

BABAR

stato e richieste 2011

Alberto Lusiani

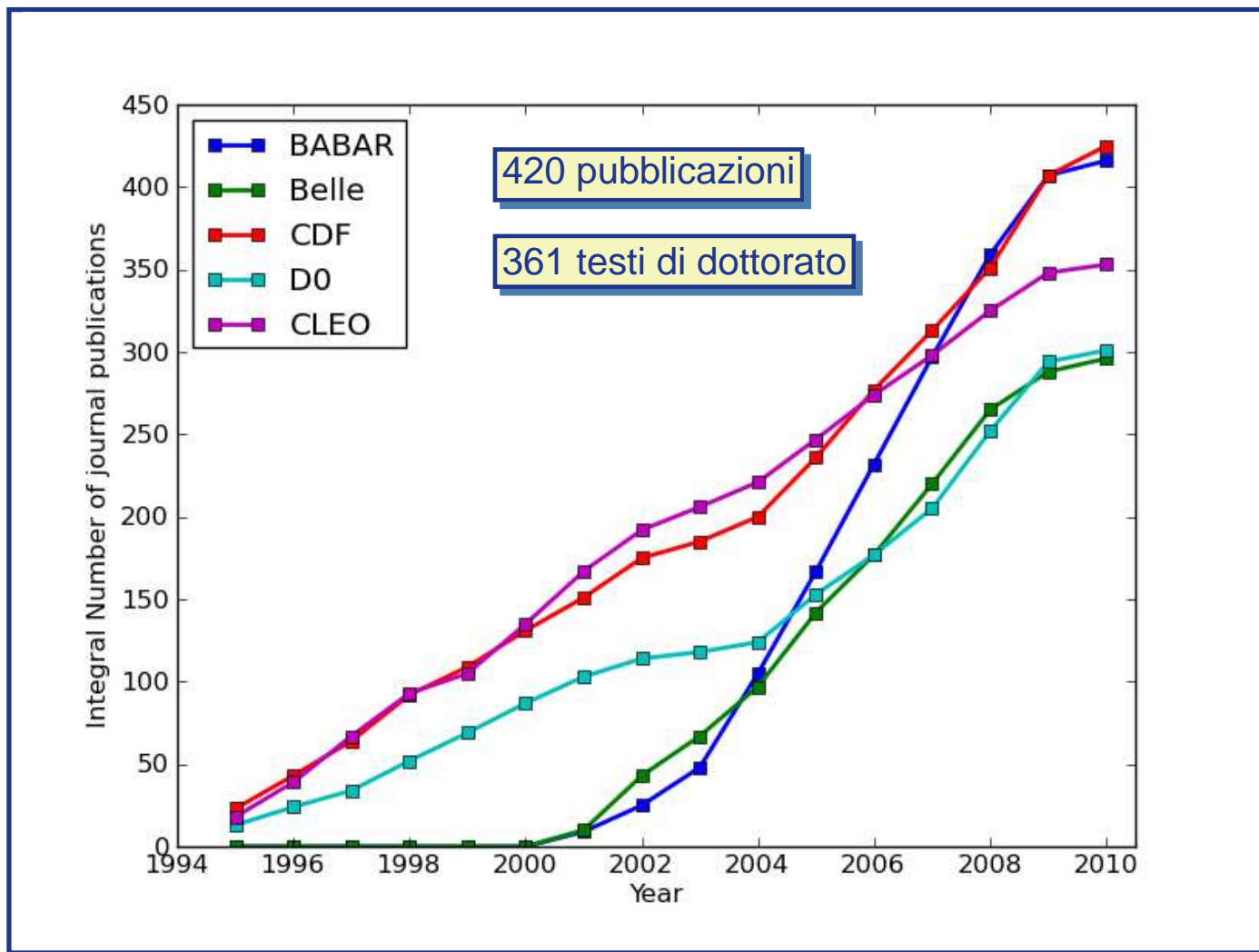
INFN Pisa, 21 giugno 2010



Babar (o Babur, Bobur, Baber) e il suo esercito

Stato

- ◆ la presa dati e' terminata in aprile 2008
- ◆ la collaborazione e' focalizzata nell' **analisi dati**
 - ▶ Fisica del B (misure di precisione su CKM, processi rari)
 - ▶ Fisica del charm (D^0 mixing, processi rari, misure di precisione)
 - ▶ Ricerca di nuova fisica su dati ai picchi $Y(2S)$ e $Y(3S)$
 - ▶ Fisica del tau (LFV, misure di precisione)
 - ▶ Fisica ISR (contributo adronico a $g-2$)
- ◆ attivita' di analisi: **intense 2009–2010** → **steady 2011–2012** → **archival 2013 →**
- ◆ ruolo trainante nella collaborazione **Long Term Data Access Effort (LTDA)**
- ◆ collaborazione con Belle su **B-factories legacy book**

***BABAR* ha pubblicato molto e continua**

Ricerche di nuova fisica su dati ai picchi $Y(3S)$ e $Y(2S)$

next-to-MSSM light CP-odd Higgs

a_1

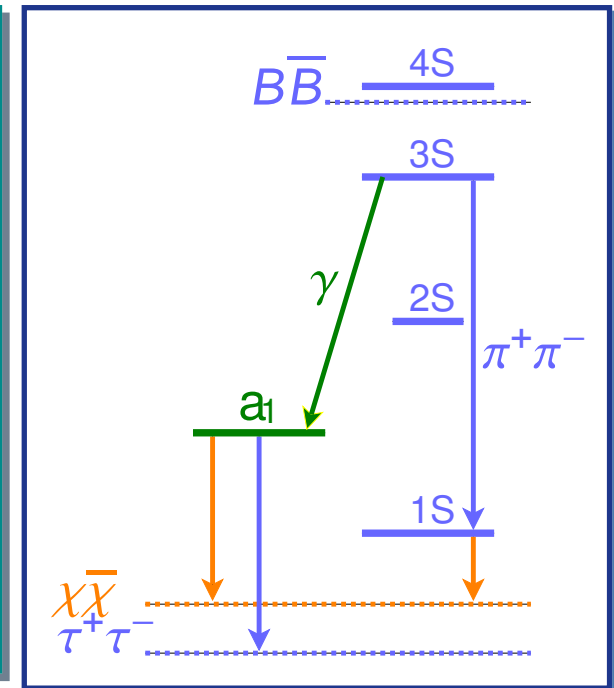
- ◆ Hiller hep-ph/0404220, Dermisek/Gunion/McElrath hep-ph/0612031
- ◆ explain Susy Higgs beyond LEP bound, using extra Higgs,
- ◆ predict low mass CP-odd Higgs a_1 , detectable from Y decays

light dark matter candidate

χ

- ◆ INTEGRAL sat.: excess e^+ annihilations \sim at rest in galactic center
- ◆ dark matter low-mass U-boson coupled to electrons and neutrinos
- ◆ detectable as invisible Y decays (McElrath, hep-ph/0506151)

