The $\Xi(1620)$ revisited. Hidden exotics ?

Igor Strakovsky
The George Washington University

Based on work in collaboration with
R. Arndt, Ya. Azimov, R. Workman

- What we know about $\Xi(1620)$ [exp]
  - Previous evidence
  - CLAS evidence ?
- Possible nature of $\Xi(1620)$
- Possible unitary partners
- Summary

Cascade Physics, Dec 1-3, 2005

PDG2005: Ξ(1620) $I(J)^P = 1/2(?)^?$ *

Citation: S. Eidelman *et al.* (Particle Data Group), Phys. Lett. B **592**, 1 (2004) and 2005 partial update for edition 2006 (URL: http://pdg.lbl.gov)

Ξ(1620)

$I(J^P) = \frac{1}{2}(?^?)$ Status: *

J, *P* need confirmation. & determination

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What little evidence there is consists of weak signals in the $\Xi\pi$ channel. A number of other experiments (e.g., BORENSTEIN 72 and HASSALL 81) have looked for but not seen any effect.

Ξ(1620) MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
≈ 1620 OUR ESTIMATE					
1624±3	31	BRIEFEL	77	HBC	$K^- p$ 2.87 GeV/c
1633±12	34	DEBELLEFON	75B	HBC	$K^- p \to \Xi^- \overline{K}\pi$
1606±6	29	ROSS	72	HBC	$K^- p$ 3.1–3.7 GeV/c

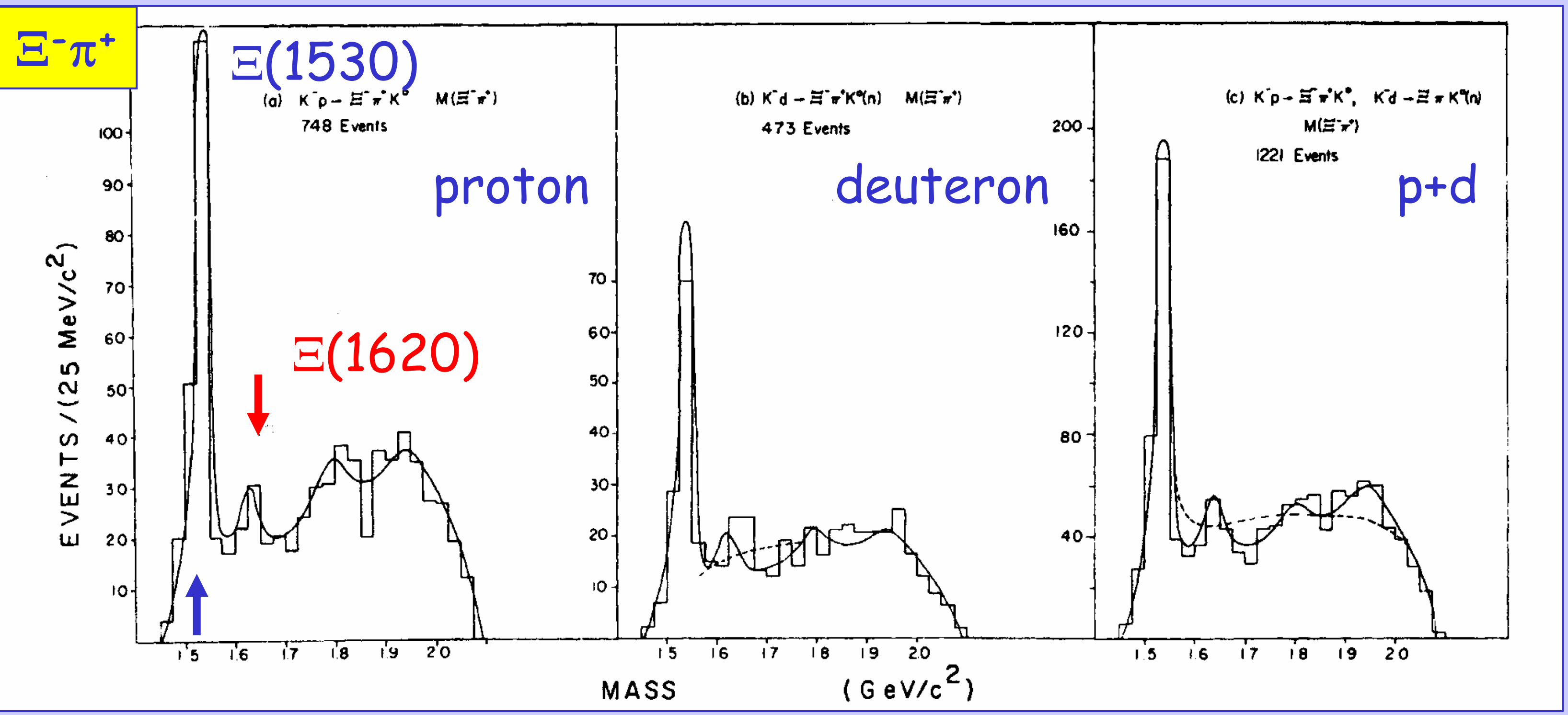
Ξ(1620) WIDTH

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
22.5	31	[1] BRIEFEL	77	HBC	$K^- p$ 2.87 GeV/c
40 ±15	34	DEBELLEFON	75B	HBC	$K^- p \to \Xi^- \overline{K}\pi$
21 ± 7	29	ROSS	72	HBC	$K^- p \to \Xi^- \pi^+ K^{*0}(892)$

