Report on ALMA-J Progress

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National Astronomical Observatory, Japan (NAOJ)

IAOC Workshop on Cool Universe
Valparaiso, Oct. 8, 2004

20 Years from Plan to Reality

- Start in 1983
- Start Site Testing in Chile in 1992
  to search the best site for Sub-mm observations
- US-Japna “Atacama Array Workshop” in March 1997
  Recognized the importance of International collaboration
  to realize high-resolution (0.01 arcsec.) & sensitivity required
- Tri-lateral Resolution toward three way ALMA in 2001
- ALMA-J 8-years construction budget was funded in Apr 2004
- (Preliminary ?) Agreement of Joint Construction was signed in Sep 2004

Nobeyama Radio Observatory (1982-)

Nobeyama 45m Telescope

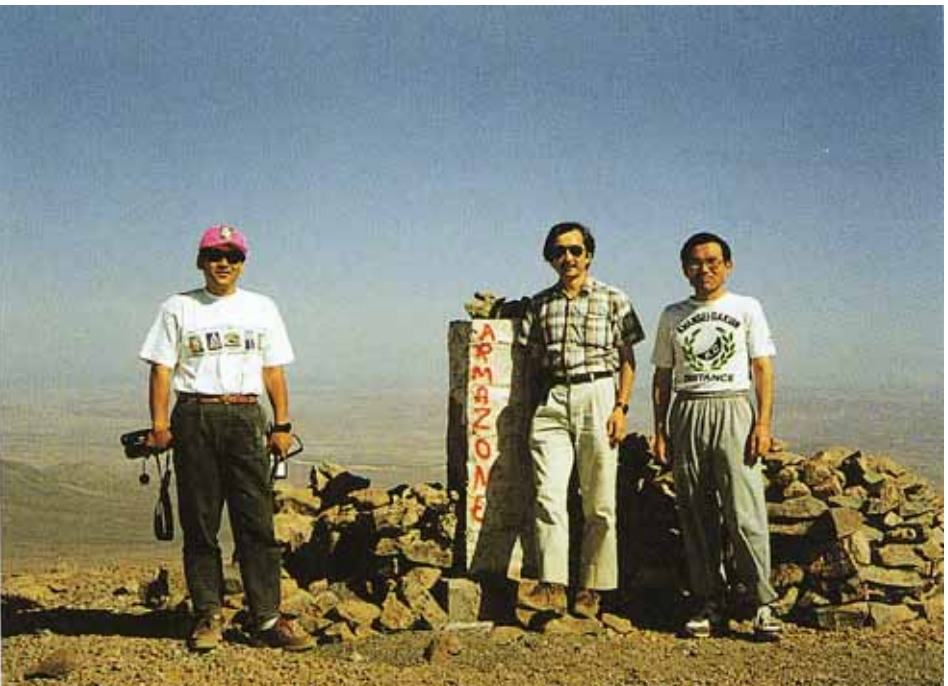
Nobeyama Millimeter Array (NMA)/Rainbow

20 Years from Plan to Reality

- Start from Large Millimeter Array (LMA) Project which is based on upgrade of Nobeyama Millimeter Array (NMA)
- NMA observations started from the year of 1986
- Importance of Sub-mm array and High Spatial Resolution led us to Large Millimeter/Submillimeter Array (LMSA) Project & Site Survey in Chile

Site Testing in Chile (I)：1992-

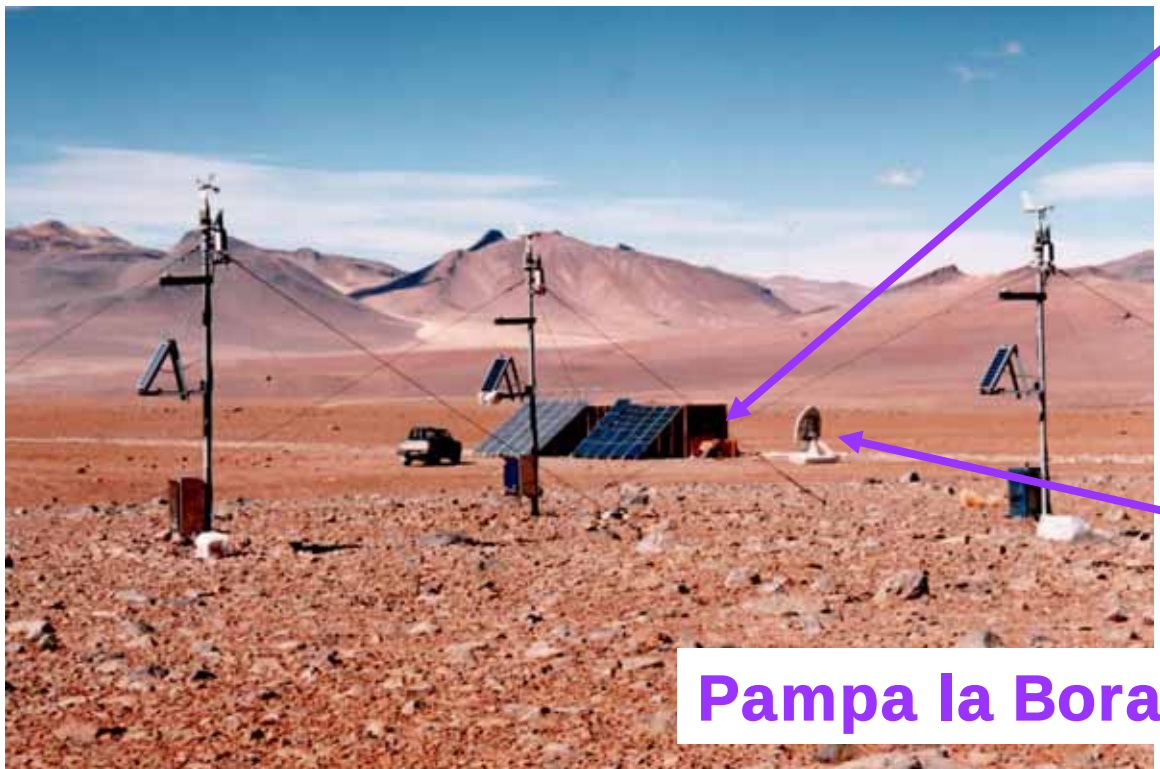
- **Collaboration with U.Chile & ESO**
- **Transportable 225 GHz Tipper**
- **Test of Radio Seeing Momitor in La Silla & Paranal**



Site Testing in Chile (II):1995-

- **Site Testing Instruments (1995-)**
- **Collaboration with U.chile, NRAO, ESO**

225 GHz Tipper

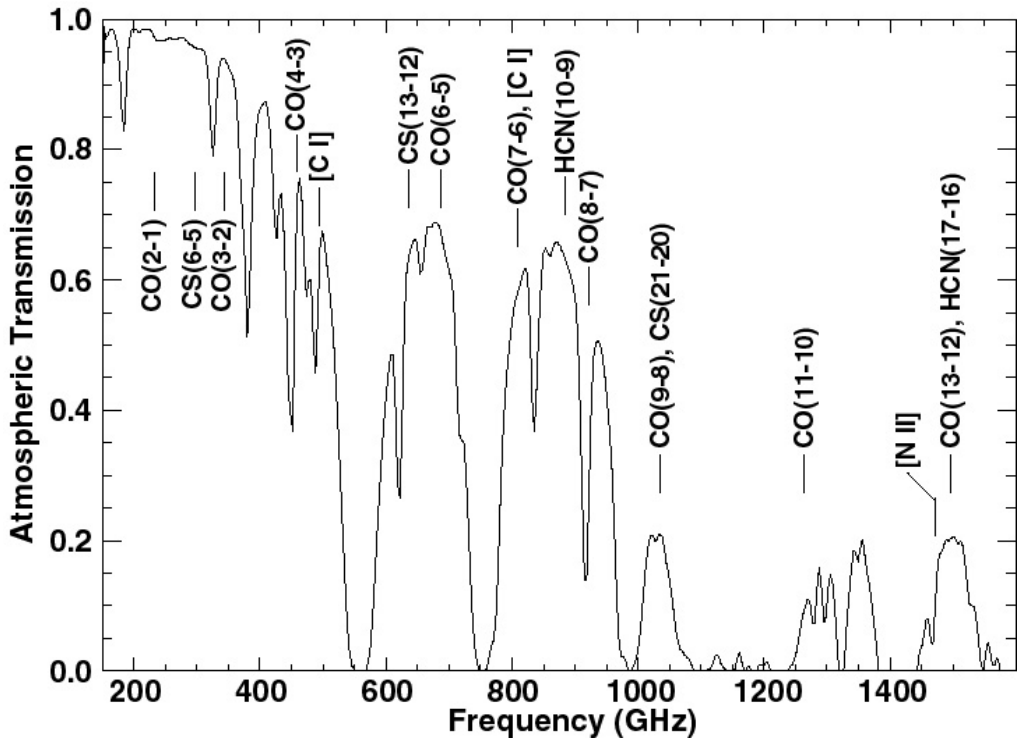


Pampa la Bora

Radio Seeing Monitor

Site Testing in Chile (III)：at Sub-mm

- **Measurement with FTS (Fourier Transform Spectrometer) ; 1997-**
- **Excellent Atmospheric Transmission at ALMA site**



