

BABAR: ACTIVITY REPORT



BABAR

@



G. Finocchiaro

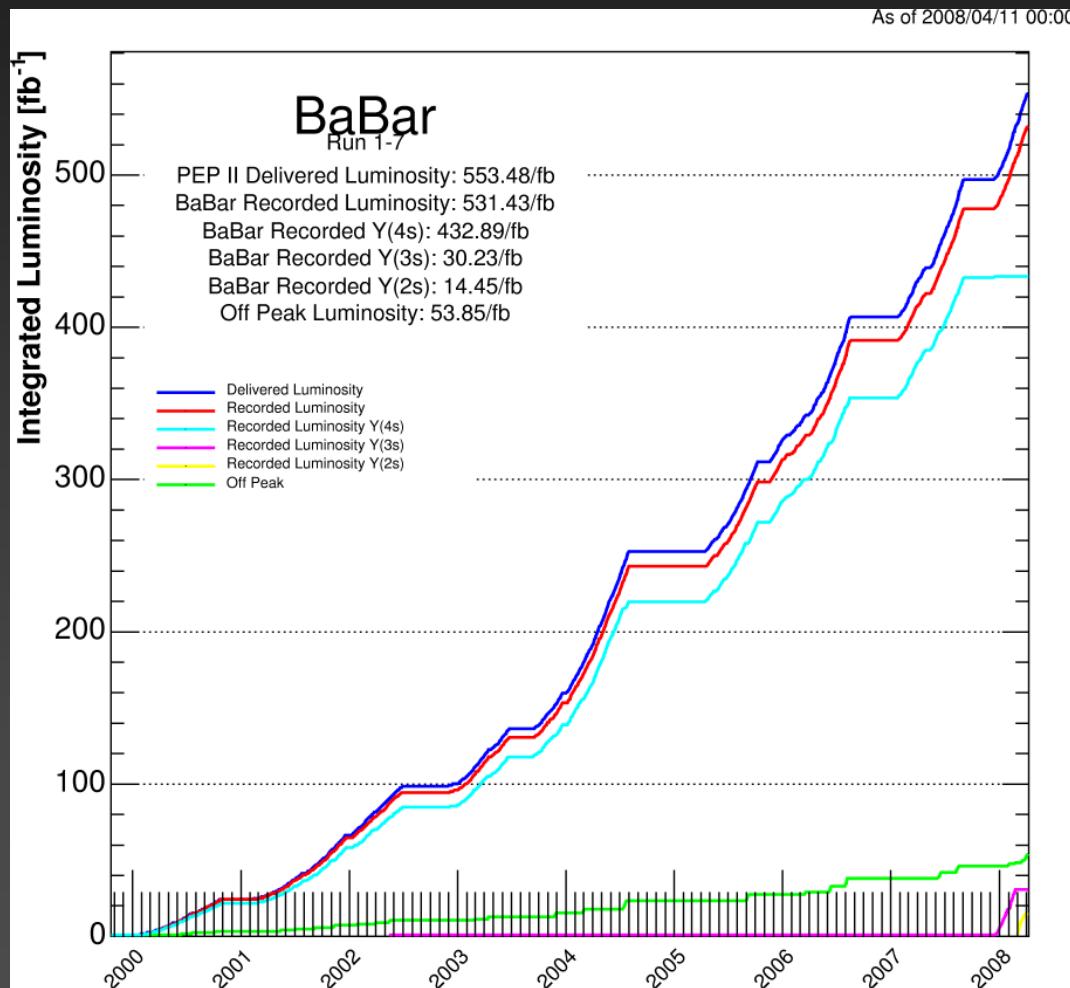
on behalf of the LNF-BABAR group:

F. Anulli, R. Baldini, A. Calcaterra, R. de Sangro,
G.F., S. Pacetti, P. Patteri, I. Peruzzi (PI), M. Piccolo,
M. Rama, A. Zallo



Monday 7 Apr 2008

Final data sample



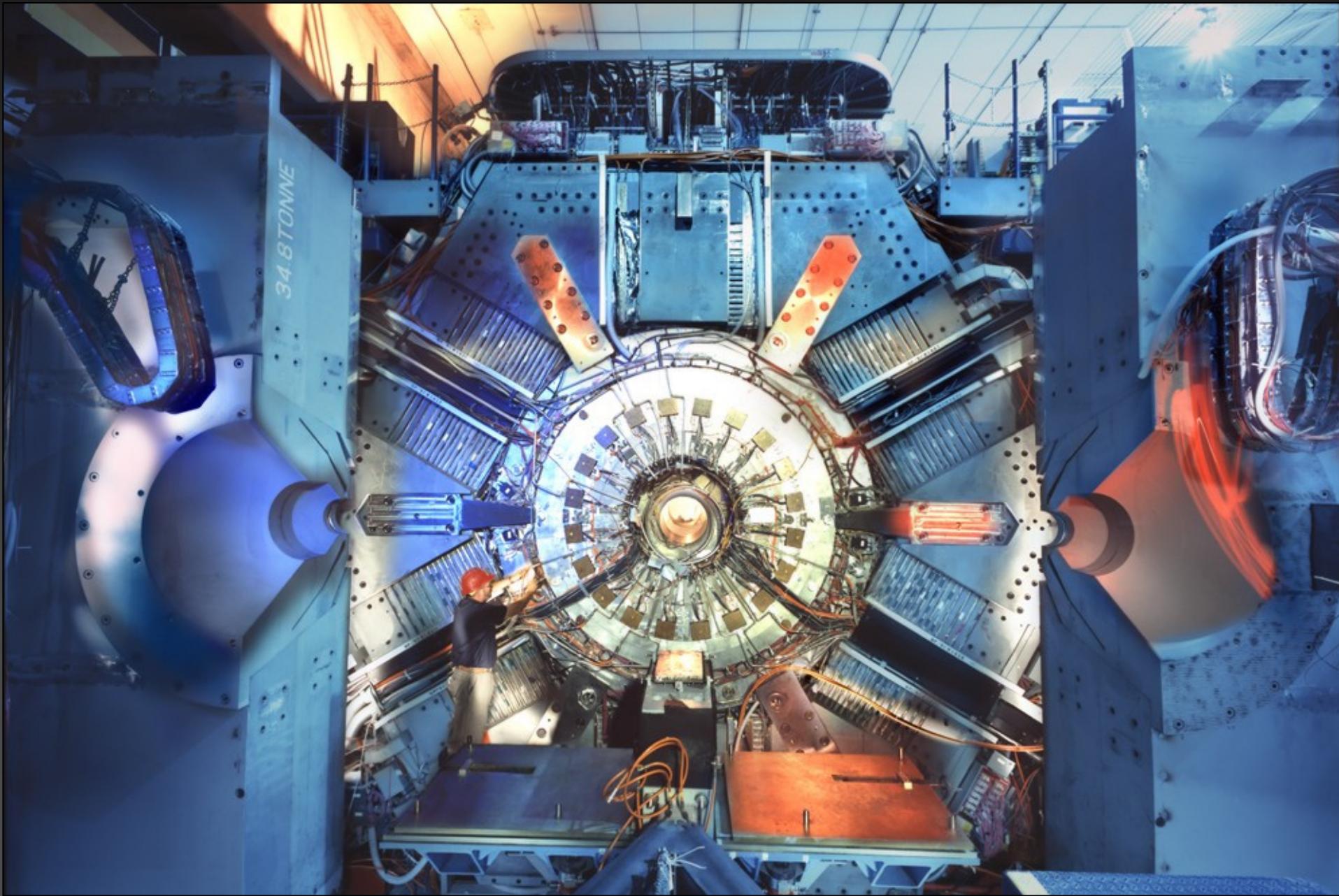
Total data collected until September 2007:

- 470M $B\bar{B}$ pairs,
- 630M $c\bar{c}$ events,
- 440M $\tau\tau$

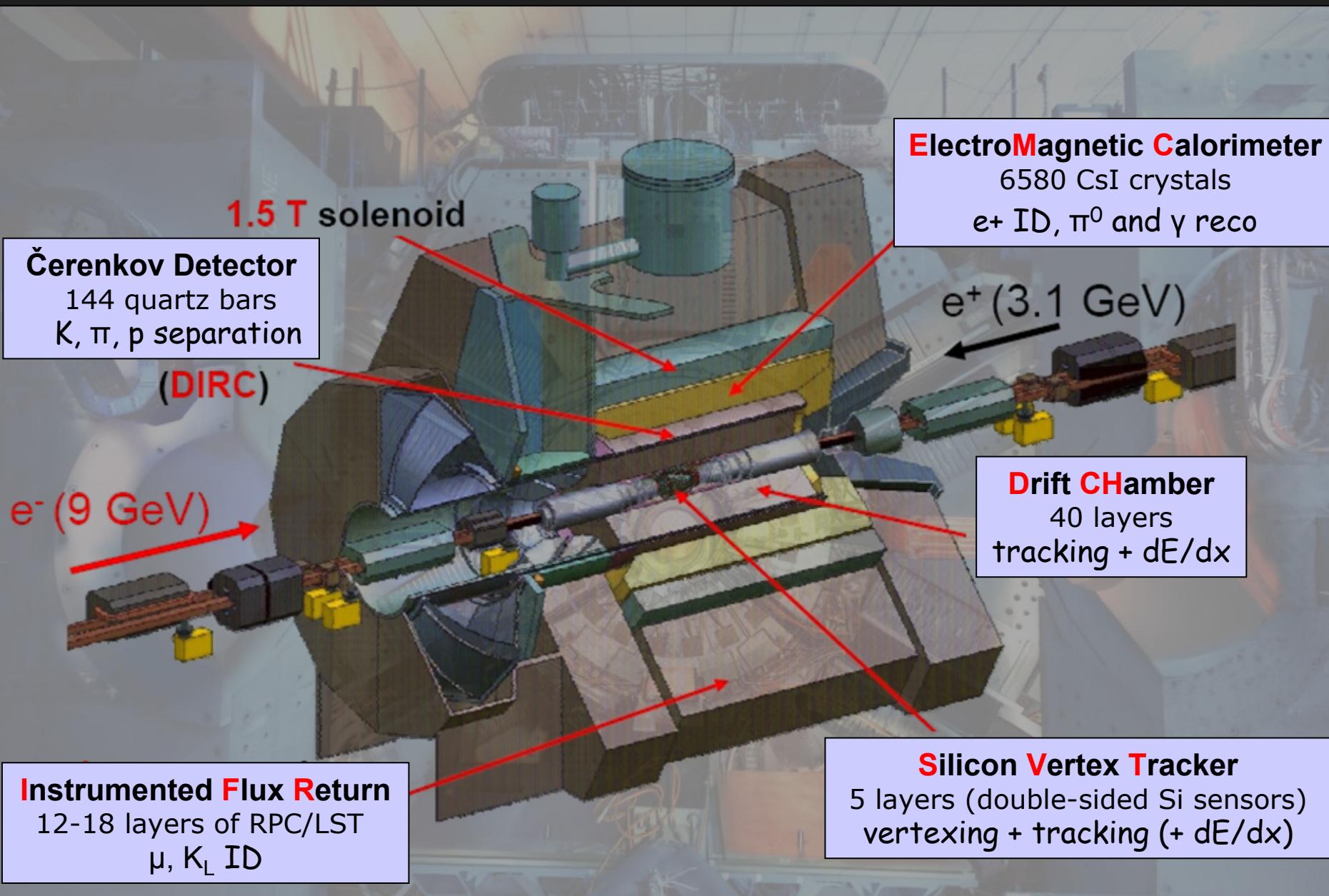
Run 7 (Dec 07- Apr 08), collected:

- 30/fb at Y(3S) [100 M Y(3S)]
- [6M from CLEO, 11M from Belle]
- searches, lepton universality
- detailed bottomonium spectroscopy
- 14/fb at Y(2S) (140 M Y(2S))
- [9M from CLEO]
- Scan above the 4S
- exotic bottomonium?

BABAR



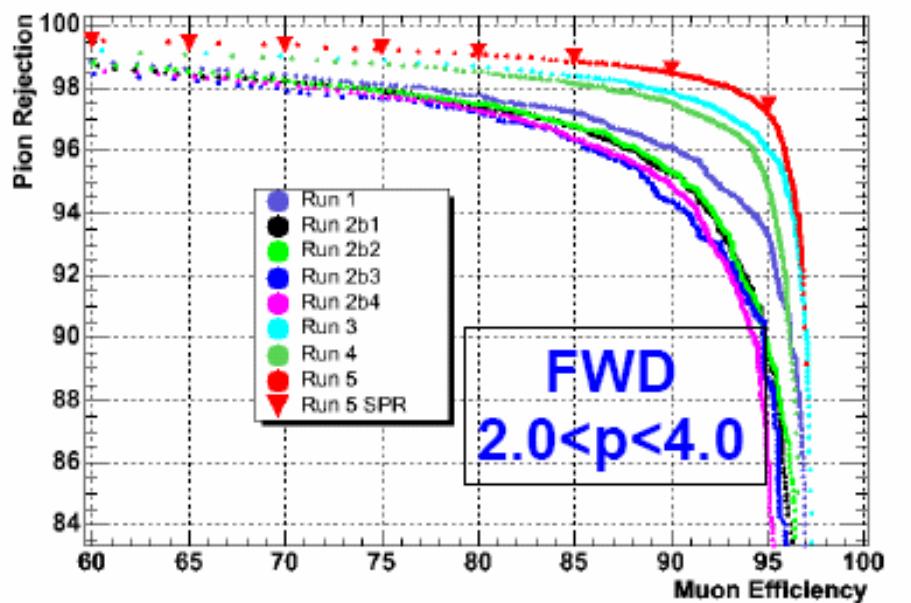
The *BABAR* detector



Instrumented Flux Return (IFR)

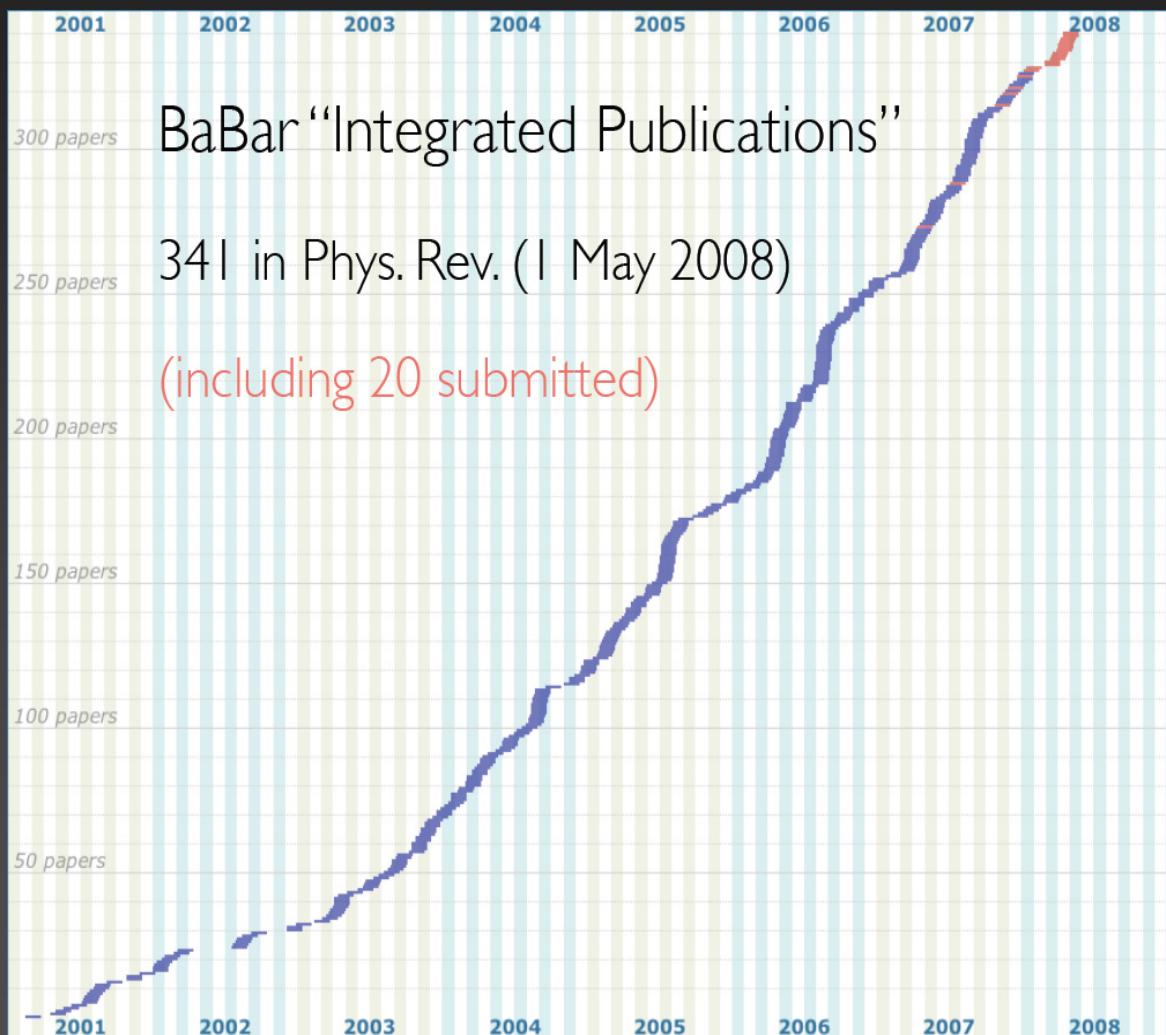
- Absorber-detector alternating layers for μ and K_L detection:
 - Bwd endcap: original **RPC** (18 layers);
 - Fwd endcap: new **RPC** (16 layers) in streamer or avalanche mode;
 - Barrel: old degraded RPC replaced by **LST** in summer 2004/2006 (12 layers)

