Studies of Charged and Neutral D Meson Inclusive Semileptonic Decays

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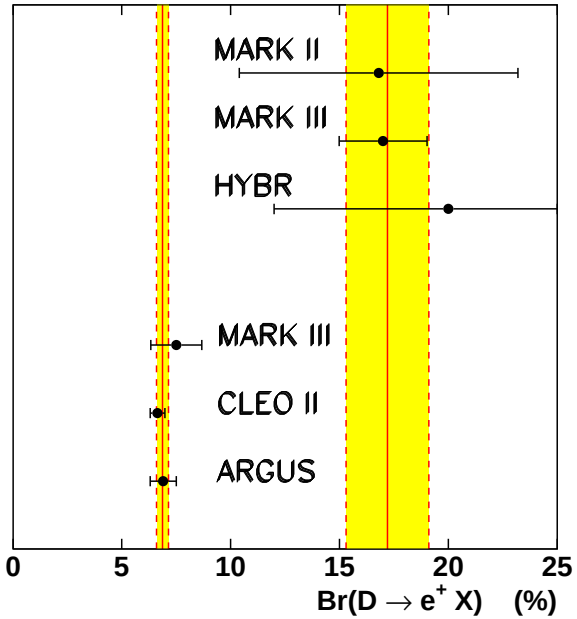
CLEO

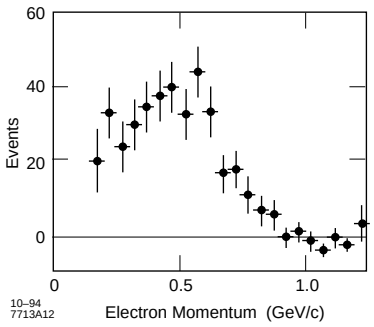
August 27, 2004

Outline

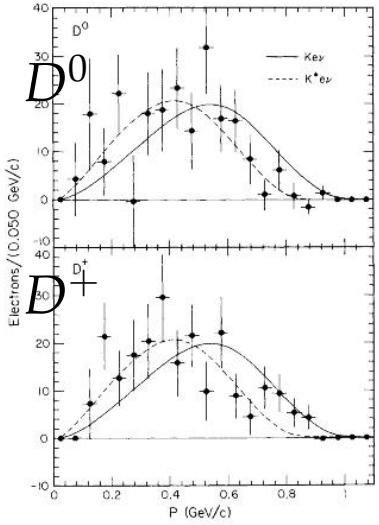
- **Objective : Direct measurement of neutral and charged D-meson inclusive semileptonic branching fractions and spectra.**
  - **PDG $\mathcal{B}(D^0 \to e^+ X) = \quad 6.87 \pm 0.28\%$**
  - **PDG $\mathcal{B}(D^+ \to e^+ X) = 17.2 \pm 1.9\%$**



