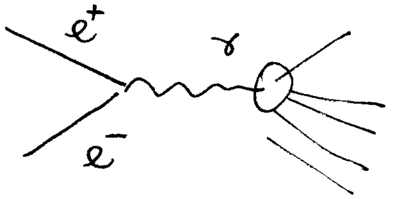
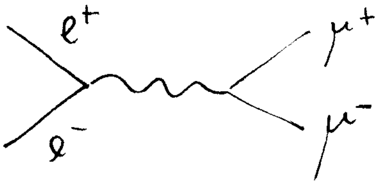
Charm, Bottom

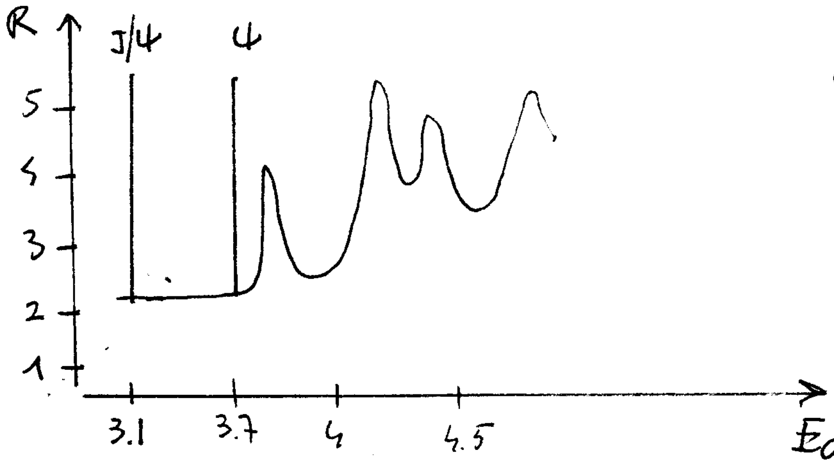


processo inclusivo



$$\sigma = \frac{4\pi\alpha^2}{3E_{cm}^2}$$

$$R = \frac{\sigma(e^+e^- \to \text{adroni})}{\sigma(e^+e^- \to \mu^+\mu^-)}$$

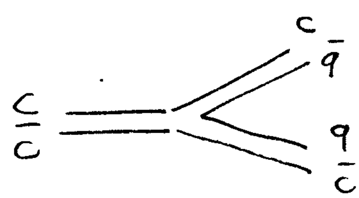


creazione di stati legati $c\bar{c}$

$$p^\mu = \Big(\underbrace{\frac{E_+ + E_-}{c}}_{E_{cm}}, 0\Big)$$

$$M c^2 = \sqrt{c^2 p_\mu p^\mu} = \sqrt{c^2 \frac{E_{cm}^2}{c^2}} = E_{cm}$$

Sopra $E_{cm} = 3.7$



$C = 1$ "D meson"

$C = -1$

particelle "charm" + leggere

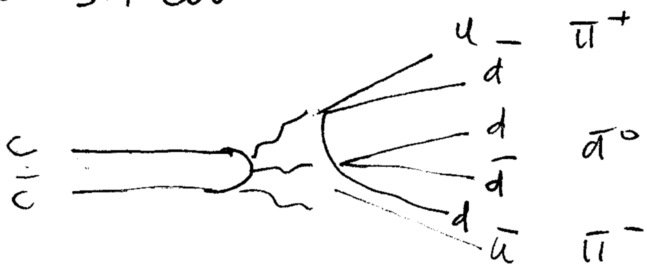
D^+	(1869)	$c\bar{d}$	$C=1$	
D^-	(1869)	$d\bar{c}$	$C=-1$	vite medie 10^{-13} secondi
D^0	(1865)	$c\bar{u}$	$C=1$	
$\bar{D}^0$	(1865)	$\bar{c}u$	$C=-1$	

Λ_c^+ (2285) udc $C=1$

particelle con "beauty" + leggere

B^+	(5279) $u\bar{b}$	B^0	(5279)	$d\bar{b}$	$\tilde{B}=+1$
B^-	(5279) $b\bar{u}$	$\bar{B}^0$	(5279)	$b\bar{d}$	$\tilde{B}=-1$

Sotto 3.7 GeV



decadimento soppresso quindi gli stati $c\bar{c}$ sotto i 3.7 GeV hanno larghezze molto piccole → J/ψ e ψ.

