Measurement of the hadronic cross sections for e^+e^- to final states with neutral kaons with the *BABAR* detector

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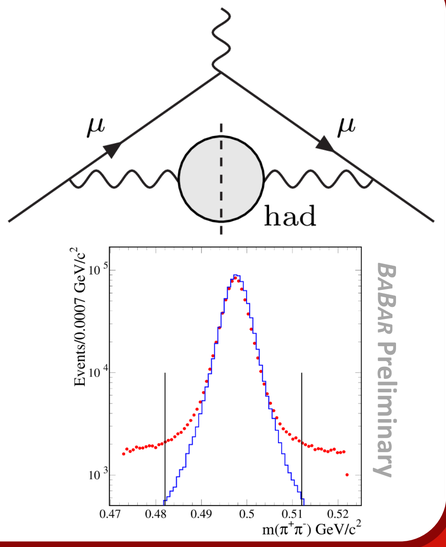
Introduction and event selection

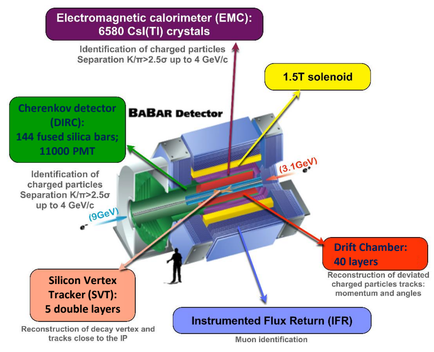
The study of e^+e^- annihilation events with initial-state radiation (ISR) allows the B-factories to explore energies below the nominal one
Such measurements are of interest for the calculation of the $(g-2)_\mu$
We report measurements of the $K_S^0\,K_L^0\,\pi^0$, $K_S^0\,K_L^0\,\eta$, $K_S^0\,K_L^0\,\pi^0\pi^0$ channels

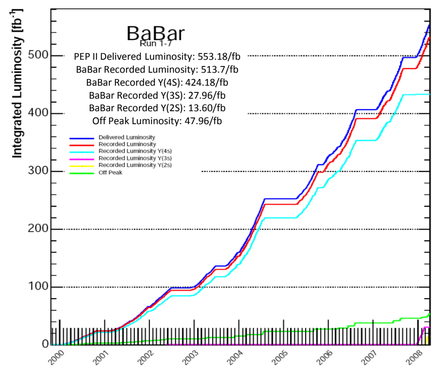
- 2 opposite-sign charged tracks and ≥ 4 clusters in the EMC
- $482 < m(\pi\pi) < 512\ \mathrm{MeV}/c^2$, $0.1 \leq d_{xy} \leq 40\ \mathrm{cm}$
- No other tracks close to beam/interaction point
- $E(\gamma) > 100\ \mathrm{MeV}$, $E(K_L^0) > 200\ \mathrm{MeV}$
- $|m(\gamma\gamma) - m(\pi^0)| < 30\ \mathrm{MeV}$, $|m(\gamma\gamma) - m(\eta)| < 50\ \mathrm{MeV}$
- Hardest photon is γ_{ISR} candidate
- Kinematic fit to constrain K_L^0 momentum



The BaBar detector

The Babar detector was located at the interaction point of PEP II at SLAC Asymmetric e^+e^- collider, mostly at the $\Upsilon(4S)$ peak $\sim 10.58\ \mathrm{GeV}$





