Precision measurement of the branching fraction of $\tau^- \to \overline{K}^0 \pi^- \nu_\tau$ at BaBar

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Outline

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- Motivation
- Event Selection
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BaBar Detector

Instrumented Flux Return (IFR)
muon / neutral hadron detection

Cherenkov Detector (DIRC)
144 quartz bars, 11000 PMTs

1.5 T Solenoid

e^+ (3.1 GeV)

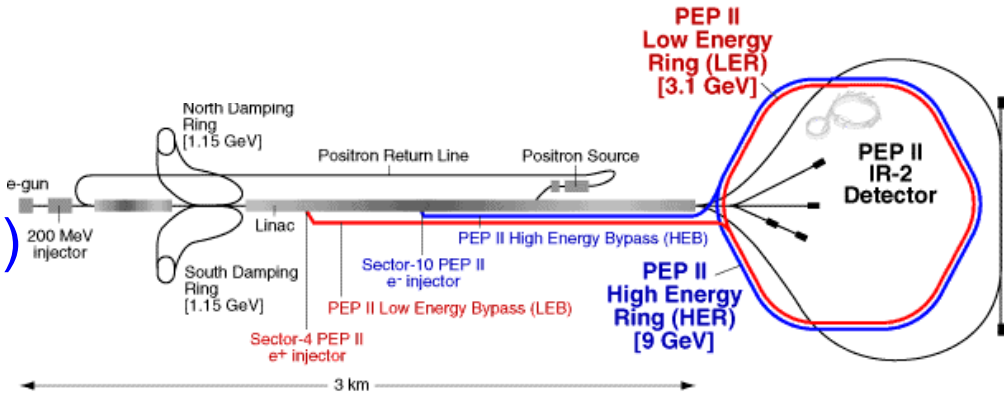
e^- (9.0 GeV)

Drift Chamber (DCH)
40 stereo layers

Silicon Vertex Tracker (SVT)
5 layers, double-sided strips

Electromagnetic Calorimeter (ECAL)
6580 CsI(T1) crystals

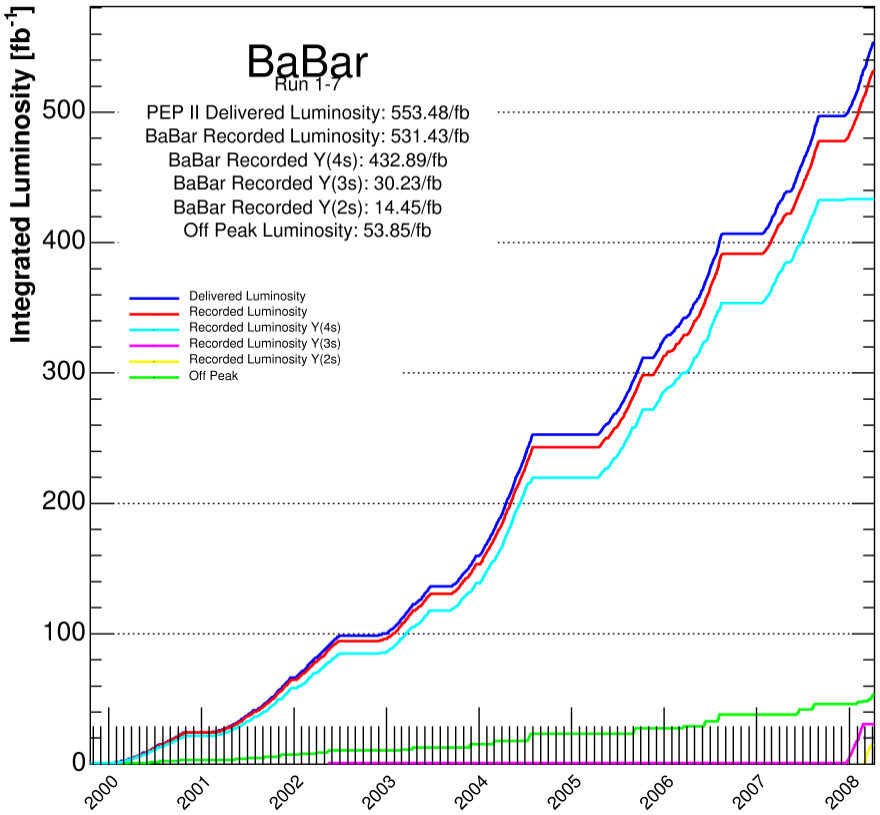
The BaBar dectector is at the collision point of PEP-II at SLAC. Collisions occur between 9.0 GeV electrons and 3.1 GeV positrons.

