Summary Working Group 2

Christoph Schwanda for the WG2 convenors

Theory: Thomas Mannel (Siegen), Shoji Hashimoto (KEK)
Experiment: Robert Kowalewski (Victoria), CS (Vienna)

WG2 sessions

- Exclusive $b \to u\, l\, \nu$ decays and V_{ub} **Wednesday**
- $b \to s\, \gamma$ spectrum and branching fractions (joint session with WG3)

- Inclusive $b \to c\, l\, \nu$ decays and V_{cb} **Thursday**

- Exclusive $b \to c\, l\, \nu$ decays and V_{cb} **Today**
- Inclusive $b \to u\, l\, \nu$ decays and V_{ub}

Exclusive $b \rightarrow u\, l\, \nu$ decays and V_{ub}

NEW: BaBar B → pi l nu with D(*) l nu tag

211 fb^{-1}

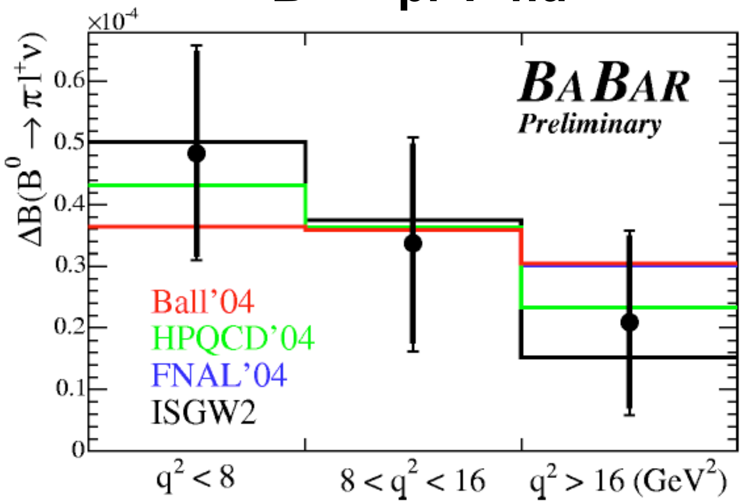
$$\mathcal{B}(B^0 \to \pi^- \ell^+ \nu) = (1.03 \pm 0.25 \pm 0.13) \times 10^{-4}$$

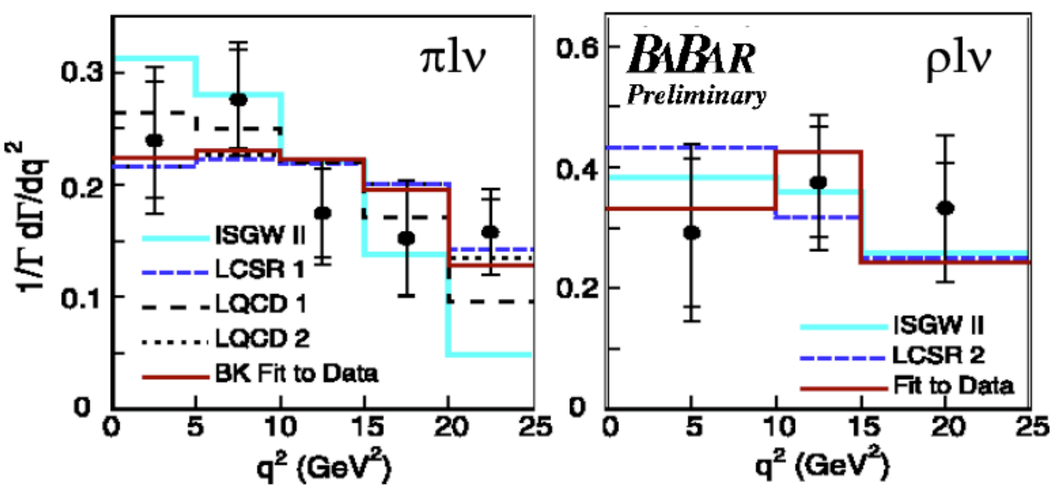
82 fb^{-1}

$$\mathcal{B}(B^+ \to \pi^0 \ell^+ \nu) = (1.80 \pm 0.37 \pm 0.23) \times 10^{-4}$$

NEW: BaBar B → pi/rho l nu untagged

$B^0 \to$ pi$^-$ l$^+$ nu



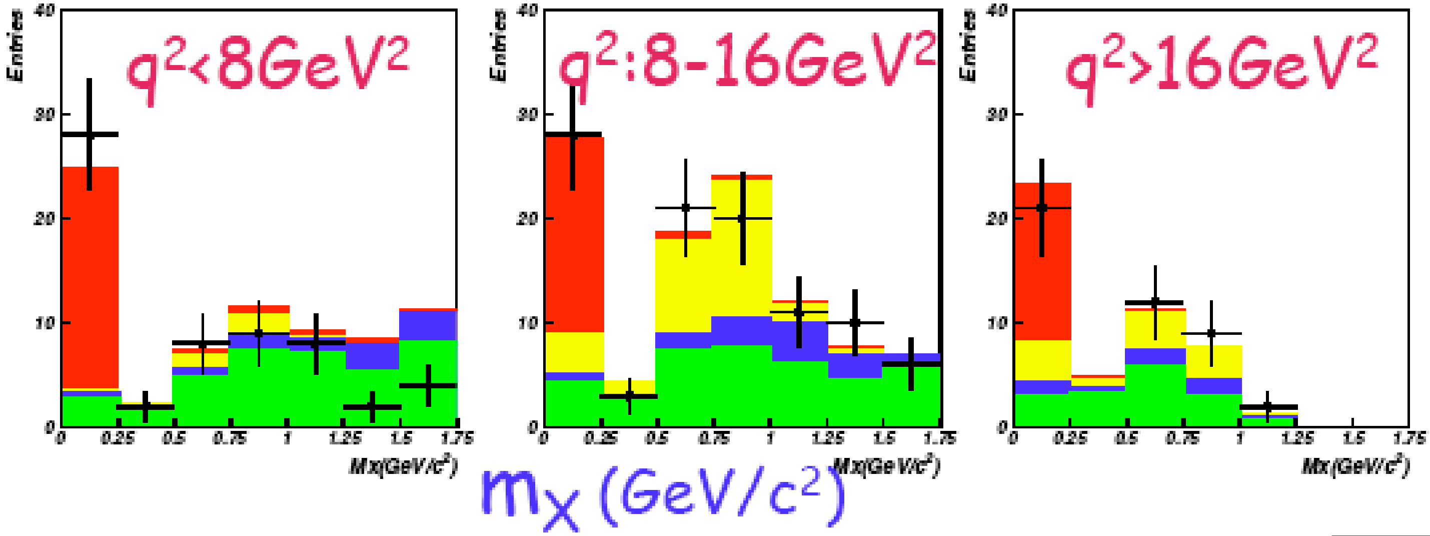


Jochen Dingfelder

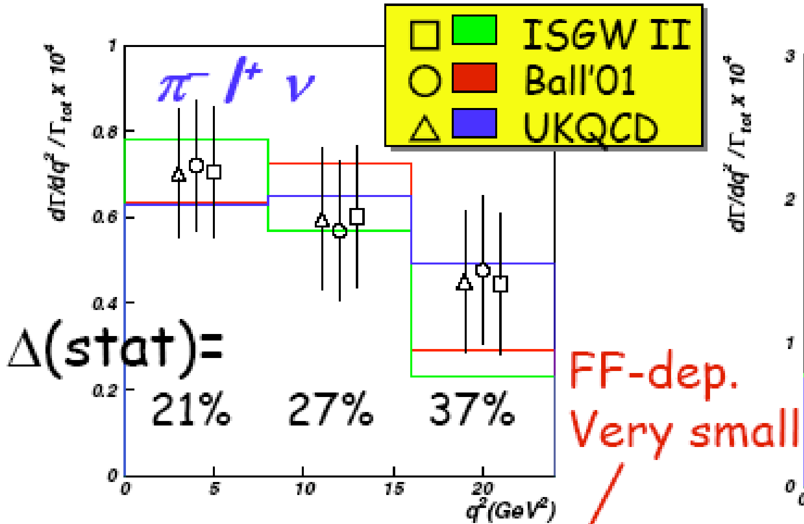
76 fb^{-1}

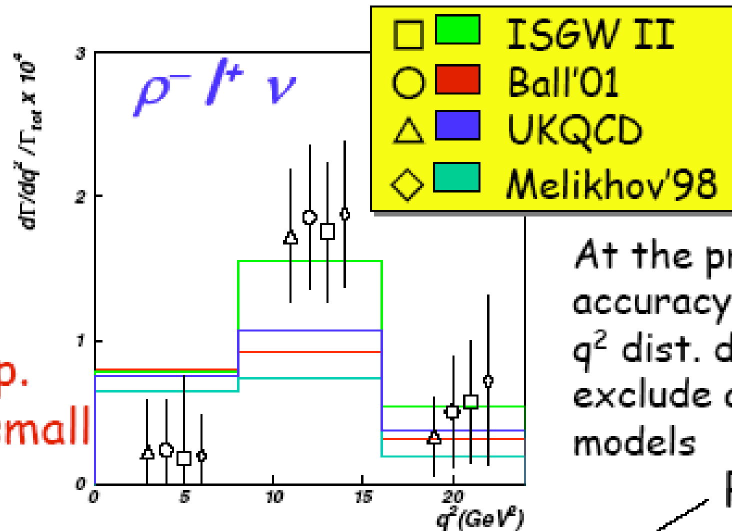
$$\mathcal{B}(B^0 \to \pi^- \ell^+ \nu) = (1.38 \pm 0.10 \pm 0.17 \pm 0.08) \times 10^{-4}$$
$$\mathcal{B}(B^0 \to \rho^- \ell^+ \nu) = (2.14 \pm 0.21 \pm 0.51 \pm 0.28) \times 10^{-4}$$

