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

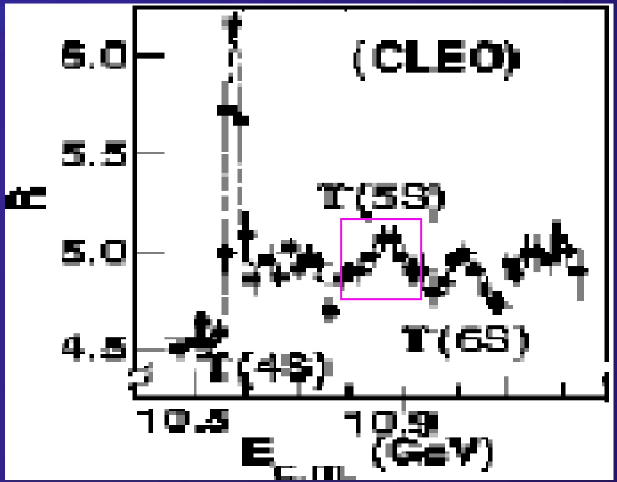
Radia Sia

Syracuse University
CLEO Collaboration
DPF Mtg.08/30/2004

We will talk about:

- Physics Motivation
- Analysis:
  The Inclusive D_s Spectrum.
- Preliminary 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. Model Expectations:

- Decay channels:

  $B_d\overline{B}_d$, $B_d\overline{B}_d^*$, $B_d^*\overline{B}_d^*$, $B_s\overline{B}_s$, $B_s\overline{B}_s^*$,
  $B_s^*B_s^*$, $B_dB_d\pi\pi$, $B_dB_d\pi$, $B_dB_d^*\pi$, $B^0B^+\pi$.
- The Unitarized Quark Model (UQM):

  The $\overline{B}$ cross section dominated by $B^*\overline{B}^*$ and $B_s^*\overline{B}_s^*$ production.
  $B_s^{(*)}\overline{B}_s^{(*)}$ production ~ 1/3 of the total Y(5S) cross section.
  $\sigma(B_s\overline{B}_s)+\sigma(B_s\overline{B}_s^*)+\sigma(B_s^*\overline{B}_s^*) \sim 0.1nb$.
- Other models:

  Predict a smaller $Y(5S) \rightarrow B_s^*\overline{B}_s^*$ component!

Why do we care ?

- *What do we know about Y(5S)?*

  From the PDG →

$\Upsilon(10860)$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 10.865 \pm 0.008$ GeV (S = 1.1)
Full width $\Gamma = 110 \pm 13$ MeV
$\Gamma_{ee} = 0.31 \pm 0.07$ keV (S = 1.3)

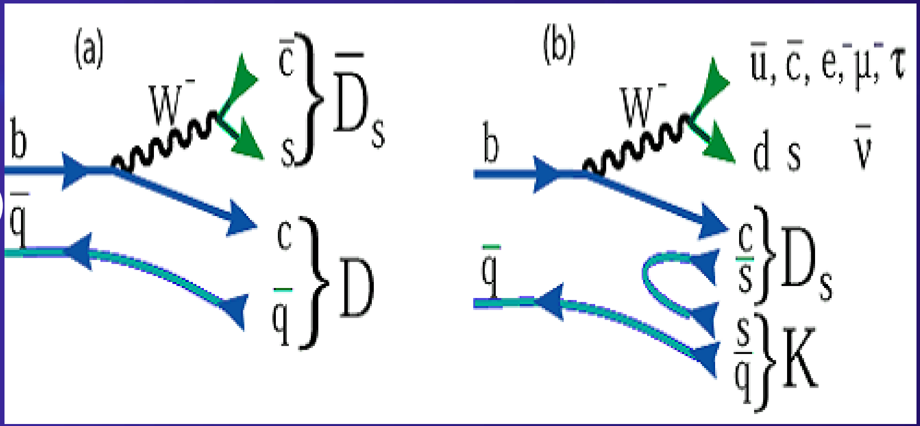
$\Upsilon(10860)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(2.8\pm0.7)\times10^{-6}$	5432

