Observation of a New Particle at BABAR

QuarkNet - 5/18/2003

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So what's this all about....



Current BABAR NEWS

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BaBar reports observation of a narrow meson near 2.32 GeV/c²

The BaBar Collaboration has observed a narrow state near 2.32 GeV/ c^2 in the inclusive $D_s^+ pi^0$ invariant mass

distribution from 91 fb⁻¹ of $e^+e^$ annihilation data taken at energies near 10.6 GeV at the PEP-II asymmetric-energy storage ring at SLAC. The state, first discovered by Antimo Palano of the Universita` di Bari Dipartimento di Fisica and Istituto Nazionale di Fisica Nucleare (INFN), Italy, has a width consistent with the experimental resolution. The small intrinsic width and the final state quantum numbers indicate that the decay violates isospin conservation. The state has natural spin-parity and the low mass suggests a $\int^2 = 0^+$ assignment.



What makes this interesting? Why do we care?

A Short Summary of the Quark Model



Quarks spin = 1/2							
Flavor	Approx. Mass GeV/c ²	Electric charge					
U up	0.003	2/3					
d down	0.006	-1/3					
C charm	1.3	2/3					
S strange	0.1	-1/3					
t top	175	2/3					
b bottom	4.3	-1/3					

Mesons:

• (Quasi-) bound states of Quark and Antiquark (quark-antiquark "atoms")

Mesons qq Mesons are bosonic hadrons. There are about 140 types of mesons.								
Symbol	Name	Quark content	Electric charge	Mass GeV/c ²	Spin			
π^+	pion	ud	+1	0.140	0			
K⁻	kaon	sū	-1	0.494	0			
$ ho^+$	rho	ud	+1	0.770	1			
B ⁰	B-zero	db	0	5.279	0			
η_{c}	eta-c	cτ	0	2 .980	0			

Mesons – as known ...

