

Configuration and Synthesised beam characteristics of NOEMA

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Version 1

This document introduces the new configurations and synthesized beam characteristics of NOEMA.

1 Introduction

The Northern Extended Millimeter Array (NOEMA) is situated on the Plateau de Bure, in the French Alps, at an altitude of 2560 m at the intersection of the Azimuth and Elevation axes of the antennas. Its longitude and latitude are 05:54:28.5 E and 44:38:02.0 N at the array phase center. The interferometer currently comprises of:

- 12 antennas of 15 m diameter,
- one north-south track 368 m long,
- one east-west track 1664 m long,
- a wide-band correlator *PolyFiX* covering ~ 16 GHz of bandwidth for up to 12 antennas in dual polarization,
- 3 receiver bands: a 3 mm receiver band (B1 receiver) tunable between 70.3 – 119.3 GHz, a 2 mm receiver band (B2 receiver) tunable between 127.0 – 182.8 GHz, a 1 mm receiver band (B3 receiver) tunable between 196.2 – 276.0 GHz,

The twelve antennas of the interferometer can be positioned on 37 stations laid out along a “T” shaped track to form the six interferometer configurations listed in Table 1. The north-south arm is 368 m long, and the east-west oriented arm extends 376 m west and 1288 m east of the intersection. The angle between the arms is 75° . The station names are taken from the arm orientation and a three-digit code indicating the distance from the track intersection (station W000) in 8 m units.

2 Configurations

Four primary 12 antenna configurations (Table 1) are available which can be combined to produce maps with different angular resolutions. All four primary configurations are usually scheduled during the course of a year. During the summer period (May until September) each antenna undergoes thorough maintenance and the interferometer operates in a 10-antenna D configuration (Table 1 for the corresponding 10C and 10D subset configurations of the full array).

The main properties of each configuration are the following:

- the 10/12D-configuration corresponds to the most compact configuration. This is thus the best-suited configuration for detection and coarse mapping with typical resolutions of $\sim 3.7''$ at 100 GHz and $\sim 1.6''$ at 230 GHz (for a source at 20° declination, see Figure 6 for more details).
- the 10/12C-configuration corresponds to the next most compact configuration. It is well adapted for detection at low declination (with reduced shadowing compared to the D-configuration), snapshot and size measurements (with typical resolution $\sim 1.9''$ at 100 GHz and $\sim 0.85''$ at 230 GHz).
- the 12B-configuration is well suited for mapping or size measurements of compact and strong sources (with a typical resolution of $1.0''$ at 100GHz and $0.45''$ at 230 GHz).
- the 12A-configuration corresponds to the most extended configuration of NOEMA, providing high-resolution mapping with a typical resolution $0.5''$ @ 100 GHz (see Figure 1).

The four configurations can be used in different combinations (Table 3) to achieve complementary sampling of the uv-plane and to improve the angular resolution and sensitivity. The configurations AB, ABC, AC, ACD, BC, BCD and CD are reasonably suited for most declinations above 0° .

Conf.	Stations											
12A	W047	W027	W009	E161	E148	E122	E068	E059	E023	N046	N029	N020
12B	W027	W020	W009	W005	E059	E024	E018	E010	N046	N029	N017	N011
12C	W023	W020	W009	W005	E023	E018	E010	E003	N029	N020	N011	N007
12D	W020	W012	W009	W005	E023	E018	E010	E003	N017	N013	N007	N002
10C	W023	W020	W009	E023	E018	E010	E003	N020	N017	N011	-	-
10D	W012	W008	W005	E010	E004	N017	N013	N009	N005	N002	-	-

Table 1: Configurations of the 12-antenna and 10-antenna array

3 Resolution

We provide natural weighted synthesized beams for each configuration (Table 2) and possible configuration combinations (Table 3), for sources at different declinations (DEC) and for each of the three frequency bands offered. We note that we only provide the beam sizes for the array configurations recommended. The estimated beam sizes are based on an hour-angle coverage of 8 hours centered on the meridian of the observatory (except for those sources below -10° declination which are limited by their time above the horizon). However, the shape of the synthesized beam may change based on the hours observed in relation to the maximum elevation of the source. The beam sizes are also dependent on the weighting scheme used, to demonstrate the difference we provide the beam sizes for each configuration assuming a uniform weighting in Table 4. In Figures 1-13, we show how the synthesized beam varies as a function of the source declination for both uniform and natural weighting.

