

## QUARKS

The  $u$ -,  $d$ -, and  $s$ -quark masses are estimates of so-called “current-quark masses,” in a mass-independent subtraction scheme such as  $\overline{MS}$  at a scale  $\mu \approx 2$  GeV. The  $c$ - and  $b$ -quark masses are the “running” masses in the  $\overline{MS}$  scheme. For the  $b$ -quark we also quote the 1S mass. These can be different from the heavy quark masses obtained in potential models.

**u**

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

$$m_u = 1.7\text{--}3.1 \text{ MeV} \quad \text{Charge} = \frac{2}{3} e \quad I_z = +\frac{1}{2}$$

$$m_u/m_d = 0.35\text{--}0.60$$

**d**

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

$$m_d = 4.1\text{--}5.7 \text{ MeV} \quad \text{Charge} = -\frac{1}{3} e \quad I_z = -\frac{1}{2}$$

$$m_s/m_d = 17 \text{ to } 22$$

$$\overline{m} = (m_u + m_d)/2 = 3.0\text{--}4.8 \text{ MeV}$$

**s**

$$I(J^P) = 0(\frac{1}{2}^+)$$

$$m_s = 100^{+30}_{-20} \text{ MeV} \quad \text{Charge} = -\frac{1}{3} e \quad \text{Strangeness} = -1$$

$$m_s / ((m_u + m_d)/2) = 22 \text{ to } 30$$

**c**

$$I(J^P) = 0(\frac{1}{2}^+)$$

$$m_c = 1.29^{+0.05}_{-0.11} \text{ GeV} \quad \text{Charge} = \frac{2}{3} e \quad \text{Charm} = +1$$

**b**

$$I(J^P) = 0(\frac{1}{2}^+)$$

$$\text{Charge} = -\frac{1}{3} e \quad \text{Bottom} = -1$$

$$m_b(\overline{MS}) = 4.19^{+0.18}_{-0.06} \text{ GeV}$$

$$m_b(1S) = 4.67^{+0.18}_{-0.06} \text{ GeV}$$

**t**

$$I(J^P) = 0(\frac{1}{2}^+)$$

$$\text{Charge} = \frac{2}{3} e \quad \text{Top} = +1$$

Mass  $m = 172.9 \pm 0.6 \pm 0.9$  GeV <sup>[a]</sup> (direct observation of top events)

Full width  $\Gamma = 2.0_{-0.6}^{+0.7}$  GeV

$\Gamma(Wb)/\Gamma(Wq(q = b, s, d)) = 0.99_{-0.08}^{+0.09}$

<b>t DECAY MODES</b>	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level	$P$ (MeV/c)
$Wq(q = b, s, d)$			—
$Wb$			—
$\ell\nu_\ell$ anything	[b,c] (9.4±2.4) %		—
$\gamma q(q=u,c)$	[d] < 5.9	$\times 10^{-3}$	95%
<b><math>\Delta T = 1</math> weak neutral current (T1) modes</b>			
$Zq(q=u,c)$	T1 [e] < 3.7	%	95%

### **$b'$ (4<sup>th</sup> Generation) Quark, Searches for**

Mass  $m > 190$  GeV, CL = 95% ( $p\bar{p}$ , quasi-stable  $b'$ )  
 Mass  $m > 199$  GeV, CL = 95% ( $p\bar{p}$ , neutral-current decays)  
 Mass  $m > 128$  GeV, CL = 95% ( $p\bar{p}$ , charged-current decays)  
 Mass  $m > 46.0$  GeV, CL = 95% ( $e^+e^-$ , all decays)

### **$t'$ (4<sup>th</sup> Generation) Quark, Searches for**

Mass  $m > 256$  GeV, CL = 95% ( $p\bar{p}$ ,  $t'\bar{t}'$  prod.,  $t' \rightarrow Wq$ )

### **Free Quark Searches**

All searches since 1977 have had negative results.

### NOTES

[a] Based on published top mass measurements using data from Tevatron Run-I and Run-II. Including also the most recent unpublished results from Run-II, the Tevatron Electroweak Working Group reports a top mass of  $173.1 \pm 0.6 \pm 1.1$  GeV. See the note "The Top Quark" in the Quark Particle Listings of this *Review*.

[b]  $\ell$  means  $e$  or  $\mu$  decay mode, not the sum over them.

[c] Assumes lepton universality and  $W$ -decay acceptance.

[d] This limit is for  $\Gamma(t \rightarrow \gamma q)/\Gamma(t \rightarrow Wb)$ .

[e] This limit is for  $\Gamma(t \rightarrow Zq)/\Gamma(t \rightarrow Wb)$ .