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Measurement of $|V_{cb}|$ and $|V_{ub}|$: Relevance for NP

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On Behalf of the SuperB Collaboration

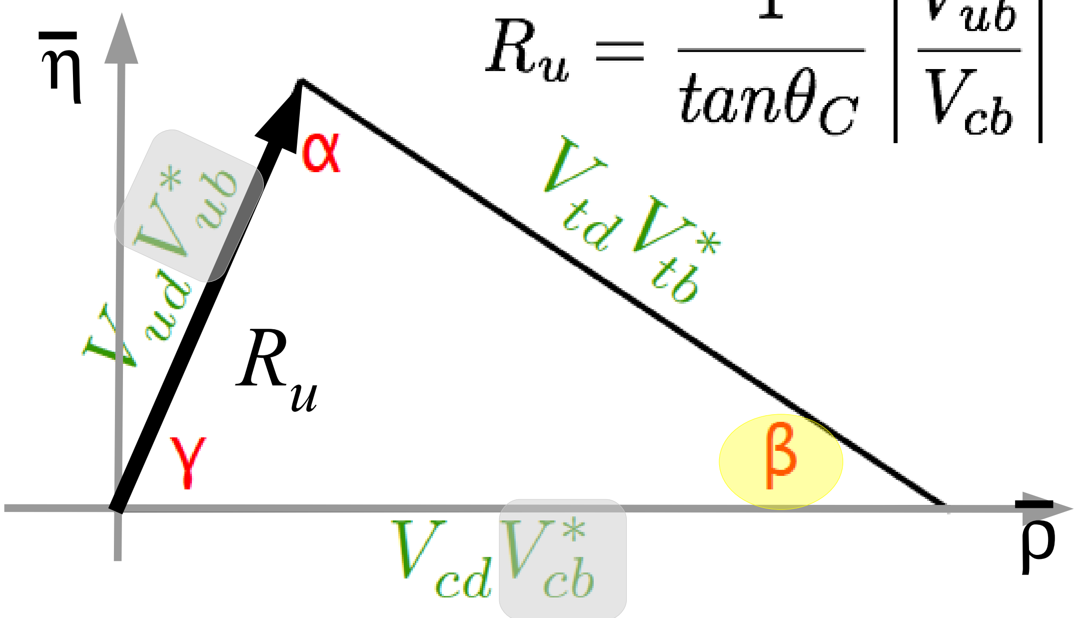
Outline

- *Introduction*
- $|V_{cb}|$
  - *Inclusive & Exclusive*
  - *Open Issues*
- $|V_{ub}|$
  - *Inclusive & Exclusive*
  - *Tensions*
  - *NP Solution?*
- *Summary*

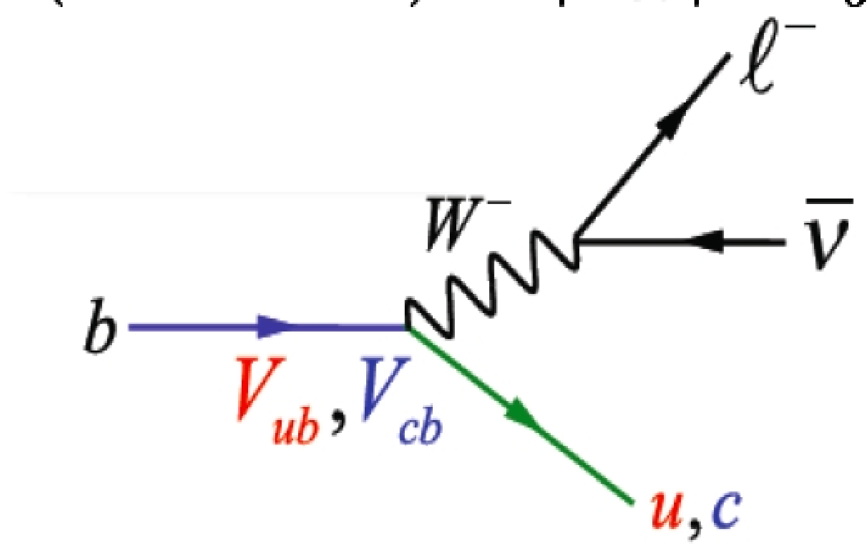
$|V_{cb}|$, $|V_{ub}|$ and the UT

- *New Physics search in the flavor sector require* ***precise*** *&* ***redundant*** *measurements of sides and angles of the Unitarity Triangle*
- *$|V_{cb}|$ and $|V_{ub}|$ special role in the UT:*
  - *Accessible from Tree Level process,*
    - *Free of NP*
  - *Fix two sides of the UT*

$$R_u = \frac{1}{tan\theta_C}\left|\frac{V_{ub}}{V_{cb}}\right|$$



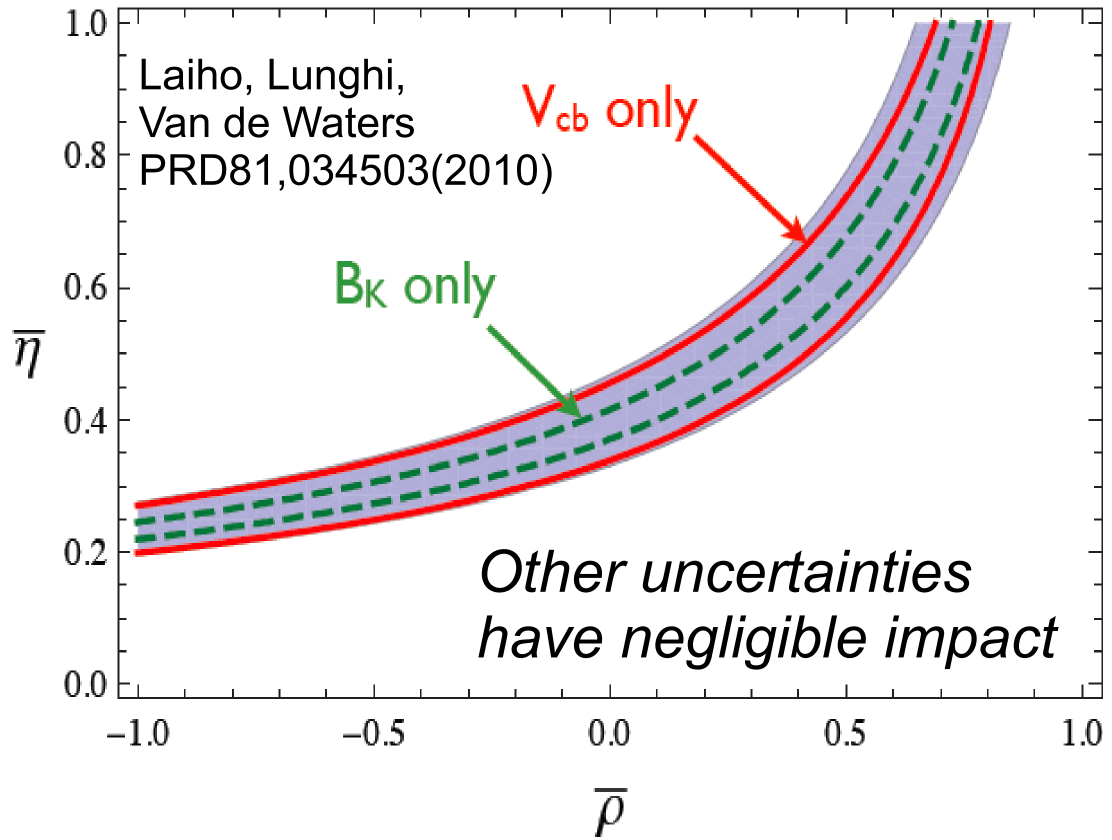
$$\Gamma(b \to c\,\ell\,\nu) \propto |V_{cb}| \cdot m_b^5$$



- *R_u is te side opposite to β*
  - *Direct interplay with $\sin(2\beta)$*

$|V_{cb}|$, $|V_{ub}|$ and New Physics

- *Indirect constraints to NP*
- *Some UT constraints strongly affected by $|V_{cb}|$ and $|V_{ub}|$:*
  - $\mathcal{B}(B \to \tau\nu) \propto f_B^2 \cdot |V_{ub}|^2$
  - ε_K *affected by $|V_{cb}|$*
  - $\mathcal{B}(K^+ \to \pi^+ \nu\bar{\nu}) \propto |V_{cb}|^4$
  - $\mathcal{B}(K_L \to \pi^0 \nu\bar{\nu}) \propto |V_{cb}|^4$



- *Direct search for NP ?*
  - *LR theoretical models could affect the $b \to u\, \ell\, \nu$ transitions*
  - *Double Charged Higgs can affect the Cabibbo Favored decays $B \to D^{(*)}\ \tau\, \nu$*

Semileptonic B decays: $|V_{cb}|$

- *Large BF, only one hadronic current:*

$$d\Gamma = \boxed{\Gamma_0 \cdot \mathcal{F}(q^2, M_x, p_\ell)} \cdot \left(1 + \sum_n \boxed{C_n \left(\frac{\Lambda_{QCD}}{m_b}\right)^n}\right)$$

Free quark decay $\propto |V_{cb}|$

Perturbative + non perturbative corrections

Complementary Measurements

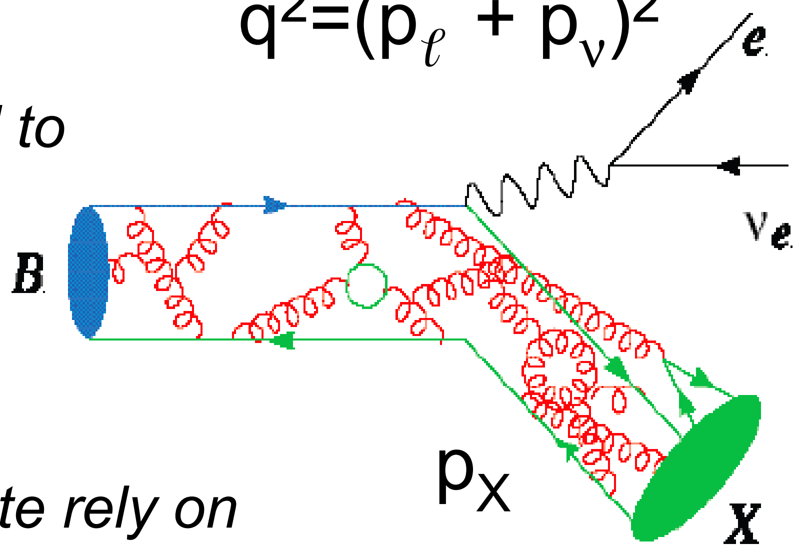
Exclusive decays ***$B \to D/D^* \ell \nu$*** *:*

- *QCD predictions of Form Factor required to parameterize hadronic effects*
- *Lattice QCD, LCSR...*

Inclusive decays ***$B \to X_c \ell \nu$*** *:*

- *QCD corrections to parton level decay rate rely on Heavy Quark Symmetry + OPE*
- *Need perturbative and non-perturbative OPE corrections from data:*
  - *Global fit of M_X and p_ℓ moments*

$q^2 = (p_\ell + p_\nu)^2$

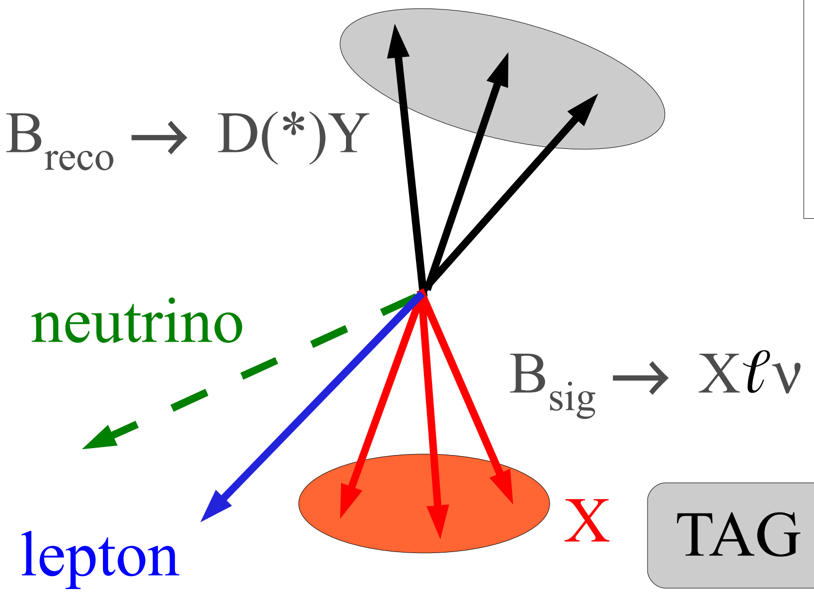


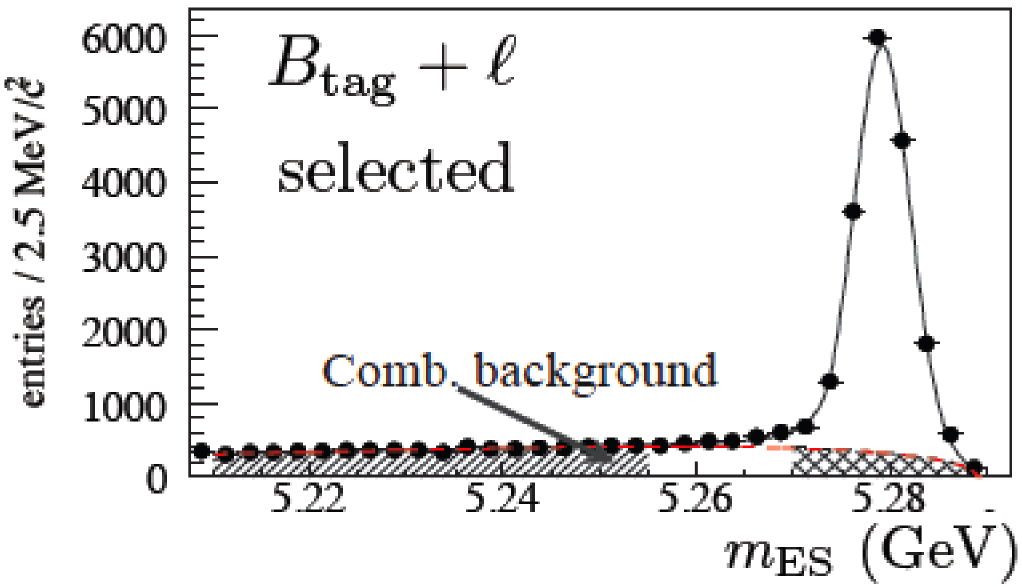
$M_X = p_X^2$

$|V_{cb}|$ From Inclusive $B \to X_c \ell\nu$

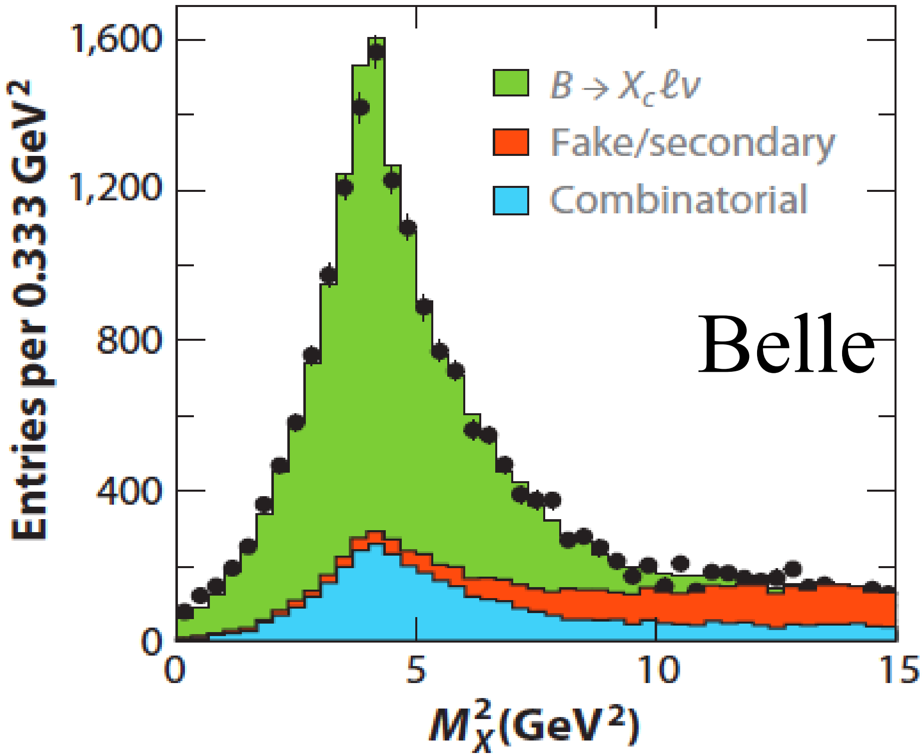
▶ *Use hadronic tag* $\boldsymbol{B_{tag} \to D^{(*)}Y}$ *($Y=n\pi, m\pi^0, pK_s, qK$), to reduce combinatorial and reconstruct M_X, with good resolution*

