Search for isotensor exotic resonance in $\gamma\gamma^*$ collision at FCC

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based on I. V. Anikin, B. Pire and O. V. Teryaev, **Phys. Lett. B 626**, 86 (2005)

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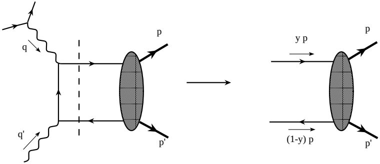
Exotic $I = 2$ 4q-meson and Twist 4

Consider pair production in $\gamma\gamma^*$ with Generalized Distribution Amplitudes describing transition of $q\bar{q}$ to hadron pair: generalization of well known pion transition form factor description $(\gamma^*\gamma \to \pi^0) \to (\gamma^*\gamma \to 2\text{mesons})$. Well established QCD framework (collinear factorization; crossed version of GPDs measured in DVCS)



$$\langle p'\, p \left| \bar{\psi}(0)\, \Gamma\, [0,z]\, \psi(z) \right| 0 \rangle \Big|_{z^2=0} = \sum_{i=\Gamma} \mathrm{L}^{(i)} \int_0^1 dy\, e^{-iy\lambda}\, \mathrm{GDA}_{(i)}(y,\zeta,s),$$

where $2\zeta - 1 = \frac{(p'-p)^+}{(p'+p)^+}$

Leading twist process (scaling amplitude like Q^0) $\rightarrow q\bar{q}$ or $gg \rightarrow$ isospin 0 or 1 final state.

Notice: hybrid states like $J^{PC} = 1^{-+}$ are still possible, see I V. Anikin, B. Pire, L. Szymanowski, O. V. Teryaev and S. Wallon, **Phys. Rev. D 71**, 034021 (2005)

Tetraquarks may have isospin 2: need higher twist description $q\bar{q}q\bar{q}$: amplitude scale like Q^{-2}

$L3$@LEP data for two ρ production

The Q^2-dependence:

- Large Q^2 region

$$\frac{d\sigma}{dQ^2}(\rho^+\rho^-) : \frac{d\sigma}{dQ^2}(\rho^0\rho^0) = 2:1$$

- Small Q^2 region

$$\frac{d\sigma}{dQ^2}(\rho^0\rho^0) > \frac{d\sigma}{dQ^2}(\rho^+\rho^-) \text{ few times lager}$$

The W-dependence:
$\sigma(\gamma\gamma^* \to \rho^+\rho^-)$ and $\sigma(\gamma\gamma^* \to \rho^0\rho^0)$ have peaks in the region $1.3 \leq W_{\gamma\gamma} \leq 2.5$ for both large and small Q^2.

Theoretical interpretation of L3 data

From isospin symmetry, we have

$$\mathcal{M}^{I=0}(\rho^0\rho^0) = -\mathcal{M}^{I=0}(\rho^+\rho^-), \quad \mathcal{M}^{I=2}(\rho^0\rho^0) = 2\mathcal{M}^{I=2}(\rho^+\rho^-)$$

Therefore, we get

$$\frac{\sigma(\rho^+\rho^-)}{\sigma(\rho^0\rho^0)} = \frac{2|\mathcal{M}^{I=0}_{2+4} - \frac{1}{2}\mathcal{M}^{I=2}_{4}|^2}{|\mathcal{M}^{I=0}_{2+4} + \mathcal{M}^{I=2}_{4}|^2} \overset{Q^2\to\infty}{\Longrightarrow} \frac{2|\mathcal{M}^{I=0}_{2}|^2}{|\mathcal{M}^{I=0}_{2}|^2} = 2$$

where

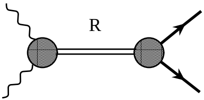
$$\mathcal{M}^{I=0}_{2} \sim \langle 0|\bar{\psi}\,\psi|p_1,\, p_2\rangle, \quad \mathcal{M}^{I=0,2}_{4} \sim \langle 0|[\bar{\psi}\,\psi][\bar{\psi}\,\psi]|p_1,\, p_2\rangle$$

The corresponding cross section reads

$$\sigma_{\gamma\gamma^*}(\langle W\rangle) = \frac{\int dQ^2 \mathcal{L}(Q^2,\langle W\rangle)\sigma_{\gamma\gamma^*}(Q^2,\langle W\rangle)}{\int dQ^2 \mathcal{L}(Q^2,\langle W\rangle)}$$

