High-resolution survey of massive cores in Cygnus-X

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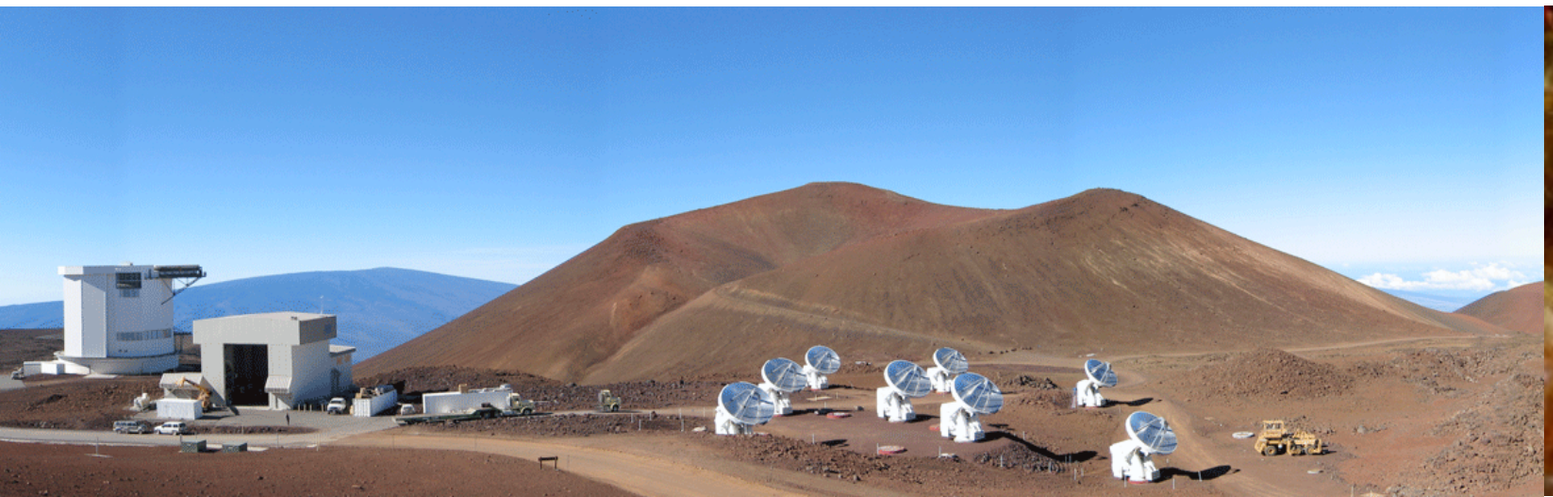
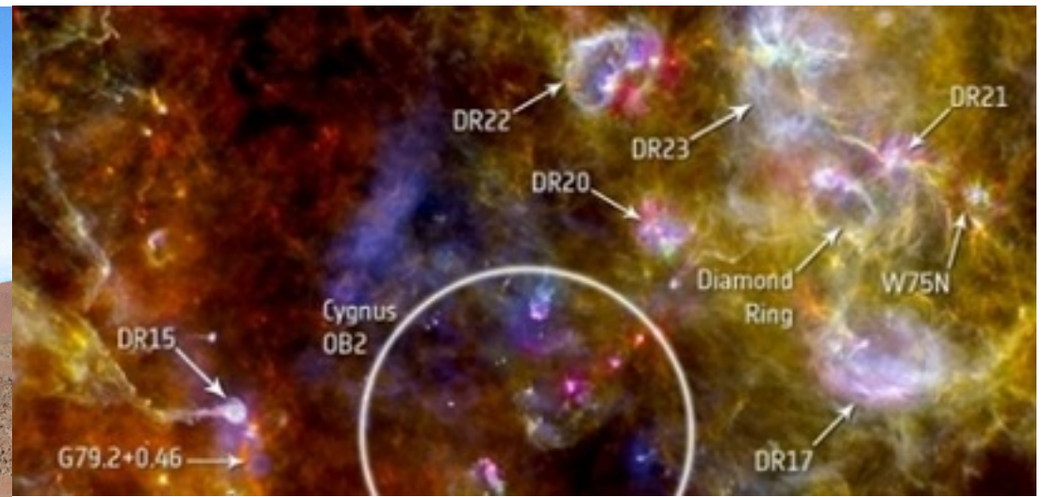
a collaboration between **CfA** and **NJU**





