Summary of $B \to D^{(*)} l \nu$ measurements

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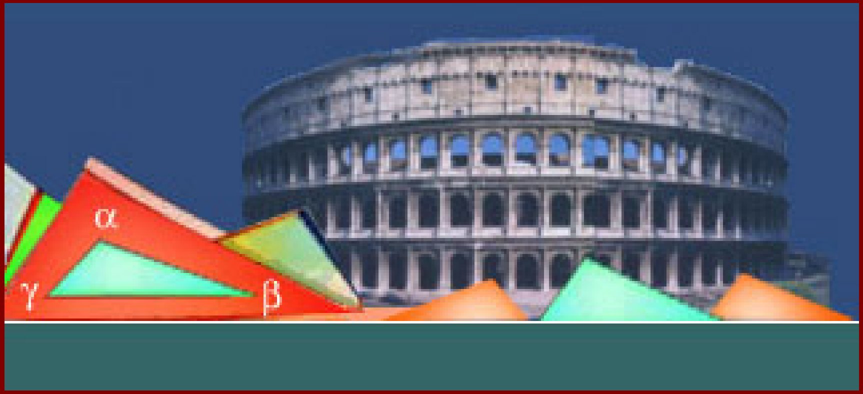
5th Wokshop on the Unitarity Triangle

Rome September 9-13 2008



OUTLINE

- Introduction
- $|V_{cb}|$ & FF from B -> $D^{(*)}l\nu$ decays
- Excited States
- Future perspectives
- Conclusions

V_{cb} & FF : Theoretical tools

- HQET expansion of Form Factors:

$$\frac{d\Gamma}{dw}(D) = \frac{G_F^2}{48\pi^3\hbar}(M_B+M_D)^2 M_D^3(w^2-1)^{3/2} |V_{cb}|^2 G^2(w) \qquad w=\frac{P_B \cdot P_D}{M_B M_D}$$

$$\frac{d\Gamma}{dw}(D^*) = \frac{G_F^2}{48\pi^3\hbar}(M_B-M_{D^*})^2 M_{D^*}^3(w^2-1)^{1/2}(w+1)^2 |V_{cb}|^2 h_{A_1}^2(w)\Sigma_{+,0,-}|\tilde{H}_i(w)|^2$$

- Use Caprini *et al.* param. (Nucl.Phys.B 530 (1998), 153)

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

$$h_A(w) = \ldots$$

- ULQCD : F.F. at w~1

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

(M.Okamoto et al NPPS 140, 461 (2005))

$h_{\mathcal{A}}(1)=0.924 \pm 0.012 \pm 0.019$

(J.Laiho et al arXiv:0710.1111 [hep-lat]

V_{cb} & FF : Theoretical tools

- HQET expansion of Form Factors:

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

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$$w = \frac{P_B \cdot P_D}{M_B M_D}$$

- Use Caprini *et al.* param. (Nucl.Phys.B 530 (1998), 153)

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

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

$$h_A(w) = \ldots$$

- ULQCD : F.F. at w~1

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

(M.Okamoto et al NPPS 140, 461 (2005))

$h_{\mathcal{A}}(1) = 0.921 \pm 0.013 \pm 0.020$

(J.Laiho et al arXiv:0808.251 [hep-lat]

- Experiments :

$|V_{cb}|$ * F.F.(w→1)

$\rho_D^2, \rho_{D^*}^2$ (slopes of ff)

R_1, R_2 : form factor ratios (D*)

Caveat

- Sometimes in this talk the D* FF is denoted as $\mathcal{F}(w)$, to be consistent with experimental papers and HFAG.
- It is however exactly $h_{A_1}(w)$
- Ambiguities with ρ should be cleared by the context

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- Ambiguities with ρ should be cleared by the context

Sides-view retaliation to (α,β,γ)-(ϕ_2,ϕ_1,ϕ_3) ambiguity

V_{cb} & FF : the Measurements

- $h_{\mathcal{A}}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{A}}$ with untagged $B^+ \to D^{*0}\, l\, \nu$ (BABAR)
- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, R_1$ & R_2 with untagged $B^0 \to D^{*+}\, l\, \nu$ (Belle)
- $\mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with tagged $B \to D\, l\, \nu$ (BABAR)

  NEW method
- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, \mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with untagged $B \to D\, l\, \nu X$ (BABAR)

  NEW method

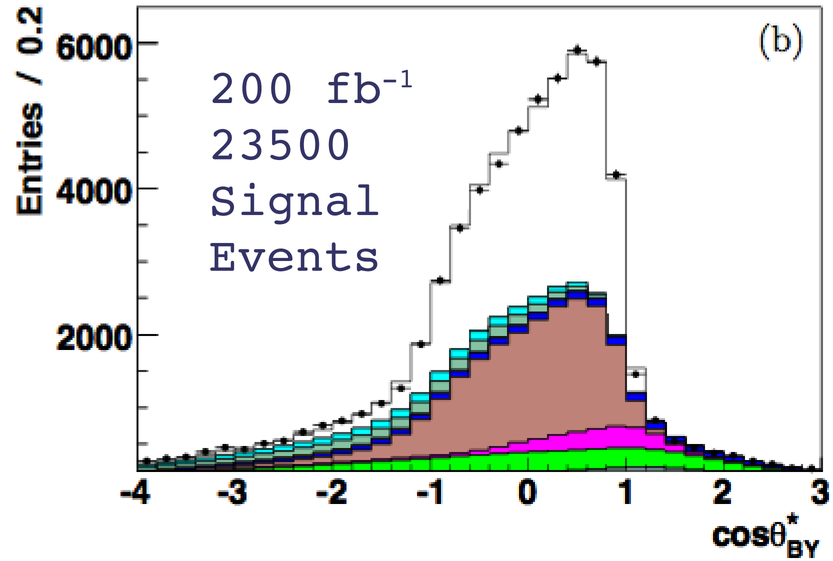
- Decay chain:

$$B^- \to D^{*0} e^- \bar{\nu}_e\,, \quad D^{*0} \to D^0 (K^- \pi^+) \pi^0$$

- 3-d ($M_{D\pi}$-M_D, $\cos\Theta_{BY}$, w) binned max- L fit

$h_{\mathcal{A}}(1)V_{cb}$, ρ^2

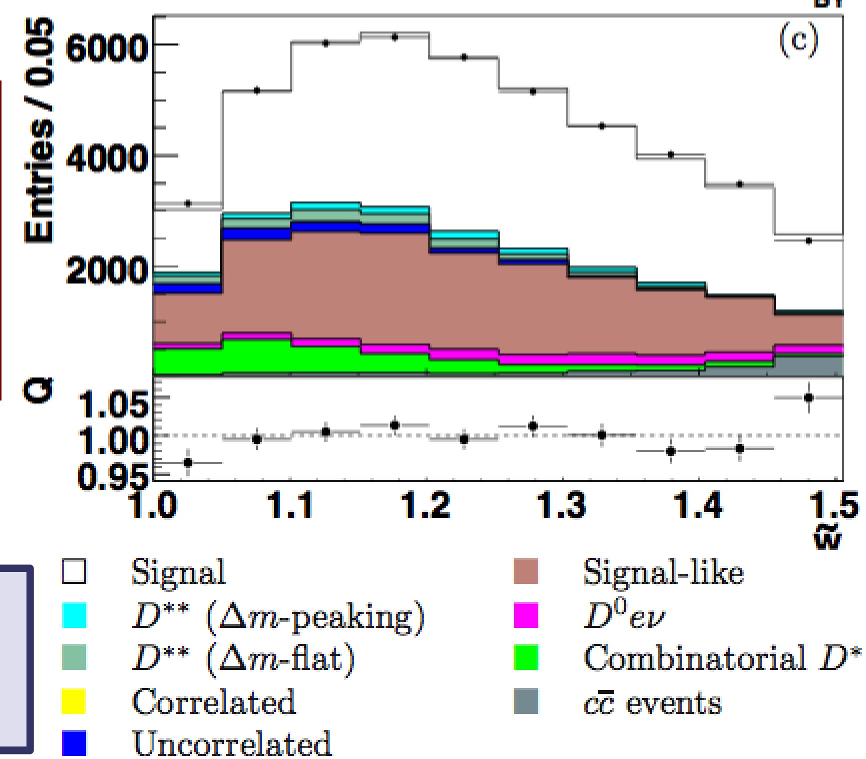
background



- Results:

PRL100, 231803 (2008)

$$F(1)\cdot|V_{cb}| = (35.9 \pm 0.6 \pm 1.4)\cdot 10^{-3}\,,$$
$$\rho^2_{A_1} = 1.16 \pm 0.06 \pm 0.08\,,$$
$$\mathcal{B}(B^- \to D^{*0} e^- \overline{\nu}_e) = (5.56 \pm 0.08 \pm 0.41)\%\,.$$



- Well consistent with $D^{*+}l\nu$ BABAR result

(PRD77, 032002,2008)

$$\mathcal{F}(1)|V_{cb}| = (34.7 \pm 0.4 \pm 1.0) \times 10^{-3}$$
$$\rho^2 = 1.157 \pm 0.094 \pm 0.027$$

V_{cb} & FF : the Measurements

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- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, R_1$ & R_2 with untagged $B^0 \to D^{*+}\, l\, \nu$ (Belle)
- $\mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with tagged $B \to D\, l\, \nu$ (BABAR)

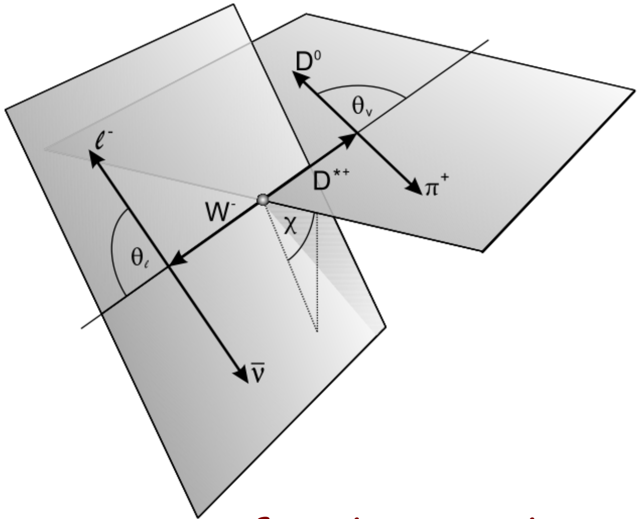
NEW method

- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, \mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with untagged $B \to D\, l\, \nu X$ (BABAR)

NEW method

- Decay chain: 140 fb^{-1} 150000 Signal Events

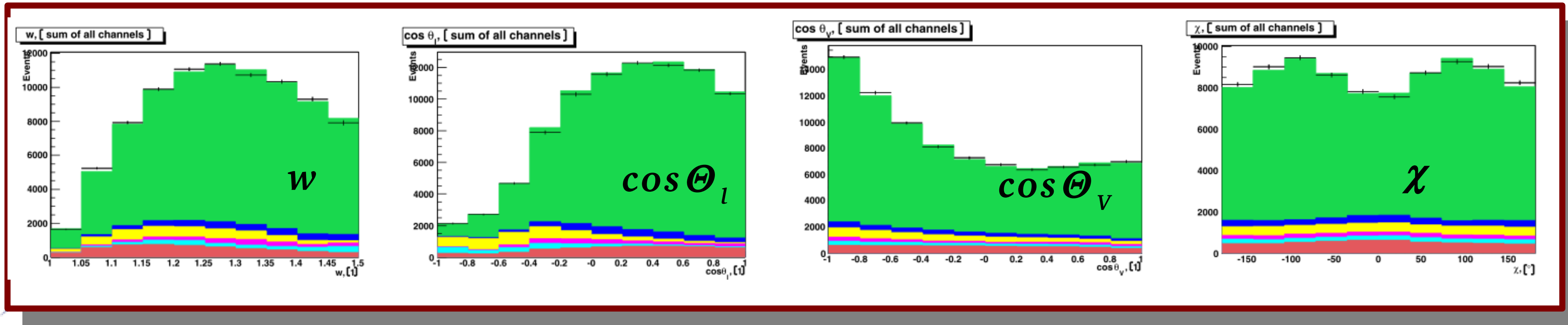
$$B^0 \to D^{*+} e^- \bar{\nu}_e, \quad D^{*+} \to D^0 (K^- \pi^+, K3\pi) \pi^+$$



- Measure helicity angles (Θ_l, Θ_V, χ) to determine also F.F. ratios
- Good overall resolution

$(\delta_w = 0.025, \delta_{\cos\theta_\ell} = 0.052, \delta_{\cos\theta_\ell} = 0.047, \delta_\chi = 6.47°)$

- Fit $\frac{d^4\Gamma}{dw\, d\chi\, d(\cos\Theta_l)\, d(\cos\Theta_V)}$ on the four projections, accounting for bin to bin correlations



V_{cb} & FF : untagged $B \to D l \nu_l$ (Belle)

- Belle Prel. (W.Dungel ICHEP08)

ρ^2	$1.293 \pm 0.045 \pm 0.029$
$R_1(1)$	$1.495 \pm 0.050 \pm 0.062$
$R_2(1)$	$0.844 \pm 0.034 \pm 0.019$
$R_{K3\pi/K\pi}$	2.153 ± 0.011
$\mathcal{B}(B^0 \to D^{*-}\ell^+\nu_\ell)$	$(4.42 \pm 0.03 \pm 0.25)\%$
$\mathcal{F}(1)\,\|V_{cb}\| \times 10^3$	$34.4 \pm 0.2 \pm 1.0$
$\chi^2/\mathrm{n.d.f.}$	$138.8/155$
P_{χ^2}	82.0%

- systematic : detector, background (D**)

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BABAR (PRD77, 032002,2008)

$1.191 \pm 0.048 \pm 0.028$
$1.429 \pm 0.061 \pm 0.044$
$0.827 \pm 0.038 \pm 0.022$
$(4.69 \pm 0.04 \pm 0.34)\%$
$34.4 \pm 0.3 \pm 1.1$

Very Good Consistency

~ 3% error on $h_{A}(1)|V_{cb}|$ each (mostly syst.)

V_{cb} & FF : the Measurements

- $h_{\mathcal{A}}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{A}}$ with untagged $B^+ \to D^{*0}\, l\, \nu$ (BABAR)

- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, R_1$ & R_2 with untagged $B^0 \to D^{*+}\, l\, \nu$ (Belle)

- $\mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with tagged $B \to D\, l\, \nu$ (BABAR)

  NEW method

- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, \mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with untagged $B \to D\, l\, \nu X$ (BABAR)

  NEW method

V_{cb} & FF : tagged $B \rightarrow D l^- \nu_l$ (BABAR)

- TAG B ~ 1000 full reco final states

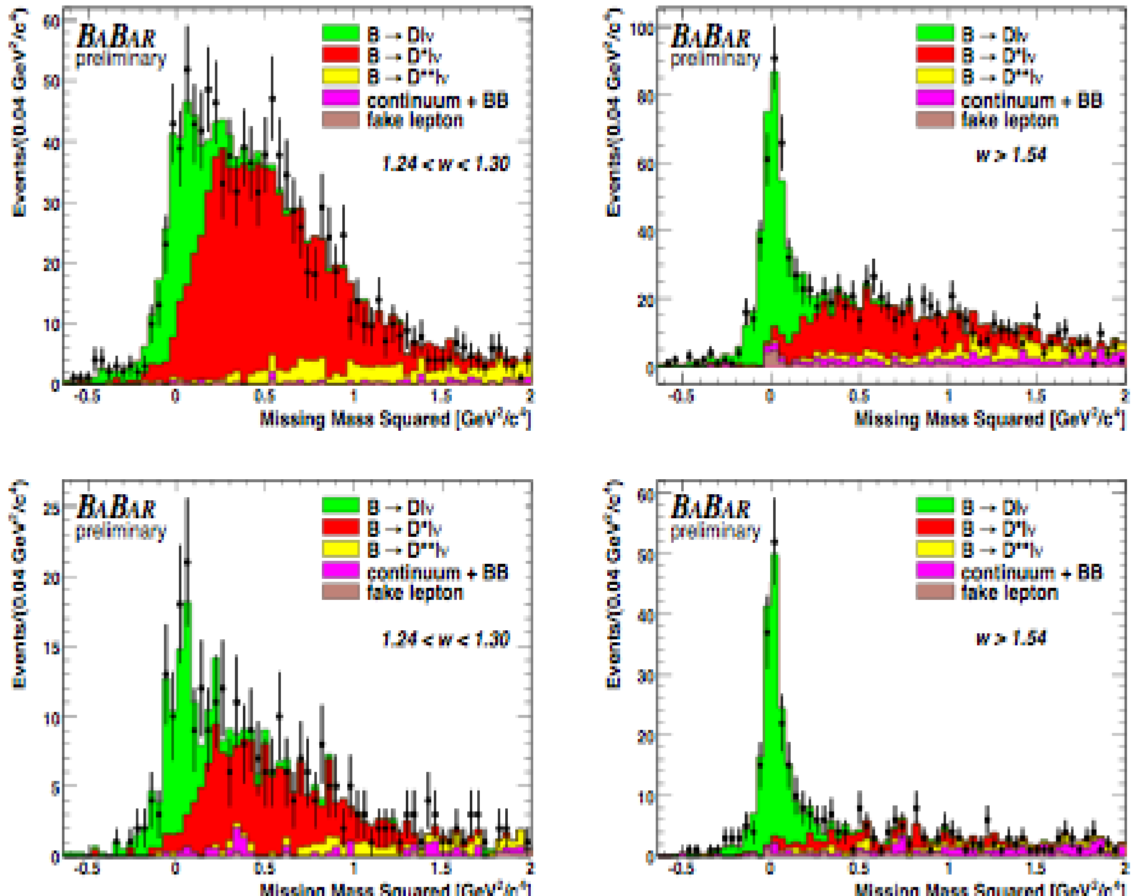
  $(116 \pm 1)10^3$ events with $p_l > 0.6$ (normalization)

