Status Report on $\phi \to \eta'\gamma \to \pi^+\pi^- 7\gamma$

Status Report

- The branching ratio measurement is ready
  - R=BR($\phi\rightarrow\eta'\gamma$)/BR($\phi\rightarrow\eta\gamma$);
  - Filfo-EVCL efficiency measured on data;
  - Systematics related to TRK-VTX on the control sample $\phi\rightarrow \pi^+\pi^-\pi^0$;
  - MC'04 studied;
  - Discussion with referee $\Rightarrow$ work in progress.

- Mixing angle evaluation

BR($\phi\to\eta'\gamma$) measurement

BR($\phi\to\eta'\gamma$) with $\pi^+\pi^-7\gamma$:

- crg$\Rightarrow$ $\eta'\to\eta\pi^+\pi^-$ and $\eta\to\pi^0\pi^0\pi^0$
- ntr$\Rightarrow$ $\eta'\to\eta\pi^0\pi^0$ and $\eta\to\pi^+\pi^-\pi^0$

BR($\phi\to\eta'\gamma$) measurement and φ_P evaluation on 2001-2002 data, run 17874-26965;

$\mathcal{L}_{int}$ =427 pb^{-1}

We look at the $\phi\to\eta\gamma$ with $\eta\to\pi^0\pi^0\pi^0$

EVCL-Filfo

Using ~40pb^{-1} selected with a minimum bias procedure and without EVCL and Filfo (see kloe memo 365) we measure $\varepsilon_{\text{EVCL-Filfo}}$ on data and we use the results directly in the ratio R

$$\varepsilon_{FE}^{\eta\gamma} = 97.88\%$$

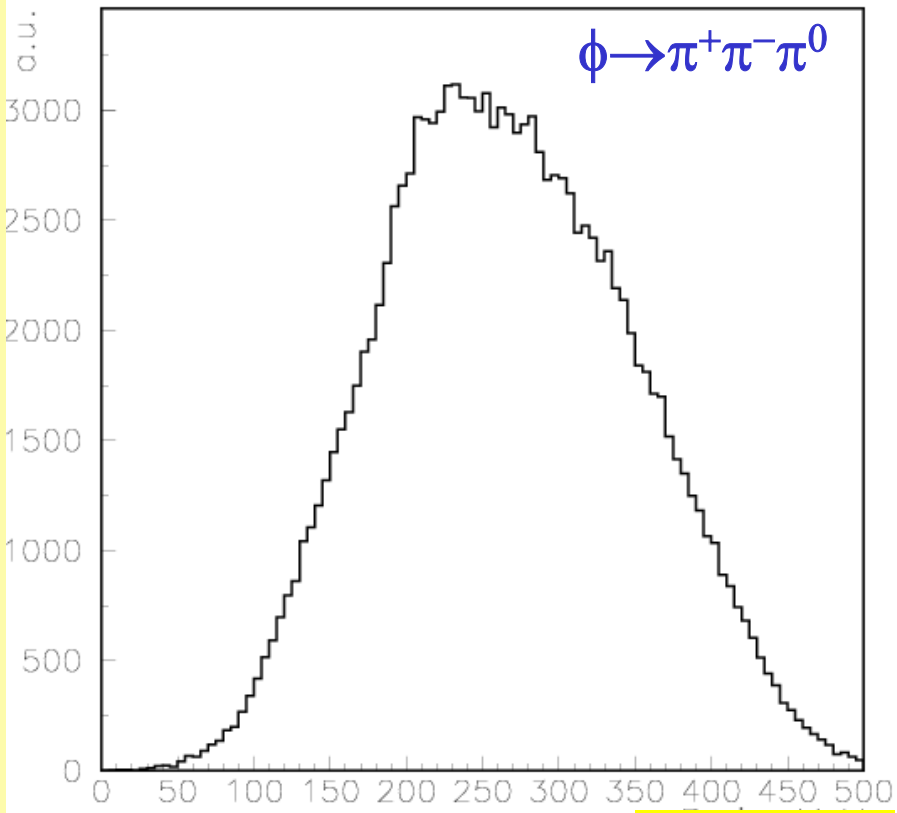
$$\varepsilon_{FE}^{\eta'\gamma} = \frac{\left[BR_{crg}\varepsilon_{crg} + BR_{ntr}\varepsilon_{ntr}\right]}{\left[BR_{crg} + BR_{ntr}\right]} = 96.72\% \qquad (N_{ev} \approx 300)$$