Outline

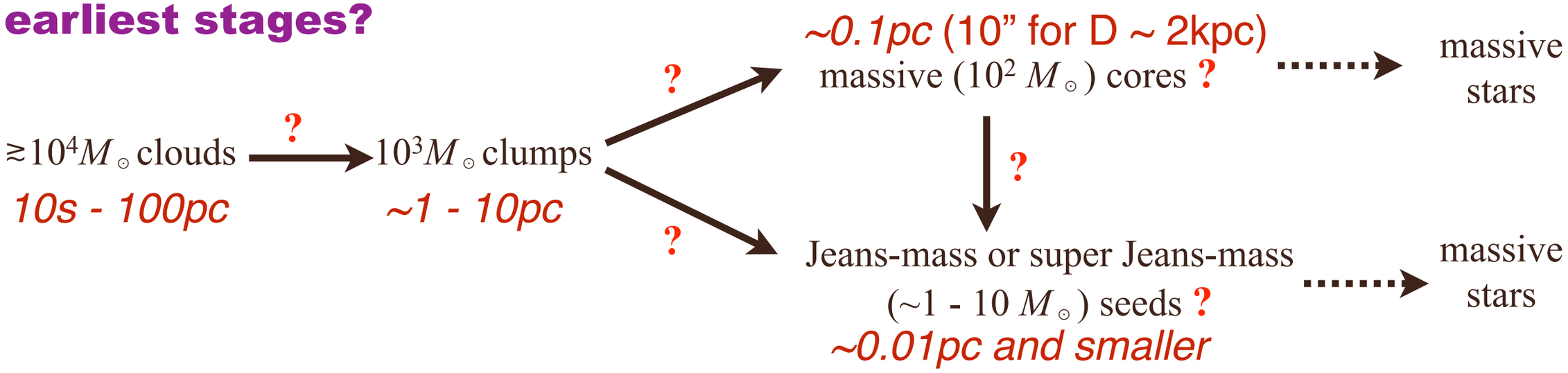
- **Background and Cygnus-X**
- The **SMA** survey, and **JVLA**, **JCMT**, **ALMA**, **CARMA**
- **Preliminary results**
- **Summary** and **outlook**

Why high resolution?

Big Questions in high-mass star formation:

initial conditions ?

earliest stages?



collapse/fragment governed by G/T/B/R ?

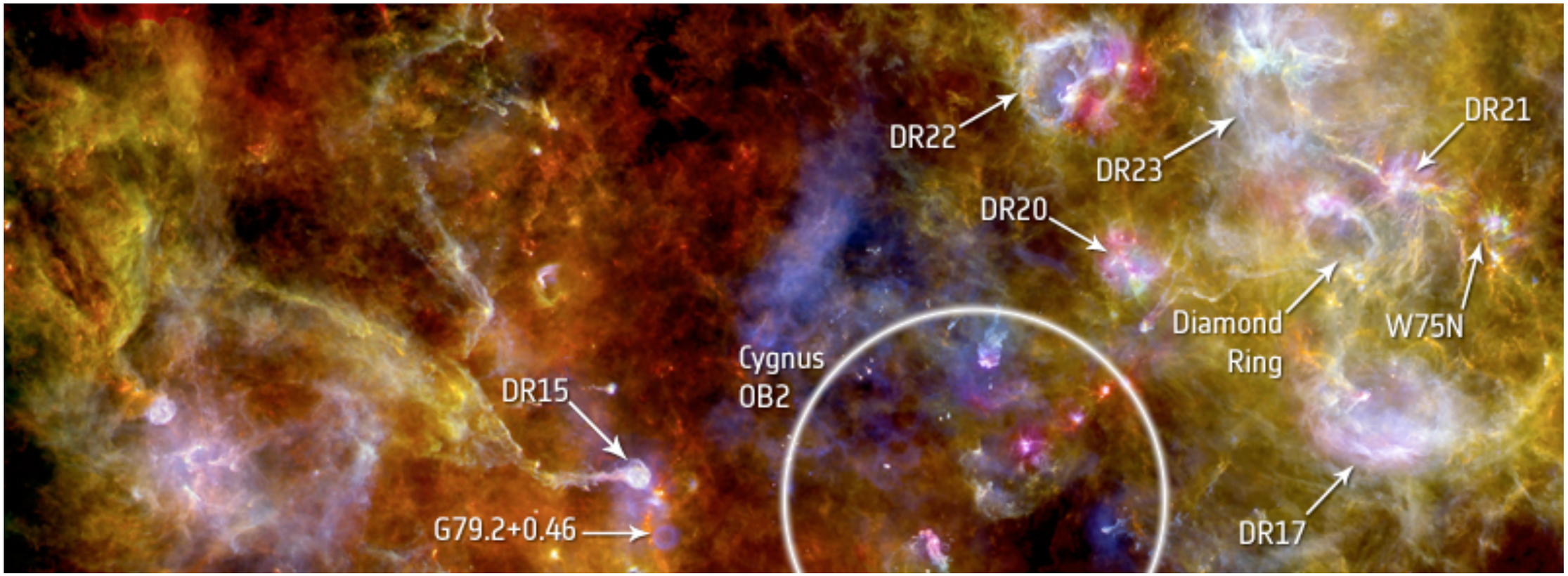
further mass grow process?

