Detection of $\phi \rightarrow a_0(980)\gamma$, $f_0(980)\gamma$ and $\phi \rightarrow \eta\gamma$, $\eta'\gamma$ with the KLOE detector at DAΦNE

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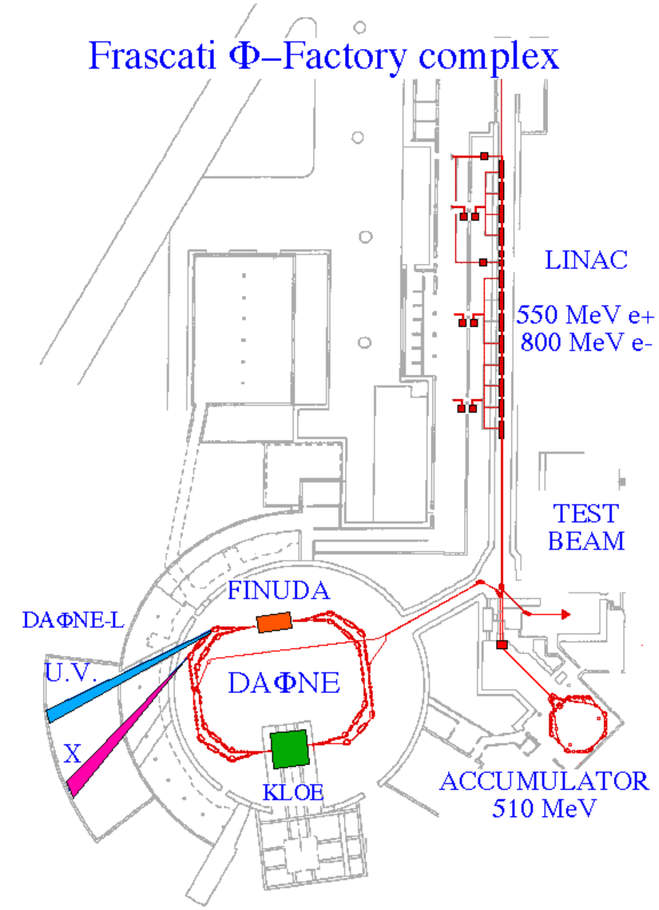
The DAΦNE Φ-Factory (I)

DAΦNE is an e^+e^- collider at $\sqrt{s} = M_\phi$ = 1020 MeV

Design parameters:

E_{BEAM} (MeV)	510
Max n. of bunches	120
Bunch spacing (ns)	2.7
Bunch current (mA)	40
Single bunch L (cm^{-2}s^{-1})	$4 \cdot 10^{30}$
Total L (cm^{-2}s^{-1})	$\mathbf{5 \cdot 10^{32}}$



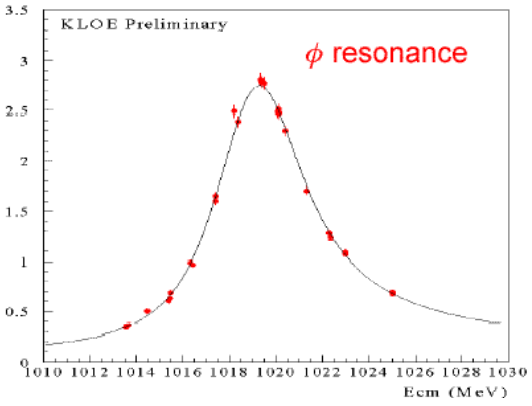
The DAΦNE Φ-Factory (II)

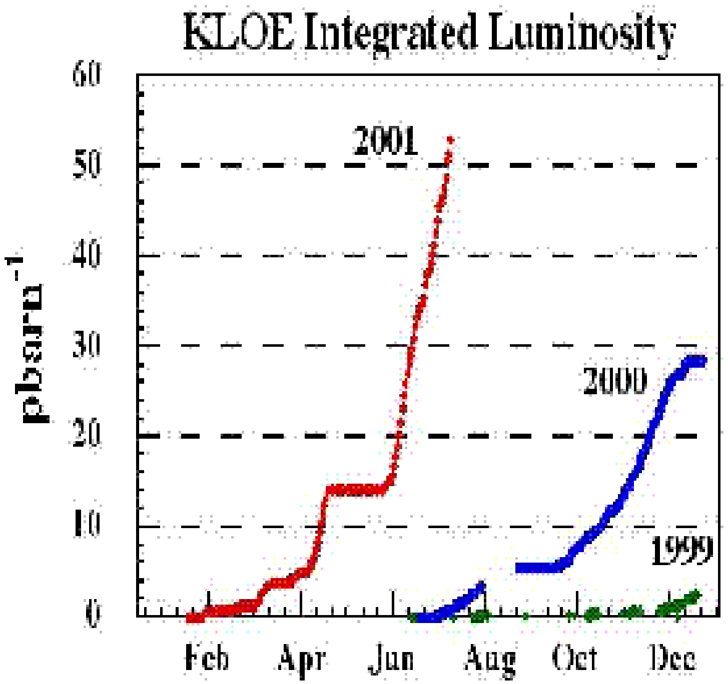
Present Performances:

$$\mathrm{L}_{max}\ (\mathrm{cm}^{-2}\mathrm{s}^{-1}) \sim 3 \cdot 10^{31}$$

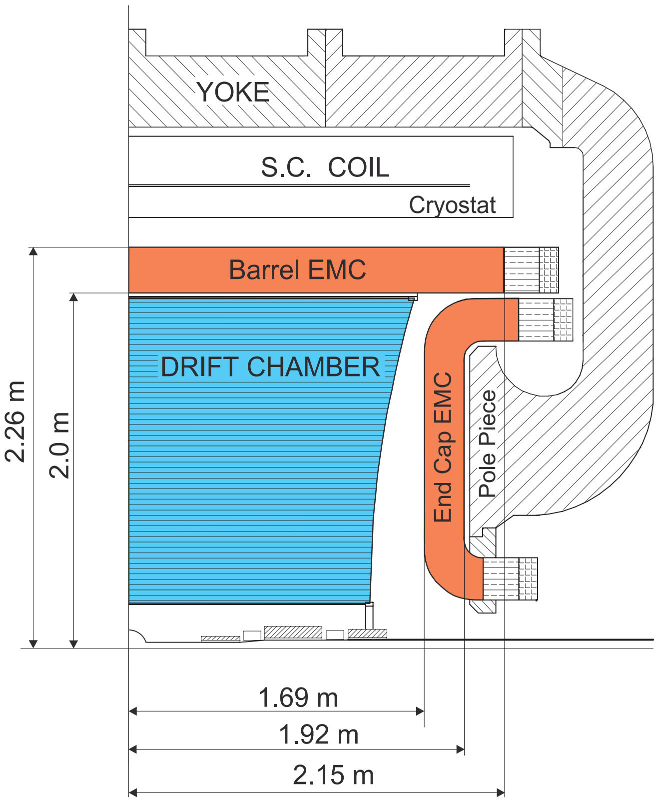
$$\int \mathrm{L}\ \mathrm{dt(day)} \sim 1.5\ \mathrm{pb}^{-1}$$

