Current status and activities in Japan: Future Instrument Plan

- **TMT instrumentation activity in Japan**
- **Synergy with Subaru**
- **TMT promotion activity in Japan**

Nobunari Kashikawa
(NAOJ/TMT project)
Mar. 2011

J-TMT instrumentation activity

Our major goals of TMT instrumentations are:

- **Contributions to the FL instrumentation**
  - IRIS: optical design, development, science team

    → see R.Suzuki's poster
  - MOBIE/IRMS: going to join to the inst./science teams

    → see C.Tokoku's poster
- **Original design/development/supply of the 2nd gen. inst.**
  - NIR High Disp. Spectrograph → see T.Usuda's/J.Rayner's talks
  - Mid-IR Imager and Spectrometer

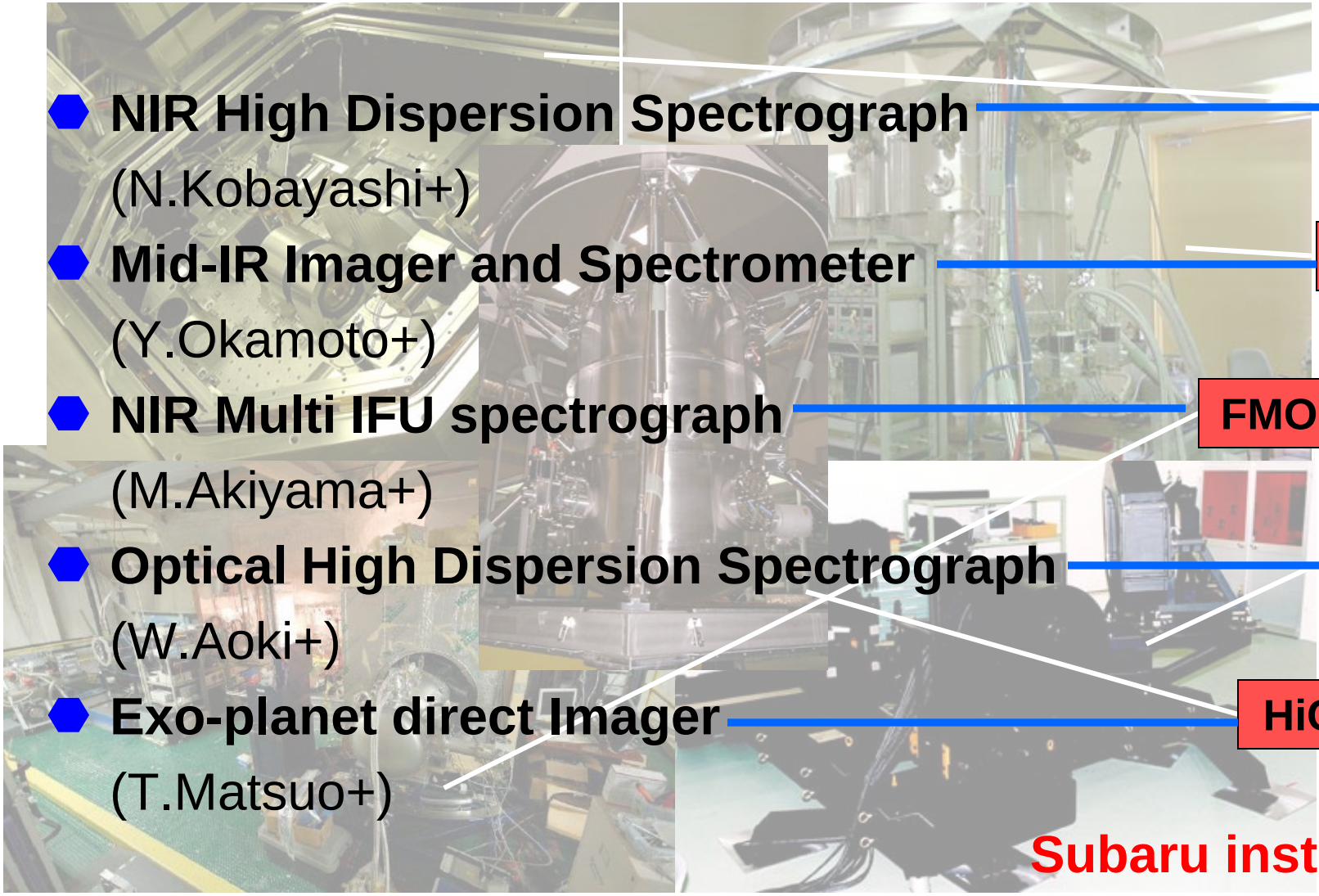
    → see M.Honda's/M.Chun's talks & A.Tokunaga's poster
  - NIR multi IFU spectrograph
  - Optical High Disp. Spectrograph
  - Exo-planet direct imager → see T.Matsuo's talk

The FL instrumentation

- **IRIS**
  - Working on conceptual design (R.Suzuki, M.Konishi, T.Usuda)
  - Discussion of in-kind contribution for prototypes: Grating turret, OIWFS arm, etc.
  - Contrib. to join the Science team (M.Goto, H.Sugai)
- **WFOS/MOBIE**
  - Intermediates MOBIE team and Canon on CaF2 glass blank supply (S.Ozaki, S.Miyazaki)
  - Possibilities to join the Inst./Science teams
- **IRMS**
  - Postdoctoral fellow at UC, RS from last Oct. (C.Tokoku)
  - Joining to the Science team (N.Kashikawa, M.Akiyama, T.Yamada)

