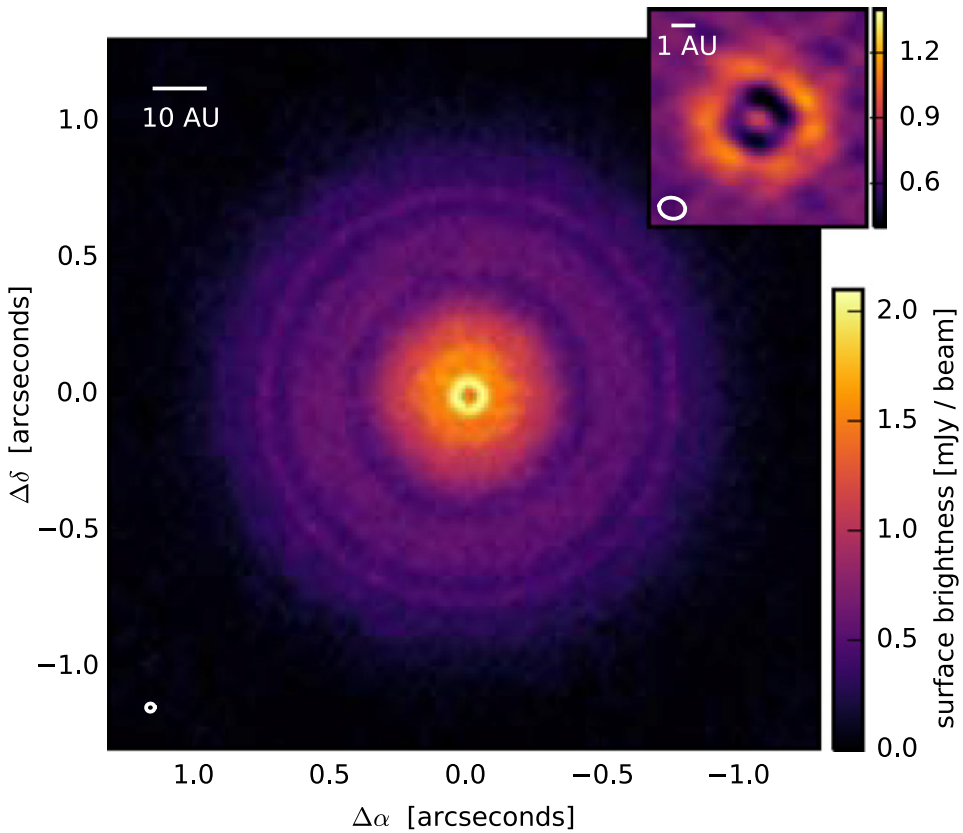
Cradle of Life

- High Priority Science Case
  - Mapping grain growth in proto-planetary discs
  - Young stellar cluster deep field
  - Preparatory work
- Consequences of proposed cuts to SKA1-Mid and Band 5
  - Significant impact
- Comparison with VLA
  - Same sensitivity

Planet Formation

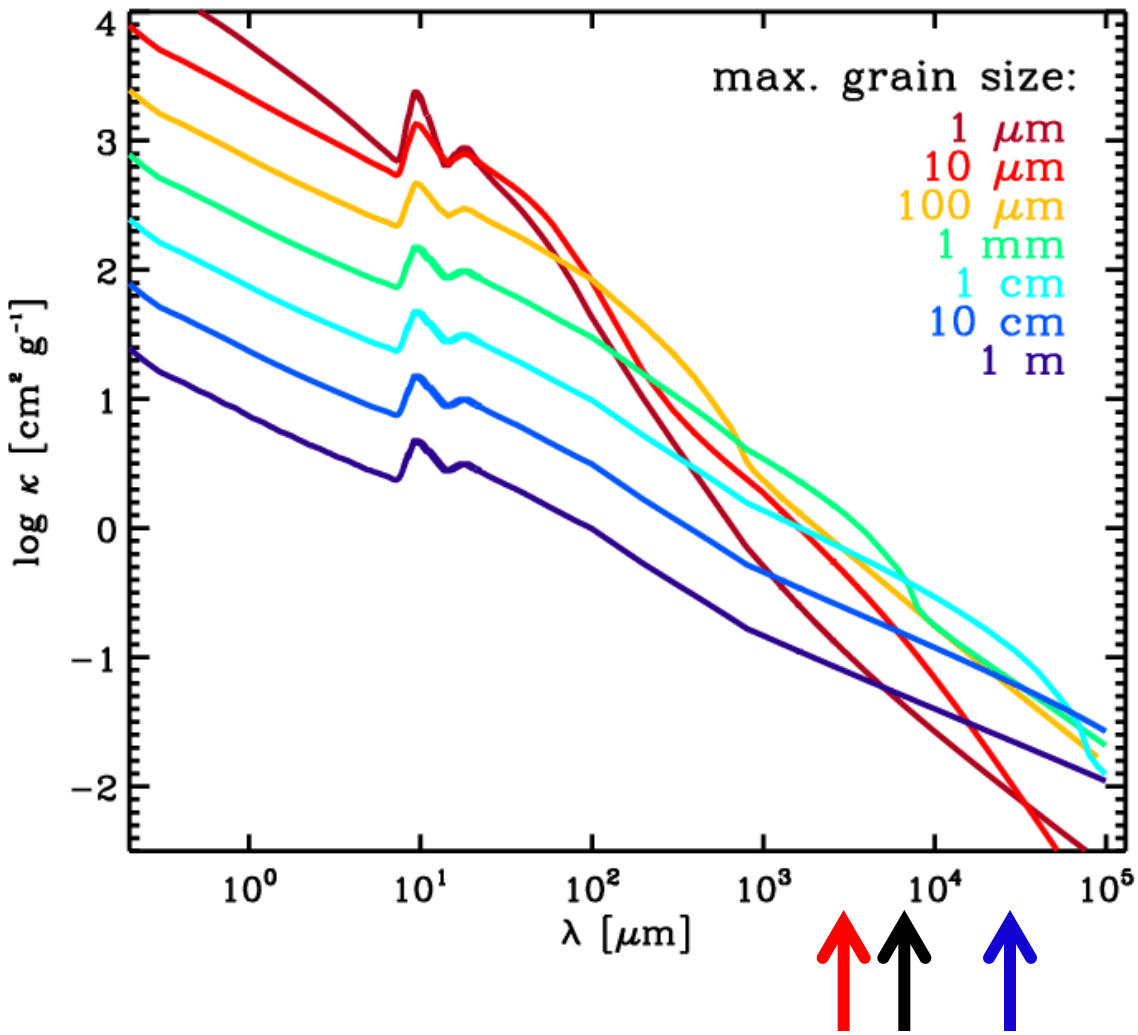
- ALMA observations with resolution 0.040″ (4 au @ 100 pc) are revealing significant structures in proto-planetary disc dust emission



0.030″ resolution 870 μm image of TW Hya
Credit: S. Andrews (Harvard-Smithsonian CfA);
B. Saxton (NRAO/AUI/NSF); ALMA (ESO/NAOJ/NRAO)

Need cm-wave data

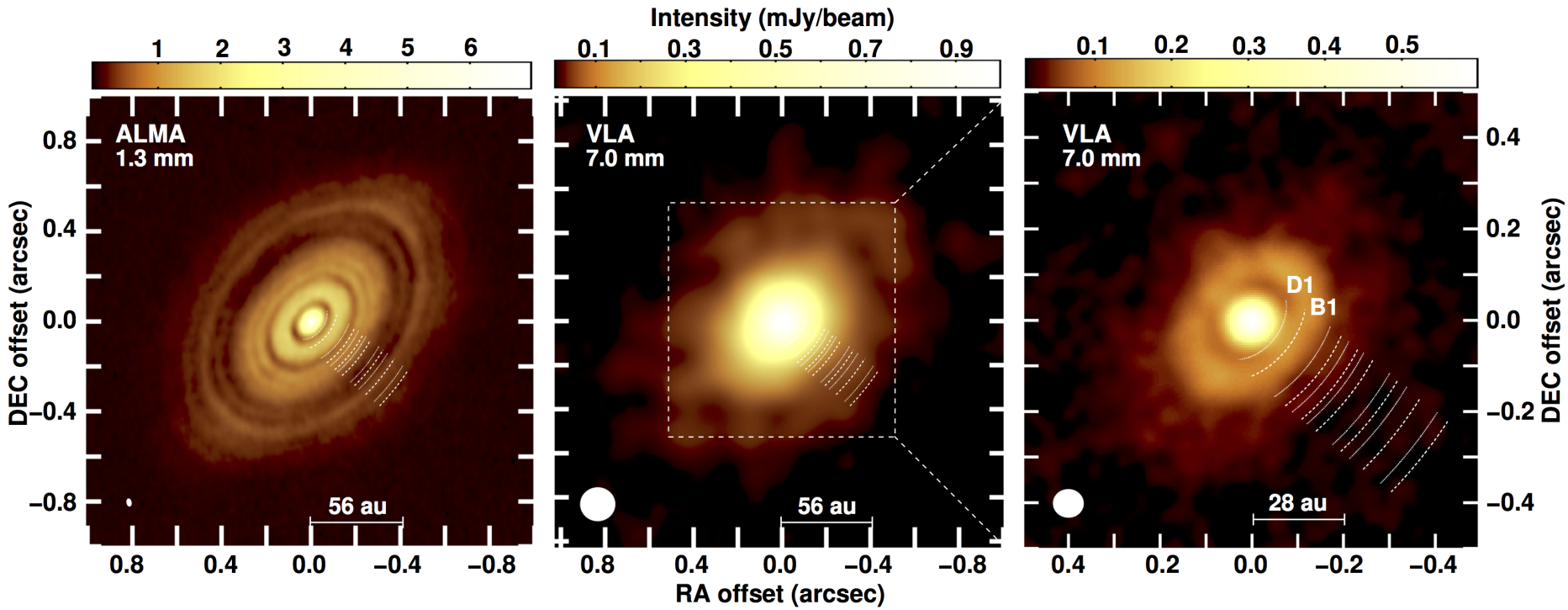
- Spectral index map gives size
- Need cm-wave observations to probe cm-sized grains
- Key problem growing grains through cm-sized regime



