

# PH3520 / Particle Physics

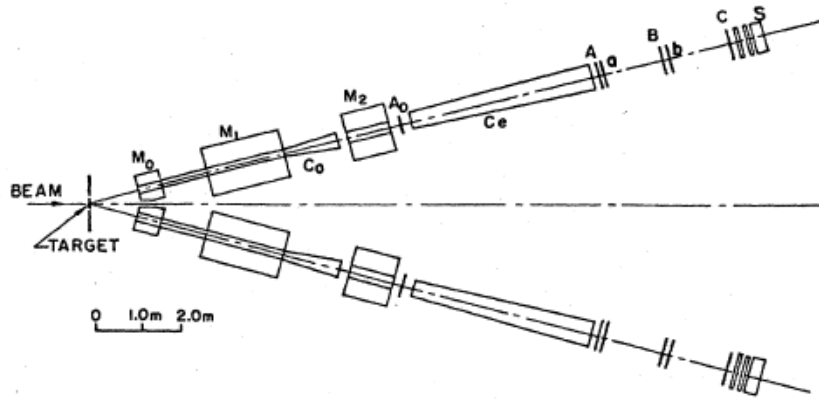
## Autumn term 2011 – week 9



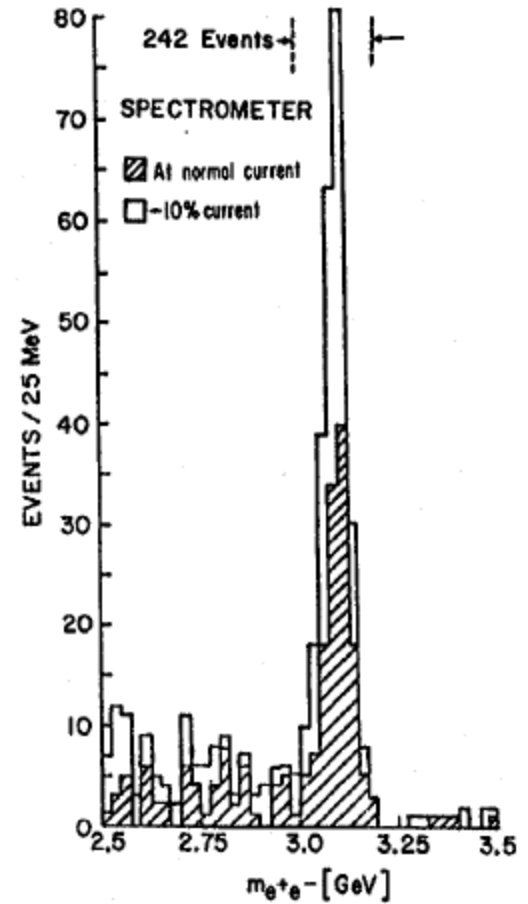
Glen Cowan  
Stewart Boogert



# Discovery of the $J$

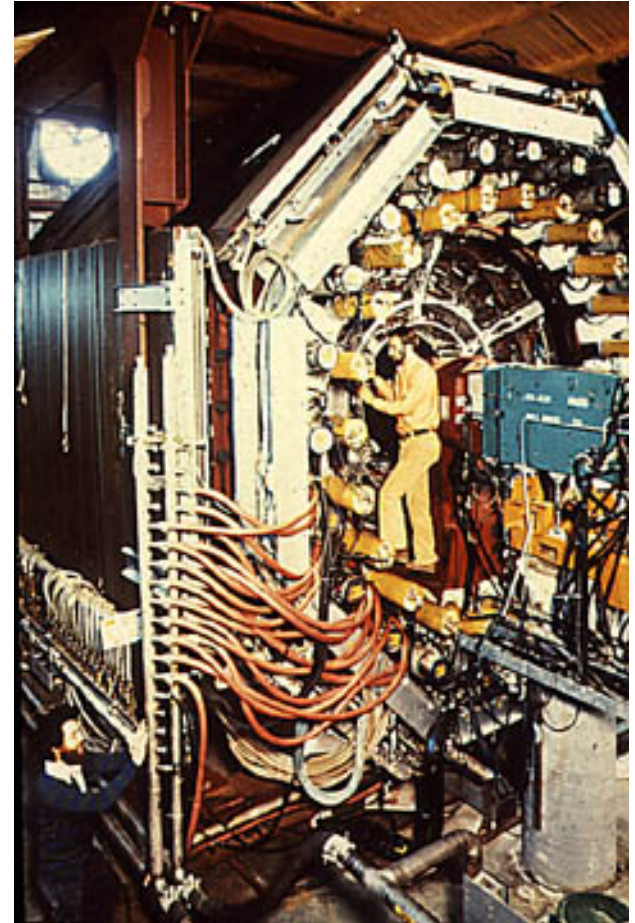


