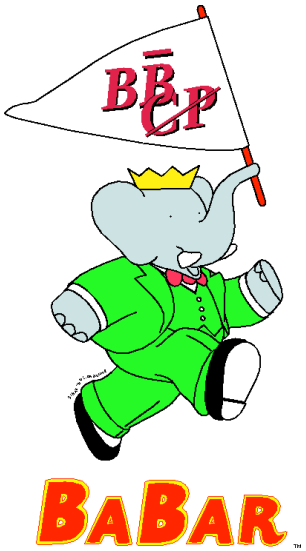


BaBar
attività a Milano

Nicola Neri
INFN - Sezione di Milano

Consiglio di Sezione
Milano,24 Giugno 2013

BaBar status

- 2008 end of data taking
  - 2009 - 2010 intense data analysis
  - 2011 - 2012 steady data analyses
  - 2013 - .... long term archival data analysis
- Relevant Italian participation also in 2013

BABAR Membership Numbers

71 institutions in 12 countries

	Faculty & Staff	Postdocs	Grad Student	ALL	Student Assoc.
CANADA	9	4	7	20	5
FRANCE	21	1	3	25	1
GERMANY	9	3	7	19	3
INDIA	1		1	2	
ISRAEL	1		3	4	
ITALY	50	10	5	65	6
NL	1	1		2	
NORWAY	2			2	
RUSSIA	8		2	10	
SPAIN	3		1	4	
UK	15	4		19	
USA	83	24	10	117	20
TOTAL	**203**	**47**	**39**	**289**	**35**
cf Jan 2013	219	51	56	325	37
cf May 2012	219	51	56	326	30

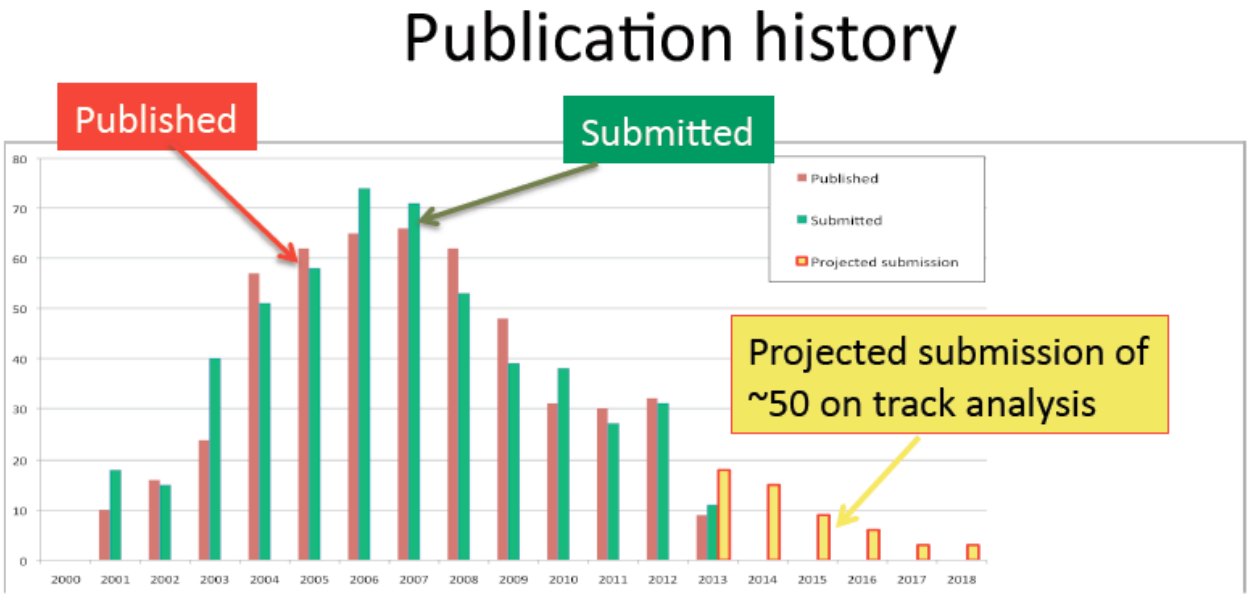
Since 1 Jan 2013

6 People joined BaBar as Associates:
- **3 Grad students**
- **2 Undergraduates**
- **2 Postdocs**
- **0 Faculty**
- **0 PhD Staff**
- **1 non-PhD Staff (SLAC)**

1 person joined BaBar as a Member:
- **1 Faculty**

BaBar publications

- 524 papers (published and submitted to PRL + PRD)
- Paper in 2013 (so far):
  - 12 published
  - 6 submitted to journal for publication



• Submission/publication rate almost flat in the las three years, and we should be close to that number also this year!!

