Recent KLOE results

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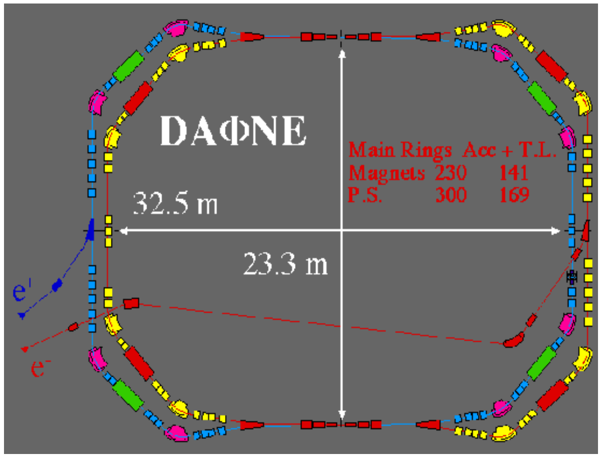
Talk outline

- Detector description
- Kaon physics
  - V_{us} and lepton universality with K neutral semileptonic decays
  - V_{us} determination from $K \rightarrow \mu\nu$
  - Measurement of $Br(K \rightarrow \mu\nu)/Br(K \rightarrow e\nu)$ and limits on MSSM
  - Search for $K_S \rightarrow e^+ e^-$
  - Measurement of $K_s \rightarrow \gamma\gamma$
- Hadron physics
  - $a_\mu^{\pi\pi}$ measurement
  - $\omega\pi^0$ cross section measurement
  - η mass measurement, $\eta \rightarrow 3\pi^0$ Dalitz Plot Slope, $\eta - \eta'$ mixing angle
  - Scalar physics

The DAFNE machine and the KLOE detector



- $\sigma(e^+e^- \to \phi) \sim 3\,\mu b$ $\sqrt{s} = m(\phi) = 1019.4\,MeV$
- Independent e^+e^- rings to reduce beam-beam interactions
- crossing angle: 25 mrad, $p_x(\phi) \sim 12{,}6$ MeV/c
- Bunch crossing every 2.7 ns $\int \mathcal{L}\,dt = 2.5\,fb^{-1}$
- injection during acquisition

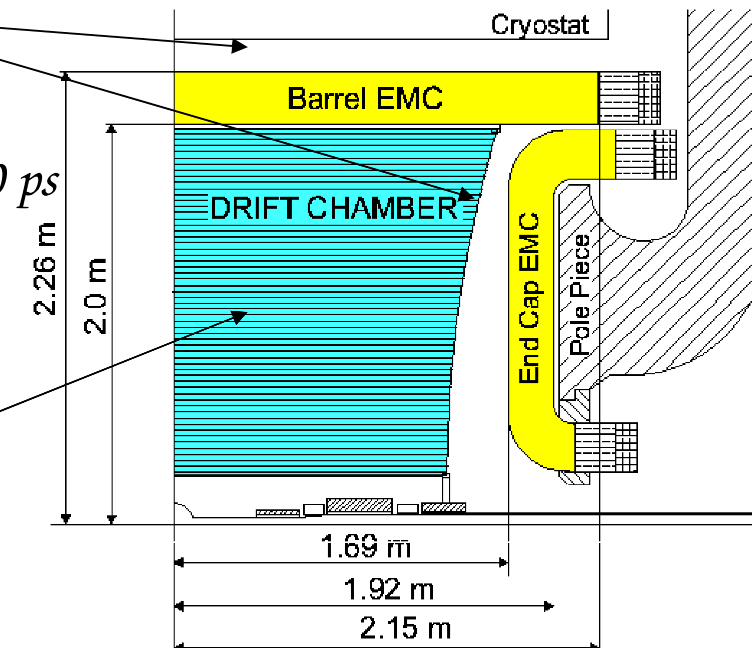
$\mathcal{L}_{peak} = 1.5\times10^{32}\ cm^{-2}s^{-1}$

Electromagnetic Calorimeter (EMC)

- Fine sampling Pb / Scifi
- Hermetical coverage
- High efficiency for low energy photons

$\sigma_E/E = 5.7\%/\sqrt{E(GeV)}$

$\sigma_t = 54ps/\sqrt{E(GeV)} \oplus 140\ ps$



Central drift chamber (DCH)

Helium based gas mixture

$\sigma_v = 1\ mm$ $\sigma_{pt}/p_t = 0.5\%$

$\sigma_{r\phi} = 200\ \mu m$ $\sigma_z = 2\ mm$

Neutral KAONS

Absolute branching ratios of the K_L decays ($K_S \to \pi^+ \pi^-$ tagging):

- Ke3, $K\mu 3$, $K3\pi^0$, $K \pi^+ \pi^- \pi^0$

K_L lifetime using $K_L \to 3\pi^0$ τ_L = 50.92 (30) ns
Ke3 form factor slopes λ'_+, λ''_+
$Br(K_S \pi^+ \pi^-)/Br(K_s \pi^0 \pi^0)$, $Br(K_S \pi e \nu)/Br(K_s \pi^+ \pi^-)$

Ke3 and $K\mu 3$ combined fit to determine λ'_+, λ''_+ and λ_0 assuming lepton universality*

$K_s \to e^+e^-$ search*, $K_S \to \gamma\gamma$ Br measurement*
CPT testing with the Belle-Steimberger relation

Charged KAONS

$K^+ l3$ Absolute Branching ratio measurement*
$K^+ \pi^+ \pi^0$ Absolute Branching ratio measurement
$K^+ \mu\nu$ Absolute Branching ratio measurement
$\tau(K^+)$ measurement*

Master formula: $\Gamma(K_{l3(\gamma)}) = |V_{us}^{\ell}|^2 \, |f_+^{K^0\pi^-}(0)|^2 \, \frac{G_{F\ell}^2 m_K^5}{128\pi^3} S_{\rm EW} \, C_K^2 \, I_{K\ell} \, (1+\delta_K^\ell)$

Theoretical inputs:

- $f_+(0)$, form factor at zero momentum transfer: purely theoretical calculation
- δ^ℓ_K, e.m.- and (for $K^\pm$) I-breaking effects, known @ few per mil level
- [S_{EW}, short distance corrections (1.0232), C_K = 1 ($2^{-½}$) for K^0 (K^+) decays]

Experimental inputs:

- $I^\ell_K = I(\{\lambda_+\},\{\lambda_0\},0)$, phase space integral, λ_+, λ_0 denote the t-dependence of vector and scalar form factors;
- $\Gamma_{K\ell 3(\gamma)}$, semileptonic decay width, evaluated from γ-inclusive BR and lifetime
- m_K, appropriate kaon mass

KLOE measurement for all relevant inputs: BR's, τ's, ff's

Can compare short distance couplings $g(\ell) = |G_{f\ell} V_{us}|$ **e and μ modes**

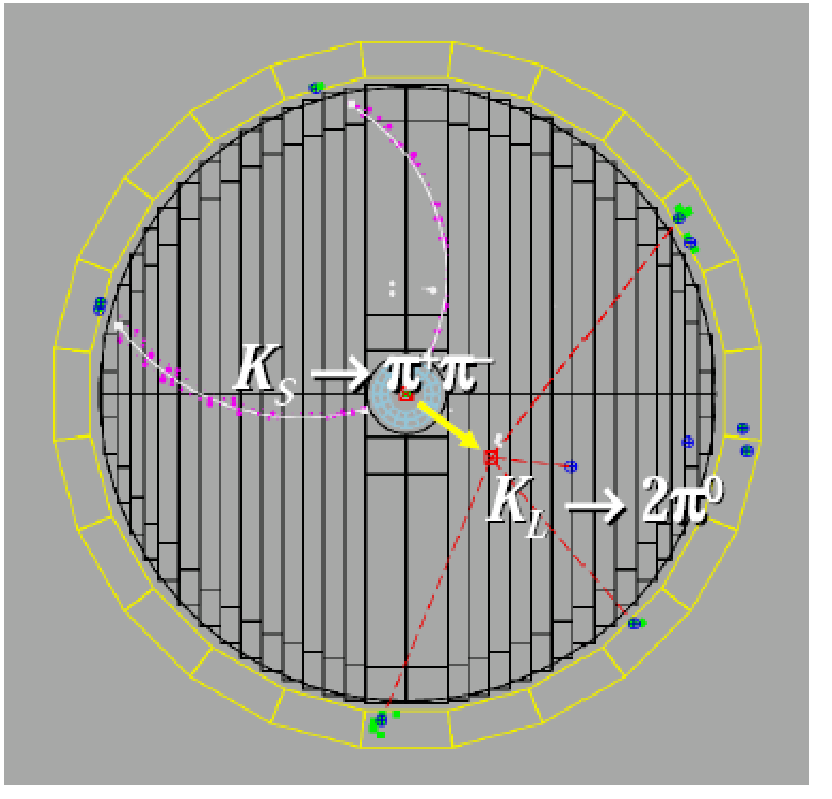
Tagging technique

$K_{S,L}$ $K^{+,-}$ pairs from ϕ decays, emitted ~back to back, p ~ 110 MeV

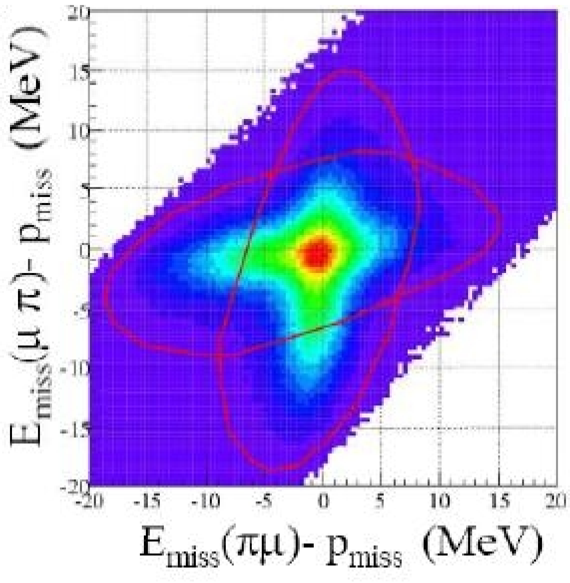
Identification of $K_{S,L}(K^{+,-})$ decay (interaction) tags presence of $K_{L,S}(K^{-,+})$

Almost pure $K_{L,S}$ and $K^{+,-}$ beams of known momentum + PID (kinematics & TOF):

- Access to absolute BR's
- Precise measurements of K_{Le3} from factors and K_L, K^+ lifetimes (acceptance ~0.5 τ_L, τ_+)



λ_o from kμ3 and ke3

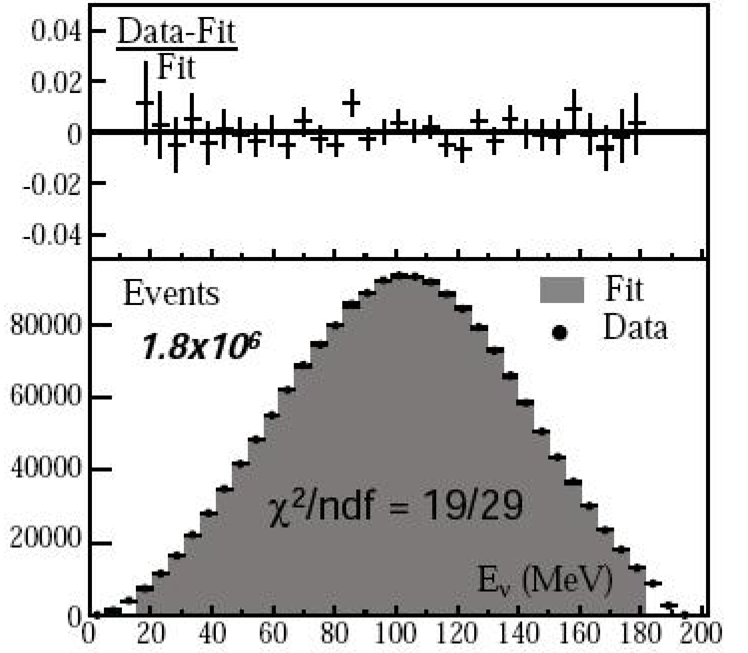


- K_L decays tagged by $K_s \rightarrow \pi^+\pi^-$
- preselection cutting on $E_{miss} - p_{miss}$
- background rejection of ππ,πππ and πeν from kinematics
- further reduction of Ke3 background with TOF & NN output (based on E/p and cluster shape)
- *π/μ ID with TOF is difficult at low energies*

λ_0 slope by fitting the E_ν distribution and combined fit with K_Le3 results for λ'_+ and λ''_+

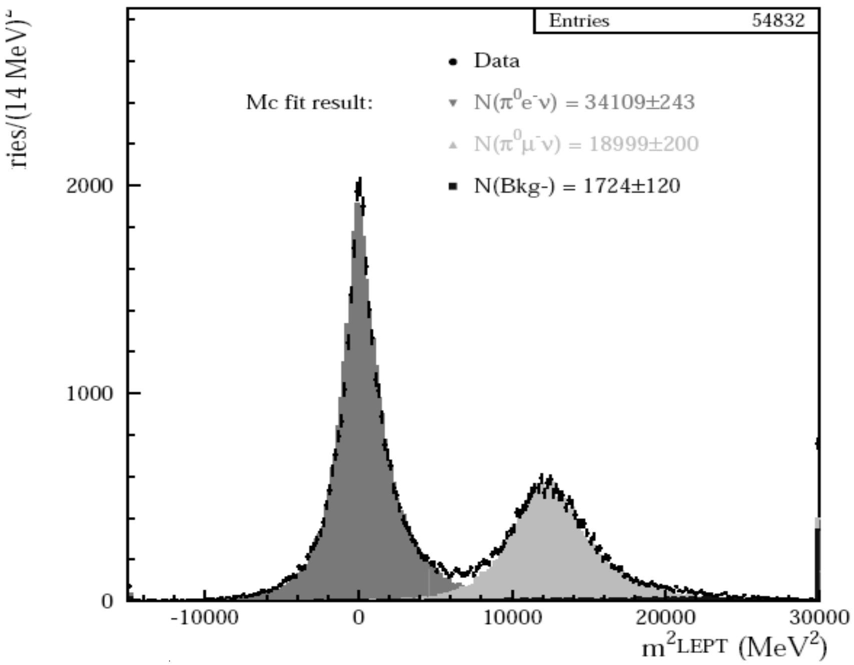
KLOE preliminary

$\lambda'_+ \times 10^3$	$\lambda''_+ \times 10^3$	$\lambda_0 \times 10^3$
25.6 ± 1.8	1.5 ± 0.8	15.4 ± 2.1



Absolute Br($K^{\pm}l3$) measurement

- ✧ **4 independent-tag samples: $K^+\mu 2$, $K^+\pi 2$, $K^-\mu 2$, and $K^-\pi 2$**
  keep under control the systematic effects due to the tag selection
- ✧ kinematical cuts to reject background
  residual background is about 1.5% of the selected $K^{\pm}{}_{l3}$ sample



8 independent measurements for each tag and charge sign.

$$m^2_{lept} = p^2_{lept} \cdot \left[\frac{c^2}{L^2_{lept}} \left(t_{lept} - t^{decay}_{\pi^0} \right)^2 - 1 \right]$$

Decay time of the Kaon

$$BR(K^-_{e3}) = (4.946 \pm 0.053_{Stat} \pm 0.038_{Syst}) \times 10^{-2} \quad BR(K^-_{\mu 3}) = (3.219 \pm 0.047_{Stat} \pm 0.027_{Syst}) \times 10^{-2}$$

$$BR(K^+_{e3}) = (4.985 \pm 0.054_{Stat} \pm 0.037_{Syst}) \times 10^{-2} \quad BR(K^+_{\mu 3}) = (3.241 \pm 0.037_{Stat} \pm 0.026_{Syst}) \times 10^{-2}$$

$$BR(K_{e3}) = (4.965 \pm 0.038_{Stat} \pm 0.037_{Syst}) \times 10^{-2} \quad BR(K_{\mu 3}) = (3.233 \pm 0.029_{Stat} \pm 0.026_{Syst}) \times 10^{-2}$$

K^+ life time measurement

- Poor consistency of PDG average with measurements spread

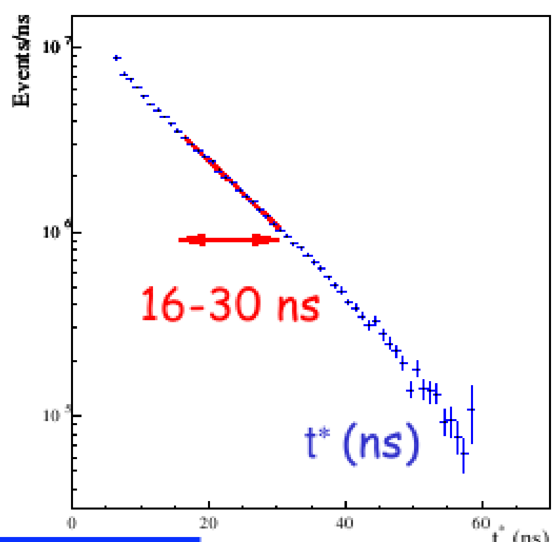
  $\delta\tau/\tau \sim 0.2\% \rightarrow \delta V_{us}/V_{us} \sim 0.1\%$ $\delta\tau/\tau \sim 0.8\% \rightarrow \delta V_{us}/V_{us} \sim 0.4\%$

- Use $K_{\mu 2}$ tagged decay vertices in drift chamber and two different methods to evaluate the proper time t^* (cross-check systematic effects)

Fit to t^* distribution from decay length

Coverage: 16-30 ns → $1.1\tau_{\pm}$

Evaluation of t^* includes dE/dx (2 mm steps)

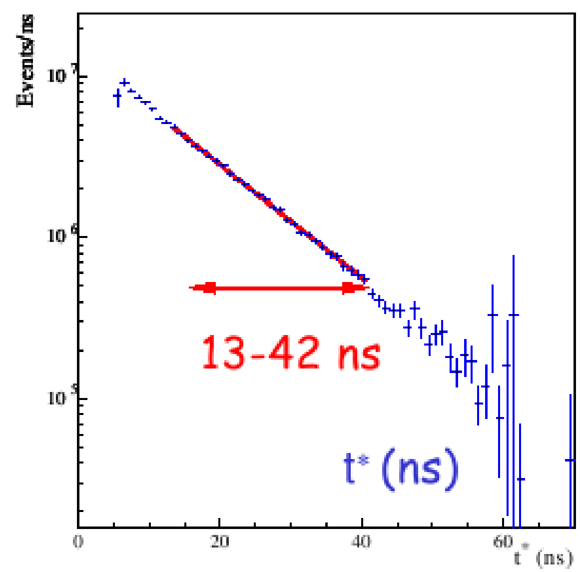


KLOE '06 preliminary

$\tau_{\pm}$= 12.367(44)(65) ns

Fit to t^* distribution from decay time

Coverage: 13-42 ns → $2.3\tau_{\pm}$



KLOE '07 preliminary

$\tau_{\pm}$= 12.391(49)(25) ns

ρ = 0.34

Use ff slopes from $KLOE_{e3}$, $KLOE_{\mu3}$ to evaluate phase space integrals

Mode	$f_+(0) \times \lvert V_{us}\rvert$	Error,%	KLOE input	External input
K_{Le3}	0.21547(72)	0.34	ff, BR, τ_L	
$K_{L\mu3}$	0.21661(93)	0.43	ff, BR, τ_L	
K_{Se3}	0.21522(145)	0.68	ff, BR	τ_S [PDG]
K^+_{e3}	0.21465(137)	0.64	ff, BR*, τ^{+*}	τ^+ [PDG]
$K^+_{\mu3}$	0.21302(155)	0.73	BR*, τ^{+*}	τ^+ [PDG]
Avg™	0.21556(59)	0.27		

e/μ universality satisfied, using only KLOE results get accuracy <0.004:

K_L $g(\mu)/g(e) = 1.0054(44)$ cfr with $g(\mu)/g(e) = 1.0232(68)$ [PDG04]

K^+ $g(\mu)/g(e) = 0.9924(54)$ cfr with $g(\mu)/g(e) = 1.0020(80)$ [PDG04]

