Machine Learning with ALMA in Preparation for the SKA

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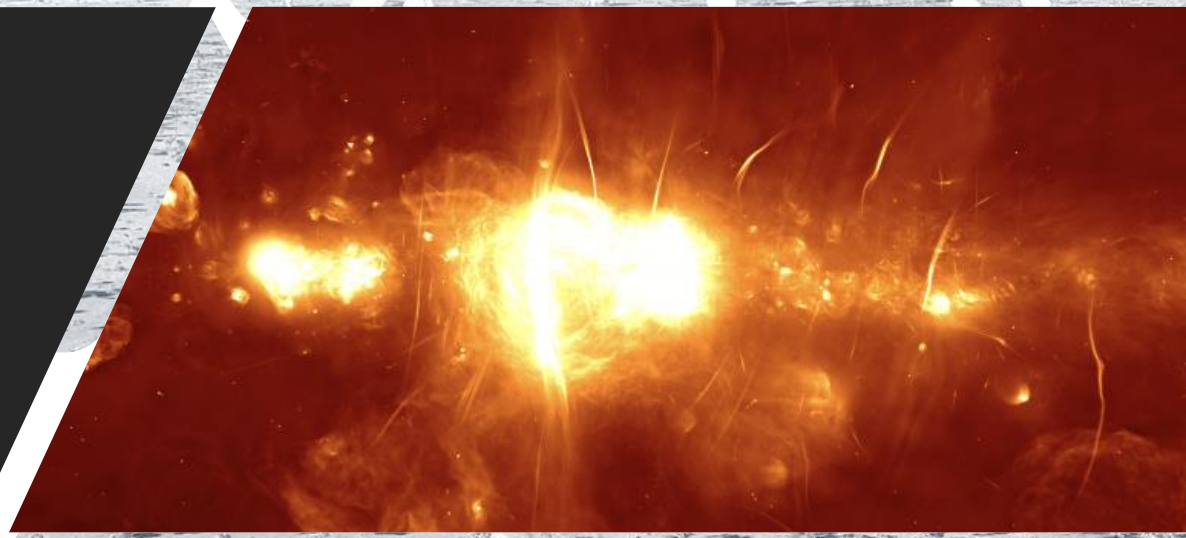
Outline of the talk

- Introduction to the SKA
- Cold gas in galaxies
- How to tackle big data
- EAGLE Project
- Kinematic modelling
- Deep Learning
- The Future

The **S**quare **K**ilometre **A**rray (SKA)

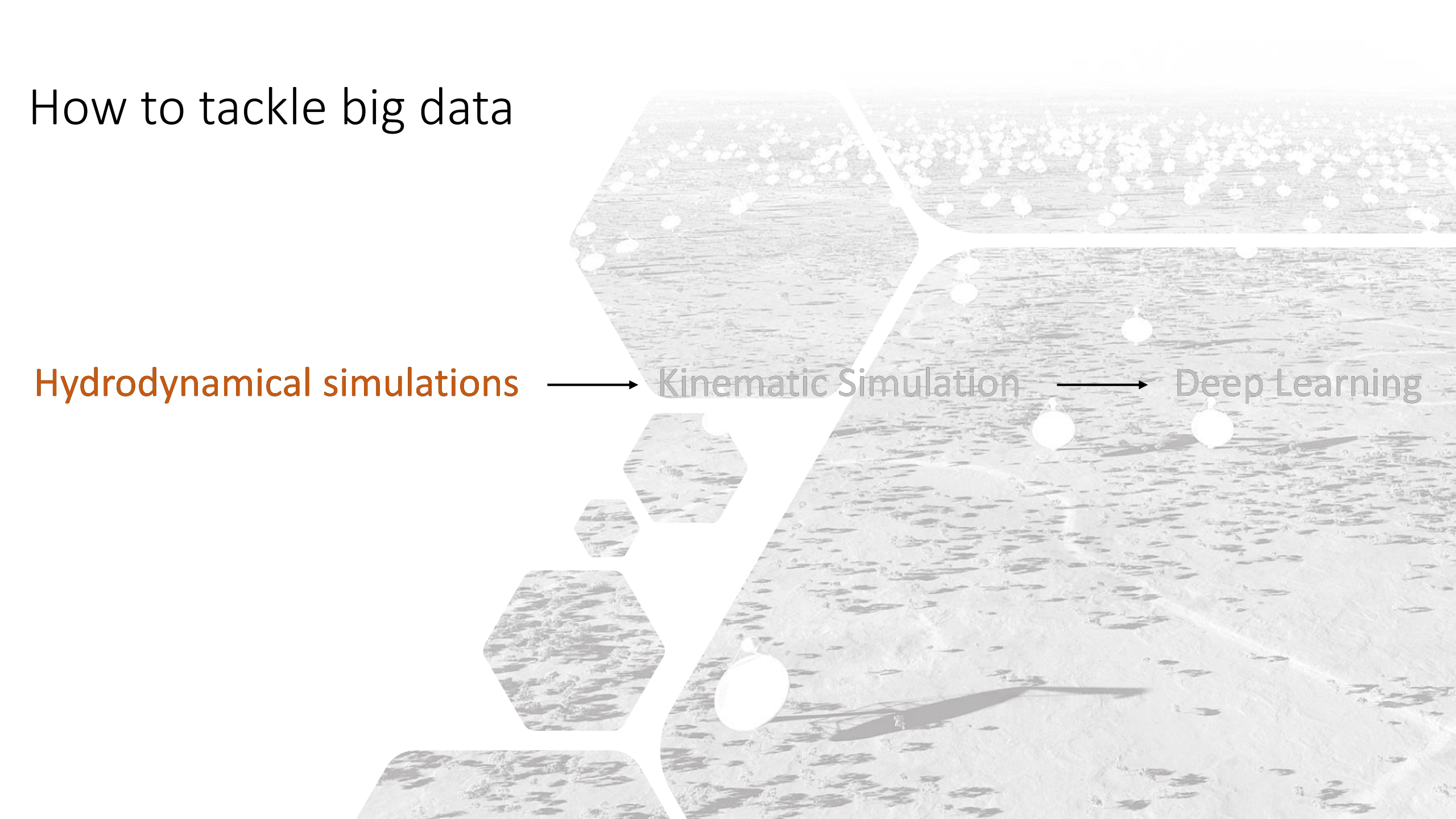
- Largest interferometer in the world
- 160 Terabytes per second
- Primarily observing HI gas for galaxy studies
- Raw data too big to store, requiring fast filtering



Cold Gas in Galaxies

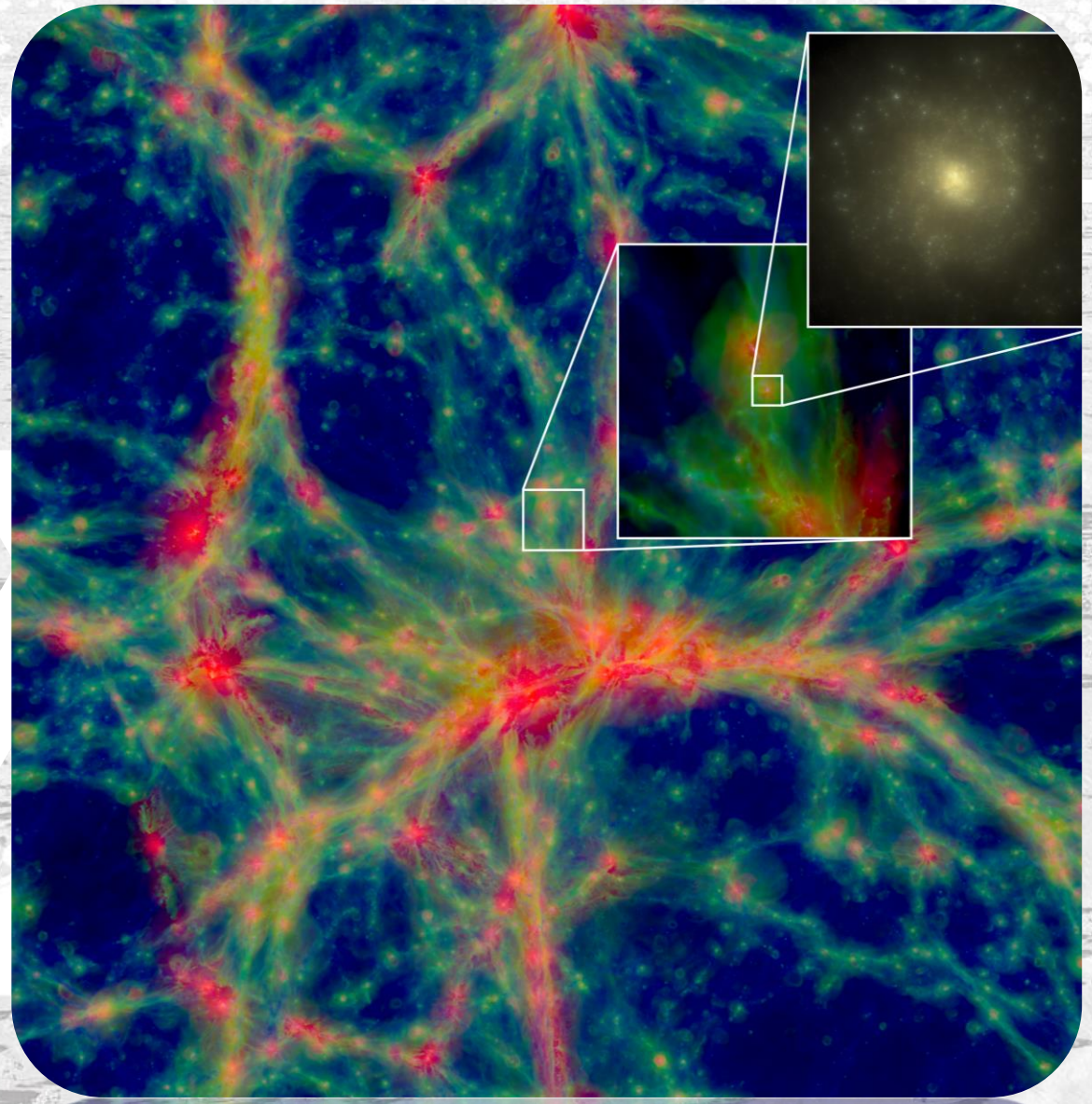
- Data comes in cubes
- Gas is not guaranteed
- Tend to find more cold gas in late-type galaxies
- Gas kinetics could lend information to galaxy evolution

