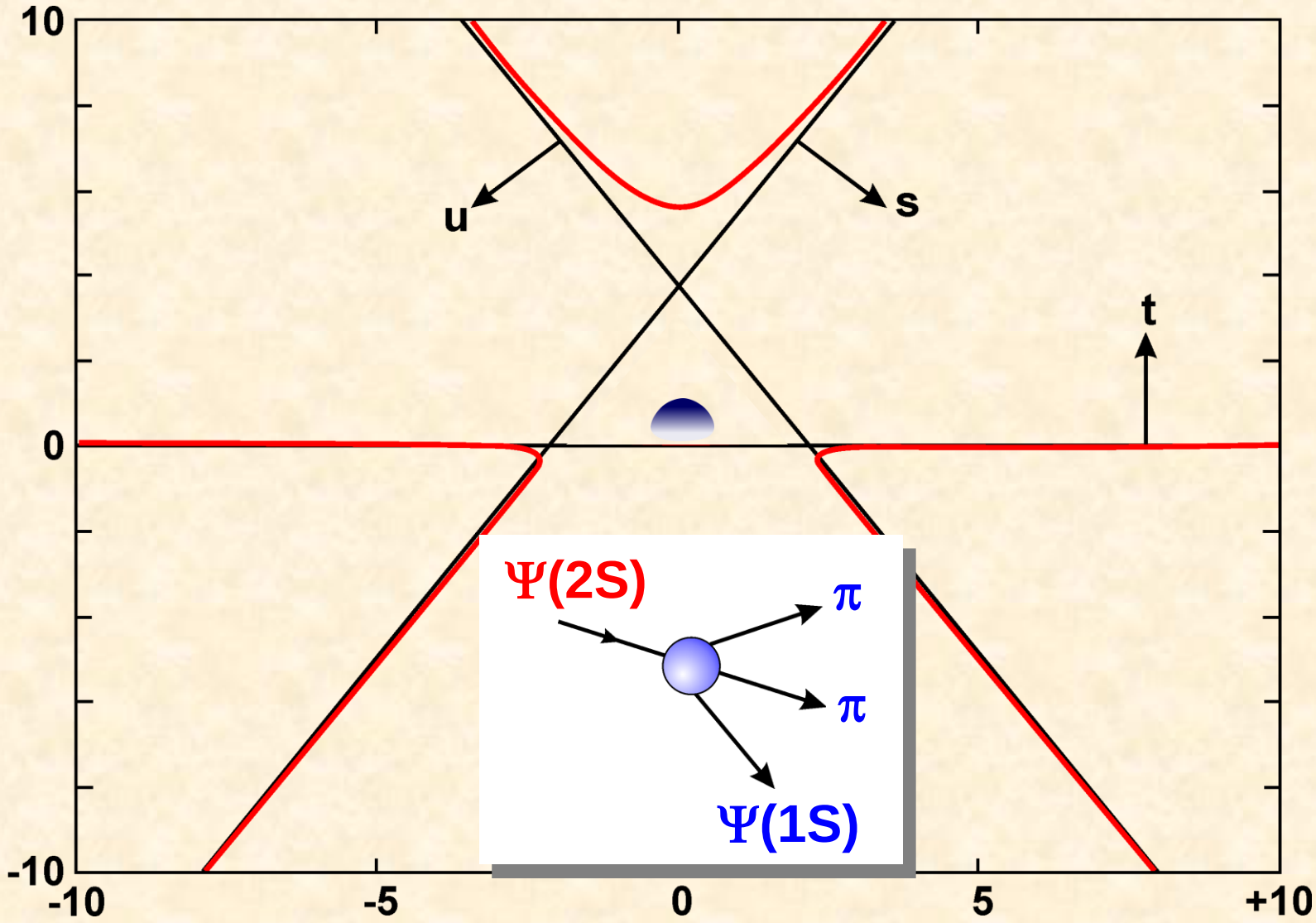
decay region



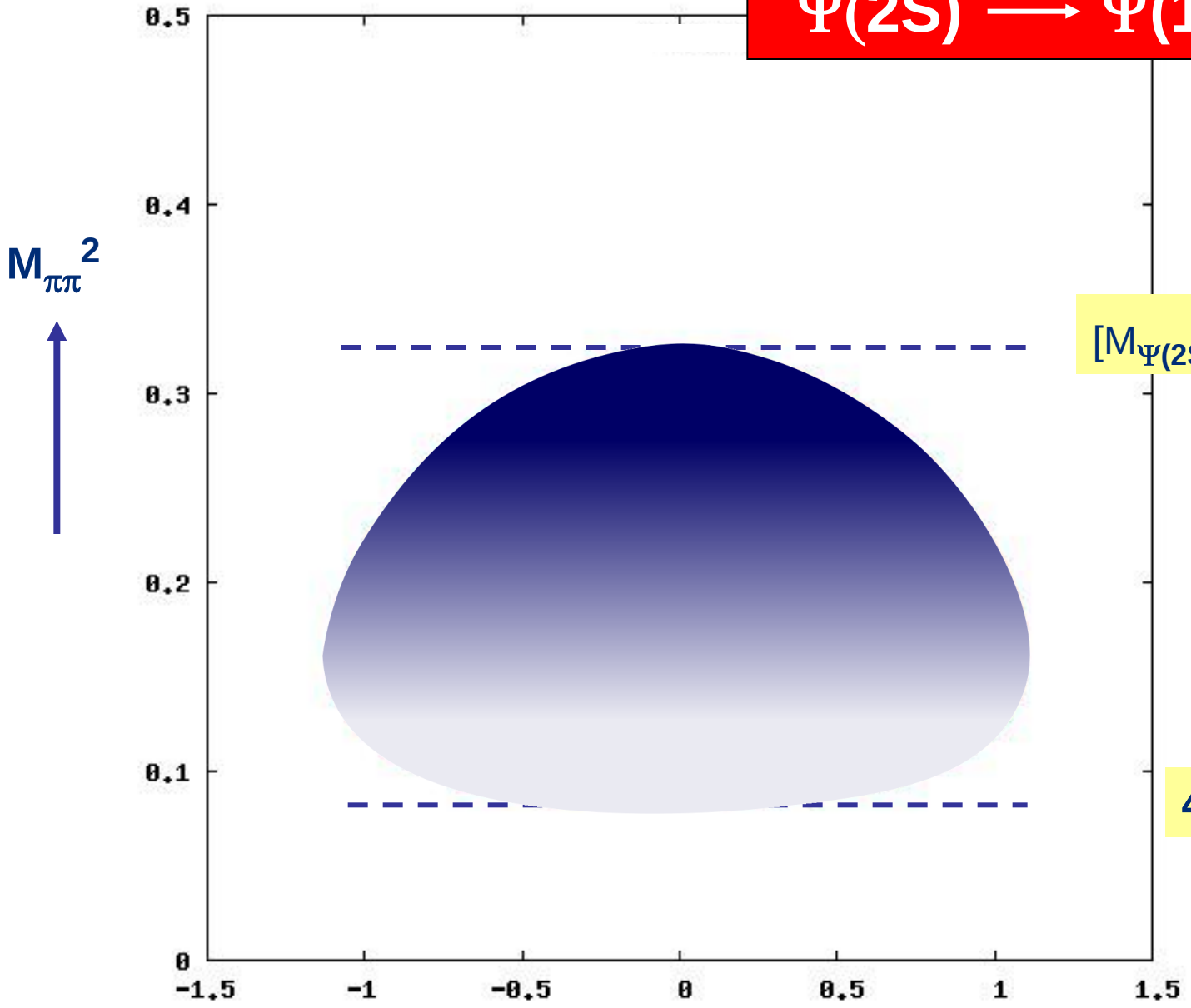
decay region



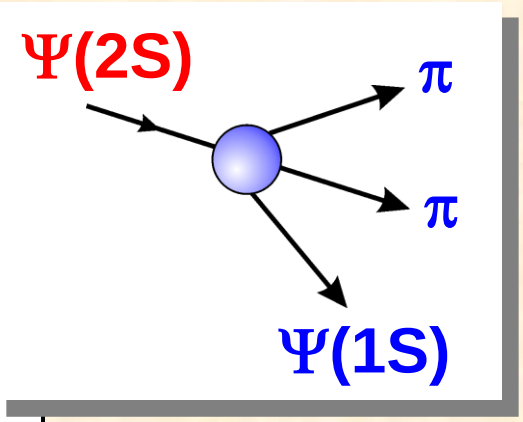
decay region

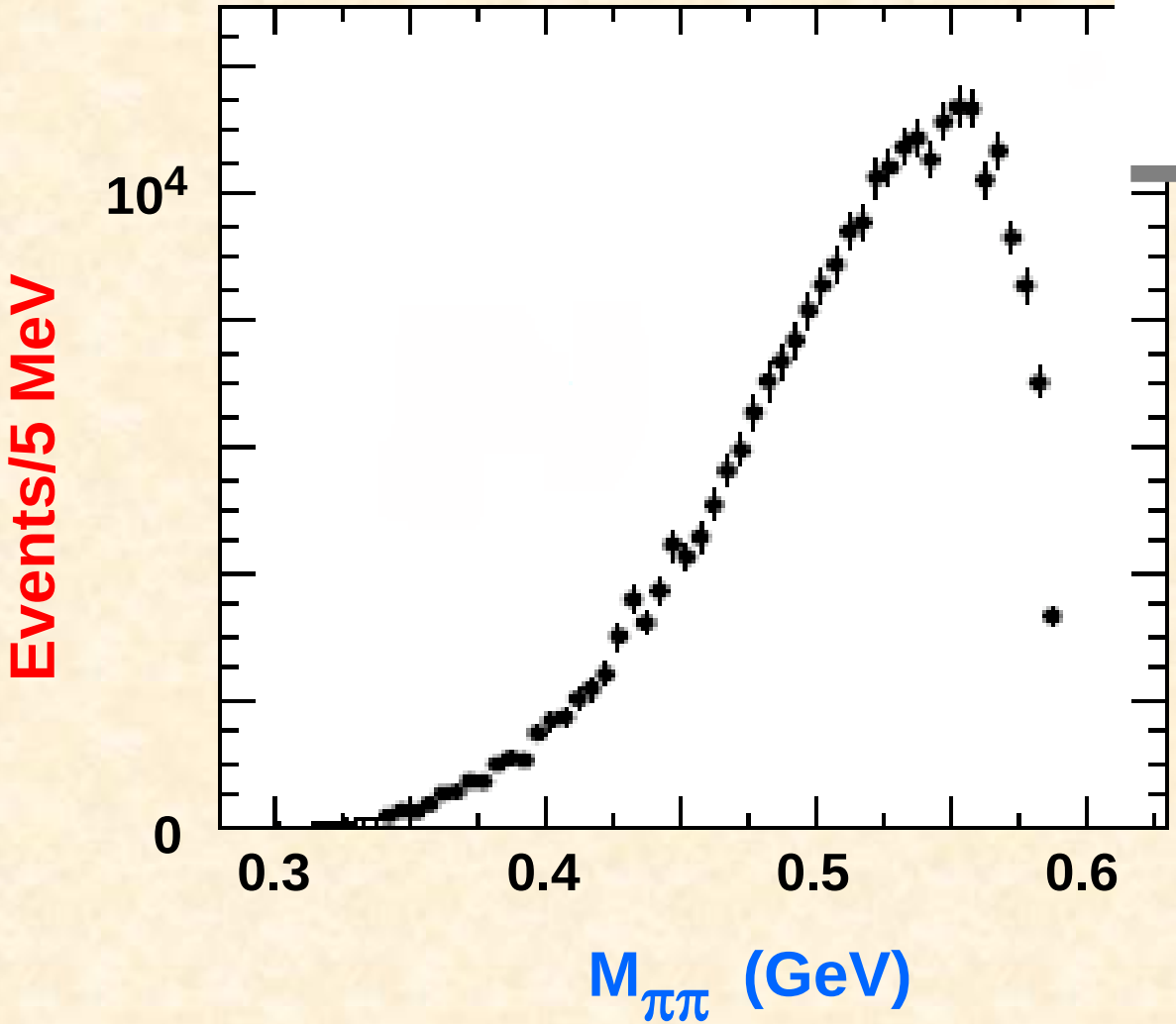


$\Psi(2S) \longrightarrow \Psi(1S)\,\pi^+\pi^-$



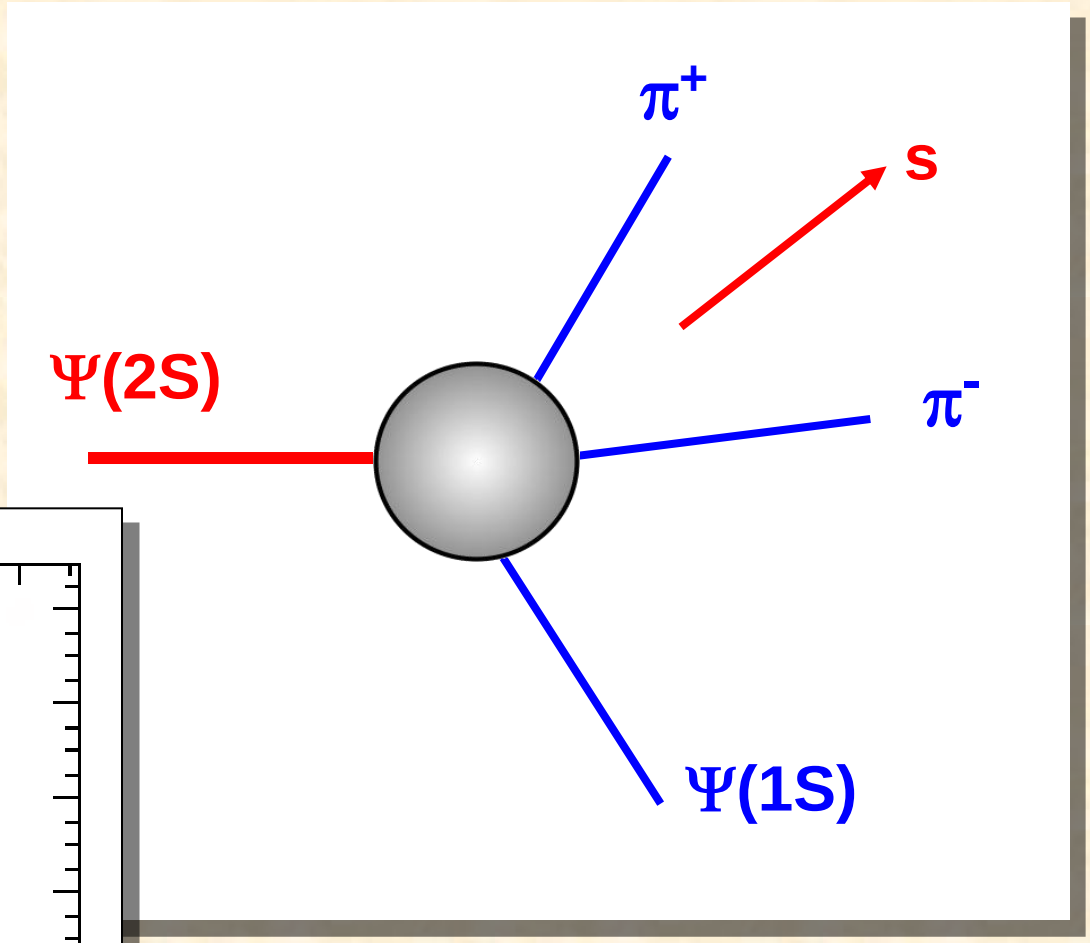
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$

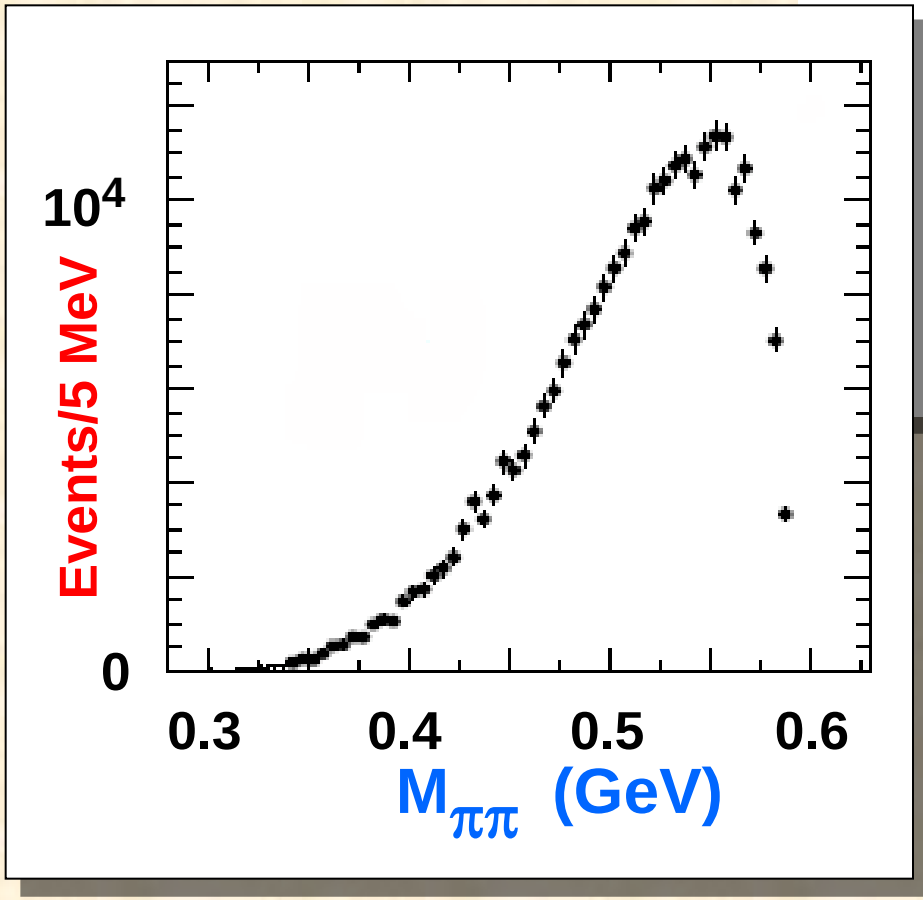




BESII

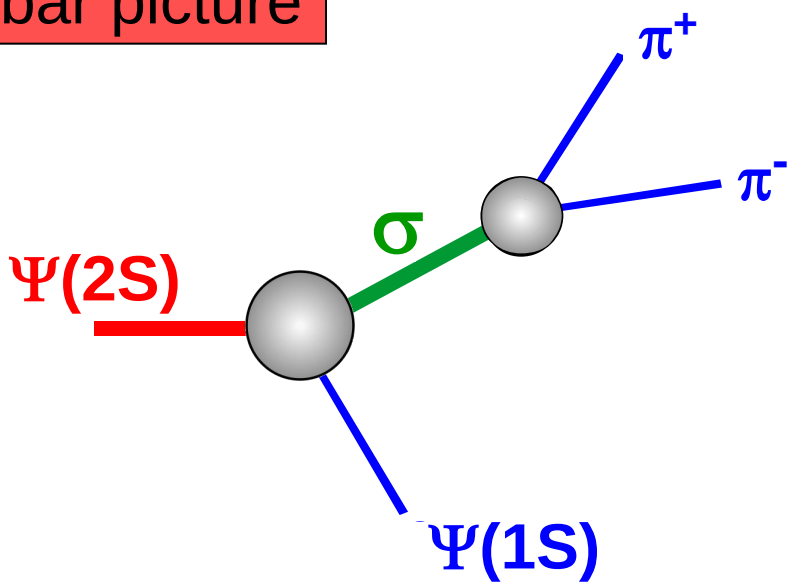
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$

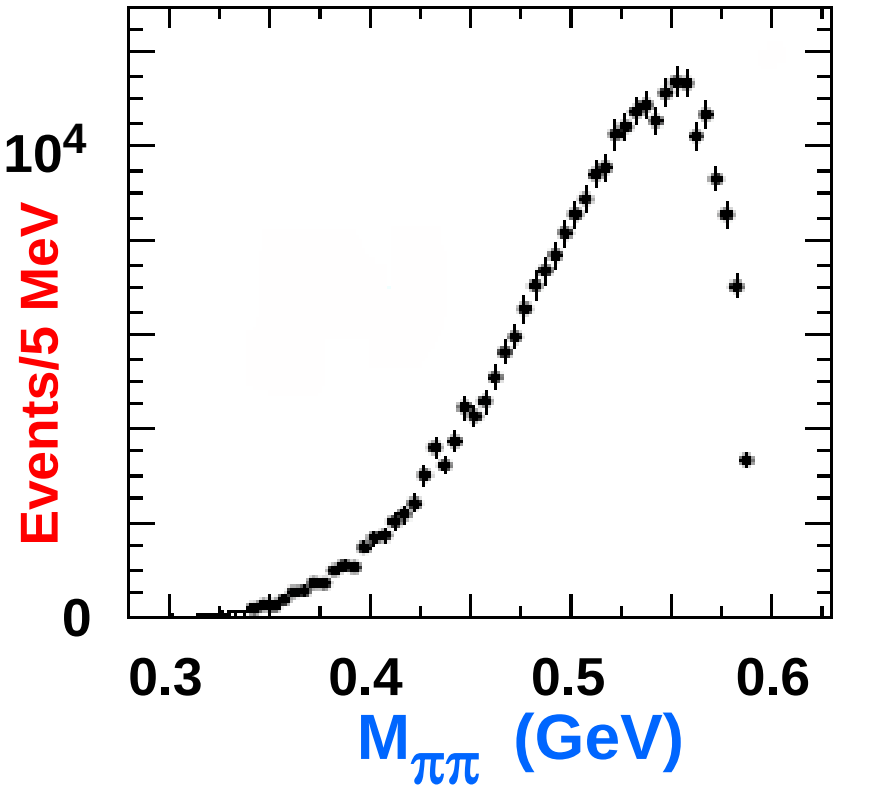




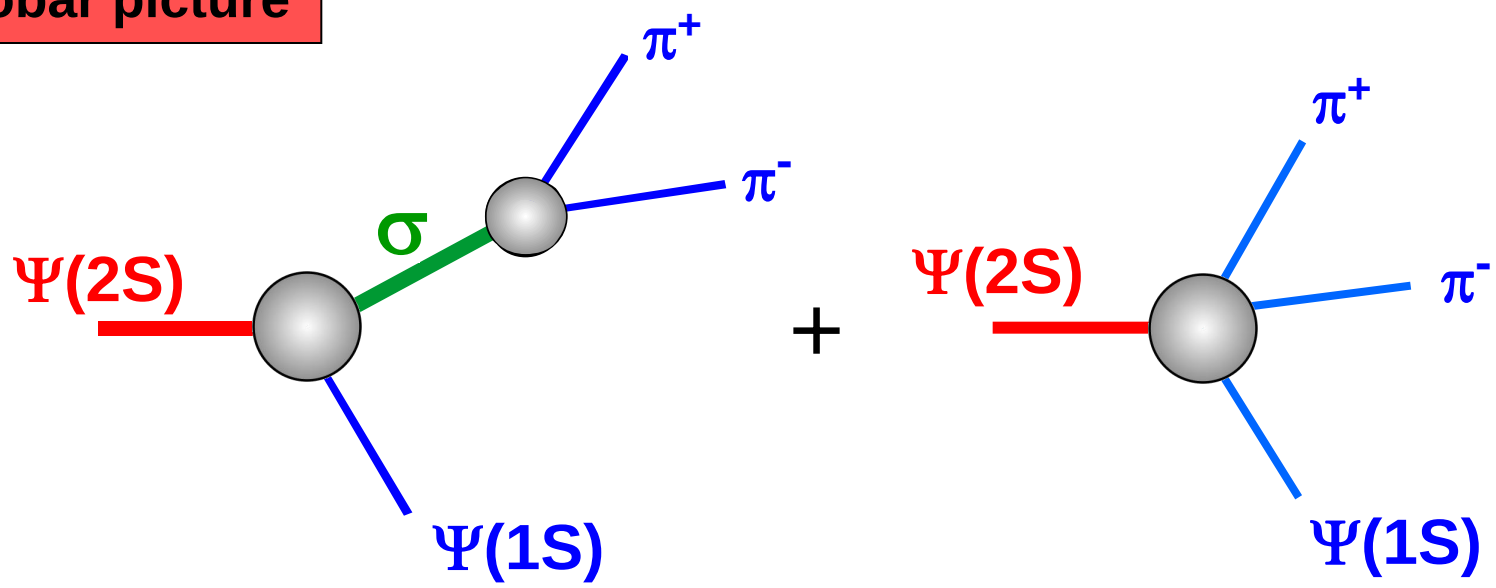
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$

isobar picture





isobar picture

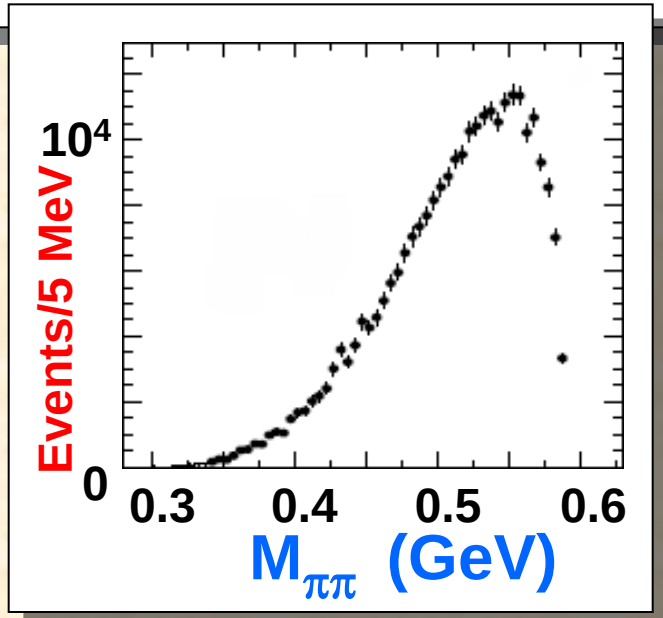


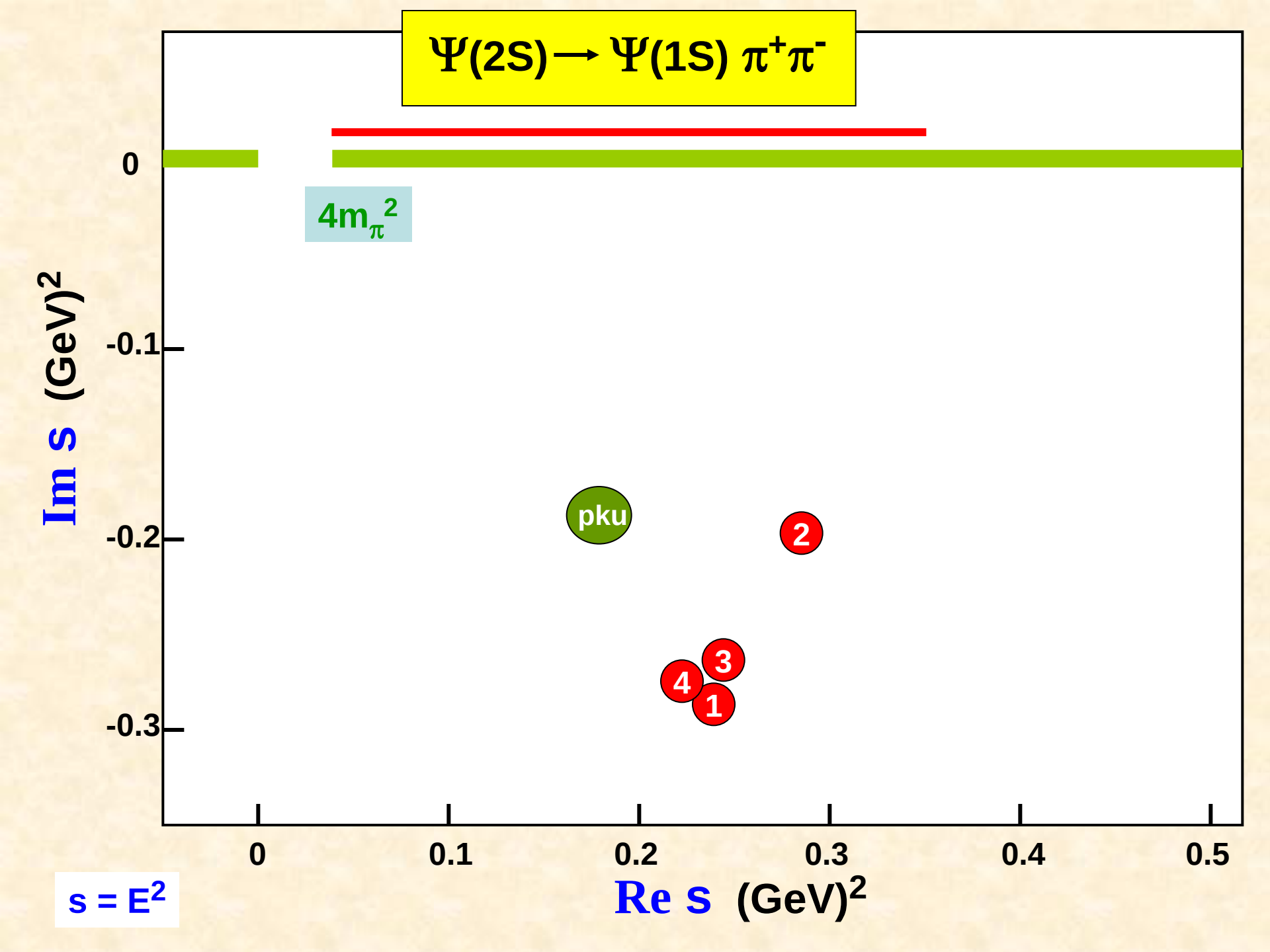
Breit-Wigner

$$\frac{1}{M^2 - s - iM\Gamma}$$

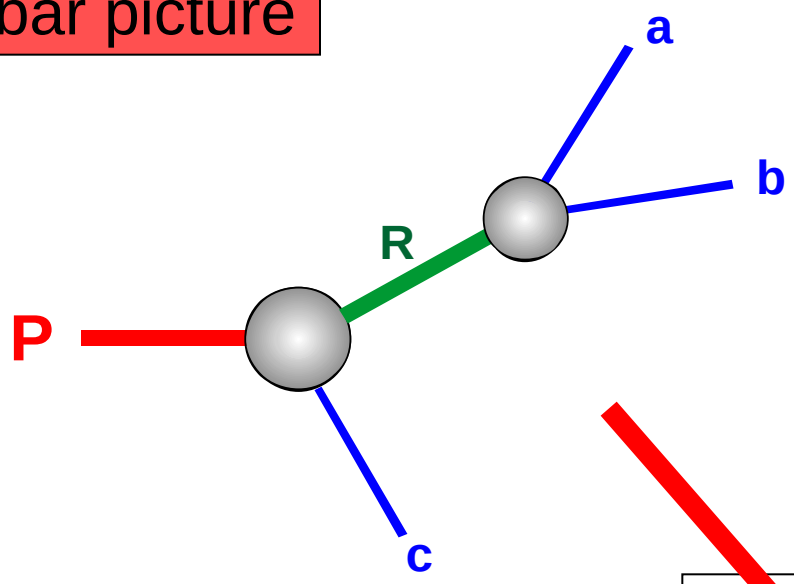
Ablikim *et al*

Phys Lett B645 (2007)1

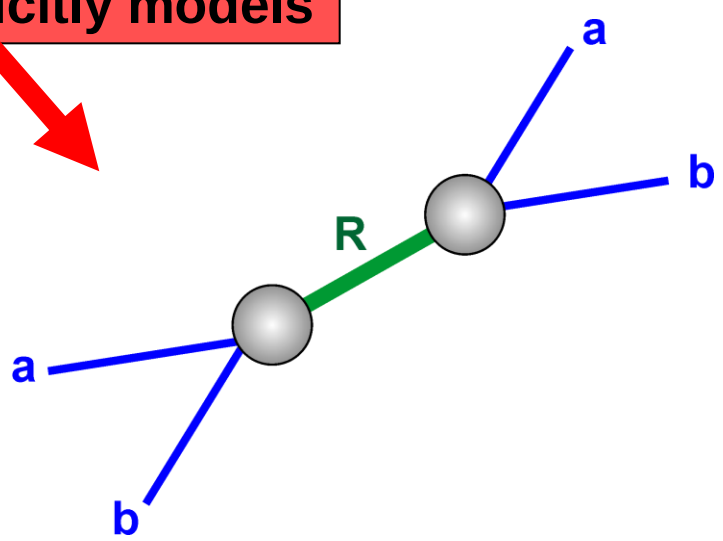



Ψ(2S)→ Ψ(1S) π+π-
0
-0.1
-0.2
-0.3
4mπ2
pku
2
3
4
1
Im s (GeV)2
0
0.1
0.2
0.3
0.4
0.5
Re s (GeV)2
s = E2

