Imaging the Radio Quasar 3C205

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01 Introduction

What is a Quasar?

Quasar - an extremely luminous type of active galactic nucleus

Jet - highly collimated relativistic flow of plasma

Hotspot - the interaction site between jet and intergalactic medium

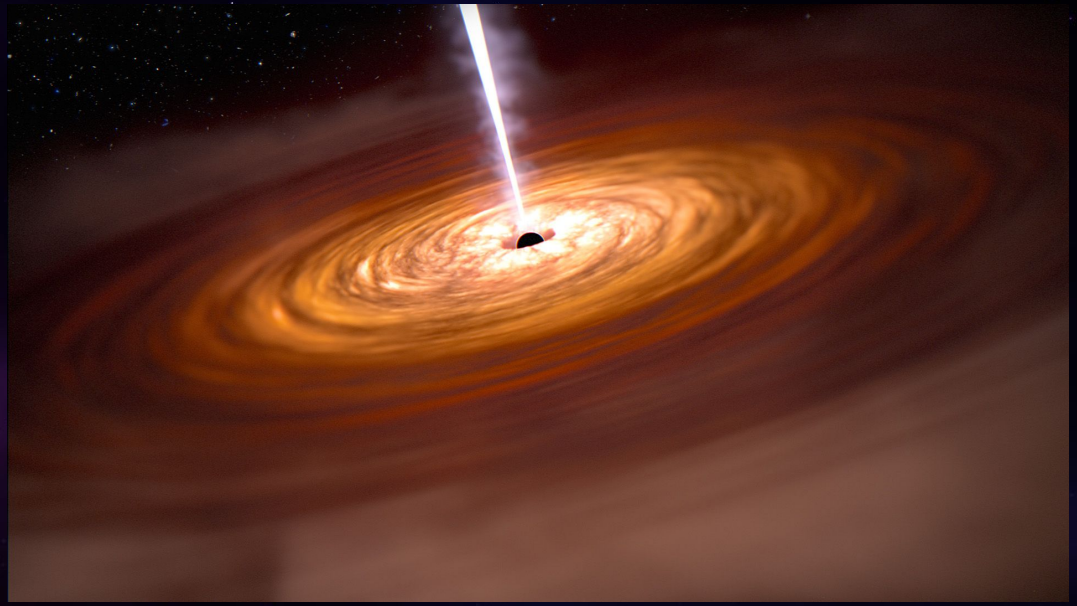

Image credit: NASA/ESA/CSA/Joseph Olmsted (STScI)

Big questions: jets and energy transport

02

3C205

3C205

What we know

- Redshift 1.534
- ~17” - almost 300,000 ly
- Highly co-linear
- **Very powerful**

What we can learn

- How do these objects work?
- How is the energy converted so efficiently?

A good laboratory for energy conversion processes

Previous Research

THE ANATOMY OF A RADIO SOURCE HOT SPOT: VERY LARGE BASELINE ARRAY IMAGING OF 3C 205

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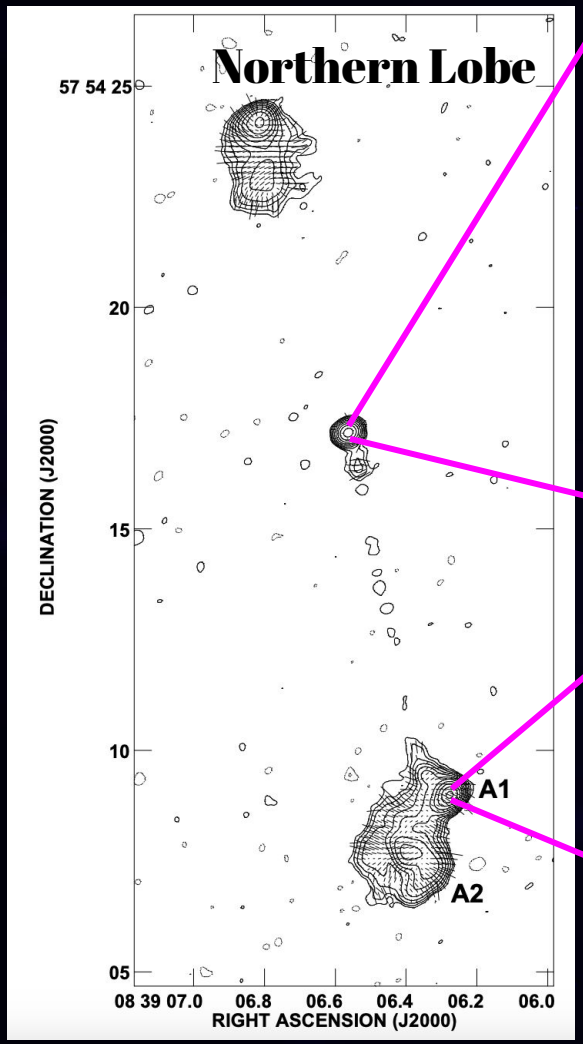
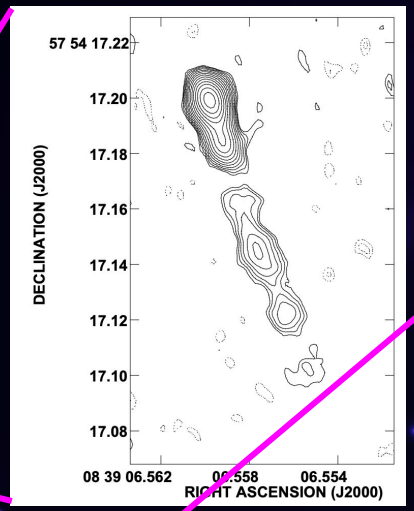
VLBA observation in 1995

- 16 MHz band, 18 cm (1.6 GHz)
- Imaged the core and hotspot separately
- Linear polarization images
- Bent jet model

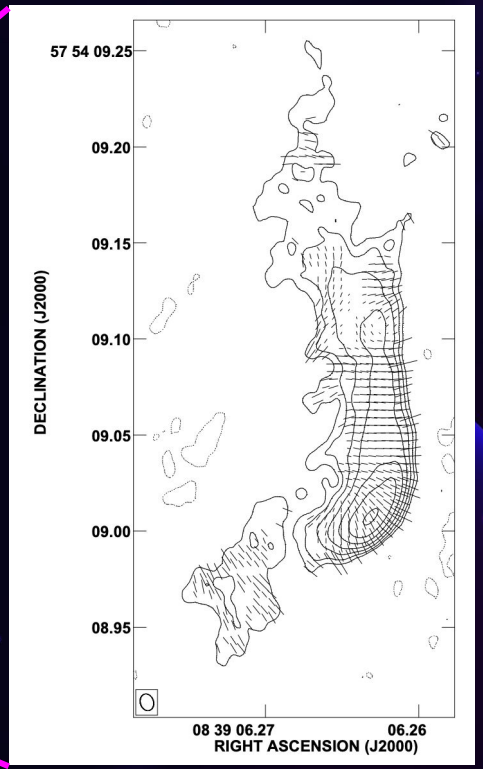
A good study that raised many questions

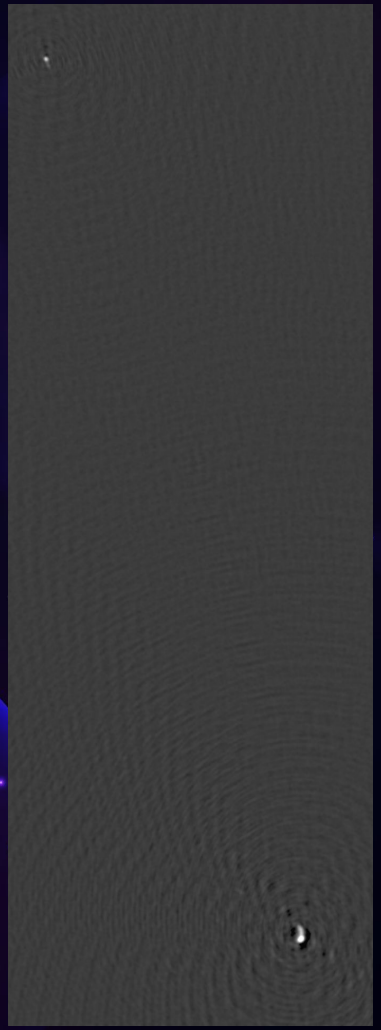




Core

Hotspot





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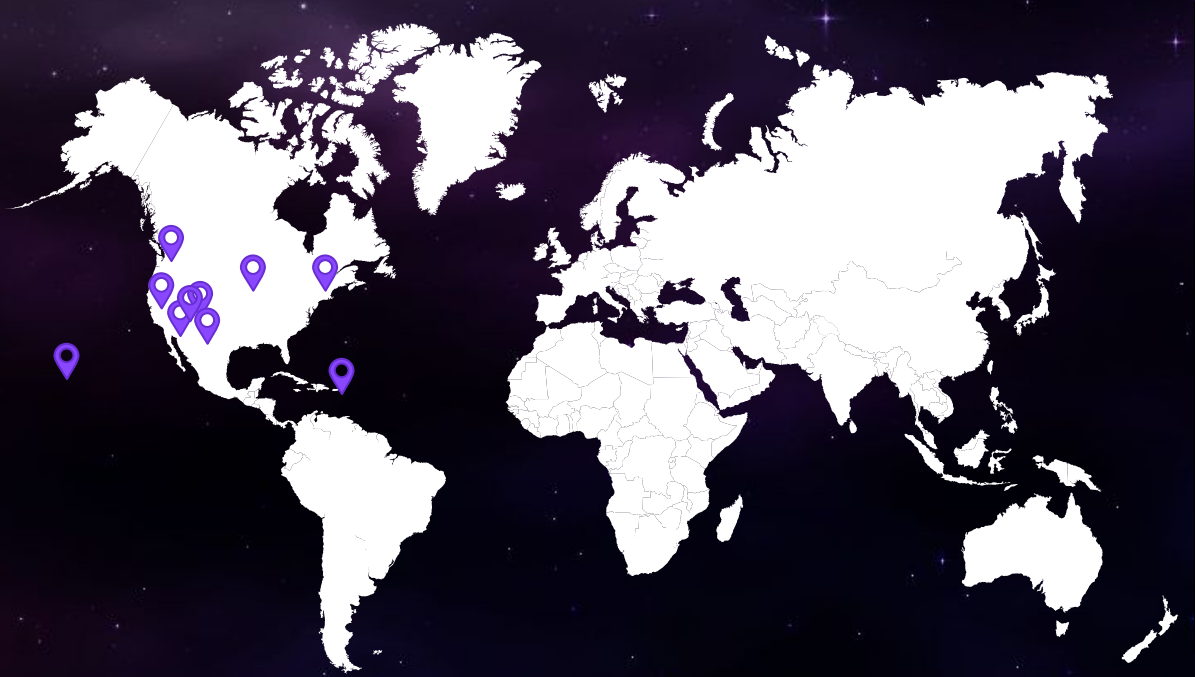
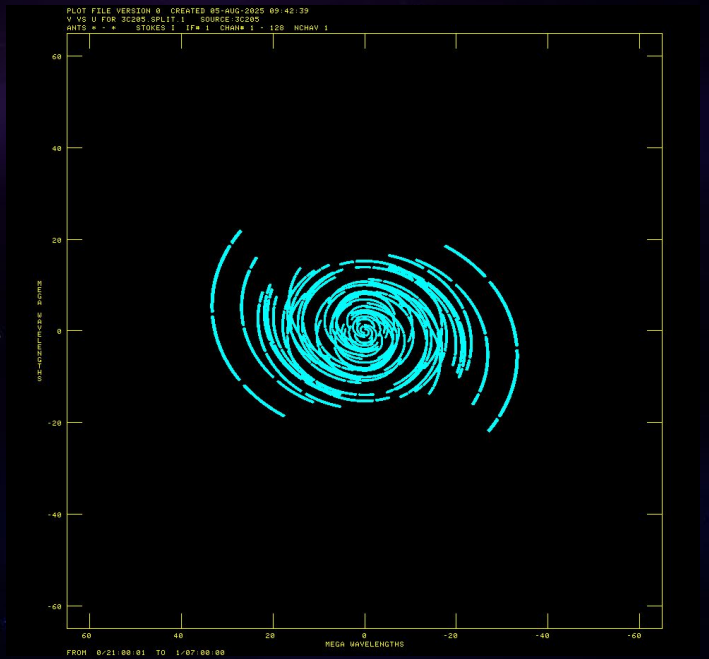
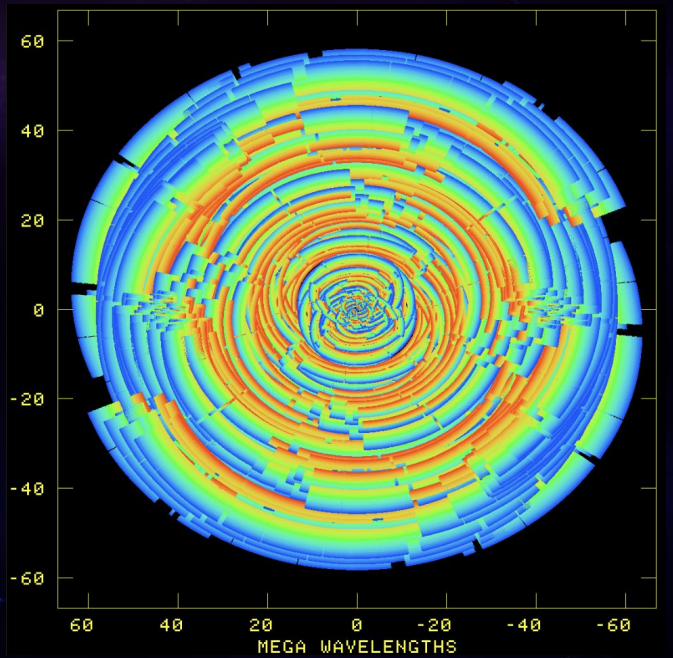