How to tackle big data



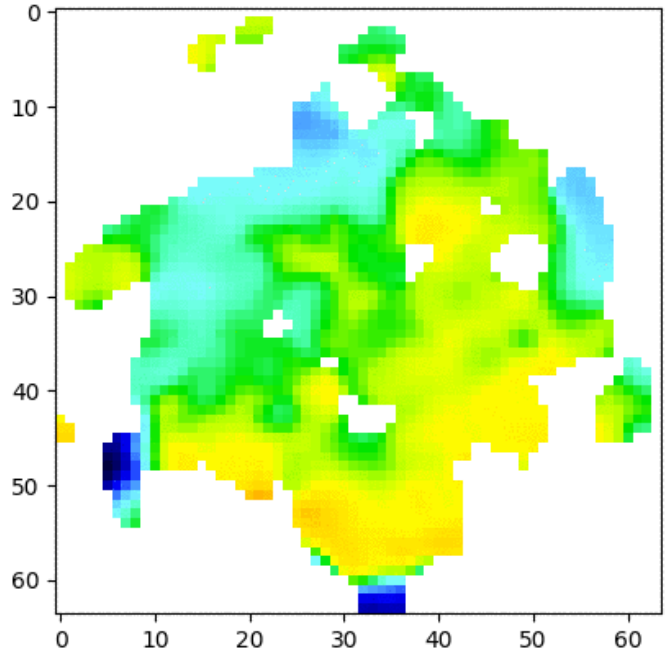
EAGLE Project

- Evolution and Assembly of GaLaxies and their Environments
- Closed volume λ cold dark matter Universe
- 25, 50, and 100 Mpc cubed simulations
- 28 snapshots per simulation



Kinematic modelling

- KinMS[1] (KINematic Molecular Simulation)
- Tailored to match ALMA observations
- Natural data augmentation
- Galaxies are saved in FITS cubes