μ -ID performance



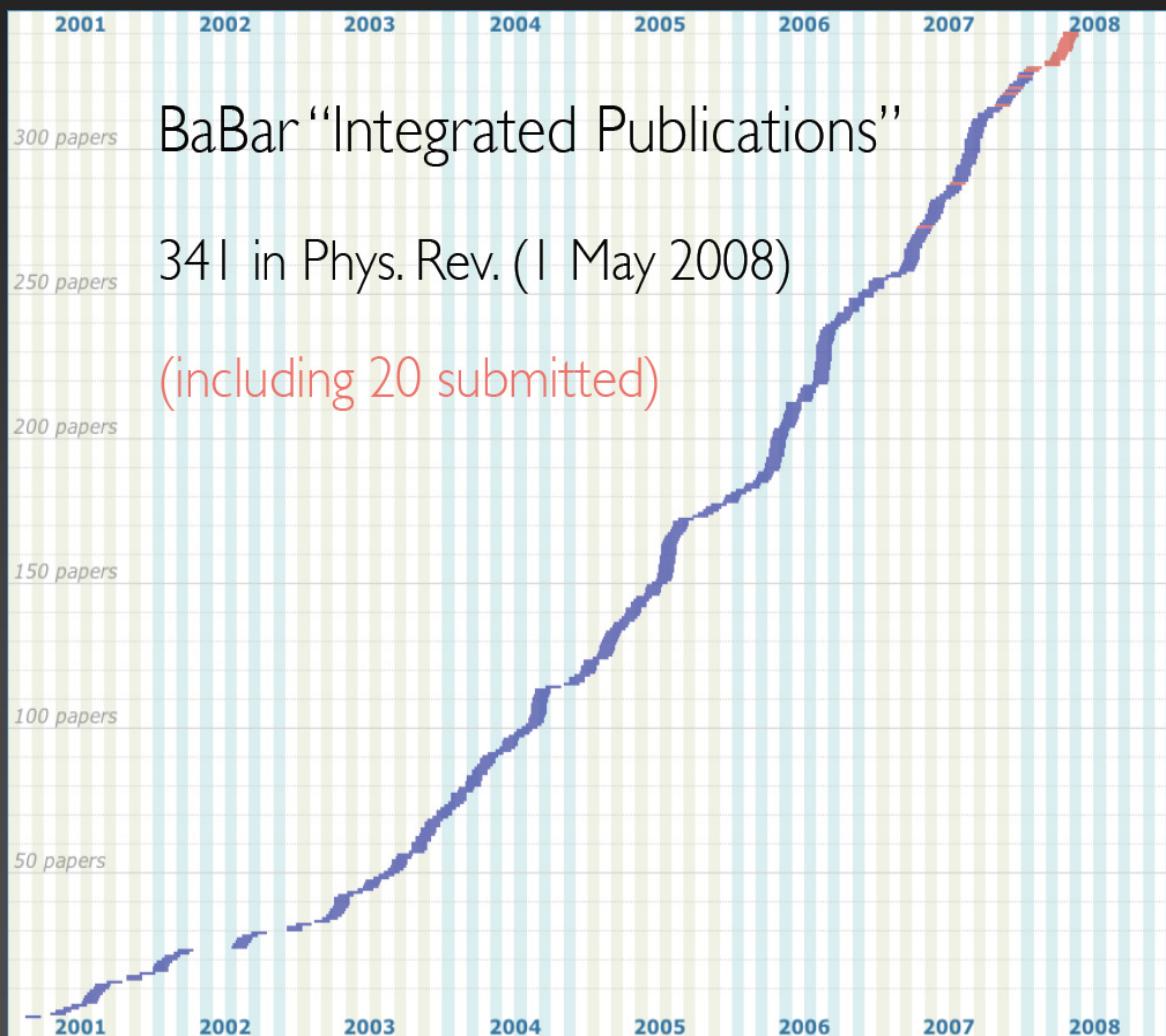
- Italy + US teams
 - Detectors and read-out built in Italy (both **RPC** and **LST**)
 - System Managers: 1 Italy + 1 US for each subsystem;
 - Operation Managers: 2/3 Italy + 1/3 US

Analyses discussed in this talk



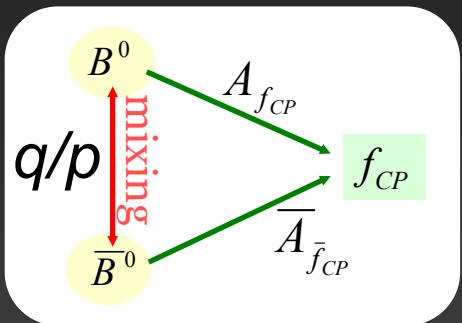
- Latest update of $\sin 2\beta$ in $b \rightarrow c\bar{c}s$
- Latest measurement of γ
- $B^0 \rightarrow D^{*+} D s^{*-}$
- $B^0 \rightarrow D^{*+} D^{*-}$ time-dependent
- $e^+ e^- \rightarrow K K \pi, K K \eta$ with ISR

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- Latest update of $\sin 2\beta$ in $b \rightarrow c\bar{c}s$
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Preamble: time-dependent measurements at the B factories (I)



CPV can arise from interference between two paths,
e.g. decay with and without mixing

$$\text{Independent of phase convention} \quad \lambda_{f_{CP}} = \frac{q}{p} \cdot \frac{\bar{A}_{f_{CP}}}{A_{f_{CP}}} \quad \begin{matrix} \text{amplitude ratio} \\ \text{mixing} \end{matrix}$$

Time-dependent (TD) CP asymmetry:

$$\begin{aligned} A_{CP}(t) &\equiv \frac{N(\bar{B}_{phys}^0(\Delta t) \rightarrow f_{CP}) - N(B_{phys}^0(\Delta t) \rightarrow f_{CP})}{N(\bar{B}_{phys}^0(\Delta t) \rightarrow f_{CP}) + N(B_{phys}^0(\Delta t) \rightarrow f_{CP})} \\ &= S_{f_{CP}} \sin(\Delta m \Delta t) - C_{f_{CP}} \cos(\Delta m \Delta t) \end{aligned}$$

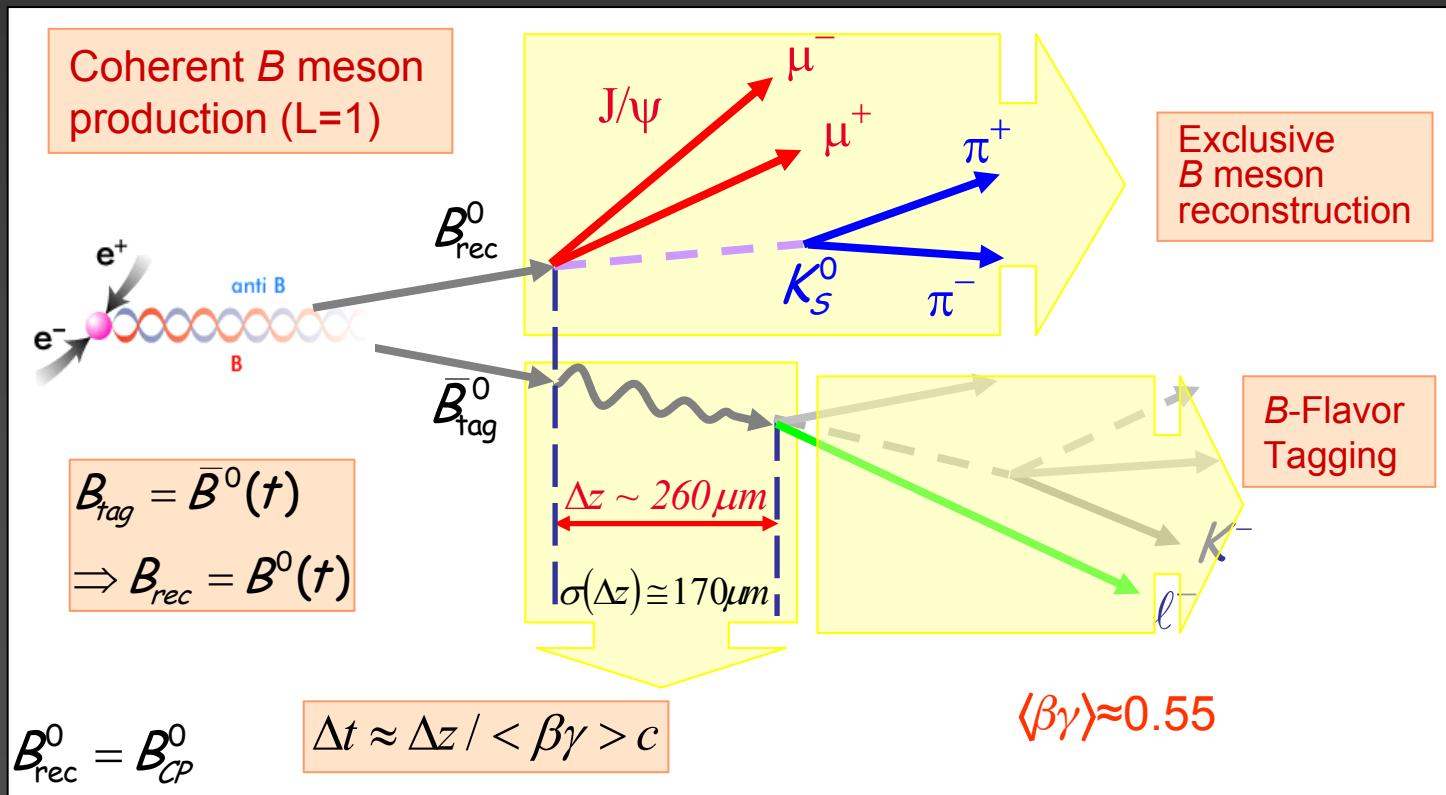
$$\begin{aligned} C_{f_{CP}} &= \frac{1 - |\lambda_{f_{CP}}|^2}{1 + |\lambda_{f_{CP}}|^2} \\ S_{f_{CP}} &= \frac{-2 \operatorname{Im} \lambda_{f_{CP}}}{1 + |\lambda_{f_{CP}}|^2} \end{aligned}$$

Quick recipe for TD measurements at B-factories

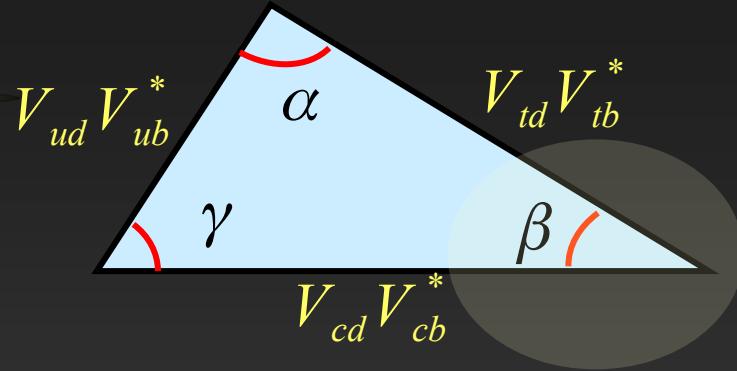
- a. reconstruct final (CP eigen)state
- b. determine ('tag') B^0 flavor at decay time
- c. measure decay vertices
- d. fit...

$$m_{ES} \equiv \sqrt{E_{beam}^{*2} - p_B^{*2}} \quad (\sigma_{m_{ES}} \approx \sigma_{beam} \approx 2.7 \text{ MeV})$$

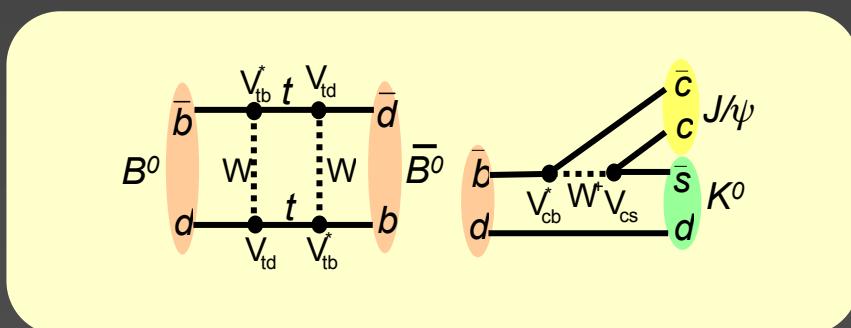
$$\Delta E \equiv E_{beam}^* - E_B^* \quad (\sigma_{\Delta E} \approx \sigma_{E_B^*} \approx 10 \div 50 \text{ MeV})$$



$\sin 2\beta$ from $b \rightarrow c\bar{c}s$



- Flagship B -factory measurement
 - background-free
- Latest $\sin 2\beta$ update from $BABAR$ (383M $B\bar{B}$), featuring:
- Detailed study of CP properties of background
 - reduced systematics
- Updated $\eta_c K_S$ selection
- Independent measurements for each charmonium mode
- Add $J/\psi K_L$ and $J/\psi K^*$ samples (larger backgrounds) to measure $|\lambda|$

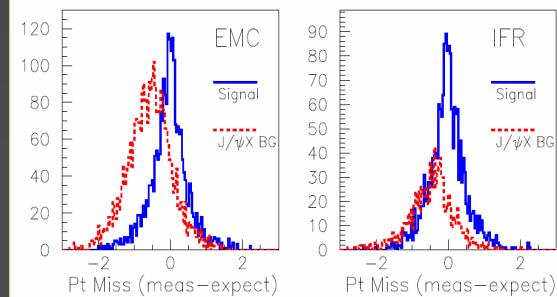
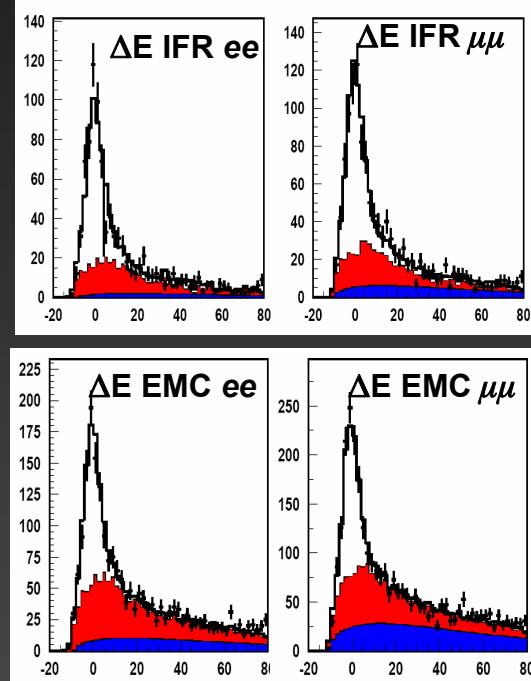


$B^0 \rightarrow J/\psi K_L$

- $J/\psi K_L$ second most abundant CP sample
- Theoretically clean
- K_L detection
 - $1 \leq p \leq 3$ GeV/c
 - no signal in DCH
 - interaction on **EMC** or **IFR**
 - IFR ‘Neutral Hadron’
 - measure direction with $\Delta\theta \sim 40/60$ mrad
 - [control sample: $\phi\gamma \rightarrow K_s K_L \gamma$ (**ISR**)]
- energy not measured
 - close kinematics with $m^2_{B0} = (p_{J/\psi} + p_{K_L})^2$
 - use $\Delta E = |E_{J/\psi}^* + E_{K_L}^*| - E_{\text{beam}}^*$

- sizeable background: fit more difficult than $J/\psi K_s$
- relative fractions from fit to ΔE

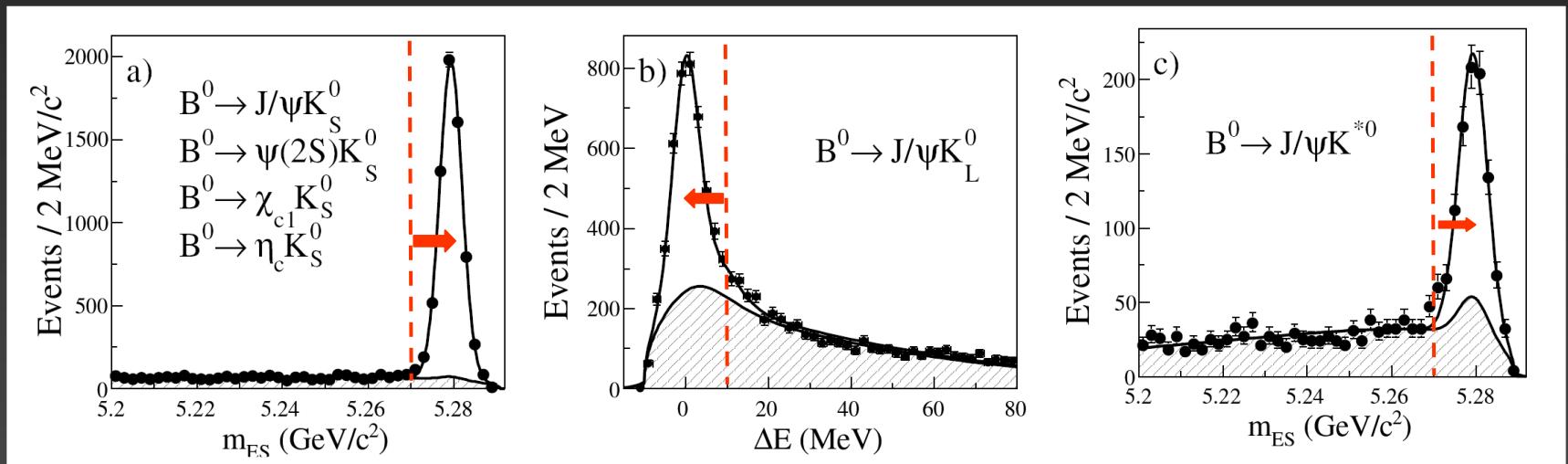
$p_T(\text{miss})$: missing measured-expected transverse momentum in the event projected along the K_L direction



