Experimental mini-review: inclusive $|V_{ub}|$

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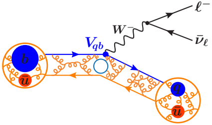
on behalf of the *BaBar* collabor



University of Victoria, British Columbia, Canada

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CKM 2012
Cincinnati
Ohio, USA

University of Victoria

Overview

I. Introduction

II. + III. Tagging and Simulation techniques.

IV. Inclusive Analyses from *BABAR* , *Belle*, and others.

V. Summary and some thoughts on current results.

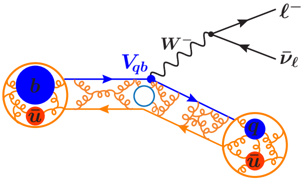
I.a Introduction

- Measurements of the partial branching fractions of charmless inclusive semileptonic decays offer a way to measure $|V_{ub}|$ (which is independent from exclusive or leptonic channels)
- Inclusive semileptonic $B \to X_u \, \ell \, \bar{\nu}_\ell$ decays characterized by

  $q^2 = (p_B - p_X)^2 = \left(p_\ell + p_{\bar{\nu}_\ell}\right)^2$: 4-momentum transfer

  m_X: hadronic mass

  $P_+ = E_X - |\vec{p}_X|$: light-cone momentum



- Abundant $B \to X_c \, \ell \, \bar{\nu}_\ell$ important Bkg.
- Inclusive decay rate $\mathrm{d}\Gamma_{\text{theory}} / \left(\mathrm{d}E_\ell \, \mathrm{d}m_X \, \mathrm{d}q^2\right)$ can be predicted by QCD:

Calculations: ADFR [EPJC:59;831], BLNP [NPB:699;335], DGE [JHEP:0601097], GGOU[JHEP:0710:058], BLL [PRD64:113004]

Differ significantly in their treatment of pert. corrections and the parameterization of non-pert. effects.

- Large $B \to X_c \, \ell \, \bar{\nu}_\ell$ and other Bkgs present $\leftrightarrow$ only partial branching fraction $\Delta\mathcal{B}$ can be measured

$$\to \quad |V_{ub}| = \sqrt{\frac{\Delta\mathcal{B}}{\tau_B \Delta\Gamma_{\text{theory}}}}$$

II.a Tag and Recoil

* Desirable to measure $\Delta\mathcal{B}$ in B-rest frame
* Useful to reconstruct hadronic X_u system

→ Full reconstruction of 2nd B meson

to separate hadronic $b \to u$ system from the rest of the event

* Candidates for recoil and tag side

(→ Illustration)

If properly assigned one can reconstruct ...

1. $p_X = \sum_i p_i^{\text{track}} + \sum_i p_i^{\text{clust.}} \; (\to m_X)$
2. $\vec{p}_{B^{\text{recoil}}} = -\vec{p}_{B^{\text{tag}}}$
3. $p_\nu = p_{B^{\text{recoil}}} - p_X - p_\ell \; (\to m^2_{\text{miss}})$
4. $q^2 = (p_{B^{\text{recoil}}} - p_X)^2 = (p_\ell + p_\nu)^2$

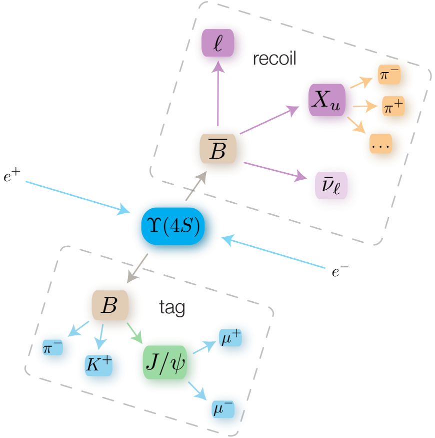
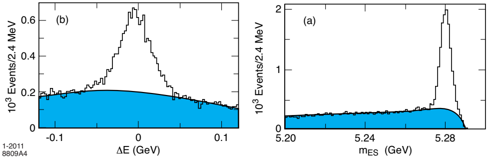


Illustration of tag & recoil side of $e^+e^- \to \Upsilon(4S) \to B\overline{B}$.

