Inclusive Semileptonic B Decays at BABAR

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Introduction
PEP-II and BABAR
Analysis I: $B \to X_c e\nu$
Analysis II: $B \to X_u e\nu$
Conclusions and Outlook

For the BABAR Collaboration

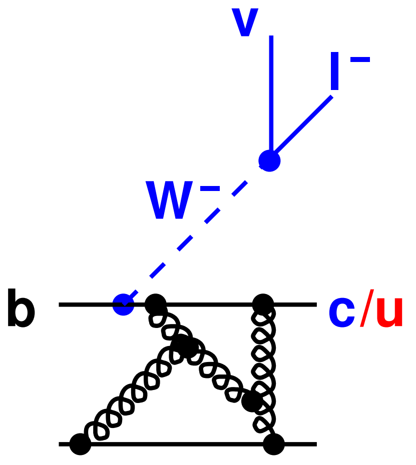
Abstracts 462, 463

All results are preliminary

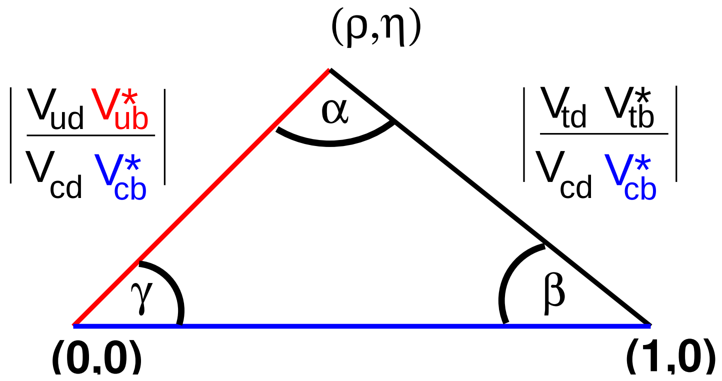
Introduction

- Inclusive semileptonic decays
  - ▷ large rate
  - ▷ easy to understand (relatively)

  allow determination of
  CKM parameters $|V_{cb}|$ and $|V_{ub}|$



- Measure sides of unitarity triangle
  $\longrightarrow$ complementary information
  to angles (e.g. $\sin 2\beta$)



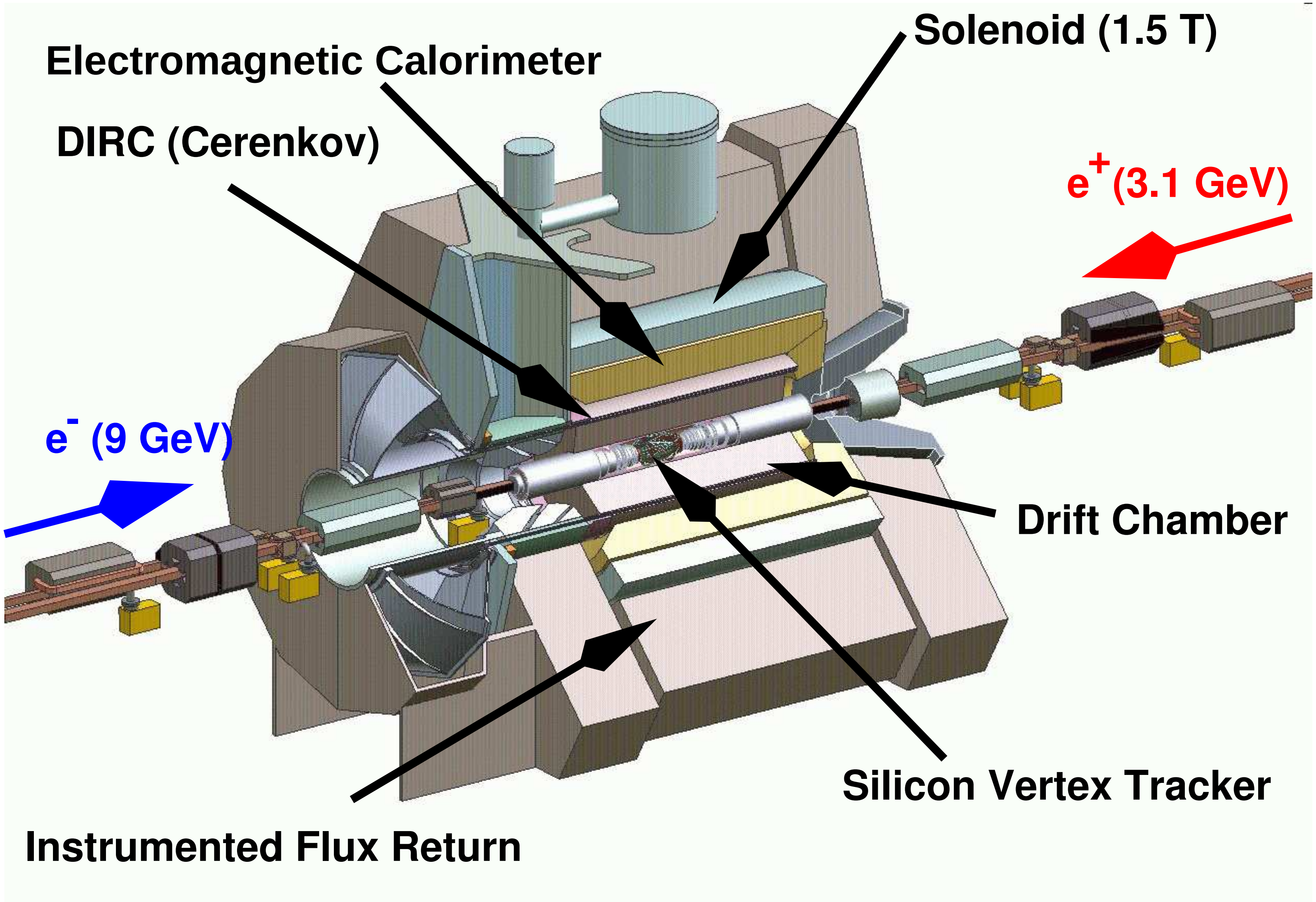
- Experimental challenges due to
  $\mathcal{B}(b \to c\ell\nu) \gg \mathcal{B}(b \to u\ell\nu)$

