Hadronic Tau Decays at BaBar

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BaBar Collaboration

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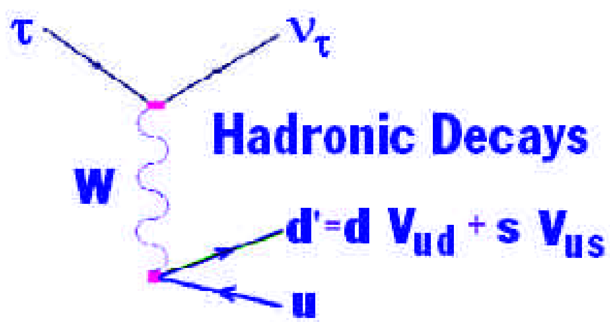
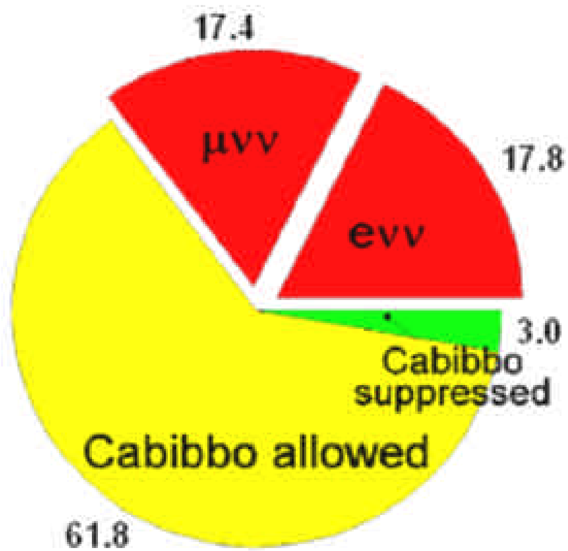
BABAR

Strange and non-Strange τ-Decays

$$B_{had} = 1 - B_e - B_\mu$$



$$R_{\tau,Strange} = R_\tau - R_{\tau,non-Strange}$$



Strange τ Decays:

Mode	$\mathcal{B}(10^{-3})$
K^-	6.81 ± 0.23
$K^-\pi^0$	4.54 ± 0.30
$\bar{K}^0\pi^-$	8.78 ± 0.38
$K^-\pi^0\pi^0$	0.58 ± 0.24
$\bar{K}^0\pi^-\pi^0$	3.60 ± 0.40
$K^-\pi^+\pi^-$	3.30 ± 0.28
$K^-\eta$	0.27 ± 0.06
$(\bar{K}3\pi)^-$ (estimated)	0.74 ± 0.30
$K_1(1270)^- \to K^-\omega$	0.67 ± 0.21
$(\bar{K}4\pi)^-$ (estimated) and $K^{*-}\eta$	0.40 ± 0.12
Sum	29.69 ± 0.86

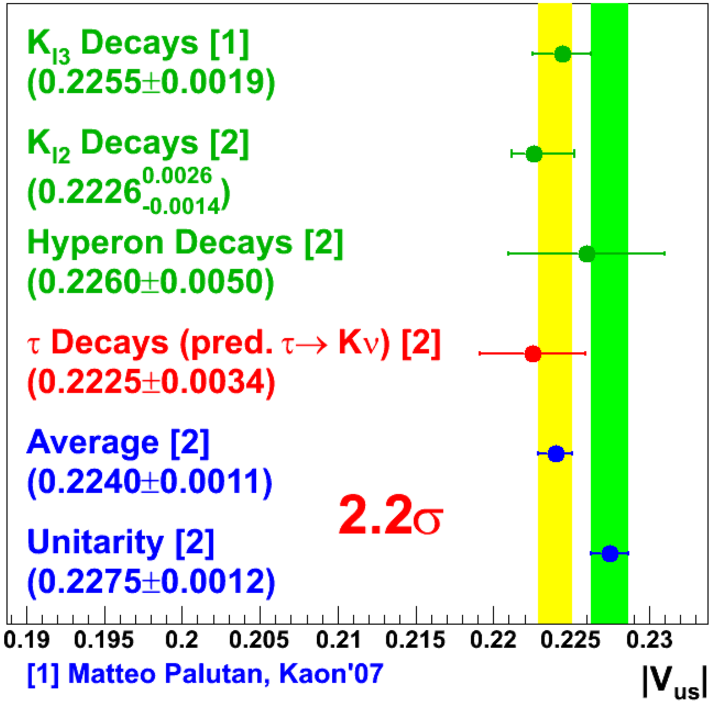
Davier, Hocker, Zhang(RMP 78, 1043, 2006)

τ-Spectral Density

Hadronic Width: $R_\tau = \frac{\Gamma(\tau^- \to \upsilon_\tau \text{hadrons}^-)}{\Gamma(\tau^- \to \upsilon_\tau \bar{\upsilon}_e e^-)}$

Flavour SU(3) Breaking: $\delta R^{kl}_{\tau,\text{Theory}}(m_s) = \frac{R^{kl}_{\tau,\text{non-Strange}}}{|V_{ud}|^2} - \frac{R^{kl}_{\tau,\text{Strange}}}{|V_{us}|^2}$

