Observation of a 1750 MeV/c^2 State in the Diffractive Photoproduction of K^+K^-

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FOCUS Collaboration
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Outline

I. Photoproduction and Spectroscopy

II. A Short History of the Photoproduction of "Higher Mass Vectors"

   A. "ρ'(1600)"

   B. "$\omega\pi^0$(1250)"

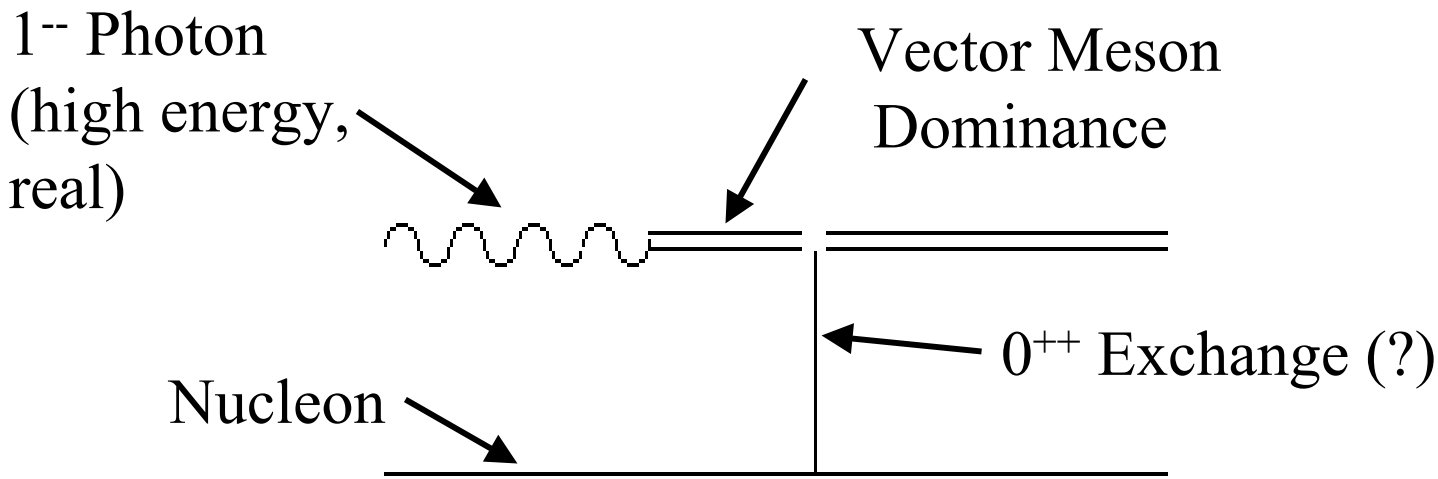
   C. "ω(1650)"

   D. "φ(1680)"

III. Fermilab's FOCUS Experiment

IV. FOCUS K^+K^- Results

Diffractive Photoproduction



- Unique production mechanism.
- Vector excitations? Hybrids?
- A “dearth of data.”

Photoproduction of Light Mesons

- 1970's: Diffractive photoproduction of ρ, ω, and φ vector mesons was mostly as expected.
- Late 1970's to Mid 1980's: Results are more unclear for the photoproduction of the "vector excitations."

"ρ'(1600)"

"$\omega\pi^0$(1250)"

"ω(1650)"

"φ(1680)"

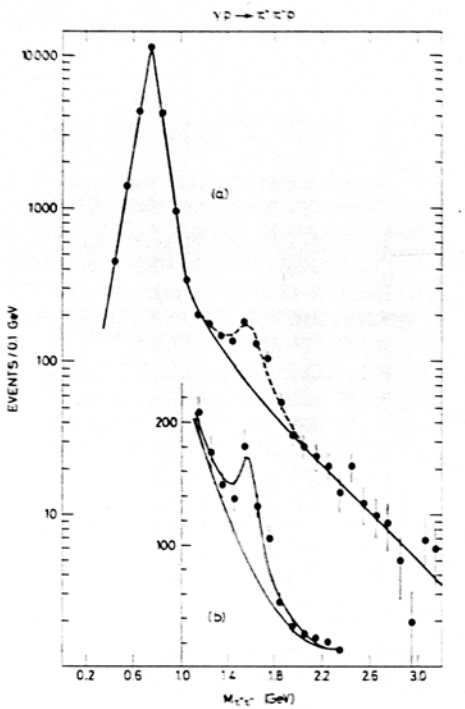
- Very little has been done since (with high energy photon beams).

Photoproduction since 1979

- The Ω-Photon Collaboration at CERN.
- LAMP2 at Daresbury.
- SLAC Hybrid.
- E401 at Fermilab.
- (E687 and E831 at Fermilab.)

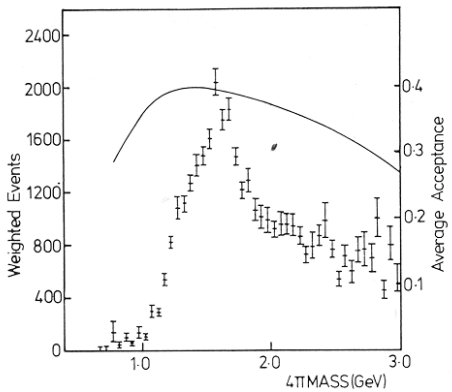
“ρ’(1600)”

