SOLAR OBSERVATIONS WITH ALMA

DESCRIPTIONS FOR “CALL FOR PROPOSAL" OF CYCLE4

DATE 2016-03-29@ NAOJ

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Today's topics

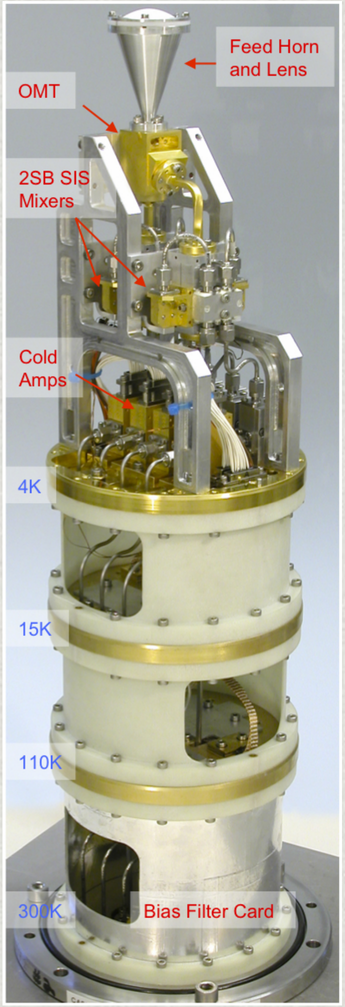
- Brief Introduction of Atacama Large mm/sub-mm Array (ALMA)
- Advantage & disadvantage of an interferometer observation
  - *What we can get, and what we cannot get?*
- Observing parameters for solar observations in Cycle 4
  - *What kinds of observing modes are available in Cycle 4?*
- Dress-Rehearsal of solar observations in Cycle 4
  - *Preliminary Results of ALMA solar development campaign 2015.*

Atacama Large Millimeter/sub-millimeter Array (ALMA)

- ALMA is the largest millimeter/sub-millimeter array in the world, constructed from 54 12m-antennas and 12 7m-antennas.
- Observing Frequency: 84 GHz ~ 950 GHz (Wavelength: 0.3 ~ 3.6 mm)
- Longest Baseline: 150 m ~ 16 km (The array configuration is changing at all times.)

Receivers of ALMA

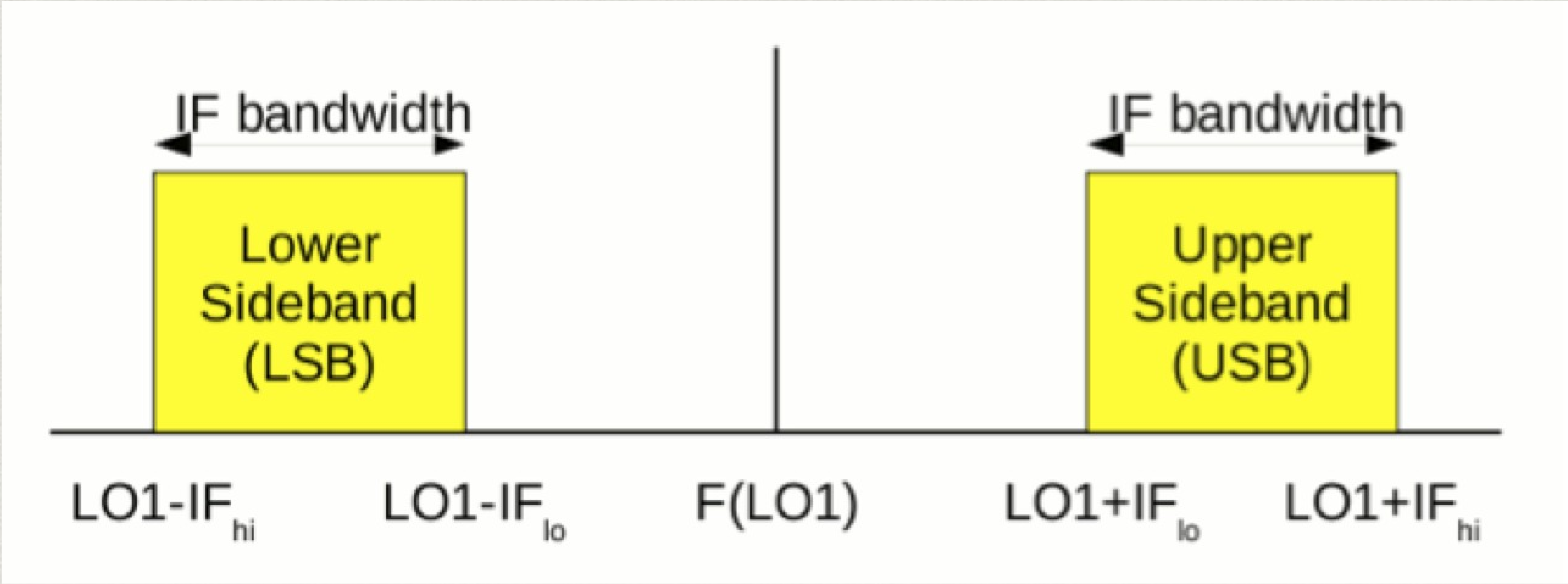
- The antenna of ALMA has 7 observing bands (receivers).
  - Band 3:   84 – 116 GHz   *   3.75 – 2.59 mm
  - Band 4:   125 – 163 GHz   *   2.40 – 1.83 mm
  - Band 6:   211 – 275 GHz   *   1.42 – 1.09 mm
  - Band 7:   274 – 373 GHz   *   1.09 – 0.80 mm
  - Band 8:   385 – 500 GHz   *   0.78 – 0.60 mm
  - Band 9:   602 – 720 GHz   0.50 – 0.43 mm
  - Band 10: 787 – 950 GHz   0.38 – 0.32 mm



Band3 receiver

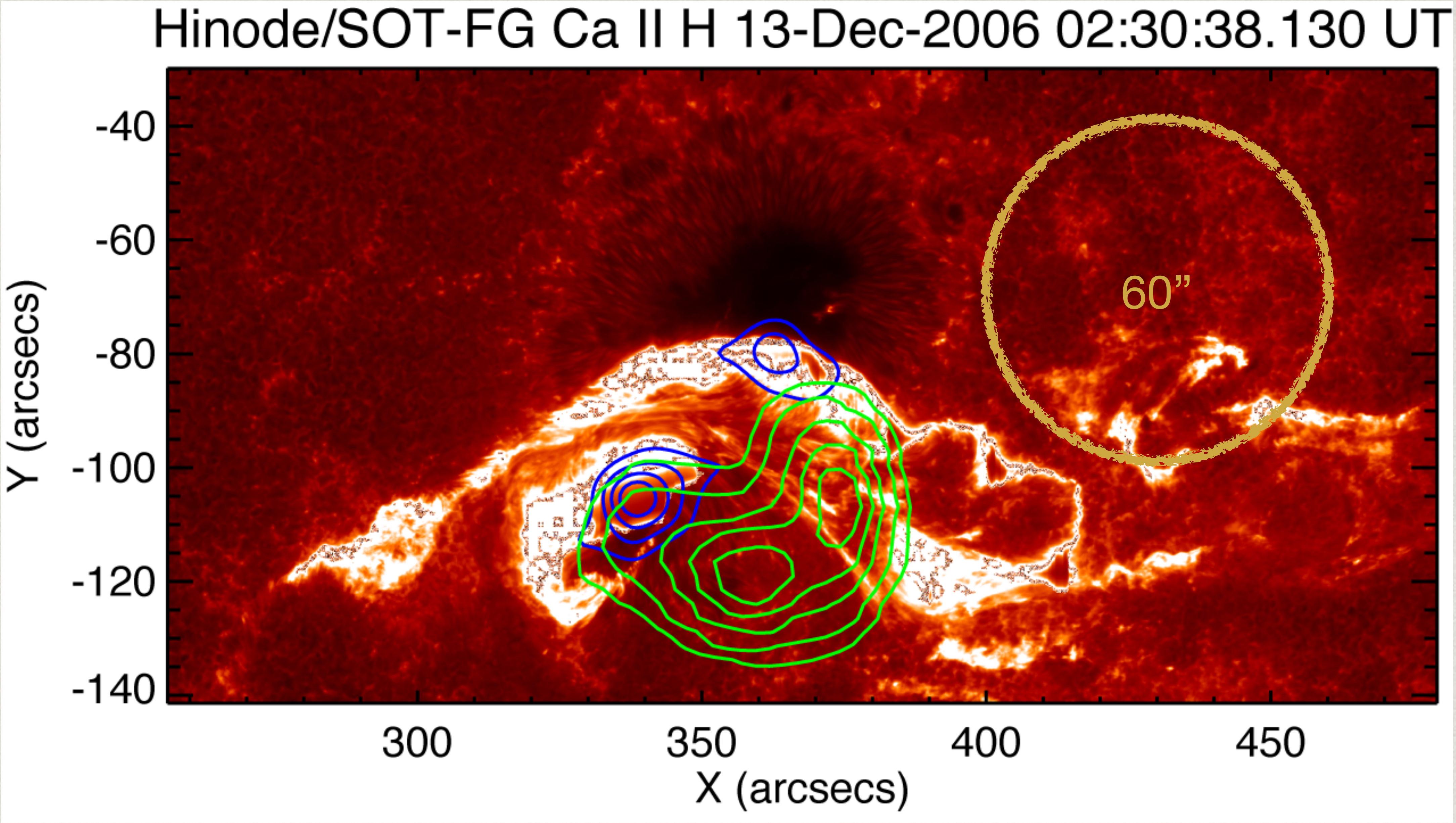
- Asterisks indicate that the receiver (band) can observe 4 frequency ranges in the band (Width of each range is 2 GHz) simultaneously. Band 9 /10 can observe 2 frequency ranges simultaneously.
- Each band has the function of measuring two linear polarizations (X, Y)
  - The full stokes information can be derived from the correlations (XX, YY, XY, YX) with all bands, ***ideally***.
- Although the observing band can be changed within a few minutes if we neglect the changing of focus and pointing, the change of the band is not permitted in one observation (one Scheduling Block: SB).

Setting of observing frequencies for standard observations (for non-solar)



- LO1 can be changed freely within the frequency range of the receivers.
- In each sideband (Bandwidth of one sideband is 4 GHz@Band3 / 5 GHz@Band6), PI can select two spectrum windows (for LSB, SPW#1 and SPW#2 / for USB, SPW#3 and SPW#4).
- PI can select the frequency range of each spectrum window and number of channels from the provided options. (Most high spectral resolution is 15.3 kHz / 3840 ch in 58.6 MHz bandwidth).
- The continue mode is called Time Domain Mode(TDM). In the case, the bandwidth, and number of channels are 2 GHz and 128 ch for each polarization and each BB (15.6 MHz = 45km/s@Band3, 20km/s@Band6).

ALMA's Field of View



- The FoV of an interferometer is limited by the size of dish, *basically*.
  The size of FoV < HalfPowerBeamWidth(HPBW) = 1.02 x [Wavelength] / [Dish size]
  - < 60"@Band3 (100GHz) / < 25"@Band6 (230GHz)
- MOSAIC (scanning) observations is for large FoV.

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  - *Preliminary Results of ALMA solar development campaign 2015.*
- Before the call for proposal of Cycle 4….
  - *Scientific Verification (SV) data is useful for your studies.*
- One strategy for the call for proposal of Cycle 4

An radio interferometer measures the coefficient of the Fourier series that indicates the brightness distribution of sky.

