

Odkrycie tetrakwarku w Fermilabie (D0)

24.02.2016.

<http://arxiv.org/pdf/1602.07588v1.pdf>

Observation of a new $B_s^0 \pi^\pm$ state

http://pdg.lbl.gov

Particle Data Group on line



[About PDG](#) [PDG Authors](#) [PDG Citation](#) [Contact Us](#)

The Review of Particle Physics (2015)

[K.A. Olive et al. \(Particle Data Group\)](#), *Chin. Phys. C*, **38**, 090001 (2014) and 2015 update.



[pdgLive - Interactive Listings](#)
[Summary Tables](#)
[Reviews, Tables, Plots](#)
[Particle Listings](#)

Search

[Order Products: 2014 book & booklet](#)

[Download or Print: Book, Booklet, Website, Figures & more](#)

[Previous Editions \(& Errata\) 1957-2013](#) [Physical Constants](#)

[Errata in current edition](#)

[Astrophysical Constants](#)

[Figures in reviews](#)

[Atomic & Nuclear Properties](#)

[Mirror Sites](#)

[Astrophysics & Cosmology](#)

Most Popular

[Reviews](#)

[Data Listings](#)

PDG Outreach

[Particle Adventure & Apps](#)

[CPEP Charts](#)

[History book](#)

Non-PDG Resources

[HEP Papers](#)

[Databases & Info](#)

[Institutions & People](#)

Funded by:

[US DOE](#), [CERN](#), [MEXT \(Japan\)](#), [INFN \(Italy\)](#), [MEC \(Spain\)](#),
[IHEP & RFBR \(Russia\)](#)

All pages © 2015 Regents of the University of California

BOTTOM MESONS

$$(B = \pm 1)$$

$$B^+ = u\bar{b}, B^0 = d\bar{b}, \bar{B}^0 = \bar{d}b, B^- = \bar{u}b, \text{ similarly for } B^{*'}s$$

BOTTOM, STRANGE MESONS

$$(B = \pm 1, S = \mp 1)$$

$$B_s^0 = s\bar{b}, \bar{B}_s^0 = \bar{s}b, \text{ similarly for } B_s^{*'}s$$

B_s^0

$$I(J^P) = 0(0^-)$$

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B_s^0} = 5366.79 \pm 0.23 \text{ MeV}$$

$$m_{B_s^0} - m_B = 87.33 \pm 0.23 \text{ MeV}$$

$$\text{Mean life } \tau = (1.510 \pm 0.005) \times 10^{-12} \text{ s}$$

$$c\tau = 452.7 \mu\text{m}$$



typowe czasy życia

μ

$$J = \frac{1}{2}$$

Mass $m = 105.6583715 \pm 0.0000035$ MeV

$e^- \bar{\nu}_e \nu_\mu$

Mean life $\tau = (2.1969811 \pm 0.0000022) \times 10^{-6}$ s

τ

$$J = \frac{1}{2}$$

Mass $m = 1776.86 \pm 0.12$ MeV

$(m_{\tau^+} - m_{\tau^-})/m_{\text{average}} < 2.8 \times 10^{-4}$, CL = 90%

Mean life $\tau = (290.3 \pm 0.5) \times 10^{-15}$ s

π^\pm

$$I^G(J^P) = 1^-(0^-)$$

Mass $m = 139.57018 \pm 0.00035$ MeV (S = 1.2)

$\mu^+ \nu_\mu$

Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s (S = 1.2)

π^0

$$I^G(J^{PC}) = 1^-(0^-+)$$

Mass $m = 134.9766 \pm 0.0006$ MeV (S = 1.1)