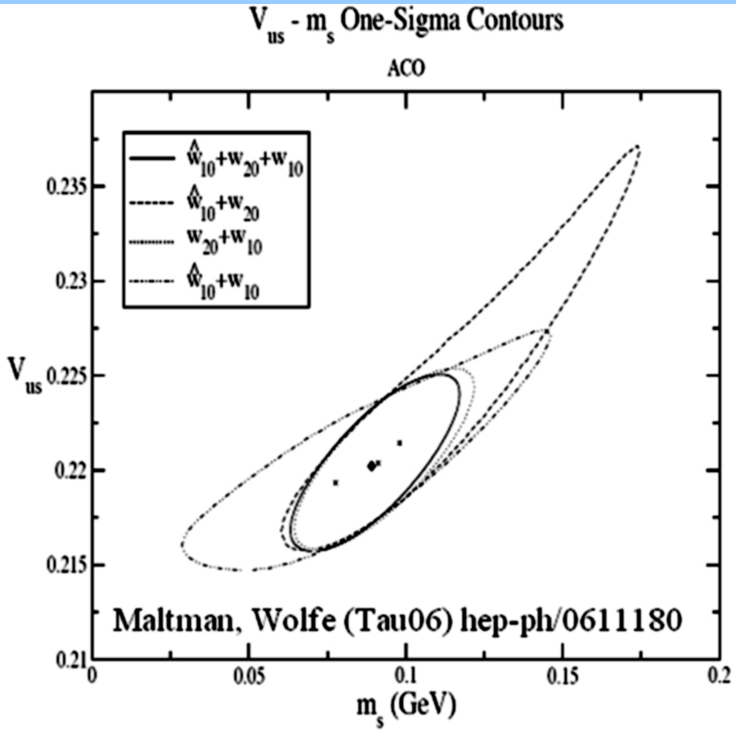
Extract |Vus| with Fixed m_s



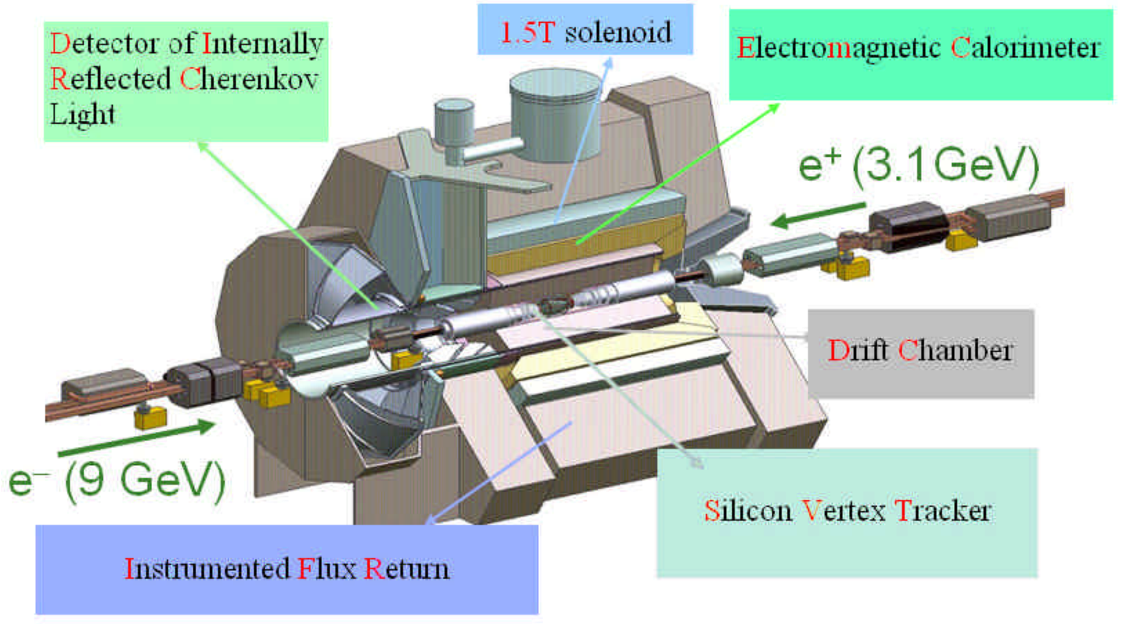
[1] Matteo Palutan, Kaon'07

[2] Matthias Jamin, Moriond EW'07

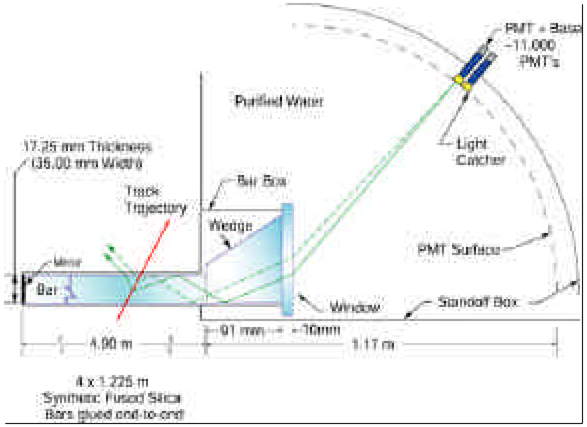
Simultaneously extract |Vus| and m_s

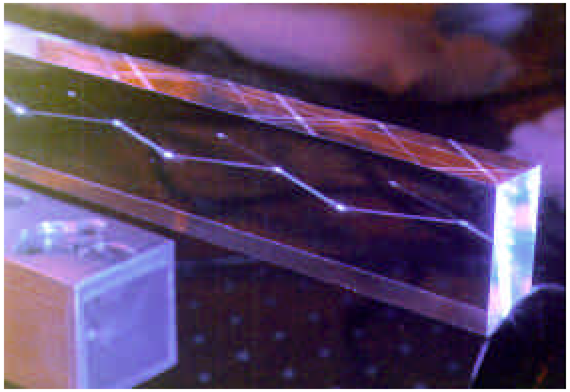


The BaBar Detector at SLAC

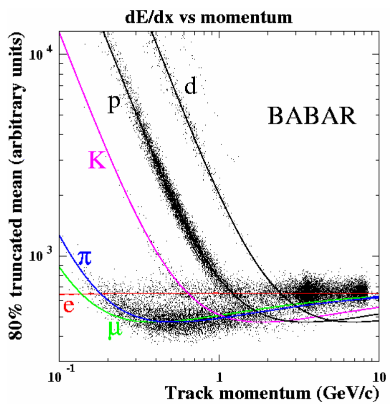


