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

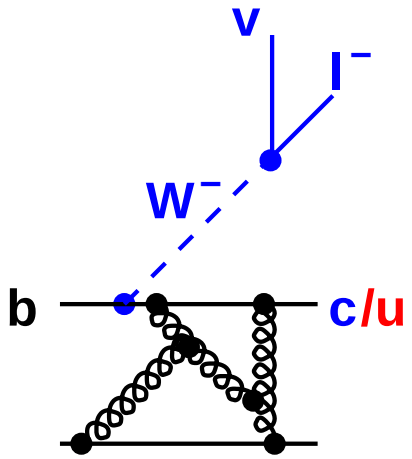
Abstracts 462, 463

All results are preliminary

Introduction

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

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

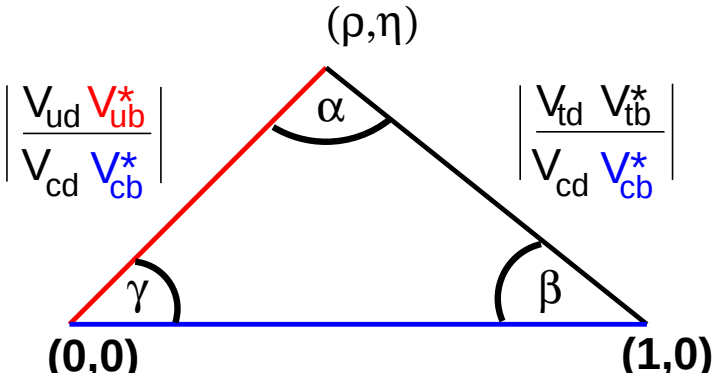


- Measure sides of unitarity triangle
  $\longrightarrow$ complementary information to angles (e.g. $\sin 2\beta$)

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

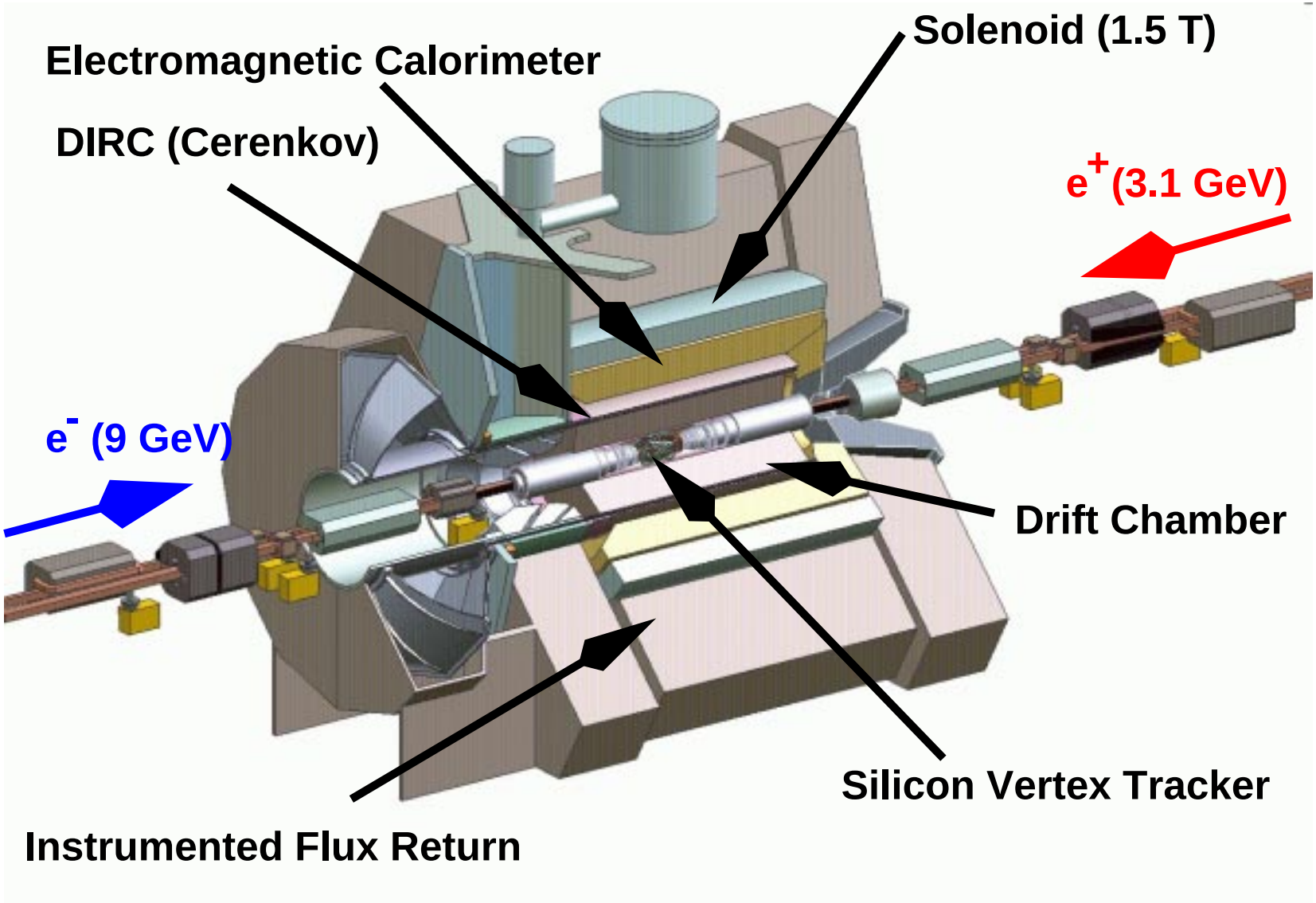
- Analyses on data set of Run 1, recorded 1999 – 2000:

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



- Results in this talk obtained with electrons

The BABAR Detector

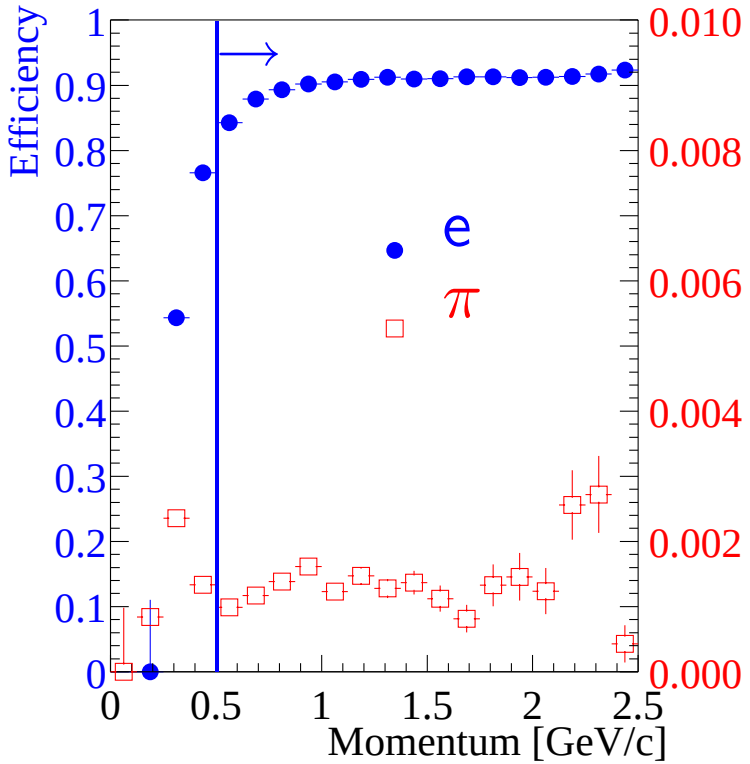


Electron Identification

- 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

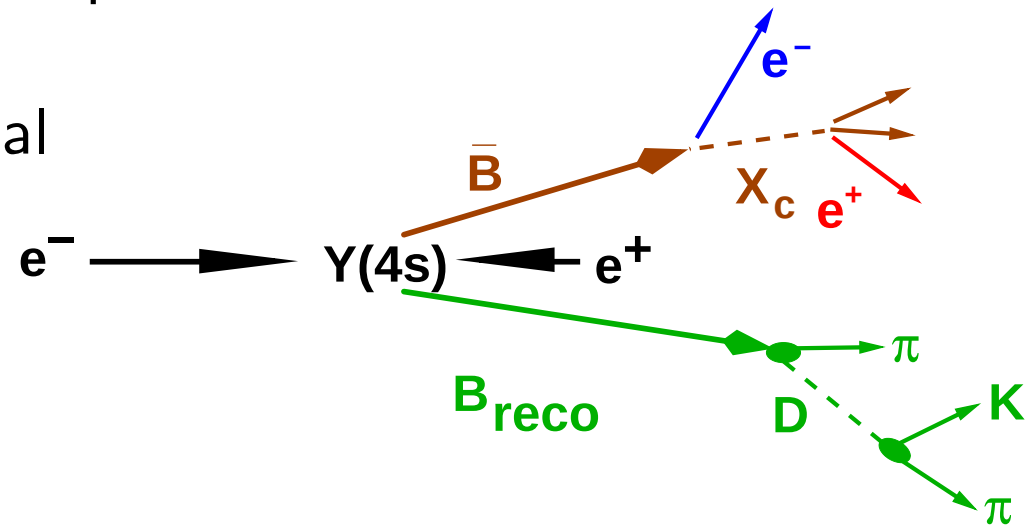
  $$N_{fake} = (f_\pi \eta_\pi + f_K \eta_K + f_p \eta_p) \times N_h$$
  $$<\eta> = 2.5 \cdot 10^{-3}$$

- 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:

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

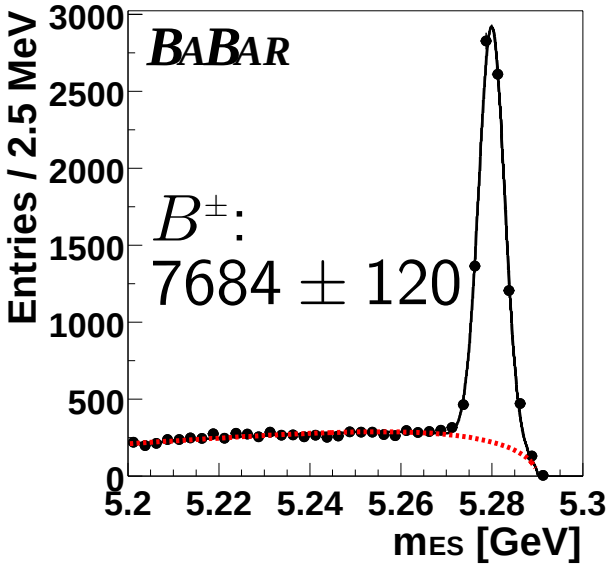
- Kinematic selection in lab frame

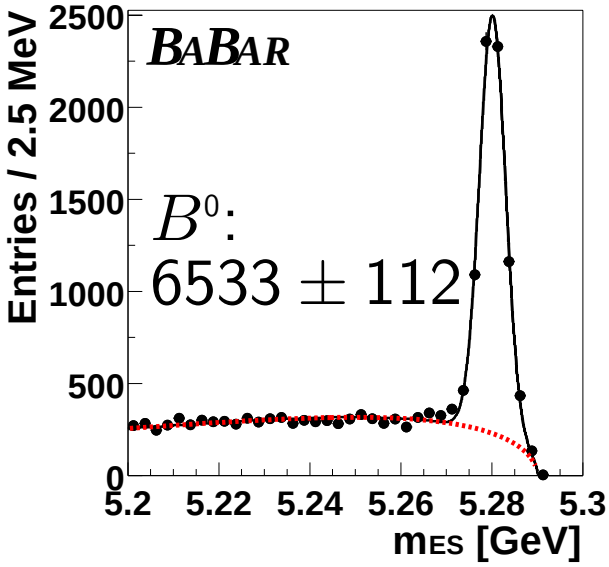
$$\Delta E = \frac{p_B \cdot p_i - s/2}{\sqrt{s}} = E^*_B - E^*_{beam}$$