Soft part - familiar hadronic physics:
The W-dependence of GDA parameterized with the Breit-Wigner formula:

$$\sigma_{\gamma\gamma^*}(Q^2,\langle W\rangle) \Longrightarrow \sum_{R}$$



where BW-propagator $= \frac{1}{M_R^2 - W^2 - i\Gamma_R M_R}$

W dependence of the cross section $\sigma_{ee \to ee \rho^0 \rho^0}$ (left panel) and $\sigma_{ee \to ee \rho^+ \rho^-}$ (right panel) normalized by the integrated luminosity function, in the $1.2 < Q^2 < 8.5$ region.

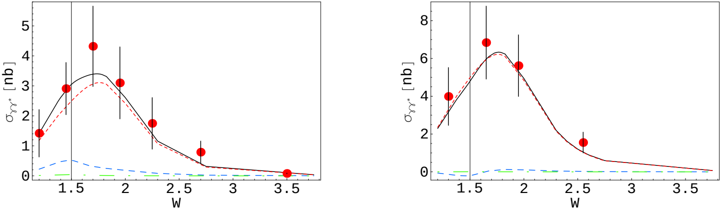


Figure: The short-dashed line corresponds to the leading twist 2 contribution; the dash-dotted line to the twist 4 contribution; the middle-dashed line to the interference of twist 2 and 4 contributions. The solid line corresponds to the sum of all contributions.

$$M_{R^0} = 1.8\,\mathrm{GeV}, \quad \Gamma_{R^0} = 1.0\,\mathrm{GeV},$$
$$\mathbf{S}_2^{I=0, I_3=0} = (0.12,\ 0.16)\,\mathrm{GeV}.$$

W dependence of the cross section $\sigma_{ee\to ee\rho^0\rho^0}$ normalized by the integrated luminosity function in the $0.2 < Q^2 < 0.85$ region.

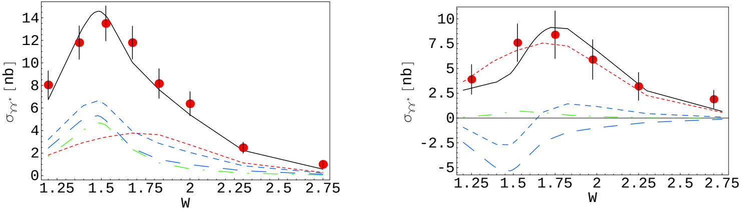


Figure: The short-dashed line corresponds to the leading twist 2 contribution; the dash-dotted line to the twist 4 contribution; the middle-dashed line to the interference of twist 2 and 4 contributions. The solid line corresponds to the sum of all contributions.

$$M_{R^2} = 1.55\,\mathrm{GeV}, \quad \Gamma_{R^2} = 0.4\,\mathrm{GeV},$$
$$\mathbf{S}_4^{I=0,I_3=0} = (0.002,\ 0.006)\,\mathrm{GeV}, \quad \mathbf{S}_4^{I=2,I_3=0} = (0.012,\ 0.018)\,\mathrm{GeV}.$$

The Q^2 dependence of the differential cross sections $d\sigma_{ee\to ee\rho^0\rho^0}/dQ^2$ and $d\sigma_{ee\to ee\rho^+\rho^-}/dQ^2$.

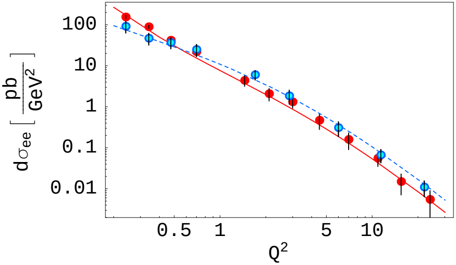


Figure: The solid line corresponds to the case of $\rho^0\rho^0$ production; the dashed line to the case of $\rho^+\rho^-$ production.

$$M_{R^2} = 1.55\,\mathrm{GeV}, \quad \Gamma_{R^2} = 0.4\,\mathrm{GeV},$$
$$\mathbf{S}_2^{I=0,I_3=0} = 0.12\,\mathrm{GeV}, \quad \mathbf{S}_4^{I=0,I_3=0} = 0.006\,\mathrm{GeV},$$
$$\mathbf{S}_4^{I=2,I_3=0} = 0.018\,\mathrm{GeV}.$$