Star Formation & The Galactic Center

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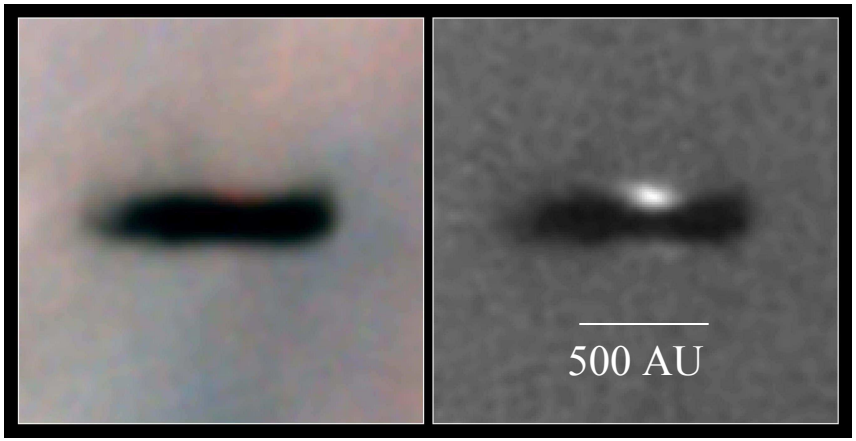
Harvard-Smithsonian CfA

Massive Star Formation

- Solar-mass star formation paradigm: accretion disk
  - Still not critically tested
- Massive star formation:
  - No paradigm yet
  - Coalescence possible



HST: Orion Nebula "Proplyd"

IR & Radio

- Orion-I (IRc2):

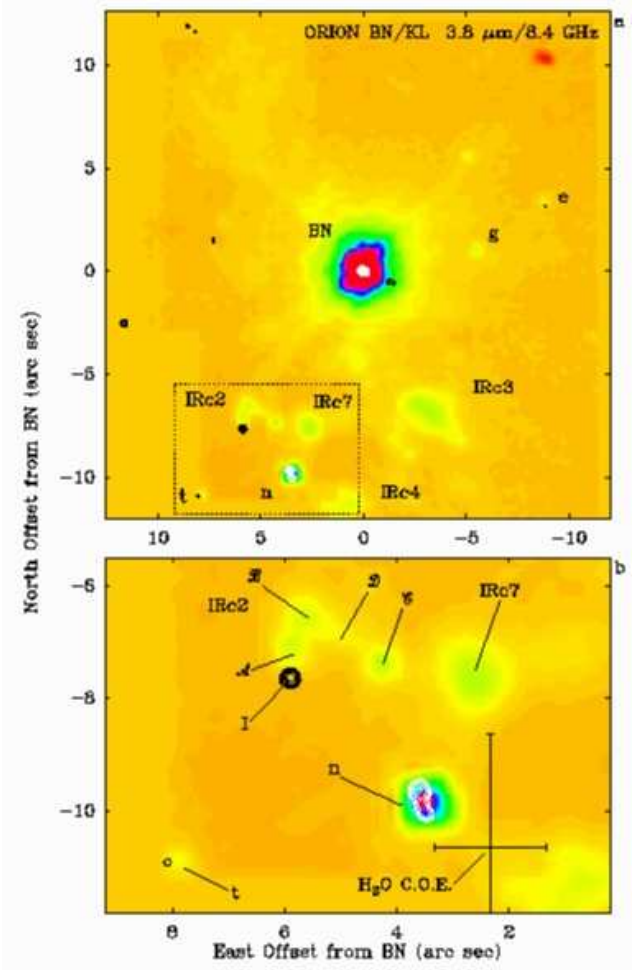
  Dominant massive star in KL region

- Obscuration problem:

  A_v ~ 100's to 1000's

  A_{IR} ~ 10's to 100's

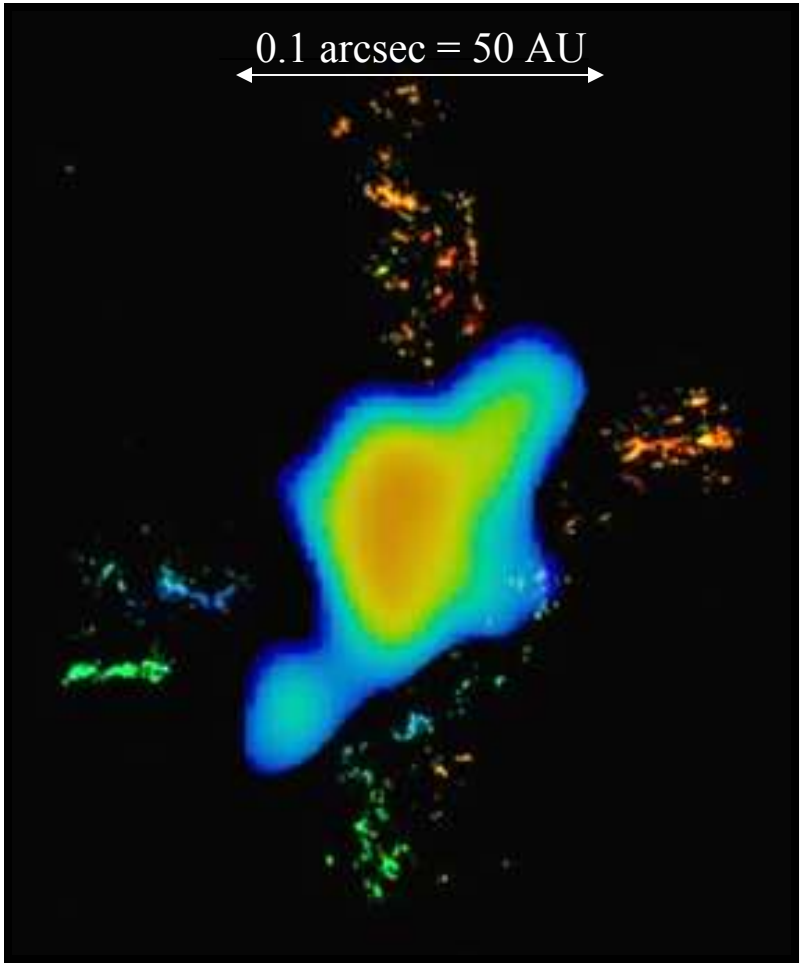
  Need radio waves to see inside



Menten & Reid (1995)