Matching 0.040″ beam

Mapping Grain Growth

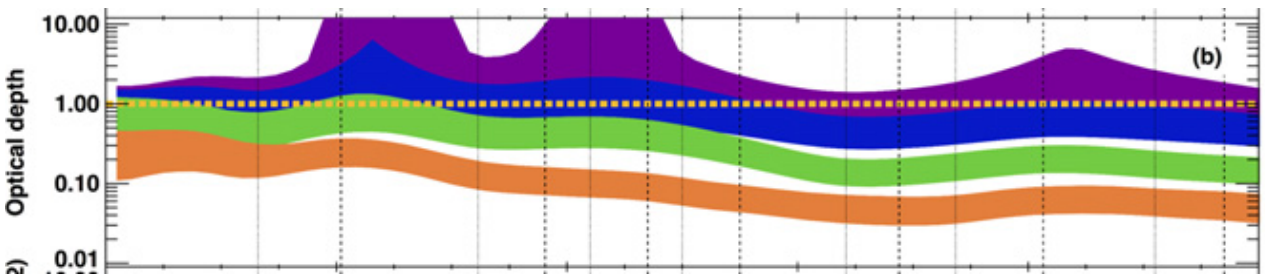
- VLA can achieve 0.04″ at 7 mm (43 GHz)
- SKA1-Mid at 2.5 cm (12 GHz)



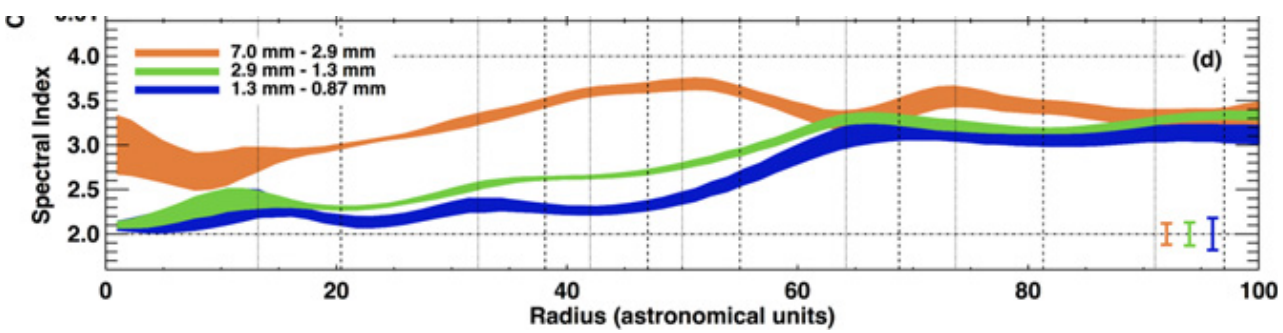
0.030″ 0.15″ 0.070″

Carrasco-Gonzalez et al. (2016)

State-of-the-art



PPDs only optically thin at cm wavelengths



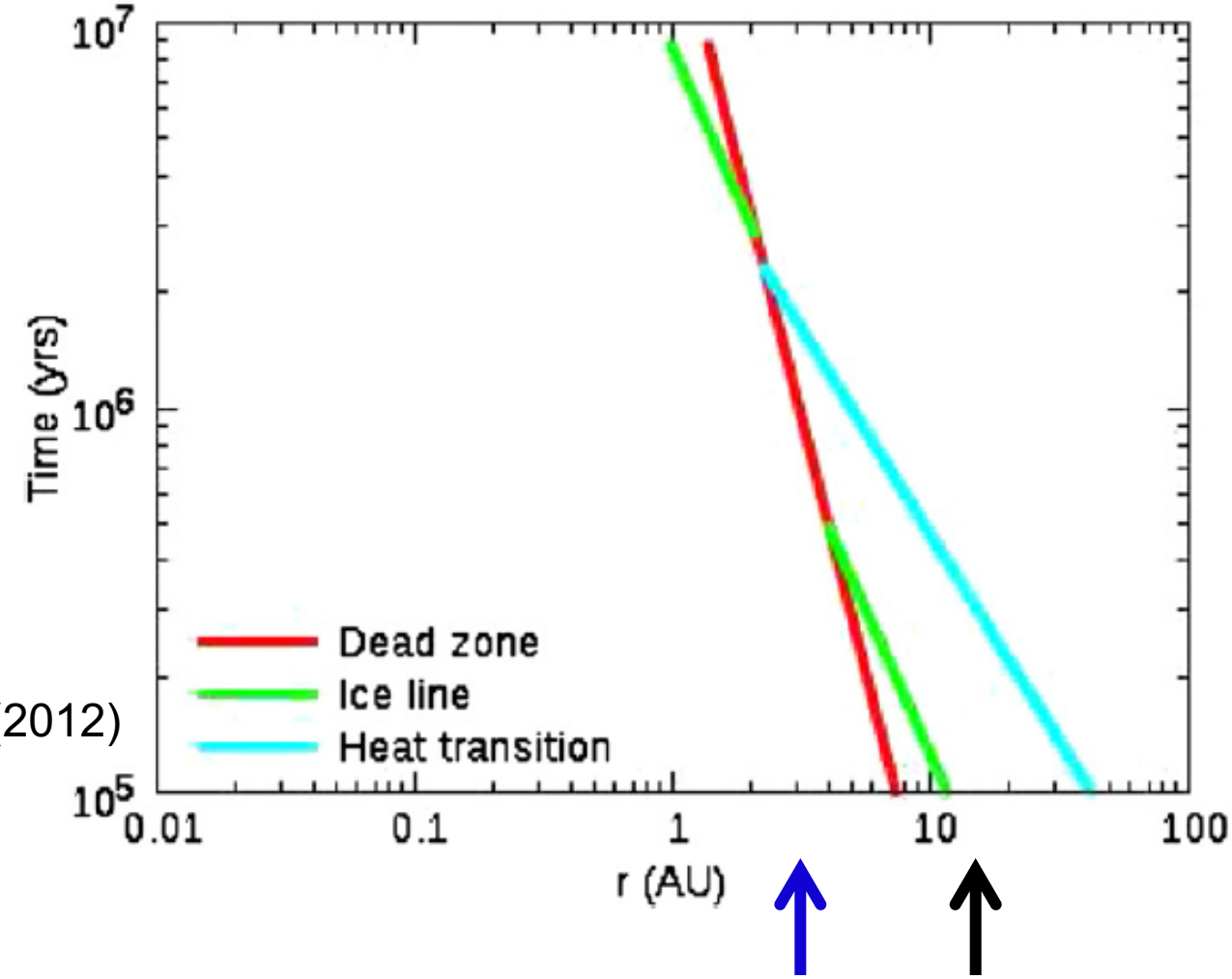
Shallower spectral index indicates grain growth in inner disc

(Carrasco-Gonzalez et al. 2016)

Inside the snow line with SKA1

- Need 'dust traps' to help grains grow
- E.g. the water snow line

Hasegawa & Pudritz (2012)

