Study of the Branching Fraction of $\mathcal{B}(\Upsilon(4S) \rightarrow B^0\bar{B}^0)$ with Partial Reconstruction of $\bar{B}^0 \rightarrow D^{*+}\ell^-\bar{\nu}_\ell$

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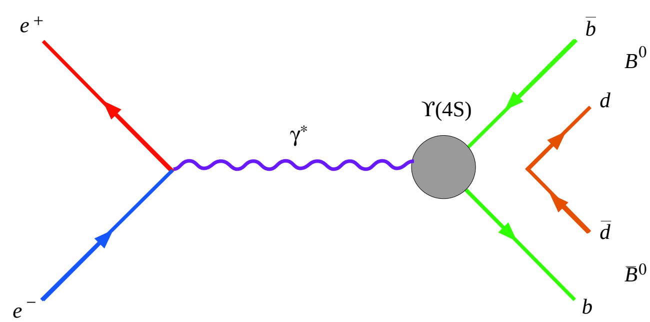
Motivation

- **Absolute measurement of** $\mathcal{B}(\Upsilon(4S) \to B^0\bar{B}^0) \equiv f_{00}$ **is necessary to enhance our knowledge of all branching fractions of** B **meson decays at the** $\Upsilon(4S)$
- $\Upsilon(4S) \to B^0\bar{B}^0$ **or** $\Upsilon(4S) \to B^+B^-$

  $B^0\bar{B}^0$ **production mechanism:**



- $B \to D^* l \bar{\nu}_l$ **decays have the largest branching fraction in any exclusive** B **decays**
- $\frac{f_{+-}}{f_{00}} = 1.04 \pm 0.07 \pm 0.04$ (PRL 86, 2737, 2001, CLEO)

  $\frac{f_{+-}}{f_{00}} = 1.10 \pm 0.06 \pm 0.05$ (PRD 65, 32001, 2002, BaBar)

  an error of 8% **(CLEO);** 7% **(**2σ**)(Babar)**

Introduction

- **BaBar:** $\sim 82\ fb^{-1}$ $B\bar{B}$ **at** $\Upsilon(4S)$
  $\sim 10\ fb^{-1}$ **off-resonance**

Single Tag Events

$$\bar{\mathrm{B}}^0 \to \mathrm{D}^{*+} l^- \bar{\nu}_l \Longrightarrow \mathrm{D}^{*+} \to \mathrm{D}^0 \pi^+$$

At least one B partially reconstructed

Double Tag Events

Within single tag sample, we also require the other B to be partially reconstructed

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Backgrounds: continuum, combinatoric, correlated

- **We can measure f_{00} without knowing ϵ_{0+}, $\mathcal{B}(\bar{B}^0 \to D^{*+}\ell^-\bar{\nu}_\ell)$ and $\mathcal{B}(D^{*+} \to D^0\pi^+)$**

$$f_{00} = \frac{N_s^2}{4 \times N_d \times N_{B\bar{B}}}$$

Partial Reconstruction Technique

- D^* **is detected through a soft pion in the decay of** $D^* \to D\pi$
- **This technique gains a factor of ∼10 in statistics compared to full reconstruction**
- **Observable Missing Mass Squared:**

$$\widetilde{\mathcal{M}}_\nu^2 \equiv (E_{\text{beam}} - \widetilde{E}_{D^*} - E_\ell)^2 - (\widetilde{\vec{\mathbf{p}}}_{D^*} + \vec{\mathbf{p}}_\ell)^2$$

where:

$$E_{D^*} \simeq \frac{E_\pi}{E_\pi^{CM}} M_{D^*} \equiv \widetilde{E}_{D^*}$$

$$\vec{\mathbf{p}}_{D^*} \simeq \hat{\mathbf{p}}_\pi \times \sqrt{\widetilde{E}_{D^*}^2 - M_{D^*}^2} \equiv \widetilde{\vec{\mathbf{p}}}_{D^*}$$

