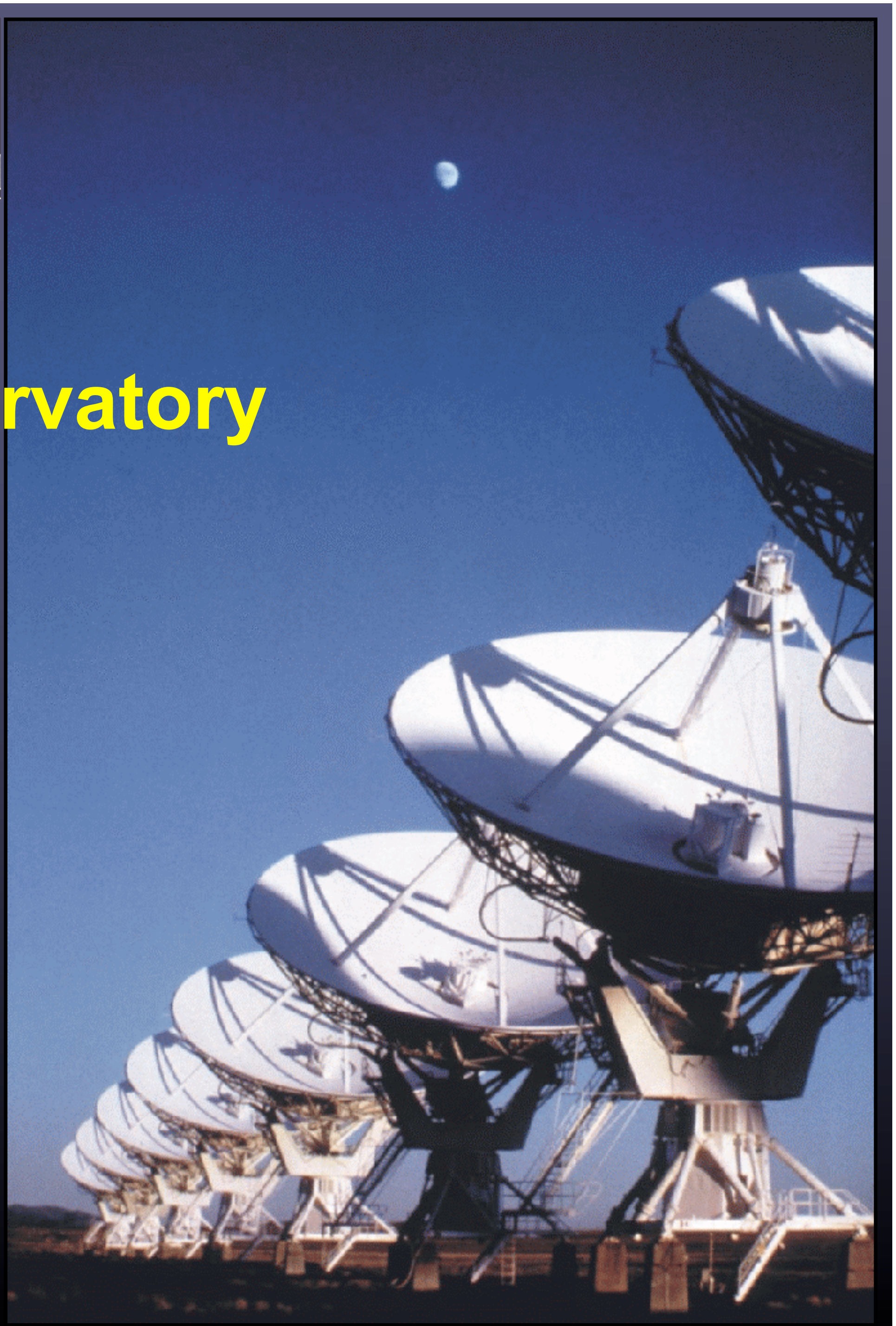
Magdalena Ridge Observatory Interferometer

M. Creech-Eakman

Project Scientist



Tenth Synthesis Imaging Summer School

UNM, Albuquerque, NM – June, 2006

Overview

- Fundamental differences between optical and radio interferometry
- Science with optical interferometers
- Magdalena Ridge Observatory Interferometer