$$\varepsilon = \varepsilon_{MC} \cdot \varepsilon_{FE}$$

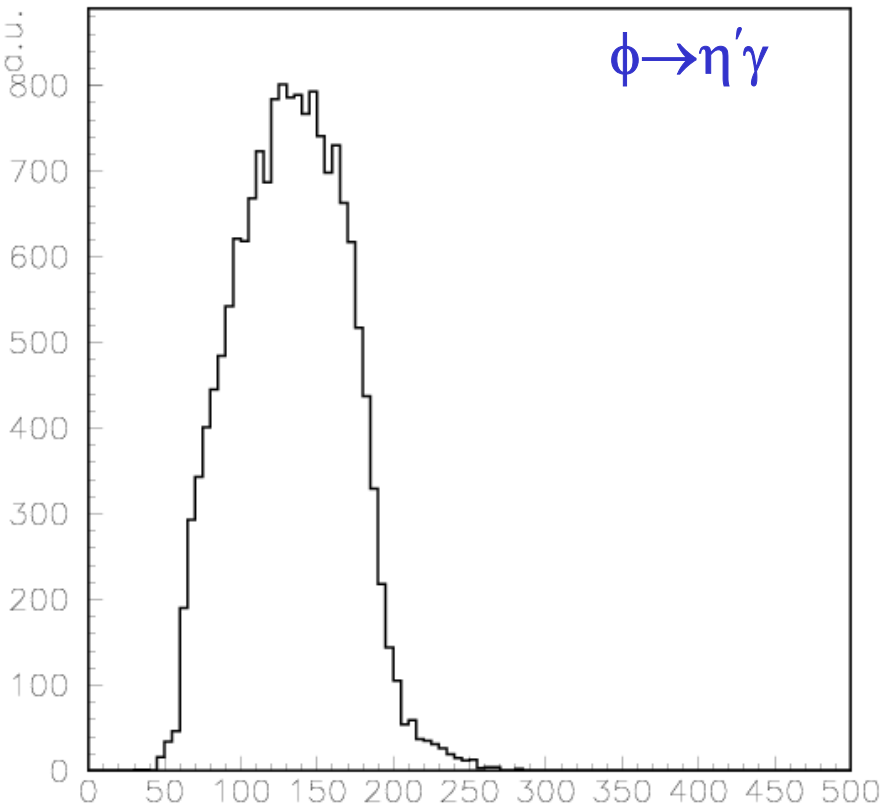
TRK-VTX efficiency

We use $\phi \to \pi^+\pi^-\pi^0$ as control sample for track-vertex efficiency run 21524-22745; $\mathcal{L}_{int}$ =9 pb^{-1}

mc



mc



TRK-VTX efficiency

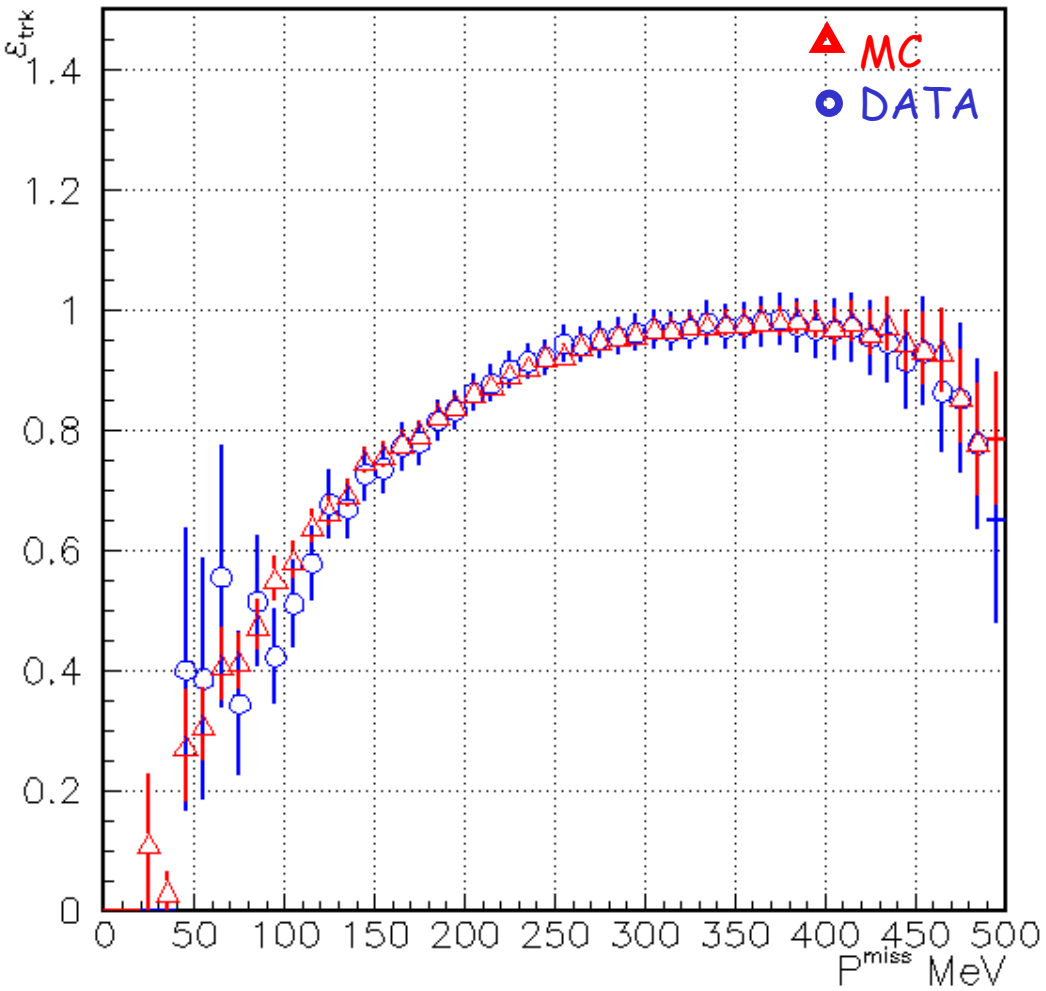
We ask for:

- one track with 200 < P_{trk} < 400 MeV, associated to a cluster in the calorimeter;
- two prompt neutral clusters over 25° with 87 < $M\gamma\gamma$ < 183 MeV