The 2nd gen. Instrumentation

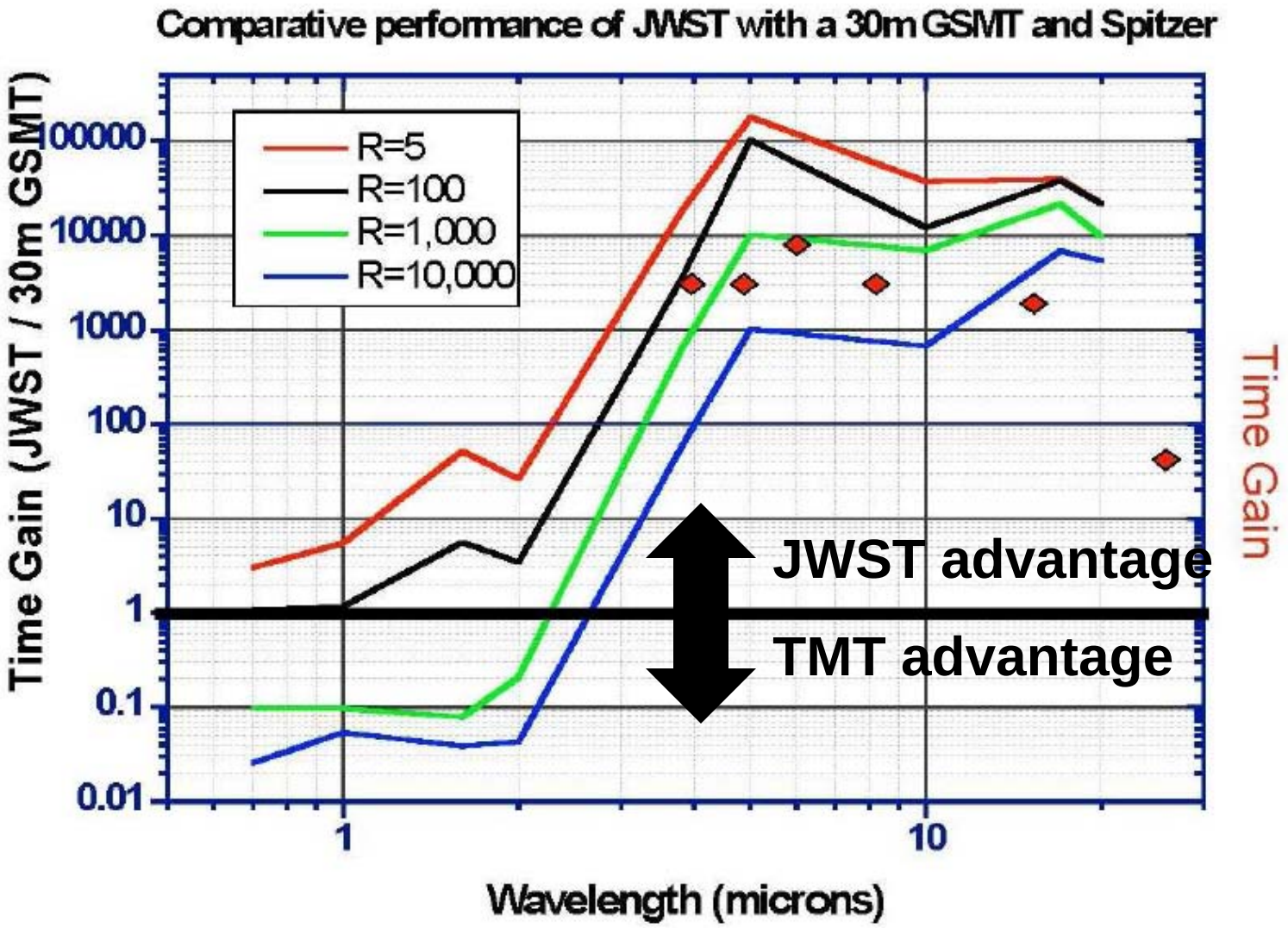
- Five 2nd Instruments concept design are on going:



- **NIR High Dispersion Spectrograph** (N.Kobayashi+) — **IRCS**
- **Mid-IR Imager and Spectrometer** (Y.Okamoto+) — **COMICS**
- **NIR Multi IFU spectrograph** (M.Akiyama+) — **FMOS/RAVEN**
- **Optical High Dispersion Spectrograph** (W.Aoki+) — **HDS**
- **Exo-planet direct Imager** (T.Matsuo+) — **HiCIAO/DPI**

