

Measurement of $\text{Br}(B^0 \rightarrow D^* D_s^*)$ and $\text{Br}(D_s \rightarrow \phi \pi)$ @ BaBar

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Outline

- Motivations
- Strategy
- $B^0 \rightarrow D^* D_s^*$
- $D_s \rightarrow \phi \pi$
- Conclusions

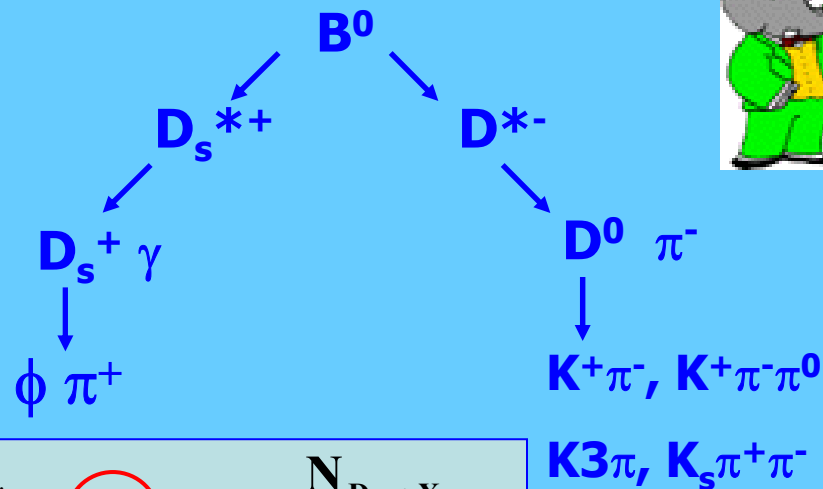


Motivations

- $B^0 \rightarrow D^* D_s^*$
 - First $\text{Br}(B \rightarrow D^* D_s^*)$ independent on $\text{Br}(D_s \rightarrow \phi \pi)$
 - Factorization tests at high q^2 values ($q^2 \sim M(D_s^*)^2$)
 - Control sample for $D^* D^*$ (CP-eigenstate)
 - Constraint on γ [hep-ph/03010252](#)
- $D_s \rightarrow \phi \pi$
 - All the D_s branching ratios (and $B \rightarrow D_s^{(*)} X$) are normalized to it
 - Current error on $\text{Br}(D_s \rightarrow \phi \pi)$ is 25%
- Analysis based on 114 fb^{-1} (preliminary results)



Strategy



Reconstruction of $B^0 \rightarrow D^* D_s^*$

- Partial($D^* + \gamma$ from D_s^*)

$$\text{Br}(B^0 \rightarrow D^* D_s^*) = \mathbf{B_1} = \kappa \frac{N_{D_s \rightarrow X}}{\sum \varepsilon_i \text{Br}_i(D^0)}$$

- Full($D^* + \gamma + D_s \rightarrow \phi \pi$)

$$\text{Br}(B^0 \rightarrow D^* D_s^*) \text{Br}(D_s \rightarrow \phi \pi) = \mathbf{B_2} = \kappa \frac{N_{D_s \rightarrow \phi \pi}}{\text{Br}(\phi \rightarrow KK) \sum \varepsilon'_j \text{Br}_j(D^0)}$$

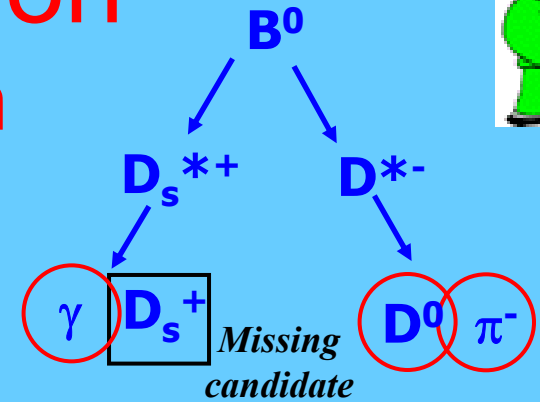
- $\kappa = (2N_{B\bar{B}} \text{Br}(D^* \rightarrow D^0 \pi) \text{Br}(D_s^* \rightarrow D_s \gamma))^{-1}$ common to both B_1 and B_2