Very wide resonance at ~1600 MeV/c^2



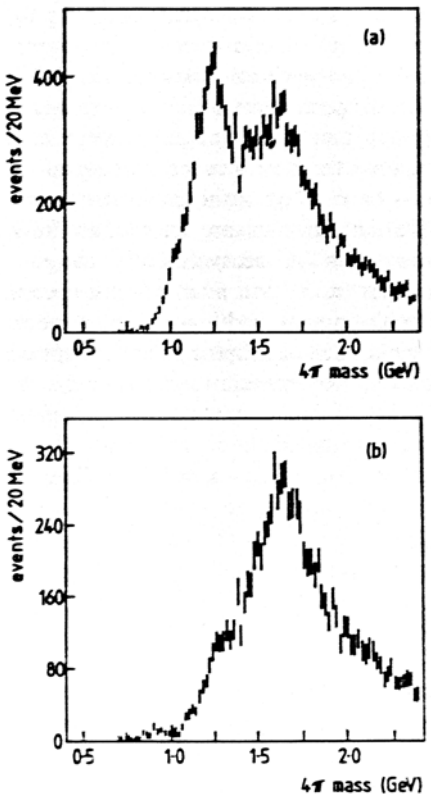
$\pi^+\pi^-$

Omega 1980



$\pi^+\pi^-\pi^+\pi^-$

Omega 1981

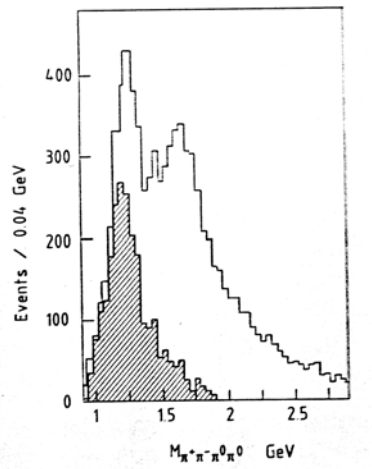


$\pi^+\pi^-\pi^0\pi^0$

Omega 1985

However, it is now considered to be two resonances, the ρ(1450) and ρ(1700).

"$\omega\pi^0(1250)$"

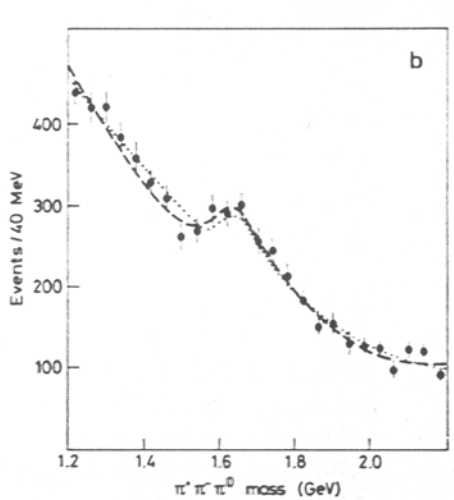


Omega 1985:
Full angular analysis favors 1^+ over 1^-.

- It now appears that this is the $b_1(1235)$.
  - The mass and width agree with the $b_1(1235)$ as it is produced in other production mechanisms.
  - The most recent angular analyses favor 1^+.
  - No corresponding resonance has been seen in e^+e^- annihilation.

"ω(1650)"

- The only published observation in photoproduction is from the Ω-photon group in 1983 in $\pi^+\pi^-\pi^0$.



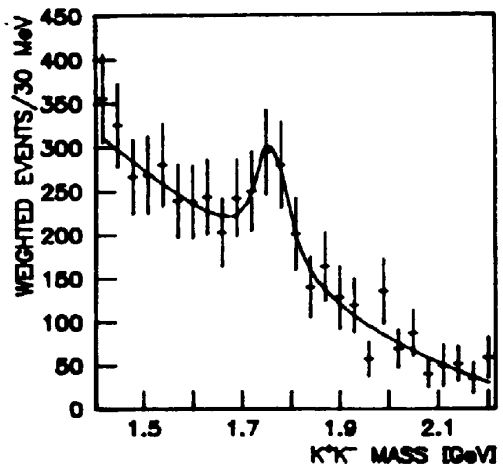
$M = 1670 \pm 20$ MeV/c²

$\Gamma = 160 \pm 20$ MeV/c²

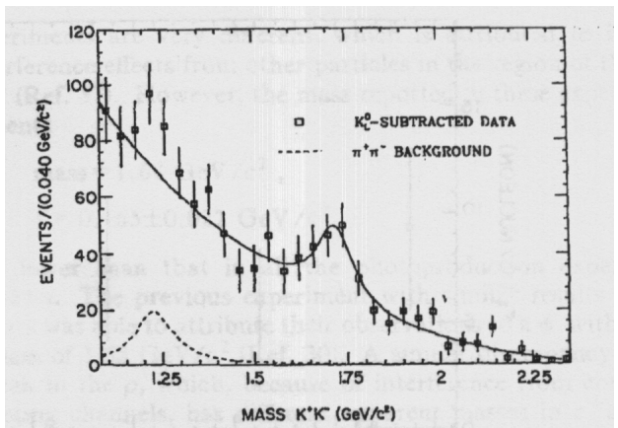
- e^+e^- annihilation observes a resonance at the same mass, but it is best seen in $\omega\pi\pi$.
- Photoproduction searches in $\omega\pi\pi$ have come up empty.

"φ(1680)" or "K^+K^-(1750)"

- The φ(1680) (radial excitation of the φ(1020)) has been established in $e^+e^- \rightarrow K_S K\pi$.
- Photoproduction, however, shows an enhancement in K^+K^- around 1750 MeV/c^2, originally interpreted, erroneously, as the φ(1680).



OMEGA 1985
1760 ± 20 MeV



E401 1989
1726 ± 22 MeV

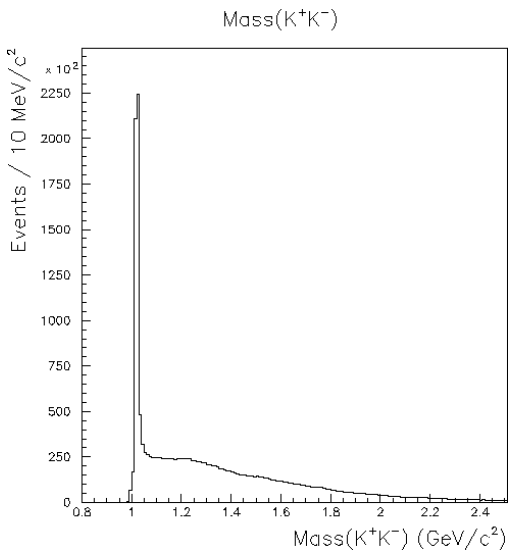
Summary of Historical Photoproduction

- $\rho'(1600)$
  - The "best established" of the photoproduced resonances is no longer a resonance at all.
- $\omega\pi^0(1250)$
  - Are we photoproducing a 1^{+-} $b_1(1235)$?
- $\omega(1650)$
  - Are photoproduction and e^+e^- consistent here?
- $\varphi(1680)$
  - The photoproduced enhancement in K^+K^- appears to be something completely different from the $\varphi(1680)$ seen in e^+e^-.