isobar picture

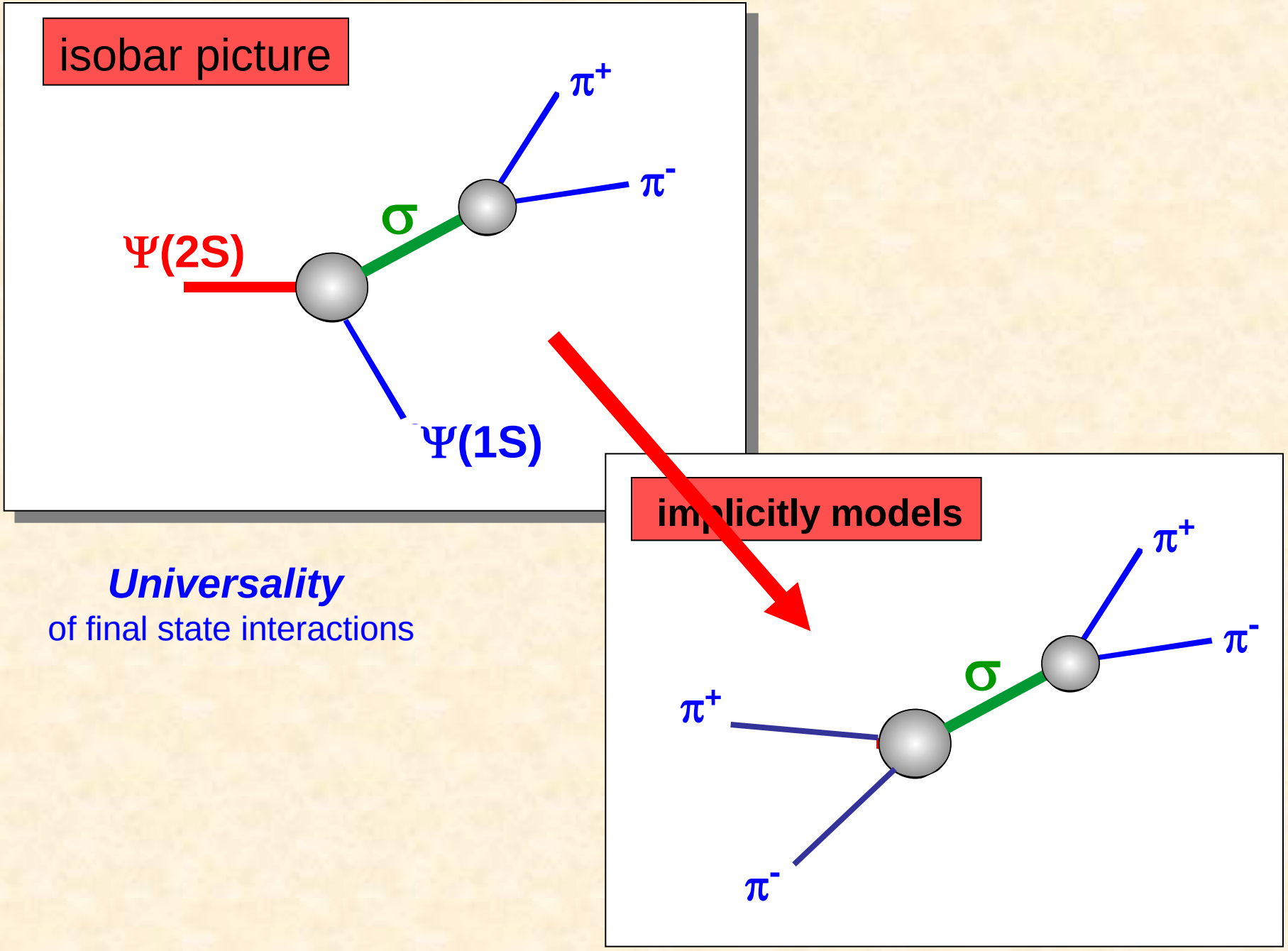


implicitly models

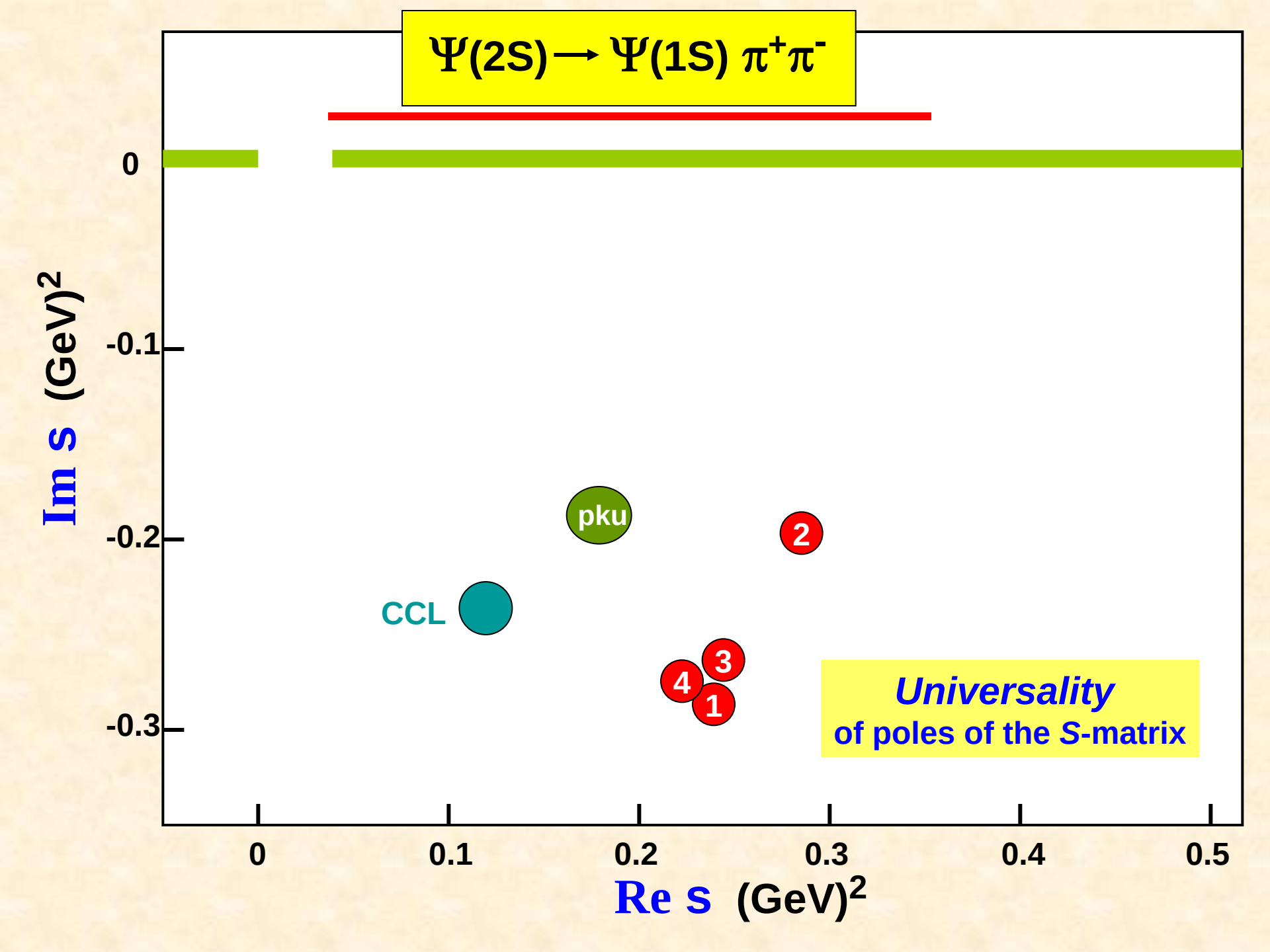


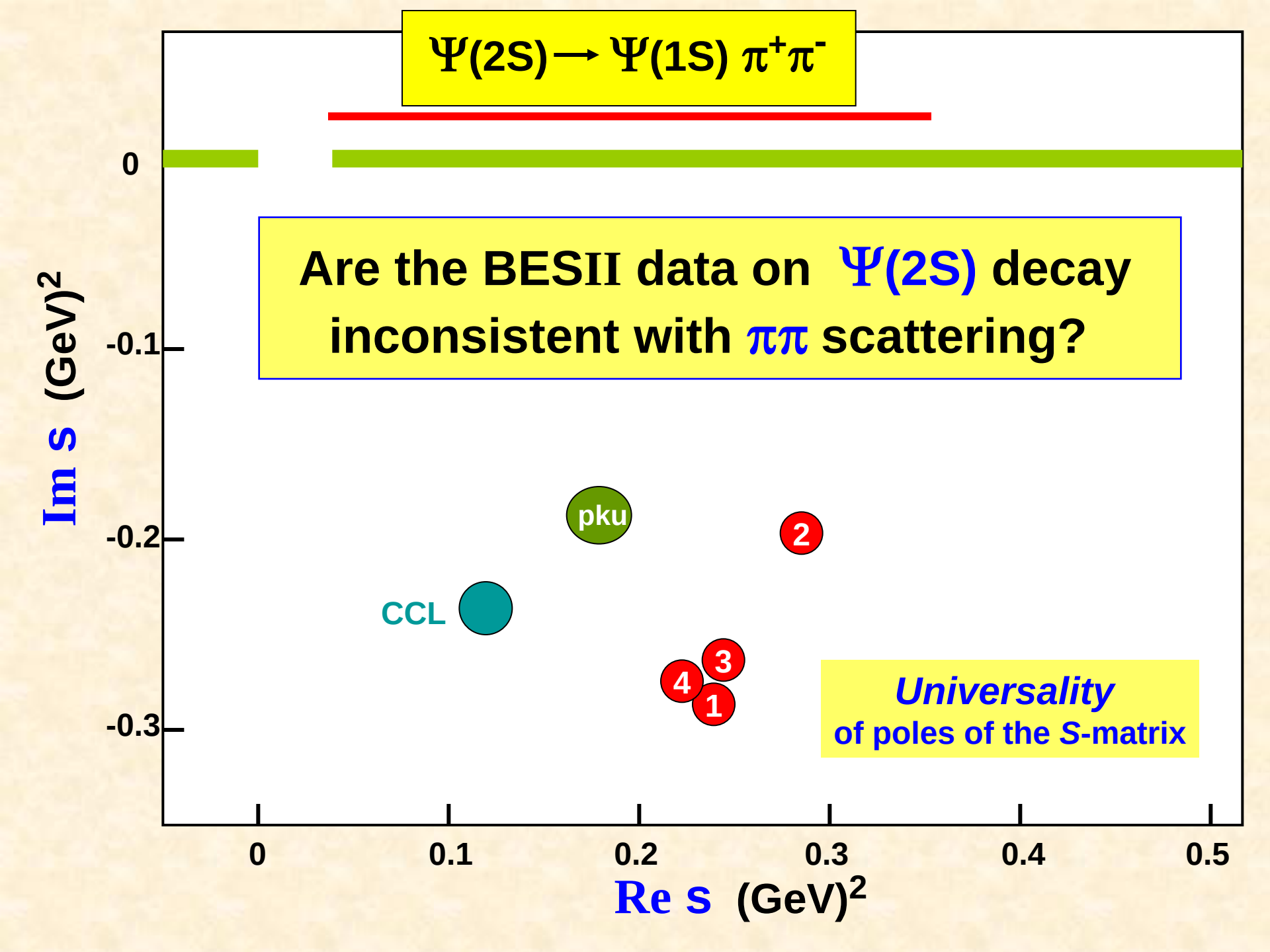
Universality
of final state interactions

P ⟶ a b c



Universality
of final state interactions


Ψ(2S)→ Ψ(1S) π+π-
0
-0.1
-0.2
-0.3
Im s (GeV)2
pku
2
CCL
3
4
1
Universality
of poles of the S-matrix
0
0.1
0.2
0.3
0.4
0.5
Re s (GeV)2

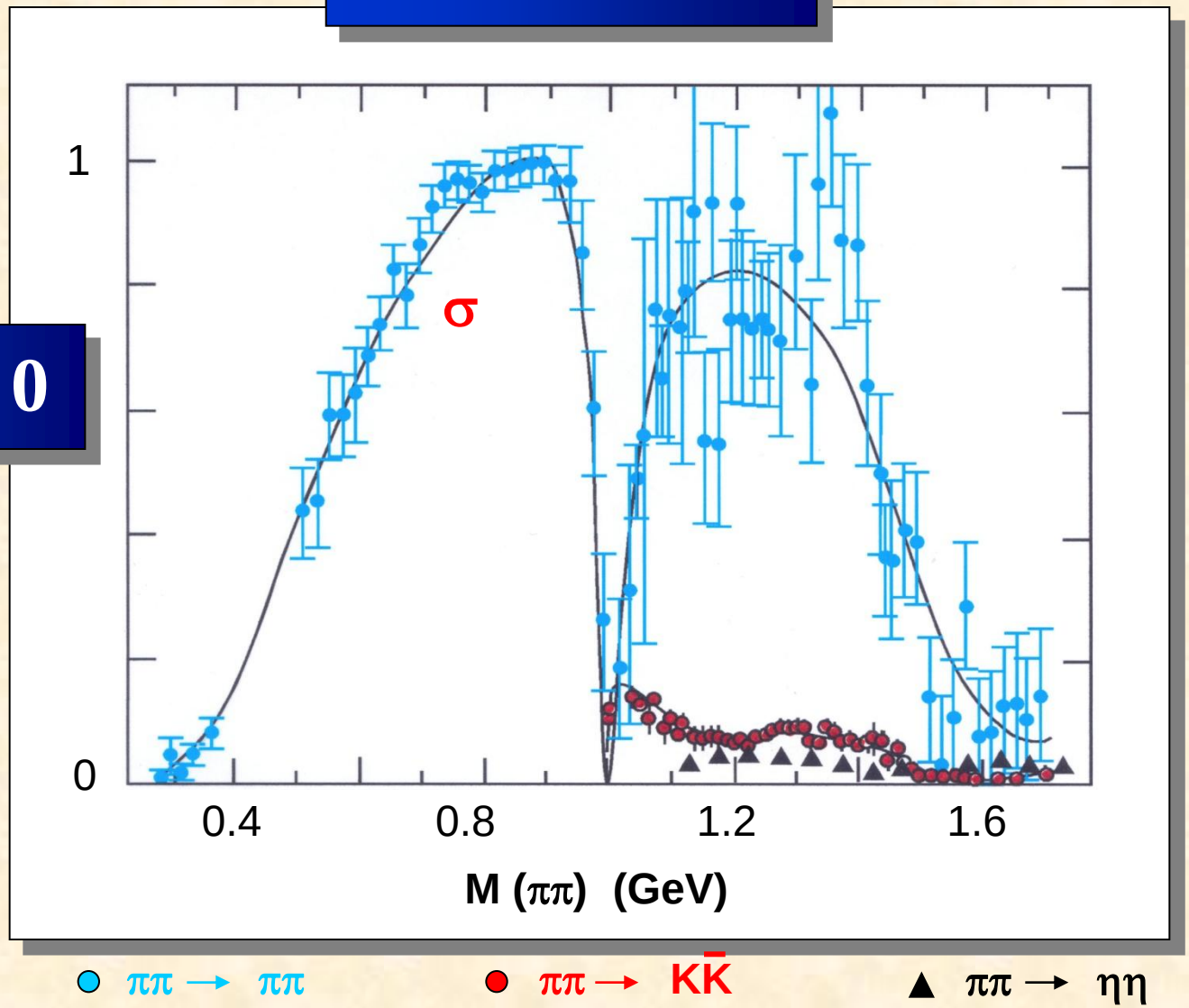

Ψ(2S)→ Ψ(1S) π+π-
Are the BESII data on Ψ(2S) decay inconsistent with ππ scattering?
pku
2
CCL
3
4
1
Universality
of poles of the S-matrix
0
-0.1
-0.2
-0.3
Im s (GeV)2
0
0.1
0.2
0.3
0.4
0.5
Re s (GeV)2

