Gluonium content of the η'

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In order to fit the gluonium we use our measurement of

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

Together with

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

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

$$\frac{\Gamma(\eta'\to\omega\gamma)}{\Gamma(\omega\to\pi^0\gamma)} = \frac{1}{3}\left(\frac{m_{\eta'}^2 - m_\omega^2}{m_\omega^2 - m_\pi^2}\frac{m_\omega}{m_{\eta'}}\right)^3 \left[C_{NS}X_{\eta'} + 2\frac{m_s}{\bar{m}}C_s\cdot\tan\phi_V\cdot Y_{\eta'}\right]^2$$

These parameters multiply the gluonium component

We took them from a fit to the same quantities + further constraints without assuming gluonium content

The Method

The χ^2 is defined as follows:

$$\chi^2 = \Sigma_{i,j=1,3} \left(y_i - y_i^{th}\right) \times V_{ij}^{-1} \left(y_j - y_j^{th}\right)$$

V_{ij} is the error matrix which is a function of theoretical uncertainties, as well as the experin

$$V_{ij} = [B_{ij} + (A_{ik} \times C_{kl} \times A_{lj}^T)]$$

B_{ij} Full covariance matrix (correlation comes from the constrained fit to η' Br)

$$; A_{ik} = \begin{pmatrix} \frac{\partial y_1^{th}}{\partial f_s} & \frac{\partial y_1^{th}}{\partial f_q} & \frac{\partial y_1^{th}}{\partial C_{NS}} & \frac{\partial y_1^{th}}{\partial C_S} & \frac{\partial y_1^{th}}{\partial \frac{m_s}{\bar{m}}} \\ \frac{\partial y_2^{th}}{\partial f_s} & \frac{\partial y_2^{th}}{\partial f_q} & \frac{\partial y_2^{th}}{\partial C_{NS}} & \frac{\partial y_2^{th}}{\partial C_S} & \frac{\partial y_2^{th}}{\partial \frac{m_s}{\bar{m}}} \\ \frac{\partial y_3^{th}}{\partial f_s} & \frac{\partial y_3^{th}}{\partial f_q} & \frac{\partial y_3^{th}}{\partial C_{NS}} & \frac{\partial y_3^{th}}{\partial C_S} & \frac{\partial y_3^{th}}{\partial \frac{m_s}{\bar{m}}} \end{pmatrix}$$

Re-evaluated at each minimization step

$$C_{kl} = \begin{pmatrix} \sigma_{f_s}^2 & 0 & 0 & 0 & 0 \\ & \sigma_{f_q}^2 & 0 & 0 & 0 \\ & & \sigma_{C_{NS}}^2 & 0 & 0 \\ & & & \sigma_{C_S}^2 & 0 \\ & & & & \sigma_{\frac{m_s}{\bar{m}}}^2 \end{pmatrix}$$

