# The JCMT Transient Survey: Single-Epoch YSO Flares

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JCMT Transient team consortium[+]

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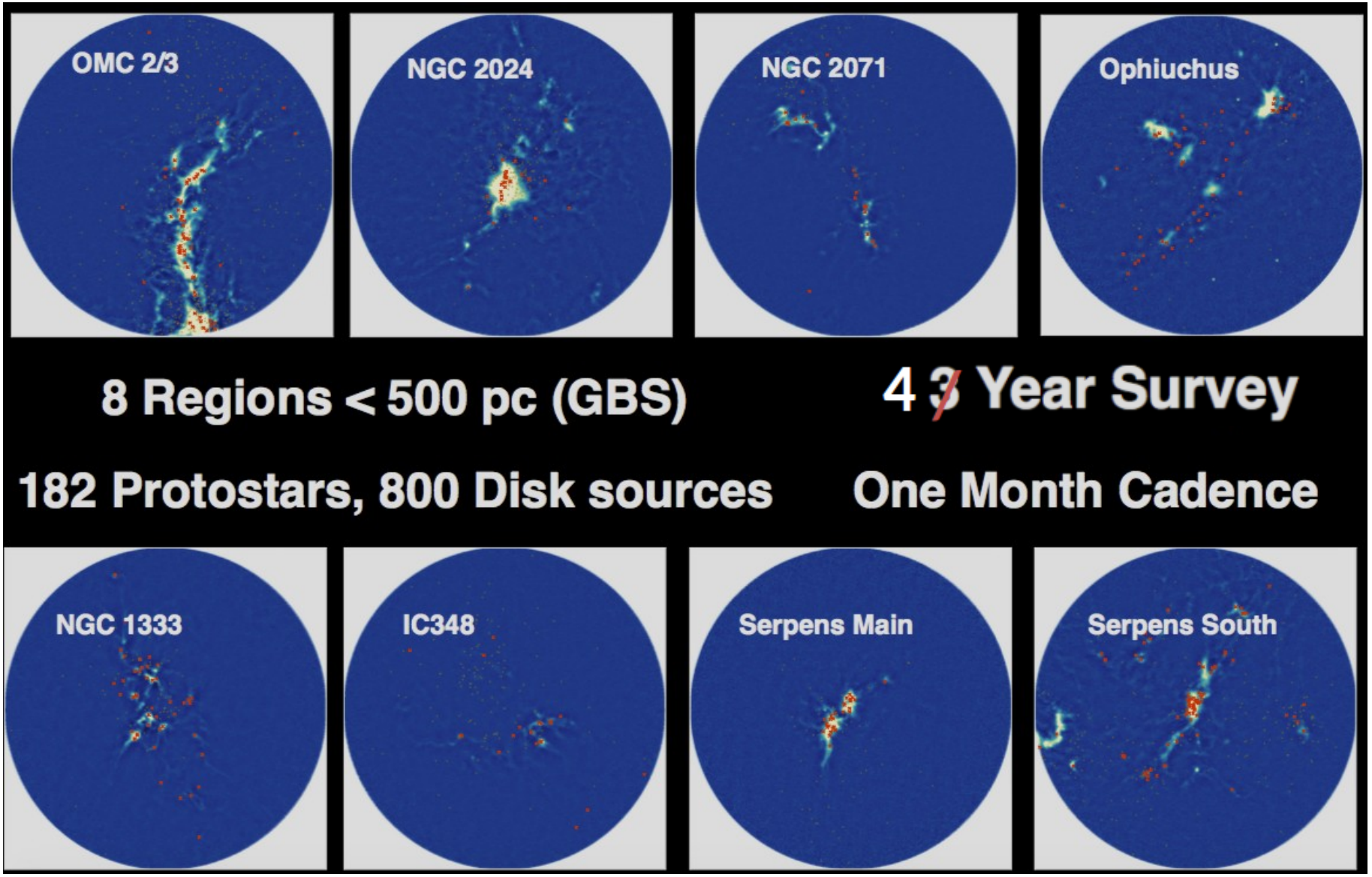
# Outline

- Introduction of the program
- Data analysis
- Results
- Conclusion

# The JCMT Transient Survey

SCUBA-2
850 μm & 450 μm




Mairs et al. 2017 & 2018, Herczeg et al. 2017, ApJ

**Regional Coordinators**

| Name | Institute | Region | notes |
|---|---|---|---|
| Gregory Herczeg | KIAA/PKU | CN | Coordinator; Regions |
| Doug Johnstone | NRC | CA | Coordinator; Analysis, Calibration, 450 |
| Yuri Aikawa | U. Tokyo | JP | Chemistry, Interferometry |
| Geoff Bower | ASIAA | TW | Calibration |
| Vivien Chen | NTHU | TW | Host of Taiwan team meeting |
| Jennifer Hatchell | Exeter | UK | JCMT GBS Liaison |
| Jeong-Eun Lee | Kyung-Hee | KR | Chemistry, Interferometry, SED-fitting |

