Low-mass young stars with the Next Generation VLA: multiplicity and the small-scale architecture of multiple systems

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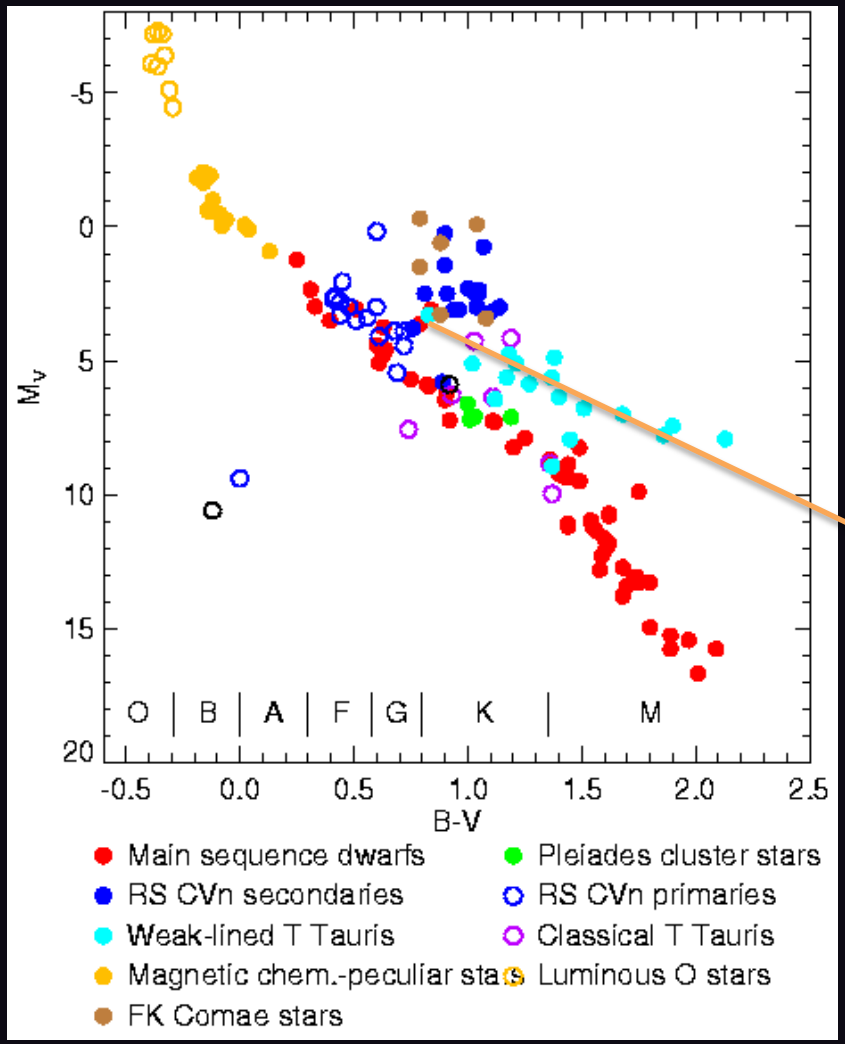
January 4, 2015

Radio Astronomy in Mexico

20 to 25 professional radio astronomers

Radio emission from stars

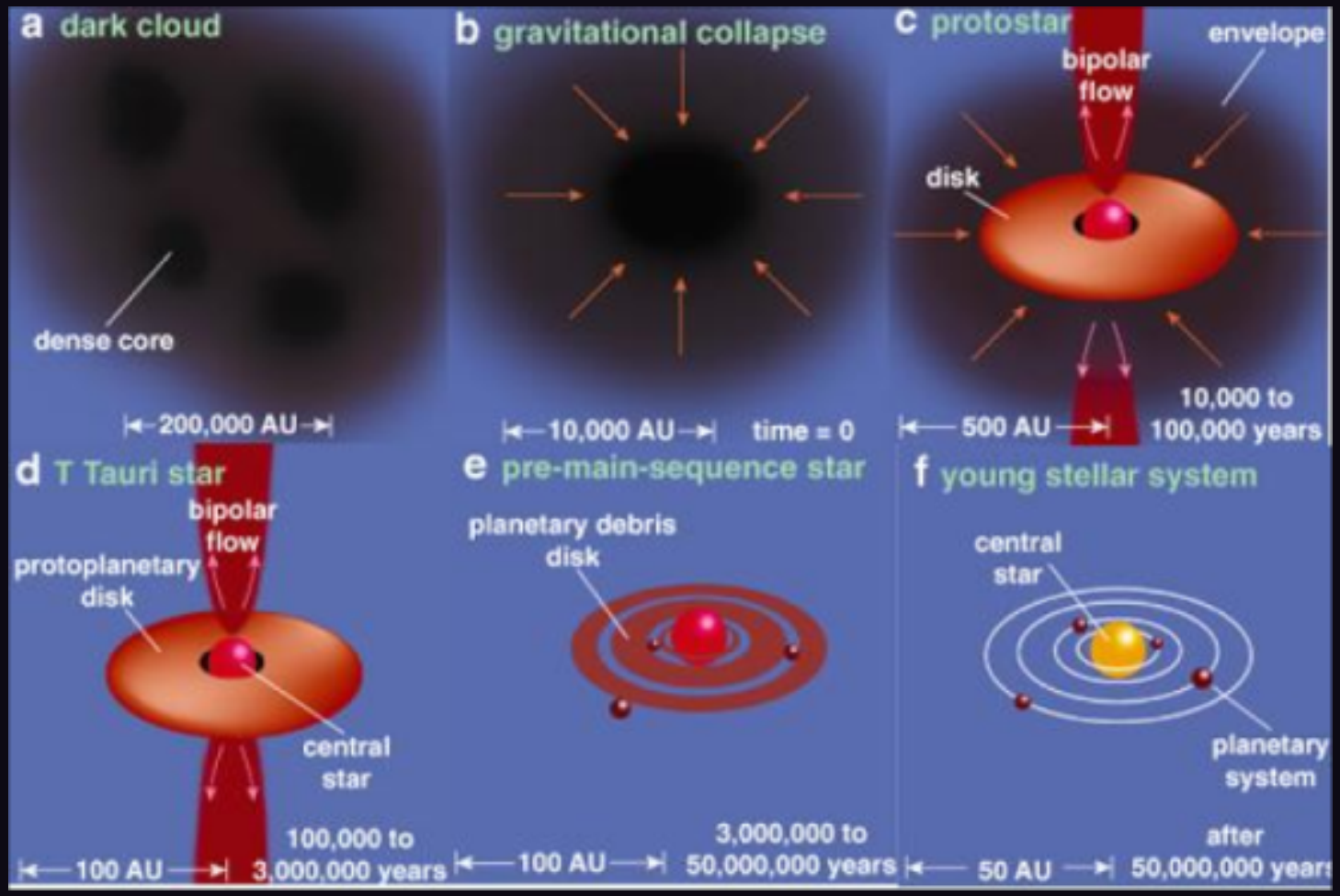


@ Stephen White

Radio emission has been detected from stars across the HR diagram.

Low-mass YSOs (Young Stellar Objects)

…and from protostars



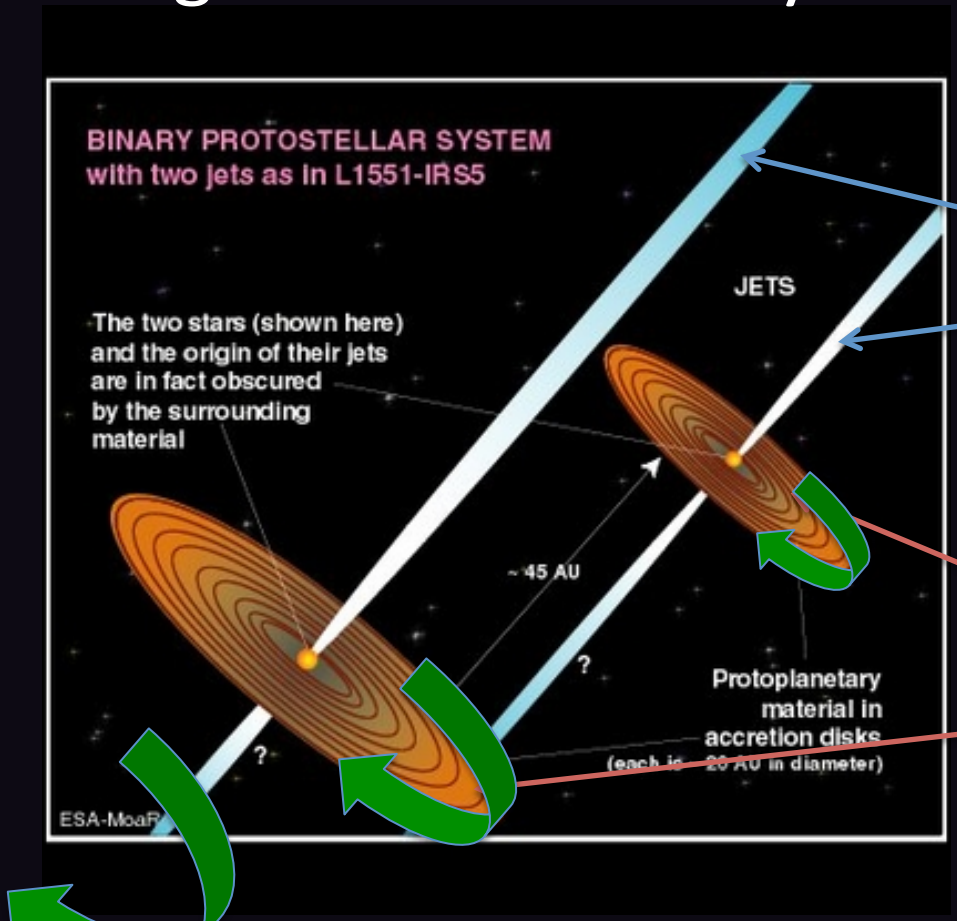
Emission mechanisms / Types of sources

- **Lines** (HI, masers, RRLs, molecules, …)
- **Continuum**
  - Thermal (Bremsstrahlung, dust, …)
  - Non-thermal (cyclotron; synchrotron, ...)

HII regions, thermal jets, protoplanetary disks, shocks, stars with active coronae, jets, outflows, …

→ Radio emission can be used as a probe of phenomena and structures around young stars

