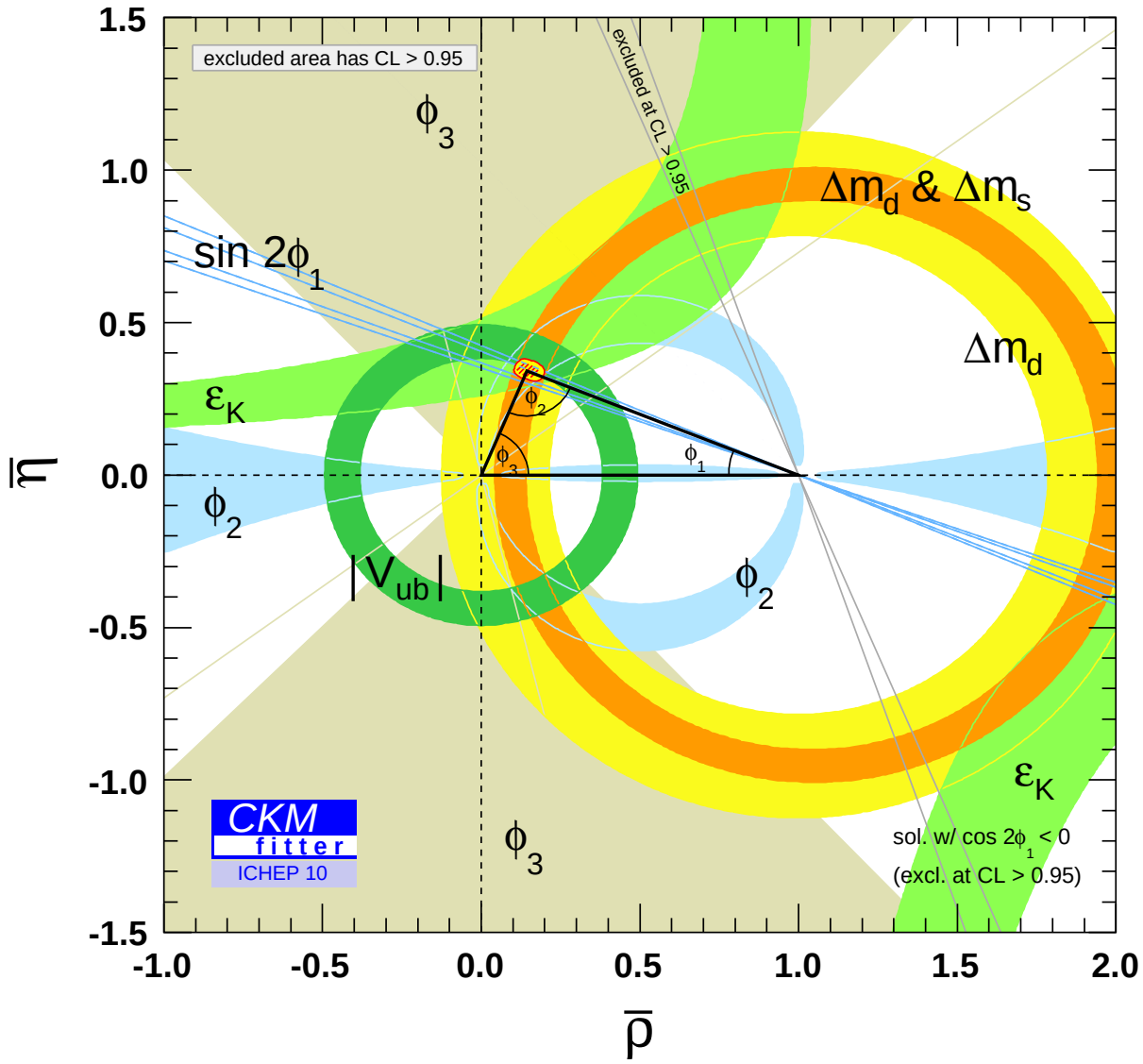
V_{ub} and V_{cb} Exclusive

The Xth International Conference on Heavy Quarks and Leptons

Frascati, Italy, 11–15.Oct.2010

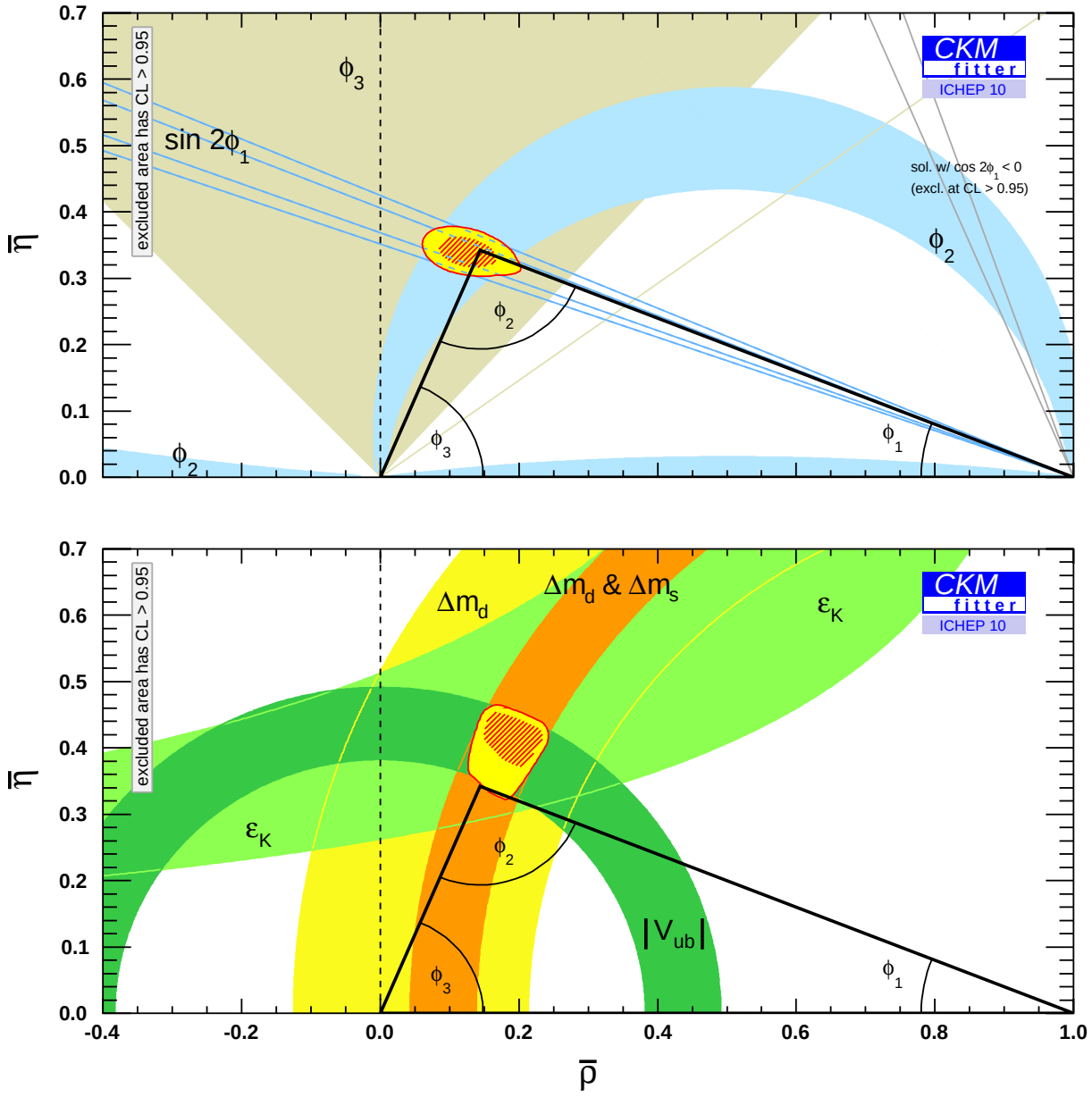
中村 勇 / KEK

Introduction



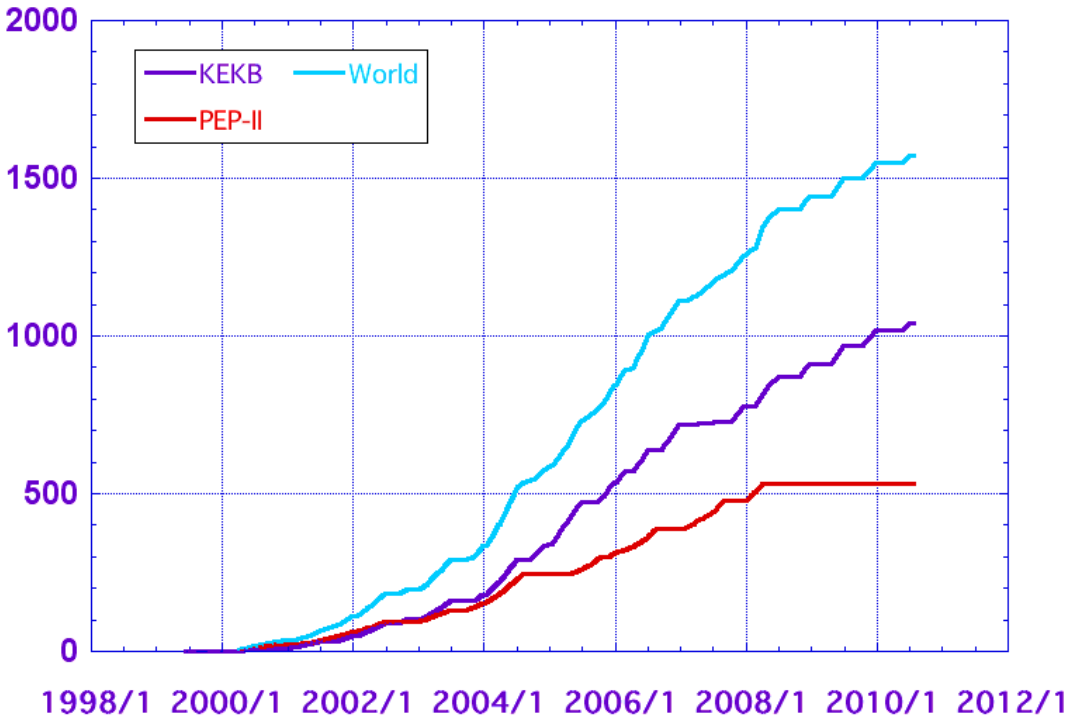
- Precise Determination of $|V_{ub}|/|V_{cb}|$ is important for test of CKM mechanism

Introduction



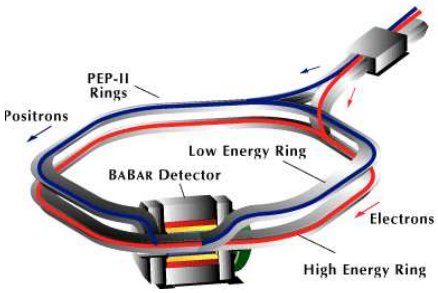
- Sides measurement not as accurate as angles

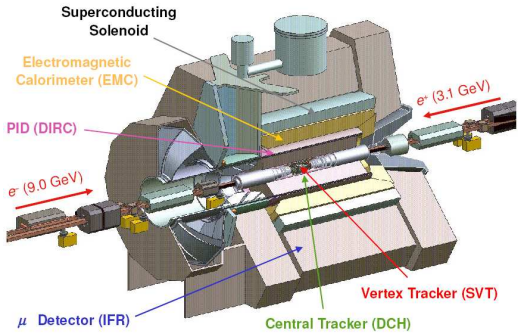
B-Factories and Luminosities



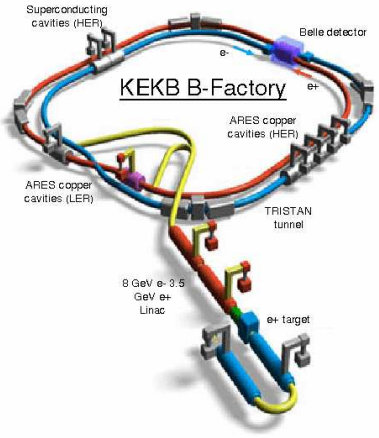
- KEKB/Belle
  - ~ 1040 fb^{-1} Total
  - ~ 711 fb^{-1} @ Υ(4S)
  - ~ 770 M B$\bar{\text{B}}$
- PEP-II/BaBar