$$\text{Br}(D_s \rightarrow \phi \pi) = \frac{B_2}{B_1} = \frac{N_{D_s \rightarrow \phi \pi} \sum \varepsilon_i \text{Br}_i(D^0)}{N_{D_s \rightarrow X} \text{Br}(\phi \rightarrow KK) \sum \varepsilon'_j \text{Br}_j(D^0)}$$

Partial reconstruction candidates selection



Preliminary cut on R_2 to reject continuum events



Photon selection:

- $E^* > 142$ MeV
- $Z_{20} > 0.82$
- $LAT > 0.016$

Best photon from
 $Lr(E, E^*, LAT, \# \text{ of cr.})$

D^* selection:

- $1.4\text{GeV} < p^*(D^*) < 1.9\text{GeV}$
- $|M(D^0)_{\text{rec}} - M(D^0)_{\text{pdg}}| < 3\sigma_i$
- $Q_i^{\text{min}} < Q(D^*) < Q_i^{\text{max}}$

Best D^* from $\chi^2(m(D^0), Q(D^*))$

Optimized maximizing $\mathbf{S}/(\mathbf{S}+\mathbf{B})^{1/2}$ in $|m_{\text{miss}} - m(D_s)_{\text{pdg}}| < 45\text{MeV}$

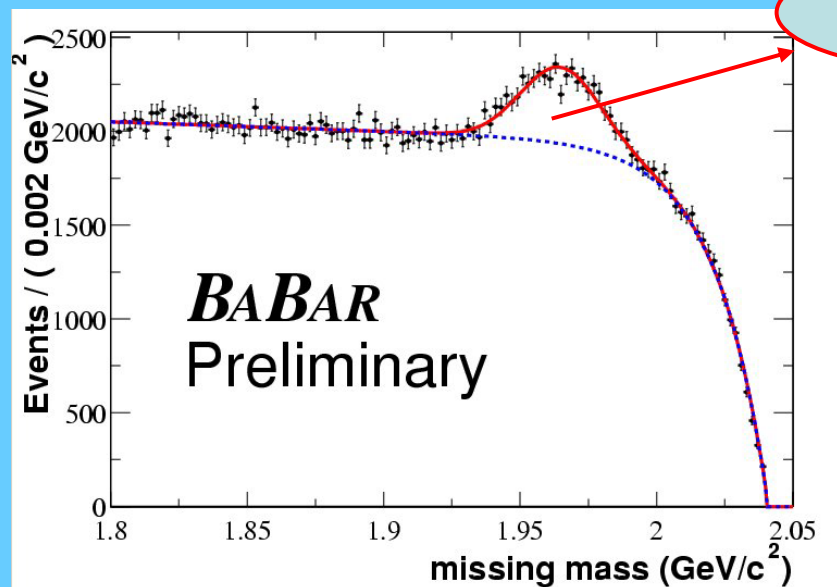
$$m_{\text{miss}} = \sqrt{(E_{\text{beam}} - E_{D^*} - E_{\gamma})^2 - (\vec{p}_B - \vec{p}_{D^*} - \vec{p}_{\gamma})^2}$$



Br($B^0 \rightarrow D^* D_s^*$)

- Efficiencies from Mc
- N_{D_s} from fit to m_{miss}
- Pdf: $B(\text{bkg}) + \text{gauss}(\text{signal})$

$$B(m) = a \left(1 - e^{-\frac{m - m_{\text{max}}}{b}} \right) \left(\frac{m}{m_{\text{max}}} \right)^c$$



$N_{D_s} \sim 7400$

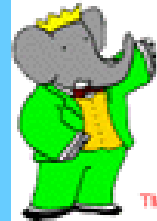
Statistic error: 4.9%

Systematic errors:

• MC statistics	0.6%
• Photon efficiency	4.6%
• Bkg shape	4.5%
• Soft pion efficiency	1.6%
• Vertexing	2.0%
• Br(D^0)	3.2%
• Br($D_s^{*+} \rightarrow D_s^+ \gamma$)	2.7%
• Other	1.8%
Total	8.6%

$$\text{Br}(B^0 \rightarrow D^* D_s^*) = (1.85 \pm 0.09_{\text{stat}} \pm 0.16_{\text{syst}}) \times 10^{-2}$$

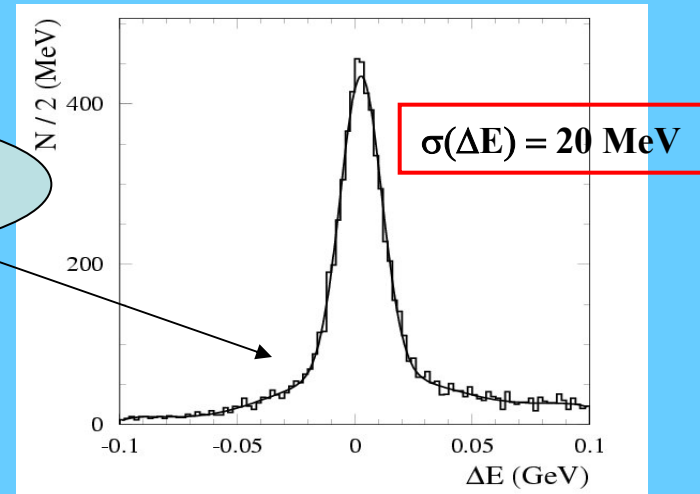
Full reconstruction candidates selection



- Selection:

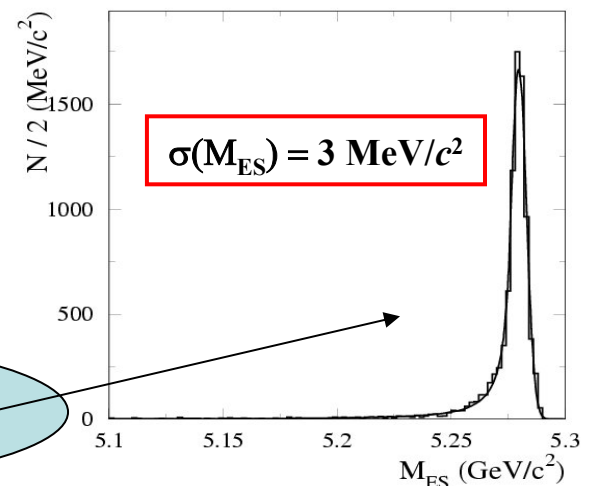
- $R_2 < 0.35$
- $Q_{i,\min} < Q(D^*) < Q_{i,\max}$
- $E_{\gamma}^* > 0.090 \text{ GeV}$
- $|\cos\theta_{\text{hel}}| > 0.35$
- $1.0077\text{GeV} < M(\phi) < 1.0347\text{GeV}$
- $0.125\text{GeV} < Q(D_s^*) < 0.160\text{GeV}$
- $|\Delta E| < 0.05\text{GeV}$

$$\Delta E = E_{\text{beam}} - E_{D^*} - E_{D_s^*}$$



Optimized maximizing $S/(S+B)^{1/2}$
in $5.27\text{GeV} < M_{\text{es}} < 5.29\text{GeV}$