TRK and VTX efficiency as function of missing momentum

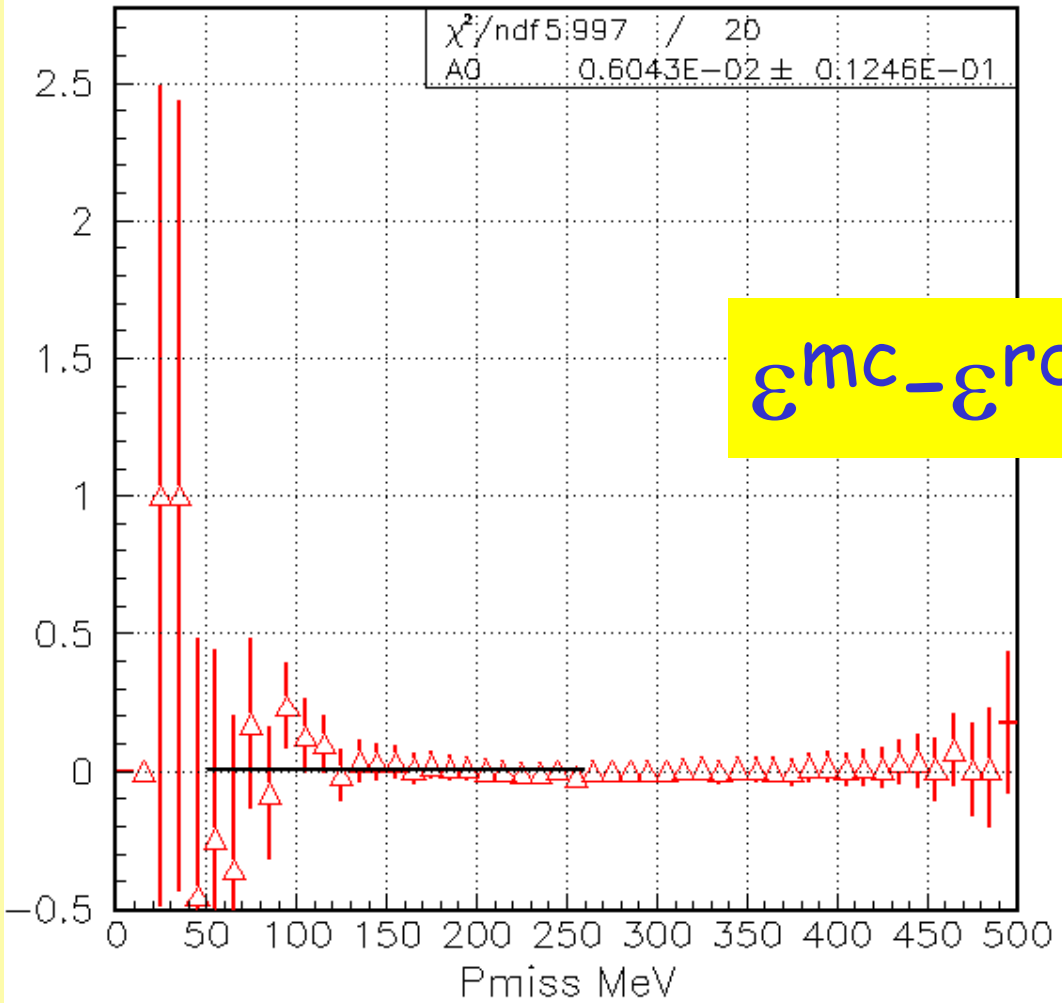
$$\vec{p}_{miss} = \vec{p}_{\phi} - \vec{p}_{trk} - \vec{p}_{\gamma 1} - \vec{p}_{\gamma 2}$$