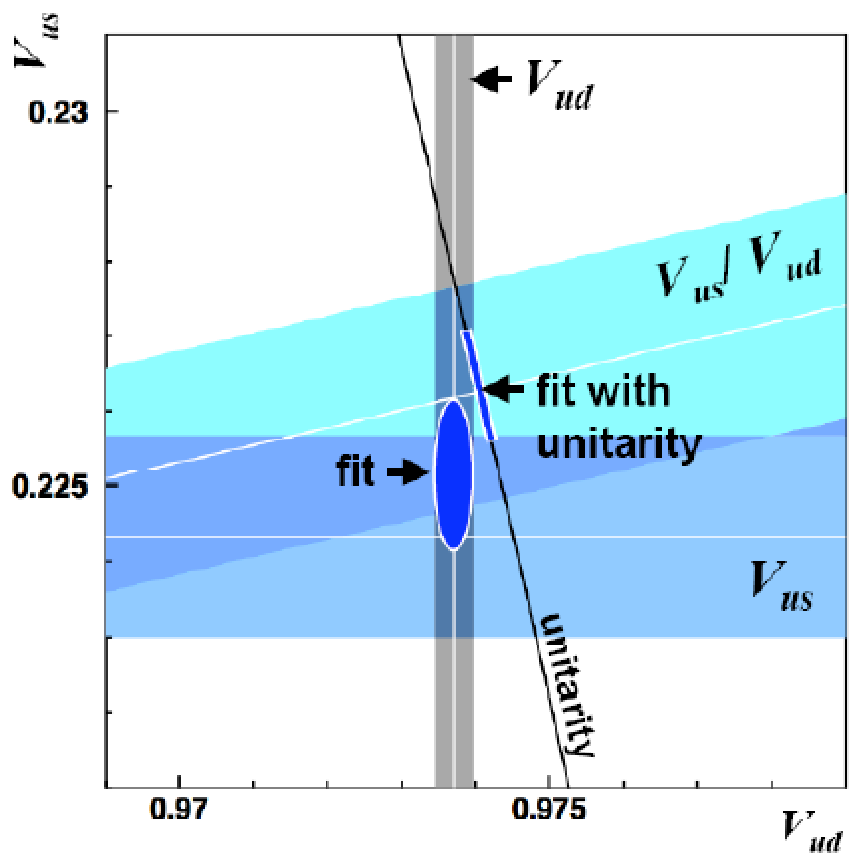
Average $g(\mu)/g(e) = 1.0005(38)$

Compare with $\tau \to l\nu\nu$ decays: $g(\mu)/g(e) = 0.9999(20)$

V_{us} determination

$f_+(0)$ from UKQCD/RBC '06

$|V_{us}|$ = 0.2243(13) from KLOE $Kl3$



Fit results, no constraint:

V_{ud} = 0.97371(26)
V_{us} = 0.2252(10)
χ^2/ndf = 0.85/1 (36%)

Unitarity constrained at < 7×10^{-4} level on $|V_{ud}|^2 + |V_{us}|^2$

Fit results, unitarity constraint:

V_{ud} = 0.97405(17)
V_{us} = 0.2263(7)
χ^2/ndf = 3.8/2 (14.6%)

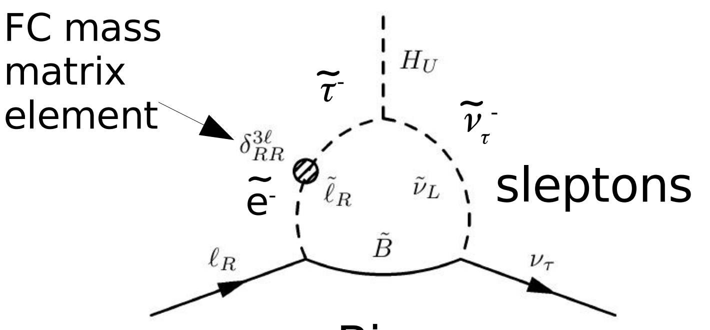
Agreement with unitarity 1.5σ

$$\frac{\Gamma(K\to\mu\nu\gamma)}{\Gamma(\pi\to\mu\nu\gamma)}=\frac{m_K\left(1-\frac{m_\mu^2}{m_K^2}\right)^2}{m_\pi\left(1-\frac{m_\mu^2}{m_\pi^2}\right)}\frac{|V_{us}|^2}{|V_{ud}|^2}\frac{f_K^2}{f_\pi^2}\frac{1+\alpha/\pi\, C_K}{1+\alpha/\pi\, C_\pi}$$

V_{us}/V_{ud} from Br($K\to\mu\nu\gamma$)$_{KLOE}$ /Br($\pi\to\mu\nu\gamma$)

ke2/kμ2 and Lepton universality

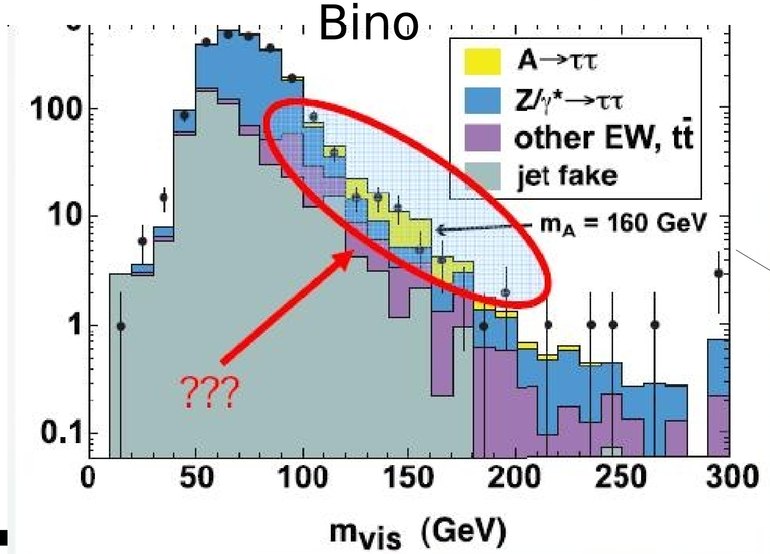
- Several extension of the standard model predict lepton flavour violation due to the contributions of new particles in the decay amplitudes.
- In the MSSM the decay rate K→e$^-\nu$,K→$\mu^-\nu$ can be strongly modified by the LFV modes K→e$^-\nu$ through H$^+$ exchange



$$R_K^{LFV} \simeq R_K^{SM}\left[1+\left(\frac{m_K^4}{M_H^4}\right)\left(\frac{m_\tau^2}{m_e^2}\right)|\Delta_R^{31}|^2\tan^6\beta\right]$$

Unluckily only an upper limit on $\Delta^{31}{}_R$ ($\propto \delta^{31}{}_{RR}$ LFV mass matrix term) is available $\Delta^{31}{}_R < 10^{-3}$

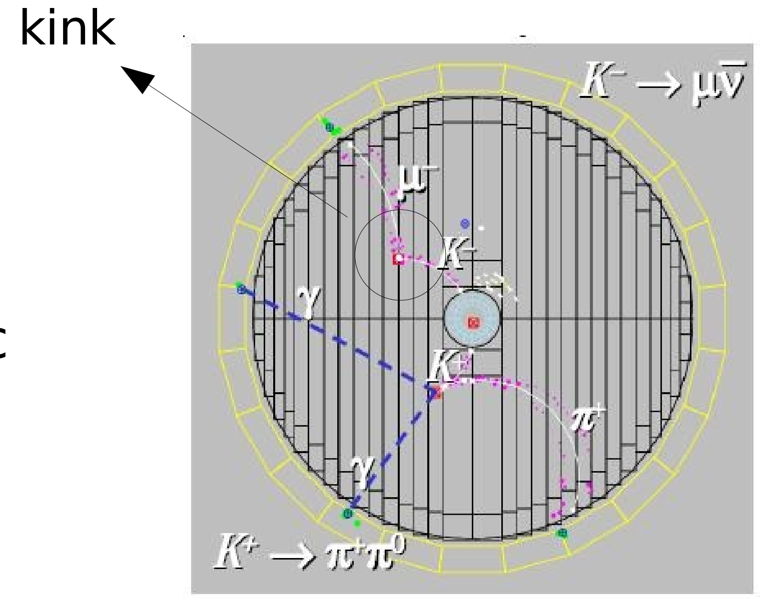
Contributions at percent level are possible with m_H = 160 GeV, tanβ = 50 and $\Delta^{31}{}_R = 4\times10^{-5}$

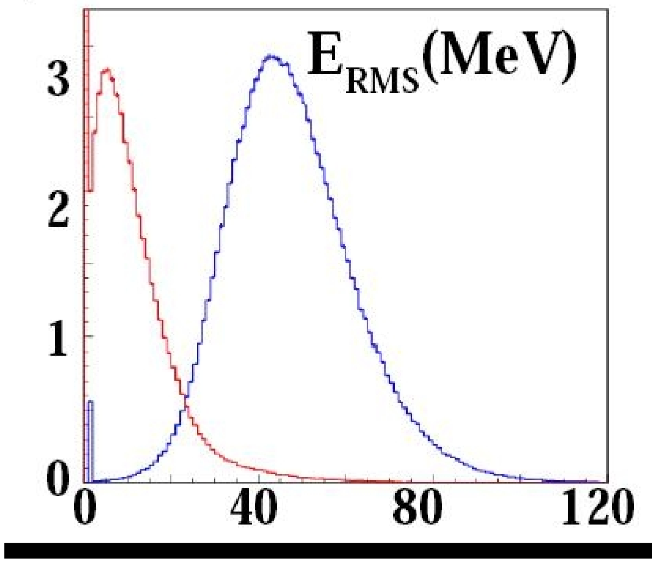


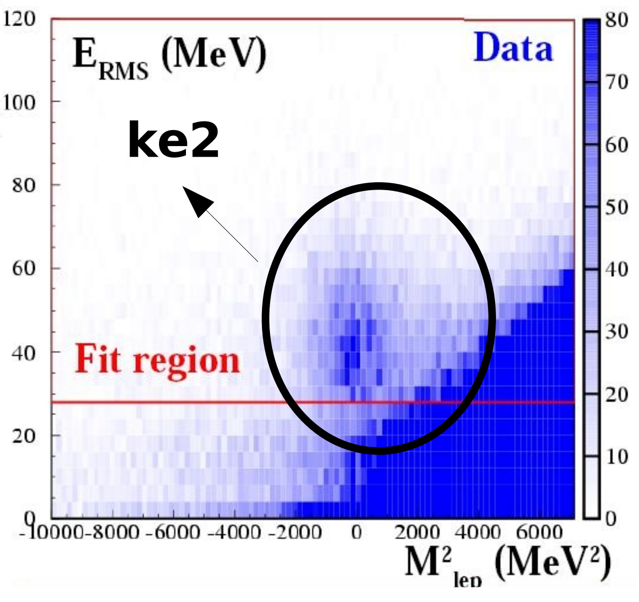
CDF 2σ hint

ke2/kμ2 at KLOE

1) Select one kink in the D.C.;
2) K track required from the I.P;
3) e/μ discrimination through E/P and EMC cluster shape analysis;
4) M^2_{lep} (m_ν = 0) from 2 bodies kinematic and E_{rms} (rms of energy distribution in calorimeter planes) used as counting variables.

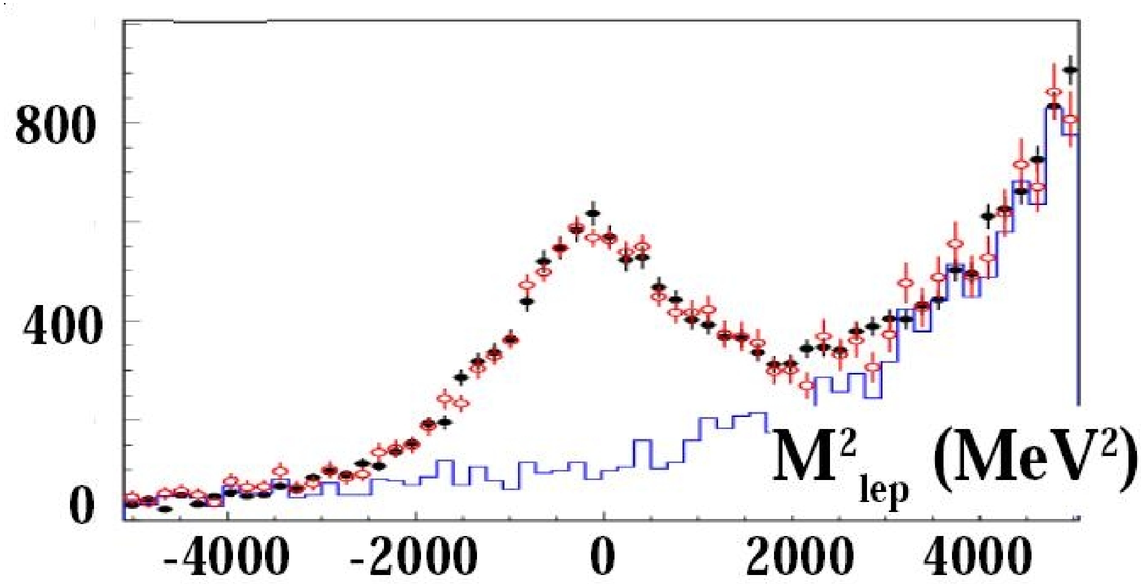






Fit 2D distribution to extract signal count

ke2/kμ2 preliminary result



Likelihood fit of MC shapes for ke2(γ) and background;

Free parameters: background and signal yield.

$N_{ke2(\gamma)}$ = 8090 ± 160 evts.

CS: Kmu2, ke3 and kmu3 to determine kink-one prong efficiency, PID efficiency, correct MC distributions.

$$R_K = \frac{N_{Ke2}}{N_{K\mu2}} \left[\frac{\varepsilon^{\rm TRG}_{K\mu2}}{\varepsilon^{\rm TRG}_{Ke2}}\right] \left[C^{\rm TRK}\frac{\varepsilon^{\rm TRK}_{K\mu2}}{\varepsilon^{\rm TRK}_{Ke2}}\right] \left[\frac{1}{C^{\rm PID}\varepsilon^{\rm PID}_{Ke2}}\right] \frac{1}{\varepsilon^{\rm IB}} = (2.55 \pm 0.05 \pm 0.05)\times 10^{-5}$$

Agrees w SM: $(2.472 \pm 0.001)\times10^{-5}$ &2 NA48 preliminary: $(2.43\pm0.04)\times10^{-5}$

E^{IB} (Inner Bremstrhalug $E_\gamma < 20$ MeV to cut Direct Emission, 0.45% sys. err.)

1% error reachable increasing DATA sample analysed, CS statistics, MC Background simulation

K→$\mu\nu$ sensitivity to new physics

H^- contribution to helicity suppressed SM decays

$$\frac{\Gamma(M\to\ell\nu)}{\Gamma_{SM}(M\to\ell\nu)} = \left[1-\tan^2\beta\left(\frac{m_{s,d}}{m_u+m_{s,d}}\right)\frac{m_M^2}{m_H^2}\right]^2$$

Hou, Phys. Rev. D48 (1993) 2342

Isidori, Paradisi, Phys. Lett. B639 (2006) 499

In the K and π case large uncertainty in Γ_{SM} due to the theoretical factors f_K and f_π. Much better determination of $(f_K/f_\pi)/f^+(0)$ using Callan-Treiman.

$$\frac{\Gamma_{SM}(K\to\mu\nu)}{\Gamma_{SM}(\pi\to\mu\nu)} = \frac{m_K\left(1-\frac{m_\mu^2}{m_K^2}\right)^2}{m_\pi\left(1-\frac{m_\mu^2}{m_\pi^2}\right)^2}\frac{|V_{us}|^2}{|V_{ud}|^2}\frac{f_K^2}{f_\pi^2} \propto \frac{|V_{us}f^+(0)|^2_{kl3}}{|V_{ud}|^2}\frac{f_K^2}{f_\pi^2}\frac{1}{f^+(0)}$$

NP contributions in kl3 can be neglected because it is not helicity suppressed.

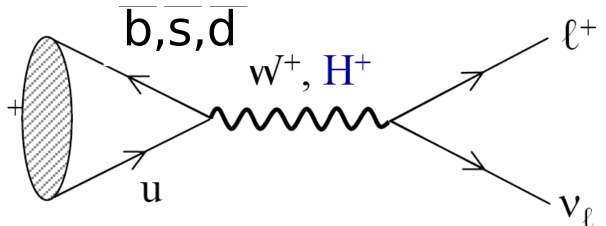
Assuming CKM unitarity, negligible NP contribution on $\pi\to\mu\nu$, $\Gamma_{SM}(k\to\mu\nu)$ can be extracted from Br($\pi\to\mu\nu\gamma$).

Using **Br($K^+\to\mu^+\nu\gamma$) = 63.66(17)** **Phys. Lett. B 632 (2006), 76 (KLOE)**

Br($K^+\to\mu^+\nu\gamma$)$_{SM}$ = 0.6353(77) from FLAVIA NET Fit (http://www.lnf.infn.it/wg/vus)

$$R=\frac{\Gamma(K\to\mu\nu)}{\Gamma_{SM}(K\to\mu\nu)}=1.002\pm0.012$$

B^+, K^+, π^+



$\tan\beta$ M_{H+} exclusion plots

Br(B → $\tau\nu$) = $(1.42 \pm 0.44)\times 10^{-4}$
Br(B → $\tau\nu$)$_{SM}$ = $(1.6 \pm 0.4)\times 10^{-4}$
Belle – Babar average (EPS '07)

$$R_K = \frac{\Gamma(K\to\mu\nu)}{\Gamma(K\to e\nu)} \qquad \Delta_R^{31} = 10^{-4}$$

R_K = (2.55 ± 0.07)×10^{-4}
preliminary KLOE result

KLOE $\frac{\Gamma(K\to\mu\nu)}{\Gamma(\pi\to\mu\nu)}$

95% C.L. excluded

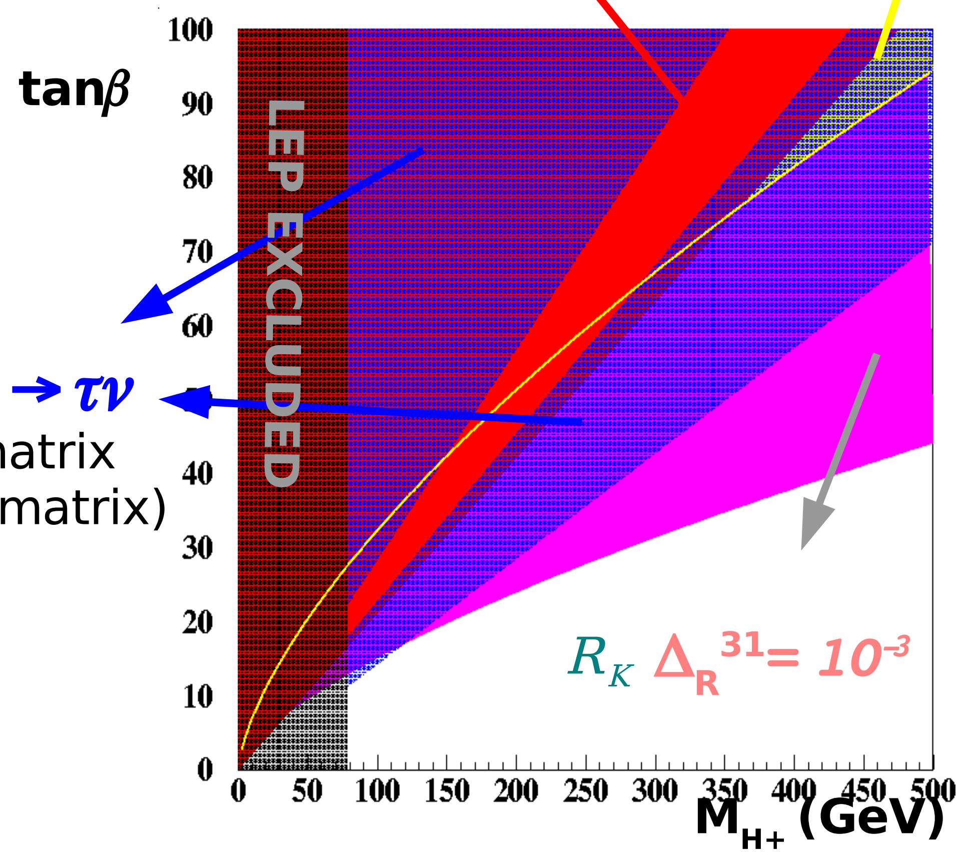
R_K very powerful but strongly dependent from LFV parametersb

$$\Delta_R^{3\ell} \simeq \frac{\alpha_1}{4\pi}\mu M_1 m_R^2 \delta_{RR}^{3\ell}\left[I'(M_1^2,\mu^2,m_R^2) - (\mu\leftrightarrow m_L)\right]$$

B → $\tau\nu$

Requires LFV in sleptons mass matrix (expected from neutrino mixing matrix)

