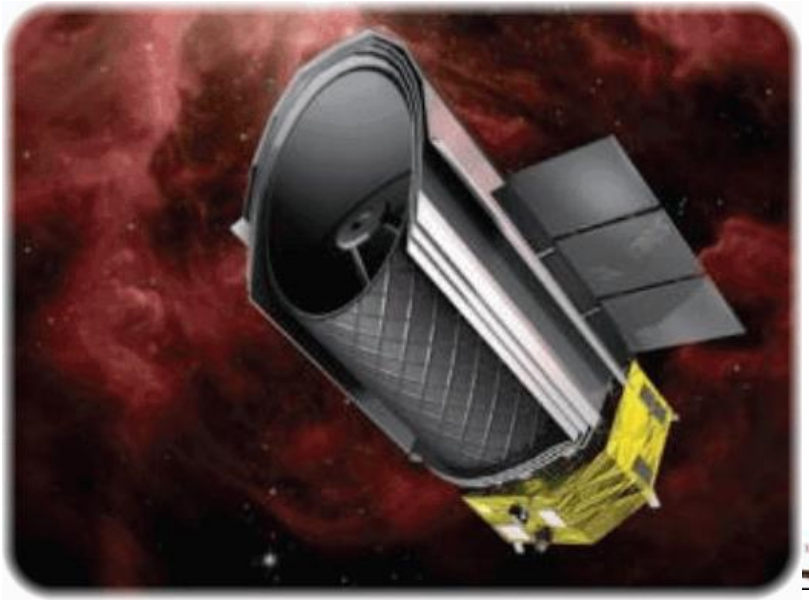
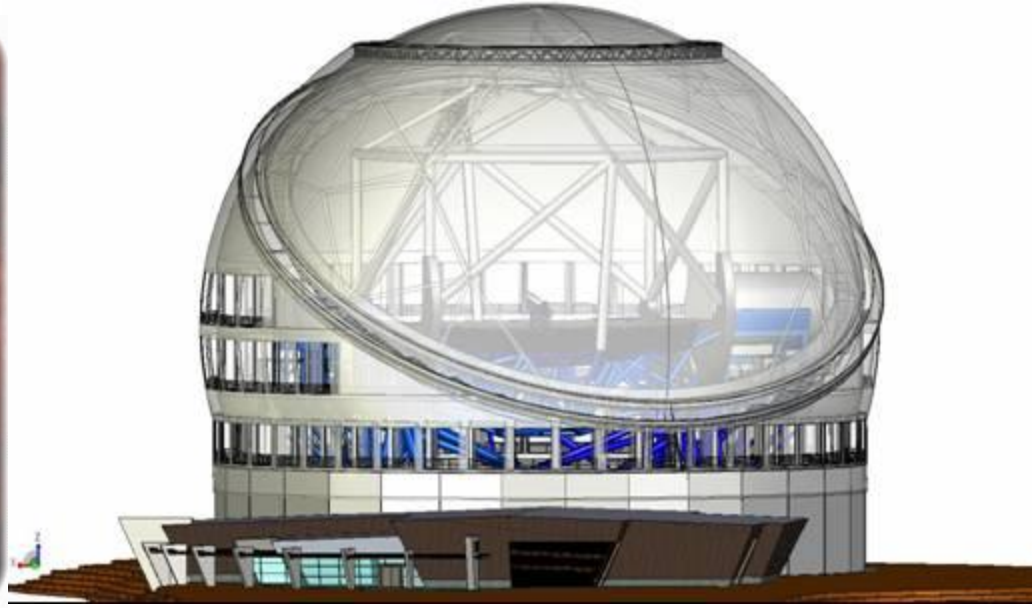
Synergy of SPICA and TMT

TMT
THIRTY METER TELESCOPE



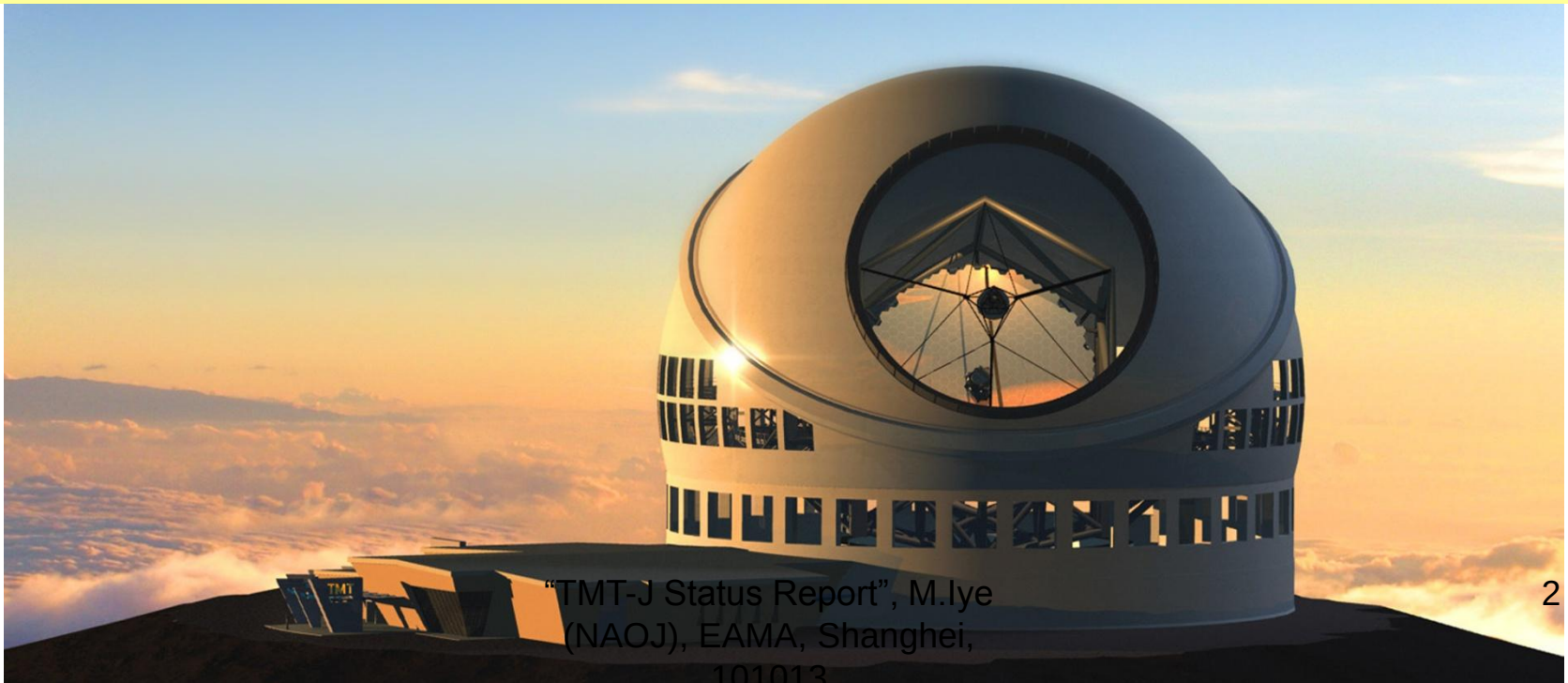


- Congratulations for the SPICA community having this many participants with very intensive and candid science discussion!
  - **But, schedule conflict with Subaru autumn school …**

Masanori Iye (TMT-J project)

