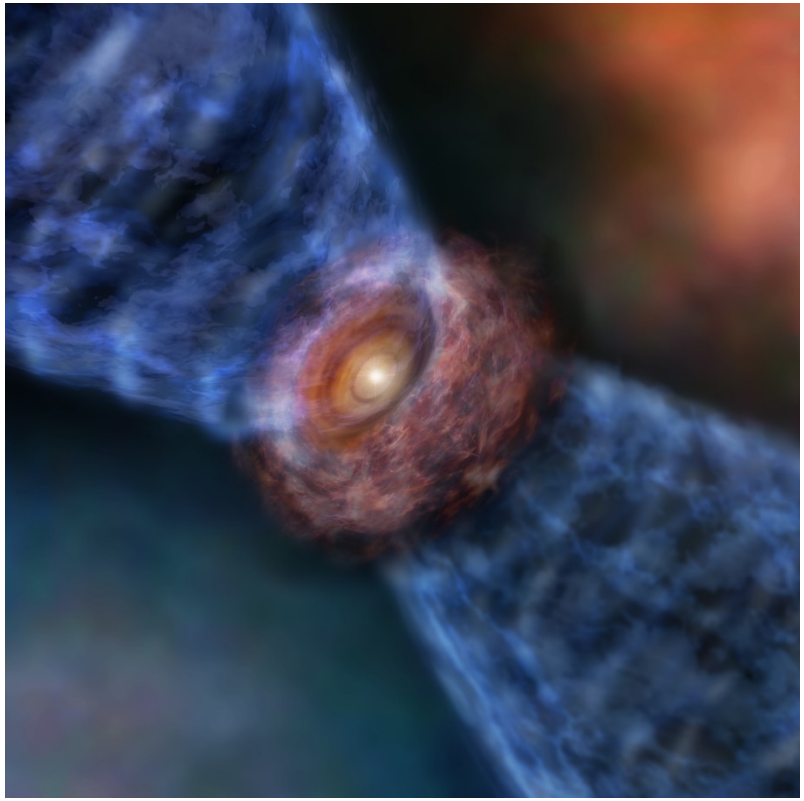
Status report of KaVA SFRs WG



Tomoya Hirota (NAOJ), Kee-Tae Kim (KASI),

on behalf of KaVA SFRs sub-WG

KaVA SFRs LP summary

- **Understanding high-mass star formation through KaVA observations of water and methanol masers**

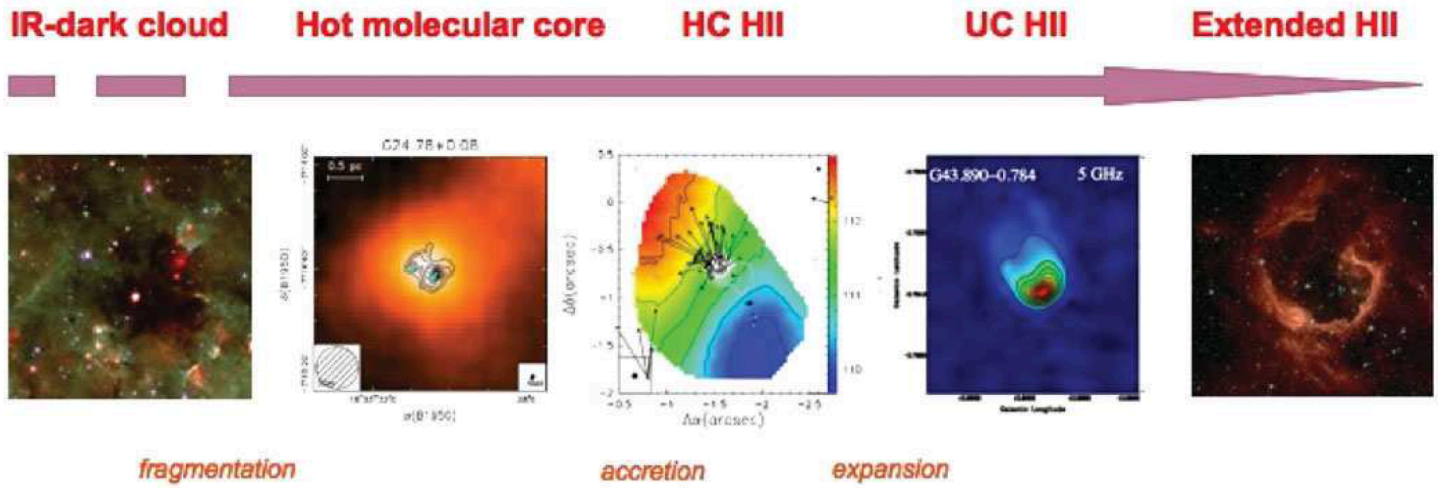
- VLBI monitoring/survey to reveal 3D velocity and spatial structures of 22GHz H_2O/44GHz CH_3OH masers in 87 high-mass YSO (HM-YSO) samples
  - Physical/dynamical properties of disk/jet/outflow
  - Evolution of disk/jet/outflow and maser chronology