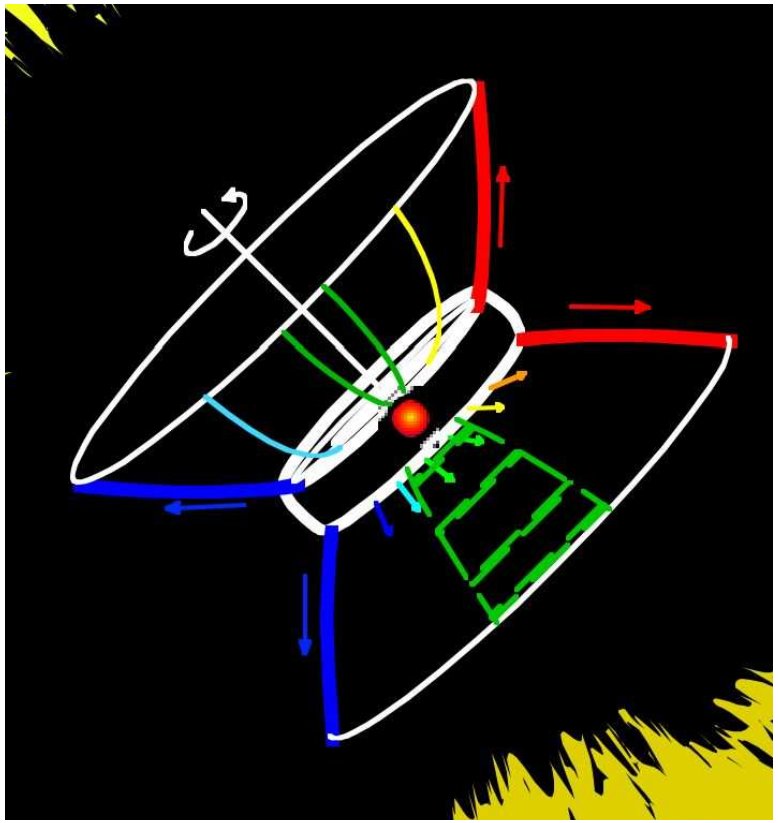
Orion-I

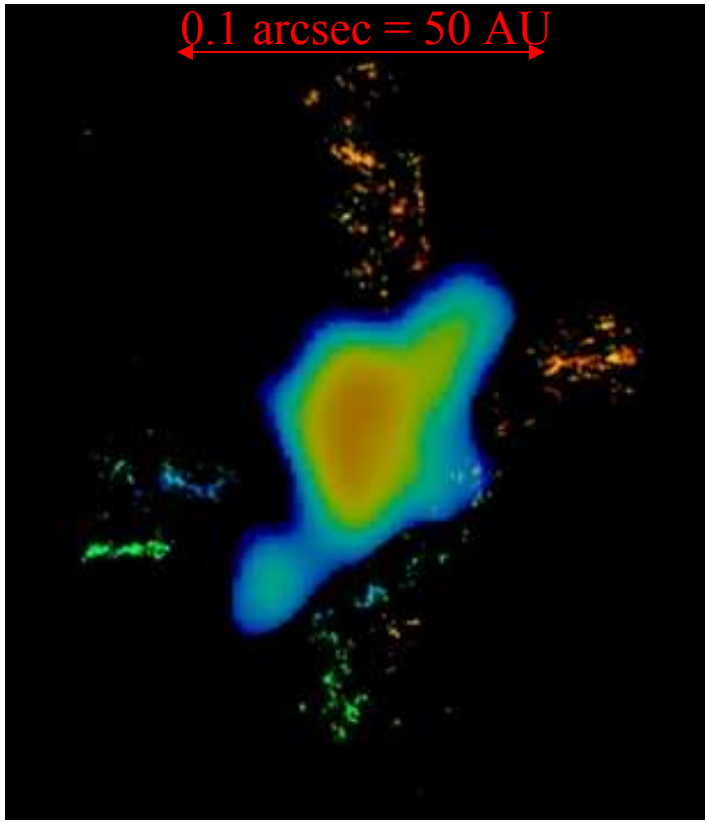
- VLA continuum image
  - 43 GHz (7mm)
  - 40 mas = 20 AU resolution
- VLBA line image
  - SiO masers
  - 0.5 mas =0.25 AU resolution



Greenhill, Reid, Menten & Chandler

Disk Geometry





Massive star protostellar “disk”: resolved by VLA

Seeing material expelled from disk (rotating outflow)

EVLA Contributions

- EVLA-I: increased sensitivity (x 10)

  Current image barely detected; increased sensitivity will allow studying details (eg, disk thickness, disk truncation, jet formation, etc.)

