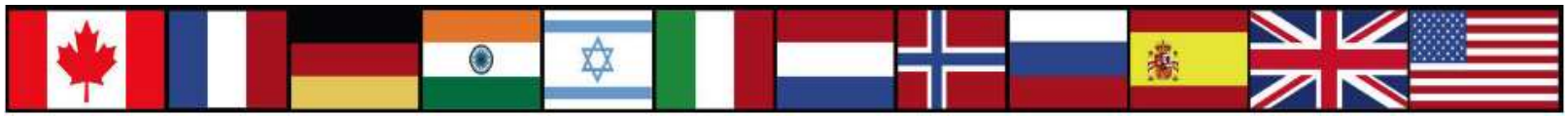
BABAR, stato e richieste 2013

Alberto Lusiani

INFN Pisa, 29 giugno 2012

Stato

- April 2008 end of data-taking
  - → 2009–2010 intense data analysis
    - → 2011–2012 steady data analysis
      - → 2013→ long term archival data analysis
- referee INFN hanno riconsiderato la chiusura nel 2013 (partecipazione italiana vigorosa)
- maggiori attività recenti locali e altre misure interessanti:
  - misura D^0 mixing (tesi PHD Giulia Casarosa, tesi master F.Padua)
  - analisi fisica B "radiative penguins" (J.Walsh convener)
  - fisica tau e ricerche di nuova fisica leggera (A.L. convener)
    - iniziata misura tau $g-2$ form factor (tesi PHD B.Oberhof)
  - Winter 2012 HFAG-tau report (A.L.)
  - rate anomali di $B \to \tau\nu$, $B \to D^{(*)}\tau\nu$
- Long Term Data Access (LTDA) farm entrata in funzione ad Aprile 2012
- B-factories legacy book in corso di review



BABAR Membership Numbers

73 institutions in 12 countries

	Faculty & Staff	Postdocs	Gr Student	ALL	Stud. Assoc.
CANADA	10	5	8	23	3
FRANCE	21	1	4	26	1
GERMANY	9	3	7	19	5
INDIA	1		1	2	
ISRAEL	1		3	4	
ITALY	52	8	12	72	6
NETHERLA	1	1		2	
NORWAY	2			2	
RUSSIA	8		3	11	
SPAIN	2	1	1	4	
UK	15	4		19	
USA	97	28	17	142	15
TOTAL	**219**	**51**	**56**	**326**	**30**
cf Nov 2011	219	50	54	323	22

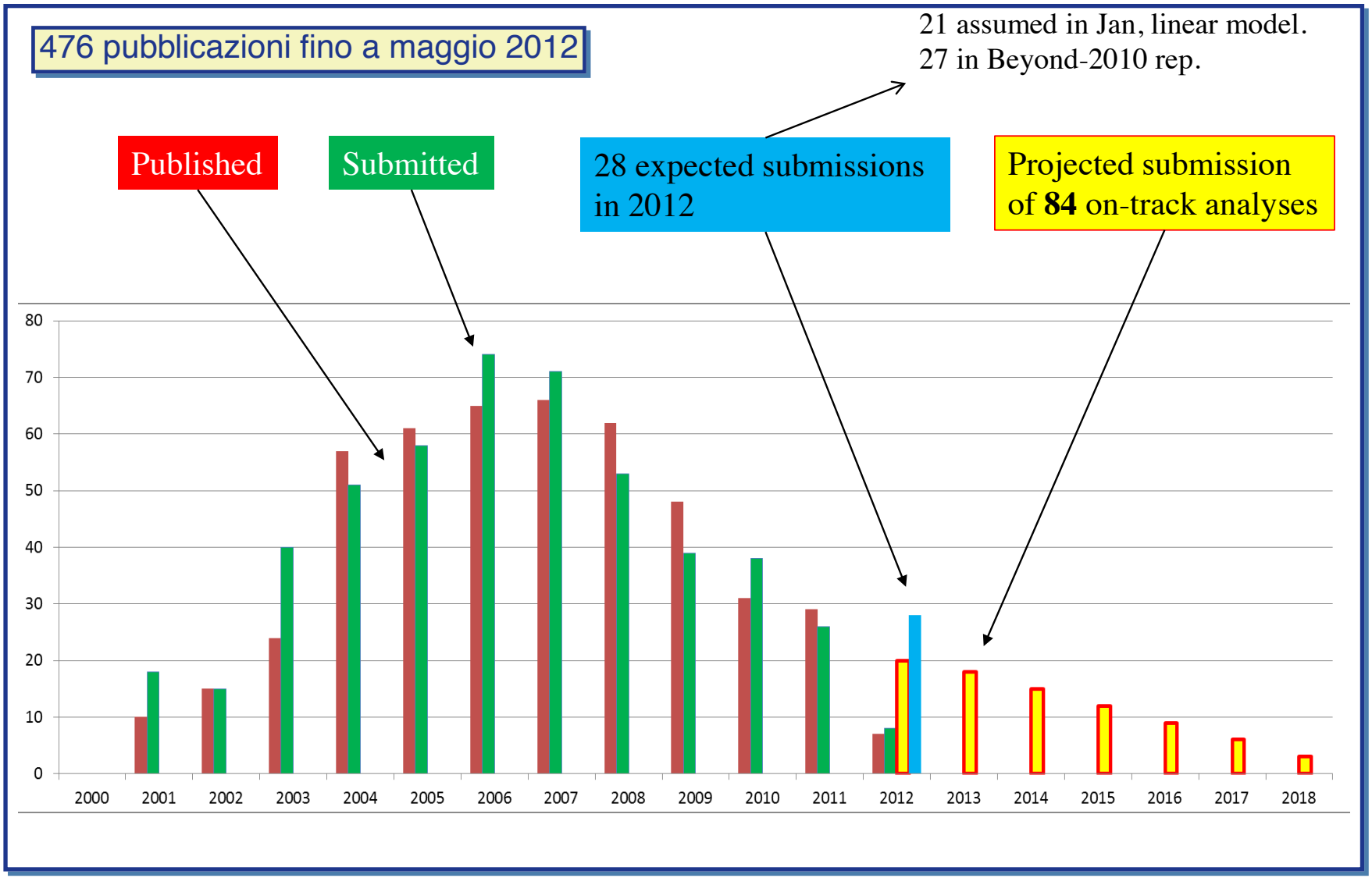
23 people joined BaBar as Members since 1 Jan 2010;
11 since 1 Jan 2011

