Total Power (and ACA) observations with ALMA

(Thomas Stanke, EU ARC, Garching)



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An interferometer does not record an image of the sky, but samples visibilities over a set of baselines defined by the antenna positions.

The largest angular scales on which emission can be recovered are given by the shortest baselines (i.e., \geq antenna diameter).



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To recover emission on all angular scales, visibilities corresponding to shorter baselines have to be provided:

 \succ Interferometric data on shorter baselines (i.e., using smaller antennas)





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To recover emission on all angular scales, visibilities corresponding to shorter baselines have to be provided:

➢ Interferometric data on shorter baselines (i.e., using smaller antennas)
 ➢ Single dish data (D≥d_{min})



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... Why?

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RA offset (arcsec)

simple simulation of ALMA observation by Y.Kurono



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The ALMA Compact Array – ACA:

7m array:

 ≥ ten 7m antennas, operated as interferometer, baselines 9 to 32m (main array: baselines > 15m)
 Bands 3-10, spectral line and continuum observations

Total power (TP) array: ≥ two 12m antennas, operated as Single Dish telescopes Bands 3-8 Spectral line observations only





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Short spacings for ALMA main array data, Cycle-3: ... do I need any?

Interferometer sensitive only for angular scales smaller than a 'Maximum Recoverable Scale', which is given by the shortest baselines (and the observing frequency):

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\Theta_{MRS} \sim 0.6 \lambda / L_{min} [radians] ~ 37100/L_{min} v [arcsec]
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(... but this is not a 'hard' limit...)

- 1. What angular resolution do I need? -> main array configuration
- 2. Up to which scale do I need to recover emission?
 - main array configuration might be sufficient
 - a more compact main array configuration might have to be added
 - ACA 7m interferometric data might have to be added
 - ACA TP might have to be added



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Short spacings for ALMA main array data, Cycle-3: ... do I need any?

Interferometer sensitive only for angular scales smaller than a 'Maximum Recoverable Scale', which is given by the shortest baselines (and the observing frequency):

	Frequency (GHz)	Max Rec Scale, Without ACA (arcsec)	Max Rec Scale ACA 7m array (arcsec
	100	25	42.8
	150	17	28.6
	230	11	18.6
	345	7.3	12.4
	460	5.5	9.3
	650	3.9	6.6
	870	2.9	4.9
RC			

$\Theta_{\rm MRS} \sim 0.67$	∿L _{min} [radia	ans] ~ 3710	0/L _{min} ν [arcsec]
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Short spacings for ALMA main array data, Cycle-3: ... do I need any? if yes, how does it affect the total time needed?

What rms is needed in the final data? ->

integration time on main array (most extended configuration needed) $t_{_{\text{int, MA}}}$

- a more compact main array configuration is needed: -> add 50%
- ACA 7m interferometric data are needed -> add 200%
- ACA TP data are needed -> add another 200% (TP time = 4x 12m extended time, but will be observed parallel to ACA 7m observations)