$\sin 2\beta$ from $B^0 \rightarrow \text{charmonium} + K^0_{S,L}$

383M B \bar{B} , PRL 99 171803 (2007)

- Measure $\sin 2\beta$ and $|\lambda|$ in 7 different modes



(c \bar{c}) K_S^0 (CP odd modes)



$$N_{\text{tag}} = 6873$$

$$P = 92\%$$

(c \bar{c}) K_L^0 (CP even mode)



$$N_{\text{tag}} = 4748$$

$$P = 55\%$$

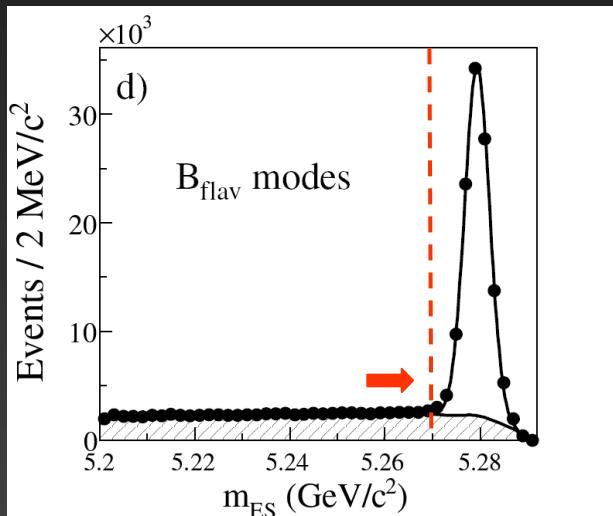
CP admixture



$$N_{\text{tag}} = 1056$$

$$P = 66\%$$

$\sin 2\beta$ from $B^0 \rightarrow \text{charmonium} + K^0_{S,L}$: fully reconstructed B flavor eigenstate channels



- Flavor eigenstate sample used to determine tagging and vertexing performance in CP sample
 - $D^{(*)} h^+$ ($h^+ = \pi^+, \rho^+, a_1^+$)
 - $J/\psi K^{*0}$ ($K^{*0} \rightarrow K^+ \pi^-$)



$$N_{\text{tag}} = 123893$$

$$P = 85\%$$

- Simultaneous fit to incorporate statistical uncertainty of tagging and vertexing parameters into the $\sin 2\beta$ statistical error

$$f(\Delta t) \approx \left\{ \frac{e^{-|\Delta t|/\tau_B}}{4\tau_B} [1 \pm (1 - 2w) \cos(\Delta m \Delta t)] \right\} \otimes R$$

$\sin 2\beta$ from $B^0 \rightarrow \text{charmonium} + K^0_{S,L}$: tagging algorithm performance

- 6 mutually exclusive categories
 - category 1, ‘lepton’: primary leptons
 - categories 2-6 split based on estimated mistag rates (from neural net)

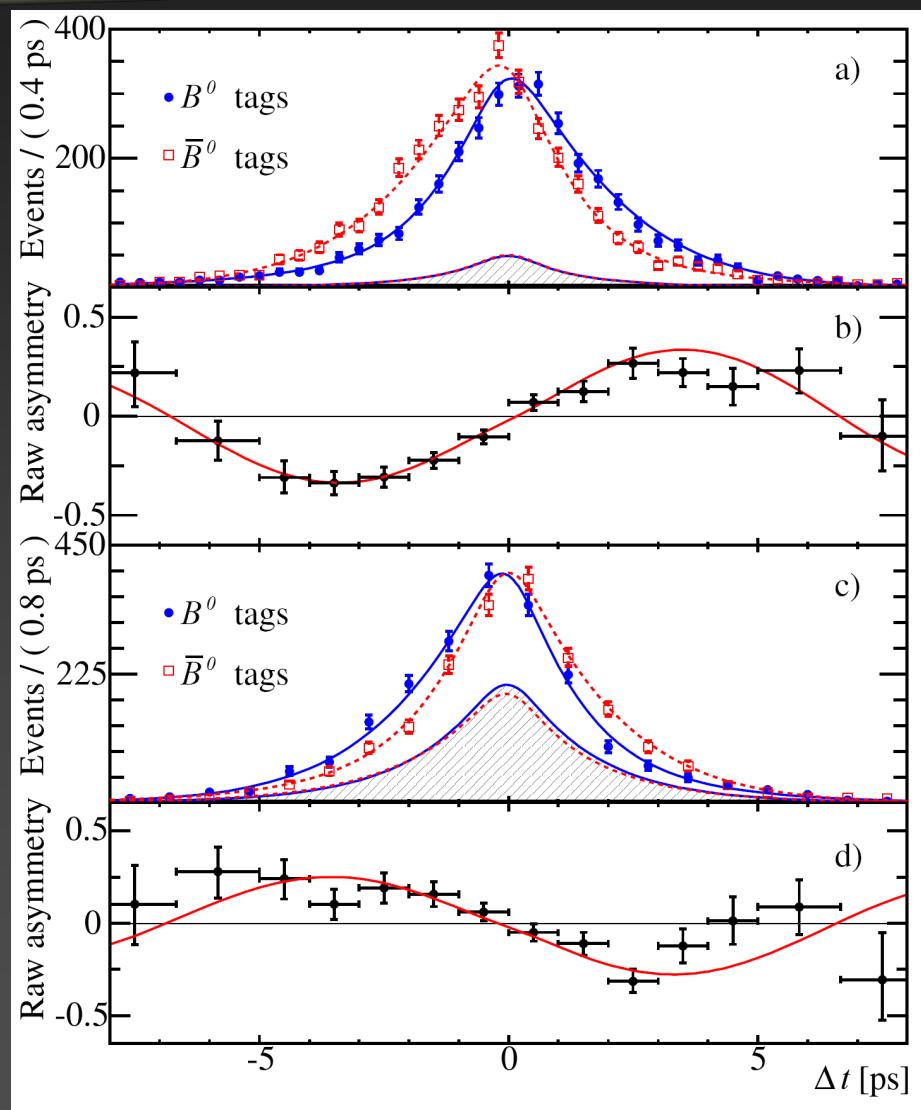
Category	ε (%)	w (%)	Δw (%)	Q (%)
Lepton	8.67 ± 0.08	3.0 ± 0.3	-0.2 ± 0.6	7.67 ± 0.13
Kaon I	10.96 ± 0.09	5.3 ± 0.4	-0.6 ± 0.7	8.74 ± 0.16
Kaon II	17.21 ± 0.11	15.5 ± 0.4	-0.4 ± 0.7	8.21 ± 0.19
Kaon-Pion	13.77 ± 0.10	23.5 ± 0.5	-2.4 ± 0.8	3.87 ± 0.14
Pion	14.38 ± 0.10	33.0 ± 0.5	5.2 ± 0.8	1.67 ± 0.10
Other	9.61 ± 0.08	41.9 ± 0.6	4.6 ± 0.9	0.25 ± 0.04
All	74.60 ± 0.12			30.4 ± 0.3

- $\varepsilon \equiv$ efficiency, $w \equiv$ mistag fraction, $\Delta w \equiv$ mistag fraction difference
- Measure of tagging performance is $Q = \varepsilon(1-2w)^2$

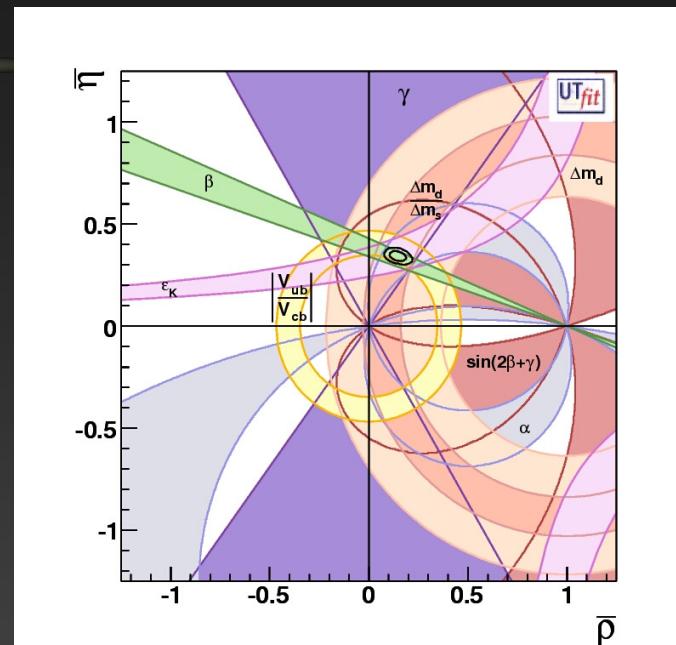
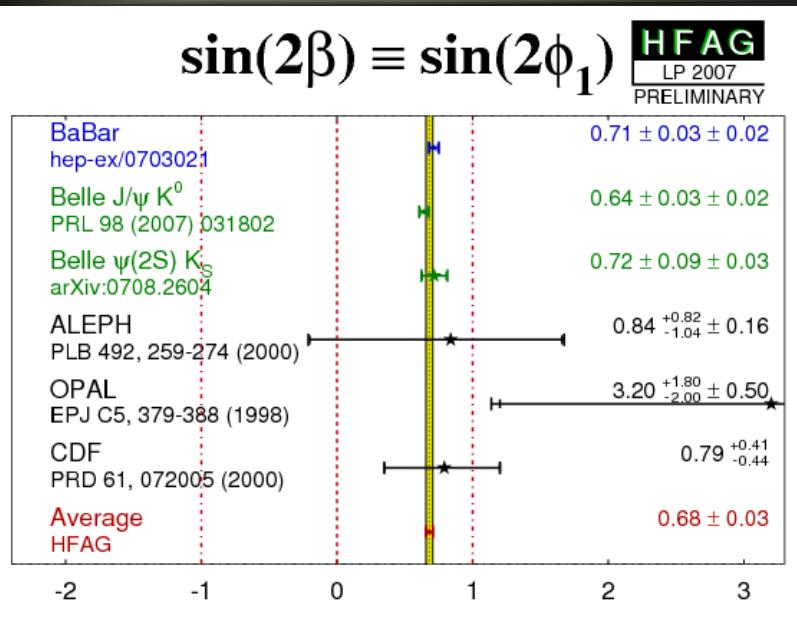
$\sin 2\beta$ from $B^0 \rightarrow \text{charmonium} + K^0_{S,L}$: results

$$\begin{aligned}\sin 2\beta &= 0.714 \pm 0.032 \pm 0.018 \\ |\lambda| &= 0.952 \pm 0.022 \pm 0.017\end{aligned}$$

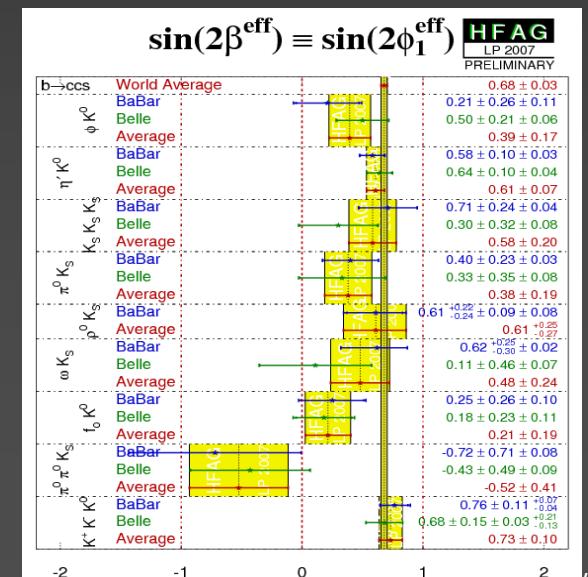
$J/\psi K_S (\pi^+ \pi^-)$	$0.702 \pm 0.042 \pm 0.020$
$J/\psi K_S (\pi^0 \pi^0)$	$0.617 \pm 0.103 \pm 0.036$
$\psi(2S)K_S$	$0.947 \pm 0.112 \pm 0.062$
$\chi_{c1} K_S$	$0.759 \pm 0.170 \pm 0.037$
$\eta_c K_S$	$0.778 \pm 0.195 \pm 0.093$
$J/\psi K^*$	$0.477 \pm 0.271 \pm 0.155$
$J/\psi K_S$	$0.686 \pm 0.039 \pm 0.015$
$J/\psi K_L$	$0.735 \pm 0.074 \pm 0.067$
$J/\psi K^0$	$0.697 \pm 0.035 \pm 0.016$
All	$0.714 \pm 0.032 \pm 0.018$



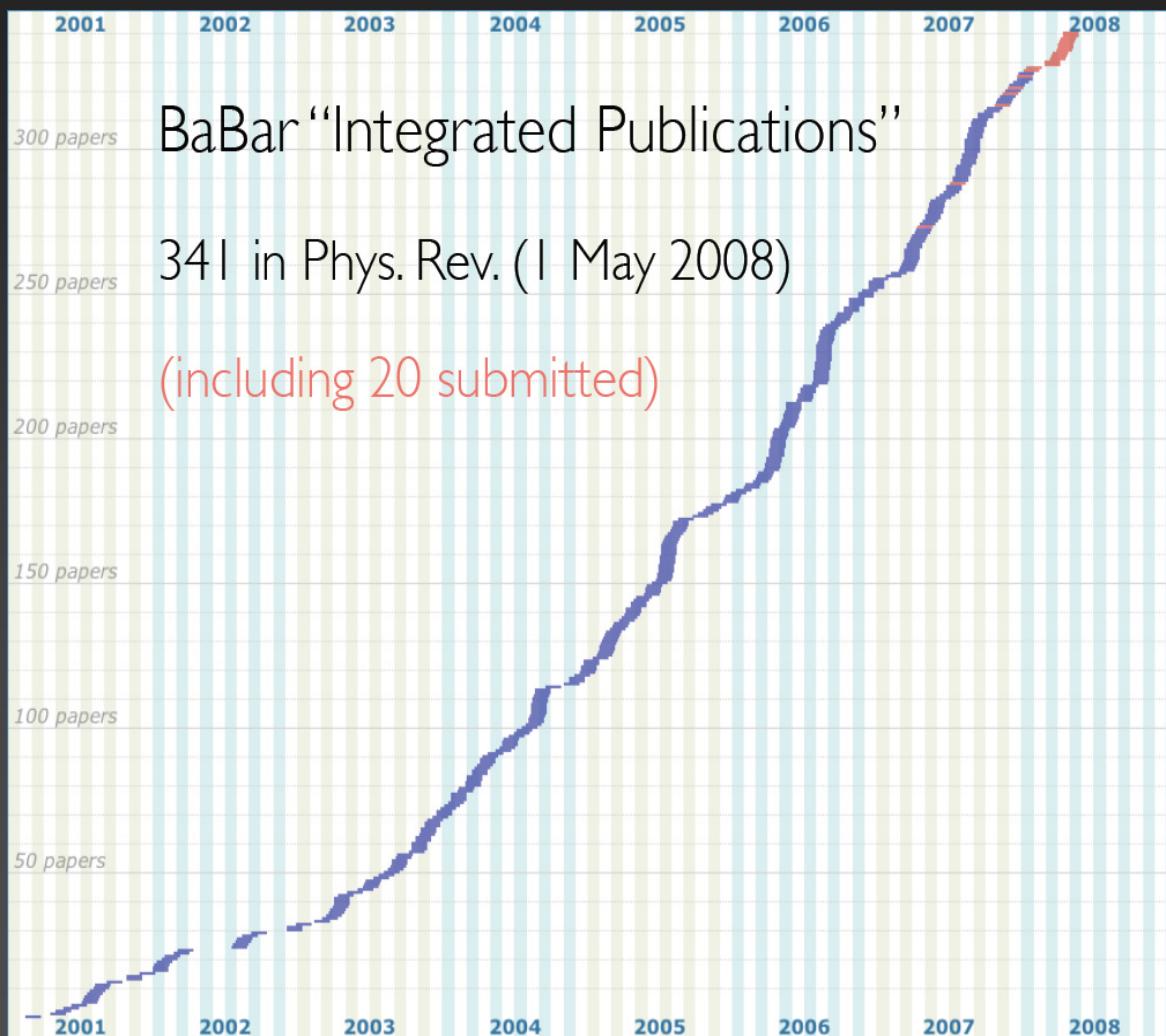
New $\sin 2\beta$ from charmonium decays ($b \rightarrow c\bar{c}s$): comparison with other results



- Experimental measurement $\sin 2\beta_{[WA]} = 0.680 \pm 0.025$ as precise as ‘indirect’ measurement $\sin 2\beta_{[UTFit]} = 0.690 \pm 0.023$
 - improving the experimental precision has still direct impact on UT fits
 - reference for loop-sensitive decay channels
 - Update on full dataset (470M BB) expected this summer

