Sub-mm astronomy in Antarctica

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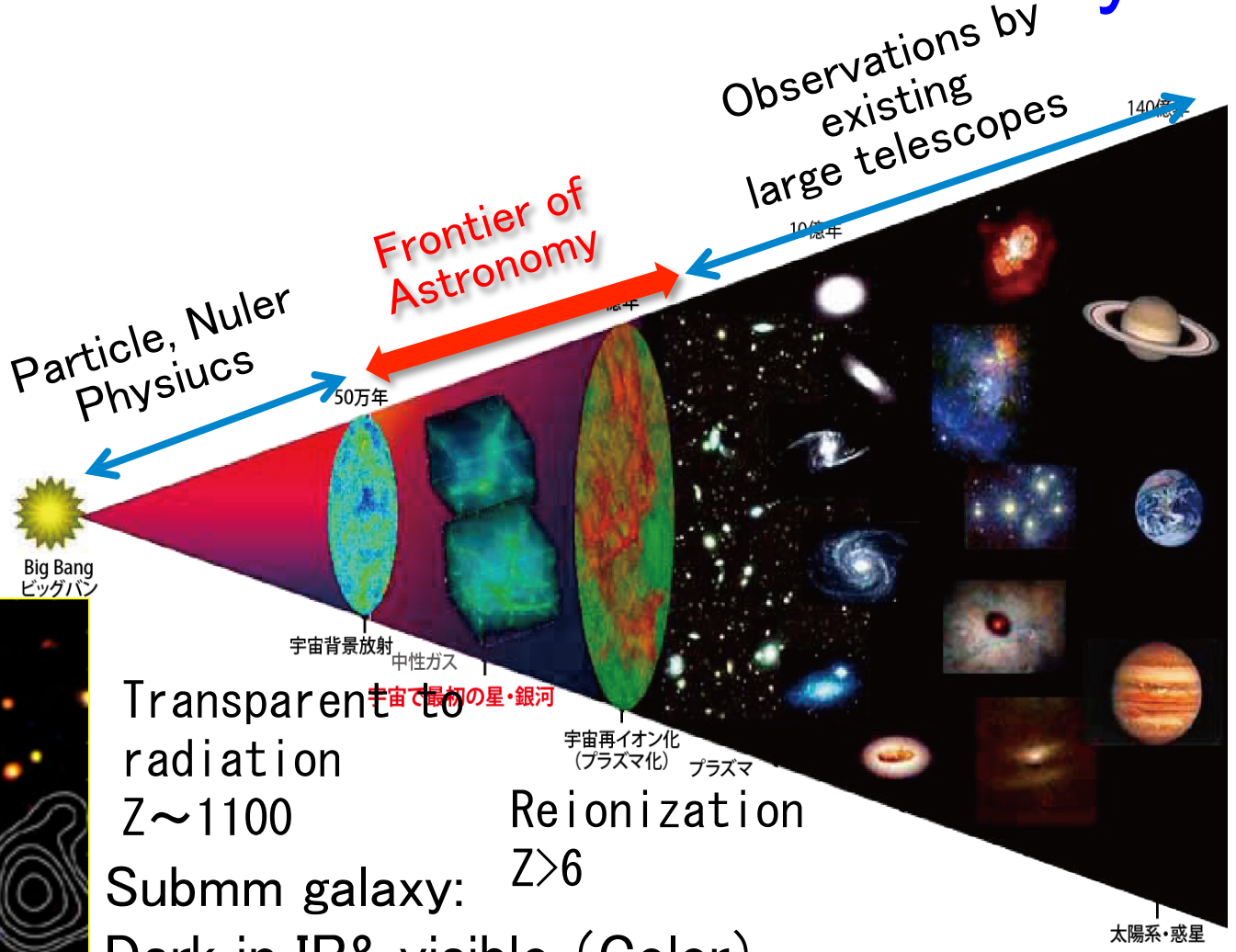
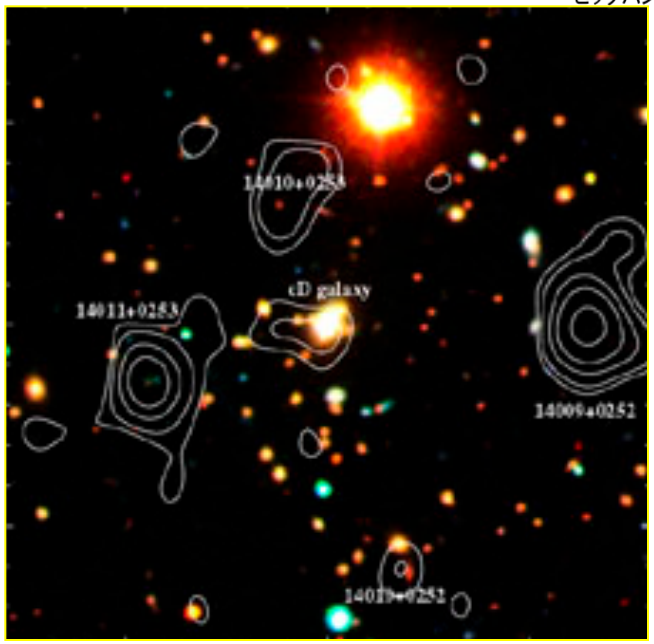
Contents

- Why astronomy in Antarctica?
  - Science:Galaxy evolution
  - Good atmospheric transparency
- Telescopes in Antarctica
  - 30 cm survey telescope
  - 10m THz telescope
  - 30m THz

THz is New Window of Radio Astronomy



(Blain et al., 2002)