- *Need to investigate the composition of the Y(5S).*

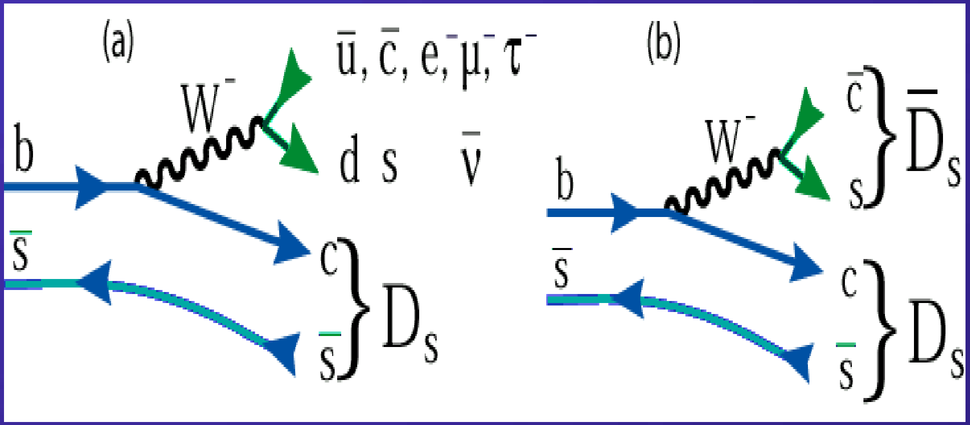
- *It is of considerable interest to establish firmly the properties of B_s mass, selected decay modes, production rate at the Y(5S), and possibly even B_s mixing, for which the data we have may not be sufficient but could lay the groundwork for a future study of this topic…*

Why The Inclusive $D_s^{\pm}$ Spectrum?

In the simple spectator model the B_s decays into the D_s nearly all the time. Since the $Br(B \rightarrow D_s X)$ has already been measured to be $(10.5 \pm 2.6 \pm 2.5)\%$,



Dominant Decay Diagrams for a B meson into D_s meson

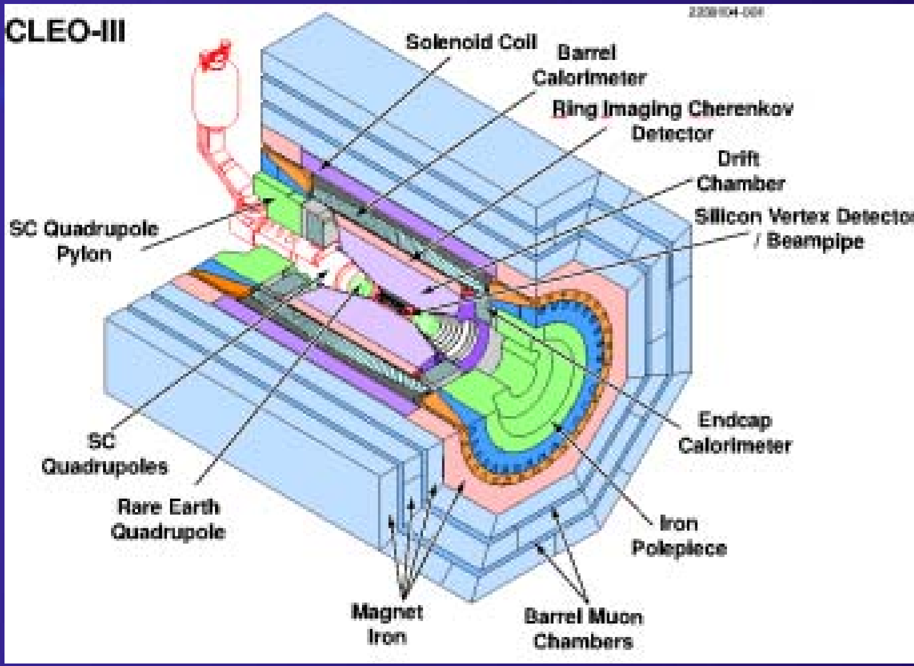


Dominant Decay Diagrams for a B_s meson into D_s meson

we expect a large difference between the D_s yields at the Y(5S) and the Y(4S) that can lead to an estimate of the size of the $B_s^{(*)}\overline{B}_s^{(*)}$ component at the Y(5S).

Data Sample from CLEO III

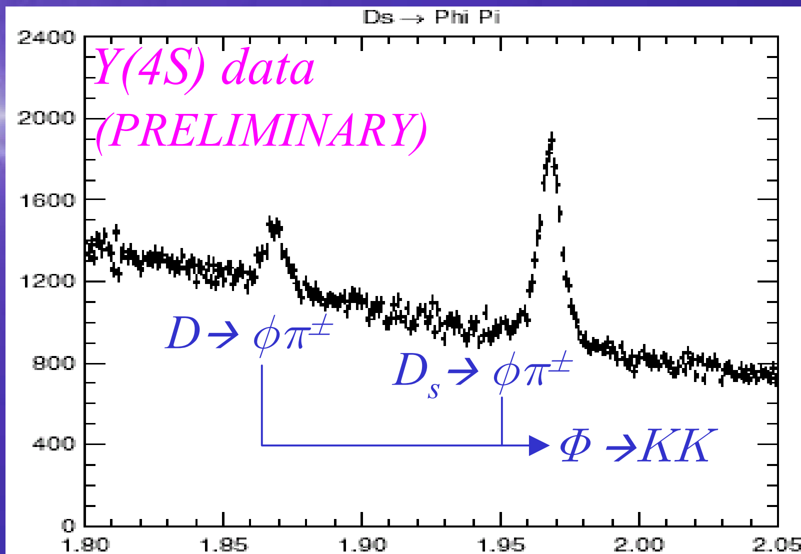
We used all the data we collected near or at the Υ(4S) resonance and all the data taken right at the Υ(5S) peak with the CLEOIII detector.



