Searches for New Sources of CP and T Violation at BaBar

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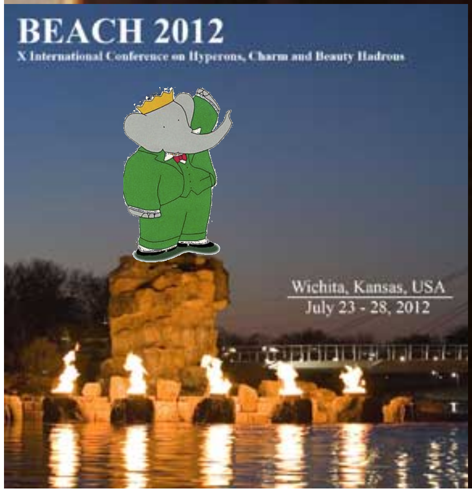
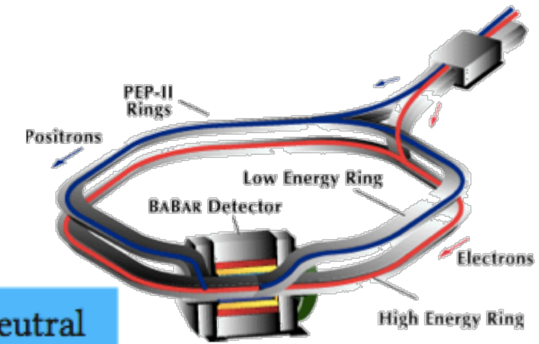
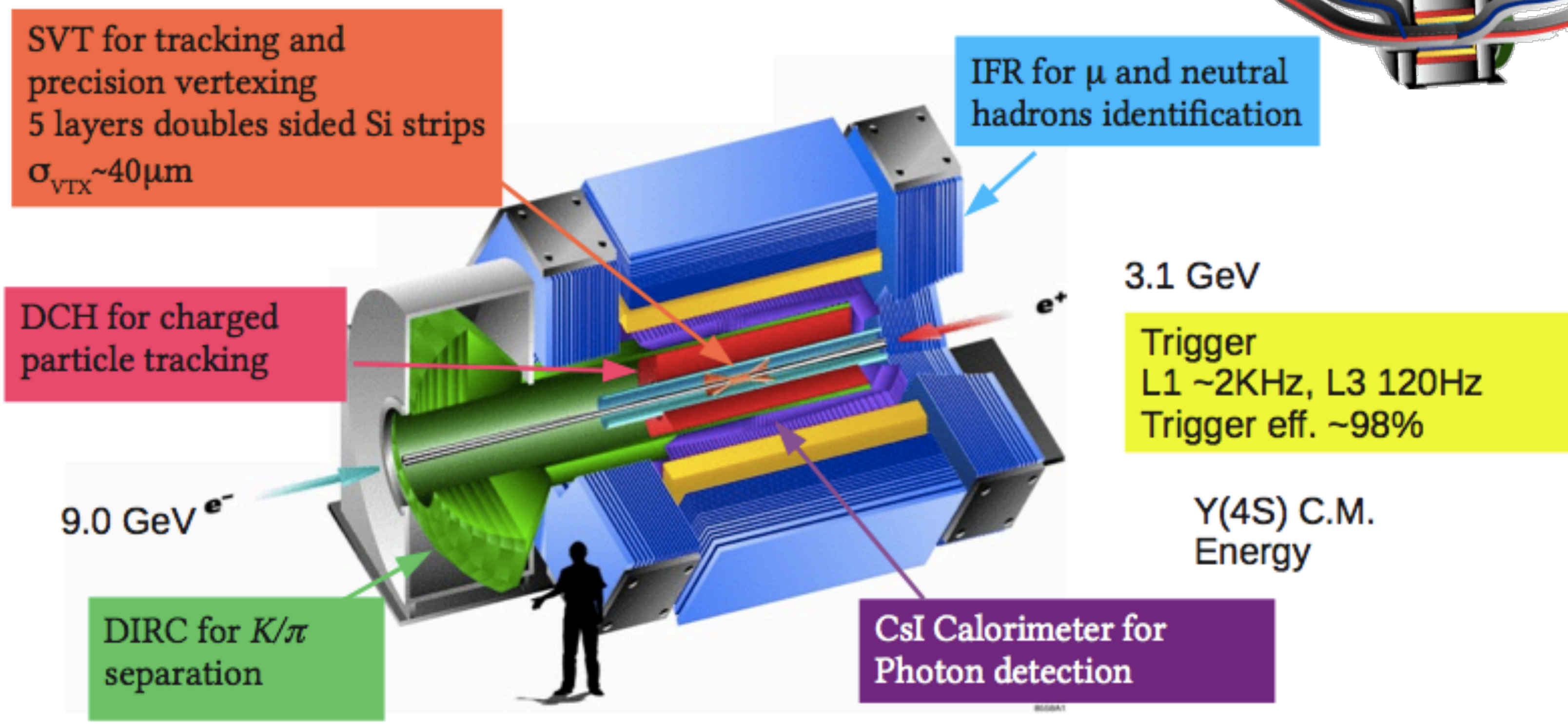
Representing the BaBar Collaboration

July 24, 2012



The BABAR Experiment





Nucl.Instrum.Meth.A479:1-116,2002

Integrated Luminosity 1999 – 2008

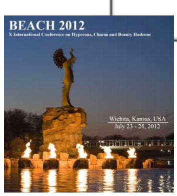
On-Peak 423 fb^{-1} ~468 MBB

Off-Peak 44 fb^{-1},

100M Υ(2S), 120M Υ(3S), 4fb^{-1} above Υ(4S)

$$M_{ES}=\sqrt{(s/2+\mathbf{p}_0\mathbf{p}_B)^2/E_0^2-p_B^2}$$

$$\Delta E=E_B^*-\frac{\sqrt{s}}{2}$$

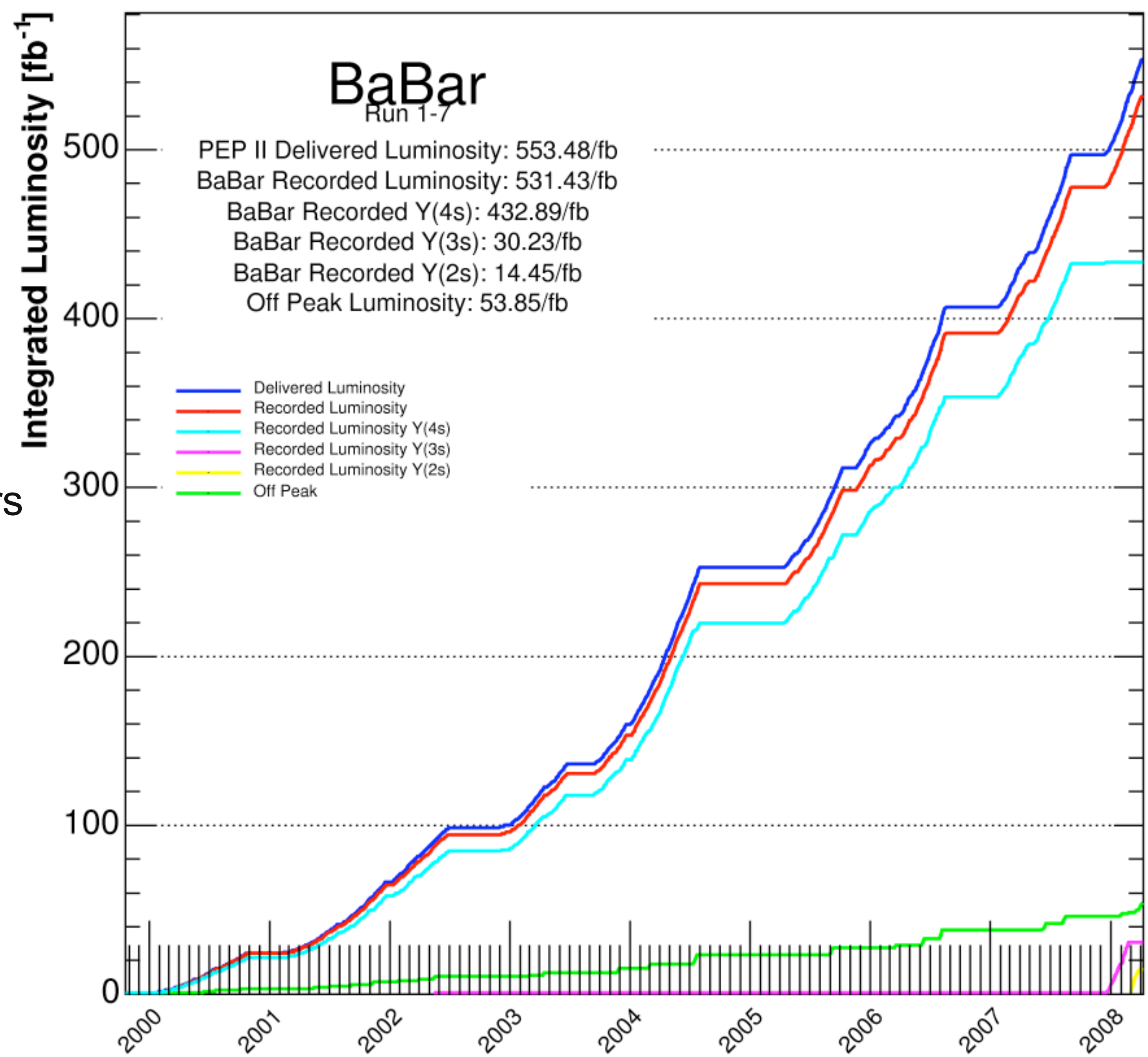


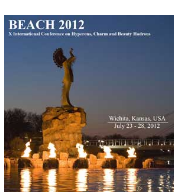
The BaBar Dataset

sample	fb^{-1}
$\Upsilon(4S)$	430
$\Upsilon(3S)$	30.2
$\Upsilon(2S)$	14.5
Off-$\Upsilon(nS)$	54