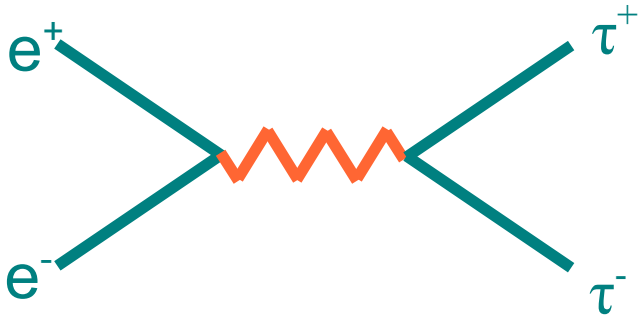


Data

Recorded between October 1999 and August 2006: 384.6 fb^{-1}

Cross section for $\tau\tau$: $\sigma(\tau\tau) = 0.919 \pm 0.003 \Longrightarrow$ 350 million $\tau\tau$ events

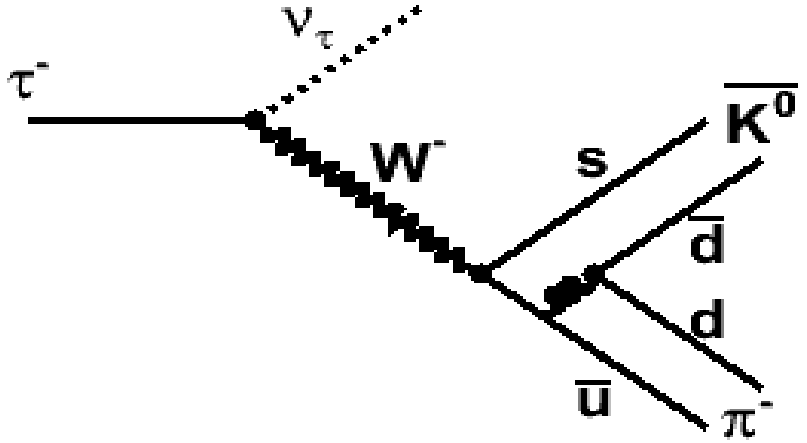




Uncertainty in this analysis is systematics dominated.

Motivation

- τ-decays offer a very clean environment to study the weak current
- τ-decays to strange hadronic final states are sensitive to V_{us}



