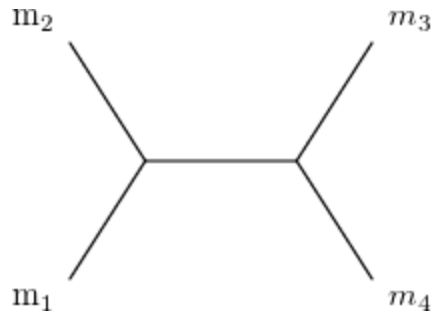


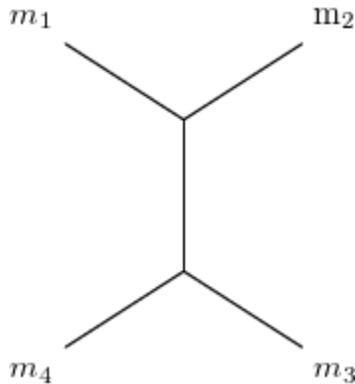
One-Hadron Exchange Diagrams

- t-channel : $\pi\pi$; πK ; KK Interaction Exchange Hadrons



ρ
 K^*
 ω
 φ
 f_2
 ε
 κ

- s-channel : $\pi\pi$; πK Interaction



Form Factor

► Monopole Type

► t-channel

$$F^{(t)}(q_\alpha^2) = \frac{\Lambda^2 - m_\alpha^2}{\Lambda^2 + q_\alpha^2}$$

Λ (MeV) cut-off parameter

► s-channel

$$F^{(s)}(\omega_p^2) = \frac{\Lambda^2 + m_\alpha^2}{\Lambda^2 + \omega_p^2}$$

m_α mass of exchanged meson

q_α momentum

► Gaussian Type

► t-channel

$$F^{(t)}(q_\alpha^2) = \exp\left(-\frac{q_\alpha^2}{\Lambda^2}\right)$$

ω_p total energy

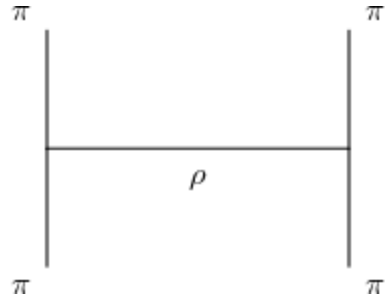
► s-channel

$$F^{(s)}(\omega_p^2) = \exp\left(-\frac{\omega_p^2}{\Lambda^2}\right)$$

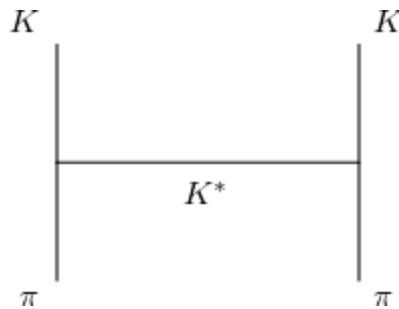
Determine Parameter

- ▶ g_1, g_2 coupling constants
- ▶ Λ cut-off parameter
- ▶ m_0 bare mass: use in s-channel

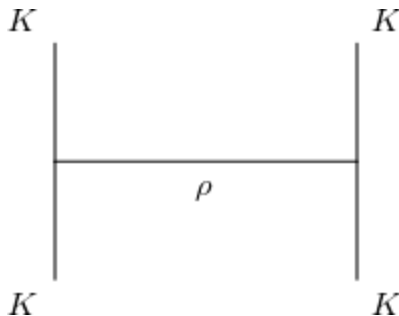
Table of parameter values



	Monopole	Gaussian
$g_1 g_2 / (4\pi)$	2.00236E+00	2.59628E+00
Λ (MeV)	1476.88408E+00	2398.84762E+00