Transparent to radiation
Z～1100

Reionization
Z>6

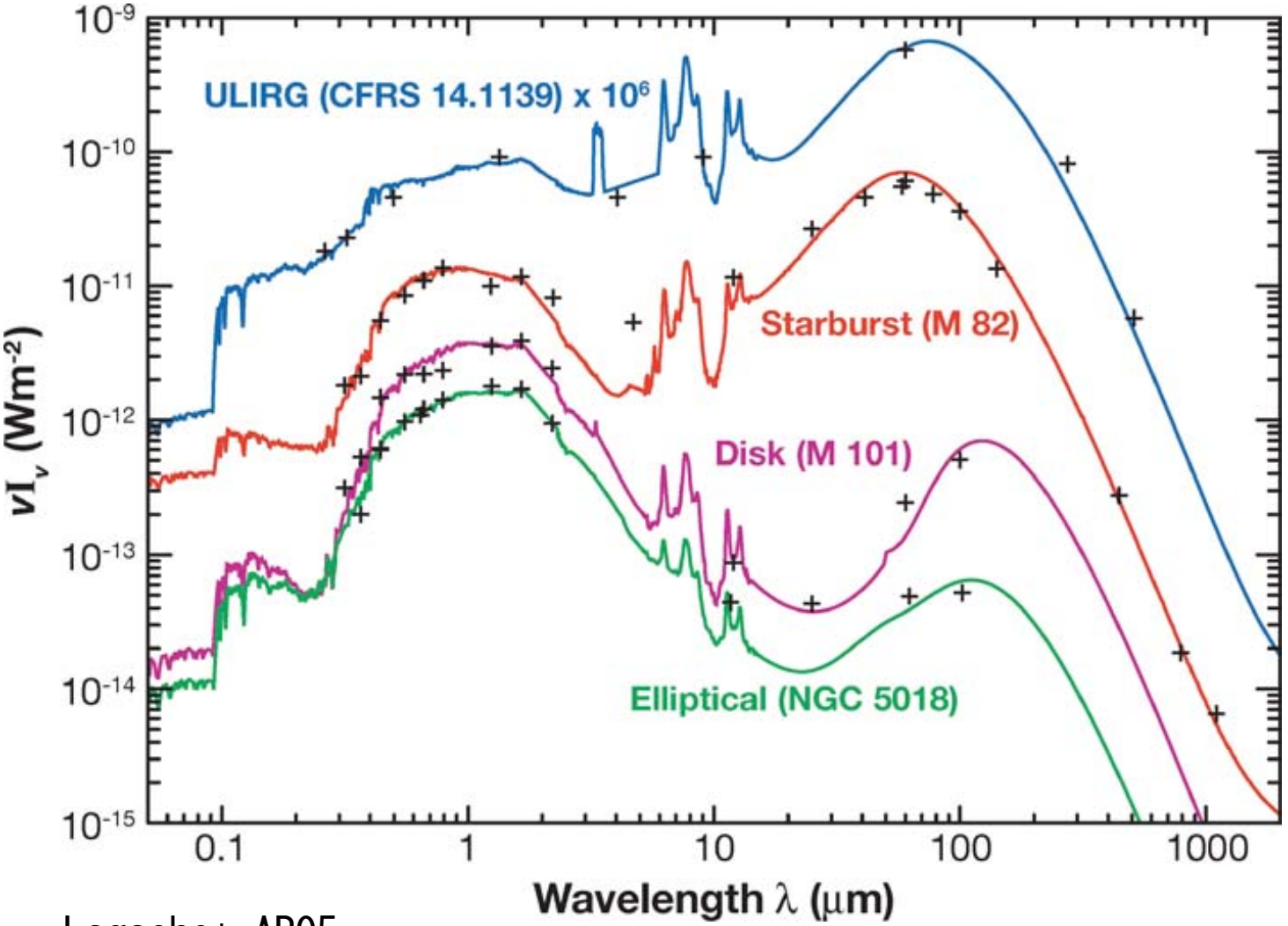
Submm galaxy:

Dark in IR& visible (Color)

Bright in radio(contour)

- Candidates of reionization source
  High Z galaxy is bright in THz

Spectrum of galaxies

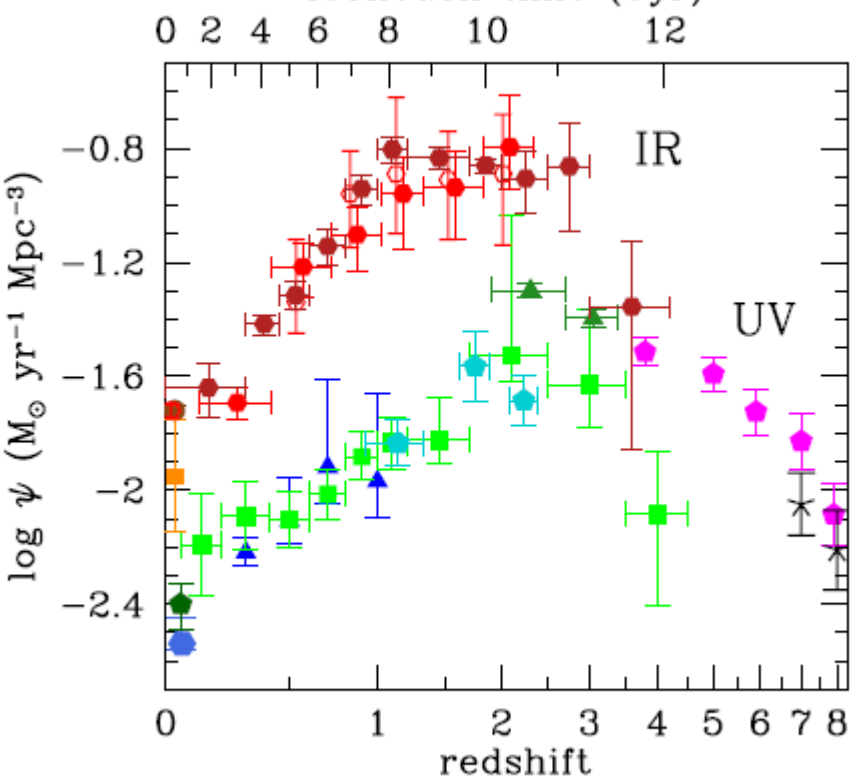


Lagache+ AR05

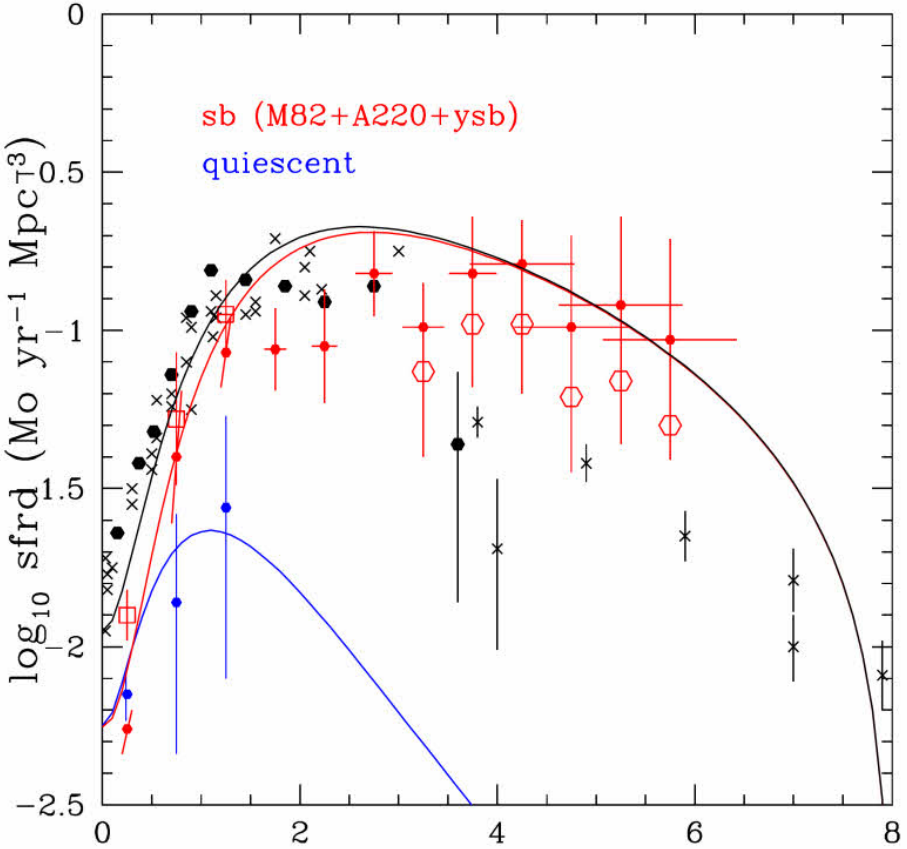
Galaxy is bright in visible and IR

Science with Antarctic THz telescope

Galaxy evolution
/star formation history of the universe
⇒ observations of dust emission



Madau & Dickinson (2014)

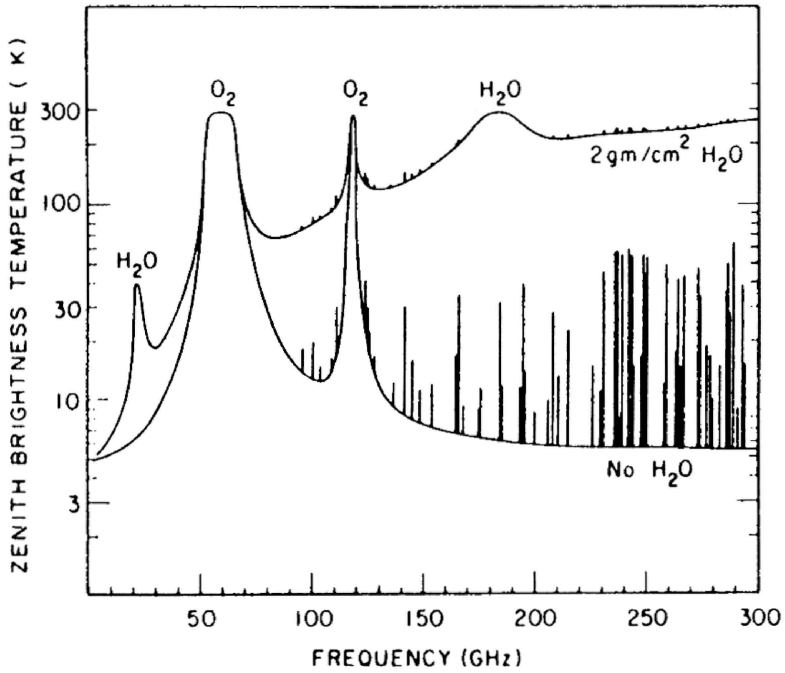


Rowan-Robinson et al. (2016)

THz observation is difficult

- THz detector is available
  - Camera:MKIDS TES
  - Heterodyne:SIS, HEB
- Heavy absorption by atmosphere
  Water vapor & oxygen

High altitude & dry site is required

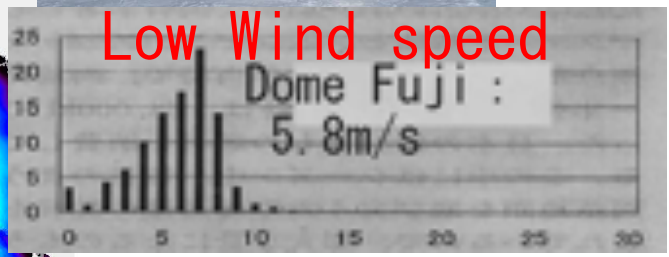


Antarctic Plateau (>3000m, < -70℃ in winter)

⇒ Best place for astronomical observations

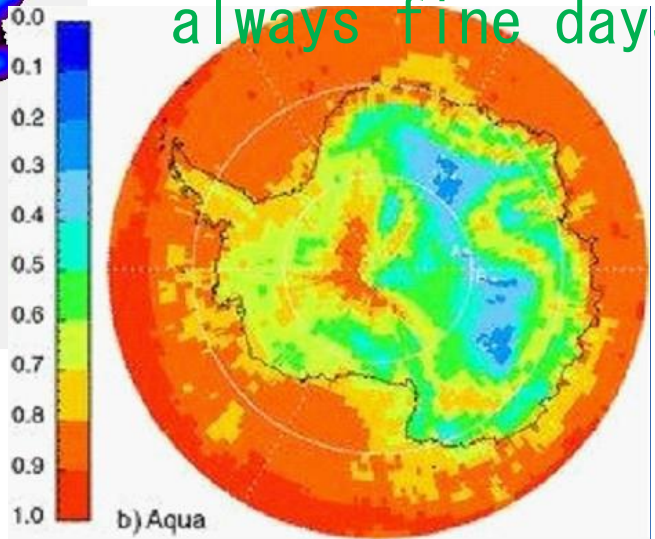
Ridge A (4050m) (USA)