D^0/D^+



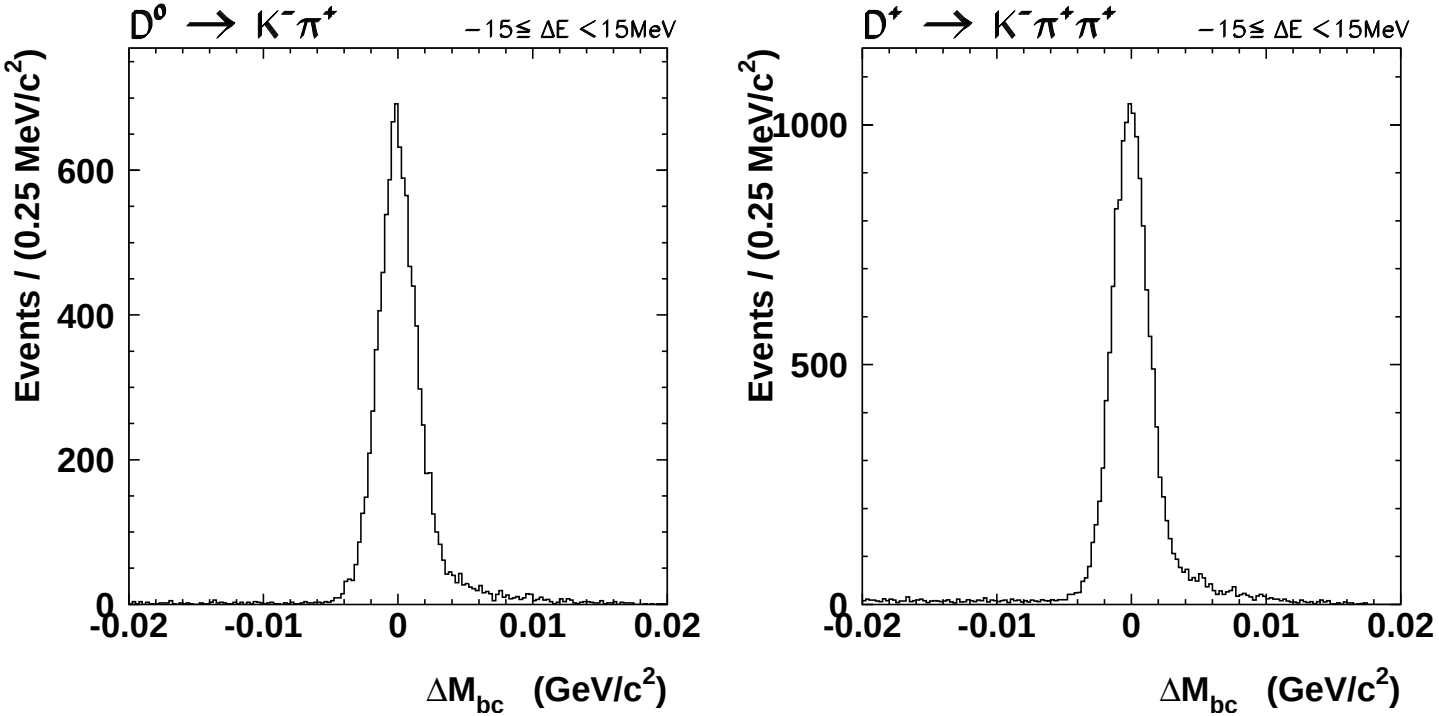
'79 DELCO



'85 MARK III

CLEO-c

- **CLEO-c : $60\mathrm{pb}^{-1}$ pilot run at the $\psi(3770)$ energy. $\psi(3770)$ decays predominantly to $D\bar{D}$ pairs.**
- **D-tagging : Single tag using hadronic decays $\Rightarrow$ Clean experimental environment.**



Inclusive $D \longrightarrow e^+ X$ Semileptonic Measurement

$$\frac{1}{\sigma_D} \cdot \frac{d\sigma_e}{dp} = \frac{1}{N_D} \cdot \frac{\Delta n_e}{\Delta p} = \frac{1}{N_D} \cdot \frac{\Delta Y_e/\epsilon_e}{\Delta p}$$

- **Working w/ ΔE sideband subtracted numbers**
- **Number of D,** $N_D = N_{D_{\rm tag}} - N_{D_{\rm b.g.}}$
- **Primary electron candidate,**
  $Y_e = Y_{e\,\rm RS} - Y_{\rm non-electron} - Y_{e\,\rm non-primary}$
- **Non-electron correction: subtract weighted hadron fake fraction,** $f_{\rm non-electron} = w_\pi^{\rm MC} \cdot f_\pi^{\rm measured} + w_K^{\rm MC} \cdot f_K^{\rm measured}$**. Or unfolding** $y_i = \epsilon_{ij}^{-1} \cdot y_j^{\rm observed}$**, where** i or $j = e, \pi$ **and** K**.**
- ϵ_e **efficiency correction:** $\epsilon_{e\,\rm ID} \cdot \epsilon_{\rm tracking} \cdot \epsilon_{\rm fiducial} \cdot \epsilon_{\rm radiative}$

D-tagging

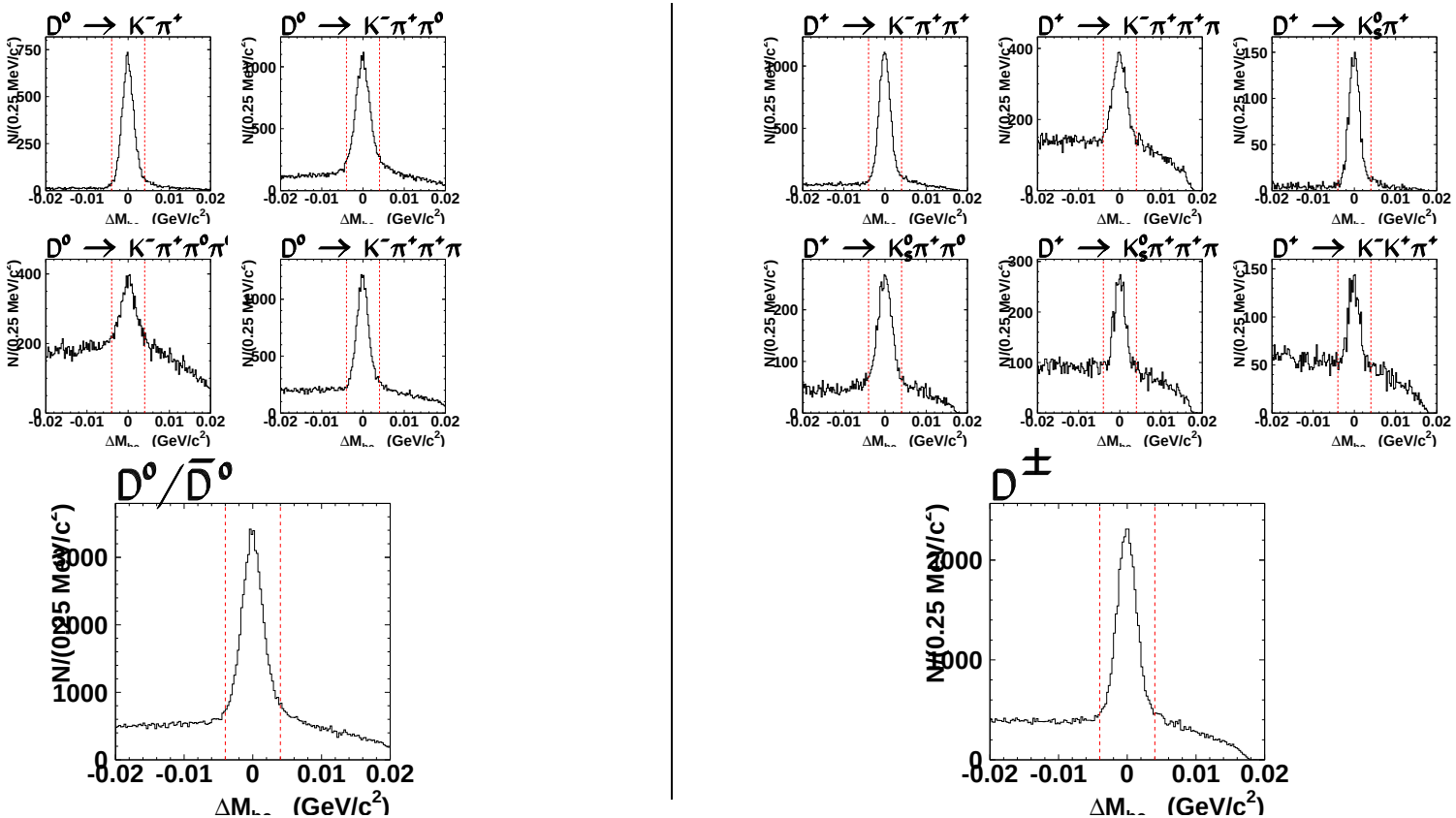
- $D \to e^+ X$:
  We need flavored D-tagging modes to define right- and wrong-sign of electron
  - D^0 **: use charge of Kaon**
  - D^+ **: use charge of** D
- **The other side tracks $\Rightarrow$ signal side**