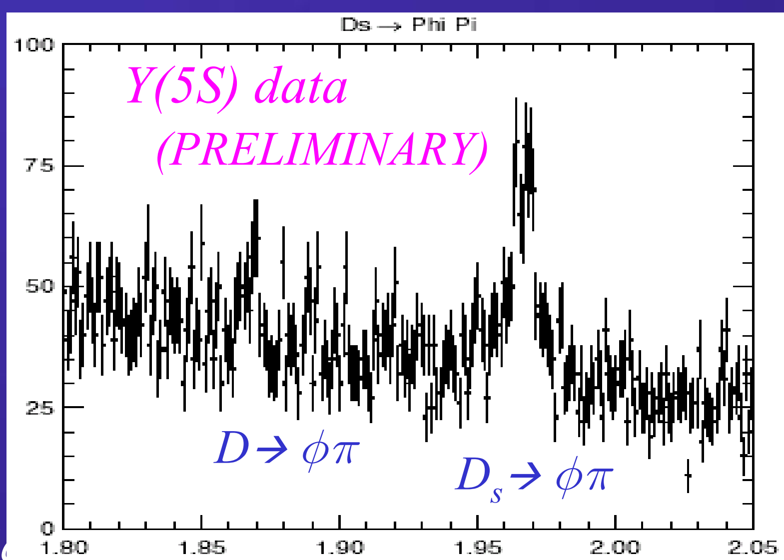
Data Type	E_{beam} *(GeV)*	*Luminosity* (fb^{-1})	*# Had events* $(x10^6)$
On the Υ(4S)	~10.58	6.34	32.2
Below the Υ(4S)	~10.54	2.32	9.5
On the Υ(5S)	~10.86	0.42	1.8