$$\int \mathrm{L}\ \mathrm{dt(tot)} \sim 80\ \mathrm{pb}^{-1}$$





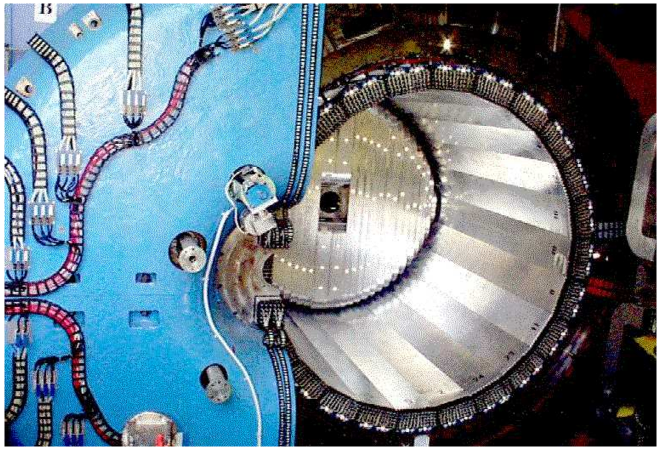
The KLOE Detector



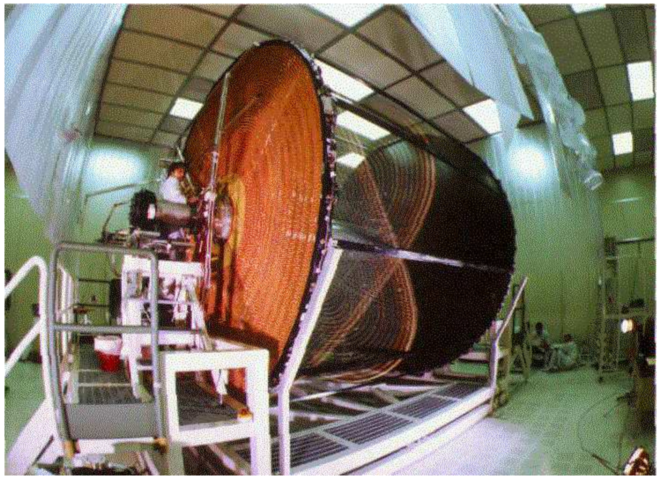
$\sigma_E/E = 5.7\ \%/\sqrt{E(GeV)}$

$\sigma_t = 54\ \text{ps}\ /\sqrt{E(GeV)} \oplus 50\ \text{ps}$

$\sigma_p/p = 0.4\%(90^\circ\ \text{tracks})$



Lead/Scintillating Fiber Calorimeter



He-iC_4H_{10} Drift Chamber

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Detection of $\phi \to a_0(980)\gamma$, $f_0(980)\gamma$ @ KLOE: motivations

- The study of the radiative decays of the ϕ to the scalar mesons $a_0(980)$ and $f_0(980)$ allows us to clarify the nature of the two mesons.
- Precise measurements of the rates $BR(\phi \to a_0\gamma)$, $BR(\phi \to f_0\gamma)$ and their ratio allow us to discriminate among different models:

  - $q\bar{q}$ state $\to BR \leq 10^{-5}$ *N.A. Törnqvist, Z. Phys. C68, (1995), 647 .*
  - $qq\overline{qq}$ states $\to BR \sim 2 \times 10^{-4}$;
    R.L. Jaffe, Phys. Rev. D 15 (1977), 267;
    N. Achasov et al., Nucl. Phys. B315 (1989), 465 ;
    R.L. Jaffe,M. Alford, Nucl. Phys. B 578 (2000), 367 .
  - $K\overline{K}$ molecule $\to BR \sim$ (0.4-1)$\times 10^{-4}$
    J.Weinstein and N.Isgur, Phys.RevD27 (1983), 588
    F.E. Close et al., Nucl. Phys. B389 (1993), 513 .
  - A compact $qq\overline{qq}$ core surrounded by a $K\overline{K}$ cloud
    F.E. Close et al., hep-ph/0106108

Detection of $\phi \to a_0(980)\gamma$, $f_0(980)\gamma$ @ KLOE (I)

- L $= 16.6$ pb^{-1} out of ~ 30 pb^{-1} collected by the end of 2000 have been analysed, corresponding to $\sim$ 50 millions of ϕ meson produced.

- Detection of $f_0(980)$ and $a_0(980)$ has been performed in the channels:

$$\boxed{\begin{array}{c} \phi \to f_0\gamma \to \pi^0\pi^0\gamma \to 5\gamma \\ \phi \to a_0\gamma \to \eta\pi^0\gamma \to 5\gamma \end{array}}$$

- These analyses are being finalized to measure both the $BR(\phi \to f_0(980)\gamma)$, $BR(\phi \to a_0(980)\gamma)$ and the $\eta\pi^0$, $\pi^0\pi^0$ invariant mass spectra.

- Since the invariant mass spectra depend strongly on the mesons structure, the analyses follow a scheme independent as much as possible from any model.

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Detection of $\phi \to a_0(980)\gamma, f_0(980)\gamma$ @ KLOE (II)

- **Signal selection criteria:**

1. Selection of events with 5 clusters on calorimeter in a appropriate time window ($|T - R/c| \leq 5\sigma_t$) and in the acceptance region ($21^\circ < \theta < 159^\circ$).
2. Photons pairing to look for the best combination in the hypotheses $\pi^0\pi^0\gamma$ and $\eta\pi^0\gamma$;
3. Constrained fit requiring *promptness* of photons, 4-momentum conservation and intermediate masses ($M_{\gamma\gamma} = M_{\pi^0}$ or $M_{\gamma\gamma} = M_\eta$) constraints.

