σ meson in the decay $\eta' \to \eta\pi^0\pi^0$ with GAMS-4π

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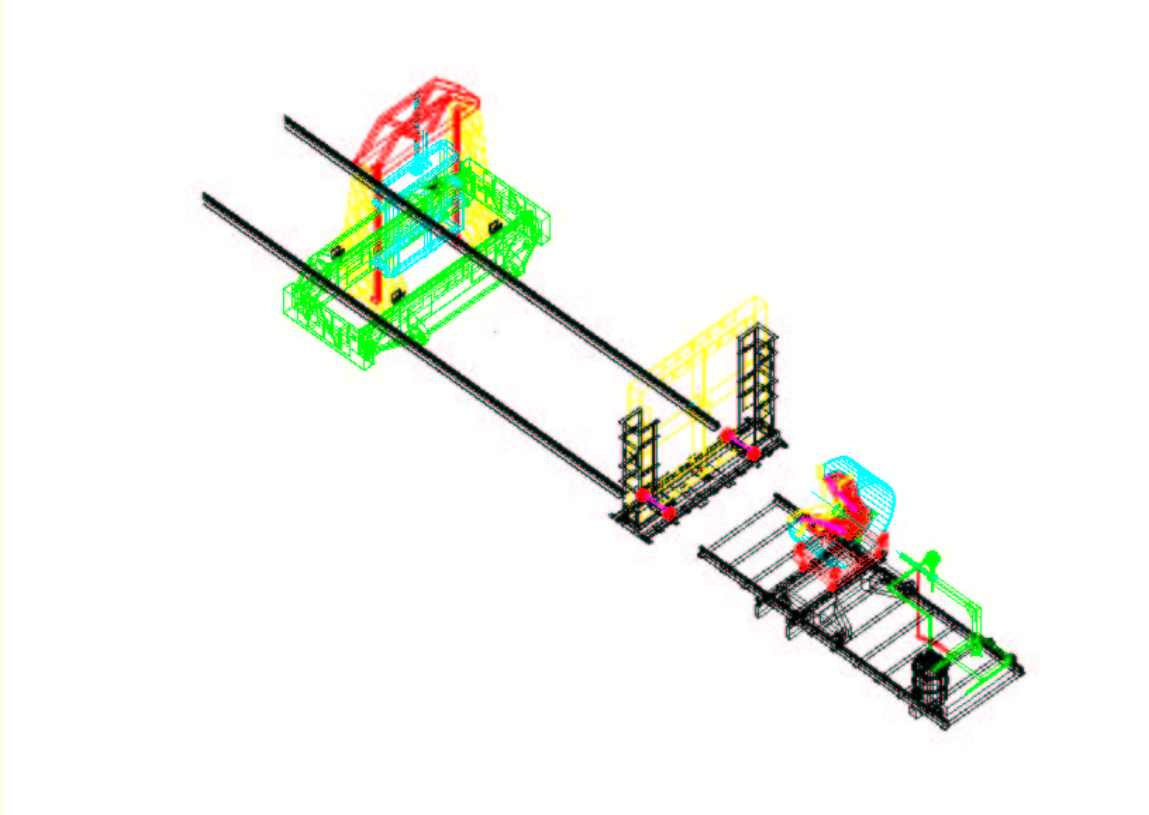
GAMS-4π (1991-2005)

Figure 1: Scitillator fiber beam hodoscopes, GAMS 2300 lead-glass cells, 64 PWO crystalls Wide Aperture Detector (WAD), Pb-scintillator Lead Glass Guard System 40 cm Length Liquiq Target

Study of $\eta' \to \eta\pi\pi$ Dalitz Plot:

GAMS (D.Alde et al.) Phys.Lett. B 177 (1987) (neutral)

VES (V.Dorofeev et al.) Phys.Lett. B 651(2007) (charged)

GAMS-4π (A.Blik et al.) YaF (2008) (neutral).

$$|M|^2 \propto 1 + aY + bY^2 + cX + dX^2, \qquad (1)$$

a, b, c, d – real parameters, X, Y – Dalitz variables.