- *Small efficiency*	*Access Signal B information:*
- *0.3% B^0B^0*	- *Charge*
- *0.5% B^+B^-*	- *Flavor*
	- *4-momentum*



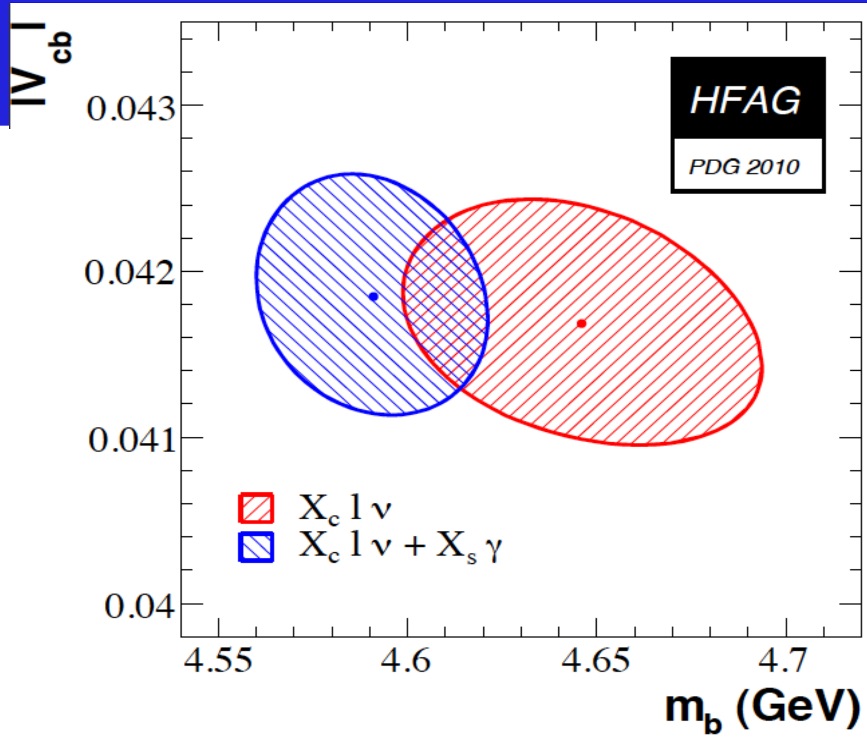


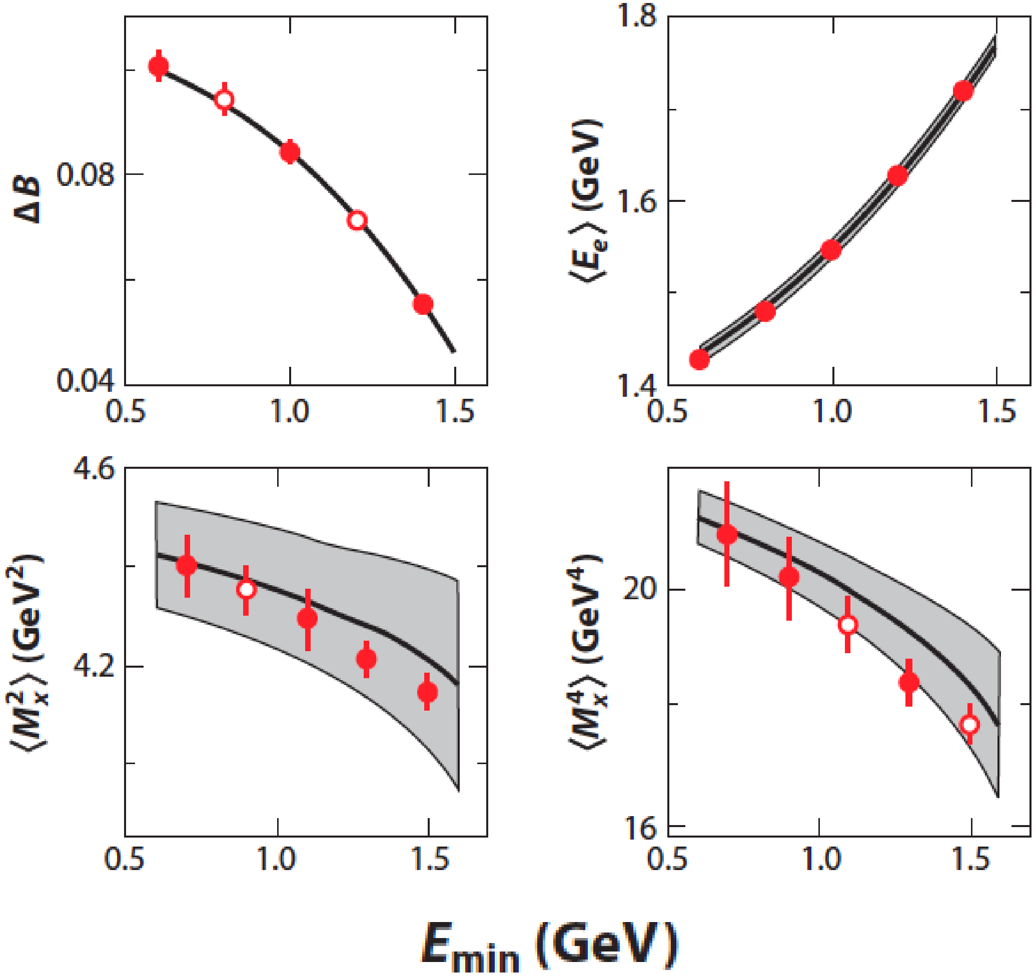
SIGNAL SIDE



|Vcb| Global Fit Results

- *Input from BaBar, Belle, CLEO, Delphi, CDF:*
  - *From SL decays and radiative b->sγ: moments of the gamma spectra*





$$|V_{cb}|_{\text{incl}} = (41.85 \pm 0.42_{\text{fit}} \pm 0.59_{\text{theor}}) \times 10^{-3}$$
$$m_b^{\text{kin}}(1\,\text{GeV}) = (4.591 \pm 0.031_{\text{fit}})\,\text{GeV}$$
$$m_c^{\text{kin}}(1\,\text{GeV}) = (1.152 \pm 0.046_{\text{fit}})\,\text{GeV}$$
$$\mu_\pi^{2\text{kin}}(1\,\text{GeV}) = (0.545 \pm 0.038_{\text{fit}})\,\text{GeV}^2$$

1.7% on $|V_{cb}|$ & 0.7% on m_b^{kin}

HQE parameters are crucial inputs for Inclusive $|V_{ub}|$ extraction

B $D(*)\ell\nu$ & $|V_{cb}|$

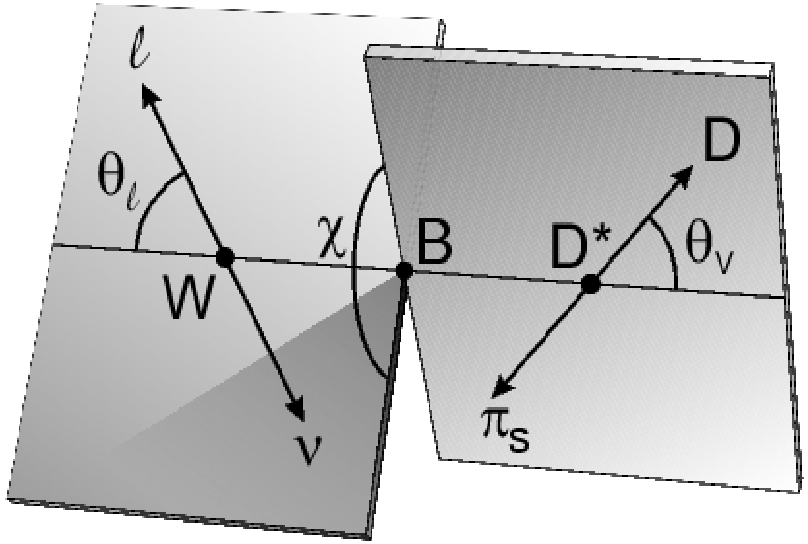
$$w = \frac{M_B^2 + M_{D*}^2 - q^2}{2M_B M_{D*}}$$

- For the $B \to D\ell\nu$

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

  - Fit also the slope of the FF, together with a global normalization

- Exclusive $B \to D^*\ell\nu$
  - Non trivial form factors
  - Need a fit on angular distribution



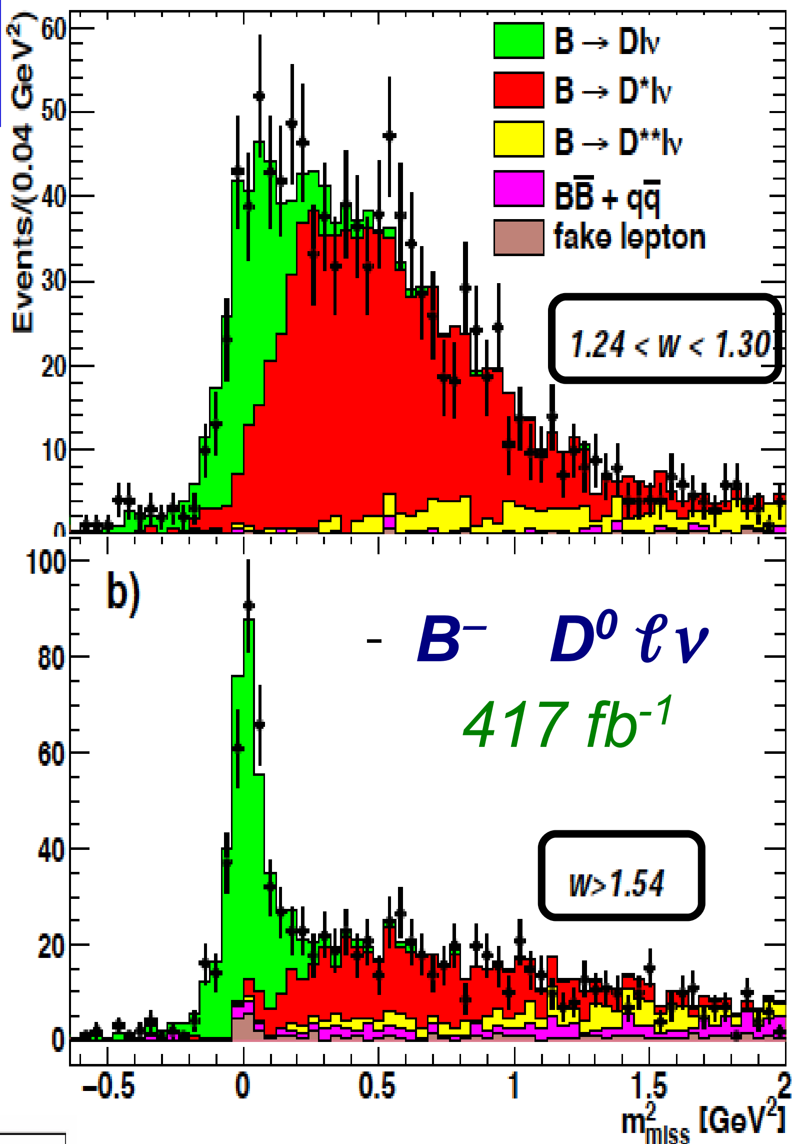
- Extrapolate to w=1 and extract:
  - $G(1)|V_{cb}|$ (together with slope ρ^2 of the
  - $F(1)|V_{cb}|$ (together with ρ^2, R_1 and R_2)
- G(1) and F(1) from theory: LQCD

$$\eta_{\rm QED}\,\mathcal{G}(w=1) = 1.007 \times (1.074 \pm 0.018 \pm 0.016)$$

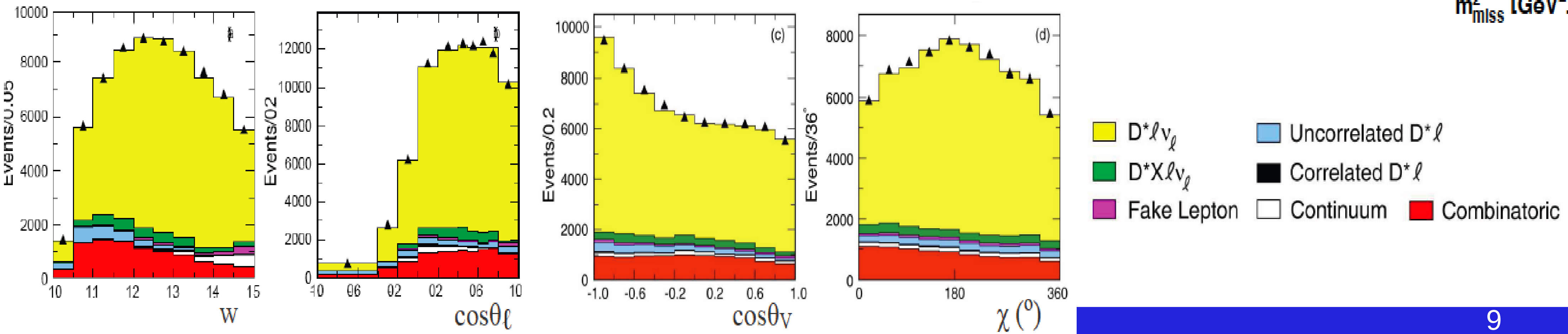
$$\eta_{\rm QED}\,\mathcal{F}(w=1) = 1.007 \times (0.908 \pm 0.005 \pm 0.016)$$