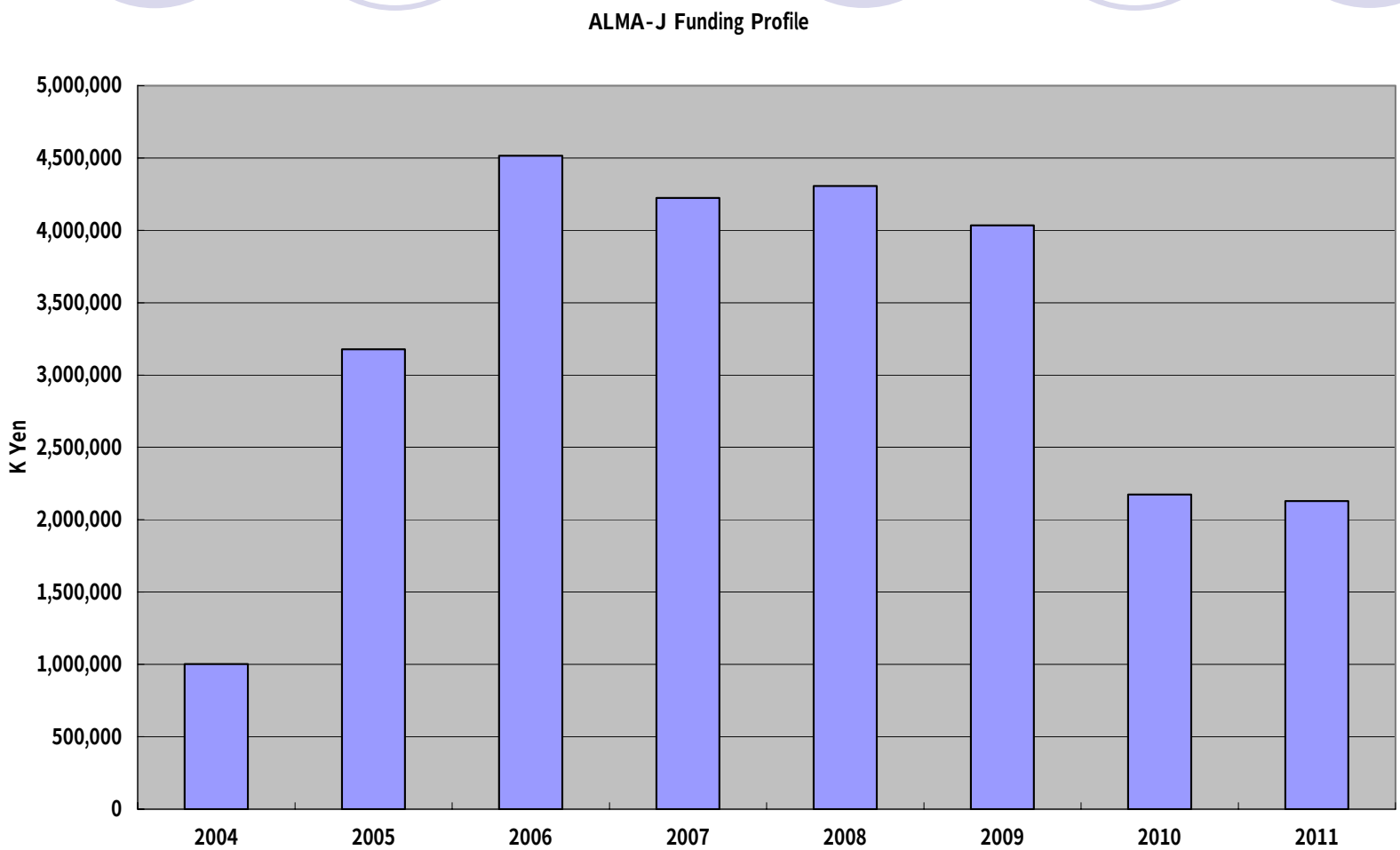
S. Matsushita et al. 1998

ALMA-J Project Funding Status

- The Ministry of Finance and the Cabinet approved **25.6 Billion Yen (241.5M$, 1$=106Yen)** for the ALMA-J budget in 8 years (FY2004-2011)
- **1.0 Billion Yen (9.43M$,1$=106Yen) for the FY2004** budget.
- The above budget includes costs for

  Buildings (**“**Technology & Science Centers” in NAOJ), Instruments used there.
- But does not include personnel costs of permanent ALMA-J staff and the other resources contributed by NAOJ. The total cost is more.

Funding Profile of 25.6 Billion Yen



Agreement been signed !

- Europe, Japan and North America signed an agreement concerning the construction of the Enhanced Atacama Large Millimeter/submillimeter Array (ALMA)
- Signed in Tokyo by Dr. Yoshiro Shimura, President of NINS, on 14 September
- Completed by adding related annexes no later than Jun 2005

AGREEMENT

CONCERNING THE CONSTRUCTION OF THE ENHANCED

ATACAMA LARGE MILLIMETER/SUBMILLIMETER ARRAY

(ALMA)

BETWEEN

THE EUROPEAN ORGANISATION for ASTRONOMICAL RESEARCH in the SOUTHERN HEMISPHERE and THE NATIONAL SCIENCE FOUNDATION of THE UNITED STATES

and

THE NATIONAL INSTITUTES OF NATURAL SCIENCES of JAPAN

ALMA-Japan

- NAOJ became a branch of **National Institutes of Natural Sciences (NINS) from this year**
- What is **NINS**?
  - Government-funded agency
  - More independent from MEXT (Ministry of Education, Science, Technology, …) than before
  - Five (5) Institutes:
    - National **Astronomical Observatory** (NAO)
    - National Institute of **Fusion Science** (NIFS)
    - National Institute of **Basic Biology** (NIBB)
    - National Institute of **Physiological Science** (NIPS)
    - Institute of **Molecular Science** (IMS)

ALMA-Japan

- **New NAOJ**
  - Director General: **Dr. Norio Kaifu**
  - Telescopes
    - Subaru 8.3m telescope in Hawaii
    - Nobeyama 45m Telescope & NMA/Rainbow
    - ASTE (Atacama Submillimeter Telescope Experiment)
    - VERA (VLBI Exploration of Radio Astrometry) etc
- **New ALMA-Japan Organization**
  - Project Director **Masato Ishiguro**
  - Deputy Project Director/ Project Scientist **Ryohei Kawabe**
  - Project Manager **Tetsuo Hasegawa**
  - Project Engineer **Satoru Iguchi**

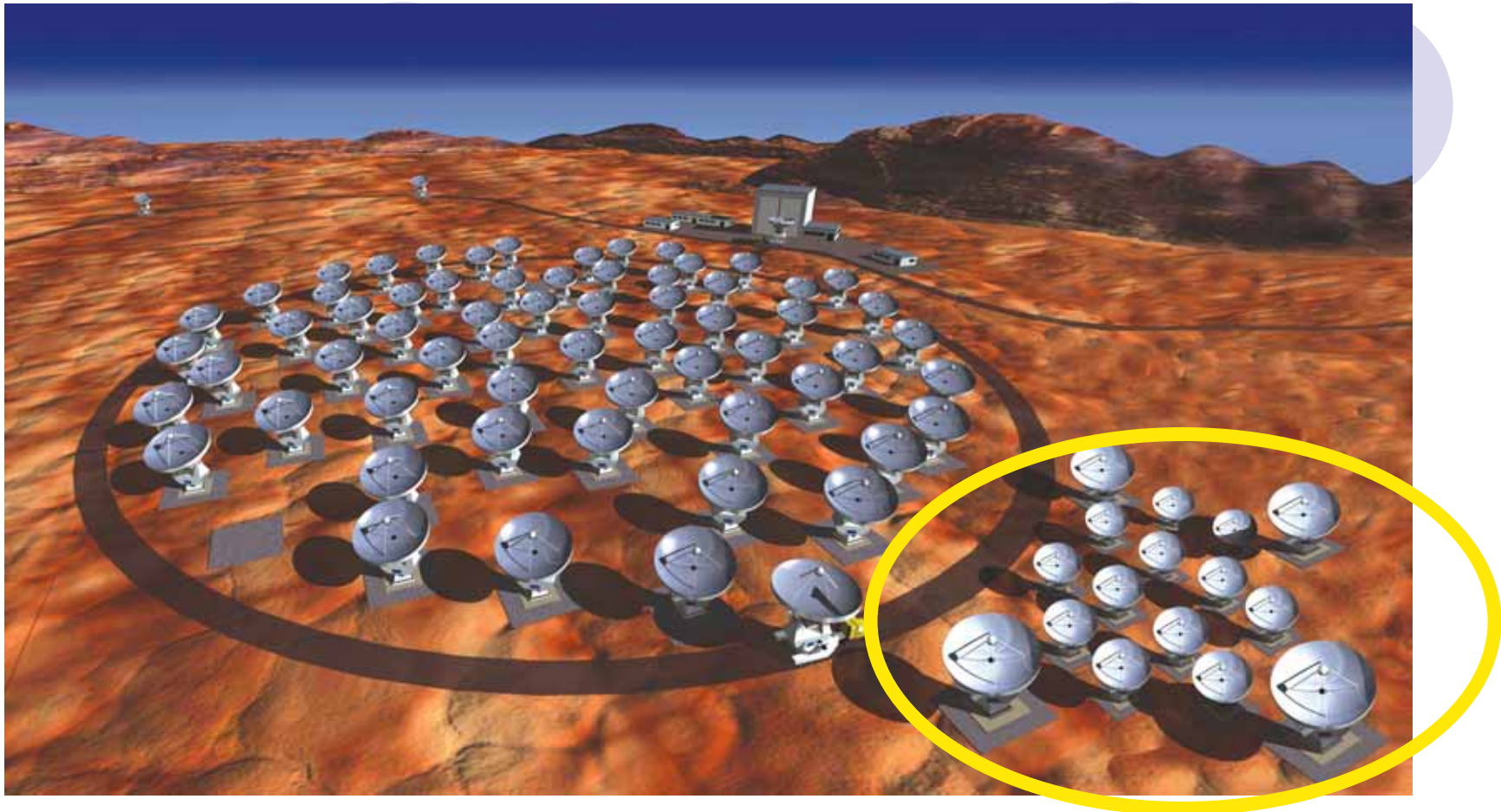
Japanese Contribution Items

- **ACA System**
  - 7-m and 12-m Antennas, FE (Baseline 4 bands + new three bands), BE, ACA Correlator, Computing

    (every thing needed for 16 element interferometer)
- **New Receiver Bands**
  - Band 4, 8, and 10 cartridges (for 64-el. And ACA)
- **Infrastructure**
  - Required by the Japanese contribution

    Expansion of facilities at Array & Operation sites
  - Contribution to the Power Plant

- **Operations**



The ACA System

- Twelve (12) 7-meter diameter antennas (18 stations)
- Four (4) 12-meter diameter antennas (4 stations)
- ACA Correlator in AOS building

Role of ACA

- **Supplement the 64-element array data with**
  - **Short baseline data (7-m antennas)**
  - **Total power data (12-m antennas); e.g., OTF**
  - ⇒***Enhance fidelity of ALMA images*** (overcome "*missing-flux*" problem)
  - ⇒ACA will be used for ¼ of 64 array observing programs to match sensitivity
- **Stand-alone mode of operation**
  - ⇒Would be available for ***target-of-opportunity*** observations, wide-field surveys, etc.