~ How to break great barriers (radiation, ionization) ?

disks accretion (collimated jets and outflows) ?

competitive accretion / merging ?

Why Cygnus X?



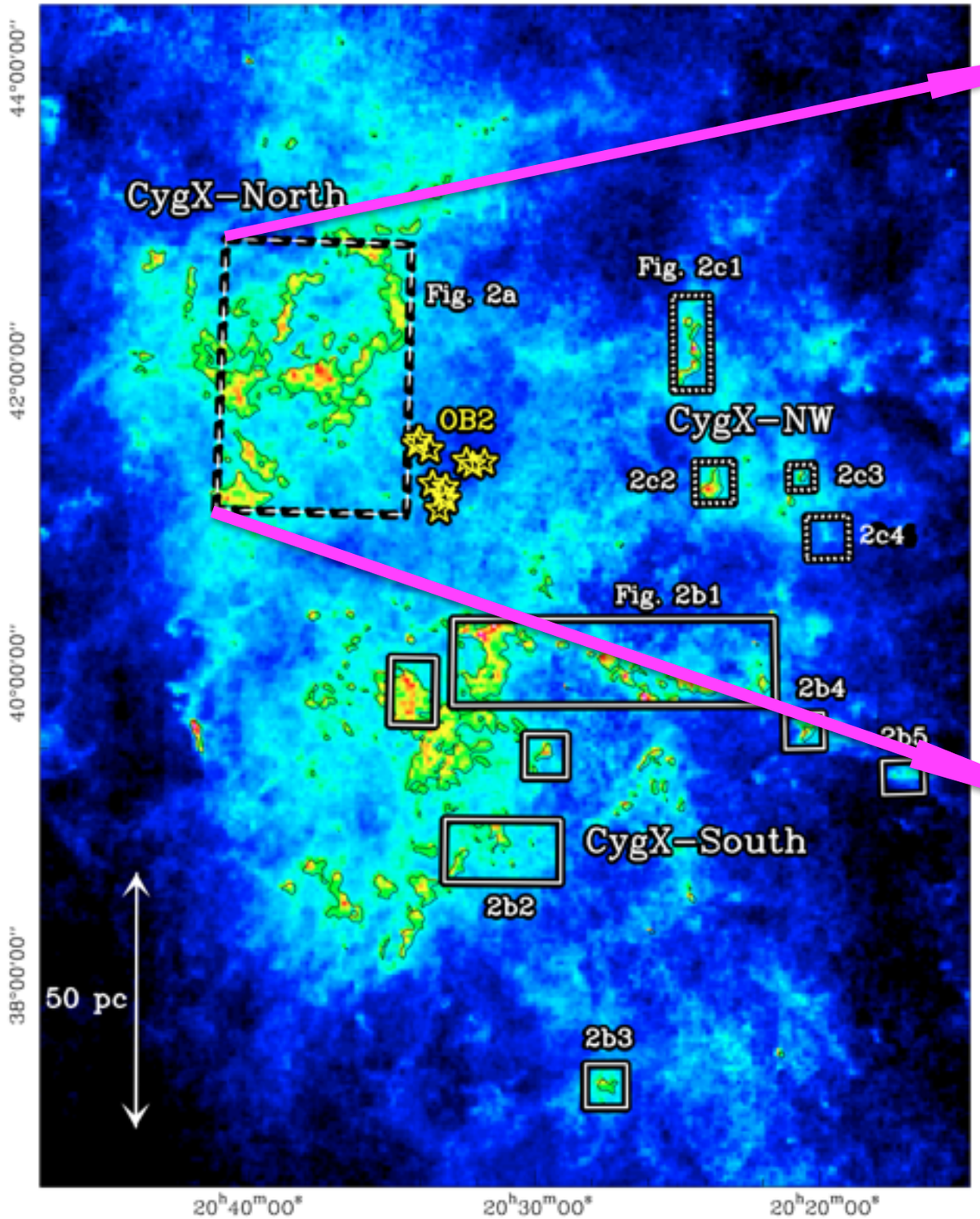
ESA/Herschel/PACS/SPIRE/HOBYS Consortium