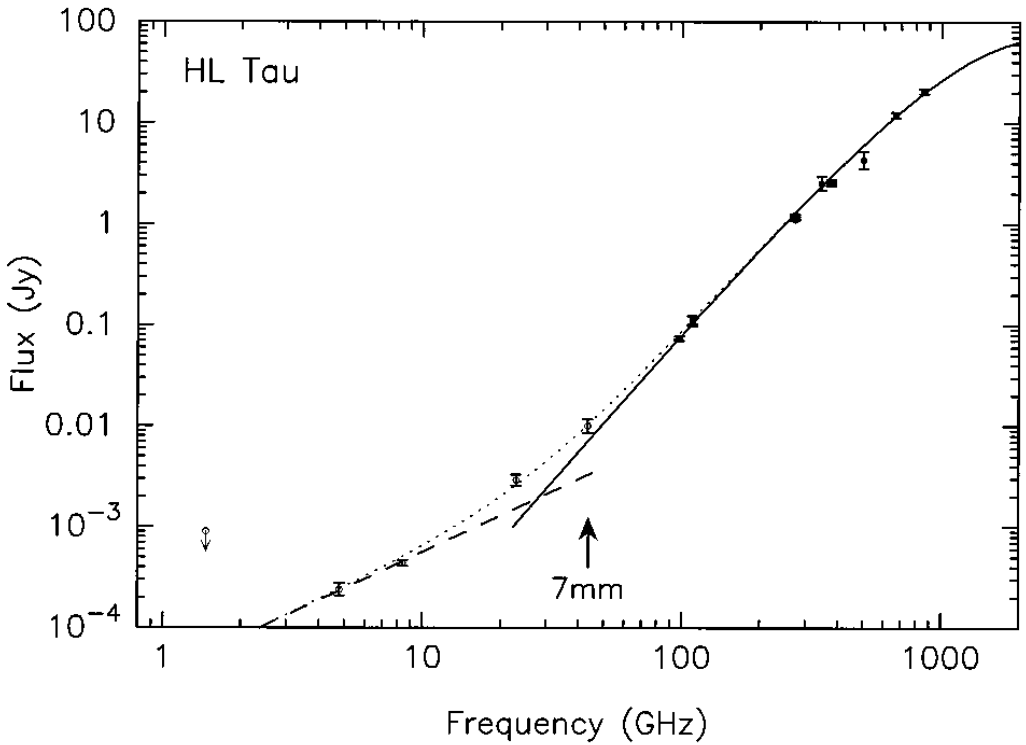


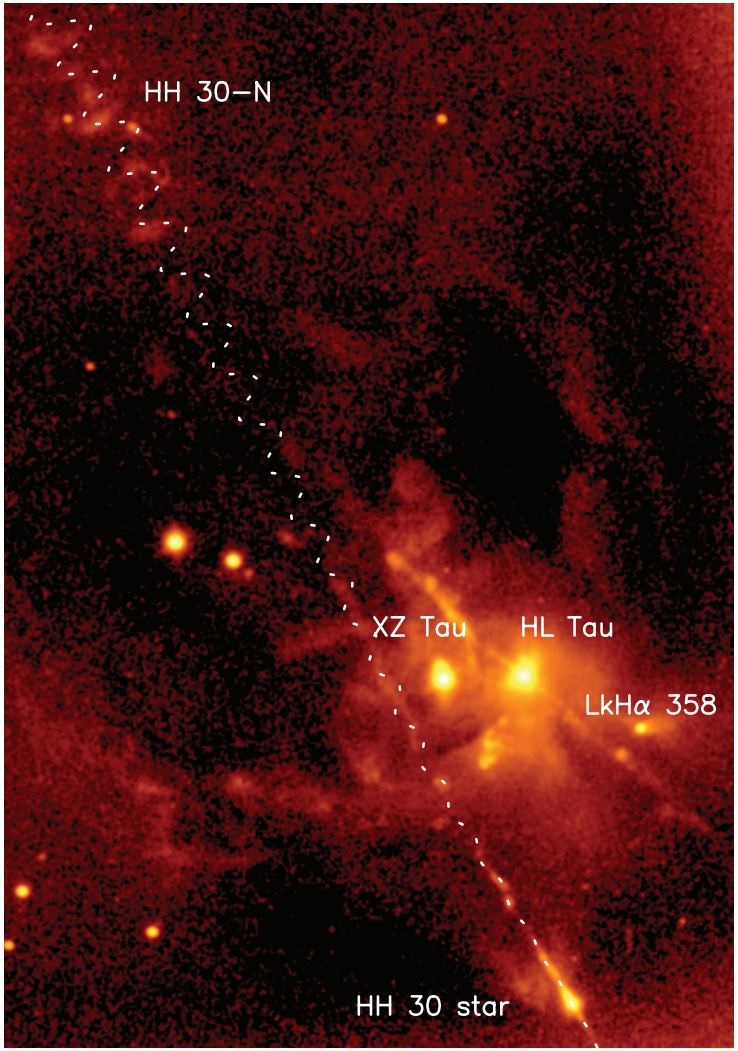
Spatial resolution at 12 GHz at 100 pc

SKA1 JVLA

Ionized Jet Emission

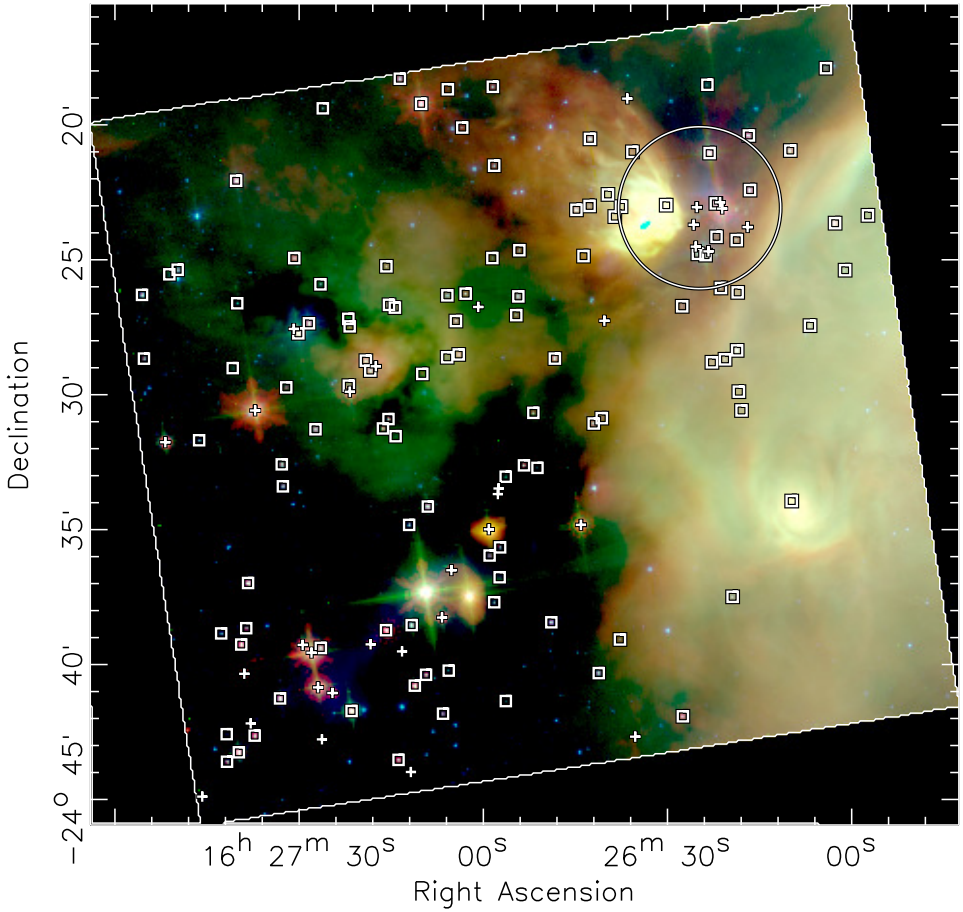
- Need to accurately resolve and subtract jet emission seen at longer cm wavelengths



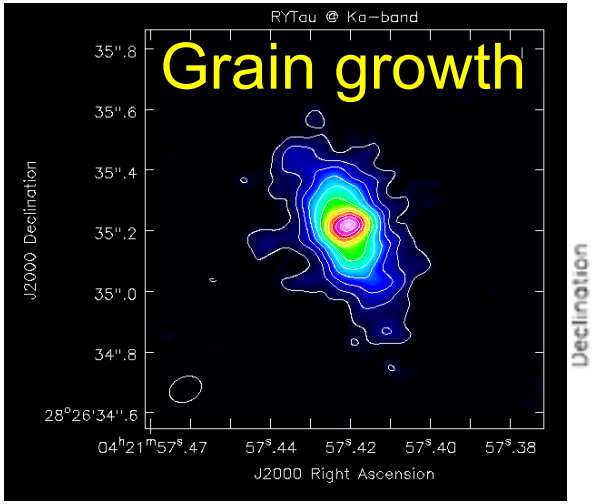


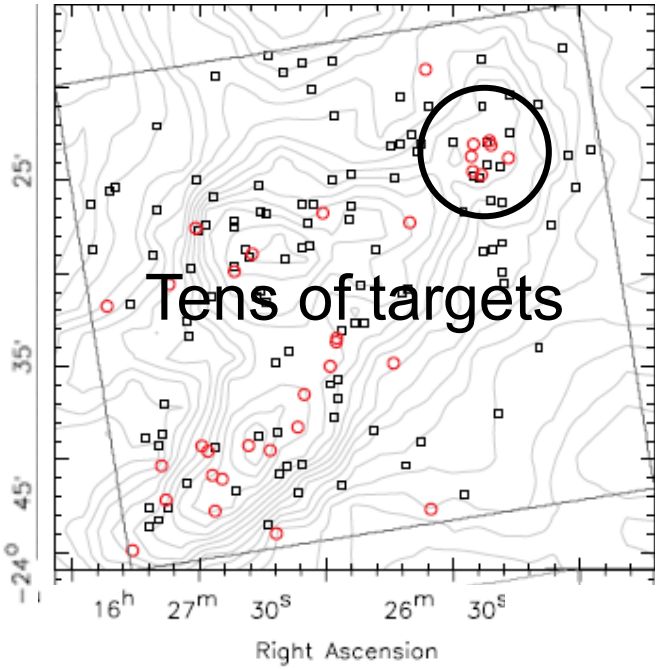
Key Science Project Outline

- ~ 1000 hr single pointing
- Top end of Band 5
- 0.04” resolution equivalent to 5 au at 125 pc
- Young nearby cluster for multiple tagets