J/ψ e ψ hanno numeri quantici $J^{\pi} = 1^{-}$ come il fotone. Ci sono però + stati legati $c\bar{c}$.
Per esempio

$$\psi(3.7) \rightarrow \chi_{cn} + \gamma$$

$$\chi_{c0}(3.4) \quad \chi_{c1}(3.5) \quad \chi_{c2}(3.56)$$

$$0^{+} \qquad 1^{+} \qquad 2^{+} \quad \Rightarrow \quad {}^{3}P_{0},\ {}^{3}P_{1},\ {}^{3}P_{2}$$

$$\psi(3.7) \rightarrow \eta_c(3.0) + \gamma$$

$$J/\psi(3.1) \rightarrow \eta_c(3.0) + \gamma$$

$$\uparrow$$

$$0^{-} \quad \Rightarrow \quad {}^{1}S_{0}$$

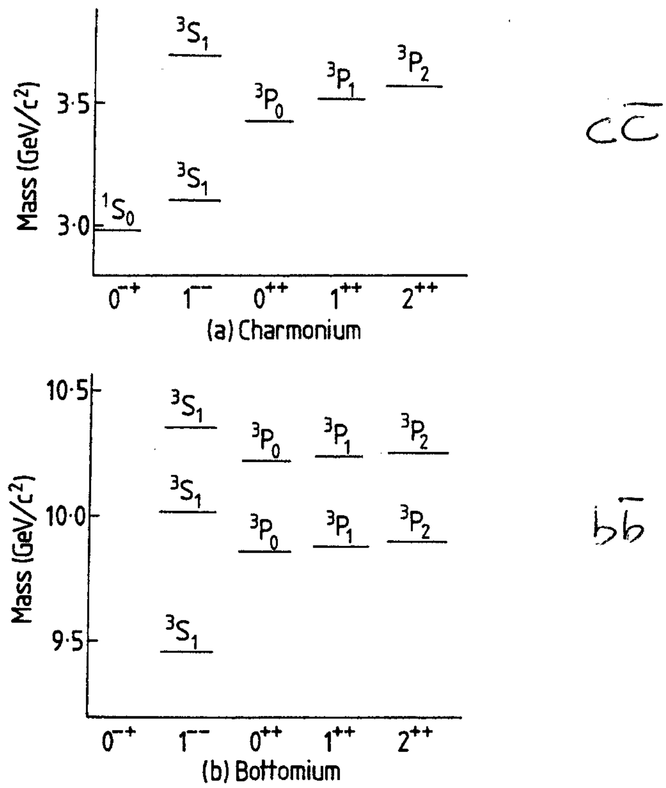
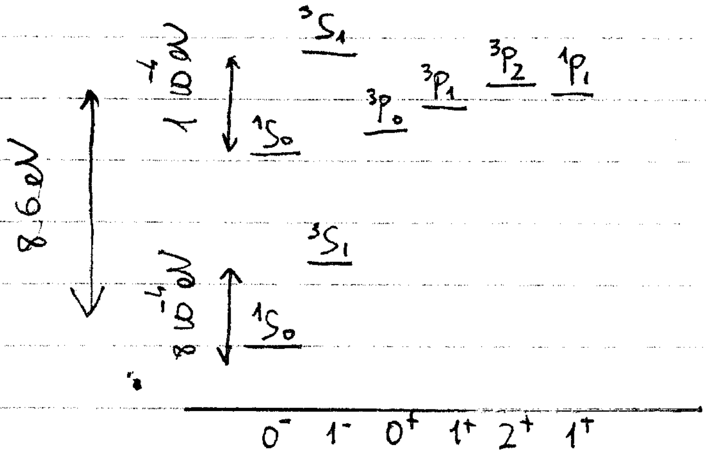


Fig. 6.4 Observed states of (*a*) charmonium and (*b*) bottomium which lie below the charm and beauty thresholds respectively.