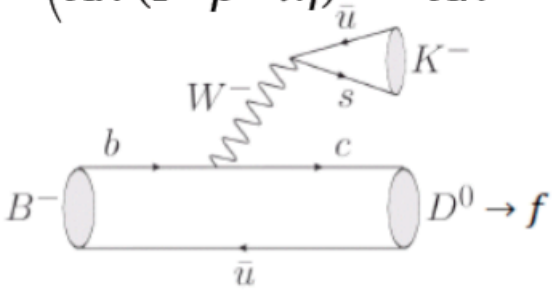
Recent results

Angle $\gamma=\phi_3$

$B^{\pm} \to D^{(*)0} K^{(*)\pm}$ decays dominate $\gamma = \phi_3$ measurements

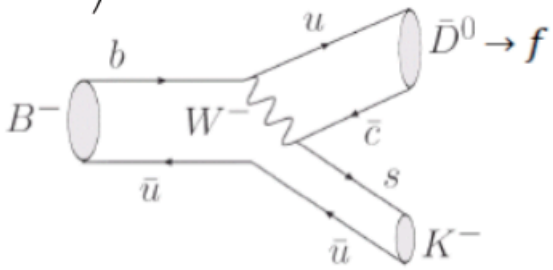
$$V = \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4)$$

$|V_{ub}| e^{-i\gamma}$



color allowed

$A_1 \propto V_{cb}V_{us}^* \sim A\lambda^3$



color suppressed

$A_2 \propto V_{ub}V_{cs}^* \sim A\lambda^3(\rho + i\eta)$

$|A_{total}|^2 = |A_1|^2 + |A_2|^2 + 2|A_1||A_2|\cos(-\gamma + \delta)$

Theoretically clean: no penguin pollution

$$r_b = \left| \frac{A(B^+ \to D^0 K^+)}{A(B^+ \to \bar{D}^0 K^+)} \right|$$

strong phase from B and D decay

Unknowns : γ, r_b, $\delta_b + \delta_D$

r_b & δ_b B hadronic parameters extracted with γ

δ_D measured at charm factories

Angle $\gamma=\phi_3$

$B^{\pm} \to D^{(*)0} K^{(*)\pm}$ decays dominate $\gamma = \phi_3$ measurements

Different methods for extracting $\gamma = \phi_3$ depending on the D decay mode final state

GLW [M. Gronau, D. London, D. Wyler, PLB253,483 (1991); PLB 265, 172 (1991)]

- D^0 to two-body CP eigenstates K^+K^-, $\pi^+\pi^-$ (even), $K_s\pi^0$, $K_s\omega$ (odd)

ADS [D. Atwood, I. Dunietz, A. Soni, PRL 78, 3357 (1997)]

- D^0 to doubly Cabibbo suppressed decays $K^+\pi^-$, $K^+\pi^-\pi^0$, ...

GGSZ (Dalitz) [D. Atwood et al., PRL78, 3257 (1997); A. Giri et al., PRD68, 054018 (2003)]

- D^0 to 3-body decays $K_s\pi^+\pi^-$, $K_sK^+K^-$, $\pi^+\pi^-\pi^0$, etc.
  - Dalitz plot fitted to determine how the strong phase of D^0 decay amplitude varies over the Dalitz plane
  - model independent analysis

BABAR and Bell[illegible] ve decay modes us[illegible] ts

LHCb with $3fb^{-1}$

$\gamma = (67 \pm 12)^\circ \pmod{180^\circ}$

BABAR

$\gamma = \left(69^{+17}_{-16}\right)^\circ \pmod{180^\circ}$

exp + DP model systematic = $\pm 4^\circ$

BABAR and Belle

$\gamma = (67 \pm 11)^\circ \pmod{180^\circ}$

Belle

$\gamma = \left(68^{+15}_{-14}\right)^\circ \pmod{180^\circ}$

T Violation: BABAR, PRL 102, 211801 (2013)