TRK efficiency



- we look for a track in a cone (20°) around the direction of missing momentum

TRK efficiency

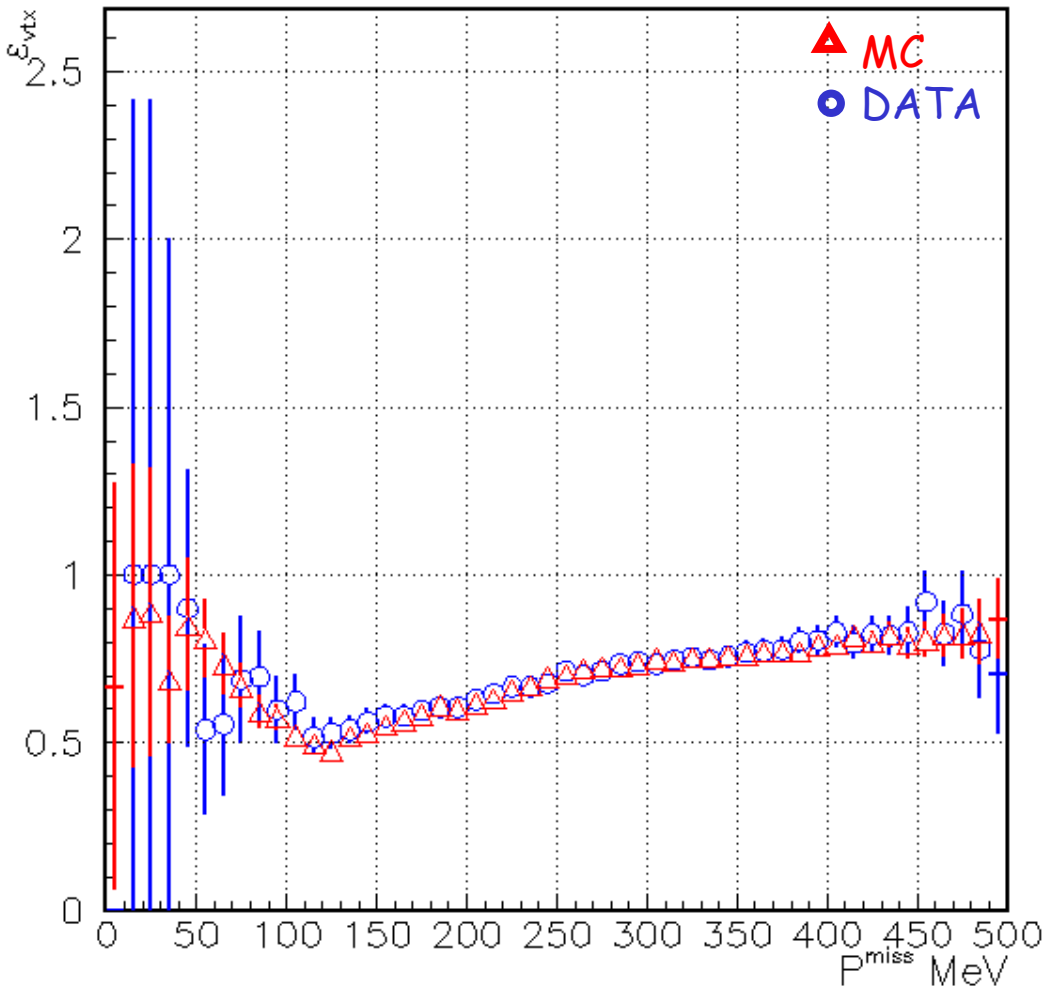


A0=0.6±1.3%
(50:250)MeV

$\varepsilon^{mc}-\varepsilon^{rd}/\ \varepsilon^{mc} \Rightarrow 1.3\%$

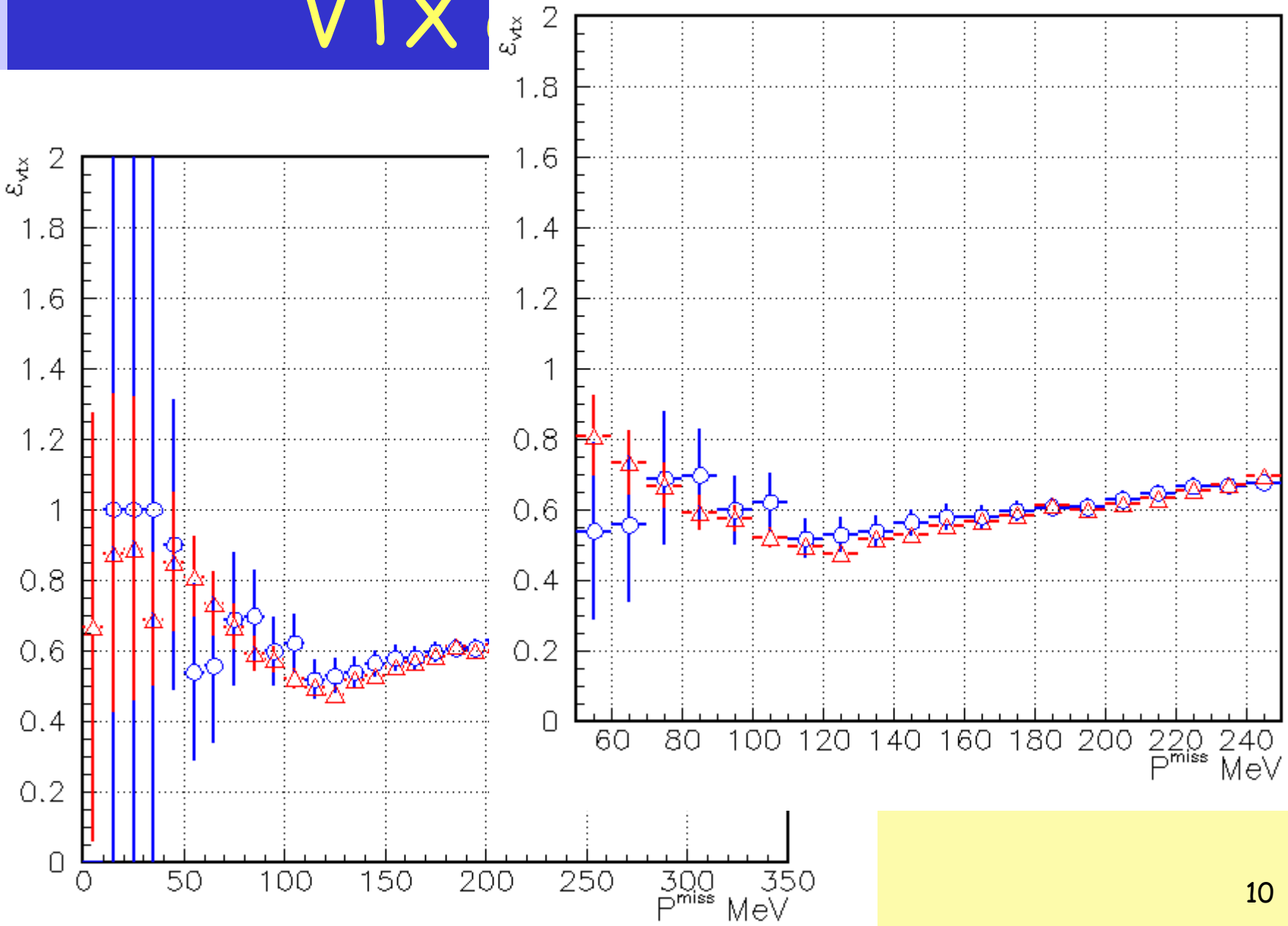
A0=0.5±0.8%
(10:500)MeV

VTX efficiency

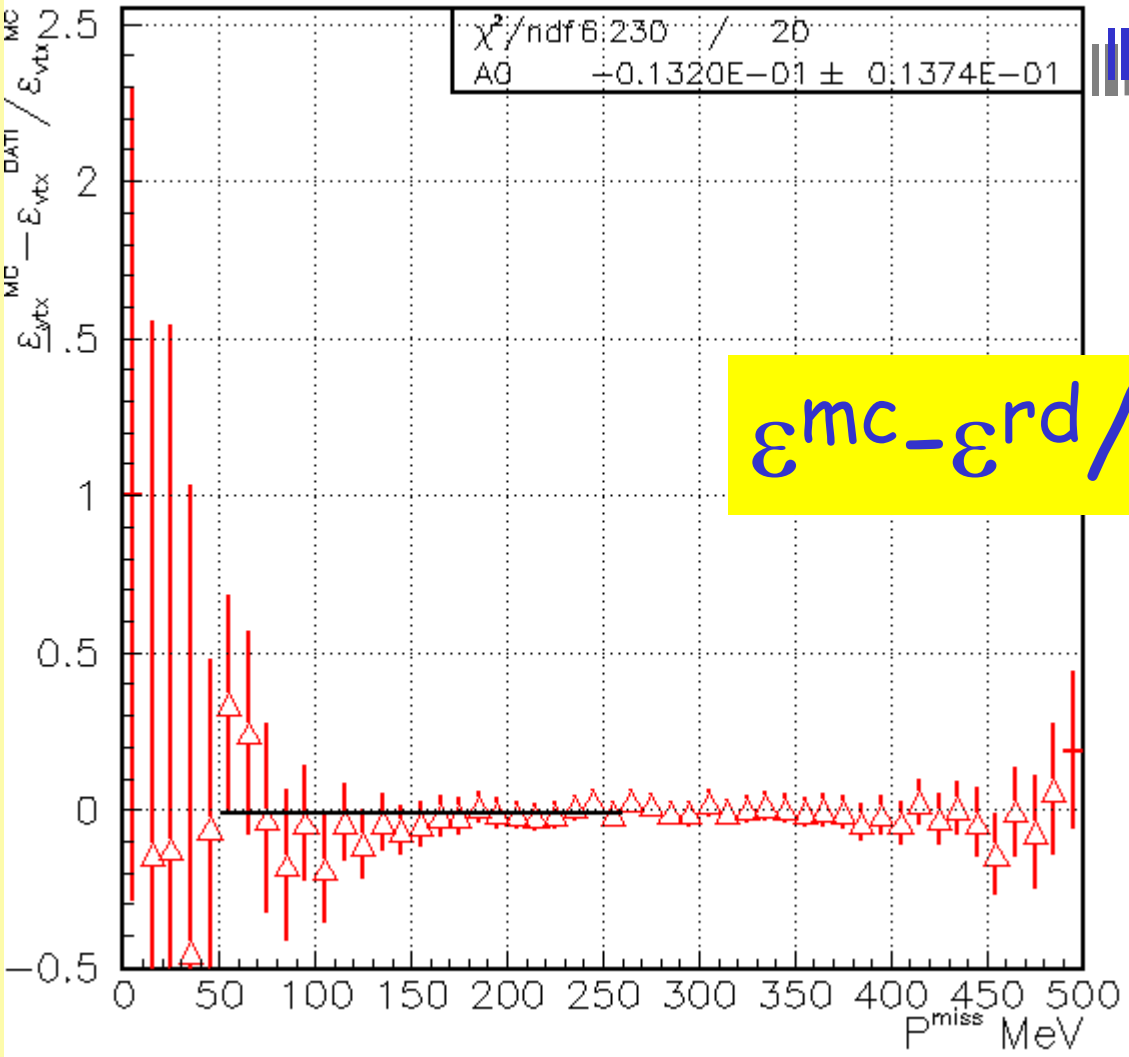


- We look for a vertex connected between the tracks

VTX


ε_{vtx}
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
P^{miss} MeV
ε_{vtx}
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
60
80
100
120
140
160
180
200
220
240
P^{miss} MeV

VTX efficiency



A0=-1.3±1.4%
(50:250)MeV

$\varepsilon^{mc}-\varepsilon^{rd}/\ \varepsilon^{mc} \Rightarrow 1.4\%$

A0=-0.7±0.9%
(10:500)MeV

Accidentals (η')

Signal: we compare MC efficiency with and without *validate cluters procedure,* using dtr_stream_code = 'mrc' AND mc_card_code = 'rad04' and we found difference at the level of 0.5% on the selection efficiency