D-tag mode	Yield (10^3)
$D^0 \to K^-\pi^+$	9.1
$D^0 \to K^-\pi^+\pi^0$	12.5
$D^0 \to K^-\pi + \pi^0\pi^0$	2.7
$D^0 \to K^-\pi + \pi + \pi-$	13.8
Sum of all D^0 modes	38.1
$D^+ \to K^-\pi^+\pi^+$	13.9
$D^+ \to K^-\pi^+\pi^+\pi^0$	3.5
$D^+ \to K^0_S\pi^+$	1.8
$D^+ \to K^0_S\pi^+\pi^0$	2.6
$D^+ \to K^0_S\pi^+\pi^+\pi^-$	2.4
$D^+ \to K^-K^+\pi^+$	1.2
Sum of all D^+ modes	25.5

D-tagging – $\Delta M_{\rm bc}$

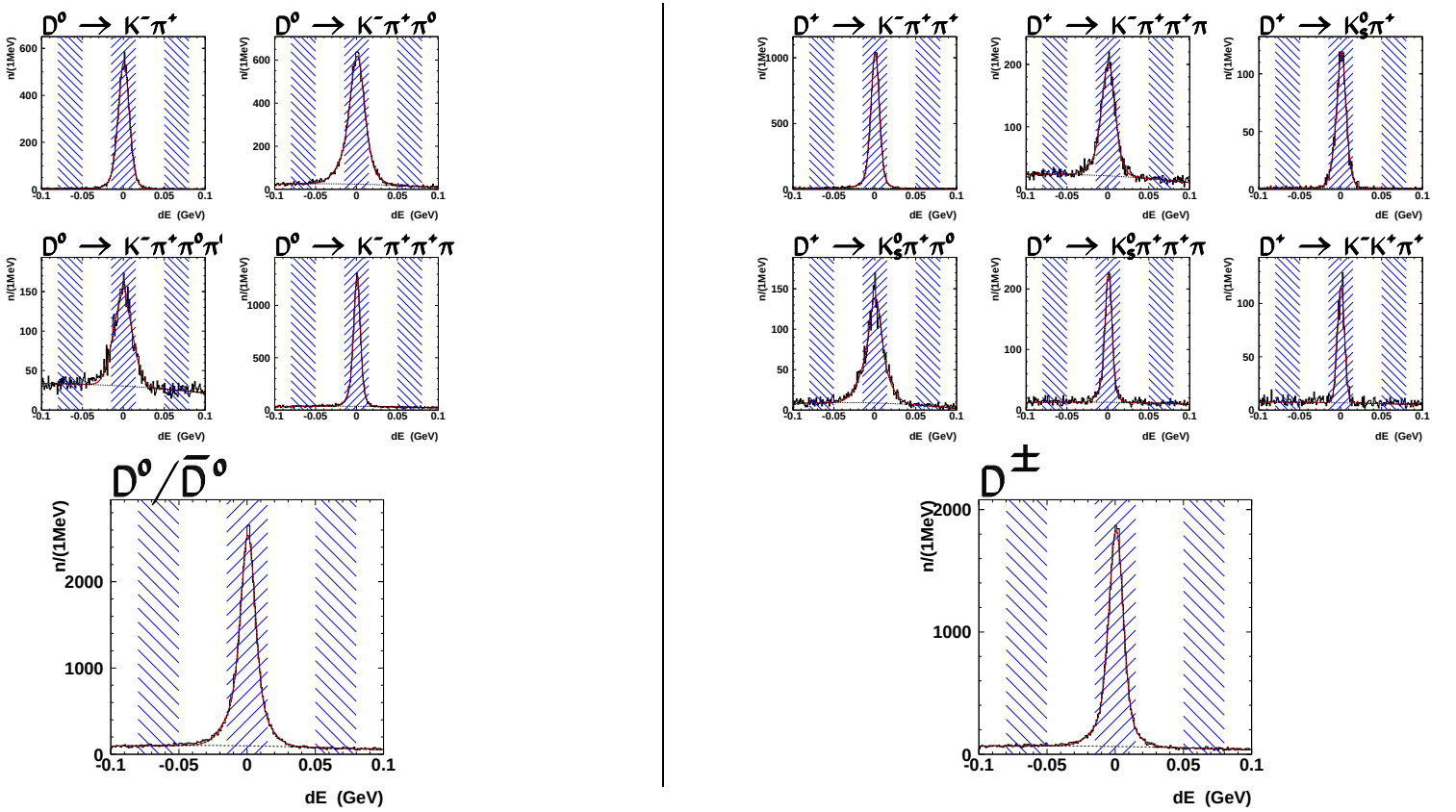
- **Beam energy constrained mass** $M_{\rm bc} = \sqrt{E^2_{\rm beam} - \vec{p}^{\,2}_D}$