D_s candidates invariant Mass Spectra

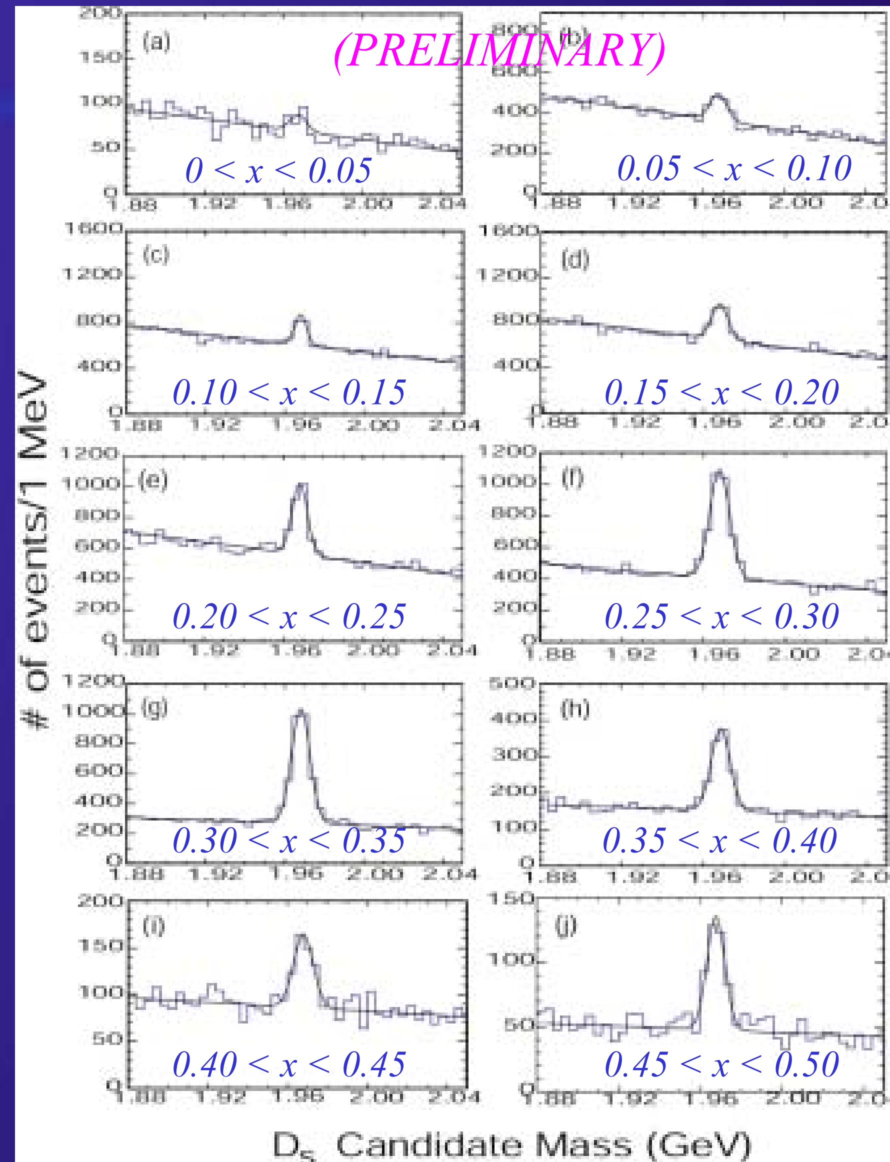
Y(4S) on resonance data



Mass (GeV)

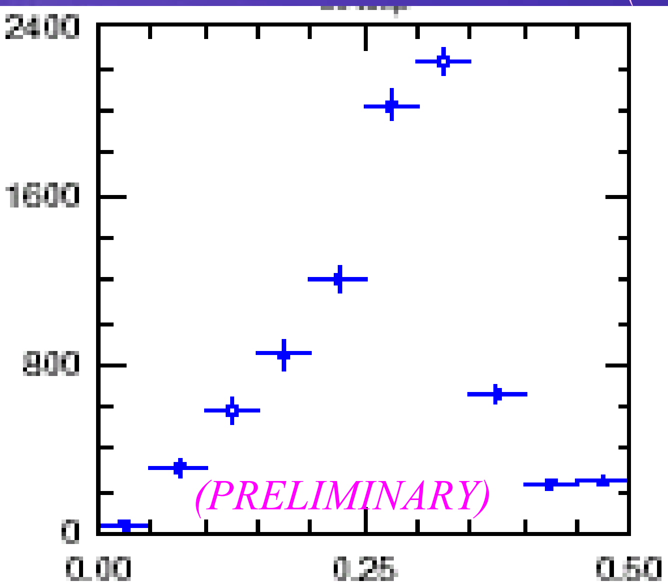


Mass (GeV)