Stato legato e^+e^- "positronio"



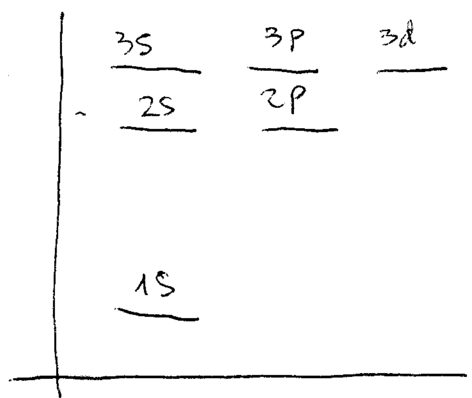
Notare la similitudine degli spettri

Quark - Antiquark potential

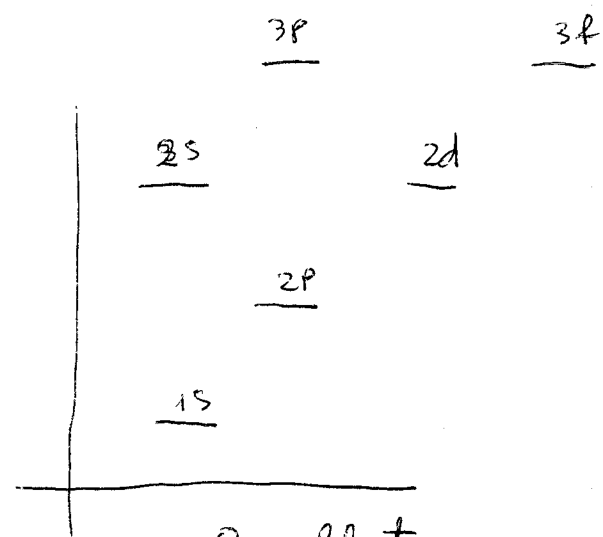
Dallo spettro del "charmonio" e "bottomio"

I quarks c & b sono pesanti (massa ~ 1.5 GeV e 5 GeV) e quindi posso usare la teoria non-relativistica

Esempio di spettri



Coulomb



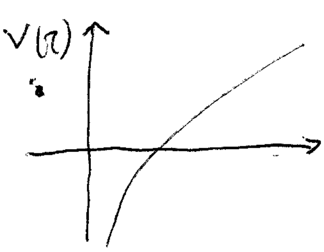
Oscillatore

Lo spettro dei sistemi $c\bar{c}$ e $b\bar{b}$ sono intermedi tra queste 2 possibilità. Si usa un potenziale della forma

$$V(r) = -\frac{a}{r} + \frac{br}{\hbar c}$$

$a \simeq 0.48\,\hbar c \simeq 100$ MeV fm

$b \simeq 0.18\,(\mathrm{GeV})^2 \qquad \frac{b}{\hbar c} \simeq 0.9$ GeV/fm



Isospin & Stranezza "fermioni"

barioni = stati qqq

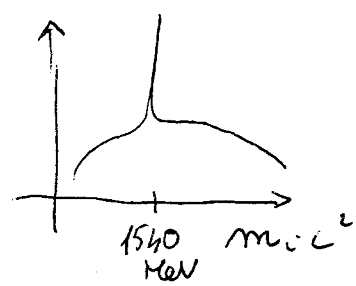
S	T_z	Q
0	$\pm 1/2, \pm 3/2$	$-e, 0, +e, +2e$
-1	$0, \pm 1$	$-e, 0, +e$
-2	$\pm 1/2$	$0, -e$
-3	0	$-e$

mesoni = stati $q\bar{q}$

S	T_z	Q
0	$0, \pm 1$	$+1, 0, -1$
-1	$\pm 1/2$	$0, -1$
$+1$	$\pm 1/2$	$0, +1$

Scoperta di stati "esotici"

