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Understanding the Early Universe: interplay of theory and collider experiments

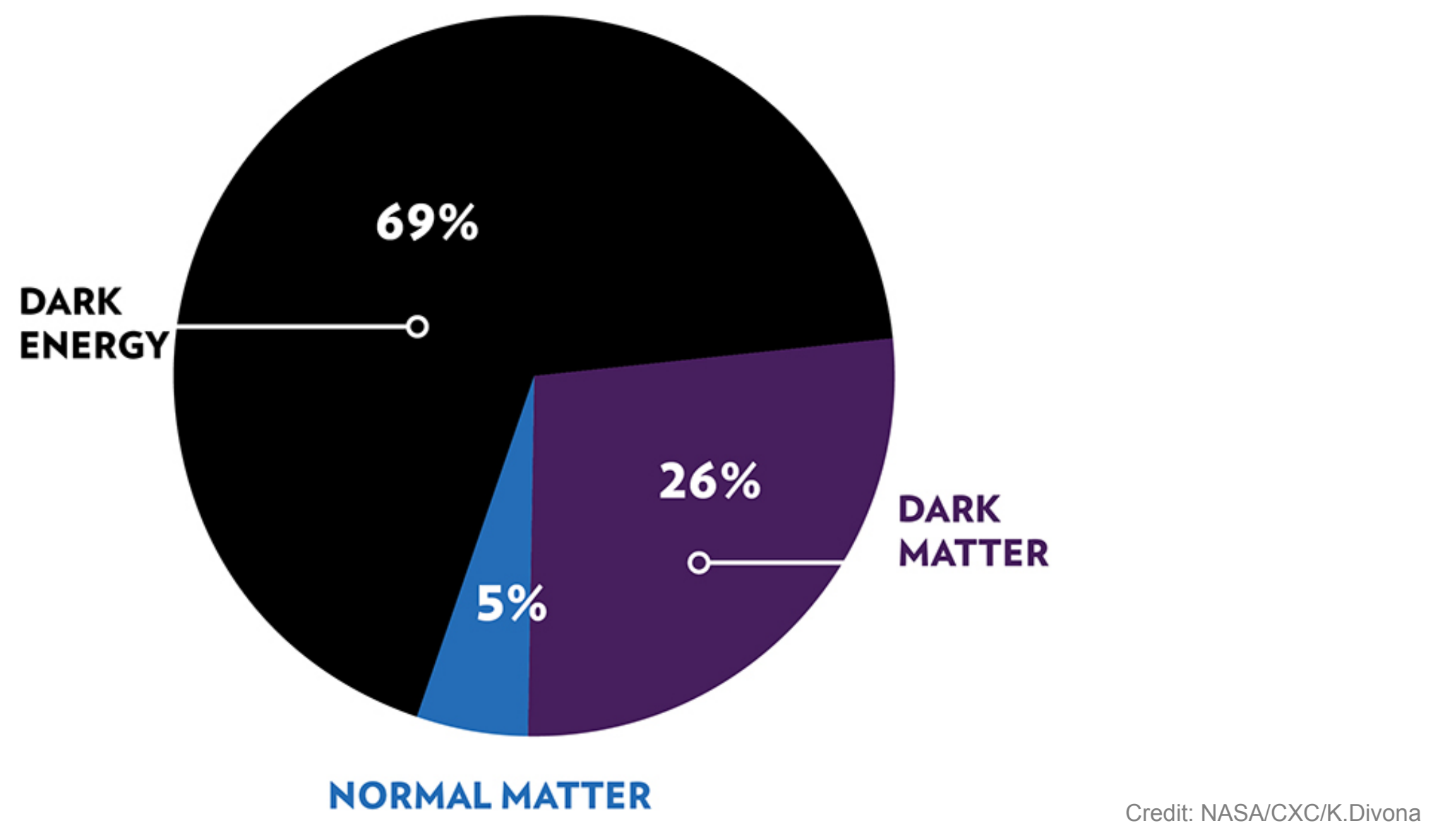
Based on:

LHC constraints on electroweakino dark matter revisited. Iñaki Lara, Trygve Buanes, Krzysztof Rolbiecki and Kazuki Sakurai.