lepton universality / flavour violation in $Y(nS)$ decay



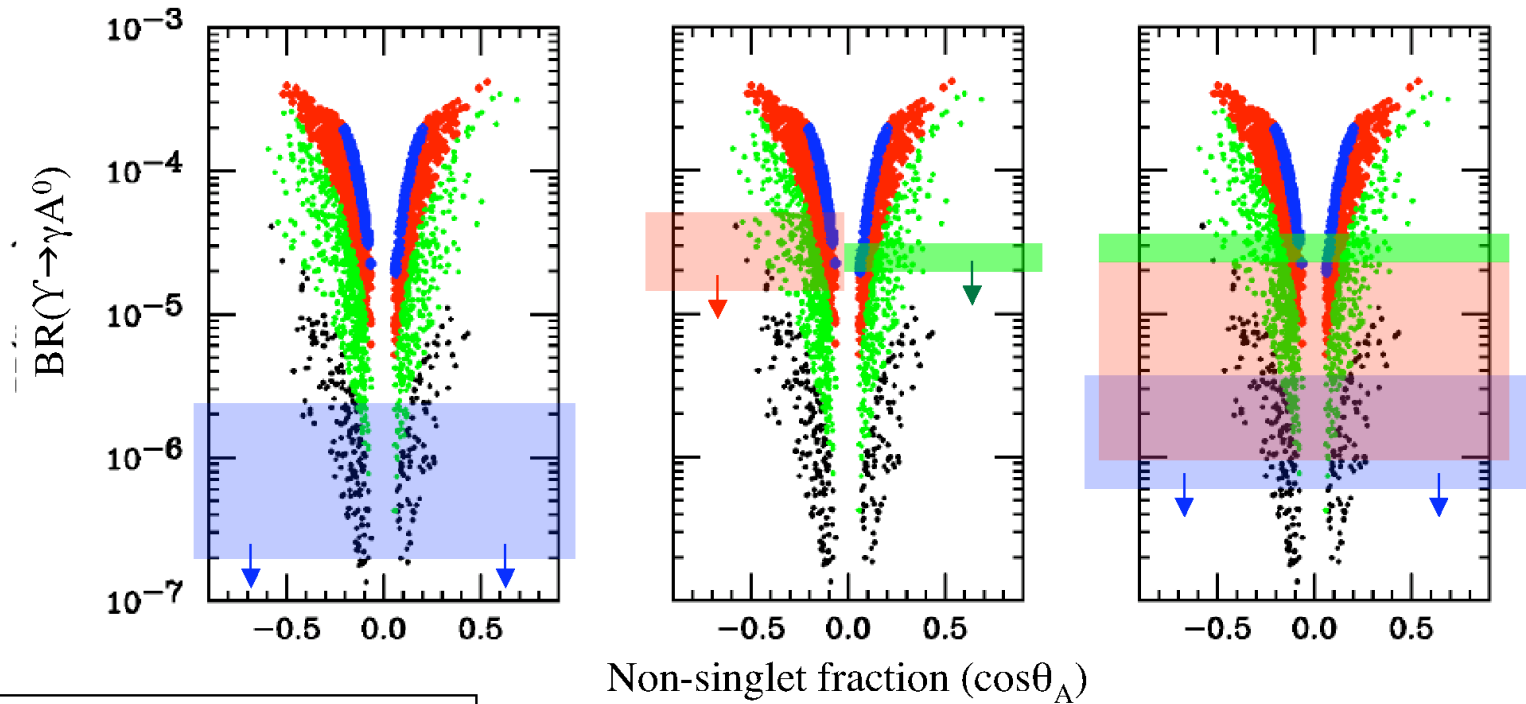
- ◆ BABAR data sample: $\sim 120M$ $Y(3S)$ [10x Belle, 25x CLEO] and $\sim 100M$ $Y(2S)$ [12x CLEO]
- ◆ limiti su Higgs leggeri e dark matter candidates migliorati di un fattore ~ 10

Ricerche di nuova fisica su picchi $Y(2S)$ e $Y(3S)$

$A^0 \rightarrow \mu^+ \mu^-$ @ $Y(2S, 3S)$
PRL103, 081803 (2009)

$A^0 \rightarrow \tau^+ \tau^-$ @ $Y(3S)$
PRL103, 181801 (2009)

$A^0 \rightarrow$ invisible @ $Y(3S)$
arXiv:0808.0017



$m_{A^0} < 2m_\tau$

$2m_\tau < m_{A^0} < 7.5 \text{ GeV}$

$7.5 \text{ GeV} < m_{A^0} < 8.8 \text{ GeV}$

$8.8 \text{ GeV} < m_{A^0} < 9.2 \text{ GeV}$

Also $\text{BF}(Y(1S) \rightarrow \text{invisible}) < 3 \times 10^{-4}$ @ 90% C.L.
[PRL103, 251801 (2009)]

$Y \rightarrow \gamma + \text{invisible}$

Ricerche di nuova fisica su picchi $\Upsilon(2S)$ e $\Upsilon(3S)$

- Constraints on light Higgs bosons in the mass region below $\sim 10 \text{ GeV}/c^2$

$$\Upsilon(2S, 3S) \rightarrow \gamma A^0, A^0 \rightarrow \mu^+ \mu^-$$

PRL 103, 081803 (2009)

$$\Upsilon(3S) \rightarrow \gamma A^0, A^0 \rightarrow \tau^+ \tau^-$$

PRL 103, 181801 (2009)

$$\Upsilon(3S) \rightarrow \gamma A^0, A^0 \rightarrow \text{invisible}$$

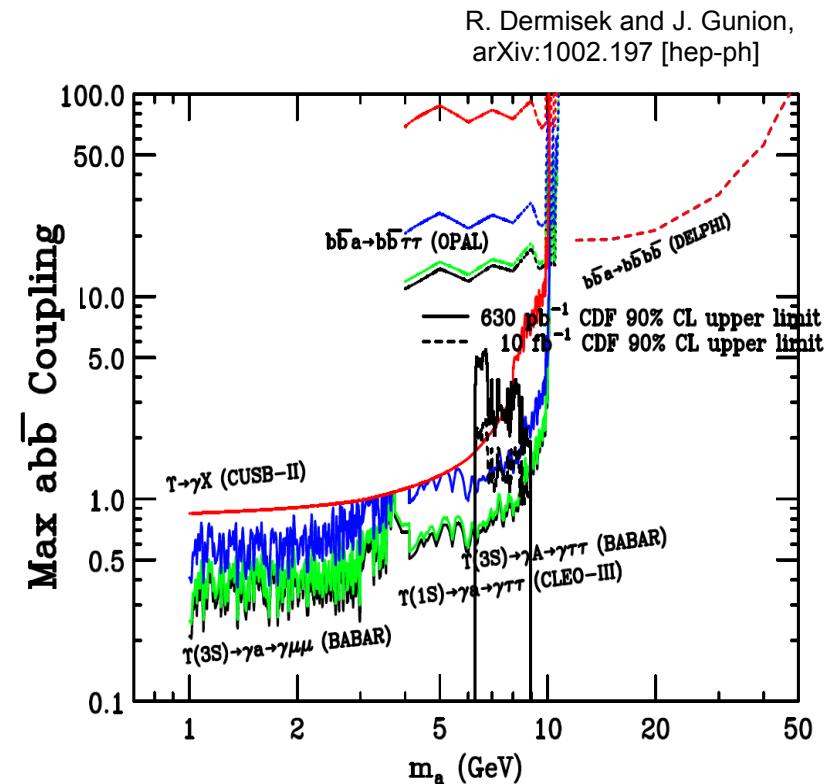
arXiv:0808.0017[hep-ex]
BABAR preliminary

can be interpreted in context of NMSSM and similar models

- Dark Matter search:

$$\Upsilon(3S) \rightarrow \pi^+ \pi^- \Upsilon(1S), \Upsilon(1S) \rightarrow \text{invisible}$$

$$B(\Upsilon(1S) \rightarrow \text{invisible}) < 3.0 \times 10^{-4} \text{ (90\% CL)} \quad \text{PRL 103, 251801 (2009)}$$



