Report of the ALMA Scientific Advisory Committee: September 2002 Meeting

October 15, 2002

ALMA Scientific Advisory Committee

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Other Participants

Members of the ALMA Project

B. Butler (NRAO), C. Cunningham (NRC), B. Glendenning (NRAO), R. Heald (NRAO), M. Holdaway (NRAO), R. Kurz (ESO), R. Lucas (IRAM), J. Kingsley (Tucson), R. Marson (NRAO), S. Myers (NRAO), S. Radford (NRAO), M. Rafal (NRAO), R. Simon (NRAO), D. Sramek (NRAO), M. Tarenghi (ESO), P. Vanden Bout (NRAO)

Others

C. Brogan (NRAO), C. Chandler (NRAO), D. Frail (NRAO), M. Goss (NRAO), M. Ishiguro (NAOJ), K. Johnson (NRAO), K.Y. Lo (NRAO), P. Napier (NRAO), M. Rupen (NRAO), E. Schinnerer (NRAO), D. Shepherd (NRAO), J. Ulvestad (NRAO), F. Walter (NRAO)

* Not present at Socorro meeting, but provided input to ASAC report.

A. Report of the ASAC Subcommitte on Early Science with ALMA

A working group was constituted with the following members: Pierre Cox, Stephane Guilloteau, Diego Mardones, Hiroshi Matsuo, Ken Tatematsu, Ewine van Dishoeck, Malcolm Walmsley, David Wilner, Christine Wilson, and Al Wootten. This is a progress report summarising the discussions and outlining some of the issues related to the Early Science with ALMA.

A.1. Definition, Requirements and Goals of Early Science

...snip...

A.2. ALMA Sensitivity

The following presents a quantitative comparison of the sensitivity expected with ALMA with 6, 12, 32 and 64 antennas for the four Bands of the baseline project compared with existing and future facilities. The results are presented in the form of tables (Tables 1 to 5) and figures (Fig. 1 & 2). They illustrate the evolution of the capabilities of the ALMA array prior to the end of 2011, when ALMA will become fully operational.

We adopted a 5 hr on-source integration time to represent a typical track in Early Science and assumed that high-frequency 650 GHz observations are only done during good weather ($\tau_{225} \approx 0.05$). For line brightness sensitivities, all values have been scaled to the same synthesized beam, rather than using specific beams for each (existing) array according to the available/planned configurations. Two baselines, 150 m and 1 km, have been taken as representative of low and high angular resolution Early Science observations.

None of the existing or planned arrays has baselines as large as 4 km, so ALMA is unique in this area. The ALMA sensitivities for 4 km are given below in the Table 4 & 5.

The sensitivities have been calculated under the following assumptions:

- **General**
  - Use standard radiometric formulae for point source continuum sensitivity (e.g., Butler & Wootten, ALMA memo 276, October 1999)
  - Calculate line brightness sensitivity in K for baseline B in km and line width $\delta\nu_{\rm line}$ in Hz from continuum sensitivity in mJy according to:
    $\delta S_{\rm line} = (\delta\nu_{\rm cont}/\delta\nu_{\rm line}) \times \delta S_{\rm cont}$ (mJy)
    $\delta T_{\rm line} = 0.32\, B_{\rm km}^2 \times \delta S_{\rm line}$
- **ALMA**
  Use input values from Butler & Wootten, ALMA memo 276, except $T_{\rm sys}$ from Guilloteau, ALMA memo 393, May 2002, Fig. 1. Specifically:
  - 110 GHz: $T_{\rm sys} = 81$ K
  - 230 GHz: $T_{\rm sys} = 153$ K

- 345 GHz: T_{sys} = 222 K
- 675 GHz: T_{sys} = 1200 K

Note that these values are up to a factor of 2 higher than those of Butler & Wootten (1999), especially at 110 and 230 GHz.

- **PdB**

  Sentivities taken from the Plateau de Bure interferometer Web page, assuming T_{sys} = 150 K at 3 mm and T_{sys} = 330 K at 1 mm.

- **PdB+**

  Sensitivities are calculated assuming the same T_{sys} as for the PdB, but for dual-polarisation wide-band receivers. At 345 GHz, T_{sys} = 320 K.

- **OVRO**

  Sensitivities from G. Blake (private communication) assuming average values of T_{sys}, i.e. T_{sys} = 350 K at 3 mm and T_{sys} = 450 K at 1 mm.