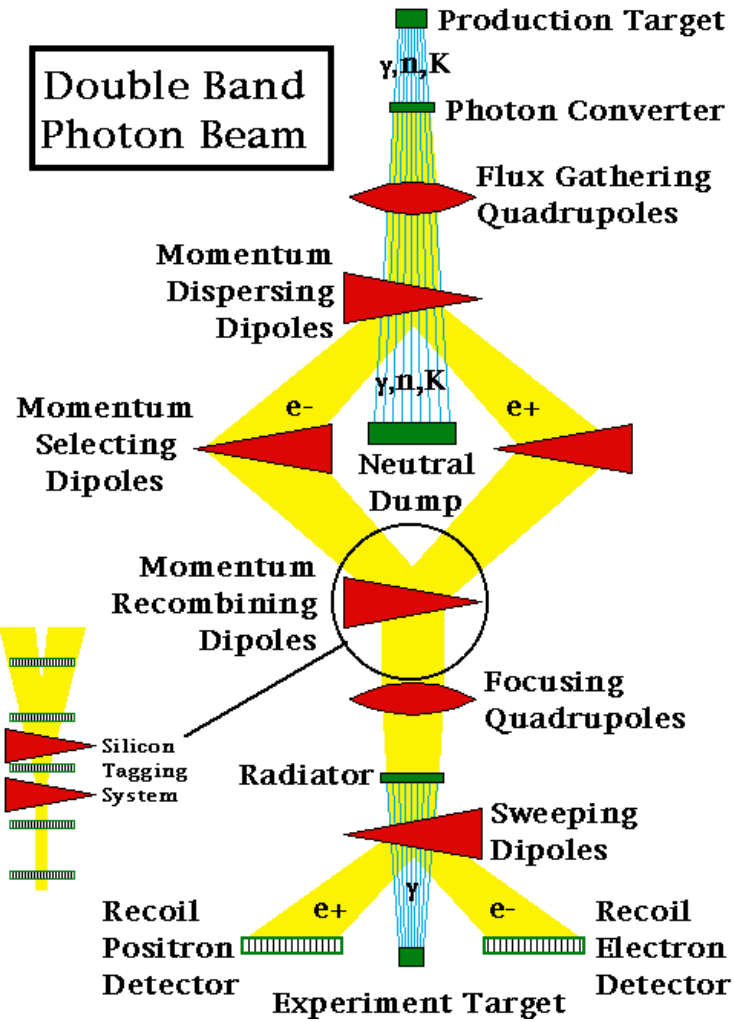
Fermilab's E831/FOCUS Experiment

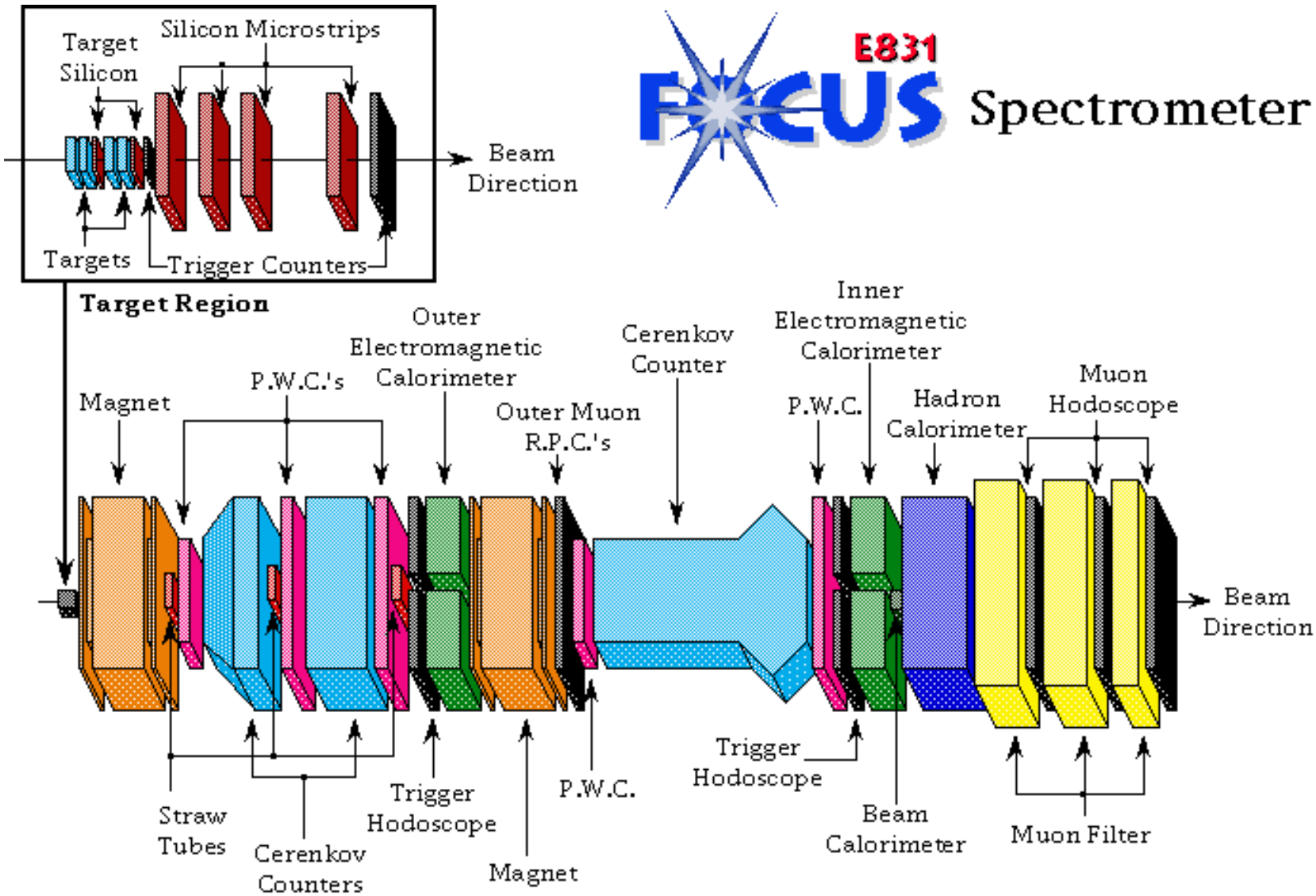
- Charm photoproduction experiment with over one million reconstructed D's.
- A continuation of the E687 experiment.
- In addition to charm, there is an enormous diffractive non-charm sample.