- **Momentum Cuts:**

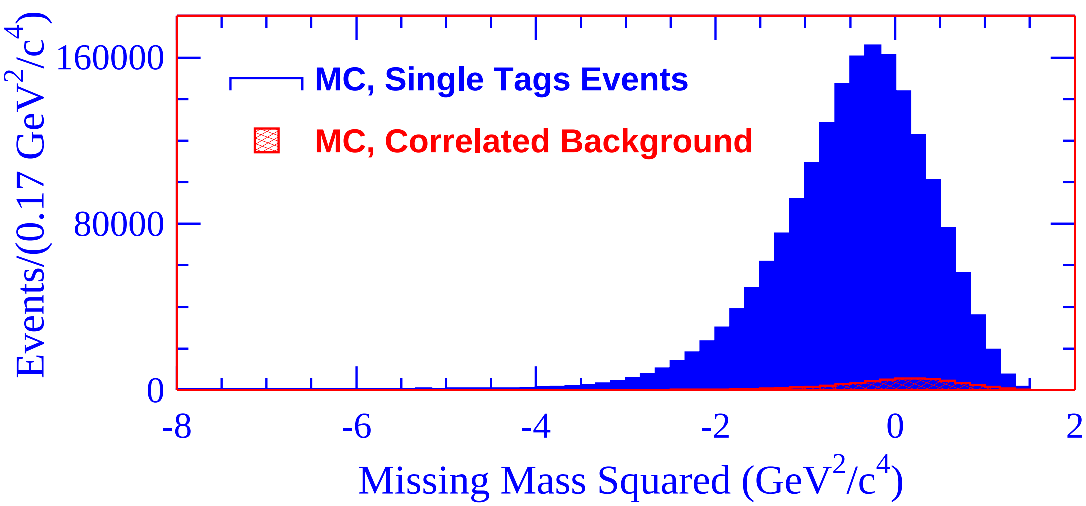
$$1.5 \text{ GeV}/c \le p_l \le 2.3 \text{ GeV}/c$$

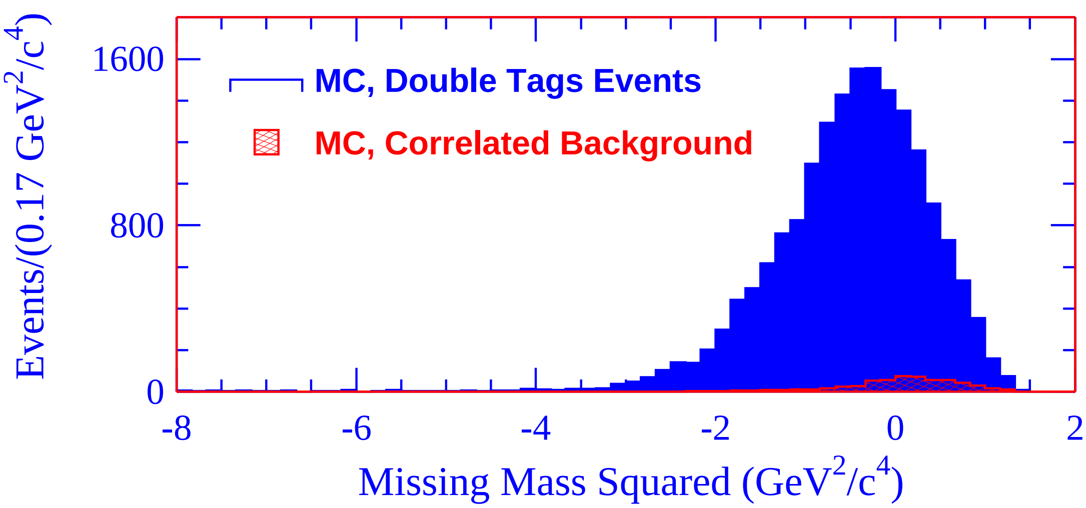
$$60 \text{ MeV}/c \le p_\pi \le 200 \text{ MeV}/c$$

Signal Events, MC

- **Signal region:** $\widetilde{\mathcal{M}}_\nu^2 > -2\ (\mathrm{GeV}/\mathrm{c}^2)^2$
- **Correlated background:** $B \to D^{**}\ell\bar{\nu}_\ell$

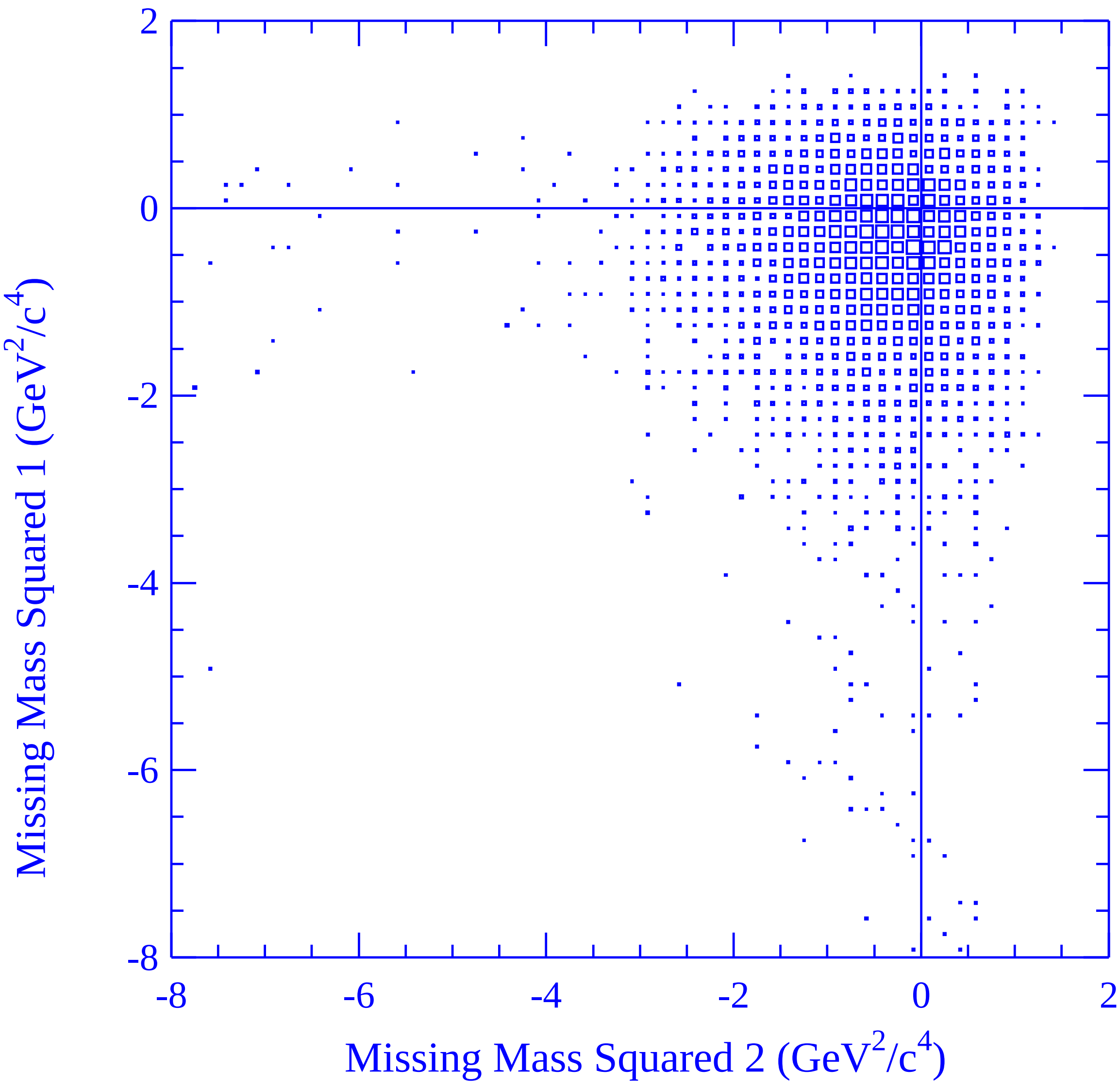
(D^{**}: resonant or nonresonant $D^*\pi$ state)





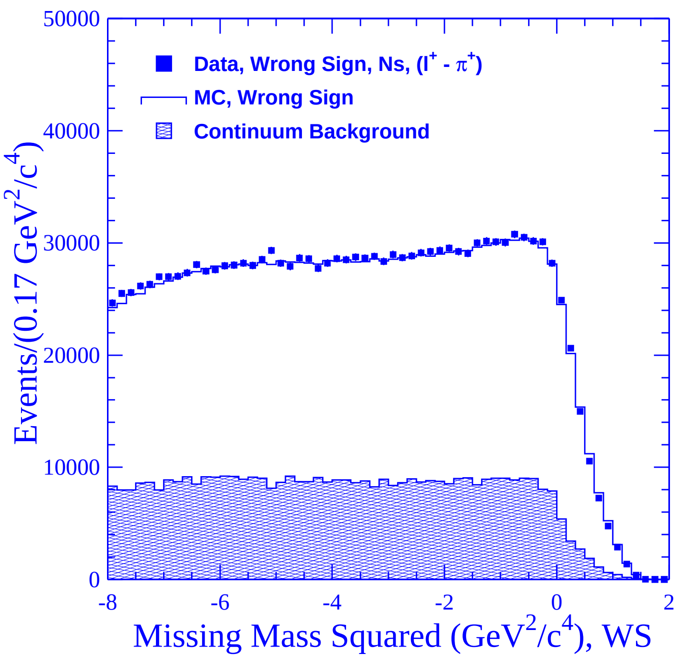
$\widetilde{\mathcal{M}}^2_{\nu 1}$ vs $\widetilde{\mathcal{M}}^2_{\nu 2}$ for Double Tag Events, MC