- Analyses on data set of
  Run 1, recorded 1999 – 2000:

  $\mathcal{L} = 20.6\,\mathrm{fb}^{-1}$ (on resonance)
  $\mathcal{L} = 2.6\ \ \mathrm{fb}^{-1}$ (off resonance)

- Results in this talk obtained with electrons

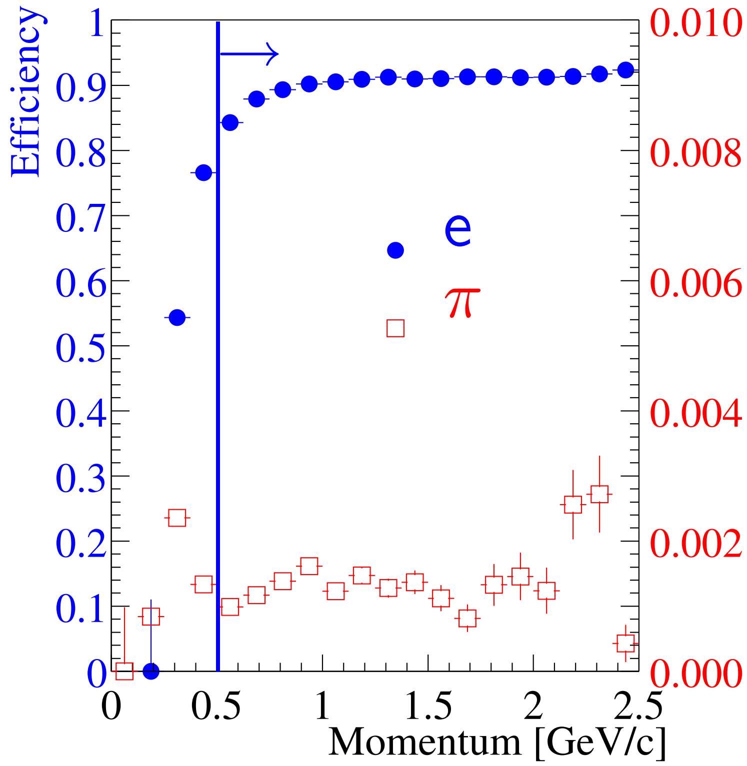
The BABAR Detector



Electron Identification

- Cut-based electron identification:

  $0.89 < E/p < 1.2$
  shower shapes
  dE/dx consistency
  DIRC consistency
  track cluster match