## J Discovery MIT-BNL



Samuel C.C. Ting, *Rev. Mod. Phys.* 49, 235 (1977),  
The discovery of the  $J$  particle: a personal recollection

# SPEAR and the SLAC-LBL Detector

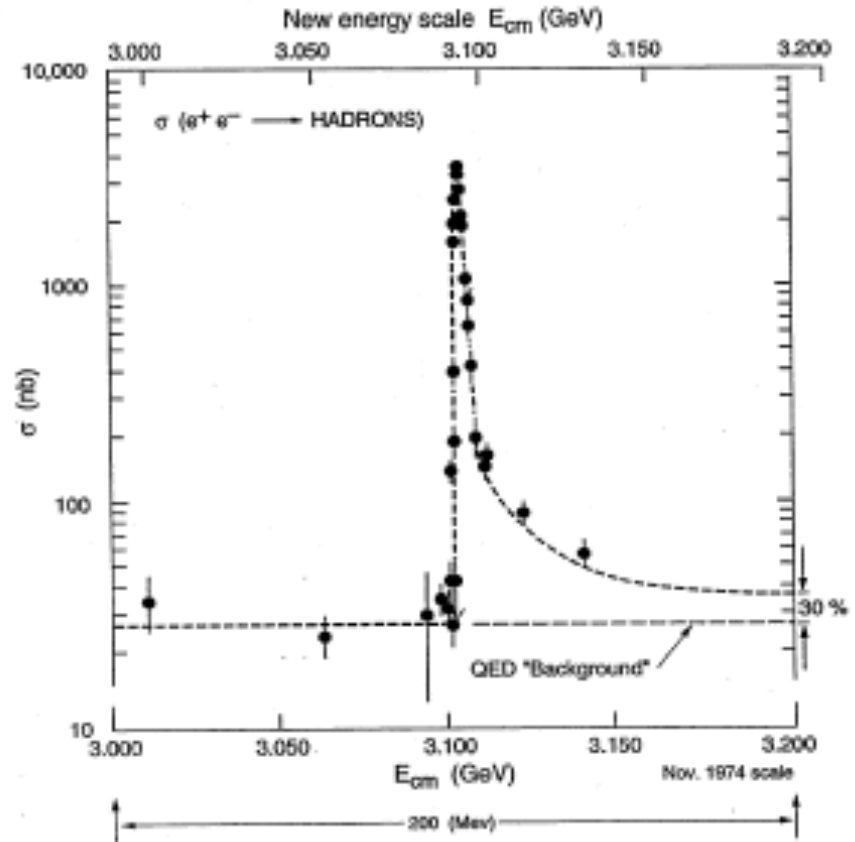
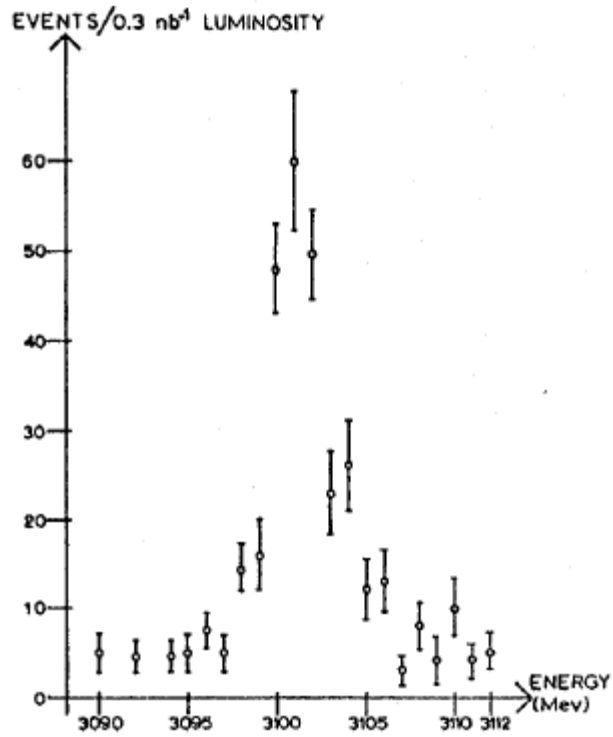