  - ~ 550 fb^{-1} Total
  - ~ 433 fb^{-1} @ Υ(4S)
  - ~ 470 M B$\bar{\text{B}}$

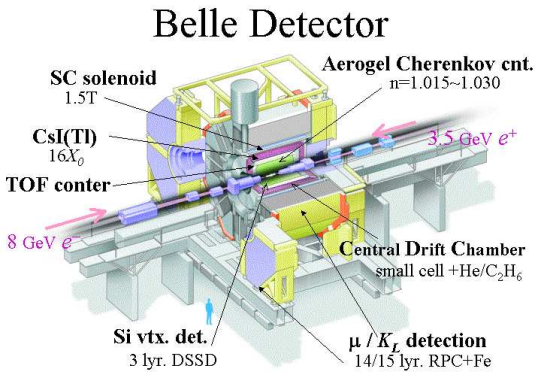
PEP-II/BaBar (1999–2008)





KEKB/Belle (1999–2010)



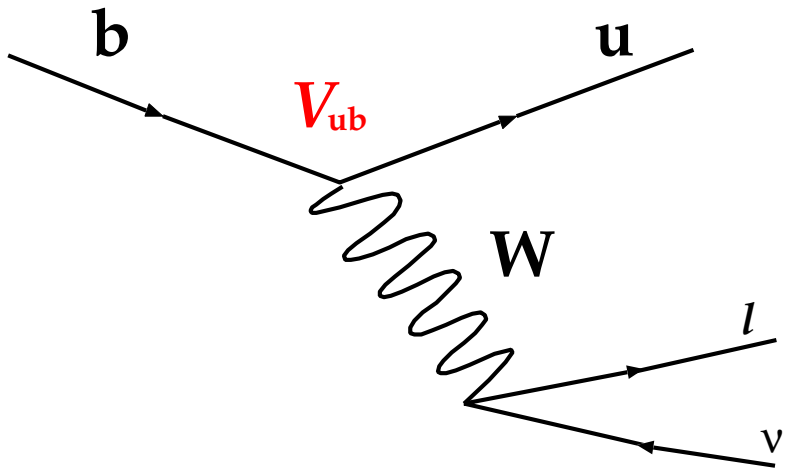


V_{ub} Exclusive

for BaBar New V_{ub} Exclusive $\Rightarrow$ P.Taras' Talk Tomorrow

Belle results are Preliminary

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ壱



- Here final state is $B^0 \to \pi^- \ell^+ \nu, \quad \ell = e, \mu$
- Measurement is done with the equation,

$$\frac{d\Gamma(B \to \pi^- \ell^+ \nu)}{dq^2} = \frac{G_F^2}{192\pi^2 m_b^3} |V_{ub}|^2 \lambda(q^2)^{\frac{3}{2}} \left| f_+^\pi(q^2) \right|^2$$
$$q^2 = (p_\ell + p_\nu)^2 = (p_B - p_\pi)^2$$