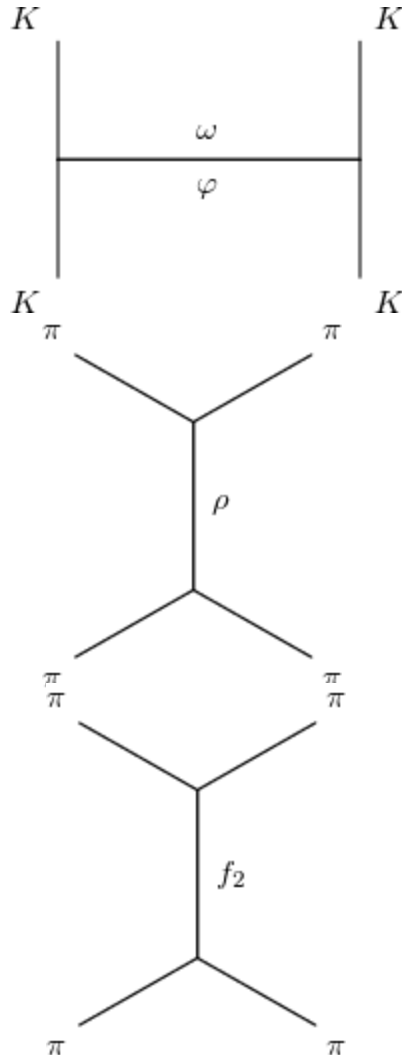


	Monotype	Gaussian Type
$g_1 g_2 / (4\pi)$	0.50059E+00	0.64907E+00
Λ (MeV)	450.986696E+00	2031.27633E+00



	Monotype	Gaussian Type
$g_1 g_2 / (4\pi)$	0.50059E+00	0.64907E+00
Λ (MeV)	2744.27137E+00	2902.30591E+00

Table of parameter values (cont.)

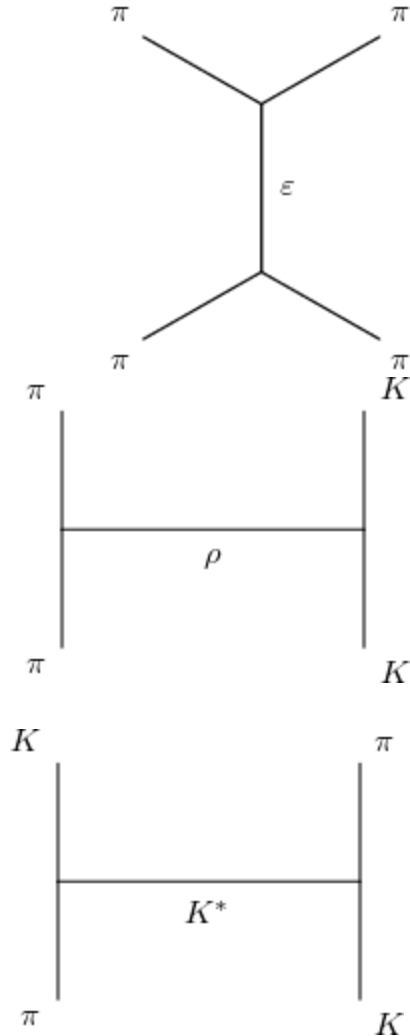


	Monopole	Gaussian
$g_1 g_2 / (4\pi)$	0.50059E+00 1.00118E+00	0.64907E+00 1.29814E+00
Λ (MeV)	7121.71551E+00	4329.69814E+00

	Monopole	Gaussian
$g_1 g_2 / (4\pi)$	2.00236E+00	2.59628E+00
Λ (MeV)	1497.74105E+00	1494.49173E+00

	Forth-order	Gaussian
$g_1 g_2 / (4\pi)$	0.55717E-01	0.28139E-01
Λ (MeV)	1629.74230E+00	1718.37207E+00

Table of parameter values (cont.)