More than 2 million diffractive K^+K^- pairs.



The FOCUS Photon Beam




Target Silicon
Silicon Microstrips
Beam Direction
Targets
Trigger Counters
Target Region
E831
FOCUS Spectrometer
Magnet
P.W.C.'s
Outer Electromagnetic Calorimeter
Outer Muon R.P.C.'s
Cerenkov Counter
Inner Electromagnetic Calorimeter
P.W.C.
Hadron Calorimeter
Muon Hodoscope
Beam Direction
Straw Tubes
Cerenkov Counters
Trigger Hodoscope
Magnet
P.W.C.
Trigger Hodoscope
Beam Calorimeter
Muon Filter

Is the Photoproduced $K^+K^-(1750)$ the $\varphi(1680)$?

- Is the mass consistent?
  - -- e^+e^- measures 1680 ± 20 MeV/c^2
  - -- photoproduction finds ~1750 MeV/c^2
- Is the K^+K^-/K^*K branching fraction consistent?
  - -- e^+e^- measures 0.07 ± 0.01
  - -- photoproduction has never seen a corresponding enhancement in K^*K

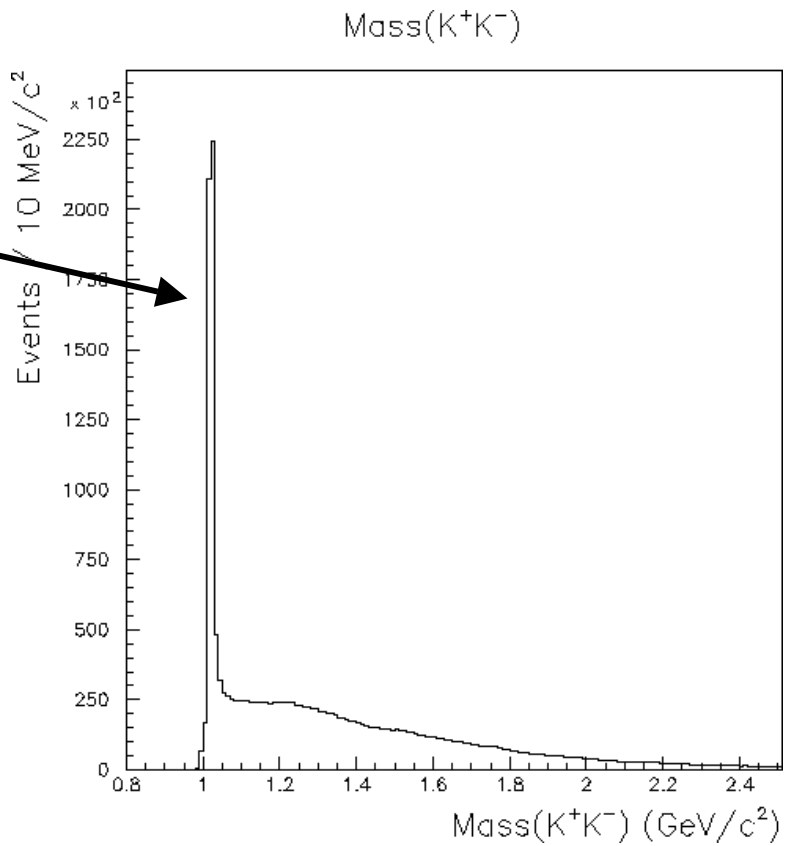
FOCUS Data Selection

Look at K^+K^- and $K_SK\pi$ samples.

- Vertex in target
- No extra reconstructed photons
- No extra reconstructed tracks
- All particles are identified by Cerenkov information
- Beam energy between 20 and 160 GeV

Initial K^+K^- Sample

Large φ(1020) signal,
as expected.

