Recent b physics results from OPAL

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Outline

- $Br(\mathrm{b} \rightarrow \mathrm{D}^{**0} \ell \overline{\nu}_{\ell} \mathrm{X})$
  - Object, motivation
  - Method
  - Results
- Charm counting in beauty decays
  - Object, motivation
  - Method
  - Results
- Conclusions

Analyses of Z^0 data!

Semileptonic decay of b hadrons to orbitally excited D mesons

Object

- Measure $Br(\mathrm{b} \to \mathrm{D}^{**0} \ell \overline{\nu}_{\ell} \mathrm{X})$
- D^{**0} are L=1 orbitally excited charm mesons.
  - Measure narrow J_q= 3/2 states (D_1^0, D_2^{*0}).
  - Wide J_q= 1/2 states not visible with statistics.

Motivation

- Reconcile difference between measured inclusive and exclusive semileptonic branching ratios.
- Reduce uncertainty in $|V_{cb}|$.
- Test HQET predictions.

Semi-leptonic decay of b hadrons to orbitally excited D mesons: Method

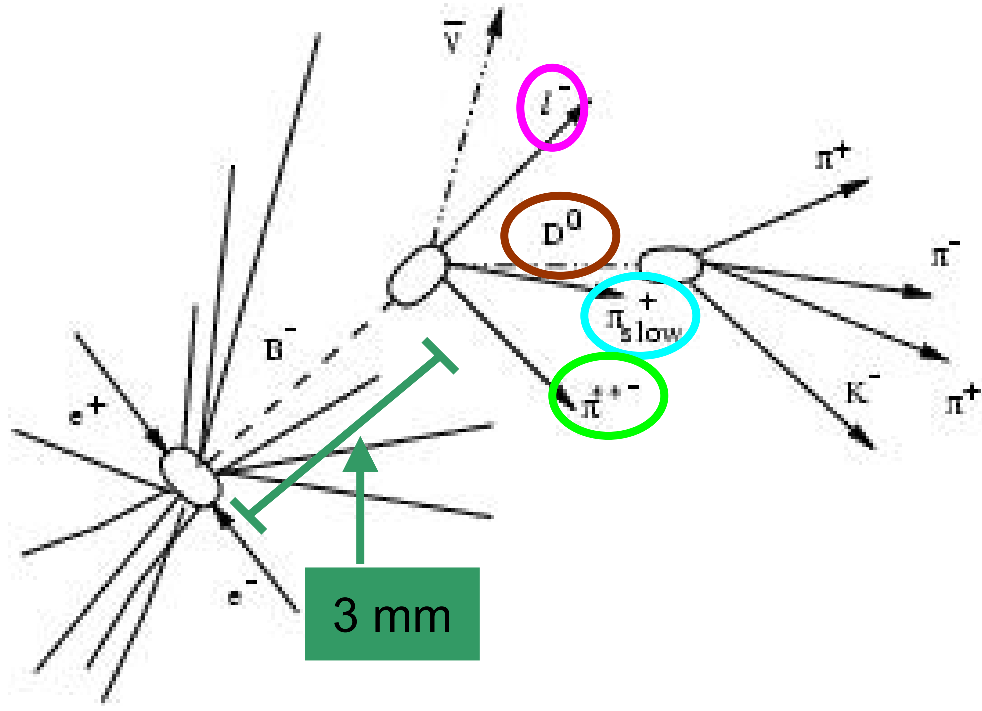
- Identify high *p* lepton (μ,*e*)
  - high efficiency and purity for p_μ> 3 GeV/*c*, p_e> 2 GeV/*c*
- Exclusively reconstruct D^{**0}