- **472** million neutral *B*
- **472** million charged *B*
- **690** million *c* anti-*c* pairs
- **500** million $\tau^+\tau^-$ pairs
- **117** million Υ(3S)
- **93** million Υ(2S)

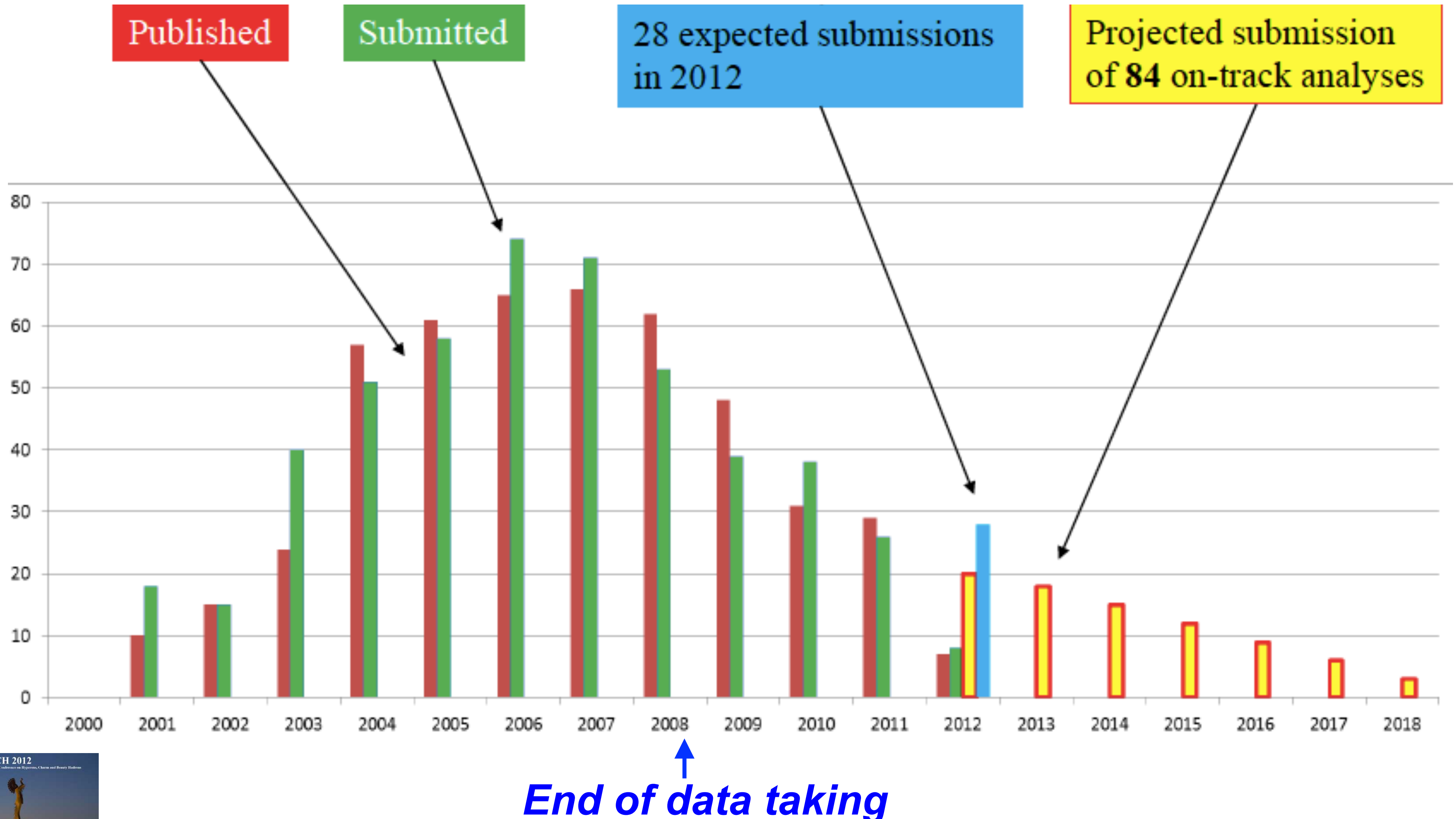
➤ ***Data taking ended 4 years ago…***

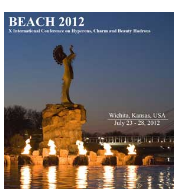




The BaBar Science Output

- *... but the physics sure hasn't ended!*





Overview: 3 Sectors, 5 New Results

- ***B*** **sector**

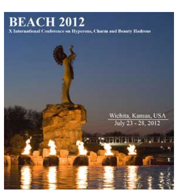
  1) $b \to s\bar{s}s$: $B \to 3K$ *CP*V

  2) $b \to s\ell^+\ell^-$: $B \to K\ell\ell$ **direct *CP*V search**

  3) $b \to c\bar{c}s$: $B^0 \to J/\psi K^0$ **first direct observation of *T*-violation in *B* system**

- **Charm sector:** $D^+ \to K^+K^0\pi^+\pi^-$ ***T*-odd correlation**

- **τ sector:** $\tau^- \to K^0\pi^-\nu$ ***CP*V search**



➢ *B* sector

arXiv: 1201.5897, PRD 85: 112010 (2012)

1) $b \to s\bar{s}s$: $B \to 3K$ CPV

arXiv: 1204.2852, submitted to PRD

2) $b \to s\ell^+\ell^-$: $B \to K\ell\ell$ direct CPV

3) $b \to c\bar{c}s$: $B^0 \to J/\psi K^0$ first direct observation of *T*-violation in *B* system

To be submitted to PRL

$B \to 3K$ CPV

arXiv:1201.5897, PRD 85:112010 (2012)
426 fb-1

- Tree amplitudes subdominant in SM
- New Physics can appear in loops – altering CP violation from SM expectation!

- $B^0 \to K^+K^-K_S$:

  Measure time-dependent CP asymmetry

$$A_{CP}(\Delta t) \sim \eta_{CP} \sin(2\beta_{eff}) \sin(\Delta m_d \Delta t)$$

  Complication -- $K^+K^-K_S$ not CP eigenstate

  CP content depends on Dalitz plot/spin structure of decay

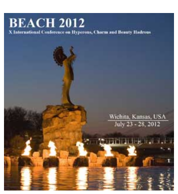
- $B^+ \to K^+K^-K^+$ and $B^+ \to K_SK_SK^+$

  Study Dalitz structure – help understand CP content in $K^+K^-K_S$

  $f_X(1500)$ – poorly understood resonance, seen in $B \to KKK$, taken to be a scalar

  Large "nonresonant" contribution needs further study

  Search for direct CP violation



$B \to 3K$ CPV: Dalitz

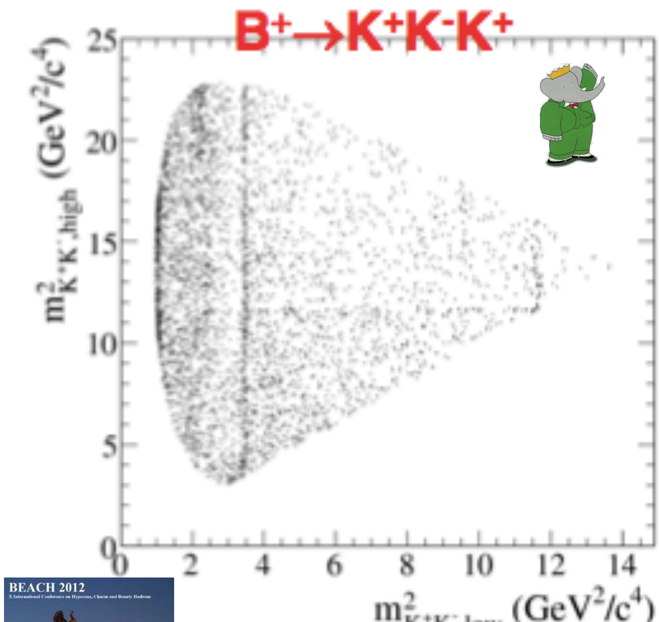
arXiv:1201.5897, PRD 85:112010 (2012)
426 fb-1