Belle B → pi/rho l nu with D* l nu tag



Toru Iijima





At the present accuracy, the obtained q^2 dist. does not exclude any tested models

FF-dep.

$$B_{total} = [1.76 \pm 0.28 \pm 0.20 \pm 0.03] \times 10^{-3}$$

$$B_{total} = [2.54 \pm 0.78 \pm 0.85 \pm 0.30] \times 10^{-3}$$

140fb^{-1}
Preliminary

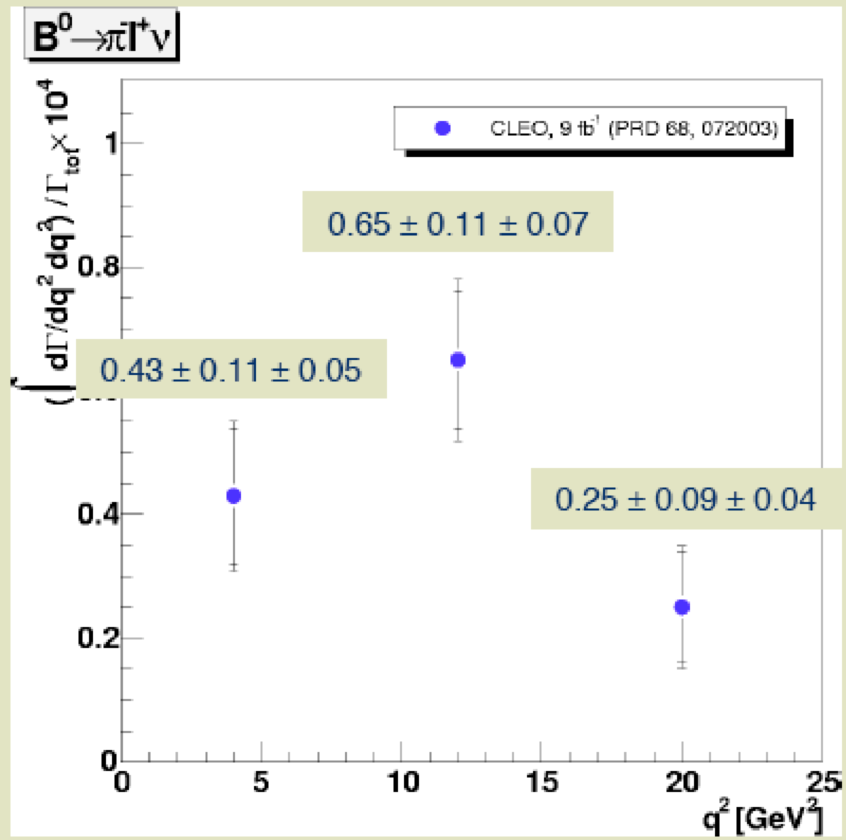
CLEO B → pi/rho/… l nu untagged

Thomas Meyer

π, ρ, η, ω

- Covers complete CLEO $\Upsilon(4S)$ dataset (15.4 M BB evts)
  - Anticipate 15-20% improvement in statistical errors for $\pi l\nu$

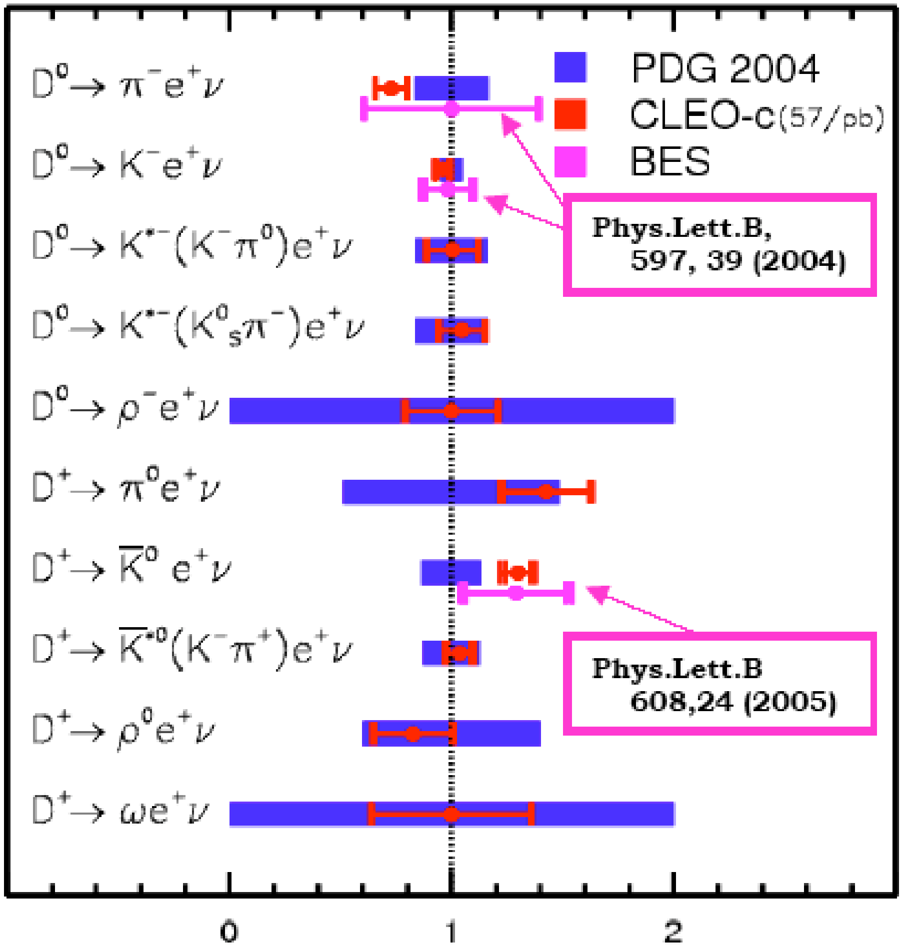
Previous Measurement:
Phys.Rev.D68:072003, 2003



- Expect preliminary results this summer!

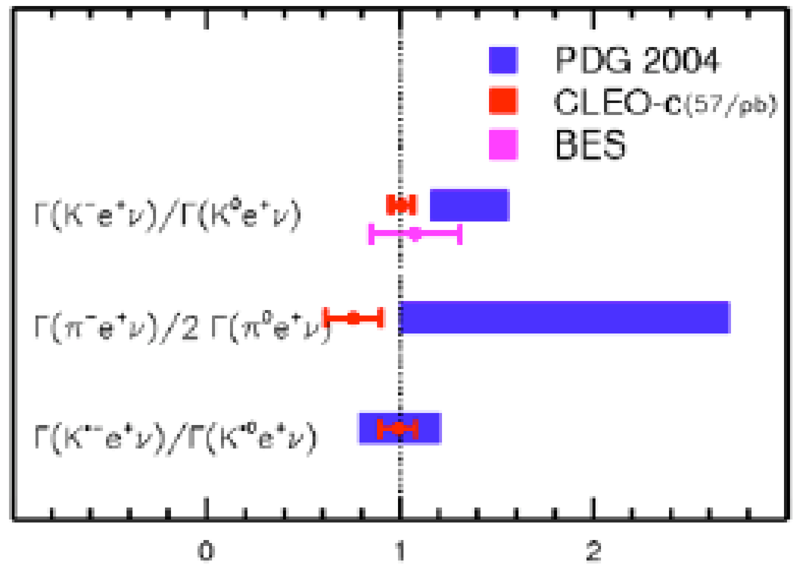
CLEO-c: Exclusive semileptonic D decays with fullrecon tag