- One pair of two antennas (baseline) measure one Fourier (complex) coefficient (visibility).
    - Since a visibility is a complex value, it has amplitude and phase using Euler's formula. (Amplitude & Phase Calibration….)
- When there is N antennas, the number of the coefficient obtained from the antennas is $N(N-1)/2$.
    - Above sentence is correct when the antennas are located randomly. Since the antennas of Nobeyama Radioheliograph are distributed linearly, the number of the obtained coefficient is not $N(N-1)/2$.
- The Fourier coefficients are derived from the cross-correlation coefficients between the signals from two antennas.
    - When the auto-correlation coefficients are derived from the signals, we can obtain the spectrum of the radio sources too.

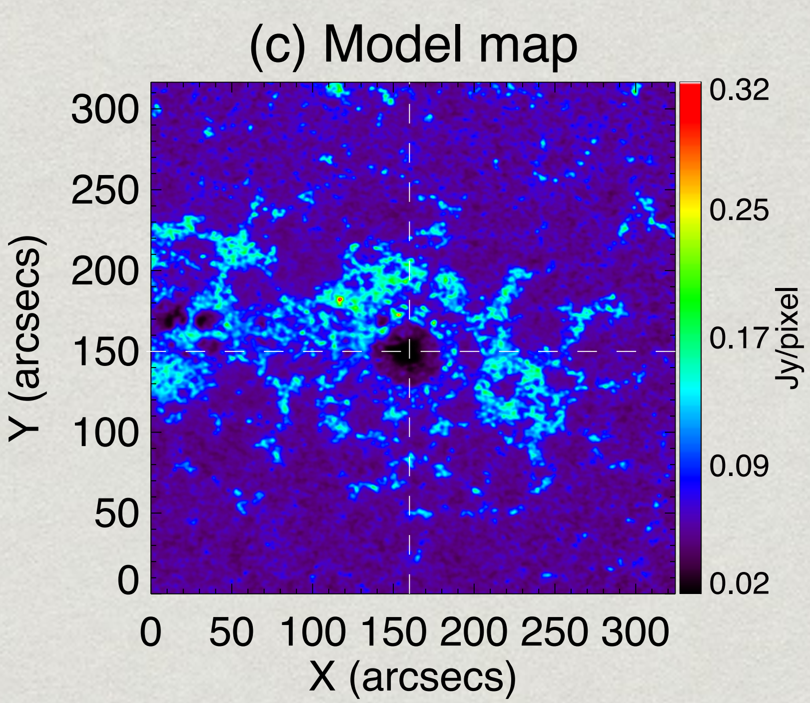
Purple words indicate the jargons in the community of radio astronomy.

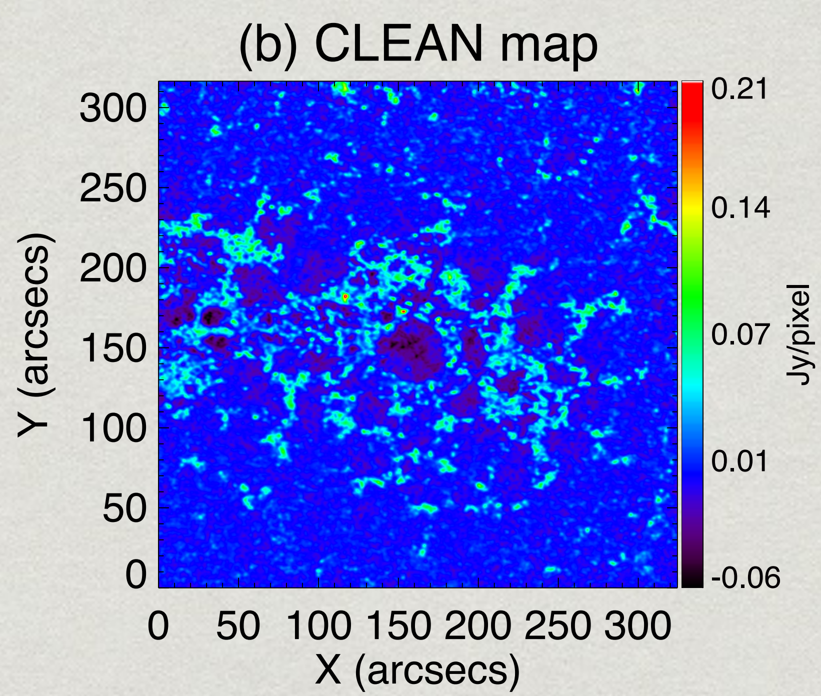
Advantage & disadvantage of an radio interferometer

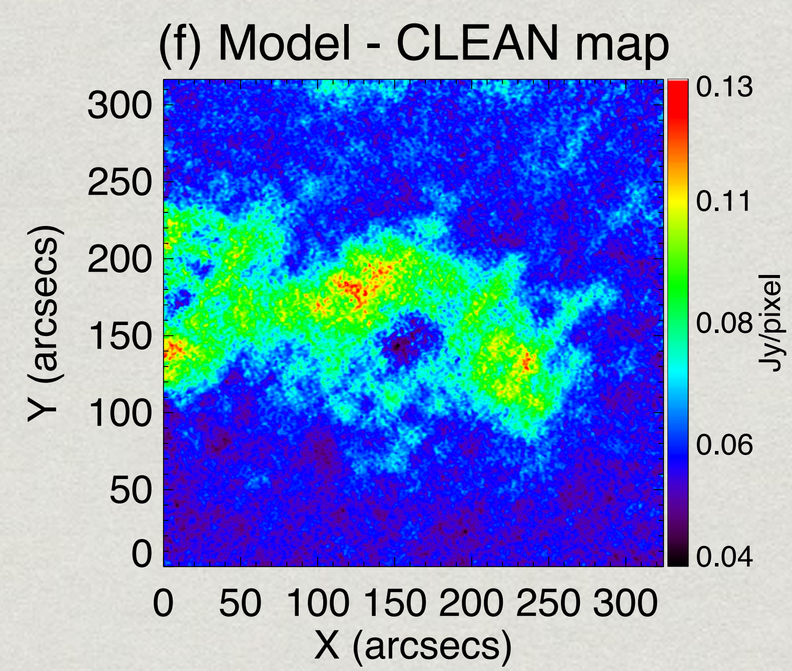
- Advantages
  - Obtain radio images with **ultra-high spatial resolution** without a huge antenna (mirror).
  - Obtain radio spectrum data **simultaneously**.
- Disadvantages
  - PSF (synthesized beam) has many ripples.
  - Absolute flux cannot be derived from interferometric data fundamentally.
    - When the spatial frequency of a brightness variation corresponds with the Fourier coefficient that is not in data, the variation does not appear in a synthesized image (resolve-out).

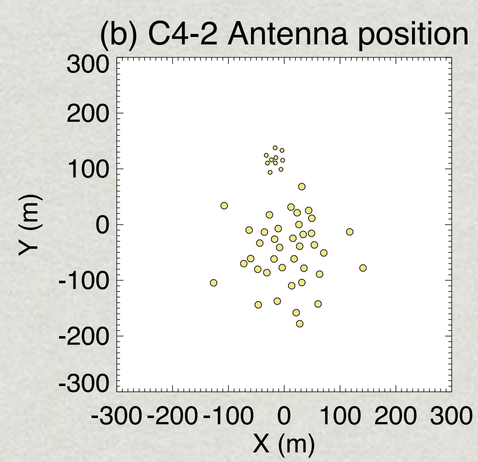
Resolve-out in solar observations
(Investigated by Miyawaki-san [Ibaraki-U])

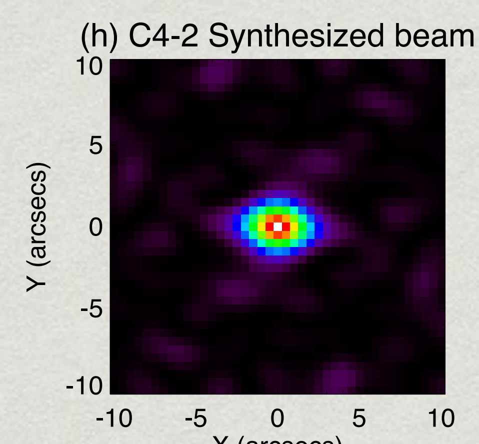
- Miyawaki-san simulated the solar MOSAIC observations with ALMA-Band3 using the ALMA simulator of CASA and AIA images.











FWHM of Beam
3.29” x 2.34”

How do we recover the disadvantages?

- All disadvantages are caused by the lack of Fourier coefficients.
  - Fundamental solution: Increasing the number of antennas! ➜❌
- Ripples of PSF
  - CLEAN process (Deconvolution Process)
  - Earth-Rotation Synthesis Mapping
- Resolve-out
  - Observe the target with multiple antenna configurations
  - Combine the data of the interferometric and single-dish observations.

Example of CLEAN process (A flare observed by SSRT)