The MINUIT fit

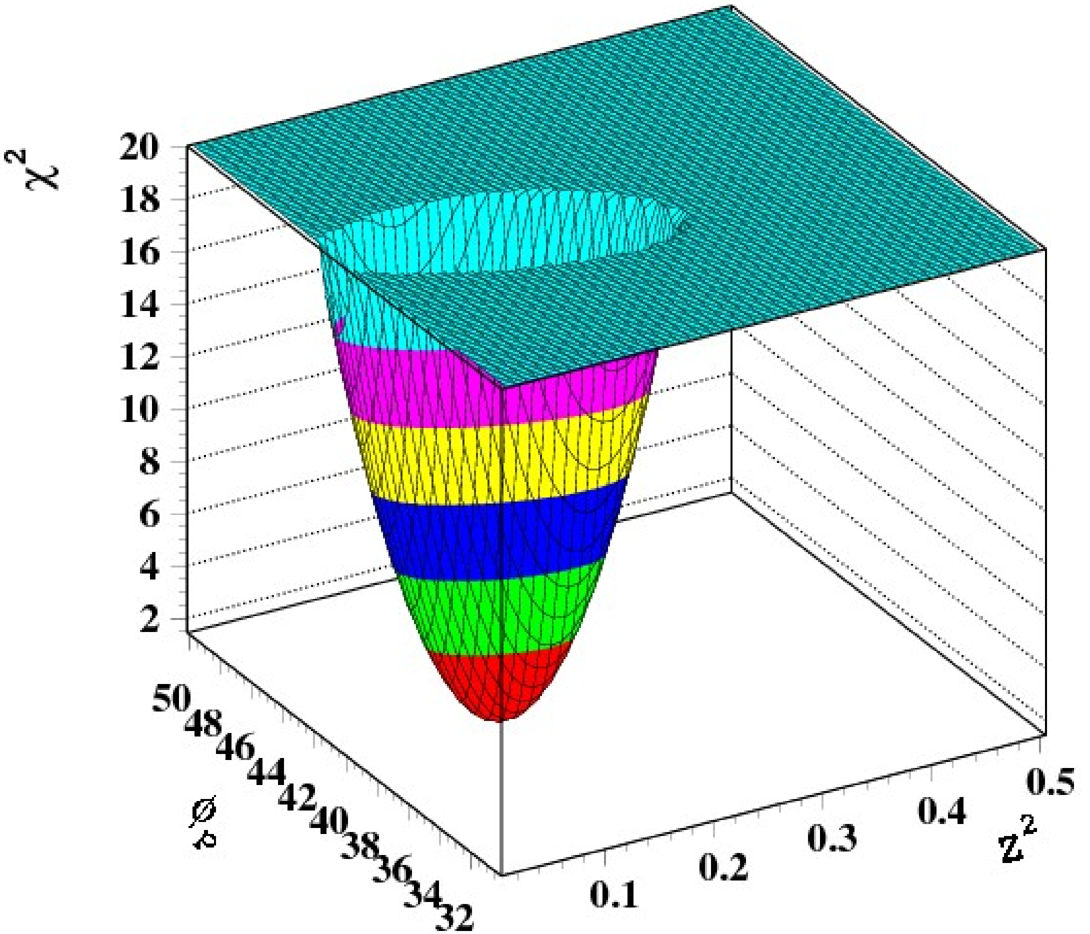
(The original fit was made with excel)