- **The main backgrounds :**

Process	S/B*
$\phi \to f_0\gamma \to \pi^0\pi^0\gamma$	–
$e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$	0.6
$\phi \to \rho^0\pi^0 \to \pi^0\pi^0\gamma$	3.7
$\phi \to a_0\gamma \to \eta\pi^0\gamma \to 5\gamma$	3.5
$\phi \to \pi^0\gamma$	0.10
$\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$	0.023

*Derived from SND measurements:

M.N.Achasov et al., Phys. Lett. B485 (2000), 349

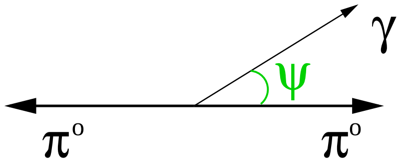
M.N.Achasov et al., Phys. Lett. B479 (2000), 53

Process	S/B*
$\phi \to a_0\gamma \to \eta\pi^0\gamma$	–
$\phi \to \rho^0\pi^0 \to \eta\pi^0\gamma$	5.3
$e^+e^- \to \omega\pi^0 \to \eta\pi^0\gamma$	71
$e^+e^- \to \omega\pi^0\pi^0\gamma$	0.14
$\phi \to \rho^0\pi^0 \to \pi^0\pi^0\gamma$	1
$\phi \to f_0\gamma \to \pi^0\pi^0\gamma$	0.27
$\phi \to \eta\gamma \to \gamma\gamma\gamma$	6.1×10^{-3}
$\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$	7.5×10^{-3}

Detection of $\phi \to f_0(980)\gamma \to \pi^0\pi^0\gamma$ @ KLOE (III)

- **Analysis cuts:**

1. $\chi^2_{\pi\pi\gamma}/\mathrm{ndf} < 5$;
2. $|M_{\pi^0} - M_{\gamma\gamma}| < 5\,\sigma$;
3. $\cos\psi_{\omega\pi^0}>$0.4;

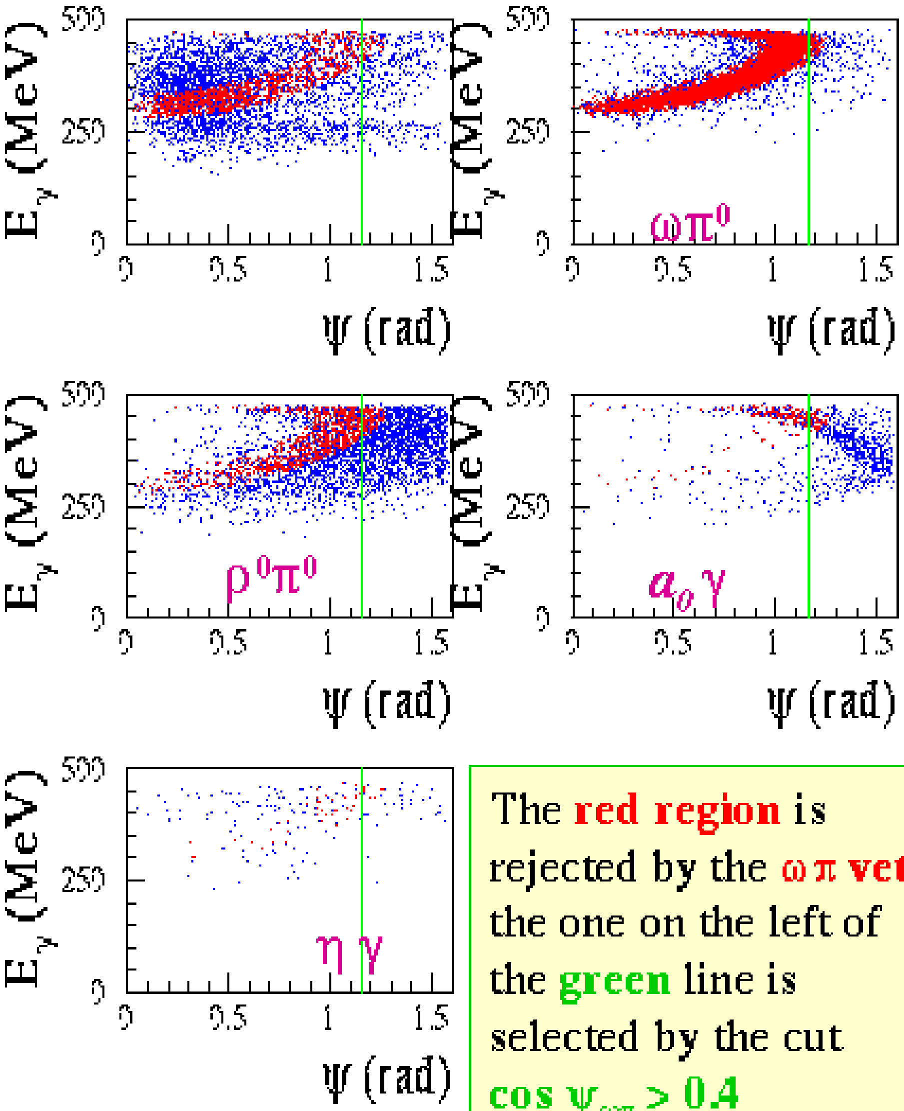


4. $e^+e^- \longrightarrow \omega\pi^0$ veto:

   reject events which survive the cuts:

   - $\chi^2_{\omega\pi}/\mathrm{ndf} < 3$;
   - $|M_\omega - M_{\pi^0\gamma}| < 3\,\sigma$.

5. further cuts to reject $e^+e^- \longrightarrow \gamma\gamma(\gamma)$ events.

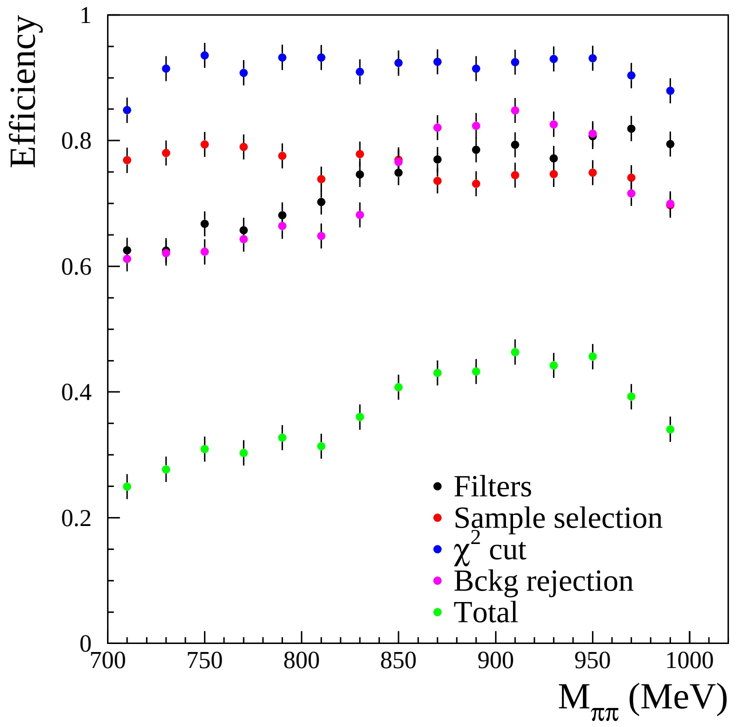


The **red region** is rejected by the **$\omega\pi$ veto**, the one on the left of the **green** line is selected by the cut **$\cos\psi_{\omega\pi} > 0.4$**