Monojet signatures from gluino and squark decays. Iñaki Lara, Trygve Buanes, Rafal Maselek, Mihoko M. Nojiri, Krzysztof Rolbiecki and Kazuki Sakurai.

Iñaki Lara Perez (University of Warsaw)

The high energy particle colliders create in the laboratories conditions similar to those existing in the very early universe, right after the BIG BANG, when it was filled with a hot dense plasma. The proton collision energies in the Large Hadron Collider (LHC) in Geneve are similar to the collision energies of the particles in the plasma 10^(-12) sec after the BIG BANG. There are several good reasons to expect that some very important processes have occurred in the universe at those tiny moments after the Big Bank. One of them is the creation of Dark Matter.



Credit: NASA/CXC/K.Divona

Most of the content that fills the universe is still unknown.

Approximately 85% of the matter content of the universe is composed by an electromagnetically neutral, non-baryonic matter species, generically referred to as Dark Matter (DM). In the Standard Model of elementary interactions there is no candidate for dark matter particles. Their existence requires physics going beyond the Standard Model which is relevant at energies higher than so far well explored and successfully described by the Standard Model, such as those in the hot plasma of the early universe and also accessible at the LHC.

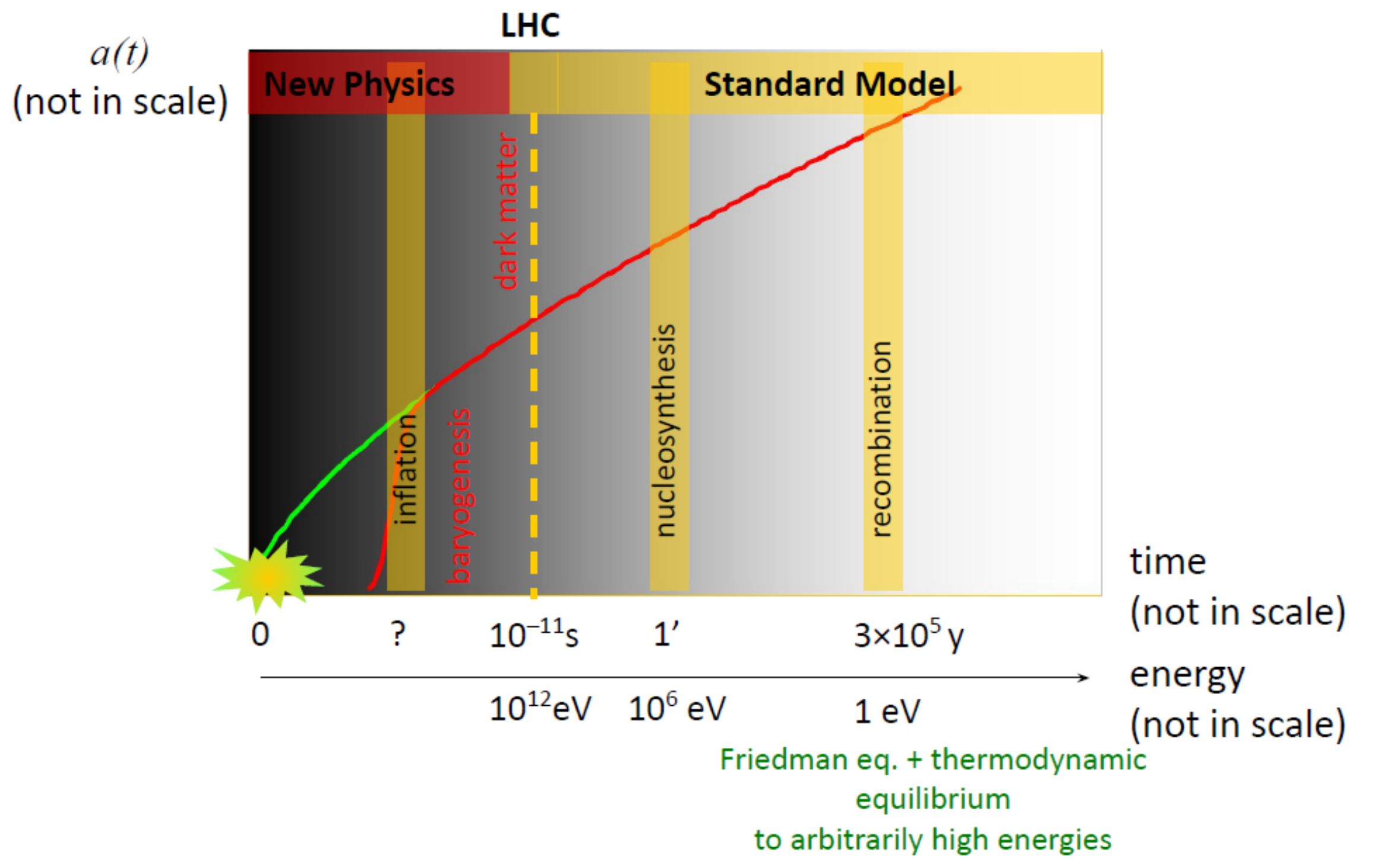
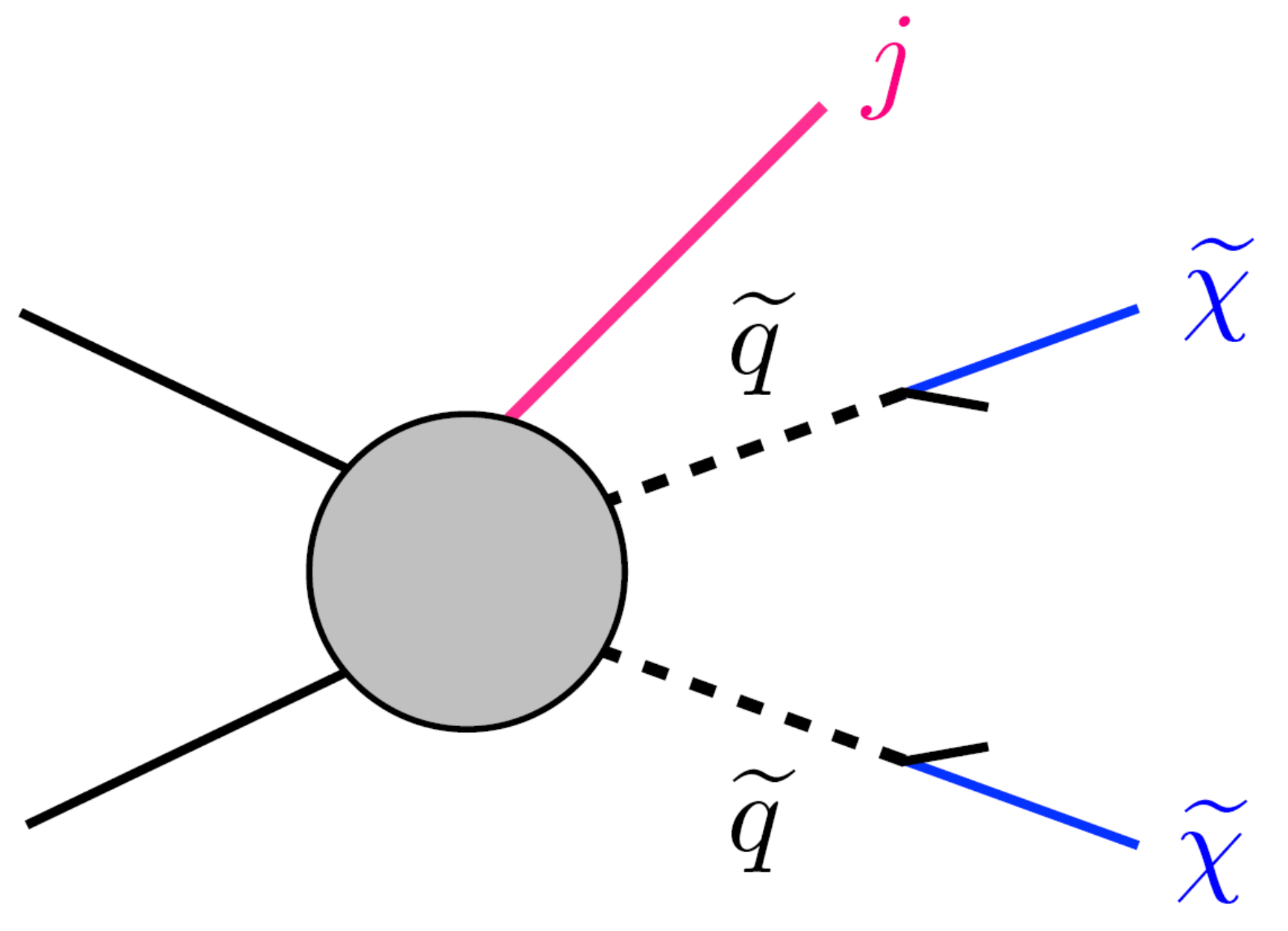


