Subaru Strategic Exploration of Exoplanets and Disks with HiCIAO/AO188 (SEEDS)
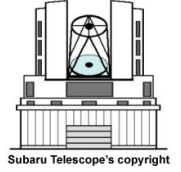## [YSO category Targets and status report]

国立天文台 NAOJ National Astronomical Observatory of Japan

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Abstract

SEEDS (Subaru Strategic Exploration of Exoplanets and Disks) is the first accepted proposal as a Subaru strategic observation project with 120 allocated nights in total for 5 years run. Our main purpose is to conduct the Subaru-HiCIAO-AO188 imaging survey, searching for giant planets (1 MJ < mass < 13 MJ) as well as protoplanetary/debris disks at a few to a few tens of AU region around ~500 nearby solar-type or more massive young stars after performance certification. SEEDS targets are composed of 4 major categories, including the Young Stellar Objecs (YSO) category. We have conducted a thorough YSO target selection during the last half year. In this poster, we will outline our goal and target selection processes.
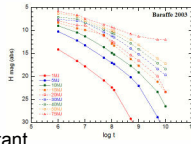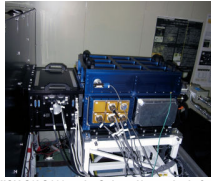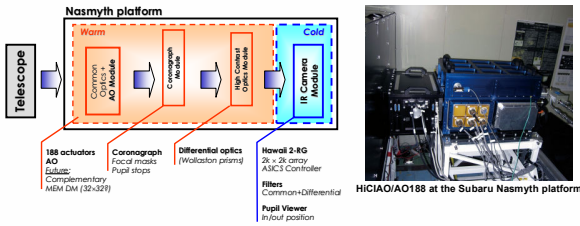
1.Introduction

[Goal of the SEEDS survey]

① The detection and census of exoplanets around solar-mass stars.
② The evolution of protoplanetary and debris disks.
③ The direct link between planets and circumstellar disks.

- to reveal the morphology of the protoplanetary disks at 15-50 AU regions such as disk structures that could be formed by planets or rather that lead to planet formation (gap, hole, warp, resonance)

[Importance and merit of YSO observations]

① Planets and BDs are expected to be brighter and less-contrast when they are younger. Thus, observations toward the youngest stars would have the greatest chance of detecting low mass companions.

② Investigation of protoplanetary disks is important to understand the origin of the Earth and our solar system.
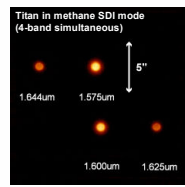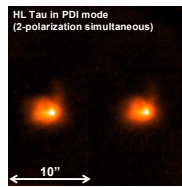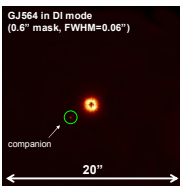
2. HiCIAO (**Hi**gh **C**ontrast **I**nstrument for the Subaru Next Generation **A**daptive **O**ptics)

Nasmyth platform

HiCIAO/AO188 at the Subaru Nasmyth platform

188 actuators AO
Future: Complementary MEM DM (32×32)

Coronagraph Focal masks Pupil stops

Differential optics (Wollaston prisms)

Hawaii 2-RG 2k x 2k array ASIC3 Controller

Filters Common+Differential

Pupil Viewer In/out position

Focus	IR Nasmyth (w/ AO188)
Wavelength	0.85 ~ 2.50 microns
Observation modes	DI, PDI, SDI, ADI (w/ & w/o coronagraph) ※
Resolution	0.03" (J), 0.04" (H), 0.055" (Ks)
Strehl ratio	0.2 (J), 0.3 (H), 0.5 (Ks) with AO
Field of view	20"x20" (DI), 20"x10" (PDI), 5"x5" (SDI)
Contrast	$10^{3.8}$ at 0.1", $10^{5.5}$ at 1.0" (SDI w/ coronagraph)
Pixel scale	0.010 "/pix
Occulting masks	0."2, 0."3, 0."4, 0."6 dia.
Filters	Y, J, H, Ks (DI, PDI), CH4, FeII, H2 (SDI)
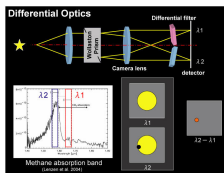
※ DI: Direct Imaging   PDI: Polarimetric Differential Imaging
SDI: Spectral Differential Imaging   ADI: Angular Differential Imaging

Differential Optics

Concept of Spectral Differential imaging (SDI)

GJ564 in DI mode (0.6" mask, FWHM=0.06")
companion
20"

HL Tau in PDI mode (2-polarization simultaneous)
10"

Titan in methane SDI mode (4-band simultaneous)
1.644um   1.575um
1.600um   1.625um
5"

3. Target selection procedure

In order to obtain the high AO performance, all targets have a declination of more than - 40 deg.