Detection of $\phi \to f_0(980)\gamma \to \pi^0\pi^0\gamma$ @ KLOE(IV)

- **Selection Efficiency:**
  - The analysis efficiency is evaluated from Monte Carlo as function of $M_{\pi\pi}$ in bins of 20 MeV.

Decay	$\varepsilon_{\mathrm{analysis}}$
$\phi \to f_0\gamma \to \pi^0\pi^0\gamma$	39.7%
$e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$	1.2%
$\phi \to \rho\pi^0 \to \pi^0\pi^0\gamma$	4.9%
$\phi \to a_0\gamma \to \eta\pi^0\gamma \to 5\gamma$	1.9%
$\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$	5×10^{-4}



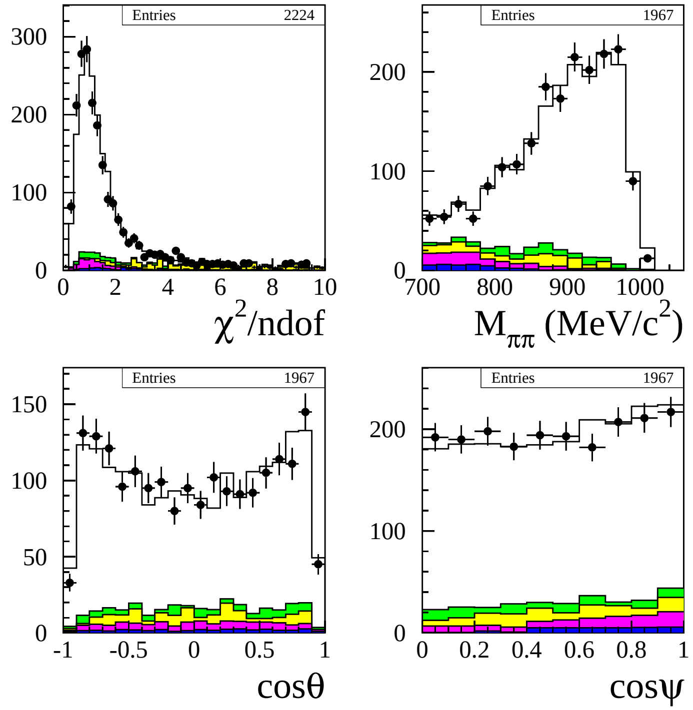
The total efficiency variation is $\sim$ 30%.

Detection of $\phi \to f_0(980)\gamma \to \pi^0\pi^0\gamma$ @ KLOE (V)

Data - Monte Carlo comparison:

In order to rule out the dependence of the Monte Carlo distribution shapes on the f_0 model we proceed this way:

1. Subtract the expected background from the observed $M_{\pi\pi}$ distribution.
2. Evaluate for each bin in $M_{\pi\pi}$ the scale factors that, applied to the MC $M_{\pi\pi}$ shape, reproduce the $M_{\pi\pi}$ data distribution.
3. Apply the scale factors to all Monte Carlo sliced histograms to reproduce all the spectra.

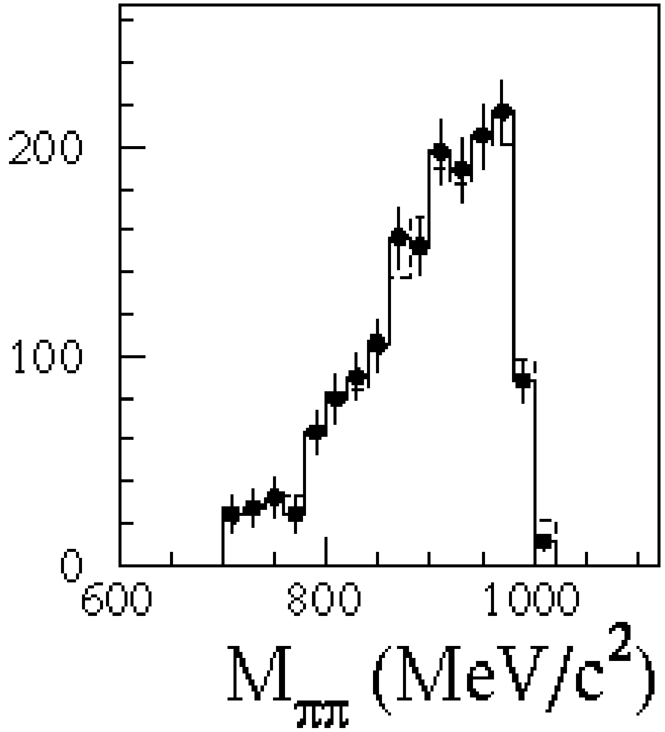


• $\phi \to f_0\gamma$ (data) — $\phi \to f_0\gamma$ (MC)
— $e^+e^- \to \omega\pi^0$ — $\phi \to \eta\gamma$
— $\phi \to \rho\pi^0$ — $\phi \to a_0\gamma$

Detection of $\phi \to f_0(980)\gamma \to \pi^0\pi^0\gamma$ @ KLOE (VI)

Results:

- N=1967 events survive the analysis with $305 \pm 13_{\text{stat}}$ expected background.
- The BR is evaluated by normalization with respect to the $\phi \to \eta\gamma \to 3\gamma$ events, using the PDG(2000) value for the $BR(\phi \to \eta\gamma \to \gamma\gamma\gamma)$.
- Neglecting interference between signal and $\phi \to \rho\pi^0 \to \pi^0\pi^0\gamma$ the result is:



$$\boldsymbol{BR(\phi \to f_0\gamma \to \pi^0\pi^0\gamma) = (7.9 \pm 0.2_{\text{stat}}) \times 10^{-5}}$$

[for $M_{\pi\pi} > 700$ MeV]

systematic error under study but not exceeding 10%

KLOE Collaboration, hep-ex/0107024

Detection of $\phi \to a_0(980)\gamma \to \eta\pi^0\gamma$ @ KLOE (I)

Signal selection criteria:

1. Selection of events with 5 clusters on calorimeter in a appropriate time window ($|T - R/c| \le 5\sigma_t$) and acceptance region ($21° < \theta < 159°$).
2. Photons pairing to look for the best photon combination for the hypotheses: $\phi \to \eta\pi^0\gamma$, $\phi \to \pi^0\pi^0\gamma$, $e^+e^- \to \omega\pi^0$, $\phi \to \eta\gamma \to \gamma\gamma\gamma$;
3. Constrained fit requiring *promptness* of photons, 4-momentum conservation and intermediate masses constraints without any assumption on the a_0 mass shape.

