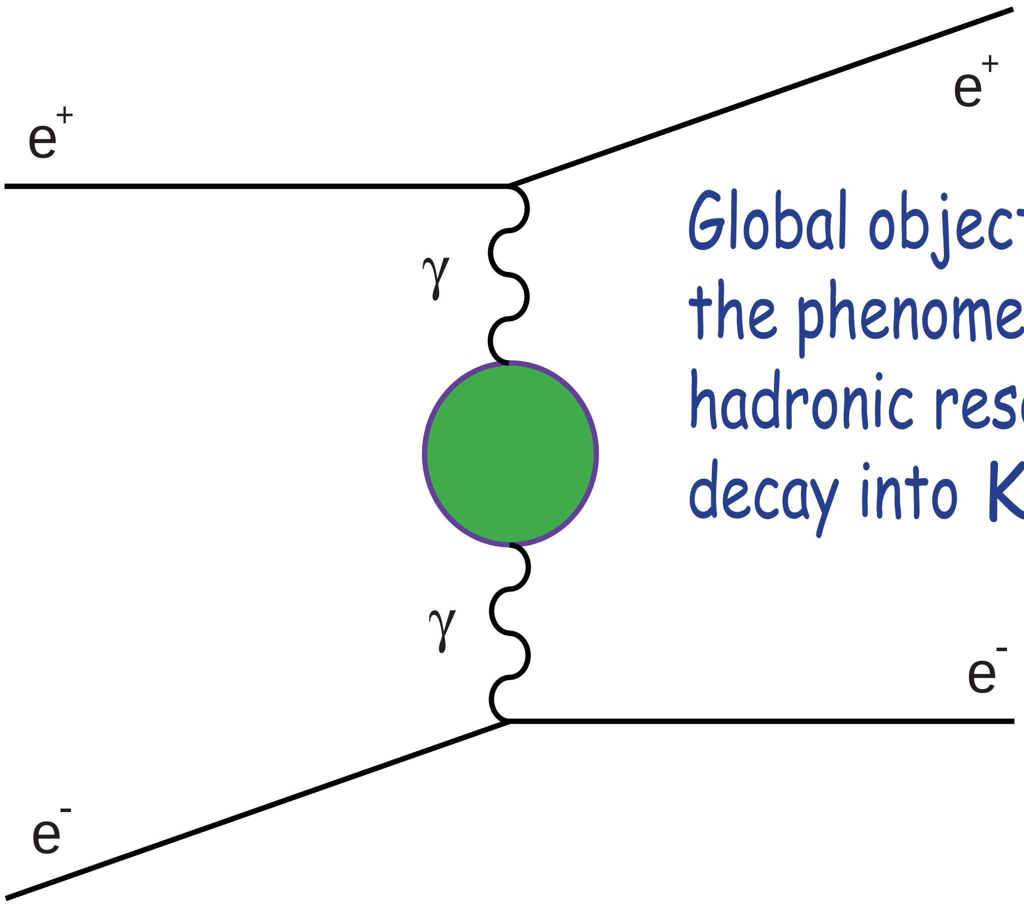
Preliminary Results on $\gamma\gamma \longrightarrow K_s K^{\pm} \pi^{\mp}$



Global objective: provide data to understand the phenomenon of confinement by studying hadronic resonances below 1.7 GeV/c^2 that decay into $K_s K^{\pm} \pi^{\mp}$ final state.

- Motivation
- Experimental Tools
- Selection Criteria
- Systematics
- Preliminary Results
- Interpretation

Representing CLEO Collaboration
vps3@pitt.edu

Understanding Hadron Mass Spectrum Quantatively would be Fundamental Verification of Low-Energy QCD

Do we understand this spectrum theoretically? ask a theorist...

Do we understand this spectrum experimentally? NO ⟶

Check PDG review and try to make sense of all reported low-mass resonances!

This study: hadrons with masses below 1.7 GeV/c^2 that decay to $K_s K^\pm \pi^\mp$ final state

Experimental tool: production in two-photon collisions:

$$\gamma\gamma \longrightarrow \eta(1440) \longrightarrow K_s K^\pm \pi^\mp$$

Two-photon cross section ~ $\Gamma_{\gamma\gamma} F^2(Q_1^2, Q_2^2)$

Properties of two-photon events: boosted along beam axis, difficult to trigger on, transverse momentum of the entire event peaks at low values, no glueballs produced

Experimental Status of $\eta(1440)$

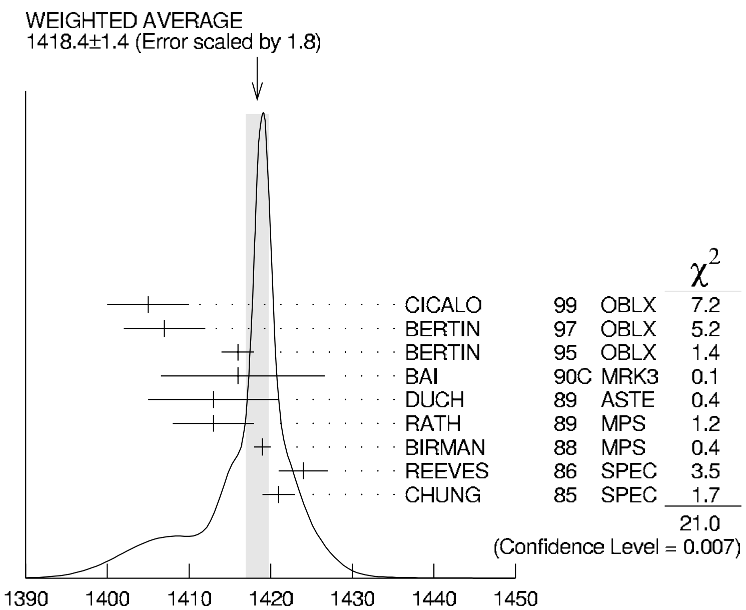
Mass region between 1200 and 1500 MeV contains several poorly-understood hadrons.

Some of these are, possibly, due to gluonic degrees of freedom.

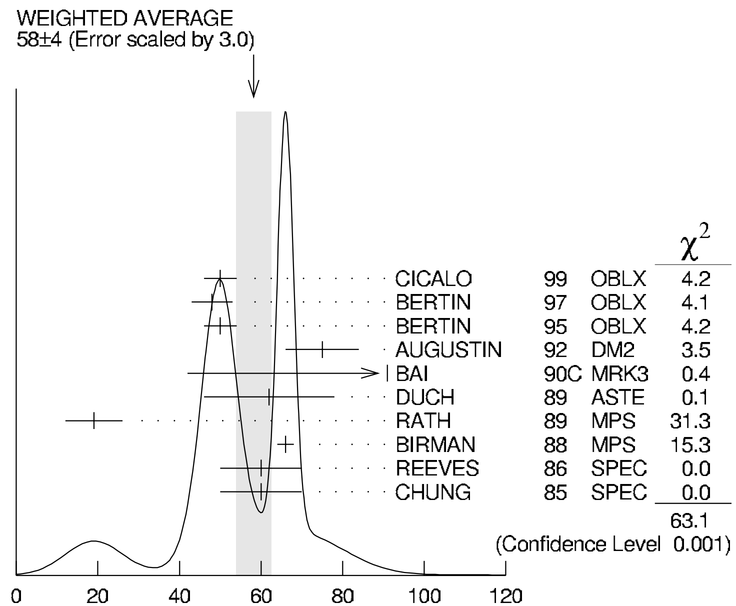
$\eta(1440)$ is one of these hadrons: was observed in hadron collisions and radiative decays of J/ψ, not observed in two-photon collisions until recently - glueball?