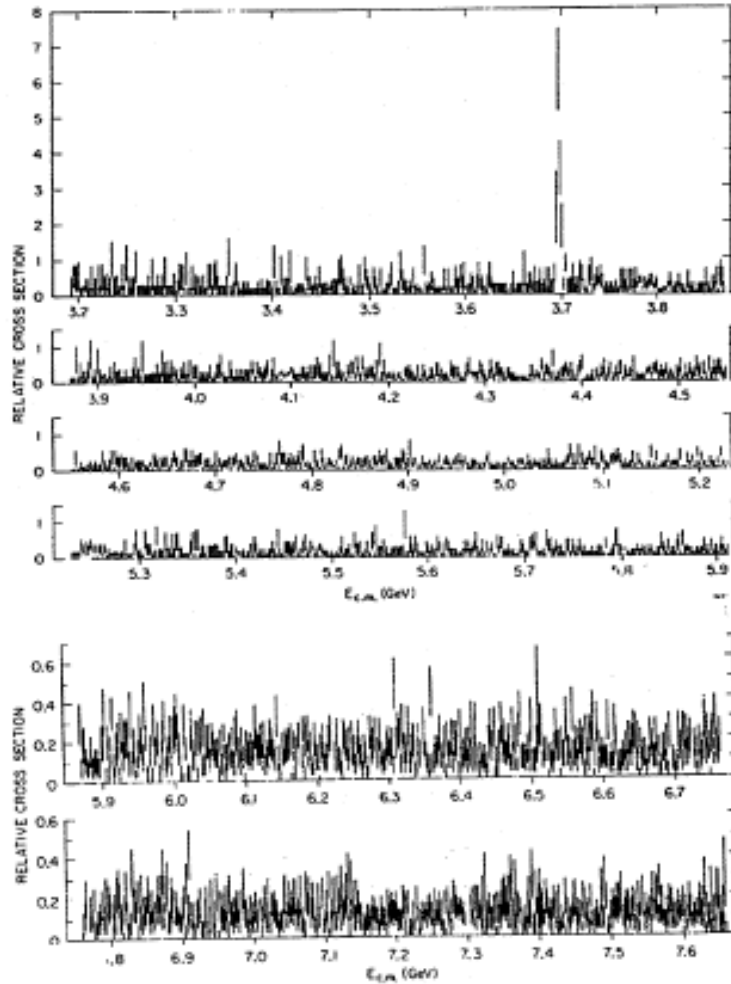


# Following up on the $\psi$

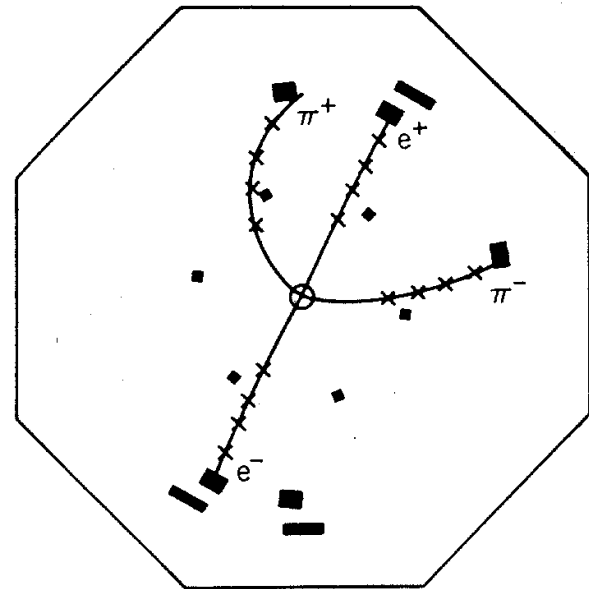
## J/ $\psi$ Confirmation Frascati



# Searching for more resonances at SPEAR



The decay  $\psi' \rightarrow \pi^+\pi^-\psi$   
with  $\psi \rightarrow e^+e^-$



G. Goldhaber, *From the  $\psi$  to Charmed Mesons*, LBL-36431

# Open charm

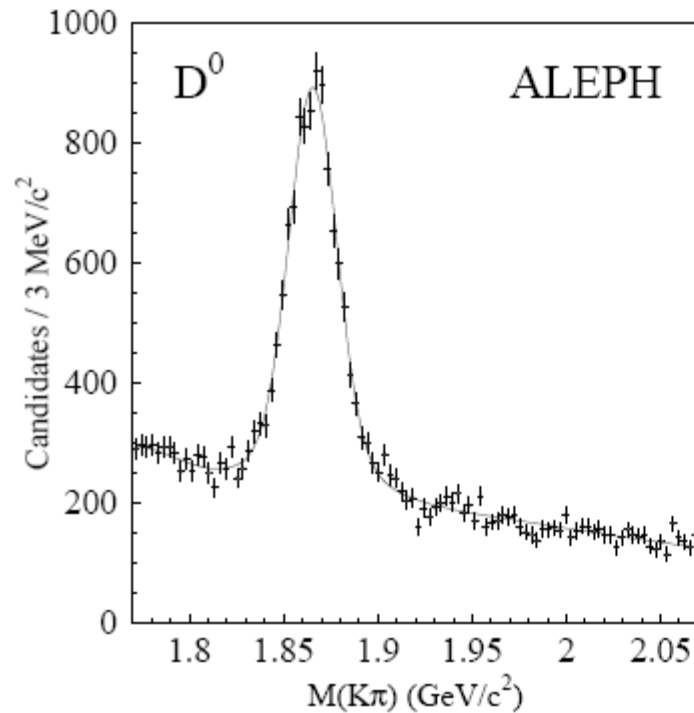


Figure 9.9: The invariant mass distribution for  $K^-\pi^+$ . The peak at 1865 MeV corresponds to the  $D^0$  meson. The width of the peak