$$X = \frac{\sqrt{3}}{Q}(T_{\pi_1^0} - T_{\pi_2^0}), \; Y = (2 + \frac{m_\eta}{m_{\pi^0}})\frac{T_\eta}{Q} - 1. \qquad (2)$$
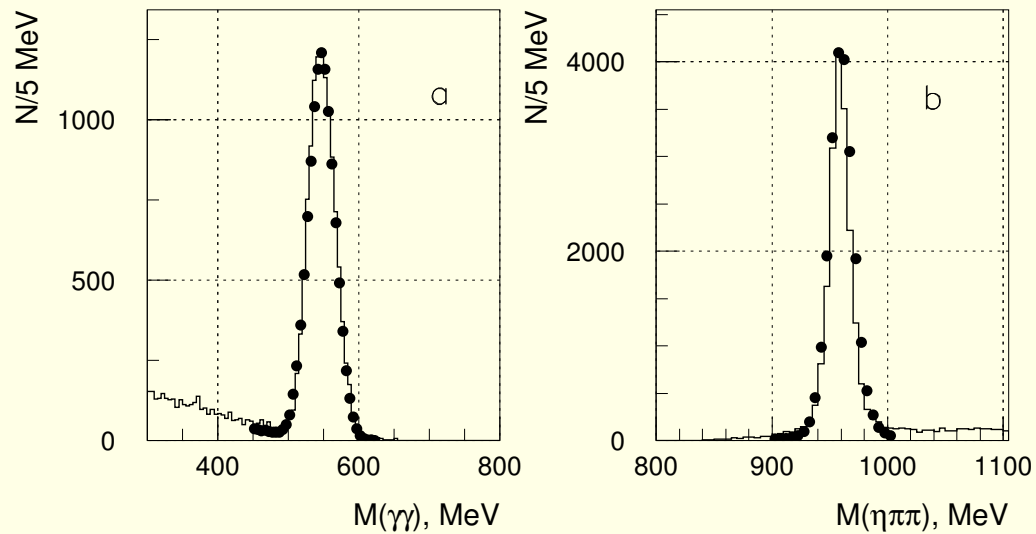
Figure 2: Data Quality: a - non-fitted $m(\gamma\gamma)$ after 3C fit(n, π^0, π^0). b - $\eta\pi^0\pi^0$ mass spectrum.
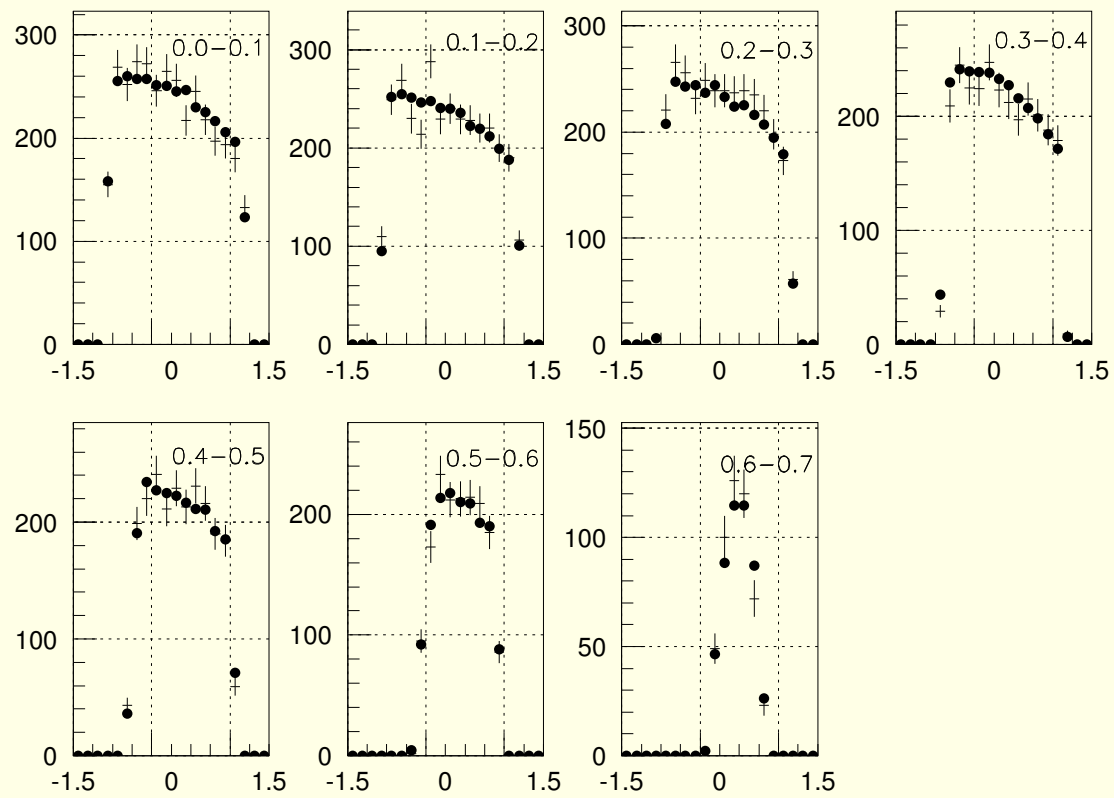
Figure 3: Y in different X slices.