$|V_{cb}|$ analyses

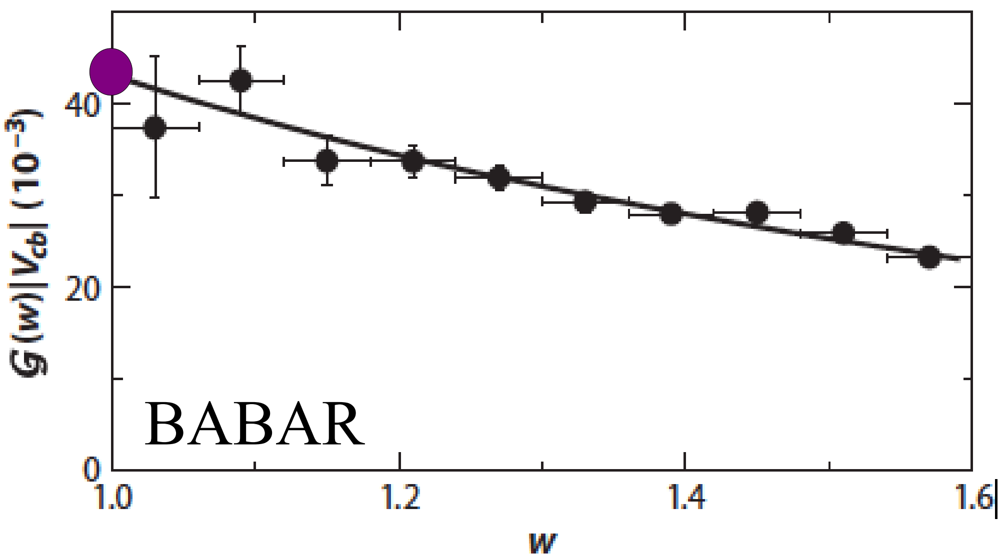
- *$B \to D\ell\nu$*
- *Reconstruct $B \quad D\ell\nu$ on the recoil of a B_{reco} sample*
  - *Reduced background (↑S/N)*
  - *Fully exploit kinematic constraints (↑resolution)*
  - *Avoid neutrino reconstruction*

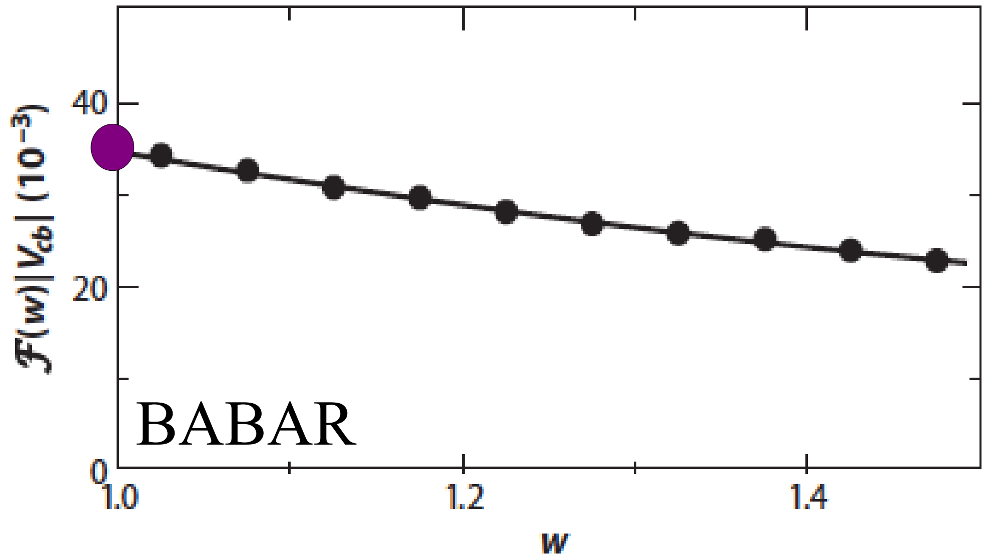


- *$B \to D^*\ell\nu$*
- *Untagged: signal is very clean*
  - *Require a multidimentional fit*
  - *The D** and the soft pion are important issues*



$B \to D \ell^+ \nu$ $B \to D^* \ell^+ \nu$

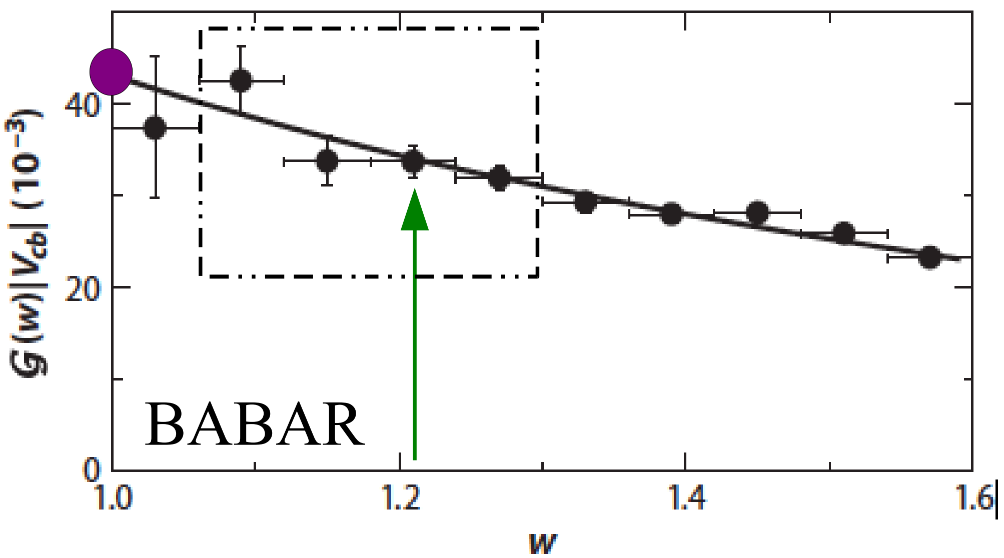


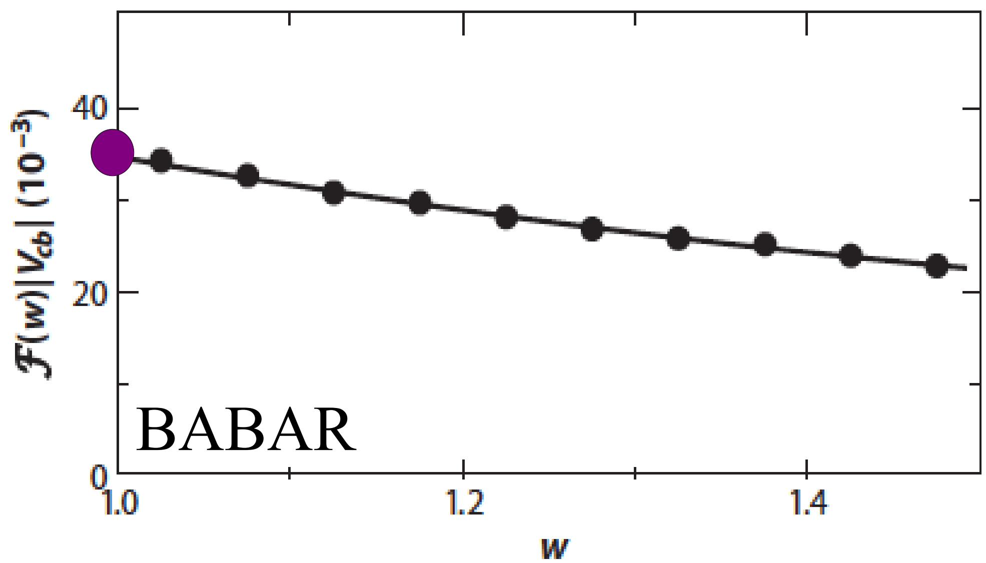


- *World Average: HFAG2010, BaBar and Belle are in perfect agreement and dominate the average!*

	$\lvert V_{cb}\rvert \times 10^3$	ρ^2
D	39.1 ± 1.3 ± 0.9	1.20 ± 0.06
D*	38.64 ± 0.64 ± 0.71	1.21 ± 0.05

B $D\ell^+\nu$ **B** $D^*\ell^+\nu$





- *World Average: HFAG2010, BaBar and Belle are in perfect agreement and dominate the average!*

	$\vert V_{cb}\vert x10^3$					ρ^2
D	*39.1*	±	*1.3*	±	*0.9*	*1.20* ± *0.06*
D*	*38.64*	±	*0.64*	±	*0.71*	*1.21* ± *0.05*

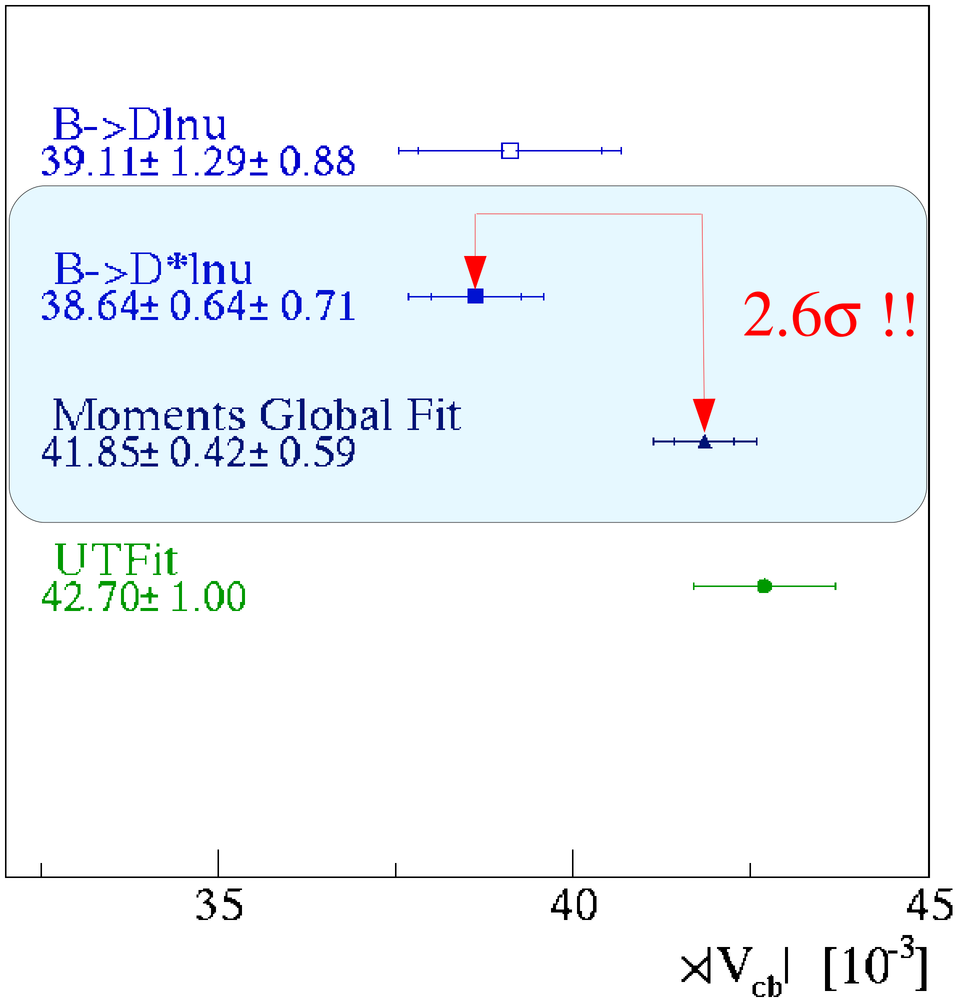
Smaller total error are possibile extrapolating to w' > 1

Quenched calculation exists: Tantalo et al.

Unquenched will be ready soon (LATTICE2011)

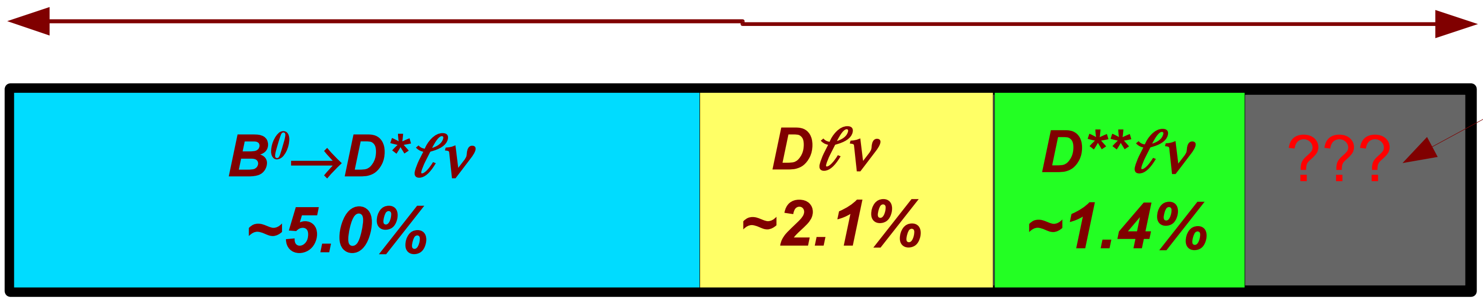
Issues with $|V_{cb}|$

- *Inclusive-Exclusive discrepancy*
  - *becaming important!*
  - *$B\to D\ell\nu$ is a useful cross checks: compatible with both*
  - *improvements expected in the near future $B\to D\ell\nu$*
  - *Error on Inclusive is reliable and it's expected to decrease*
  - *Exclusive F(1) ?*



