Semileptonic B and D Decays

A Review of Recent Progress

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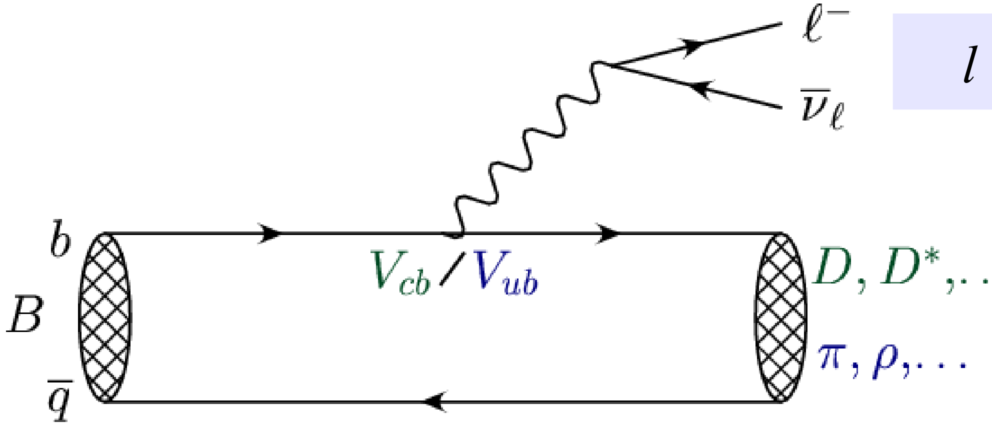
Representing the B Factories

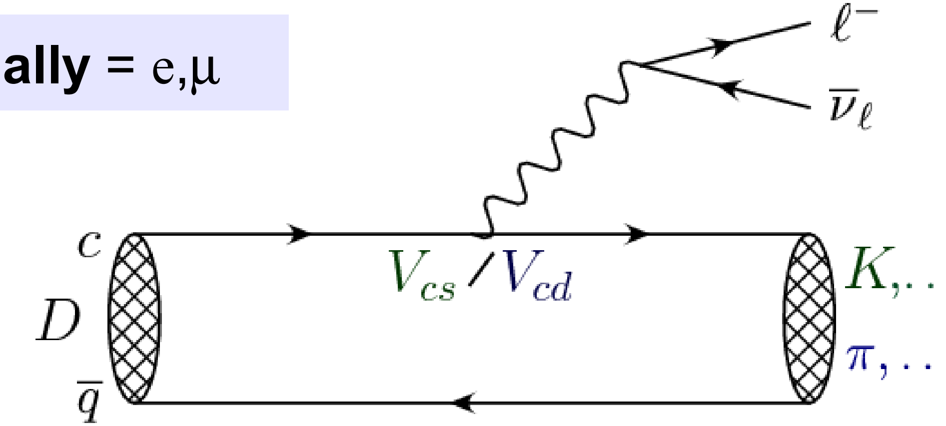
Outline

- Motivation – why study semileptonic decays?
- Inclusive decays
  - $|V_{cb}|$ and heavy-quark parameters
  - $|V_{ub}|$ from inclusive decays
- Exclusive decays
  - Charm semileptonic decays, form factors
  - $|V_{ub}|$ from exclusive decays
  - $B \to D l\nu$, $D^{*} l\nu$, and $D^{**} l\nu$
  - $B \to D^{(*)}\tau\nu$
- Conclusions

Why Study Semileptonic Decays?

l **usually** = e,μ





$B^- \to \ell^- \overline{\nu}_\ell$ anything	$(10.9 \pm 0.4)\%$
$D^0 \ell^- \overline{\nu}_\ell$	$(2.15 \pm 0.22)\%$
$D^{*0} \ell^- \overline{\nu}_\ell$	$(6.5 \pm 0.5)\%$
$B \to X_u \ell^- \overline{\nu}_\ell$	$(0.233 \pm 0.022)\%$
$B^0 \to \pi^- \ell^- \overline{\nu}_\ell$	$(0.00136 \pm 0.00015)\%$

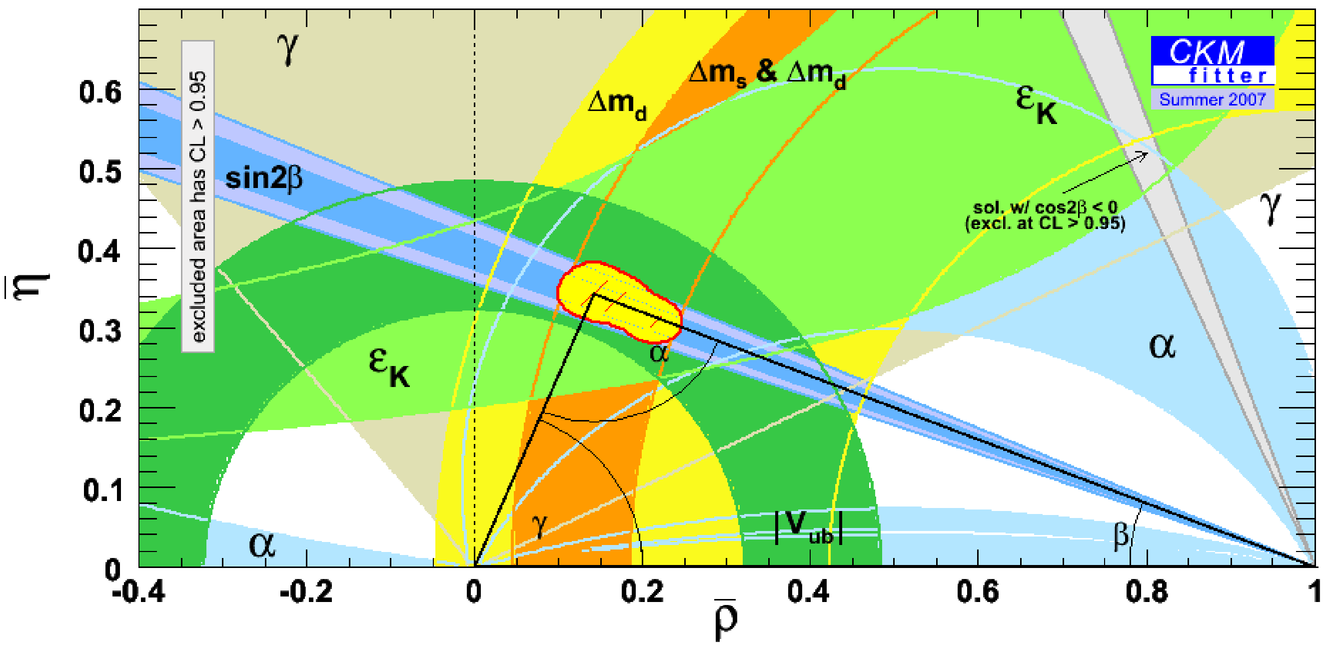
$D^+ \to e^-$ anything	$(17.2 \pm 1.9)\%$
$\overline{K}^0 e^- \overline{\nu}_e$	$(8.6 \pm 0.5)\%$

Selections from PDG07

- SL decays provide experimental access to studies of:
  - CKM mixing matrix elements
  - QCD – form factors
  - Heavy quark parameters, mass of *b* and *c* quarks
  - New physics

Why (II) – The Unitarity Triangle

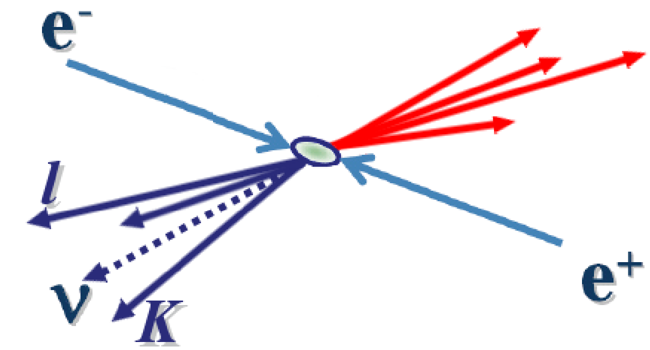
- Want to overconstrain the unitarity triangle
  - Need to measure $|V_{ub}|$ & $|V_{cb}|$ along with $\sin 2\beta$
  - Tension between inclusive and exclusive measures of $|V_{ub}|$ & $|V_{cb}|$ – need redundant methods

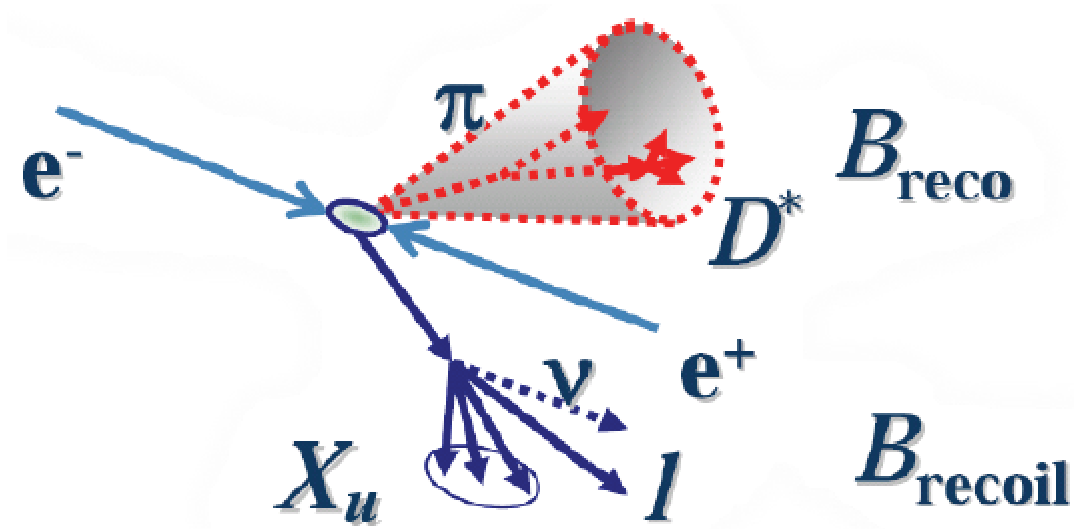


How to Study SL Decays

Need a handle on the neutrinos!

- Can infer from missing momentum
- Can use event topology to estimate ν momentum





- Very large datasets allow B_{reco} tagging
  - Fully reconstruct one *B*
  - Low efficiency (~3x10^{-3})
  - High purity sample with kinematic constraints

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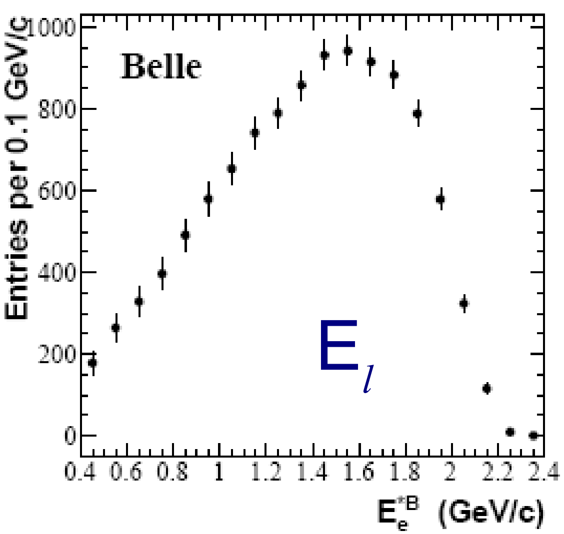
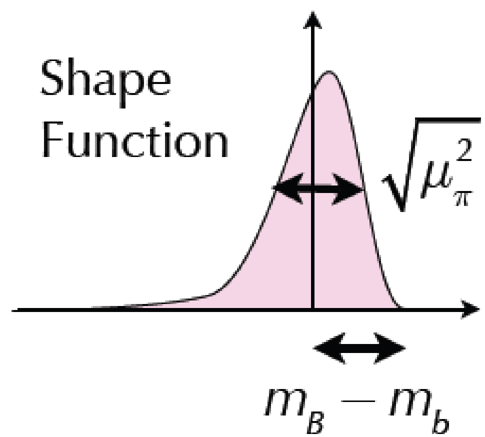
Inclusive Decay Formalism

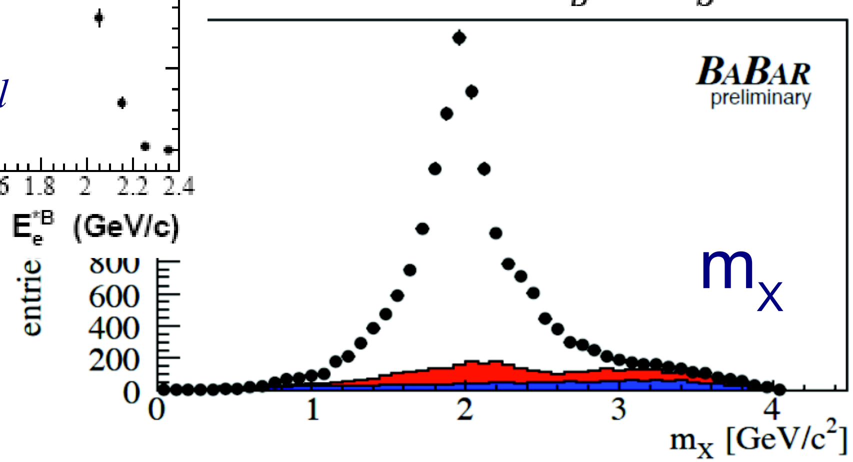
$$\Gamma(B \to X_c \ell \nu) = \frac{G_F^2 |V_{cb}|^2 m_b^5}{192\pi^3}(1 + A_{\rm ew})A_{\rm pert}A_{\rm nonpert}$$

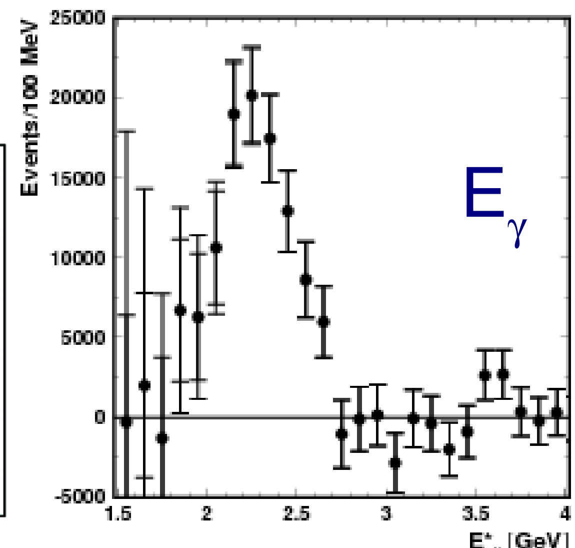
Measure nonperturbative parameters from shapes (moments) of inclusive decays