$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV

2γ

Mean life $\tau = (8.52 \pm 0.18) \times 10^{-17}$ s (S = 1.2)

czas życia a szerokość

stała „konwersji” $\hbar/2\pi = 6.58 \times 10^{-22}$ MeV s

$$\Gamma = \frac{\hbar}{\tau}$$

$$\pi^0 : 8.5 \times 10^{-17} \text{ s} = 7.7 \text{ eV}$$

$$\rho : 149.1 \text{ MeV} = 4.4 \times 10^{-24} \text{ s}$$

$$\phi : 4.27 \text{ MeV} = 1.55 \times 10^{-22} \text{ s}$$

$$\Delta : 120 \text{ MeV} = 5.4 \times 10^{-24} \text{ s}$$

$$J/\psi : 92.9 \text{ keV} = 7.1 \times 10^{-21} \text{ s}$$

BOTTOM, STRANGE MESONS

$$(B = \pm 1, S = \mp 1)$$

$$B_s^0 = s\bar{b}, \bar{B}_s^0 = \bar{s}b, \quad \text{similarly for } B_s^{*'}s$$

B_s^0

$$I(J^P) = 0(0^-)$$

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B_s^0} = 5366.79 \pm 0.23 \text{ MeV}$$

B_s^0 DECAY MODES

Fraction (Γ_i/Γ)

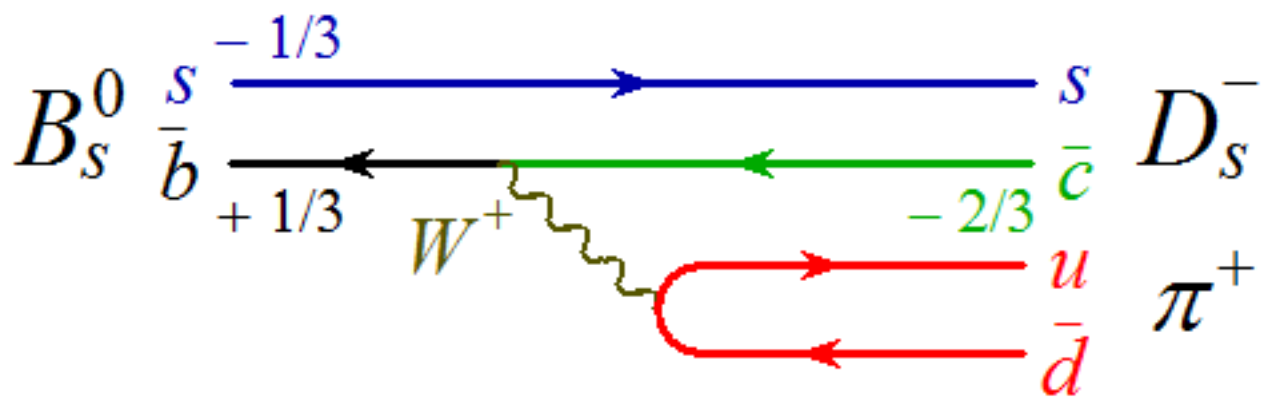
D_s^- anything

(93 \pm 25) %

CHARMED, STRANGE MESONS

$$(C = S = \pm 1)$$

$$D_s^+ = c\bar{s}, D_s^- = \bar{c}s, \quad \text{similarly for } D_s^{*'}s$$



W może się rozpaść na cokolwiek

BOTTOM, STRANGE MESONS

$$(B = \pm 1, S = \mp 1)$$

$$B_s^0 = s\bar{b}, \bar{B}_s^0 = \bar{s}b, \quad \text{similarly for } B_s^{*'}\text{'s}$$

B_s^0

$$I(J^P) = 0(0^-)$$

I, J, P need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B_s^0} = 5366.79 \pm 0.23 \text{ MeV}$$

