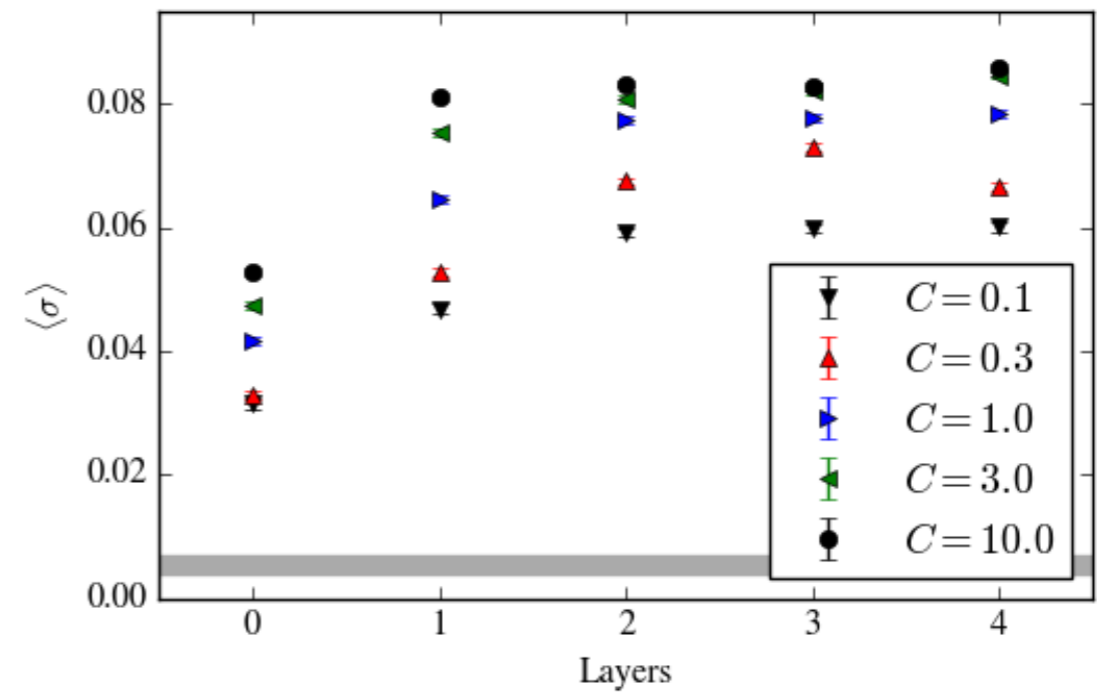
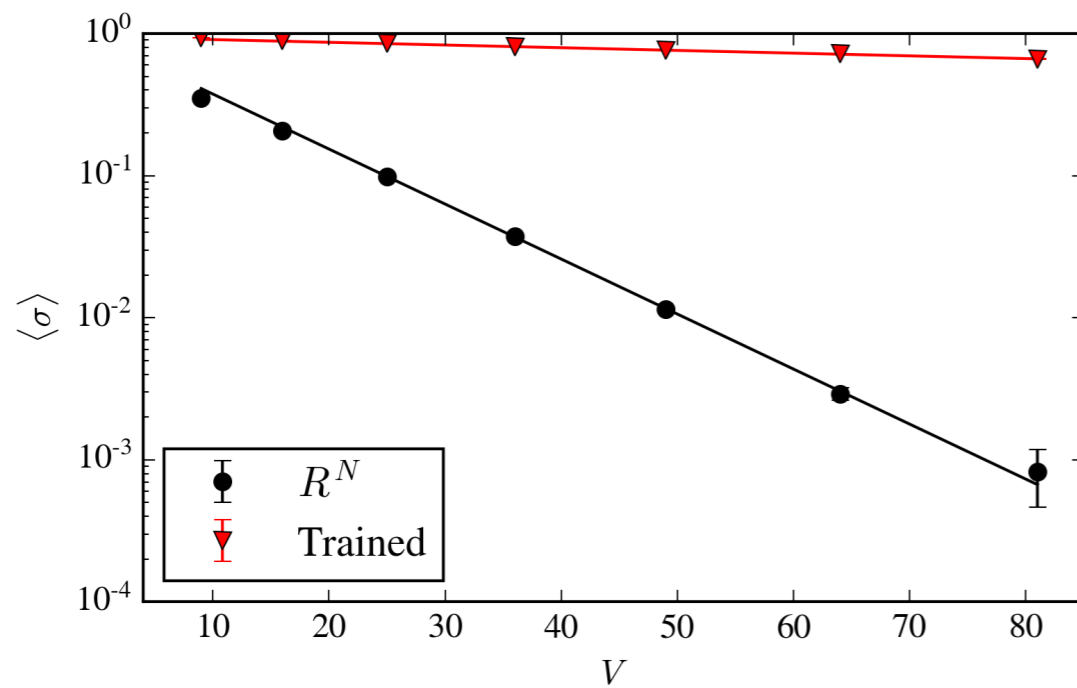


# ML for phase transitions and sign problem mitigation: Contour deformation

- 1) Is there a way to determine the maximum improvement in  $\langle \text{sign} \rangle$  or in S-to-N that is achievable through contour deformations and related approaches?
- 2) How can ML be targeted towards such a maximal improvement?
- 3) Are there features of specific observables that make contour deformation particularly effective or ineffective?
- 4) How do contour deformations for one observable/theory translate to other observables/theories?

1) and 2)

- ① Maximal improvement within method itself.
- ② Maximal improvement via machine-learning.



# Integrand choice for contour deformations

Any integrand with equivalent value can be taken as the integrand for deformation ...

1D example: 
$$\int_0^{2\pi} \frac{dz}{2\pi} e^{iz} e^{\beta \cos z} = \int_0^{2\pi} \frac{dz}{2\pi} e^{-iz} e^{\beta \cos z} = \int_0^{2\pi} \frac{dz}{2\pi} \cos z e^{\beta \cos z} = I_1(\beta)$$

... however, some choices appear better than others:

