Queen Mary
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Measurement of the partial branching fraction for $\overline{B} \to X_u \ell \overline{\upsilon}$ using the lepton endpoint and the determination of $|V_{ub}|$

The *BaBar* Collaboration

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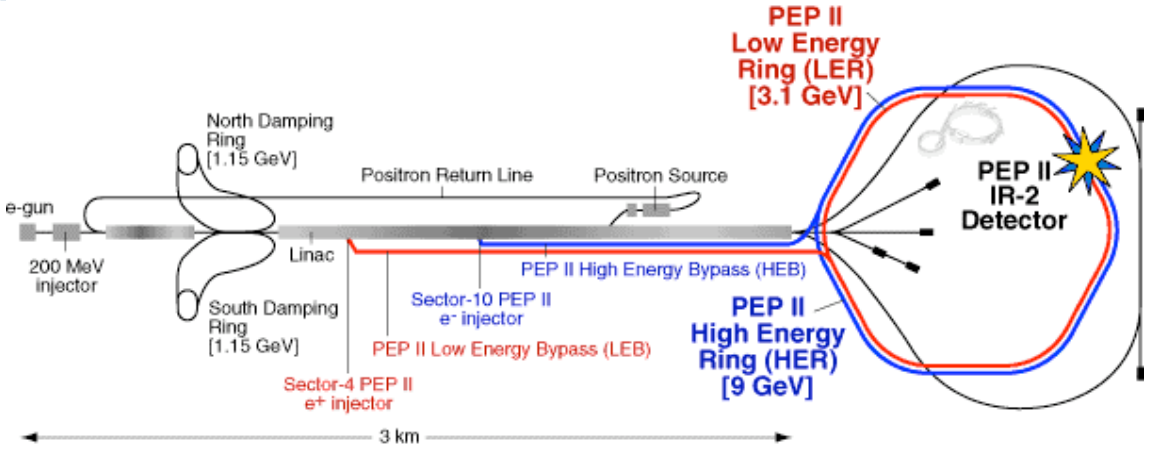
Outline

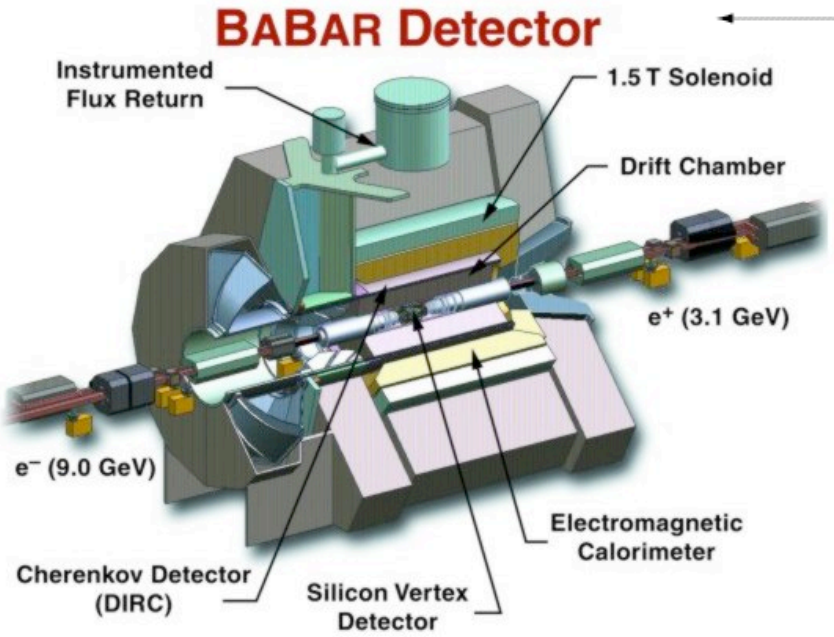
- Overview of the *BaBar* experiment
- Motivation
- Event selection
- Results
- Translation of $\Delta B(\overline{B} \to X_u \ell \overline{\upsilon})$ into $|V_{ub}|$
- Conclusions & prospects