Scalar mesons

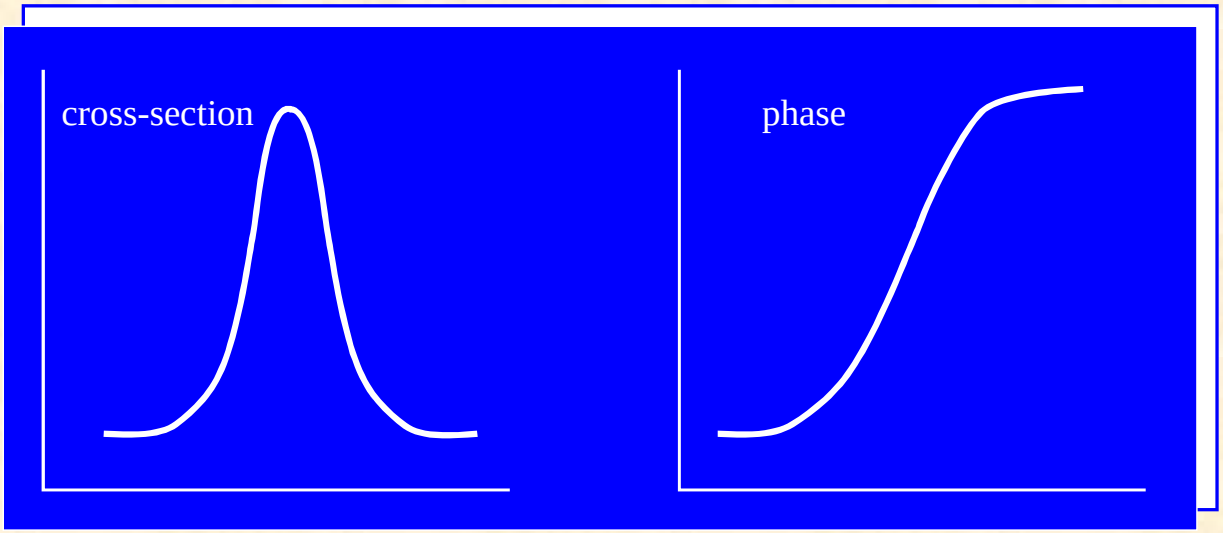
$f_0(600)$

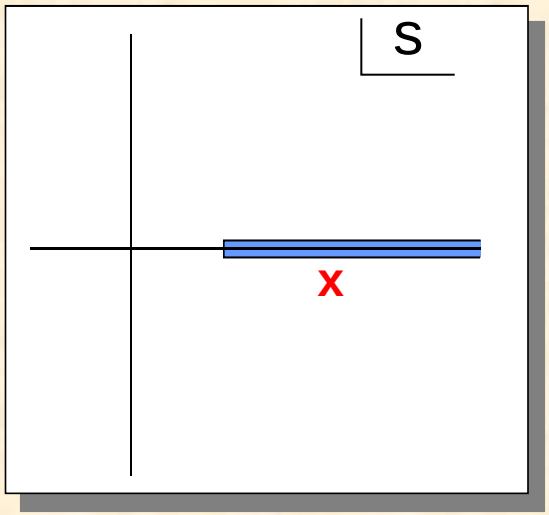
$I = J = 0$

$\pi\pi \longrightarrow \pi\pi$



Hadron States

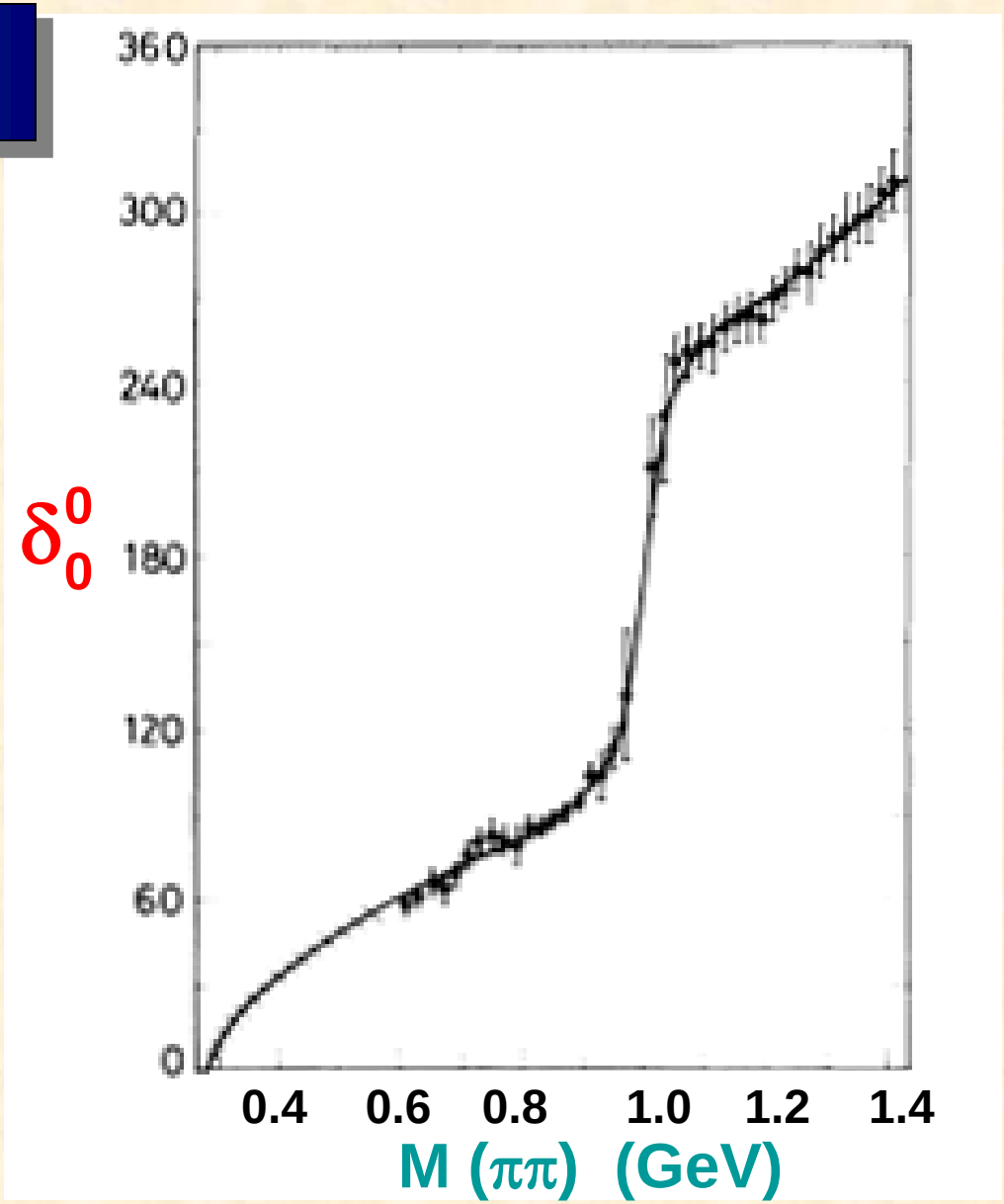




Breit-Wigner

$$\frac{1}{M^2 - s - iM\Gamma}$$

$\pi\pi \longrightarrow \pi\pi$

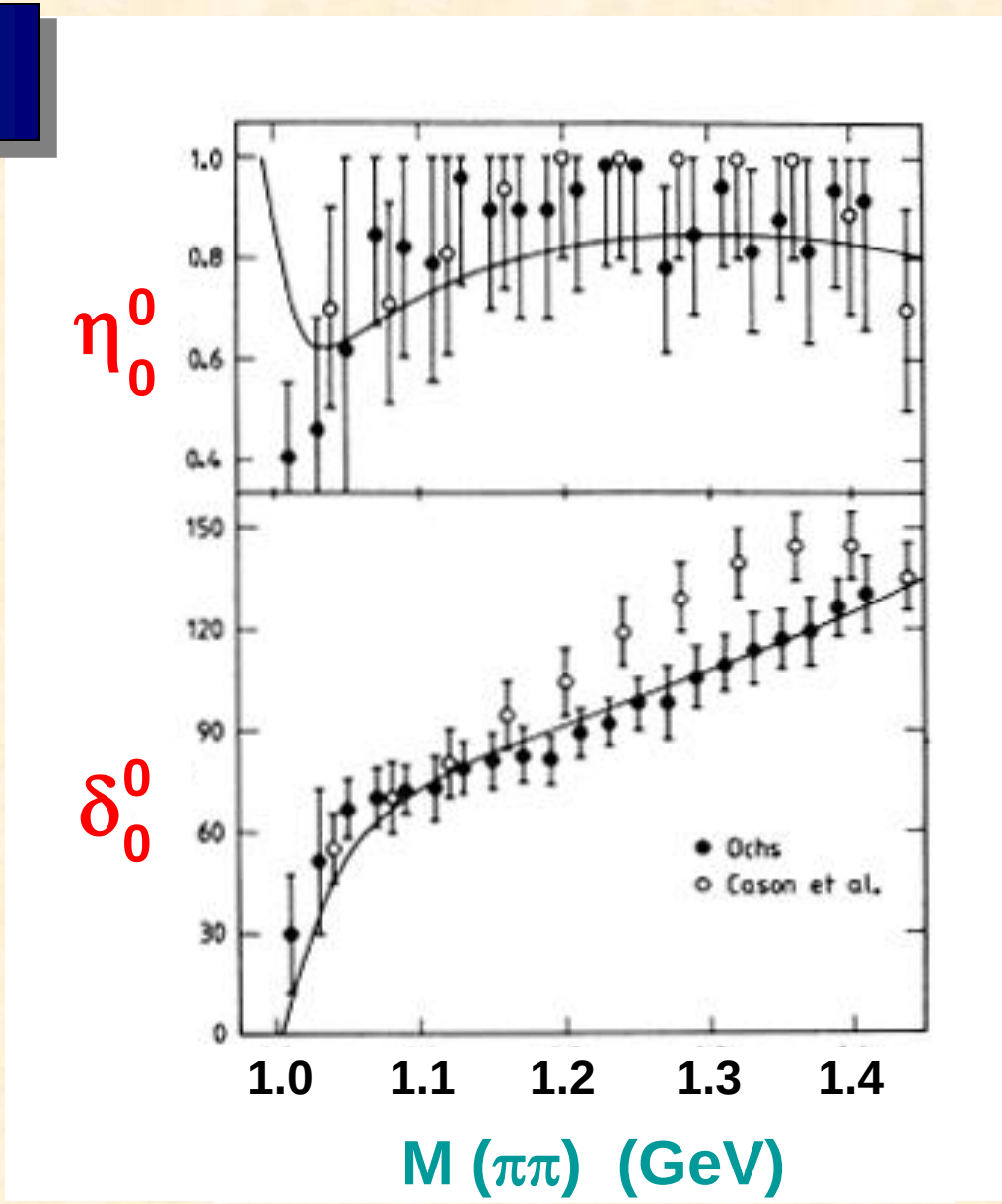


I = J = 0

Ochs

CERN/Munich

$\pi\pi \longrightarrow \pi\pi$



I = J = 0

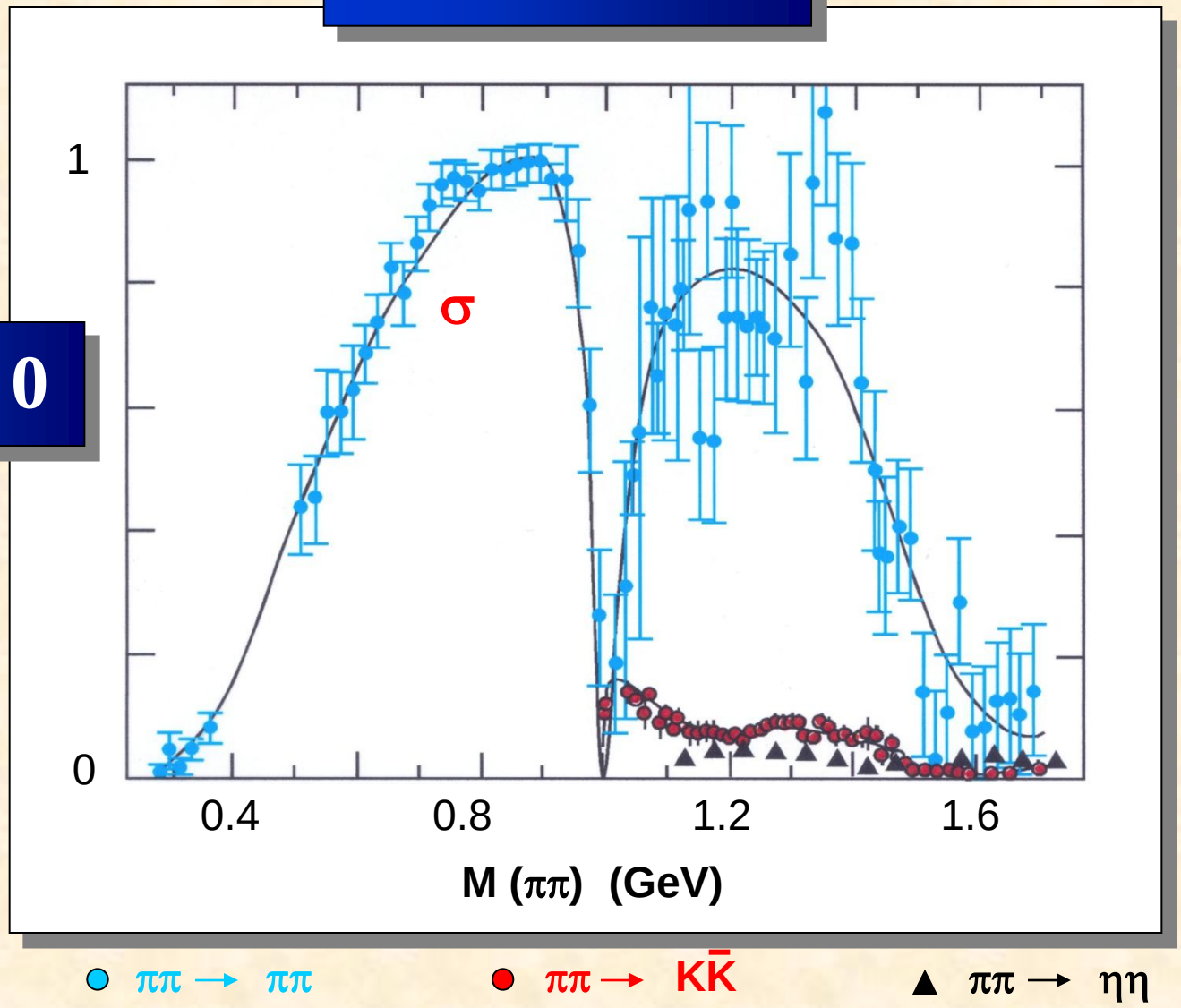
Sarantsev et al

Scalar mesons

$f_0(600)$

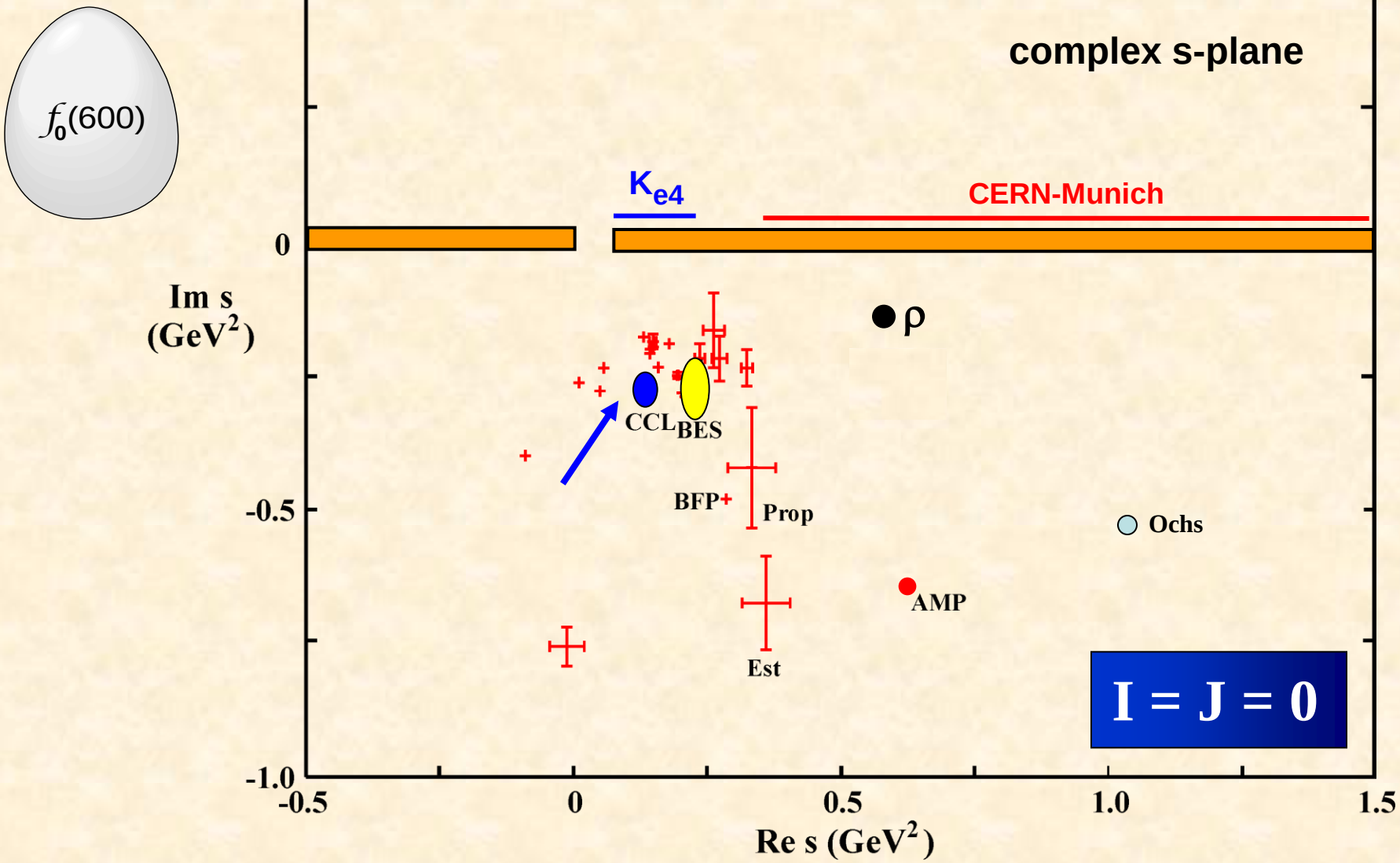
I = J = 0

$\pi\pi \longrightarrow \pi\pi$



Scalar mesons

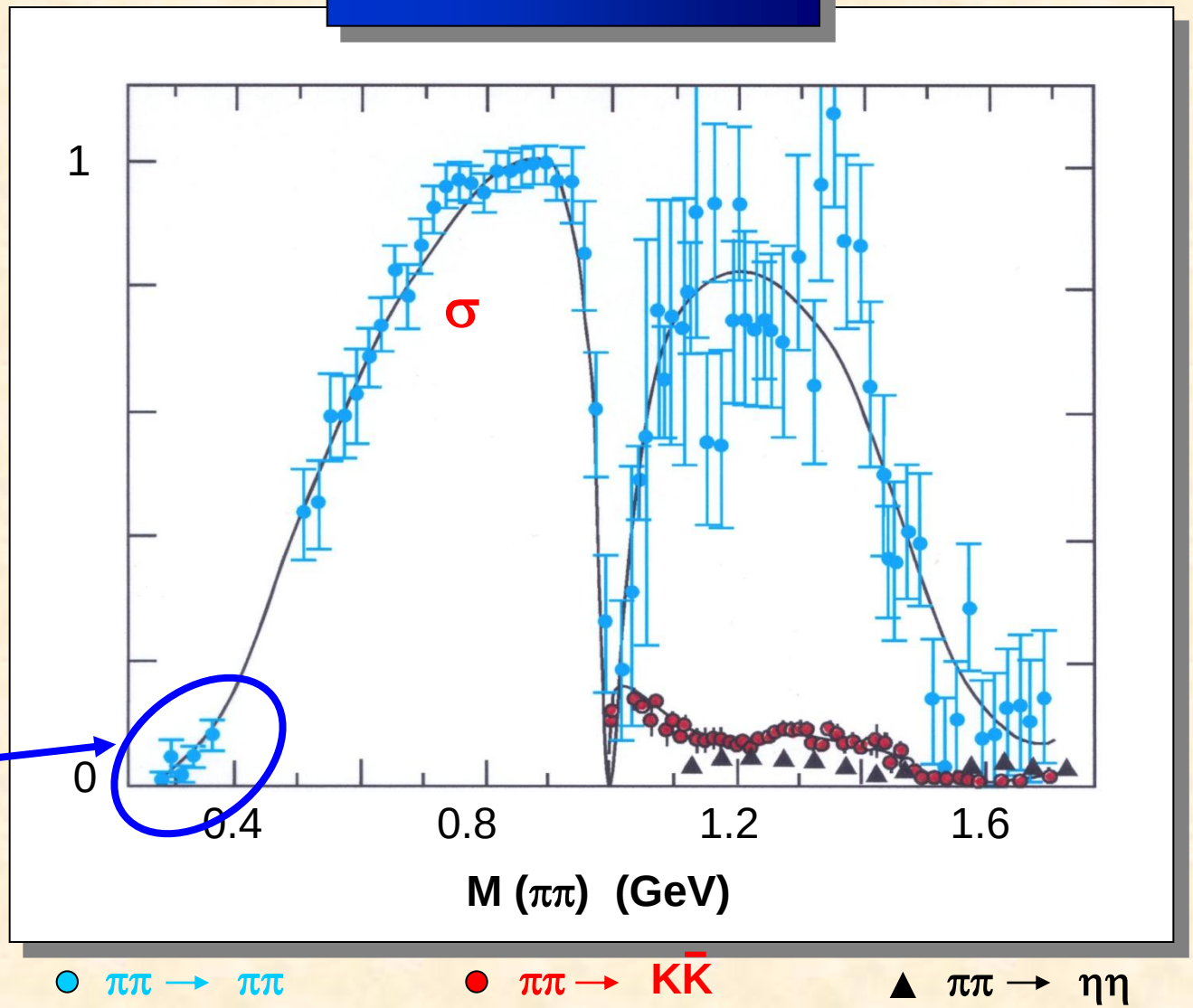
$s = E^2$



Scalar mesons

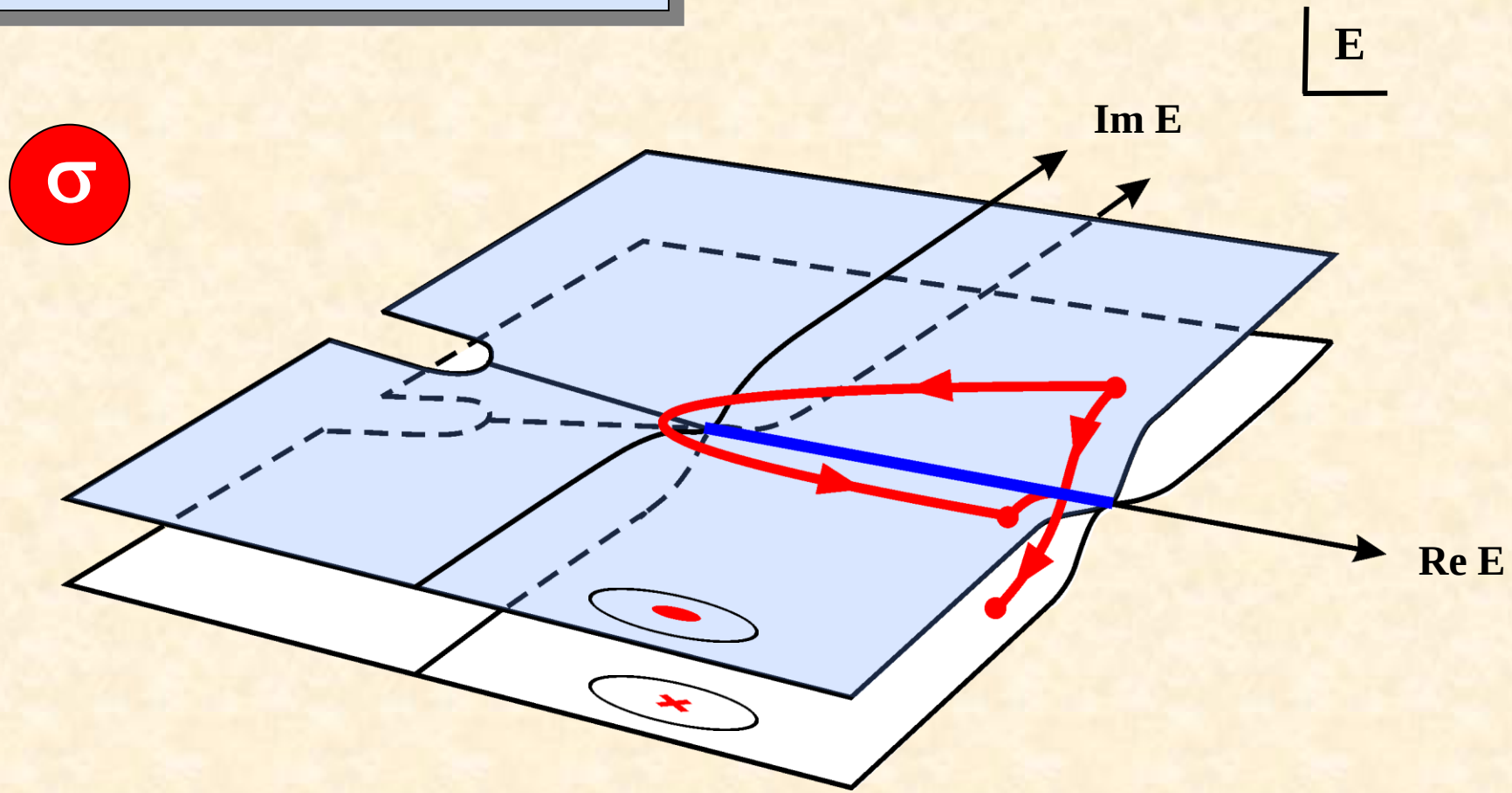
$f_0(600)$

$\pi\pi \longrightarrow \pi\pi$



$K \rightarrow e\nu\pi\pi$

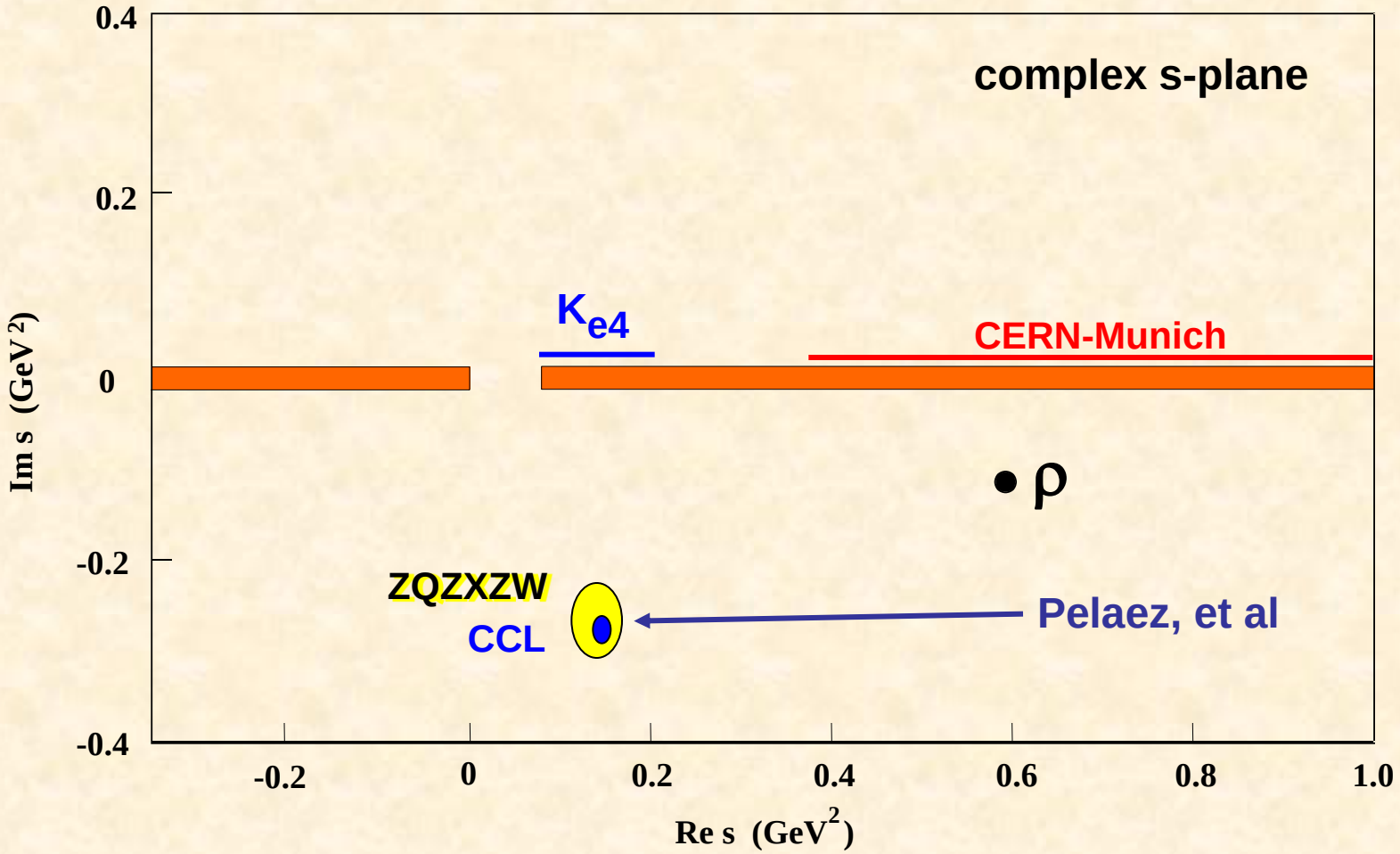
Into the complex plane



Caprini, Colangelo, & Leutwyler

$E_R = 441 - i\,272$ MeV

$\pi\pi$: I = 0, J = 0



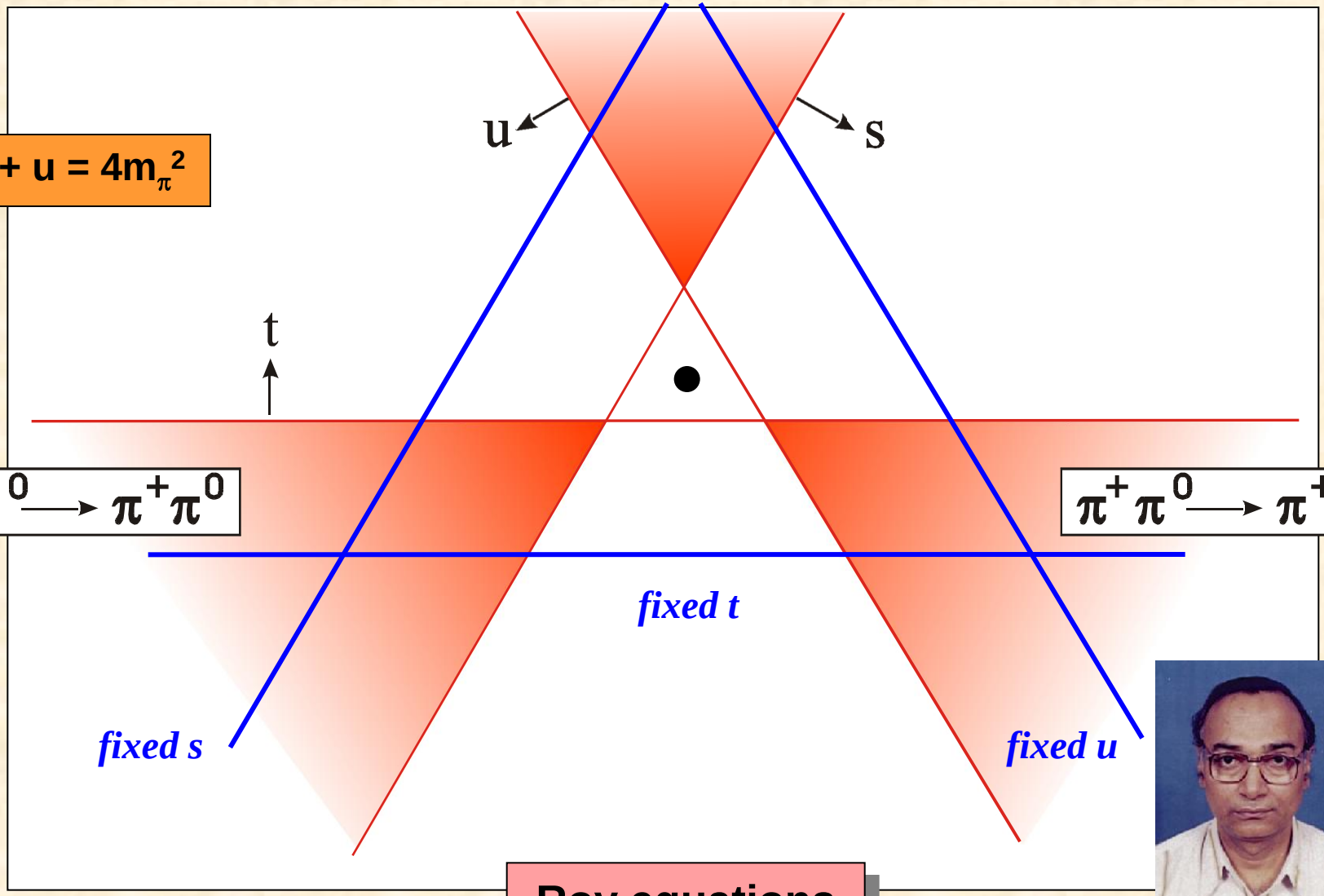
Caprini, Colangelo, & Leutwyler

Zhou, Qin, Zhang, Xiao, Zheng & Wu

$E_R = 441 - i\,272$ MeV

$\pi^+\pi^- \longrightarrow \pi^0\pi^0$

$s + t + u = 4m_\pi^2$

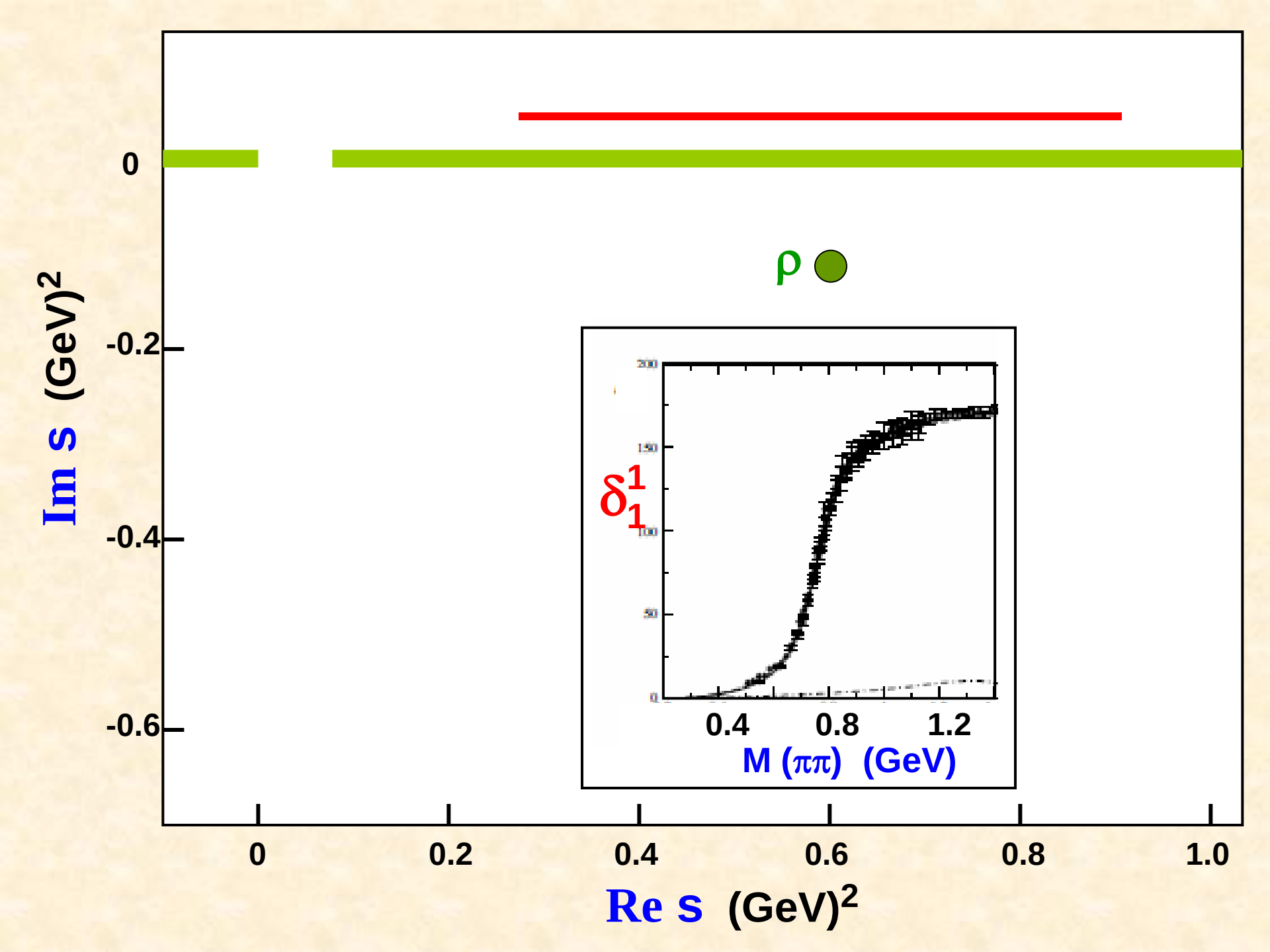


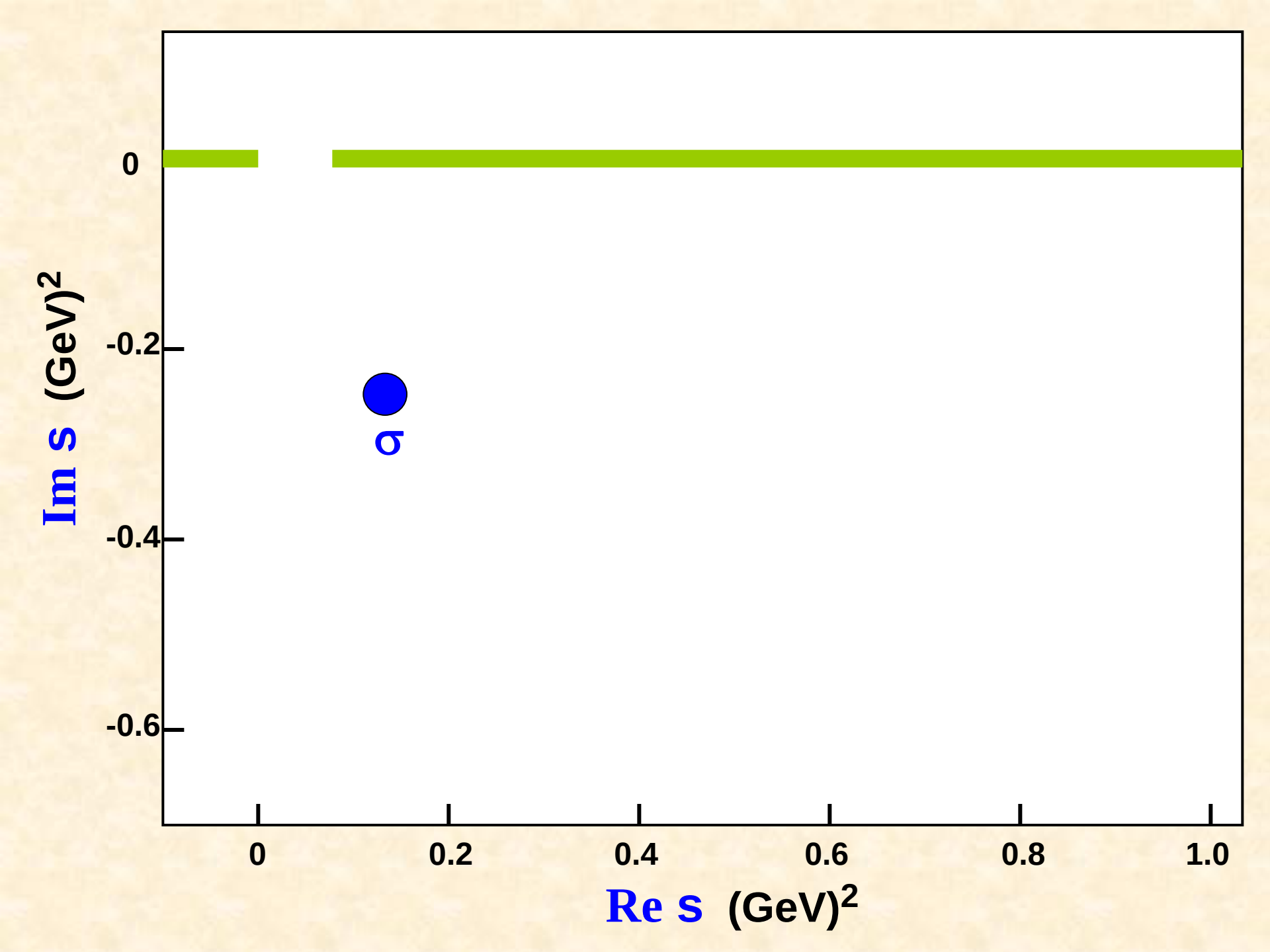
$\pi^+\pi^0 \longrightarrow \pi^+\pi^0$

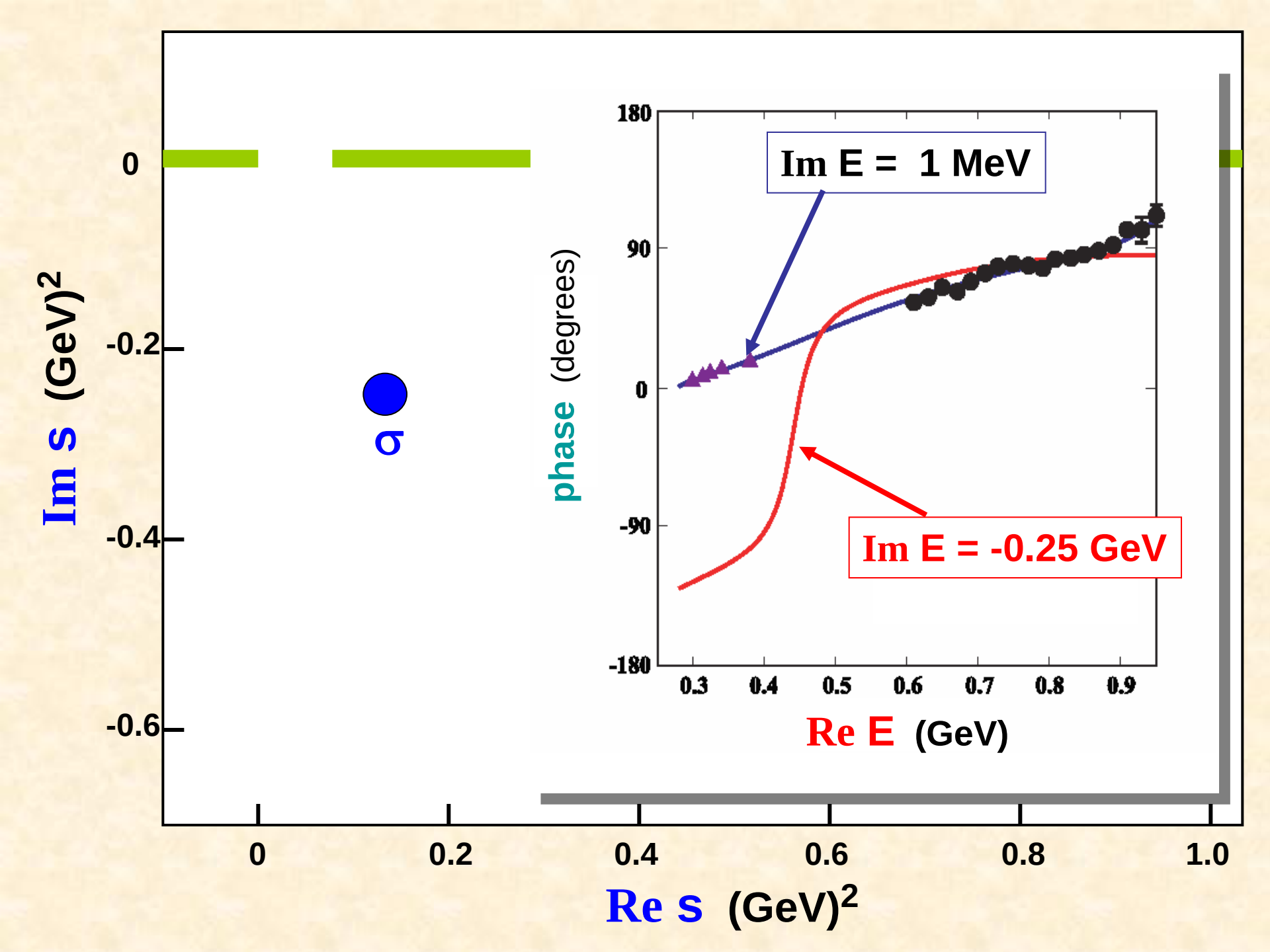
$\pi^+\pi^0 \longrightarrow \pi^+\pi^0$

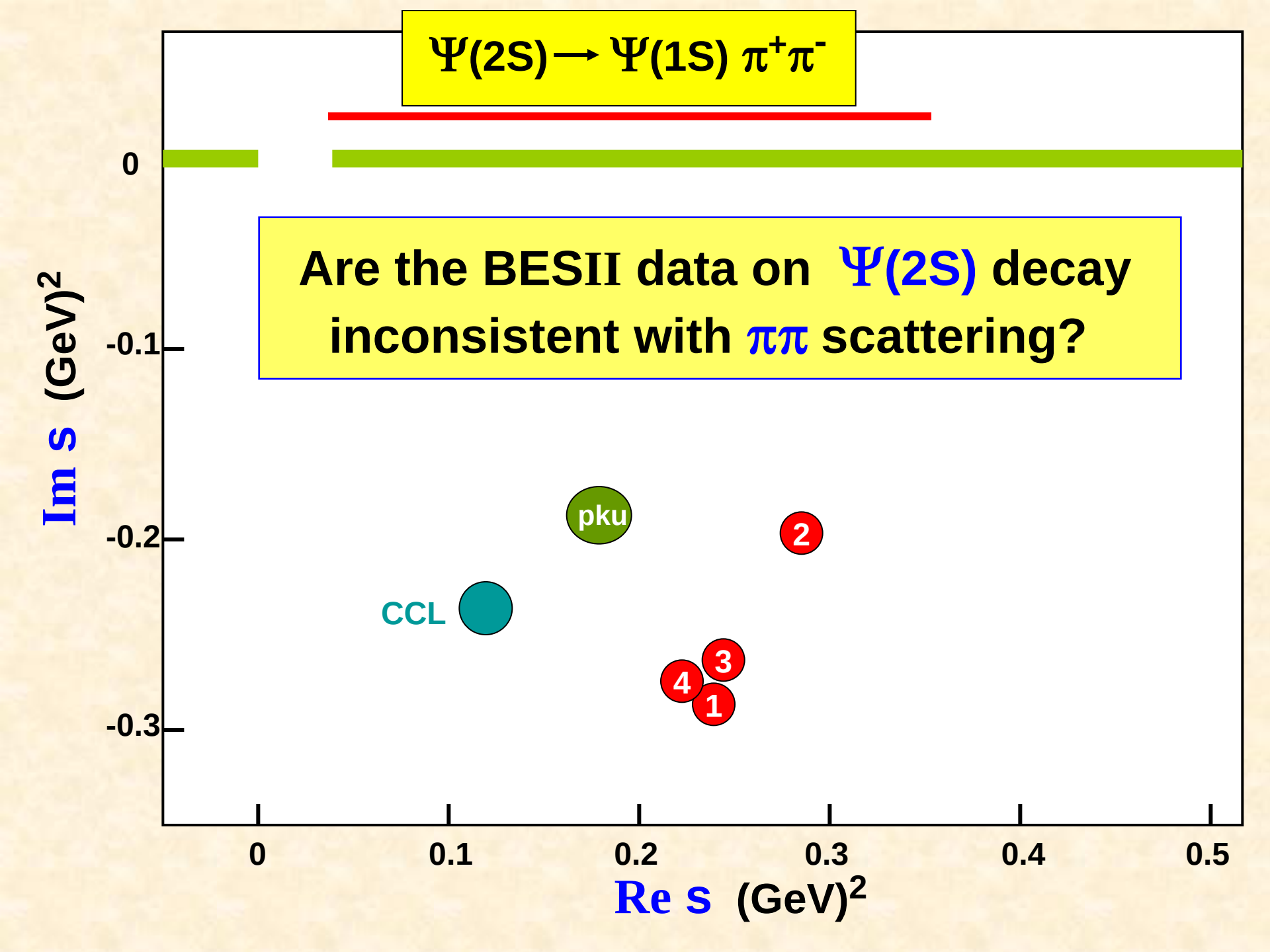
Roy equations

S M Roy

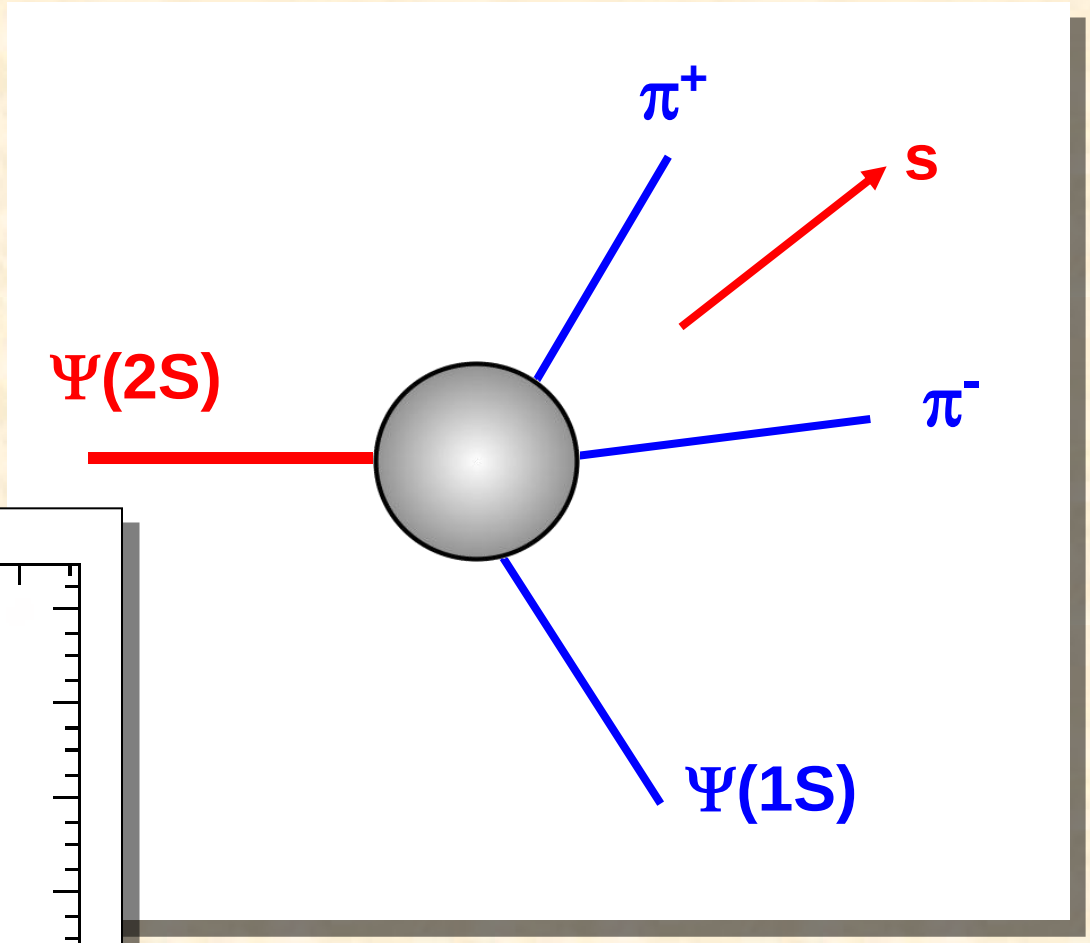

0
-0.2
-0.4
-0.6
Im s (GeV)^2
ρ
δ_1^1
0.4
0.8
1.2
M (ππ) (GeV)
0
0.2
0.4
0.6
0.8
1.0
Re s (GeV)^2

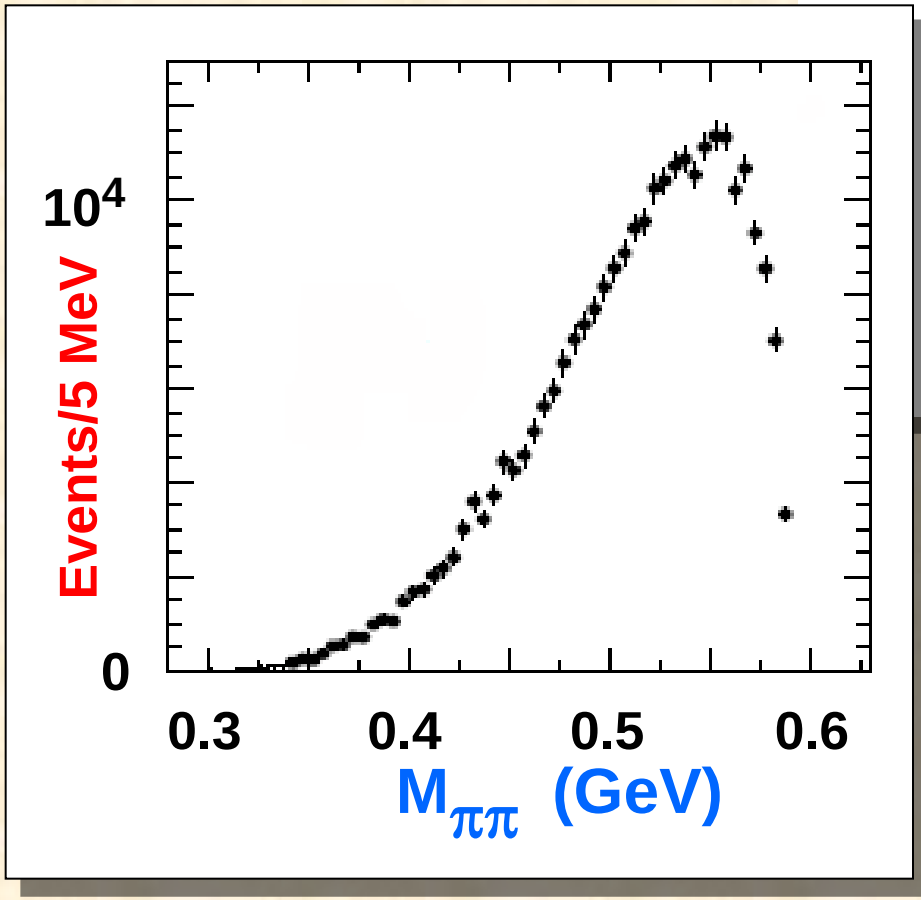

0
-0.2
-0.4
-0.6
Im s (GeV)2
σ
0
0.2
0.4
0.6
0.8
1.0
Re s (GeV)2


0
-0.2
-0.4
-0.6
Im s (GeV)²
σ
0
0.2
0.4
0.6
0.8
1.0
Re s (GeV)²
180
90
0
-90
-180
phase (degrees)
Im E = 1 MeV
Im E = -0.25 GeV
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Re E (GeV)


Ψ(2S)→ Ψ(1S) π+π-
Are the BESII data on Ψ(2S) decay inconsistent with ππ scattering?
pku
2
CCL
3
4
1
0
-0.1
-0.2
-0.3
0
0.1
0.2
0.3
0.4
0.5
Im s (GeV)2
Re s (GeV)2

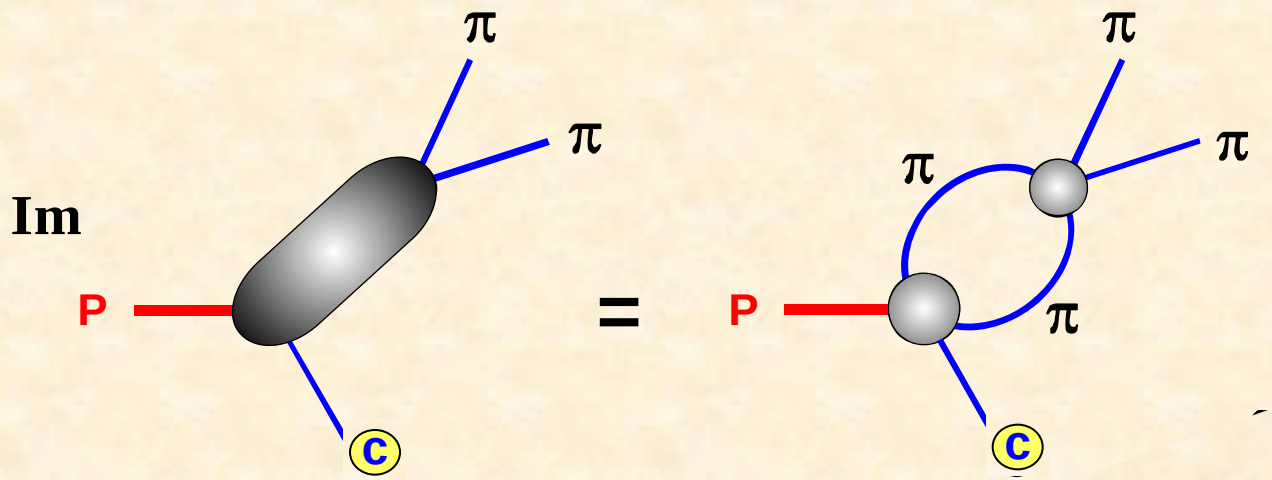
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$





no need for isobar picture

Unitarity : decays in spectator picture

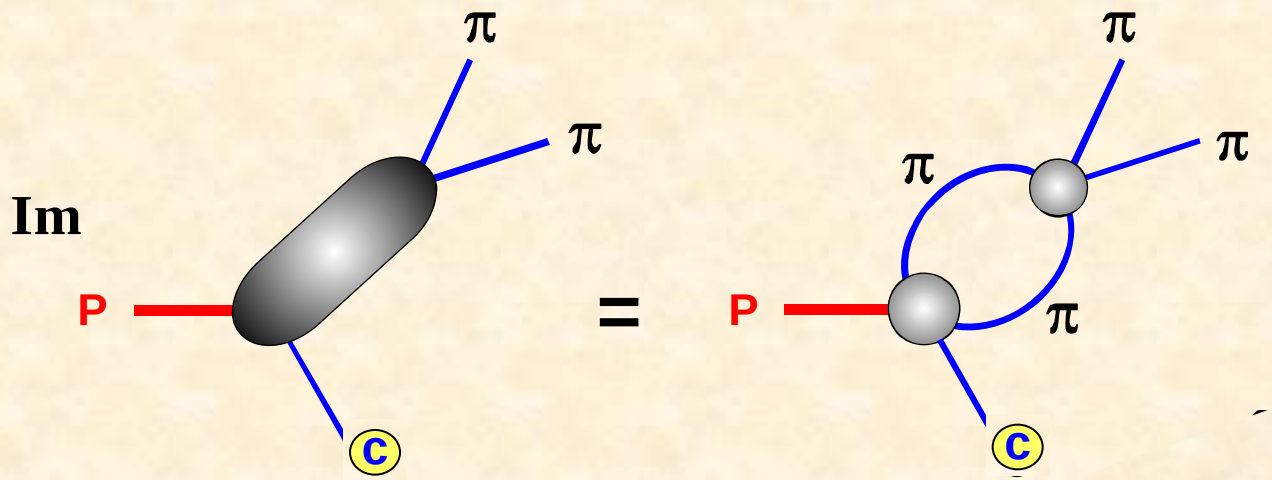


$$T = \frac{K}{1 - i\rho K}$$

$$F = \frac{P}{1 - i\rho K} = \alpha T$$

C spectator

Unitarity : decays in spectator picture



$F = \alpha T$ →

Watson's theorem

elastic

phases simply related if no rescattering

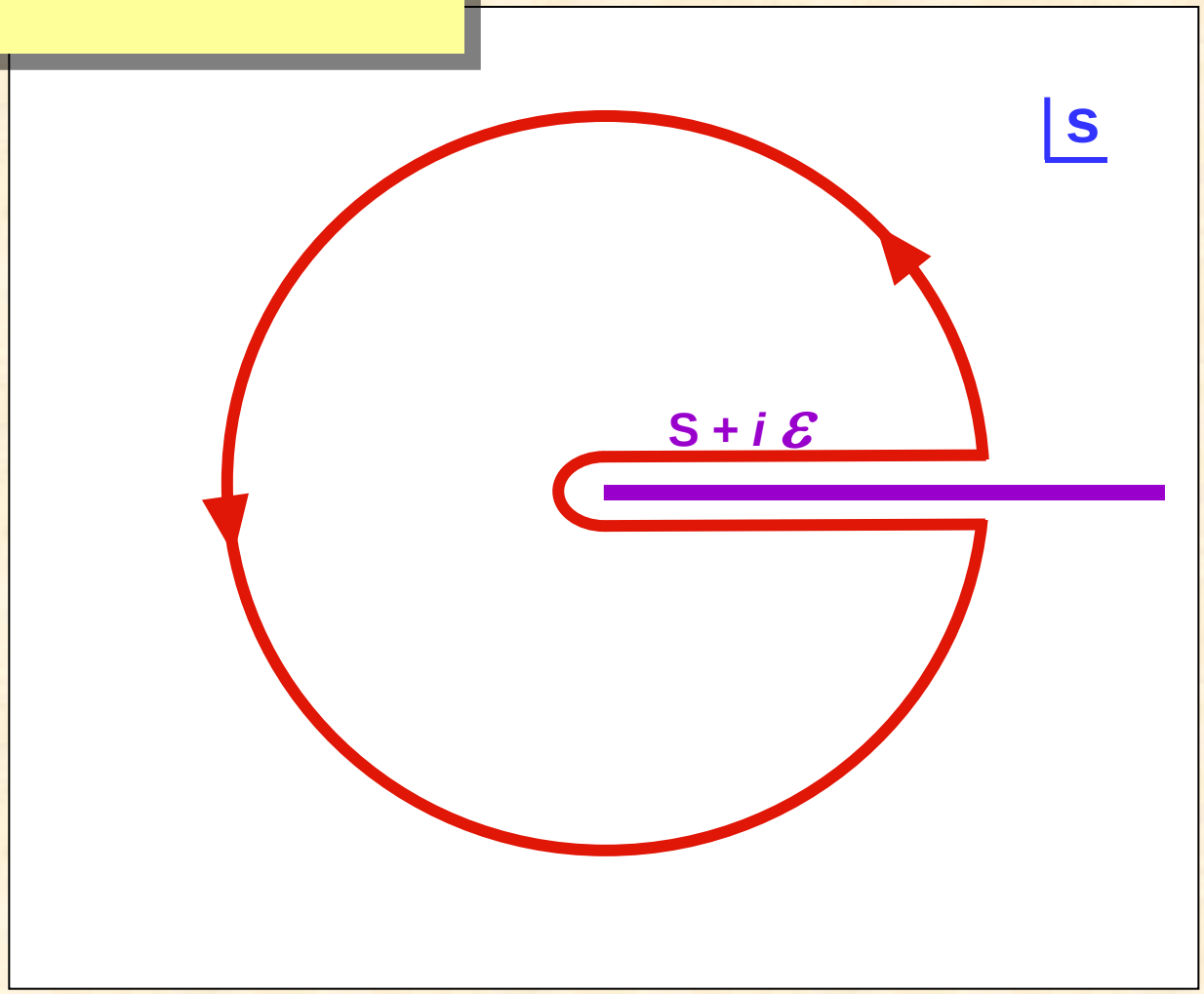
Universality

of final state interactions on the real energy axis

C **spectator**

$$f(s) = \frac{1}{\pi} \int_{s_t}^{\infty} \frac{ds' \ \mathrm{Im}\, f(s')}{(s' - s)}$$