- Recoil : $B \rightarrow D\, l\, \bar{\nu}_l$ — D^0 to 9 final states; D^+ to 7 final states

- Event yield:

  fit MM^2 in 10 w bins

  2147±69 signal D^0 events
  1108±45 signal D^+ events



$$MM^2 = (P_B - P_D - P_l)^2 \equiv M_\nu^2 \; [GeV^2/c^4]$$

V_{cb} & FF : tagged $B\to Dl^-\nu_l$ (BABAR)

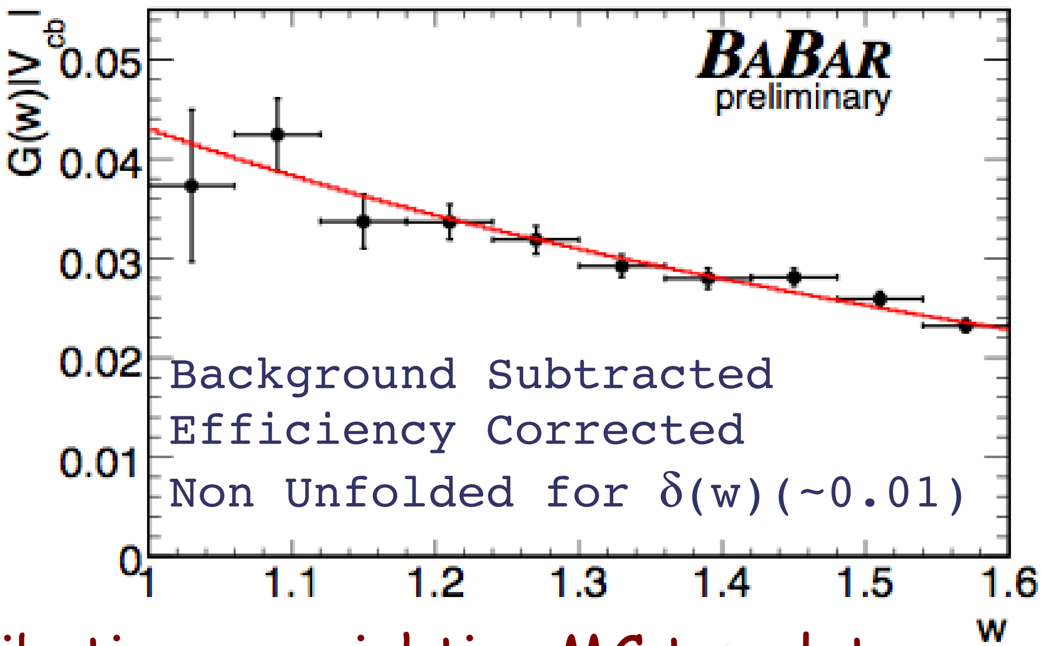
- TAG B ~ 1000 full reco final state

  $(116\pm1)10^3$ events with $p_l>0$

- Recoil : $B \to D\, l\, \bar{\nu}_l$ D^0 to 9 f / D^+ to 7 f

- Event yield:

  fit MM^2 in 10 w bins



- $|\mathcal{G}(1)V_{cb}|$ & $\rho^2_{\mathcal{G}}$ from fit to w distribution, reweighting MC template

$$\begin{aligned} \mathcal{G}(1)|V_{cb}| &= (43.0 \pm 1.9 \pm 1.4) \times 10^{-3} \\ \rho^2_{\mathcal{G}} &= 1.20 \pm 0.09 \pm 0.04 \\ \mathcal{B}(\overline{B}^0 \to D^+ \ell^- \bar{\nu}_\ell) &= (2.17 \pm 0.06 \pm 0.07)\%. \end{aligned}$$

5.5 % error on $G(1)\,|V_{cb}|$, mostly statistical

V_{cb} & FF : the Measurements

- $h_{\mathcal{A}}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{A}}$ with untagged $B^+ \to D^{*0}\, l\, \nu$ (BABAR)
- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, R_1$ & R_2 with untagged $B^0 \to D^{*+}\, l\, \nu$ (Belle)
- $\mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with tagged $B \to D\, l\, \nu$ (BABAR)

  NEW method
- $h_{\mathcal{A}}(1)\,|V_{cb}|, \rho^2_{\mathcal{A}}, \mathcal{G}(1)\,|V_{cb}|$ & $\rho^2_{\mathcal{G}}$ with untagged $B \to D\, l\, \nu X$ (BABAR)

  NEW method

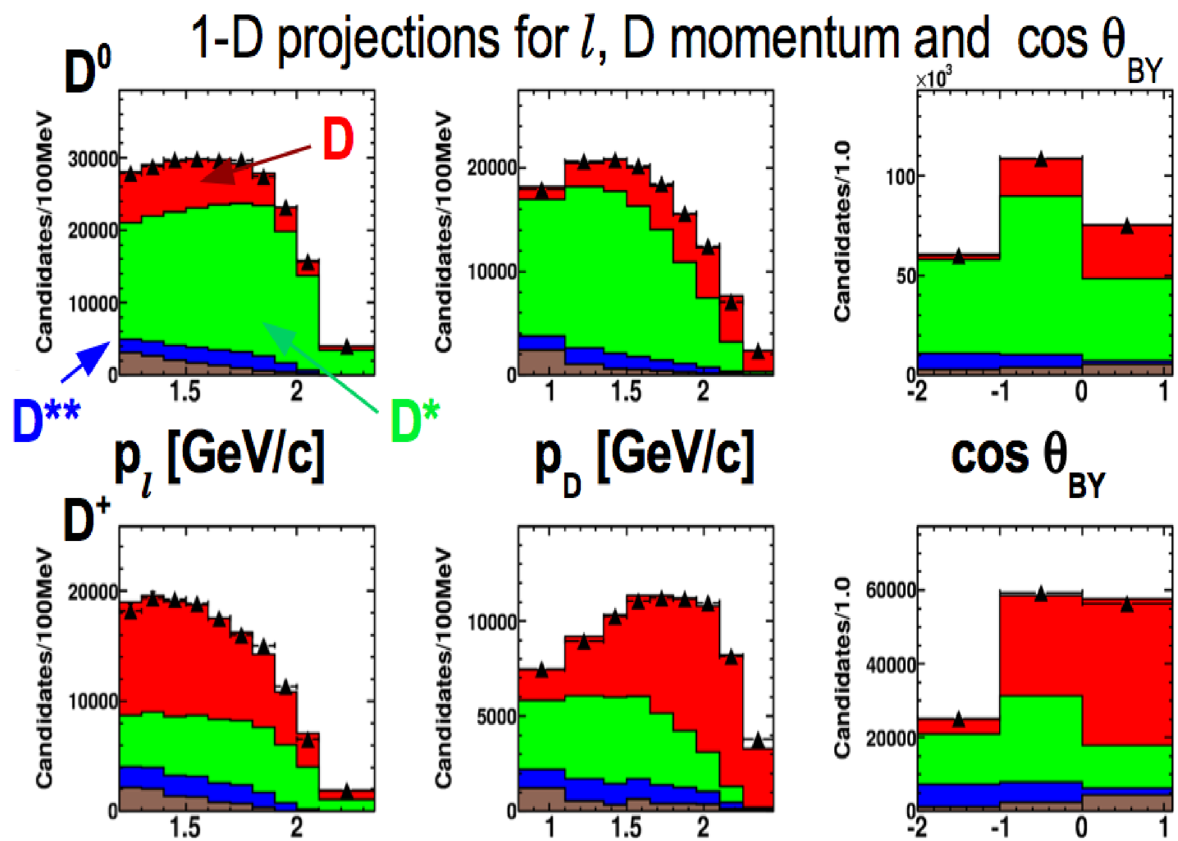
- Select $D^0(K\pi)\, l\, \nu_l X$, $D^+(K\pi\pi)\, l\, \nu_l X$ events with $p_l > 1.2$ GeV/c

- No π_{soft} reconstruction for D*
  (↑evt. rate; ↓ σ syst.)