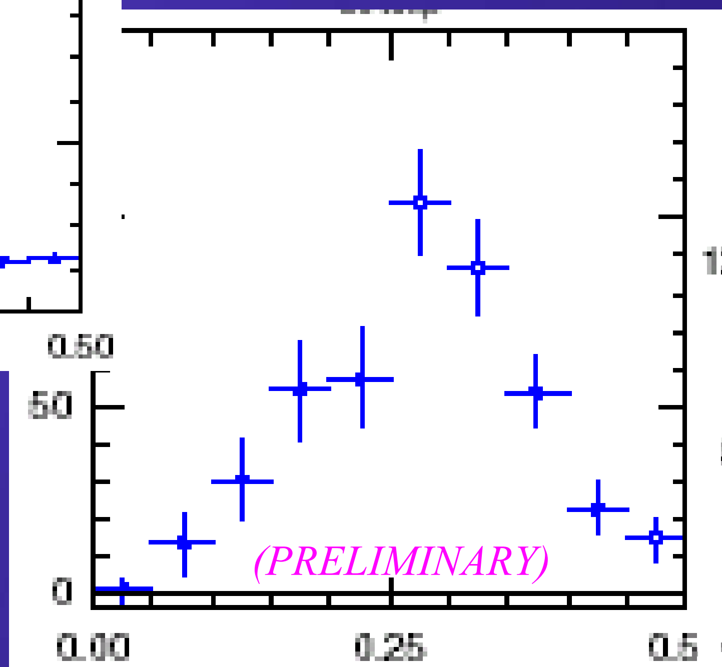
D_s Yields from data

Y(4S) on resonance data



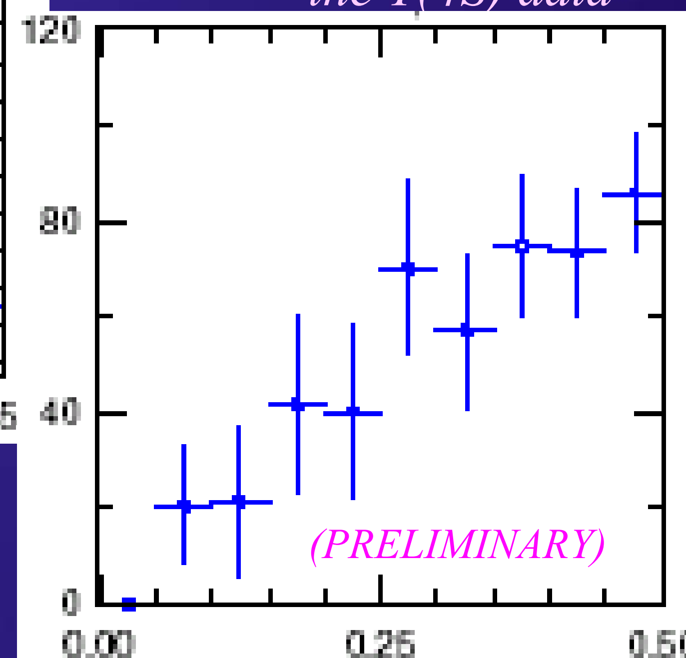
x (|p|/beamE)

Y(5S) on resonance data



x (|p|/beamE)

Continuum below the Y(4S) data



x (|p|/beamE)

Continuum Subtraction

- Properly scale the continuum by S_2 (S_1) scale factors.

- Subtract it from the distribution of D_s at the 5S(4S)-on resonance data.

- The difference is then inclusive D_s distribution at the Υ(5S)(Υ(4S)) resonance.

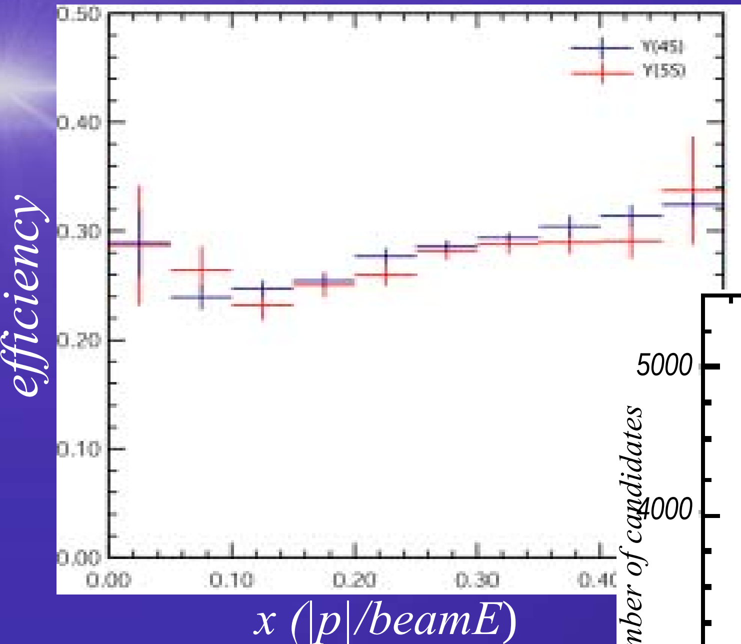
$$S_1 = \left(\frac{E_{cont}}{E^{\Upsilon(4S)}}\right)^2 \cdot \frac{L^{\Upsilon(4S)}}{L_{cont}}$$

$$S_2 = \left(\frac{E_{cont}}{E^{\Upsilon(5S)}}\right)^2 \cdot \frac{L^{\Upsilon(5S)}}{L_{cont}}$$

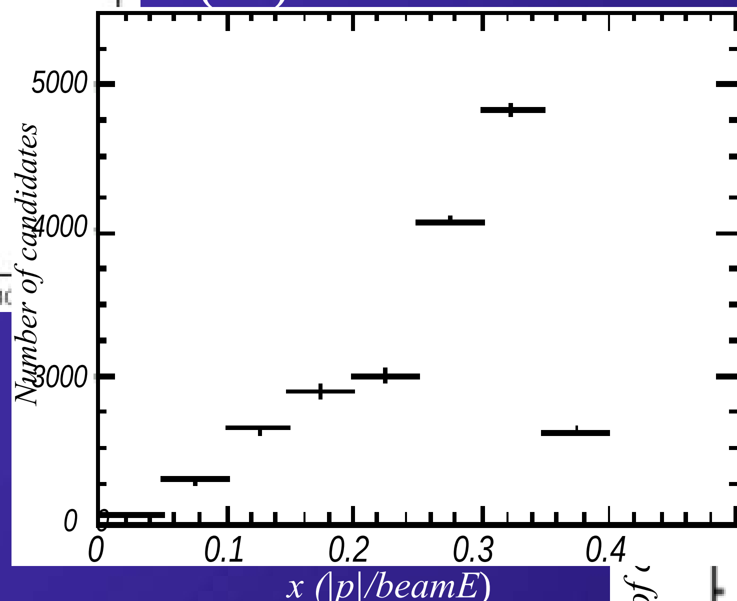
$$N^{Res}_{\Upsilon(4S)} = N^{on}_{\Upsilon(4S)} - S_1 * N^{off}_{\Upsilon(4S)} = (642.1 \pm 0.6 \pm 24.1) x 10^4$$