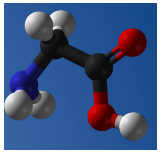


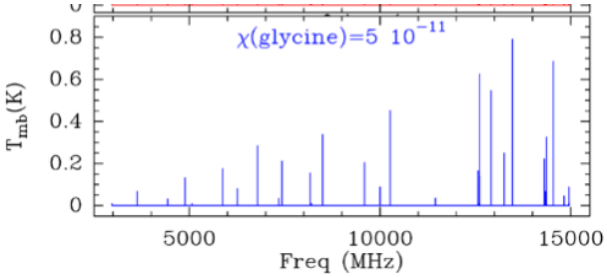
Young Cluster Deep Field



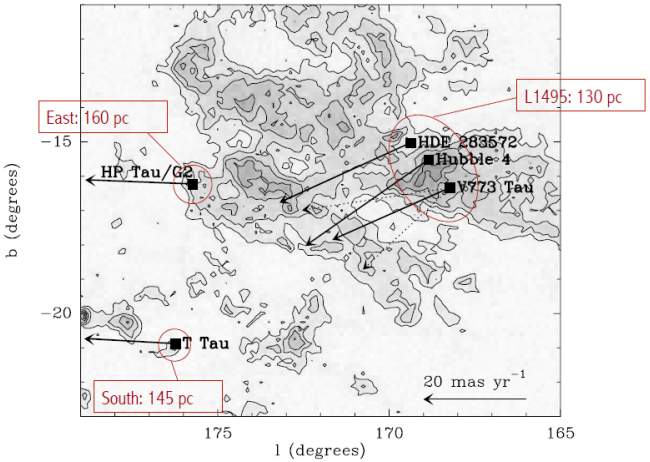


Pre-biotic molecules

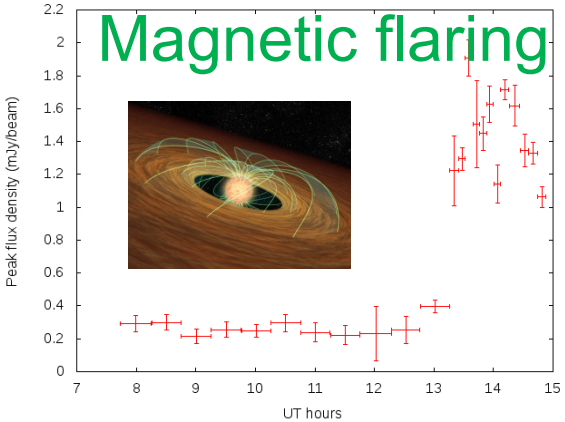


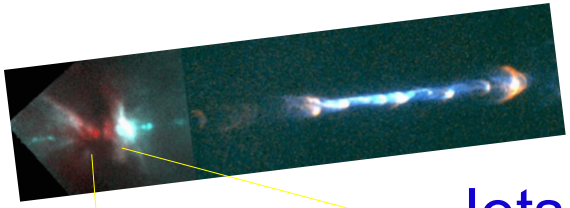


6D tomography

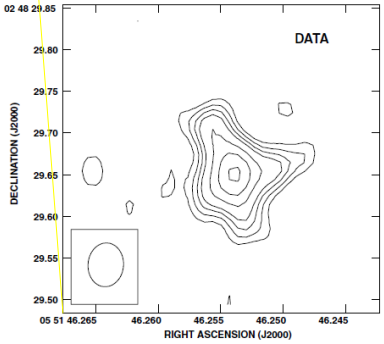


Magnetic flaring



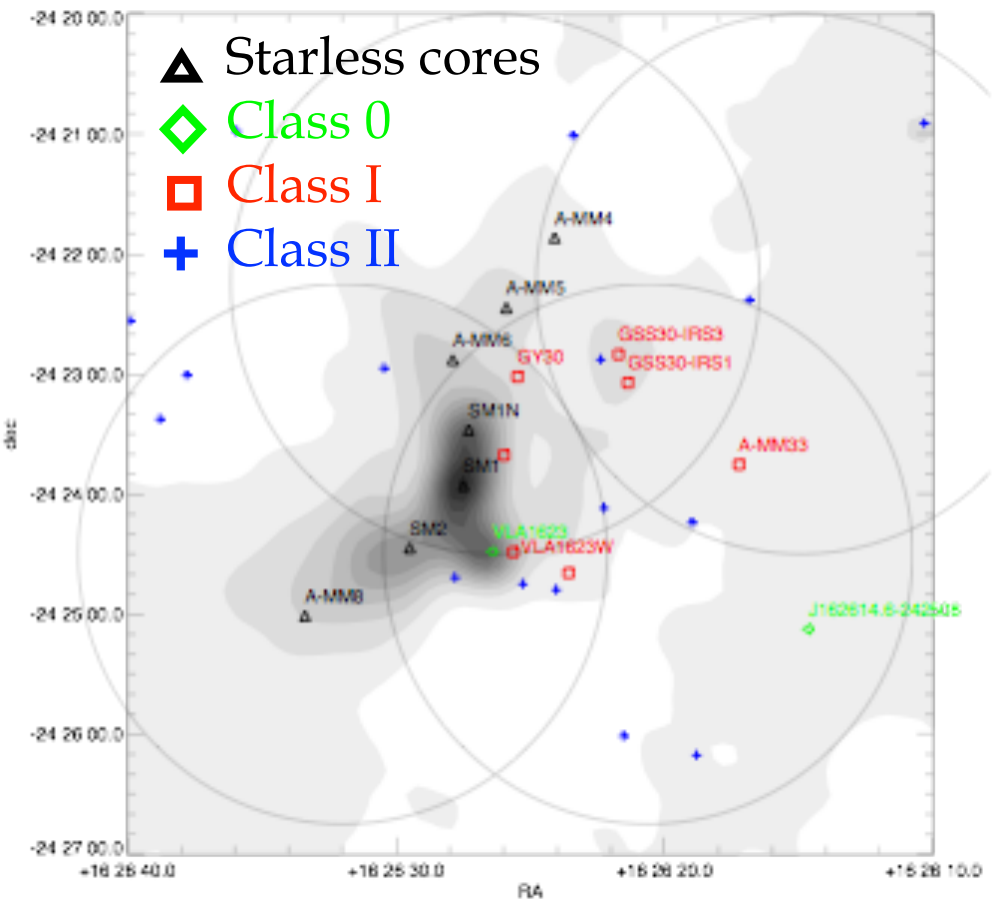


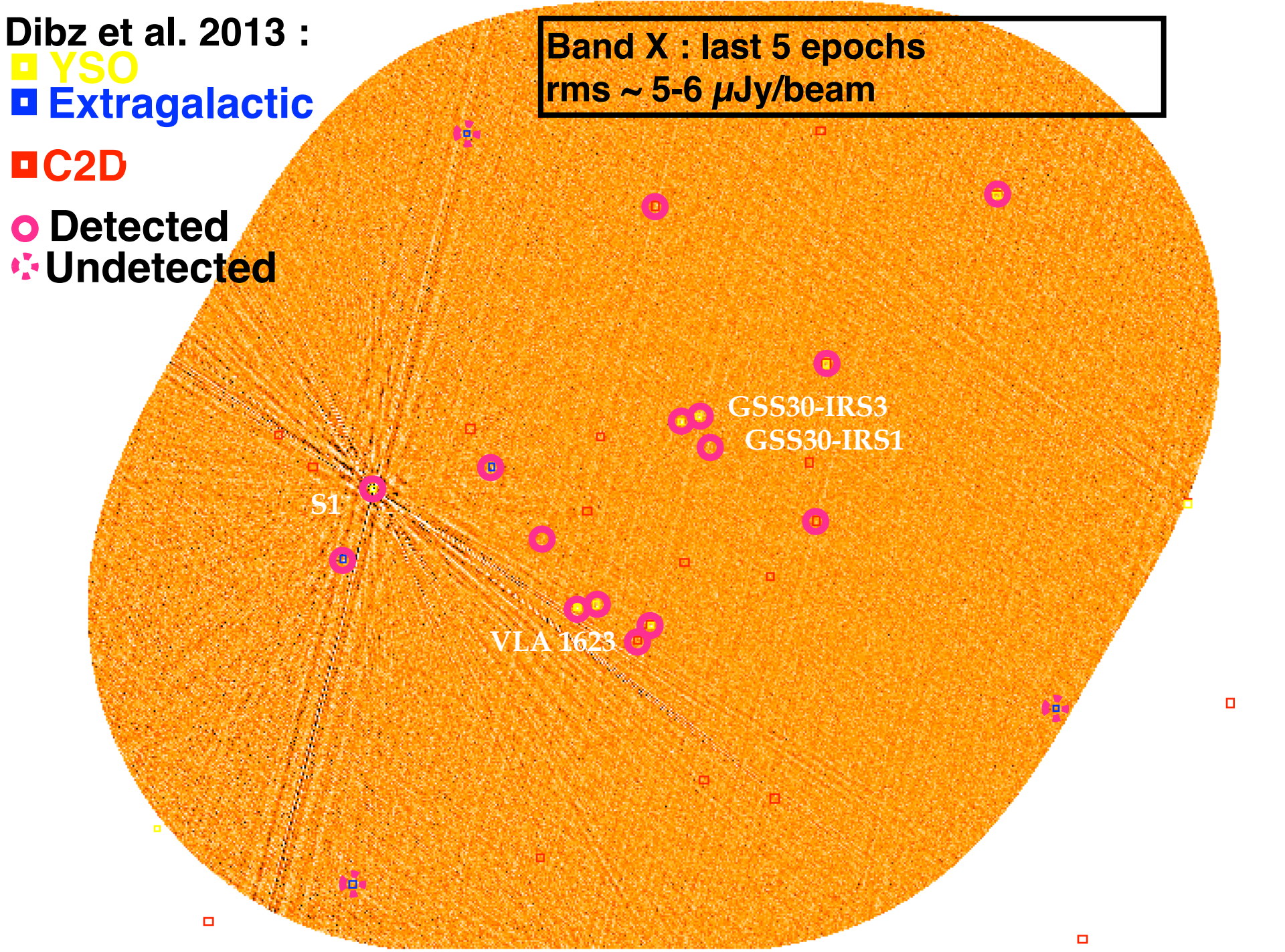
Jets



VLA Pilot

- 15 x 42 min epochs observed so far in a pilot study of the selected target ρ Oph A (PI Coutens, UCL)
- Objects at different stages of evolution
- X-band in A config giving 0.2″ resolution at 4 GHz bandwidth




Dibz et al. 2013 :
YSO
Extragalactic
C2D
Detected
Undetected
Band X : last 5 epochs
rms ~ 5-6 μJy/beam
GSS30-IRS3
GSS30-IRS1
S1
VLA 1623

Catalogue of the sources detected in Band X

VLA name	Source type[1]	Flux (mJy)[2] 10.0 GHz	Flux (mJy)[2] 7.5 GHz	Flux (mJy)[2] 4.5 GHz	Other names
J162610.32-242054.9	YSO/II	0.307[3]	0.160 ± 0.022	0.100 ± 0.012	GSS 26
J162616.85-242223.5	YSO/II	0.121 ± 0.023	0.360 ± 0.024	0.337 ± 0.017	
J162617.24-242346.0	YSO	0.363 ± 0.075	–	–	A-MM33/CRBR12/ISO-Oph 21
J162621.36-242304.7	YSO	0.157 ± 0.042	–	–	GSS30-IRS1/Elias 21
J162621.72-242250.9	YSO/I	0.364 ± 0.030	0.304 ± 0.029	0.238 ± 0.017	GSS30-IRS3/LFAM1
J162622.39-242253.4	YSO/II	0.292 ± 0.027	1.42 ± 0.07	2.02 ± 0.10	GSS30-IRS2/VSSG12/ISO-Oph 34
J162623.36-242059.9	YSO?	0.133[3,4]	–	–	
J162623.42-242101.9	YSO?	0.216 ± 0.069	–	–	
J162623.58-242439.9	YSO/FS	0.237 ± 0.035	< 0.06	0.125 ± 0.015	
J162624.04-242448.5	YSO	0.181 ± 0.040	–	–	
J162625.63-242429.4	YSO/I	0.277 ± 0.041	0.198 ± 0.023	0.218 ± 0.014	VLA1623 W
J162626.31-242430.7	YSO/0?	0.485 ± 0.033	0.189 ± 0.034 ?	0.189 ± 0.034 ?	VLA1623 B
J162626.39-242430.8	YSO/0	0.289 ± 0.030	0.125 ± 0.025	0.087 ± 0.030	VLA1623 A
J162627.83-242359.3	Unknown[5]	0.340 ± 0.055	–	–	
J162629.62-242317.3	EG	0.255 ± 0.054	0.124 ± 0.018	0.228 ± 0.014	
J162634.17-242328.7	YSO/III	7.75 ± 0.11	7.07 ± 0.35	7.98 ± 0.40	S1
J162635.33-242405.3	EG	0.377 ± 0.039	0.329 ± 0.033	0.650 ± 0.038	