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

  p_D correlated to w: sensitivity to ρ_G, ρ_h and V_{cb}

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



- Fix D** rate (HFAG), assume BR($D^{(*)}\pi\pi l\nu$)= (1.1±1.1) %

arXiv:0809.0828

- ICHEP08 BABAR Prel. Results (as quoted for B^+):

Parameters	e sample	μ sample	combined result
ρ^2_D	$1.26 \pm 0.05 \pm 0.07$	$1.15 \pm 0.06 \pm 0.09$	$1.22 \pm 0.04 \pm 0.07$
$\rho^2_{D^*}$	$1.22 \pm 0.02 \pm 0.07$	$1.23 \pm 0.03 \pm 0.07$	$1.21 \pm 0.02 \pm 0.07$
$\mathcal{B}(D^0 \ell \overline{\nu})(\%)$	$2.41 \pm 0.03 \pm 0.14$	$2.29 \pm 0.04 \pm 0.16$	$2.36 \pm 0.03 \pm 0.12$
$\mathcal{B}(D^{*0} \ell \overline{\nu})(\%)$	$5.42 \pm 0.03 \pm 0.22$	$5.23 \pm 0.04 \pm 0.37$	$5.37 \pm 0.02 \pm 0.21$
χ^2/n.d.f. (probability)	424/470 (0.94)	496/466 (0.16)	2.1/4 (0.72)

$$\mathcal{G}(1)|V_{cb}| = (43.8 \pm 0.8 \pm 2.3) \times 10^{-3}$$
$$\mathcal{F}(1)|V_{cb}| = (35.7 \pm 0.2 \pm 1.2) \times 10^{-3}$$

5.5 % error on $G(1)\,|V_{cb}|$

3.3 % error on $h_A(1)\,|V_{cb}|$

- Comparable precision and good consistency with previous meas.
- Fit with R_1, R_2 free consistent with published values, but large σ(stat.)

- ICHEP08 BABAR Prel. Results (as quoted for B^+):

Parameters	e sample	μ sample	combined result
ρ_D^2	$1.26 \pm 0.05 \pm 0.07$	$1.15 \pm 0.06 \pm 0.09$	$1.22 \pm 0.04 \pm 0.07$
$\rho_{D^*}^2$	$1.22 \pm 0.02 \pm 0.07$	$1.23 \pm 0.03 \pm 0.07$	$1.21 \pm 0.02 \pm 0.07$
$\mathcal{B}(D^0 \ell \overline{\nu})(\%)$	$2.41 \pm 0.03 \pm 0.14$	$2.29 \pm 0.04 \pm 0.16$	$2.36 \pm 0.03 \pm 0.12$
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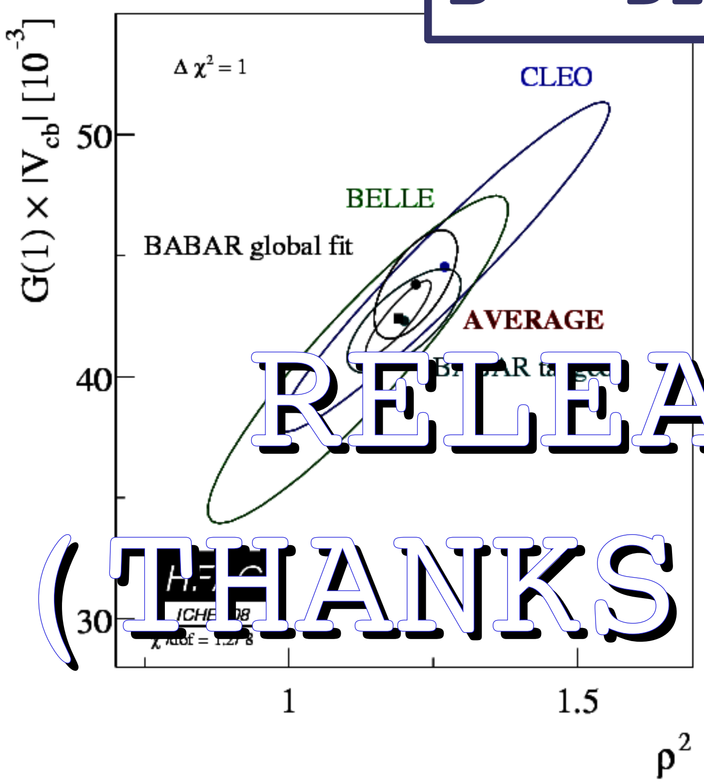
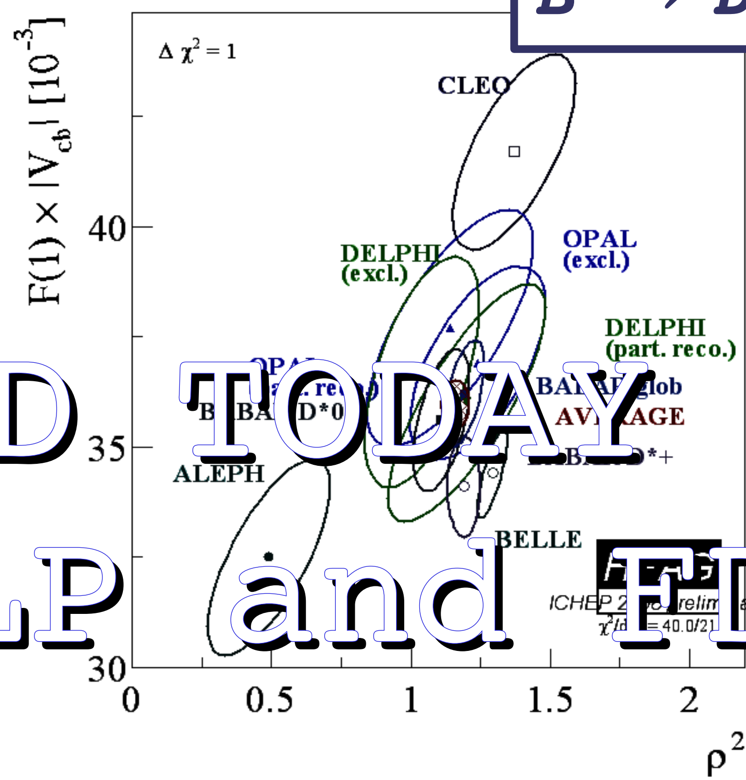
$$\mathcal{F}(1)|V_{cb}| = (35.7 \pm 0.2 \pm 1.2) \times 10^{-3}$$

- Theory validations :

Par	exp.	th.	Ref.
$\frac{G(1)}{h_A(1)}$	1.23 ± 0.09	1.16 ± 0.04	see above
$\rho_G^2 - \rho_F^2$	0.01 ± 0.04	$\simeq 0$	hep-ph 0111392