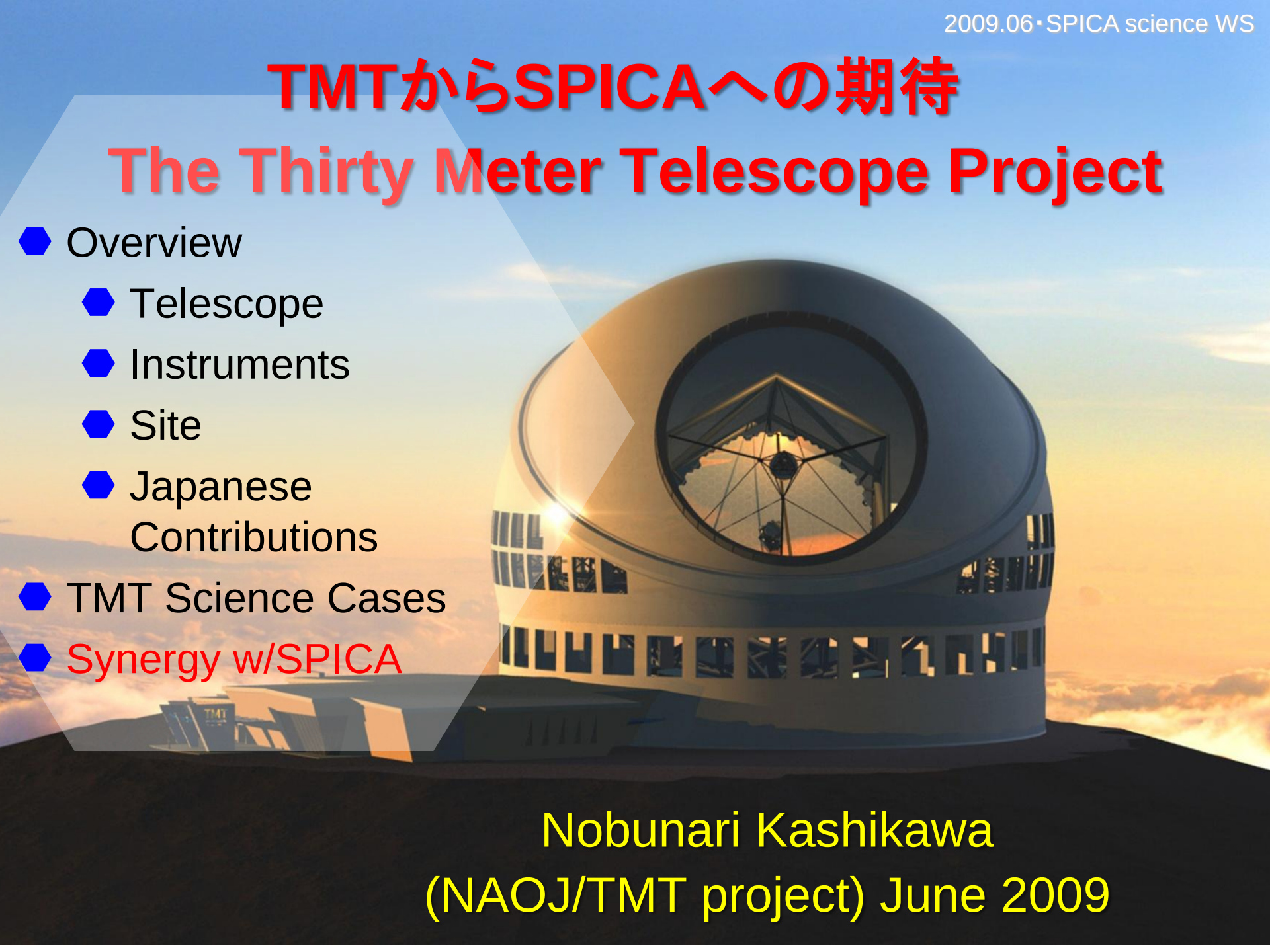
Thirty Meter Telescope Project

- 492 hexagonal mirrors of 1.5m, 30m effective array
- Costs ~1300$ (Secured ~30%), FL expected in 2019
- Three FL instruments: IRIS, WFOS, IRMS
- TMT board meets quarterly in Pasadena
- Partners: Caltech+ U.California+ ACURA+ NAOJ+NAOC+ India+ NSF
- NSF decision expected at the end of 2011.
- Science Council of Japan recommendations



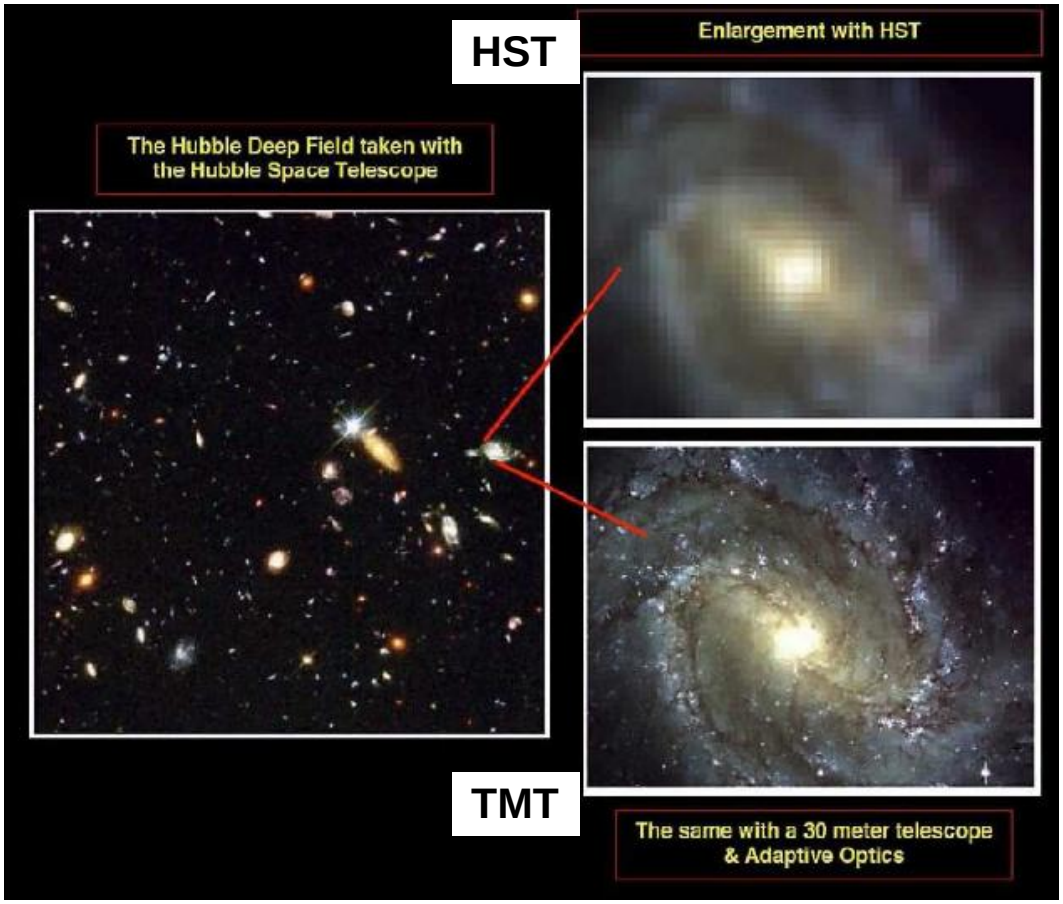
TMTからSPICAへの期待
The Thirty Meter Telescope Project

- Overview
  - Telescope
  - Instruments
  - Site
  - Japanese Contributions
- TMT Science Cases
- Synergy w/SPICA



Nobunari Kashikawa
(NAOJ/TMT project) June 2009

Adaptive Optics(AO)



- Angular resolution 0.6→0.015arcsec (2.2μm)
- sensitivity upgrades by 1order
- Several thousand elements
- Much higher resolution than HST
- 5 times higher resolution than JWST
- Almost all the TMT NIR observation will use AO in TMT.

