results on light mesons

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(on behalf of the KLOE collaboration)
Talk outline

- **DAφNE and KLOE**
- **Scalar Mesons:**
  - $\phi \rightarrow a_0(980)\gamma \rightarrow \eta \pi^0 \gamma$
  - Search for $\phi \rightarrow K^0\bar{K}^0 \gamma$
- **Pseudoscalar mesons:**
  - $\eta \rightarrow \pi^+\pi^- e^+ e^-$: Branching ratio and decay plane asymmetry
  - $\eta - \eta'$ pseudoscalar mixing angle and $\eta'$ gluonium content
- **KLOE-2: $\gamma\gamma$ physics outlook**
- **Conclusions**
Physics at a $\phi$ – factory:
 a window on the lowest mass mesons

$\phi$ decays give access to light mesons (scalar, pseudoscalar, vector)
These processes allow us to study the structure of these mesons, in particular their s-quark content via couplings with $\phi(\bar{s}s)$ and Kaons

<table>
<thead>
<tr>
<th>Main decay channels</th>
<th>Branching fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\to K^+K^-$</td>
<td>49.2 %</td>
</tr>
<tr>
<td>$\to K_SK_L$</td>
<td>34.0 %</td>
</tr>
<tr>
<td>$\to \rho\pi + \pi^+\pi^-\pi^0$</td>
<td>15.3 %</td>
</tr>
<tr>
<td>$\to \eta\gamma$</td>
<td>1.301 %</td>
</tr>
<tr>
<td>$\to \pi^0\gamma$</td>
<td>0.125 %</td>
</tr>
<tr>
<td>$\to \eta'\gamma$</td>
<td>$6.2 \times 10^{-5}$</td>
</tr>
<tr>
<td>$\to \pi^0\pi^0\gamma$</td>
<td>$\sim 10^{-4}$</td>
</tr>
<tr>
<td>$\to \eta\pi^0\gamma$</td>
<td>$7\div8 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

+ “radiative return” to $\pi^+\pi^-$

$\phi(1020)$

$\eta'(960)$

$\eta(980)$

$\eta(980)'$

$\pi^0$

$\rho(770)$

$\alpha_0(980)$

$\eta(980)'$

$\phi(1020)$

$\eta(960)$

$\rho(770)$

$\pi^0$

$\gamma$

#events in KLOE data = Br.F. $\times 8 \times 10^9$ $\Rightarrow \sim 10^8 \eta; \sim 10^5 \eta', \pi\pi, \eta\pi$
The DAΦNE e⁺e⁻ Φ-factory

ϕ-factory: an e⁺e⁻ collider with center of mass energy $\sqrt{s}=m(\phi)=1019.4\text{MeV}$

- $\sigma(e^+e^- \rightarrow \phi) \sim 3\, \mu\text{b}$
- Separate e⁺e⁻ rings to reduce beam-beam interactions
- Crossing angle: 25 mrad
- Bunch crossing every 2.7 ns
- Injection during acquisition

$\int L\, dt = 2.4\, \text{fb}^{-1} + 0.3\, \text{fb}^{-1}$ off-peak

$L_{\text{peak}}=1.5 \times 10^{32}\, \text{cm}^{-2}\text{s}^{-1}$
The KLOE detector

Drift chamber (4 m ∅ × 3.3 m, CF frame)
- Gas mixture: 90% He + 10% iso-C₄H₁₀
- 12582 stereo sense wires
- almost squared cells

Calorimeter
- lead/scintillating fibers (1 mm ∅), 15 X₀
- 4880 PMT’s
- 98% solid angle coverage

\[
\begin{align*}
\sigma_{p/p} &= 0.4 \% \text{ (tracks with } \theta > 45^\circ) \\
\sigma_{x_{hit}} &= 150 \mu m \ (xy), \ 2 \ mm \ (z) \\
\sigma_{x_{vertex}} &\sim 1 \ mm \\
\sigma(M_{\pi\pi}) &\sim 1 \ MeV \\
\sigma_{E/E} &= 5.7\% /\sqrt{E(GeV)} \\
\sigma_t &= 54 \ ps /\sqrt{E(GeV)} \oplus 140 \ ps \\
\sigma_{vtx(\gamma\gamma)} &\sim 1.5 \ cm \ (neutral \ vertex \ resolution)
\end{align*}
\]
Scalar mesons
$e^+e^- \rightarrow \eta \pi^0 \gamma :$ search for $a_0(980)$