Victor Pavlunin



~57/pb

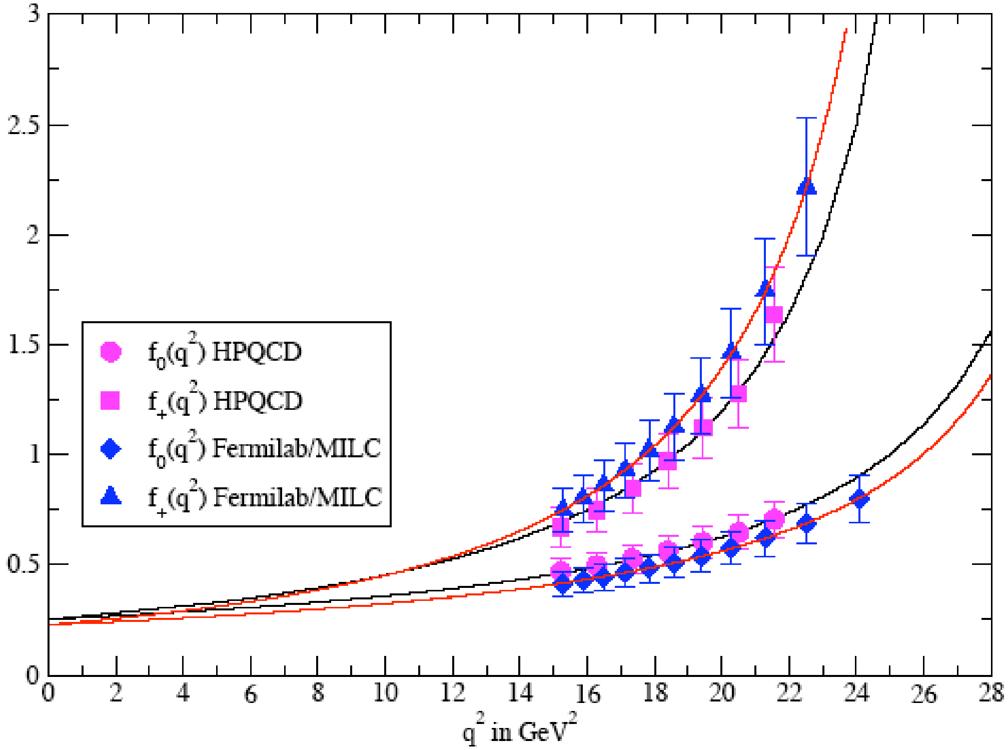
Test of isospin symmetry



- It is hoped to obtain first results for form factors (in $D \to \pi\, e\, \nu$ and $D \to K\, e\, \nu$) for the summer conferences using a larger (~285/pb) data set.

Two new unquenched lattice results for B → pi l nu

Junko Shigemitsu



$$f_+(q^2) = \frac{C_B(1-\alpha_B)}{(1-\tilde{q}^2)(1-\alpha_B\tilde{q}^2)}$$

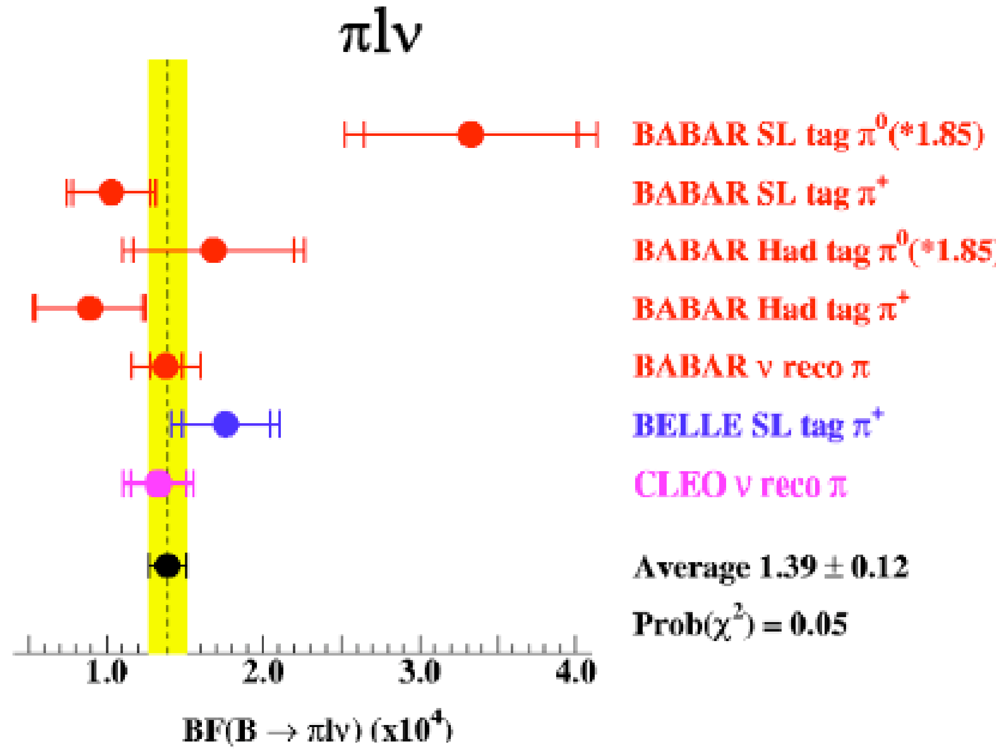
$$f_0(q^2) = \frac{C_B(1-\alpha_B)}{(1-\tilde{q}^2/\beta_B)}$$

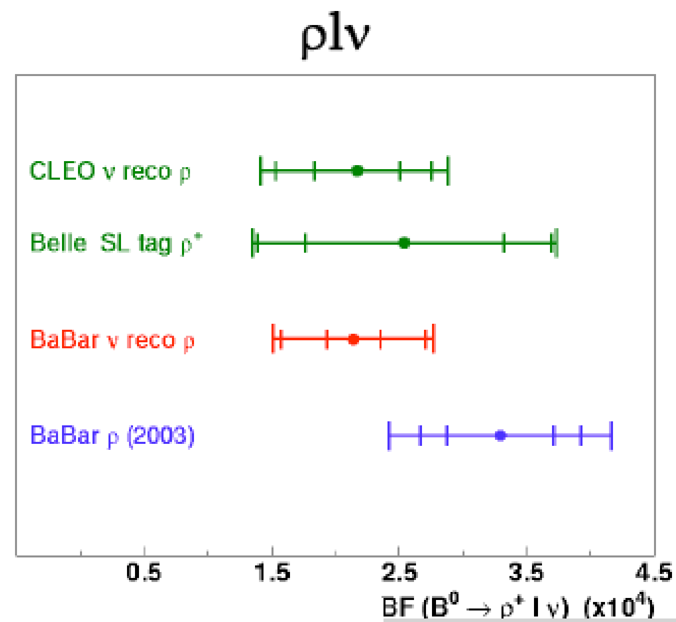
	Fermilab/MILC	HPQCD
α_B	0.63(5)	0.41(7)
β_B	1.18(5)	1.18(5)
$f_{0/+}(0)$	0.23(2)	0.25(2)

- lattice errors are currently at the $10 \sim 14\%$ level.
- with a lot of hard work it should be possible to reduce these errors down to $5 \sim 6\%$.

Mini summary

- Exclusive b → u l nu measurements in bins of q^2 now available from all experiments
- With present statistics, untagged analyses give highest precision, at 500 fb^{-1}, their performance will be similar
- How can we extract Vub from our measurement?



