On diffractive magnetic monopole production in pp collisions

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Here we propose diffractive production of the monopole pair via two-photon fusion. We used FPMC [1] for estimation of the total cross section for the spin 1 Dirac monopole diffractive production via the two-photon fusion.

1 Introduction, Motivation and Result

Over seventy years ago P.A.M. Dirac [2] proposed a model which postulated the existence of the isolated magnetic charge, presently known as the *Dirac magnetic monopole*. Since then massive theoretical and experimental efforts has been devoted to the problem. But up to now no experimental evidence of the monopole existence has been found. Nevertheless, the interest in magnetic monopole remains strong due to its elegance and the unifying nature of the model.

The strongest argument in favor of the existence of the magnetic monopole is the quantization of electric charge. In his paper Dirac established the relation between the elementary electric charge e and the basic magnetic charge g

$$eg = \frac{n\hbar c}{2}, \text{where } n = 0, \pm 1, \pm 2, ..., ^{1} \quad (1)$$

and $g_D = \hbar c/2e \simeq 68,5e$ is the unit Dirac magnetic charge.

Secondly, the monopole's existence leads to the symmetrization of Maxwell's equations in classical electrodynamics. The introduction of magnetic charge density ρ_m and magnetic current density j_m would make the equations invariant under a global duality transformation.

And, finally, magnetic monopoles are predicted from field theories which unify the fundamental forces [4]-[5]. While most of the theoretical models tend to favor GUT monopoles with masses $\sim 10^{16} - 10^{17}$GeV and cannot discovered on the accelerators, in some Grand Unified models lower mass monopoles, with masses of order a few TeV, are allowed [5, 6].

These circumstances has stimulated the experimental searches for magnetic monopoles at accelerators [7]-[11] and in cosmic radiation experiments [12].

Now the favored model for monopole production has been Drell-Yan mechanism. This process was considered at Tevatron [8, 10] and LEP2 [11]. Maybe $\gamma\gamma$ direct production of the monopole-antimonopole pair was not considered at these experiments following an assumption of the small probability of usual particle-antiparticle pair production, for example e, μ, τ and so

[1]In the Schwinger approach [3] the the integer n takes on the values $n = 0, \pm 2, \pm 4, ...$

on. On the other hand, due to the large coupling constant for interaction with a photon α_g, the $\gamma\gamma$ fusion mode of monopole production, first pointed out by Cabibbo and Ferrari in 1962 [14], can be shown to be competitive with and, even in excess of, the Drell-Yan production cross-section.[2] We note that in the absence of the exactly schemes for calculating processes involving the magnetic monopoles, two-photon production and the Drell-Yan production, should be used concurrently. In paper [15] we have shown that $\gamma\gamma$ fusion (elastic case) at high energy pp-collisions could be more convenient mechanism. At present the diffraction in high energy physics has become a fashionable subject. Since the diffractive production of elementary particles is simply enough carried out experimentally. The main excellence of this method is consisted in a possibilities to obtain additional information on produced particles such as spins and parities at considerably reduced backgrounds. Therefore it seems to us interesting to propose and consider the diffractive production monopole pair via $\gamma\gamma$ fusion.

Here we consider the Dirac monopole for the case when $n = 1$ (see 1) with mass up to 2 TeV, a spin $s = 1$ only. It should be note that by the Dirac monopole means a pointlike particle without electric charge or hadronic interactions and with magnetic charge satisfying the Dirac charge quantization condition (1). As well known the dual symmetry of Maxwell's equations due to the existence of the magnetic monopole can be used to obtain the magnetic monopole versions of the Bethe-Bloch equation, Lorentz force and other relations. Milton [13] has shown that the electron-monopole scattering this cross section may be obtained from the Rutherford electron-electron scattering cross-section by substitution $\frac{e}{v} \to \frac{g}{c}$. Thus, to estimate the monopole production cross sections one uses the principle of the duality which require only replacement of electric charge with the monopole's effective charge $g\beta$, where β is the monopole speed. The photon-monopole coupling constant thus becomes: $\alpha_g = g^2\beta^2$, in the case $n = 1$.

The spin 1 Dirac monopole diffractive production via the two-photon fusion can be easily added into the FPMC generator. Just we need realize the following schema:

• You generate the diffractive W pair production $\gamma\gamma$ fusion. The WW production is switched on with a standard process IPROC=12030.

• Then you should replace mass of W on the monopole mass through RMASS(198)= monopole mass.D0.

