# Semileptonic B-Decays at BABAR - Measurements of $|V_{cb}|$ and $|V_{ub}|$

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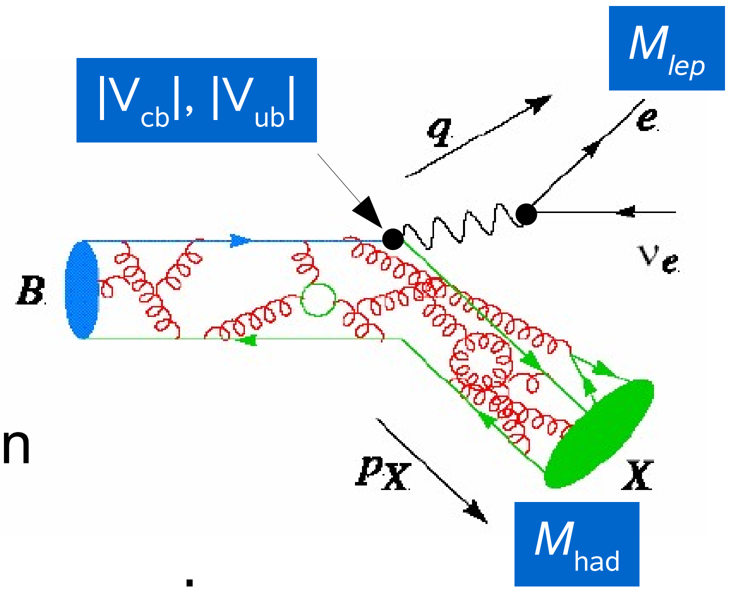
# Outline

- $|V_{cb}|$ measurement with inclusive $B \to X_c l \nu$ decays:
  - Moments of the invariant hadronic mass distribution
  - Moments of the electron energy distribution
  - Extraction of $|V_{cb}|$, $Br(B \to X_c l \nu)$, and HQE parameters with a combined fit to measured moments
- $|V_{ub}|$ measurement with inclusive $B \to X_u l \nu$ decays:
  - Electron endpoint spectrum
  - $q^2$-$E_l$ with neutrino reconstruction
  - $m_X$ and $q^2$-$m_X$ on the recoil of fully reconstructed B mesons
- Summary of results from exclusive $B \to X_u l \nu$ decays

# Semileptonic B Decays

- Semileptonic B decays provide best way to measure $|V_{cb}|$ and $|V_{ub}|$
  - Hadronic and leptonic currents factorize
  - Hadronic matrix element needs to be corrected for interactions within B meson




- Theoretical framework: **H**eavy **Q**uark **E**xpansion
  - Provides method to separate perturbative from non-perturbative scales
  - Expansion of $M_{had}$ in powers of $1/(m_b\text{-}m_c)$ in terms of local operators
  - Non-perturbative physics enters through matrix elements of local operators
  - Perturbative effects enter through coefficients of operators

# HQE & Semileptonic B Decays ($B \to X_c l \nu$)

$$\Gamma_{sl}(B \to X_c l \nu) = \frac{G_F^2 m_b^5(\mu)}{192\pi^3} |V_{cb}|^2 (1 + A_{ew}) \times \left( z_0(r)\left[1 - A_3^{pert}(r;\mu)\right]\left(1 - \frac{\mu_\pi^2(\mu) - \mu_G^2(\mu) + \frac{\rho_D^3(\mu) + \rho_{LS}^3(\mu)}{m_b(\mu)}}{2 m_b^2(\mu)}\right) - \left(1 + A_5^{pert}(r;\mu)\right) 2(1-r)^4 \frac{\mu_G^2(\mu) - \frac{\rho_D^3(\mu) + \rho_{LS}^3(\mu)}{m_b(\mu)}}{m_b^2(\mu)} + O\left(\frac{1}{m_b^3}\right) \right)$$

free-quark rate

perturbative corr.: $\alpha_s$, $\alpha_s^2 \beta_0$

order $1/m_b^2$ parameters

order $1/m_b^3$ parameters

$\mu$: scale separating effects from long- and short-distance dynamics
$z_0$: phase space factors, $r = m_c^2/m_b^2$, $A_{ew}$: electroweak corrections

*(Benson-Bigi-Mannel-Uraltsev, Nucl.Phys.B665:367;
Gambino and Uraltsev, hep-ph/0401063 hep-ph/0403166)*

- Contains b- and c-quark masses
- Non-perturbative parameters ↔ properties of the b-quark
  - $\mu_\pi^2$: related to kinetic energy
  - $\mu_G^2$: related to chromomagnetic interaction (B-B* mass splitting)
  - $\rho_D^3$, $\rho_{LS}^3$: order $1/m_b^3$ parameters Darwin term and spin-orbit interaction

# Moments of Inclusive Distributions

- HQE does not provide local prediction of $d\Gamma/dE_l$ and $d\Gamma/dM_X$
- Rate and moments of inclusive observables ($E_l$, $M_X$) reliably predicted

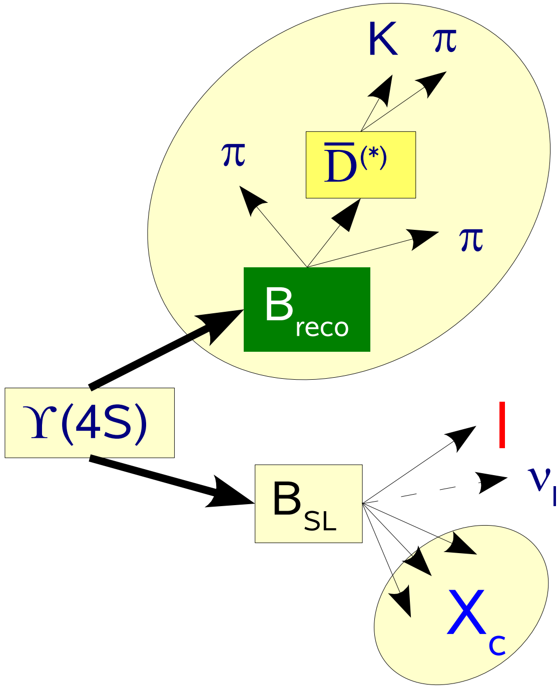
$$\langle (X-X_0)^n \rangle (E_{l,cut}) = \frac{\int_{E_l \geq E_{l,cut}} (X-X_0)^n \frac{d\Gamma}{dX} dX}{\int_{E_l \geq E_{l,cut}} \frac{d\Gamma}{dX} dX} = f_{HQE}(E_{l,cut}; m_b, m_c, \mu_\pi^2, \mu_G^2, \rho_D^3, \rho_{LS}^3)$$

  - Moments of inclusive invariant hadronic mass distribution: $\mathcal{M}^X$
  - Moments of lepton energy distribution: $\mathcal{M}^\ell$
  - Additional information provided by photon spectrum in decays $B \to X_s \gamma$
- Measure moments with different threshold lepton momenta and perform combined fit
  - Extract $|V_{cb}|$, quark masses, and HQE parameters
  - Check HQE consistency

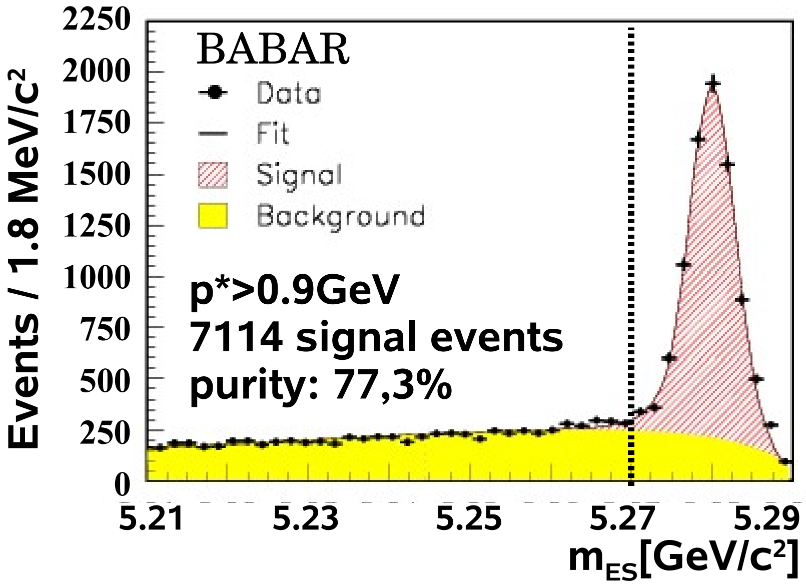
# Hadronic Mass Moments: Event Selection

PR D69:111103

- Dataset: 89 million $B\bar{B}$ pairs
- On the "recoil" of fully-reconstructed $B_{reco}$
  - flavor and four-momentum of recoiling $B_{SL}$ known
  - $m_{ES} = \sqrt{\frac{s}{4} - \vec{p}_B^{\,2}}$ used to subtract combinatorial background



