# Simulating Turbulence in HII Regions

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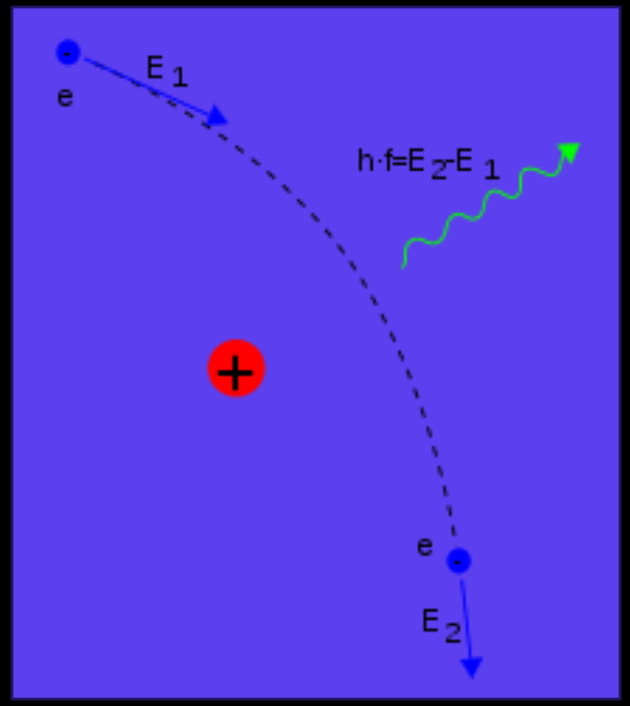
# Introduction to HII Regions

- What does the HII mean?
- Physical traits
  - Powered by hot stars
  - Roughly 1 parsec in size
  - A type of nebulae

Image attribution: M20 | Trifid Nebula HII Region in Sagittarius 6° from Kaus Borealis (top of the teapot) taken by R Jay GaBany

# More on HII Regions




- How do we observe them?
  - Free-free emission
  - Radio recombination lines (RRLs)

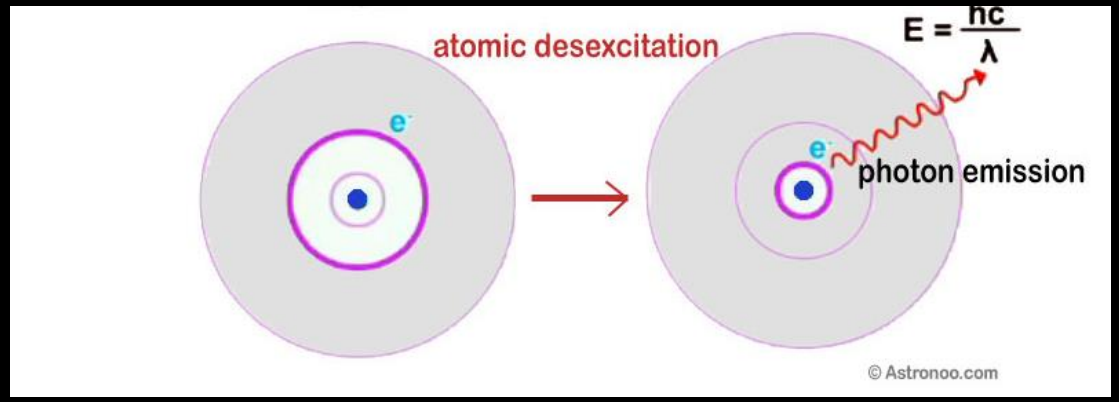
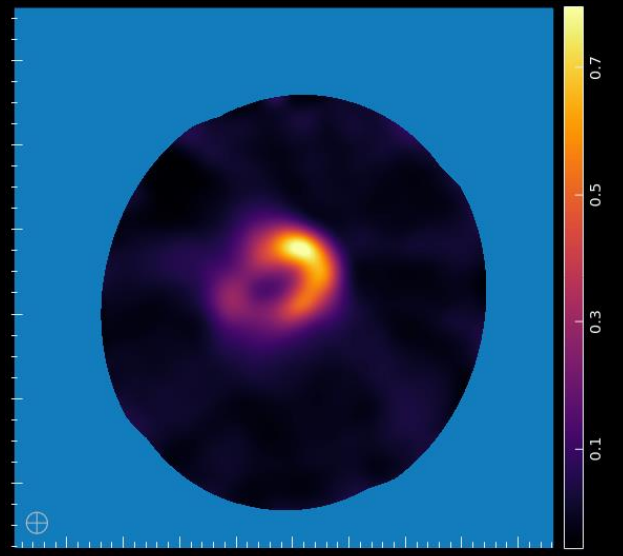
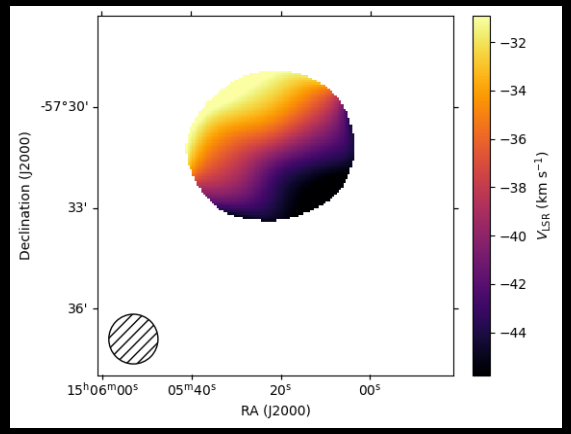