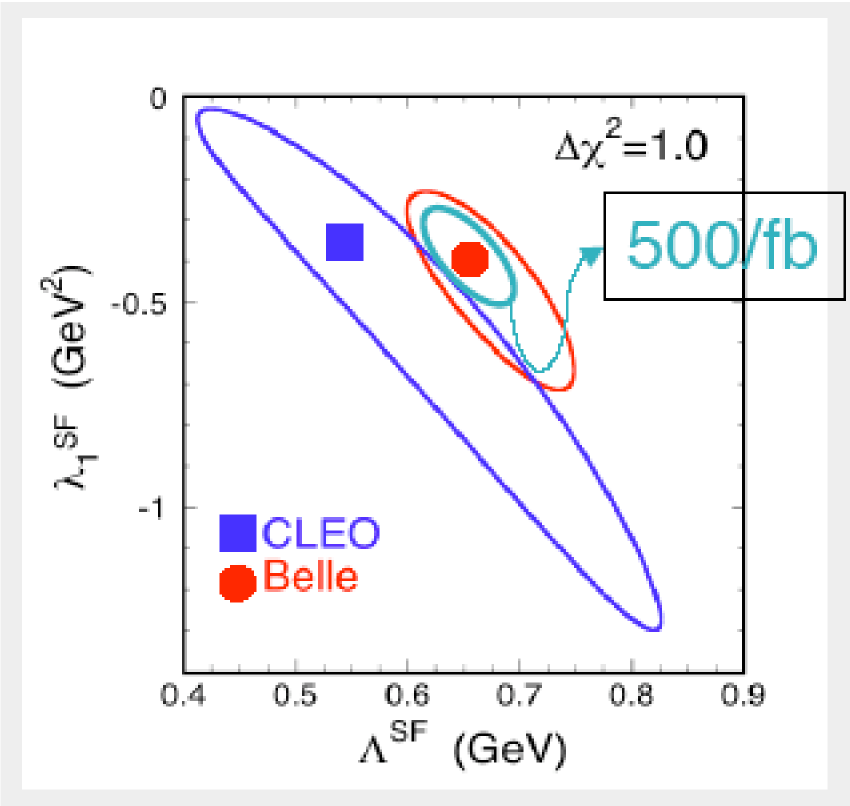


Dan Pirjol

$b \to s\gamma$ spectrum and moments

Belle: Leading-order shape fct parameters from b → s gamma spectrum

Antonio Limosani



140 / fb

$$\Lambda^{SF} = (0.66^{+0.08}_{-0.05})\ \mathrm{GeV}/c^2$$

$$\lambda_1^{SF} = (-0.40^{+0.17}_{-0.31})\ \mathrm{GeV}^2/c^2$$

500 / fb

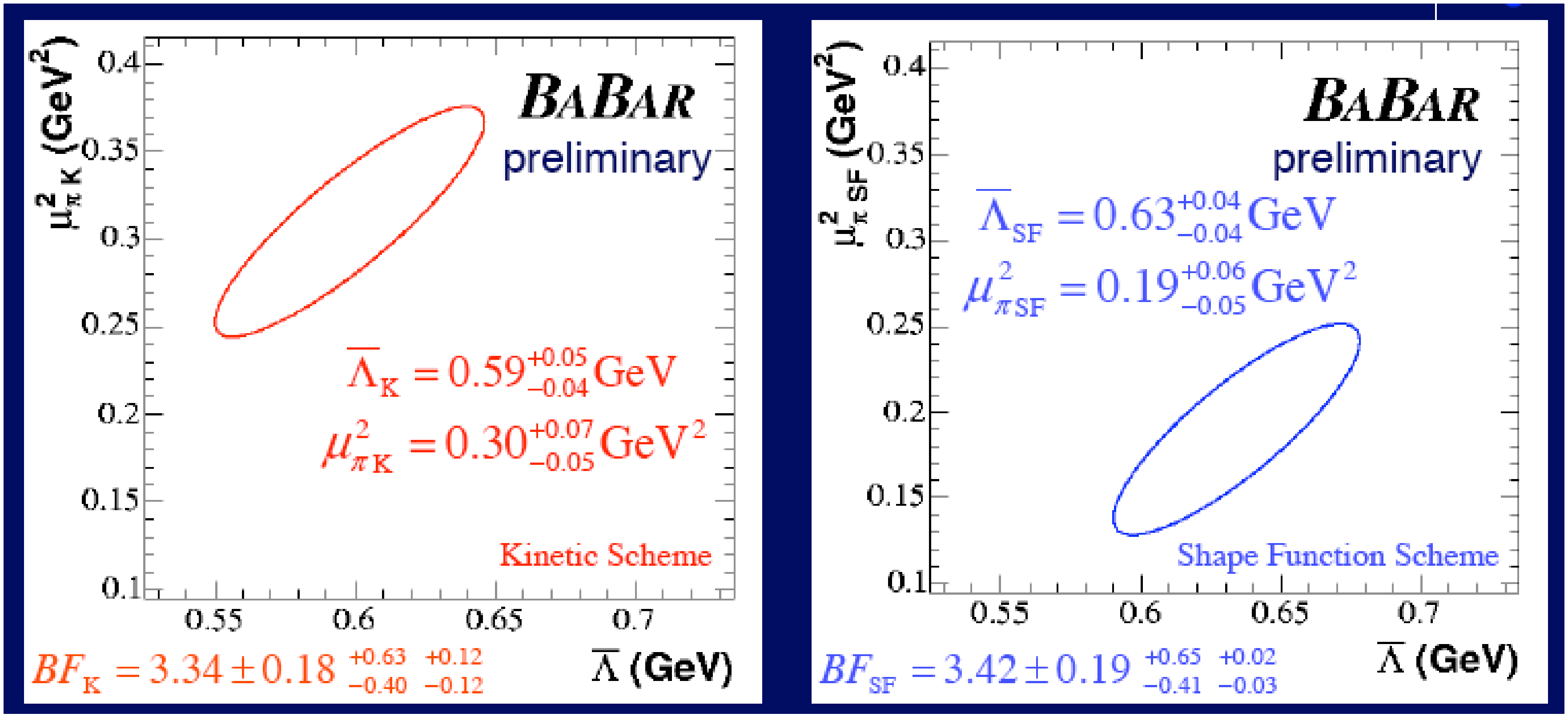
$$\Lambda^{SF} = (0.67^{+0.03}_{-0.03})\ \mathrm{GeV}/c^2$$

$$\lambda_1^{SF} = (-0.43^{+0.11}_{-0.11})\ \mathrm{GeV}^2/c^2$$

$$B(B \to X_u l \nu) = \frac{\Delta B}{f_u},\ \text{where}\ f_u \propto \iiint_{Sel} H(E_l, M_X, q^2) \otimes f(k_+; \Lambda^{SF}, \lambda_1^{SF})$$

BaBar: Fit to new b → s gamma spectrum

Erkcan Ozcan



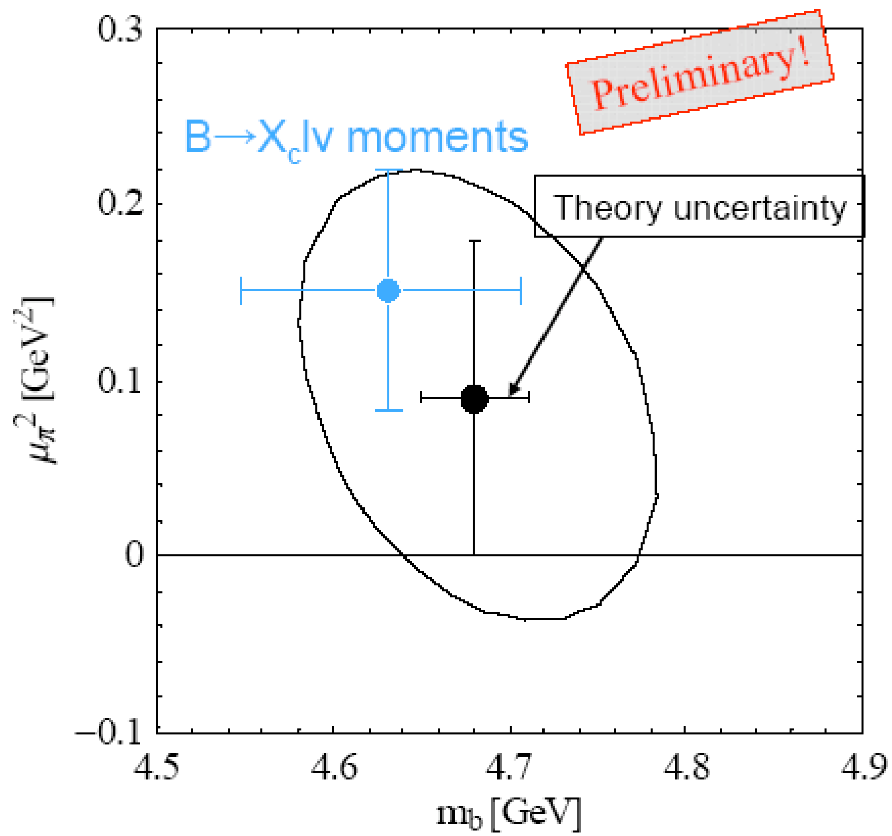
Benson-Bigi-Uraltsev

Neubert

b → s gamma moments

Matthias Neubert

Fit to Belle Data (E_0 = 1.8 GeV)