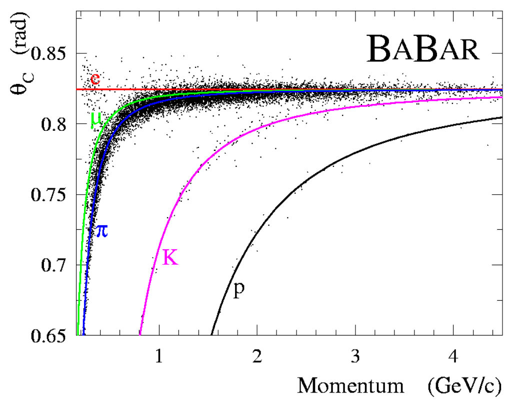
DIRC used for K/p separation





Excellent K/p Separation





The Number of t's at BaBar

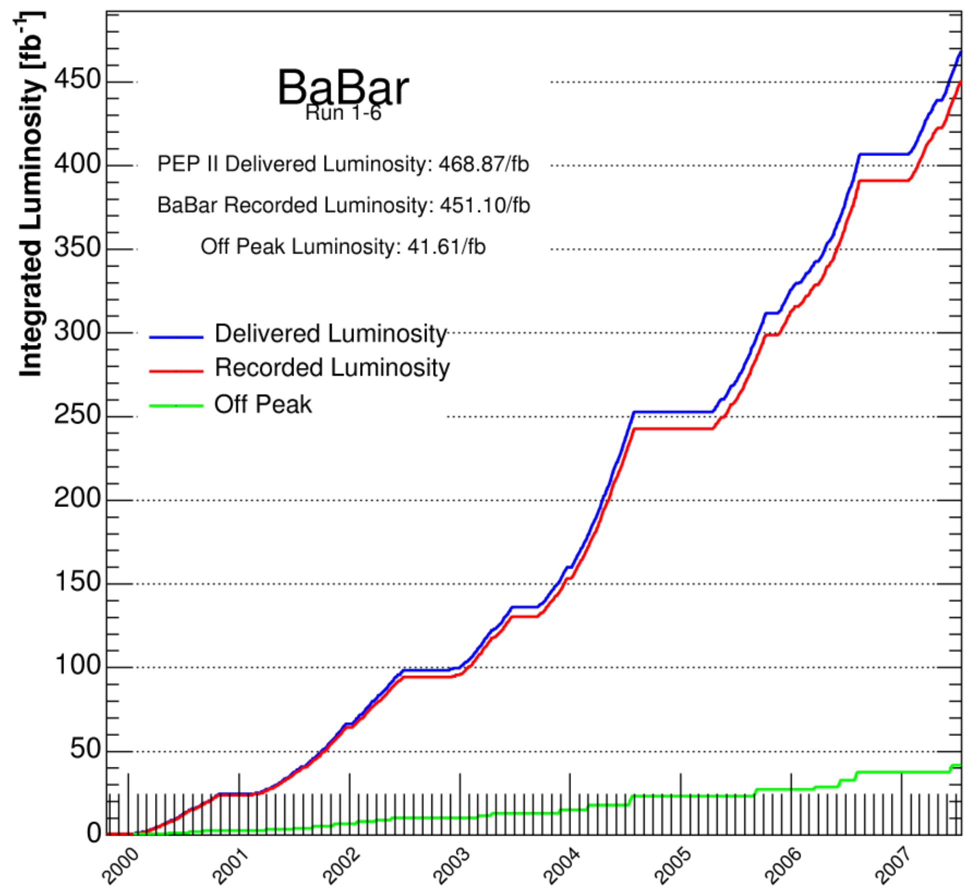
The t$^-$®K$^-$p^{0}n analysis uses **230fb^{-1}** Data (on-peak and off-peak) and the t$^-$®**h$^-$h$^-$h$^+$**n analysis uses **342fb^{-1}** Data (on-peak and off-peak)