D⁰ mixing Dalitz plot analysis

Study event distribution as a function of
Dalitz plot position and time

$$\frac{dN_f(s_{12}, s_{13}, t)}{ds_{12}ds_{13}dt} \propto e^{-\Gamma t} \left\{ |A_f|^2 + \left[y \underbrace{\text{Re}(A_f^* \bar{A}_f)} - x \underbrace{\text{Im}(A_f^* \bar{A}_f)} \right] (\Gamma t) + \frac{x^2 + y^2}{4} (\Gamma t)^2 |\bar{A}_f|^2 \right\}$$

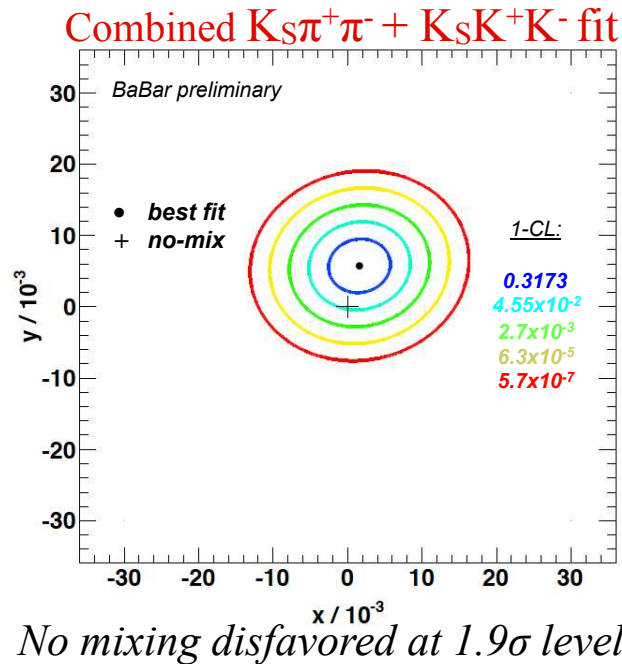
larger sensitivity in regions populated by Doubly Cabibbo Suppressed and CP eigenstates.

$A_f = A(s_{12}, s_{13})$ $\bar{A}_f = \bar{A}(s_{12}, s_{13})$ and $(s_{12}, s_{13}) =$ Dalitz plot location

- if f and \bar{f} belong to the same Dalitz plot (e.g. $K_S^0 \pi^+ \pi^-$) by assuming CP conservation in decay ($\bar{A}_f = A_{\bar{f}}$) is possible to extract directly x, y mixing parameters, without relative strong phase uncertainty.

Method pioneered by CLEO Collaboration: D.Asner *et. al. Phys.Rev.D72:012001,2005.*

D⁰ mixing Dalitz plot analysis: submitted



Experimental systematics

| Source | x[%] | y[%] |
|----------------------------------------|--------|--------|
| SVT misalignment | 0.0279 | 0.0826 |
| Fit bias | 0.0745 | 0.0662 |
| Charge-flavor correlation (mistagging) | 0.0487 | 0.0398 |
| Event selection | 0.0395 | 0.0508 |
| Efficiency map | 0.0367 | 0.0175 |
| Background Dalitz-plot distribution | 0.0331 | 0.0142 |
| D ⁰ mass window | 0.0250 | 0.0250 |
| Proper lifetime PDF | 0.0134 | 0.0128 |
| Signal and background yields | 0.0109 | 0.0069 |
| Mixing in background | 0.0103 | 0.0082 |
| Dalitz-plot normalization | 0.0106 | 0.0053 |
| Proper lifetime error PDF | 0.0058 | 0.0087 |
| Experimental systematics | 0.1177 | 0.1302 |

D⁰ decay amplitude model systematics

| | | |
|-------------------------------------------------------------------------|--------|--------|
| Dominated by uncertainty on K*(892), K-matrix, K π Lasso parameters | 0.0678 | 0.0532 |
| Total | 0.0830 | 0.0685 |

Combined $K_S\pi^+\pi^- + K_SK^+K^-$ fit results assuming CP conservation:

$$x = [0.16 \pm 0.23(\text{stat.}) \pm 0.12(\text{syst.}) \pm 0.08(\text{model})] \%$$

$$y = [0.57 \pm 0.20(\text{stat.}) \pm 0.13(\text{syst.}) \pm 0.07(\text{model})] \%$$

Best measurement of x parameter so far.

4

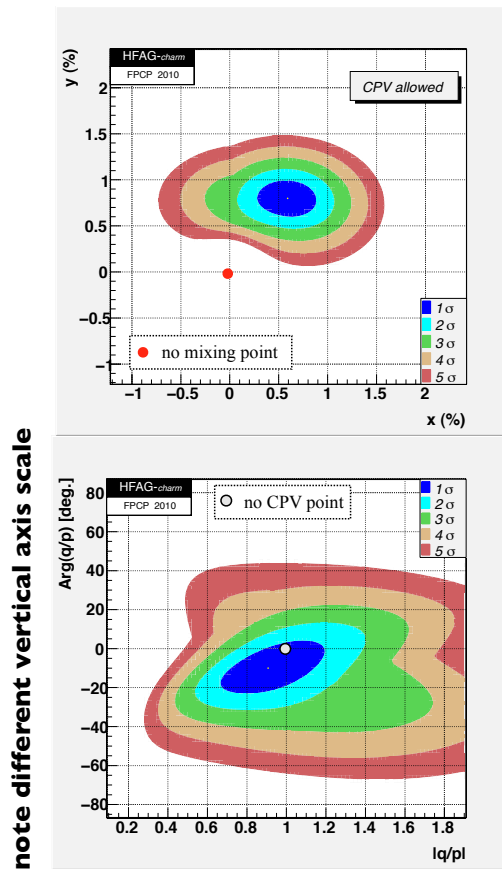
arXiv:1004.5053 [hep-ex], N.Neri (seminario INFN) & G.Casarosa

D^0 mixing significativo a $\approx 10\sigma$



HFAG preliminary FPCP2010 results

courtesy of Alan Schwartz on behalf of HFAG



HFAG averages including new BaBar $K_S\pi^+\pi^- + K_S K^+K^-$ results:

- *sizable improvement in mixing contours*
- *noticeable effect on x parameter value*

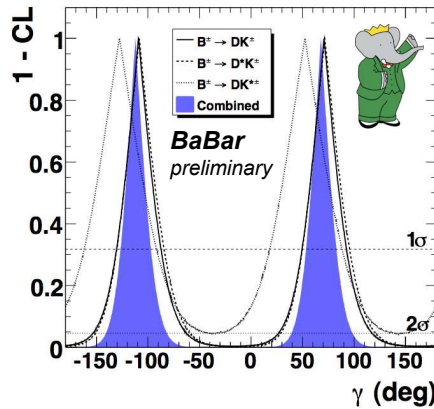
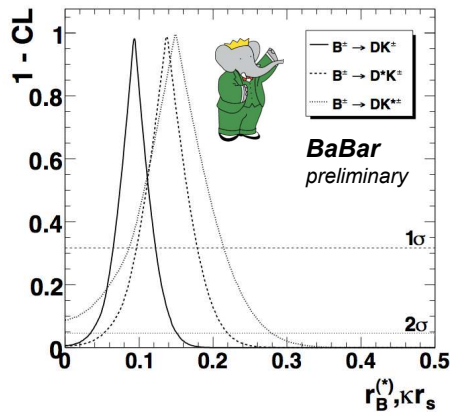
| EPS 2009 | FPCP 2010 |
|-------------------------------|-----------------------------------------|
| $x = (0.976 \pm 0.249)\%$ | $x = (0.59 \pm 0.20)\%$ |
| $y = (0.833 \pm 0.160)\%$ | $y = (0.80 \pm 0.13)\%$ |
| $ q/p = 0.866 \pm 0.160$ | $ q/p = 0.91^{+0.19}_{-0.16}$ |
| $\phi = -0.148 \pm 0.126$ rad | $\phi = -10^{+9.3}_{-8.7}$ deg |
| | $(\phi = -0.175^{+0.162}_{-0.152}$ rad) |