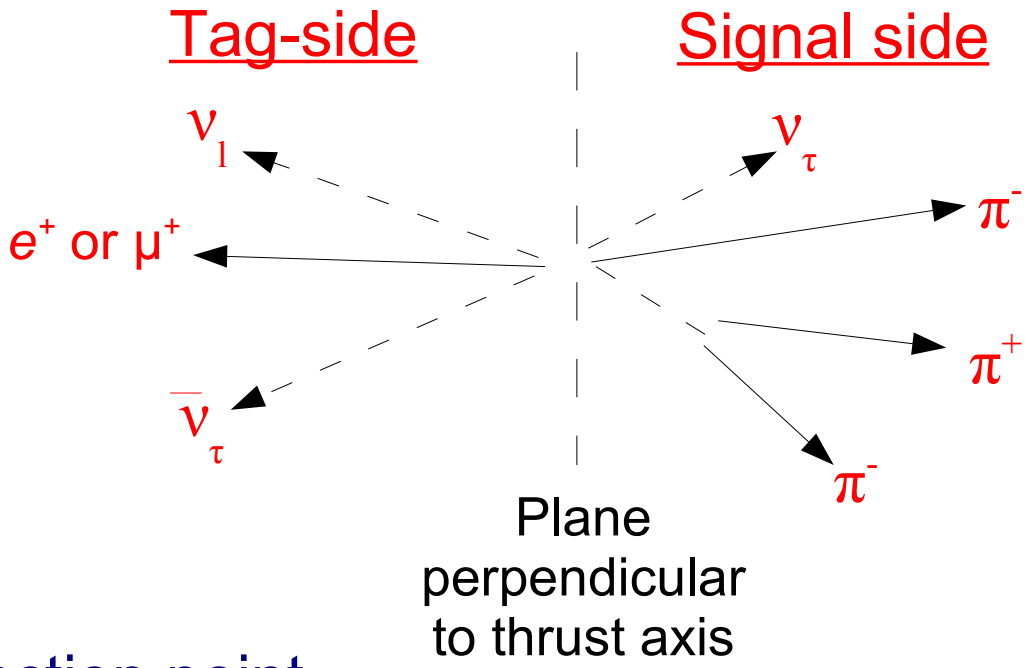
- Current measurements of $|V_{us}|$ based on τ branching fractions differ by 3σ from $|V_{us}|$ measurements by CKM unitarity where a measurement of $|V_{ud}|$ is made. Currently the dominant uncertainty in the extraction of $|V_{us}|$ from τ decays is from the strange branching fraction experimental uncertainties.
- Belle measured this mode last year to to be over 2σ below the PDG value.
  D. Epifanov et al, Phys. Lett. B654 65-73 (2007) arXiv:0706.2231

Event Selection

Looking for: $\tau^- \rightarrow \overline{K^0}\pi^-\nu_\tau$

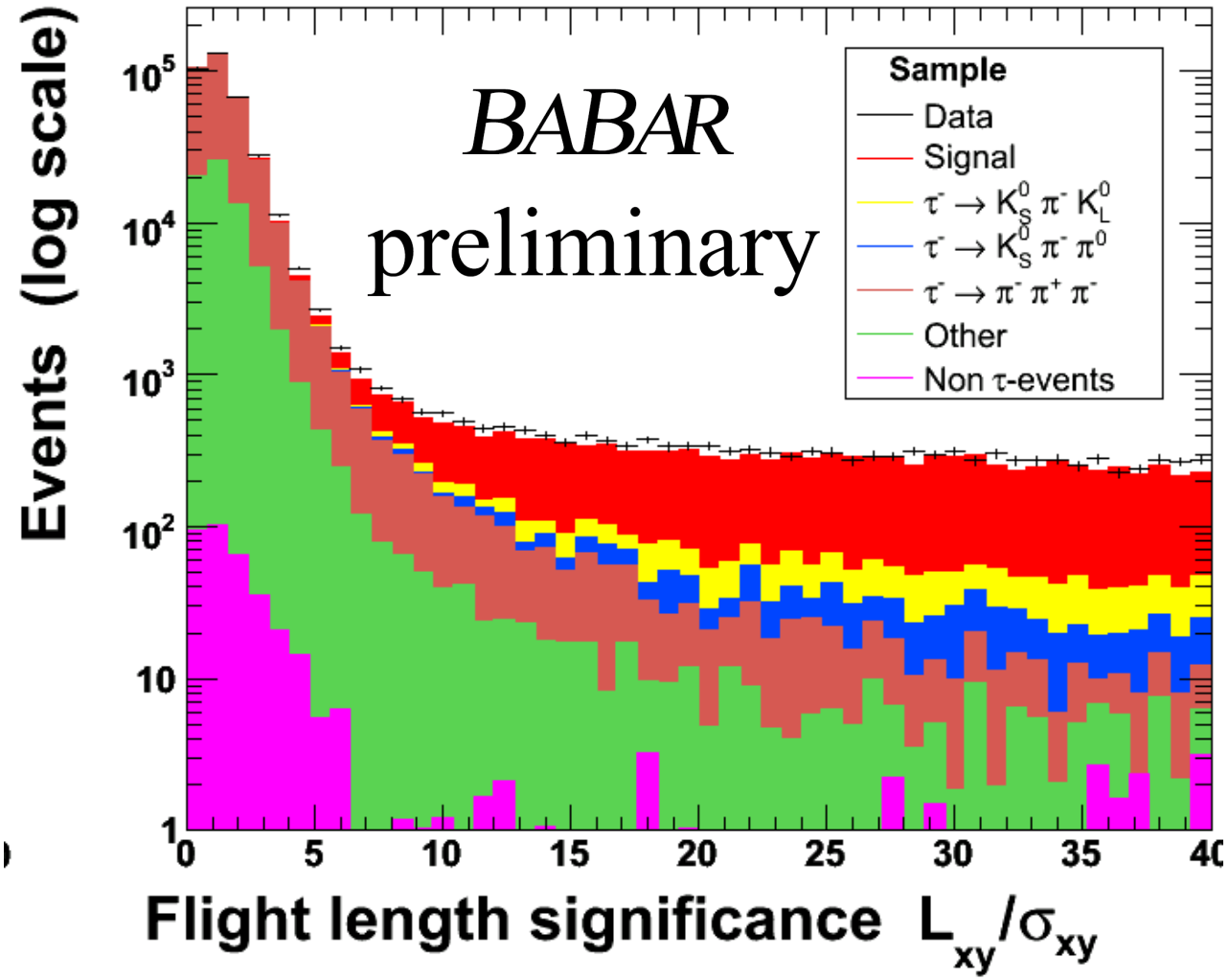
where: $\tau^- \rightarrow K_S^0\pi^-\nu_\tau$