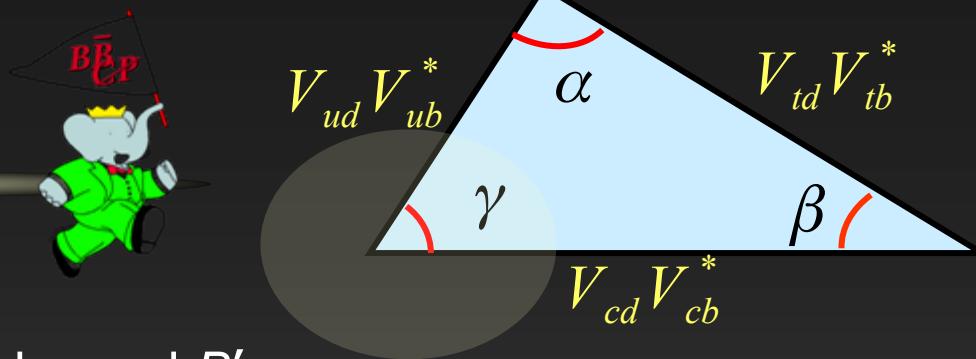


Analyses discussed in this talk

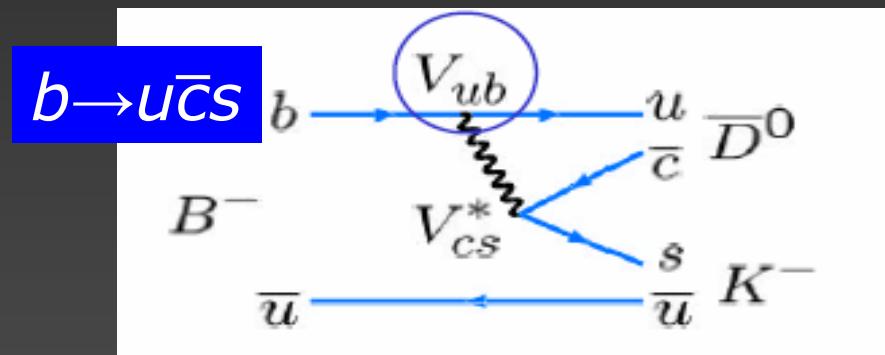
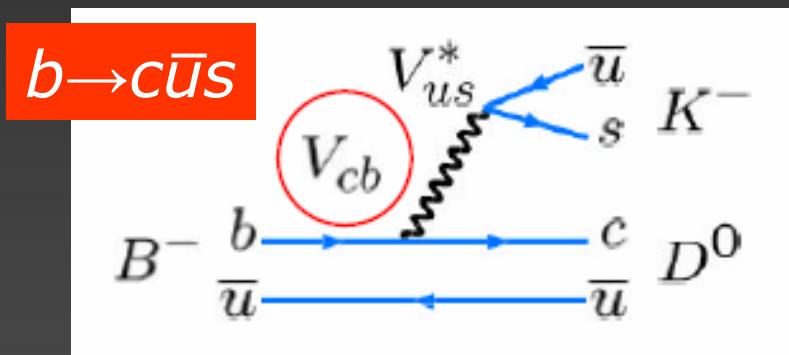


- Latest update of $\sin 2\beta$ in $b \rightarrow c\bar{c}s$
- Latest measurement of γ
- $B^0 \rightarrow D^{*+} D s^{*-}$
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Measurement of γ



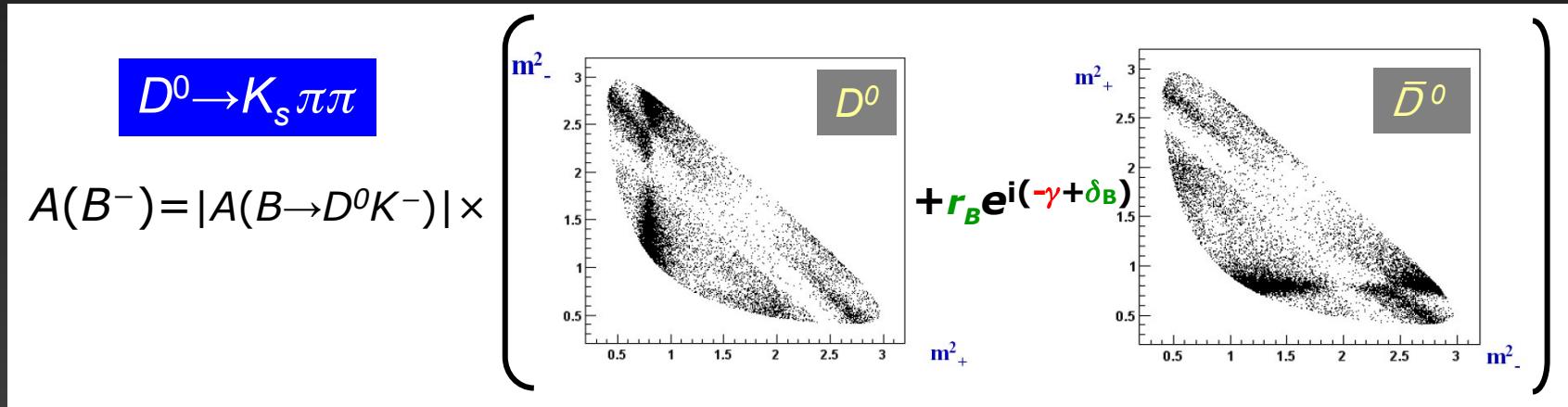
- The phase of V_{ub}
- From direct CPV in the decay of charged B 's
 - Interfering tree amplitudes w/ CP -violating relative weak phase γ and CP -conserving relative strong phase δ
 - theoretically clean (i.e., no penguins involved)



- Interference if D^0/\bar{D}^0 decay into identical final state
 - Dalitz plot (DP) analysis of 3-body decays, e.g., $D^0 \rightarrow K_s \pi \pi$
 - CP -eigenstate decay: Gronau-London-Wyler (GLW)
 - Doubly-Cabibbo-suppressed (DCS) decay: Atwood-Dunietz-Soni (ADS)

Dalitz Plot analysis of $B \rightarrow D\bar{K}$

- The idea in pictures:



- CP -conjugate B^- and B^+ decay amplitudes

$$A(B^-) = |A_B| \times [A_D(m_-^2, m_+^2) + r_B e^{-i\gamma} e^{i\delta_B} A_D(m_+^2, m_-^2)]$$

$$A(B^+) = |A_B| \times [A_D(m_+^2, m_-^2) + r_B e^{+i\gamma} e^{i\delta_B} A_D(m_-^2, m_+^2)]$$

$$m_{\pm}^2 = m(K_S \pi^{\pm})^2$$

Assume D decays conserve CP ...

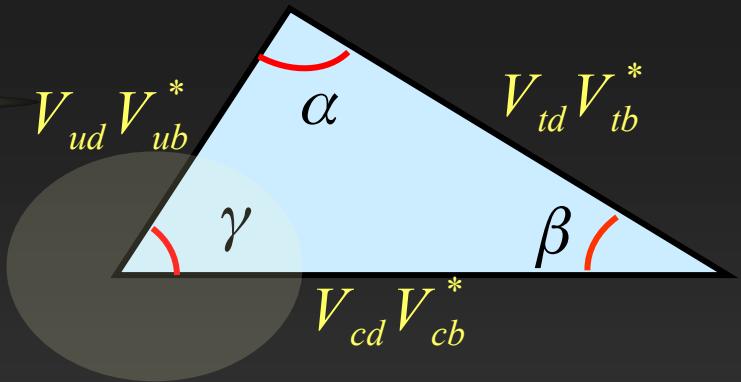
- B^\pm Dalitz Plot distribution depends on γ , r_b and δ . It is convenient to write the Likelihood as a function of the cartesian coordinates x_\pm and y_\pm

- Likelihood is Gaussian and unbiased

$$\begin{aligned} x_\pm &= r_b \cos(\delta \pm \gamma) \\ y_\pm &= r_b \sin(\delta \pm \gamma) \end{aligned}$$

$$\Gamma(B^-) \propto |f_-|^2 + r_b^2 |f_+|^2 + 2x^- \operatorname{Re}(f_- f_+^*) + 2y^- \operatorname{Im}(f_- f_+^*)$$

Latest γ measurement



New features:

- Added $D^0 \rightarrow K_S KK$ (first time)
- Improved $D^0 \rightarrow K_S \pi\pi$ Dalitz model
- Added $B \rightarrow D^0 K^*$ ($D^0 \rightarrow K_S \pi\pi$ only)
- Increased reconstruction efficiency

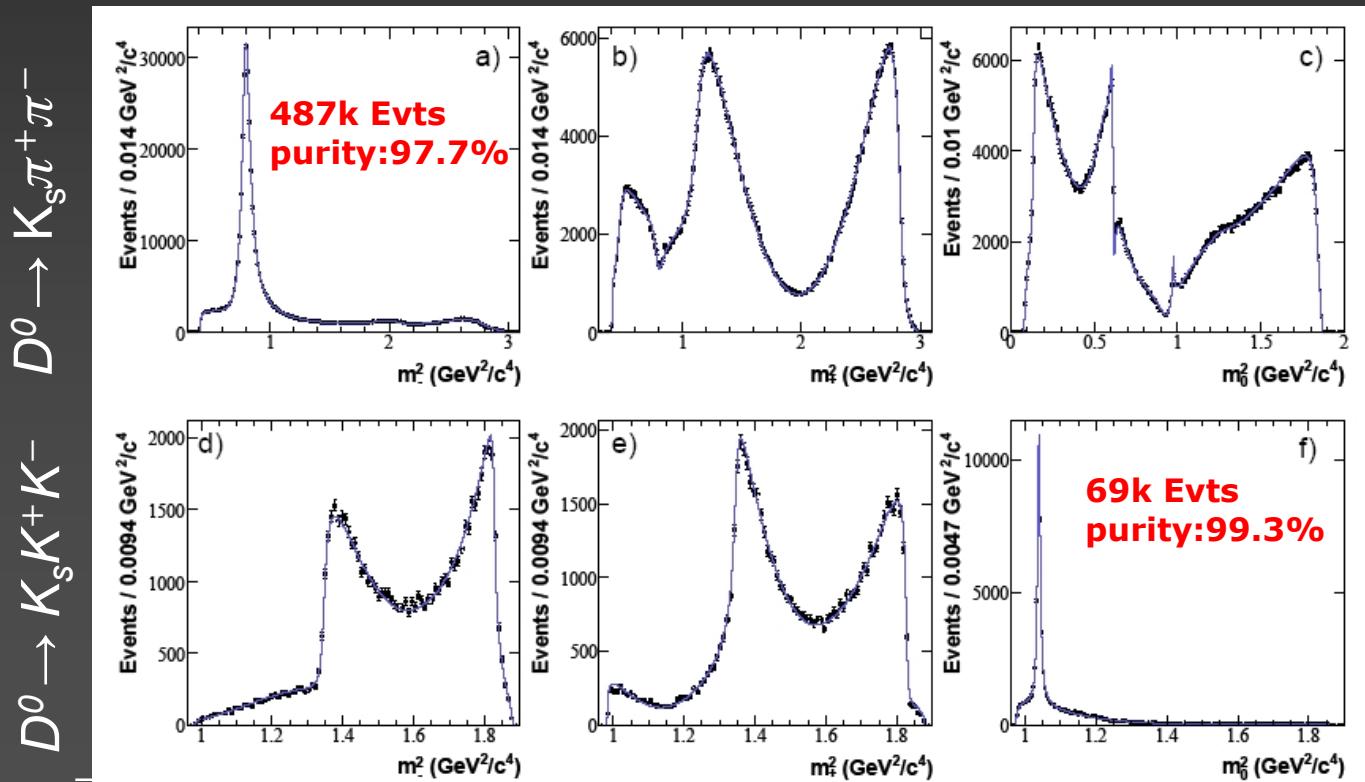


DP analysis of D^0/\bar{D}^0 decays

arXiv:0804.2089

subm. to PRD

- Extract $D^0(\bar{D}^0)$ decay amplitudes from DP analysis of independent high-statistics $c\bar{c}$ sample with flavor-tagged $D^0 \rightarrow K_S \pi^+ \pi^-$ and $D^0 \rightarrow K_S K^+ K^-$ decays from $D^{*+} \rightarrow D^0 \pi^+$
- For $D \rightarrow K_S \pi \pi$ we use the K -matrix model: 9 BW resonances + K -matrix formalism for $\pi\pi$ S-wave
 - Deals with broad, overlapping, multi-channel scalar resonances



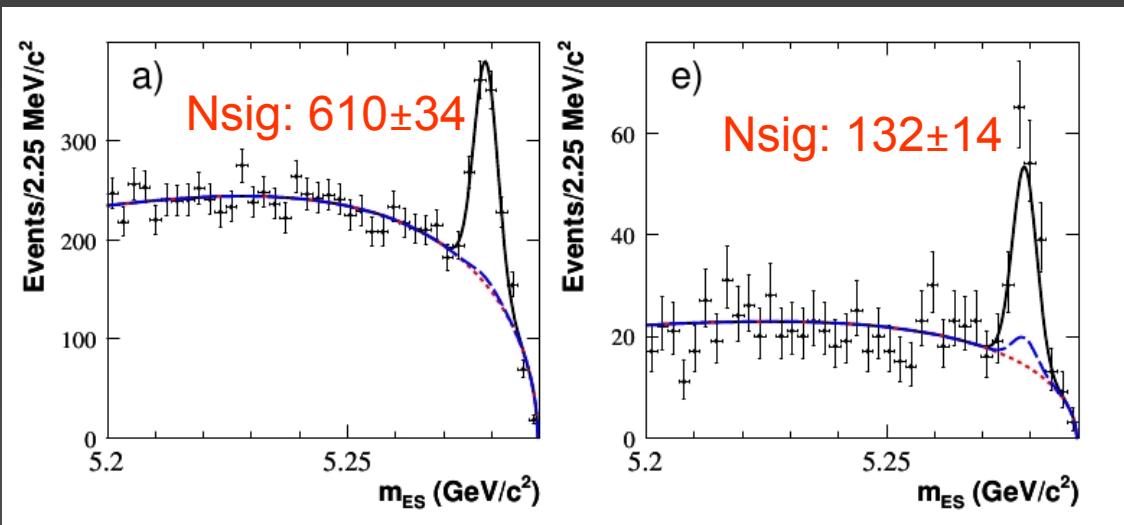
Selection of signal

- Select $B^\pm \rightarrow D^{(*)0}K^\pm$, $D^{*0} \rightarrow D^0\pi^0/\gamma$ and $B^\pm \rightarrow D^0K^{*\pm}$, $K^{*\pm} \rightarrow K_s\pi^\pm$, with $D^0 \rightarrow K_s\pi\pi/K_sKK$
- m_{ES} , ΔE and Fisher are used in a max. likelihood fit to discriminate between signal and background
- Control samples $B \rightarrow D^{(*)}\pi$ and $B \rightarrow Da_1$ are also reconstructed to determine the shape parameters

386 10^6 BB

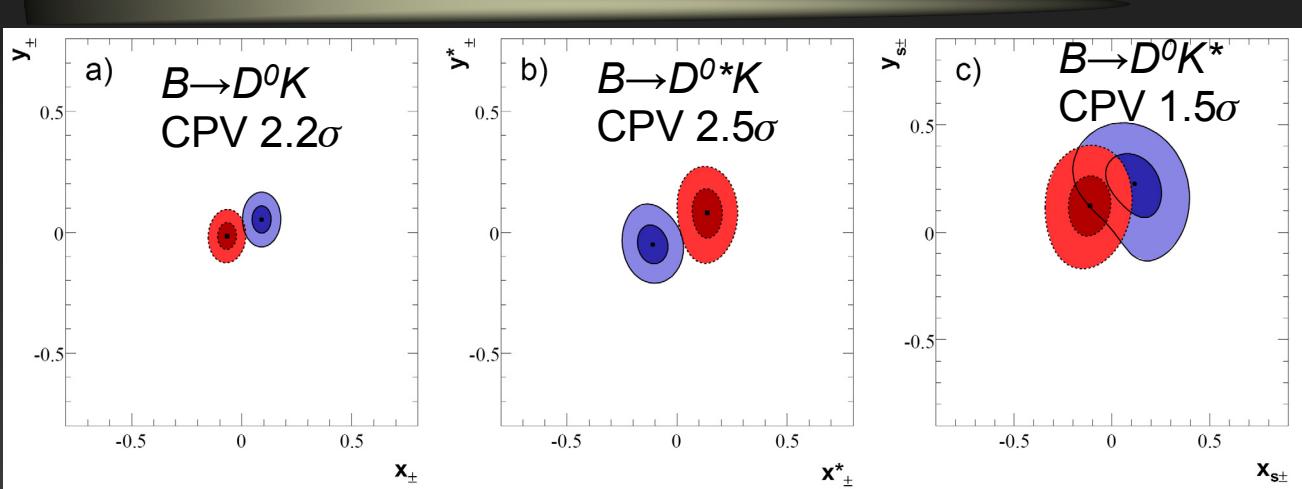
$B \rightarrow DK, D \rightarrow K_s\pi\pi$