SF relates
- Lepton energy
- Hadronic mass
- Photon energy in $b \to s\gamma$

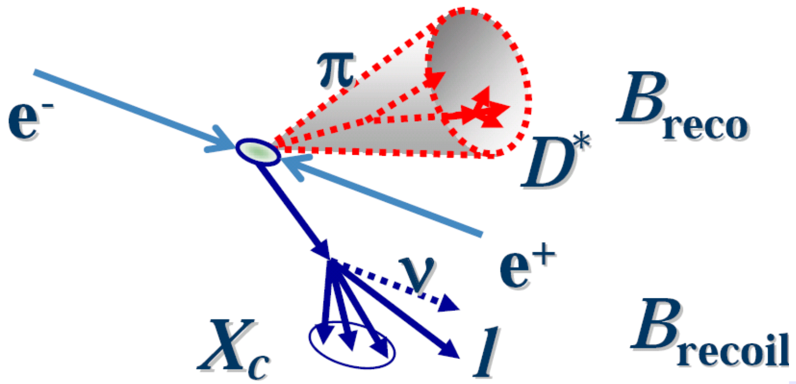


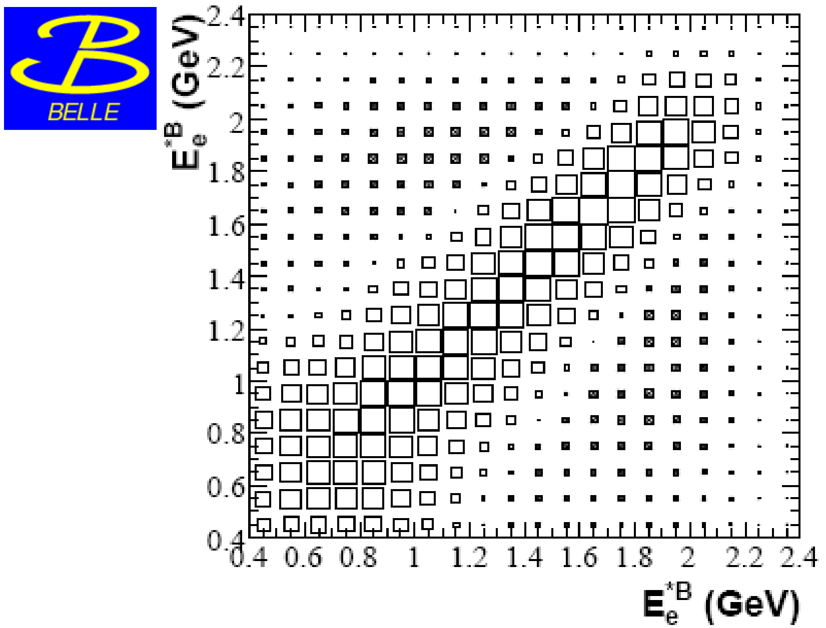






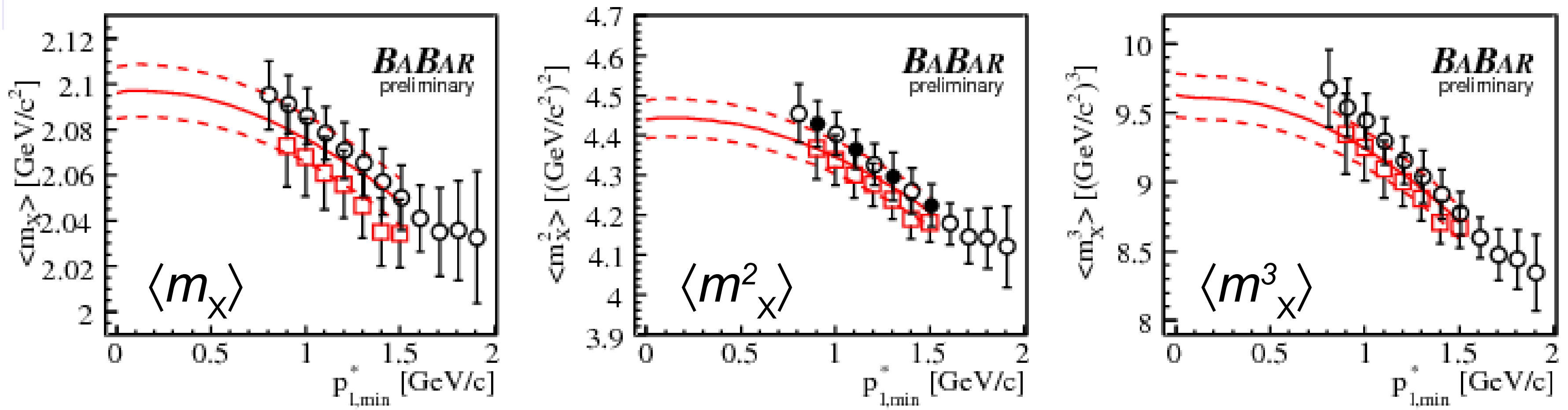
Measurement of $B \to X_c l\nu$ Moments





Need to correct for biases due to lost particles, resolution

- Belle: unfolding
- BaBar: calibration curves

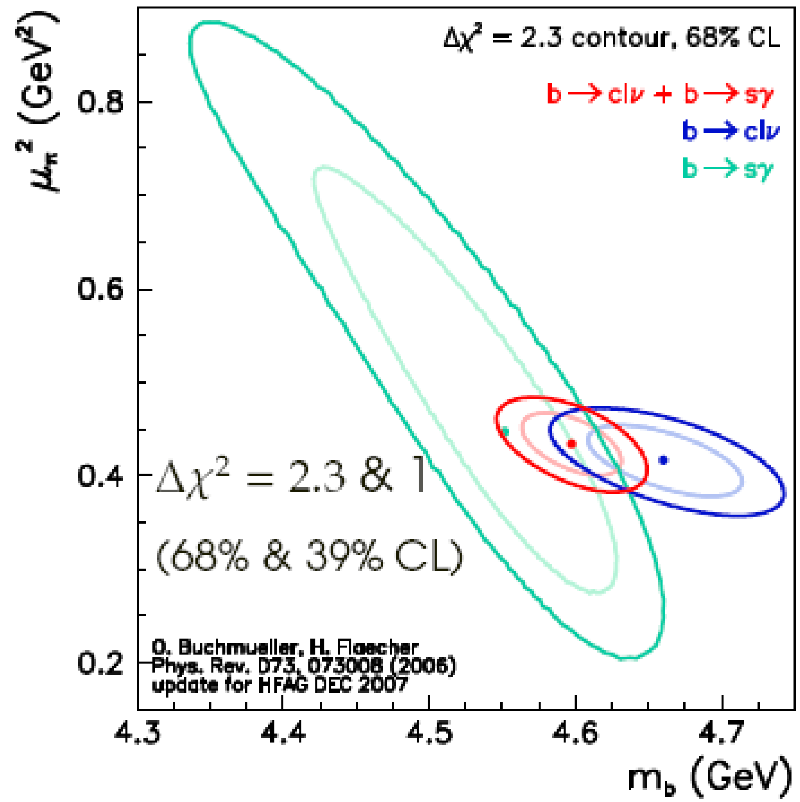


OPE Global Fit (Kinetic Scheme)

Global fit also includes moments from CLEO, CDF, and DELPHI

$$|V_{cb}| = (42.04 \pm 0.34_{\rm fit} \pm 0.59_{\Gamma_{\rm sl}}) \times 10^{-3}$$
$$m_b^{\rm kinetic} = 4.597 \pm 0.034_{\rm fit}\ \text{GeV}$$
$$m_c = 1.1634 \pm 0.051_{\rm fit}\ \text{GeV}$$
$$\mu_\pi^2 = 0.4341 \pm 0.033_{\rm fit}\ \text{GeV}^2$$
$$\rho_D^3 = 0.2927 \pm 0.020_{\rm fit}\ \text{GeV}^2$$

1.6% precision on $|V_{cb}|$, 0.7% on m_b



Belle E_l 152M BB, PRD75, 032001 (2007)
Belle m_X 152M BB, PRD75,032005 (2007)
BaBar m_X 232M BB, arXiv:0707.2670 (2007)

- Different mass schemes available
  - Kinetic – Gambino & Uraltsev, Phys J C34, 181
  - 1S – Bauer *et al*., Phys Rev D70, 094017

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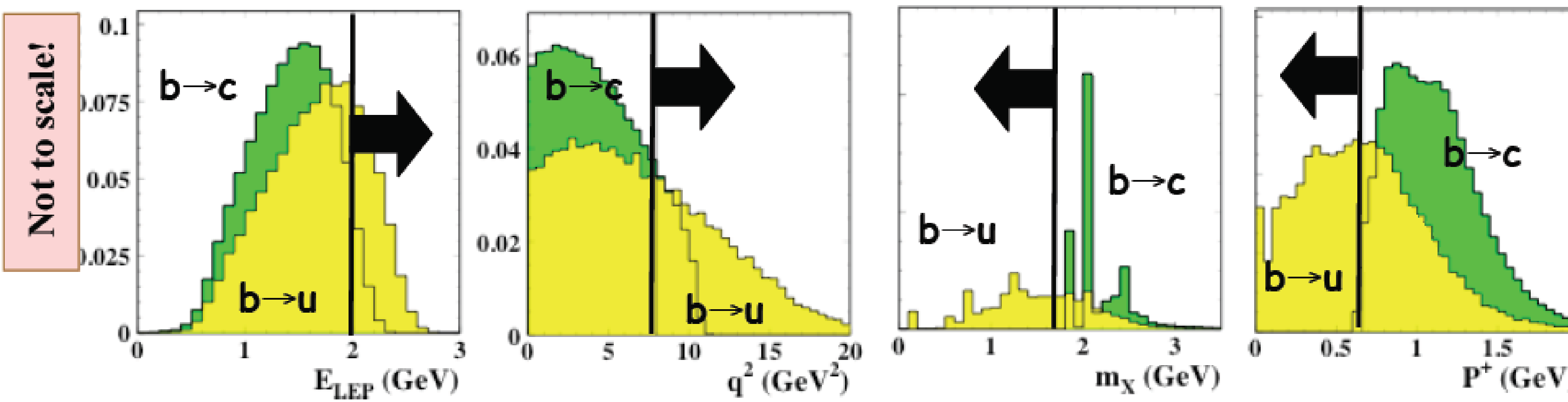
Inclusive $|V_{ub}|$ Measurement

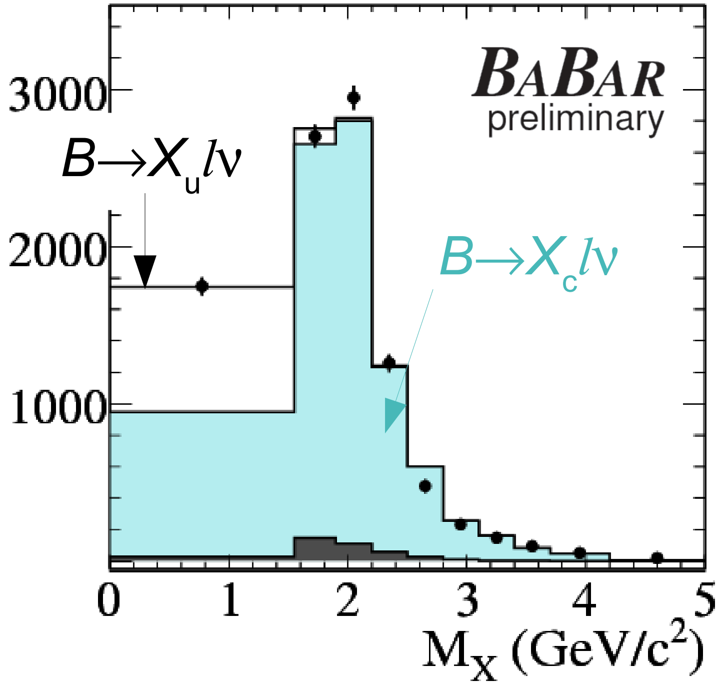
Charm background ~50x larger than signal
Use kinematics to distinguish X_u signal from X_c BG ($m_c >> m_u$)

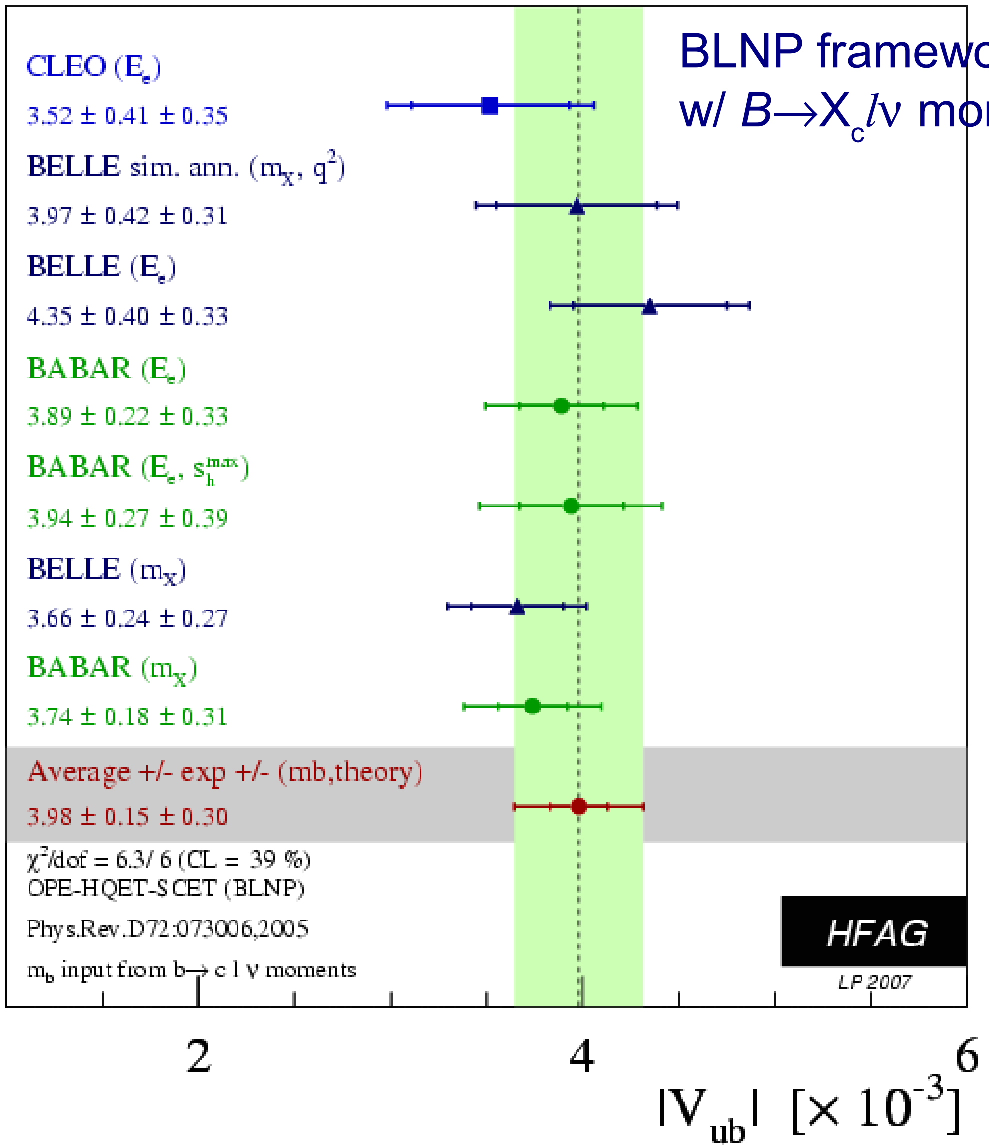


- E_{LEP} = lepton energy
- q^2 = momentum transfer squared = $(p_B - p_X)^2 = (p_l + p_\nu)^2$
- m_X = mass of the hadronic system
- $P^+ = E_X - |p_X|$ = light-cone component of X momentum