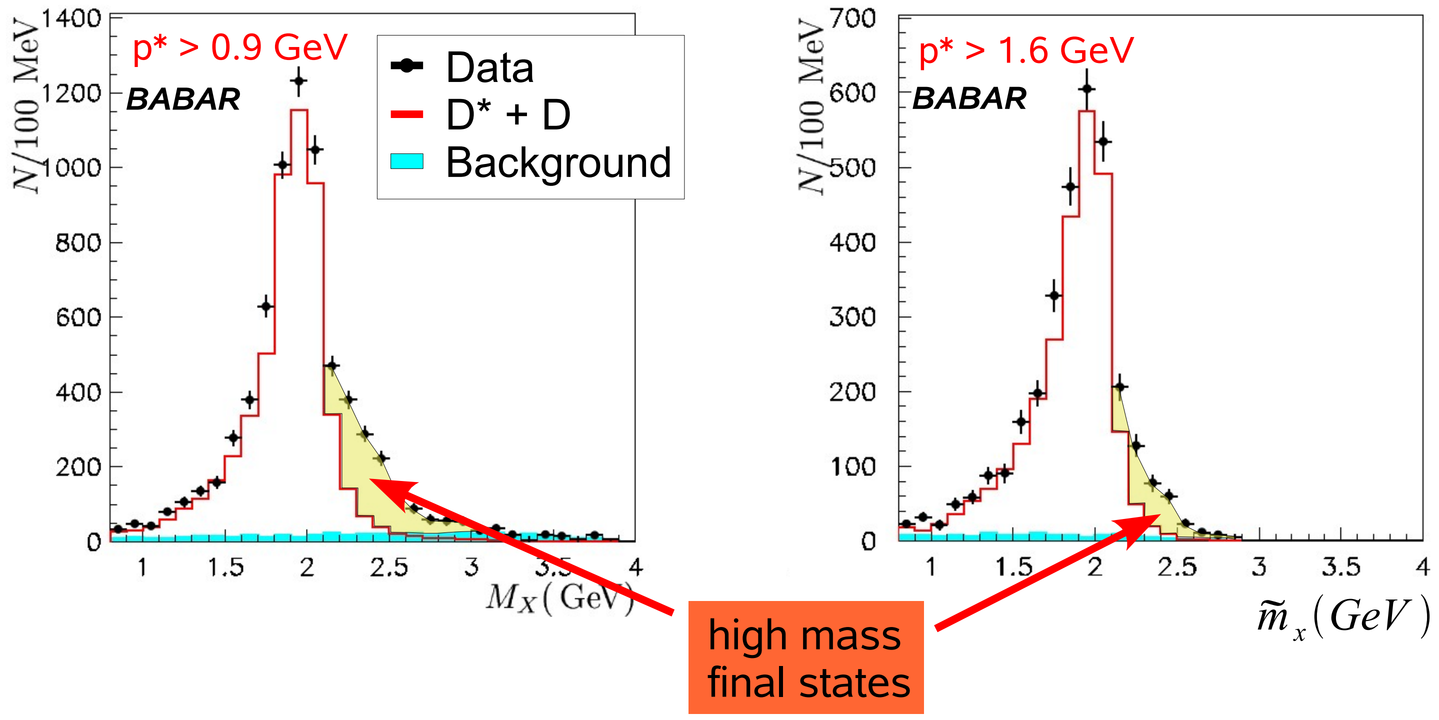

- Measure one recoiling lepton to identify semileptonic decay
  - Momentum $p^* > p^*_{cut}$ in the $B_{SL}$ restframe
  - Charge correlation: $Q_{b,B_{SL}} \cdot Q_l > 0$
  - Missing mass ($m_{miss}$), energy ($E_{miss}$), and momentum ($p_{miss}$) calculated from $B_{SL}$, lepton, and remaining particles $\Rightarrow$ consistent with unmeasured neutrino



# Hadronic Mass Moments: $X_c$-System

PR D69:111103

- Remaining particles belong to the $X_c$-system
  - Perform kinematic 2C fit to whole event to improve $m_X$ resolution
  - Increasing contribution from high mass final states for low lepton momenta

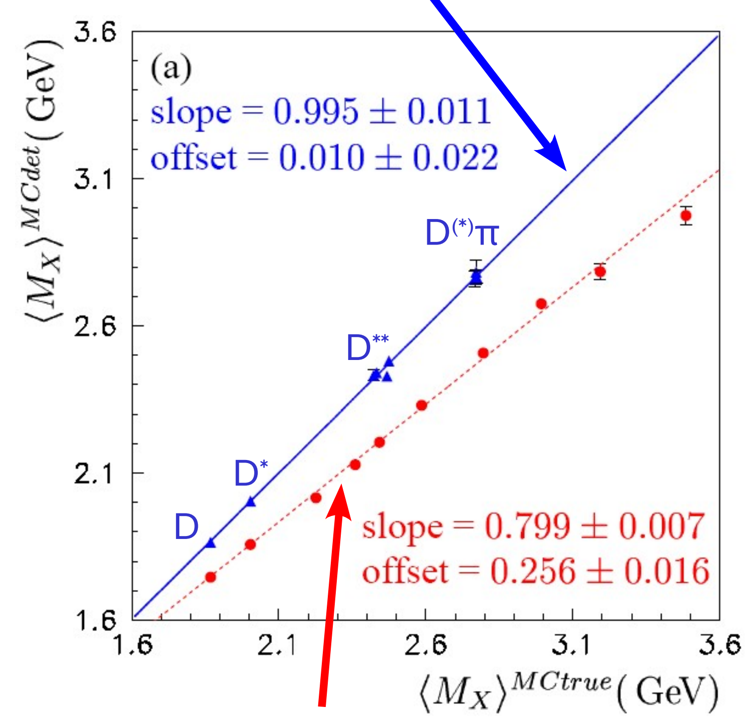


# Hadronic Mass Moments: Calibration

PR D69:111103

- Unmeasured particles: $m_{X,meas} < m_{X,true}$
  - Utilizing simulation to correct for detector and efficiency effects
  - Calibration applied event-by-event
  - Varies slightly as a function of $E_{miss}$-$p_{miss}$ and $X_c$-multiplicity
- Calibration procedure verified using
  - simulated exclusive final states
  - partially reconstructed $B \rightarrow D^* l \nu$ decays in data
- Main systematic uncertainties:
  - Detector response
  - Background subtraction

simulated exclusive final states after calibration

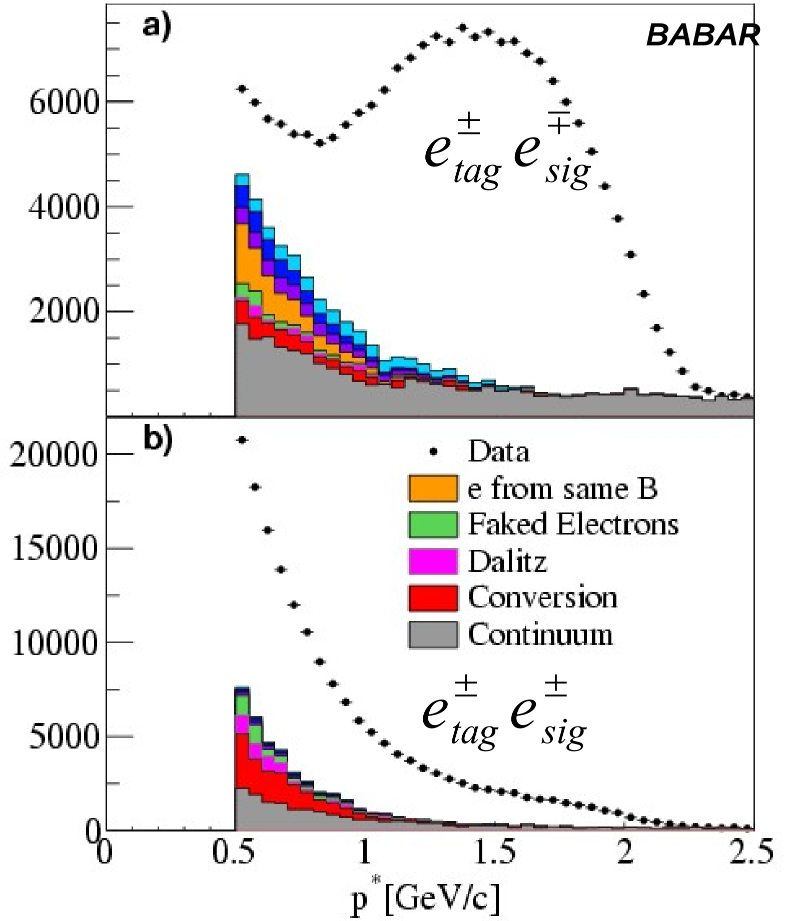



calibration curve: $\langle m_{X,meas} \rangle$ vs. $\langle m_{X,true} \rangle$ in bins of true $m_X$ with mix of exclusive final states