Mixing significance still exceeding 10.2σ

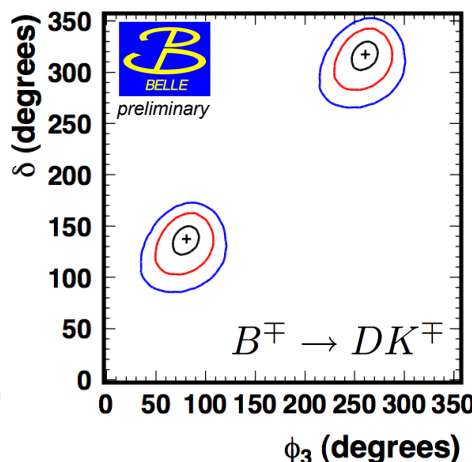
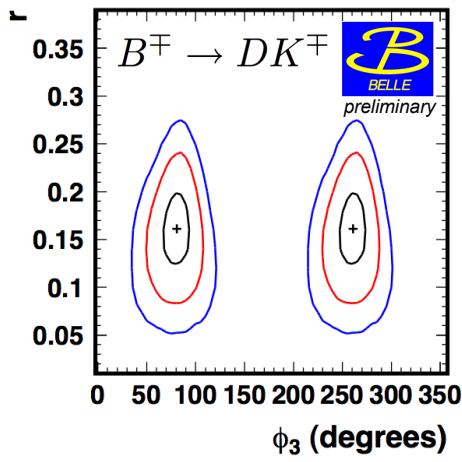
No CPV point is within 1σ contour

Aumenta la precisione sull'angolo gamma

$B^\pm \rightarrow D^{(*)}K^{(*)\pm}$ Dalitz: Interpretation



BaBar preliminary
 $\gamma = (68 \pm 14 \pm 4 \pm 3)^\circ$
 (value \pm stat. \pm sys. \pm model)^o
Excludes $\gamma = 0$ at 3.5 std. dev.
 $r_B(DK) = (9.4^{+2.8}_{-2.9})\%$
 (value \pm total error)^o
 Error breakdown (± 0.5 expt., ± 0.4 model)%



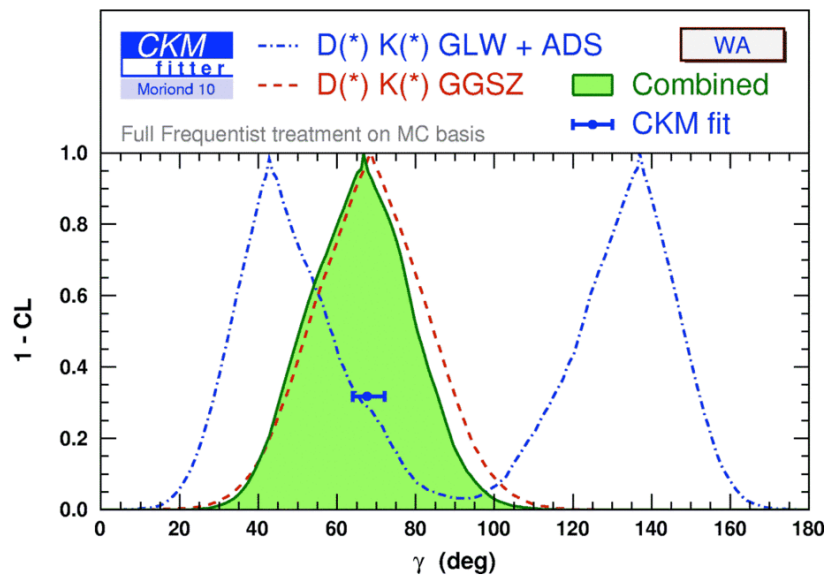
BELLE preliminary
 $\gamma = (78.4^{+10.8}_{-11.6} \pm 3.6 \pm 8.9)^\circ$
 (value \pm stat. \pm sys. \pm model)^o
*B \rightarrow DK and B \rightarrow D*K only, 657 MB \bar{B}*
Excludes $\gamma = 0$ at 3.5 std. dev.
 $r_B(DK) = (16.0^{+4.0}_{-3.8} \pm 0.011^{+5.0}_{-1.0})\%$
 (value \pm stat. \pm sys. \pm model)^o

More results for individual modes in backup slides.

Aumenta la precisione sull'angolo gamma

Frequentist interpretation

<http://ckmfitter.in2p3.fr>



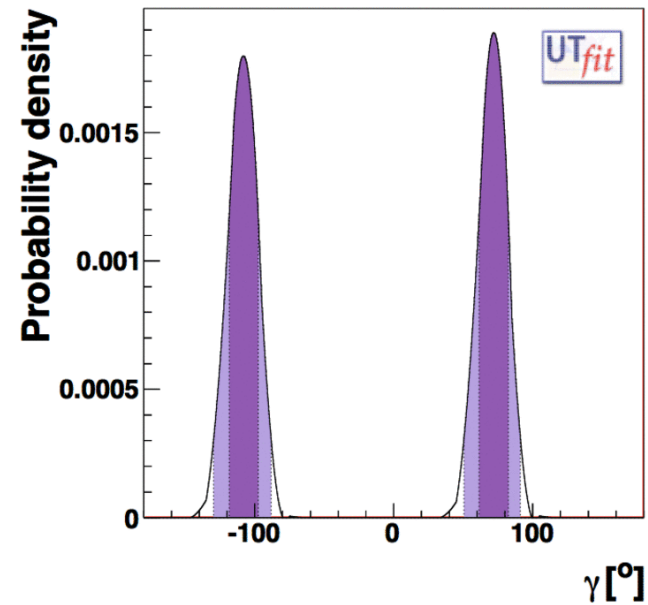
$$\gamma = (69^{+19}_{-21})^\circ$$

μ supremum method used to combine HFAG averages of experimental inputs (conservative, but guarantees coverage).

See Karim Trabelsi's talk at CKM 2008 for details.