SSRT Synthesized beam

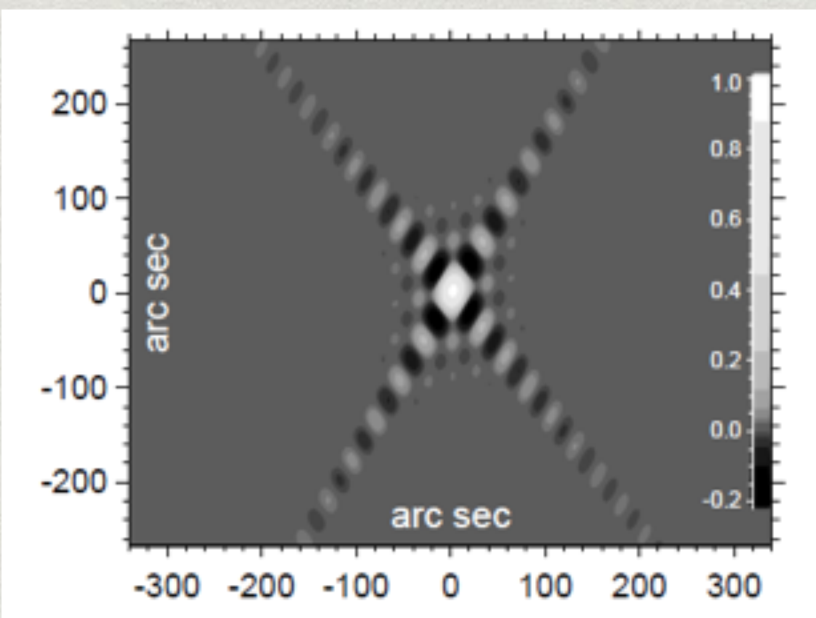
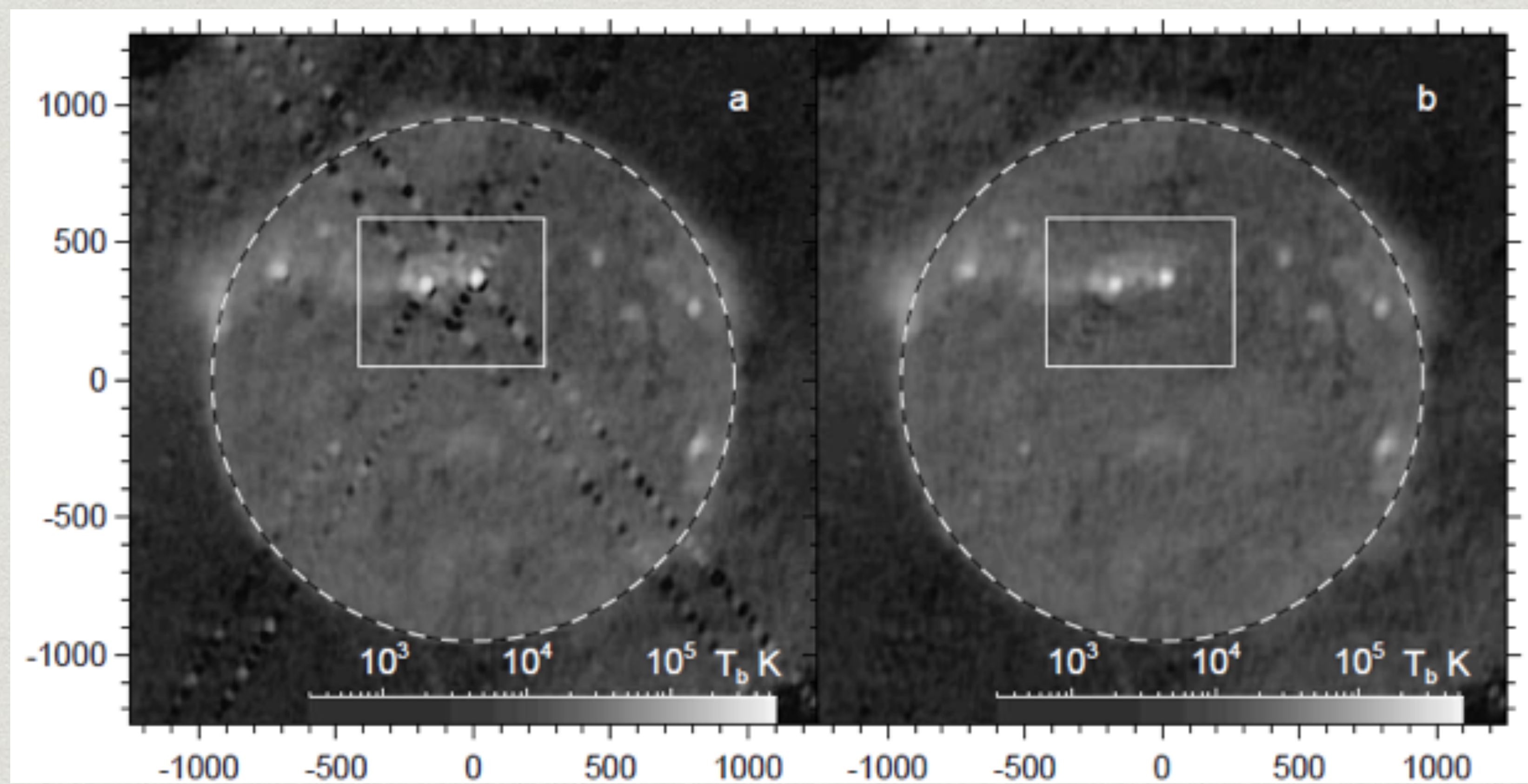


Fig. 3. The SSRT PSF used as an input for the deconvolution process. The observation time and field of view correspond to those in Figure 2c, d.

Before CLEAN | After CLEAN



Kochanov et al. 2013

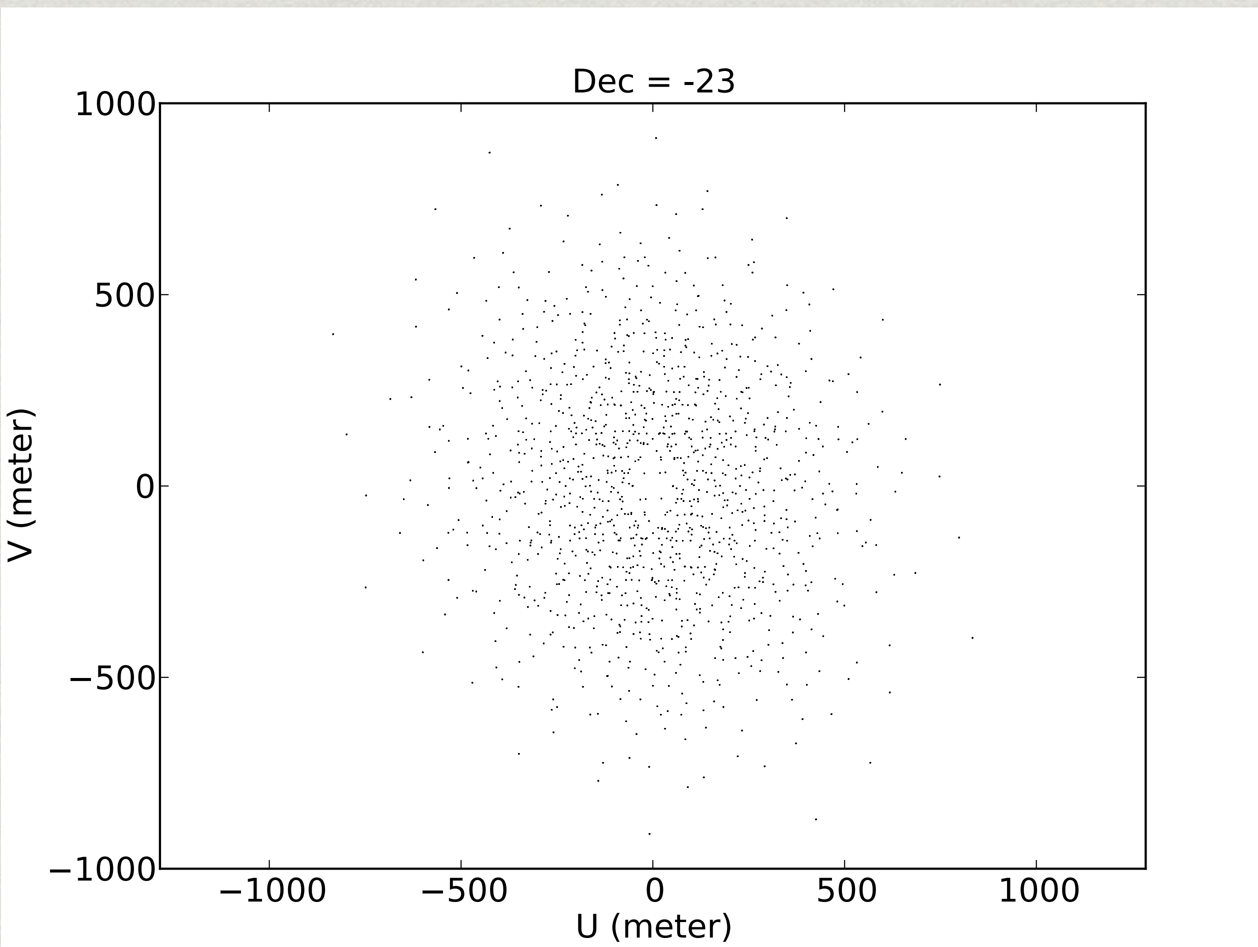
Issue of CLEAN process

(Clark 1982)

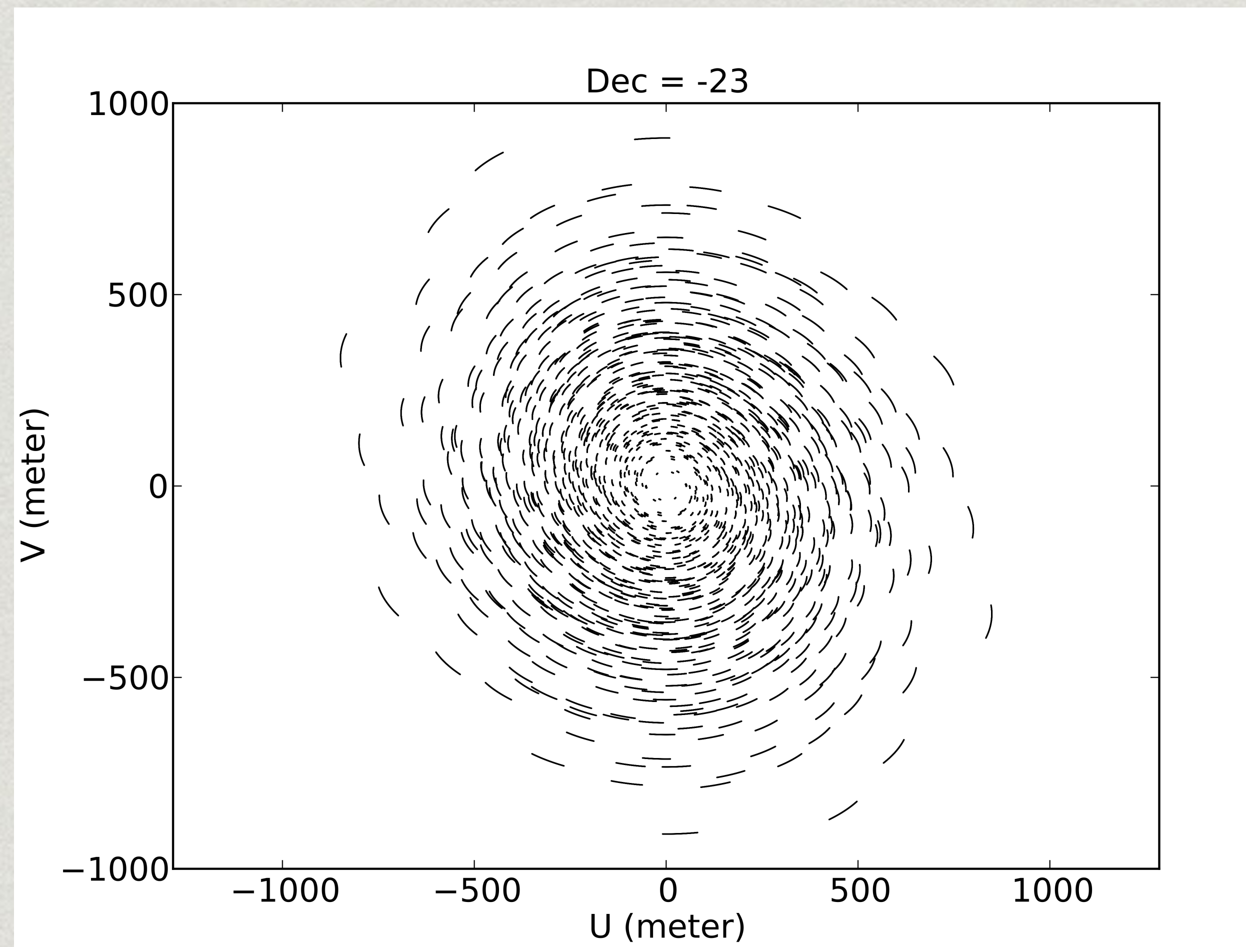
- When CLEAN process is applied to a large structure, the artificial pattern appears as in above image.
  - Solutions
    - Steer-CLEAN (“koshix” synthesizing program of NoRH)
    - Multi-Scale CLEAN (“msclean" option of the CLEAN task of CASA)

Earth-rotation Synthesis mapping (Super-Synthesis)

1 min observations



1 hour observations



Earth-rotation Synthesis mapping (Super-Synthesis)