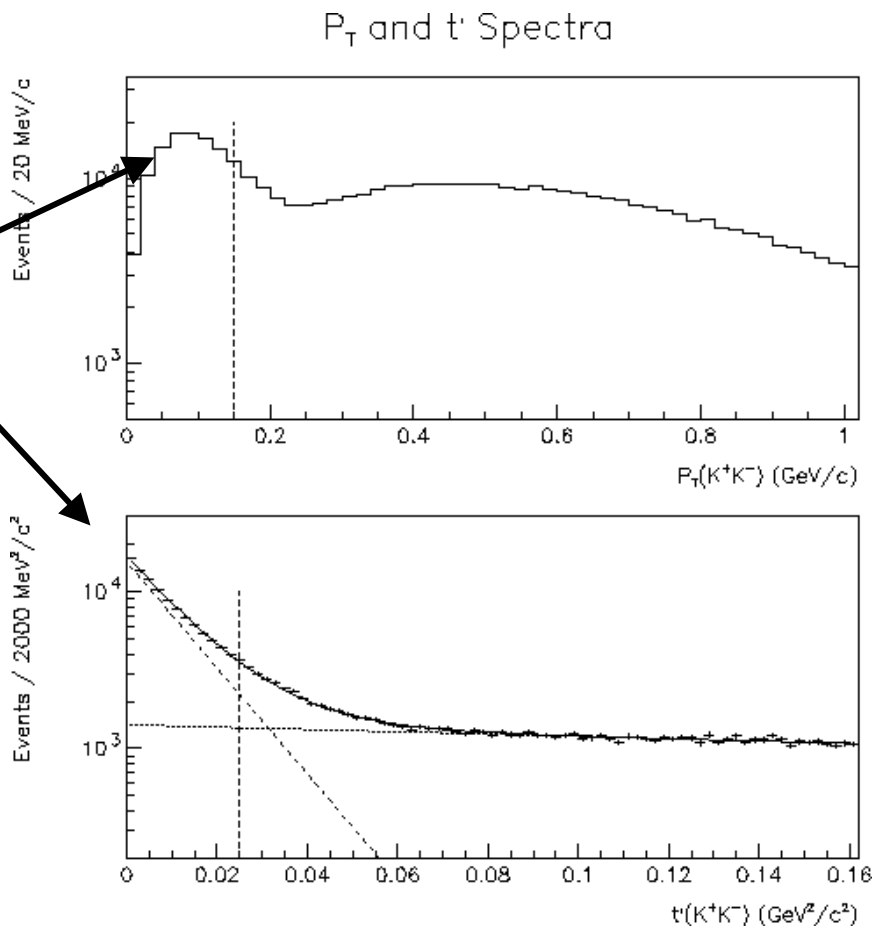


φ Production Characteristics

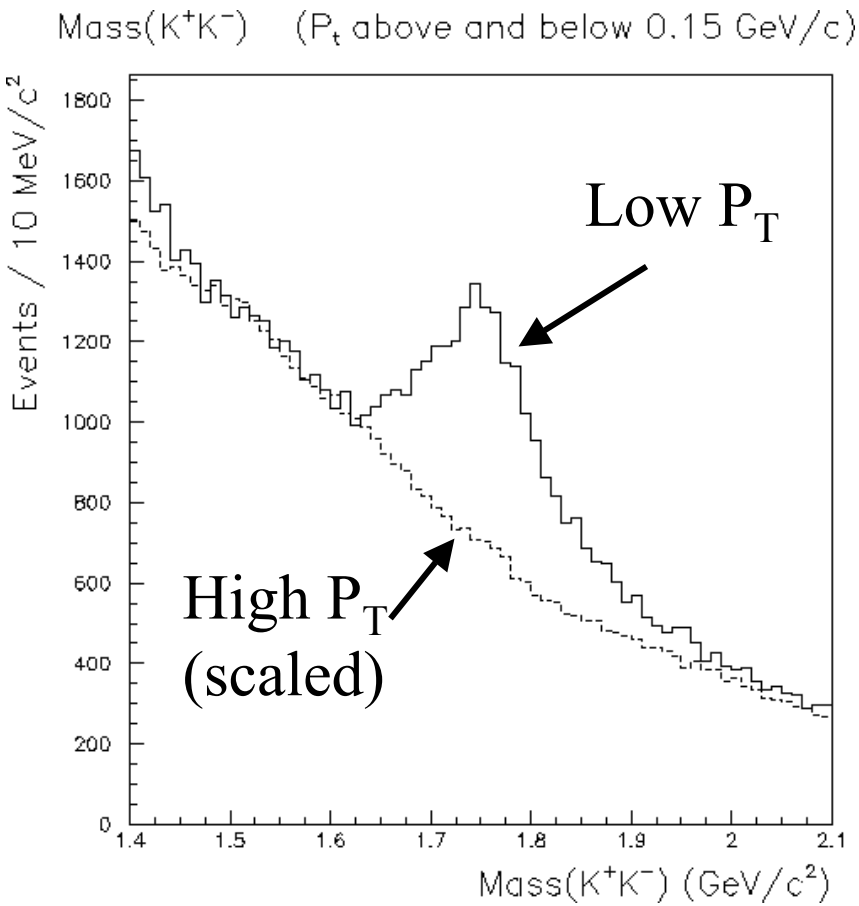
Diffraction

$t' = |t| - |t|_{min}$
$\approx p_T^2$

$t \equiv (P_\gamma - P_{KK})^2$



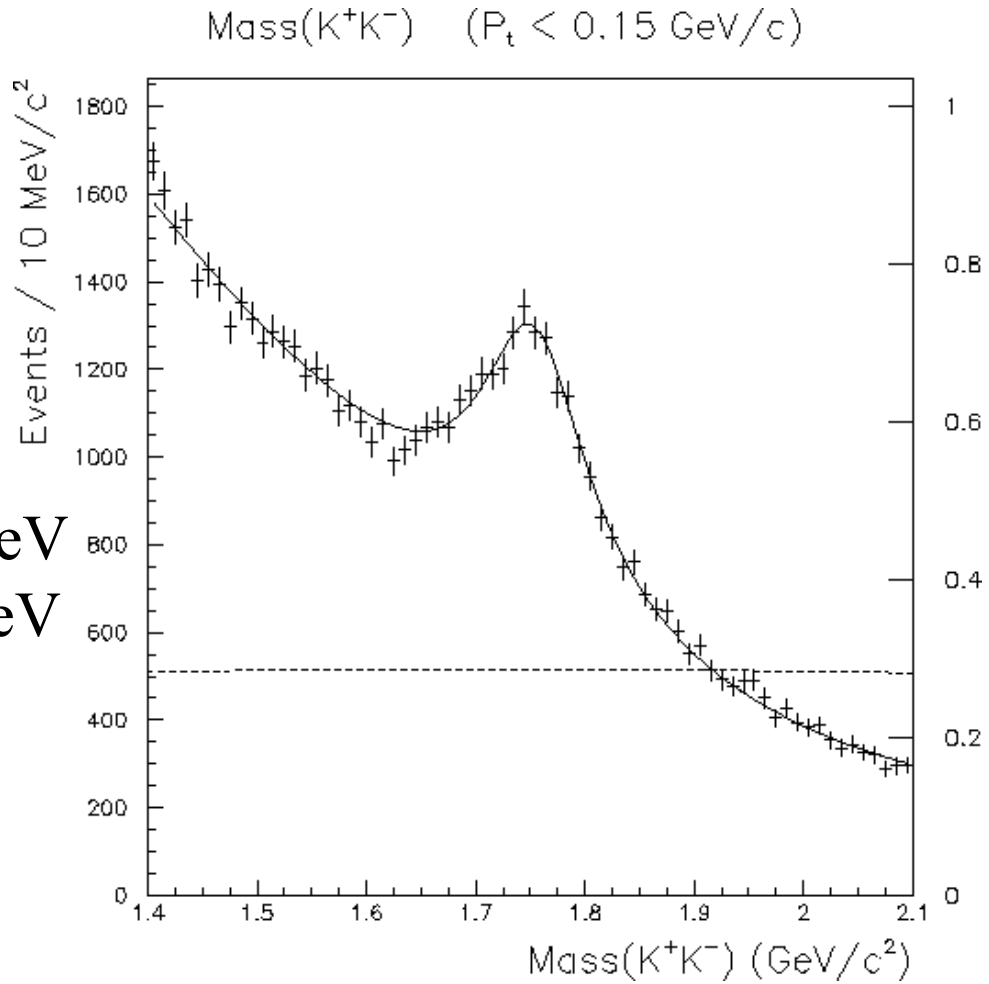
The X(1750) Signal… K^+K^- at High and Low P_T