- need extra input $f_+^\pi(q^2)$, determined by theorist

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ弐

- A charged pion and a lepton as a signal side
- missing 3 momentum

$$\vec{p}_{\rm miss} \equiv -\sum_i \vec{p}_i$$

- neutrino 4 momentum

$$p_\nu = (|\vec{p}_{\rm miss}|, \vec{p}_{\rm miss})$$

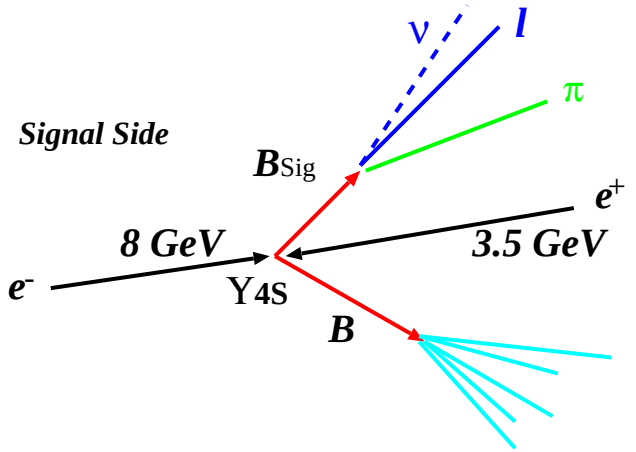
- Momentum transfer, q^2

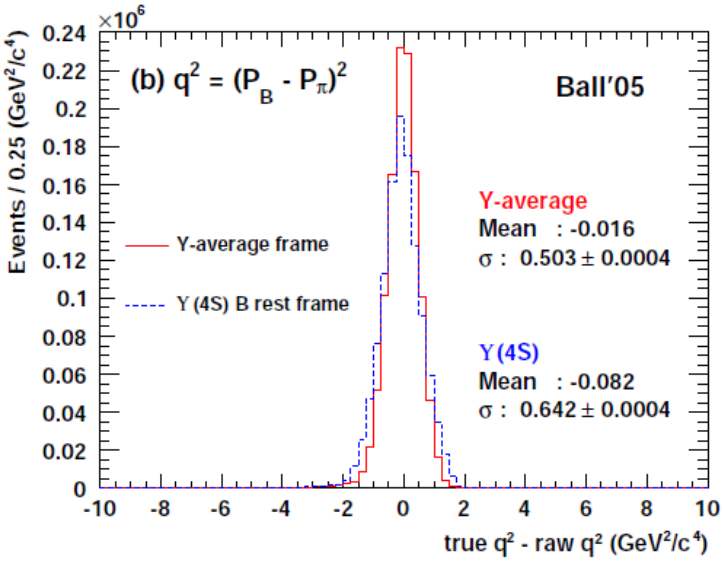
$$q^2 = (p_\ell + p_\nu)^2 = (p_{\rm B} - p_\pi)^2,$$

  averaged over B direction ambiguity

- Estimate B yield by fitting distributions,

$$m_{\rm bc} = \sqrt{E^2_{\rm beam} - \left|\vec{p}_\pi + \vec{p}_\ell + \vec{p}_\nu\right|^2}$$
$$\Delta E = E_{\rm beam} - (E_\pi + E_\ell + E_\nu)$$



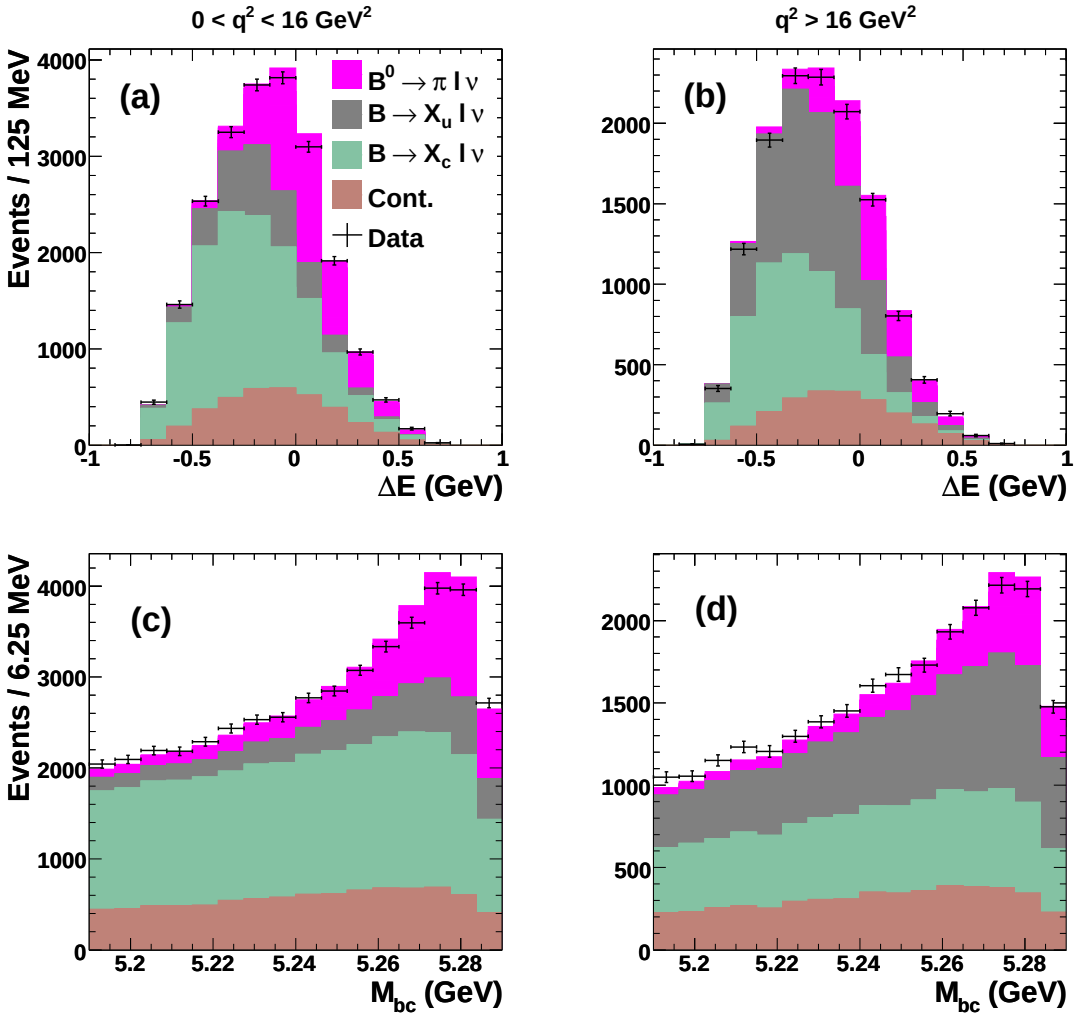


σ_{q^2} ~0.5 GeV^2

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ参

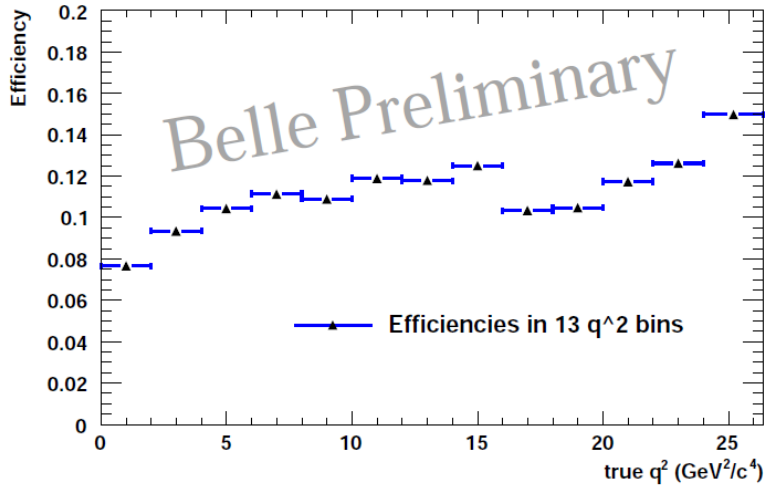
- Belle Data sample 605 fb^{-1}
- m_{bc} and ΔE distributions fitted with MC template