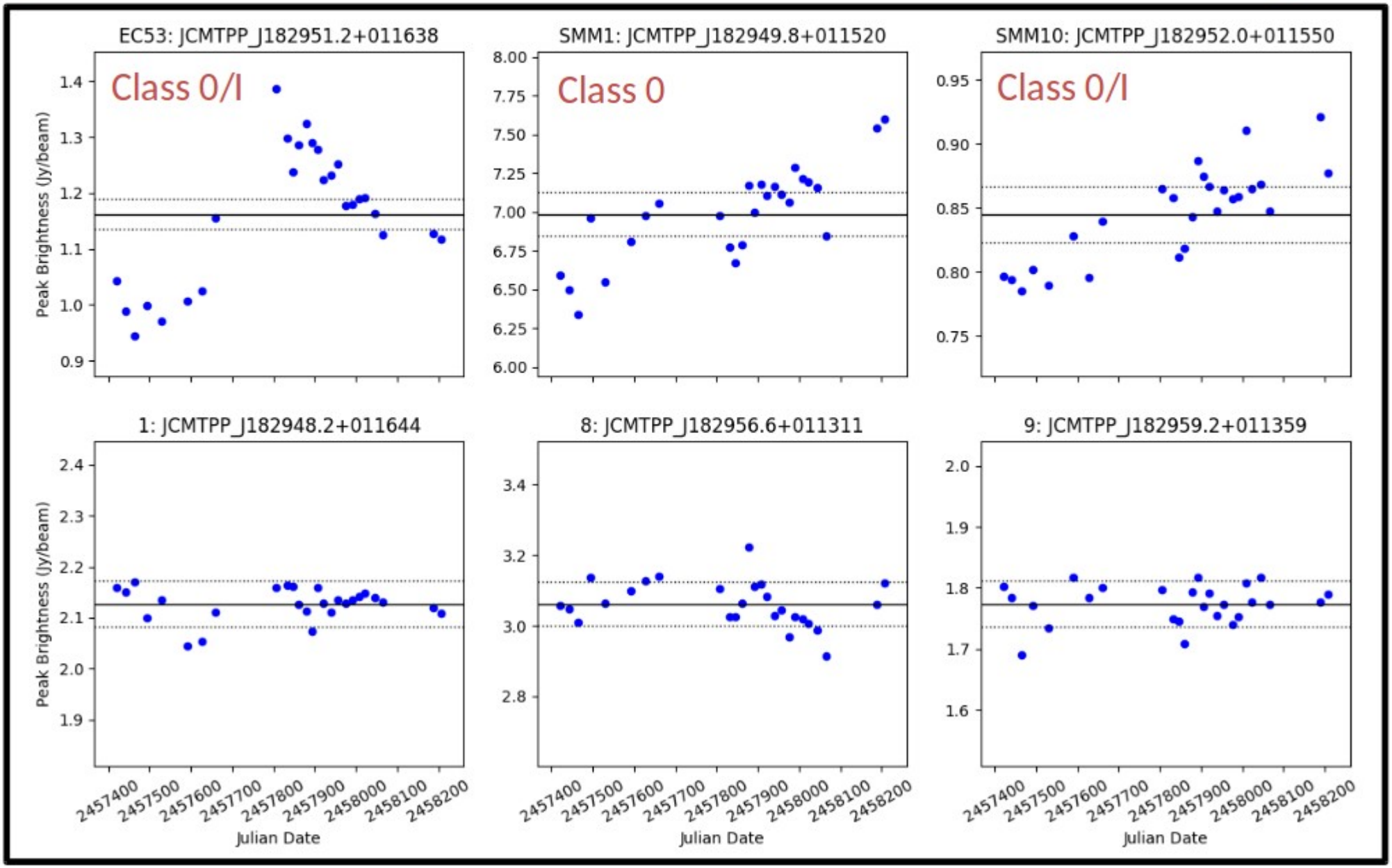
**Most Active Members of Sub-Teams**

| | | | |
|---|---|---|---|
| James Lane | Victoria | CA | Undergrad; Calibration |
| Helen Kirk | NRC Herzberg | CA | Calibration |
| Yong-Hee Lee | Kyung-Hee | KR | Analysis |
| Miju Kang | KASI | KR | Regions |
| Sung-ju Kang | KASI | KR | Regions |
| Giseon Baek | Kyung-Hee | KR | PhD student; SED-fitting |
| Oscar Morata | ASIAA | TW | faint sources |
| Wen-Ping Chen | NCU | TW | single-epoch variability |
| Bhavana Lalchand | NCU | TW | PhD student; single-epoch variability |
| Aleks Scholz | St. Andrews | UK | Regions, IR-Monitoring |
| Tim Naylor | Exeter | UK | IR-Monitoring |
| Carlos Contreras-Pena | Exeter | UK | IR-Monitoring |
| Dimitris Stamatellos | Lancashire | UK | SED-fitting |
| Benjamin Macfarlane | Lancashire | UK | PhD Student; SED-fitting |
| Paula Teixeira | St. Andrews | UK | Faint sources |
| Mi-Ryang Kim | KASI | Korea | Filaments |
| Mitsuhiko Honda | Kusube Univ | Japana | mid-IR follow-up |
| Graham Bell | EAO | EAO | Calibration |
| Sarah Graves | EAO | EAO | Calibration |
| Steve Mairs | EAO | EAO | (former PhD student) Calibration, 450 |

