

# Rational functions yield better approximations than polynomials in HEP applications

## Scientific Achievement

First algorithm for pole-free multivariate rational approximations (RAs).

## Significance and Impact

RAs are more flexible and accurate than polynomials when approximating expensive-to-compute HEP simulations.

## Research Details

- HEP simulations are used to understand observed phenomena, but simulations are computationally too expensive for direct use in parameter optimization
- We use rational functions (polynomial divided polynomial) to approximate the simulation
- Two methods for computing RAs: Stieltjes process (may have poles, *Fig. C*); Semi-infinite programming (SIP, pole-free, *Fig. B* at 1/50 of CPU cost)
- SIP yields significantly better approximations of the true data (*Fig. A*) than RAs based on Stieltjes process (*Fig. C*) and polynomial (*Fig. D*)
- Fermilab preprint <https://arxiv.org/abs/1912.02272> to be published in CPC

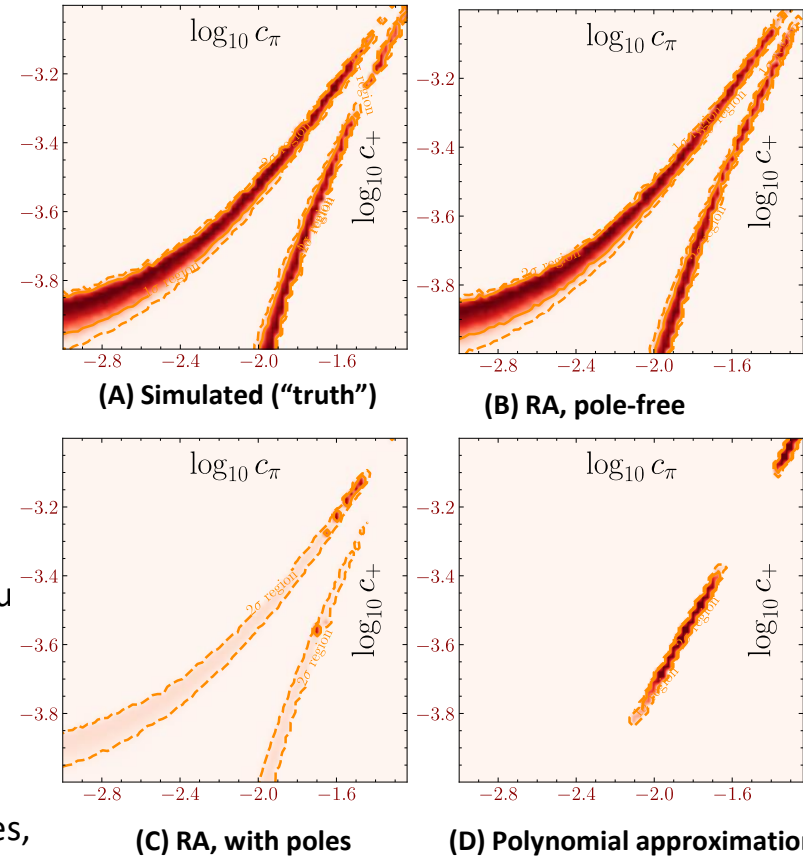


Figure shows the data of direct detection of dark matter by high-fidelity simulation (A), pole free RA (B), and RA with poles (C), and polynomial (D)