Dome F (3810m) (Japan)



Cloud coverage

always fine days



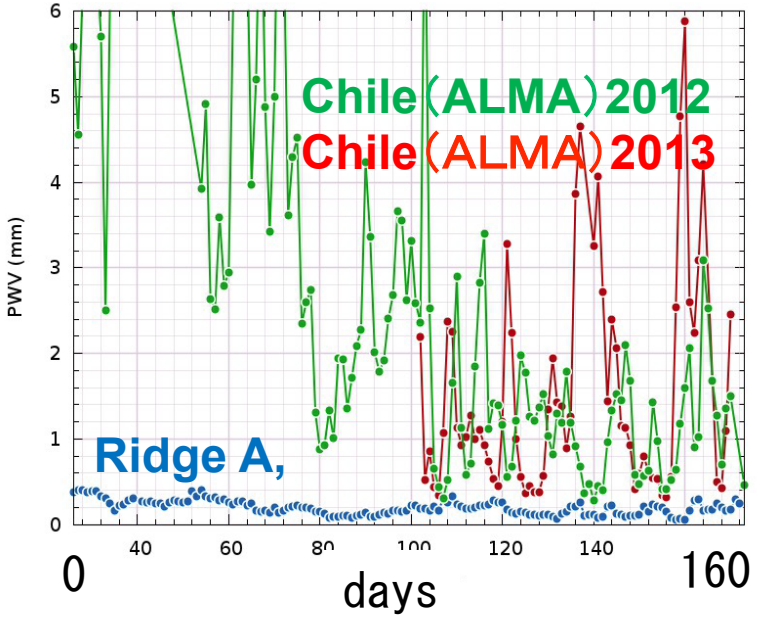
South Pole (2835m) (USA)

Dome A (4090m) (China)

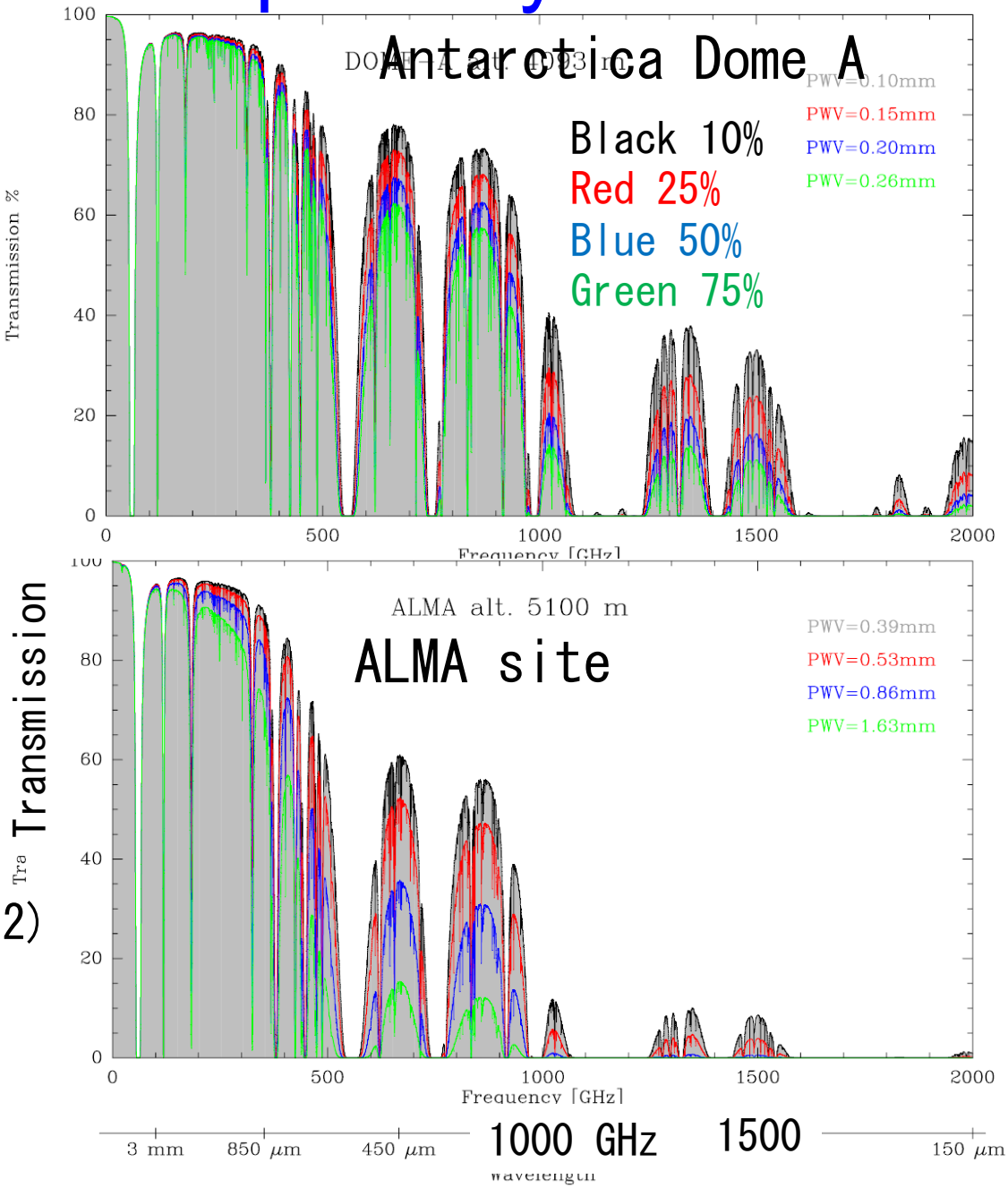
Dome C (3230m) (France & Italy)

Atmospheric transparency

・PMW from submm observation (Kulesa 2013)



Simulatio→ (Tremblin et al. 2012)