- Efficiency determination with control samples in Data

$$< \varepsilon >= 90\%$$

for electrons from B-decays

- Hadron fake determination with input from Monte Carlo and Data

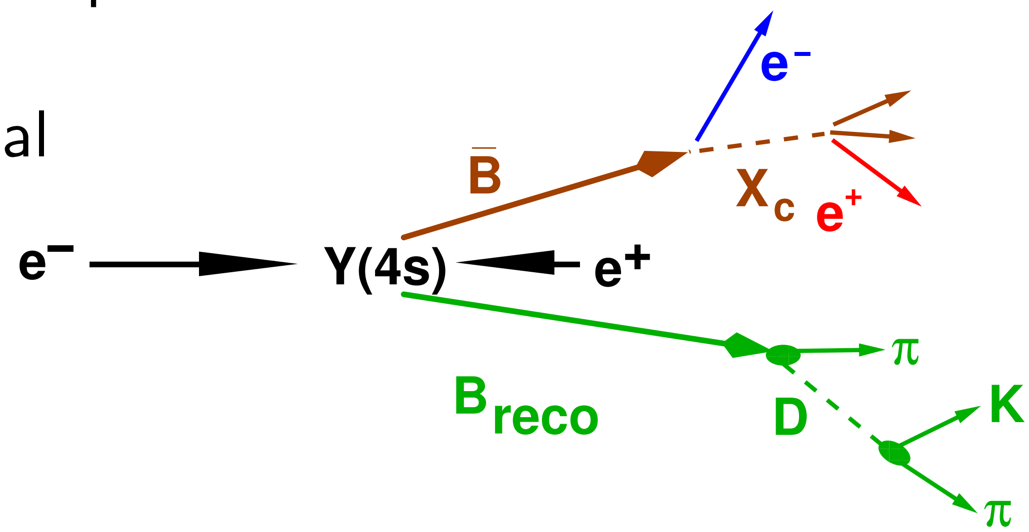
$$N_{fake} = (f_\pi \eta_\pi + f_K \eta_K + f_p \eta_p) \times N_h$$
$$< \eta > = 2.5 \cdot 10^{-3}$$

- Background removal:
  - ▷ photon conversions
  - ▷ π^0 Dalitz decays
  - ▷ J/ψ decays

Analysis I: Motivation and Strategy

- Semileptonic branching fractions of $B^\pm$ and B^0 not precisely measured
- Differences predicted in lepton spectra from $B^\pm$ and B^0 decays
- Under the assumption of equal semileptonic decay widths:

$$\frac{\mathcal{B}^+_{sl}}{\mathcal{B}^0_{sl}} = \frac{\Gamma^+_{sl}/\Gamma^+_{tot}}{\Gamma^0_{sl}/\Gamma^0_{tot}} = \frac{\Gamma^0_{tot}}{\Gamma^+_{tot}} = \frac{\tau_{B^+}}{\tau_{B^0}}$$



- Prompt N_p and cascade N_c electron spectrum from charge correlation with B_{reco}

$$B^+ \to X_c \ell^+ \bar{\nu}_\ell$$
$$B^- \to X_{\bar{c}} \ell^- \bar{\nu}_\ell$$

- Neutral B-mesons: Correct for mixing

Event Selection

- Fully reconstructed hadronic B-decays:

$$B \to D^{(*)}\pi, D^{(*)}\rho, D^{*}a_1$$
$$\to J/\psi K^{(*)}, \psi(2S)K^{(*)}$$