Full membership list: https://www.eao.hawaii.edu/transient/WelcomePage

# Calibrated Light Curves and Variance

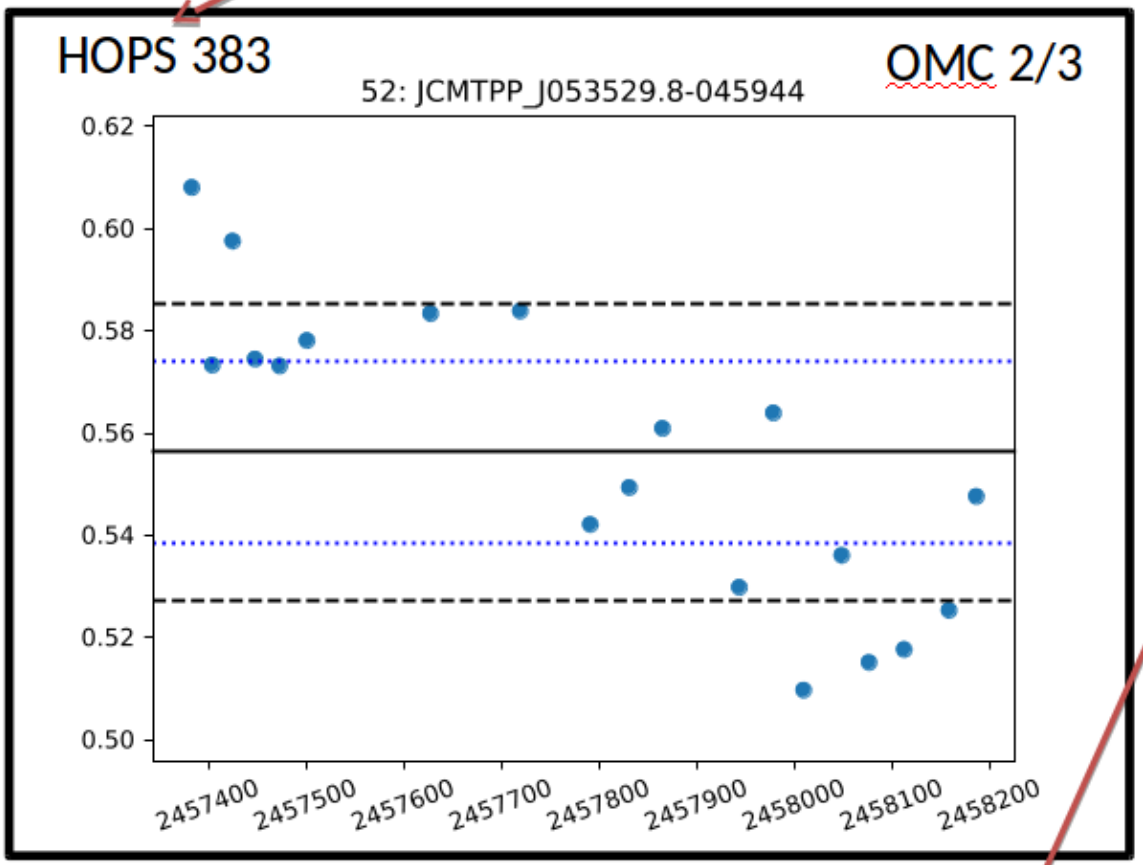
**Light Curves** at 850 microns – Secular Variations (Johnstone et al. 2018, ApJ)