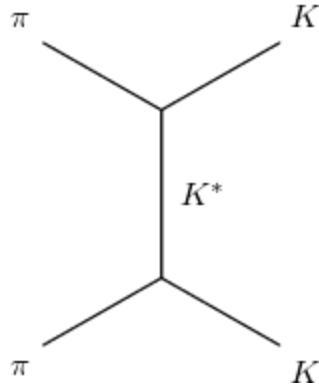


	Fouth-order	Gaussian
$g_1 g_2 / (4\pi)$	0.59431E-01	0.78643E-02
Λ (MeV)	6536.94627E+00	3682.70295E+00

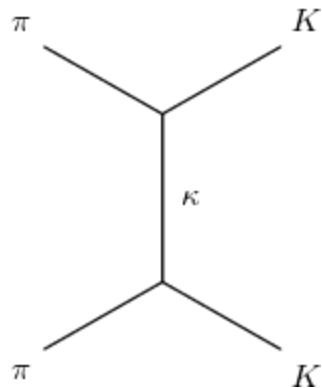
	Monopole	Gaussian
$g_1 g_2 / (4\pi)$	1.00118E+00	1.29814E+00
Λ (MeV)	2744.27137E+00 1476.88408E+00	2902.30591E+00 2398.84762E+00

	Monopole	Gaussian
$g_1 g_2 / (4\pi)$	0.50059E+00	0.64907E+00
Λ (MeV)	450.986696E+00	2031.27633E+00

Table of parameter values (cont.)

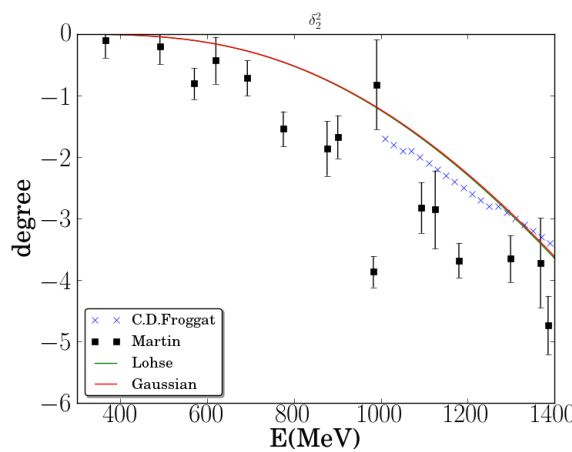
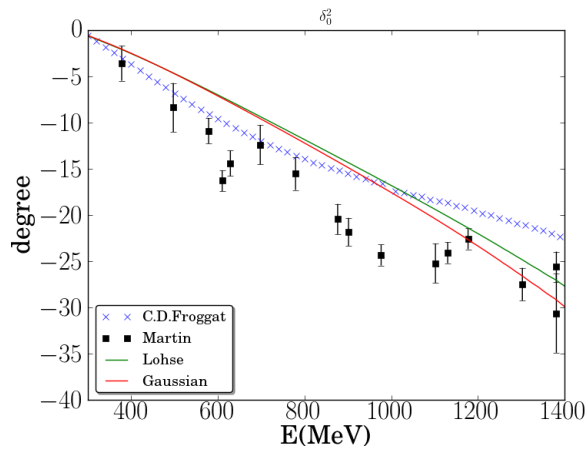
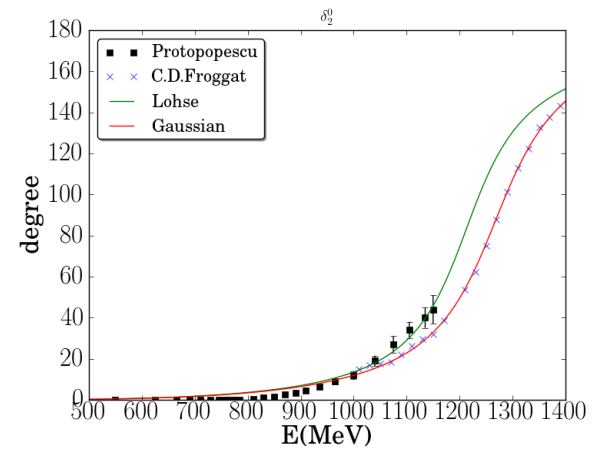
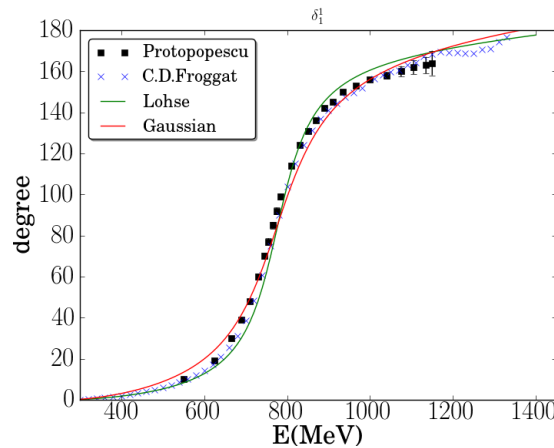
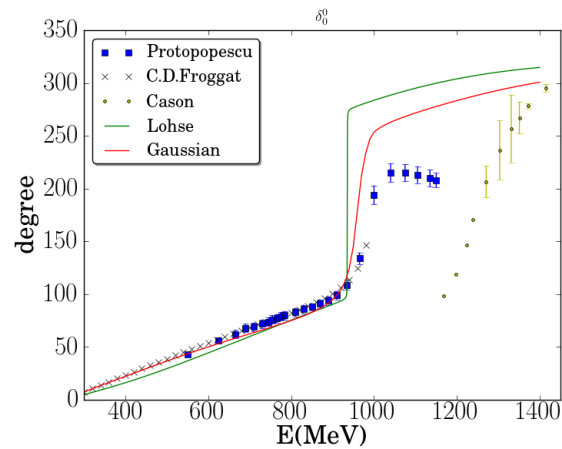


