Swave Tests 2.0

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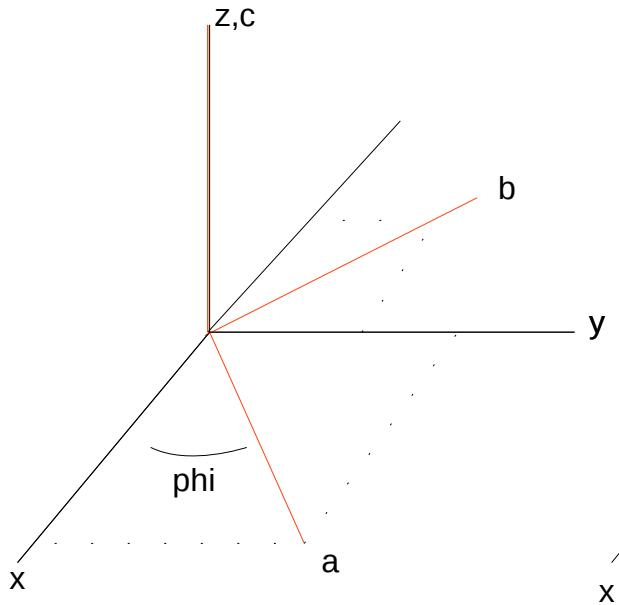
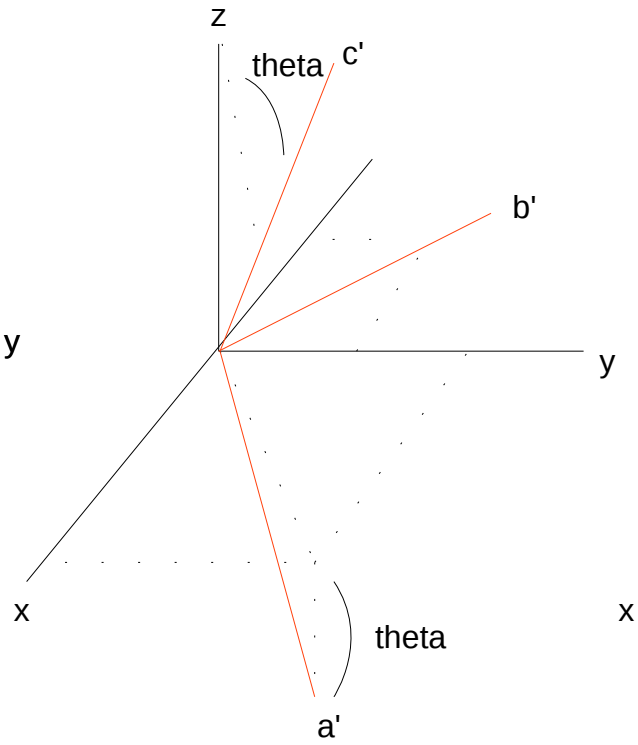
Polarization Convention

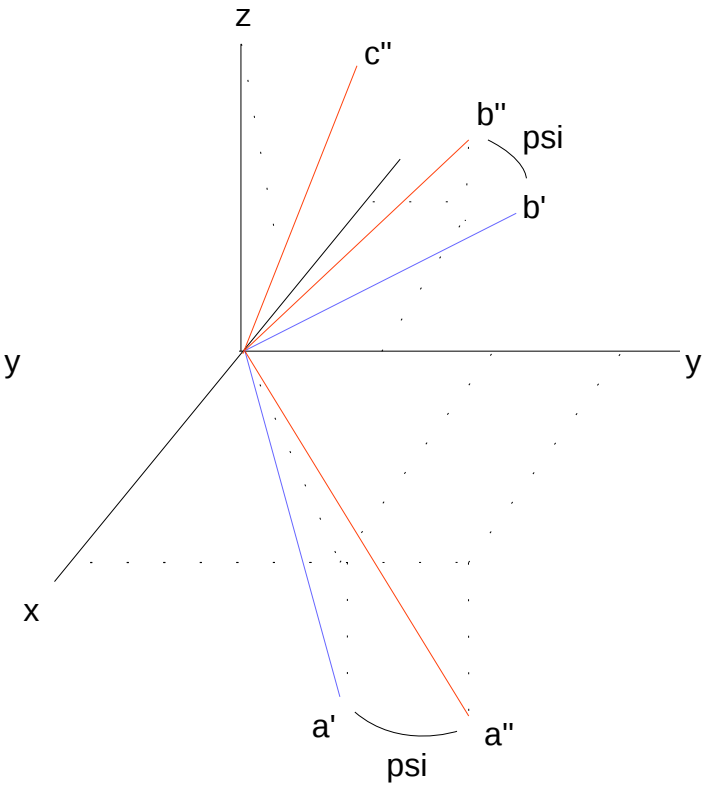
The following diagrams depict how Euler Angles are used to construct and characterize S-waves. Let x,y,z be set axes of the coordinate system in which the wave, passing through the origin, is observed.



Rotation around the z axis by phi to form the a,b, and c axes



Rotation of the a and c axes around the b axis to form the a', b', and c' axes. Note the deviation from the "usual" euler characterization, which instead contains a rotation by theta around the a axis. The purpose of this deviation is so that (theta, phi) signifies the propagation direction of the wave in geographical coordinates, which are used throughout



Rotation of the a' and b' axes around the c' axis to form the a", b", and c" axes.

Polarization Convention Cont.

Hence using these transformations, c'' is the propagation direction of the S-wave, and is characterized by (theta, phi) as it would be in geographical coordinates. The accumulation of all of the preceding transformations is below:

$$\begin{bmatrix} \cos(\psi)\cos(\phi+90)-\cos(\theta)\sin(\phi+90)\sin(\psi) \\ \cos(\psi)\sin(\phi+90)+\cos(\theta)\cos(\phi+90)\sin(\psi) \\ \sin(\theta)\sin(\phi+90) \end{bmatrix}$$

Psi is the polarization angle; it characterizes in which direction the amplitude of the wave oscillates. It is implicitly defined so that when psi = 0, the amplitude oscillates in the b'' direction. This was determined by substituting theta = 0, phi = 0, and psi = 0 into the above transformation, so that a'', b'', c'' coincided with x,y,z. The calculation gave Transpose([0,1,0]).

Scale Testing

- The following parameters are kept constant:

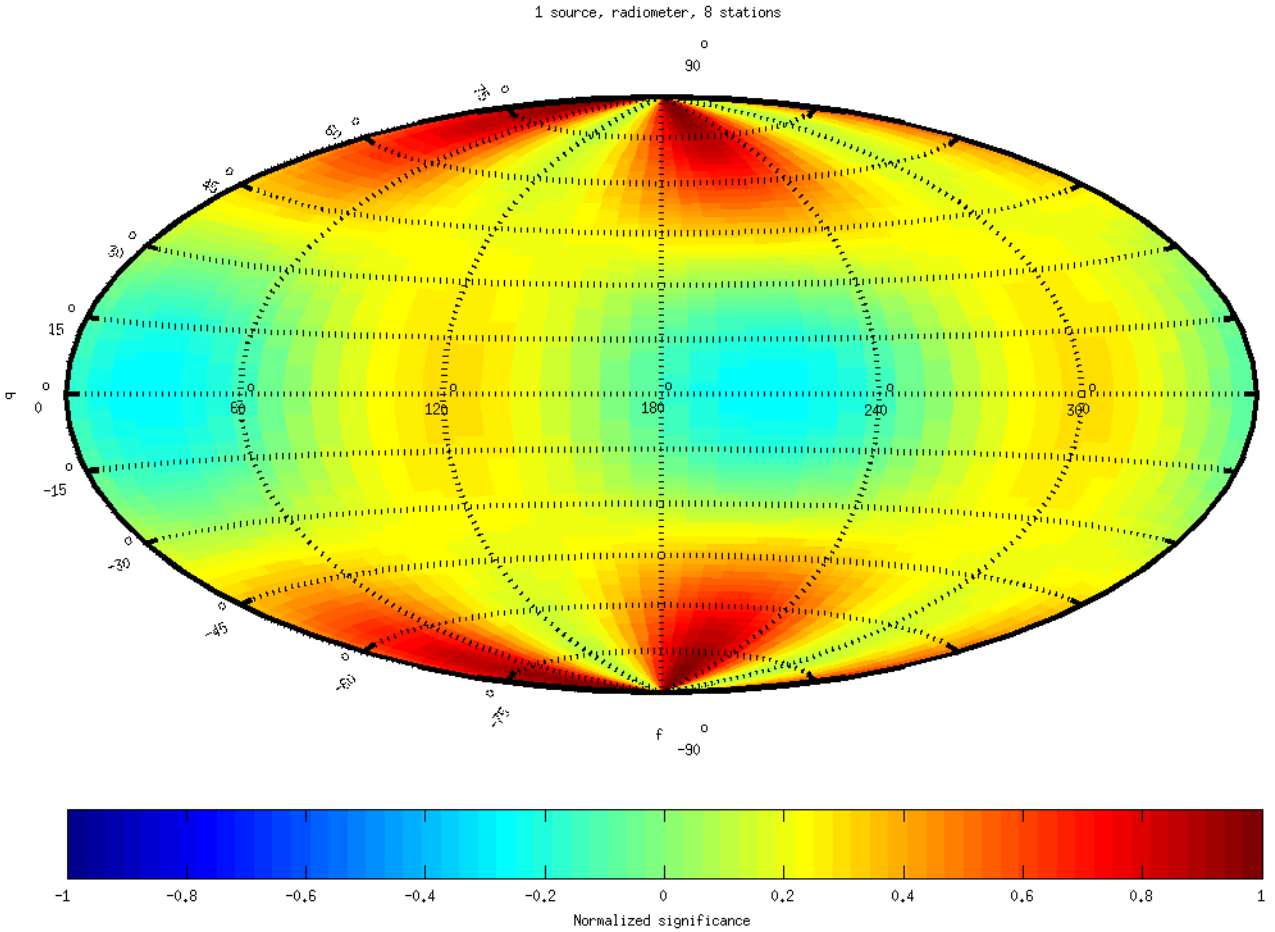
number of detectors = 8
Phi = 90 degrees
Theta = 30 degrees
Psi = 45 degrees
monochromatic source of freq = 1 Hz
Amplitude = 10 m
Speed = 2100 m/s

Detector Location is varied thusly:

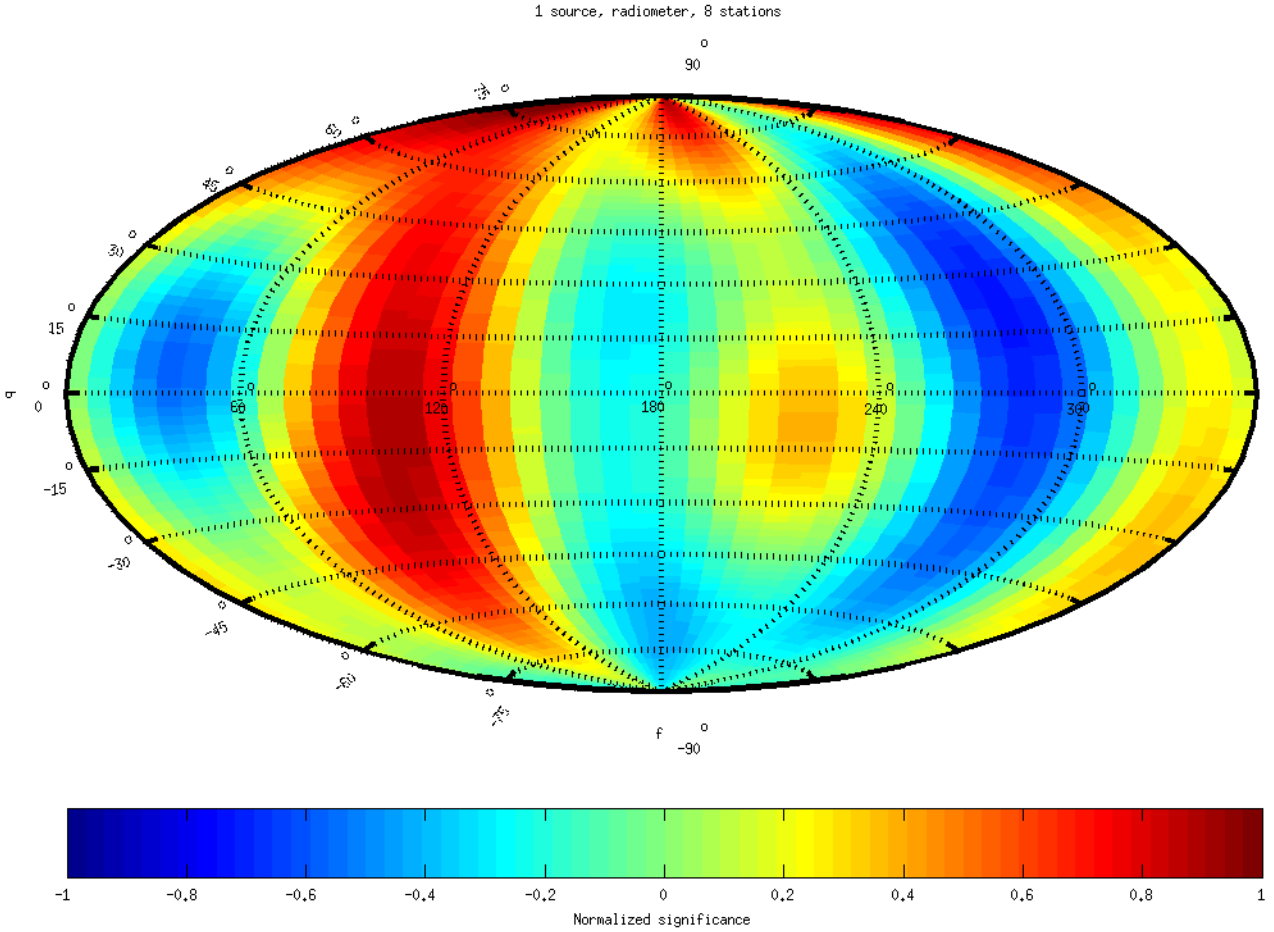
detloc = scale*

0.2356	0.2256	0.2556
0.2257	0.2978	0.1350
0.5375	0.9833	0.4396
0.9891	0.0892	0.1755
0.8970	0.7286	0.9501
0.8163	0.8914	0.2313
0.1514	0.5209	0.7084
0.1264	0.5037	0.8124