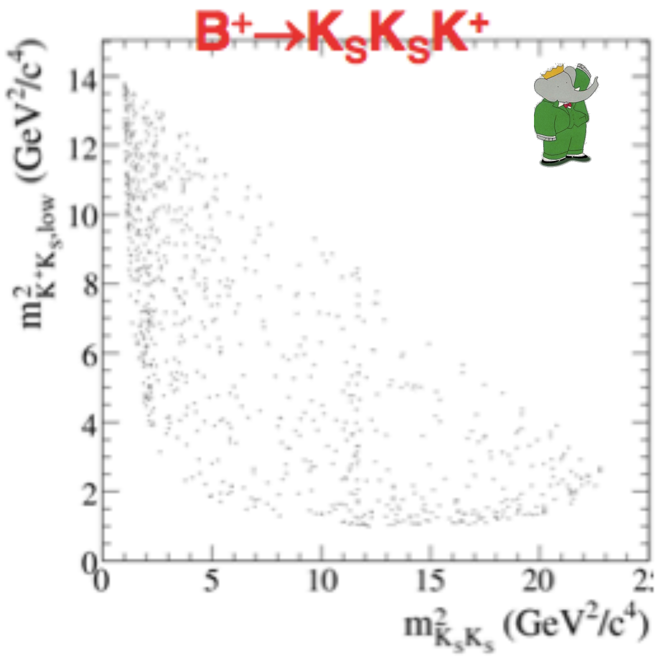
$$\mathcal{A} \equiv \mathcal{A}(B \to KKK; m_{12}, m_{23}) = \sum_j a_j F_j(m_{12}, m_{23})$$

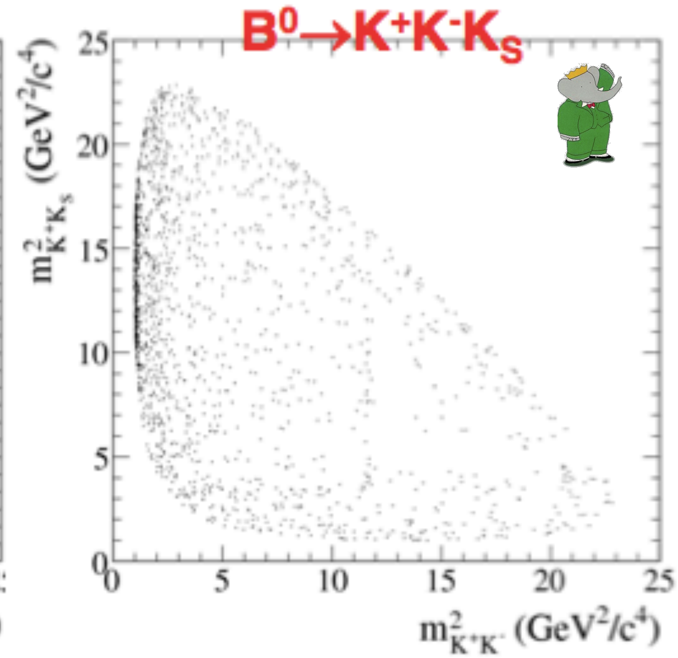
$$a_j = c_j(1+b_j)e^{i(\phi_j+\delta_j)}$$
$$\bar{a}_j = c_j(1-b_j)e^{i(\phi_j-\delta_j)}$$

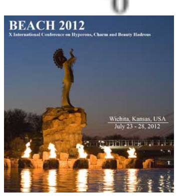
F_j are resonant or nonresonant lineshapes: relativistic Breit-Wigner, spin-factors, etc.

From isobar coefficients can derive: partial branching fractions, A_{CP} (= $-2b/(1+b^2)$), β_{eff} (= $\beta + \delta$), etc.









$B \rightarrow 3K$ CPV: Summary

- Indication of direct CP violation in $B^+ \rightarrow \phi K^+$ at 2.8σ.
  - $A_{CP} = (12.8 \pm 4.4 \pm 1.3)\%$
  - SM: $(0 - 4.7)\%$

$A_{CP}(\phi K^+)$ larger than SM expectation:

$A_{CP} = (1.6^{+3.1}_{-1.4})\%$ (QCDF) Beneke, Neubert, Nucl Phys B675, 333

$A_{CP} = (1^{+0}_{-1})\%$ (PQCD) Li, Mishima, PRD 74, 094020

- World's most precise measurement of $\beta_{eff}(\phi K_S)$:
  - $\beta_{eff} = (21 \pm 6 \pm 2)$ degrees

Good agreement with SM

Charmonium:
$\beta = 21.4 \pm 0.8$ deg

- $f_X(1500)$ not a single resonance – well described by $f_0(1500)$ + $f_2'(1525)$ + $f_0(1710)$

arXiv:1201.5897,
PRD 85:112010 (2012)
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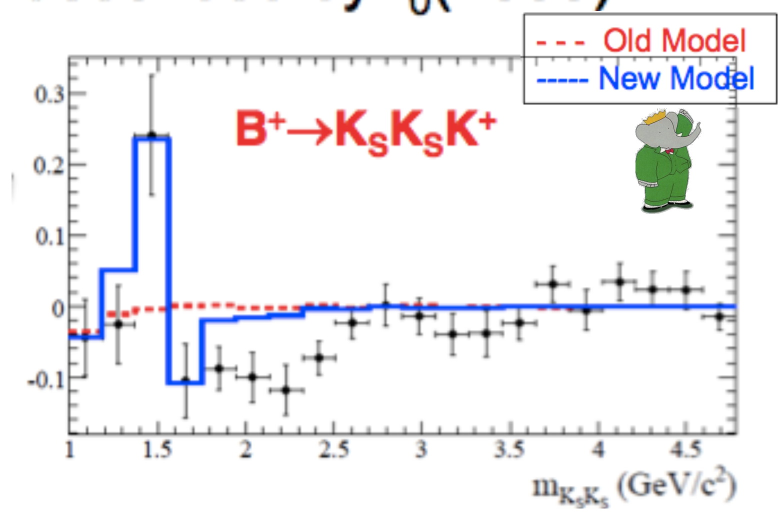
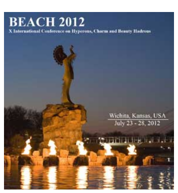
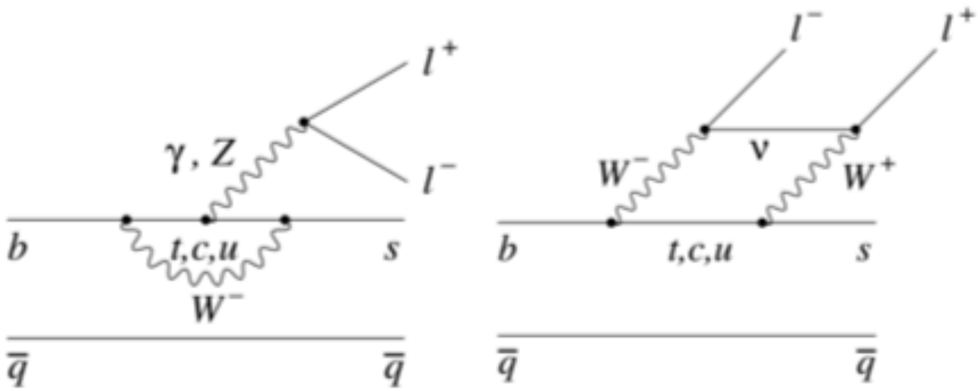


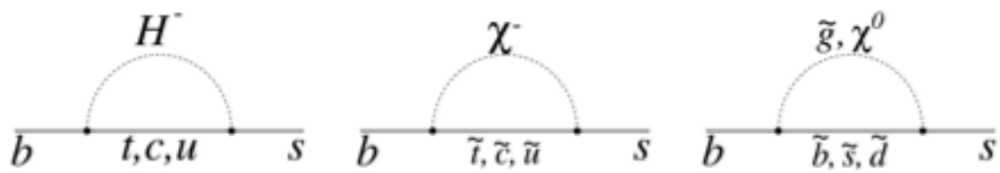


$B \to K\ell\ell$ direct CPV

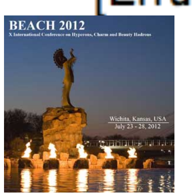
arXiv:1204.3933, PRD submitted
426 fb-1



$$\mathcal{A}_{CP}^{K^{(*)}} \equiv \frac{\mathcal{B}(\overline{B} \to \overline{K}^{(*)}\ell^+\ell^-) - \mathcal{B}(B \to K^{(*)}\ell^+\ell^-)}{\mathcal{B}(\overline{B} \to \overline{K}^{(*)}\ell^+\ell^-) + \mathcal{B}(B \to K^{(*)}\ell^+\ell^-)}$$