Config:	12A	12B	12C	12D	10C	10D
Dec. [deg]	100 GHz					
-20	2.09×0.32	2.82×1.04	4.41×1.59	7.21×1.82	5.68×1.42	7.14×3.25
-10	2.11×0.33	2.32×1.07	3.55×1.67	5.68×1.87	4.31×1.50	5.22×3.54
0	1.91×0.33	1.98×1.06	3.03×1.66	5.03×1.89	3.49×1.52	4.53×3.63
15	1.25×0.34	1.64×1.03	2.51×1.63	3.93×1.89	2.81×1.50	3.79×3.57
30	0.91×0.35	1.45×1.02	2.21×1.62	3.24×1.91	2.38×1.50	3.66×3.31
45	0.74×0.36	1.35×1.02	2.05×1.61	2.88×1.93	2.15×1.51	3.62×3.17
60	0.66×0.37	1.32×1.05	1.99×1.63	2.73×1.96	2.06×1.53	3.61×3.21
80	0.63×0.39	1.38×1.10	2.08×1.69	2.78×2.03	2.11×1.57	3.69×3.55
	150 GHz					
-20	1.41×0.22	1.95×0.70	2.95×1.06	4.81×1.22	4.11×0.95	4.76×2.17
-10	1.40×0.22	1.56×0.72	2.36×1.12	3.82×1.24	2.87×1.00	3.48×2.36
0	1.31×0.22	1.34×0.71	2.01×1.12	3.44×1.26	2.33×1.02	3.02×2.42
15	0.85×0.22	1.12×0.70	1.66×1.10	2.62×1.26	1.87×1.00	2.55×2.34
30	0.61×0.23	0.98×0.69	1.48×1.08	2.16×1.27	1.59×1.00	2.40×2.24
45	0.50×0.24	0.91×0.69	1.37×1.08	1.92×1.29	1.44×1.01	2.41×2.11
60	0.44×0.25	0.89×0.70	1.33×1.10	1.82×1.31	1.37×1.02	2.41×2.14
80	0.42×0.26	0.93×0.75	1.39×1.13	1.86×1.35	1.40×1.05	2.46×2.37
	230 GHz					
-20	0.91×0.15	1.26×0.46	1.92×0.69	3.11×0.78	2.45×0.62	3.11×1.41
-10	0.91×0.15	1.05×0.47	1.54×0.73	2.45×0.82	1.86×0.65	2.27×1.54
0	0.90×0.14	0.94×0.46	1.32×0.72	2.09×0.83	1.52×0.66	1.97×1.58
15	0.55×0.15	0.75×0.45	1.10×0.71	1.67×0.82	1.22×0.65	1.66×1.53
30	0.39×0.15	0.64×0.45	0.97×0.70	1.40×0.83	1.04×0.65	1.58×1.44
45	0.32×0.16	0.59×0.45	0.89×0.70	1.26×0.84	0.94×0.66	1.57×1.38
60	0.29×0.16	0.58×0.46	0.87×0.71	1.19×0.85	0.90×0.67	1.57×1.40
80	0.27×0.17	0.61×0.49	0.90×0.74	1.21×0.88	0.92×0.69	1.60×1.54

Table 2: Synthesized beam sizes for 8hrs of observation and **natural** weighting. We provide the beam sizes for each individual configuration and Band, at different source declinations (DEC). Where 100 GHz, 150 GHz and 230 GHz correspond to Bands 1, 2, and 3 respectively.

Config:	12AB	12ABC	12AC	12ACD	12BC	12BCD	12CD	12AC-10D	12BC-10D	12C-10D	10CD
Dec. [deg]	100 GHz										
-20	2.50 × 0.65	3.19 × 1.02	3.62 × 1.00	4.73 × 1.39	3.55 × 1.33	4.21 × 1.49	5.54 × 1.71	4.39 × 1.49	3.97 × 1.58	5.21 × 1.98	6.44 × 1.92
-10	2.14 × 0.67	2.60 × 1.01	2.92 × 0.98	3.74 × 1.45	2.86 × 1.38	3.41 × 1.55	4.68 × 1.76	3.66 × 1.65	3.26 × 1.73	4.32 × 2.16	4.77 × 2.21
0	1.85 × 0.65	2.32 × 1.00	2.67 × 0.97	3.28 × 1.45	2.51 × 1.36	2.98 × 1.55	4.32 × 1.77	3.24 × 1.69	2.86 × 1.74	3.87 × 2.20	3.97 × 2.24
15	1.46 × 0.66	1.90 × 1.03	2.04 × 1.04	2.73 × 1.46	2.11 × 1.34	2.52 × 1.53	3.27 × 1.76	2.61 × 1.72	2.44 × 1.71	3.12 × 2.17	3.26 × 2.20
30	1.25 × 0.70	1.63 × 1.07	1.75 × 1.09	2.32 × 1.51	1.85 × 1.33	2.23 × 1.54	2.69 × 1.76	2.27 × 1.76	2.21 × 1.71	2.71 × 2.14	2.90 × 2.21
45	1.15 × 0.75	1.48 × 1.09	1.58 × 1.12	2.10 × 1.54	1.70 × 1.33	2.05 × 1.55	2.40 × 1.76	2.11 × 1.78	2.08 × 1.71	2.54 × 2.12	2.67 × 2.19
60	1.12 × 0.79	1.44 × 1.12	1.53 × 1.16	2.05 × 1.57	1.66 × 1.36	1.98 × 1.58	2.32 × 1.79	2.09 × 1.81	2.05 × 1.75	2.49 × 2.15	2.67 × 2.24
80	1.16 × 0.84	1.52 × 1.18	1.64 × 1.24	2.10 × 1.62	1.74 × 1.44	2.04 × 1.64	2.38 × 1.84	2.24 × 1.88	2.14 × 1.83	2.65 × 2.26	2.85 × 2.35
	150 GHz										
-20	1.75 × 0.44	2.14 × 0.67	2.42 × 0.66	3.11 × 0.94	2.38 × 0.89	2.95 × 0.98	3.63 × 1.13	2.92 × 0.99	2.70 × 1.06	3.47 × 1.32	4.31 × 1.30
-10	1.47 × 0.44	1.72 × 0.68	1.92 × 0.65	2.52 × 0.96	1.88 × 0.92	2.25 × 1.03	2.98 × 1.18	2.44 × 1.10	2.30 × 1.15	2.86 × 1.44	3.16 × 1.47
0	1.30 × 0.42	1.50 × 0.68	1.72 × 0.65	2.27 × 0.96	1.60 × 0.91	1.92 × 1.03	2.66 × 1.18	2.16 × 1.13	2.09 × 1.16	2.57 × 1.46	2.65 × 1.49
15	1.00 × 0.44	1.21 × 0.69	1.35 × 0.69	1.85 × 0.98	1.36 × 0.89	1.60 × 1.02	2.18 × 1.17	1.74 × 1.14	1.77 × 1.15	2.07 × 1.44	2.18 × 1.46
30	0.84 × 0.47	1.08 × 0.71	1.15 × 0.73	1.55 × 1.01	1.21 × 0.89	1.43 × 1.01	1.79 × 1.18	1.52 × 1.17	1.51 × 1.15	1.81 × 1.42	1.92 × 1.46
45	0.77 × 0.50	0.99 × 0.73	1.05 × 0.74	1.40 × 1.03	1.13 × 0.89	1.33 × 1.02	1.62 × 1.18	1.41 × 1.19	1.39 × 1.14	1.68 × 1.39	1.80 × 1.46
60	0.74 × 0.52	0.96 × 0.74	1.02 × 0.77	1.35 × 1.06	1.11 × 0.91	1.29 × 1.04	1.54 × 1.19	1.39 × 1.21	1.36 × 1.16	1.66 × 1.43	1.78 × 1.49
80	0.77 × 0.56	1.02 × 0.80	1.09 × 0.83	1.40 × 1.08	1.16 × 0.96	1.34 × 1.08	1.59 × 1.23	1.49 × 1.26	1.43 × 1.22	1.76 × 1.50	1.91 × 1.56
	230 GHz										
-20	1.16 × 0.28	1.42 × 0.45	1.56 × 0.43	2.06 × 0.63	1.55 × 0.58	1.67 × 0.62	2.40 × 0.74	1.93 × 0.65	1.73 × 0.69	2.28 × 0.86	2.76 × 0.86
-10	0.96 × 0.29	1.16 × 0.44	1.27 × 0.45	1.70 × 0.63	1.27 × 0.60	1.43 × 0.65	2.01 × 0.77	1.59 × 0.71	1.44 × 0.75	1.88 × 0.94	2.10 × 0.98
0	0.80 × 0.28	1.05 × 0.44	1.12 × 0.42	1.56 × 0.63	1.12 × 0.59	1.24 × 0.65	1.84 × 0.77	1.49 × 0.75	1.27 × 0.76	1.68 × 0.96	1.73 × 0.97
15	0.64 × 0.29	0.82 × 0.45	0.91 × 0.46	1.21 × 0.64	0.95 × 0.58	1.02 × 0.65	1.42 × 0.77	1.14 × 0.74	1.10 × 0.75	1.35 × 0.94	1.42 × 0.96
30	0.55 × 0.31	0.70 × 0.46	0.75 × 0.47	1.01 × 0.66	0.81 × 0.58	0.92 × 0.66	1.17 × 0.77	1.00 × 0.77	0.98 × 0.75	1.18 × 0.93	1.25 × 0.95
45	0.50 × 0.33	0.64 × 0.47	0.69 × 0.49	0.92 × 0.68	0.74 × 0.58	0.84 × 0.65	1.05 × 0.77	0.92 × 0.78	0.90 × 0.75	1.10 × 0.92	1.17 × 0.95
60	0.49 × 0.34	0.63 × 0.49	0.67 × 0.51	0.87 × 0.67	0.72 × 0.59	0.82 × 0.66	1.01 × 0.78	0.91 × 0.79	0.89 × 0.76	1.08 × 0.94	1.16 × 0.97
80	0.51 × 0.36	0.66 × 0.52	0.71 × 0.54	0.92 × 0.71	0.76 × 0.62	0.85 × 0.68	1.04 × 0.80	0.97 × 0.82	0.94 × 0.80	1.15 × 0.98	1.24 × 1.02