High fidelity imaging

:Role of the Compact Array

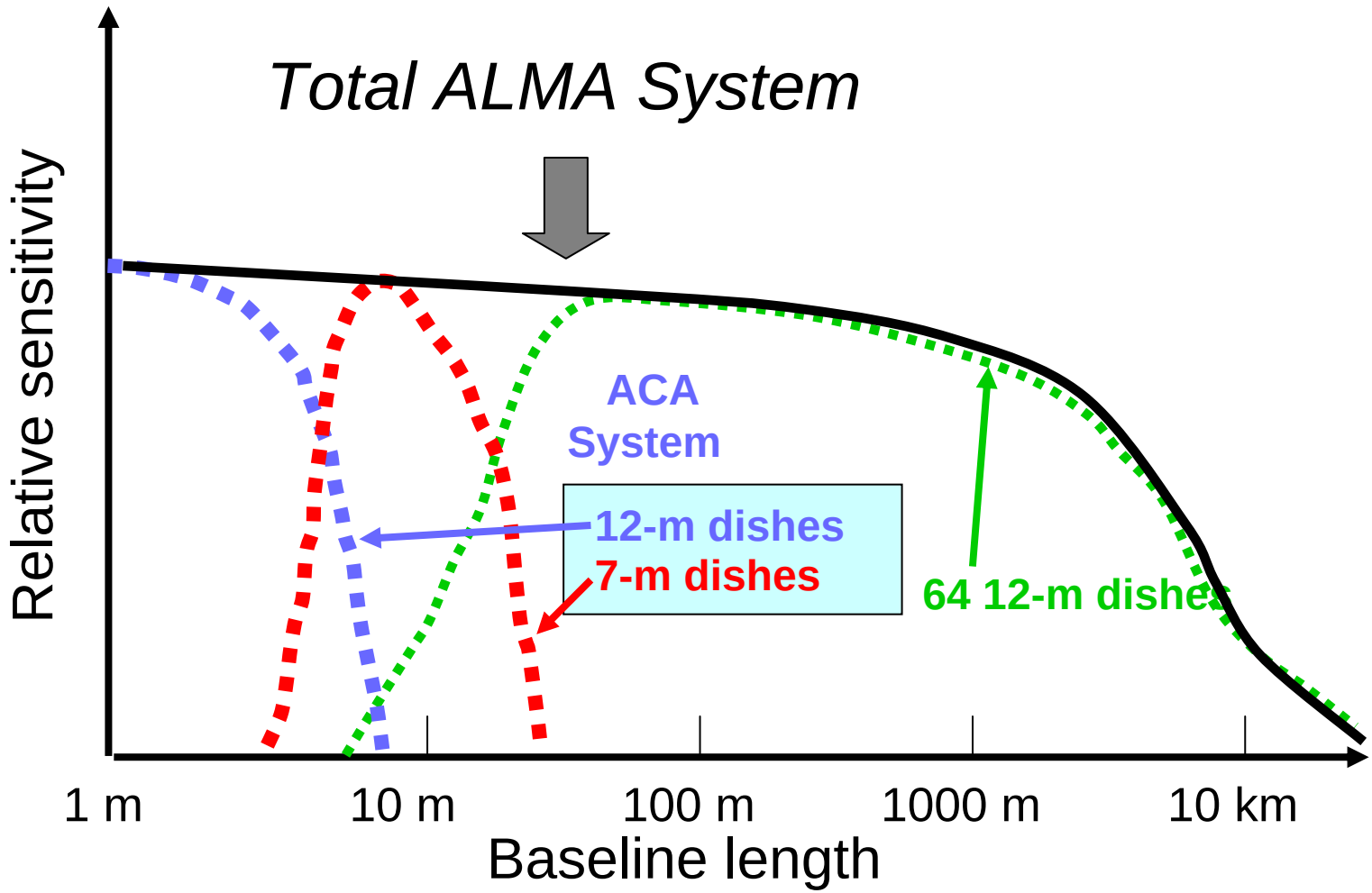
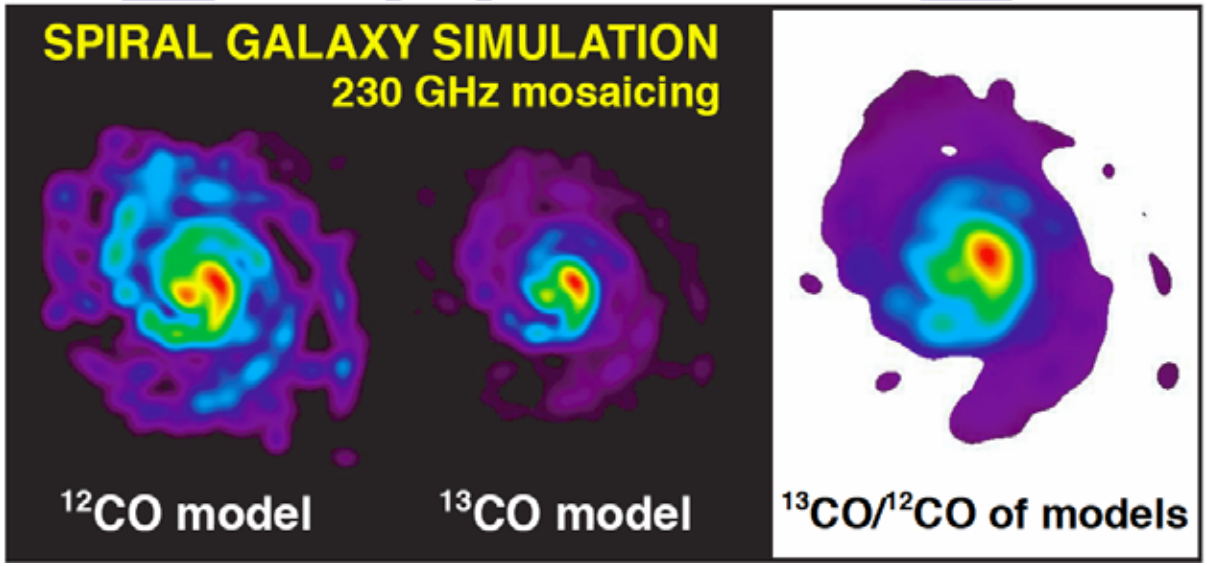
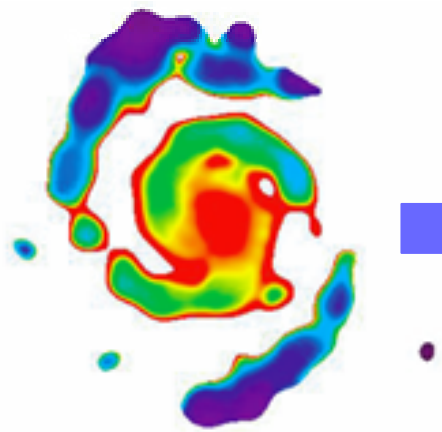


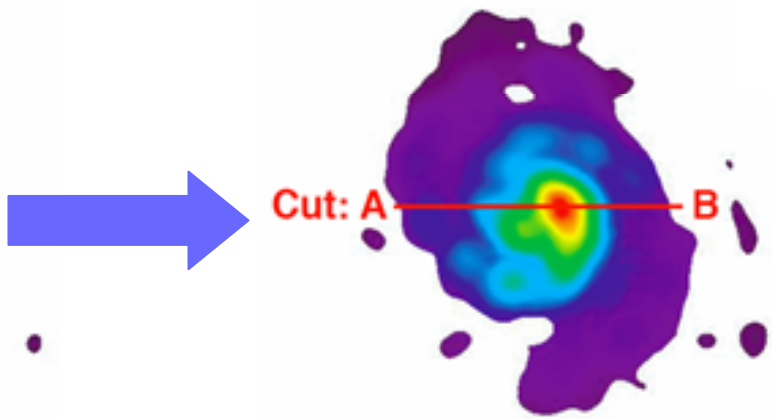
Image Fidelity Improved by ACA (1)

Simulation (Tsutsumi et al.)





