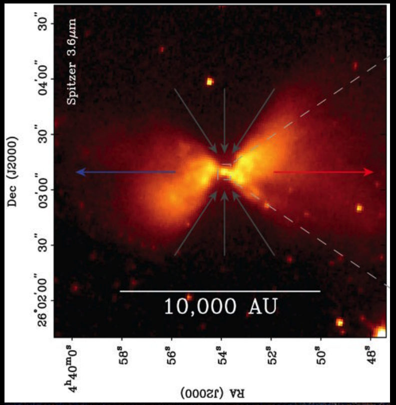
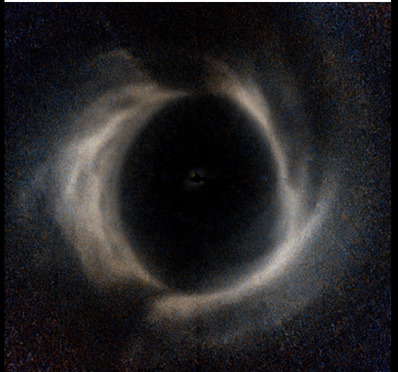
Star and Planet Formation with JWST (& NIRISS) GTO

Michael R. Meyer
LSA ASTRONOMY
UNIVERSITY OF MICHIGAN
https://sites.lsa.umich.edu/feps/

(for M. Rieke, R. Doyon, and the NIRCam & NIRISS teams)

January 4, 2020 Honolulu, HI #aas235





NIRCam GTO “Origins” Topics, Times, and Leads

Initial Conditions Massive Star Formation: 18 hours (E. Young)
Evolution of Volatiles in Icy Clouds: 38 hours (K. Hodapp)
End of the IMF & Free-floating Planets: 12 hours (M. Meyer)
Protostars & Planets: 37 hours (J. Leisenring & T. Greene)
Physics and Chemistry of PDRs: 20 hours (K. Misselt)

Complementary NIRISS GTO:

Star cluster slitless spectroscopy (A. Scholz & R. Jaywardhana)
Imaging Transition Disks with AMI (D. Johnstone)

Further synergies with MIRI, NIRSPEC, IDS, and ERS Teams.

Initial Conditions of Massive Star Formation

Massive stars drive evolution of the ISM and impact local star formation.

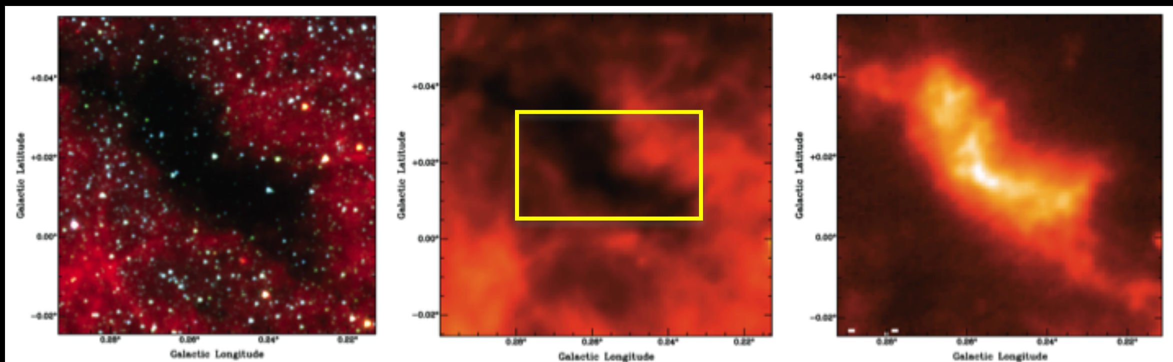
Extreme star formation: 10^5 solar masses, temperatures ~ 5 – 10 K, column densities > 0.2 g-cm^2 ($A_v > 50^m$)

1. What are the conditions in the earliest stages of massive star formation? Core collapse or competitive accretion models predict differences in filament structure and local conditions.