# Electron Energy Moments: Strategy

PR D69:111104

- Dataset: 47.4 $fb^{-1}$ at Υ(4S) + 9.1 $fb^{-1}$ off-peak
- Select events with 2 electrons
  - "tag-electron": p*>1.4GeV/c [Υ(4S) frame]
    - Veto J/ψ decays
    - $e_{tag}$ predominantly from B→Xeν decays
  - "signal-electron": p*>0.5GeV/c.
    Charge correlation of $e_{tag}$ and $e_{sig}$:
    - $e^{\pm}_{tag} e^{\mp}_{sig}$ : mostly B→Xeν
    - $e^{\pm}_{tag} e^{\pm}_{sig}$ : mostly D→Yeν, $B^0\bar{B}^0$ mixing
- e from secondary decays (same B) suppressed by cutting on $\cos(\theta_{e_{tag}e_{sig}})$
- Combinatorial background subtracted using off-peak data




B→Xτ$^+$ν$_τ$ (τ$^+$→e$^+$ν$_e\bar{ν}_τ$)

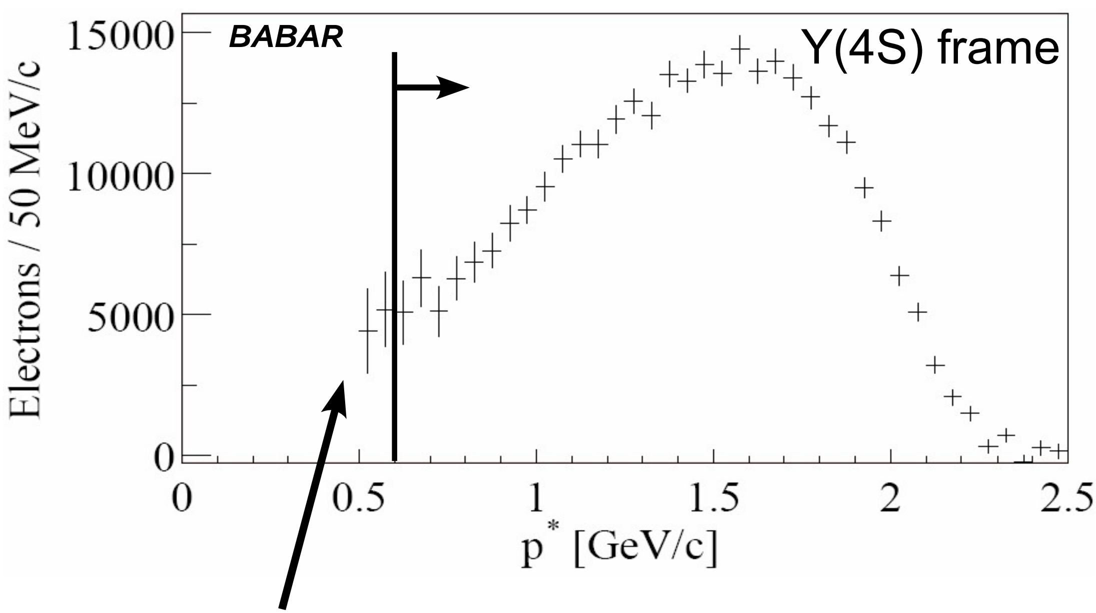
B→D$^{(*)}\bar{D}^{(*)}$K (D$^{(*)}$→Ye$^+$ν$_e$)

B→D$_s^+\bar{D}$ (D$_s^+$→Ye$^+$ν$_e$)

# Electron Energy Spectrum & Moments

PR D69:111104

- Moments calculated from spectrum. Corrected for:
  - $B^0\bar{B}^0$ mixing
  - Electron efficiency
  - Interaction with detector material (Bremsstrahlung)
  - B movement
  - Final state radiation
  - $B \to X_u e \nu$ background




$B \to X e \nu(\gamma)$ spectrum after correction for efficiency and Bremsstrahlung

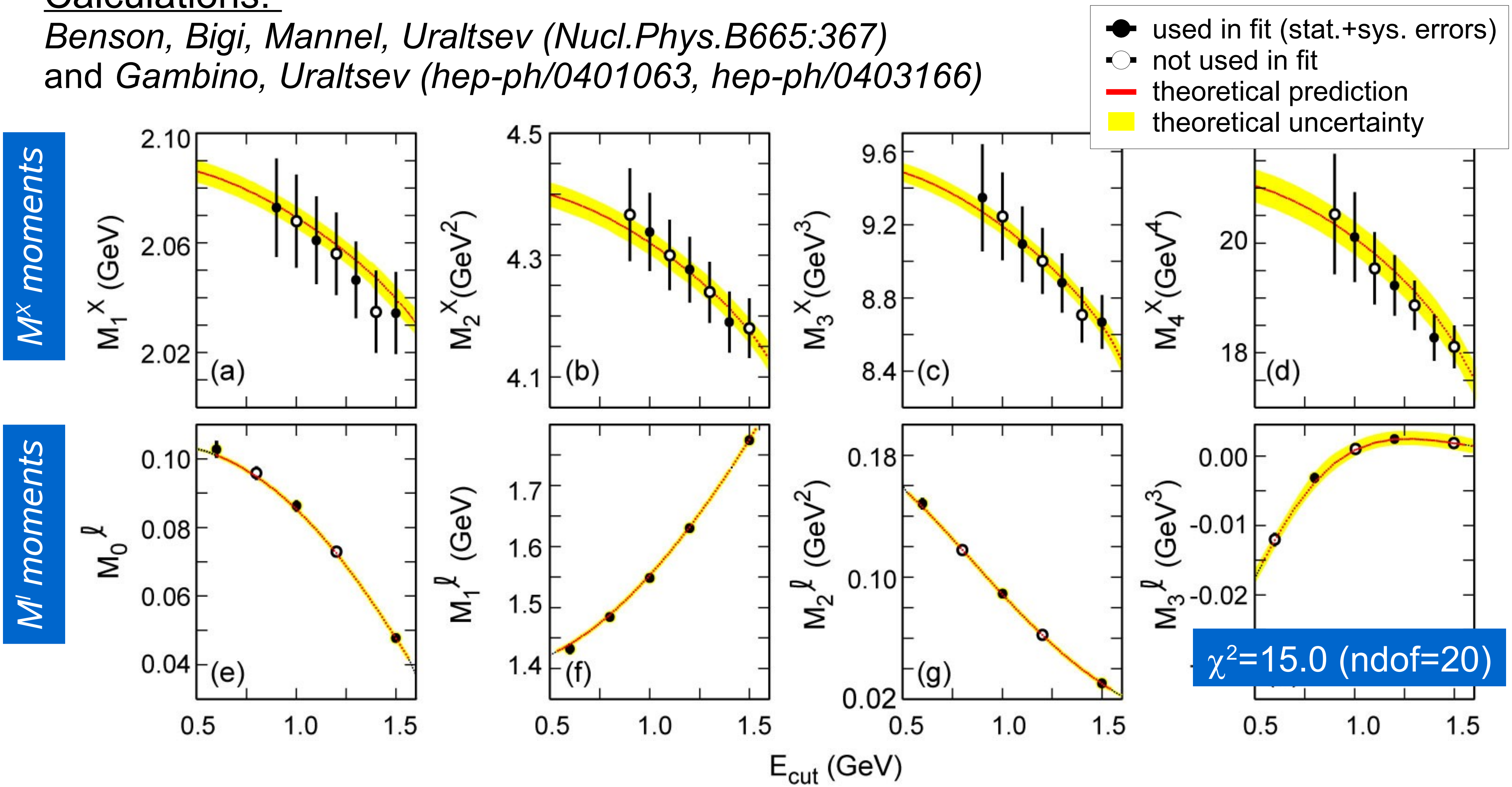
Partial branching fraction:

$\Delta Br\ (B \to X e \nu(\gamma),\ E_e > 0.6\ \text{GeV})$
$= (10.36 \pm 0.06\ (\text{stat.}) \pm 0.23\ (\text{sys}))\%$

# Combined Fit to $E_e$ and $M_x$ Moments

PRL 93:011803

- 8 fit parameters: $|V_{cb}|, Br(B \to X_c l \nu), m_b, m_c, \mu_\pi^2, \mu_G^2, \rho_D^3, \rho_{LS}^3$
- 27 measured moments used: 0th-3th $E_e$ moments, 1th-4th $M_x$ moments (highly corr.)
- Calculations:
  *Benson, Bigi, Mannel, Uraltsev (Nucl.Phys.B665:367)*
  and *Gambino, Uraltsev (hep-ph/0401063, hep-ph/0403166)*



# Combined Fit: Results

PRL 93:011803

$$
\begin{aligned}
|V_{cb}| &= (41.390 \pm 0.437_{exp} \pm 0.398_{HQE} \pm 0.150_{\alpha_s} \pm 0.620_{\Gamma}) \cdot 10^{-3} \\
BR_{cl\,\nu} &= (10.611 \pm 0.163_{exp} \pm 0.063_{HQE} \pm 0.000_{\alpha_s})\% \\
m_b &= (4.611 \pm 0.052_{exp} \pm 0.041_{HQE} \pm 0.015_{\alpha_s})\, GeV/c^2 \\
m_c &= (1.175 \pm 0.072_{exp} \pm 0.056_{HQE} \pm 0.015_{\alpha_s})\, GeV/c^2
\end{aligned}
$$

2% uncertainty ($|V_{cb}|$)