1) $\eta \rightarrow \gamma \gamma$:

$$\text{Br}(\phi \rightarrow \eta \pi^0 \gamma) = (7.01 \pm 0.10_{\text{stat}} \pm 0.20_{\text{syst}}) \times 10^{-5}$$

![Graph showing data and fit to $M_{\eta\pi}$ spectra from 1) & 2)](image)

Combined fit to $M_{\eta\pi}$ spectra from 1) & 2)

✓ Good consistency between the two samples: expected $R_{\eta} = 1.73 \pm 0.04$ [PDG]

2) $\eta \rightarrow \pi^+ \pi^- \pi^0$:

$$\text{Br}(\phi \rightarrow \eta \pi^0 \gamma) = (7.12 \pm 0.13_{\text{stat}} \pm 0.22_{\text{syst}}) \times 10^{-5}$$

![Graph showing data and fit to $M_{\eta\pi}$ spectra from 1) & 2)](image)

Parameter | Kaon-Loop | No structure
--- | --- | ---
$M_{a_0}(\text{MeV})$ | $982.5 \pm 1.6 \pm 1.1$ | $982.5$ (fixed)
$g_{a_0KK}(\text{GeV})$ | $2.15 \pm 0.06 \pm 0.06$ | $2.01 \pm 0.07 \pm 0.28$
$g_{a_0\pi\pi}(\text{GeV})$ | $2.82 \pm 0.03 \pm 0.04$ | $2.46 \pm 0.08 \pm 0.11$
$R_{\eta} = \frac{\text{BR}(\eta \rightarrow \gamma \gamma)}{\text{BR}(\eta \rightarrow \pi^+ \pi^- \pi^0)}$ | $1.70 \pm 0.04 \pm 0.03$ | $1.70 \pm 0.03 \pm 0.01$

Salvatore Fiore

QCD09 - September 24th 2009 – Beijing
New theory for scalar mesons: $S(4q) \rightarrow PP$ decays

\[ \mathcal{L}_{\text{dec}} (S) = c_f O_f (S) + c_I O_I (S) \]

Couplings: $f_0(980)$ vs $a_0(980)$

Inputs from KLOE: $g_{f0KK}$, $g_{f0\pi\pi}$ + masses + $\varphi_P \Rightarrow$ output $g_{a0KK}$, $g_{a0\eta\pi}$

\[ \begin{array}{|c|c|c|c|c|c|} \hline \text{Processes} & A_{2a}(qq) [\text{fit}] & A_{12}(q\bar{q}) & \text{instant} \\ \hline \text{with inst.} & \text{no inst.} & \text{best fit} & \text{with inst.} & \text{no inst.} & \text{best fit} \\ \hline \sigma \rightarrow \pi^+ \pi^- & 7.3 & 7.7 & 5.2 & 5.2 & 3.2 \pm 0.4 \\ \kappa^+ \rightarrow K^+ \pi^+ & 7.3 & 7.7 & 3.3 & 6.0 & 5.5 \\ \kappa^- \rightarrow K^- \pi^- & [0-1.8] & 1.6 & [0-1.8] & 1.4 \pm 0.6 \\ \eta \rightarrow \pi^+ \pi^- & 6.7 & 6.1 & 2.1 & 12.4 & 11.6 & 2.8 \pm 0.1 \\ \eta \rightarrow K^+ K^- & 4.9 & 5.2 & 2.3 & 4.1 & 3.7 & 2.16 \pm 0.04 \\ \hline \end{array} \]

\[ g_{f0KK} (\text{GeV}) = 3.97 - 4.74 \]
\[ g_{f0\pi\pi} (\text{GeV}) = -1.82 - 2.23 \]

\[ [qq] [qbarqbar] \]
\[ c_i = ( -2.8 - 3.4 ) \text{ GeV}^{-1} \]
\[ c_f = ( 20.5 - 24.5 ) \text{ GeV}^{-1} \]

\[ [g_{a0KK}, g_{a0\eta\pi}] \]
\[ \varphi_P \]

\[ q\bar{q} \]
\[ c_i = ( -3.9 - 4.8 ) \text{ GeV}^{-1} \]
\[ c_f = ( 16.5 - 19.7 ) \text{ GeV}^{-1} \]

\[ g_{a0KK} (\text{GeV}) = 2.15 \]
\[ g_{a0\eta\pi} (\text{GeV}) = 2.82 \]

\[ \downarrow \]
\[ 2.1 - 2.5 \]
\[ 3.3 - 3.9 \]

\[ \downarrow \]
\[ 2.4 - 2.9 \]
\[ 6.6 - 7.9 \]
Search for $\phi \rightarrow K^0\overline{K}^0\gamma$