HQE parameters from $B \to X_c l\nu$ and $B \to s\gamma$ allow extrapolation to full phase space and extraction of $|V_{ub}|$

Inclusive $|V_{ub}|$ Results





BLNP framework
w/ $B \to X_c l\nu$ moments

BaBar 383M BB arXiv:0708.3702 (2007)
Belle 275M BB PRL 95 241801 (2005)

$|V_{ub}| = (3.98 \pm 0.15 \pm 0.30) \times 10^{-3}$

Measured to 8%

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Exclusive Decay Formalism

- Dynamics described by form factors:

i.e. $D \to K l \nu$

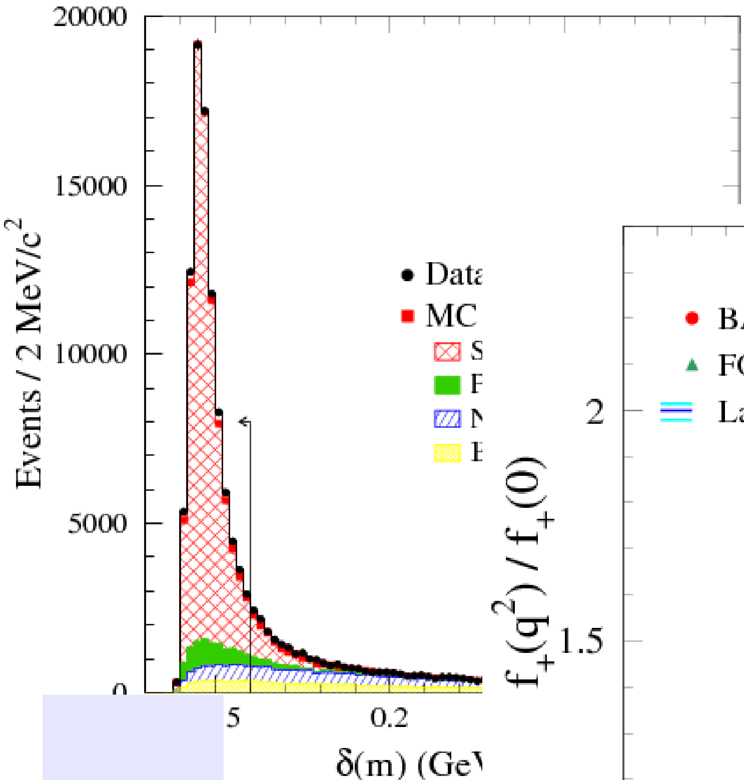
$$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cs}|^2 \left|\vec{p}_K(q^2)\right|^3 \left|f_+(q^2)\right|^2$$

FFs functions of $q^2=(p_l+p_\nu)^2$

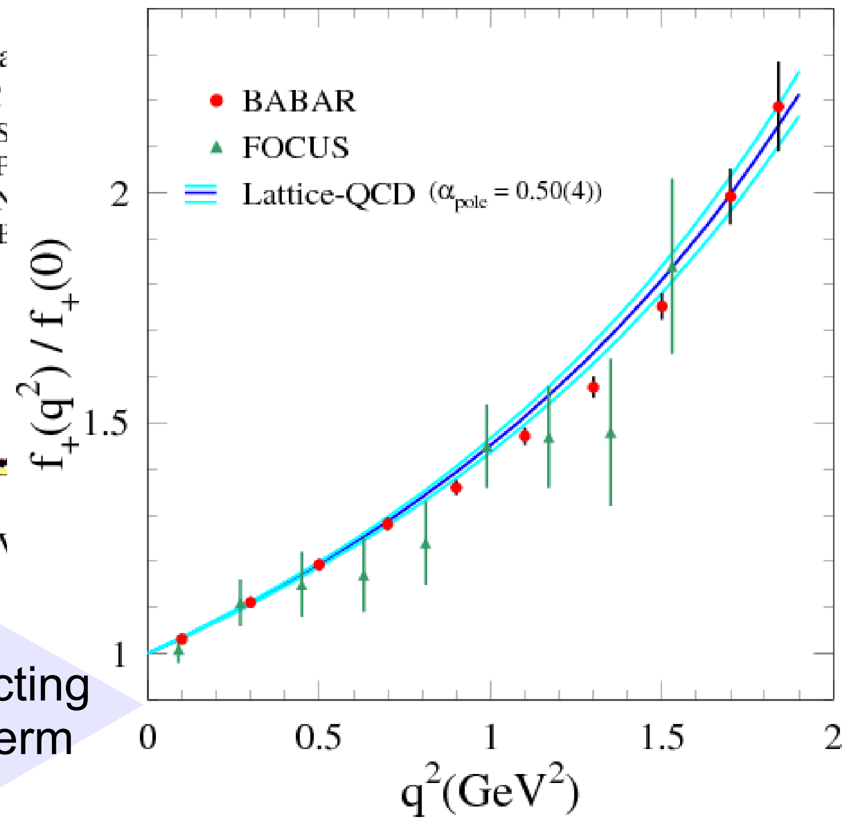
- FF calculations on the market
  - Lattice QCD
  - Simple (modified) pole model
  - Quark models – ISGW2, ...
  - HQET and dispersion relations

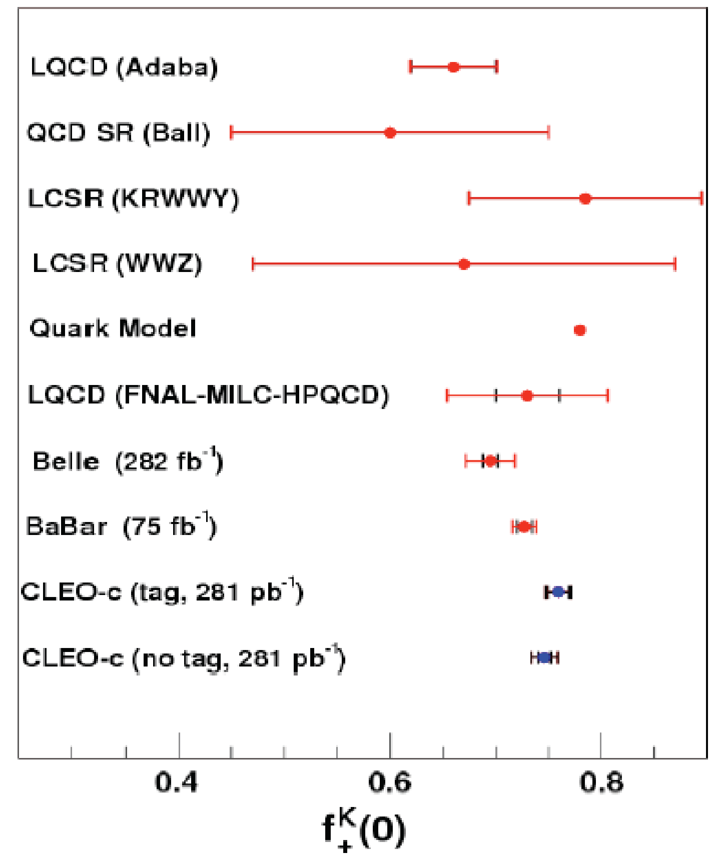
$D^0 \to K l \nu$ Form Factor Measurement

Results exclude ISGW2, simple pole models
Good agreement with LQCD predictions



$d\Gamma/dq^2$ after correcting for p^3 kinematic term





BaBar PRD 76 052005 (2007)
Belle PRL 97 061804 (2006)
Cleo-c arXiv:0712.0998 (2007)

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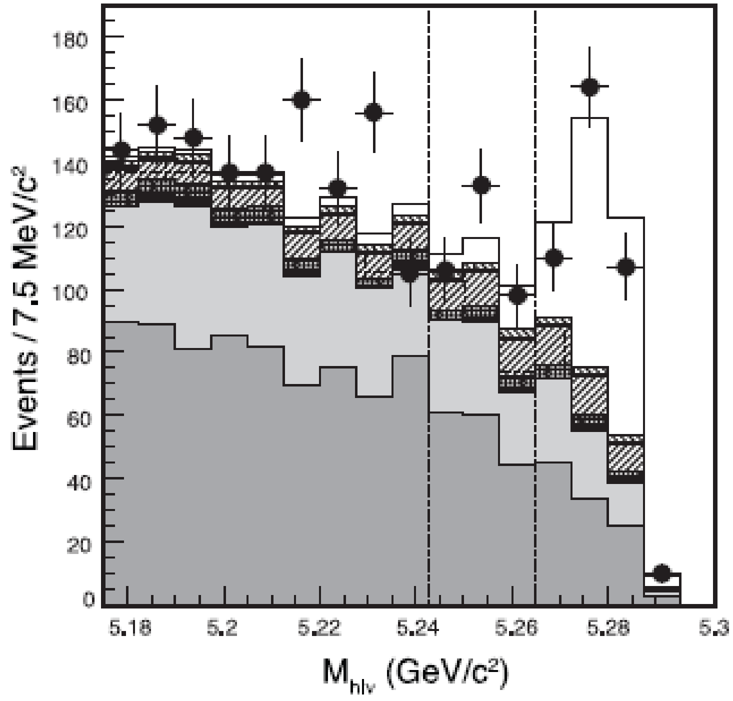
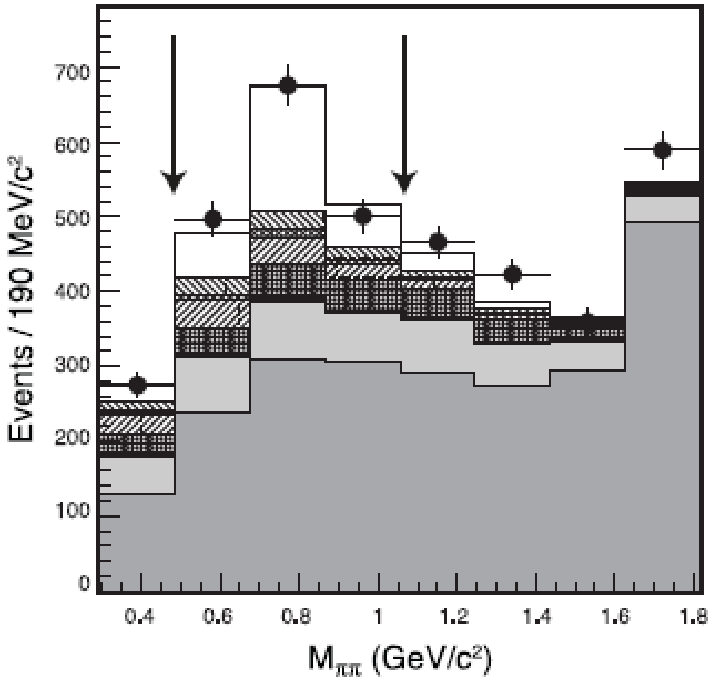
Exclusive $|V_{ub}|$ Modes

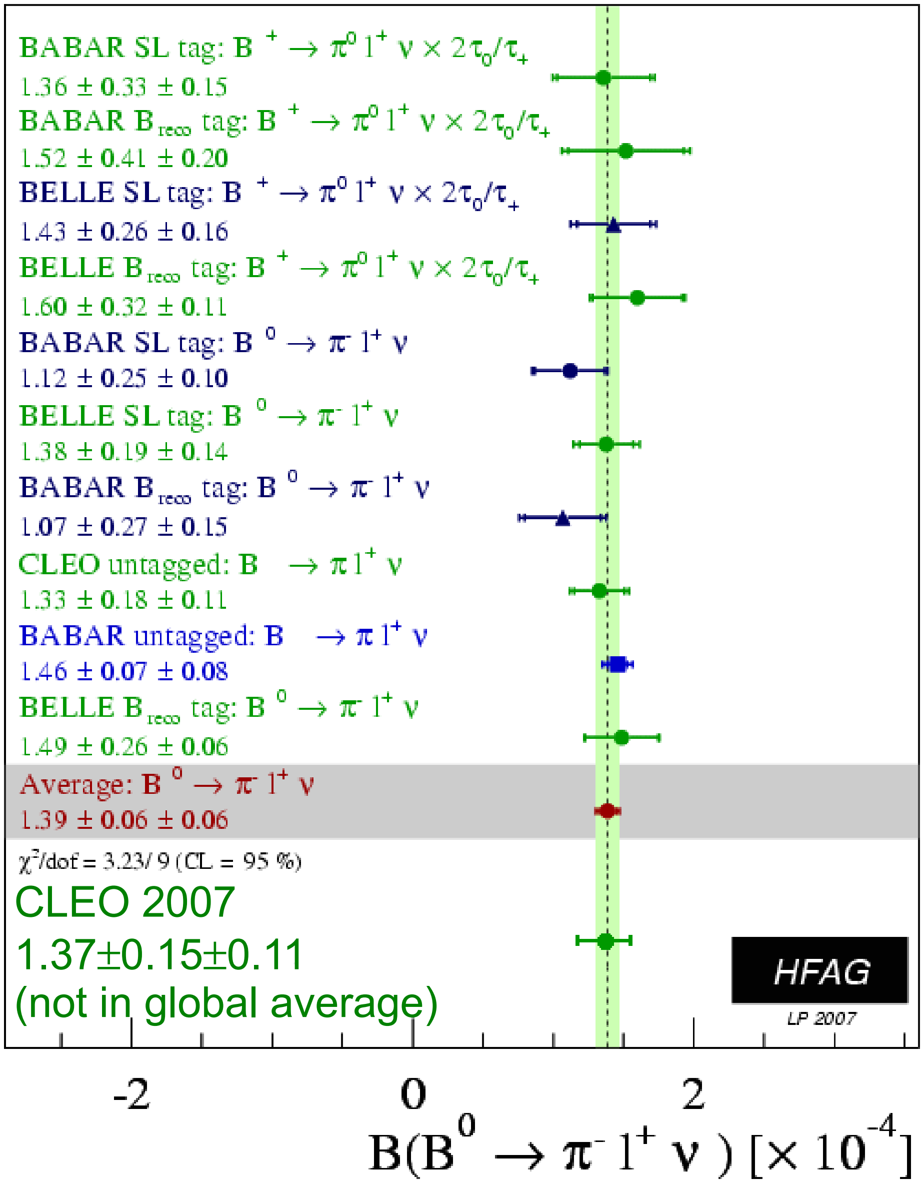
- New results from CLEO on $B \to \pi, \pi^0, \rho, \rho^0, \omega, \eta, \eta' \, l\nu$:





CLEO 17M BB, PRD 76 012007 (2007)
Belle SL tag 275M BB, PLB 648 139 (2007)
BaBar untagged 227M BB, PRL 98 091801 (2007)

Exclusive $|V_{ub}|$ (II)



	$\mathcal{B}\ [10^{-4}]$
$B^0 \to \pi^- \ell^+ \nu$	$1.37 \pm 0.15 \pm 0.11$
$B^0 \to \rho^- \ell^+ \nu$	$2.93 \pm 0.37 \pm 0.37$
$B^0 \to \eta \ell^+ \nu$	$0.44 \pm 0.23 \pm 0.11$
$B^0 \to \eta' \ell^+ \nu$	$2.66 \pm 0.80 \pm 0.56$

Using HPQCD form factor

$|V_{ub}| = (3.6\pm0.4\pm0.2^{+0.6}_{-0.5}) \times 10^{-3}$

Consistent w/ HFAG average

$|V_{ub}| = (3.33\pm0.21^{+0.58}_{-0.38}) \times 10^{-3}$

3σ evidence for η' mode, BF much larger than η... not theoretically favored...