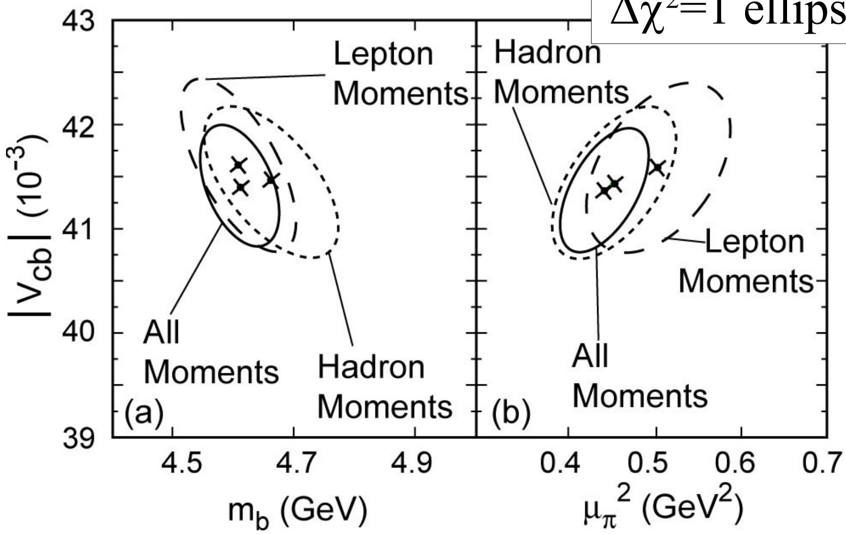
1.5% uncertainty ($m_b$)

additional 1.5% error on $\Gamma$

$\mu = 1 GeV$

- HQE predictions agree very well with measurements
- Separate fits to $E_l$ and $M_x$ moments are in good agreement
- Fit results compatible with external knowledge from B-B* mass splitting ($\mu_G^2$) and heavy-quark sum rules ($\rho_{LS}^3$)

$\Delta\chi^2=1$ ellipses



# $|V_{ub}|$

# Inclusive $B \to X_u l\nu$ Decays: Experimental Problems

- Experimental problems:
  - CKM suppressed, large $b \to cl\nu$ background
- HQE does not provide local prediction of differential rates: Poor convergence in the region where $b \to cl\nu$ background kinematically forbidden
- Non-perturbative *Shape Function (SF)* needed to extrapolate to full spectrum
  - Light-cone momentum distribution of b quark: $F(k^+)$
  - Cannot be calculated but can be measured:
    - Photon energy distribution in $b \to s\gamma$:
      Compute kinematic acceptance $f_u$: $\Delta Br = f_u \cdot Br$
      Use HQE to calculate $|V_{ub}|$
      (De Fazio-Neubert, JHEP 06:17 (1999); Limosani-Nozaki, hep-ex/0407052 )
    - HQ parameters derived from $b \to cl\nu$ moments:
      Translate partial branching fraction in partial rate
      Theory relates partial rate directly to $|V_{ub}|$
      (Bosch-Lange-Neubert-Paz, Nucl. Phys. B699:335 (2004); Neubert, hep-ph/0412241)

# Inclusive $B \to X_u l\nu$ Decays: Experimental Techniques

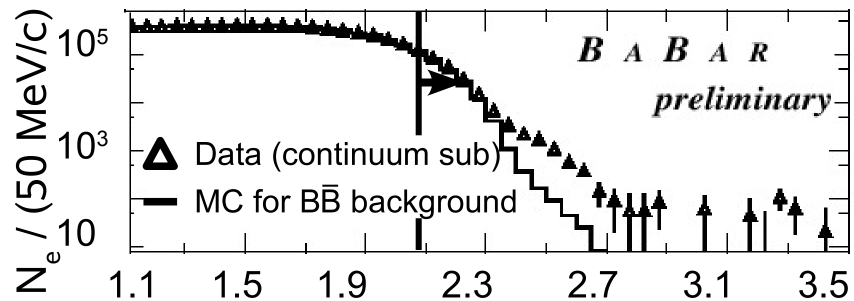
- Three different techniques to measure $|V_{ub}|$ inclusively
- Different signal to background ratios and efficiencies

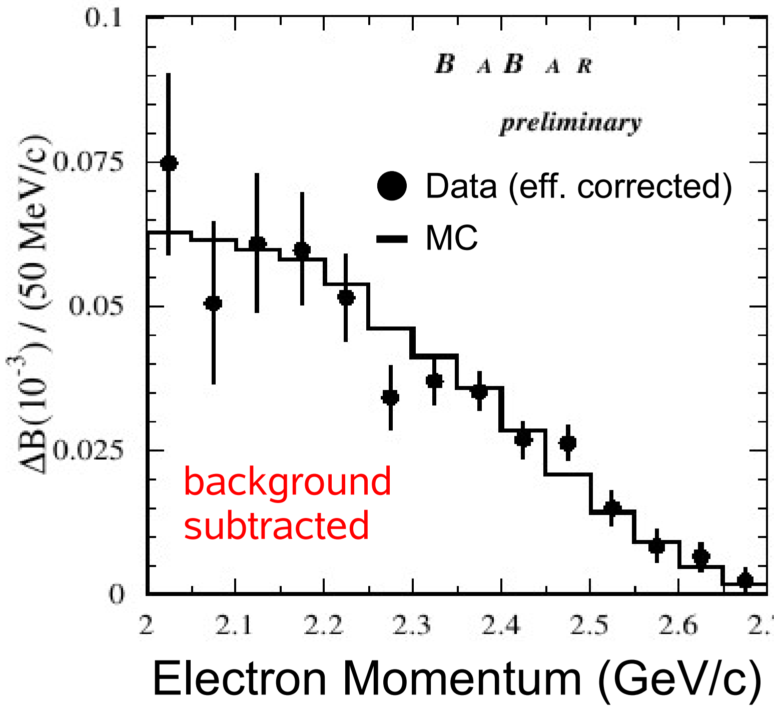
| | S/B | ~eff. |
|---|---|---|
| Electron energy spectrum near the kinematic endpoint | 1/14 | 35% |
| $q^2$-$E_l$ with neutrino reconstruction | 1/2 | 20% |
| $m_X$, $q^2$-$m_X$ on the recoil of fully reconstructed B meson | 2 | (0.4*34)% |

# Electron Endpoint Spectrum

hep-ex/0408075

- Dataset: 88 million $B\bar{B}$ decays
- Select one $e^{\pm}$ with $2.0 \le p^* \le 2.6$GeV/c
- Cuts on $p_{miss}$ and event shape
- Modeling of background crucial
  - Off-peak data for non-$B\bar{B}$ background
  - Fit $E_e$ spectrum with simulated $b \to u\ell\nu$, $B \to D^{(*)}\ell\nu$, $B \to D^{**}\ell\nu$, $B \to D^{(*)}\pi\ell\nu$
  - Correct spectrum for efficiency, radiative effects, and B momentum
- Main sources of systematic uncertainties:
  - Signal modeling (8%)
  - Event selection efficiency (6%)
  - $B \to D^{(*,**)}\ell\nu$ modeling (3%)




$$\Delta Br_{2.0\text{-}2.6GeV} = (5.31 \pm 0.32_{stat} \pm 0.49_{syst})10^{-4}$$

extrapolation factor → $f_u = 0.246 \pm 0.031$

(using SF derived from BELLE $b \to s\gamma$ spectrum)

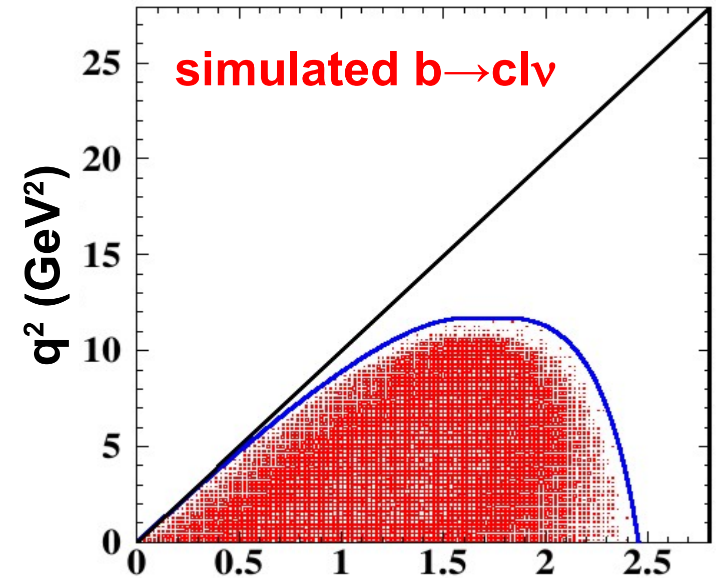
# $q^2$-$E_l$ With Neutrino Reconstruction