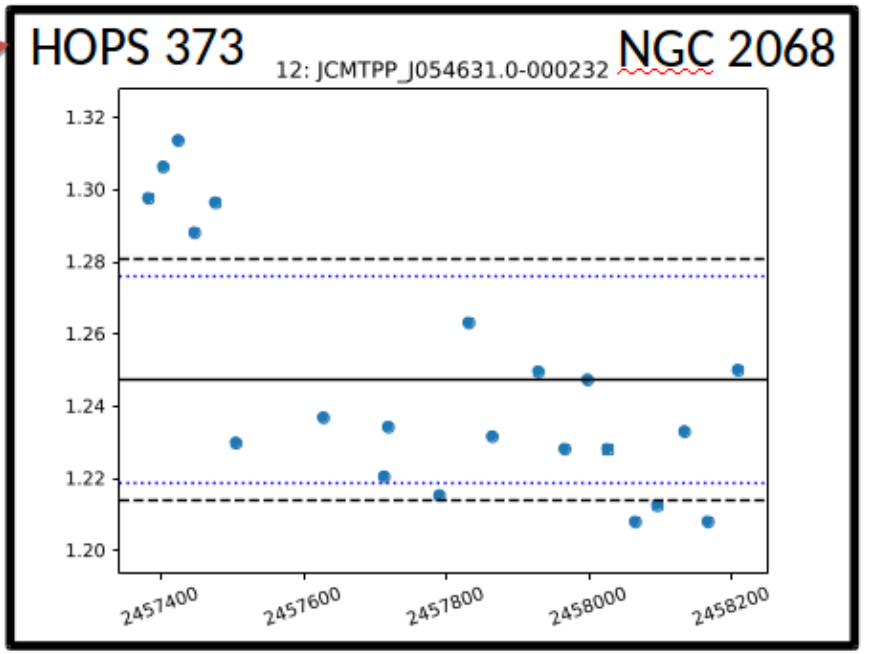


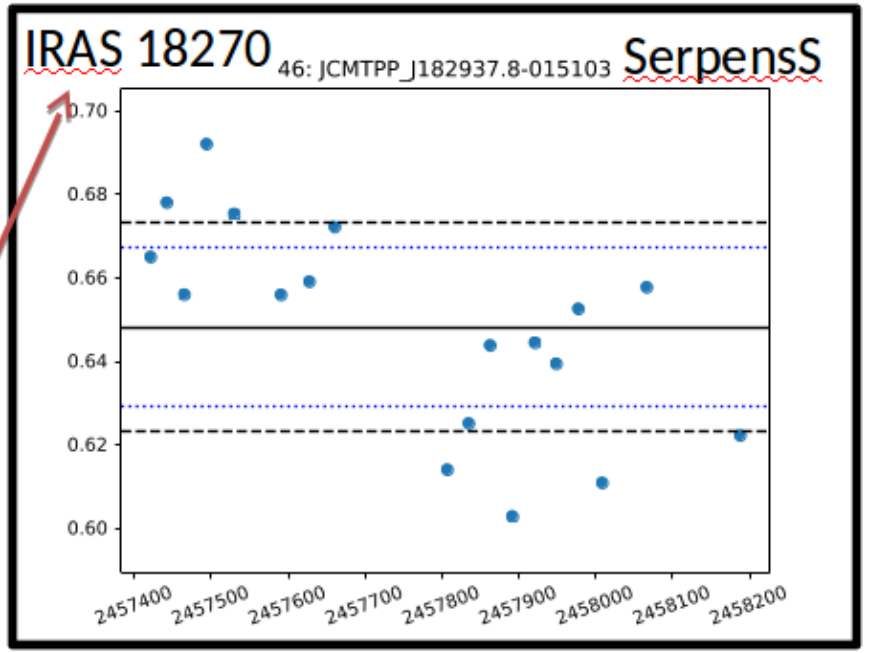
# Calibrated Light Curves and Variance

PBRS source (Stutz et al. 2013)

Outburst (Safron, Fischer et al. 2015)



