Evidence for $B_s^{(*)}$ Production at the Y(5S)

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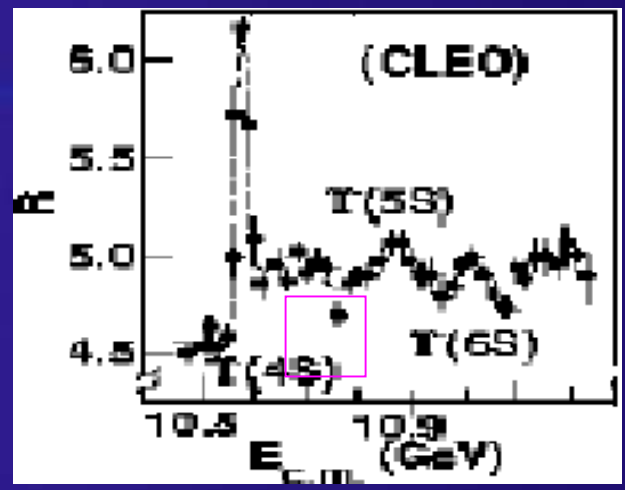
Outline:

- Physics Motivation
- Analysis:
  The Inclusive D_s Spectrum.
- Exclusive Bs reconstruction
- Inclusive D^0 & D^+ yields of η, η' & ϕ
- Conclusions & Summary.

Y(5S), Knowledge & Expectations

1. Knowledge from CLEO 1.5

- $\sigma(Y(5S))/\sigma(cont) \sim 1/10$.
- $L=116\ pb^{-1} \rightarrow$ No direct measurement of B_s production cross section.



2. Expectations:

- Decay channels:

$B_d\bar{B}_d$, $\bar{B}_d B_d^*$, $\bar{B}_d^* B_d^*$, $B_s\bar{B}_s$, $B_s B_s^*$,
$B_s^*\bar{B}_s^*$, $\bar{B}_d B_d \pi\pi$, $B_d B_d \pi$, $B_d B_d^* \pi$, $B^0 B^+ \pi$.

- The Unitarized Quark Model (UQM):

The B cross section dominated by B^*B^* and $B_s^*B_s^*$; $B_s^{(*)}B_s^{(*)}$ production ~ 1/3 of the total Y(5S) cross section.

$\sigma(B_s\bar{B}_s) + \sigma(B_s\bar{B}_s^*) + \sigma(B_s^*\bar{B}_s^*) \sim 0.1nb$.

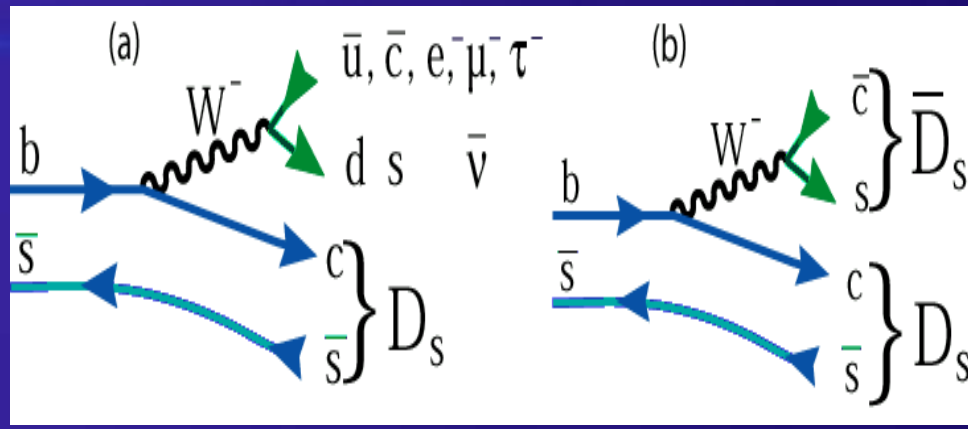
- Other models: Predict a smaller Y(5S) $\rightarrow B_s^*\bar{B}_s^*$ component

Can we Use the Y(5S) to study B_s?

