Exclusive $B \to X_c \ell \nu$ Decays at BaBar and determination of $|V_{cb}|$

On Behalf of the BaBar Collaboration
Marcello Rotondo
(INFN Padova)

Outlines

- $|V_{cb}|$ and Form Factors from $B \to D \ell \nu$ decays
  - Tagged $B \to D \ell \nu$
  - Untagged global fit $B \to DX \ell \nu$
- Excited states: $B \to D^{**} \ell \nu$
  - Tagged $B \to D^{**} \ell \nu$
- $B \to D^{(*)} \tau \nu$ decays and NP
- Conclusions

Extracting $|V_{cb}|$ with $B \to D\ell\nu$

- *$|V_{cb}|$ from $B \to D^*\ell\nu$ differ by ~2.5σ from inclusive determination*
  - *Cross check with $B \to D\ell\nu$*
- *Form Factor normalization in $B \to D\ell\nu$ can be computed with precision comparable with D* from LQCD*

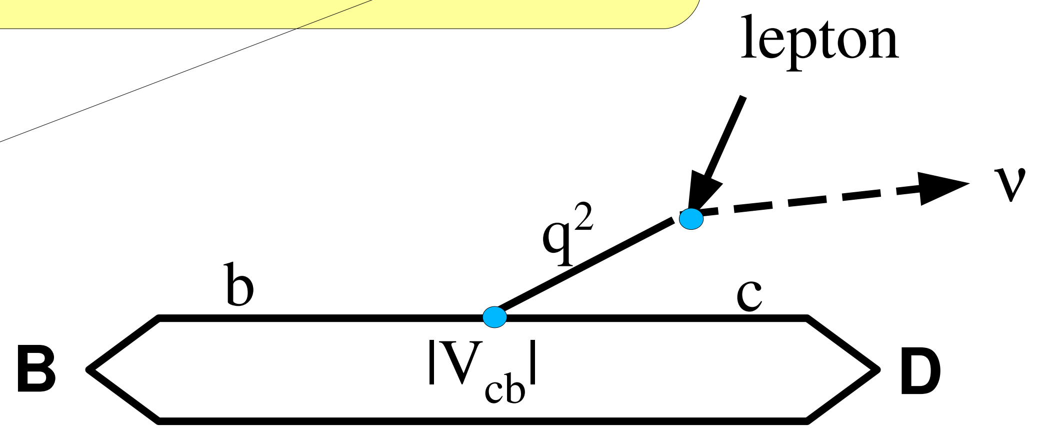
Extracting $|V_{cb}|$ with $B\to D\ell\nu$

HQET expansion of Form Factor:

$$w = \frac{m_B^2 + m_D^2 - q^2}{2 m_B m_D}$$

$$\frac{d\Gamma}{dw}(D) = \frac{G_F^2}{48\pi^3}(m_B + m_D)^2 m_D^3 (w^2 - 1)^{3/2} |V_{cb}|^2 \mathcal{G}^2(w)$$

$B\to$ D Form Factor
in the null lepton mass limit, only 1 form factor is relevant



For $B\to D\ell\nu$
$1.0 < w < 1.6$

- ***w ~ 1.0 D at rest***
- ***w ~ 1.6 W boson opposite to D***

G(w~1) From Lattice QCD + HQET

Helicity suppression at w~1 require extrapolation to w=1

Extracting $|V_{cb}|$ with $B \to D\ell\nu$

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Caprini et al. parameterization (CLN): Nucl.Phys.B 530 (1998), 153

$$\mathcal{G}(w) = \mathcal{G}(1)[1 - 8\rho^2 z + (51\rho^2 - 10)z^2 - (252\rho^2 - 84)z^3]$$

$$z = \frac{\sqrt{w+1} - \sqrt{2}}{\sqrt{w+1} + \sqrt{2}}$$

G(w) depends only on a single parameter: $\boldsymbol{\rho^2}$, the slope of G(w) at w=1
$\boldsymbol{\rho^2}$ is fitted together with $G(1)|V_{cb}|$

Note: similar expressions for $B \to D^*\ell\nu$ where $\rho_{D^*}^2$ fitted together with $F(1)|V_{cb}|$

Tagged $B^{+/0} \rightarrow D^{0/+}\ell\nu$

0904.4063[hep-ex]
submitted to PRL

- *B meson fully reconstucted in about 1000 adronic final states*
- *Reconstruct $B \rightarrow D\ell\nu$ in the recoil*
  - *9 final states for the D0*
  - *7 final states for the D+*
  - *Reduced background (↑S/N)*
  - *Fully exploit kinematic constraints (↑resolution)*
  - *Avoid neutrino reconstruction*
- *Identify semileptonic B decays through the missing mass squared in the event*

$$m^2_{\mathrm{miss}} = [p(\Upsilon(4S)) - p(B_{\mathrm{tag}}) - p(D) - p(\ell)]^2$$

- *Binned maximum likelihood fit, MC shapes to different components:*
  - *Signal*
  - *Feed-up(down), continuum, BB bkg, fake leptons*

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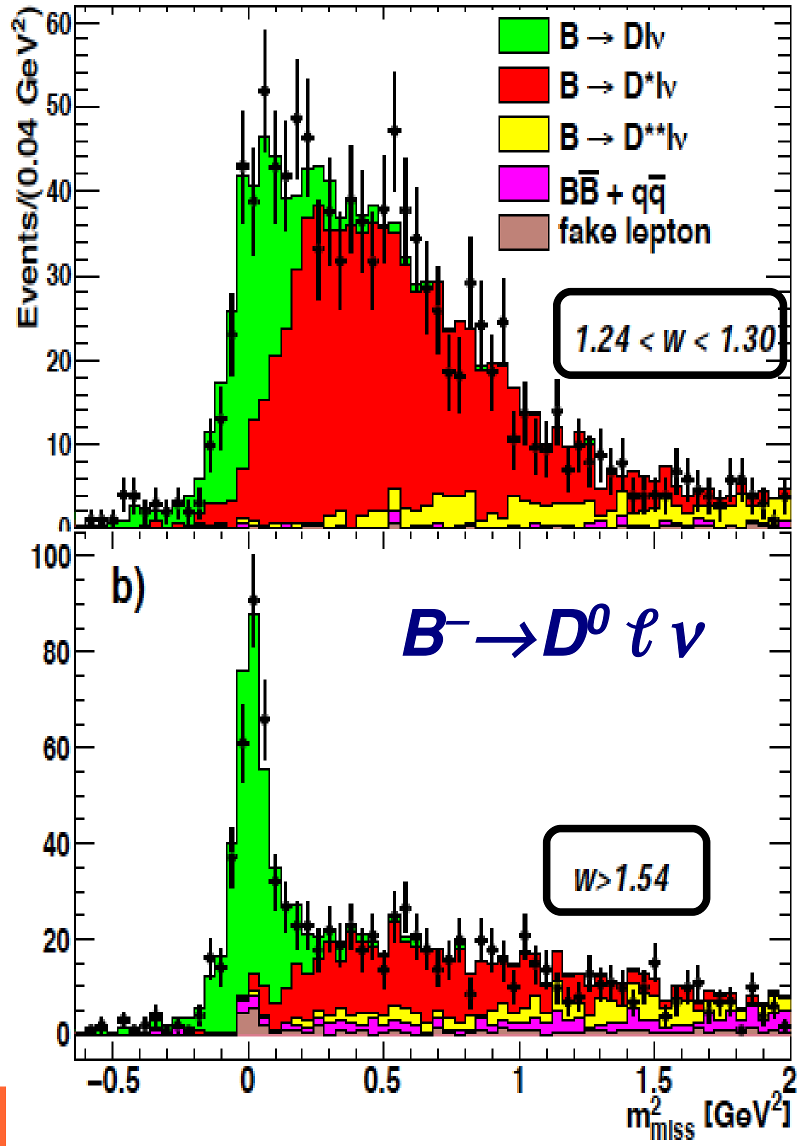
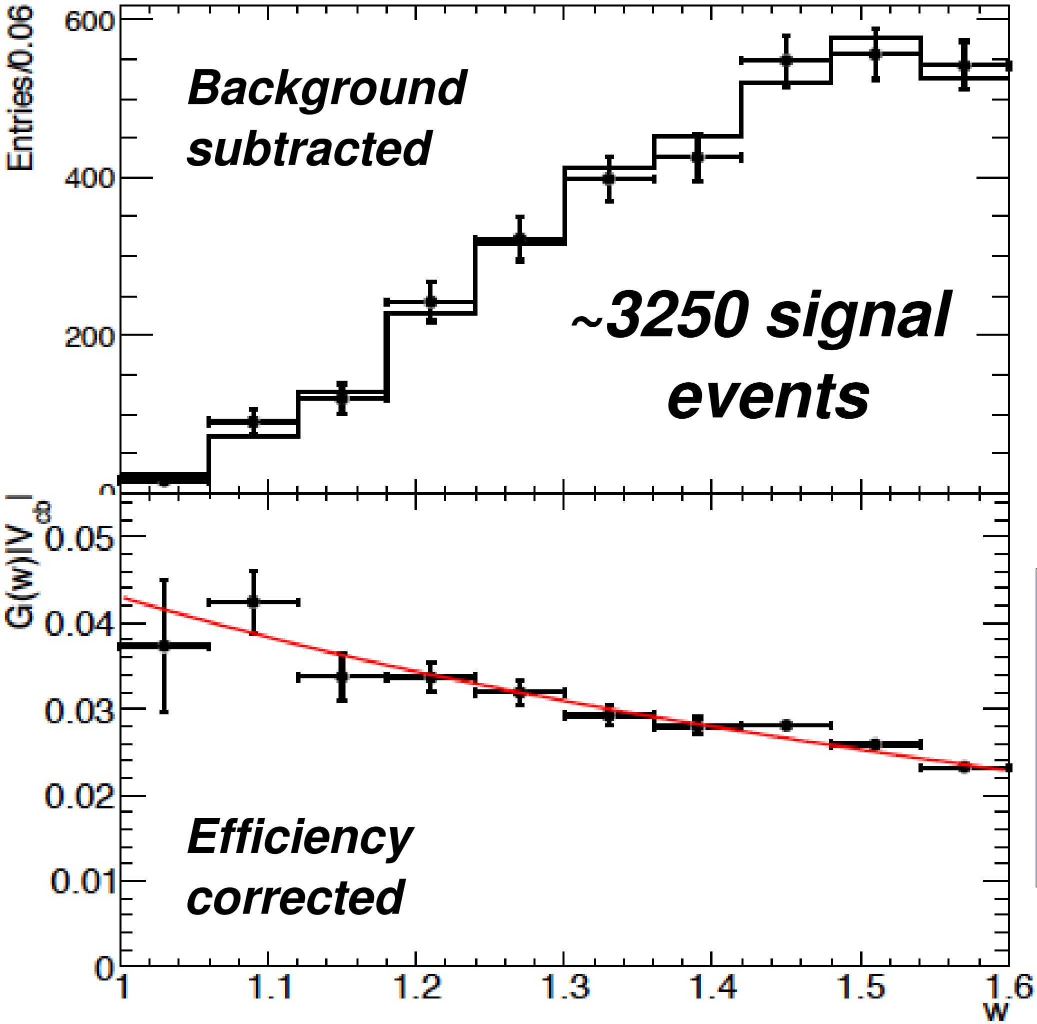