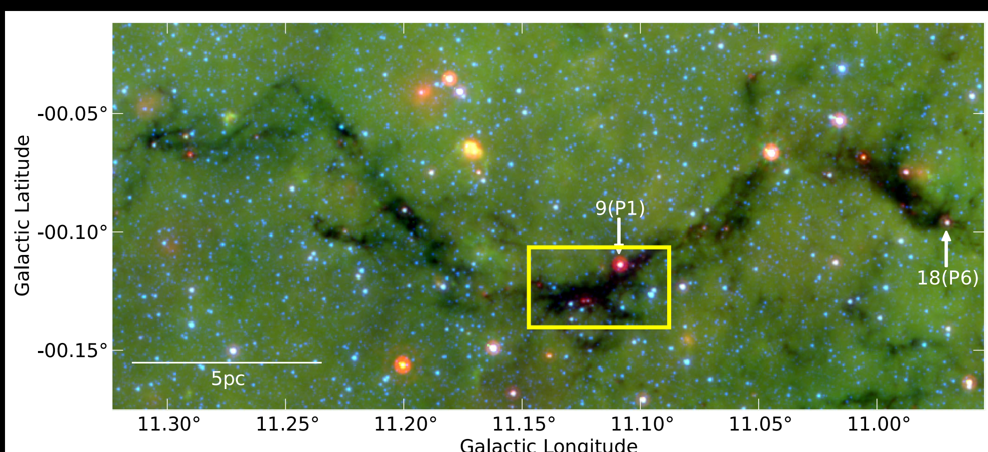
2. When do the first UCHII regions emerge? Could triggering be important?

Goals are i) characterize the size distribution clumps in the filaments using extinction mapping (minimum in opacity) and ii) search for evidence of the emerging clusters.

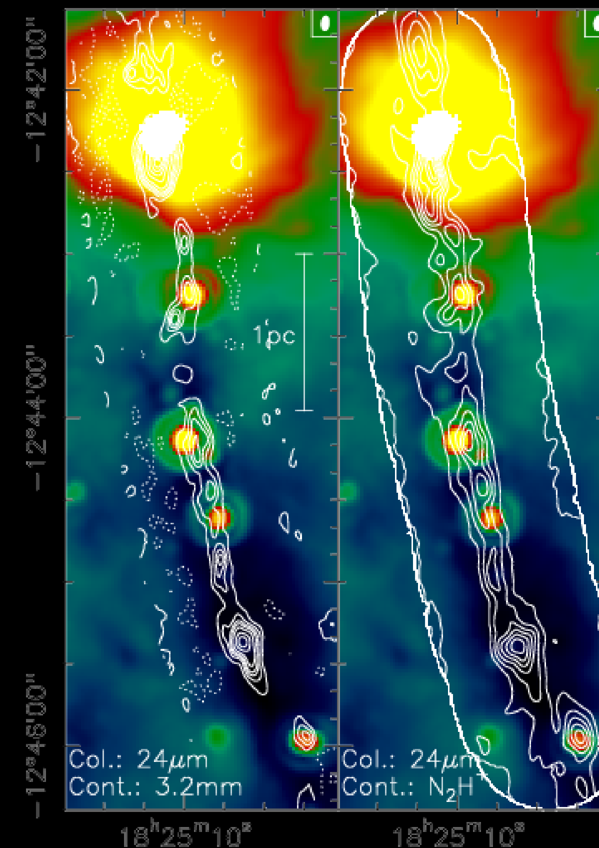
NIRCam: Star Formation in Molecular Ring



Left: IRAC 3-color image of the Brick (3.6, 4.5, 8 microns). Center: Herschel 70 micron (Molinari et al. 2011). Right: SCUBA/JCMT 450 micron (Di Francesco et al. 2008).



Spitzer 4.5 mm, 8 mm, & 24 mm of the Snake:
4 x 2 arc-minute box is shown.



