Pentaquark Search @ NA49.SPS.CERN

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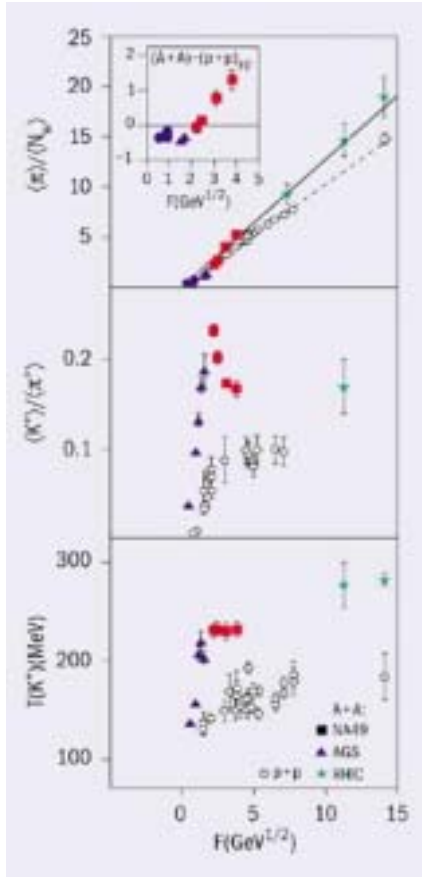
Outline

- Motivation
- Experiment and Data Analysis
- Results and Discussion
- Conclusion and Outlook

Motivation

- Main Goal of the NA49 Experment in SPS.CERN :
  - QGP Search via Pb+Pb @ E_{lab}=158 AGeV
  - as References : p+p @ 158 AGeV ; p+Pb @ 158 AGeV
  - p+p, p+Pb, Pb+Pb @ various collision Energies & Centralities (min.bias)
- NuRI (Nuclear Research Institute) @ PNU founded:
  - JKAhn, HChKim : Exotic Particle Search (Λ1405, Θ^+) in Japan
  - Quark Nuclear Physics 2004 Workshop (http://www.nuri.pusan.ac.kr)

CERN COURIER



SuperProtonSynchrotron@CERN

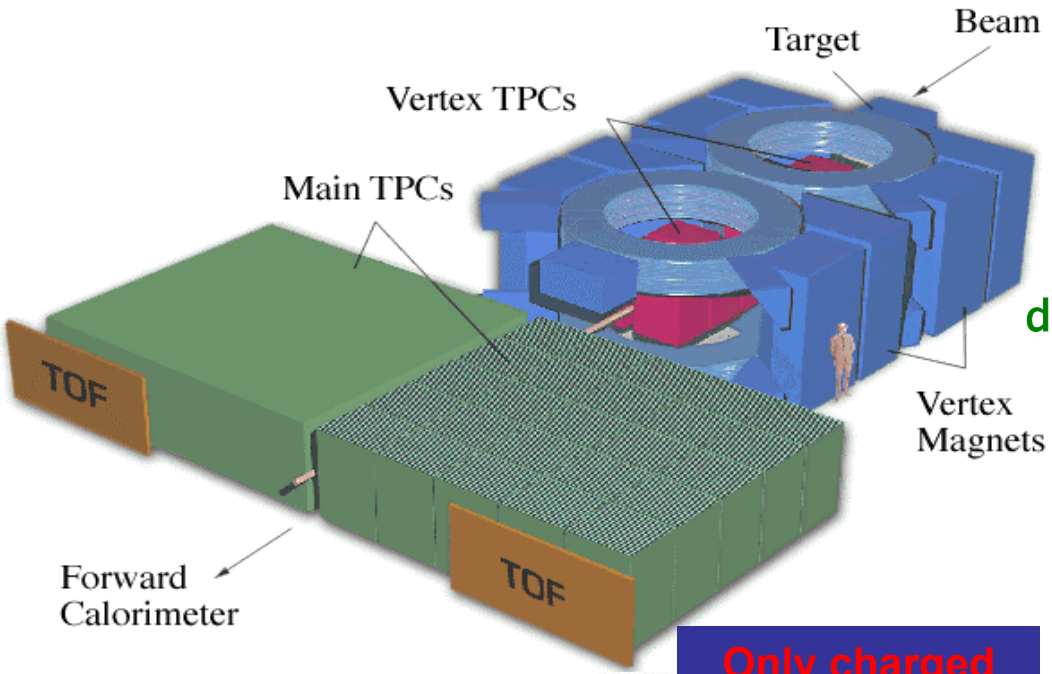
Motivation

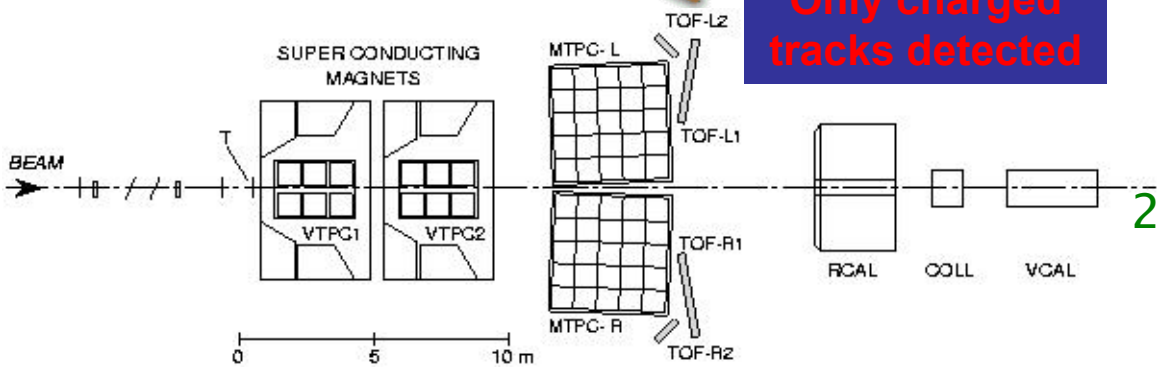
- Hadronic Interest : the other exotic states w.r.t
  - -The **Chiral Soliton Model** (Diakonov et al., Z.Phys.A359 (1997) 305)
  - -The **Correlated Quark Model** (Jaffe et al., arXiv:hep-ph/0307341) etc.
- Multiquark in hot and Dense Matter ?
  - -J.Randrup, *Production of the exotic Theta baryon in relativistic nuclear collisions*, PRC68, 031903 (2003)
  - -L.W.Chen et al., *Pentaquark baryon production at the Relativistic Heavy Ion Collider*, arXiv:nucl-th/0308906
  - -J.Rafelski et al., *Strange Pentaquark Hadrons in Statistical Hadronization*, PRC68, 061901
  - -HchKim, ChLee et al, *Pentaquark Θ^+ mass and width in dense matter,* arXiv: hep-ph/0402141