GAMS-4π(2007):

$$
\begin{aligned}
a &= -0.066 \pm 0.016 \\
b &= -0.063 \pm 0.028 \\
c &= -0.107 \pm 0.096 \\
d &= 0.018 \pm 0.078
\end{aligned}
\quad
\begin{pmatrix}
1.000 & -0.395 & 0.191 & -0.210 \\
 & 1.000 & -0.600 & 0.512 \\
 & & 1.000 & -0.968 \\
 & & & 1.000
\end{pmatrix}
\tag{3}
$$

VES(2007):

$$
\begin{aligned}
a &= -0.127 \pm 0.016 \pm 0.008 \\
b &= -0.106 \pm 0.028 \pm 0.014 \\
c &= 0.015 \pm 0.011 \pm 0.014 \\
d &= -0.082 \pm 0.017 \pm 0.008
\end{aligned}
$$

GAMS-4π(2007): c=0

$$
\begin{aligned}
a &= -0.067 \pm 0.016 \\
b &= -0.064 \pm 0.029 \\
d &= -0.067 \pm 0.020
\end{aligned}
\quad
\begin{pmatrix}
1.000 & 0.151 & -0.698 \\
 & 1.00 & -0.406 \\
 & & 1.000
\end{pmatrix}
\tag{4}
$$
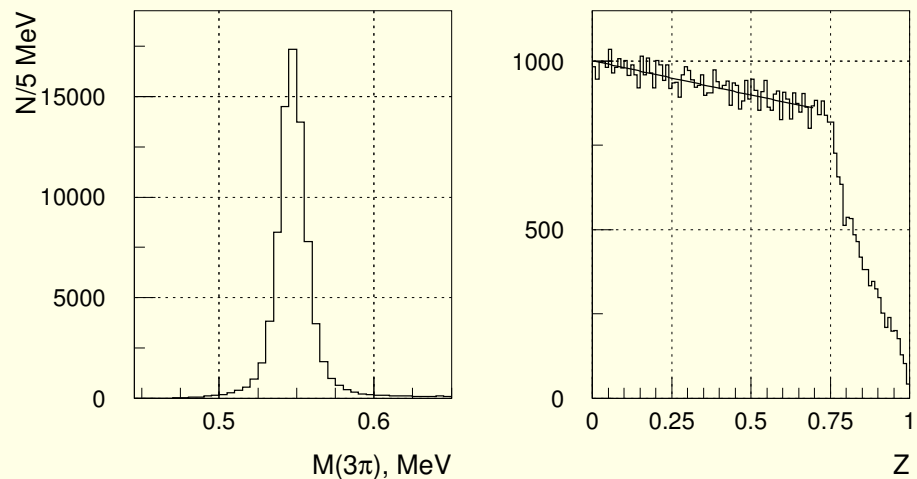
$$\eta \to 3\pi^0 : |M|^2 \propto 1 + 2\alpha Z, \tag{5}$$

$$Z = \left(\frac{r}{r_{max}}\right)^2 = \frac{6}{(M_\eta - 3M_{\pi^o})^2} \sum_{i=1}^{3} \left(E_{\pi^o}^i - \frac{M_\eta}{3}\right)^2. \tag{6}$$