Cross Section at BaBar

$\sigma(\tau^+\tau^-)=(0.919\pm0.003)$nb

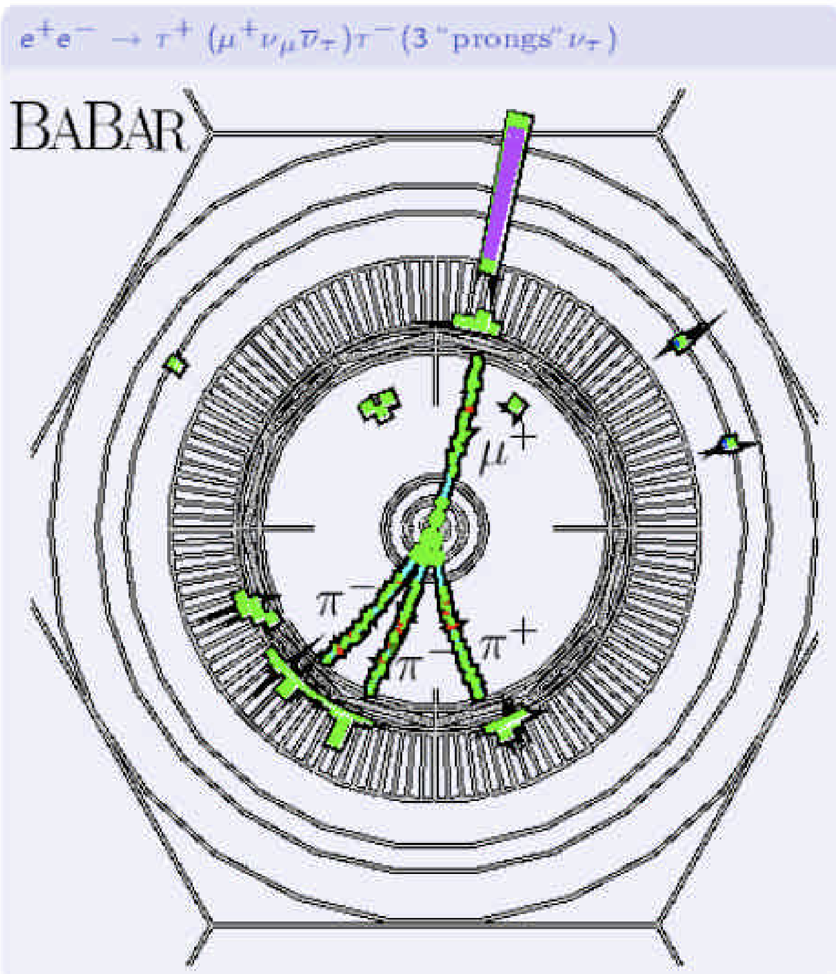
arXiv:0706.3235 [hep-ph]

Experiment	Number of τ Pairs
LEP	$\sim 3\times10^5$
CLEO	$\sim 1\times10^7$
BaBar	$\sim 4\times10^8$
Belle	$\sim 7\times10^8$

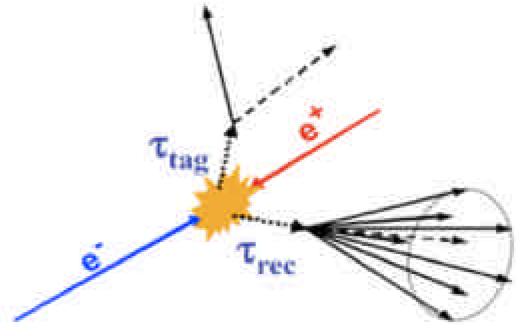


t -Pair Events

τ-Pair Signature:
Leptonic+Hadronic Decay

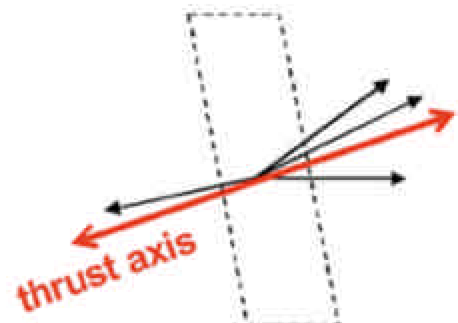


The hadronic decay and lepton tag are well separated in space.



Lab Frame

This allows the hemisphere to be separated with the thrust in the CM.