NA49 Datasets

E_{lab} (AGeV)	20	30	40	80	100	158	250
$E_{CM} = s^{1/2}$	6.3	7.6	8.8	12.3	13.8	17.2	21.7
Pb+Pb	360k	440k	710k	381k		3.93M	
Pb+Pb (m.b.)			1.27M			1.07M	
Si+Si			140k			410k	
C+C			250k			560k	
p+Pb					470k	3.49M	190k
p+Al						355k	
p+C (m.b.)					200k	570k	
π^++Pb						1.54M	
π^-+Pb						910k	
d+p			650k			980k	
p+p			410k		640k	6.8M	
π^++p						1.28M	
π^-+p						900k	

NA49 Experiment





Only charged tracks detected

$dp/p^2 =$ 7 (0.3) x 10^{-4} $(GeV/c)^{-1}$

in VTPC1 (VTPC2+MTPC)

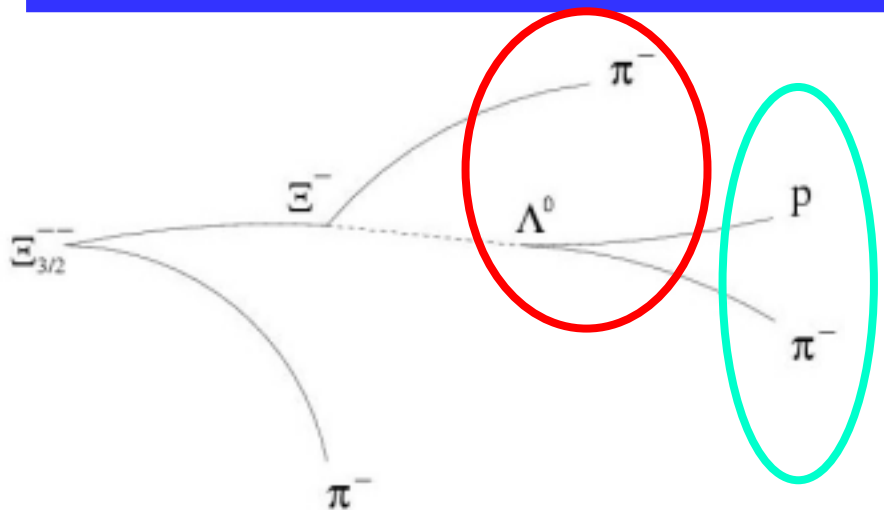
3-6 % dE/dx resolution

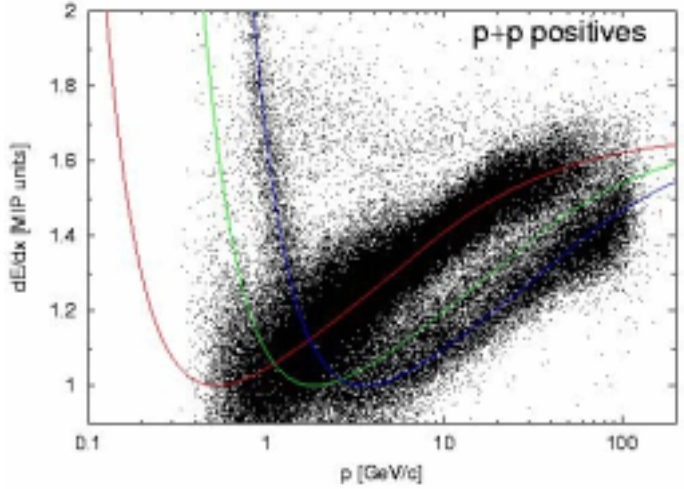
Main vertex cuts (within Target):

1) $x^2+y^2 < 1$ cm^2

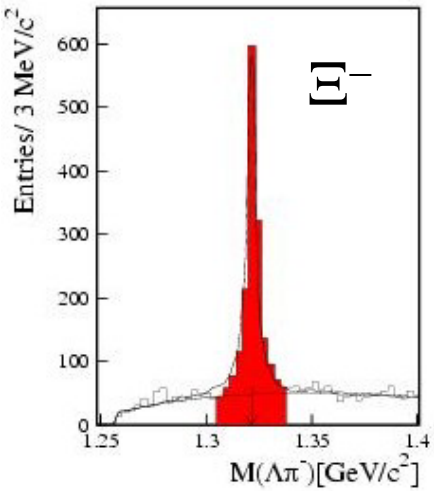
2) $-590.5\text{cm} < z < -572.5\text{cm}$