1995

The Data



2024

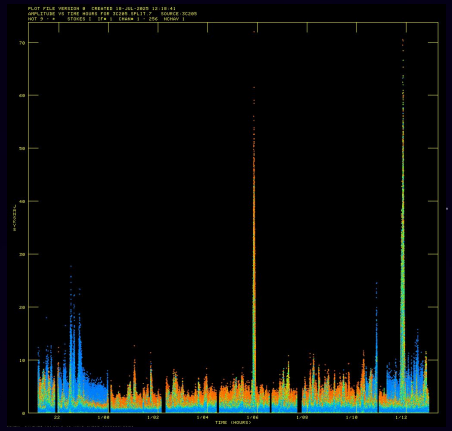
Project Goal

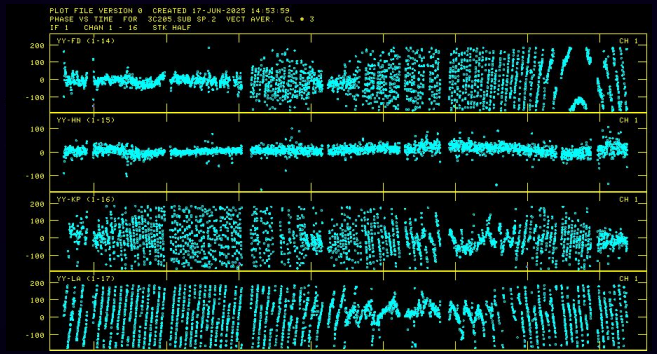
total intensity imaging of data subset

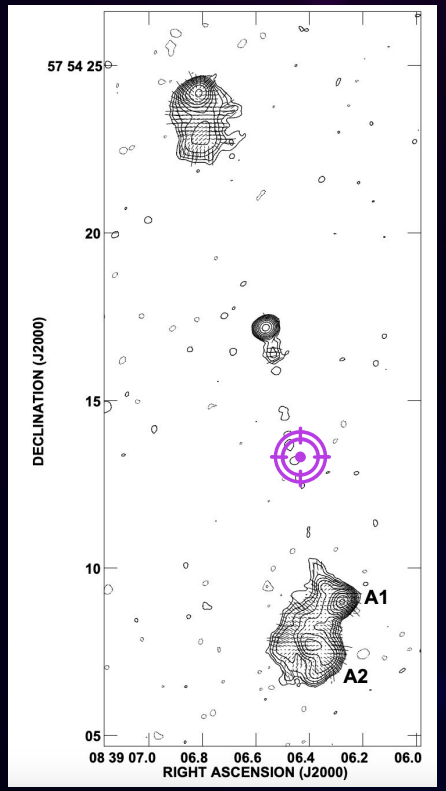
03 Methods

Data Complications

- RFI
- Phasing problems - IF 3-6
  - Testing IF 1
- Bad data
- Bad telescopes







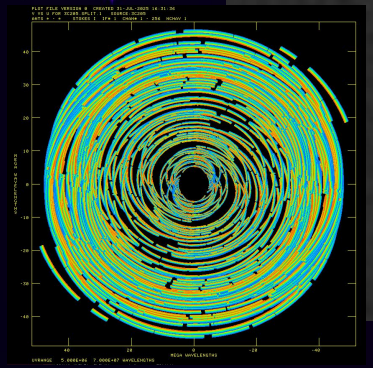
The Challenge:

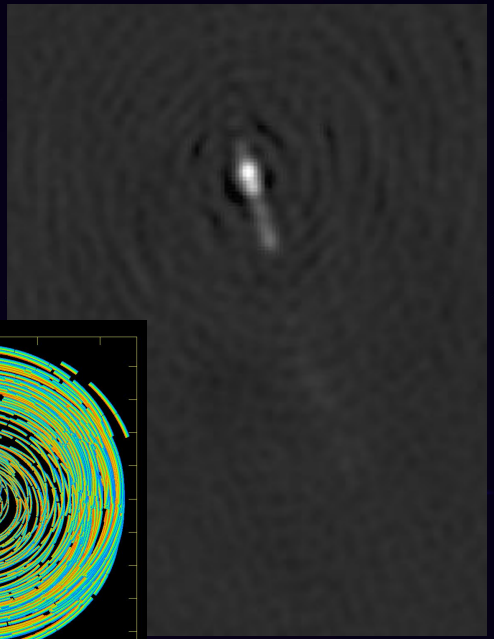
calibrating and imaging several regions of emission

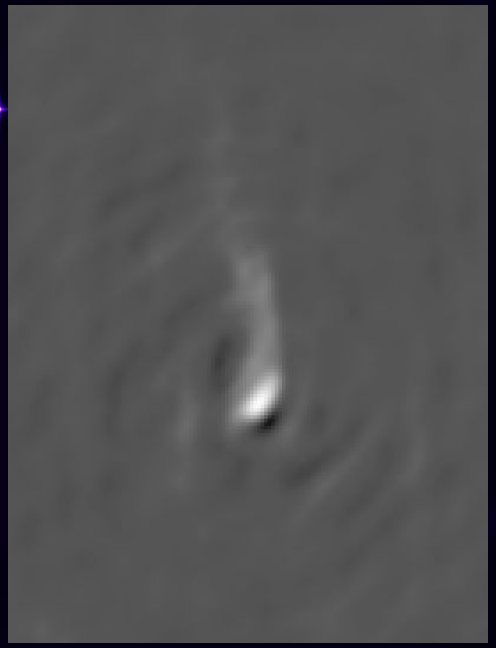
Process

Trial 1

Separate the emission regions







Too interconnected

Process

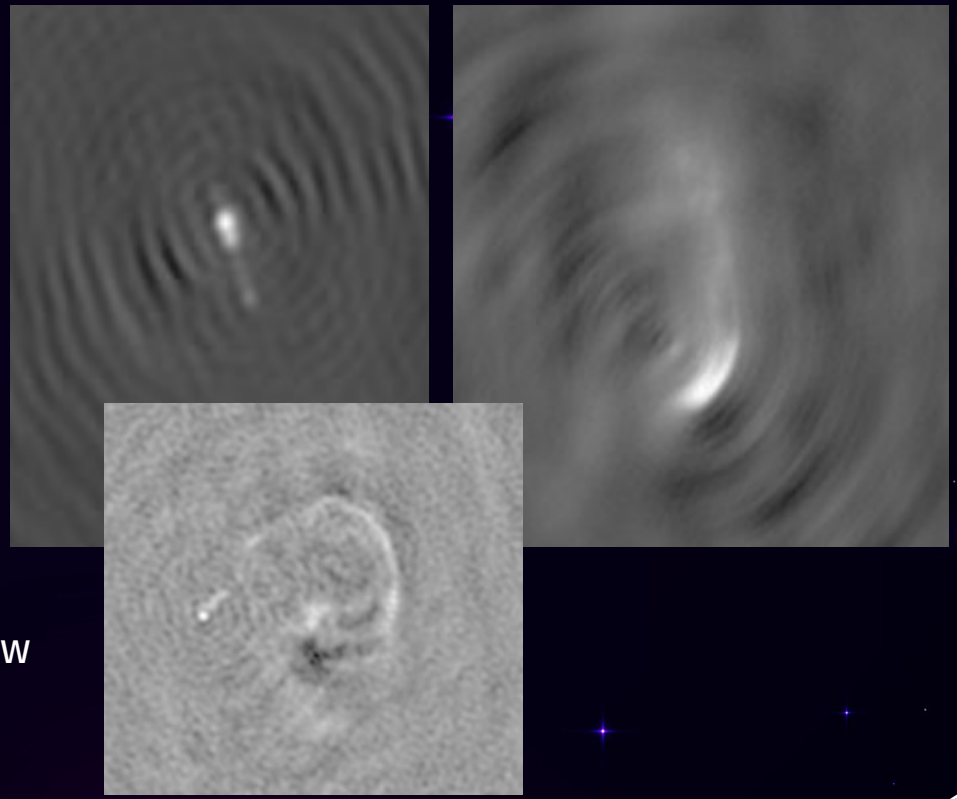
Trial 1

Separate the emission regions

Trial 2

Three field of view imaging

Miscalibrated data



Process

Trial 1

Separate the emission regions

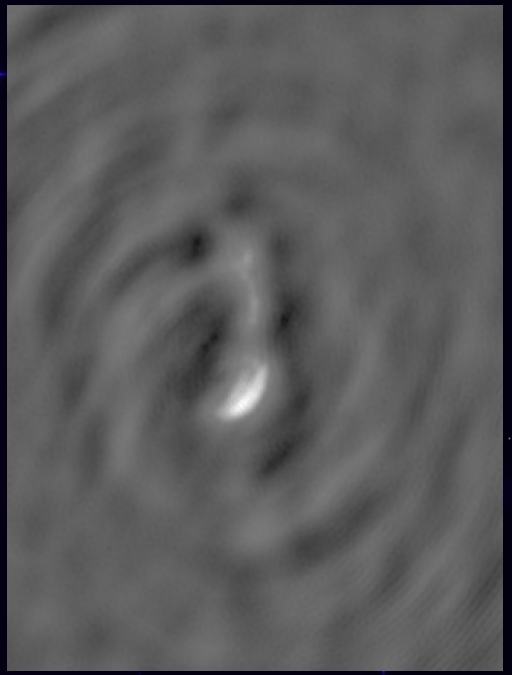