Radio vs. Optical

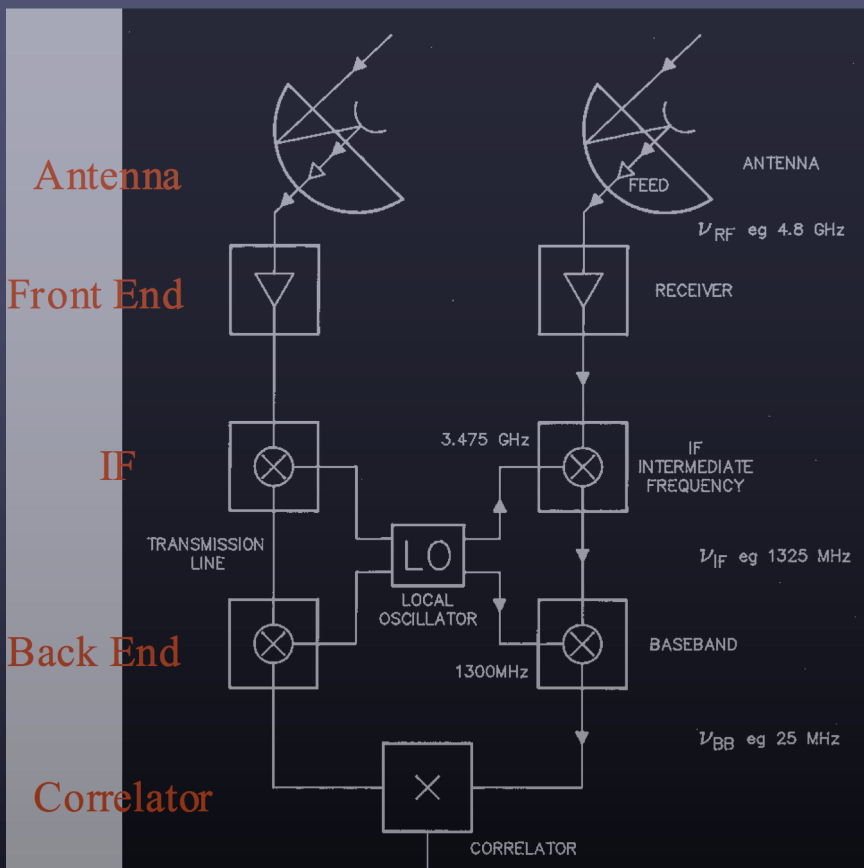
- VLA – 27 antennae

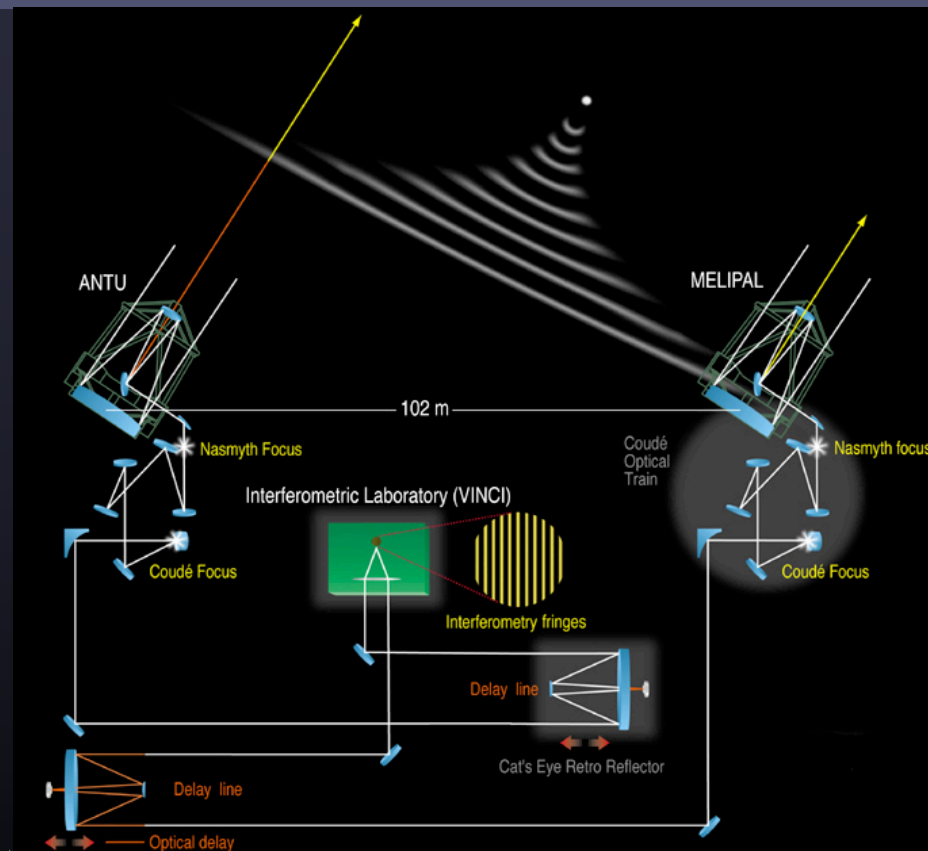
  B_{max} ~ 5.2 Mλ at 44 GHz

- NPOI – 6 antennae

  B_{max} ~ 967 Mλ at 667 THz

Radio vs. Optical





Radio vs. Optical

- Baseline ~ 3E4 m
- Wavelength ~ 1E-2 m
- Integration time ~ 6E2 s
- Spatial coherence scale ~ 3E6 waves

- Baseline ~ 3E2 m
- Wavelength ~ 1E-6 m
- Integration time ~ 1E-2 s
- Spatial coherence scale ~ 1E5 waves

Coherence Volume $r_0^2\ t_0$:

Radio: 5.4E15 Optical: 1E8 (normalized)

(5.4E11) (1E-4) (non-normalized)

Factor of ~5E7 (5E15) advantage for radio over optical interferometry

Fundamental Differences – Radio & Optical

- Temporal coherence of atmosphere – t_0
  - Minutes vs. milliseconds
- Spatial coherence of atmosphere – r_0
  - Kilometers vs. centimeters
- Coherence function of the fields
  - Radio -- Direct measurement of amplitude and phase
  - Optical -- No direct measurement of either

Facility-Class Optical Interferometers

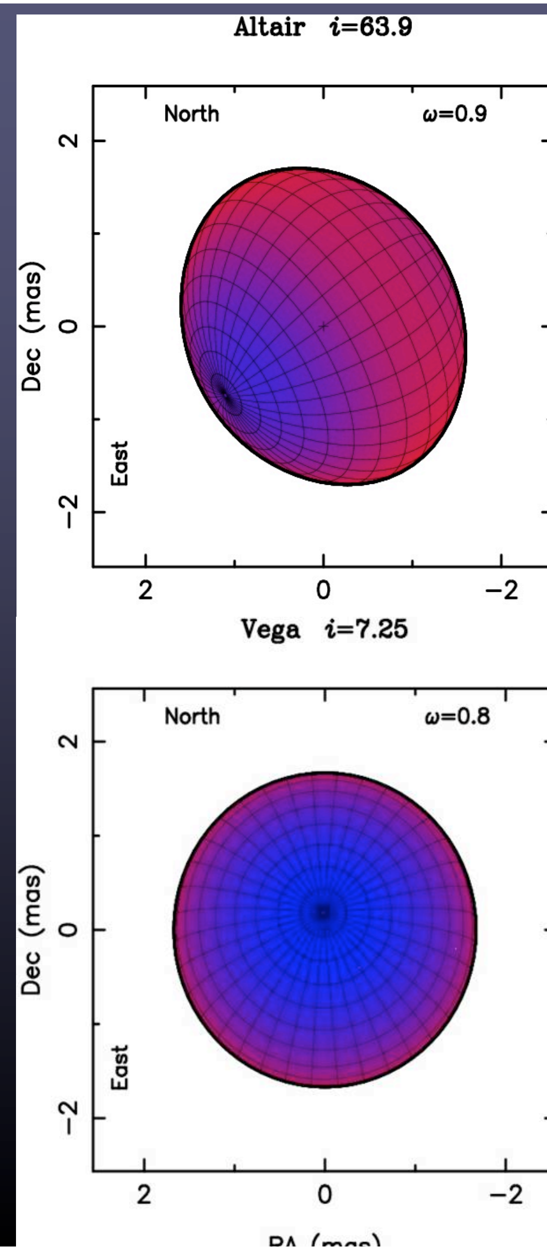
Science with Optical Interferometers

Rapidly rotating stars

- Rotating close to breakup speed.
- Non-spherical, strong pole-to-equator temperature gradient.
- Many found, consistent with rotations at 0.8-0.9 ω_C (including Vega, nearly pole-on!)
- Begin to test gravity-darkening laws.