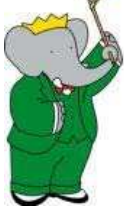
Bayesian interpretation

<http://www.utfit.org>



$$\gamma = (72 \pm 11)^\circ$$

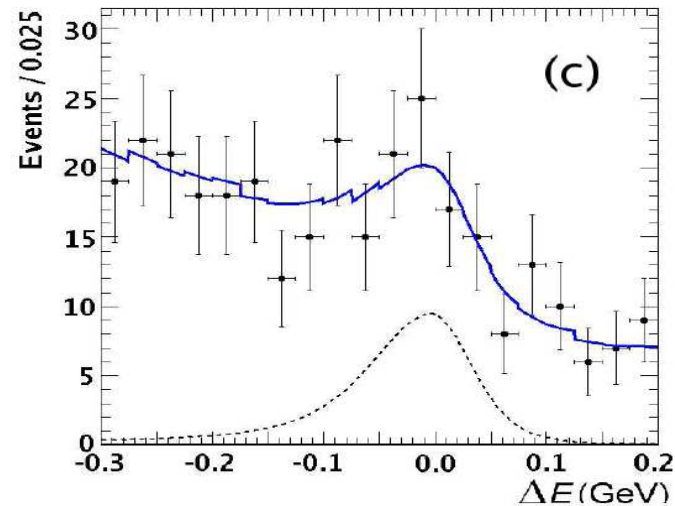
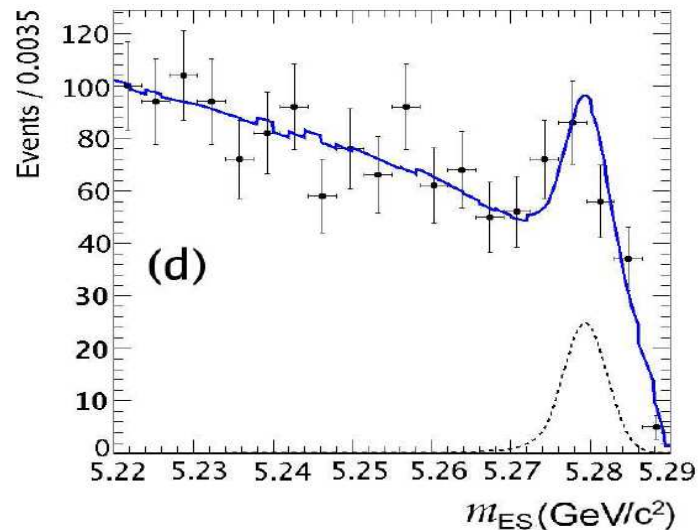
Misura inclusiva $B \rightarrow X_d \gamma$ (somma di esclusivi)



471M BB (full dataset) !! NEW!!

[arXiv:1005.4087](https://arxiv.org/abs/1005.4087) (submitted to PRL)

- Semi-inclusive
- $M(X_d)$ range is extended: <1.0 GeV to <2.0 GeV
 \rightarrow Better $|V_{td}/V_{ts}|$ determination than in excl. mode



Sum-of exclusive

$$\overline{B \rightarrow X_d \gamma}$$

$$\overline{B^0 \rightarrow \pi^+ \pi^- \gamma}$$

$$\overline{B^+ \rightarrow \pi^+ \pi^0 \gamma}$$

$$\overline{B^+ \rightarrow \pi^+ \pi^- \pi^+ \gamma}$$

$$\overline{B^0 \rightarrow \pi^+ \pi^- \pi^0 \gamma}$$

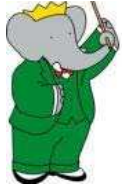
$$\overline{B^0 \rightarrow \pi^+ \pi^- \pi^+ \pi^- \gamma}$$

$$\overline{B^+ \rightarrow \pi^+ \pi^- \pi^+ \pi^0 \gamma}$$

$$\overline{B^+ \rightarrow \pi^+ \eta \gamma}$$

$$B(B \rightarrow X_d \gamma) = (9.2 \pm 2.0(\text{stat.}) \pm 2.3(\text{syst.})) \times 10^{-6}$$

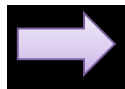
Misura inclusiva $B \rightarrow X_d \gamma$ (somma di esclusivi)



471M BB (full dataset) !! NEW!!

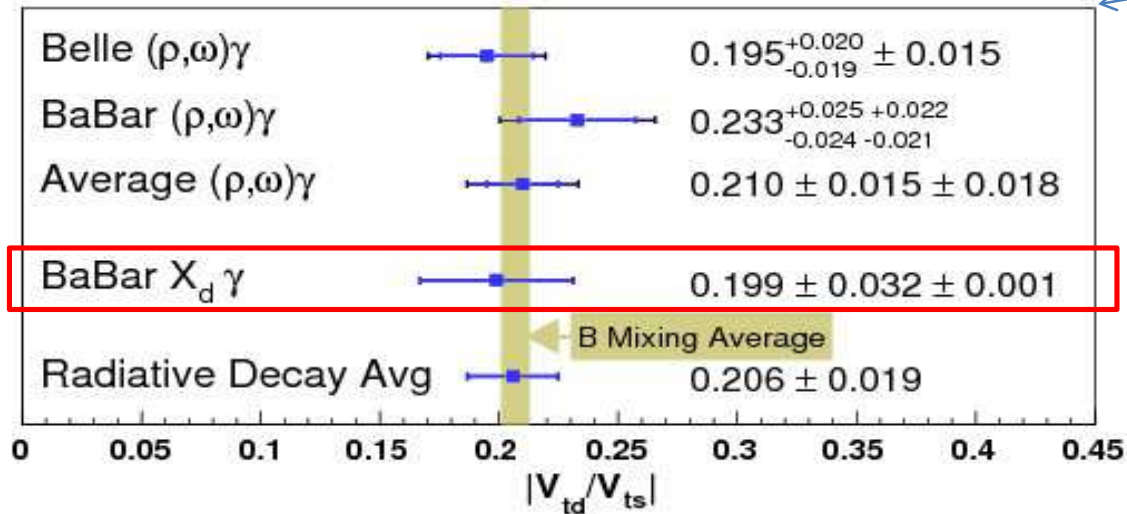
[arXiv:1005.4087](https://arxiv.org/abs/1005.4087) (submitted to PRL)