- **Require** $\sim 2.5\sigma$ **signal region**



D-tagging – ΔE w/ $\Delta M_{\rm bc}$ cut

- **Energy difference $\Delta E = E_D - E_{\rm beam}$, $\sim 2.5\sigma$ signal and sidebands for sideband subtraction. Fit to a double Gaussian plus 2nd order polynomial to determine sideband scaling factor.**



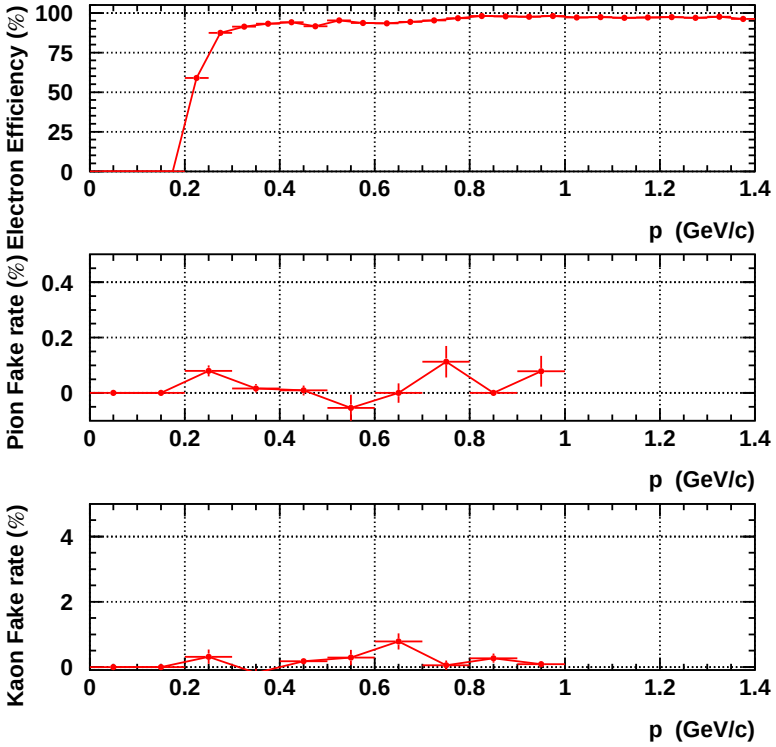
Signal Side – Electron Identification

- $p \geq 200$ MeV/c
  $|\cos\theta| < 0.90$
- **Select good quality tracks from Interaction Point**
- **Electron identification : E/p (calorimeter), dE/dx (drift chamber), and RICH (ring imaging Cherenkov)**

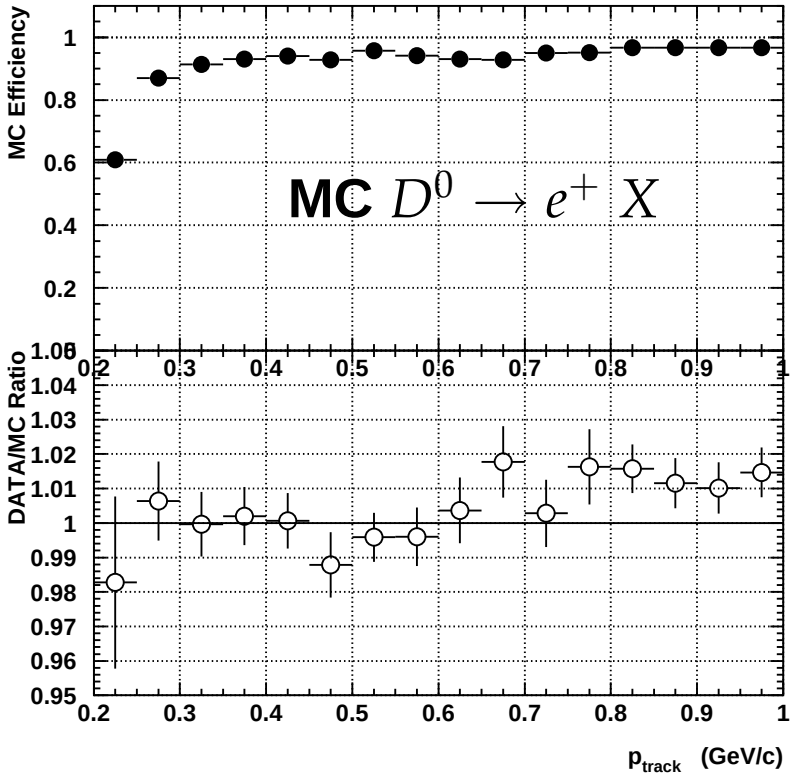
$$\mathcal{F}(e|x) = \frac{\mathcal{L}(e|x)}{\mathcal{L}(e|x) + \mathcal{L}(\pi|x) + \mathcal{L}(K|x)}$$

