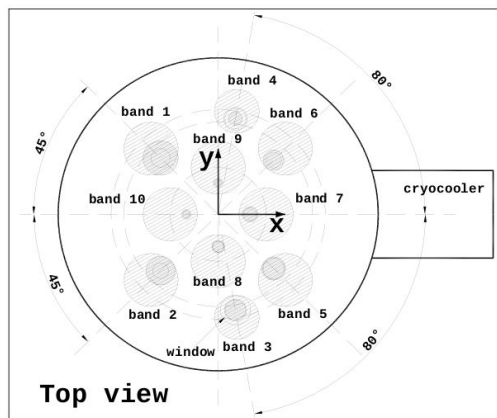
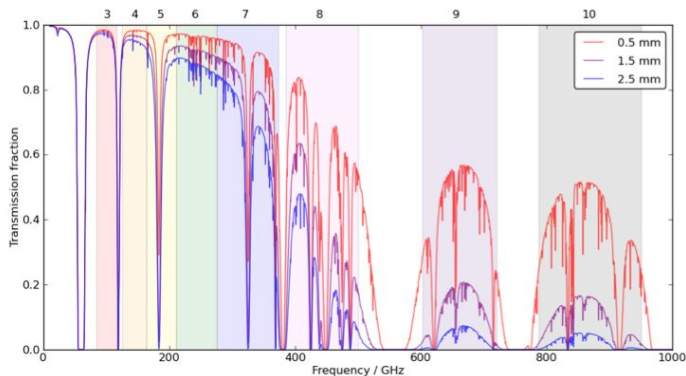


# Status and overview of the ALMA Band 1 project

Ciska Kemper



# The Band 1 atmospheric window on ALMA



## The Atacama Large Millimeter Array (ALMA) Quick Reference

Timeline: Early 2011 (Call for ALMA Early Science Proposals), Mid 2011 (Early Science Proposal submission deadline), Late 2011 (Early Science begins), 2013 (66 ALMA Antennas).

Bands:	3	4	5	6	7	8	9	10
Frequency (GHz)	84-116	125-163	163-211	211-275	275-373	385-500	602-720	787-950
Wavelength (mm)	3.57-2.59	2.40-1.84	1.84-1.42	1.42-1.09	1.09-0.80	0.78-0.60	0.50-0.42	0.38-0.32

	Early Science	Array Completion
Antennas	≥16 x 12m	At least 54 x 12m & 12 x 7m
Bands	Bands 3, 6, 7, 9	Bands 3, 4, 6, 7, 8, 9 & 10
Maximum Bandwidth	16 GHz (2 polarizations x 8 GHz)	
Correlator Configurations	21 (0.02 – 40 km/s)	71 (0.01 – 40 km/s)
Maximum Angular Resolution	0.02" $\left( \frac{\lambda}{1 \text{ mm}} \right) \left( \frac{10 \text{ km}}{\text{Max Baseline}} \right)$	
Max Baseline	250m (may achieve 500m)	15 km
Continuum Sensitivity (60 sec, Bands 3–9)	~0.2 – 4.2 mJy	~0.05 – 1 mJy
Spectral Line Sensitivity (60 sec, 1 km/sec, Bands 3–9)	~30 – 250 mJy	~7 – 62 mJy