Of these	23
CAN	4
FR	2
GE	3
IS	2
IT	5
SP	1
US	6

31 Associates joined since 1 Jan 2011;
12 Ugrad, 9 Grad,
3 Postdoc, 5 faculty/staff

Seven new Associates since 1 Jan 2012

Pubblicazioni di fisica, previste 28 sottomissioni nel 2012



Eccesso rispetto a MS in $B \to D^{(*)}\tau\nu$ / $B \to D^{(*)}\ell\nu$

Z. Phys, C46, 93 (1990)

- S.L. decays involving a τ have an additional helicity amplitude (for D*τν):

$$\frac{d\Gamma_\tau}{dq^2} = \frac{G_F^2 |V_{cb}|^2 |\mathbf{p}| q^2}{96\pi^3 m_B^2} \left(1 - \frac{m_\tau^2}{q^2}\right)^2 \left[\left(|H_{++}|^2 + |H_{--}|^2 + |H_{00}|^2\right) \left(1 + \frac{m_\tau^2}{2q^2}\right) + \frac{3}{2}\frac{m_\tau^2}{q^2} |H_t|^2 \right]$$

For Dτν, only H_{00} and H_t contribute!

- To test the SM Prediction, we measure

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

Leptonic τ decays only

Several experimental and theoretical uncertainties cancel in the ratio!

- $B\bar{B}$ events are fully reconstructed:
  - hadronic B tag (tag efficiency improved 2x)
  - reconstruction of $D^{(*)}$ and e or μ (extend to lower momenta)
  - no additional charged particles
  - kinematic selections: $q^2 > 4$ GeV^2

  Background suppression by BDT (combinatorial and D**ℓν)

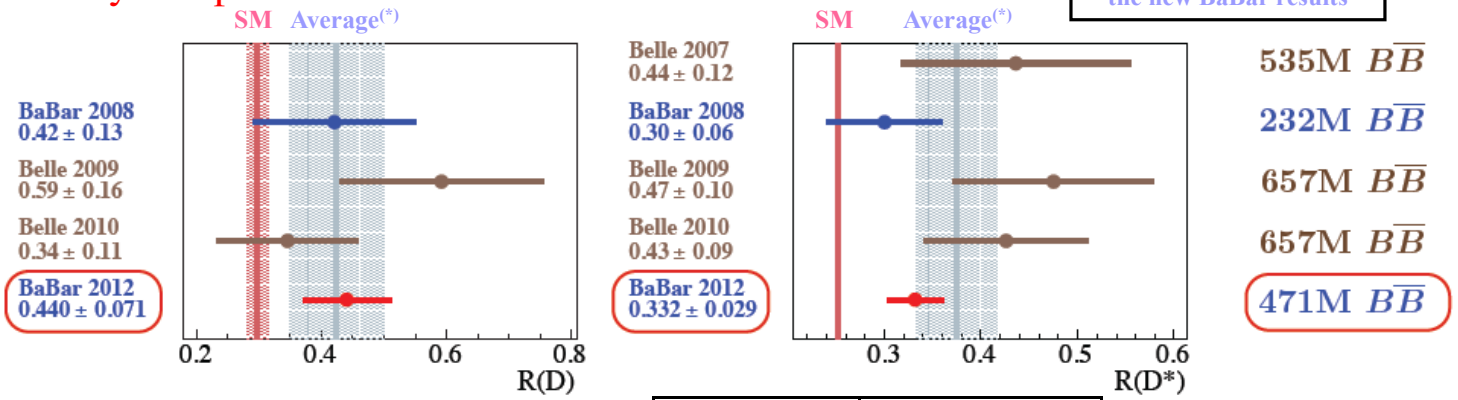
- Full BABAR data sample, MC correction based on data control samples

V. Lüth FPCP 2012 @ Hefei 2012 22

BABAR ha le migliori misure di $B \to D^{(*)}\tau\nu$ / $B \to D^{(*)}\ell\nu$

- Fully compatible with earlier measurements …

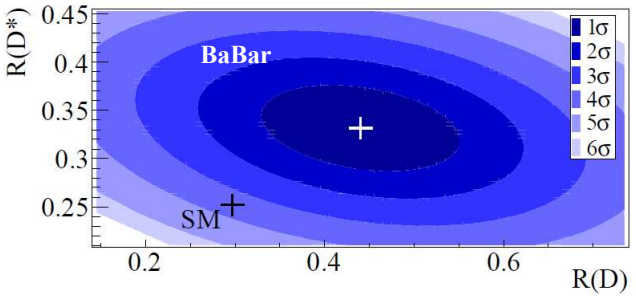
(*)Averages do not include the new BaBar results



- … and above the SM predictions!

	R(D)	R(D*)
BaBar 2012	0.440 ± 0.071	0.332 ± 0.029
Standard Model	0.293 ± 0.017	0.252 ± 0.003
Difference	2.0 σ	2.7 σ

- Combination of the two measurements
  - Correlation of –0.27
    → Feed down from D* in D sample
    → χ^2/NDF = 14.6/2,
    p value = 6.9×10^{-4} [3.4σ away]



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Confronto con modello 2HDM Type II

- A charged Higgs (2HDM type II) of spin 0 coupling to the τ will only affect H_t

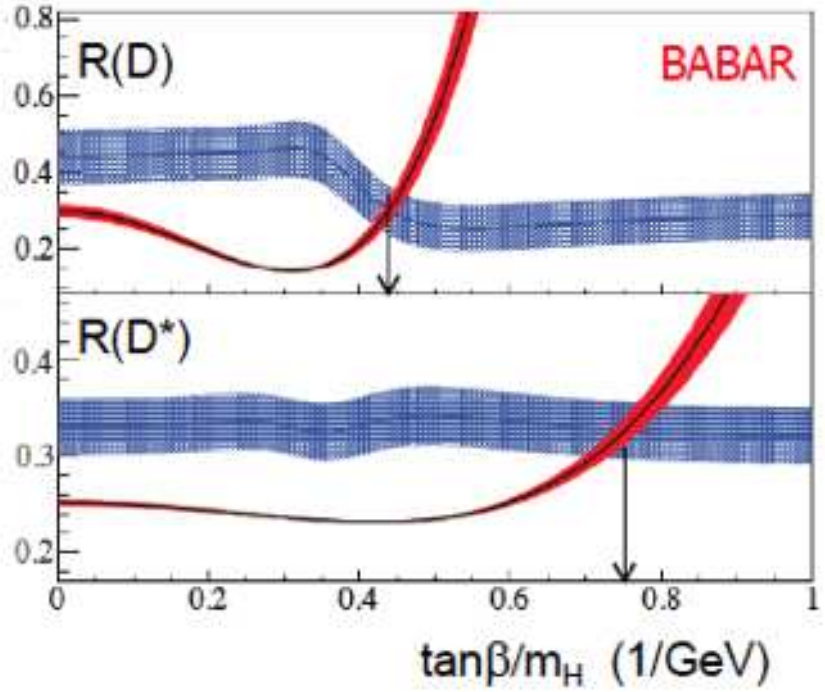
$$H_t^{2HDM} = H_t^{SM} \times \left(1 - \frac{\tan^2\beta}{m_{H\pm}^2} \frac{q^2}{1 \mp m_c/m_b}\right)$$