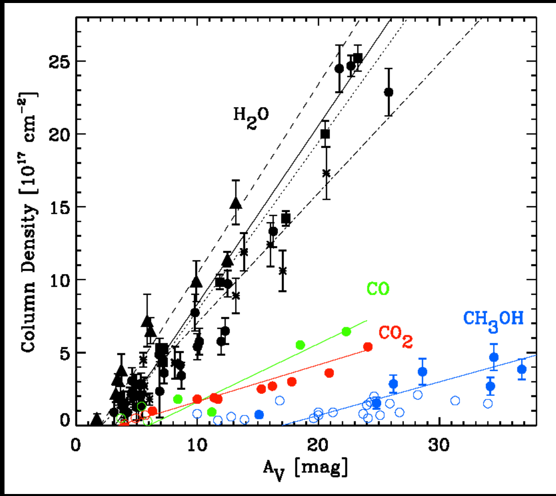
3.2 mm continuum (left) and N_2H+ emission (right).
Data taken at the Plateau de Bure Interferometer.
Beuther et al., 2015, A&A, 584, 67B

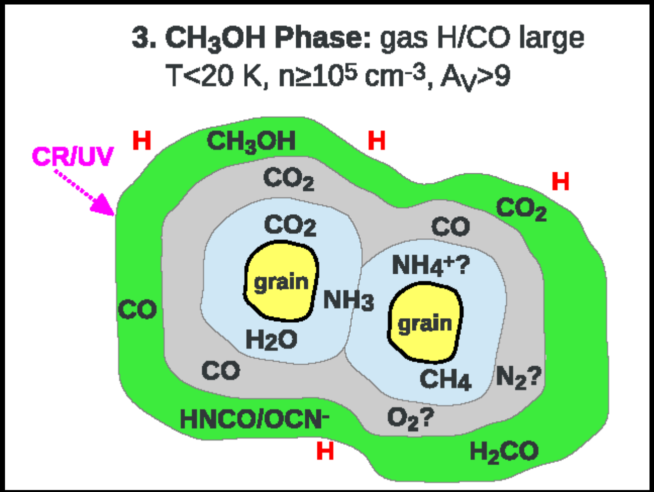
Evolution of Volatiles in Icy Clouds: Energetics & Alchemy

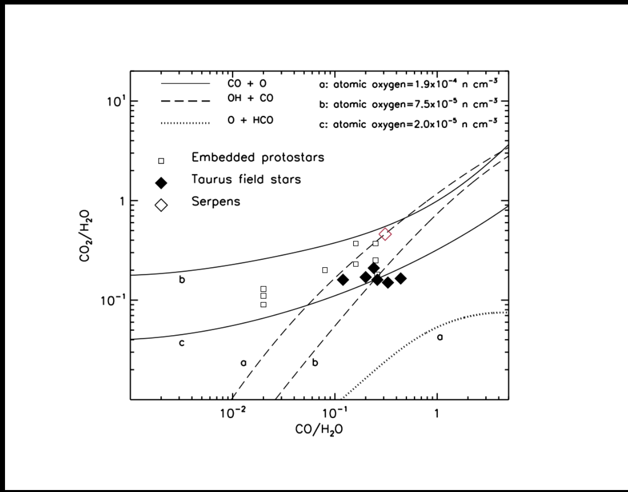
- Study three Bok globules in distinct early stages of evolution.
- Obtain absorption spectra of ice grains against background field stars.
- Observe grain growth and chemistry initiated on icy grains that transmutes volatile budget in star (and planet) forming cloud cores.