MC signal sample



- Best candidate(D^* , γ , D_s) from minimum $|\Delta E|$

$$M_{\text{es}} = (E_{\text{beam}}^2 - (p_{D^*} - p_{D_s^*})^2)^{1/2}$$

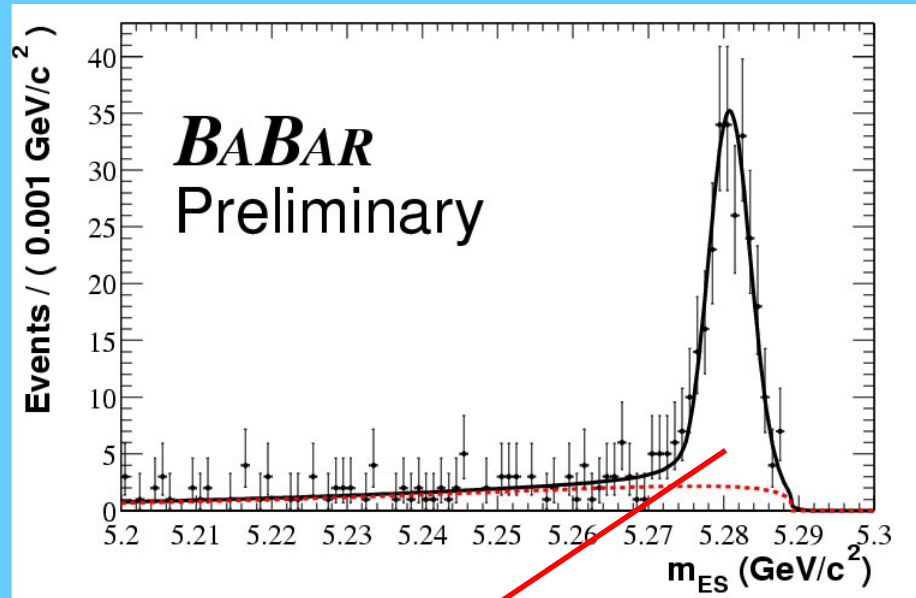


$\text{Br}(D_s \rightarrow \phi\pi) \quad (1)$

- Efficiencies from MC
- Peaking background from MC
- $N_{D_s \rightarrow \phi\pi}$ from fit to M_{ES}
- Pdf: Crystal Ball (signal + peak bkg)

+ Argus (combinatorial bkg)

$$A(m) = Nm \left(1 - \frac{m^2}{m_0^2}\right)^p \exp \left[k \left(1 - \frac{m^2}{m_0^2}\right) \right]$$



$$N_{D_s \rightarrow \phi\pi} \sim 210$$

$$\text{Br}(B^0 \rightarrow D^* D_s^*) \text{Br}(D_s^- \rightarrow \phi\pi) = (8.71 \pm 0.78_{\text{stat}}) \times 10^{-4}$$



Br($D_s \rightarrow \phi\pi$) (2)

$$\text{Br}(D_s \rightarrow \phi\pi) = \frac{B_2}{B_1}$$

**Combining partial and full reconstructions
many systematic effects cancel out**

Source of systematic error surviving:

Partial reconstruction:

- Monte Carlo statistic 0.6%
- Bkg shape 4.5%

Full reconstruction:

- Monte Carlo statistic 3.2%
- Tracking efficiency 2.6%
- Particle identification 0.9%
- Peaking bkg 2.8%
- Combinatorial bkg 2.9%
- Br($\phi \rightarrow K^+K^-$) 1.2%

Total 7.5%

$$\text{Br}(D_s \rightarrow \phi\pi) = (4.71 \pm 0.47_{\text{stat}} \pm 0.35_{\text{syst}}) \times 10^{-2}$$

Global error $\sim 12.4\%$



Conclusions

- $\text{Br}(B^0 \rightarrow D^* D_s^*)$
 - First measurement independent on $\text{Br}(D_s \rightarrow \phi \pi)$
 - Preliminary result: $\text{Br}(B^0 \rightarrow D^* D_s^*) = (1.85 \pm 0.09_{\text{stat}} \pm 0.16_{\text{syst}}) \times 10^{-2}$
 - Error reduced by a factor of 3 respect with previous measurement
- $\text{Br}(D_s \rightarrow \phi \pi)$
 - Preliminary result: $\text{Br}(D_s \rightarrow \phi \pi) = (4.71 \pm 0.47_{\text{stat}} \pm 0.35_{\text{syst}}) \times 10^{-2}$
 - Error reduced by a factor of 2 respect with previous measurement