Testing models of binary star-formation

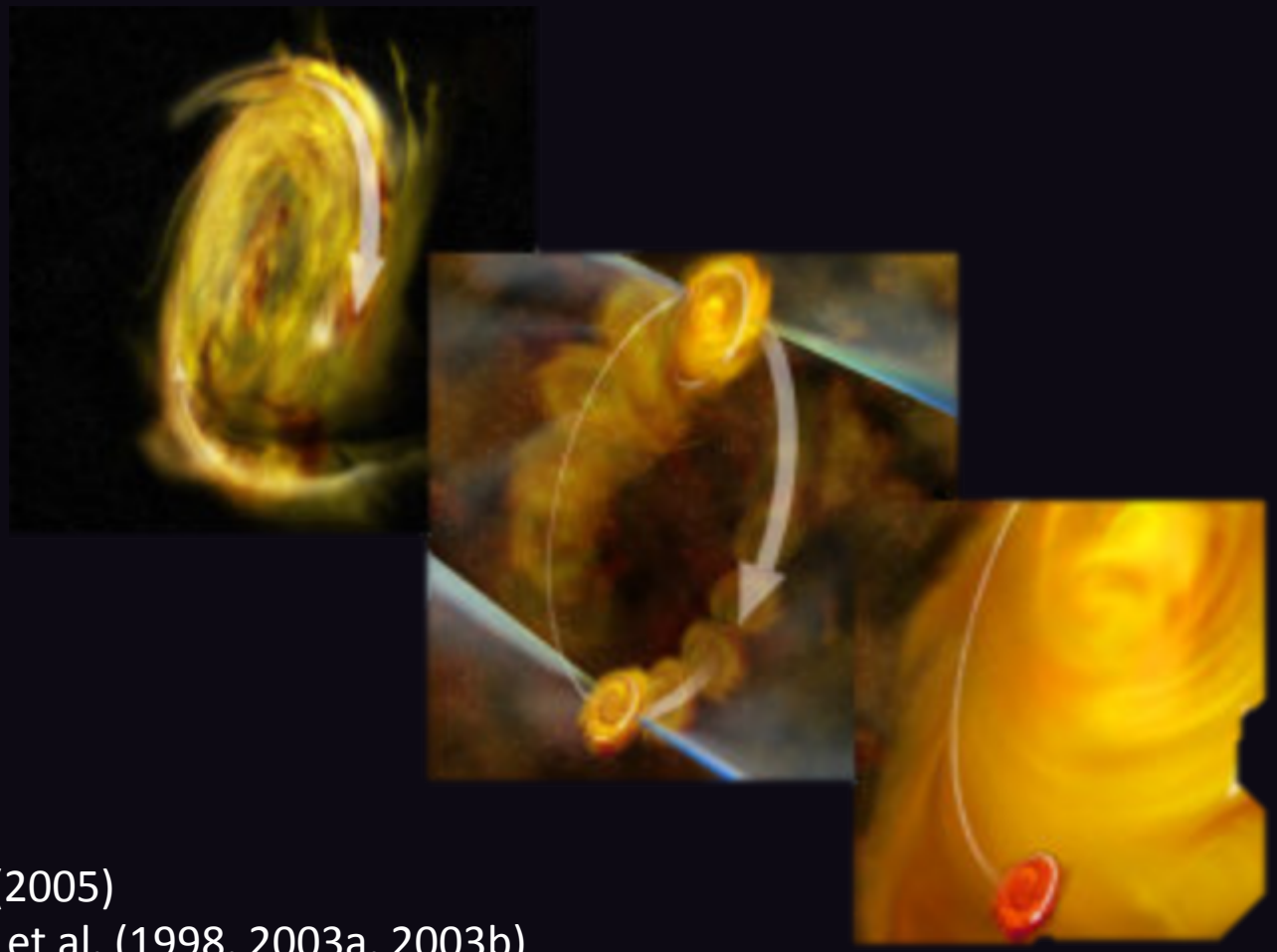


Jets seen at high-res in 10 GHz VLA data

Disks seen at high-res in 50 GHz VLA data

Orbital motions (from multi-epoch VLA observations + line data

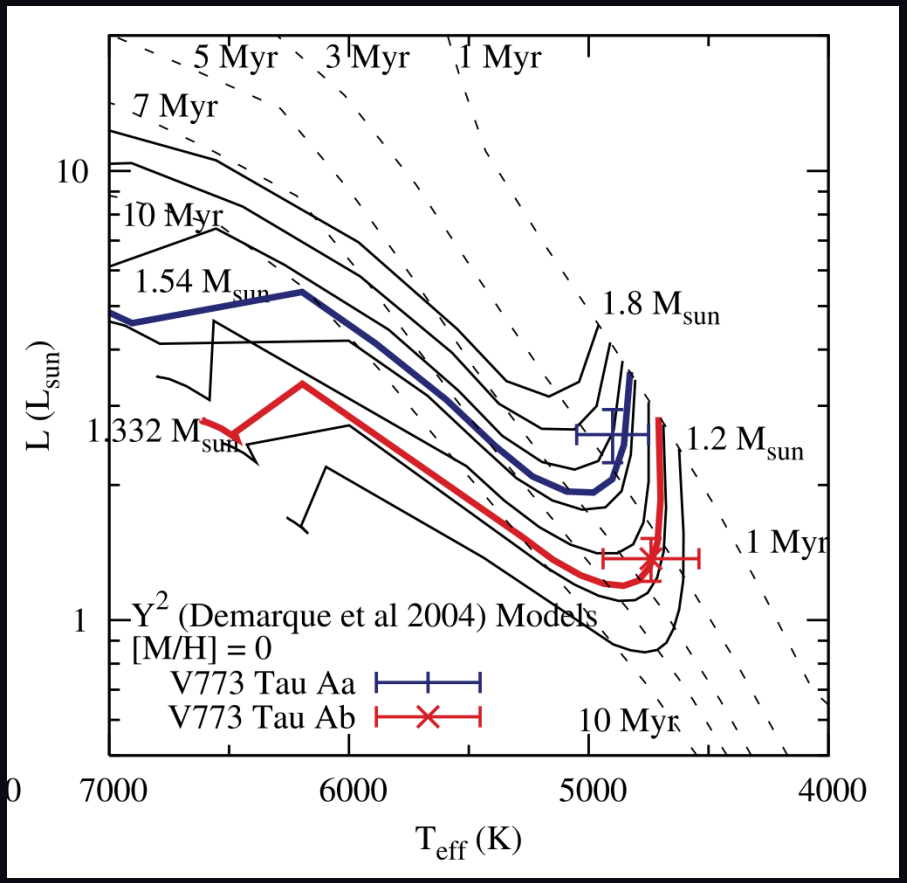
Testing models of binary star-formation

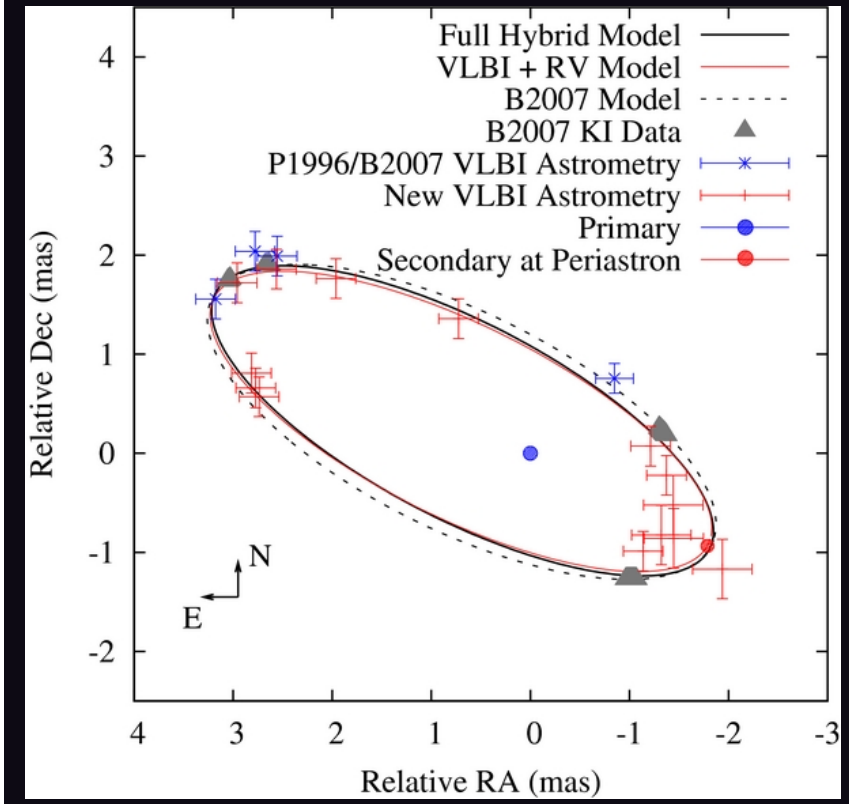


Lim et al. (2005)
Rodríguez et al. (1998, 2003a, 2003b)