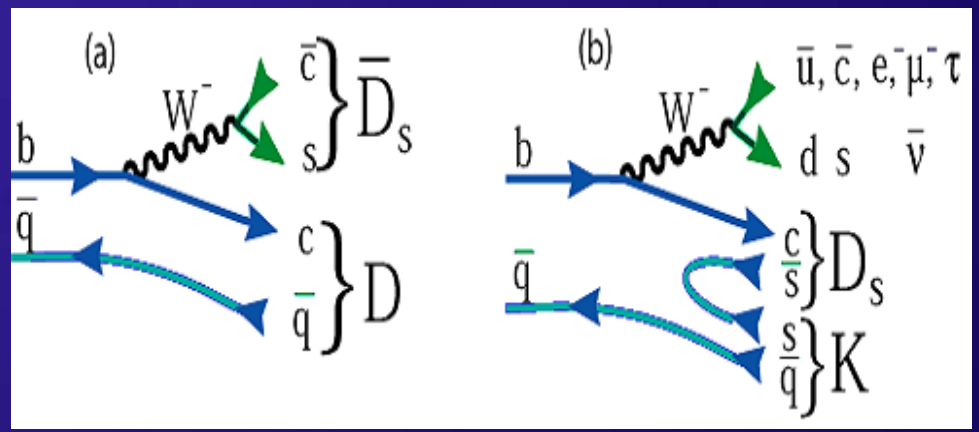
- *Need to investigate the composition of the Y(5S) and see how much B_s is produced*
- *If enough is found, some properties of the B_s can be determined, i.e. semileptonic decay rates, etc…*
- *We will use here inclusive D_s yields as a measure of B_s production*

Inclusive $D_s^{\pm}$ Yields

In the simple spectator model the B_s decays into the D_s nearly all the time. "Normal" B's have smaller rates, in fact $\mathcal{B}(B \to D_s X) = (10.5 \pm 2.6 \pm 2.5)\%$,



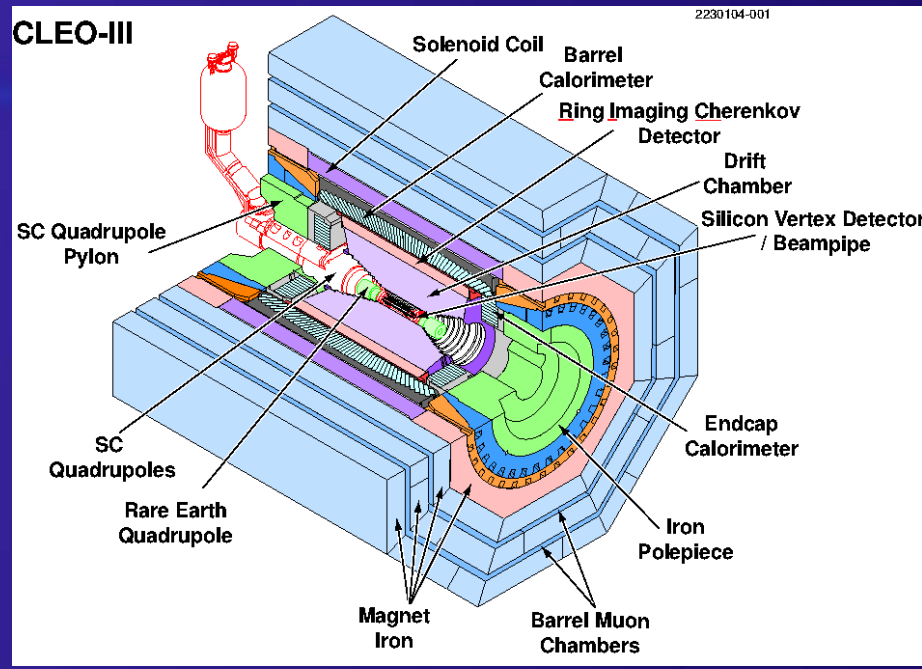
Dominant Decay Diagrams for a B_s meson into D_s meson