Specific Questions to address:

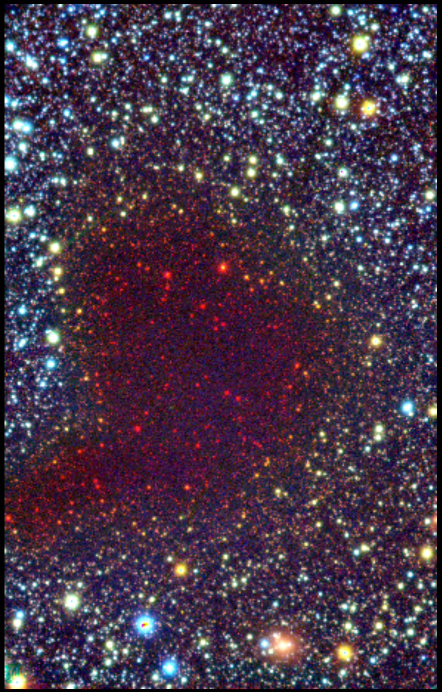
1. What self-shielding is required for the onset of ice mantle formation (H_2O & CO)?
2. When do grain surface reactions begin leading to CO_2, CH_3OH, and XCN?
3. Under what conditions does H_2O ice crystalize?



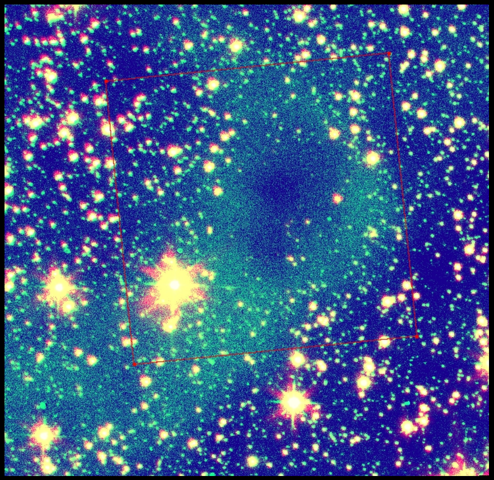




NIRCam: Globules in Three Evolutionary Stages

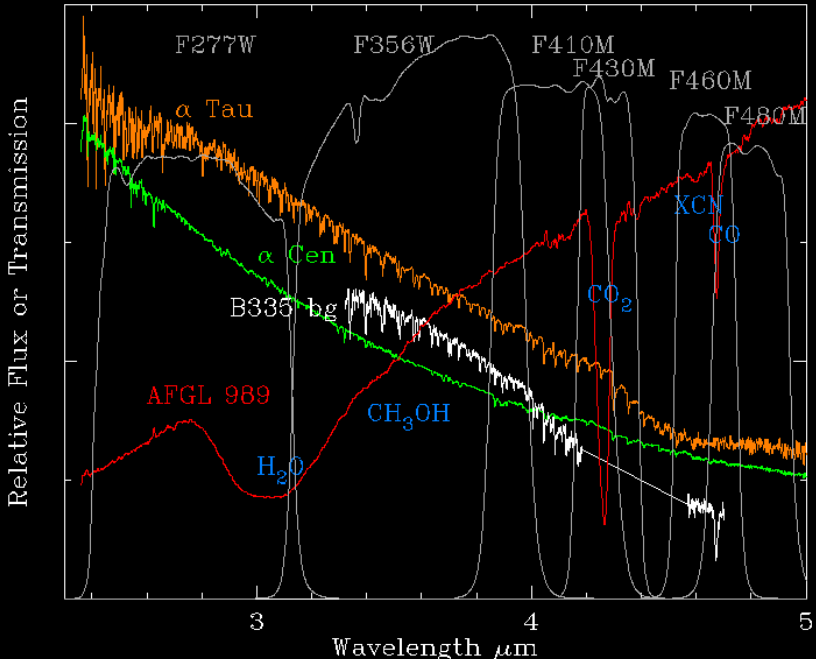


B68: 17 22 38.2, -23 49 34 (J2000)
a stable starless large clump.