Validate cluters: we use efficiency table from S. Miscetti to solve the clusters background problem in rad04 (by Paolo Massarotti)

Background (η')

Possible background can be produced by $\phi \rightarrow$ Ks Kl:

1. Ks$\rightarrow \pi^+ \pi^-$; Kl$\rightarrow \pi^0 \pi^0 \pi^0$
2. Ks$\rightarrow \pi^0\pi^0$; Kl$\rightarrow \pi^+ \pi^- \pi^0$
3. Ks$\rightarrow \pi^+ \pi^- \gamma$; Kl$\rightarrow \pi^0 \pi^0 \pi^0$

Background subtraction (η')

We observed $N^{ob.ev.}$= (3750 ± 61) no background subtracted.
From MC study the expected background is

$$N^{bg} = N^{bg1} + N^{bg2} + N^{bg3} = 59+155+131$$

it's at level of 9.2% on $N^{ob.ev.}$; from MC'04 with right machine background simulation, but low statistic, the expected N^{bg} is at level of 8.5% on $N^{ob.ev.}$.
We use the discrepancy as systematics, it's at level of 7.5% on N^{bg}, so N^{bg}=345±28

$$N^{\eta'\gamma} = N^{ob.ev.} - N^{bg} = \mathbf{3405 \pm 61_{stat} \pm 28_{syst}}$$