Consistent with previous BaBar upper limit on η' at only 5% CL... need more measurements to understand

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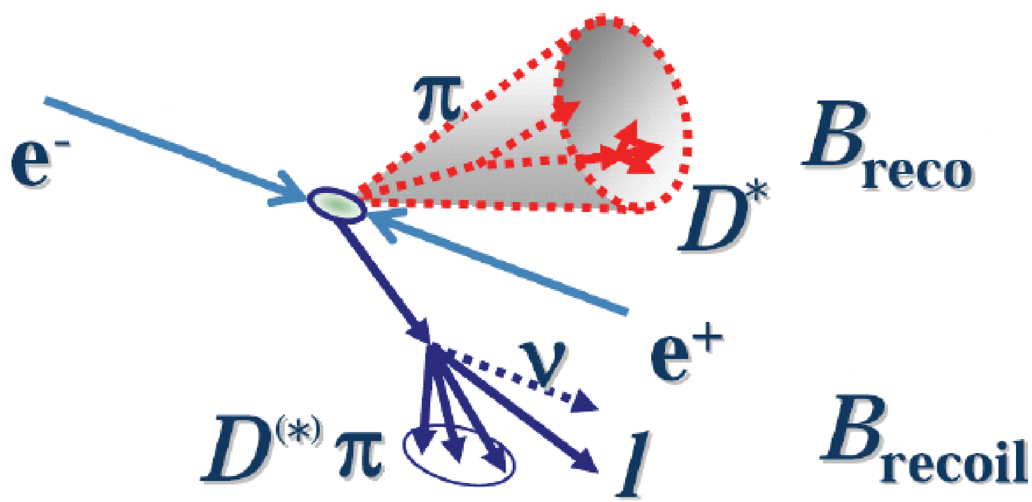
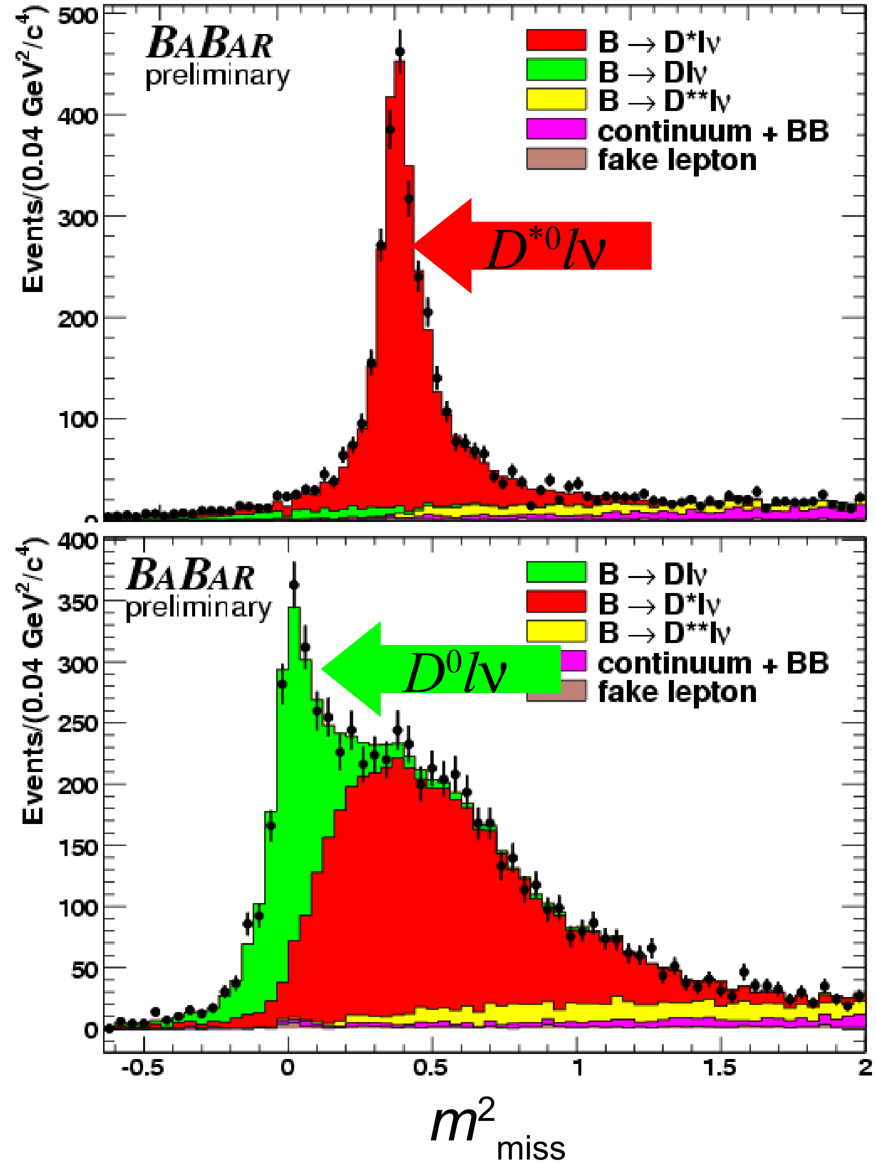
$B \to D/D^*/D^{**}\ l\nu$





BaBar 378M BB, arXiv:0712.3503 (2007)

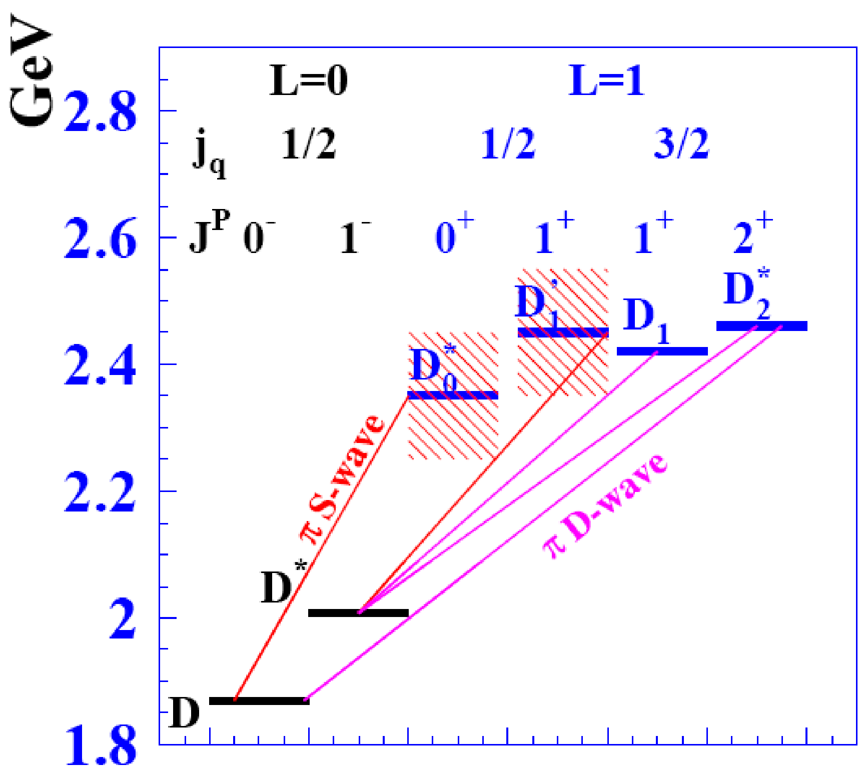
Mode	$\mathcal{B}(B^-)$ [%]	$\mathcal{B}(\overline{B}^0)$ [%]
$D\ell^-\overline{\nu}_\ell$	$2.33 \pm 0.09 \pm 0.09$	$2.21 \pm 0.11 \pm 0.12$
$D^*\ell^-\overline{\nu}_\ell$	$5.83 \pm 0.15 \pm 0.30$	$5.49 \pm 0.16 \pm 0.25$
$D\pi^\pm\ell^-\overline{\nu}_\ell$	$0.42 \pm 0.06 \pm 0.03$	$0.43 \pm 0.08 \pm 0.03$
$D^*\pi^\pm\ell^-\overline{\nu}_\ell$	$0.59 \pm 0.05 \pm 0.04$	$0.48 \pm 0.08 \pm 0.04$

$$\mathcal{B}(B^- \to D^{(*)}\pi\ell^-\overline{\nu}_\ell) = (1.52 \pm 0.12_{stat.} \pm 0.10_{syst.})\%$$
$$\mathcal{B}(\overline{B^0} \to D^{(*)}\pi\ell^-\overline{\nu}_\ell) = (1.37 \pm 0.17_{stat.} \pm 0.10_{syst.})\%$$

$B \to D^{**} l\nu$

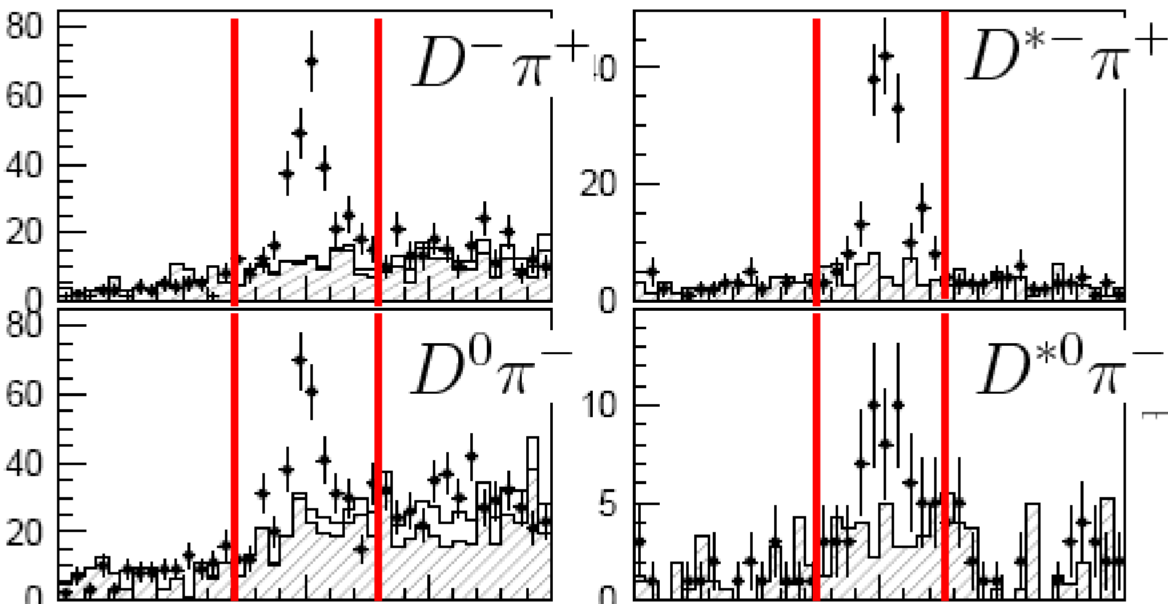
- Saturation puzzle:
  - Σ_{excl} < inclusive $B \to X_c l\nu$?
  - D and D^* only account for ~70% of X_c rate
- 1/2 vs. 3/2 puzzle:
  - HQET strongly favors j=3/2 states
  - Constrast to DELPHI result

$$\mathcal{B}(\bar{B} \to D_1'^0 X \ell^- \bar{\nu}_\ell) = (1.24 \pm 0.25 \pm 0.27)\%$$
$$\mathcal{B}(\bar{B} \to D_0^{*0} X \ell^- \bar{\nu}_\ell) = (0.42 \pm 0.33 \pm 0.22)\%$$



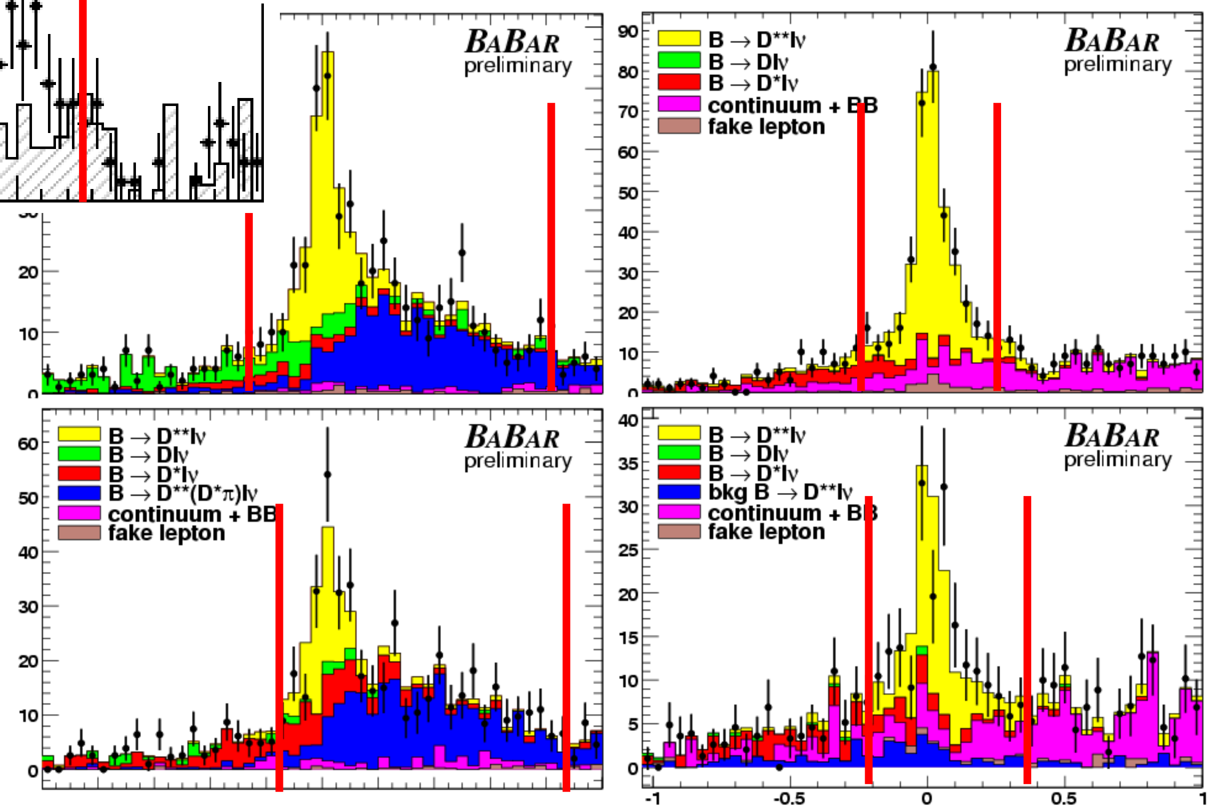
Use $D^{(*)}\pi l\nu$ samples to disentangle D^{**} states...