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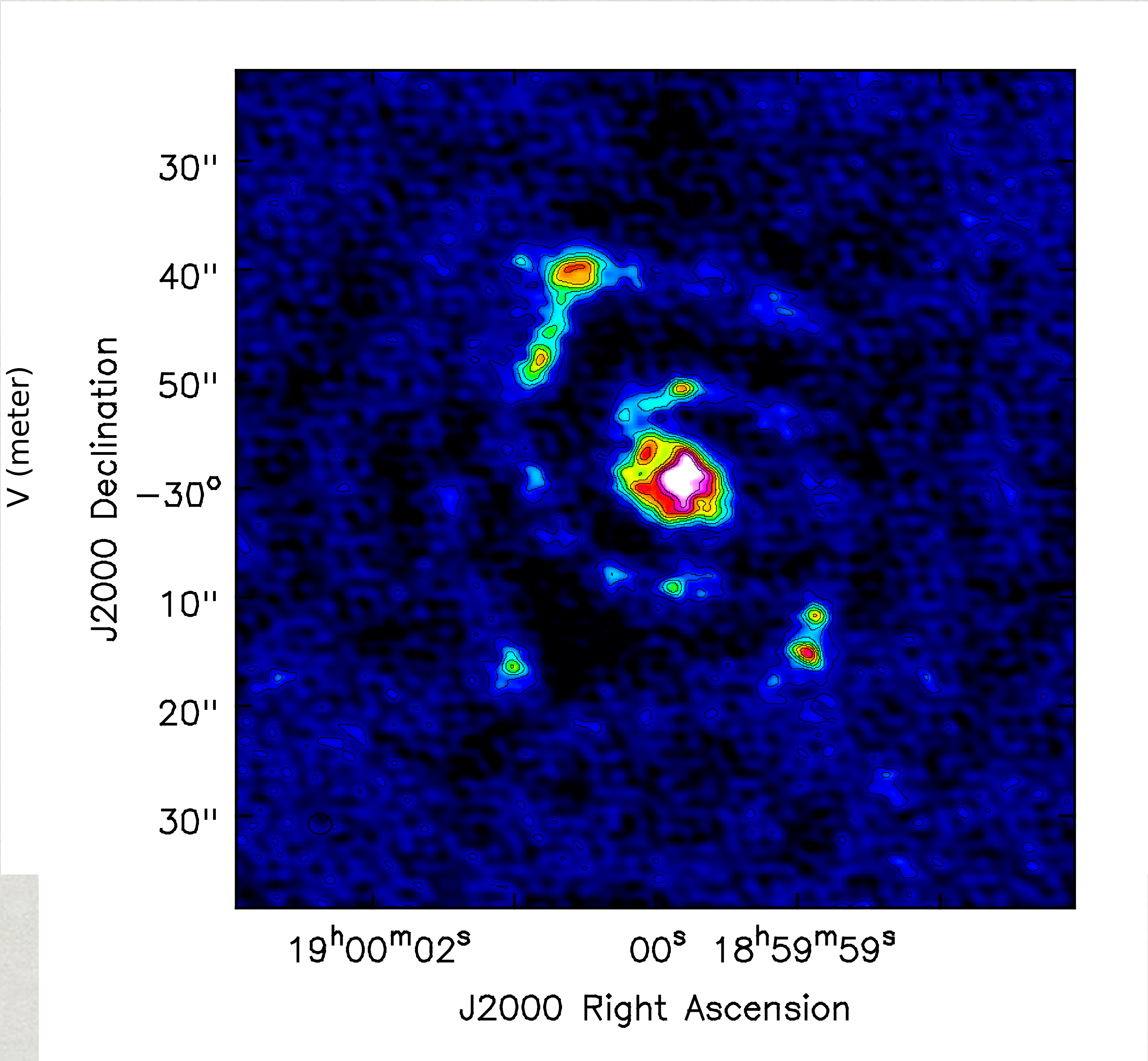

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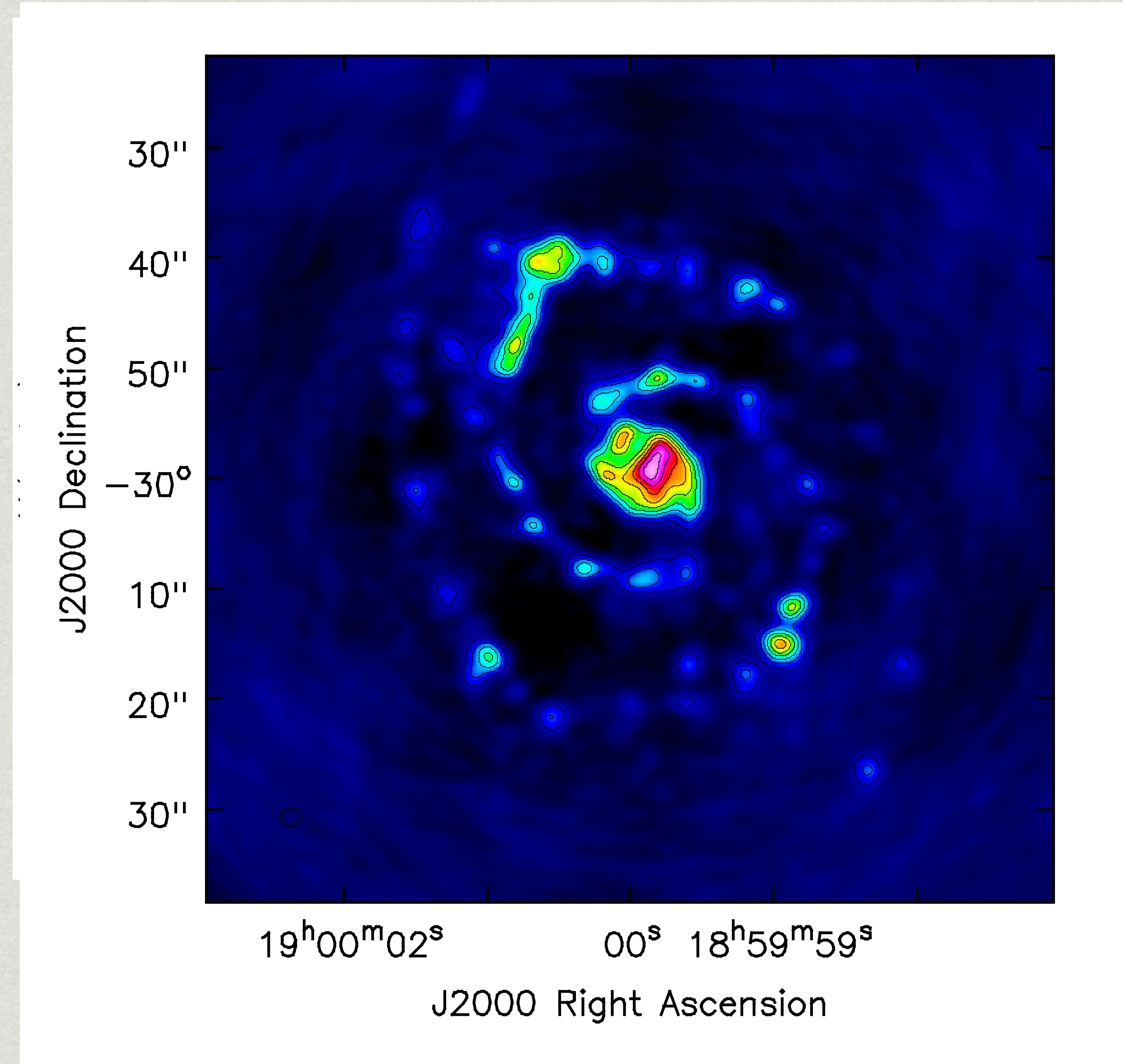


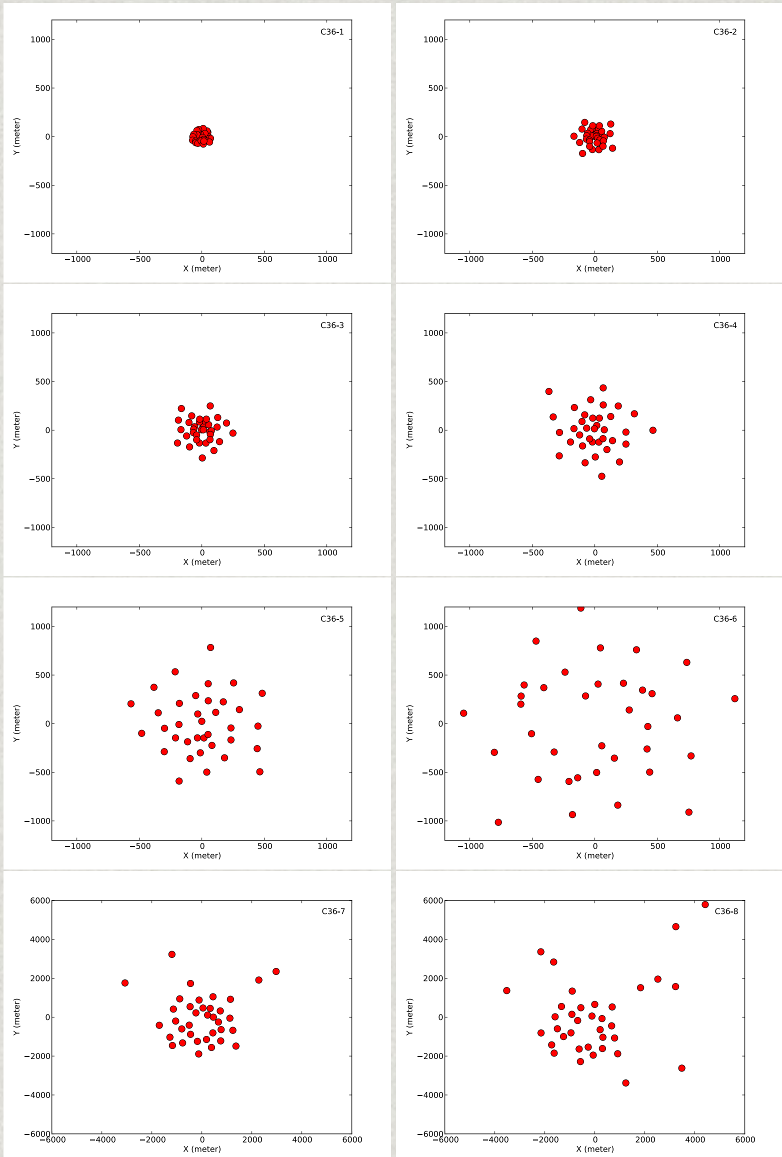
Solution of "resolve-out":1

Observe the target with multiple antenna configurations

- ALMA prepared the 7m-array of the Atacama Compact Array (a.k.a. Morita-array) for short baselines.

Solution of “resolve-out”:1
Observe the target with multiple antenna configurations 2

- Array configuration of ALMA is changing in everyday.