- for Dτν
+for D*τν

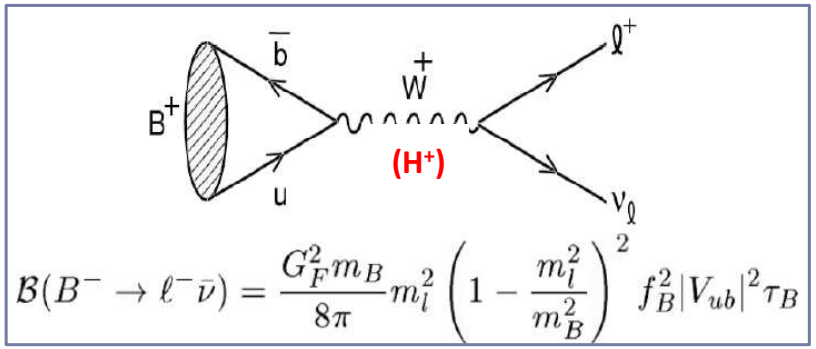
PRD 78, 015006 (2008)
PhD 85, 094025 (2012)

This could enhance or decrease the ratios R(D*) depending on $\tan\beta/m_H$

- We estimate the effect of 2DHM, accounting for difference in efficiency, and its uncertainty
- The data match 2DHM Type II at
  $\tan\beta/m_H = 0.44 \pm 0.02$ for R(D)
  $\tan\beta/m_H = 0.75 \pm 0.04$ for R(D*)
- The combination of R(D) and R(D*) excludes the Type II 2HDM in the full $\tan\beta$-m_H parameter space with a probability of >99.8%, provided M_H>10GeV !



Ci sarà aggiornamento su eccesso di $B \to \tau\nu$ a ICHEP 2012

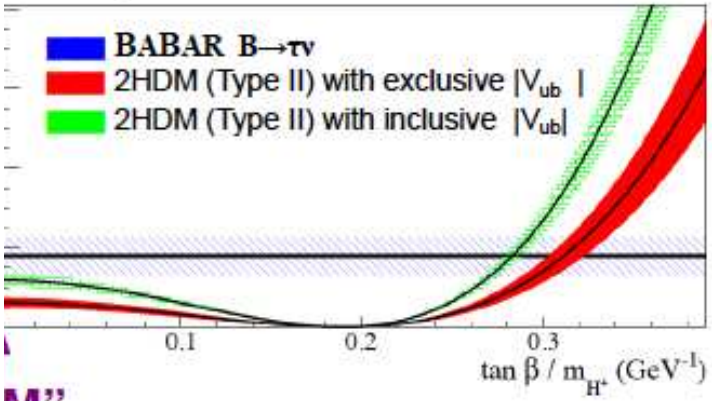


$$\mathcal{B}(B^- \to \ell^- \bar{\nu}) = \frac{G_F^2 m_B}{8\pi} m_l^2 \left(1 - \frac{m_l^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

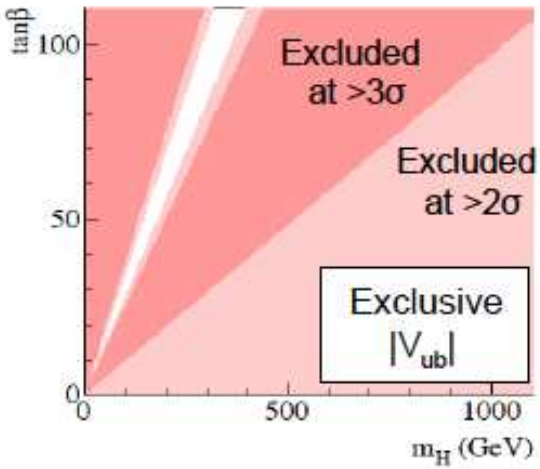
- Branching ratio affected by possible charged Higgs:
  - Exp: BF = (1.67 ± 30) x 10^{-4} (HFAG, 2011)
  - SM: BF = $\mathcal{B}(B \to \tau\nu)^{\rm SM} = (0.79 \pm 0.07) \times 10^{-4}$ [UTfit] ,
    $\mathcal{B}(B \to \tau\nu)^{\rm SM} = (0.76 \,^{+\,0.10}_{-\,0.06}) \times 10^{-4}$ [CKMfit]
  - Mystery: most NP scenarios (2HDM-II, MSSM) ***reduce*** BF wrt SM
- Tension with V_{ub} and sin 2β
- Only can be measured at e+e- machines
  - no new measurements until Super Flavour Factories come online

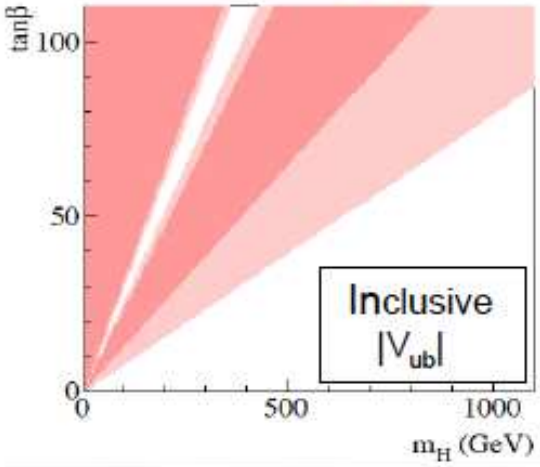
Vincoli su nuova fisica da $B \to \tau\nu$

$$\mathcal{B}(B^+ \to \tau^+\nu) = (1.83^{+0.53}_{-0.49}(\text{stat.}) \pm 0.24(\text{syst.})) \times 10^{-4}$$