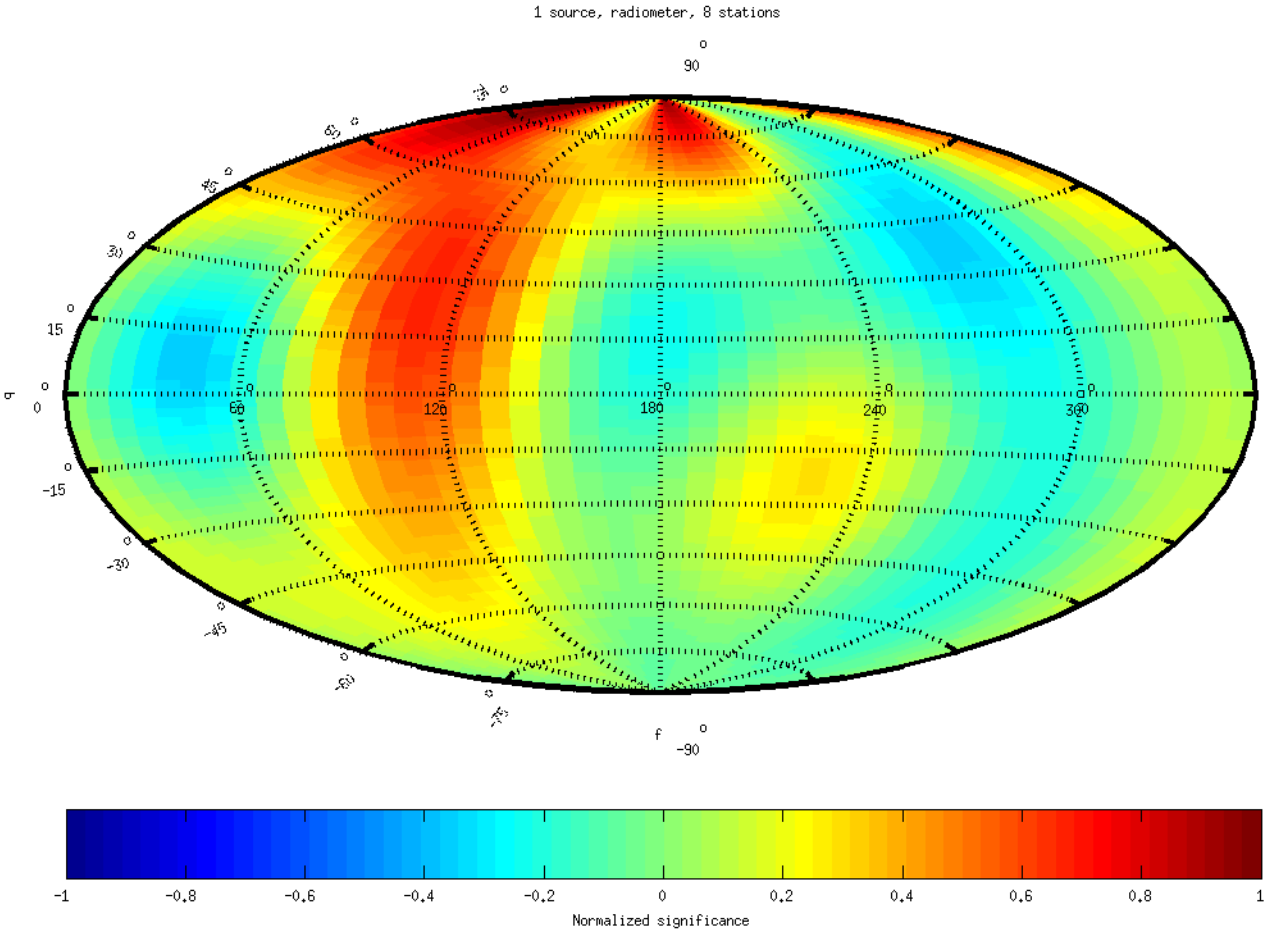
Scale = 1 m nstest1



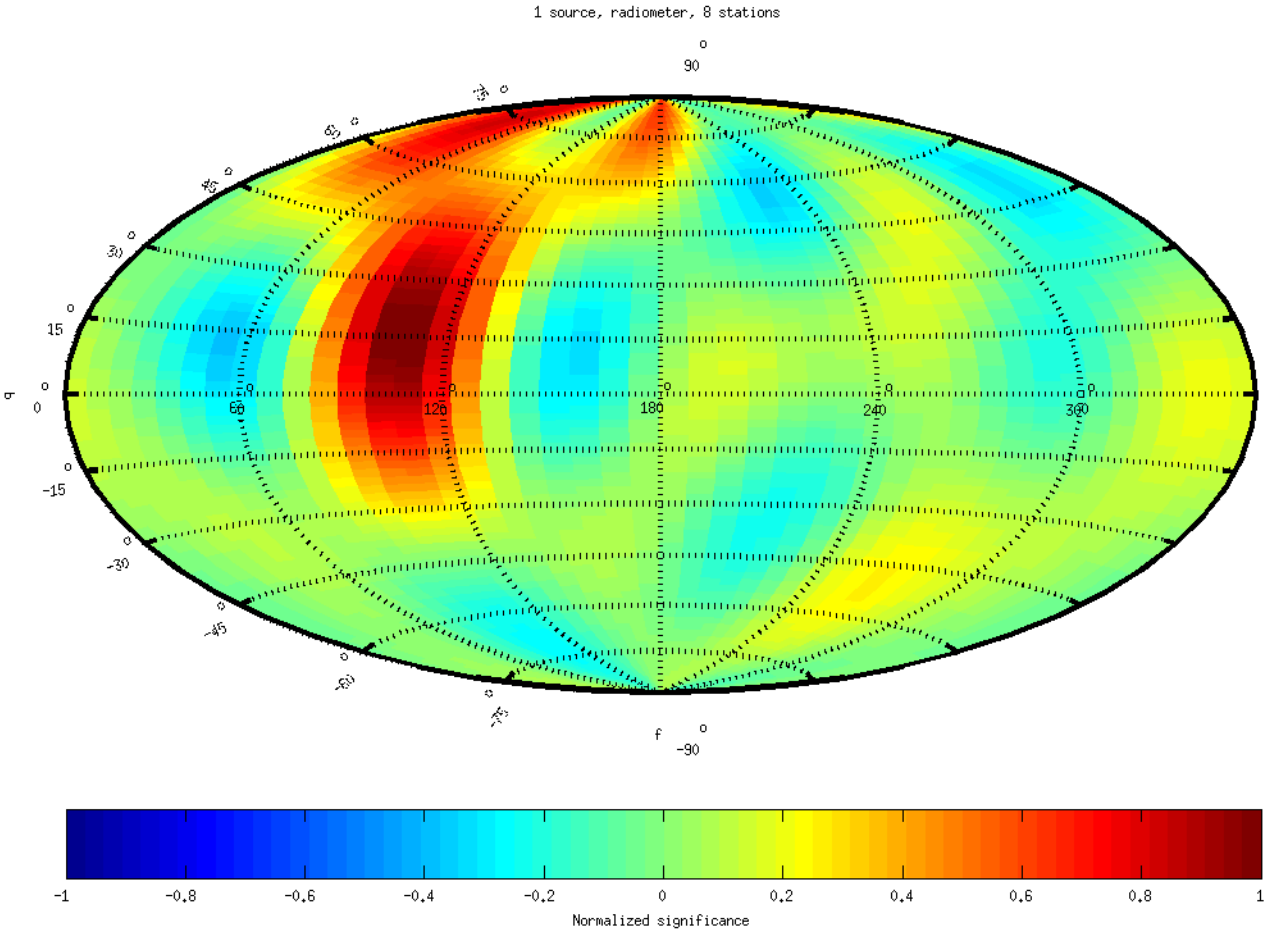
Scale = 10 m nstest2



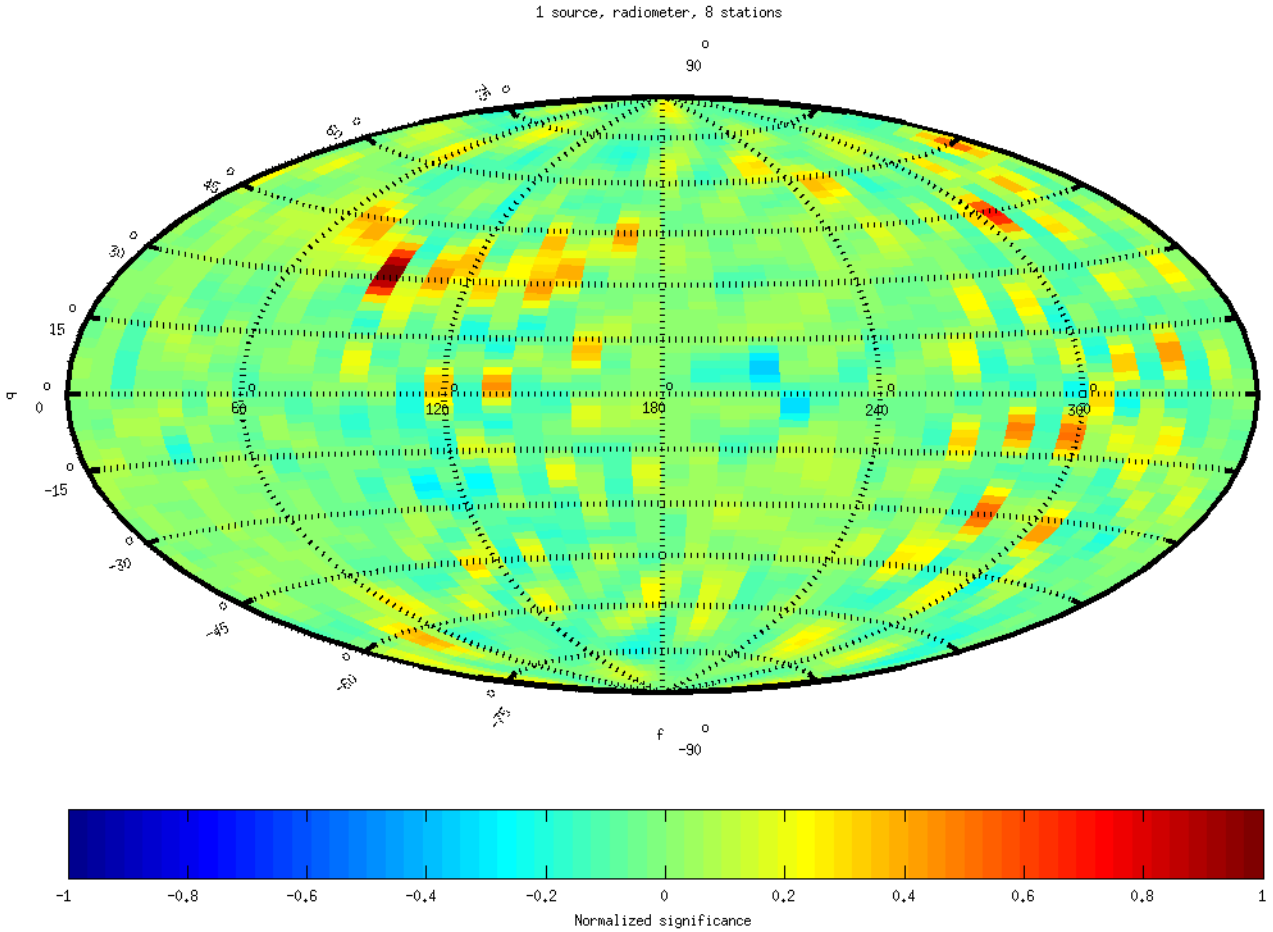
Scale = 100 m nstest3



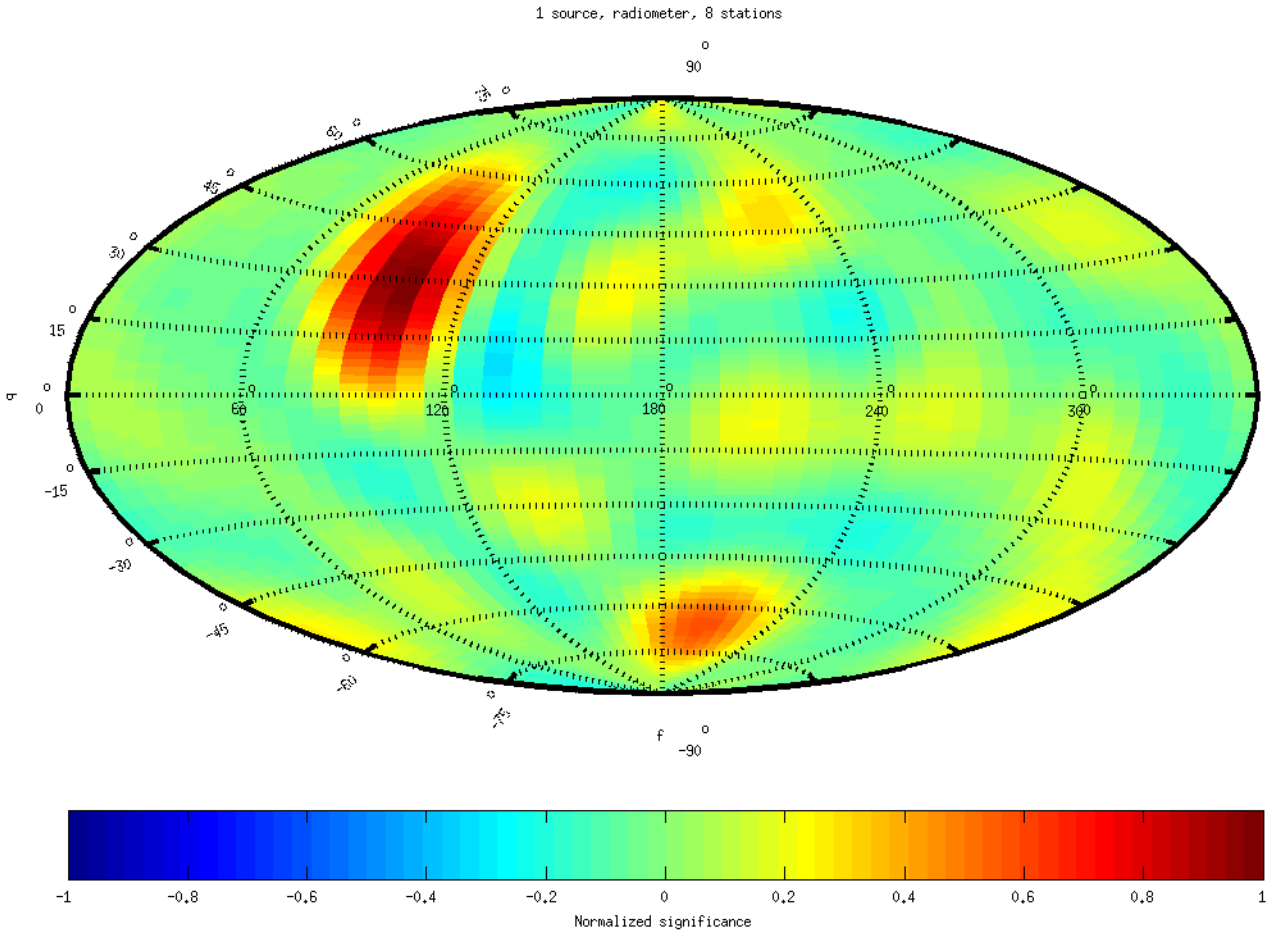
Scale = 1000 m nstest4



Scale = 10000 m nstest5



Scale = 2000 m nstest6



Detector Location Testsing

- In this series of test, random detectors are chosen and placed in a box of size 2000 m. All arrays below should be multiplied by 1000 m. All other parameters are the same as before.

nstest7

0.1029	0.2454	0.8232
0.8982	0.8457	1.9393
1.4311	0.8961	0.6799
1.2009	0.0914	0.3934
1.0414	0.5484	1.6074
0.8644	1.5812	0.5884
1.8625	1.5193	0.1478
0.7602	0.2315	0.9579

nstest8

0.1029	0.2454	0.8232
0.8982	0.8457	1.9393
1.4311	0.8961	0.6799
1.2009	0.0914	0.3934
1.0414	0.5484	1.6074
0.8644	1.5812	0.5884
1.8625	1.5193	0.1478
0.7602	0.2315	0.9579

nstest9

1.6261	0.4242	0.0199
0.9645	0.2903	0.4060
0.0591	0.7474	0.6155
0.5057	1.6122	1.1543
1.5517	0.2439	0.1788
0.2289	0.1101	1.0854
1.2931	1.0616	1.2513
0.9351	1.2163	0.0869