$$N^{Res}_{\Upsilon(5S)} = N^{on}_{\Upsilon(5S)} - S_2 * N^{off}_{\Upsilon(4S)} = (13.1 \pm 0.1 \pm 2.7) x 10^4$$

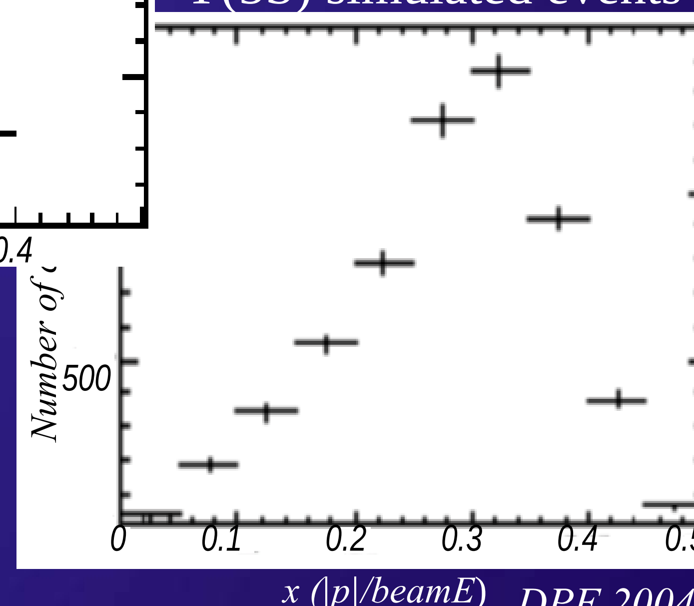
Reconstruction Efficiency & D_s yields from MC