Subaru instruments

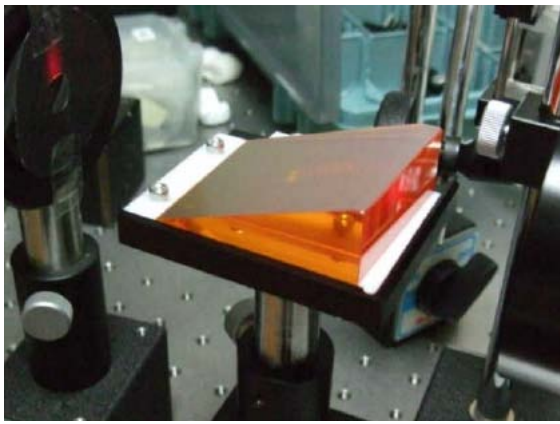
vs. JWST

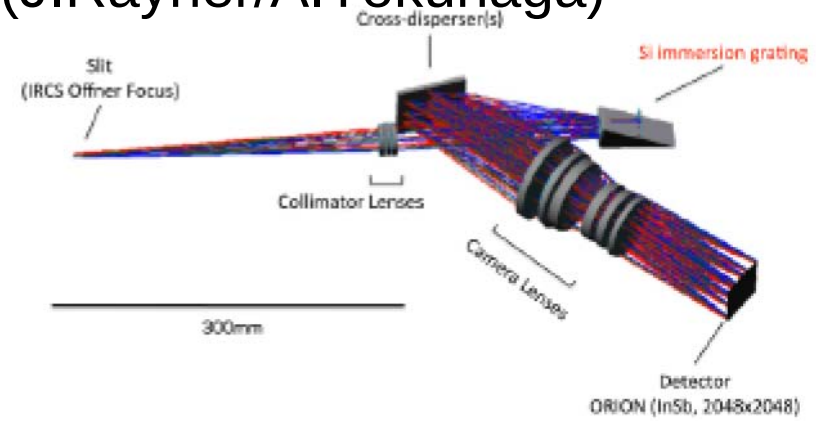


Windhorst 2007

NIR High Dispersion Spectrograph

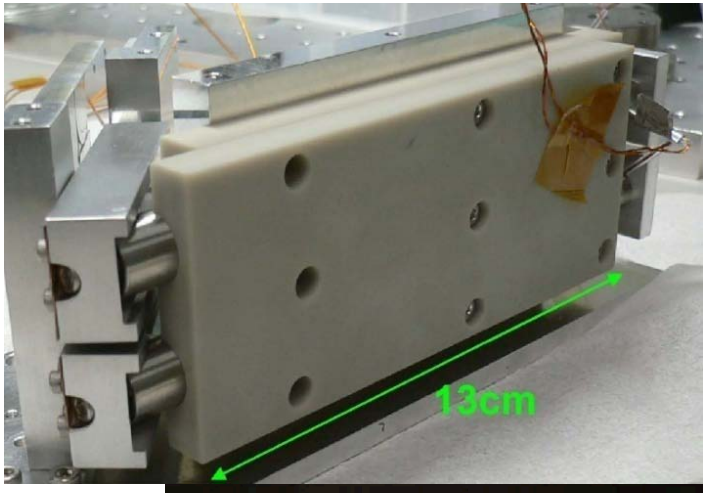
- PI: Kobayashi, N. (U.Tokyo)
- R=40,000 (80,000 max)
- Short arm (0.9~2.4um) & Long arm (1.9~5.5um)
- Slit: 0.”02 x 0.5~1”
- Options: Long slit (15~30”) / MOS (5~10 targets)
- J~20, H~20, K~19.5 (10σ) R~50,000, 1hr
- Key sciences
  - IGM at 2.5<z<6(metallicity), and z>6 (re-ionization)
  - Atmosphere of exoplanets
- Collaborations with UH NIRES team (J.Rayner/A.Tokunaga)
- Prototype: WINERED, IRCS-HDU
  - ZnSe & Si immersion gratings
  - Molecular gas cell, Laser comb.



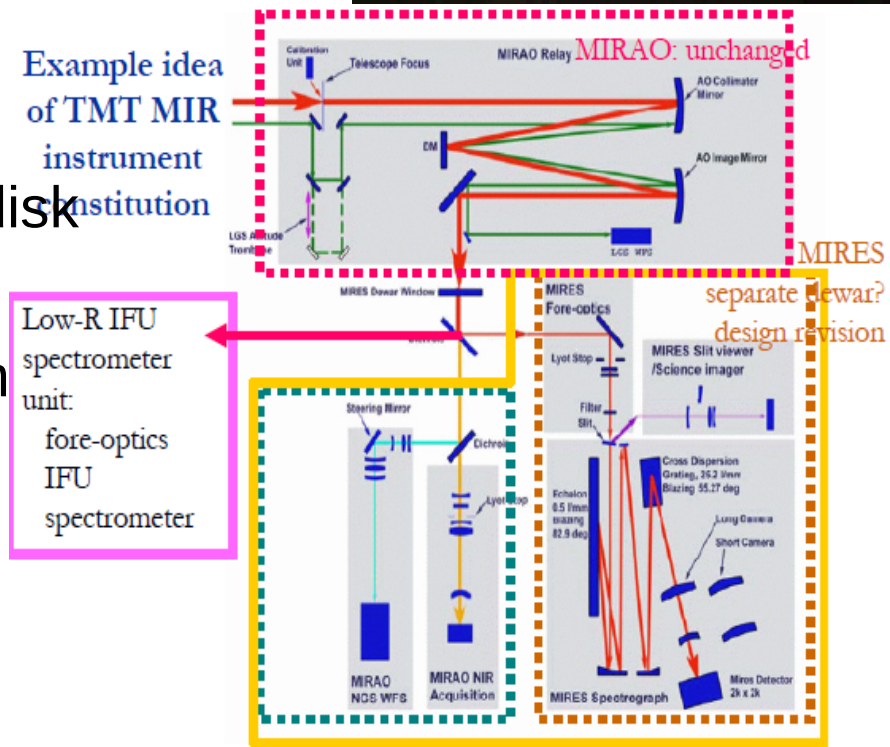


Mid-IR Imager & Spectrometer (MICHI)

- PI: Okamoto,Y. (U.Ibaragi)
- Imaging & Spectroscopy @7~25um
- FOV=27.5x27.5” / 0.”08@10um w/ MIRAO
- IFU (R=300@N / 600@Q), Long-slit (900 / 1800), Echelle (120,000 / 60,000)
- Options: Polarimetry @N-band
- Key sciences
  - Planet formation & Biomarkers
  - Dynamics and chemistry of PP disk
  - AGN & Cosmology
- Collaborations w/ UH & Florida team (Tokunaga/Chun/Packham)
- R&Ds
  - Image slicer etc.