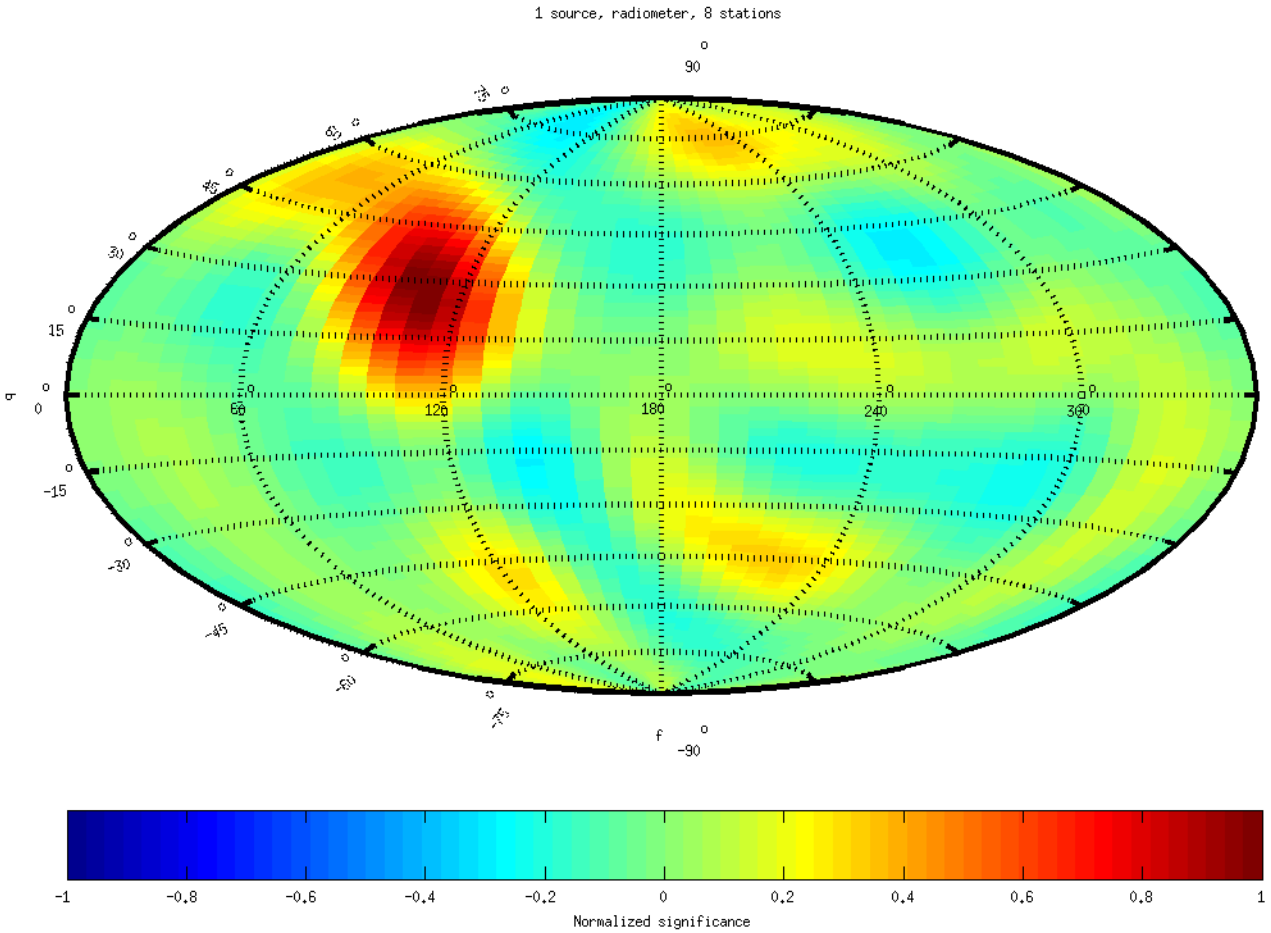
nstest10

0.7531	1.8556	1.0045
0.8954	1.9566	1.0640
1.2440	1.8548	1.9017
0.9623	1.9656	0.7943
1.1583	1.9147	0.2922
1.0722	0.7694	0.6055
0.6859	0.2447	0.5166
1.5639	1.4368	0.8301

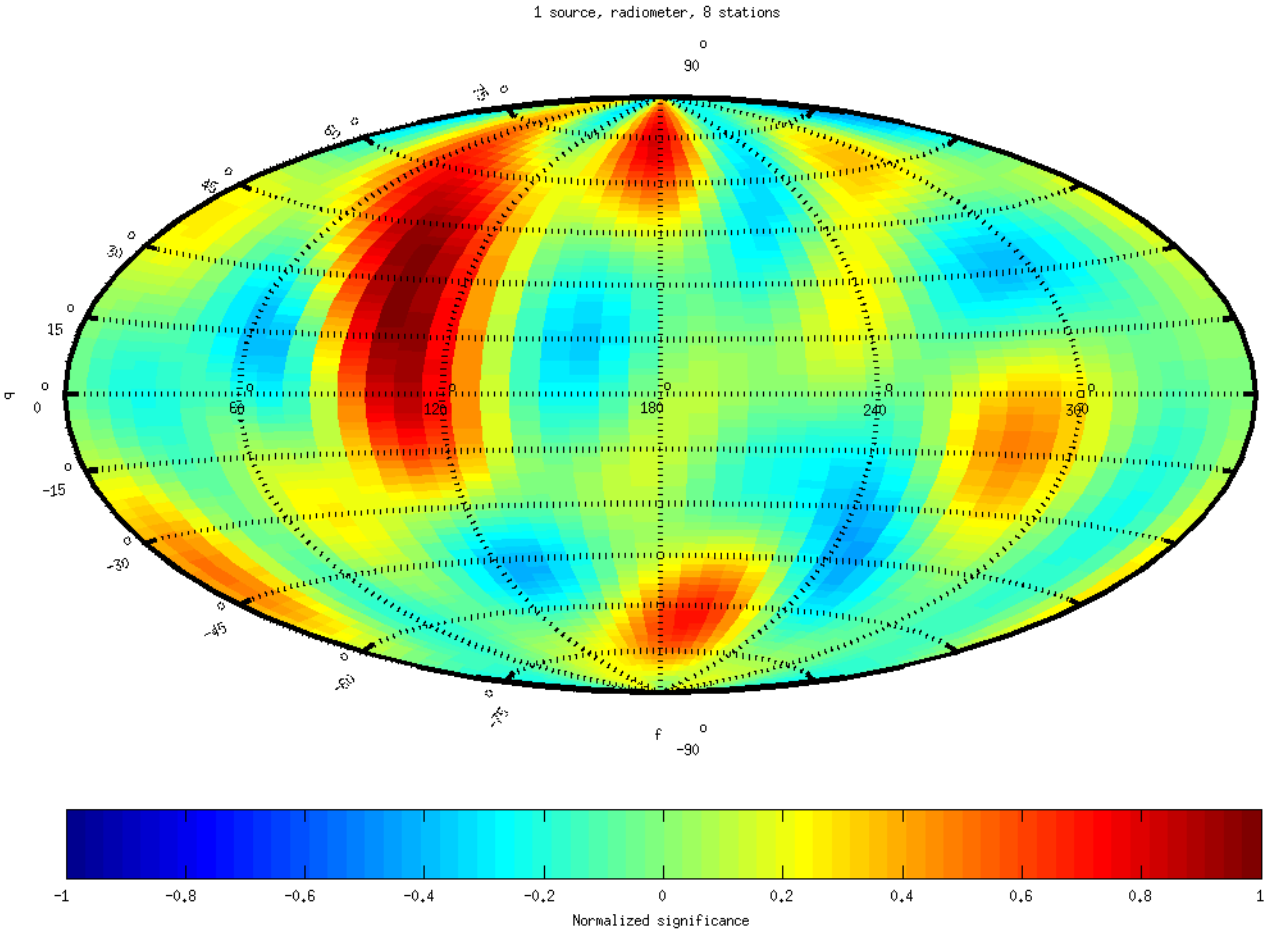
nstest11

1.0049	0.8696	1.5024
0.9540	1.4846	0.5536
1.7282	1.7792	1.8847
0.8537	0.4295	1.0085
0.7172	0.3935	1.1054
1.4601	1.3522	1.1130
0.8472	0.0663	1.3949
0.8863	0.5722	0.4442