Sensitivity Calculator: <http://science.nrao.edu/alma/tools.html>

# History of the Band 1 project (I)

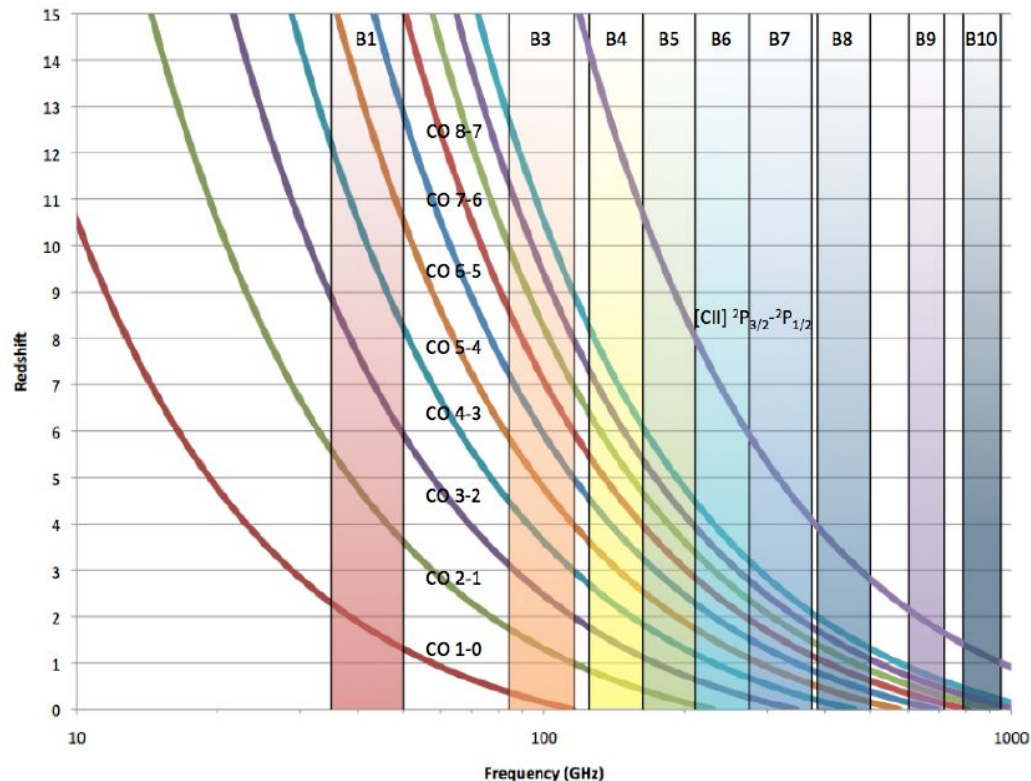
- 2001 re-baselining exercise removes Band 1 (31-45 GHz) and Band 2 (67-90 GHz) from ALMA basic capabilities
- re-alignment of future priorities, with Band 1 now immediately after Band 10
- SZE imaging of cluster gas at all redshifts
  - Mapping cold ISM at intermediate and high redshifts
- 2008 first Band 1 science meeting in Victoria, Canada
- 2009 second Band 1 science meeting in Manchester, UK
- release of initial science document to astronomical community:  
<https://arxiv.org/abs/0910.1609v1>

# ALMA Level I science goals

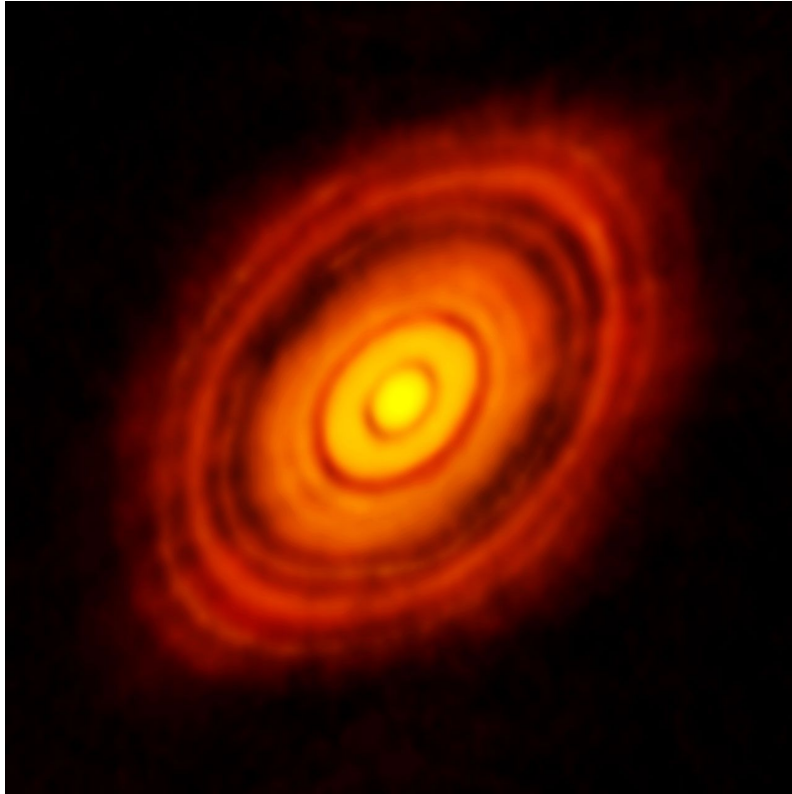
- The ability to detect spectral line emission from CO or C<sup>+</sup> in a normal galaxy like the Milky Way at a redshift of  $z=3$ , in less than 24 hours of observation
- The ability to image gas kinematics in a solar-mass protostellar/protoplanetary disk at a distance of 150 pc, enabling one to study the physical, chemical and magnetic field structure of the disk and to detect the tidal gaps created by planets undergoing formation
- The ability to provide precise images at an angular resolution of 0.1". Here the term "precise image" means an accurate representation of the sky brightness at all points where the brightness is greater than 0.1% of the peak image brightness. This requirement applies to all sources visible to ALMA that transit at an elevation greater than 20 degrees.