Table 3: Synthesized beam sizes for 8hrs of observation and **natural** weighting. We provide the beam sizes for each of the recommended configuration combinations, and Band, at different source declinations (DEC). Where 100 GHz, 150 GHz and 230 GHz correspond to Bands 1, 2, and 3 respectively.

Config:	12A	12B	12C	12D	10C	10D
-20	2.08×0.32	2.75×0.97	3.93×1.45	5.88×1.54	5.13×1.30	5.89×2.84
-10	2.07×0.33	2.16×0.99	3.11×1.51	4.72×1.65	3.85×1.36	4.33×3.04
0	1.85×0.32	1.75×0.98	2.52×1.59	3.84×1.81	2.94×1.49	3.73×3.20
15	1.23×0.33	1.56×0.97	2.25×1.50	3.36×1.69	2.59×1.41	3.36×3.00
30	0.90×0.34	1.37×0.94	1.98×1.49	2.81×1.71	2.24×1.42	3.20×2.85
45	0.72×0.35	1.28×0.96	1.85×1.47	2.52×1.70	2.05×1.44	3.23×2.79
60	0.65×0.36	1.26×0.98	1.85×1.51	2.42×1.74	1.98×1.47	3.23×2.82
80	0.61×0.38	1.32×1.04	1.94×1.57	2.43×1.77	2.00×1.50	3.22×3.14
	150 GHz					
-20	1.37×0.22	1.81×0.65	2.62×0.96	3.88×1.03	3.48×0.86	3.93×1.89
-10	1.39×0.22	1.44×0.66	2.09×1.01	3.12×1.09	2.57×0.91	2.89×2.03
0	1.25×0.21	1.19×0.65	1.68×1.06	2.56×1.21	1.95×0.99	2.49×2.13
15	0.83×0.22	1.06×0.64	1.50×1.01	2.24×1.13	1.73×0.94	2.24×2.00
30	0.60×0.23	0.92×0.63	1.33×0.99	1.88×1.14	1.49×0.95	2.14×1.90
45	0.49×0.23	0.86×0.64	1.24×0.98	1.68×1.13	1.37×0.96	2.15×1.86
60	0.43×0.24	0.84×0.66	1.23×1.01	1.61×1.16	1.32×0.98	2.16×1.88
80	0.42×0.25	0.88×0.70	1.30×1.05	1.62×1.18	1.34×1.00	2.15×2.09
	230 GHz					
-20	0.88×0.14	1.19×0.42	1.68×0.63	2.64×0.67	2.22×0.56	2.56×1.24
-10	0.89×0.14	0.96×0.43	1.35×0.66	2.08×0.72	1.68×0.59	1.88×1.32
0	0.85×0.14	0.78×0.43	1.08×0.69	1.69×0.79	1.28×0.65	1.62×1.39
15	0.54×0.14	0.69×0.42	0.98×0.65	1.47×0.74	1.13×0.61	1.46×1.30
30	0.39×0.15	0.60×0.41	0.86×0.65	1.23×0.74	0.97×0.62	1.39×1.25
45	0.32×0.15	0.56×0.42	0.81×0.64	1.10×0.74	0.89×0.62	1.41×1.23
60	0.28×0.16	0.55×0.43	0.80×0.65	1.05×0.76	0.86×0.64	1.40×1.24
80	0.27×0.16	0.57×0.46	0.84×0.68	1.06×0.77	0.87×0.65	1.40×1.36