Sensitive at high values of SUSY breaking scale

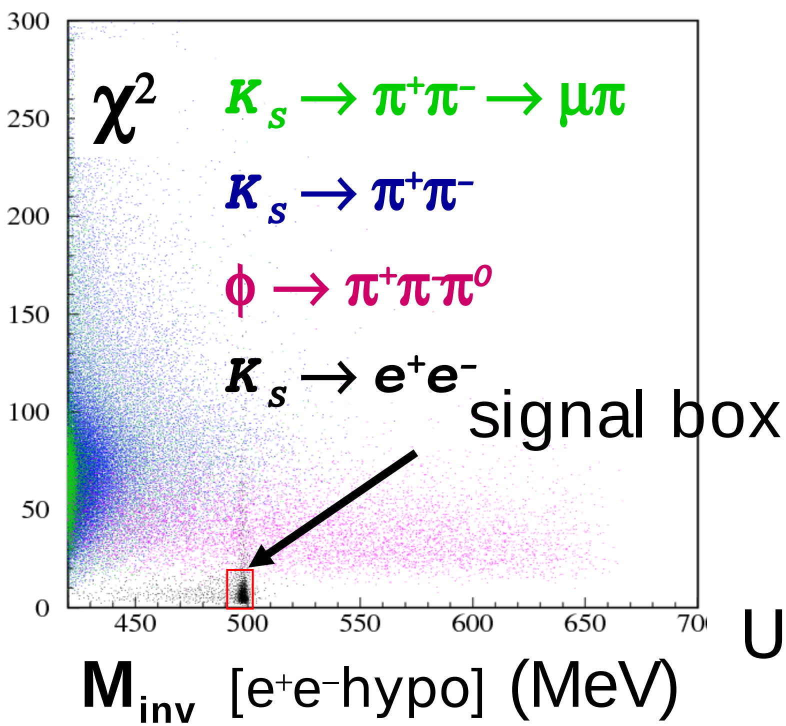


SM prediction very low $BR(K_S \rightarrow e^+e^-) = 1.6\times 10^{-15}$ *[Ecker, Pich 91]*

Large room for discovery

event selection (**1.32 fb^{-1}**)

- K_S tagged by K_L crash
- 2 tracks from IP to EmC with M_{inv} [e+ e- hypo] > 420 MeV



χ^2 like variable based on:

- TOF of the 2 particles, E/p

- distance between track impact point and cluster centroid

$N_{obs} = 3$ and $\mu_{BKG} = 7.1\pm3.6$

$$UL(BR) = UL(N_{sig}) \times \frac{\varepsilon_{\pi\pi}}{\varepsilon_{sig}} \times \frac{BR_{\pi\pi}}{N_{\pi\pi}}$$

$K_s \rightarrow \pi\pi$

KLOE preliminary:

$BR(K_S \rightarrow e^+e^-(\gamma)) < 2.1 \times 10^{-8}$ @ 90% CL

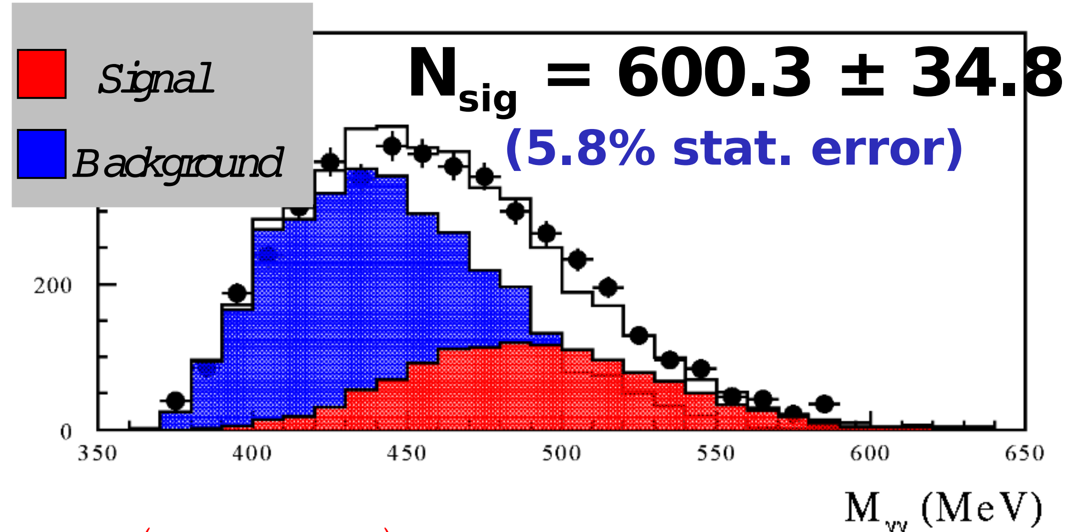
CPLEAR: $< 1.4 \times 10^{-7}$

$K_s \to \gamma\gamma$ (ChPT testing) arxiv:0707.3933

Data sample analyzed: 1.6fb^{-1}

- K_S tagged from K_L interacting in EMC
- 2 prompt photons required

Main background $K_S \to \pi^0 \pi^0$ with two photons lost at small angle, rejected using kinematic fit.

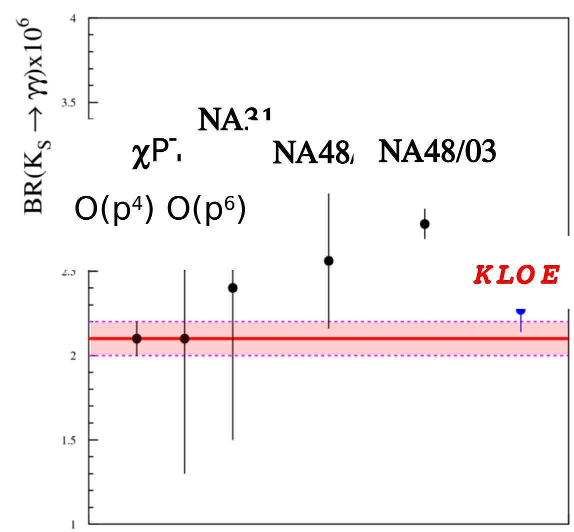


$$BR(K_S \to \gamma\gamma) = N_{\gamma\gamma} \frac{\varepsilon_{2\pi^0}(tot\,|\,K_L - crash)}{\varepsilon_{SIG}(tot\,|\,K_L - crash)} \frac{BR(K_S \to 2\pi^0)}{N_{2\pi^0}}$$

ε_{SIG} (tot| K_L-crash) = (50.8 ± 0.6)%

$\varepsilon_{2\pi 0}$ (tot | K_L-crash) = (65.0 ± 0.2$_{stat}$ ± 0.1$_{sys}$)%

$$BR(K_S \to \gamma\gamma) = \left(2.27 \pm 0.13_{stat} \, {}^{+0.03}_{-0.04}\right) 10^{-6}$$



Hadron cross section measurement

- $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ at small angle*
- $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ at large angle*
- $\sigma(e^+e^- \to \pi^+\pi^-\gamma)/\sigma(e^+e^- \to \mu^+\mu^-\gamma)$

η/η' physics

- η mass*
- η/η' mixing angle*
- Slope parameter in the $\eta\to 3\pi^0$ decay*
- $\eta\to\pi^+\pi^-\pi^0$ Dalitz plot fit*
- $\eta\to\pi^+\pi^- e^+ e^-$ Br and asymmetry measurement
- $\eta\to\pi^0\gamma\gamma$ Br measurement and fit to $M_{\gamma\gamma}$ spectrum

Scalar physics

- $f_0\to\pi^+\pi^-$ and $f_0\to\pi^0\pi^0$
- Search for $f_0\to K_S K_S$*
- a_0 Br($\phi\to\eta\pi^0\gamma$) and fit to $M_{\eta o}$*

} *4q candidates*

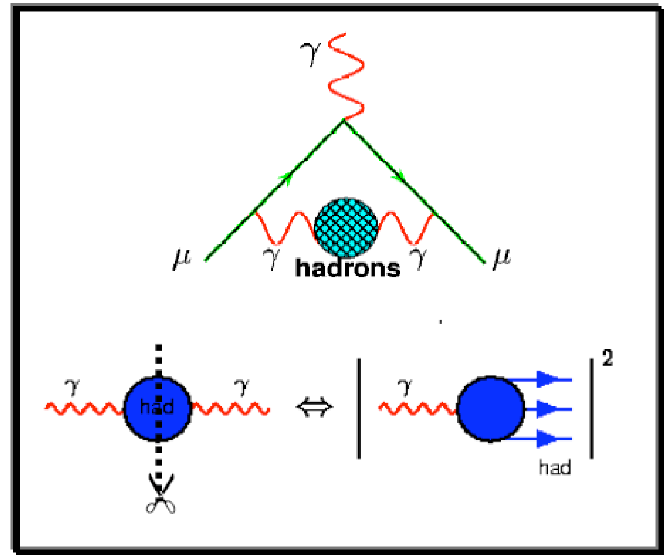
$e^+e^-\to\omega\pi^0$ cross section measurement*

Hadronic cross section measurement

arxiv:0707.4078

a_μ is one of the most accurate measurements in physics

Theoretical calculation uses hadronic cross section through dispersion integral to evaluate low energy QCD contributions.

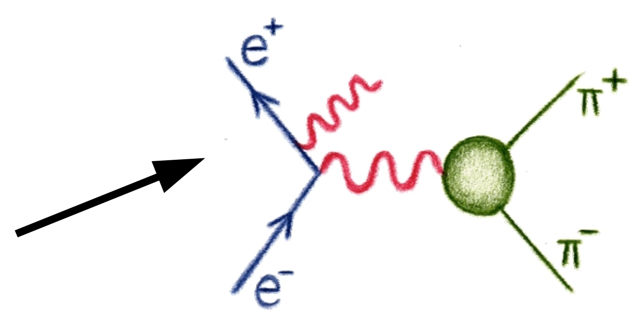


$$a_\mu^{hadr} = \frac{1}{4\pi^3}\left(\int_{4m_\pi^2}^{E_{Cut}^2} ds\,\sigma^{hadr,exp}(s)K(s) + \int_{E_{Cut}^2}^{\infty} ds\,\sigma^{hadr,pQCD}(s)K(s)\right)$$

K(s) ~ 1/s
Low energy contributions enhanced, largely dominated by the $\pi^+\pi^-$ channel

Traditionally measured with sqrt(s) scan (CMD-2, SND at VEPP-2M)

KLOE started to measure with ISR technique need the knowledge of the radiator function H Phokhara MC generator (Eur. Phys. J C27, 2003)



KLOE hadronic cross section analyses

Pion tracks at large angles

$50° < \theta_\pi < 130°$

a) Photons at small angles

$\theta_\gamma < 15°$ or $\theta_\gamma > 165°$

➔ **No photon detection!**

$$\vec{p}_\gamma = \vec{p}_{miss} = -(\vec{p}_+ + \vec{p}_-)$$

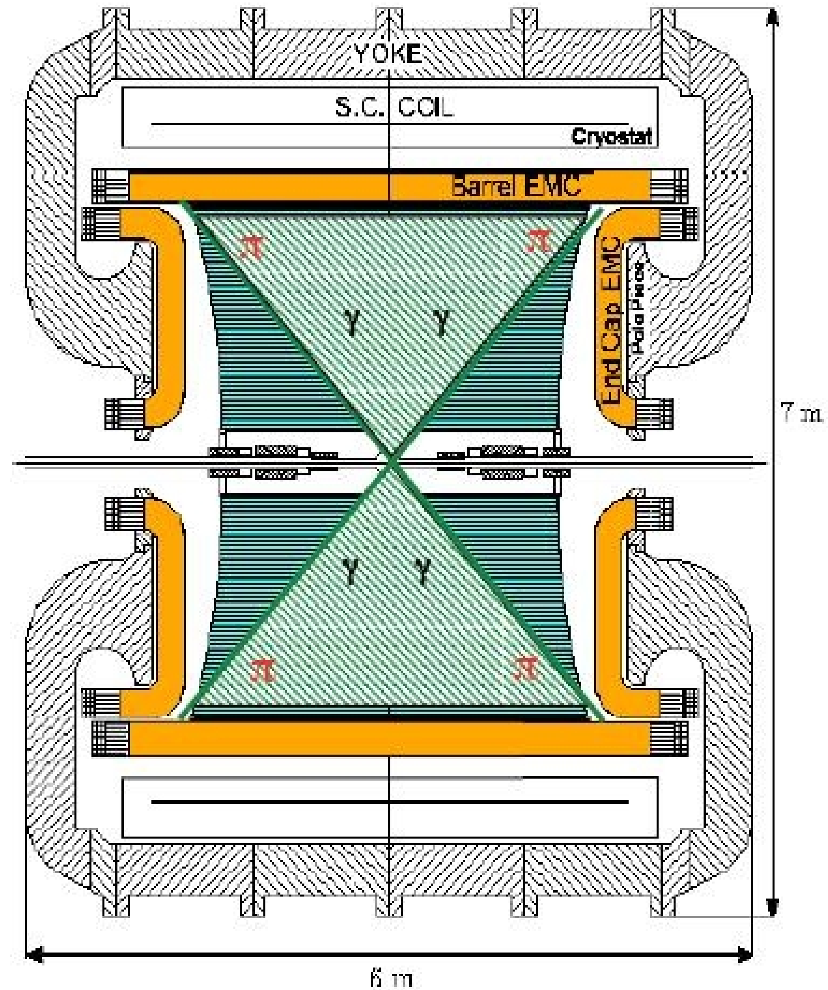
- High statistics for ISR photons
- Very small contribution from FSR
- Reduced background contamination

b) Photons at large angles

$50° < \theta_\gamma < 130°$

➔ **Photon is observed in the detector!**

- Threshold region accessible
- Increased contribution from FSR
- *Contribution from* $\phi \to f_0(980)\gamma \to \pi^+\pi^-\gamma$



Small angle analysis

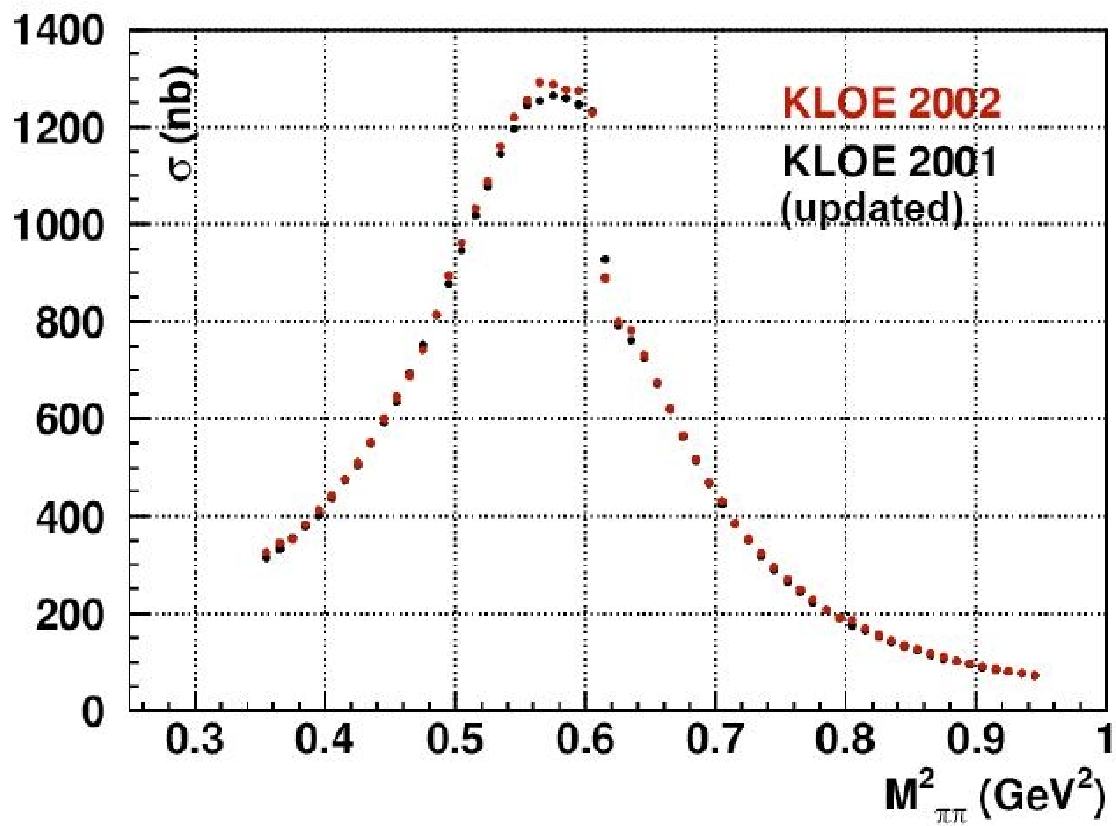
Small bug found in the trigger efficiency evaluation procedure on 2001 published result (the result has been updated).

Improvement in 2002 analysis.

1) 30% cosmic veto inefficiency recovered by introducing an additional software trigger level;

2) Background rejection filter and pre-filter improved reducing systematic < 0.1 %

3) Luminosity more accurate thanks to the new Bhabha MC generator Babayaga@NLO (error from 0.5% to 0.1%)



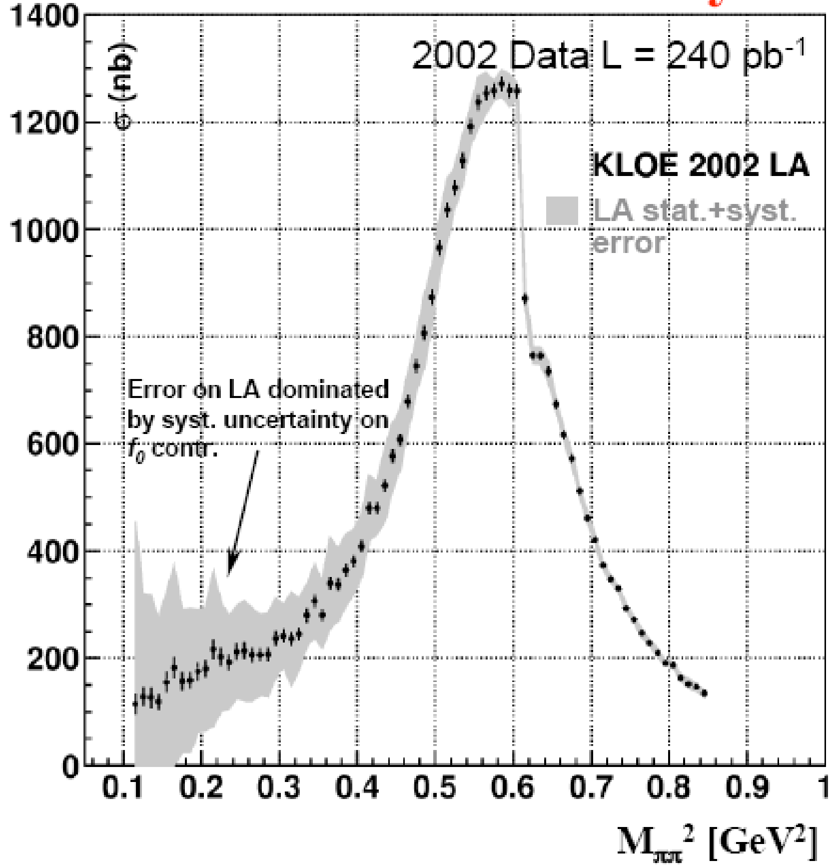
$a_\mu^{\pi\pi}(0.35\text{-}0.95\text{GeV}^2) = (388.7 \pm 0.8_{stat} \pm 4.9_{syst}) \cdot 10^{-10}$

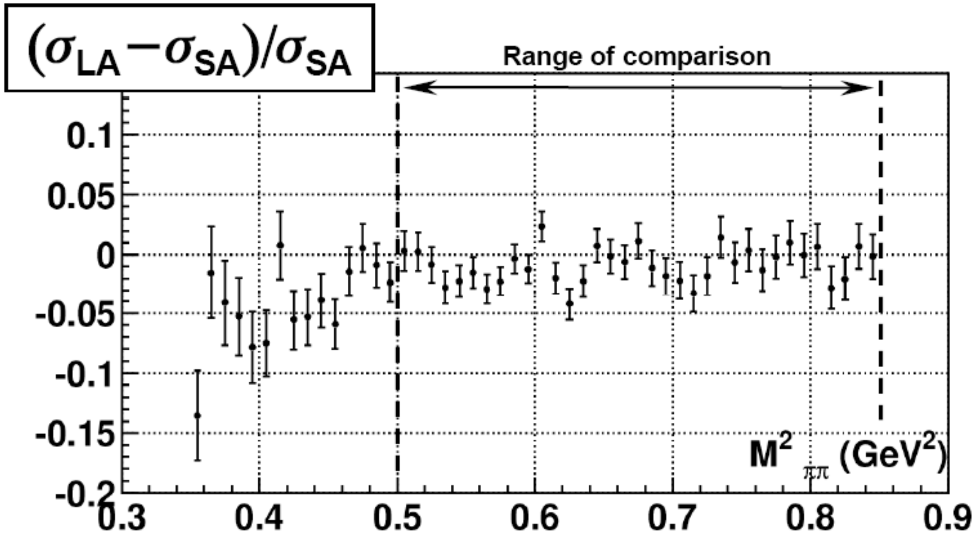
$a_\mu^{\pi\pi}(0.35\text{-}0.95\text{GeV}^2) = (384.4 \pm 0.8_{stat} \pm 4.9_{syst}) \cdot 10^{-10}$

$a_\mu^{\pi\pi}(0.35\text{-}0.95\text{GeV}^2) = (386.3 \pm 0.6_{stat} \pm 3.9_{syst}) \cdot 10^{-10}$

Large angle analysis

Preliminary!!!