$B \to Dl\nu$ **$B \to D^*l\nu$**





RELEASED TODAY

(THANKS DLP and FDL)

$$G(1)|V_{cb}| = (42.4 \pm 1.5)10^{-3}$$
$$\rho_G^2 = 1.19 \pm 0.05$$

$$h_A(1)|V_{cb}| = (35.4 \pm 0.5) \cdot 10^{-3}$$
$$\rho_A^2 = 1.16 \pm 0.05$$

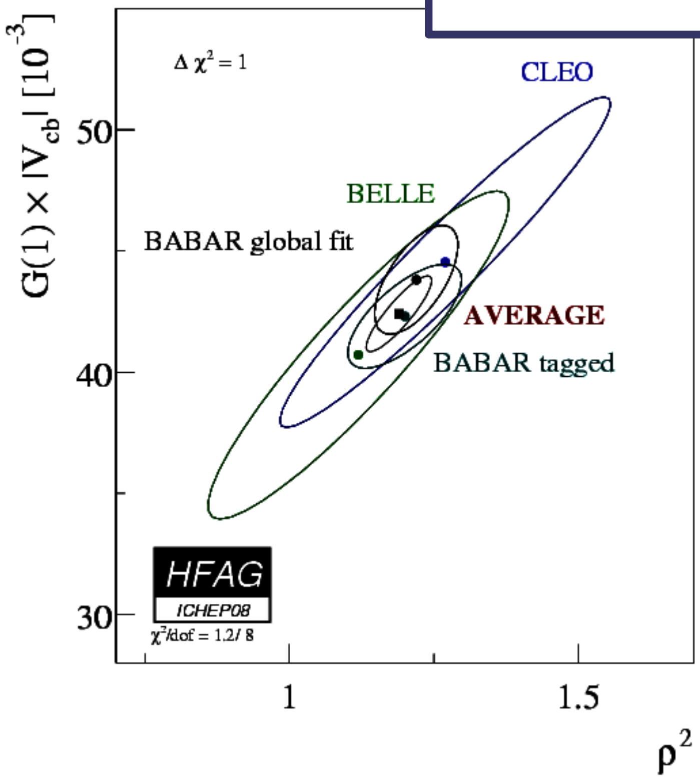
$|V_{cb}| = (39.7 \pm 1.4_{exp} \pm 0.9_{theo})\ 10^{-3}$ (D)

$|V_{cb}| = (38.1 \pm 0.6_{exp} \pm 0.9_{theo})\ 10^{-3}$ (D*)

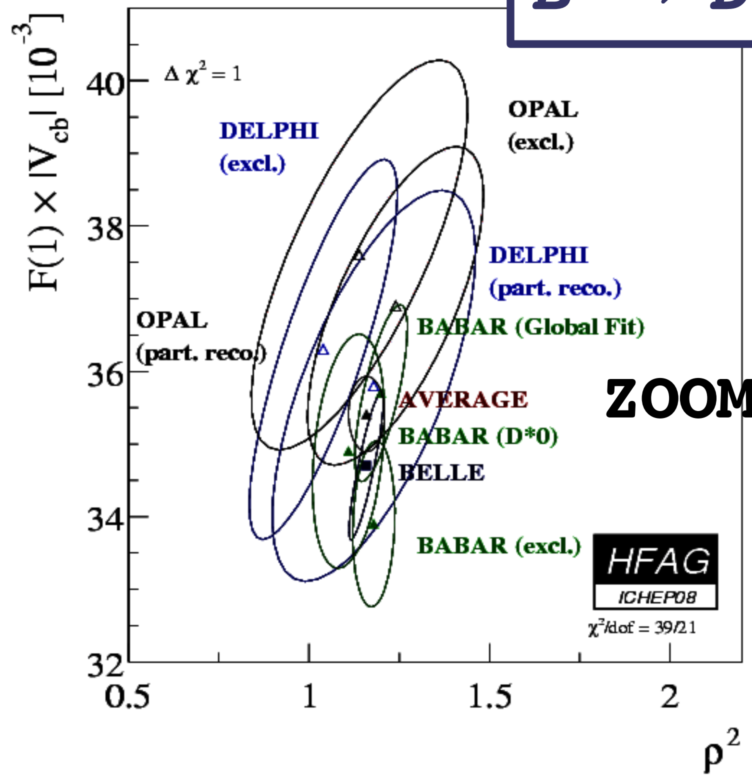
BELLE D* not included

V_{cb} & FF: W.A. @ ICHEP08

$B \to Dl\nu$



$B \to D^* l\nu$



$G(1)|V_{cb}| = (42.4 \pm 1.5)10^{-3}$

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$h_A(1)|V_{cb}| = (35.4 \pm 0.5) \cdot 10^{-3}$

$\rho_A^2 = 1.16 \pm 0.05$

$|V_{cb}| = (39.7 \pm 1.4_{exp} \pm 0.9_{theo})\ 10^{-3}$ (D)

$|V_{cb}| = (38.1 \pm 0.6_{exp} \pm 0.9_{theo})\ 10^{-3}$ (D*)

BELLE D* not included

V_{cb} & FF: Conclusions

☺ Six independent measurements from B-factories, from D and D* decays provide precise consistent results both as for $|V_{cb}|$ and for shape parameters

☺ V_{cb} from D almost as precise as from D* . Time to start thinking of correlated errors between G(1) and $h_A(1)$

☺ V_{cb} from exclusive decays might tackle inclusive result. Time to worry ?

$$|V_{cb}| = (39.7 \pm 1.4_{exp} \pm 0.9_{theo})\ 10^{-3} \quad (D)$$

$$|V_{cb}| = (38.1 \pm 0.6_{exp} \pm 0.9_{theo})\ 10^{-3} \quad (D^*)$$

V_{cb} & FF: Worries

☹ New results from both D^{*0} and D^{*+} will increase the BR deficit

PDG 2008

Decay Mode	Branching Fraction
$B^- \to \ell^- \bar{\nu}_\ell$ + anything	10.99 ± 0.28 %
$B^- \to D^0 \ell^- \bar{\nu}_\ell$	2.27 ± 0.11 %
$B^- \to D^{*0} \ell^- \bar{\nu}_\ell$	6.07 ± 0.29 %
$B^- \to D^+ \pi^- \ell^- \bar{\nu}_\ell$	0.42 ± 0.05 %
$B^- \to D^* \pi^- \ell^- \bar{\nu}_\ell$	0.61 ± 0.05 %
$B^- \to D^{(*)} n\pi \ell^- \bar{\nu}_\ell$	$\simeq$??
$B^- \to D^{(*)0} (\pi) \ell^- \bar{\nu}_\ell$	9.9 ± 0.3 %

$B(D^{*0} l\nu) = (5.4 \pm 0.2)\%$
BABAR prel.(not included)

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$\bar{B}^0 \to \ell^- \bar{\nu}_\ell$ + anything	10.33 ± 0.28 %
$\bar{B}^0 \to D^+ \ell^- \bar{\nu}_\ell$	2.17 ± 0.12 %
$\bar{B}^0 \to D^{*+} \ell^- \bar{\nu}_\ell$	5.16 ± 0.11 %
$\bar{B}^0 \to D^0 \pi^+ \ell^- \bar{\nu}_\ell$	0.43 ± 0.06 %
$\bar{B}^0 \to D^{*0} \pi^+ \ell^- \bar{\nu}_\ell$	0.49 ± 0.08 %
$\bar{B}^0 \to D^{(*)} n\pi \ell^- \bar{\nu}_\ell$	$\simeq$??
$\bar{B}^0 \to D^{(*)} (\pi) \ell^- \bar{\nu}_\ell$	8.7 ± 0.2 %

$B(D^{*+} l\nu) = (4.4 \pm 0.3)\%$
Belle prel.(not included)

☹ New results from both D^{*0} and D^{*+} will increase the BR deficit

PDG 2008

Decay Mode	Branching Fraction
$B^- \to \ell^- \bar{\nu}_\ell$ + anything	10.99 ± 0.28 %
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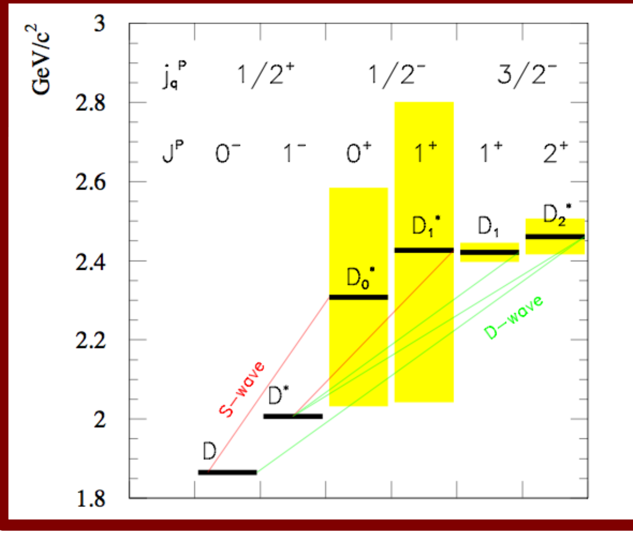
$B(D^{*+} l\nu) = (4.4 \pm 0.3)$%

Belle prel.(not included)

☹ A problem in "traditional" B-fact. measurements of $Br(B^0 \to D^{*+} l\nu)$?