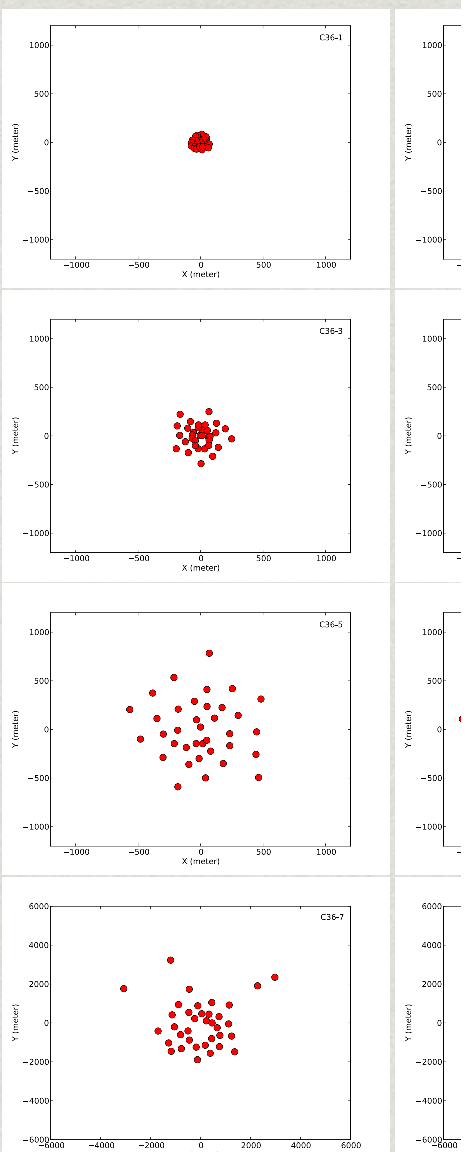
Combination of Array Configurations for Band3

θ_{res} (arcsec)	θ_{LAS} (arcsec)	Array combination	Time ratios	Total Time
0.075	< 1.1	C36-8	1	$1.0 \times \Delta_{extended}$
0.075	> 1.1	-	-	-
0.1	< 1.5	C36-7	1	$1.0 \times \Delta_{extended}$
0.1	> 1.5	-	-	-
0.3	< 4.8	C36-6	1	$1.0 \times \Delta_{extended}$
0.3	4.8-25.2	C36-6 + C36-3	1 : 0.5	$1.5 \times \Delta_{extended}$
0.3	25.2-42.8	C36-6 + C36-3 + 7-m	1 : 0.5 : 2	$3.5 \times \Delta_{extended}$
0.3	> 42.8	C36-6 + C36-3 + 7-m + TP	1 : 0.5 : 2 : 4	$5.5 \times \Delta_{extended}$
0.5	< 7.8	C36-5	1	$1.0 \times \Delta_{extended}$
0.5	7.8-25.2	C36-5 + C36-2	1 : 0.5	$1.5 \times \Delta_{extended}$
0.5	25.2-42.8	C36-5 + C36-2 + 7-m	1 : 0.5 : 2	$3.5 \times \Delta_{extended}$
0.5	> 42.8	C36-5 + C36-2 + 7-m + TP	1 : 0.5 : 2 : 4	$5.5 \times \Delta_{extended}$
0.7	< 9.6	C36-4	1	$1.0 \times \Delta_{extended}$
0.7	9.6-25.3	C36-4 + C36-1	1 : 0.5	$1.5 \times \Delta_{extended}$
0.7	25.3-42.8	C36-4 + C36-1 + 7-m	1 : 0.5 : 2	$3.5 \times \Delta_{extended}$
0.7	> 42.8	C36-4 + C36-1 + 7-m + TP	1 : 0.5 : 2 : 4	$5.5 \times \Delta_{extended}$
1.2	< 25.2	C36-3	1	$1.0 \times \Delta_{extended}$
1.2	25.2-42.8	C36-3 + 7-m	1 : 2	$3.0 \times \Delta_{extended}$
1.2	> 42.8	C36-3 + 7-m + TP	1 : 2 : 4	$5.0 \times \Delta_{extended}$
1.8	< 25.2	C36-2	1	$1.0 \times \Delta_{extended}$
1.8	25.2-42.8	C36-2 + 7-m	1 : 2	$3.0 \times \Delta_{extended}$
1.8	> 42.8	C36-2 + 7-m + TP	1 : 2 : 4	$5.0 \times \Delta_{extended}$
3.4	< 25.3	C36-1	1	$1.0 \times \Delta_{extended}$
3.4	25.3-42.8	C36-1 + 7-m	1 : 2	$3.0 \times \Delta_{extended}$
3.4	> 42.8	C36-1 + 7-m + TP	1 : 2 : 4	$5.0 \times \Delta_{extended}$

Solution of “resolve-out”:1
Obser…
multipl… ns 2

* Array c… everyday.

…Band3



Cycle 3 Observing & Configuration Schedule: 12-m Array (Config schedule is SUBJECT TO CHANGE)

Block	Start date	End date	Purpose	Allocated Time (h)	Average # of ANT	Approx Config.[1]	min - max baseline (m)	beam[2] (")	maximum recoverable scale[2] (")
1	2015-10-01	2015-10-06	Long Baseline Campaign						
2	2015-10-06	2015-10-13	Long Baseline Campaign						
3	2015-10-13	2015-10-20	PI (Observing Report)			LBC/C36-8	267-12645	0.06"	1.4"
4	2015-10-20	2015-10-27	PI (Observing Report)			C36-8	267-12645	0.06"	1.4"
5	2015-10-27	2015-11-03	PI (Observing Report)			C36-8/7	82-11053	0.07"	4.5"
6	2015-11-03	2015-11-10	PI (Observing Report)			C36-7	82-11053	0.07"	4.5"
7	2015-11-10	2015-11-17	PI (Observing Report)			C36-7	82-11053	0.07"	4.5"
8	2015-11-17	2015-11-23	PI (Observing Report)			C36-7	82-11053	0.07"	4.5"
9	2015-11-23	2015-11-30	PI (Observing Report)			move	82-11053	0.07"	4.5"
10	2015-11-30	2015-12-07	PI (Observing Report)			move	82-11053	0.07"	4.5"
11	2015-12-07	2015-12-14	PI (Observing Report)			move			
12	2015-12-14	2015-12-21	PI (Observing Report)			move			
13	2015-12-21	2015-12-28	PI (Observing Report)			C36-1	15-310	2.3"	24.7"
14	2015-12-28	2016-01-04	PI (Observing Report)			C36-1	15-310	2.3"	24.7"
15	2016-01-04	2016-01-11	PI (Observing Report)			C36-1	15-310	2.3"	24.7"
16	2015-01-11	2016-01-18	PI (Observing Report)			C36-1	13-302	2.4"	28.2"
	2015-01-18	2016-01-30				C36-1			
	2016-03-01	2016-04-11				C36-2			
	2016-04-19	2016-05-16				C36-3			
	2016-05-24	2016-06-20				C36-4			
	2016-06-28	2016-07-18				C36-5			
	2016-07-26	2016-08-29				C36-6			
	2016-09-06	2016-09-19				C36-7			
	2016-09-20	2016-09-30				C36-3			
			End of Cycle 3						

…ratios	Total Time
	$1.0 \times \Delta_{extended}$ -
	$1.0 \times \Delta_{extended}$ -
: 2 : 2 : 4	$1.0 \times \Delta_{extended}$ $1.5 \times \Delta_{extended}$ $3.5 \times \Delta_{extended}$ $5.5 \times \Delta_{extended}$
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- All disadvantages are caused by the lack of Fourier coefficients.
  - Fundamental solution: Increasing the number of antennas! ➜❌
- Ripples of PSF
  - CLEAN process (Deconvolution Process)
    - For Solar: Multi-Scale CLEAN is essential.
  - Earth-Rotation Synthesis Mapping➜❌
- Resolve-out
  - Observe the target with multiple antenna configurations
    - For Solar: Simultaneous observation is essential. The observation with multiple antenna configurations is impossible except 7m-array.
  - Combine the data of the interferometric and single-dish observations.
    - For Solar: Simultaneous observation is essential.

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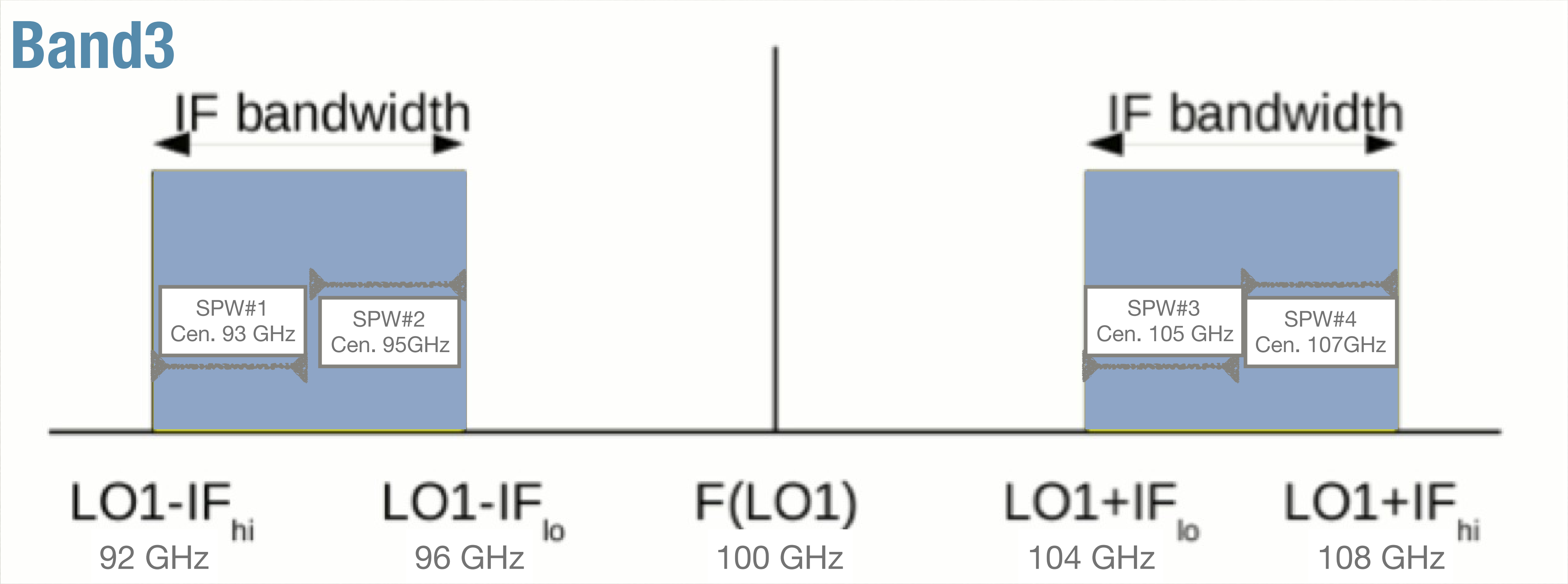
Items of the observing setup

- **Receiver setup**
  - Observing frequencies, Spatial resolution
- **Correlator setup**
  - Spectrum resolution, Time cadence of visibility (integration time), Polarization
- **Array Configuration**
  - Spatial resolution, Dynamic range, Season of the observations
- **Observing Sequence**
  - On-source time, Frequency and duration of the suspension for phase & amplitude calibrations.
- **Single-Point or MOSAIC (How many pointings for one image?)**
  - **Field of View, Time cadence of images**
- **The setup of Single-Dish (TP-array) observations**
- **Observing Season in a year and Observing Period of a day**
  - Joint observations with the other telescopes

Receiver & Correlator Setup for solar observations in Cycle4



- For solar observations in Cycle4, observations with Band3 and Band6 receivers are offered.
- LO1 is fixed to 100 GHz for Band3, 239 GHz for Band6.
- Polarization is Stokes-I or XX only
- The correlator mode is TDM only.
  - # of ch is 128 ch/spw (Stokes-I), 256ch/spw (XX only)
  - Spectrum resolution: 15.6 MHz (Stokes-I) / 7.8 MHz (XX only)
- Integration time is 2 seconds. ➜ Shortest time cadence of images is 2 seconds.