vs. SPICA in MIR

Resolution & Sensitivity

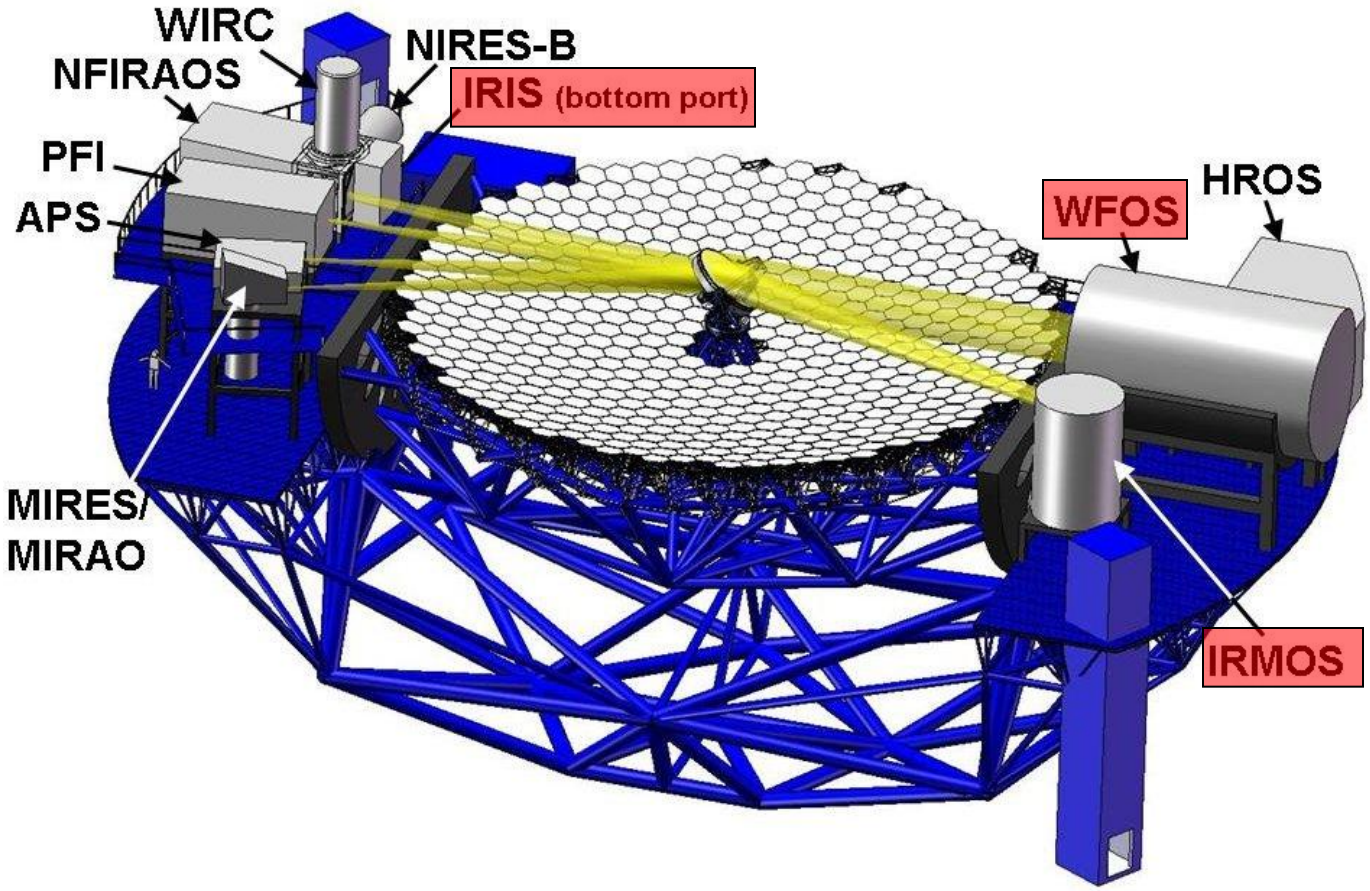
	Resolution @ λ=10μm	Sensitivity 5σ 1hr @ λ=10μm	Spectr.Resolution R
30mTMT + MIR	0.09"	150μJy	数百、数千、100,000
8mSubaru + COMICS	0.32"	2,000μJy	250 2,500 10,000
3.5mSPICA + MIR	0.75"	1μJy	1,500 3.000 (30,000)
6.5mJWST + MIRI	0.4"	0.1μJy	3,000

- 宇宙望遠鏡の１桁上をいく空間分解能
- ２桁上をいく波長分解能

©Okamoto

Nasmyth Configuration: First Decade Instrument Suite

- Platform 7 m below elevation axis
- Articulated M3 – facilitates quick instrument change
- Addressable regions: -28° to 6° and 174° to 208° for small FOV



4. TMT-J Four Groups for Instruments

High Priority & Feasibility

- MICHI (Mid-IR Camera, High-disperser, and IFU) (Y.Okamoto+): Modified MIRES ← **COMICS,** TAO
- NIR High Dispersion Spectrograph (N.Kobayashi+): NIRES-b and NIRES-r ← **IRCS-HRU, WINERED** & **IRDI (Immersion Gr., Astro-Comb, fiber)**

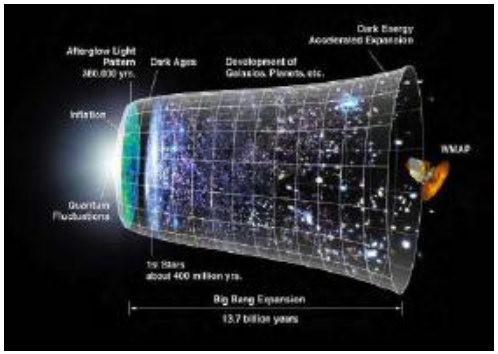
Medium Priority & Feasibility

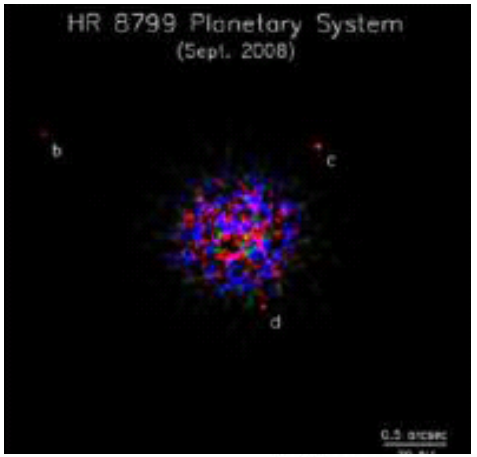
- NIR Multi IFU spectrograph with MOAO (M.Akiyama+): IRMOS ← **RAVEN, SIRMOS**
- Optical High Dispersion Spectrograph (W.Aoki+): HROS ← **HDS, HIDES (I2 cell, image slicer, fiber)**

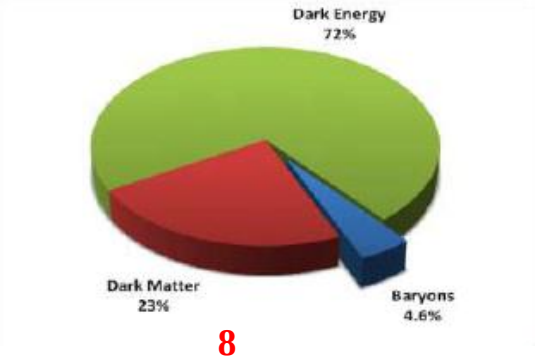
·Big Objectives for next Decade

TMT
THIRTY METER TELESCOPE

- ★ First stars(Cosmic dawn)
  - ★ Look for first stars
  - ★ Cosmic re-ionization
- ★ Second Earth
  - ★ Habitable planets
- ★ Dark Energy
  - ★ Cosmic expansion history
  - ★ Modification for General relativity