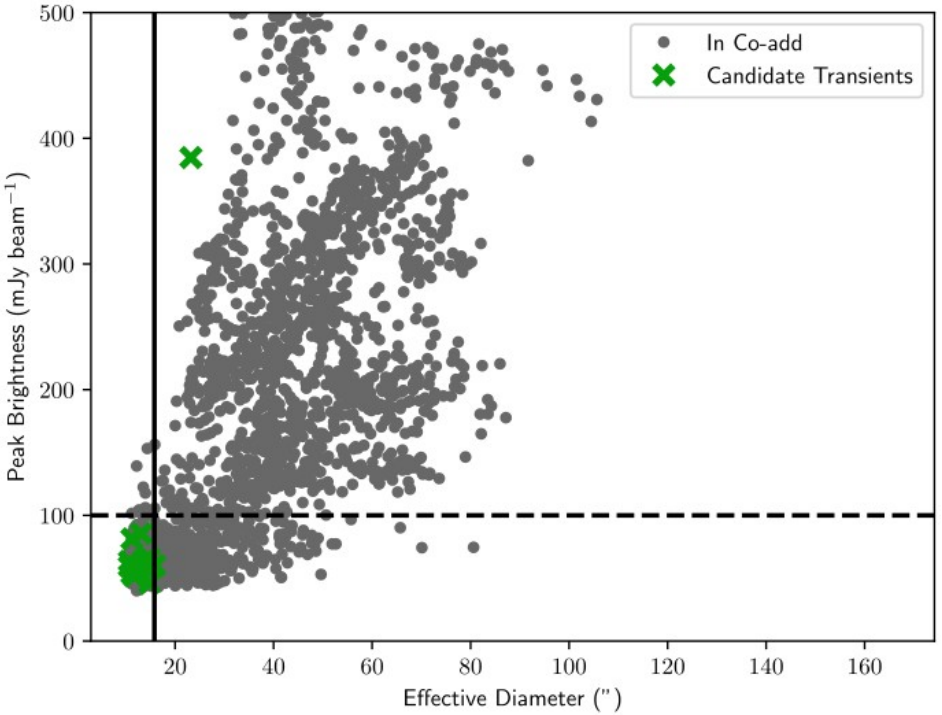



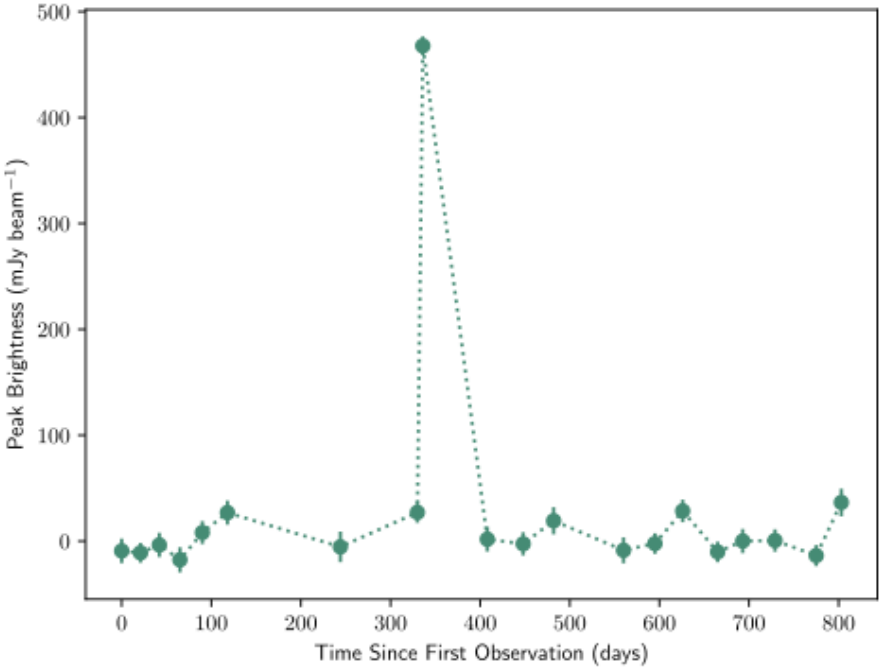



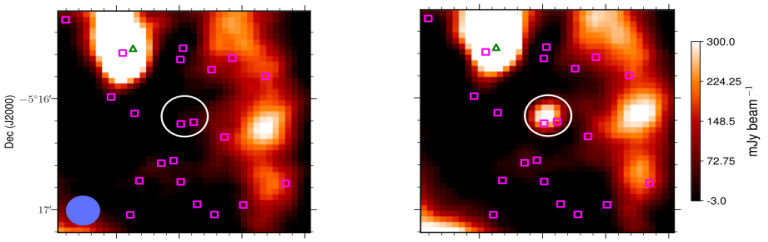

FU Ori Candidate (Connelley & Greene 2010)

First sub-mm/YSO Atels(Johnstone; Mairs)

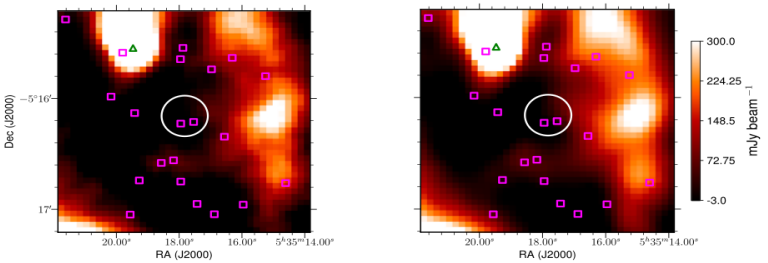
# Our latest discovery





(a) 850 $\mu$m 2016-11-20 (UT).


(b) 850 $\mu$m 2016-11-26 (UT).


(c) 850 $\mu$m 2017-02-06 (UT).


(d) The co-add of all 850 $\mu$m epochs not including 2016-11-26.

- T Tauri Binary System in the Orion Molecular Cloud.
- A K7+M1.5 with a projected separation of 0.86″.
- It has been classified as a “Disk” by Megeath et al. (2012) based on its mid-infrared colors.
- Strongly suggests that this arguably the most powerful radio flare ever seen from a solar-like corona, and is also the first stellar flare detected in the sub-millimeter.

Mairs,Lalchand et.al (2019) ApJ

# My Data Analysis

1. We used ClumpFind Algorithm – Fellwalker.

- Fellwalker algorithm: Considers pixel which are above the background noise and merges the adjacent pixels calling it as a clump. From which a list a clump parameters is produced.