- $K^0\overline{K}^0$ final state is a $J^{PC} = 0^{++}$ symmetric quantum state, coming from $f_0(980)$ and $a_0(980)$ scalar mesons decays.

- Possible final states will be $K_SK_S$ or $K_LK_L$:
  - Invariant mass $\in [995,1020]$ MeV ($2m(K_0)\rightarrow m(\phi)$)

predicted but no experimental measure exists

\[ \int L dt = 2.18fb^{-1} \text{ at } \phi \text{ peak} \]

**Signal MC**: modified Phokhara5


With $N_{obs}=5$ observed events and $N_{bkg}=3.2\pm0.7$ expected background events,

$B.R.(\phi \rightarrow K^0\overline{K}^0\gamma) < 1.9 \cdot 10^{-8}$ at 90% C.L.


Comparison with theoretical estimates

1. S.Fajfer, R.J.Oakes (Low-E effective Lag.)
2. A.Bramon, A.Grau, G.Pancheri (no explicit S)
3. J.A.Oller (UχPT)
4. J.A.Oller (UχPT)
5. R.Escribano (S and P mesons Ab Initio)
6. S.Nussinov, T.N.Truong,
7. N.N.Achasov, V.N.Ivanchenko (Kaon Loop)
8. J.Lucio, J.Pestieau (f0 only)
   Phys.Rev.D42 (1990) 3253
9. N.N.Achasov, V.V.Gubin (SND data K-Loop)
   Phys.Rev.D64, 094016 (2001)
Comparison with theoretical estimates

Consistency with KLOE measurements

Using $g_{f_0\pi\pi}$, $g_{a_0\eta\pi}$ couplings as measured with $f_0$, $a_0$ KLOE analyses and inserting these couplings in the Kaon-Loop model it is possible to check consistency of different KLOE measurements done in the scalar meson sector.

The obtained range is consistent with our Upper Limit.
Pseudoscalar mesons
$\eta \rightarrow \pi^+\pi^- e^+ e^-$ \textit{branching ratio}

- $\eta$ decay into $\pi\pi ee$ predicted with a branching ratio of $26\div36 \times 10^{-5}$
- At KLOE $\eta$ mesons produced by radiative decay $\phi \rightarrow \eta\gamma$, monochromatic photon of 363 MeV: 1.7 fb$^{-1}$ of $\phi$-decays data $\rightarrow 7 \times 10^7 \eta$'s, 0.24 fb$^{-1}$ off the $\phi$ peak (background evaluation), 50 fb$^{-1}$ of signal MC
  - FSR included by PHOTOS MC
  - 4-track events, mass assignment through $\pi$ decay ID or TOF, kinematic fit
  - Background:
    - $\phi$-decays ($\pi^+\pi^-\pi^0$ or $\eta\gamma$, $\eta \rightarrow \pi^+\pi^-\pi^0$, $\pi^+\pi^-\gamma$)
    - continuum (radiative Bhabha + conversion)
  - Background rejection through kinematic costraints, and then fitting the background components out of the signal region
\[ \eta \rightarrow \pi^+\pi^-e^+e^- \] branching ratio

- \( \eta \) decay into \( \pi\pi ee \) predicted with a branching ratio of \( 26 \div 36 \times 10^{-5} \)

- At KLOE, \( \eta \) mesons produced by radiative decay \( \phi \rightarrow \eta \gamma \), monochromatic photon of 363 MeV: 1.7 fb\(^{-1}\) of \( \phi \)-decays data \( \rightarrow 7 \times 10^7 \) \( \eta \)'s, 0.24 fb\(^{-1}\) off the \( \phi \) peak (background evaluation), 50 fb\(^{-1}\) of signal MC