Overview of the BaBar experiment

E_{CM} = 10.58 GeV

$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$





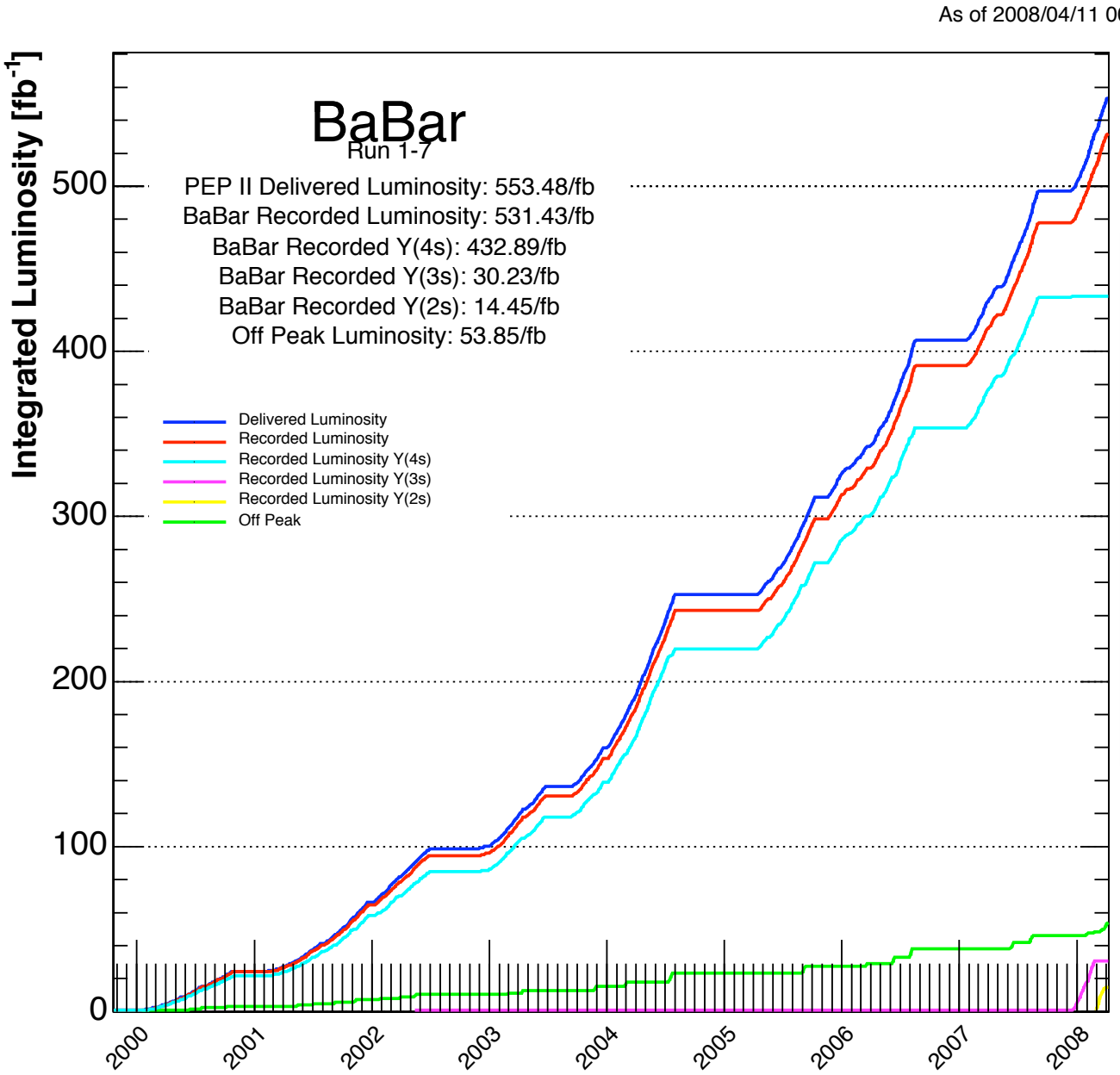
SVT – 5 layers of double-sided silicon strips

DCH – 40 stereo layers of drift/sense wires in helium/isobutane gas mix (dE/dx)

DIRC – Provides π/K separation (above 700 MeV)

EMC – 6580 CsI(Tl) crystals. Energy/position measurements for $e^{\pm}$, γ, K_L

IFR – Identifies μ and neutral hadrons (primarily K_L and neutrons)



Collaboration:

~500 physicists

Data-taking:

October 1999 – April 2008

Peak luminosity:

1.2×10^{34} cm^{-2} s^{-1} (4 x design)

Integrated Υ(4S) sample:

433 fb^{-1}

Motivation

CP Violation is accounted for in the SM using V_{CKM}.