- *Inclusive-Exclusive saturation problem:*

$Br(B^0\to X_c\ell\nu)=10.14 \pm 0.14$ %



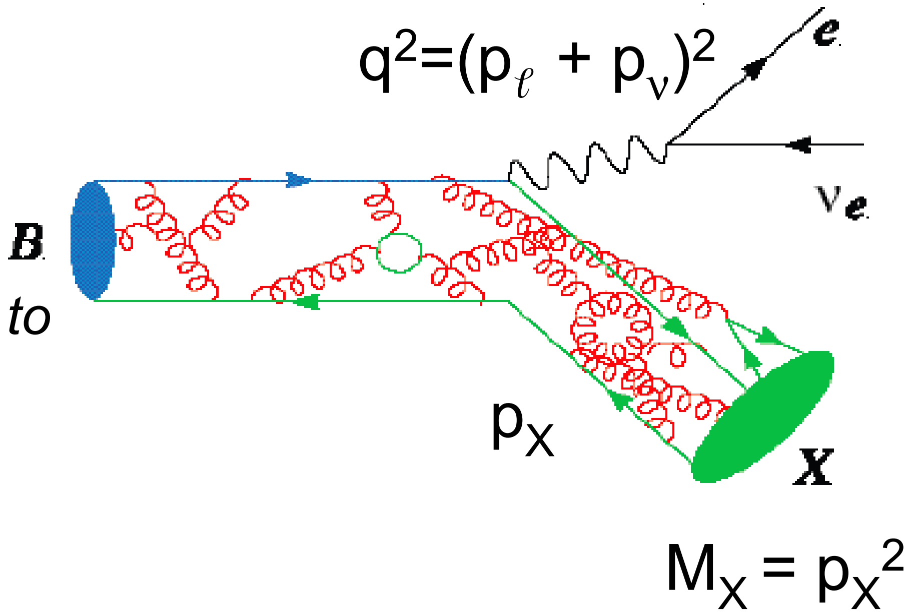
$\Delta=1.6 \pm 0.3$ %

- *3 body decay of the D***
- *Multipion emission?*
- *Other resonances?*

Semileptonic B decays: $|V_{ub}|$

- *Only one hadronic current:*

$$\Gamma(B \to \pi/X_u \ell\nu) = |V_{ub}|^2 \mathcal{F}^2(q^2, M_x, p_\ell)$$



Complementary Measurements

Exclusive decays ***$B \to \pi/\rho\, \ell\, \nu$*** *:*

- *QCD predictions of Form Factor required to parameterize hadronic effects*
- *Lattice QCD, LCSR...*

Inclusive decays ***$B \to X_u \ell\, \nu$****:*

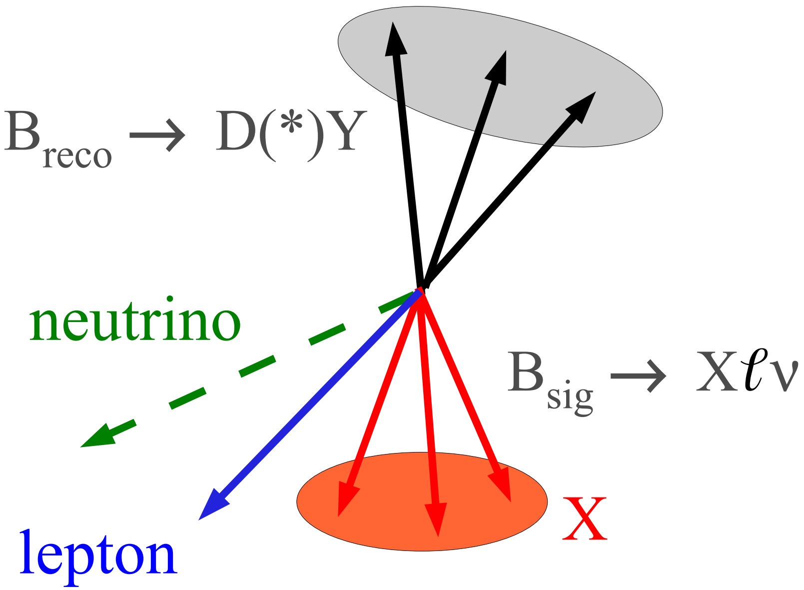
- *QCD corrections to parton level decay rate*
- *Need perturbative and non-perturbative corrections*
  - *4 approaches* ***BLNP***, ***DGE***, ***GGOU***, ***ADFR***
  - *Non-pert. parameters (m_c, m_b, μ_π^2) from $B \to X_c \ell\, \nu$ (and $B \to X_s \gamma$)*

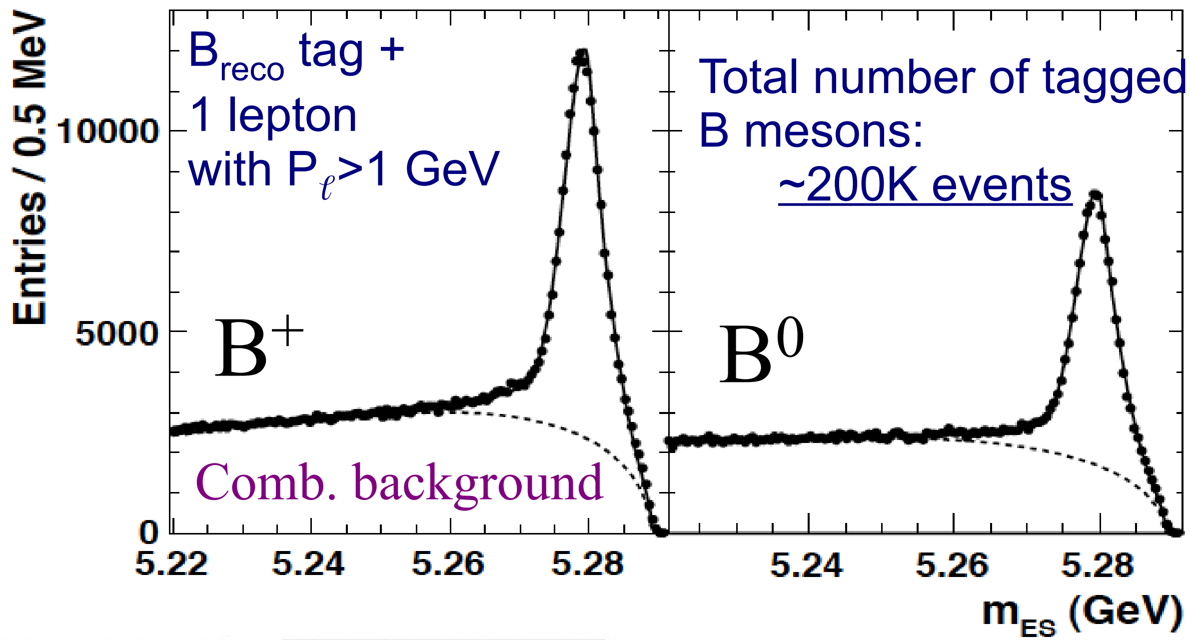
Neubert et al PRD72, 073006 (2005)
Gardi et al JHEP0601, 097 (2006)
Gambino et al JHEP0710, 058 (2007)
Aglietti et al EPJC 59, 831 (2009)

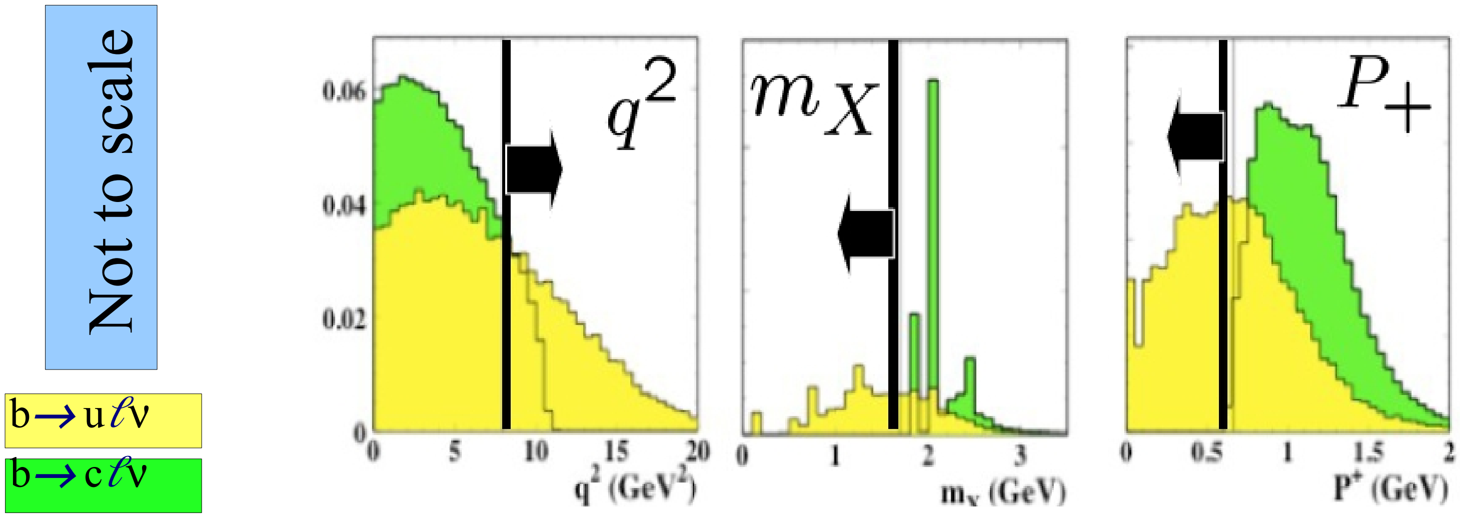
$|V_{ub}|$ From Inclusive $B \to X_u \ell \nu$

- *Large background from $B \to X_c \ell \nu$:*
  - *Kinematics to extract the signal (lepton endpoint, $M_X < M_D$,...)*

Use hadronic tag $\mathbf{B_{tag}} \to \mathbf{D^{(*)}Y}$ to reduce combinatorial and reconstruct M_X, q^2 and $P_+ = E_X - p_X$ with good resolution





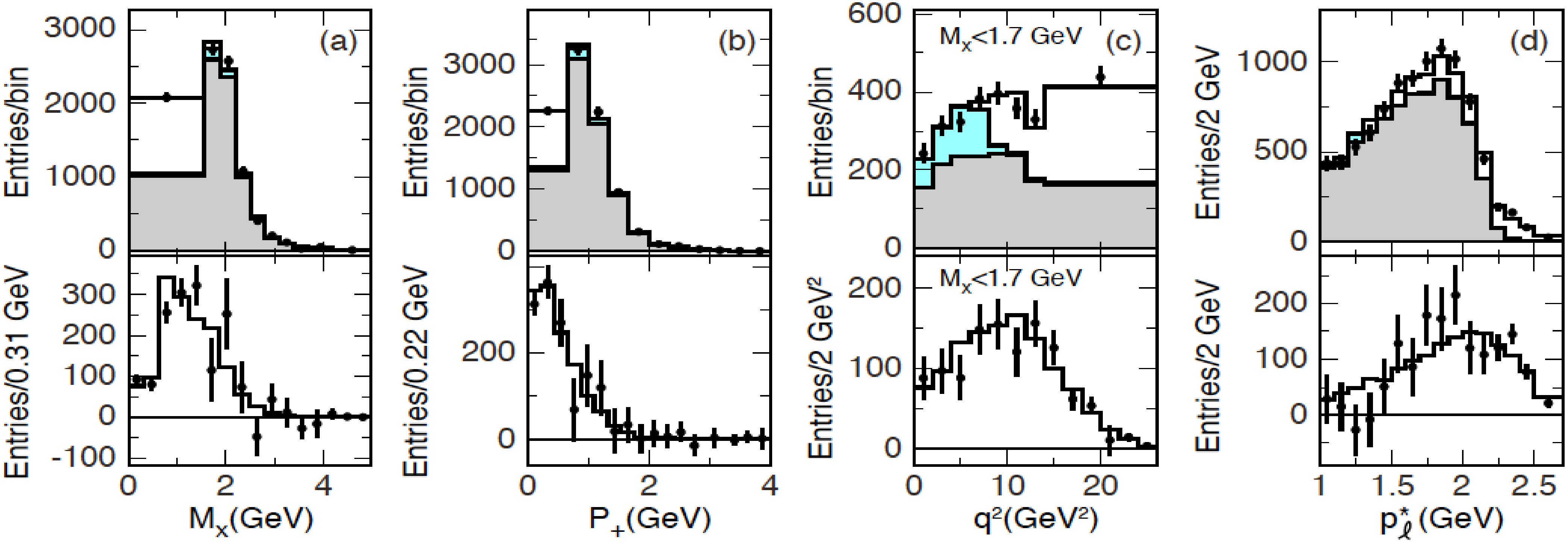


- *Experimental Resolution leads to irreducible $b \quad c\ell\nu$ contamination*

$|V_{ub}|$ From Inclusive $B \to X_u \ell\nu$

Veto $B \to D(*)\ell\nu$ with Kaons, soft pions, and missing mass

D^{**} fraction constrained from control samples

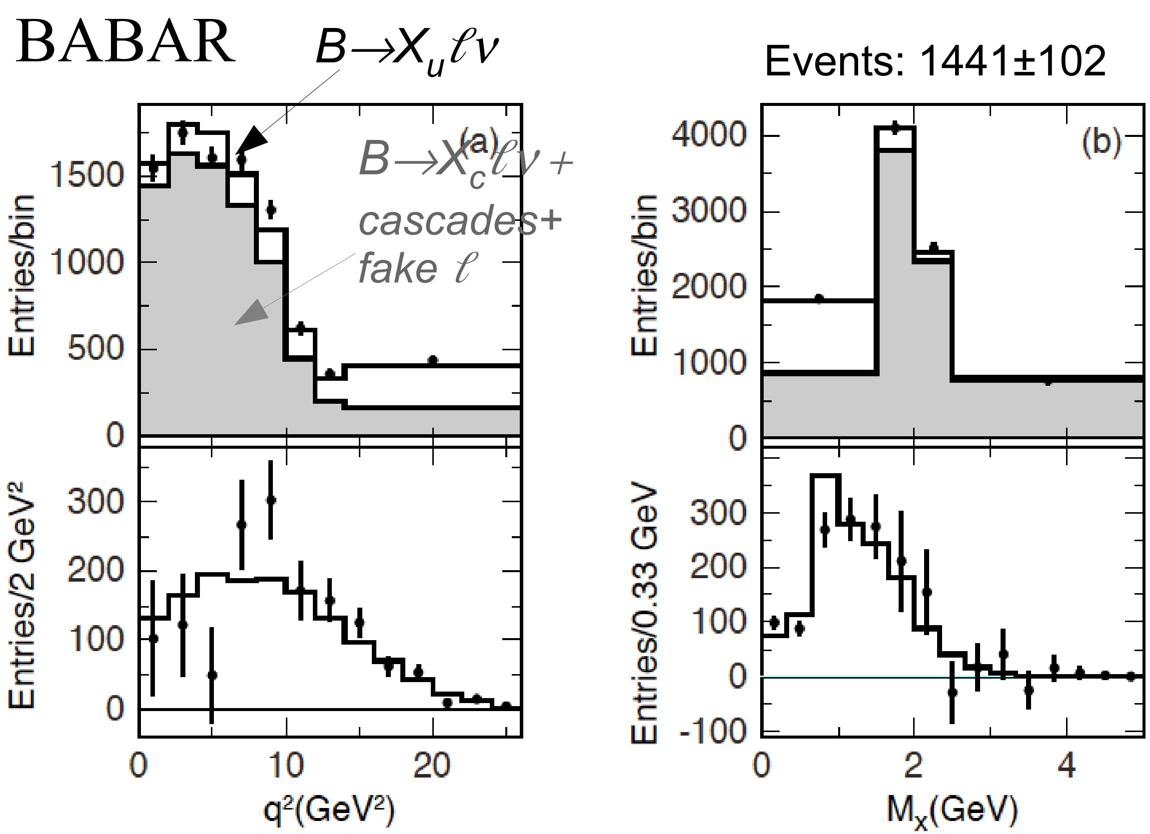


$$\frac{\Delta B(X_u \ell\nu)}{B(X\ell\nu)} = \frac{N_{b\to u}}{N_{X\ell\nu}} \cdot \frac{F}{\epsilon_{sel}}$$