$K_S^0 \rightarrow \pi^+\pi^-$



- 4 charged tracks, 2 from interaction point.
- Tag track required to be e^- or μ^-.
- Require on bachelor track to be a pion .
- Tag track momentum (CM) < 4.9 GeV
- $|\mathrm{Cos}\,\theta^{Ks0}_{hel}| < 0.97$

Event Selection



- Signal side tracks are within the acceptance of DIRC and ECAL.
- K_S^0 mass within 25 MeV of PDG K_S^0 mass.
- K_S^0 daughters < 0.2 cm at distance of closest approach.
- K_S^0 transverse flight length significance $L_{xy}/\sigma_{xy} > 5$.
- Event neutral energy < 0.5 GeV and signal side < 0.25 GeV.

Selected Sample

Efficiency: 1.16 % for selecting $\tau^- \to \bar{K}^0 \pi^- \nu_\tau$ events

Purity: ~80%

Selected events

(Monte Carlo $\tau^- \to K^0 \pi^- \nu_\tau$ branching fraction set at 0.90%)

Data	e-tag	μ-tag	Combined
Real	47092	36641	83733
Signal MC	39445	30749	70194
$\tau\tau$ background	9942	7645	17587
non $\tau\tau$ backgrounds	57.8	126.6	184.5

Monte Carlo scaled to the data luminosity.

Backgrounds

Decay Channel	w[%]	$\frac{\sigma}{\mathcal{B}}$[%]
$\tau^- \to \pi^- K_S^0 \pi^0 \nu_\tau$	4.93	10.53
$\tau^- \to K^- K_S^0 \pi^0 \nu_\tau$	0.12	17.54
$\tau^- \to \pi^- \bar{K}^0 K_L^0 \nu_\tau$	8.38	10.38
$\tau^- \to \pi^- \bar{K}^0 K_S^0 \nu_\tau$	0.04	20.83
$\tau^- \to K^- \bar{K}^0 \nu_\tau$	0.54	10.46
$\tau^- \to \pi^- \pi^0 \nu_\tau$	0.15	0.39
$\tau^- \to 2\pi^+ \pi^- \nu_\tau$	4.81	0.89
$\tau^- \to 2\pi^- \pi^+ \pi^0 \nu_\tau$	0.70	1.35
$\tau^- \to K^- K^+ \pi^- \nu_\tau$	0.13	2.78
$\tau^- \to K^- \pi^+ \pi^- \nu_\tau$	0.16	10.26