Trial 2

Three field of view imaging

Trial 3

Self-calibration from scratch

Bad data somewhere



Process

Trial 1

Separate the emission regions

Trial 2

Three field of view imaging

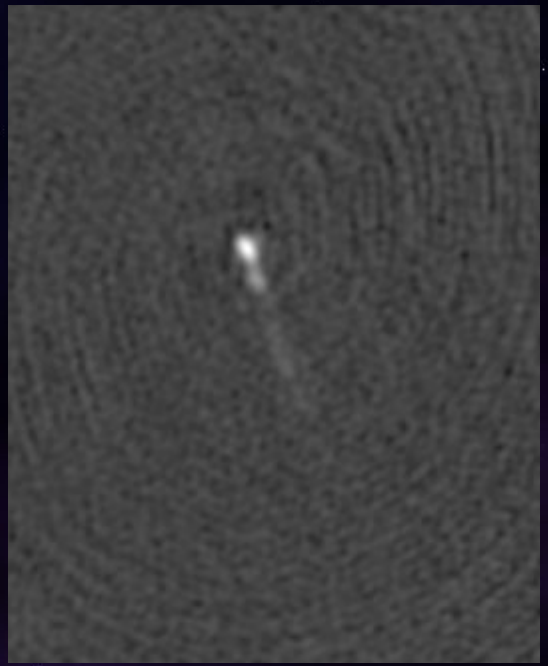
Trial 3

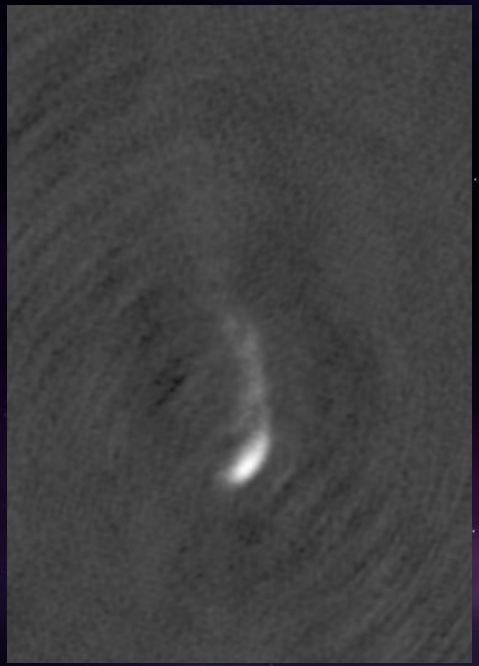
Self-calibration from scratch

Trial 4

VLBA-only imaging

Trial 4: VLBA-only imaging





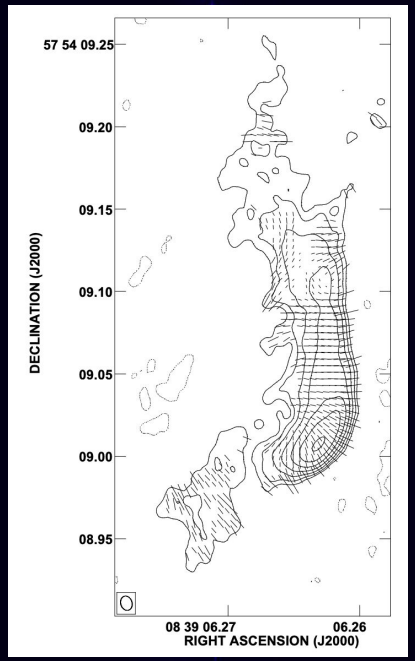
A good start!