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

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

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





The Electron Spectra

- Background-subtracted spectra compared to Monte Carlo:

Charged B-mesons

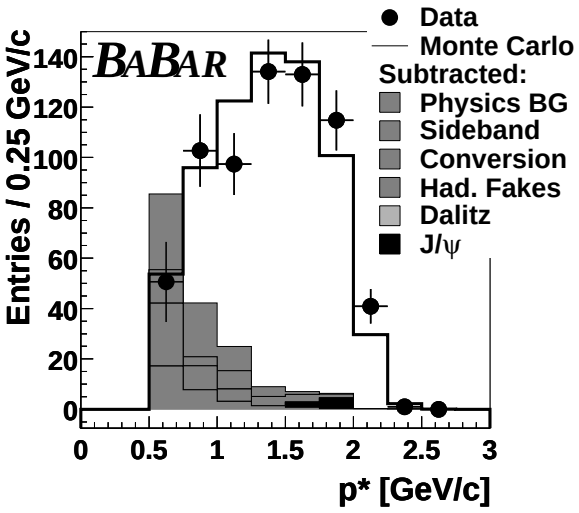
$$N^{+}_{right-sign} = N^{+}_{p}$$

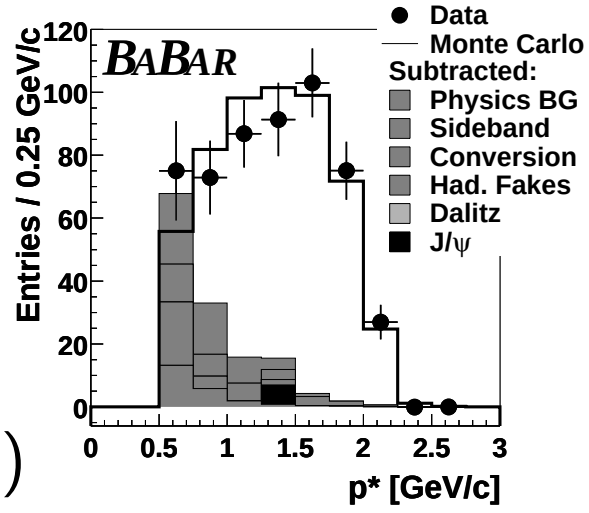
Neutral B-mesons

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

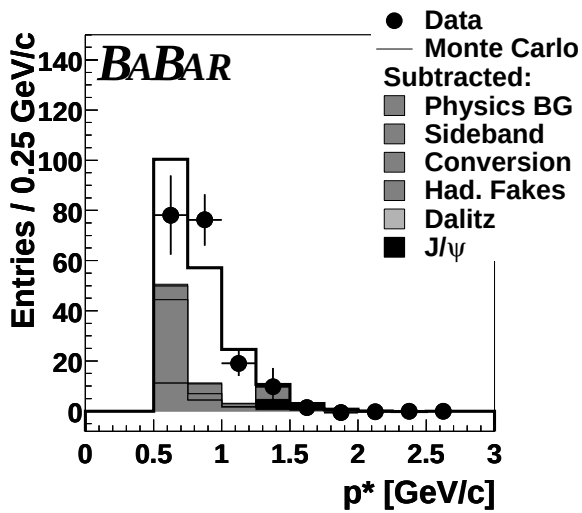
$$N^{0}_{wrong-sign} = N^{0}_{p}\chi_d + N^{0}_{c}(1-\chi_d)$$

