ABSTRACT

The following slides summarize the Cycle 0 capabilities of the ALMA correlator. They compile the basic information from the ALMA Science Portal and the Cycle 0 Technical Handbook, and include some correlator set-up examples with screenshots from the ALMA Observing Tool. These slides are meant to be included in the NA presentations for ALMA Community Days Events.

A power point version of the slides can be found at https://sites.google.com/site/almacommunityoutreach/slides-folder/alma-capabilities.
**Receivers: mixers**

- The first Local Oscillator (LO₁) can be tuned at different frequencies.
- The Sky Frequencies will be:
  \[ \nu_{\text{sky}} = \nu_{\text{LO₁}} - \nu_{\text{IF}} \] (LSB)
  \[ \nu_{\text{sky}} = \nu_{\text{LO₁}} + \nu_{\text{IF}} \] (USB)
- Data will be collected setting-up different spectral windows within one or both sidebands.

**Diagram Notes:**
- Fixed Separation:
  - Band 3, 7, 9: 8 GHz
  - Band 6: 10 GHz
- IF bandwidth
- Lower Sideband (LSB)
- Upper Sideband (USB)
## Cycle 0 Receivers

<table>
<thead>
<tr>
<th>Band</th>
<th>Freq Range (GHz)</th>
<th>Wavelength range (mm)</th>
<th>Receiver type</th>
<th>IF range (GHz)</th>
<th>Inst. IF bandwidth (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>84-116</td>
<td>3.6-2.6</td>
<td>2SB</td>
<td>4-8</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>211-275</td>
<td>1.4-1.1</td>
<td>2SB</td>
<td>5-10</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>275-373</td>
<td>1.1-0.8</td>
<td>2SB</td>
<td>4-8</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>602-720</td>
<td>0.5-0.4</td>
<td>DSB</td>
<td>4-12</td>
<td>8*</td>
</tr>
</tbody>
</table>

- Dual side-band (2SB): two separated sidebands available simultaneously
- Double side-band (DSB): LSB and USB are super-imposed out from the receiver but can be separated in later processing.

* Cycle 0: In Band 9, only one sideband per spectral window will be correlated. In future cycles both sidebands will be simultaneously separated and correlated.
Correlator Set-up

• Up to 4 basebands available which can be moved within the sideband width; spectral windows can be moved within the baseband (2 GHz wide)
• Setup limits: Edges of the baseband cannot lie outside the IF range & edges of the spectral window cannot lie outside the baseband
* Cycle 0: only one spectral window per baseband & all spectral windows with the same configuration (bandwidth and spectral resolution)
Correlator Set-up

• Correlator modes:
  – Time division mode (TDM): low-spectral resolution $\rightarrow$ continuum observations and sources with very broad spectral lines.
  – Frequency division mode (FDM): high-spectral resolution mode
    * Cycle 0: One TDM and 6 FDM set-ups available

• Dual or Single Polarizations can be processed:
  – Dual Polarization: separate spectra obtained for each linear polarization $\rightarrow$ can be combined to improve sensitivity
  – Single Polarization: only a single polarization is analyzed $\rightarrow$ poorer sensitivity but provides twice as many channels
## Cycle 0 Correlator Modes

### Dual Polarization

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>Channel spacing (MHz)</th>
<th>Number of channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>15.6</td>
<td>128*</td>
</tr>
<tr>
<td>58.6</td>
<td>0.0153</td>
<td>3840</td>
</tr>
<tr>
<td>117</td>
<td>0.0305</td>
<td>3840</td>
</tr>
<tr>
<td>234</td>
<td>0.061</td>
<td>3840</td>
</tr>
<tr>
<td>469</td>
<td>0.122</td>
<td>3840</td>
</tr>
<tr>
<td>938</td>
<td>0.244</td>
<td>3840</td>
</tr>
<tr>
<td>1875</td>
<td>0.488</td>
<td>3840</td>
</tr>
</tbody>
</table>