- Well established cannon of SM that weak interactions maximally violate parity (P) and charge conjugation (C) - neutrinos are LH, antineutrinos are RH.
- CP also measured to be violated in neutral kaon and B-meson systems - phenomena well described within CKM framework
- The CPT Theorem (Locally Lorentz-invariant QFT conserves CPT) ⟶ if there is CP violation, there is also be violation of time reversal invariance (T)
- Difficult to establish experimentally T violation independent of CPT: need a system where we experimentally know what QM state is in before it decays.

$e^+e^- \longrightarrow \Upsilon(4S) \longrightarrow B(\alpha)\, B(\overline{\alpha})$ is an entangled P-wave state: EPR tells us the state of a B-meson prior to its decay if its EPR-entangled partner decays and is identified – it's how BaBar and Belle measure CP violation …
can also use this to search for direct T violation

Bernabeau, Martinez-Vidal, Villanueva-Perez, arXiv: JHEP08,064 (2012)

T Violation: BABAR, PRL 102, 211801 (2013)

- *BABAR* uses this approach to measure a non-zero violation of T - value predicted by CPT and the CP violation measured by *BABAR* and Belle

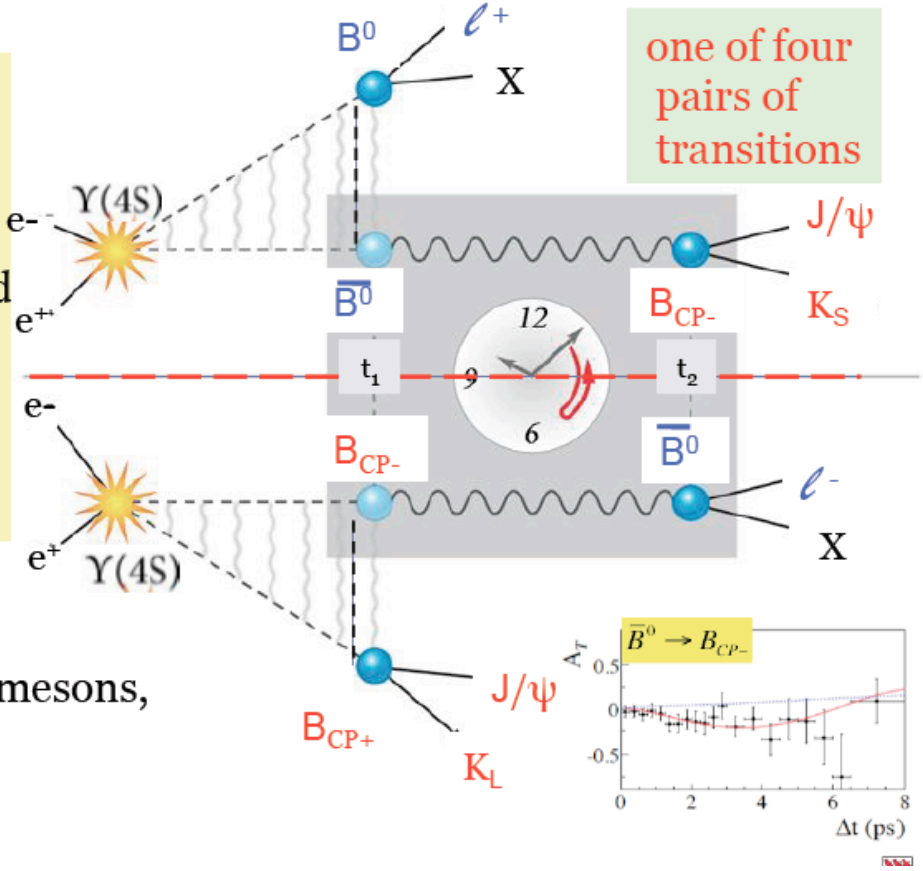
$$|i\rangle = \frac{1}{\sqrt{2}}\left[B^0(t_1)\overline{B}^0(t_2) - \overline{B}^0(t_1)B^0(t_2)\right] = \frac{1}{\sqrt{2}}\left[B_{CP+}(t_1)\overline{B}_{CP-}(t_2) - B_{CP-}(t_1)B_{CP+}(t_2)\right]$$