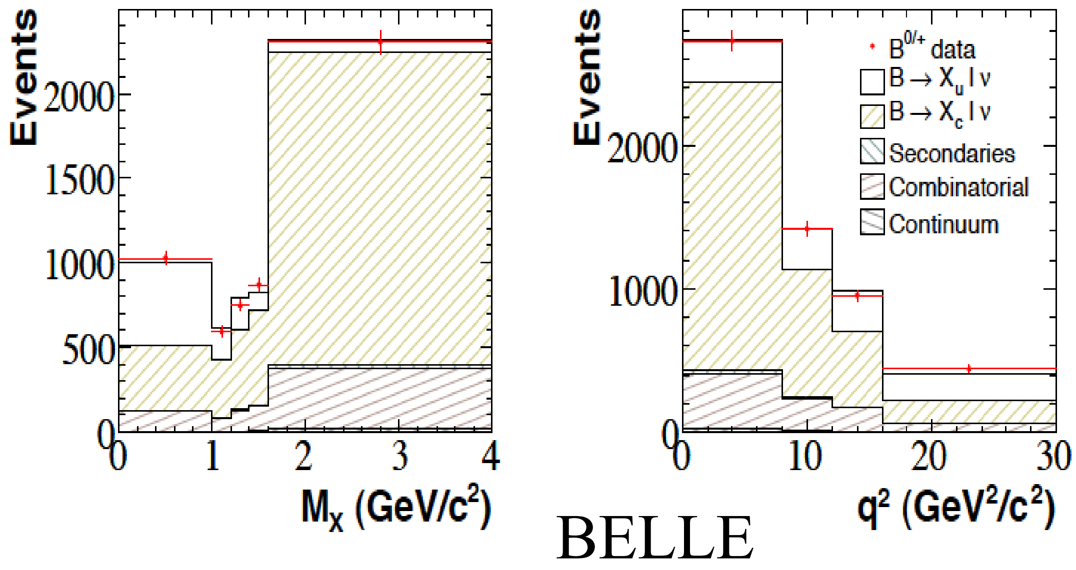
$$|V_{ub}| = \sqrt{\frac{\Delta\mathcal{B}(\overline{B} \to X_u \ell\bar{\nu})}{\tau_B \, \Delta\Gamma_{\text{theory}}}}$$

Phase space Region	**BLNP x 10³**	**ADFR x 10³**
$M_X \leq 1.55$ GeV	$4.03 \pm 0.15 \pm 0.11^{+0.28}_{-0.26}$	$3.84 \pm 0.14 \pm 0.11^{+0.24}_{-0.25}$
$M_X \leq 1.70$ GeV	$3.91 \pm 0.17 \pm 0.12^{+0.25}_{-0.23}$	$3.96 \pm 0.17 \pm 0.14^{+0.23}_{-0.24}$
$P_+ \leq 0.66$ GeV	$3.90 \pm 0.18 \pm 0.16^{+0.28}_{-0.26}$	$3.59 \pm 0.17 \pm 0.15^{+0.23}_{-0.24}$
$M_X \leq 1.70$ GeV, $q^2 \geq 8$ GeV	$4.22 \pm 0.19 \pm 0.12^{+0.30}_{-0.28}$	$3.77 \pm 0.17 \pm 0.12^{+0.23}_{-0.23}$
$M_X - q^2$, $p^*_\ell > 1.0$ GeV	$4.27 \pm 0.15 \pm 0.18^{+0.23}_{-0.20}$	$4.35 \pm 0.19 \pm 0.20^{+0.26}_{-0.26}$
$p^*_\ell > 1.0$ GeV	$4.26 \pm 0.19 \pm 0.23^{+0.23}_{-0.20}$	$4.28 \pm 0.20 \pm 0.23^{+0.24}_{-0.28}$
$p^*_\ell > 1.3$ GeV	$4.25 \pm 0.19 \pm 0.19^{+0.23}_{-0.21}$	$4.30 \pm 0.19 \pm 0.20^{+0.24}_{-0.28}$

$|V_{ub}|$ From Inclusive $B \to X_u \ell \nu$



- *Most precise ($\sigma_{exp} \oplus \sigma_{theory}$) result from a 2-D fit in q^2-M_x (P_ℓ>1 GeV)*



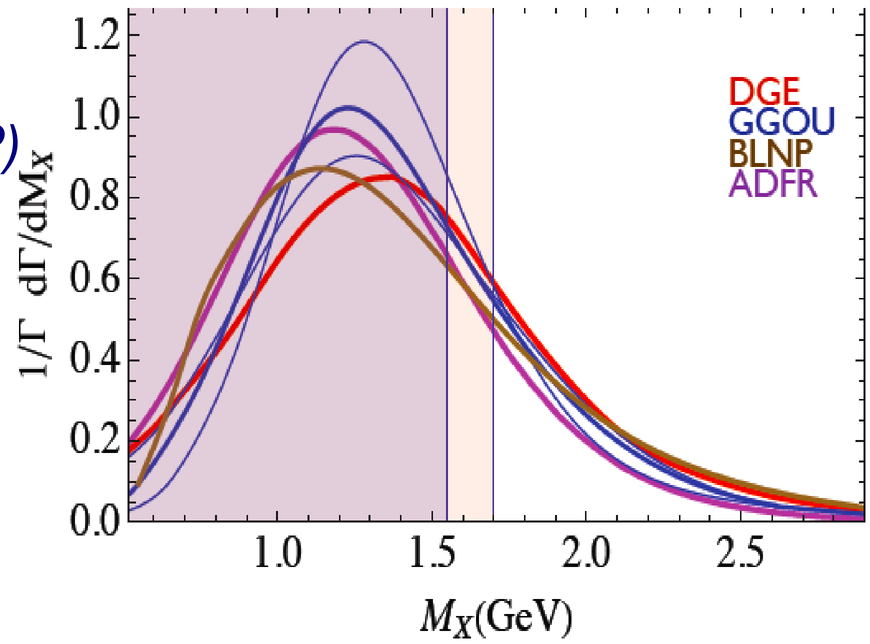
	BaBar $|V_{ub}| \cdot 10^3$	Belle $|V_{ub}| \cdot 10^3$
BLNP	$4.27 \pm 0.23_{exp.} \pm 0.23_{th.}$	$4.37 \pm 0.26_{exp.} \pm 0.23_{th.}$
DGE	$4.34 \pm 0.24_{exp.} \pm 0.15_{th.}$	$4.46 \pm 0.26_{exp.} \pm 0.16_{th.}$
GGOU	$4.29 \pm 0.23_{exp.} \pm 0.14_{th.}$	$4.41 \pm 0.26_{exp.} \pm 0.15_{th.}$
ADFR	$4.35 \pm 0.26_{exp.} \pm 0.26_{th.}$	

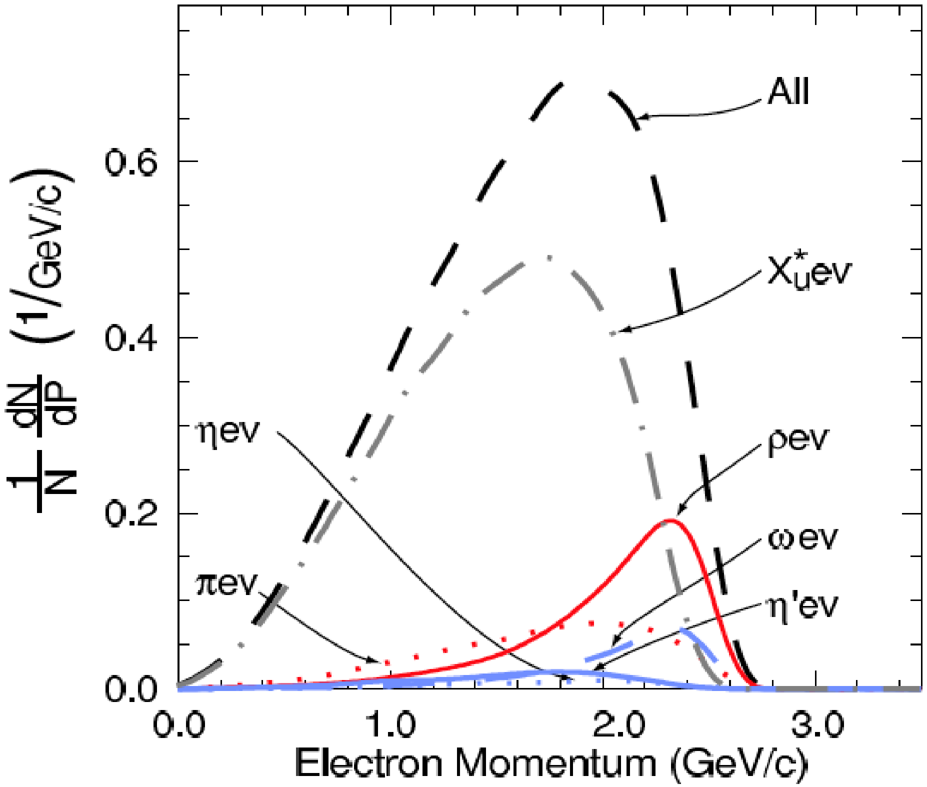
Agreement between experiments and theoretical calculations
Theoretical error dominates (5-7%)
Largest contribution from HQE parameters

HFAG World Average, BLNP $(4.30 \pm 0.16_{exp.} \pm 0.23_{th.}) \cdot 10^3$

Inclusive: uncertainties

- *Uncertainties dominated by theoretical error*
  - *Recent calculation at NNLO (plugged in BLNP) increase $|V_{ub}|$ by 7%!*
  - *Test frameworks studying spectra!*
  - *Ongoing work on SIMBA ($|V_{ub}|$ global fit)*





- *Detector effects not relevant*
- *Dominant experimental systematic is due to the modeling of signal*
  - *Resonant and not-resonant contribution*
  - *Important systematics for both inclusive and exclusive determination of $|V_{ub}|$*

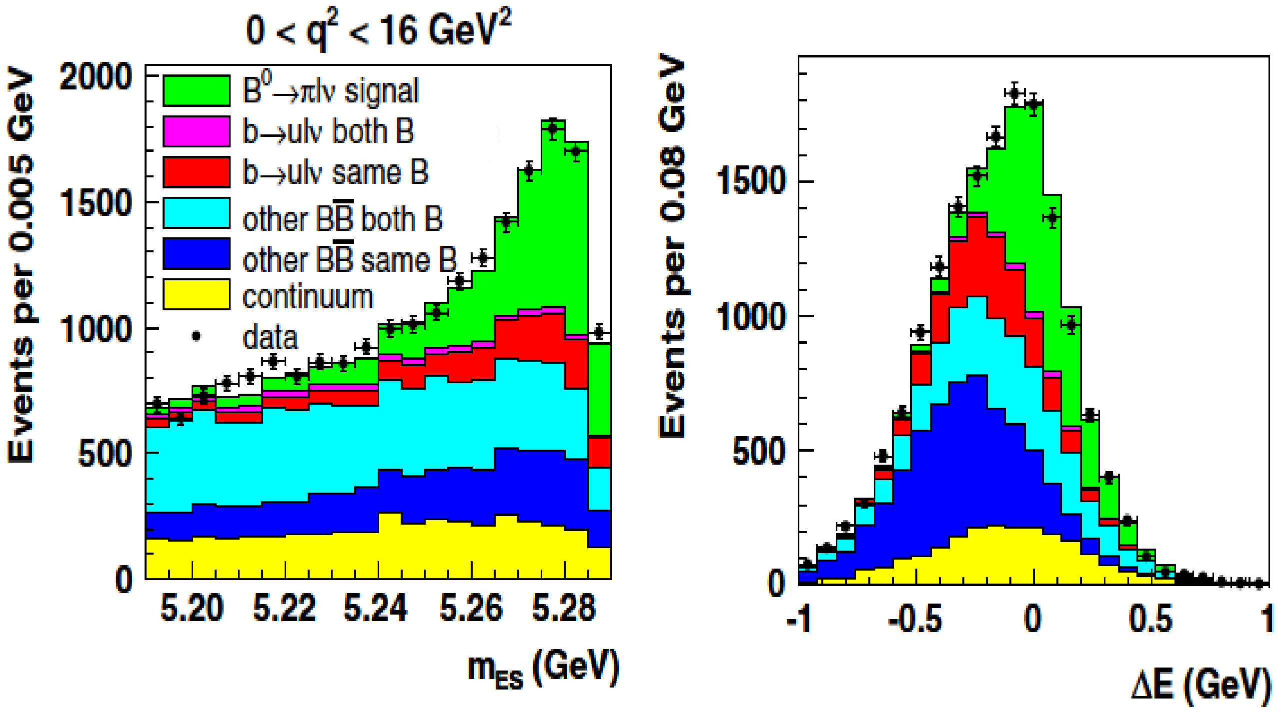
Exclusive $|V_{ub}|$ with $B \to \pi \ell \nu$

- *Untagged analysis: reconstruct π+e/μ*
- *Neutrino from the rest of the event*

$$m_{ES} = \sqrt{E^{*2}_{beam} - \mathbf{p}^{*2}_{\pi\ell\nu}}$$
$$\Delta E = E^{*}_{\pi\ell\nu} - E^{*}_{beam}$$

- Background reduced with q^2-dependent cuts
- **S/N = 0.09**
- m_{ES}-ΔE fit to $\pi^+\ell\,\nu$
- two analysis:
  6 or 12 bins of q^2

Fitted signal events:
– π^+: 11778 ± 435
Using 422 fb^{-1}



Exclusive $|V_{ub}|$ with $B \to \pi \ell \nu$

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$$m_{ES} = \sqrt{E^{*2}_{beam} - \mathbf{p}^{*2}_{\pi\ell\nu}}$$
$$\Delta E = E^*_{\pi\ell\nu} - E^*_{beam}$$