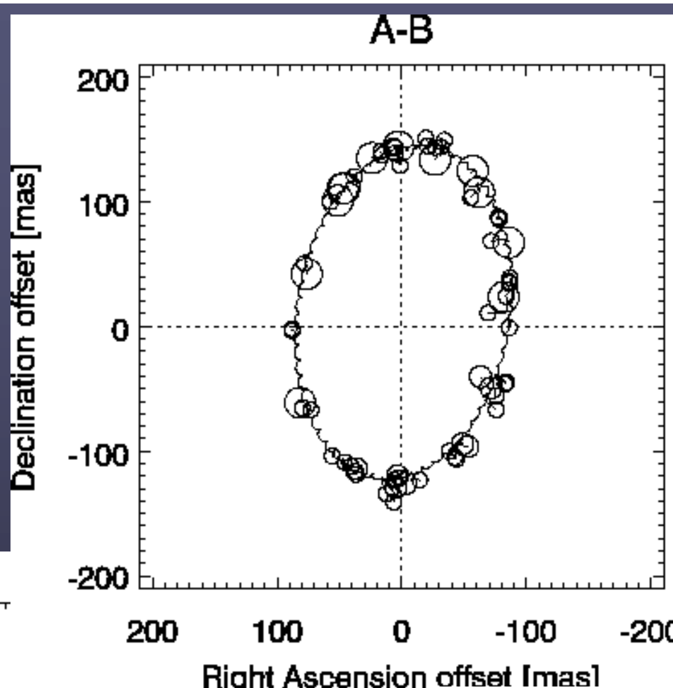
T_p=8740K, T_{eq}=6890K

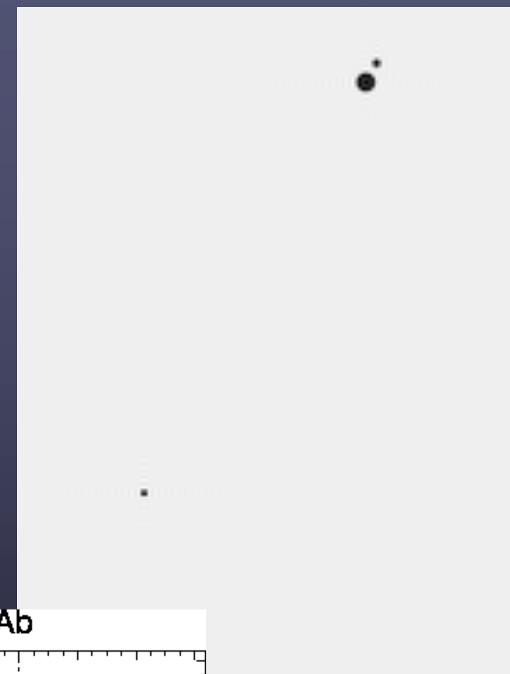
Peterson et al. 2004 (NPOI)

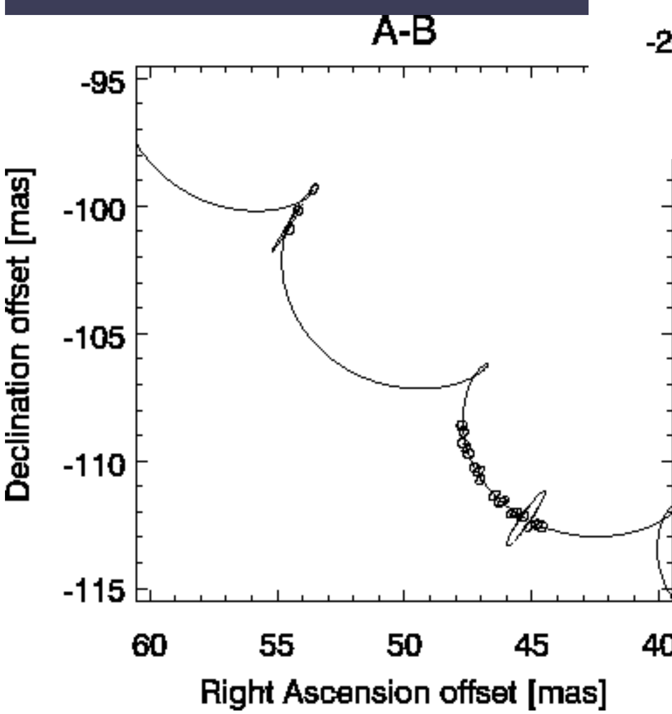


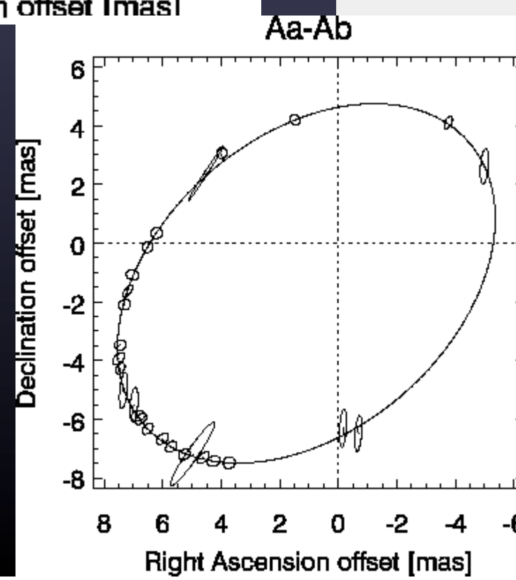
Hierarchical systems

- η Vir: P_{AB} = 4794d
  P_{AaAb} = 71d
- Hummel et al. 2005 (NPOI)