Dominant Decay Diagrams for a B meson into D_s meson

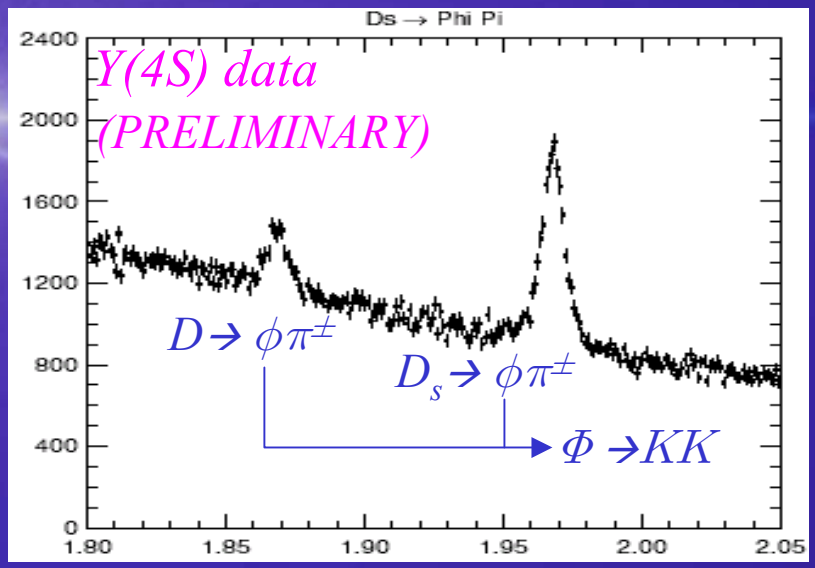
Data Sample from CLEO III

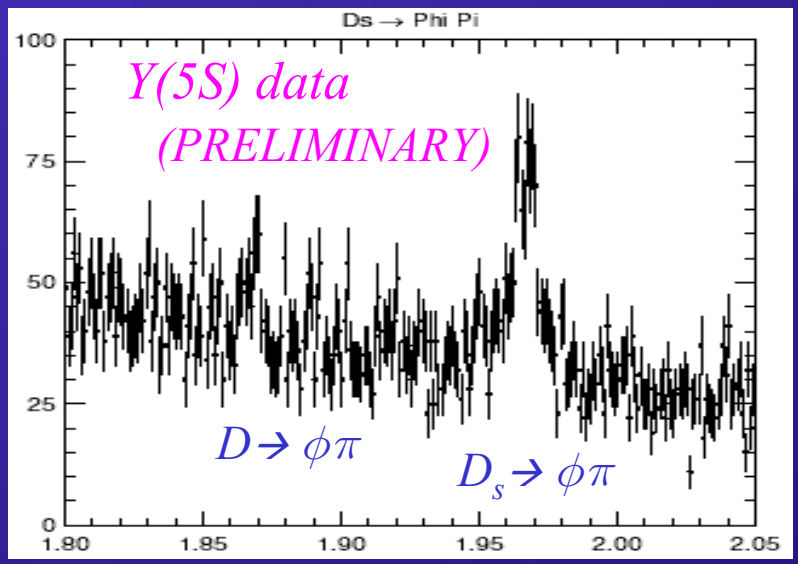
We used all the data we collected near or at the Y(4S) resonance and all the data taken right at the Y(5S) peak with the CLEOIII detector.