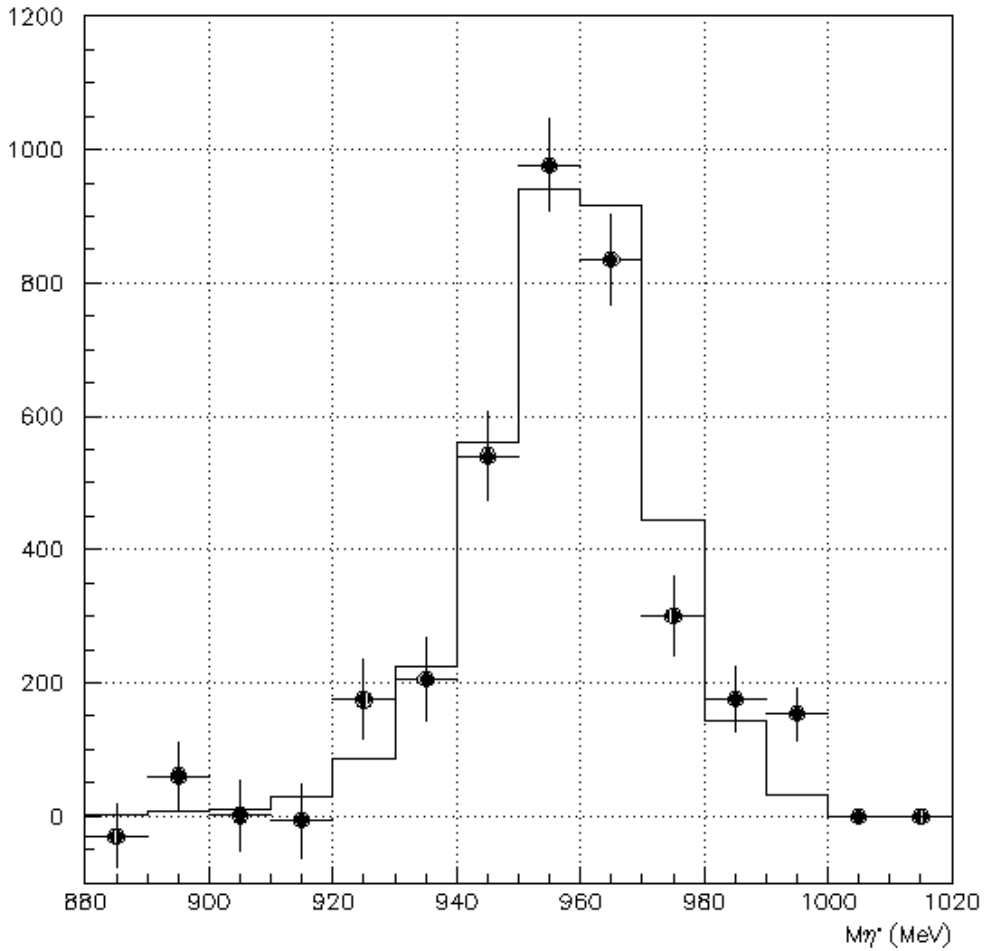
$\phi \rightarrow \eta\gamma$ with $\eta \rightarrow \pi^0\pi^0\pi^0$

We observed $N^{ev.}=(1665000\pm1300)$ ϕ with 7γ, with a selection efficiency of $(28.17\pm0.04\%)$

$\varepsilon_{MC} * \varepsilon_{FE} = 28.78\% * 97.88\%$

From MC study we estimated a background at level of $\sim 1 \cdot 10^{-7}$ $N\phi$ @90% C.L.
(F.Perfetto Degree Thesis)

BR($\phi \to \eta'\gamma$) measurement



$BR(\phi \to$

$BR(\phi \to$ %

$BR(\phi \to$ $.28_{sys}$)%

Conclusions (I)

- We look at the full 2001-2002 KLOE statistic;
- EVCL-Filfo systematics using 10% of the analysed data;
- MC'04 systematics on background subtraction;
- VTX -TRK efficiency with $\phi \rightarrow \pi^+\pi^-\pi^0$
- BR($\phi \rightarrow \eta'\gamma$) measurement completed, using $\phi \rightarrow \eta\gamma$ with $\eta \rightarrow \pi^0\pi^0\pi^0$: we measured the ratio

$$R = BR(\phi \rightarrow \eta'\gamma) / BR(\phi \rightarrow \eta\gamma)$$

Conclusions (II)

We found

- **$BR(\phi \to \eta'\gamma) = (6.16 \pm 0.10_{stat} \pm 0.28_{sys}) \cdot 10^{-5}$**

to be compared with $BR(\phi \to \eta'\gamma) = (6.10 \pm 0.61 \pm 0.43) \cdot 10^{-5}$ measured with $\pi^+\pi^-3\gamma$ (our Phys. Lett. B541 (2002))

- Mixing angle $\varphi_P \sim 40°$

$\phi \rightarrow \eta\gamma$ with $\eta \rightarrow \pi^0\pi^0\pi^0$

We observed $N^{ev.}=(1665000\pm1300)$ ϕ with 7γ

Nexp/Nob = 0.92 (Dreucci & ……)
Nexp/Nob = 1.02 (Simona & Stefano)

Motivations

Value of $\eta-\eta'$ mixing angle:

- one of the most interesting SU(3)-breaking hadronic parameters since SU(3) symmetry was proposed; Bramon, Escribano, Scadron (Eur.Phys. J., C7, 271-278(1999))
- $R_\phi = BR(\phi\to\eta'\gamma)/BR(\phi\to\eta\gamma) \Rightarrow$

$$R_\phi = \cot^2\varphi_P\left(1-\frac{m_s}{\overline{m}}\cdot\frac{\tan\varphi_V}{\sin 2\varphi_P}\right)^2\cdot\left(\frac{p_{\eta'}}{p_\eta}\right)^3$$

$BR(\phi\to\eta'\gamma) = (6.10\pm0.61\pm0.43)\cdot10^{-5}$ measured with $\pi^+\pi^-$ 3γ (our Phys. Lett. B541 (2002))