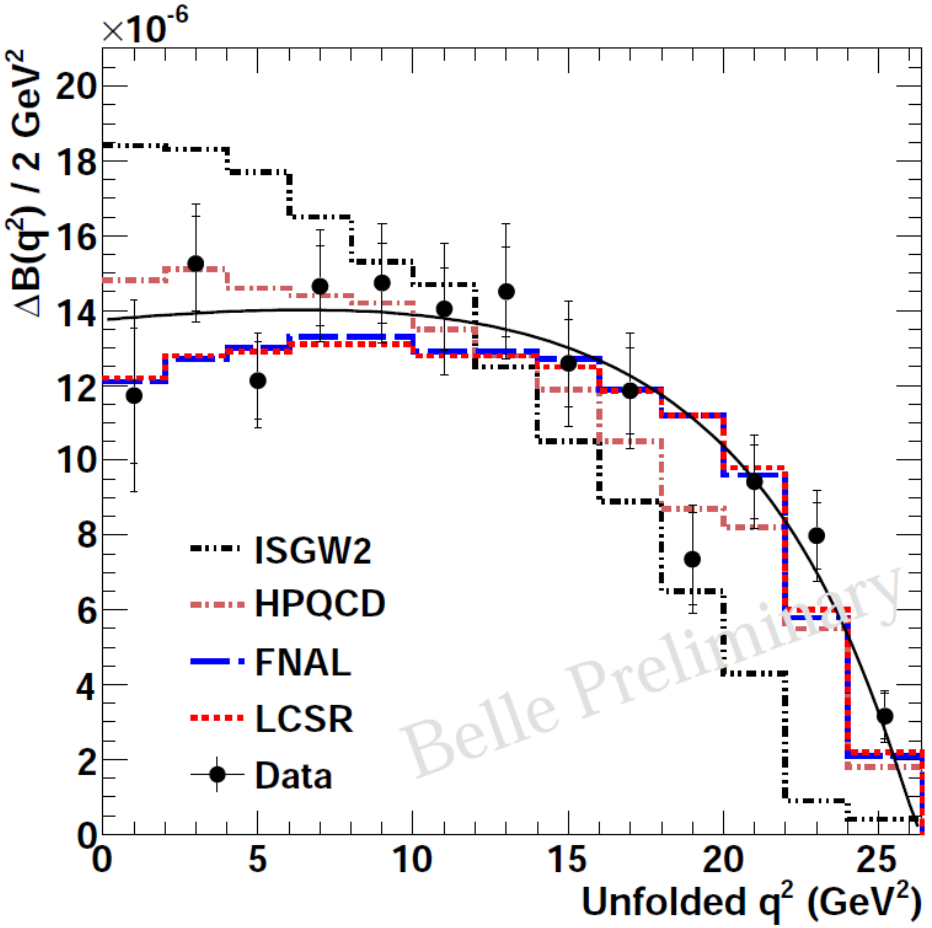
fitted m_{bc} and ΔE Distributions



- Components, q^2 bins
  - 13 bins for $\pi \ell \nu$
  - 3 bins for $X_u \ell \nu$
  - 4 bins for $X_c \ell \nu$
  - fixed(scaled) continuum

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ四





- Efficiency calculated in each q^2 bins
- unfolded q^2 distribution
- ISGW2 disfavored

$$\mathcal{B} = (1.49 \pm 0.04(\text{stat}) \pm 0.07(\text{syst})) \times 10^{-4}$$

- Major Source of Syst. Error is detector effect (3.4%)

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ伍

Systematic Uncertainties (relative to $\Delta\mathcal{B}$)

q^2 (GeV^2/c^4)	0 - 16	16 - 26.4	Total	q^2 (GeV^2/c^4)	0 - 16	16 - 26.4	Total
$\Delta\mathcal{B}$ ($\times 10^{\prime}$)	1096	397	1494	$\Delta\mathcal{B}$ ($\times 10^{\prime}$)	1096	397	1494
Lepton ID	2.40	2.49	2.44	$B \to \rho\ell\nu$ BF	0.44	0.42	0.43
Pion ID	1.37	1.08	1.26	$B \to \omega\ell\nu$ BF	0.11	0.31	0.16
Tracking efficiency	2.00	2.09	2.04	$B \to b_1\ell\nu$ BF	0.14	0.14	0.14
γ efficiency	0.37	0.51	0.42	V_{ub} + other $X_u\ell\nu$	0.19	0.15	0.15
Detector effects	3.43	3.46	3.44	$B \to D^*\ell\nu$ BF	0.18	0.13	0.16
				$B \to D\ell\nu$ B	0.07	0.14	0.08
Cont. Correction	2.14	2.62	1.80	$B \to D^{**}\ell\nu$ BF	0.11	0.22	0.13
				Other $X_c\ell\nu$	0.06	0.13	0.06
$\Upsilon(4S) \to B^0\bar{B}^0$ BF	1.56	1.72	1.40	**Physics parameters(BF)**	0.56	0.64	0.55
Signal MC stat. error	0.12	0.39	0.15				
FSR	0.45	0.60	0.37	$B^0 \to \pi^-\ell^+\nu$ FF	0.63	0.86	0.53
B counting	1.36	1.36	1.36	$B^0 \to \rho^-\ell^+\nu$ FF	0.72	0.95	0.60
Other sources	2.12	2.30	1.99	SF parameter	0.71	1.17	0.63
				$B^0 \to D^{*-}\ell^+\nu$ FF	0.81	1.01	0.62
				$B^0 \to D^-\ell^+\nu$ FF	0.11	0.16	0.10
				Physics parameters(FF)	1.28	1.77	1.07
				Total systematics	4.78	5.26	4.53
				Total statistics	3.03	5.31	2.63
				Total error	5.66	7.47	5.23

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ六

- V_{ub} can be extracted from the partial Branching Fraction,

$$|V_{ub}| = \sqrt{\Delta\mathcal{B}(q^2)/\tau_{B^0}\Delta\zeta},$$

where,
$\Delta\zeta$: form factor in corresponding q^2 range

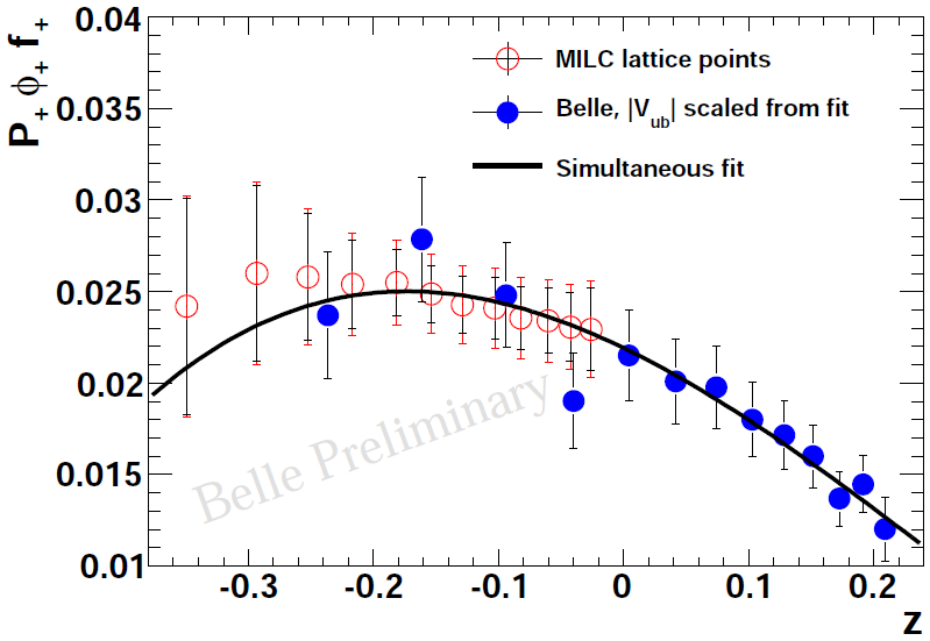
- Result

	q^2 (GeV^2)	$\Delta\zeta$ (ps^{-1})	$\lvert V_{ub}\rvert(10^{-3})$
HPQCD	> 16	2.07 ± 0.57	$3.55 \pm 0.09 \pm 0.09^{+0.62}_{-0.41}$
FNAL	> 16	1.83 ± 0.50	$3.78 \pm 0.10 \pm 0.10^{+0.65}_{-0.43}$
LCSR	< 16	5.4 ± 1.4	$3.64 \pm 0.06 \pm 0.09^{+0.60}_{-0.40}$
ISGW2	all	9.6 ± 4.8	$3.19 \pm 0.04 \pm 0.07^{+1.32}_{-0.59}$

- Form factor uncertainties largest contribution

$B^0 \to \pi^- \ell^+ \nu$ untagged 其ノ七

- F.F. model independent V_{ub} extraction method (PRD**79**054507 (2009))
- $f(|V_{ub}|; f(z)) = f(|V_{ub}|; a_0 + a_1 z + a_2 z^2 + a_3 z^3)$
- $z = z(q^2)$
- simultaneous fit with
  - MILC lattice result,
  - Belle experimental result



$$|V_{ub}| = (3.43 \pm 0.33) \times 10^{-3}$$

(stat. and syst. errors combined)