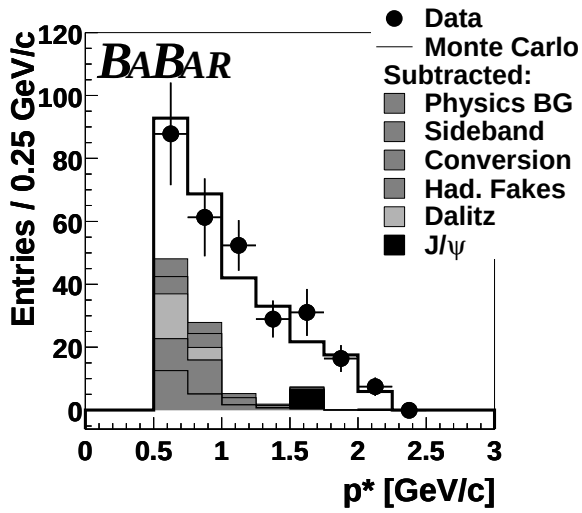
right-sign





wrong-sign

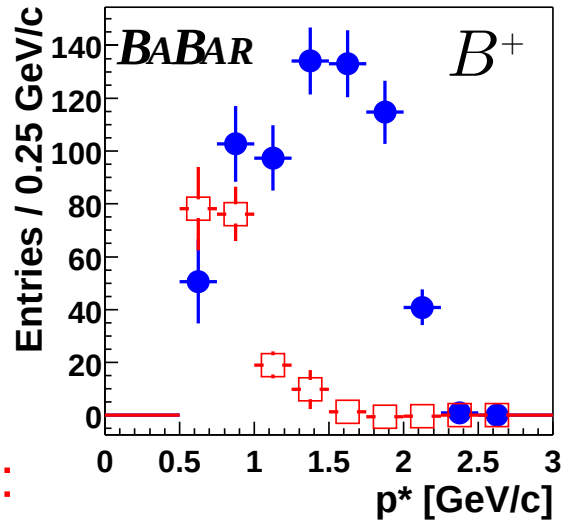


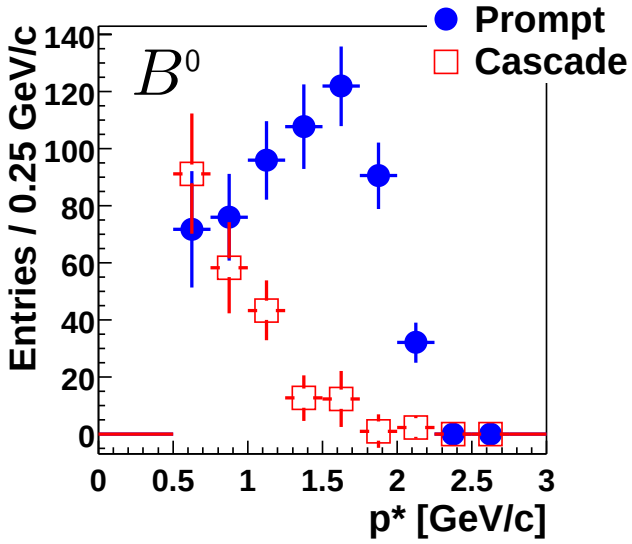


Results

- Electrons from prompt B-decays

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





PRELIMINARY Results:

- Branching fractions

$$b_+ = 10.3 \pm 0.6_{stat} \pm 0.5_{syst}\,\%$$
$$b_0 = 10.4 \pm 0.8_{stat} \pm 0.5_{syst}\,\%$$

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

- Ratio of branching fractions (many systematics cancel)

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

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

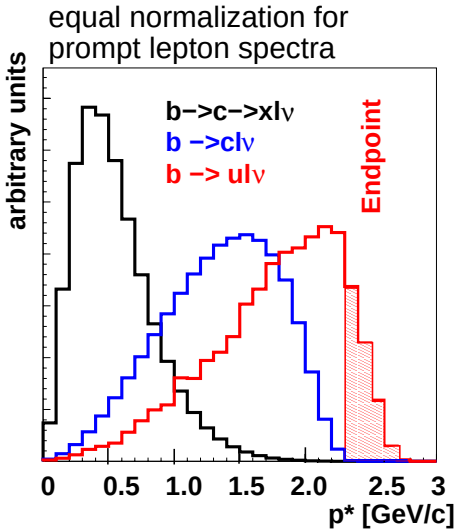
- Measure $b \to u\ell\nu$ decay where dominant $b \to c\ell\nu$ contribution is suppressed:

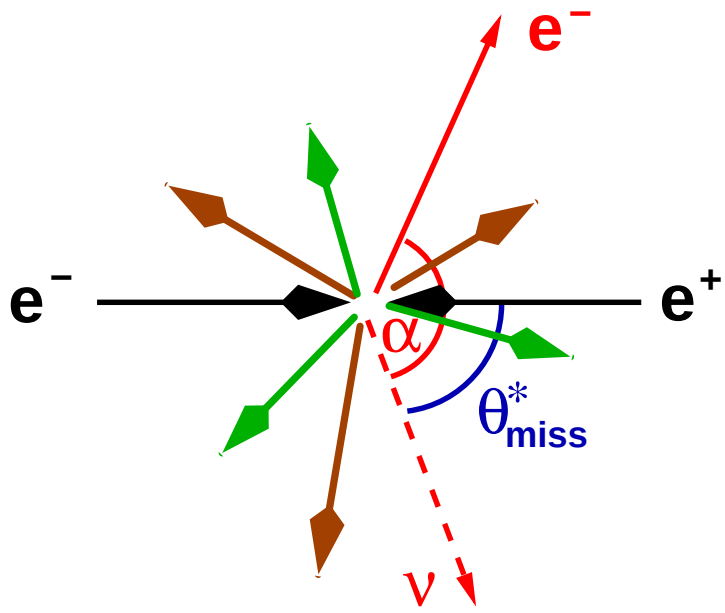
$$2.3\,\text{GeV} < p^*_\ell < 2.6\,\text{GeV}$$