Table 4: Synthesized beam sizes for 8hrs of observation and **uniform** weighting. We provide the beam sizes for each individual configuration and Band, at different source declinations (DEC). Where 100 GHz, 150 GHz and 230 GHz correspond to Bands 1, 2, and 3 respectively.

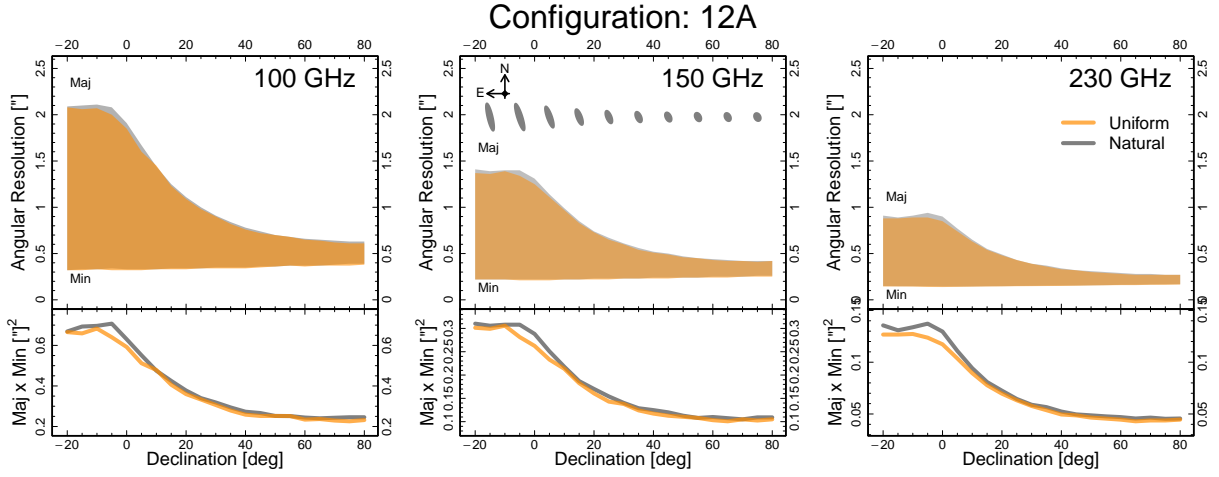


Figure 1: Visualisation of the synthesised beam parameters in the 12A configuration for an hour-angle coverage of 8 hours centered on the meridian of the observatory (except for those sources below -10° declination which are limited by their time above the horizon) at frequencies of 100 GHz (left), 150 GHz (middle) and 230 GHz (right). The grey (natural weighting) and orange (uniform weighting) shaded regions in the top panels indicated the difference in major and minor synthesised beam axes as a function of source declination. The lines of the same colour in the bottom panels show how major \times minor changes with source declination. In the upper middle panel, we indicate the shape and position angle of the synthesised beam.

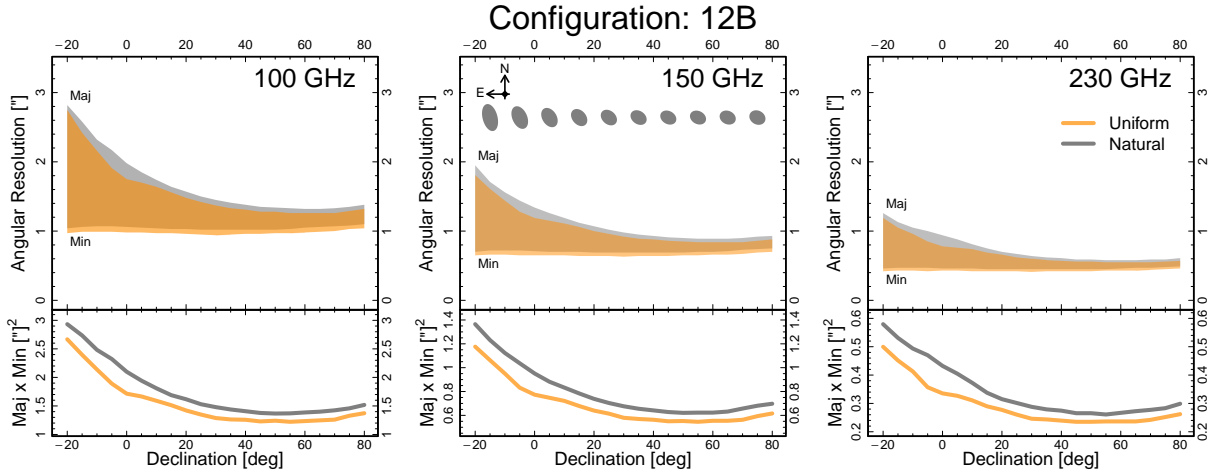


Figure 2: Visualisation of the beam parameters in the 12B configuration.