- **Signal region:** $\widetilde{\mathcal{M}}^2_{\nu} > -2\ (\mathrm{GeV/c^2})^2$



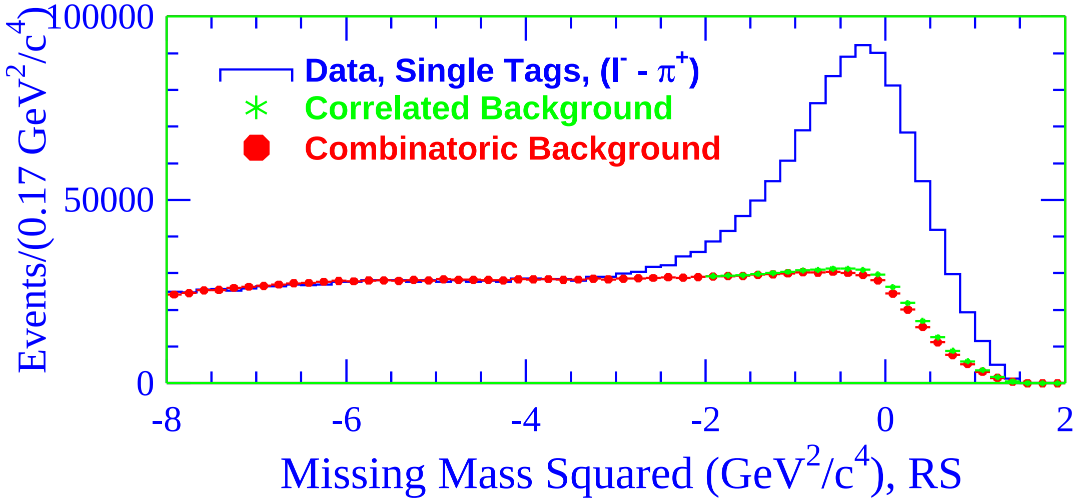
Continuum, Combinatoric Backgrounds

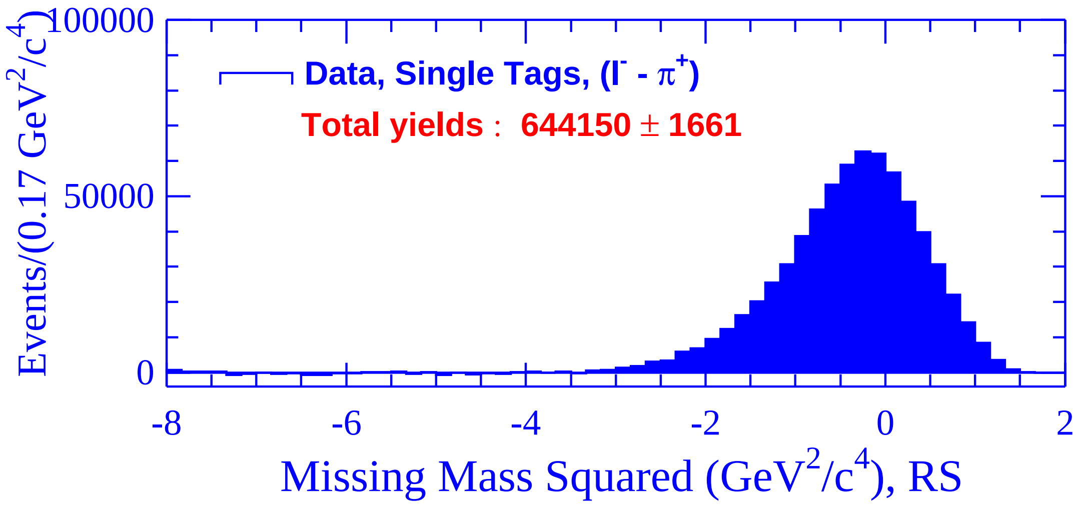
- **Fox-Wolfram moments:** $R_2 \equiv H_2/H_0 < 0.4$ **has been used to reduce continuum events** **$(e^+e^- \to \gamma^* \to q\bar{q}$, where $q = u, d, s, c)$**
- **Wrong sign events are defined when ℓ^+ has the same sign with soft π^+ $\Longrightarrow$ $(\ell^+ - \pi^+)$**
- **Wrong sign MC has been used to estimate the combinatoric background in sideband region:** $-8 < \widetilde{\mathcal{M}}_\nu^2 < -4\ (\mathrm{GeV/c^2})^2$