Define ratio

$$A_T = \frac{P(a \to b) - P(b \to a)}{P(a \to b) + P(b \to a)}$$

a : Flavour eigenstate B^0 or $\overline{B}^0$ identified by semileptonic decay : ℓ^+ or ℓ^-

b : *CP* eigenstate B_{CP+} or B_{CP-} identified by decay to : $J/\psi\, K_S$ or $J/\psi\, K_L$



Measure time-ordered decays of both B-mesons, time difference defined as:

$\Delta t = t_{CP} - t_{flavour}$ > 0 for $B^0 \to B_{CP-}$

< 0 for $B_{CP-} \to B^0$

T Violation: BABAR, PRL 102, 211801 (2013)

- Time dependent rate 8 decays

$$g^{\pm}_{\alpha,\beta}(\Delta\tau) \propto e^{-\Gamma\Delta\tau}\{1 + S^{\pm}_{\alpha,\beta}\sin(\Delta m_d \Delta\tau) + C^{\pm}_{\alpha,\beta}\cos(\Delta m_d \Delta\tau)\}$$

four pairs of transitions

S and C probe interference in decay-mixing and decay

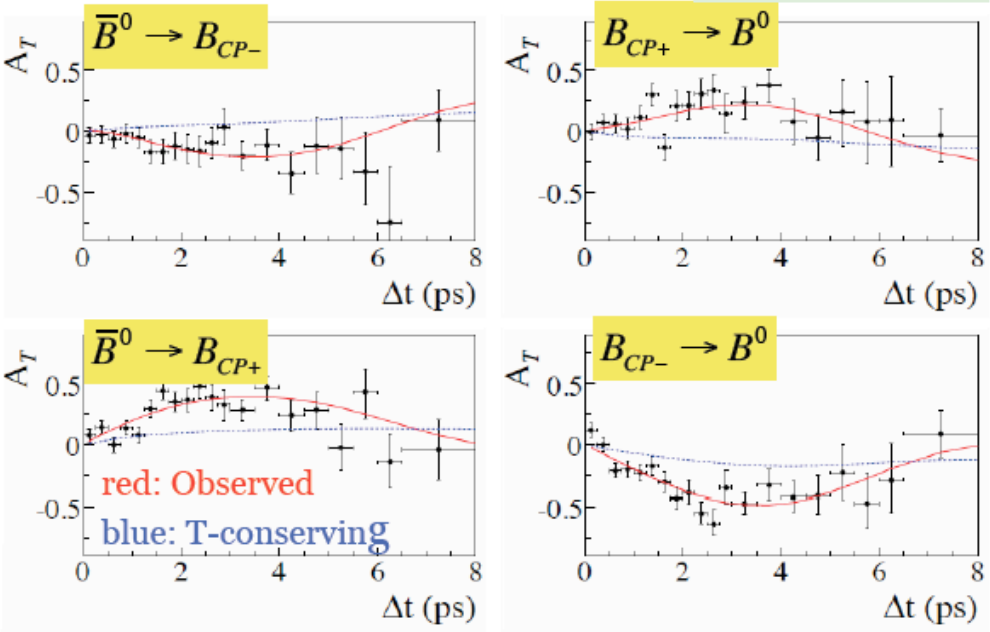
ML fit to determine 8 pairs of $S^{\pm}_{\alpha,\beta}$ and $C^{\pm}_{\alpha,\beta}$ parameters

$\pm\{\Delta t>0, \Delta t<0\}$

α flavour tag $\{\ell^+, \ell^-\}$

β CP tag $\{K_L, K_S\}$

$$A_T(\Delta t) \approx \frac{\Delta C^+_T}{2}\cos\Delta m\Delta t + \frac{\Delta S^+_T}{2}\sin\Delta m\Delta t$$



Combined Fit results:	Expected:
ΔS^+_T = -1.37 ± 0.14 ± 0.06	-2 sin2β
ΔC^+_T = +0.10 ± 0.14 ± 0.08	0.0
ΔS^-_T = +1.17 ± 0.18 ± 0.11	+2 sin2β
ΔC^-_T = +0.04 ± 0.14 ± 0.08	0.0

