Current generation arrays: current status, getting the most out of them and future development

Working group report for the Future Direction for Interferometry Workshop

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Working group

- Contributing members

  Rachel Akeson

  Theo ten Brummelaar

  Josh Eisner

  Chris Haniff

  Margarita Karovska

  John Monnier

  Denis Mourard

  Guy Perrin

  Jean Surdej

  Chris Tycner

Outline

- Current and near-future arrays
- Getting the most out of them
  - Operations
  - Resources available to users
  - Attracting new users
  - Collaborations
- Further development
- Summary

- Goal: Identify relevant issues for mid- and long-term planning

Current Arrays

- Here defined as arrays which have produced at least one peer-reviewed paper and operated within the last 2 years

CHARA Array	Center for High Angular Resolution Astronomy Array	Collaboration
COAST	Cambridge Optical Aperture Synthesis Telescope	Collaboration
GI2T	Grand Interférometre á deux Télescopes	Closed
IOTA	Infrared Optical Telescope Array	Closed
ISI	Infrared Spatial Interferometer	Collaboration
KI	Keck Interferometer	Open
MIRA-I.2	Mitaka IR Array	Collaboration
NPOI	Navy Prototype Optical Interferometer	Collaboration
PTI	Palomar Testbed Interferometer	Collaboration
SUSI	Sydney University Stellar Interferometer	Collaboration
VLTI	Very Large Telescope Interferometer	Open

Arrays in development

- Defined as those expected to be operational within 5 years

LBT	Large Binocular Telescope	Open
MROI	Magdalena Ridge Observatory	TBD
OHANA	Optical Hawaiian Array for Nanoradian Astronomy	TBD

See SPIE conferences for latest updates on each of these

Current arrays summary

- The 9 listed arrays which are currently operational range from small testbeds operated with minimal staff, to large well-funded national and international facilities
  - See lessons learned for more details on operational models
- Array access classified as collaboration or open
  - Collaboration: Run by a single group or collaboration of groups. Generally more access for new instruments and black-belt observers
  - Open: Run by a large group for the wider community. Generally more access for inexperienced users through proposal calls and supported observing and data reduction

Both categories are important for continued expansion of the optical/infrared interferometry community

Efficient operations

- There is a spectrum of users from the experienced expert with their own instrument to the inexperienced astronomer who wishes to address a particular object or question and is not interested in the details of the observing
  - Efficient operations means something different to these various user groups

Operations Issues

- Balancing development, maintenance and science observing
- Adequate day and night time staffing

Recommendations

- When budgeting, consider both day and night staffing levels
- Explicitly schedule engineering time for maintenance and for development
- Account for time needed for instrument or configuration changes when scheduling observations

