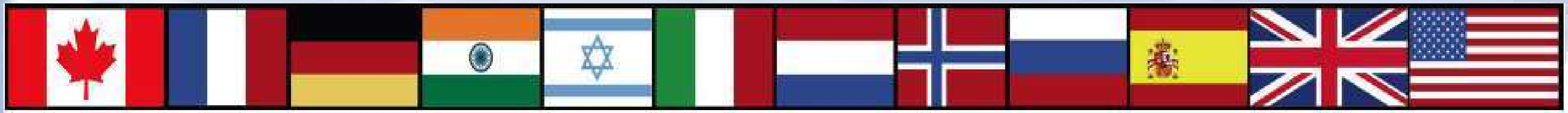
BABAR, stato e richieste 2012

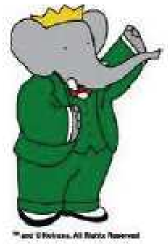
Alberto Lusiani

INFN Pisa, 20 giugno 2011

Stato

- April 2008 end of data-taking
  - → 2009–2010 intense data analysis
    - → 2011–2012 steady data analysis
      - → 2013→ long term archival data analysis
- **2012 ultimo anno** con sigla *BABAR* autonoma nell'INFN
- maggiori attività recenti di fisica:
  - misure di precisione di fisica del flavour (B, adroni con charm, tau)
  - ricerca di nuova fisica (tau LFV, (Dark) Higgs leggeri, processi soppressi nello SM)
  - spettroscopia, sezione d'urto adronica a basse energie con eventi ISR
- Long Term Data Access (LTDA) ruolo trainante, framework quasi pronto
- B-factories legacy book in collaborazione con Belle





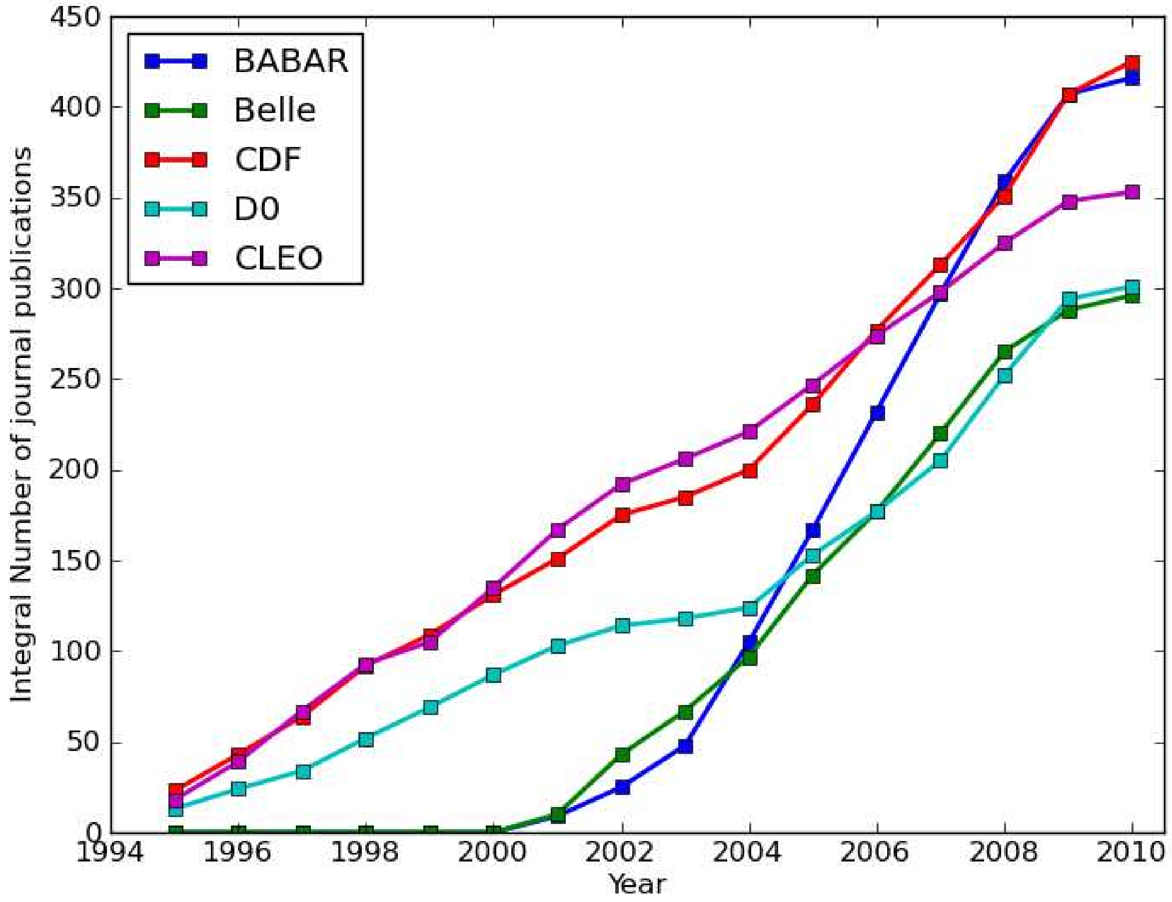
BABAR Membership Numbers

72 institutions in our 12 countries

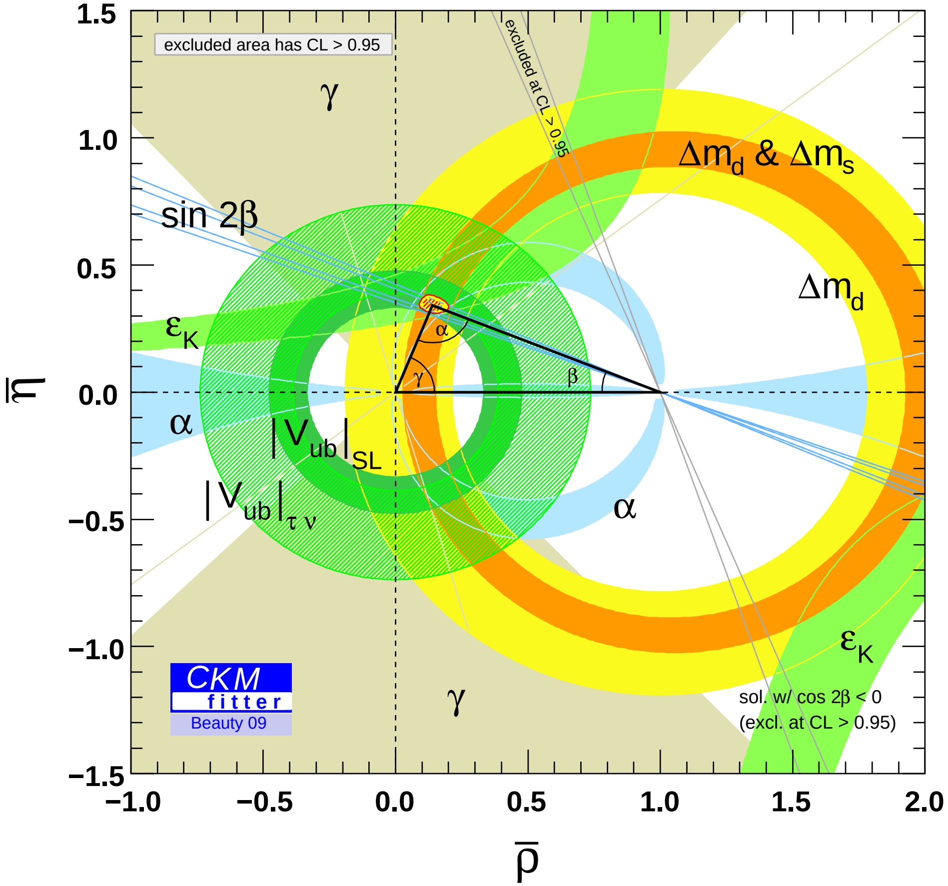
	Faculty & Staff	Postdocs	Gr Student	ALL	Stud. Assoc.
CANADA	10	5	7	22	1
FRANCE	21	2	3	26	
GERMANY	7	3	11	21	
INDIA	1		1	2	
ISRAEL	1		3	4	
ITALY	50	10	12	72	6
NETHERLANDS	1		1	2	
NORWAY	2	1		3	
RUSSIA	8		3	11	
SPAIN	2	2		4	
UK	17	6	2	25	
USA	104	27	20	151	5
TOTAL	**224**	**56**	**63**	**343**	**12**