One of the **richest** molecular cloud and HII region complexes located at a **distance <2kpc** (~1.4 kpc, Rygl+2012);

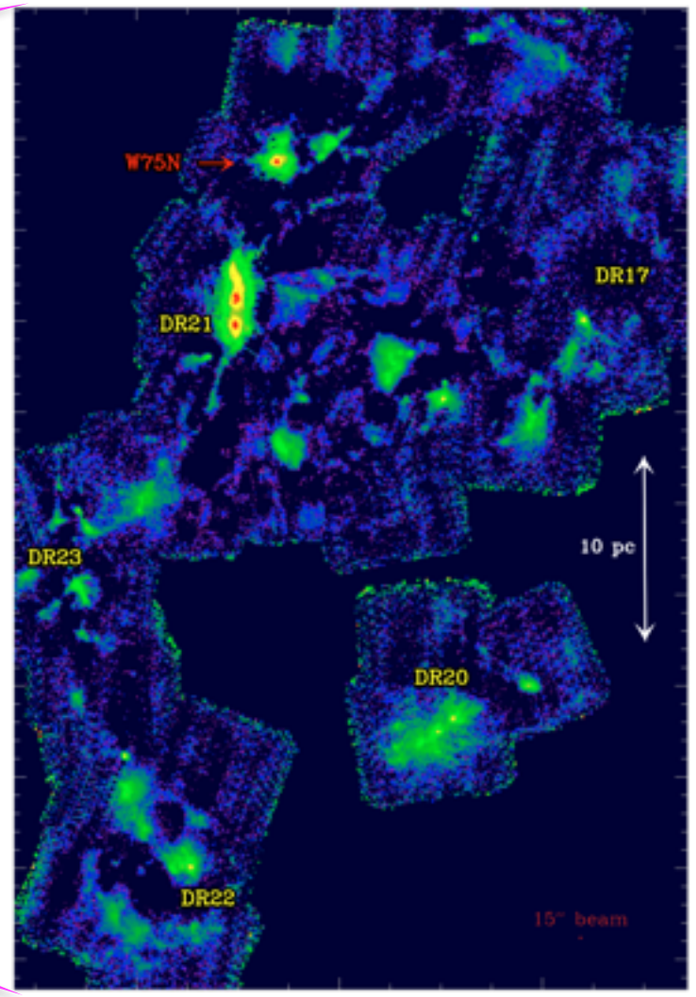
The molecular cloud complex: mass ~ **10^6 $M_\odot$**; size ~ **100 pc**;

Already Mapped by various IR to mm telescopes (e.g., Spitzer, Herschel, JCMT, IRAM 30m).

Why Cygnus X?



2MASS extinction map (Motte+ 2007)