- **BIMA**

  Sensitivities taken from L. Mundy (private communication), assuming T_{sys} = 300 K at 3 mm and T_{sys} = 500 K at 1 mm.

- **CARMA**

  Sensitivities from Tony Beasley July 2002 as provided with NSF proposal.

- **NMA and Rainbow**

  Sentivities taken from Nobeyama Web page. It is not clear if the NMA and Rainbow arrays will still operate after the ALMA Early Science operations. In the tables, Rainbow is labeled as RB.

- **SMA**

  Use sensitivities from D. Wilner (private communication) with:

  230 GHz: T_{sys} = 164 K

  345 GHz: T_{sys} = 413 K

  675 GHz: T_{sys} = 3650 K

- **eSMA**

  eSMA=SMA + JCMT + CSO. Sensitivities have been calculated by, e.g., Moriarty-Schieven (1996), JCMT upgrade proposal. Roughly, the improvement is a factor of 2 compared with SMA.

Table 1: Point source continuum sensitivity (mJy) - 5 hr, 1 σ

Freq.	PdB	PdB$^+$	OVRO	BIMA	CARMA	NMA	RB	SMA	eSMA	ALMA		
GHz										6	12	64
110	0.3	0.06	0.6	1.1	0.04	0.7	0.5	-	-	0.028	0.013	0.0024
230	0.9	0.14	1.6	2.5	0.10	6.3	3.2	0.4	0.2	0.056	0.027	0.0049
345	-	-	-	-	0.70	-	-	0.9	0.46	0.088	0.042	0.0076
675	-	-	-	-	-	-	-	8.5	4.9	0.69	0.33	0.060

Table 2: Line sensitivity (K) for 1 $\mathrm{km\,s^{-1}}$ line width, 5 hr 1 σ, 150 meter baseline

Freq.	θ	PdB	PdB$^+$	OVRO	BIMA	CARMA	NMA	RB	SMA	eSMA	ALMA		
GHz	$''$										6	12	64
110	4.5	0.11	0.07	0.35	0.24	0.04	0.40	0.28	-	-	0.03	0.014	0.003
230	2.1	0.27	0.11	0.48	0.62	0.06	2.31	1.6	0.15	0.07	0.04	0.020	0.004
345	1.4	-	-	-	-	-	-	-	0.27	0.14	0.05	0.025	0.005
675	0.7	-	-	-	-	-	-	-	1.8	1.1	0.3	0.14	0.03

Table 3: Line sensitivity (K) for 1 $\mathrm{km\,s^{-1}}$ line width, 5 hr 1 σ, 1 kilometer baseline

Freq.	θ	PdB	PdB$^+$	OVRO	BIMA	CARMA	NMA	RB	SMA	eSMA	ALMA		
GHz	$''$										6	12	64
110	0.67	7.1	-	16.8	13.9	1.8	-	-	-	-	1.3	0.64	0.12
230	0.32	0.27	-	21.2	34.6	3.3	-	-	6.9	3.3	1.7	0.85	0.16
345	0.22	-	-	-	-	-	-	-	12.0	6.1	2.1	1.15	0.20
675	0.11	-	-	-	-	-	-	-	46.7	46.7	12.3	6.1	1.15

Table 4: Line sensitivity (K) for 1 $\mathrm{km\,s^{-1}}$ line width, 5 hr 1 σ, 4 kilometer baseline

Freq.	θ	PdB	PdB$^+$	OVRO	BIMA	CARMA	NMA	RB	SMA	eSMA	ALMA		
GHz	$''$										6	12	64
110	0.17	-	-	-	-	-	-	-	-	-	21.4	10.2	1.8
230	0.08	-	-	-	-	-	-	-	-	-	29.5	14.1	2.5
345	0.05	-	-	-	-	-	-	-	-	-	37.4	17.9	3.2
675	0.03	-	-	-	-	-	-	-	-	-	211.0	10.1	18.2

Table 5: Continuum sensitivity (K), 5 hr $1\,\sigma$, 4 kilometer baseline and 8 GHz Bandwidth

Freq. GHz	θ $''$	PdB	PdB^{+}	OVRO	BIMA	CARMA	NMA	RB	SMA	eSMA	ALMA 6	ALMA 12	ALMA 64
110	0.17	-	-	-	-	-	-	-	-	-	0.14	0.07	0.013
230	0.08	-	-	-	-	-	-	-	-	-	0.29	0.14	0.025
345	0.05	-	-	-	-	-	-	-	-	-	0.45	0.21	0.039
675	0.03	-	-	-	-	-	-	-	-	-	3.5	1.7	0.31

