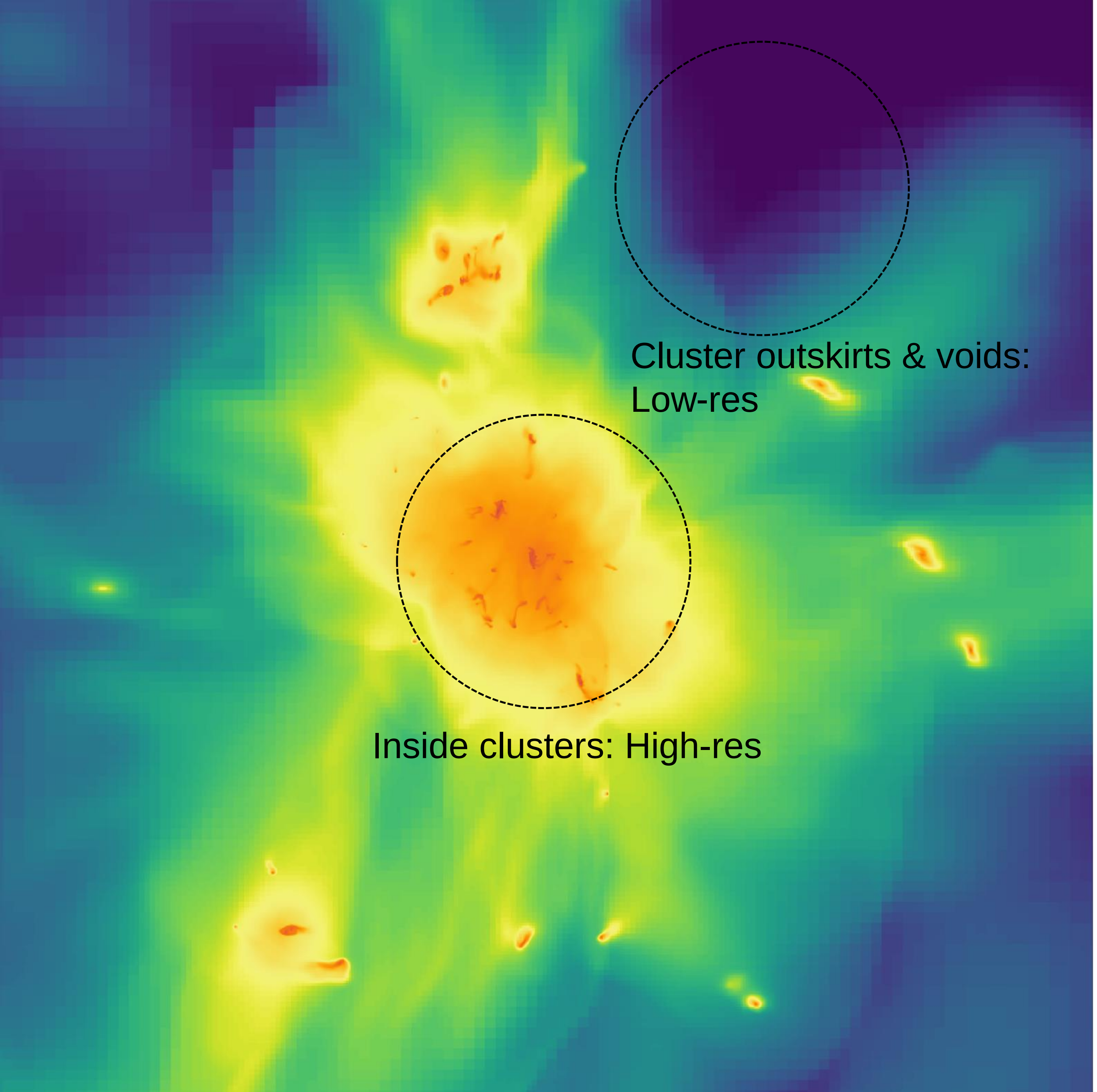