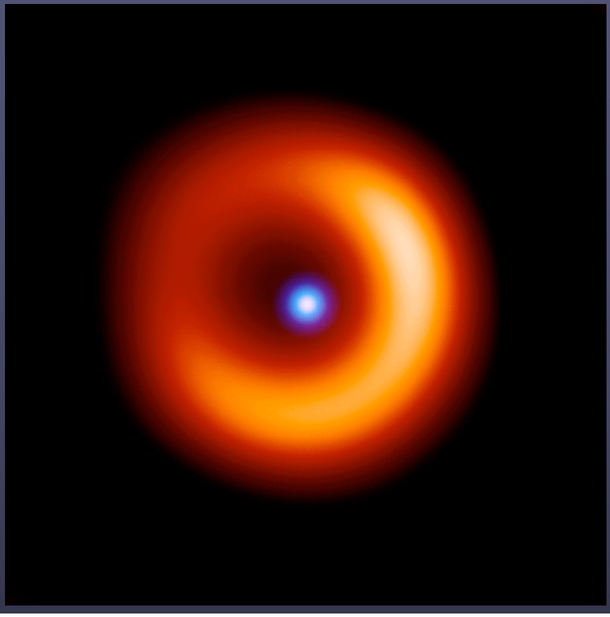


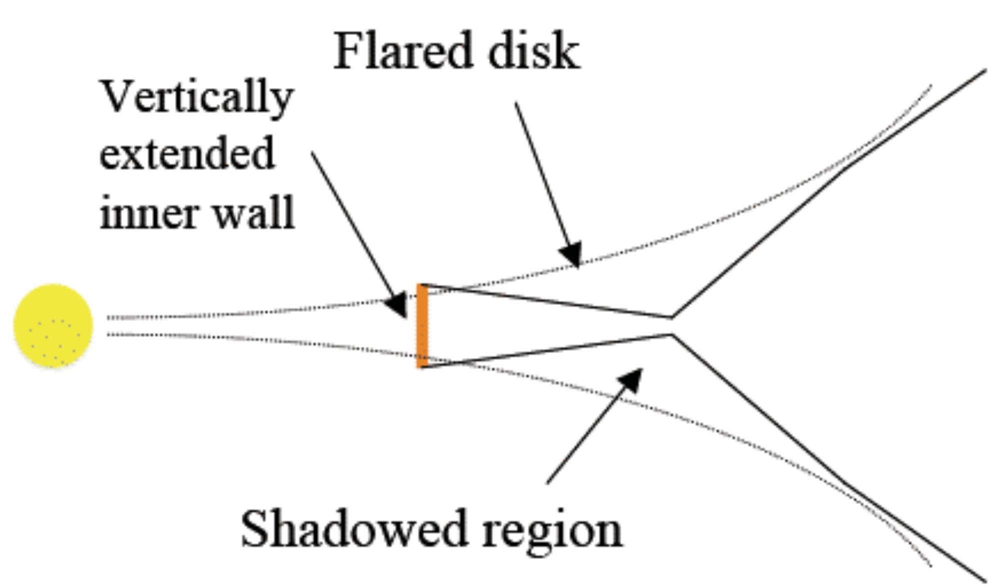


Star formation

- Statistical numbers of disks around young stars: T-Tauri, Herbig Ae/Be.
- Measured inner disk radii *larger* than predicted from simple disk models, except in highest-luminosity sources where they are *undersized* (Monnier et al. 2005).
- Strong evidence for hollow cavity with puffed up inner wall.

LkHα 101 Tuthill et al. 2001 (Keck Aperture masking + IOTA)

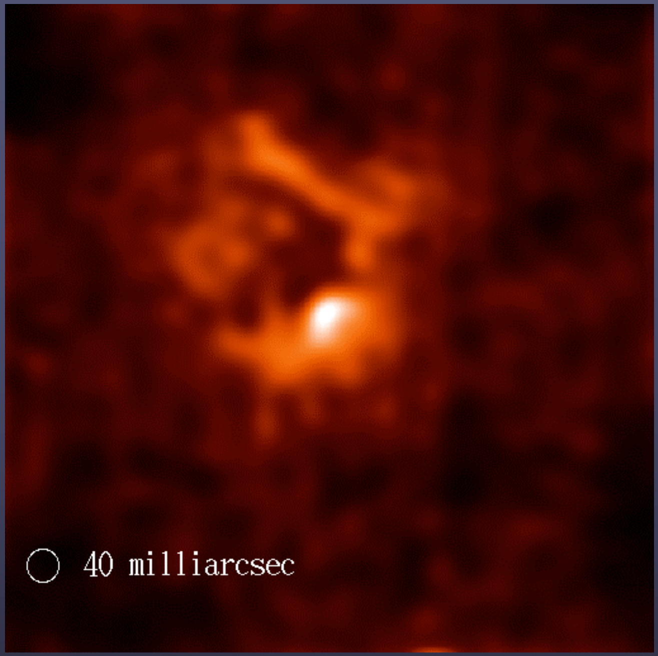





Magdalena Ridge Observatory Interferometer

MROI Science Mission (i)

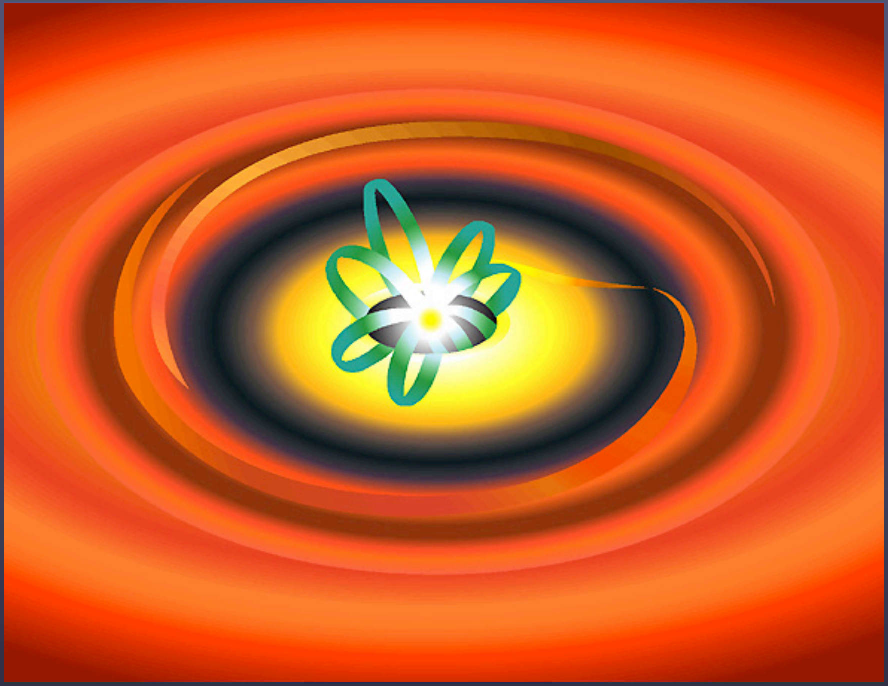
- Stellar Science goals:
  - Mass-loss in single stars:
    - Convection: latitudinal or longitudinal?
    - Distribution of circumstellar material, the onset of bipolarity, shocks and wind geometries.
  - Mass-loss in binaries:
    - Recurrent novae & symbiotics. Orbit, wind & accretion geometry.
    - Eclipsing binaries. Clumpiness in mass transfer.
  - Dynamical studies:
    - Pulsational models for Cepheids, Miras, RV Tauris etc.