Constraining PMS evolutionary models

V773 Tau A – tight binary system





Massi et al. 2006; Boden et al. 2009; Torres et al. 2013

Measuring multiplicity as a function of age

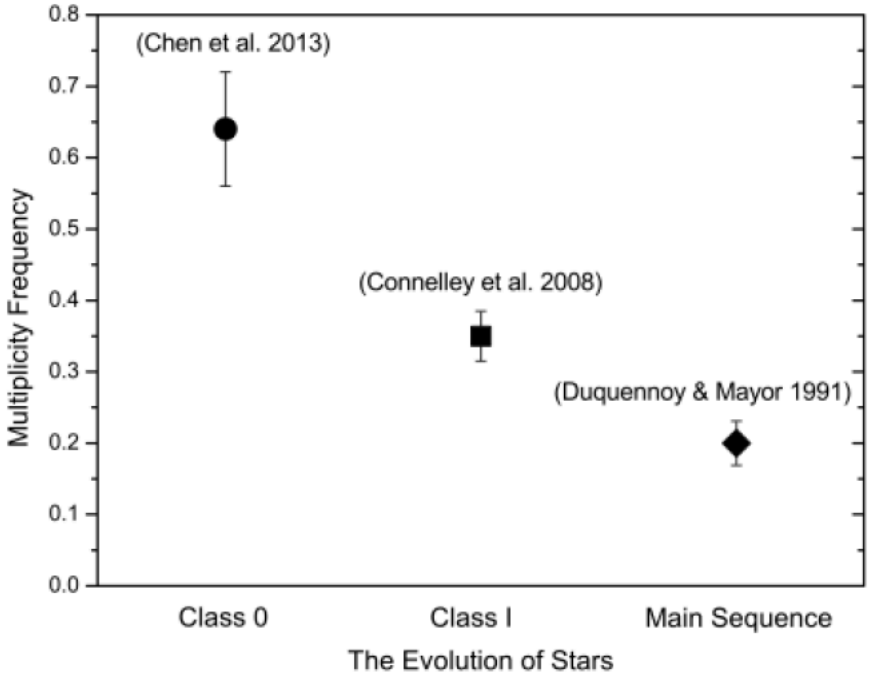
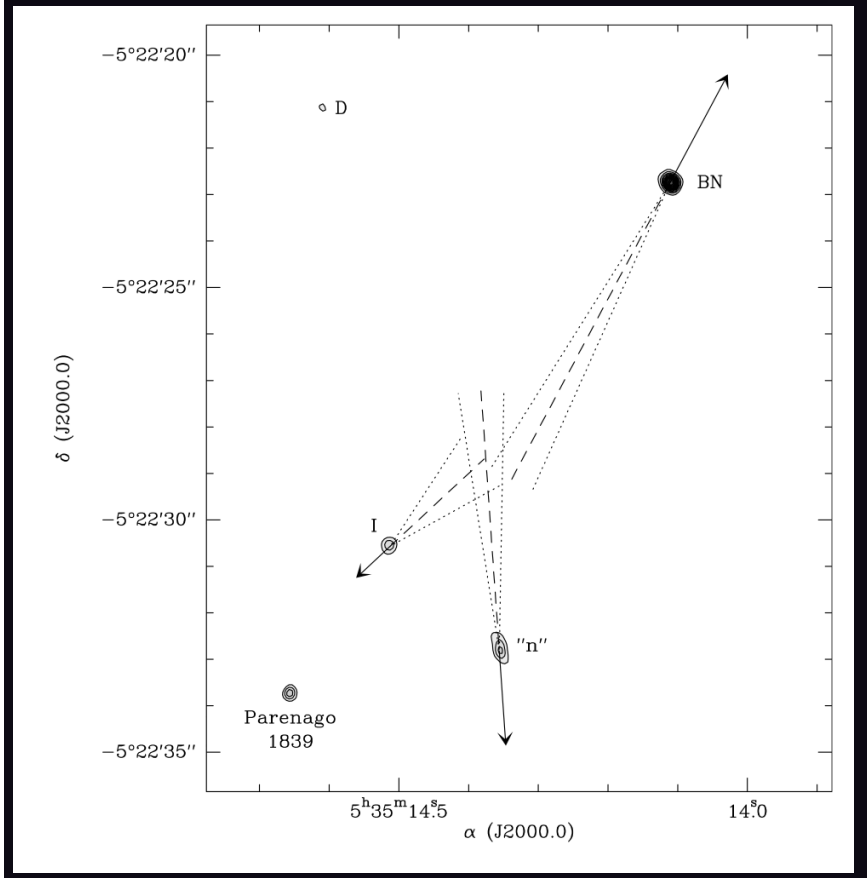


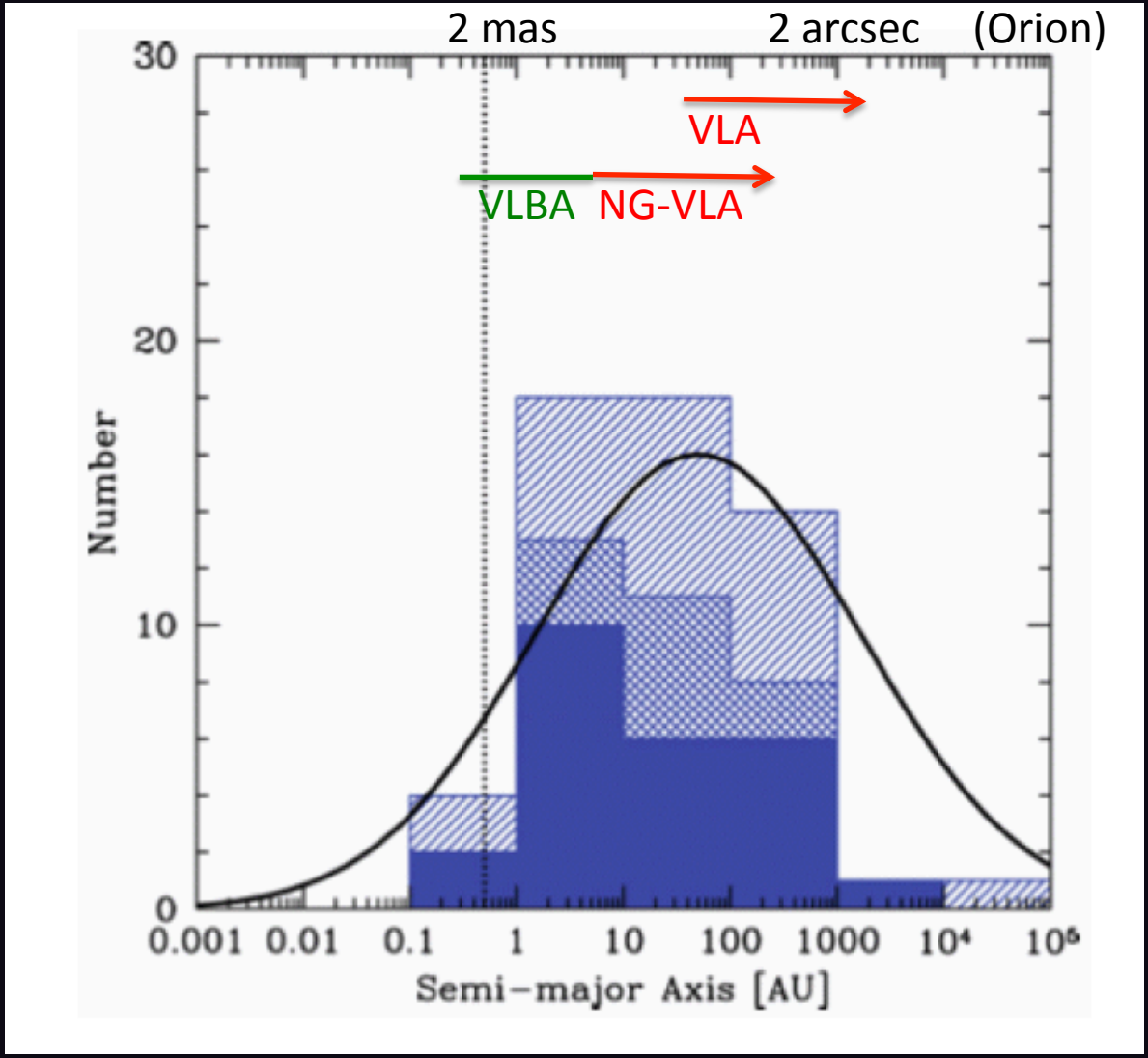
Fig. 4.— The multiplicity frequency declines through the protostellar phase because of the breakup of small multiple systems. From *Chen et al.* (2013).