$B \to D^{**} l\nu$ Sample Selection



Reconstruct "D^{**}" as $D^{(*)}\pi^+$

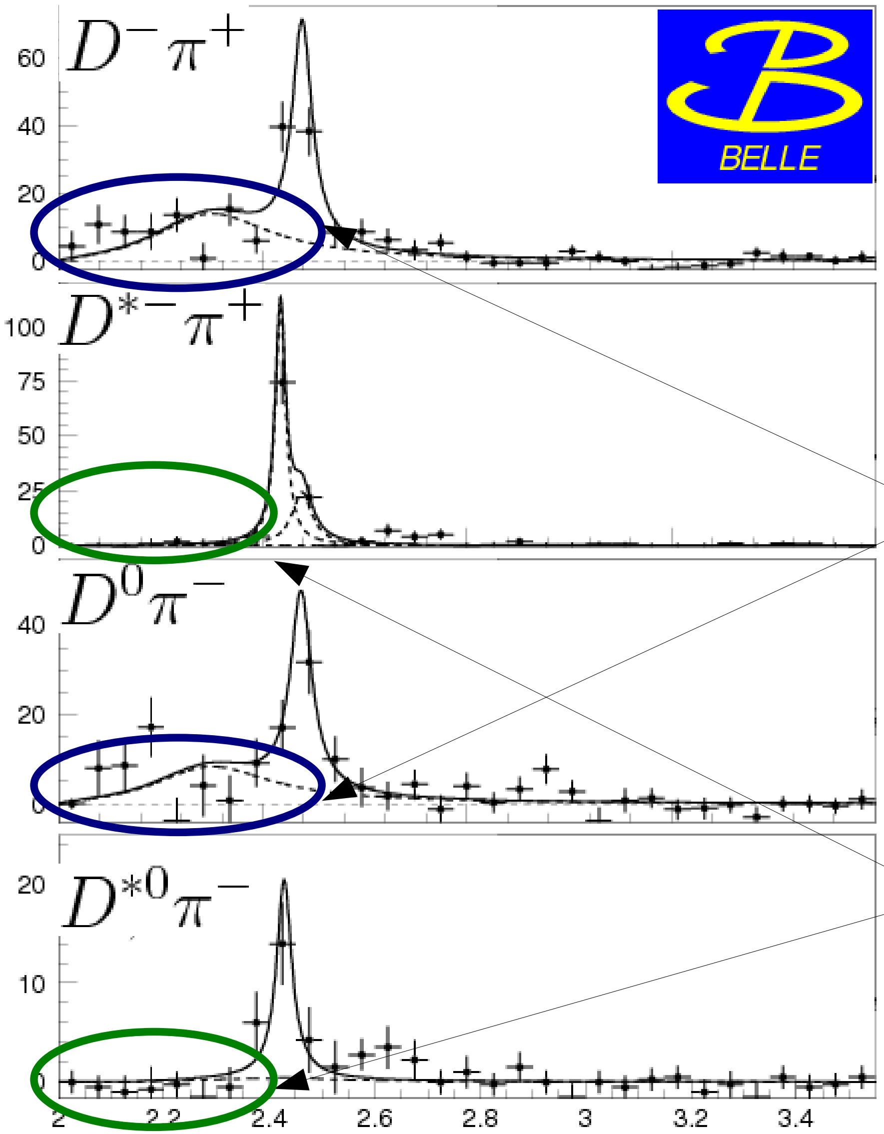
Select $B \to D^{**} l\nu$ cutting on m^2_{miss}



Main difference in selection:

BaBar uses larger, asymmetric window in m^2_{miss}

$B \to D^{**} l\nu$ $D^{(*)}\pi$ Mass Distributions



Very clear peaks for narrow D_1 and D_2^* states

D_0^* signal as large as narrow D_2^*

Consistent with DELPHI

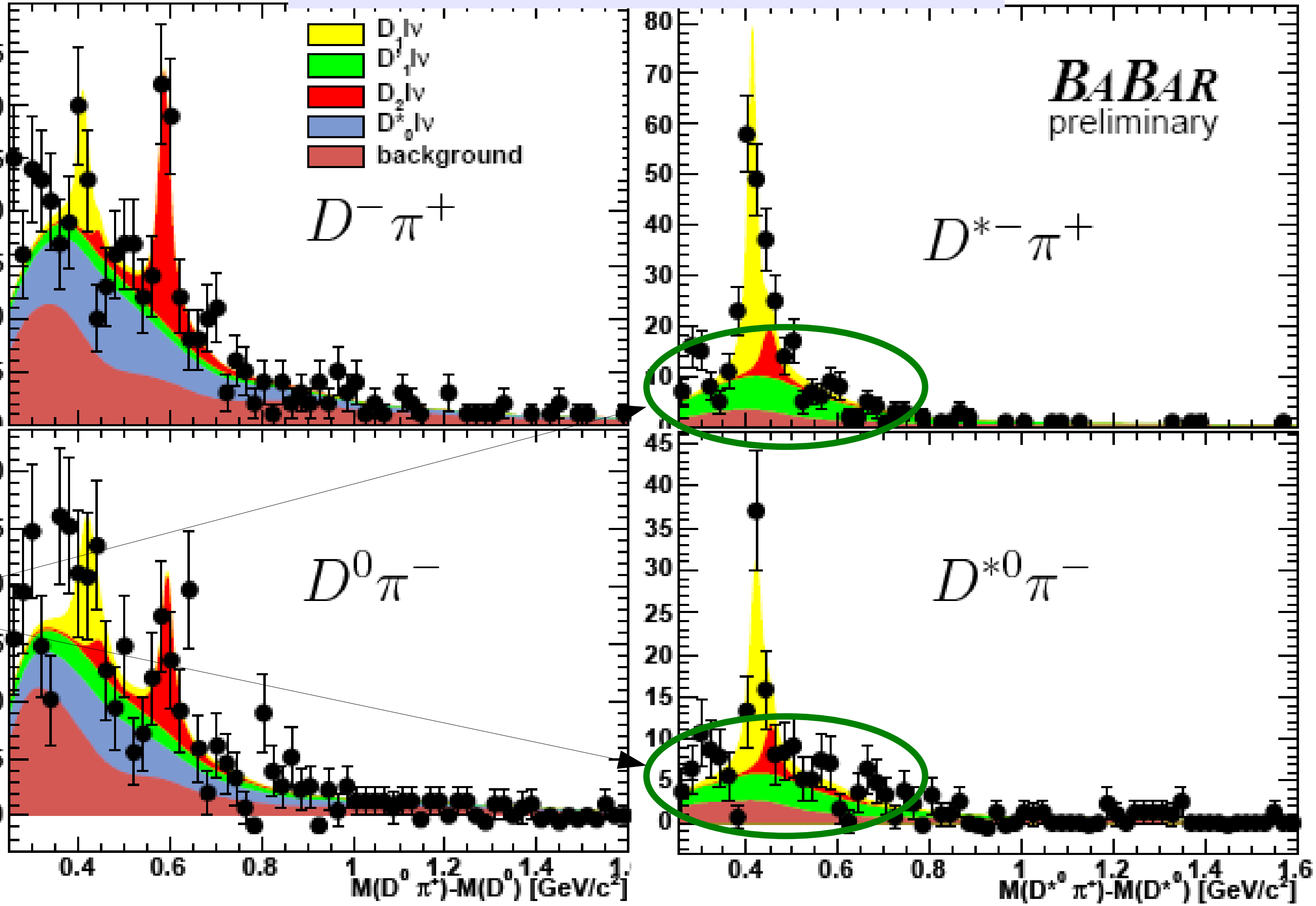
Unexpected in HQET

But no evidence for D_1' ?

$B \to D^{**} l\nu$ $D^{(*)}\pi$ Mass Distributions

Brand new for Moriond '08

- Simultaneous fit to all 4 channels, including crossfeeds
- BG normalized from fits to B_{tag} mass
- See $D_1'l\nu$ component



$B \to D^{**} l\nu$ Branching Fraction Results

Decay Mode	$\mathcal{B}\,(\bar{B} \to D^{**}\ell^-\bar{\nu}_\ell\,) \times \mathrm{B}\,(D^{**} \to D^{(*)}\pi)$ %(BELLE)	BABAR Branching Fraction
	$D\pi$ invariant mass fit	
$B^- \to D_0^{*0}\ell^-\bar{\nu}_\ell$	$0.24 \pm 0.04 \pm 0.06$	$0.28 \pm 0.05 \pm 0.04$
$B^- \to D_2^{*0}\ell^-\bar{\nu}_\ell$	$0.22 \pm 0.03 \pm 0.04$	$0.16 \pm 0.03 \pm 0.01$
$\bar{B}^0 \to D_0^{*+}\ell^-\bar{\nu}_\ell$	$0.20 \pm 0.07 \pm 0.05$	$0.47 \pm 0.09 \pm 0.07$
$\bar{B}^0 \to D_2^{*+}\ell^-\bar{\nu}_\ell$	$0.22 \pm 0.04 \pm 0.04$	$0.08 \pm 0.04 \pm 0.02$
	$D^*\pi$ invariant mass fit	
$B^- \to D_1'^0\ell^-\bar{\nu}_\ell$	< 0.07 @ 90CL	$0.27 \pm 0.05 \pm 0.05$
$B^- \to D_1^0\ell^-\bar{\nu}_\ell$	$0.42 \pm 0.07 \pm 0.07$	$0.29 \pm 0.03 \pm 0.03$
$B^- \to D_2^{*0}\ell^-\bar{\nu}_\ell$	$0.18 \pm 0.06 \pm 0.03$	$0.07 \pm 0.01 \pm 0.01$
$\bar{B}^0 \to D_1'^+\ell^-\bar{\nu}_\ell$	< 0.5 @ 90CL	$0.37 \pm 0.07 \pm 0.05$
$\bar{B}^0 \to D_1^+\ell^-\bar{\nu}_\ell$	$0.54 \pm 0.19 \pm 0.09$	$0.25 \pm 0.05 \pm 0.03$
$\bar{B}^0 \to D_2^{*+}\ell^-\bar{\nu}_\ell$	< 0.3 @ 90CL	$0.04 \pm 0.02 \pm 0.01$

Belle: nonresonant $D^{(*)}\pi l\nu$ consistent with zero. BaBar: nonres fixed to zero in fit

Belle 657M BB, arXiv:0711.3252 (2007)

- Main difference w.r.t. Belle: significant signal (>6σ) for $D_1' l\nu$
- 1/2 vs. 3/2 puzzle still lingers

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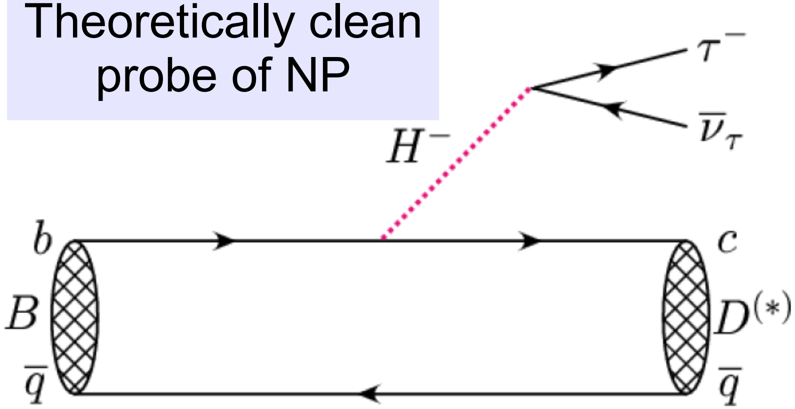
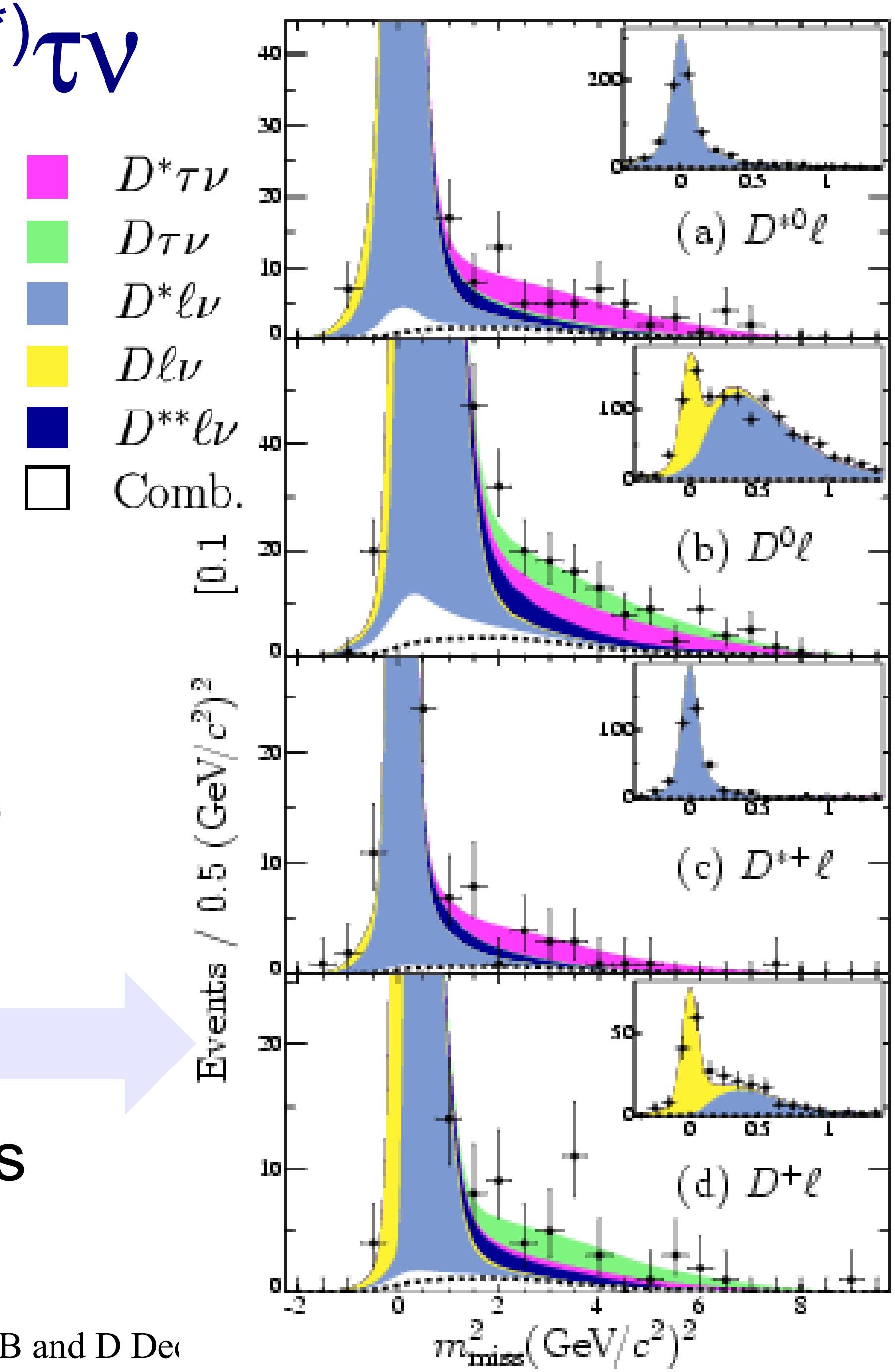
Theoretically clean probe of NP