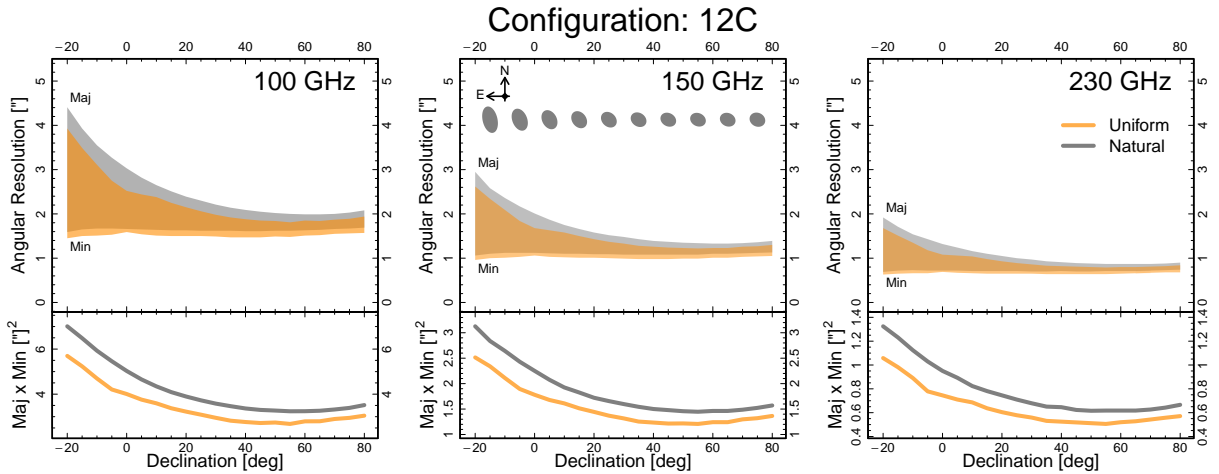


Figure 3: Visualisation of the beam parameters in the 12C configuration.

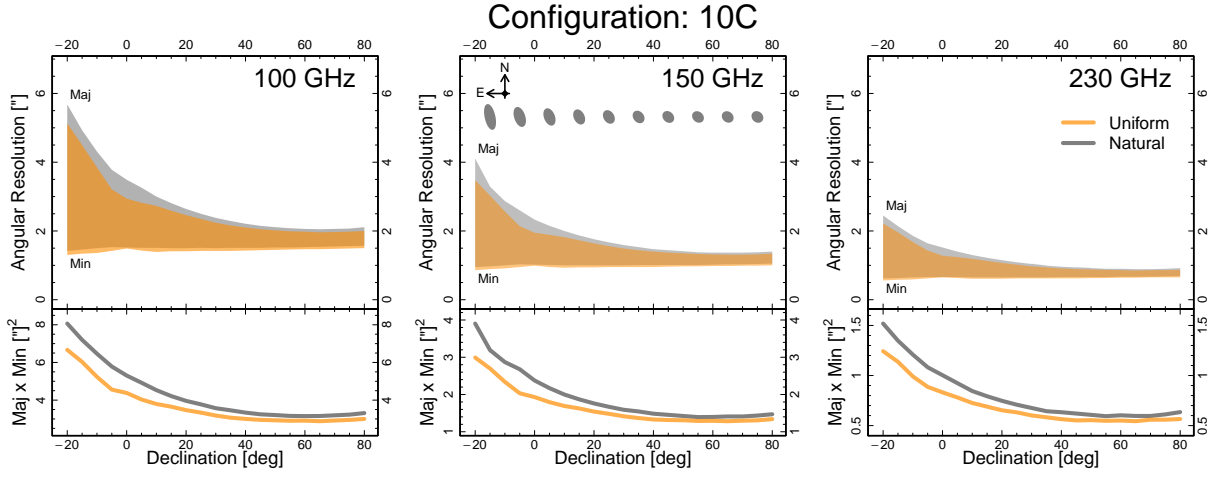


Figure 4: Visualisation of the beam parameters in the 10C configuration.

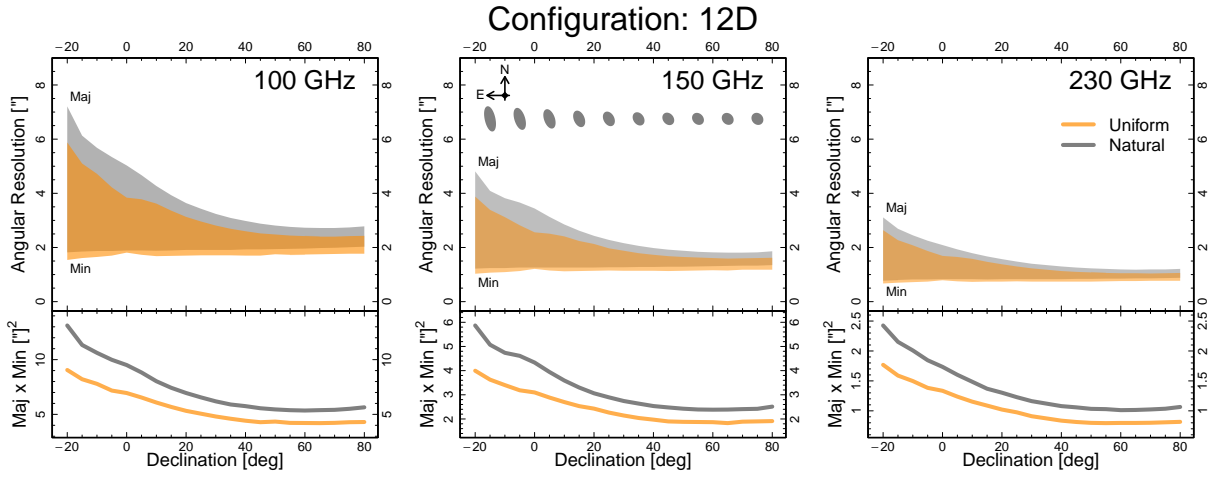


Figure 5: Visualisation of the beam parameters in the 12D configuration.