Experiments disagree about the properties of this resonance...

Citation: D.E. Groom *et al.* (Particle Data Group), Eur. Phys. Jour. **C15**, 1 (2000) and 2001 partial update for edition 2002 (URL: http://pdg.lbl.gov)



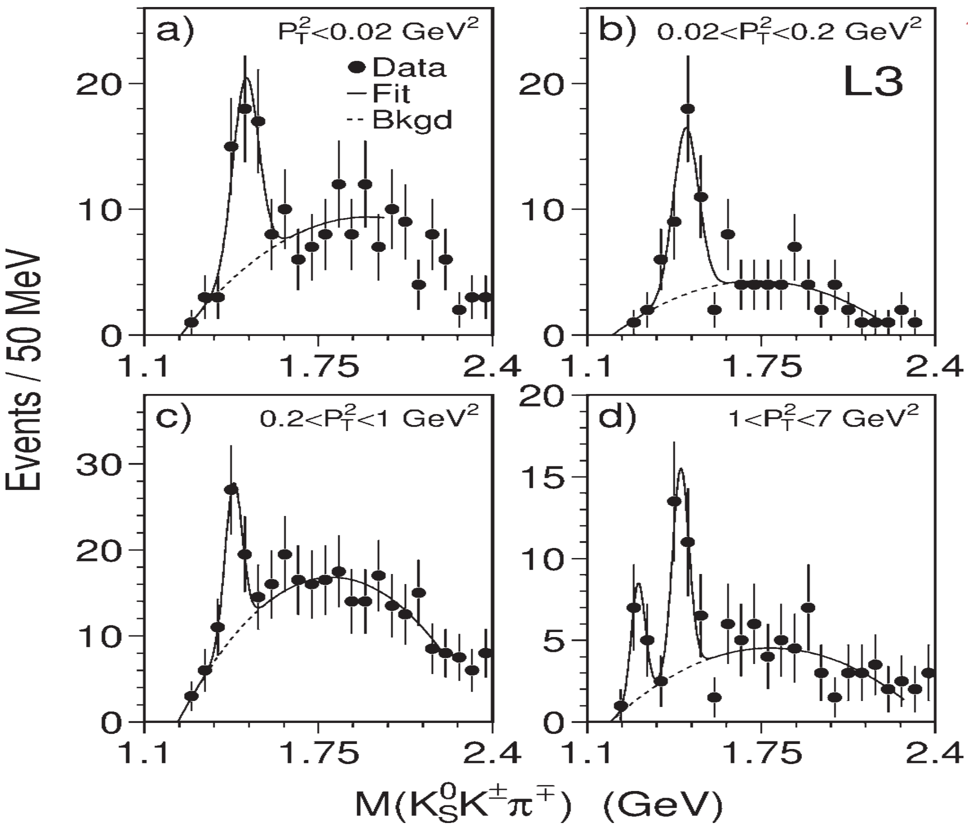
$\eta(1440)$ mass, $K\overline{K}\pi$ mode ($a_0(980)\ \pi$ dominant) (MeV)



$\eta(1440)$ width $K\overline{K}\pi$ mode ($a_0(980)\ \pi$ dominant)

Recent news on $\eta(1440)$

L3 Collaboration / Physics Letters B 501 (2001) 1–11



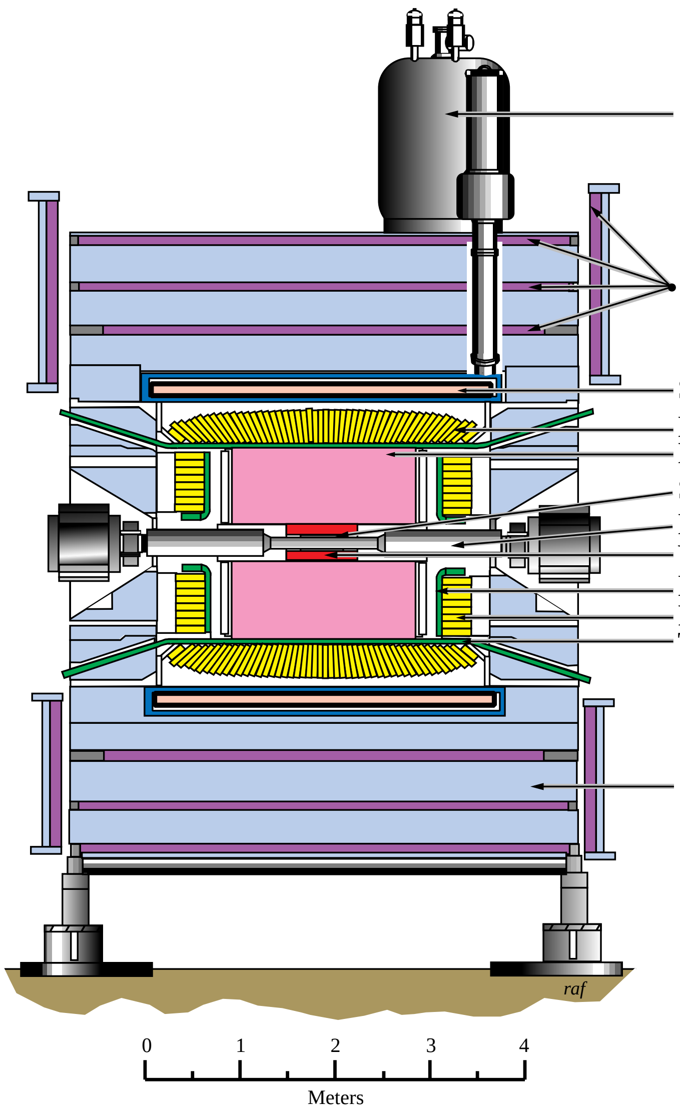
$$\Gamma_{\gamma\gamma}(\eta(1440)) \times \mathrm{BR}(\eta(1440) \to \mathrm{K}^0_\mathrm{S}(\to \pi^+\pi^-)\mathrm{K}^{\pm}\pi^{\mp}) = 49 \pm 12\ (\mathrm{stat.})\ \mathrm{eV}.$$ (BR ~ 1 for $s\bar{s}$ meson)

$\Gamma_{\gamma\gamma}$ too small for a meson - mixing with a glueball?