D_s Spectrum from the Y(4S) simulated events

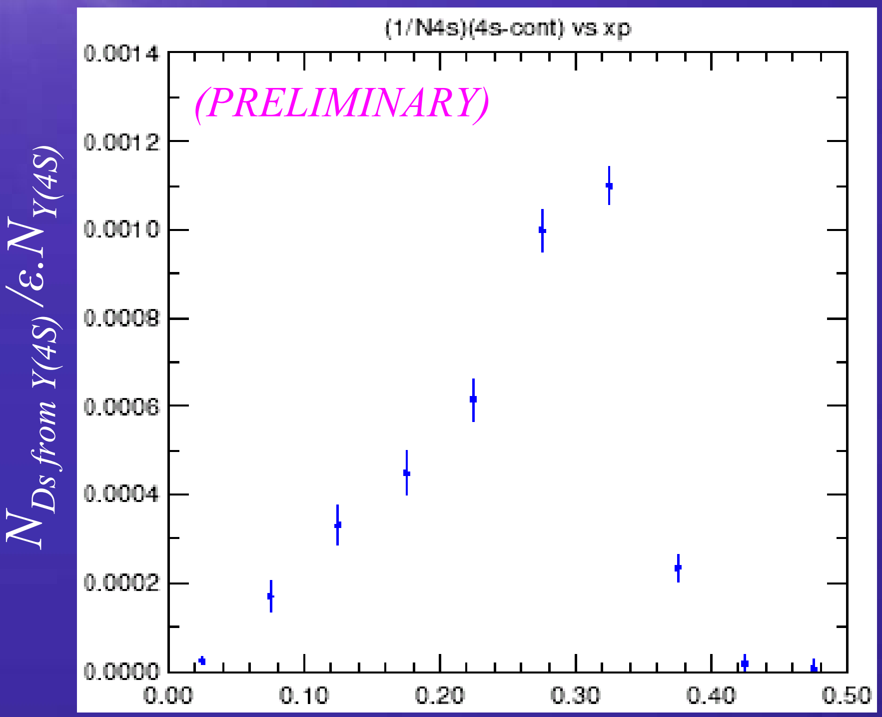


D_s Spectrum from the Y(5S) simulated events



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

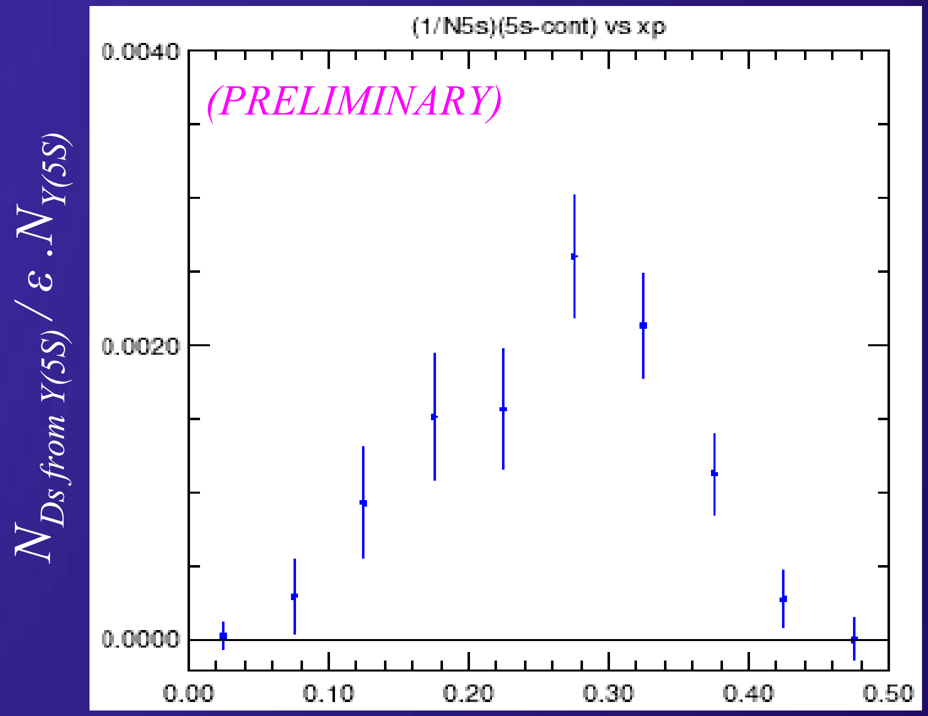
D_s yields from Υ(4S) data continuum subtracted, efficiency corrected & normalized to # of resonance events.



x (|p|/beamE)

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

D_s yields from Υ(5S) data continuum subtracted, efficiency corrected & normalized to the # of resonance events



x (|p|/beamE)

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

Partial and total Br ($\Upsilon(5S, 4S) \longrightarrow D_s X$) vs x

(PRELIMINARY)

Y(4S)

$x(\frac{\|p\|}{Ebeam})$	D_s yields	$\epsilon(\%)$	$\frac{\Delta B}{\Delta x}(\%)$
0 - 0.05	44 ± 16	28.9	0.1 ± 0.1
0.05-0.10	261 ± 51	23.9	1.0 ± 0.3
0.10-0.15	525 ± 68	24.7	1.9 ± 0.5
0.15-0.20	732 ± 77	25.4	2.5 ± 0.7
0.20-0.25	1097 ± 78	27.7	3.5 ± 0.9
0.25-0.30	1838 ± 80	28.6	5.6 ± 1.4
0.30-0.35	2079 ± 75	29.4	6.2 ± 1.6
0.35-0.40	457 ± 55	30.4	1.3 ± 0.4
0.40-0.45	34 ± 43	31.4	0.1 ± 0.1
0.45-0.50	13 ± 40	32.4	0.0 ± 0.1

Y(5S)

$x(\frac{\|p\|}{Ebeam})$	D_s yields	$\epsilon(\%)$	$\frac{\Delta B}{\Delta x}(\%)$
0 - 0.05	1 ± 3	28.9	0.1 ± 0.1
0.05-0.10	9.7 ± 8.3	23.9	1.8 ± 1.6
0.10-0.15	26.7 ± 10.7	24.7	4.7 ± 2.2
0.15-0.20	47.2 ± 13.3	25.4	8.0 ± 3.0
0.20-0.25	50.7 ± 13.0	27.7	7.9 ± 2.8
0.25-0.30	92.0 ± 14.3	28.6	13.9 ± 4.1
0.30-0.35	76.9 ± 12.4	29.4	11.3 ± 3.4
0.35-0.40	41.0 ± 9.7	30.4	5.8 ± 2.0
0.40-0.45	10.1 ± 7.0	31.4	1.4 ± 1.0
0.45-0.50	0.1 ± 6.0	32.4	0.0 ± 0.8