Reipurth et al. 2014



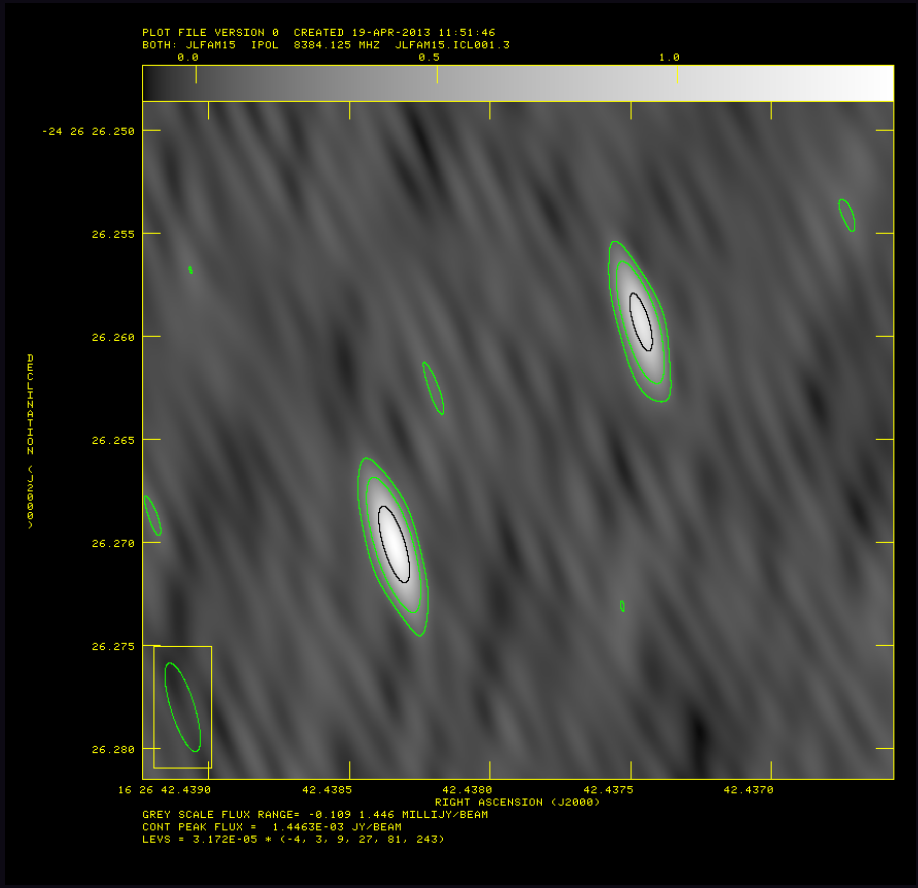
Gomez et al. 2008

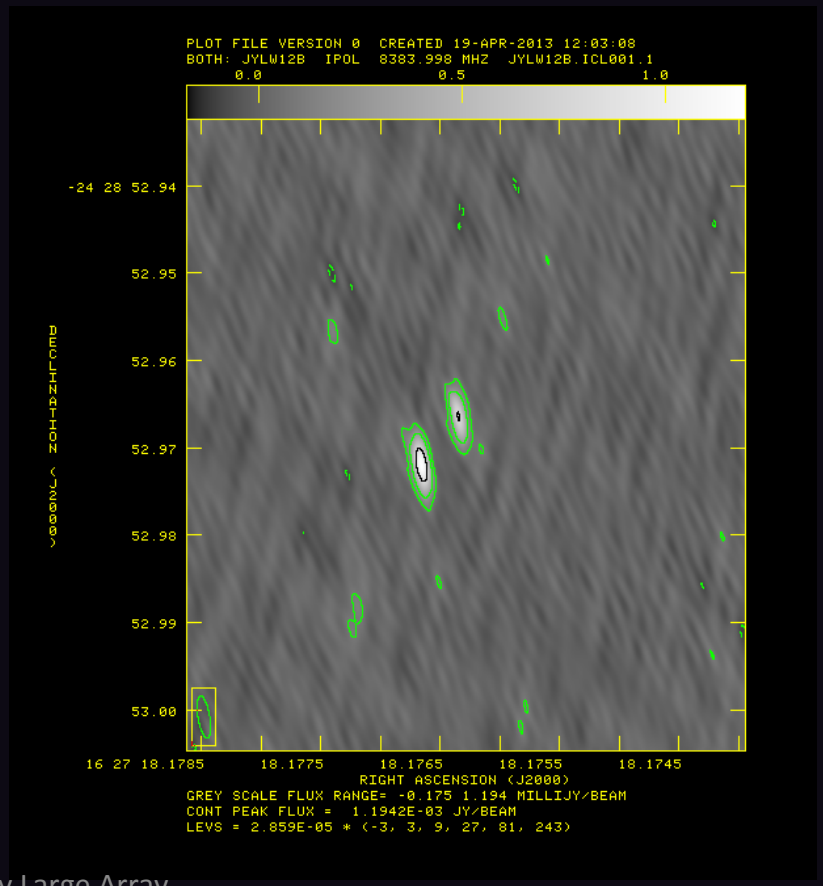
NG-VLA: improvement in separation coverage



Bate et al. 2002

Tight (VLBA) binaries in Ophiuchus





Improvement to sensitivity (number of detections)

THE ASTRONOMICAL JOURNAL VOLUME 100, NUMBER 5 NOVEMBER 1990

A RADIO SURVEY OF WEAK T TAURI STARS IN TAU URIGA

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Department of Astronomy, Pennsylvania State University, 525 Davey Lab ania 16802

ROBERT D. M
Department of Astronomy, University of Wisconsin-M adison, Wisconsin 53706

Harvard–Smithsonian Center , Cambridge, Massachusetts 02138

18 July 1990

TRACT

A multi-ep didate or confirmed weak T Tauri stars in the Taurus–Auriga molecul ucted with the Very Large Array. The stars were chosen from those having c romospheric emission, and weak-emission-line pre-main-sequence stars found by apshots of 99 VLA fields containing 119 candidate stars were obtained with a sensitivity , most fields were observed on two or three dates. Nine radio sources coincident with catalog ars were found. One may be an RS CVn binary system; the other eight are pre-main-sequence stars. Three of the detected stars—HD 283447, V410 Tau, and FK x-ray 1—were previously known radio sources. Five new detections are Herbig's Anon 1, Hubble 4, HDE 283572, Elias 12, and HK Tau/c. At least five of the sources are variable, and no linear or circular polarization was found. Several lines of evidence suggest that the radio-detected weak T Tauri stars are quite young, perhaps younger on average than nondetected stars. Also, these data support earlier evidence that about 12% of weak-emission-line pre-main-sequence stars emit at GHz frequencies at levels $\geq 2 \times 10^{16}$ ergs /s/ Hz. This emission is probably due to gyrosynchrotron radiation occurring in large flares near the stellar surface.