- Just submitted proposal for the second year
  - Interim review on November 22 at Daejeon (KaVA/EAVN SWG)

Why HM-YSOs?

- Major impact on astronomy
  - Strong influence on formation and evolution of stars, clusters, ISM, and galaxies

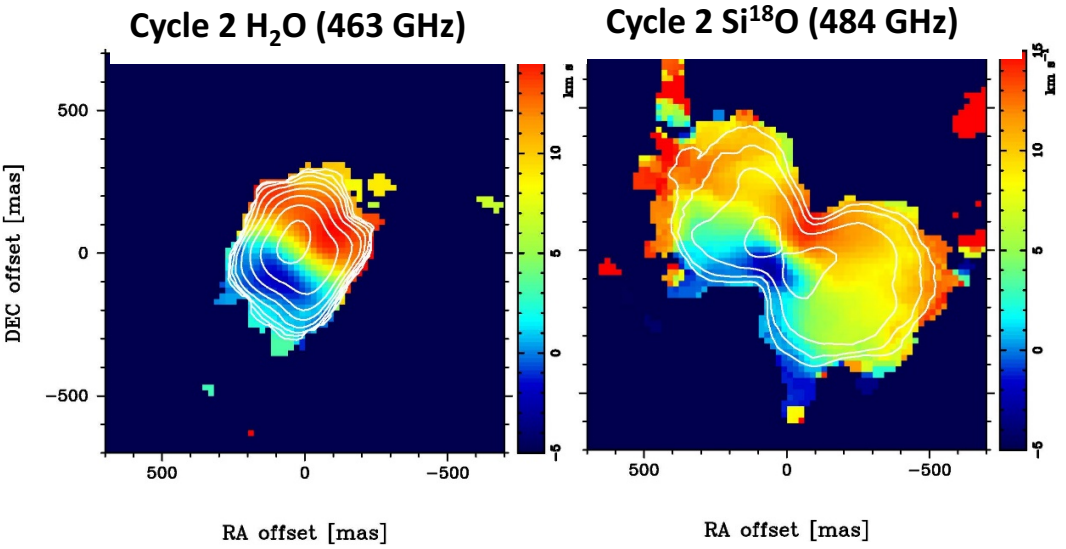
- Not understood in contrast to low-mass YSOs
  - Initial condition? Accretion process? Feedback process? Initial mass function?



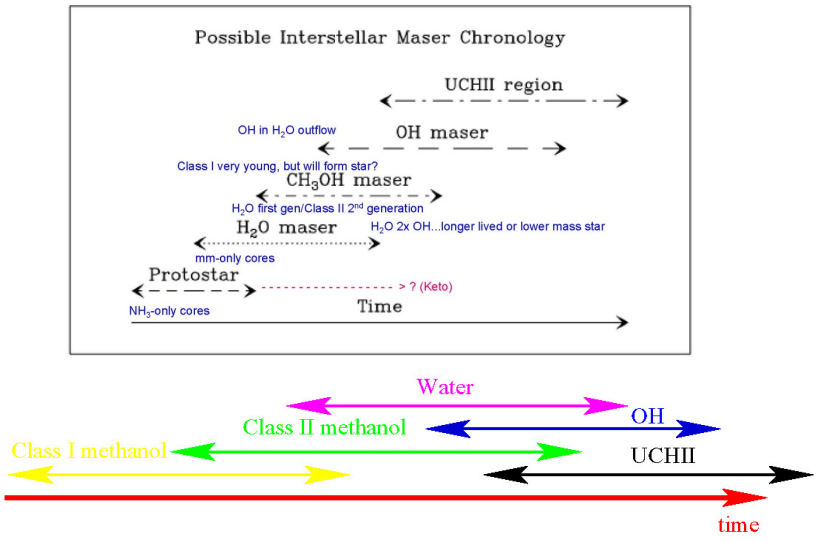
Evolutionary sequence of high-mass young star (Beltran 2011)