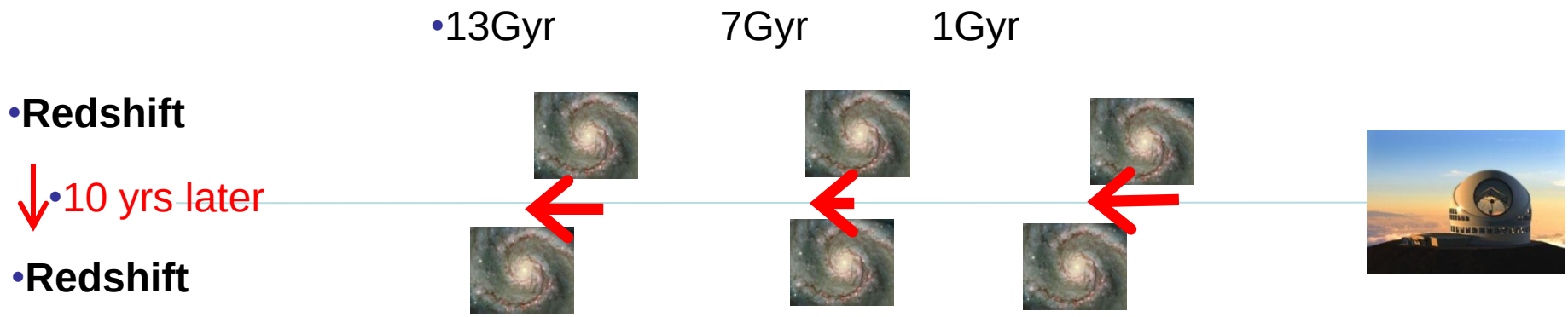




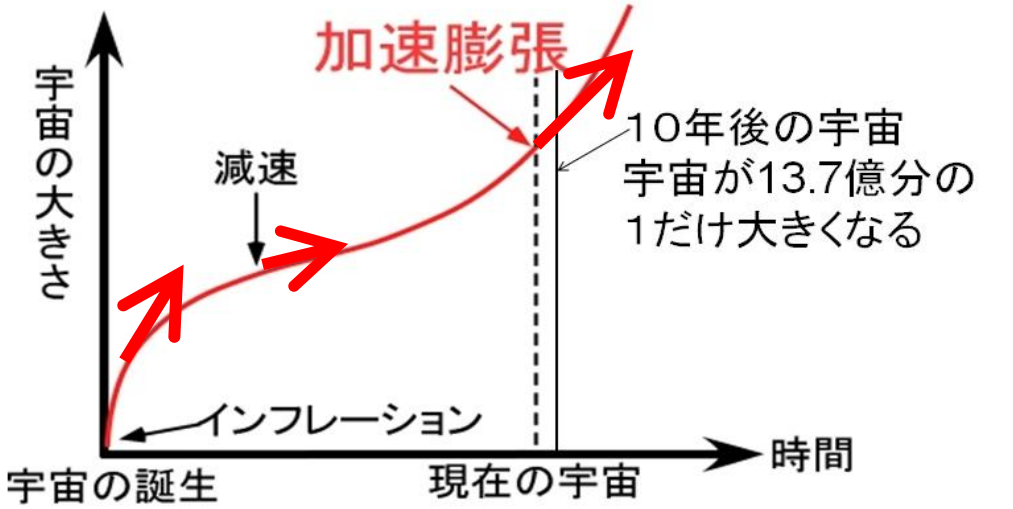


Dark Energy

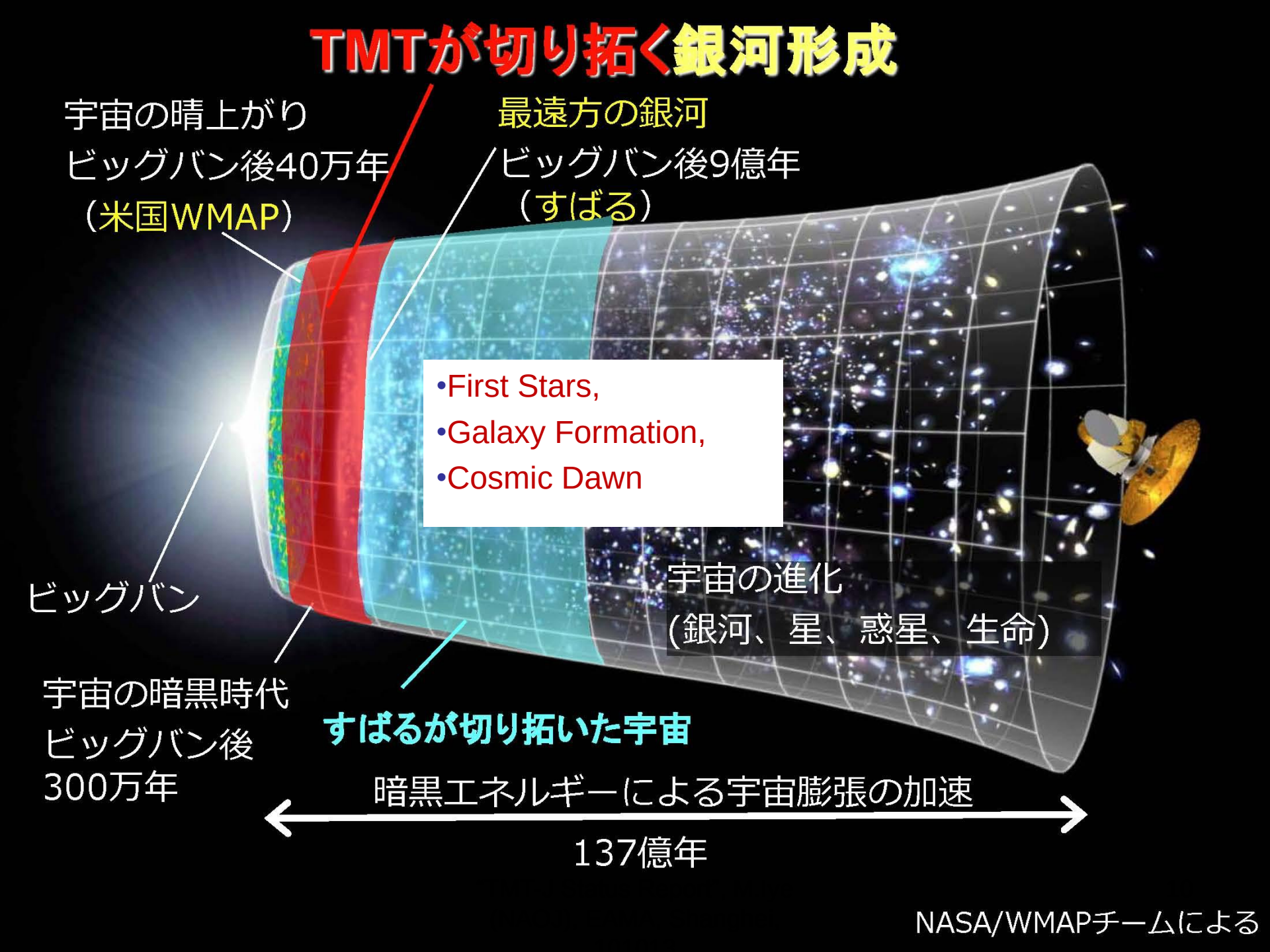
Direct measurement of cosmic expansion history (Feasibility assessment TBD)



- **Needs to measure variation of 10cm/sec over 10 years**
- **Doppler survey for exoplanets at 50cm/sec**
- **on 4m class telescopes**