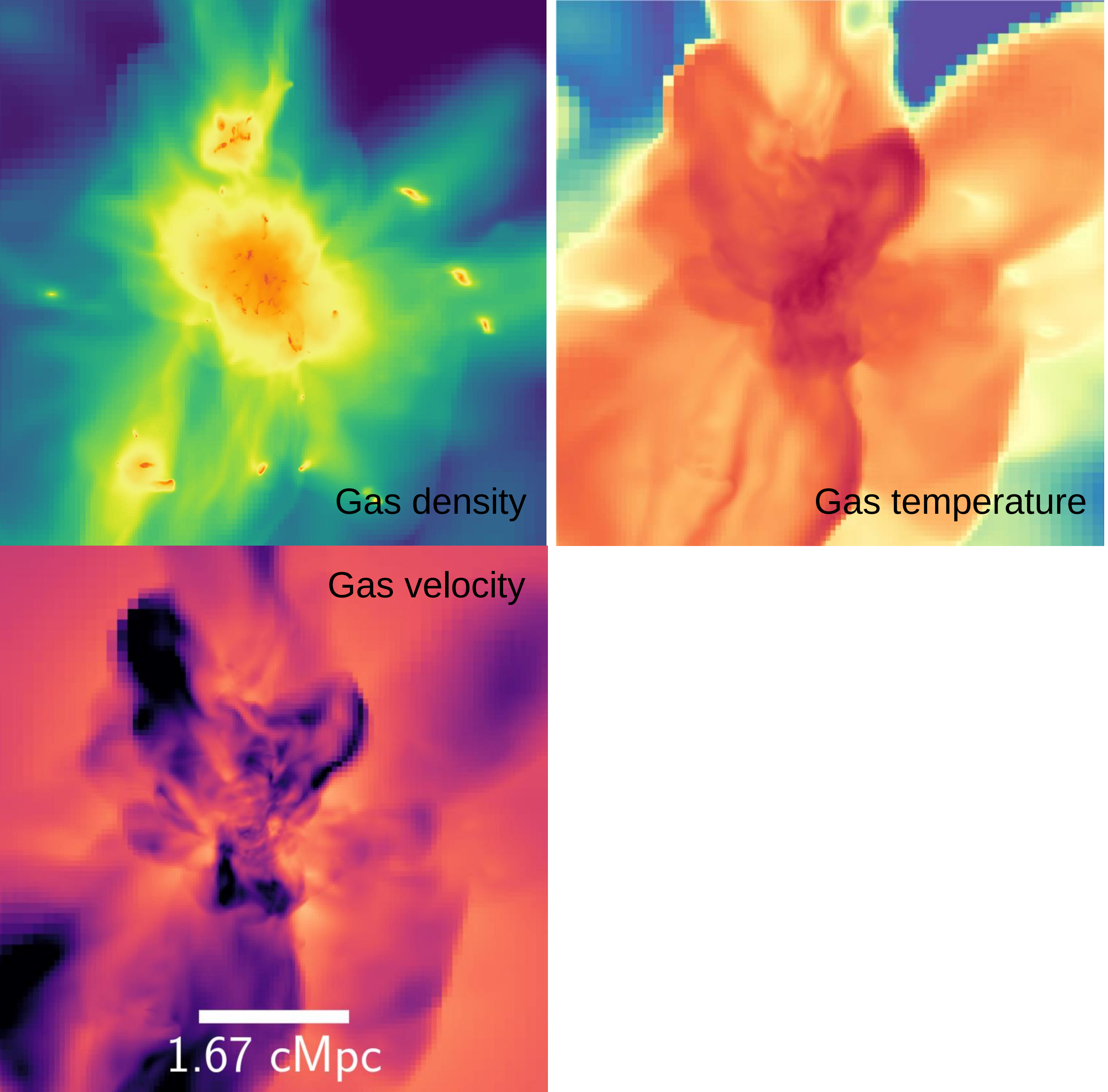