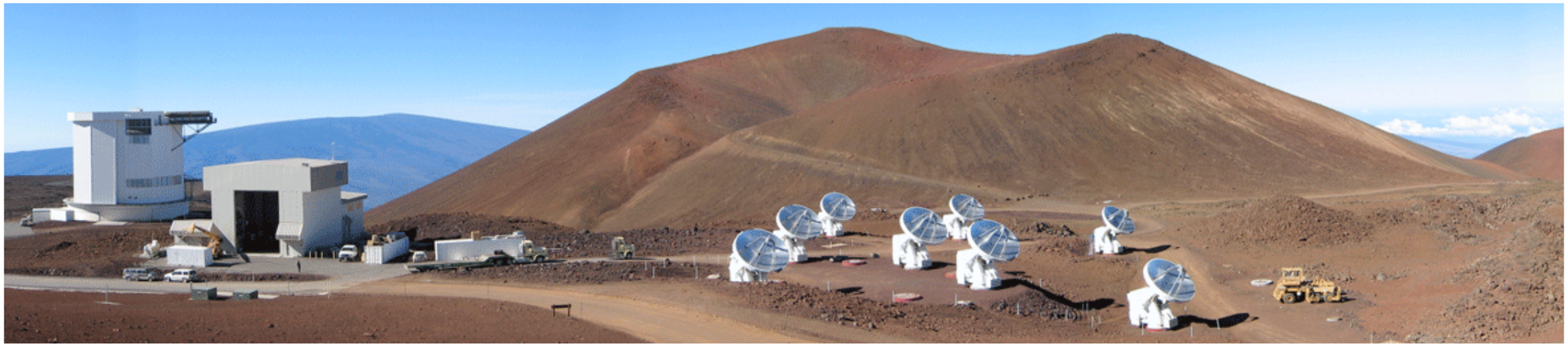


MAMBO 1.2mm survey:
discovered **129 cores** (~0.1pc);
42 massive (>30 M ⊙)

(Motte+ 2007; also see followups by Schneider+ 2010; Bontemps+ 2010; Csengeri+ 2010; 2011; Duarte-Cabral+ 2013, 2014)

The SMA survey of massive CygX cores

A collaboration between Nanjing University and Harvard-Smithsonian Center for Astrophysics (PI: K. Qiu)



1.3 mm, **2 × 6 GHz**, continuum and various molecular spectral lines (e.g., CO, ^{13}CO, $C^{18}O$, SiO, H_2CO, SO, CH_3OH, CH_3CN, …);

Subcompact + Compact + Extended + Very Extended

Angular resolution **~1"**, or **~1500 AU**, "core" thermal **Jeans length ~ 10,000 AU**

Continuum sensitivity **≲1mJy**, or **<0.1 M⊙** , "core" thermal **Jeans mass ~ 0.5 M⊙**