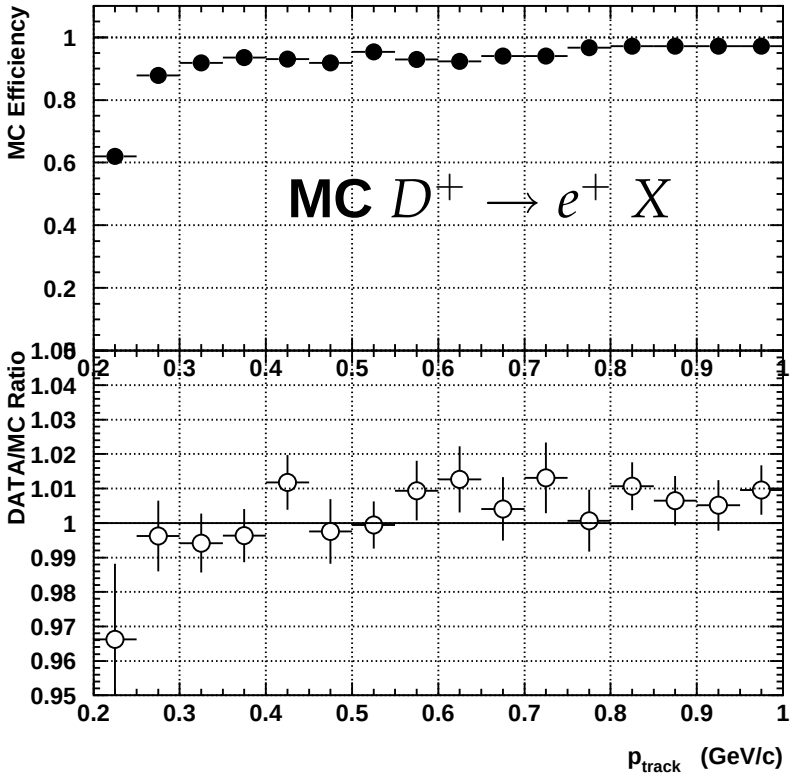
- **Efficiency : radiative Bhabha re-weight angular and momentum distributions**

- **Fake rates : $K^0_S \to \pi^+\pi^-$, $D^0 \to K^-\pi^+$, and $D^+ \to K^-\pi^+\pi^+$ w/o PID.**



Signal Side – Electron ID DATA/MC



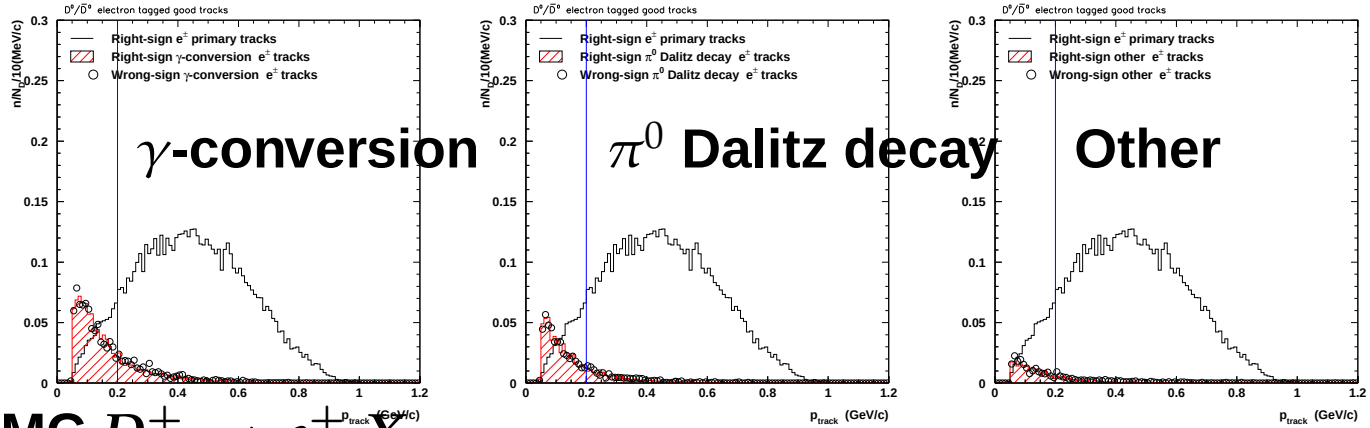


- **Event environment dependence : radiative Bhabha embedding study is going on.**

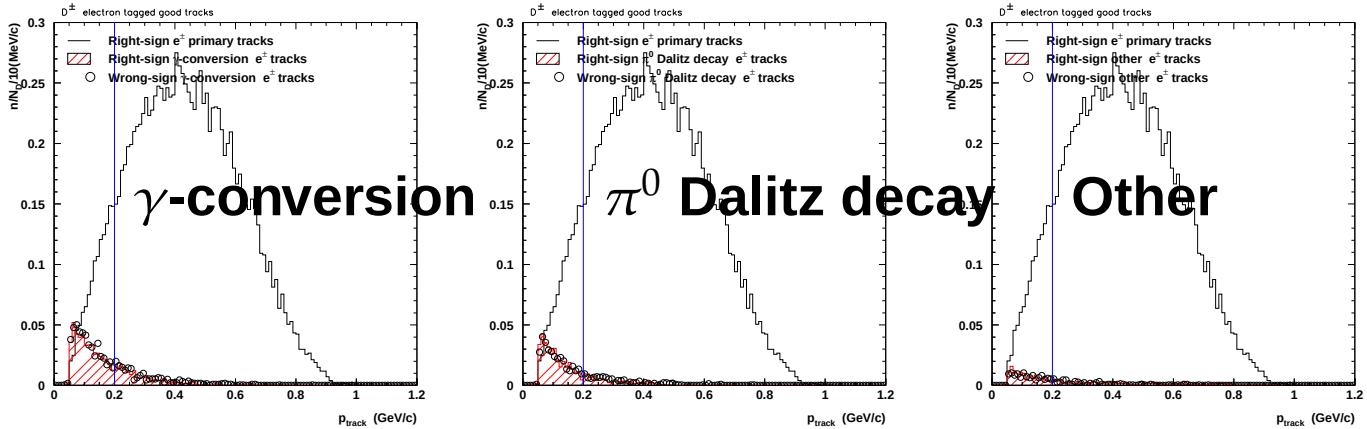
Signal Side – non-primary electron b.g.