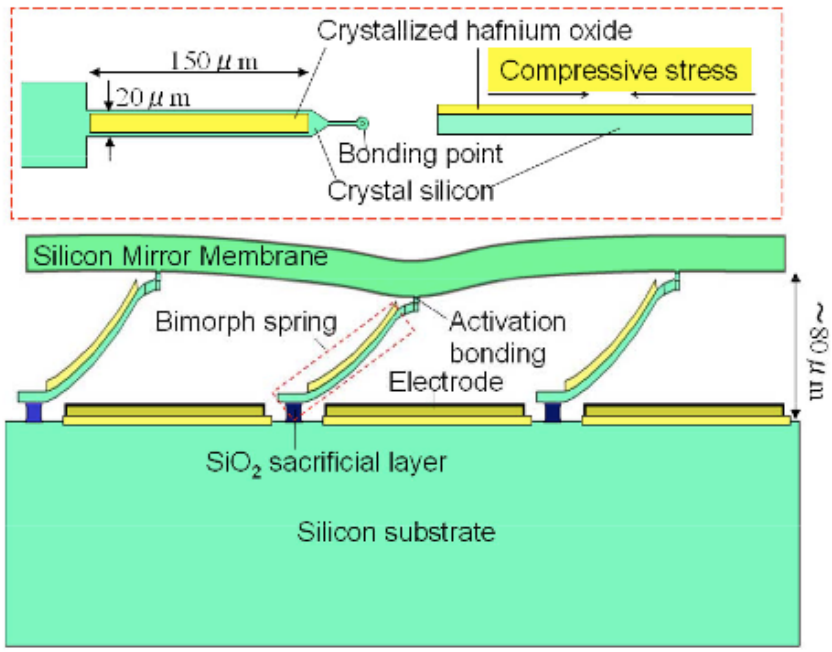


Example idea of TMT MIR instrument



NIR multi IFU spectrograph w/ MOAO

- PI: Akiyama, M. (U.Tohoku)
- NIR IFU spectroscopy of 10~20 objects simultaneously (cf. IRMOS)
- FOV 5arcmin w/MOAO, spatial resolution 0.”02@2um
- 20 IFU units, R=1,000~20,000
- Key sciences
  - Search for galaxies in formation-phase at 7<z
  - Physical properties of galaxies in growing-phase at 2<z<7
- Collaborations w/ U.Victoria, HIA for RAVEN on Subaru Telescope
- R&Ds
  - Large stroke (>20um) MEMS-DM
  - tomography algorithm
  - Fiber IFU
  - …

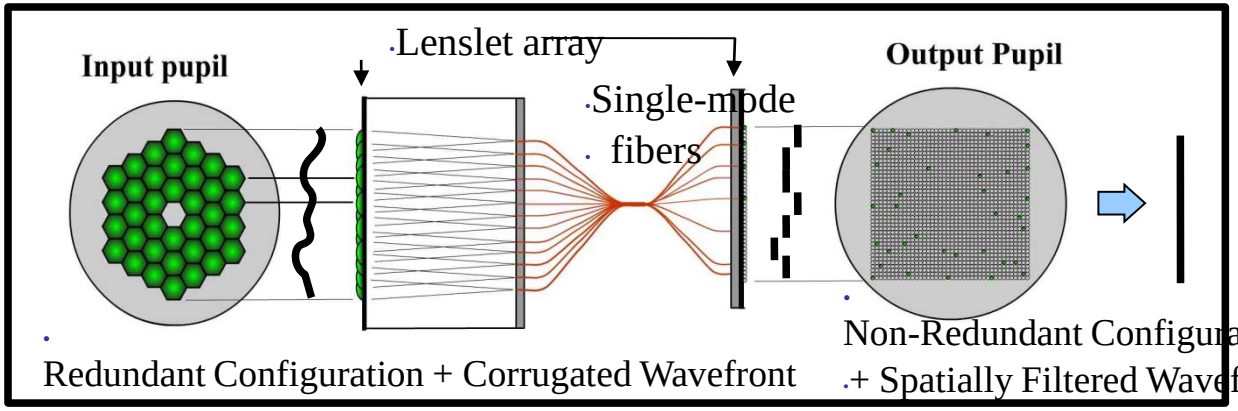


Optical High Dispersion Spectrograph

- PI: Aoki,W. (NAOJ)
- “Ulitimate” Optical Spectrograph focusing on the accuracy and stability (e.g., CODEX, ESPRESSO)
- Key sciences
  - Detection of terrestrial exoplanets around solar-type stars
  - Direct measurement of cosmic expansion
- Required accuracy of radial velocity ~10 cm/s (e.g. 1m/s accuracy is attained with current ESO HARPS)
- R&Ds (experiments with 1.8m telescope and Subaru)
  - Stabilities of inst. Flexures, temperature, air pressure.
  - Laser comb
  - Image Slicer

Second-Earth Imager for TMT (SEIT)

- PI: Matsuo,T. (NAOJ)
- Contrast requirements : 10^{-8} @0”.01 for I<7.8, 10^{-9} @0”.03
- Inner working area: 0”.01 (2l/D at 0.08μm)
- A new concept for both speckle and sky background suppressions by using an interferometric technique
- Nulling interferometer with polarization + High-contrast visible imaging by pupil remapping
- 0.8-1.2μm, FOV 0.”1
- Key science: Direct detection of earth-like exoplanets
- Requires ExAO



J-TMT instrument review meeting

- Discussions on all aspects of each instrument plan and support R&D
- Since 2008.11.20, twice/year
- Concept, feasibility, science, key technology, team structure, schedule, cost, and risks
- Support to get external funding
- Catch up many people to TMT project by instrumentation plan & science cases
- Interface between TMT/NAOJ and J-universities/community
- In liaison with several community symposiums/workshops

