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New capabilities for future Cycles

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as behalf of the collaborators of developing new capabilities of ALMA

Note:

This presentation is preliminary information. In this talk, I will present the candidates for the new capabilities offered in near future Cycles.

The pre-announcement for Cycle 10 will be released by the ALMA observatory in January, and the actual new capabilities for Cycle10 will be announced.

The candidates for the new capabilities in near future Cycles

In this talk, I will briefly introduce the following candidates, except for ACASPEC and Band1.

- **Performance improvement**
  (PI cannot select them. The OT or/and Observatory applies them to suitable projects.)
  - ACA Spectrometer (ACASPEC): new spectrometer for the TP-array ➜ Later talk (Ishii-san)
  - Band-to-Band (B2B) phase calibration for 7m-array and compact 12m-array
  - 4x4 bit mode of the Base-Line Correlator (BLC) for FDM
- **New observing modes for new science**
  - Band1 : new receivers for 35–50 GHz ➜ The talk series of Band1 (Nagai-san, Yen-san, and Zavala-san)
  - Spectral scan with the TP array
  - VLBI: flexible tuning for spectral line VLBI, and new Band (Band1)
  - Solar polarization observations with Band3 and 12m-array (Stokes-V)

<<Performance Improvement>>

Band-to-Band (B2B) phase calibration

Expanding to the 7m-array and compact 12m-array

- When higher-band projects are scheduled, the ALMA observatory searches the calibrators near the scientific targets with the observing Bands. However, there is sometimes no suitable phase calibrator near the target. Since Cycle 9, if there is a suitable phase calibrator near the target for lower bands, we observe the phase calibrator with lower band, obtain the Gain, and apply the processed gain table to the higher-band science data (the Band-to-Band[B2B] phase calibration transfer).

- The function have been used since Cycle 9 only for the projects using large 12m-array configurations (C-8, 9, 10).

- In near future Cycles, the treatment might be applied to the observations with the 7m-array and compact 12m-array configurations (< C-8).

Mode type	Band Pairs	High Freq. LO1 range
Non-harmonic	B7 - B3	282.9 - 324.0 GHz
Harmonic	B7 - B3	324.0 - 365.0 GHz
Non-harmonic	B8 - B4	393.0 - 399.0 GHz
Harmonic	B8 - B4	399.0 - 465.0 GHz
Harmonic	B8 - B6	465.0 - 492.0 GHz
Harmonic	B9 - B4	610.2 - 697.5 GHz
Harmonic	B9 - B6	697.5 - 711.9 GHz
Harmonic	B10 - B5	794.7 - 848.7 GHz
Harmonic	B10 - B7	848.7 - 942.3 GHz

Table 10.1: Band pairings used for B2B phase calibration.

