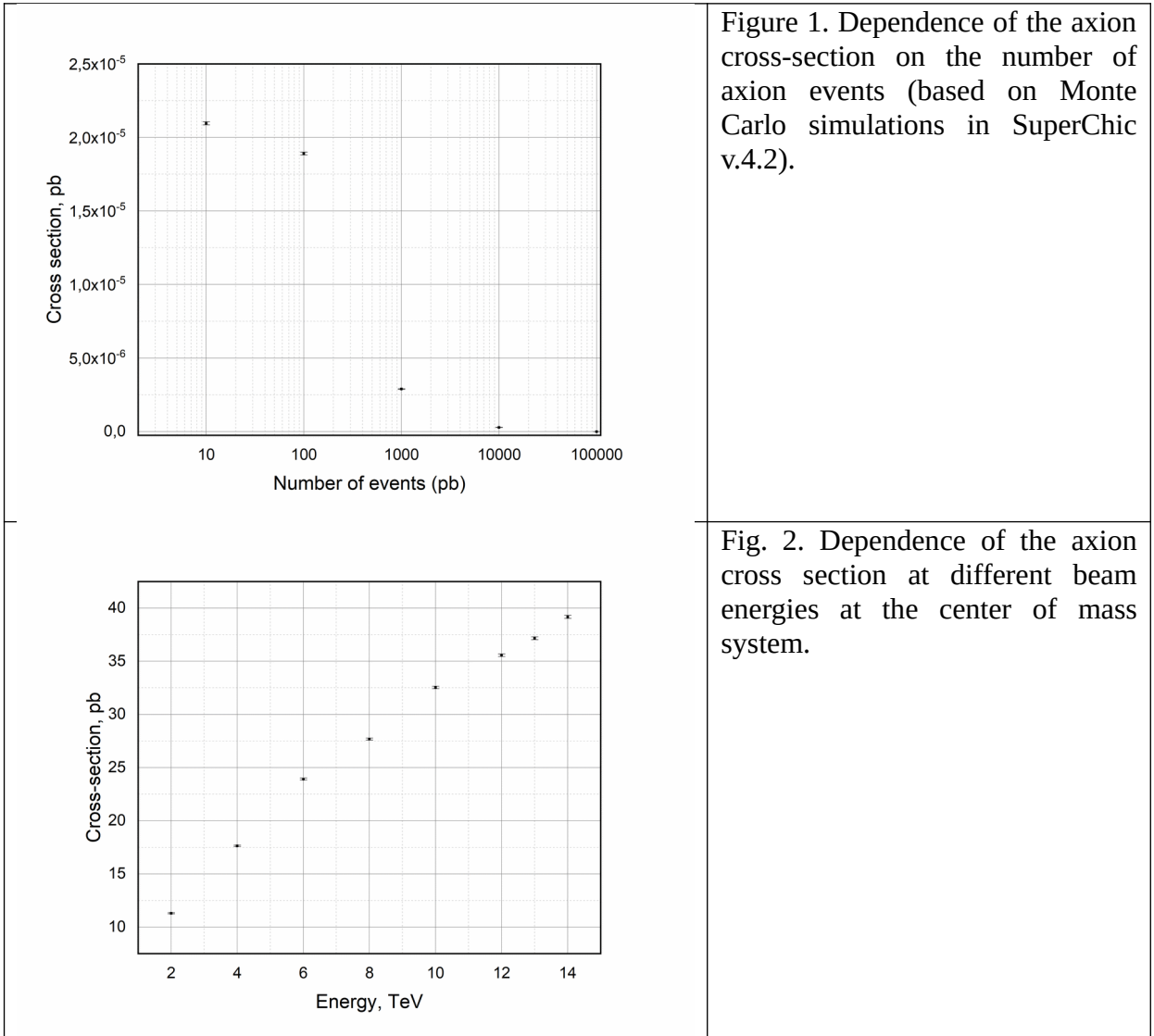


SEARCHES FOR AXIONS IN PROTON-PROTON AND ION-ION COLLISIONS AT ENERGIES OF 5.02 TEV AND 13 TEV

As a part of the ATLAS Collaboration experimental measurements of light-by-light scattering in Pb+Pb collisions during 2015 and 2018 at an integrated luminosity of 2.2 nb^{-1} and energy of 5.02 TeV, taking into account the obtained experimental constraints [1], we have modeled the production cross sections of axion production, which is candidate for dark matter with subsequent decay into $\gamma\gamma$. Candidates for light-by-light scattering are selected in events with two photons, pseudorapidity, $|\eta_\gamma| < 2.37$, diphoton invariant mass $m_{\gamma\gamma} = 5\text{-}30 \text{ GeV}$, and an interaction constant of the order of 10^{-3} GeV^{-1} [2]. The obtained calculations showed the dependence of the cross section on the number of axion events (Fig. 1), on the energy in the center of mass system (Fig. 2), and on the mass distribution of axions.



Proton-proton and ion-ion collisions were processed for QCD-axion formation using the SuperChic v.4.2 Monte Carlo event generator [3]. Corresponding production cross sections were obtained and compared with recent measurements of light-by-light scattering by ATLAS and CMS collaborations at the LHC during lead-to-lead collisions [4,5]. It is shown that the axion production cross section in proton-proton collisions is seven orders of magnitude larger than that in Pb+Pb collisions at an energy in the center-of-mass system of 5.02 TeV. An order of magnitude difference in the axion production cross section in proton-proton collisions for single dissociation

in relation to double dissociation at an energy of 5.02 TeV and a mass range of 5-30 GeV was revealed (approximately 20-21 pb to 9-10 pb, depending on the model). In the same mass range, the axion production cross sections were calculated at 13 TeV and a difference of about 2.5 times in the axion production cross sections for single dissociation versus double dissociation was found. The advantage of the 2nd model at 5.02 TeV and the 1st model at 13 TeV was found. The results of calculations for the four models are presented in Table 1.

Table 1: The axion production cross-sections in the 5-30 GeV mass region for 4 models

E, TeV	Cross section for each model (pb)							
	1		2		3		4	
	Single dis.	Double dis.	Single dis.	Double dis.	Single dis.	Double dis.	Single dis.	Double dis.
5,02	20.908 +/- 0.081	9.167 +/- 0.079	20.926 +/- 0.081	9.219 +/- 0.079	20.922 +/- 0.081	9.161 +/- 0.079	20.905 +/- 0.081	9.086 +/- 0.079
13	$0.461 \cdot 10^{-4}$ +/- $0.31 \cdot 10^{-6}$	$0.176 \cdot 10^{-4}$ +/- $0.18 \cdot 10^{-6}$	$0.461 \cdot 10^{-4}$ +/- $0.31 \cdot 10^{-6}$	$0.171 \cdot 10^{-4}$ +/- $0.165 \cdot 10^{-6}$	$0.416 \cdot 10^{-4}$ +/- $0.26 \cdot 10^{-6}$	$0.173 \cdot 10^{-4}$ +/- $0.183 \cdot 10^{-6}$	$0.419 \cdot 10^{-4}$ +/- $0.27 \cdot 10^{-6}$	$0.173 \cdot 10^{-4}$ +/- $0.183 \cdot 10^{-6}$

The analysis of experimental data with 441 candidates for axions obtained during proton-proton collisions at an energy of 13 TeV [6] led to the need for us to search for a narrow resonance in the distribution of diphoton masses in the mass range of 5–1400 GeV with the number of events of 100,000. The obtained data do not exceed the experimental value of the upper limit of the production cross-section of a narrow resonance and are about 0.024 fb.

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