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## Multi-messenger astroparticle physics through hierarchical modelling

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The goal of multi-messenger astroparticle physics is to bring together observations and constraints from different messengers into a consistent physical picture, allowing us to test theoretical predictions and deepen our understanding. This is no easy task, with data from very different instruments, possible explanations from a range of complex models, unknown source populations and selection effects at play. I will show how we can leverage Bayesian hierarchical modelling as a statistical technique to address these challenges and use data to constrain models with more of what we know about the problem built in. As a concrete example, I will present a hierarchical model for the association of ultra-high-energy cosmic rays to potential astrophysical sources. This demonstrates that the inclusion of more information (energies as well as arrival directions) has a strong impact on the results. Coming back to the multi-messenger problem, I will also mention current work on the extension of these ideas to neutrino and gamma-ray data and how such a framework can help us to ask the right questions for the data we have.

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