M"





responsabilità e tesi di dottorato a Pisa

- J.Walsh: Radiative *B* Penguin decays physics analysis co-convener
- A.L.: Tau Physics & light New Physics Searches co-convener
  HFAG-tau convener since September 2011
- Giulia Casarosa, tesi dottorato su D0-mixing, vicina alla conclusione
- Benjamin Oberhof, tesi dottorato su τ $g-2$ form factor

cambiamenti rispetto a luglio 2011

- Alberto Cervelli ha lasciato Pisa per un post-doc a Berna
- Giulia Casarosa ha ottenuto un assegno di ricerca

D^0-mixing from lifetime ratio into CP-even states (G.Casarosa)

➔ We perform a simultaneous fit to 5 signal channels and extract:

flavour tagged	• $D^{*+} \to D^0 \pi_s^+$; $D^0 \to K^+K^-$ • $D^{*+} \to D^0 \pi_s^+$; $D^0 \to \pi^+\pi^-$ • $D^{*+} \to D^0 \pi_s^+$; $D^0 \to K^-\pi^+, K^+\pi^-$
flavour untagged	• $D^0 \to K^+K^-$ • $D^0 \to K^-\pi^+, K^+\pi^-$

- Mixing:

$$y_{CP} = \frac{\tau_D}{2}\left(\frac{1}{\tau^+} + \frac{1}{\overline{\tau}^+}\right) - 1$$

- Indirect CPV:

$$\Delta Y = \frac{\tau_D}{2}\left(\frac{1}{\tau^+} - \frac{1}{\overline{\tau}^+}\right)$$

- in general y_{CP} and ΔY depend on the final state
- in case of no *CP* violation: $y_{CP} = y$ and $\Delta Y = 0$

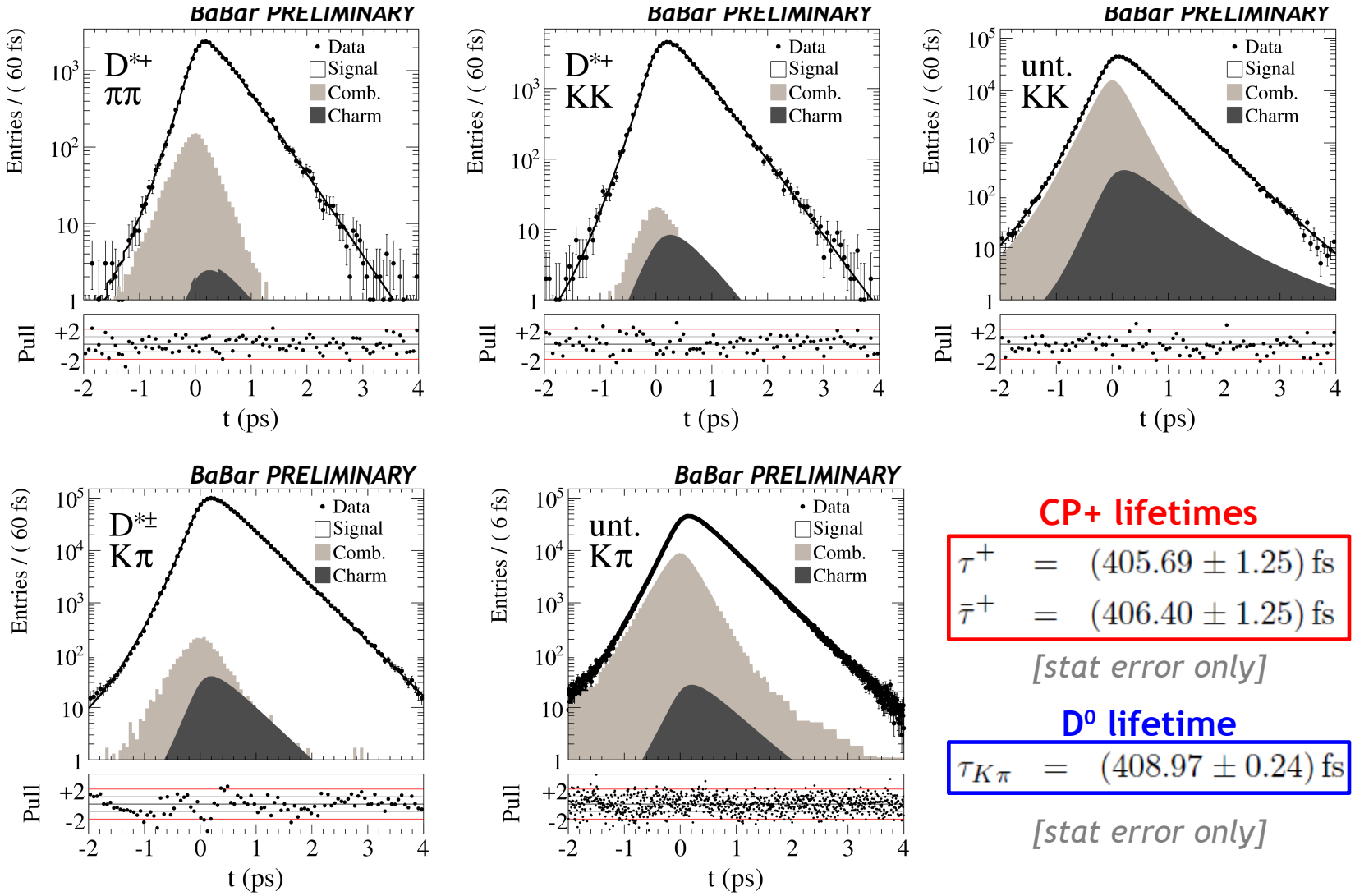
- τ_D = D^0 lifetime ($D^0 \to K\pi$)
- τ^+ and τ^+ = D^0 ($\overline{D}^0$) effective lifetime for decays to CP+ eigenstates ($D^0 \to$ KK, ππ)

➔ Experimental assumptions:

- small mixing (|x|, |y| << 1) → proper time distribution are exponential with effective lifetimes to a very good approximation; [PRD 80. 076008 (2009)]
- not sensitive to direct CPV + weak phase φ does not depend on final state → KK and ππ modes share common effective lifetimes,
  - ✔ crosscheck fit on data.

$$y_{CP} = y\cos\phi - \frac{A_M}{2}\, x\sin\phi$$
$$\Delta Y = -x\sin\phi + \frac{A_M}{2}\, y\cos\phi$$

D^0-mixing from lifetime ratio into CP-even states (G.Casarosa)