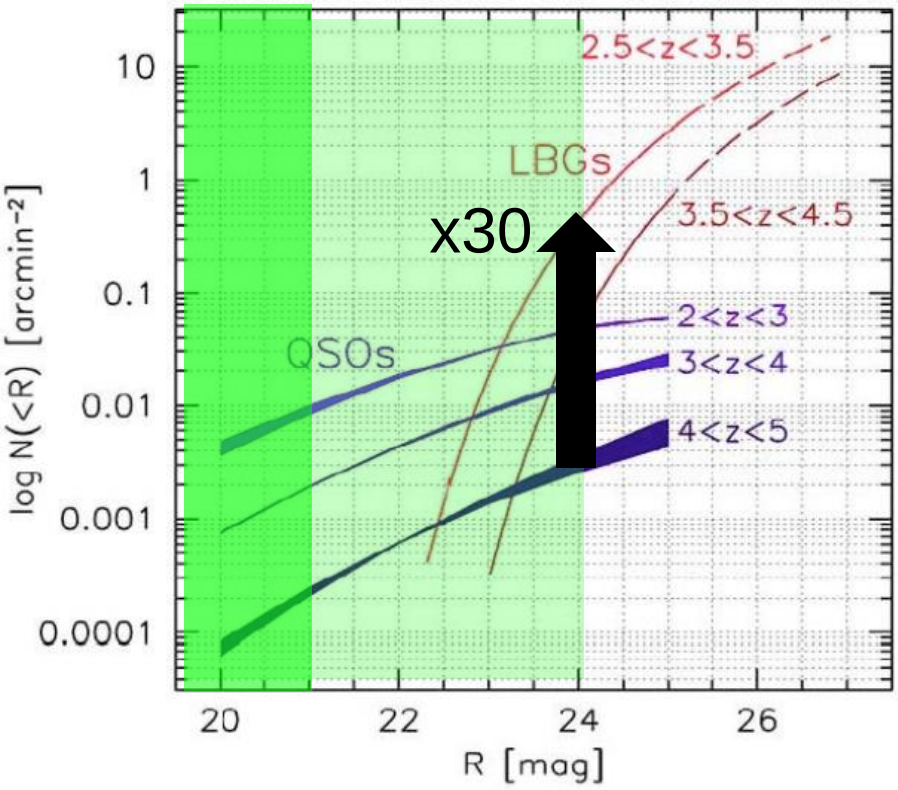


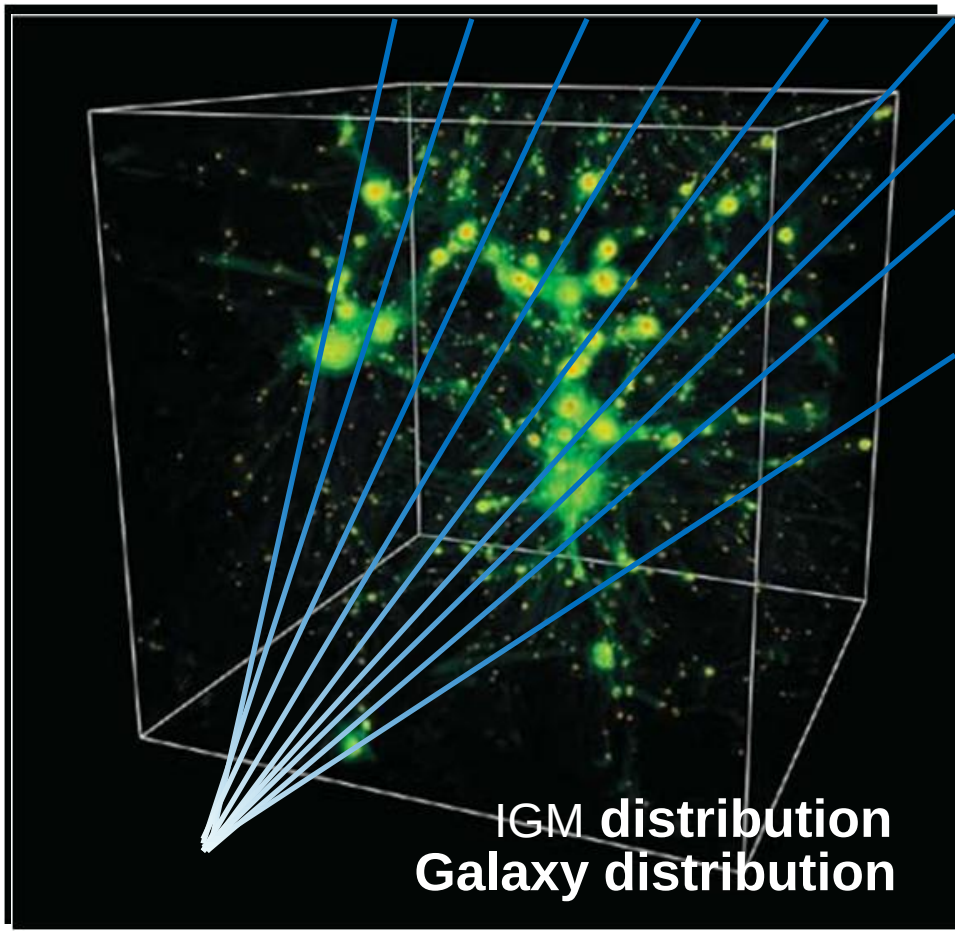
"TMT-J Status Report", M.Iye (NAOJ), EAMA, Shanghei, 101013


TMTが切り拓く銀河形成
宇宙の晴上がり
ビッグバン後40万年
（米国WMAP）
最遠方の銀河
ビッグバン後9億年
（すばる）
•First Stars,
•Galaxy Formation,
•Cosmic Dawn
宇宙の進化
(銀河、星、惑星、生命)
ビッグバン
宇宙の暗黒時代
ビッグバン後
300万年
すばるが切り拓いた宇宙
暗黒エネルギーによる宇宙膨張の加速
137億年
NASA/WMAPチームによる

IGM tomography

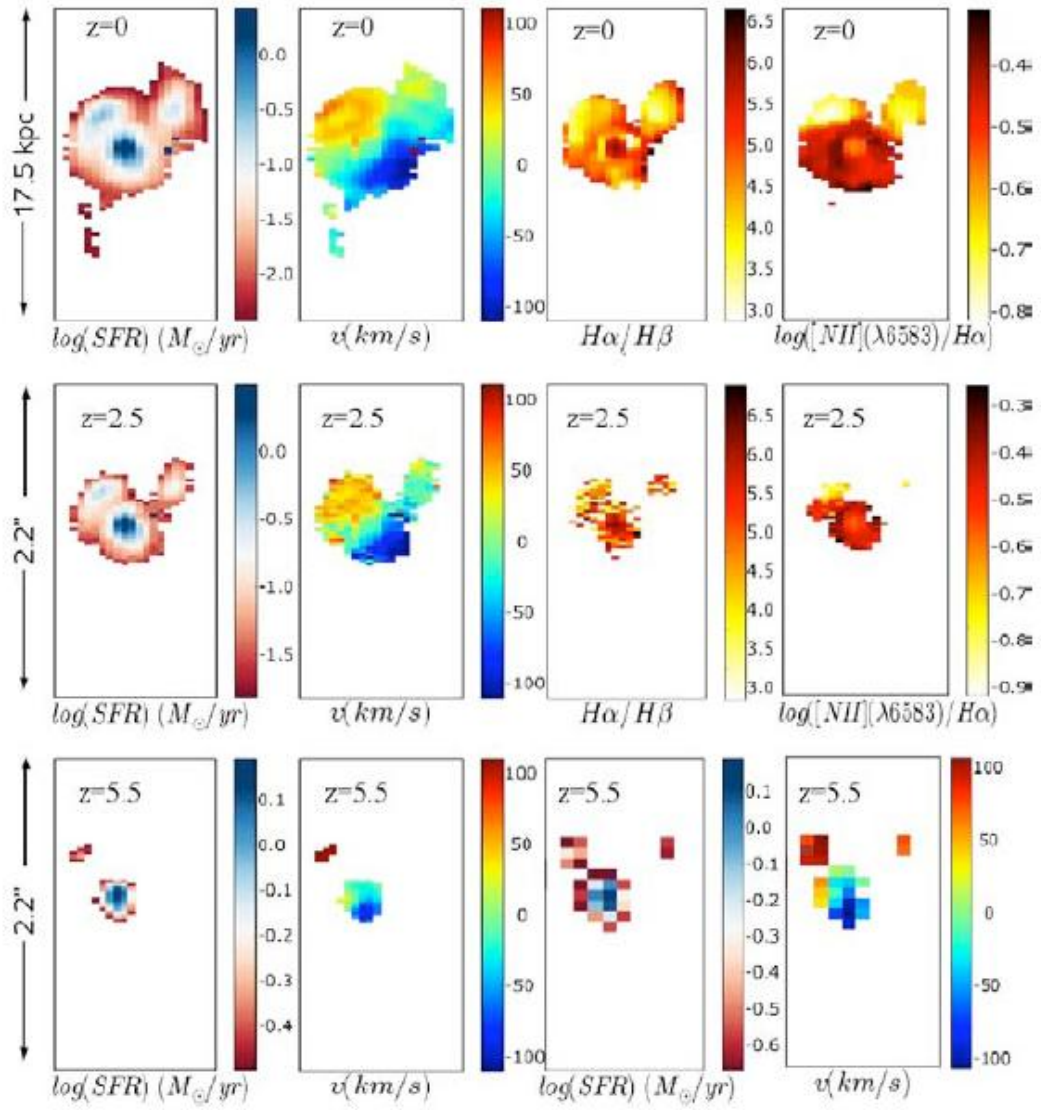
- TMT R=10,000 mode: lim.mag.=24mag
- Not QSO but Galaxies are dominant in number density (2/arcmin^2)
- Space correlation <300kpc scale
- 3Dmap of HI・metal・star・DM