$D^{**0} \rightarrow D^{*+}\,\pi^{**-}$

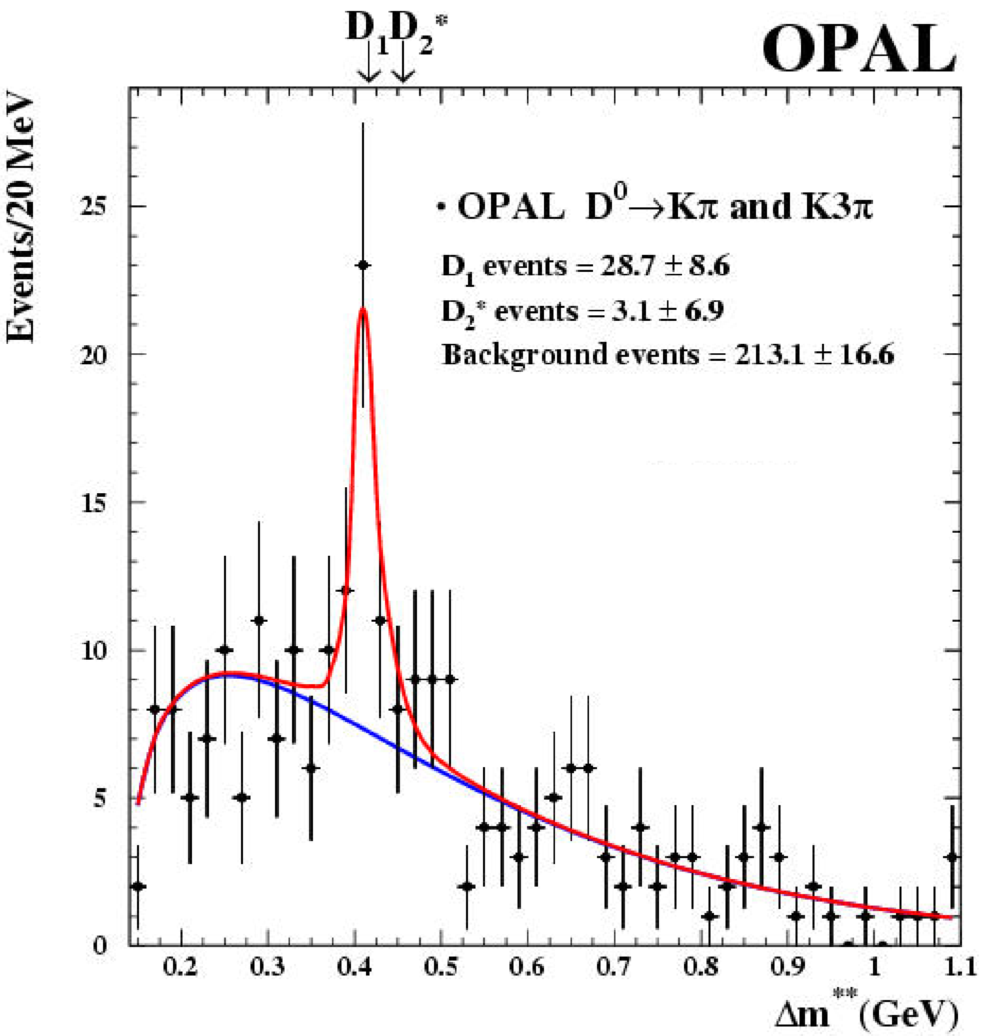
$\hookrightarrow D^0\,\pi^+_{slow}$

$\hookrightarrow K^-\pi^+(\pi^+\,\pi^-)$

- Background cuts to remove fake π^{**-} (π from fragmentation)
  - main background from $b \rightarrow D^{*0}\ell\bar{\nu}_\ell X$ decays plus fake π^{**-}
  - ANN (p, p_T, $d0/\sigma_{d0}$) to select π^{**-}



$D^{**0} - D^{*+}$ mass difference



Combine $D^0 \rightarrow K\pi$ and $K3\pi$ channels to reduce uncertainty due to background.

Unbinned ML fit to determine number of D_1 and D_2^* events (B.-W. ⊗ Gaussian).

Number of wrong sign and right sign background events fit simultaneously.

Results for $Br(\mathrm{b} \to \mathrm{D}^{**0} \ell \overline{\nu}_\ell \mathrm{X})$

$$Br(\mathrm{b} \to \overline{\mathrm{B}}) \times Br(\overline{\mathrm{B}} \to \mathrm{D}_1^0 \ell^- \overline{\nu}\ \mathrm{X}) \times Br(\mathrm{D}_1^0 \to \mathrm{D}^{*+} \pi^-)$$
$$= (2.64 \pm 0.79(\mathrm{stat}) \pm 0.39(\mathrm{syst})) \times 10^{-3}$$

$$Br(\mathrm{b} \to \overline{\mathrm{B}}) \times Br(\overline{\mathrm{B}} \to \mathrm{D}_2^{*0} \ell^- \overline{\nu}\ \mathrm{X}) \times Br(\mathrm{D}_2^{*0} \to \mathrm{D}^{*+} \pi^-)$$
$$\leq 1.4 \times 10^{-3} (95\%\ \mathrm{C.L.})$$