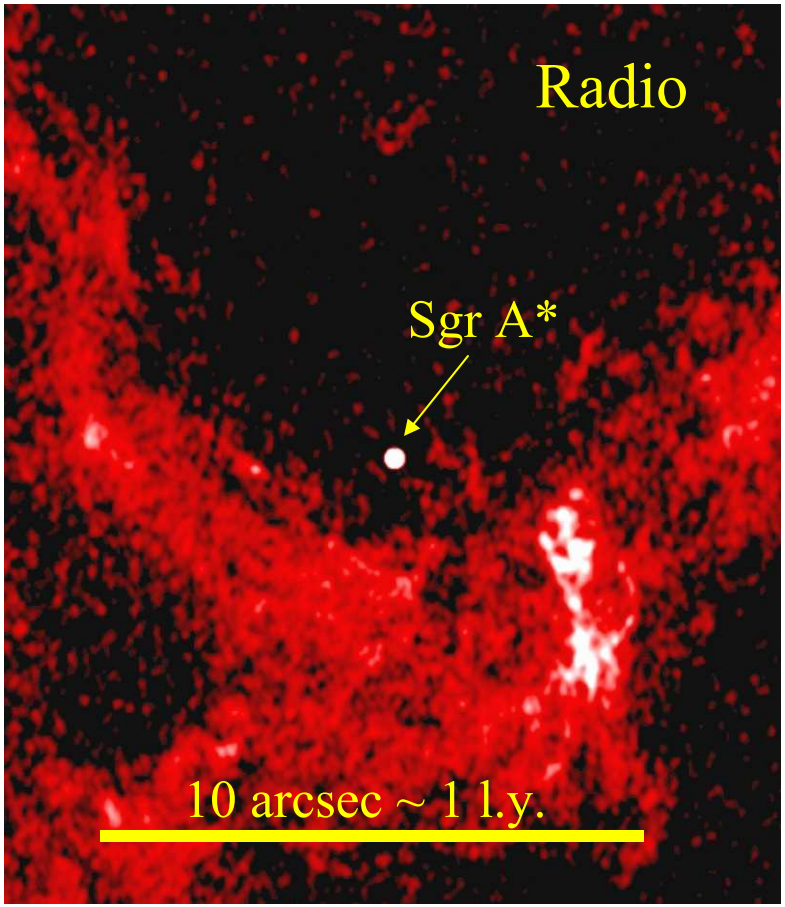
  Move from studying nearest source to many others, eg, in

  Cep A, NGC 6334, W3, etc.

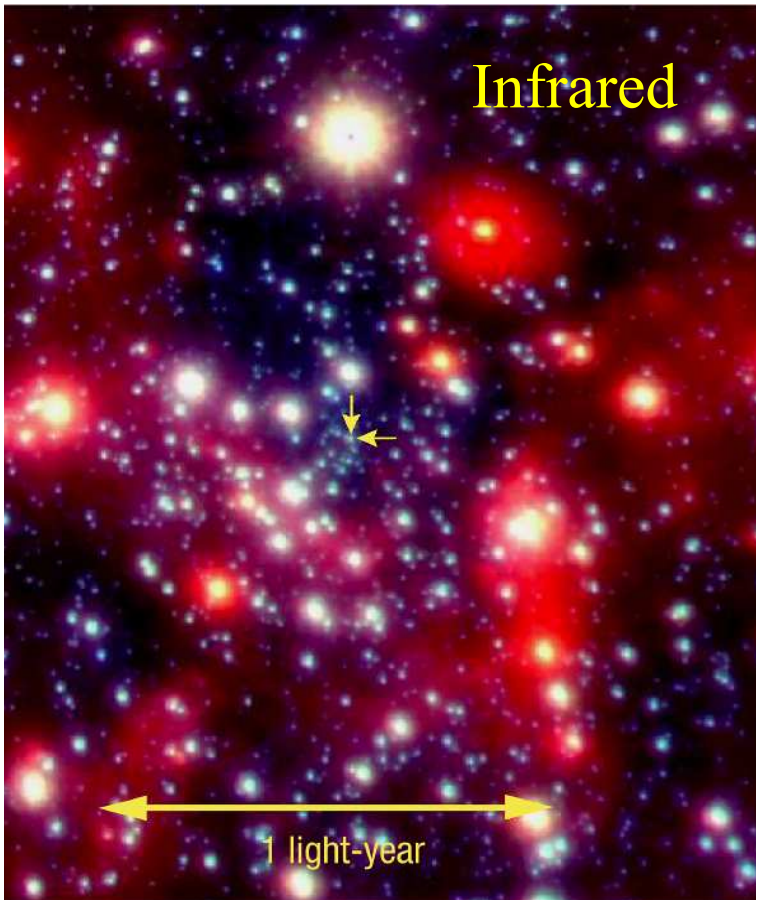
- EVLA-II: increased angular resolution (x 10)