B_s^0 DECAY MODES

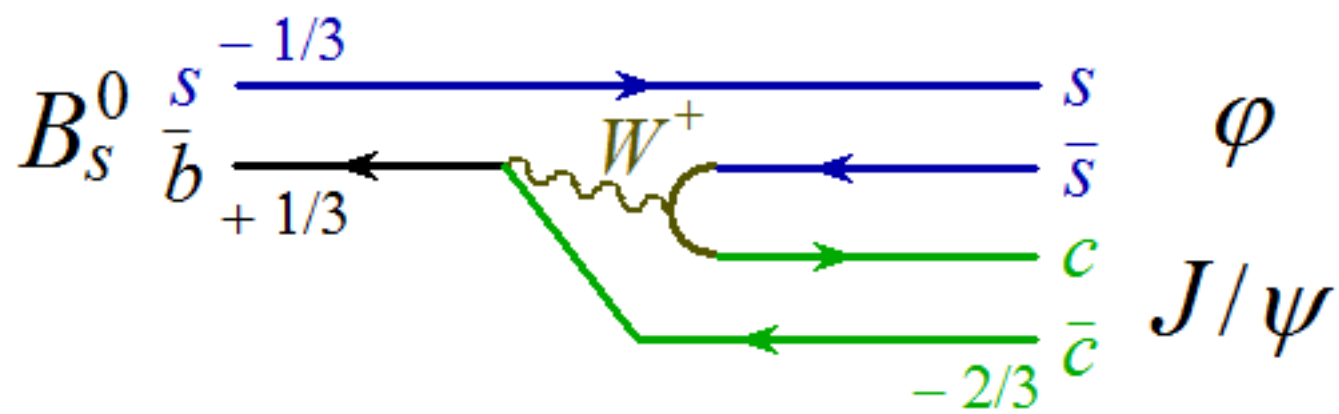
Fraction (Γ_i/Γ)

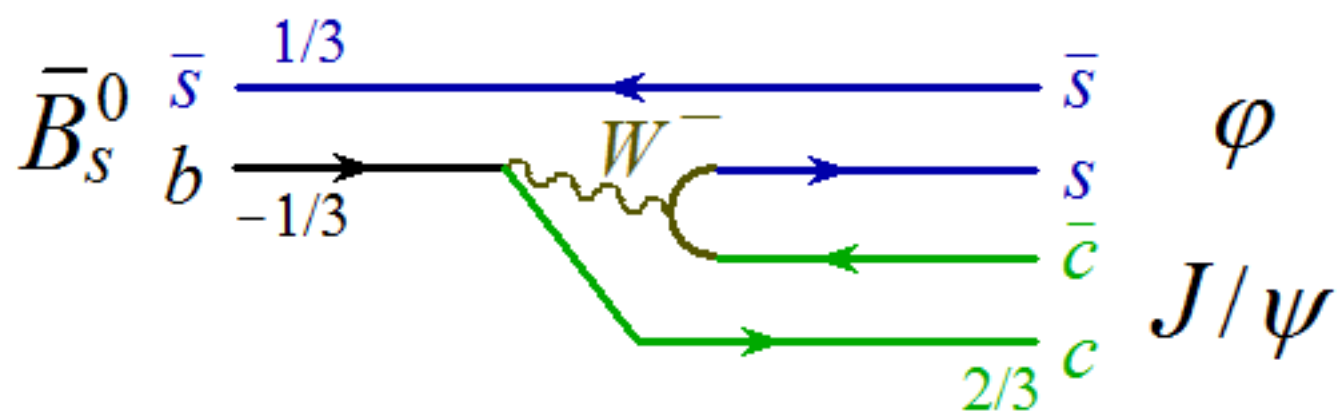
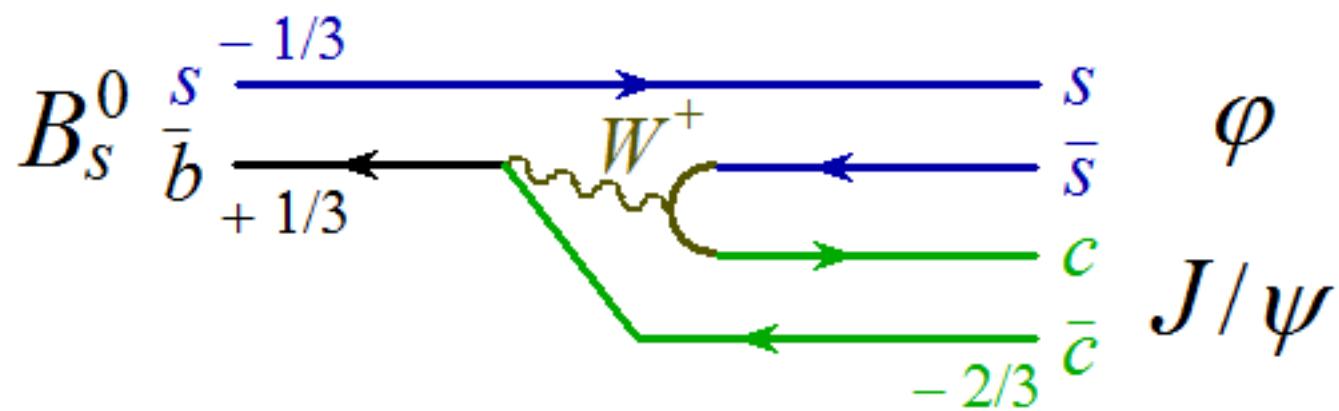
D_s^- anything