64+SD



64+ACA+SD

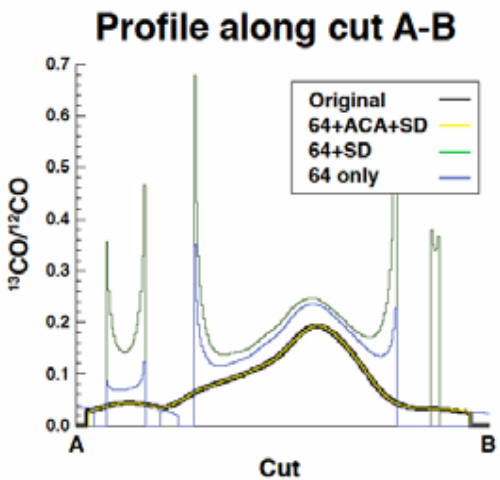
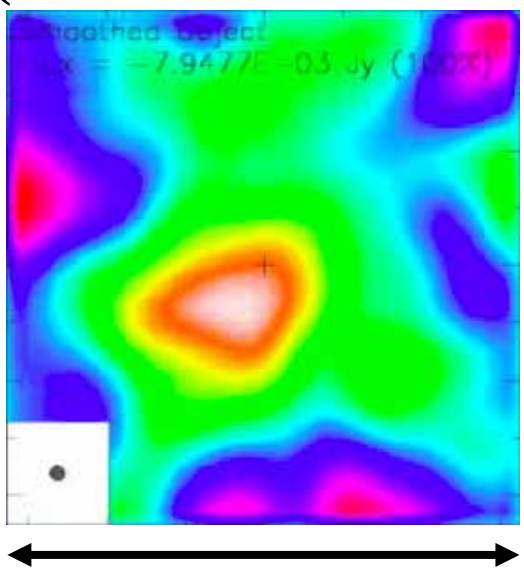


Image Fidelity Improved by ACA (2)

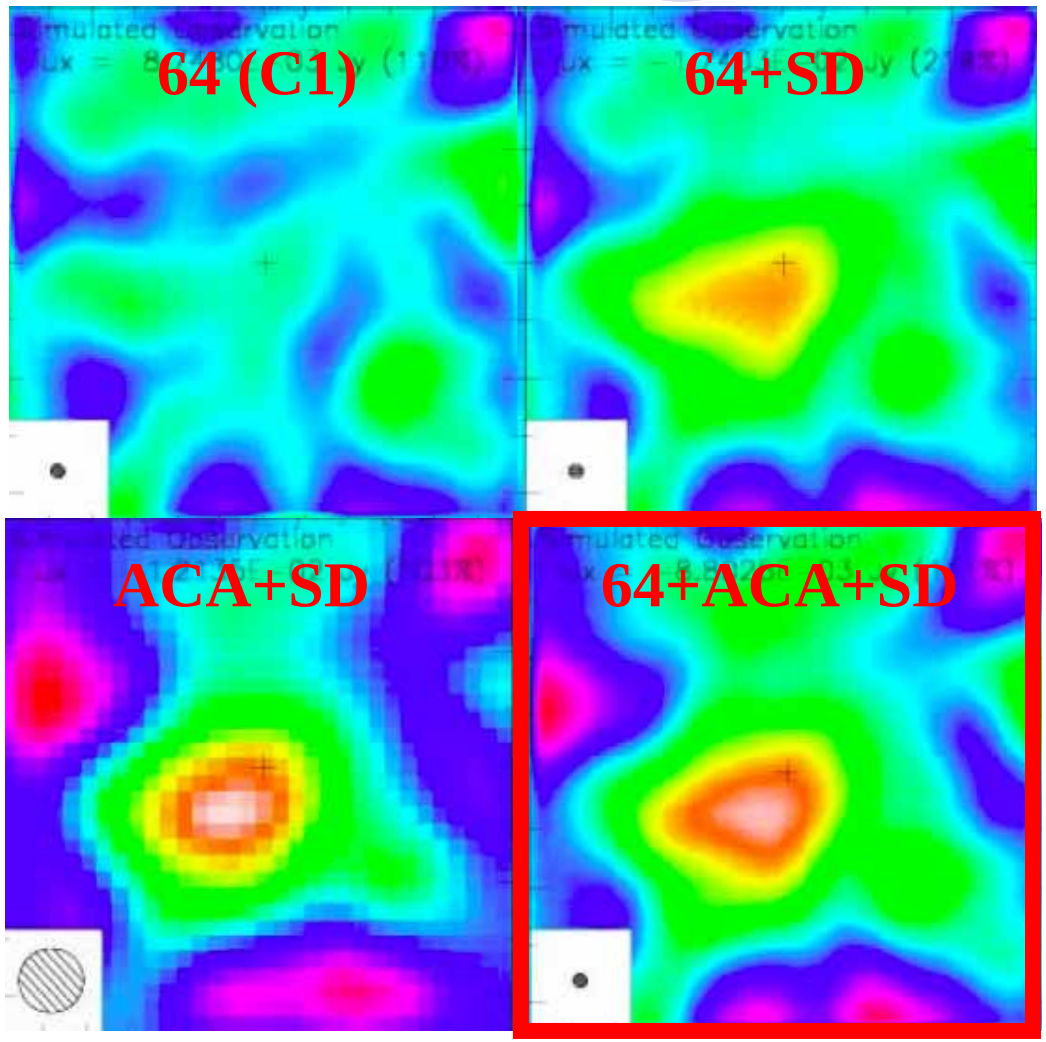
SZ effect
RXJ1347–1145
NRO 150GHz data
(Komatsu et al. 2001)



90 arcsec

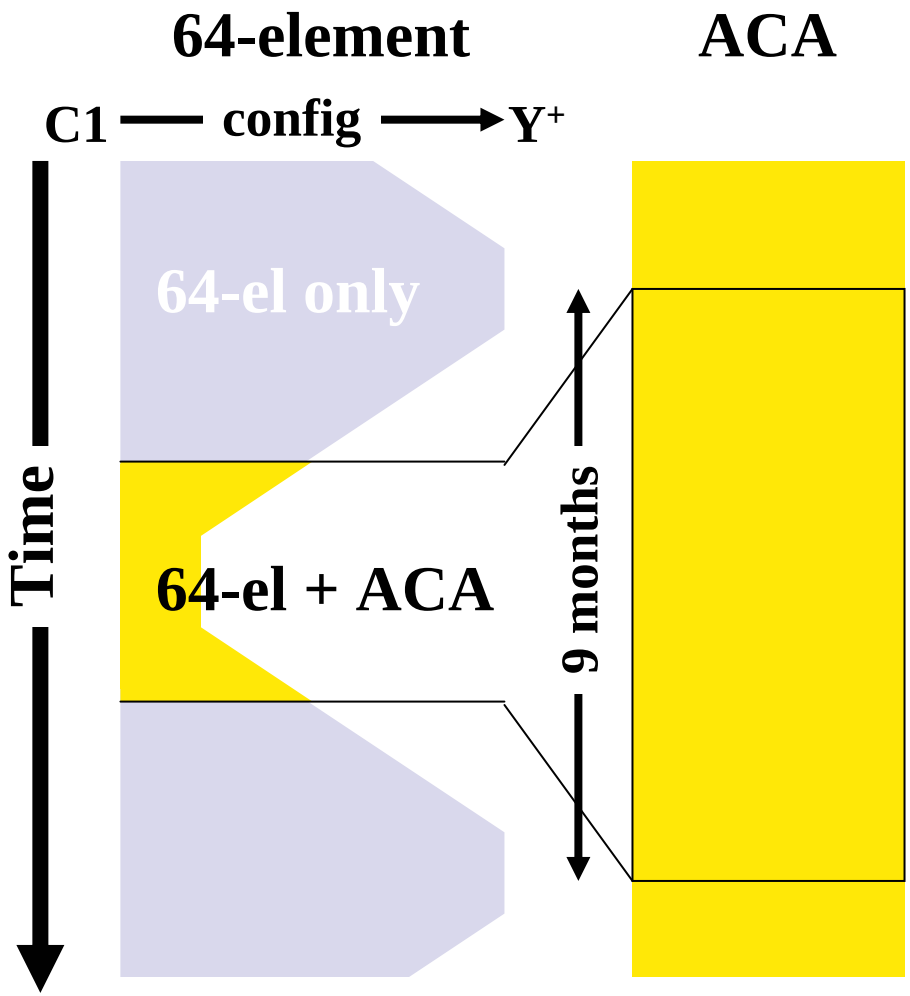
–0.22 mJy/beam

Simulation (Kitayama, Tsutsumi et al.)



13-field mosaic, 18 min (64), 72 min (ACA)