14σ signal
Consistent with sin2β
results on CP Violation and with CPT invariance

$B^- \to \tau^- \nu_\tau$ Results

Main discriminating variable on the signal side: remaining energy in the calorimeter, not associated with any charged track or photon

→ Signal at $E_{ECL} = 0$

Belle ICHEP2012

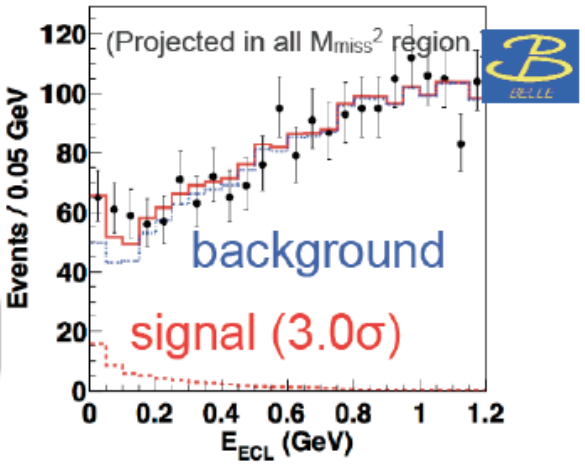
$$Br(B \to \tau\nu) = [0.72\ ^{+0.27}_{-0.25} \pm 0.11] \times 10^{-4}$$

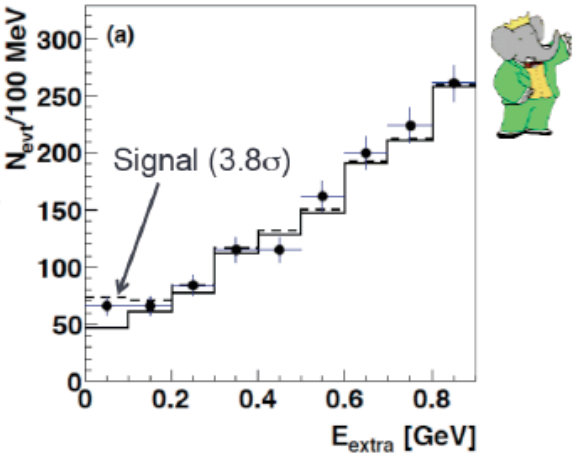
BaBar

$$Br(B \to \tau\nu) = [1.83\ ^{+0.53}_{-0.49} \pm 0.24] \times 10^{-4}$$

All measurements combined

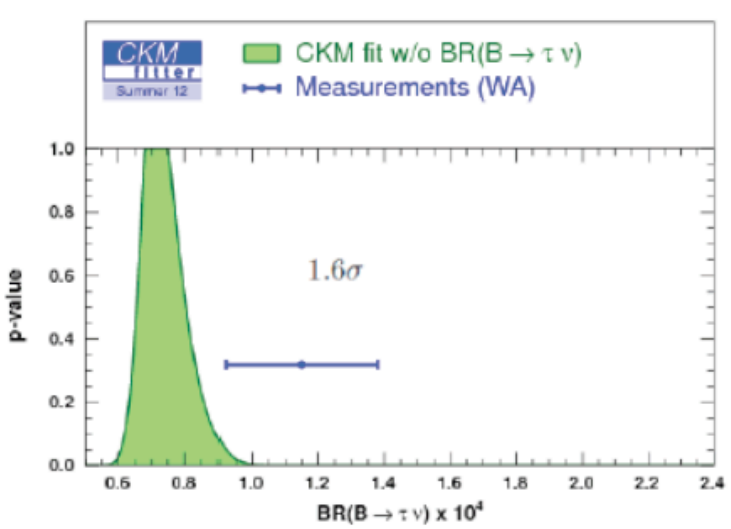
$$BF(B \to \tau\nu) = (1.15 \pm 0.23) \cdot 10^{-4}$$