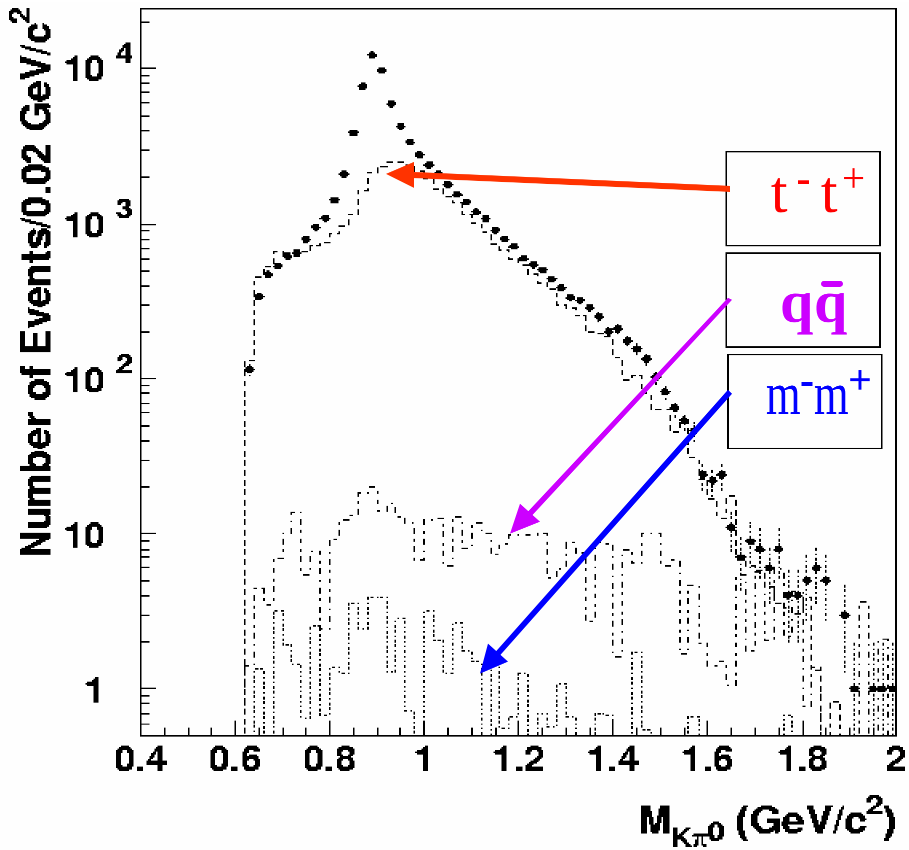
CM Frame

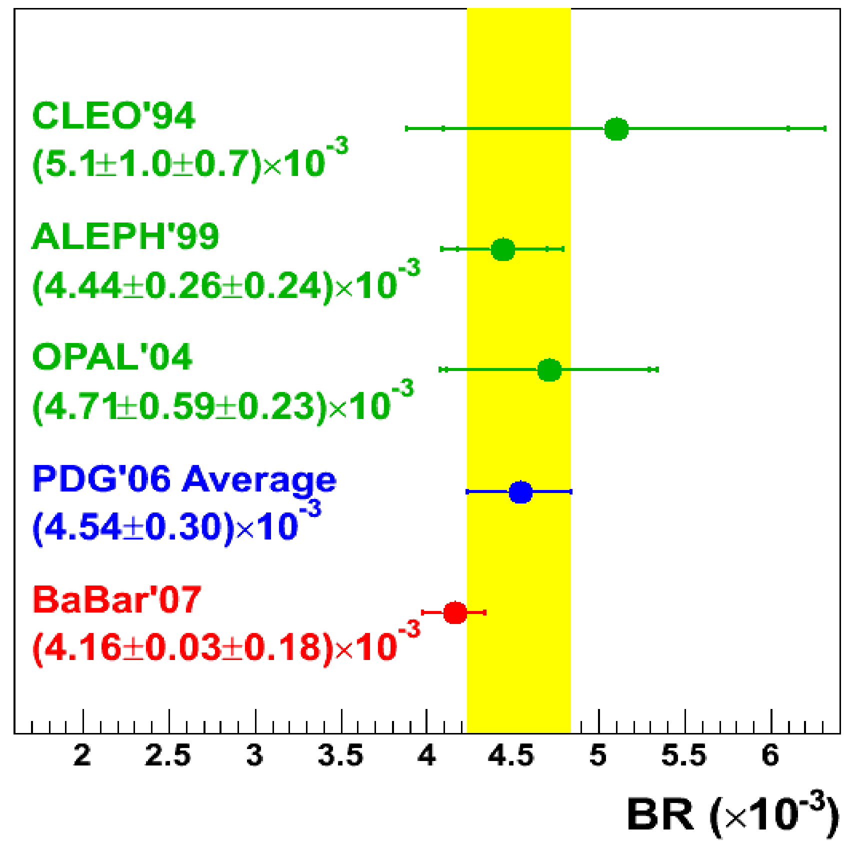
Tau Energy ~5.29GeV

Due to missing neutrinos, the τ decay events have missing energy/momentum.

Branching Ratio for t$^-$®K$^-$p^{0}n

arXiv:0707.2922 [hep-ex]





ε	(2.267±0.008)%
N^{Data}	78,112±280
N^{Bkg}	38,247±159

Branching Ratios for t^{-} ® $h^-h^-h^+n$

arXiv:0707.2981 [hep-ex]

$$\sum_j M_{ij} N_j^{Sig} = (N_i^{Data} - N_i^{Bkg\,(MC)})$$

$$\Rightarrow N_j^{Sig} = \sum_i \left(M^{-1}\right)_{ij} (N_i^{Data} - N_i^{Bkg\,(MC)})$$

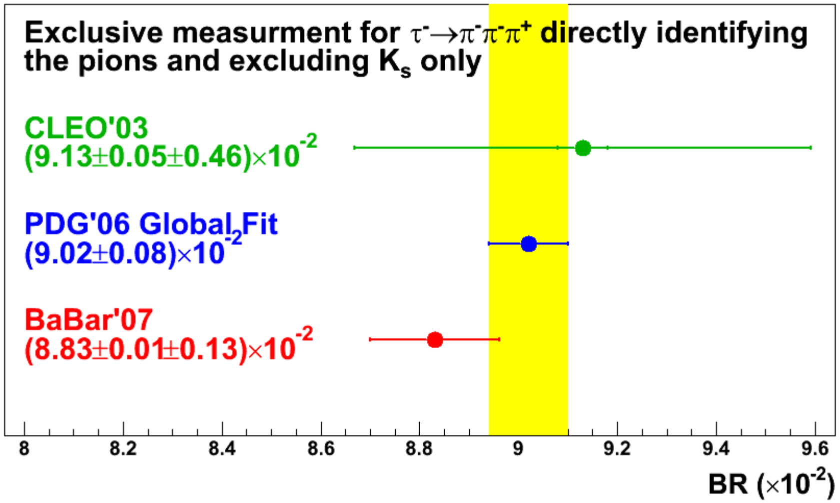
$$Br_j = \frac{N_j^{Sig}}{2L\sigma_{\tau^+\tau^-}}$$