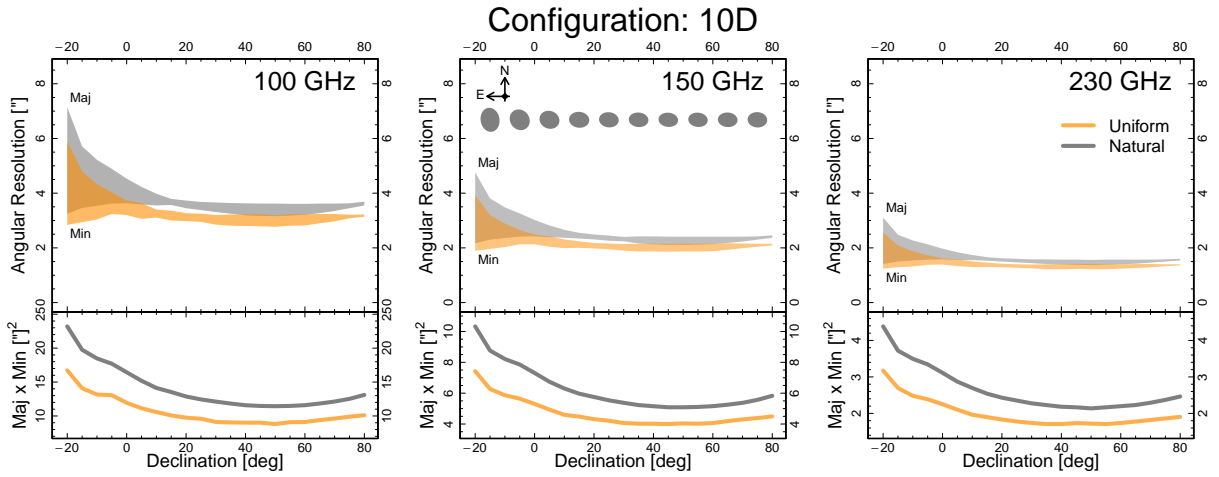


Figure 6: Visualisation of the beam parameters in the 10D configuration.

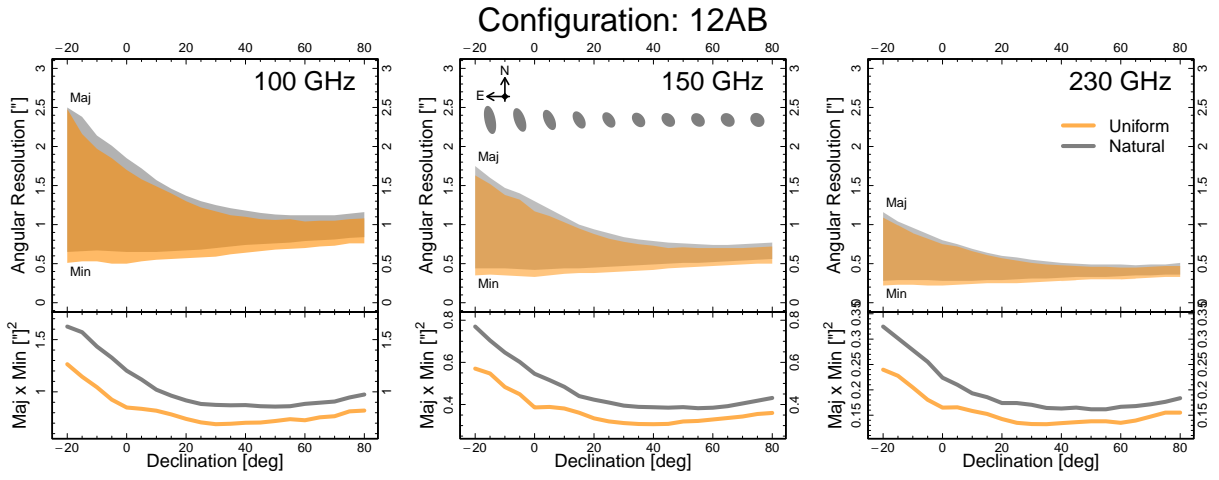


Figure 7: Visualisation of the beam parameters in the 12AB configuration.