Tagged $B^{+/0} \to D^{0/+} \ell \nu$: results

- *Extract w spectrum by fitting m^2_{miss} in 10 w bins (w resolution < 0.01)*
- *χ^2 fit to w spectrum to measure $G(1)|V_{cb}|$ and ρ^2, reweighting MC template*



	$B^- \to D^0 \ell^- \bar{\nu}_\ell$	$\overline{B}^0 \to D^+ \ell^- \bar{\nu}_\ell$
$\mathcal{G}(1)\lvert V_{cb}\rvert \cdot 10^3$	41.0±2.1 ±1.3	44.9± 3.2±1.6
ρ^2	1.14± 0.11±0.04	1.29± 0.14±0.05
ρ_{corr}	0.943	0.950
χ^2/ndf	3.4/8	5.6/8
Signal Yield	2147 ± 69	1108 ± 45
Recon. efficiency	$(1.99 \pm 0.02) \times 10^{-4}$	$(1.09 \pm 0.02) \times 10^{-4}$
$\mathcal{B}$	(2.29± 0.08 ± 0.09)%	(2.21± 0.11 ± 0.11)%

$G(1)|V_{cb}| = (42.3 \pm 1.9 \pm 1.4) \times 10^{-3}$

$\rho^2 = 1.20 \pm 0.09 \pm 0.04$

$Br(B^0 \to D \ell \nu) = (2.15 \pm 0.06 \pm 0.07)\%$

5.5% error on G(1)|Vcb|, mostly statistical

Untagged $B^{+/0} \to D^{0/+} \ell \nu X$

PRD79,012002 (2009)

- *Select $B \to D^0 \ell \nu X$ and $B \to D^+ \ell \nu X$ with $p_\ell > 1.2$ GeV/c*

$D^0 \to K\pi$
$D^+ \to K\pi\pi$

- *Get D/D* rates with binned 3-D fit to p_ℓ, p_D, $\cos\theta_{BY}$*

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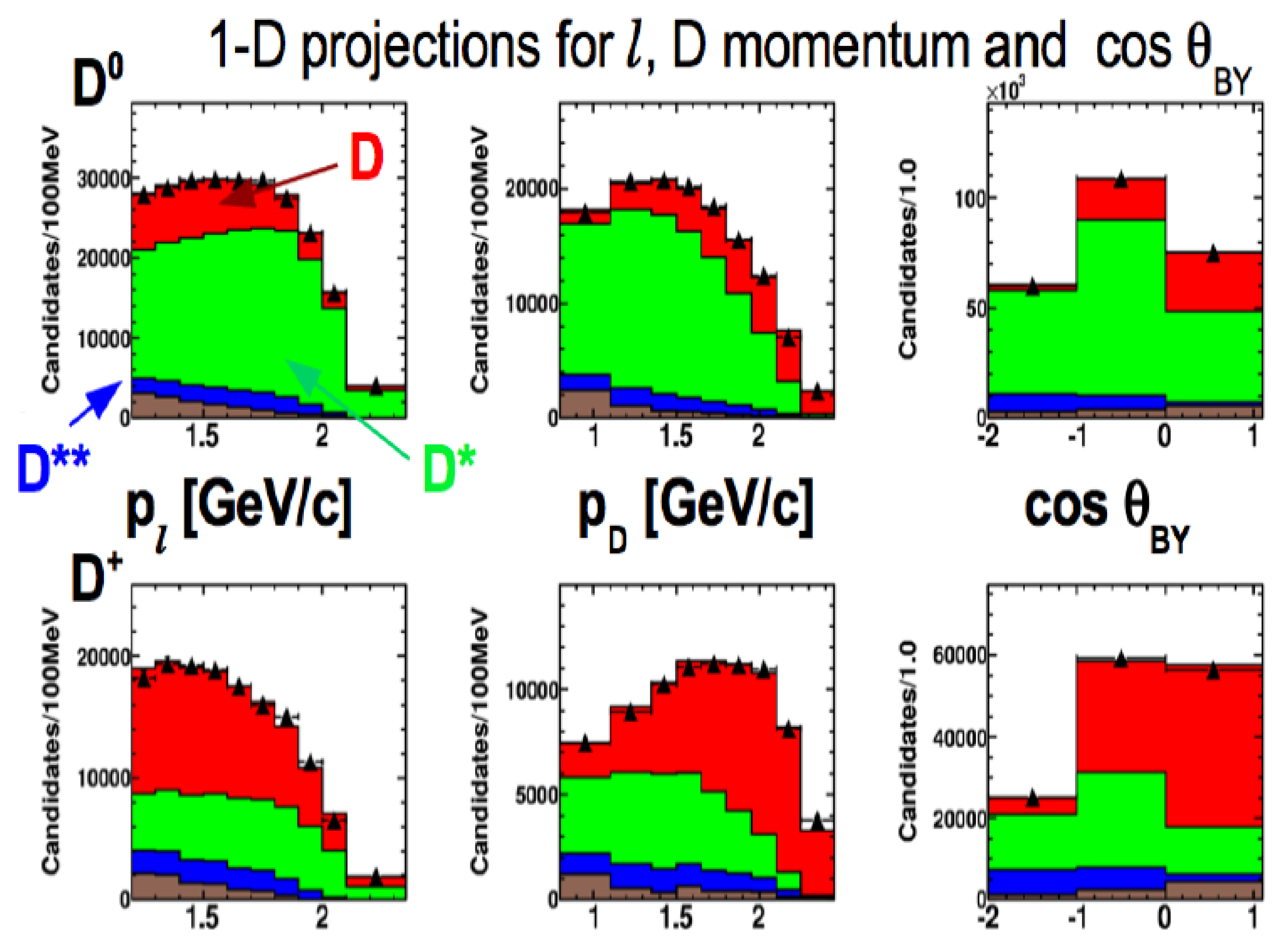
- *No π_{soft} reco from D**
  - *↑signal, ↓syst.*



- *Momentum of the D is correlated to w*
  - *The analysis has sensitivity to ρ_D^2, $\rho_{D^*}^2$ and $|V_{cb}|$*

- *Fix D** rate to HFAG, and assume $BR(B \to D(*)\pi\pi\nu) = 1.1 \pm 1.1\%$*

Untagged $B^{+/0} \to D^{0/+}\ell\nu X$: Results

Result of the e+μ+ D^0+D^+ combined fit

Relate BR(B^0) to BR(B^+) using lifetime ratio

Parameters	Combined result
ρ_D^2	$1.20 \pm 0.04 \pm 0.07$
$\rho_{D^*}^2$	$1.22 \pm 0.02 \pm 0.07$
$\mathcal{B}(D^0\ell\bar{\nu})(\%)$	$2.34 \pm 0.03 \pm 0.13$
$\mathcal{B}(D^{*0}\ell\bar{\nu})(\%)$	$5.40 \pm 0.02 \pm 0.21$
χ^2/n.d.f. (probability)	2.2/4 (0.71)

D $\quad \mathcal{G}(1)|V_{cb}| = (43.1 \pm 0.8 \pm 2.3)\times10^{-3}$ *5.5% mostly systematics*

*D** $\quad \mathcal{F}(1)|V_{cb}| = (35.9 \pm 0.2 \pm 1.2)\times10^{-3}$ *3.3%*

- *Good consistency with existing measurements, with comparable precision*

- *Theory validation:*
  - *G(1)/F(1)=1.20 ± 0.09: in agreement with lattice computation (1.17 ± 0.04)*
  - *Slope difference $\rho_D^2 - \rho_{D^*}^2$ consistent with 0 as expected*

Babar $B \to D\ell\nu$ average and World Average

Combining tagged $B \to D\ell\nu$ with results from untagged $B \to DX\ell\nu$ global fit