Charm counting in b decays: Object and Motivation

- **Object**:(1) measure $Br(\mathrm{b} \rightarrow \mathrm{D\overline{D}X})$ with inclusive method.
  (2) use $Br(\mathrm{b} \rightarrow \mathrm{D\overline{D}X})$ to calculate average number of ***c*** plus anti-***c*** quarks per ***b*** quark decay, $\boldsymbol{n_c}$.

$$n_c = 1 + Br(\mathrm{b} \rightarrow \mathrm{D\overline{D}X}) + Br(\mathrm{b} \rightarrow (c\bar{c})\mathrm{X}) - Br(\mathrm{b} \rightarrow \text{no charm})$$

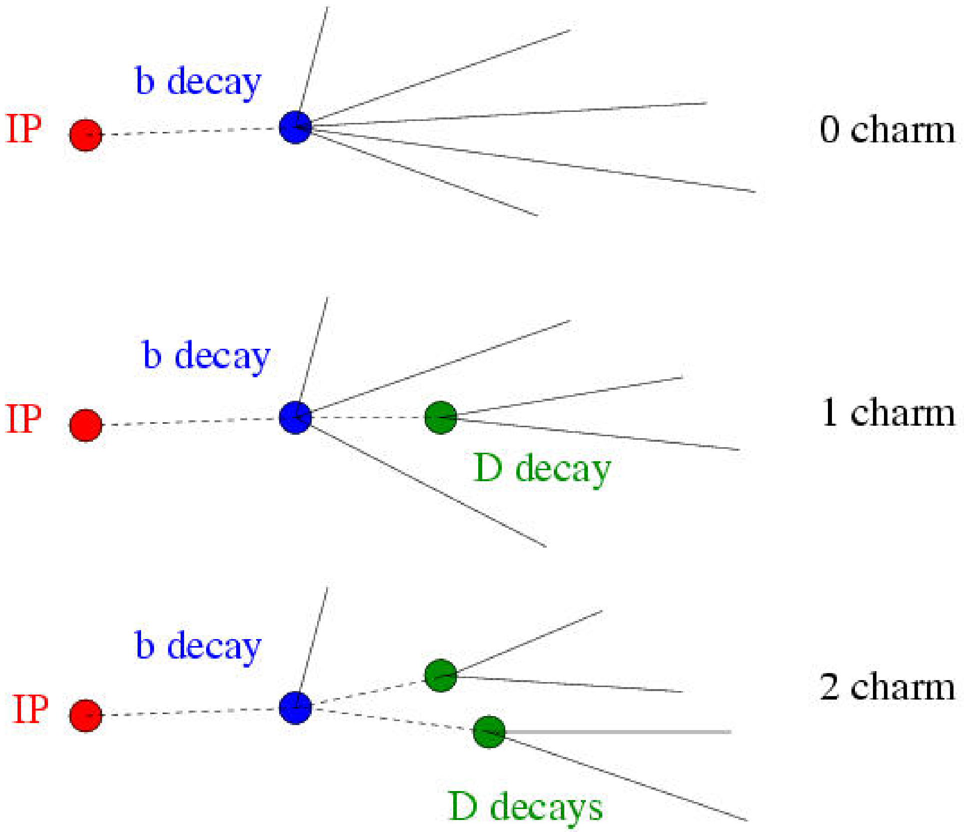
Use PDG values

- **Motivation**: compare experimental value of $\boldsymbol{n_c}$ to theoretical prediction:

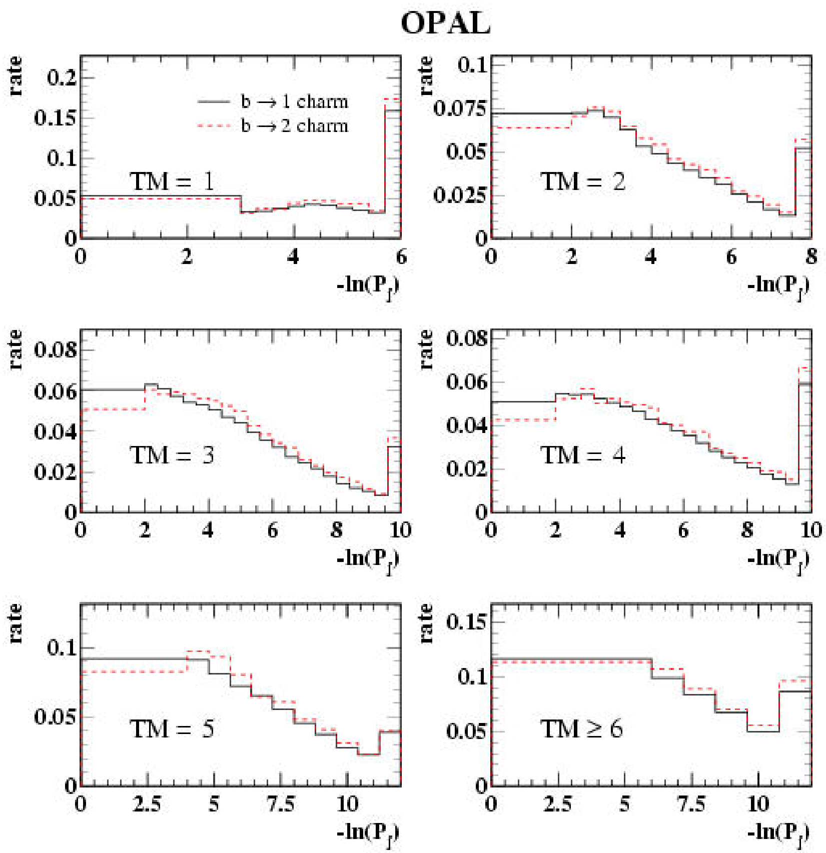
  $\boldsymbol{n_c}$ = 1.20 ± 0.06 (Neubert & Sachrajda)

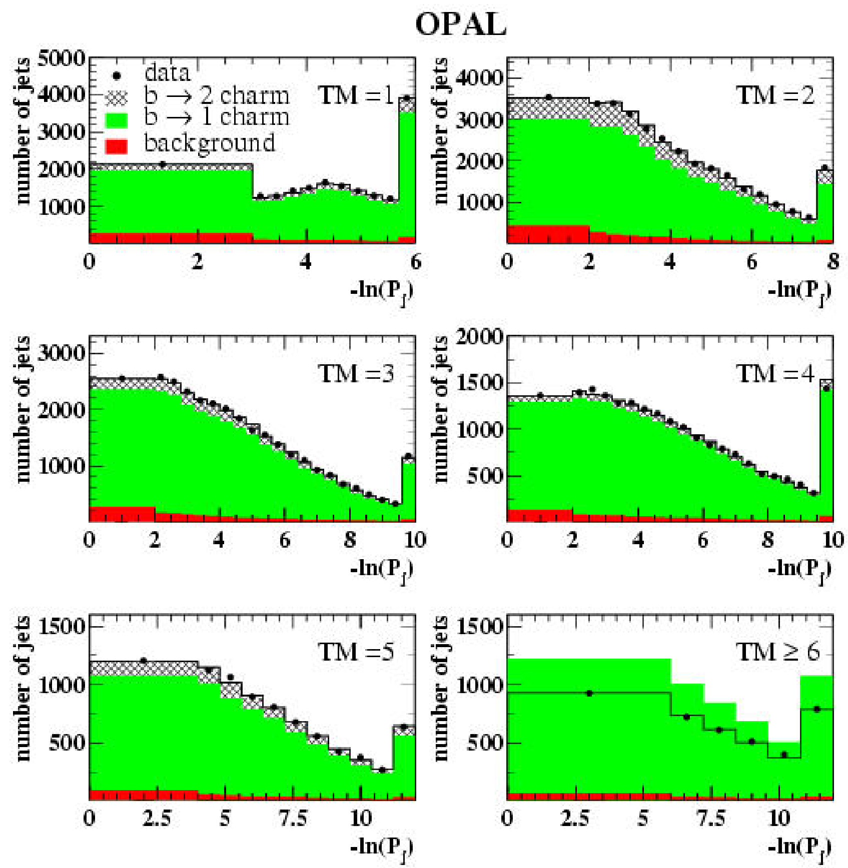
Charm counting in b decays: Inclusive method