# CO emission at $z=3$ in $< 24$ hours

- Low-J CO lines at high  $z$
- $5\sigma$  detection in less than 5 hours
- Possibility of a multiline detection, in combination with other bands
- HCN and  $\text{HCO}^+$  at high  $z$ ?
- Normal galaxies up to  $z\sim 6$
- Massive galaxies: redshift records are possible



# Tidal gaps and planet formation



- Dust particles emit up to wavelengths similar to their size -> Band 1 required to find distribution of grains with sizes of 7 mm
- Studies of coagulation of grains from mm to cm sizes: where and how
- Finding where protoplanets are forming, with a resolution of 0.08''

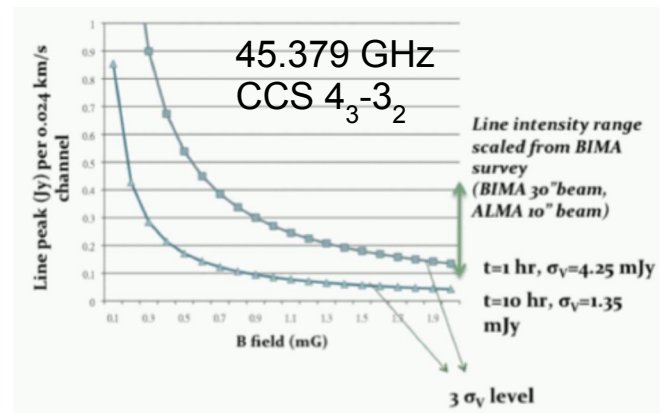
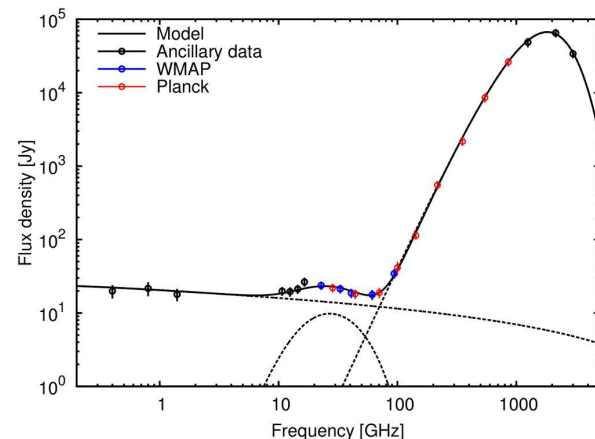
HL Tau at 1.3 mm (Band 6)

# Multiple additional science goals

- Molecular tracers of star formation; large molecules
- Anomalous emission from very small grains
- Sunyaev-Zel'dovich (SZ) effect imaging of cluster gas
- Pulsars and radio supernovae
- Methanol and SiO masers
- Probing magnetic fields with the Zeeman effect

Full ALMA Band 1 science case:

<http://arxiv.org/abs/1310.1604>



# Advantages of Band 1 compared to the JVLA

- Faster imaging capabilities
- Greater image fidelity
- Synergy with other ALMA Bands and use on ACA
- Access to the Southern hemisphere
- ALMA has much more Band 1 weather than the JVLA
- 50-52 GHz range is unique to ALMA

Talks by Oscar Morata  
and James di Francesco  
later in this session





# History of the Band 1 project (II)

- 2012 Formation of Band 1 consortium (kick-off meeting): ASIAA (PI institute), U. Chile, HIA, NRAO, NAOJ
- 2013 Down-selection of components to eliminate duplicate development effort  
  
Approval of change of frequency to 35-50 (52) GHz, to include the CS (1-0) line and reduce the frequency overlap with JVLA
- 2014 Preliminary design review (PDR) passed; prototype production approved
- 2016 Critical design review (CDR) passed  
  
ALMA Board approved the production of all Band 1 cartridges

# Band 1 current status

Band 1 is an ALMA-EA development project.

Consortium consists of ASIAA, NAOJ and the U. Chile, with contributions from HIA and NRAO. Cartridge production will be carried out at ARL in Taichung (Taiwan).

ASIAA is the PI institute.

Production has started, and is expected to complete with cartridge #73 at the end of 2019.

Band 1 first offered on a subset of the antennas in Cycle 7; science verification planning starting now.