Adaptive Mesh Grid (AMR)
Nature of the Horizon Run 5 Simulation (HR5)

- Start simulation with low-res uniform grids
- Increase the spatial/mass resolution for dense cells

- Possible to achieve high-res for galaxies & substructures with less computational cost

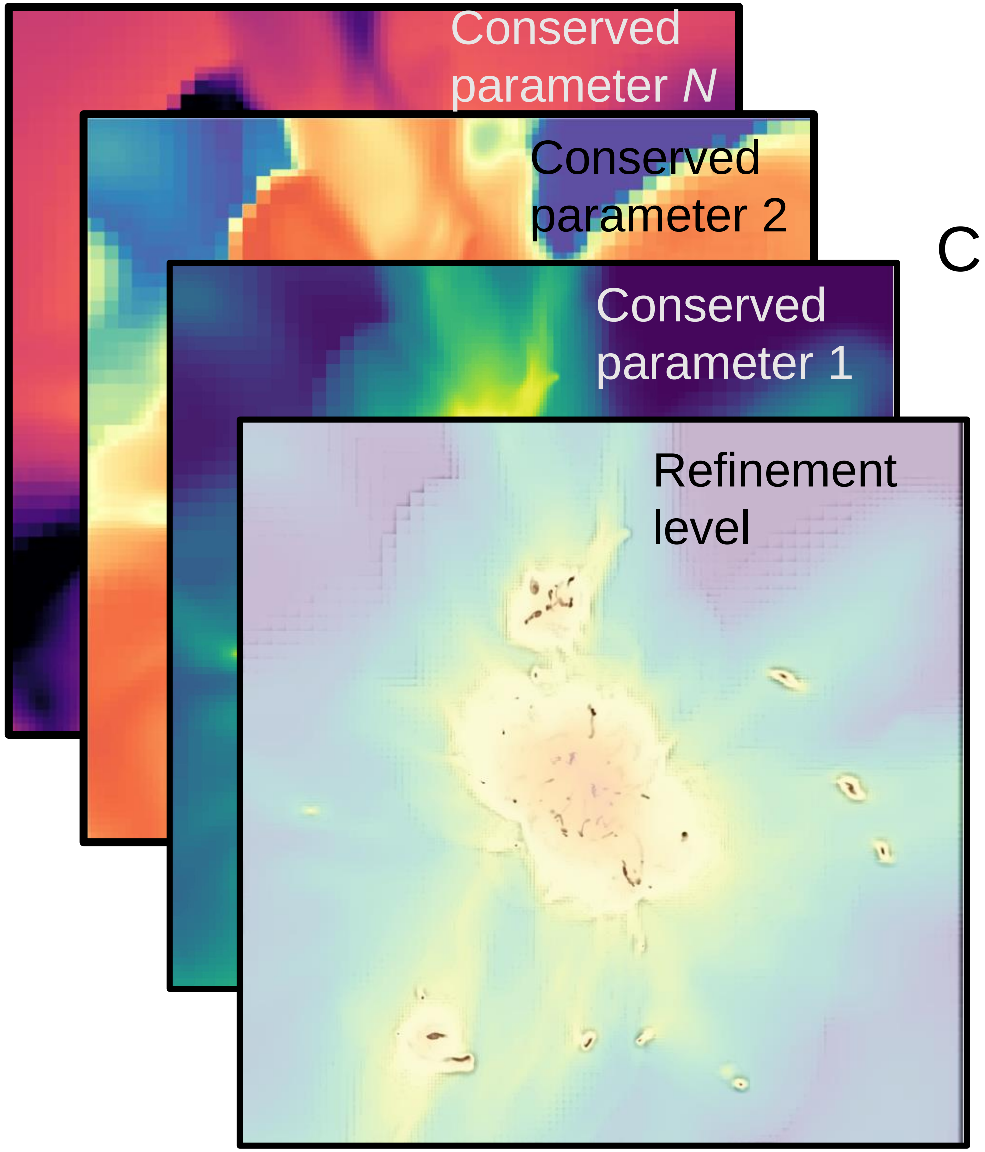
- Hard to statistically compare high-res and low-res cells
(especially if someone is interested in cluster outskirts or voids)
- Artifacts for shock-finding
- Gives poor visualization