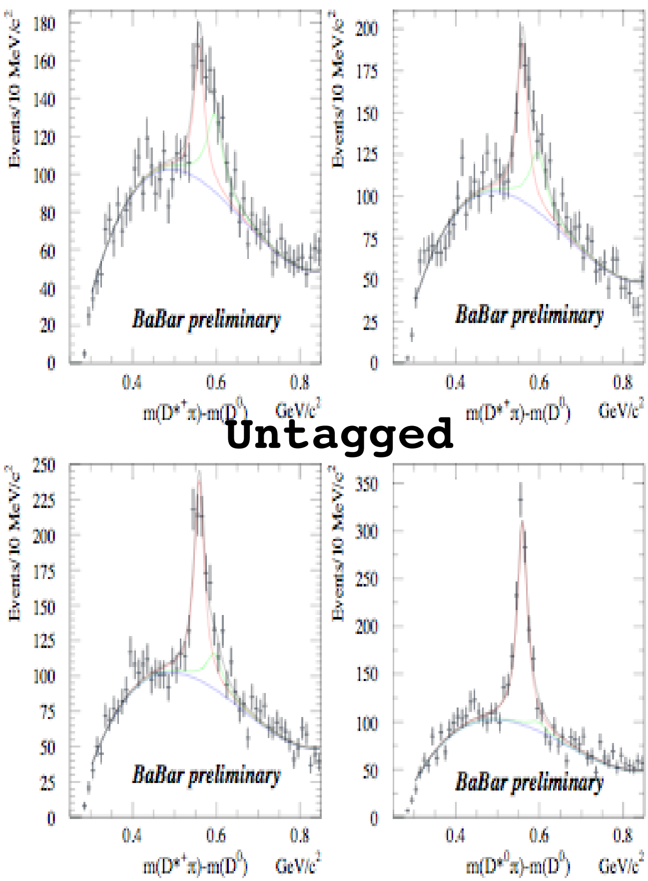
BABAR PRD77,32002,08	4.7 ± 0.4
Belle ICHEP 08	4.4 ± 0.3
PDG 2008	5.2 ± 0.1
Rescaled B+ PDG2008	5.7 ± 0.1
Rescaled B+ BABAR PRL100, 231803 (2008)	5.2 ± 0.4

Anatomy of SL Decays: D **

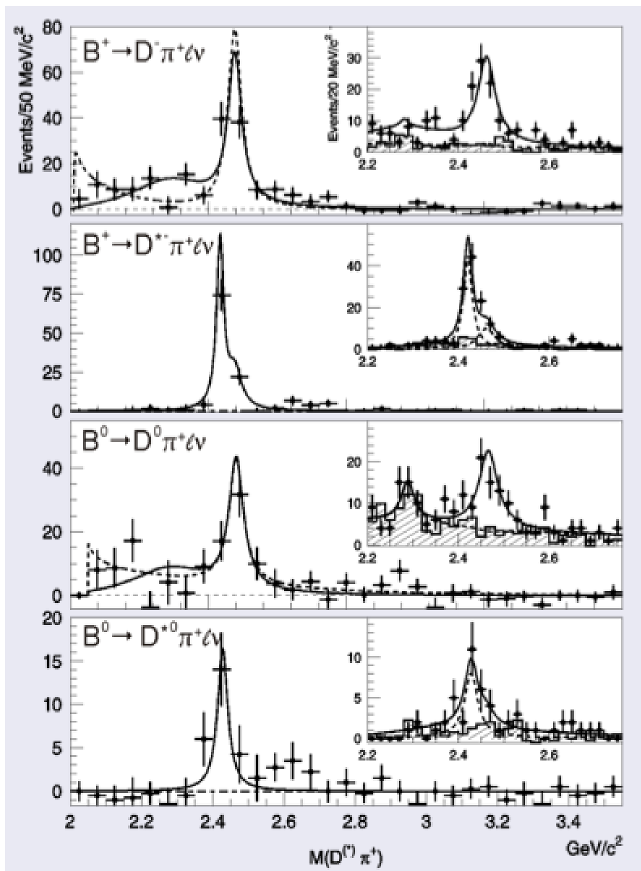


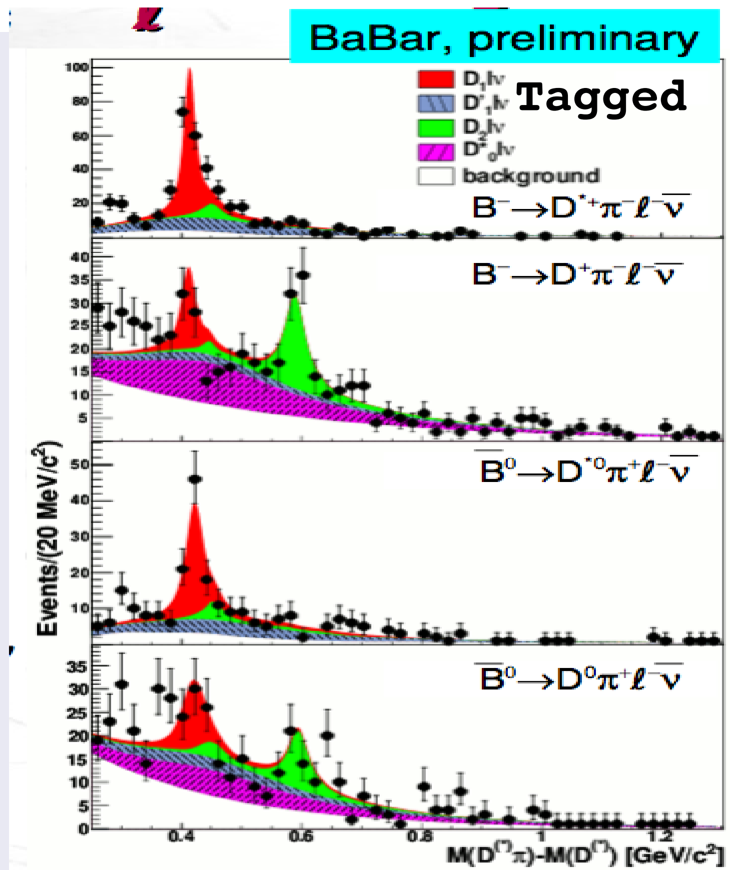
Presented at ICHEP:

- Untagged meast. of narrow states (BABAR)
- Tagged meast. of narrow and wide states (Belle and BABAR)

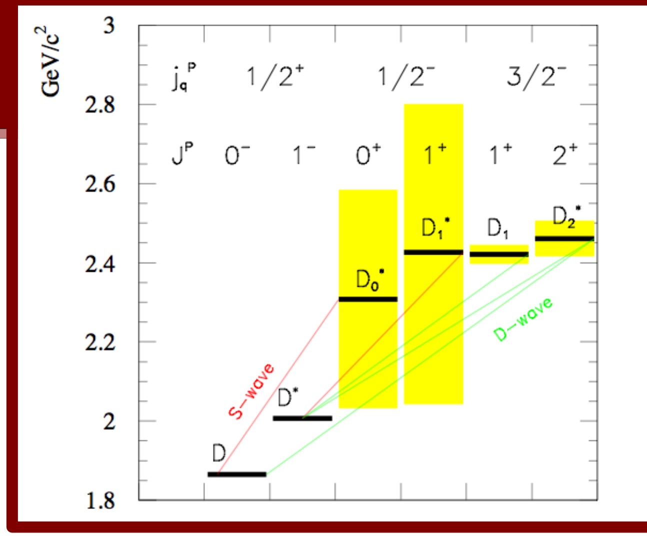


Belle Prel.





