Search for X particle
(Kπ bound state)

(Another explanation of Θ^+)

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  - E548 is to study kaonic nuclei (in-flight (K^-,N))

T. K and T. Sato
hep-ex/0312003

Properties of Θ^+

- Penta-quark state ($uudd\bar{s}$): $\Theta^+ ! K^+ n$ or $K_s p$
- Mass ~1540 MeV
- Width ~10 MeV (upper limit)
- Spin-parity ½+ (original prediction, yet to be confirmed)
- Isospin 0 (original prediction, no charge 2 state seems to exist)

Θ^+: Another explanation

- $K\pi N$ bound state (TK TS, hep-ph/0308073, nucl-th/0311020)
- Mass ~1540 MeV
  - M($K\pi N$) ~1570 MeV (30 MeV bound)
  - 10 MeV/particle (usual)
- Spin parity ½+ (original prediction)
  - K π N system (s-wave) ½+ (0^- 0^- ½+)
- Narrow width
  - Exp: Γ< 9 MeV
  - Phase shift analysis: Γ< 1 MeV (Kd scatt.) nucl-th/9505040

Bound state with κ

Negative results appearing from “high energy” experiments.

- Positive results
  NA49, ZEUS, SVD

- Negative results
  HERA-B
  PHENIX
  BES
  E690
  CDF
  :

) **@ QNP2004, May, Indiana**

Could Θ^+ be a $K\pi N$ bound state

- Known two Body interaction
  - πN: weakly attractive
  - KN: weakly repulsive
  - $K\pi$ weaklv attractive

→ **No bound state**

TABLE I: Spin, parity and isospin of two particle subsystems.

	Θ^+ $(K\pi N)$	πN	KN	$K\pi$
$J\pi$	$1/2^+$	$1/2^-$	$1/2^-$	0^+
I	0	1/2	1	1/2

- $K\pi$ int. may have ambiguity
  - So strong to make $K\pi$ bound state

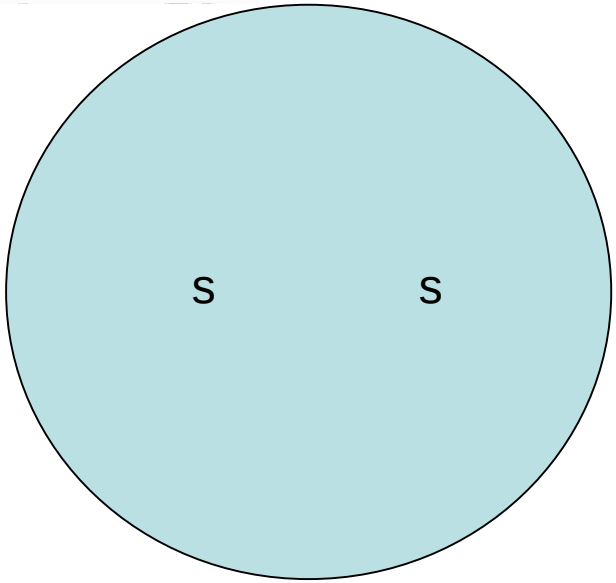
X (new particle)

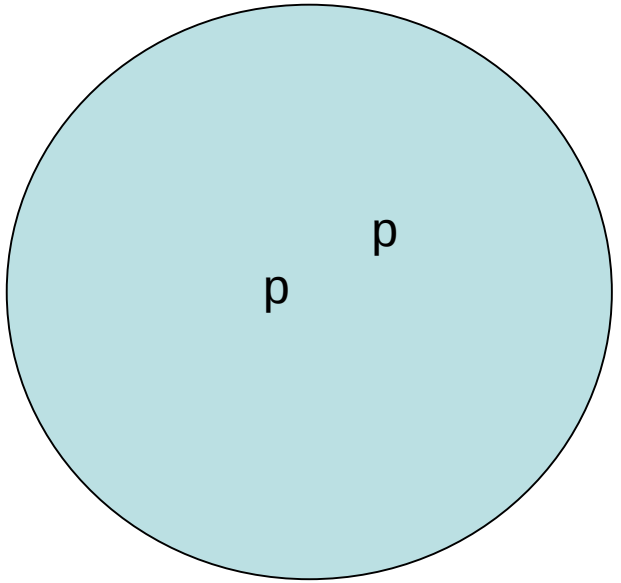
Θ^+ : $K\pi N$

Width of Θ^+ in KπN conjecture

- In order Θ to decay
  - KπN ! KN (π has to be absorbed in N)
  - πN (s-wave) ! πN (p-wave)
  - K-πN (s-wave) ! K-πN (p-wave)
- KπN have to interact simultaneously
- Width ~ Γ(strong) (R(int)/R(Θ))^6
  - R(int): Radius of Interaction
  - R(Θ): Radius of Θ