Fitting the X(1750)

Using a non-relativistic Breit-Wigner and a quadratic background…

Yield = 11,700 ± 480
Mass = 1753.5 ± 1.5 ± 2.3 MeV
Width = 122.2 ± 6.2 ± 8.0 MeV



Is the Photoproduced $K^+K^-(1750)$ the $\varphi(1680)$?

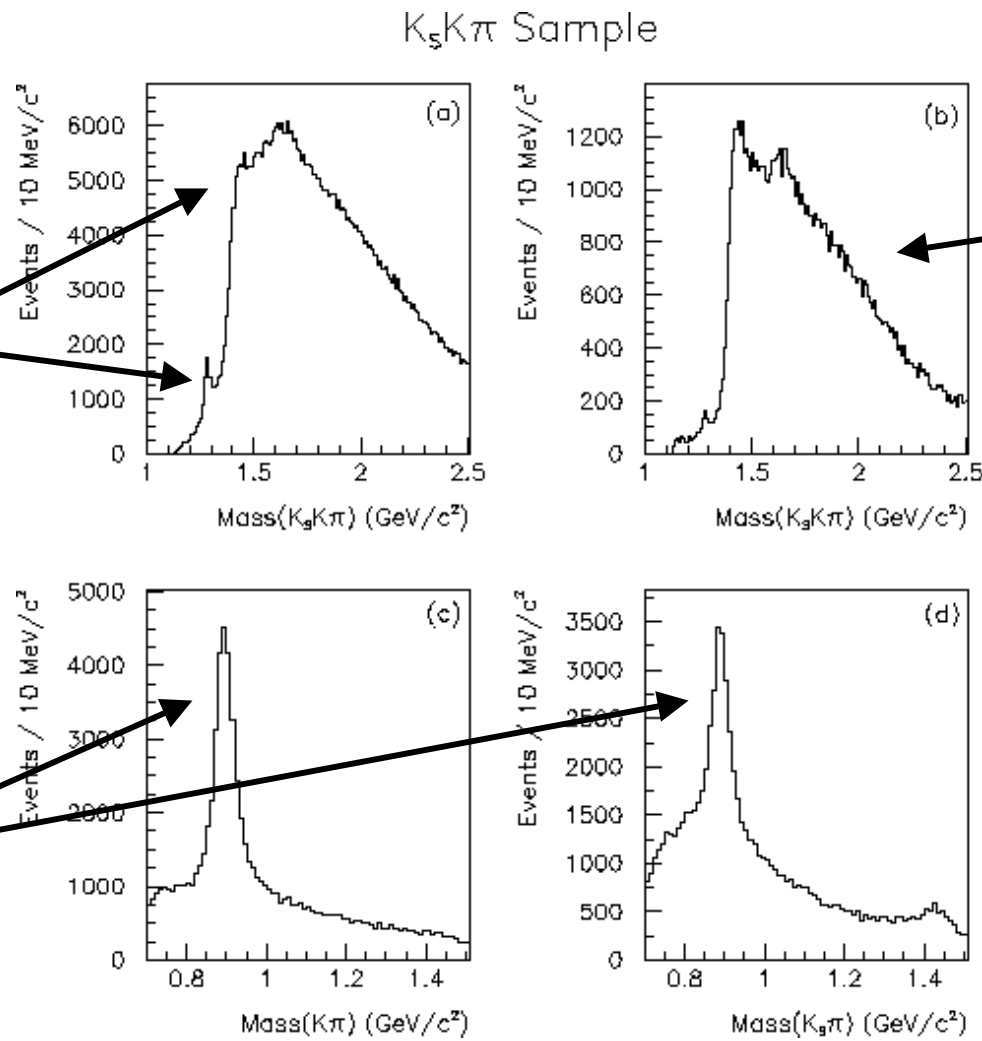
- MASS
  - -- e^+e^- measures 1680 ± 20 MeV/c^2
  - -- FOCUS finds $1753.5 \pm 1.5 \pm 2.3$ MeV/c^2
- K^+K^-/K^*K BRANCHING FRACTION
  - -- e^+e^- measures K^*K dominant

