Study of dimuon final states in the decay of B and Υ

Claus Buszello for the DØ Collaboration ICHEP 2012, Melbourne





Tevatron





X_b Search

- Search for particles decaying to $\Upsilon(1S)\gamma \rightarrow \mu^+\mu^- e^+e^-$
- Between $\chi_b(2P)$ and the BB threshold





· BB threshold · · · · ·

χь**(2P)**

χ_b(ΙΡ)

I⁺⁺ 2⁺⁺







Tracking



C. Buszello - Study of dimuon final states



$\eta = 2$ η = 3

7

Tracking



Differences Δz^0 used to remove background

C. Buszello - Study of dimuon final states



$\eta = 2$ η = 3



Vertexing

- Using transverse IPS: S_T
 - $S_T(\mu)$ small
 - S_T(e) large
 - $S_{T}(\mu) < S_{T}(e)$
 - $S_T(\gamma)$ small
- gamma conversion in the "right" direction
 - $\cos_{xy}(\theta) > .8$
- Vertexing Cuts optimised on χ_c





Vertexing

- Using transverse IPS: S_T
 - $S_T(\mu)$ small
 - S_T(e) large
 - $S_{T}(\mu) < S_{T}(e)$
 - $S_T(\gamma)$ small
- gamma conversion in the "right" direction
 - $\cos_{xy}(\theta) > .8$
- Vertexing Cuts optimised on χ_c



Y Selection

- Two track matched muons
 - Segments in- and outside of toroid magnet
 - Opposite sign
 - рт > 1.5 GeV
 - χ^2_V < 7
- Di-muon vertex
 - $\chi^2 < |4|$
 - 9.1 < $m_{\mu\mu}/GeV$ < 9.7



y Selection

- Pair of well measured tracks
 - Associated to same PV
 - Opposite Sign
 - p_T > 180 MeV
 - $\chi^2_V > 7$
- Di-electron Vertex
 - $\chi^2 < |4|$
 - $\chi^2 V < 16$
 - m_{ee} < 80 MeV



C. Buszello - Study of dimuon final states



DØ, I.3 fb⁻¹

Yy Selection

- All particles, tracks associated to the same PV
- Good $\mu\mu\gamma$ Vertex
 - $\chi^2 < 16$
- Tracks close in z
 - $\Delta z(e, \gamma) < 0.8$ cm
 - $\Delta z(e,\Upsilon) < 1.2 \text{ cm}$
- **p**_T(μμγ) > 5 GeV



Yy Selection

- All particles, tracks associated to the same PV
- Good $\mu\mu\gamma$ Vertex
 - $\chi^2 < 16$
- Tracks close in z
 - $\Delta z(e, \gamma) < 0.8$ cm
 - $\Delta z(e,\Upsilon) < 1.2 \text{ cm}$
- pτ(μμγ) > 5 GeV
- ⇒ Third peak near threshold



round

- Using mass difference $M_{\mu\mu\gamma} M_{\mu\mu} (+ m_{\Upsilon(IS)})$
- Mix events: one Υ and one Υ from different events \Rightarrow Good description of combinatoric BKG
- Υ sidebands and same sign muons show no sign of excess anywhere





X_b Mass

- Unbinned extended likelihood fit
 - Signals: Crystal Ball Functions (N,μ,σ,α,k) Gaussian (N,μ,σ) from μ - $\alpha\sigma$ to $+\infty$ Power law (k) from $-\infty$ to μ - $\alpha\sigma$
 - Background: exponential with turn-on

 $B \cdot (1 - 1./(s \cdot x + s_0)) \cdot e^{-\tau x} + o$

- Masses of known χ_b states linked: $s_m \cdot m(\chi_b(1P,2P))$
- Widths of gaussians scaled linearly

$M = M_{\mu\mu\gamma}$ - $M_{\mu\mu} + m(\Upsilon(1S))$	Main	
= 10.551 GeV	χ _{b1,2,3} mixture	
±.014(stat.) GeV	mass scale s _m	
$\pm .017$ (syst.) GeV	Bkg model	



systematics 0.013 GeV 0.010 GeV 0.005 GeV

Significance

- Using the same fit
 - Likelihood ratio of fit with and without 3rd peak
 - p-value from χ^2 distribution (NDF $\chi^2 = \Delta$ NDF_{LL})
 - → Local significance: 6.1σ
 - → Look elsewhere effect: -0.3 σ



Interpretation

- DØ currently only sees decay to $\Upsilon(1S)$
- ... calls it a narrow structure (X_b)
 - Branching ratios?
 - Spin structure?
 - Just one state?
- DØ's mass:

10.551 GeV ±0.009 GeV (stat.)±0.017 GeV (syst.)

Υ**(4S)** Υ**(3S)** Υ(2S) Υ**(IS)** 0++

Kwong, Rosner Phys.Rev.D38:279,1988 $m(\chi_b(3P)) \approx 10.520 \,\text{GeV}$

Törnqvist Phys.Lett.B590:209-215,2004 $m(BB^*) \approx 10.545 \, GeV$





Comparison

- Atlas also sees decay to $\Upsilon(2S)$
- ... interprets it as:
 - χ_b(3P)

ATLAS' mass:

 I0.530 GeV ±0.005 GeV
 (stat.)±0.009 GeV (syst.)







From: Full Data-Set To: DO b-physics Do NOT Open before ICHEP approval

mai states





	June 2010	
Dataset	6.1 fb ⁻¹	
Preselection	Cut based	Cu
Background suppression	ANN	BI
Limit on $\mathcal{B}(B_s \rightarrow \mu \mu)$	< 5.1 x 10 ⁻⁸	e





marv



• 6 σ observation of narrow structure $X_b \rightarrow \Upsilon(1S)\gamma$ • $m(X_b) = 10.551 \pm 0.009$ (stat.) ± 0.017 (syst.) GeV



$B_s \rightarrow \mu\mu$ update to be









x [cm]





x [cm]

Correlation