Observational studies on HM-YSOs

- How they evolve? What maser tells us?
  - Need high resolution to reveal 3D velocity structure
  - Unique capability of VLBI providing proper motions
  - Complementary with high resolution ALMA/JVLA data
  - Statistical studies with large survey data from IR to cm



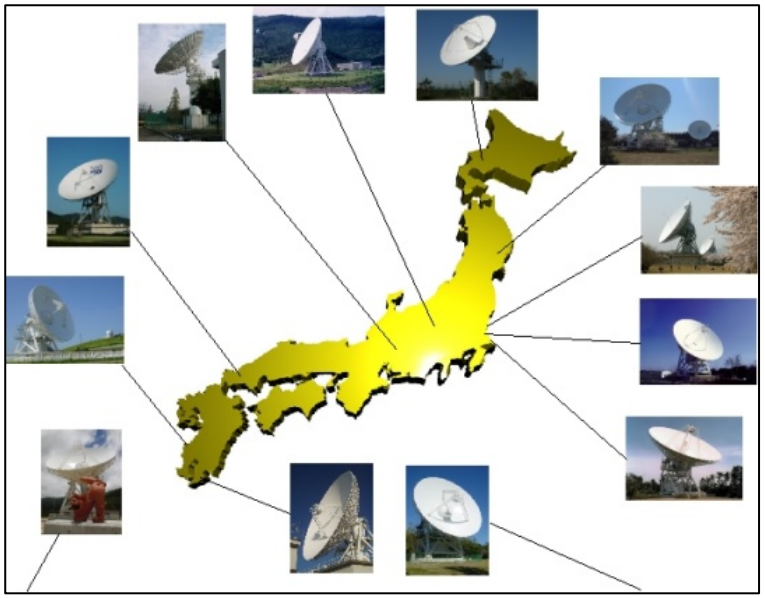
Orion Source I (Hirota et al. 2017)

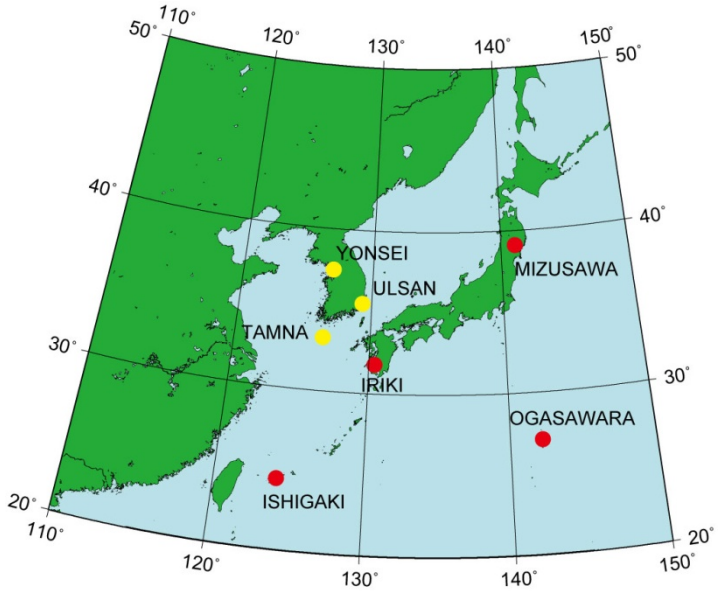


Reid (2007) vs Ellingsen (2007)
Updated with slight modification but still controversial