Cauchy's theorem



$$F(s) = |F(s)| \exp\left[i\,\Phi(s) \right]$$

$\Psi(2S) \rightarrow \Psi(1S)\,\pi^+\pi^-$

Step 1: define

$$\Omega(s) = |\Omega(s)| \exp\left[i\,\Phi(s) \right]$$

only has right hand cut

where $\Phi(s) = \Phi(\pi\pi \rightarrow \pi\pi)$ with same I, J in elastic region

$$F(s) = |F(s)| \exp\left[i\,\Phi(s) \right]$$

$\Psi(2S) \rightarrow \Psi(1S)\,\pi^+\pi^-$

Step 1: define

$$\Omega(s) = |\Omega(s)| \exp\left[i\,\Phi(s) \right]$$

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where $\Phi(s) = \Phi(\pi\pi \rightarrow \pi\pi)$ with same I, J in elastic region

Step 2: then

$$F(s) = P(s)\,.\,\Omega(s)$$

where $P(s)$ is real for $s > s_t$

Step 1: define

$$\Omega(s) = |\Omega(s)| \exp\left[i \Phi(s) \right]$$

only has right hand cut

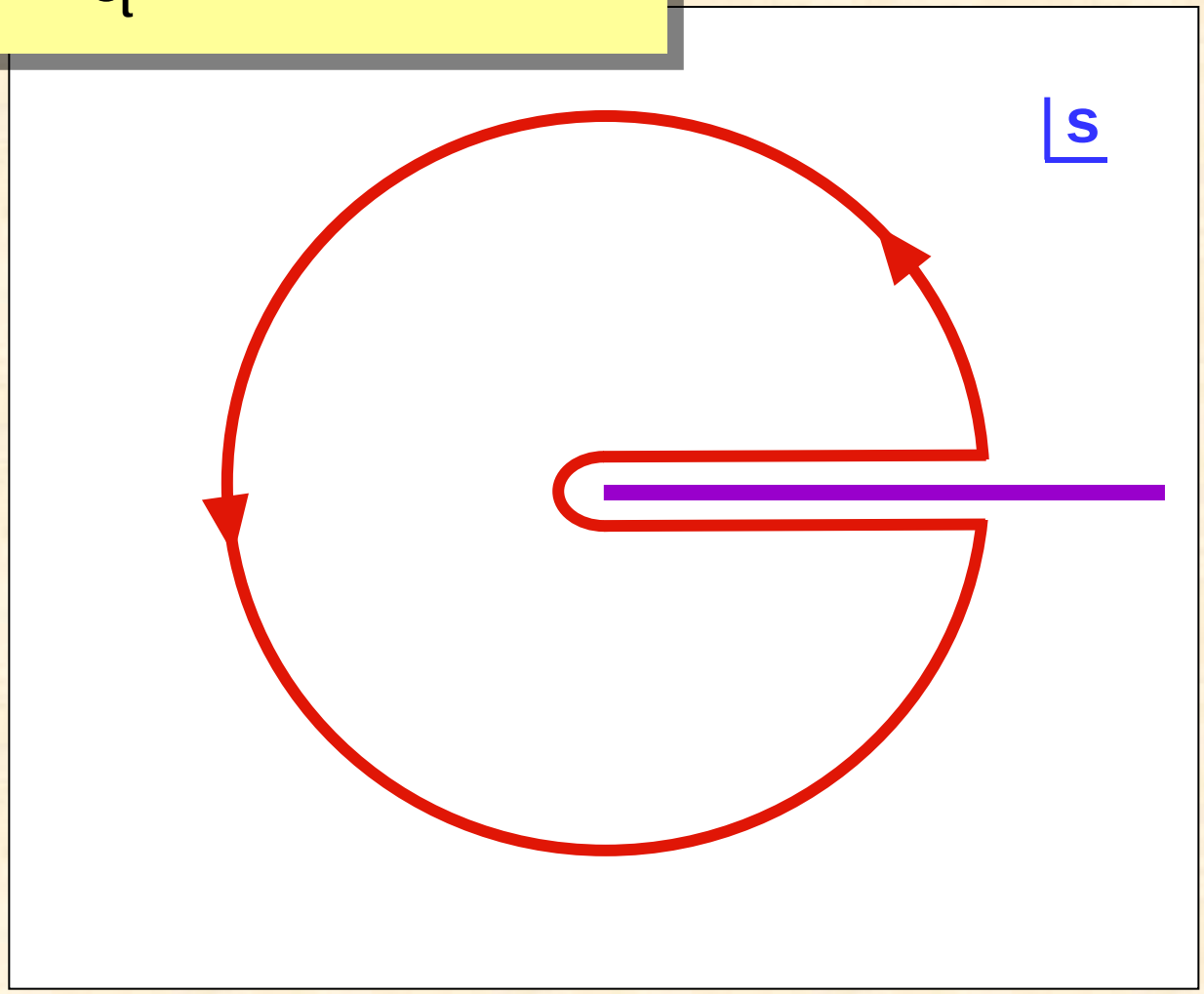
where $\Phi(s) = \Phi(\pi\pi \to \pi\pi)$ with same I, J in elastic region

$$f(s) = \frac{1}{\pi} \int_{s_t}^{\infty} \frac{ds' \ \mathrm{Im}\, f(s')}{(s' - s)}$$

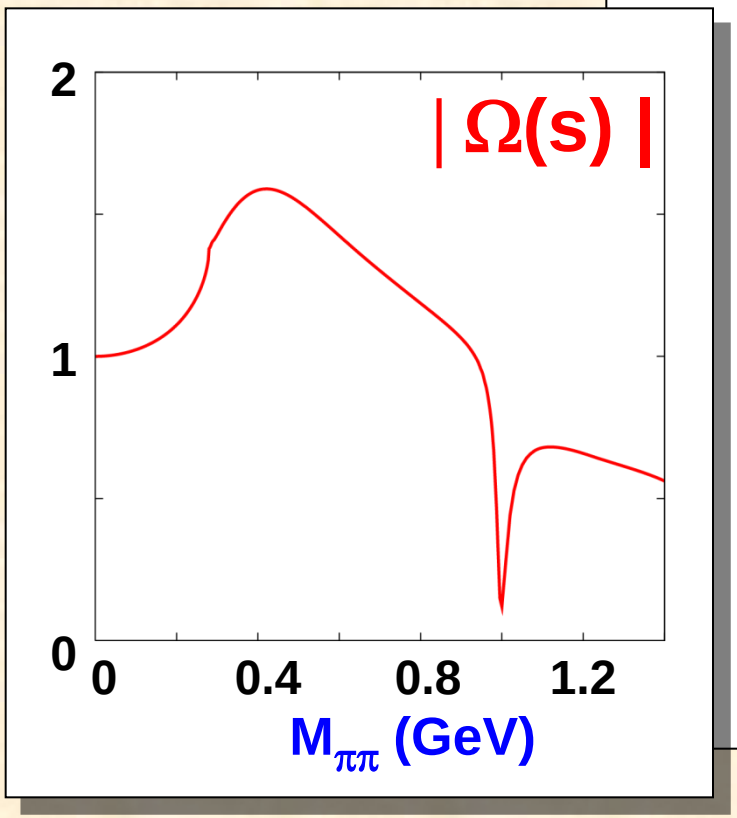
only has right hand cut

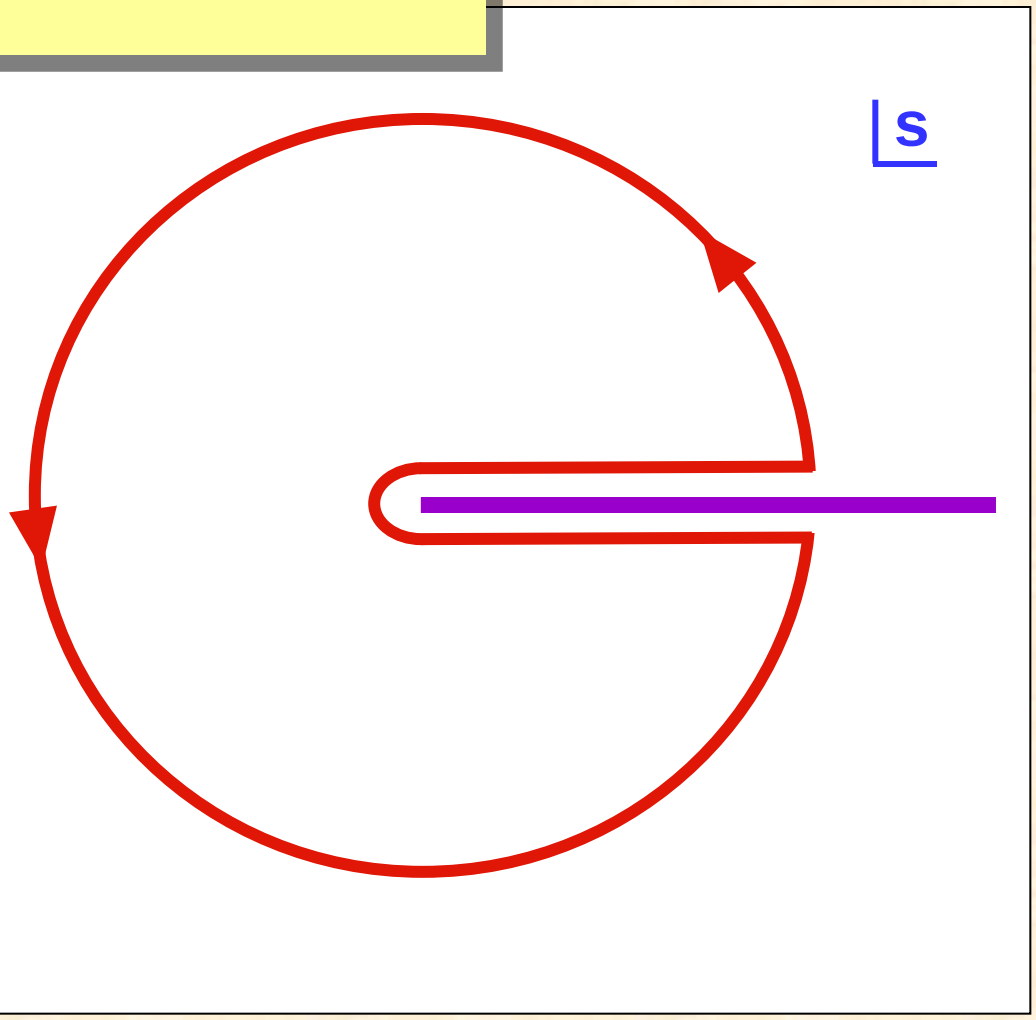
let $f(s) = \ln \Omega(s)$

$$\Omega(s) = \exp\left[\frac{i\,s}{\pi}\int_{s_t}^{\infty}\frac{ds'\ \Phi(s')}{s'\,(s'-s)}\right]$$



$$\Omega(s) = \exp\left[\frac{i\,s}{\pi}\int_{s_t}^{\infty}\frac{ds'\ \Phi(s')}{s'\,(s'-s)}\right]$$





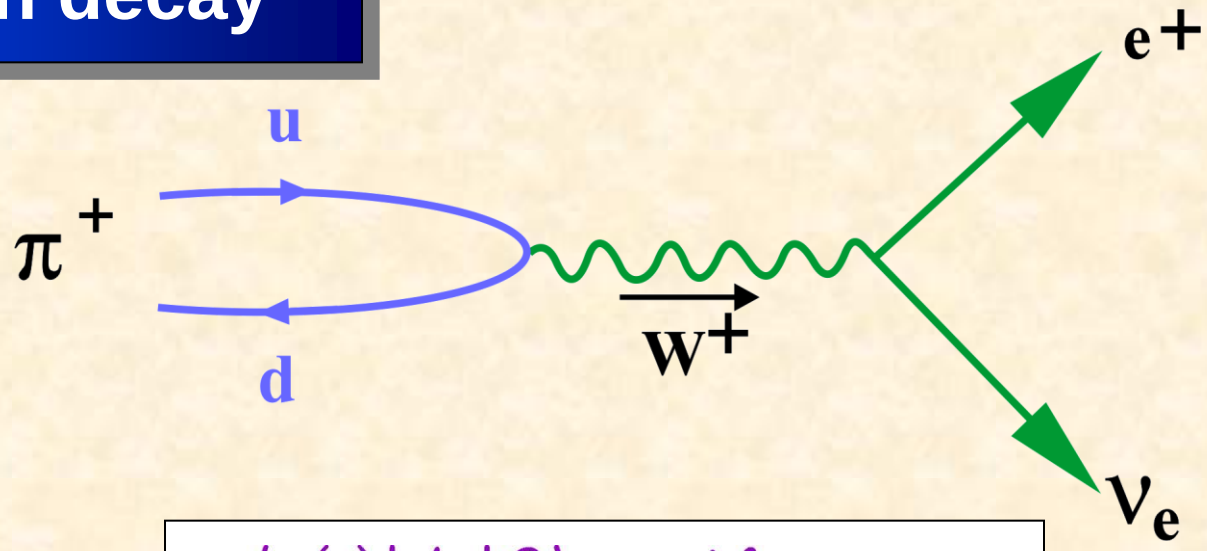
Step 2: then

$$F(s) = P(s) \cdot \Omega(s)$$

where $P(s)$ is real for $s > s_t$

what is $P(s)$ for $\Psi(2S) \rightarrow \Psi(1S)\,\pi^+\pi^-$?

Pion decay



$$\langle \pi(p) | A_\mu | O \rangle = i f_\pi p_\mu$$

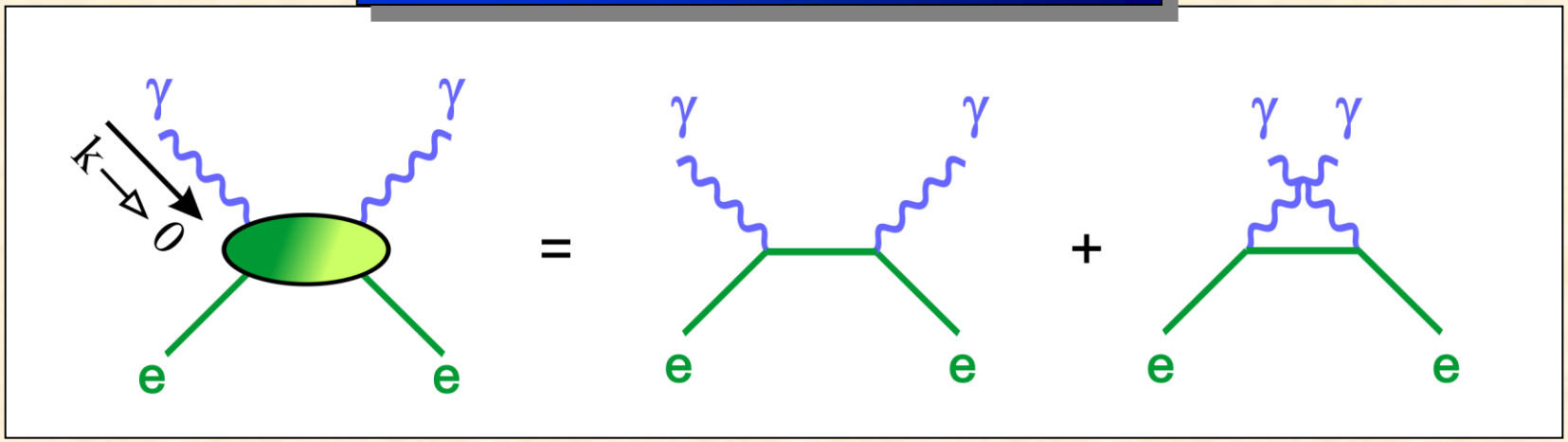
$$\langle \pi(p) | \partial^\mu A_\mu | O \rangle = i f_\pi p_\mu (-i p^\mu)$$

$$= f_\pi m_\pi^2$$

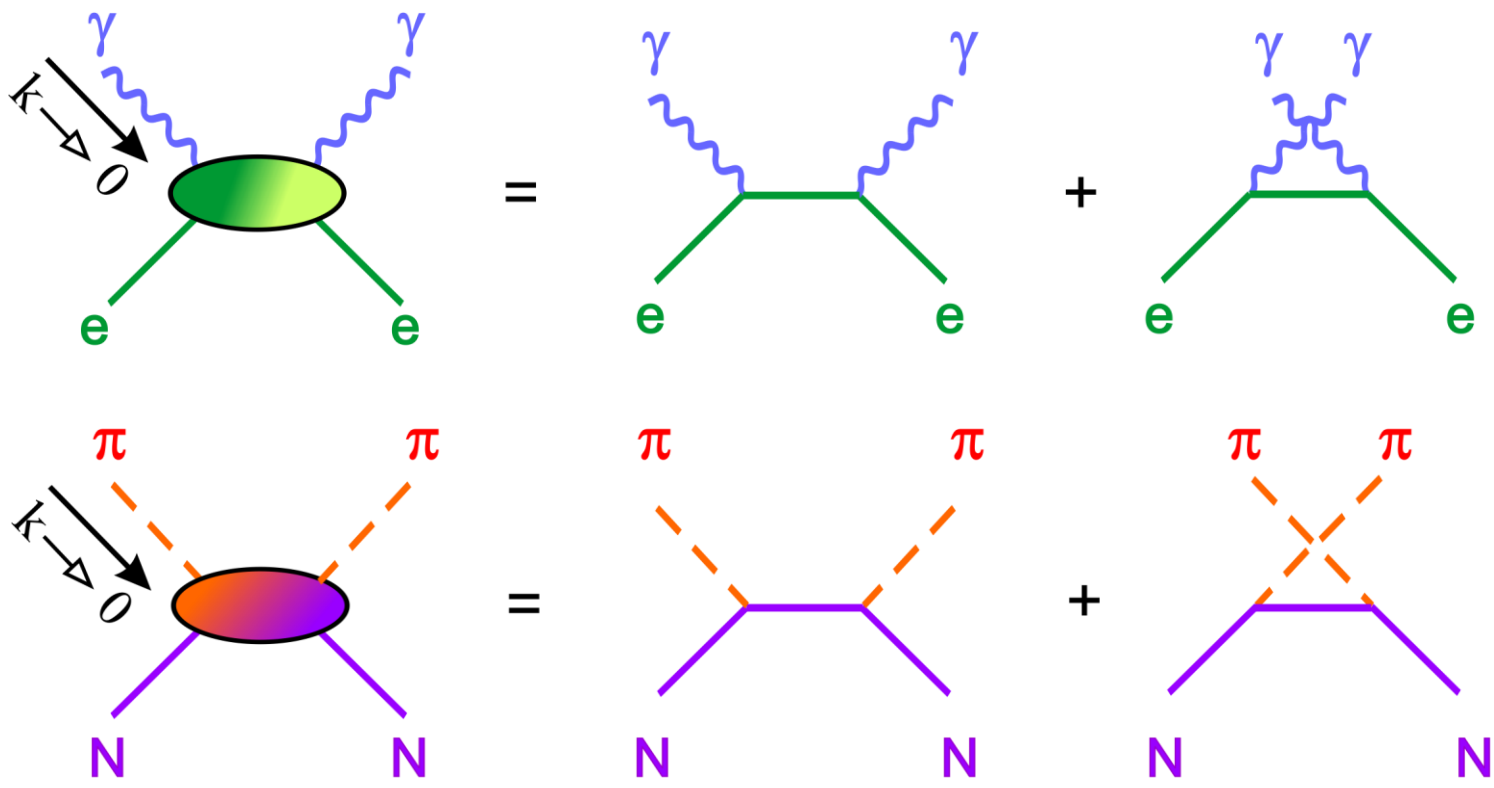
$m_\pi \to 0$ $\qquad$ $\partial^\mu A_\mu = 0$

CAC PCAC

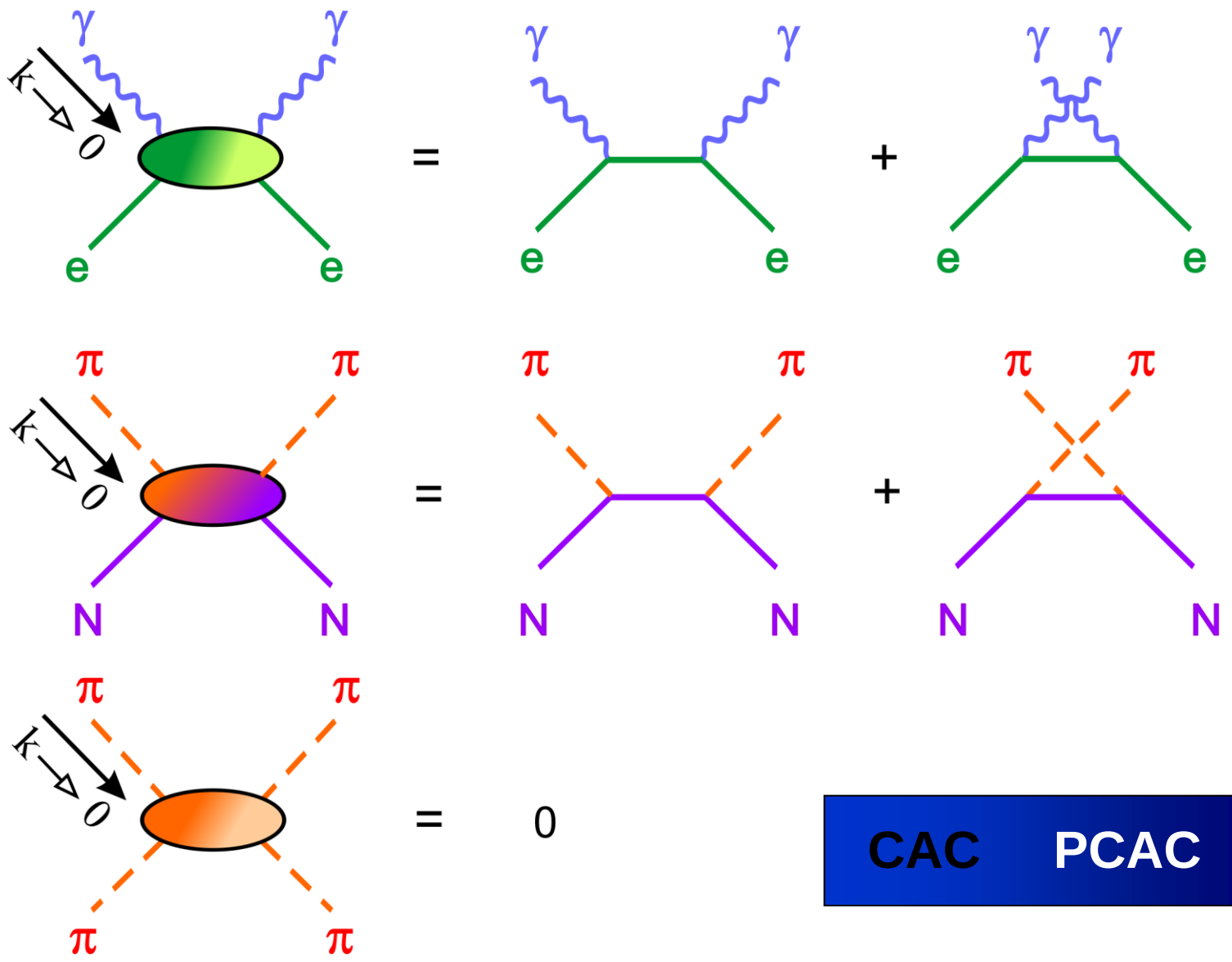
Low energy theorems

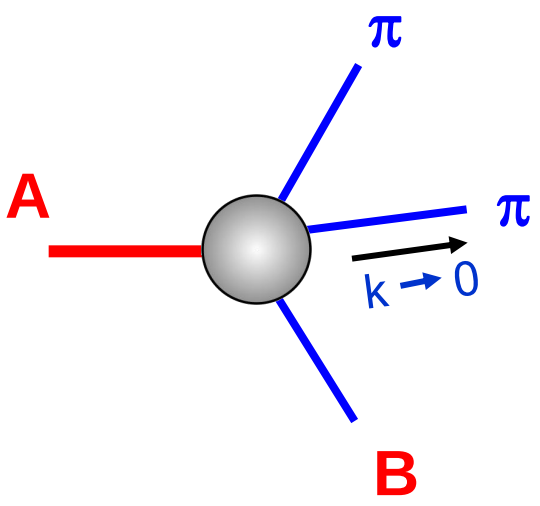


Low energy theorems

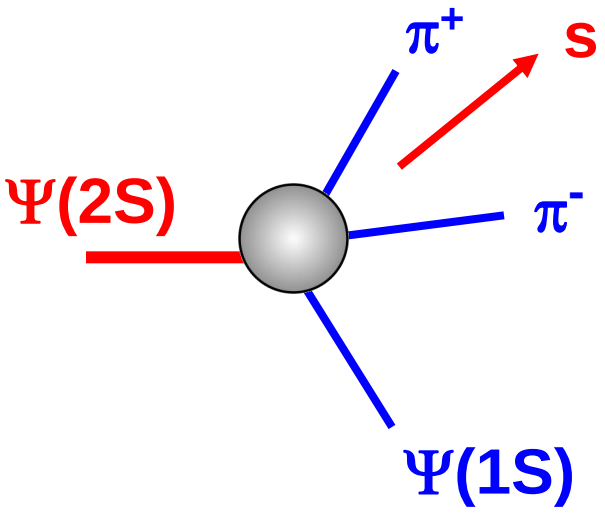


Low energy theorems





= Born amplitude



= 0

$s = O(m_\pi^2)$

PHYSICAL REVIEW D VOLUME 12, NUMBER 5 1 SEPTEMBER 1975

$\psi' \to \psi\pi\pi$ decay as a test of partial conservation of axial-vector current

D. Morgan and M. R. Pennington
Rutherford Laboratory, Chilton, Didcot, Berkshire, OX11 0QX, England
(Received 14 April 1975)

The shape of the $\pi^+\pi^-$ mass distribution in the recently analyzed $\psi' \to \psi\pi\pi$ decay is explained. Although the explanation assumes the known general features of the $\pi\pi$ s-wave amplitude, detailed alternatives are not distinguished; rather, it is the on-shell appearance of the Adler zero which is crucial. The extension of this description to other dipion production processes is illustrated with a discussion of low energy $\pi^- p \to \pi^+\pi^- n$.

$\Psi(2S) \to \Psi(1S)\ \pi^+\pi^-$

$P(s) = N \cdot (s - \lambda m_\pi^2)$

PHYSICAL REVIEW LETTERS

VOLUME 35 7 JULY 1975 NUMBER 1

Chiral Symmetry and $\psi' \to \psi\pi\pi$ Decay

Lowell S. Brown
Fermi National Accelerator Laboratory, Batavia, Illinois 60510, and Physics Department, University of Washington, Seattle, Washington 98195

and

Robert N. Cahn
Physics Department, University of Washington, Seattle, Washington 98195
(Received 23 April 1975)

Unbroken chiral symmetry (with a vanishing σ term) relates the $\psi' \to \psi\pi\pi$ decay amplitude to three basic parameters. Two of these parameters put strong angular correlations in the amplitude which, apparently, are not observed. Taking these two parameters to vanish, we obtain an isotropic decay which is strongly peaked in the region where the invariant mass of the $\pi\pi$ system is large.

Step 2: then $\Psi(2S) \rightarrow \Psi(1S)\, \pi^+\pi^-$

$$F(s) = P(s) \,.\, \Omega(s)$$

where $P(s)$ is real for $s > s_t$

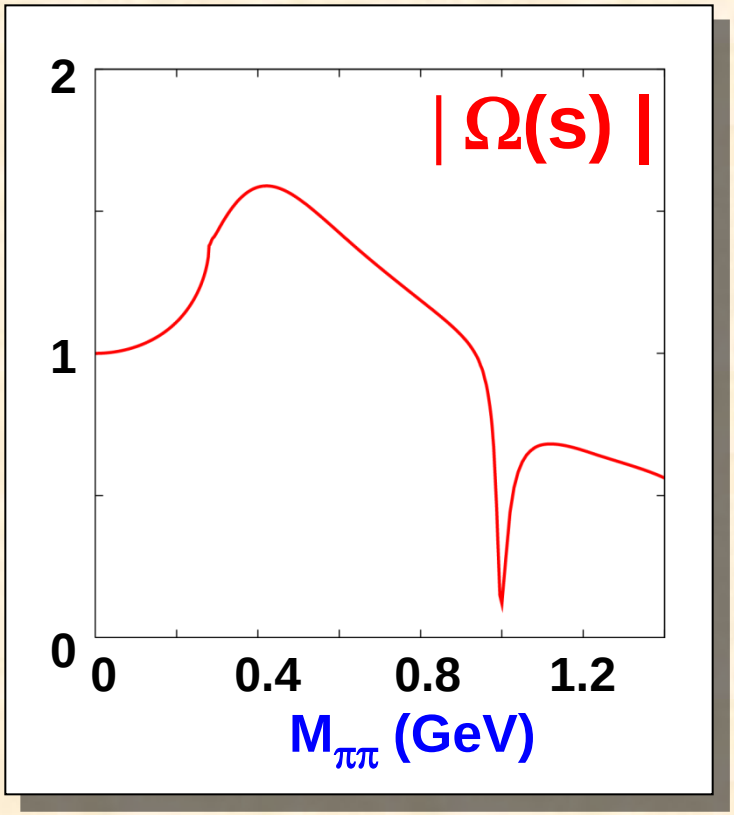
$$P(s) = N \,.\, (s - \lambda\, m_\pi^2)$$

Step 2: then $\Psi(2S) \rightarrow \Psi(1S)\, \pi^+\pi^-$

$$F(s) = P(s) \,.\, \Omega(s)$$

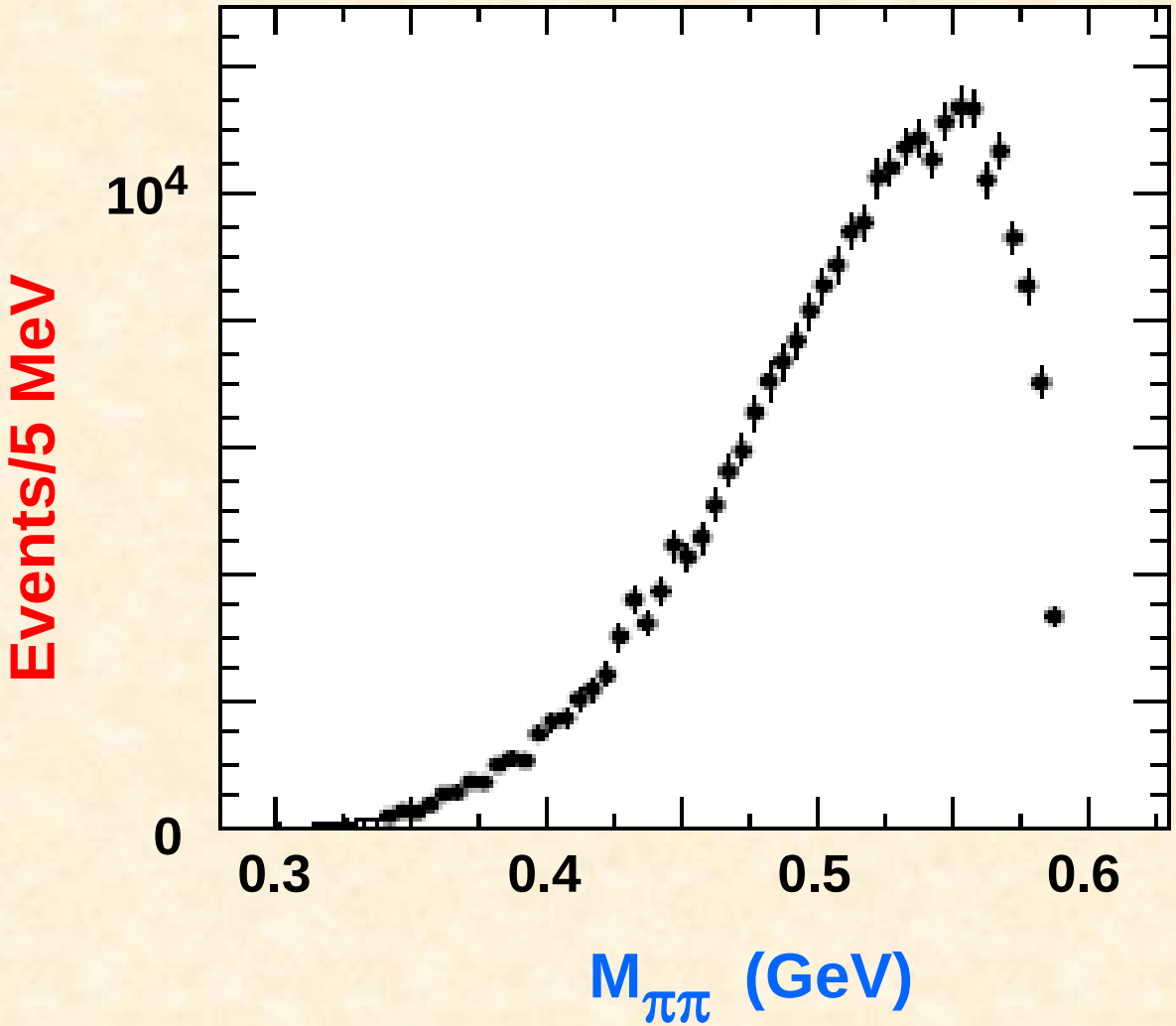
where $P(s)$ is real for $s > s_t$

$$P(s) = N \,.\, (s - \lambda\, m_\pi^2)$$

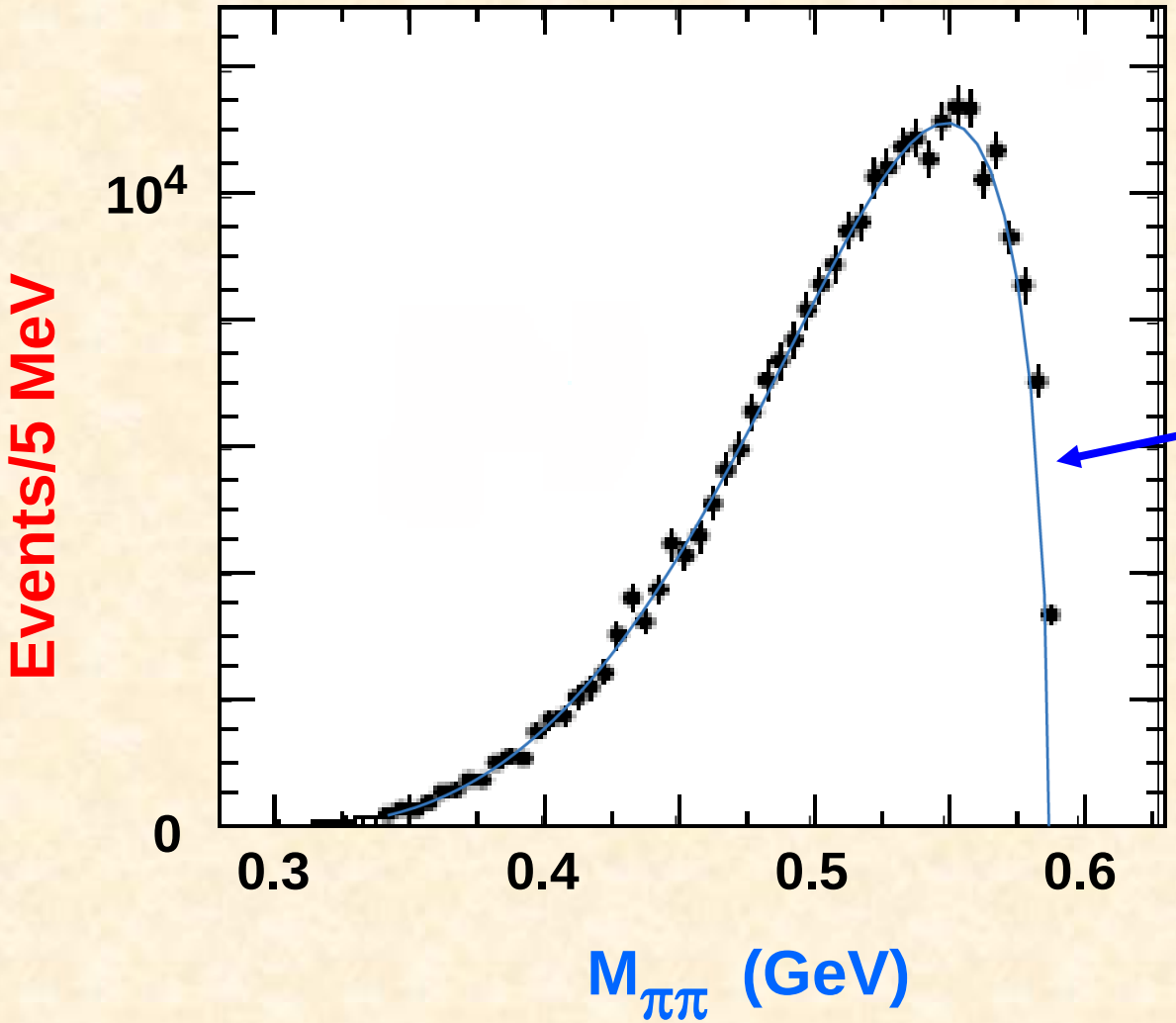


$|\,\Omega(s)\,|$ encodes σ

$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$



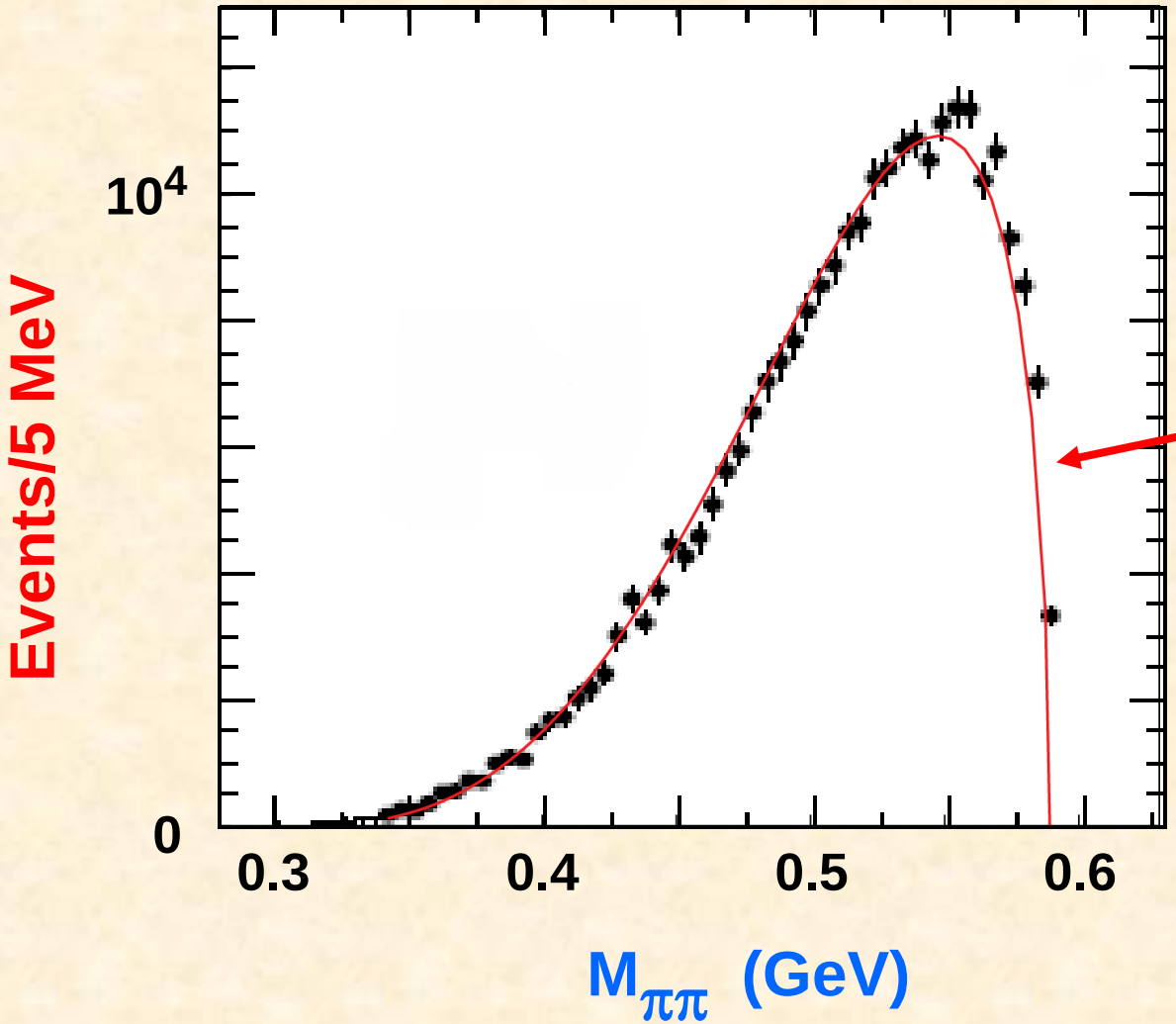
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$