Monnier et al. ApJ (2000)

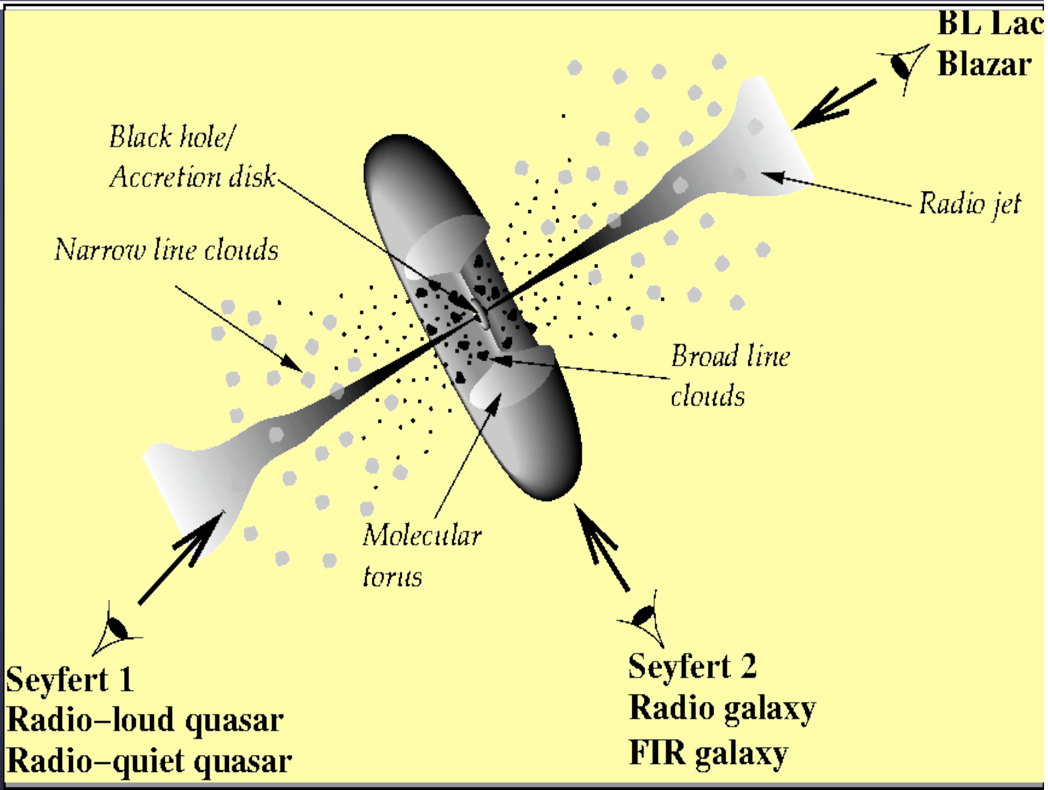
MROI Science Mission (ii)

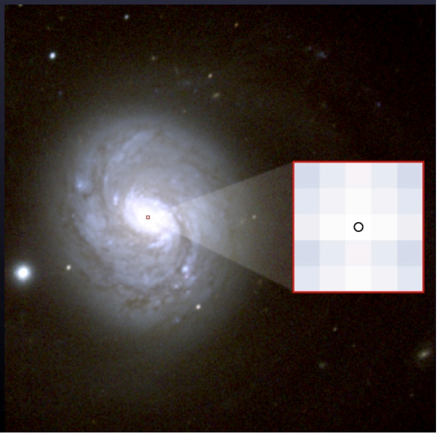
- YSO and Planetary Science goals:
  - Protostellar accretion:
    - Imaging of thermal dust and scattered emission on sub-AU scales.
    - Disk clearing as evidence for the epoch of planet formation.
    - Emission line imaging of jets, outflows and magnetically channeled accretion, x-winds.
  - Companions:
    - Physical and compositional characterization.
    - Direct detection of sub-stellar companions to M dwarfs.



MROI Science Mission (iii)

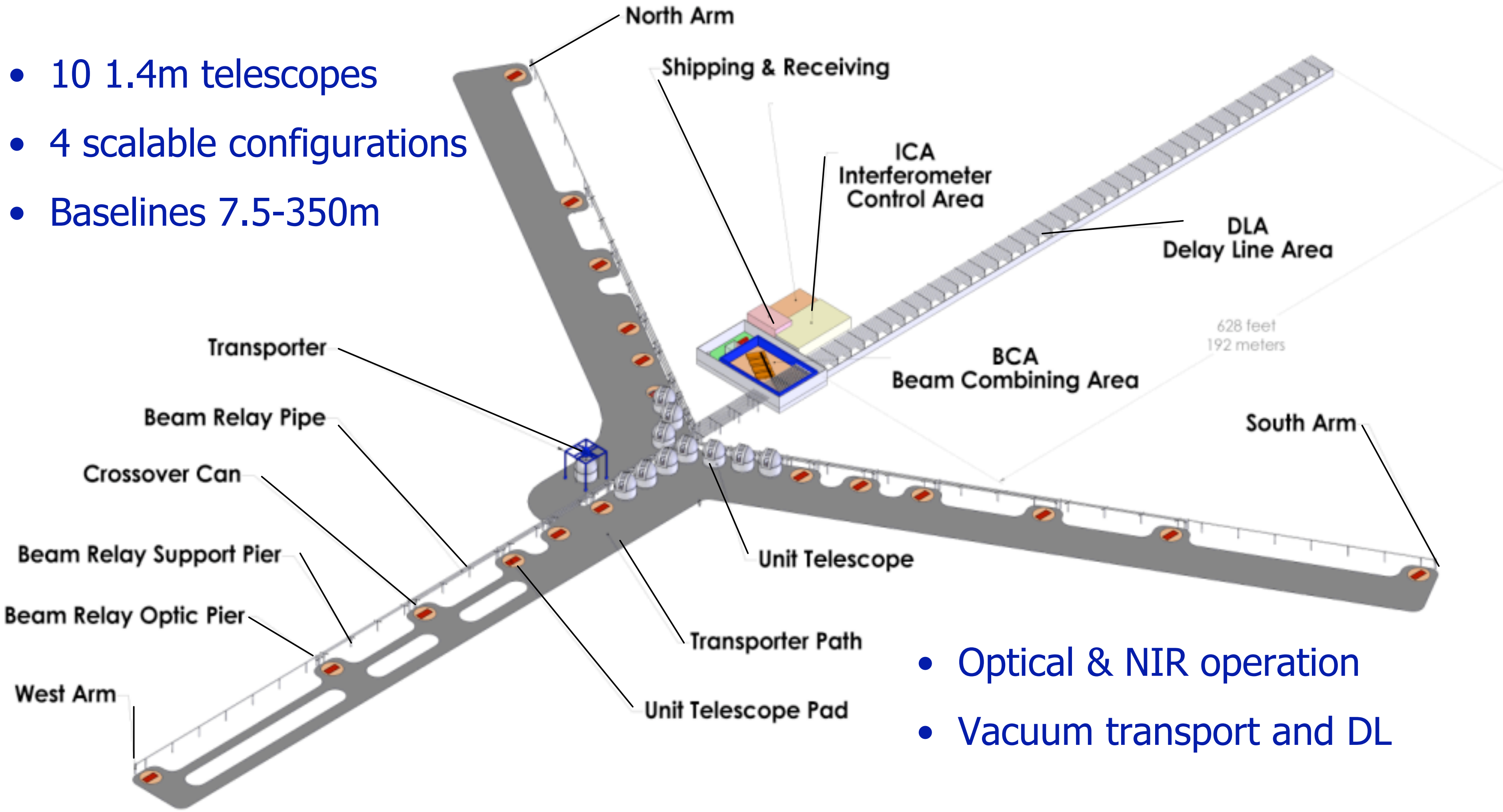
- AGN Science Goals:
  - Verification of the unified model:
    - Direct detection of the obscuring tori.
    - Geometry and orientation of the tori – thick, thin or warped? Relationship to other observables.
  - Nature and contribution of nuclear and extra-nuclear starbursts.
  - Imaging and dynamics of the BLR in nearby AGN.
  - Detection of optical and infrared counterparts of synchrotron jets.





