

## SCENARIO 2024 (Dark Matter discovery)

The ATLAS and CMS experiments at the CERN LHC have analysed the first years of Run 3 data, combining with the full Run 2 data sets, using advanced 'machine learning' techniques, yielding tantalising evidence for a new particle that could be responsible for "Dark Matter". This could be the first evidence of the long-awaited Physics beyond the Standard Model. These are fresh results, so the scientists are being cautious about making definitive claims, but there is a very high likelihood that the discovery is real. The LHC experiments continue to collect more data right now. These data will allow confirmation of the signal or disprove it.

The exact nature of the dark matter candidate is yet unknown. A possible explanation is the theory of Supersymmetry (SUSY) but other theories are not excluded.

(For reference, only about 5% of the universe is in the form of normal matter, i.e. stars, planets, etc.; about 25% is Dark Matter; and the remaining 70% is so-called "Dark Energy".)

### More information

In this scenario, you are working on one of the two experiments and being interviewed about the discovery.

Both experiments have seen events with many jets and large missing transverse energy at a rate significantly above what is expected in the Standard Model. The combined significance is 5.2 sigma, although each individual experiment only sees an effect of less than 5 sigma. More data will be needed before definitive claims can be made, but there is a lot of discussion in the physics community that has been picked up by the press.

In more detail, the results in your experiment are based on two zero-lepton analyses, i.e. analyses that veto isolated leptons. One analysis considers events with 2–6 jets, while the other one requires 7–10 jets; in both cases large missing transverse energy is required. Each of these two analyses has a significance of about 4 sigma. Correlations in the background modelling between the two channels are still being finalised before publication. The main improvement with respect to earlier Run-2 analyses, comes from the introduction of adversarial neural networks to reduce the impact of pileup, thus improving the missing-transverse-energy resolution. The use of the Run 3 data also benefits from improvements in the trigger, with increased use of GPUs.

You don't have much detail about the analysis of the other experiment, but you are aware that a signal excess of about 4.5 standard deviations is observed. You know that this is from a zero-lepton search requiring high jet multiplicity and large missing transverse energy.

*You know details that you are not allowed to discuss in public from your own experiment. A search looking for events with two same-sign leptons plus missing transverse energy has a significant excess of more than 5 sigma by itself. However,*

*there are some issues with the background determination method that are still being sorted out.*