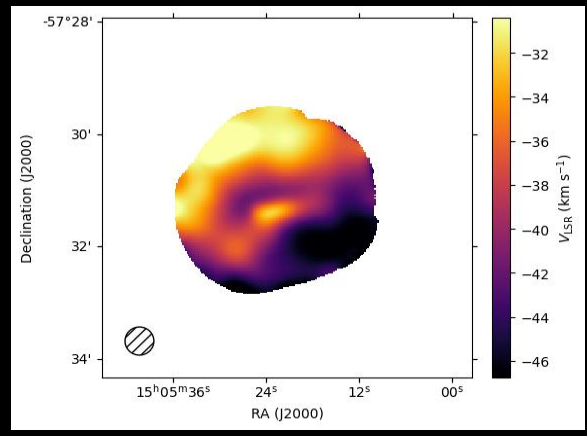

Image attribution: https://astronoo.com/images/lumiere/absorption-et-emission.jpg https://en.wikipedia.org/wiki/Bremsstrahlung#/media/File:Bremsstrahlung.svg

# Motivation for Project

- Previous work suggested rotation of HII regions
- New data doesn't match prediction
- Could turbulence explain the differences?



# Project Goals

- Simulate turbulence in HII regions
  - Calculating emission for each pixel
  - Overlaying density and velocities
- Test different turbulence parameters
  - Comparing to reality
  - Use statistical models to compare

Image attribution: https://www.advancedsciencenews.com/wp-content/uploads/2023/07/swirl-g52ac5d4ac_1280.jpg

# Exploring Turbulence

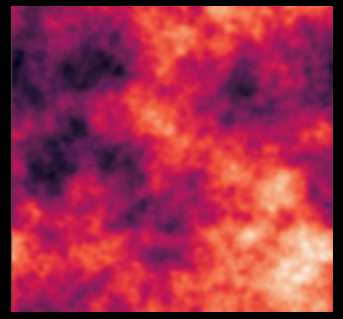
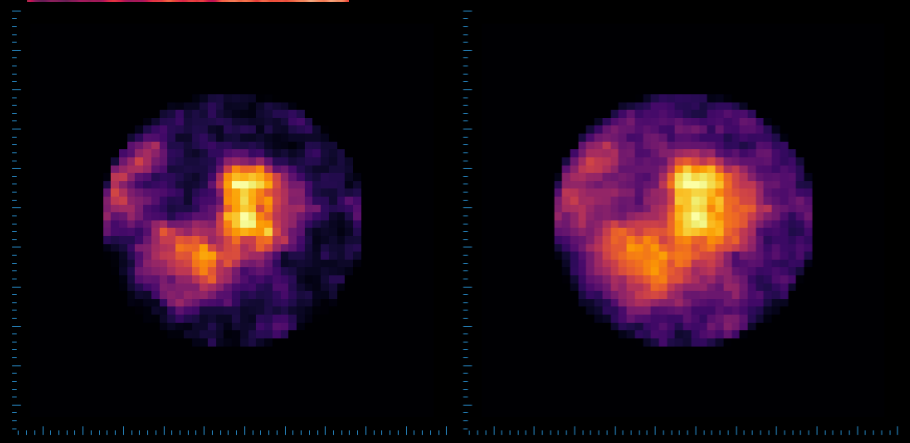


Image attribution: https://turbustat.readthedocs.io/en/latest/generating_test_data.html#three-dimensional-fields



Density squared Density

- Not all turbulence is made equal
- Using Turbustat
  - Python package
  - Cubes of density and velocity
- Special case for RRLs

# Work Done So Far

- Simulation in working order
  - Turbulence can be added to our region
  - Turbulence currently acting unexpectedly
- Simulation looks similar to data

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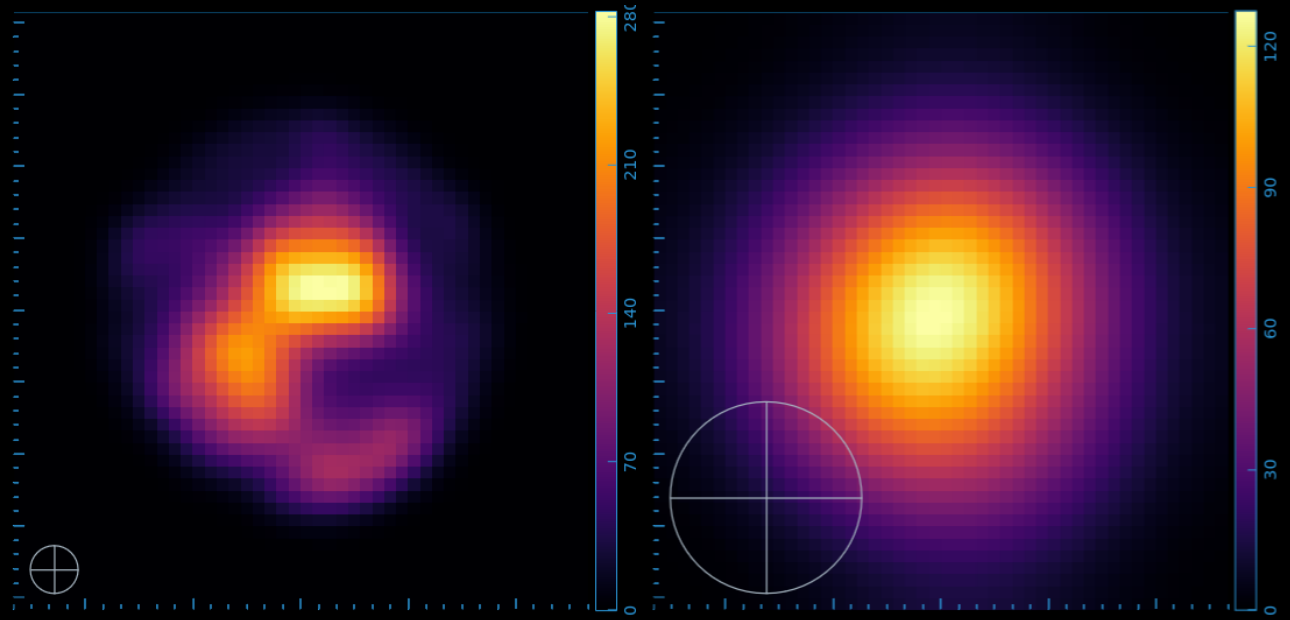
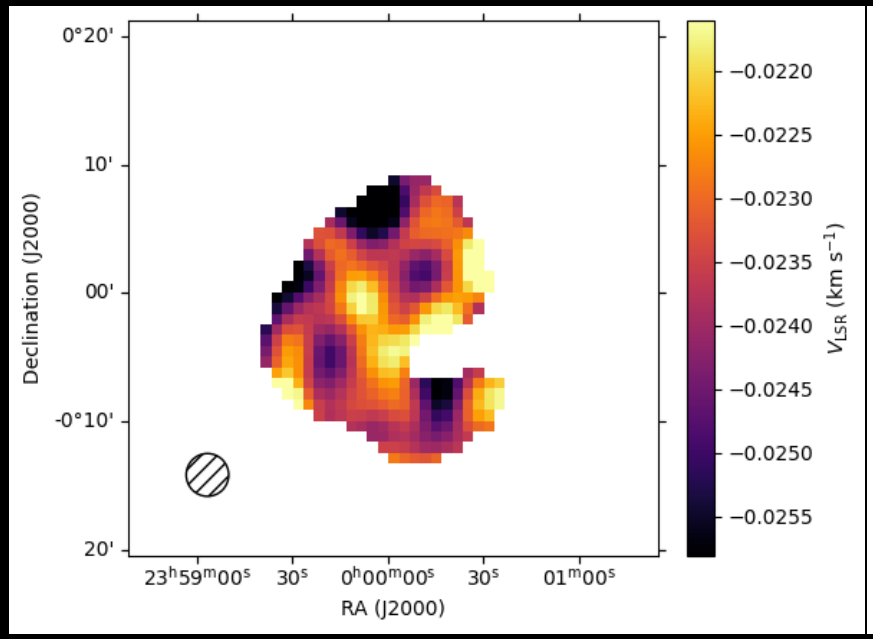
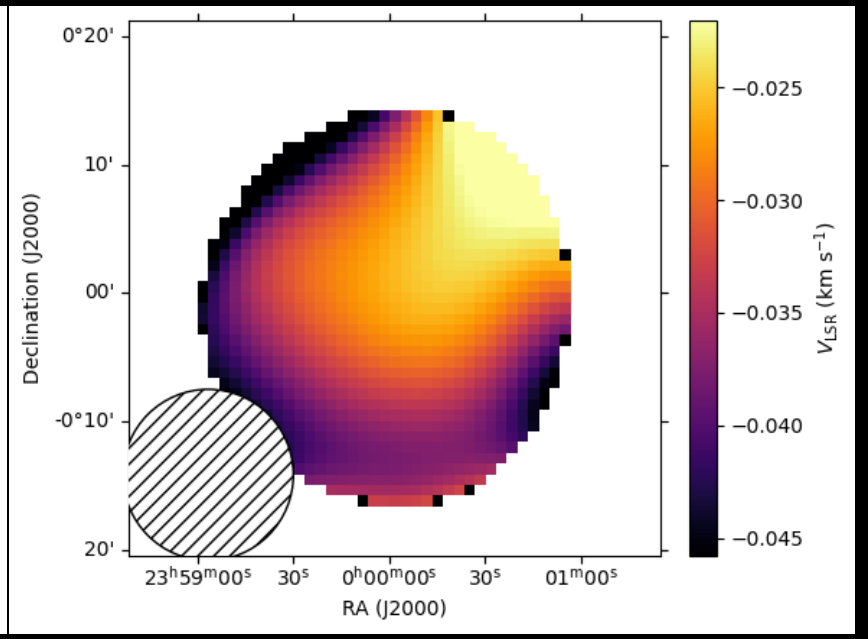
But, what does it look like?