$G(1)|V_{cb}| = (42.4 \pm 0.7 \pm 1.6)\times 10^{-3}$

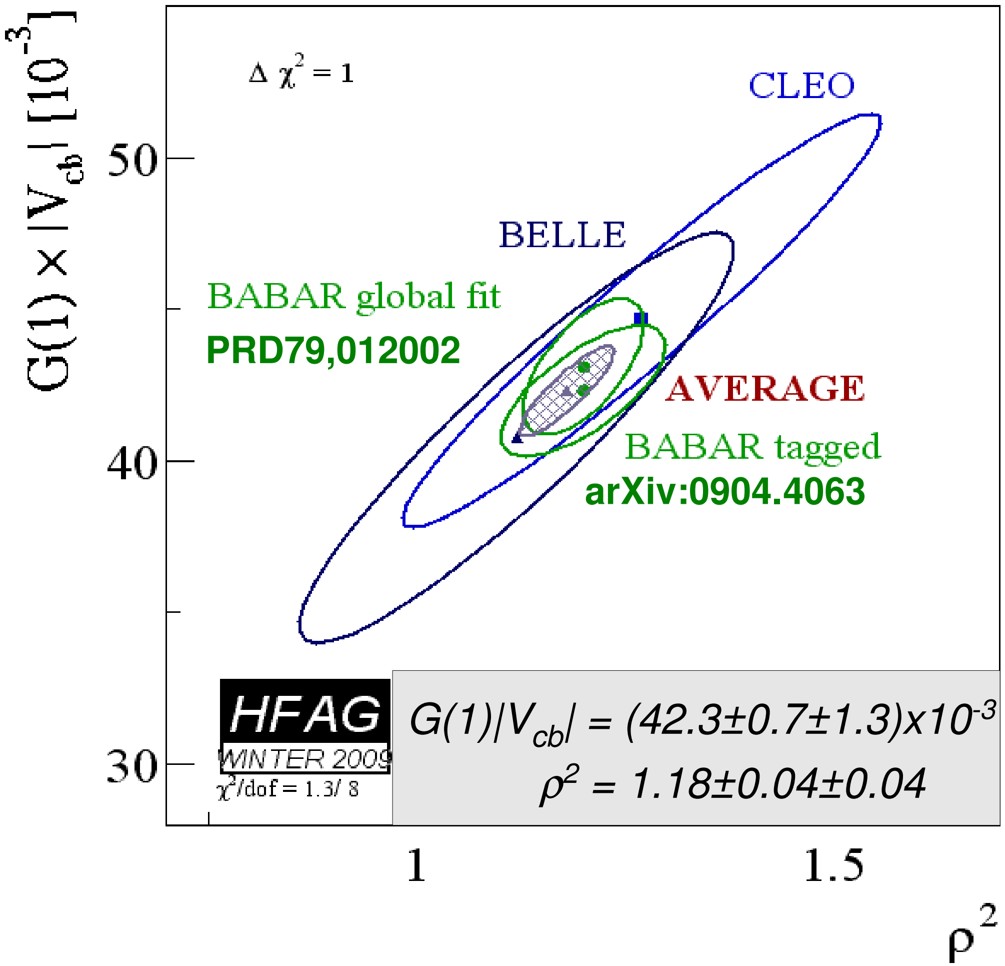
$\rho^2 = 1.18 \pm 0.04 \pm 0.04$

$Br(B^0 \to D\ell\nu) = (2.16 \pm 0.08)\%$

Using the Okamoto et al. (FNAL05) LQCD

$$\mathcal{G}(1) = 1.074 \pm 0.018 \pm 0.016$$

$$|V_{cb}| = (39.2 \pm 1.6 \pm 0.9_G)\times 10^{-3}$$



Compatible with $B \to D^*$ and inclusive determinations:

- *HFAG+FNAL08* $|V_{cb}| = (38.1 \pm 0.5 \pm 1.0_F)\times 10^{-3}$
- *Global Fit (kin scheme)* $|V_{cb}| = (41.5 \pm 0.7)\times 10^{-3}$

Recent BaBar measurements have given a dramatic improvement: total error on WA $G(1)|V_{cb}|$ reduced to 4% !

Form factor normalization in $B \to D\ell\nu$

- *Normalization of the FF at w=1 available in quenched and unquenched (2+1) calculations*
- *Computation of G(w) at w>1 start to be available Tantalo et al. (PLB655,45 (2007)) with quenched approximation, and more recently T. Mannel et al. (arXiv:0809.0222) using LCSR*

w	G(w)		
1.00	1.074±0.024	unquenched	LAT05 (Okamoto)
1.00	1.058±0.020	quenched	PRD61,014502 (2005)
1.00	1.026±0.017	quenched	PLB655, 45 2007
1.03	1.001±0.019	"	"
1.05	0.987±0.015	"	"
1.10	0.943±0.011	"	"
1.20	0.853±0.021	"	"
w_{max}	0.61±0.16	LCSR	arXiv.0809.0222 (2008)

Not published

Calculation at finite momentum transfer, where data are available, allows to extract $|V_{cb}|$ without additional model dependence extrapolation.

Note: unknown further systematics due to the quenched approximation

Tagged $B \to D\ell\nu$ results at w>1

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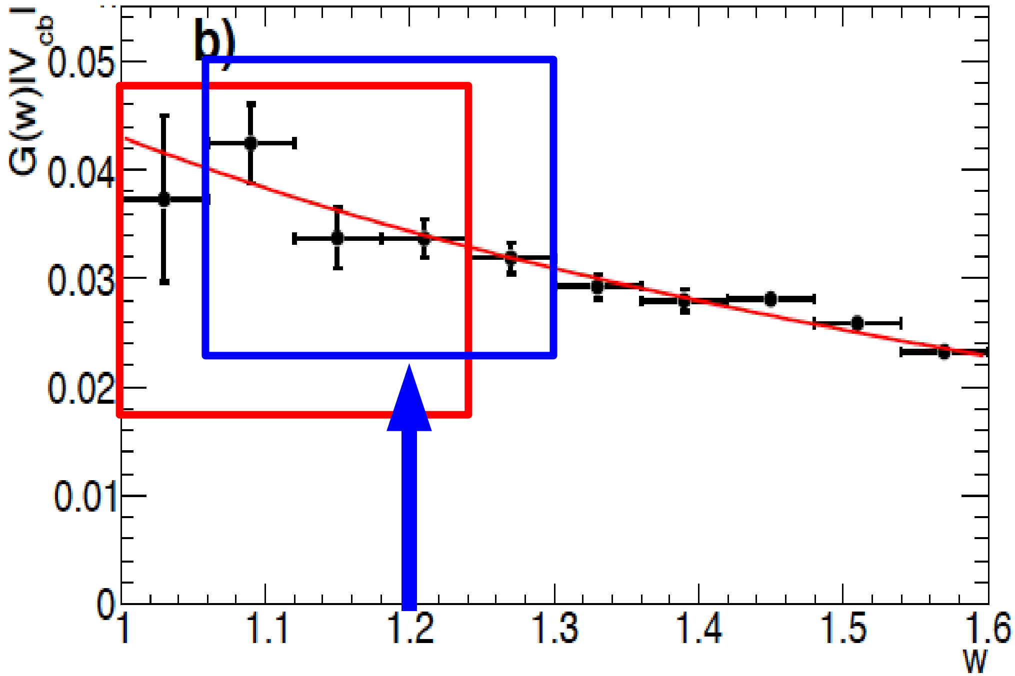
Reduce the model dependence determining $G(w')|V_{cb}|$ from a fit in a limited region of phase-space



w'	$\lvert V_{cb}\rvert G(w')/G(w')\ 10^{-3}$	
	unquenched (FNAL)	
1.00	39.2 ± 1.8 ± 1.3 ± 0.9	Full PS
	quenched (Tantalo)	
1.00	40.9 ± 1.8 ± 1.3 ± 0.7	Full PS
1.03	40.2 ± 5.6 ± 1.3 ± 0.8	4 bins
1.05	40.0 ± 5.0 ± 1.4 ± 0.6	4 bins
1.10	40.0 ± 3.4 ± 1.4 ± 0.5	4 bins
1.20	**40.7 ± 1.3 ± 1.4 ± 1.0**	**4 bins**
	stat syst FF	

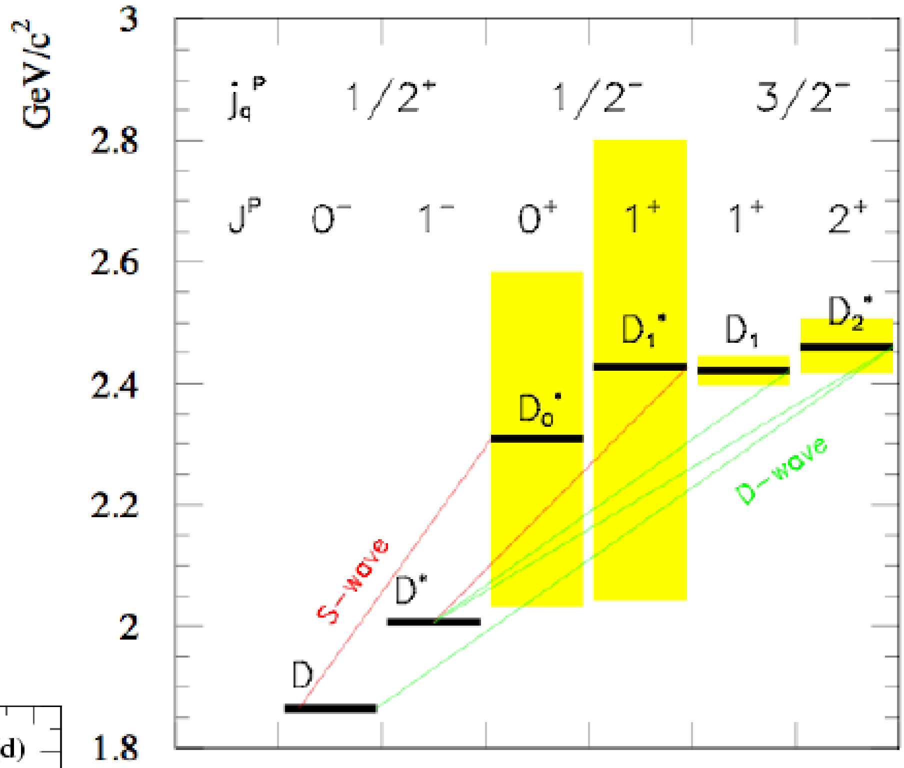
- *Experimental error **interpolating** 4 bins around w=1.2 is competitive with the **extrapolation** to w=1 using the full phase-space*
- ***We expect lattice community provide un-quenched (2+1) computation of the FF at w=1 and at w>1***