is almost entirely due to the experimental resolution for the invariant mass [56].

# Charm summary

Table 9.1: Some  $c\bar{c}$  states, their quantum numbers, masses and decay widths [6].

particle	$J^P$	mass (GeV)	$\Gamma$
$\eta_c$	$0^-$	2.980	13 keV
$J/\psi(1S)$	$1^-$	3.097	87 keV
$\psi(2S)$	$1^-$	3.686	277 keV
$\chi_{c0}(1P)$	$0^+$	3.415	15 MeV
$\chi_{c1}(1P)$	$1^+$	3.510	0.9 MeV
$\chi_{c2}(1P)$	$2^+$	3.556	2.0 MeV

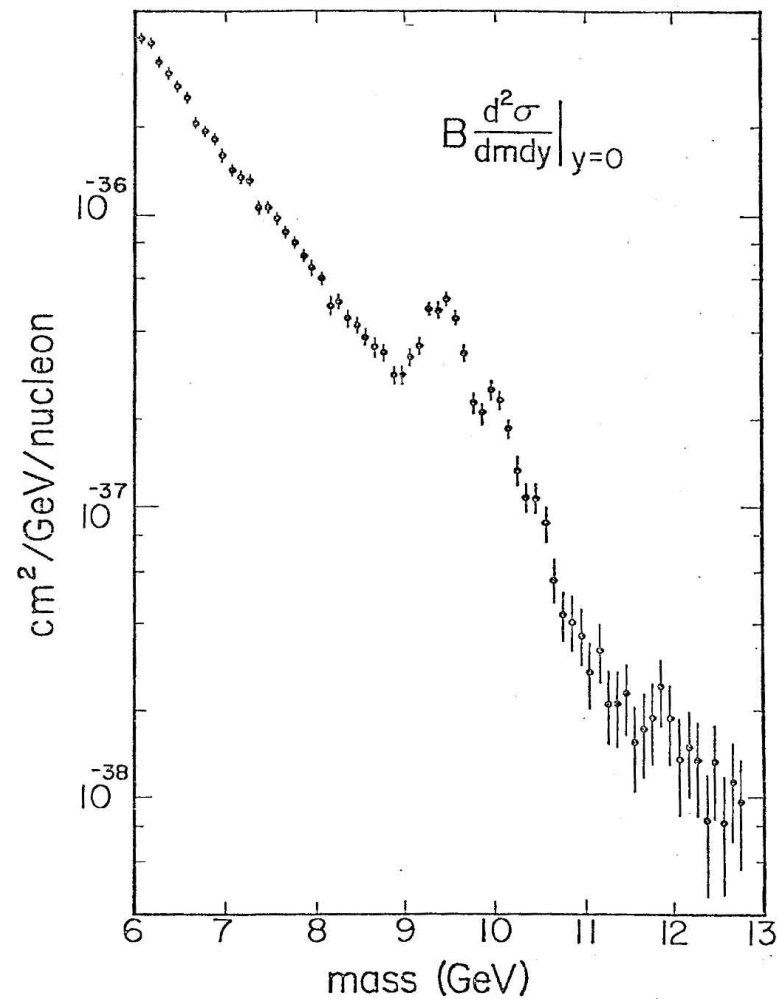
Table 9.2: Some hadrons containing  $c$  quarks and their properties [6].