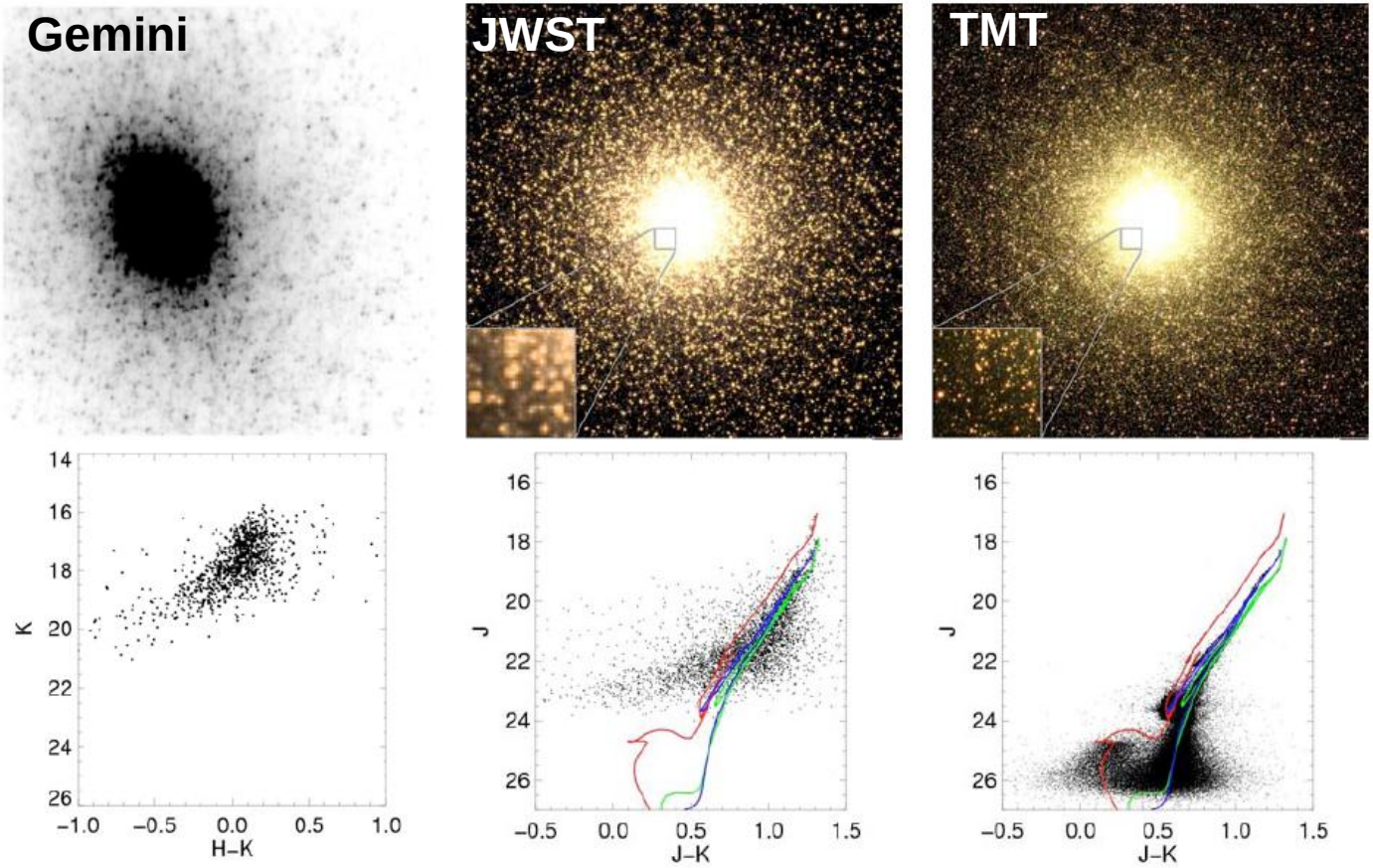
Mapping of kinematic/chemical evolutions

- 2D mapping of SFR, velocity, extinction, and metallicity.
- TMT will gain 10-100 in sensitivity and >3-5 in angular resolution over current facilities.
- Understand the Internal dynamics and complex baryonic processes within a DM halo.
- SPICA: dust, obscured AGN@z<3
- ALMA: molecular gas



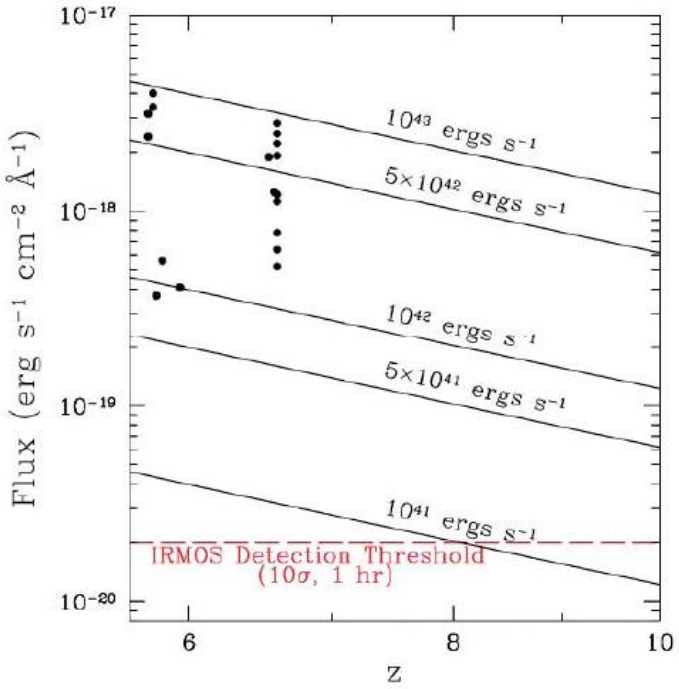
SFH of nearby galaxies

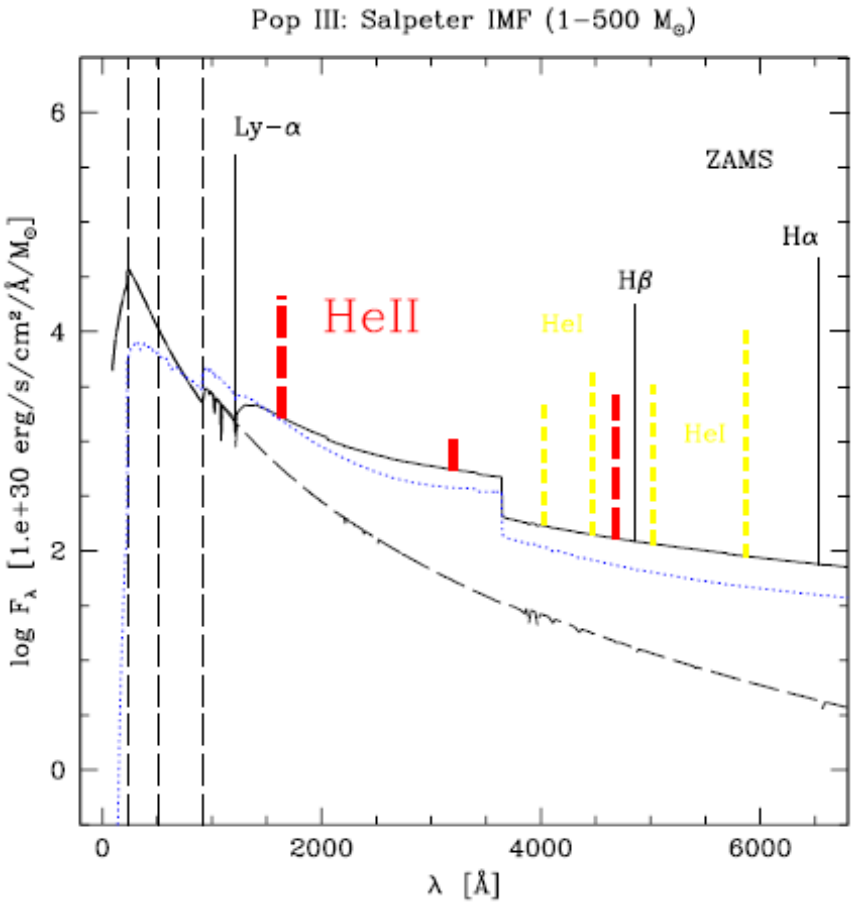
- Deep CMD for nearby galaxies can be drawn even in crowded regions. In the case of M32, TMT will reach to the MS turnoff.
- TMT R~4000 spec. for RGB stars will constrain SFH.
- SPICA: dust distribution, feedback from activity, merging