  Resolve internal structures: eg, gaps, density distribution

Galactic Center

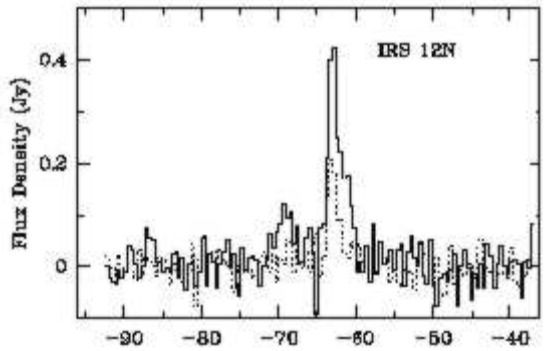


VLA: 1 cm (Zhao)



VLT / NACO 1.6-3.5 microns

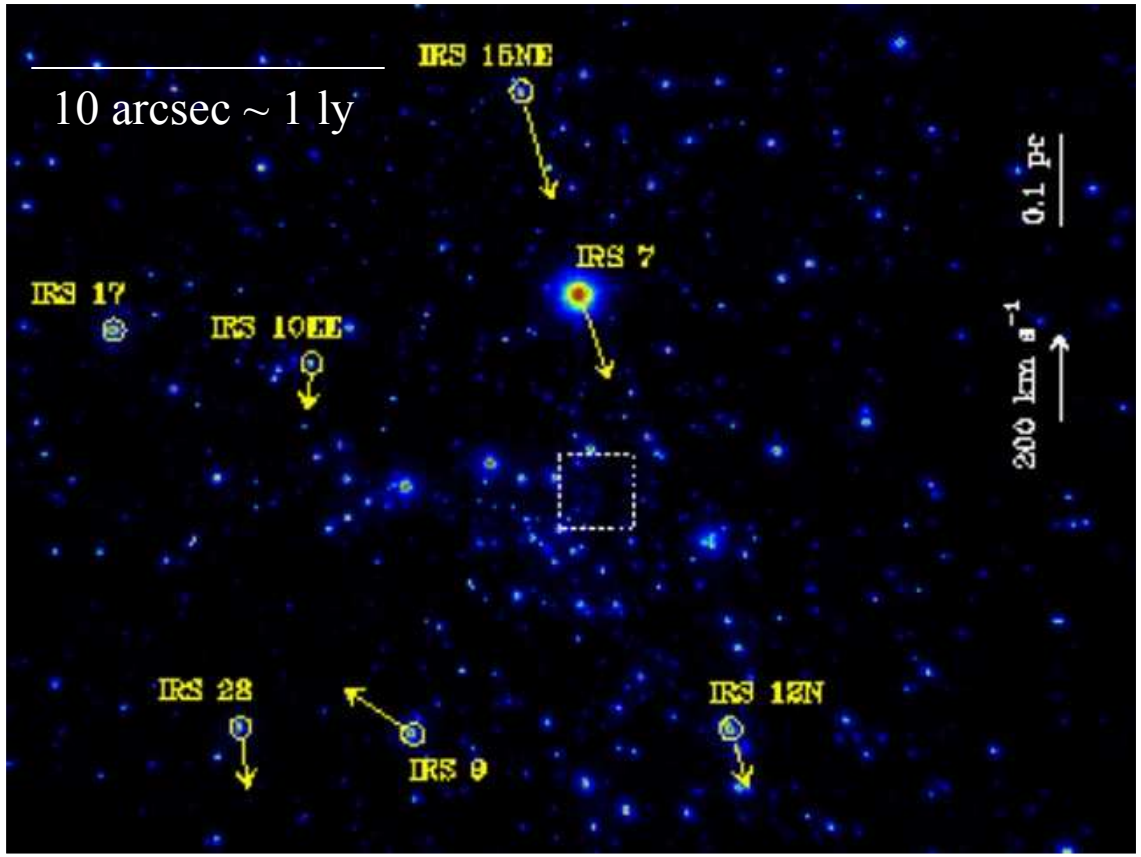
Radio/IR Astrometry



Grid of stars visible in IR and Radio

Red Giant stars with SiO masers:

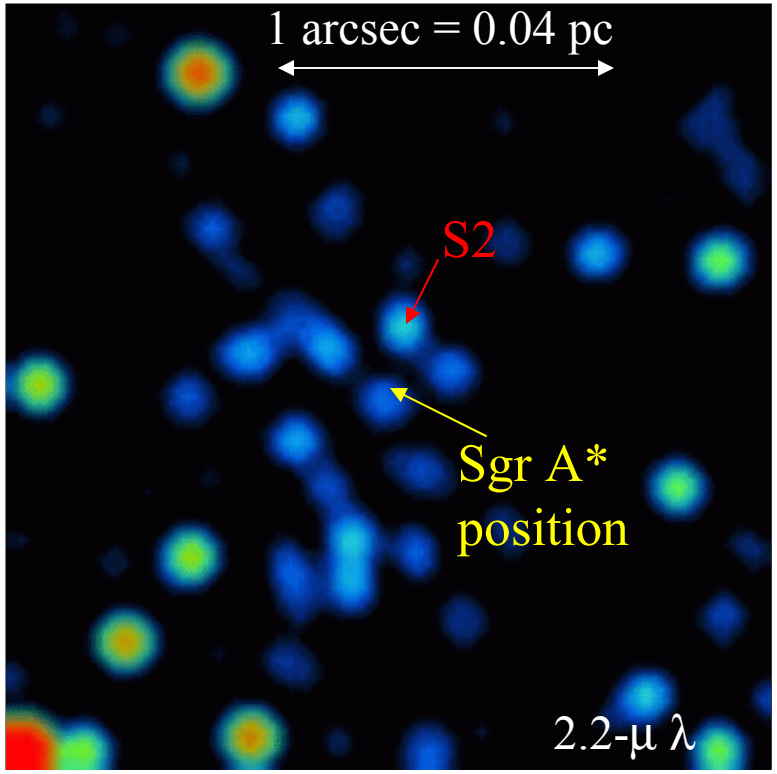
Radio frame "perfect"



Reid & Menten (2003)

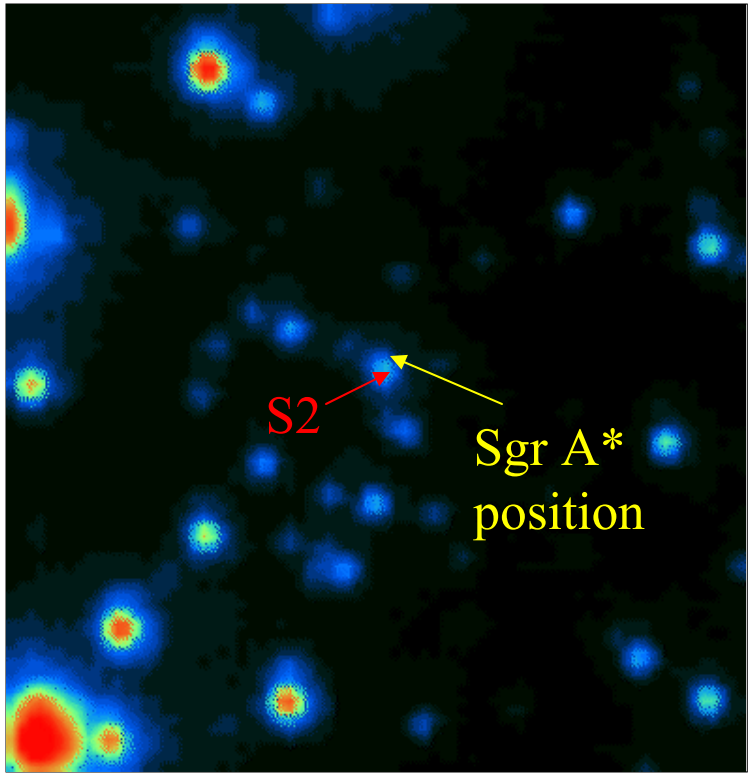
Where is Sgr A*?