From the Cycle 9 Technical handbook

<<Performance Improvement>>

4x4 bit mode of the BaseLine Correlator (BLC) for FDM

Reducing the sensitivity loss by the quantization in BLC

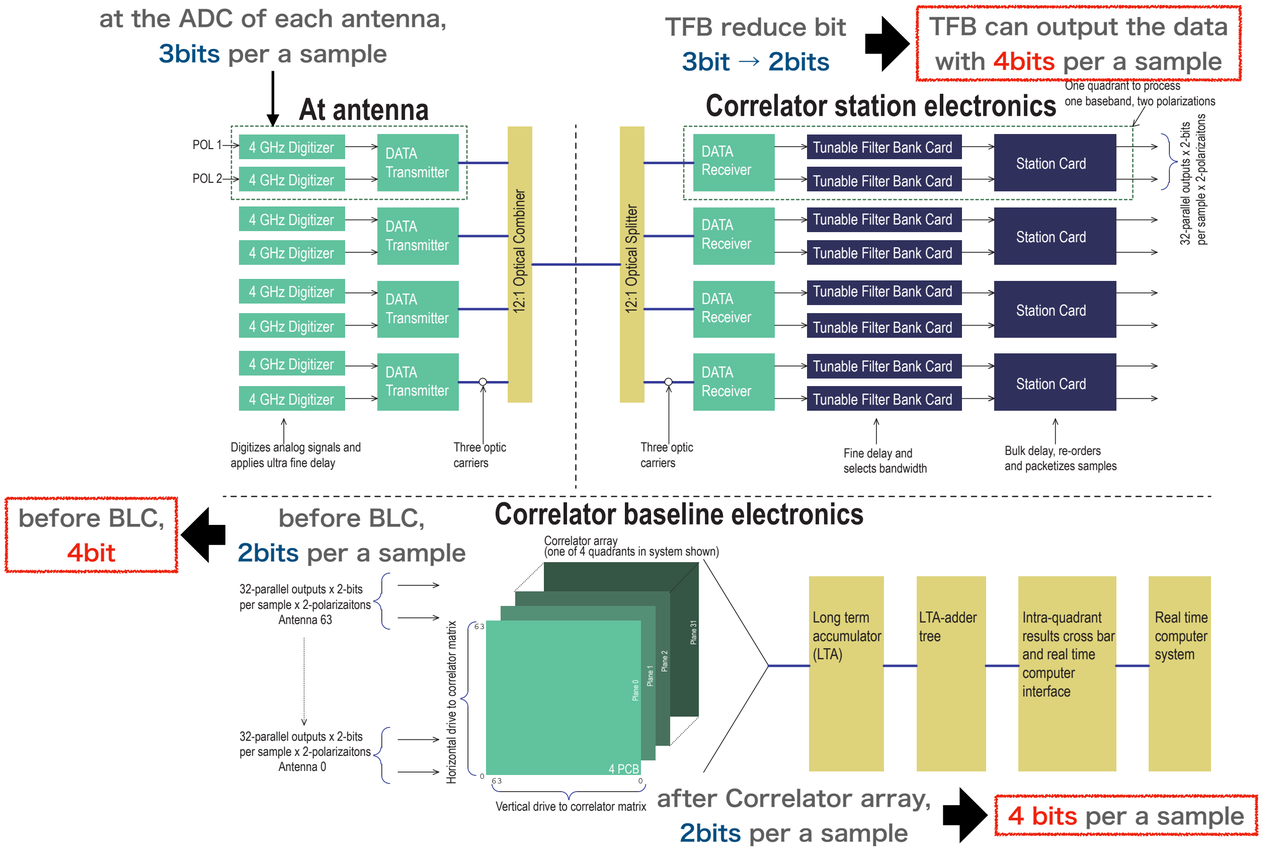


Figure 5.2: Overview diagram of the ALMA digitizers, data transmission system and 64-input Correlator (Escoffier et al. 2007, A&A 462, 801). The digitized data from the individual BBs are transferred to the Tunable Filter Banks (TFBs) and station cards (top right) for the parallelization and processing required on each antenna data stream. The correlator array (lower half) produces auto-correlations on the main diagonal and cross-correlations elsewhere in the correlator matrix. The correlations are then integrated in the Long-Term Accumulators (LTAs, lower right).

From the Cycle 9 Technical handbook

- Current BLC operation mode:
  Input: 2 bits, Output: 2bits→ 2x2 bit mode.
- TFB can output the data with 4 bits per sample.
- BLC can treat 4 bits input data and can output 4 bits data → 4x4 bit mode.
- Due to 4x4 bit mode, the sensitivity loss by the quantization can be reduced.
- The mode would be applied to the FDM data mainly with narrow bandwidth.
- In near future Cycles, the mode might be applied to the FDM with the Dual Polarization (XX and YY).

<< New observing modes for new science >>

Spectral scan with the TP array

- In the spectral scan mode, we can change local frequencies (LO1) five times in one observation to cover the required frequency range.
- The mode can be used only for interferometric observations (12m-array and 7m-array).
- In near future Cycles, we might be able to use the mode for the TP-array.