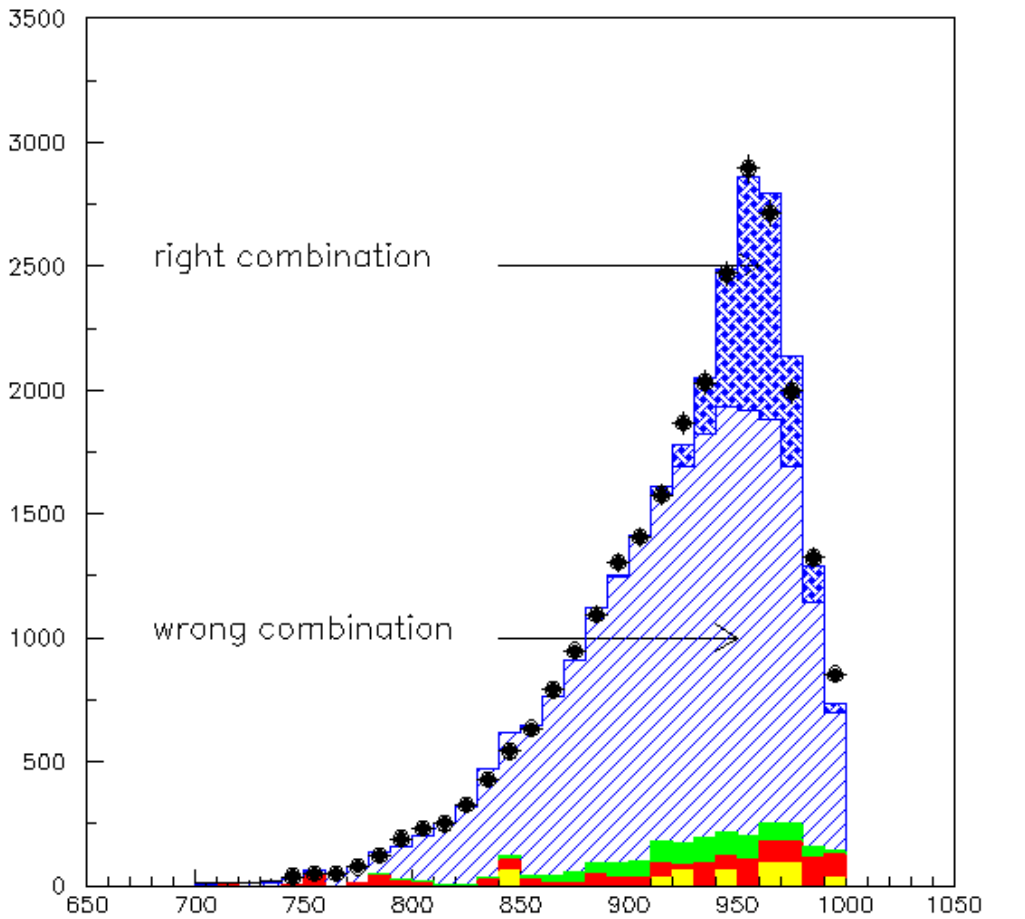
2001- 2002: $\mathcal{L}_{int}$ =427 pb^{-1}

We observed $N^{ev.}$=(1665000±1300) ϕ with 7γ, with a selection efficiency of (28.57±0.04%)

From MC study we estimated a background at level of ~1•10^{-7} Nϕ @90% C.L. (F.Perfetto Degree Thesis)

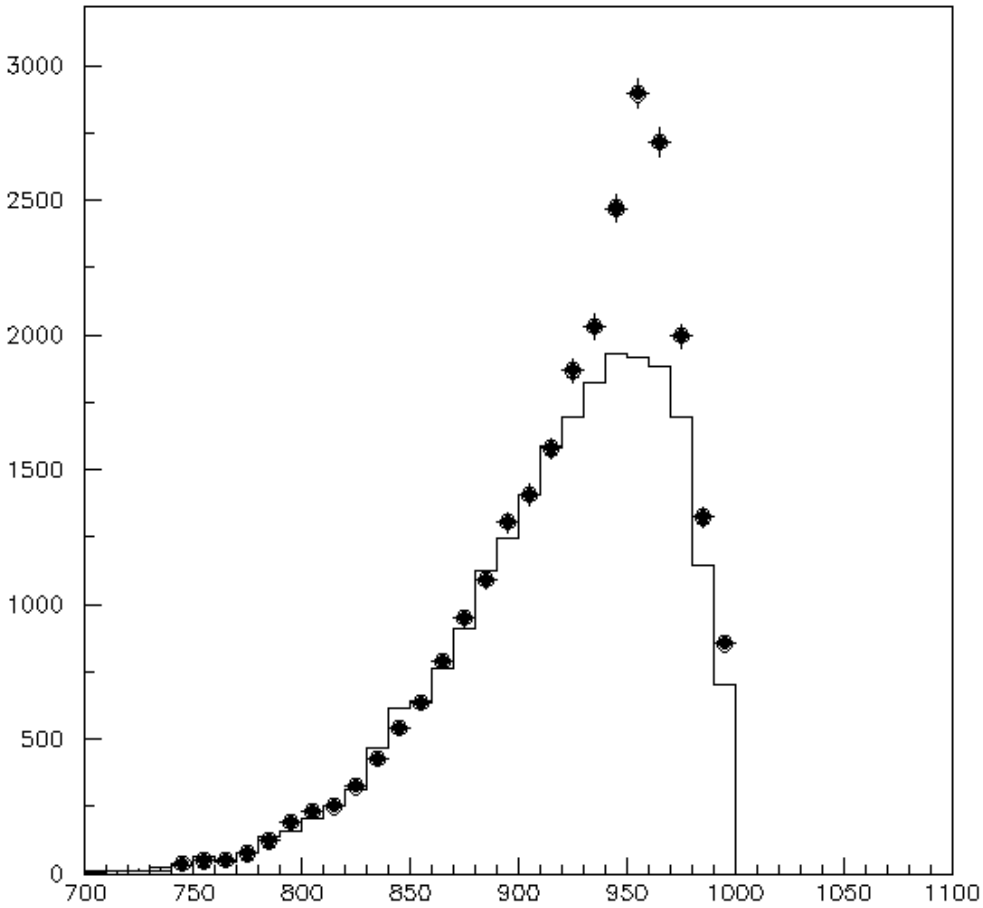
The η′ invariant mass $M_{\eta'}$

- $K_S \rightarrow \pi^+ \pi^-$ $K_L \rightarrow \pi^0 \pi^0 \pi^0$
- $K_S \rightarrow \pi^0 \pi^0$ $K_L \rightarrow \pi^+ \pi^- \pi^0$
- $K_S \rightarrow \pi^+ \pi^- \gamma$ $K_L \rightarrow \pi^0 \pi^0 \pi^0$
- Signal