Appears as complex phase i η

$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \mathcal{O}(\lambda^4)$$

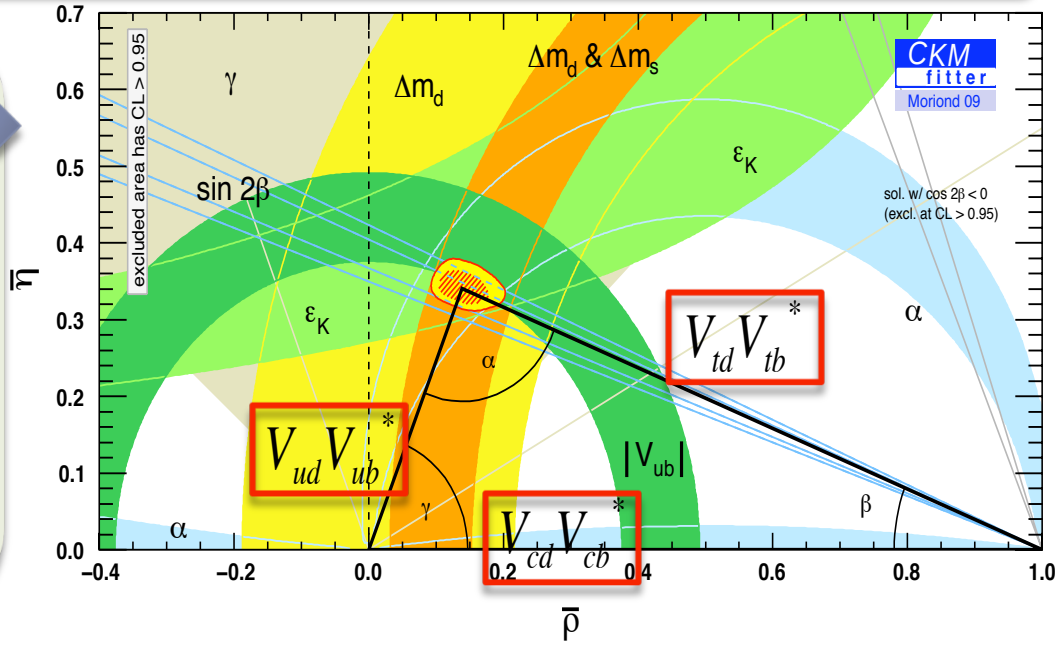
Unitarity of V_{CKM} gives rise to various relations such as: $V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$

Can be represented as a 'unitarity triangle'