An independent verification would be very useful, also, expecting larger signal with CLEO

ΔP_T^2 (GeV^2)	Events	M (MeV)	σ (MeV)	CL (%)	ϵ (%)	$\Delta\sigma$ (pb)
0–0.02	37 ± 9	1481 ± 12	48 ± 9	89	1.03 ± 0.04	8.0 ± 2.0
0.02–0.2	28 ± 7	1473 ± 11	37 ± 8	77	0.85 ± 0.09	7.4 ± 2.3
0.2–1	29 ± 9	1435 ± 10	32 ± 10	99	1.74 ± 0.14	3.7 ± 1.2
1–7	21 ± 6	1452 ± 11	35 ± 10	55	3.49 ± 0.24	1.4 ± 0.4

CLEO II / II.V Detector



Performance of the Detector

- Electromagnetic Calorimeter (96% 4π)
  - 7800 CsI crystals, each $\approx 16\ \chi_0$ long
  - $\sigma_E/E \approx 2\%$ at 5 GeV, 5% at 200 MeV
- Tracking (PT/SVX, VD, DR; 95% 4π)
  - $\sigma_p/p = \sqrt{(0.0059)^2 + (0.0016p(\mathrm{GeV/c}))^2}$
- Muon System (85% 4π, $|p_\mu| \geq 1.0$ GeV/c)
- Particle Identification
  - Specific ionization energy losses ($dEdx$)
  - Time-of-flight (TOF) scintillator
- Trigger
  - L0: (VD and TOF) or (CsI)
  - L1 and L2: VD, DR, CsI, TOF
  - L3: beam-gas rejection (software)

$\hookrightarrow$ General purpose e^+e^- detector

Event Selection Criteria

- Exactly four reconstructed charged tracks in the entire detector (13% efficiency, 20% syst.)
- Exactly 1 K_s candidate (vertex radially displaced by two or more standard deviations
- Signal candidates' properties:
  - transverse momentum below 100 MeV/c
  - amount of energy detected in calorimeter in unmatched clusters below 100 MeV
  - at least one large transverse momentum track reaching barrel calorimeter
  - make sure events were recorded with reliable triggers and pass beam-gas rejection
  - 3 standard deviations PID consistensy for charged K and non-K_s π using TOF and dEdx

This selection is based (in part) on the hermeticity of CLEO detector, efficiency is shown for 1475 MeV

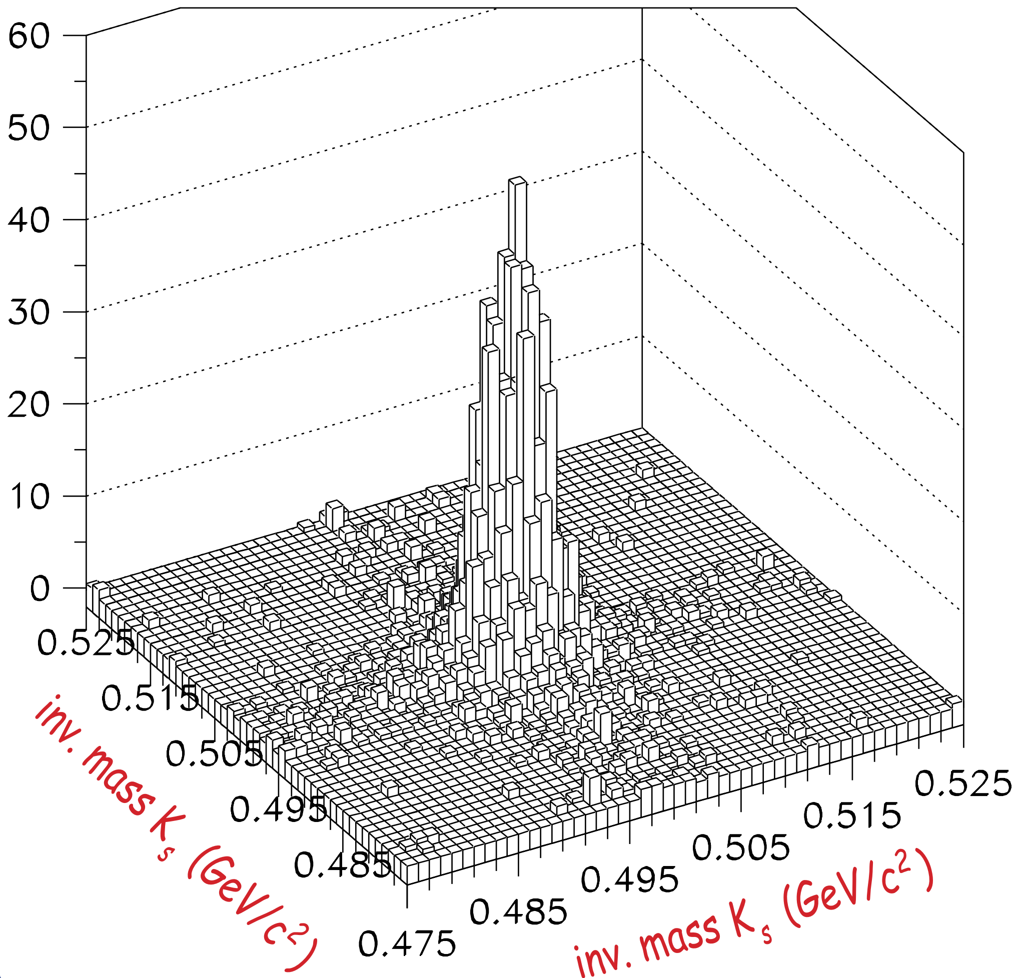
Efficiency of this selection for MC samples (independent data is also used):

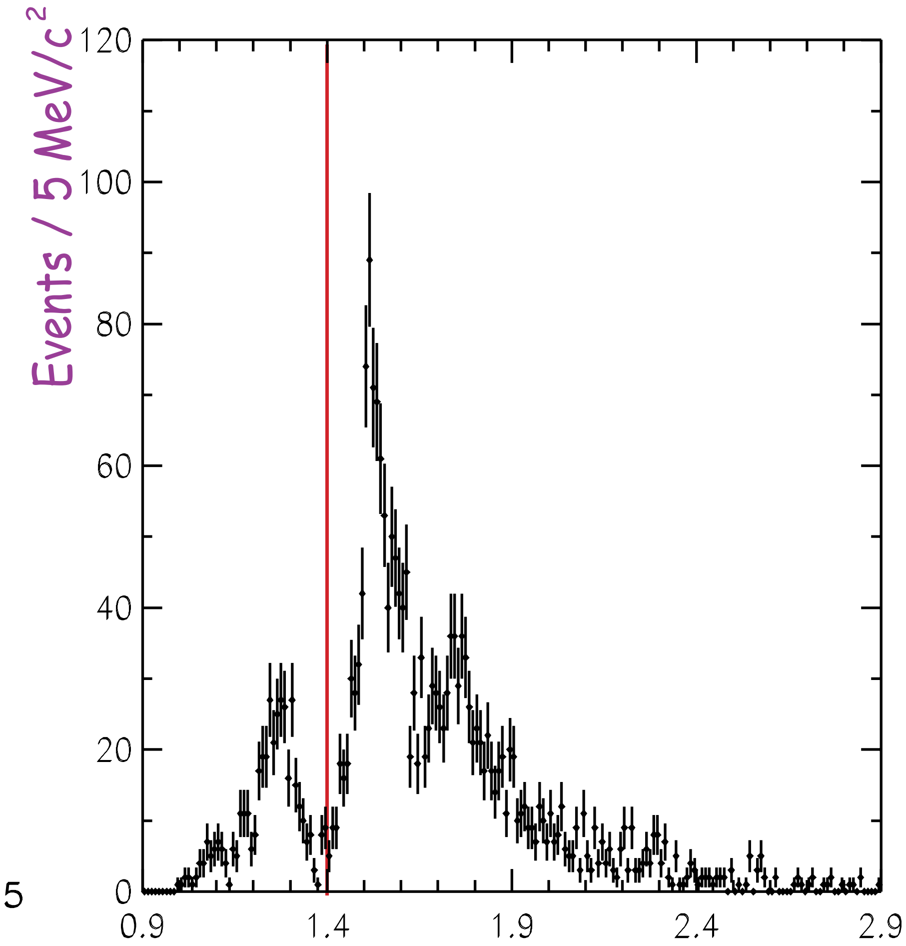
Signal MC ($\eta(1440)$): 0.84% (total systematics is 30%)