- lowest order SM processes are at the same order as a possible new physics contribution
- direct CP asymmetry predicted to be $\mathcal{O}(10^{-3})$
- significant enhancement from new physics contribution possible
  Kruger, Sehgal, N. Sinha, and R. Sinha, Phys. Rev. D **61**, 114028 (2000)
  [Erratum-ibid. D **63**, 019901 (2001)]



$B \to K\ell\ell$ direct CPV

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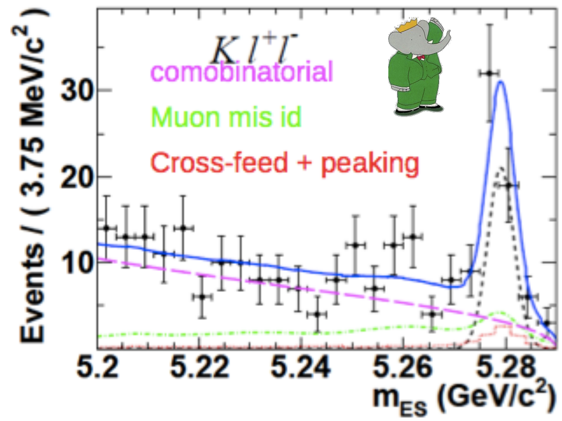


- eight final states reconstructed
  - $B^0 \to K^0_S \mu^+\mu^-$ $\quad B^0 \to K^0_S e^+e^-$
  - $B^+ \to K^+ \mu^+\mu^-$ $\quad B^+ \to K^+ e^+e^-$
  - $B^+ \to K^{*+} \mu^+\mu^-$ $\quad B^+ \to K^{*+} e^+e^-$ $\quad K^{*+} \to K^0_S \pi^+$
  - $B^0 \to K^{*0} \mu^+\mu^-$ $\quad B^0 \to K^{*0} e^+e^-$ $\quad K^{*0} \to K^+ \pi^-$

- $K^{(*)} h^\pm \mu^\mp$ used to study hadronic background

- J/ψ and $\psi(2S)$ mass regions excluded and used as control sample

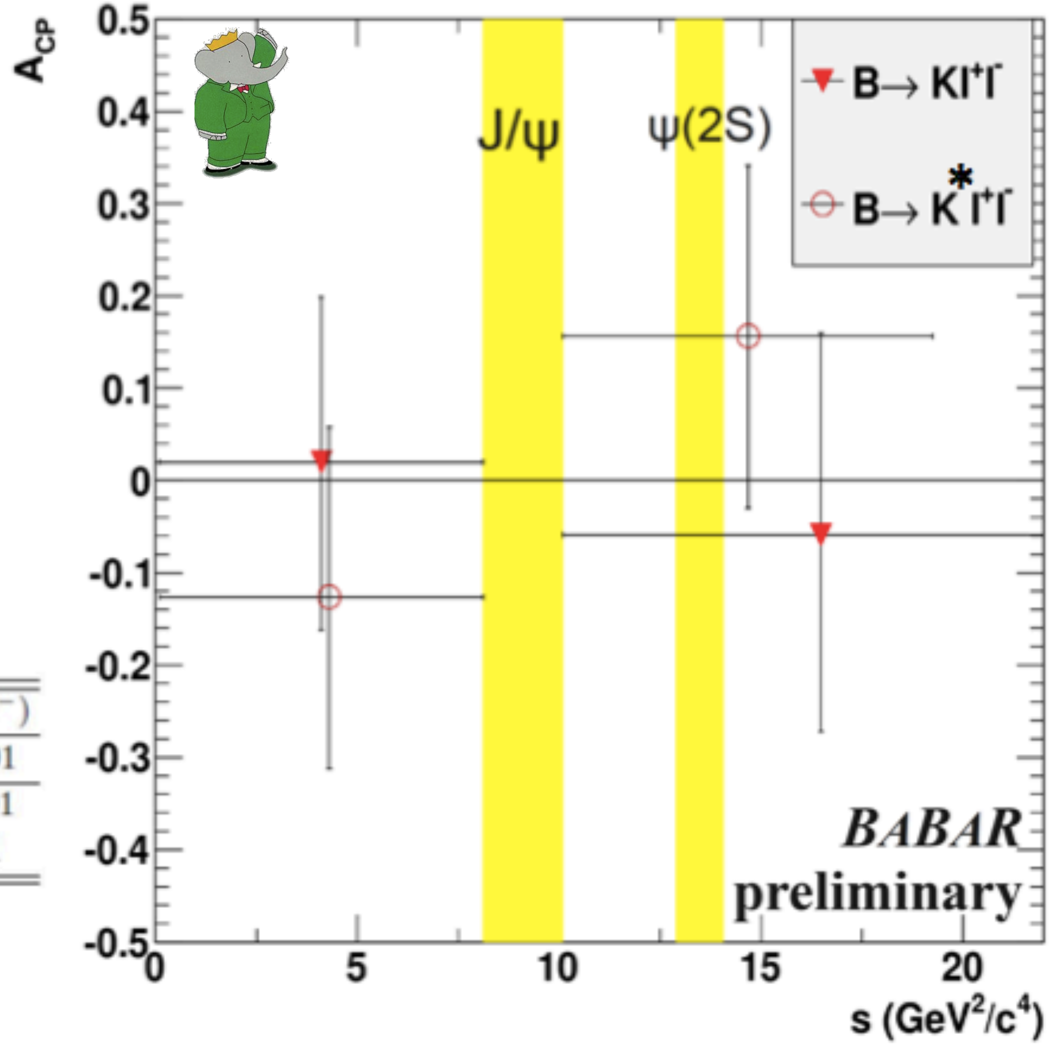
- signal extraction in $m_{\rm ES}$ (and $m_{K\pi}$ for K^* modes)

$B \to K\ell\ell$ direct CPV

arXiv:1204.3933, PRD submitted
426 fb-1

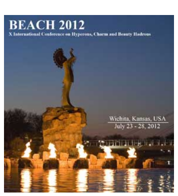
- Rate asymmetry sensitive to New Physics at TeV level
- 8 modes studied
- Direct *CP* asymmetries match SM expectation

$$A_{CP}^{K^{(*)}} \equiv \frac{\mathcal{B}(\overline{B} \to \overline{K}^{(*)}\ell^+\ell^-) - \mathcal{B}(B \to K^{(*)}\ell^+\ell^-)}{\mathcal{B}(\overline{B} \to \overline{K}^{(*)}\ell^+\ell^-) + \mathcal{B}(B \to K^{(*)}\ell^+\ell^-)}$$



s (GeV^2/c^4)	$A_{CP}(B^+ \to K^+\ell^+\ell^-)$	$A_{CP}(B \to K^*\ell^+\ell^-)$
All	$-0.03 \pm 0.14 \pm 0.01$	$0.03 \pm 0.13 \pm 0.01$
0.10–8.12	$0.02 \pm 0.18 \pm 0.01$	$-0.13^{+0.18}_{-0.19} \pm 0.01$
>10.11	$-0.06^{+0.22}_{-0.21} \pm 0.01$	$0.16^{+0.18}_{-0.19} \pm 0.01$

arXiv:1204.3933v1,
Submitted to PRD



$B^0 \to J/\psi K^0$: first direct observation of *T*-violation in the *B* system

To be submitted to PRL, 426 fb-1

Υ(4S) produces an entangled $B^0 \overline{B}^0$ state:

$$|\psi_i\rangle = \frac{1}{\sqrt{2}}\left[B^0(t_1)\overline{B}^0(t_2) - \overline{B}^0(t_1)B^0(t_2)\right] = \frac{1}{\sqrt{2}}\left[B_+(t_1)\overline{B}_-(t_2) - \overline{B}_-(t_1)B_+(t_2)\right]$$

Two *B* bosons in symmetric state: Bose statistics , C=−1

Υ(4S) has J=1, B's are spin 0 ∴ L=1. ➞ B's in opposite state (when one oscillates, so must the other)

Reconstruct one B to CP eigenstate, identify flavour of other B :

T violation: Examine difference: $B^0 \to B_+$ and $B_+ \to B^0$

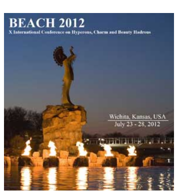
Physical Process Reconstructed states (X,Y)

Reference (X, Y)	*T-Transformed (X, Y)*
$B^0 \to B_+$ $(l^-, J/\psi K_L)$	$B_+ \to B^0$ $(J/\psi K_S, l^+)$
$B^0 \to B_-$ $(l^-, J/\psi K_S)$	$B_- \to B^0$ $(J/\psi K_L, l^+)$
$\overline{B}^0 \to B_+$ $(l^+, J/\psi K_L)$	$B_+ \to \overline{B}^0$ $(J/\psi K_S, l^-)$
$\overline{B}^0 \to B_-$ $(l^+, J/\psi K_S)$	$B_- \to \overline{B}^0$ $(J/\psi K_L, l^-)$

