Penta-Quark Search @ COSY

COSY Accelerator, FZ-Jülich

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(presented on behalf of the author to JLab workshop by R. Schumacher)

COSY
(Cooler Synchrotron @ FZJ)

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RUB-TPII-02/97
NORDITA-97/19 N
hep-ph/9703373

Exotic Anti-Decuplet of Baryons:
Prediction from Chiral Solitons

Dmitri Diakonov[◇*], Victor Petrov[◇] and Maxim Polyakov[◇† 1],

the Z^+. Let us list several possibilities of the Z^+ production particles.

- Nucleon–nucleon collisions
  $pn \to \Lambda Z^+ \to \Lambda K^+ n$ or $\Lambda K^0 p$, $p_{lab} > 2.60\ GeV/c$
  $pp \to \Sigma^+ Z^+ \to \Sigma^+ K^+ n$ or $\Sigma^+ K^0 p$, $p_{lab} > 2.8\ GeV/c$

From early on, hadron-induced reactions were proposed to seach for Θ^+:

$p\,n \to \Theta^+ \Lambda$ (779 MeV)*

$p\,d \to \Theta^+ \Lambda\, p$

$p\,p \to \Theta^+ \Sigma^+$ (843 MeV)

also possible:

$p\,p \to \Theta^+ \pi^+ \Lambda$ (909 MeV)

$p\,p \to p\, \Theta^+ K^0_{bar}$ (1100 MeV)**

$p\,p \to K^+ \Theta^+ \Xi^0$ (1473 MeV)

* For $M(\Theta^+)$ = 1540 MeV

** Not accessible at COSY

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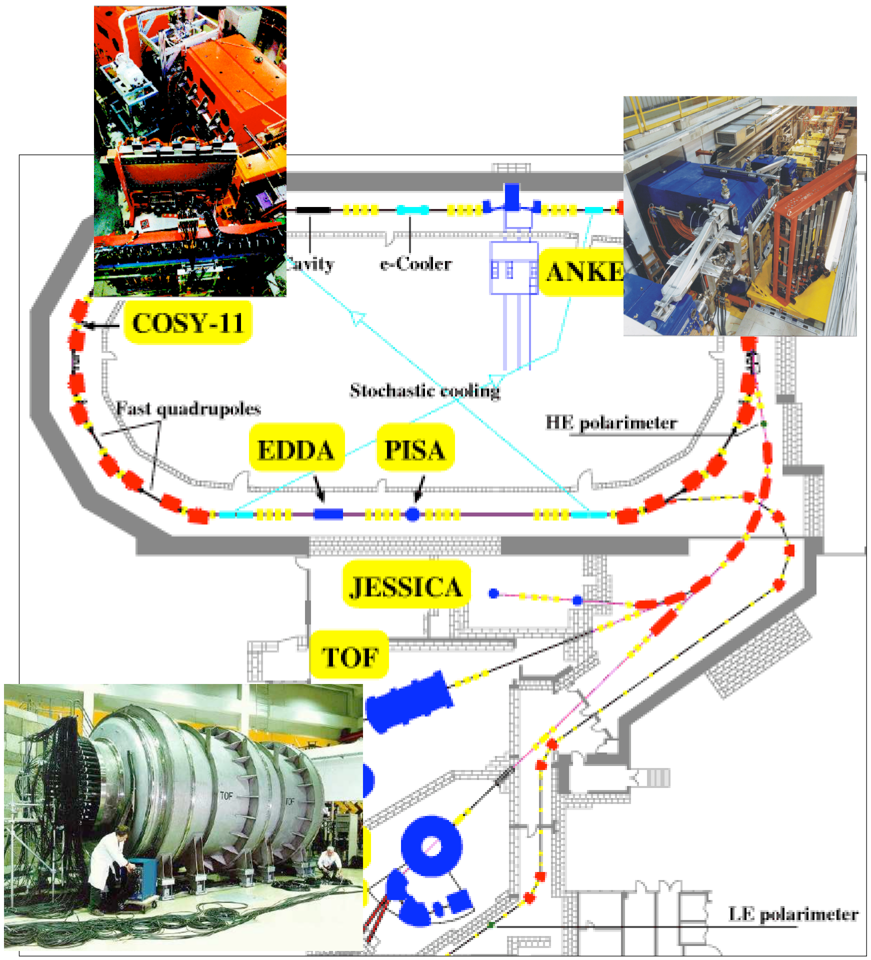

Detectors at COSY:

- Internal:
  - ANKE
  - COSY-11
- External:
  - BIG KARL
  - TOF

NO electromagnetic calorimeter („photon blind")

→ only charged particles

NO dedicated experiment yet !