Best site for <1THz

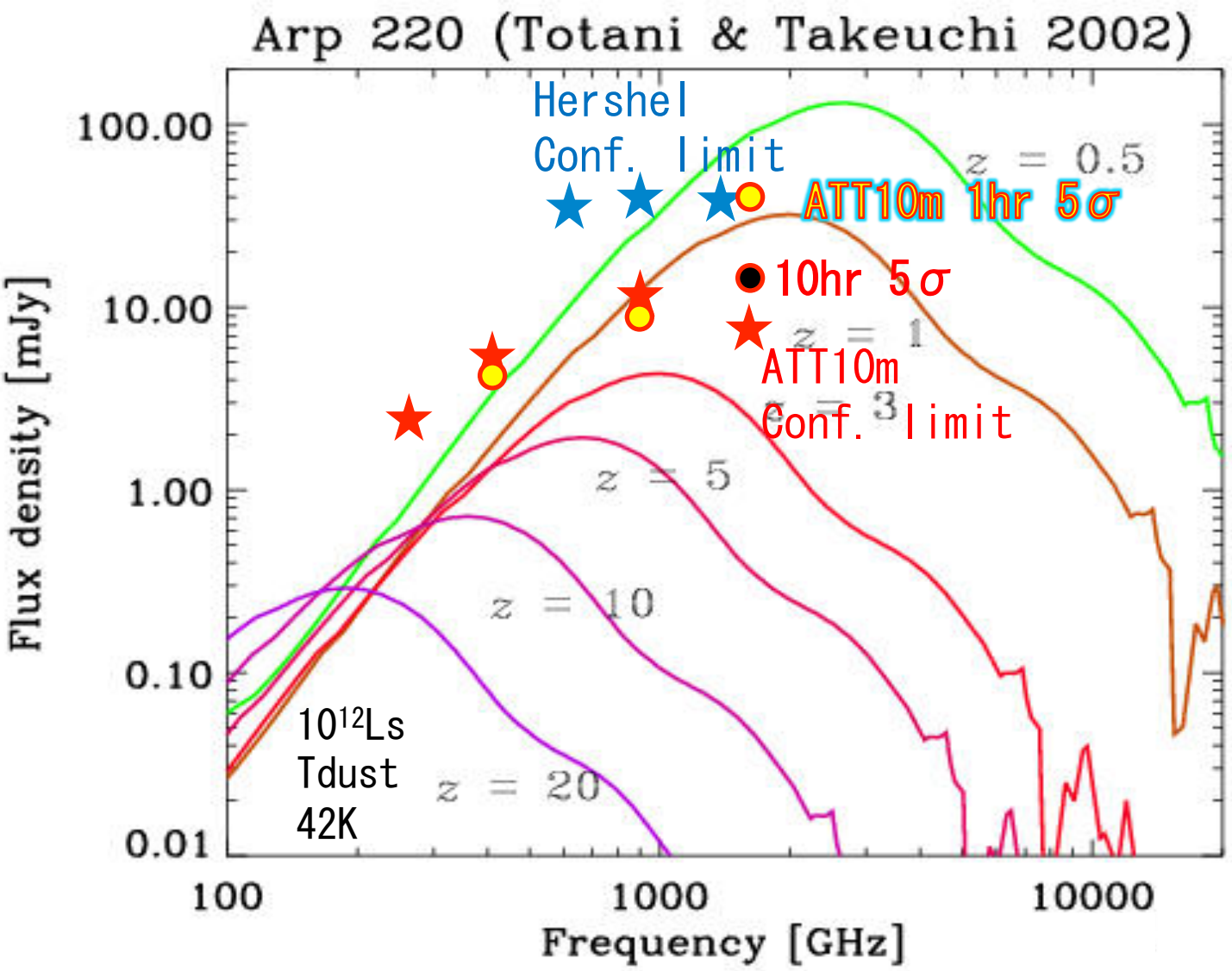
Unique site for >1THz

Antarctic THz telescope project

1. 30cm telescope
2. 10m THz telescope
   - Concordia station @ Dome C
     - Overwintering station
   - New Dome Fuji station? (National Institute of Polar Research of Japan)

3. 30m class THz telescope
   - Higher site than Dome C
     - New Dome Fuji station? (National Institute of Polar Research of Japan)
   - International collaboration (East Asia)

Survey of distant galaxies



Antarctic astronomy consortium

- University of Tsukuba
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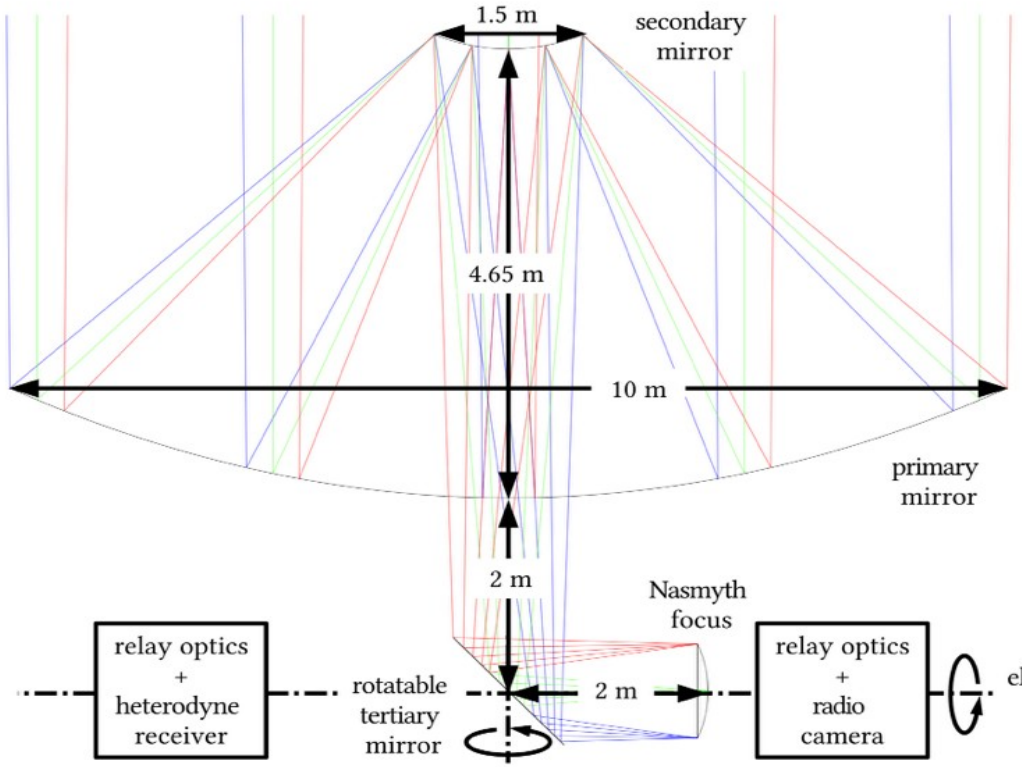
埼玉大学