$\Delta\tau = t_Y - t_X > 0$

CP CP

Four independent processes to compare



$B^0 \to J/\psi K^0$: first direct observation of T-violation in the B system

To be submitted to PRL, 426 fb-1

Each of 8 transitions has time-dependent decay rate:

$$g^{\pm}_{\alpha,\beta}(\tau) \propto e^{-\Gamma|\tau|}\{1+S^{\pm}_{\alpha,\beta}\sin(\Delta m_d \tau)+C^{\pm}_{\alpha,\beta}\cos(\Delta m_d \tau)\} \quad \text{with } \alpha=\ell^+X,\ell^-X; \quad \beta=c\bar{c}K^0_S, J/\psi K^0_L$$

$$\mathcal{H}_{\alpha,\beta}(\Delta t) \propto g^{+}_{\alpha,\beta}(\Delta t_{true})\times H(\Delta t_{true})\otimes\Re(\delta t,\sigma_{\Delta t})+g^{-}_{\alpha,\beta}(-\Delta t_{true})\times H(-\Delta t_{true})\otimes\Re(\delta t,\sigma_{\Delta t})$$

Γ=average decay width $\quad \Delta t_{true}=t_{CP}-t_{flav} \quad \Delta\tau=t_y-t_x$

Δm=mass difference between B mass eigenstates

H(t)= Heaviside function

C and S coefficients: upper index + or − indicates if the decay to flavour final state α occurred before or after the CP final state β

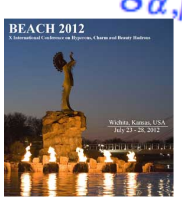
8 different sets of S and C parameters:

$$2\,\Delta t(\Delta t>0,\Delta t<0) \times 2\,flavour(B^0,\bar{B}^0) \times 2\,CP(K_S,K_L)$$

Perform unbinned maximum likelihood fit.

Contrast with "classic" CPV analysis, one set of parameters, S, C:

$$g^{\pm}_{\alpha,\beta}(\Delta t) \propto e^{-\Gamma|\Delta t|}\{1\pm\eta_f S\sin(\Delta m_d \Delta t)+C\cos(\Delta m_d \Delta t)\} \quad \text{and assumes CPT and } \Delta\Gamma=0$$



$B^0 \to J/\psi K^0$: first direct observation of T-violation in the B system

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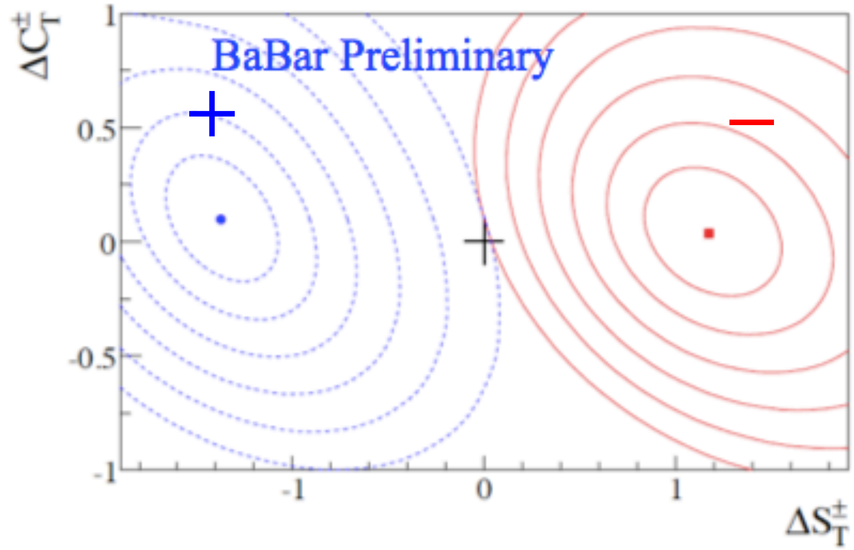
Parameter	Result
$\Delta S_T^+ = S^-_{\ell^- X, J/\psi K_L^0} - S^+_{\ell^+ X, c\bar{c} K_S^0}$	$-1.37 \pm 0.14 \pm 0.06$
$\Delta S_T^- = S^+_{\ell^- X, J/\psi K_L^0} - S^-_{\ell^+ X, c\bar{c} K_S^0}$	$1.17 \pm 0.18 \pm 0.11$
$\Delta C_T^+ = C^-_{\ell^- X, J/\psi K_L^0} - C^+_{\ell^+ X, c\bar{c} K_S^0}$	$0.10 \pm 0.16 \pm 0.08$
$\Delta C_T^- = C^+_{\ell^- X, J/\psi K_L^0} - C^-_{\ell^+ X, c\bar{c} K_S^0}$	$0.04 \pm 0.16 \pm 0.08$
$\Delta S_{CP}^+ = S^+_{\ell^- X, c\bar{c} K_S^0} - S^+_{\ell^+ X, c\bar{c} K_S^0}$	$-1.30 \pm 0.10 \pm 0.07$
$\Delta S_{CP}^- = S^-_{\ell^- X, c\bar{c} K_S^0} - S^-_{\ell^+ X, c\bar{c} K_S^0}$	$1.33 \pm 0.12 \pm 0.06$
$\Delta C_{CP}^+ = C^+_{\ell^- X, c\bar{c} K_S^0} - C^+_{\ell^+ X, c\bar{c} K_S^0}$	$0.07 \pm 0.09 \pm 0.03$
$\Delta C_{CP}^- = C^-_{\ell^- X, c\bar{c} K_S^0} - C^-_{\ell^+ X, c\bar{c} K_S^0}$	$0.08 \pm 0.10 \pm 0.04$
$\Delta S_{CPT}^+ = S^-_{\ell^+ X, J/\psi K_L^0} - S^+_{\ell^+ X, c\bar{c} K_S^0}$	$0.16 \pm 0.20 \pm 0.09$
$\Delta S_{CPT}^- = S^+_{\ell^+ X, J/\psi K_L^0} - S^-_{\ell^+ X, c\bar{c} K_S^0}$	$-0.03 \pm 0.13 \pm 0.06$
$\Delta C_{CPT}^+ = C^-_{\ell^+ X, J/\psi K_L^0} - C^+_{\ell^+ X, c\bar{c} K_S^0}$	$0.15 \pm 0.17 \pm 0.07$
$\Delta C_{CPT}^- = C^+_{\ell^+ X, J/\psi K_L^0} - C^-_{\ell^+ X, c\bar{c} K_S^0}$	$0.03 \pm 0.14 \pm 0.08$

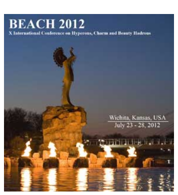
Fit coefficients:



Cross checks:

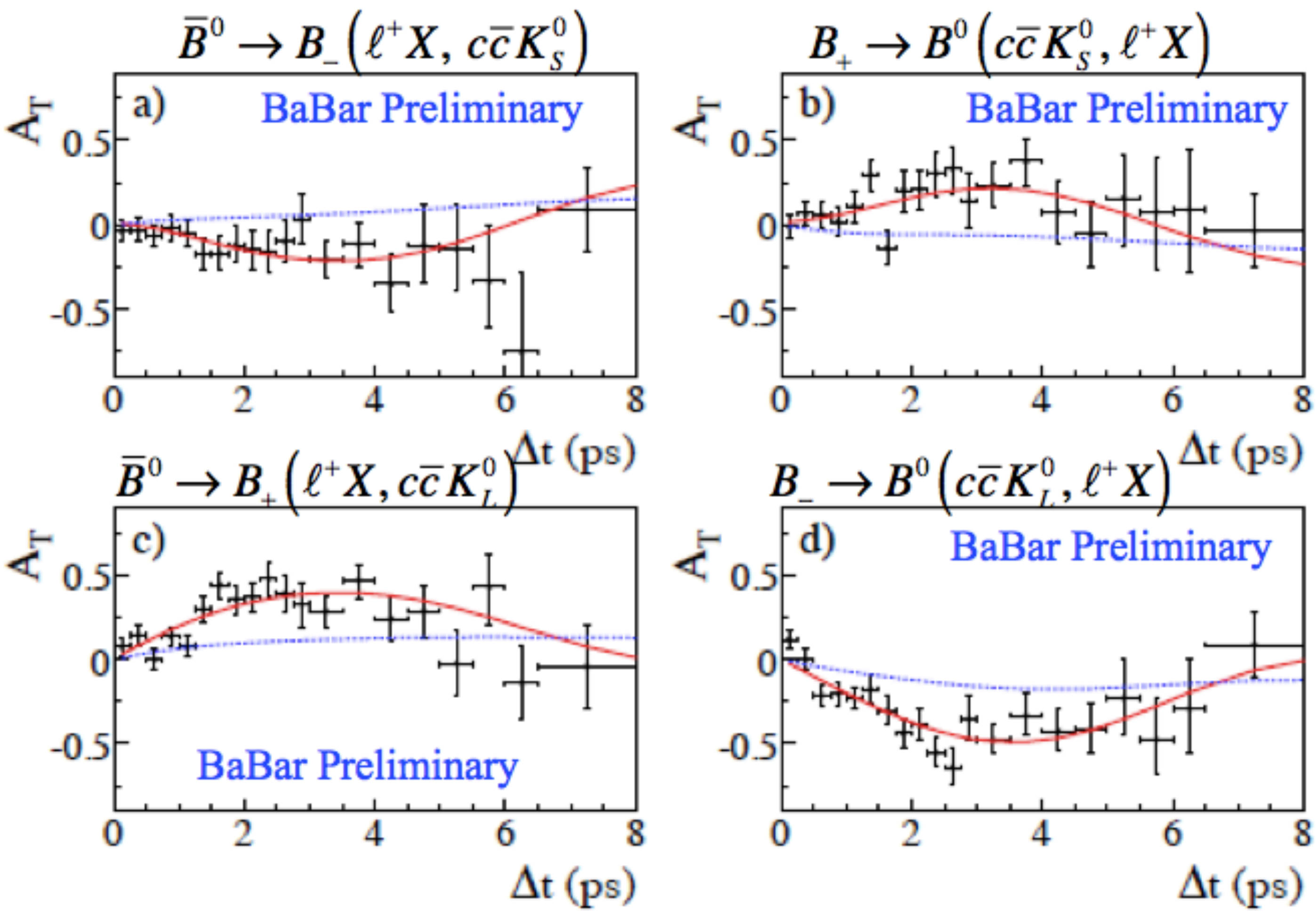
$$c\bar{c}K^+, J/\psi K^{*+}$$

charged final states
(✓all fit to zero: unbiased)



$B^0 \to J/\psi K^0$: first direct observation of *T*-violation in the *B* system

To be submitted to PRL, 426 fb-1



First direct observation of Time Reversal Violation, in ANY system

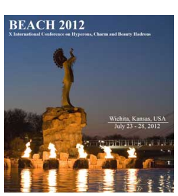
$\Delta S_T^+ = -1.37 \pm 0.14 \pm 0.06$

$\Delta S_T^- = 1.17 \pm 0.18 \pm 0.11$

T violation, independent of CP, CPT

14σ significance

Result consistent with CPV, assuming CPT



arXiv:1204.2852,
PRD 84, 031103 (2012)

- **Charm sector:**
  $D^+ \to K^+K^0\pi^+\pi^-$ T-odd correlation

$D^+ \to K^+K^0\pi^+\pi^-$ *T*-odd correlation

arXiv:1105.4410,
PRD 84:031103 (2011)
520 fb-1

Standard Model:

•Charm physics is ~CP conserving:

$$[\text{CKM}]=\begin{bmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho-i\eta+\frac{i}{2}\eta\lambda^2) \\ -\lambda & 1-\frac{\lambda^2}{2}-i\eta A^2\lambda^4 & A\lambda^2(1+i\eta\lambda^2) \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{bmatrix}$$

•Indirect CPV predicted to be $a_{CP}^{ind} < O(10^{-3})$ and **universal** for CP eigenstates

•Direct CPV a_{CP}^{dir}:

- Negligible in Cabibbo-Favoured & Doubly-Cabibbo-Suppressed decays (Bergman et al. JHEP 09, 031)
- Largest in Singly-Cabibbo-Suppressed decays $O(10^{-4} – 10^{-3})$ (Buccella et al. Phys. Rev. D 51, 3478)

•Recent evidence in Time-integrated D^0 asymmetry from LHCb (see Ukleja talk):

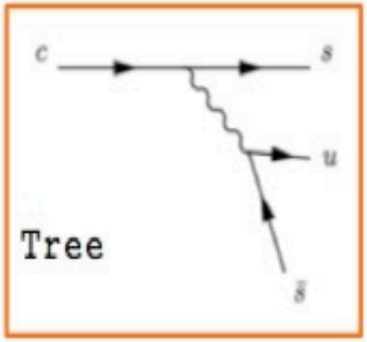
$A_{CP}(K^+K^-)-A_{CP}(\pi^+\pi^-)=(-8.2\pm2.1\pm1.1)10^{-3}$

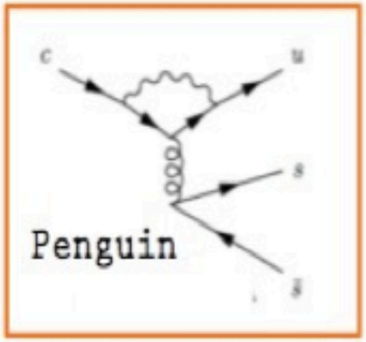
(arXiv:1112.0938v1)

Beyond Standard Model:

•New Physics could enhance direct & indirect CPV up to ~$O(10^{-2})$ through loop diagrams (Grossman et al. Phys. Rev. D 75, 036008; Bigi, arXiv:0907.2950)

•**Today:**
SCS modes with gluonic penguin very promising to search for direct CPV from interference between Tree and Penguin amplitudes



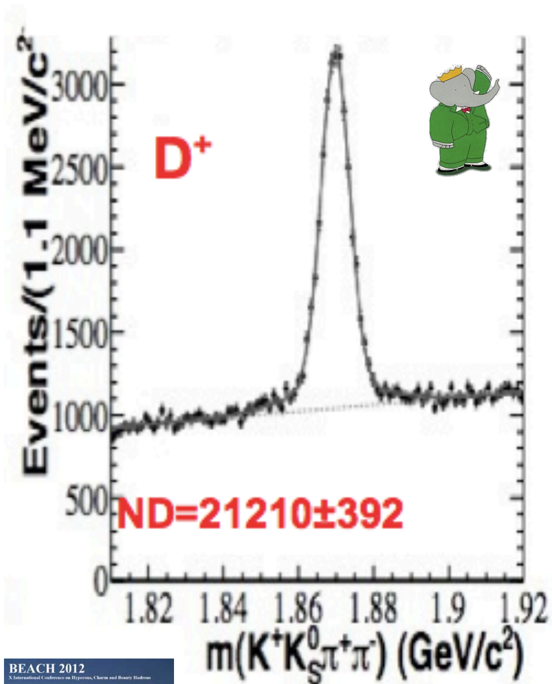


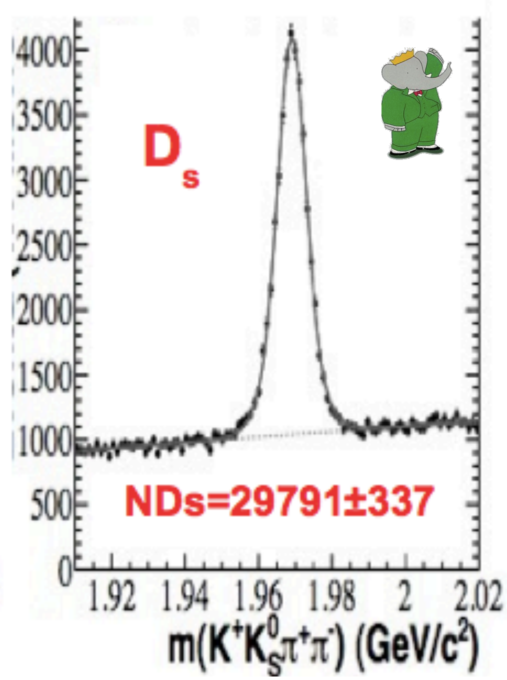
$D^+ \to K^+K^0\pi^+\pi^-$ *T*-odd correlation

arXiv:1105.4410, PRD 84:031103 (2011)
520 fb-1

D reconstruction:

- Singly-Cabibbo-Suppressed & Cabibbo-favoured $D^+_{(s)} \to K^+K^0_s(\pi^+\pi^-)\pi^+\pi^-$ selected with cuts on $M(\pi^+\pi^-)$, $\pi^+\pi^-$ vertex quality, K^0_s decay length
- K^0_s combined with $K^+\pi^+\pi^-$ with common vertex detached from interaction region (ε_K=90%, $\varepsilon_{\pi \to K}$=1.5%)
- Signal selected by means of a Likelihood Ratio ($p_{CM}(D)$, D transverse decay length, vertex probability)