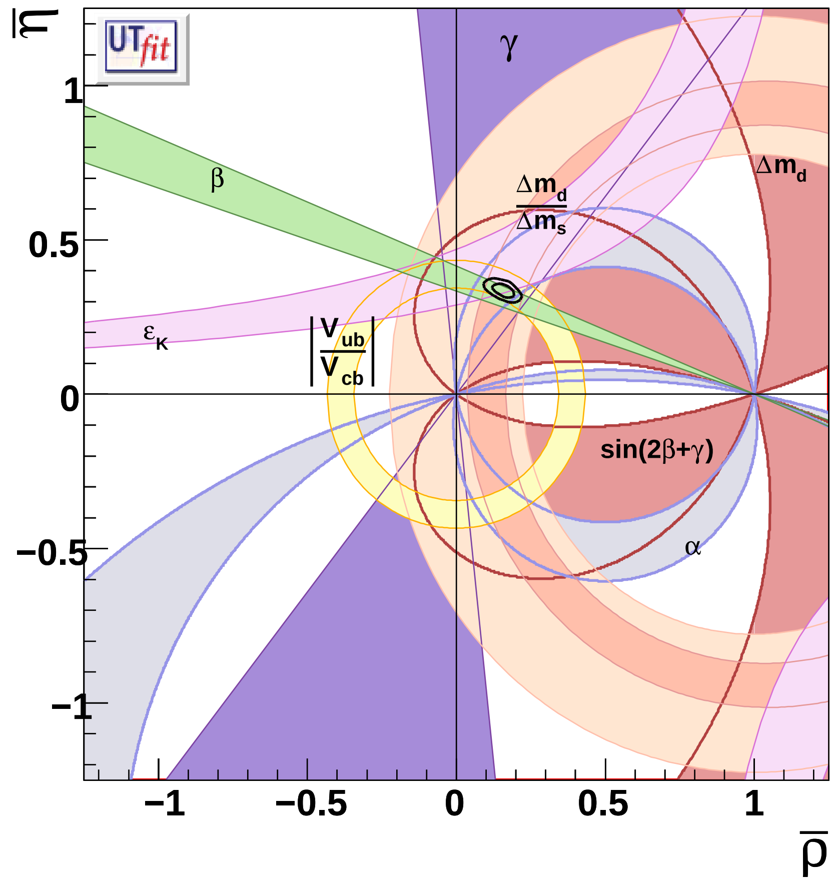
Pubblicazioni di fisica: da 420 a 466 rispetto a giugno 2010

(grafico dell'anno scorso, arriva a metà 2010)



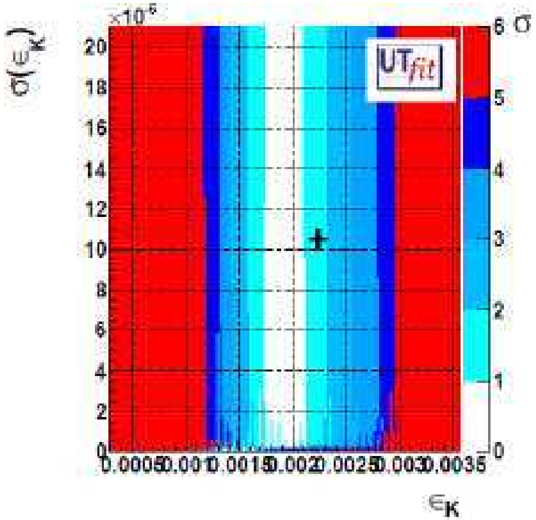
Fits → CKM mechanics dominates *CPV* phenomenology (from CKM 2010)





Essential contribution of B-factories

Ci sono alcune tensioni nel fit CKM (P.Paradisi, CKM 2010)

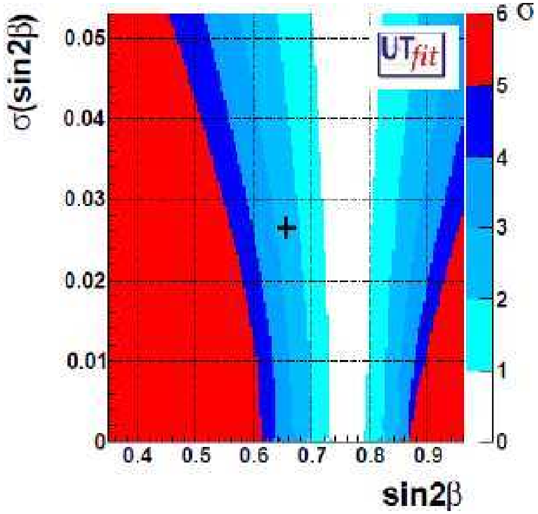


1. $\sim$ 6% reduction of $\epsilon_K^{\rm SM}$

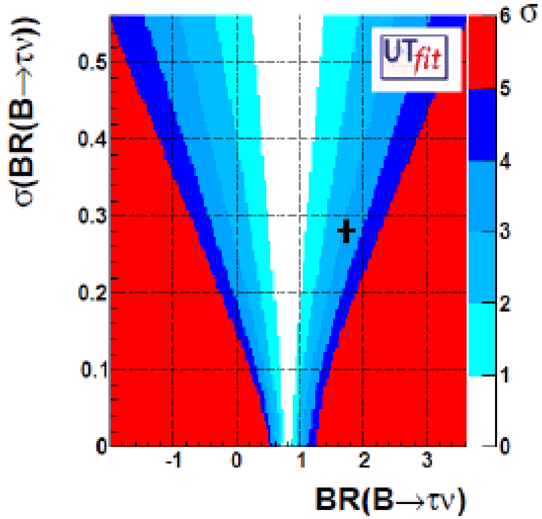
   [Buras & Guadagnoli; BG & Isidori]
2. smaller $\hat{B}_K$ from unquenced analyses

   [Antonio et al. '08; Aubin et al. '10]
3. fit vs. exp. $\approx -1.7\sigma$

NEW: $\epsilon_K^{\rm SM}$ @ NNLO QCD: $\sim +3\%$ [Brod & Gorbahn, '10]



1. fit vs. exp. $\approx +2.6\sigma$



1. $B(B\to\ell\nu) \sim f_B^2 |V_{ub}|^2$
2. $B(B\to\ell\nu)/\Delta M_d \sim (\sin\beta/\sin\gamma)^2/\hat{B}_{B_d}$
3. fit vs. exp. $\approx -3.2\sigma$

Several consistent $B \to \tau\nu$ measurements (B.Kowalewski, Beauty 2011)

- Purely leptonic decay, measures product $(f_B|V_{ub}|)^2$
- At least two missing neutrinos; ***no kinematic constraints***
- Must reconstruct 2nd B meson, ***veto*** on any additional tracks or significant ***calorimeter energy***

	$BF(B \to \tau\nu) \times 10^6$	
BaBar SL tag	$180 \pm 80 \pm 10$	arXiv:0809.4027
Belle SL tag	$154\ ^{+38}_{-37}\ ^{+29}_{-31}$	arXiv:1006.4201
BaBar had tag	$180\ ^{+57}_{-54} \pm 26$	arXiv:1008.0104
Belle had tag	$179\ ^{+56}_{-49}\ ^{+46}_{-51}$	PRL 97:251802 (2006)
HFAG average	164 ± 34	