CP+ lifetimes

$$\tau^+ = (405.69 \pm 1.25)\ \text{fs}$$
$$\bar{\tau}^+ = (406.40 \pm 1.25)\ \text{fs}$$

[stat error only]

D^0 lifetime

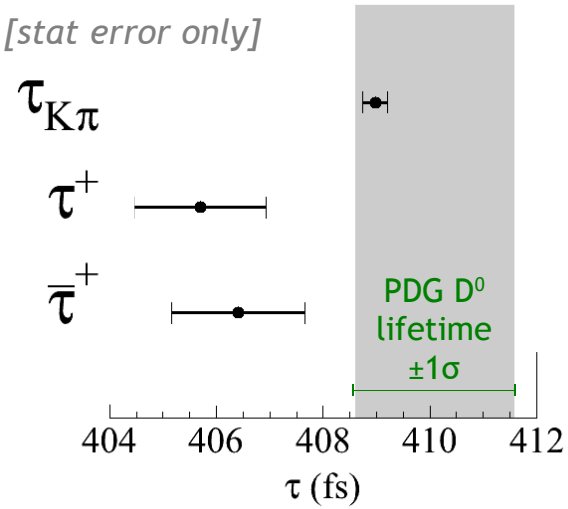
$$\tau_{K\pi} = (408.97 \pm 0.24)\ \text{fs}$$

[stat error only]

BABAR has smallest single-measurement uncertainty on y_{CP} (G.Casarosa)

BaBar PRELIMINARY

[stat error only]



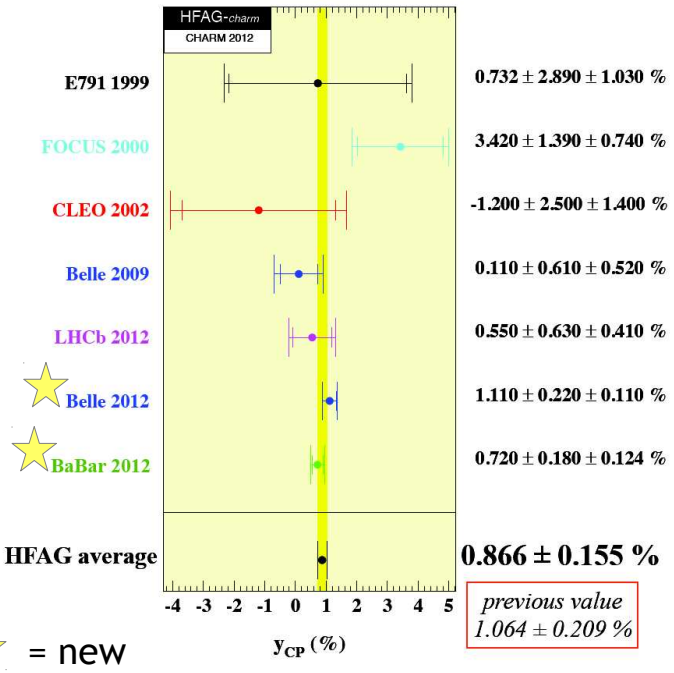
BaBar PRELIMINARY

$$y_{CP} = [0.720 \pm 0.180(\text{stat}) \pm 0.124(\text{syst})]\%$$

$$\Delta Y = [0.088 \pm 0.255(\text{stat}) \pm 0.058(\text{syst})]\%$$

➔ exclude no-mixing hypothesis @ 3.3σ
➔ no CPV observed

- most precise single measurement of y_{CP};
- this measurement favors lower values for y_{CP}, in closer agreement with HFAG value for y;
- this result is compatible with previous *BaBar* results [PRD 80, 071103 (2009)], [PRD 78, 011105 (2008)] :
  - $\Delta Y = (-0.26 \pm 0.36 \pm 0.08)$ % (sign difference in the def.)
  - $y_{CP} = (1.16 \pm 0.22 \pm 0.18)$ %
- this result supersedes the previous *BaBar* results.



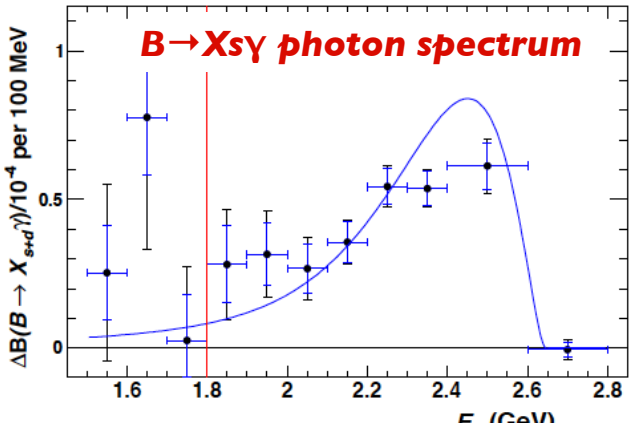
= new

Radiative *B* penguins (analysis group convener J.Walsh)

- Still an active group, working to finish analyses on full Babar data set
- Several new results have emerged in the last 12 months:
  - Rates and asymmetries in $B \to K^{(*)} l^+ l^-$ decays:
  - Angular analysis of $B \to K^* l^+ l^-$ decays
  - Branching fraction and CP asymmetry of $B \to X_s \gamma$
    - semi-inclusive with 38 sub-modes
    - fully inclusive with lepton-tags
  - Search for lepton number violation in $B^- \to h^+ l^- l^-$ decays

Radiative *B* penguins preliminary results

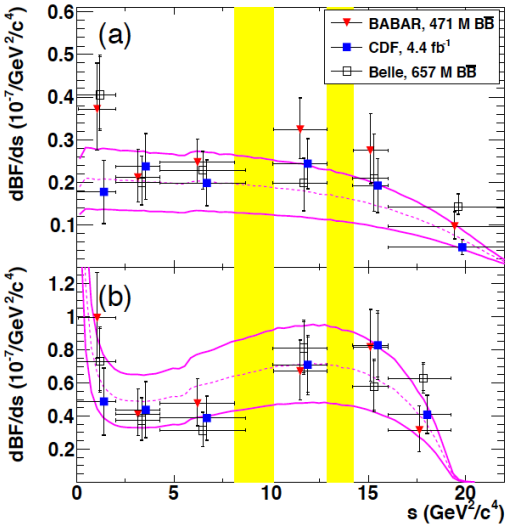
B→Xsγ photon spectrum



$$\mathcal{B}(B \to X_s\gamma, E_\gamma > 1.8\ GeV) = (3.21 \pm 0.33) \times 10^{-4}$$