- **Wrong-sign electron subtraction: mainly charge symmetric backgrounds from γ-conversion and π^0 Dalitz decay**

MC $D^0 \longrightarrow e^+ X$

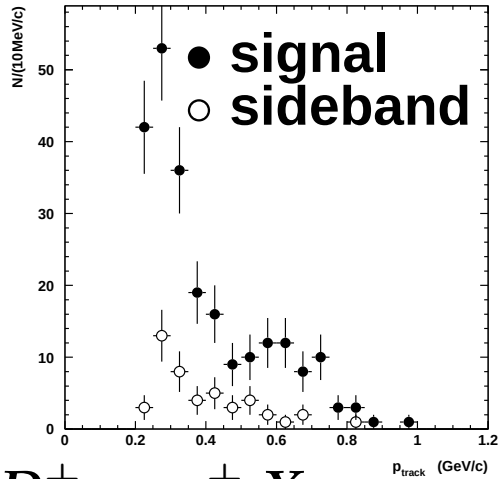


MC $D^+ \longrightarrow e^+ X$

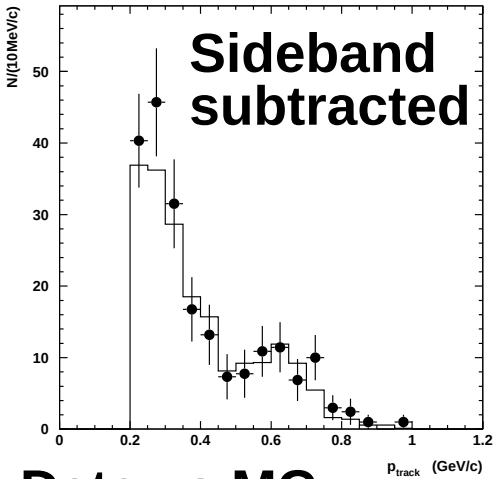


Signal Side – wrong-sign subtraction

$D^0 \longrightarrow e^+ X$



Data vs MC



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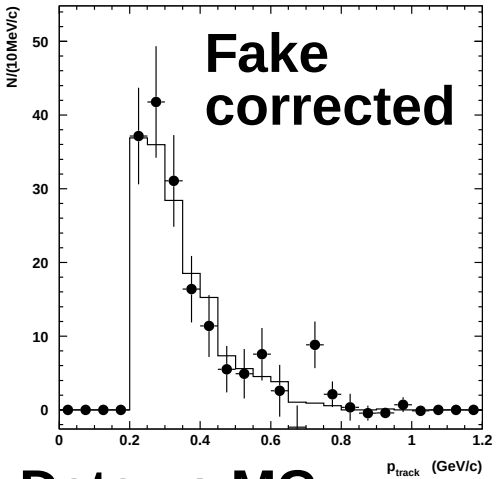
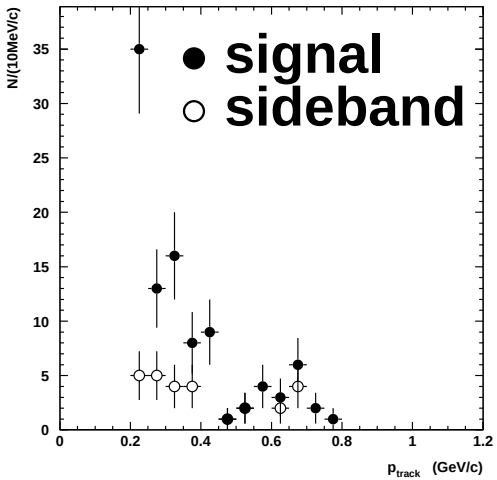
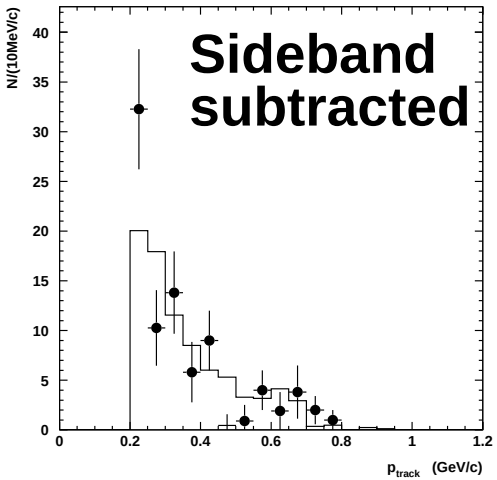