All targets have a distance within 200 pc, thereby allowing us to observe disks and planets at the close vicinity of the central star.

Step.1: We picked up ALL YSOs with the spectral type from B0 to M9.
Step.2: Extracting objects with the spectral type unknown and M2-M9.
Step.3: Class I objects are excepted.
[Note that Flat spectrum (FS) objects were included to find the disk using PDI mode.]
Step.4: We excluded close binaries (separation is less than 3 arcsec.)
[※ Binary is one of the sub-categorys.]
**Step.5:** The R-band mangitude should be brighter than 15.
This step is essential for us to achieve the higher angular resolution with the full performance of the new AO188 system.

※ Most sub-categories in YSO adopt the same manner.

4. Details of the YSO target selection in 7 sub-category

Taurus-Aurigae

Distance: ~ 140 pc
Location: 04h00m, 25d
Typical age : ~ 1 Myr
Extinction(Av): < ~10 mag

¹³CO map in Taurus. (Goldsmith et al. 2005)
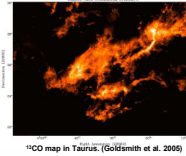
Taurus-Auriga molecular cloud is one of the nearest and most well-known star-forming regions.

The region have relatively small extinctions (Av < ~10) and rise up to the zenith in Hawaii. Therefore, the best performance is expected for AO correction.

We checked many papers to select targets. And these various parameters from previous studies are added in our candidates list.
[Optical Jet, Millimeter continuum, Subaru/CIAO, HST and Spitzer archive data, etc..]

The one of the most important aim of SEEDS is to make clear the relation between disk and planet formations in star-planet forming process. Therefore, the transition objects have the highest priority.
※ Transitional Object - defined as the object with no or weak IR excess shortward of 10 μm and a significant excess at longer wavelengths.
- a possible signature of planets at least in the very inner region (<a few AU)

As an additional original data, we added the result of *JHKs* polarimetric imaging for Taurus targets, using SIRIUS/SIRPOL mounted on the 1.4m IRSF telescope in South Africa.

Finally, we suggest the 25 targets for the first 2 years survey. (~ 65 targets to be observed during the whole project)

Upper Scorpius

Distance: ~ 145 pc
Location: RA: 16h00m, Dec: -20d
Typical age : ~ 5 Myr
Extinction(Av): < 2 mag

Extinction map of U-Sco (Harju 1993).
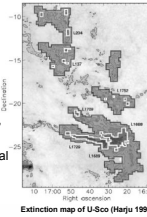
Upper Sco is the nearest OB association, located at a distance of ~145 pc.

The region have a intermediate evolutional stage. Therefore, U-Sco targets can become complementary target to Taurus (~1Myr) and open clusters (~100Myr).

Sample Selection
- Hα and X-ray surveys cover the whole region
- Almost whole regions of U-sco are observed by Spitzer.
- very few radio survey observations toward Upper Sco.

Only 10 stars have infrared excess out of 79 Spitzer targets. These 10 targets are good for disk targets for 5 years survey. For Planet search, we listed up target which are strong in both Hα and X-ray. The number of candidates is 58.

ρ Ophiuchus

Distance: ~ 125 pc
Location: 16h27m , -25d
Typical age : < 1Myr
Extinction(Av): 50 - 100 mag

Extinction map of ρOph (Allen et al.2002)
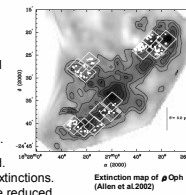
Targets were selected in much same manner of Taurus.

More than 100 sources are listed. But, this region have very high extinctions. Observable targets with AO have reduced.

Considering R-mag and Spitzer archive data, the number of candidate is 28.

We selected targets for disk search: 12 objects（8 in 2 yrs）for planet: 16 objects（10 in 2 yrs), respectively.