II.b m_{bc}/m_{ES} and ΔE

→ Beam constraint mass (m_{bc}/m_{ES}) and energy difference (ΔE) help to distinguish random assignments from true tag candidates.



$$\Delta E = E_B^* - E_{\text{beam}}^*/2 \qquad m_{ES}/m_{bc} = \sqrt{E_{\text{beam}}^{*2}/4 - \vec{p}_B^{*2}}$$

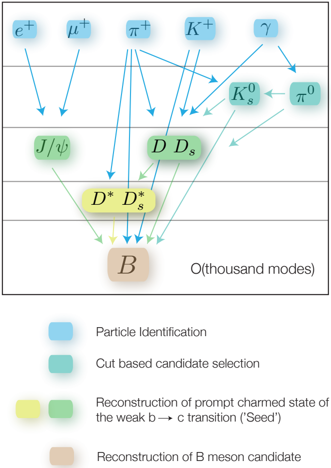
Formulae in CM frame: E_{beam}^* denotes the beam energy, and $(E_B^*, \vec{p}_B^*)$ the 4-momentum of the B meson.

→ # of true B mesons on tag side evaluated via binned or unbinned LH fits using these variables.

→ Slight difference between the B-Factories in what reference frame they are calculated: Lab (*BABAR*) vs CM (*Belle*)

II.c Tagging Algorithmes at the B-Factories

Cut Based approach



ϵ^{tag} (in %)	*BABAR* cut based	*Belle* cut based	*Belle* multivariate
B^+_{tag}	$0.40^\dagger$	0.14	**0.28**
B^0_{tag}	$0.21^\dagger$	0.10	**0.18**

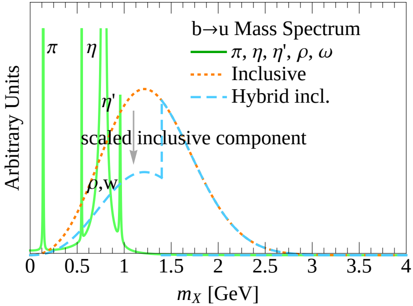
recently *Belle* showed multi-variate tagging *More about this later.*

† = contributions from all modes, including low purity ones.

III.a Simulation of $B \to X_u \, \ell \, \bar{\nu}_\ell$

→ Crucial to simulate $B \to X_u \, \ell \, \bar{\nu}_\ell$ as accurate as possible.

- * Need MC for efficiencies (e.g. $q^2 - E_\ell$ type analyses).
- * Need actual MC shape for fits (e.g. inclusive analyses).



Sketch of the mix of exclusive and inclusive $B \to X_u \, \ell \, \bar{\nu}_\ell$ in m_X to create 'Hybrid' signal Monte Carlo.

→ Simulation done in a four step procedure:

1. Simulate inclusive $b \to u \, \ell \, \bar{\nu}_\ell$; Hadronization via JETSET.
2. Reweigh in (m_X, q^2, E_ℓ) to match the inclusive $B \to X_u \, \ell \, \bar{\nu}_\ell$ QCD calculations (cf. slide 3)
3. Simulate exclusive $B \to h \, \ell \, \bar{\nu}_\ell$ for $h = \pi, \rho \, \omega, \eta, \eta'$;
4. Mix the two to create 'Hybrid MC'. In the resonant region ($m_X < 1.4$ GeV) the inclusive prediction is scaled down in (m_X, q^2, E_ℓ) so that $\mathcal{B}(B \to X_u \, \ell \, \bar{\nu}_\ell)$ is conserved.