$X_s \gamma$ measurement is also updated from 383MBB \rightarrow 471MBB



$$|V_{td}/V_{ts}| = 0.199 \pm 0.022(stat.) \pm 0.024(syst.) \pm 0.002(th.)$$

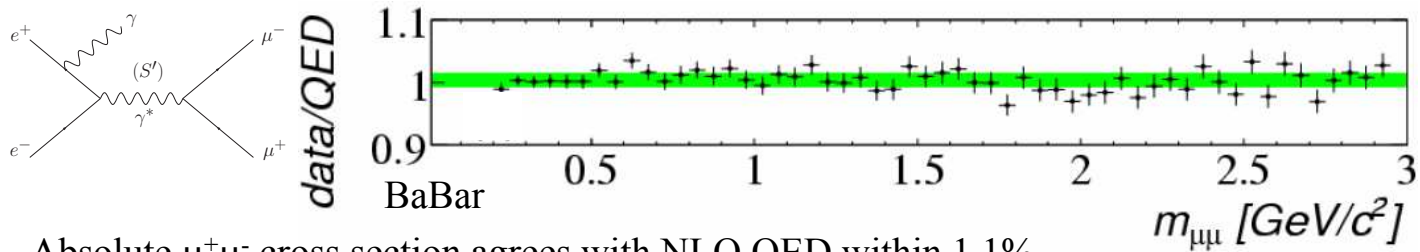
$|V_{td}/V_{ts}|$ averages



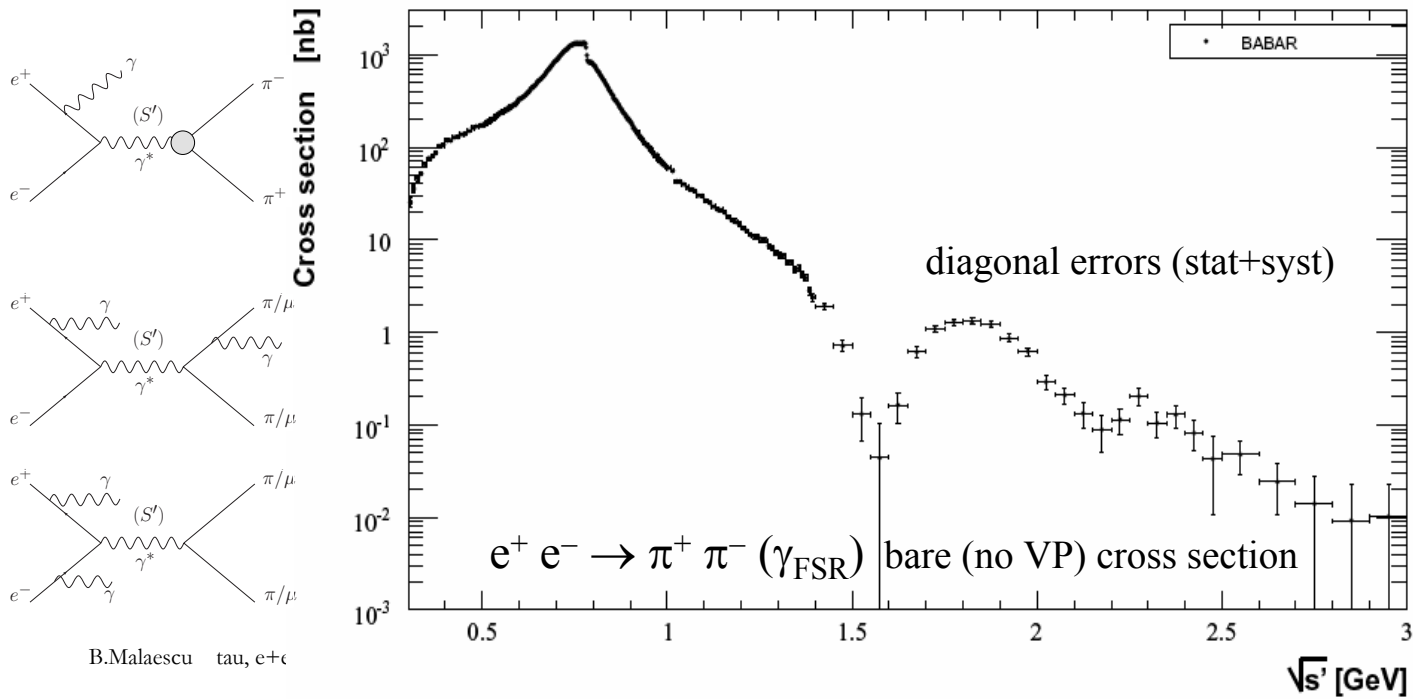
From Deborah Joanne Bard, in private communication

New results on ISR $\sigma(e^+e^- \rightarrow \text{hadrons})$ for hadronic contr. to $g-2$

BaBar results (arXiv:0908.3589, PRL 103, 231801 (2009))



Absolute $\mu^+\mu^-$ cross section agrees with NLO QED within 1.1%



Diminuisce leggermente la discrepanza di $g-2$

Where are we?

- including BaBar 2π results in the e^+e^- combination + estimate of hadronic LBL contribution (Prades-de Rafael-Vainhstein, 2009) yields

$$a_\mu^{\text{SM}}[e^+e^-] = (11\,659\,183.4 \pm 4.1 \pm 2.6 \pm 0.2) 10^{-10}$$

HVP LBL EW (± 4.9)

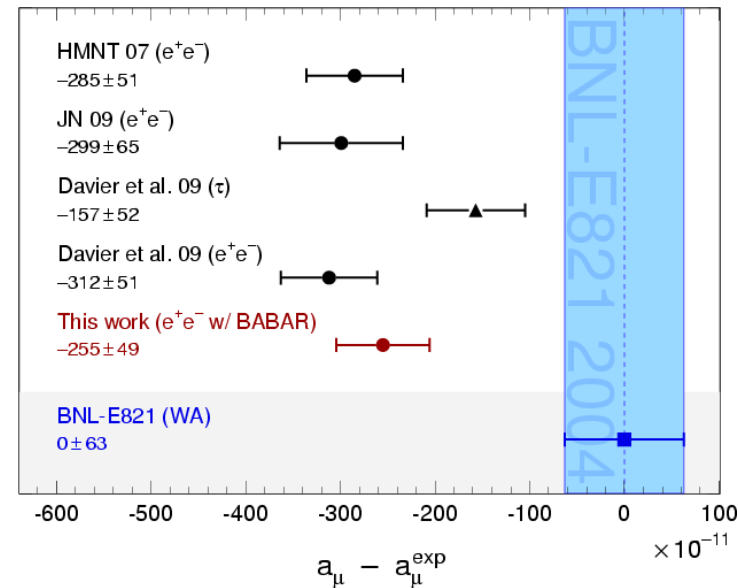
- E-821 updated result*

$$(11\,659\,208.9 \pm 6.3) 10^{-10}$$

- deviation (ee) $(25.5 \pm 8.0) 10^{-10}$
(3.2σ)

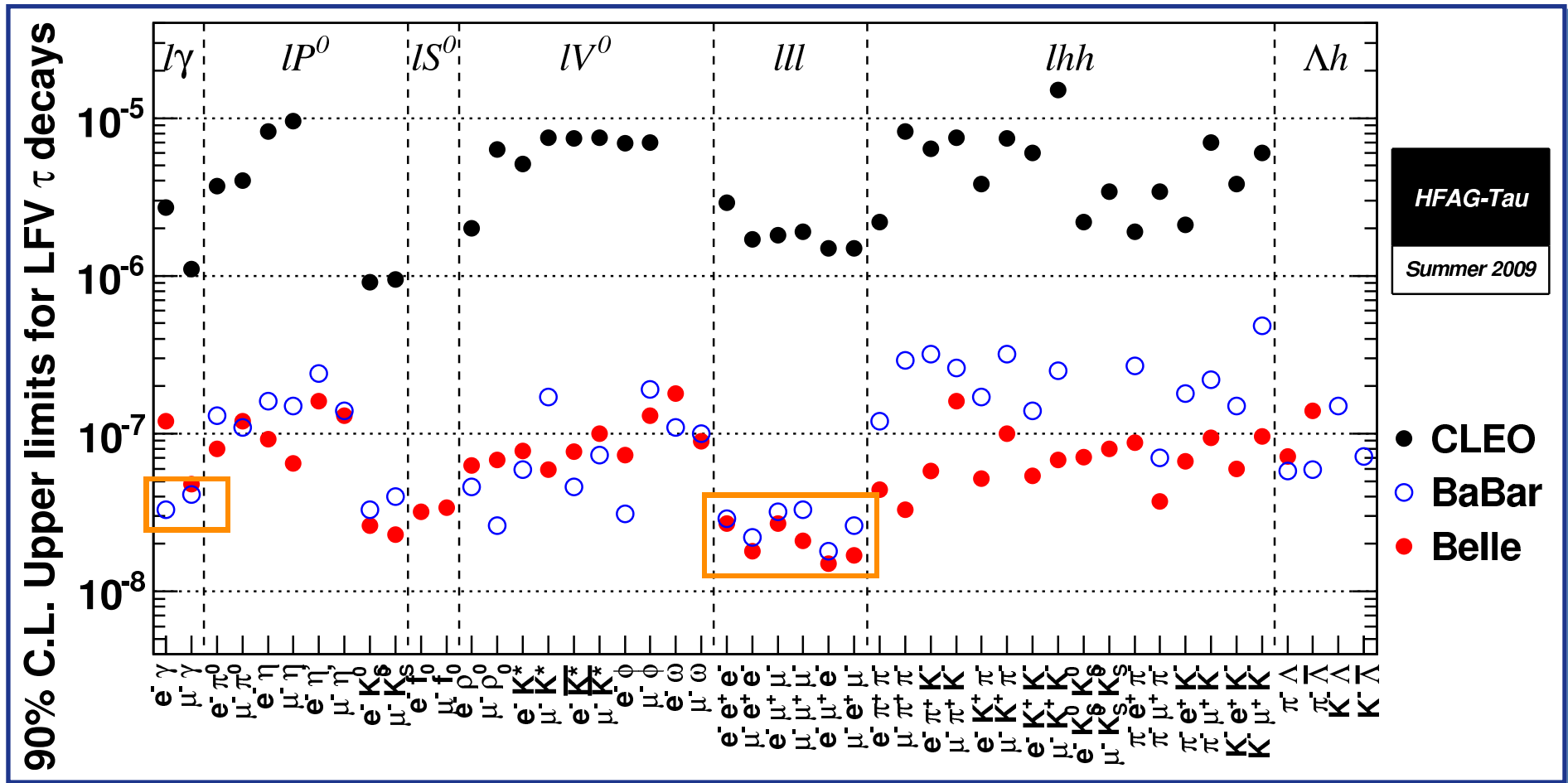
- updated τ analysis
+Belle +revisited IB corrections