Illustration of the correspondence between the collider energies and the time scales in the evolution of the universe

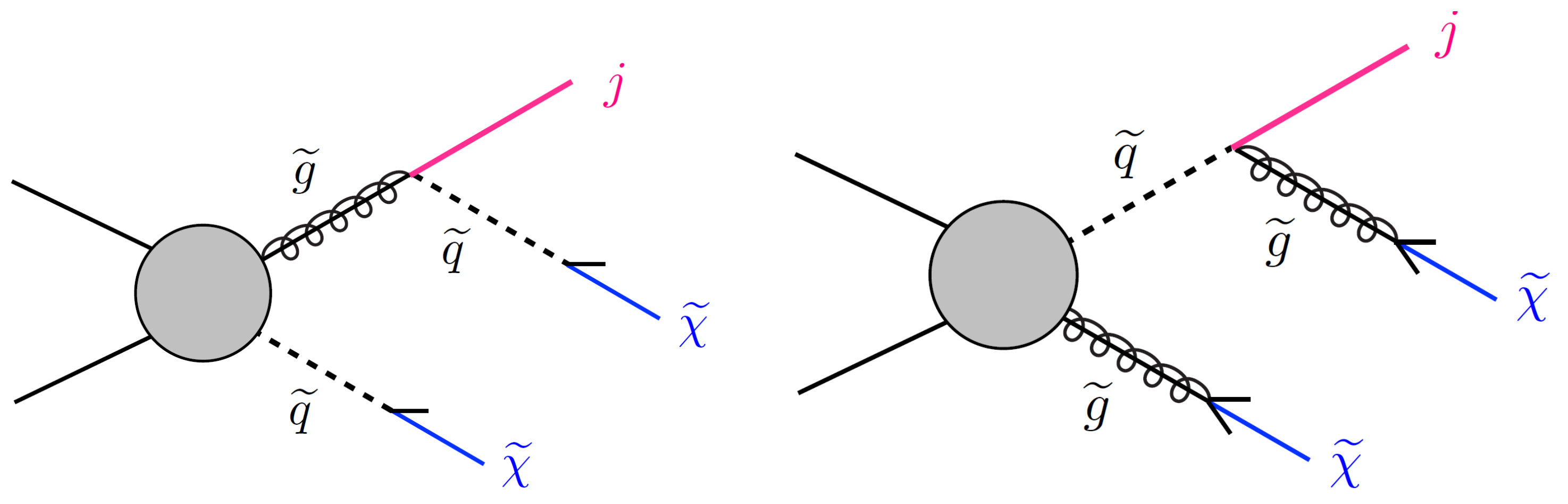
Thus, the same interactions that mediate the process of dark matter production in the early universe can be tested at collider experiments at the LHC.