particle	quarks	$J^P$	mass (GeV)	$\tau$ (s)	$c\tau$ ( $\mu\text{m}$ )
$D^\pm$	$d\bar{c}, c\bar{d}$	$0^-$	1.869	$1.05 \times 10^{-12}$	315
$D^0$	$c\bar{u}$	$0^-$	1.864	$0.413 \times 10^{-12}$	124
$D_s^\pm$	$s\bar{c}, c\bar{s}$	$0^-$	1.969	$0.496 \times 10^{-12}$	149
$\Lambda_c^+$	$udc$	$\frac{1}{2}^+$	2.285	$0.21 \times 10^{-12}$	62

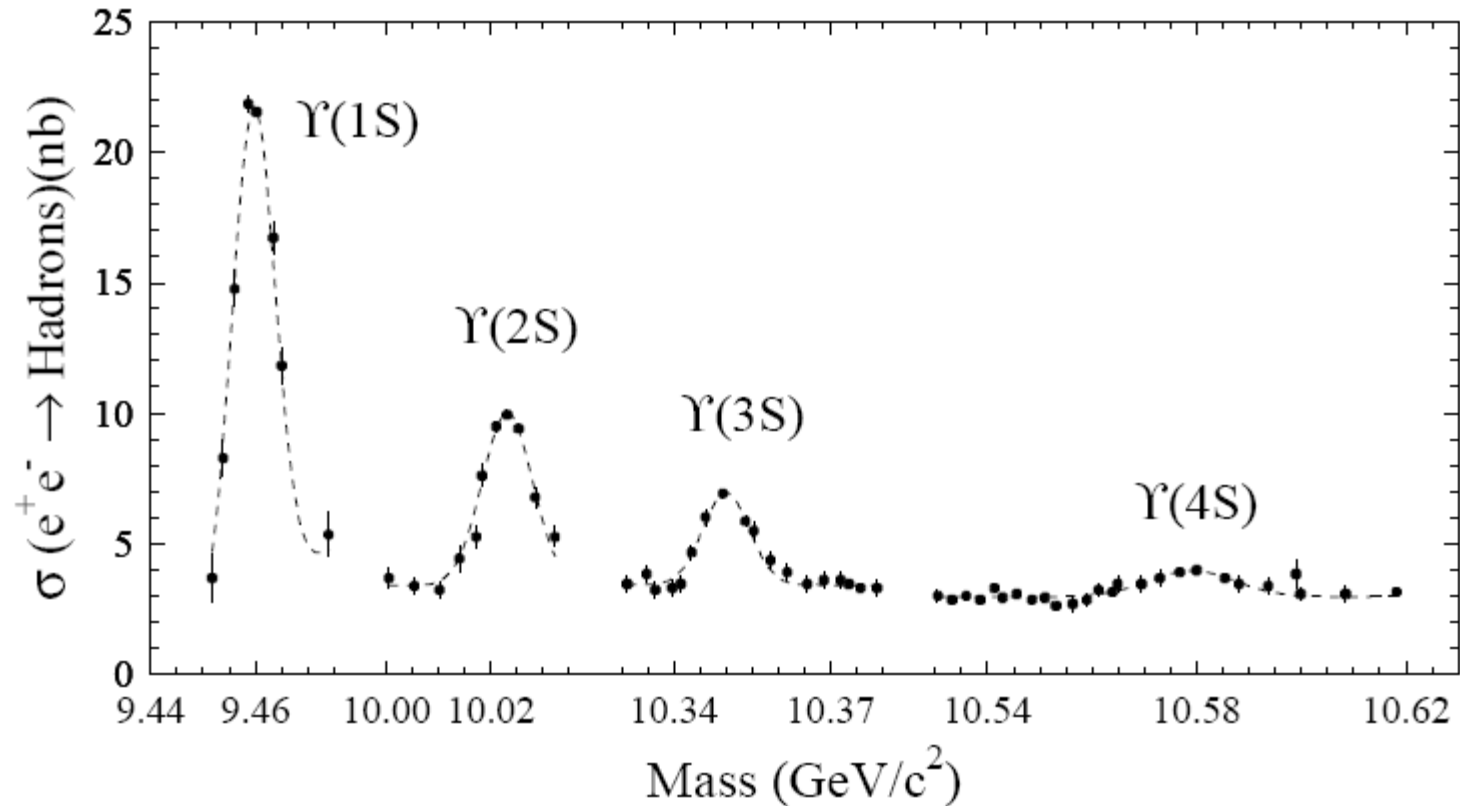


# Discovery of the Upsilon

S.W. Herb *et al.*, Phys. Rev. Lett. **39** (1977) 252.