- Differentiate $b\rightarrow 1$ charm from $b\rightarrow 2$ charm using topology.
- Impact parameter significance, ***S*** *($=d_0/\sigma_{d0}$)*, of tracks from D decay greater than *S* of tracks from b decay.
- In $b\rightarrow 2$ charm most tracks from D decay.
- Combine ***S*** of tracks in jet into single joint probability variable: $\mathbf{P_J}$



Charm counting in b decays:
Probability Density Functions and Fits





1 and 2 charm PDFs for **–ln(P_J)** for different track multiplicities (TM)

Hatched = 2 charm
Green = 1 charm
Red = 0 charm, charmonium, bckgd

Charm Counting in b decays: Results

- $Br(\mathrm{b} \to \mathrm{D\bar{D}X})$ measured for each year separately.
- Results for each year combined → consistent.

$$Br(\mathrm{b} \to \mathrm{D\bar{D}X}) = 10.0 \pm 3.2(\mathrm{stat})^{+2.4}_{-2.9}(\mathrm{det})^{+10.4}_{-9.0}(\mathrm{phys})$$

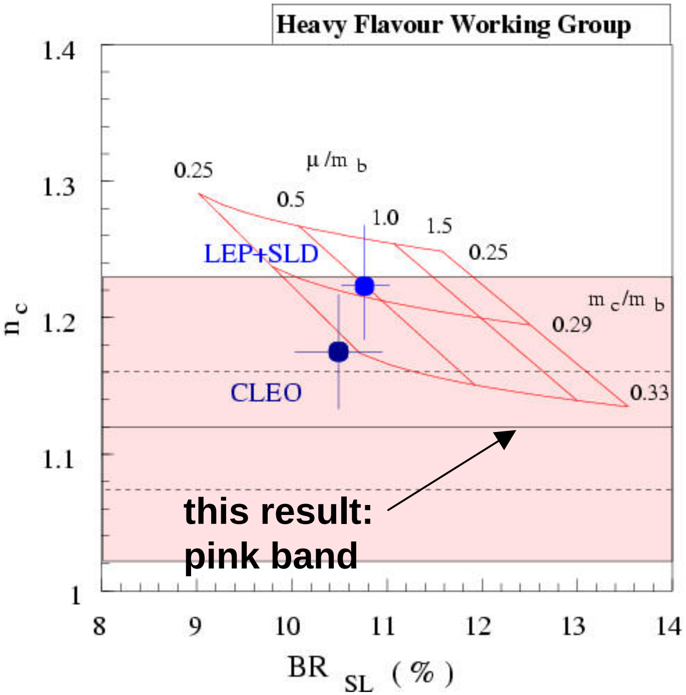
- Two dominant systematics from physics modelling:
  - charged particle multiplicity in fragmentation (±6.2%)
  - neutral K and π multiplicities in D decays ($^{+7.2}_{-4.6}$%)

- $Br(\mathrm{b} \to \mathrm{D\bar{D}X})$ combined with $Br(\mathrm{b} \to \mathrm{no\ charm})$ and $Br(\mathrm{b} \to (\mathrm{c\bar{c}})\mathrm{X})$ to yield $\boldsymbol{n_c}$.