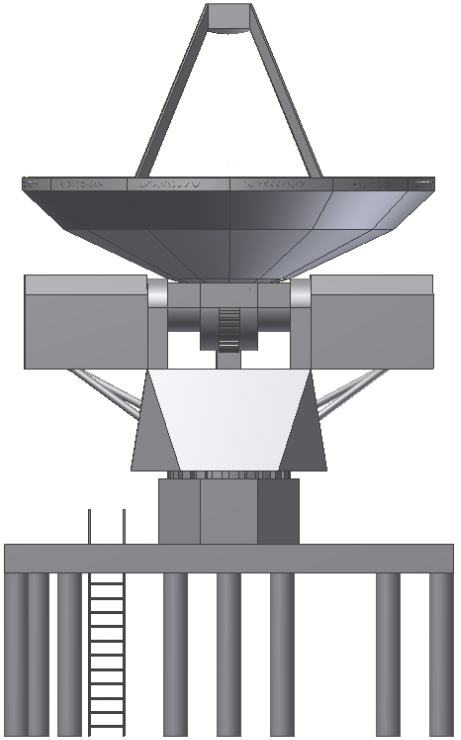
国立天文台
NAOJ
National Astronomical Observatory of Japan

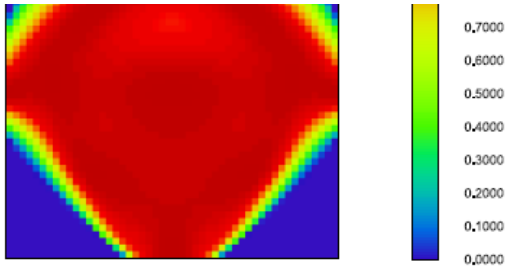
極地研
National Institute of Polar Research

10m telescope

- Frequency：0.2–1.5THz
- Surface accuracy：< 20μm
- Ritchey–Chrétien（Hyperboloid）
  - Field of view ：~1°
  - Nasmyth focuses : Radio camera
  - + Heterodyne receivers