→ use existing data

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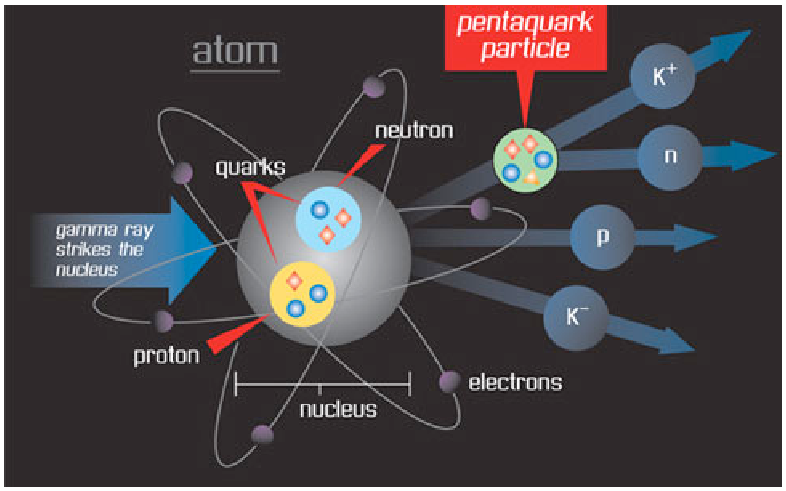

A closer look at the proposed reactions:

1) Neutron target:

a) pn → □+ □ → [(n) K+][p □□] ✗

b) pn → □+ □ → [p K0][p □□]

2) Proton target:

c) pp → □+ □+ → [p K0] [p ✗(□°)] ✗

d) pp → □+ □+ → [p K0] [(n) ✗ □+]

e) pp → □+□+□ → □+ [K+(n)][p □□]

f) pp → □+□+□ → □+ [p K0][p □□]

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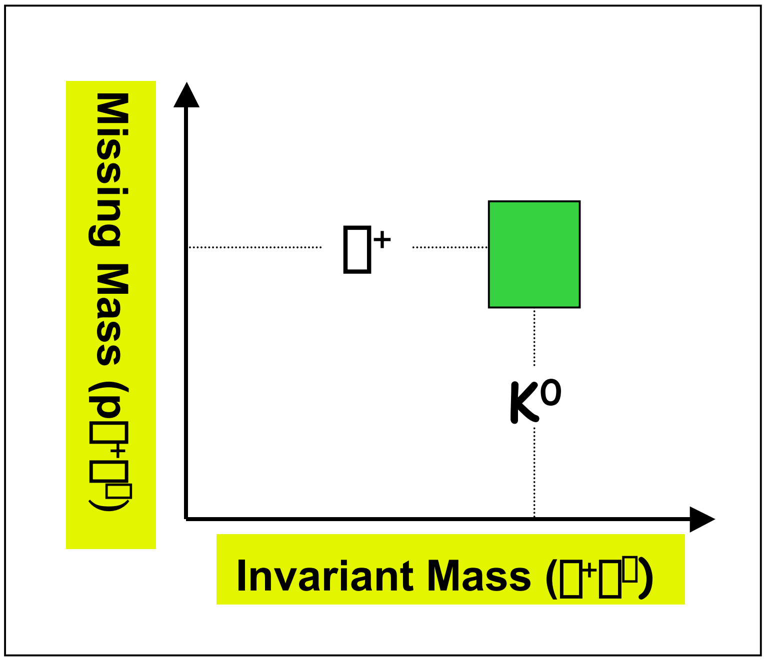

3-charged-particle events:

$p\,p \rightarrow p\,□^{+}\,□^{□}X$

2c: $pp \rightarrow □^{+}\,□^{+} \rightarrow pK^{0}\,□^{+} \rightarrow p_{1}(□^{+}\,□^{□})(p_{2}□^{\circ})$