Planned observations

- VLBI survey/monitoring of sources; 87
  - 22 GHz H_2O masers; high-velocity jet/outflow (KaVA)
  - 44 GHz CH_3OH masers; low-velocity outflow (KaVA)
  - 6.7 GHz CH_3OH masers; low-velocity outflow/disk (JVN)
  - Association of multiple masers, high velocity jets, …





Timeline and strategy

- First year; finished
  - Snap-shot survey of 25 H_2O masers at 22 GHz
    - Selected from SD/archive data with no previous VLBI data
  - Snap-shot survey of 19 CH3OH masers at 44 GHz
    - Based on KVN fringe-check, most of them are the first VLBI
- Second year; being proposed
  - Proper motion measurements of selected sources
- Third year and beyond; TBD
  - Continue proper motion measurements of further sources
  - Intensive monitoring for highly variable sources

First year; H_2O maser at 22 GHz

- Snap-shot imaging toward 25 HM-YSOs
  - H_2O maser maps toward 21 sources
  - Variety of spatial/spectral features
  - Jet-like structure, bow-shock, very high velocity features, . . .

Preliminary results of the first year survey (See presentation by Kim-san)

First year; H_2O maser at 22 GHz

- Collaboration with ALMA cycle 3 for 11 sources
  - Mainly for 44 GHz methanol maser sources
  - Thermal methanol, organic molecules, SiO, etc.
  - Direct comparison with spatial/velocity structures
  - Rotating disk traced by thermal lines

Preliminary results of the first year survey (See presentation by Kim-san)

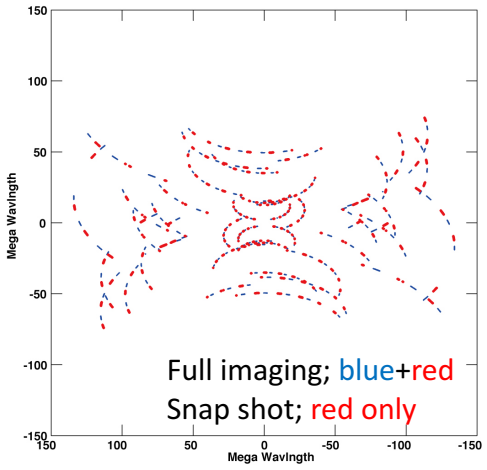
First year; CH_3OH maser at 44 GHz

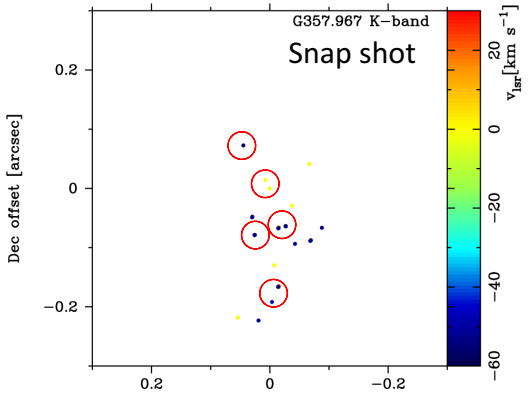
- First VLBI imaging toward 18 HM-YSOs
  - Selected from KVN SD survey (K.T. Kim et al.)
  - Resolved out in most sources but feasible for proper motion measurements in a few sources
  - Extended distributions with >arcseconds, need wide FoV

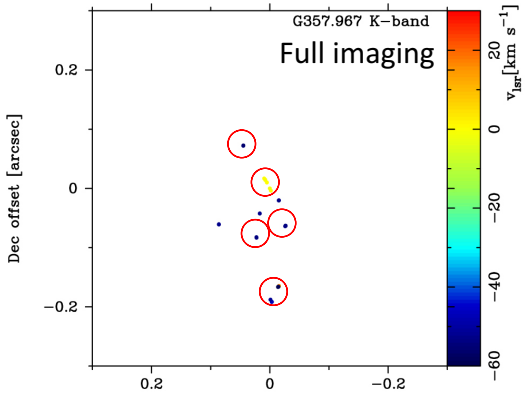
Results of from the KaVA PET (See presentation by Sugiyama-san)