Isospin relation

$B(\tau \to K^+ \pi^- K^- \nu_\tau) = (0.1346 \pm 0.0037)\%$ [1]

$B(\tau \to K^0_L \pi^- K^0_S \nu_\tau) = ½ \times B(\tau \to K^+ \pi^- K^- \nu_\tau)$ [2]

$= (0.067 \pm 0.007)\%$

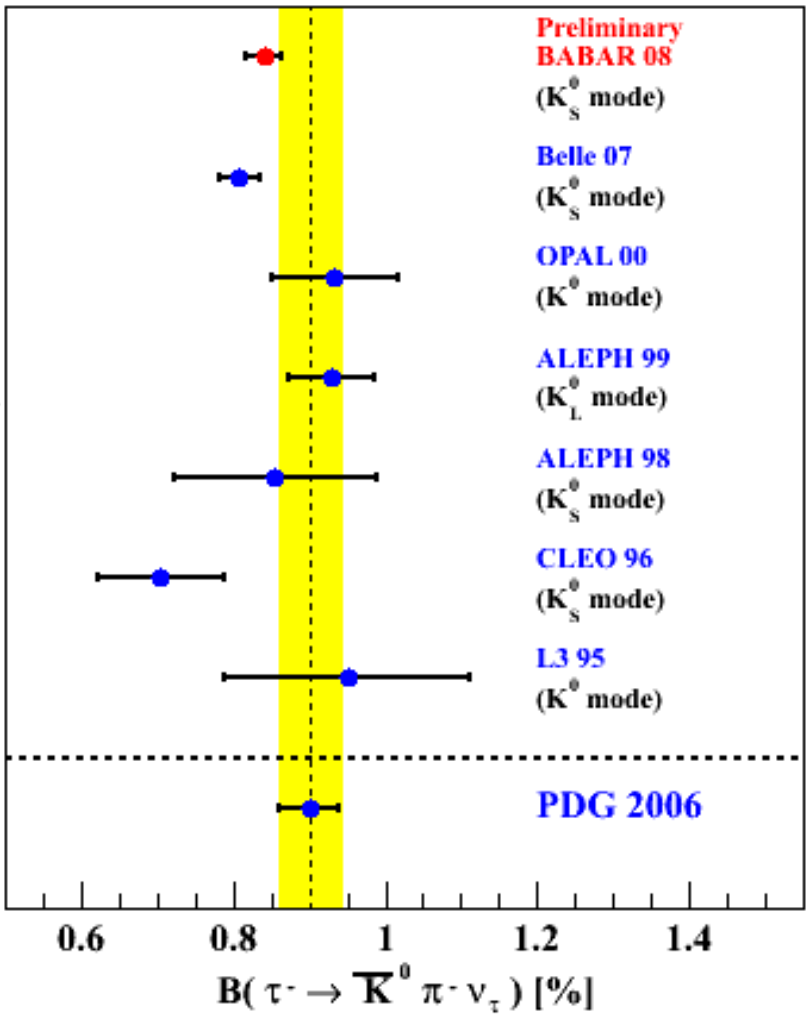
[1] B. Aubert et al, Phys. Rev. Lett. 100, 011801 (2008) arxiv:0707.2981

[2] M. Finkemeier, E. Mirkes, Z. Phys. C69, 243-252 (1996) arxiv9503474

Systematic Uncertainties

Systematic	e-tag	μ-tag	combined
Tracking	0.58%	0.58%	0.58%
K_S^0 efficiency	1.40%	1.40%	1.40%
PID	1.45%	1.68%	1.50%
$L/\sigma_{\tau\tau}$	0.83%	0.83%	0.83%
τ backgrounds	1.37%	1.37%	1.37%
MC statistics	0.58%	0.64%	0.43%
MC modeling	0.37%	0.37%	0.37%
Total	2.73%	2.87%	2.72%