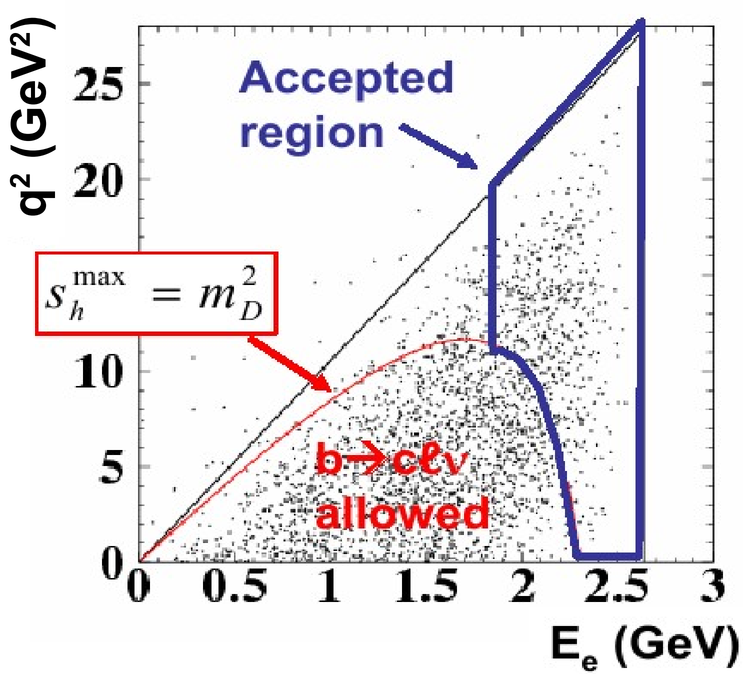
hep-ex/0408045

- Dataset: 88 million $B\bar{B}$ decays
- Require one $e^{\pm}$ with $p^* \geq 2.0$GeV
- Cuts on $E_{miss}$-$p_{miss}$, $p_{miss,}$ and event shape
- Estimate $p_\nu$ from bias corrected $p_{miss}$
- Combined cut on $q^2=(p_e+p_\nu)^2$ and $E_e$ to suppress $b\to c\ell\nu$ background

$$s_h^{max} = m_B^2 + q^2 - 2m_B\left(E_e - \frac{q^2}{4E_e}\right) < m_D^2$$

+ small modifications for B boost

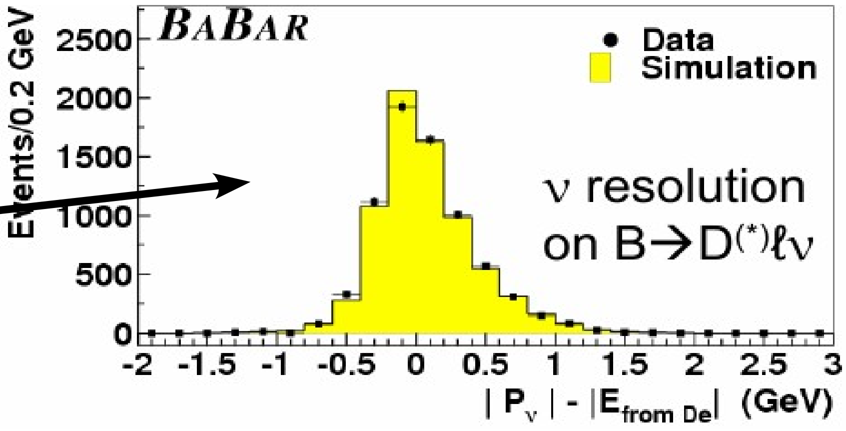


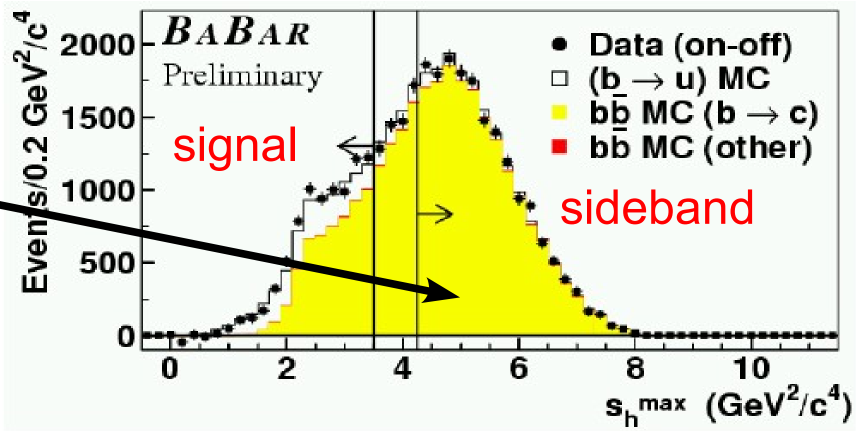



# $q^2$-$E_l$ With Neutrino Reconstruction

hep-ex/0408045

- Utilize control sample of reconstructed $B \to D\ell\bar{\nu}(X)$:
  - Verify neutrino reconstruction
  - Improve modeling of $b \to c\ell\nu$ background
- Subtract background
  - Non-$B\bar{B}$ taken from off-peak data
  - Simulated $B\bar{B}$ background normalized by $s_h^{max}$ sideband
- Systematic uncertainties:
  - Neutrals (6%),
  - Energy from $K_L^0$ (7%),
  - Stability tests (12%),
  - Background (7%),
  - Signal modeling (5%)




$$\Delta Br_{E_e > 1.9 GeV,\ s_h^{max} < 3.5 GeV^2} = \left(4.46 \pm 0.42_{stat} \pm 0.83_{syst}\right) \cdot 10^{-4}$$
$$f_u = 0.163 \pm 0.010$$

(using SF derived from BELLE $b \to s\gamma$ spectrum)

# Recoil Analyses ($m_X$ & $q^2$-$m_X$)

hep-ex/0408068

- Use same recoil technique as for $b \to c \ell \nu$ $m_X$-moments
- Require recoiling lepton with p*>1GeV/c
- $m_X$ measured from remaining particles (kinematically fitted)
- Suppress background from $b \to c \ell \nu$ by vetoing $D^{(*)}$ decays
  - Reject events with $K^{\pm}$ and $K_s$
  - $B^0 \to D^*(\to D^0 \pi^+) \ell \nu$ decays: D* momentum can be estimated from $\pi^+$ alone
    - Calculate $m_\nu^2 = (p_B - p_{D^*} - p_\ell)^2$ for all $\pi^+$
    - Reject events consistent with neutrino ($m_\nu^2 = 0$)

# Recoil Analyses: $m_X$

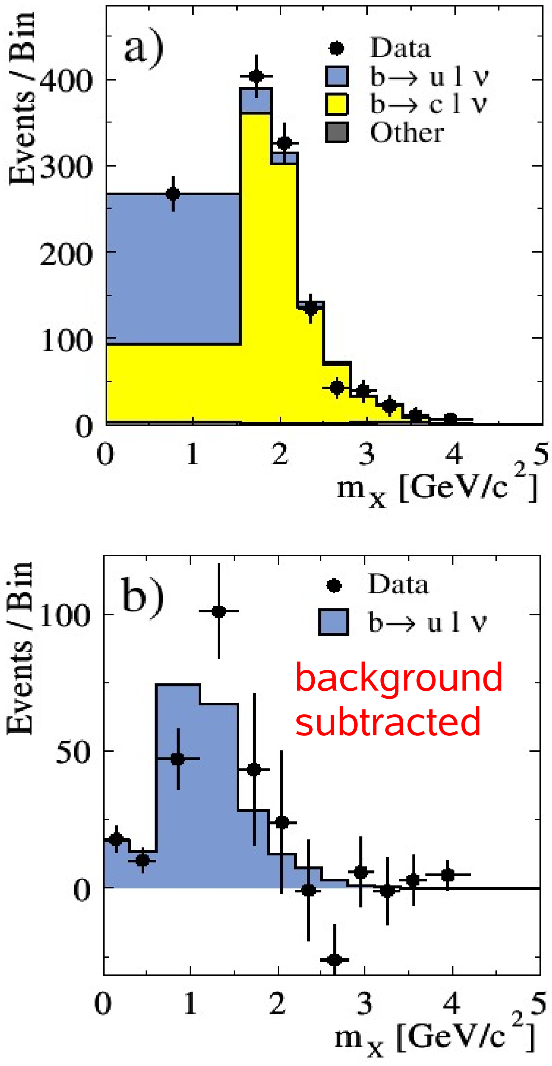
hep-ex/0408068

- Dataset: 88 million $B\bar{B}$ decays
- $m_X < 1.55 GeV/c^2$
- Fit simulated signal and backgr. shapes to measured spectrum

$$\frac{Br_{B\to X_u l\nu}}{Br_{B\to X_u l\nu}} = \left(2.81 \pm 0.32_{stat} \pm 0.31_{syst} \, {}^{+0.23}_{-0.21(theo)}\right)\cdot 10^{-2}$$

$$|V_{ub}| = \left(5.22 \pm 0.30_{stat} \pm 0.31_{syst} \, {}^{+0.22}_{-0.20(SF)} \pm 0.25_{pert+1/mb^3}\right)\cdot 10^{-3}$$