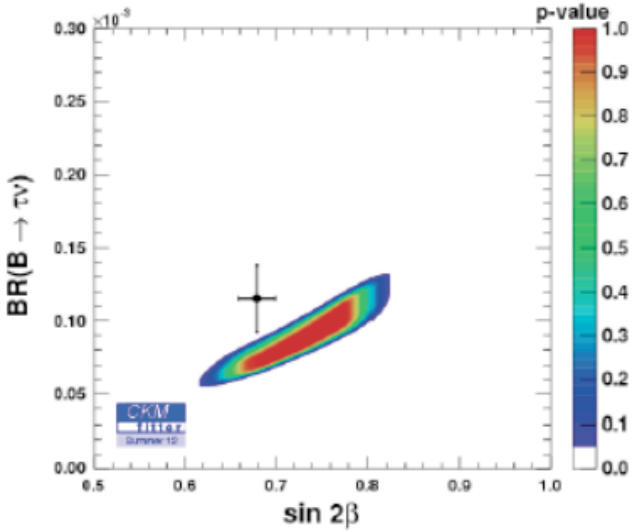




Results after ICHEP 2012

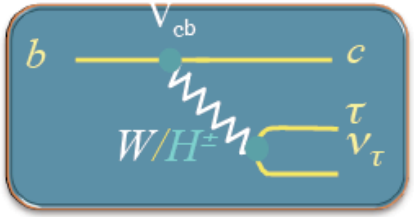
$$BF(B \to \tau\nu) = (1.15 \pm 0.23) \cdot 10^{-4}$$





B → D(*)τν Decays

Semileptonic decay sensitive to charged Higgs



Ratio of τ to μ,e could be reduced/enhanced significantly

$$R(D) = \frac{\Gamma(\overline{B} \to D\tau\nu)}{\Gamma(\overline{B} \to D\ell\nu)} \qquad R(D^*) = \frac{\Gamma(\overline{B} \to D^*\tau\nu)}{\Gamma(\overline{B} \to D^*\ell\nu)}$$

- A well understood process, form factors measured for B → D(*)ℓν, decays involving τ have additional helicity amplitude
- Several experimental and theoretical uncertainties cancel in the ratio!
- non-SM contribution from H± expected to change rates for B → D(*)τν

$$H_t^{2\mathrm{HDM}} = H_t^{\mathrm{SM}} \times \left(1 - \frac{\tan^2\beta}{m_{H^\pm}^2} \frac{q^2}{1 \mp m_c/m_b}\right)$$

- for Dτν
+ for D*τν

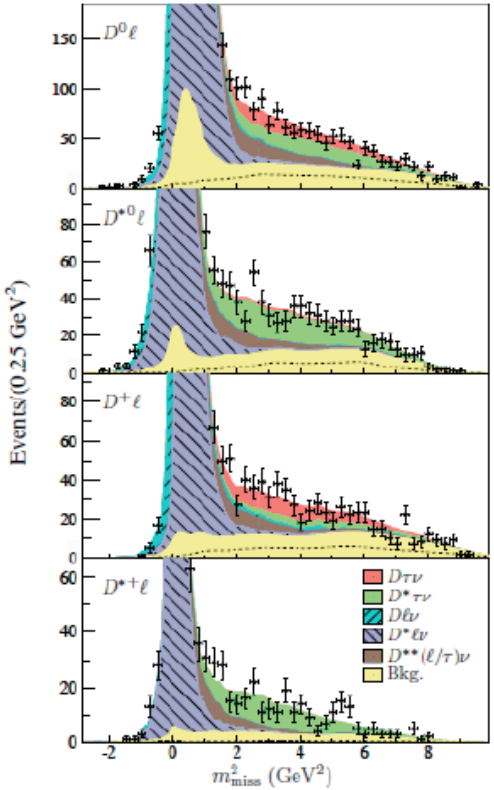
$$\mathcal{R}(D)_{\rm exp} = 0.440 \pm 0.072 \quad \mathcal{R}(D^*)_{\rm exp} = 0.332 \pm 0.030$$