$\begin{array}{c c c c c c c c c c c c c c c c c c c $		LIGHT UNFLAVORED		STRANGE		BOTTOM		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		(S = C = G (PC)	= B = 0)	GUPC	$(S = \pm 1, C)$	B = 0	(B =	±1)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		10(3.0)		1°(J°)		1(5)	- 1	10(5.0)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• π^{\pm}	$1^{-}(0^{-})$	 φ(1680) 	0-(1)	• K [±]	1/2(0-)	• B [±]	1/2(0-)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• π ⁰	$1^{-}(0^{-+})$	 <i>ρ</i>₃(1690) 	1+(3)	• K ⁰	1/2(0)	• B ⁰	1/2(0-)
	• η	$0^+(0^{-+})$	 ρ(1700) 	$1^+(1^{})$	• K ⁰ _S	1/2(0)	• B [±] /B ⁰ ADM	IXTURE
$\begin{array}{c} \rho(70) & 1^{-1}(1-) & \phi_0(1710) & 0^{+}(0^{-1}) \\ \circ(782) & 0^{-}(1) & \eta(1760) & 0^{+}(0^{-1}) \\ \circ(783) & 0^{+}(0^{-1}) & (\pi(1800) & 1^{-}(0^{-1}) \\ \circ(1800) & 1^{-}(0^{-1}) & (\pi(1800) & 1^{-}(0^{-1}) \\ \circ(1800) & 1^{-}(0^{-1}) & (\pi(1800) & 1^{-}(0^{-1}) \\ \circ(1200) & 0^{-}(1^{}) & \eta(1850) & 0^{-}(2^{}) \\ \circ(1170) & 0^{-}(1^{}) & \eta(1850) & 0^{-}(2^{}) \\ \circ(1125) & 1^{+}(1^{+-}) & f_{2}(1870) & 0^{+}(2^{-+}) \\ \circ(1220) & 1^{-}(1^{+-}) & f_{2}(1870) & 0^{+}(2^{++}) \\ \circ(1220) & 1^{-}(1^{++}) & f_{2}(1900) & 1^{+}(1^{}) \\ \circ(1225) & 0^{+}(1^{++}) & f_{2}(1900) & 1^{+}(2^{++}) \\ \circ(1220) & 1^{-}(2^{++}) & f_{2}(1990) & 1^{+}(3^{}) \\ \circ(1225) & 0^{+}(1^{++}) & f_{2}(1990) & 1^{+}(3^{}) \\ \circ(1225) & 0^{+}(1^{++}) & f_{2}(1900) & 1^{-}(2^{++}) \\ (\pi(1300) & 1^{-}(0^{-+}) & f_{2}(200) & 0^{+}(0^{++}) \\ (\pi(1300) & 1^{-}(0^{-+}) & f_{2}(200) & 0^{+}(0^{++}) \\ \circ(1420) & 0^{-}(1^{}) & f_{2}(2150) & 0^{+}(4^{++}) \\ (f_{1430}) & 0^{+}(2^{++}) & f_{2}(2150) & 0^{+}(2^{++}) \\ \circ(1430) & 0^{-}(2^{++}) & f_{2}(2150) & 0^{+}(2^{++}) \\ \circ(1430) & 0^{-}(2^{++}) & f_{2}(220) & 0^{+}(0^{++}) \\ (f_{1430}) & 0^{+}(2^{++}) & f_{2}(220) & 0^{+}(0^{++}) \\ (f_{1450}) & 1^{-}(0^{-+}) & f_{2}(2250) & 1^{+}(1^{}) \\ \rho(1450) & 1^{-}(1^{}) & \rho(2150) & 1^{+}(1^{}) \\ (f_{1450}) & 1^{+}(1^{}) & f_{2}(2250) & 1^{+}(1^{}) \\ (f_{1450}) & 1^{+}(1^{}) & f_{2}(2250) & 1^{+}(1^{}) \\ f_{1}(150) & 0^{+}(1^{++}) & f_{2}(220) & 0^{+}(2^{++}) \\ \rho(1450) & 1^{-}(1^{}) & \rho(2250) & 1^{+}(1^{}) \\ \rho(1450) & 1^{-}(1^{}) & \rho(2250) & 1^{+}(1^{}) \\ \rho(1450) & 0^{-}(1^{}) \\ \rho(1450) & 0^{-}(1^{}) \\ \rho(1250) & 0^{+}(2^{++}) \\ f_{1}(1640) & 1^{+}(1^{++}) \\ f_{2}(2400) & 0^{+}(2^{++}) \\ f_{1}(1640) & 1^{+}(1^{++}) \\ f_{2}(2400) & 0^{+}(2^{++}) \\ \rho(1450) & 0^{-}(1^{}) \\ \rho(1450) & 0^{-}(1^{}) \\ \rho(1450) & 0^{-}(1^{}) \\ \rho(140) & 0^{+}(1^{++}) \\ \rho(140) & 0^{-}(1^{}) \\ \rho(1240) & 1^{+}(2^{+}) \\ \rho(140) & 0^{-}(1^{}) \\ \rho(140) & 0^{+}(1^{++}) \\ \rho(140) & 0^{-}(1^{}) \\ \rho(140) & 0^{+}(1^{++}) \\ \rho(140) & 0^{-}(1^{}) \\ \rho(140) & 0^{+}(1^{++}) \\ $	• f ₀ (600)	$0^+(0^{++})$	a ₂ (1700)	$1^{-}(2^{++})$	• K ⁰ _L	1/2(0 ⁻)	• B [±] /B ⁰ /B ⁰ _s /b	-baryon