This is not unusual for low-mass untagged two-photon events

Using Data to Measure Efficiencies and Estimate Systematics

Exclusive two-photon K_s pairs in data

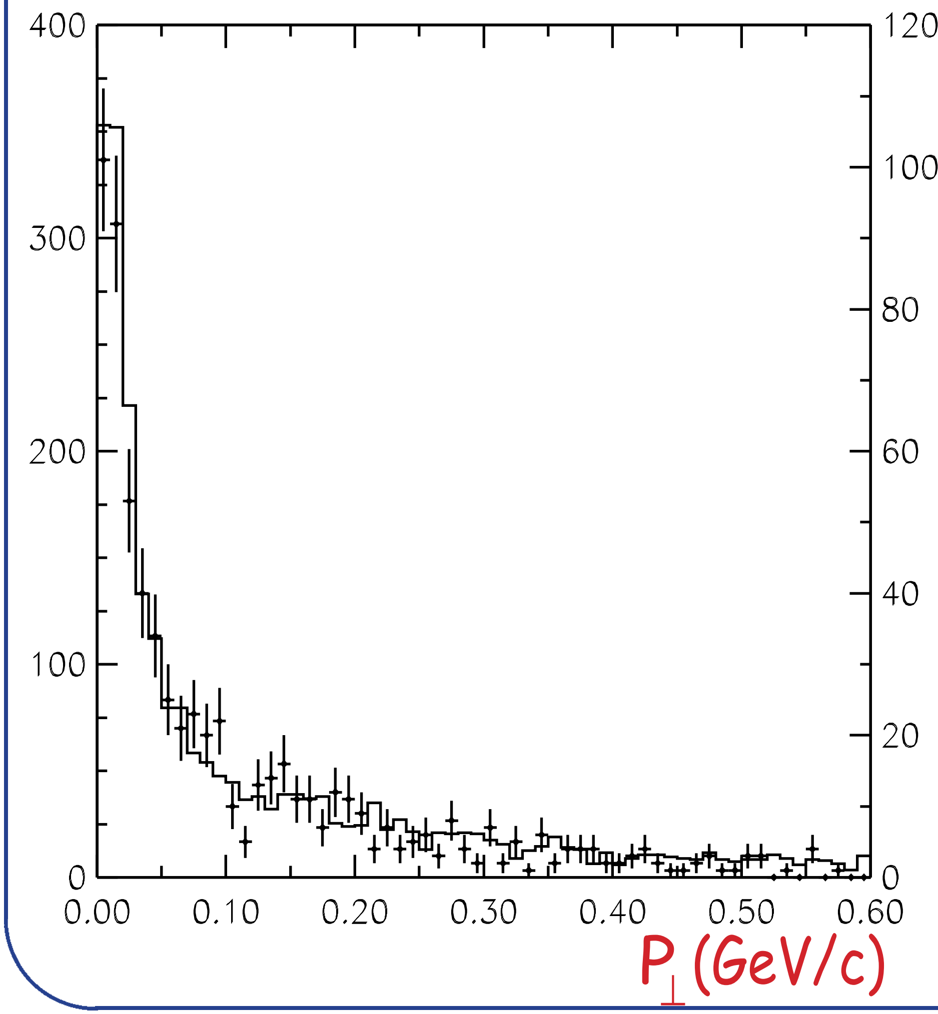


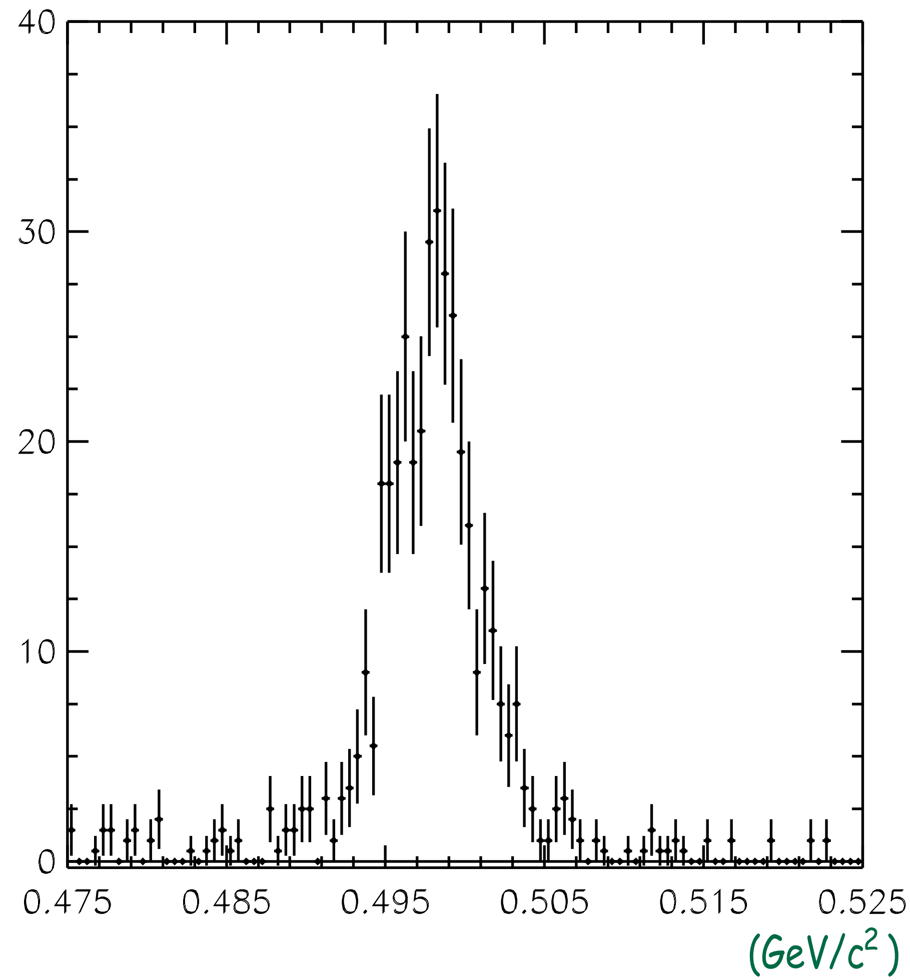


Invariant mass of K_s K_s candidates (GeV/c^2)

Two-Photon K_s Pairs Below 1.4 GeV/c^2 are utilized

Transverse momentum in calibration data (points) and signal MC (line)