- deviation (τ) $(15.7 \pm 8.2) 10^{-10}$
(1.9σ)



*new proposal submitted to Fermilab
to improve accuracy by a factor 4

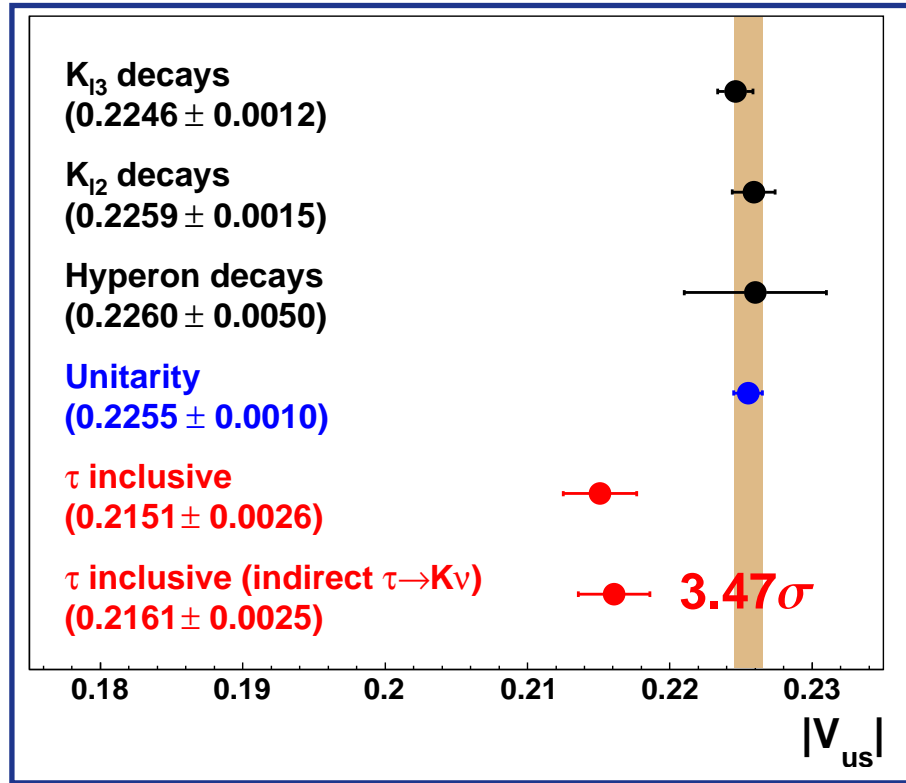
Completate le principali ricerche di LFV nel decadimento del tau



- ◆ Pisa contributions to both latest results
- ◆ A.Cervelli main author of $\tau \rightarrow 3\ell$ LVF search

Progress on $\tau \rightarrow s$ inclusive for V_{us}

| hadronic system in $\tau \rightarrow X_S \nu$ | now (%) | most precise measurements |
|------------------------------------------------------------|------------------------------------------|------------------------------------------------------------------------------|
| K^- [from τ decay] [indirect, from $K_{\mu 2}$] | 0.690 ± 0.010 (0.715 ± 0.004) | <i>BABAR</i> 2009 subm, my average Gamiz <i>et al.</i> , PoSKAON:008,2008 |
| $K^- \pi^0$ | 0.426 ± 0.016 | <i>BABAR</i> 2007, my average |
| $\bar{K}^0 \pi^-$ | 0.821 ± 0.024 (S = 1.2) | Belle 2008, <i>BABAR</i> 2008, my average |
| $K^- \pi^0 \pi^0$ | 0.058 ± 0.024 | ALEPH 1999 |
| $\bar{K}^0 \pi^0 \pi^-$ | 0.344 ± 0.015 | <i>BABAR</i> 2009 prelim., my average |
| $K^- \pi^- \pi^+$ | 0.292 ± 0.018 (S = 2.5) | <i>BABAR</i> 2008, Belle 2010 subm, my average |
| $(\bar{K}3\pi)^-$ (est'd) | 0.074 ± 0.030 | ALEPH 2005 |
| $K_1(1270) \rightarrow K^- \omega$ | 0.067 ± 0.021 | ALEPH 2005 |
| $(\bar{K}4\pi)^-$ (est'd) | 0.011 ± 0.007 | ALEPH 2005 |
| $K^- \eta$ | 0.016 ± 0.001 (S = 1.2) | Belle 2009, my average |
| $K^{*-} \eta$ | 0.014 ± 0.002 (S = 1.7) | Belle 2009, my average |
| $K^- \phi$ | 0.0037 ± 0.0003 (S = 1.3) | Belle 2006, <i>BABAR</i> 2007, my average |

Updated V_{us} from $\tau \rightarrow s$ inclusive

V_{us} precision: 1.17%

was 1.34% at ICHEP08

Constants

- ◆ $V_{us}(K, \text{Hyp.}, \text{unitarity})$: A.Denig, Chiral2009
- ◆ $V_{ud} = 0.97425 \pm 0.00022$ Towner-Hardy, 2009
- ◆ $m_s(2 \text{ GeV}) = 94 \pm 6 \text{ MeV}$: M.Jamin *et al.*, 2006
- ◆ $\delta R_{\text{OPE}}^W = 0.240 \pm 0.032$: Gamiz *et al.*, 2007
- ◆ $\text{BF}(\tau \rightarrow s)$ S.Banerjee, ICHEP08 proceedings
 - ▶ updated with new $\text{BF}(\tau \rightarrow K\pi\pi^0\nu)$
- ◆ other constants from PDG 2008