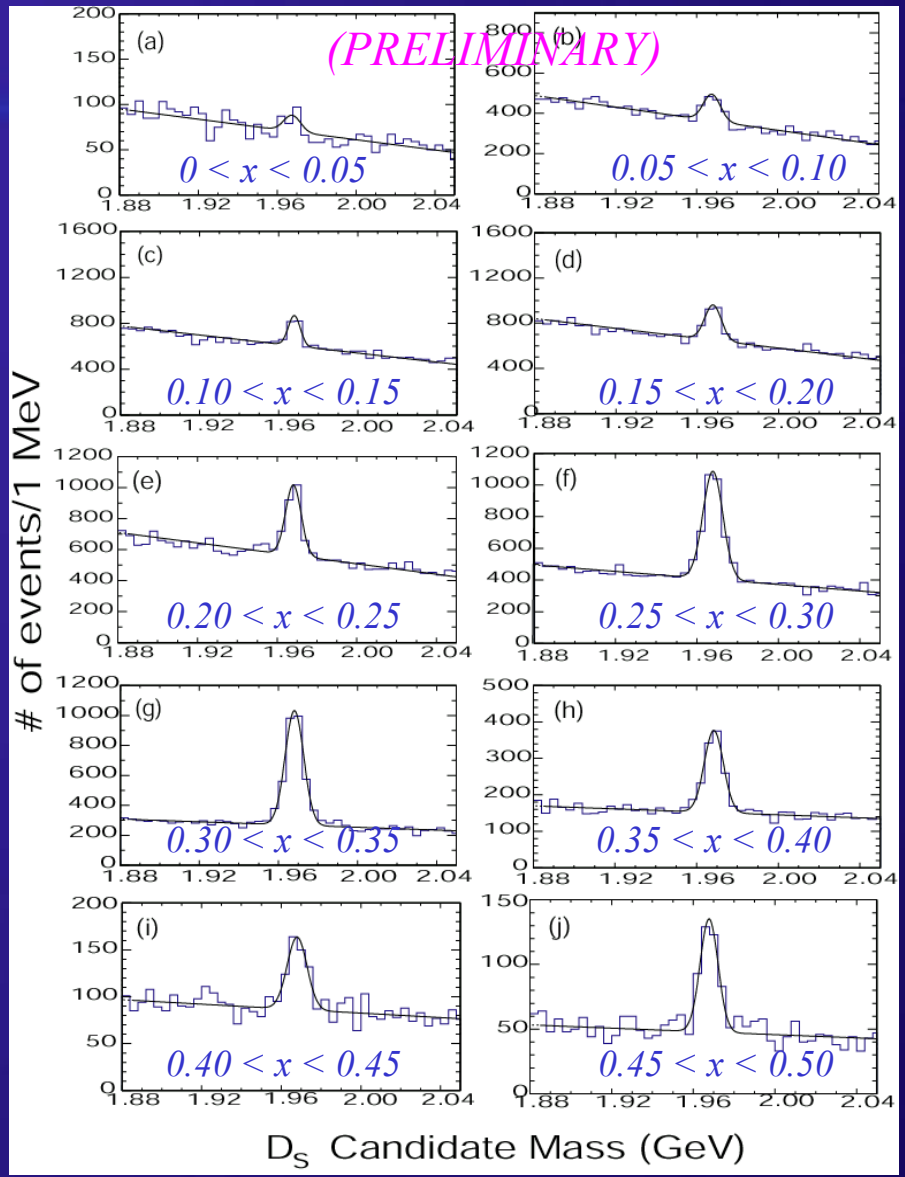
Data Type	E_{beam} *(GeV)*	*Luminosity* (fb^{-1})	*# Had events* ($x10^6$)
On the Y(4S)	~10.58	6.34	32.2
Below the Y(4S)	~10.54	2.32	9.5
On the Y(5S)	~10.86	0.42	1.8