Single Tag Yields

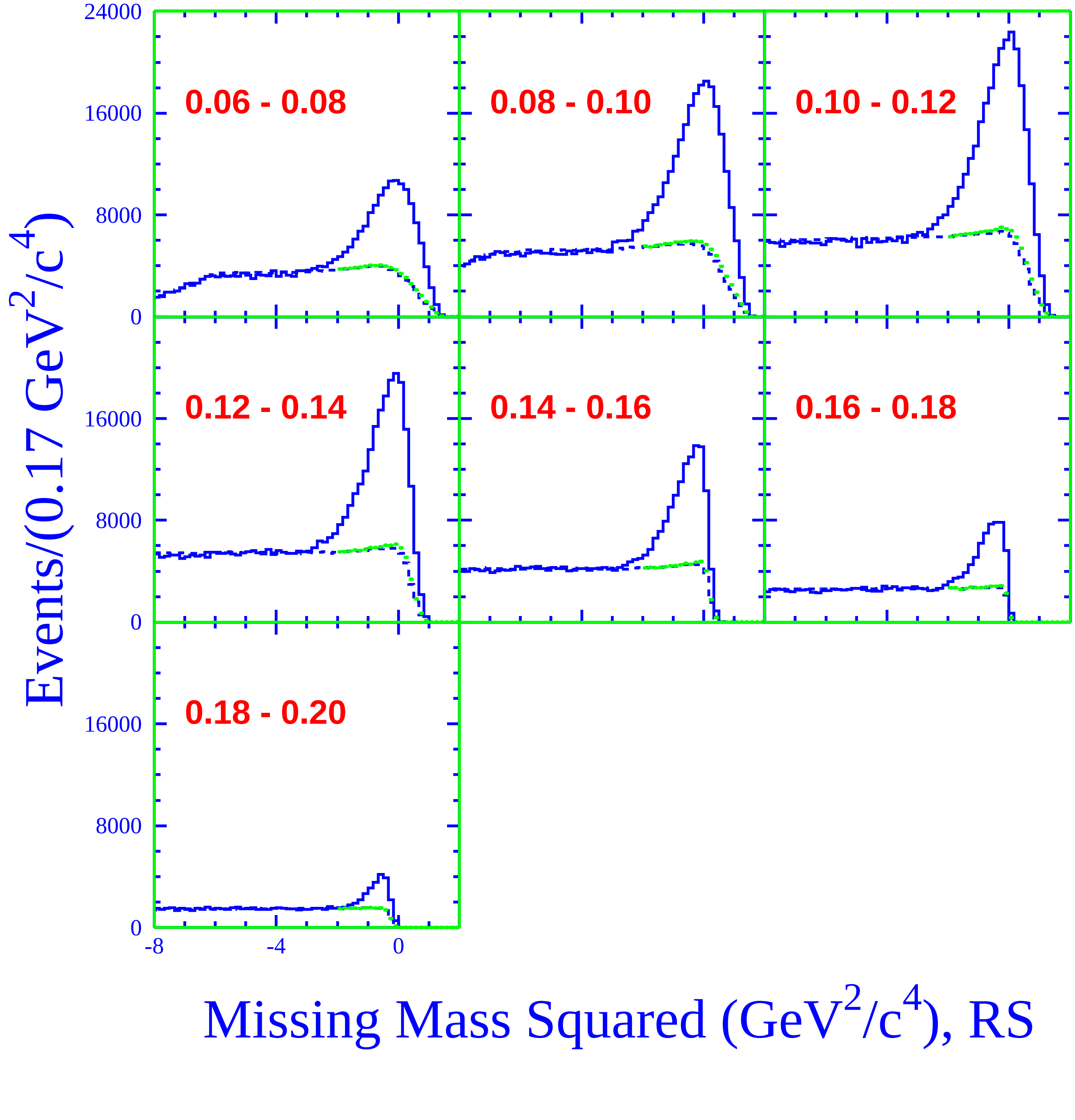
- **Correlated background is estimated using MC in signal region:** $\widetilde{\mathcal{M}}_\nu^2 > -2\ (\mathrm{GeV}/c^2)^2$