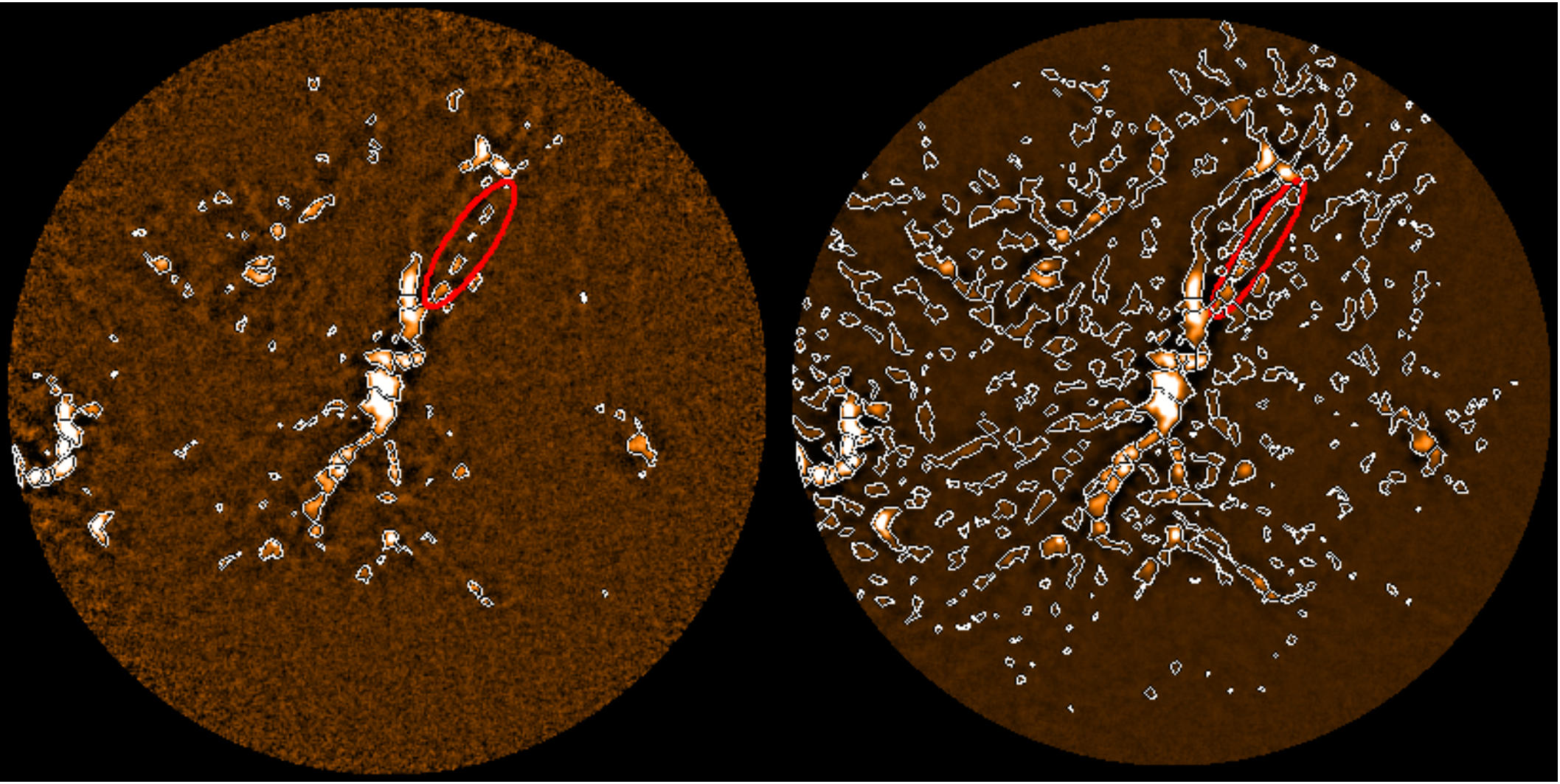
2. Detection threshold is 3 σ (above sky noise) and above.

| Regions | Regions | Central R.A | Central Decl | Number of Epochs |
|---|---|---|---|---|
| Perseus | NGC 1333 | 03:28:54 | +31:16:52 | 33 |
| Perseus | IC348 | 03:44:18 | +32:04:59 | 30 |
| Orion | OMC2/3 | 05:35:33 | -05:00:32 | 28 |
| Orion | NGC 2024 | 05:41:41 | -01:53:51 | 30 |
| Orion | NGC 2068 | 05:46:13 | -00:06:05 | 31 |
| Ophiuchus | Core | 16:27:05 | -24:32:37 | 27 |
| Serpens | Main | 18:29:49 | +01:15:20 | 48 |
| Sepens | South | 18:30:02 | -02:02:48 | 30 |