$$\boldsymbol{n_c} = 1.12^{+0.11}_{-0.10}$$

Conclusion

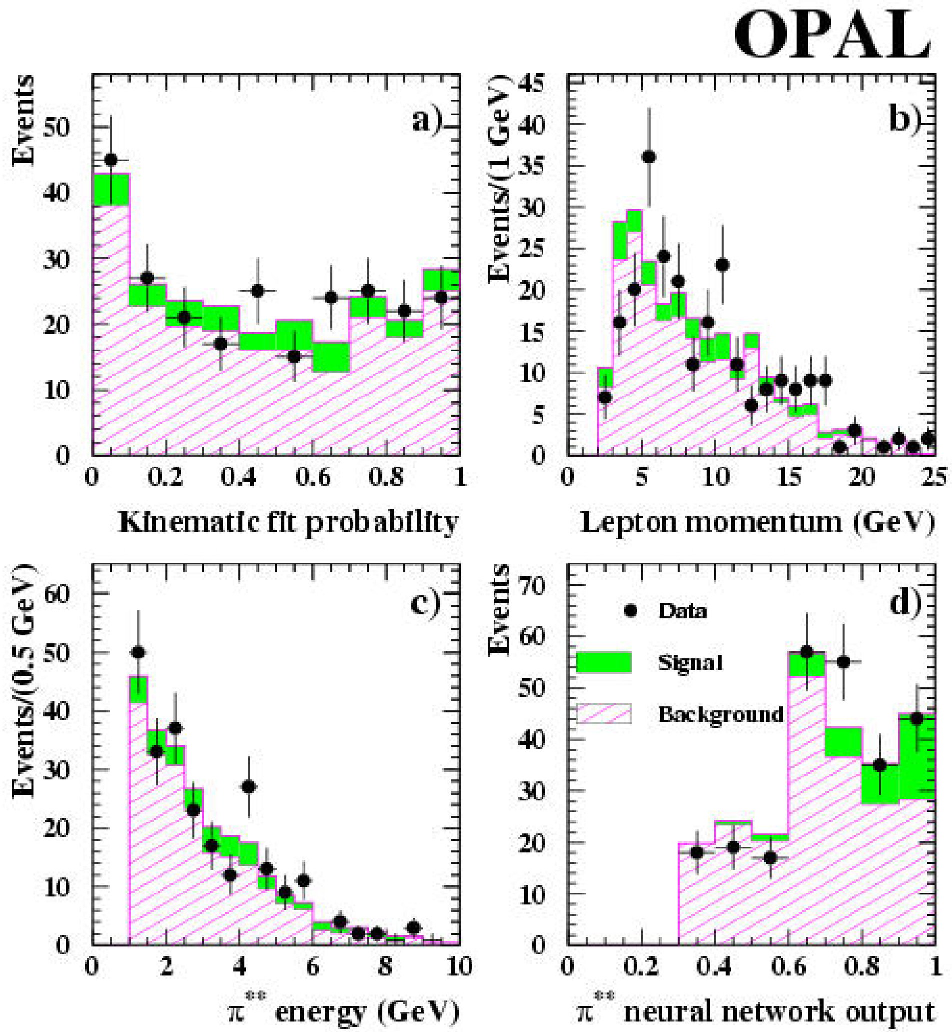
- Results of these recent OPAL charm counting and $Br(\mathrm{b} \to \mathrm{D}^{**0} \ell \bar{\nu}_\ell \mathrm{X})$ analyses consistent with previous measurements and theoretical predictions.



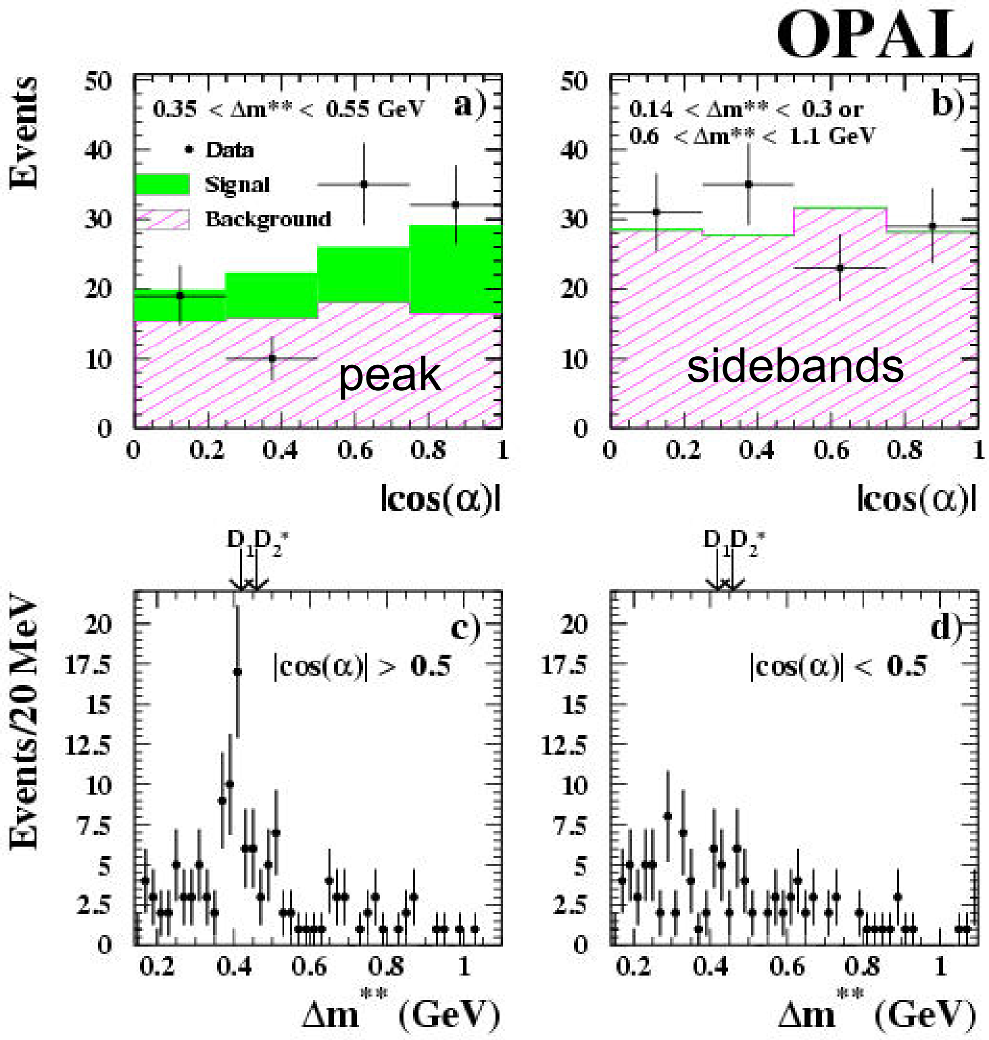
Semileptonic B decays to narrow L=1 D mesons