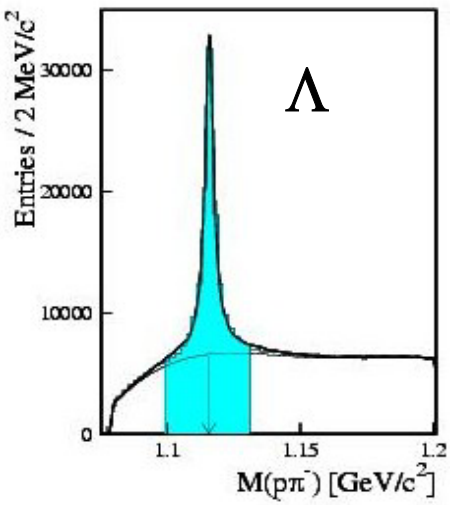
$\Xi^{--}_{3/2}$ Search

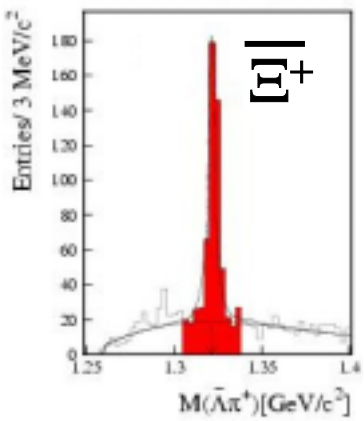


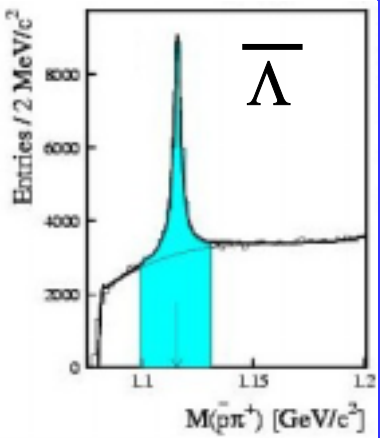


- dbb < 3σ
- Vertices Cut for $p\pi^-$ Combi









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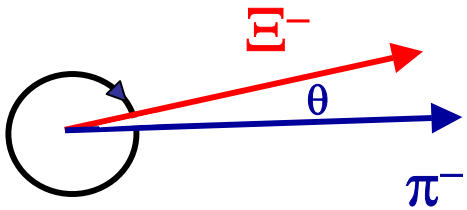
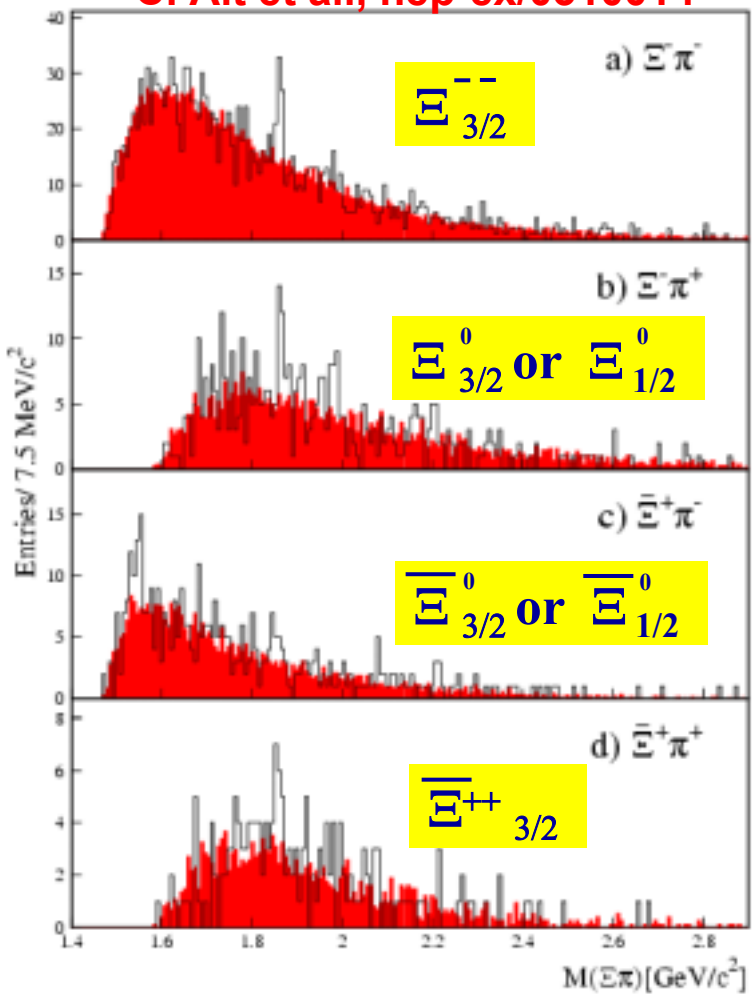
$\Xi^{--}_{3/2}$ Search

- Pions from the primary vertex
  - Position at main vertex
  - $|b_x| < 1.5$cm && $|b_y| < 0.5$cm
  - dbb $< 1.5\sigma$ for π^-
  - $-0.5\sigma <$ dbb $< 1.5\sigma$ for π^+
- Number of point in the track > 10
- Angular cut $\theta_{lab} > 4.5°$