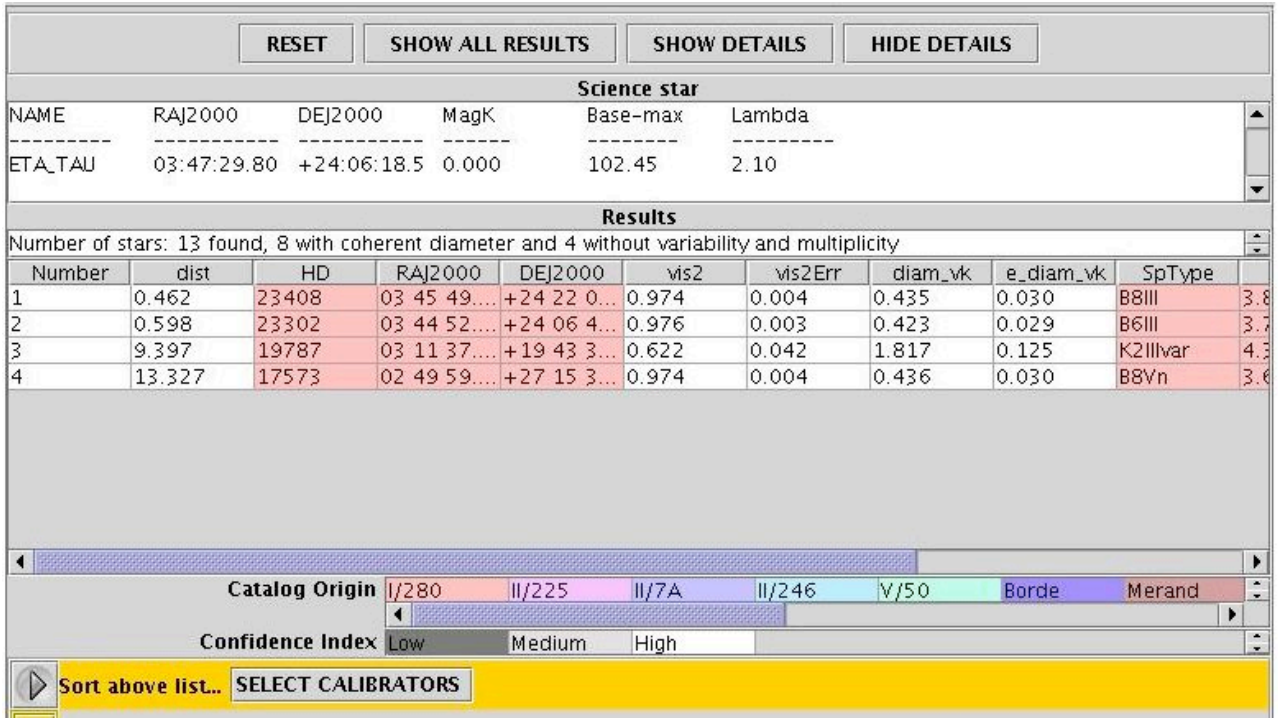
Data Tools

- Good tools can help users get the most out of their observing time
- Planning
- Reduction and calibration
- Modeling and visualization
- Imaging

- This is one area where collaborations between groups can have big benefits for the entire community

Planning

- Several packages available (getCal, SearchCal, CHARA_PLAN etc)
- Choosing calibrators
- Planning instrument configurations