This result:	$Br(\mathrm{b} \to \overline{\mathrm{B}}) \times Br(\overline{\mathrm{B}} \to \mathrm{D}_1^0 \ell^- \bar{\nu}\ \mathrm{X}) \times Br(\mathrm{D}_1^0 \to \mathrm{D}^{*+}\pi^-)$ $= (2.64 \pm 0.79(\mathrm{stat}) \pm 0.39(\mathrm{syst})) \times 10^{-3}$	D_1^0
ALEPH (1997):	$Br(\overline{\mathrm{B}} \to \mathrm{D}_1^0 \ell^- \bar{\nu}\ \mathrm{X}) \times Br(\mathrm{D}_1^0 \to \mathrm{D}^{*+}\pi^-)$ $= (1.68 \pm 0.38(\mathrm{stat}) \pm 0.29(\mathrm{syst})) \times 10^{-3}$	D_1^0
CLEO (1998):	$Br(\mathrm{B}^- \to \mathrm{D}_1^0 \ell^- \bar{\nu}) \times Br(\mathrm{D}_1^0 \to \mathrm{D}^{*+}\pi^-)$ $= (3.73 \pm 0.85(\mathrm{stat}) \pm 0.52(\mathrm{syst})) \times 10^{-3}$	D_1^0
This result:	$Br(\mathrm{b} \to \overline{\mathrm{B}}) \times Br(\overline{\mathrm{B}} \to \mathrm{D}_2^{*0} \ell^- \bar{\nu}\ \mathrm{X}) \times Br(\mathrm{D}_2^{*0} \to \mathrm{D}^{*+}\pi^-)$ $\leq 1.4 \times 10^{-3}$ (95% CL)	D_2^{*0}
ALEPH (1997):	$Br(\overline{\mathrm{B}} \to \mathrm{D}_2^{*0} \ell^- \bar{\nu}\ \mathrm{X}) \times Br(\mathrm{D}_2^{*0} \to \mathrm{D}^{*+}\pi^-)$ $\leq 1.29 \times 10^{-3}$ (95% CL)	D_2^{*0}
CLEO (1998):	$Br(\mathrm{B}^- \to \mathrm{D}_2^{*0} \ell^- \bar{\nu}) \times Br(\mathrm{D}_2^{*0} \to \mathrm{D}^{*+}\pi^-)$ $\leq 1.6 \times 10^{-3}$ (90% CL)	D_2^{*0}

Key variables



Cross check of results



α angle between π^{**-} and π_{slow} in rest frame of D^{*+}.

Signal peaks at higher $|\cos(\alpha)|$ while background is flat.

Extra slide: charm counting