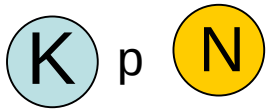
How to Decay





$(R(int)/R(\Theta))^6$

Decay



Radius of Θ^+ and X

Asymptotic wave function (π)

$$\phi_{out}(r) = N\frac{1}{r}exp\left(-\frac{\sqrt{2\mu E_B}}{\hbar c}r\right)$$

E_B=30 MeV r~ 2 fm

5 MeV r~ 4.4 fm

Extended object

Low momentum transfer reaction

Width of Θ^+

- Width ~ Γ(strong) (R(int)/R(Θ))^6
  - R(int) ~ 1 fm
  - R(Θ) ~ (2-4)fm

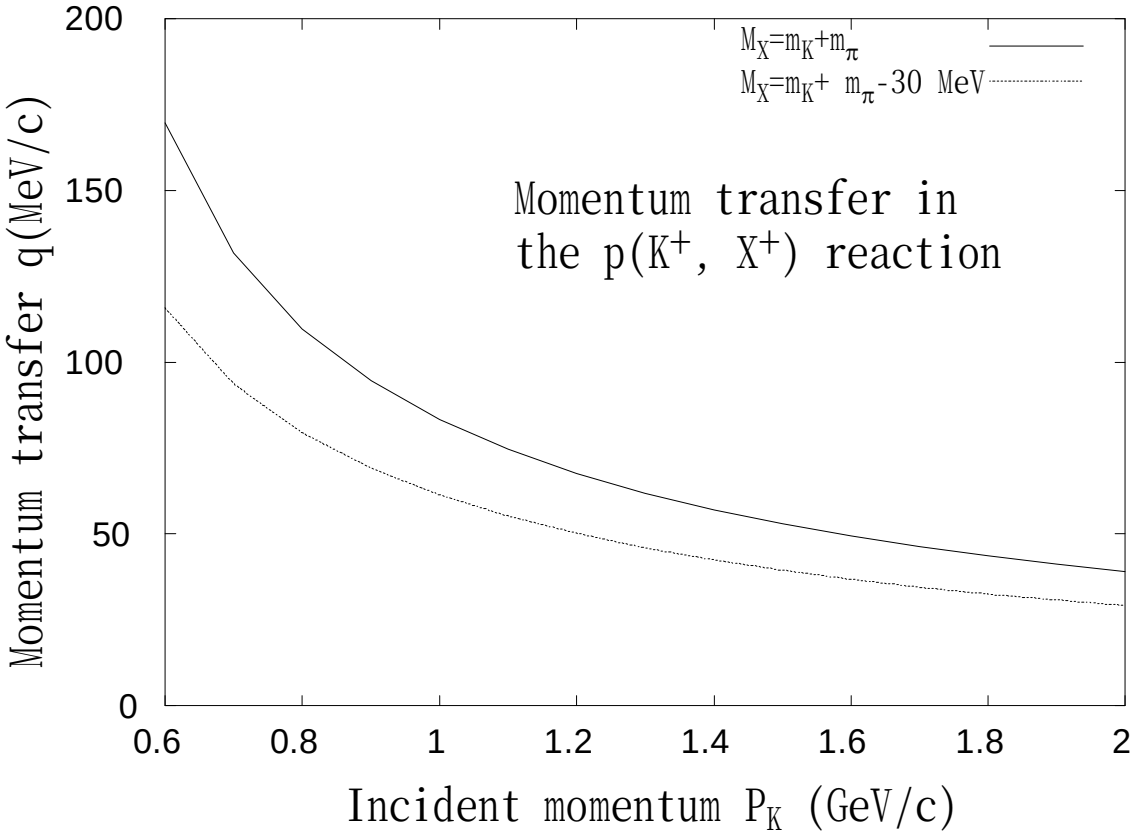
- Γ » a few 100 MeV (1/(2~4))^6 ~ MeV
  - Less than 1 MeV (K-n phase shift analysis)