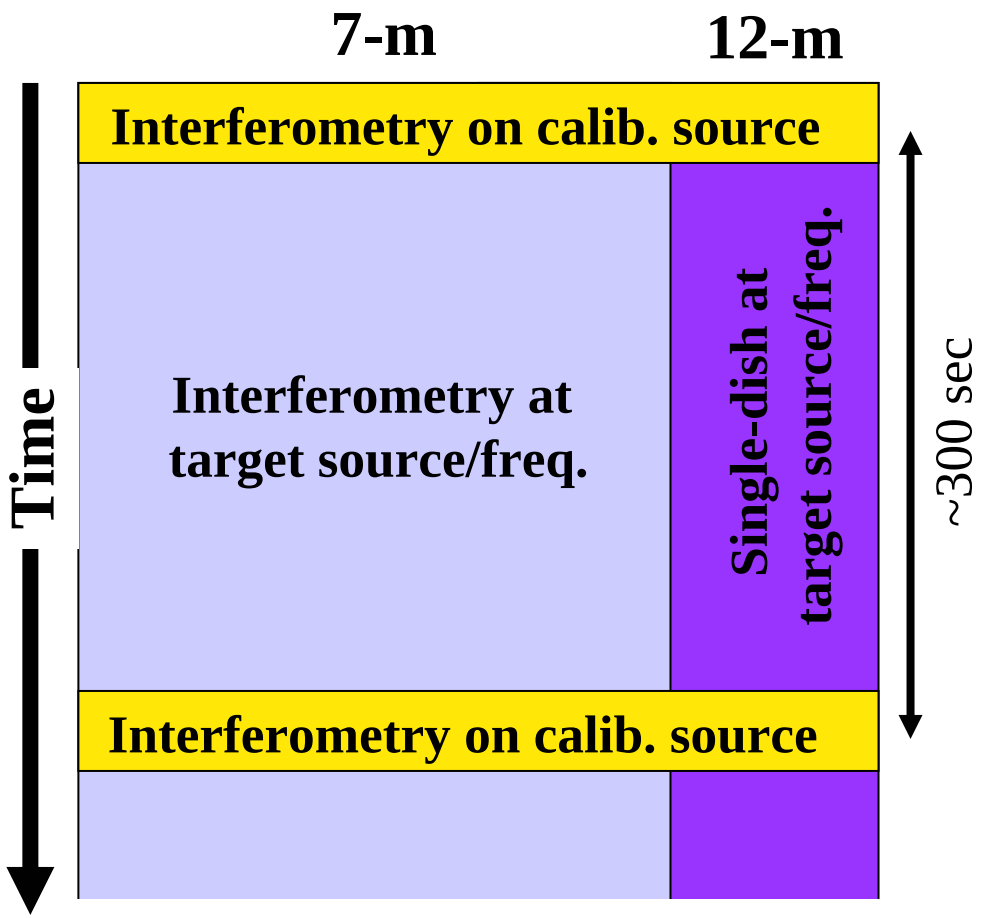
ACA Operation Scenario



Long-term coordination needed

- 64-array executes common program in narrow time window
- But ACA always !
- To minimize the time lag between observations with the two arrays
- Variation of the source
- Observing conditions
- Semesters for CfPs

ACA Operation Scenario



Calibration as "common" mode

- Cal source within <4 deg from target
- Pointing/phase (Band 3)
- Bandpass/relative phase between Bands (less frequent)

7-m interferometry

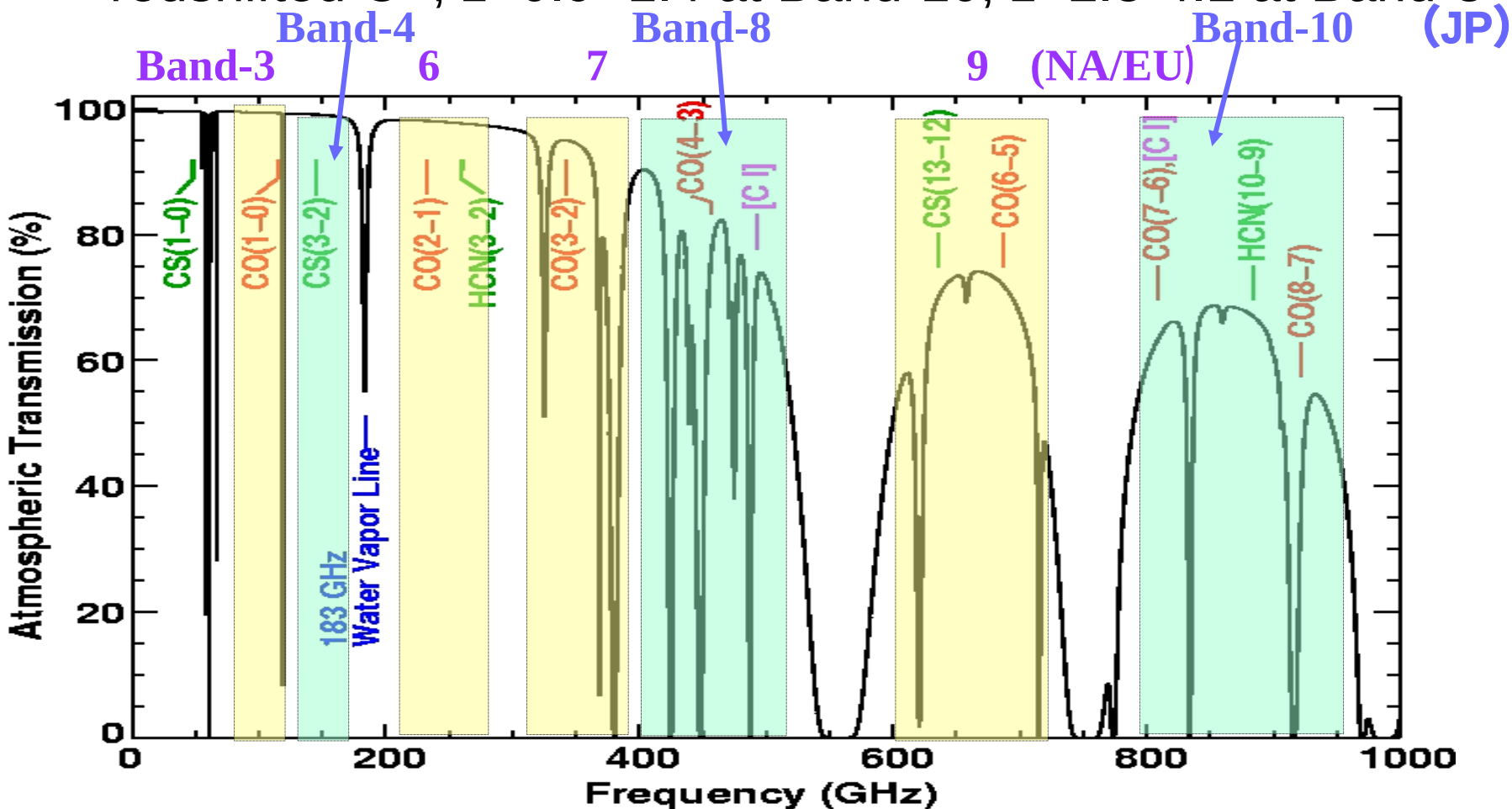
- Multi-field mosaic
- On-the-fly (OTF) mosaic

12-m single-dish

- Beam switching
- On-the-fly (OTF) mapping

New Receiver Bands

- Covers most of Atmospheric windows up to 1 THz
- Highest Freq Band-10 is cutting edge of science
- Neutral Carbon Lines high-J CO at Band-8 & 10
- redshifted C+; z=0.9 -1.4 at Band-10, z=2.8-4.1 at Band-8



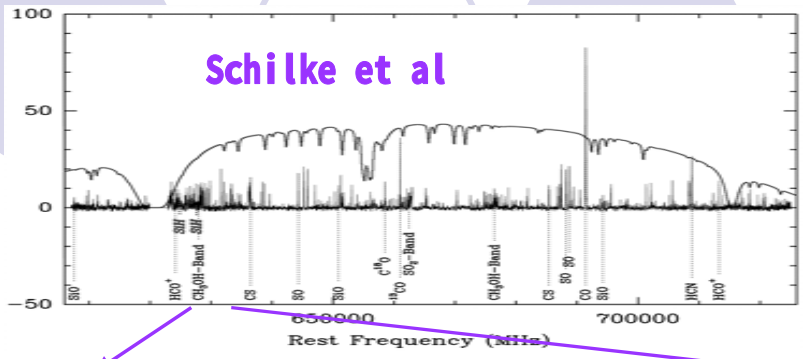
New Receiver Bands

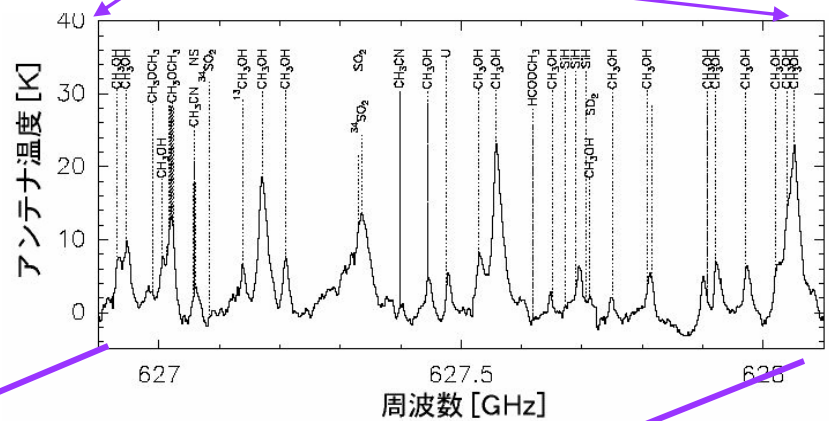
Band	Mixer	IF	Frequency range
Band 4	SIS (2SB)	4 - 8 GHz x 4	RF = 125 - 163* GHz LO = 133 - 155* GHz
Band 8	SIS (2SB)	4 - 8 GHz x 4	RF = 385 - 500 GHz LO = 393 - 492 GHz
Band 10	SIS (DSB) NbTiN or NbN	4 - 12 GHz x 2	RF = 787 - 950 GHz LO = 799 - 938 GHz

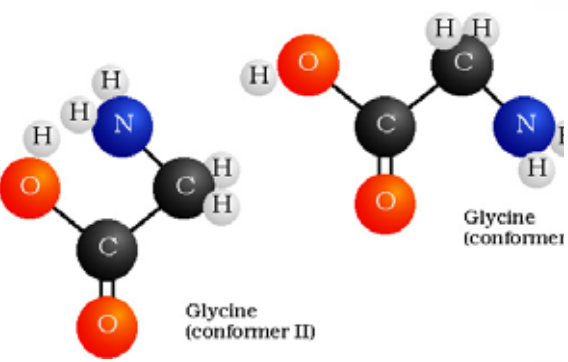
* Informal request to expand to 168.8 GHz received. Feasibility yet to be checked.