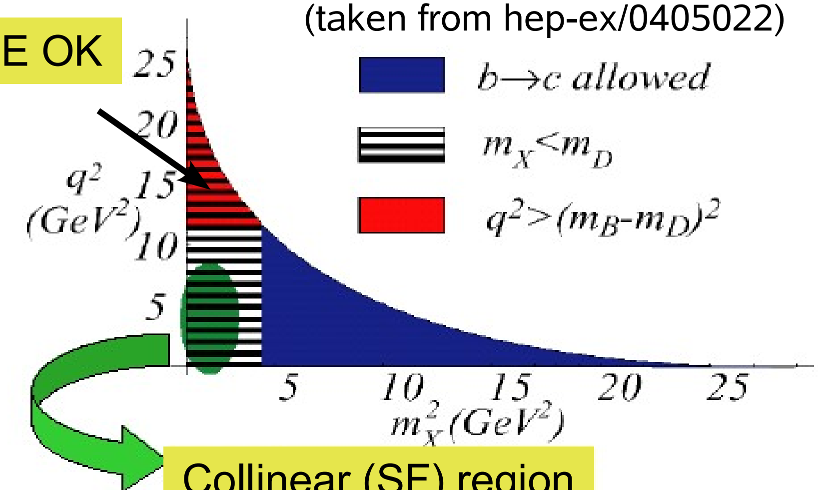
(using SF derived from BELLE b→sγ spectrum)



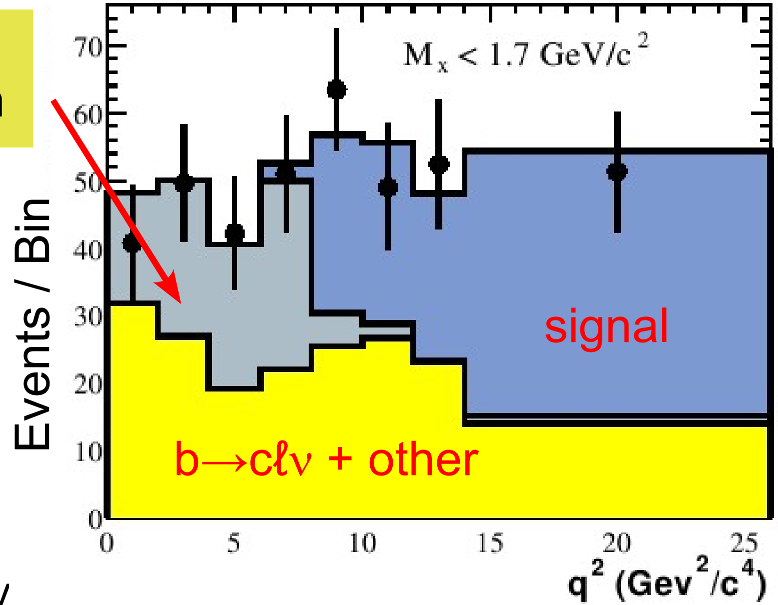
# Recoil Analyses: $q^2$-$m_X$

hep-ex/0408068

- Introduce additional cut on $q^2$ to reduce SF dependence
  - $q^2 > 8 GeV^2$ & $m_X < 1.7 GeV/c^2$
- 2D fit in bins of $m_X$ to extract $\Delta Br$
- Main exp. systematic:
  - Detector (10%)
  - Stability Tests (7%)
  - Background (7%)




downfeed from different $m_X$ bin




$$\Delta Br_{m_X < 1.7 GeV, q^2 > 8 GeV^2} = \left(8.96 \pm 1.43_{stat} \pm 1.44_{syst}\right) \cdot 10^{-4}$$

$$f_u = 0.300^{+0.023}_{-0.028}$$

$$f_u = 0.325 \pm 0.061$$

Pure OPE calculation can be applied
*(Bauer, Ligeti Luke, hep-ph/0111387)*

using SF deriv
BELLE b→sγ spectrum

# Summary of BABAR $|V_{ub}|$ Measurements

Using $\mathbf{m_b = 4.63 \pm 0.08}$**GeV** and $\boldsymbol{\mu_\pi^2}$**(SF) = 0.15 ± 0.07GeV²**
(correlation: -0.4)

| errors: | | expt ± SF ± theory | expt ± (SF + theory) |
|---|---|---|---|
| Method | $\Delta Br \times 10^{-4}$ | $\lvert Vub\rvert\ 10^{-3}$ (BLNP) (SF params from $b \to c l \nu$) | $\lvert Vub\rvert\ 10^{-3}$ (ICHEP) (DFN, BELLE $b \to s \gamma$) |
| Endpoint | 5.31 ± 0.59 | 3.93 ± 0.34 ± 0.38 ± 0.18 (8.7 ± 9.7 ± 4.6)% | 4.40 ± 0.24 ± 0.35 ( ± 6.4 ± 8.6)% |
| $q^2$-$E_l$ | 4.46 ± 0.93 | 3.89 ± 0.40 ± 0.45 ± 0.21 (10.3 ± 11.5 ± 5.4)% | 4.99 ± 0.48 ± 0.29 ( ± 9.6 ± 5.8)% |
| $q^2$-$M_x$ | 8.96 ± 2.04 | 4.45 ± 0.49 ± 0.40 ± 0.22 (11.1 ± 9.0 ± 4.9)% | 5.18 ± 0.57 ± 0.34 ( ± 11.0 ± 6.5)% |
| Average | | 4.07 ± 0.51 (± 12.5)% | 4.61 ± 0.46 ( ± 10.0)% |

significant change in inclusive $|V_{ub}|$ value

# Exclusive $B \to X_u l\nu$ Decays: Experimental Techniques

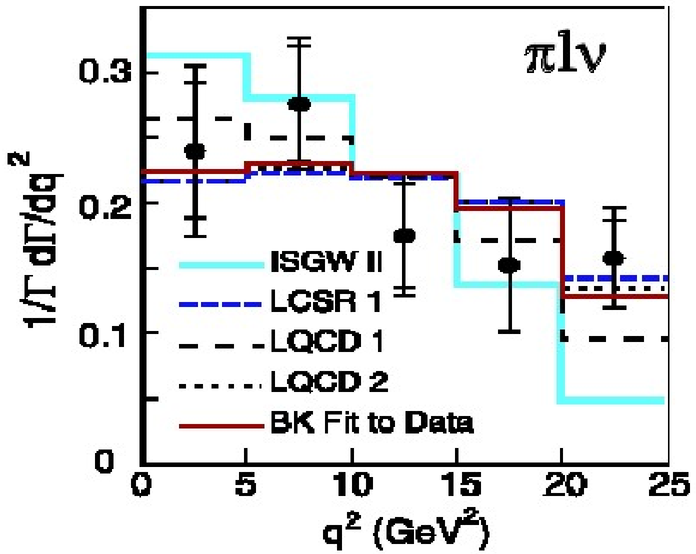
- $B_{reco}$ tags (ICHEP04)
- Semileptonic tags ($82 fb^{-1}$)
  - Reconstruct $B \to D^{(*)} l\nu$ and study semileptonic recoil

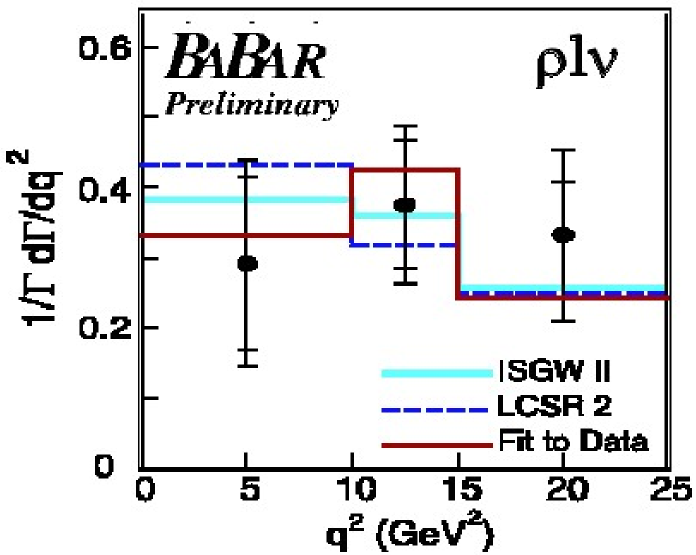
$$Br(B^+ \to \pi^0 l^+ \nu) = (1.80 \pm 0.37_{stat} \pm 0.23_{syst}) \cdot 10^{-4}$$
$$Br(B^0 \to \pi^- l^+ \nu) = (1.03 \pm 0.25_{stat} \pm 0.13_{syst}) \cdot 10^{-4}$$

  - Currently statistically limited
- Untagged ($76 fb^{-1}$)
  - Neutrino reconstruction: reconstruct $\nu$ from full event, ensure good reco. quality
  - Fit FF shape in bins of $q^2$