$B \to D^{(*)}\tau\nu$

- Extremely challenging: 2-3 ν
- B_{reco} tag + $D^{(*)}$ + l
  - (Belle also uses $\tau \to \pi\nu$ mode)
- Signal extraction
  - BaBar: fit to m^2_{miss} and p^*_l
  - Belle: cut on X_{miss}, fit tag mass



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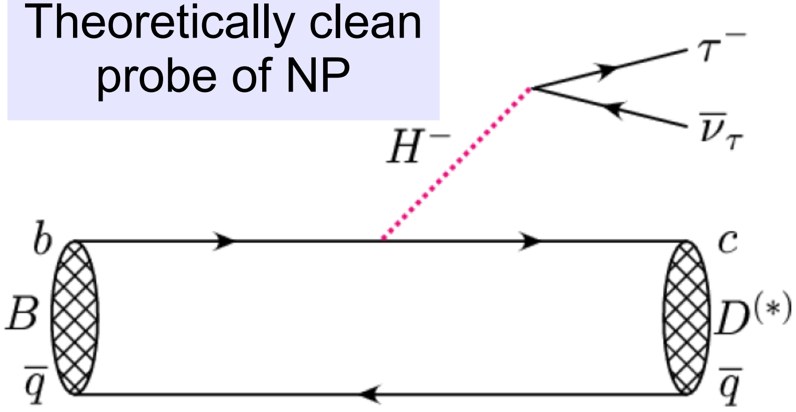

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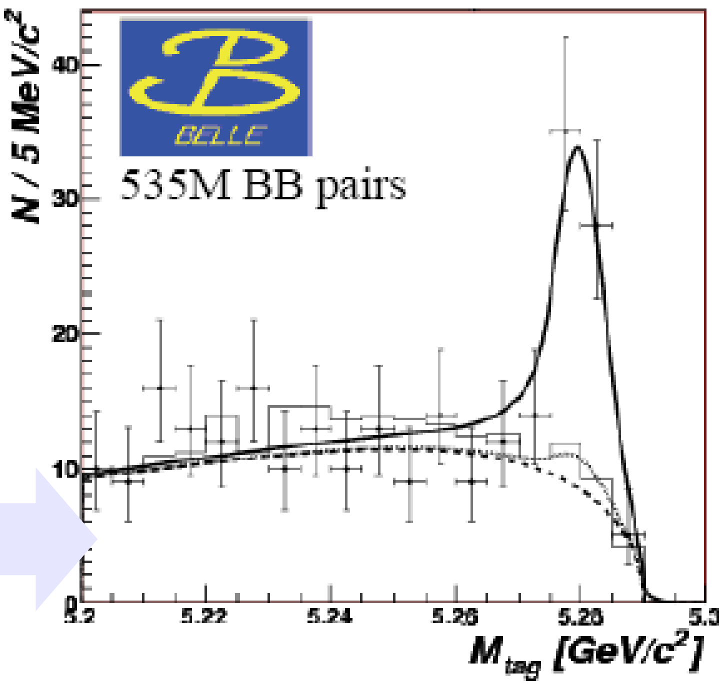
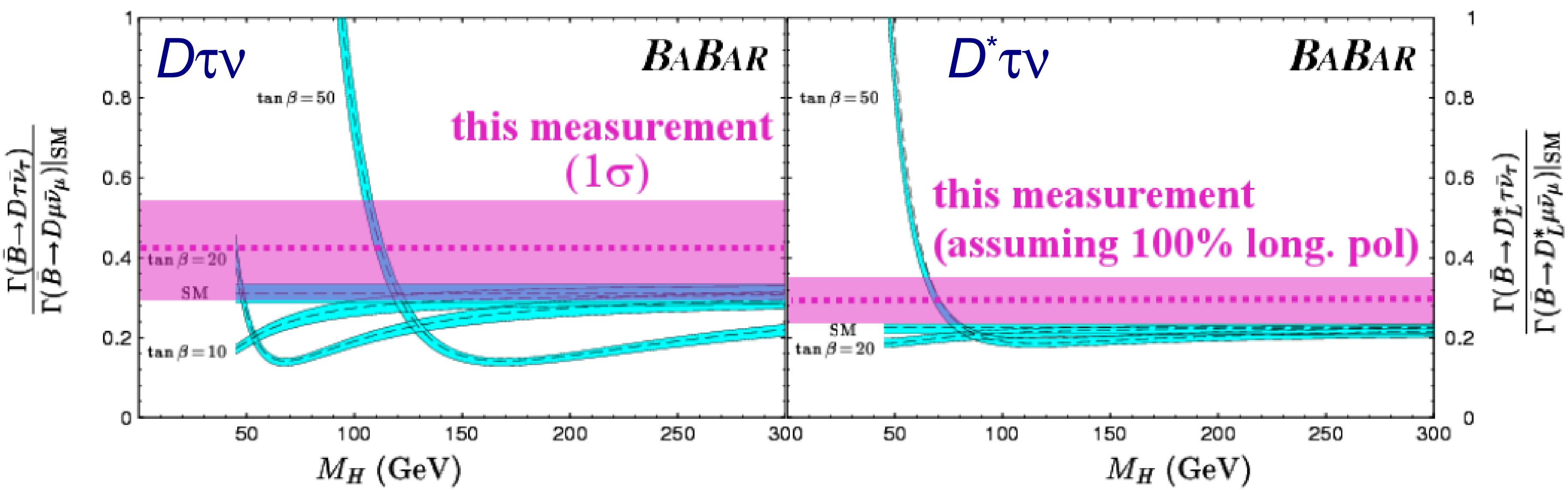


$B \to D^{(*)}\tau\nu$ Branching Fractions

Mode		$\mathcal{B}$ [%]
B^-	$\to D^0\tau^-\overline{\nu}_\tau$	$0.67 \pm 0.37 \pm 0.11 \pm 0.07$
B^-	$\to D^{*0}\tau^-\overline{\nu}_\tau$	$2.25 \pm 0.48 \pm 0.22 \pm 0.17$
$\overline{B}^0$	$\to D^+\tau^-\overline{\nu}_\tau$	$1.04 \pm 0.35 \pm 0.15 \pm 0.10$
$\overline{B}^0$	$\to D^{*+}\tau^-\overline{\nu}_\tau$	$1.11 \pm 0.51 \pm 0.04 \pm 0.04$
B	$\to D\tau^-\overline{\nu}_\tau$	$0.86 \pm 0.24 \pm 0.11 \pm 0.06$
B	$\to D^*\tau^-\overline{\nu}_\tau$	$1.62 \pm 0.31 \pm 0.10 \pm 0.05$

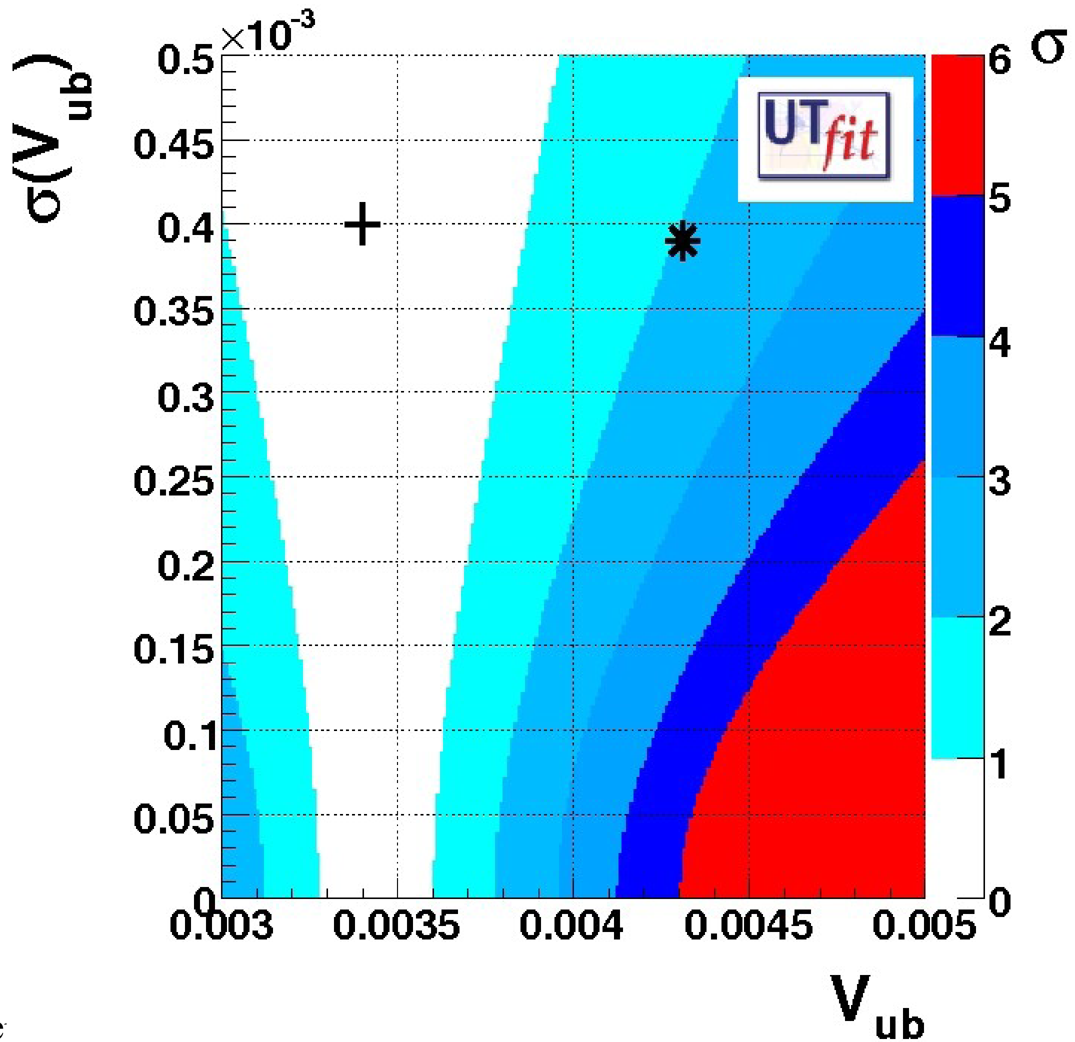
$$\mathcal{B}(\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau) = (2.02^{+0.40}_{-0.37} \pm 0.37)\%$$

Belle 535M BB, PRL 99 191807 (2007)
BaBar 232M BB, PRL 100 021801 (2008)



Summary and Outlook

- Lots of work ongoing at the B factories to fully explore semileptonic physics
  - $|V_{ub}|$ from exclusive decays = $(3.33 \pm 0.21^{+0.58}_{-0.38}) \times 10^{-3}$
  - Consistent with global UT fit $(3.44 \pm 0.16) \times 10^{-3}$ **[UTFit Collab]**
  - $|V_{ub}|$ from inclusive decays = $(3.98 \pm 0.15 \pm 0.30) \times 10^{-3}$

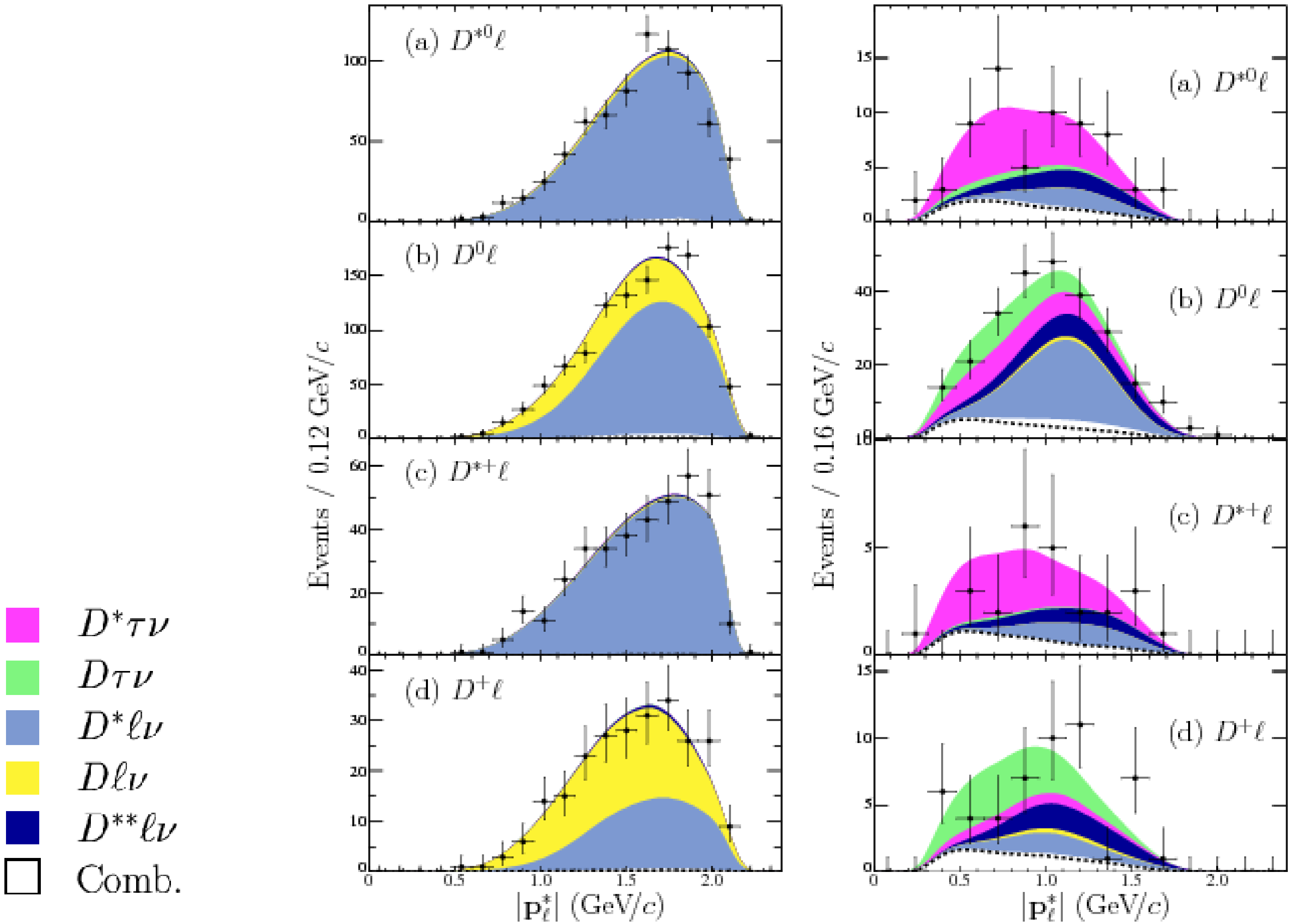


Summary and Outlook (II)