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	 ρ(770) (700) 	$1^{+}(1^{-})$	• f ₀ (1710)	$0^+(0^{++})$	• K*(892)	$1/2(1^{-})$	V _{ch} and V _{ub}	CKM Matrix
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	• ω(782)	0(1)	$\eta(1760)$	$0^{+}(0^{-+})$	• K ₁ (1270)	$1/2(1^+)$	Elements	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• η (958)	$0^+(0^+)$	• $\pi(1800)$	$1(0^{+})$	• K ₁ (1400)	1/2(1+)	• B*	$1/2(1^{-})$
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• <i>f</i> ₀ (980)	$1^{-}(0^{+})$	$T_2(1810)$	$0^{-}(2^{-})$	• K*(1410)	$1/2(1^{-})$	B [*] _J (5732)	?(?')
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	• a ₀ (980)	$1^{(0+1)}$	• $\phi_3(1850)$	0(3)	• K ₀ (1430)	1/2(0 ')	BOTTOM	STRANGE
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• $\phi(1020)$	$0^{-(1+-)}$	$\eta_2(1870)$	$1^{+}(1^{-})$	• K [*] ₂ (1430)	1/2(2+)	$(B = \pm 1,$	$S = \mp 1$
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• $h_1(1170)$ • $h_2(1225)$	$1^{+}(1^{+})$	$\rho(1900)$	$a^{+}(2^{+}^{+})$	K(1460)	1/2(0-)	• B ⁰	0(0-)
$\begin{array}{c} 1_{\{1(250)} & 1_{\{1(2+)\}} & 1_{\{2(2+)\}} & 1_{\{2(2+)\}} & 1_{\{2(2+)\}} & 1_{\{2(2+)\}} & 1_{\{1(350)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1+)\}} & 1_{\{1(650)} & 1_{\{2(1-)\}} & 1_{\{2(2-)\}} &$	• D ₁ (1255)	$1^{-}(1^{+})$	$f_2(1910)$	$0^+(2^+)$	K ₂ (1580)	1/2(2-)	B*	$0(1^{-})$
$\begin{array}{c} 1 1 1 1 1 1 1 1$	• a1(1200)	$0^+(2^+)$	¹ 2(1950)	1+(2)	K(1630)	1/2(?`)	D _S R* (E9E0)	2(2?)
$\begin{array}{c} \gamma_1(1259) & 0^+(1-\gamma) \\ \pi_1(1300) & 1^-(0^-+) \\ \delta_2(1320) & 1^-(2^++) \\ \delta_2(1320) & 1^-(2^++) \\ \delta_2(1320) & 1^-(2^++) \\ \delta_1(1380) & ?^-(1^+-) \\ \pi_1(1400) & 1^-(1^-+) \\ f_1(1420) & 0^+(1^++) \\ \delta_2(1200) & 0^+(0^++) \\ f_1(1420) & 0^-(1^) \\ f_1(1420) & 0^-(1^) \\ f_1(1420) & 0^-(1^) \\ f_2(150) & 0^+(2^++) \\ \pi_1(1440) & 0^+(0^-+) \\ f_1(1220) & 0^+(2^++) \\ \pi_2(150) & 1^+(1^) \\ f_1(150) & 0^+(2^++) \\ \delta_2(1200) & 0^+(2^++) \\ \delta_2(1200) & 0^+(2^++) \\ f_1(2220) & 0^+(2^++) \\ \delta_2(1200) & 0^+(2^++) \\ f_1(2220) & 0^+(2^++) \\ f_1(150) & 1^-(0^++) \\ \phi_1(150) & 1^-(0^++) \\ \phi_1(150) & 1^-(1^-+) \\ f_1(150) & 0^+(1^++) \\ f_2(150) & 0^+(2^++) \\ f_2(160) & 1^-(1^) \\ f_2(150) & 0^-(1^) \\ f_2(120)^+ & 1/2(2^-) \\ f_2(120)^+ & 1/2(2^-) \\ f_2(120)^+ & 1/2(2^-) \\ f_2(120)^+ & 1/2(2^-) \\ f_2(120)^+ & 0^-(1^) \\ f_2(150) & 0^-(1^) \\ f_2(120)^+ & 1/2(2^-) \\ f_2(160)^+ & 1/2(2^+) \\ f_2(160) & 0^-(1^) \\ f_2(160)^- & 0^-(2^) \\ f_2(1$	• f ₂ (1270) • f ₂ (1285)	$0^{+}(1^{+}+)$	$p_3(1990)$	$1^{-}(3^{+})$	K ₁ (1650)	$1/2(1^+)$	$D_{sJ}(5050)$.()