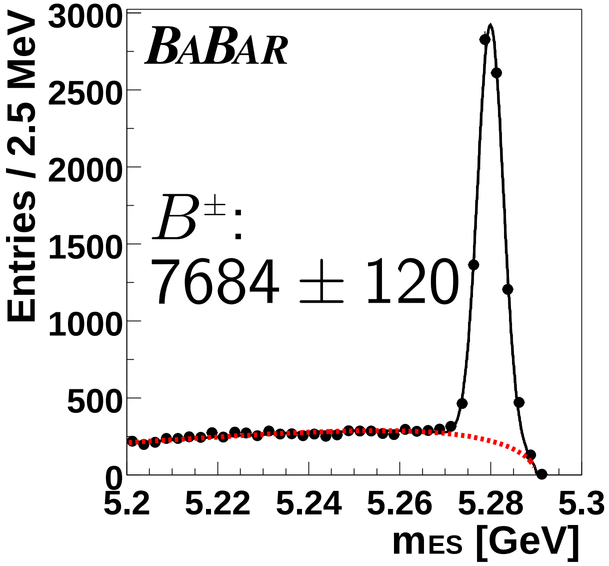
- Kinematic selection in lab frame

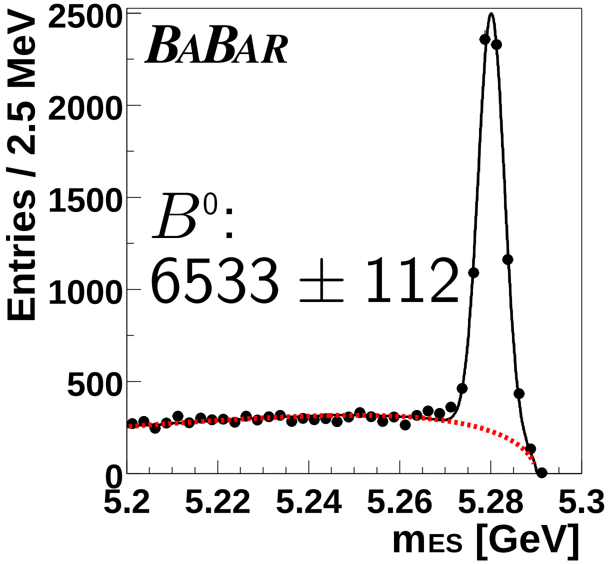
$$\Delta E = \frac{p_B \cdot p_i - s/2}{\sqrt{s}} = E^*_B - E^*_{beam}$$

$$m_{ES} = \sqrt{\frac{(s/2 + \vec{p}_B \cdot \vec{p}_i)^2}{E_i^2} - \vec{p}_B^{\,2}} = \sqrt{E^{*2}_{beam} - \vec{p}^{\,*2}_B}$$

- Low cross-feed $B^0 \leftrightarrow B^+$ of $1 \div 2\%$.
- Additional cuts:

$R_2 < 0.5$, Fox Wolfram moments
$N_{trk} \geq 1$, in rest of event
$N_{el} \geq 1$, in fiducial volume