$M_{inv}(□^{+}\,□^{□}) = K^{0}$ & $X = (p_{2}\,□^{\circ}) \rightarrow □^{+}$

2d: $pp \rightarrow □^{+}\,□^{+} \rightarrow pK^{0}\,□^{+} \rightarrow p(□^{+}{}_{1}\,□^{□})(n□^{+}{}_{2})$

$M_{inv}(□^{+}\,□^{□}) = K^{0}$ & $X = (n□^{+}{}_{2}) \rightarrow □^{+}$

$\rightarrow M_{inv}(□^{+}\,□^{□})$ vs. $MM\,(p\,□^{+}\,□^{□})$

Candidate events in $[K^{0}, □^{+}]$

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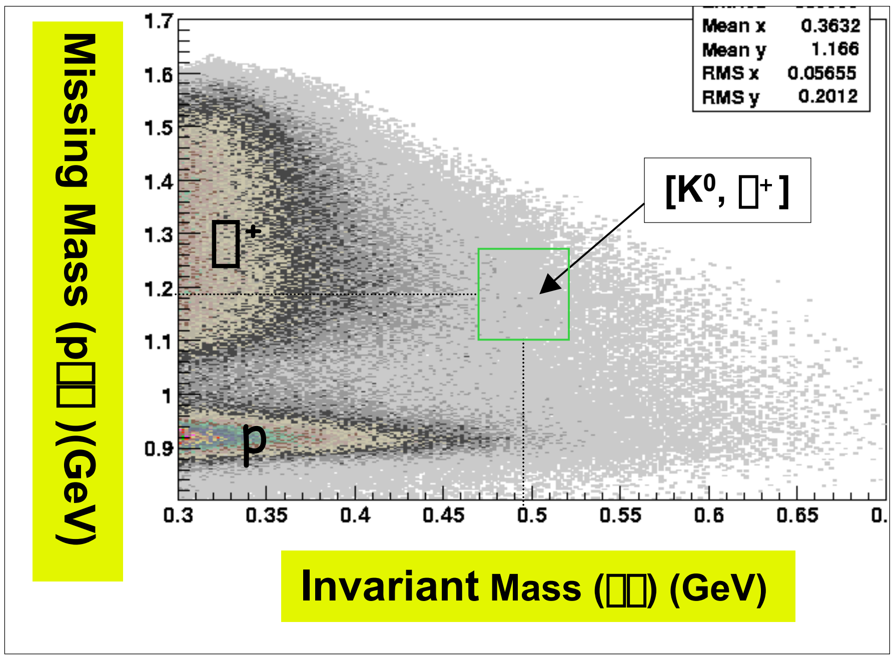

Y.M., Oct.2003

Experimental result:

ANKE data for pp @ T_p = 2.83 GeV

→ too much background:

- pp → p □⁺□□(p, □⁺, …)
- wrong proton (2c), wrong pion (2d)

→ invariant mass distribution of (pK^0) !!

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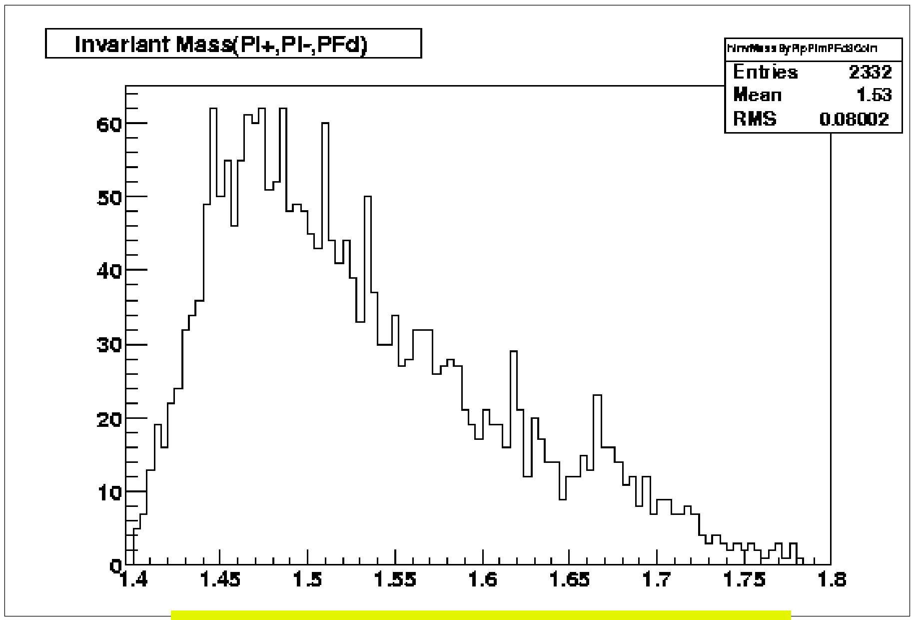