D_s candidates invariant Mass Spectra



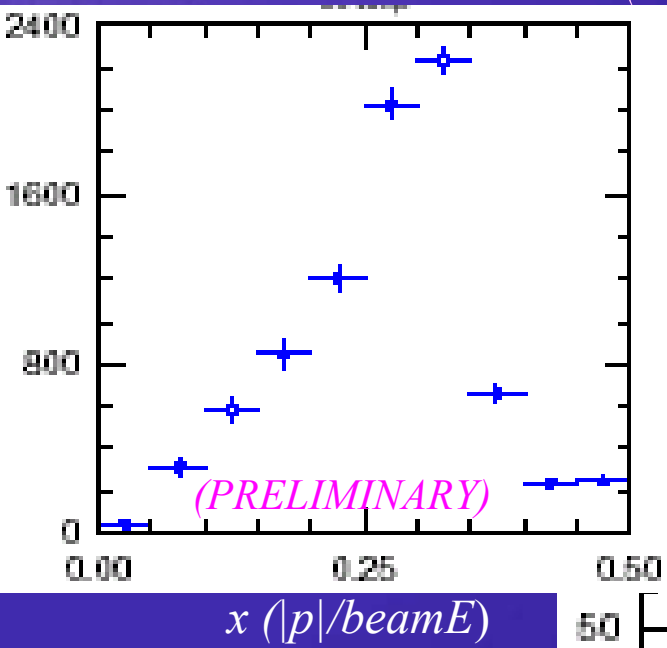


Y(4S) on resonance data

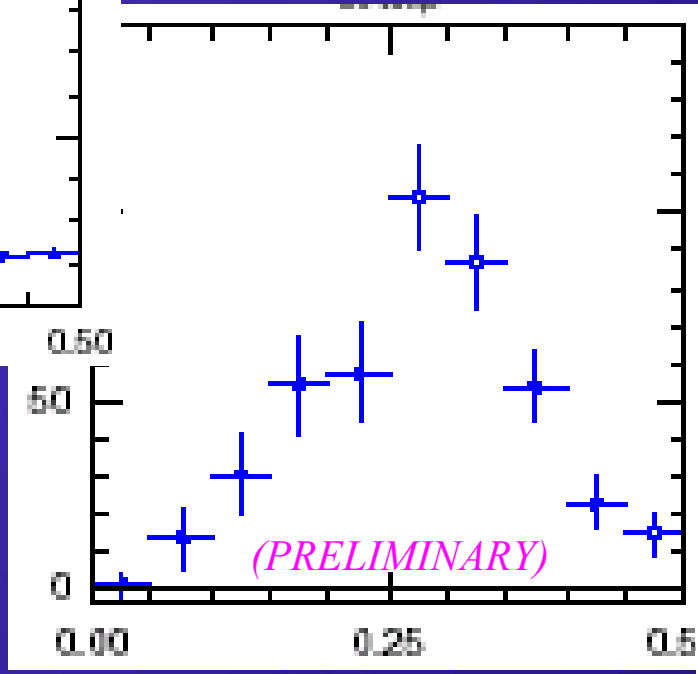


D_s Yields from data

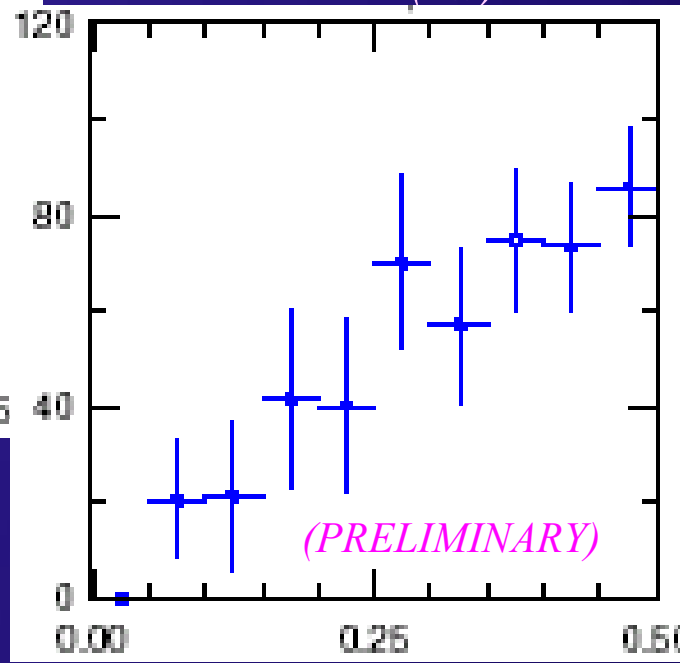
Y(4S) on resonance data



Y(5S) on resonance data

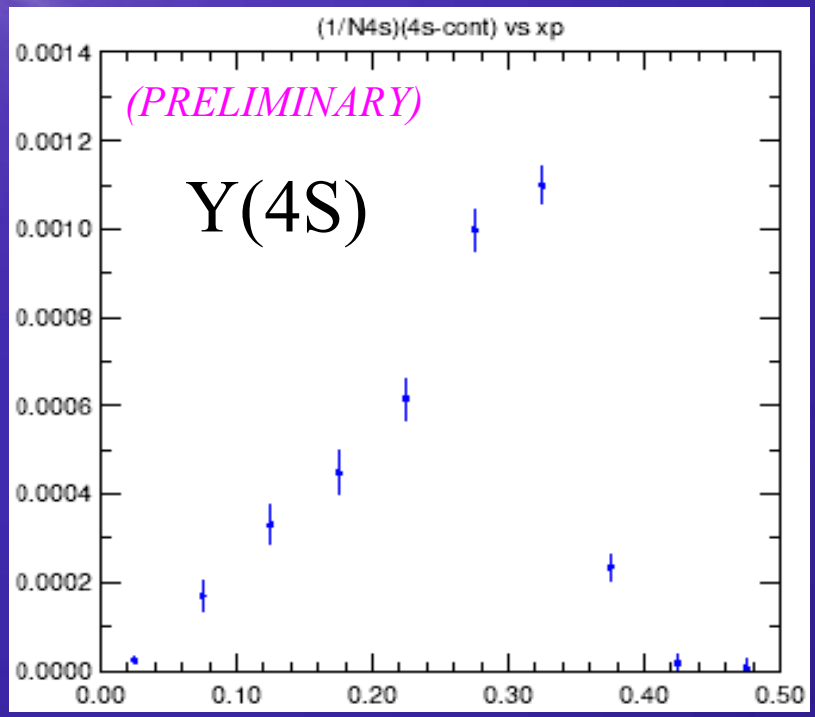


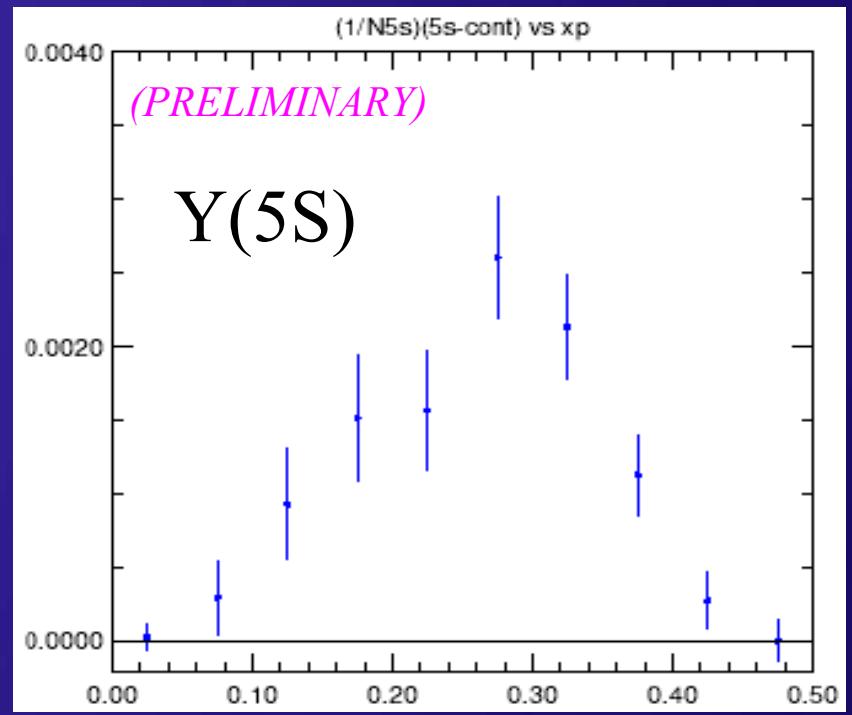
Continuum below the Y(4S) data