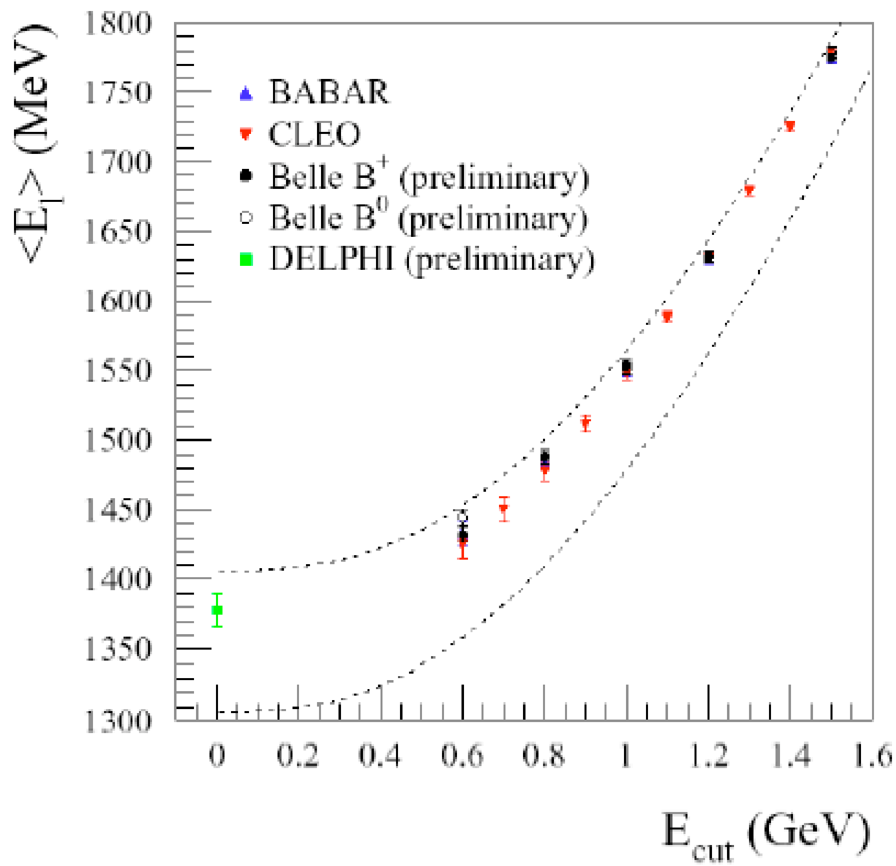


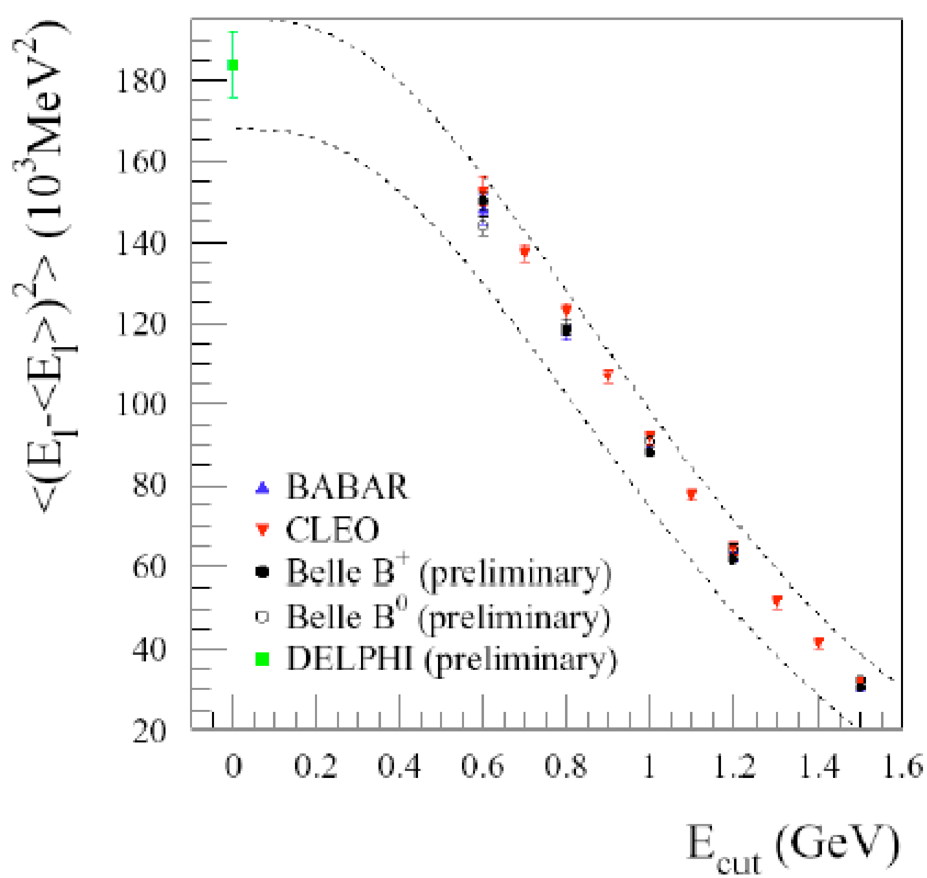
- $\langle E_\gamma \rangle = 2.270 + (m_b - 4.65)/2 + 0.063\,\mu_\pi^2$ ± 0.005 (pars.) ± 0.013 (pert.)
- $\langle E_\gamma^2 \rangle - \langle E_\gamma \rangle^2 = 0.023 + 0.080\,\mu_\pi^2$ ± 0.002 (pars.) ± 0.007 (pert.)