f_0 systematic error evaluated using different theoretical models reproducing the KLOE result (**Phys. Lett. B634 (2006) 148-154**

Small angle:

$a_\mu^{\pi\pi}(0.50\text{-}0.85\text{GeV}^2)$ =

$(255.4 \pm 0.4_{stat} \pm 2.5_{syst}) \cdot 10^{-10}$

Large angle:

$a_\mu^{\pi\pi}(0.50\text{-}0.85\text{GeV}^2)$ =

$(252.5 \pm 0.6_{stat} \pm 5.1_{syst}) \cdot 10^{-10}$

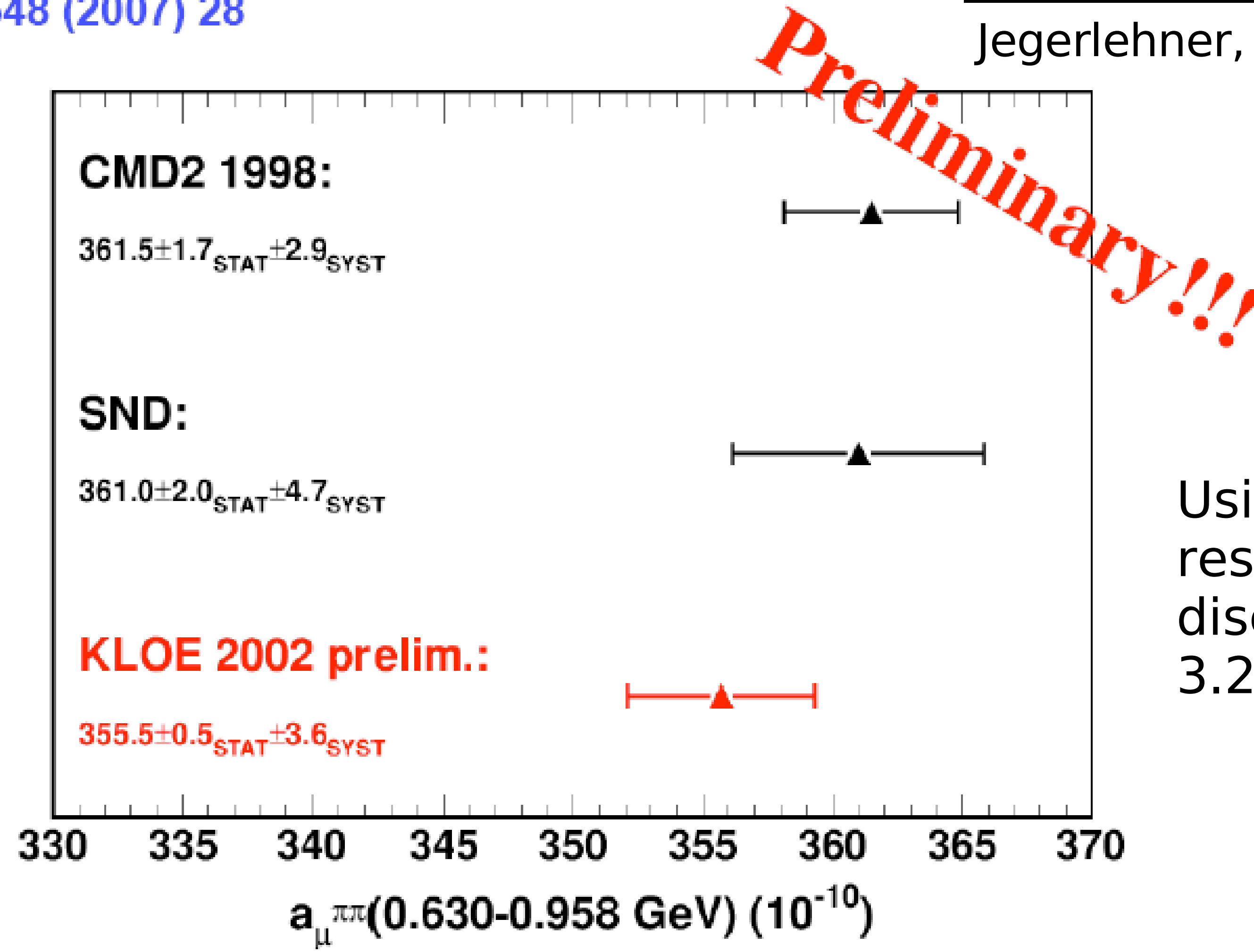
60% of systematics due to f_0 !!!

Comparison with $a_\mu^{\pi\pi}$ from CMD2 and SND in the range 0.630-0.958 GeV :

Phys. Lett. B648 (2007) 28

$$\Delta a_\mu = a_\mu^{\exp} - a_\mu^{the} = (28.7 \pm 9.1) \cdot 10^{-10}$$

Jegerlehner, hep-ph/0703125



Using KLOE results discrepancy from 3.2 σ to 3.4 σ

Status of the η mass measurement

The two most recent and precise measurements show a 8s discrepancy on the η mass :

GEM *[COSY, Julich]*

M_η = (547.311 ± 0.028 ± 0.032) MeV/c^2

[M. Abdel-Bary et al., Phys. Lett. B 619 (2005) 281]

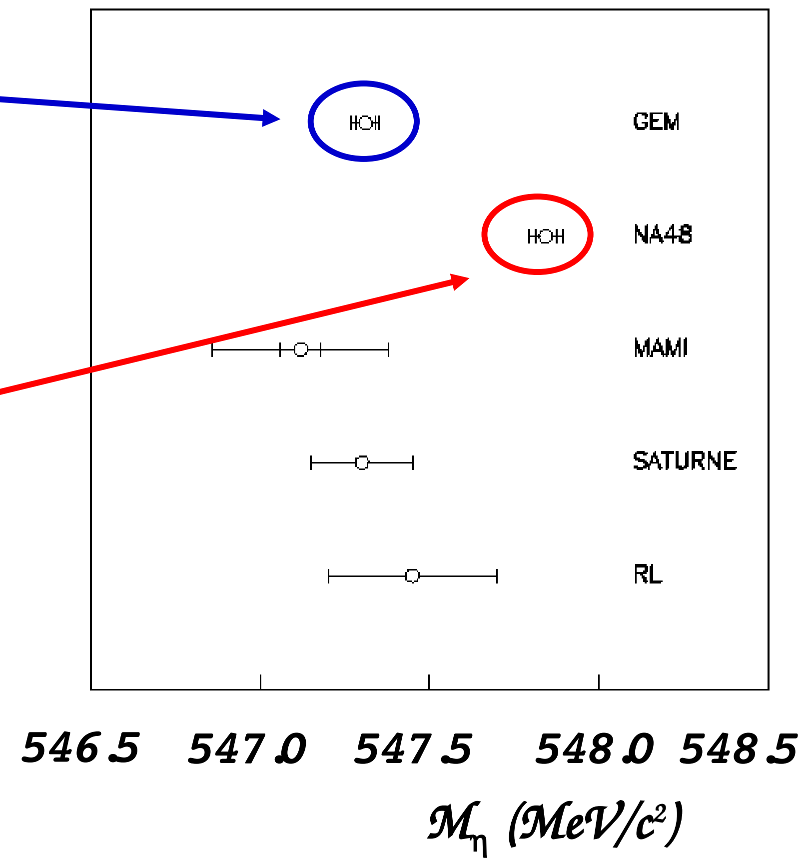
Missing mass in p + d → ^{3}He + η

NA48

M_η = (547.843 ± 0.030 ± 0.041) MeV/c^2

[A. Lai et al., Phys. Lett. B 533 (2002) 196]

Using $\eta \rightarrow 3\pi^0$ from $\pi^- + p \rightarrow \eta + n$

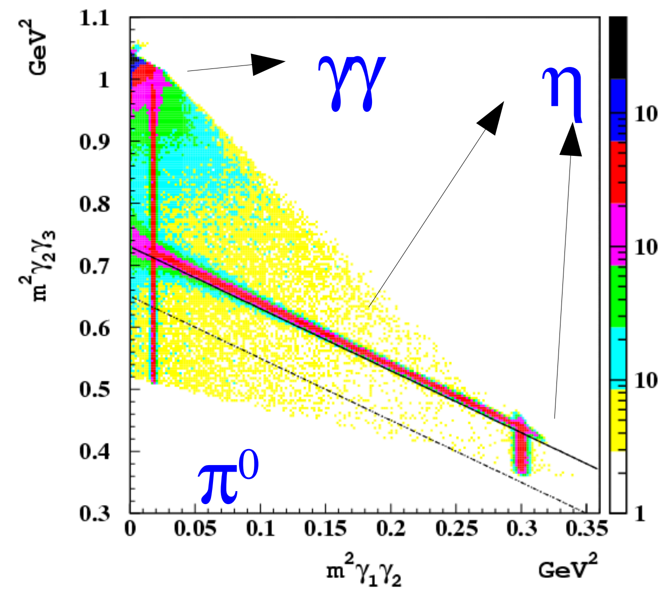


Measurement of the η mass.

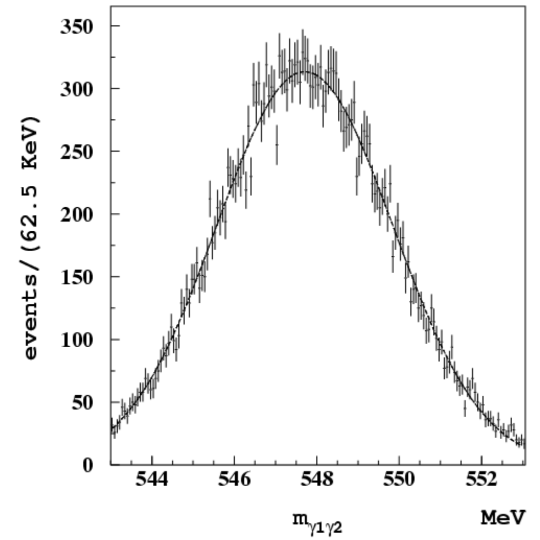
$\phi \to \eta\gamma$ $(\eta \to \gamma\gamma)$ → η *mass*

$\phi \to \pi^0\gamma$ $(\pi^0 \to \gamma\gamma)$ → π^0 *mass*

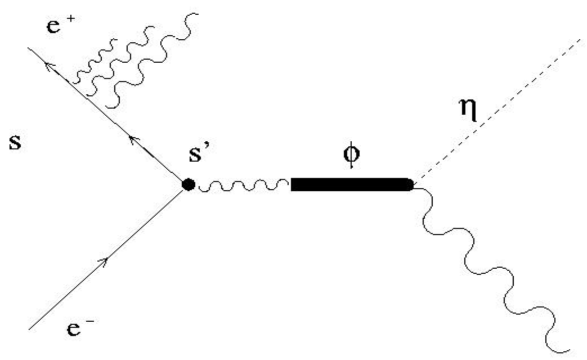
$E_1 < E_2 < E_3$



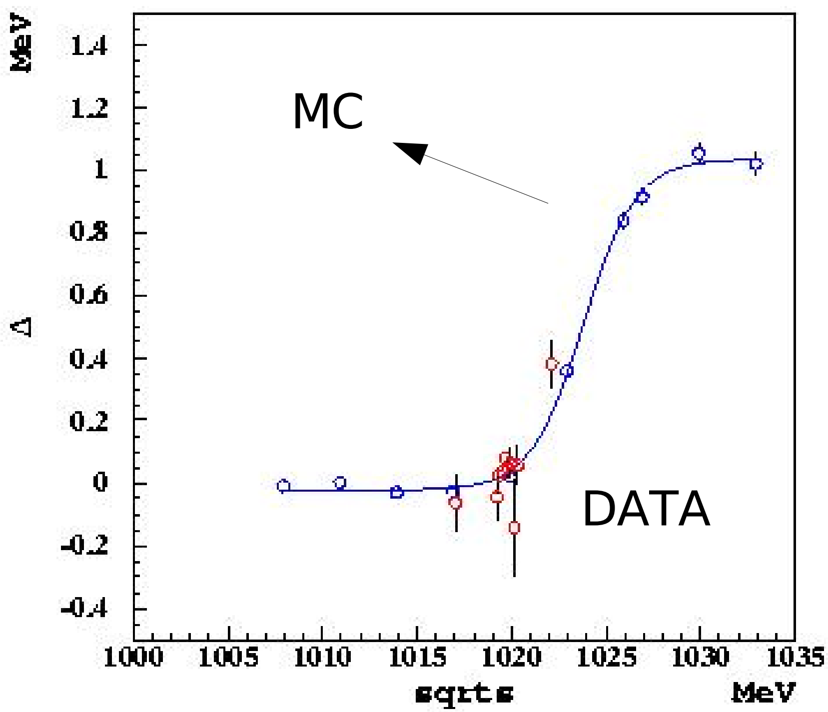
- The photon energies are over constrained by a kinematic fit which links the energy to the position and times of the clusters.
- The time scale and t_0 is calibrated run by run using $e^+e^- \to \gamma\gamma$
- The mean position of the interaction vertex is determined by Bhabha events and cross-checked with $\pi^+ \pi^- \gamma$ events.
- The dis-alignment of the calorimeter respect to the Drift Chamber is evaluated using $\pi^+ \pi^- \gamma$ comparing the extrapolated tracks with the cluster position.
- The ϕ total momentum is determined run by run using $e^+e^- \to e^+e^-$ events.

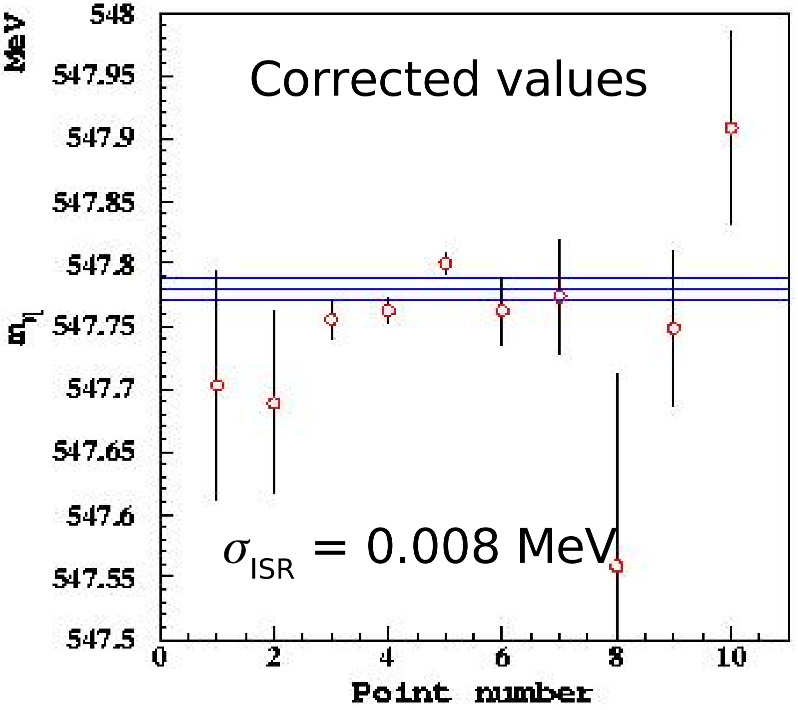


ISR correction



ISR radiation lowers the average √s value of the ϕ meson.
The shift is evaluated on MC and compared with the DATA using on peak points and 2 off peak scan points.





Results

Systematic table

systematic effect	m_η (keV)	m_{π^0} (keV)	$m_\eta/m_{\pi^0} \times 10^{-5}$
Calorimeter energy constants	4	1	5.6
Calorimeter not linearity	4	11	31
Vertex position	4	6	19
Angular uniformity ϕ	15	12	37
Angular uniformity θ	10	44	120
ISR effect	8	9	28
Dalitz plot slope	12	4	15
Dalitz plot cut (constant)	12	1.9	10
χ^2 cut	0.7	4	13
overall	27	49	136

$$m_\eta = 547.873 \pm 0.007(\text{stat.}) \pm 0.031(\text{syst.}) \quad \text{MeV}$$

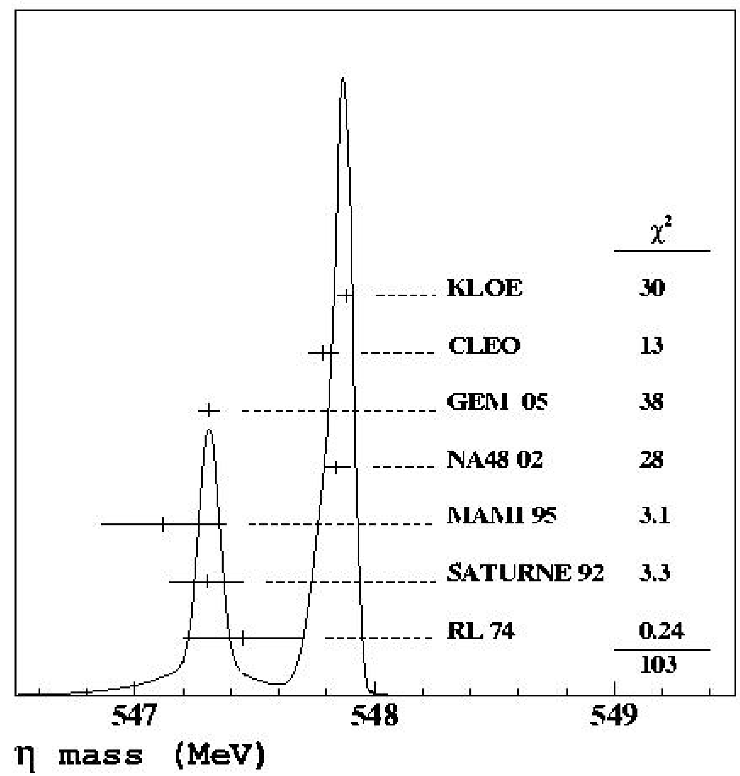
$$m_{\pi_0} = 134.906 \pm 0.012(\text{stat.}) \pm 0.048(\text{syst.}) \quad \text{MeV}$$

(1.4 σ from PDG)

arxiv:0707.4616

Comparison with recent determinations

η mass puzzle solved!!!



427 pb^{-1} ('01-'02 data)

$\mathcal{N}(\eta\gamma) = 1.665 \times 10^6$

(no bck)

$N(\pi^+\pi^- 7\gamma\text{'s}) = 3750 \pm 60$ ($\mathcal{N}_{bckg} = 345$)

$\mathcal{N}(\eta'\gamma) = 3405 \pm 61_{stat} \pm 43_{syst}$

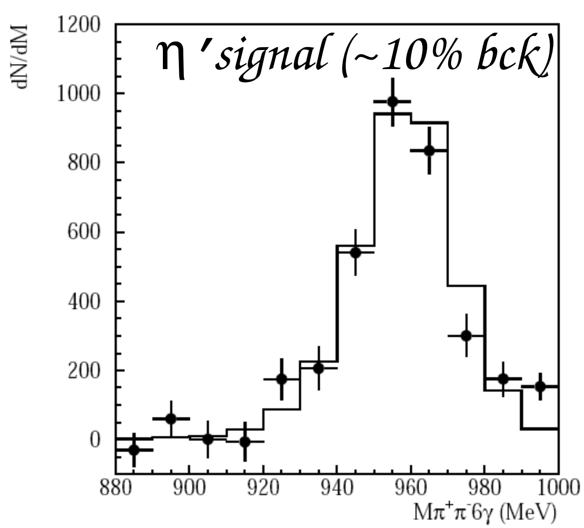
$\mathcal{R} = (4.77 \pm 0.09_{stat.} \pm 0.19_{syst}) \times 10^{-3}$

Using PDG BR($\phi \to \eta\gamma$)

$Br(\phi \to \eta'\gamma) = (6.20 \pm 0.09_{stat.} \pm 0.25_{syst.}) \times 10^{-5}$

Systematics are dominated by knowledge of η,η' branching ratios

49% χ^2 probability

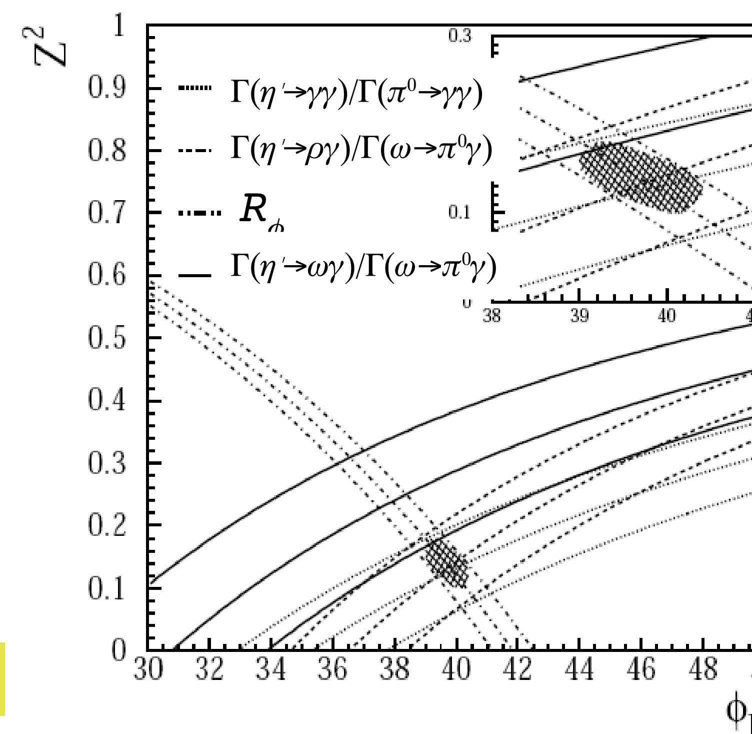


Fit results

$\phi_P = (39.7 \pm 0.7_{tot})°$

$|\phi_G| = (22 \pm 3)°$

$\sin^2\phi_G = Z^2 = 0.14 \pm 0.04$

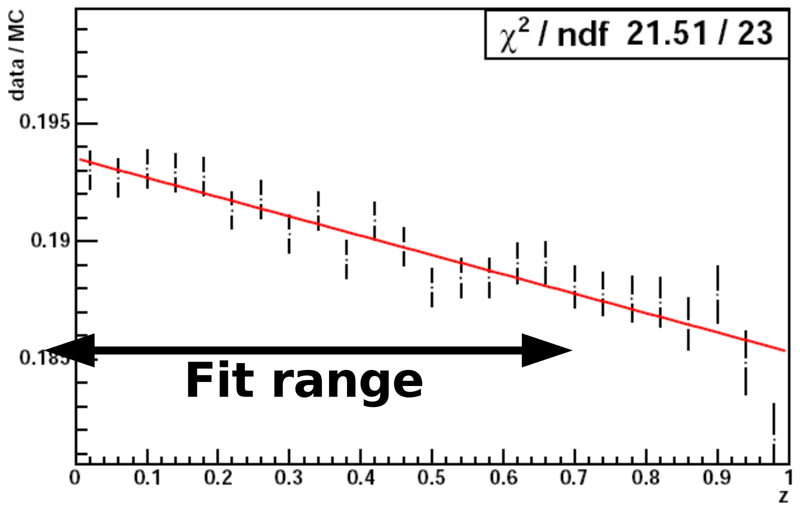


$\eta \to 3\pi^0$ slope parameter determination

$\eta \to 3\pi^0$ is an SU(2) breaking decay, it can be used for m_u-m_d determination.