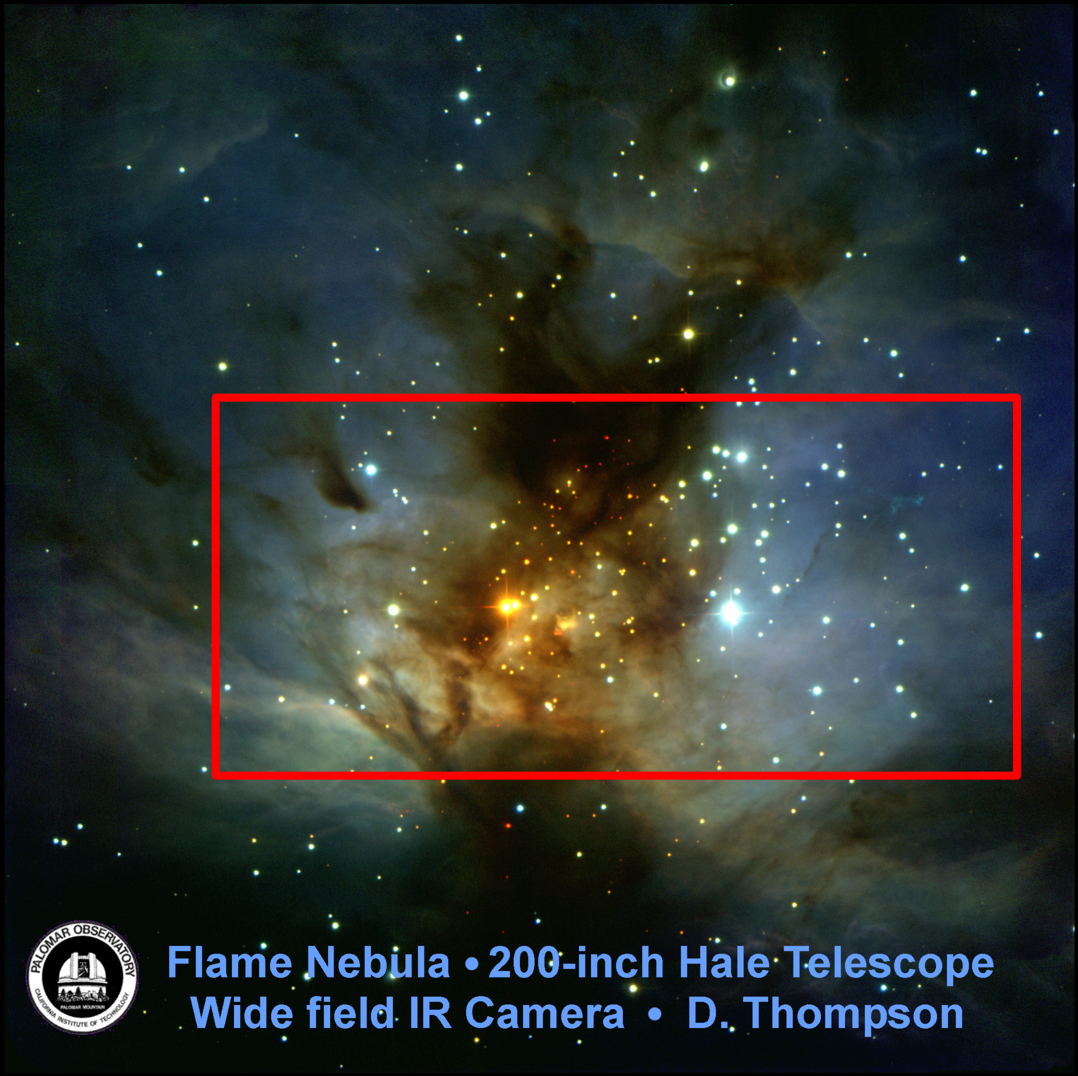


L694-2: 19 41 04.5, +10 57 02 (J2000)
a collapsing starless core.

B335: 19 37 01.0, +07 34 10 (J2000)
a Class 0 star-forming globule.