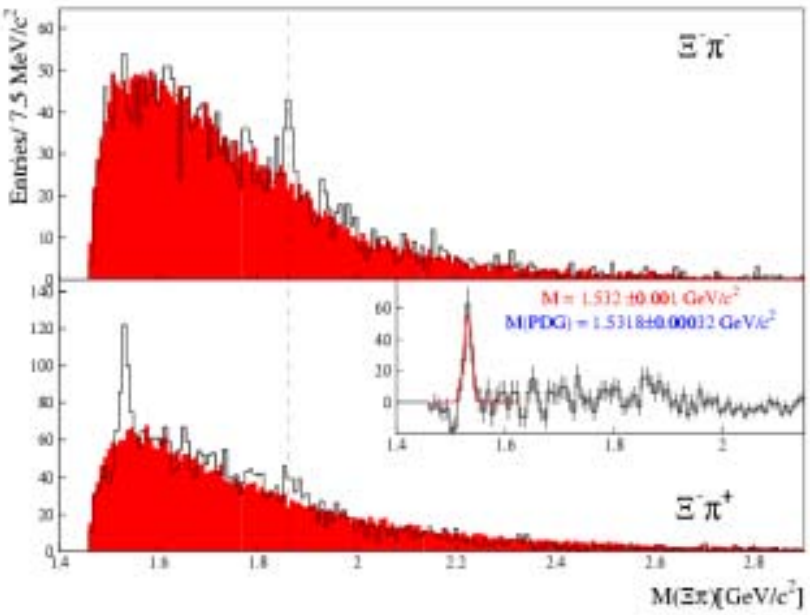


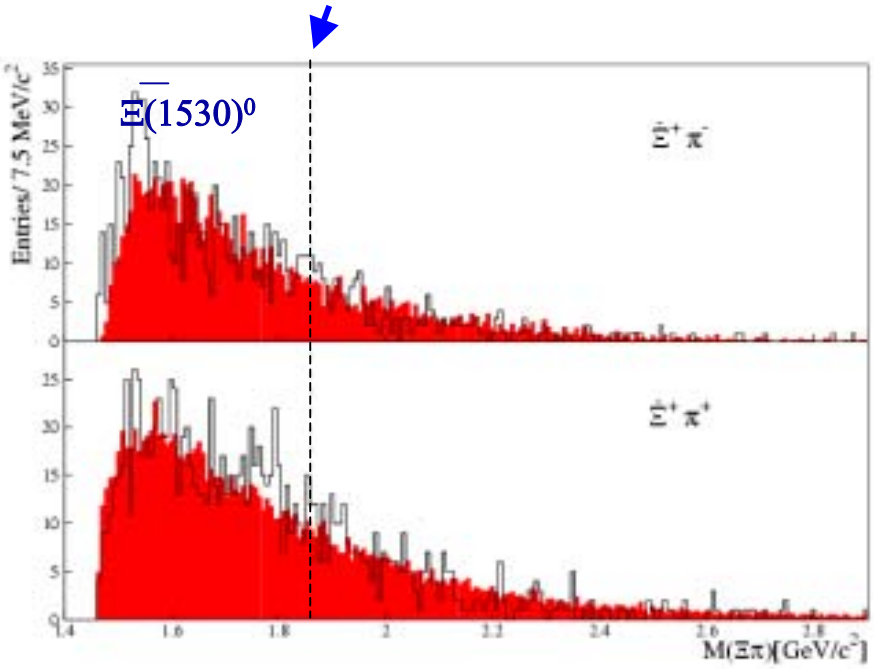
C. Alt et al., hep-ex/0310014



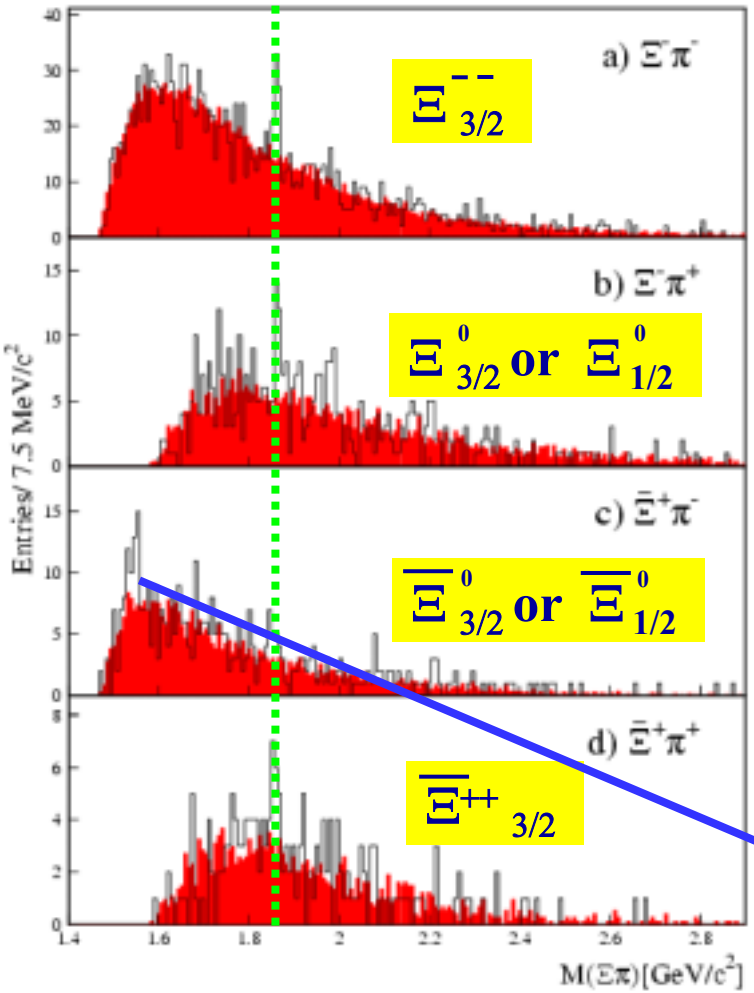
$\Xi^{--}_{3/2}$ Search (the 1st look)