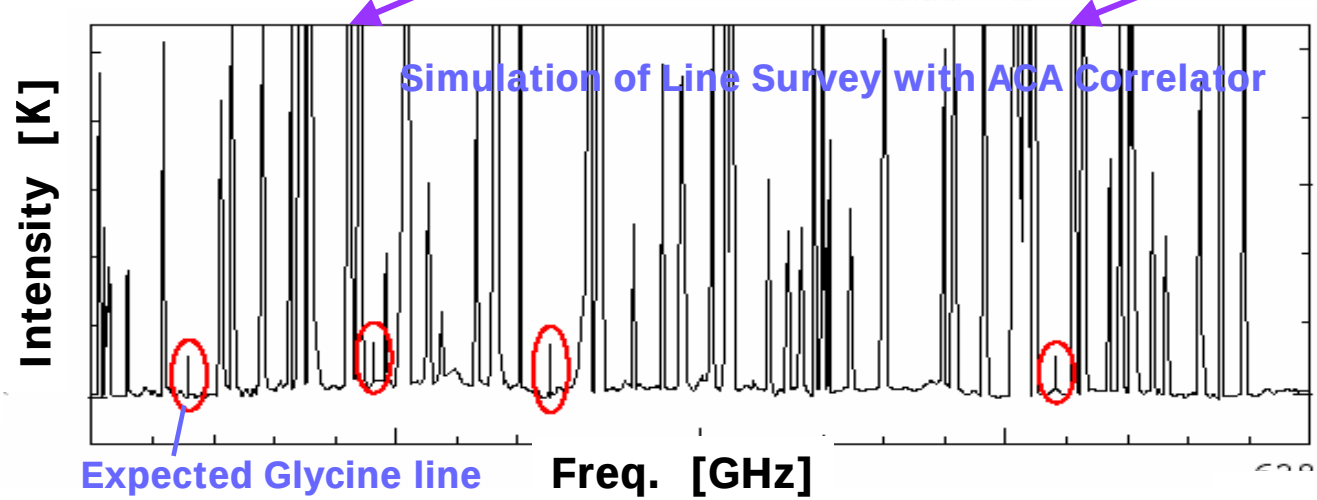
ACA Correlator

- **3-bit FX Correlator**
- Specifications are compatible with the Baseline Correlator with Digital Filter Expansion (eBLC)
  - 2GHz x 8 IF /baseline
  - 4096 ch. for each 2GHz









Proposed Milestones

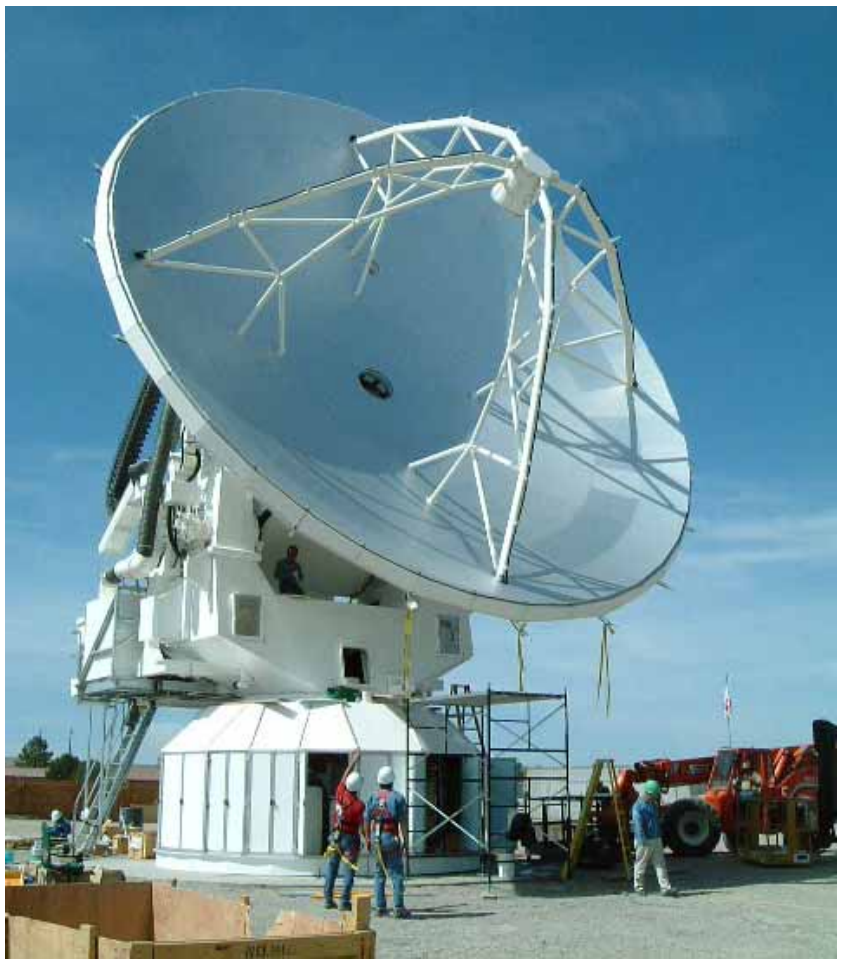
- Q4 2006 First ACA 12-m Antenna equipped with Initial Front End Subsystem available at OSF
- Q2 2007 ACA Correlator available at AOS
- Q3 2007 Start Early Science Observations with an ACA 12-m Antenna in single-dish mode
- Q3 2009 Start Early Science Observations with the ACA System (including about half of 7m antennas)
- Q4 2011 Installation of Japanese Cartridges in all antennas complete
- Q1 2012 Start ACA Full Science Operation

Other Progress

- Negotiation with ASIAA in Taiwan
  face-to-face meeting at Tokyo on Sep. 2004
  Basic Scheme Similar to that in US/Canada
  Possible contribution Items by ASIAA etc.
    being discussed (not add new items)

- Prototyping of Antenna been performed
- Pre-production of FE cartridges is underway

ACA System: 12m Prototype Antenna



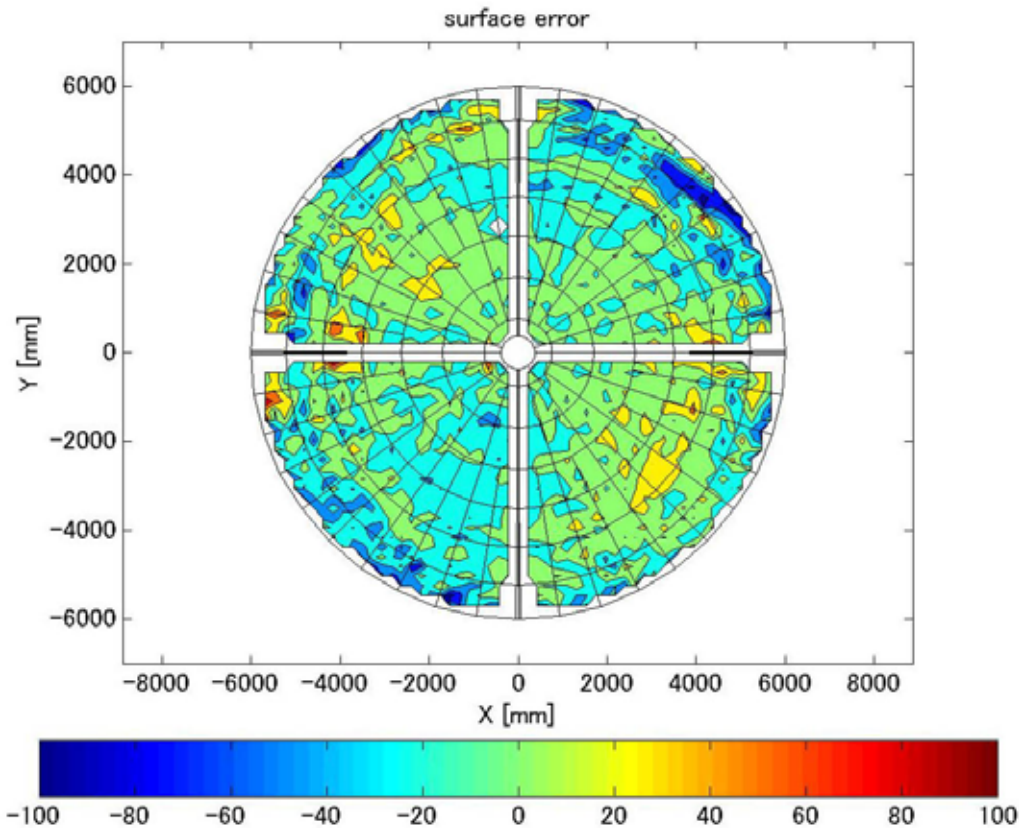
- Report of Prototype antenna Evaluation at Socorro will be completed soon
- The evaluation shows that the ALMA-J prototype antenna meets mostly the ALMA specification

Surface Accracy

- Measured surface error: after 3 sets of surface panel adjustments (< 6 hours/measurement)

20 μm in rms

(−12dB weight at edge)