Invariant Mass M(pK^0) (GeV)

Experimental result:

→ Invariant mass distribution of (p K^0) for events within [K^0, □$^+$] range:

- covers proper inv. mass range
- No signal; too much back-ground !

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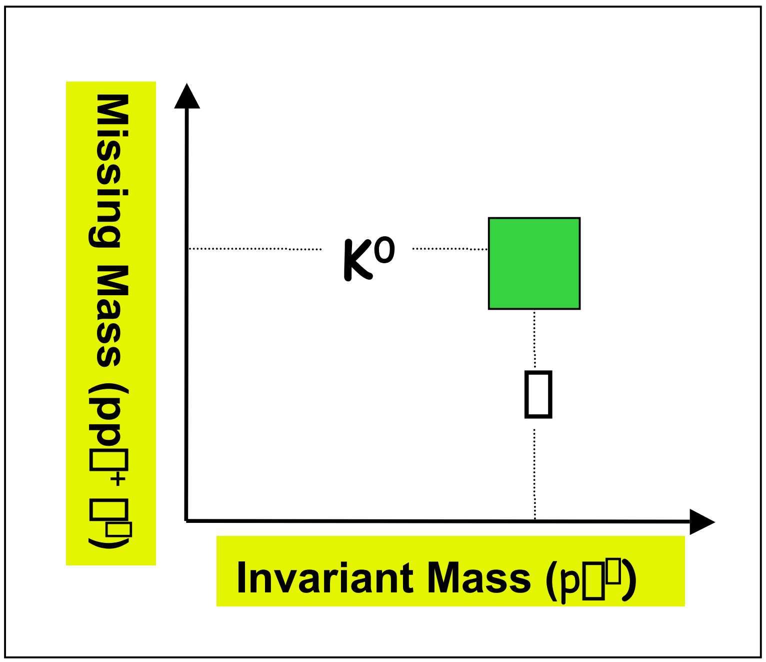

→ 4-charged-particle events:

a) Is there a <u>second</u> proton ?

$p\,p \rightarrow p_1\,p_2$ □+ □□ X

<u>2c:</u> M_{inv}(□+ □□) = K^0 & X = □° & M_{inv}(p_1 □°) = □+

<u>2f:</u> M_{inv}(p_1 □□) = □ & X = K^0

→ M_{inv}(p □□) vs. MM (pp □+ □□)

Candidate events in [K^0, □]