X (Why missed)

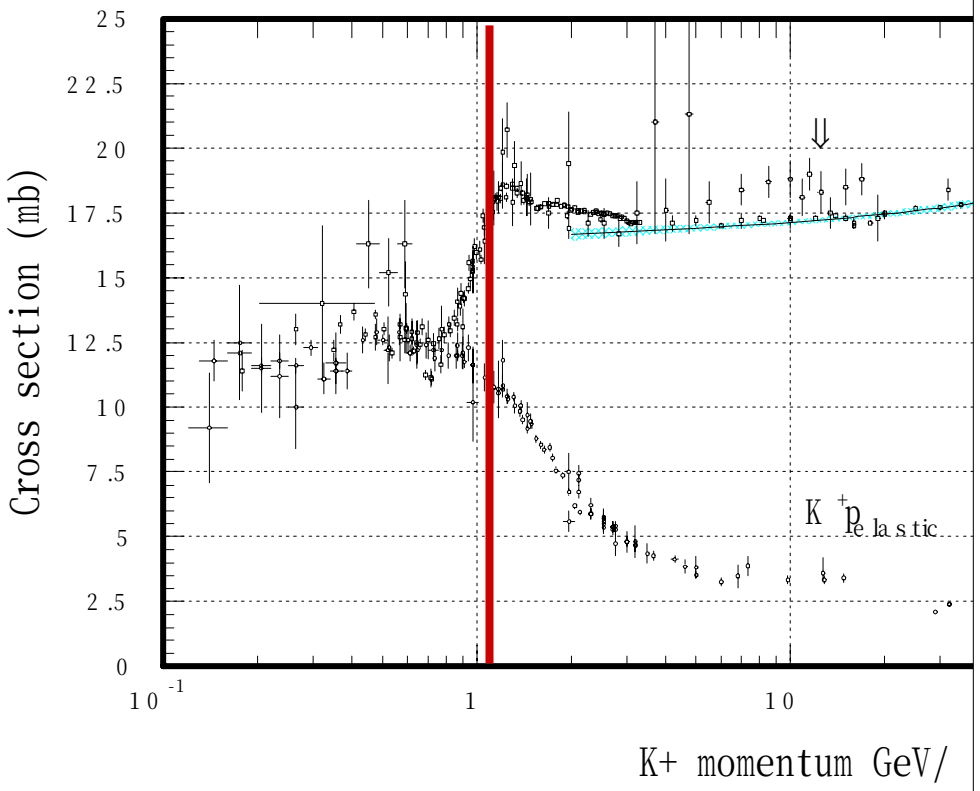
- Lowest order decay mode **X ! K$\gamma\gamma$**
  - No strong decay $M_X < M_K + M_\pi$
  - No X→K γ decay ($0^+ \rightarrow 0^- + 1^-$ L non cons.)
  - No X→K e^+e^-
    - (vec. curr. vs axial charge ($0^+ \rightarrow 0^-$)
- No decay mode is listed in PDG
- If it exists.
  - Hard to believe but possibility is there.

X Search

- low momentum transfer reaction.
- $p(K^{-+}, X^{-+})p$ @P_K~1 GeV/c
- q ~ 50 MeV/c



Cross section



P_K~1.05 GeV/c
Inelastic σ: ~5 mb
(π production)

σ(X) ~ σ(Kπ) £ F(q)
~σ(Kπ)£(R(int)/R(X))^3
~mb £ $10^{-(2\sim3)}$
~μb/sr

How to measure (KEK-PS-E548(Kanic nuclei)

- $p(K^{-+}, X^{-+})p$, X! K γ γ
  - Measure Kaon momentum in coincidence with γ rays
- BG process: $p(K^{-+}, K^{-+} \pi^0)$, π^0 ! γ γ
- X particle gives highest P_K
- Measure invariant mass of K and two γ's
  - Dedicated detector system
- Study of Kπ final state interaction

Summary

- $K\pi$ bound system X: hard to believe
- Might have been missed experimentally
- Explains almost all Θ^+ properties
- If no X, Θ^+ is difficult to explain as $K\pi N$

Exploratory Experiment (PS-E548)

We just bought a lottery ticket.
Our experiment might make it a lucky ticket.

- If X is there,
  - meson meson spectroscopy