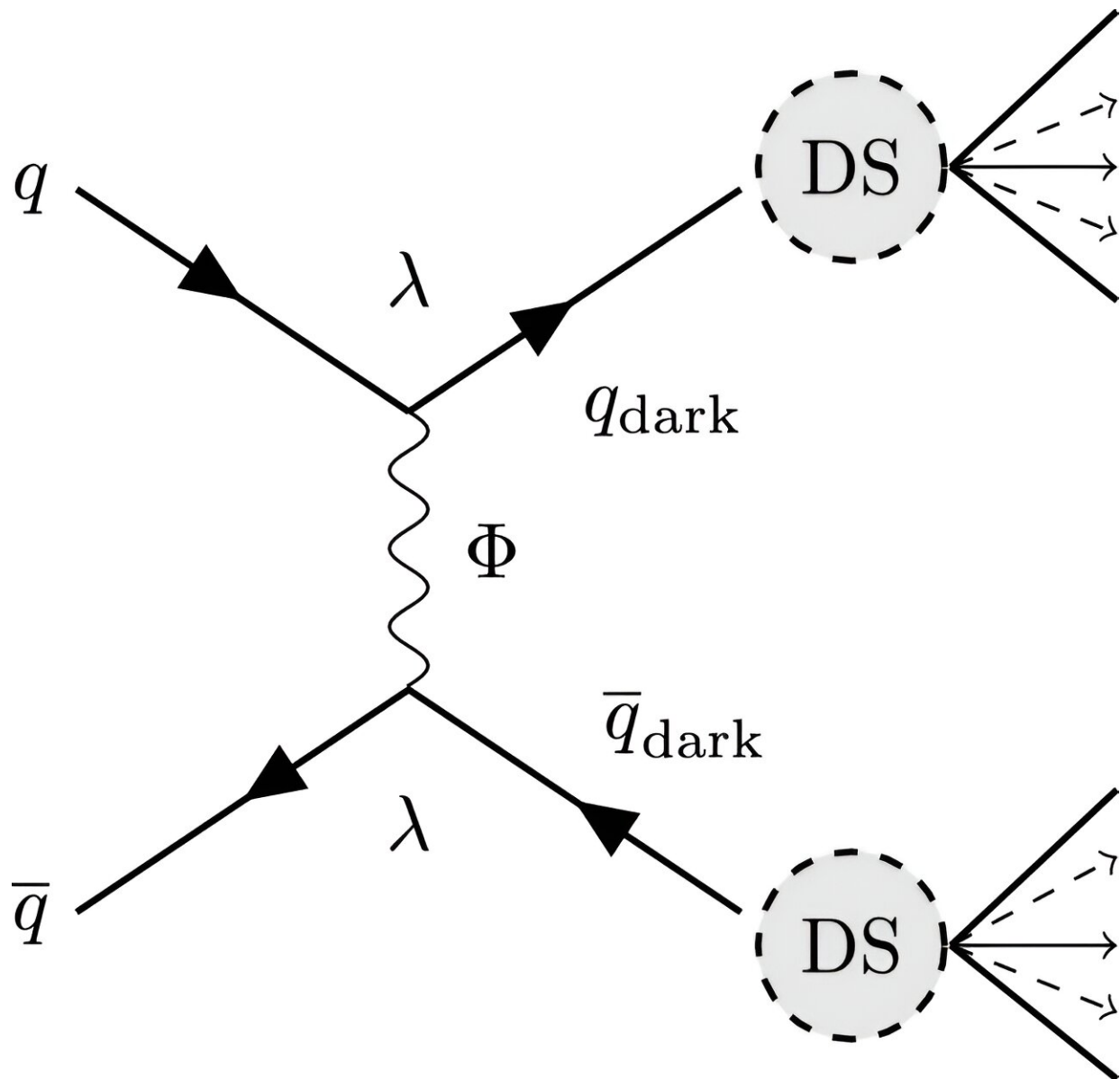


Researchers pioneer a new way of searching for dark matter

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A diagram illustrating the production of semi-visible jets via a t-channel mediator, Φ , producing a pair of dark quarks, labeled q_{dark} . DS denotes the dark shower which produces a final state consisting of SM hadrons and dark hadrons, governed by the R_{inv} fraction. The coupling strength of the q - q_{dark} - Φ interaction is denoted by λ . Credit: *Physics Letters B* (2023). DOI: 10.1016/j.physletb.2023.138324

The existence of dark matter is a long-standing puzzle in our universe. Dark matter makes up about a quarter of our universe, yet it does not interact significantly with ordinary matter.

The existence of [dark matter](#) has been confirmed by a series of astrophysical and cosmological observations, including in the stunning recent pictures from the James Webb Space Telescope. However, to date, no experimental observation of dark matter has been reported. The existence of dark matter has been a question that astrophysicists around the world have been investigating for decades.

"This is the reason we do research in [basic science](#), probing the deepest mysteries of the universe. The Large Hadron Collider at CERN is the largest experiment ever built, and [particle collisions](#) creating Big Bang-like conditions can be exploited to look for hints of dark matter," says Professor Deepak Kar, from the School of Physics at the University of the Witwatersrand in Johannesburg, South Africa.

Working at the ATLAS experiment at CERN, Kar and his former Ph.D. student, Sukanya Sinha (now a postdoctoral researcher at the University of Manchester), have pioneered a new way of searching for dark matter. Their research has [been published in the journal, *Physics Letters B*](#).

"There have been plethora of collider searches for dark matter over the

past few decades so far have focused on weakly interacting [massive particles](#), termed WIMPs," says Kar. "WIMPs is one class of particles that are hypothesized to explain dark matter as they do not absorb or emit light and don't interact strongly with other particles. However, as no evidence of WIMPs' has been found so far, we realized that the search for dark matter needed a paradigm shift."

"What we were wondering, was whether dark matter particles actually are produced inside a jet of standard model particles," said Kar. This led to the exploration of a new detector signature known as semi-visible jets, which has also been searched for by the CMS collaboration in [JHEP 2206 \(2022\) 156](#) in a different production mode.

High energy collisions of protons often result in the production of a collimated spray of particles, collected in what is termed as jets, from the decay of ordinary quarks or gluons. Semi-visible jets would arise when hypothetical dark quarks decay partially to standard-model quarks (known particles) and partially to stable dark hadrons (the "invisible fraction").

Since they are produced in pairs, typically along with additional Standard-Model jets, the imbalance of energy or the missing energy in the detector arises when all the jets are not fully balanced. The direction of the missing energy is often aligned with one of the semi-visible jets.

This makes searches for semi-visible jets very challenging, as this event signature can also arise due to mis-measured jets in the detector. Kar and Sinha's new way of looking for dark matter opens up new directions into looking for the existence of dark matter.

"Even though my Ph.D. thesis does not contain a discovery of dark matter, it sets the first and rather stringent upper bounds on this production mode, and already inspiring further studies," says Sinha.

More information: G. Aad et al, Search for non-resonant production of semi-visible jets using Run 2 data in ATLAS, *Physics Letters B* (2023). [DOI: 10.1016/j.physletb.2023.138324](https://doi.org/10.1016/j.physletb.2023.138324)

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