$|\Omega(s)| = 1$

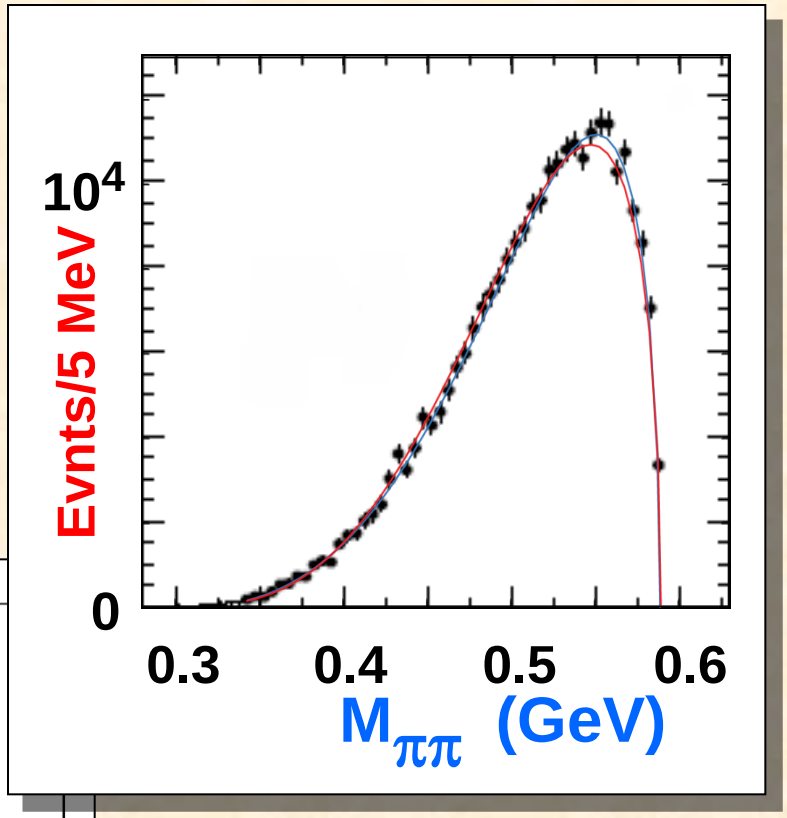
no σ

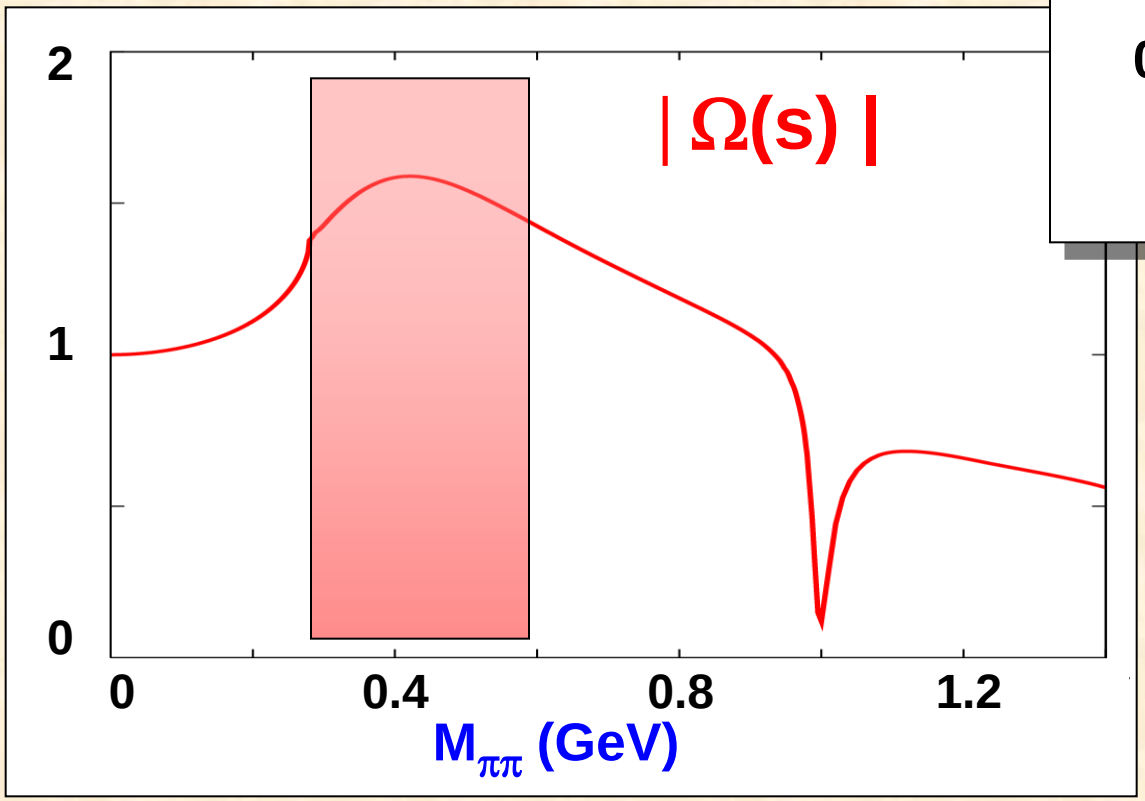
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$



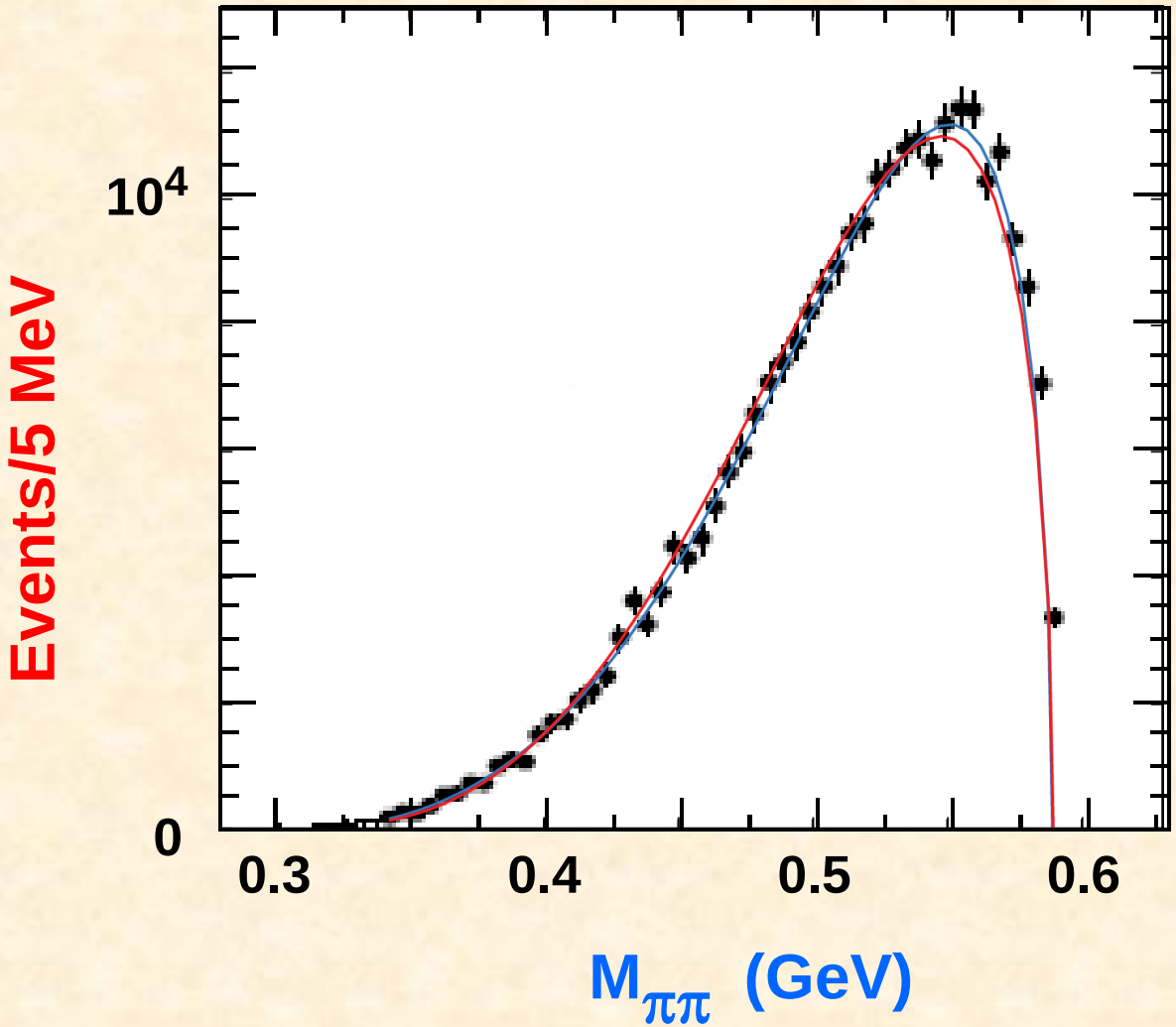
$|\Omega(s)|$ with σ

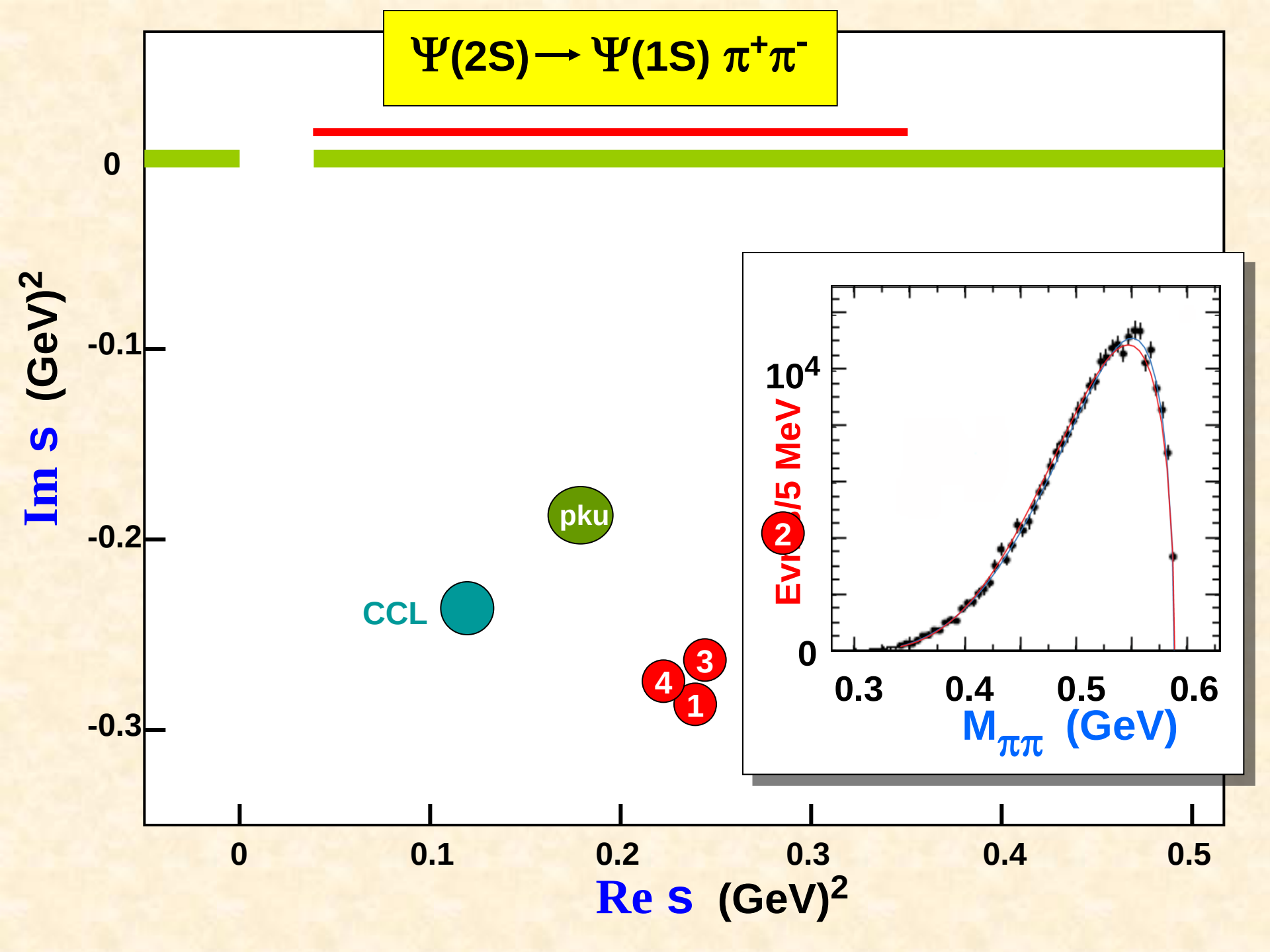
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$





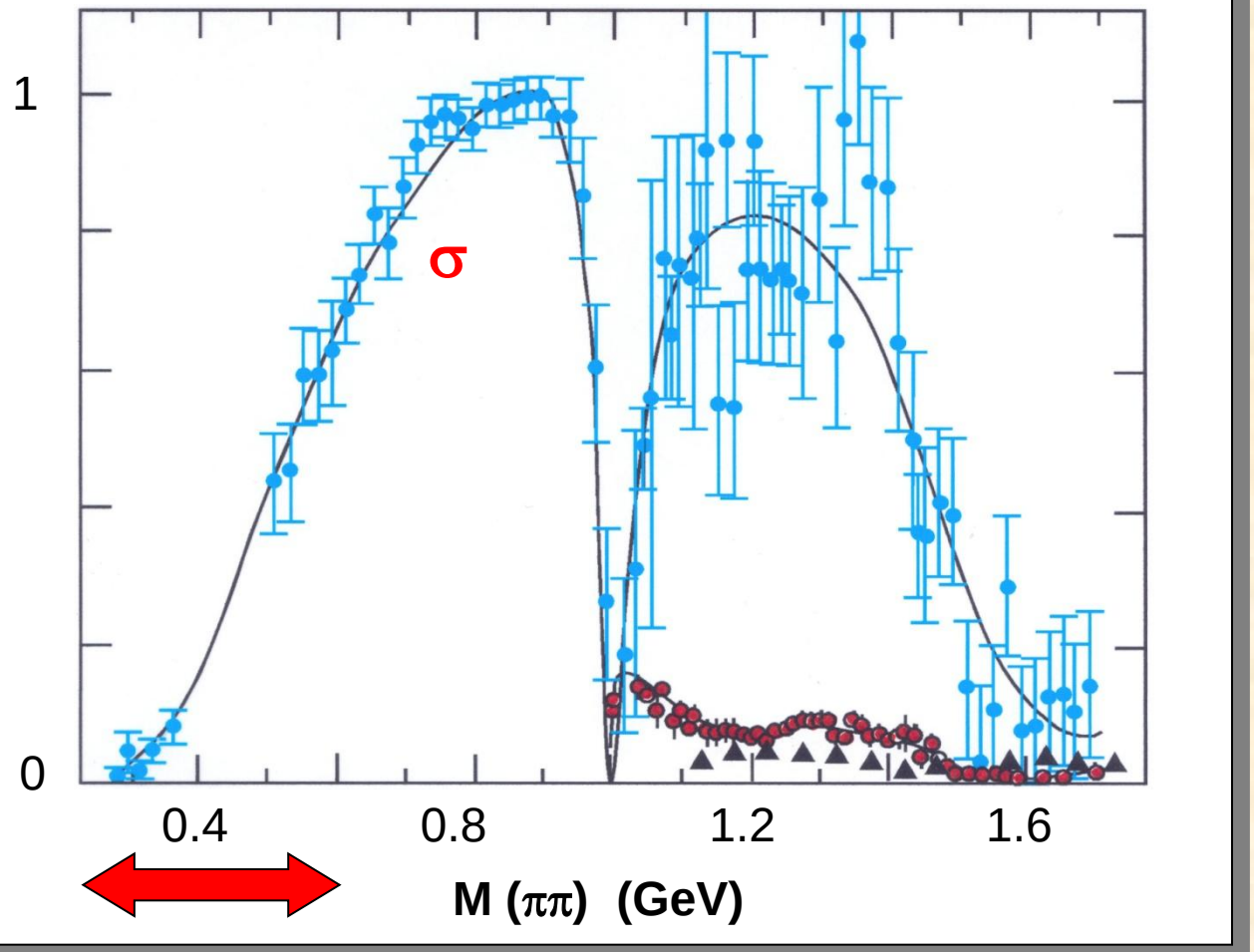
$\Psi(2S) \rightarrow \Psi(1S)\ \pi^+\pi^-$




Ψ(2S)→ Ψ(1S) π+π-
0
-0.1
-0.2
-0.3
Im s (GeV)2
0
0.1
0.2
0.3
0.4
0.5
Re s (GeV)2
pku
CCL
3
4
1
2
10^4
0
0.3
0.4
0.5
0.6
Mππ (GeV)

$\pi\pi \longrightarrow \pi\pi$

I = J = 0

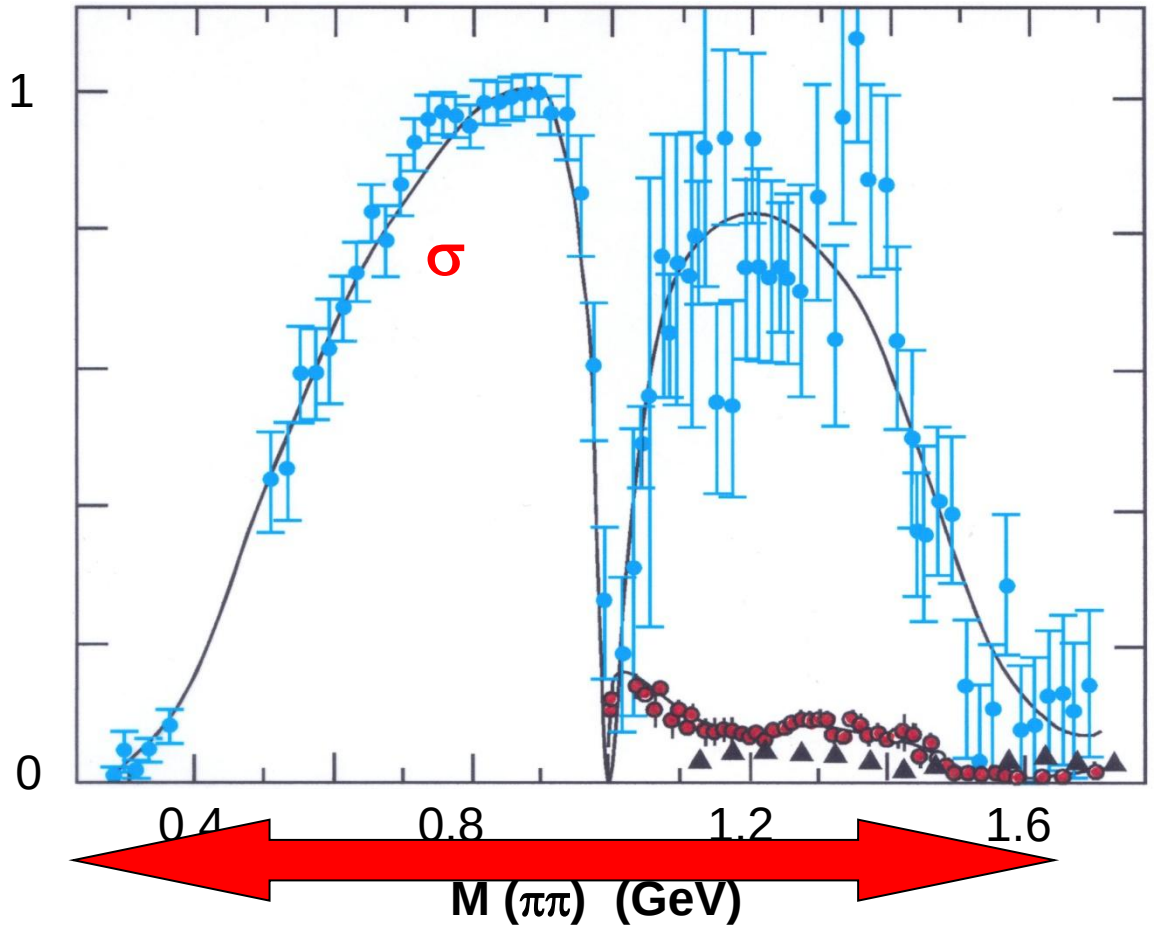


● ππ → ππ ● ππ → $K\bar{K}$ ▲ ππ → ηη

BES III can add to our knowledge

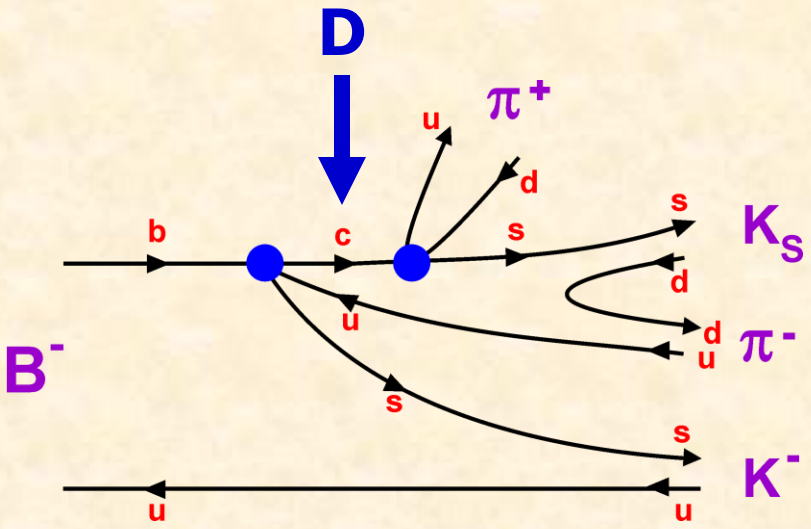
$\pi\pi \longrightarrow \pi\pi$

I = J = 0

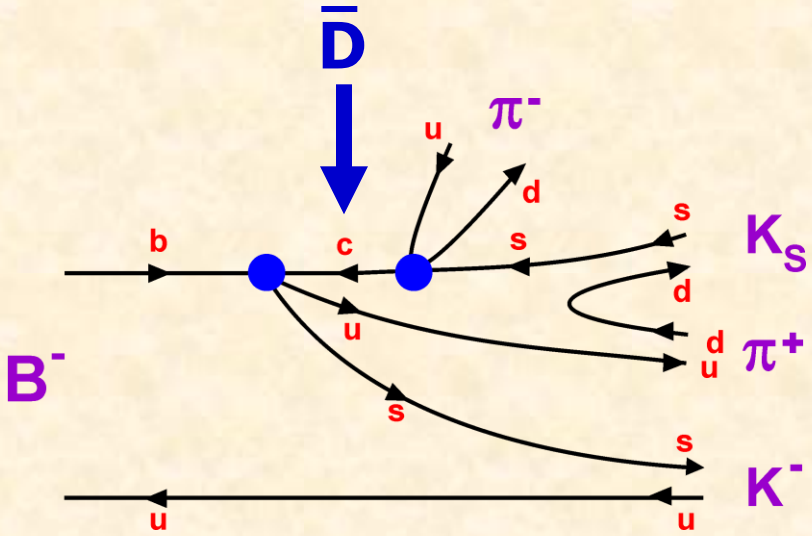


BES III can add to our knowledge

$B \to D\bar{K} \to \bar{K}K\pi\pi$



$B \to \bar{D}K \to \bar{K}K\pi\pi$



$$J/\Psi \rightarrow K^* K \pi$$
$$\hookrightarrow K\pi$$

PHYSICS LETTERS B

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Physics Letters B 633 (2006) 681–690

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Evidence for κ meson production in $J/\psi \to \bar{K}^*(892)^0 K^+ \pi^-$ process

BES Collaboration

M. Ablikim[a], J.Z. Bai[a], Y. Ban[o], J.G. Bian[a], X. Cai[a], H.F. Chen[p], H.S. Chen[a], H.X. Chen[a], J.C. Chen[a], Jin Chen[a], Y.B. Chen[a], S.P. Chi[b], Y.P. Chu[a], X.Z. Cui[a], Y.S. Dai[w], Z.Y. Deng[a], Q.F. Dong[a], S.X. Du[a], Z.Z. Du[a], J. Fang[a], S.S. Fang[b], C.D. Fu[a], F.A. Harris[t], K.L. He[a], M. He[n], Y.K. Heng[a], Y.T. Gu[d], Y.N. Guo[a], Y.Q. Guo[a], Z.J. Guo[t], F.A. Harris[t], K.L. He[a], M. He[n], Y.K. Heng[a], H.M. Hu[a], T. Hu[a], G.S. Huang[a,3], X.P. Huang[a], X.T. Huang[l], T. Komada[n], S. Kurokawa[h], M. Ishida[j], S. Ishida[n], X.B. Ji[a], X.S. Jiang[a], J.B. Jiao[l], D.P. Jin[a], S. Jin[a], Yi Jin[a], T. Komada[n], S. Kurokawa[h], M. Ishida[j], S. Ishida[n], X.B. Ji[a], H.B. Li[a], H.H. Li[a], J. Li[a], R.Y. Li[a], S.M. Li[a], W.D. Li[a], W.G. Li[a], X.L. Li[a], G. Li[b], Y.F. Liang[g], H.B. Liao[f], C.X. Liu[a], Z.A. Liu[a], F. Liu[f], Fang Liu[u], G.R. Liu[s], H.J. Liu[u], J.G. Lu[a], H.M. Liu[a], J. Liu[a], X.Q. Li[m], Y.F. Lai[a], Y.L. Li[a], J.P. Liu[v], R.G. Liu[a], L.L. Ma[a], Q.M. Ma[a], F. Lu[a], G.R. Lu[s], H.J. Lu[u], J.G. Lu[a], C.L. Luo[i], F.C. Ma[i], H.P. Peng[a], N.D. Qi[a], H. Qin[j], J.F. Qiu[a], Z.Y. Ren[a], G. Rong[a], X.Y. Shen[a], H.Y. Sheng[a], F. Shi[a], X. Shi[a,2], H.S. Sun[a], J.F. Sun[a], K. Takamatsu[h,x], Z.Q. Tan[a], X. Tang[a], Y.R. Tian[s], G.L. Tong[a], L. Wang[a], L.S. Wang[a], M. Wang[a], P. Wang[a], P.L. Wang[a], W. Wang[a], Z.Y. Wang[a], Zhe Wang[a], Zheng Wang[c], C.L. Wei[a], D.H. Wei[c], I. Yamanaki[r], B. Xin[t,1], G.F. Xu[a], Y. Xu[m], K. Yamada[n], N. Wu[a,4], X.M. Xia[a], G.F. Xu[a], X.P. Xu[r], J. Yang[a], Y.X. Yang[a], M.H. Ye[b], Y. Xu[m], Y.X. Ye[p], C.X. Yu[j], C.Z. Yuan[a], Y. Yuan[a], Y. Zeng[g], Y. Zeng[g], Yu Zeng[g], J.Y. Zhang[a], B.X. Zhang[a], B.Y. Zhang[a], C.C. Zhang[a], J.W. Zhang[a], Z.Q. Zhang[a], D.X. Zhao[a], Q.J. Zhang[a], X.M. Zhang[a], J.W. Zhao[a], M.G. Zhao[a], H.Q. Zheng[o], J.P. Zheng[a], Z.P. Zheng[a], L. Zhou[a], N.F. Zhou[a], Y.S. Zhu[a], Yingchun Zhu[a,5], Z.A. Zhu[a], Z.L. Zhu[c], B.A. Zhuang[a], B.S. Zou[a]

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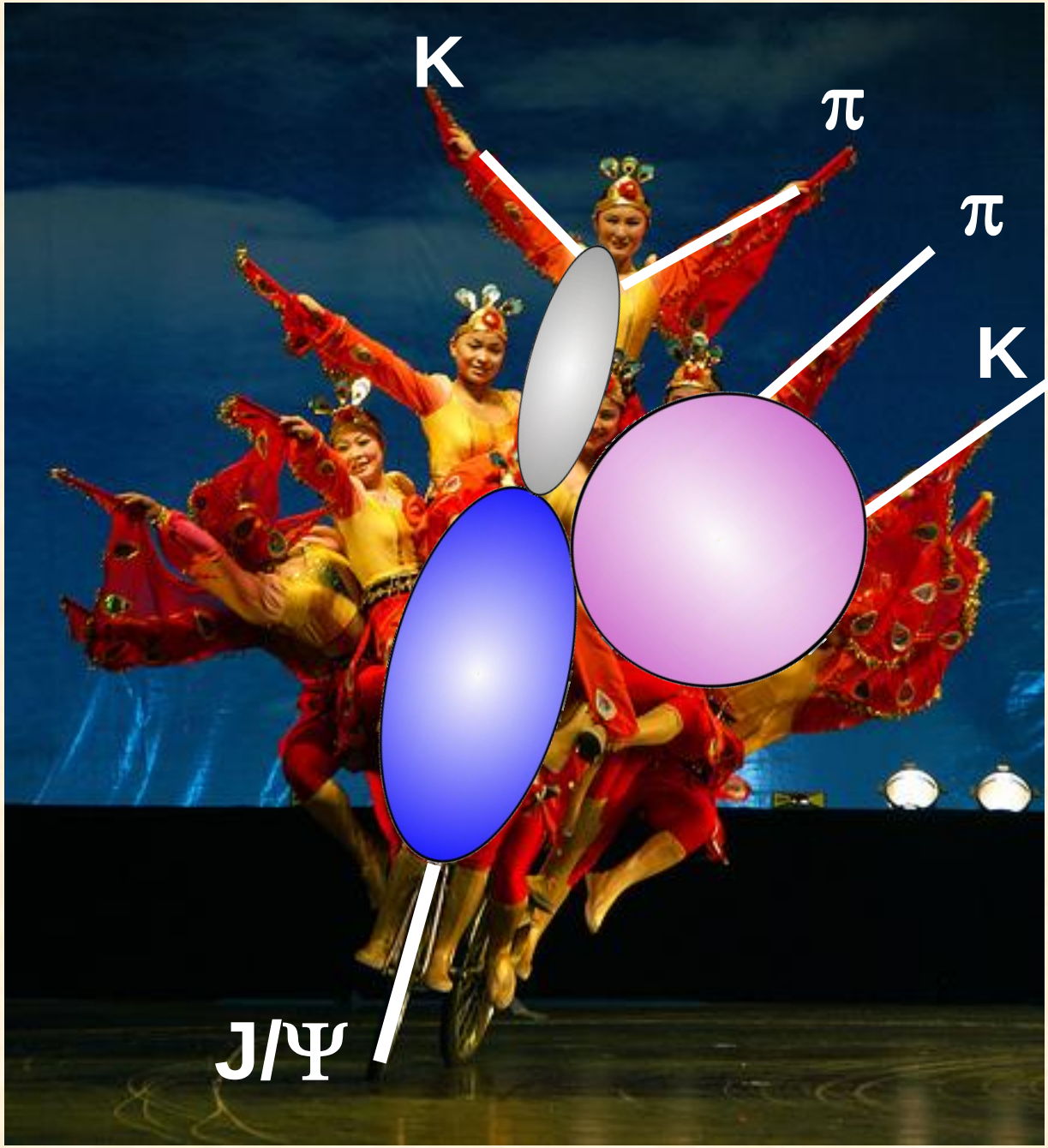
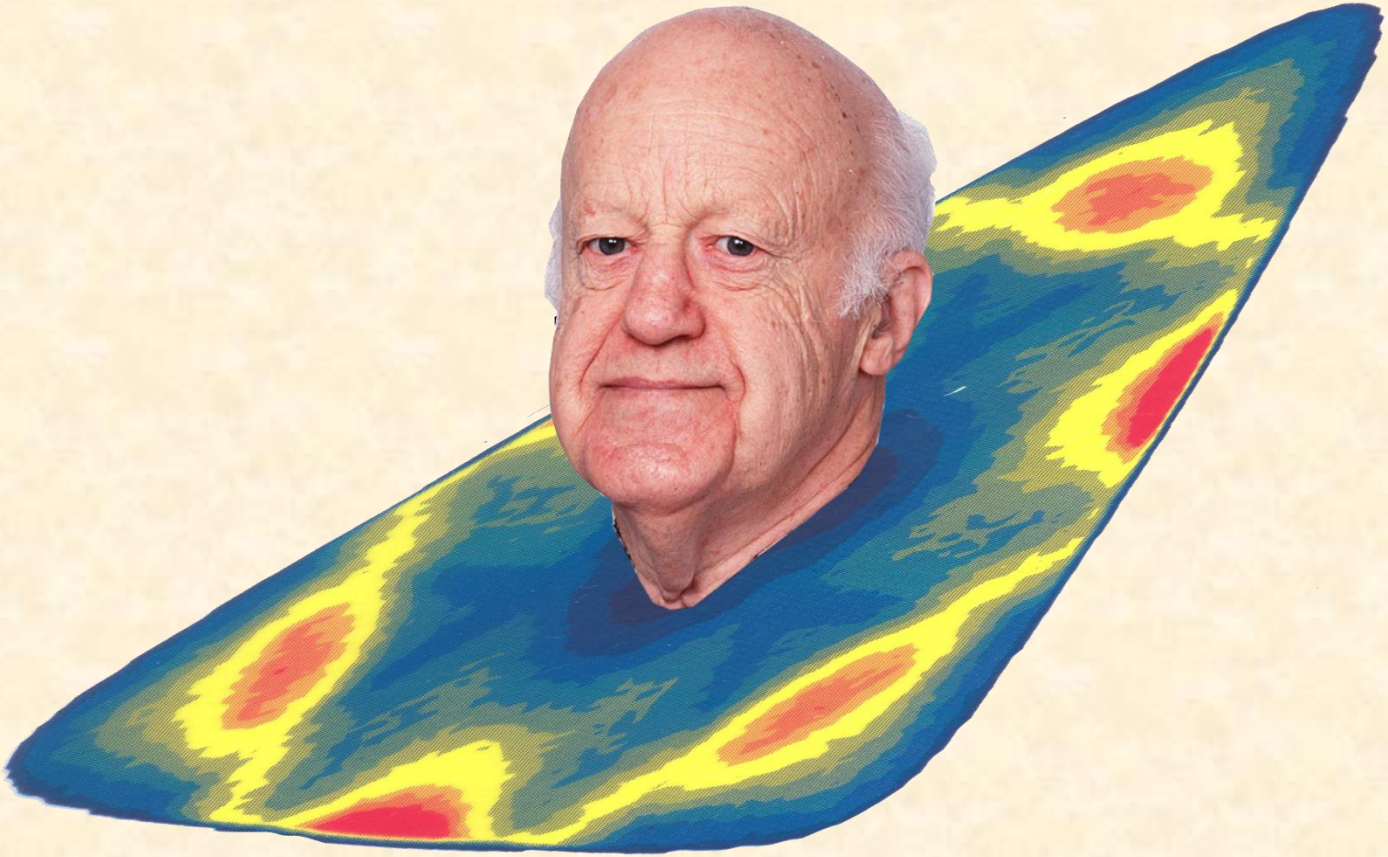
A study of charged κ in $J/\psi \to K^{\pm} K_S \pi^{\mp} \pi^0$

