PROCEEDINGS OF SCIENCE

Exclusive scalar $f_0(1500)$ meson production

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We evaluate differential distributions for exclusive scalar $f_0(1500)$ meson (glueball candidate) production. Both QCD diffractive, pion-pion meson exchange current (MEC) components as well as double-diffractive mechanism with intermediate pionic loop are calculated. The pion-pion component, which can be reliably calculated, dominates close to the threshold while the diffractive component may take over only for larger energies. At the moment only upper limit for the QCD-diffractive component can be obtained. The diffractive component is calculated based on the Khoze-Martin-Ryskin approach proposed for diffractive Higgs boson production. Different unintegrated gluon distribution functions (UGDFs) from the literature are used. Rather large cross sections (due to pion-pion fusion) are predicted for PANDA energies, where the gluonic mechanism is shown to be negligible.

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1. Introduction

Many theoretical calculations, including lattice QCD, predicted existence of glueballs (particles dominantly made of gluons) with masses $M > 1.5$ GeV. No one of them was up to now unambiguously identified. The nature of scalar mesons below 2 GeV is also not well understood. The lowest mass meson considered as a glueball candidate is a scalar $f_0(1500)$ [1] observed by the Crystall Barrel Collaboration in $p\bar{p}$ annihilation [2]. It was next confirmed by the WA102 Collaboration in central production in pp collisions in two-pion [3] and four-pion [4] decay channels.

2. Mechanisms of exclusive scalar $f_0(1500)$ meson production

We concentrate on exclusive production of scalar $f_0(1500)$ in the following reactions: $pp \to pp f_0(1500)$, $p\bar{p} \to p\bar{p} f_0(1500)$, $p\bar{p} \to n\bar{n} f_0(1500)$. While the first process can be measured at the J-PARC complex, the latter two reactions could be measured by the PANDA Collaboration. We have proposed a different mechanisms (shown in Fig.1) for exclusive scalar $f_0(1500)$ meson production (more details can be found in Ref. [5]).

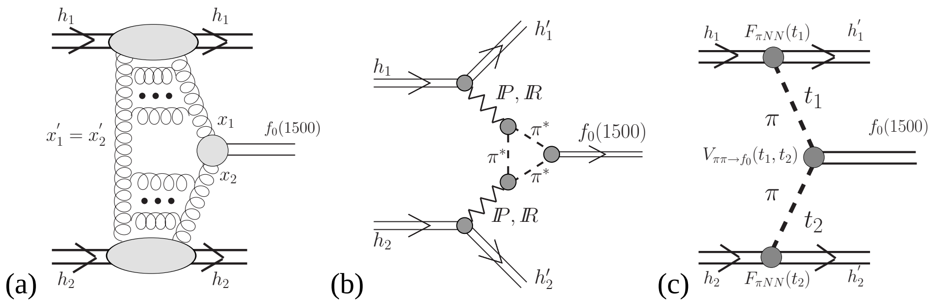

Figure 1: The sketch of the bare mechanisms of exclusive scalar $f_0(1500)$ meson production: (a) the QCD mechanism, (b) double-diffractive mechanism with intermediate pionic triangle and (c) pion-pion fusion.

If $f_0(1500)$ is a glueball (or has a strong glueball component [6]) then the diffractive mechanism (see Fig.1a) may be important. This mechanism is often considered as the dominant mechanism of exclusive Higgs boson [7] and $\chi_c(0^+)$ meson [8] production at high energies. At lower energies ($\sqrt{s} < 20$ GeV) other processes may become important as well. Since the two-pion channel is one of the dominant decay channels of $f_0(1500)$ (34.9 $\pm$ 2.3 %) [9] one may expect the two-pion fusion (see Fig.1c) to be one of the dominant mechanisms at the FAIR energies. The two-pion fusion can be relative reliably calculated in the framework of meson-exchange theory. The pion coupling to the nucleon is well known [10].

3. Results and Conclusions

We have estimated the integrated cross section for the exclusive $f_0(1500)$ meson production (see Fig.2). We have included both gluon induced diffractive and triangle-double-diffractive mechanisms as well as the $\pi\pi$ exchange contributions. We predict the dominance of the $\pi\pi$ contribution close to the threshold and the dominance the diffractive components at higher energies. In Fig.3 we

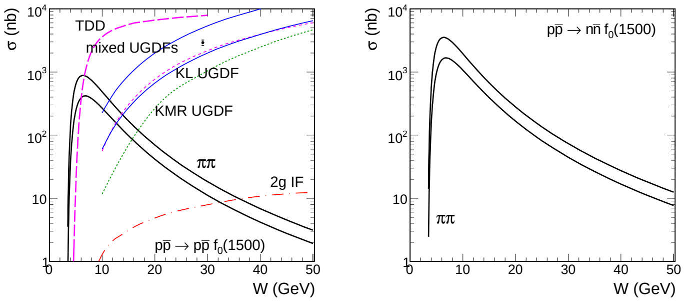

Figure 2: The integrated cross section as a function of the center-of-mass energy for $p\bar{p} \to p\bar{p} f_0(1500)$ (left panel) and $p\bar{p} \to n\bar{n} f_0(1500)$ (right panel) reactions. The thick solid lines: $\pi\pi$ contribution, the dashed line: QCD diffractive contribution (KL UGDF), the dotted line: the KMR approach, the thin solid lines: "mixed" UGDF (KL $\otimes$ Gauss) and the long-dashed line: the mechanism with intermediate pionic triangle. The WA102 experimental data point at W = 29.1 GeV is from [11].

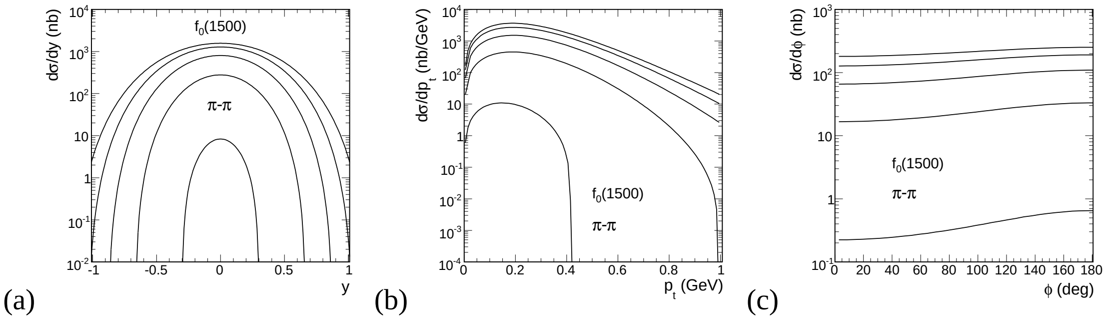

Figure 3: Differential cross sections $\frac{d\sigma}{dy}$ (a), $\frac{d\sigma}{dp_t}$ (b) and $\frac{d\sigma}{d\phi}$ (c) for the reaction $p\bar{p} \to n\bar{n} f_0(1500)$ ($\pi^+\pi^-$ fusion only) at W = 3.5, 4.0, 4.5, 5.0, 5.5 GeV (from bottom to top).

present differential cross sections for the $\pi\pi$ exchange mechanism at energies of future experiments at HESR at the FAIR facility in GSI.

The experimental studies of exclusive production of $f_0(1500)$ are not easy at all as in the $\pi\pi$ decay channel one expects a large continuum. We have performed an involved calculation of the four-body $p\bar{p}\pi^+\pi^-$ background. Our calculation [5] shows that imposing extra cuts should allow to extract the signal of the glueball $f_0(1500)$ candidate at the highest PANDA energy.

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