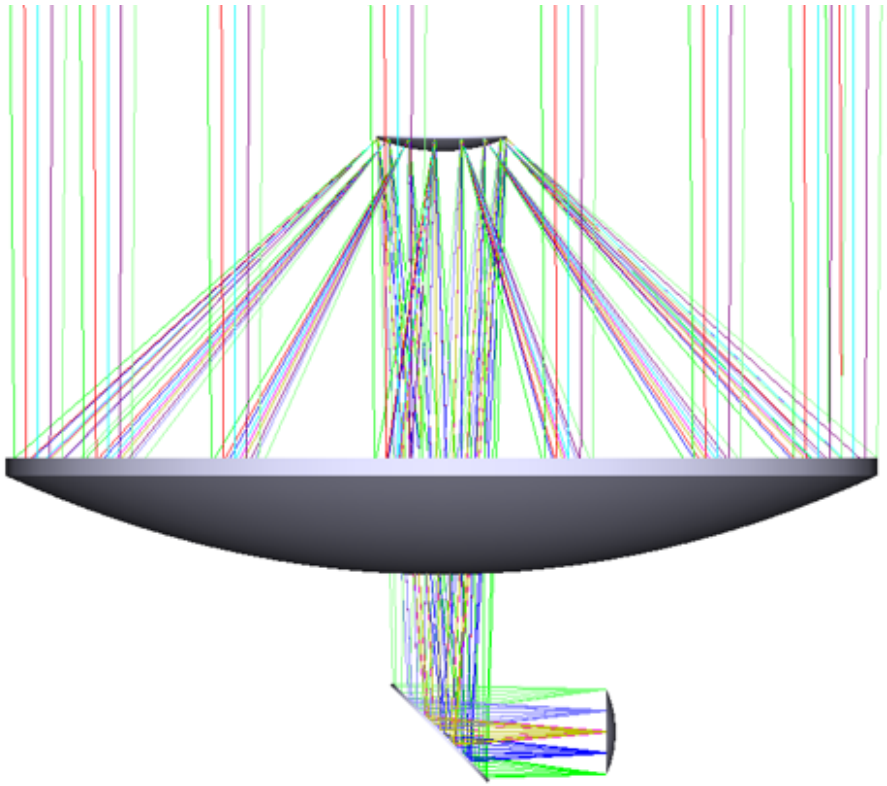


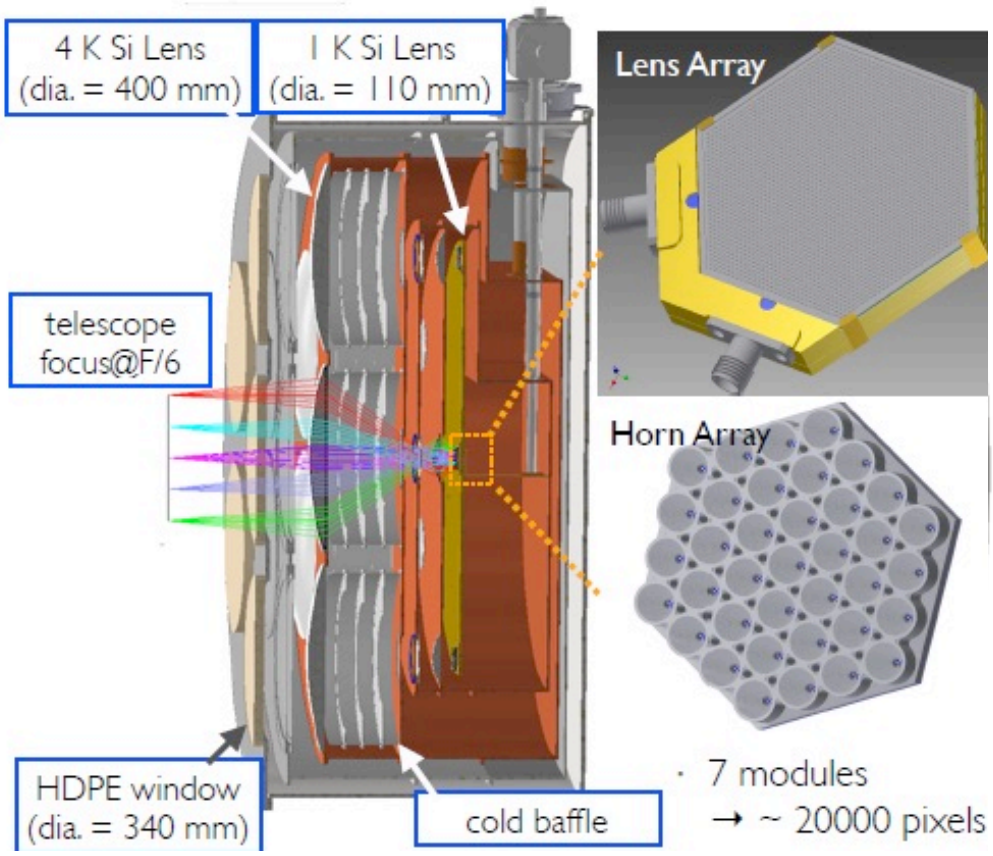
(a) 850 GHz

0.2 THz	0.8THz	1.3THz
37″	9.3″	5.8″

Wide Field MKID Camera

(Microwave Kinetic Inductance Detector)



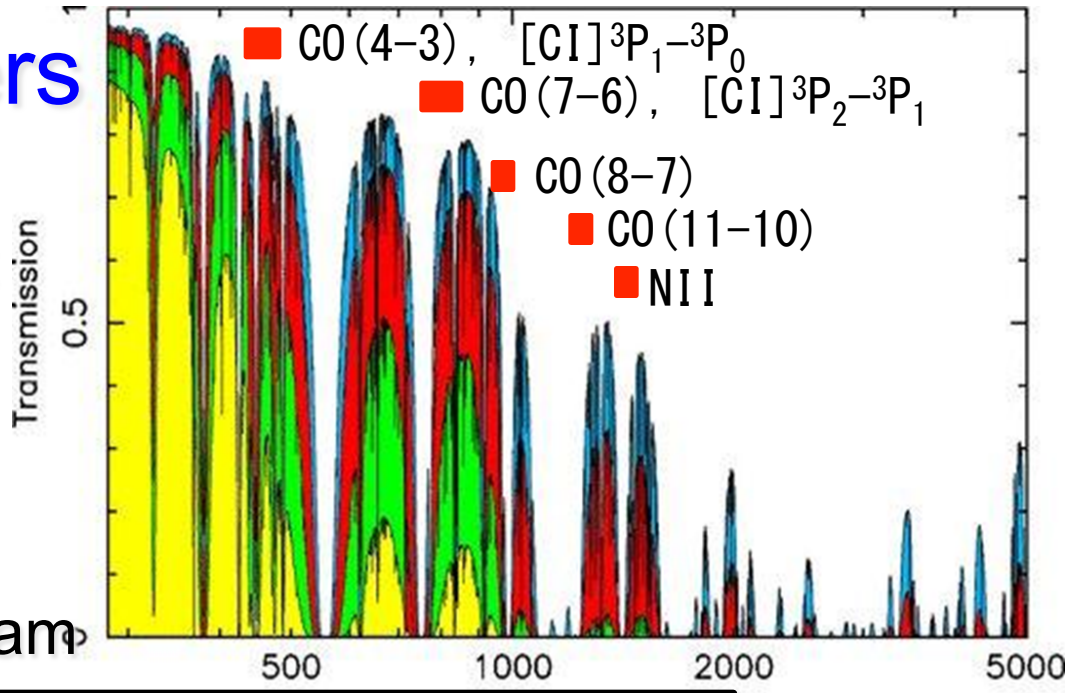


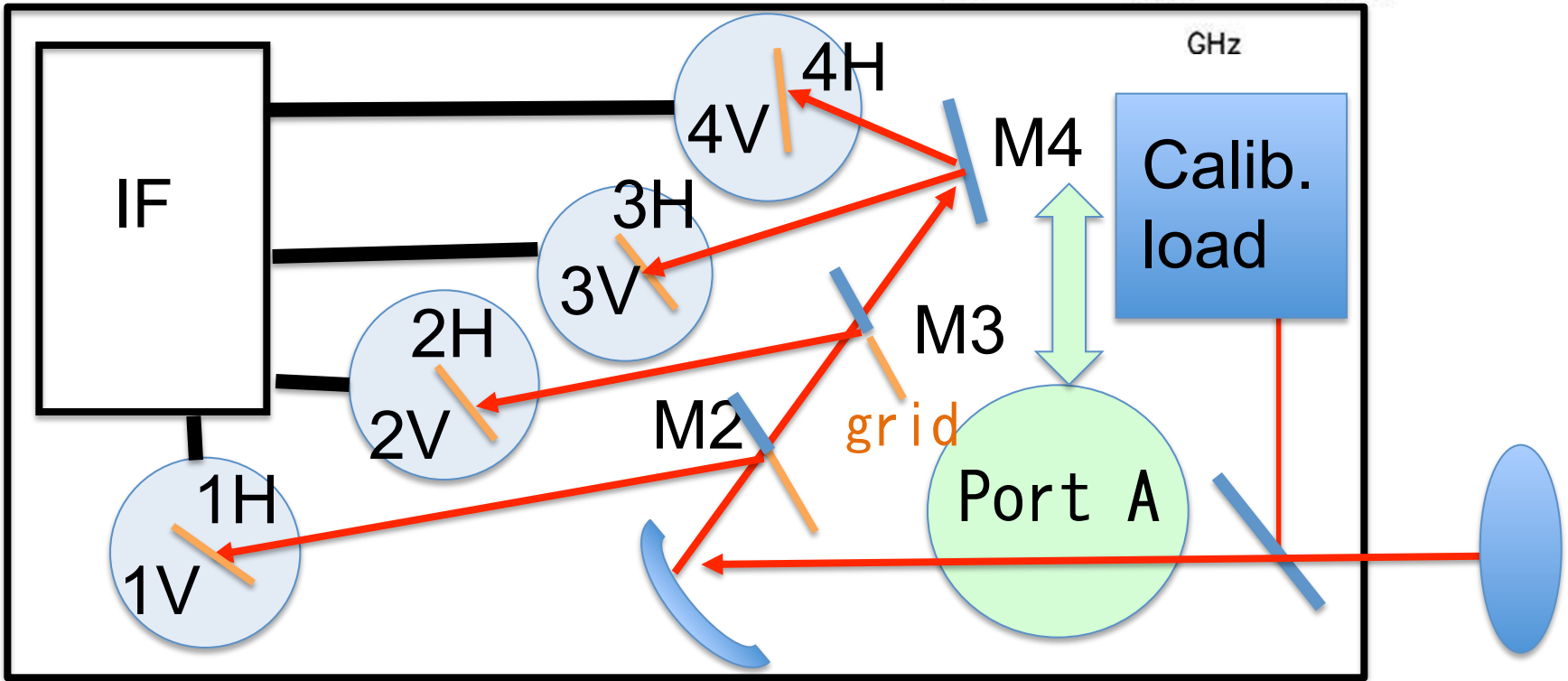
- 400GHz, 850GHz, 1.3THz
  - Simultaneous observations