$\Xi(1630)$ via $K^-p \rightarrow \Xi^-\pi^+K^0$ at BNL

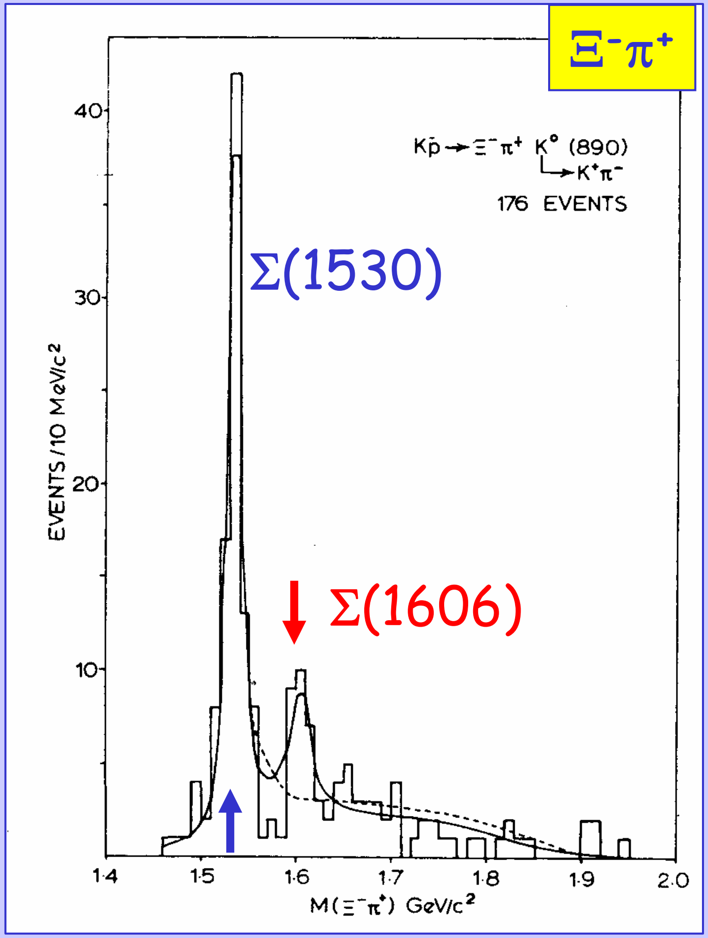
[Briefel *et al.* PRD**16**, 2706(1977)]

- P_π=2.87 GeV/c
- M = 1624±3 MeV
  Γ = 22.5 MeV



Ξ(1606) via $K^-p \to \Xi^-\pi^+K^0$ at CERN

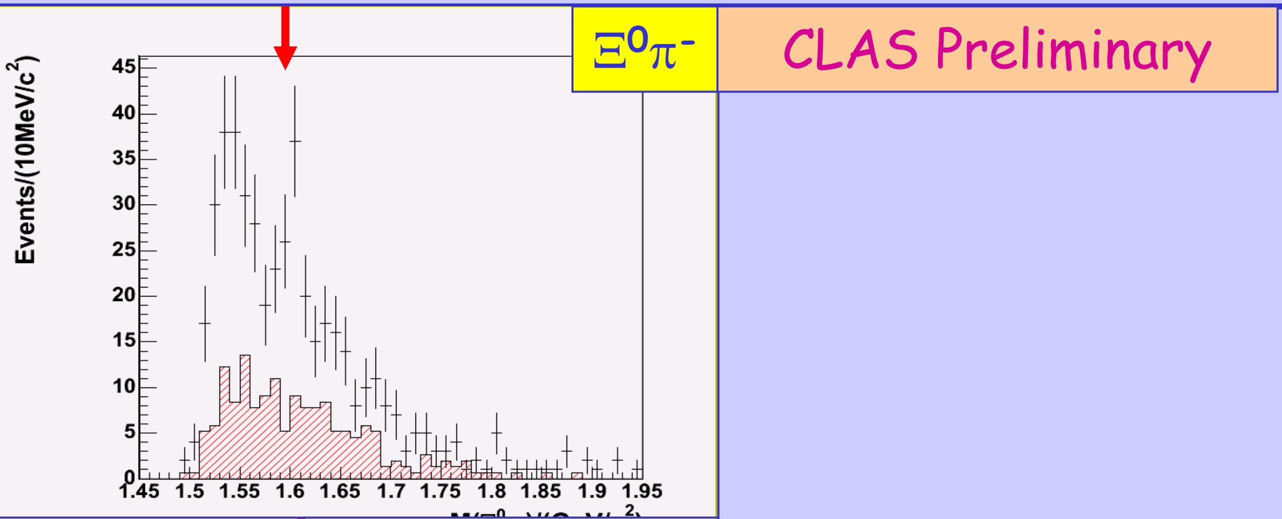
[Ross *et al.* PL**38B**, 177(1972)]

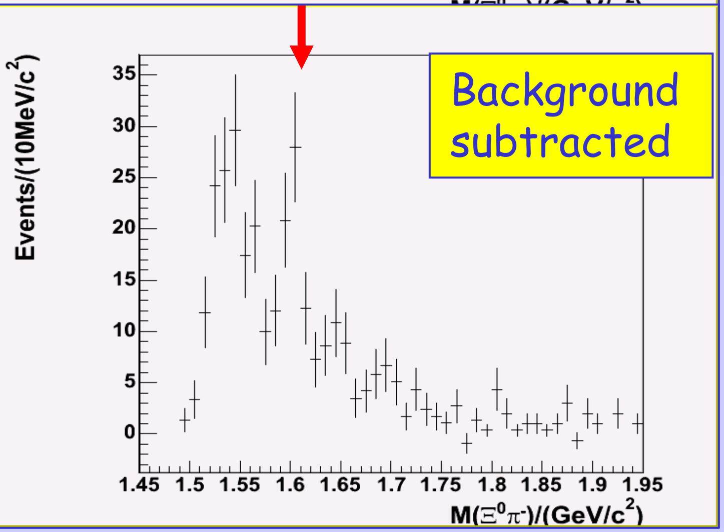


- P_π=3.13, 3.30, 3.58 GeV/c
- ***M*** = 1606±6 MeV
  Γ = 21±7 MeV

$\Xi(1620)$ via $\gamma p \rightarrow K^+K^+\pi^-(\Xi^0)$ at JLab Hall B [g11]