- FSR included by PHOTOS MC
- 4-track events, mass assignment through \( \pi \) decay ID or TOF, kinematic fit
- Background:
  - \( \phi \)-decays (\( \pi^+\pi^-\pi^0 \) or \( \eta \gamma \), \( \eta \rightarrow \pi^+\pi^-\pi^0 \), \( \pi^+\pi^-\gamma \))
  - continuum (radiative Bhabha + conversion)
- Background rejection through kinematic constraints, and then fitting the background components out of the signal region

\[ \text{BR}(\eta \rightarrow \pi^+\pi^-e^+e^-(\gamma)) = (26.8 \pm 0.9_{\text{stat}} \pm 0.7_{\text{syst}}) \times 10^{-5} \]

Phys.Lett.B 675 (2009), 283
A possible CP violating mechanism has been proposed, which could induce interference between electric and magnetic decay amplitudes.

- this would result in an observable asymmetry in the angle between the planes containing the pions and the electrons, of the order of $10^{-2}$

$$A_\phi = \frac{N_{\sin\phi\cos\phi>0} - N_{\sin\phi\cos\phi<0}}{N_{\sin\phi\cos\phi>0} + N_{\sin\phi\cos\phi<0}}$$

- the asymmetry has been evaluated on the final event sample to be $A_\phi = -(0.6\pm2.5\pm1.8) \times 10^{-2}$

  *phys.Lett.B 675 (2009), 283*

  **first measurement of $A_\phi$**

- also checked with a control sample
The $\eta'$ meson can probe the $s\bar{s}$ and gluonium content of $\eta'$.

The ratio $R = \frac{BR(\phi \to \eta'\gamma)}{BR(\phi \to \eta\gamma)}$ can be related to the $\eta$-$\eta'$ mixing parameters and determine the mixing angle in the flavor basis $\varphi_p$, the best parameter for a description of the mixing.

Using the approach by Bramon et al. [Eur. Phys. J. C7, 271(1999)] and introducing a possible gluonium content via $\cos^2 \varphi_G$, KLOE extracts the $\eta$-$\eta'$ mixing angle $\varphi_p$ by measuring the quantity:

$$R_\phi = \frac{BR(\phi \to \eta'\gamma)}{BR(\phi \to \eta\gamma)} = \cot^2 \varphi_p \cdot \cos^2 \varphi_G \left( 1 - \frac{m_s}{m} \cdot \frac{Z_q}{Z_s} \cdot \tan \psi_V \right)^2 \cdot \left( \frac{p_{\eta'}}{p_{\eta}} \right)^3$$


$$(4.77 \pm 0.09_{\text{stat}} \pm 0.19_{\text{syst}}) \times 10^{-3}$$

using similar $\eta$ and $\eta'$ decay chains:

$\phi \rightarrow \eta'\gamma$, $\eta' \rightarrow \pi^0 \pi^0 \eta$, $\eta \rightarrow \pi^+ \pi^- \pi^0$

$\eta' \rightarrow \pi^+ \pi^- \eta$, $\eta \rightarrow \pi^0 \pi^+ \pi^- \pi^0$

$\phi \rightarrow \eta\gamma$, $\eta \rightarrow \pi^0 \pi^+ \pi^- \pi^0$

The $\eta$-$\eta'$ mesons wave function can be decomposed in the quark mixing base


$\eta' = X_{\eta'} \frac{1}{\sqrt{2}} \left| u\bar{u} + d\bar{d} \right| + Y_{\eta'} \left| s\bar{s} \right| + Z_{\eta'} \left| \text{glue} \right|$
New global fit with more free parameters: $Z_q$, $Z_s$, $\psi_V$, $m_s/m$, plus from PDG06:

\[
\begin{array}{c|ccc}
\frac{\Gamma(\omega \to \eta')}{\Gamma(\omega \to \pi^0\gamma)} & \frac{\Gamma(\phi \to \pi^0\gamma)}{\Gamma(\omega \to \pi^0\gamma)} & \frac{\Gamma(\phi \to \pi^0\gamma)}{\Gamma(\omega \to \pi^0\gamma)} & \frac{\Gamma(K^+ \to K^+\gamma)}{\Gamma(K^- \to K^0\gamma)} \\
\hline
\Gamma(\omega \to \eta') & \Gamma(\phi \to \pi^0\gamma) & \Gamma(\phi \to \pi^0\gamma) & \Gamma(K^+ \to K^+\gamma) \\
\end{array}
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>KLOE old fit</th>
<th>KLOE new fit</th>
<th>PDG08+ωπ⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_{\eta'}^2$</td>
<td>0.14±0.04</td>
<td>0.105±0.037</td>
<td>0.115±0.036</td>
</tr>
<tr>
<td>$\varphi_P$</td>
<td>(39.7±0.7)°</td>
<td>(40.7±0.7)°</td>
<td>(40.4±0.6)°</td>
</tr>
<tr>
<td>$Z_q$</td>
<td>0.91±0.05</td>
<td>0.866±0.025</td>
<td>0.936±0.025</td>
</tr>
<tr>
<td>$Z_s$</td>
<td>0.89±0.07</td>
<td>0.79±0.05</td>
<td>0.83±0.05</td>
</tr>
<tr>
<td>$\psi_V$</td>
<td>3.2°</td>
<td>(3.15±0.10)°</td>
<td>(3.32±0.09)°</td>
</tr>
<tr>
<td>$m_s/m$</td>
<td>1.24±0.07</td>
<td>1.24±0.07</td>
<td>1.24±0.07</td>
</tr>
<tr>
<td>$P(\chi^2)$</td>
<td>49%</td>
<td>17%</td>
<td>20%</td>
</tr>
</tbody>
</table>

We also fit PDG08 data, using KLOE measurement for $\phi \to \omega\pi^0$, and the relation:

\[
\frac{\Gamma(\eta' \to \gamma\gamma)}{\Gamma(\pi^0 \to \gamma\gamma)} = \frac{1}{9} \left( \frac{m_{\eta'}}{m_{\pi}} \right)^3 \left( \frac{f_\pi}{f_{\eta'}} \right)^2 \left( \frac{X_{\eta'}}{\sqrt{2} F_{\eta'}} \right)^2 \quad f_q/f_\pi \text{ from lattice QCD (UKQCD)}
\]

E. Kou, PRD63(2001)54027

**Gluonium content confirmed at 3σ (if $Z_{\eta'}=0$, $\varphi_P=(41.65\pm0.5)°$, $P(\chi^2)=1%$)**

$Z_G$ can be interpreted as a mixing with a glueball with $m_G = (1.41 \pm 0.1)$ GeV ($\eta(1405)$) determined using KLOE fit results [Hai-Yang Cheng, Phys. Rev. D79 (2009) 014024]
More to come:

- measurement of 
  \[ \frac{\Gamma(\eta \to \pi^+ \pi^- \gamma)}{\Gamma(\eta \to \pi^+ \pi^- \pi^0)} \]

- Data sample of $6 \times 10^5$ events in $1.18$ fb$^{-1}$ after selection

- preliminary result: 
  \[ \frac{\Gamma(\eta \to \pi^+ \pi^- \gamma)}{\Gamma(\eta \to \pi^+ \pi^- \pi^0)} = 0.2014 \pm 0.0004 \pm 0.0063 \]
  (PDG: 0.202 $\pm$ 0.007)

- $\eta \to e^+ e^- e^+ e^-$: process never observed.
  - CMD-2 gives an upper limit:
    \[ \text{BR}(\eta \to e^+ e^- e^+ e^-) < 6.9 \times 10^{-5} \]
  - theoretical predictions are
    \[ \text{BR}(\eta \to e^+ e^- e^+ e^-) = 2.52 - 2.64 \times 10^{-5} \]

KLOE: 413 $\pm$ 31 events in data sample: first evidence
The near future: KLOE-2

- KLOE will restart taking data at the beginning of 2010 on the DAFNE collider, on the \( \phi \) peak.
- Expected integrated luminosity for 2010 is 5fb\(^{-1}\)
- The detector is being upgraded for \( \gamma \gamma \) physics measurements

\( \gamma \gamma \) physics stands for \( e^+e^- \rightarrow e^+e^- \gamma^* \gamma^* \rightarrow e^+e^- + X \)

This process gives access to \( J^{PC} = 0^{\pm}, 2^{\pm} \) states:
\( \pi\pi \) (\( \sigma \)), \( \eta, \eta', f_0, a_0 \)

