Dome-F, Antarctica

Antarctic Infrared Telescope (AIR-T) and its Scientific Drivers

Tohoku University
Takashi Ichikawa
The ideal site for astronomy

Dome F (3810m)
Dome A (4100m)
Syowa
Ridge A (4050m)
Zhongshan
South Pole
Dome C (3250m)

80cm Infrared telescope
40cm optical telescope
50cm Schmidt telescope
10m Sub-mm telescope
60cm THz
1000km
Astronomical Station at Dome-Fuji since 2011

National Institute of Polar Research

PLATO-F (UNSW)
Power station and instruments

Jan, 2013
TwinCAM
10cmx2 telescopes

exoplanets

16m pole temperature

SNODAR (Bonner et al.)
Whole sky camera

Aurora cameras

midwinter
2.5m Infrared Telescope

- Three-Color Infrared Camera (1~5μm)
  + simple multi-slit spectrograph (option)
- Heterodyne spectrograph (R~100000)
  10μm, 17μm, (30μm)

Ultra-lightweight telescope mount (Kurita+2009)
Good Reasons

- Clear sky (>65% photometric), weak wind
- Cold atmosphere: dark infrared sky (50 – 100 times darker)
- The free-atmosphere seeing 0.2”, the best in the world
- Dry atmosphere: 0.14mmPWV (~10 times lower) in winter
- Stable transparancy
- The atmospheric boundary layer is only 11m or lower
- Long periods of uninterrupted darkness for months
Low sky background

<table>
<thead>
<tr>
<th>Color</th>
<th>Location</th>
<th>Altitude</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>blue</td>
<td>Dome Fuji</td>
<td>3810 m</td>
<td>-70°C</td>
</tr>
<tr>
<td>red</td>
<td>Mounakea</td>
<td>4200 m</td>
<td>0°C</td>
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Near-infrared

Mid-infrared
### Good Reasons

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Excellent seeing

11m

\[ \sim 0.2" (\lambda = 0.47 \mu m) \]

Okita+ 2013
Comparison of Sensitivities - Subaru and AIRT

Point sources with 1 hour integration S/N=5

- Mouna Kea (Subaru)
- Dome Fuji (2.5m)

Subaru

AIIRT

- 0.12"
- 0.24"

diffraction limit
✓ High sensitivity of Subaru telescope
✓ High quality of HST

Unique opportunity for deep, high photometric and spatial precision astronomy
Long way to Dome Fuji and harshest environment

Dome Fuji

Novolazarevskaya

Showa station

Mizuho

ARP2

3810m

2800m

2012/2013

Sydney

Fremantle

Shirase

Cape Town (South Africa)

Japan

DROMLAN

IL76
In near-infrared, “Big science” with small telescope
Dusty Star Burst Galaxies

Herschel galaxy at $z=6.5$

Riechers+ 2013

~10m THz telescope

1 hour integration

Confusion limit

SPICA

ALMA

AIRT

2.4μm, S/N=5 (1 hour)
Near-infrared wide area survey

Most active star-forming era in history
Widest and Deepest High-Redshift Galaxy Survey in K band

Complete samples of $10^9$ $M_{\text{sun}}$ at $z \sim 3$

<table>
<thead>
<tr>
<th>Survey area (arcmin$^2$)</th>
<th>Depth $(K_{\text{AB}} \ 5\sigma)$</th>
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<tbody>
<tr>
<td>VLT GOODS-S</td>
<td>24</td>
</tr>
<tr>
<td>Subaru+MOIRCS</td>
<td>25</td>
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<tr>
<td>MUSYC</td>
<td>26</td>
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<tr>
<td>FIRES</td>
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<td>MODS</td>
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<td>VISTA UKIDSS</td>
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<td>4m telescope</td>
<td>23</td>
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Our Goal
Deepest K-band galaxies with MOIRCS + HST WFC3 data

Clustering evolution of low mass galaxies

Ichikawa+ 2007

Size evolution

Morishita+ 2013 (submitted)

GOODS-N region
Large scale structure of galaxy populations

- Massive quiescent and SF galaxies
- Low mass galaxies (~$10^9$Msun)
- THz galaxies
- Morphology

SSA22 ($z\sim3$) (Uchimoto+2012)

THz + near-infrared

Observations will be completed in one season

Proto-Quasar?

AzTEC1

Tamura+ 2010
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High Transmittance

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Stability of Optical Depth in Summer

Dome F

(a) Dome Fuji (summer)

(b) Atacama (summer)

(c) Atacama (winter)

Seta+

No data
water-dominated atmosphere on super-earths

Spectroscopic transit observations with low resolution $\lambda/\Delta \lambda \sim 100$ on multi-slits

Minimum effect of terrestrial water vapor in Antarctica

Transit and secondary eclipse

$\sim$10 reference stars in large slits

many molecular lines ($\text{H}_2\text{O}, \text{CO}_2, \text{CH}_4$...)

HST

GJ 1214b

SPITZER
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Continuous observations of multiple systems

- Super earth
- Hot Jupiter
Candidates of multiple systems

TESS (2017)

Bright G, K, M type stars

CCD camera at Dome-F

Collaboration with Dome A

50cm Schmidt x3