Overview on VLBI data reduction packages

by Gabor Orosz

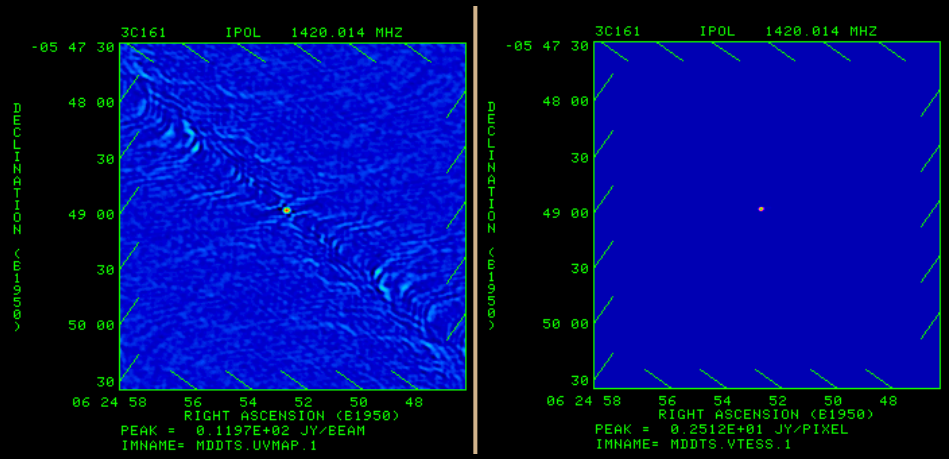
1967: First fringes found by hand
1978: AIPS revolutionizes processing
1992: Difmap brings interactivity
2018: CASA-VLBI emerges
Now: Automation and AI

What is data reduction?

The VLBI Challenge:

1. No shared reference signal between telescopes
2. Terabytes of independently recorded data
3. Must extract coherent signals with nanosecond precision

Data Reduction = Correlation → Calibration → Imaging.



https://www.aips.nrao.edu/whatisaips.html

The Heroic Era: Manual Processing (1967)

Spring of 1967: First successful VLBI observation

- Correlation was still difficult
- One baseline at a time, manual fringe search
- Expensive magnetic tape reels holding minutes of data
- Slow and costly, phase-referencing impractical

Yet achieved: 0.001 arcsecond resolution by 1968.

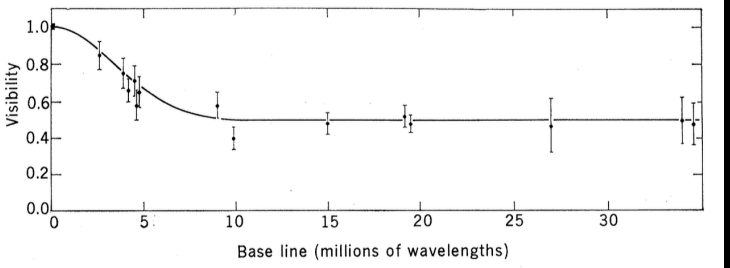


Fig. 3. Visibility function of the quasi-stellar source 3C 273. The curve is the visibility function of a source with half the flux in a "halo" of half-power width 0
of arc and half in an unresolved "core."

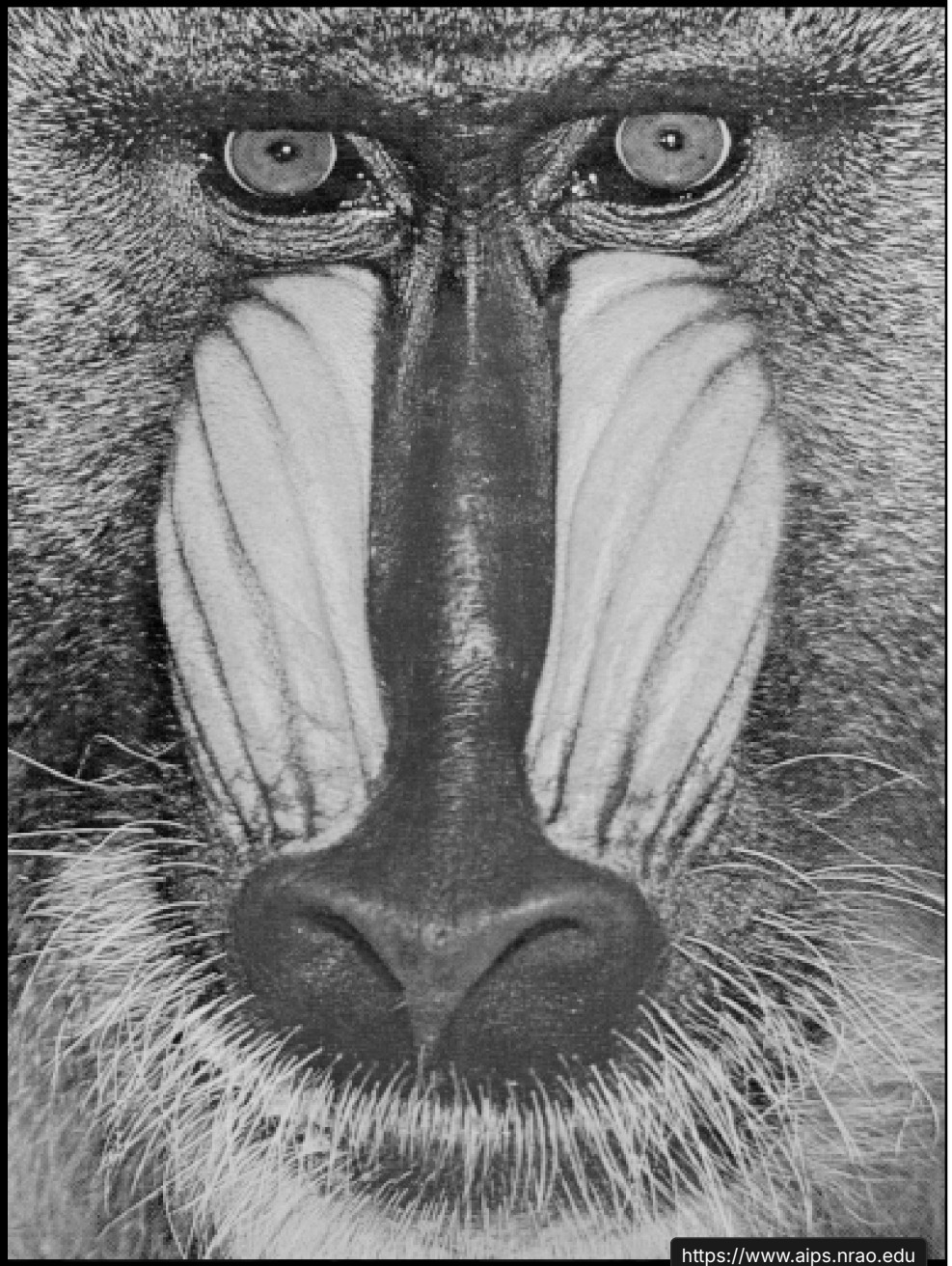
Radio Interferometry at One-Thousandth Second of Arc (Cohen, Jauncey, Kellermann, Clark 1968, Science, 162, 3849