The amplitude can be written as: $|A_{\eta\to 3\pi^0}(z)|^2 \sim 1 + 2\alpha z$ $\quad z = \frac{2}{3}\sum_{i=1}^{3}\left(\frac{3E_i - m_\eta}{m_\eta - 3m_{\pi^0}}\right)^2 = \frac{\rho^2}{\rho^2_{MAX}}$

The z distribution is fitted with a Likelihood fit taking into account efficiency and resolution effects, kinematic fit imposing $M_\eta = 547.822 \pm 0.005_{stat.} \pm 0.069_{syst}$ MeV (KLOE preliminary).

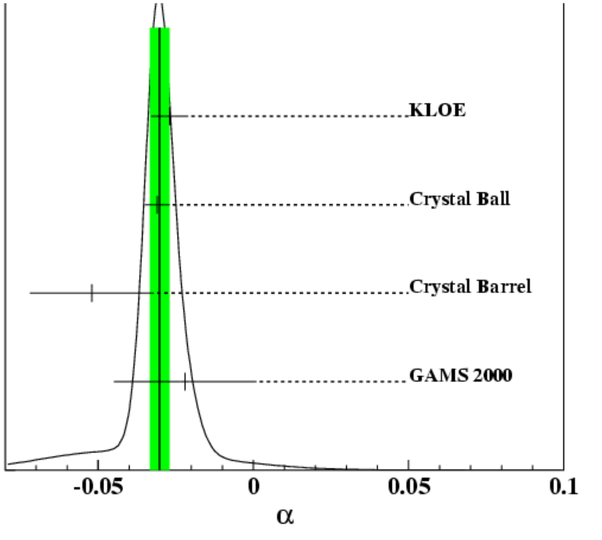


arxiv:0707.4137

PRELIMINARY

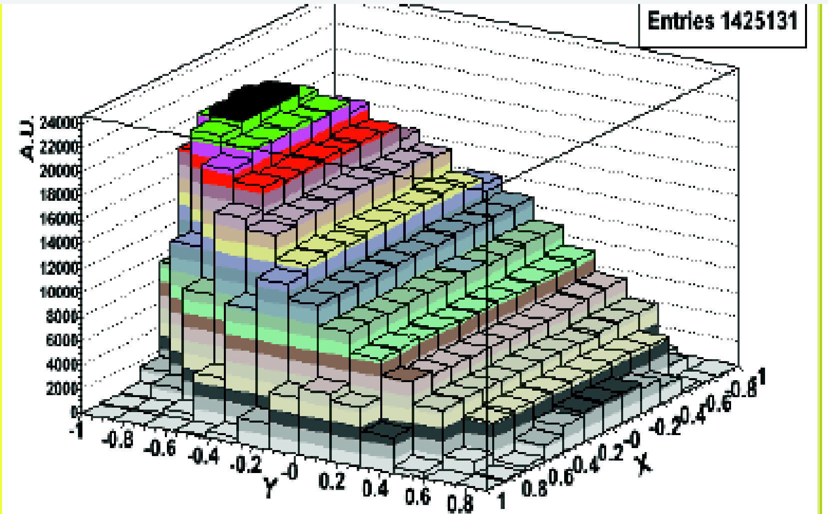
$$\alpha = -0.027 \pm 0.004\,(stat)\,^{+0.004}_{-0.006}\,(syst)$$

Average α = -0.030 ± 0.003



19×10^6 η from $\phi\to\eta\gamma$. Tagging: recoil monochromatic photon (363 MeV)

$$|M^2| = 1 + aY + bY^2 + cX + dX^2 + eXY + fY^3$$



Bckg. contamination ~ 0.3%

$a = -1.090 \pm 0.005\,(\text{stat})\ ^{+0.008}_{-0.019}\,(\text{syst})$

$b = \ 0.124 \pm 0.006\,(\text{stat}) \pm 0.010\,(\text{syst})$

$d = \ 0.057 \pm 0.006\,(\text{stat})\ ^{+0.007}_{-0.016}\,(\text{syst})$

$f = \ 0.14 \pm 0.01\,(\text{stat}) \pm 0.02\,(\text{syst})$

$c = \ 0.002 \pm 0.003\,(\text{stat}) \pm 0.001\,(\text{syst})$

$e = -0.006 \pm 0.007\,(\text{stat})\ ^{+0.005}_{-0.003}\,(\text{syst})$

C-parity conservation

$$A(s,t,u) = \frac{1}{Q^2}\frac{m_K^2}{m_\pi^2}(m_\pi^2 - m_K^2)\frac{M(s,t,u)}{3\sqrt{3}F_\pi^2}$$

$$Q^2 \equiv \frac{m_s^2 - \hat{m}^2}{m_d^2 - m_u^2}$$

$$\Gamma(\eta \to 3\pi) \propto |A|^2 \propto Q^{-4}$$

B.V. Martemyanov and V.S. Sopov [PRD 71 (2005)] using preliminary KLOE result:

$Q = 22.8 \pm 0.4$

In agreement with other theoretical calculations (e.m. K/π mass differences, higher order corrections)

The error is currently dominated by the knowledge of $\Gamma(\eta\to\pi\pi\pi)$

The $\eta\pi^0\gamma$ analysis – neutral channel

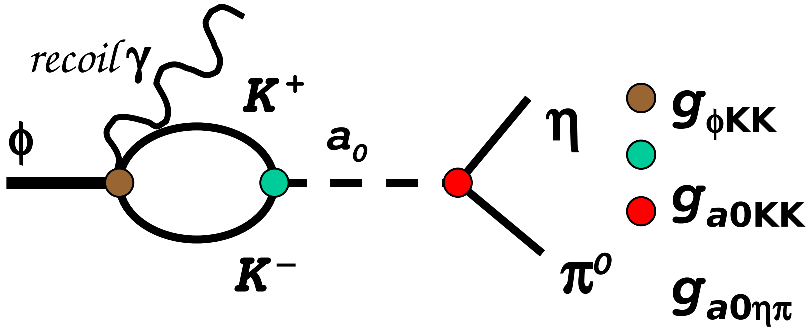
The a_0(980) model parameters are obtained from the $M_{\eta\pi}$ spectrum

Kaon loop (5 parameters)

M_{a0} $g_{a0KK}{}^2/(4\pi)$,

$g_{a0\eta\pi}/g_{a0KK}$, $Br(\phi \to \rho\pi^0 \to \eta\pi^0\gamma)$,

δ (phase between scalar and vector ampl.)

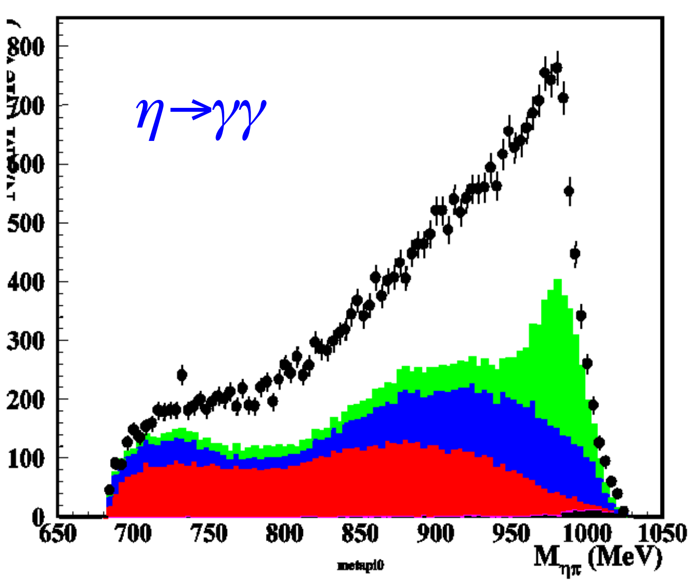


(Achasov - Kiselev Phys.Rev.D68(2003)014006)

• data

$\omega\pi^0$ $\eta\gamma 7$

$f_0\gamma$ $\eta\gamma 3$



$N - N_{bkg}$ = 13269 ± 192 events

ε = 39 %

$Br(\eta \to \gamma\gamma)$ = (39.38 ± 0.26) %

The normalization is obtained counting the number of $\eta \to 3\pi^0$

$Br(\phi \to \eta\pi^0\gamma) = (6.92 \pm 0.10_{stat} \pm 0.20_{syst}) \times 10^{-5}$

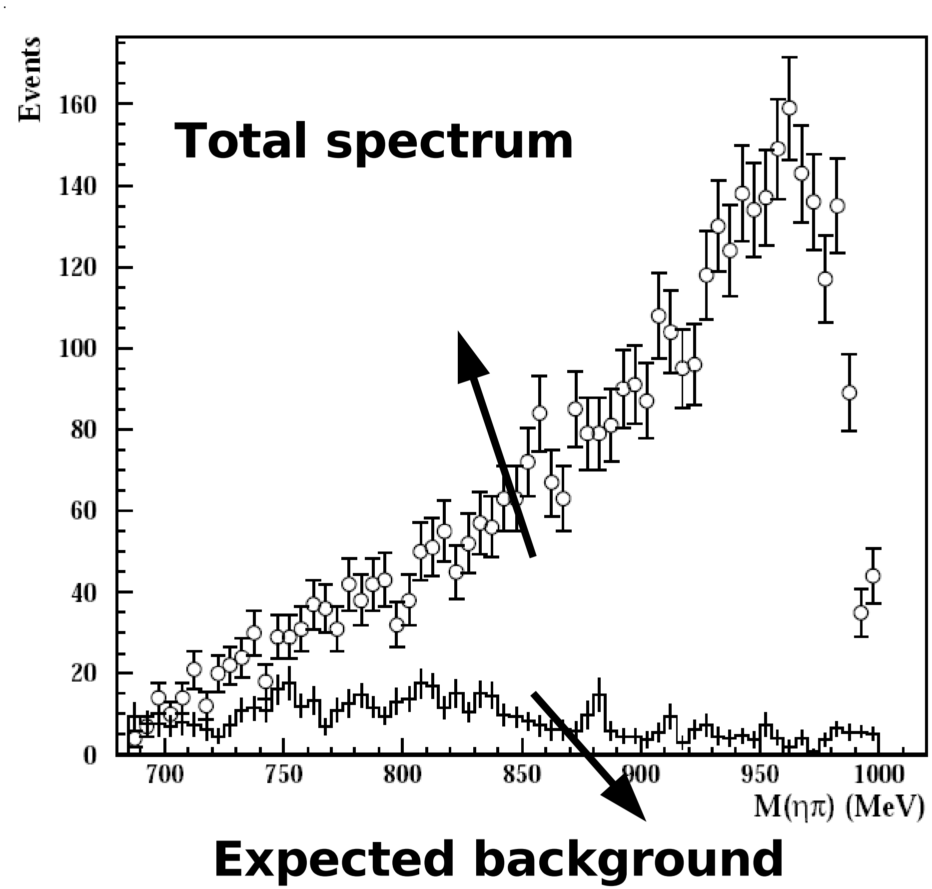
PRELIMINARY

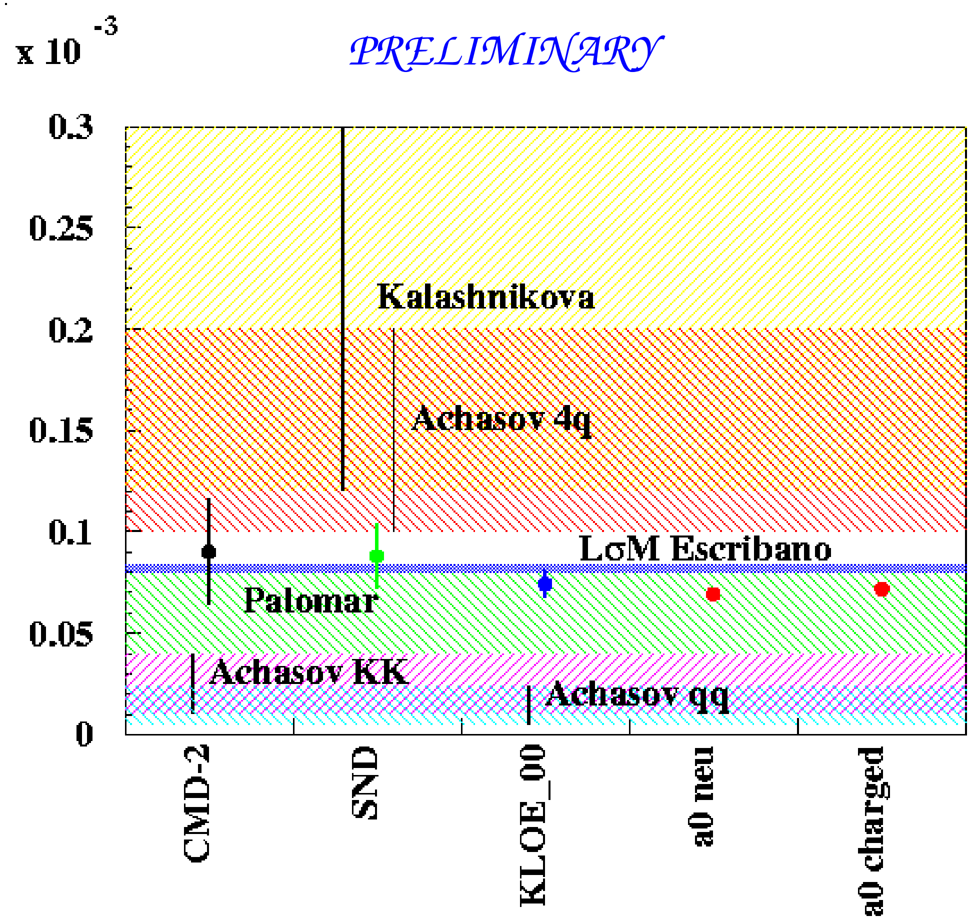
The $\eta\pi^0\gamma$ analysis – charged channel

The decay $\eta \to \pi^+ \pi^- \pi^0$ is identified

$N_{evt} = 4180$ $N_{background} = 542 \pm 57$

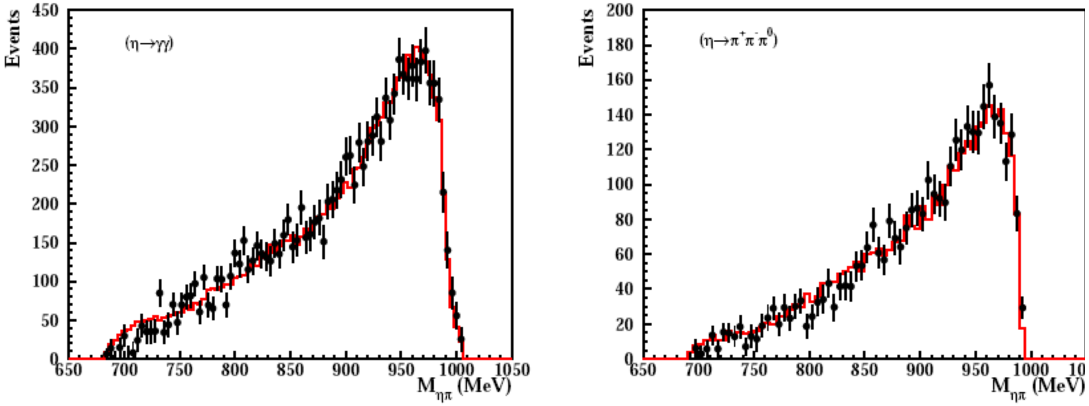
$Br(\phi \to \eta\pi^0\gamma) = (7.19 \pm 0.17_{stat} \pm 0.24_{yst}) \times 10^{-5}$



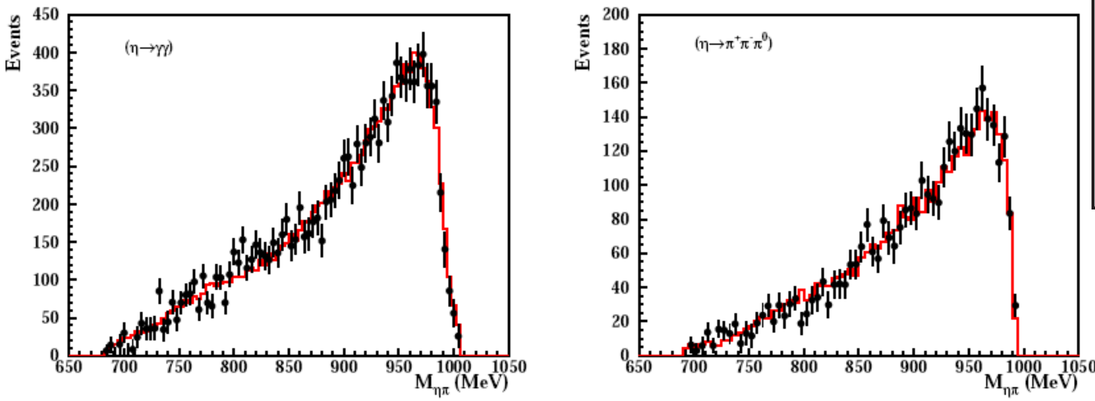


The $\eta\pi^0\gamma$ analysis – combined fit to the spectra

Kaon Loop model



No structure model



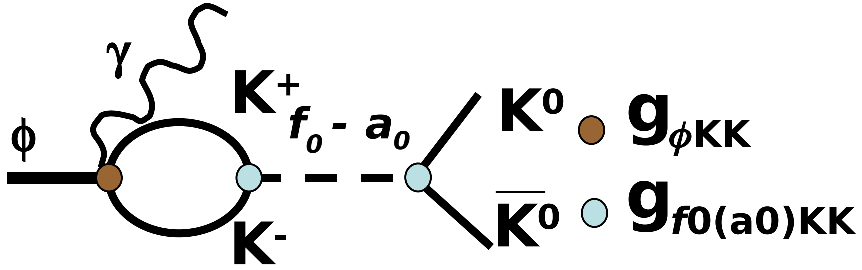
PRELIMINARY

	KL	NS
M_{a_0} (MeV)	983 ± 1	983 (fixed)
$g_{a_0 K^+K^-}$ (GeV)	2.16 ± 0.04	1.57 ± 0.13
$g_{a_0\eta\pi^0}$ (GeV)	2.8 ± 0.1	2.2 ± 0.1
$g_{\phi a_0 \gamma}$ (GeV^{-1})	—	1.61 ± 0.05
$\delta(^\circ)$	222 ± 12	—
$Br(\phi \to \rho\pi^0 \to \eta\pi^0\gamma) \times 10^6$	0.9 ± 0.4	4.1 (fixed)
$Br(\eta \to \gamma\gamma)/Br(\eta \to \pi^+\pi^-\pi^0)$	1.69 ± 0.04	1.69 ± 0.04
χ^2	156.6	146.8
ndf	136	134
$P(\chi^2, ndf)$	11%	21%

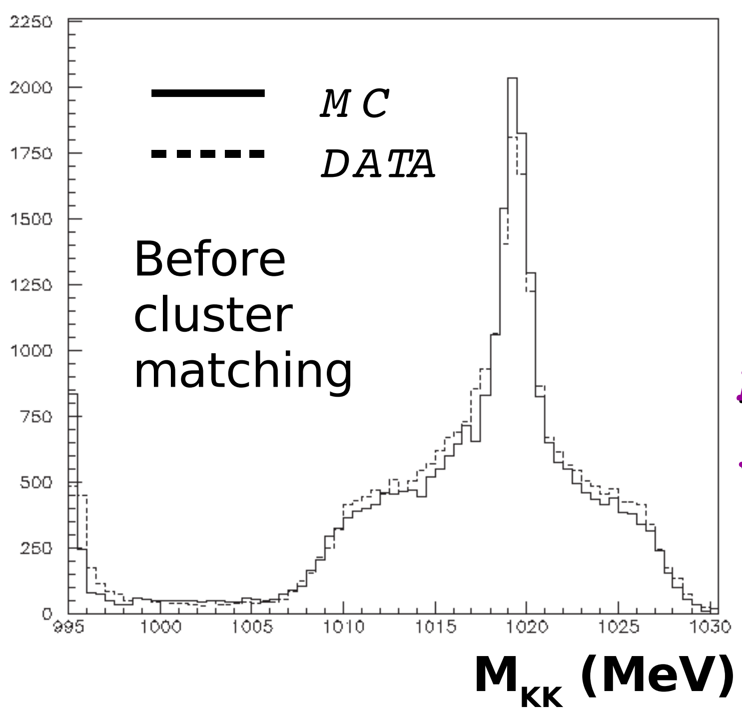
In NS model, we need to fix some parameters in order to have acceptable fit stability.