<< New observing modes for new science >>

Flexible tuning for spectral line VLBI, and new Band

- Current VLBI observations with ALMA (Band3, 6, and 7)
  - The observing frequencies cannot be changed in each Band (see the table).
  - Since Cycle 9, spectral-line VLBI observations with Band3 have been offered. The mode does not have the function to tune the LO1 frequency flexibly. The mode is that phasing of the array is computed using a narrow spectral window within the fixed frequency range of the spectrum window(spw)#1 (using the LO1 frequency in the table). So, the mode is suited for observations mainly of Galactic SiO masers.
- For the furture cycles, the following VLBI capabilities are investigated
  - VLBI continuum and spectral line observations with **Band1**.
  - In the Spectral Line VLBI mode with Band1, 3, 6, and 7,
    - 1 spw can be used for VLBI with Band1 & 3
    - 4 spws can be used for VLBI with Band6 & 7.
      - However, how many spws are usable for VLBI depends on the data obtained with other observatories.
    - **The center frequency of each spw is tunable (The LO1 frequency is also tunable).**
      - The bandwidth of each spw is fixed to 1875 MHz.

& Band1

Table A-9: Observing Frequencies for Cycle 9 VLBI Observations

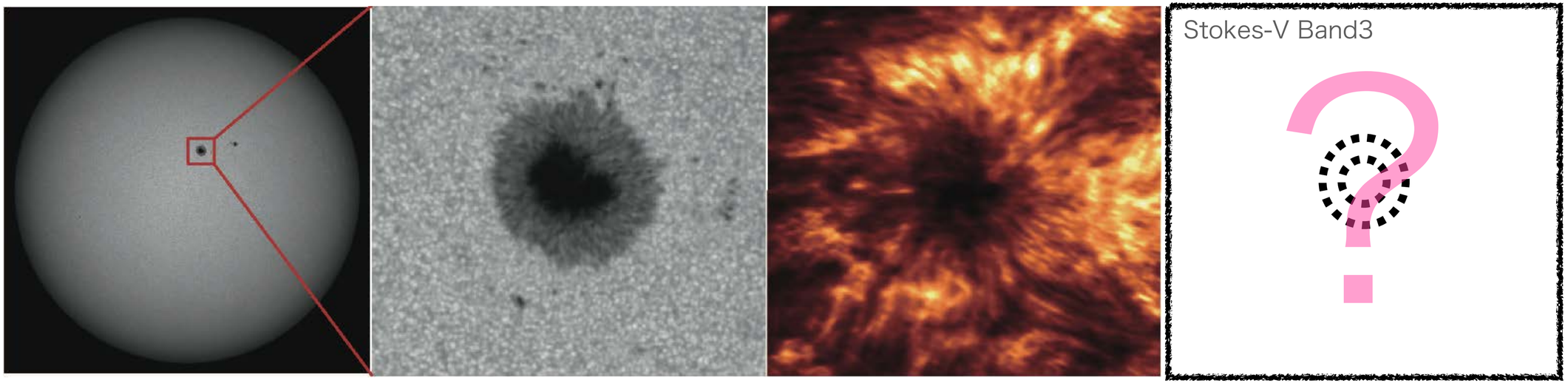
Band	spw1 (GHz)	spw2 (GHz)	LO1 (GHz)	spw3 (GHz)	spw4 (GHz)
3	86.268	88.268	93.268	98.328	100.268
6	213.1	215.1	222.1	227.1	229.1
7	335.6	337.5414	342.6	347.6	349.6
Band1	41.168	43.168		45.168	47.124

<< New observing modes for new science >>

Solar polarization observation with Band3 and 12m-array

To measure chromospheric magnetic field strength above sunspots

- The linear polarized emission from the Sun is predicted as negligible small in microwave and millimeter-wave range, and no one succeeded in detecting linear polarization signal.
- The circular polarized mm-wave emission (Stokes-V) above a sunspot is predicted (< a few %). The polarization is caused by the opacity difference of X- and O-mode. From the Stokes-V data, we would be able to estimate chromospheric magnetic field strengths.
- Full polarization solar observations only with Band3+12m-array might be offered in near future Cycles.



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