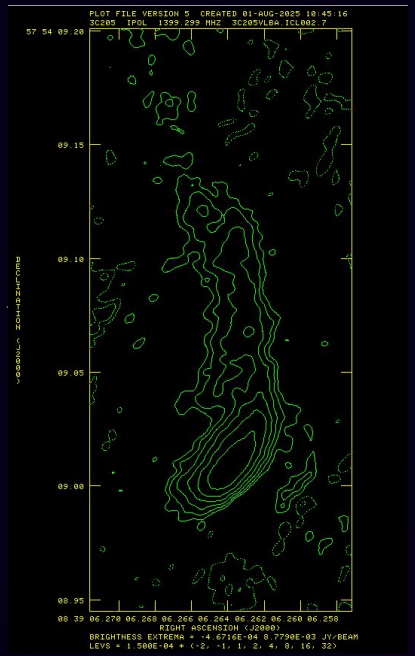
04

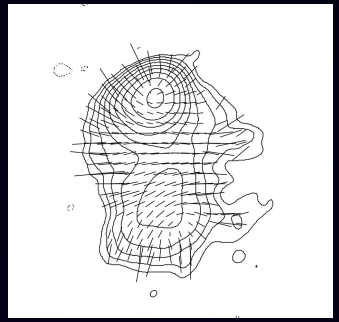
Results

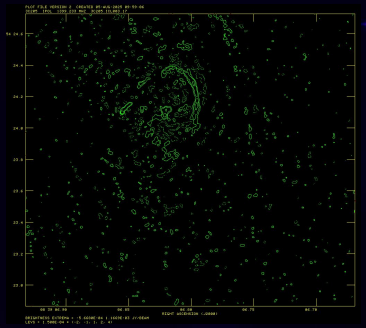
Results

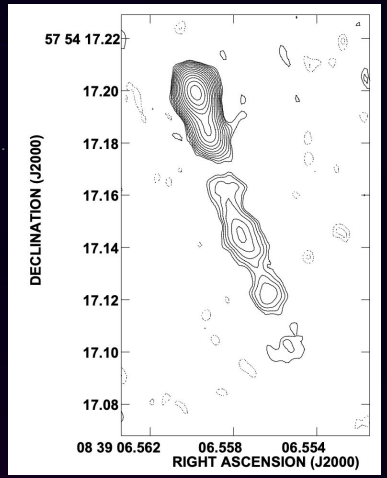
Comparison to 1995 results

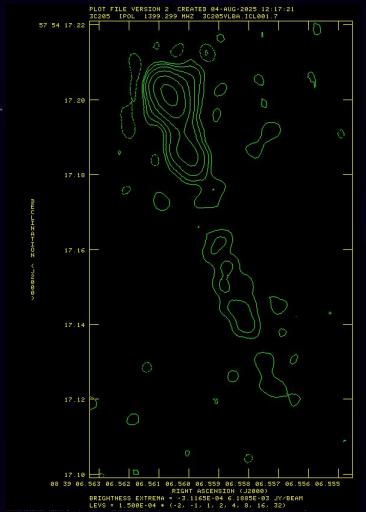








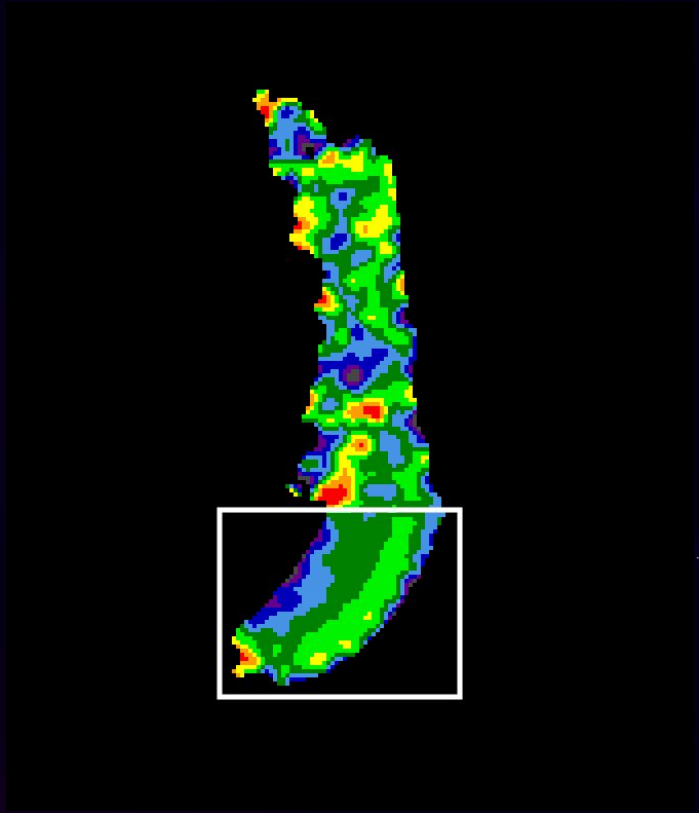




Results

Spectral index - measures how brightness varies with frequency

IF 1 vs. IF 8



Plasma expansion away from collision site

Image credit: Colin Lonsdale

Future Work

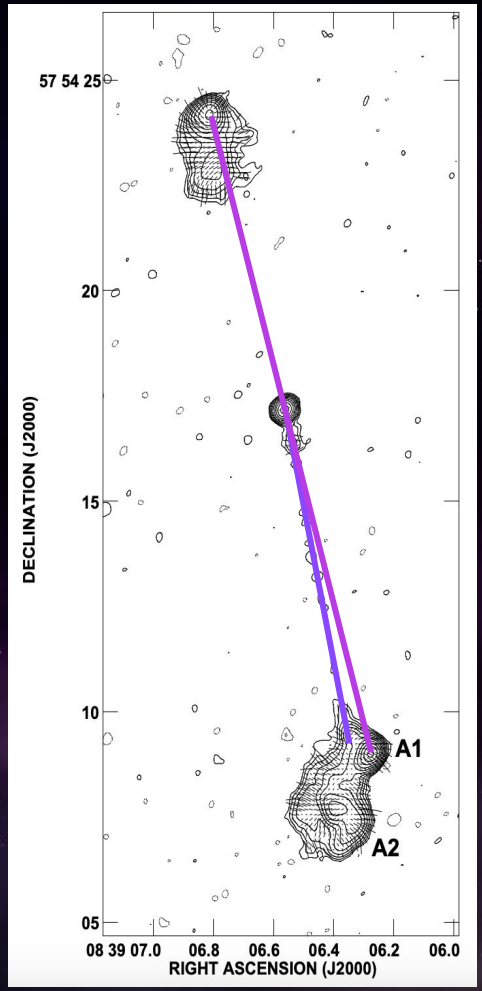
Polarization
Rotation Measure (RM) mapping