	Monopole	Gaussian
$g_1 g_2 / (4\pi)$	0.50059E+00	0.64907E+00
Λ (MeV)	2532.90053E+00	5214.31755E+00



	Forth-order	Gaussian
$g_1 g_2 / (4\pi)$	0.10131E-02	0.10420E-02
Λ (MeV)	3006.60018E+00	2861.30149E+00

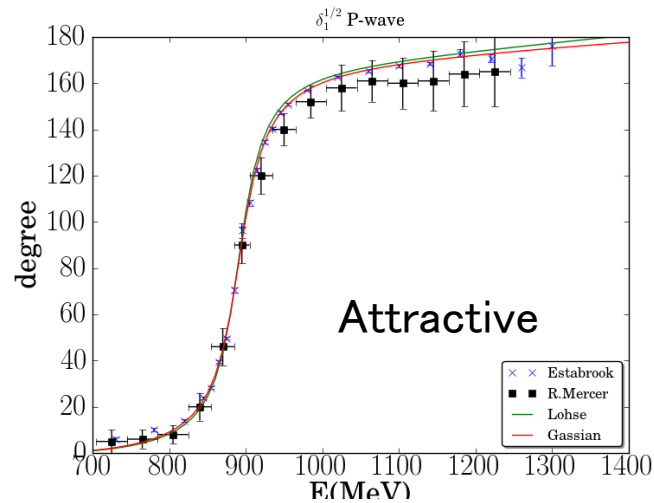
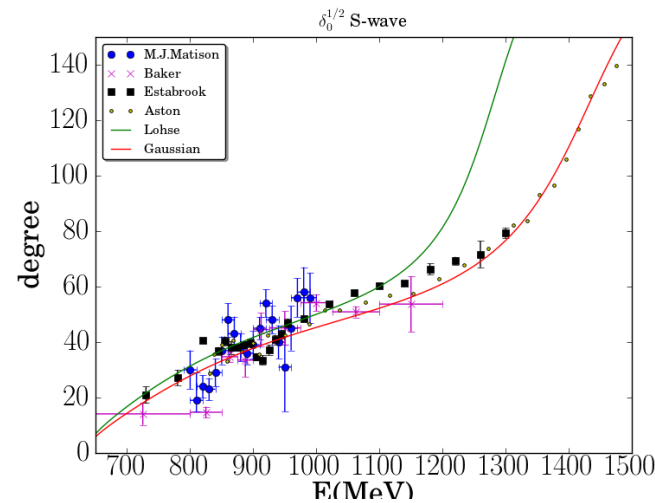
Results of $\pi\pi$ Phase Shifts