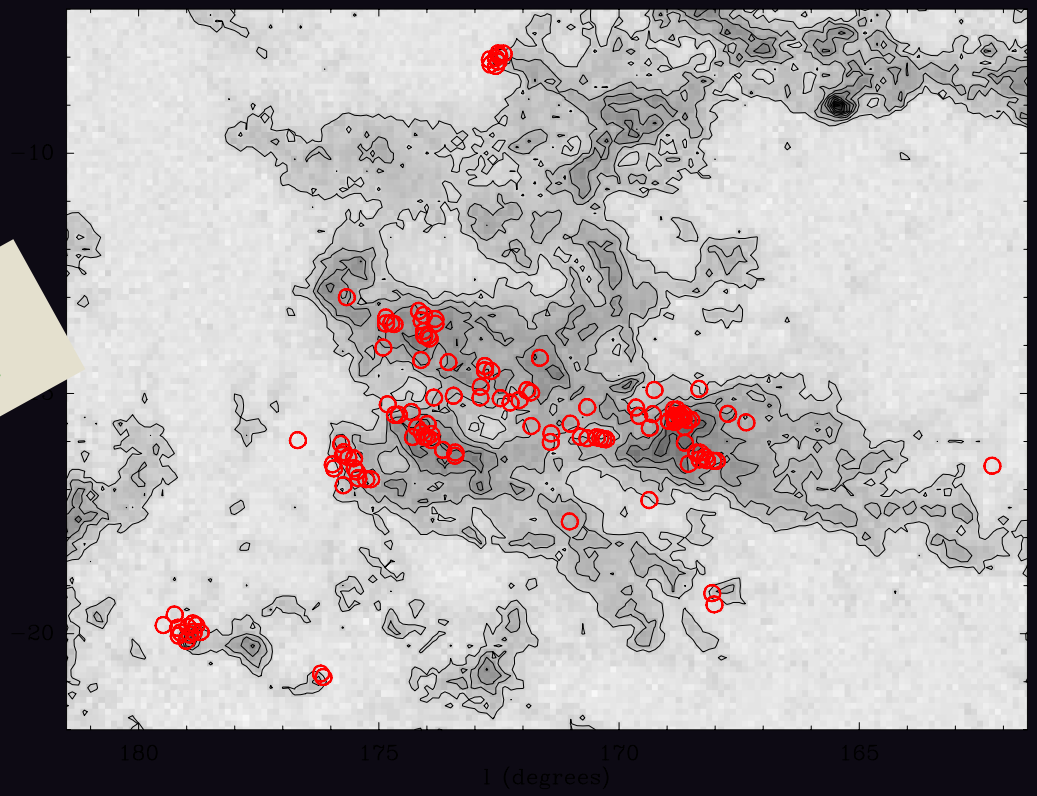
6.7% detection rate

The Jansky VLA era

$\Delta\nu$ went from 50 MHz to 1-8 GHz

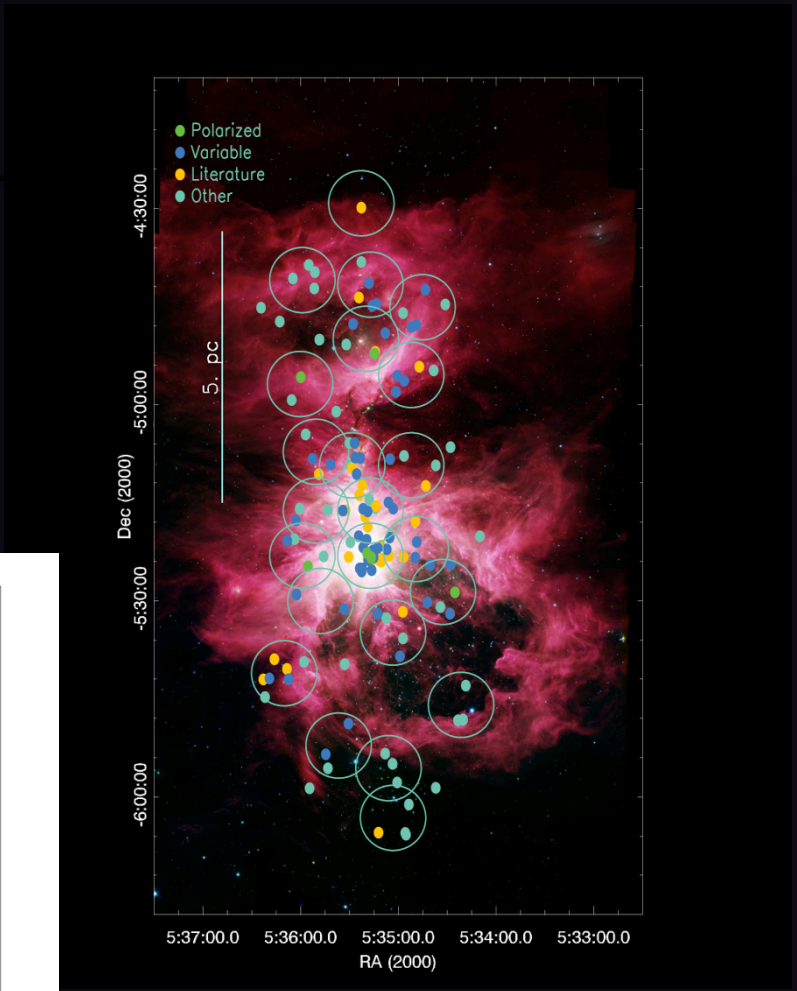
128 fields containing 196 known YSOs
σ = 22 μJy
610 detected sources
77 YSOs detected

40% detection rate

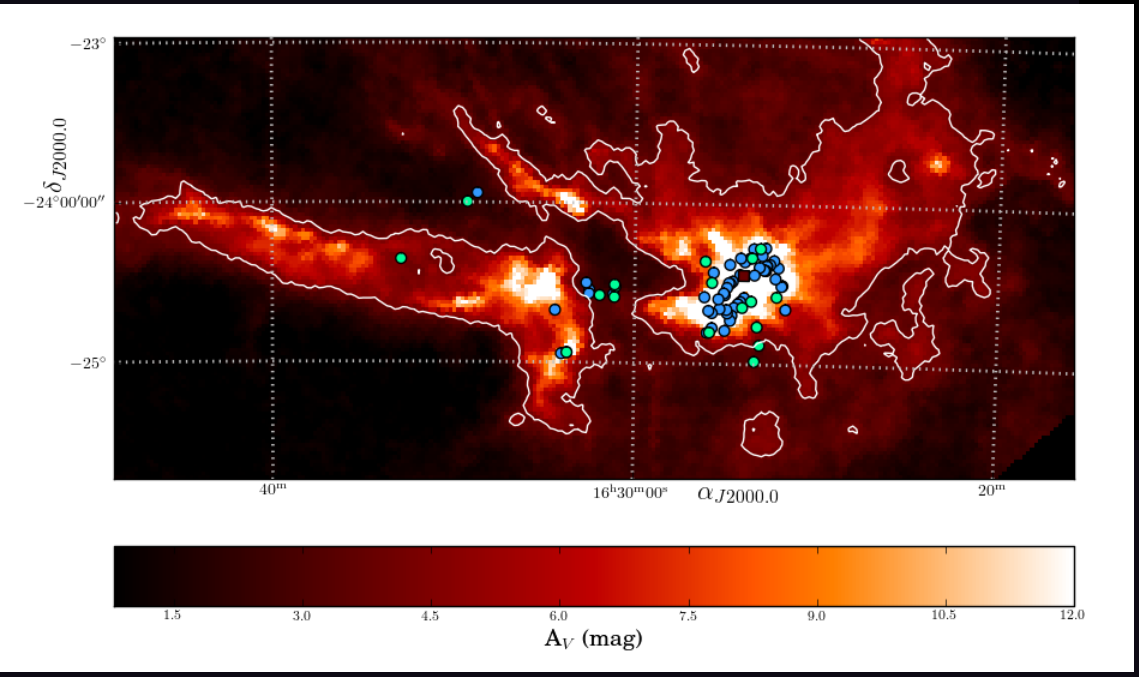


That's a general trend

Orion (Kounkel et al. 2014)



Ophiuchus (Dzib et al. 2013)