Inclusive $b \to c\, l\, \nu$ decays and V_{cb}

Lepton spectrum moments

Phill Urquijo

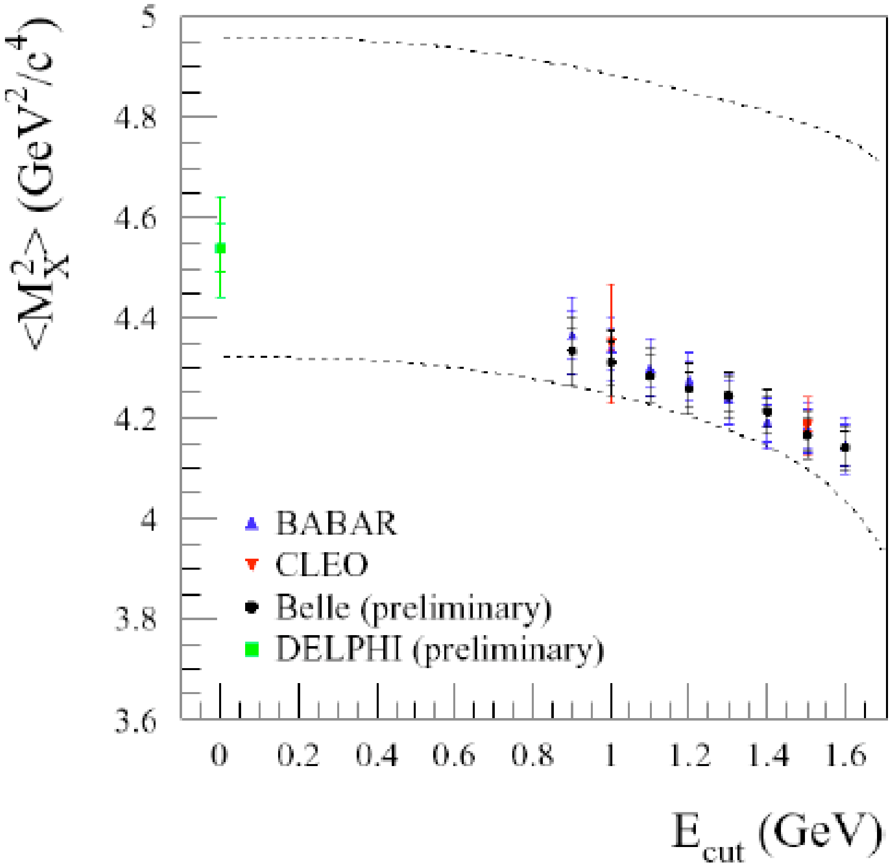


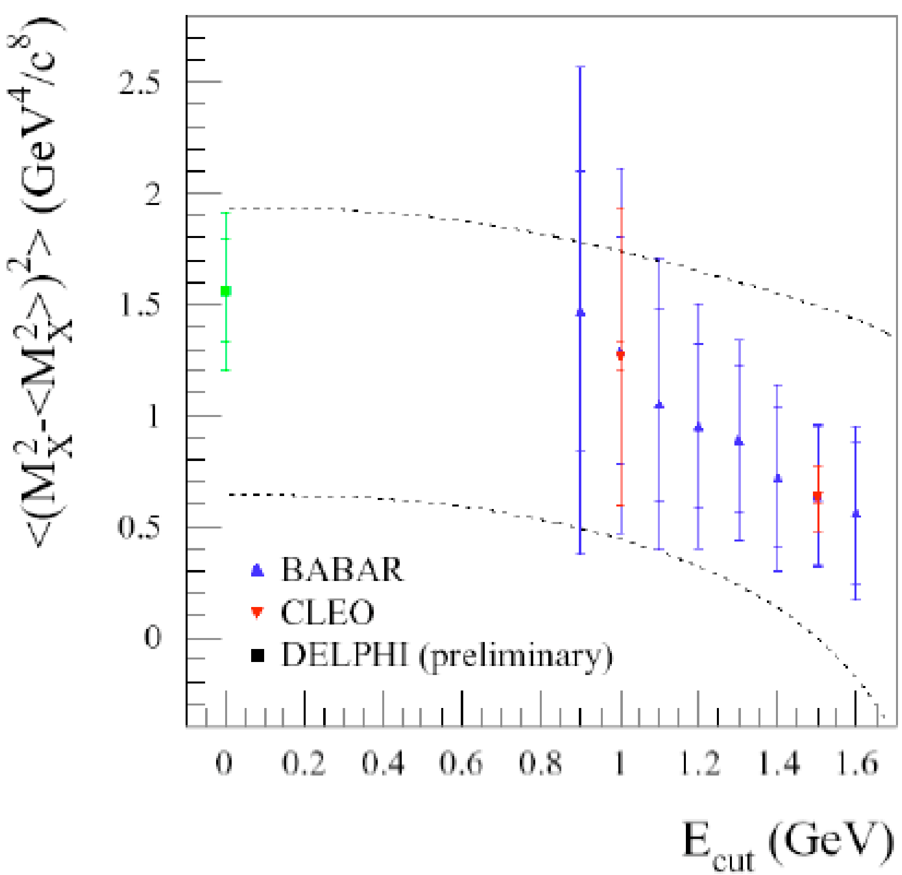


theory: hep-ph/0401063

Kinetic running mass

M(X) spectrum moments from lepton collider data





theory: hep-ph/0401063

Kinetic running mass

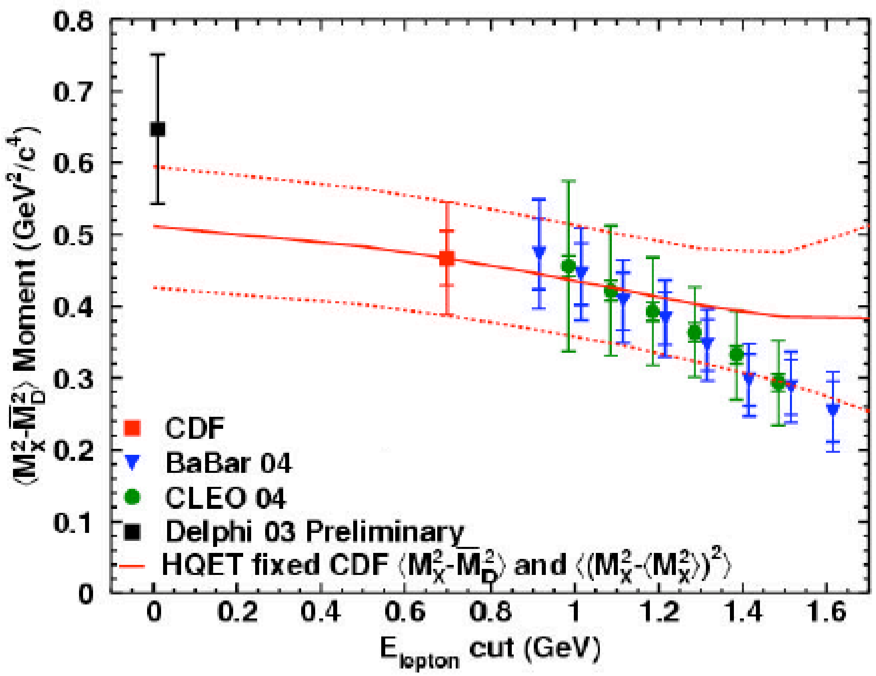
M(X) spectrum moments from CDF

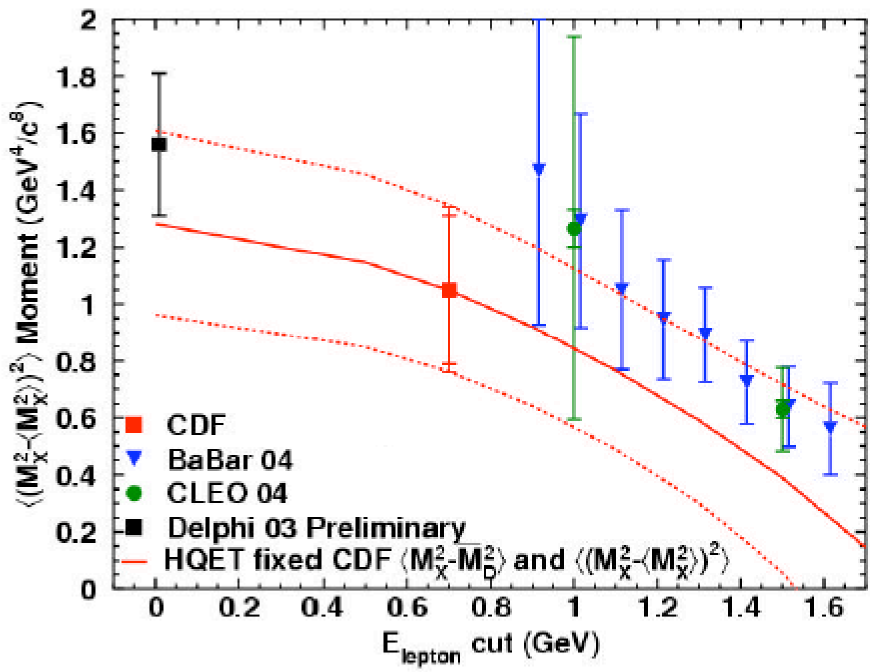
$$M_1 \equiv \langle s_H \rangle - m_D^2 \;=\; (0.467 \pm 0.038_{\rm stat} \pm 0.019_{\rm exp} \pm 0.065_{\rm BR})\ \ {\rm GeV}^2$$

$$M_2 \equiv \left\langle (s_H - \langle s_H \rangle)^2 \right\rangle \;=\; (1.05 \pm 0.26_{\rm stat} \pm 0.08_{\rm exp} \pm 0.10_{\rm BR})\ \ {\rm GeV}^4 \ ,$$

$\rho(M_1,M_2)=0.69$

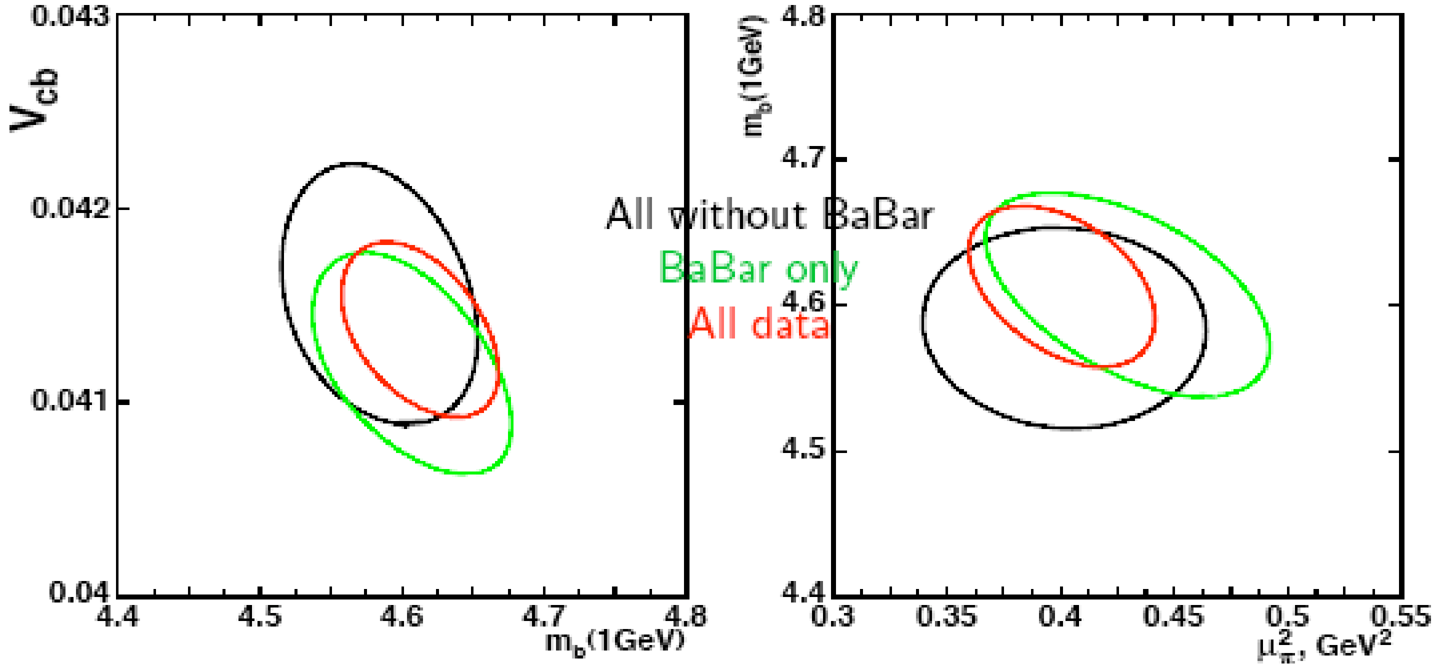
Alessandro Cerri





Moments in the kinetic scheme

Nikolai Uraltsev

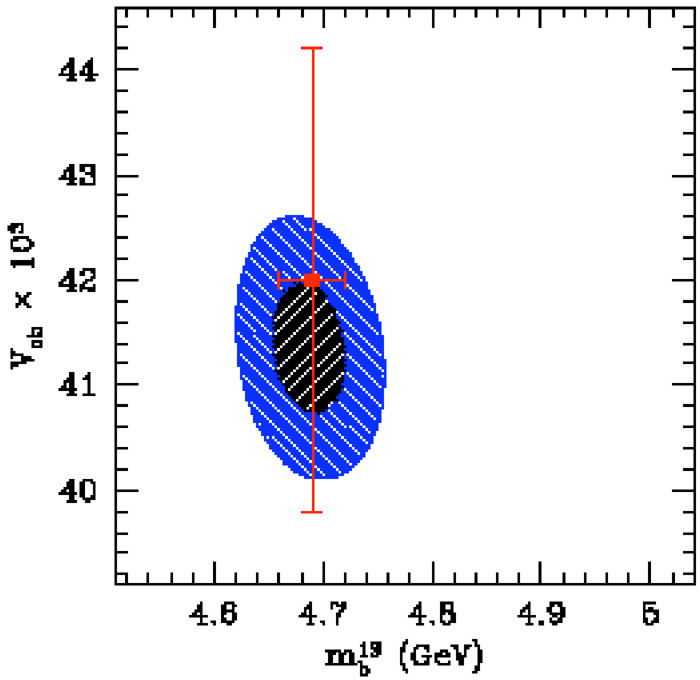


Experimental fit to all these data:

$$V_{cb} = (4.144 \pm 0.043) \cdot 10^{-3}$$

Moments in the 1S scheme

Aneesh Manohar



Best fit for V_{cb} and m_b compared with Hoang, hep-ph/008102 and PDG exclusive

$$\begin{aligned}
V_{cb} &= (41.4 \pm 0.6 \pm 0.1_\tau) \times 10^{-3} \\
m_b^{1S} &= 4.68 \pm 0.03 \ \text{GeV} \\
m_b - m_c &= 3.41 \pm 0.01 \ \text{GeV} \\
\lambda_1 &= -0.27 \pm 0.04 (\text{GeV})^2 \\
\bar m_c(\bar m_c) &= 0.90 \pm 0.04 \ \text{GeV} \\
\bar m_c(\bar m_c) &= 1.07 \pm 0.04 \ \text{GeV}
\end{aligned}$$