PopIII detection

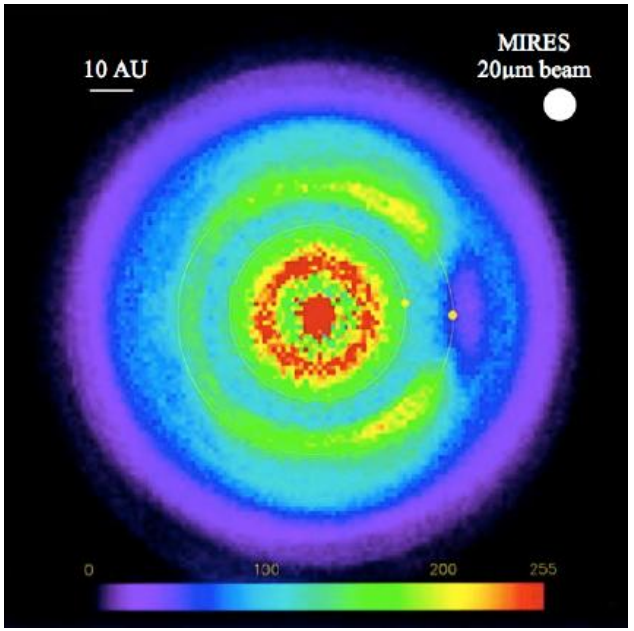
- HeII 1640A is a characteristic signature of popIII.
- Tiny (<30mas) & faint sources
- TMT can detect HeII at z<14.
- JWST: detection of sources
- SPICA: Hα, H_2 detection

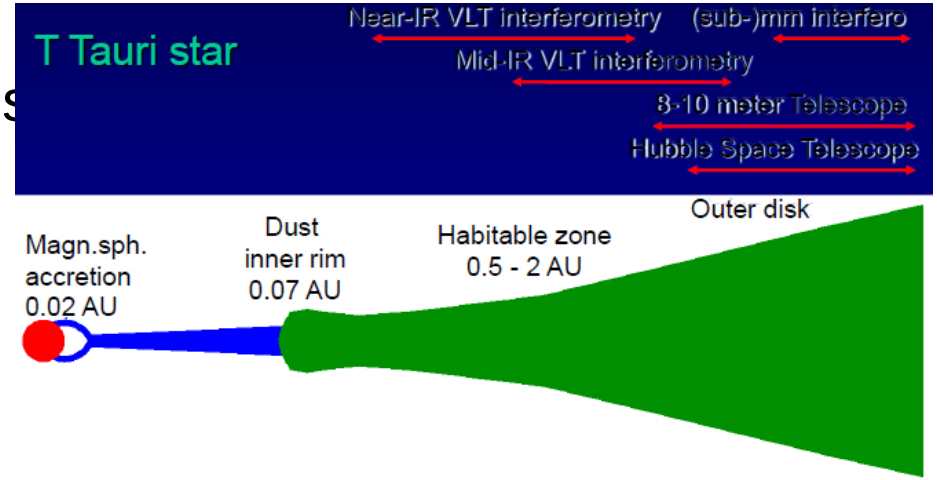




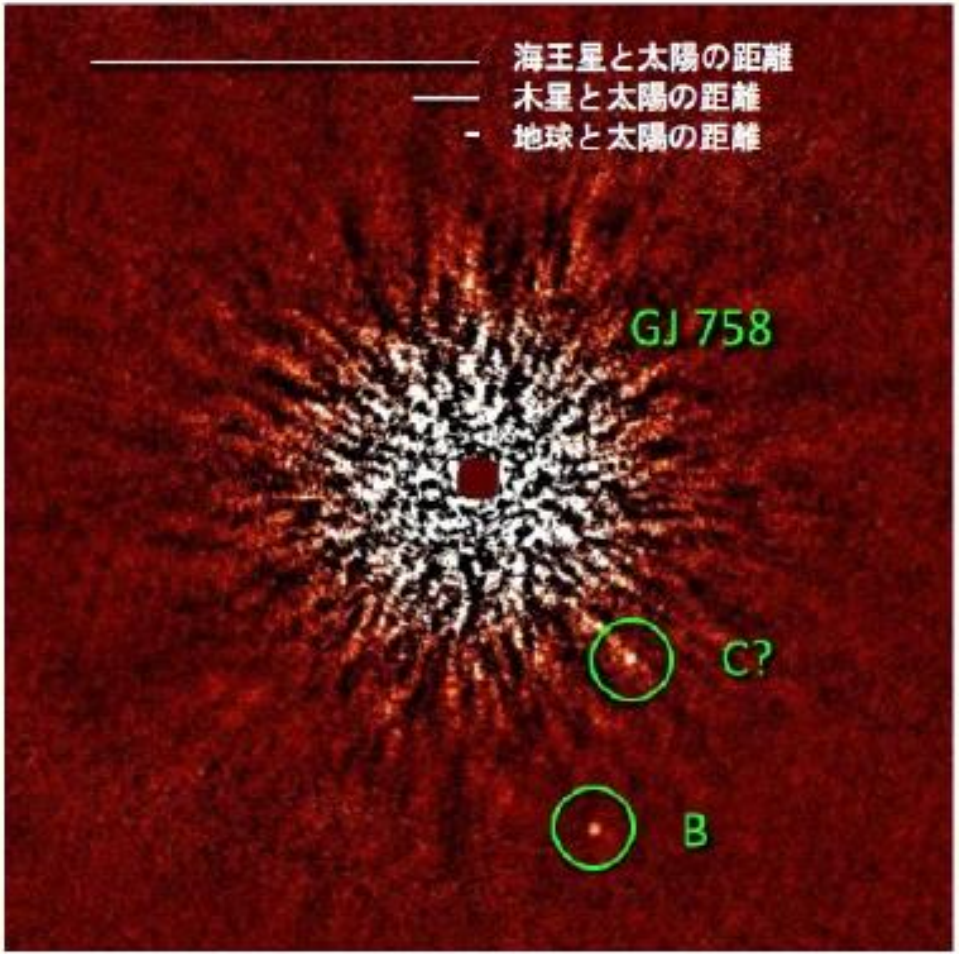
Protoplanetary disk

- TMT MIR R~100000 spec. for protostellar cores to reveal structure and kinematics of infalling envelopes /jets/winds.
- H_2O, CO as diagnostics to map T/ρ/v at <1AU
- MIRES will be able to image protoplanetray disks at <1au
- SPICA: H_2 flux, H_2Oice
- ALMA: outer molecular clouds