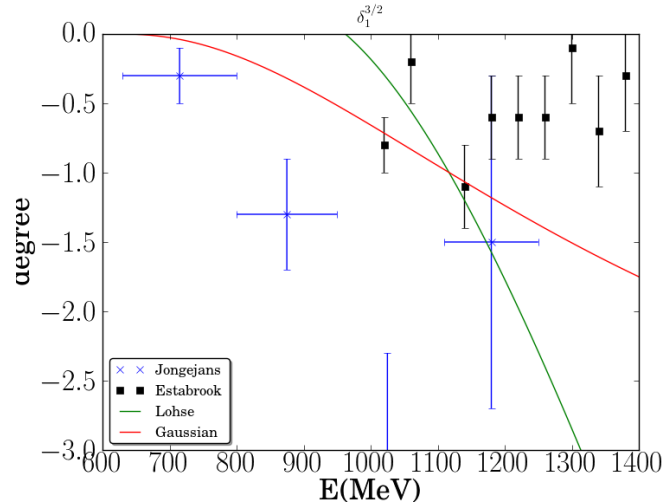
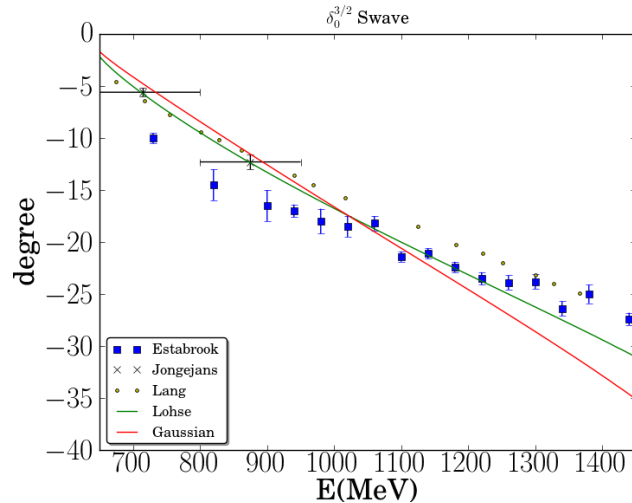
δ_0^0 *Atracctive*
 δ_1^1 *Atracctive*
 δ_2^0 *Atracctive*

δ_0^2 *Repulsive*
 δ_2^2 *Repulsive*

Results of πK Interaction



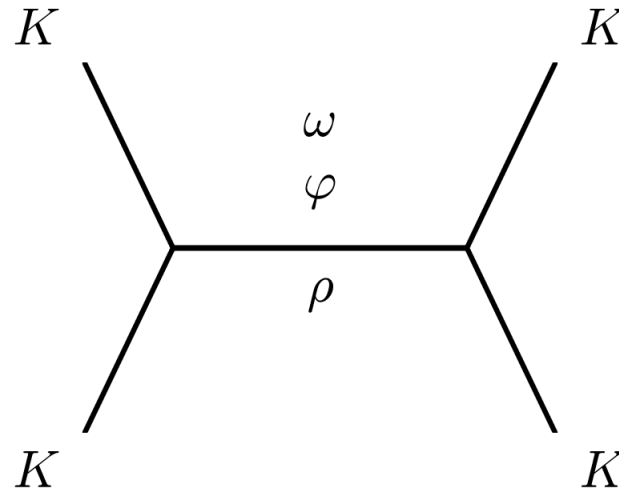
$\delta_0^{\frac{1}{2}}$ Attractive
 $\delta_1^{\frac{1}{2}}$ Attractive