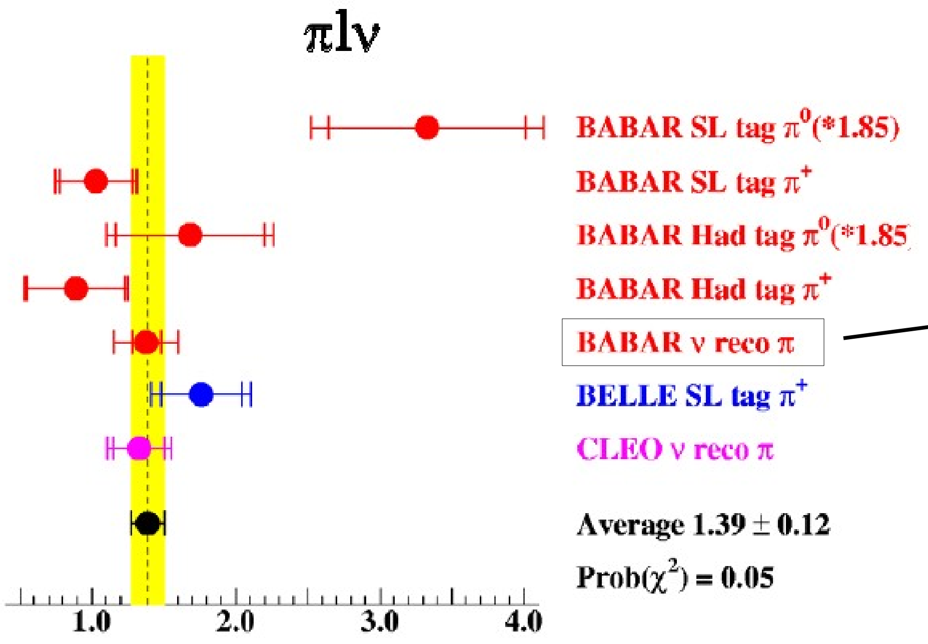
$$Br(B^0 \to \pi^- l^+ \nu) = (1.38 \pm 0.10_{stat} \pm 0.17_{syst} \pm 0.08_{FF}) \cdot 10^{-4}$$
$$Br(B^0 \to \rho^- l^+ \nu) = (2.14 \pm 0.21_{stat} \pm 0.51_{syst} \pm 0.28_{FF}) \cdot 10^{-4}$$

  - Sys. error dominated by $\nu$ reconstruction



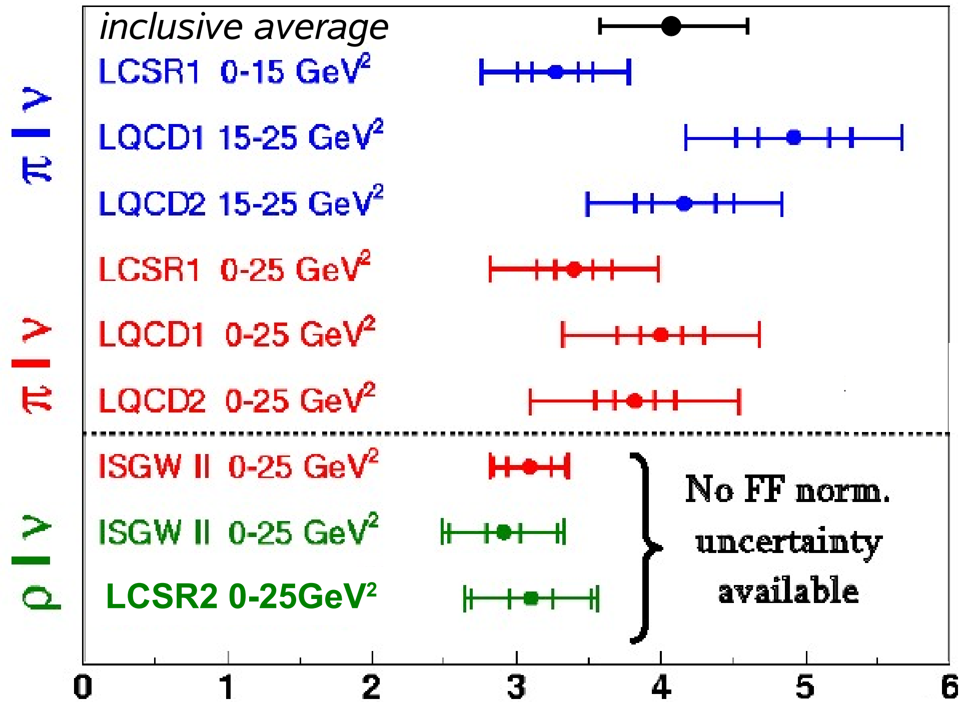



# Exclusive B→$X_u$lν Decays: Summary




BF(B→πlν) (x$10^4$)

inclusive average: $|V_{ub}|$ = (4.07 ± 0.51) $10^{-3}$




|Vub| (x$10^3$)

LCSR $q^2$<15GeV2, LQCD $q^2$>15GeV
or extrapolation to whole $q^2$ range

Light Cone Sum Rules (LCSR)
*(Ball-Zwicky, Phys.Rev.D71:014015, Phys.Rev.D71:014029,2005)*
New unquenched LQCD2 calculations
(*HPQCD'04, FNAL'04*)

# Summary & Outlook

- $|V_{cb}|$ measured using $m_X$ and $E_l$ moments:

  $$|V_{cb}| = \left(41.4 \pm 0.4_{\exp} \pm 0.4_{HQE} \pm 0.6_{th}\right) \cdot 10^{-3}$$

  - Combined HQE fit shows very good agreement with measurements
  - Improved calculation of $\Gamma$ will reduce theoretical error
- Three different techniques to measure $|V_{ub}|$ inclusively
  - Experimental systematics can be improved for all of them

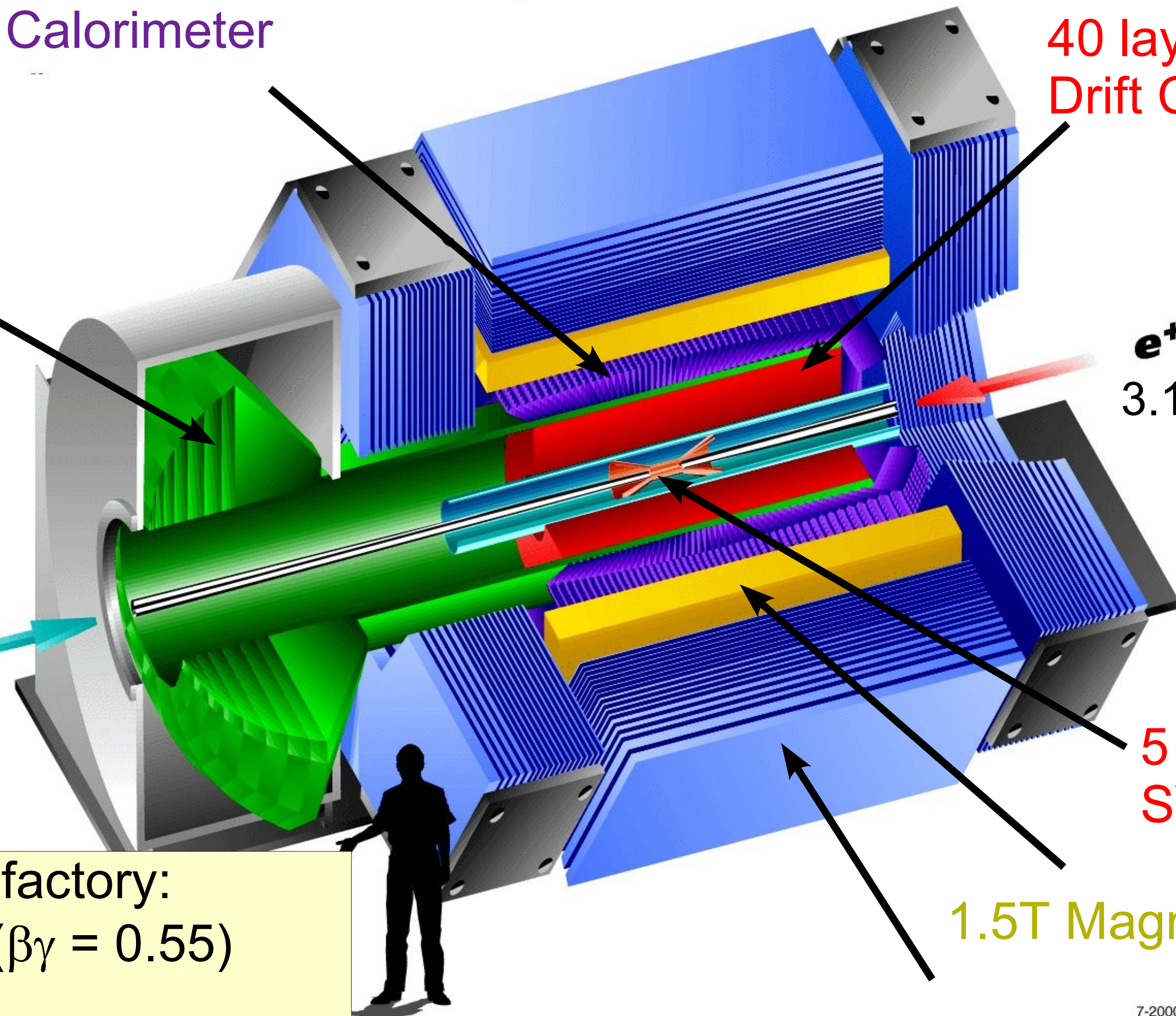
    preliminary:

    $$|V_{ub}| = \left(4.07 \pm 0.51\right) \cdot 10^{-3}$$

  - Statistical error can be improved especially for $q^2$-$E_l$ and recoil analyses
  - Significant change in inclusive $|V_{ub}|$ values when changing shape function parameters to the ones determined from $b \to c\ell\nu$ moments
- New exclusive $|V_{ub}|$ measurements with SL tags and untagged