IV.a Overview: $|V_{ub}|$ measurements

Measurement	Variable	Cut	Reference	Year
CLEO	E_ℓ	$2.1\ \text{GeV} < E_\ell < 2.6\ \text{GeV}$	[Phys.Rev.Lett.88:231803]	2002
Belle	(m_X, q^2)	$m_X < 1.7\ \text{GeV},\ q^2 > 8\ \text{GeV}^2$	[Phys.Rev.Lett.92:101801]	2004
Belle	E_ℓ	$1.9\ \text{GeV} < E_\ell < 2.6\text{GeV}$	[Phys.Lett.B621:28-40]	2005
BABAR	E_ℓ	$2.0\ \text{GeV} < E_\ell < 2.6\ \text{GeV}$	[Phys.Rev.D73:012006]	2006
BABAR	$(E_\ell, s_h^{\text{max}})$	$2.0\ \text{GeV} < E_\ell,\ s_h^{\text{max}} < 3.5\ \text{GeV}^2$	[Phys.Rev.Lett.95:111801]	2005
Belle	(m_X, q^2)	$E_\ell > 1.0\ \text{GeV}$	[Phys.Rev.Lett.104:021801]	2010
BABAR	(m_X, q^2)	$E_\ell > 1.0\ \text{GeV}$	[Phys.Rev.D86,032004]	2012
	E_ℓ	$E_\ell > 1.0\ \&\ E_\ell > 1.3$		
	m_X	$m_X < 1.55\ \text{GeV}\ \&\ m_X < 1.7\ \text{GeV}$		
	q^2	$m_X < 1.7\ \text{GeV}\ \&\ q^2 > 8\ \text{GeV}^2$		
	P_+	$P_+ < 0.66\ \text{GeV}$		

List of measurements considered by HFAG for $|V_{ub}|$ averages.

→ Clear trend to increase the acceptance and measure larger fractions of the accessible phase space

(E.g. first measurement covered ≈19%, the latest ≈89% of the available phase space)

→ Will only cover [Phys.Rev.Lett.104:021801] & [Phys.Rev.D86,032004]

IV.b Analyses side-by-side

Belle [Phys.Rev.Lett.104:021801]:

* 605 fb^{-1} analyzed using cut-based hadronic tag

tag side m_{bc} (calculated in CM frame)

* Multivariate recoil selection using a Boosted Decision Tree (BDT) Purity ∽ 22 %
* Measures $\Delta\mathcal{B}$

  i.e. normalize with # of tagged events
* $p_\ell^{B*} > 1.0$ GeV; analyzed via 2D fit in (m_X, q^2)

BaBar [Phys.Rev.D86,032004]:

* 426 fb^{-1} analyzed using cut-based hadronic tag

tag side m_{ES} (calculated in lab frame)

* Cut based recoil selection

  Purity ∽ 18 %
* Measures $\frac{\Delta\mathcal{B}}{\mathcal{B}(B\to X\,\ell\,\bar{\nu}_\ell)}$

  i.e. through normalization mode
* $p_\ell^{B*} > 1.0$ GeV; analyzed via 2D fit in (m_X, q^2)
* Further phase-space regions considered using 1D fits: p_ℓ, m_X, q^2, P_+

IV.c *Belle* [Phys.Rev.Lett.104:021801]

∗ BDT trained to separate $B \to X_u \ell \bar{\nu}_\ell$ from other $B\bar{B}$ Bkg decays.

Selection of highest discriminative variables:

Variable	Comment
$\left\|\sum_i Q_i\right\|$	Net charge correlated with track multiplicity
# of K	$b \to u + s\bar{s}$ popping vs $b \to c \to s$
m^2_{miss}	Peaks at zero for SL event, missing particles create a tail towards pos. values
$m^2_{\text{miss } D*}$	D^* momentum infered from slow pions in event.

∗ Cut on BDT classifier optimized with respect to total uncertainty (stat+sys+theo) and lower threshold of $p_\ell^{B*} > 1.0$ GeV imposed

Tag Fit to m_{bc} to subtract non-$B\bar{B}$ Bkg (comb. + continuum)

Recoil χ^2 fit in (m_X, q^2) which floats

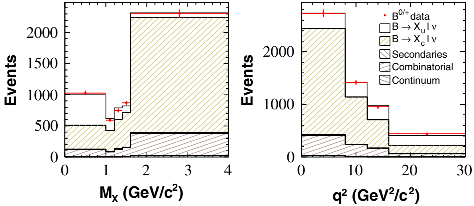
1. $B \to X_u \ell \bar{\nu}_\ell$
2. $B \to X_c \ell \bar{\nu}_\ell$
3. Secondary and Fake leptons

$\chi^2/ndf = 24/17$; P-Value = 12%

∗ $$\Delta\mathcal{B} = \frac{N^{\Delta}_{b\to u}}{2\epsilon^{\Delta}_{b\to u} N_{\text{tag}}}$$

$N^{\Delta}_{b\to u}$ #, $\epsilon^{\Delta}_{b\to u}$: signal yields + eff.

