

# Evidence for dark gluon in three dark showers event at the LHC

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## 1 Motivation

The dark matter (DM) models with freeze-out mechanism of Weakly Interacting Massive Particle (WIMP) are overwhelming for both theoretical and experimental communities in the past decades. However, we don't find any evidence based on this picture. Especially, for the Energy Frontier, the mono-X searches at the large hadron collider (LHC) are the icon of WIMP-type DM. Unfortunately, we also don't receive any positive evidence of this kind of searches until now. It's time to open our mind to consider different types of dark sector models and their exotic signatures at the LHC. The dark sectors may be even more complicate than the ones we previously expected. Especially, it is also possible that there are new gauge symmetries in dark sectors. Among these dark sector models with hidden gauge symmetries, dark QCD model [1] is well-motivated and rich in phenomenological studies. Similar to the structure of QCD, dark quarks in this model can form different kind of dark mesons and bayrons from the confinement mechanism. The stable dark hadron would be the dark matter candidate. On the other hand, if the mass scale of these dark hadrons are around  $\mathcal{O}(10)$  GeV, this sort of dark QCD models can naturally connect with the concept of asymmetry dark matter [2] to further explain the matter-antimatter asymmetry problem in the universe. Besides, confinement in dark sectors may also trigger strong first-order phase transition and can be detected at gravitational wave experiments [3].

## 2 Proposal

Exporting dark QCD properties via different portal models at the LHC is an exciting prospect. The s-channel leptophobic  $Z'$  and t-channel bi-fundamental complex scalar  $\Phi$

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with  $SU(3)_c$  and  $SU(N)_d$  symmetries are two popular mediators connecting dark QCD sector with SM sector. Depending on the lifetime and decay modes of dark hadrons, the new physics signatures at the LHC can be classified into three types : emerging jets [4], semi-visible jets [5,6] and dark jets [7]. As we known, the dark gluon( $g_v$ ) is an indispensable ingredient in dark QCD models. However, the previous studies for two dark showers event with two dark quarks ( $q_v\bar{q}_v$ ) in the final state cannot directly look for the evidence of dark gluon at the LHC. In this proposal, inspired from the studies of  $e^+e^- \rightarrow q\bar{q}g$  process at lepton colliders for the three jet event [8], we suggest to search for the three dark showers event ( $q_v\bar{q}_vg_v$ ) at the LHC for the evidence of dark gluon. The goal of this proposal is two-fold :

- The three dark showers event may indicate the spin of dark gluon via the type of EllisKarliner angle [8] such that we can further make sure if the dark sector is QCD-like or not.
- The topologies of three dark showers event for s-channel and t-channel portal models are different. It can further help us to distinguish the production mode of dark showers event is either from s-channel portal or t-channel portal.

## References

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