The $K_S K\pi$ Sample

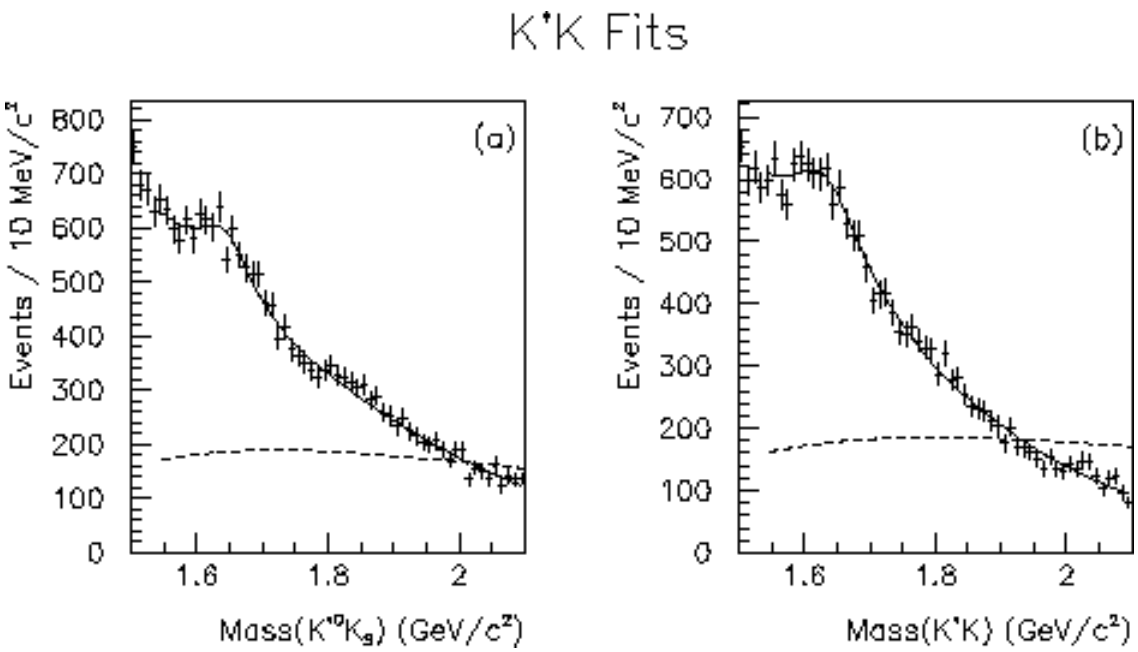
Classic "D" and "E" regions…

P_T cut

Two K^* combinations



Fitting K*K



With K^* to $K\pi$,
$BF(K^*K/K^+K^-) < 0.065$
at 90% C.L.

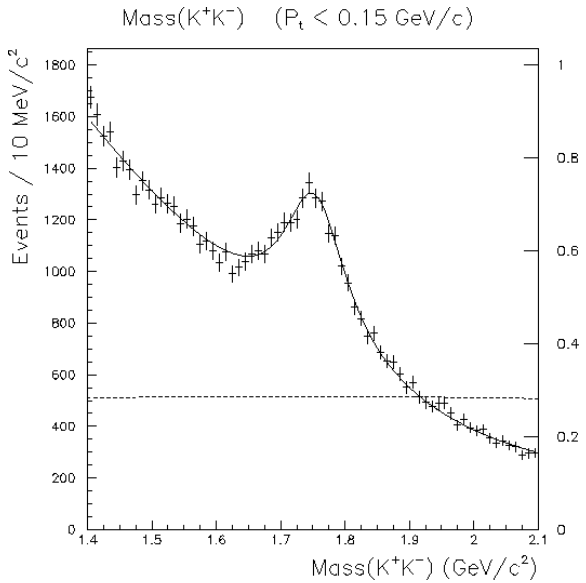
With K^* to $K_S\pi$,
$BF(K^*K/K^+K^-) < 0.183$
at 90% C.L.

Is the Photoproduced $K^+K^-(1750)$ the $\varphi(1680)$?

- MASS
  - -- e^+e^- measures 1680 ± 20 MeV/c^2
  - -- FOCUS finds $1753.5 \pm 1.5 \pm 2.3$ MeV/c^2

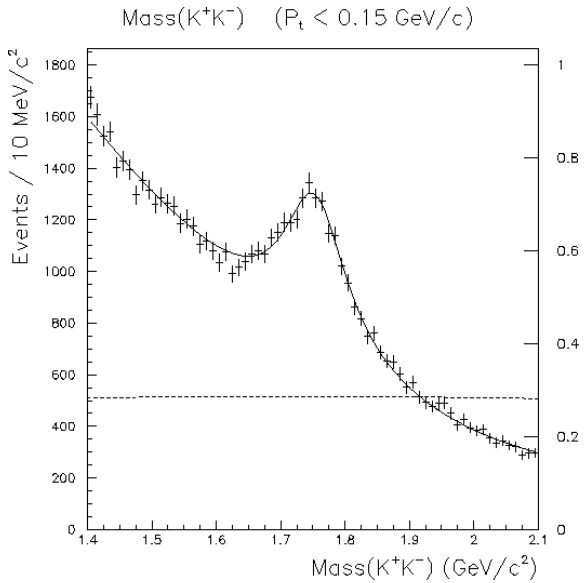
- K^+K^-/K^*K BRANCHING FRACTION
  - -- e^+e^- measures K^*K dominant
  - -- FOCUS finds K^+K^- dominant

What is the $K^+K^-(1750)$?



- By CP, it must be 0^{++}, 1^{--}, 2^{++}, etc.
- Look at K_SK_S…
- Angular analysis…