N_{tag}: number of tag B



Projections of m_X and q^2 after fit

IV.c *Belle* [Phys.Rev.Lett.104:021801]

* Leading systematic uncertainty are due to $B \to X_u \, \ell \, \bar{\nu}_\ell$ modeling and due to PID and the BDT:

Source	$\Delta B/B$ (%)
$B \to X_u \, \ell \, \bar{\nu}_\ell$ (SF)	3.6
$B \to X_u \, \ell \, \bar{\nu}_\ell$ ($g \to s\bar{s}$)	1.5
$B \to X_u \, \ell \, \bar{\nu}_\ell$ exclusive	4.0
$B \to X_u \, \ell \, \bar{\nu}_\ell$ other	2.9
All $B \to X_u \, \ell \, \bar{\nu}_\ell$	**5.8**
$B \to X_c \, \ell \, \bar{\nu}_\ell$	**1.7**
PID and reconstruction	**3.1**
BDT	**3.1**
Other	**2**
Total	**8.1**

* Determined values of $|V_{ub}|$ and the partial branching fraction:

$\Delta B(p_\ell^{B*} > 1.0\text{GeV})$ [10^{-3}]	BLNP $|V_{ub}|$ [10^{-3}]	GGOU $|V_{ub}|$ [10^{-3}]	DGE $|V_{ub}|$ [10^{-3}]
$\mathbf{1.96 \pm 0.17 \pm 0.16}$	$4.47 \pm 0.27^{+0.19}_{-0.21}$	$4.54 \pm 0.27^{+0.10}_{-0.11}$	$4.60 \pm 0.27^{+0.11}_{-0.13}$

IV.c BaBar [Phys.Rev.D86,032004]

* Cut based $B \to X_u \ell \bar{\nu}_\ell$ selection.

Selection of cuts and the corresponding efficiencies for signal and background

Variable	$B \to X_u \ell \bar{\nu}_\ell$	$B \to X_c \ell \bar{\nu}_\ell$	Other
Only one lepton	99.3%	98.1%	95.8%
Total charge $Q = 0$	65.5 %	52.9 %	49.1%
m^2_{miss}	44.2 %	17.8 %	17.8 %
$m^2_{\text{miss}\ D*}$ veto	34.8 %	6.3 %	9.1 %
Kaon veto	33.8 %	2.2 %	4.7 %

Tag unbinned LH fit to m_{ES} to subtract non-$B\bar{B}$ Bkg (comb. + continuum)

Many regions of phase-space considered:

Recoil

1) $m_X < 1.55$ GeV
2) $m_X < 1.70$ GeV
3) $P_+ < 0.66$ GeV
4) $m_X < 1.70$ GeV & $q^2 > 8$ GeV^2
5) $m_X - q^2$, $p_\ell^{B\,*} > 1.0$ GeV
6) $p_\ell^{B\,*} > 1.0$ GeV
7) $p_\ell^{B\,*} > 1.3$ GeV

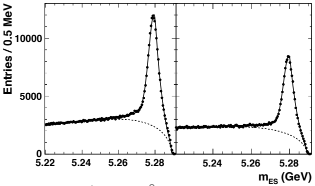
* χ^2 fit in ($\to$ List) which floats

1 $B \to X_u \ell \bar{\nu}_\ell$
2 Bkg (mainly $B \to X_c \ell \bar{\nu}_\ell$)

Fit quality for e.g.

5.) $\chi^2/ndf = 31.0/29$, P-Value= 37%

6.) $\chi^2/ndf = 21.6/14$, P-Value= 9%



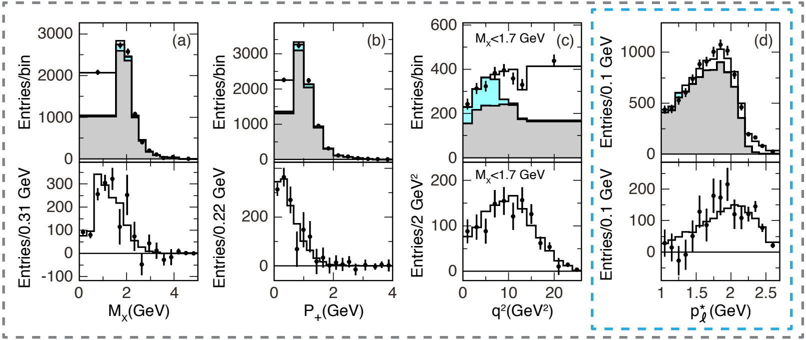
m_{ES} for B^+ and B^0 of normalization channel