[Lei Guo, Weygand, Nstar2005]





- M = 1620 MeV
  Γ ~ 30 MeV

- $\gamma p \rightarrow K^+K^+\pi^-(\Xi^0)$ [g6c] analysis has been presented by Weygand

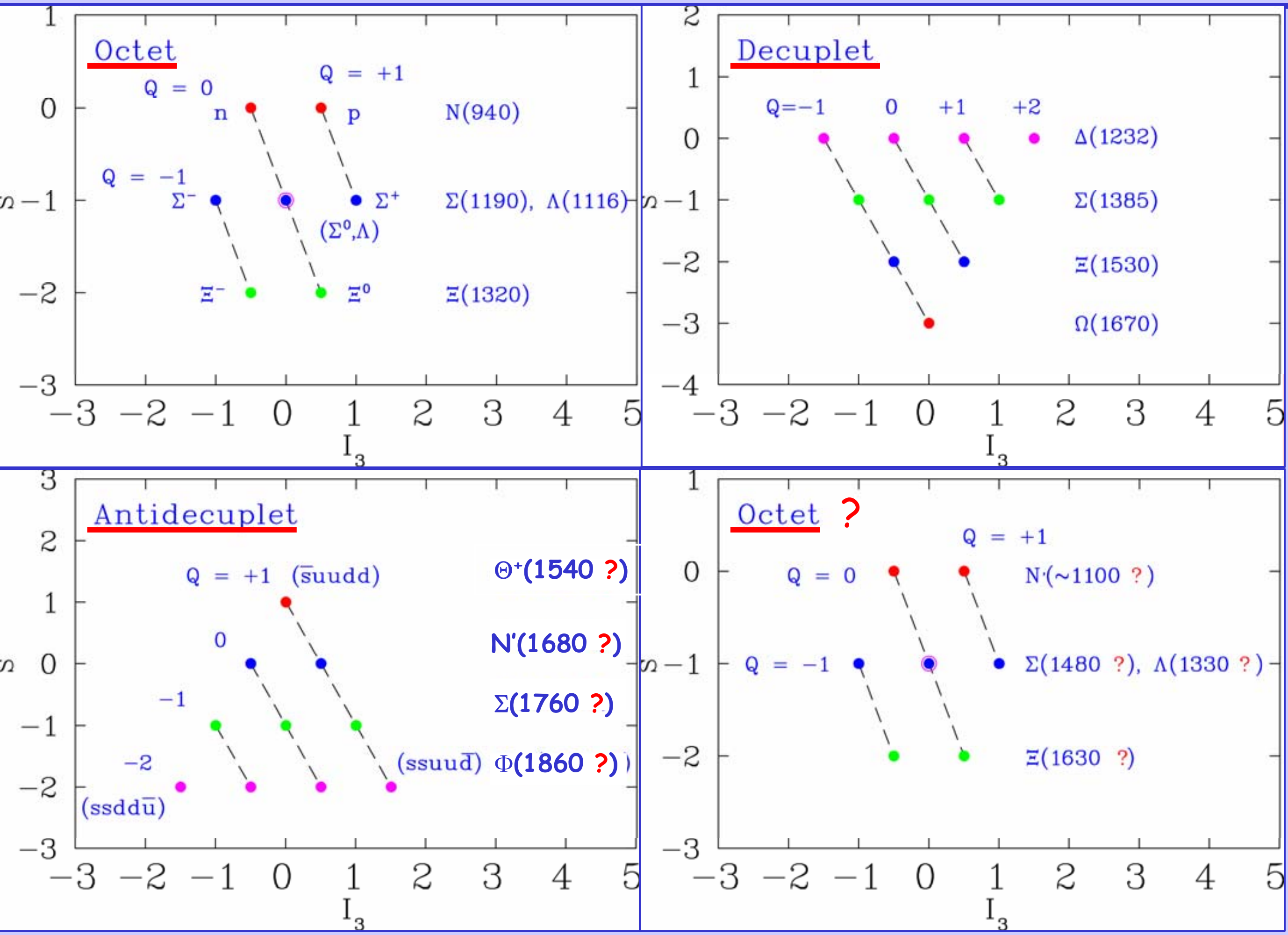
Possible Nature of $\Xi(1620)$

- $\overline{10}$ is predicted to be $1/2^+$ (P-wave)
  Where is the ground (S-wave) state ($1/2^-$) ?

- If this state is analogue to $\overline{10}$
  then its intrinsic structure must be different,
  and its flavor structure must be different as well,
  could be 8