Measurement of left side compliments measurements of Sin2 β

Goal is to over-constrain triangle

BSM possibilities in

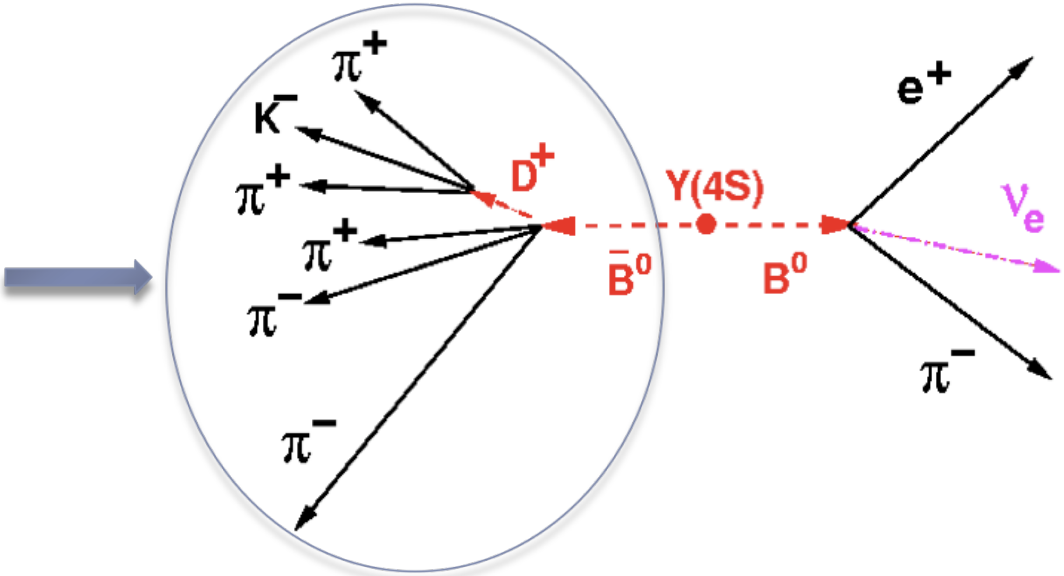


Analysis technique

We can measure $|V_{ub}|$ from semi-leptonic $\overline{B} \to X_u \ell \overline{\upsilon}$ decays

Fully reconstruct one of the *B* mesons (B_{reco})

Over 1000 hadronic modes used



Advantages

Achieve good neutrino mass resolution (used for missing mass cuts)

Effective at eliminating 'continuum' $e^+e^- \to q\overline{q}$ (q = u,d,s,c).

Disadvantages

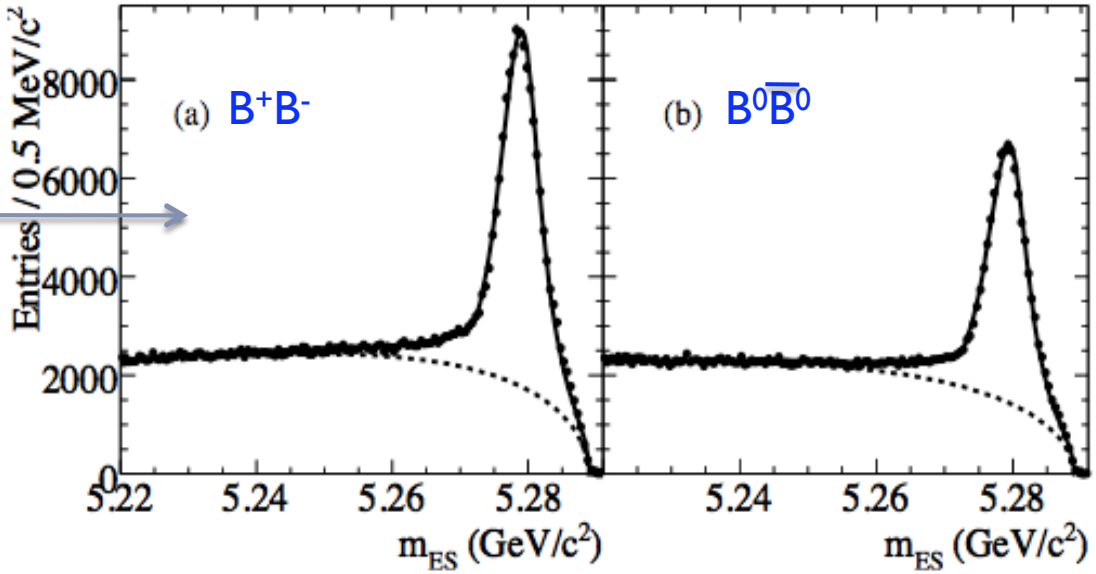
Very low efficiency (roughly 4 events in every 1000 $B\overline{B}$ is fully reconstructed)

Analysis technique

Perform a fit on the m_{ES} distribution of the B_{reco} to remove combinatorial and continuum background

$$m_{ES} = \sqrt{s/4 - p_B^2}$$

$$\sqrt{s} = 10.58 GeV$$



Then make selection on recoiling *B* (B_{recoil})