- Earth like Exoplanets in habitable zone
  - Spectroscopy of atmosphere by TMT



惑星候補の性質

- 明るさ

性質	GJ758B	GJ758C
赤外線等級	19.3	18.5
距離（角度）	1.9"	1.2"
距離（AU）	29AU～海王星	18AU～天王星

- 質量と温度（明るさから求めた値）

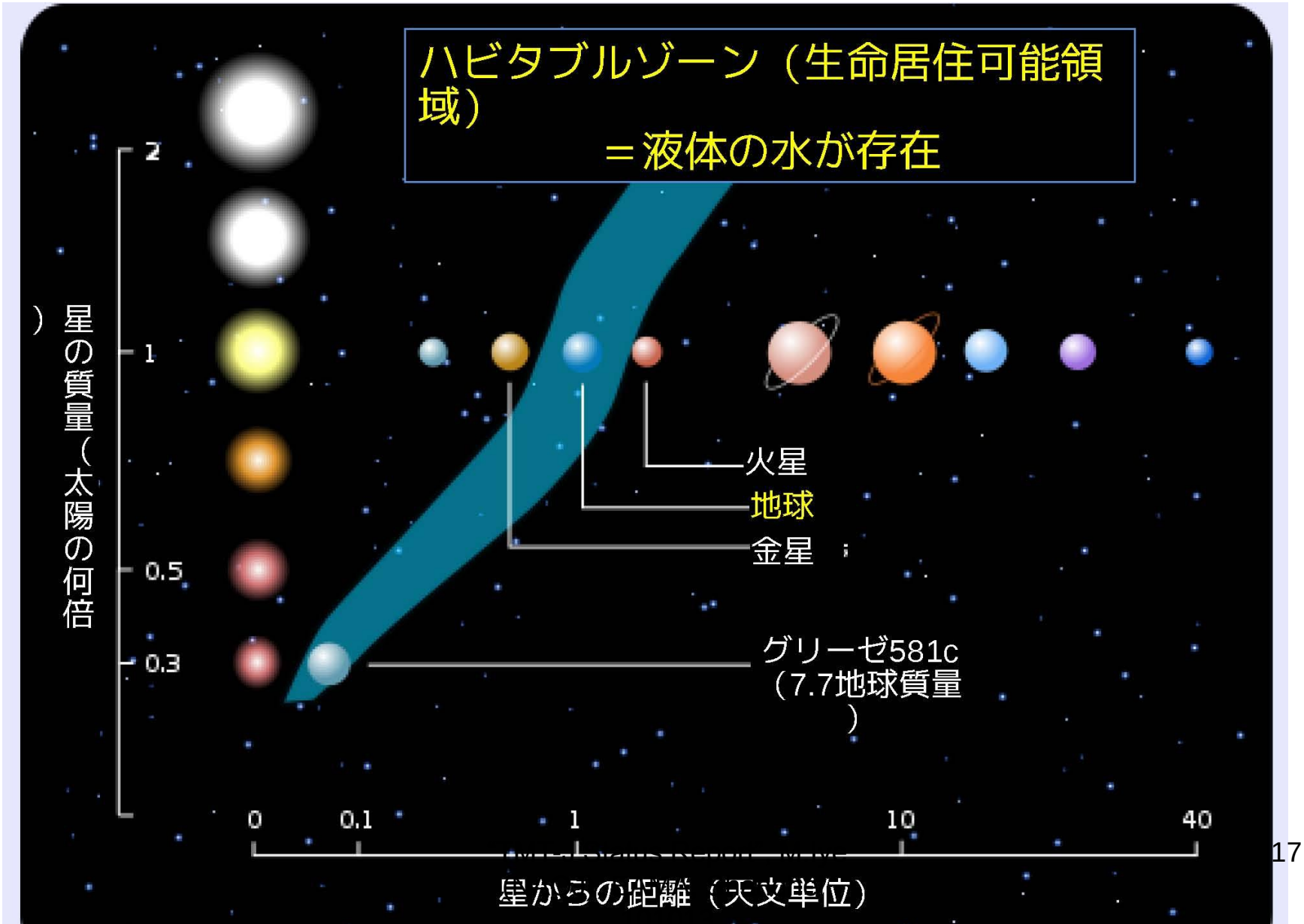
年齢	GJ758B	GJ758C
7億年（ベスト）	10木星質量 270℃	12木星質量 360℃
87億年（最大値）	40木星質量 360℃	41木星質量 460℃

標準モデル、あるいは、重力不安定性でも説明難
⇒ 惑星散乱？

“TMT-J Status Report”, M.Iye (NAOJ), EAMA, Shanghei, 101013

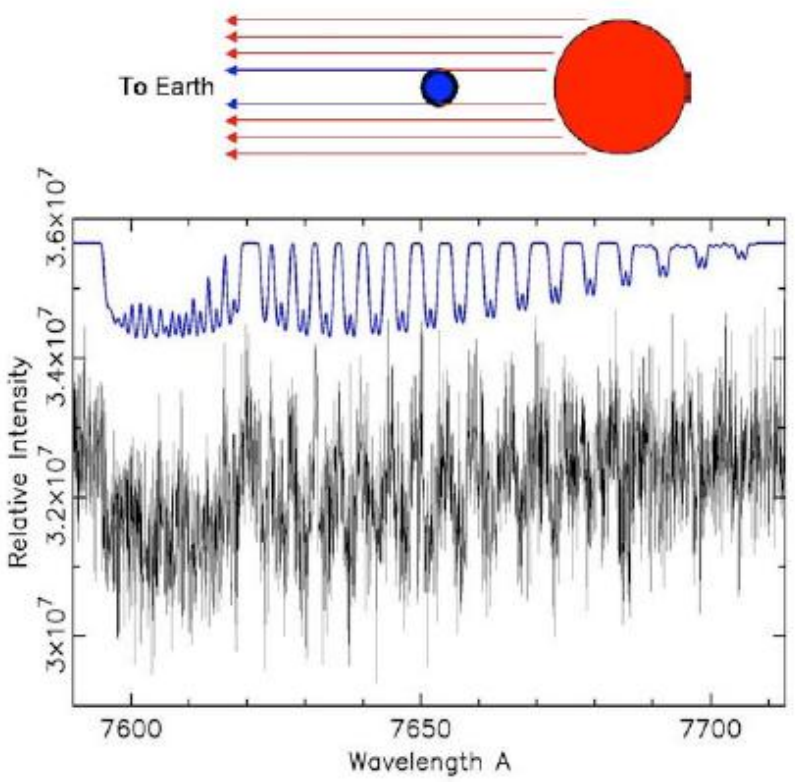
Exoplanets in habitable zone

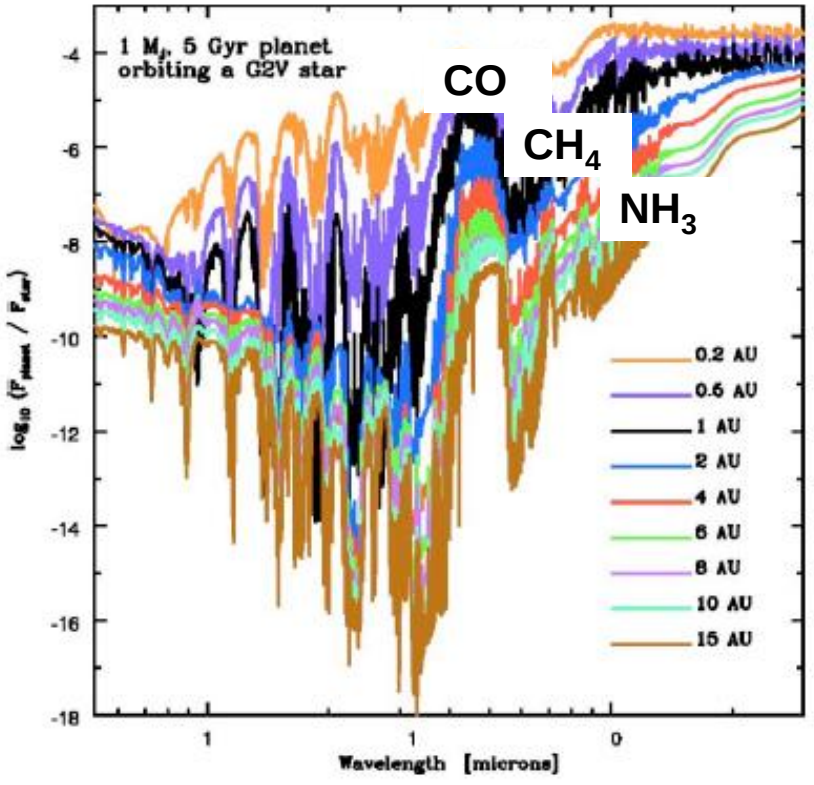
Spectroscopy to search for biomarkers in the atmosphere during transit



Planetary atmosphere

- Absorptions due to molecules in the transiting planetary atmosphere are superimposed on the spectrum of the host star.
- 3hrs integ. (snr=30000, 6km/s)of TMT/HROS for O_2 of Mstar
- MIR high. res. Spec. for organic hydrocarbon molecules





MIR+NIR+Opt Users Migration

- Exploding Akari/SPiCA User population

fostering native MIR youngsters

encouraging redshift immigrants from Subaru community

inviting blueshfit immigrants from ALMA community

inviting foreigners from Physics/Planetary Science communities

(bringing targets, ideas, instruments, ）

- Emigrants to Subaru/ TMT

NIR/Opt science for MIR targets

Participation in TMT instrumentation

(No channel for cosmological blueshift immigrants)

14/49 TMT SWG members are also SPICA SWG members

TMT SWS in Victoria (late March- mid April?) : status reports

- SPICA SCIENCE MANIFESTO
  SUPPORT FROM FUNDING AGENCIES
- SPICA SCIENCE PRIORITY
- MIR baseline
- Bonus to FIR or NIR

- Clarifying science objectives
  (differences among ALMA,TMT,SPICA)
- International Partnership
- Communities tie with ALMA and Subaru/TMT
- NAOJ's future roles in Space Astrophysics
  discussion at NAOJ Research Program Adv. Comm
- Importance of having a coherent future strategy for NAOJ+ISAS .