BES Collaboration

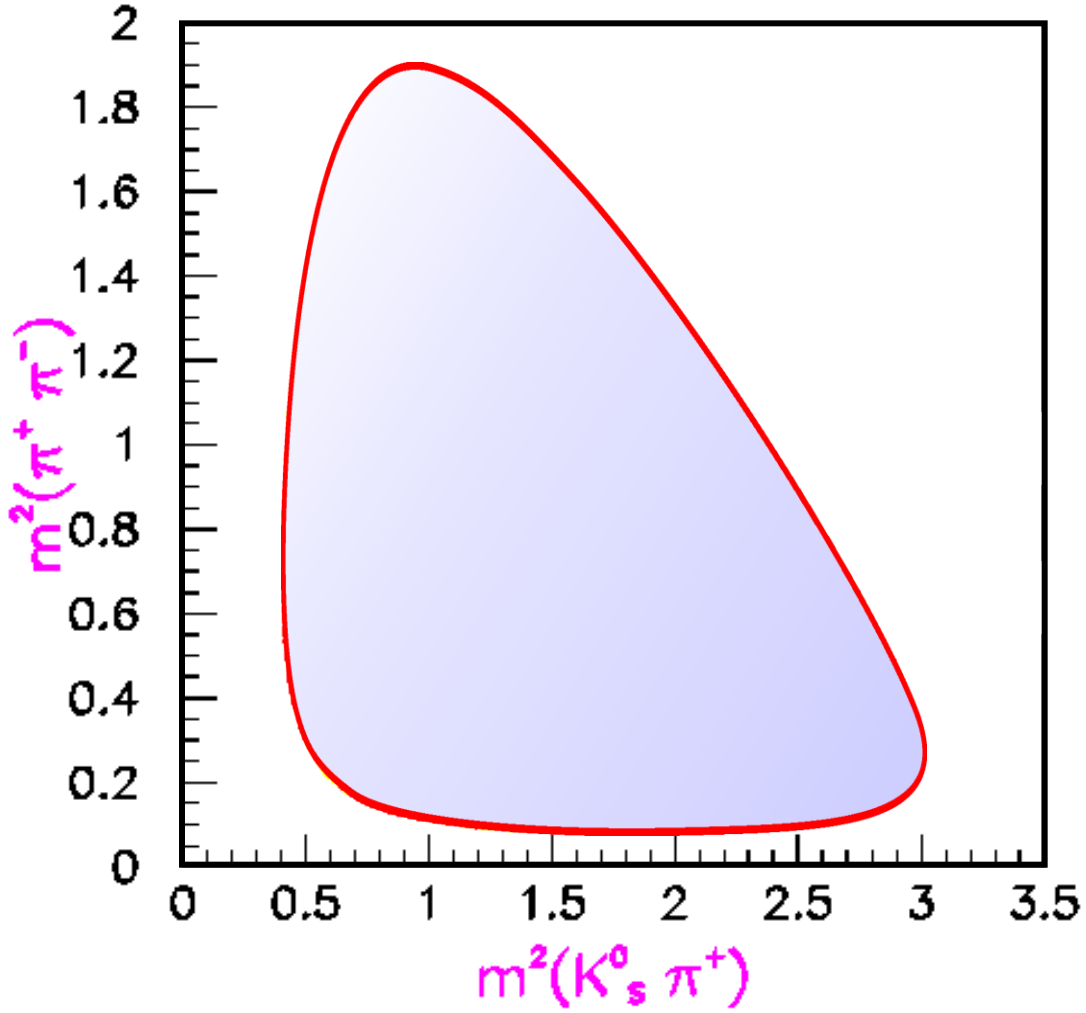
M. Ablikim[a], J.Z. Bai[a], Y. Bai[a], Y. Ban[k], X. Cai[a], H.F. Chen[p], H.S. Chen[a], H.X. Chen[a], J.C. Chen[a], Jin Chen[a], X.D. Chen[e], Y.B. Chen[a], Y.P. Chu[a], Y.S. Dai[r], Z.Y. Deng[a], S.X. Du[a,1], J. Fang[a], C.D. Fu[a], C.S. Gao[a], Y.N. Gao[n], S.D. Gu[a], Y.T. Gu[d], Y.N. Guo[a], Z.J. Guo[o,2], F.A. Harris[o], K.L. He[a], M. He[l], Y.K. Heng[a], H.M. Hu[a], T. Hu[a], G.S. Huang[a,3], X.T. Huang[l], Y.P. Huang[a], X.B. Ji[a], X.S. Jiang[a], J.B. Jiao[l], D.P. Jin[a], S. Jin[a], G. Li[a], H.B. Li[a], J. Li[a], L. Li[a], R.Y. Li[a], W.D. Li[a], W.G. Li[a], X.L. Li[a], X.N. Li[a], X.Q. Li[j], Y.F. Liang[m], B.J. Liu[a,4], C.X. Liu[a], Fang Liu[a], Feng Liu[f], H.M. Liu[a], J.P. Liu[q], H.B. Liu[d,5], J. Liu[a], Q. Liu[o], R.G. Liu[a], S. Liu[h], Z.A. Liu[a], F. Lu[a], G.R. Lu[e], J.G. Lu[a], C.L. Luo[i], F.C. Ma[h], H.L. Ma[b], Q.M. Ma[a], M.Q.A. Malik[a], Z.P. Mao[a], X.H. Mo[a], J. Nie[a], S.L. Olsen[o], R.G. Ping[a], N.D. Qi[a], J.F. Qiu[a], G. Rong[a], X.D. Ruan[d], L.Y. Shan[a], L. Shang[a], C.P. Shen[o], X.Y. Shen[a], H.Y. Sheng[a], H.S. Sun[a], S.S. Sun[a], Y.Z. Sun[a], Z.J. Sun[a], X. Tang[a], J.P. Tian[n], G.L. Tong[a], G.S. Varner[o], X. Wan[a], L. Wang[a], L.L. Wang[a], L.S. Wang[a], P. Wang[a], P.L. Wang[a], Y.F. Wang[a], Z. Wang[a], Z.Y. Wang[a], C.L. Wei[a], D.H. Wei[c], N. Wu[a,4], X.M. Xia[a], G.F. Xu[a], X.P. Xu[r], Y. Xu[j], M.L. Yan[p], H.X. Yang[a], M. Yang[a], Y.X. Yang[c], M.H. Ye[b], Y.X. Ye[p], C.X. Yu[j], C.Z. Yuan[a], Y. Yuan[a], Y. Zeng[g], B.X. Zhang[a], B.Y. Zhang[a], C.C. Zhang[a], D.H. Zhang[a], F. Zhang[n,6], H.Q. Zhang[a], H.Y. Zhang[a], J.W. Zhang[a], J.Y. Zhang[a], X.Y. Zhang[l], Y.Y. Zhang[m], Z.X. Zhang[k], Z.P. Zhang[p], D.X. Zhao[a], J.W. Zhao[a], M.G. Zhao[a], P.P. Zhao[a], Z.G. Zhao[p], B. Zheng[a], H.Q. Zheng[k], J.P. Zheng[a], Z.P. Zheng[a], B. Zhong[i], L. Zhou[a], K.J. Zhu[a], Q.M. Zhu[a], X.W. Zhu[a], Y.S. Zhu[a], Z.A. Zhu[a], Z.L. Zhu[c], B.A. Zhuang[a], B.S. Zou[a]

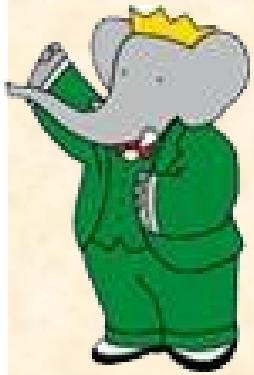

K
π
π
K
J/Ψ

Dalitz Analysis

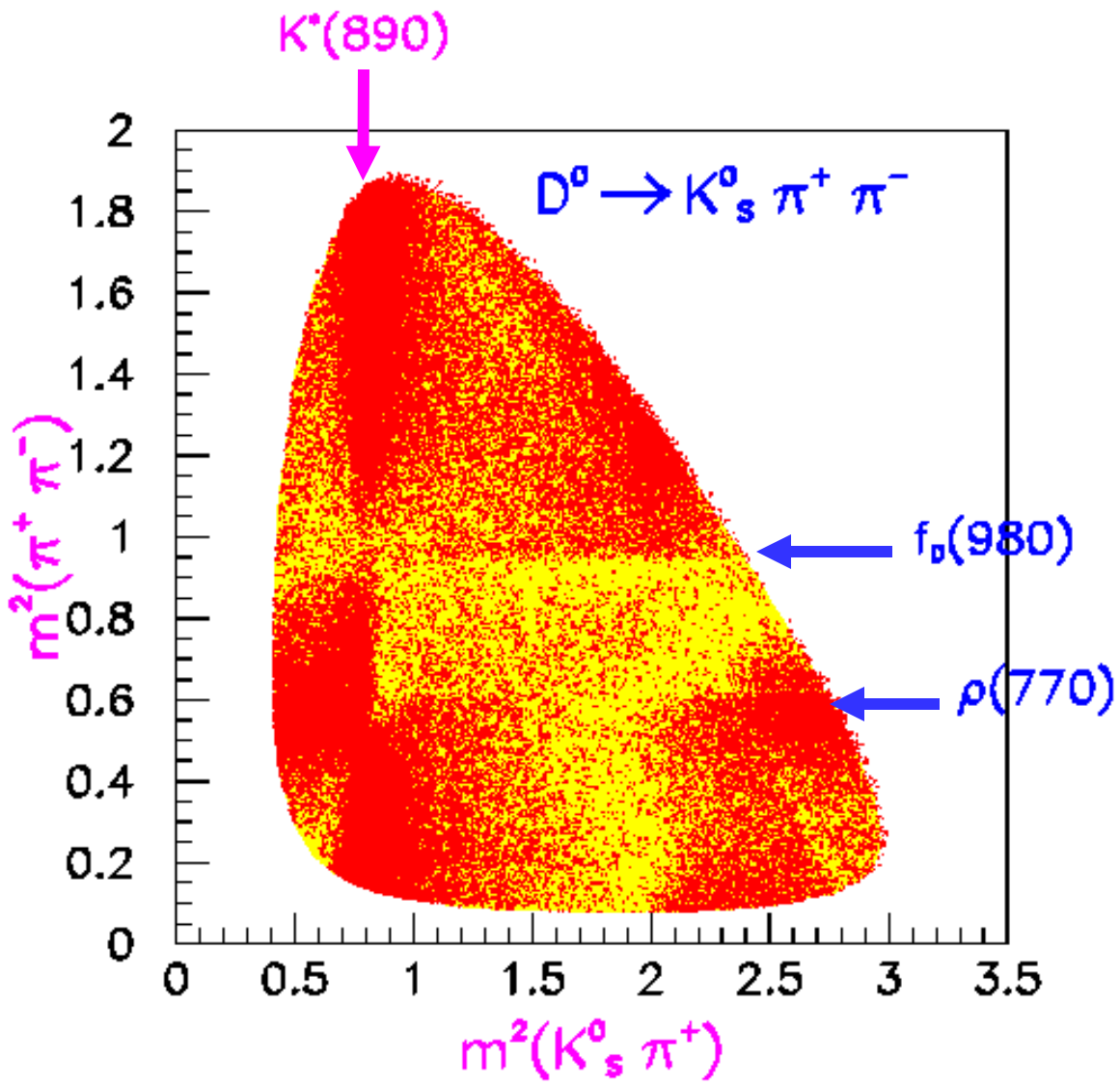


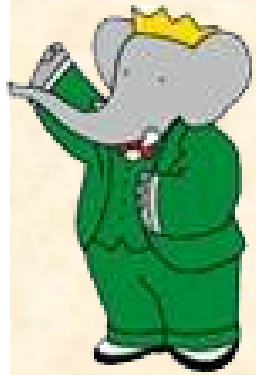
Dalitz plot of $D^0 \to \bar{K}^0\pi^+\pi^-$.



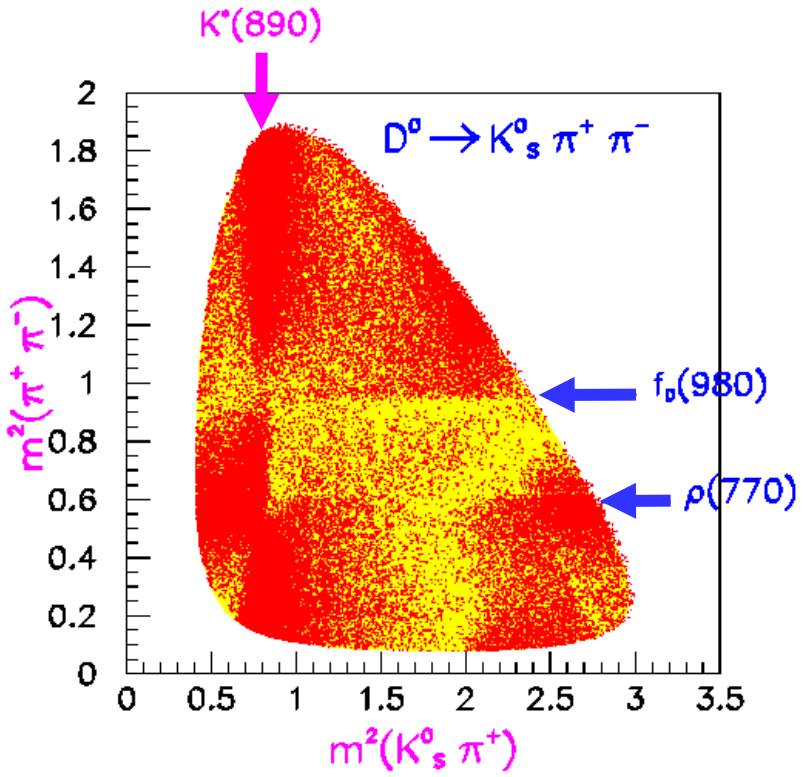


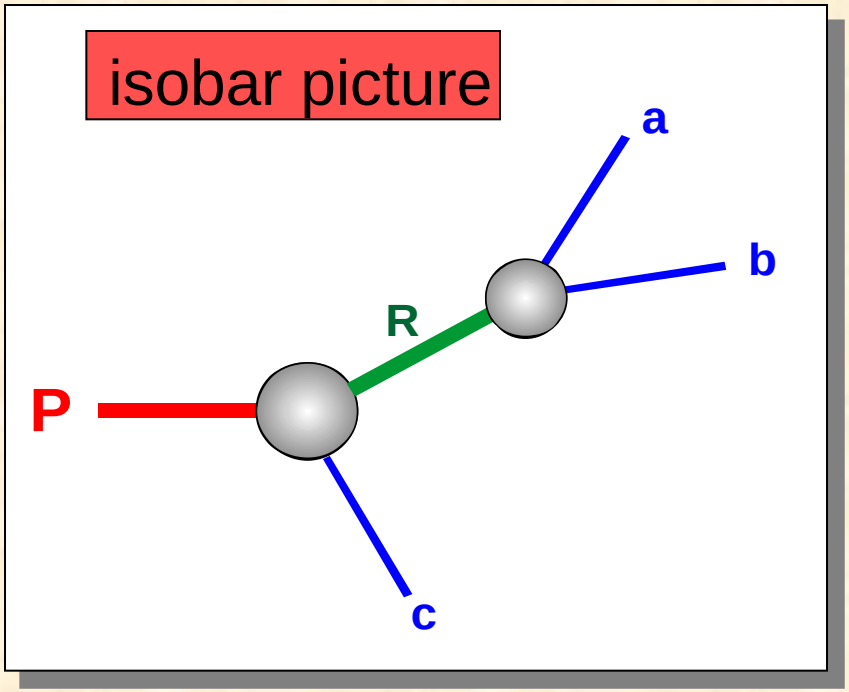
Dalitz plot of $D^0 \to \bar{K}^0\pi^+\pi^-$.



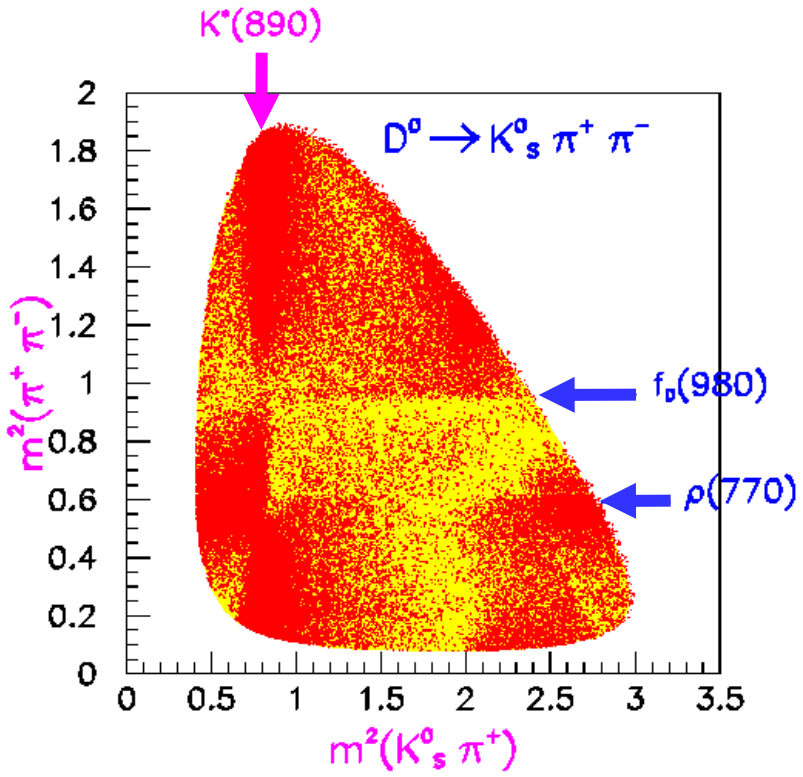


Dalitz plot of $D^0 \to \bar{K}^0\pi^+\pi^-$.





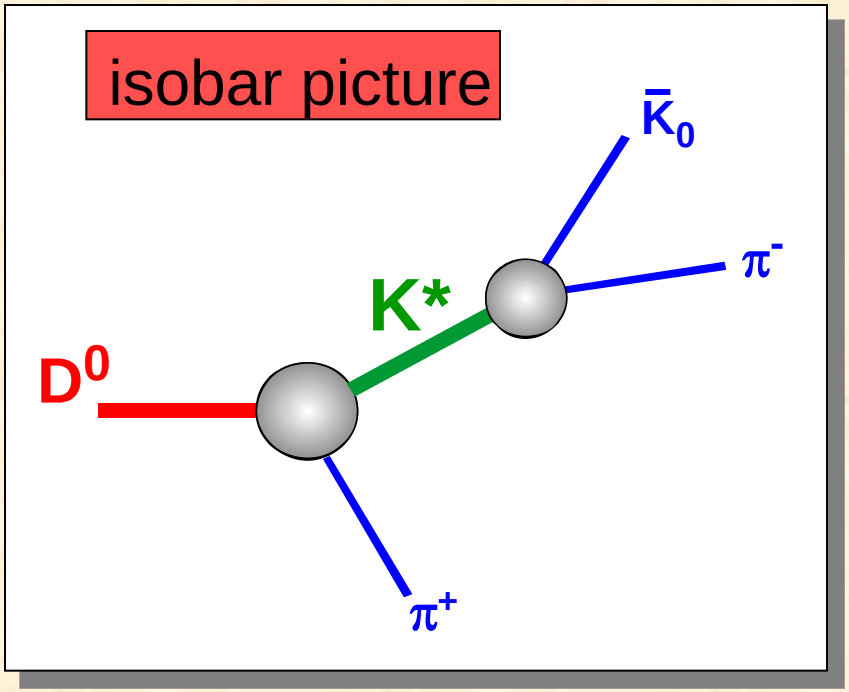
Dalitz plot of $D^0 \to \bar{K}^0\pi^+\pi^-$.



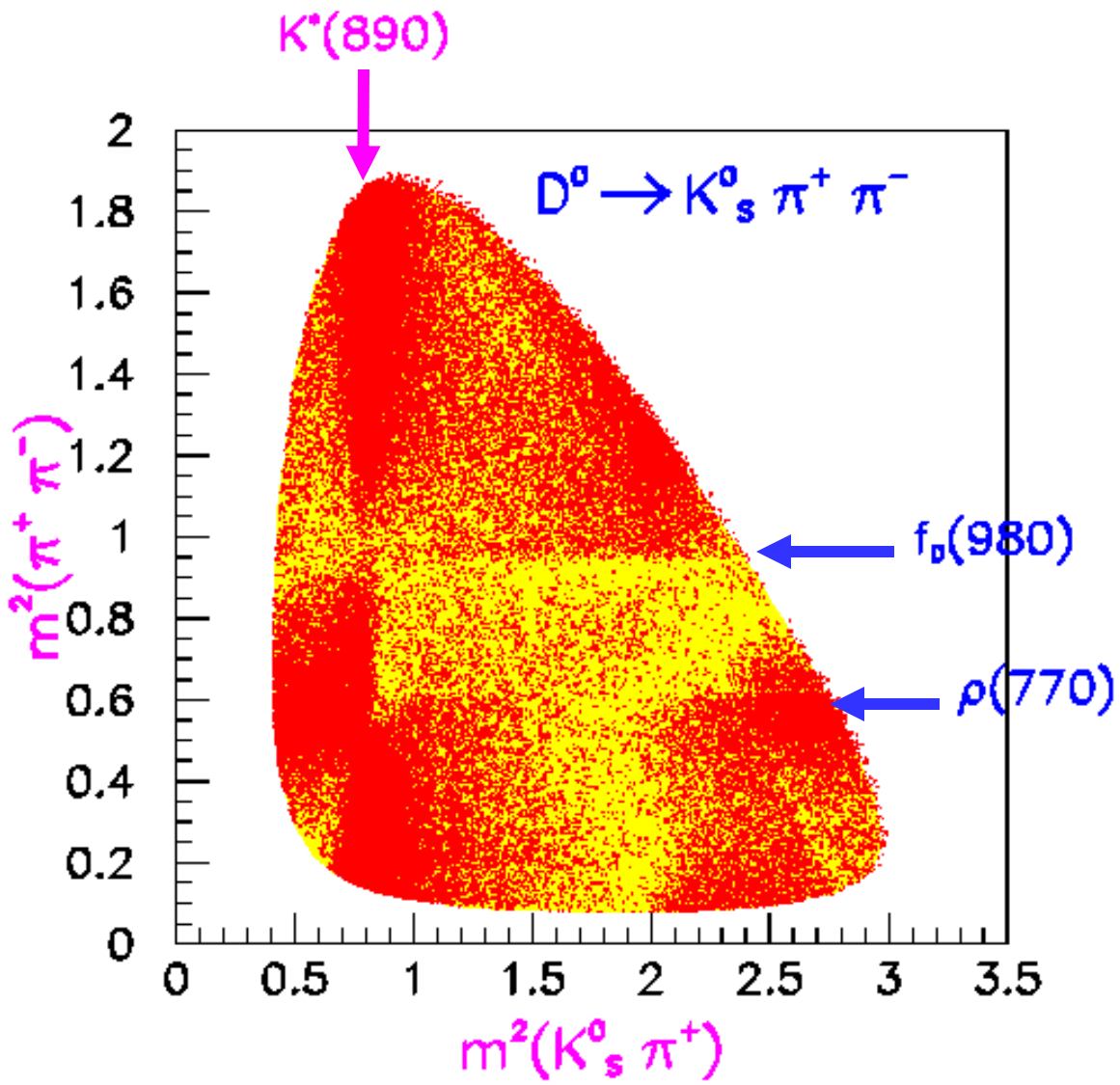
Universality

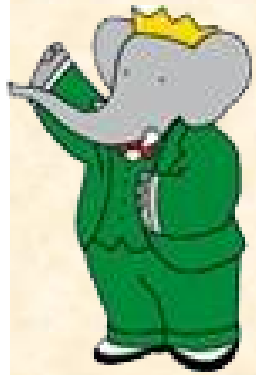
of final state interactions

beyond

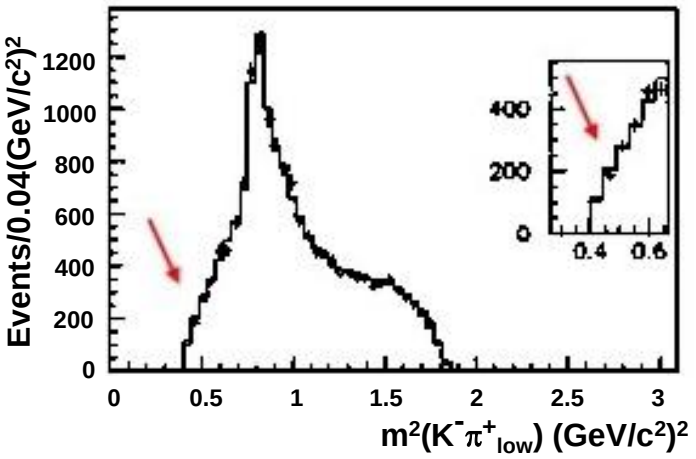


Dalitz plot of $D^0 \to \bar{K}^0\pi^+\pi^-$.





E791 $D^+ \longrightarrow K^- \pi^+ \pi^+$



D^+

non-resonant	$13.0 \pm 5.8 \pm 2.6\%$	$349 \pm 14 \pm 8^o$
$\kappa(E791)\pi^+$	$47.8 \pm 12.1 \pm 3.7\%$	$187 \pm 8 \pm 17^o$
$K^*(890)\pi^+$	$12.3 \pm 1.0 \pm 0.9\%$	0^o (fixed)
$K_0^*(1430)\pi^+$	$12.5 \pm 1.4 \pm 0.4\%$	$48 \pm 7 \pm 10^o$
$K_2^*(1430)\pi^+$	$0.5 \pm 0.1 \pm 0.2\%$	$306 \pm 8 \pm 6^o$
$K_1^*(1680)\pi^+$	$2.5 \pm 0.7 \pm 0.2\%$	$28 \pm 13 \pm 15^o$

$\sim 89\%$

$\chi^2/\text{d.o.f} = 0.73$
(95%)

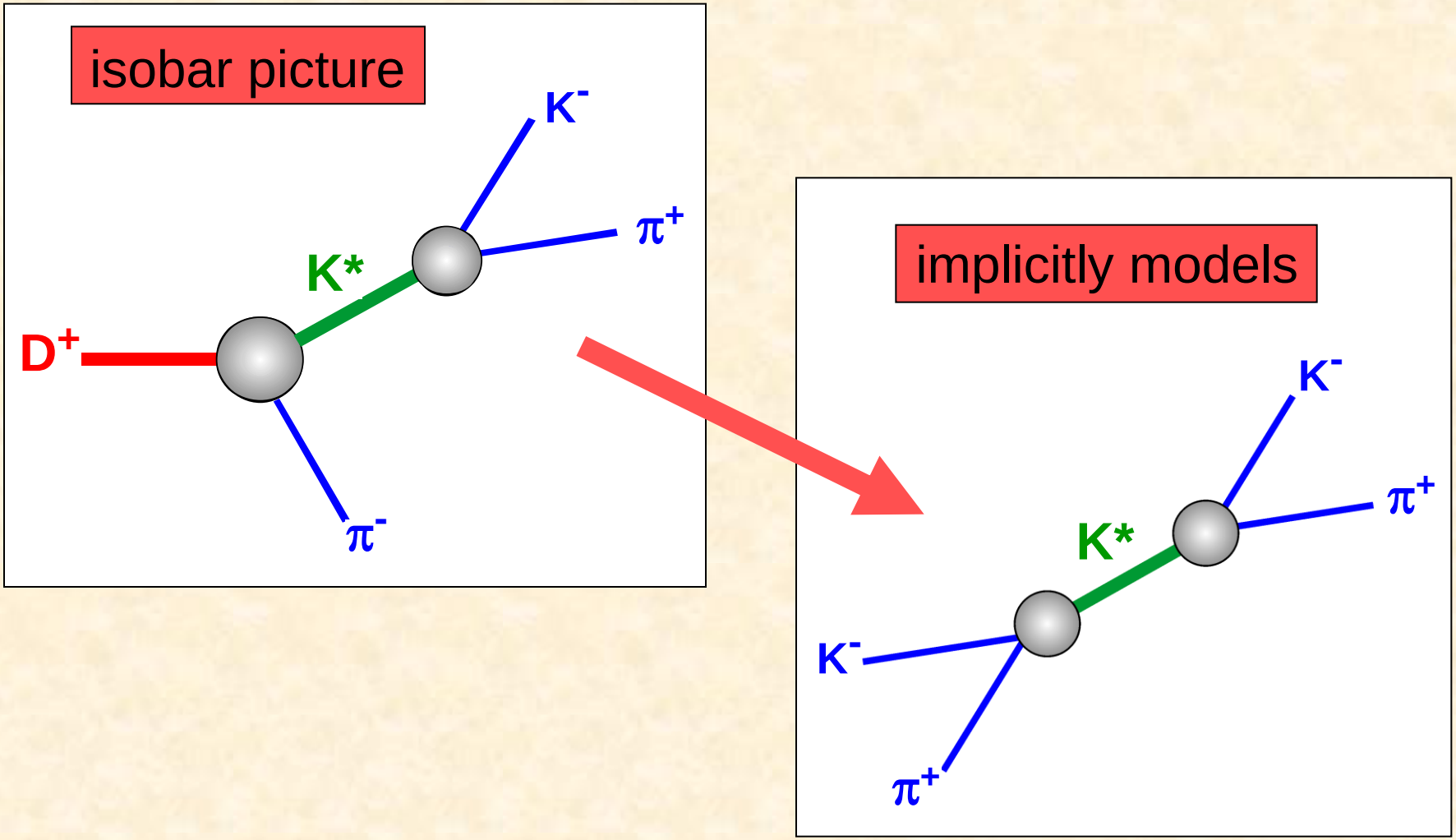
Probability

κ

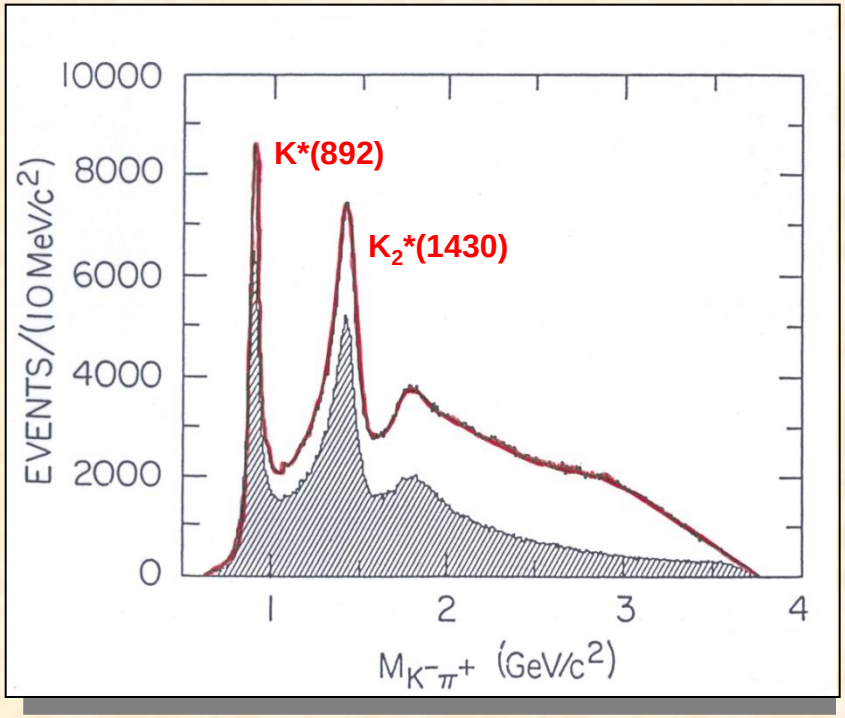
$M_\kappa = 797 \pm 19 \pm 42$ MeV

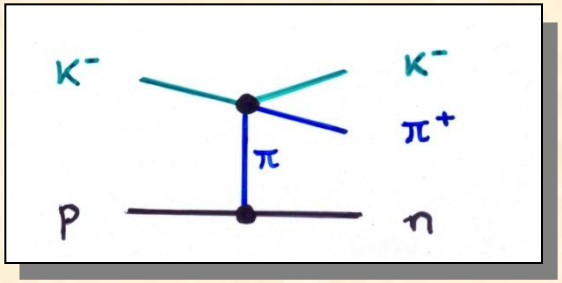
$\Gamma_\kappa = 410 \pm 43 \pm 85$ MeV

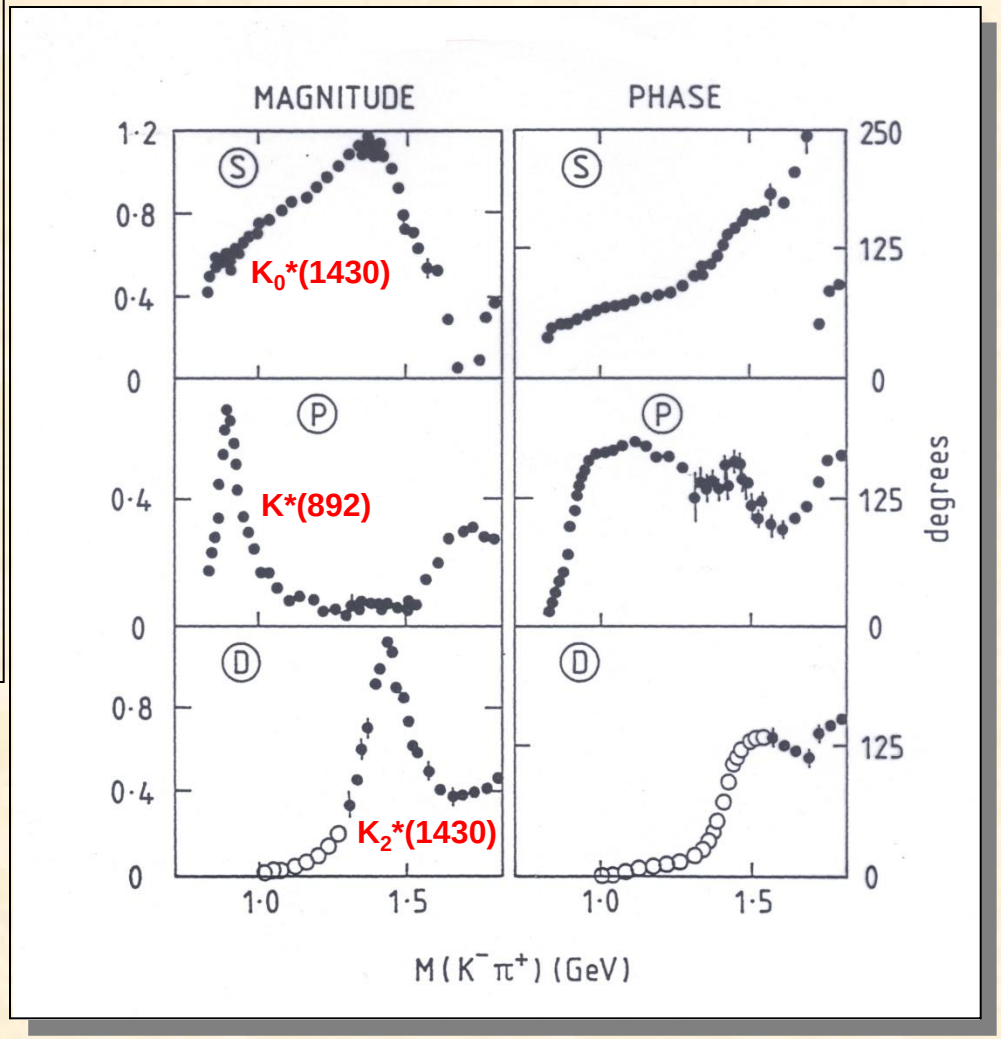
$D^+ \longrightarrow K^-\pi^+\pi^-$



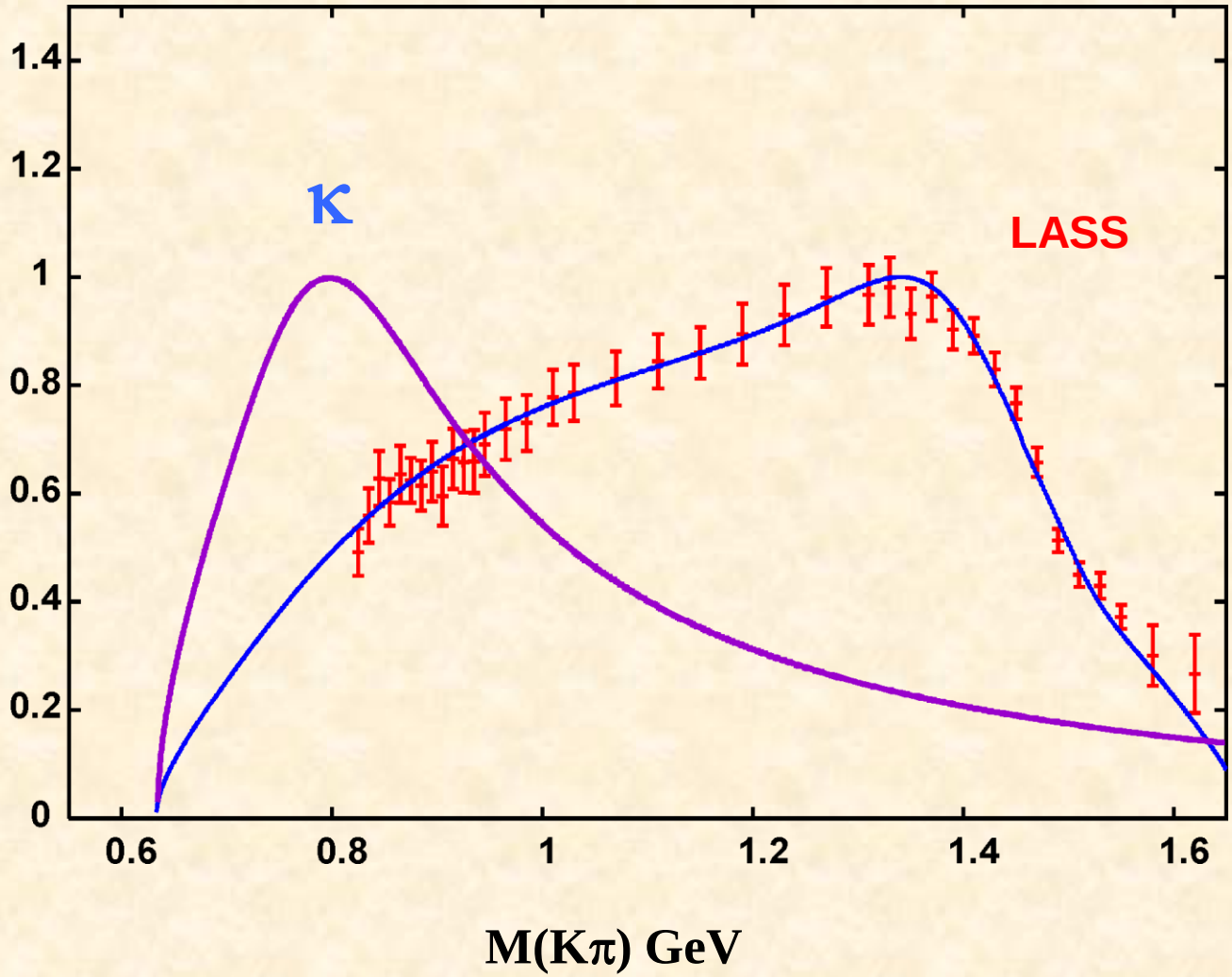
LASS: $K^- p \longrightarrow K^- \pi^+ n$