Conclusions



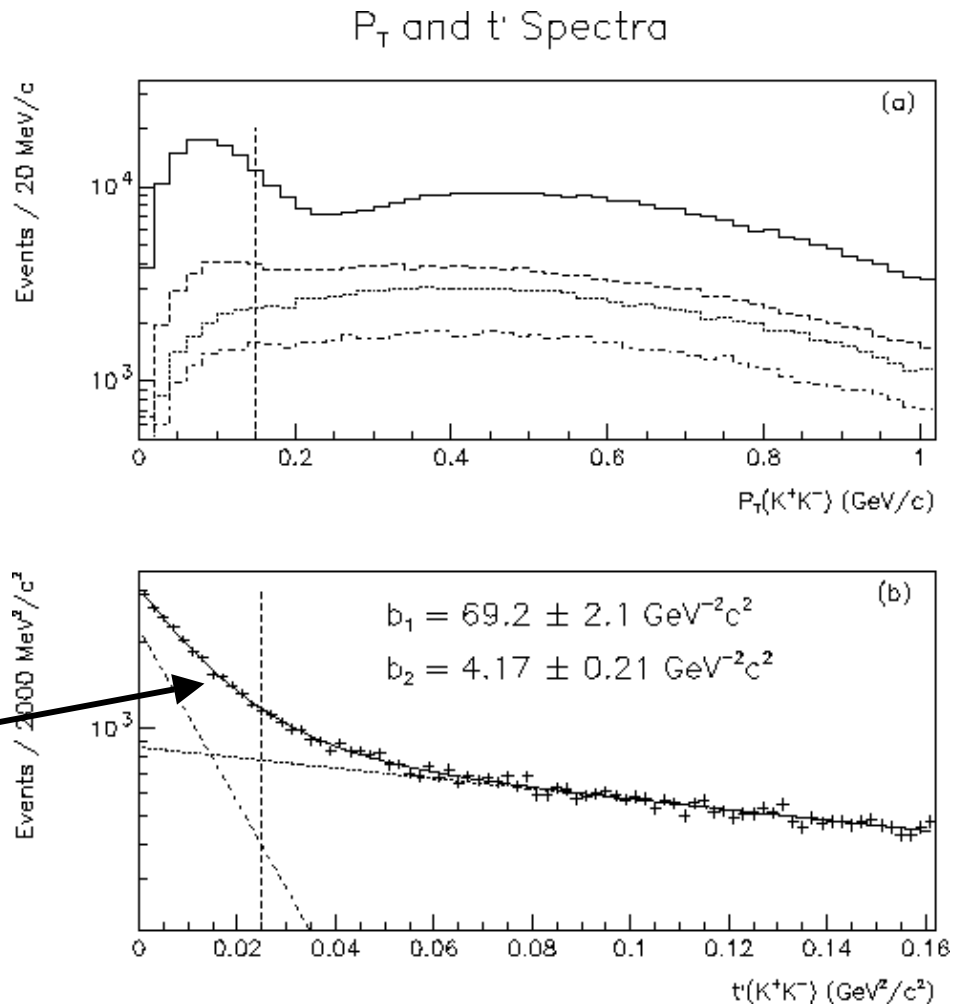
Phys. Lett. B 545:50-56, 2002.

Preprint: hep-ex/0208027

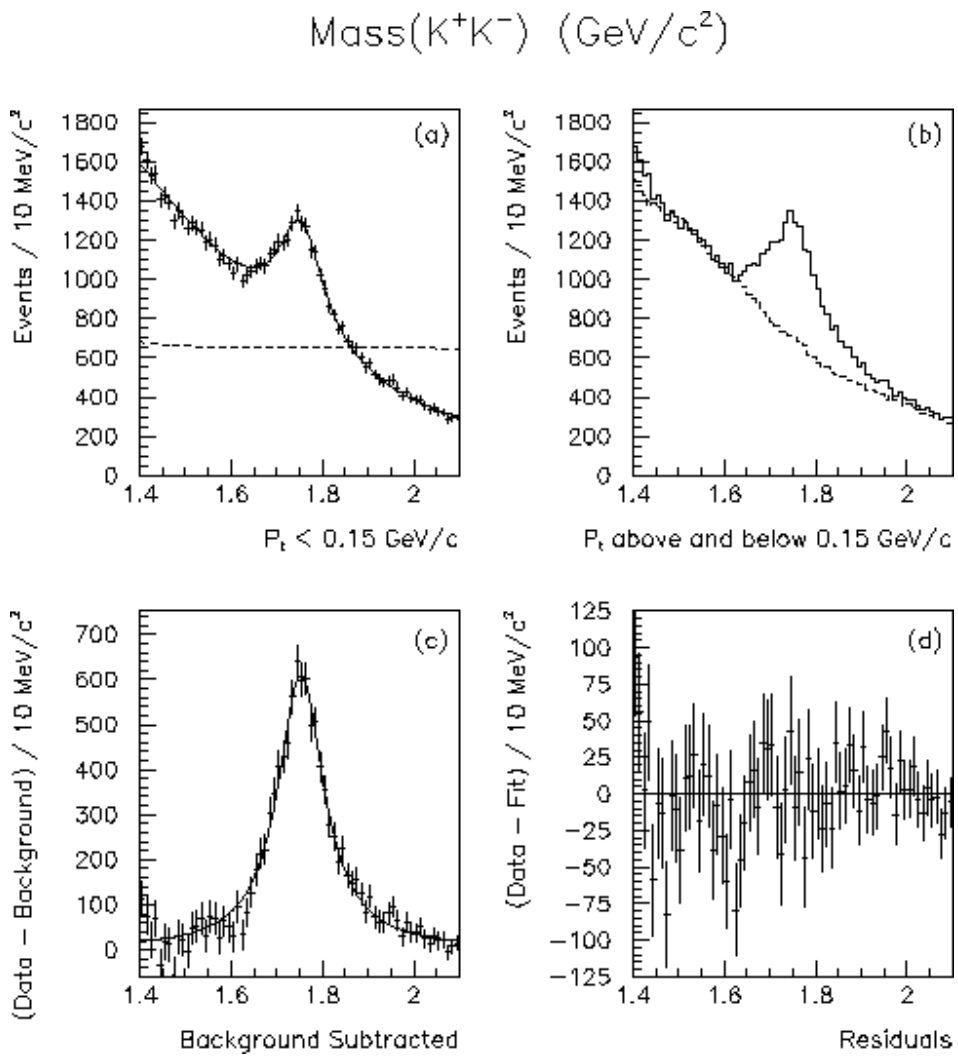
- The $K^+K^-(1750)$ is not the φ(1680)
- The interpretation remains uncertain
- Watch for many more interesting results from photoproduction…

Production of the X(1750)

Fit with two exponentials



The X(1750) Signal



Interference Scenarios?

The mass never drops below 1747 MeV/c^2