Complementary survey and observations

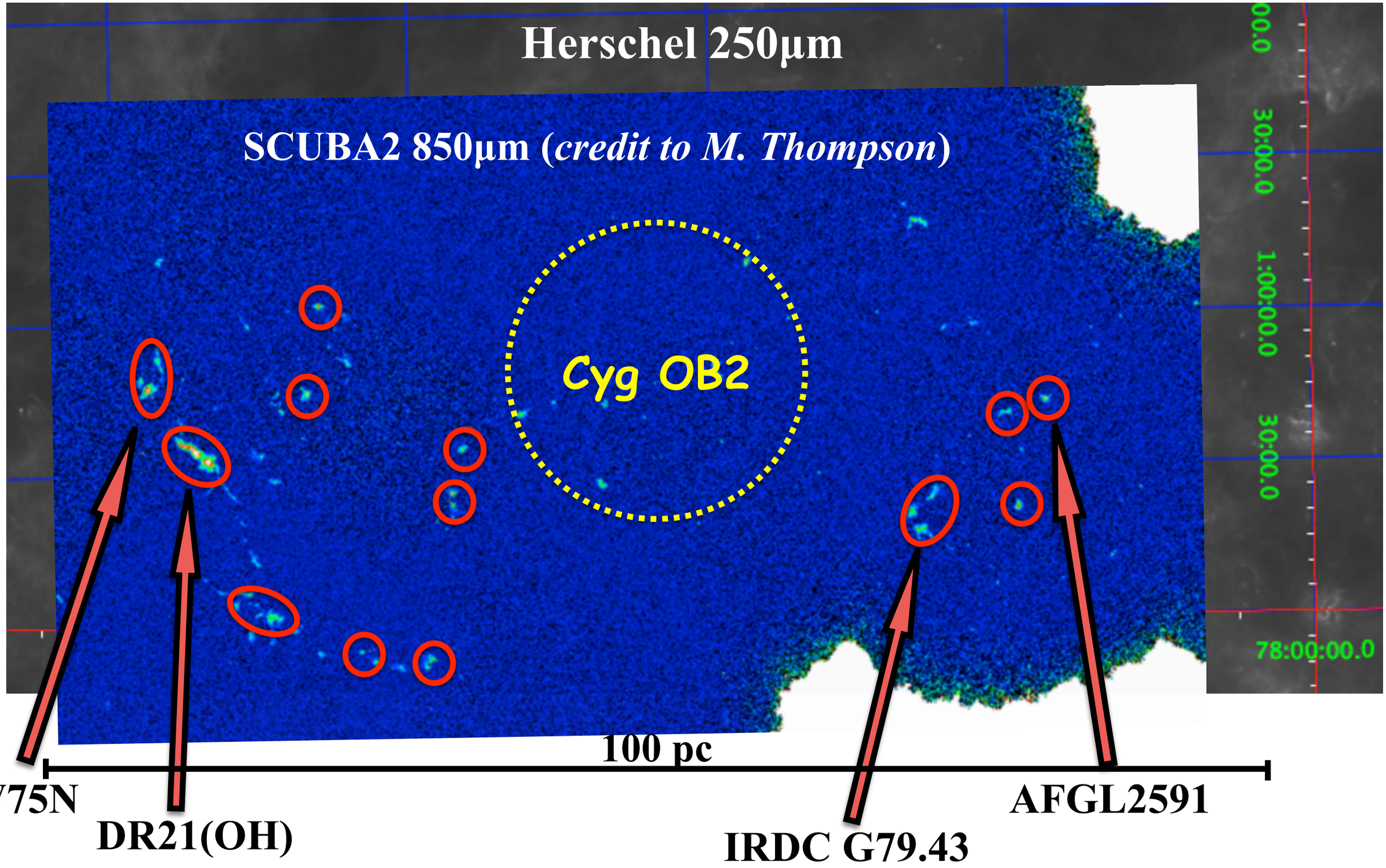
JVLA
radio continuum, NH_3

JCMT
CO(2-1), dust continuum

ALMA (selected sources)

CARMA (selected sources)

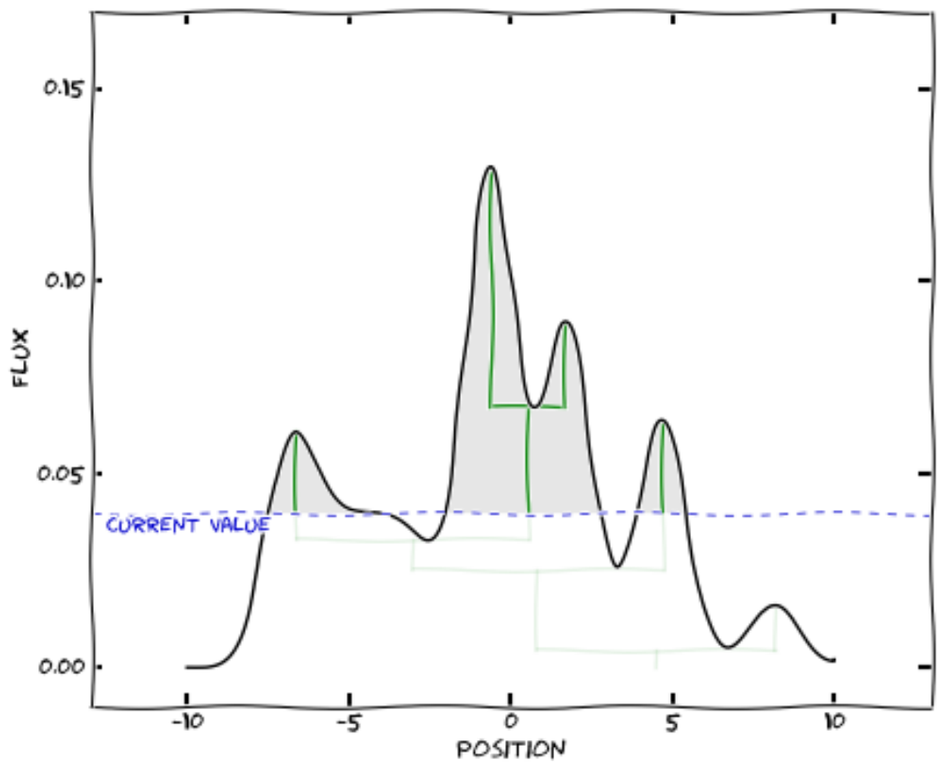
The SMA survey of massive CygX cores



Preliminary results - [dust] continuum

source finding: dendrogram

Compared with other programs (e.g., ***SExtractor***, ***Clumpfind***), ***dendrogram*** works well in a hierarchical system, such as a fragmented core, and is better for sources with different structures (point-like, extended).