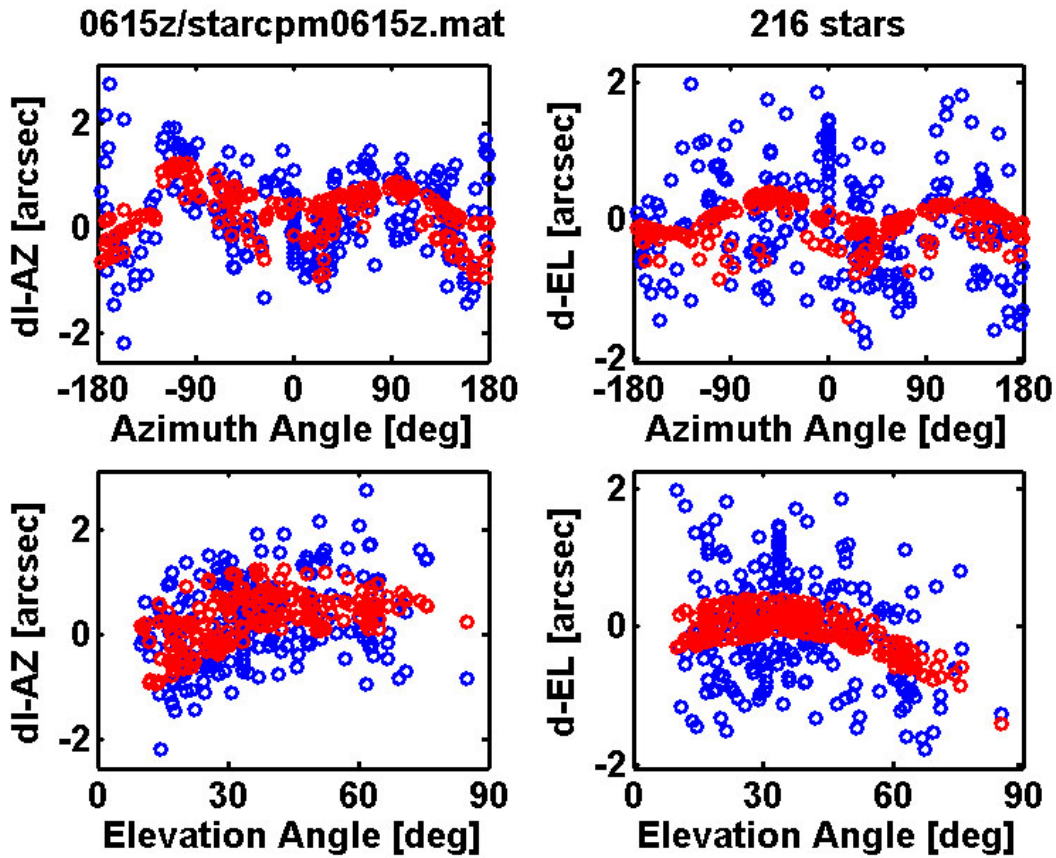


Pointing

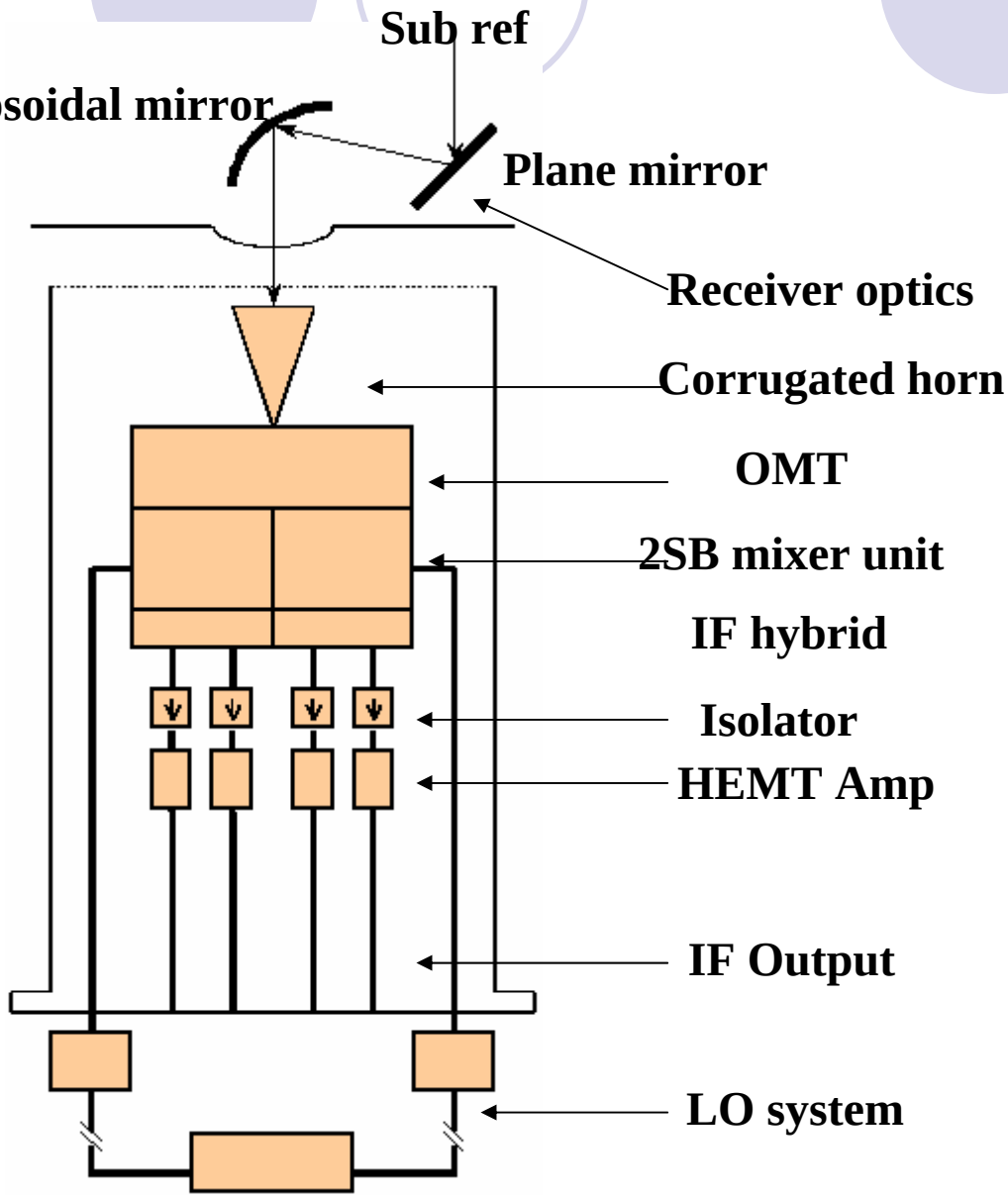
- All Sky Pointing: Absolute Pointing
  =1”.1 (< ALAM spec of 2”.0)
  (dAz =0”.8, dEl= 0”.8)

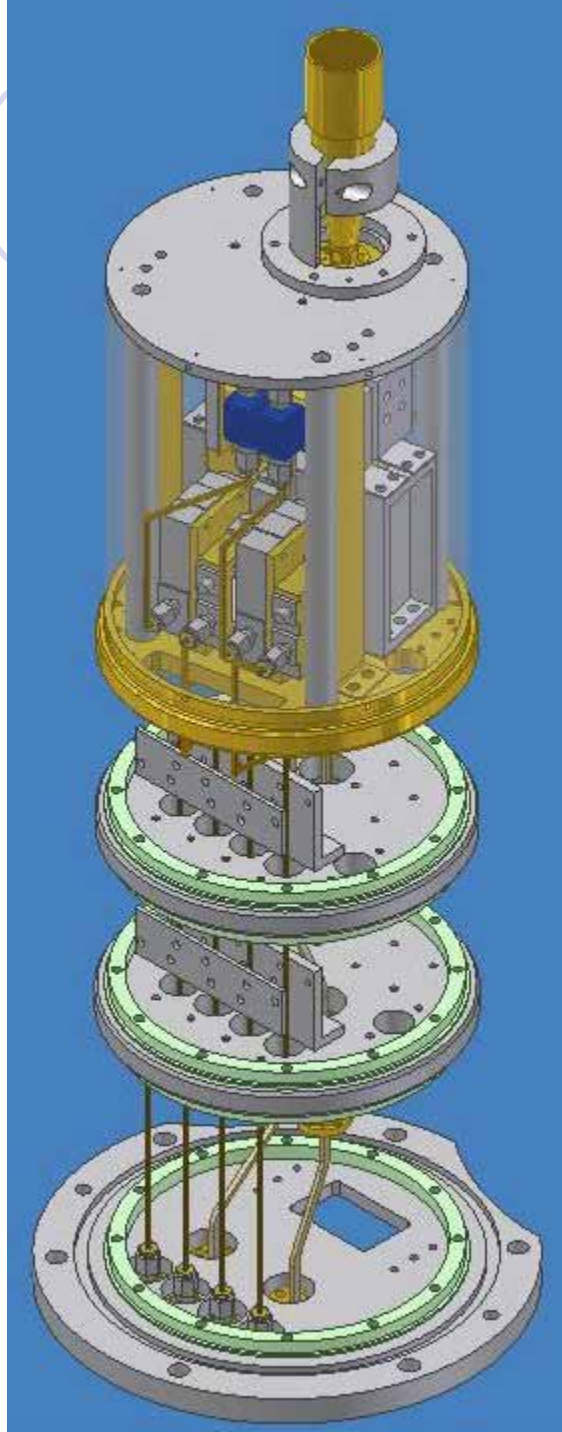
- Detailded analysis is on going;e.g., Time variation of Pointing Model parameters