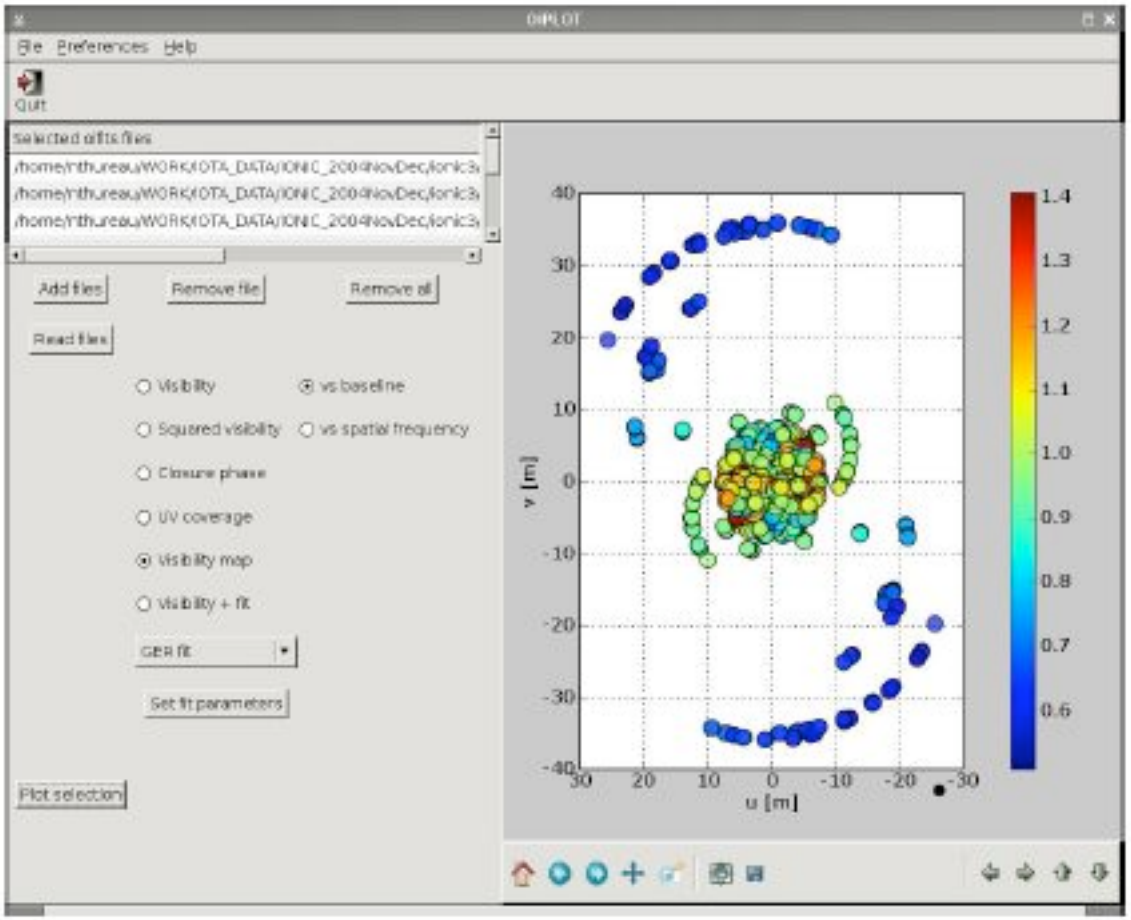


Data reduction and calibration

- Generally array or instrument specific for first stage
- More possibilities for general packages for system visibility/transfer function calculation, but so far, packages tend to be array specific
- Calibrated data should be available in OI-FITS
  - Greatly facilitates exchange between groups

Modeling and visualization

- Ideal for collaborations, as should be array independent at this stage



OiPlot; Thureau et al

Imaging

- Imaging at optical/infrared wavelengths is still in the beginning stages but is a key capability in attracting new users
  - Most astronomers are not interested in working with visibilities
  - Even limited imaging (i.e. sparse uv sampling) will be used if astrophysically relevant, as demonstrated by the early years of millimeter interferometry