Jet Structure
Colinearity vs. VLA jet

Image in Detail
Jet closeup
All 8 IF's

Spectral Index Mapping
All structure with all IF's

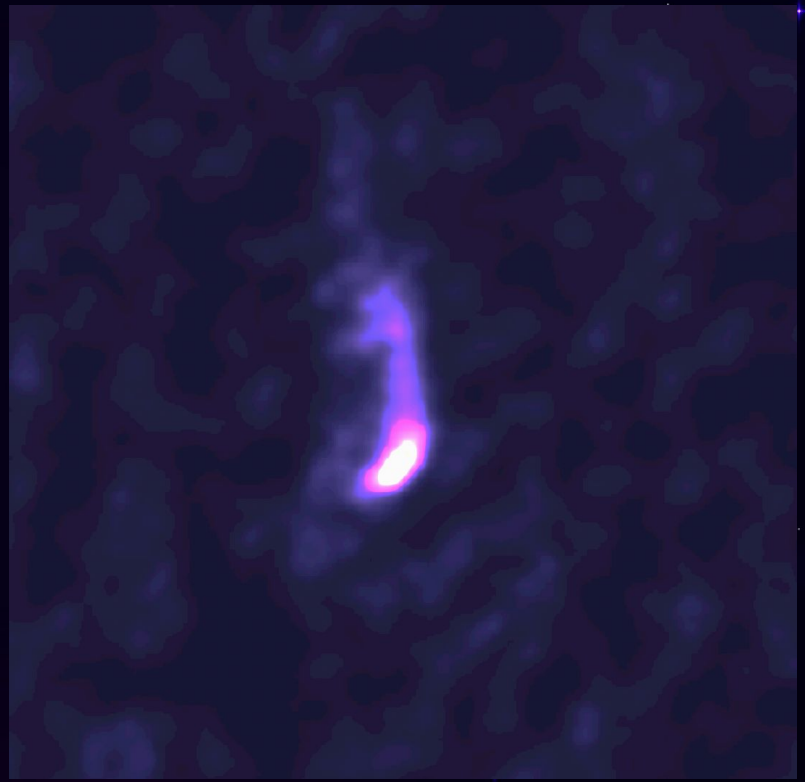
New Observations
VLBA C band
Optical and IR



Comrade

Bayesian differentiable modular modeling framework for use with Very Long Baseline Interferometry

Created and used for the Event Horizon Telescope (EHT) project



Kazu Akiyama

Promising results with very little data

Conclusions

- 2024 VLBI observation gives us the chance to study quasar energy conversions in a simple system
- Calibrating and imaging is a challenge
  - Separation of emission regions ✗
  - Three fields of view ✗
  - Self calibration from scratch ✗
  - VLBA-only model ✓
- First pass analysis
  - Images that closely match previous data
  - Relatively detailed total intensity images
  - Spectral index of hotspot plasma flow

But we can do so much more!

Thank you!

Questions?

I would like to thank Colin Lonsdale and Kazu Akiyama for their mentorship on this project, and their help with complicated problems especially.

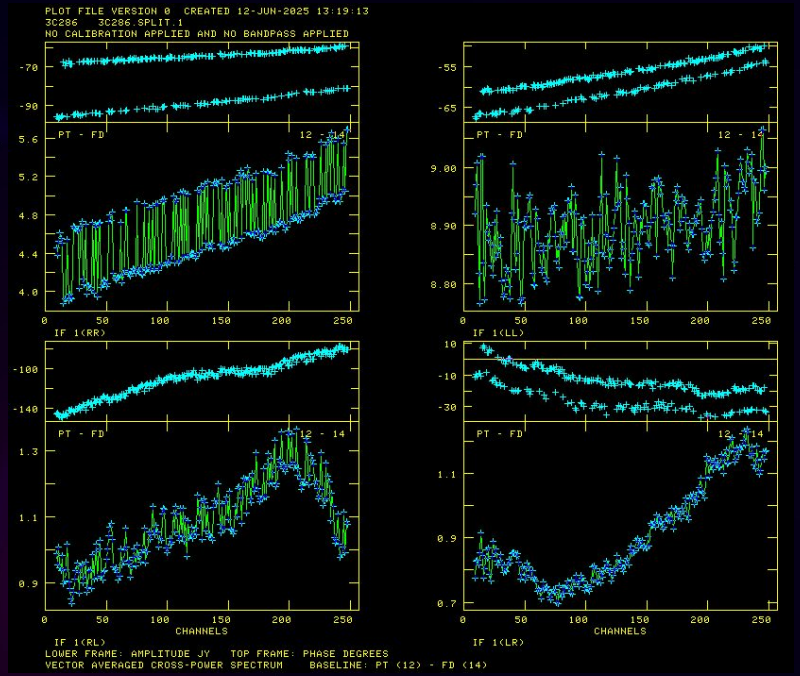
I also thank the MIT Haystack staff and scientists for their support of the REU program and interns.