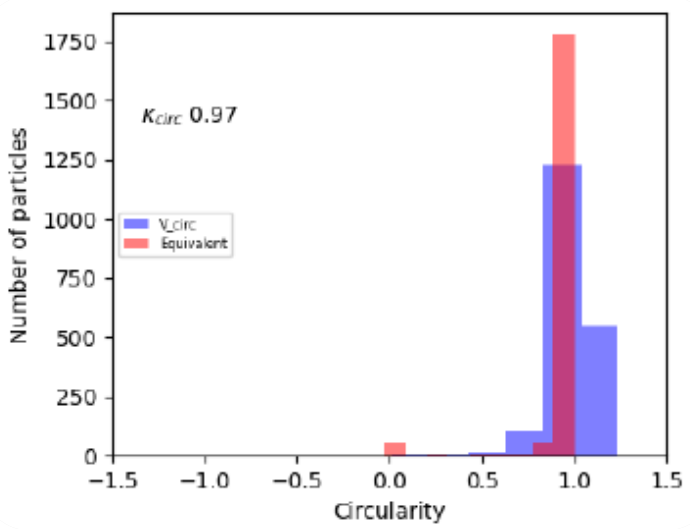
[1]*https://github.com/TimothyADavis/KinMSpy*

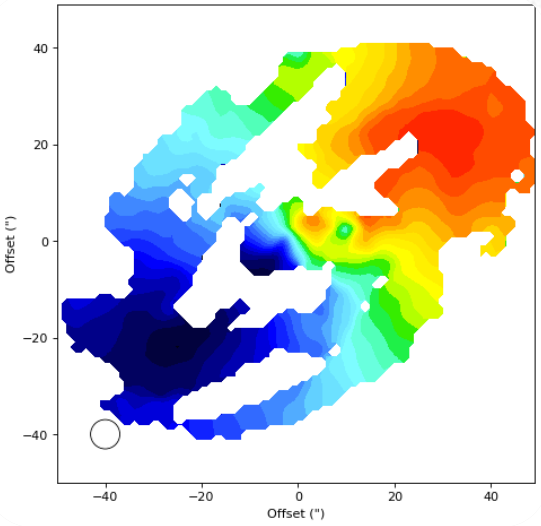
Kinematic modelling

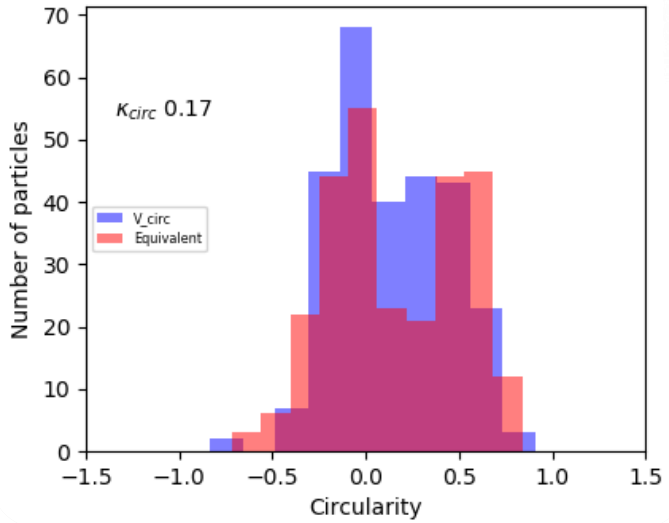
- Labelling the dataset based on kinematics

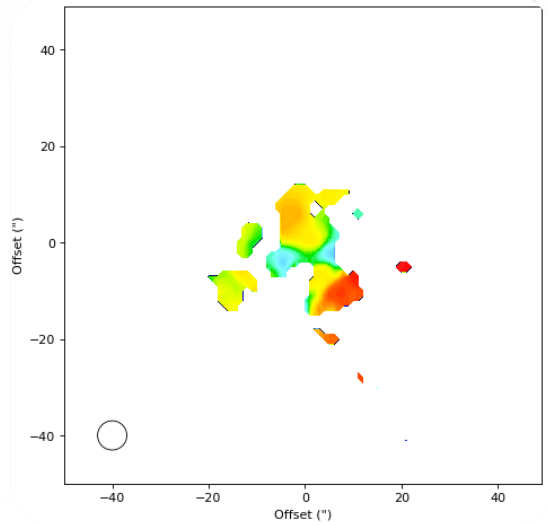
$$\kappa = \frac{K_{rot}}{K} \quad , \quad K_{rot} = \sum_{i=1}^{N} \frac{1}{2} m_i \left(\frac{j_{z,i}}{R} \right)^2 \quad , \quad K = \sum_{i=1}^{N} \frac{1}{2} m_i v_i^2$$