NPOI; eta Vir

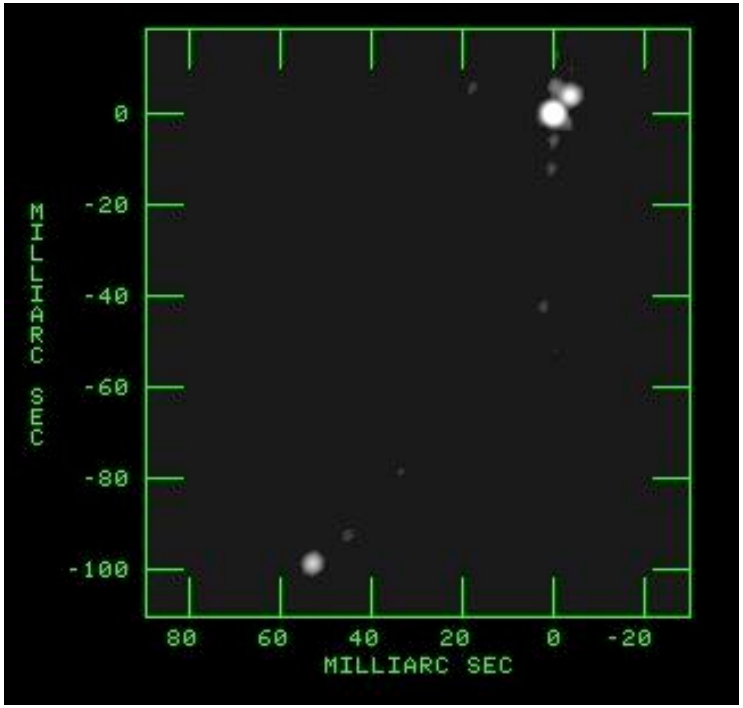
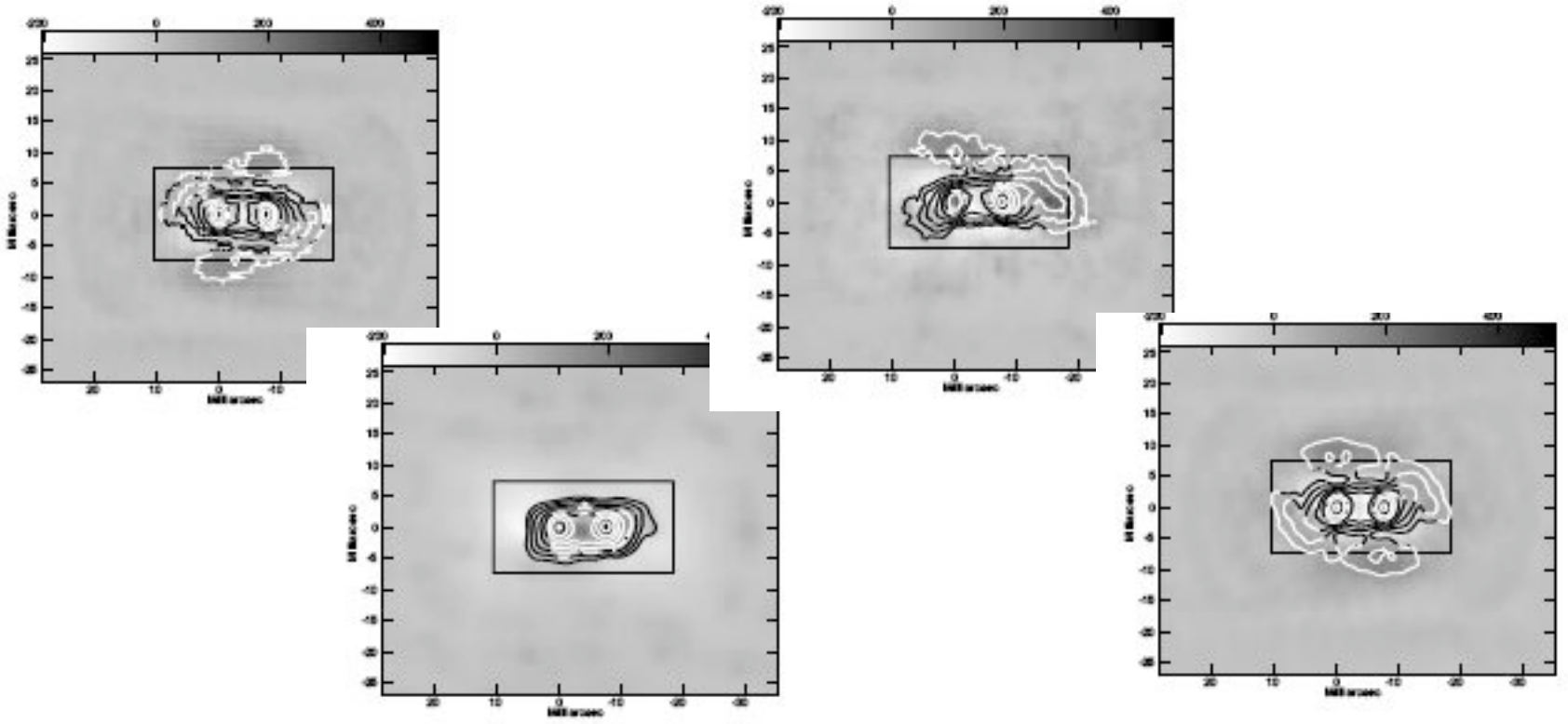


Image construction

- Unlike radio/millimeter interferometry, there are not yet standard techniques and software packages
- But progress is being made as shown in the "Imaging Beauty Contests" (Lawson, SPIE, 2004, 2006)



Data availability

- Creating a data archive for non-PI users requires significant effort in data standardization and documentation but can have good returns in attracting new users
- Currently provided by larger groups (VLTI, KI/PTI)
- Also, some published data in OI-FITS formats at olbin.jpl.nasa.gov
- Note that for time-dependant studies, multiplicity, variability, etc., good access to already collected data is as productive as taking new observations