• The next step is replacement the electromagnetic coupling constant α on the monopole coupling to photons α_g in the production subprocess cross section $\gamma\gamma -> W+W-$.

• And finally it is necessary to recompile and run ./module_reco < Datacards/dataQEDMonopole with following main parameters TYPEPR='EXC', TYPINT='QED', ECMS=14000, IPROC= 16030, NFLUX=15, AAANOM=10.

By varying the monopole mass in the `module_reco.f` file, we obtain the dependence of the $\gamma\gamma$ production cross-section on the monopole mass as shown in Fig. 1. In Fig. 2 – Fig. 4 we show representative distributions of the monopole-antimonopole pairs with masses of 500 GeV and 1500 GeV obtained with FPMC.

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[2] It should be noted that in the experiment at HERA, a monopole–antimonopole pair was assumed to be produced by the process $e^+p \longrightarrow e^+M\overline{M}p$ via the interactions of photons emitted from each positron and proton [9].

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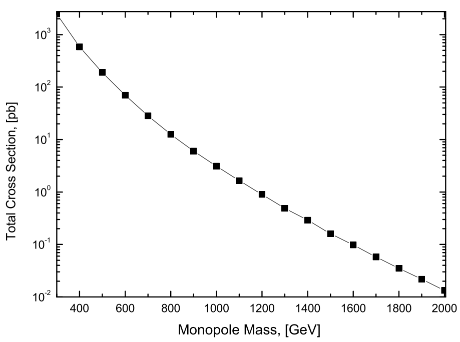

Figure 1: Diffractive monopole production via $\gamma\gamma$ fusion in pp-collisions at $\sqrt{s} = 14$TeV.

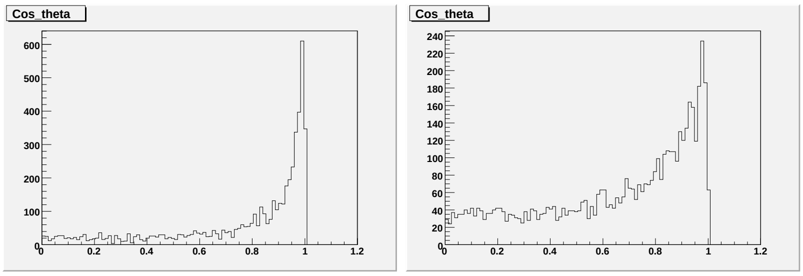

Figure 2: Monopole and antimonopole pair distributions as a function of $\cos\theta$ for monopole/antimonopole masses of 500 GeV (left) and 1.5 TeV (right).

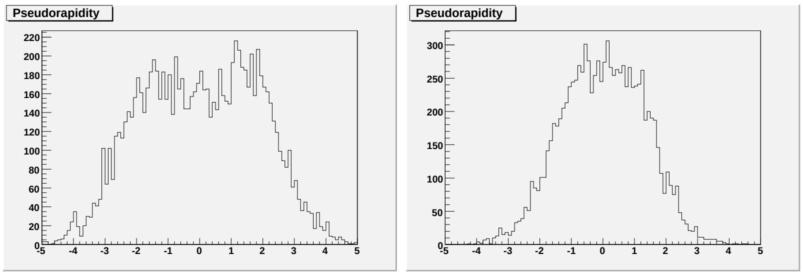

Figure 3: Monopole and antimonopole pair distributions as a function of pseudorapidity for monopole/antimonopole masses of 500 GeV (left) and 1.5 TeV (right).

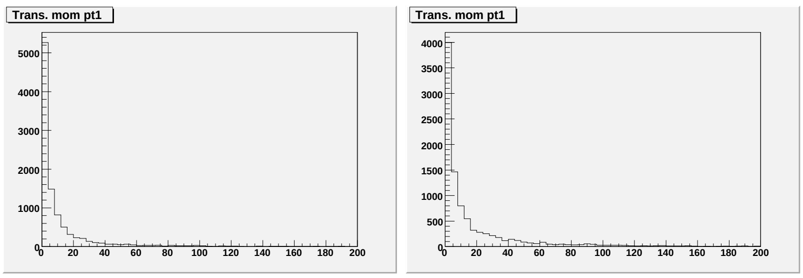

Figure 4: Monopole and antimonopole pair distributions as a function of p_T for monopole/antimonopole masses of 500 GeV (left) and 1.5 TeV (right). High p_T values for the given monopole masses would ensure high detection efficiency.