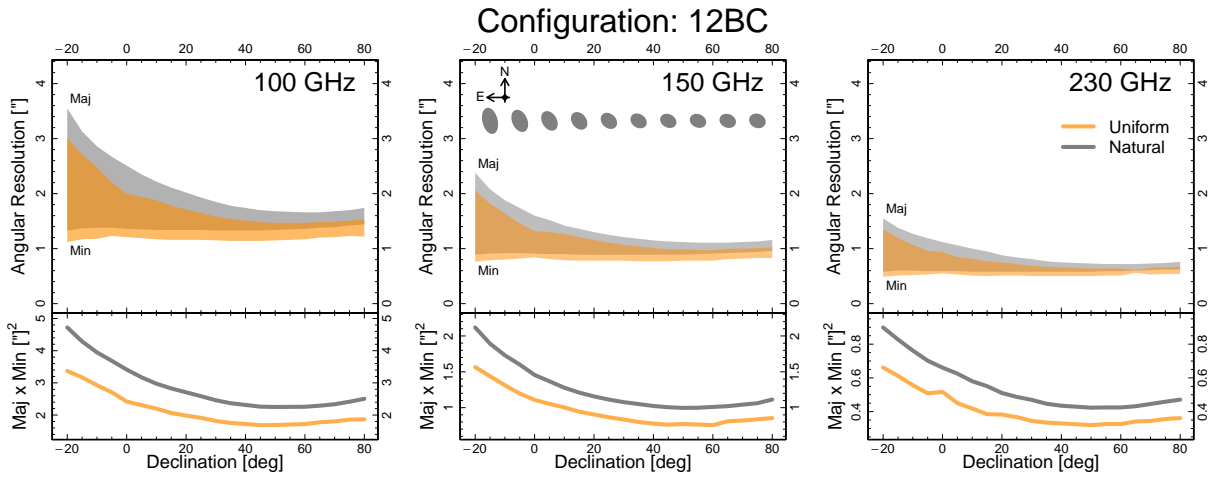


Figure 8: Visualisation of the beam parameters in the 12BC configuration.

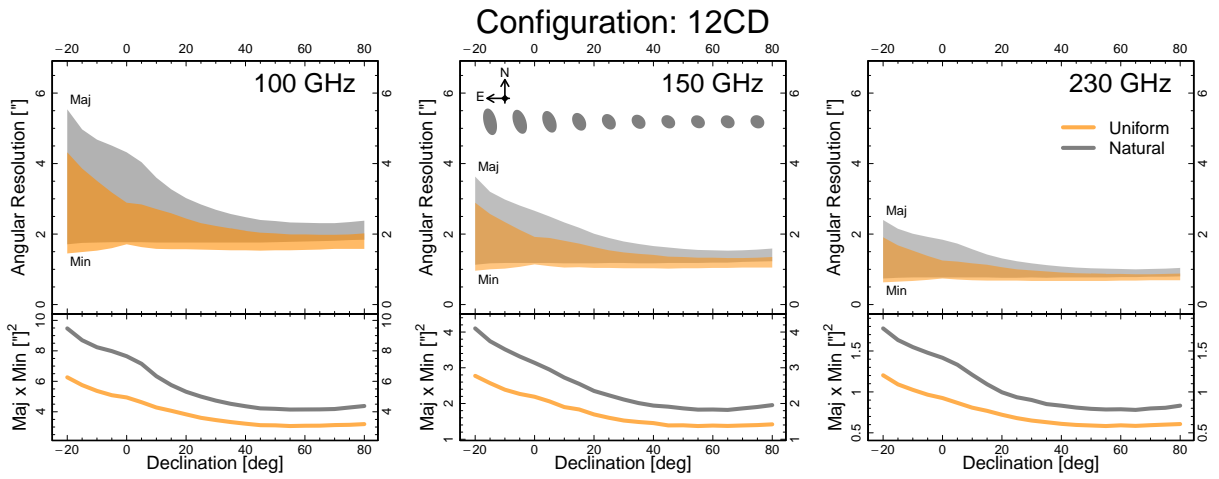


Figure 9: Visualisation of the beam parameters in the 12CD configuration.

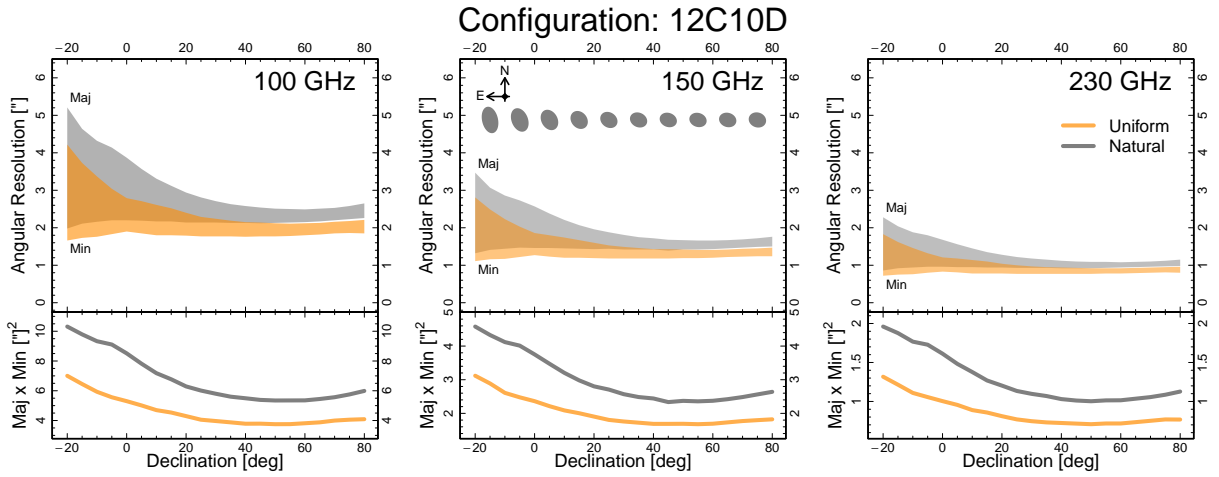


Figure 10: Visualisation of the beam parameters in the 12C10D configuration.