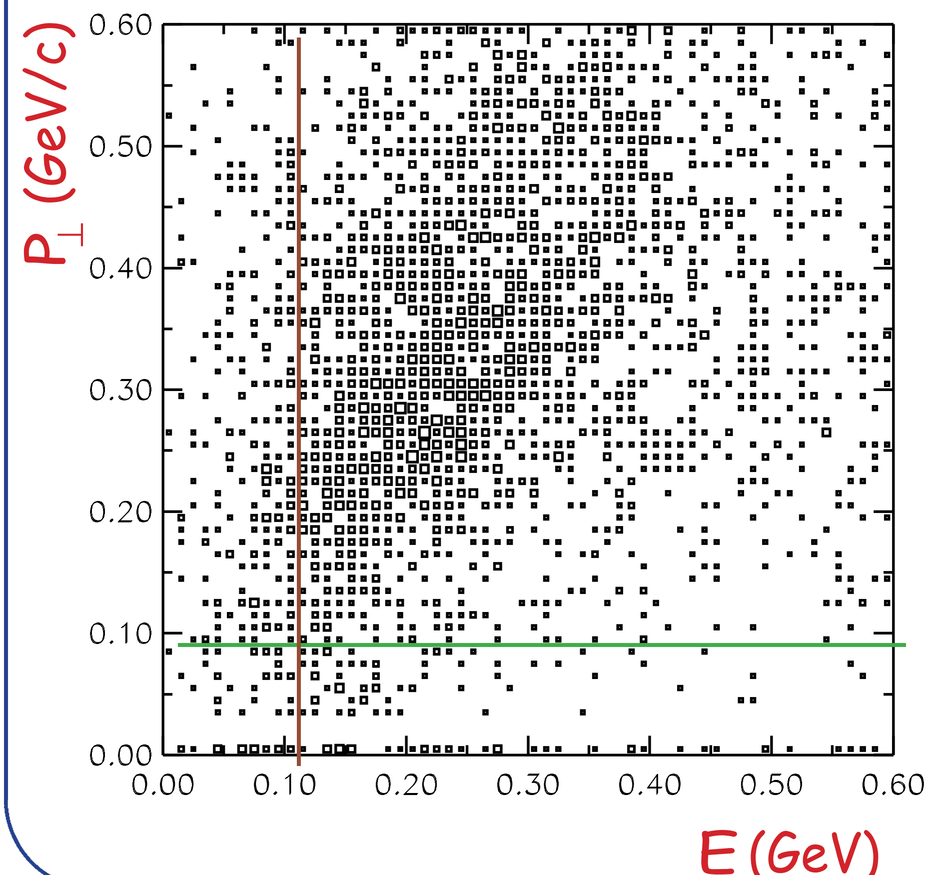


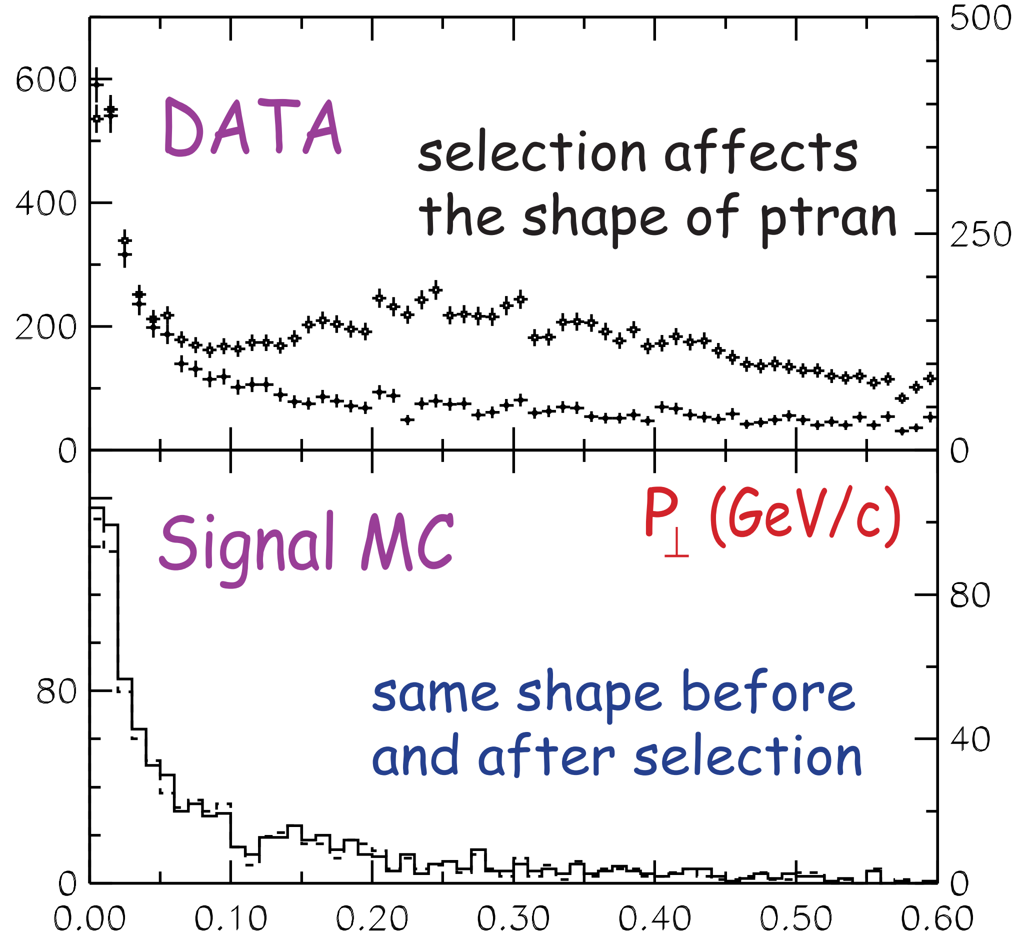


Invariant mass of K_s candidates in calibration data at low invariant mass

Tight Selection Criteria and Two-Photon Backgrounds

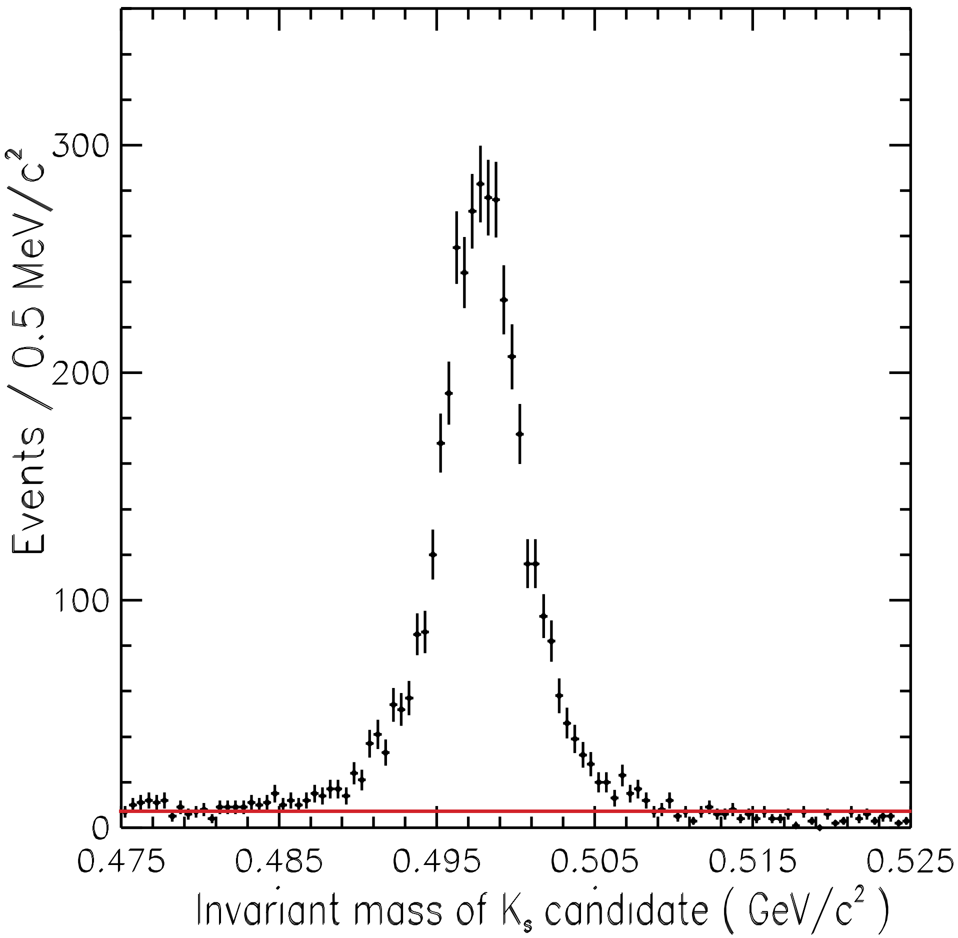
Transverse momentum vs unmatched energy for bckg $K^{*+}K^{*-}$ two-photon MC - this effect is verified in data!