This analysis uses $468.6\ \mathrm{fb}^{-1}$ of data, both on- and off-peak

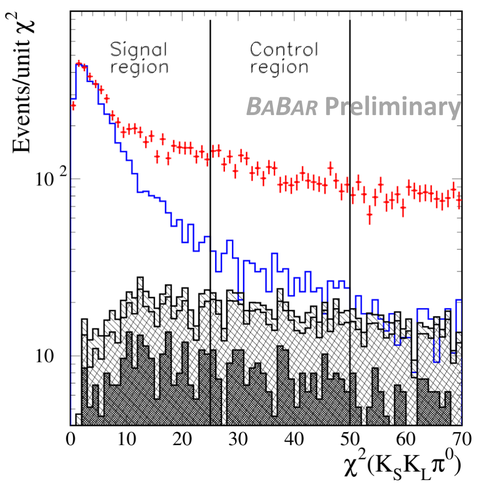
$K_S^0K_L^0\pi^0$ channel

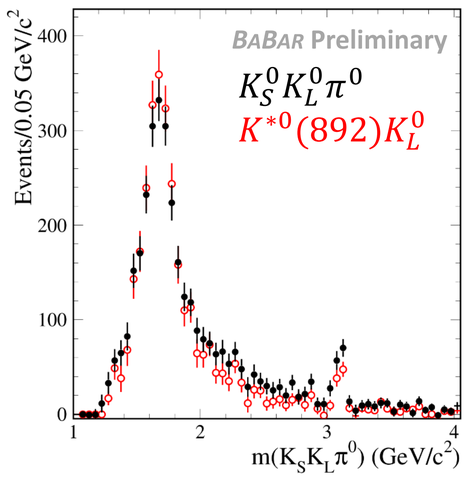
Additional cuts to reduce specific backgrounds

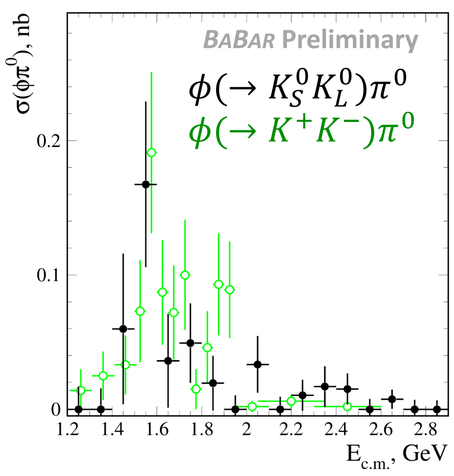
- Residual clusters can produce π^0, must have $E(\gamma) < 500\ \mathrm{MeV}$
- To reduce huge ϕ ISR, we require $m(K_S^0K_L^0) > 1040\ \mathrm{MeV}$ or $\chi^2(K_S^0K_L^0\gamma) > 15$

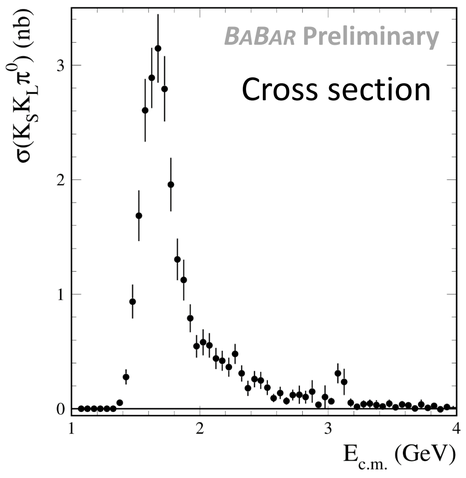
In the control region, MC bkg events barely reach half of data events, we rescale the events in the sideband to subtract bkg in the signal region
The systematics induced is $\sim 10\%$ until 2.2 GeV, 3669 signal events left

The cross section is dominated by quasi 2-body decay $K^{*0}(892)\overline{K}^0$, but also evidence for $K_2^{*0}(1430)\overline{K}^0$ and $\phi\pi^0$