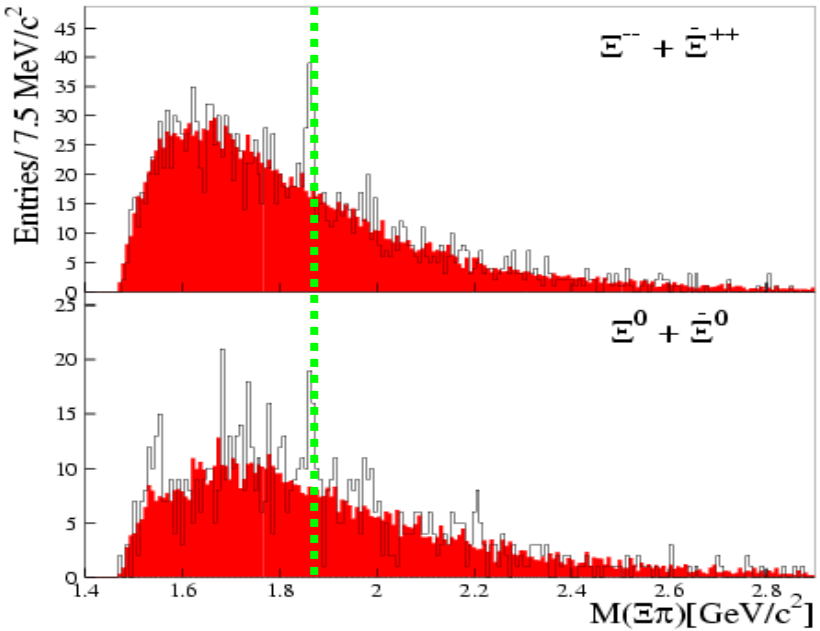
No clear structures at 1.86 GeV/c²





Results



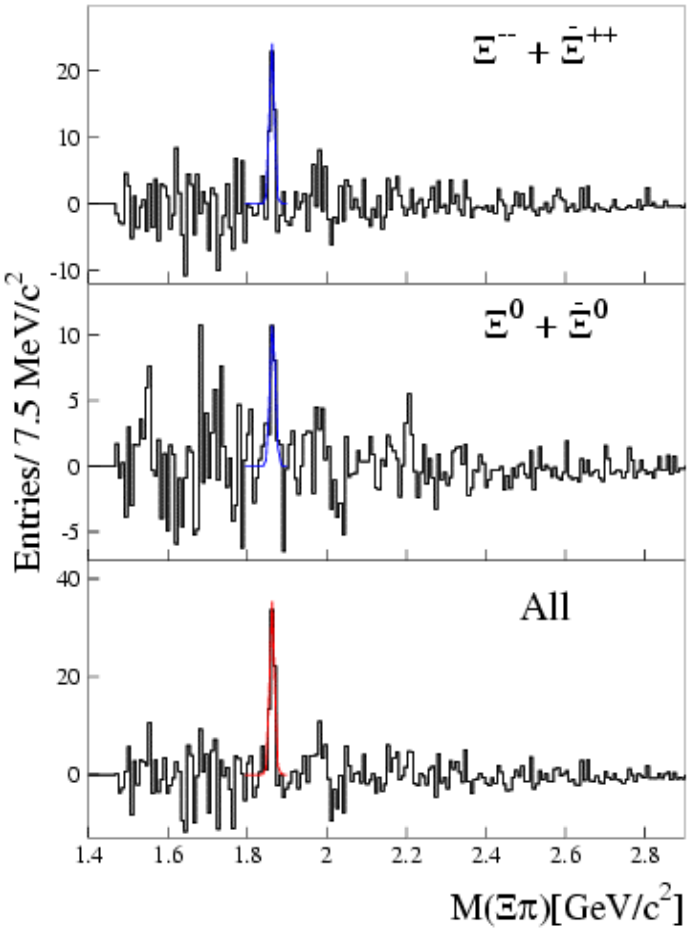


Mass window : 1.85 – 1.8725 GeV/c^2

$S/(S+B)^{1/2} \simeq 4.2$

Ξ(1530)⁰ : systematic error estimation < 0.001 GeV/c^2

Results



$M = 1.862 \pm 0.002$ GeV/c^2

$M = 1.864 \pm 0.005$ GeV/c^2

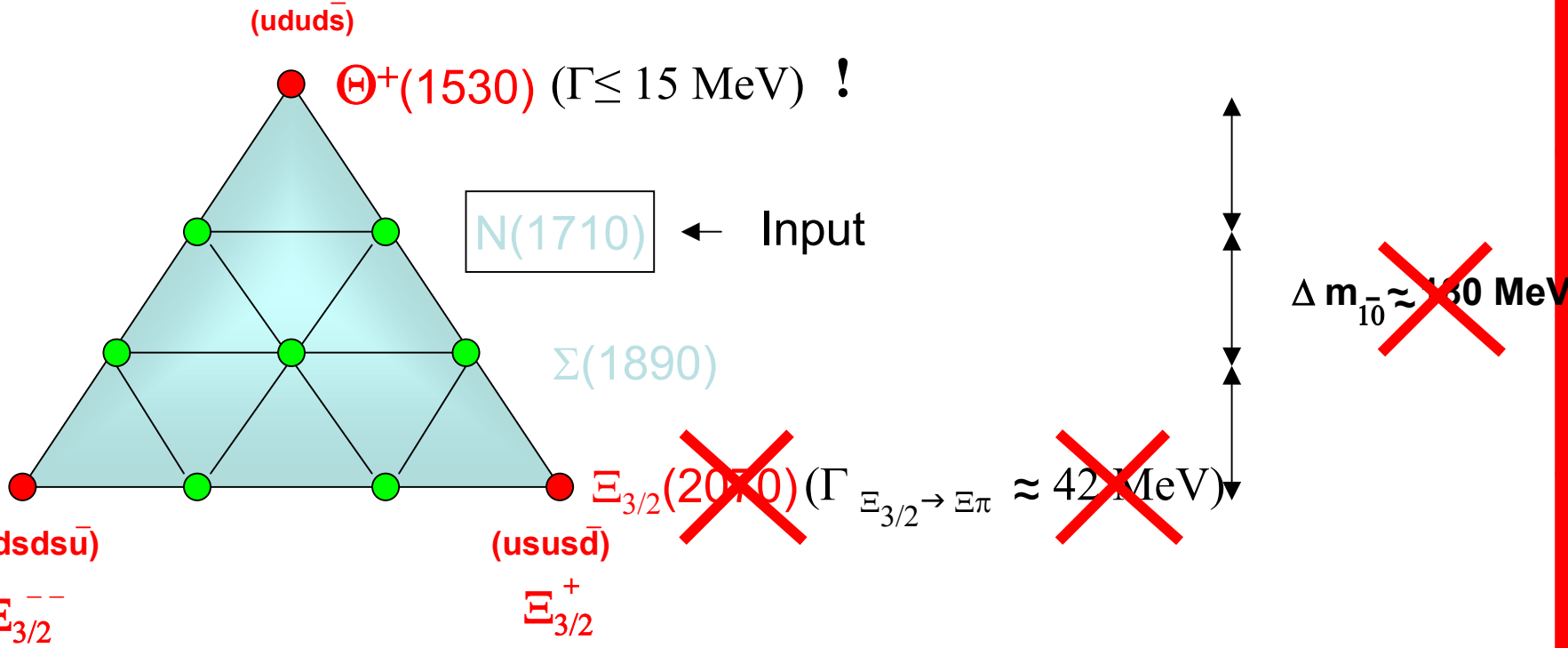
$M = 1.862 \pm 0.002$ GeV/c^2

$\Gamma \leq 18$ MeV/c^2

Chiral Soliton Model

Suggested anti-decuplet of baryons: $J^P=1/2^+$

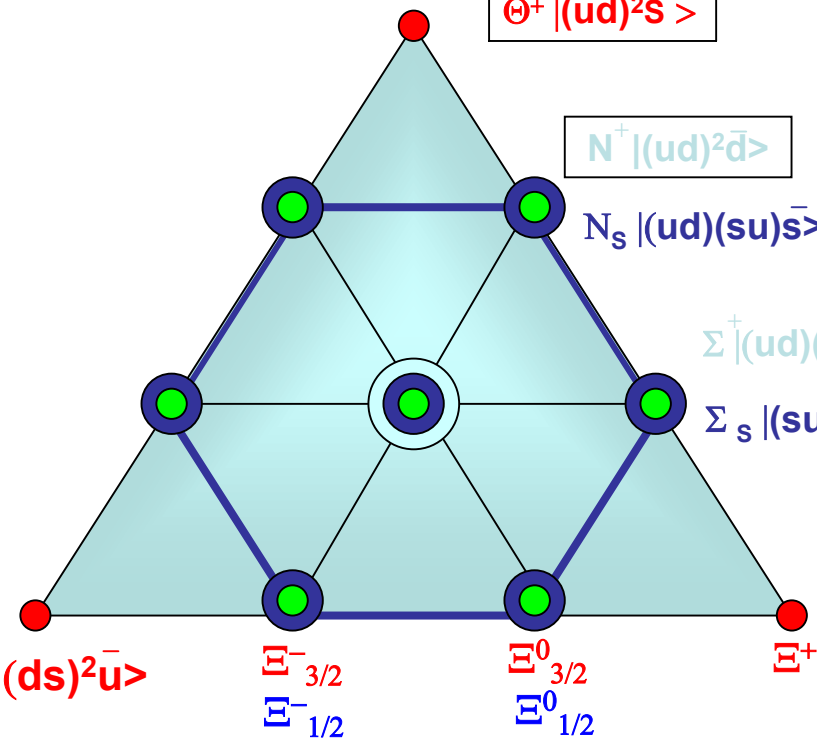
D. Diakonov, V. Petrov, M. Polyakov, Z.Phys. A 359 (1997) 305