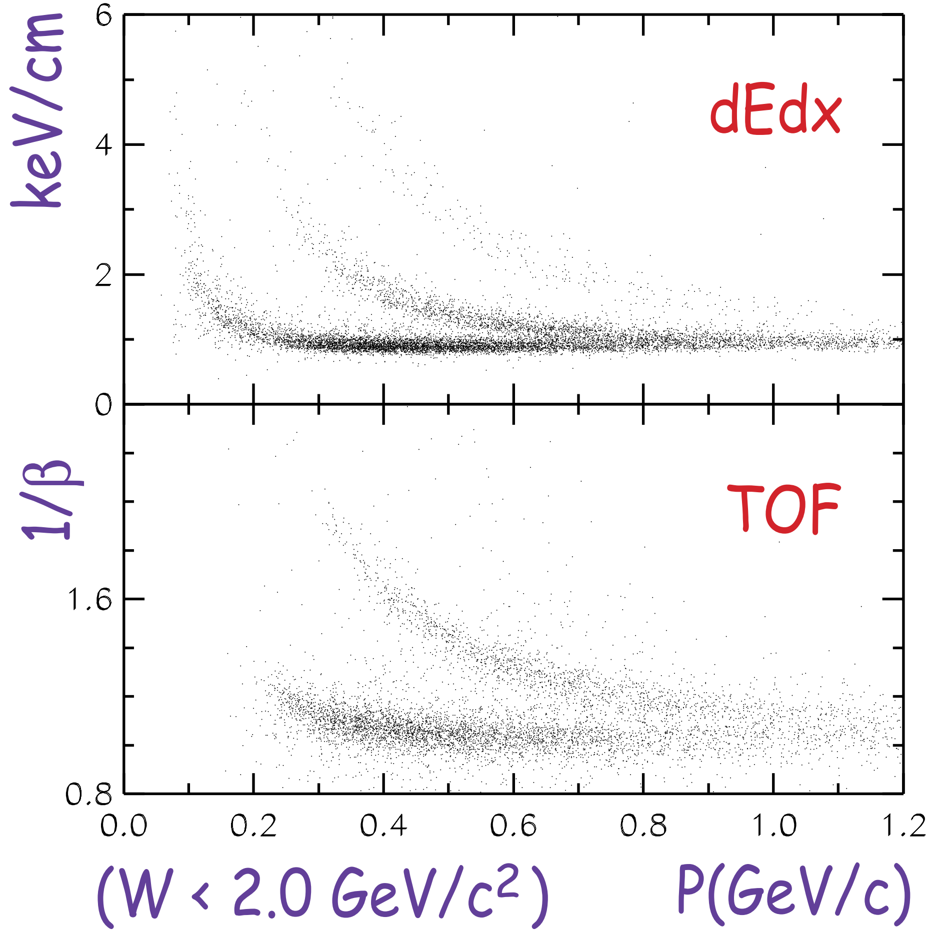




Transverse momentum for signal candidates in data (below 2 GeV/c^2) and signal $\eta(1440)$ MC before and after unmatched energy selection

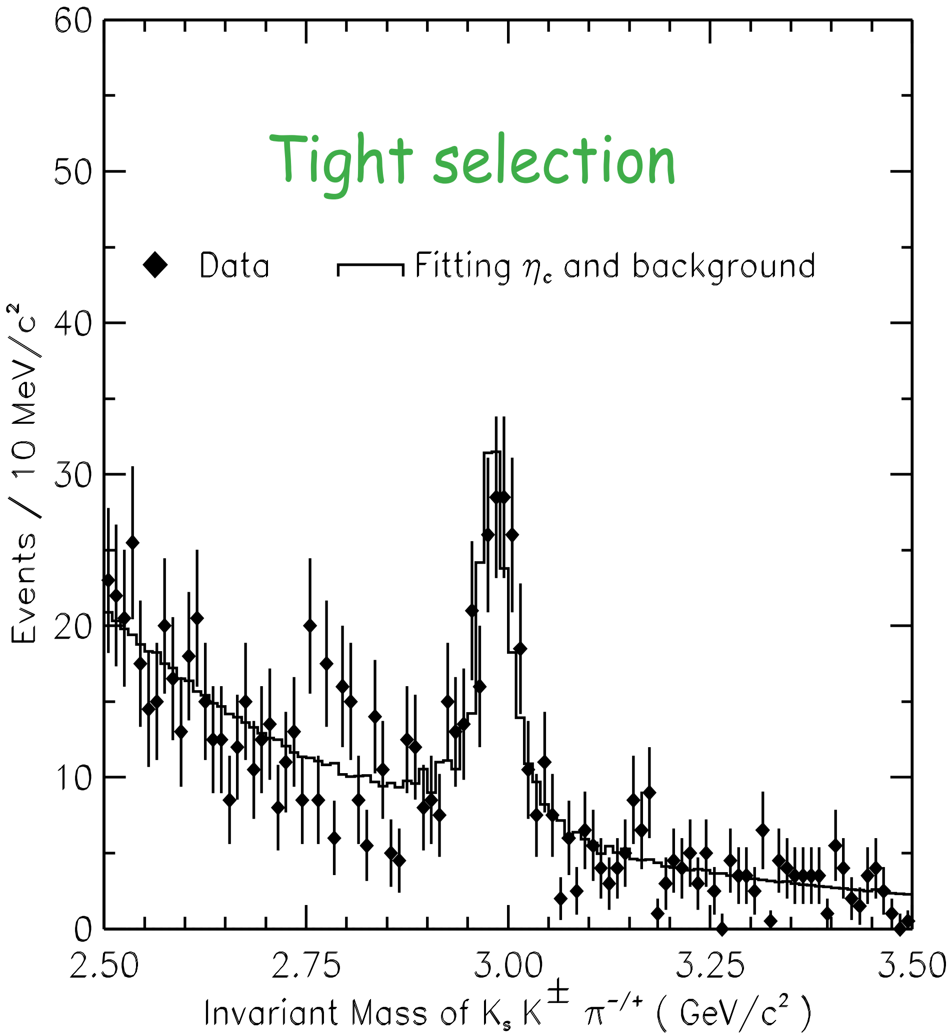
Some Important Distributions in Signal Data