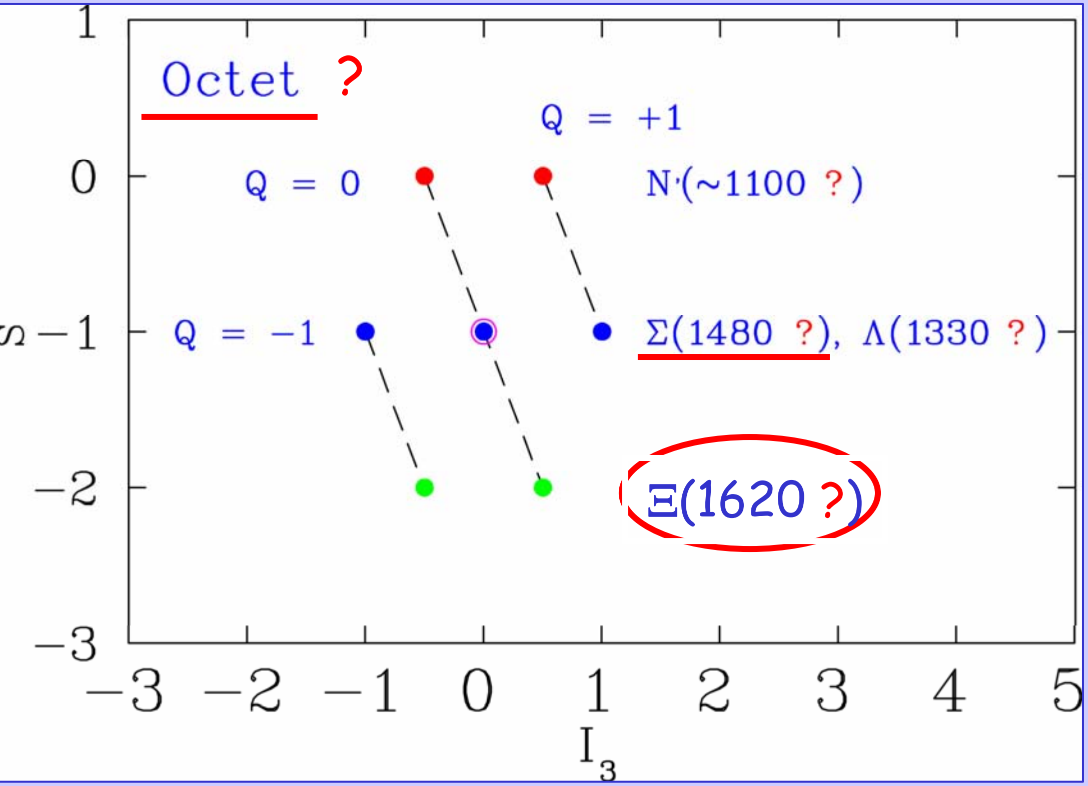
- There is no prediction of $1/2^-$ in ChSA (no predictions for the negative parity at all)

Unitary $SU(3)_F$ Multiplets



- Mixing is able to shift some masses

Completeness of Unitary Multiplets



- If Ξ(1620) exists, then there is no slot for it among 3q states
- It could be a good candidate for S-wave partner of $\overline{10}$
- Σ(1480), if exists, looks to be a good partner of Ξ(1620)

Possible Unitary Octet with $\Xi(1620)$

[Azimov, PL**32B**, 499(1970); Azimov, Arndt, IIS, Workman, PRC**68**, 045204(2003)]

State	Mass (MeV)	Width (MeV)	Decay Modes	Hadron Production Xsections
N'	$\sim$1100 ?	<0.05	$N\gamma$?	$< 10^{-4}$ of "normal"
Λ	1330 ?		$\Lambda\gamma$	$\sim 10\mu b$
Σ	1480	30-80 ?	$\Lambda\pi$, $\Sigma\pi$, $N\bar{K}$	$\sim 1\mu b$
Ξ	1630	20-50 ?	$\Xi\pi$	$\sim 1\mu b$

- PR Xsection has additional $\sim\alpha/\pi$ factor
- EPR has $\sim(\alpha/\pi)^2$

- On the base of positive observations

PDG2005: Σ(1480) $I(J)^P = 1(?)^?$ *

Citation: S. Eidelman *et al.* (Particle Data Group), Phys. Lett. B **592**, 1 (2004) and 2005 partial update for edition 2006 (URL: http://pdg.lbl.gov)

Σ(1480) Bumps

$I(J^P) = 1(?^?)$ Status: *

OMITTED FROM SUMMARY TABLE

J, P need determination

Σ(1480) MASS (PRODUCTION EXPERIMENTS)

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
≈ 1480 OUR ESTIMATE						
1480	120	ENGELEN	80	HBC	+	$K^- p \to (p \overline{K}^0)\pi^-$
1485±10		CLINE	73	MPWA	−	$K^- d \to (\Lambda\pi^-)p$
1479±10		PAN	70	HBC	+	$\pi^+ p \to (\Lambda\pi^+)K^+$
1465±15		PAN	70	HBC	+	$\pi^+ p \to (\Sigma\pi)K^+$

Σ(1480) WIDTH (PRODUCTION EXPERIMENTS)

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
80±20	120	ENGELEN	80	HBC	+	$K^- p \to (p \overline{K}^0)\pi^-$
40±20		CLINE	73	MPWA	−	$K^- d \to (\Lambda\pi^-)p$
31±15		PAN	70	HBC	+	$\pi^+ p \to (\Lambda\pi^+)K^+$
30±20		PAN	70	HBC	+	$\pi^+ p \to (\Sigma\pi)K^+$

Σ(1480) via $pp \to pK^+Y^{*0}$ at COSY-ANKE

[Zychor *et al.* PRL (2005) in press; nucl-ex/0506014]