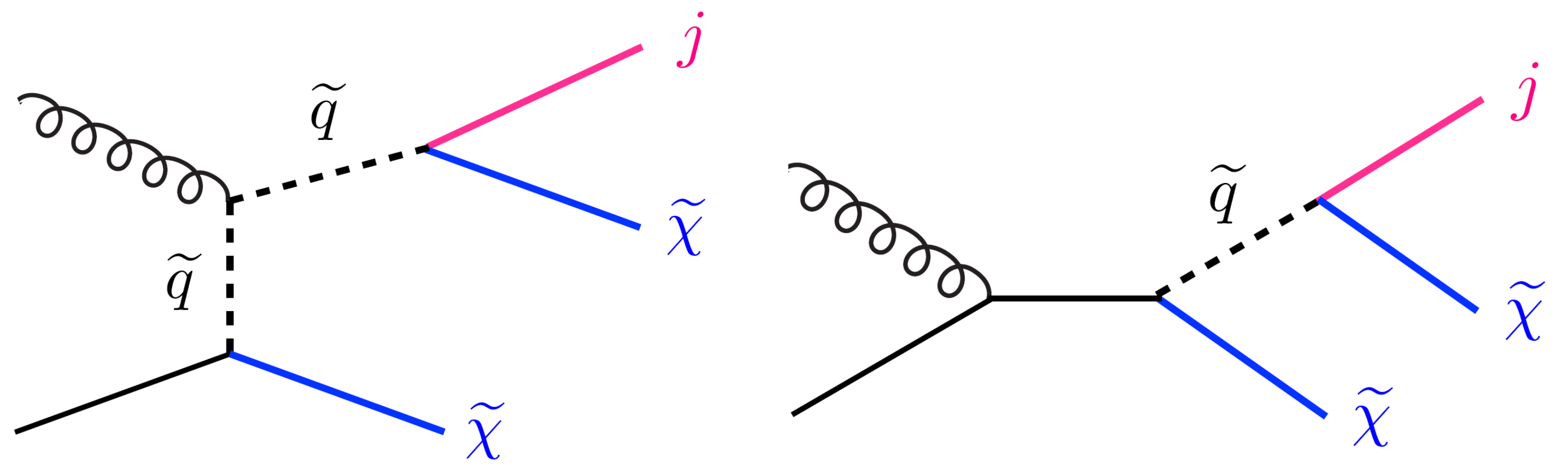
To identify DM at colliders we need to look at the rest of the particles produced.

The main challenge in such searches is the fact that dark matter particles are invisible for the detectors.Therefore, to identify the dark matter production at colliders, one has to assemble a puzzle of visible particles produced at the same time to single out the missing piece. Several new physical scenarios have been studied with new interesting signals to appear in combination with the production of dark matter. These collider signals, not yet experimentally tested, will help to gain insight to the physical models that explain the mechanism of dark matter production after the Big Bang.