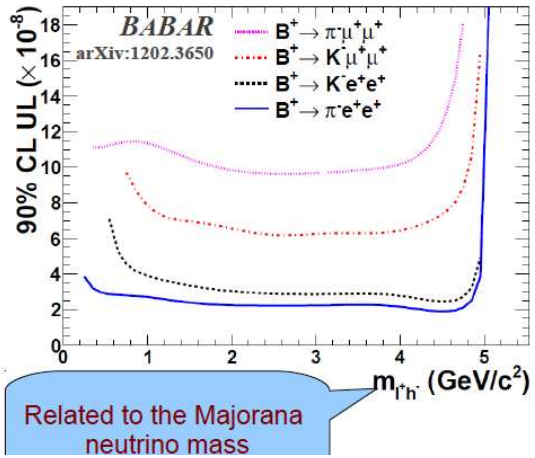
$$A_{CP}(B \to X_{s+d}\gamma) = 0.057 \pm 0.063$$

B→K(*)l+l- rates



arXiv:1204.3933

Search for LNV



arXiv:1202.3650

Secluded sector dark matter candidates search (A.L. analysis group convener)

The search continues for WIMPs, as the favoured candidates for dark matter, motivated by SUSY and the proposed existence of a lightest supersymmetric particle (LSP)

In (non-SUSY) models with hidden (dark) gauge sectors, WIMP-like dark matter particles may be charged, and can annihilate into pairs of dark photons, A', the gauge bosons of the new group. The dark photon mass is generated by a Higgs mechanism, by including a dark Higgs boson, h'

Such models could explain observed positron excess by PAMELA, FERMI …

Astrophysics constrains A' mass below a few GeV, and the h' mass could also be low

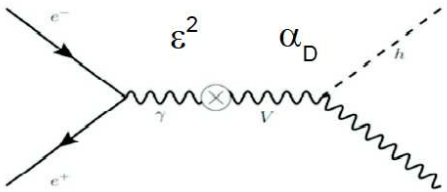
The dark sector has a coupling constant α_D and mixing strength ε with SM

We present a BaBar search for such a light, dark-sector Higgs boson and put limits on the product $\alpha_D \varepsilon^2$

Secluded sector dark matter candidates search

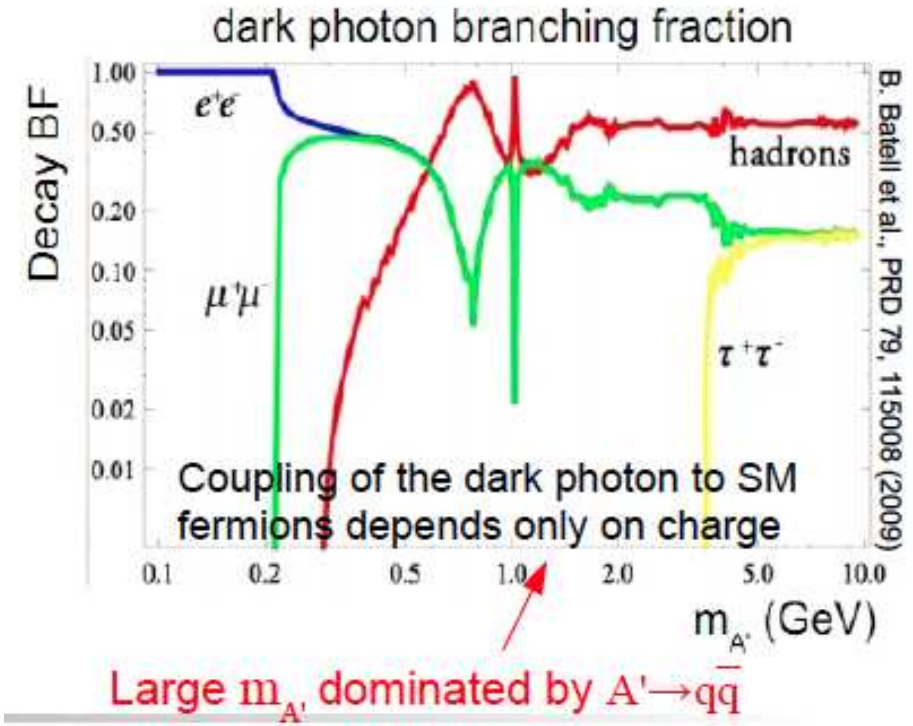
BaBar Collaboration, Phys Rev Lett 108, 211801 (2012)

We search for the "Higgs-strahlung" process
$e^+e^- \to A'^* \to h'A'$ with $h' \to A'A'$
(with $m_{h'} > 2m_{A'}$)



Event selections:

- Uses full BaBar dataset of 516fb^{-1}
- Full reconstruction of all 3 dark photons in $A' \to e^+e^-$, $\mu^+\mu^-$, $\pi^+\pi^-$ (using PID)
  - Requires 6 tracks with mass >0.95√s
- Partial reconstruction with 2 A' decays via lepton pairs and the other reconstructed by kinematic constraints
  - Requires 4 or more tracks
- Require the 3 A' candidates to have similar masses



Secluded sector dark matter candidates search

Results:

The search covers h′ mass from 0.8 to 10 GeV with A′ mass range 0.25 to 3 GeV

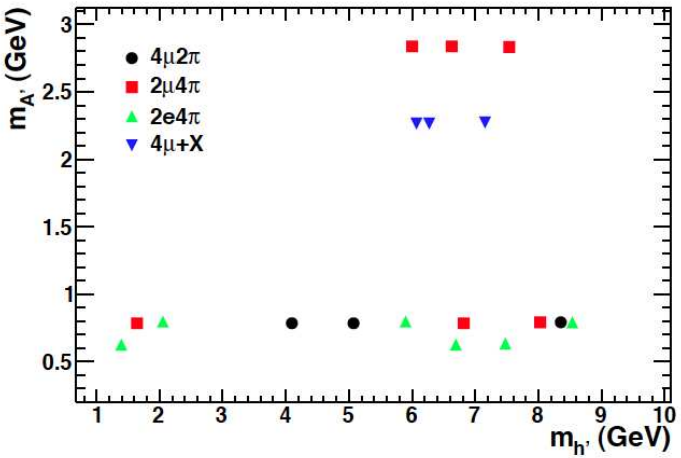
We see 6 events in the data (each candidate has 3 entries for the possible h′ → A′A′ assignments)

