**SUMMARY**

- The **UNIVERSEACHINE (UM)** is a cosmological model that links dark matter halos to galaxies [1].
- UM is massively parallel and takes over 2M CPU hours to optimize; deep learning captures the model accurately and efficiently.

**DATASET**

- Halo data: 10^6 halos from Bolshoi-Planck cosmological dark matter simulation [2]; 4 features per halo (3D position + \(V_{\text{Peak}}\)).
- Galaxy data: UM-predicted galaxy number density in 32 mass bins.

**METHOD**

- Segment simulation into 3D boxes; bin halos by position; feed binned halo properties into convolutional ResNet; predict SMF.
  
  \[ L = -\left(\langle \log \Phi_{\text{obs}} \rangle - \log \Phi_{\text{pred}} \right)^2 \langle \log \Phi_{\text{obs}} \rangle^{- 1} \left(\log \Phi_{\text{obs}} - \log \Phi_{\text{pred}} \right) \]

- \( \Phi_{\text{obs}} \) (\( \Phi_{\text{pred}} \)): observed (predicted) SMF
- \( \Sigma \): observational covariance matrix
- (...) average over stellar mass bins

**SINGLE-SNAPSHOT RESULTS**

- Loss on training and validation set plateaus after ~5 training epochs.

**OPTIMIZATION**

- Scan over architecture hyperparameters:

<table>
<thead>
<tr>
<th>( N_{\text{channels}} )</th>
<th>( \mathcal{L} )</th>
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<tbody>
<tr>
<td>20</td>
<td>135</td>
</tr>
<tr>
<td>100</td>
<td>93</td>
</tr>
<tr>
<td>200</td>
<td>84</td>
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**FUTURE WORK**

- Connect halos across time by simultaneously predicting SMF at different simulation snapshots.
- Run trained model on independent simulation to test generality of halo \(\rightarrow\) galaxy mapping.

**REFERENCES**