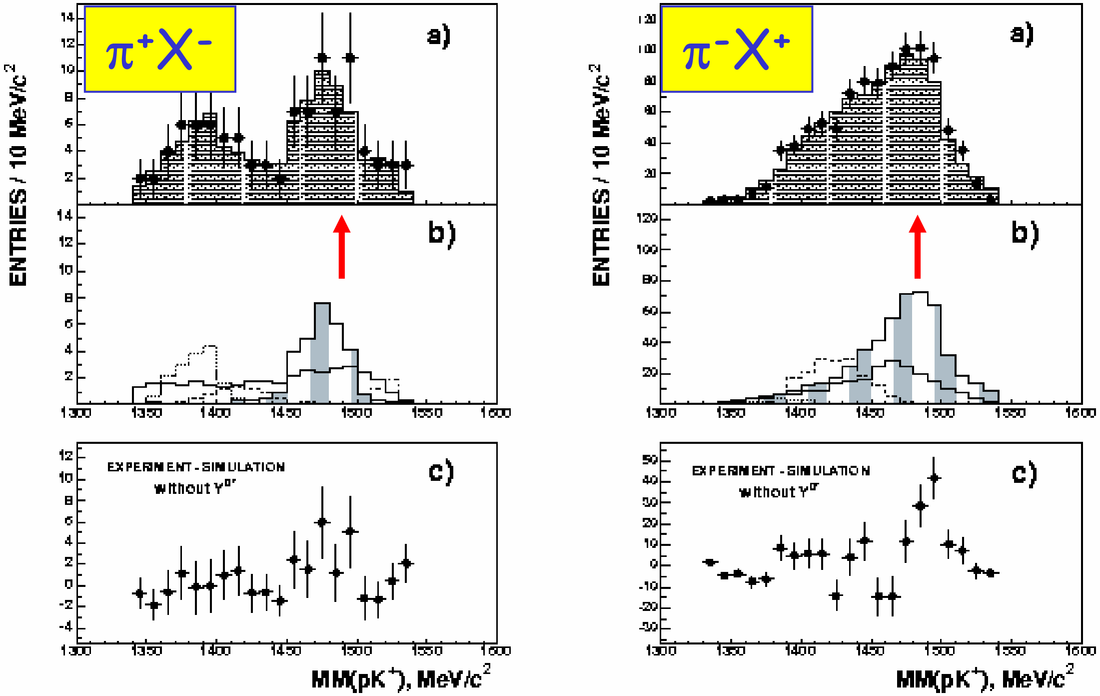
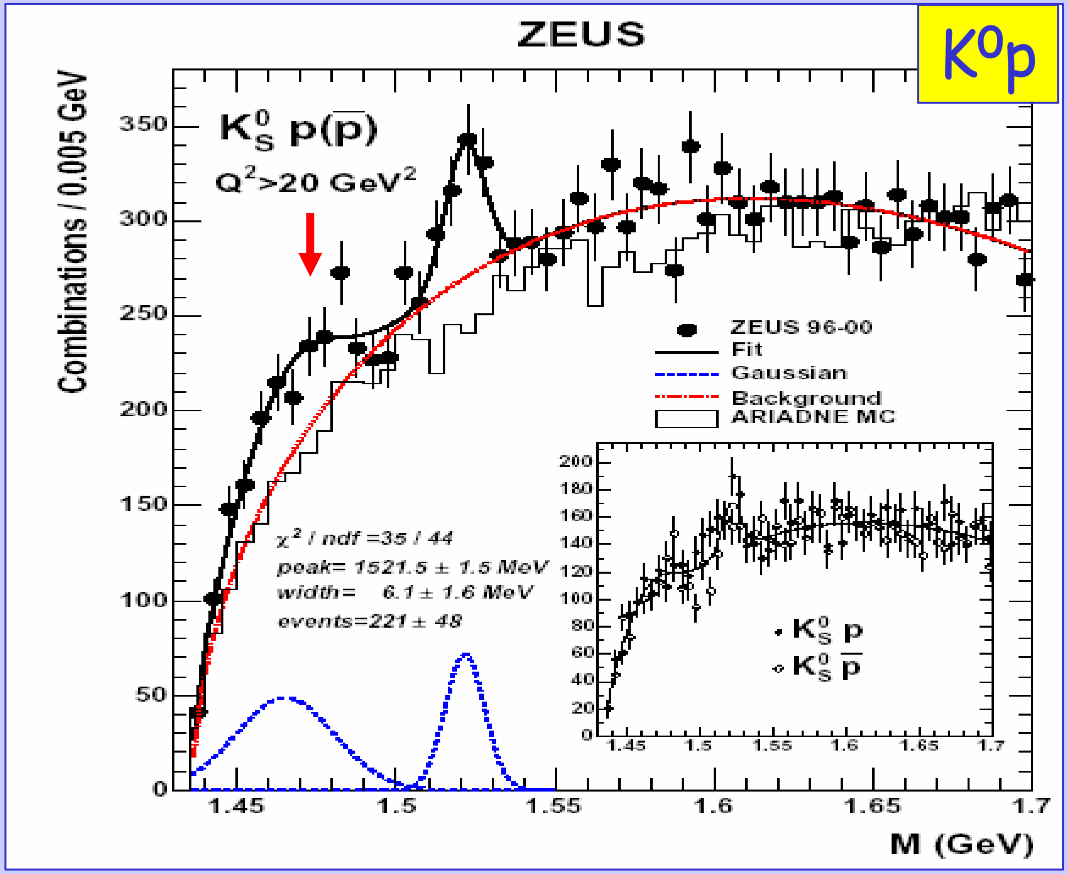


FIG. 3: Missing mass $MM(pK^+)$ spectra for the reaction $pp \to pK^+\pi^+X^-$(left) and $pp \to pK^+\pi^-X^+$(right). a) Experimental points with statistical errors are compared to the shaded histograms of the fitted overall Monte Carlo simulations; b) The simulation includes contributions from (i) resonances (Σ(1385)(dotted), Λ(1405)(dashed), Λ(1520)(dotted-dashed)), (ii) non-resonant phase-space production (solid), and (iii) the Y^{0*} resonance (shaded histogram), as described in the text; c) Difference between the measured spectra and the sum of contributions (i)+(ii) fitted *without* Y^{0*} production. Note that the contributions of the individual partial channels are different for b) and c).

- M=1480±15 MeV
  Γ= 60±15 MeV
- $\sigma(\pi^+X^-)$=0.45±.15±.15 μb
  $\sigma(\pi^-X^+)$=1.20±.25±.50 μb

$\Sigma(1480)$ via $e^+p \to e'K^0pX$ at ZEUS

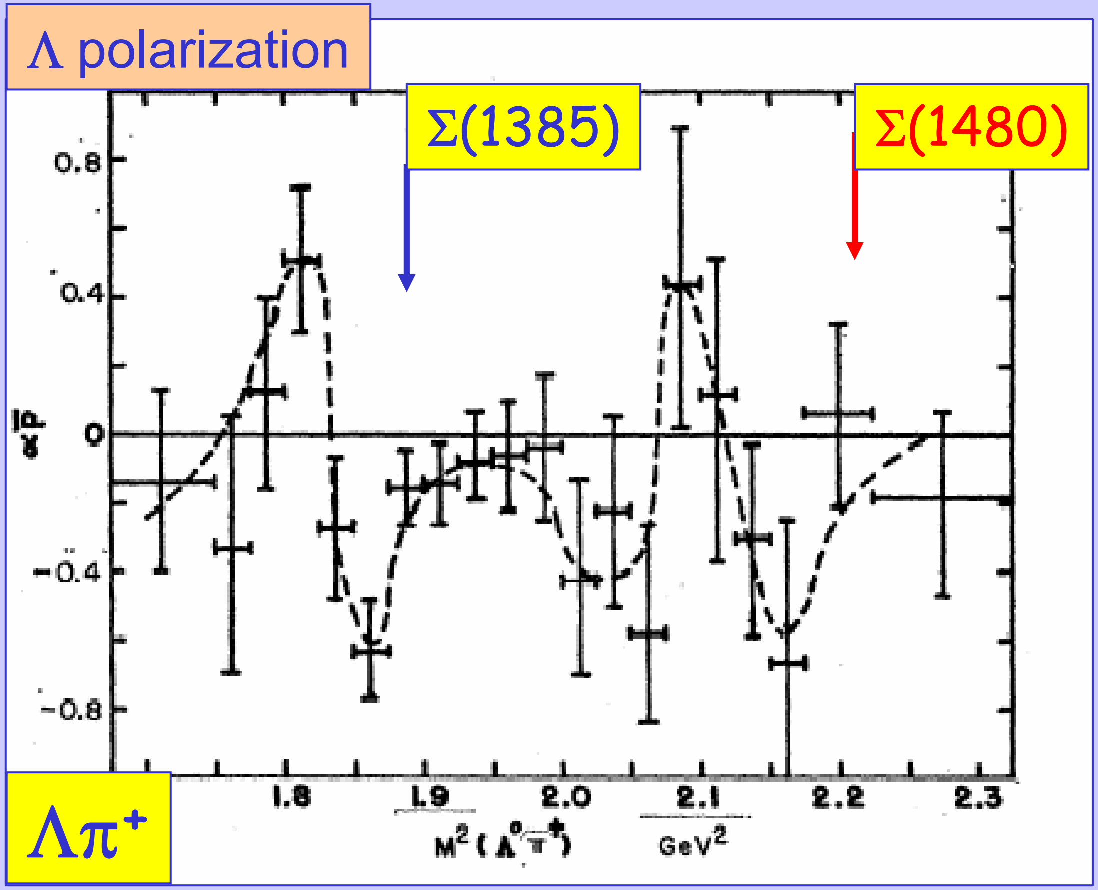
[Chekanov *et al.* PLB**591**, 7(2004)]



- M=1470 MeV
  Γ~ 30 MeV

$\Sigma(1480)$ via $\pi^+ p \to K^+\Lambda\pi^+$, $K^+\Sigma^0\pi^+$, $K^+\Sigma^+\pi^0$ at PPA

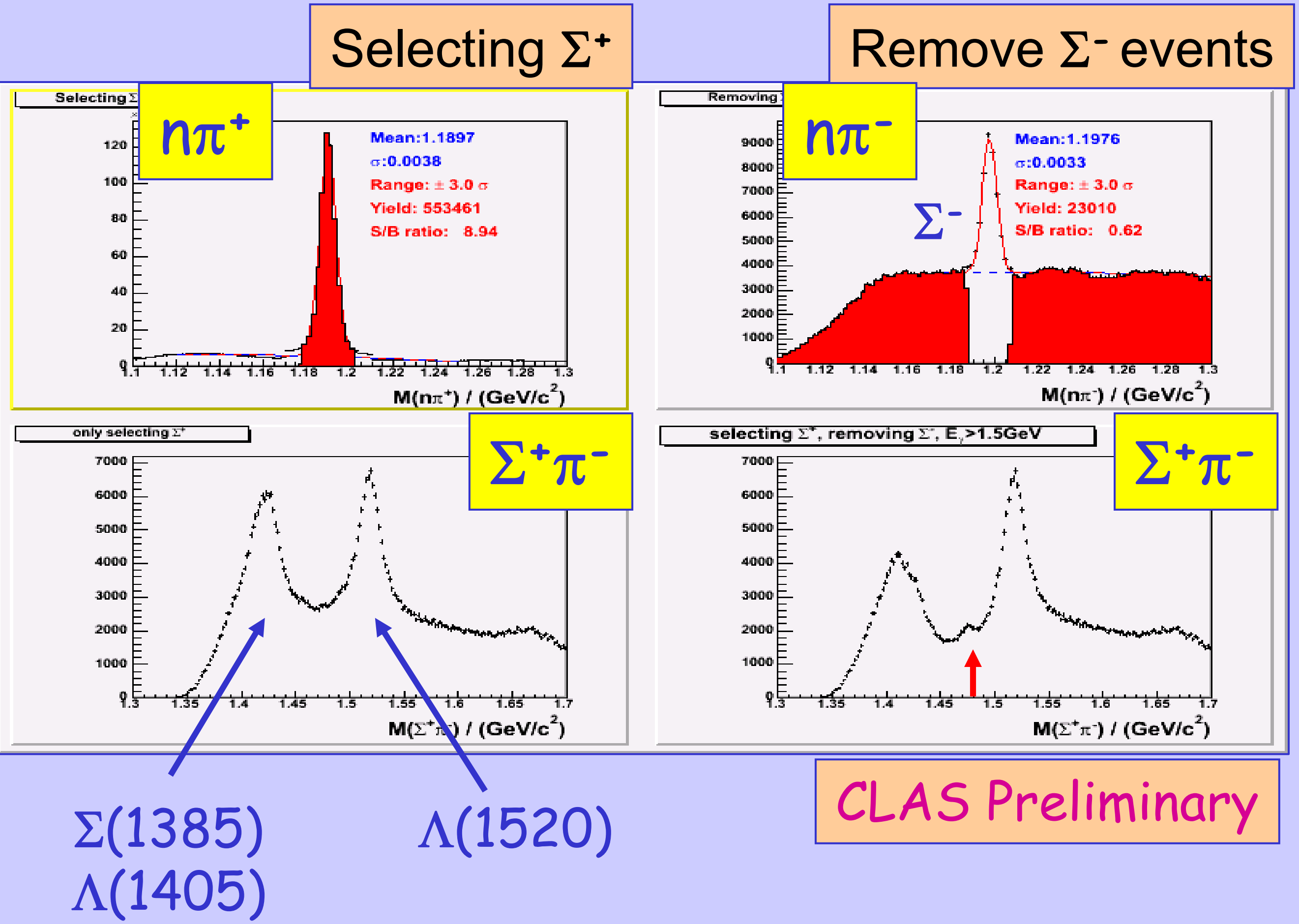
[Pan *et al.* PRD**2**, 449(1970)]