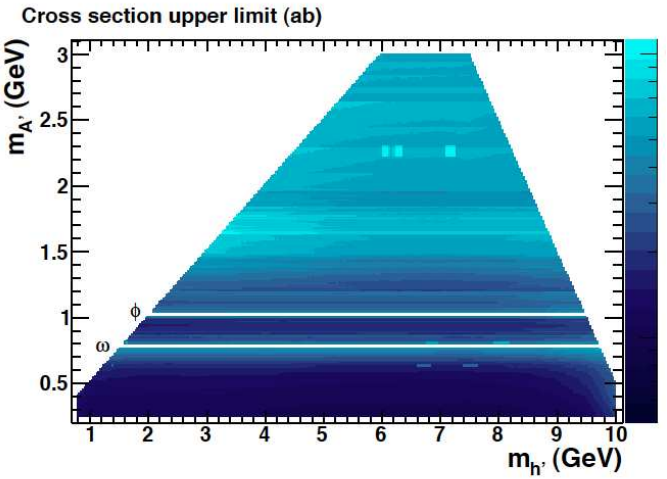
No candidates in the 6-lepton search

4 candidates consistent with $e^+e^- \to e^+e^-\rho\rho$ or 6π

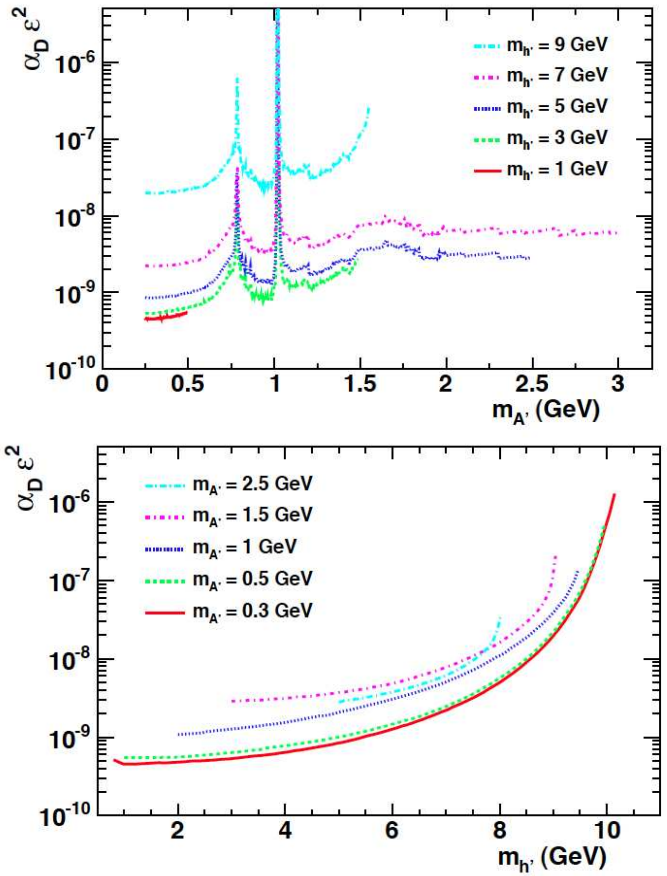
Results consistent with expectation from pure background hypothesis (using control samples)

We set limits:
$\sigma(e^+e^- \to h'A', h' \to A'A') < 10\text{-}100$ ab at 90% CL





No dark matter candidate found, upper limits set



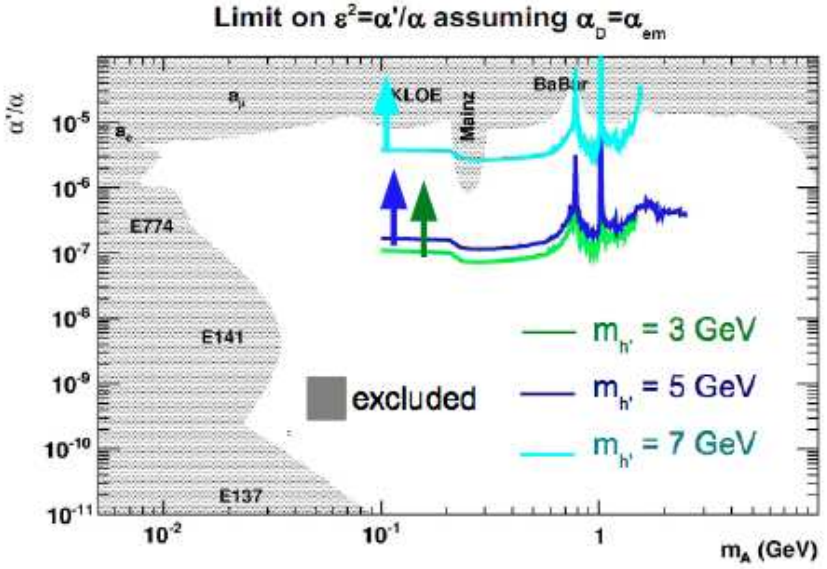
Upper limits (90% CL) as functions of A′ and h′ masses