1995



Menten, Reid, Eckart & Genzel (1997)

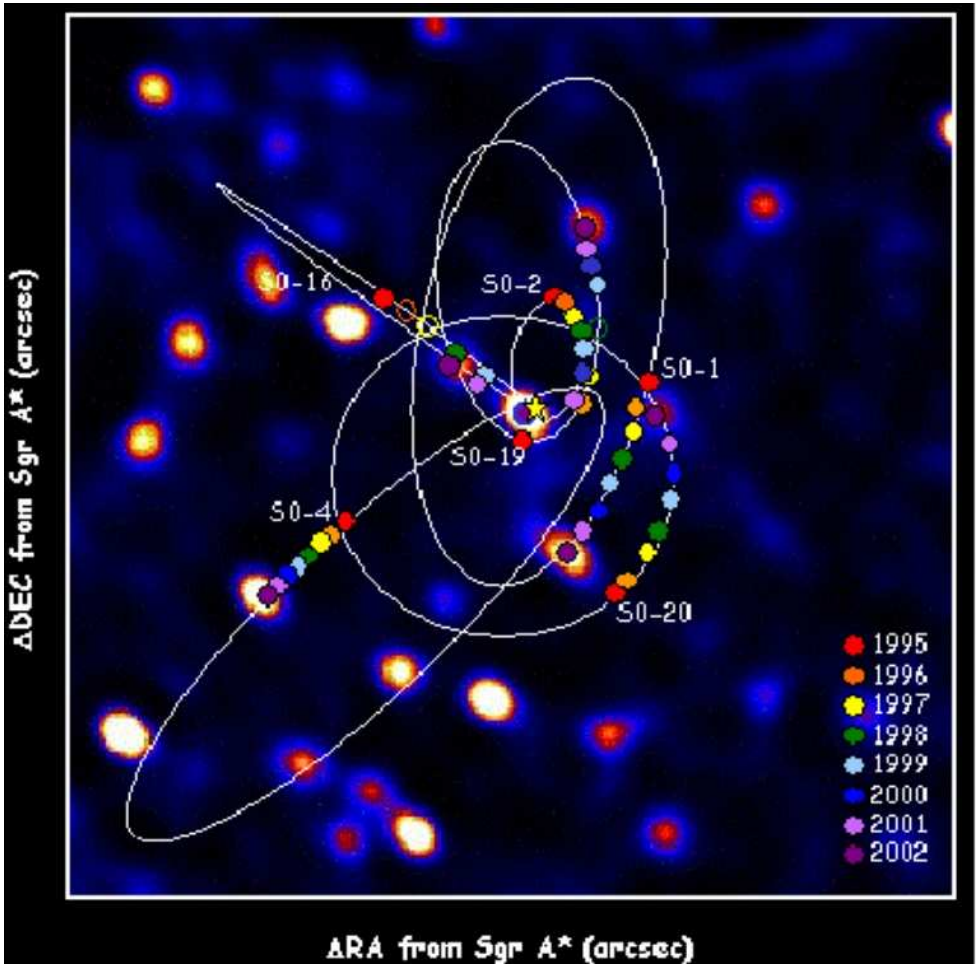
2002



Reid et al (2003)

Stellar Orbits

- Limited by distortions across IR frame
  - Requires grid of reference stars to remove systematic errors
  - Need < 1 mas accuracy
- Deviation from elliptical orbits give
  - Extended dark matter
  - Stellar remnant graveyard
  - Effects of BH spin (precession)
- G.C. distance: R_o (<1% unc.)
  - Galaxy rotation speed (<1% unc.)
  - Recalibrate EG distance scale



Credit: Ghez & Tanner

EVLA Contributions

- EVLA-I: Super correlator (x 12 speed-up)

  Observe all stars (+/- 400 km/s) simultaneously;

  currently requires >12 bands observed sequentially

  Increased sensitivity => more stars, <1 mas positions

- EVLA-II: increased angular resolution (x 10)

  Increase astrometric accuracy from <1 mas to <0.1 mas