- 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 $R_2 < 0.3$



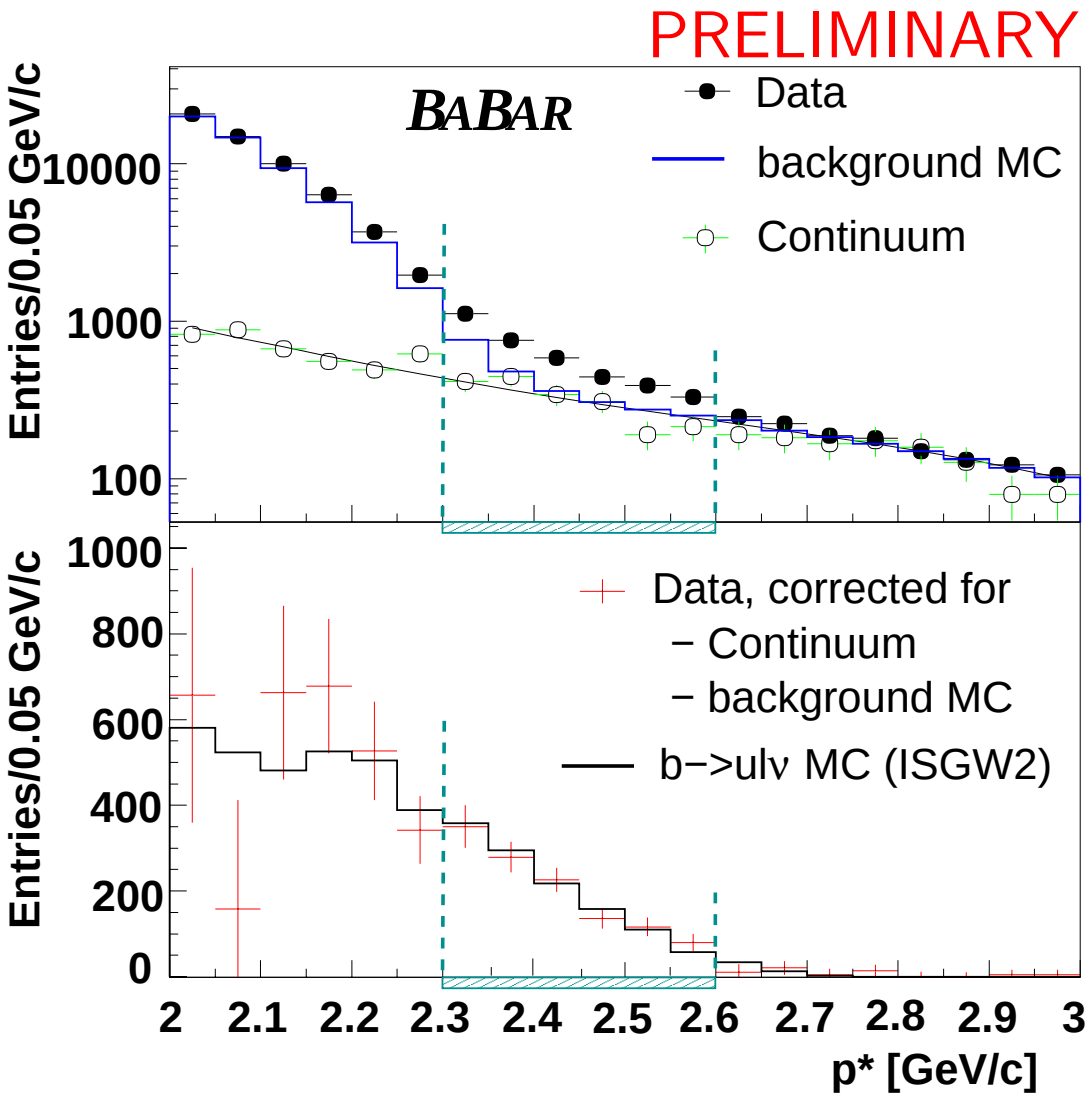


Endpoint Spectrum cont'd

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

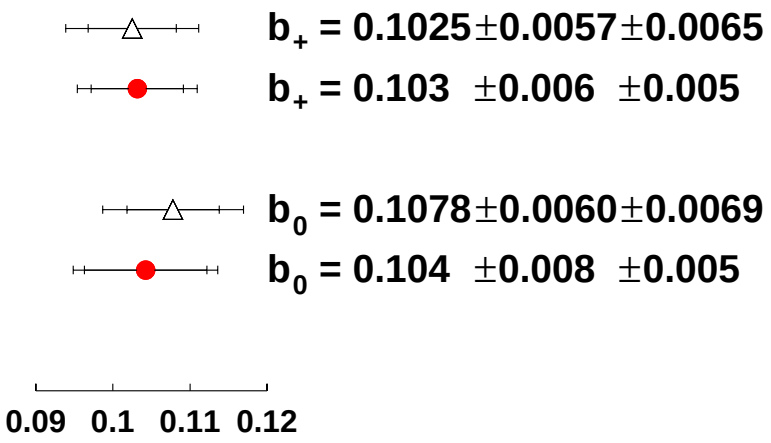