Higher mass states in SL decays

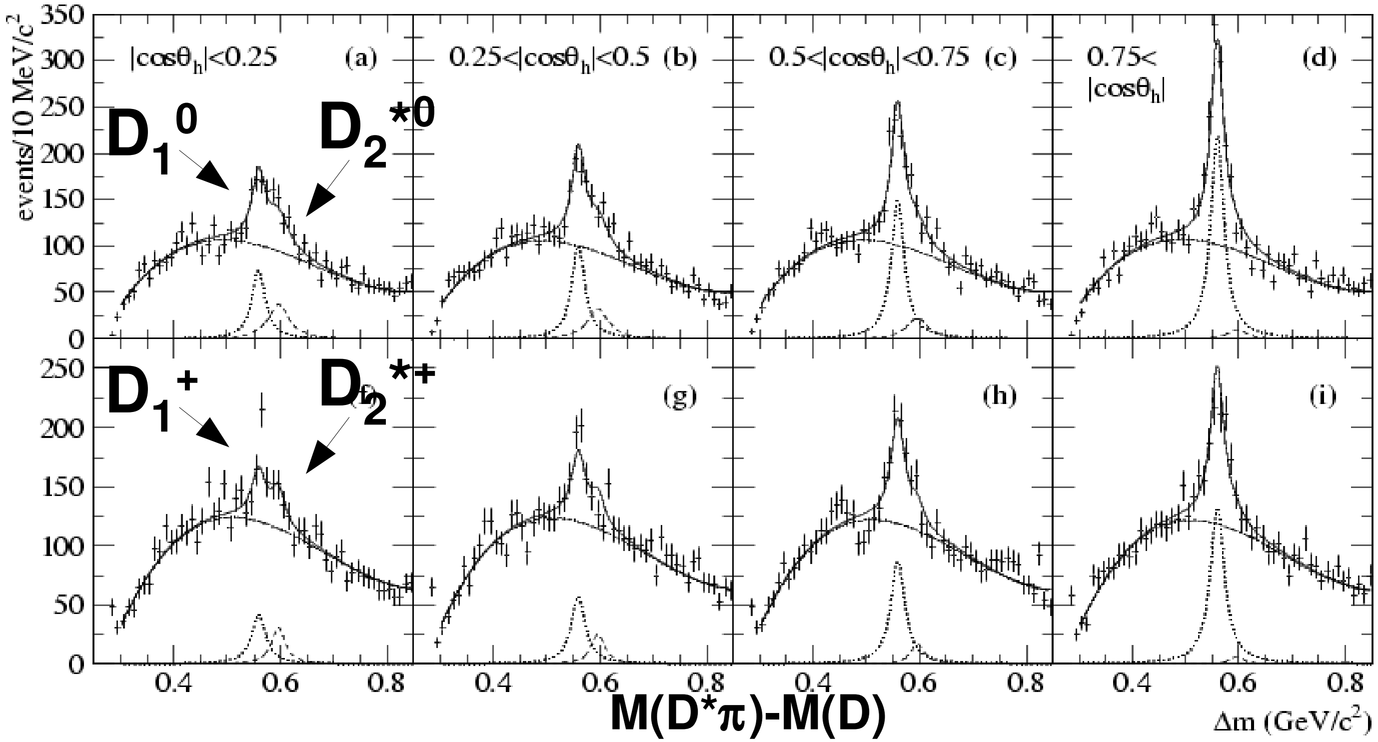
- *Studies of these final states are crucial:*
  - *Historical puzzle: sum of known exclusive states misses inclusive semileptonic BR*
  - *Need detailed understanding of $B \to D/D^*/D^{**}\ell\nu$ spectra to fix background for $|V_{ub}|$ measurements and $B \to D/D^*\tau\nu$ studies (next slides)*

Higher mass states: $B \to D^{**}\ell\nu$

- *D^{**}: short name for $D(^*)n\pi$ (n>0) final states, includes*
  - *Narrow states (D_1, D_2^*): well established*
  - *Broad States (D_0^*, D_1')*
  - *Non resonant ($D^*n\pi$ & $Dn\pi$)*



- *BaBar: Narrow states with untagged analysis*



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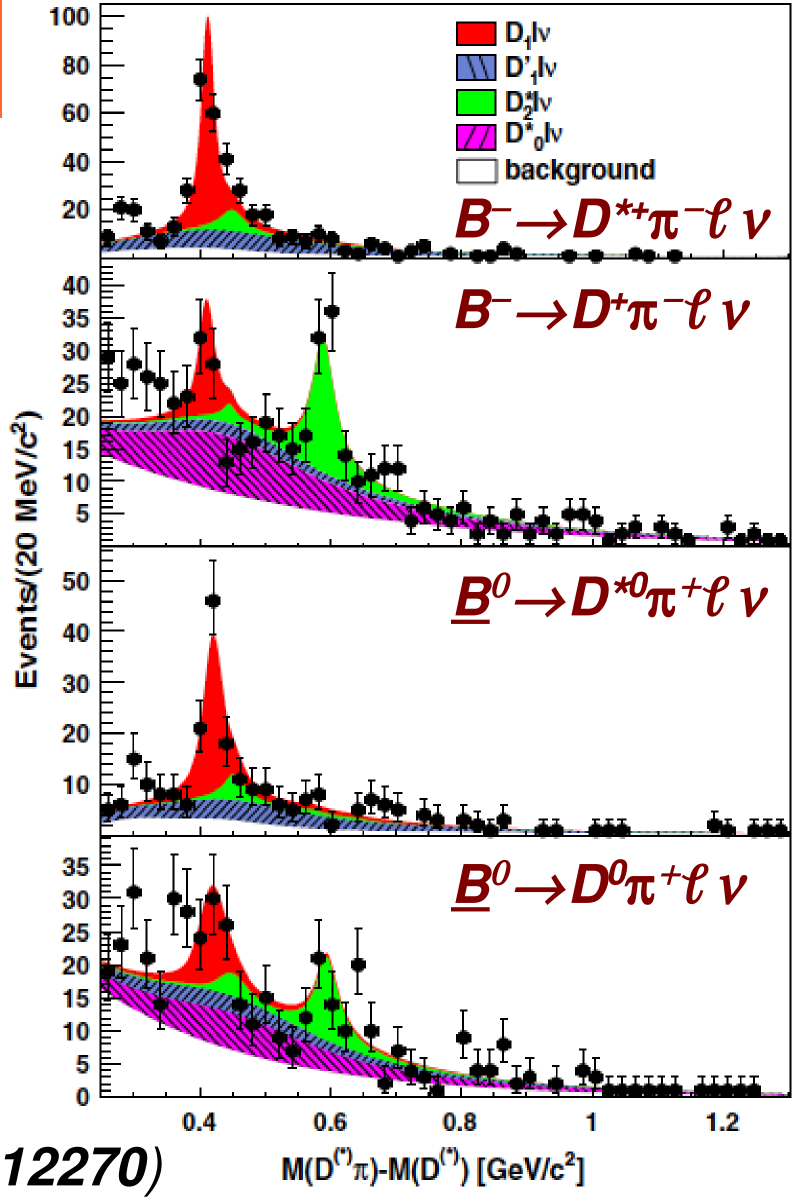
Four D^* helicity bins to split D_1 from D_2^*

Fit together with $D_2^* \to D\pi$

Tagged $B \to D^{**}\ell\nu$

- *Use the B_{reco} sample to reduce background, results are mainly statistical limited*

Decay Mode	Yield	$\epsilon_{sig}(\times 10^{-4})$	$\mathcal{B}(\bar{B} \to D^{**}\ell^-\bar{\nu}_\ell) \times \mathcal{B}(D^{**} \to D^{(*)}\pi^\pm)\%$
$B^- \to D_1^0\ell^-\bar{\nu}_\ell$	165 ± 18	1.24	$0.29 \pm 0.03 \pm 0.03$
$B^- \to D_2^{*0}\ell^-\bar{\nu}_\ell$	97 ± 16	1.44	$0.15 \pm 0.02 \pm 0.02$
$B^- \to D_1^{\prime 0}\ell^-\bar{\nu}_\ell$	142 ± 21	1.13	$0.27 \pm 0.04 \pm 0.05$
$B^- \to D_0^{*0}\ell^-\bar{\nu}_\ell$	137 ± 26	1.15	$0.26 \pm 0.05 \pm 0.04$
$\bar{B}^0 \to D_1^+\ell^-\bar{\nu}_\ell$	88 ± 14	0.70	$0.27 \pm 0.04 \pm 0.03$
$\bar{B}^0 \to D_2^{*+}\ell^-\bar{\nu}_\ell$	29 ± 13	0.91	$0.07 \pm 0.03 \pm 0.02$ (<0.12@90%CL)
$\bar{B}^0 \to D_1^{\prime +}\ell^-\bar{\nu}_\ell$	86 ± 18	0.60	$0.31 \pm 0.07 \pm 0.05$
$\bar{B}^0 \to D_0^{*+}\ell^-\bar{\nu}_\ell$	142 ± 26	0.70	$0.44 \pm 0.08 \pm 0.06$



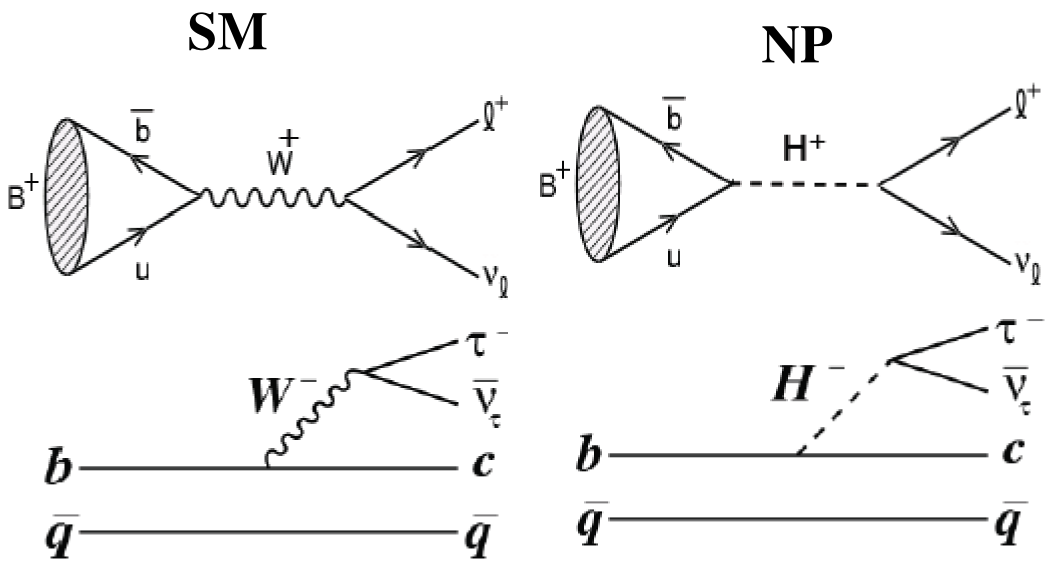
- *Narrow states (D_1, D_2*) in agreement with existing measurements (D0, Belle and BaBar)*
- *Wide found to be large in contrast to theory (**hep-ph/0512270**)*
- *In the past assume single pion saturates D** decays: but D(*)ππ are possible and start to be measured (could solve the problem with the missing decay modes)*
- *D_1' not observed by Belle, but in agreement with Delphi*