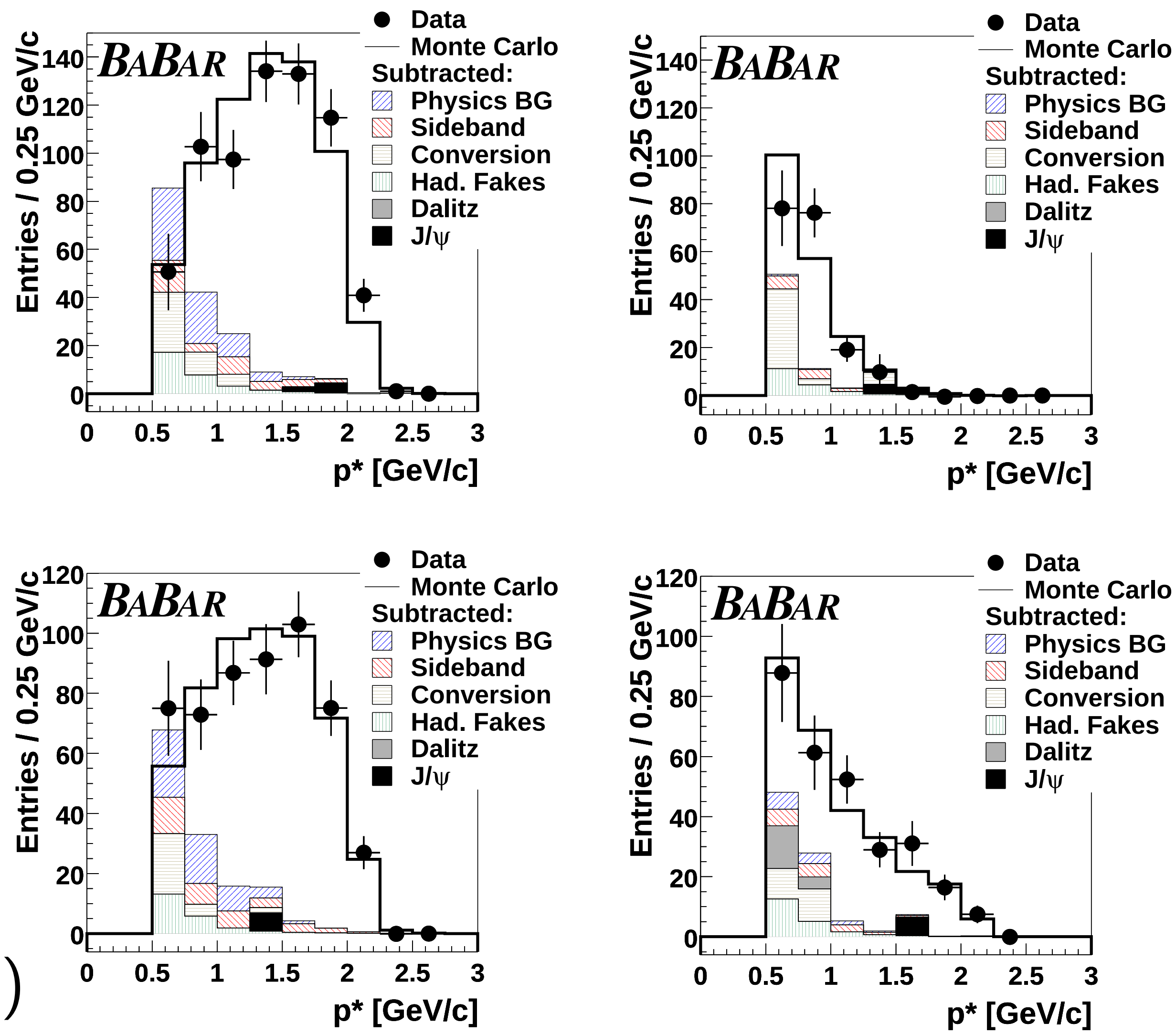




The Electron Spectra

- Background-subtracted spectra compared to Monte Carlo:

right-sign wrong-sign



Charged B-mesons

$$N^{+}_{right-sign} = N^{+}_{p}$$

Neutral B-mesons

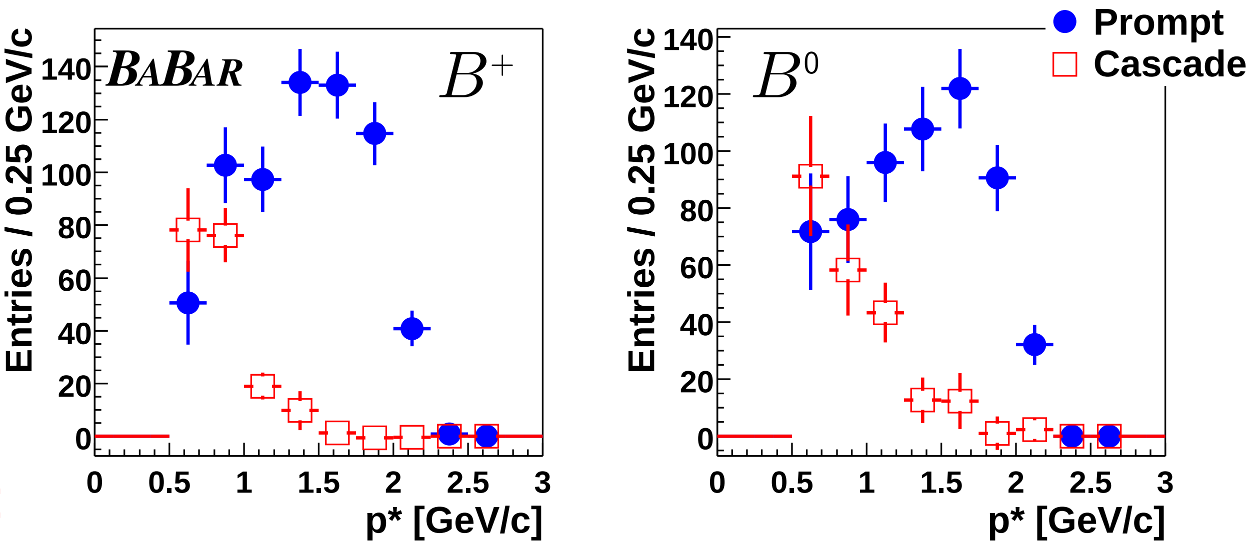
$$N^{0}_{right-sign} = N^{0}_{p}(1-\chi_d) + N^{0}_{c}\chi_d$$

$$N^{0}_{wrong-sign} = N^{0}_{p}\chi_d + N^{0}_{c}(1-\chi_d)$$

Results

- Electrons from prompt B-decays

$$N^p_{B^+} = 674 \pm 34$$
$$N^p_{B^0} = 597 \pm 38$$



PRELIMINARY Results:

- Branching fractions

$$\boxed{\begin{array}{l} b_+ = 10.3 \pm 0.6_{stat} \pm 0.5_{syst}\% \\ b_0 = 10.4 \pm 0.8_{stat} \pm 0.5_{syst}\% \end{array}}$$

$$\boxed{\rightarrow b = 10.4 \pm 0.5_{stat} \pm 0.4_{syst}\%}$$

- Ratio of branching fractions (many systematics cancel)

$$\boxed{\frac{b_+}{b_0} = 0.99 \pm 0.10_{stat} \pm 0.03_{syst}}$$

Systematics

- Main systematics for the current analysis:

Source	$\delta x/x[\%]$	$\delta b_+/b_+[\%]$	$\delta b_0/b_0[\%]$
Analysis efficiency	$1.3 \div 2.5$	±1.3	±2.5
B_{reco} cross-feed	2.0	±2.0	±2.0
Mixing $\Delta\chi_d$	5.2		±0.8
Trk'ing efficiency	1.5	±1.5	±1.5
Extrapolation	10	±1.8	±1.8
Physics BG		±1.6	±1.7
Electron ID	1.7	±1.8	±1.8
Hadron fakes	50	±1.6	±1.4
Pair background	15	±0.18	±0.17
Total		±4.5	±5.0

- Reduction to $< 4\%$ possible.

Analysis II: Lepton Endpoint Spectrum

- Measure $b \to u\ell\nu$ decay where dominant $b \to c\ell\nu$ contribution is suppressed:

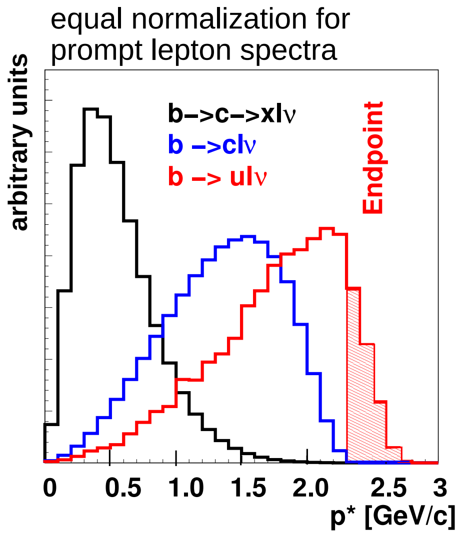
$$2.3\,\text{GeV} < p^*_\ell < 2.6\,\text{GeV}$$

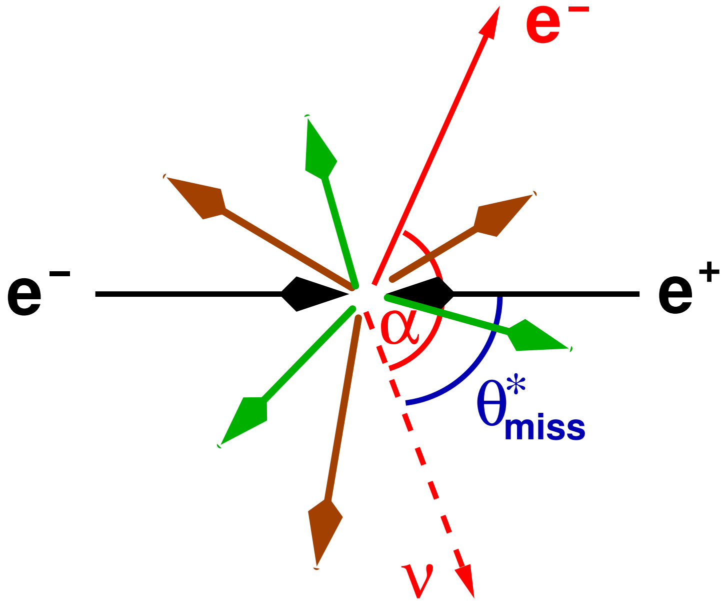
- Original method to measure $|V_{ub}|$, but: Sample only $\sim 10\%$ of phase space