2.0σ 2.7σ

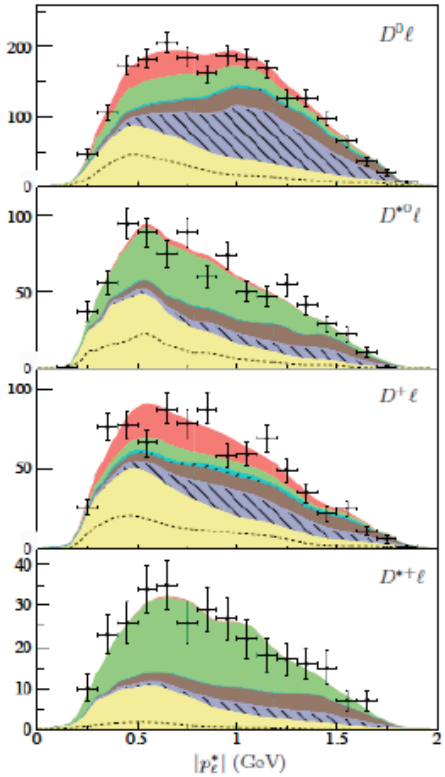
$$\mathcal{R}(D)_{\rm SM} = 0.297 \pm 0.017 \quad \mathcal{R}(D^*)_{\rm SM} = 0.252 \pm 0.003$$

BABAR, PRL101802 (2012)

SM expectations in S. Faifer, J. Kamenik, I. Nisandzic, PRD 85, 094025 (2012).

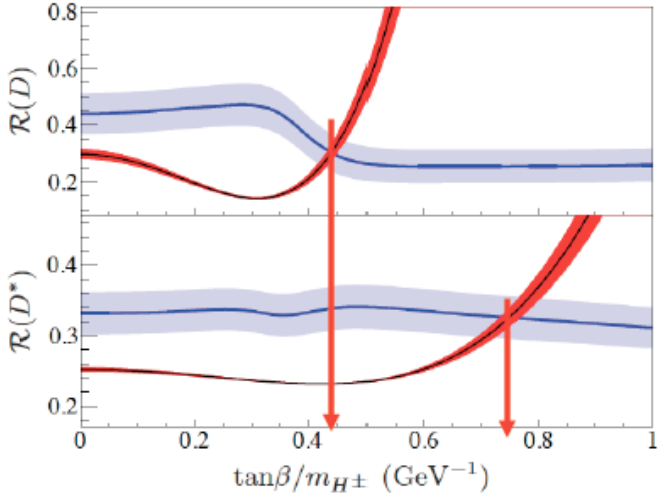


Missing Mass Squared



Lepton momentum in B frame

Combined BaBar result: 3.4σ above SM



$$\frac{\mathrm{BF}(B \to D^{(*)}\tau\upsilon)}{\mathrm{BF}(B \to D^{(*)}\ell\upsilon)} \; vs \; \tan\beta/\mathrm{m}_{H^\pm}$$

Responsabilita' a Milano

- Publication Board Member
  - Fernando Palombo
- B factories Legacy Book editor
  - Fernando Palombo
- Charm Physics Analysis Working Group Co-Convener
  - Nicola Neri

Charm Physics (analysis group convener N. Neri)

- Still a very active group, working to complete analyses on full BaBar dataset.
- Results in 2013:
  - Search for direct CPV in $D^+ \to K^+K^-\pi^+$ Phys. Rev. D 87, 052010 (2013)
  - Search for CPV in $D_{(s)}^+ \to K_S K^+$ and $D_s^+ \to K_S\pi^+$ Phys. Rev. D 87, 052012 (2013)
  - Measurement of D^0 mixing and CPV parameters y_{CP} and ΔY Phys. Rev. D 87, 012004 (2013
  - Precision measurement of D^{*+} total width Submitted to PRL and PRD
  - Precision measurement of D^{*+} total width

Presentazioni a conferenze

- December 2012, Nicola Neri: "CP violation in charm and tau decays at BaBar" - Discrete 2012, Lisbon, Portugal
- August 2013, Nicola Neri: "Searches for CP violation in Charm decays at BaBar" - Charm 2013, Manchester, UK

Partecipanti e richieste finanziarie 2014

	2013	2014
N. Neri RIC INFN	20%	10%
F. Palombo PA	30%	10%
FTE Ricercatori	0.5	0.2

- MI:
  - Metabolismo: 0.6 K€
- ME:
  - Metabolismo: 2.2 K€
- Consumi:
  - metabolismo: 0.6 K€

1 summer student a SLAC nel 2013

Responsabilita'

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