i=Channels Selected
j=Decay Mode

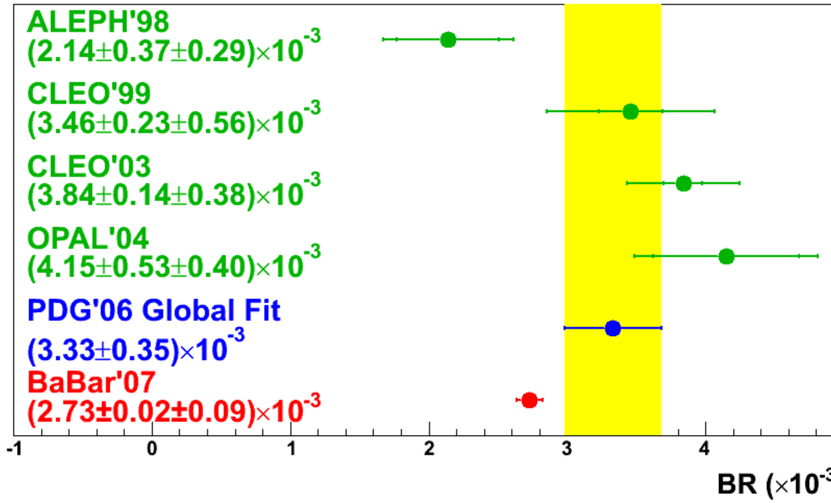
Particle Identification (PID) Efficiency Matrix				
Candidates	**Decay Modes (MC Truth)**			
	$p^-p^-p^+u$	$K^-p^-p^+u$	$K^-p^-K^+u$	$K^-K^-K^+u$
$p^-p^-p^+u$	97.40%	22.49%	4.73%	1.02%
$K^-p^-p^+u$	1.42%	74.87%	16.43	6.38%
$K^-p^-K^+u$	0.01%	0.49%	59.63%	25.54%
$K^-K^-K^+u$			0.26%	50.87%
Characteristic Efficiency (excluding PID)				
e	2.8%	3.1%	3.5%	3.9%