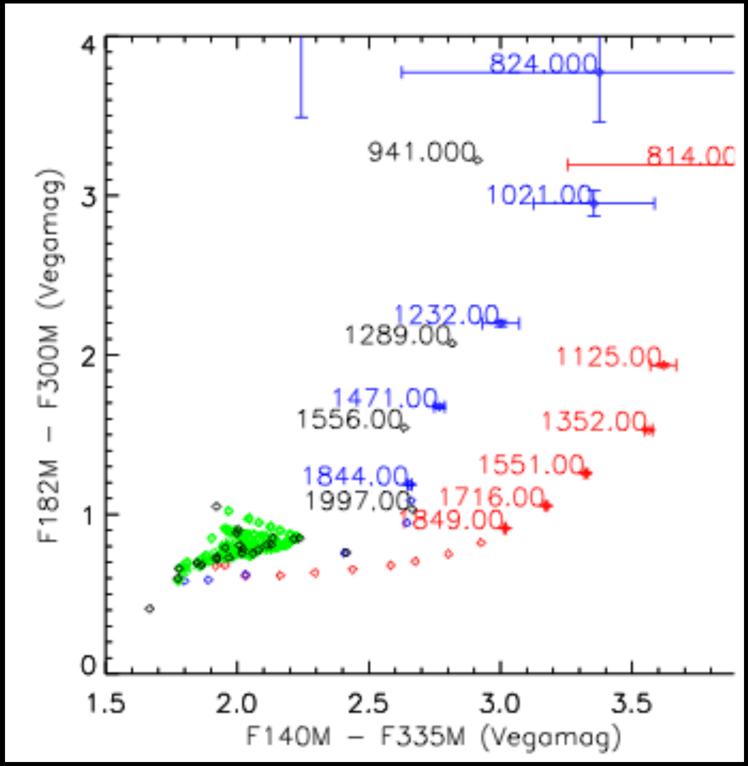
End of the IMF: Science Goals



- Determine the IMF down to 1 M_{jup}
- Companion Mass Ratios down to planetary masses beyond 100 AU.
- Identify free-floating planetary mass objects for follow-up spectroscopy.

NIRCam: Expectations for NGC 2024

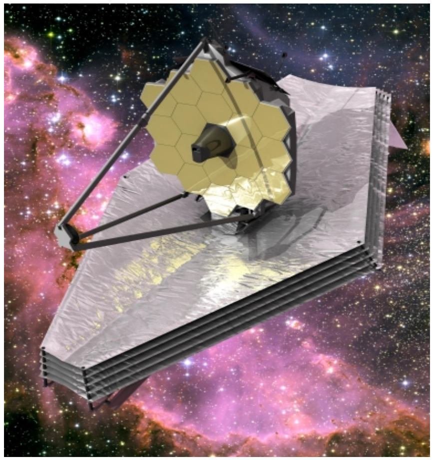
- Carefully assess target density, field contamination, and our ability to distinguish between them.
- "normal" IMF predicts 30+ cluster members (2-30 Mjupiter), 30+ ejected planets (?), and 30+ contaminating field stars.