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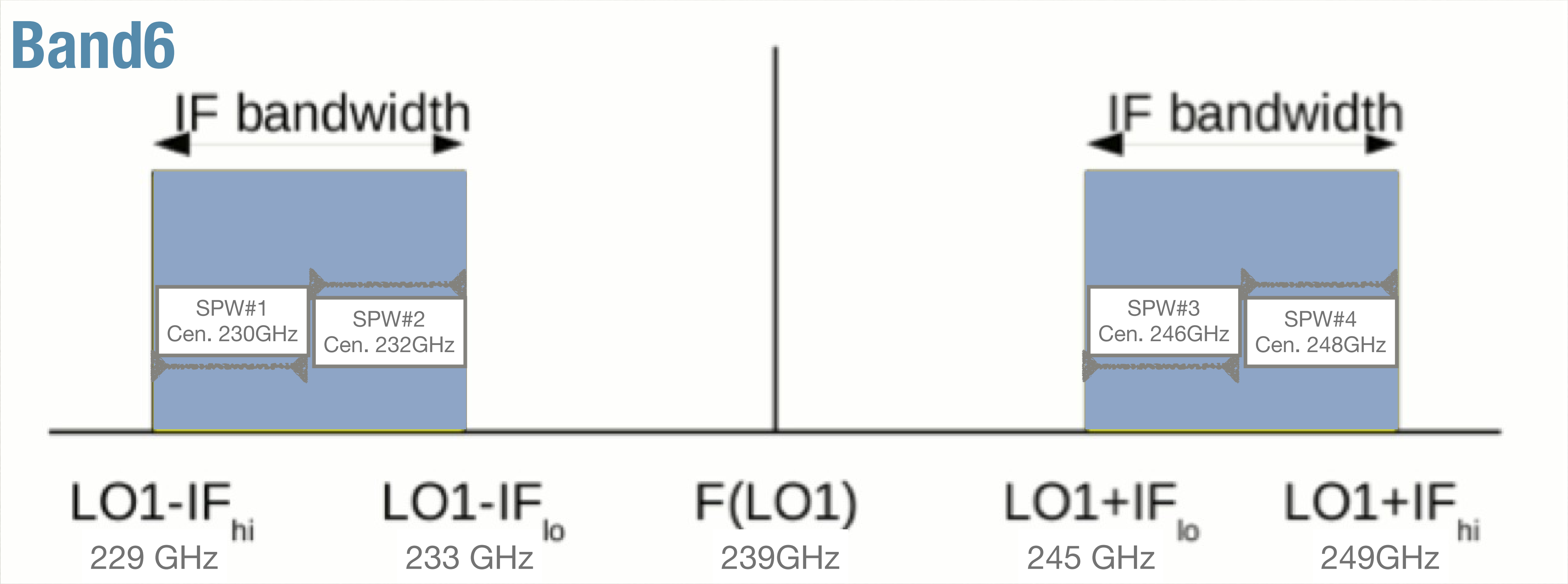

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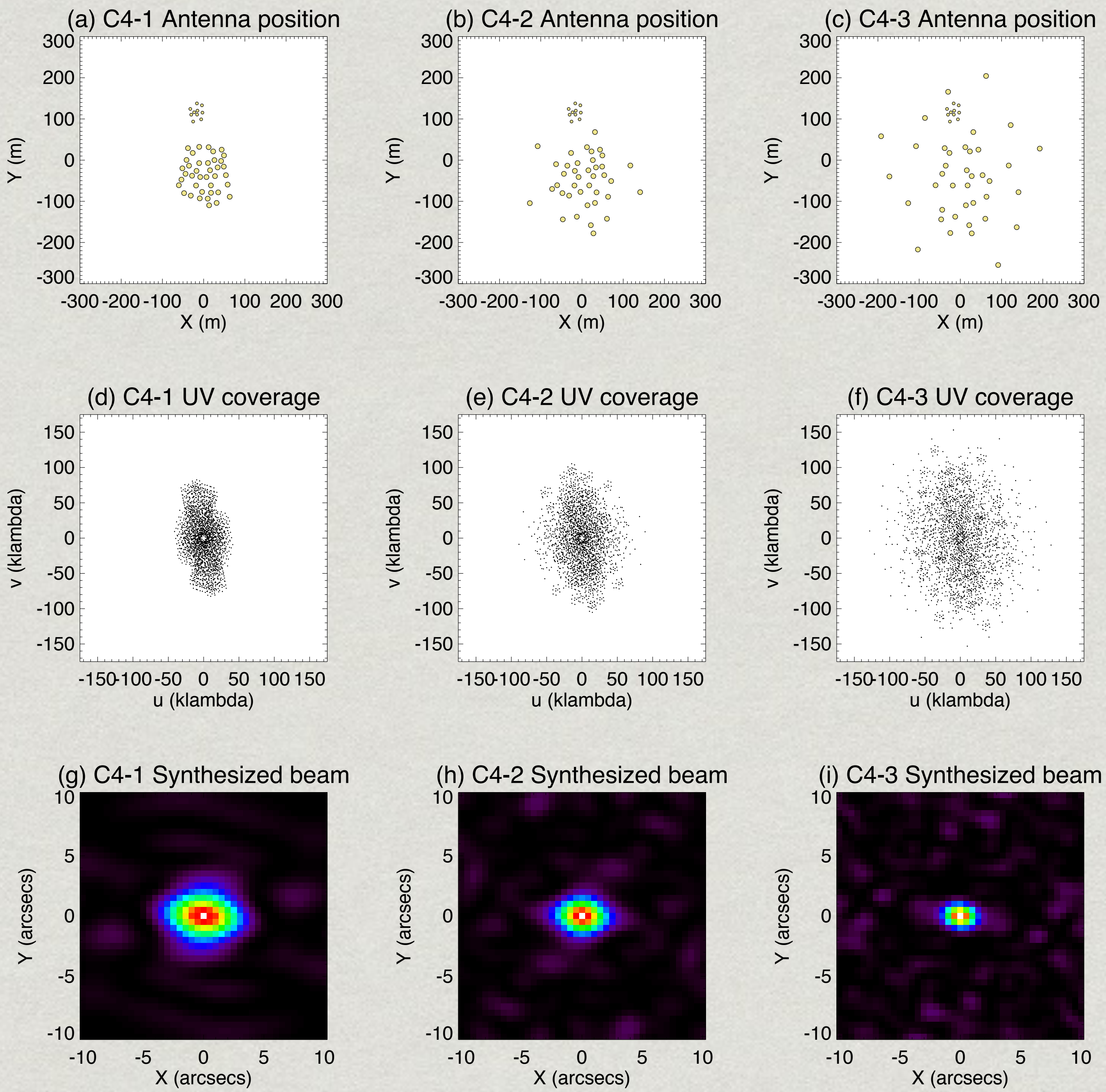
- Integration time is 2 seconds. ➜ Shortest time cadence of images is 2 seconds.

Array configuration for solar observation in Cycle 4

- The heterogeneous array is constructed from 40 12-m antennas and 10 7m-antennas only for solar observation.
  - All antennas is connected to the 64-input correlator (BL correlator).
- The array configurations of 12m-array for solar observations are C40-1, C40-2, C40-3 [TBC].
  - Typical spatial resolution [TBC]

	Band3	Band6
C40-1+7m	3.4”	1.5”
C40-2+7m	1.8”	0.8”
C40-3+7m	1.2”	0.5”



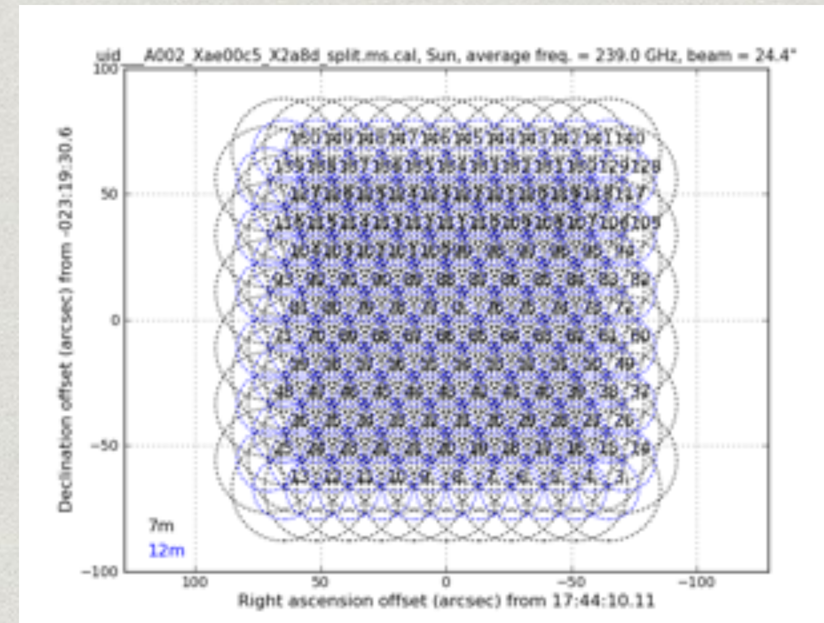
Observing sequence of solar observations in Cycle4

- The observing sequence of one solar observation (Scheduling Block: SB)
  1. Calibration of the Zero level of the SQLD detector
  2. Pointing Calibration for Bandpass Calibrator
  3. Sideband-ratio Calibration
  4. Atmospheric Calibration for Bandpass Calibrator
  5. Bandpass Calibration
  6. Pointing Calibration for Flux/Phase Calibration and Target(Sun)
  7. Atmospheric Calibration for Flux Calibrator
  8. Flux Calibration
  9. Phase Calibration
  10. Atmospheric Calibration for Phase Calibrator and Target
  11. Scientific Observations (On & OFF-source: Duration: ~10min)
  12. Phase Calibration
  13. Atmospheric Calibration for Phase Calibrator and Target

  Repeat from 11 to 13 until the total observation time exceeds the PI's requirement.

  - The initial calibration (1~10) takes about 25 mins.
  - The duration of calibration between scientific observations (12 & 13) is less than 3 mins.
- The band changing in one SB and a simultaneous observation with two bands are not offered.
- One target (one ephemeris file) is for one SB; multiple targets for one SB is not permitted.
- **The limit of total observing time for one SB is 2 hours.**

FoV & Time-cadence of images Single-pointing vs. MOSAIC Obs. in Cycle4



FoV of 149pts-MOSAIC@Band6

- **Single-pointing observation**
  - Band3: < 60”Φ / Band6: < 25”Φ
  - Minimum time cadence of images: 2 seconds
    - It is limited by the integration time in the correlator.
- **MOSAIC observation**
  - Maximum number for pointing one map: 150 pts.
    - “150 pts" corresponds with 350” x 350”@Band3, 150”x150”@Band6.
      - FoV is not need to be a square. A rectangular FoV is OK too.
    - Integration time for one pointing (included overhead): ~7.6 seconds
      - Time cadence of MOSAIC images
        - [< a few x 10 pts] 7.6 sec x # of points [[Ex. 8-pts MOSAIC (90” x 90”@Band3) 1 image/min]]
        - [> a few x 10 pts] 7.6 sec x # of points + 3mins <Calibration between scientific observations>
- *The pointing accuracy of ALMA is very good. You can believe the coordinate (RADEC) in the FITS header.*

Setup for Single-Dish (Total Power:TP) observations in Cycle4

- Total-power single-dish observations are offered as supporting for interferometric observations; proposals requesting purely single-dish observations will not be accepted in Cycle 4.
- Observing Frequencies are the same as that for the interferometric observation.
    - # of channel in one spectrum window is ONE.
- Polarization setup is also the same as the interferometric one.
- The FoV is fixed to the Full Sun.
    - 2400”-diameter circle FoV centered on solar disk center.
- Spatial resolution: ~60”@Band3 / ~25”@Band6
    - Nyquist Smapling
- Time-cadence of TP images: 7mins@Band3 / 10mins@Band6
- Simultaneous observation with the interferometric observation.