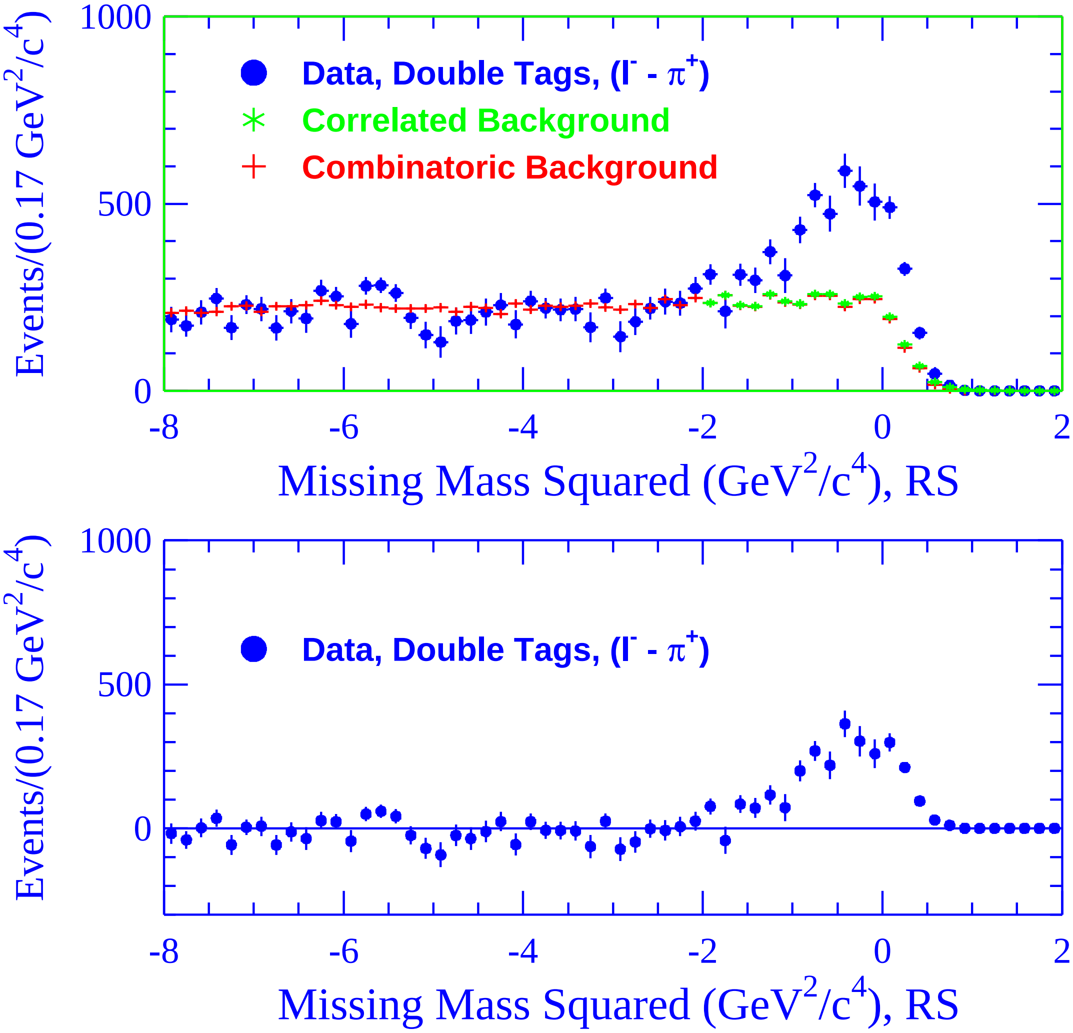
Single Tag Yields in π^+ Momentum Bin

- $\widetilde{\mathcal{M}}_\nu^2$ distributions in soft π^+ momentum bin



First Look of Double Tag Events

- Backgrounds are estimated with the same technique as they are in single tag events



- The estimation of the double tag events is under study

Summary

- **This will be the first measurement of the absolute $\mathcal{B}(\Upsilon(4S) \to B^0\bar{B}^0)$ and independent of $\bar{B}^0$ as well as D^{*+} branching fractions**
- **Expected: $\sim 3\%$ in statistical error**
- **Published result is expected in summer**