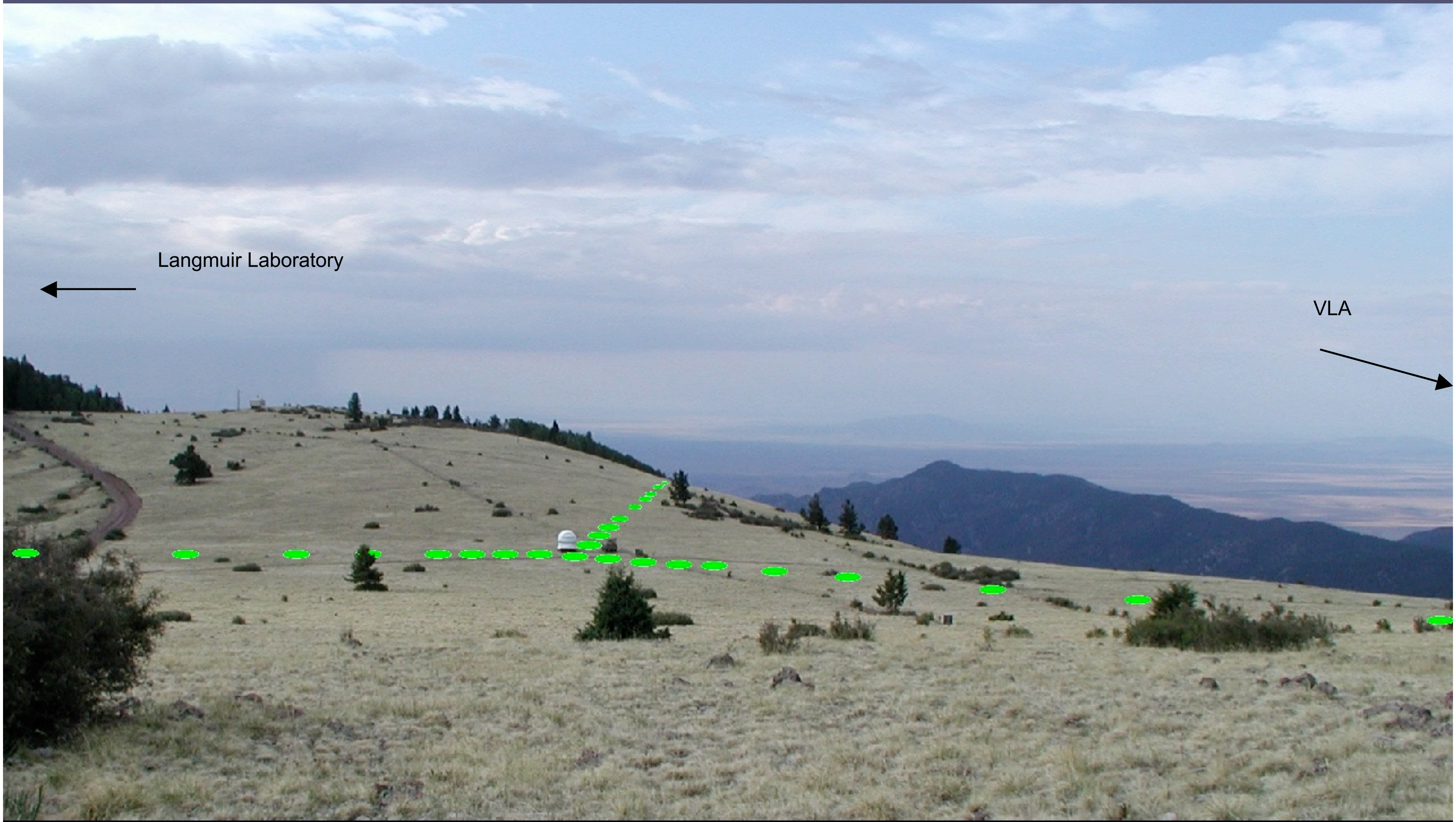
MROI Vision Instrument

- 10 1.4m telescopes
- 4 scalable configurations
- Baselines 7.5-350m

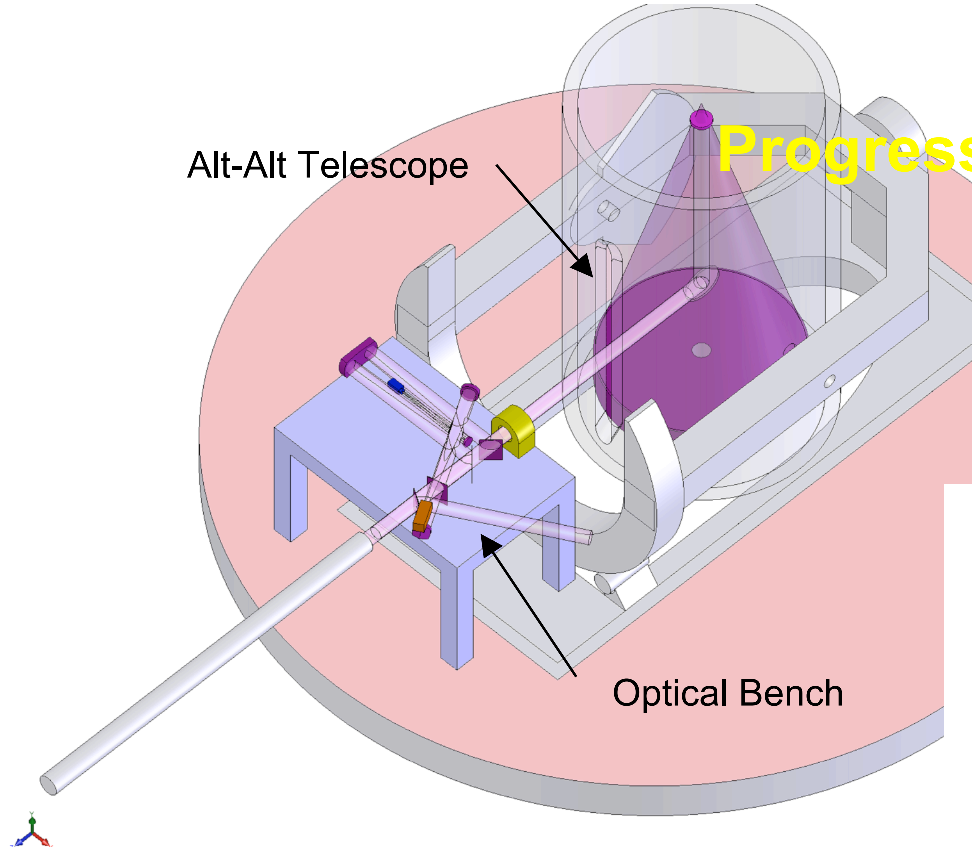


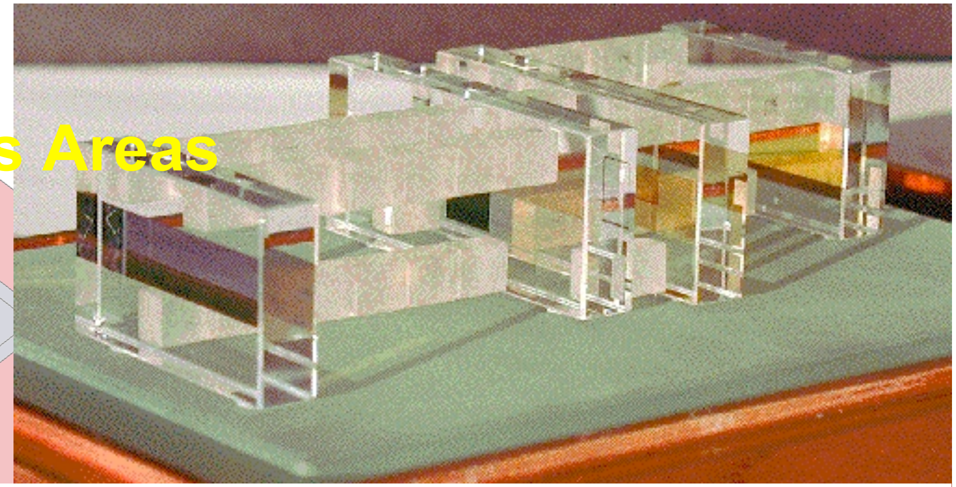
- Optical & NIR operation
- Vacuum transport and DL