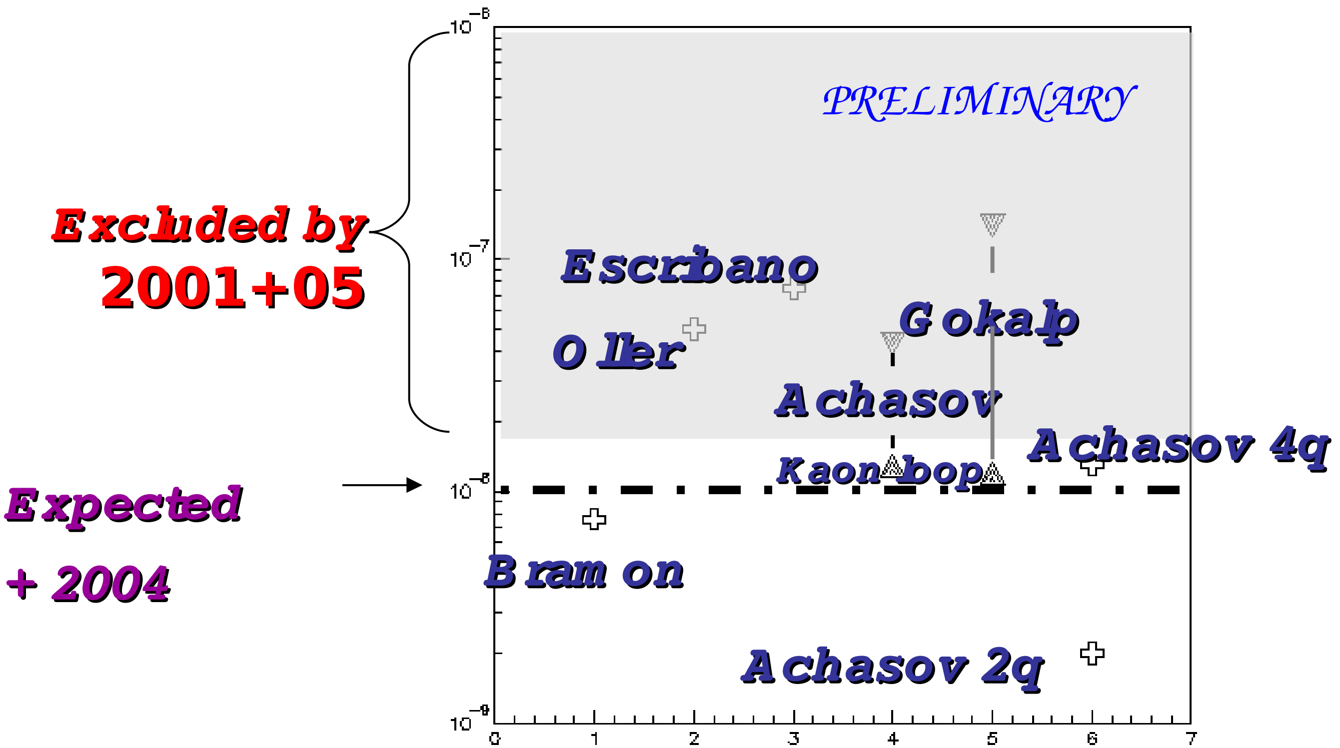
arxiv:0707.4609

$\phi \to (f_0 + a_0)\gamma \to K_s K_s \gamma$ arxiv:0707.4148



- Event selected in the $\pi^+ \pi^- \pi^+ \pi^- \gamma$ final state;
- K_S mass required for $\pi^+ \pi^-$ pairs
  $|M_{\pi\pi} - M_{ks}| < 4$ MeV
- Cut on the missing mass $E^2_{miss} - P^2_{miss} < 300$ MeV^2
- Cluster required matching missing energy and missing momentum direction.
- $M_{KK} > 1010$ MeV





$e^+e^- \to \omega\pi^0$ arxiv:0707.4130

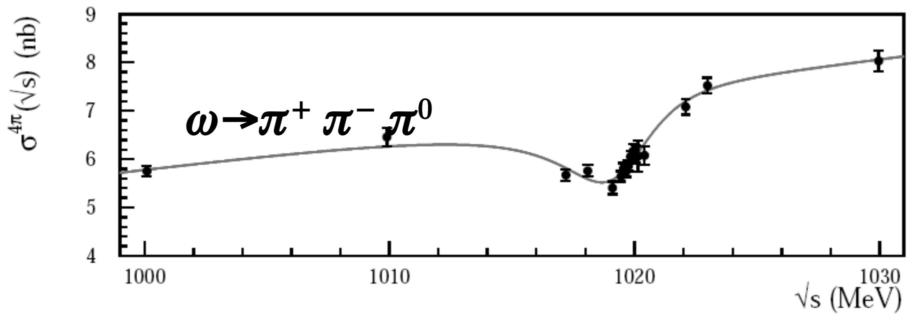
Fitted function

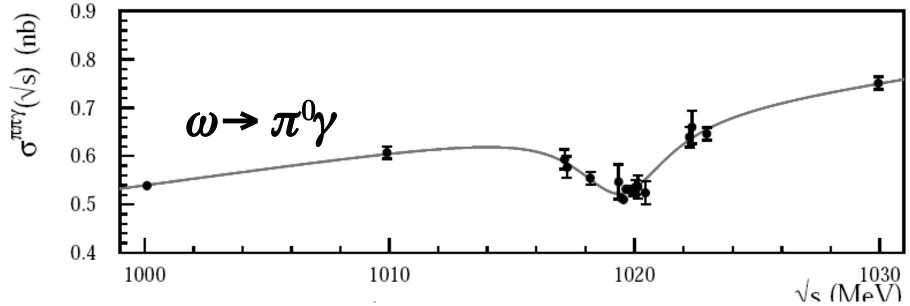
$$\sigma(\sqrt{s}) = \sigma_0(\sqrt{s}) \cdot \left| 1 - Z\frac{M_\phi \Gamma_\phi}{D_\phi} \right|$$

ϕ propagator

Parameter $(e^+e^- \to \pi^+\pi^-\pi^0\pi^0)$	
$\sigma_0^{4\pi}$ (nb)	8.12 ± 0.14
$\Re(Z_{4\pi})$	0.097 ± 0.012
$\Im(Z_{4\pi})$	-0.133 ± 0.009
$\sigma'_{4\pi}$ (nb/MeV)	0.072 ± 0.008

Parameter $(e^+e^- \to \pi^0\pi^0\gamma)$	
$\sigma_0^{\pi\pi\gamma}$ (nb)	0.776 ± 0.012
$\Re(Z_{\pi\pi\gamma})$	0.013 ± 0.013
$\Im(Z_{\pi\pi\gamma})$	-0.155 ± 0.007
$\sigma'_{\pi\pi\gamma}$ (nb/MeV)	0.0079 ± 0.0006

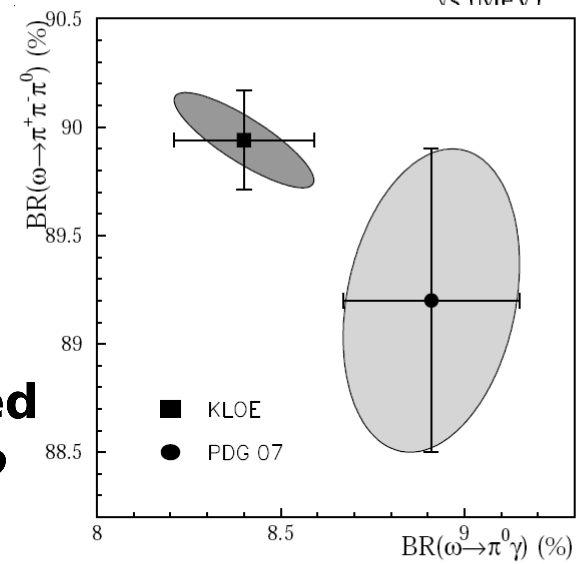




$$\frac{\sigma_0(\omega \to \pi^0\gamma)}{\sigma_0(\omega \to \pi^+\pi^-\pi^0)} = 0.0956 \pm 0.0022$$

$$\frac{\Gamma(\omega \to \pi^0\gamma)}{\Gamma(\omega \to \pi^+\pi^-\pi^0)} = 0.0934 \pm 0.0021$$

Branching ratios obtained assuming unitarity and ω rare decays from PDG.



Conclusions

KAONS

Unitarity test at per mil level
Lepton universality with kl3 checked with < 0.5 %
MSSM sensitivity in kμ2/$\pi\mu$2 (complementary to B$\rightarrow\tau\nu$ and direct search) channels and kμ2/ke2
$K_s\rightarrow\gamma\gamma$ compatible with p^4 ChPT predictions

η/η'

Best measurement of the η mass agrees with NA48 and CLEO (η mass puzzle solved);
Competitive measurement of α in $\eta\rightarrow3\pi^0$;
3σ valence gluon contribution seen in the η' meson

SCALARS

New data available on the a_0 meson, useful to establish its nature;
$\phi\rightarrow f_0\gamma\rightarrow KK\gamma$ Upper limit in the observation region pointed by many theoretical models.

Hadronic cross section

2 new independent measurements in agreement, better determination of $a_\mu^{\pi\pi}$ respect to the previous publications.

SPARES

Relate mixing matrix elements and final states amplitudes assuming unitarity

$$\left(\frac{\Gamma_S+\Gamma_L}{\Gamma_S-\Gamma_L}+i\tan\phi_{SW}\right)\left(\frac{\Re\epsilon-i\Im\delta}{1+\epsilon^2}\right)=\frac{1}{\Gamma_S-\Gamma_L}\Sigma_f A_L(f)A_S^*(f)$$

Test basic assumptions of QFT:

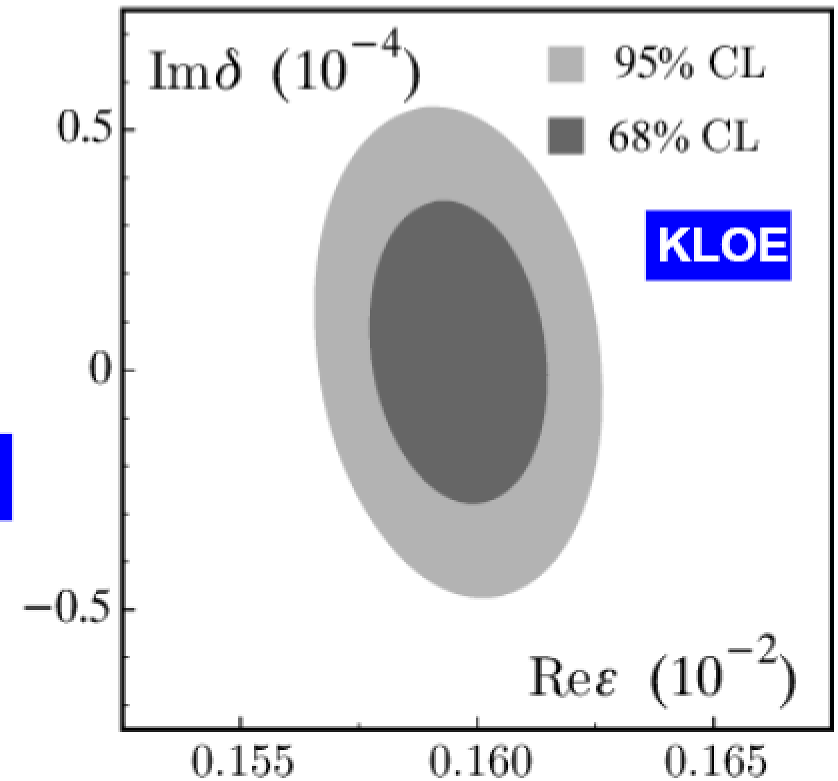
$$\Im\delta=(0.4\pm2.1)\times10^{-5}$$

~2.5 improvement wrt CPLEAR '99

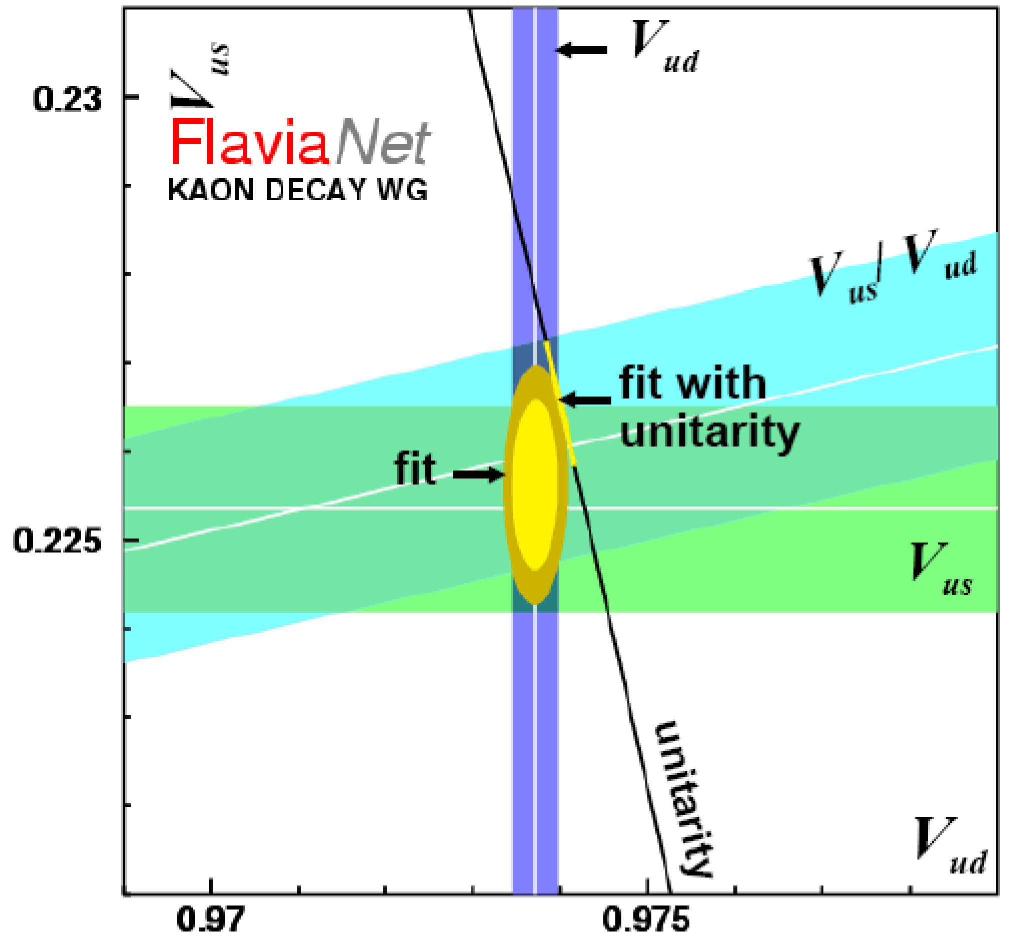
CP̸ in kaon mixing:

$$\Re\epsilon=(159.6\pm1.3)\times10^{-5}$$

~3.6 σ change wrt PDG04



[KLOE + D'Ambrosio, Isidori JHEP0612]



Fit results, no constraint:

V_{ud} = 0.97372(26)

V_{us} = 0.2256(10)

χ^2/ndf = 0.17/1 (68%)

Fit results, unitarity constraint:

$V_{us} = \sin\theta_c = \lambda$ = 0.2265(7)

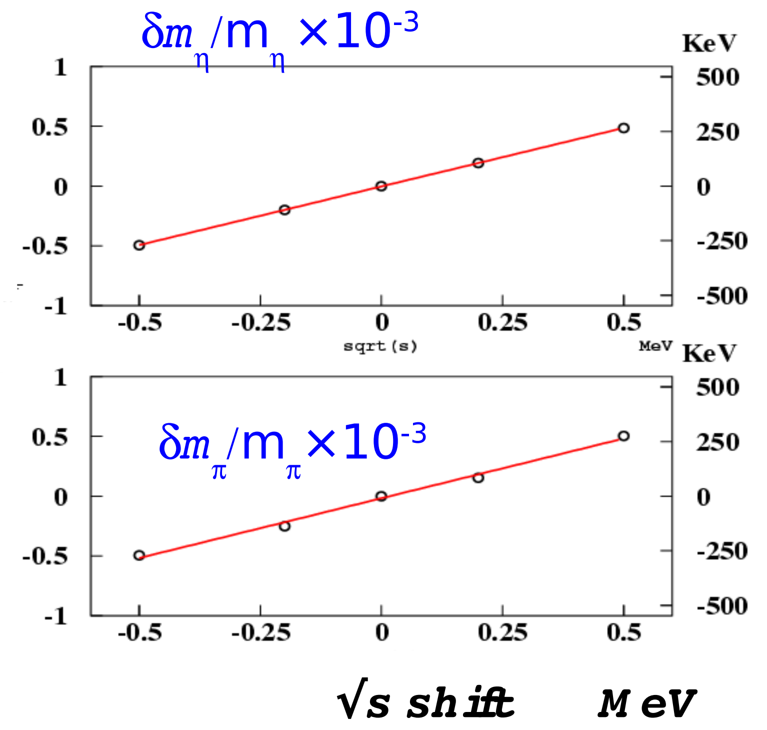
χ^2/ndf = 2.24/2 (33%)

0.3 % accuracy!

√s determination

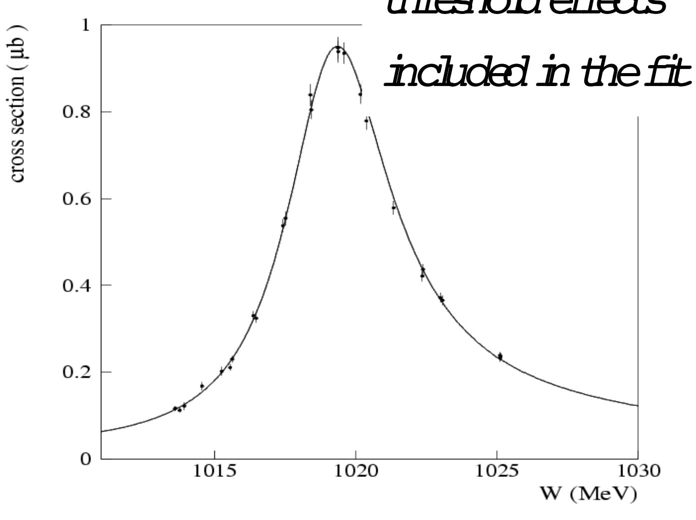
- **Calorimeter energy scale independent;**
- **Background free;**
- **Simple analysis with small selection systematics;**

- **Heavily dependent from the √s;**
- **Need to know ISR corrections.**



$e^+e^- \to K_S K_L$

radiative return and threshold effects included in the fit



√s calibrated using CMD-2 m_ϕ value.