- Similar behavior for true resonance $\Sigma(1385)$ and suspected $\Sigma(1480)$
- $\Lambda\pi^+$: $M = 1479 \pm 10$ MeV
  $\Gamma = 30 \pm 15$ MeV
- $\Sigma\pi$: $M = 1465 \pm 10$ MeV
  $\Gamma = 30 \pm 20$ MeV

$\Sigma(1480)$ via $\gamma p \to K^+\pi^+\pi^-(n)$ [$K^+\pi^+\Sigma^-$, $K^+\pi^-\Sigma^+$] at JLab Hall B [g11]

[Lei Guo, Weygand, Nstar2005]



- Xsection estimation will allow to get a picture
- Status sensitivity is unclear

Summary

- Light unusual resonances have no place in 3q sector
- 5q sector could accept them
- Detailed study is required

  because the question of exotics is still active

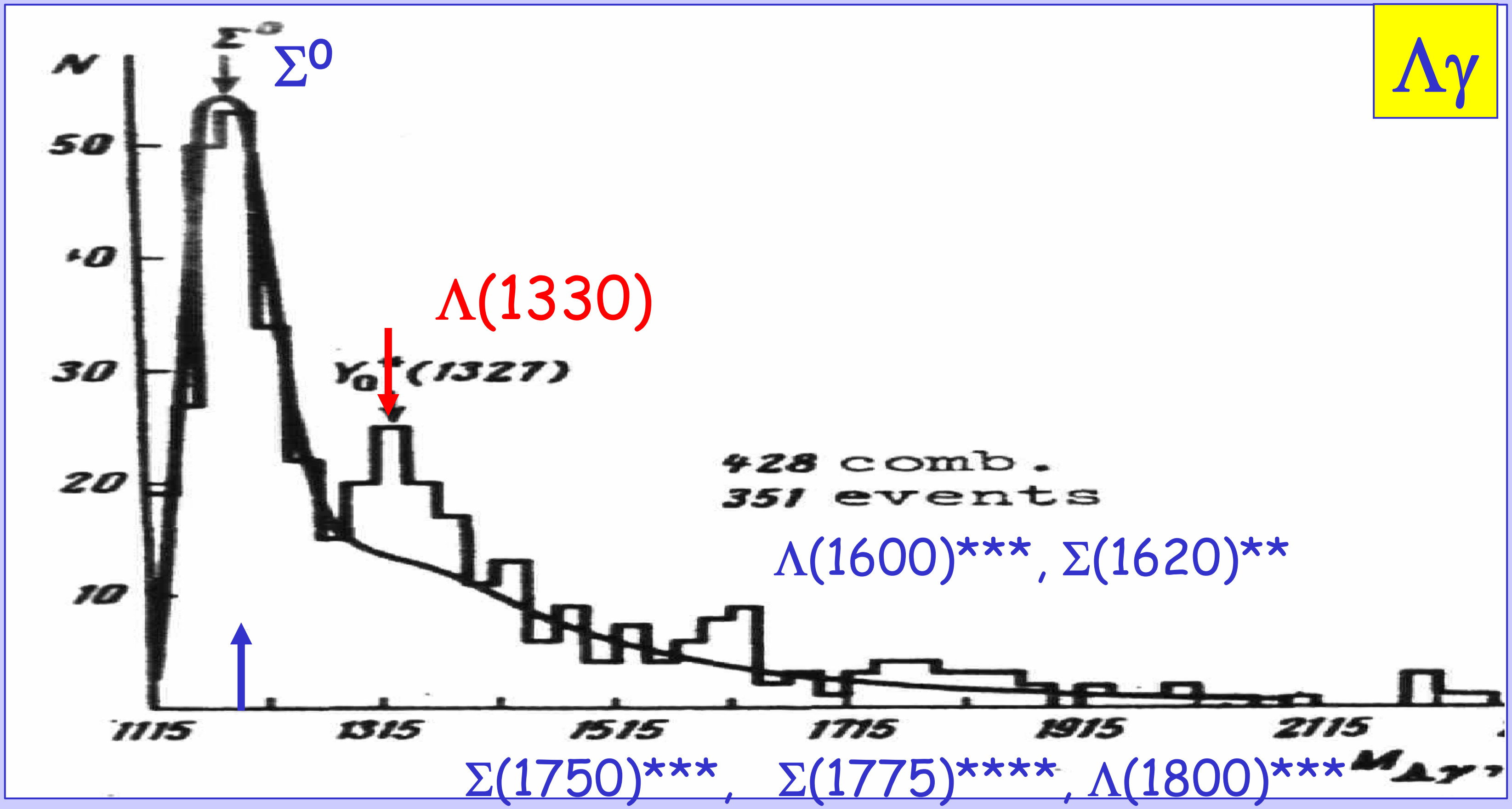
- `…either these states will be found by experimentalists or our confined, quark-gluon theory of hadrons is as yet lacking in some fundamental, dynamical ingredient which will forbid the existence of these states or elevate them to much higher masses'