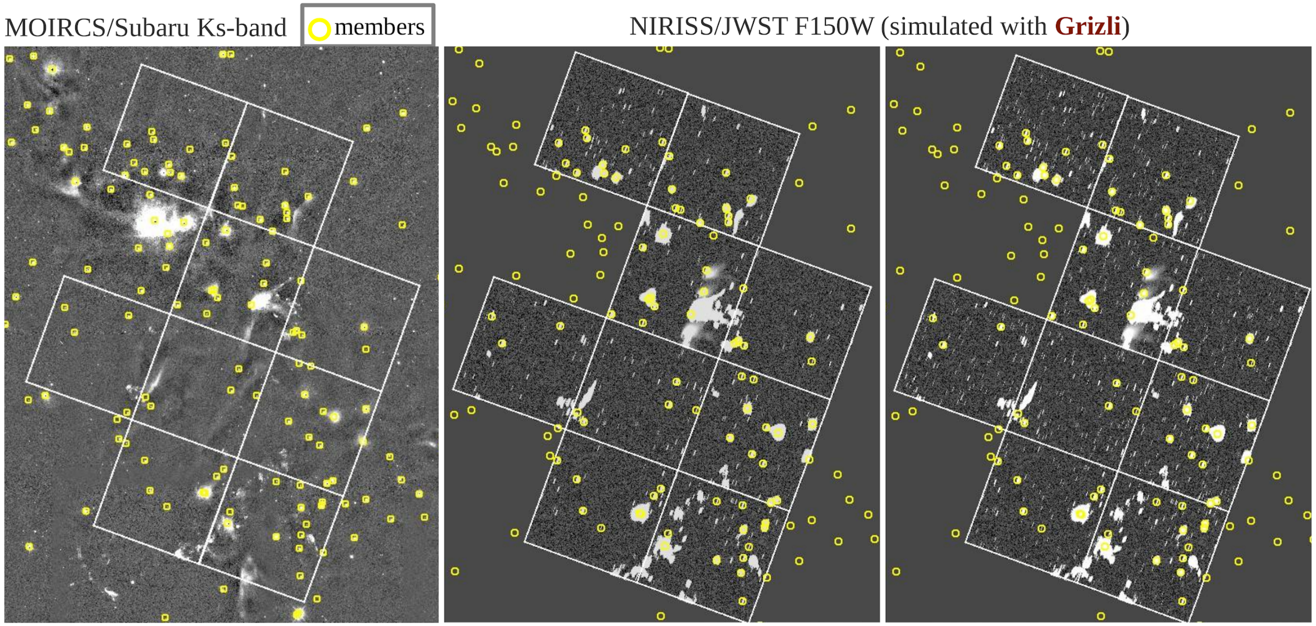


F140M, F182M, F300M, and F335M gives SNR needed to sort old field objects (4.8 < logg < 5.2) from 2 Myr old members (3.1 < logg < 3.6) at temp (1000-3000 K) complete > 2 Mjupiter.

100+ candidates per field with < 50 % contamination for NIRSPEC follow-up to get C/O ratio.