### Single Polarization

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>Channel spacing (MHz)</th>
<th>Number of channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>7.8</td>
<td>256*</td>
</tr>
<tr>
<td>58.6</td>
<td>0.0076</td>
<td>7680</td>
</tr>
<tr>
<td>117</td>
<td>0.0153</td>
<td>7680</td>
</tr>
<tr>
<td>234</td>
<td>0.0305</td>
<td>7680</td>
</tr>
<tr>
<td>469</td>
<td>0.061</td>
<td>7680</td>
</tr>
<tr>
<td>938</td>
<td>0.122</td>
<td>7680</td>
</tr>
<tr>
<td>1875</td>
<td>0.224</td>
<td>7680</td>
</tr>
</tbody>
</table>

* Correlator mode for continuum observations (TDM), effective bandwidth is only 1875 MHz

In all cases, the effective resolution is twice the channel spacing
Correlator set-up:
line vs. continuum

- "continuum mode": automatically place 4 spectral windows, with the largest bandwidth, across the sidebands

**Band 3 (or 7)**

**Spectral line mode:**

**Continuum mode:**

2000 MHz bandwidth, 15.625 MHz channels
Correlator set-up: continuum

Standard continuum placement in Band 6

- Even in “spectral line mode”, can choose a continuum setup (drop-down menu)
- Use if you want to manually place spws (e.g., to avoid a bright line in Band 6)
Correlator set-up: continuum

- Band 9: 8 GHz continuum, but all in one sideband

Continuum placement in Band 9
• Select “single continuum” in OT
• Single vs Dual polarization allowed

• Single polarization provides same total bandwidth, but twice the spectral resolution: lower sensitivity for averaged continuum!
• (Unless your science case is very special, you should always select Dual polarization for continuum observations.)
Survey of carbon isotopologues and other species in old planetary nebula

Observe molecular gas in NGC 7293 (Helix Nebula) in Band 7

**Main species of interest**

*Lower sideband (LSB)*
- CO (J=3 → 2) : 345.795 GHz
- H^{13}CN (J=4 → 3) : 345.339 GHz
- H^{13}CO^+ (J=4 → 3): 346.998 GHz

*Upper sideband (USB)*
- HCO^+ (J=4 → 3): 356.734 GHz

**Other interesting molecular species present within the spectral setup**

CS, CS^+, HCP, MgCCH, NaCN, MgH, SiH, MgNC, KC, AlNC, SO, ^34SO
Correlator Setup

LSB Rest Frequency coverage: 343.281-347.021 GHz
USB Rest Frequency coverage: 355.343-359.076 GHz

Band 7:
4 GHz each sideband
double pol. mode

1.875 GHz spw
Channel Spacing of ~488 kHz or ~0.4 km/s
Example: $^{12}$CO and $^{13}$CO in Band 6

- 2 spectral windows, 0.9375 GHz wide, 0.3 km/s spectral resolution
- Can observe both $^{13}$CO 2-1 (220.4 GHz) and CO 2-1 (230.5 GHz) only at low $z$
  - MUST set rest frequency for spectral windows such that the windows remain entirely within the sidebands, e.g. can’t center on lines for wider spectral windows
- can place 2 additional windows to observe CH$_3$OH, SO$_2$, etc.
Example: $^{12}\text{CO}$ and $^{13}\text{CO}$ in Band 6

In the OT spectral setup:

- MUST set rest frequency for spectral windows such that the windows remain entirely within the sidebands (i.e. not centered on lines)
- can place 2 additional windows to observe $\text{CH}_3\text{OH}, \text{SO}_2$, etc.
Example: Spectral Lines in Band 9

- for Band 9, there is full flexibility in that each baseband can be connected to either one or the other sideband
- in Cycle 0, only one sideband per spectral window will be correlated
  - e.g. Observe $D_2H^+$ at 691.66 GHz with one spectral window
  - can place 3 additional windows in USB or LSB