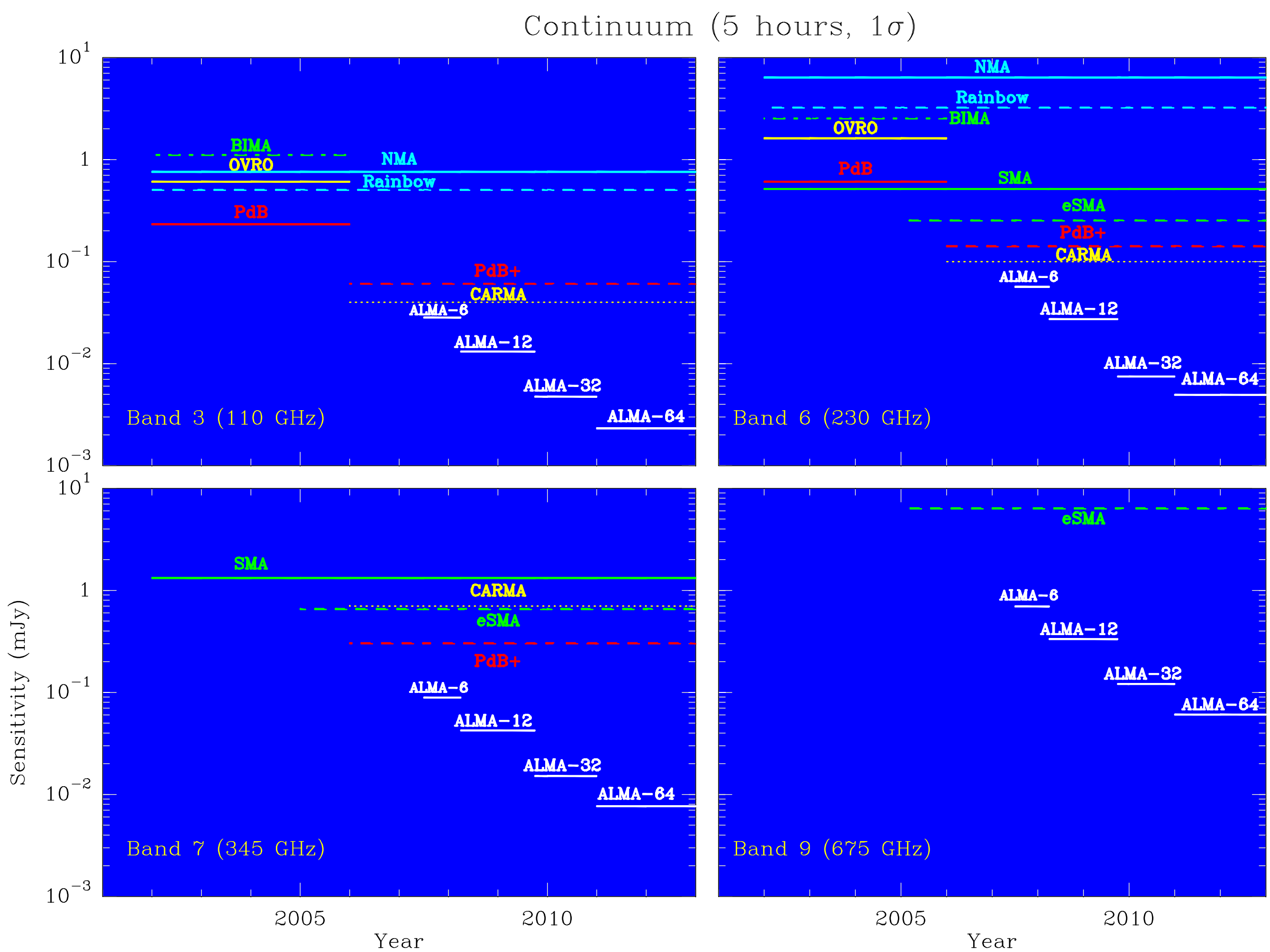

Fig. 1.— Sensitivity in the continuum (1 σ, 5 hours) for ALMA with 6, 12, 32 and 64 antennas in the four Bands of the baseline project compared to the sensitivities of the present and planned millimeter/submillimeter arrays. See text for details.