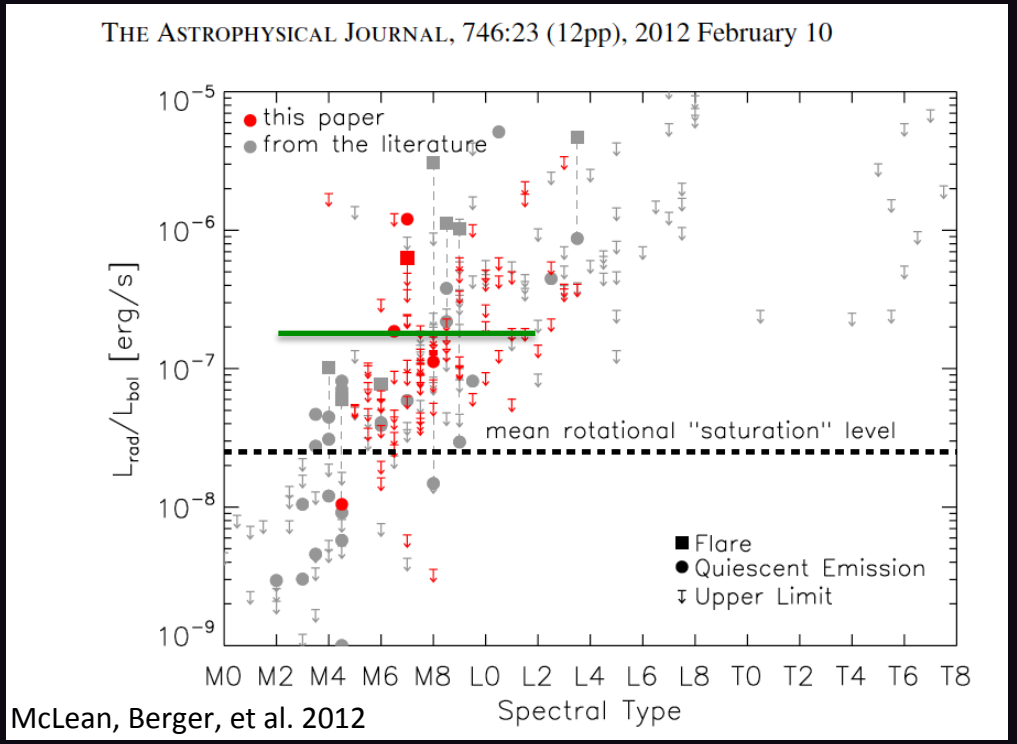
Detections of candidate young brown dwarfs!!

GBS-VLA J162722.96-242236.6	Marsh et al. (2010)	BD Candidate
GBS-VLA J162715.70-243845.6	Alves de Oliveira et al. 2010)	BD Candidate
GBS-VLA J162556.09-243015.3		M5 / Class III
GBS- VLA J162759.95-244819.5		M4.75 / WTTS

0.02 Msun… Believable?

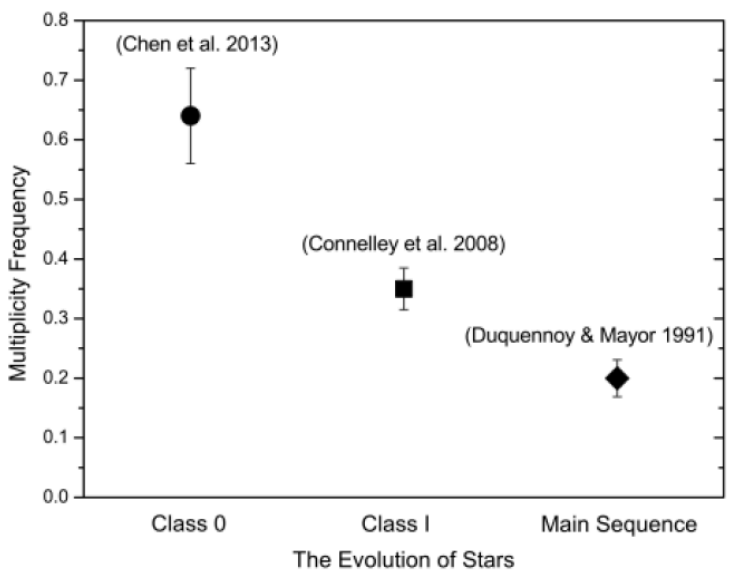
Properties similar to that of more mature brown dwarfs detected in radio…

Loinard et al., in prep.



McLean, Berger, et al. 2012

The NG-VLA will detect all nearby low-mass young stars (> 1,000 in the 500 pc around the Sun)