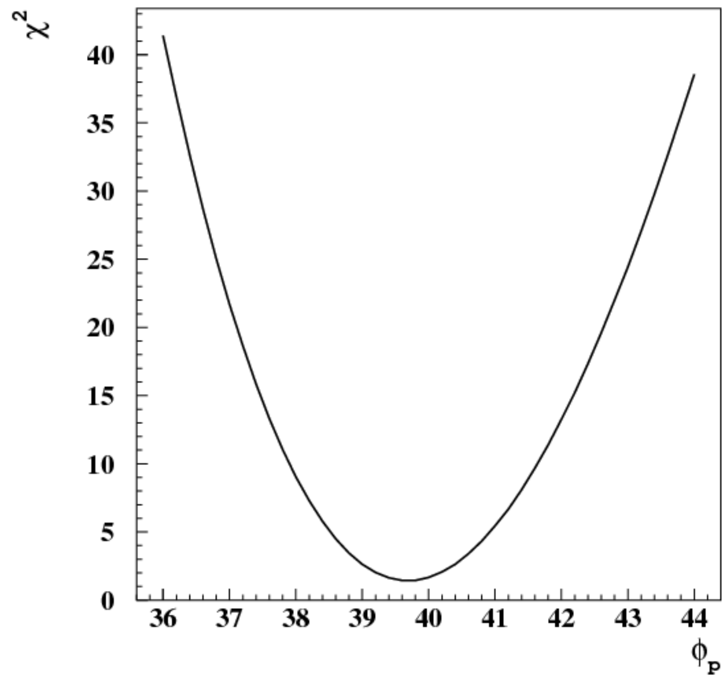
Fit result

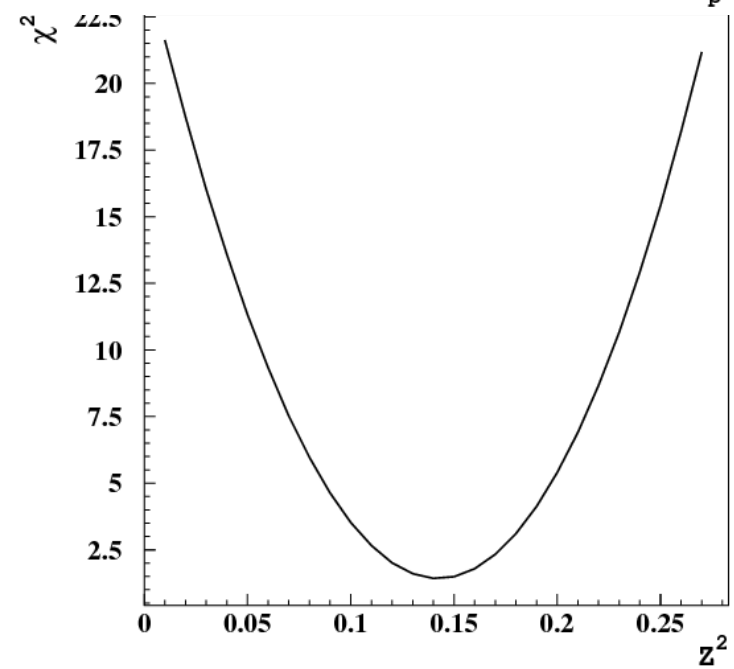
```
FCN=   1.420049     FROM MIGRAD    STATUS=CONVERGED     30 CALLS       31 TOTAL
                    EDM=  0.46E-08    STRATEGY= 1      ERROR MATRIX ACCURATE

 EXT PARAMETER                                  STEP         FIRST
 NO.   NAME        VALUE          ERROR          SIZE      DERIVATIVE
  1     z2        0.14239      0.33030E-01   0.22096E-04   0.32092E-02
  2     PHIP       39.685       0.72252      0.48340E-03   0.10265E-03

EXTERNAL ERROR MATRIX.    NDIM=  50    NPAR=  2    ERR DEF=  1.00
 0.109E-02-0.113E-01
-0.113E-01 0.522E+00

PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2
       1  0.47489  1.000-0.475
       2  0.47489 -0.475 1.000
```

	This fit	**Paper**
z^2	0.14 ± 0.03	0.14 ± 0.04
ϕ_p	$(39.7 \pm 0.7)^\circ$	$(39.7 \pm 0.7)^\circ$

Check of the χ^2 behaviour







Only one minimum in the whole parameters' domain.

Check of the Escribano hypothesis

Fit redone using Escribano fit parameters:
C_{NS} = 0.86 ± 0.03 C_S=0.78± 0.05

	Fit	**Paper**
z^2	0.12 ± 0.03	0.14 ± 0.04
ϕ_p	$(40.0 \pm 0.7)^\circ$	$(39.7 \pm 0.7)^\circ$