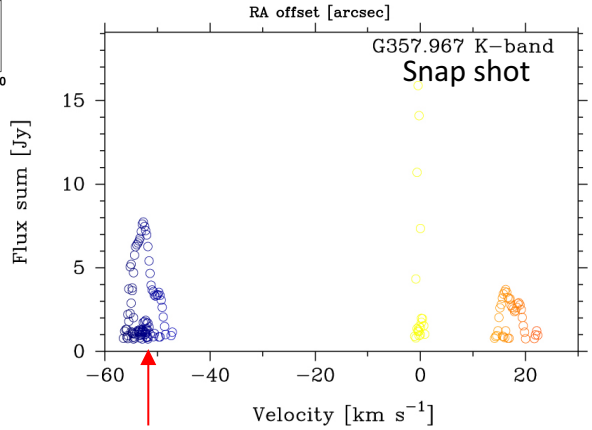
Proposal for second year; K-band

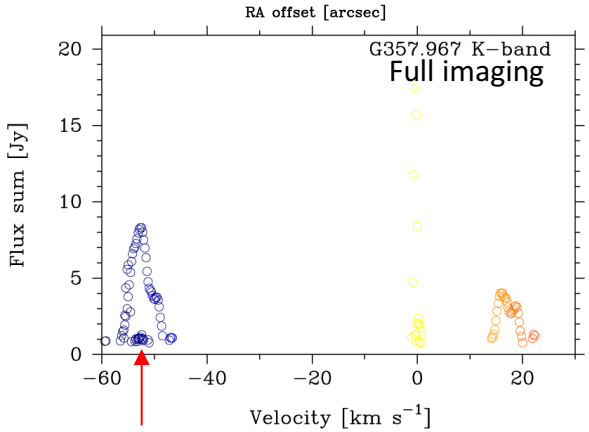
- Proper motion measurements for 16 samples
  - Multiple features to see systematic motions
  - 5 epochs, 4 sources/track, 8 hrs, need 160 hr











Snap-shot imaging test from the first year result

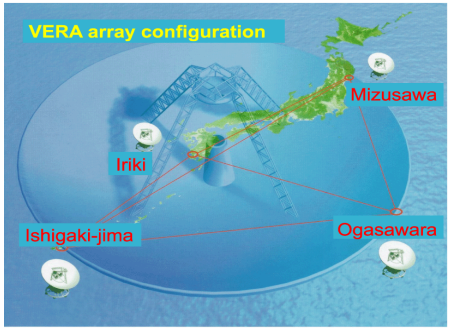
Proposal for second year; Q-band

- Proper motion measurements for 3 samples
  - Multiple features to see systematic motions
  - 5 epochs, 3 sources/track, 8 hrs, need 40 hrs
  - Need wide-field imaging

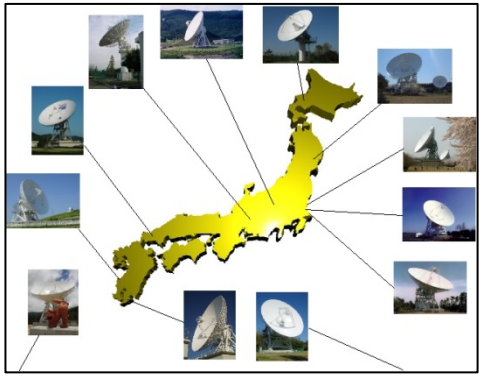
Results of from the KaVA PET (See presentation by Sugiyama-san)

Follow-up projects and status

- All are complementary to KaVA results
  - VERA; partially observed, on-going (2 finished, 2 monitoring)
  - JVN; resumed from November (observed 5/22 sources)
  - ALMA cycle 3; data available for 11 sources, more proposals!
  - SD; troubles in ASTE, to be resumed soon
  - JVLA; failed -- planning collaboration with Bessel
  - Others; large survey data archive from cm to IR