An alternative approach: NIRISS Slitless



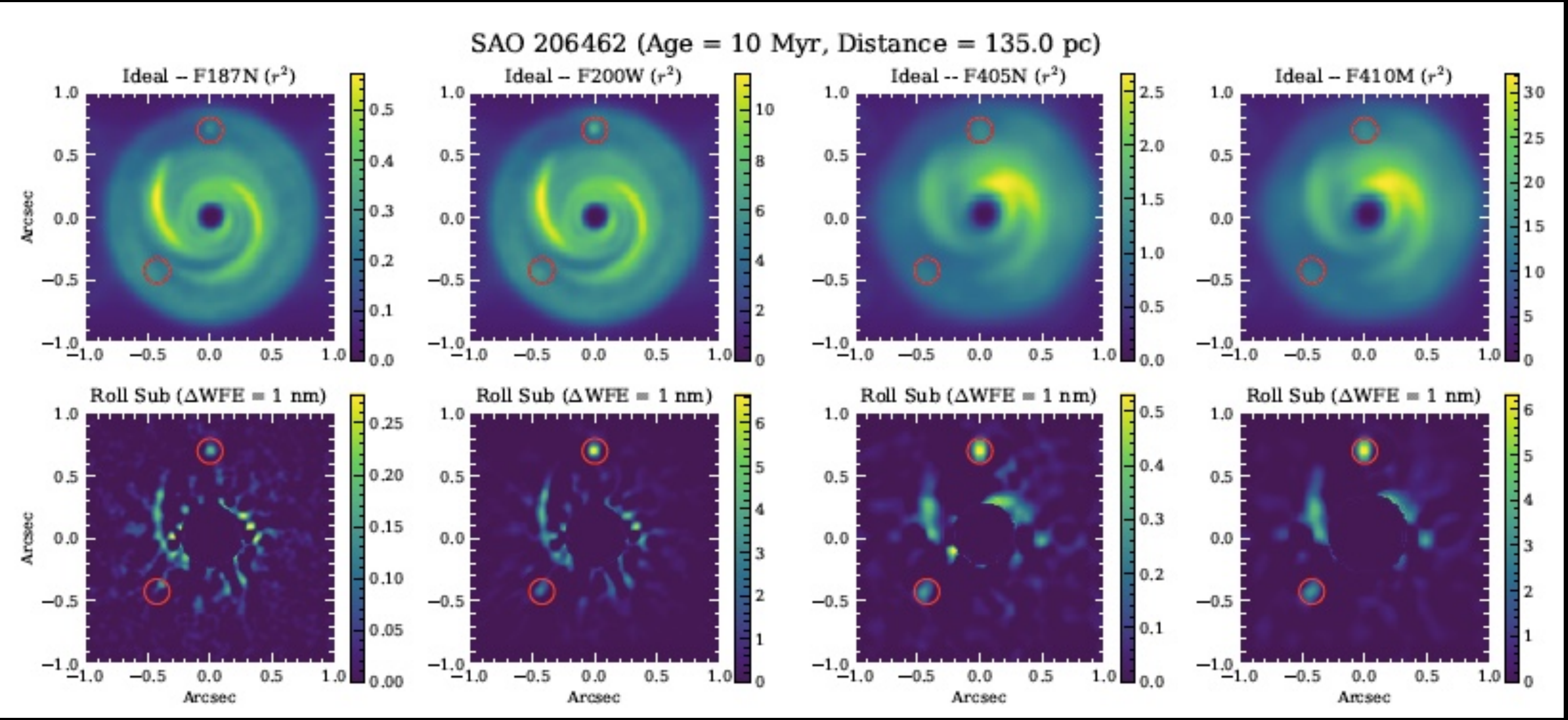


GTO Leads: A Scholz & R. Jaywardhana
Slitless spectroscopy
NGC 1333: spectra of free-floating planets down to 1 MJup

Proto-planets Detection & Characterization

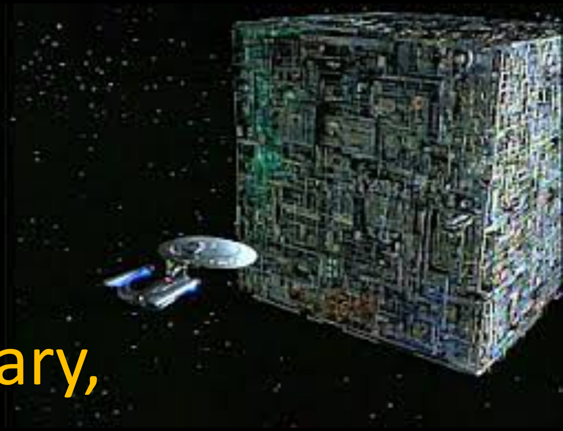
NIRCam Direct imaging: saturate core, PSF roll subtraction (total time 18.4 hours).

PDS70 K ~ 8.5 (protoplanets < 1”+ multiple rings) + NIRISS AMI.
SAO206462 K ~ 5.8 (protoplanets predicted at 1”) + NIRISS AMI.
MWC 758 K ~ 5.8 (protoplanets expected ~ 1”).
HL Tau K ~ 7.4 (ALMA image show multiple rings)
TW Hya K ~ 7.3 (ALMA and scattered light show multiple rings)



HD 100546 K ~ 5.4 (protoplanets + disk structure) NIRISS AMI (led by D. Johnstone).

Origins of Stars and Planets:
You too may be assimilated…



NIRCam+NIRISS programs are complementary,
cross-cutting a matrix of astrophysical interest:

X - Age (pre-stellar cores to transition disks).

Y – Mass (isolated YSO to massive star-forming events)

Z - Environment (nearby "normal" star formation,
triggered regions, low/high metallicity).

- Whole program is greater than the sum of parts.
- Links to exgal and exoplanet (GTO+ERS) programs.