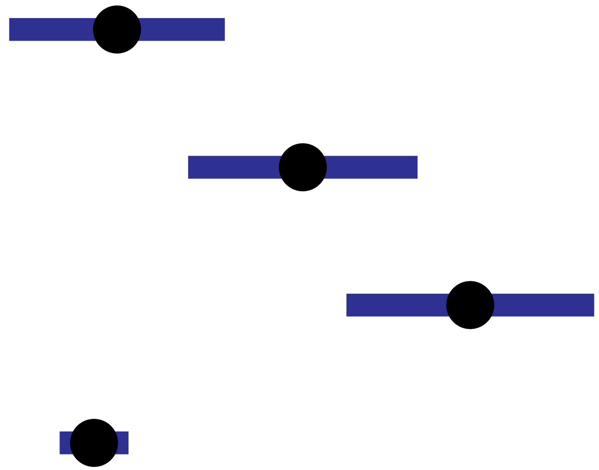
$|V_{ub}|$ puzzle (U.Nierste, MoriondEW 2011)

$$|V_{ub,\mathrm{excl}}| = (3.51 \pm 0.47) \cdot 10^{-3}$$

$$|V_{ub,\mathrm{incl}}| = (4.32 \pm 0.50) \cdot 10^{-3}$$

$$|V_{ub,B\to\tau\nu}| = (5.10 \pm 0.59) \cdot 10^{-3}$$

$$|V_{ub,\mathrm{ind}}| = (3.41 \pm 0.15) \cdot 10^{-3}$$



Alleviate the 2.9σ tension between $|V_{ub,\mathrm{ind}}|$ and $|V_{ub,B\to\tau\nu}|$ with new physics in

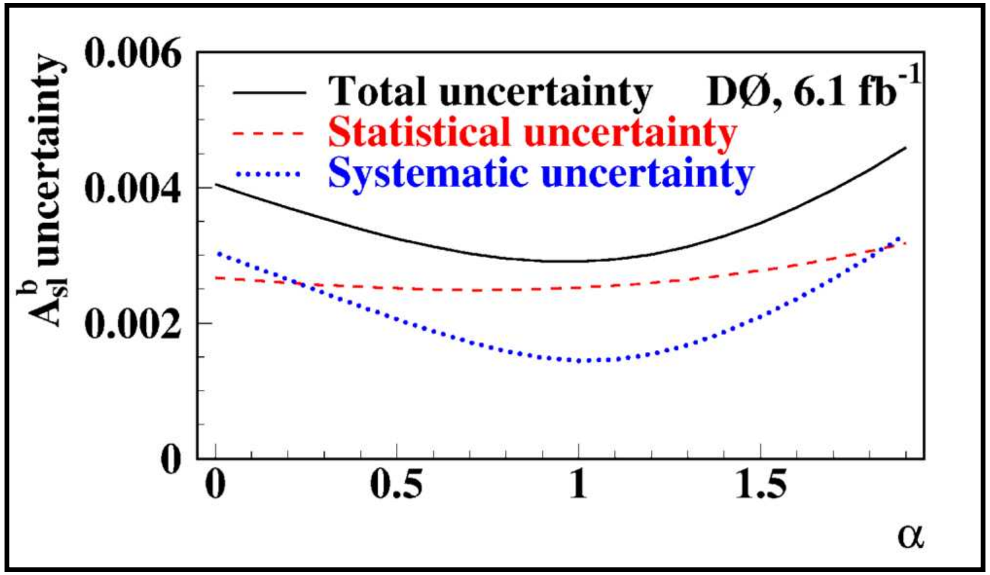
- $B^+ \to \tau^+\nu_\tau$ or
- $A_{\mathrm{CP}}^{\mathrm{mix}}(B_d \to J/\psi K_S)$. $\leftarrow$ easier!

A^{b}_{sl} from D0 ≫ than predicted by SM (M.Williams, FPCP 2011)

Results: Part II

Scan over total uncertainty on final measurement, yields **α = 0.959**.

Reduces overall systematic uncertainty – precision is now **statistically limited**.



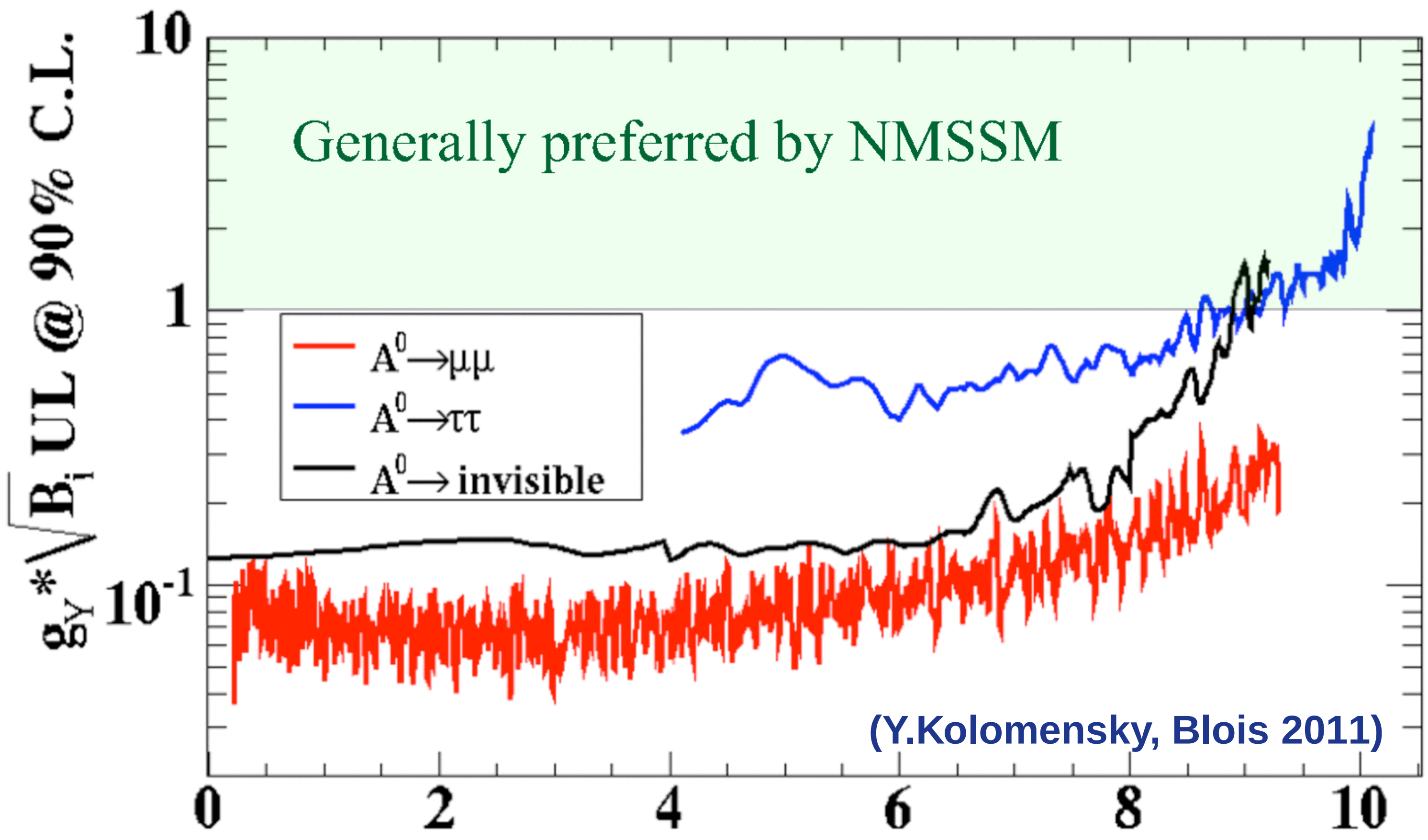
From $A' = A - \alpha\, a$ we obtain:

$$A^{b}_{sl} = [\,-0.957 \pm 0.251\,(\text{stat.}) \pm 0.146\,(\text{syst.})\,]\,\%$$

This result differs from the SM prediction, [– 0.023 ± 0.006] %, by ~3.2 σ.