# *Backup Slides*

# The BABAR Detector



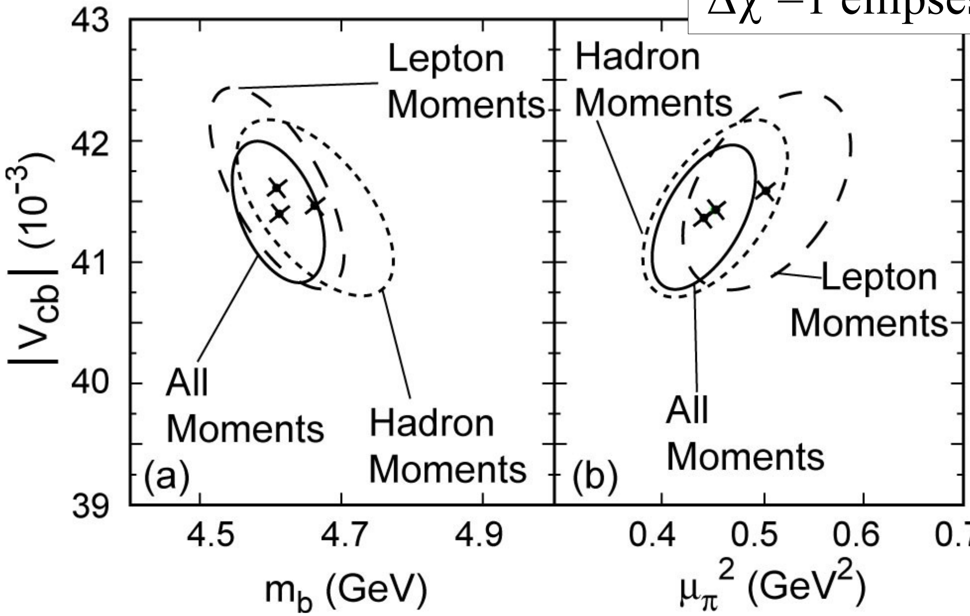

- PEP-II asymmetric B factory: 9GeV $e^-$ / 3.1GeV $e^+$ ($\beta\gamma = 0.55$)
- $E_{CM}$ = 10.58GeV
- Peak luminosity: 9.213 x $10^{33} cm^{-2} s^{-1}$
- Recorded luminosity: ~253$fb^{-1}$

# Combined Fit: Consistency Check

PRL 93:011803

- $\alpha_s$ corrections calculated
  - up to order $\alpha_s^2\beta_0$ for $E_l$ moments and $\Gamma_{SL}$
  - up to order $\alpha_s$ for $M_x$ moments

$\Delta\chi^2$=1 ellipses




- Comparable sensitivity of fit parameters to $m_X$ and $E_l$ moments
  - $M_x$: higher sensitivity but higher experimental uncertainty
  - $E_l$: lower sensitivity but more precise measurement
- Separate fits to $E_l$ and $M_x$ moments are in good agreement

# Combined Fit: Results

PRL 93:011803

additional 1.5% error on $\Gamma$

2% uncertainty → $|V_{cb}|$

1.5% uncertainty → $m_b$

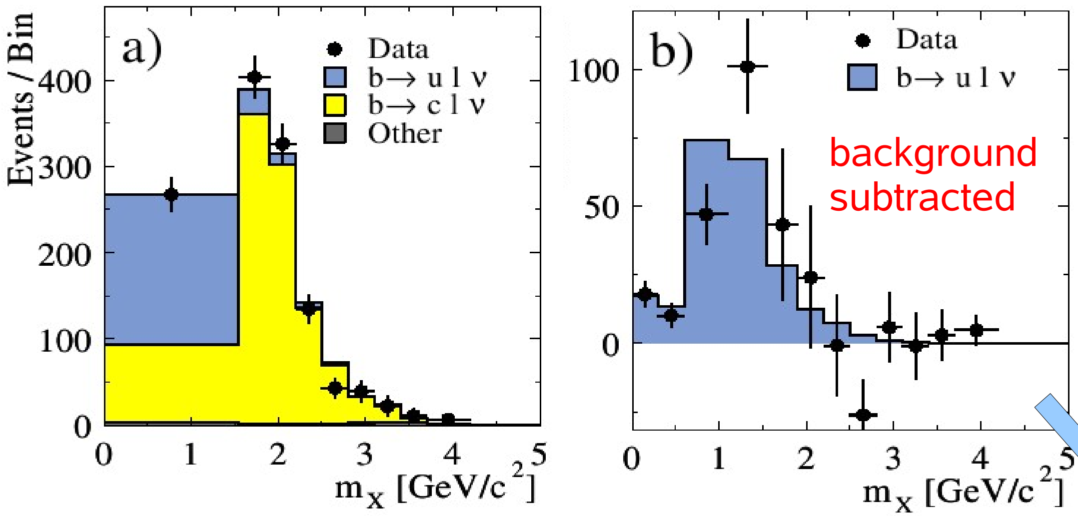
$$
\begin{aligned}
|V_{cb}| &= (41.390 \pm 0.437_{exp} \pm 0.398_{HQE} \pm 0.150_{\alpha_s} \pm 0.620_{\Gamma}) \cdot 10^{-3} \\
BR_{cl\nu} &= (10.611 \pm 0.163_{exp} \pm 0.063_{HQE} \pm 0.000_{\alpha_s}) \% \\
m_b &= (4.611 \pm 0.052_{exp} \pm 0.041_{HQE} \pm 0.015_{\alpha_s}) GeV/c^2 \\
m_c &= (1.175 \pm 0.072_{exp} \pm 0.056_{HQE} \pm 0.015_{\alpha_s}) GeV/c^2 \\
m_b - m_c &= (3.436 \pm 0.025_{exp} \pm 0.018_{HQE} \pm 0.010_{\alpha_s}) GeV/c^2 \\
\mu_\pi^2 &= (0.447 \pm 0.035_{exp} \pm 0.038_{HQE} \pm 0.010_{\alpha_s}) GeV^2 \\
\mu_G^2 &= (0.267 \pm 0.055_{exp} \pm 0.033_{HQE} \pm 0.018_{\alpha_s}) GeV^2 \\
\rho_D^3 &= (0.195 \pm 0.023_{exp} \pm 0.018_{HQE} \pm 0.004_{\alpha_s}) GeV^3 \\
\rho_{LS}^3 &= (-0.085 \pm 0.038_{exp} \pm 0.072_{HQE} \pm 0.010_{\alpha_s}) GeV^3
\end{aligned}
$$

$\mu = 1 GeV$

- HQE prediction agree very well with BABAR measurements
- Fit results compatible with external knowledge:
  - $\mu_G^2 = (0.35 \pm 0.07) GeV^2$ B-B* mass splitting
  - $\rho_{LS}^3 = (-0.15 \pm 0.10) GeV^3$ heavy-quark sum rules

# Recoil Analyses: $m_X$ & Unfolding

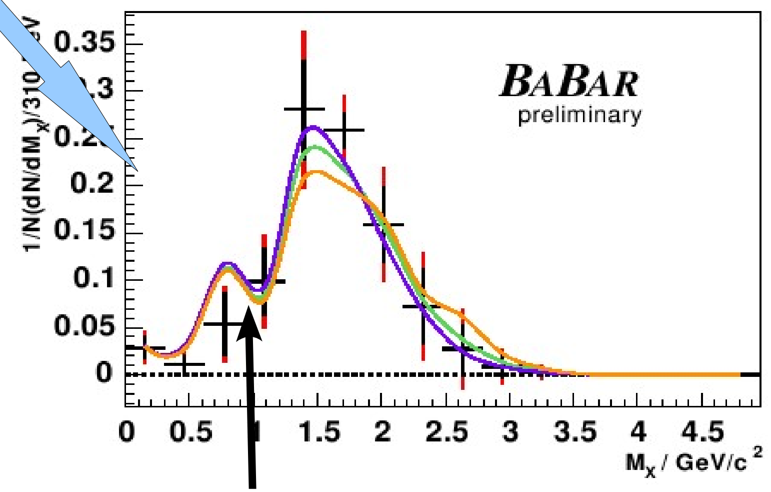
hep-ex/0408068




- Dataset: 88 million $B\bar{B}$ decays
- $m_X < 1.55 GeV/c^2$
- Fit simulated signal and backgr. shapes to measured spectrum

Unfold

- Unfold $m_X$ spectrum to correct for detector effects
- Moments of unfolded spectrum carry information about SF parameters
- *More data needed ...*




SF derived from BELLE $b \to s\gamma$ spectrum