$B \rightarrow DK, D \rightarrow K_sKK$



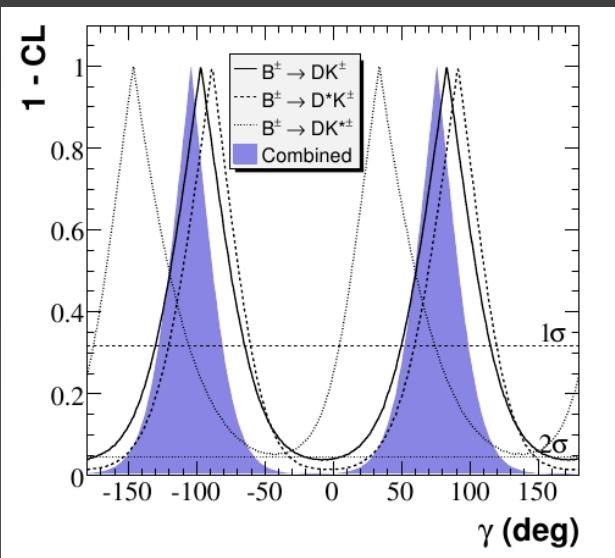
Results

arXiv:0804.2089
subm. to PRD



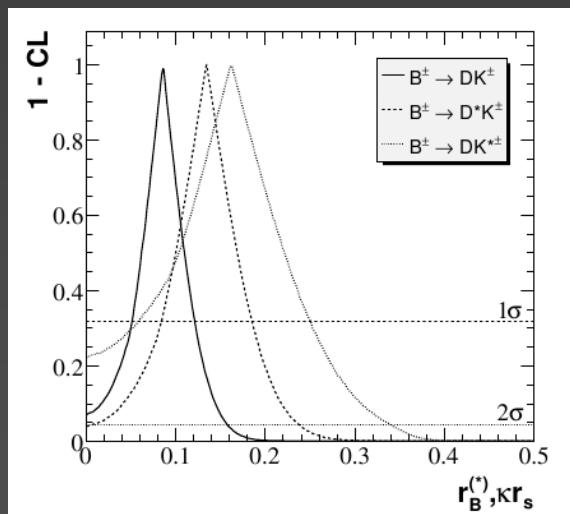
Distance between $(B^+ B^-)$
points is $2r_b |\sin 2\gamma|$
combined CPV: 3.0σ

extract CL for γ , r_b and δ_b from x^\pm, y^\pm with frequentist stat. procedure



$$\begin{aligned} r_b(DK) &= 0.086 \pm 0.035 \\ r_b(D^*K) &= 0.135 \pm 0.051 \\ kr_s &= 0.163^{+0.088}_{-0.105} \\ \gamma &= (76^{+23}_{-24})^\circ \end{aligned}$$

includes exp. (5°) and
Dalitz (5°) errors



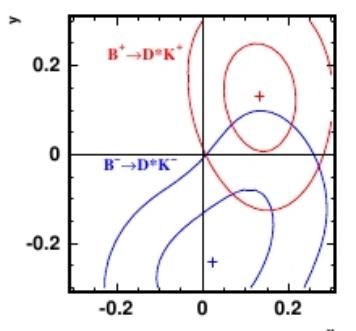
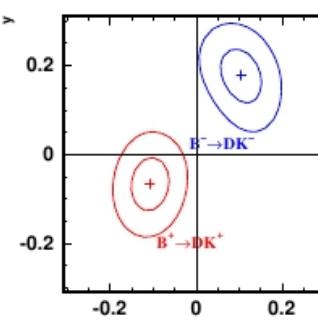
Comparison with Belle

386 10^6 BB

Parameters	$B^- \rightarrow \tilde{D}^0 K^-$	$B^- \rightarrow \tilde{D}^{*0} K^-$	$B^- \rightarrow \tilde{D}^0 K^{*-}$
x_- , x_-^* , x_{s-}	$0.090 \pm 0.043 \pm 0.015 \pm 0.011$	$-0.111 \pm 0.069 \pm 0.014 \pm 0.004$	$0.115 \pm 0.138 \pm 0.039 \pm 0.014$
y_- , y_-^* , y_{s-}	$0.053 \pm 0.056 \pm 0.007 \pm 0.015$	$-0.051 \pm 0.080 \pm 0.009 \pm 0.010$	$0.226 \pm 0.142 \pm 0.058 \pm 0.011$
x_+ , x_+^* , x_{s+}	$-0.067 \pm 0.043 \pm 0.014 \pm 0.011$	$0.137 \pm 0.068 \pm 0.014 \pm 0.005$	$-0.113 \pm 0.107 \pm 0.028 \pm 0.018$
y_+ , y_+^* , y_{s+}	$-0.015 \pm 0.055 \pm 0.006 \pm 0.008$	$0.080 \pm 0.102 \pm 0.010 \pm 0.012$	$0.125 \pm 0.139 \pm 0.051 \pm 0.010$

Parameter	$B^+ \rightarrow D K^+$	$B^+ \rightarrow D^* K^+$
x_-	$+0.105 \pm 0.047 \pm 0.011$	$+0.024 \pm 0.140 \pm 0.018$
y_-	$+0.177 \pm 0.060 \pm 0.018$	$-0.243 \pm 0.137 \pm 0.022$
x_+	$-0.107 \pm 0.043 \pm 0.011$	$+0.133 \pm 0.083 \pm 0.018$
y_+	$-0.067 \pm 0.059 \pm 0.018$	$+0.130 \pm 0.120 \pm 0.022$

657 10^6 BB



r	$0.161^{+0.041}_{-0.035} \pm 0.011 \pm 0.049$	$0.208^{+0.083}_{-0.083} \pm 0.015 \pm 0.049$
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$$r_b = 0.086 \pm 0.035; \quad r_{b^*} = 0.135 \pm 0.051$$

Babar:	$\gamma = (76^{+22}_{-23} \pm 5 \pm 5)^\circ$
Belle:	$\gamma = (81^{+13}_{-15} \pm 5 \pm 9)^\circ$



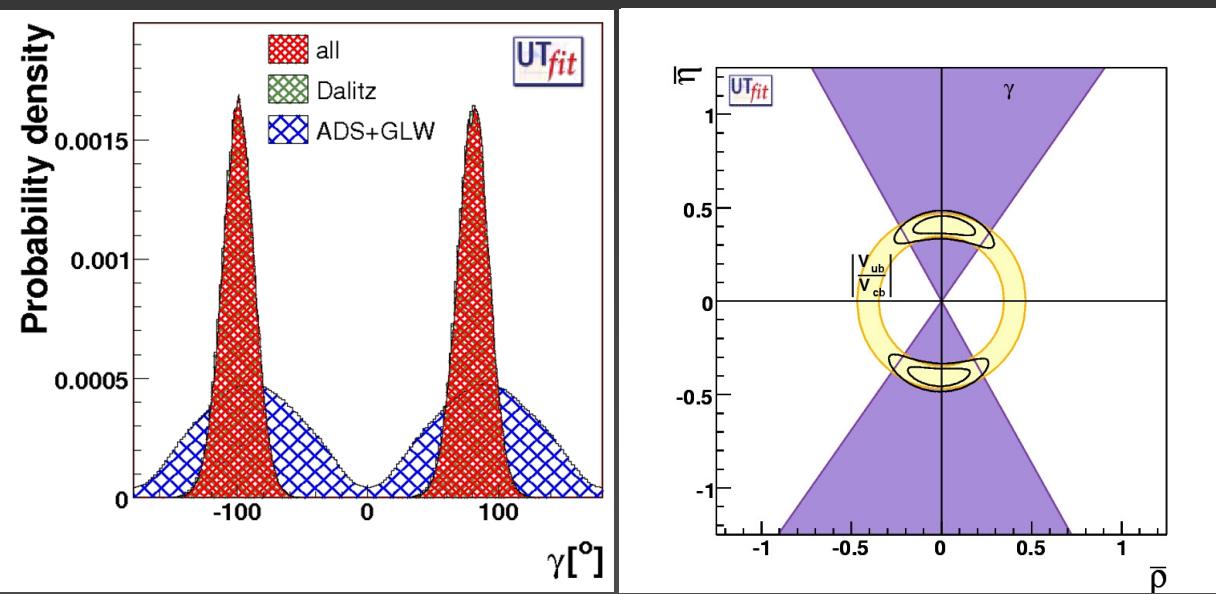
Despite *BABAR* errors on x,y
are better than *Belle*, error on γ
is worse: the “ $1/r_b$ effect”

γ summary

From the BABAR physics book, 1999

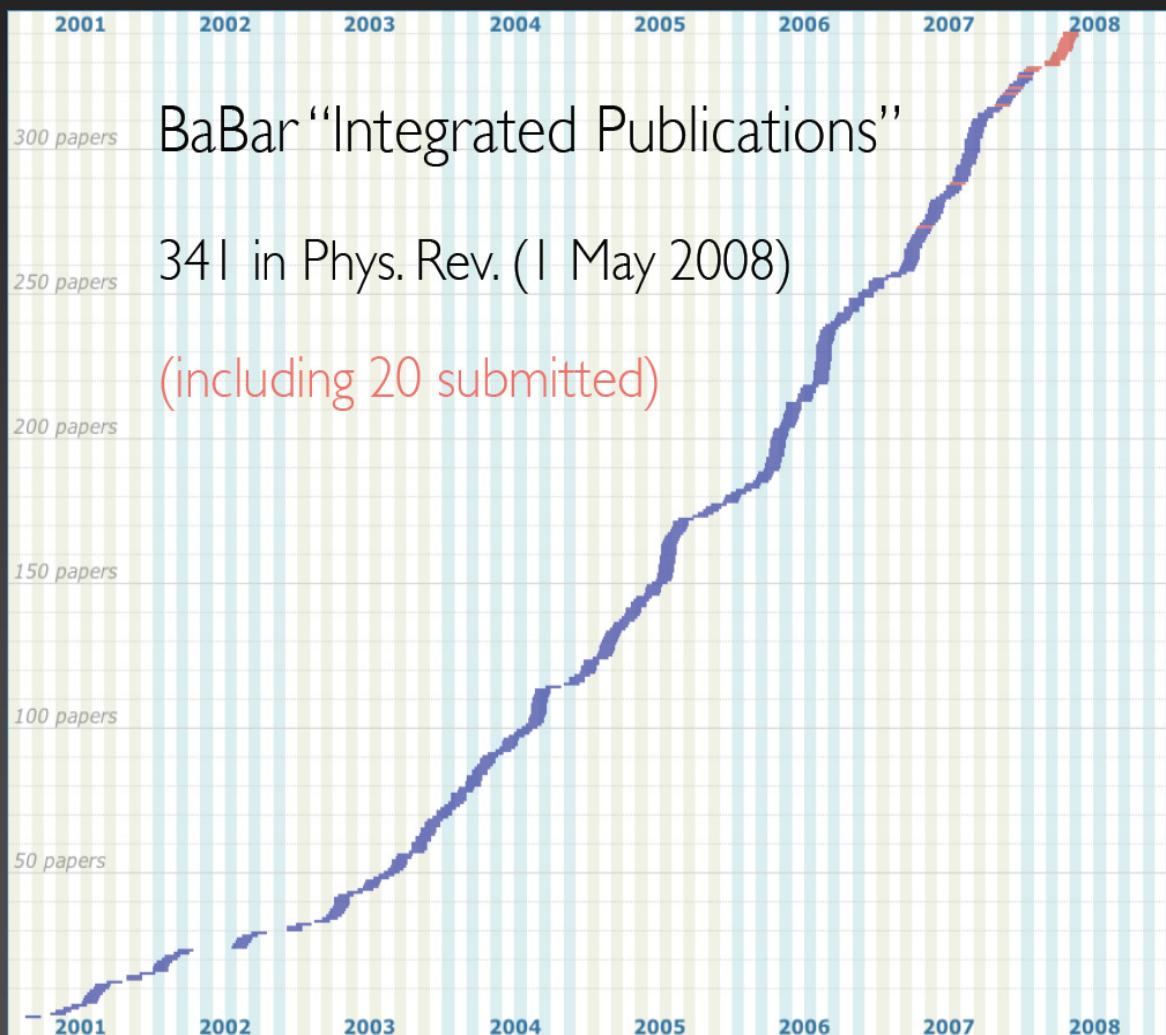
7.8 Summary of Results and Overall γ Reach

A clean measurement of the angle γ of the unitarity triangle is very desirable but not easy. Possibly the best tools to extract γ are measurements of time-dependent asymmetries in B_s decays: experiments at the B factories are not likely to have access to these decays in the near future.



- In fact, we can measure γ !
 $\gamma = (80 \pm 13)^\circ$
(Winter 2008 WA)
- Together with V_{ub} , defines New Physics-free region(s) in the $\rho - \eta$ plane which any NP model must take into account

Analyses discussed in this talk



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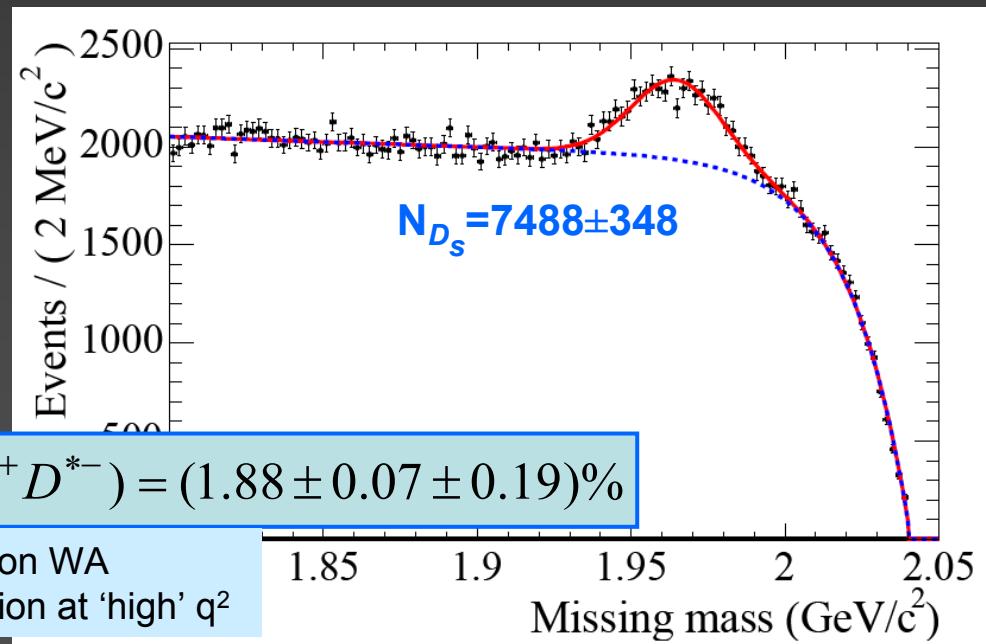
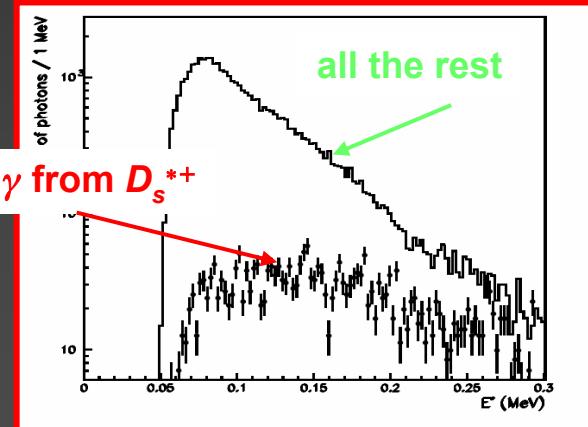
Measurement of $BF(B^0 \rightarrow D_s^{+} D^{*-})$ and $BF(D_s^+ \rightarrow \phi \pi^+)$*

- $B(D_s^+ \rightarrow \phi \pi^+)$ is necessary to normalize all D_s branching fractions
 - consequently, all $B \rightarrow D_s^+ X$ branching fractions as well
- absolute charm branching fractions are difficult to measure because in general
 - backgrounds are sizeable
 - normalization (number of produced D 's) is unknown
- both difficulties circumvented by *BABAR*'s measurement using partial reconstruction:
 - x2 improvement in *BF accuracy*

$B^0 \rightarrow D_s^{*+} D^{*-}$ with partial reconstruction

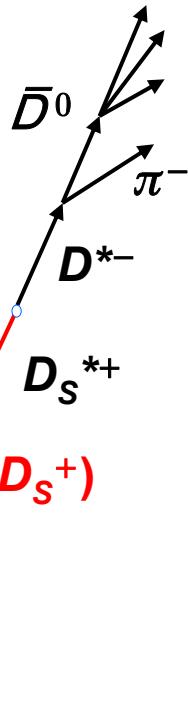
- $D^{*+} \rightarrow D^0 \pi^+$; D^0 to $K^- \pi^+, K^- \pi^+ \pi^0, K^- \pi^+ \pi^+ \pi^-, K_s \pi^+ \pi^-$
- Do not reconstruct D_s^{*+} from $D_s^{*+} \rightarrow D_s^{*+} \gamma$: combine D^* and γ , and
 - calculate ($E_B = E_{\text{beam}}$) $\cos \vartheta_{BD^{*-}} = -\frac{m_B^2 + m_{D^{*-}}^2 - m_{D_s^{*+}}^2 - 2E_B E_{D^{*-}}}{2|\vec{p}_B| |\vec{p}_{D^{*-}}|}$
 - $\phi(BD_s^*)$ unmeasured
 - ➡ fixed arbitrarily ($=0$): no bias, small additional spread
 - ➡ calculate $m_{\text{miss}} = \sqrt{(E_{\text{beam}} - E_{D^*} - E_\gamma)^2 - (\mathbf{p}_B - \mathbf{p}_{D^*} - \mathbf{p}_\gamma)^2}$