- Lots of work ongoing at the B factories to fully explore semileptonic physics
  - $|V_{ub}|$ precision better than 10%, multiple techniques converging
  - $|V_{cb}|$
    - Inclusive: $(42.04 \pm 0.34 \pm 0.59) \times 10^{-3}$ 1.6% precision
    - Exclusive: $(38.4 \pm 0.7 \pm 1.4) \times 10^{-3}$ ~2σ discrepancy
  - Ongoing efforts to understand the composition of "D**" states
  - τ final states becoming accessible, opening up windows to new physics

Backup

$B \to D^{(*)}\tau\nu$ – p^*_l Spectrum



$D^{**}l\nu$ Fit Yields

Decay Mode	Yield	$\mathcal{B} = \mathcal{B}\ (B \to D^{**}\ell^-\bar{\nu}_\ell\ )\ \%$	Stat. Sign. (Incl. Syst.)
$B^- \to D^{(*)+}\pi^-\ell^-\bar{\nu}_\ell$ invariant mass fit			
$B^- \to D_1^0\ell^-\bar{\nu}_\ell$	134 ± 16	0.43 ± 0.05	11.6 (9.)
$B^- \to D_2^{*0}\ell^-\bar{\nu}_\ell$	36 ± 6	0.34 ± 0.06	7.8 (6.8)
$B^- \to D_1^{'0}\ell^-\bar{\nu}_\ell$	117 ± 19	0.41 ± 0.07	6.9 (4.8)
$B^- \to D_0^{*0}\ell^-\bar{\nu}_\ell$	125 ± 23	0.42 ± 0.08	5.6 (4.5)
$\bar{B}^0 \to D^{(*)0}\pi^+\ell^-\bar{\nu}_\ell$ invariant mass fit			
$\bar{B}^0 \to D_1^+\ell^-\bar{\nu}_\ell$	64 ± 12	0.37 ± 0.07	6.9 (5.9)
$\bar{B}^0 \to D_2^{*+}\ell^-\bar{\nu}_\ell$	11 ± 5	0.17 ± 0.08	2.6 (2.4)
$\bar{B}^0 \to D_1^{'+}\ell^-\bar{\nu}_\ell$	81 ± 16	0.55 ± 0.11	6.0 (4.8)
$\bar{B}^0 \to D_0^{*+}\ell^-\bar{\nu}_\ell$	124 ± 23	0.71 ± 0.13	5.8 (4.6)
$B^- \to D^{(*)}\pi\ell^-\bar{\nu}_\ell$ invariant mass fit (isospin-constraint)			
$B^- \to D_1\ell^-\bar{\nu}_\ell$	132 ± 13	0.42 ± 0.04	13.4 (9.8)
$B^- \to D_2^*\ell^-\bar{\nu}_\ell$	31 ± 5	0.29 ± 0.05	8.2 (5.6)
$B^- \to D_1'\ell^-\bar{\nu}_\ell$	134 ± 16	0.47 ± 0.06	8.0 (6.7)
$B^- \to D_0^*\ell^-\bar{\nu}_\ell$	156 ± 20	0.52 ± 0.07	7.8 (6.)

$$\begin{aligned}
\mathcal{B}(B^- \to D_1^0\ell^-\bar{\nu}_\ell) &= (0.42 \pm 0.04_{stat.} \pm 0.04_{syst.})\% \\
\mathcal{B}(B^- \to D_1^{'0}\ell^-\bar{\nu}_\ell) &= (0.47 \pm 0.06_{stat.} \pm 0.06_{syst.})\% \\
\mathcal{B}(B^- \to D_2^{*0}\ell^-\bar{\nu}_\ell) &= (0.29 \pm 0.05_{stat.} \pm 0.03_{syst.})\% \\
\mathcal{B}(B^- \to D_0^{*0}\ell^-\bar{\nu}_\ell) &= (0.52 \pm 0.07_{stat.} \pm 0.06_{syst.})\%
\end{aligned}$$

Isospin-constrained absolute BF's, assuming $D^{**} \to D^{(*)}\pi^+ = 2\ D^{**} \to D^{(*)}\pi^0$ and $D_2^* \to D^*\pi\ /\ D_2^* \to D\pi = 31/69$

$D^{**}l\nu$ Systematic Uncertainties

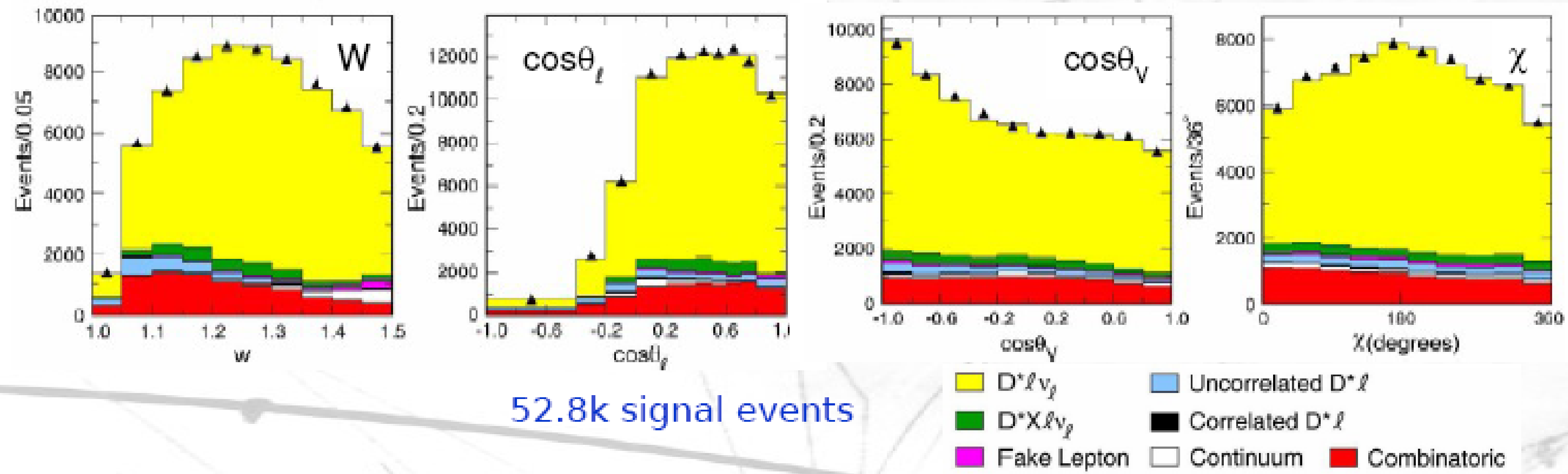
	Systematic uncertainty on $\Gamma(\overline{B} \to D^{**}(D^{(*)}\pi)\ell^-\bar{\nu}_\ell)/\Gamma(\overline{B} \to X\ell^-\bar{\nu}_\ell)$			
	$\bar{B} \to D_1\ell^-\bar{\nu}_\ell$	$\bar{B} \to D_1'\ell^-\bar{\nu}_\ell$	$\bar{B} \to D_2^*\ell^-\bar{\nu}_\ell$	$\bar{B} \to D_0^*\ell^-\bar{\nu}_\ell$
Tracking efficiency	1.5	1.9	1.2	1.6
Neutral reconstruction	2.6	1.8	1.2	0.9
lepton ID	1.2	1.2	1.2	1.5
Soft particle efficiency	1.2	1.2	0.4	-
Monte Carlo corrections				
$\overline{B^0} - B^-$ cross-feed	0.3	0.3	0.2	0.2
$D^{(*)}$ Form factors	0.8	0.8	0.5	0.4
D^{**} Form factors	1.0	2.5	1.2	2.0
$D^{(*)}$ branching fractions	3.9	3.9	3.8	3.8
$\overline{B} \to X\ell^-\bar{\nu}_\ell$ branching fraction	1.7	1.7	1.7	1.7
B_{tag} selection	4.8	4.8	4.7	4.6
Fit technique				
$\overline{B} \to X\ell^-\bar{\nu}_\ell$ yield	0.7	0.7	0.7	0.7
$\overline{B} \to D^{**}\ell^-\bar{\nu}_\ell$ yield	5.6	10.6	7.4	8.5
Total systematic error	9.3	13.0	10.0	11.0
Statistical error	9.9	12.2	15.2	13.1

$D^{*+}\ell\nu$: Form Factors and $|V_{cb}|$

- Simultaneous χ^2 fit of 1D projections in three variables w, $\cos\theta_l$, $\cos\theta_V$ (integrated over angle χ)

79M $B\bar{B}$

- First simultaneous measurement of form factors and $|V_{cb}|$, fully accounting for all correlations



52.8k signal events

- Final results combined with Phys.Rev. D74 (2006) 092004 (which uses a full 4D fit) to give a combined value of the form factors:

$\rho^2 = 1.179 \pm 0.048 \pm 0.028$ $\quad R_1(1) = 1.417 \pm 0.061 \pm 0.044$

$R_2(1) = 0.836 \pm 0.037 \pm 0.022$ $\quad F(1)|V_{cb}| = (34.7 \pm 0.3 \pm 1.1)\ 10^{-3}$

Syst. Uncertainties dominated by detector efficiencies, Bg, R_1, R_2

New BaBar FF are ~5 times better than the old ones from CLEO (with ~3 fb^{-1})

$B^- \to D^{*0} l\nu$ Analysis Strategy

- b quark is heavy – change variables from q^2 to w (HQET): $w \equiv \frac{m_B^2 + m_{D^*}^2 - q^2}{2 m_B m_{D^*}}$

$$\frac{d\Gamma}{dw}(B \to D^* \ell \nu) = \frac{G_F^2 |V_{cb}|^2}{48\pi^3} \mathcal{F}^2(w) \mathcal{G}(w)$$

Form factor

Phase space

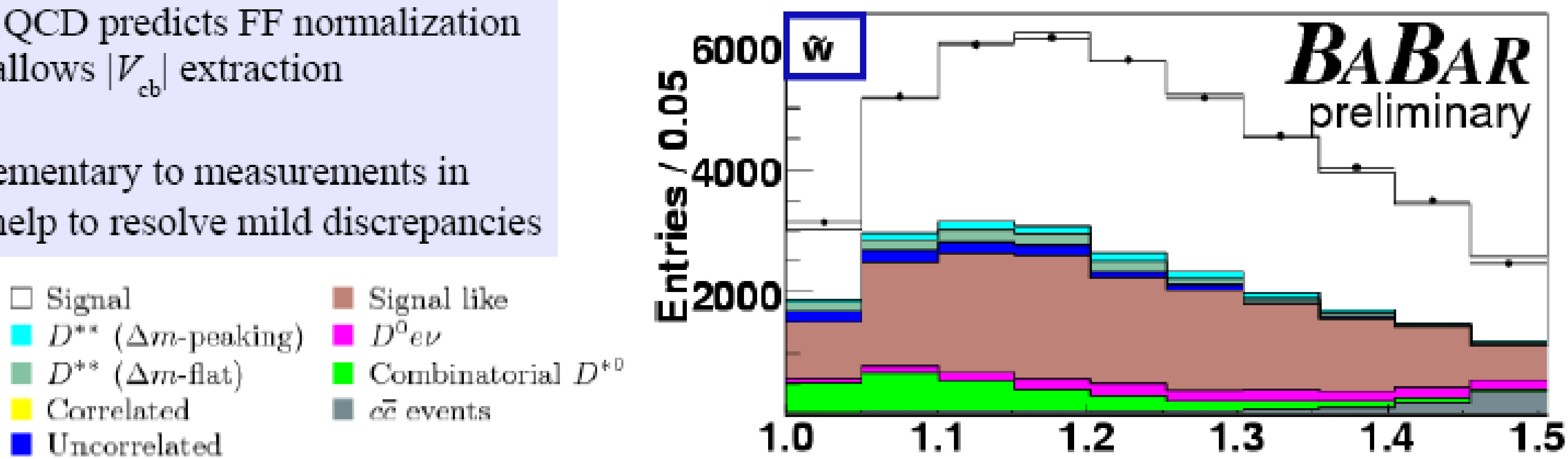
$$B^- \to D^{*0} e^- \overline{\nu}_e$$
$$\hookrightarrow D^0 \pi^0$$
$$\hookrightarrow K^- \pi^+$$

Use data to measure form factor slope in HQET parameterization

Lattice QCD predicts FF normalization which allows $|V_{cb}|$ extraction

Complementary to measurements in $D^{*+} l\nu$, help to resolve mild discrepancies