Anatomy of SL Decays: D**



Prel. results:

- Agreement on Narrow (D_1, D^*_2) rates
- Rates from broad larger than Sum Rules expectations
- Disagreement on D_1', observed only by BABAR

Decay Mode	Yield	$\mathcal{B}(\bar{B} \to D^{**}\ell^-\bar{\nu}_\ell) \times \mathrm{B}(D^{**} \to D^{(*)}\pi)$ %(BELLE)	BABAR Yield	BABAR Branching Fraction
		$D\pi$ invariant mass fit		
$B^- \to D_0^{*0}\ell^-\bar{\nu}_\ell$	102 ± 19	$0.24 \pm 0.04 \pm 0.06$	137 ± 26	$0.26 \pm 0.05 \pm 0.04$
$B^- \to D_2^0\ell^-\bar{\nu}_\ell$	94 ± 13	$0.22 \pm 0.03 \pm 0.04$	97 ± 16	$0.15 \pm 0.02 \pm 0.01$
$\bar{B}^0 \to D_0^{*+}\ell^-\bar{\nu}_\ell$	61 ± 22	$0.20 \pm 0.07 \pm 0.05$	142 ± 26	$0.44 \pm 0.08 \pm 0.07$
$\bar{B}^0 \to D_2^+\ell^-\bar{\nu}_\ell$	68 ± 13	$0.22 \pm 0.04 \pm 0.04$	29 ± 13	$0.07 \pm 0.03 \pm 0.01$
		$D^*\pi$ invariant mass fit		
$B^- \to D_1'^0\ell^-\bar{\nu}_\ell$	-5 ± 11	< 0.07 @ 90CL	142 ± 21	$0.27 \pm 0.04 \pm 0.05$
$B^- \to D_1^0\ell^-\bar{\nu}_\ell$	81 ± 13	$0.42 \pm 0.07 \pm 0.07$	165 ± 18	$0.29 \pm 0.03 \pm 0.03$
$B^- \to D_2^0\ell^-\bar{\nu}_\ell$	35 ± 11	$0.18 \pm 0.06 \pm 0.03$	40 ± 7	$0.07 \pm 0.01 \pm 0.006$
$\bar{B}^0 \to D_1'^+\ell^-\bar{\nu}_\ell$	4 ± 8	< 0.5 @ 90CL	86 ± 18	$0.31 \pm 0.07 \pm 0.05$
$\bar{B}^0 \to D_1^+\ell^-\bar{\nu}_\ell$	20 ± 7	$0.54 \pm 0.19 \pm 0.09$	88 ± 14	$0.27 \pm 0.05 \pm 0.03$
$\bar{B}^0 \to D_2^+\ell^-\bar{\nu}_\ell$	1 ± 6	< 0.3 @ 90CL	12 ± 5	$0.03 \pm 0.01 \pm 0.006$

D.Lopes-Peña, ICHEP08

Prospects

$|V_{cb}| = (39.7 \pm 1.4_{exp} \pm 0.9_{theo})\ 10^{-3}$ (D)

$|V_{cb}| = (38.1 \pm 0.6_{exp} \pm 0.9_{theo})\ 10^{-3}$ (D*)

Still much room for experimental improvements on FF & Vcb:

- UnTagged Dlv (BABAR+Belle) $\sigma_{stat.+syst.}$ ~2%
- Tagged D*lv (BABAR+Belle) $\sigma_{stat.+syst.}$ ~3%
- Tagged Dlv (Belle) $\sigma_{stat.+syst.}$ ~4%
- Untagged D^{*+} lv, $D^{*+} \to D^{+} \pi^{0}$ (cross check of B^0 B.R.)
- Look for $D^{(*)}\pi\pi(...)$lv

Reasonable to expect $\sigma_{exp}(V_{cb})/V_{cb}$ ~ 1.-1.5 %

How about theoretical errors ?

Prospects

Questions to Theory

- How about the correlation between $\mathcal{G}(1)$ and $h_A(1)$?
- Can the precision improve ?
- Can get calculation of FF away from 0 recoil ?
    - large statistical benefit for D (“helicity” suppression)
    - large systematic benefit for D* (soft pion systematic error)

Conclusions

- Form Factor measurements do validate QCD predictions
- B->Dlv enters the precision era -> start caring about correlated theoretical errors between $h_A(1)$ and G(1)

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$$|V_{cb}| = (38.7 \pm 0.6_{exp} \pm 0.9_{theo})\ 10^{-3} \quad (D^*)$$

- Br(D+D*+D**) < Br (Inclusive) requires further investigations of SL decays
- Maybe also a problem in untagged Br($B^0 \to D^{*+} l\nu$)

Conclusions

- Form Factor measurements do validate QCD predictions
- B->Dlν enters the precision era -> start caring about correlated theoretical errors between $h_A(1)$ and G(1)

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- Br(D+D*+D**) < Br (Inclusive) requires further investigations of SL decays
- Maybe also a problem in untagged $Br(B^0 \to D^{*+} l\nu)$
- A lot still to do , unless we are prevented by a

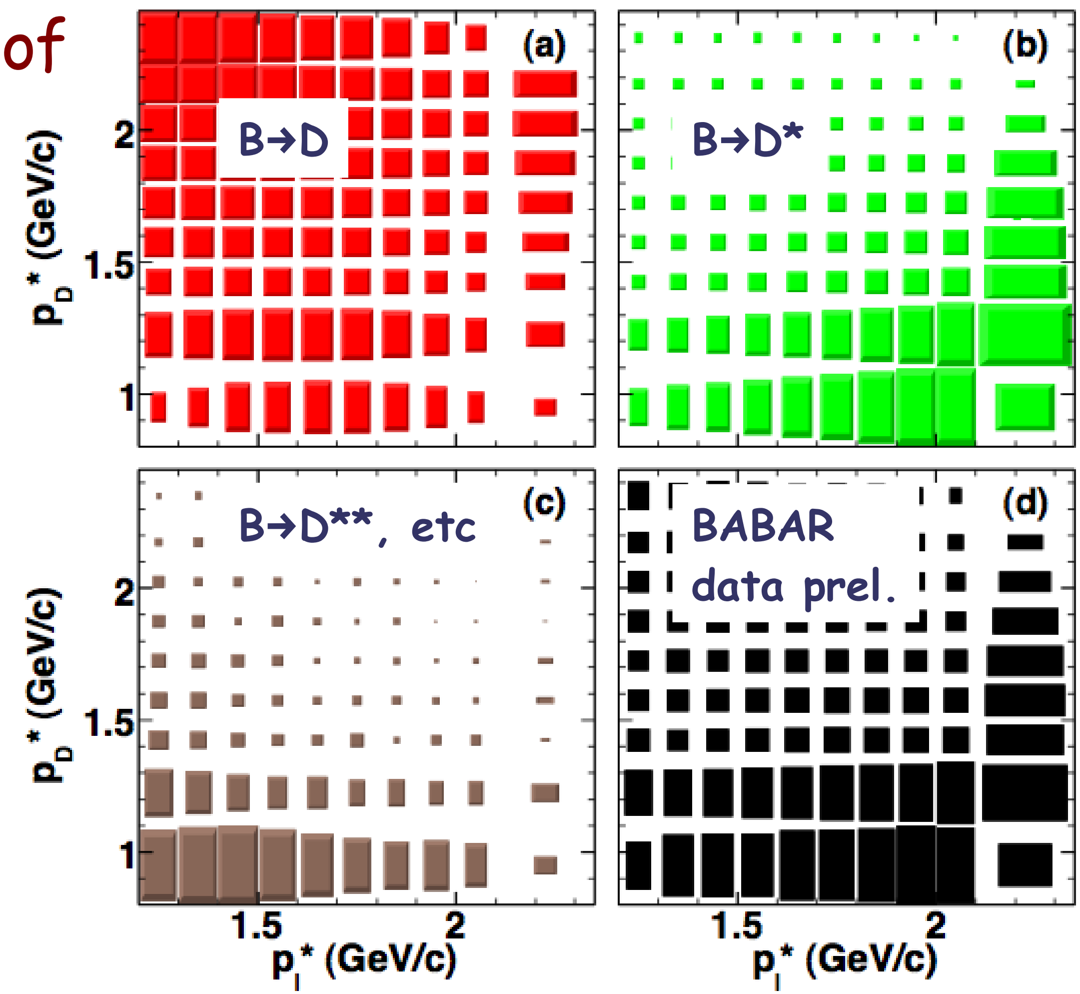
Large Hypotetical Catastrophe

backup

- V-A decay allows separation of B->Dlν from B->D*lν decays based on Kinematics:

$$p_l(D^*) > p_l(D)$$

$$p_D(D^*) < p_D(D)$$



- Decay chain:

$$B^- \to D^{*0} e^- \bar{\nu}_e \,, \quad D^{*0} \to D^0 (K^- \pi^+) \pi^0$$

- 3-d ($M_{D\pi}$-M_D, $\cos\Theta_{BY}$, w) binned max- L fit

$h_{\mathcal{A}}(1)V_{cb}$, ρ^2

background

- Results:

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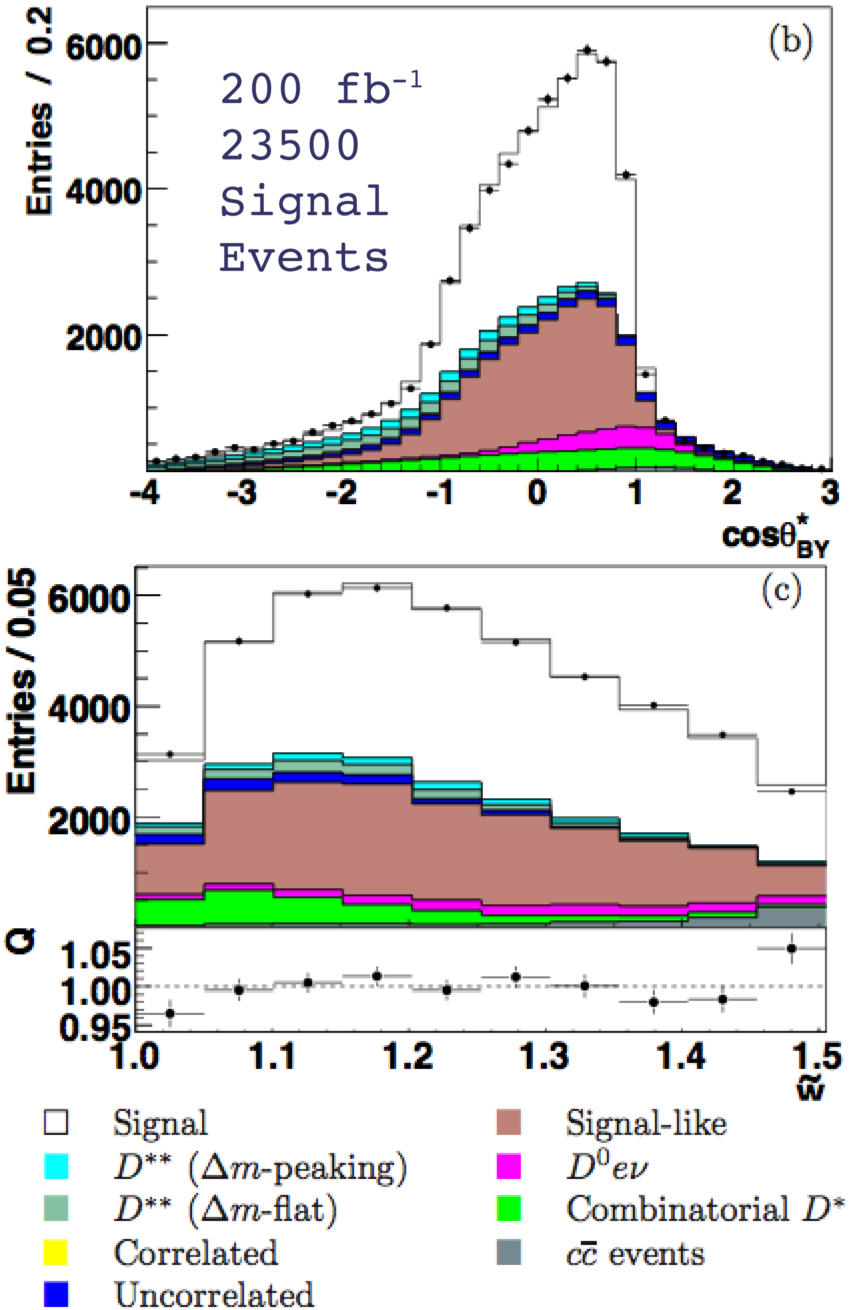
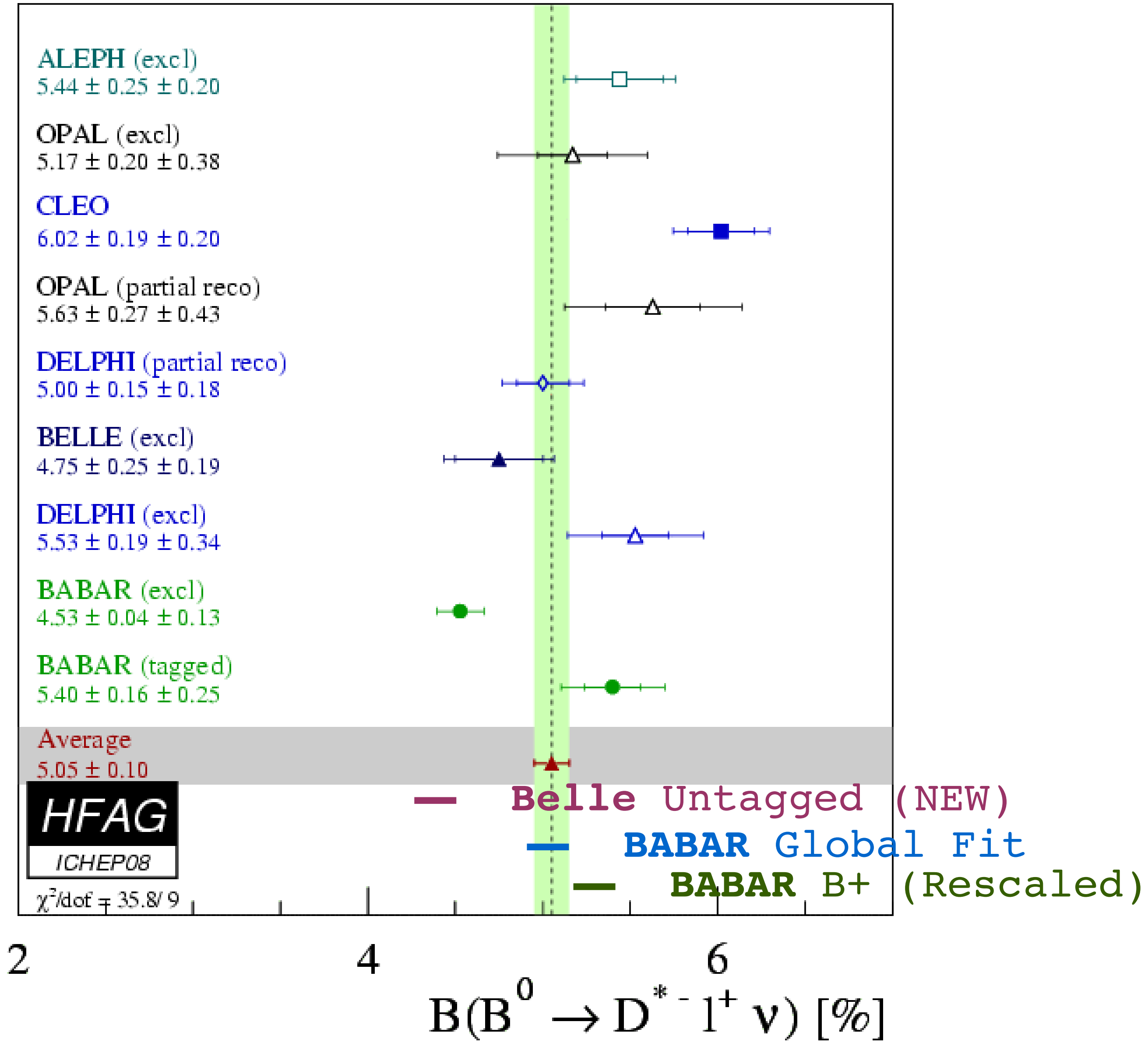
$$F(1) \cdot |V_{cb}| = (35.9 \pm 0.6 \pm 1.4) \cdot 10^{-3} \,,$$
$$\rho^2_{A_1} = 1.16 \pm 0.06 \pm 0.08 \,,$$
$$\mathcal{B}(B^- \to D^{*0} e^- \overline{\nu}_e) = (5.56 \pm 0.08 \pm 0.41)\% \,.$$

- Main σ(syst) rates : π^0 reco., BR(D^{*0})

- Main σ(syst) slope : R_1,R_2 (from BABAR)



BR (B->D*lν)


ALEPH (excl)
5.44 ± 0.25 ± 0.20
OPAL (excl)
5.17 ± 0.20 ± 0.38
CLEO
6.02 ± 0.19 ± 0.20
OPAL (partial reco)
5.63 ± 0.27 ± 0.43
DELPHI (partial reco)
5.00 ± 0.15 ± 0.18
BELLE (excl)
4.75 ± 0.25 ± 0.19
DELPHI (excl)
5.53 ± 0.19 ± 0.34
BABAR (excl)
4.53 ± 0.04 ± 0.13
BABAR (tagged)
5.40 ± 0.16 ± 0.25
Average
5.05 ± 0.10
HFAG
ICHEP08
χ²/dof = 35.8/ 9
Belle Untagged (NEW)
BABAR Global Fit
BABAR B+ (Rescaled)
2
4
6
B(B⁰ → D*⁻ l⁺ ν) [%]