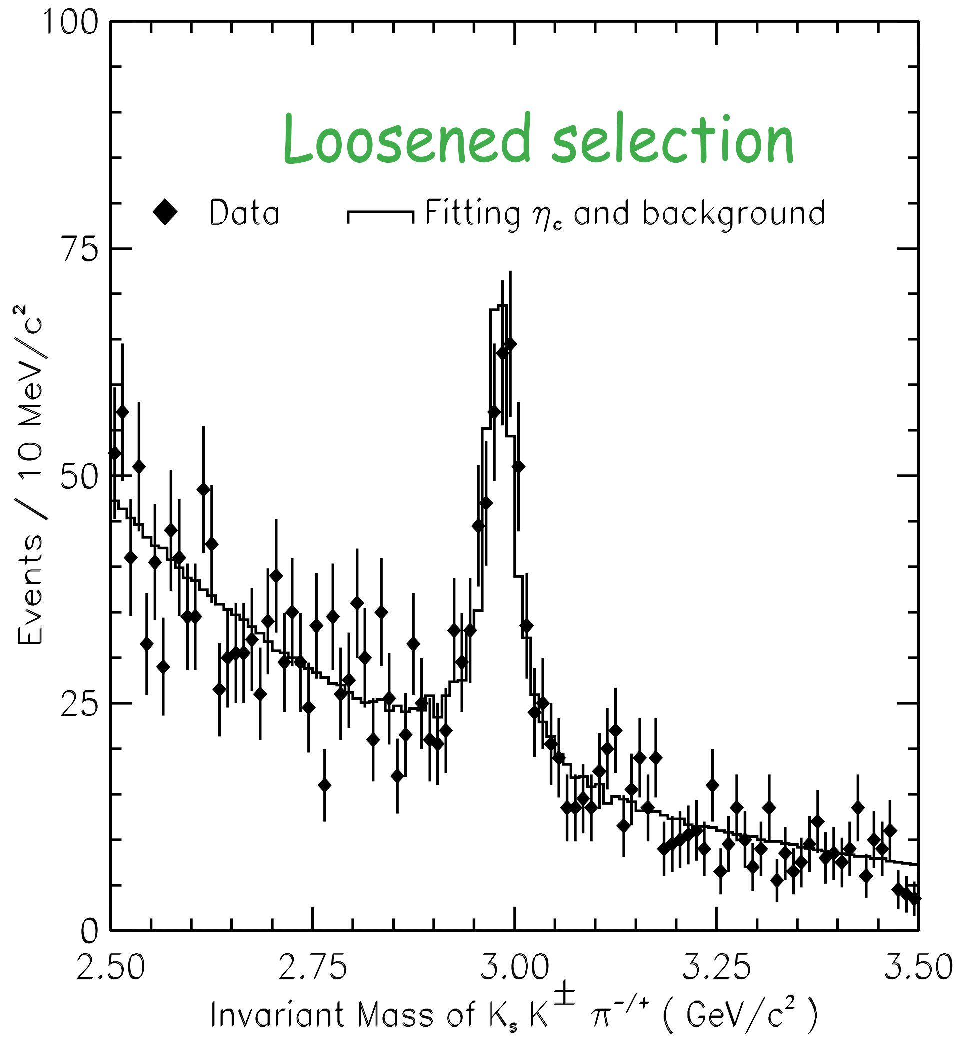




These distributions are shown for data after applying all selection criteria (for right plot we removed PID requirement). Plots prove that there are $K_s K^{\pm} \pi^{\mp}$ events in data.

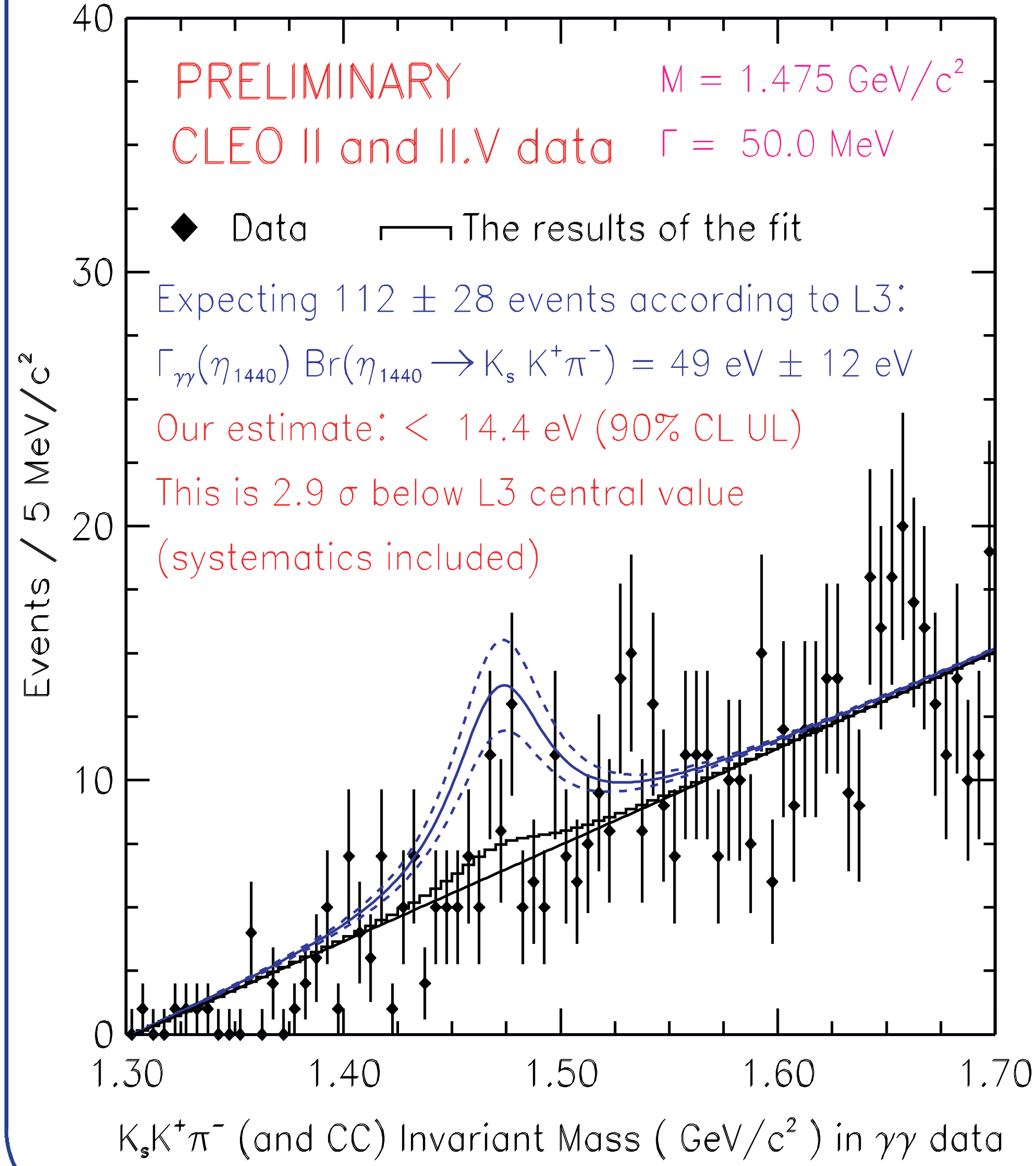
Testing the Analysis on η_c Measurement





We obtain central value of 6.7 keV in both tests, while we reported $\Gamma_{\gamma\gamma}(\eta_c) = 7.6$ keV +- 0.8 keV (PRL 85, 3095 (2000)) - good (same data used).