Process	S/B
$\phi \to a_0\gamma \to \eta\pi^0\gamma$	–
$\phi \to \rho^0\pi^0 \to \eta\pi^0\gamma$	5.3
$e^+e^- \to \omega\pi^0 \to \eta\pi^0\gamma$	71
$e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$	0.14
$\phi \to \rho^0\pi^0 \to \pi^0\pi^0\gamma$	1
$\phi \to f_0\gamma \to \pi^0\pi^0\gamma$	0.27
$\phi \to \eta\gamma \to \gamma\gamma\gamma$	6.1×10^{-3}
$\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$	7.5×10^{-3}

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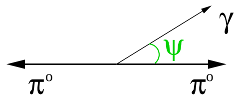
Detection of $\phi \to a_0(980)\gamma \to \eta\pi^0\gamma$ @ KLOE (II)

Background rejection:

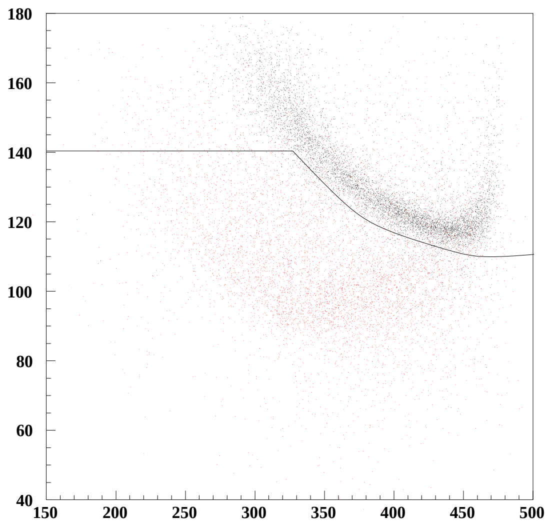
1. $e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$:
   $\Longrightarrow$ cut on (E_{rad},ψ) plane;



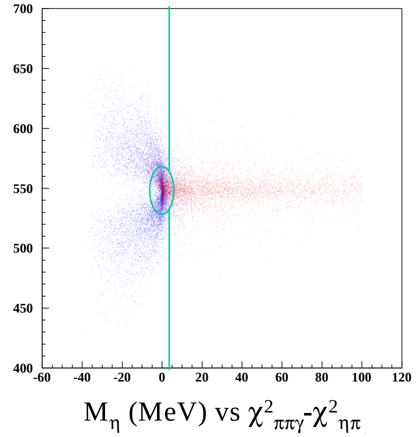
2. $\phi \to \rho^0\pi^0 \to \pi^0\pi^0\gamma$:
   $\Longrightarrow$ cut on $(\chi^2_{\eta\pi^0} - \chi^2_{\pi^0\pi^0},\ M_\eta)$ plane.

3. $\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$:
   $\Longrightarrow$ cut on M_η distribution.

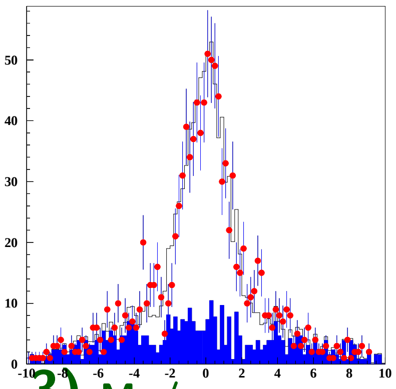
4. $\phi \to \eta\gamma \to \gamma\gamma\gamma$:
   $\Longrightarrow$ reject events with $M_{\gamma\gamma} = M_\eta$ and $E_{\mathrm{rad}} = 363$ MeV;



1)



2)



3) M_η/σ_{M_η}

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Detection of $\phi \to a_0(980)\gamma \to \eta\pi^0\gamma$ @ KLOE: Results (I)

- Search of $\phi \to a_0\gamma \to \eta\pi^0\gamma$ decay performed using 16.6 pb^{-1} collected @ KLOE in year 2000.

- 666 ± 26 events survive the analysis cuts with 253 ± 11 expected background (mainly $\phi \to \rho^0\pi^0 \to \pi^0\pi^0\gamma$ and $\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$).

Process	Natural S/B	Final efficiency
$\phi \to a_0\gamma \to \eta\pi^0\gamma$	–	27.2%
$\phi \to \rho^0\pi^0 \to \eta\pi^0\gamma$	5.3	27.1%
$e^+e^- \to \omega\pi^0 \to \eta\pi^0\gamma$	71	25.8%
$e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma$	0.14	3.5×10^{-3}
$\phi \to \rho^0\pi^0 \to \pi^0\pi^0\gamma$	1	5.0%
$\phi \to f_0\gamma \to \pi^0\pi^0\gamma$	0.27	1.4–$3.0\times10^{-3(*)}$
$\phi \to \eta\gamma \to \gamma\gamma\gamma$	6.1×10^{-3}	3.3×10^{-6}
$\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$	7.5×10^{-3}	5.4×10^{-4}

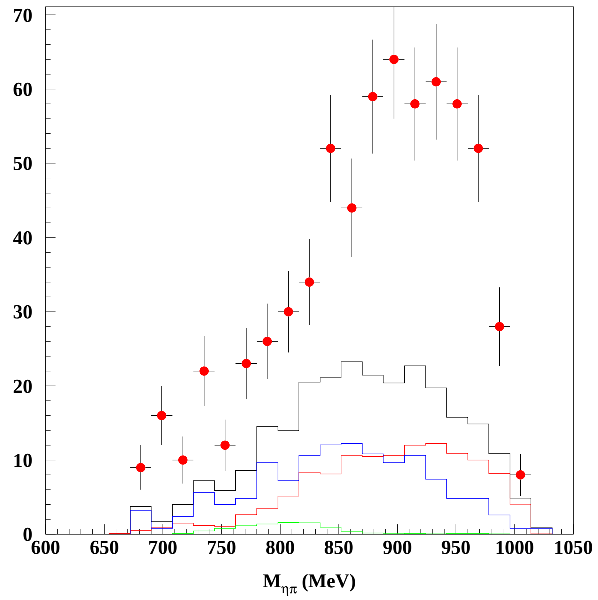
*Depending on the f_0 model

Detection of $\phi \to a_0(980)\gamma \to \eta\pi^0\gamma$ @ KLOE: Results (II)

- The BR is evaluated by normalization with respect to the $\phi \to \eta\gamma \to 3\gamma$ events, using the PDG(2000) value for the $BR(\phi \to \eta\gamma \to \gamma\gamma\gamma)$.