Blue: observed points
Red: fitted model function

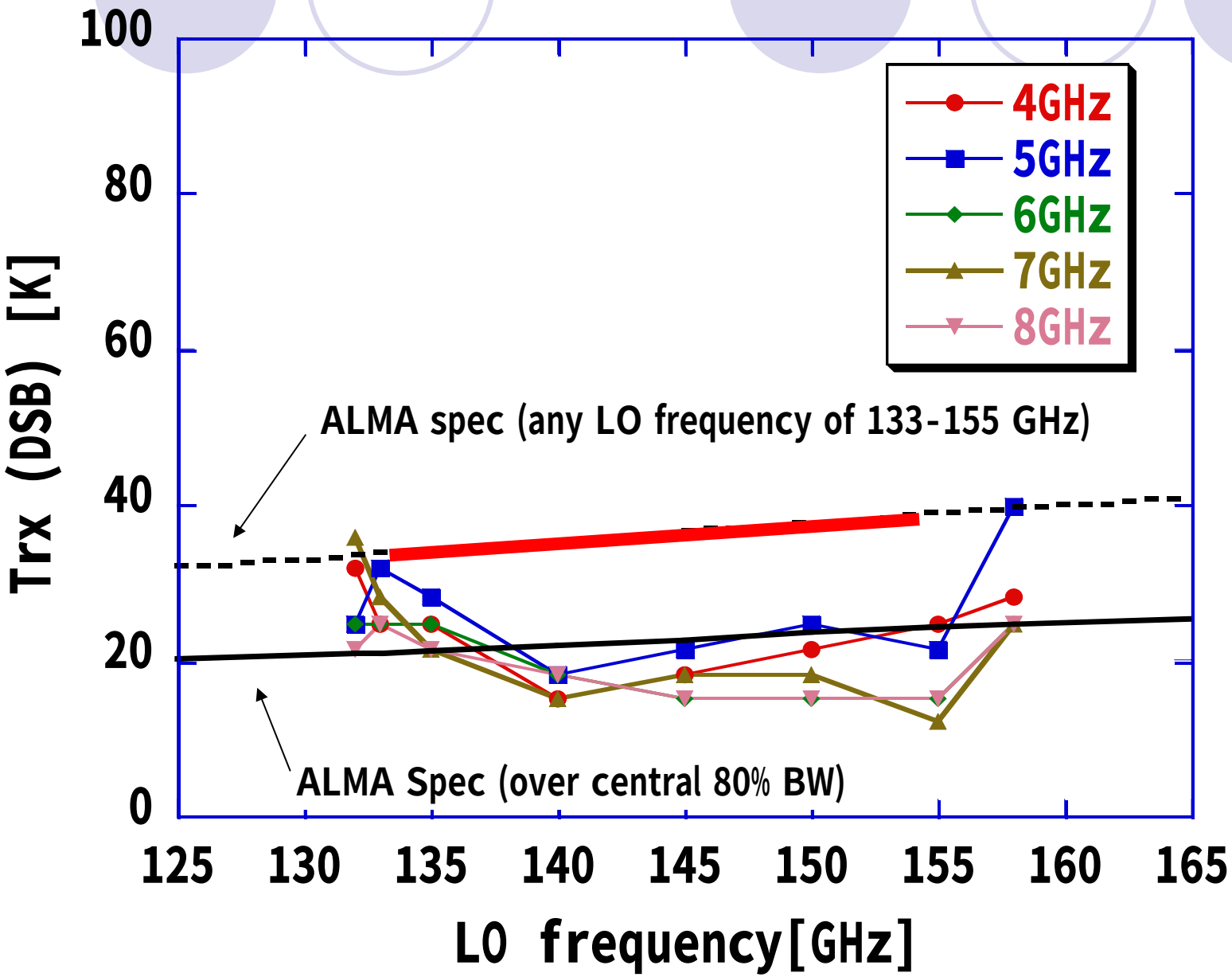


Band 4 Cartridge (2SB)
Qualification Model Design For Pre-Production

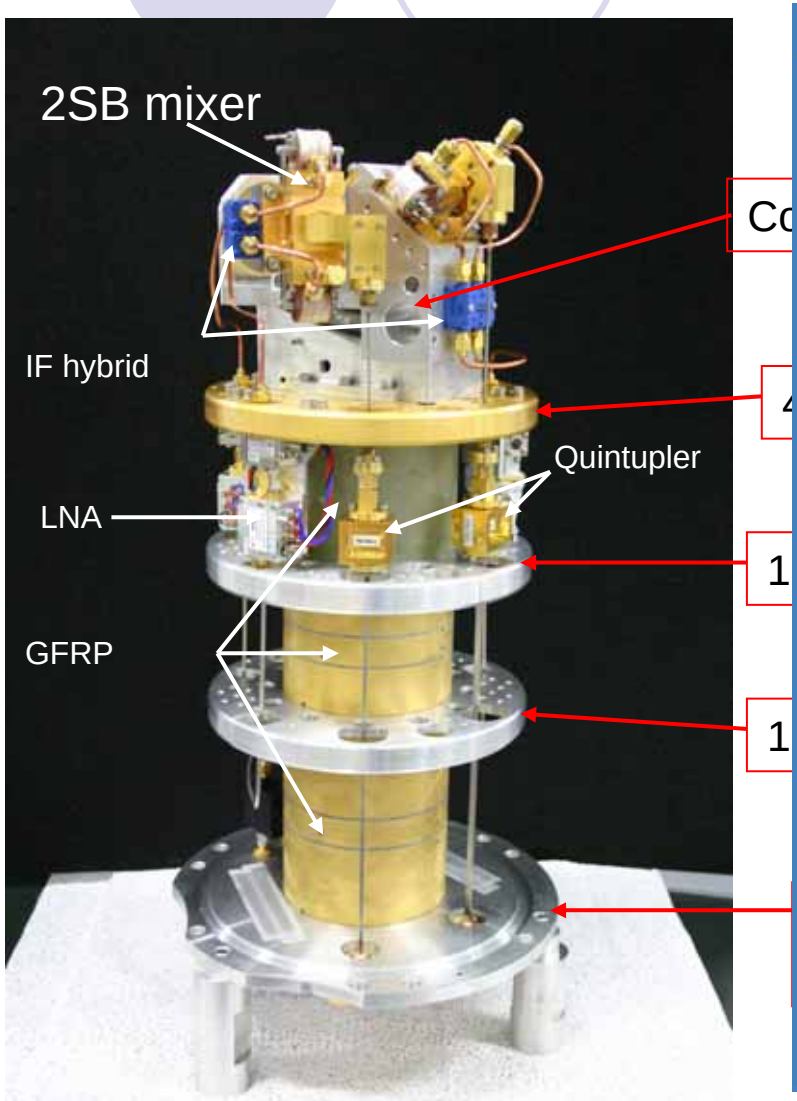


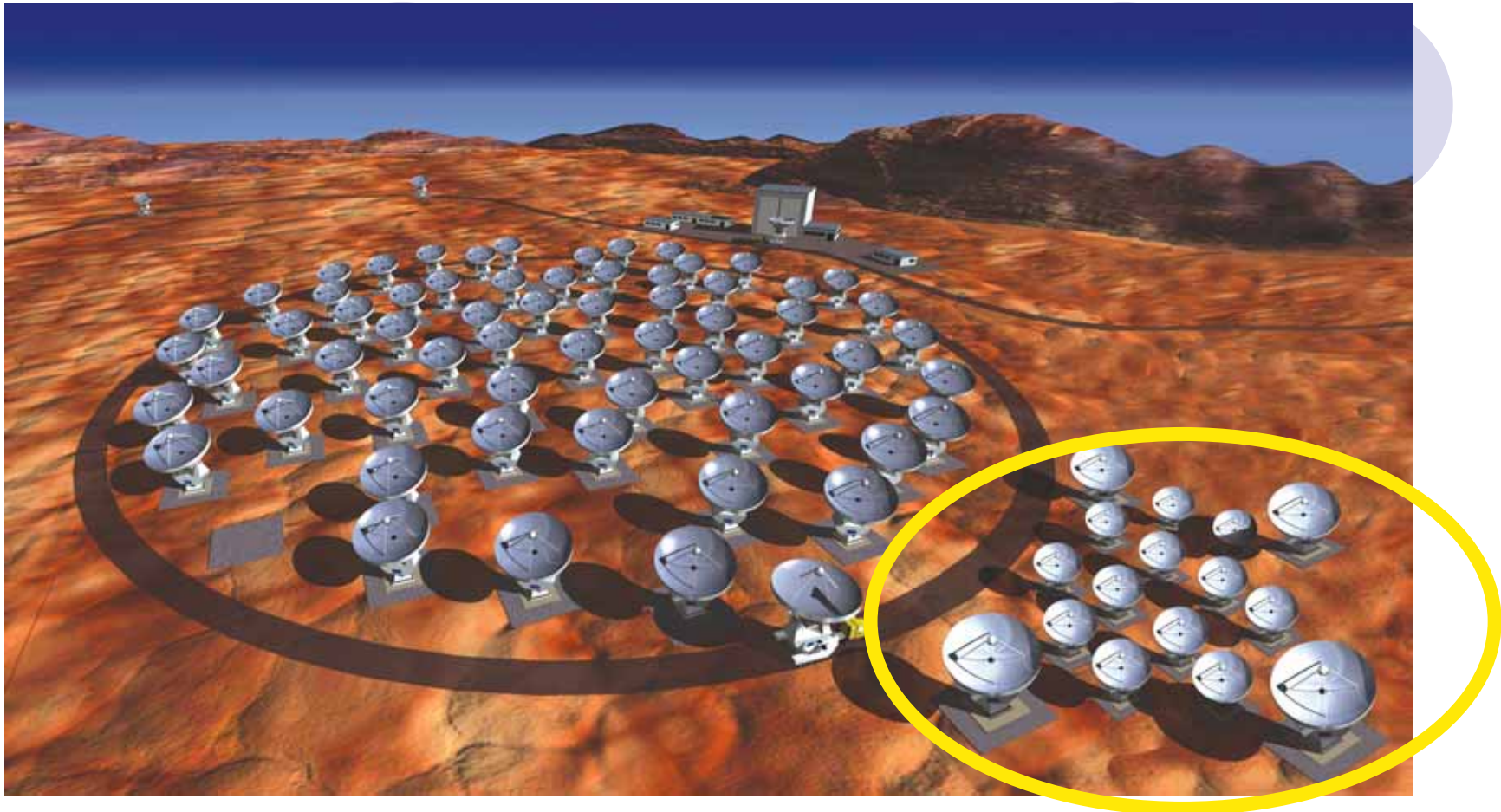


Band4 Cartridge results with DSB mixer



Band 8 Cartridge





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