AIPS: The 50-Year Standard (1978)

Why AIPS Dominated for 50 Years:

- Global fringe fitting and imaging
- 530+ specialized tasks for whole processing
- Non-destructive calibration tables
- Portable across all platforms
- Selected for VLBA in 1983

Still widely used today.

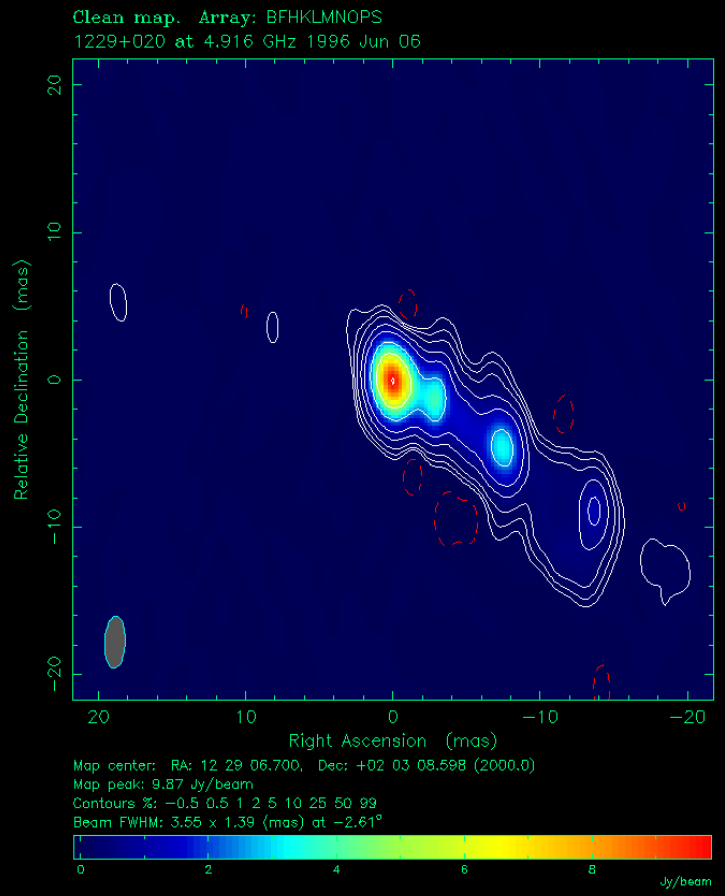


Difmap: Interactive Innovation (1992)

The Power of Seeing Your Data

- Difference mapping: Edit without restarting
- Real-time visualization of visibility ↔ image connection
- Mouse-driven flagging
- Developed by one person (Martin Shepherd)
- Frozen since 1995, still widely used

Perfect for: Teaching, Final imaging, Quick inspection.



3C 286, The VSOP 5 GHz Continuum Survey (Fomalont, et al. 2000, ApJS, 131, 95)

CASA–VLBI: The Modern Transition (2018)

Python-Powered Processing

- JIVE-led development (BlackHoleCam/EHT)
- Full VLBI capability achieved 2022
- Jupyter notebook integration
- MPI parallelization
- Foundation for modern pipelines

The software used in this school.

The Future: Automation and AI

Two Revolutions Happening Now:

Automation (Today):

- rPICARD/VPIPE: CASA-based calibration pipelines
- ParselTongue: Python-controlled AIPS pipelines

  Data to images with limited human intervention

Intelligence (Emerging):

- Finding RFI with near-perfect accuracy
- Neural networks reconstruct images independently
- Machines learning to recognize structures (e.g., DIReCT)

Remember

Each tool has its place

- AIPS: Comprehensive but complex
- Difmap: Interactive and educational
- CASA: Modern and actively developed
- You'll likely use all three and more!

Use the software that gets your science done.