Soft photon selection: π^0 veto;
Energy and shower shape cuts



$$BF(B^0 \rightarrow D_s^{*+} D^{*-}) = (1.88 \pm 0.07 \pm 0.19)\%$$

x3 improvement on WA
Test of factorization at 'high' q^2



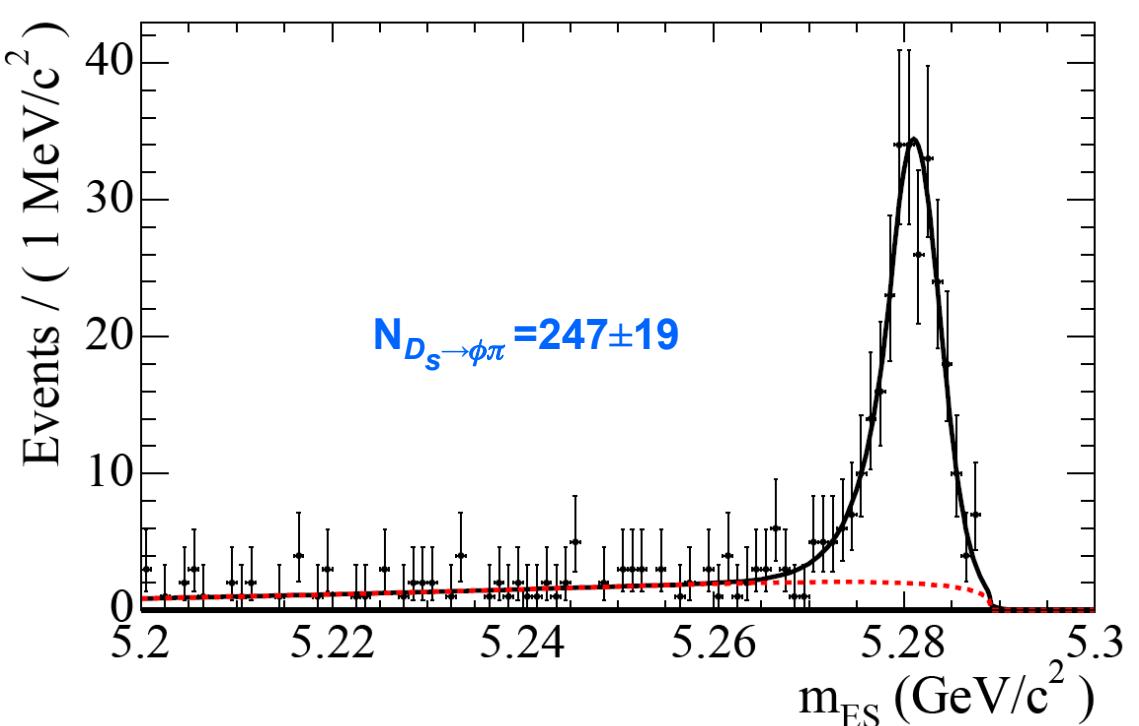
$B^0 \rightarrow D_s^{*+} D^{*-}$ with partial and exclusive reconstruction

Exclusive reconstruction of $D_s^+ \rightarrow \phi\pi^+$

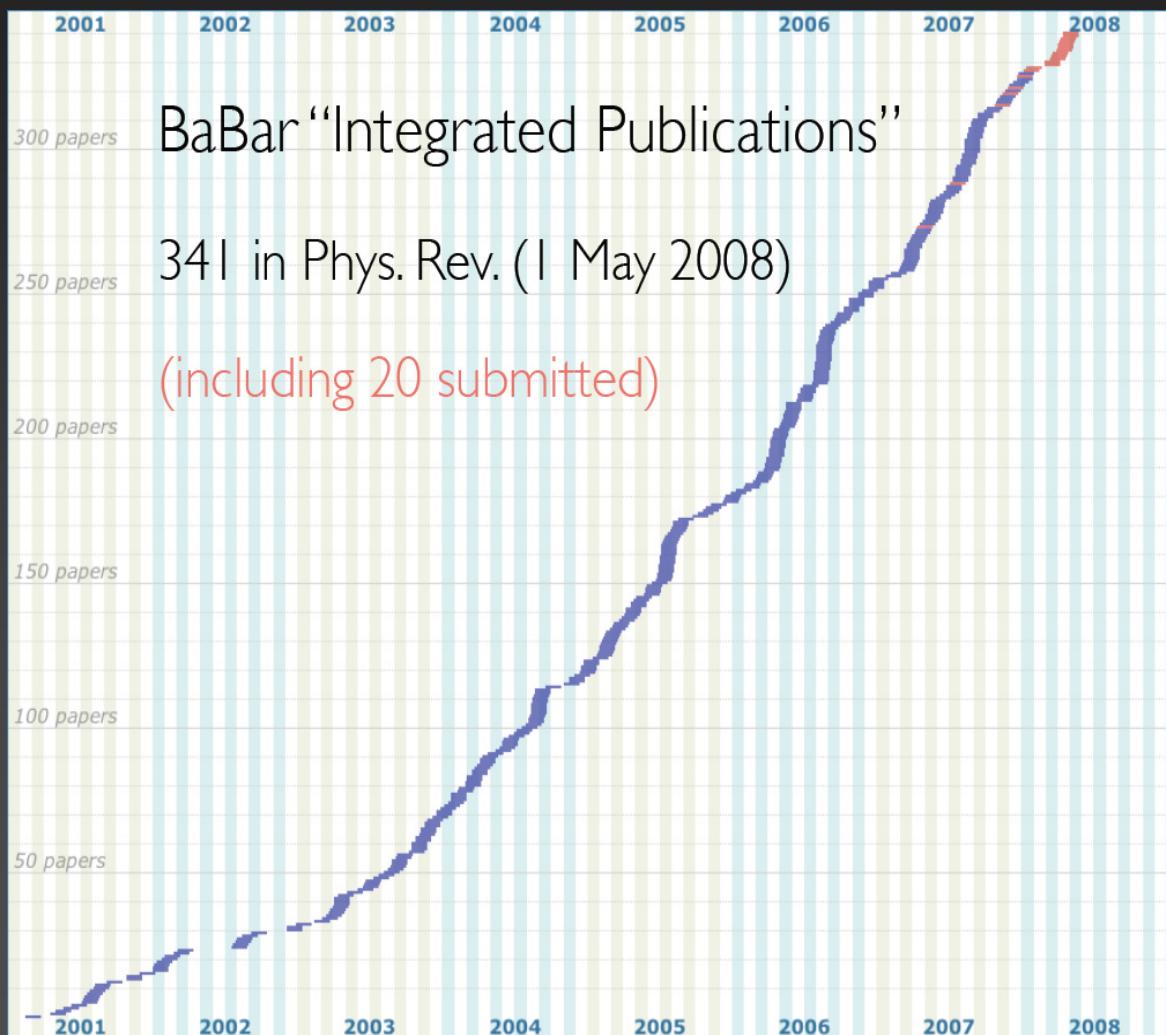
- Measure $BF(D_s^+ \rightarrow \phi\pi^+) = (4.81 \pm 0.52 \pm 0.38)\%$ from

ratio
$$\mathcal{B}(D_s^+ \rightarrow \phi\pi^+) = \frac{\mathcal{N}_{D_s \rightarrow \phi\pi} \sum_i (\varepsilon_i \mathcal{B}_i)}{\mathcal{N}_{D_s} \mathcal{B}(\phi \rightarrow K^+K^-) \sum_i (\varepsilon'_i \mathcal{B}_i)}$$

- Most systematic uncertainties cancel out
- x2 error improvement → benefit on all channels with D_s



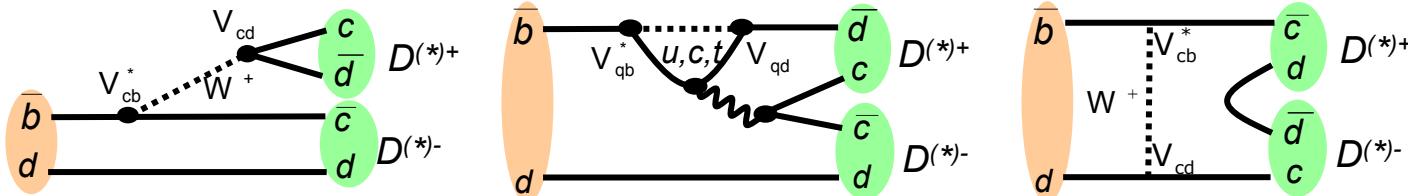
Analyses discussed in this talk



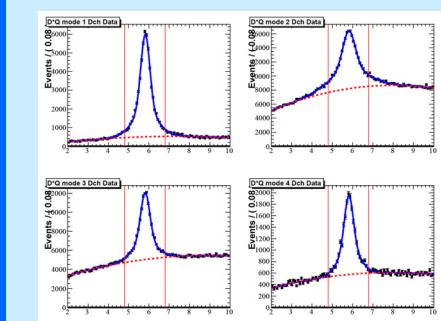
- Latest update of $\sin 2\beta$ in $b \rightarrow c\bar{c}s$
- Latest measurement of γ
- $B^0 \rightarrow D^{*+} D s^{*-}$
- $B^0 \rightarrow D^{*+} D^{*-}$ time-dependent
- $e^+ e^- \rightarrow K K \pi, K K \eta$ with ISR

$B^0 \rightarrow D^{*\pm} D^{*\mp}$ with partial reconstruction

- Not a tree-level-only decay



- $|S + \sin 2\beta|_{\text{teor.}} = 0.02 \div 0.05$ (factorization)
- $\sigma(S_{D^* D^*})_{\text{exp.}} = 0.19$ (*BABAR*, exclusive reconstruction, statistics-dominated)
- Partial reco: $\epsilon_{\text{Excl. reco}} \times 5$
 - aiming at comparable error as exclusive reco
 - samples almost statistically independent

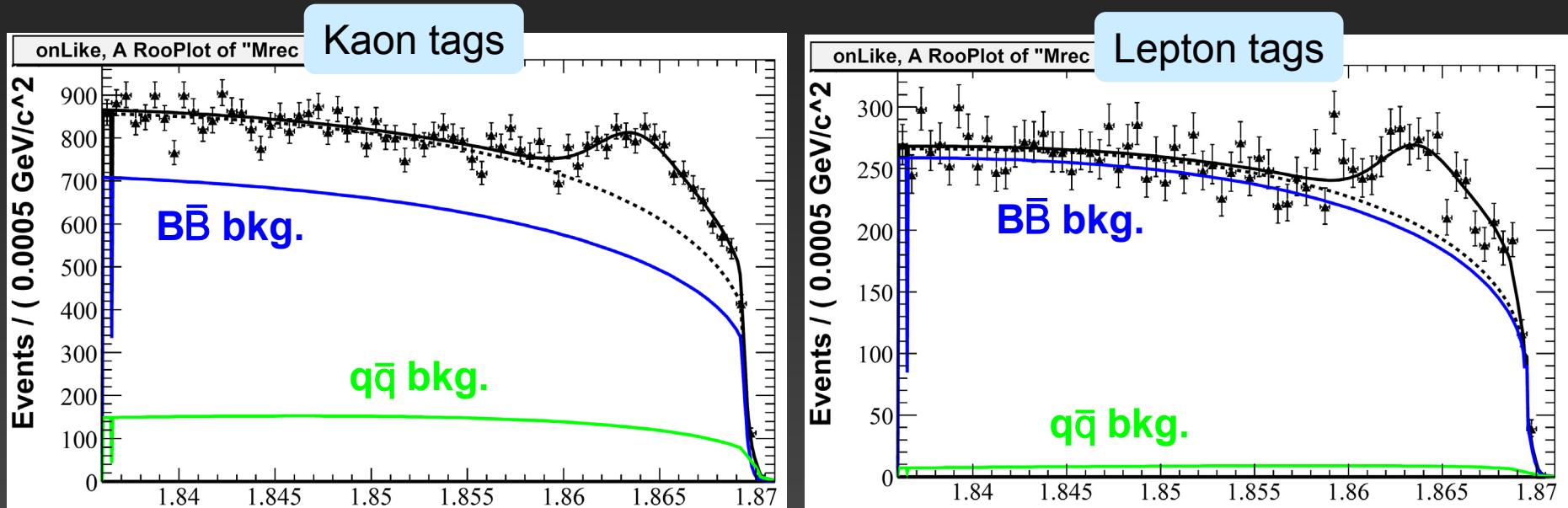


D^* selection

$P(\text{vtx}) > 1\%$; $\Delta m_{\text{lo}} < m_{D^*} - m_{D^0} < \Delta m_{\text{hi}}$, with $\Delta m_{\{\text{lo}, \text{hi}\}}$ depending on D^0 decay mode and $n\text{HIT(DCH)}$ of π_{soft} ; $|m_{D^0} - m_{\text{peak}}| < 3\sigma_{m_{D^0}}$; flight length and m_{K_s} per $K_s \pi^+ \pi^-$; best D^* from $\chi^2(\Delta m, m_{D^0})$ and expected purity

$B^0 \rightarrow D^{*\pm} D^{*\mp}$ with partial reconstruction

$D^{*+} + \pi^-$ soft recoil mass (470M $B\bar{B}$ pairs)



- Fractions of components determined on data from m_{miss} fit
- $B^0 \rightarrow D^{*+} D^{*-}$ is VV decay
 - not a CP eigenstate
 - A_{CP} diluted by $(1-2R_T)$ $R_T = CP\text{-odd fraction}$
- ad-hoc tagging algorithm: exclude tracks from unreconstructed D^0

$B^0 \rightarrow D^{*\pm} D^{*\mp}$ with partial reconstruction

$$f_{S_{tag}}(\Delta t) = e^{-\frac{|\Delta t|}{\tau}} \cdot \begin{bmatrix} [1 - S_{tag} \cdot \Delta w] + S_{tag} \cdot (1 - 2\langle w \rangle)(1 - \alpha) \cdot C \cdot \cos(\Delta m \Delta t) \\ -S_{tag} \cdot (1 - 2\langle w \rangle)(1 - \alpha) \cdot \bar{S} \cdot \sin(\Delta m \Delta t) \end{bmatrix}$$

$$S_{tag} = \begin{cases} +1 & B^0 \text{ tag} \\ -1 & \bar{B}^0 \text{ tag} \end{cases} \quad \langle w \rangle = \frac{w + \bar{w}}{2} \text{ average mistag fraction}; \quad \Delta w = \frac{w - \bar{w}}{2};$$

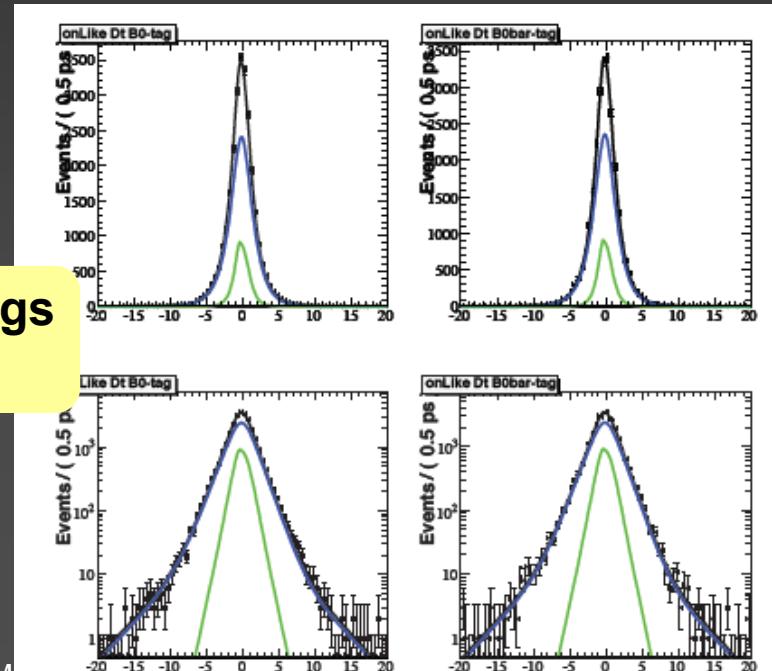
$$\alpha = \text{fraction of tags from } D^0; \quad \bar{S} = (1 - 2R_\perp) \cdot S^{even} = \frac{|A_0^0|^2 + |A_\parallel^0|^2 - |A_\perp^0|^2}{|A_0^0|^2 + |A_\parallel^0|^2 + |A_\perp^0|^2} \cdot S^{even}$$

We assume $\alpha_+ = \alpha_- = \alpha$

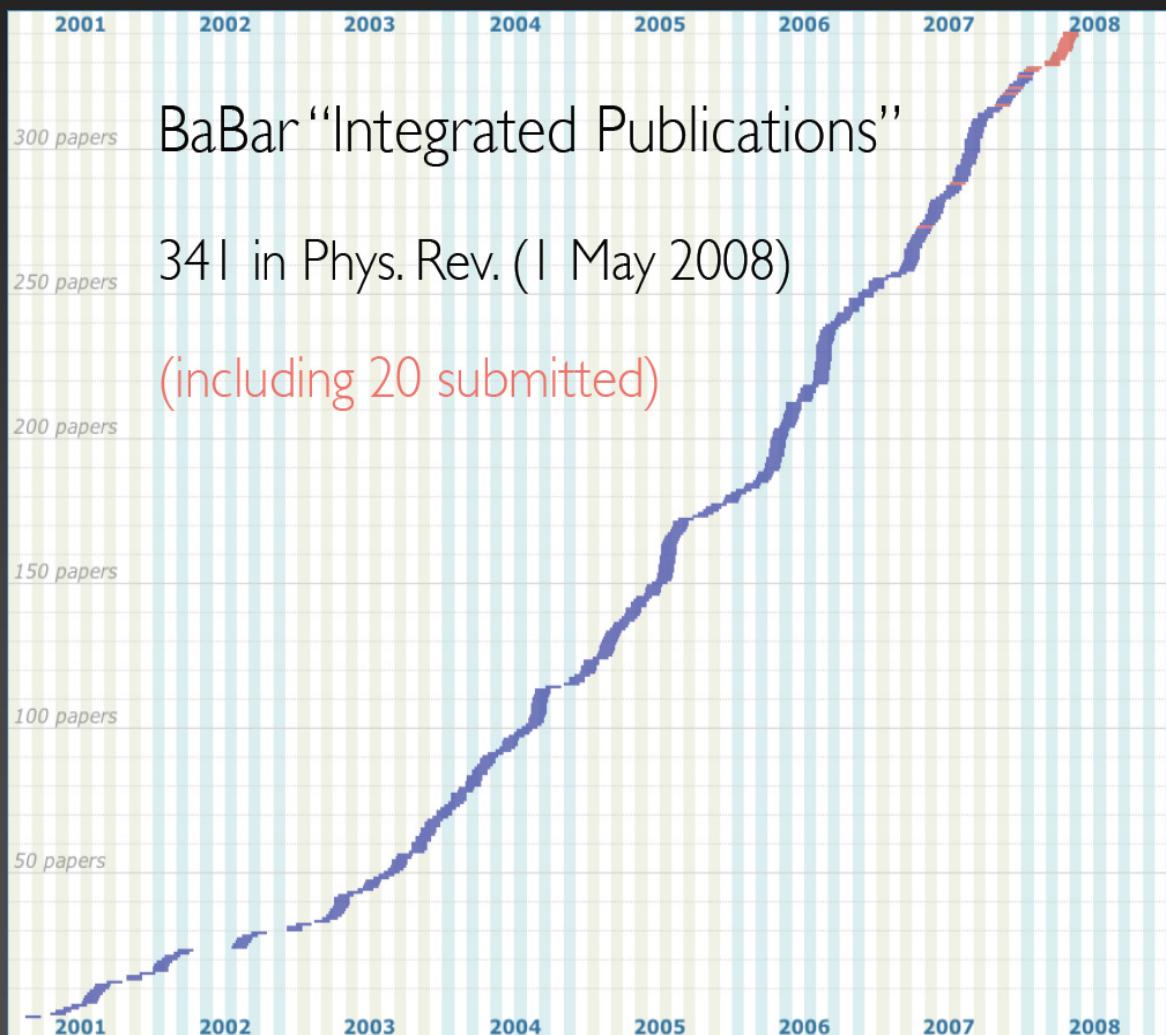
(blind) $B^0/B^0\bar{b}$ Δt distributions for Kaon tags