Light NMSSM Higgs bosons not found in Υ(3S) and Υ(2S) decays

(Hiller hep-ph/0404220, Dermisek/Gunion/McElrath hep-ph/0612031)



In NMSSM: $g_\Upsilon = \tan\beta\cos\theta \times \sqrt{C_{\rm binding}}$

Dark sector gauge bosons (dark matter candidates)

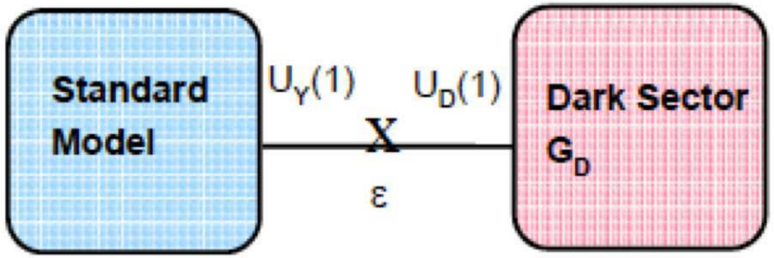
Models motivated by γ-ray and positron emission from the galactic center (INTEGRAL, PAMELA, ATIC, etc)

Dark matter particles in ~TeV range, but new gauge bosons in ~GeV range

Coupling to leptons due to small mixing between SM and DS

New gauge bosons decay to lepton pairs, anti-proton production forbidden by kinematics or suppressed → explains PAMELA/ATIC features

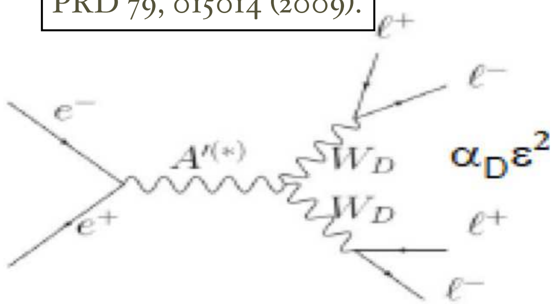
Search for low-mass states in e^+e^- annihilation @ B-Factories



$$\Delta\mathcal{L}_{mix} = \varepsilon F^{\upsilon\nu} B_{\upsilon\nu}$$

Generic dark boson
Non-abelian structure

N. Arkani-Hamed *et al.*, PRD 79, 015014 (2009).



4 leptons (+gamma)

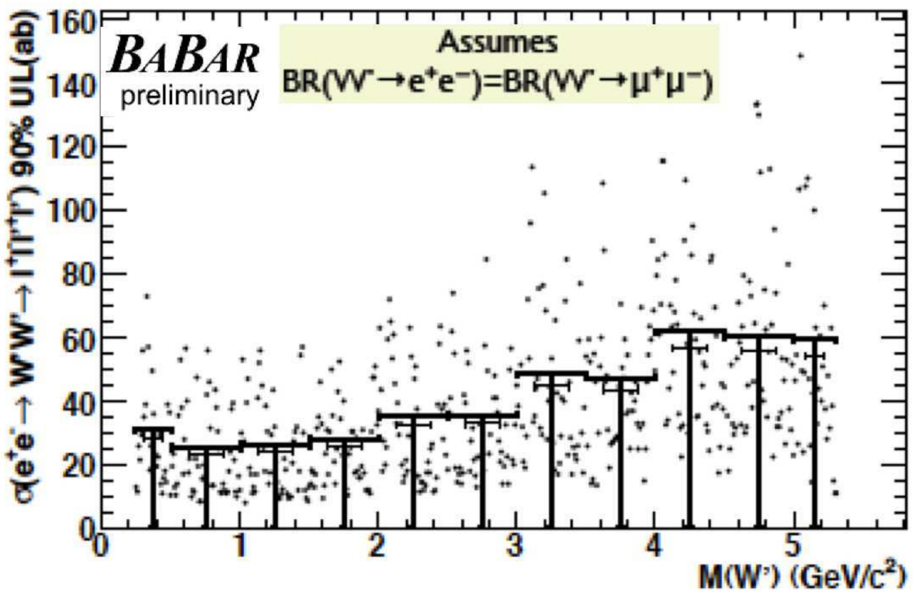
(Y.Kolomensky, Blois 2011)

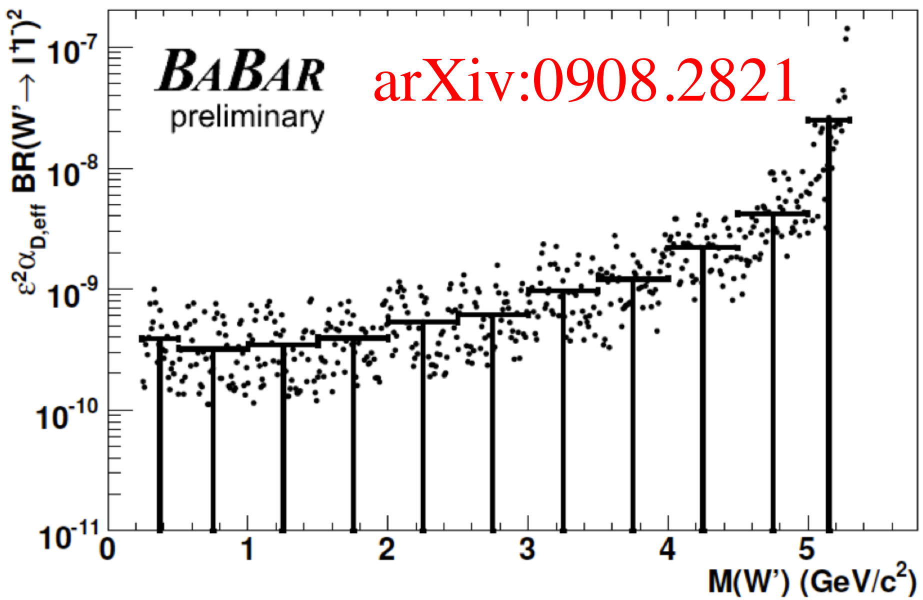
Dark sector gauge bosons not found in Y(3S) e Y(2S) decays

Look for $e^+e^- \to l^+l^-l^+l^-$ final states (4e, 2e,2μ,4μ) as a function of two-lepton mass

Full BaBar dataset (~540 fb^{-1})