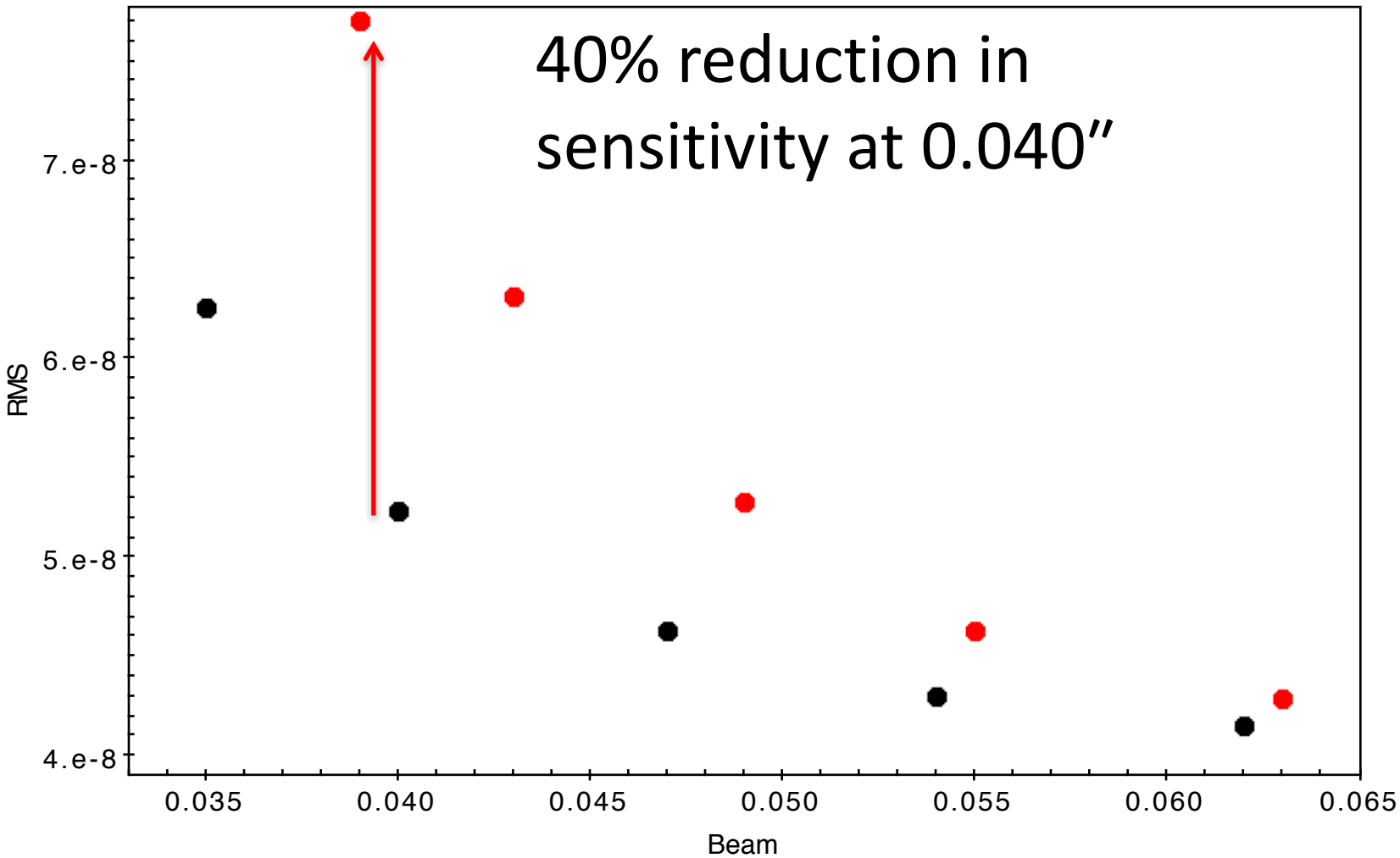
Ours

Dzib et al. (2013)

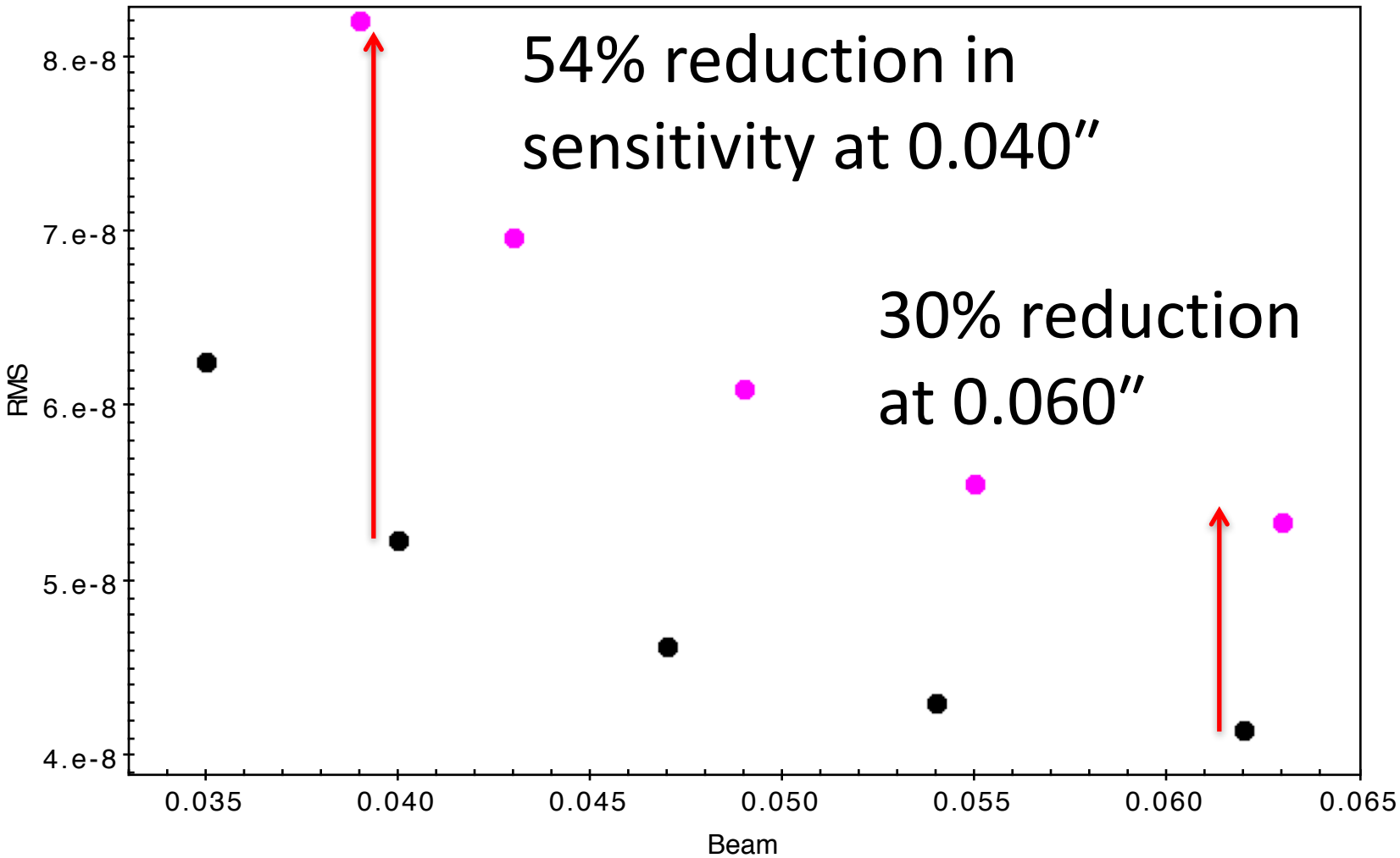
Affect of Proposed Cuts

- Run simulations using Robert's scripts
  - 1000 hours
  - Centred at 11.3 GHz
  - No Band 5 on MeerKAT dishes
  - Use Band 5a/b Tsys as in ECP giving 20K
- Investigate noise level for the various cuts
- Simulate affect on proto-planetary disc model simulation