383M $B\bar{B}$

Expect to publish by 2008 on full data set
(Run 1-6)



Analyses discussed in this talk



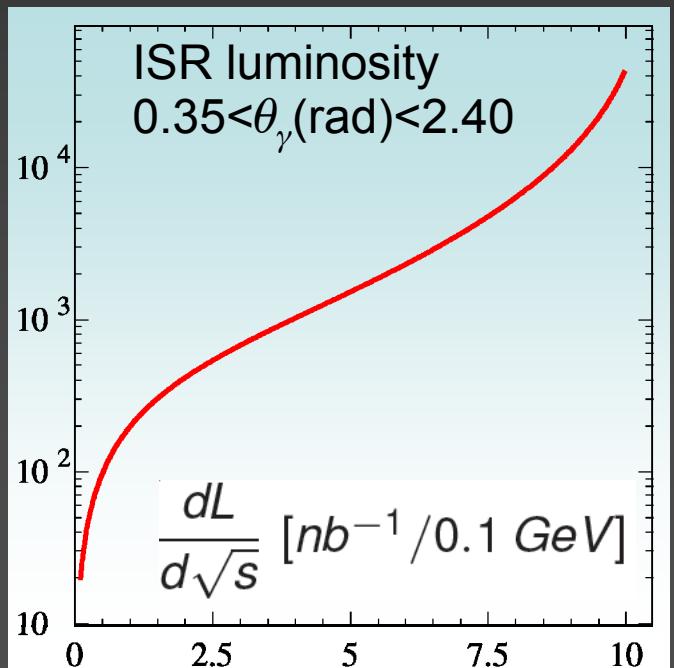
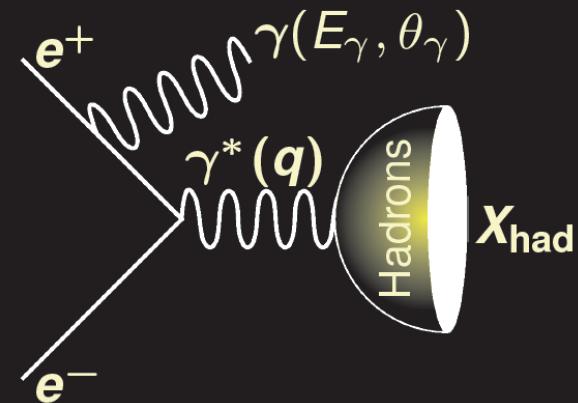
- Latest update of $\sin 2\beta$ in $b \rightarrow c\bar{c}s$
- Latest measurement of γ
- $B^0 \rightarrow D^{*+} D s^{*-}$
- $B^0 \rightarrow D^{*+} D^{*-}$ time-dependent
- $e^+ e^- \rightarrow 6\pi, K K \pi, K K \eta$ with ISR

Initial State Radiation

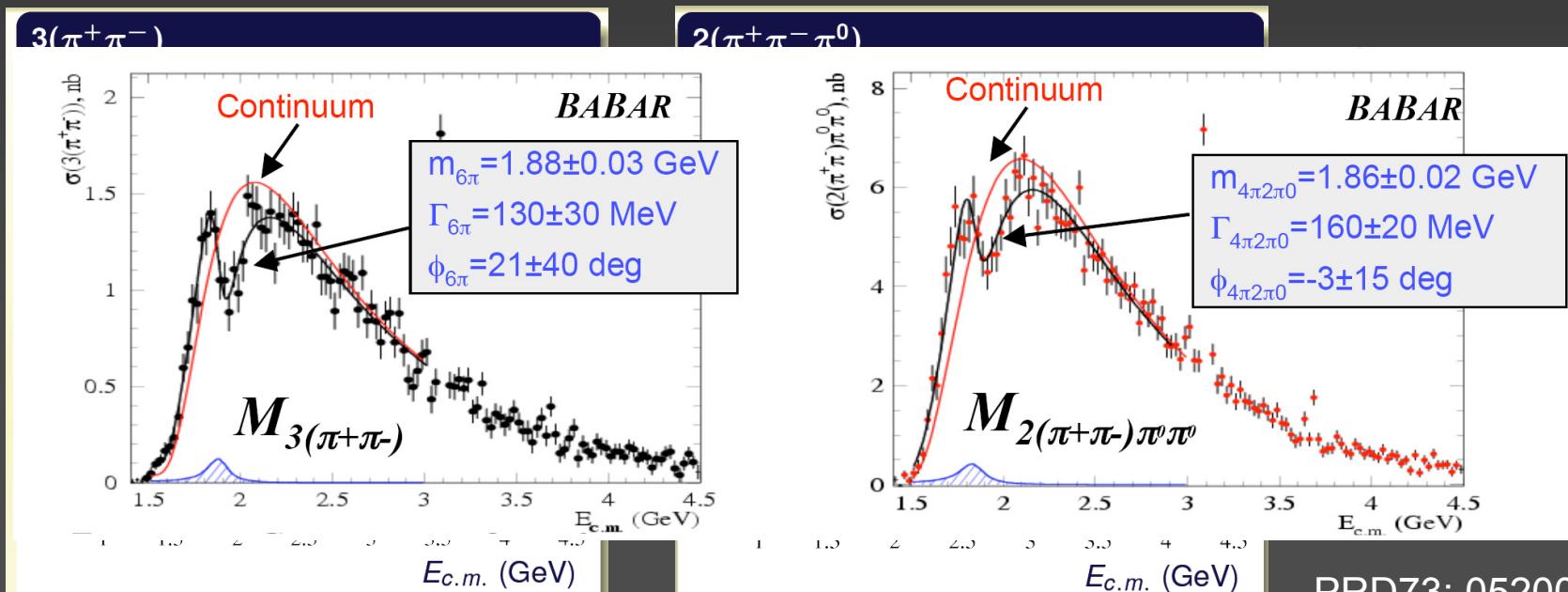
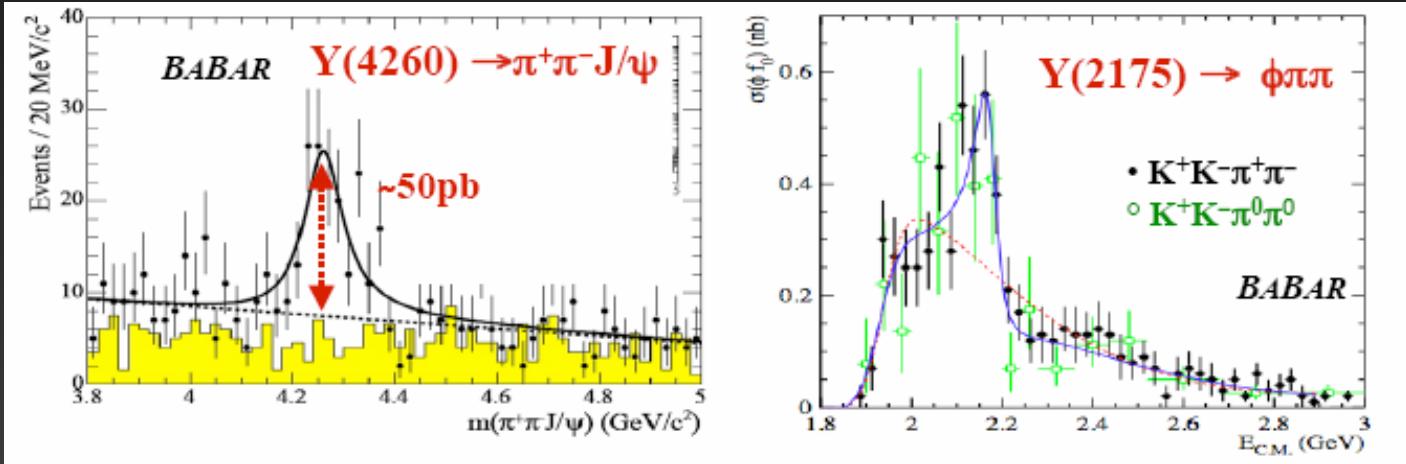
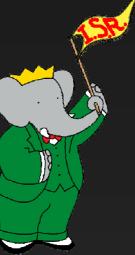
- ISR processes at the $\Upsilon(4S)$ can yield the same observables as low energy e^+e^- experiments, allowing for:
 - Precise measurements of hadronic cross section
 - $J^{PC}=1^{--}$ hadron spectroscopy for $1 < \sqrt{s} < 5$ GeV
 - Form Factor measurements
 - Discovery potential for new states [e.g. $\Upsilon(4260)$, $X(2175)$]
- Advantages:
 - All q at the same time → reduced uncertainties
 - CM boost
 - $\varepsilon \neq 0$ at threshold
 - $\sigma(E)$ is $O(\text{few MeV})$
- Disadvantages:
 - $L \sim \Delta S$ bin width
 - More backgrounds

ISR Cross section

$$\sigma_{X_{\text{had}}}(s) = \frac{dN/d\sqrt{s}}{\epsilon(1 + \delta_{\text{rad}})(dL/d\sqrt{s})}$$



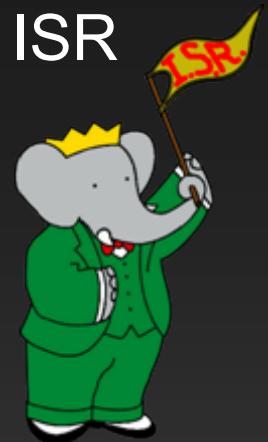
Motivation: Hadron spectroscopy



PRD73: 052003, 2006

Measurement of the $KK\pi$ and $KK\eta$ cross sections with ISR

arXiv:0710.4451 [hep-ex]
Accepted by PRD



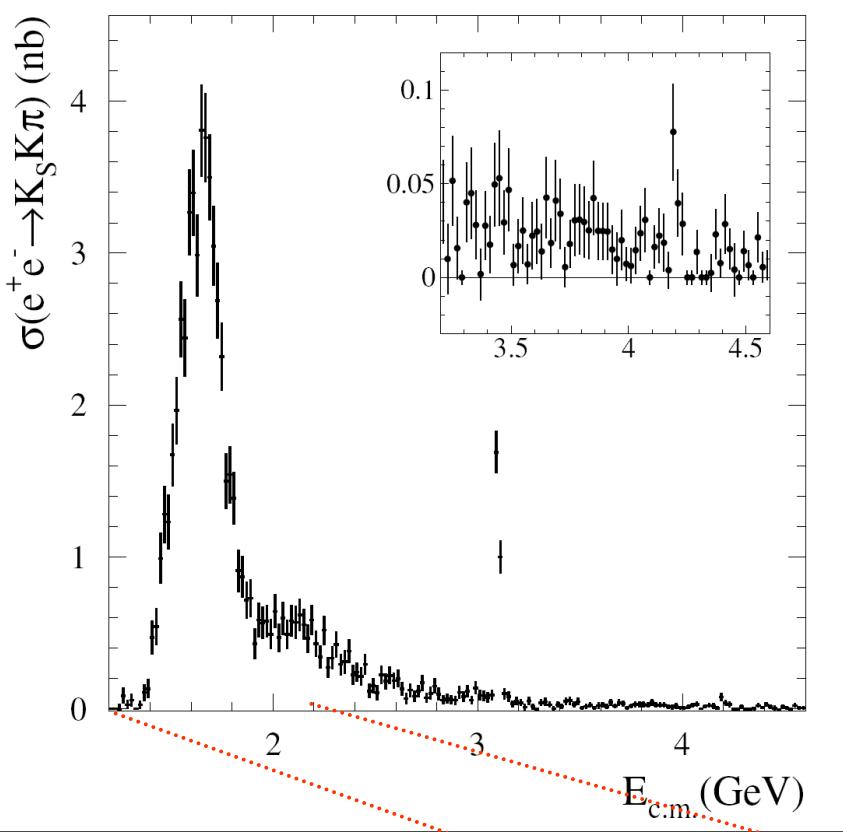
■ Cross section measurement from production threshold to ~ 4.6 GeV for:

- $e^+e^- \rightarrow K^+K^-\pi^0$
 - $e^+e^- \rightarrow K_S K^-\pi^+$
- } Mainly through $e^+e^- \rightarrow KK^* \rightarrow KK\pi$ Dalitz plot analysis to disentangle the different isospin contributions to the cross section and the relative phase
- $e^+e^- \rightarrow \phi\pi^0$ → OZI suppressed, never measured before, search for isovector exotic states
 - $e^+e^- \rightarrow \phi\eta$ → search for $\phi(l=0)$ recurrences
 - $e^+e^- \rightarrow K^+K^-\eta$

- Measured cross sections contribute to R in the corresponding energy range
- Measurement of the J/ψ decay rates in all observed final states



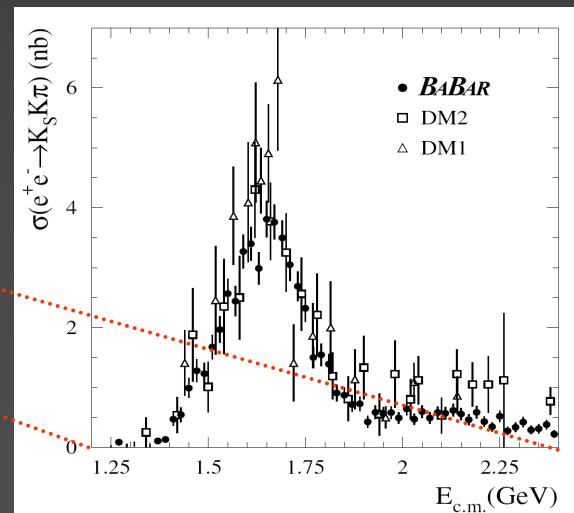
$e^+e^- \rightarrow K_S K^\pm \pi^\mp$ cross section



Good agreement w/ old data
much higher precision

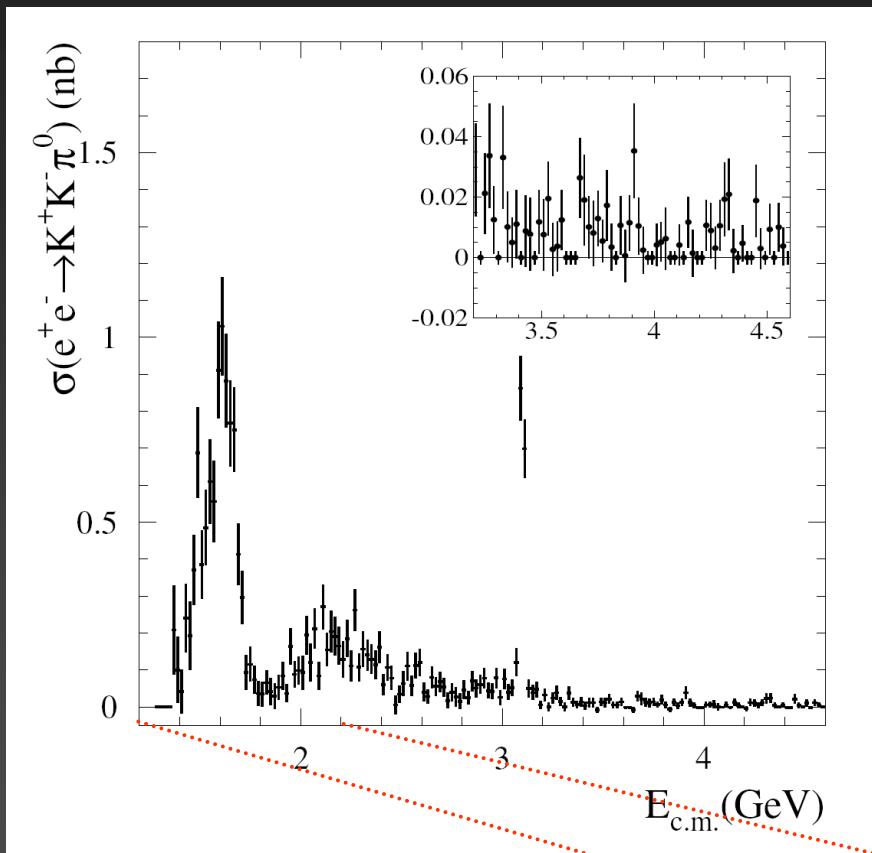
$$\sigma_{e^+e^- \rightarrow K_S^0 K^\pm \pi^\mp}(E_{c.m.}) = \frac{dN_{K_S^0 K\pi\gamma}(E_{c.m.})}{d\mathcal{L}(E_{c.m.}) \cdot \epsilon(E_{c.m.})}$$