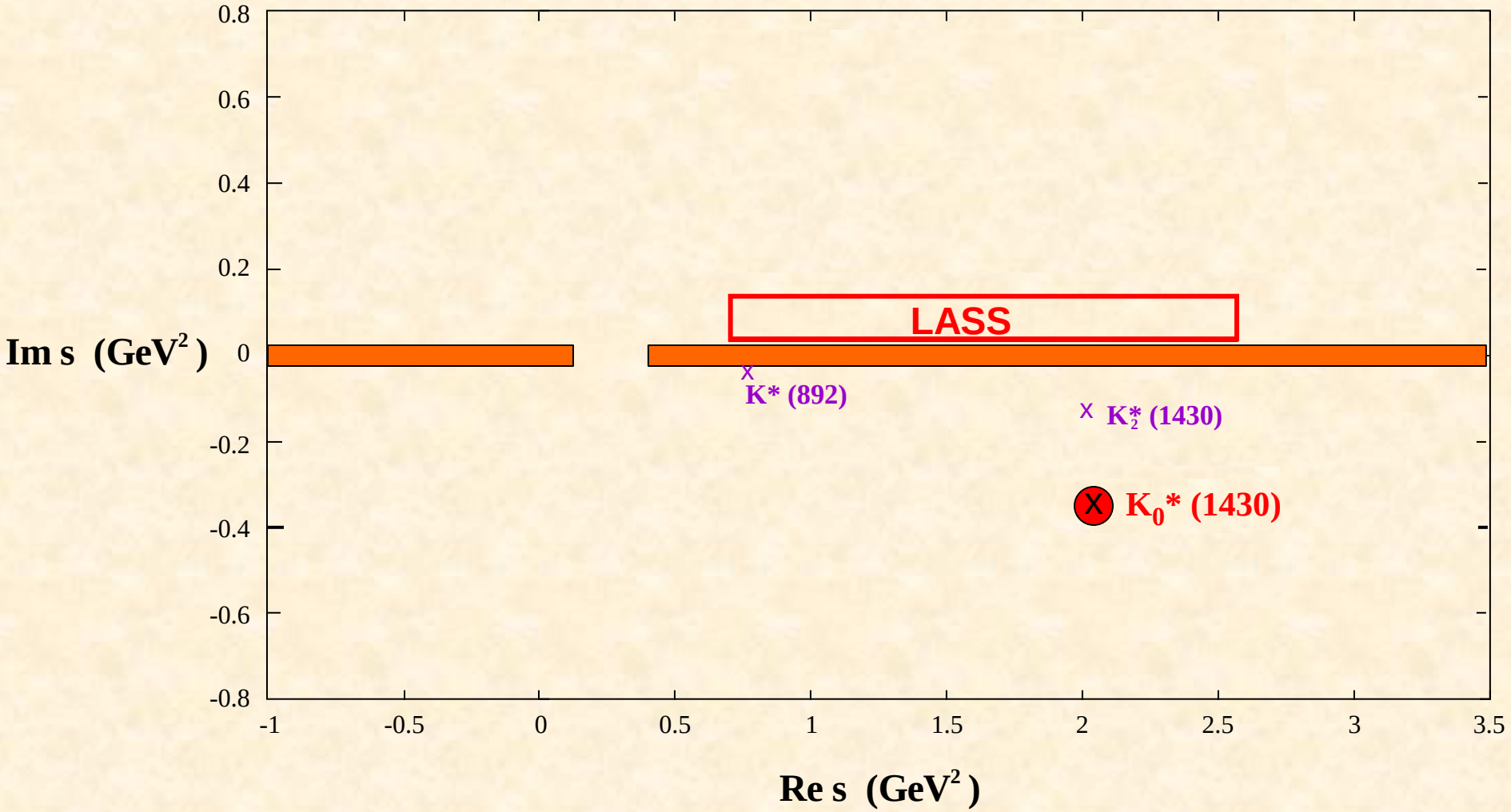




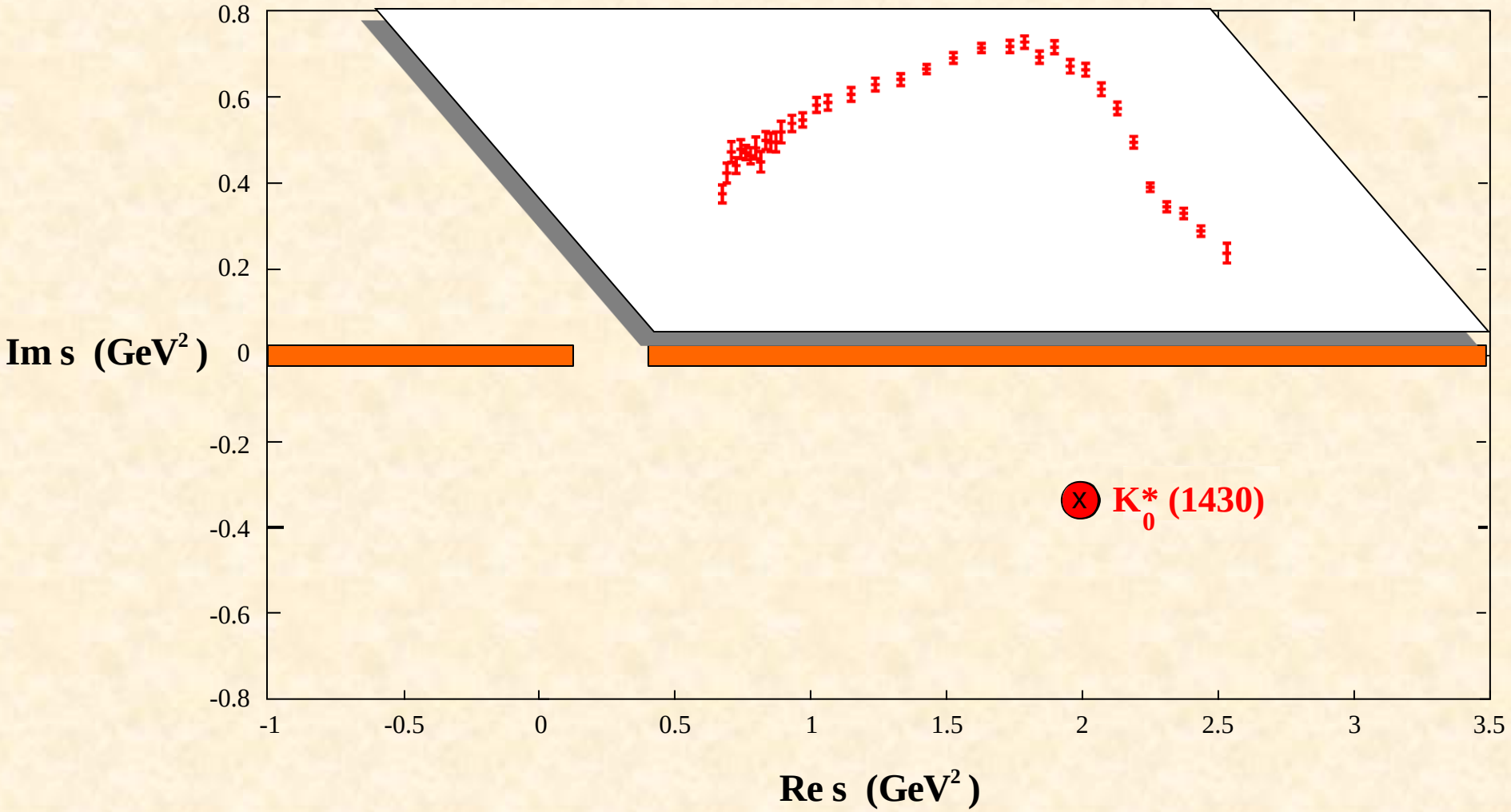
I=1/2, J=0 : $K\pi \rightarrow K\pi$



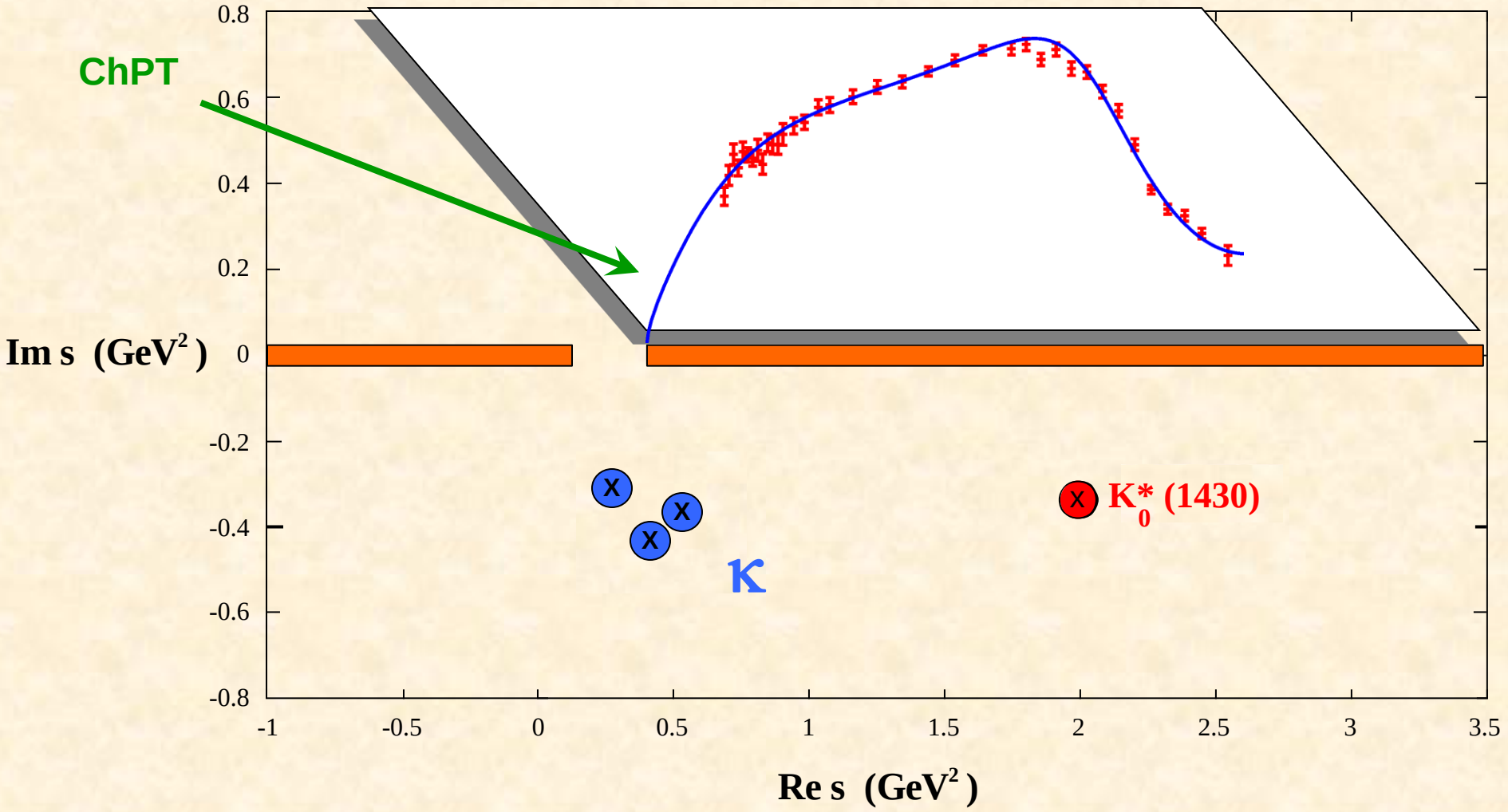
πK : I = ½, J = 0


0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
Im s (GeV²)
Re s (GeV²)
LASS
K* (892)
K₂* (1430)
K₀* (1430)

πK : I = ½, J = 0


0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
Im s (GeV²)
Re s (GeV²)
K*0 (1430)

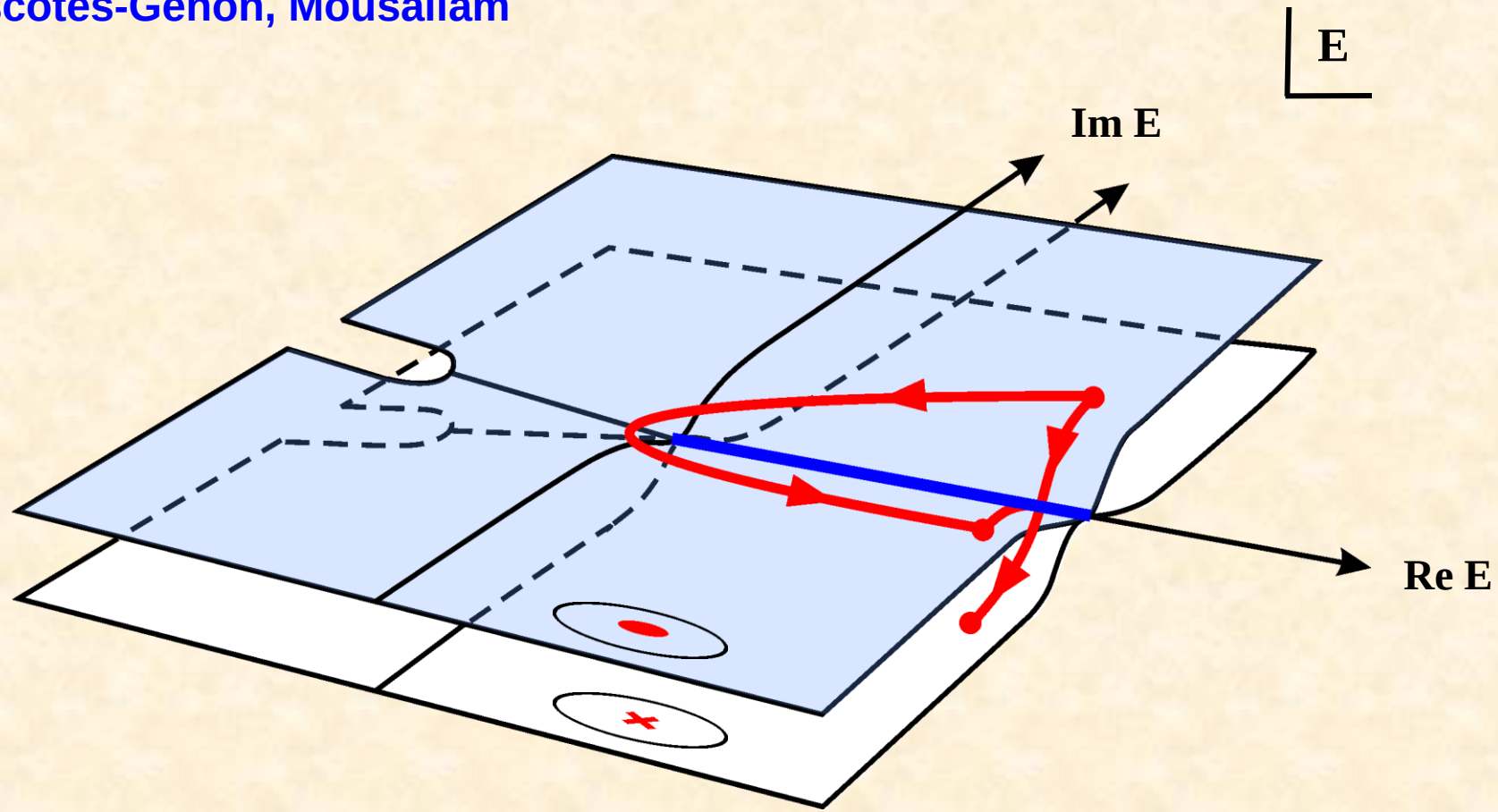
πK : I = ½, J = 0


ChPT
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Im s (GeV²)
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
Re s (GeV²)
K*0 (1430)
κ

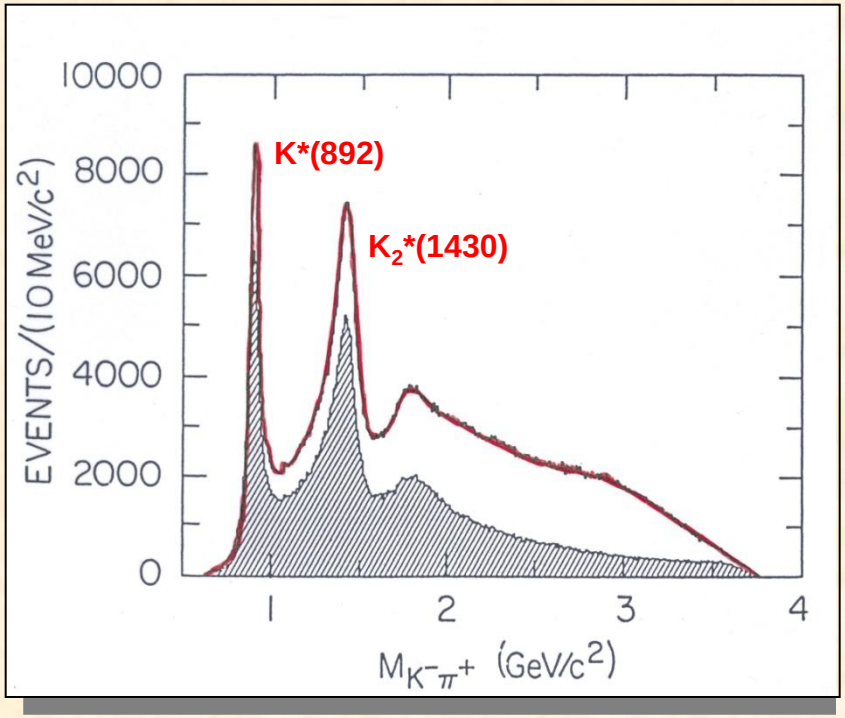
Kπ scattering into the complex plane

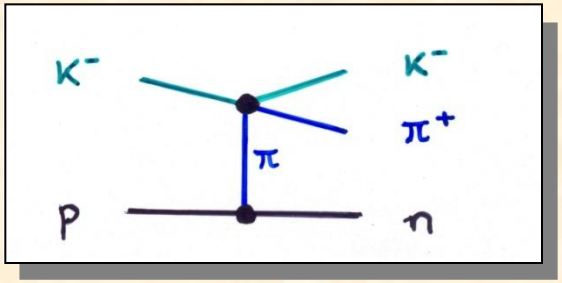
$E_R = 658 - i\,289$ MeV

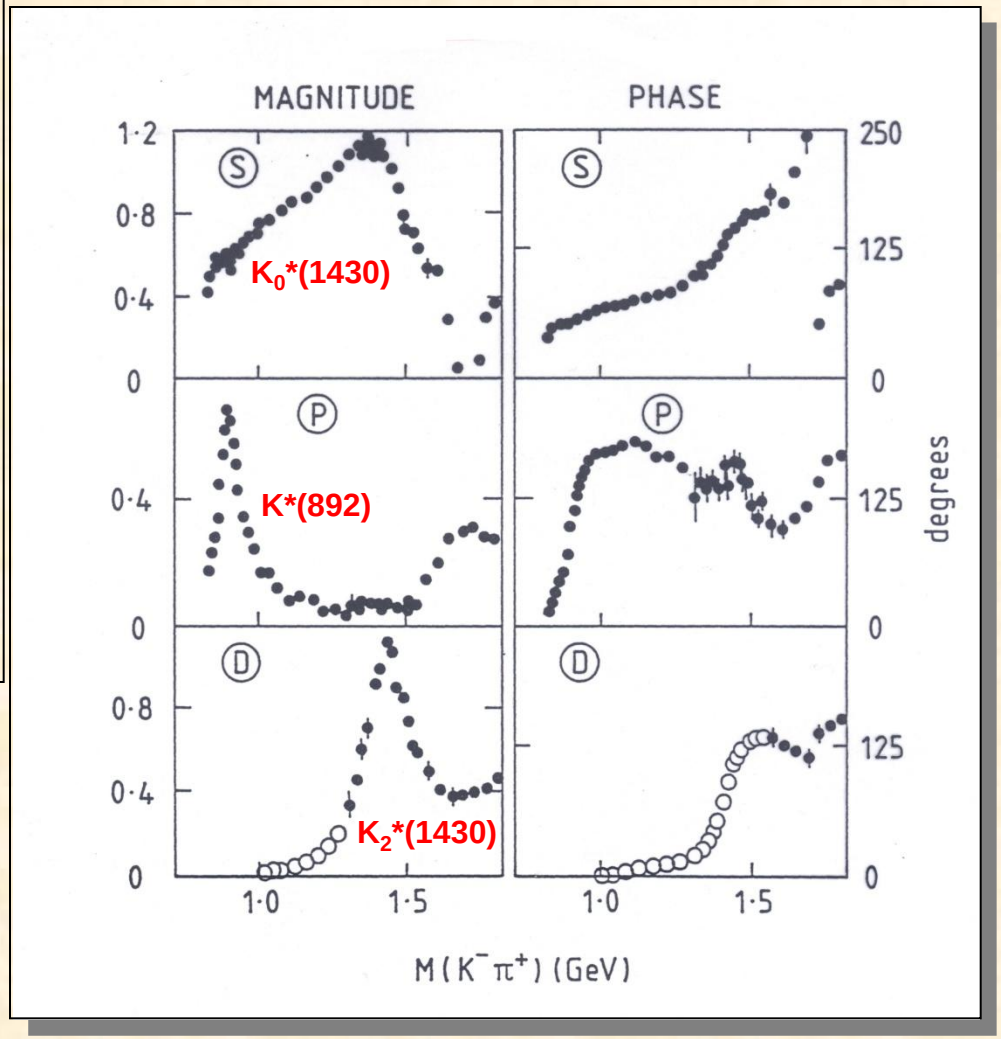
Descotes-Genon, Mousallam



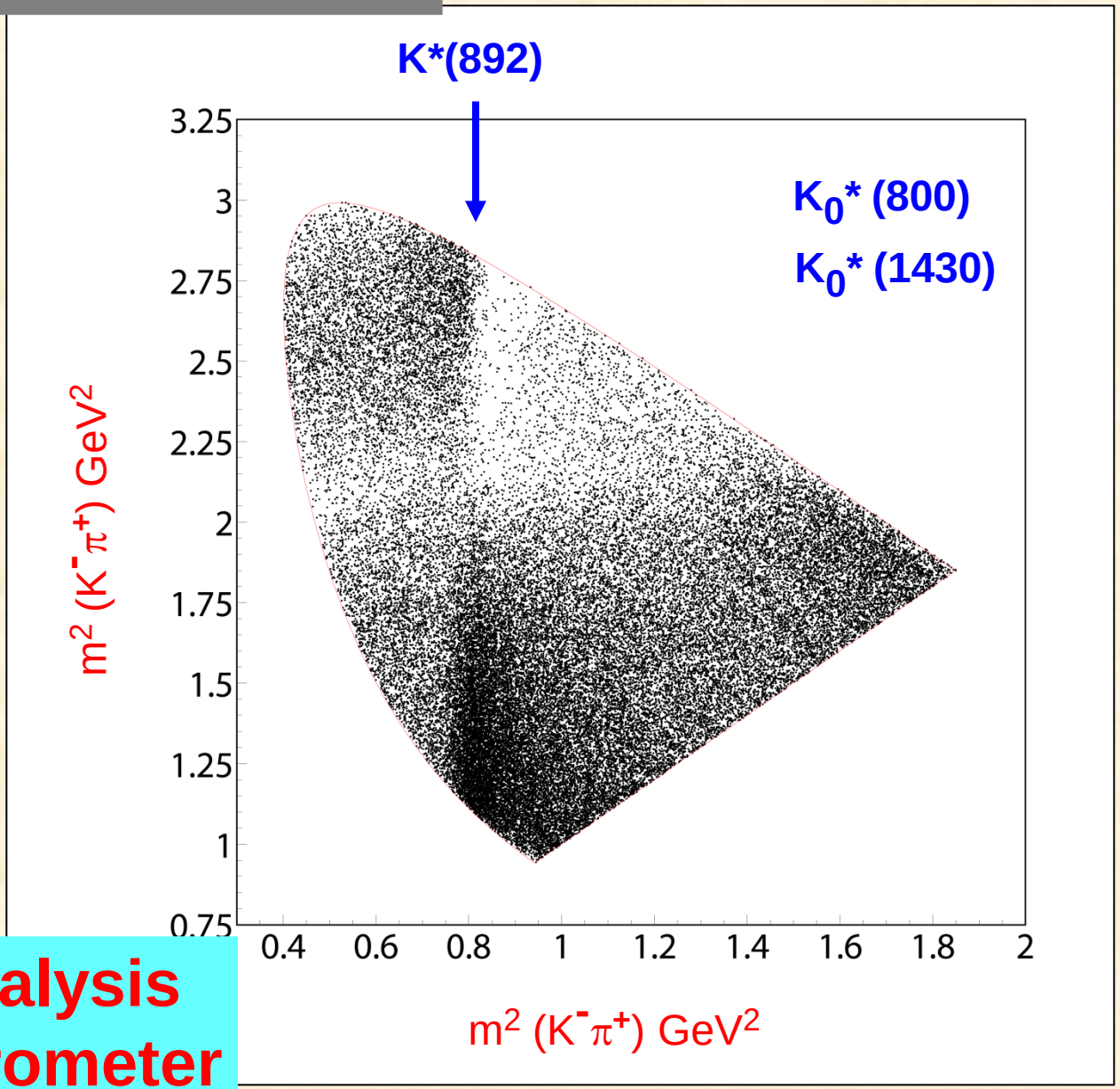
LASS: $K^- p \longrightarrow K^- \pi^+ n$







Dalitz plot: $D^+ \longrightarrow K^- \pi^+ \pi^+$



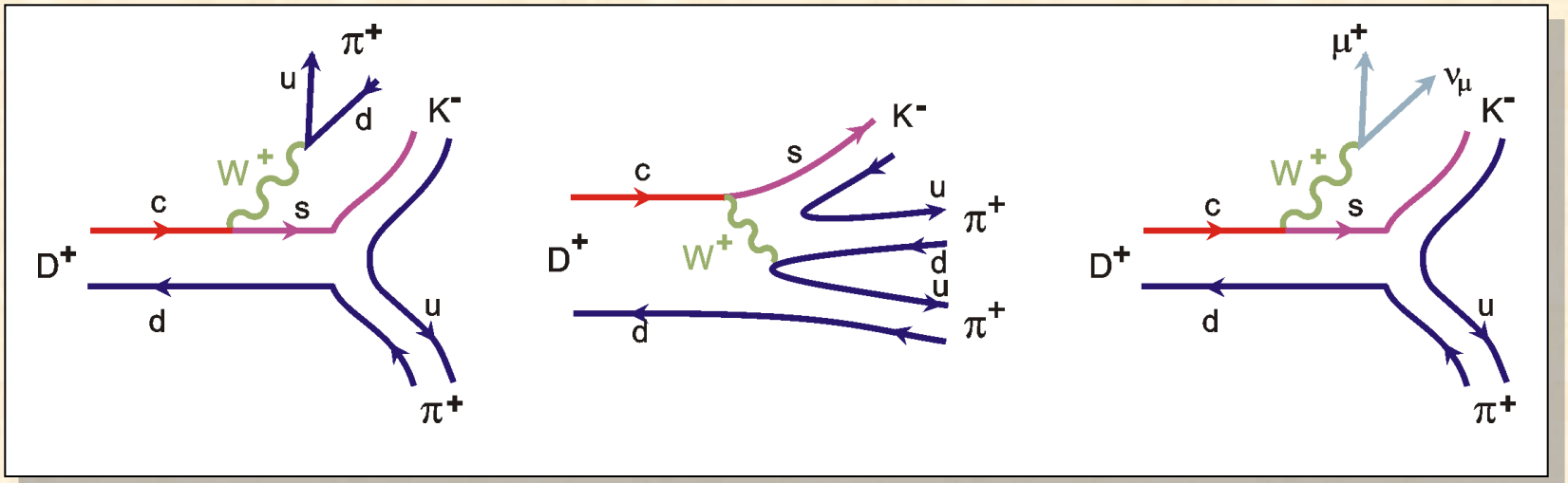
E831 FOCUS

Malvezzi, P

53.6k events

Dalitz plot analysis as an Interferometer

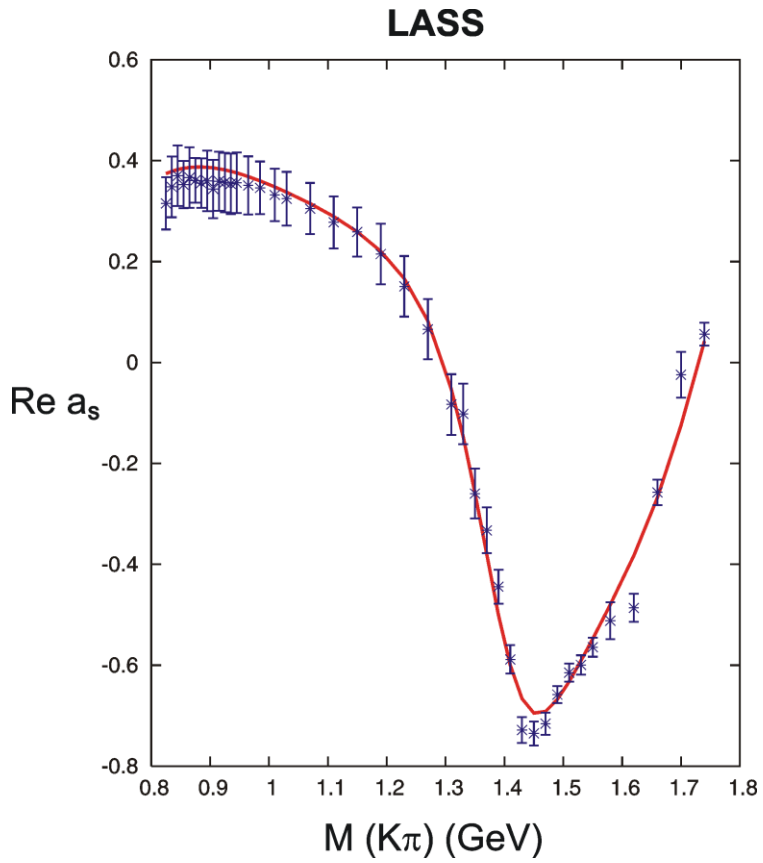
Dalitz plot: $D^+ \longrightarrow K^- \pi^+ \pi^+$

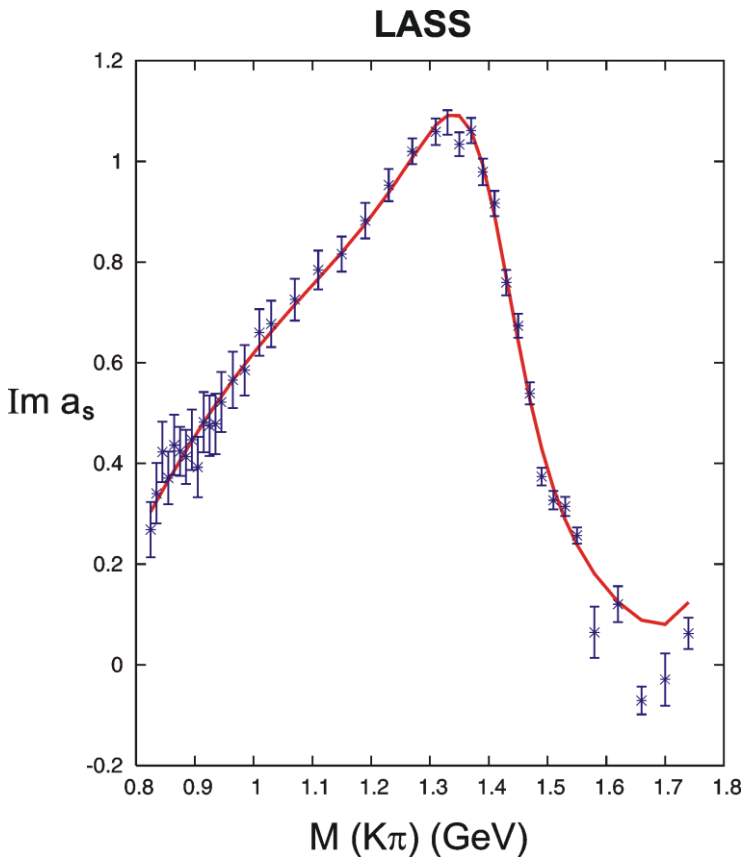


$I = 1/2, 3/2$

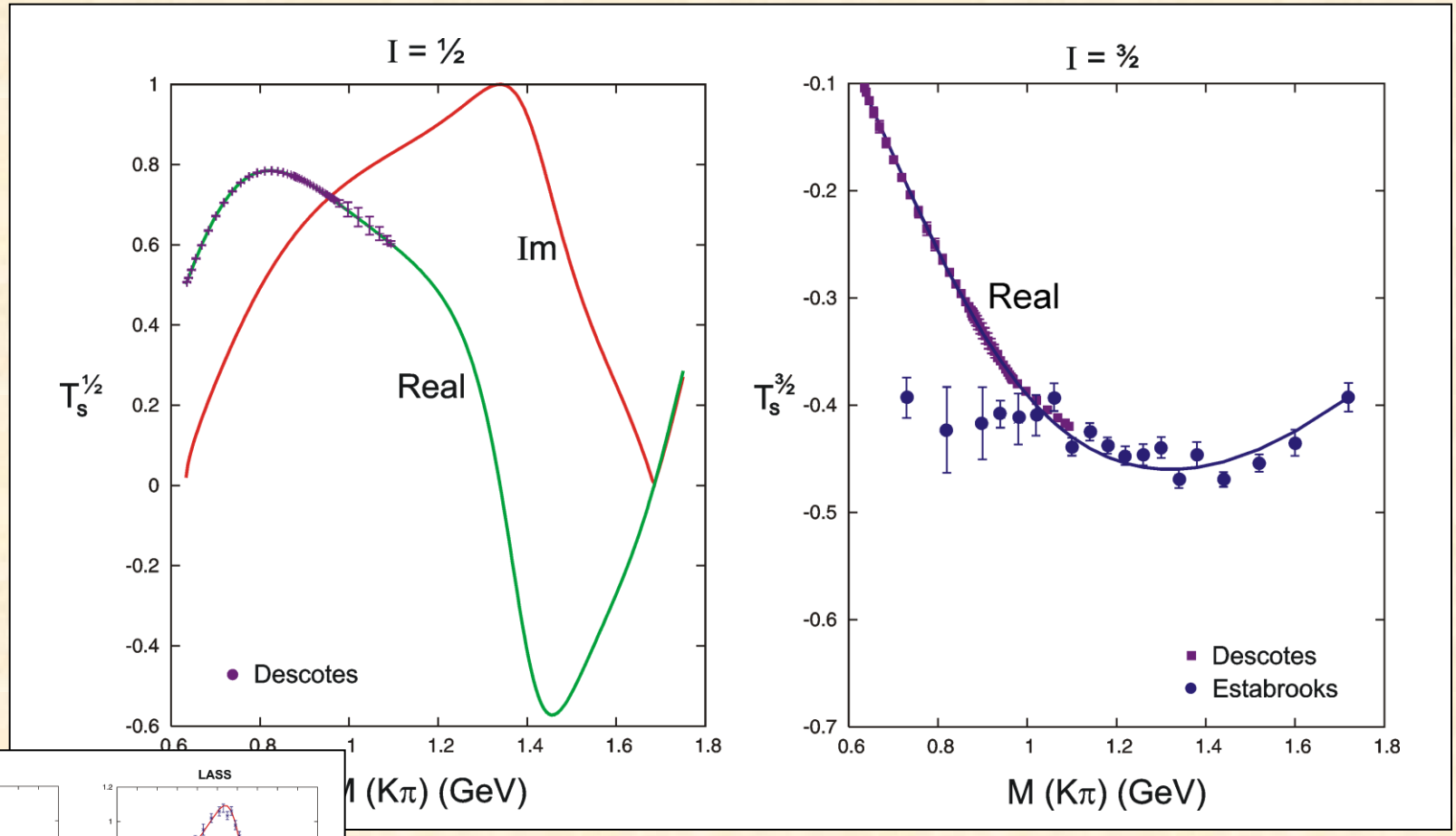
SLAC: $K^- \pi^+ \longrightarrow K^- \pi^+$, $K^+ \pi^+ \longrightarrow K^+ \pi^+$