J-TMT instrument review meeting

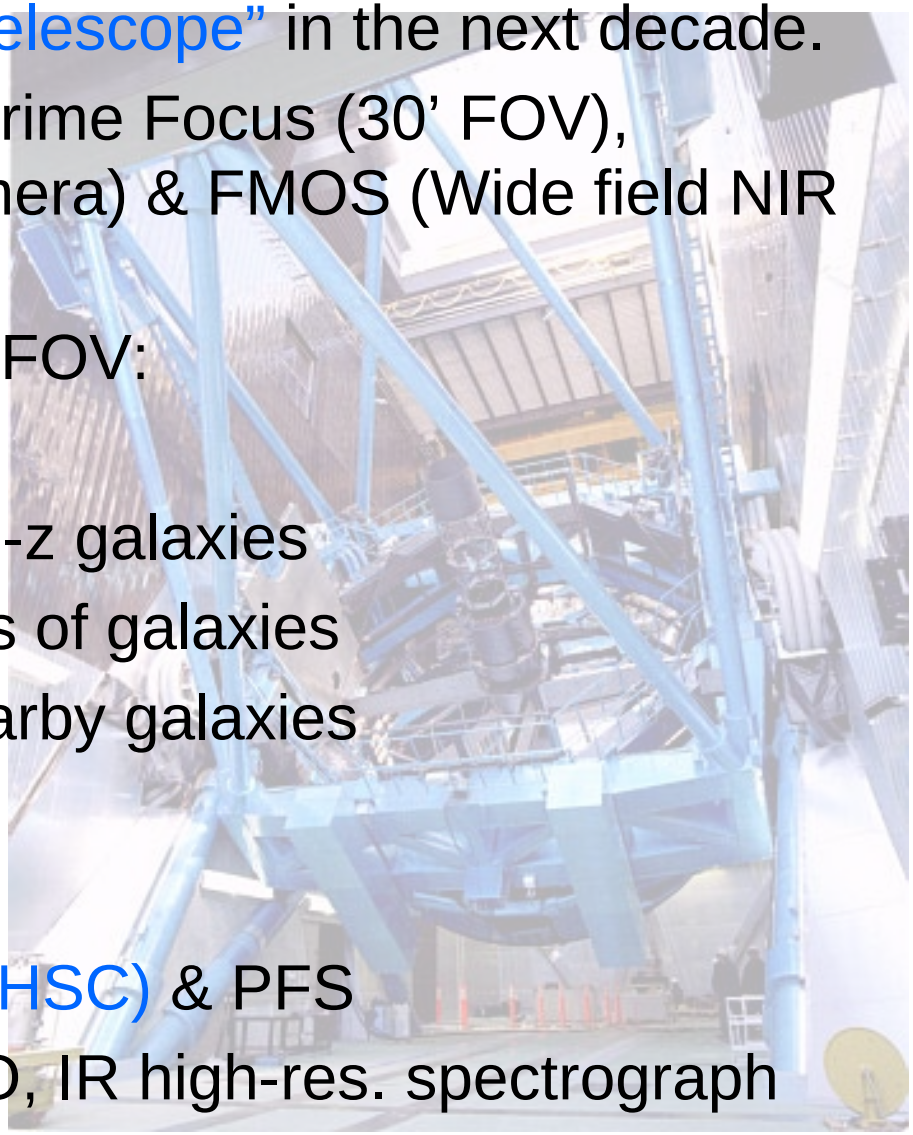
http://jelt.mtk.nao.ac.jp/tmtinst/

ATC (Advanced Technology Center)

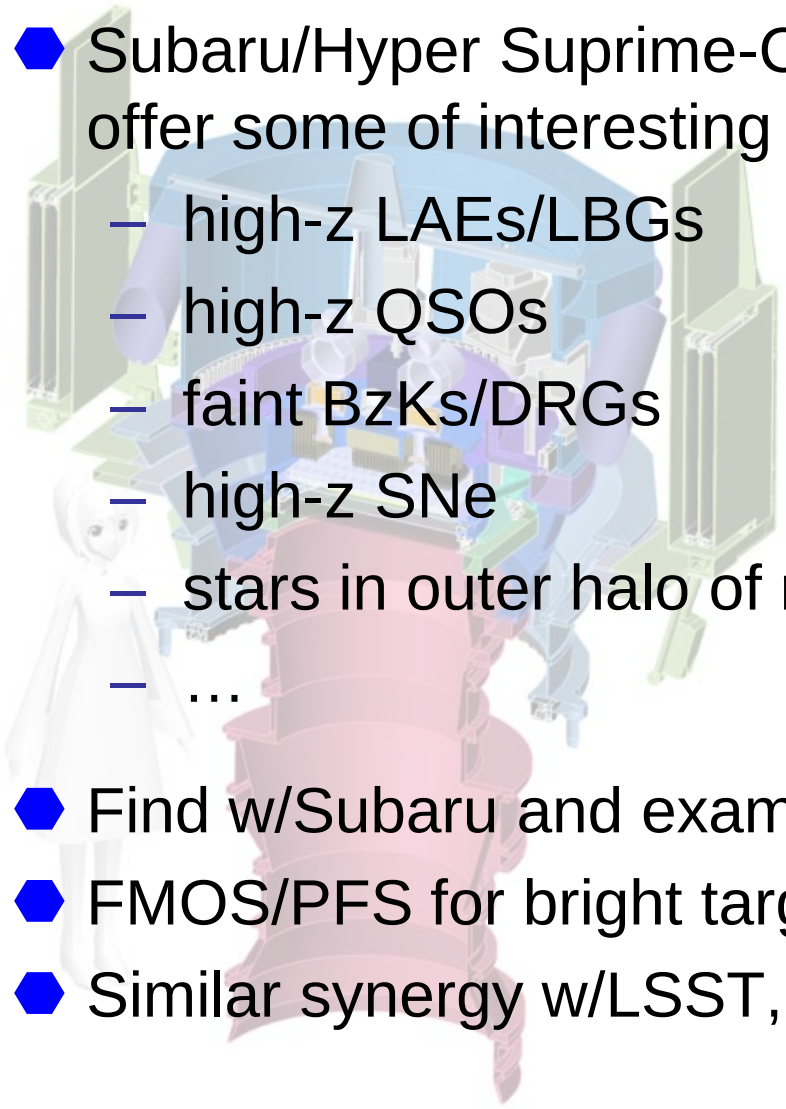
- ATC has opt./mechanics/electronics facilities and ~20 engineers.
- Important infrastructure for developing Subaru instruments. They are currently working on ALMA.
- TMT project was approved to be the most promising major project that ATC should pursue in the next decade.
- Good news for future developments of IRIS and the 2nd gen. instruments