$Br(\Upsilon(4S) \rightarrow D_s X) = (22.3 \pm 0.7 \pm 5.7)\%$

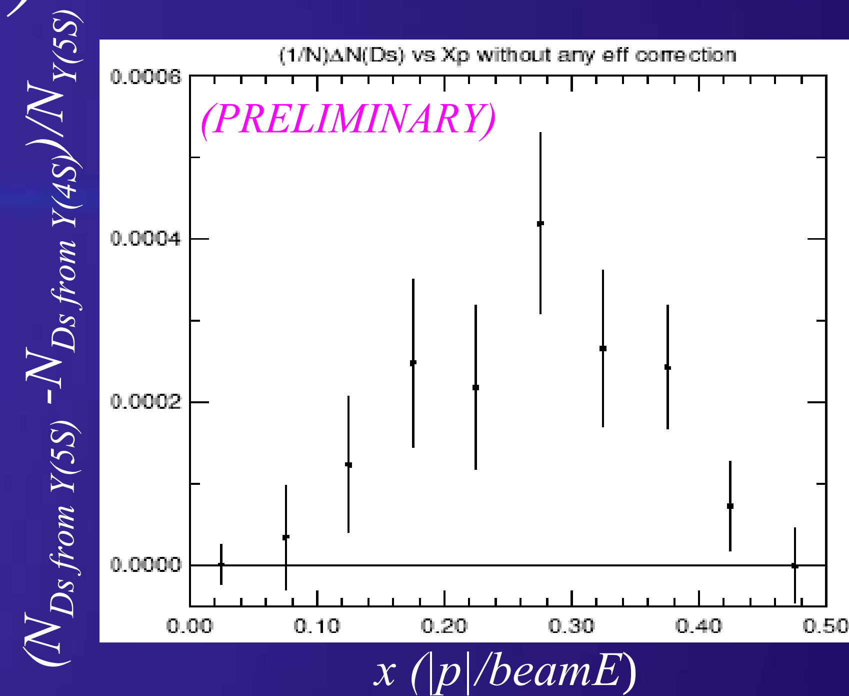
$Br(B \rightarrow D_s X) = (11.1 \pm 0.4 \pm 2.9)\%$

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

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

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

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



Using:

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

- *a model dependent estimate of* $Br(B_s \to D_s X) = (92 \pm 11)\ \%$
- *and the productions rates in slide 10 ,*

we find the ratio of $B_s^{(*)}\overline{B_s^{(*)}}$ *to the total* $b\overline{b}$ *quark pair production at the Y(5S) energy:* $f_s = Br(Y(5S) \to B_s^{(*)}\overline{B_s^{(*)}}) = (21 \pm 3 \pm 9)\ \%$

Systematic Errors

- Are dominated by:

➢ the 25% error on the absolute branching ratio $D_s \longrightarrow \phi\pi$

➢ the 1% relative error on the S_1 scale factor (which caused a 4% error on the number of Υ(4S) resonance events), and 1.7% on S_2 (which caused a 21% error on the number of Υ(5S) resonance events).

➢ the 12% on our estimate of $Br(B_s \longrightarrow D_s X)$.

- And have components from:

➢ the 4.1% component from the D_s detection efficiency.

- Because of the large relative error on the luminosity measurement, we did a second measurement of the scale factors used for continuum subtraction. We used the data to measure the ratio of the number of tracks with $0.5 < x < 0.8$. The difference between the two values gave an estimate of the systematic error.

- Ongoing work to improve the systematic errors…

Conclusions

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

- ✓ $Br(Y(4S) \to D_s X) \,.\, Br(D_s \to \phi\pi) = (8.0 \pm 0.3 \pm 0.4).10^{-3}$
- ✓ $Br(Y(5S) \to D_s X) \,.\, Br(D_s \to \phi\pi) = (20 \pm 2 \pm 4).10^{-3}$

Hence:

- ✓ $Br(Y(5S) \to D_s X) / BR(Y(4S) \to D_s X) = 2.5 \pm 0.3 \pm 0.6$

Using $Br(D_s \to \phi\pi) = (3.6 \pm 0.9)\%$, *we measure:*

- ✓ $Br(Y(4S) \to D_s X) = (22.3 \pm 0.7 \pm 5.7)\%$
- ✓ $Br(Y(5S) \to D_s X) = (55.0 \pm 5.2 \pm 17.8)\%$
- ✓ $Br(B \to D_s X) = (11.1 \pm 0.4 \pm 2.9)\%$

And using $BR(B_s \to D_s X) = (92 \pm 11)\%$, *we report a preliminary model dependent estimate of the ratio of* $B_s^{(*)}\bar{B}_s^{(*)}$ *to the total* $b\bar{b}$ *quark pair production at the Y(5S) energy:*

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

More information is available on: hep-ex/0408070