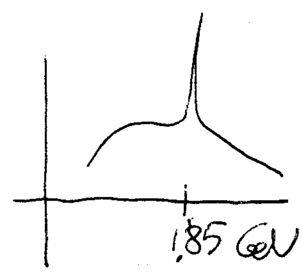
$$\gamma + p \rightarrow K^- + \pi^+ + \underbrace{n + K^+}$$



carica $Q = +1$
$S = +1$

$ddu\,u\bar{s}$ "pentaquark"

$$p + p \rightarrow X + \underbrace{\Xi^- + \pi^-}$$



$dd\,ss\bar{u}$

$Q = -2$
$S = -2$

PENTAQUARKS

New five-quark states found at CERN

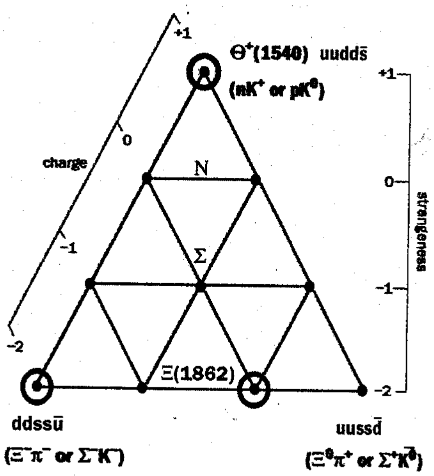


Fig. 1. A hypothetical antidecuplet of pentaquark baryons. The states at the corners of the triangle are manifestly exotic and cannot be made of three quarks. Experiments now see candidates for the three circled members.

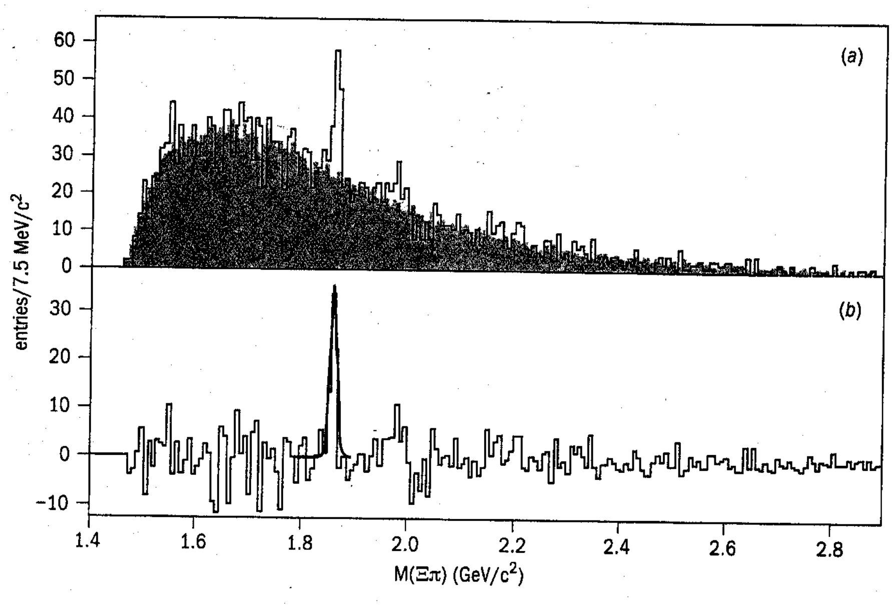


Fig. 2. (a) The sum of the $\Xi^-\pi^-$, $\Xi^-\pi^+$, $\bar{\Xi}^-\pi^-$ and $\bar{\Xi}^-\pi^+$ mass distribution; (b) the mass distribution with combinatorial background subtracted and with a Gaussian fit to the $\Xi\pi$ peak.

Only a few months after the first burst of

Courier September 2003 p5). The Θ^+ is a

width of the peak must be smaller than the