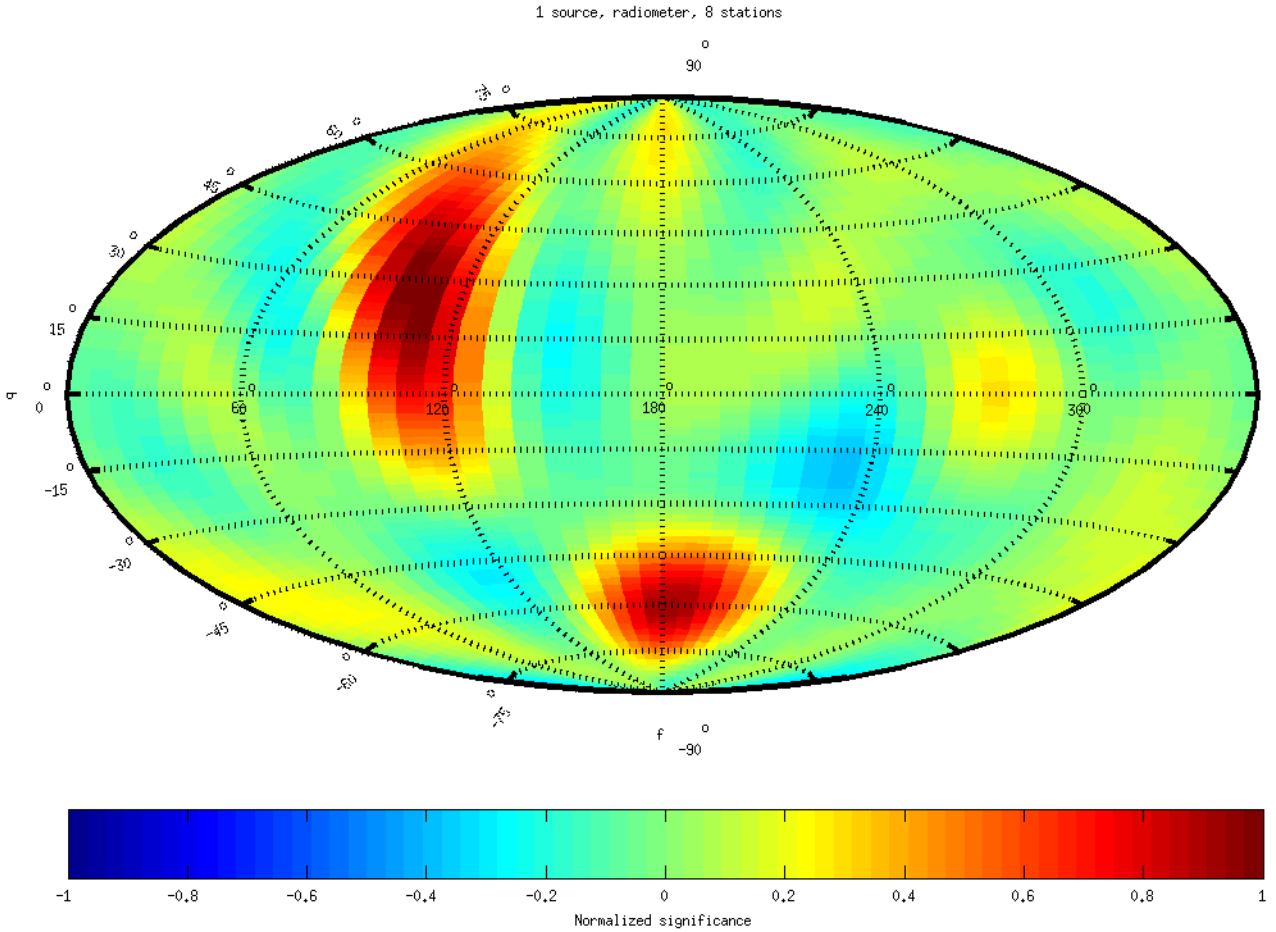
nstest7


1 source, radiometer, 8 stations
90
60
30
15
0
-15
-30
-45
-60
-75
-90
b
f
60
120
180
240
300
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Normalized significance

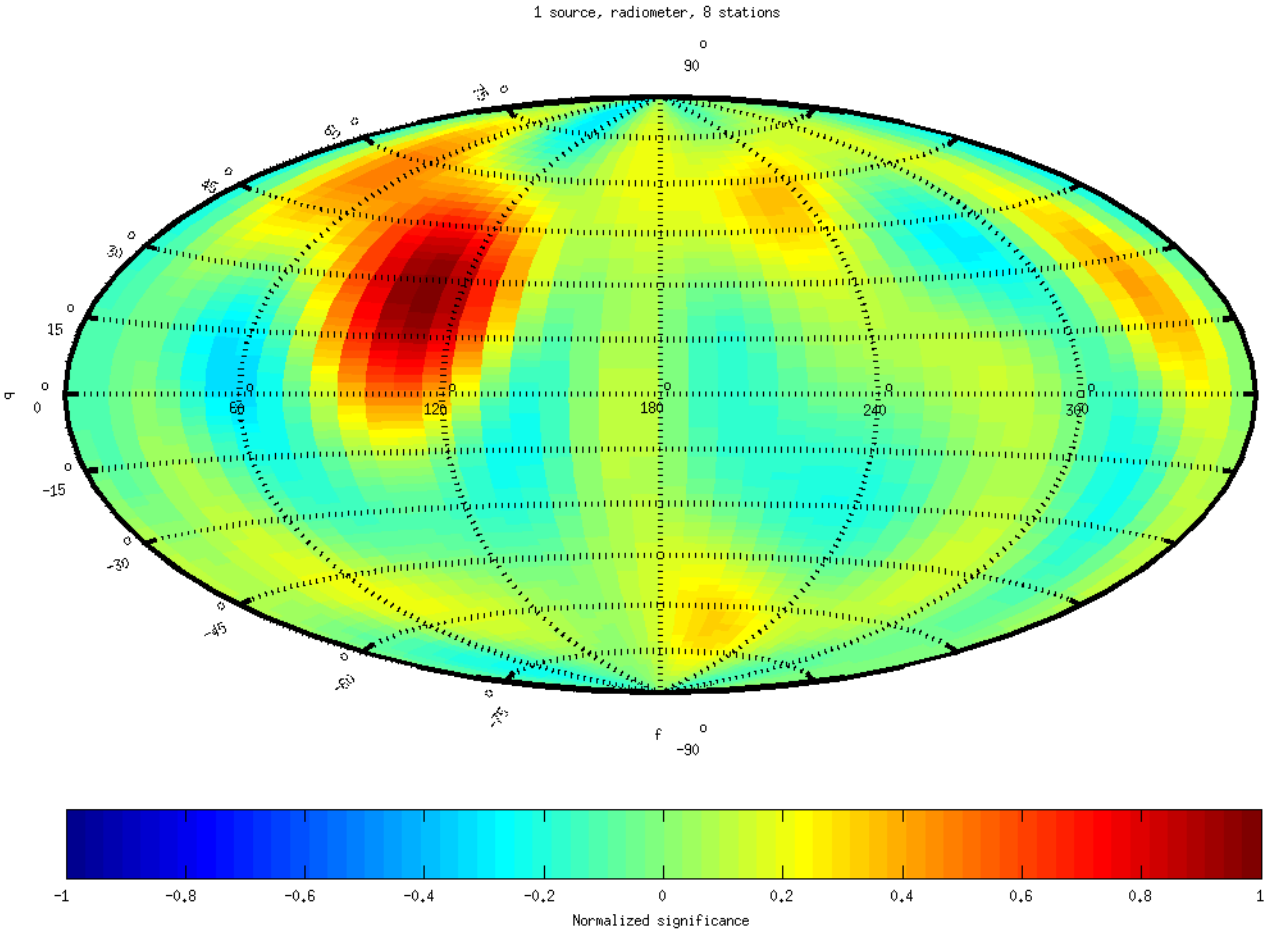
nstest8


1 source, radiometer, 8 stations
90
-90
f
b
Normalized significance
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