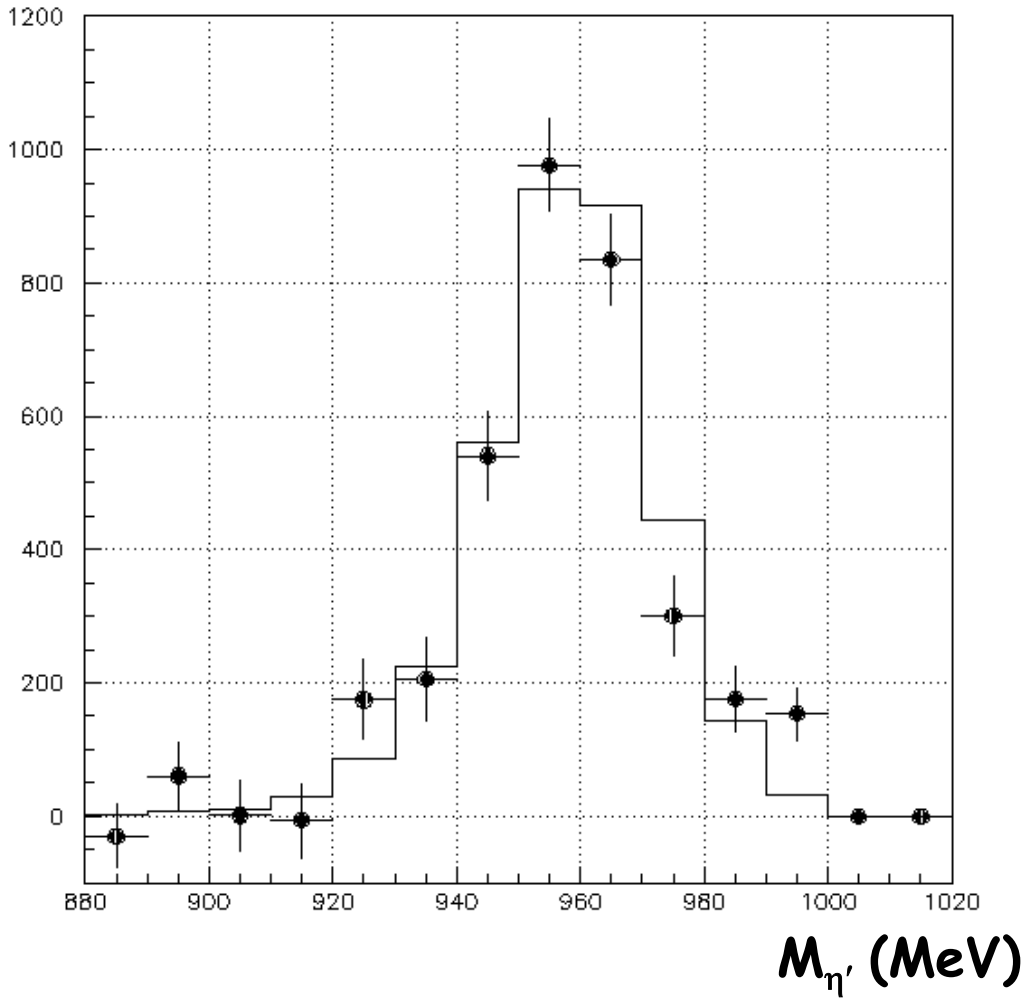
We don't try to resolve the combinatorial but we take all seven combinations

The η' invariant mass $M_{\eta'}$



We subtract the physical bg + combinatorial bg from the data (dots)

The η′ invariant mass $M_{\eta'}$



We have data-MC comparison for η′ invariant mass;
dots are data and histo is mc η′ invariant mass for right combination from kine info

BR($\phi \to \eta'\gamma$) measurement

Update the old analysis

- Analysed 427pb^{-1} from 2001-2002 data collection
- time window = min($5\sigma_t$,2ns)
- EMC-MC threshold
- accidentals in DC
- input kin.fit: pull
- cut on $\cos\theta_{\pi\pi}$<-0.9 and on $E_{\pi^+\pi^-}$ removed
- Analysis of background $\cos\theta_{\pi\pi} \sim 1$ with didone
- Systematic error evaluation almost completed
- Invariant η' mass shape from data-bg subtraction
- On the same sample: we look at $\phi \to \eta\gamma$ with 7γ final state ($\eta \to 3\pi^0$ and each $\pi^0 \to \gamma\gamma$)

Results

$$BR(\phi \to \eta'\gamma) = \frac{N^{\eta'\gamma}}{N_\phi \left[BR_{crg}\,\varepsilon_{crg} + BR_{ntr}\,\varepsilon_{ntr} \right]} \cdot K_\rho$$

- $N^{\eta'\gamma}$ = 3405±61±31 (±31 from bg-sub)
- $N^{\phi} = \mathcal{L}_{int} \cdot \sigma_{(e+e-\to\phi)}$ ⇒ 2%
  - $\mathcal{L}_{int}$ = 427 pb^{-1} (with VLAB) ⇒ 0.5%
  - $\sigma_{(e+e-\to\phi)}$=(3.25±0.07)μb (preliminary extimation)
- $\left[BR_{crg}\,\varepsilon_{crg} + BR_{ntr}\,\varepsilon_{ntr} \right]$ ⇒4% (due to BR" from PDG'02)
- Δ(N/ε)/(N/ε) ⇒1.5%
- Filfo-Evcl ⇒2%

$BR(\phi\to\eta'\gamma) = (6.36 \pm 0.11_{stat} \pm 0.34_{stat}) \cdot 10^{-5}$

BR($\phi \to \eta'\gamma$) measurement

News: Systematic error evaluation

- EVCL-Filfo efficiency measured on data
- efficiency on a control sample: $\phi \to \pi^+ \pi^- \pi^0$
  - -TRK $(\varepsilon_{MC} - \varepsilon_{DATA})/\varepsilon_{MC} = 1.3\%$
  - -VTX $(\varepsilon_{MC} - \varepsilon_{DATA})/\varepsilon_{MC} = 1.4\%$
- Background subtraction $\Rightarrow$ at level of 1%