(*) indirect $\tau \rightarrow K\nu$

use precise measurement of $\text{BF}[K \rightarrow \mu\nu(\gamma)]$
 to get indirect measurement of $\text{BF}[\tau \rightarrow K\nu(\gamma)]$
 Rev.Mod.Phys. 78 1043 (2006)

- ◆ new HFAG-Tau group will combine with correlations (A.L. is one of the 3 BABAR members)

responsabilita' di Pisa

- ◆ **J.Walsh**: Radiative B Penguin decays physics analysis co-convener
- ◆ **N.Neri**: Charm Physics physics co-convener
- ◆ **A.L.:** Tau Physics co-convener
HFAG-tau member

cambiamenti rispetto a luglio 2009

- ◆ B.Oberhof, nuovo studente dottorato (era laureando)
- ◆ A.Cervelli, nuovo assegnista di ricerca (era studente di dottorato)
- ◆ R.Cenci ha terminato il suo contratto
- ◆ elevata compartecipazione a P-SuperB e a VIPIX

Attività a Pisa

- ◆ **Charm Physics** (3 pubblicazioni, 3 sottomissioni)
 - ▶ pubblicata analisi D^0 mixing – Dalitz (N.Neri, G.Casarosa)
- ◆ **Radiative Penguins ($B \rightarrow s\gamma$)** (1 sottomissione)
 - ▶ sottomessa misura “Inclusive $B \rightarrow d\gamma$ ”
- ◆ **Tau Physics** (5 pubblicazioni, 1 sottomissione)
 - ▶ pubblicata analisi LFV $\tau \rightarrow 3\ell$ (A.Cervelli autore principale)
 - ▶ pubblicata analisi LFV $\tau \rightarrow \ell\gamma$ (contributi di Pisa)
- ◆ contributi al referaggio delle analisi, impegni sul B-factories legacy book

Tesi recenti e in corso

- ◆ R.Cenci, **dottorato**, ricerca LFV in tau $\rightarrow K_s^0\ell$
- ◆ A.Cervelli, **dottorato**, ricerca LFV in tau $\rightarrow 3$ leptoni
- ◆ G.Casarosa, **laurea specialistica**, **dottorato** in corso su D^0 -mixing
- ◆ B.Oberhof, **laurea specialistica** su LFV in tau $\rightarrow 3$ leptoni da BABAR a SuperB, **dottorato** in corso

Presentazioni a conferenze

- ◆ N.Neri, Beauty09, Set 2009: “D0 mixing and CP violation at the B factories”
- ◆ N.Neri, WS on Open Charm Physics at PANDA, Nov 2009, “Review of Open Charm Physics at the B-Factories”
- ◆ N.Neri, **sem. INFN Pisa** 9 Marzo 2010, “Results on Charm mixing and CP violation from the B Factories”
- ◆ N.Neri, IFAE2010, apr 2010, “Risultati recenti alle B factories a prospettive a SuperB”
- ◆ N.Neri, FPCP2010, mag 2010, “D0 mixing, *BABAR* and Belle mini-review”
- ◆ A.Cervelli, CIPANP 2009, mag 2009, “Tau Lepton Flavor Violation Results at *BABAR*”
- ◆ A.Cervelli, IFAE2010, apr 2010, “Ricerca di nuova fisica a *BABAR*”
- ◆ A.Cervelli, DIS2010, apr 2010, “Direct Searches for New Physics at the e+e- B-factories”
- ◆ R.Cenci, WIN09, set 2009, “LFV in tau decays”
- ◆ G.Casarosa, SIF Bari, ott 2009, “D0 mixing and CP Violation at the *BABAR* Experiment”
- ◆ G.Casarosa, APS Washington 2010, feb 2010, “D0 mixing at the *BABAR* experiment: recent results”
- ◆ G.Casarosa, IFAE2010, apr 2010, “D0 mixing at the *BABAR* experiment: recent results”
- ◆ A.L., ICFP 2009, set 2009, “*BABAR* Tau Physics Results”
- ◆ A.L., ICHEP 2010, lug 2010, “Measurements of $|V_{us}|$ and SCC, Searches for LFV and CPT in Tau Decays at *BABAR*”

Attivita' 2011

- ◆ analisi dati e pubblicazioni (lo scopo ultimo della fisica...)
 - ▶ 3 convener
 - ▶ 1 HFAG member
 - ▶ 2 tesi di dottorato
- ◆ realizzazione B-factories legacy book
- ◆ collaboration service tasks (soprattutto computing)

Personale e percentuali BABAR 2011

| | | 2010 | 2011 | | |
|----|-----------------------------|------------|------------|----------|------------------------|
| 1 | C.Angelini | 50% | 50% | p.o. | |
| 2 | G.Batignani | 30% | 30% | p.o. | |
| 3 | S.Bettarini | 20% | 20% | ric. | |
| 4 | G.Calderini | 30% | 30% | ric. | |
| 5 | M.Carpinelli | 50% | 50% | p.o. | dot.1 Cagliari |
| 6 | G.Casarosa | 70% | 70% | dott. | |
| 7 | A.Cervelli | | 50% | ass.ric. | |
| | R.Cenci | 50% | | bors. | |
| 8 | F.Forti | 30% | 30% | p.a. | |
| 9 | M.Giorgi | 20% | 20% | p.o. | |
| 10 | A.Lusiani | 60% | 60% | ric. | |
| 11 | N.Neri | 40% | 40% | ass.ric. | |
| 12 | E.Paoloni | 20% | 20% | ric. | |
| 13 | G.Rizzo | 20% | 20% | ric. | |
| 14 | G.Triggiani | 20% | 20% | p.a. | |
| 15 | J.Walsh | 60% | 60% | ric. | |
| | FTE fisici | 5.7 | 5.7 | | |
| | F.Donno | 30% | | tecn. | |
| 16 | G.Terreni | 20% | 20% | tecn. | |
| 17 | TBD | | 30% | tecn. | |
| | FTE tecnologi dalla sezione | 0.5 | 0.5 | | |
| | Totale FTE | 6.2 | 6.2 | | 5.7 Pisa, 0.5 Cagliari |

BABAR Pisa, richieste 2011 (calcolo identico al 2010)

| Missioni interne | k€ | |
|---------------------------|-------------|----------------|
| Missioni interne | | |
| Pisa 1.4 kE * 5.7 FTE | 7.98 | |
| Cagliari 1.4 kE * 0.5 FTE | 0.70 | dot-1 Cagliari |
| totale | 8.68 | |

| Missioni estere (5.40 kE/mu) | | | k€ | |
|-----------------------------------------|------|-------|--------------|----------------|
| Tasks | m.u. | k€ | | |
| Physics convener Rad.Penguins - J.Walsh | 1.00 | 5.40 | 16.20 | |
| Physics convener Charm - N.Neri | 1.00 | 5.40 | | |
| Physics convener Tau - A.Lusiani | 1.00 | 5.40 | | |
| totale | 3.00 | 16.20 | | |
| Pisa, 1.0 m.u. * 5.7 FTE * 5.40 kE | | | 30.78 | |
| Cagliari, 1.0 m.u. * 0.5 FTE * 5.40 kE | | | 2.70 | dot-1 Cagliari |
| totale | | | 49.68 | |

| Consumi | k€ | |
|----------------------------------|-------|--|
| 1.7 kE * 6.2 FTE (Pisa+Cagliari) | 10.54 | |

| Inventariabile | k€ | |
|----------------|------|--|
| nulla | 0.00 | |

nessuna specifica richiesta di servizi di sezione