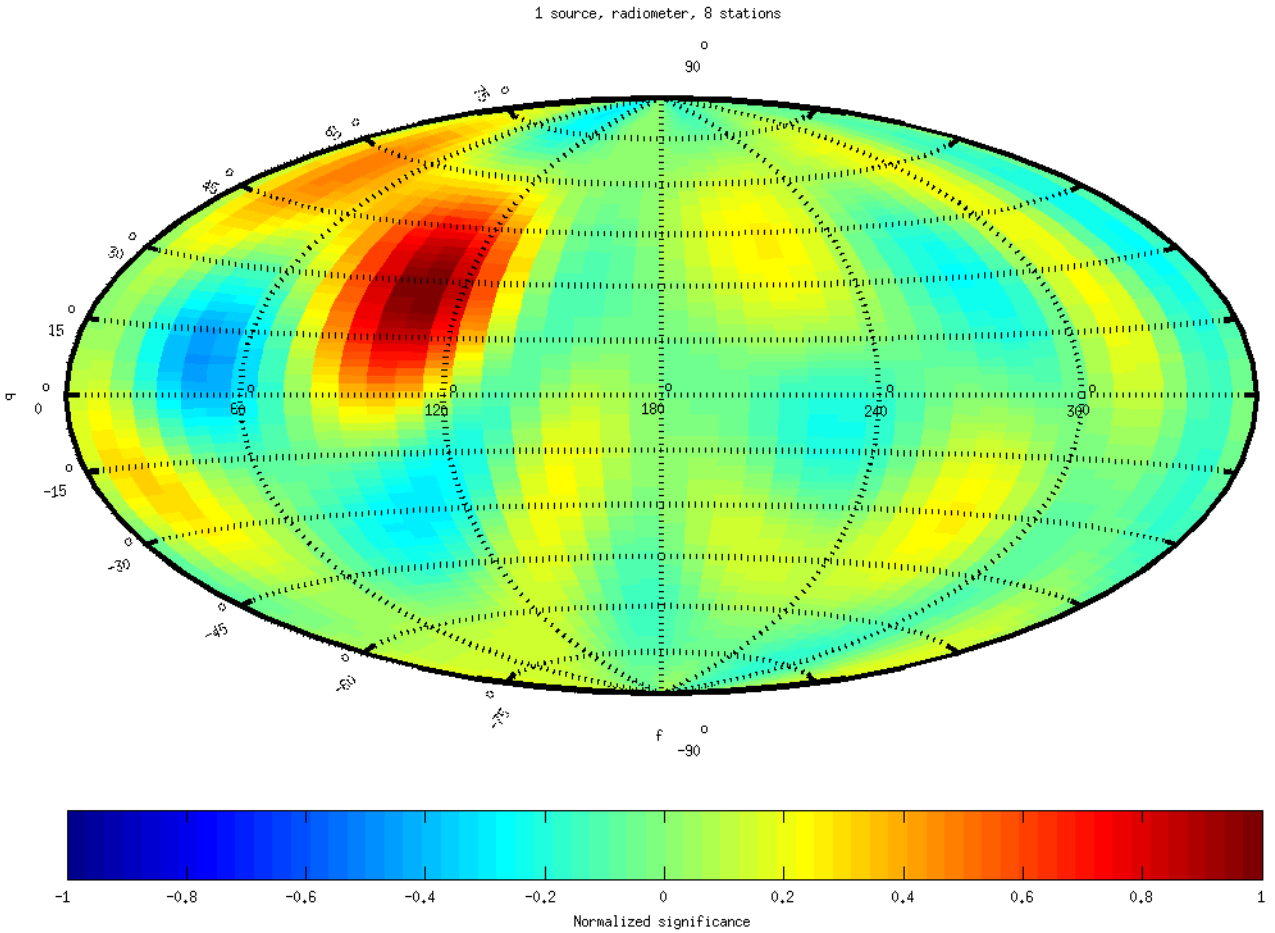
nstest9


1 source, radiometer, 8 stations
90
-90
f
b
Normalized significance
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

nstest10


1 source, radiometer, 8 stations
90
-90
15
-15
-30
-45
-60
-75
120
180
240
300
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Normalized significance

nstest11


1 source, radiometer, 8 stations
90
-90
b
f
Normalized significance
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

Source Location Testing

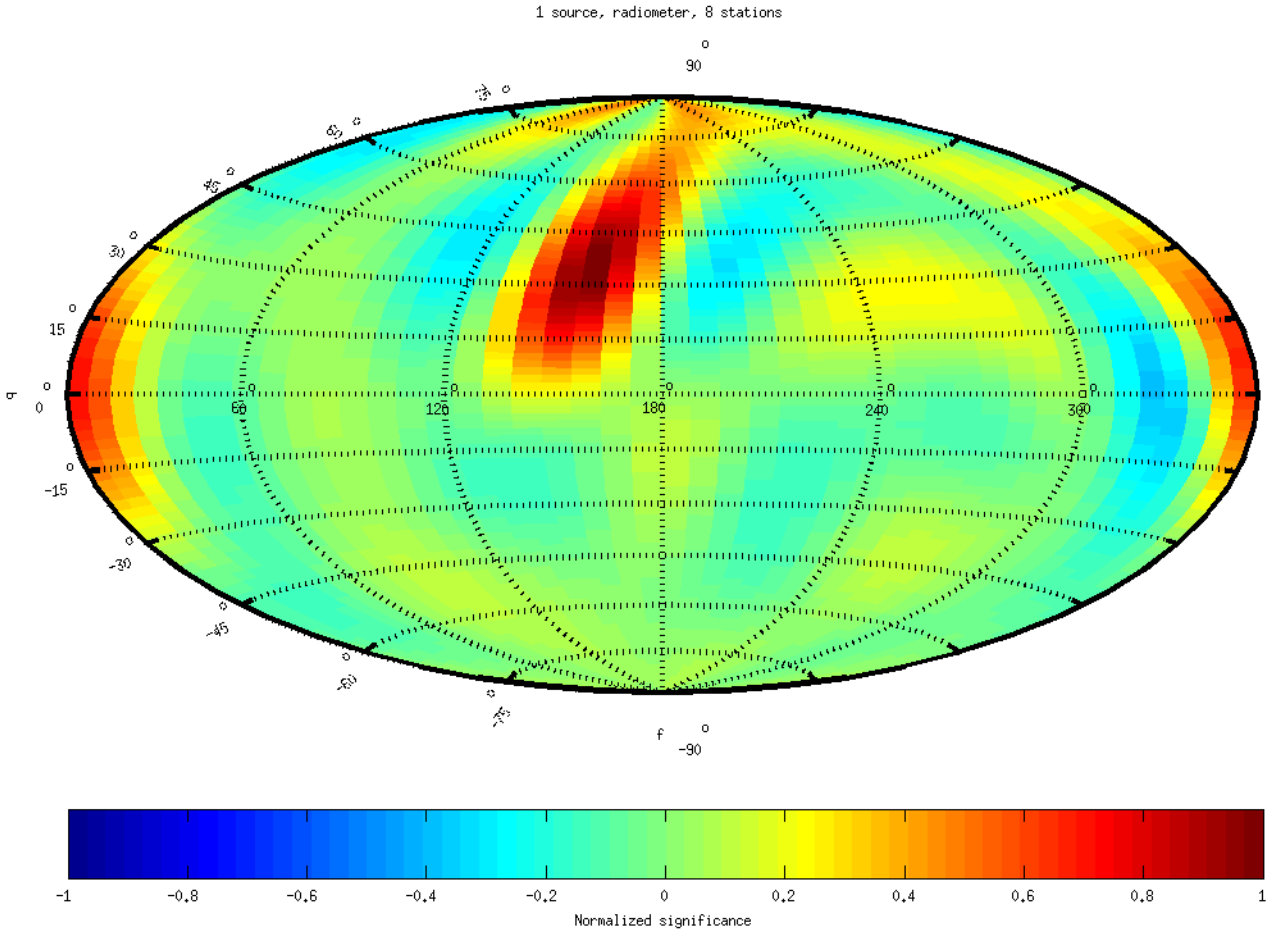
The following detector array is used(from nstest11):