$\begin{array}{c} (1252) & 0 & (0 & -1) \\ \pi(1300) & 1^{-}(0 & +1) \\ a_{2}(1320) & 1^{-}(2 & +1) \\ b_{3}(1370) & 0^{+}(0 & +1) \\ h_{1}(1380) & ?^{-}(1 & -1) \\ \pi_{1}(1400) & 1^{-}(1 & -1) \\ f_{1}(1420) & 0^{+}(1 & +1) \\ f_{1}(1420) & 0^{-}(1 & -1) \\ f_{1}(1420) & 0^{+}(1 & +1) \\ f_{2}(150) & 0^{+}(2 & +1) \\ f_{3}(1400) & 0^{+}(0 & +1) \\ f_{4}(140) & 0^{+}(0 & +1) \\ f_{4}(140) & 0^{+}(0 & +1) \\ f_{4}(150) & 1^{-}(0 & +1) \\ f_{4}(150) & 1^{-}(0 & +1) \\ f_{4}(150) & 1^{-}(0 & +1) \\ f_{4}(150) & 0^{+}(1 & +1) \\ f_{4}(150) & 0^{+}(1 & +1) \\ f_{4}(150) & 0^{+}(1 & +1) \\ f_{5}(1500) & 0^{+}(0 & +1) \\ f_{4}(1500) & 0^{+}(0 & +1) \\ f_{4}(1500) & 0^{+}(0 & +1) \\ f_{4}(1500) & 0^{+}(1 & +1) \\ f_{4}(2300) & 0^{+}(2 & +1) \\ f_{5}(2350) & 1^{+}(5 & -1) \\ h_{1}(1500) & 2^{+}(2 & +1) \\ f_{4}(2300) & 0^{+}(2 & +1) \\ f_{4}(2300) & 0^{+}(2 & +1) \\ f_{5}(2510) & 1^{+}(5 & -1) \\ h_{1}(1640) & 1^{+}(1 & +1) \\ f_{4}(2510) & 0^{-}(1 & -1) \\ f_{5}(2510) & 0^{+}(6 & +1) \\ f_{5}(2640)^{1} & 1/2(?)^{2} \\ f_{5}(2460)^{1} & 1/2(?)^{2} \\ f_{5}$	• n(1205)	$0^{+}(0^{-}+)$	A (2000)	$0^+(2^+)$	• K*(1680)	1/2(1)	BOTTOM,	CHARMED
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• $\eta(1293)$	$1^{-}(0^{-}+)$	• 12(2010) 6(2020)	$0^+(0^++)$	• K ₂ (1770)	1/2(2)	(B = C	$=\pm 1)$
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	• a (1320)	$1^{-}(2^{+}+)$	• a.(2040)	$1^{-}(4^{+}+)$	• K ₃ (1780)	1/2(3)	• B_c^{\pm}	0(0-)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	• fo(1370)	$0^{+}(0^{+})$	• f.(2050)	$0^+(4^{++})$	• K ₂ (1820)	1/2(2)		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$h_1(1380)$	$\frac{2}{7}(1+-)$	$\pi_2(2100)$	$1^{-}(2^{-}+)$	K (1830)	1/2(0)	c	c .
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\pi_1(1400)$	$1^{-}(1^{-}+)$	$f_{0}(2100)$	$0^{+}(0^{+})$	K ₀ (1950)	$1/2(0^{+})$	• $\eta_c(1S)$	0+(0-+
$\begin{array}{c} \chi_{1}(1,0) & 0^{-}(1^{-}) \\ \chi_{1}(1,20) & 0^{-}(1^{-}) \\ f_{2}(1,30) & 0^{+}(2^{+}) \\ \eta(1440) & 0^{+}(0^{-}+) \\ \eta(1440) & 0^{+}(0^{-}+) \\ \eta(1440) & 0^{+}(0^{-}+) \\ f_{3}(220) & 0^{+}(2^{+}+) \\ \eta(1450) & 1^{+}(1^{-}-) \\ \eta(1450) & 0^{+}(0^{+}+) \\ f_{3}(150) & 0^{+}(0^{+}+) \\ f_{4}(150) & 0^{+}(1^{+}+) \\ f_{4}(150) & 0^{+}(2^{+}+) \\ f_{4}(150) & 0^{+}(2^{+}+) \\ f_{4}(150) & 0^{+}(2^{+}+) \\ \eta(150) & 0^{-}(1^{-}-) \\ \eta(1150) & 0^{+}(2^{+}+) \\ f_{4}(150) & 0^{+}(2^{+}+) \\ f_{4}(150) & 0^{-}(1^{-}-) \\ \chi_{1}(1600) & 1^{-}(1^{-}-) \\ \chi_{1}(1600) & 0^{-}(1^{-}-) \\ \chi_{2}(1670) & 0^{-}(3^{-}-) \\ \chi_{2}(1670) & 0^{-}(3^{-}-) \\ \chi_{2}(1670) & 1^{-}(2^{-}+) \\ $	• f ₁ (1420)	$0^{+}(1^{+})$	fo(2150)	$0^+(2^+)$	K ₂ (1980)	$1/2(2^{+})$	 J/ψ(1S) 	0-(1
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	 ω(1420) 	$0^{-}(1^{-})$	o(2150)	$1^{+}(1^{-})$	• K ₄ (2045)	1/2(4 ')	• $\chi_{c0}(1P)$	0+(0++
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	£(1430)	$0^{+}(2^{+}+)$	f ₀ (2200)	$0^+(0^{++})$	K ₂ (2250)	1/2(2)	• $\chi_{c1}(1P)$	$0^+(1^{++})$
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	 η(1440) 	$0^{+}(0^{-}+)$	f ₁ (2220)	$0^{+}(2^{+})^{+}$	K ₃ (2320)	1/2(3 ')	$h_c(1P)$?'(?'')