Lupus

Distance: ~ 140 pc
Location: 16h00m, -33~ -40d
Typical age : ~ 1 Myr
Extinction(Av): ~ 30 mag

Extinction map of Lupus. (Cambresy 1999).
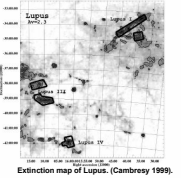
Lower Declination…
Systematic sample selection is NOT needed. Sources with "unique" features should be included.
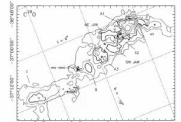
ASTE will cover Lupus I - IV regions and provide uniform catalogue of disk sources (up to 1MJ).

The number of candidates is 5, including newly detected Sources at millimeter continuum with ASTE.

※ We are checking new ASTE data and still going on.

R Coronae Australis

Distance: ~ 170 pc
Location: 19h00m, -37d
Typical age : ~ 1 Myr
Extinction(Av): ~ 35 mag

C¹⁸O contour map (Harju 1993).

There is a population of young, low-mass stars around Herbig Ae star "R CrA".

We checked polarization data by SIRPOL and refined these objects. As a result, we listed 8 sources in R CrA region. (2 soueces have the polarization degree of ~2%.)

Our selected sources could not find in Spizter archive data.

Binary Stars

UY Aur (H-band image)

Some of the previous studys showed that more than half of the T Tauri stars are binaries (e.g. Ghez 1995).
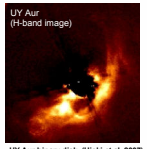
Theoretical Predictions (e.g., Nelson 2003)
1. Proto-planet stably survives in a binary system (especially eccentric orbit).
2. Circumbinary planet tends to have large mass (> a few MJ) than a planet around a single star.

UY Aur binary disk. (Hioki et al. 2007)

We would like to make sure these theoretical Predictions.

Targets were selected from the various star-forming regions. We selected targets - for disk search: 21 objects（8 in 2 yrs）
- for planet: 16 objects（7 in 2 yrs）

Massive Stars

Dust around forming planet and gap around them ?

Advantage:
- Brighter and larger disks than around lower mass stars.
- Disk that has been resolved so far: "Detection" of a disk is guaranteed.
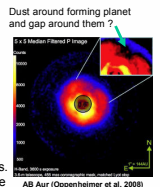
We picked up Nearby (<~200pc) Herbig Ae/Be/(Fe) stars.

7 targets were selected for the first 2 years. About 30 targets to be observed during the whole project. (40 targets are listed as possibly interesting)

AB Aur (Oppenheimer et al. 2008)

5. Summary of YSO targets

Disk	Distance (pc)	RA (hour)	Dec (degree)	Age (Myr)	Mother Sample	disk search (5 year)	disk search (2 year)
Taurus	140	04	+15 ~ +30	1	288	65	25
Upper Sco	145	16	-20 ~ -30	5	78	10	6
ρ Oph	125	16	-20 ~ -30	< 1	~100	12	8
Lupus	140	16	-33 ~ -40	1	~50	5	3
R CrA	170	19	-37	1	~40	8	3
Binary	< 200	---	---	~ 1	37	20	8
Massive	< 200	---	---	~ 5	40	25	7
Total					633	145	60

Planet	Distance (pc)	RA (hour)	Dec (degree)	Age (Myr)	Mother Sample	planet (5 year)	planet (2 year)
Taurus	140	04	+15 ~ +30	1	288	[65]	[25]
Upper Sco	145	16	-20 ~ -30	5	78	58	8
others	< 200	---	---	~ 1		30 [68]	11 [52]
Total	~ 140				633	88	19

- Mother list = all the known young stars in nearby star forming regions (d<200 pc).
- Taurus/U Sco are the main sub-categories.
- 5 other sub-categories. (Oph, Lup, R CrA, binaries, massive stars)
- A total of 233 stars for planet/disk search in 5 yrs.
- A total of 79 stars for planet/disk search in 2 yrs.
- For 2 years, disk search is emphasized.

The one of the most important aim of our disk search survey is to make clear the relation between disk and planet formations in star-planet forming process. We should show the results of the disk search within the first two years.

Schedule

2009. May: HiCIAO engineering Obs. (finished)
2009. Aug: HiCIAO engineering Obs final.
2009. Nov: SEEDS science Obs START!   (~ 2010. Jan)