- *Background reduced with q^2-dependent cuts*

- *S/N = 0.09*

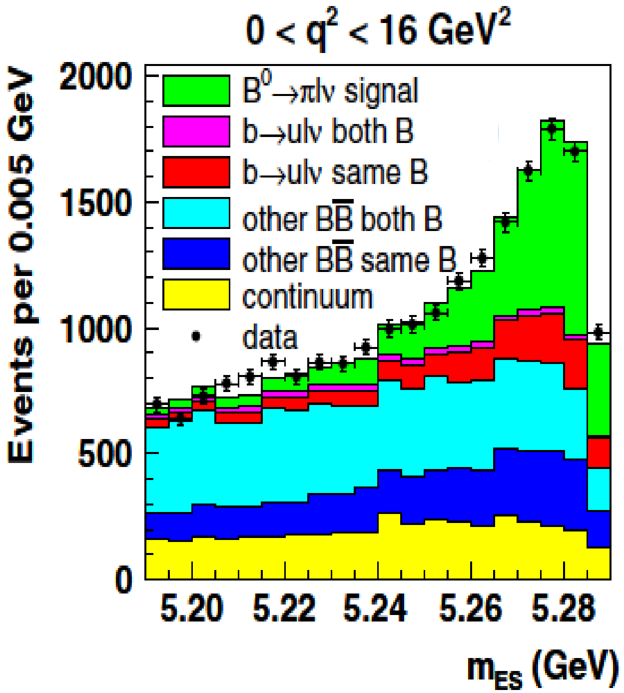
- *m_{ES}-ΔE fit to $\pi^+ \ell \nu$*
- *two analysis:*
  6 or 12 bins of q^2

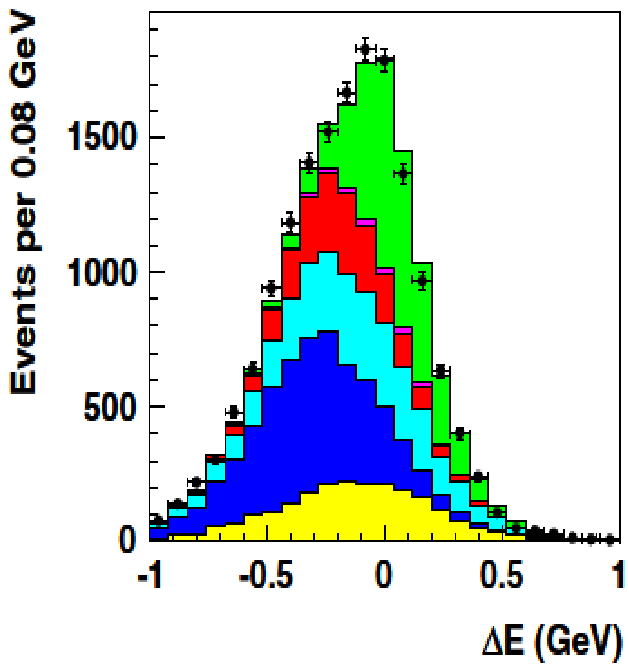
Fitted signal events:

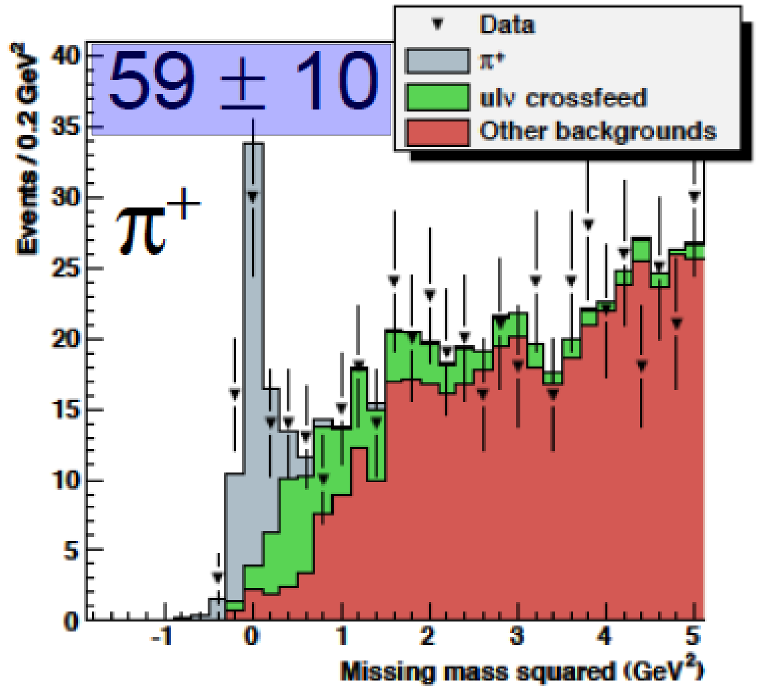
– π^+: 11778 ± 435

Using 422 fb^{-1}

Comparison with Belle
Hadronic B tag with 605 fb-1







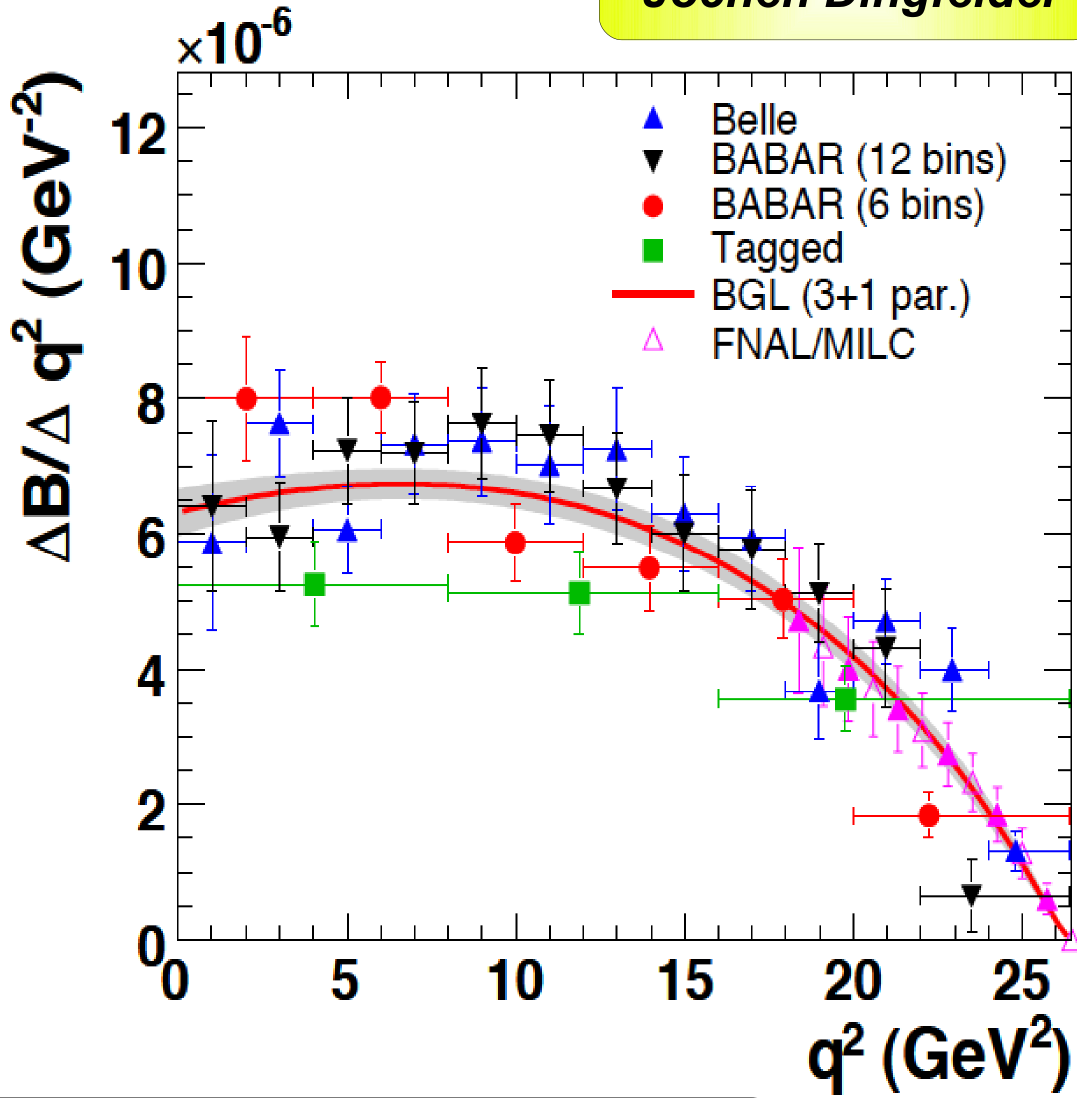
S/N ~ 10

Untagged $B\to\pi^+\ell\nu$

- *Precise experimental determination of the Form-Factor shape*

Fits Provided by Jochen Dingfelder

- *Combined fit to FNAL/MILC lattice calculations and data*
- *Untagged + Tagged measurements*
  - $|V_{ub}|=(3.19 \pm 0.29)\cdot 10^{-3}$
- *Only Untagged measurements*
  - $|V_{ub}|=(3.28 \pm 0.30)\cdot 10^{-3}$
- *9% uncertainty!*
- *Error budget:*
  - *2% from total rate*
  - *4% from q^2 shape*
  - *8% from FF normalization*



Future improvements require progress in form factor calculations

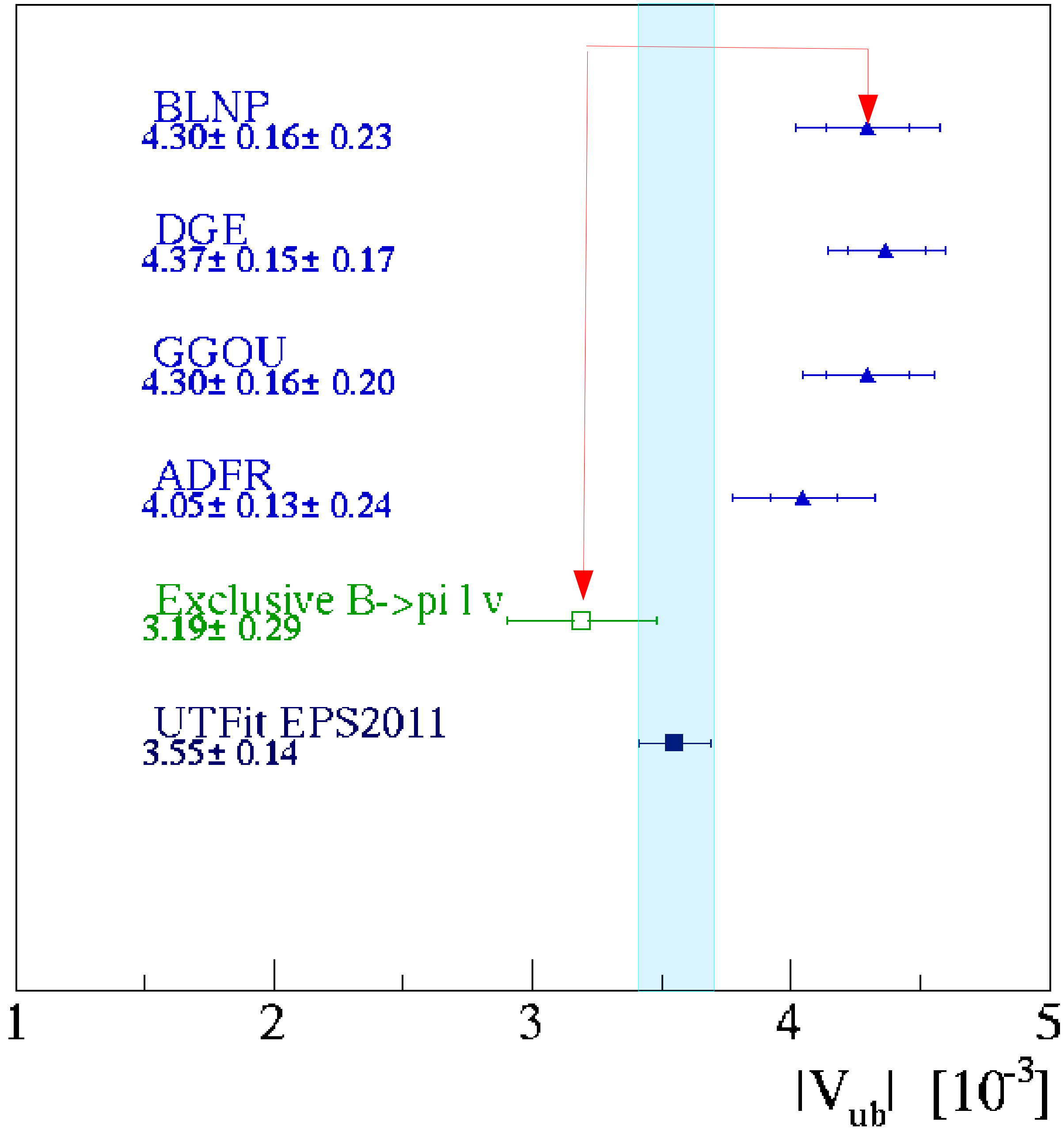
Comments

- *B-Factory era: untagged measurements give best measurements*
  - *Very high efficiency*
  - ***But large background due combinatorics from other B and from $B \to X_u \ell\nu$ bakground, very similar to the signal***
- *SuperB: will use mainly tagging (B_{reco} or SL)*
  - *Small efficiency*
  - ***Possible to apply loose cuts (es: low momentum cut)***
  - ***Reduce model dependence and overall systematics***

Measurements	Total BR($B \to \pi^+ \ell \nu$) · 10^4
BaBar I	$1.41 \pm 0.05_{stat} \pm 0.07_{syst}$
BaBar II	$1.42 \pm 0.05_{stat} \pm 0.07_{syst}$
Belle	$1.49 \pm 0.04_{stat} \pm 0.07_{syst}$
Average Untagged	$1.44 \pm 0.03_{stat} \pm 0.04_{syst}$
Average Tagged	$1.44 \pm 0.08_{stat} \pm 0.03_{syst}$

- *To improve the high q^2 region is crucial to:*
  - *Understand the dynamics and composition of the $B \to X_u \ell\nu$*
- *Improvements expected from Lattice (<5% error ?)*