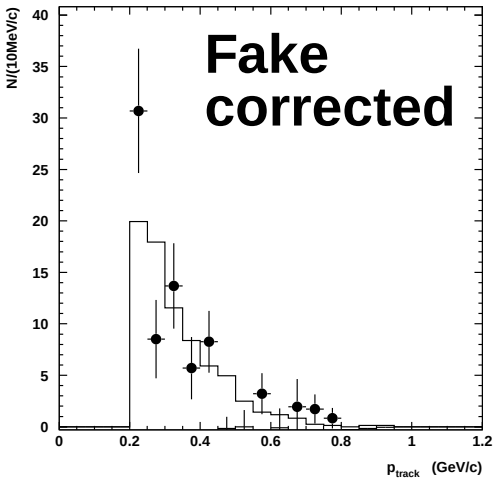
$D^+ \longrightarrow e^+ X$



Data vs MC

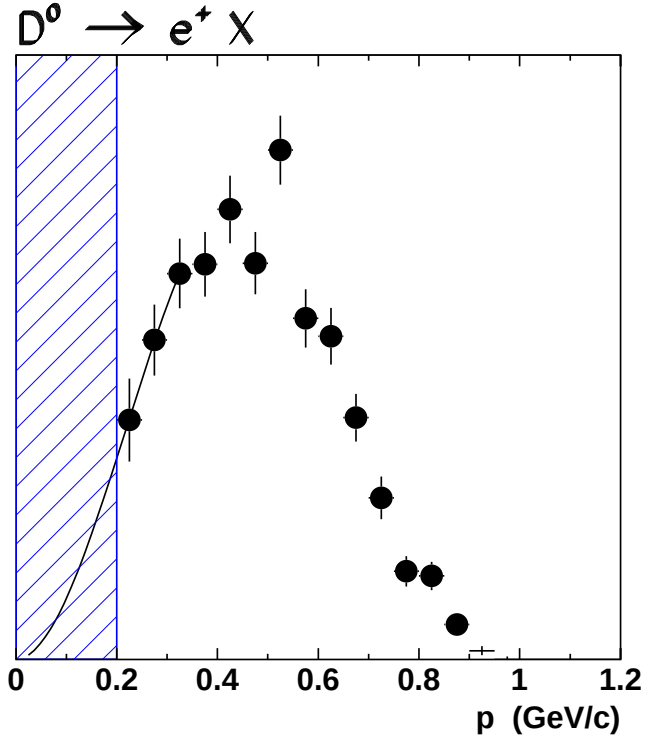


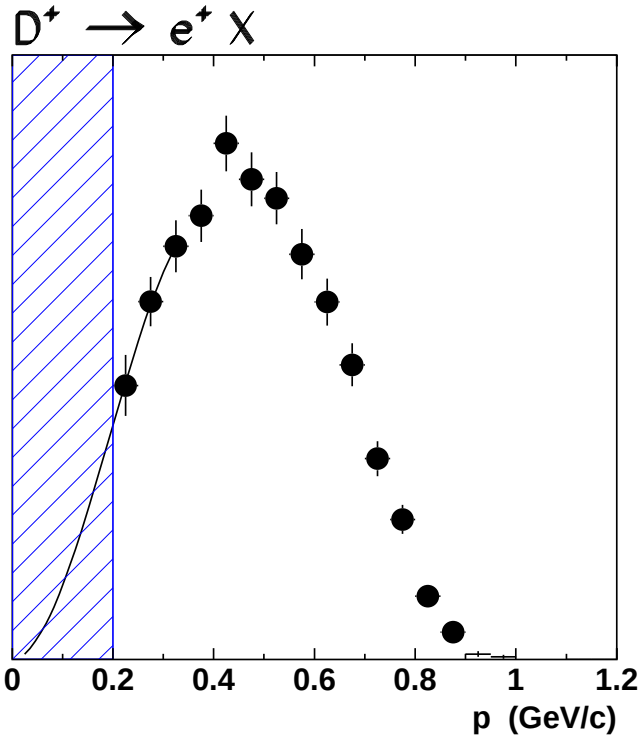
Data vs MC



Spectra

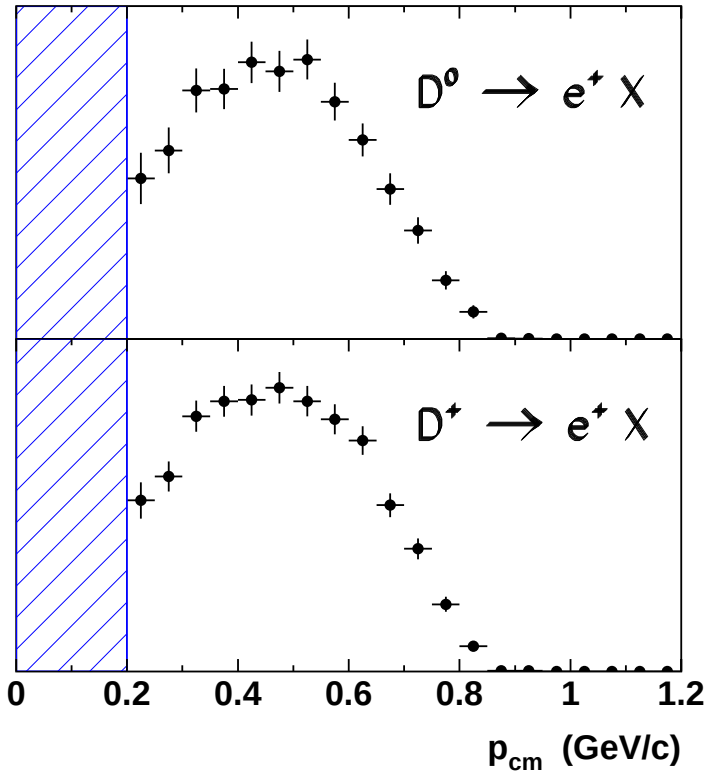
- **Momentum cutoff (200 MeV/c) : spectrum extrapolation ($\sim 10\%$)**
- **D^0 modes : subject to Cabibbo suppressed decay (DCSD/SCSD) contributions $\Rightarrow$ flavor mis-tagging correction**

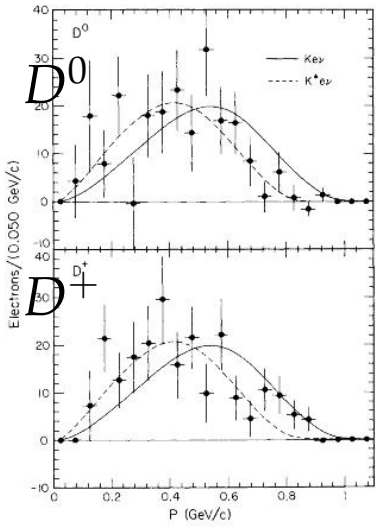




Spectra – D-rest frame, VERY PRELIMINARY

- $-p_{D_{\mathrm{tag}}}$ at $\psi(3770)$-rest frame $\Rightarrow$ signal side p_D.
- Working with 2-dimensional yield matrix $y(p, p^*)$