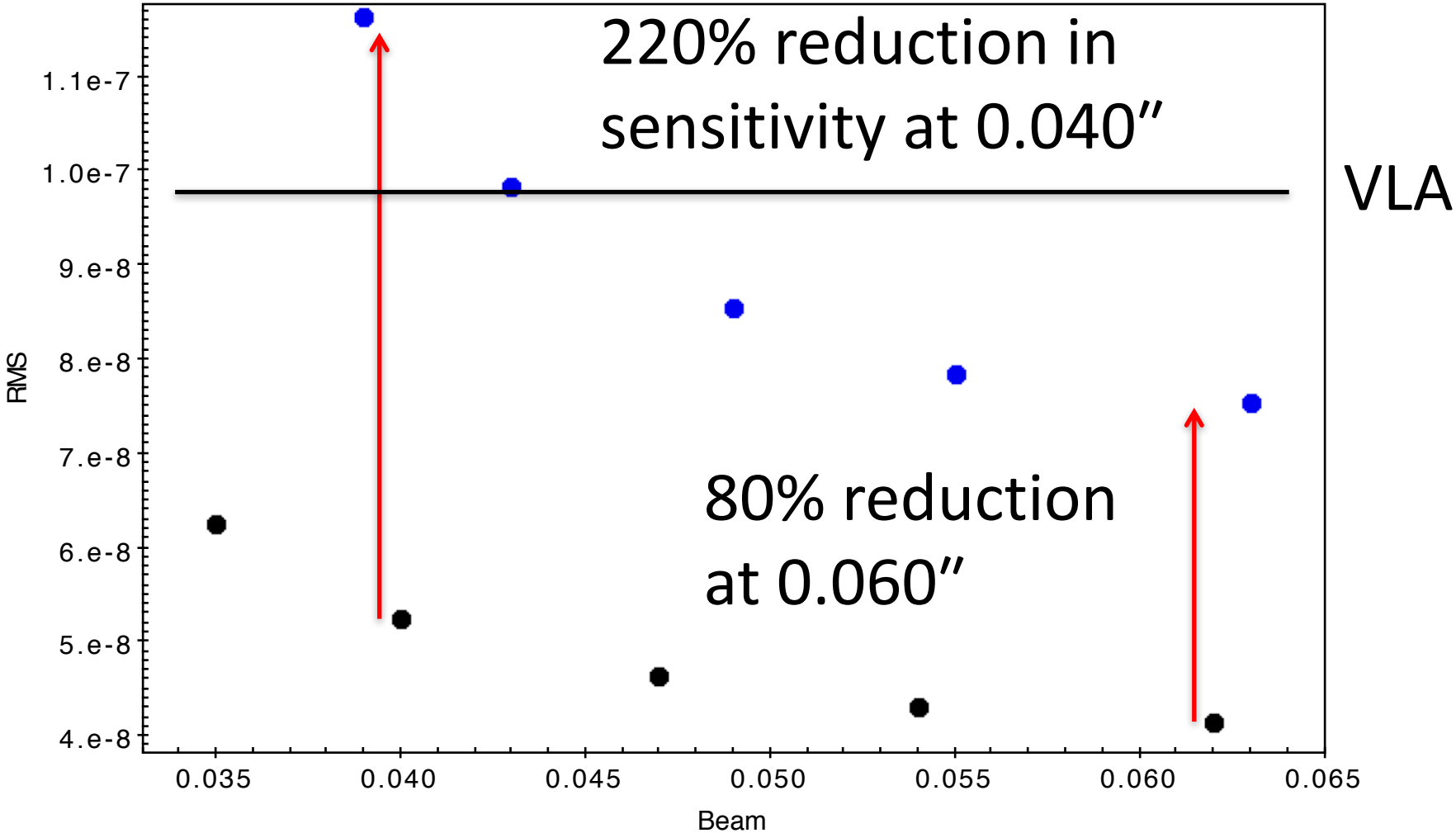
Reduce Bmax MID to 120 km



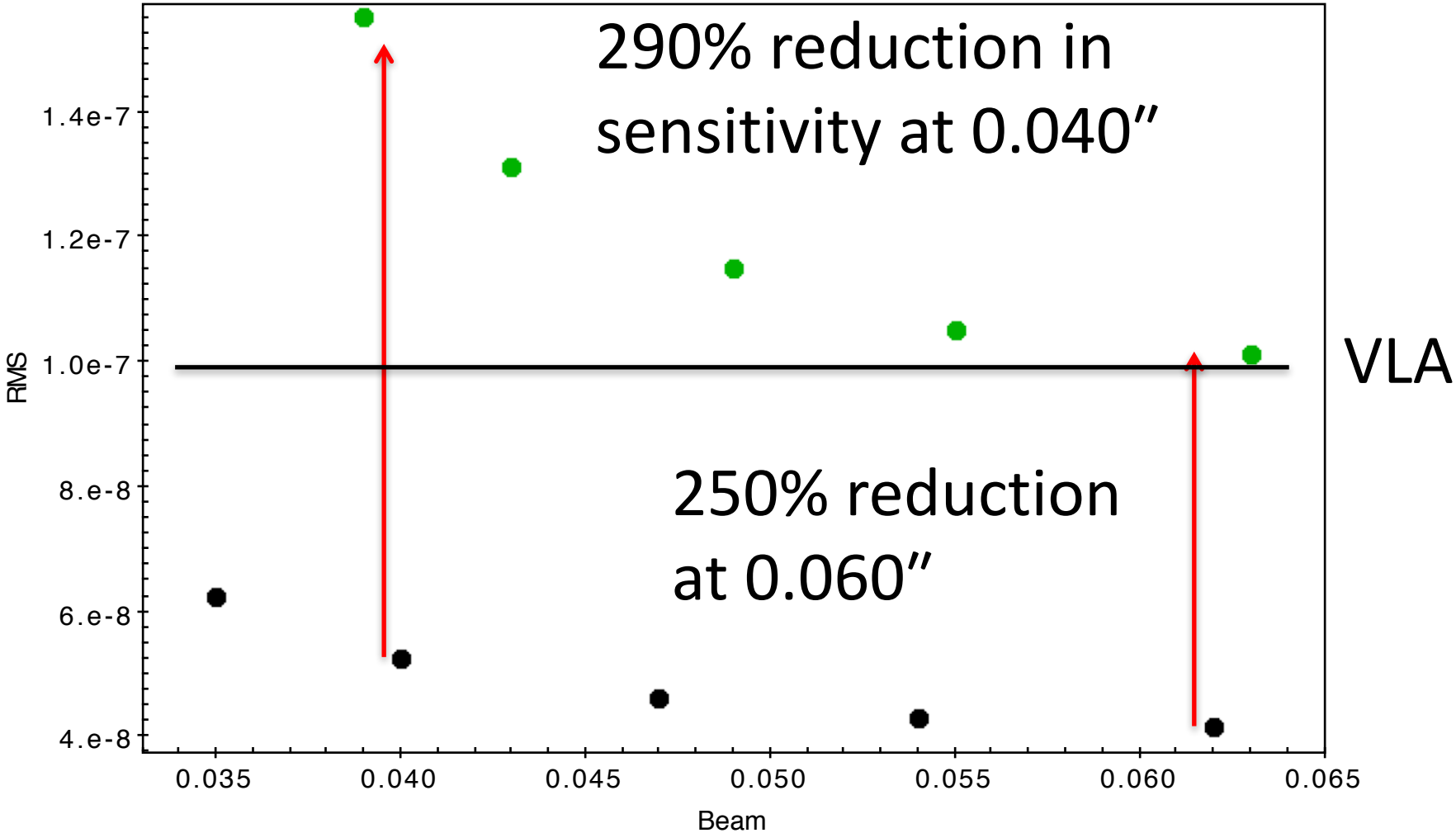
Reduce MID Band 5 feeds to 64



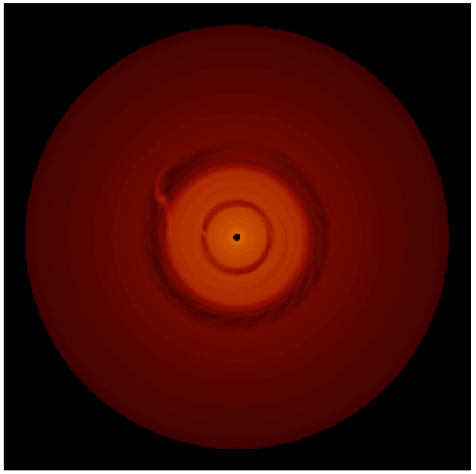
Reduce MID Band 5 BW to 2.5 GHz



Reduce MID Band 5 BW to 1.4 GHz



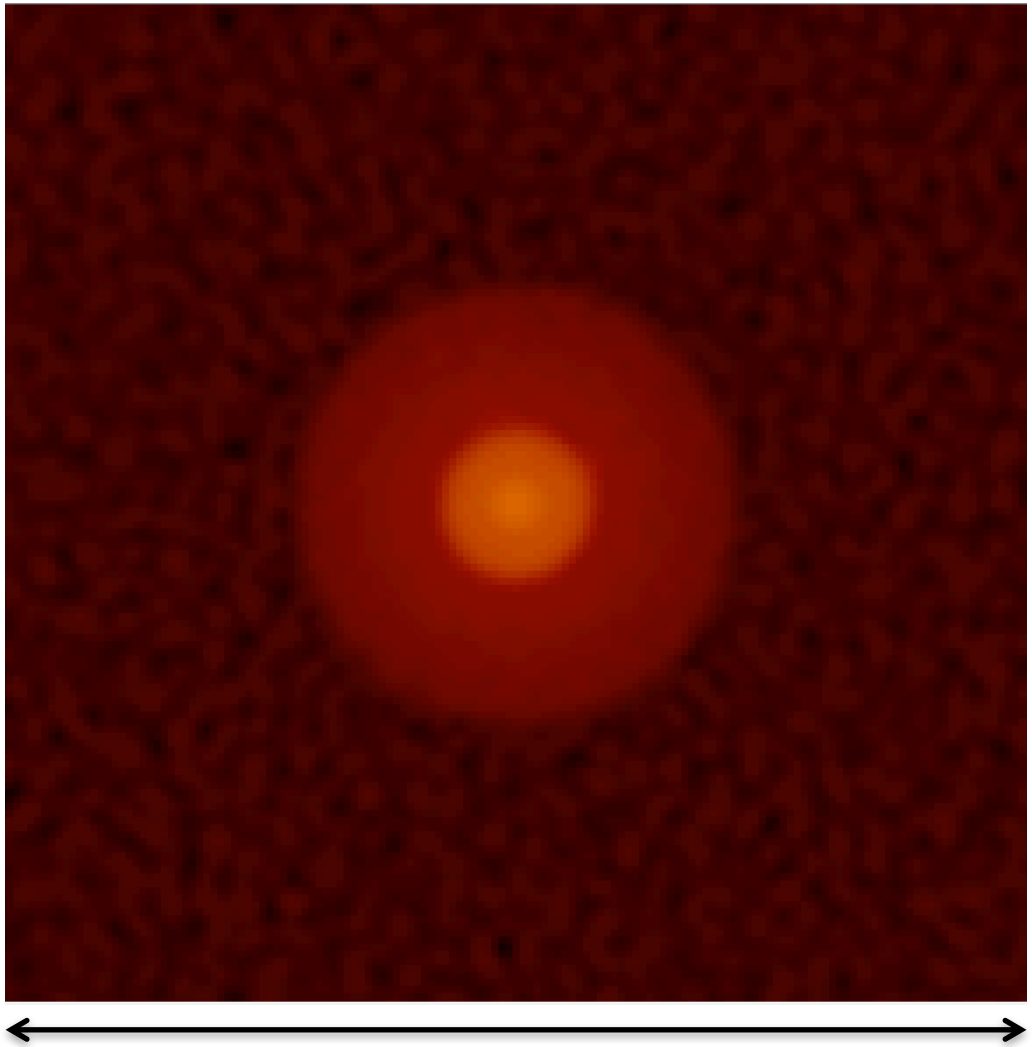
Proto-Planetary Disc Model



0.7″
90 au

From Andrea Isella
via Tyler Bourke
d=130 pc

Seen through full 133 feed array



1000 hours
11.3 GHz
5 GHz BW
0.040” beam

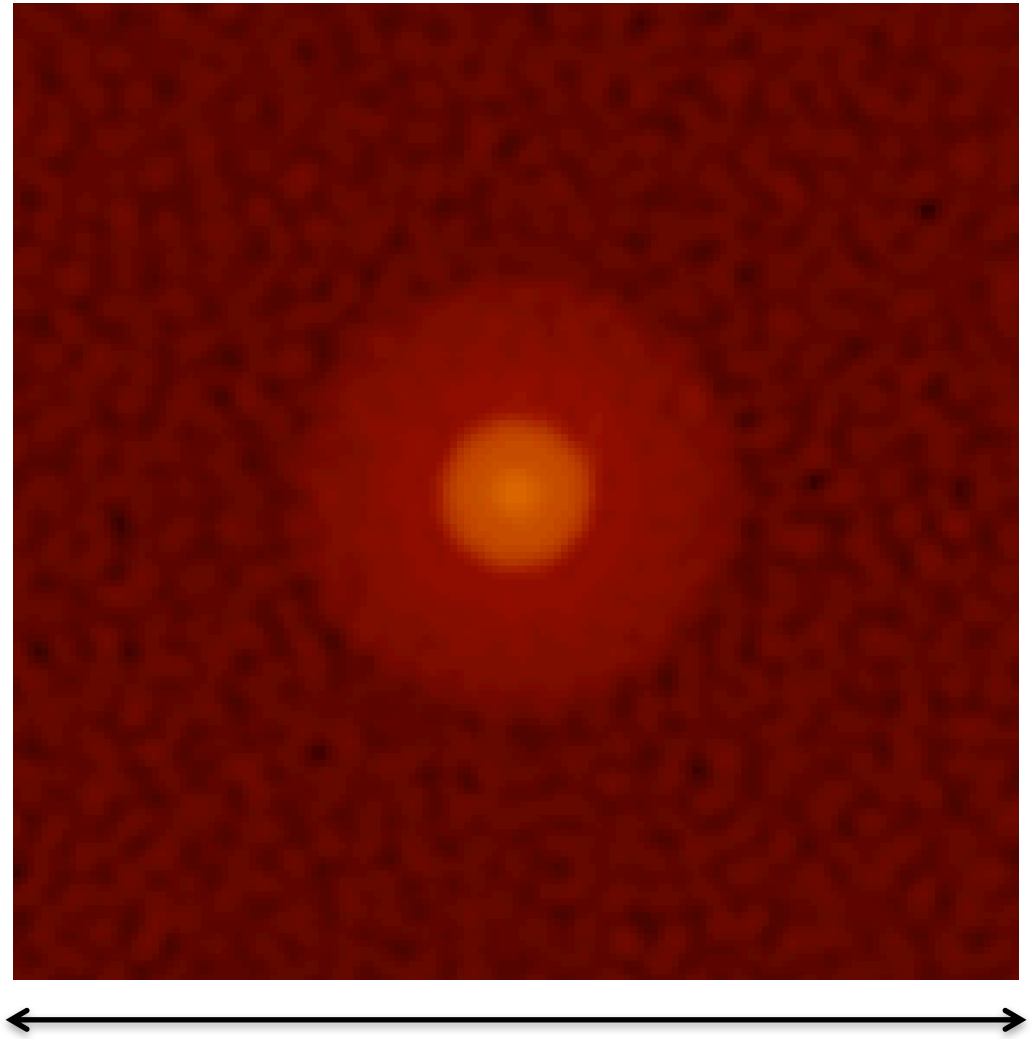
Total flux density:
350 μJy

Peak flux:
21 μJy/beam
T_b=125 K

Noise level:
57 nJy/beam
T_b=0.3 K

1.3”
170 au

Through arms only with 1.4 GHz BW



1000 hours
11.3 GHz
1.4 GHz BW
0.044” beam

Total flux density:
320 μJy

Peak flux:
21 μJy/beam
T_b=125 K

Noise level:
130 nJy/beam
T_b=0.8 K

1.3”
170 au

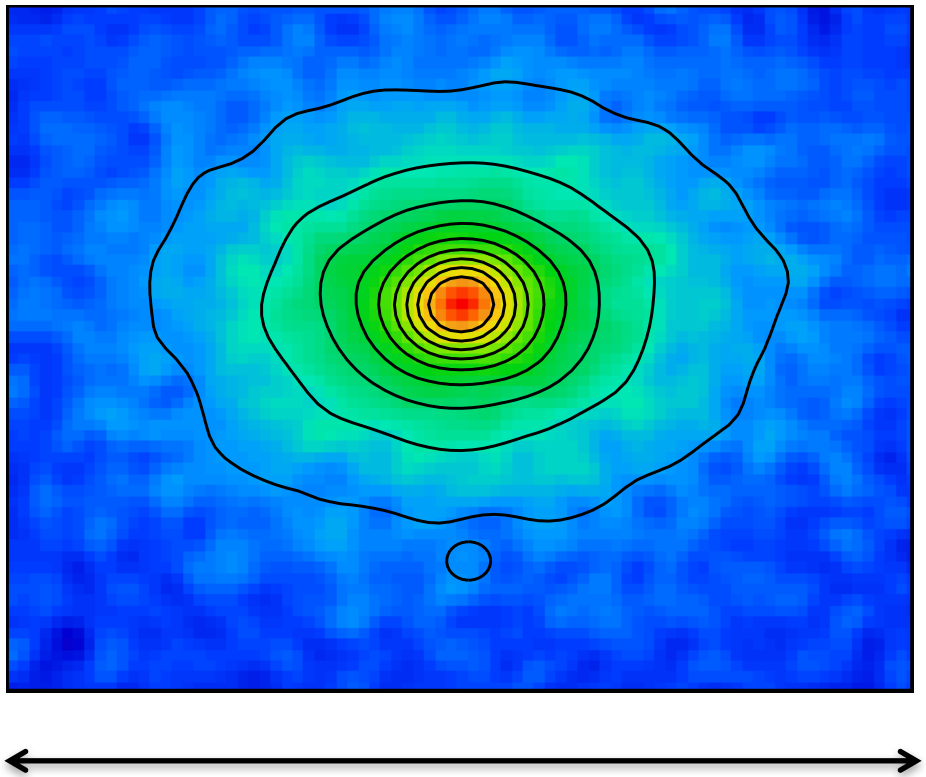
Alternative PPD Model

From Laura Perez

d=125 pc

1 $M_\odot$ star

Minimum Mass Solar Nebula of material



0.85”
105 au

1000 hours
11.3 GHz
5 GHz BW