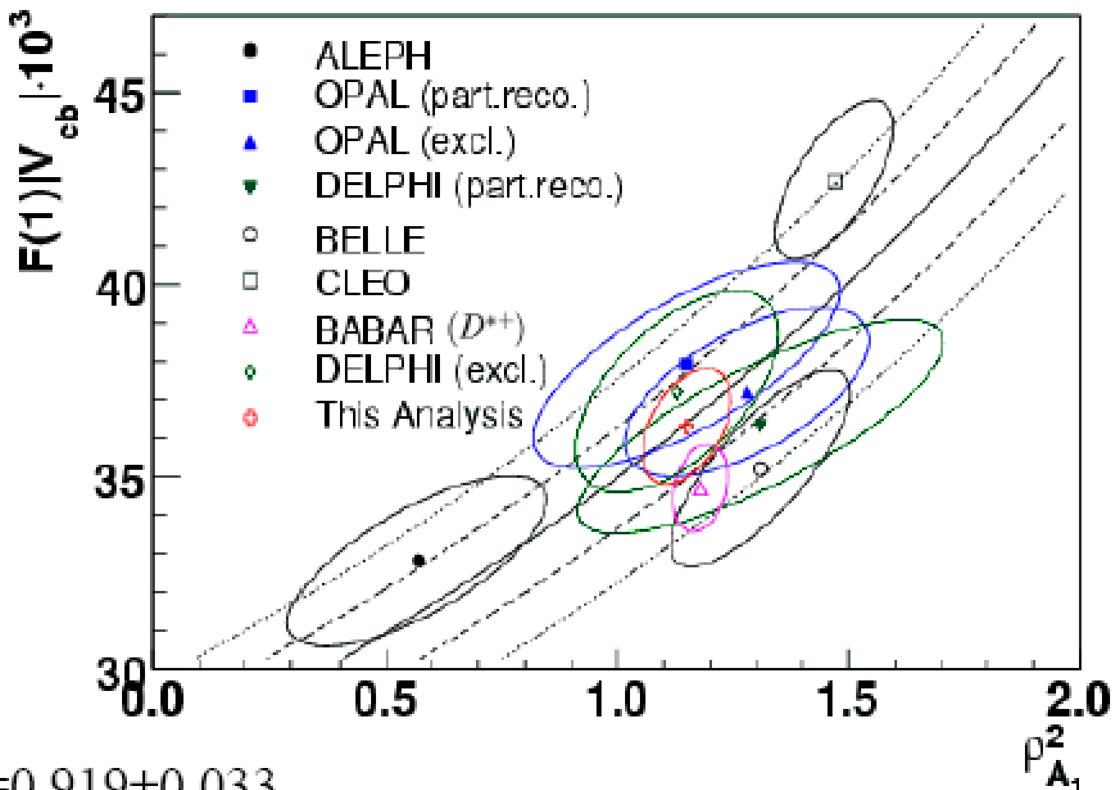
Infer ν direction from $m_\nu \approx 0$ and the fact that the B is ~ at rest in the 4S frame



$B^- \to D^{*0} l\nu$ Results

226M BB pairs
arXiv: 0707.2655

Consistent with previous measurements, help resolve mild discrepancies



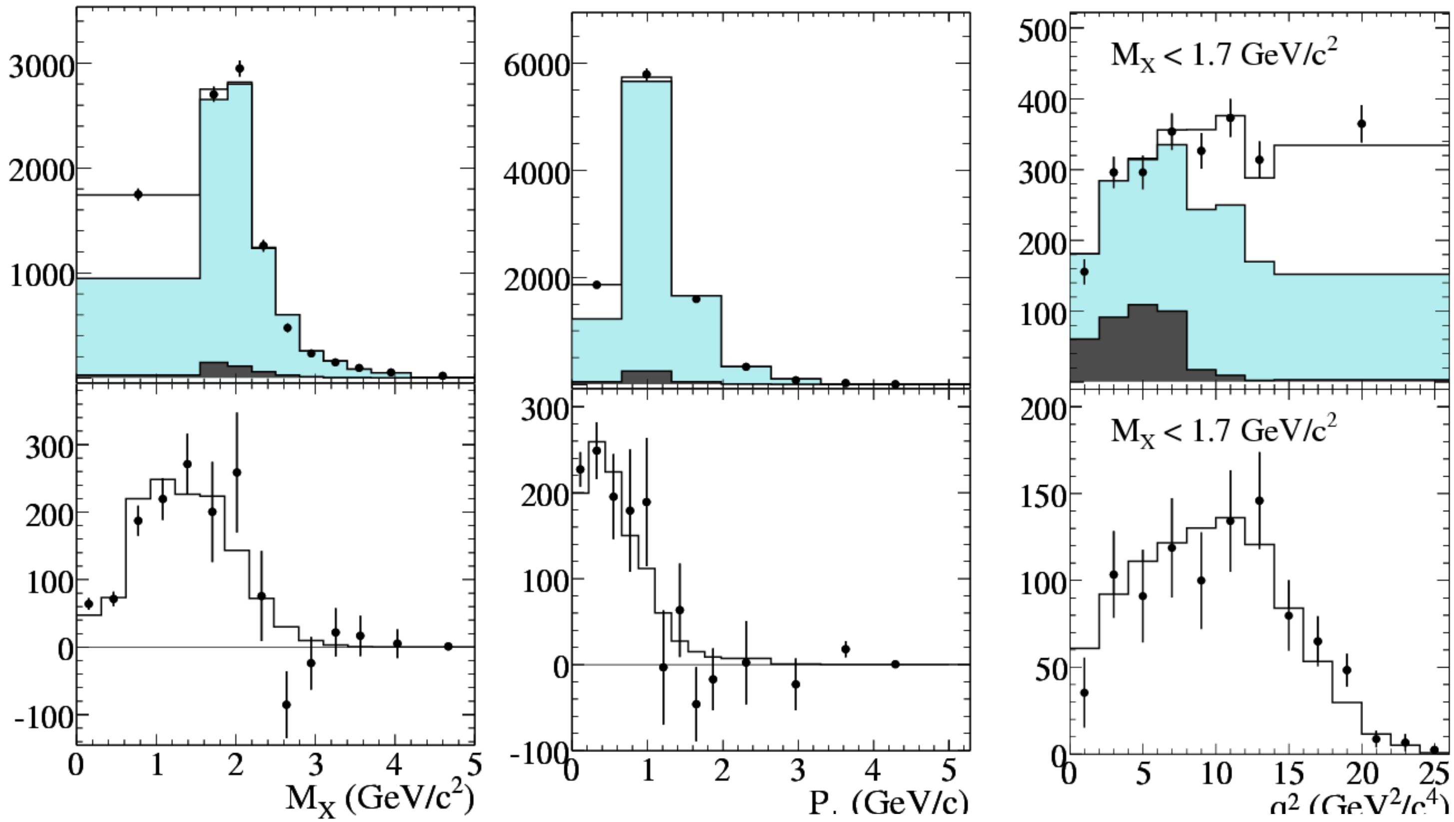
Lattice gives $F(1)$=0.919±0.033
Hashimoto et al., PR**D66** 104503

$|V_{cb}|$= (39.5±0.6±2.0) 10^{-3}

$|V_{cb}|$ from inclusive methods = (41.91±0.19±0.28±0.59) 10^{-3}

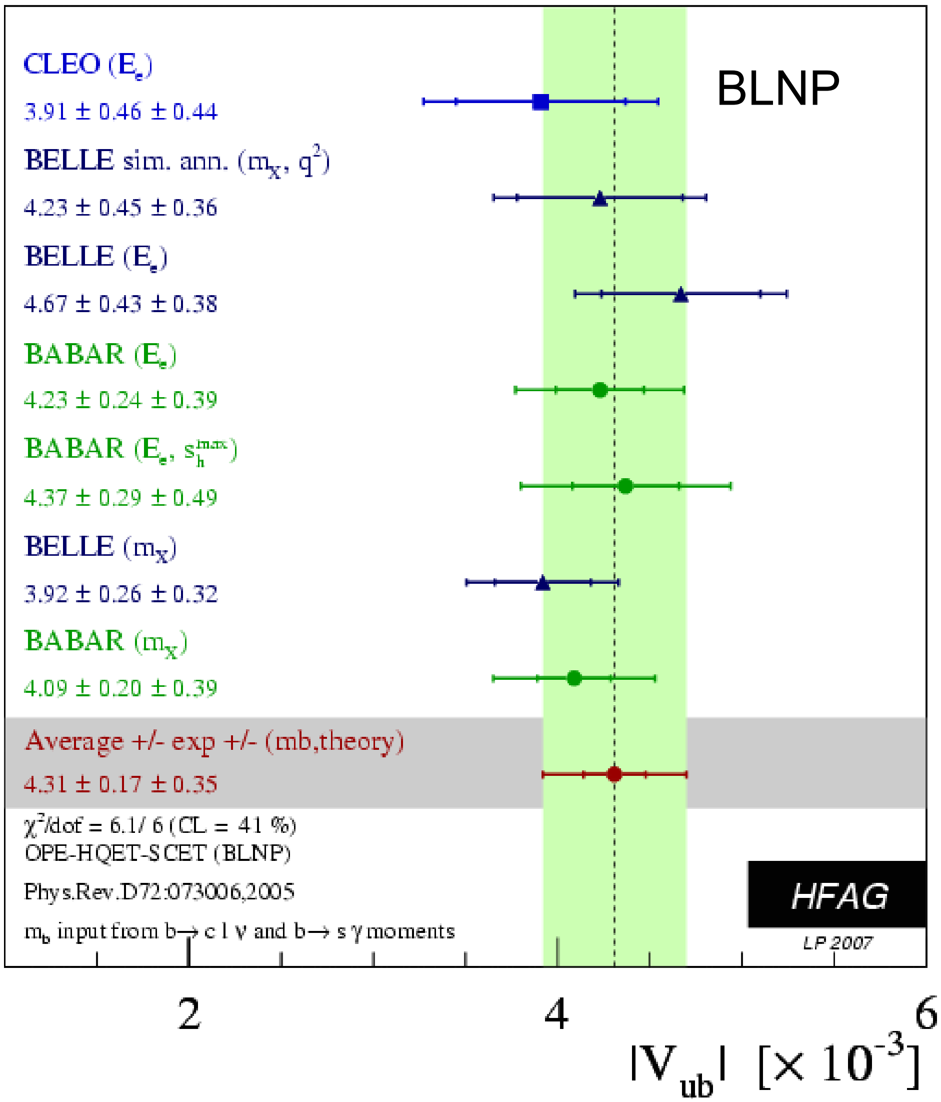
Total error on $|V_{cb}|$ from exclusive $D^*l\nu$ ~3%

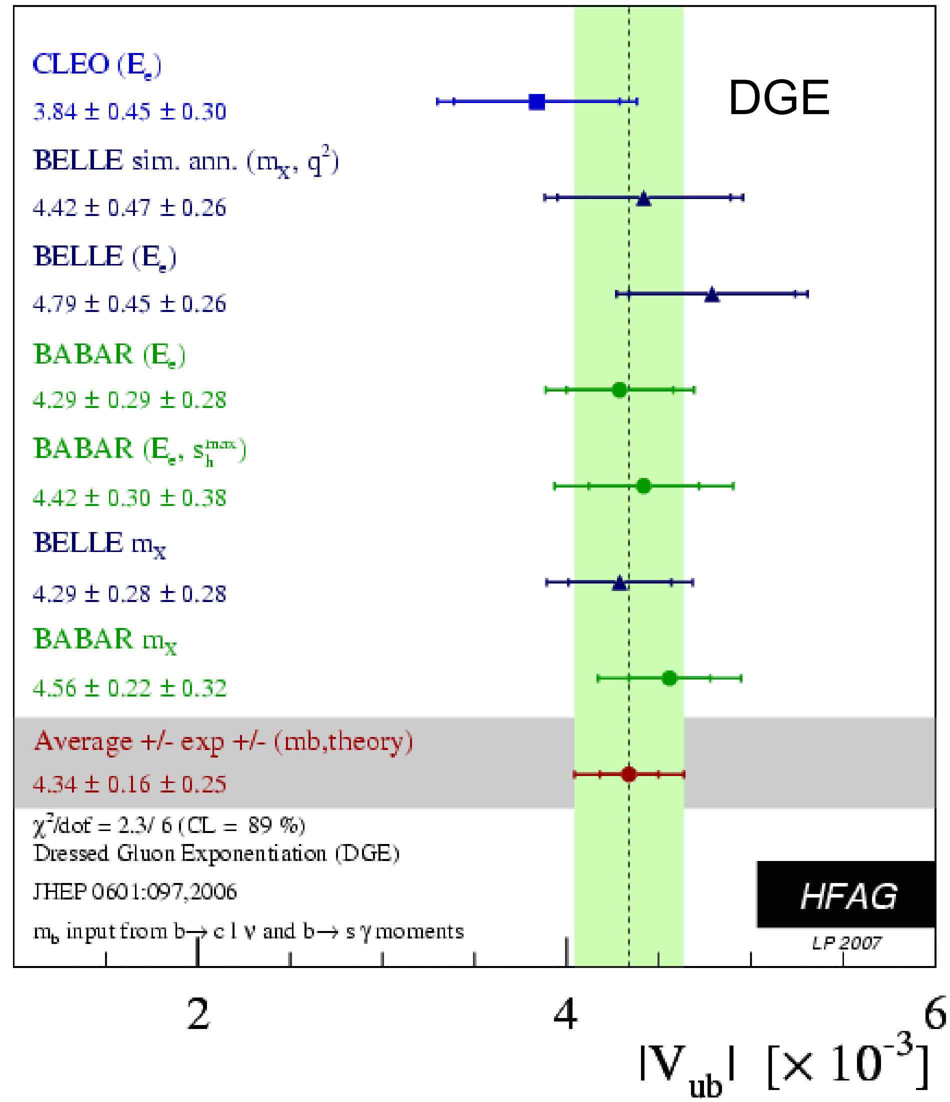
Other $|V_{ub}|$ Inclusive Fits



	$\Delta\mathcal{B}(\overline{B} \to X_u \ell \bar{\nu})$ (10^{-3})	$\lvert V_{ub}\rvert$ (10^{-3})
$M_X < 1.55$ GeV/c^2	$1.18 \pm 0.09 \pm 0.07 \pm 0.01$	$4.27 \pm 0.16 \pm 0.13 \pm 0.30$ $4.56 \pm 0.17 \pm 0.14 \pm 0.32$
$P_+ < 0.66$ GeV/c^2	$0.95 \pm 0.10 \pm 0.08 \pm 0.01$	$3.88 \pm 0.19 \pm 0.16 \pm 0.28$ $3.99 \pm 0.20 \pm 0.16 \pm 0.24$
$M_X < 1.7$ GeV/c^2 $q^2 > 8.0$ GeV^2/c^4	$0.76 \pm 0.08 \pm 0.07 \pm 0.02$	$4.48 \pm 0.22 \pm 0.19 \pm 0.30$ $4.53 \pm 0.22 \pm 0.19 \pm 0.25$ $4.81 \pm 0.23 \pm 0.20 \pm 0.36$

Other $|V_{ub}|$ Inclusive Results





Including $B \to s\gamma$, $(4.31 \pm 0.17 \pm 0.35) \times 10^{-3}$ $(4.34 \pm 0.16 \pm 0.25) \times 10^{-3}$