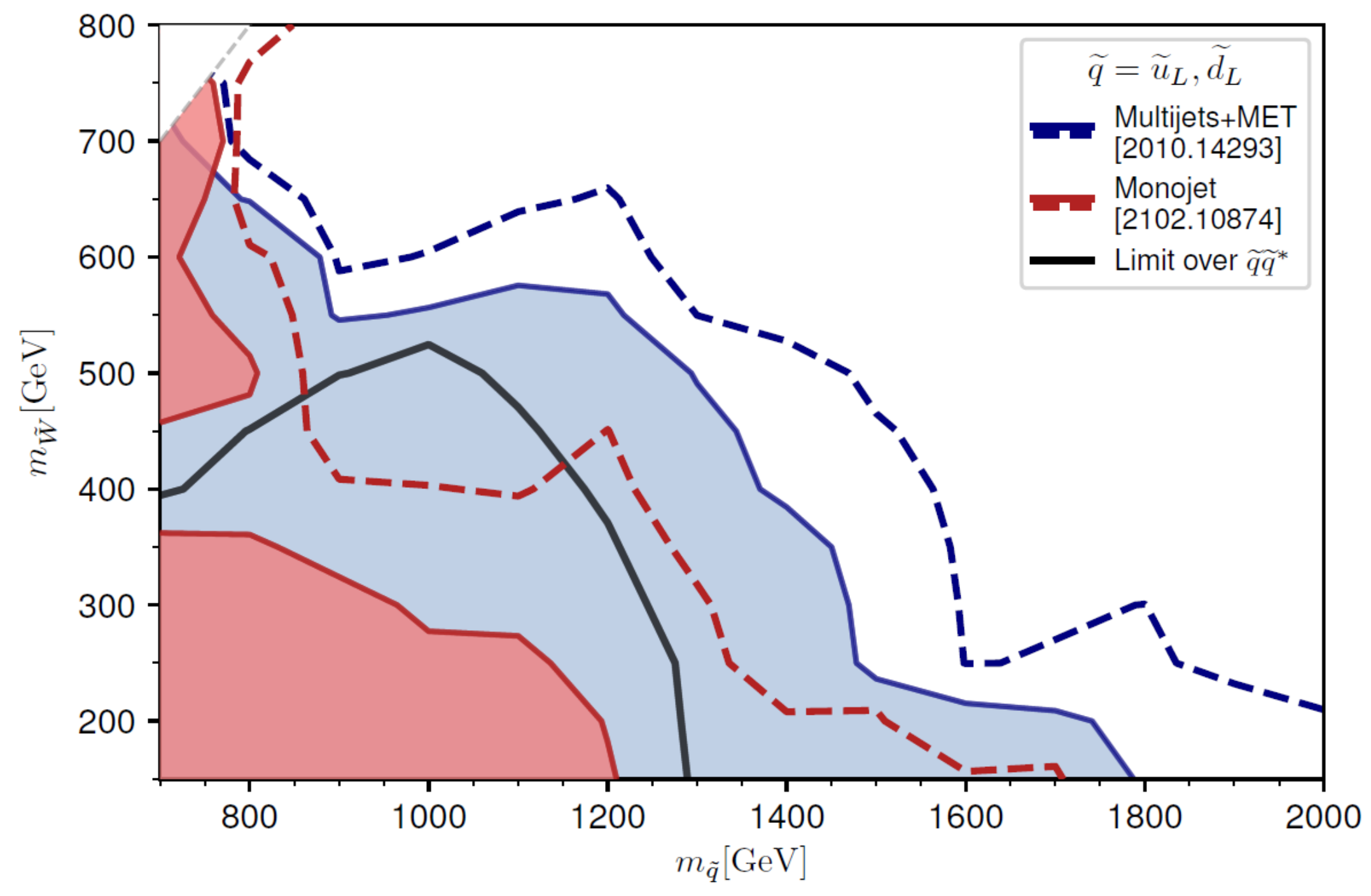
The physics beyond the standard model proposed in this work predicts the existence of extra particles additionally to the DM particles. This extra matter will help in the process of Dark Matter creation after the BIG BANG. Additionally, the extra exotic matter will be produced at the LHC. Our theoretical extension is characterized by predicting extra exotic matter and dark matter with similar masses. At the LHC this will cause the new particles to remain hidden together with the DM. We explore some interesting interactions that can make visible the DM and this extra exotic matter.



The so-called *gluinos* and *squarks* can be created together at the LHC. The visible signal in the detectors of the LHC will be the energetic stream of mesons and baryons produced from an ejected quark.



The dark matter particles can be sometimes created together with the *squark* at the LHC



This process will be visible for a large range of masses of the new matter.

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