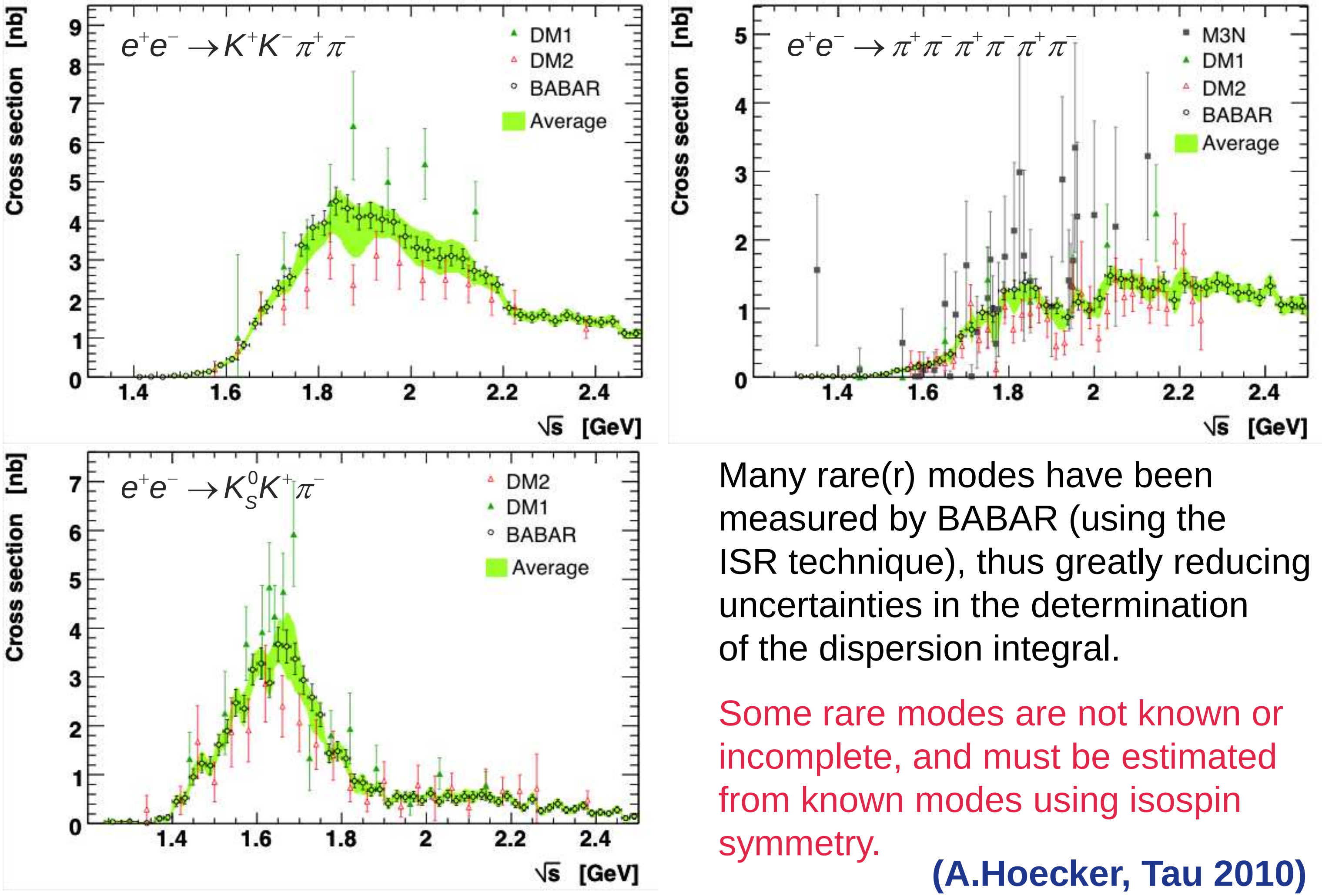
(Y.Kolomensky, Blois 2011)





$$\sigma(e^+e^- \to W'W' \to l^+l^-l'^+l'^-) < (25-60)\,\mathrm{ab}$$

$e^+e^- \rightarrow$ hadrons processes cross-sections precisely measured with ISR events

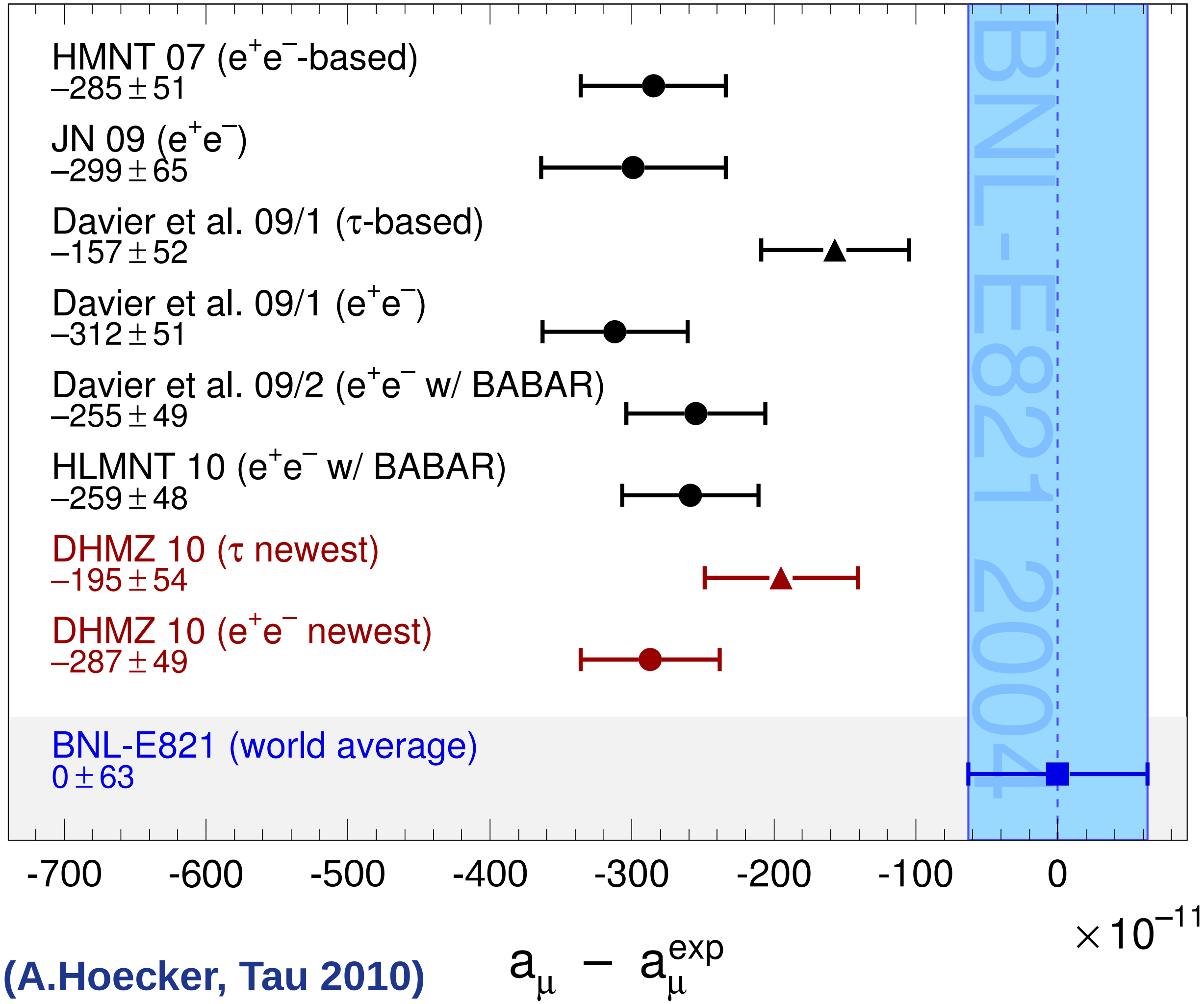


Many rare(r) modes have been measured by BABAR (using the ISR technique), thus greatly reducing uncertainties in the determination of the dispersion integral.

Some rare modes are not known or incomplete, and must be estimated from known modes using isospin symmetry.