# The Upsilon Resonances



Website of the Cornell Laboratory of Nuclear Studies, [www.lns.cornell.edu](http://www.lns.cornell.edu).

# Bottom summary

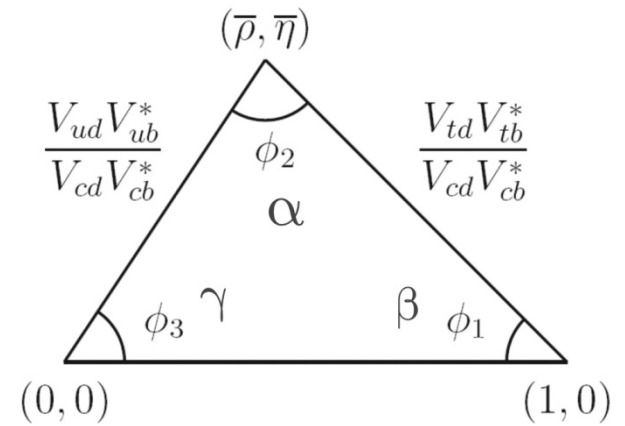
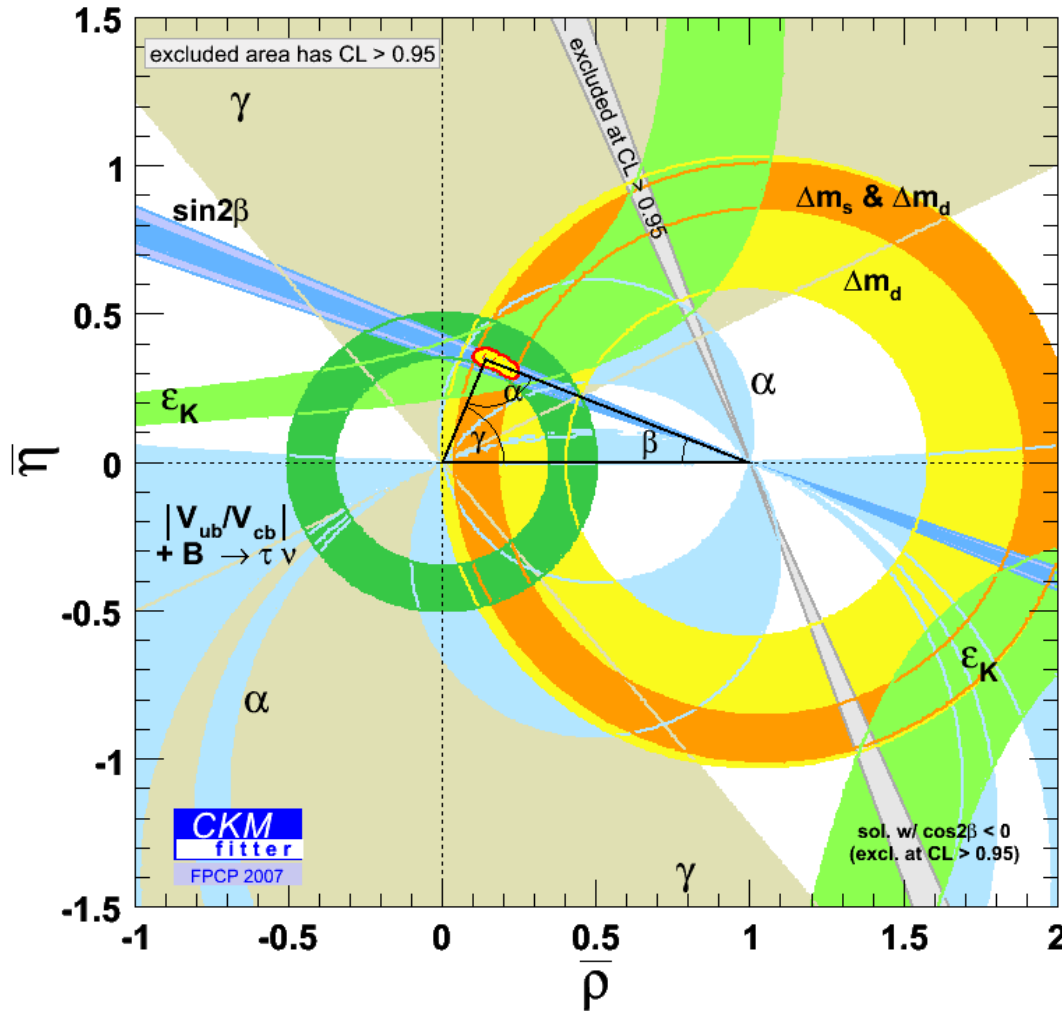
Table 9.3: Some  $b\bar{b}$  states, their quantum numbers, masses and decay widths. The widths of the  $\chi_b$  states have not yet been measured [6].