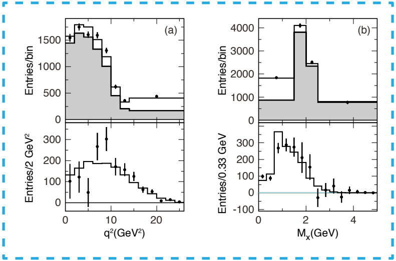
Normalization mode:

$$\Delta\mathcal{B}(B \to X_u \ell \bar{\nu}_\ell)/\mathcal{B}(B \to X \ell \bar{\nu}_\ell)$$

($\to$ many systematics cancel)

IV.c BABAR [Phys.Rev.D86,032004]





↑

a) $m_X < 1.55$ GeV or $m_X < 1.70$ GeV

b) $P_+ < 0.66$ GeV

c) $m_X < 1.70$ GeV & $q^2 > 8$ GeV^2

d) $p_\ell^{B\,*} > 1.0$ GeV or $p_\ell^{B\,*} > 1.3$ GeV

← a) & b) $m_X - q^2$, $p_\ell^{B\,*} > 1.0$ GeV

(White) $B \to X_u \ell \bar{\nu}_\ell$; (Cyan) $B \to X_u \ell \bar{\nu}_\ell$ contamination from outside signal region; (Grey) Bkg: $B \to X_c \ell \bar{\nu}_\ell$ & other

IV.c BaBar [Phys.Rev.D86,032004]

* Leading systematic uncertainty are due to $B \to X_u \ell \bar{\nu}_\ell$, PID and tracking:

Source	$\Delta B/B$ (%)	*Belle* $\Delta B/B$ (%)
$B \to X_u \ell \bar{\nu}_\ell$ (SF)	5.6	3.6
$B \to X_u \ell \bar{\nu}_\ell$ ($g \to s\bar{s}$)	2.7	1.5
$B \to X_u \ell \bar{\nu}_\ell$ exclusive	1.9	4.0
$B \to X_u \ell \bar{\nu}_\ell$ unmeasured	-	2.9
All $B \to X_u \ell \bar{\nu}_\ell$	**6.5**	**5.8**
$B \to X_c \ell \bar{\nu}_\ell$	**2.7**	**1.7**
PID and reconstruction	**3.4**	**3.1**
BDT	-	**3.1**
Other	**2.1**	**2**
Total	**8.4**	**8.1**

* Determined values of $|V_{ub}|$:

Measurement	BLNP $\|V_{ub}\|$ $[10^{-3}]$	GGOU $\|V_{ub}\|$ $[10^{-3}]$	DGE $\|V_{ub}\|$ $[10^{-3}]$
(m_X, q^2); $p_\ell^{B*} > 1.0$ GeV	$4.28 \pm 0.23^{+0.18}_{-0.20}$	$4.35 \pm 0.24^{+0.09}_{-0.10}$	$4.40 \pm 0.24^{+0.12}_{-0.13}$
$p_\ell^{B*} > 1.0$ GeV	$4.30 \pm 0.28^{+0.18}_{-0.20}$	$4.36 \pm 0.30^{+0.09}_{-0.10}$	$4.42 \pm 0.30^{+0.13}_{-0.13}$
Belle [Phys.Rev.Lett.104:021801]	$4.47 \pm 0.27^{+0.19}_{-0.21}$	$4.54 \pm 0.27^{+0.10}_{-0.11}$	$4.60 \pm 0.27^{+0.11}_{-0.13}$

$\to$ Good agreement with *Belle* [Phys.Rev.Lett.104:021801]:

IV.x Summary of inclusive $|V_{ub}|$

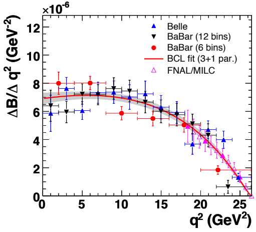
* Tagged and untagged world averages:

Measurement	BLNP $|V_{ub}|$ $[10^{-3}]$	GGOU $|V_{ub}|$ $[10^{-3}]$	DGE $|V_{ub}|$ $[10^{-3}]$
BABAR [Phys.Rev.D86,032004]	$4.28 \pm 0.23^{+0.18}_{-0.20}$	$4.35 \pm 0.24^{+0.09}_{-0.10}$	$4.40 \pm 0.24^{+0.12}_{-0.13}$
Belle [Phys.Rev.Lett.104:021801]	$4.47 \pm 0.27^{+0.19}_{-0.21}$	$4.54 \pm 0.27^{+0.10}_{-0.11}$	$4.60 \pm 0.27^{+0.11}_{-0.13}$
Average Tagged [PBF]	$4.35 \pm 0.19^{+0.19}_{-0.20}$	$4.43 \pm 0.21^{+0.09}_{-0.11}$	$4.49 \pm 0.21^{+0.13}_{-0.13}$
Average Untagged [PBF]	$4.65 \pm 0.22^{+0.26}_{-0.29}$	$4.39 \pm 0.22^{+0.18}_{-0.24}$	$4.44 \pm 0.21^{+0.21}_{-0.25}$
Average All [PBF]	$\mathbf{4.40 \pm 0.15^{+0.19}_{-0.21}}$	$\mathbf{4.39 \pm 0.15^{+0.12}_{-0.14}}$	$\mathbf{4.45 \pm 0.15^{+0.15}_{-0.16}}$

[Phys.Rev.D86,032004] is the (m_X, q^2); $p_\ell^{B\,*} > 1.0$ GeV result; average untagged calculated from untagged results on slide 9. All averages are from the Physics of the B-Factory Book.

→ Good agreement between different QCD calculations.

* But poor agreement with exclusive measurements from $B \to \pi\, \ell\, \bar{\nu}_\ell$



Fit result to the FNAL/MILC points, and untagged BaBar and Belle measurements:

[Phys.Rev.D.79.054507],[Phys.Rev.D.83.032007],

[Phys.Rev.D83.052011],[Phys.Rev.D.83.071101]

$|V_{ub}|$ $[10^{-3}]$	$\mathbf{3.23 \pm 0.30}$

→ tension of about 2.2 - 2.9 σ

(BLNP average, with and w/o 100% corr. of sys.)

Hint for new physics?

or

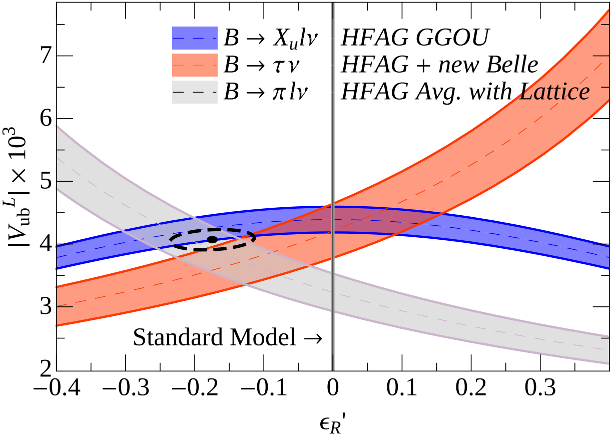
Are we underestimating our uncertainties?

Three thoughts and what's next :

New physics, $b \to c$, the shape function, and multivariate B tagging

Thought #1: Is there new physics hiding in $|V_{ub}|$?

New physics observable via right-handed currents? $|V_{ub}| = |V_{ub}^L| \, f(\epsilon'_R = \epsilon_R \Re \frac{V_{ub}^R}{V_{ub}^L})$



$f(\epsilon'_R)$:

$B \to \pi \ell \bar{\nu}_\ell$: $1 + \epsilon'_R$

$B \to \tau \bar{\nu}_\tau$: $1 - \epsilon'_R$

$B \to X_u \ell \bar{\nu}_\ell$: $1 + \epsilon'^2_R$

Proposed by

[hep-ph/0505166]

[arXiv:0907.2461]

[arXiv:1007.1993]