The fit is very stable respect to the overlapping parameters

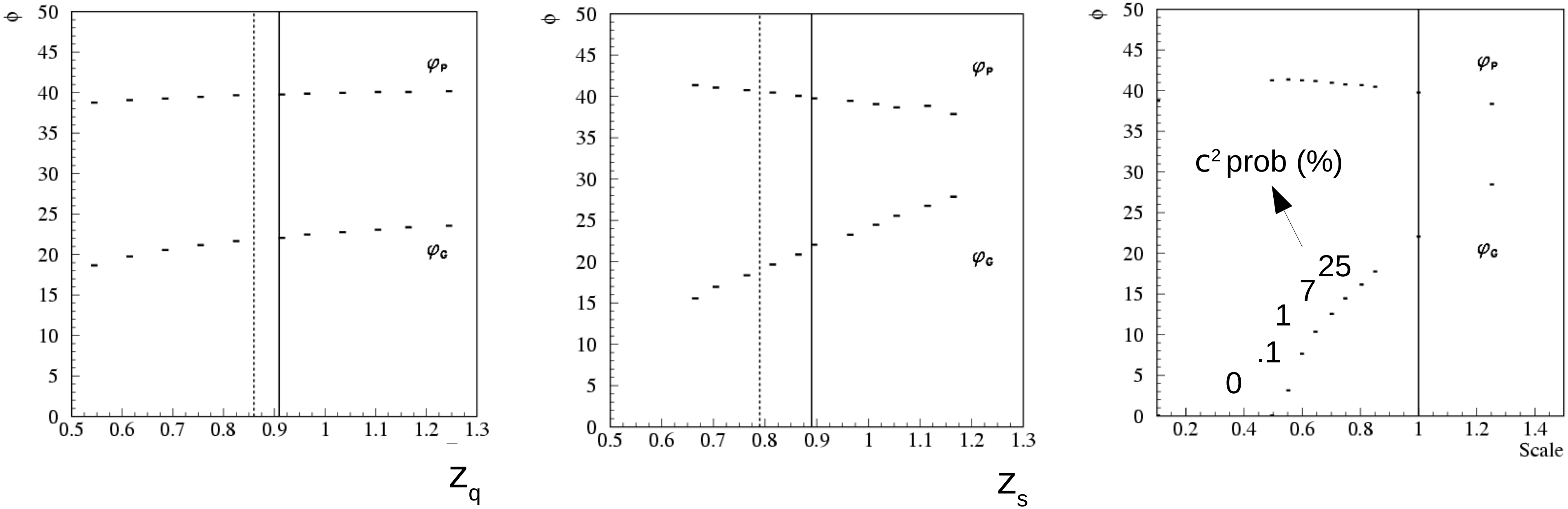
Just mean value and same error

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

[illegible]
$\frac{m_s}{\bar{m}} = 1.24 \pm 0.07$. We obtain: $(\varphi_p = 40.0 \pm 0.7)^\circ$ and $Z_G^2 = 0.12 \pm 0.03$ with $\chi^2/n.d.f = 0.35/2$ in perfect agreement with the previous determination. The value of the fit has been also repeated for different values of Z_{NS} and Z_S in a range $0.5 - 1.3$, and the resulting Z_G^2 varied between 0.07 and 0.18. Ex-

a range $0.5 - 1.3$, and the resulting Z_G^2 varied between 0.07 and 0.18. Ex-
cluding the $P \to \gamma\gamma$ constraint from the fit we obtain $\varphi_p = (40.1 \pm 0.9)^\circ$ and $Z_G^2 = 0.12 \pm 0.05$ with $\chi^2/n.d.f = 0.28/2$, showing that the $P \to \gamma\gamma$ constraint significatively improves the determination of the gluonium content. A global

Improves the sensitivity

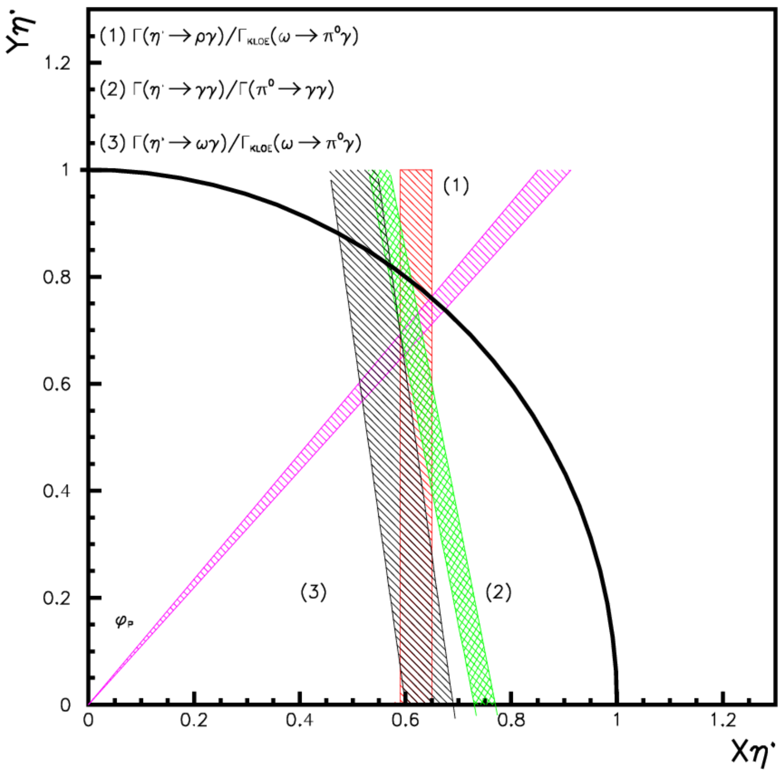
Using $Br(\omega \to \pi^0 \gamma)_{KLOE} = 8.40 \pm 0.19$ % (hep-ex:arXiv:0707.4130)

$\phi_P = (40.0 \pm 0.7_{tot})^\circ$
$|\phi_G| = (21 \pm 3)^\circ$

$\sin^2\phi_G = Z^2 = 0.13 \pm 0.04$

$C_S/C_{NS} = 1.0 \pm 0.1$

C.L 55%



Stress that the fit are different and also the input values