230GHz Single-Dish Obs. (2015.12.18)

Solar Observing Season & Observing Period in a day

- **Solar observing season**
  - Solar observations are carried out using C40-1, 2, and 3 [TBC]. The configurations might be formed between December, 2016 and May 2017, considering the configuration schedule of Cycle3.
  - Solar observations are done by ‘campaign mode’.
    - ALMA observatory will determine the week (or days) for solar observations in above season, based on the result of the proposal review.
    - ALMA observatory will inform the schedule of solar observing week to PIs [TBD] months before the week. In the week, PI has to prepare the ephemeris file for own target using ALMA solar ephemeris generator, and provide to the observatory in the week.
- **Solar observing period in a day**
  - To avoid shadowing of 7m antennas, observations will be carried out between 13:00 UT and 20:00 UT.
  - Although PI can inform the demand of his/her observing date & time to the observatory, it is not guaranteed that his/her observation is executed along the demand.
  - The observatory informs the time table of the observations of a day to the community [TBD].

The total observing time of a solar project is **NOT** determined based on the sensitivity.

- The limitations of ALMA observations
  1. The longest duration of one scheduling block (SB) is 2 hours.
  2. Every SB includes a calibration session before starting scientific observation. The duration of the session is 25~30 minutes. Therefore, the maximum of on-source (solar observation) in a SB is about 1.5 hours.
  3. Solar proposals are considered 'Regular Proposal' and total observing time is therefore less than 50 hours. When you determine the total observing time for your project
- **The total observing time of a solar project must be determined from the scientific point of view.** For example, if your target phenomenon is present always in the Sun, the total observing time might be based on the lifetime of the target phenomenon. On the other hand, if your target phenomenon is not always present, the total observing time might be determined based on the occurrence frequency of your target phenomenon.

Items of the observing setup

- **Receiver setup**
  - Observing frequencies, Spatial resolution
- **Correlator setup**
  - Spectrum resolution, Time cadence of visibility (integration time), Polarization
- **Array Configuration**
  - Spatial resolution, Dynamic Range, Season of the observations
- **Observing Sequence**
  - On-source time, Frequency and duration of the suspension for phase & amplitude calibrations.
- **Single-Point or MOSAIC (How many pointings for one image?)**
  - **Field of View, Time cadence of images**
- **The setup of Single-Dish (TP-array) observations**
- **Solar Observing Season / Observing Period in a day**
  - Joint observations with the other telescopes

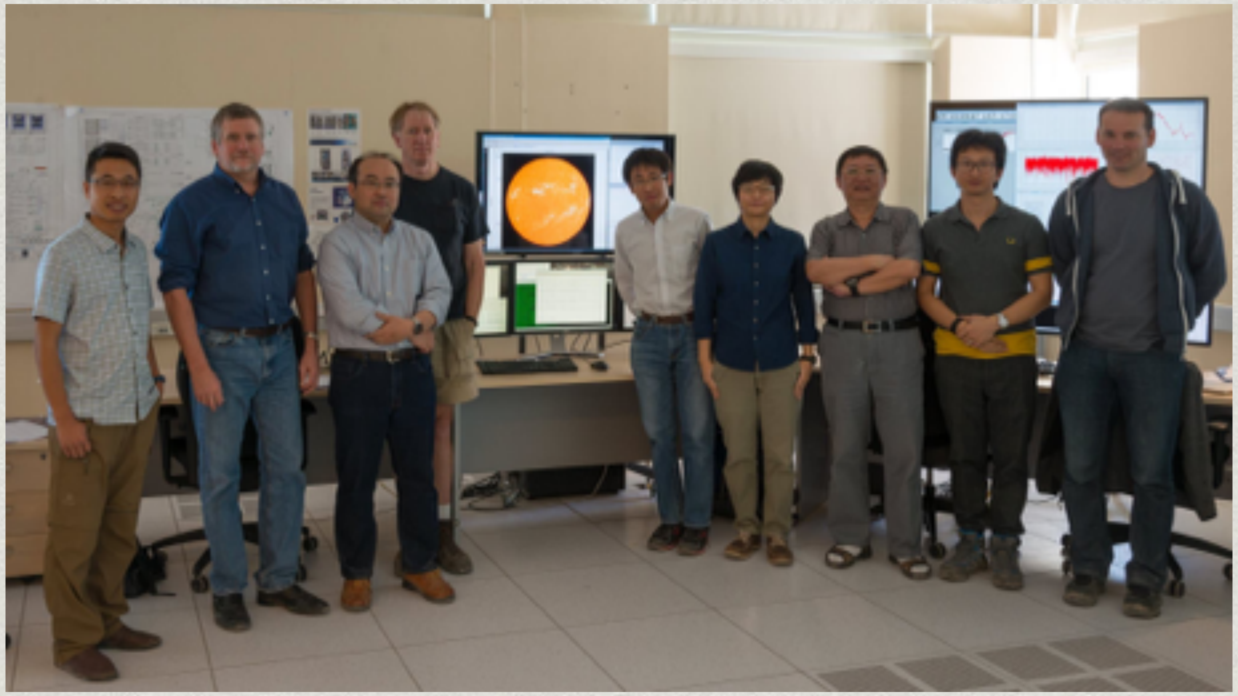
Today’s topics

- Brief Introduction of Atacama Large mm/sub-mm Array (ALMA)
- Advantage & disadvantage of an interferometer observation
  - *What we can get, and what we cannot get?*
- Observing parameters for solar observations in Cycle 4
  - *What kinds of observing modes are available in Cycle 4?*
- Dress-Rehearsal of solar observations in Cycle 4
  - *Preliminary Results of ALMA solar development campaign 2015.*

Solar Development Campaign 2015

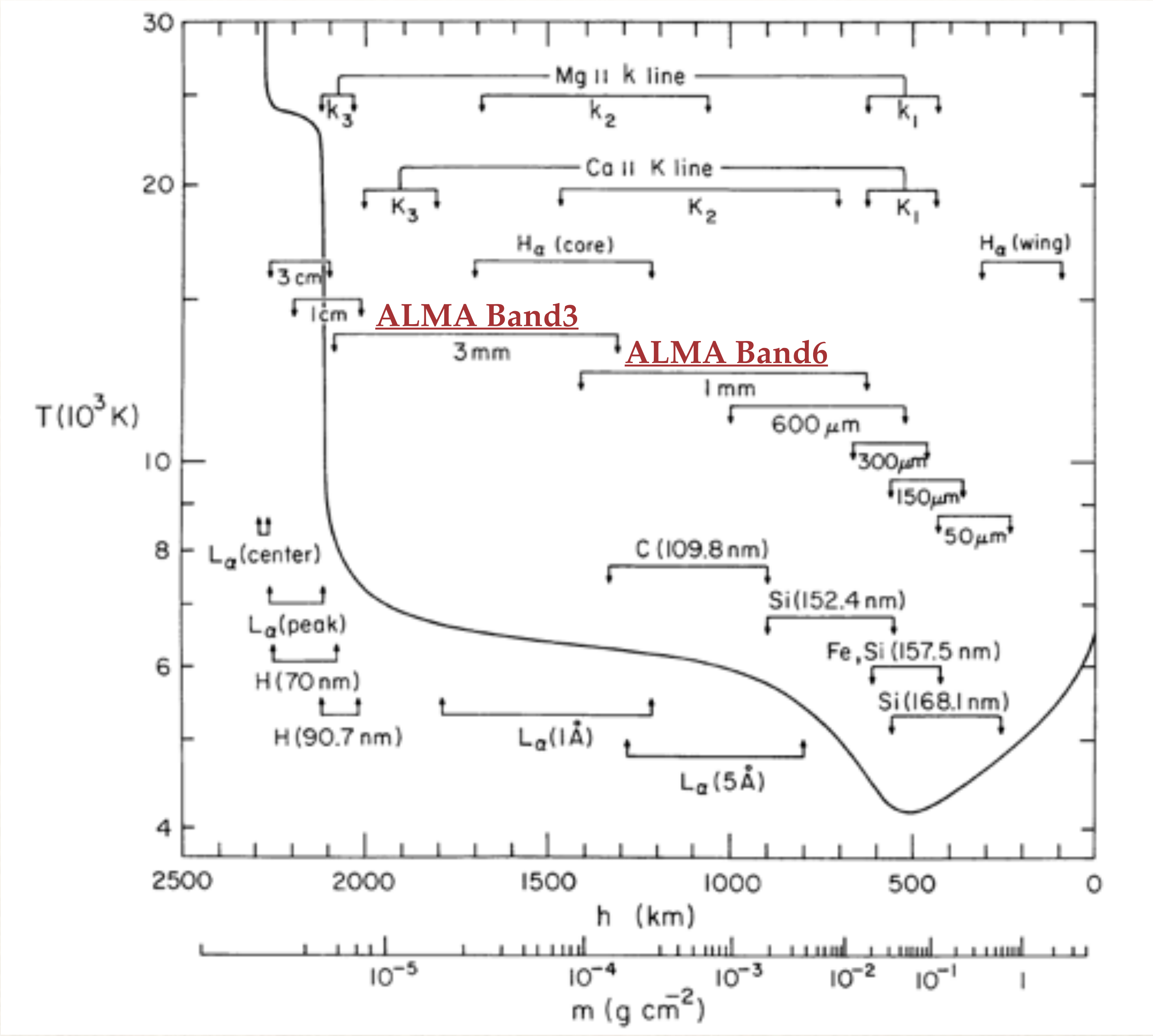
- 2015/12/14 - 2015/12/21
  - We could not carry out observations in afternoon 19-21 Dec, because the wind in the antenna site is too strong mainly (>20m/s : threshold of suspending operations).
- # of antennas: 20~23 12-m + 7~8 7-m antennas. Total: 27~31 antennas… (Cycle4: 50 antennas)
- Lead of The Campaign: Tim Bastian (NRAO)
  - Lead of the interferometric obs. : Masumi Shimojo (NAOJ)
  - Lead of the single-dish obs.: Stephen White (AFRL)
  - Supporters from Joint ALMA Observatory: Antonio Hales,
- Goals: Dress-Rehearsal of Cycle4 / New function of Cycle5

- EastAsia (EA)
  - Masumi Shimojo (NAOJ)
  - Kazumasa Iwai (NICT)
  - Sujin Kim (KASI)
- Europe (EU)
  - Ivica Skokie (Ondřejov Observatory)
- NorthAmerica (NA)
  - Tim Bastian (NRAO)
  - Stephen White (AFRL)
- China (as participants of NA development team)
  - Yihua Yang, Sijie Yu, Donghao Liu (NAOC)



In solar atmosphere, where mm/sub-mm waves come from?