0.038” beam

Total flux density:
180 μJy

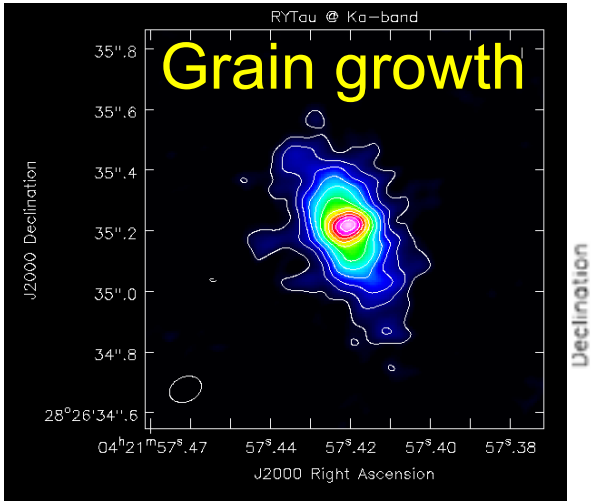
Peak flux:
4 μJy/beam
T_b=30 K

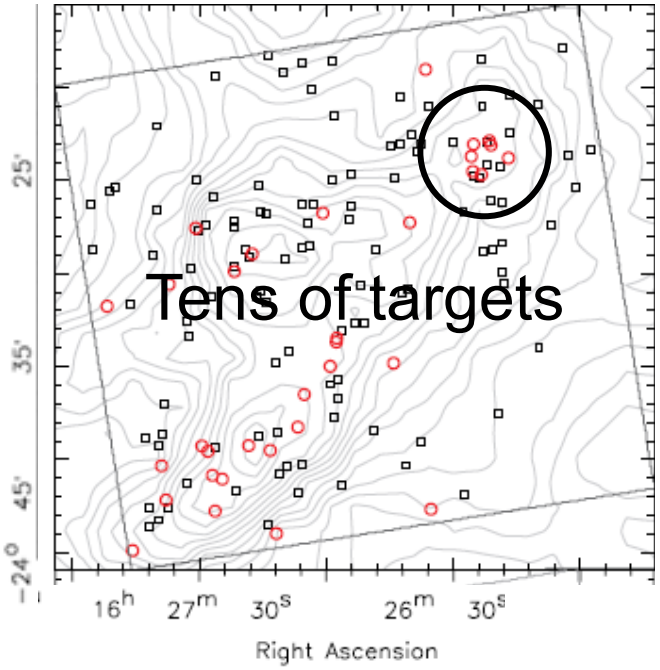
Noise level:
70 nJy/beam
T_b=0.5 K

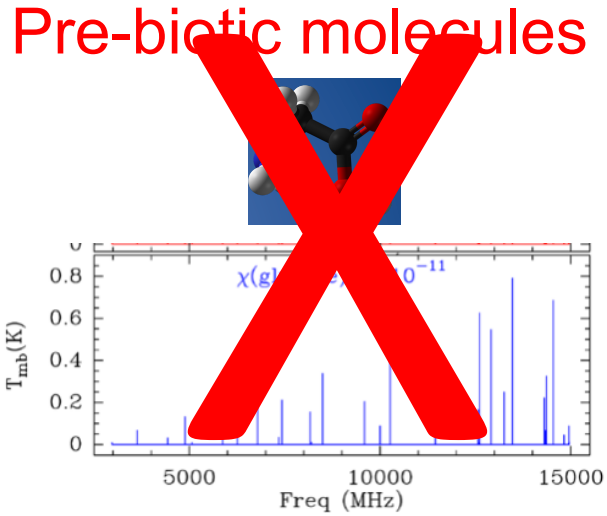
Flux levels

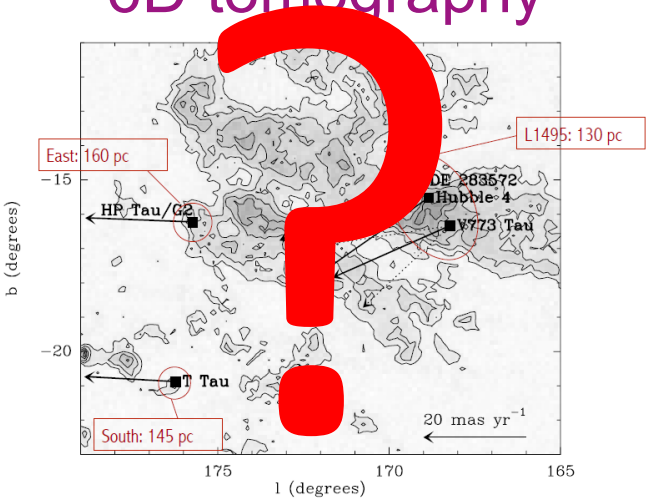
Model	Flux Density (μJy) at 11.3 GHz
Isella	350
Perez	180
TW Hya	98
HL Tau (including free-free)	270
HL Tau (dust only estimate)	12
Average ρ Oph A (inc. f-f)	~250

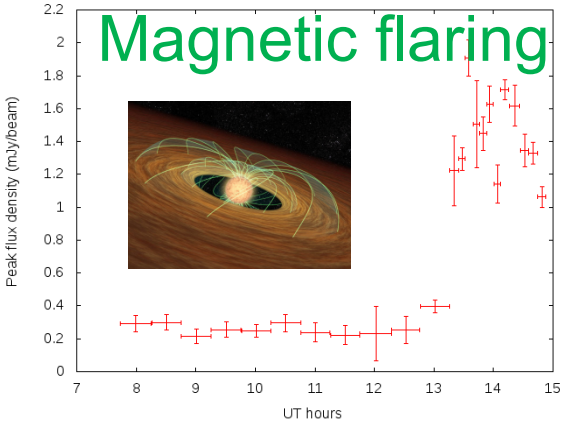
Other Aspects of the KSP

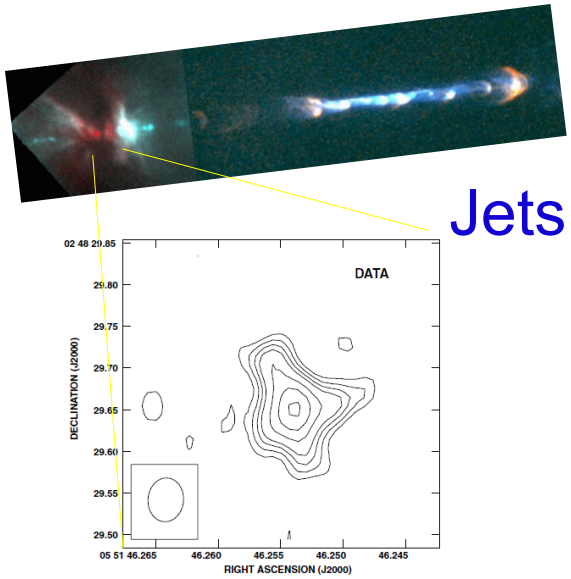






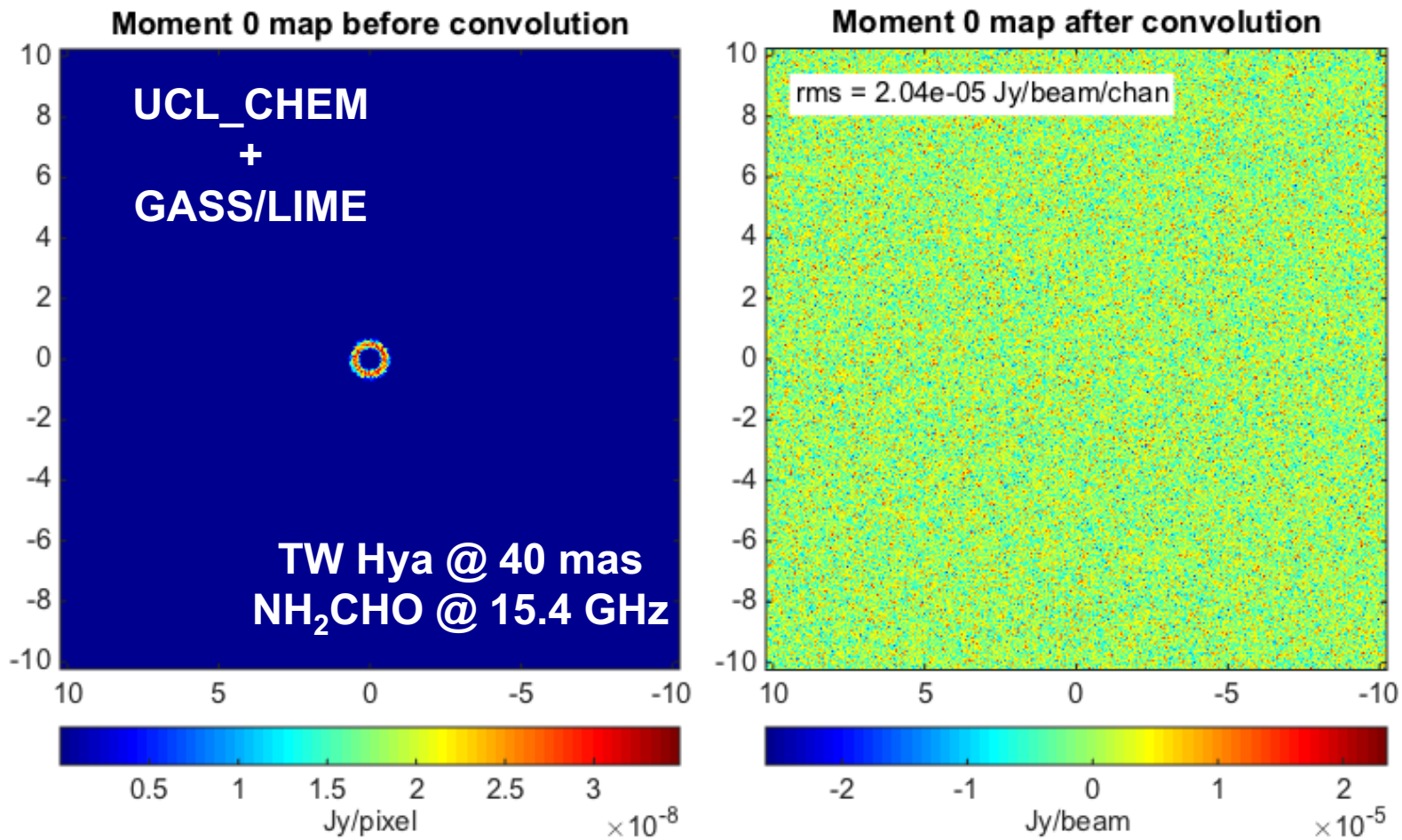






Simulations of Formamide on TW Hya

- Physical structure from Rosenfeld et al. (2012)
- 1D chemical modelling with 100 points from 1AU to 100 AU using UCL_CHEM (Holdship, Viti, Jimenez-Serra+ 2017, submitted).
- Chemical network for NH_2CHO (Quenard, Jimenez-Serra+, in prep).
- Radiative transfer done with GASS/LIME code (Quenard+2017, MNRAS,468,685Q)



Comparison with VLA

Parameter	SKA1-Mid (CC)/VLA
Sensitivity (10 GHz)	1
Resolution	5
Field of view area	2.8
Number of spectral channels	4
Baselines	5.6

Alternative Cost Controls

- Band 5 was prioritized ahead of Band 1 in the last science review process
- Band 1 overlaps with MeerKAT UHF
- Remove 66 Band 1 feeds
- Removing 22 Band 1 feeds on outer 7 dishes per arm gives max baseline of 38 km and 2 arcsec resolution at 800 MHz
- Remove next 44 feeds as dictated by Band 1 teams
- Can still do all HPSO Band 1 cases
  - Pulsars – core only
  - H I intensity mapping – auto-correlations
  - High-z H I in galaxies requires 2-10 arcsec resolution
- -Saves €6M

Conclusions

- The removal of outer 3 dishes has a significant impact on Cradle of Life HPSO
  - Let's get the steel in the ground and stop cutting dishes
- Can still do the HPSO post cuts
  - Will all the extra time needed be available?
- Simultaneous science lost without core and VLBI
  - Very poor message to African VLBI Network

Compare MID Band 5 feeds from 130 to 64