D_s Spectra & Production Rates at the Y(4S) & at the Y(5S)

Continuum subtracted, ε corrected & normalized to # of resonance events.





$$B(\Upsilon(4S)\to D_s X).B(D_s\to\phi\pi) = (8.0\pm 0.3\pm 0.4).10^{-3}$$

$$B(\Upsilon(5S)\to D_s X).B(D_s\to\phi\pi) = (20\pm 2\pm 4).10^{-3}$$

Yields

$B(\Upsilon(4S) \to D_s X) = (22.3 \pm 0.7 \pm 5.7)\%$

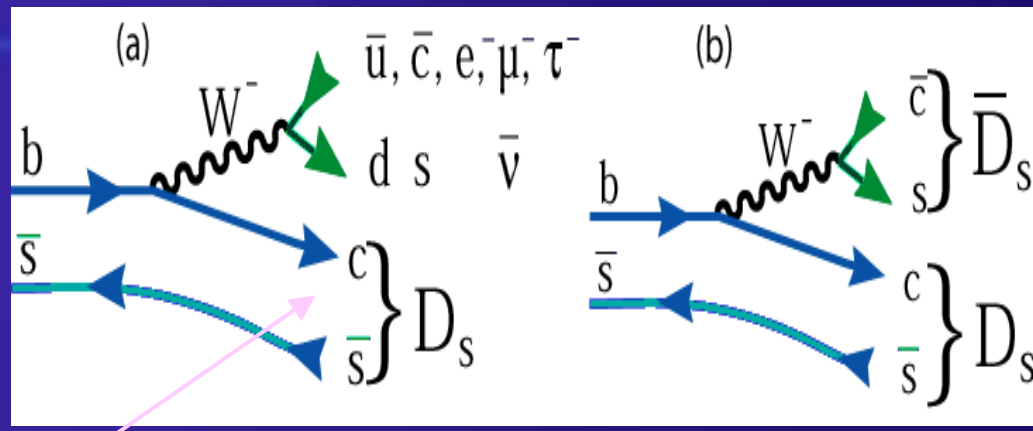
$B(B \to D_s X) = (11.1 \pm 0.4 \pm 2.9)\%$