PRL,101, 261802 (2008)

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

$B\to D(^*)\tau\nu$: motivation

- *Similar to $B\to\tau\nu$, but:*
  - *From annihilation to the exchange*
  - *From V_{ub} to V_{cb}*
  - *Not a rare decay, from LEP*
    - ***$Br(b\to c\tau\nu)=2.48 \pm 0.26\%$***
- *Complications, lepton mass:*
  - *2 form factor for the D, 4 for the D**
  - *But HQET relates the extra FF to the well measured FF in light leptons*
- *BaBar result **PRL100,021801(2008)***
- *More analysis details in:*
  - ***PRD79,092002(2009)***



- *Use the hadronic $B_{tag} \to D^{(*)}Y$*
  - *Reduce combinatoric*
- *Reconstruct 4 channels:*
  - *D^0, D^{*0}, D^+, D^{*+}*
- *Only $\tau\to \ell\nu\nu$ (e o μ): 3 ν in the final state*

$B \rightarrow D(^*)\tau\nu$: fit results

PRL100,021801(2008)
PRD79,092002(2009)

- *Simultaneous 2D unbinned fit of missing mass m_{miss}^2 and P_ℓ to 4 signal sample and the D** control samples*

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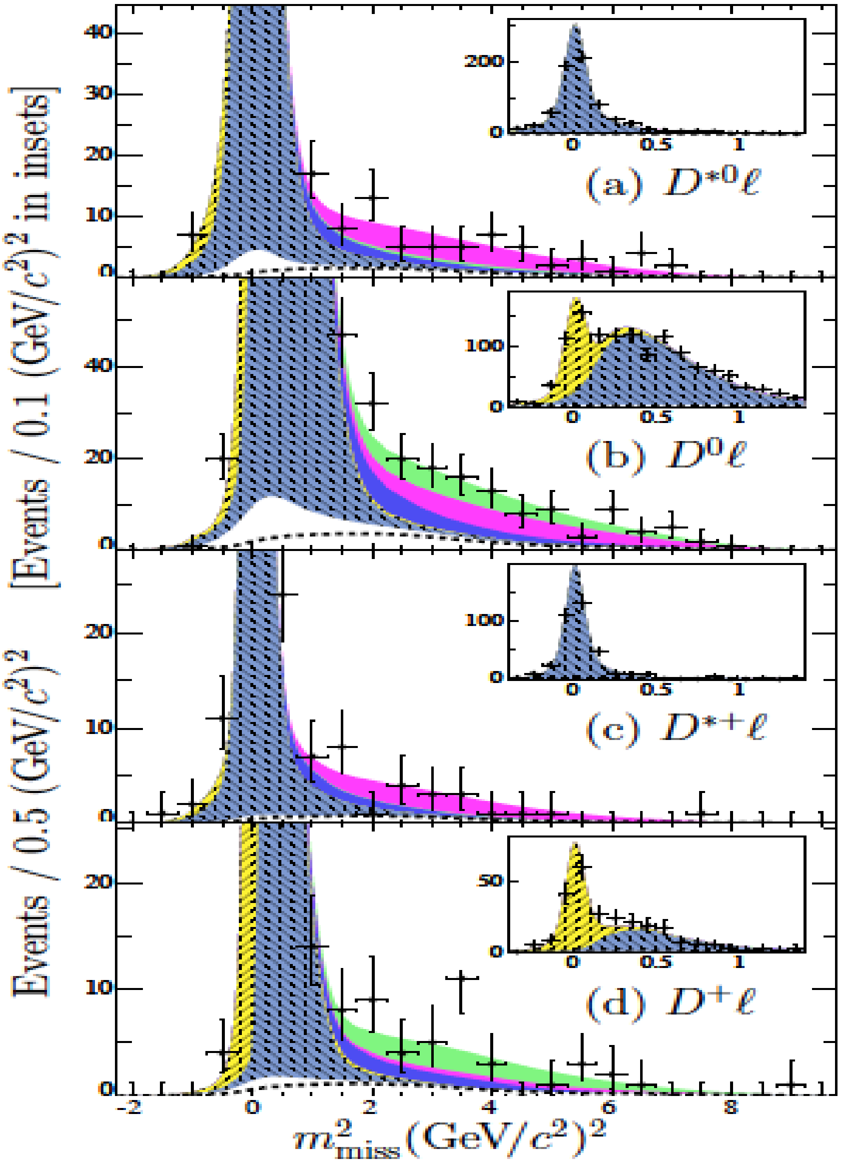
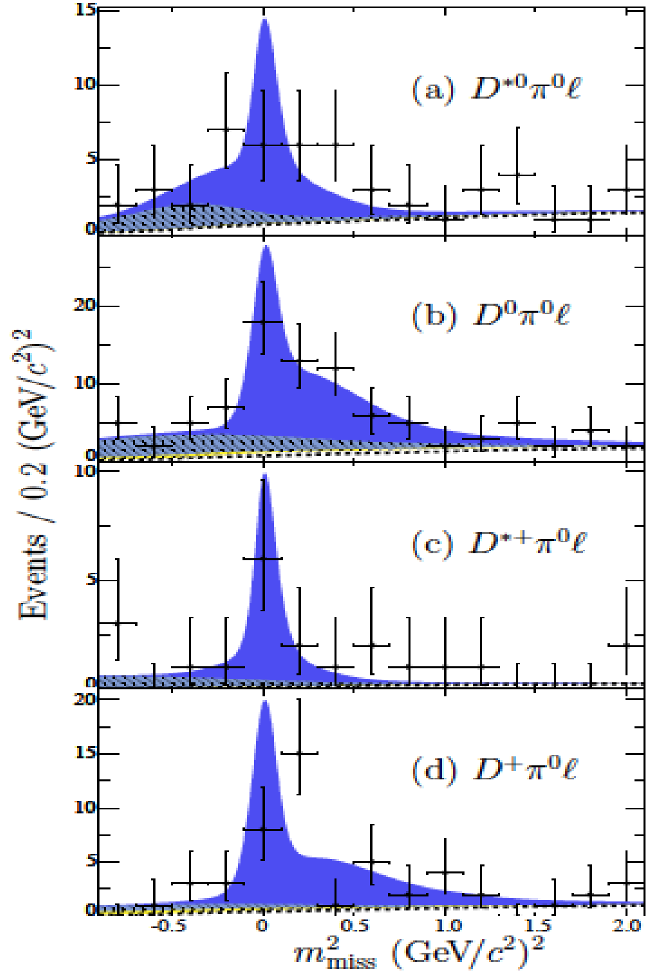
Most dangerous bkg from $B \rightarrow D^{**}\ell\nu$
*Select $D(^*)\pi^0$ candidates and fitted together with the signal sample to reduce the sensitivity to D** modeling*



*Fit results projected on the D** sample*

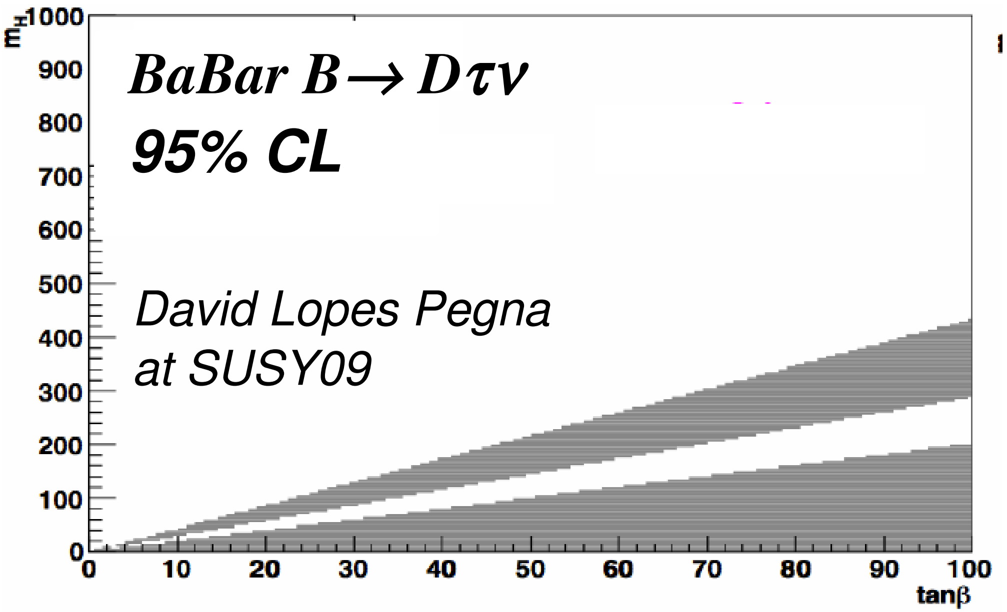


$B \to D(*)\tau\nu$: results

Mode	N_{sig}	N_{norm}	$(\Delta R/R)_{fit}$ [%]	$(\Delta R/R)_{\varepsilon}$ [%]	R [%]	$\mathcal{B}$ [%]	σ_{tot} (σ_{stat})
$B^- \to D^0\tau^-\overline{\nu}_\tau$	35.6±19.4	347.9±23.1	15.5	1.6	31.4±17.0±4.9	0.67±0.37±0.11±0.07	1.8 (1.8)
$B^- \to D^{*0}\tau^-\overline{\nu}_\tau$	92.2±19.6	1629.9±63.6	9.7	1.5	34.6± 7.3±3.4	2.25±0.48±0.22±0.17	5.3 (5.8)
$\overline{B}^0 \to D^+\tau^-\overline{\nu}_\tau$	23.3±7.8	150.2±13.3	13.9	1.8	48.9±16.5±6.9	1.04±0.35±0.15±0.10	3.3 (3.6)
$\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau$	15.5±7.2	482.3±25.5	3.6	1.4	20.7± 9.5±0.8	1.11±0.51±0.04±0.04	2.7 (2.7)
$B \to D\tau^-\overline{\nu}_\tau$	66.9±18.9	497.8±26.4	12.4	1.4	41.6±11.7±5.2	0.86±0.24±0.11±0.06	3.6 (4.0)
$B \to D^*\tau^-\overline{\nu}_\tau$	101.4±19.1	2111.5±68.1	5.8	1.3	29.7± 5.6±1.8	1.62±0.31±0.10±0.05	6.2 (6.5)