Results Comparison



$$B(\tau^- \to \overline{K}^0 \pi^- \nu_\tau)$$

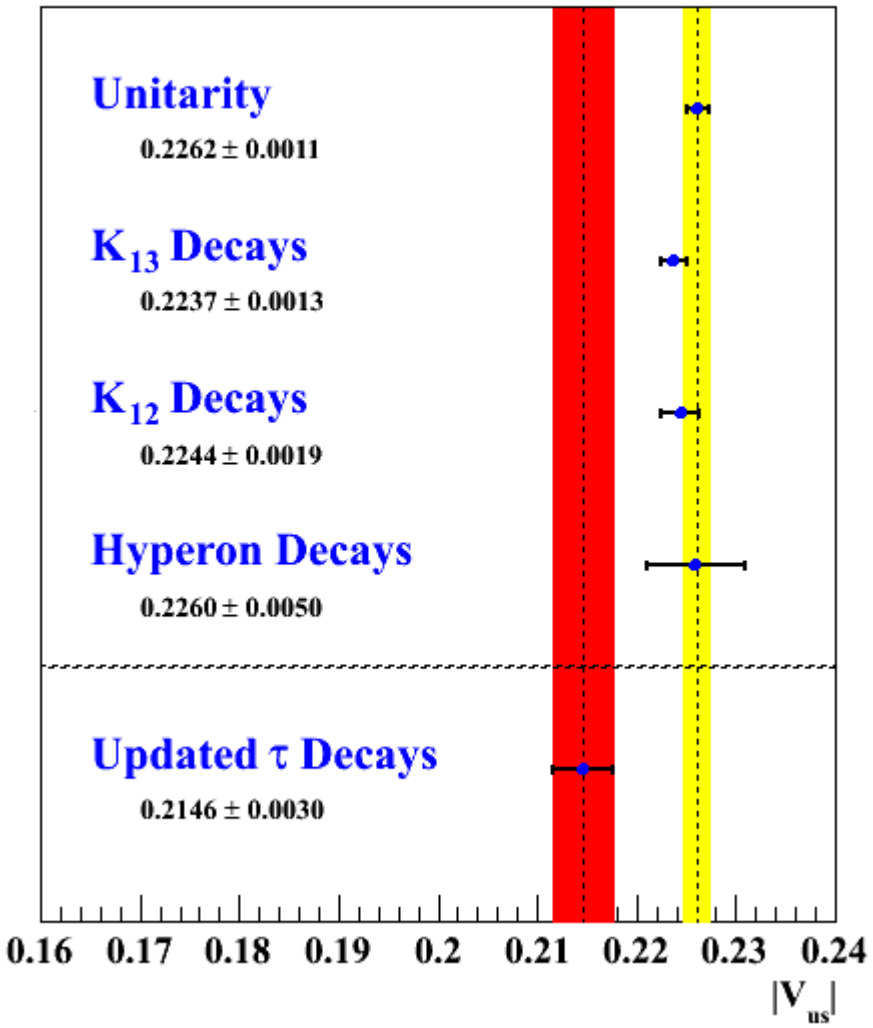
Preliminary BaBar 2008:
(0.840 ± 0.004 ± 0.023) %