Branching Ratios for t^{-} ® $h^{-}h^{-}h^{+}n$

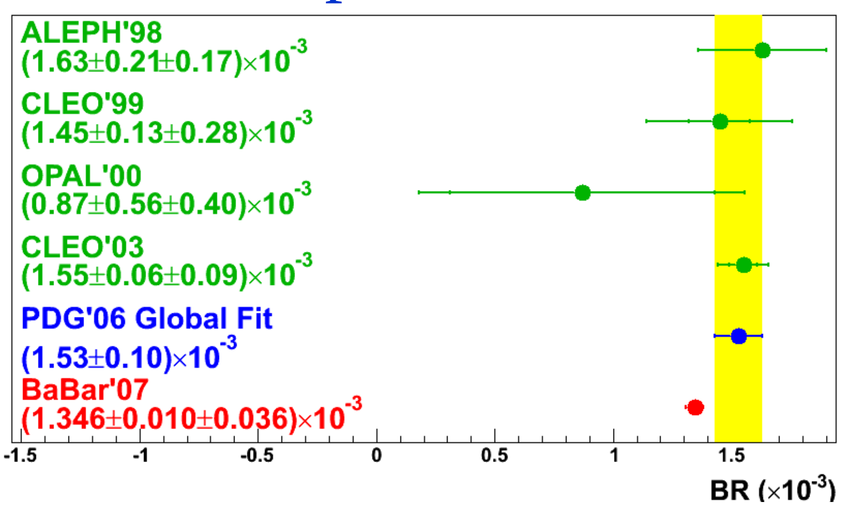
$p^{-}p^{-}p^{+}$



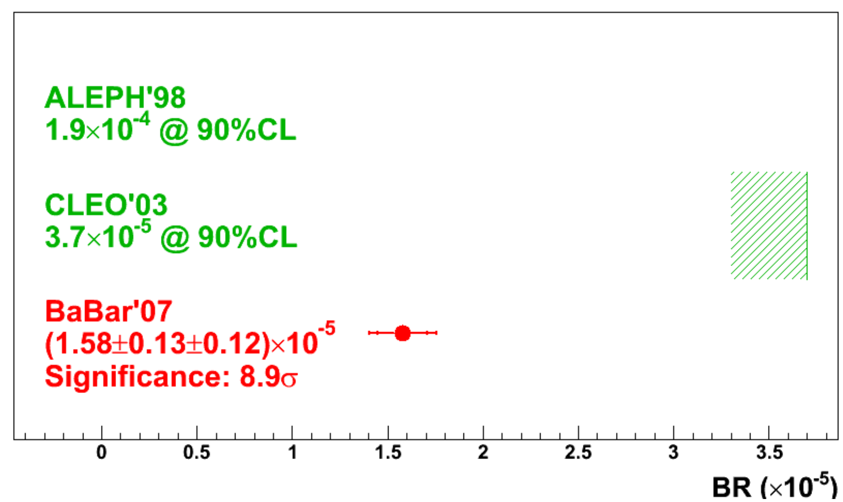
$K^{-}p^{-}p^{+}$



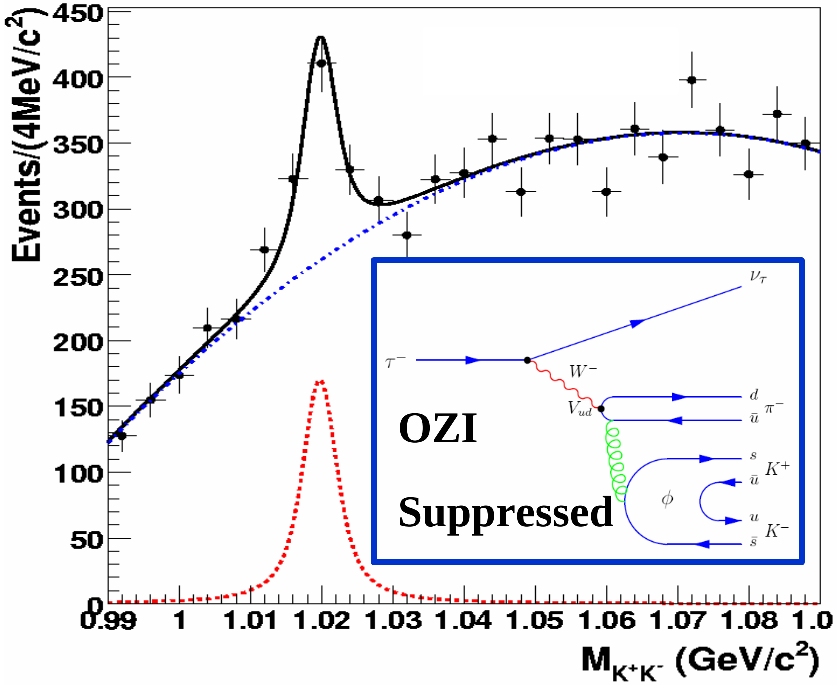
$K^{-}p^{-}K^{+}$

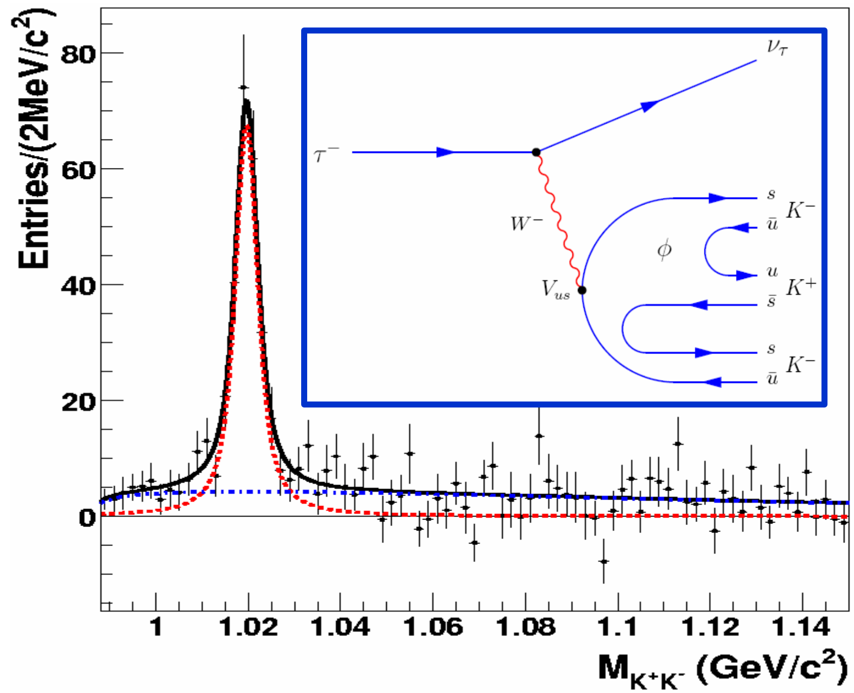


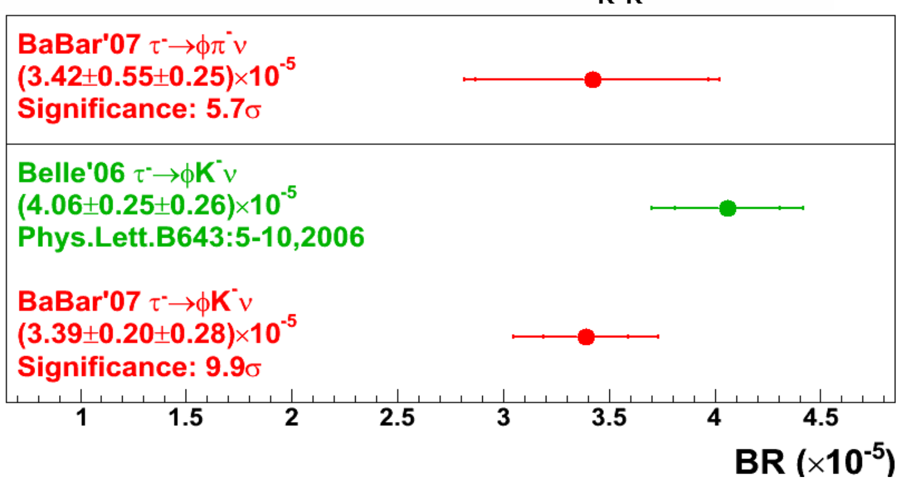
$K^{-}K^{-}K^{+}$



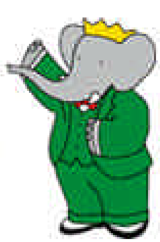
f **Peak in K**p**K**n **and KKK**n



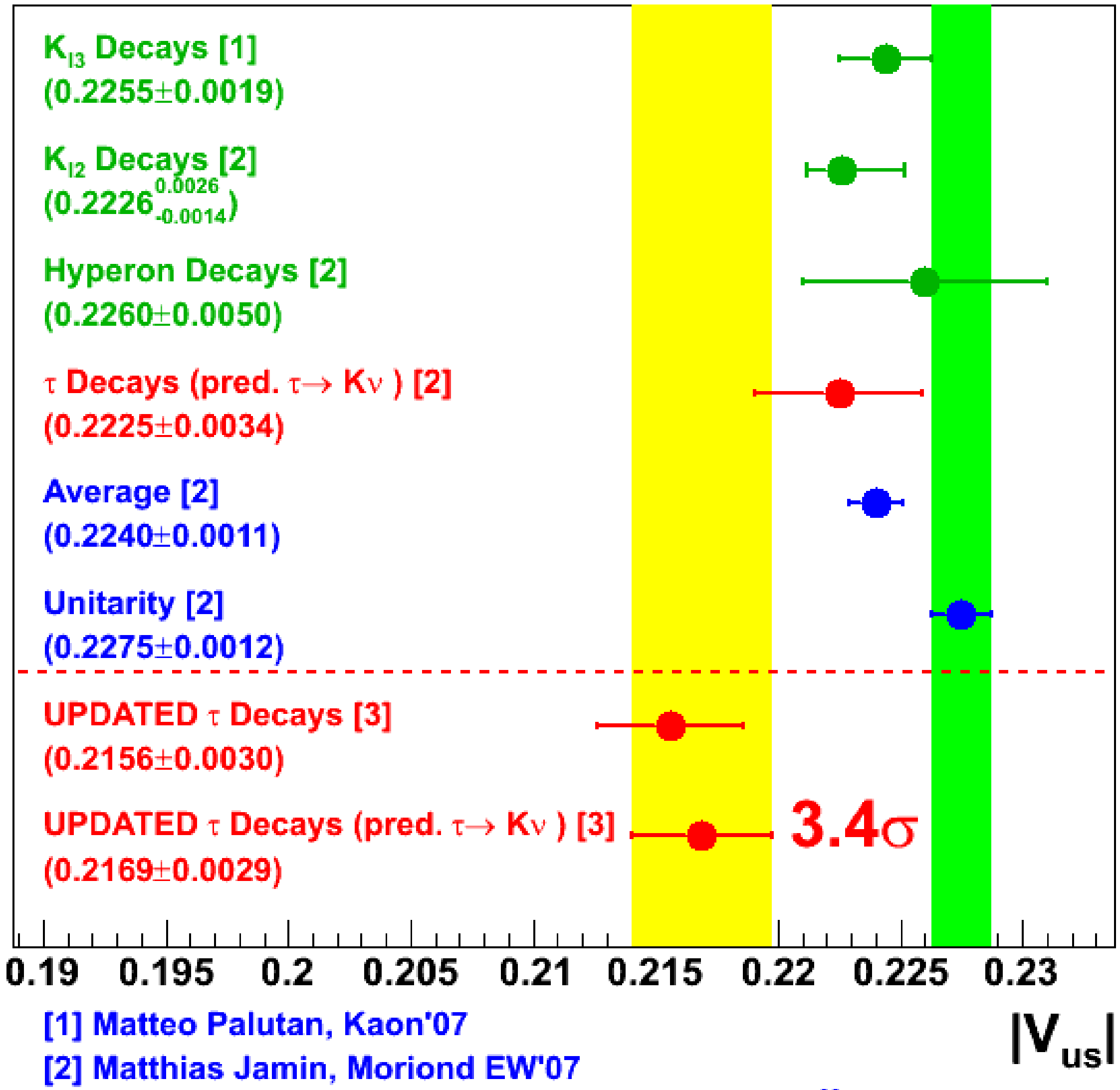




$\tau^- \to K^- \phi \nu$ is consistent with saturating the $\tau^- \to K^- K^- K^+ \nu$ Channel.



Update to $|V_{us}|$



[1] Matteo Palutan, Kaon'07
[2] Matthias Jamin, Moriond EW'07
[3] Swagato Banerjee, arXiv:0707.3058 [hep-ex] (R^{00} moment)

UPDATED

t^{-}® $K^{-}p^{0}u$
arXiv:0707.2922 [hep-ex]
t^{-}® $K^{-}p^{-}p^{+}u$
arXiv:0707.2981 [hep-ex]

t^{-}® $K^{0}p^{-}u$
arXiv:0706.2231 [hep-ex]

Conclusion

Results

$\boldsymbol{B}(\tau^- \to K^- \pi^0 \nu) = (4.16 \pm 0.03 \pm 0.18) \times 10^{-3}$

arXiv:0707.2922 [hep-ex]