$m(\phi) = 1019.483 \pm 0.011 \pm 0.025$ MeV
Phys. Lett. B578, 285

$Br(\phi\to\eta'\gamma)/Br(\phi\to\eta\gamma)$

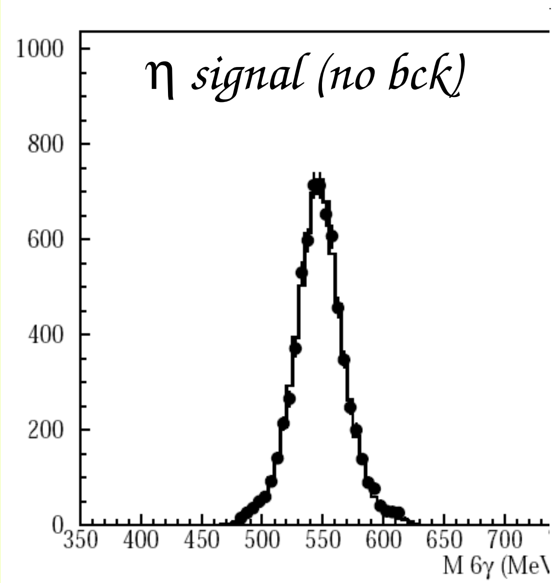
427 pb^{-1} *('01-'02 data)*

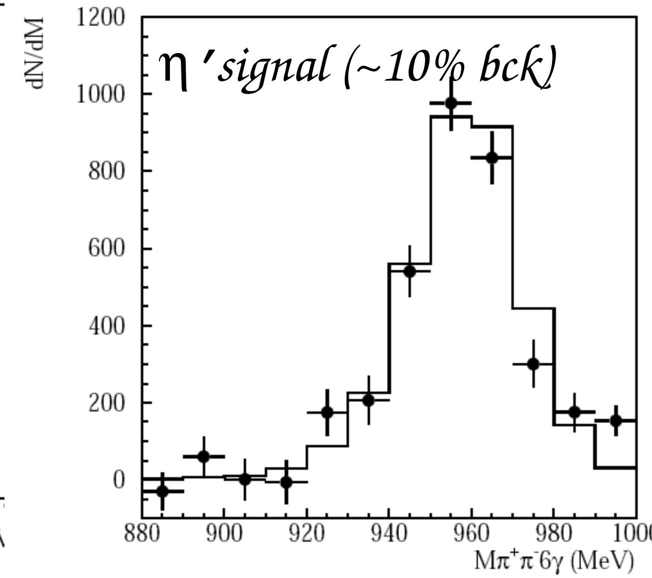
$N(\eta\gamma) = 1.665\times 10^{6}$

(no bck)

$N(\pi^+\pi^- 7\gamma\text{'s}) = 3750 \pm 60 \quad (N_{bckg} = 345)$

$N(\eta'\gamma) = 3405 \pm 61_{stat} \pm 43_{syst}$





$$\mathcal{R} = (4.77 \pm 0.09_{stat.} \pm 0.19_{syst})\times 10^{-3}$$

Using PDG BR($\phi\to\eta\gamma$)

Phys. Lett. B

$$Br(\phi\to\eta'\gamma) = (6.20 \pm 0.09_{stat.} \pm 0.25_{syst.})\times 10^{-5}$$

Systematics are dominated by knowledge of η,η' branching ratios

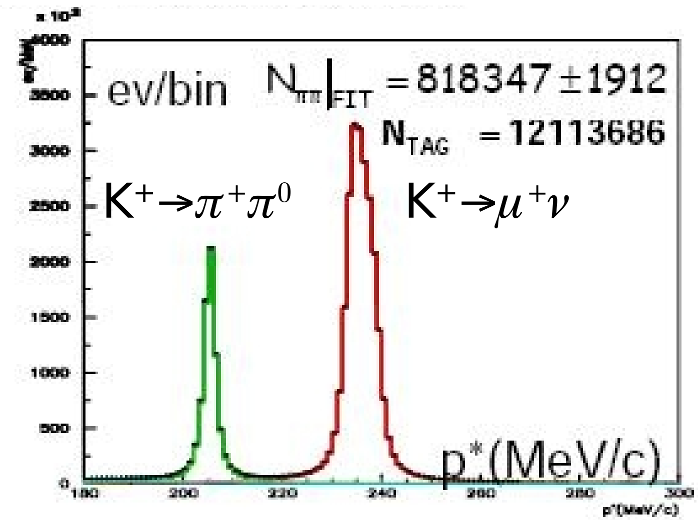
Previous KLOE results $\qquad R = (4.70 \pm 0.47_{stat} \pm 0.31_{sys})\cdot 10^{-3}$

Phys. Lett. B541 (2002) $\qquad BR(\phi\to\eta'\gamma) = (6.10 \pm 0.61 \pm 0.43)\cdot 10^{-5}$

$K^+ \to \pi^+ \pi^0$ absolute branching ratio measurement

- K^+ tagged by $K^- \to \mu^- \nu$;
- Track efficiency evaluated on data through $K^\pm \to X^\pm \pi^0$ sample;
- P^* distributions from $\mu\nu$ and $\pi\pi^0$ CS using only calorimeter informations;
- 3 body decays from MC simulation

Relevant for kl3 normalisation at hadron machines.



KLOE preliminary

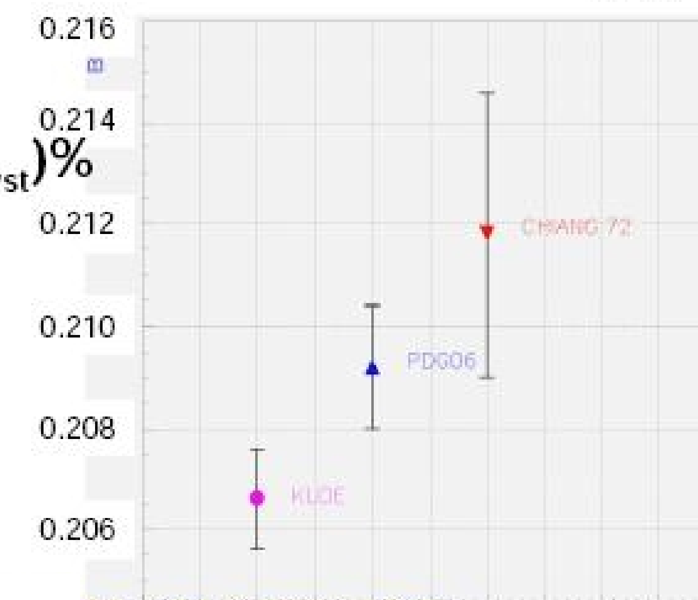
$$BR(K^+ \to \pi^+ \pi^0(\gamma)) = (20.658 \pm 0.065_{stat} \pm 0.090_{syst})\%$$

PDG fit '06

$BR(K^\pm \to \pi^\pm \pi^0) = (20,92 \pm 0.12)\%$ $\Delta BR/BR = 5,7 \times 10^{-3}$

CHIANG '72

$BR(K^\pm \to \pi^\pm \pi^0) = (21,18 \pm 0.28)\%$ $\Delta BR/BR = 1,3 \times 10^{-2}$



η,η': mixing and gluonium

The η,η' mesons wave function can be decomposed in the strangeness non strangeness base.

$$|\eta' >= X_{\eta'}|q\bar{q} > +Y_{\eta'}|s\bar{s} > +Z_{\eta'}|gluon >$$

$$|\eta > = \cos\varphi_P|q\bar{q} > + \sin\varphi_P|s\bar{s} >$$

$$X_{\eta'} = \cos\phi_G \sin\varphi_P$$
$$Y_{\eta'} = \cos\phi_G \cos\varphi_P$$
$$Z_{\eta'} = \sin\phi_G$$

$$\frac{Br(\phi\to\eta'\gamma)}{Br(\phi\to\eta\gamma)} = R_\phi = \cot^2\phi_P\cdot\cos^2\phi_G\left(1-\frac{m_s}{\overline{m}}\cdot\tan\frac{\phi_V}{\sin 2\phi_P}\right)^2\cdot\left(\frac{p_{\eta'}}{p_\eta}\right)^3$$

Comparing with other decay rates using SU(3) relations:

$$\Gamma(\eta'\to\gamma\gamma)/\Gamma(\pi^0\to\gamma\gamma) = \frac{1}{9}\left(\frac{m_{\eta'}}{m_\pi}\right)^3(5\cos\phi_G\sin\varphi_P + \sqrt{2}\frac{f_q}{f_s}\cos\phi_G\cos\varphi_P)^2$$

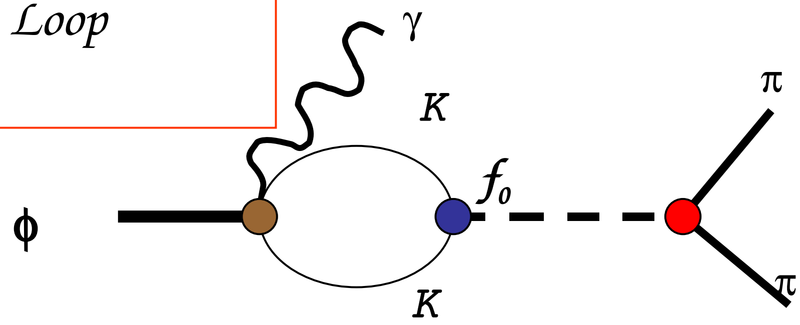
$$\Gamma(\eta'\to\rho\gamma)/\Gamma(\omega\to\pi^0\gamma) = \frac{C_{NS}}{\cos\varphi_V}\cdot 3\left(\frac{m_{\eta'}^2-m_\rho^2}{m_\omega^2-m_\pi^2}\frac{m_\omega}{m_{\eta'}}\right)^3\cos^2\phi_G\sin^2\varphi_P$$

$$\Gamma(\eta'\to\omega\gamma)/\Gamma(\omega\to\pi^0\gamma) = \frac{1}{3}\left(\frac{m_{\eta'}^2-m_\omega^2}{m_\omega^2-m_\pi^2}\frac{m_\omega}{m_{\eta'}}\right)^3[C_{NS}\cdot\cos\phi_G\sin\varphi_P + 2\frac{m_s}{\bar{m}}C_S\cdot\tan\varphi_V\cdot\cos\phi_G\cos\varphi_P]^2$$

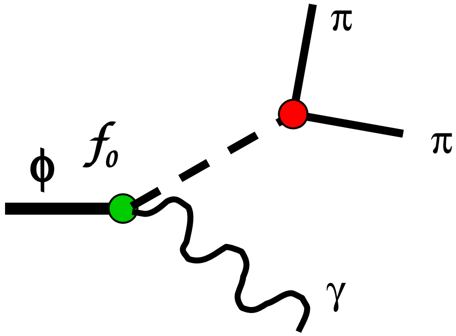
The gluonium coupling is neglected.

The $\pi^0\pi^0\gamma$ analysis

Kaon Loop

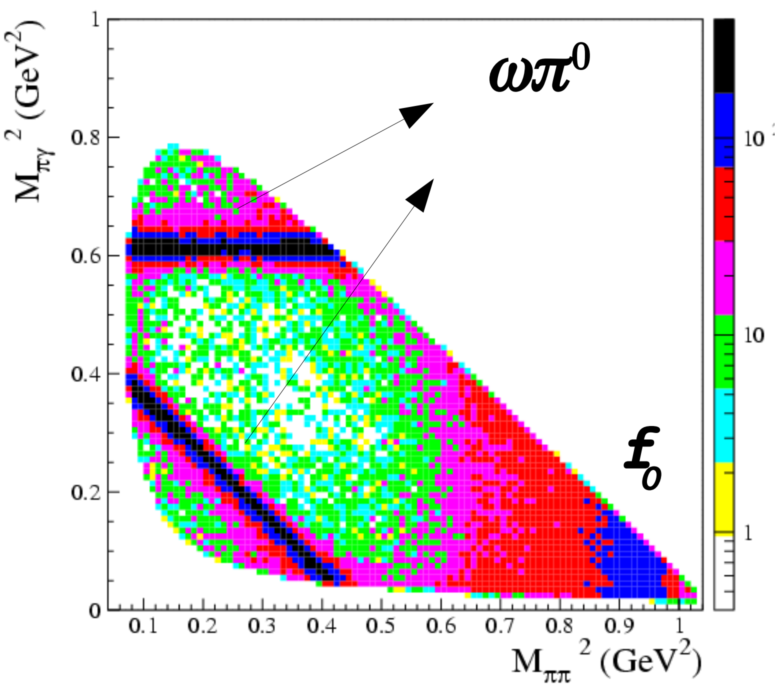


No Structure

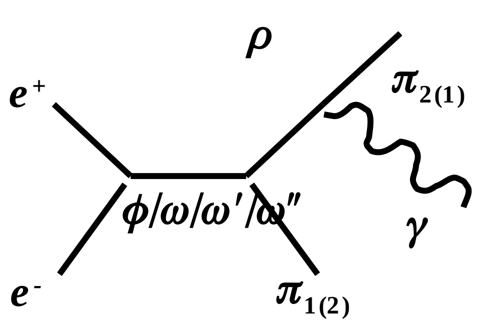


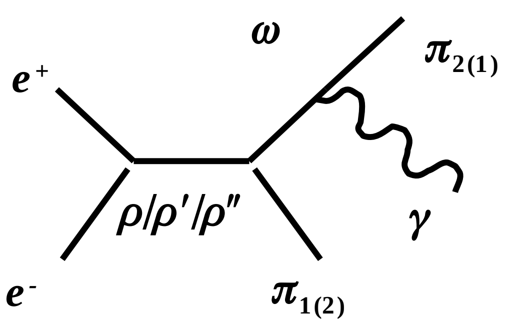
S to ϕ	$g_{\phi S}$	Coupling ratio	$R_{f0}=(g_{f0K+K-}/g_{f0\pi+\pi-})^2$
S to kaons	$g_{SKK}=g_{SK+K-}=g_{SK0K0}$	($S=f_0$ or a_0)	$R_{a0}=(g_{a0K+K-}/g_{a0\eta\pi})^2$
f_0 to $\pi\pi$ (I=0)	$g_{f0\pi\pi}=\sqrt{3/2}\,g_{f0\pi+\pi-}$ $=\sqrt{3}\,g_{f0\pi0\pi0}$	a_0 to $\eta\pi$ (I=1)	$g_{a0\eta\pi}$

The Dalitz plot



Interfering background





Dalitz plot fit

Models: Improved *Kaon-Loop* (introducing the $\phi \rightarrow \sigma(500)\gamma$) - *"No Structure"*

$f_0(980)$ param.	NS model	KL model
m_{f0} (MeV)	981 - 987	976 - 987
$g_{\phi f\gamma}$ (GeV^{-1})	2.5 - 2.7	-
$g_{f\pi+\pi-}$ (GeV)	1.3 - 1.4	1.4 -2.0
g_{fKK} (GeV)	0.1 -1.0	3.3 - 5.0
$R = g^2_{fKK}/g^2_{f\pi+\pi-}$	0. - 0.9	3.0 -7.3

An acceptable fit is obtained with both models:
$P(\chi^2)$(KL)=14%
$P(\chi^2)$(NS)= 4%

NS systematic dominated by the fit stability

KL systematic dominated by several versions of the fitting model.

- ✔ **σ(500)** is **needed** in KL fit [p(χ^2) ~ 10^{-4} → 14%] *EPJ C49 (2007) 473*

(best σ parameters are: M=462 MeV, Γ=300 MeV – Imposed to the fit);

- ✔ Integral of the |scalar amplitude|^2 evaluated

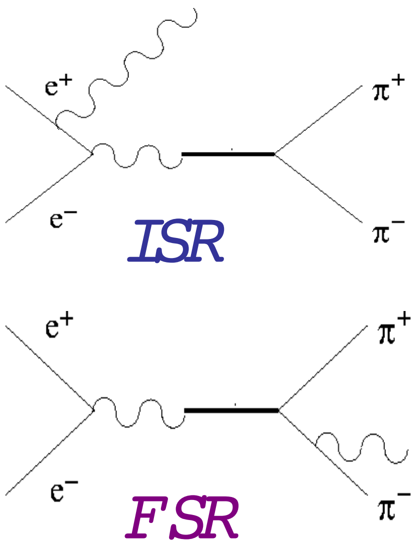
$$Br\left(\phi \rightarrow S\gamma \rightarrow \pi^0\pi^0\gamma\right) = \left[1.07^{+0.01}_{-0.04}(fit)^{+0.04}_{-0.02}(syst)^{+0.06}_{-0.05}(mod)\right] \times 10^{-4}$$

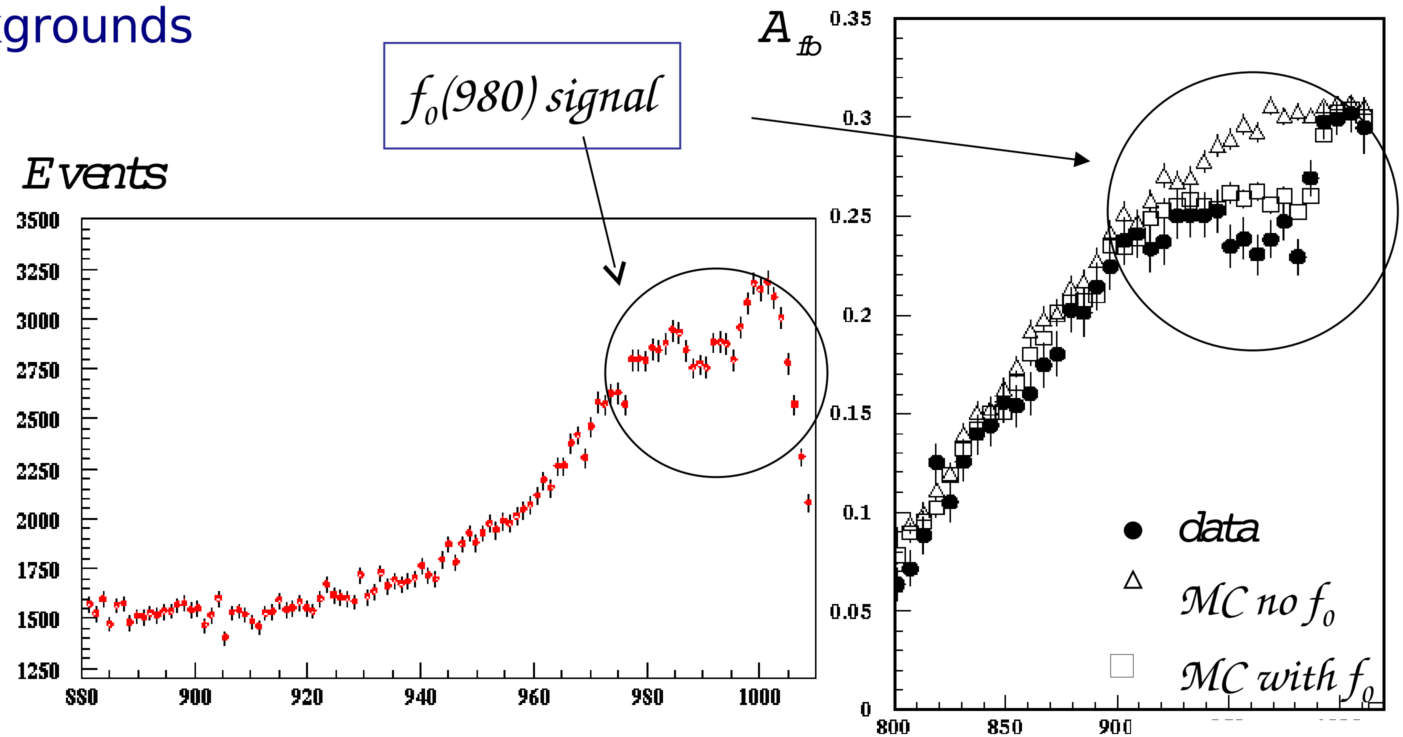
With $BR(\pi^0\pi^0\gamma) \sim 1/2 \times BR(\pi^+\pi^-\gamma)$:

$BR(\phi \rightarrow f_0(980)\gamma) = (3.1 \div 3.5) \times 10^{-4}$, $\Gamma(\phi\ f_0(980)\gamma) = 1.2 \div 1.6$ keV

The $f_0 \to \pi^+\pi^-\gamma$ analysis

Dominant interfering backgrounds





parameter	KL	NS	
m_{f_0} (MeV)	980–987	973–981	$\Leftarrow$ *Mass values agree*
$R = g^2_{f_0 K^+K^-}/g^2_{f_0\pi^+\pi^-}$	2.2– 2.8	2.6– 4.4	$\Leftarrow g_{f_0K^+K^-} > g_{f_0\pi^+\pi^-}$
$g_{\phi f_0 \gamma}$ (GeV^{-1})	–	1.2– 2.0	$\Leftarrow$ *"Large" coupling to the* ϕ

$BR(\phi \to f_0(980)\gamma \to \pi^+\pi^-\gamma) = 2.1 - 2.4 \times 10^{-4}$ ($\int |\text{Amplitude}|^2$)

In $\mathcal{KL}$ framework $f_0(980)$ parameters agree with $\pi^+\pi^-\gamma$: $\mathcal{R} > 1$ ($g_{f_0KK} > g_{f_0\pi^+\pi^-}$), masses and integral of the scalar amplitude.