PDG $(10.5 \pm 2.6 \pm 2.5)\%$

Using $B(D_s \to \phi\pi) = (3.6 \pm 0.6)\%$

$Br(\Upsilon(5S) \to D_s X) = (55.0 \pm 5.2 \pm 17.8)\%$

Model Estimate of $B_s \to D_s X$

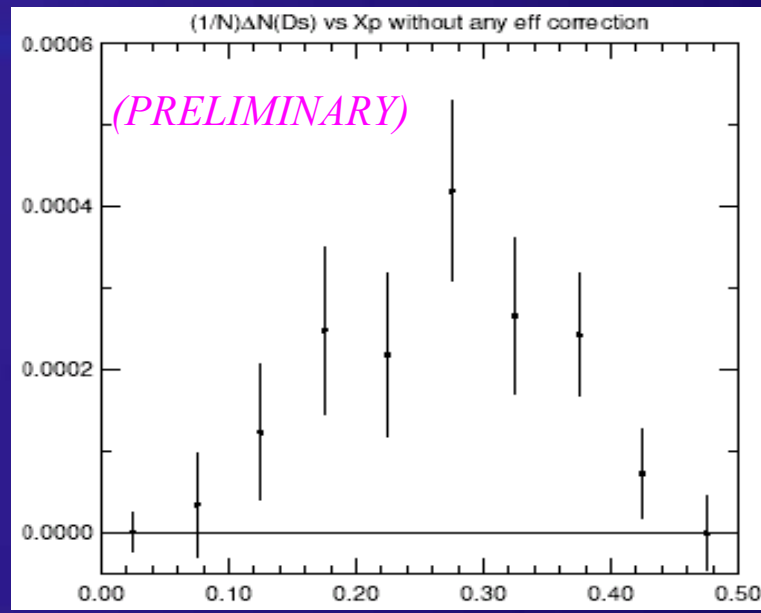


- For B_s, b→c is ~100%, W →c, ~ 15%, could get >100% D_s
- However, B →DD_s is ~5%, include unmeasured $D^{**}D_s + DD_{sJ}$, estimate upper vertex gives (7±3)%
- However, some Ds are lost due to popping of light quark pair at lower vertex, estimate (-15 ±10)%
- Total $B_s \to D_s$ X then is (100 + 7 - 15)% = 92% with an error of 11%

$B_s^{(*)}$ Production at the Y(5S)

Significant excess of D_s yields at the Y(5S) ⟶

{Yield Y(5S)-Yield Y(4S)}/N5S



x (|p|/beamE)

- $$B(Y(5S) \to B_s^{(*)}\overline{B_s^{(*)}})B(D_s \to \phi\pi)/2$$
$$= f_s.B(B_s \to D_s X)B(D_s \to \phi\pi^{\pm})$$
$$+\frac{(1-f_s)}{2}.B(B \to D_s X)B(D_s \to \phi\pi^{\pm})$$

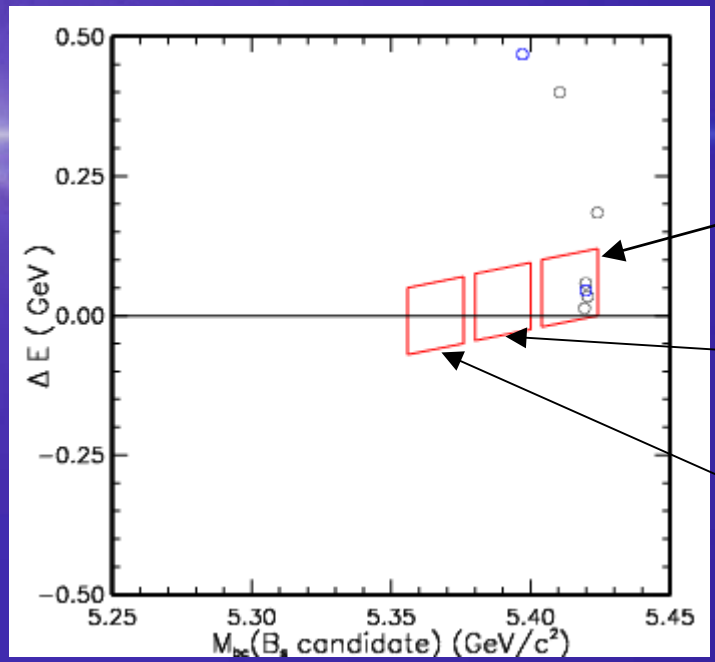
- *Using $\mathcal{B}(B_s \to D_s X) = (92 \pm 11)\%$ we find:*

$$f_s = Br(\Upsilon(5S) \to B_s^{(*)}\overline{B}_s^{(*)}) = (21 \pm 3 \pm 9)\%$$