(A.Hoecker, Tau 2010)

g–2 hadronic contribution calculation updated with BABAR measurements



(A.Hoecker, Tau 2010)

responsabilità e tesi di dottorato a 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
- Giulia Casarosa, tesi dottorato su D0-mixing
- Benjamin Oberhof, tesi dottorato su fisica del tau, Skim Manager

cambiamenti rispetto a luglio 2010

- Super*B* è stato approvato
  → accelerazione del passaggio di persone e percentuali da *BABAR* a Super*B*
- N.Neri diventa ricercatore a Milano

(Rad. B penguins) A_{CP} in $B \to X_s\gamma$ (SM prediction ~10^{-6})

A_{CP} inclusive $B \to X_{(s+d)}\gamma$:

383 M BB pairs

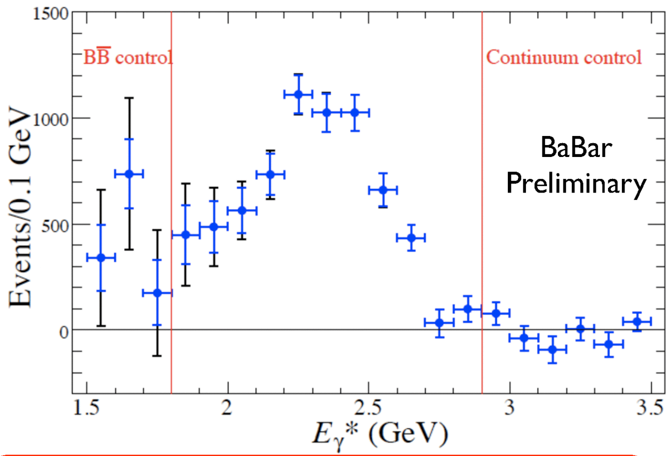
- Control regions:
  - continuum: On-Off Data = -100±138 events
  - BB: 1252±272±841⇒ 1.4σ (assumes no signal, where expect 100-400 signal events in low-energy tail)
- A_{CP} is insensitive to photon energy cut: optimize ⇒ (2.1-2.8) GeV
- Yields:
  - N(l+) = 2623±158
  - N(l-) = 2397±151
- Account for mistag and bias:

$$A_{CP} = \frac{A_{CP}^{\rm meas}}{1-2\omega} + \Delta A_{CP}$$

$\omega = 0.131 \pm 0.0064$
(B^0 mixing)

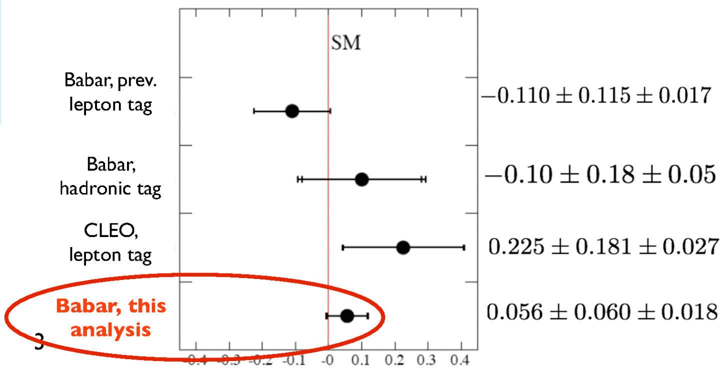
$\Delta A_{CP} = -.004 \pm 0.0013$
(A_{CP} of background)

Moriond EW, La Thuile, 2011



BaBar preliminary:

$A_{CP} = 0.056 \pm 0.060_{stat} \pm 0.018_{syst}$



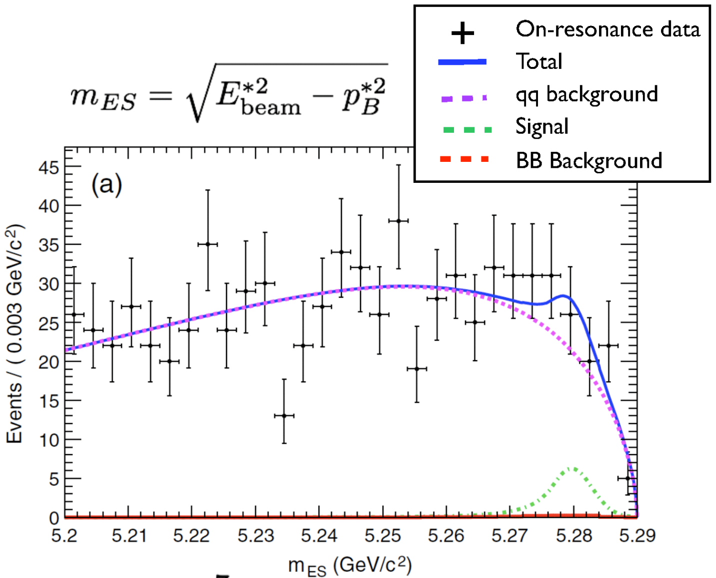
(Rad. *B* penguins) $B^0 \to \gamma\gamma$ (SM prediction $3.1^{+6.4}_{-1.6} \cdot 10^{-8}$)

$B^0 \to \gamma\gamma$: Results

467 M BB pairs

- 2-D likelihood fit to m_{ES} and ΔE variables
- Signal yield: $21.3^{+12.8}_{-11.8}$ events

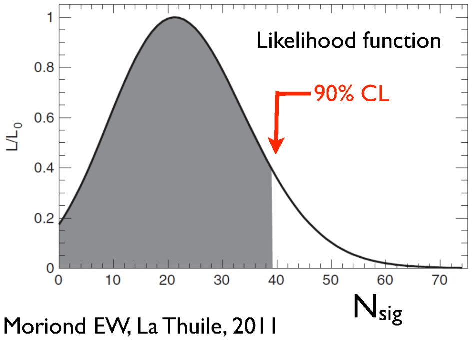
$$m_{ES} = \sqrt{E^{*2}_{\rm beam} - p^{*2}_B}$$



Measured branching fraction:

$$B(B \to \gamma\gamma) = (1.7 \pm 1.1_{\rm stat} \pm 0.2_{\rm syst}) \times 10^{-7}$$

(1.9σ significance)



Upper limit:

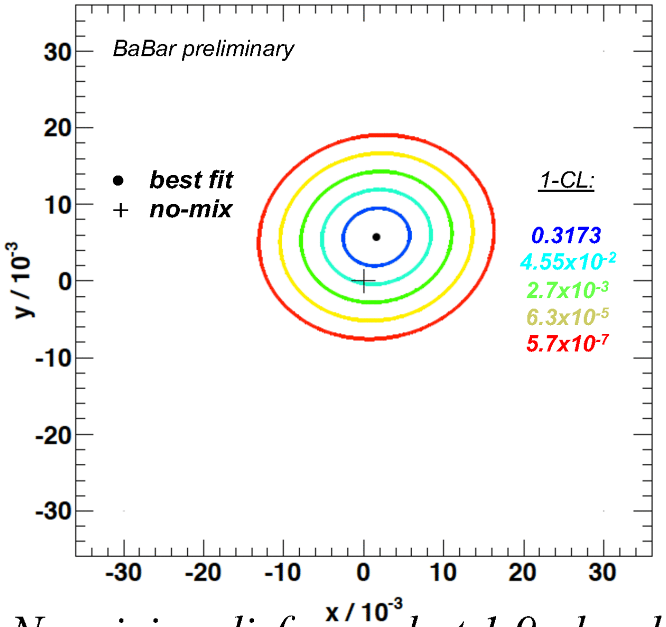
$$B(B \to \gamma\gamma) < 3.3 \times 10^{-7} \text{ at } 90\% \text{ CL}$$

improves best limit by factor ~ 2

Moriond EW, La Thuile, 2011 5 John Walsh, INFN Pisa

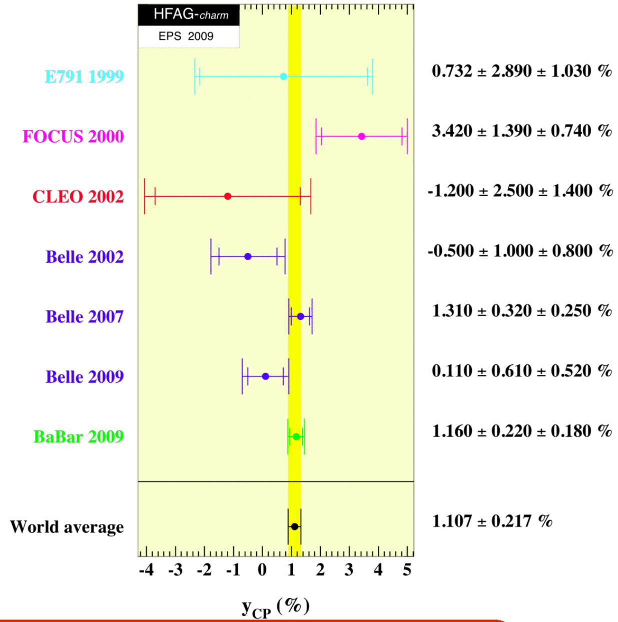
(Charm) D0-mixing – Dalitz method pubblicato, PRL 105, 081803 (2010)

Combined $K_S\pi^+\pi^- + K_SK^+K^-$ fit



No mixing disfavored at 1.9σ level

y_{CP} measurement using the entire data sample coming soon!