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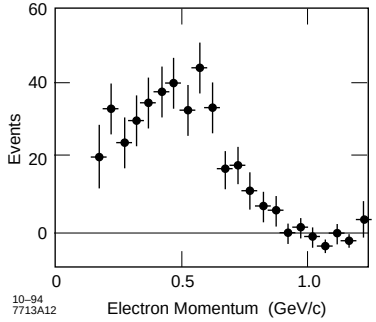
D^0/D^+



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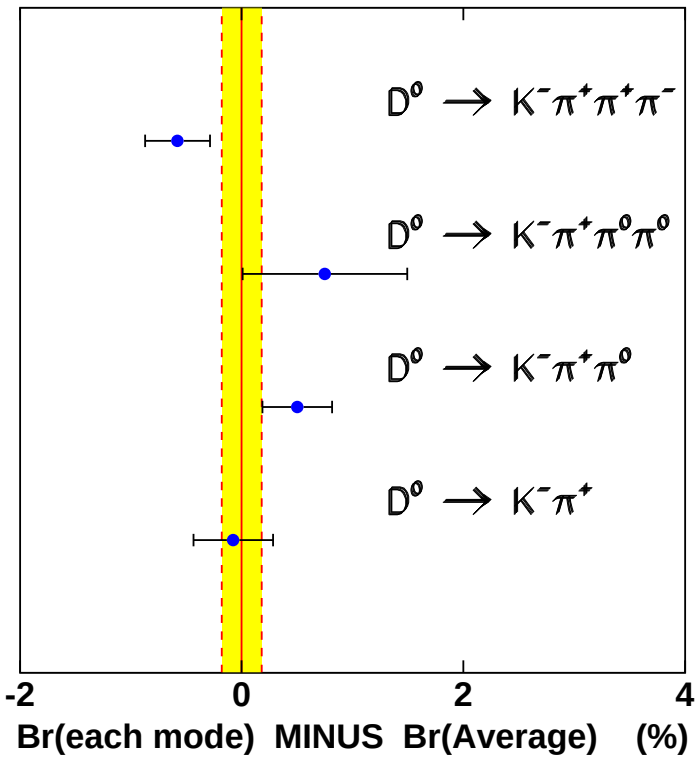
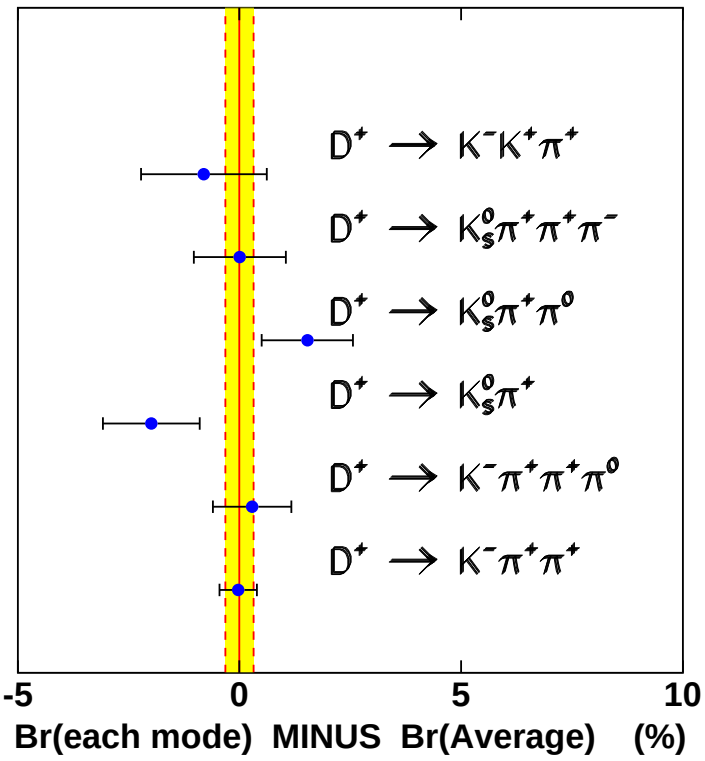
Statistical Significance

- **Statistical significance: sum of all modes**
  - **Stat. error** $\mathcal{B}(D^0 \to e^+ X) \sim 0.2\%$ **(PDG incl. syst.** $\sim 0.3\%$**)**
  - **Stat. error** $\mathcal{B}(D^+ \to e^+ X) \sim 0.3\%$ **(PDG incl. syst.** $\sim 1.9\%$**)**





Summary & Outlook

- **With $60\mathrm{pb}^{-1}$ pilot data, already statistically competitive with PDG values, systematics-limited**
  - **Statistical significance: sum of all modes**
    - **Stat. error $\mathcal{B}(D^0 \to e^+ X) \sim 0.2\%$ (PDG incl. syst. $\sim 0.3\%$)**
    - **Stat. error $\mathcal{B}(D^+ \to e^+ X) \sim 0.3\%$ (PDG incl. syst. $\sim 1.9\%$)**
  - **Statistical significance: using 2 cleanest modes $D^0 \to K^-\pi^+$ and $D^+ \to K^-\pi^+\pi^+$**
    - **Stat. error $\mathcal{B}(D^0 \to e^+ X) \sim 0.4\%$**
    - **Stat. error $\mathcal{B}(D^+ \to e^+ X) \sim 0.4\%$**
- **Systematics Study : work in progress, we hope to provide results in the near future.**