- The $BR(\phi \to a_0(980)\gamma)$ is obtained after subtraction of the $\phi \to \rho^0\pi^0$ contribution:
  $BR(\rho^0 \to \eta\gamma) = (3.0 \pm 0.3) \times 10^{-4}$
  M.N. Achasov et al., JETP Lett. 72 (2000), 282;
  R.R. Akhmetshin et al., Phys. Lett. B509 (2001), 217

$\eta\pi^0$ invariant mass shape



- data
- $\phi \to \pi^0\pi^0\gamma$
- $\phi \to \eta\gamma \to \pi^0\pi^0\pi^0\gamma$
- $e^+e^- \to \omega\pi^0$
- total backg.

$$BR(\phi \to a_0\gamma \to \eta\pi^0\gamma) = (5.8 \pm 0.5_{stat})10^{-5}$$

$\longrightarrow$ systematic error $\sim$ 10 %

KLOE Collaboration, hep-ex/0107024

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE: motivations (I)

- The study of the radiative decays of the ϕ to the pseudoscalar mesons $\eta'(958)$, $\eta(547)$ allow us to probe:

  1. The $|s\bar{s}\rangle$ content of η' by measuring the $\eta - \eta'$ flavor mixing angle θ_P.
  2. The gluonium content of η' by measuring the absolute branching ratio, $BR(\phi \to \eta'\gamma)$.

- Theoretical predictions on $BR(\phi \to \eta'\gamma)$ range from $\sim 2 \times 10^{-4}$ down to $\sim 10^{-6}$ in case of significant gluonic content.

N. Deshpande and G. Eilan, Phys. Rev. D25 (1980),270.
J.L. Rosner, Phys. Rev. D27 (1983),1101.
F.E. Close, The DAΦNE Physics Handbook Vol.II, Frascati, 1992

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE: motivations (II)

- The mass eigenstates $\boldsymbol{\eta(547)}$ and $\boldsymbol{\eta'(958)}$ can be related to the SU(3) octet singlet states η_8 and η_1 through the mixing angle $\boldsymbol{\theta_P}$:

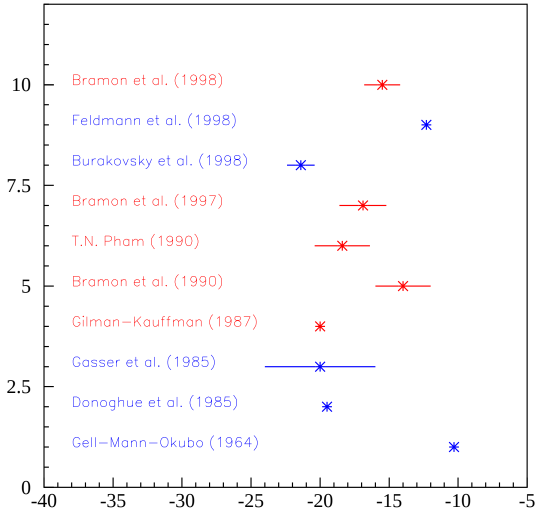
$$\eta(547) = \eta_8 \cos\theta_P - \eta_1 \sin\theta_P$$
$$\eta'(958) = \eta_8 \sin\theta_P + \eta_1 \cos\theta_P$$

- The value of the mixing angle has been discussed many times in the last 30 years:
  - $\theta_P \sim -10^\circ$ (GMO quadratic formula)
  - $\theta_P \sim -20^\circ$ (Chiral calculations)

    F.J. Gilman, R.Kauffman, Phys.Rev.D 36,2761 (1987)
  - $-13^\circ < \theta_P < -20^\circ$ (Phenomenological analyses.)

    A. Bramon et al., Phys.Lett.B403, (1997), 339

    A. Bramon et al., Phys.Lett.B503, (2001), 571



- theoretical predictions
- phenomenological analyses

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE: motivations (III)

- The ratio $R = BR(\phi \to \eta'\gamma)/BR(\phi \to \eta\gamma)$ can be related to the $\eta - \eta'$ mixing angle φ_P in the flavor basis:

$$\boxed{R = \frac{BR(\phi\to\eta'\gamma)}{BR(\phi\to\eta\gamma)} = \cot^2\varphi_P \left(1 - \frac{m_s}{\bar{m}}\frac{\tan\varphi_V}{\sin 2\varphi_P}\right)^2 \left(\frac{p_{\eta'}}{p_\eta}\right)^3}$$

Bramon et al., Eur.Phys.J. C7 (1999), Phys. Lett.B503 (2001)

with:

$$\boxed{\theta_P = \varphi_P - \arctan\sqrt{2}}$$

$\sim 10\%$ uncertainty on R will result in $\Delta\theta_P \sim 1^\circ$.

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE (IV)

- The measurement of $R = BR(\phi \to \eta'\gamma)/BR(\phi \to \eta\gamma)$ has been performed in the following channels:

$BR \approx 10^{-5}$

$$\begin{aligned} \phi &\to \eta'\gamma \\ \eta' &\to \eta\pi^+\pi^- \\ \eta &\to \gamma\gamma \end{aligned}$$

$BR \approx 2.9 \times 10^{-3}$

$$\begin{aligned} \phi &\to \eta\gamma \\ \eta &\to \pi^0\pi^+\pi^- \\ \pi^0 &\to \gamma\gamma \end{aligned}$$

- The final state $\pi^+\pi^-\gamma\gamma\gamma$ is the same both for the η and η' decay
  $\Rightarrow$ most of the systematics cancel out in the ratio.

- The η decay is:
  $\Rightarrow$ a useful control sample for the analysis;
  $\Rightarrow$ the main source of background for η' signal.