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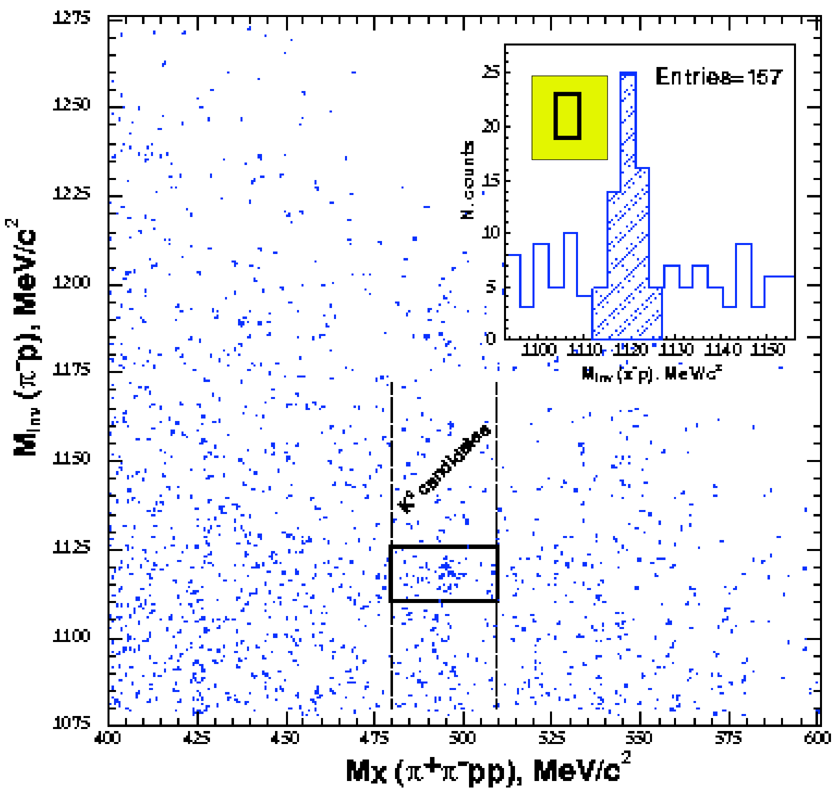

Experimental Result:

ANKE data for pp @ T_p = 2.83 GeV

→ Clear [K^0, □] signal

→ missing mass of (p_1□$^+$□$^□$) !

(equivalent: inv. mass of (p_2 K^0))

A total of 64 events between 1400 and 1600 MeV/c^2; no indication for any structure !

(note: 2 days of beamtime)

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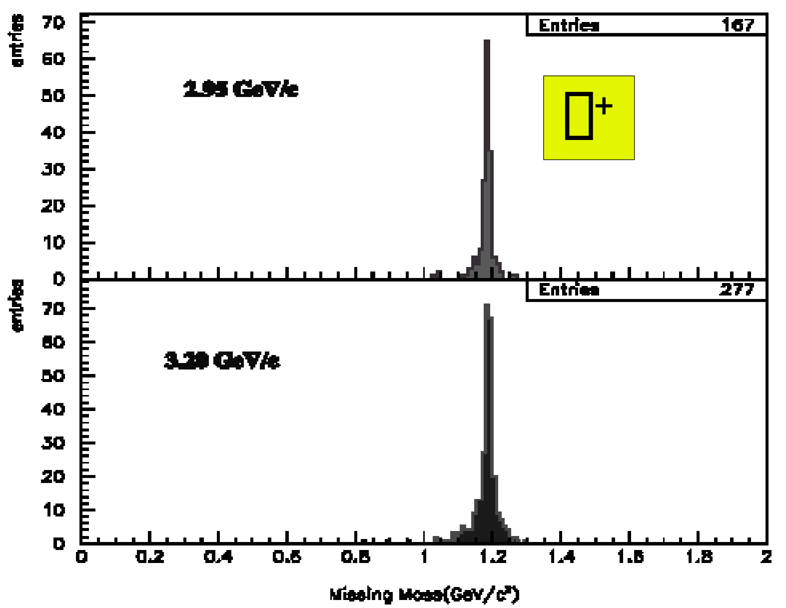

Figure 5. Σ^+ missing mass distributions at 2.95 GeV/c (upper part) and 3.2 GeV/c (lower part).

Experimental Result:

TOF-Spectrometer (W.Eyrich):

p p → K^0 □$^+$ p

- Very clean □$^+$ peak (decay tracking close to production)

→ Invariant mass of K^0p sub-system:

!! Preliminary; not to be quoted !!

→ Signal (5□); □ ~ 0.4 □b

→ M = 1530 +- 5 MeV

→ □ <= 22 MeV

!! Preliminary; not to be quoted !!

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How to proceed ?

a) (pn)-reactions: $p\ n \rightarrow$ □$^{+}$ □

b) also: $p\ d \rightarrow$ □$^{+}$ □ p

c) isospin: $p\ p \rightarrow$ □$^{++}$ □

→ Dedicated proposals to PAC: (Nov. 2003)

ANKE: $p\ p \rightarrow K^{0}\ p$ □ □$^{+}$

$p\ p \rightarrow K^{0}\ p$ □$^{+}$

$p\ n \rightarrow K^{0}\ p$ □