$\alpha = -0.022 \pm 0.023$ GAMS, Z.Phys.C 25 (1984)

$\alpha = -0.031 \pm 0.004$ Crystal Ball, Phys.Rev.Let. 87(2001)

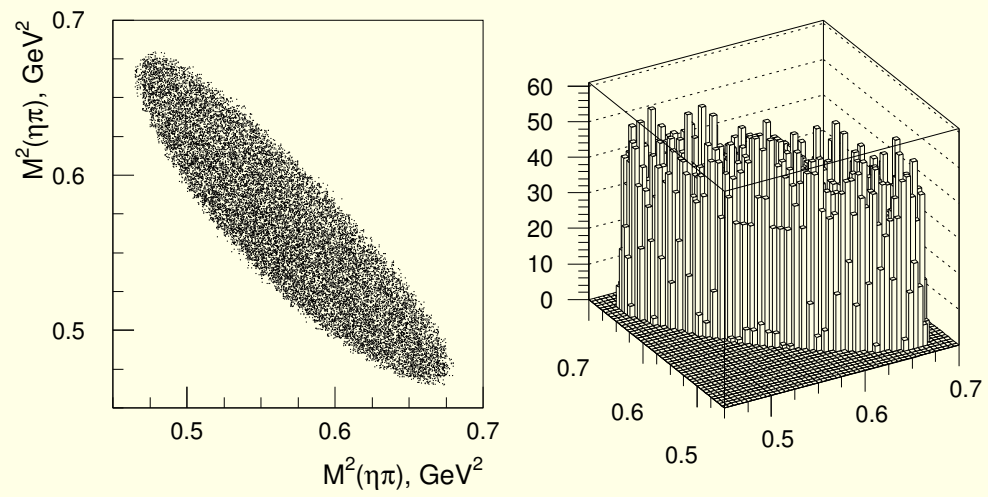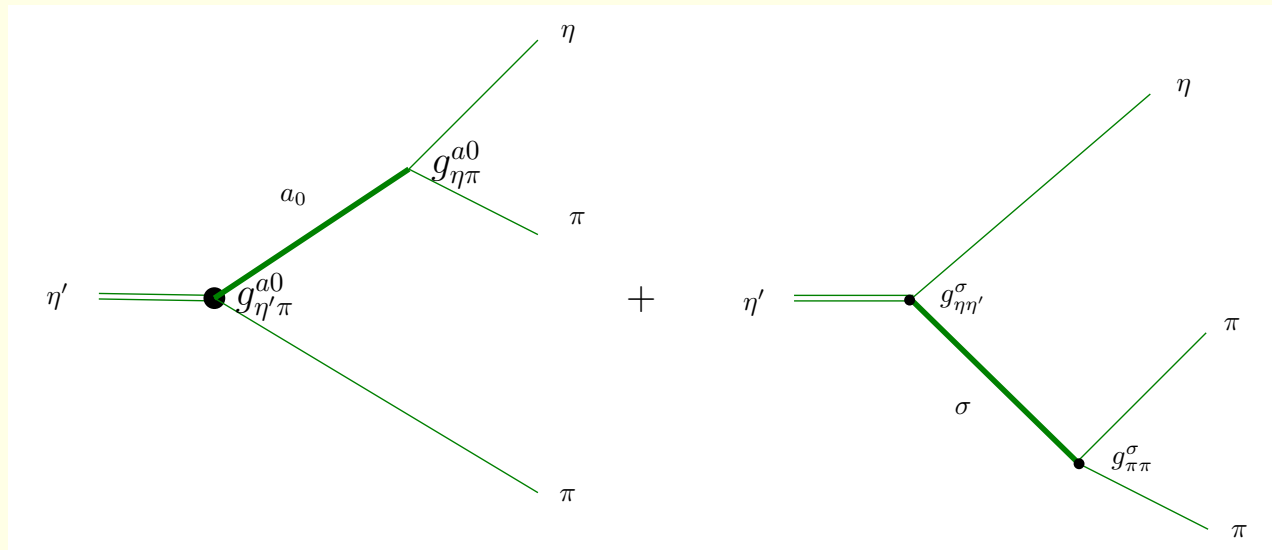$\alpha = -0.022 \pm 0.010$ GAMS-4π, not published, 2007