V_{cb} Exclusive

Belle results are Preliminary

Exclusive $B \to D^{(*)} \ell \nu$ 序

- Determination via differential rate

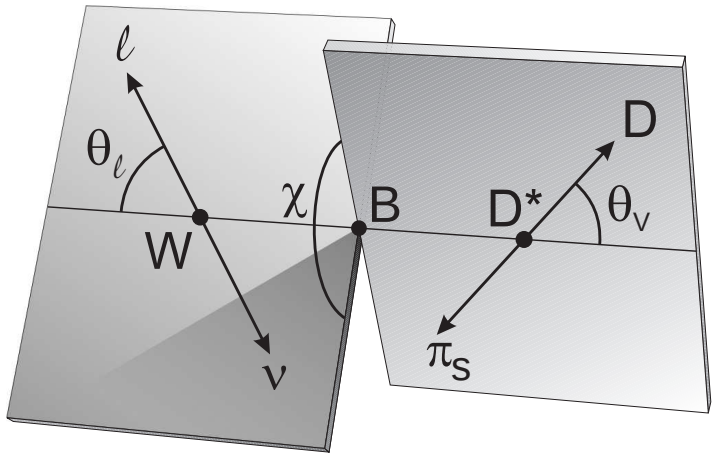
$$\frac{d\Gamma(B \to D^* \ell \nu)}{dw\, d\cos\theta_\ell\, d\cos\theta_V\, d\chi} = \frac{G_F^2}{48\pi^3} |V_{cb}|^2 m_{D^*}^3 (w^2-1)^{1/2} P(w) \mathcal{F}(w, ...)^2$$

$$\mathcal{F}(w) \Rightarrow \mathcal{F}(w, \cos\theta_\ell, \cos\theta_V, \chi, R_1, R_2, \rho^2)$$

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

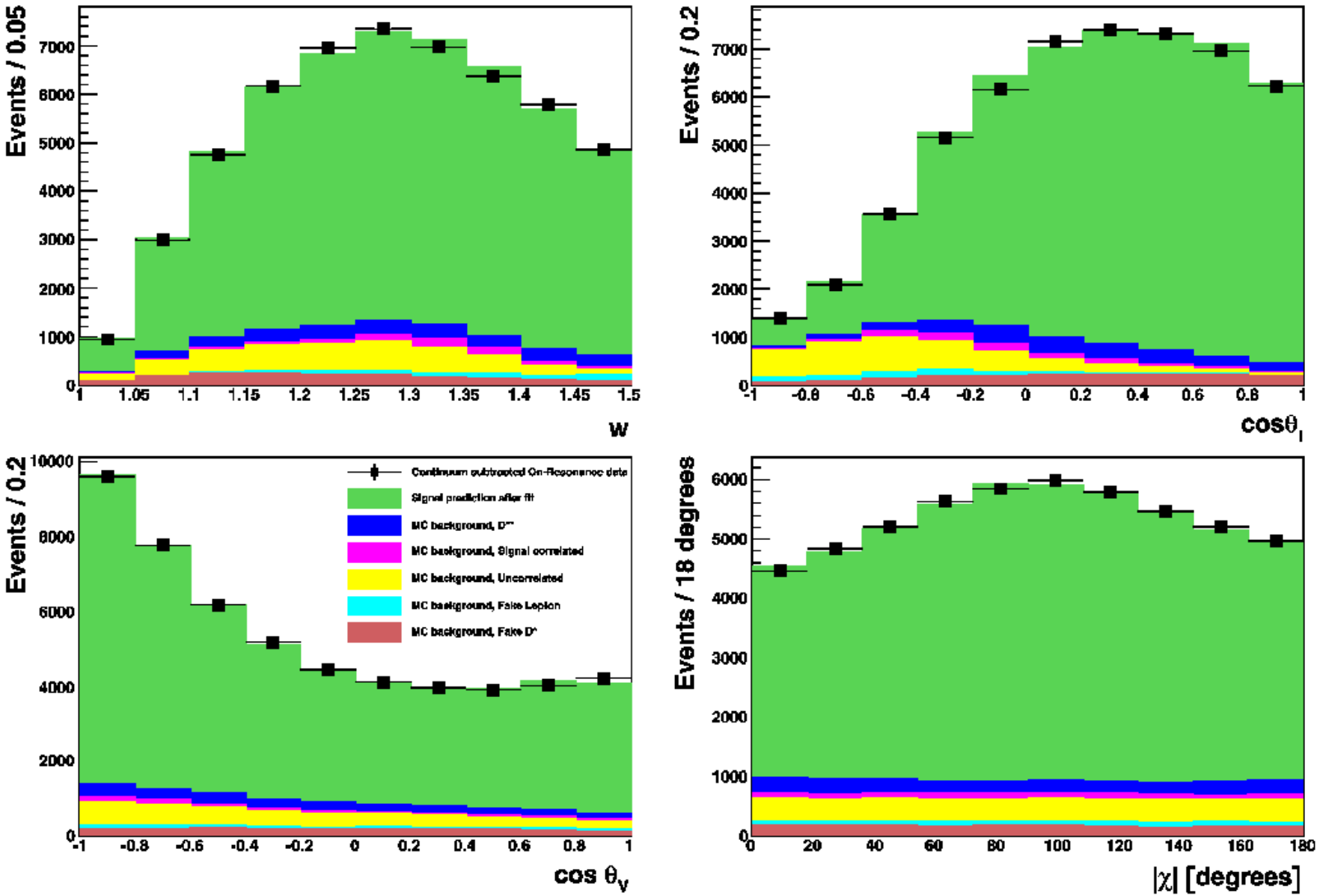
$$w \equiv v_B \cdot v_{D^{(*)}} = \frac{p_B \cdot p_{D^{(*)}}}{m_B \cdot m_{D^{(*)}}} : D^{(*)} \text{ boost}$$

- Fit angular distributions, $\cos\theta_\ell, \cos\theta_V, \chi$ $\Rightarrow$ Form Factors R_1, R_2, ρ^2
- simultaneously fit w distribution to get $\mathcal{F}(1)|V_{cb}|$ or $\mathcal{G}(1)|V_{cb}|$
- $|V_{cb}|$ is obtained with $\mathcal{F}(1)$, $\mathcal{G}(1)$ from FF calculation.



Exclusive B→ D*$\ell\nu$ 其ノ壱

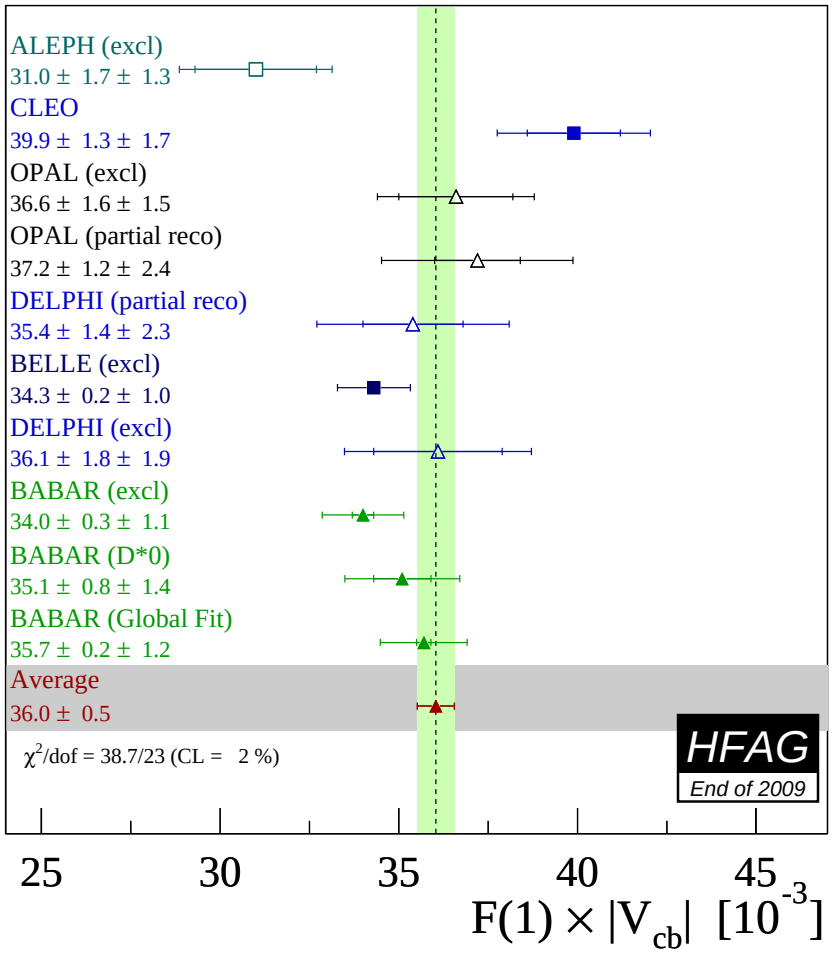
Belle 711fb^{-1} B→ D $*$ $\ell\nu$ Analysis