(93 \pm 25) %

$J/\psi(1S)\phi$

(1.08 \pm 0.09) $\times 10^{-3}$





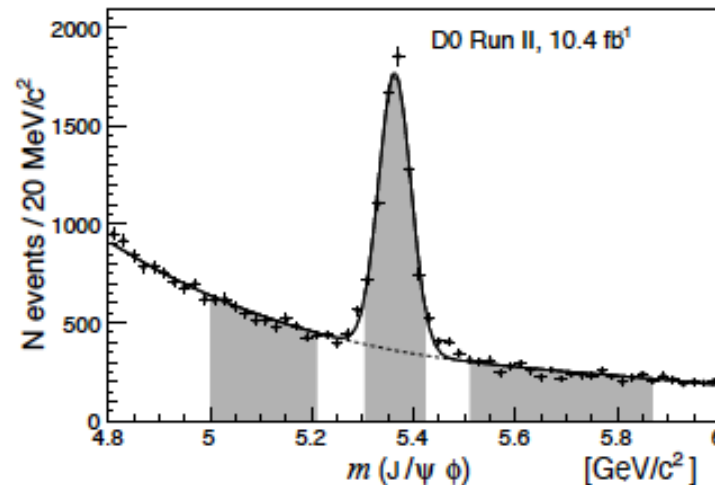
$J/\psi(1S)\phi$ $(1.08 \pm 0.09) \times 10^{-3}$ **$J/\psi(1S)$ DECAY MODES**Fraction (Γ_i/Γ)