Must have only one lepton > 1.0 GeV

Missing mass squared < 0.5 GeV^2/c^2

Sum of all charged particles equal to zero

Charges must be correlated

Reject Kaons

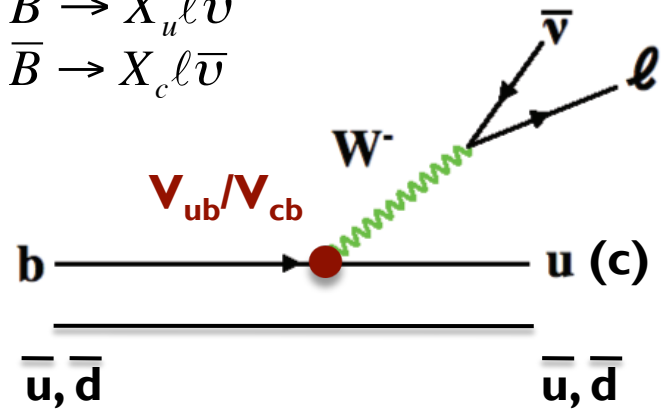
Reject events with partially reconstructed $B \to D^* l \nu$

Analysis technique

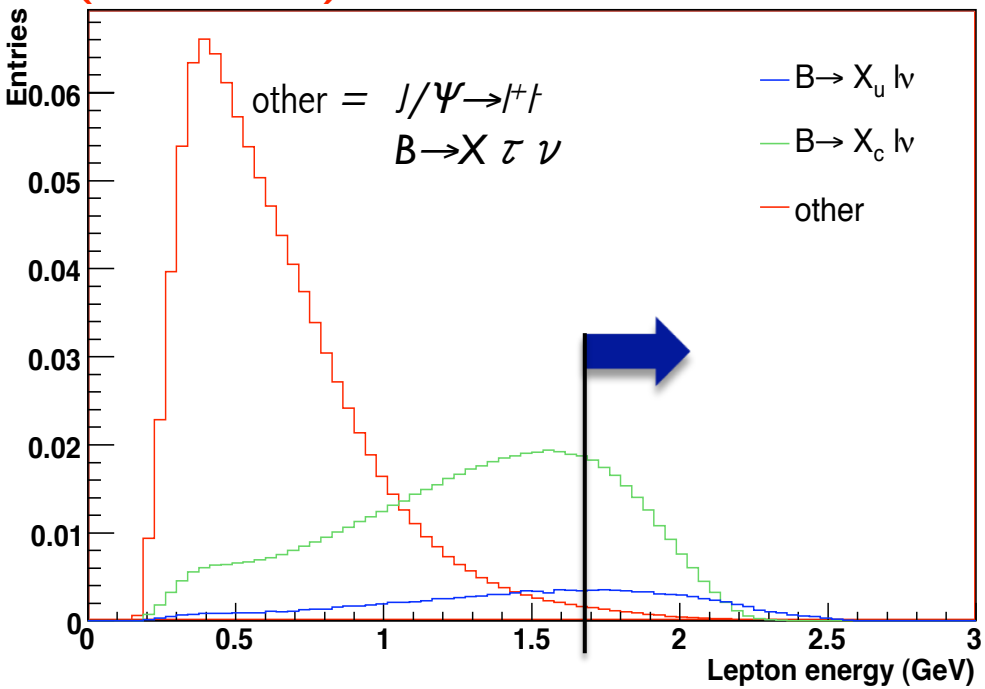
$$\frac{\Gamma(b \to u l \upsilon)}{\Gamma(b \to c l \upsilon)} = \frac{|V_{ub}|^2}{|V_{cb}|^2} \approx \frac{1}{50}$$

Overwhelming / irreducible charm background

$$\overline{B} \to X_u \ell \overline{\upsilon}$$
$$\overline{B} \to X_c \ell \overline{\upsilon}$$



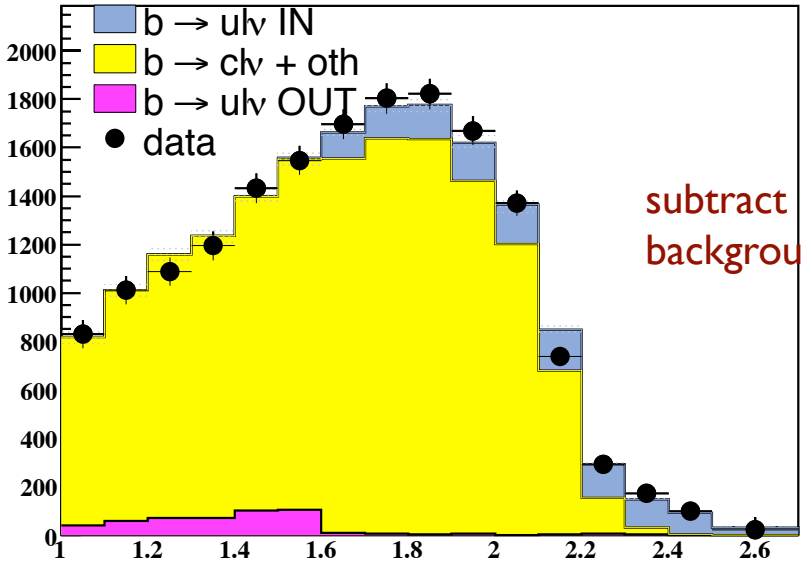
(not to scale)