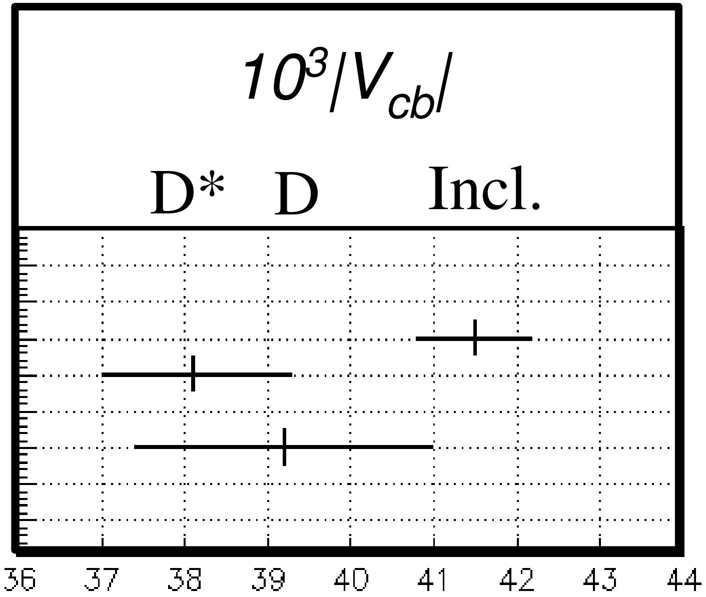
- *Results compatible with Belle latest results*
- *Statistically limited*
- *Standard Model predictions, Chen and Geng,JHEP 0610,053 (2006):*
  - $B \to D\tau\nu$ ~0.69%
  - $B \to D^*\tau\nu$ ~1.41%

M_H–tanβ exclusion regions



Conclusions

- *BaBar $B \to D\ell\nu$ analyses reach the precise measurements era:* $|V_{cb}| = (39.2 \pm 1.6 \pm 0.9_{FF}) \times 10^{-3}$
  - *compatible with both the inclusive and the exclusive with the D*:* ***(D* - incl) differ by 2.5σ, time to worry?***
  - *expect Lattice community put efforts to compute un-quenched FF for $B \to D\ell\nu$: It is important to go further the zero-recoil regime.*



HFAG averages

- *Heavy final states studied in SL decays:*
  - *Still open puzzles, further investigation of SL decays are required and multi-pion D** final states states are the possible missing part: more data are needed*
- *$B \to D(^*)\tau\nu$ are promising channels to test NP effects*
  - *With present data exclusion region competitive with $B \to \tau\nu$*
  - *Improvements possible also using the data already collected by BaBar (and Belle)*

STOP HERE

BACKUP SLIDES

Tagged $B \to D\ell\nu$: systematics

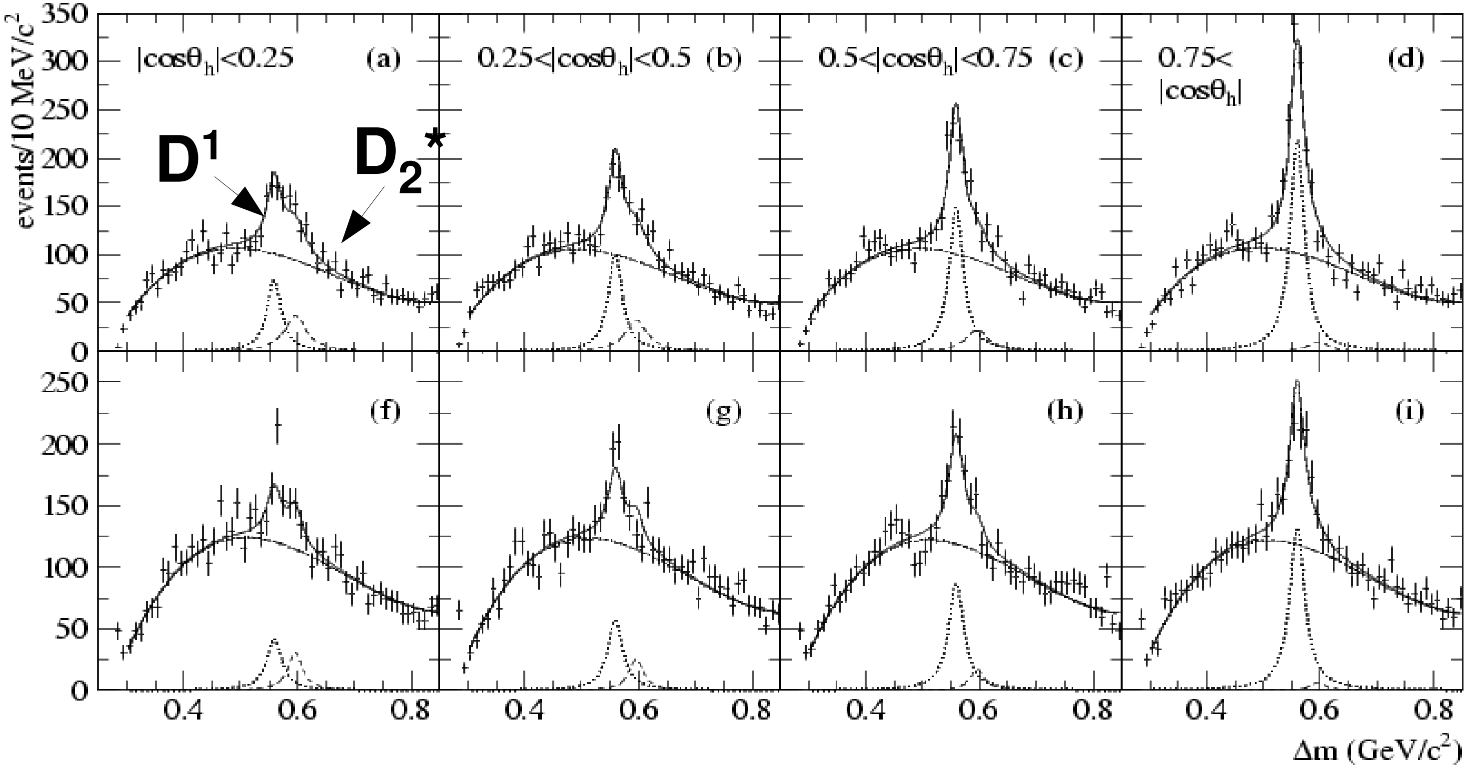
- *Tracking efficiency*
- *Neutral efficiency*
- *PID & fake rate*
- *Radiative Corrections*
- *Cascade B decay subtraction*
- *D/D*/D** Form Factor and D** composition*
- *D daughter branching fraction*
- *Uncertainty on normalization*
- *Difference in B_{reco} selection between exclusive and inclusive reconstruction*
- *Fit technique*
  - *MC shapes, w binning, background yield*

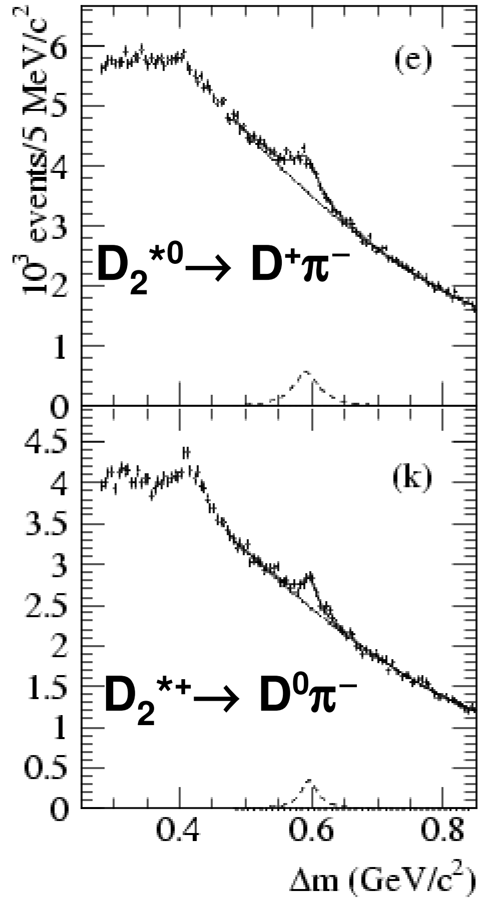
	Systematic uncertainty on $\lvert V_{cb}\rvert$ and ρ^2					
	$D^0\ell^-\bar{\nu}_\ell$		$D^+\ell^-\bar{\nu}_\ell$		$D\ell^-\bar{\nu}_\ell$	
	$\lvert V_{cb}\rvert(\%)$	ρ^2	$\lvert V_{cb}\rvert(\%)$	ρ^2	$\lvert V_{cb}\rvert(\%)$	ρ^2
Tracking efficiency	0.5	0.008	1.1	0.003	0.7	0.004
Neutral reconstruction	1.	0.003	0.8	0.006	0.9	0.004
Lepton ID	1.0	0.009	0.9	0.009	0.95	0.009
PHOTOS	0.13	0.005	0.10	0.005	0.12	0.005
Cascade $\bar{B} \to X \to \ell^-$ decay background	0.6	-	1.0	-	0.75	-
$\bar{B} - B^-$ cross-feed	0.24	0.003	0.24	0.003	0.24	0.003
$\bar{B} \to D^*\ell^-\bar{\nu}_\ell$ Form factors	0.56	0.008	0.20	0.003	0.38	0.006
$\bar{B} \to D^{**}\ell^-\bar{\nu}_\ell$ Form factors	0.24	0.007	0.34	0.006	0.29	0.007
D branching fractions	1.0	-	1.35	-	1.12	-
$\mathcal{B}(\bar{B} \to D^{**}\ell^-\bar{\nu}_\ell)$	1.18	0.023	0.96	0.011	1.08	0.019
$\mathcal{B}(\bar{B} \to X\ell^-\bar{\nu}_\ell)$	0.95	-	0.95	-	0.85	-
$B_{\rm tag}$ selection	1.1	0.021	1.8	0.036	1.5	0.028
$\bar{B} \to X\ell^-\bar{\nu}_\ell$ yield	0.7	-	1.1	-	0.85	-
$\bar{B} \to D\ell^-\bar{\nu}_\ell$ yield	1.27	0.018	1.06	0.027	1.25	0.020
Total systematic error	3.1	0.04	3.6	0.05	3.3	0.04