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	 a₀(1450) 	1 - (0 + +)		or 4 + +)	K ₅ (2380)	1/2(5)	• $\chi_{c2}(1P)$	0+(2++
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	 ρ(1450) 	1+(1-)	$\eta(2225)$	0+(0-+)	K4(2500)	$\frac{1}{2}(4)$	$\eta_c(2S)$	0+(0-+
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	 f₀(1500) 	$0^{+}(0^{+}+)$	$\rho_3(2250)$	1+(3)	K (3100)	r(r.)	• $\psi(25)$	0 (1
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$f_1(1510)$	$0^{+}(1^{+})$	 f₂(2300) 	$0^{+}(2^{++})$	CHAR	MED	• $\psi(3770)$	0 (1
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	 f'_2(1525) 	$0^+(2^{++})$	f ₄ (2300)	0+(4++)	(C =	±1)	$\psi(3836)$	0 (2
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	f2(1565)	$0^{+}(2^{++})$	f ₀ (2330)	$0^{+}(0^{++})$	• D [±]	$1/2(0^{-})$	• ψ(4040)	0 (1
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$h_1(1595)$	$0^{-(1+-)}$	 f₂(2340) 	0+(2++)	• D ⁰	$1/2(0^{-})$	• $\psi(4160)$	0 (1
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\pi_1(1600)$	$1^{-(1^{-}+)}$	$\rho_5(2350)$	1+(5)	 D*(2007)⁰ 	$1/2(1^{-})$	• $\psi(4415)$	1) 0
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	X(1600)	$2^{+}(2^{++})$	a ₆ (2450)	$1^{-}(6^{++})$	 D*(2010)[±] 	$1/2(1^{-})$	b	b
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$a_1(1640)$	$1^{+}(1^{++})$	f ₆ (2510)	0+(6++)	 D₁(2420)⁰ 	$1/2(1^+)$	n ₊ (15)	$0^{+}(0^{-}+$
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	f ₂ (1640)	0+(2++)			$D_1(2420)^{\pm}$	$1/2(?^{?})$	• T(15)	0-(1
• $\omega(1650)$ 0 - (1) • $\omega_3(1670)$ 0 - (3) • $\pi_2(1670)$ 1 - (2 - +) • $\pi_2(1670)$ 1 - (2 -	$\eta_2(1645)$	0+(2 - +)	(S = C)	= B = 0	 D[*]₂(2460)⁰ 	$1/2(2^{+})$	• Yto(1P)	$0^{+}(0^{+})^{+}$
• $\omega_3(1670)$ 0 ⁻ (3 ⁻) • $\pi_2(1670)$ 1 ⁻ (2 ⁻⁺) • $\pi_2(1670)$ 1 ⁻ (2 ⁺⁺) • $\pi_2(1670)$ 1 ⁻ (2 ⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺	 ω(1650) 	0-(1)	Easther Chat	,	 D[*]₂(2460)⁺ 	$1/2(2^+)$	• Xm(1P)	$0^{+}(1^{+})^{+}$
• $\pi_2(1670)$ 1 ⁻ (2 ⁻⁺) CHARMED, STRANGE (C = S = +1) • $\chi_{b0}(2P)$ 0 ⁻ (1) • $\chi_{b0}(2P)$ 0 ⁺ (0 ⁺⁺)	 ω₃(1670) 	0-(3)	Further State	25	D*(2640)±	$1/2(?^{?})$	$\bullet \chi_{b2}(1P)$	$0^{+}(2^{+})^{+}$
CHARMED, STRANGE $(C = S = +1)$ $(\chi_{b0}(2P))$ $0^+(0^+)$	 π₂(1670) 	$1^{-}(2^{-+})$					• T(25)	0-(1
$(1 = S = \pm 1)$ (Solver 1)					CHARMED,	STRANGE	• $\chi_{b0}(2P)$	$0^+(0^{++})$
(2-3-1) $(2-3-1)$ $(1+1)$					(c = 5	= ±1)	 χ_{b1}(2P) 	$0^{+}(1^{+})$
$\bullet D_s^{\pm} = 0(0^-) = \chi_{12}(2P) = 0^+(2^+)$					• D _s	0(0-)	 χ_{b2}(2P) 	$0^{+}(2^{+})$
$\bullet D_s^{*x}$ 0(?') $\bullet \tau(35)$ 0 ⁻⁽¹⁾					• D ^{*±} _s	0(?')	 <i>\(\Tau(3S))\)</i> 	0-(1
$ \bullet D_{s1}(2536)^{\pm} 0(1^+) \bullet \gamma(4S) 0^{-}(1^{-})$					• $D_{s1}(2536)^{\pm}$	$0(1^+)$	• T(4S)	0-(1
$\bullet D_{sJ}(2573)^{\pm} 0(?^{\circ}) \bullet \Upsilon(10860) 0^{-}(1^{-})$					• D _{sJ} (2573) [±]	0(?')	 \$\mathcal{T}\$(10860) 	0-(1
• <i>T</i> (11020) 0 ⁻ (1							• T(11020)	0-(1