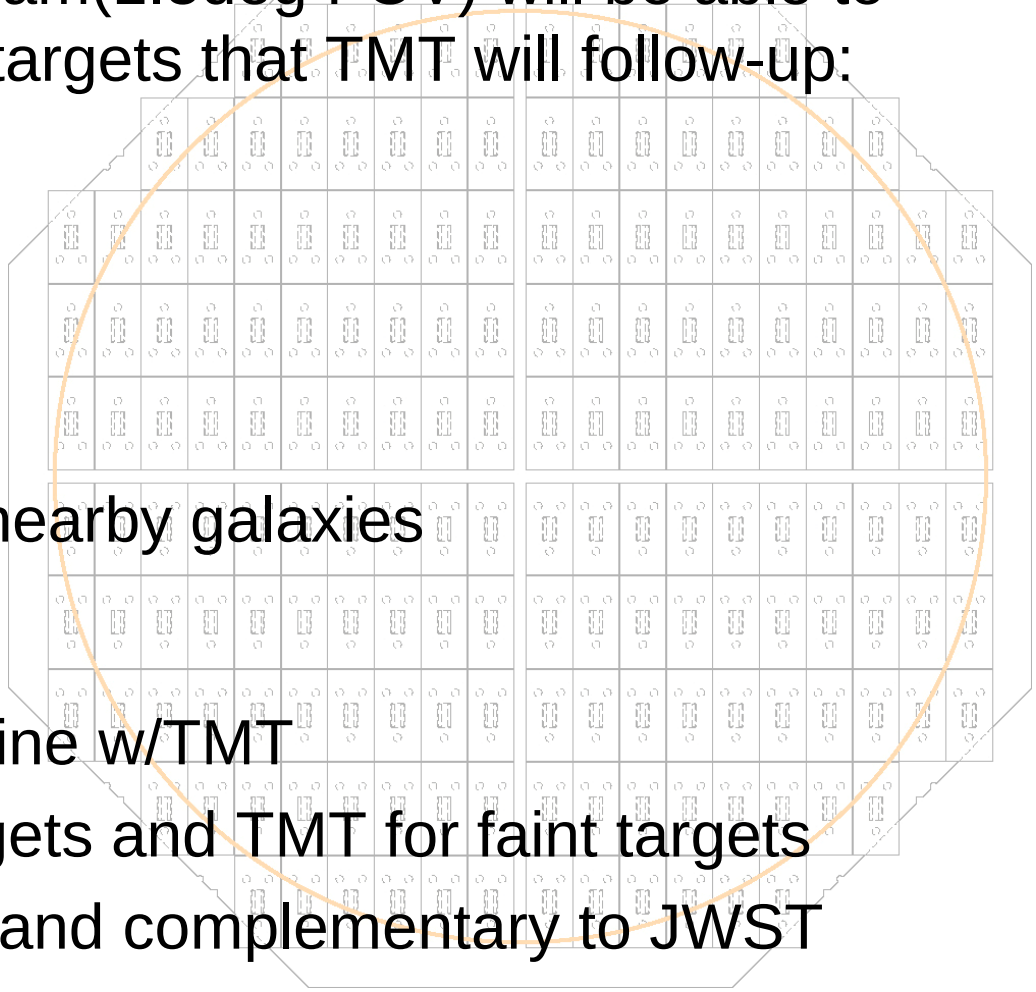
Synergy with Subaru

- Subaru will turn to a “survey telescope” in the next decade.
- The most unique capability: Prime Focus (30’ FOV), Suprime-Cam (Wide field camera) & FMOS (Wide field NIR fiber spectrograph)
- Subaru has explored w/ wide FOV:
  - The highest-z galaxies
  - LSS and clustering of high-z galaxies
  - Global structure of clusters of galaxies
  - Outer halo structure of nearby galaxies
  - …
- New (upgraded) instrument
  - PF: Hyper Suprime-Cam (HSC) & PFS
  - IR: HiCIAO+ExAO, WF AO, IR high-res. spectrograph



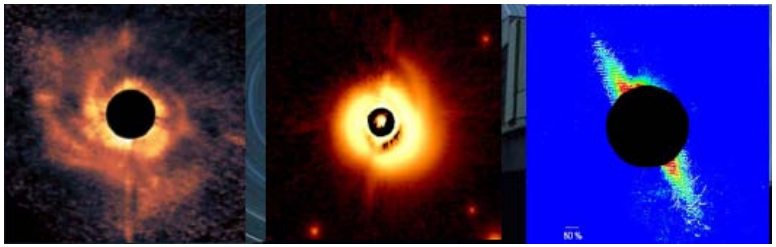
Subaru/HSC survey



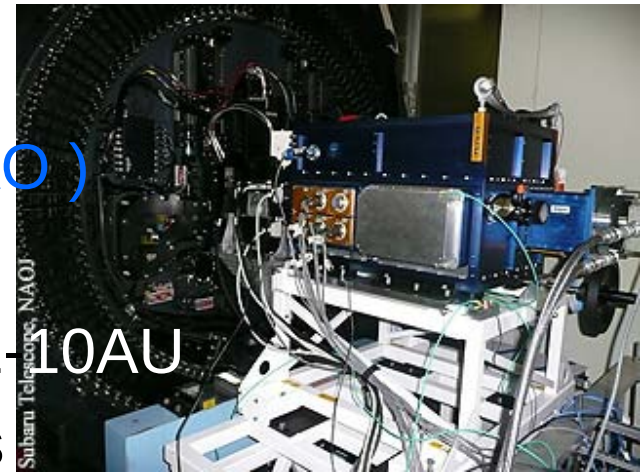


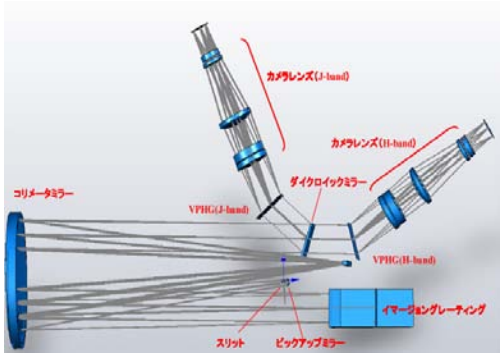
- Subaru/Hyper Suprime-Cam(1.5deg FOV) will be able to offer some of interesting targets that TMT will follow-up:
  - high-z LAEs/LBGs
  - high-z QSOs
  - faint BzKs/DRGs
  - high-z SNe
  - stars in outer halo of nearby galaxies
  - …
- Find w/Subaru and examine w/TMT
- FMOS/PFS for bright targets and TMT for faint targets
- Similar synergy w/LSST, and complementary to JWST