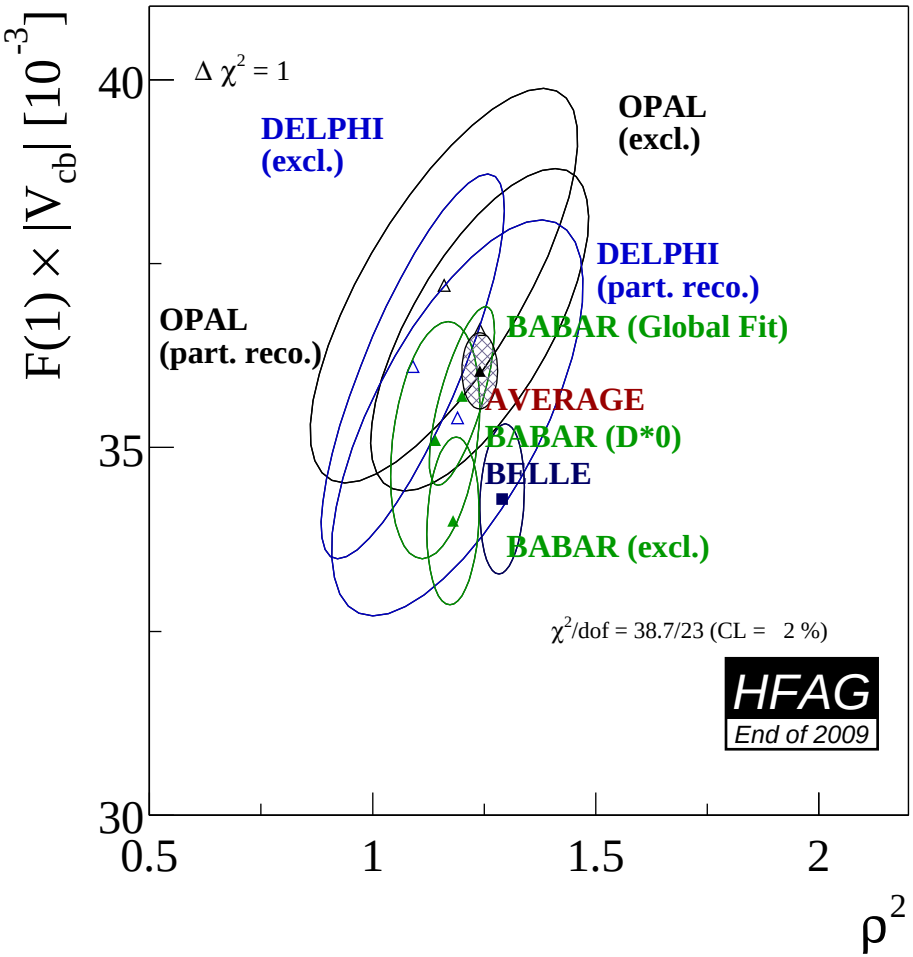


Exclusive B→ D*ℓν Results

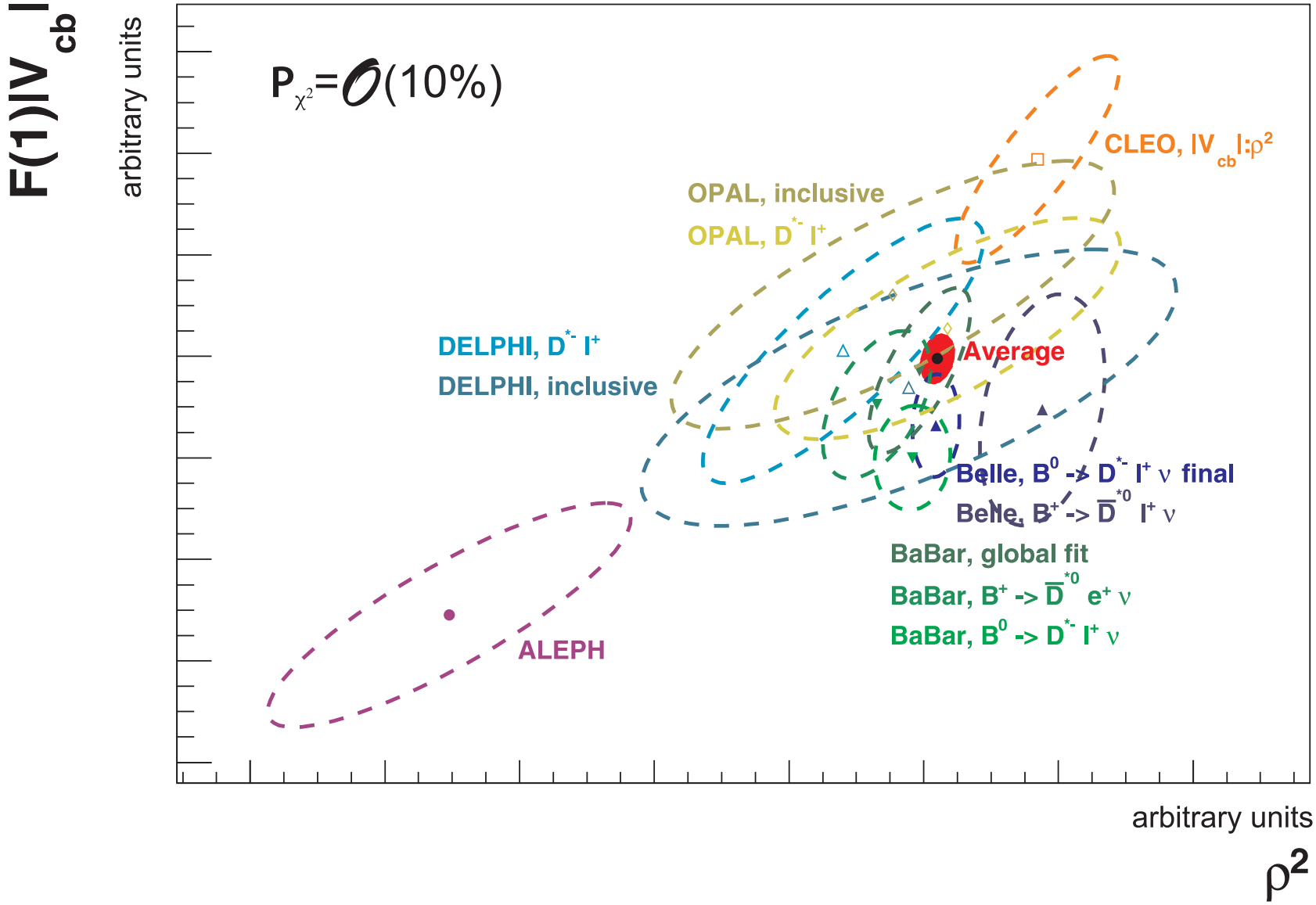
Belle Preliminary		
	$B^+ \to \bar{D}^{*0}\ell\nu$	$B^0 \to D^{*-}\ell\nu$
$\mathcal{B}(B \to D^*\ell\nu)$	$(4.84 \pm 0.04 \pm 0.56)\%$	$(4.56 \pm 0.03 \pm 0.26)\%$
$\mathcal{F}(1)\lvert V_{cb}\rvert \times 10^3$	$35.0 \pm 0.4 \pm 2.2$	$34.5 \pm 0.2 \pm 1.0$
BaBar		
	$B^+ \to \bar{D}^{*0}\ell\nu$	$B^0 \to D^{*-}\ell\nu$
$\mathcal{B}(B \to D^*\ell\nu)$	$(5.56 \pm 0.08 \pm 0.41)\%$	$(4.69 \pm 0.04 \pm 0.34)\%$
$\mathcal{F}(1)\lvert V_{cb}\rvert \times 10^3$	$35.9 \pm 0.6 \pm 1.4$	$34.4 \pm 0.3 \pm 1.1$
	PRL**100**,231803(2008)	PRD**77**,032002(2008)
	Global $B \to \bar{D}X\ell\nu$	
$\mathcal{B}(B \to D^*\ell\nu)$	$(5.40 \pm 0.02 \pm 0.21)\%$	
$\mathcal{F}(1)\lvert V_{cb}\rvert \times 10^3$	$35.9 \pm 0.2 \pm 1.2$	
	PRD**79**, 012002(2009)	