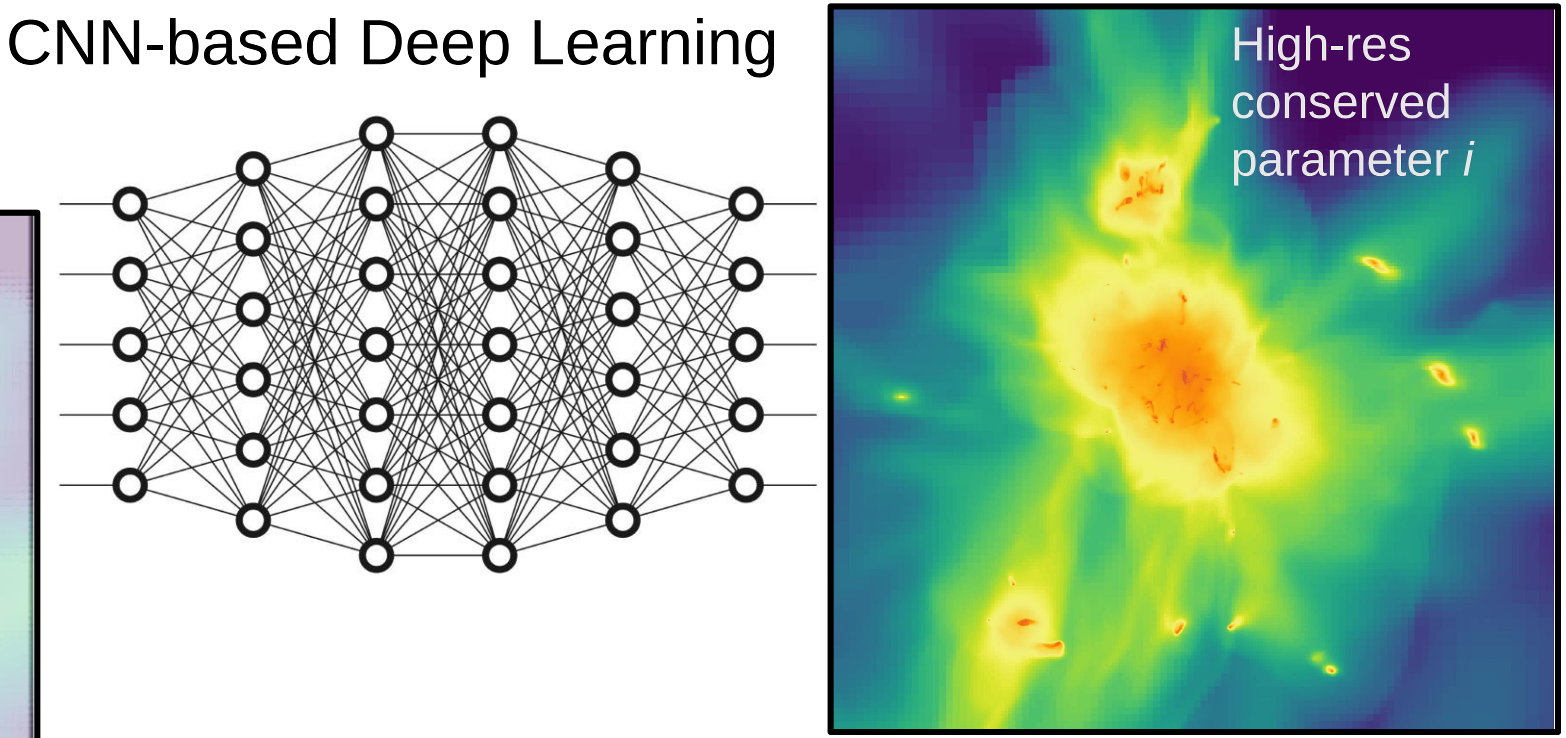


Requirements for **Successful** High-res Reconstruction

- Continuity to nearby high-res cells
  - Easiest part --- even Gaussian smoothing with multiple smoothing length can do this.
- Conservation of fluid equation
  - Note that the value at each grid is “averaged” value over the grid volume, rather than the value “at the grid center”.
  - Therefore, typical smoothing cannot properly reconstruct high-res values.
- No strange small-scale artifacts
  - Since we know there is no small-scale objects in underdense regions.
- Consistency over multiple parameters