Annual parallax

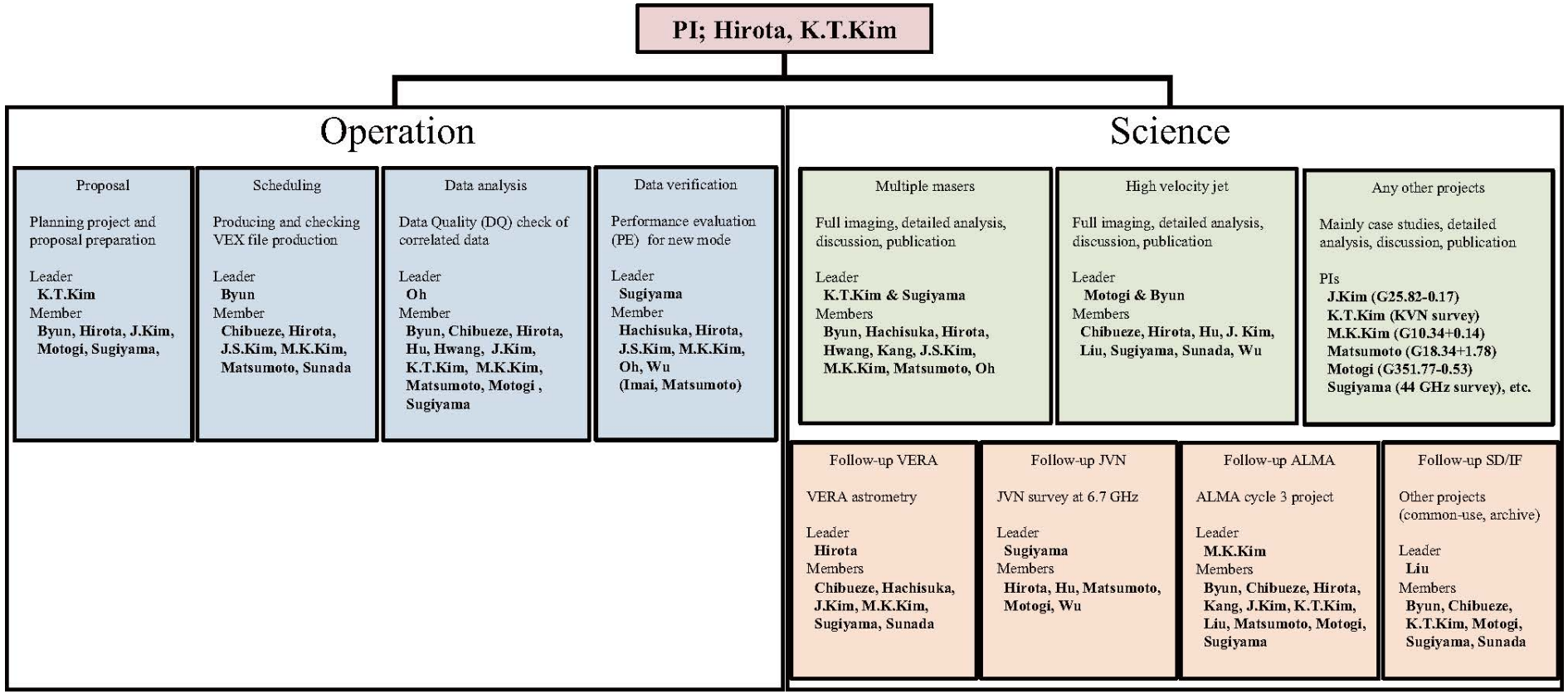

6.7GHz methanol masers

Thermal continuum/lines


Large-scale structure

Organization

- Slightly changed from original plans
  - Need more man power for science team
  - Always welcome contribution from new comer!



Schedule

- First year; finished
- Preparation for the second year
  - Proposal deadline; October 31
  - Interim review; November 22
  - Iteration between referees; within 2017?
  - New season; Early January (2018A)?
- Publication from the first year
  - About 10 at maximum (hopefully) within 1 year
  - Mainly for case studies and initial catalog

Summary

- KaVA LP for SFRs has started since early 2017
  - First year results have provided promising samples for further proper motions measurements
  - We will continue monitoring of the selected targets in the second year
  - Part of the first year results will be published within one year, mainly for case studies of spatial structures of HM-YSOs (and initial catalogue)
  - Follow-up proposals will be prepared continuously as they are also essential for our success