Preliminary results

$N - N_{bkg}$ = 13269 ± 192 events $\varepsilon = 39\ \%$

L = (424.0 ± 2.5) pb^{-1} $\sigma_{\phi_{avg.}}$=3090 nb Br($\eta\rightarrow\gamma\gamma$) = (39.38 ± 0.26) %

$Br(\phi\rightarrow\eta\pi^0\gamma) = (6.92 \pm 0.10_{stat} \pm 0.20_{yst}) \times 10^{-5}$

Systematics	$\delta Br/Br$
Bckg subtraction	1.7 %
Photon efficiency curves	1.2 %
Analysis cuts	1.7 %
Luminosity	0.6 %
σ_ϕ	2.5 %
$Br(\eta\rightarrow\gamma\gamma)$	0.7 %
Total	3.7 %

outlook

250 pb^{-1} @$\sqrt{s}$ = 1 GeV, 4 scan points around m(ϕ)

- $\pi\pi\gamma$ without the background coming from the ϕ ;
- $\gamma\gamma \to \pi\pi$ to search for the σ meson;
- $e^+e^- \to \omega\pi^0$ cross section measurement;
- Study of the f_0 and of the FSR.

On peak data 2 fb^{-1}

- Combined fit to $\pi^0\pi^0$ and $\pi^+\pi^-$ f_0 channels;
- Search for $f_0, a_0 \to$ KK;
- $\eta \to \pi^+ \pi^- e^+ e^-, \eta \to \pi^0\gamma\gamma, \eta \to e^+e^-\gamma, \eta \to e^+e^-e^+e^-$
- Dalitz plot analysis $\eta' \to \pi\pi\eta$ (extracting scalar mesons contribtion)

Scalar physics at KLOE

$\phi \to f_0(980)\,\gamma$; $f_0(980)$ (I= 0) $\to \pi^0\pi^0, \pi^+\pi^-$

$\phi \to a_0(980)\,\gamma$; $a_0(980)$ (I= 1) $\to \eta\pi^0$

What is the quark content?

Not trivial f_0, a_0 almost degenerate,

but f_0 heavily coupled to the $K\bar{K}$ channel.

$q\bar{q}$ $\quad {}^3P_0$

Quarks in 1 orbital angular momentum, 1 spin state

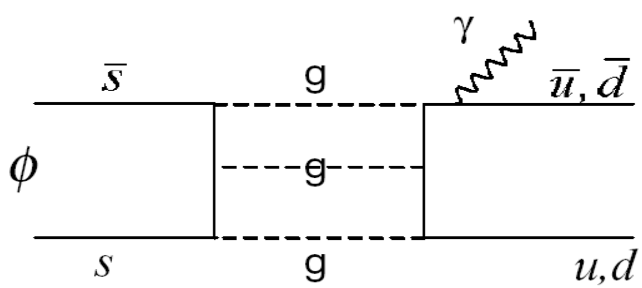
Alternative approaches

f_0	a_0
$s\bar{s}(u\bar{u}+d\bar{d})$	$s\bar{s}(u\bar{u}-d\bar{d})$

The decay rate $\phi \to S\gamma$ can distinguish (Achasov-Ivanchenko, NPB315 (1989) 465)

KK molecules

Ozi forbidden



Ozi allowed

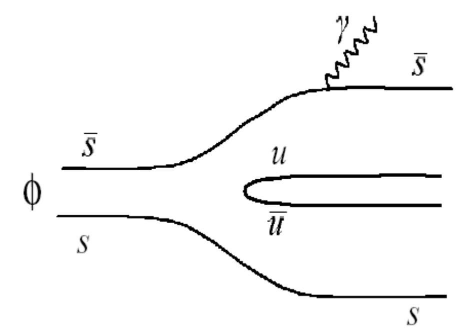


Table 3
Fixed parameters used in the fit for $\cos^2\varphi_G$ and $\cos^2\varphi_P$

Parameter	f_q	f_s	C_{NS}	C_S	$\frac{m_s}{\bar{m}}$
Value	1 ± 0.01	1.4 ± 0.014	0.91 ± 0.05	0.89 ± 0.07	1.24 ± 0.07

C_{NS},C_S OZI rules effect reducing the vector and pseudoscalar function overlap

f_q, f_s are the f_P pseudoscalar decay constant after a rotation in the q,s base.

$<0|J^a_{\mu 5}(0)|P(p)>=if_P p_\mu$

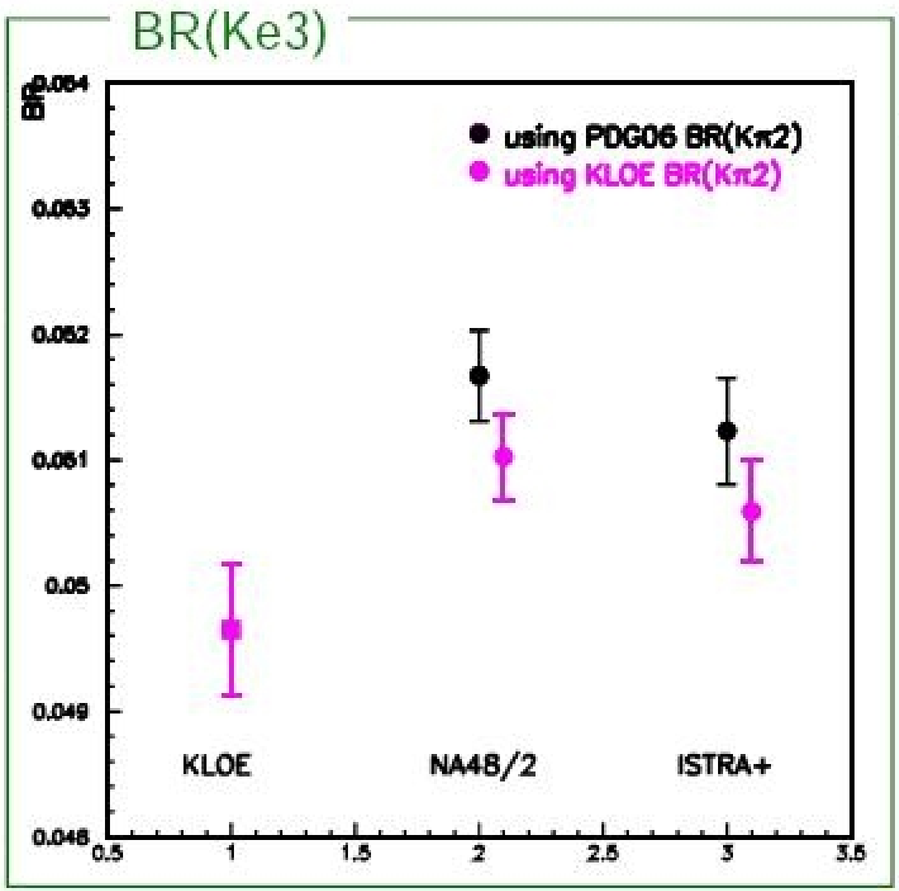
$<0|J^a_{m5}(0)|P_q(p) + P_s(p)>=if_P p_\mu$

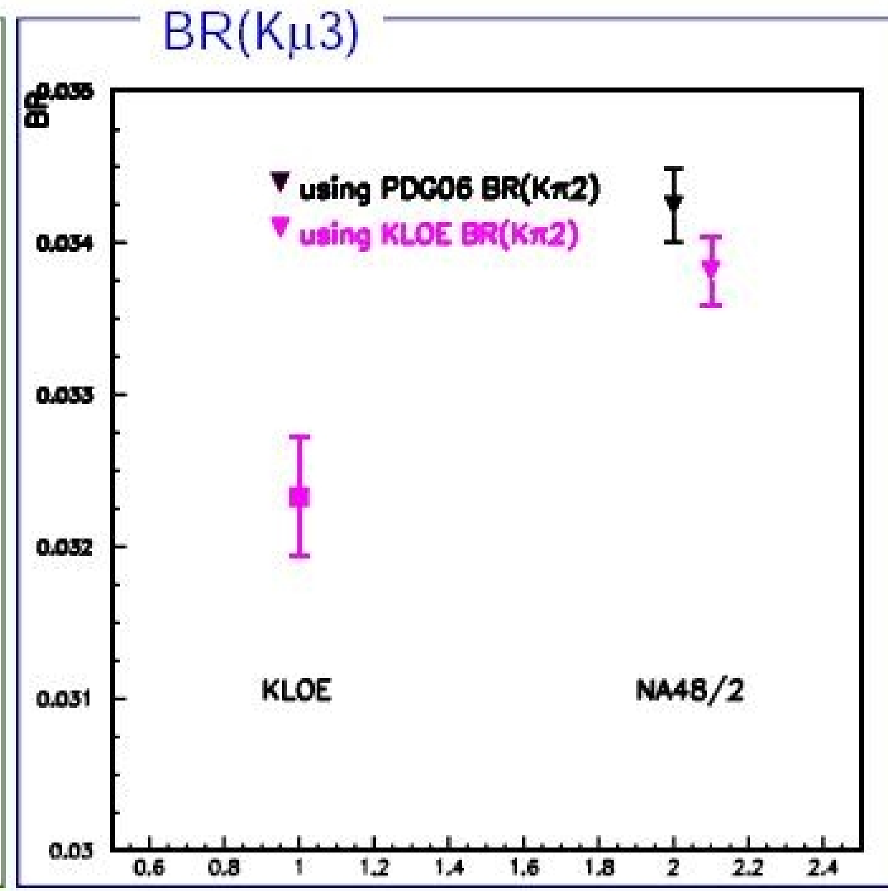
$<0|J^a_{m5}(0)|P_q(p)> = if^q_P p_\mu$

$$\begin{pmatrix} f^q_\eta & f^s_\eta \\ f^q_{\eta'} & f^s_{\eta'} \end{pmatrix} = \begin{pmatrix} f_q \cos\phi_q & -f_s \sin\phi_s \\ f_q \sin\phi_q & f_s \cos\phi_s \end{pmatrix}$$

Present status	To complete analysis
1.1% Signal counts/1.7fb^{-1}	+30% of data under processing
	+40% w recover of prompt K decays
0.7% Bkg subtraction	×2 rejection from kinematics
1.4% MC Bkg statistics	×2 MC stat under processing
1.9% stat error	
1.5% incomplete PID CS coverage	× 4--8 CS stat available, loosen PID cut
0.9% one-prong CS stat	< 0.3% using all data
0.9% TRG minimum-bias stat	Better control of trigger variables
2.0% syst error	

Impact of the new measurement wrt PDG06 fit value on the BR(Kl3) measurements normalized to Kπ2 decays and comparison with absolute BR(Kl3) measurements from KLOE



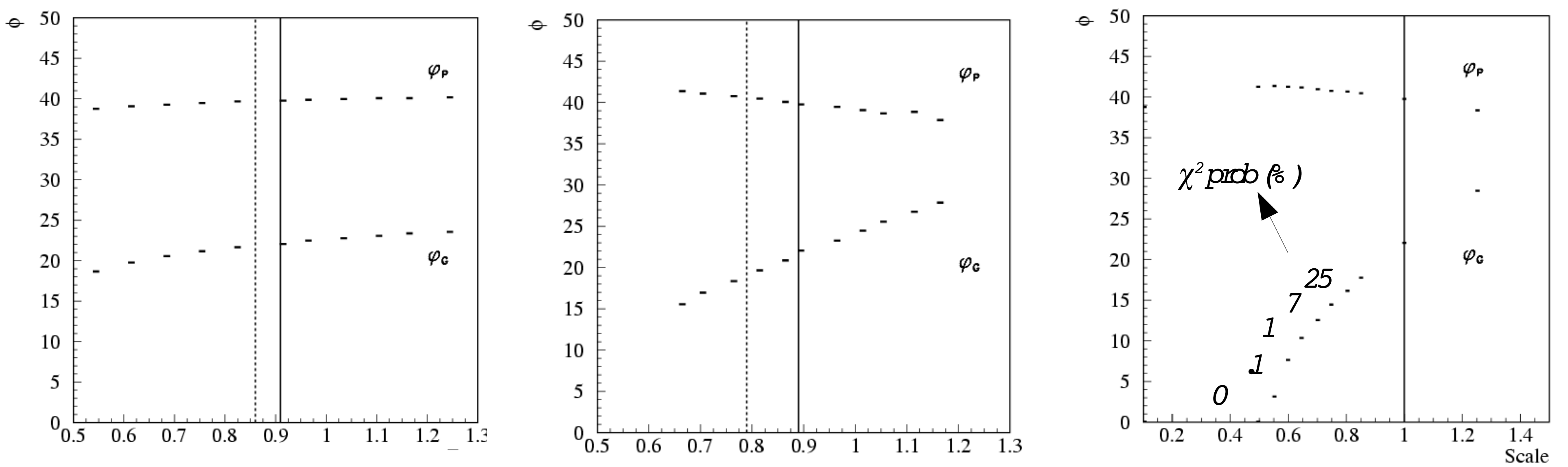


Escribano asserts that this is due to the use of different parameters z_q and z_s that we take from a fit without assumption of gluonium, we have investigated the dependence of the fit result from the z_q and z_s parameter.

KLOE $z_q = 0.91 \pm 0.05$ $z_s = 0.89 \pm 0.07$

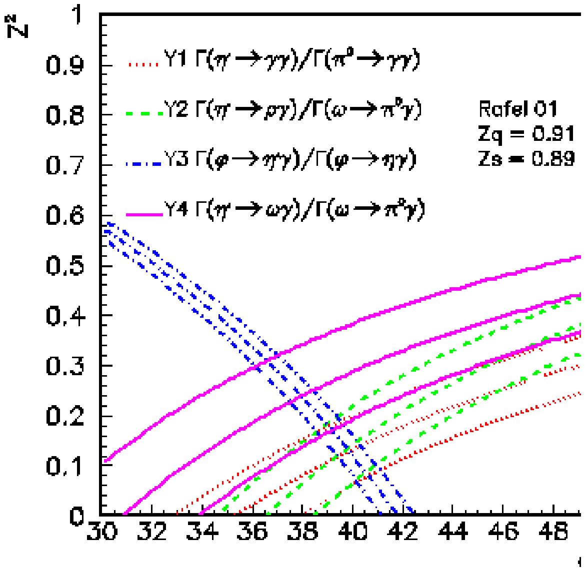
Escribano $z_q = 0.83 \pm 0.03$ $z_s = 0.79 \pm 0.05$

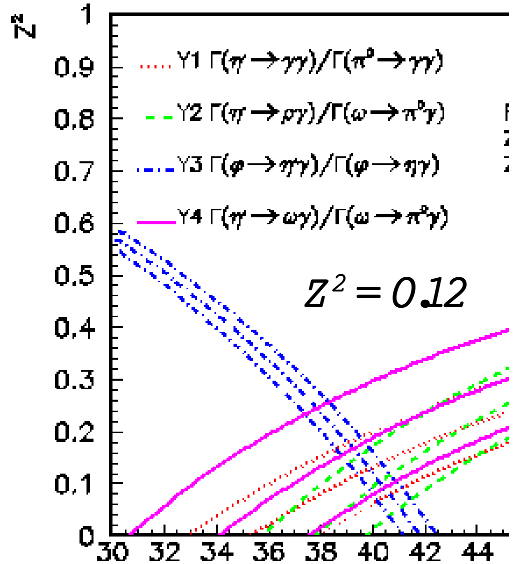
$$\frac{z_q(Escribano)}{z_q(KLOE)} \sim \frac{z_s(Escribano)}{z_s(KLOE)} \sim 0.9$$

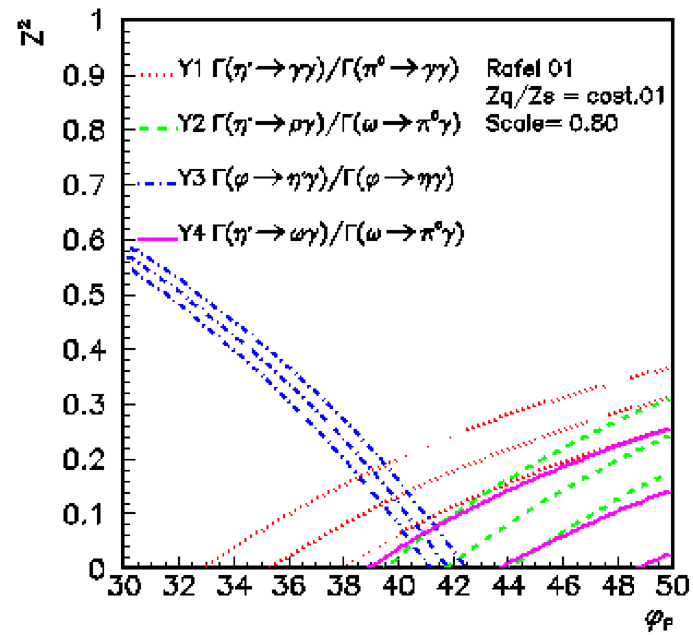


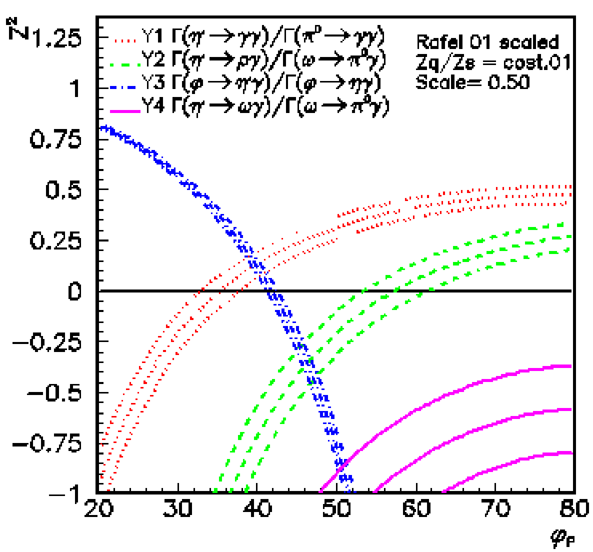
The gluonium is sensitive to a scale factor variation of both overlapping parameters. But to reach the null value we have to go far from the Escribano estimate and we obtain meaningless χ^2 values

Constraints variation with the scale factor.









Dropping away $\Gamma(\eta'\to\gamma\gamma)$ makes the fit much more sensitive to the overlapping parameters.
The $\eta'\to\gamma\gamma$ constraint makes the fit more stable and fix much better the overlapping parameter itself.

The difference with Escribano outcome is in the use of $\eta'\to\gamma\gamma$.

[redacted]

$K\to\mu\nu$ sensitivity to new physics

H- contribution to helicity suppressed SM decays

$$\frac{\Gamma(M\to\ell\nu)}{\Gamma_{SM}(M\to\ell\nu)}=\left[1-\tan^2\beta\left(\frac{m_{s,d}}{m_u+m_{s,d}}\right)\frac{m_M^2}{m_H^2}\right]^2$$

Hou, Phys. Rev. D 48 (1993) 2342

Isidori, Paradisi, Phys. Lett. B 639 (2006) 499

In the K and π case large uncertainty in Γ_{SM} due to the theoretical factors f_K and f_π. Much better determination on lattice of f_K/f_π (finite volume effects cancel out).

$$\frac{\Gamma(K\to\mu\nu)}{\Gamma(\pi\to\mu\nu)}\approx\left[1-2\tan^2\beta\left(\frac{m_s}{m_s+m_u}m_K^2-\frac{m_u}{m_u+m_d}m_\pi^2\right)\frac{1}{m_H^2}\right]\frac{\Gamma_{SM}(K\to\mu\nu)}{\Gamma_{SM}(\pi\to\mu\nu)}\approx\left[1-2\tan^2\beta\frac{m_K^2}{m_H^2}\right]\frac{m_K\left(1-\frac{m_\mu^2}{m_K^2}\right)^2}{m_\pi\left(1-\frac{m_\mu^2}{m_\pi^2}\right)^2}\frac{|V_{us}|^2}{|V_{ud}|^2}\frac{f_K^2}{f_\pi^2}$$

Using: $f_K/f_\pi = 1.189\,(7)$ HPQCD-UKQCD [arxiv 0706.1726],

C_π and C_K from Marciano, PRL 93 231803, 2004

V_{ud} = 0.97372 (26) world average, V_{us} = 0.22635 (86) from Kl3 (not helicity suppressed)

masses from PDG, $\Gamma(\pi\to\mu\nu\,(\gamma))$ from PDG, $\tau(K^+)$ from average of KLOE + PDG

$Br(K^+\to\mu^+\nu\gamma)$ = 63.66(9)(15) Phys. Lett. B 632 (2006), 76 (KLOE)

$$a_\mu^{teo} = (11\,659\,180.5 \pm 4.4_{had} \pm 3.5_{LBL} \pm 0.2_{QED+EW}) \times 10^{-10}$$

$$a_\mu^{exp} - a_\mu^{teo} = (27.5 \pm 8.4) \times 10^{-10}\ [3.3\sigma]$$

Hadron cross section