Private Fit

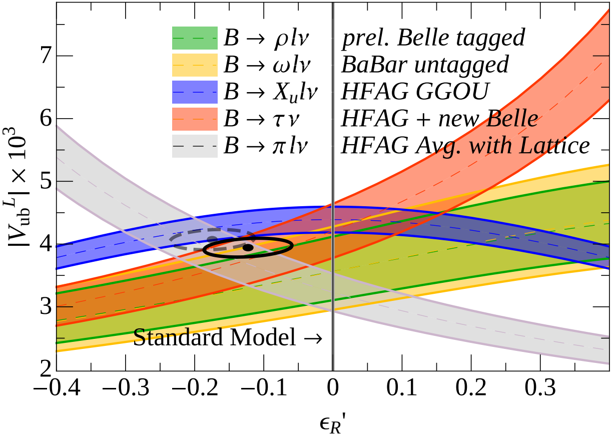
Dashed: All

Input: see Backup

Fit Scenario	$\lvert V_{ub}^L \rvert$	ϵ'_R	Tension wrt SM	χ^2/ndf	P-Value
$B \to \pi, X_u, \tau$ (dashed)	4.07 ± 0.16	-0.17 ± 0.06	**2.8σ**	2.8/1	0.09

Thought #1: Is there new physics hiding in $|V_{ub}|$?

New physics observable via right-handed currents? $|V_{ub}| = |V_{ub}^L| \, f(\epsilon'_R = \epsilon_R \Re \frac{V_{ub}^R}{V_{ub}^L})$



$f(\epsilon'_R)$:
$B \to \pi \, \ell \, \bar{\nu}_\ell$: $1 + \epsilon'_R$
$B \to \tau \bar{\nu}_\tau$: $1 - \epsilon'_R$
$B \to X_u \, \ell \, \bar{\nu}_\ell$: $1 + \epsilon'^2_R$

Proposed by
[hep-ph/0505166]
[arXiv:0907.2461]
[arXiv:1007.1993]

Private Fit
Solid: All
Dashed: w/o ρ & ω
Input: see Backup

Fit Scenario	$\lvert V_{ub}^L \rvert$	ϵ'_R	Tension wrt SM	χ^2/ndf	P-Value
$B \to \pi, X_u, \tau$ (dashed)	4.07 ± 0.16	-0.17 ± 0.06	**2.8σ**	2.8/1	0.09
$B \to \pi, X_u, \tau + \omega, \rho$ (solid)	3.94 ± 0.15	-0.12 ± 0.06	**1.9σ**	9.0/3	0.03

Thought #2: The problem with $B \to X_c \, \ell \, \bar{\nu}_\ell$...

* Inclusive vs exclusive 'Gap':

  $\mathcal{B}(B \to X_c \, \ell \, \bar{\nu}_\ell) - \mathcal{B}(B \to D^{(*)} \, \ell \, \bar{\nu}_\ell) - \mathcal{B}(B \to D^{(*)} \, \pi \, \ell \, \bar{\nu}_\ell) = (1.61 \pm 0.25)\,\%$ [private+HFAG11]

  Often 'gap' is filled with NR and $B \to D^{**} \, \ell \, \bar{\nu}_\ell$; [Phys.Rev.D86,032004] applies a further correction of:

$$\lambda_{D^{**}} = \frac{\mathcal{B}(B \to D^{**} \, \ell \, \bar{\nu}_\ell) + \mathcal{B}^{NR}(B \to D^{(*)} \, \ell \, \bar{\nu}_\ell)}{\mathcal{B}(B \to D^{(*)} \, \ell \, \bar{\nu}_\ell) + \mathcal{B}(B \to \text{other})} = 0.73 \pm 0.08$$

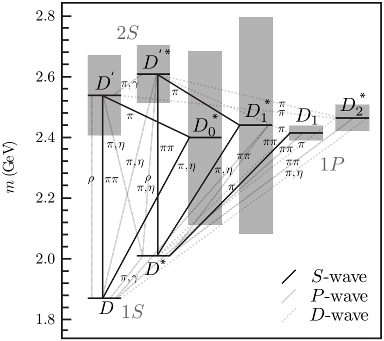
→ Not the culprit for $|V_{ub}|$ tension, but could contribute to the difference:

need an ad-hoc increase of this systematic by a factor of 5 eases the tension to $\approx 2\sigma$

But need to study this 'gap' for further progress in $|V_{ub}|$

* Which are the missing D^{**} modes?
  * 3-body D^{**} (Observed for $D_1 \to D\pi\pi$ by *Belle*)
  * radial excit. [Phys.Rev.D.85.094033]?

⇒ Sascha Turczyk's talk on Sunday.