$\alpha_D \varepsilon^2 <$ few x 10^{-10} at 90% CL

$\alpha_D \equiv g_D^2/4\pi$

g_D = dark sector coupling constant

ε = mixing strength



J. D. Bjorken, R. Essig, P. Schuster and N. Toro, Phys. Rev. D80, 075018 (2009) and references therein

S. Giovannella, J. Phys. Conf. Ser. 335, 012067 (2011)

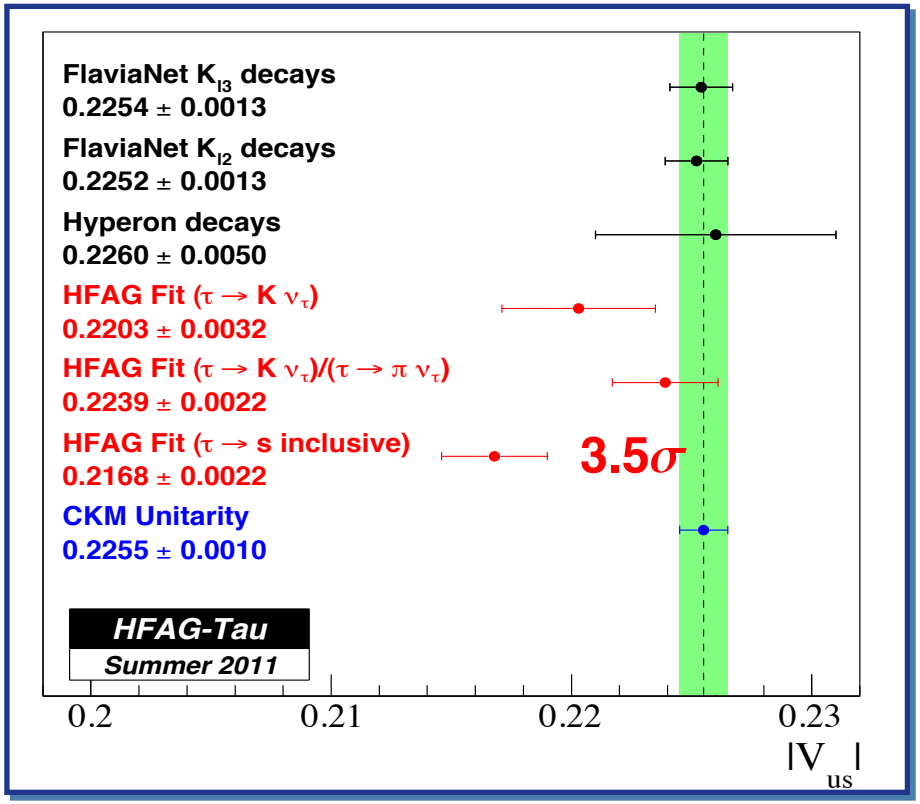
S. Abrahamyan et al. [APEX Collab.], Phys. Rev. Lett. 107, 191804 (2011)

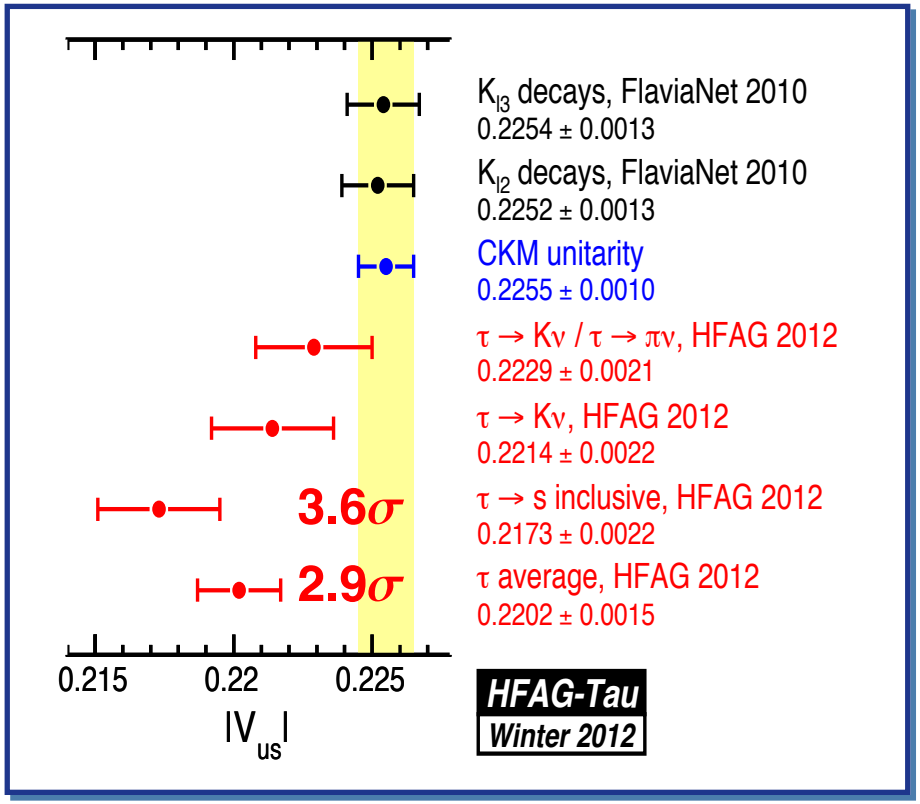
Also no light (NMSSM) Higgs found yet

Channel	Analysis Status
$\Upsilon(2,3S) \to \gamma A^0; A^0 \to \mu^+\mu^-$	PRL 103, 081803 (2009)
$\Upsilon(1S) \to \gamma A^0; A^0 \to \mu^+\mu^-$	In progress
$\Upsilon(3S) \to \gamma A^0; A^0 \to \tau^+\tau^-$	PRL 103, 181801 (2009)
$\Upsilon(1S) \to \gamma A^0; A^0 \to \tau^+\tau^-$	In progress
$\Upsilon(1S) \to \gamma A^0; A^0 \to$ invisible	PRL 107, 021804 (2011)
$\Upsilon(2,3S) \to \gamma A^0; A^0 \to$ hadrons	PRL 107, 221803 (2011)
$\Upsilon(1S) \to \gamma A^0; A^0 \to$ hadrons	In progress
$\Upsilon(1S) \to \gamma A^0; A^0 \to \gamma\gamma$	In progress

- More than 4 years after the end of data-taking BaBar is still able to search for new particles and probe the parameter space for BSM physics
- Searches for low-mass Higgs and dark sector particles are ongoing
- So, far no evidence for either
- But we haven't yet excluded all possibilities

Winter 2012 HFAG report about to be published (A.L. HFAG-Tau convener)





- first average of all 3 tau $|V_{us}|$ determinations, accounting for correlations
- prelim. HFAG-Tau report at `http://www.slac.stanford.edu/xorg/hfag/tau/winter-2012/`

Personale e percentuali *BABAR* 2012 → 2013

		2011	2012	
1	C.Angelini	50%	50%	p.o.
2	G.Casarosa	70%	50%	ass.ric.
	A.Cervelli	40%	0%	ora a Berna
3	A.Lusiani	50%	50%	ric.
4	B.Oberhof	70%	70%	dott.
5	G.Triggiani	20%	20%	p.a. (da confermare)
6	J.Walsh	50%	50%	primo ric.
	FTE fisici	3.5	2.9	
	G.Terreni	10%	?	tecn.
	FTE tecnologi dalla sezione	0.1	0.0	
	Totale FTE	**3.6**	**2.9**	(preliminare)

- richieste: solo metabolismo

BABAR Pisa, richieste 2013

Richieste	k€
missioni interne 1.4 kE * 2.9 FTE	4.06
missioni estere 1.0 m.u. * 2.9 FTE * 5.40 kE	15.66
consumi 1.5 kE * 2.9 FTE	4.35
nessuna richiesta per materiale inventariabile	0.00

nessuna specifica richiesta di servizi di sezione