$\sim$ 1200 events above background

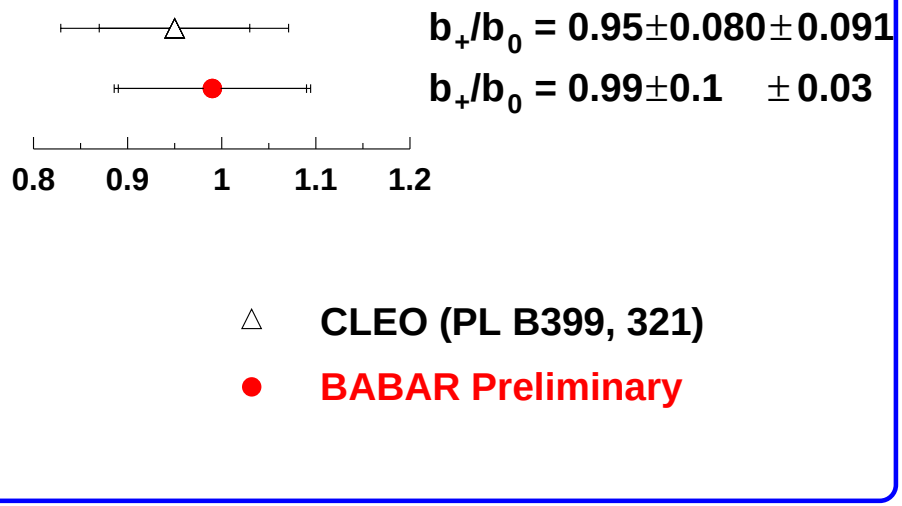
- Continuum fitted for subtraction
- Main systematics:
  - ▷ efficiency
  - ▷ continuum subtraction
  - ▷ MC simulation of backgrounds



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!