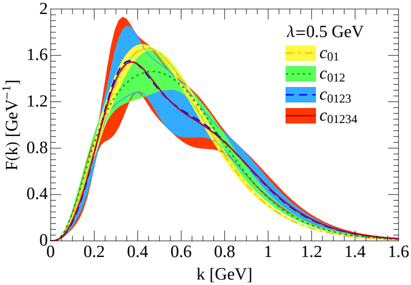
Selection of strong fragmentations of excited charm

Thought #3: The shape function

* So far the shape-function forces us to measure the partial branching fraction $\Delta\mathcal{B}$ where experimental uncertainties are large.

→ Most discriminating regions with low systematic uncertainties are not being used.

* Complementary to the increase in acceptance, we should make sure to push for having a global fit that combines all available information to determine $|V_{ub}|$

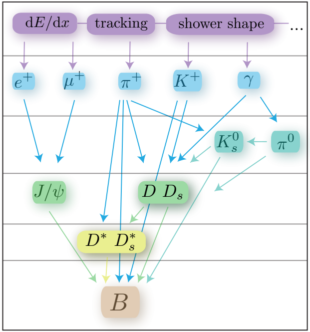


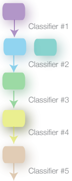
The shape function with absorbed Λ_{QCD}/m_b corrections from fits to selected $B \to X_s\gamma$ spectra is shown.

→ Talk on Sunday about SIMBA and the status of global fits for $|V_{ub}|$

What's next? Multivariate Tagging (with NeuroBayes)

Multivariate approach





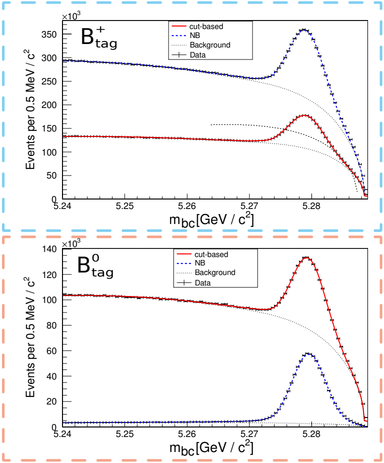
} Reconstruction of stable and unstable particles

} Reconstruction of prompt charmed state of the weak b → c transition ('Seed')

Reconstruction of B meson candidate

Same Purity

Same Efficiency



⇒ Impressive performance demonstrated by *Belle* at the summer conferences.

[Nucl.Instrum.Meth. A654, 432-440 (2011), arXiv:1102.3876.]

V. Summary and Conclusions

* Presented a review of the two latest inclusive $|V_{ub}|$ measurements.
* Persisting gap between inclusive and exclusive $|V_{ub}|$ remains an issue.
* Are right-handed currents playing a role?
* Are we underestimating some uncertainties? The treatment of $B \to X_c \, \ell \, \bar{\nu}_\ell$ is not satisfying, granted. Could it cause trouble?
* New multivariate tagging looks like a very promising tool for tagged inclusive analyses. We are looking forward to see new results from *Belle*.

Backup

a. Input for ϵ'_R and $\left|V^L_{ub}\right|$ fit

* $B \to \tau \bar{\nu}_\tau$: Private HFAG + Belle average from Phillip Urquijo ICHEP12 talk

  $V_{ub} = (4.21 \pm 0.43) \times 10^{-3}$

* $B \to X_u \ell \bar{\nu}_\ell$: HFAG End of 2011 GGOU result

  $V_{ub} = (4.39 \pm 0.21) \times 10^{-3}$

* $B \to \pi \ell \bar{\nu}_\ell$: HFAG End of 2011 combined Lattice+Data result

  $V_{ub} = (3.23 \pm 0.30) \times 10^{-3}$

* $B \to \omega \ell \bar{\nu}_\ell$: untagged BaBar result shown at ICHEP12

  $\mathcal{B}(\text{full } q^2 \text{ range}) = (1.15 \pm 0.19) \times 10^{-4}$

* $B \to \rho \ell \bar{\nu}_\ell$: uncertainty weighted average of ρ^0 and ρ^+ *Belle* results shown at ICHEP12

  $\mathcal{B}(\text{full } q^2 \text{ range}) = (3.3 \pm 0.3) \times 10^{-4}$