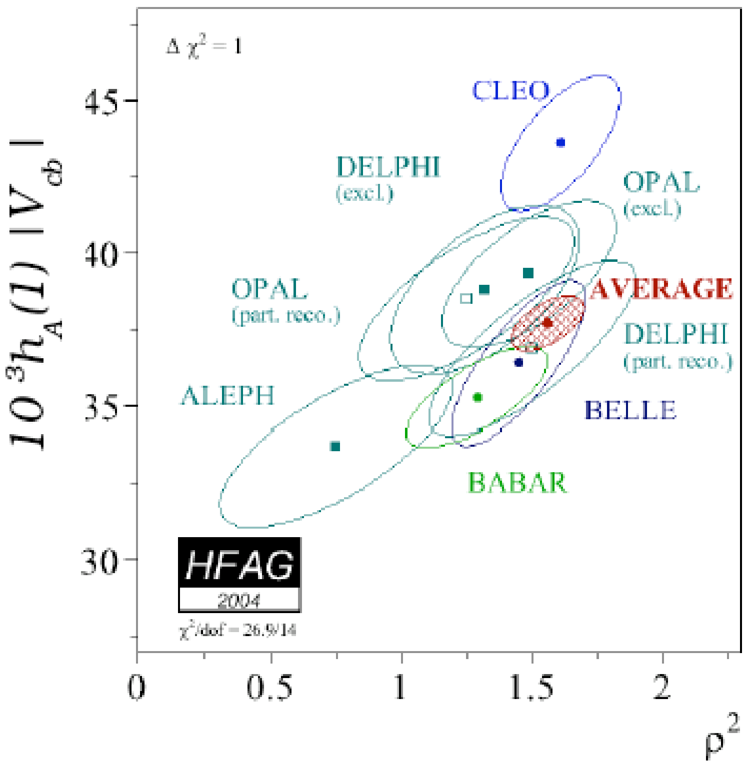
$$\chi^2/\nu = 51/86.$$

Mini summary

- Experimental data consistent with theory, V_{cb} extracted with 1-2% uncertainty
- Future perspectives: difficult to improve on V_{cb} but a lot can be learned about hadronic physics (HQET parameters, V_{ub})

Exclusive $b \to c\, l\, \nu$ decays and V_{cb}

B → D* l nu



☹ Loose internal consistency: $\chi^2/ndof = 27/14$

- Even without $\mathcal{L}$ increase many correlated errors will soon decrease due to ongoing measurements of :
  - R_1, R_2 (BABAR, *next slide*)
  - f_{00} (BABAR, *ICHEP04*)
  - $\tau(B)$ (BB & Belle, *ICHEP04)*
  - *D B.R.* (CLEO-C)

My guess for w.a.: $\sigma(h_A(1)V_{cb}) \sim 1.5\%$

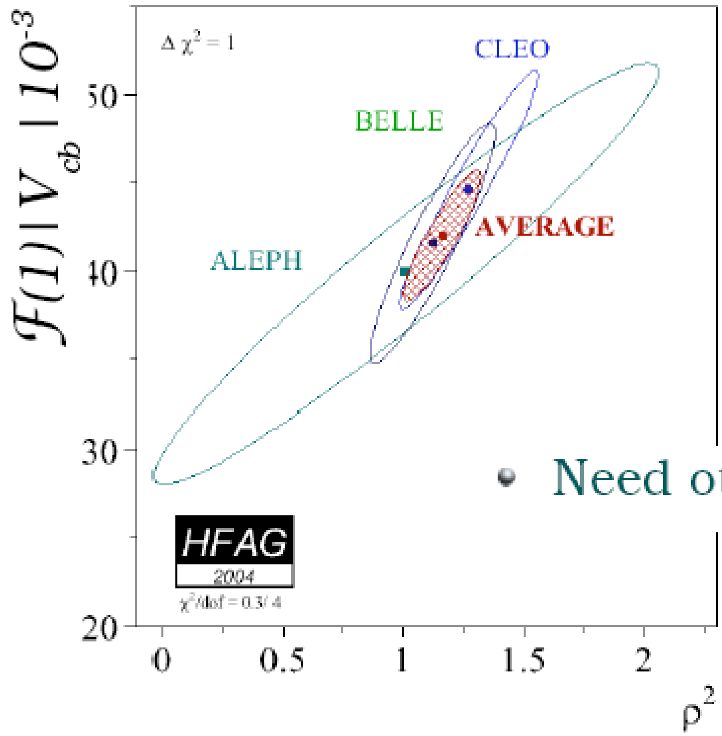
$h_A(1)\ |V_{cb}| = (37.7 \pm 0.9)\ 10^{-3}$

$|V_{cb}| = (41.4 \pm 1.0 \pm 1.8)\ 10^{-3}$

2.4% exp., 4% th. error

Franco Simonetto

B → D l nu



$$\mathcal{F}(1)\ |V_{cb}| = (42.0 \pm 3.7)\ 10^{-3}$$
$$|V_{cb}| = (39.1 \pm 3.6 \pm 1.3)\ 10^{-3}$$

9% exp., 3.5% th. error

☹ Large experimental error !

- Need other methods. Consider tagged samples !

- Combining D (3% , exp. dominated) and D* (4% th. dominated) could go down to ~ 2.5 % (my estimate)

Theory presentations

- Andreas Kronfeld: F(1) from lattice QCD
- Ben Grinstein: Dispersive bounds

Andreas Kronfeld

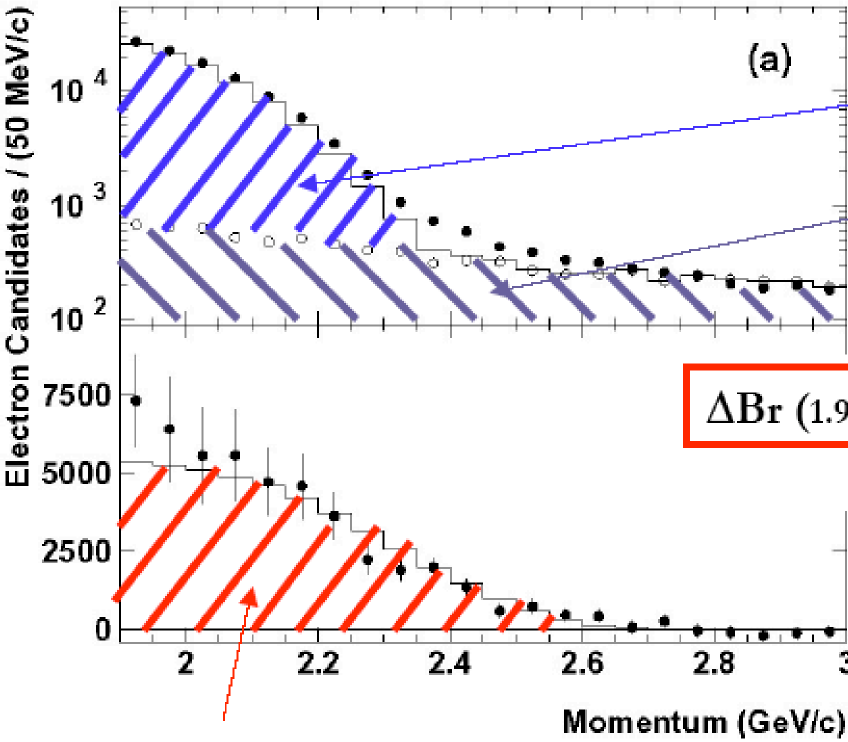
Summary

- No dramatic update from Yellow Book
- 2+1 flavor calculations underway or starting soon
- More things to contemplate
  - shape of form factors
  - ratio test
  - $|V_{cb}|$ from optimal bin in w

Inclusive $b \rightarrow u\, l\, \nu$ decays and V_{ub}

Belle NEW: Lepton endpoint yield

Ilija Bizjak



BB background (b→c MC expectation)

continuum background

b→u MC expected shape

ΔBr (1.9 GeV/c < p_e^* < 2.6 GeV/c) $= (8.47 \pm 0.37 \pm 1.53) \times 10^{-4}$

stat syst

De Fazio&Neubert, JHEP 9906,017 (1999)

1.9 GeV/c < p_e < 2.6 GeV/c :

$|V_{ub}| = (5.01 \pm 0.47 \pm 0.17 \pm 0.32 \pm 0.24) \times 10^{-3}$

exp, stat/sys, f_u error, theo, Br → $|V_{ub}|$

Total error on $|V_{ub}|$ ….. 13%

Bosch, Lange, Neubert, Paz, Nucl.Phys. B699 (2004)

$|V_{ub}| = (4.50 \pm 0.42 \pm 0.32 \pm 0.21) \times 10^{-3}$

exp SF theo

Belle NEW: $b \to u\, l\, \nu$ inclusive with fullrecon tag

$$\Delta Br\,(M_x<1.7,\ q^2>8,\ p^*>1) = (8.41 \pm 1.14 \pm 0.69)\times 10^{-4}$$

$$\Delta Br\,(M_x<1.7,\ p^*>1) = (1.24 \pm 0.15 \pm 0.08)\times 10^{-3}$$

$$\Delta Br\,(P_+<0.66,\ p^*>1) = (1.10 \pm 0.15 \pm 0.12)\times 10^{-3}$$

Full reconstruction tagging

$$|V_{ub}| = (4.34 \pm 0.29 \pm 0.43)\times 10^{-3}$$ M_x/q^2: 12%

$$|V_{ub}| = (3.80 \pm 0.21 \pm 0.35)\times 10^{-3}$$ M_x: 11%

$$|V_{ub}| = (3.87 \pm 0.25 \pm 0.43)\times 10^{-3}$$ P_+: 13%

BaBar: summary $b \to u\, l\, \nu$ inclusive

Concezio Bozzi

Errors are: expt ± SF ± theory   expt ± (SF+theory)