Agt 💿			ALMA Observing To	ol (Cycle3) - Project	-	,	-	\odot \odot \otimes	
<u>File Edit View Tool S</u> earch	i <u>H</u> elp						Pers	spective I	
Project Structure	Editors								
Proposal Program	Spectral Spatial Control and Perfo	rmance							
Proposal Project Proposal	These parameters are used to control	various aspects of the ob	servations, including the required	antenna configurations and integration ti	Not	Estimated Time te: The time in brackets is that required to erational requirements often mean that the	reach the sensitivity. e actual observed time is l	longer,	
P 🔄 Planned Obse						pecially for mosaics. Please see the User M	anual for more details.	J .	
- General	Configuration Information Antenna Beamsize(1.13 * λ / D)	12m 16.840 arcsec	7m 28.868 arcsec		ing Be	put Parameters quested sensitivity	2.500 mlv		
- 🗋 Field Se	Number of Antennas	12m 36 7m 10		TP 2	Ba	ndwidth used for sensitivity	0.977 MHz		
- 🗋 Calibrat		Mast compact 12m co	figuration. Most extended 12m cs	ofiguration	Representative frequency (sky, first source)	345.79 GHz			
- Control	Longest baseline (L _{max})	0.161 km	6.074 km	Ingulation	Pre	ecipitable water vapour (all sources)	0.658mm (2nd Octile)		
	Synthesized beamsize (\/L _{max})	1.015 arcsec	0.037 arcsec		Tir	ne required for largest 12-m array			
	Shortest baseline (L.,)	0.015 km	0.249 km		Tim	ne on source per pointing (first source)	45.36 min [45.28 min]		
		0.013 Kill	0.240 KIII		Tot	tal number of pointings (all sources)	1		
	Maximum recoverable scale (0.6//L	min ⁾ 8.111 arcsec	0.470 arcsec		Nui Toʻ	imber of tunings tal time on source	1 45.26 min [45.29 min]		
	Desired Performance				Tot	tal calibration time	43.30 min [43.20 min] 32.22 min		
	Desired Associate Resolution (Outloade	- d D V	20000		Oth	her overheads	7.25 min		
	Desired Angular Resolution (Synthes	5.00000 arcsec		`	Tot	tal time for 1 SB execution	1.41 h		
	Largest Angular Structure in source				Nu	mber of SB executions	1		
	Desired sensitivity per pointing	2500.0 UV v equivalent to 0.28405 K v			Total time to complete SB	tal time to complete SB	1.41 h		
						Calibration Breakdown per SB execution			
	Bandwidth used for Sensitivity	RepresentativeWindowResolution Frequency Width 0.97		 Frequency Width 0.976563 MHz 	3:	× Pointing	36.00 s		
	Do you request complementary ACA Observations? Yes Yes No Science goal integration time estimate Time Estimate Override OT's sensitivity-based time estimate (must be justified) Yes No 				1 :	x SidebandRatio	1.58 min		
					1 x Amplitude 1 x Bandpass 7 x Phase 4 x Phase reference check source 8 x Atmospheric	x Amplitude	2.50 min		
						10.00 min			
						3.50 min			
						x Phase reference check source	2.00 min		
						x Atmospheric libration quarboada	5.33 min 6.30 min		
	Are the observations time-constrained	?	Ves 🖲 No		Cal	indration overneads	0.70 mm		
			0 100 0 110		Δd	ditional Arrays			
					Nu	mber of additional 12-m configurations	1		
					Tirr	ne required for additional 12-m	42.41 min		
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Overview					ES	stimated total time for science goa	12.12 h		
Contextual Halp Dhase Is Science Dra									
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3 Click on the life proposal tree node and complete the LANC LUDIARY LANGER PROSE 2									
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Moto File Edit View	ALMA Observing Tool (Cycle3) - Project 😔 😔 🖉							
Broject Structu						AQT 🕤	Estimated Time	\odot \otimes
Proposal Pro	igram	Spectral Spatial Control and Pe	erformance			i	Note: The time in brackets is that required to Operational requirements often mean that the capacity for massive Places can the Lister M	reach the sensitivity. e actual observed time is longer,
Project	pusai	These parameters are used to cont	rol various aspects of the obs	ervations, including the required a	antenna configurations and integration t		Input Parameters	andarior more details.
- 📑 Plar	nned Obse	Control and Performance					Requested sensitivity	2.500 mJy
e 🛞	ScienceGo	Configuration Information					Bandwidth used for sensitivity	0.977 MHz
	- 🗋 General Antenna - 🗋 Field Se Number	Antenna Beamsize (1.13 * λ / D) 12m 16.840 arcsec	7m 28.868 arcsec			Representative frequency (sky, first source) Precipitable water vapour (all sources)	345.79 GHz 0.658mm (2nd Octile)
-		Number of Antennas	12m 36	7m 10	TP 2			
-	🗋 Calibrat		Most compact 12m conf	iguration Most extended 12m cor	nfiguration		Time required for largest 12-m array	
-	Control	Longest baseline (L)	0.161 km	6.074 km	3		Time on source per pointing (first source)	45.36 min [45.28 min]
							Total number of pointings (all sources)	1
		Synthesized beamsize (AVL _{max})	1.015 arcsec	0.037 arcsec			Number of tunings	1 45-20 min (45-20 min)
		Shortest baseline (L _{min})	0.015 km	0.248 km			Tatal calibration time	45.36 min [45.28 min]
		Movimum resourcelle coole (0.6	3// 3				Other everbands	32.22 IIIII 7.25 min
	S M	Maximum recoverable scale (0.0	8.111 arcsec	0.470 arcsec			Total time for 1 SR evecution	1.41 b
		Desired Performance					Number of SB executions	1
		Desired Angular Resolution (Synthe	sized Beam)	30000 arcsec	•		Total time to complete SB	1.41 h
	Largest A	Largest Angular Structure in source	3	5.00000 arcsec 👻			Calibration Breakdown per SB execution	
		Desired sensitivity per pointing	2	50000 mlu – aquivalant t	0.39405		3 x Pointing	36.00 s
		Desired sensitivity per pointing	2.	soudo inity equivalent to	0 0.28405 K		1 x SidebandRatio	1.58 min
		Bandwidth used for Sensitivity	B	epresentativeWindowResolution	Frequency Width 0.976563 MHz		1 x Amplitude	2.50 min
		, , , , , , , , , , , , , , , , , , ,					I x Bandpass	10.00 min
		Do you request complementary ACA Obser	Observations?	Yes O No Suggest			/ x Phase reference shock source	3.50 min
						8 x Atmospheric	9 v Atmospheric	5.32 min
		Science goal integration time estimate	ate	Т	ime Estimate		Calibration overheads	6.70 min
	Override OT's sensitivity-based time estimate (must be justified) O Yes () No			Additional Arrays				
							Number of additional 12-m configurations	1
		Are the observations time-constrained? O Yes No				Time required for additional 12-m	42.41 min	
							ACA 7-m time (t_12m x 2)	2.83 h
							ACA TP time (t_12m x 4)	5.66 h
•							Total ACA time (max[t_7-m,t_TP])	5.66 h
^								
Overview							Estimated total time for science goa	l 7.78 h
	Contextual Help Phase I: Science Pro							
1. Please ensure you and your co-Is are registered with New L Create L Valid						OK		
	the <u>ALMA Science Portal</u>						Proposal	
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ACA 7m array will cover the same field as the 12m main array

ACA 12m total power antennas will observe a slightly larger field

Observations will use, if possible, the same calibrators

Single Dish data will include a map of a bright unresolved source to measure the K \rightarrow Jy conversion factor

Observations will be done close in time, but not simultaneously with 12m main array

Data reduction: 7m array: similar to 12m main array TP: pipeline reduced data cubes Combination: CASA guides (still...) in preparation



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Summary

Short spacings in Cycle-3:

➢ 7m array: spectroscopy, continuum, B3,4,6,7,8,9,10

Total Power array: spectroscopy, B3,4,6,7,8

All you need to think about: what is the largest scale I want to recover?
 OT will work out the rest!

Future developments: B9,10; continuum (using 'nutators'...)



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