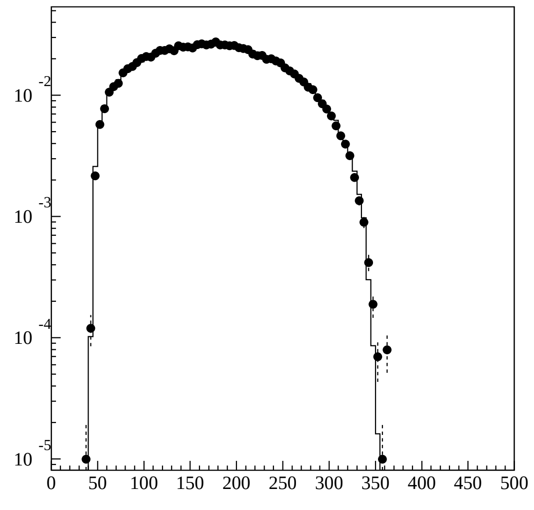
- Further background events are:
  $\Rightarrow$ $\phi \to K_S K_L$, where K_L decays near I.P. and ≥ 1 photon is lost;
  $\Rightarrow$ $\phi \to \pi^+\pi^-\pi^0$, with additional photon coming from splitting/accidentals.

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE (V)

Selection of $\pi^+\pi^-\gamma\gamma\gamma$ final state:

- 3 prompt neutral clusters with $21^\circ < \theta_\gamma < 159^\circ$;
- opening angle between each $\gamma\gamma$ pair $> 18^\circ$;
- 1 charged vertex inside a cylindrical region: $r < 4$ cm, $|z| < 8$ cm.
- kinematic fit constraining the total 4-momentum conservation and the speed of light for each photon: $P(\chi^2) > 1\%$.
- $E_{\pi^+} + E_{\pi^-} < 430$ MeV (to reduce the $\phi \to \pi^+\pi^-\pi^0$ background).

$\phi \to \eta\gamma \to \pi^+\pi^-\gamma\gamma\gamma$



Charged pions momentum

- data
- Monte Carlo

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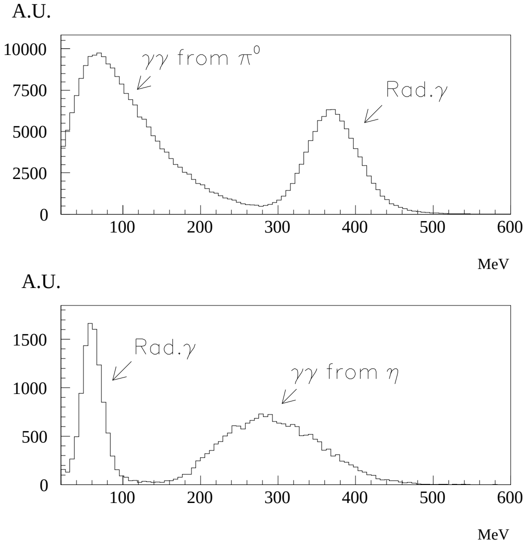
Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE (VI)

Selection of $\phi \to \eta'\gamma$ events:

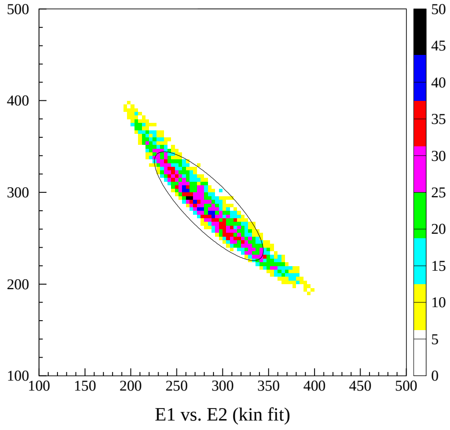
- To select $\phi \to \eta'\gamma$ events over the $\phi \to \eta\gamma$ background we use the energy spectra of the three photons: $\Longrightarrow \Longrightarrow \Longrightarrow$
- A cut on the energy plane (E_1 vs E_2) of the two hardest photons allows to identify the signal:

$\Downarrow \Downarrow \Downarrow$

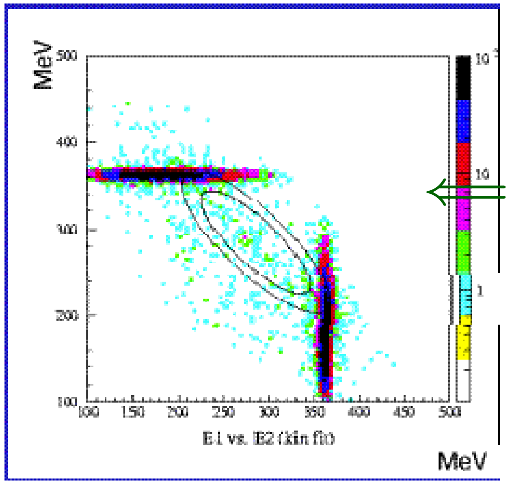
$\phi \to \eta\gamma$ (up), $\phi \to \eta'\gamma$ (down)



MC $\phi \to \eta'\gamma$ (E_1 vs E_2)



Data (E_1 vs E_2)

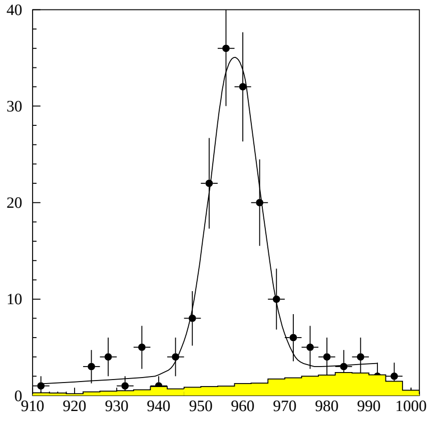


$\Longleftarrow$ **Events inside the ellipse are selected.**

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE (VII)

Selection of $\phi \to \eta'\gamma$ events:

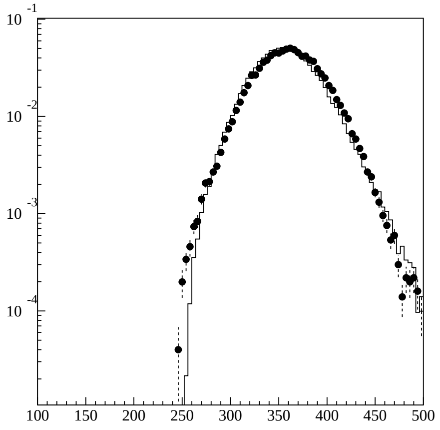
- Selected events show a clear peak at η' mass.
- The background is evaluated directly on data.
- The final number of events is:
  $N_{\eta'\gamma} = 124 \pm 12_{\mathrm{stat}} \pm 5_{\mathrm{syst}}$