Untagged $B \to XD\ell\nu$: systematics

Item	Electron sample ρ^2_D	$\rho^2_{D^*}$	$\mathcal{B}(D\ell\bar{\nu})$	$\mathcal{B}(D^*\ell\bar{\nu})$	$\mathcal{G}(1)\lvert V_{cb}\rvert$	$\mathcal{F}(1)\lvert V_{cb}\rvert$	Muon sample ρ^2_D	$\rho^2_{D^*}$	$\mathcal{B}(D\ell\bar{\nu})$	$\mathcal{B}(D^*\ell\bar{\nu})$	$\mathcal{G}(1)\lvert V_{cb}\rvert$	$\mathcal{F}(1)\lvert V_{cb}\rvert$
R_1'	0.44	2.74	0.71	−0.38	0.60	0.71	0.50	2.67	0.74	−0.40	0.63	0.70
R_2'	−0.40	1.02	−0.18	0.30	−0.32	0.49	−0.45	0.96	−0.19	0.30	−0.33	0.48
D^{**} slope	−1.42	−2.52	−0.07	−0.09	−0.82	−0.87	−1.42	−2.58	−0.10	−0.10	−0.77	−0.92
D^{**} FF approximation	−0.87	0.33	−0.12	0.19	−0.54	0.20	−0.99	0.59	−0.12	0.21	−0.59	0.30
$\mathcal{B}(B^- \to D^{(*)}\pi\ell\bar{\nu})$	0.28	−0.27	−0.22	−0.80	0.04	−0.49	0.59	−0.32	−0.13	−0.86	0.24	−0.54
$f_{D_2^*/D_1}$	−0.39	0.16	−0.38	0.16	−0.41	0.13	−0.50	0.17	−0.41	0.18	−0.47	0.15
$f_{D_0^* D\pi/D_1 D_2^*}$	−2.30	1.12	−1.53	0.97	−2.07	0.85	−3.13	1.23	−1.53	1.02	−2.41	0.93
$f_{D_1' D^*\pi/D_1 D_2^*}$	1.82	−1.14	1.30	−0.65	1.65	−0.70	2.44	−1.15	1.35	−0.72	1.91	−0.75
$f_{D\pi/D_0^*}$	−0.88	−1.28	0.36	0.17	−0.31	−0.34	−0.83	−1.23	0.31	0.18	−0.27	−0.33
$f_{D^*\pi/D_1'}$	−0.21	−0.05	−0.13	0.21	−0.18	0.09	−0.30	−0.04	−0.15	0.23	−0.23	0.10
NR D^*/D ratio	0.58	−0.16	0.11	−0.09	0.38	−0.04	0.66	−0.16	0.11	−0.09	0.40	−0.03
$\mathcal{B}(B^- \to D^{(*)}\pi\pi\ell\bar{\nu})$	1.19	−1.97	0.25	−1.28	0.78	−1.28	1.98	−1.71	0.40	−1.20	1.20	−1.18
X^*/X and Y^*/Y ratio	0.61	−1.15	0.09	−0.27	0.39	−0.52	0.74	−1.02	0.08	−0.24	0.42	−0.47
X/Y and X^*/Y^* ratio	0.76	−0.83	0.21	−0.65	0.52	−0.60	1.09	−0.76	0.25	−0.63	0.68	−0.57
$D_1 \to D\pi\pi$	2.22	−1.54	0.74	−1.08	1.63	−1.05	2.74	−1.48	0.76	−1.06	1.81	−1.03
$f_{D_2^*}$	−0.14	−0.01	−0.10	0.07	−0.12	0.03	−0.16	−0.01	−0.10	0.07	−0.13	0.03
$\mathcal{B}(D^{*+} \to D^0\pi^+)$	0.73	−0.01	0.43	−0.34	0.62	−0.17	0.80	−0.00	0.41	−0.33	0.61	−0.17
$\mathcal{B}(D^0 \to K^-\pi^+)$	0.69	0.02	−0.21	−1.63	0.29	−0.80	0.92	0.12	−0.27	−1.68	0.35	−0.80
$\mathcal{B}(D^+ \to K^-\pi^+\pi^+)$	−1.46	−0.42	−2.17	0.30	−1.89	0.01	−1.43	−0.42	−2.10	0.28	−1.77	−0.01
τ_{B^-}/τ_{B^0}	0.26	0.16	0.63	0.27	0.46	0.19	0.22	0.16	0.58	0.28	0.41	0.19
f_{+-}/f_{00}	0.88	0.43	0.66	−0.53	0.82	−0.12	0.91	0.48	0.57	−0.52	0.75	−0.10
Number of $B\bar{B}$ events	0.00	−0.00	−1.11	−1.11	−0.55	−0.55	0.00	−0.00	−1.11	−1.11	−0.55	−0.55
Off-peak luminosity	0.05	0.01	−0.02	−0.00	0.02	0.00	0.07	0.00	−0.02	−0.00	0.02	−0.00
B momentum distribution	−0.96	0.63	1.29	−0.54	−1.15	0.48	1.30	−0.10	1.27	−0.64	1.31	−0.35
Lepton PID efficiency	0.52	0.16	1.21	0.82	0.90	0.46	3.30	0.06	5.11	5.83	1.99	2.90
Lepton mis-ID	0.03	0.01	−0.01	−0.01	0.01	−0.00	2.65	0.70	−0.59	−0.50	1.06	−0.01
Kaon PID	0.07	0.80	0.28	0.23	0.18	0.38	1.02	0.71	0.35	0.29	0.70	0.39
Tracking efficiency	−1.02	−0.43	−3.35	−2.00	−2.25	−1.15	−0.63	−0.28	−3.37	−2.09	−2.02	−1.14
Radiative corrections	−3.13	−1.04	−2.87	−0.74	−3.02	−0.71	−0.76	−0.61	−0.82	−0.25	−0.79	−0.33
Bremsstrahlung	0.07	0.00	−0.13	−0.28	−0.04	−0.14	0.00	0.00	0.00	0.00	0.00	0.00
Vertexing	0.83	−0.64	0.63	0.60	0.78	0.09	1.79	−0.76	0.97	0.54	1.41	0.01
Background total	1.39	1.12	0.64	0.34	1.07	0.51	1.58	1.09	0.67	0.38	1.16	0.49
Total	6.25	5.66	6.01	4.03	5.99	3.20	8.12	5.47	7.35	7.07	6.06	4.23

Untagged B→ $D_1/D_2^* \ell\nu$





0808.333[hep-ex] submitted to PRL

Four D helicity bins to split D_1 from D_2^**

Fit together with $D_2^* \to D\pi$

$$\mathcal{B}(B^+ \to D_1^0 \ell^+ \nu_\ell) \times \mathcal{B}(D_1^0 \to D^{*+}\pi^-) = (2.97 \pm 0.17_{\rm stat} \pm 0.17_{\rm syst}) \times 10^{-3}$$

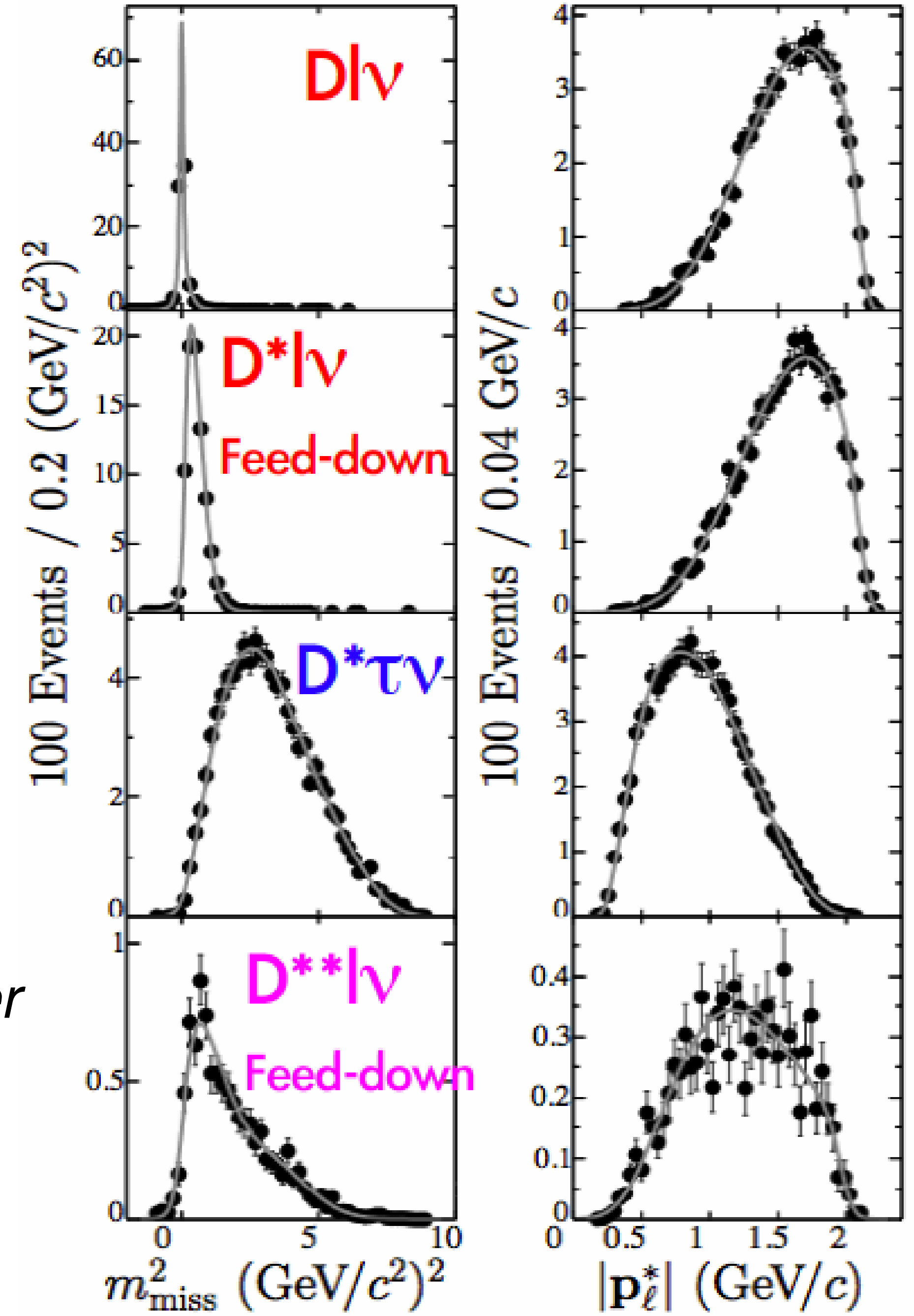
$$\mathcal{B}(B^+ \to D_2^{*0} \ell^+ \nu_\ell) \times \mathcal{B}(D_2^{*0} \to D^{(*)+}\pi^-) = (2.29 \pm 0.23_{\rm stat} \pm 0.21_{\rm syst}) \times 10^{-3}$$