Subaru/SEEDS project



- Subaru/CIAO (cold coronagraph)
  - PP disks
  - Young very low-mass companion
- SEEDS (Subaru Strategic Exploration of Exoplanets and Disks with HiCIAO w/exAO)
  - From 2009, 5 yrs
  - ~500 stars to reveal disk structure @1-10AU
- IRDoppler: indirect detection of exoearths
- Interests in TMT (high throughput, high res., high contrast)
  - Spec. for atmospheric lines of exoplanets
  - Direct Imaging of exoearth around M stars
  - Transit of exoplanets around M stars





JPN community meeting

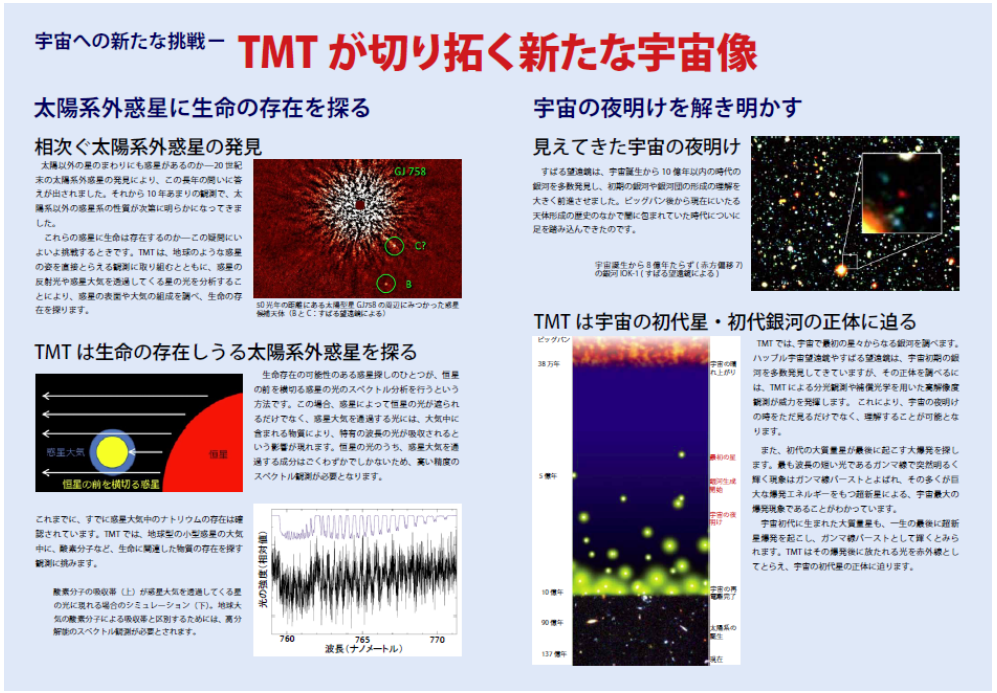
- Symposium: “Science in the next decade”
  2008.Aug.21-22, 120 participants
- “High-dispersion WS” 2010.Feb.12-13, 50 participants
- TMT special session in the Annual meeting of ASJ
  2010.Mar.24-27, 200 participants
- Symposium: “New Astronomy in 2020’s with TMT”
  2010.Oct.4~5, 130 participants

Outreach/Promotion

- “New Astronomy explored by TMT”, 2011, Feb.
- Japanese ver. of “TMT: Detailed science case 2007”
- 5 categories:
  - cosmology/the first objects,
  - galaxy formation/evolution,
  - AGN,
  - our Galaxy/local universe,
  - star foramtion/exoplanets/solar system
- 392pages, written in Japanese but essential points are summarized in English.

Outreach/Promotion

- Flyer to promote TMT to other communities and the public.
- Wide and strong support from JPN community



宇宙への新たな挑戦ー **TMT が切り拓く新たな宇宙像**

太陽系外惑星に生命の存在を探る

相次ぐ太陽系外惑星の発見

太陽以外の星のまわりにも惑星があるのか―20 世紀末の太陽系外惑星の発見により、この長年の問いに答えが出されました。それから 10 年あまりの観測で、太陽系以外の惑星系の性質が次第に明らかになってきました。

これらの惑星に生命は存在するのか―この疑問にいよいよ挑戦するときです。TMT は、地球のような惑星の姿を直接とらえる観測に取り組むとともに、惑星の反射光や惑星大気を透過してくる星の光を分析することにより、惑星の表面や大気の組成を調べ、生命の存在を探ります。

50 光年の距離にある太陽型星 GJ758 の周辺にみつかった惑星候補天体（B と C：すばる望遠鏡による）

TMT は生命の存在しうる太陽系外惑星を探る

生命存在の可能性のある惑星探しのひとつが、恒星の前を横切る惑星の光のスペクトル分析を行うという方法です。この場合、惑星によって恒星の光が遮られるだけでなく、惑星大気を透過する光には、大気中に含まれる物質により、特有の波長の光が吸収されるという影響が現れます。恒星の光のうち、惑星大気を透過する成分はごくわずかでしかないため、高い精度のスペクトル観測が必要となります。

これまでに、すでに惑星大気中のナトリウムの存在は確認されています。TMT では、地球型の小型惑星の大気中に、酸素分子など、生命に関連した物質の存在を探す観測に挑みます。

酸素分子の吸収帯（上）が惑星大気を透過してくる星の光に現れる場合のシミュレーション（下）。地球大気の酸素分子による吸収帯と区別するためには、高分解能のスペクトル観測が必要とされます。

宇宙の夜明けを解き明かす

見えてきた宇宙の夜明け

すばる望遠鏡は、宇宙誕生から 10 億年以内の時代の銀河を多数発見し、初期の銀河や銀河団の形成の理解を大きく前進させました。ビッグバン後から現在にいたる天体形成の歴史のなかで闇に包まれていた時代についに足を踏み込んできたのです。