- When flares don't occur,
  - Thermal emission from lower chromosphere.
    - from optically thick layer (τ=1 layer), basically
      - $T_{brightness} = T_{physical}$
- When a flare occurs,
  - Gyro-synchrotron emission from non-thermal electrons accelerated by the flare



Vernazza, Avrett & Loeser, 1981

ALMA Cycle4の日程

- 2016年3月22日：プロポーザル受付開始
  - 同日：プロポーザル投稿用ツール(Observing Tool)の公開。
- **2016年4月21日 15:00UT (2016年4月22日00:00JST)：プロポーザル受付〆切**
- 2016年8月：プロポーザル採択結果を応募者に発送。
- 2016年10月：Cycle4の観測が開始
- 2016年12月~2017年5月：太陽観測シーズン
  - 2月は装置保守月間のため観測は中断　(ボリビア・ウィンター)
  - プロポーザルのレビュー結果により、太陽観測の総時間やキャンペーン日程が決定
- 2017年9月：Cycle4の観測が終了

プロポーザルのタイプ：1

- Regular Proposal
  - 太陽観測のプロポーザルはこのタイプ。
  - 総観測時間が50時間以下
- Target of Opportunity (ToO) Proposal
  - PIからの連絡後、48時間以内に行うことを要求する観測提案
- Large Proposal
  - 総観測時間が50時間以上150~300時間以下の観測提案
- mm-VLBI Proposal
- Director Discretionary Time (DDT) Proposal

プロポーザルのタイプ：2

- Standard Proposal
  - 該当する観測モードがこなれていて、観測所で行うキャリブレーションがパイプライン処理で行われる観測提案
- Non-standard Proposal
  - 試験的な観測モードで、キャリブレーションが人力で行われる観測提案
    - Bands 8, 9 & 10 observations
    - Band 7 observations with maximum baselines > 5.3 km
    - All polarization observations
    - Spectral Scans
    - Bandwidth switching projects
    - Solar Observations
    - VLBI observations
    - User-defined calibrations

Cycle4 レビューパネルのカテゴリー

- レビューパネルのカテゴリー
  - 同じカテゴリーのプロポーザルが、最初に同じレビューパネルで評価される。
  - 最終的には全プロポーザル(のうち上位)に順番をつけ、受諾の可否を決定する。
- カテゴリー

1. Cosmology and the high redshift universe
2. Galaxies and galactic nuclei
3. Interstellar medium, star formation and astrochemistry
4. Circumstellar disks, exoplanets and the solar system
5. Stellar evolution and **the Sun**

a. The Sun
b. Main sequence stars
c. Asymptotic Giant Branch (AGB) stars
d. Post-AGB stars
e. Hypergiants
f. Evolved stars: Shaping/physical structure
g. Evolved stars: Chemistry
h. Cataclysmic stars
i. Luminous Blue Variables (LBV)
j. White dwarfs
k. Brown dwarfs
l. Supernovae (SN) ejecta
m .Pulsars and neutron stars
n. Black holes
o. Transients

Cycle4での太陽観測のプロポーザルは、

- Regular Proposal
  - 総観測時間：< 50 hours
- Non-Standard Proposal
  - 観測所でのキャリブレーションが人力
- Category 5: Stellar evolution and the Sun
  - 最初の競争相手は、AGB/Supernovae/Black Hole/Brown Dwarf/White Dwarf/Pulsar/Neutron Star…
  - 最終的には全分野で順位付けされる。

受諾プロポーザルの種別

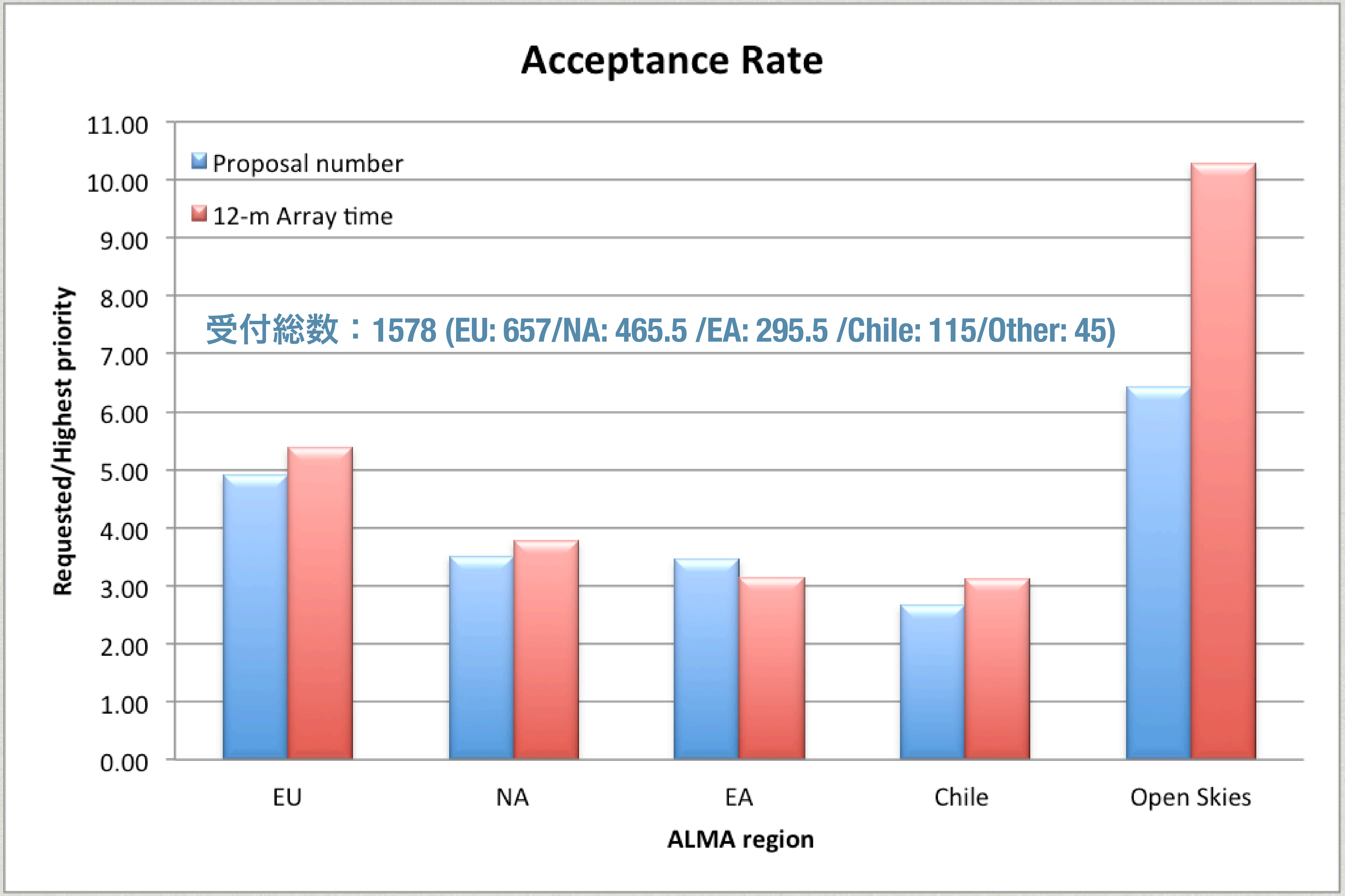
- Grade A: 最優先で観測される。Cycle4で観測できなかった場合は、Cycle 5 に持ち越しされる。
- Grade B: 優先的に観測される。Cycle4で観測できなかった場合、Cycle5への持ち越しはなし。
- Grade C: Grade AやBが観測が終了または、LSTやAntenna Configuration、天候状況により観測できない場合に観測が行われる。

総観測時間への制限

- Cycle4で提供される総観測時間
  - 12-m array: 3000 hrs / Morita-array: 2000[TBC] hrs
- 観測対象毎に保障される観測時間はない。
  - 最悪、Cycle4で太陽観測がない場合もありえる。
- 保障されているのは、各領域に対する観測時間の割り当て。
  - EU: Europe (ESO参加国): 33.75%
  - NA: North America(アメリカ/カナダ/台湾) 33.75%
  - EA: East Asia(日本/台湾/大韓民国) 22.5%　(675 hrs for 12-m array)
  - Chile: 10%
    - PIの所属する研究所の国籍により、受諾観測提案の総観測時間が上記の領域別に積算される。領域別の総観測時間が上記の割合を超える場合、受諾観測提案に調整が行われる。

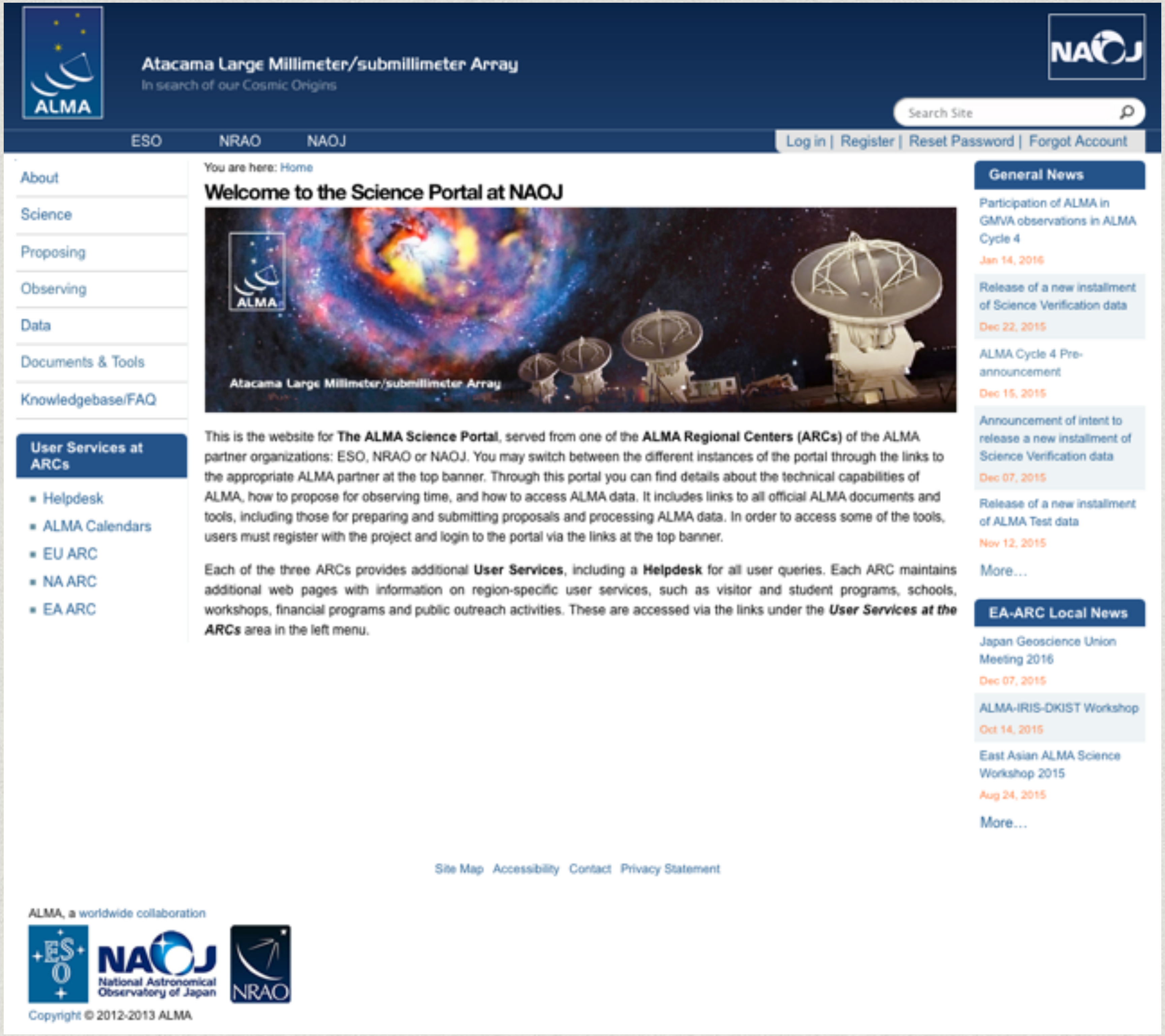
各領域での倍率 (in Cycle3)

(ALMA Early Science Cycle 3: Outcome of the Proposal Review Process より)



ALMA Science Portal (EA)

- https://almascience.nao.ac.jp



プロポーザル投稿に関する注意

- PIだけでなくCo-Iも、ALMA観測所のアカウントを取得する必要がある。