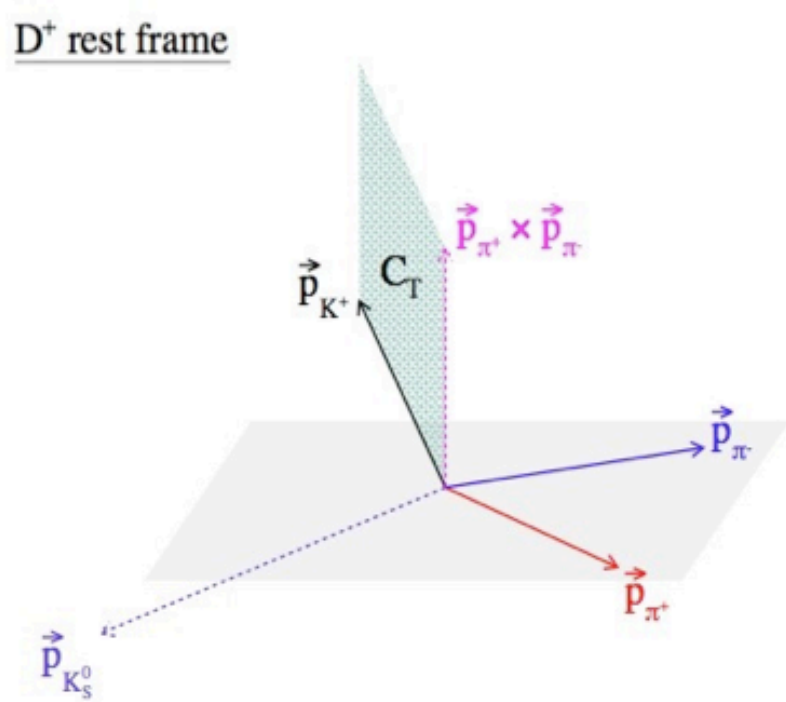
- Combinatorial BKG from B decays suppressed by $p_{CM}(D)$>2.5GeV/c
- Charm BKG with the same topology: $D^{*+} \to \pi^+D^0(K^0_sK^+\pi^-)$, $D^+ \to K^+K^0_sK^0_s(\pi^+\pi^-)$ removed by means of $M(D^*)$-$M(D^0)$ & $M(\pi^+\pi^-)$ requirements
- BKG from $D^+ \to K^0_s\pi^+\pi^+\pi^-$, $\Lambda_c^+ \to pK^0_s\pi^+\pi^-$ does not bias the signal yield extraction

arXiv:1105.4410,
PRD 84:031103 (2011)
520 fb-1

$D^+ \to K^+ K^0 \pi^+ \pi^-$ *T*-odd correlation

- T-odd correlation observable built from final state momenta:

$$C_T \equiv \vec{p}_{K^+} \cdot (\vec{p}_{\pi^+} \times \vec{p}_{\pi^-})$$



- CPT theorem:
Asymmetry in T-odd observable indicates CPV

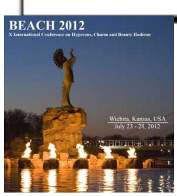
$$A_T \equiv \frac{\Gamma(C_T > 0) - \Gamma(C_T < 0)}{\Gamma(C_T > 0) + \Gamma(C_T < 0)}$$

- Final State Interactions could produce $A_T \neq 0$ due to strong phases
(Bigi et al. Int. J. Mod. Phys. A 24S1, 657)

  - Effects removed by using

$$\mathcal{A}_T \equiv \frac{1}{2}\left(A_T - \bar{A}_T\right)$$

  - $\bar{A}_T$ defined on CP-conjugate process
(Bensalem et al. Phys. Rev. D 66, 094004; Phys. Lett. B 538, 309; Phys. Rev. D 64. 116003))



$D^+ \rightarrow K^+K^0\pi^+\pi^-$ *T*-odd correlation

arXiv:1105.4410,
PRD 84:031103 (2011)
520 fb-1

- Sample divided according to $D_{(s)}$ charge and C_T sign
- Signal yields & asymmetries obtained from simultaneous fit to mass spectra sharing same parameters among different subsamples

$$A_T(D^+) = (+11.2 \pm 14.1_{\mathrm{stat}} \pm 5.7_{\mathrm{syst}}) \times 10^{-3}$$

$$\bar{A}_T(D^-) = (+35.1 \pm 14.3_{\mathrm{stat}} \pm 7.2_{\mathrm{syst}}) \times 10^{-3}$$

$$A_T(D_s^+) = (-99.2 \pm 10.7_{\mathrm{stat}} \pm 8.3_{\mathrm{syst}}) \times 10^{-3},$$

$$\bar{A}_T(D_s^-) = (-72.1 \pm 10.9_{\mathrm{stat}} \pm 10.7_{\mathrm{syst}}) \times 10^{-3}$$

- Final State Interaction produces CPV effects only in D_s decays due to different resonance substructure between D and D_s (e.g. $K^{*0}K^{*+}$)

RESULTS

$\mathcal{A}_T(D^+)=(-12.0\pm10.0\pm4.6)10^{-3}$

$\mathcal{A}_T(D_s)=(-13.6\pm7.7\pm3.4)10^{-3}$

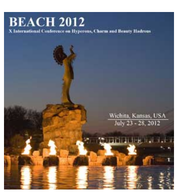
In agreement with SM

To be compared with FOCUS previous results (Phys. Lett. B 622, 239):

$\mathcal{A}_T(D^+)=(23\pm62\pm22)10^{-3}$

$\mathcal{A}_T(D_s)=(-36\pm67\pm23)10^{-3}$

- Systematics dominated by reconstruction asymmetries, Likelihood Ratio selection and particle identification



- τ **sector:**

  $\tau^- \rightarrow K^0 \pi^- \nu$ **CPV search**

arXiv:1109.1527,
PRD-RC 85:031102 (2012)

arXiv:1109.1527,
PRD-RC 85:031102 (2012)
476 fb-1

$\tau^- \rightarrow K^0\pi^-\nu$ CPV search

Standard Model:

- Negligible Direct CPV expected
- Small O(10^{-3}) A_{CP} into final states with K^0_s due to CPV in the kaon sector

(Bigi, Sanda, Phys. Lett. B 625, 47;
Calderon et al., Phys. Rev D 75, 076001)

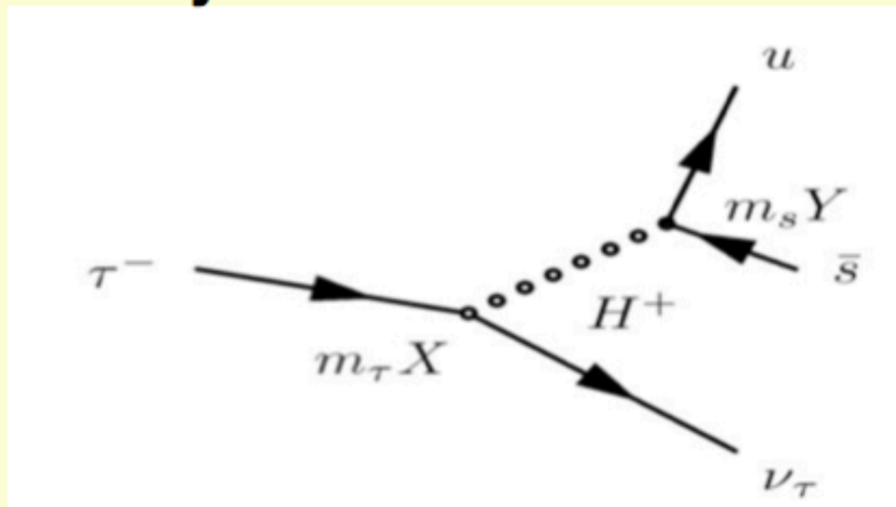
- **Today:** $\tau^- \rightarrow \pi^- K^0_s\, \nu$
- Interference between K^0_s & K^0_L intermediate amplitudes plays an important role. Assuming a $K^0_s \rightarrow \pi^+\pi^-$ selection efficiency independent of decay times long compared to the K^0_s lifetime:

$$A_Q = \frac{\Gamma\left(\tau^+ \to \pi^+ K^0_S\, \bar{\nu}_\tau\right) - \Gamma\left(\tau^- \to \pi^- K^0_S\, \nu_\tau\right)}{\Gamma\left(\tau^+ \to \pi^+ K^0_S\, \bar{\nu}_\tau\right) + \Gamma\left(\tau^- \to \pi^- K^0_S\, \nu_\tau\right)}$$

=(0.33±0.01)% for decay times~τ_{K0s}

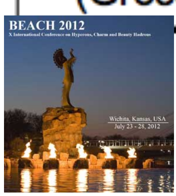
(Grossman, Nir, arXiv:1110.3790)

Beyond Standard Model:



- New Physics could significantly modify the measured $\tau^- \rightarrow \pi^- K^0_s\, \nu$ decay-rate charge asymmetry from the SM expectations
- Charged scalar boson exchange could reflect in differences between the τ^+ & τ^- decay angular distributions