20,000 pixels
FOV～1°

Heterodyne receivers

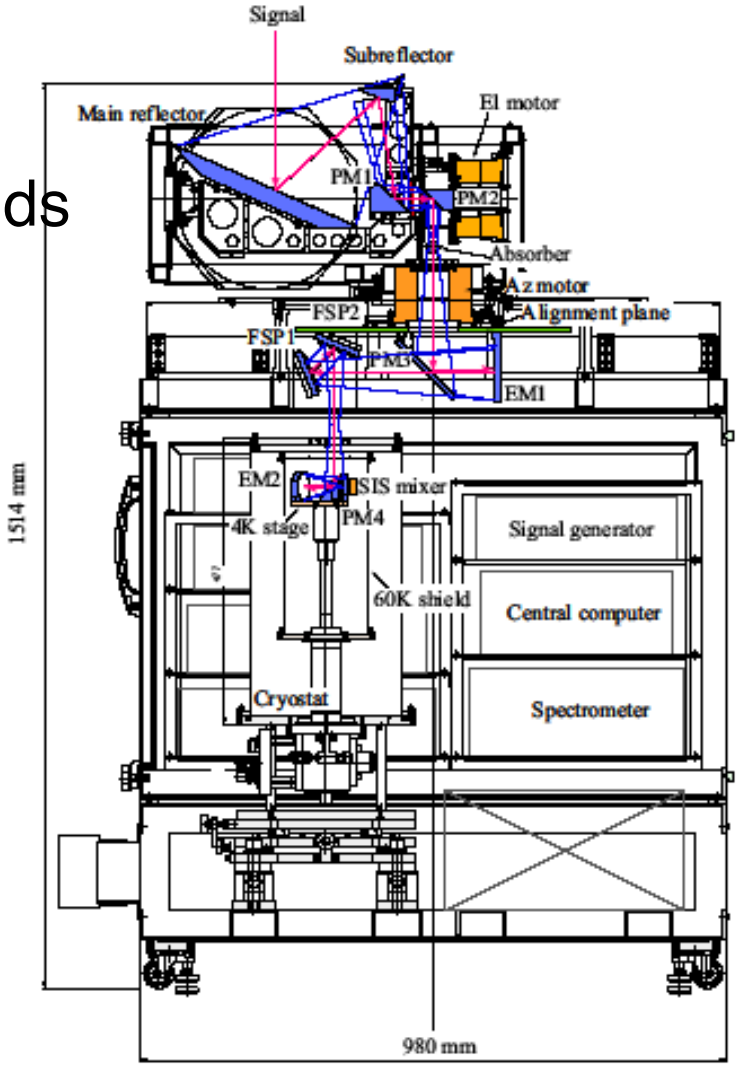
- 0.5, 0.8, 1.0, 1.3, 1.5THz
  - Tsys: ~280K@0.5THz
    ~600K@0.8THz
- 2 pol/2 sideband
- simultaneous observation
- Single beam ⇒ Multi-beam



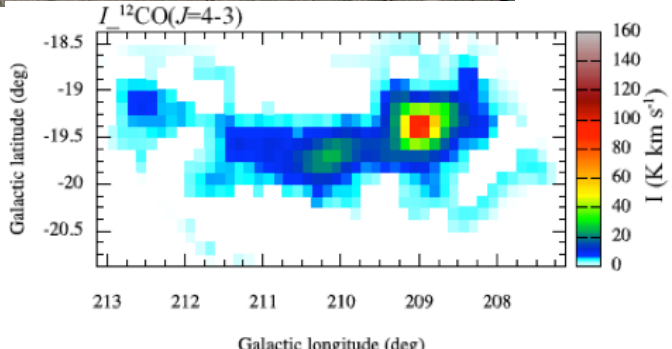


30cm Radio Telescope for antarctica

- Equipped with a 0.5 THz SIS receiver
- Mapping Milky Way in CO 4-3, CI lines
- Can be assembled by 4 peoples by hands
- 0.1W@4K cooler



Orion CO 4–3
(Ishii et al. 2016)



Summary

- Antarctic plateau is

  best site for <1THz astronomy

  unique site for >1THz astronomy on ground

- 10m terahertz telescope
  - –Wide filed view of 1deg
  - –Total electric power is less than 40 kVA
  - –20000 pixels MKID Radio camera

    (3 bands centered at 850 GHz)
  - –Heterodyne receivers for 0.4-1.5 THz
- 30cm survey telescope for Milky Way survey in CI and CO