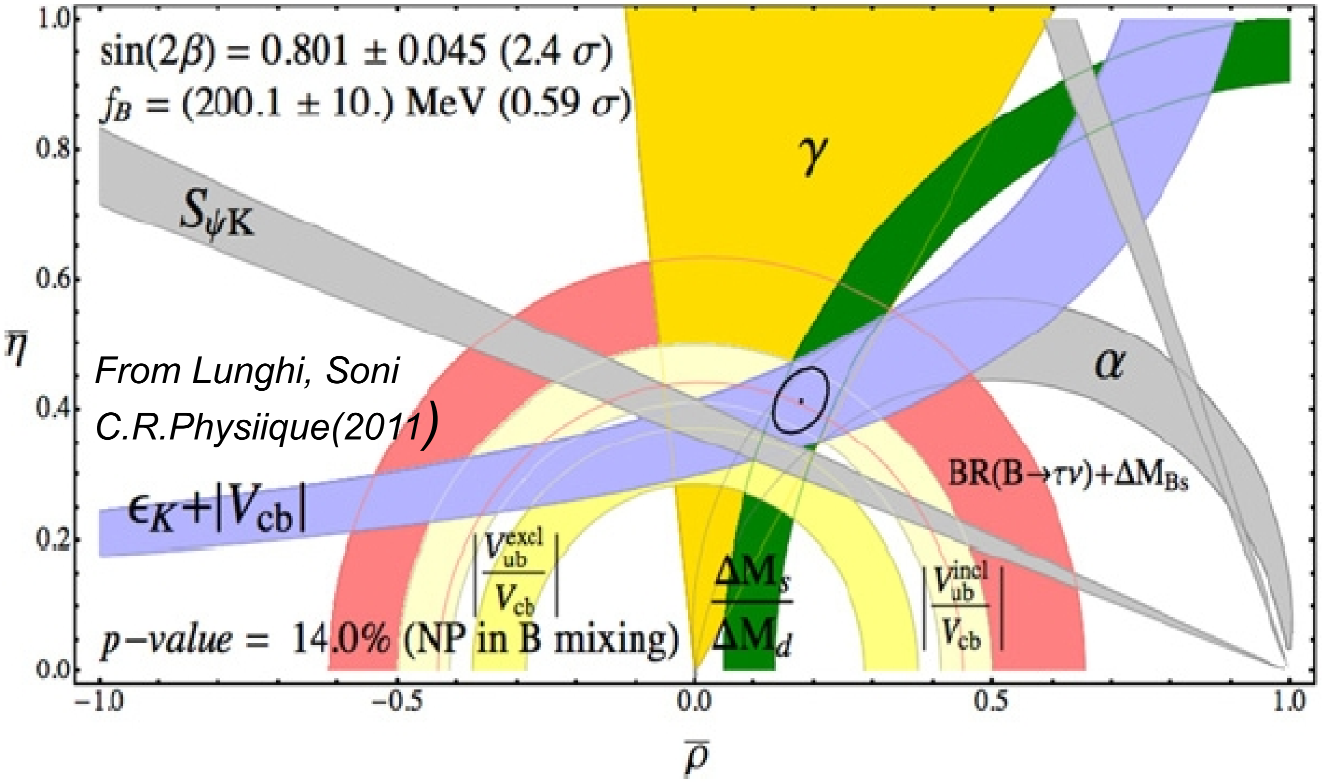
Inclusive-Exclusive Puzzle



Inclusive-Exclusive Puzzle

- *Despite progresses from Bfactories, the inclusive-exclusive discrepancy still present: 2.0-3.0σ differencies*

- *Crucial impact on UT constraints*



Will stay with us for a long time!

SuperB
- larger dataset
- tagged sample: cleaner
- better understanding of the background composition / dynamics

BUT:
Exclusive: Progress in QCD calculations, LQCD and LCSR
Inclusive: Require advanced QCD calculation and precise mb

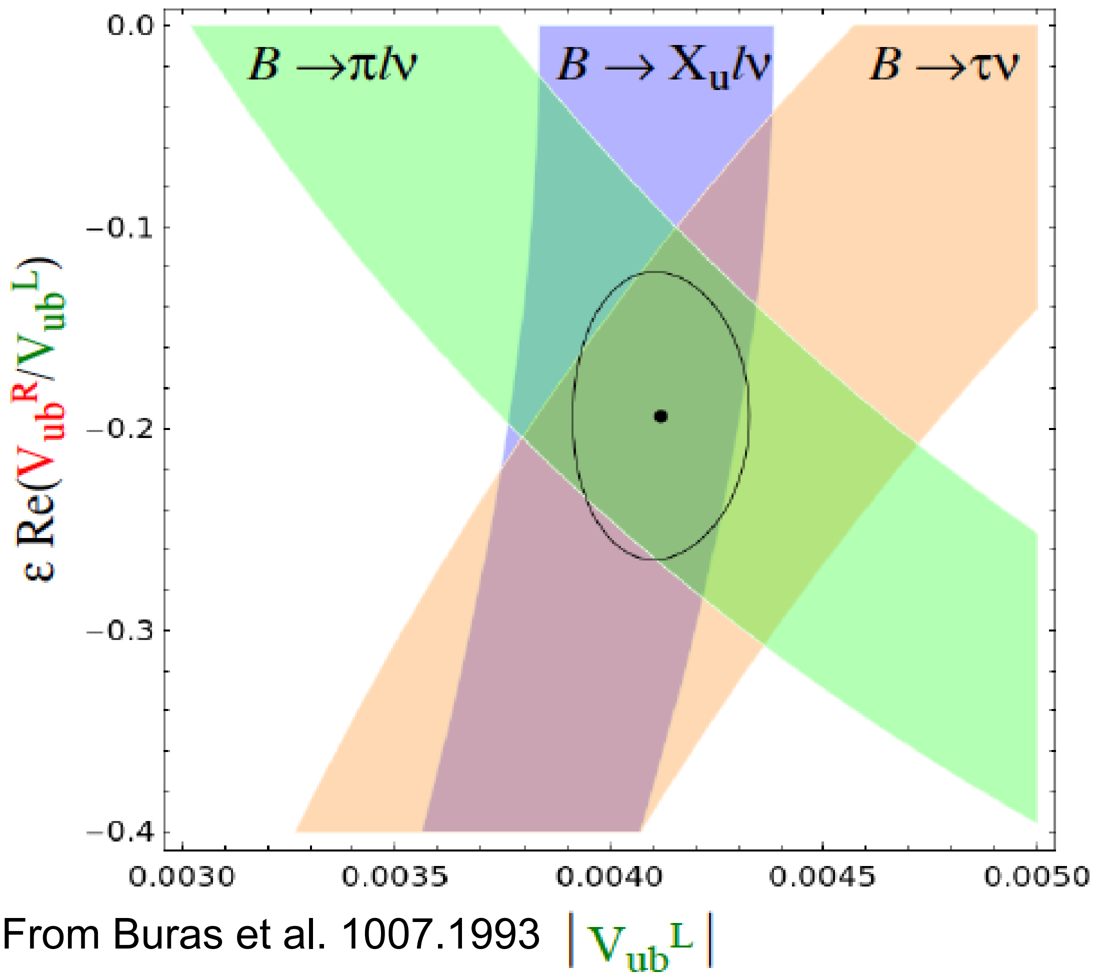
Puzzle solution: New Physics ?

- *The Right-Handed currents could explain the differencies:*

$$V_{ub} u_L \; W \; b_L \;\; \Longrightarrow \;\; V_{ub}(u_L \; W \; b_L + \xi^R_{ub} \cdot u_R \; W \; b_R)$$

Chen, Nam
Buras, Gemmler
Lunghi, Soni

- *Impact SL and Leptonic decays*



From Buras et al. 1007.1993

$$|V_{ub}|_{\rm incl} \Longrightarrow \sqrt{1+|\xi^R_{ub}|^2}\,|V_{ub}|_{\rm incl}$$

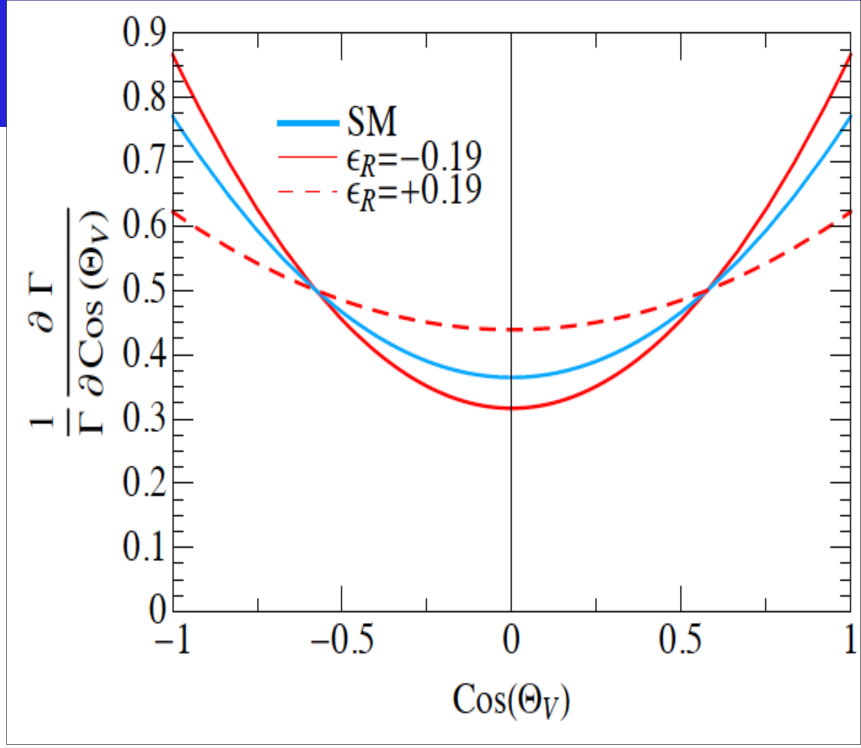
$$|V_{ub}|_{\rm excl} \Longrightarrow |1+\xi^R_{ub}|\;|V_{ub}|_{\rm excl}$$

$$\mathrm{BR}(B\to\tau\nu) \Longrightarrow |1-\xi^R_{ub}|^2\mathrm{BR}(B\to\tau\nu)$$

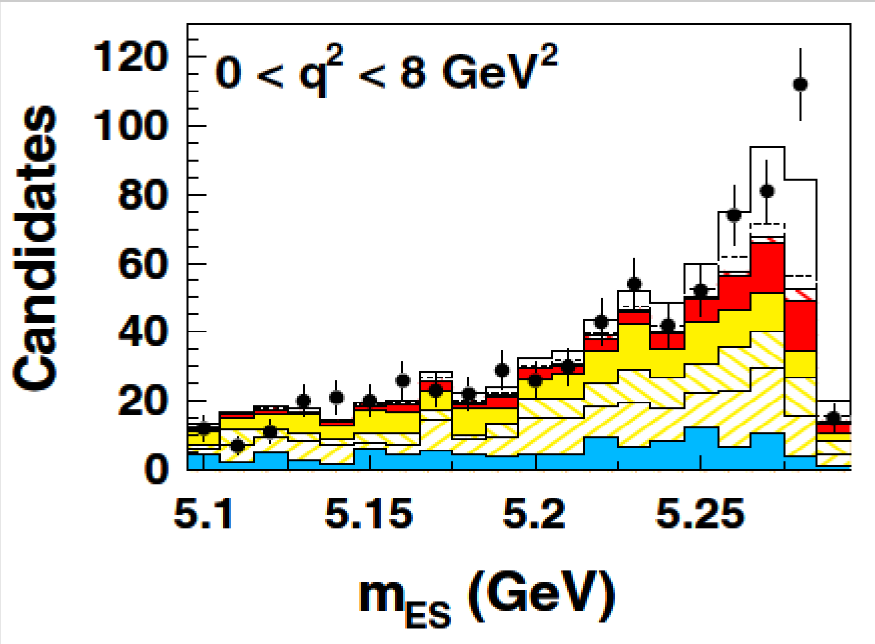
- *Large RH contribution is required (~20%)*
- *An RH current does not significantly contradict existing observables*
- *Need to study specific observables*
  - $B \to \rho \ell \nu$ ...

$B \to \rho \ell \nu$

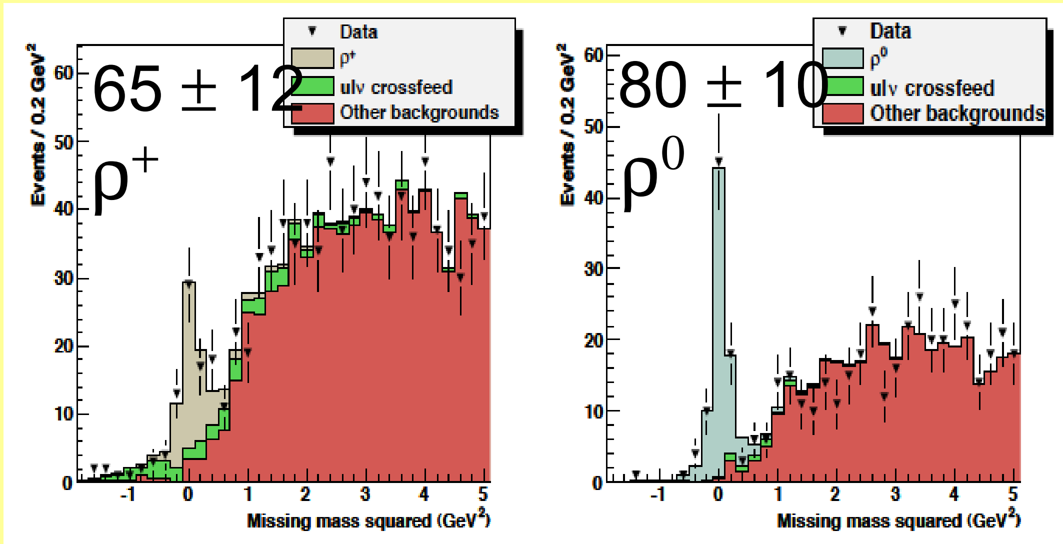
- *$B \to \rho \ell \nu$: non trivial test of V-A, V+A contribution*
- *ρ helicity distribution: affected by phase space*
  - *Require high statistics and good precision!*



Untagged is affected by large bkg:
- need tight cuts: ***pl>2.0 GeV***
- BaBar 350fb-1:
3300 ± 290 events with S/N~0.1



B_{reco} with 670 fb-1 (Belle)



pl>1.0 GeV

Approach $|V_{ub}|$ differently ?