In the following we will need: • π^0 $(u\bar{u}, d\bar{d})$ • π^{\pm} ($u\bar{d}$) • $K^{\pm}(u\bar{s})$ • K^* $(d\bar{s})$ • ϕ (s \bar{s}) • $D_S^{\pm}(c\bar{s})$ Note: every meson (almost) has it's own

unique mass...

The BABAR Experiment

■ Uses the PEPII ring at SLAC: e^+e^- Reaction



The BABAR Experiment

The BABAR Detector



Measures:

- energy and momentum of photons
- momentum of charged particles (π^{\pm} , K^{\pm} , μ^{\pm} , e^{\pm})
- identification of particle types (π^{\pm} , K^{\pm} , μ^{\pm} , e^{\pm})



Reconstruction of intermediate states

Energy and momentum of intermediate states:

Energy and momentum conservation

Energy and momentum of the intermediate state is the sum of it's daughter particles

How do we identify an intermediate state:

Invariant mass: energy of a particle in it's own rest-frame Can easily be calculated in any reference frame:

 $m_{12} = \sqrt{(E_1 + E_2)^2 - (p_{x1} + p_{x2})^2 - (p_{y1} + p_{y2})^2 - (p_{z1} + p_{z2})^2}$

with $E_{1,2}$, $p_{1,2}$ energy, momentum of daughters

Example inv. mass spectra



Data Selection

Data sample: 91 fb⁻¹ \sim 500 mill. interaction (events)

- select events with K⁺, K⁻, π[±], γ, γ +....
 K⁺K⁻π[±] should all come from the same point
 γγ → π⁰
- $K^{\mp}\pi^{\pm} \to K^*$ or $K^+K^- \to \phi$
- $K^* K^{\pm}$ or $\phi \pi^{\pm} \to D_S^{\pm}$

Then look at the inv. mass spectrum of the $D_S^{\pm}\pi^0$

Ok.... here we go:



Interpretation

- $(c\overline{s})$ state
- predicted spectrum



• low inv. mass $\rightarrow 0^+$

• But:

What's with the difference from predictions?

So, now again - why do we care?

meson are really simple objects

- 2 quarks (quark antiquark)
- (quasi-) bound states

So why do we have such problems predicting:

- masses of mesons,
- decays of mesons,
- how mesons (hadrons) are 'created'

 we need better understanding of mechanisms in QCD — need more information!