In the low-energy region, for \( W_{\gamma\gamma} < 1 \text{GeV} \), present experimental situation is unsatisfactory:
- Small data samples and large backgrounds
  \( \rightarrow \) large stat. and syst. uncertainties
- Small detection efficiencies and particle ID for low-mass hadronic states

2-loop ChPT

\( \gamma \gamma \rightarrow \pi^0\pi^0 \) (σ nb)
**gamma-gamma physics in a Φ-factory**

**TRUE, BUT...**

**γγ** events acquired at the φ peak would suffer from φ decays as background:

<table>
<thead>
<tr>
<th>γγ channel</th>
<th>(L = 10 fb⁻¹)</th>
<th>Missing particle</th>
<th>Events</th>
<th>Background for :</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e^+ e^- \rightarrow e^+ e^- \pi^0$</td>
<td>$4 \times 10^6$</td>
<td>$K_L$</td>
<td>$\pi^0\pi^0$</td>
<td></td>
</tr>
<tr>
<td>$e^+ e^- \rightarrow e^+ e^- \eta$</td>
<td>$1 \times 10^6$</td>
<td>$K_L$</td>
<td>$\eta$</td>
<td></td>
</tr>
<tr>
<td>$e^+ e^- \rightarrow e^+ e^- \pi^+\pi^-$</td>
<td>$2 \times 10^6$</td>
<td>$\pi^0$</td>
<td>$\pi^+\pi^-$</td>
<td></td>
</tr>
<tr>
<td>$e^+ e^- \rightarrow e^+ e^- \pi^0\pi^0$</td>
<td>$2 \times 10^4$</td>
<td>$\gamma$</td>
<td>$\pi^0$</td>
<td></td>
</tr>
</tbody>
</table>

**tagging γγ events by detecting $e^+e^-$ is mandatory to reduce backgrounds, together with $P_T$ kinematical selection on the tagged events.**
The new tagging system in KLOE

**Scattered electrons escape from the KLOE** detector along the DAFNE beam lines. **Magnetic elements will deflect these “off-energy” particles out of vacuum tubes.** Four tagging stations will be added: their task will be to identify $e^+e^- \rightarrow e^+e^- \gamma^*\gamma^*$ events through the detection of off-energy electrons close to the nominal beam trajectories.

Combining all the possible tagging combinations, we can get 500 pb$^{-1}$ of clean $\gamma\gamma$ physics during 2010 data taking.
Conclusions

- $\phi \rightarrow \eta \pi^0 \gamma$ with $5\gamma$ final state and $\pi^+\pi^- + 5\gamma$ final state:
  - New published result for Branching Ratio and couplings; consistency with $4$ quark instantons’ model

- $\phi \rightarrow K^0\bar{K}^0\gamma$:
  - First published result ever for the upper limit on this channel;
  - Comparison with theoretical estimates and consistency with KLOE measurements from scalars

- $\eta \rightarrow \pi^+\pi^- e^+ e^-$:
  - Great improvement of BR accuracy, first measurement of decay plane asymmetry

- $\eta/\eta'$ mixing angle and gluonium content:
  - New improved fit results confirm gluonium content for $\eta'$

- First observation of $\eta \rightarrow e^+ e^- e^+ e^-$, and $\frac{\Gamma(\eta \rightarrow \pi^+\pi^-\gamma)}{\Gamma(\eta \rightarrow \pi^+\pi^-\pi^0)}$ on the way
With 5 fb\(^{-1}\) acquired by KLOE at DAFNE during 2010:

- **Increase of** \(\phi \rightarrow K^0 K^0 \gamma\) statistics, setting UL below \(10^{-8}\) or seeing signal
- **Improvement of** \(\eta'\) gluonium content accuracy (\(\eta'\) BR’s down to 1%)
- **\(\gamma\gamma\)** physics will enrich the KLOE physics program probing new interesting processes and improving \(\Gamma(\eta' \rightarrow \gamma\gamma)\) accuracy

11pb\(^{-1}\) out of 230 available @ \(\sqrt{s}=1\)GeV

Excess of events: hint of \(\sigma\) meson?

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**Outlook**

\(\eta'\) BR’s down to 1%  
+ \(\Gamma(\eta' \rightarrow \gamma\gamma)\) accuracy to 1%

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**Preliminary**

**Salvatore Fiore**  
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