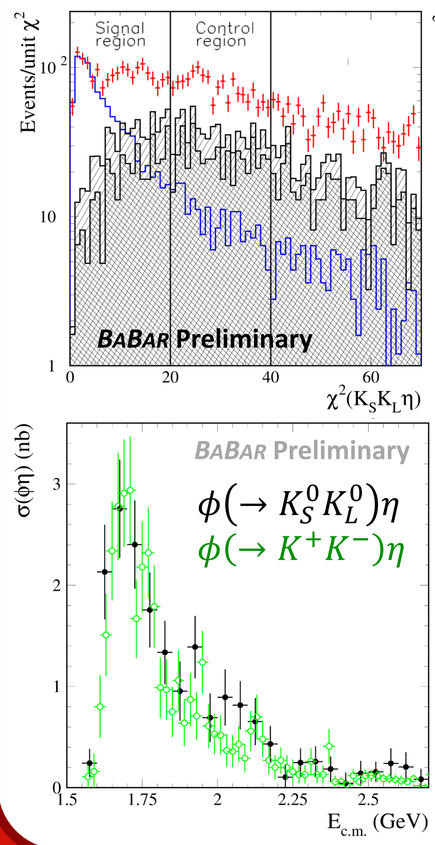


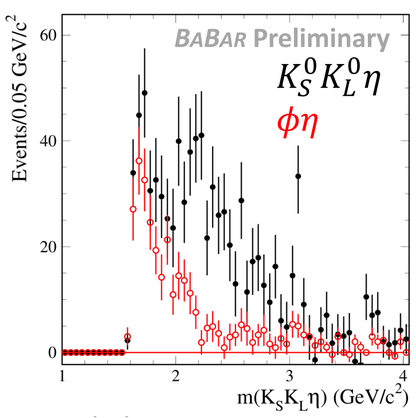


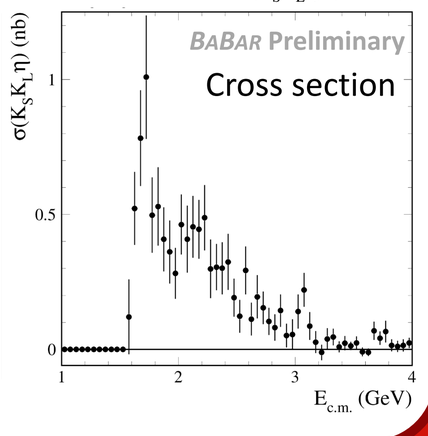
$K_S^0K_L^0\eta$ channel

We rescale the events in the sideband to subtract bkg in the signal region, the systematics induced is $\sim 15\%$ at 1.05 GeV, 864 signal events left