Figure 4: Dalitz Plot

Amplitudes for $\eta' \to \eta\pi^0\pi^0$

$$A \sim g_{\pi\eta'}^{a0}(A_{\pi\eta}(s13, g_{\pi\eta}^{a0}) + A_{\pi\eta}(s23, g_{\pi\eta}^{a0}))g_{\pi\eta}^{a0} + g_{\eta\eta'}^{\sigma}A_{\pi\pi}(s12)g_{\pi\pi}^{\sigma} \quad (7)$$

<div align="center">Parametrization:</div>

$A_{\pi\pi}$: Amplitude with σ pole ($M_\sigma = 447$ MeV, $\Gamma/2 = 258$ MeV) below KK threshold from $\pi\pi$ scattering (K_{e4} data) $-$ I.Caprini et al., hep-ph 0804.3504

$A_{\pi\eta}$: BW with loop integral in $\eta\pi$ rescattering,

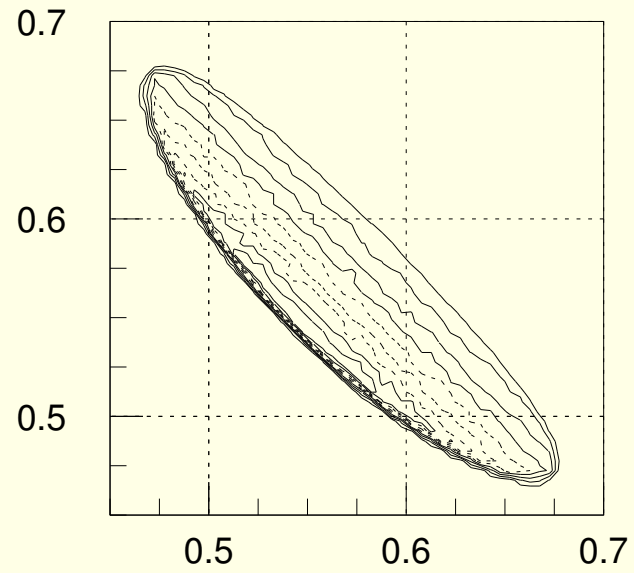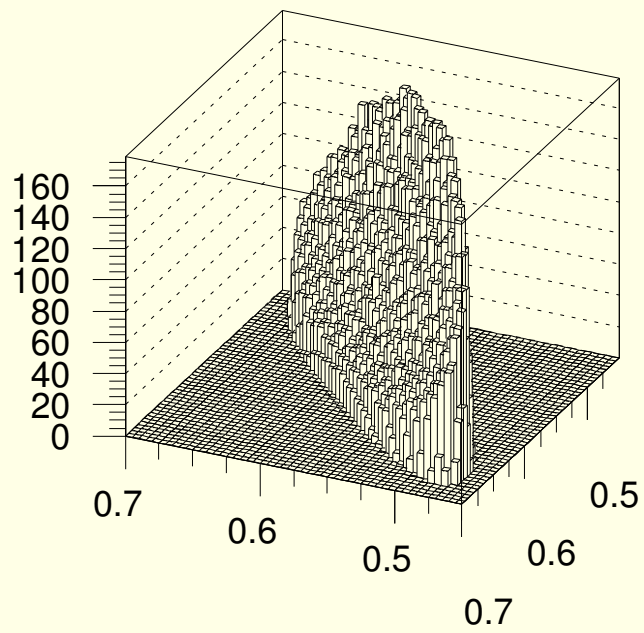$$A_{\pi\eta} = \frac{1}{s - m_{a0}^2 + (g_{\pi\eta}^{a0})^2 J(s)}$$