→ **Will be hard for classical ways!**

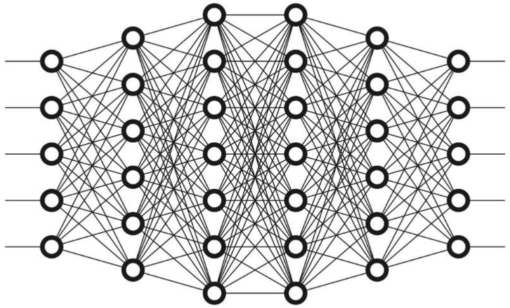




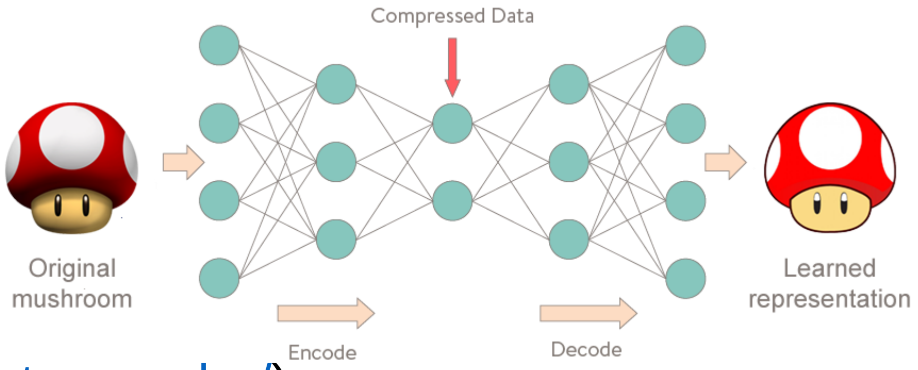
Loss function : Mean Square Error

$$\mathcal{L} = \sum \left(y_{ijk}^{\text{pred}} - y_{ijk}^{\text{truth}} \right)^2$$

Would be okay if the parameters satisfy conservation law.

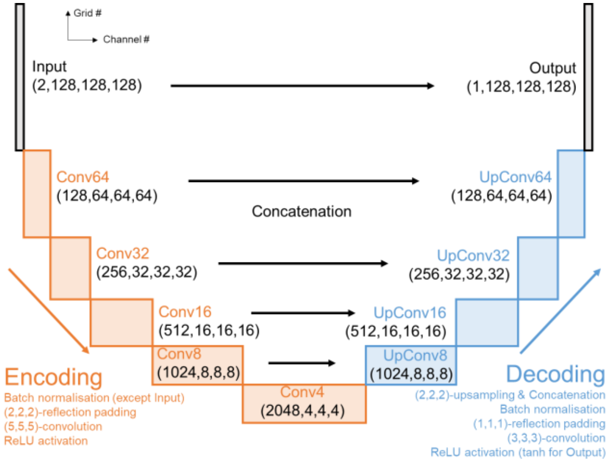


What kinds of Deep Learning Methods?



#1. CNN autoencoder

(see https://keraskorea.github.io/posts/2018-10-23-keras_autoencoder/)



#2. U-Net or V-Net

(see https://arxiv.org/pdf/2008.01738.pdf)

#3. DCGAN

(see https://taeoh-kim.github.io/blog/image2image/)