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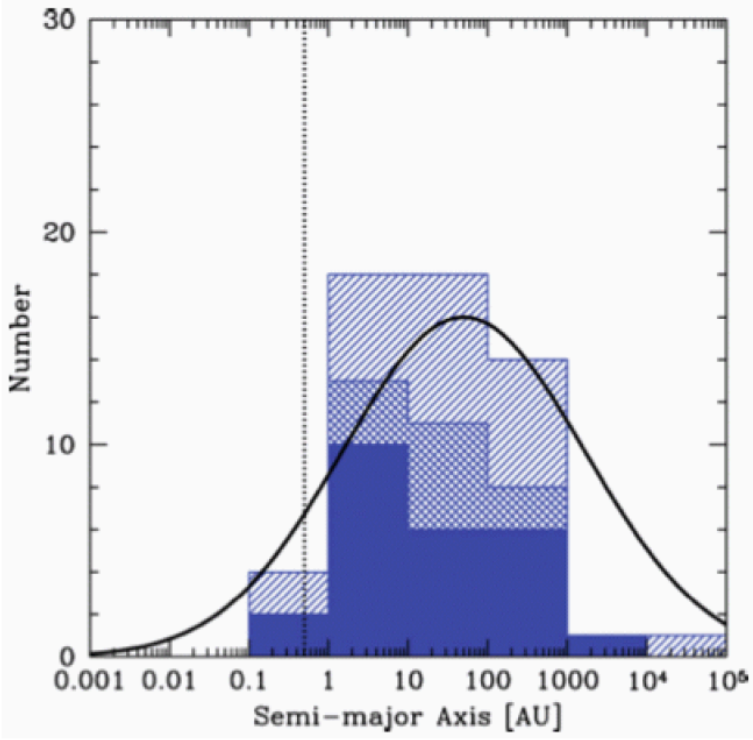
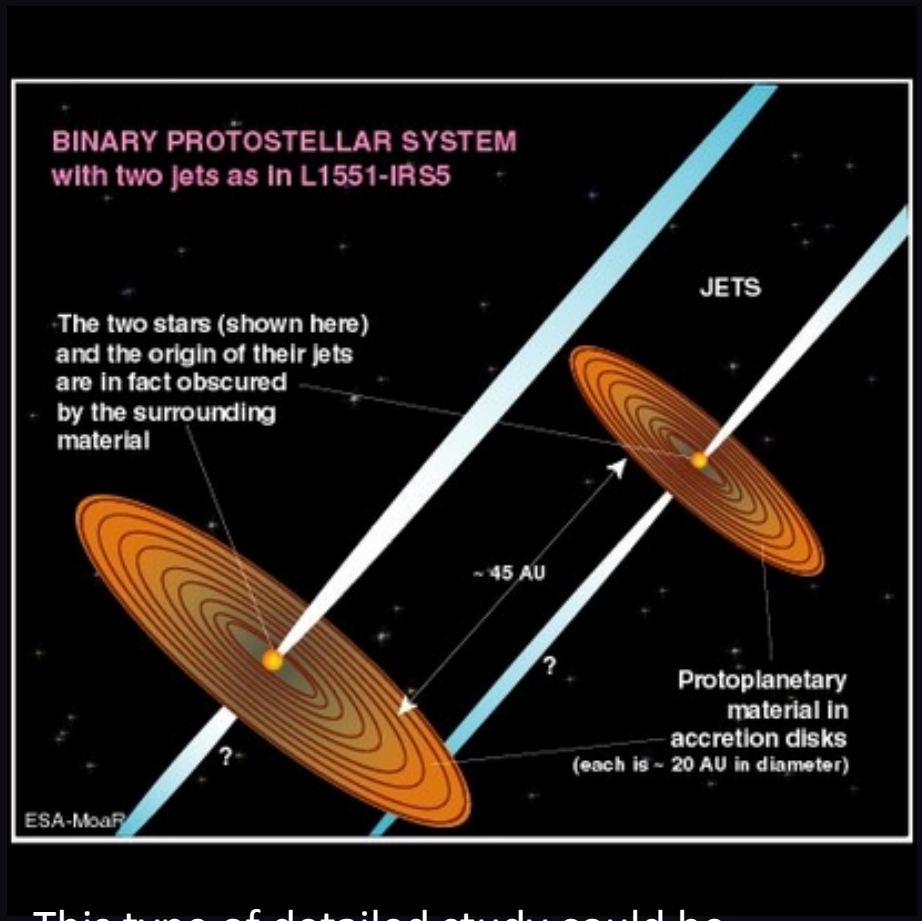
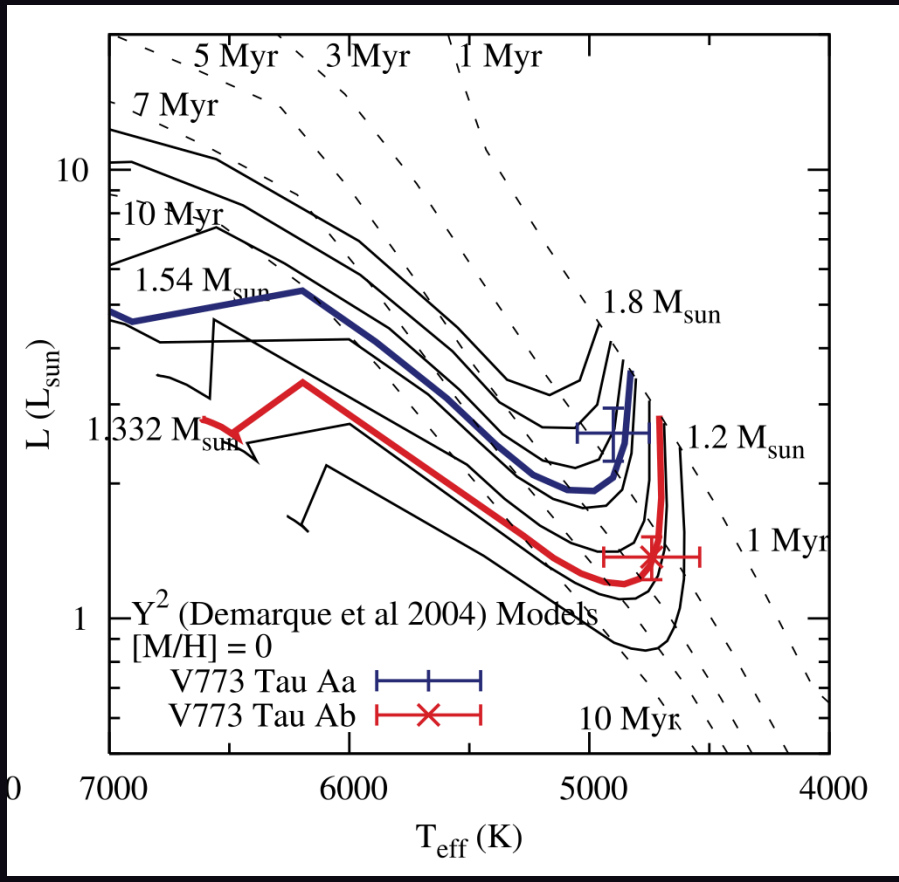


Possibility of producing this type of diagram as a function of age…

The NG-VLA will detect all nearby low-mass young stars (> 1,000 in the 500 pc around the Sun)



This type of detailed study could be done for tens of systems…



Conclusion and perspectives

So…

The NG-VLA with a large field-of-view; speedy mapping; high sensitivity; high resolution; multi-frequency; multi-epoch; full Stokes would have an enormous impact on study of low-mass star-formation.

In particular, it would enable systematic studies of hundreds of low-mass multiple systems, and address the issue of their formation and evolution.

It would also provide important constraints for PMS models.


This map is part of the Global Overlay Mapper suite. See online demo at www.qsl.net/ei8ic
© mapAbilty.com
Beaufort Sea
Greenland
OX
Baffin Bay
KL7
Alaska
VE8
VY1
Yukon
North West Territories
VY0
Nunavut
Hudson Bay
Labrador Sea
Gulf of Alaska
British Columbia
VE7
Alberta
VE6
VE5
VE4
Manitoba
Canada
VE3
Ontario
Saskatchewan
VE2
Quebec
VO2
Labrador
Newfoundland
VO1
New Brunswick
P.E.I
CY9
VY2
FP
St Pierre & Miguelon
CY0
St Paul Is
Sable Is
Washington
Montana
North Dakota
Minnesota
Oregon
Idaho
Wyoming
South Dakota
W0
Wisconsin
W9
Michigan
W8
New Hampshire
Maine
VE9
Nova Scotia
W1
W2
Vermont
Massachusetts
VE1
Rhode Island
New York
Connecticut
W7
Nevada
Nebraska
Iowa
Illinois
Pennsylvania
Ohio
W3
New Jersey
Delaware
Colorado
Kansas
Missouri
Indiana
West Virginia
Maryland
District of Columbia
Utah
Kentucky
California
W6
Oklahoma
Tennessee
North Carolina
Virginia
New Mexico
Arkansas
Alabama
W4
Arizona
Texas
W5
Mississippi
Georgia
South Carolina
Louisiana
Florida
Atlantic Ocean
VP9 Bermuda
Sargasso Sea
Pacific Ocean
Gulf of Mexico
XE
Mexico
Cuba
C6
Bahamas
CO
VP5
VP2V
KP2
VP2E
FS,PJ7
KP3
PJ5
V2
PJ6
FG
J7
V4
YV0
FM7
J6
VP2M
J8
8P
J3
9Y
Trinidad
Surinam
PZ
8R
Guyana
Venezuela
YV
HK
Colombia
Panama
HP
TI
Costa Rica
YN
Nicaragua
YS
El Salvador
HR
Honduras
TG
Guatemala
V3
Belize
ZF
6Y
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HH HI
KP5
HK0
Caribbean Sea
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PJ2
PJ4
Cocos Is
TI9
Clipperton Is
FO
Revilla Gigedo
XF4
Hawaii
KH6
KH3
Johnston Is
KH5K Kingman Reef
KH5 Palmyra Atoll
United States of America