Progress on $F_{\psi}$ with the KLOE experiment (untagged)

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(For the KLOE collaboration)
in 2001, the veto of cosmic events (hardware) caused non-negligible inefficiency in \( p p g \) events and made the measurement of \( m m g \) events not feasible, from 2002 on, this effect is taken out
KLOE: performances for the penguin analysis

Electromagnetic Calorimeter
Pb / Scintillating Fibres
Endcap + Barrel = 98% (4\%)

Drift Chamber
4 m $\varnothing$, 3.3 m length
90% He, 10% i-C$_4$H$_{10}$

$\Delta E/E = 5.4\% / E(\text{GeV})$

$\sigma_t = 56\text{ps} / \sqrt{E(\text{GeV})} + 133\text{ps}$

the whole structure is surrounded by a superconducting coil $B=0.52$ T

$\square_{p/p} = 0.4\% \ (\square > 45^\circ)$
$\square_{r\square} = 150 \text{ mm}, \quad \square_{z} = 2 \text{ mm}$
$\square_{vtx} \sim 3 \text{ mm}, \quad \square_{M\square} \sim 1 \text{ MeV}$
Fiducial volume

\[ e^+ e^- \rightarrow \gamma \rightarrow s + s' \]

- 1 and only 1 vertex (|z| < 7 cm, $\Delta_{X_Y} < 8$ cm) connected to 2 tracks
- each track with $50^o < \theta_{\text{track}} < 130^o$
- small angle $\theta$ ($\theta < 15^o$)

**no photon tagging:** $p_\perp = p_{\text{miss}} = \Box(p_+ + p_-)$

- high statistics for ISR ($\sim \Box^2$)
- low relative FSR contribution
- suppressed $\Box \rightarrow p_+ p_0$ wrt the signal
- the threshold region is not covered

Normalization to \( \pi \pi \) events benefits from normalizing to \( \pi \pi \) events, in the limit of neglecting FSR effects:

\[
\frac{d^n \text{obs}}{ds} = \frac{d^n \text{Born}}{ds} F_\pi(s)
\]

Luminosity: 0.5\%\text{theory} + 0.3\%\text{exp.}, Bhabha

<table>
<thead>
<tr>
<th>Source</th>
<th>Systematic Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminosity</td>
<td>0.6 %</td>
</tr>
<tr>
<td>Vacuum Polarization</td>
<td>0.2 %</td>
</tr>
<tr>
<td>FSR resummation</td>
<td>0.3 %</td>
</tr>
<tr>
<td>Radiation function (H(s_\pi))</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Total theory systematics</td>
<td>0.9 %</td>
</tr>
</tbody>
</table>

- most of the theoretical systematic effects cancel out
- also improvements in experimental systematics to be expected
compared to the luminosity normalization with Bhabhas, statistical error becomes larger using muons, however it is a good cross check of the intriguing region because of the difference with data estimate performed with PHOKHARA-4

Improvements wrt the published result

**improved selection**

- enlarged $m_{\text{trk}}$ acceptance, from 90 MeV to 80 MeV in order to accept muons
- improved offline background filter:
  eff. from 95\% to 98.5\% AND syst. error considerably lower
- events with $m_{\text{miss}} > 120$ MeV are downscaled with a factor $1/1000$

$m_{\text{trk}}$, defined by 4-momentum conservation under the hypothesis of 2 equal mass tracks and one $\square$

$$\left(\sqrt{s} \quad \sqrt{p_1^2 + m_{\text{trk}}^2} \quad \sqrt{p_2^2 + m_{\text{trk}}^2}\right)^2 \cdot (p_1 + p_2)^2 = 0$$

$m_{\text{miss}}$, defined by the 4-momentum conservation under the hypothesis of $e^+e^-\square \quad \square \quad \square \quad X$

$$m_{\text{miss}} = \sqrt{E_X^2 + p_X^2}$$
Discrimination \( \pi \) vs. \( e \): time and energy

\( \pi/e \) separation is performed using a particle ID function based on time and quantity and shape of the energy released in the calorimeter.

- Time of flight: for low \( p \) values \( \pi \neq e \sim 1 \)

- Pions deposit \( \sim 40 \) MeV in each plane.

- Electrons deposit mostly in the first plane and negligible amount in the rest.

\[
E = \frac{L_{\text{trk}}}{c} \quad \text{(ns)}
\]
Discrimination efficiencies for $p p g$ and $m m g$

1) the procedure is tested
2) the event is selected if at least one of the 2 tracks is not identified to be an electron

It leads to a rejection power $\sim 97\%$ for $e^+ e^- e^+ e^-$ events while keeping a selection efficiency $> 99.8\%$ for $e^+ e^- p^+ p^-$ events
Definition of $p\bar{p}$ and $m\bar{m}$ events (I)

$130 \text{ MeV} < m_{\text{trk}}$ and inside the area, are $p\bar{p}$

$m_{\text{trk}} < 115 \text{ MeV}$ are $m\bar{m}$
Definition of $\text{ppg}$ and $\text{mmg}$ events (II)

$$
\frac{(n_1 + n_2)}{2}
$$

$$
M_{\text{ppg}}^2 \in [0.57,0.62] \text{ GeV}^2
$$

$$
M_{\text{mmg}}^2 \in [0.87,0.92] \text{ GeV}^2
$$
Tracking efficiencies for $\pi\pi$ events evaluated from data samples of $p^+p^-$ and $p^+p^-p^0$ events, and from a MC sample of $p^+p^-g$ events, and compared to the agreement between data and MC is on the level of 0.5-0.6% preliminary.
Background yields are estimated using MC distributions after the whole selection, normalized to the luminosity of the selected data sample for data and 2 background sources:

$$\frac{d\mathcal{L}_{\text{vis}}}{dM^2} = \frac{1}{L} \frac{N_{\text{Bin}}}{\mathbb{E}M^2}$$
The "raw" \( pp \) spectrum

a) pion with \( 50^\circ < \theta_{\text{track}} < 130^\circ \)
b) small angle \( \theta (\theta < 15^\circ) \)
c) \( m_{\text{trk}} > 130 \text{ MeV} \) and inside the area \( (m_{\text{trk}} \text{ vs } M) \)
d) at least 1 track not to be identified as an electron

\[ \Delta M^2 = 0.01 \text{ GeV}^2, \ L = 242 \ \text{pb}^{-1} \]
of data taken in 2002

\[ \text{Entries: 3427614} \]
Background yields are estimated using MC distributions after the whole selection, normalized to the luminosity of the selected data sample for data and 2 background sources:

\[
\frac{d\mathcal{O}_{vis}}{dM^2} = \frac{1}{L} \frac{N_{Bin}}{\Delta M^2}
\]
The "raw" $\square M^2$ spectrum

a) muon with $50^\circ < \square_{\text{track}} < 130^\circ$
b) small angle $(\square_{\text{M}} < 15^\circ)$
c) $m_{\text{trk}} < 115$ MeV
d) at least 1 track not to be identified as an electron

$\square M^2 = 0.01$ GeV$^2$, $L = 242$ pb$^{-1}$

of data taken in 2002

preliminary

Entries 873729
Conclusions and perspectives

- the extraction of $F_{\Omega}$ from both the absolute measurement of $\pi\pi$ events and from the ratio of $\pi\pi$ to $\pi\pi$ events, is in an advanced state,
- these methods allow to cross check systematics,
- we are finalizing the estimate of the corrections and of the systematic uncertainties,
- good control of $\pi/\pi/e$ discrimination,
- even on the theory side some improvements are expected.

Results will come soon...
Please, stay tuned.