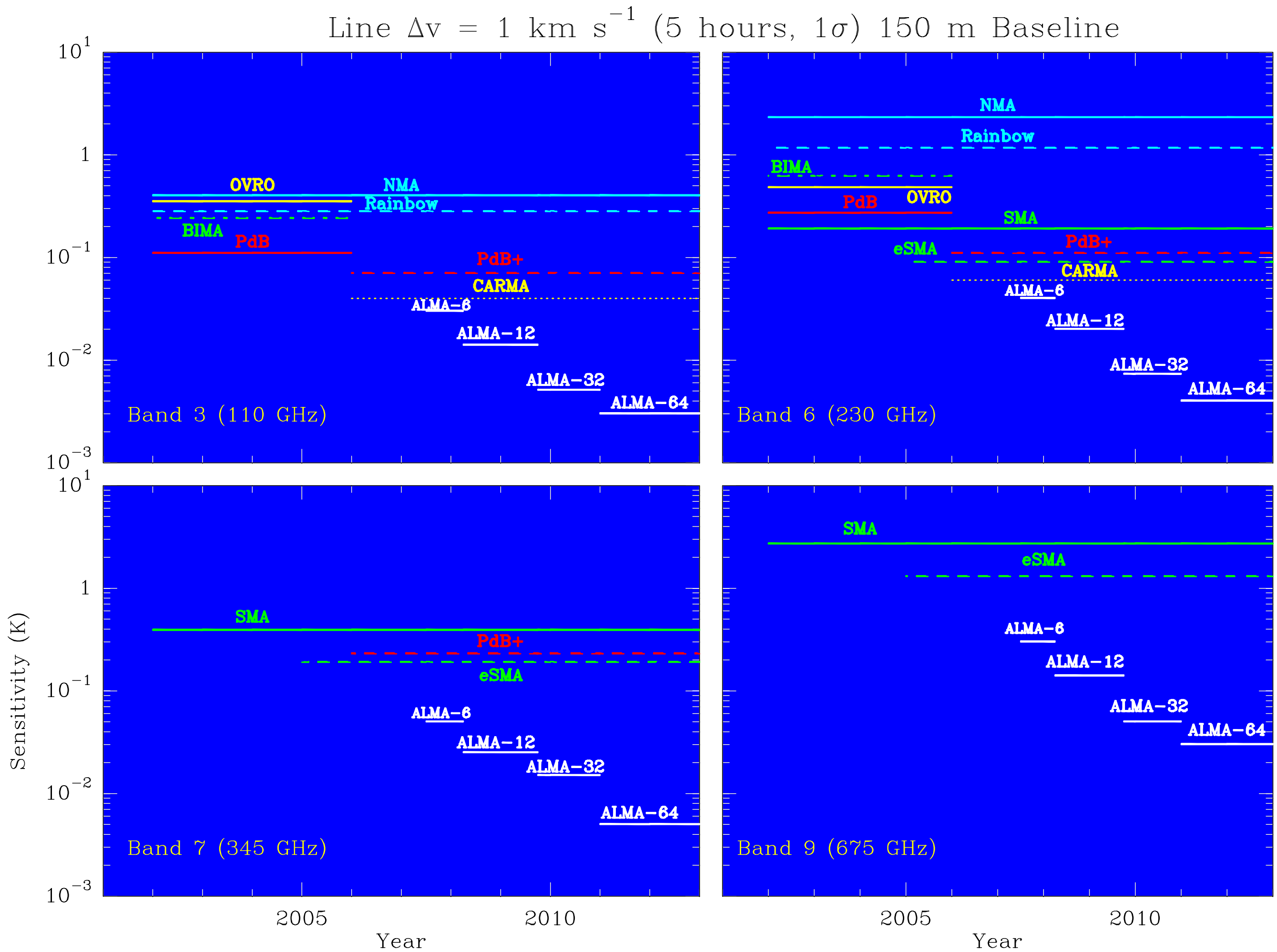

Fig. 2.— Sensitivity for line emission of width $1\,\mathrm{km\,s^{-1}}$ (1 σ, 5 hours) for ALMA with 6, 12, 32 and 64 antennas in the four Bands of the baseline project compared to the sensitivities of the present and planned millimeter/submillimeter arrays. See text for details.