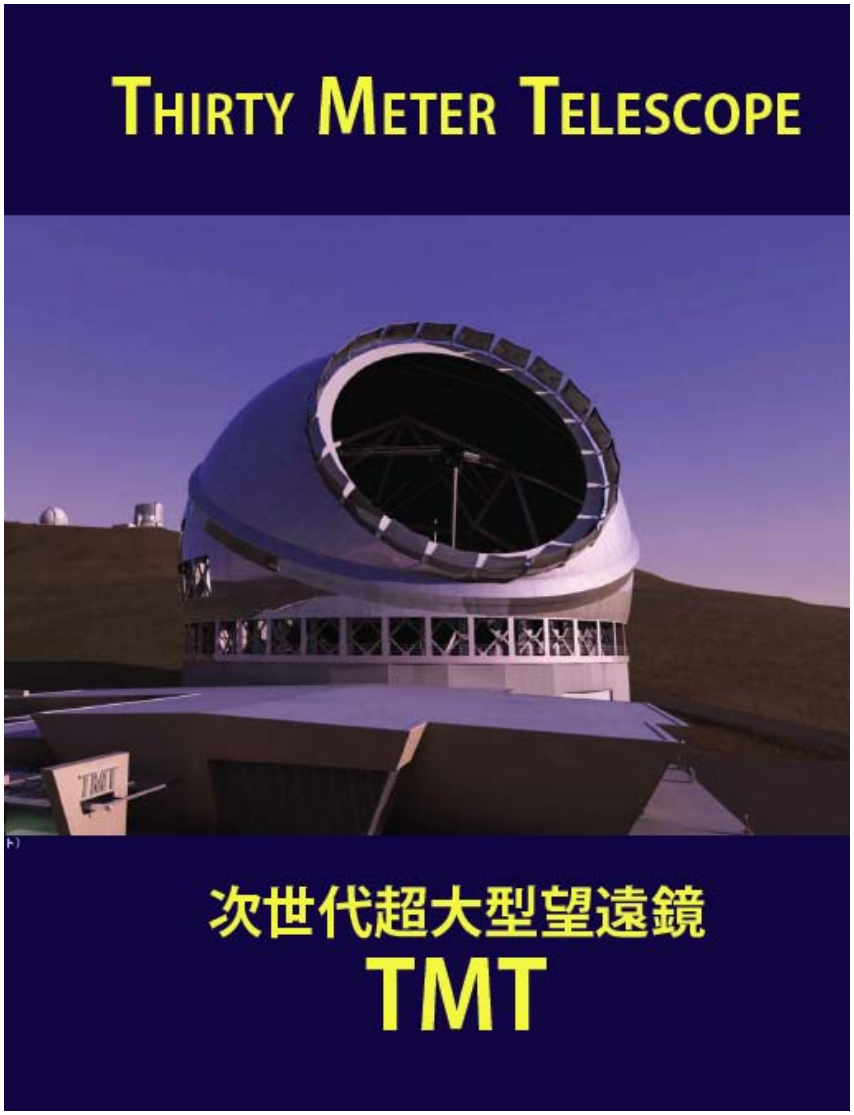
宇宙誕生から 8 億年たらず（赤方偏移 7）の銀河 IOK-1（すばる望遠鏡による）

TMT は宇宙の初代星・初代銀河の正体に迫る

TMT では、宇宙で最初の星々からなる銀河を調べます。ハッブル宇宙望遠鏡やすばる望遠鏡は、宇宙初期の銀河を多数発見してきていますが、その正体を調べるには、TMT による分光観測や補償光学を用いた高解像度観測が威力を発揮します。これにより、宇宙の夜明けの時をただ見るだけでなく、理解することが可能となります。

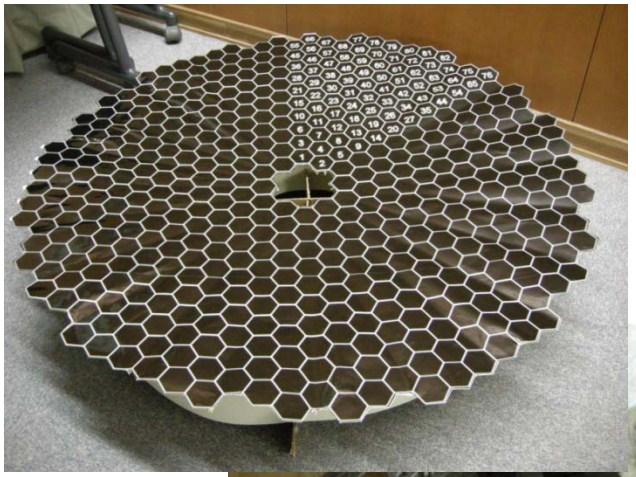
また、初代の大質量星が最後に起こす大爆発を探します。最も波長の短い光であるガンマ線で突然明るく輝く現象はガンマ線バーストとよばれ、その多くが巨大な爆発エネルギーをもつ超新星による、宇宙最大の爆発現象であることがわかっています。

宇宙初代に生まれた大質量星も、一生の最後に超新星爆発を起こし、ガンマ線バーストとして輝くとみられます。TMT はその爆発後に放たれる光を赤外線としてとらえ、宇宙の初代星の正体に迫ります。



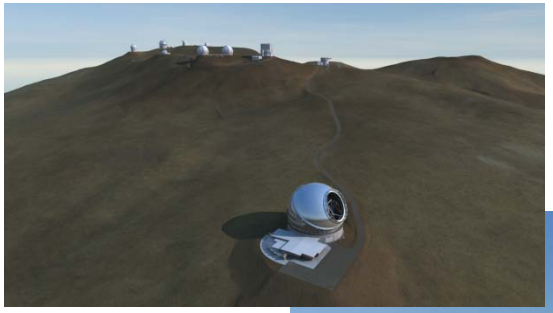
Outreach/Promotion

- Exhibition of 1/30 model of TMT primary mirror at NAOJ open house



- TMT promotion video

  http://4d2u.nao.ac.jp/



Summary

- Strong interests in contributing to the three TMT FL instruments
- Investigating five Japanese 2nd gen. instruments
- Natural extension from Subaru instrumentation
- Unique science cases based on a synergy with Subaru