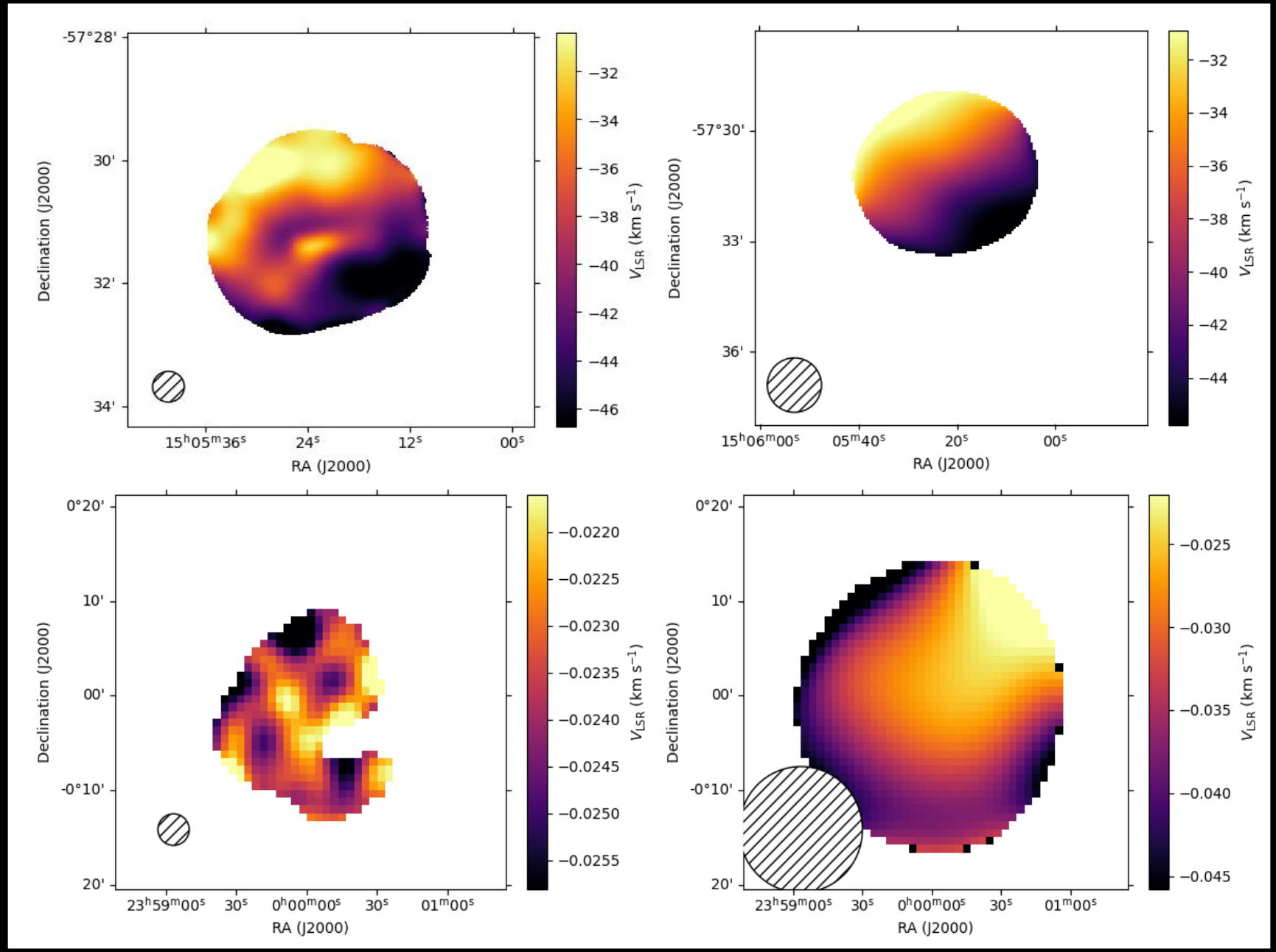
Narrow beam

Wide beam



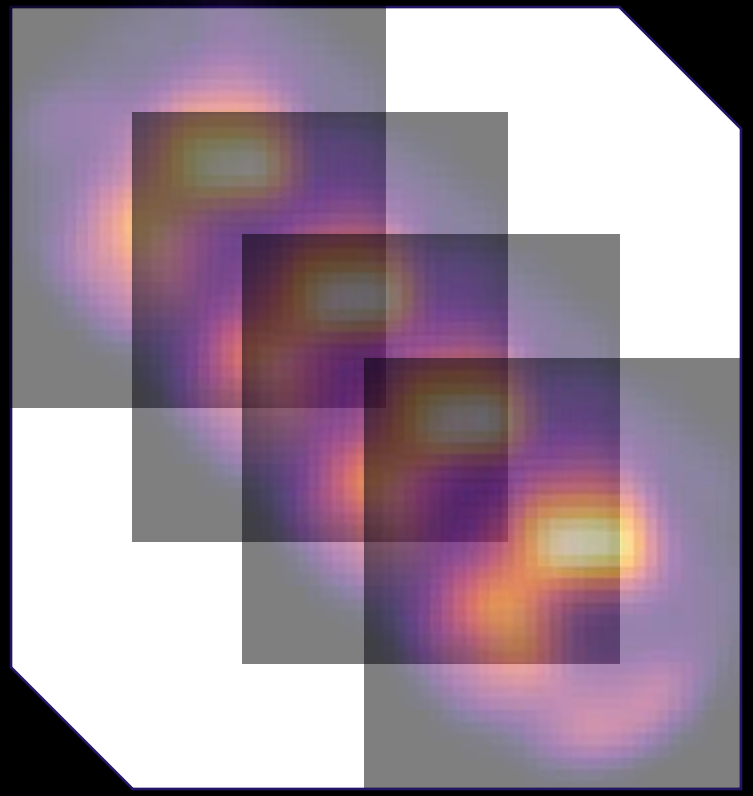



Narrow beam




Wide beam

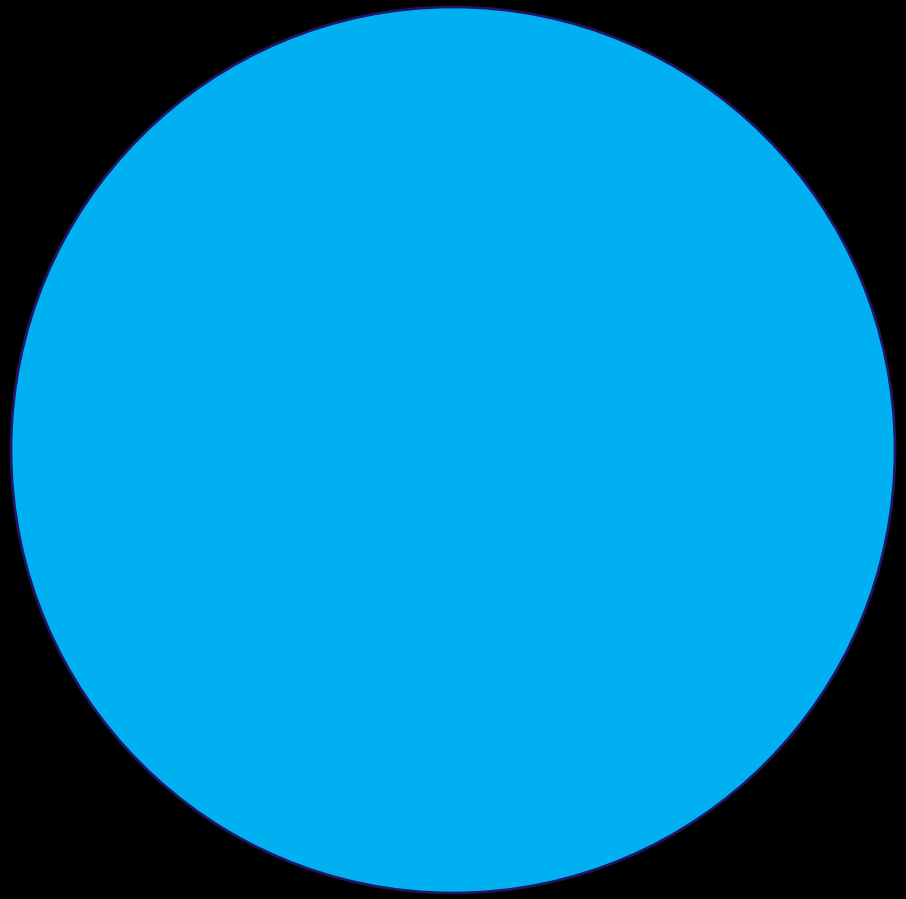
# Future Work



- Comparing simulation with reality
  - Using new dataset to test
- Calculating different features of simulation
  - Finding good test values
  - Making many data cubes

# Significance

- We don't understand HII region motion
- Insight into high-mass star formation
- Transfer of energy into surrounding media



# Takeaways

- Goal of project
- Progress
- Next steps