$$\mathcal{B}(B^0 \to D_1^- \ell^+ \nu_\ell) \times \mathcal{B}(D_1^- \to D^{*0}\pi^-) = (2.78 \pm 0.24_{\rm stat} \pm 0.25_{\rm syst}) \times 10^{-3}$$

$$\mathcal{B}(B^0 \to D_2^{*-} \ell^+ \nu_\ell) \times \mathcal{B}(D_2^{*-} \to D^{(*)0}\pi^-) = (1.77 \pm 0.26_{\rm stat} \pm 0.11_{\rm syst}) \times 10^{-3}$$

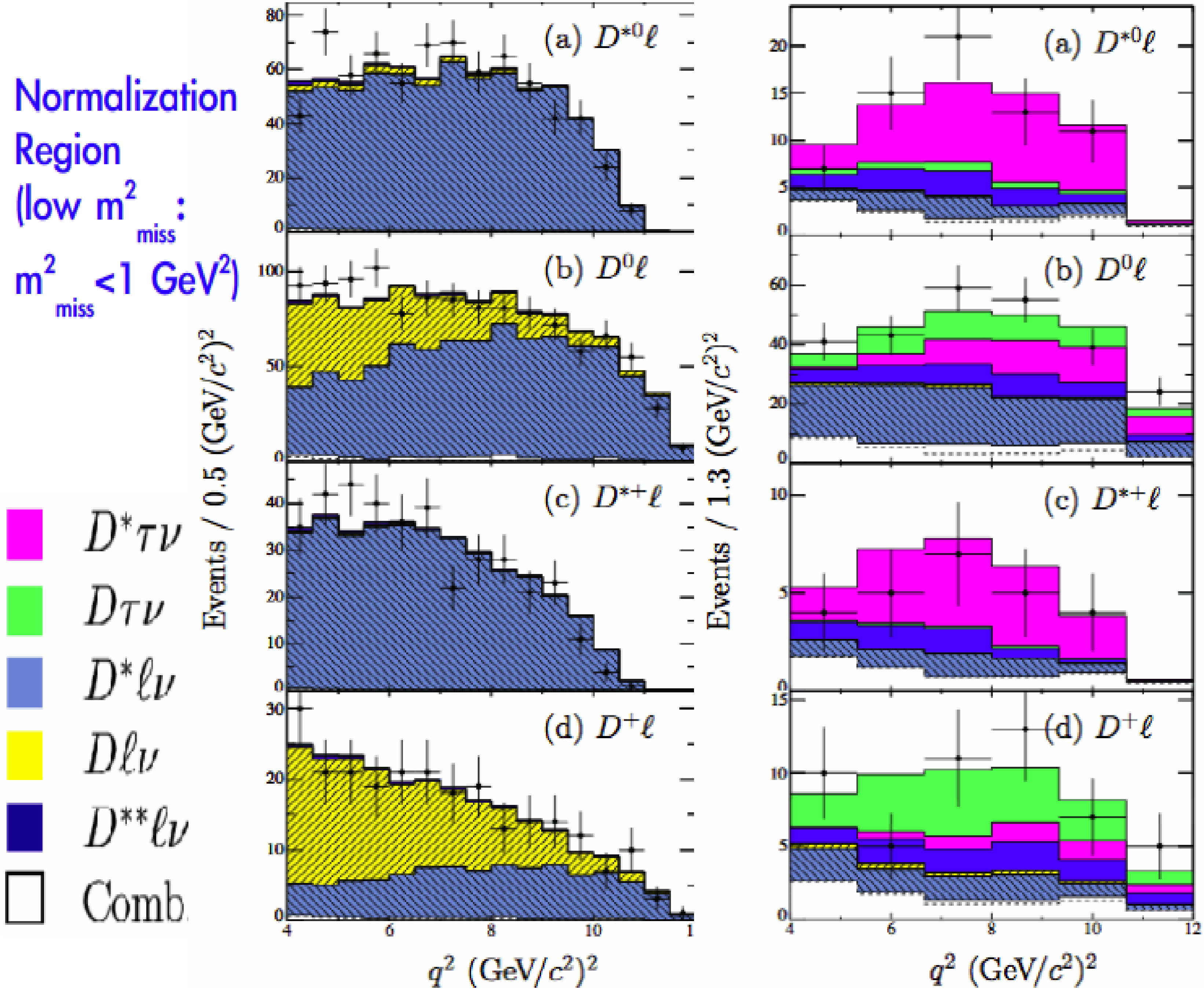
$B\to D(*)\tau\nu$: backgrounds

- *Largest background from $B\to D(*)\ell\nu$*
  - *Direct or from D** feed-down*
- *Combine* $\mathbf{B_{tag}}$**+**$\mathbf{D^{(*)}}$**+**$\boldsymbol{\ell}$ $\to \Upsilon$**(4S)**
  - P_{miss}**=**$(p_{e+e-} - p_{tag} - p_{D(*)} - p_{\ell})$
  - $\mathbf{m_{miss}^{2}} = P_{miss}^{2}$ *signal form a broad tail out to:* m_{miss}^{2}*~8* GeV^2/c^4
  - *Leptons from* τ *tipically have a soft spectrum*
- *Most dangerous background from $B\to D^{**}\ell\nu$*
  - *Select $D(*)\pi^0$ candidates and fitted togheter with the signal sample to reduce the sensitivity to D** modeling*



B→ D(*)τν: q² projection

Normalization Region
(low m^2_{miss} : m^2_{miss} <1 GeV^2)



Signal Region
(high m^2_{miss} : m^2_{miss} >1 GeV^2)

$B \to D(^*)\tau\nu$: systematics

Source	Fractional uncertainty (%)					
	$D^0\tau\nu$	$D^{*0}\tau\nu$	$D^+\tau\nu$	$D^{*+}\tau\nu$	$D\tau\nu$	$D^*\tau\nu$
	Additive systematic uncertainties					
MC stat. (PDF shape)	11.5	8.4	4.5	1.8	6.9	4.7
MC stat. (constraints)	4.2	1.9	6.1	1.3	3.6	1.4
Comb. BG modeling	7.5	4.1	11.5	2.6	9.1	2.9
D^{**} modeling	5.7	0.5	1.6	0.2	3.0	0.4
$B \to D^*$ form factors	1.9	0.7	0.8	0.2	1.4	0.4
$B \to D$ form factors	0.2	0.7	0.6	0.2	0.3	0.4
$m^2_{\rm miss}$ tail modeling	1.5	0.5	1.2	0.4	1.6	0.1
π^0 crossfeed constraints	0.5	1.1	0.5	0.9	0.5	1.0
D^{**} feed-down	0.4	0.1	0.1	0.3	0.2	0.2
$D^{**}\tau^-\overline{\nu}_\tau$ abundance	0.4	1.3	0.3	0.2	0.3	0.8
Total additive	15.6	9.7	14.0	3.6	12.5	5.8
	Multiplicative systematic uncertainties					
MC stat. (efficiency)	1.2	1.1	1.5	1.1	1.0	0.8
Bremsstrahlung/FSR	0.6	0.5	0.3	0.4	0.4	0.5
Tracking ε	0.0	0.0	0.0	0.0	0.0	0.0
e PID ε	0.5	0.5	0.6	0.6	0.6	0.6
μ PID ε	0.5	0.6	0.7	0.6	0.6	0.6
K PID ε	0.2	0.1	0.2	0.0	0.2	0.0
π PID ε	0.1	0.1	0.2	0.0	0.1	0.1
K^0_S ε	0.1	0.0	0.1	0.1	0.1	0.0
Neutral (π^0 and γ) ε	0.0	0.0	0.0	0.1	0.0	0.0
Daughter $\mathcal{B}$'s	0.1	0.3	0.0	0.1	0.1	0.3
$\mathcal{B}(\tau^- \to \ell^-\overline{\nu}_\ell\nu_\tau)$	0.2	0.2	0.2	0.2	0.2	0.2
Total multiplicative	1.6	1.5	1.8	1.4	1.4	1.3
Total	15.6	9.9	14.0	3.9	12.5	6.0
$\mathcal{B}(B \to D^{(*)}\ell^-\overline{\nu}_\ell)$	10.2	7.7	9.4	3.7	6.8	3.4