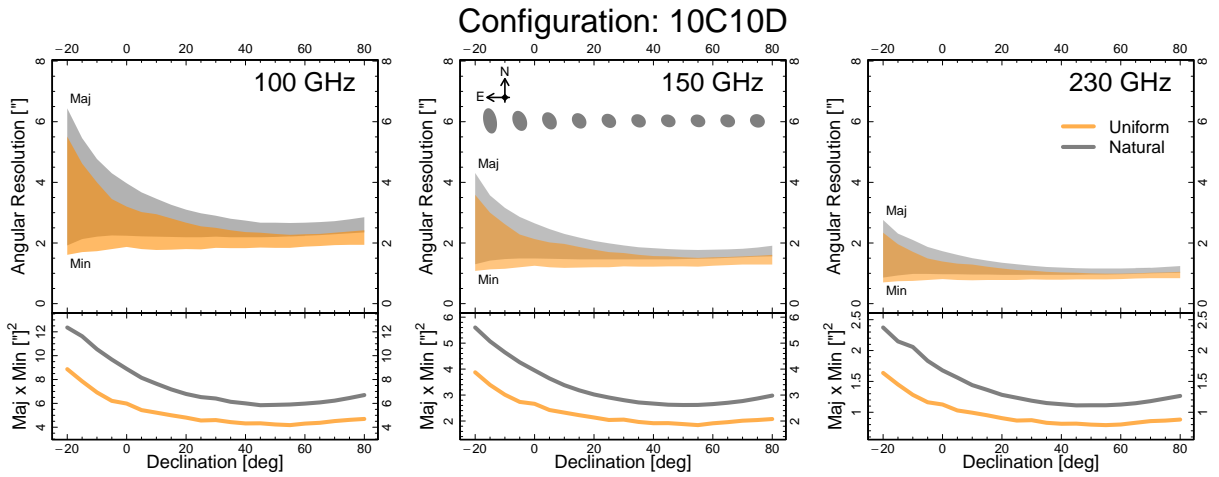


Figure 11: Visualisation of the beam parameters in the 10C10D configuration.

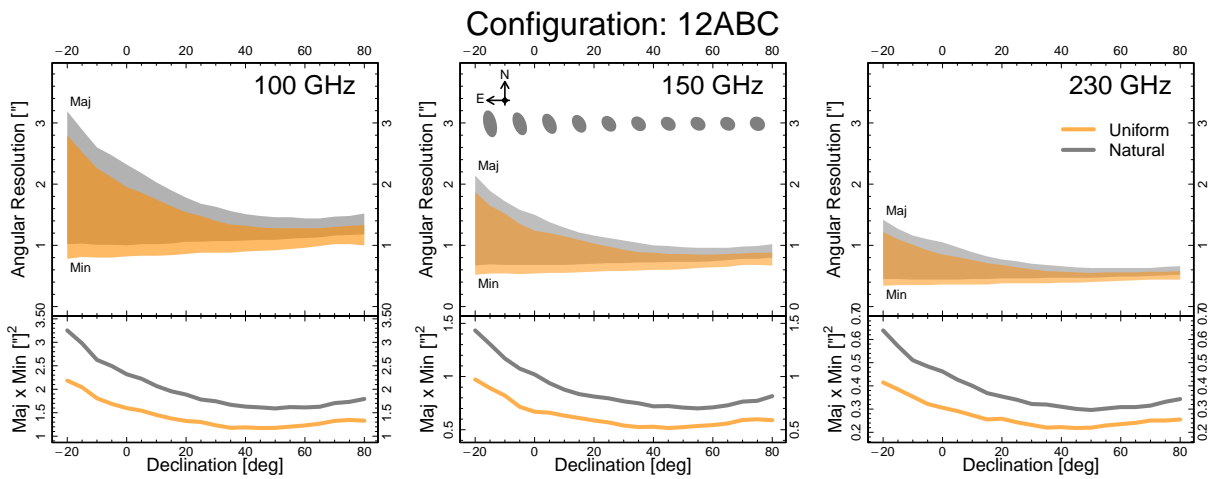


Figure 12: Visualisation of the beam parameters in the 12ABC configuration.

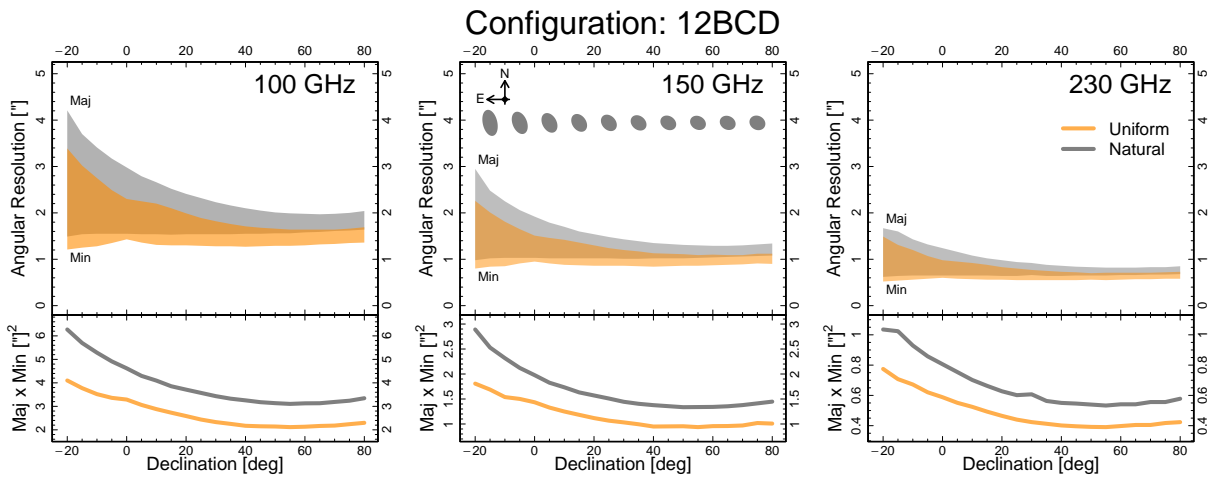


Figure 13: Visualisation of the beam parameters in the 12BCD configuration.