# Serpens South

Single-Epoch

Co-add



RMS = 0.0117 Jy/beam

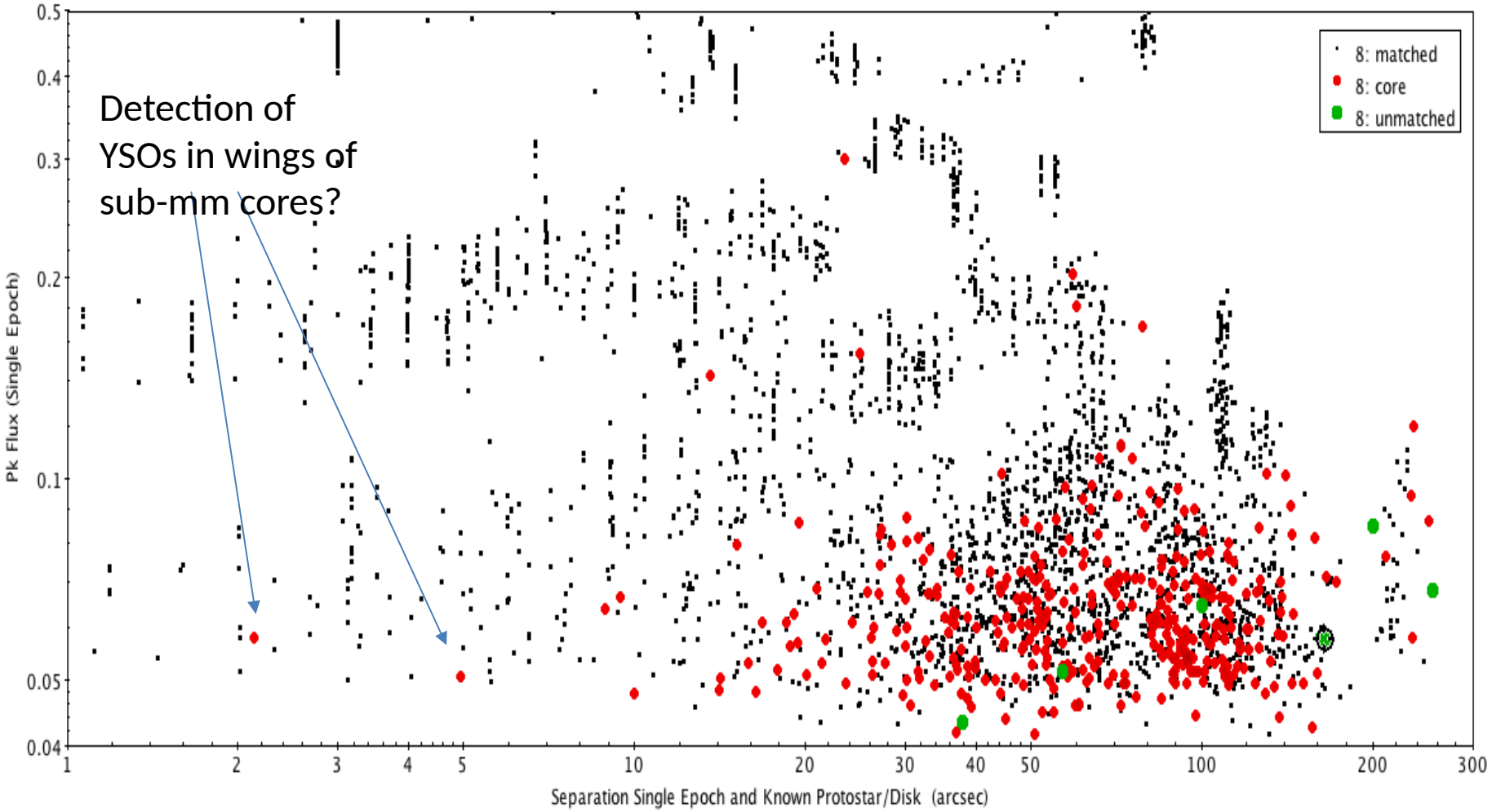
- Matched
- Core
- Unmatched

RMS = 0.002 Jy/beam

# Serpens South

- 430 distinct sub-mm sources found in the co-add.
- 3384 distinct sub-mm sources found over ~30 epochs (100 per epoch).
  - ~3000 (90%) of these match with co-add sources.
  - ~360 (10 %) are ‘close’ to co-add sources.
  - 7 are entirely unmatched with co-add sources.