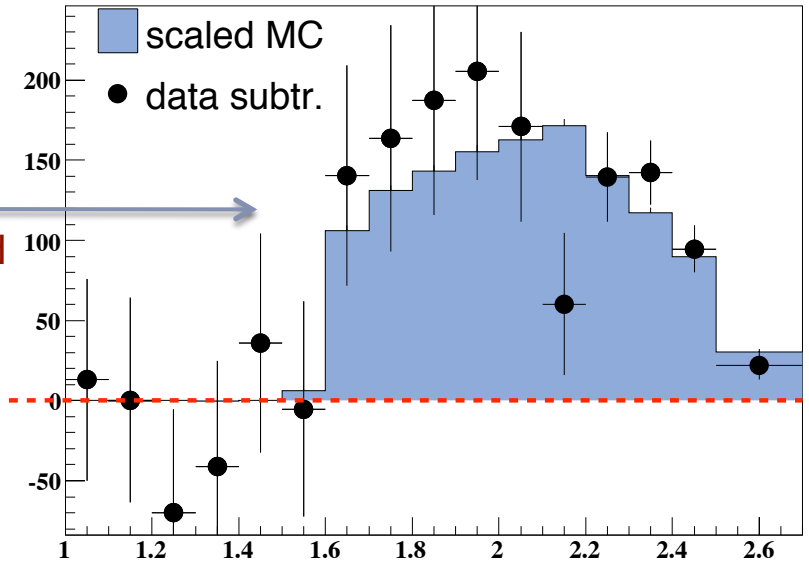
Measure partial branching fraction near the **LEPTON ENDPOINT (E_l > 1.6 GeV)** to suppress charm background

Restricting the phase space in this way challenges the theory

Results



subtract background



Lastly, fit MC to data then subtract yellow and magenta background.

$\overline{B} \to X_u \ell \overline{\upsilon}$ **(>1.6 GeV)** = 1326 ± 132

Backgrounds **(>1.6 GeV)** = 8361 ± 221

χ^2/ndof = 1.06

$$\Delta B(\overline{B} \to X_u \ell \overline{\upsilon}) = 0.00759 \pm 0.00077$$

Translation of $\Delta B(B \to X_u l \nu)$ into $|V_{ub}|$

- No agreed theoretical approach to translate branching fraction into $|V_{ub}|$
- Therefore use what is available and compare resulting values of $|V_{ub}|$
- General form:

$$|V_{ub}| = \sqrt{\frac{\Delta B(\overline{B} \to X_u l \overline{\upsilon})}{\tau_B \Delta\zeta}}$$

τ_B = life-time of B meson

$\Delta\zeta$ = Input from theory

- Four models will be used in this analysis, each utilizing different theoretical approaches
  - Expansion in shape functions matched with OPE (BLNP)
  - Re-summed perturbation theory + power corrections (DGE)
  - OPE-based structure function parameterization (GGOU)
  - Re-summed perturbation theory + analytic time-like QCD coupling (ADFR)

Conclusions & prospects

- Presented is a partial branching fraction for $\overline{B} \to X_u \ell \overline{\upsilon}$ on a dataset of 433fb^{-1}.
- Final results expected for summer
- Traditionally, endpoint measurements employ E_l > ~2.0 GeV.
- With the fully tagged sample, I will increase the phase space to E_l > 1.6 GeV (or lower). Decreasing the theoretical uncertainty.
- This is possible with a fully-tagged analysis as kinematics are very well known
- This analysis is currently the only lepton endpoint measurement of $|V_{ub}|$ using a fully-tagged sample.