- 3734 signal evts, purity 97%
- Only stat. errors in figure
 - Syst. errors ~5%
- $B(J/\psi \rightarrow K_SK\pi) = (3.20 \pm 0.23 \pm 0.18) \times 10^{-3}$



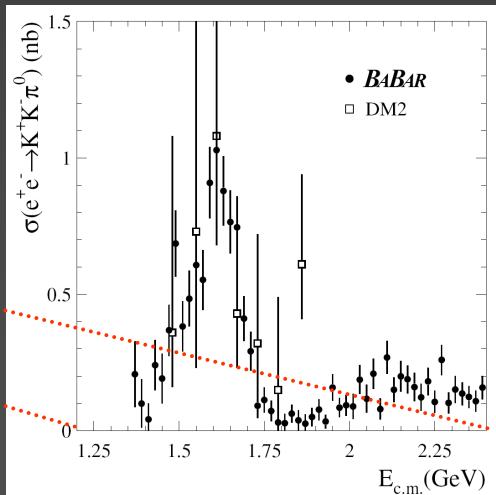


$e^+e^- \rightarrow K^+K^-\pi^0$ cross section



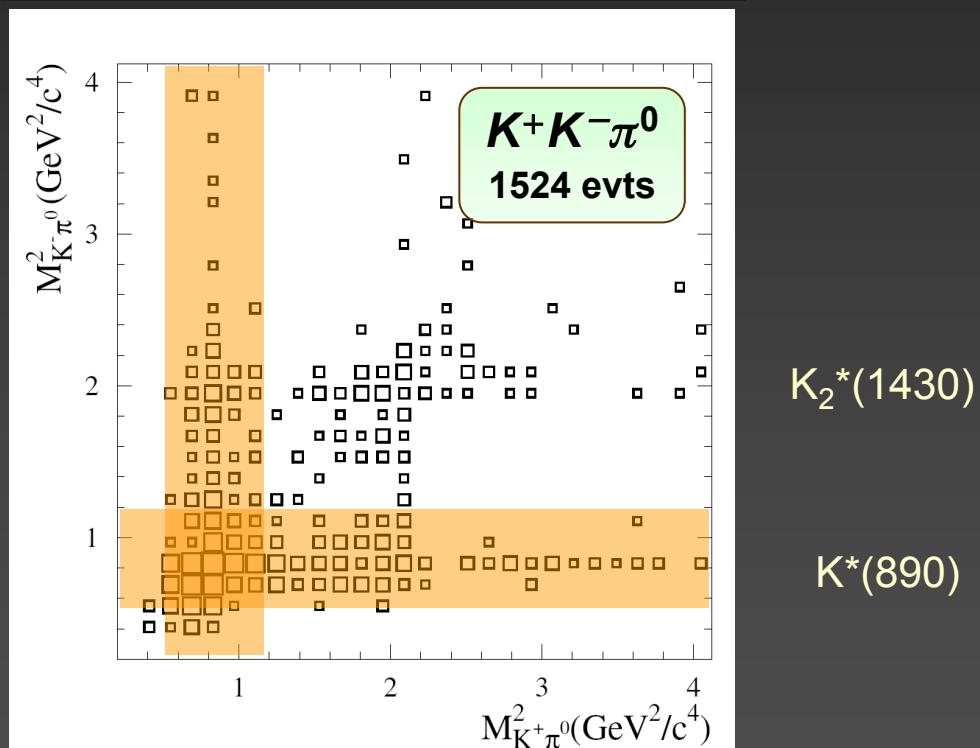
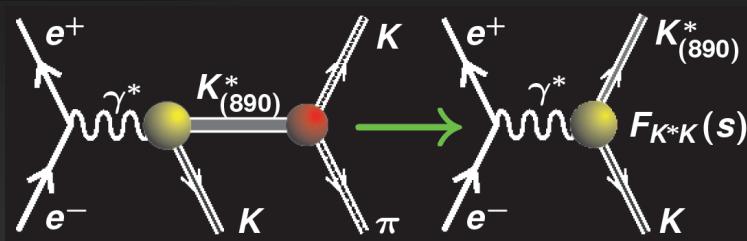
Good agreement with old data
much higher precision

- 1378 signal evts, purity 90%
- Only stat. errors in figure
 - Syst. errors ~6.5%
- $B(J/\psi \rightarrow KK\pi^0) = (1.97 \pm 0.16 \pm 0.13) \times 10^{-3}$





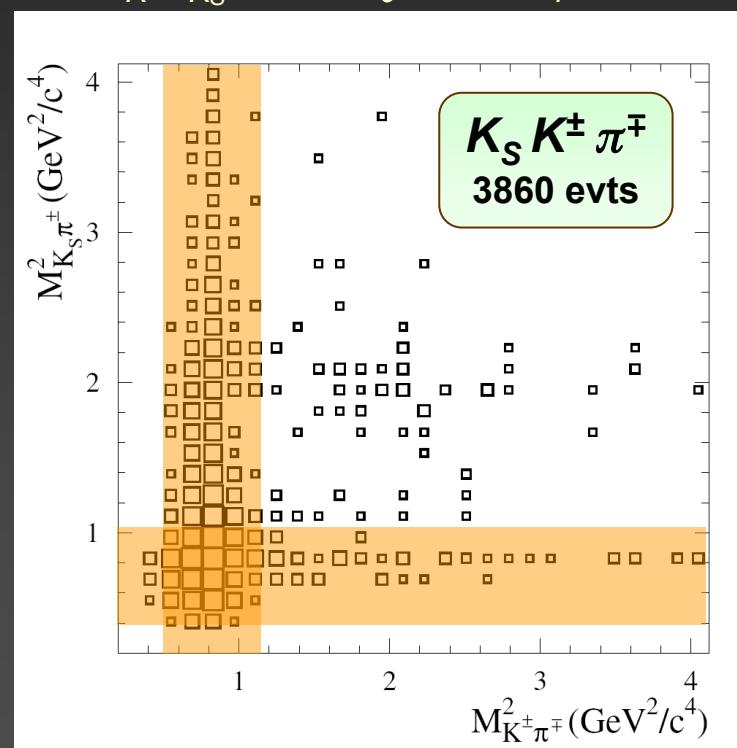
Dalitz plot analysis of $e^+e^- \rightarrow K\bar{K}\pi$



Symmetric Dalitz no isospin separation
 $|F_0 - F_1|$

Main process: $e^+e^- \rightarrow VP$

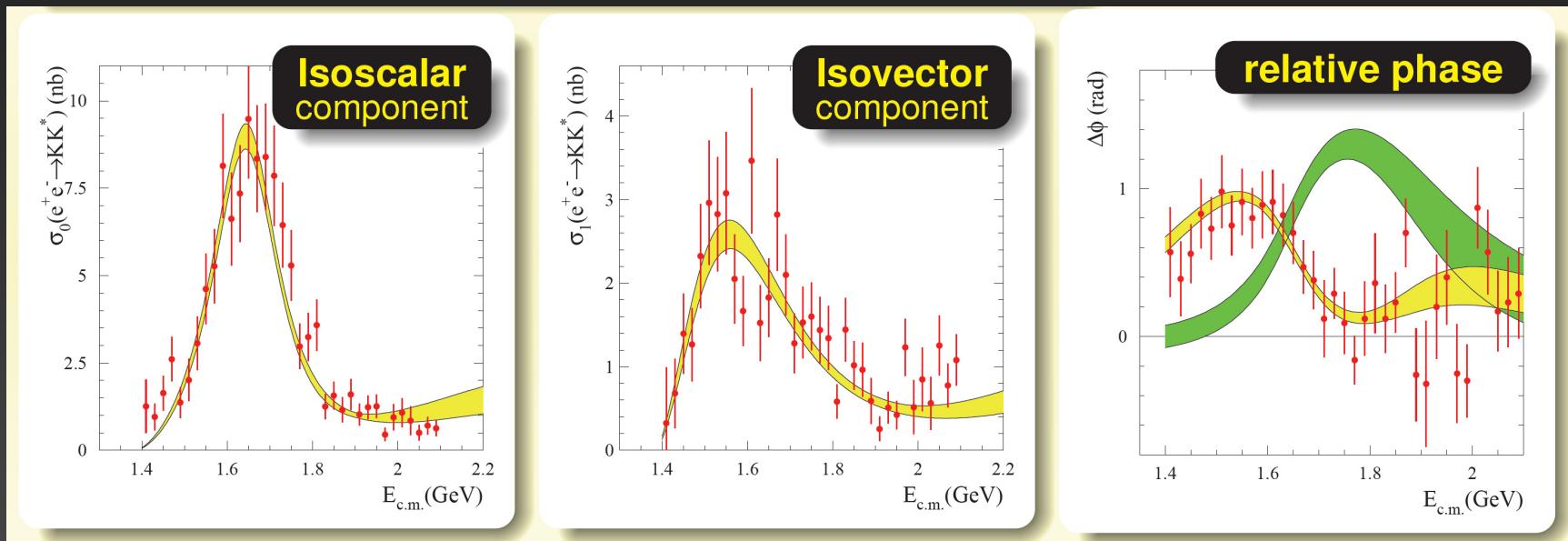
- Two isospin components:
- $F_{K^{*\pm}K^\mp}(s) = F_0(s) - F_1(s)$
- $F_{K^{*0}K_S}(s) = F_0(s) + F_1(s)$



Asymmetric Dalitz \rightarrow isospin separation
 $|F_0|, |F_1|$ and relative phase



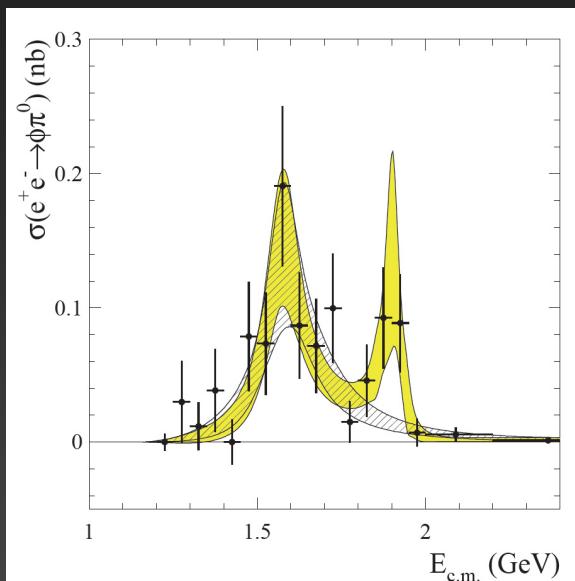
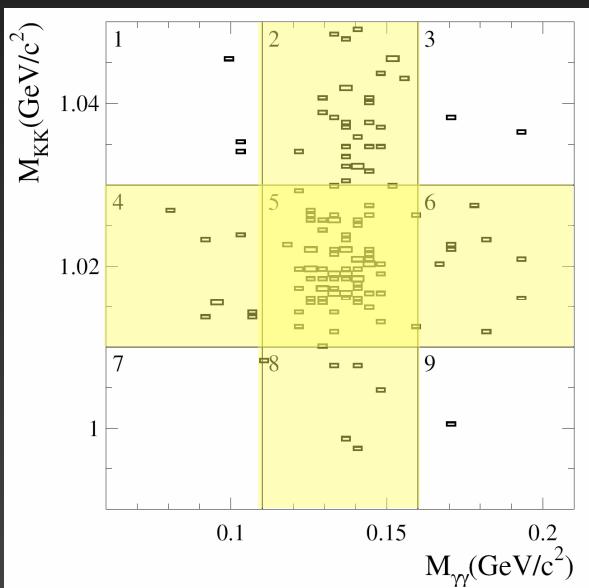
$e^+e^- \rightarrow K^*(892)K \rightarrow K_S K^\pm \pi^\mp$: isospin analysis



- ⌚ $K^*(892)K$ dominant for $E_{\text{cm}} < 2\text{GeV}$
- ⌚ $I=0$ component has clear evidence of $\phi(1680) \rightarrow K^*(892)K$
- ⌚ Resonant isovector component [$\rho(1500)$?] favored by relative phase
- ⌚ green band would correspond to non-resonant $I=1$ component



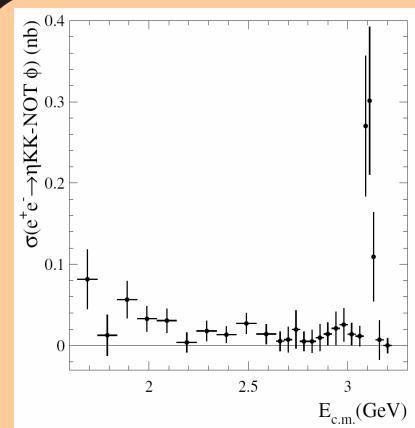
$e^+ e^- \rightarrow \phi \pi^0 \rightarrow K^+ K^- \pi^0$



- $\phi \pi^0$ is OZI-suppressed
- pure isovector $\rightarrow \rho$ -like contributions
- Broad structure (ρ'') at ~ 1.6 GeV
- Sharp peak at Ecm ~ 1.9 GeV compatible with the “dip” seen in multi-hadronic final states
- adding a “ $\rho(1900)$ ” the fit quality improves slightly

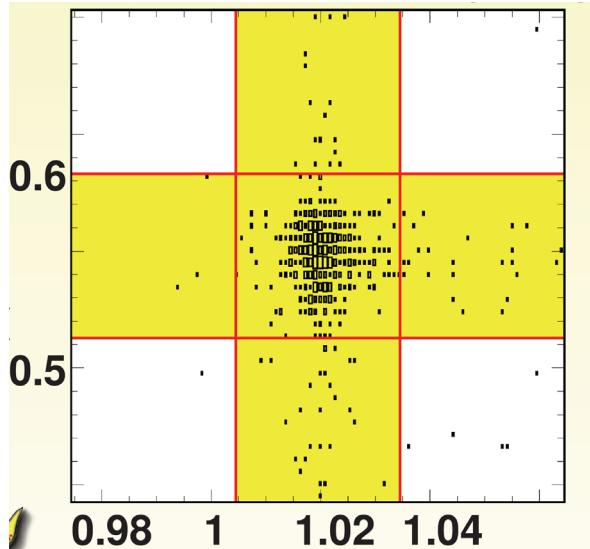


$e^+e^- \rightarrow K^+K^-\eta$



Non
resonant KK

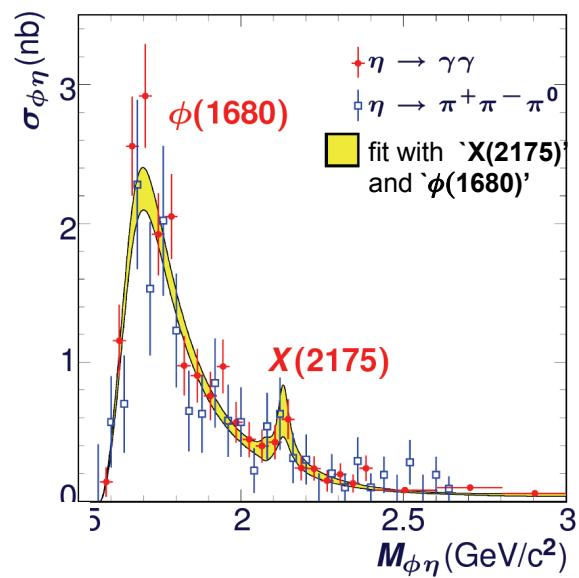
First measurement of
 $B(J/\psi \rightarrow K^+K^-\eta) = (8.7 \pm 1.3 \pm 0.7) 10^{-4}$



$\phi \rightarrow K^+K^-$
492 evts, purity 98%

Parameters
 $M_X = 2125 \pm 22 \pm 10 \text{ MeV}/c^2$
 $\Gamma_X = 61 \pm 50 \pm 13 \text{ MeV}$
 Significance 2.5σ

First observation of $\phi(1680) \rightarrow \phi\eta$ decay
 The parameters of ϕ'' are compatible with the
 $\phi f_0(980)$ state already observed by *BABAR* [X(2175)]





Global fit of $e^+e^- \rightarrow KK\pi / KK\eta$

Global fit using all available information (KK^* , $K^+K^-\pi^0$, $\phi\eta$, $\phi\pi^0$) to extract the parameters of observed states (ϕ' , ϕ'' , ρ' , ρ'' , $\rho(1900)$)

Isospin	R	$\Gamma_{ee}^R \mathcal{B}_{KK^*}^R$ (eV)	$\Gamma_{ee}^R \mathcal{B}_{\phi\eta}^R$ (eV)	M_R (MeV)	Γ_R (MeV)
0	$\phi(1680)$	$369 \pm 53 \pm 1$	$138 \pm 33 \pm 28$	$1709 \pm 20 \pm 43$	$322 \pm 77 \pm 160$
	$X(2175)$	—	$1.7 \pm 0.7 \pm 1.3$	$2125 \pm 22 \pm 10$	$61 \pm 50 \pm 13$
1	$\rho'(1500)$	$127 \pm 15 \pm 6$	—	$1505 \pm 19 \pm 7$	$418 \pm 25 \pm 4$

Summary and outlook

- *BABAR* data taking is now concluded
 - the SM survived all challenges so far
- More, improved measurements using final data set
 - data with the “final reprocessing” will feature the best of the best in reconstruction, PID, analysis algorithms
- Next step could be *SuperB*
 - group is responsible for the SuperB Drift Chamber upgrade