Models: Correlated quarks

Suggested $\overline{10}_f \oplus 8_f$ of baryons: $J^P = 1/2^+$

R. Jaffe and F. Wilczek, arXiv:hep-ph/0307341



← **Input** $M_\Theta = 1540\ MeV/c^2$

← **Input (the Roper)** $M_N = 1440\ MeV/c^2$

$M_{N_S} = 1700\ MeV/c^2$

$M_\Sigma = 1600\ MeV/c^2$

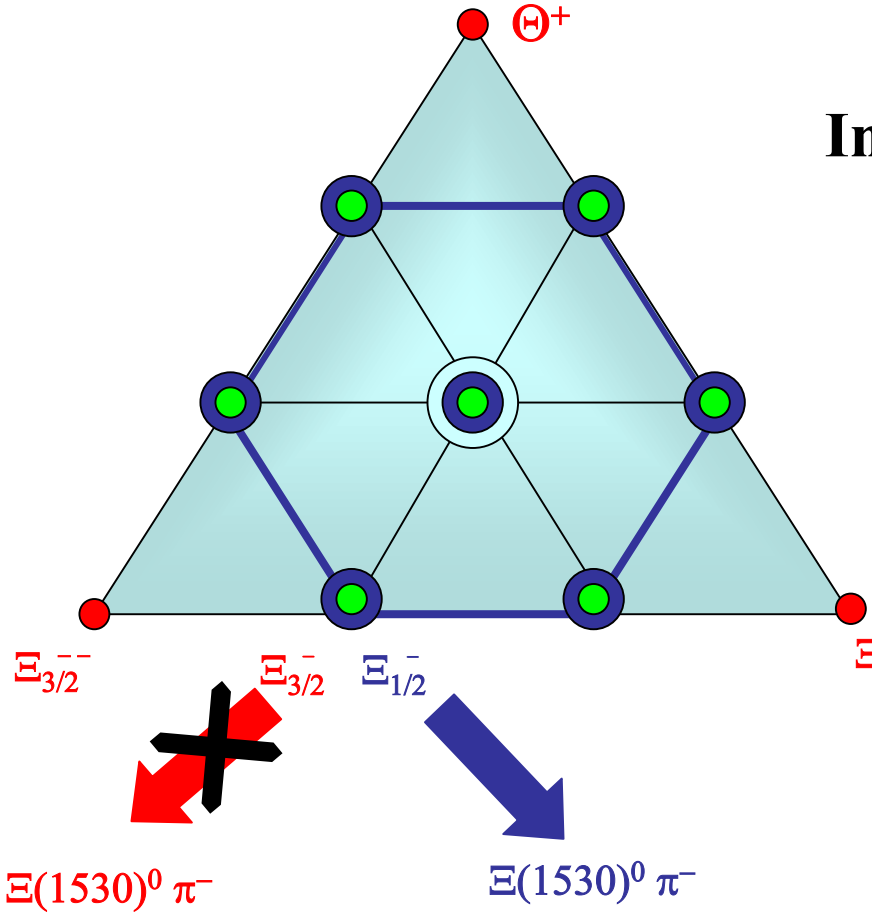
$M_{\Sigma_S} = 1850\ MeV/c^2$

$M_\Xi = 1750\ MeV/c^2$

$\Gamma_\Xi \approx 1.5 * \Gamma_\Theta$

Note : the $\Xi_{3/2}$ and $\Xi_{1/2}$ have the same mass

Models: Correlated quarks

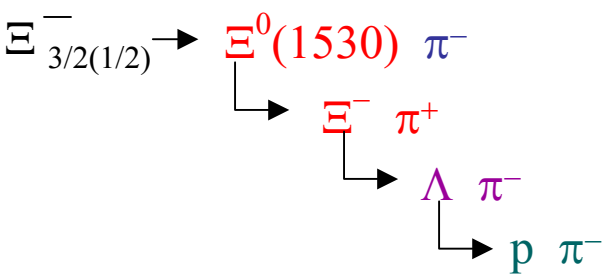


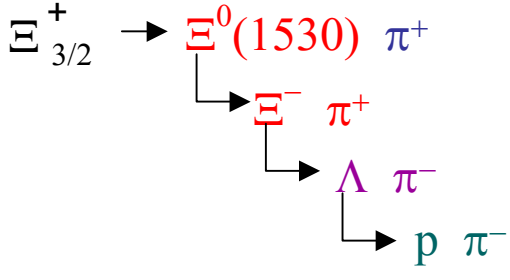
In SU(3)