Belle 2007:
(0.808 ± 0.004 ± 0.026) %

PDG 2006:
(0.90 ± 0.04) %

New world average
(0.835 ± 0.022) %
includes (PDG) scale factor = 1.4

$|V_{us}|$ Status

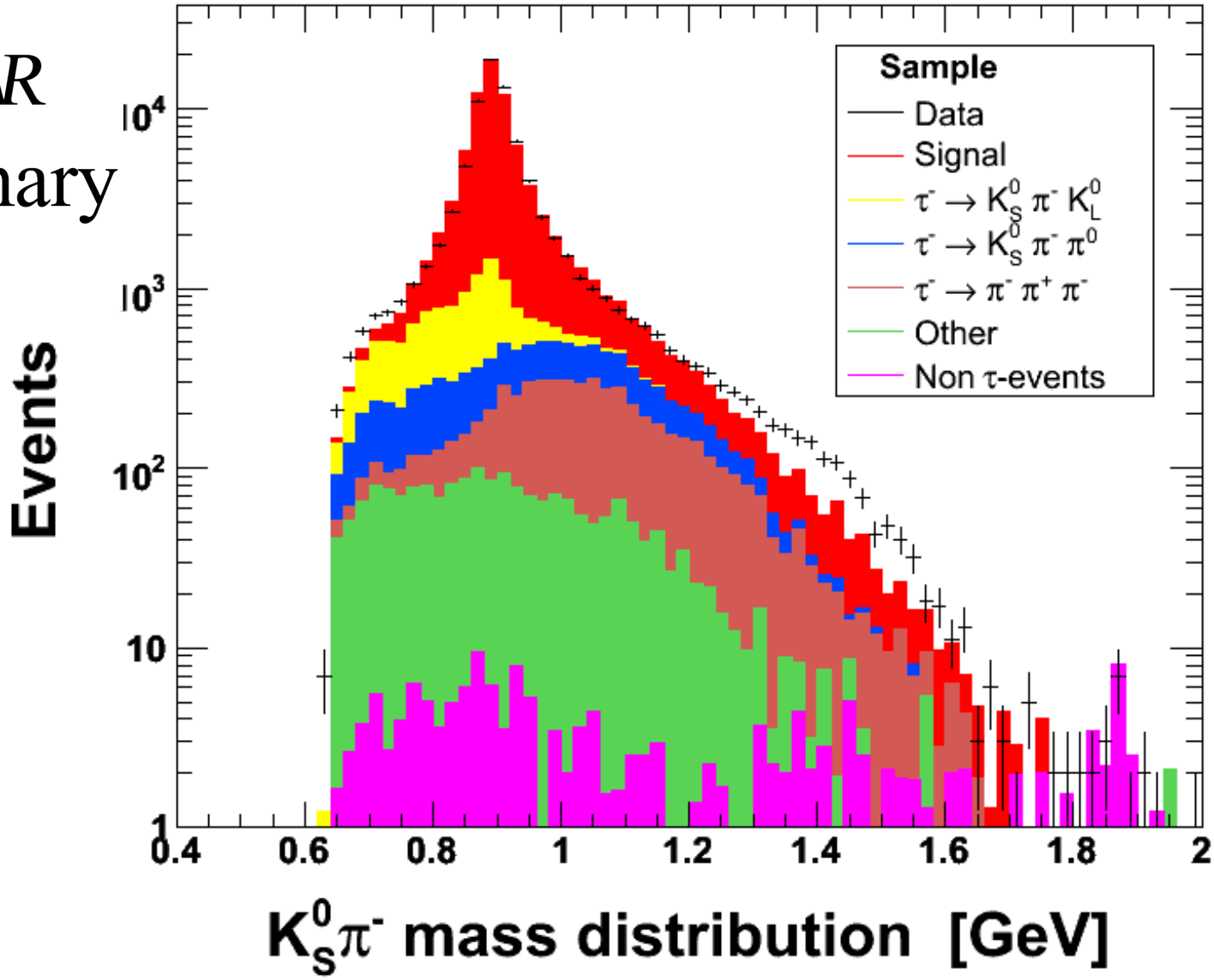


Discrepancy w.r.t. Unitarity ~3σ

Includes Preliminary BaBar 2008 $B(\tau^- \to \bar{K}^0 \pi^- \nu_\tau)$ measurement

$K_S^0\pi^-$ mass distribution

BABAR preliminary



Summary and Conclusion

Preliminary measurement:

$$B(\tau^- \to \overline{K}^0 \pi^- \nu_\tau) = (0.840 \pm 0.004\ (\text{stat}) \pm 0.023\ (\text{syst}))\ \%$$

ICHEP conference note: arXiv:0808.1121v2

Interpretation of mass spectrum coming soon.

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BABAR