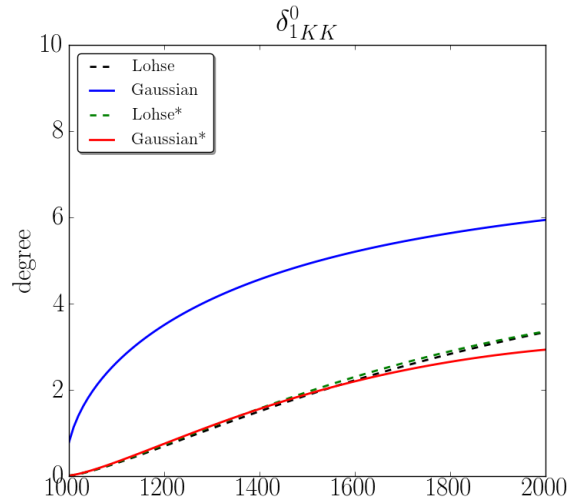
$\delta_0^{\frac{3}{2}}$ Repulsive
 $\delta_1^{\frac{3}{2}}$ Repulsive

KK Interaction

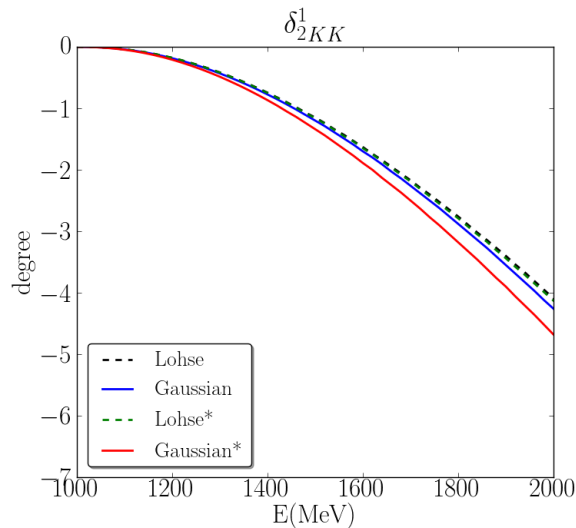
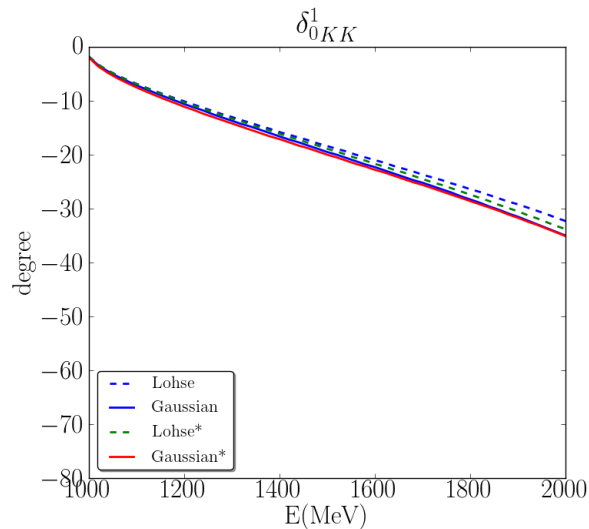
- t-channel with ρ , ω , and φ meson-exchange



Results of KK interaction



- ▶ δ_1^0 weak attractive
- ▶ δ_0^1 and δ_2^1 repulsive



K^{bar} -Hadron S-wave Attractive Force

- ▶ $K^{\text{bar}} N$, $K^{\text{bar}} \Lambda$, $K^{\text{bar}} \Sigma$, $K^{\text{bar}} \Xi$
- ▶ $K^{\text{bar}} \pi$ ($K \pi$), $K^{\text{bar}} K$

現象論的なパラメータの決定 + LQCDによる短距離力
QCDの反映 QCDによる理解が可能

$K-\Sigma^+$ と $K-\Sigma^-$ のquark組成

まとめ

▶ ハドロン交換機構によるハドロン間の相互作用

▶ 湯川理論以来の長い歴史

▶ 武谷3領域論 有効な自由度

▶ 短距離力 現象論的 (LQCDの結果)

▶ 中間領域 実体論的

▶ 長距離力 本質論的

▶ カイラル摂動論モデル

 本質論的構造を取り込んだ「現象論」 有効な自由度は π のみ

ハドロン交換機構

本質論
QCD

低エネルギーのハドロン相互作用: ハドロン交換機構は有効な自由度

K^{bar} -hadronの強い引力相互作用の存在 → QCDによる理解へ

短距離力だけでなく中間領域におけるQCD ← LQCD