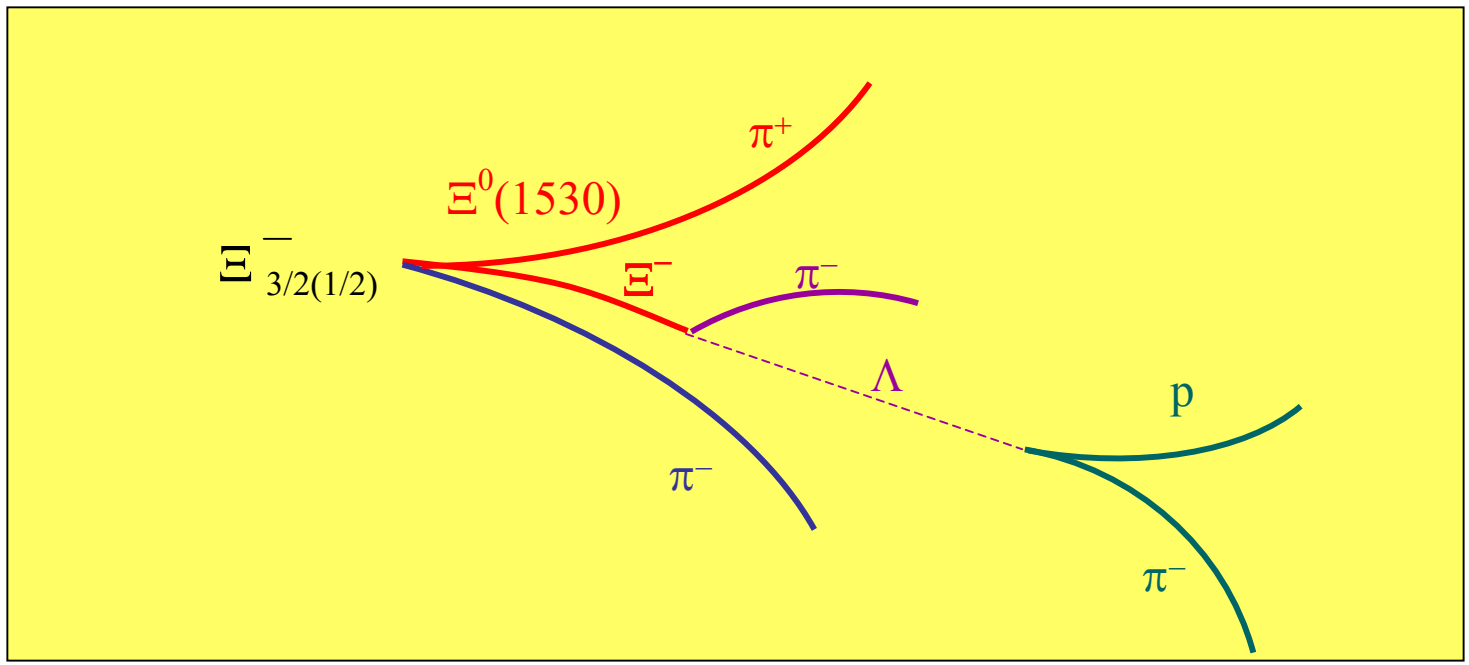
$\overline{10} \not\rightarrow 10 \oplus 8$

R. Jaffe and F. Wilczek, hep/ph/0312369

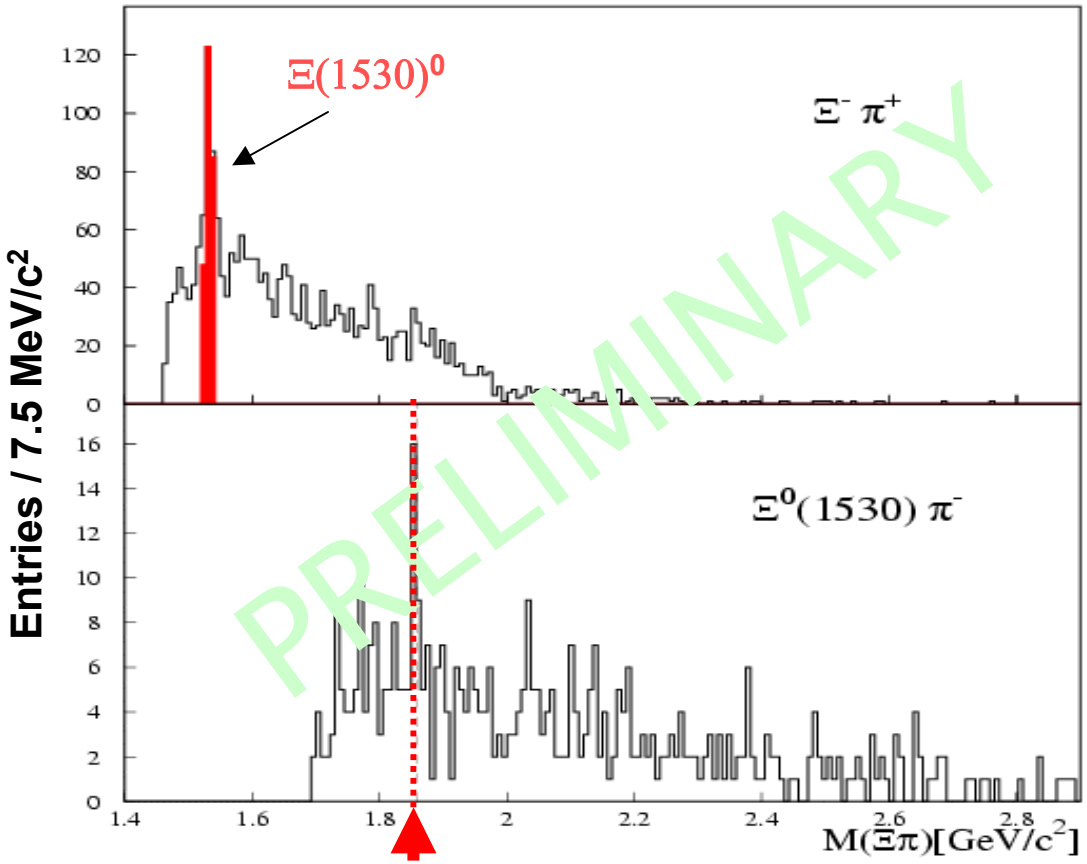
Search for Ξ^- and Ξ^+ via $\Xi(1530)^0$ decay