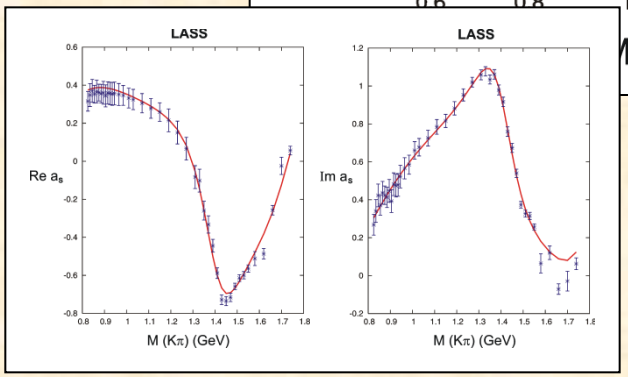
SLAC: $K^-\pi^+ \longrightarrow K^-\pi^+$, $K^+\pi^+ \longrightarrow K^+\pi^+$



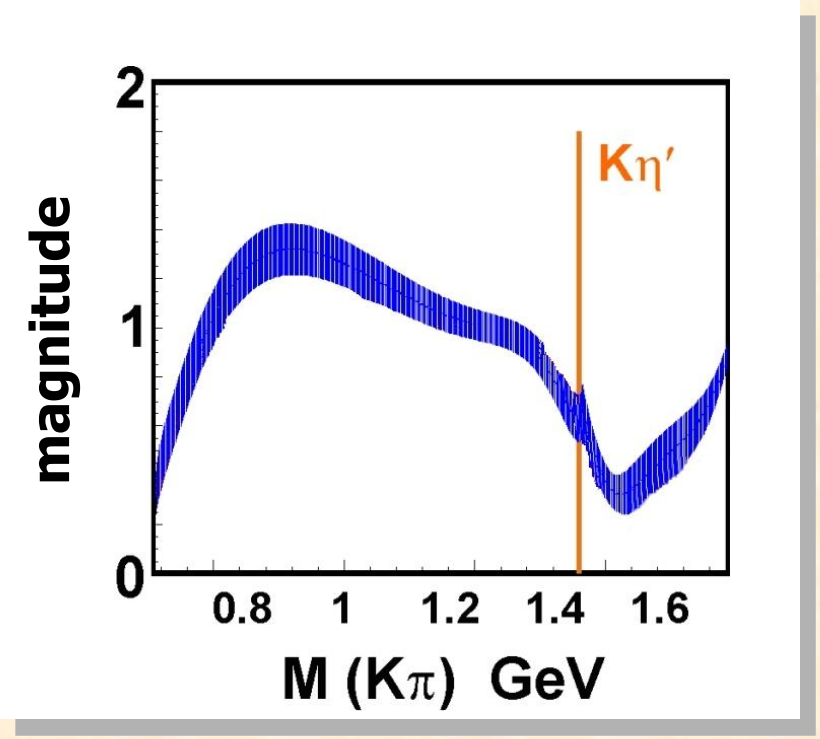


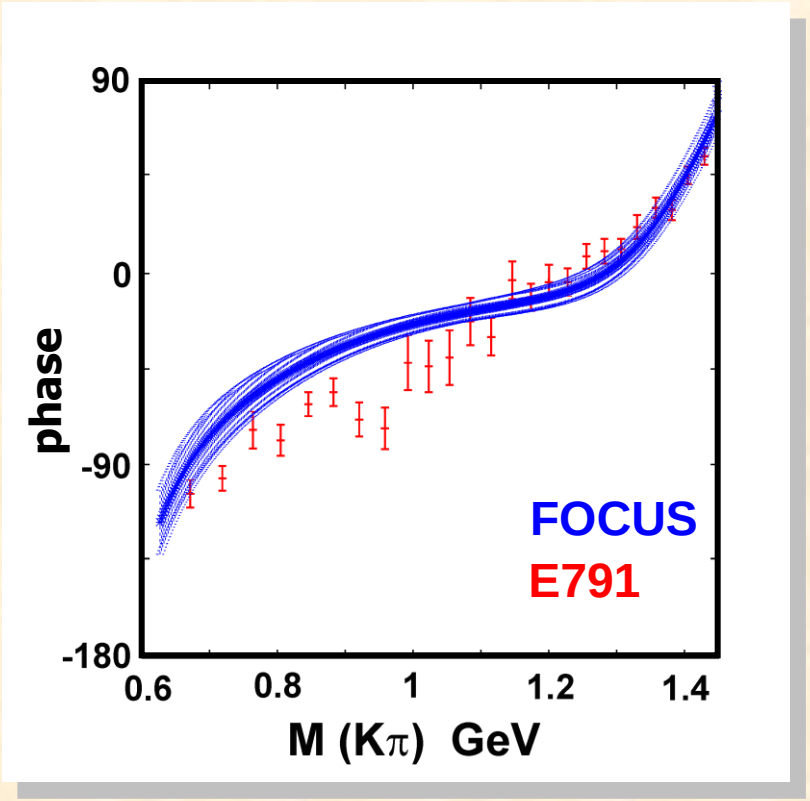
SLAC: $K^-\pi^+ \longrightarrow K^-\pi^+$, $K^+\pi^+ \longrightarrow K^+\pi^+$





Dalitz plot: $D^+ \longrightarrow K^- \pi^+ \pi^+$

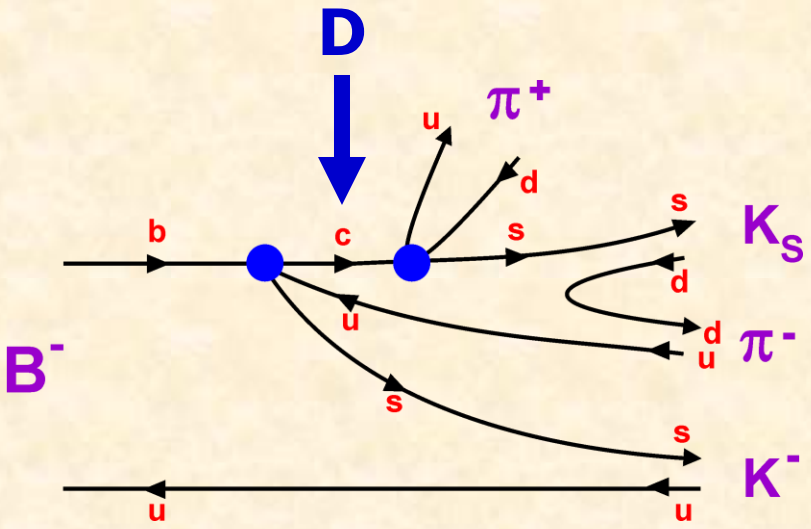




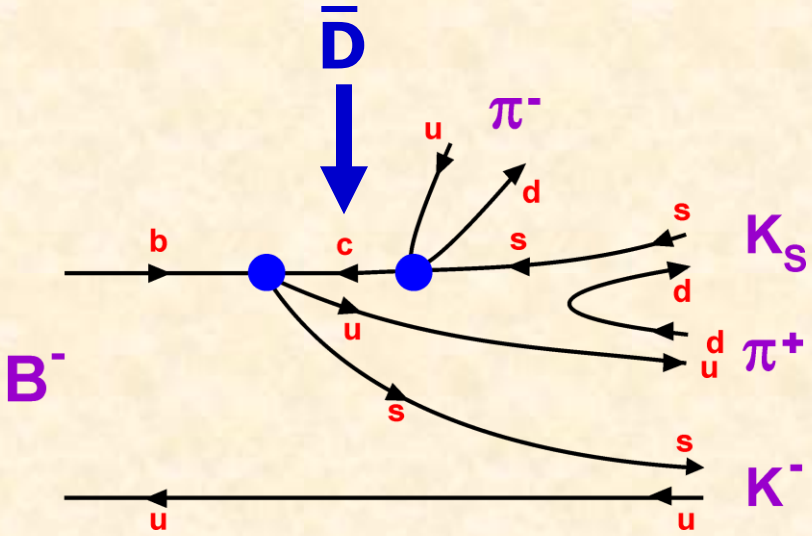
Malvezzi, P & FOCUS

(Bugg)

$B \to D\bar{K} \to \bar{K}K\pi\pi$



$B \to \bar{D}K \to \bar{K}K\pi\pi$



$$J/\Psi \rightarrow K^* K \pi$$
$$\hookrightarrow K\pi$$

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Evidence for κ meson production in $J/\psi \to \bar{K}^*(892)^0 K^+ \pi^-$ process

BES Collaboration

M. Ablikim[a], J.Z. Bai[a], Y. Ban[o], J.G. Bian[a], X. Cai[a], H.F. Chen[p], H.S. Chen[a], H.X. Chen[a], J.C. Chen[a], Jin Chen[a], Y.B. Chen[a], S.P. Chi[b], Y.P. Chu[a], X.Z. Cui[a], Y.S. Dai[w], Z.Y. Deng[a], Q.F. Dong[a], S.X. Du[a], Z.Z. Du[a], J. Fang[a], S.S. Fang[b], C.D. Fu[a], F.A. Harris[t], K.L. He[a], M. He[n], Y.K. Heng[a], Y.T. Gu[d], Y.N. Guo[a], Y.Q. Guo[a], Z.J. Guo[t], F.A. Harris[t], K.L. He[a], M. He[n], Y.K. Heng[a], H.M. Hu[a], T. Hu[a], G.S. Huang[a,3], X.P. Huang[a], X.T. Huang[l], T. Komada[n], S. Kurokawa[h], M. Ishida[j], S. Ishida[n], X.B. Ji[a], X.S. Jiang[a], J.B. Jiao[l], D.P. Jin[a], S. Jin[a], Yi Jin[a], T. Komada[n], S. Kurokawa[h], M. Ishida[j], S. Ishida[n], X.B. Ji[a], H.B. Li[a], H.H. Li[a], J. Li[a], R.Y. Li[a], S.M. Li[a], W.D. Li[a], W.G. Li[a], X.L. Li[a], G. Li[b], Y.F. Liang[g], H.B. Liao[f], C.X. Liu[a], Z.A. Liu[a], F. Liu[f], Fang Liu[u], G.R. Liu[s], H.J. Liu[u], J.G. Lu[a], H.M. Liu[a], J. Liu[a], X.Q. Li[m], Y.F. Lai[a], Y.L. Li[a], J.P. Liu[v], R.G. Liu[a], L.L. Ma[a], Q.M. Ma[a], F. Lu[a], G.R. Lu[s], H.J. Lu[u], J.G. Lu[a], C.L. Luo[i], F.C. Ma[i], H.P. Peng[a], N.D. Qi[a], H. Qin[j], J.F. Qiu[a], Z.Y. Ren[a], G. Rong[a], X.Y. Shen[a], H.Y. Sheng[a], F. Shi[a], X. Shi[a,2], H.S. Sun[a], J.F. Sun[a], K. Takamatsu[h,x], Z.Q. Tan[a], X. Tang[a], Y.R. Tian[s], G.L. Tong[a], L. Wang[a], L.S. Wang[a], M. Wang[a], P. Wang[a], P.L. Wang[a], W. Wang[a], Z.Y. Wang[a], Zhe Wang[a], Zheng Wang[c], C.L. Wei[a], D.H. Wei[c], I. Yamanaki[r], B. Xin[t,1], G.F. Xu[a], Y. Xu[m], K. Yamada[n], N. Wu[a,4], X.M. Xia[a], G.F. Xu[a], X.P. Xu[r], J. Yang[a], Y.X. Yang[a], M.H. Ye[b], Y. Xu[m], Y.X. Ye[p], C.X. Yu[j], C.Z. Yuan[a], Y. Yuan[a], Y. Zeng[g], Y. Zeng[g], Yu Zeng[g], J.Y. Zhang[a], B.X. Zhang[a], B.Y. Zhang[a], C.C. Zhang[a], J.W. Zhang[a], Z.Q. Zhang[a], D.X. Zhao[a], Q.J. Zhang[a], X.M. Zhang[a], J.W. Zhao[a], M.G. Zhao[a], H.Q. Zheng[o], J.P. Zheng[a], Z.P. Zheng[a], L. Zhou[a], N.F. Zhou[a], Y.S. Zhu[a], Yingchun Zhu[a,5], Z.A. Zhu[a], Z.L. Zhu[c], B.A. Zhuang[a], B.S. Zou[a]

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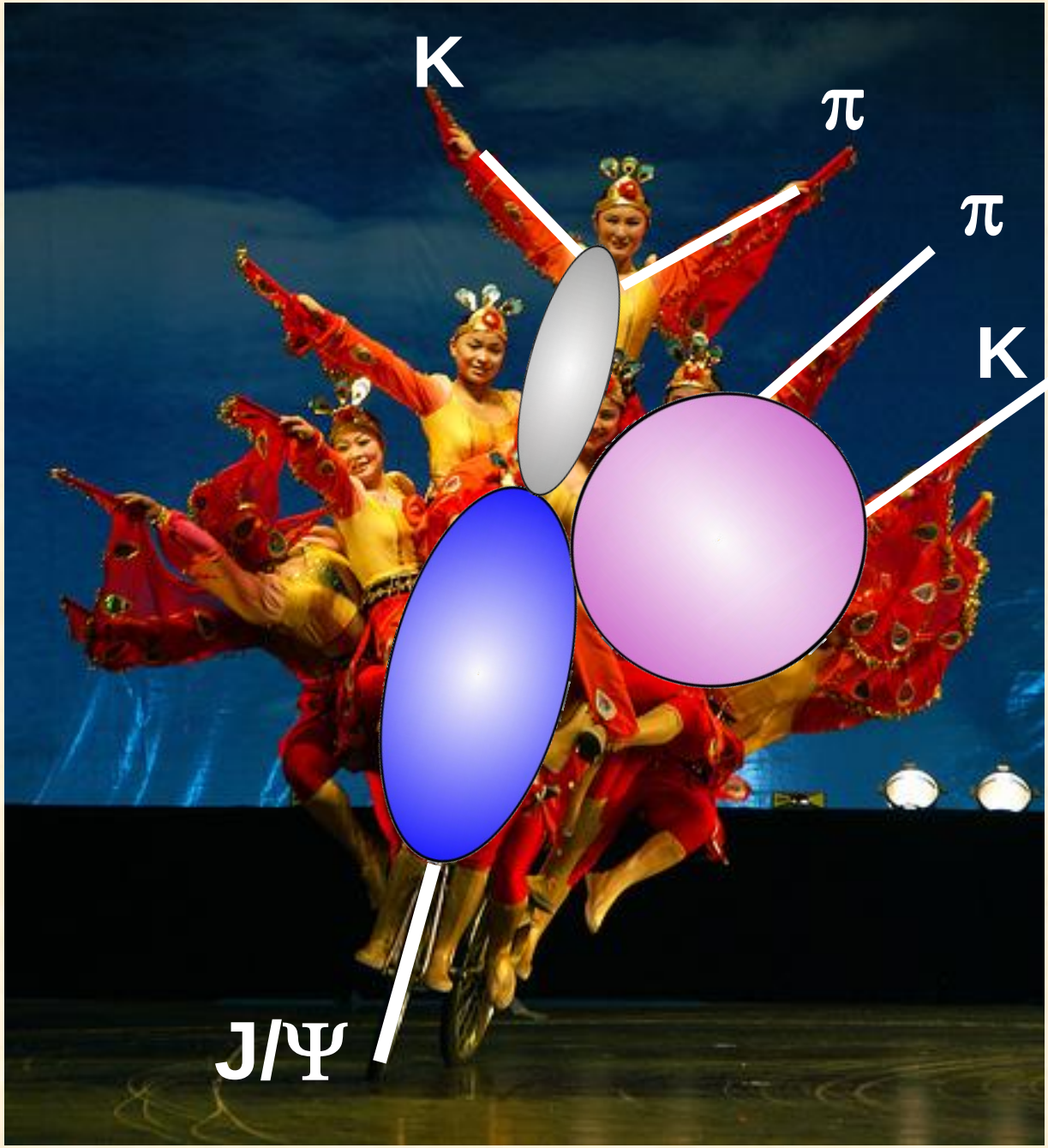
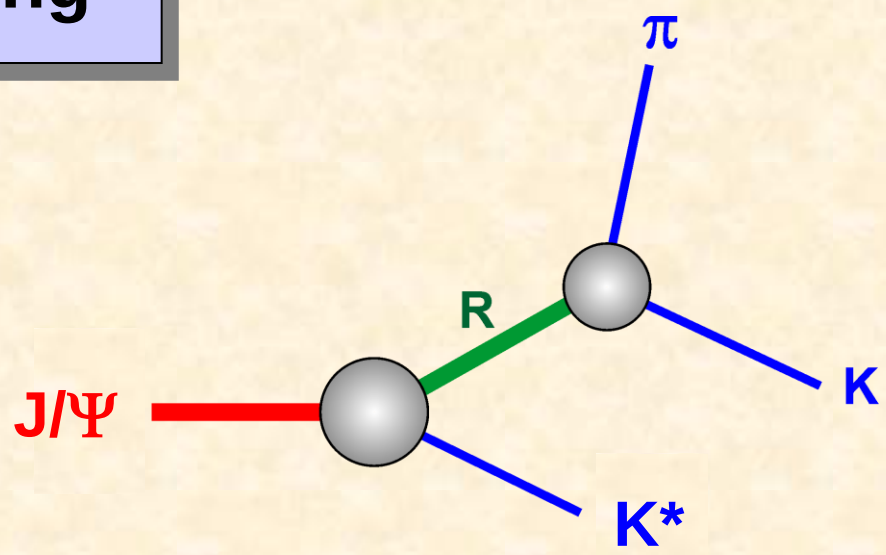
A study of charged κ in $J/\psi \to K^{\pm} K_S \pi^{\mp} \pi^0$

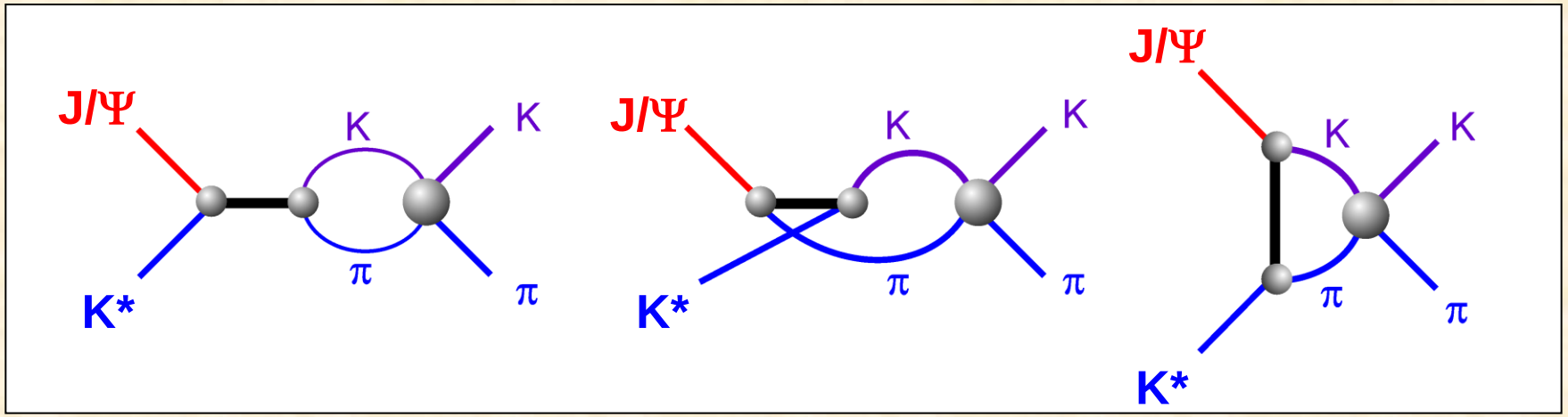
BES Collaboration

M. Ablikim[a], J.Z. Bai[a], Y. Bai[a], Y. Ban[k], X. Cai[a], H.F. Chen[p], H.S. Chen[a], H.X. Chen[a], J.C. Chen[a], Jin Chen[a], X.D. Chen[e], Y.B. Chen[a], Y.P. Chu[a], Y.S. Dai[r], Z.Y. Deng[a], S.X. Du[a,1], J. Fang[a], C.D. Fu[a], C.S. Gao[a], Y.N. Gao[n], S.D. Gu[a], Y.T. Gu[d], Y.N. Guo[a], Z.J. Guo[o,2], F.A. Harris[o], K.L. He[a], M. He[l], Y.K. Heng[a], H.M. Hu[a], T. Hu[a], G.S. Huang[a,3], X.T. Huang[l], Y.P. Huang[a], X.B. Ji[a], X.S. Jiang[a], J.B. Jiao[l], D.P. Jin[a], S. Jin[a], G. Li[a], H.B. Li[a], J. Li[a], L. Li[a], R.Y. Li[a], W.D. Li[a], W.G. Li[a], X.L. Li[a], X.N. Li[a], X.Q. Li[j], Y.F. Liang[m], B.J. Liu[a,4], C.X. Liu[a], Fang Liu[a], Feng Liu[f], H.M. Liu[a], J.P. Liu[q], H.B. Liu[d,5], J. Liu[a], Q. Liu[o], R.G. Liu[a], S. Liu[h], Z.A. Liu[a], F. Lu[a], G.R. Lu[e], J.G. Lu[a], C.L. Luo[i], F.C. Ma[h], H.L. Ma[b], Q.M. Ma[a], M.Q.A. Malik[a], Z.P. Mao[a], X.H. Mo[a], J. Nie[a], S.L. Olsen[o], R.G. Ping[a], N.D. Qi[a], J.F. Qiu[a], G. Rong[a], X.D. Ruan[d], L.Y. Shan[a], L. Shang[a], C.P. Shen[o], X.Y. Shen[a], H.Y. Sheng[a], H.S. Sun[a], S.S. Sun[a], Y.Z. Sun[a], Z.J. Sun[a], X. Tang[a], J.P. Tian[n], G.L. Tong[a], G.S. Varner[o], X. Wan[a], L. Wang[a], L.L. Wang[a], L.S. Wang[a], P. Wang[a], P.L. Wang[a], Y.F. Wang[a], Z. Wang[a], Z.Y. Wang[a], C.L. Wei[a], D.H. Wei[c], N. Wu[a,4], X.M. Xia[a], G.F. Xu[a], X.P. Xu[r], Y. Xu[j], M.L. Yan[p], H.X. Yang[a], M. Yang[a], Y.X. Yang[c], M.H. Ye[b], Y.X. Ye[p], C.X. Yu[j], C.Z. Yuan[a], Y. Yuan[a], Y. Zeng[g], B.X. Zhang[a], B.Y. Zhang[a], C.C. Zhang[a], D.H. Zhang[a], F. Zhang[n,6], H.Q. Zhang[a], H.Y. Zhang[a], J.W. Zhang[a], J.Y. Zhang[a], X.Y. Zhang[l], Y.Y. Zhang[m], Z.X. Zhang[k], Z.P. Zhang[p], D.X. Zhao[a], J.W. Zhao[a], M.G. Zhao[a], P.P. Zhao[a], Z.G. Zhao[p], B. Zheng[a], H.Q. Zheng[k], J.P. Zheng[a], Z.P. Zheng[a], B. Zhong[i], L. Zhou[a], K.J. Zhu[a], Q.M. Zhu[a], X.W. Zhu[a], Y.S. Zhu[a], Z.A. Zhu[a], Z.L. Zhu[c], B.A. Zhuang[a], B.S. Zou[a]

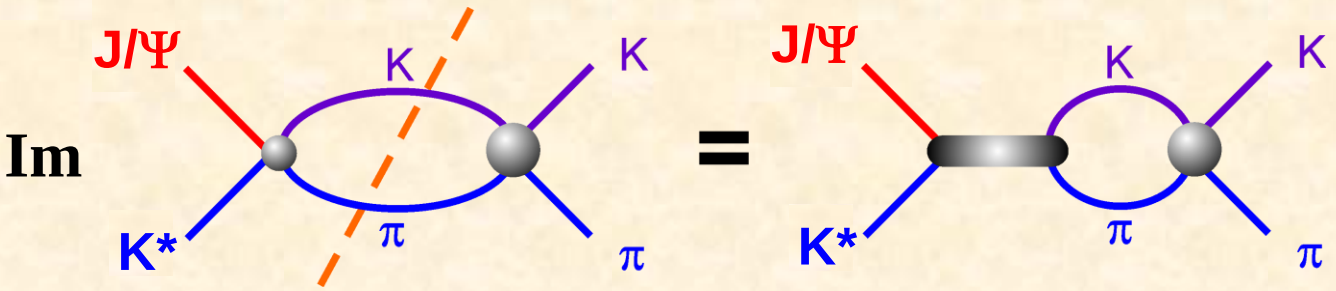

K
π
π
K
J/Ψ

Rescattering





Rescattering : Unitarity

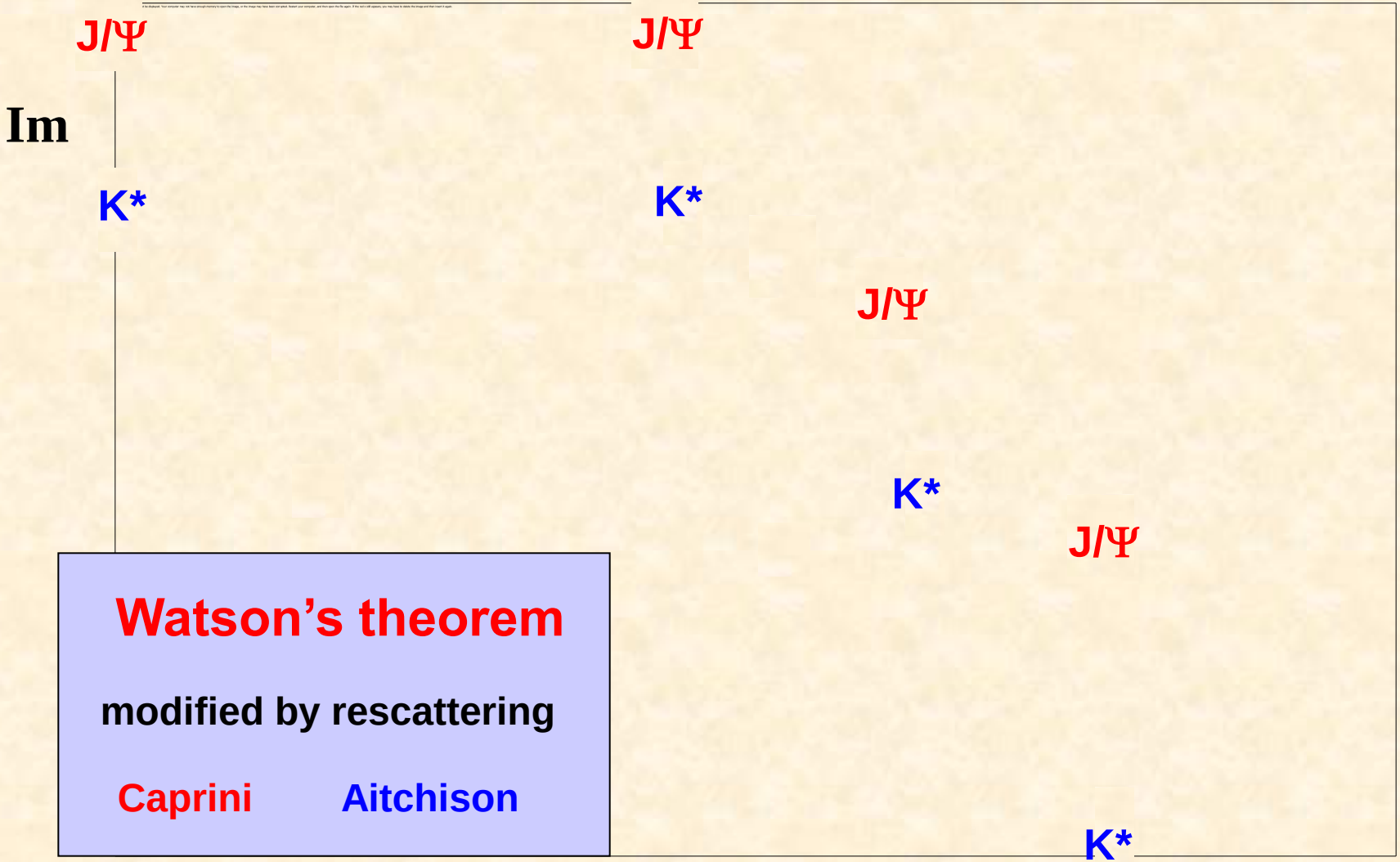


Watson's theorem

elastic

phases simply related if no rescattering

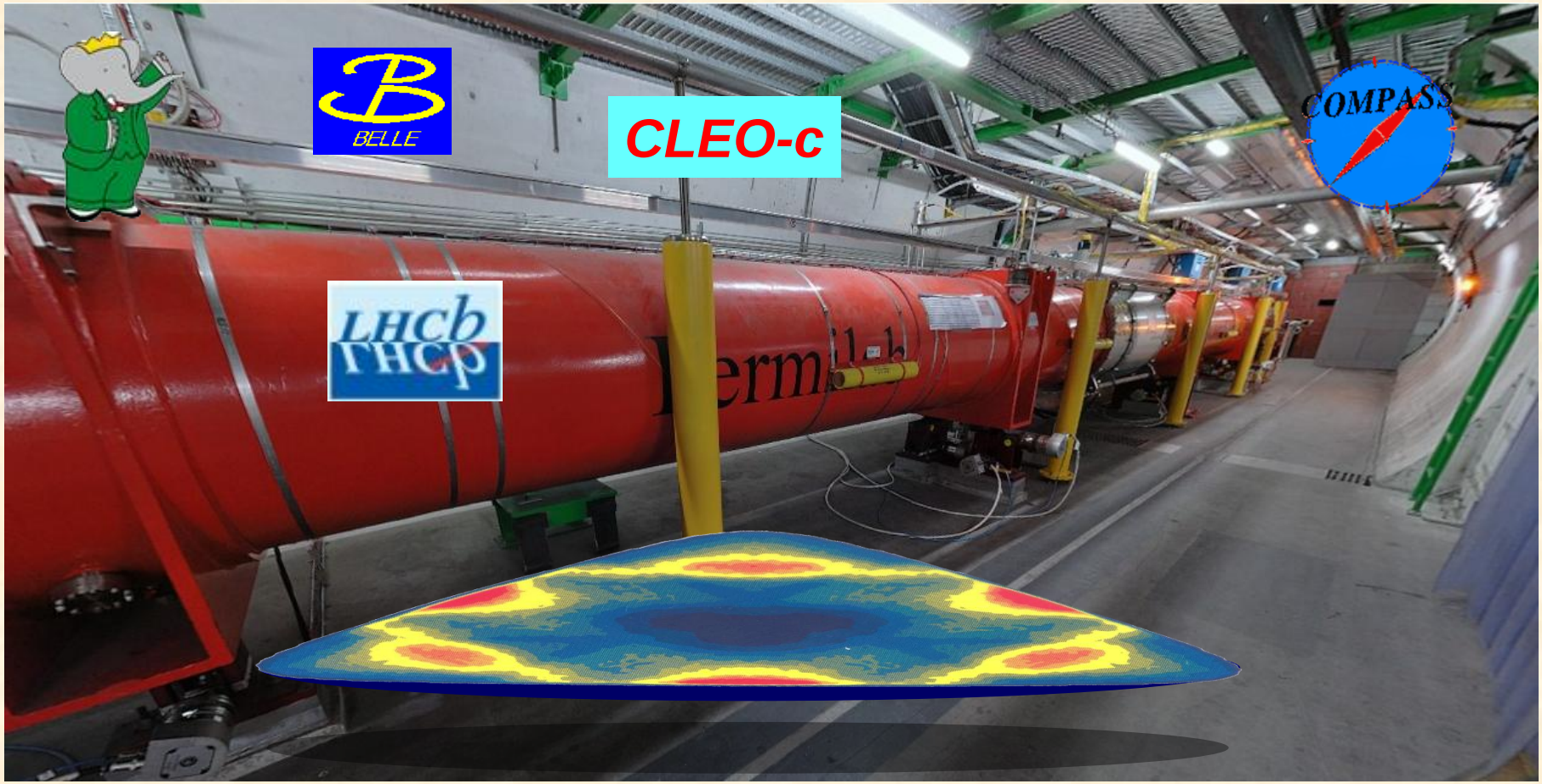
Rescattering : Unitarity



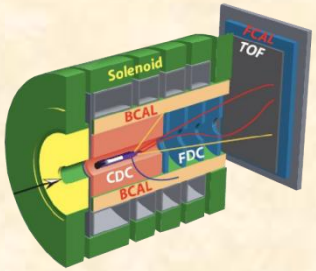
Watson's theorem

modified by rescattering

Caprini **Aitchison**



GLUEX CITATIONS PERIMENT
Hall D@JLab



FAIR

PANDA
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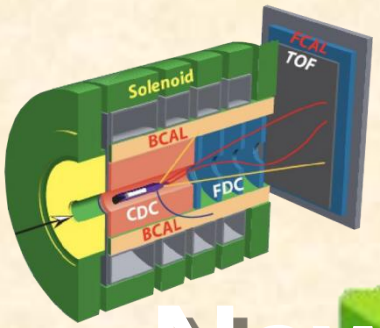
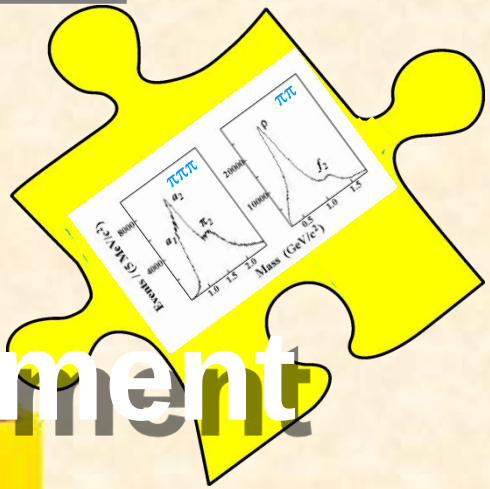
Physics Analysis Center



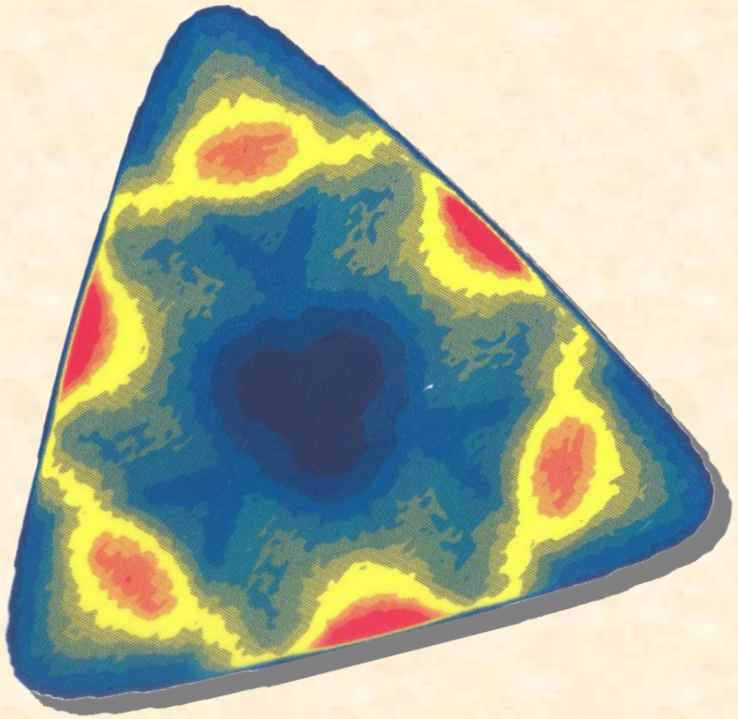


New Theory/Experiment Staff Position

Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

Physics Analysis Center

Techniques of Amplitude Analysis



Jefferson Lab Advanced Study Institute

EXTRACTING PHYSICS FROM PRECISION EXPERIMENTS:

Techniques of Amplitude Analysis

COLLEGE OF WILLIAM & MARY
WILLIAMSBURG, VIRGINIA, USA

Wednesday, May 30th, 2012
through Wednesday, June 13th, 2012

To prepare for the analysis of precision experiments at BESIII, COMPASS, LHCb, JLAB@12 GeV, and PANDA@FAIR, Thomas Jefferson National Accelerator Facility (JLab) is organizing a two week advanced course covering *Techniques of Amplitude Analysis*, aimed at postdoctoral researchers and advanced doctoral students in nuclear and particle physics.

May/June 2012

LECTURERS:

Suh-Urk Chung	(BNL/TUM)
Jozef Dudek	(ODU)
Bastian Kubis	(Bonn)
T-S Harry Lee	(ANL)
Brian Meadows	(Cincinnati)
Antimo Palano	(Bari)
Klaus Peters	(GSI Darmstadt)
Michael Pennington	(JLab)
Ronald Workman	(GWU)

CONTACT:
mfox@jlab.org

For application details and all other information see:
http://www.jlab.org/conferences/asi2012/

End