η' invariant mass

Selection of $\phi \to \eta\gamma$ events:

- Cut on the energy of the radiative photon:
  320 MeV $<$ E$_{rad}$ $<$ 400 MeV
- The final number of events is:
  $N_{\eta\gamma} = (502.1 \pm 2.2_{\mathrm{stat}}) \cdot 10^{2}$



Energy of radiative photon

• data - Monte Carlo

Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE: Results (I)

- The ratio $N_{\eta'\gamma}/N_{\eta\gamma}$ is related to $R = BR(\phi \to \eta'\gamma)/BR(\phi \to \eta\gamma)$ as follows:

$$R = \frac{N_{\eta'\gamma}}{N_{\eta\gamma}} \left(\frac{\varepsilon_{\eta\gamma}}{\varepsilon_{\eta'\gamma}}\right)_{common} \times \left(\frac{\varepsilon_{\eta\gamma}}{\varepsilon_{\eta'\gamma}}\right)_{analysis} \times \frac{BR(\eta \to \pi^+\pi^-\pi^0)BR(\pi^0 \to \gamma\gamma)}{BR(\eta' \to \pi^+\pi^-\eta)BR(\eta \to \gamma\gamma)}$$

- Using the values in the table:

Quantity	Value	Syst. err.
$N_{\eta'\gamma}/N_{\eta\gamma}$	$2.5 \cdot 10^{-3}$	4%
$\left(\frac{\varepsilon_{\eta'\gamma}}{\varepsilon_{\eta\gamma}}\right)_{common}$	0.923	$< 1\%$
$\left(\frac{\varepsilon_{\eta'\gamma}}{\varepsilon_{\eta\gamma}}\right)_{analysis}$	0.662	5%
$\frac{BR(\eta\to\pi^+\pi^-\pi^0)BR(\pi^0\to\gamma\gamma)}{BR(\eta'\to\pi^+\pi^-\eta)BR(\eta\to\gamma\gamma)}$	1.30	5%

- We get:

$$\boldsymbol{R = (5.3 \pm 0.5_{\mathrm{stat}} \pm 0.4_{\mathrm{syst}}) \cdot 10^{-3}}$$

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- And we can extract the mixing angle:

$$\boldsymbol{\varphi_P = \left(40^{+1.7}_{-1.5}\right)^{\circ} \longrightarrow \theta_P = \left(-14.7^{+1.7}_{-1.5}\right)^{\circ}}$$

KLOE Collaboration, hep-ex/0107022

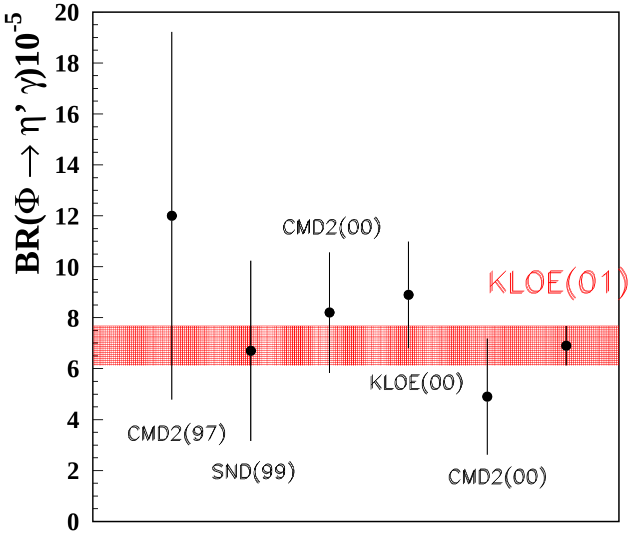
Detection of $\phi \to \eta'(958)\gamma, \eta(547)\gamma$ @ KLOE: Results (II)

- Moreover, using the value of $\phi \to \eta\gamma$ of PDG (2000) we extract the most precise determination of $BR(\phi \to \eta'\gamma)$ to date:

$$\boldsymbol{BR(\phi \to \eta'\gamma) = (6.8 \pm 0.6_{\rm stat} \pm 0.5_{\rm syst}) \cdot 10^{-5}}$$

hep-ex 0107022 (KLOE Collaboration)

which, together with the value of the mixing angle, disfavours a large gluonium content of η'.



Conclusions (I)

KLOE has analysed 16.6 pb^{-1} (out of ~ 80 pb^{-1} collected) corresponding to 50 millions of ϕ mesons.

The scalar sector:

– The absolute values of the two BR's:

$$\boldsymbol{BR(\phi \rightarrow f_0(980)\gamma \rightarrow \pi^0\pi^0\gamma) = (7.9 \pm 0.2_{\mathrm{stat}}) \cdot 10^{-5}}$$
$$\boldsymbol{BR(\phi \rightarrow a_0(980)\gamma \rightarrow \eta\pi^0\gamma) = (5.8 \pm 0.5_{\mathrm{stat}}) \cdot 10^{-5}}$$
systematic error of the order of $\sim 10\%$.

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are at least 1 order of magnitude larger than what expected if they were members of the $q\overline{q}$ nonet and their ratio:

$$\boldsymbol{\frac{BR(\phi\rightarrow f_0\gamma)}{BR(\phi\rightarrow a_0\gamma)} = \frac{3\times(7.9\pm0.2_{\mathrm{stat}})}{5.8\pm0.5_{\mathrm{stat}}} = 4.1 \pm 0.4_{\mathrm{stat}}}$$

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is well in agreement with the hypothesis of a compact $qq\overline{qq}$ core surrounded by a $K\overline{K}$ cloud.

Conclusions (II)

The pseudoscalar sector:

– the $\eta - \eta'$ mixing angle θ_P in the flavor basis has been extracted from the ratio of the two $BR's$. The KLOE measurement is the most accurate to date:

$$\boxed{\boldsymbol{\theta_P = (-14.7^{+1.7}_{-1.5})^\circ}}$$

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– The absolute value of $BR(\phi \to \eta'\gamma)$:

$$\boxed{\boldsymbol{BR(\phi \to \eta'\gamma) = (6.8 \pm 0.6_{\rm stat} \pm 0.5_{\rm syst}) \cdot 10^{-5}}}$$

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together with the value of the mixing angle definitively rules out models with large gluonium content of the η' meson.