Search for Ξ^- and Ξ^+ via $\Xi(1530)^0$ decay



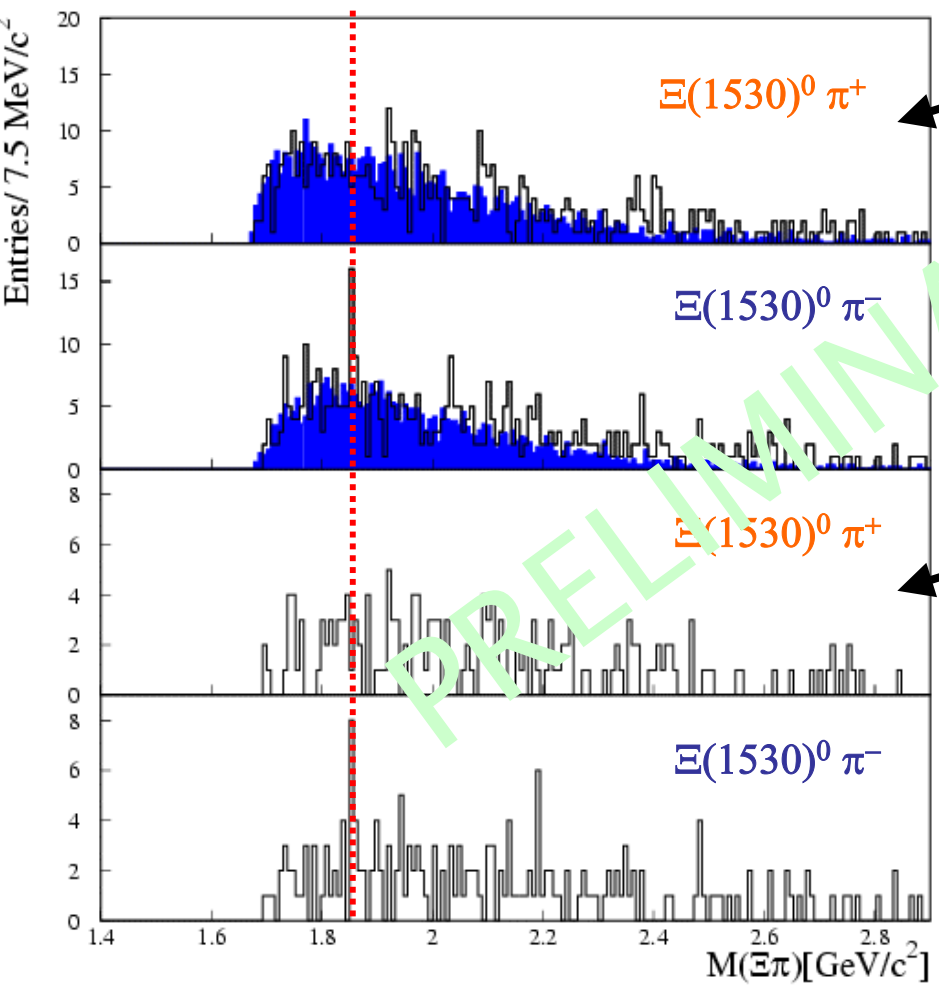
M=1.855 ± 0.003 GeV/c²

R. Jaffe and F. Wilczek

octet member

$\Xi^-_{1/2}$

Search for Ξ^- and Ξ^+ via $\Xi(1530)^0$ decay



No evidence for $\Xi^+_{3/2}$ to $\Xi(1530)^0\,\pi^+$ decay

No evidence for $\Xi^+_{3/2}$ to $\Xi(1530)^0\,\pi^+$ decay

Finer cut

Conclusion

- Strong Evidence for the existence of a narrow $\Xi^-\pi^-$ resonance at M = 1.862 ± 0.002 GeV/c^2 ($\Gamma \leq 18$ MeV/c^2) is observed.
- At the same mass a peak is observed in the $\Xi^-\pi^+$ spectrum.
- The corresponding antibaryon spectra show enhancements at the same mass.
- There is a preliminary evidence for existence of a narrow $\Xi(1530)^0\pi^-$ resonance at M = 1.855 ± 0.003 GeV/c^2.
- There is no indication for a $\Xi(1530)^0\pi^+$ resonance.

Outlook

- Open Question
  - Spin is unknown
  - Parity is unknown
  - Width ? Structure? Production mechanism?
  - Production in the hot and dense matter?

- NA49 (Pentaquark Working Group)
  - CERN-SPSC-2003-038
  - (3-6)·10^7 p+p events (new DAQ system)
  - Further improvement of experimental resolution
  - Search for $\Sigma_s^0(-)$ ➔ Ξ^-K^+ ($\Xi^-K^0_s$)
  - Search for the exotic particles in hot and dense matter (in peripheral Pb+Pb, p+Pb, Pb+Pb at various collision energies)

NA49 Collaboration

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