Exclusive B→ D*ℓν 其ノ参

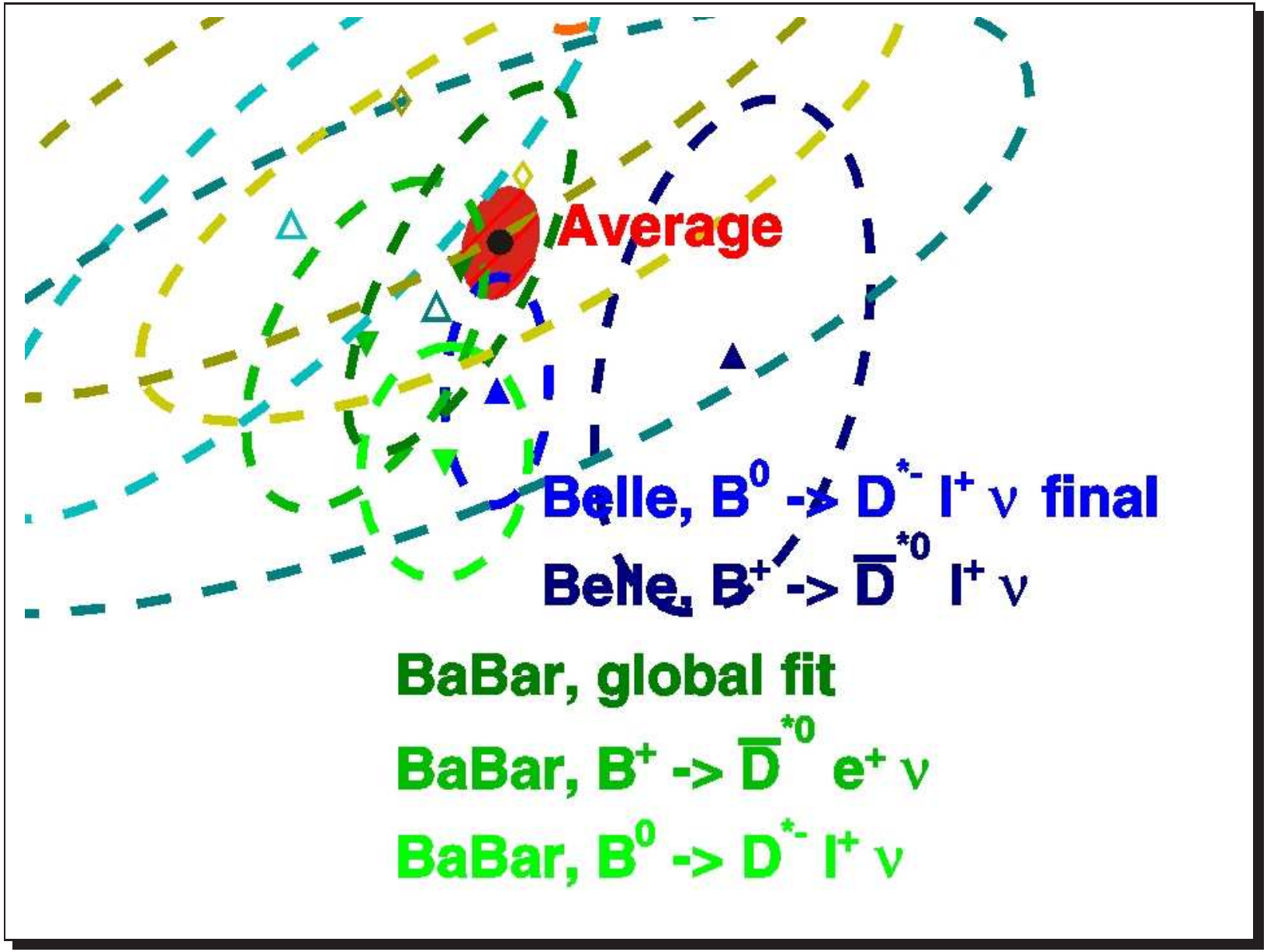




Exclusive B→ D*ℓν 其ノ四

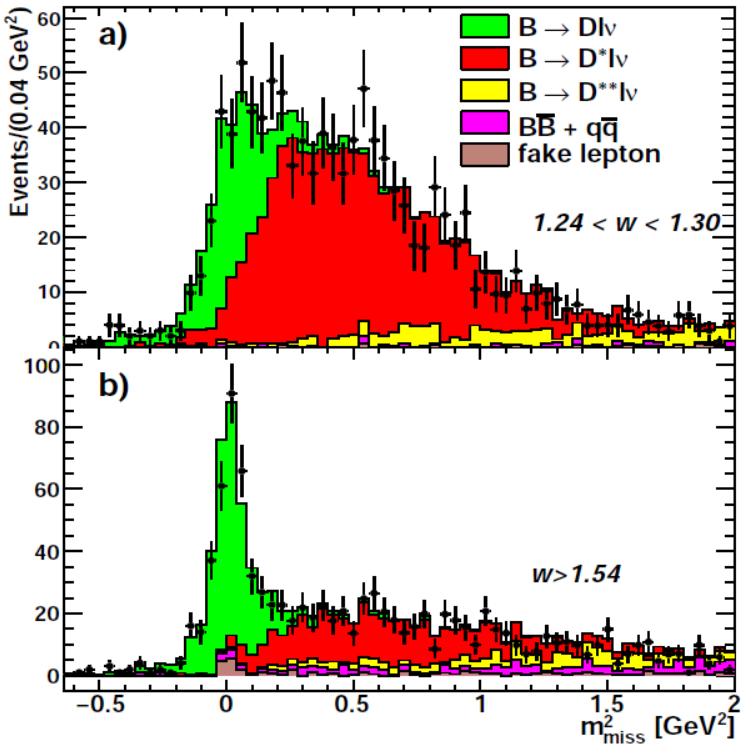


Exclusive B→ $D^{*}\ell\nu$ 其ノ伍

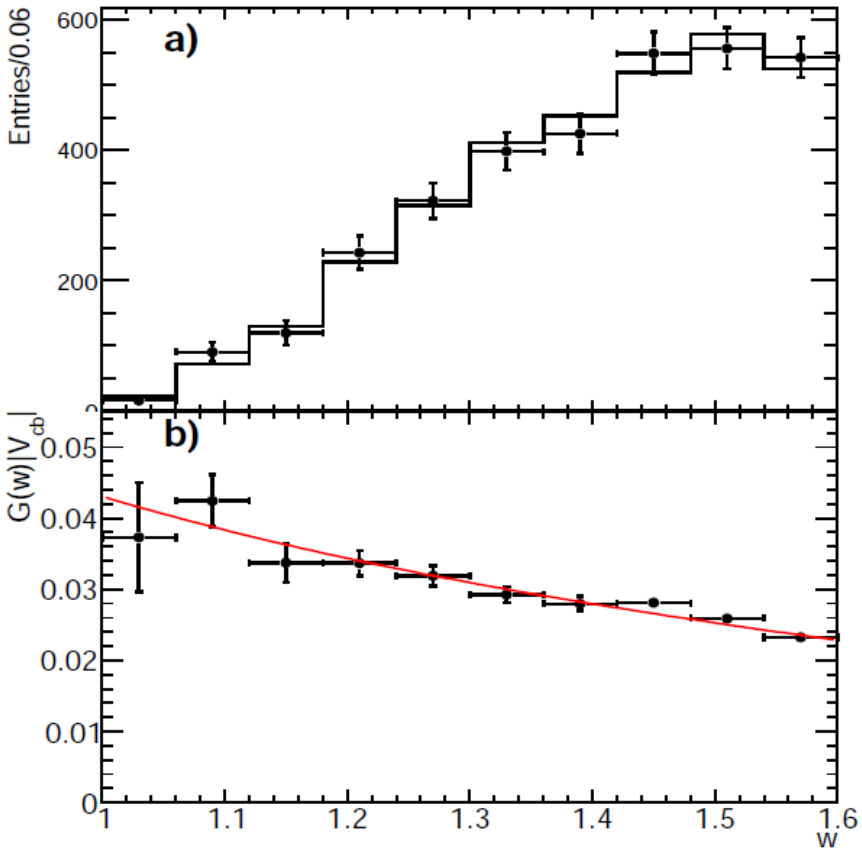


BaBar Exclusive B→ D$\ell\nu$ with Hadron Tag 其ノ壱

m_{miss} Distribution



w and $\mathcal{G}(w)|V_{cb}|$



- Hadron Tag
  - Better S/N
  - kinematic reconstruction
- Fit m_{miss} in 10 w bins