The cross section at low energies is dominated by $\phi\eta$

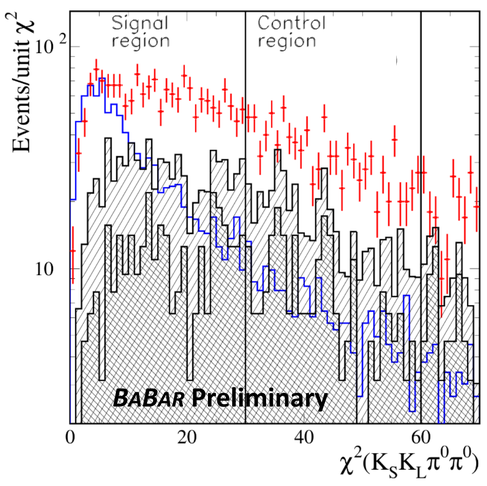


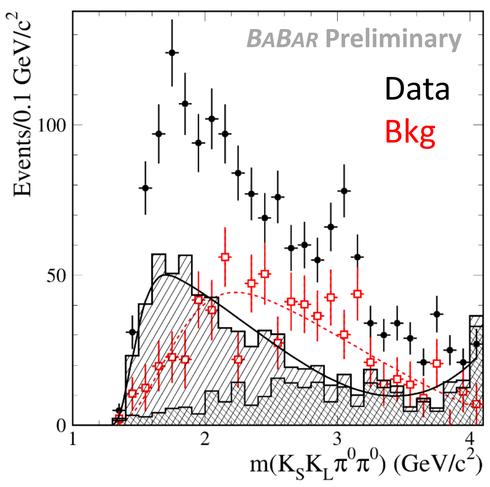


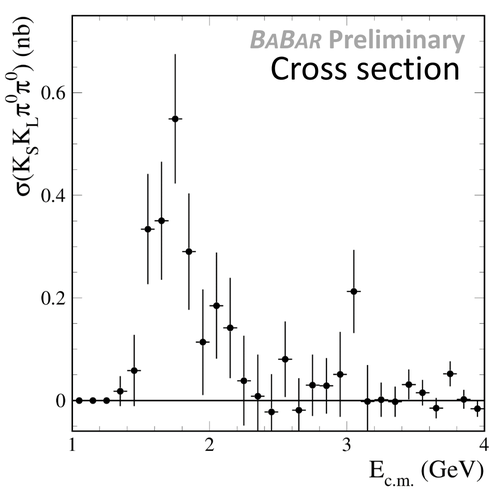


$K_S^0K_L^0\pi^0\pi^0$ channel

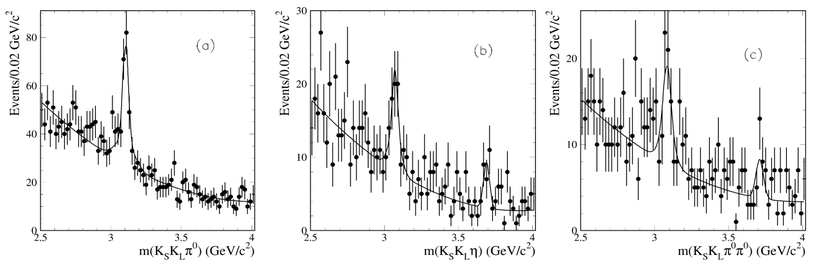
We rescale the events in the sideband to subtract bkg in the signal region, smooth with an empirical fit, the systematics induced is $\sim 25\%$ until 2.2 GeV, 392 signal events left. Evidence for $K^{*0}(892)\overline{K}^0\pi^0$ and $\phi\pi^0\pi^0$







The J/ψ and $\psi(2S)$ regions



J/ψ Branching fraction (10^{-3})		
$\mathcal{B}\left(J/\psi \to K_S^0K_L^0\pi^0\right)$	$2.06 \pm 0.24 \pm 0.10$	6.1 ± 1.0 $(K\bar{K}\pi)$
$\mathcal{B}\left(J/\psi \to K_S^0K_L^0\eta\right)$	$1.45 \pm 0.32 \pm 0.08$	0.85 ± 0.14 $(K^+K^-\eta)$
$\mathcal{B}\left(J/\psi \to K_S^0K_L^0\pi^0\pi^0\right)$	$1.86 \pm 0.43 \pm 0.10$	2.35 ± 0.41 $(K^+K^-\pi^0\pi^0)$
$\mathcal{B}\left(J/\psi \to K^*(892)^0{}_{(\to K^0\pi^0)}\bar{K}^0\right)$	$1.20 \pm 0.15 \pm 0.06$	1.97 ± 0.20 $(K^*(892)^0\bar{K}^0\eta)$
$\mathcal{B}\left(J/\psi \to K_2^*(1430)^0{}_{(\to K^0\pi^0)}\bar{K}^0\right)$	$0.43 \pm 0.12 \pm 0.02$	< 4
$\mathcal{B}\left(\psi(2S) \to K_S^0K_L^0\pi^0\right)$	< 0.3	–
$\mathcal{B}\left(\psi(2S) \to K_S^0K_L^0\eta\right)$	$1.33 \pm 0.46 \pm 0.07$	–
$\mathcal{B}\left(\psi(2S) \to K_S^0K_L^0\pi^0\pi^0\right)$	$1.24 \pm 0.54 \pm 0.06$	–

References

Other ISR BaBar analyses with Kaons:

[1] J.P. Lees *et al.* [BaBar Collaboration], "Cross sections for the reactions $e^+e^- \to K_S^0K_L^0, K_S^0K_L^0\pi^+\pi^-, K_S^0K_S^0\pi^+\pi^-$ from events with initial-state radiation", Phys.Rev. D89 (2014), 092002, arXiv:1403.7593

[2] J.P. Lees *et al.* [BaBar Collaboration], "Precision measurement of the $e^+e^- \to K^+K^-(\gamma)$ cross section with the initial-state radiation method at BABAR, Phys.Rev. D88 (2014), 032013, arXiv:1306.3600

[3] J.P. Lees *et al.* [BaBar Collaboration], "Cross Sections for the Reactions $e^+e^- \to K^+K^-\pi^+\pi^-, K^+K^-\pi^0\pi^0, K^+K^-K^+K^-$ Measured Using Initial-State Radiation Events", Phys.Rev. D86 (2014), 012008, arXiv: 1103.3001

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