Method	ΔB × 10^4	$\lvert V_{ub}\rvert$ (BLNP) SF params from $b \to c\ell\nu$	$\lvert V_{ub}\rvert$ (BLNP) (Belle SF)	$\lvert V_{ub}\rvert$ ICHEP (DFN, Belle SF)
Endpoint	5.31±0.59	3.93 ± 0.34 ± 0.38 ± 0.18 (8.7 ± 9.7 ± 4.6)%	4.55	4.40 ± 0.24 ± 0.35 (± 6.4 ± 8.6) %
q^2-E_e	4.46±0.93	3.89 ± 0.40 ± 0.45 ± 0.21 (10.3 ±11.5 ± 5.4)%	4.53	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)%	5.00	5.18 ± 0.57 ± 0.34 (±11.0 ± 6.5) %
Average		4.07 ± 0.51		4.61 ± 0.46

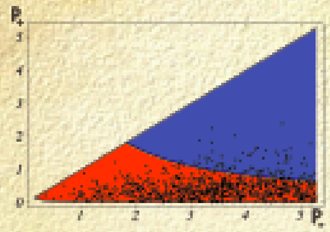
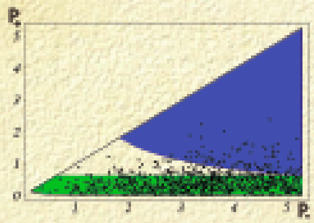
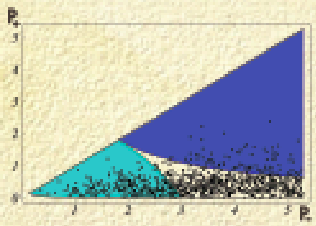
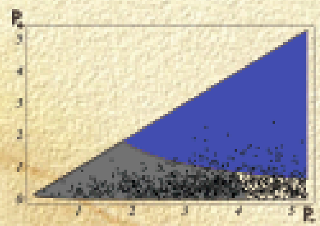
$b \to c\ell\nu$ moments: significant change in inclusive $\lvert V_{ub}\rvert$ values
BLNP: increased sensitivity to SF

Theory presentations

- Stefan Bosch: Shape functions
- Gil Paz: Chamless B decays and extraction of V_{ub}
- Christian Bauer: Extraction of V_{ub}

Christian Bauer

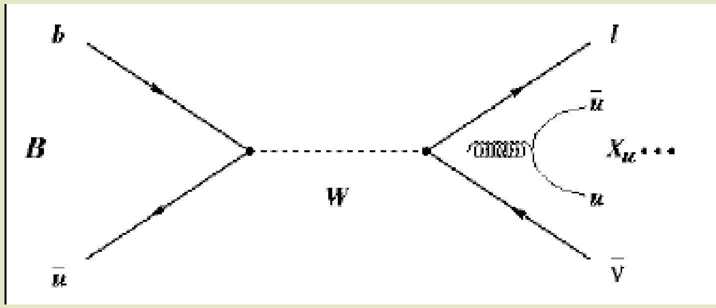
Comparison of Methods

cut	% of rate	good	bad
	~80%	lots of rate	depends on $f(k^+)$ (and subleading corrections)
	~70%	-still lots of rate - relation to radiative decays simplest	depends on $f(k^+)$ (and subleading corrections)
	~20%	insensitive to $f(k^+)$	- very sensitive to m_b - WA corrections may be substantial - effective expansion parameter is $1/m_c$
	~45%	insensitive to $f(k^+)$	Still "only" 45% of rate

Should do all possible measurements and check for consistency

CLEO: Impact of Weak Annihilation

Thomas Meyer



Endpoint

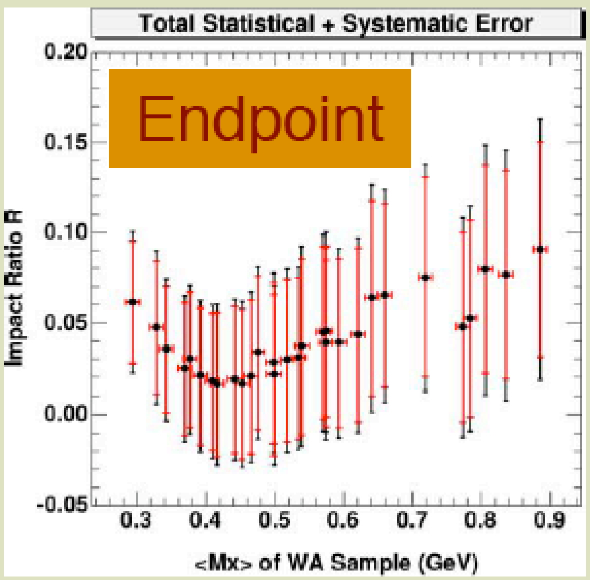
- $E_l > 2.2$ GeV

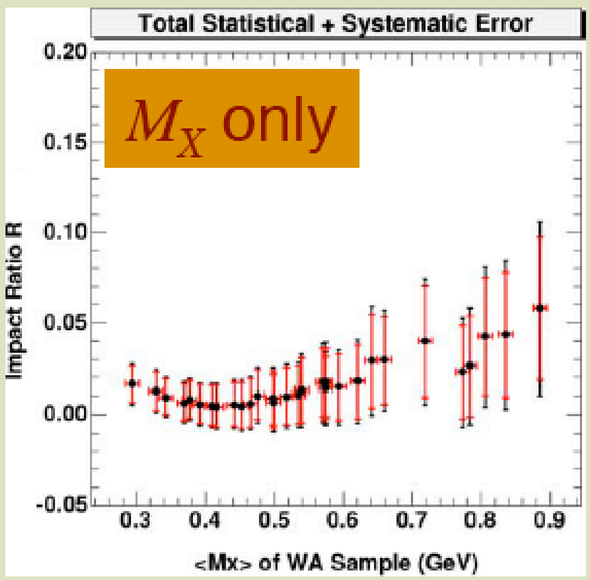
M_X

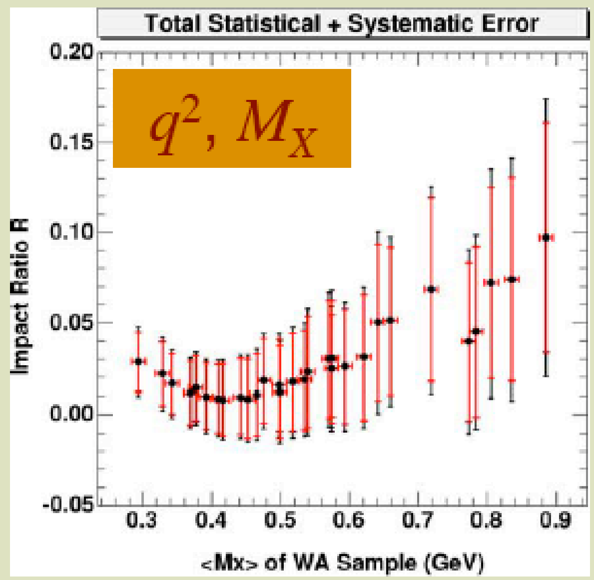
- $|p_l| > 1.0$ GeV
- $M_X < 1.55$ GeV

q^2 and M_X

- $|p_l| > 1.0$ GeV
- $q^2 > 8.0$ GeV^2
- $M_X < 1.7$ GeV







$$\sigma_{tot} = \sigma_{stat} \oplus \sigma_{expt} \oplus \sigma_{b \to c} \oplus \sigma_{b \to u}$$

Mini summary

- Endpoint measurement systematically limited, tagged analyses will improve with more data

	stat	syst	SF	other	total
M_x/q^2	5.0%	4.4%	7.5%	6.2%	**12%**
M_x	4.6%	3.5%	7.7%	4.7%	**11%**
P_+	4.7%	4.6%	9.1%	6.3%	**13%**

	stat	syst	SF	other	total
M_x/q^2	1.5%	3.7%	6.8%	6.2%	**10%**
M_x	1.6%	3.1%	6.9%	4.7%	**9%**
P_+	1.6%	3.8%	8.2%	6.3%	**11%**

S/N increasing ↓
acceptance increasing ↓
statistics decreasing ↓

Technique	$\Delta\|V_{ub}\| / \|V_{ub}\|$ (%)		
	Statistical	Experimental systematics	Theory (current)
$E_\ell > 2.0$ GeV	$3 \rightarrow 2 \rightarrow 1$	$6 \rightarrow 3$	$6_{\text{fu}} \otimes 5_{\text{OPE}}$
E_ℓ vs. q^2	$5 \rightarrow 3 \rightarrow 2$	$9 \rightarrow 4$	$3_{\text{fu}} \otimes 5_{\text{OPE}}$
m_X vs. q^2	$8 \rightarrow 5 \rightarrow 3$	$8 \rightarrow 5$	$4_{\text{fu}} \otimes 5_{\text{OPE}}$

500 fb^{-1}

- Very active on the theory side, challenging to reduce the theory error

(Big) summary

- The measurement of V_{cb} and V_{ub} is a very mature field
- Still there impressive progress which cannot be assessed (just) by looking at the error bars on V_{ub}/V_{cb}