- Event selection
  - ▷ high-momentum electron
  - ▷ missing momentum (ν):

$$\begin{aligned} p_{miss} &> 1\,\text{GeV} \\ -0.9 < \cos\theta^*_{miss} &< 0.8 \\ 0 &> \cos\alpha \end{aligned}$$

  - ▷ J/ψ veto
  - ▷ Fox-Wolfram moments $R_2 < 0.3$





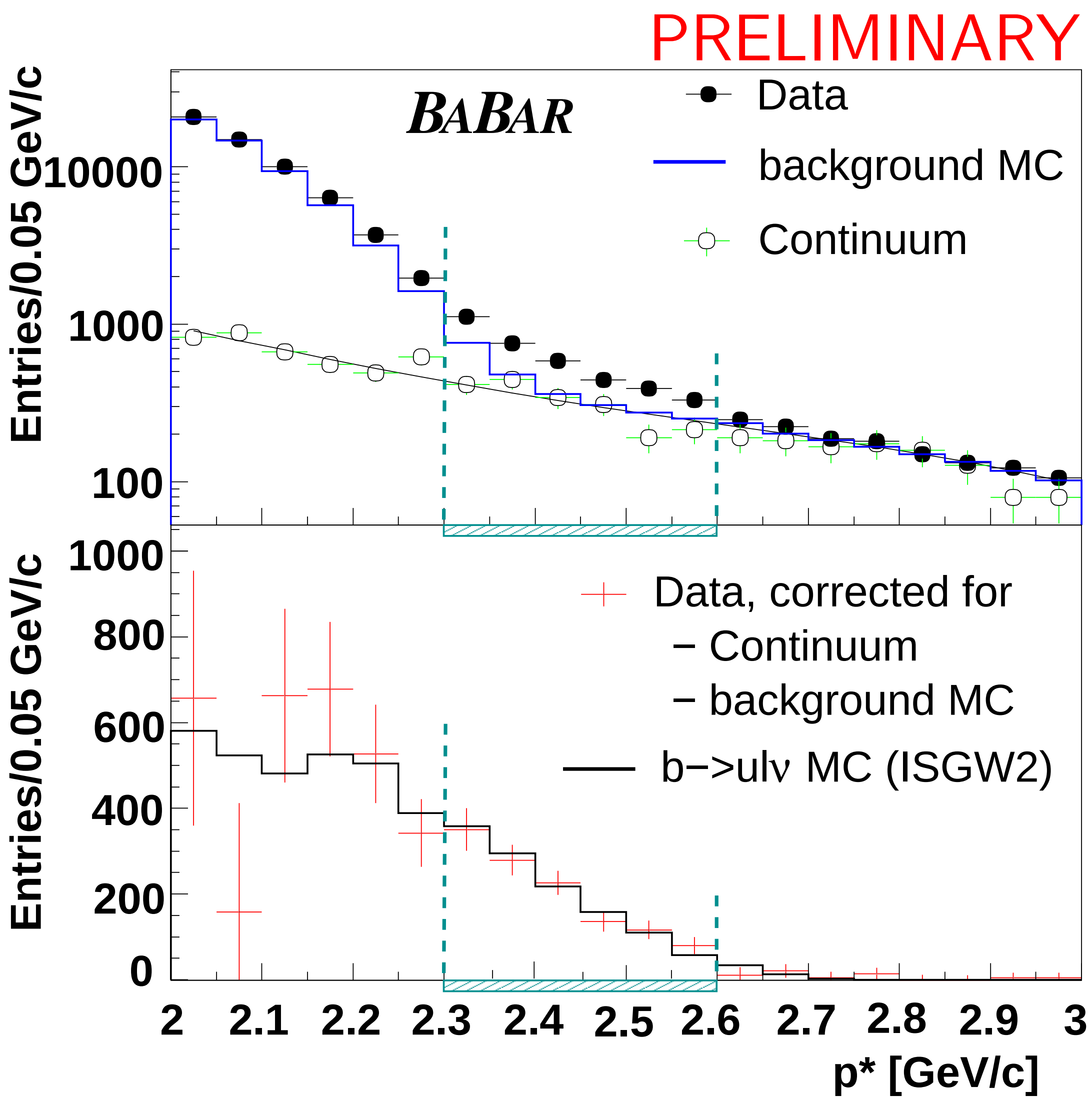
Endpoint Spectrum cont'd

- Resulting Spectrum in $2.3\,\text{GeV} < p^* < 2.6\,\text{GeV}$

$\sim$ 1200 events above background

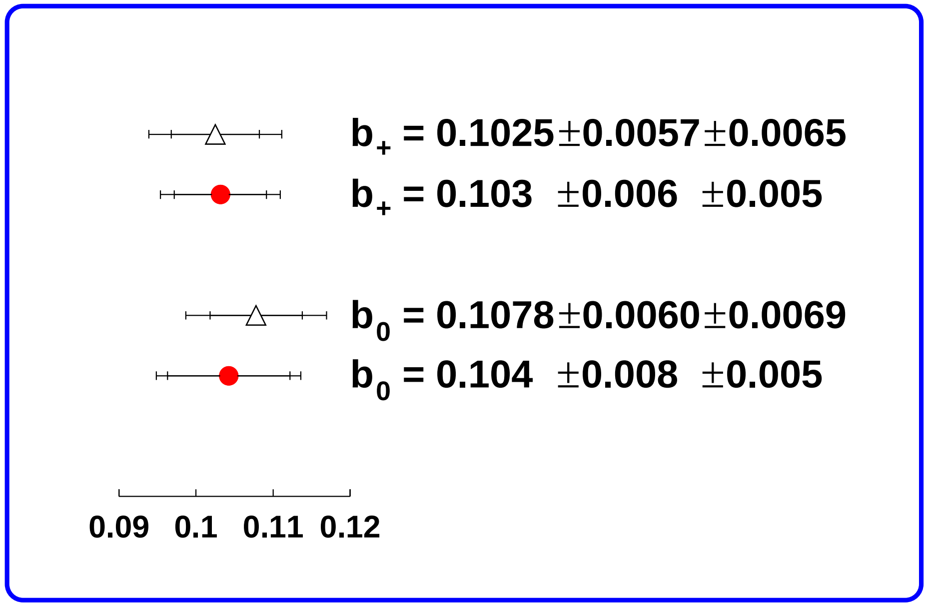