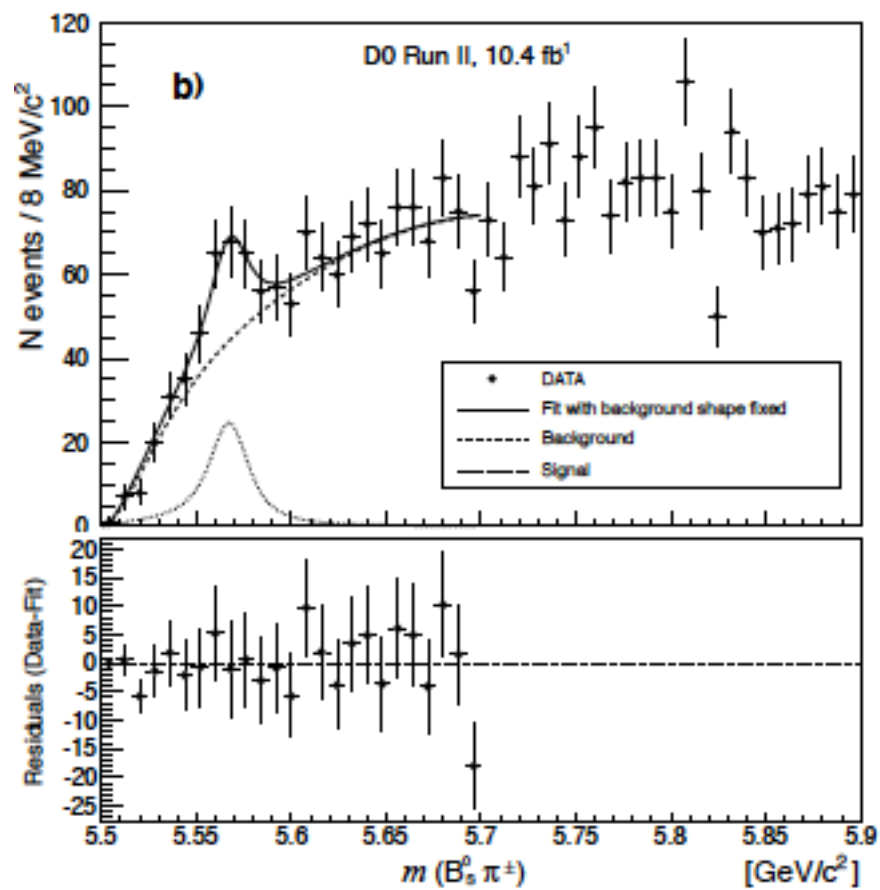
Cor

hadrons

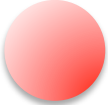

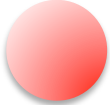






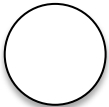
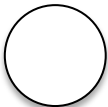
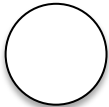
 $(87.7 \pm 0.5) \%$ virtual $\gamma \rightarrow$ hadrons $(13.50 \pm 0.30) \%$ ggg $(64.1 \pm 1.0) \%$ γgg $(8.8 \pm 1.1) \%$ e^+e^- $(5.971 \pm 0.032) \%$ $e^+e^- \gamma$ [a] $(8.8 \pm 1.4) \times 10^{-3}$ $\mu^+ \mu^-$ $(5.961 \pm 0.033) \%$ **$\phi(1020)$ DECAY MODES**Fraction (Γ_i/Γ) K^+K^- $(48.9 \pm 0.5) \%$

w ten sposób
identyfikujemy
mezon B_s^0





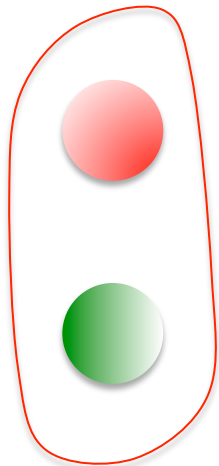
Składniki materii, oddziaływania

	u [$q = 2/3$] 3 MeV		c 1 275		t 173 000	
	d [$q = -1/3$] 5 MeV		s 95		b 4 660	
	e [$q = 1$] 0.5 MeV		μ 105		τ 1 777	spin 1/2
	ν_e [$q = 0$] ?		ν_μ ?		ν_τ ?	

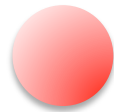
0, 80 000, 71 000, 0
foton (γ), W^\pm , Z^0 , gluony, grawitacja
 spin 1

spin 0
bozon Higgosa
 125 000

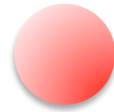
Składniki materii, oddziaływania



u [$q = 2/3$]
3 MeV



c
1 275



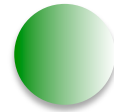
t
173 000



d [$q = -1/3$]
5 MeV



s
95



b
4 660

spin 1/2



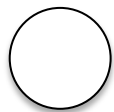
e [$q = 1$]
0.5 MeV



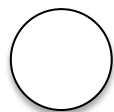
μ
105



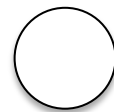
τ
1 777



ν_e [$q = 0$]
?



ν_μ
?



ν_τ
?