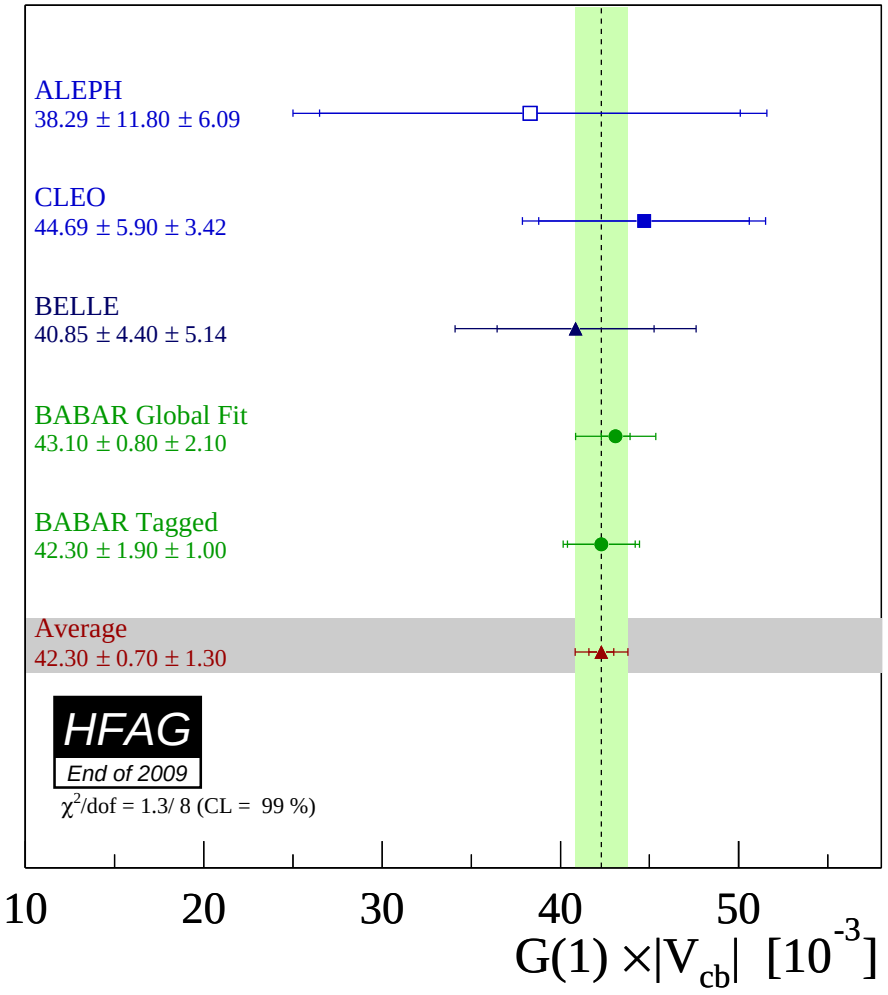
$$m_{\mathrm{miss}} = \left(p_{\Upsilon(4S)} - p_{\mathrm{B_{tag}}} - p_{\mathrm{D}} - p_{\ell}\right)^2$$

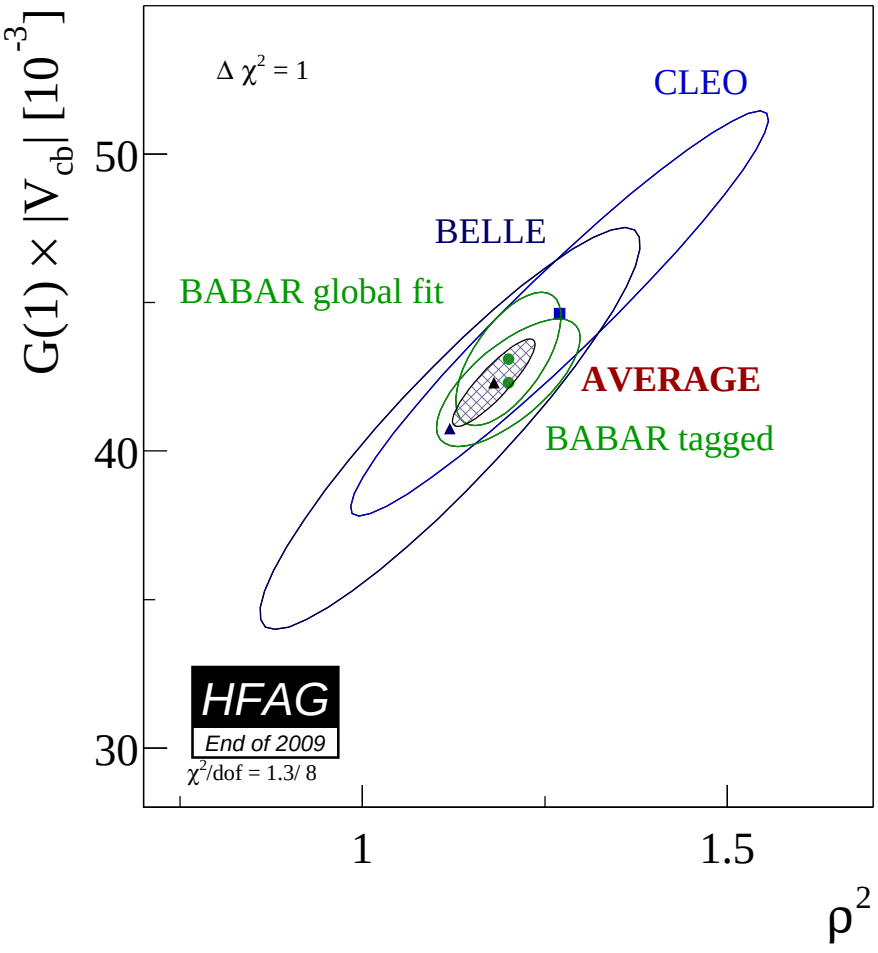
$$\mathcal{B}(\mathrm{B} \to \mathrm{D}\ell\nu) = (2.15 \pm 0.06 \pm 0.07)\%$$

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

PRL**104**,011802(2010)

BaBar Exclusive B→ D$\ell\nu$ with Hadron Tag 其ノ弐





纏め (Preliminary)

- Exclusive V_{ub} (Belle $B^0 \to \pi^- \ell^+ \nu$ untagged)

	q^2 (GeV^2)	$\Delta\zeta$ (ps^{-1})	$\lvert V_{ub}\rvert(10^{-3})$
HPQCD	> 16	2.07 ± 0.57	$3.55 \pm 0.09 \pm 0.09^{+0.62}_{-0.41}$
FNAL	> 16	1.83 ± 0.50	$3.78 \pm 0.10 \pm 0.10^{+0.65}_{-0.43}$
LCSR	< 16	5.4 ± 1.4	$3.64 \pm 0.06 \pm 0.09^{+0.60}_{-0.40}$

  - FF model independent

$$|V_{ub}| = (3.43 \pm 0.33) \times 10^{-3}$$

  - V_{ub} inclusive

$$|V_{ub}| = (4.37 \pm 0.39) \times 10^{-3}$$

- Exclusive V_{cb}

	$(\mathcal{F}(1), \mathcal{G}(1))\lvert V_{cb}\rvert \times 10^{-3}$	$\mathcal{F}(1), \mathcal{G}(1)$	$\lvert V_{cb}\rvert \times 10^{-3}$
$B \to D^* \ell \nu$	36.0 ± 0.5	0.91 ± 0.02	36.7 ± 0.8
$B \to D \ell \nu$	42.3 ± 1.5	1.07 ± 0.02	39.4 ± 1.6

  - V_{cb} inclusive

$$|V_{cb}| = (41.9 \pm 0.7) \times 10^{-3}$$