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.

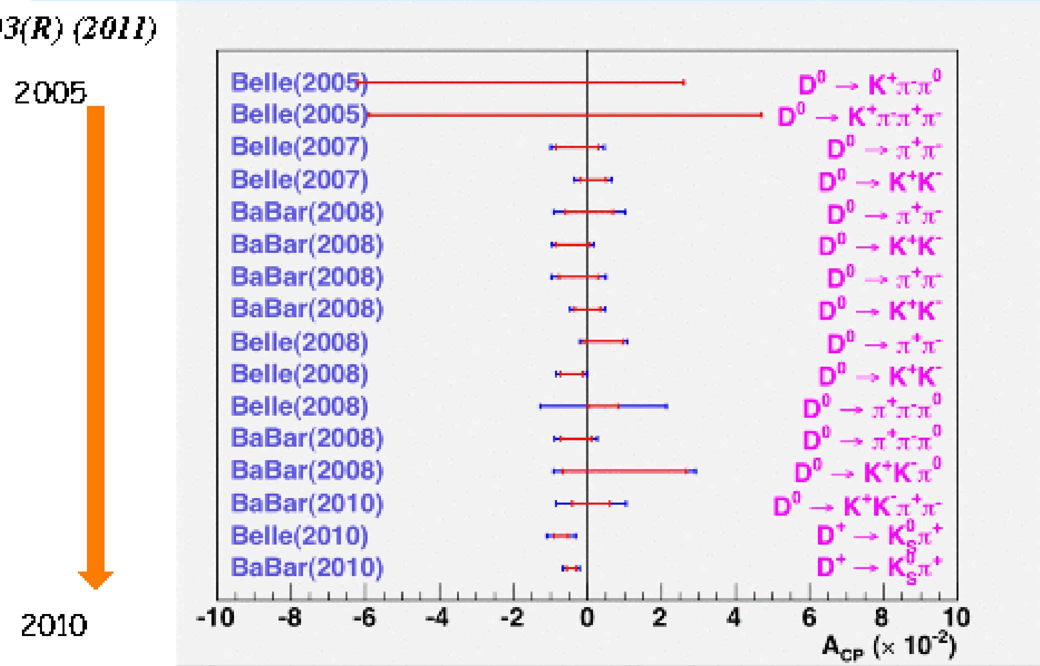
(Charm) time-integrated A_{CP} in $D^+ \to K_s\pi^+$, pubblicato

$D^+ \to K_s^0\pi^+$

A_{CP}=[-0.44±0.13(stat)±0.10(sys)]% (BaBar 470fb^{-1})

A_{CP}=[-0.71±0.19(stat)±0.20(sys)]% (Belle 673fb^{-1})

Phys. Rev. D 83, 071103(R) (2011)



CDF recently provided a very competitive result in $D^0 \to \pi^+\pi^-$

$$A_{CP}(D^0 \to \pi^+\pi^-) = [0.22 \pm 0.24\ (stat.) \pm 0.11\ (syst.)]\%$$

arXiv:1012.2415 [hep-ex]
5.94 fb^{-1} of data

(Charm) G.Casarosa, analisi in corso su D0-mixing, obiettivo 5σ

D^0 mixing and CPV with a Lifetime Ratio analysis

➔ **Experimental Situation:**

Combining all the measurements of D^0 mixing the no-mixing hypothesis is excluded with a confidence level equivalent to 10.2σ but *no single measurement exceeds 5σ*. *There is no* evidence of CPV in the charm sector.

➔ Experimental observables sensitive to mixing and to indirect CPV
[assuming no direct CPV and small mixing (|x|, |y| << 1)]

Mixing & indirect CPV observables

$$y_{CP} = \frac{\tau_D}{\langle\tau(CP+)\rangle} - 1 \quad \& \quad \Delta Y = \frac{\tau_D}{\langle\tau(CP+)\rangle} A_\Gamma$$

τ_D = D^0 lifetime

$\langle\tau(CP+)\rangle$ = effective D^0 lifetime for decays to CP+ eigenstates

$$A_\Gamma = \frac{\tau(D^0 \to CP+) - \tau(\overline{D}^0 \to CP+)}{\tau(D^0 \to CP+) + \tau(\overline{D}^0 \to CP+)}$$

➔ **Decay channels:**

- Tagged D^0: $D^{*+} \to D^0\pi^+$; $D^0 \to K^+K^-$, $\pi^+\pi^-$, $K\pi$
- Untagged D^0: $D^0 \to K^+K^-$, $K\pi$

the 2 samples are statistically independent

➔ The most significant measurement (4.1σ) of mixing is obtained combining the BaBar results using tagged and untagged samples.

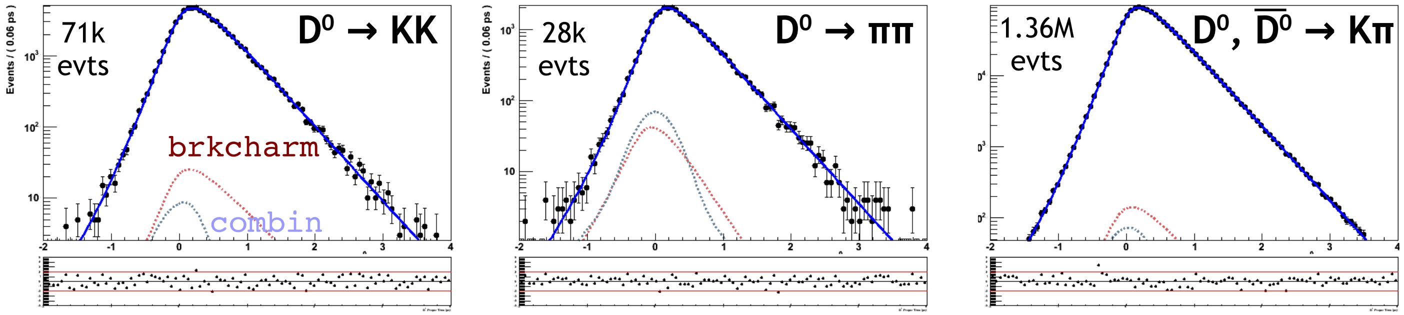
1

(Charm) G.Casarosa, analisi in corso su D0-mixing, obiettivo 5σ

Reduction of the statistical error

- Reduction of statistical error:
  - optimization of the selection → + 80% signal efficiency
  - perform a *simultaneous* fit to tagged and untagged samples sharing the parameters of the signal resolution function.