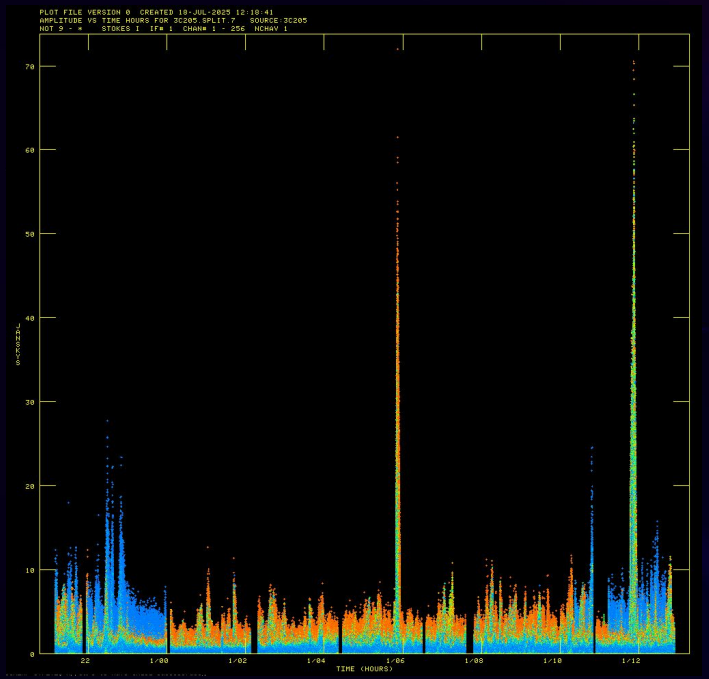
References

C. Lonsdale and P. Barthel. The Anatomy of a Radio Source Hot Spot: Very Large Baseline Array Imaging of 3C205. *The Astronomical Journal*, 115:895-908, 1998 March.


MIT
HAYSTACK
OBSERVATORY

Data Complications (Extra)





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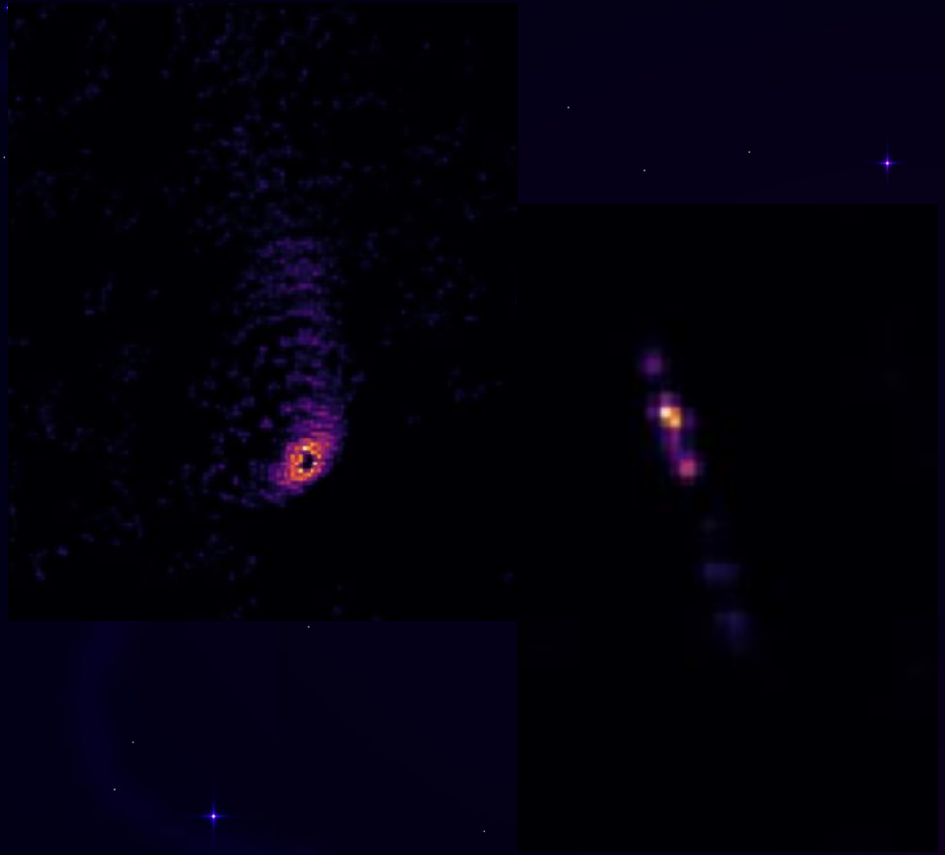

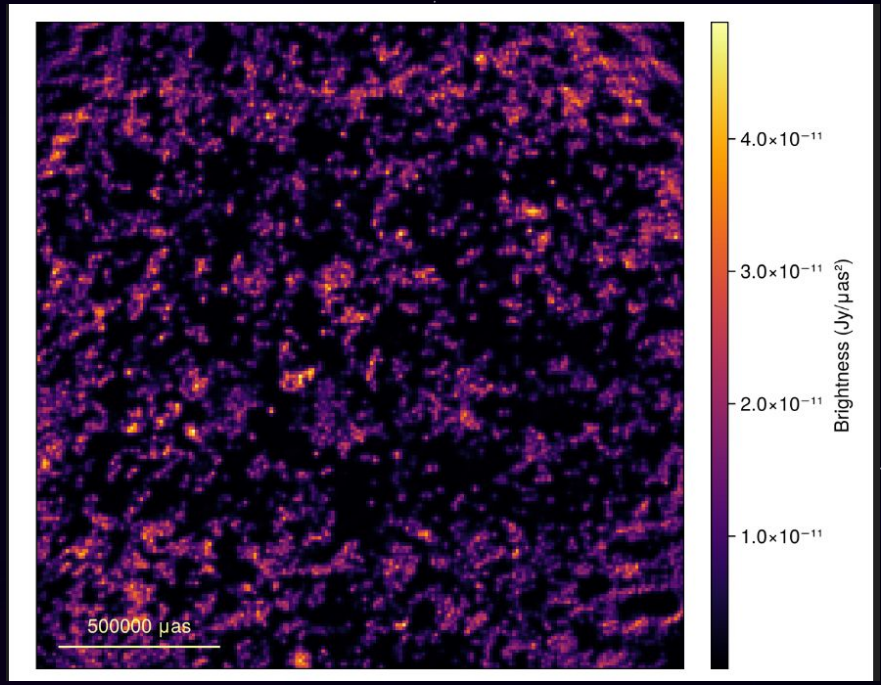

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