Systematic Errors

- *The 25% error on the absolute branching ratio $D_s \to \phi\pi$*
- *The 1% relative error on the S_1 scale factor (which caused a 4% error on the number of Y(4S) resonance events), and 1.7% on S_2 (which caused a 21% error on the number of Y(5S) resonance events).*
- *The 12% on our estimate of $B(B_s \to D_s X)$.*
- *The 4.1% component from the D_s detection efficiency.*

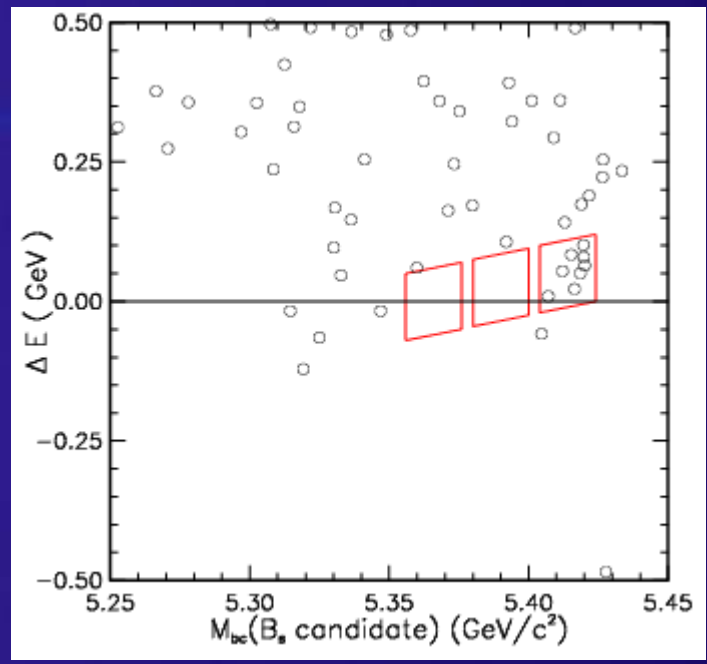
Evidence for Exclusive B_s Decays



$B_s^* \bar{B}_s^*$

$B_s \bar{B}_s^*$

$B_s \bar{B}_s$



$B_s \to J/\psi\, \eta,\ \eta',\ \phi$

$B_s \to D_s^{(*)}\, \pi^-,\ \rho^-$

$B_s^* \bar{B}_s^*$ production appears to be dominant

Inclusive η, η′, and ϕ Rates

- Maybe useful to distinguish B from B_s
- Use CLEO-c data to measure
- Tag a D^o or a D^+

Mode	D^o(%)		D^+(%)	
	Our result	PDG	Our result	PDG
η X	9.4±0.4±0.6	<13	5.7±0.5±0.5	<13
η' X	2.6±0.2±0.2	-	1.0±0.2±0.1	-
ϕ X	1.0±0.1±0.1	1.7±0.8	1.1±0.1±0.2	<1.8

- Since $D_s \to \eta'$ X & ϕ X are >≈ 16%, then these
- particles indicative of Bs decays & will be used to
- further investigate the Y(5S)

Conclusions

We report a preliminary measurement of the following Inclusive Production Rates:

$$B(\Upsilon(4S) \to D_s X) \cdot B(D_s \to \phi\pi) = (8.0 \pm 0.3 \pm 0.4) \cdot 10^{-3}$$

$$B(\Upsilon(5S) \to D_s X) \cdot B(D_s \to \phi\pi) = (20 \pm 2 \pm 4) \cdot 10^{-3}$$

$$B(\Upsilon(5S) \to B_s^{(*)} \bar{B}_s^{(*)}) = (21 \pm 3 \pm 9)\ \%$$

At the $\Upsilon(5S)$ $B_s^* \bar{B}_s^*$ appears dominant