particle	$J^P$	mass (GeV)	$\Gamma$
$\Upsilon(1S)$	$1^-$	9.46	52 keV
$\Upsilon(2S)$	$1^-$	10.02	44 keV
$\Upsilon(3S)$	$1^-$	10.35	26 keV
$\Upsilon(4S)$	$1^-$	10.58	14 MeV
$\Upsilon(5S)$	$1^-$	10.86	110 MeV
$\Upsilon(6S)$	$1^-$	11.02	79 MeV
$\chi_{b0}(1P)$	$0^+$	9.86	—
$\chi_{b1}(1P)$	$1^+$	9.89	—
$\chi_{b2}(1P)$	$2^+$	9.91	—

Table 9.4: Some hadrons containing  $b$  quarks and their properties [6].

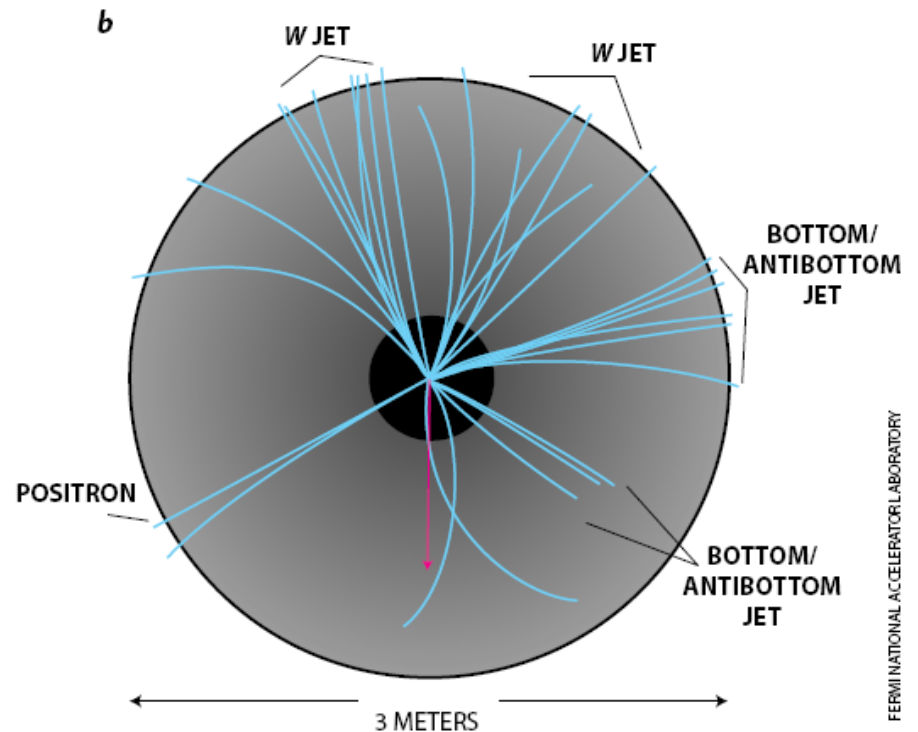
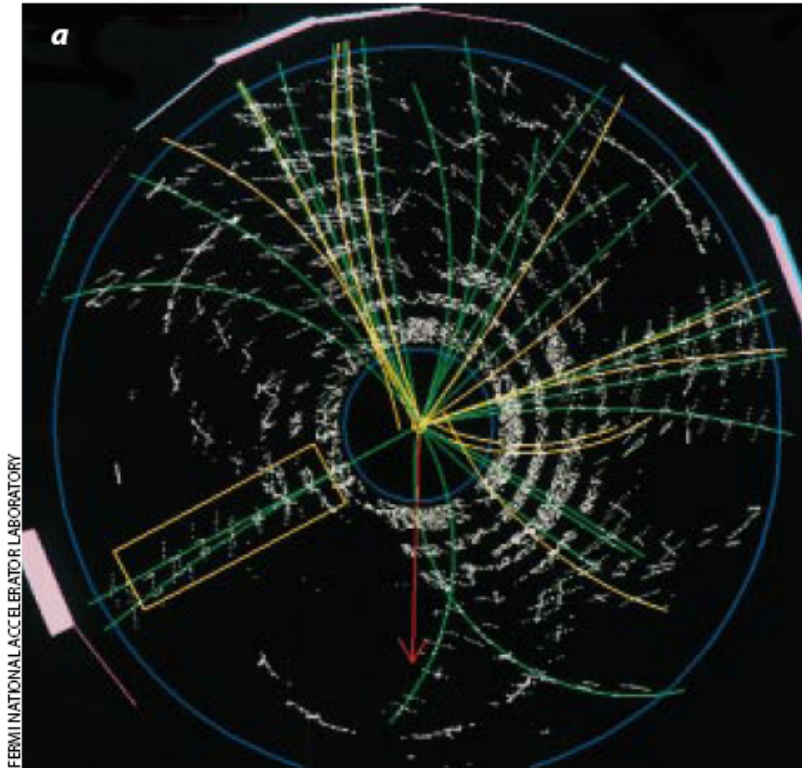
particle	quarks	$J^P$	mass (GeV)	$\tau$ (s)	$c\tau$ ( $\mu\text{m}$ )
$B^\pm$	$u\bar{b}, b\bar{u}$	$0^-$	5.28	$1.65 \times 10^{-12}$	496
$B^0$	$d\bar{b}$	$0^-$	5.28	$1.55 \times 10^{-12}$	464
$B_s^0$	$s\bar{b}$	$0^-$	5.37	$1.49 \times 10^{-12}$	448
$B_c^\pm$	$c\bar{b}, b\bar{c}$	$0^-$	6.4	$0.5 \times 10^{-12}$	150
$\Lambda_b$	$udb$	$\frac{1}{2}^+$	5.62	$1.2 \times 10^{-12}$	368

# The Unitarity Triangle



# Discovery of the top quark

Top-antitop candidate event by CDF detector in 1995.



*The Discovery of the Top Quark*, Scientific American, September 1997,  
<http://www.hep.uiuc.edu/home/tml/SciAmTop.pdf>