Data tools and archives: recommendations

- Although any one set of software is not dominant, many packages addressing all basic parts of observing are available
  - But can be hard to find for someone unfamiliar with the field

- Recommendations:
  - Software collaborations should be encouraged where possible
  - Central list of available software and data
  - More current arrays should consider making older data available to the public

Fostering collaborations

- Collaborations can be a very good way for resource-limited groups to get the most out of an array
- Many different kinds of collaborations already exist
  - Hardware
  - Software
  - Operations
  - Resources
- Great way for university groups (and students) to be directly involved in array development

Collaborations: Recommendations

- Maintain a list of existing facilities, resources and expertise to foster collaborations
  - Could also help guide prospective users to appropriate facilities for their astrophysics
- Competition will always be present (and isn't always a bad thing) but we must also look to improving the field as a whole
- Look at existing collaborations for good models for future ones
- The larger (and better funded) arrays should consider having a visitor instrument capability

Attracting new users

- A very small fraction of the astronomical community has worked with optical/infrared arrays or data
- We need to attract new users at all levels (expert builders to general users to science users) if we want to gain support for sufficient resources to build the next big facility

Issues for non-expert users

- Lack of sensitivity
  - This is true for most areas of astrophysics and is only slowing improving but will get better with on-going development and new arrays
- Optical/infrared interferometry is inefficient and the observations are too complex
  - Operations need to be as efficient as possible
  - Tools should be available so that users don't have to develop their own
  - Imaging will help here!
- The perception that no major results have been produced

Issues for non-expert users: Recommendations

- Interact with our colleagues at scientific meetings (not just technical ones) to make them aware of existing interferometry science results
  - Even with limited sensitivity, there are many fields where interferometry can have a big impact
  - Many astronomers are not aware of existing science results
- Existing arrays should consider making a small amount of observing time available to users outside their "normal" user group, even if the new users do not become experts

Further development

- Many of the operational arrays continue to expand their sensitivity and observing modes
- In addition to considering the long-term strategy and direction, we need to think about the next 5 to 10 years
  - What facilities will be available for technical and scientific use
  - SPIE conference proceedings summarize proposed capabilities, but we must recognize the difficulties the current arrays have had in really reaching the advertised performance levels

Lessons from millimeter interferometry

- In a similar situation several years ago, but now a major international facility (ALMA) is under construction
- Several mostly university-based arrays with some overlapping capabilities but also different strengths
- Technical development continued, but also a substantial amount of observing time was offered to community
- Millimeter interferometry became a vital observational technique for many fields from cosmology to our own solar system

Lesson from mm: Differences

- Only 4 arrays were fully operational previous to the approval of ALMA
- Each of these arrays was considerably better funded than most optical/infrared arrays
- Each gave substantial (up to 50%) of the observing time to the general community
- These arrays produced images
- No direct competition from other techniques at similar wavelengths (i.e. no equivalent of AO)

Trade-offs between support of existing facilities and developing new ones

1. What is the appropriate number single institution/collaboration and national/international facilities which should be supported?
2. To increase the visibility of optical/infrared interferometry, how should efforts and resources be divided between producing unique astrophysical results, operating current facilities for existing and new users and developing new capabilities at current and new facilities?
3. Where are the best opportunities for collaborations between groups within the optical interferometry community and with other astronomy groups: hardware development, joint operations, software development.

Summary

- To convince our colleagues that optical/infrared interferometry is worthy of a major investment in an era of increasingly scarce resources, the current arrays must be viewed as successful
  - This does not mean that they can do everything but that the astrophysical contributions are substantial and in proportion to the resources already allocated
  - In the next 10 years, under-funding the current arrays in favor of future projects will be detrimental to the field
- We must work together to increase the scientific output of the current arrays and the scientific use of these results

Even in the era of 20 and 30 meter telescopes, long baseline interferometry will provide the highest angular resolution