  [Jaffe and Johnson, Phys Lett **60B**, 201(1976)]

Backup

$\Lambda(1330)$ via $\pi^- p \rightarrow \Lambda\gamma X^0$ at JINR

[Bogachev *et al.* JETP Lett**10**, 105(1969); Bozoki *et al.* PL**29B**, 360(1968)]



Σ(1750)***, Σ(1775)****, Λ(1800)***

Λ(1820)****, Σ(1880)**

Boundaries for N′ (below/above πN thr)

[Azimov, Arndt, IIS, Workman, PRC68, 045204(2003)]

Purely Hadronic

$$\frac{g^2_{\pi NN'}}{g^2_{\pi NN}} < 10^{-2} \qquad \Gamma_{N'} < 50\ keV$$

$$\frac{\sigma(pp \to nX^{++})}{\sigma(pn \to np)} < 10^{-7} \qquad [\frac{\Gamma_{N'}}{\Gamma_\Delta} < 4\ 10^{-4}]$$

$$\frac{\sigma(pp \to \pi^+ pX^0)}{\sigma(pp \to \pi^+ pn)} \sim 10^{-3} - 10^{-4} \quad ?$$

Hadronic and EM

< 3 10-6   < 4 10-6

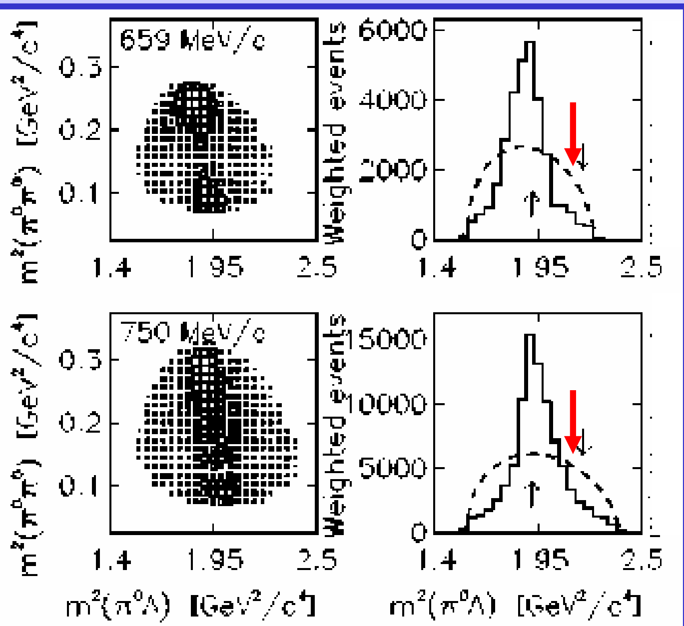
$$\frac{W(\pi^- p \to n'\gamma)}{W(\pi^- p \to n\gamma)}$$ < ~~$8\ 10^{-5}$~~ ~~$[\sim 10^{-5}]$~~

$$\Gamma_{N' \to N\gamma} < 5\ eV \qquad Br^2_\gamma\ \Gamma_{p'} < 10\ eV$$

$$\frac{Y(ep \to e'\pi^+ X^0)}{Y(ep \to e'\pi^+ n)} < 10^{-4} \qquad [\frac{Br_\gamma\ \Gamma_{p'}}{Br_\gamma\ \Gamma_\Delta} < 3\ 10^{-3}]$$

$$\frac{Y(ed \to e'pX^0)}{Y(ed \to e'pn)} < 10^{-4}$$

$K^-p \rightarrow 2\pi^0\Lambda$ vs $\Sigma(1480)$



$\pi^0\Lambda$

CB: Prakhov *et al.* PRC**69**, 042202(2004)

'In our data, we do not see a trace of either this controversial state Σ(1480) or other light Σ states'*

PPA: Pan & Forman, PRL**23**, 806(1969)

'Some general conclusions can be drawn from our literature search as to why this resonance has not been observed before. The major source of data on the πΛ channel comes from the reaction $K^-p \rightarrow \Lambda\pi^+\pi^-$ for K-momenta in the 1 GeV/c region. In this momentum region, the reaction above suffers large interferences due to the formation of both $Y_1^{*+}(1385)$ and $Y_1^{*-}(1385)$. The associated production experiments using $\pi^\pm$, p, and $\bar{p}$ are all hindered in observing this resonance by low statistics due to the small production cross section involved and competition from the formation of other resonances, e.g K(890)'*

- The case $K^-p \rightarrow 2\pi^0\Lambda$ is even worse because of two identical pions at low K-momenta