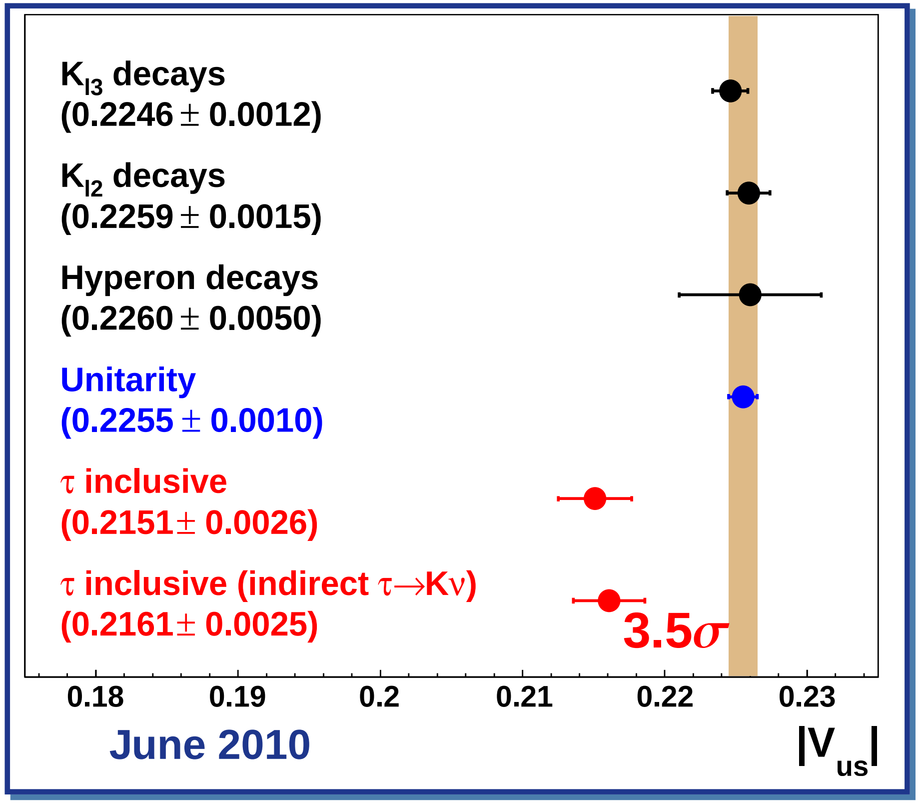
simultaneous fit to the tagged samples (same lum. as prev. analysis):

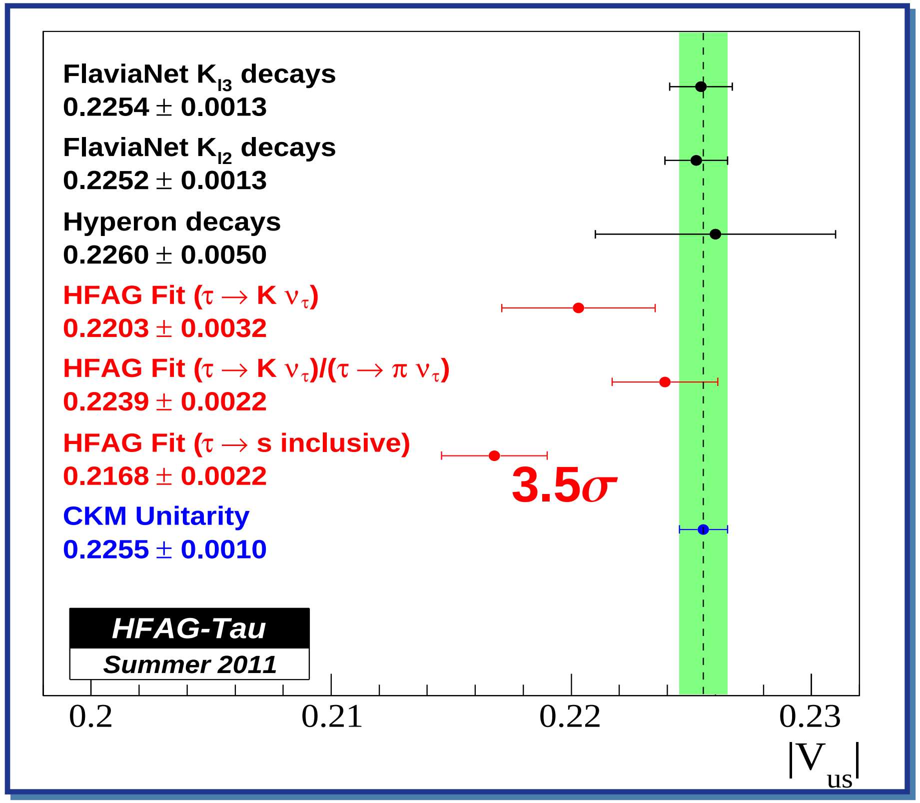


- statistical error reduction of the order of 35% for τ+ and τ- and of 25% for $\tau_{K\pi}$ w.r.t. the previous tagged analysis.

- use of full Y(4S) BaBar recorded data → +25% luminosity
  - stat error on lifetimes will decrease when adding also Run6 (+23% evts). 2

(Tau) HFAG report published, HFAG-tau update Summer 2011





- averages accounting for correlations, updated external parameters biases & uncertainties
- arXiv:1010.1589v2 [hep-ex], arXiv:1101.5138v1 [hep-ex]
- V_{us} from $\tau \to s$ inclusive discrepancy persists

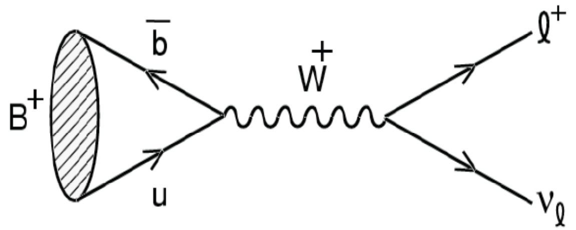
Personale e percentuali BABAR 2011 ⟶ 2012

		2011	2012	
1	C.Angelini	50%	50%	p.o.
	G.Batignani	30%	0%	p.o.
	S.Bettarini	20%	0%	ric.
	G.Calderini	30%	0%	ric.
2	G.Casarosa	70%	70%	dott.
3	A.Cervelli	40%	40%	ass.ric.
	F.Forti	30%	0%	p.a.
	M.Giorgi	20%	0%	p.o.
4	A.Lusiani	60%	50%	ric.
	N.Neri	40%	0%	ric.
5	B.Oberhof	70%	70%	dott.
	E.Paoloni	20%	0%	ric.
	G.Rizzo	20%	0%	ric.
6	G.Triggiani	20%	20%	p.a. (da confermare)
7	J.Walsh	60%	50%	primo ric.
	FTE fisici	5.8	3.5	
	F.Donno	30%	?	tecn.
	G.Terreni	20%	?	tecn.
	FTE tecnologi dalla sezione	0.5	0.0	
	Totale FTE	**6.3**	**3.3–3.5**	(da finalizzare)

- richieste: solo metabolismo

Backup slides

$B \to \tau\nu$ esclude ampio spazio di parametri di nuova fisica



$$\mathcal{B}(B^- \to \ell^- \bar{\nu}) = \frac{G_F^2 m_B}{8\pi} m_l^2 \left(1 - \frac{m_l^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

$$\mathcal{B}_{SM}(B^+ \to \tau^+\nu) = (0.80 \pm 0.20) \times 10^{-4}$$

(using f_B=190±13 MeV and V_{ub}=(3.5±0.4)×10^{-3}

Charged Higgs contribution:

$$\mathcal{B}(B \to \tau\nu) = \mathcal{B}(B \to \tau\nu)_{\mathrm{SM}} \times r_H$$

$$r_H = (1 - \frac{m_B^2}{m_H^2} \tan^2\beta)^2$$

05/31/2011

(Y.Kolomensky, Blois 2011)