- Continuum fitted for subtraction

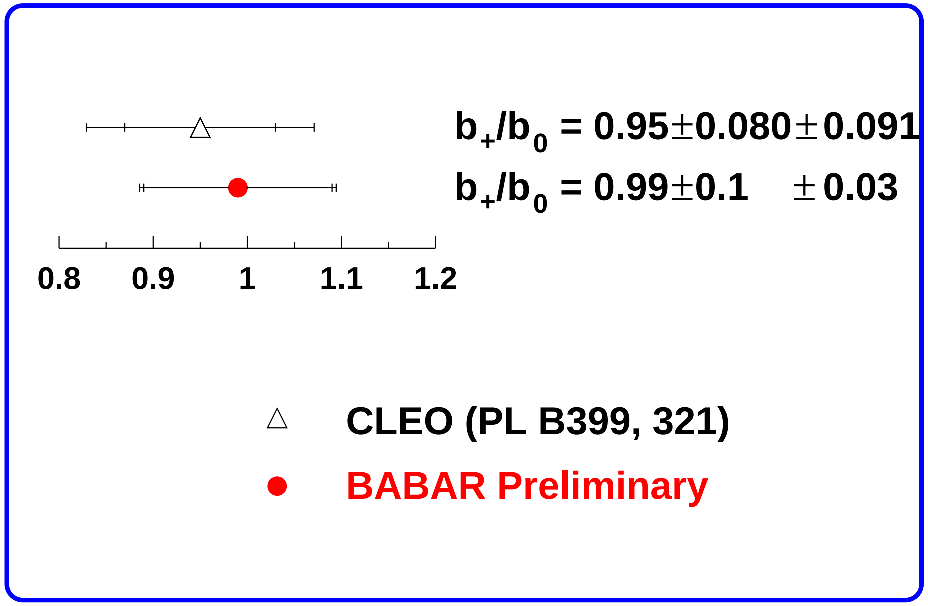
- Main systematics:
  - ▷ efficiency
  - ▷ continuum subtraction
  - ▷ MC simulation of backgrounds



Conclusions and Outlook

- Measurement of semileptonic branching fractions and ratio:





- Work in progress:
  - ▷ End-point analysis $\longrightarrow |V_{ub}|$
  - ▷ Inclusive analysis with lepton tags $\longrightarrow |V_{cb}|$
  - ▷ Fully reconstructed tags $\longrightarrow |V_{ub}|$

Stay tuned!