Invariant Mass Distribution for Signal Candidates



Can only do upper limits, no observation.
Is this surprising? Not necessarily:
L3 integrated luminosity: 3% of CLEO
but L3 $\gamma\gamma$ cross section: 6 times larger
We can do sqrt(5) better with bckg

90% CL UL: approx. < 33 events
Efficiency (with systematics): 0.0051
Luminosity: 13.8 inverse femtobarns
Cross section per 1 keV $\gamma\gamma$ width: 36 pb

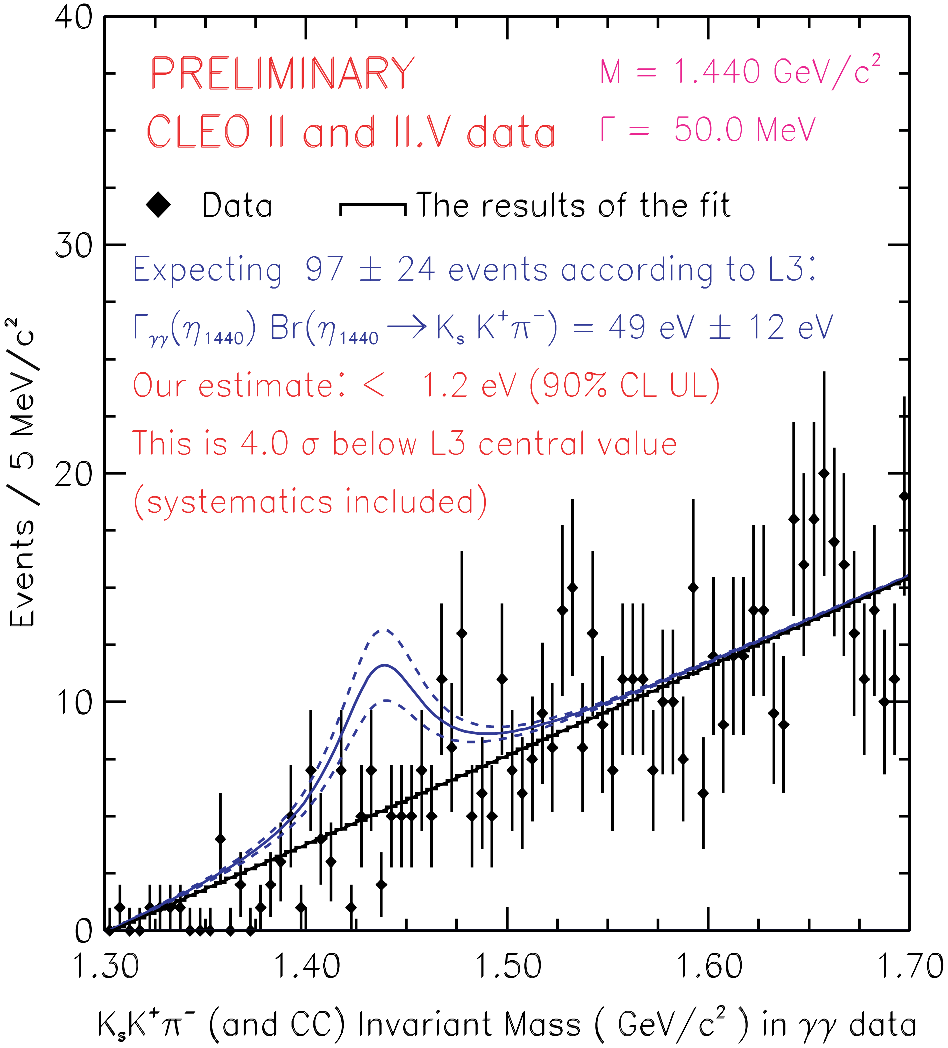
Setting 90% CL UL on the product:

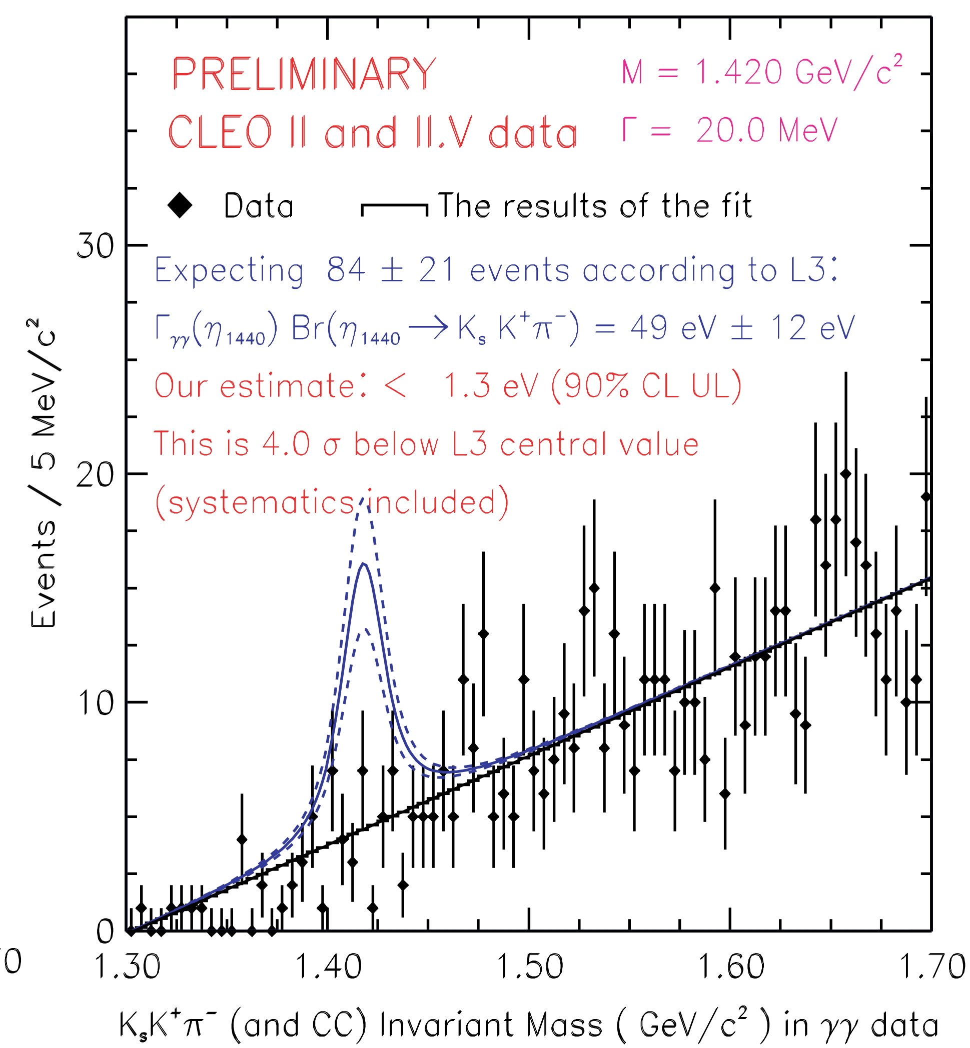
$$\Gamma_{\gamma\gamma}(\eta(1440))\, B\,(\eta(1440) \to K_s K^{\pm} \pi^{\mp})$$

< 14 eV (systematics included, preliminary)

(L3 reports: 49 +- 12 eV for this value)

Two More Fits for Other Mass and Width Hypotheses





Conclusions

In our analysis we do not observe any narrow resonances between 1.3 GeV and 1.7 GeV, also, we do not confirm L3 observation.

We set upper limits on the product of partial two-photon width and branching fraction (K_s branching fraction included)

For example, assuming M = 1.475 GeV, Γ = 50 MeV

$\Gamma_{\gamma\gamma}(\eta(1440))\, B\, (\eta(1440) \to K_s K^{\pm} \pi^{\mp}) < 14$ eV

(this is 2.9 σ below L3 number of 49 eV +- 12 eV)

Final result of our analysis will include tables of upper limits estimated using various values for the mystery resonance mass and width (analysis continues).