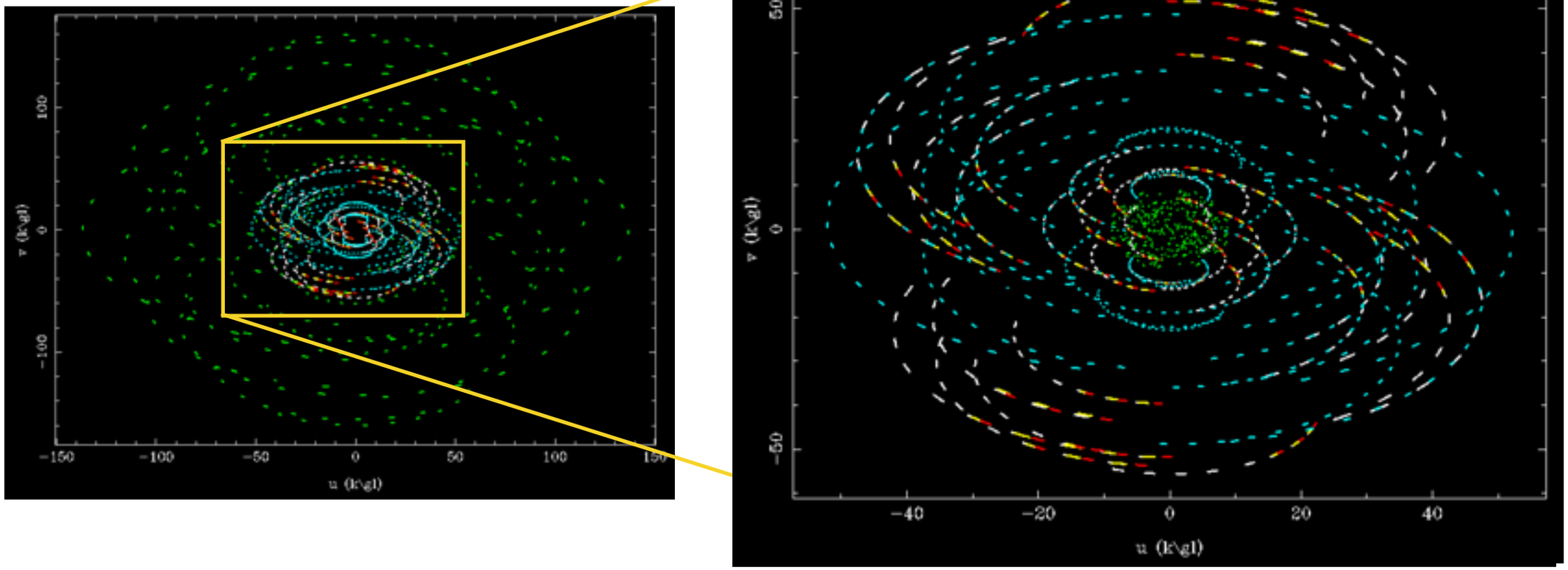


leaf ➠ branch ➠ trunk

statistical analysis: MST? NNS?

Preliminary results - CO outflows

CO outflows: SMA + JCMT



Summary

- **40+ massive cores** (how many to from massive stars?) & 10+ lower mass cores
- **fragmentation** seen in almost all the cores;
  ~1/2 cores have fragments nearly linearly distributed
  a characteristic length (L_{Jeans}) between fragments?
- **singly peaked** (down to 0.01pc) sources, though very rare, also seen (**why, fragmentation suppressed? how?**)
- **starless sources** also fragment (**why no SF, not yet or would never happen?**)
- **bipolar outflows** seen toward most sources

followup analysis and future plan

core fragmentation

kinematics

chemistry & evolutionary sequence

future plan

SMA: VEX & 345GHz for the whole sample, selected sources for mosaics, polarization for bright sources

ALMA/NOEMA: sub-sample or selected sources for particular interests