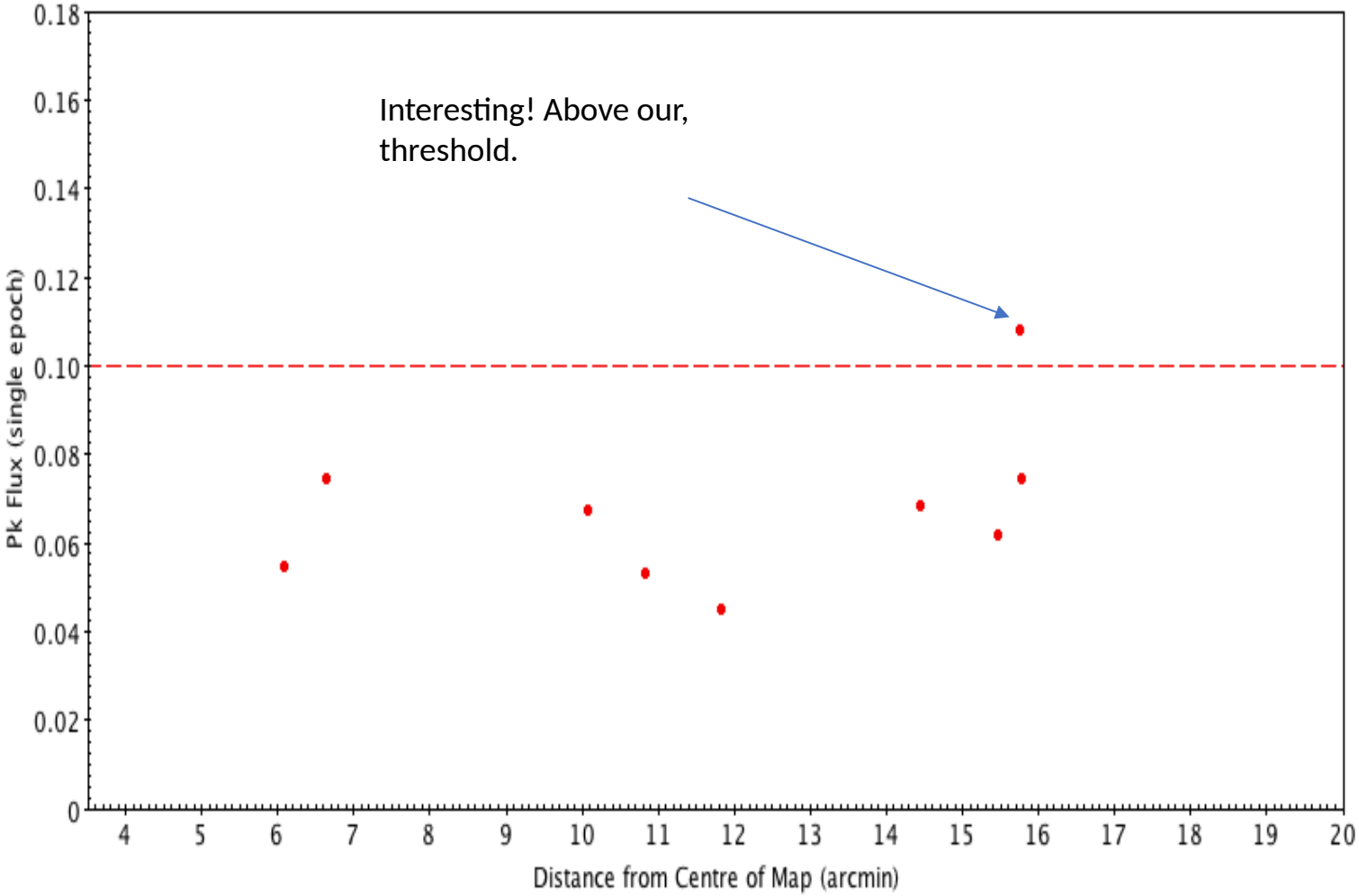
# Serpens South – Single Epoch vs Known YSOs

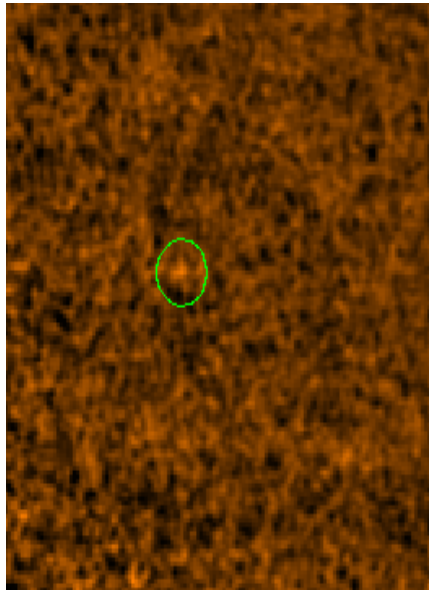


# Oph Core

- 350 distinct sub-mm sources found in the co-add.
- 2389 distinct sub-mm sources found over ~25 epochs (10 per epoch).
  - ~2200 (90%) of these match with co-add sources.
  - ~200 (8 %) are ‘close’ to co-add sources.
  - 7 are entirely unmatched with co-add sources.
    - Steve finds all of these as well.

# Oph Core– Single Epoch



# Conclusion

- **Time Allocation:** A total of 200 hrs spread uniformly over 4 years (through January 2020), including a 1 yr/50 hr extension. At present the program is 85% complete in time allocation (169.4 hrs used).
- **Success:** Our survey has demonstrated the feasibility of a sub-mm transient survey, developed the techniques needed to reach the necessary precision of 2%, and have applied these results to measure the variability of protostars.
- **Survey Extension:** Continue monthly monitoring of 8 fields

  Higher cadence monitoring (1-2 weeks for 1-2 fields?  Flare monitoring?)

  Additional monitoring campaigns

  Other nearby low-mass regions

  Intermediate/high-mass star forming region

  ToO requests of FUors/Exors identified in other surveys
- **Pipeline:** We discovered a T Tauri flare JW566 in Orion. We could have discovered as soon as it occurred. Once detected we can do a follow-up using for example ALMA and other telescope.