- *Use MORE rare decays, very clean:*

$$\frac{d\Gamma(\bar{B}_d \to \rho\ell\nu)/dq^2}{d\Gamma(\bar{B}_d \to K^*\ell^+\ell^-)/dq^2} = \frac{|V_{ub}|^2}{|V_{ts}V_{tb}|^2} \cdot \frac{8\pi^2}{\alpha^2} \cdot \frac{1}{N(q^2)} \cdot R_B$$

  - *R_B from 'Grinstein double ratio':*

CLEO-c

SuperB

$$\frac{f^{(B\to\rho\ell\bar{\nu})}}{f^{(B\to K^*\ell^+\ell^-)}} \times \frac{f^{(D\to K^*\ell\bar{\nu})}}{f^{(D\to\rho\ell\bar{\nu})}}$$

LHC-b

- *Use EVEN more Rare Decays, even more clean:*

$$\frac{\dfrac{\Gamma(B_u\to\tau\nu)}{\Gamma(B_s\to\ell^+\ell^-)}}{\dfrac{\Gamma(D_d\to\ell\nu)}{\Gamma(D_s\to\ell\nu)}} \sim \frac{|V_{ub}|^2}{|V_{ts}V_{tb}|^2} \cdot \frac{\pi^2}{\alpha^2} \cdot \left(\frac{f_B/f_{B_s}}{f_D/f_{D_s}}\right)^2$$

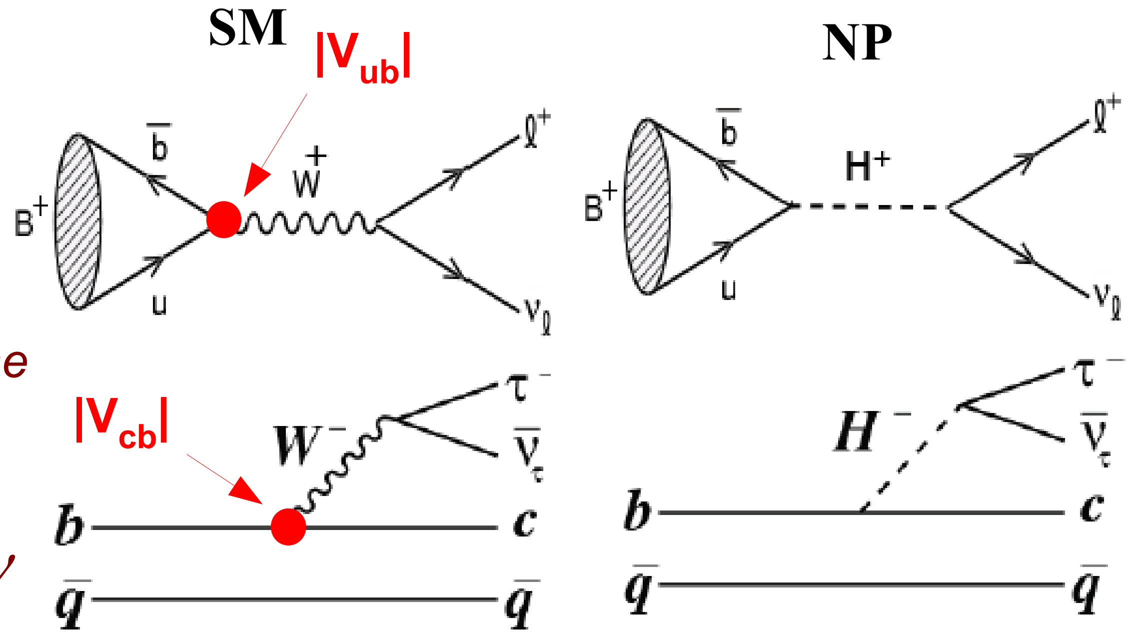
Summary

- *Great improvements in the last decade*
  - *We have not reached the desired uncertainty for inclusive $|V_{ub}|$*
  - *Many puzzles still present and are now more important!*
  - ***Will stay with us for a long time!***

- *Improve the SL knowledge, for both $|V_{cb}|$ and $|V_{ub}|$*
  - *Reduce systematics due to background signal and background composition*
  - *Fix the gap of the missing exclusive decays*
- *Use the large B_{reco} sample available:*
  - *Expect 5000/fb of tagged B meson!*
  - *SuperB boost → higher acceptance: better ν_{reco} and B_{reco} efficiency*

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

- *Similar to $B \to \tau\nu$, but:*
  - *From annihilation to exchange*
  - *From V_{ub} to V_{cb} : not a rare decay!*
  - *(tau mass no negligible): 2 form factor for the D, 4 for the D*, but HQET relates the extra FF to the well measured FF in light leptons*
- *Look only at $\tau \to \ell\nu\nu$ ($\ell \to$ e or μ) 3ν in the final state $\to$ signal signature: **large missing mass***



Extract directly the ratio R

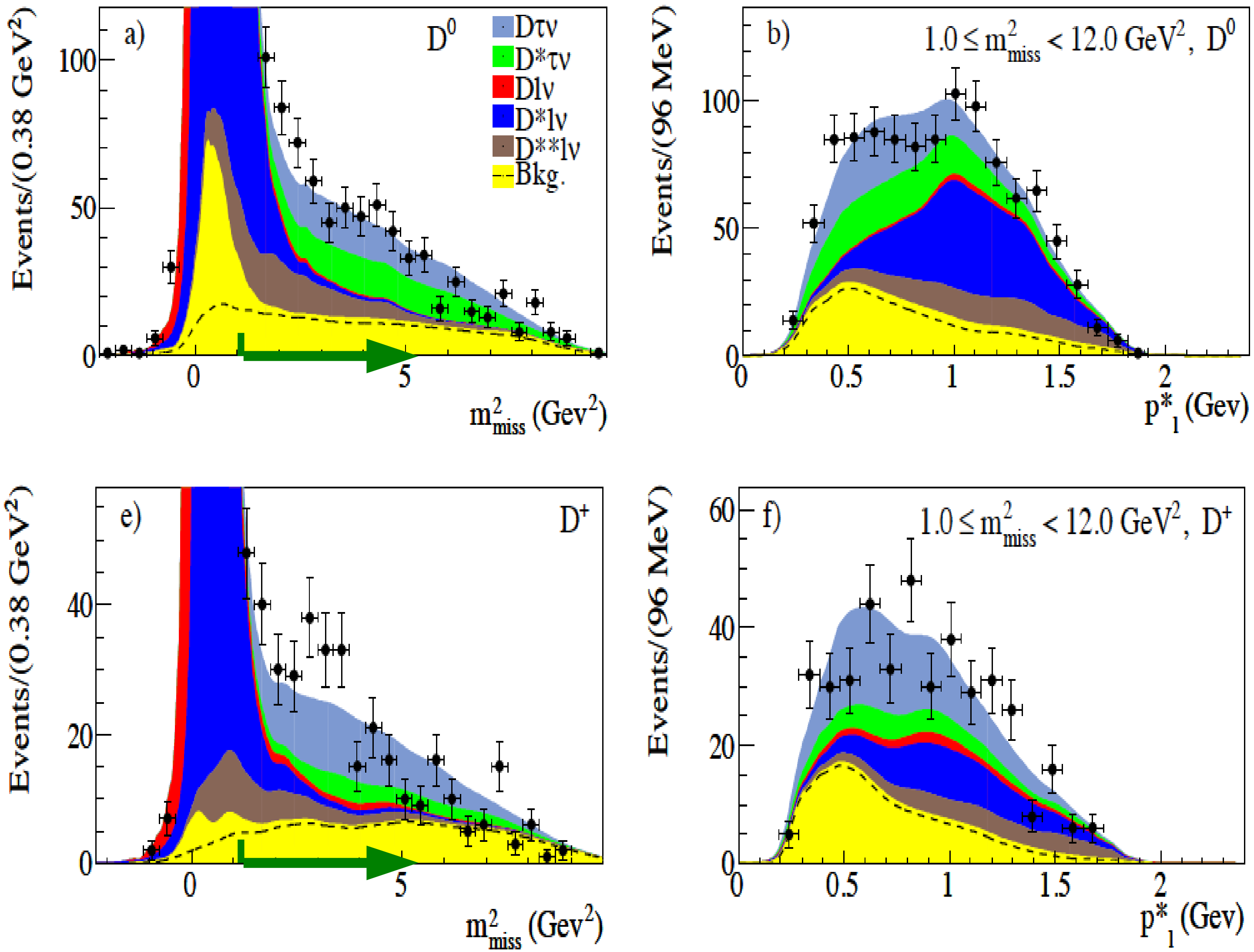
$$R(D^{(*)}) = \frac{\mathcal{B}\left(B \to D^{(*)}\tau\nu_\tau\right)}{\mathcal{B}\left(B \to D^{(*)}\ell\nu_\tau\right)}$$

Reduce theoretical and experimental errors

- *Use the hadronic tag $B_{tag} \to D^{(*)}Y$*
  - *Y is a combination of π, π^0 and K*
  - *Reduce combinatoric*
- *Reconstruct 4 signal decay channels (fitted together):*
  - *D^0, D^{*0}, D^+, D^{*+}*

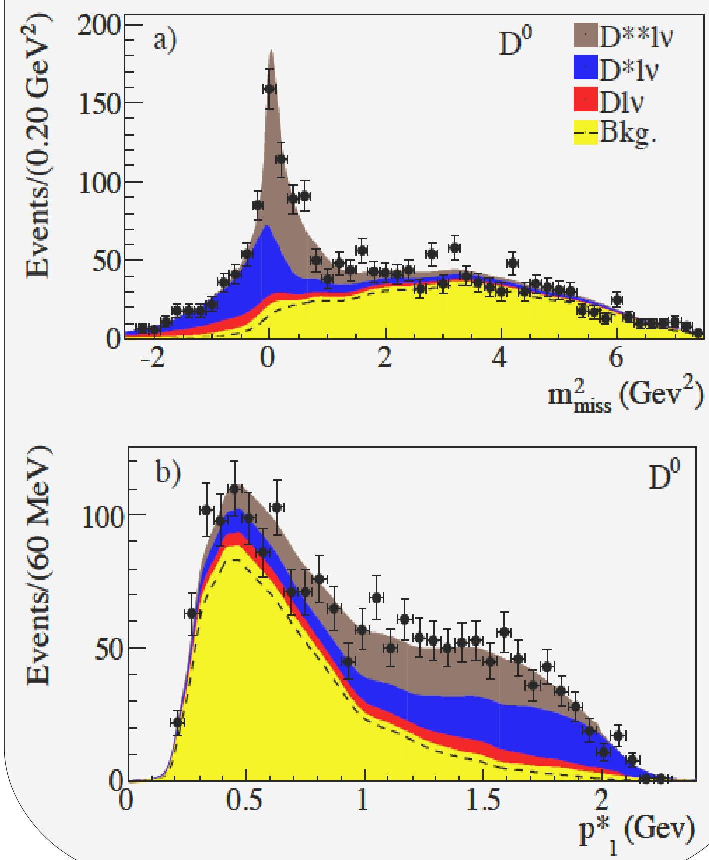
$B \rightarrow D(*)\tau\nu$: fit

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



$B \rightarrow D^{**}\ell\nu$ poorly known

Select $D(*)\pi^0$ candidates and fitted together with the signal sample



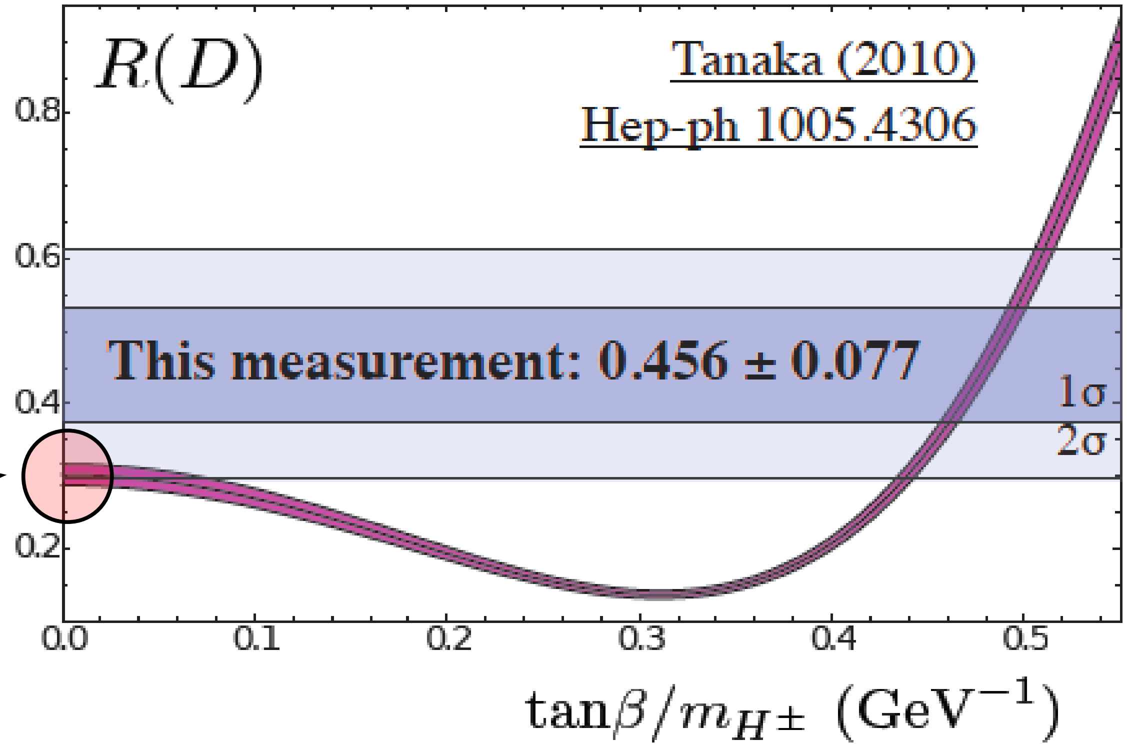
$B \to D(*)\tau\nu$: preliminary results

Mode	N_{sig}	N_{norm}	$\varepsilon_{sig}/\varepsilon_{norm}$	$\mathcal{R}(D^{(*)})$	$\mathcal{B}(B \to D^{(*)}\tau\nu)$ (%)	Σ_{tot} (Σ_{stat})
$D^0\tau^-\overline{\nu}_\tau$	226 ± 39	1433 ± 46	2.13 ± 0.06	$0.422 \pm 0.074 \pm 0.059$	$0.96 \pm 0.17 \pm 0.14$	5.0 (6.2)
$D^{*0}\tau^-\overline{\nu}_\tau$	511 ± 48	6839 ± 90	1.36 ± 0.02	$0.314 \pm 0.030 \pm 0.028$	$1.73 \pm 0.17 \pm 0.18$	8.9 (11.9)
$D^+\tau^-\overline{\nu}_\tau$	139 ± 21	704 ± 29	2.19 ± 0.08	$0.513 \pm 0.081 \pm 0.067$	$1.08 \pm 0.19 \pm 0.15$	6.0 (7.5)
$D^{*+}\tau^-\overline{\nu}_\tau$	220 ± 23	2802 ± 56	1.25 ± 0.03	$0.356 \pm 0.038 \pm 0.032$	$1.82 \pm 0.19 \pm 0.17$	9.5 (12.1)
$D\tau^-\overline{\nu}_\tau$	368 ± 42	2140 ± 54	2.15 ± 0.05	$0.456 \pm 0.053 \pm 0.056$	$1.04 \pm 0.12 \pm 0.14$	6.9 (9.6)
$D^*\tau^-\overline{\nu}_\tau$	730 ± 50	9639 ± 107	1.33 ± 0.07	$0.325 \pm 0.023 \pm 0.027$	$1.79 \pm 0.13 \pm 0.17$	11.3 (17.1)

Isospin constraints

PRELIMINARY

- *Systematics are preliminary: expected to improve for the publication*
- *Results compatible with Belle latest results and previous BaBar one*
- *5σ in all channels*
- *1.8 σ from SM*
- *Results favors large tanβ*



More details: Manuel F Sevilla talk at EPS11