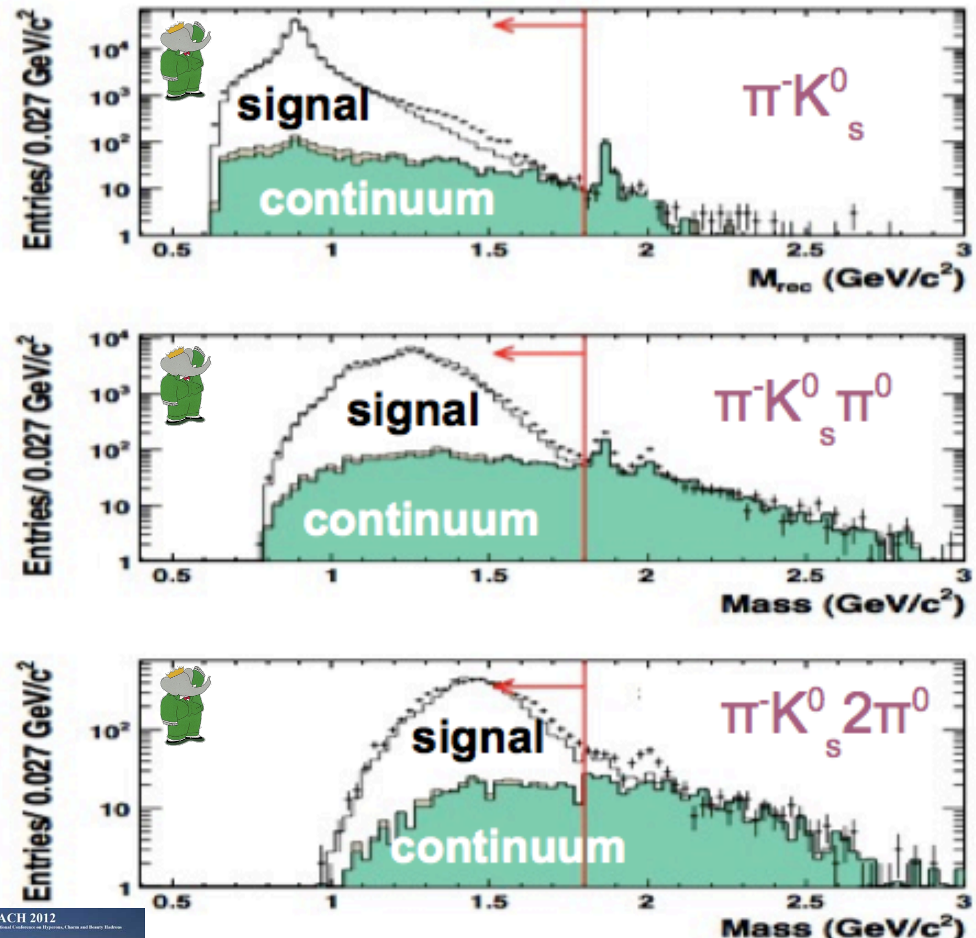
(Kuhn, Mirkes, Phys. Lett. B 398, 407)



arXiv:1109.1527,
PRD-RC 85:031102 (2012)
476 fb-1

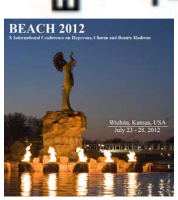
$\tau^- \to K^0 \pi^- \nu$ CPV search

- Events divided in two hemispeheres according to Thrust axis
- $\tau^+\tau^-$ events selected with a single prompt track + $K^0_s \to \pi^+\pi^-$ candidate in one hemisphere and one prompt Tag-lepton (e/μ) with opposite charge in the other
- Additional $\pi^0 \to \gamma\gamma$ candidates permitted (do not affect A_Q)



- Signal selected by means of two Likelihood Ratios (topological & kinematical quantities) to distinguish τ from $q\bar{q}$ and to reduce K^0_s BKG
- Bhabha, $\mu^+\mu^-$, and Continuum BKG suppressed exploiting p_{Prompt}, Thrust-value, $M(\pi^- K^0_s\ (\leq 3\pi^0))$
- Residual BKG from $\tau \to K K^0_s (\geq 0\pi^0)\nu$ & $\tau \to \pi K^0 \bar{K}^0 \nu$ estimated from MC & corrected using L.R. data side-band f_{BKG}=(20.0±3.7)%

$N_{signal}(\tau^-)$=170211
$N_{signal}(\tau^+)$=169455



$\tau^- \to K^0\pi^-\nu$ CPV search

arXiv: 1109.1527, PRD-RC 85:031102 (2012)
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- After Continuum & non-K^0_s τ decays subtraction, raw charge asymmetry:

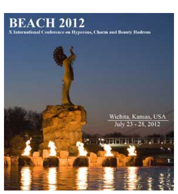
A_Q(e-Tag)=(-0.32±0.23)%
A_Q(μ-Tag)=(-0.05±0.27)%

- No significant decay-rate asymmetries from selection criteria and detector response found in real & simulated $\tau \to h^+h^-h^+(\geq 0\pi^0)\nu$, BKG events rejected from the data sample and MC signal sample

- Decay-rate asymmetry modified by the different $K^0/\overline{K}^0$ nuclear interaction cross-sections with the material, related to $K^\pm$-nucleon one via isospin symmetry (Ko et al., arXiv:1006.1938v1)
  - Corrections computed on event-by-event basis in terms of (p, θ) of K^0_s :

    A_{K0}(e-Tag)=(0.14±0.03)%; A_{K0}(μ-Tag)=(0.14±0.02)%

    Have to be subtracted from the raw asymmetry result



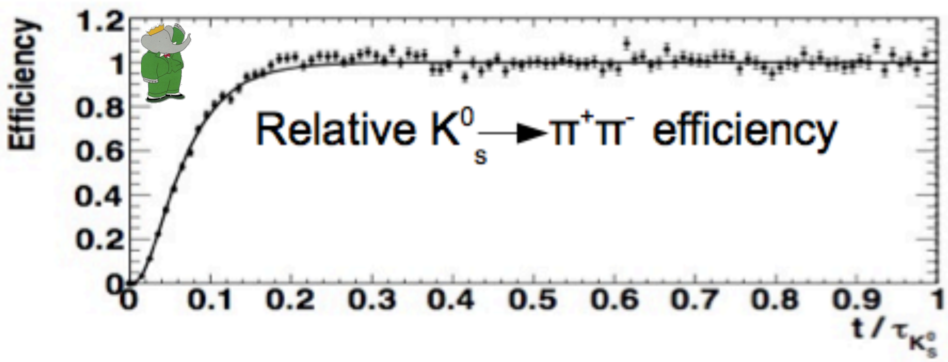
$\tau^- \to K^0\pi^-\nu$ CPV search

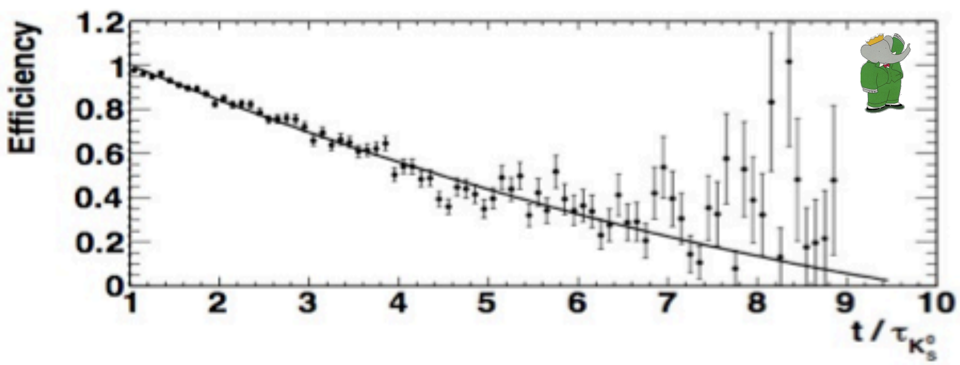
arXiv:1109.1527, PRD-RC 85:031102 (2012) 476 fb-1

- After correction and taking into account the residual $\tau \to K^0_s$ BKG charge asymmetries:

A_Q=(-0.45±0.24±0.11)% FIRST MEASUREMENT

- Systematics from detector & selection bias, BKG subtraction and $K^0/\overline{K^0}$ nuclear interaction





- K^0_s - K^0_L interference affects the predicted A_Q =(0.33±0.01)%
  - → Correction to be applied in terms of the $K^0_s \to \pi^+\pi^-$ decay time dependence of the selection efficiency (Grossman, Nir, arXiv:1110.3790):
- $A_Q^{COR}=A_Q$*(1.08±0.01)=(0.36±0.01)%

Measurement is 3.1 standard deviations from the SM predictions

Summary: 5 new results in 3 sectors

See also talks from Vasseur and Kass, with many other new Babar results!

- **B sector**

arXiv:1201.5897, PRD 85:112010 (2012)

1) $b \to s\bar{s}s$: $B \to 3K$ *CP*V

arXiv:1204.3933, PRD submitted

2) $b \to s\ell^+\ell^-$: $B \to K\ell\ell$ direct *CP*V search

3) $b \to c\bar{c}s$: $B^0 \to J/\psi K^0$ first direct observation of T-violation in B system

To be submitted to PRL

- **Charm sector:** $D^+ \to K^+K^0\pi^+\pi^-$ T-odd correlation

arXiv:1105.4410, PRD 84:031103 (2011)

- **τ sector:** $\tau^- \to K^0\pi^-\nu$ *CP*V search

3.1σ deviation from SM prediction

arXiv:1109.1527, PRD-RC 85:031102 (2012)