$\boldsymbol{B}(\tau^- \to \pi^- \pi^- \pi^+ \nu) = (8.83 \pm 0.01 \pm 0.13) \times 10^{-2}$

$\boldsymbol{B}(\tau^- \to K^- \pi^- \pi^+ \nu) = (2.73 \pm 0.02 \pm 0.09) \times 10^{-3}$

$\boldsymbol{B}(\tau^- \to K^- \pi^- K^+ \nu) = (1.346 \pm 0.010 \pm 0.036) \times 10^{-3}$

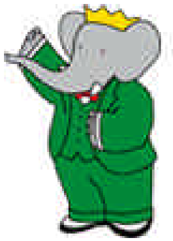
$\boldsymbol{B}(\tau^- \to K^- K^- K^+ \nu) = (1.58 \pm 0.13 \pm 0.12) \times 10^{-5}$

$\boldsymbol{B}(\tau^- \to \pi^- \phi \nu) = (3.42 \pm 0.55 \pm 0.25) \times 10^{-5}$

$\boldsymbol{B}(\tau^- \to K^- \phi \nu) = (3.39 \pm 0.20 \pm 0.28) \times 10^{-5}$

The $\tau^- \to K^- \phi \nu$ is observed to completely saturate the $\tau^- \to K^- K^- K^+ \nu$ channel.

arXiv:0707.2981 [hep-ex]



Maltman and Wolfe predict that the uncertainty on V_{us} from τ decays can be measured more precisely then the world average (below 0.0010) with measurements from BaBar and Belle (hep-ph/0703314v1). In addition, the determination of V_{us} from tau decays is currently dominated by experimental uncertainties.