- Galaxies sorted into 10 bins corresponding to labels 0-9 (disordered->ordered)



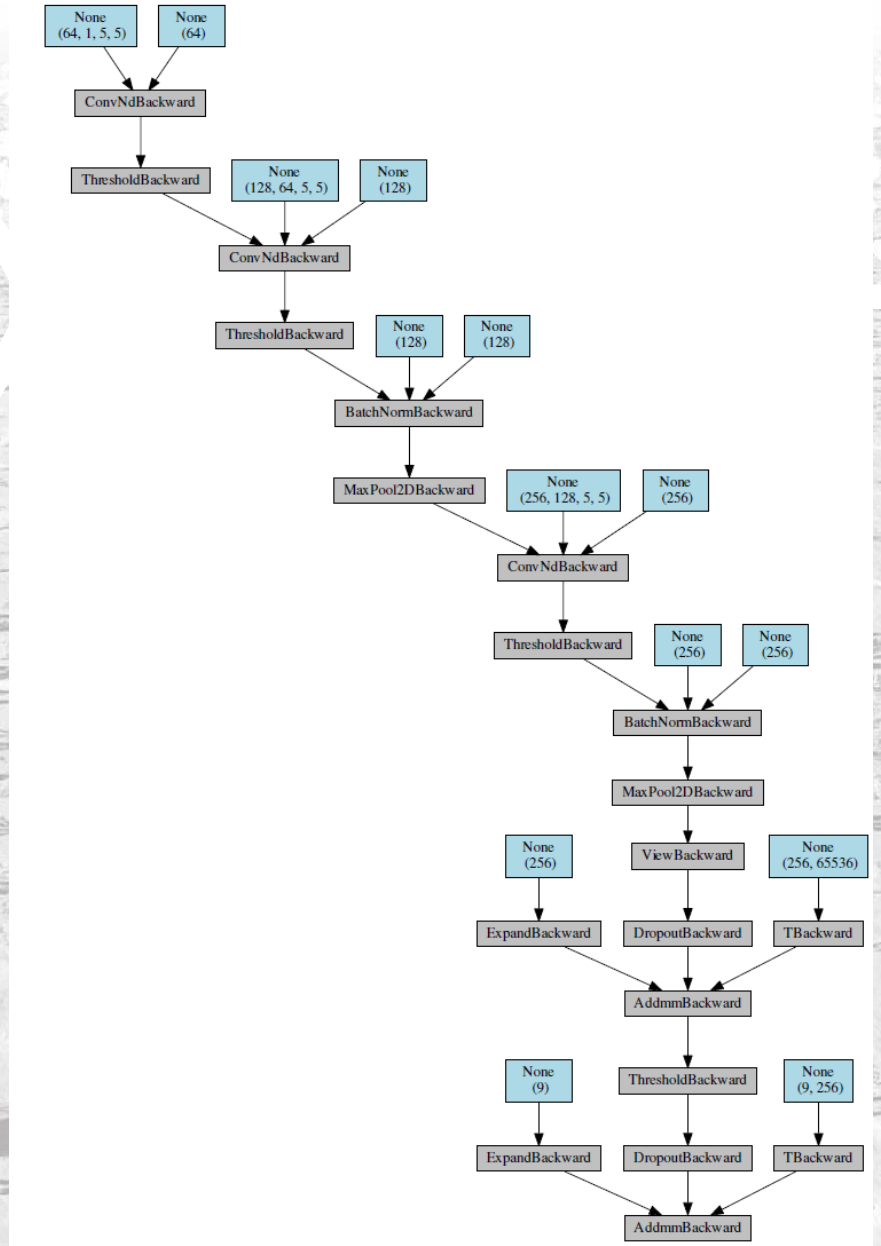






Deep Learning

- PyTorch
- 2D Convolutional Neural Network (CNN)
- Two different sized networks
- Employing regularisation techniques:
  - Dropout
  - Weighted sampling
  - BatchNorm



Testing

- We will present a variety of data to the trained network:
- More simulation data:
  - Validation and training sets are from simulations too (think train test split)
- ALMA moment 1 maps
- Wealth of VLA moment 1 maps for transfer learning tests

The Future

- Galaxy merger rate estimations
- Other gas properties, e.g. central black hole mass
- Much needed global statistics on gas kinematics
- SKA Transfer learning tests

Question time