0, 80 000, 71 000, 0

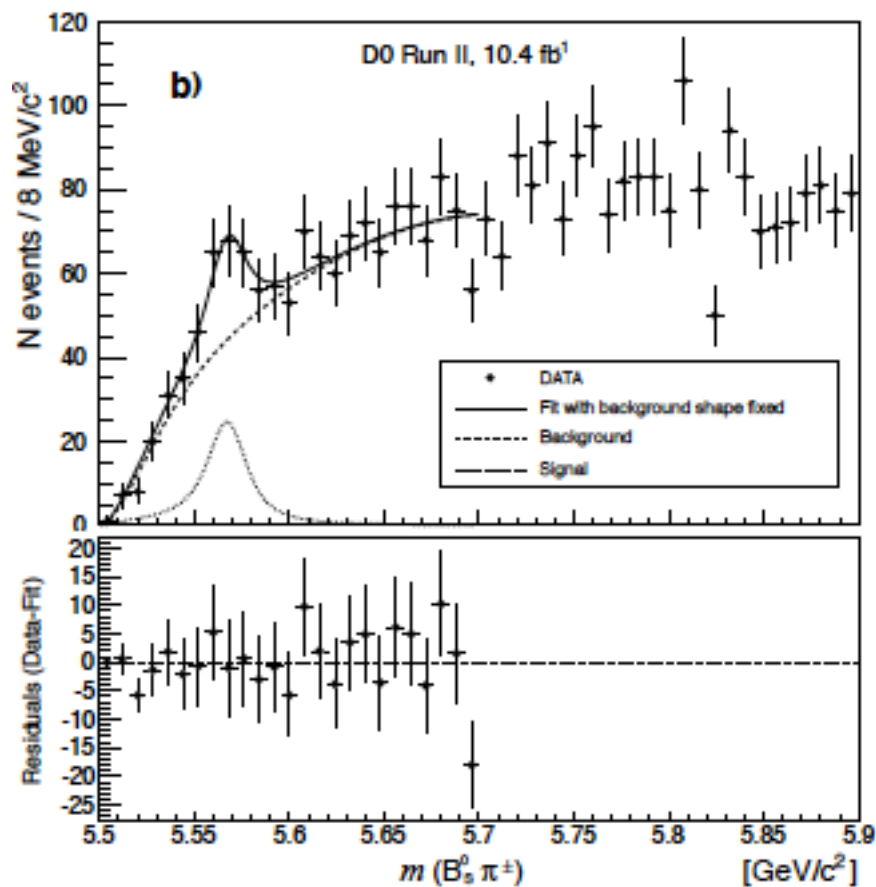
foton (γ), W[±], Z⁰, gluony, grawitacja

spin 1

spin 0

bozon Higgosa

125 000



$\bar{b}s \quad \bar{u}d$

$\bar{b}s \quad u\bar{d}$

$b\bar{s} \quad \bar{u}d$

$b\bar{s} \quad u\bar{d}$

In summary, a structure is observed in the $B_s^0\pi^\pm$ invariant mass spectrum near threshold with a statistical significance, including the look-elsewhere effect, of 6.1σ . When the systematic uncertainties are included, the significance of the observed signal is 5.1σ . This structure may be interpreted as a tetraquark state with four different valence quark flavors, b, s, u, d . The mass and natural width of the observed $X(5568)$ state are $m = 5567.8 \pm 2.9$ (stat) $_{-1.9}^{+0.9}$ (syst) MeV/ c^2 and $\Gamma = 21.9 \pm 6.4$ (stat) $_{-2.5}^{+5.0}$ (syst) MeV/ c^2 .

In summary, a structure is observed in the $B_s^0 \pi^\pm$ invariant mass spectrum near threshold with a statistical significance, including the π - π -elsewhere effect, of 6.1σ . When the systematic uncertainties are included, the significance of the observed signal is 5.1σ . This structure may be interpreted as a tetraquark state with four different valence quark flavors, b, s, u, d . The mass and natural width of the observed $X(5568)$ state are $m = 5577.8 \pm 2.0$ (stat) $^{+0.9}$ (syst) MeV/ c^2 and $\Gamma = 21.9 \pm 6.4$ (stat) $^{+5.0}$ (syst) $_{-2.5}$ MeV/ c^2 .