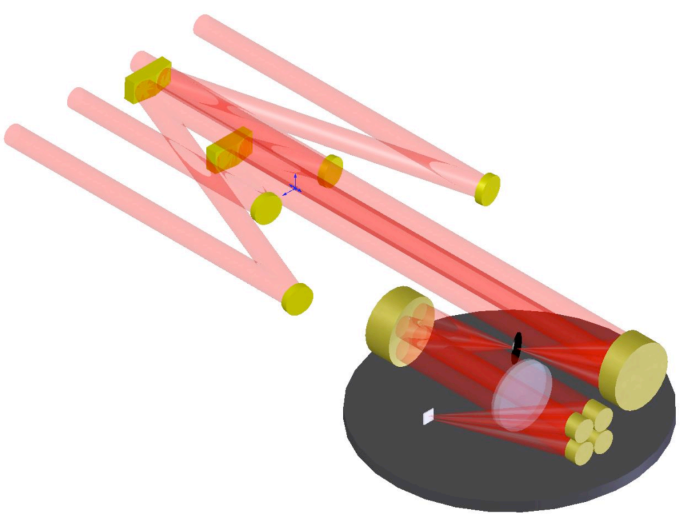
Ridge Layout

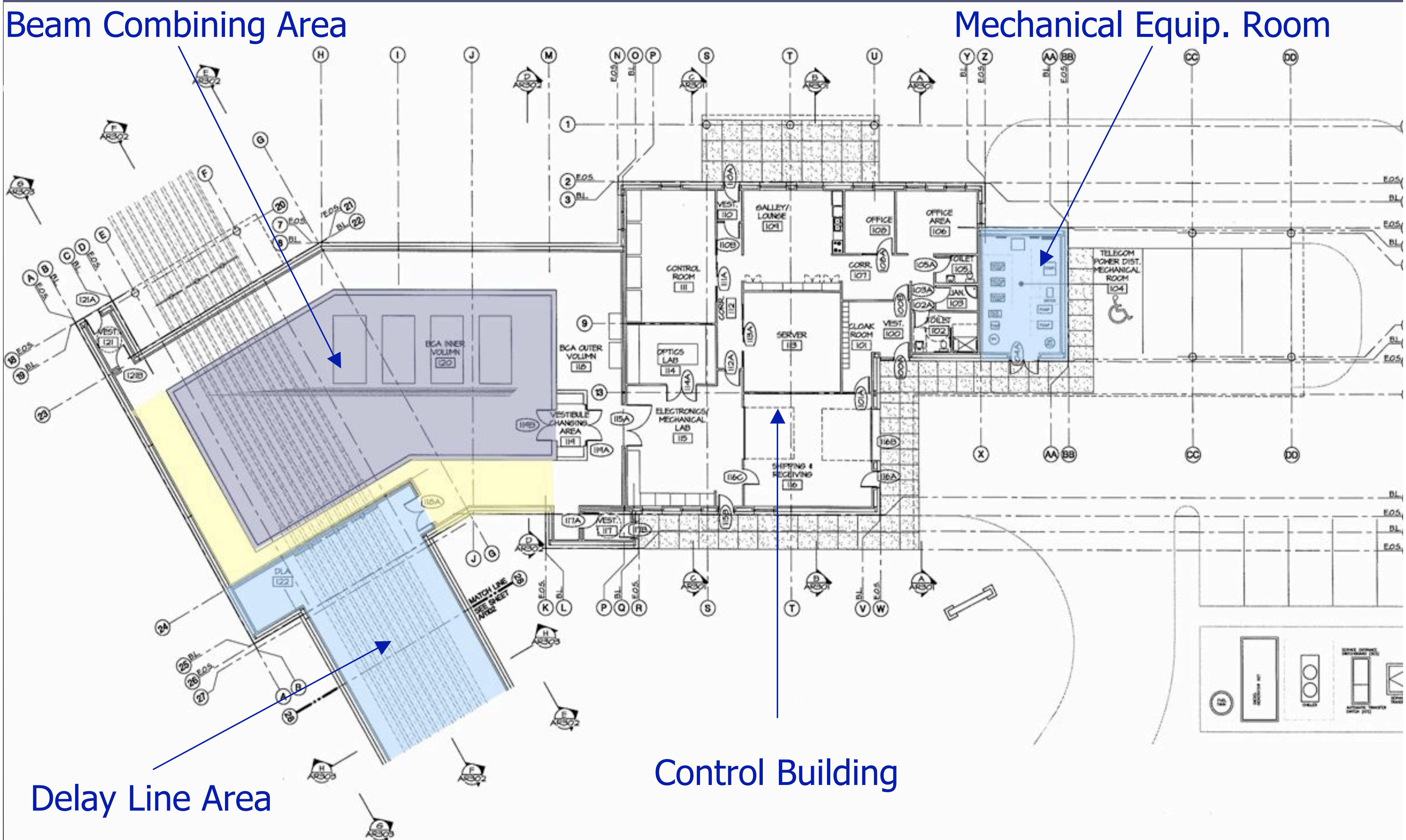


Progress Areas

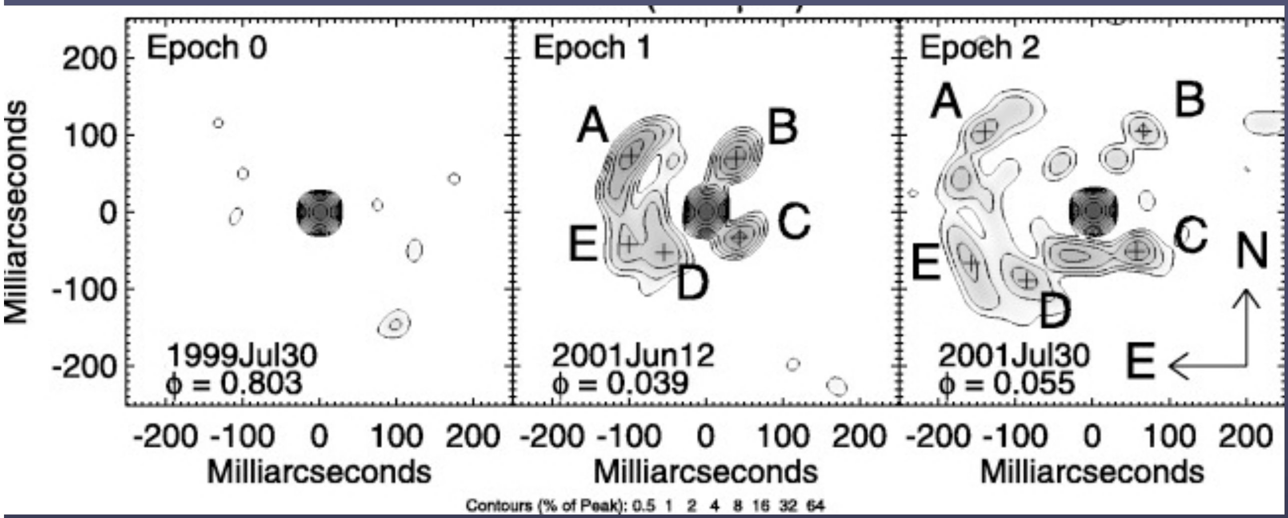






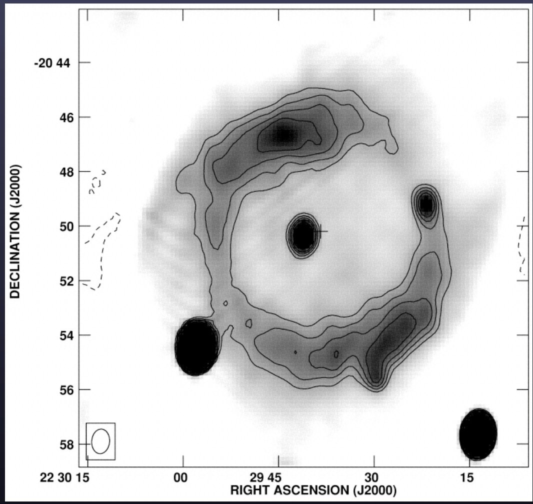

Beam Combining Area
Mechanical Equip. Room
Delay Line Area
Control Building
CONTROL ROOM
GALLEY/ LOUNGE
OFFICE
OFFICE AREA
CORR.
SERVER
OPTICS LAB
ELECTRONICS/ MECHANICAL LAB
SHIPPING & RECEIVING
CLOAK ROOM
VEST.
TOILET
JAN.
BCA INNER VOLUMN
BCA OUTER VOLUMN
VESTIBULE CHANGING AREA
TELECOM POWER DIST. MECHANICAL ROOM
DLA
MATCH LINE SEE SHEET

Optical Interferometry is Coming of Age



Monnier et al, ApJ, 567, L137, 2002

Rodriguez et al, ApJ, 574, 2002



Which is the radio interferometric map?