<div align="right">Fit:</div>

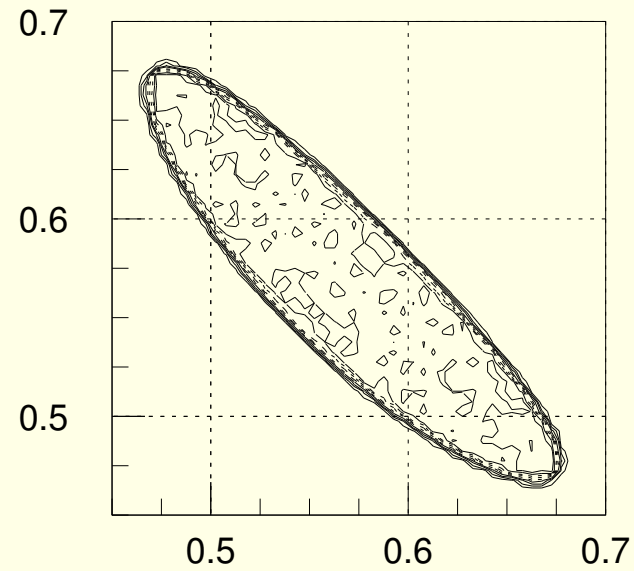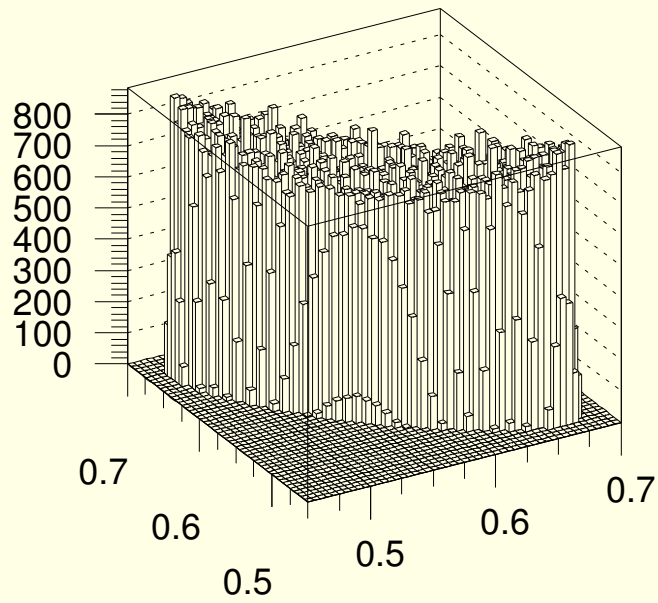$g_{\pi\eta'}^{a0} = 0.5 \pm 0.2$

$g_{\eta\eta'}^{\sigma} = 0.5 \pm 0.2$

$g_{\pi\eta}^{a0} = 2.0 \pm 0.4$

$\chi^2/NDF = 1.1$

$$A \sim g^{\sigma}_{\eta\eta'} A_{\pi\pi}(s12) g^{\sigma}_{\pi\pi} \tag{8}$$

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$$A \sim g_{\pi\eta'}^{a0}(A_{\pi\eta}(s13, g_{\pi\eta}^{a0}) + A_{\pi\eta}(s23, g_{\pi\eta}^{a0}))g_{\pi\eta}^{a0} \qquad (9)$$

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Conclusion:

Good Fit of the Dalitz plot $\eta' \rightarrow \eta\pi^0\pi^0$ decay with σ and $a0$ Amplitudes.