detloc = 1.0e+03 m *

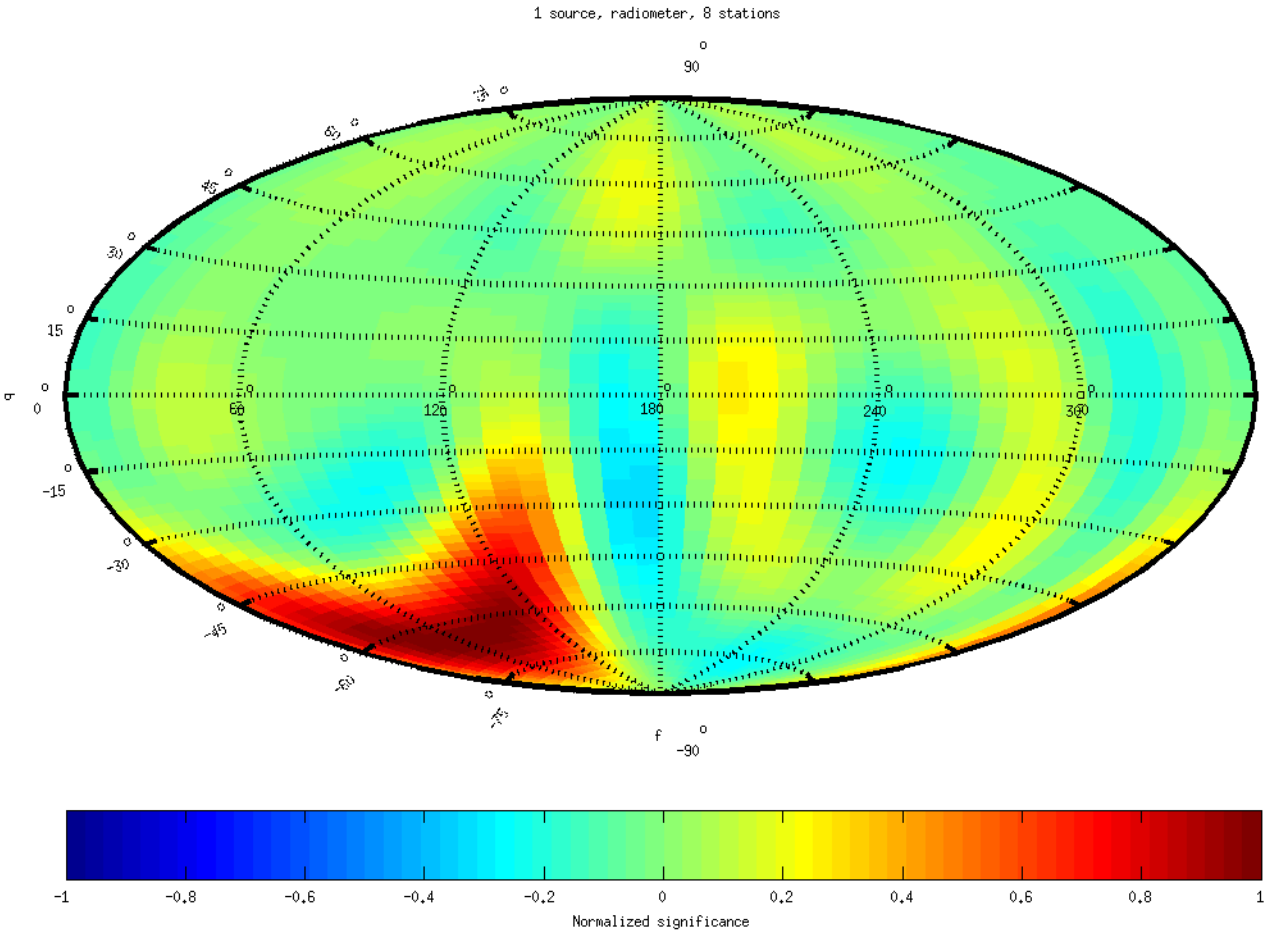
1.0049	0.8696	1.5024
0.9540	1.4846	0.5536
1.7282	1.7792	1.8847
0.8537	0.4295	1.0085
0.7172	0.3935	1.1054
1.4601	1.3522	1.1130
0.8472	0.0663	1.3949
0.8863	0.5722	0.4442

The source location is chosen randomly. All other parameters are the same as before.

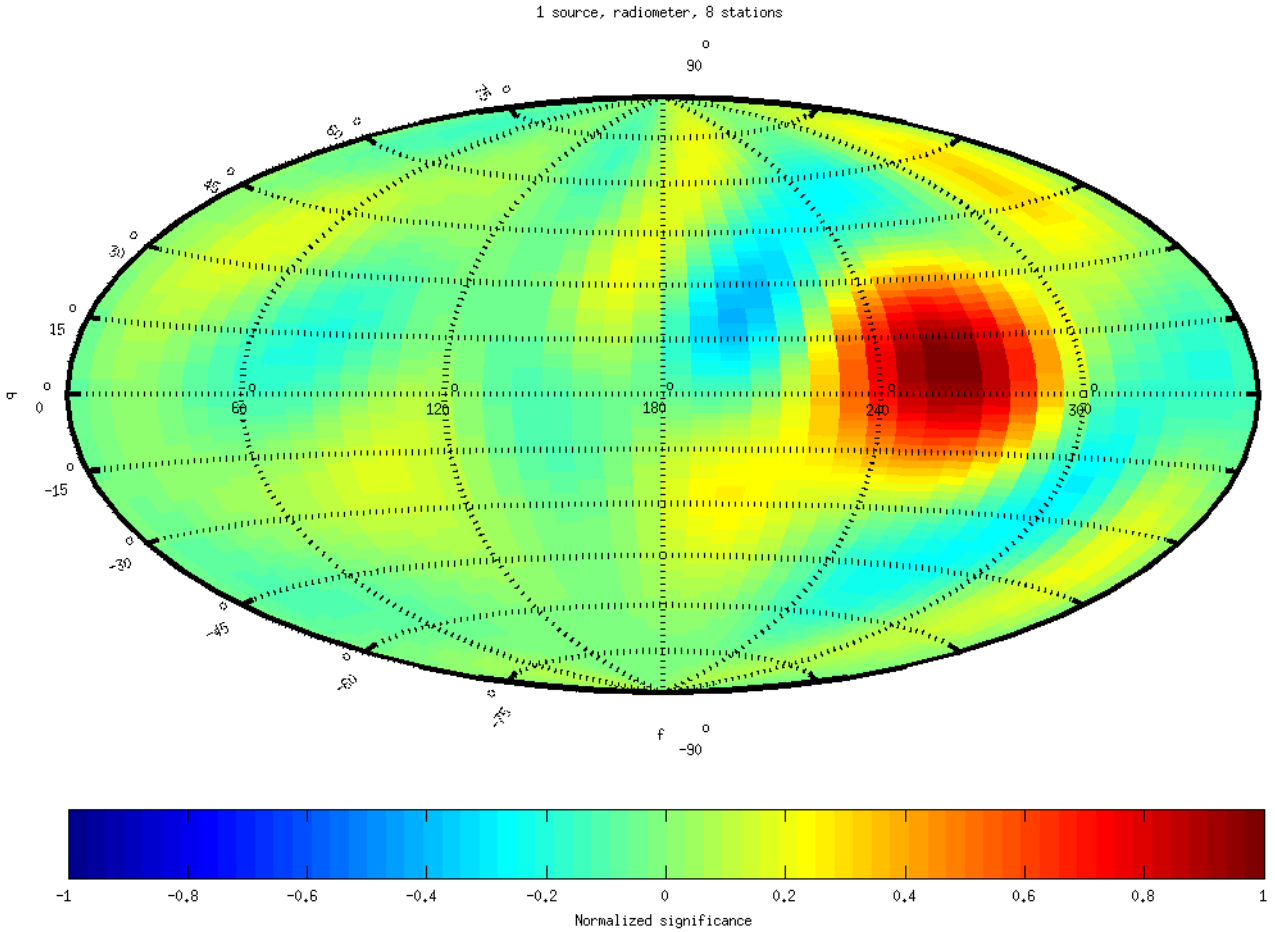
(theta, phi) = (39.8411, 138.4983) nstest12



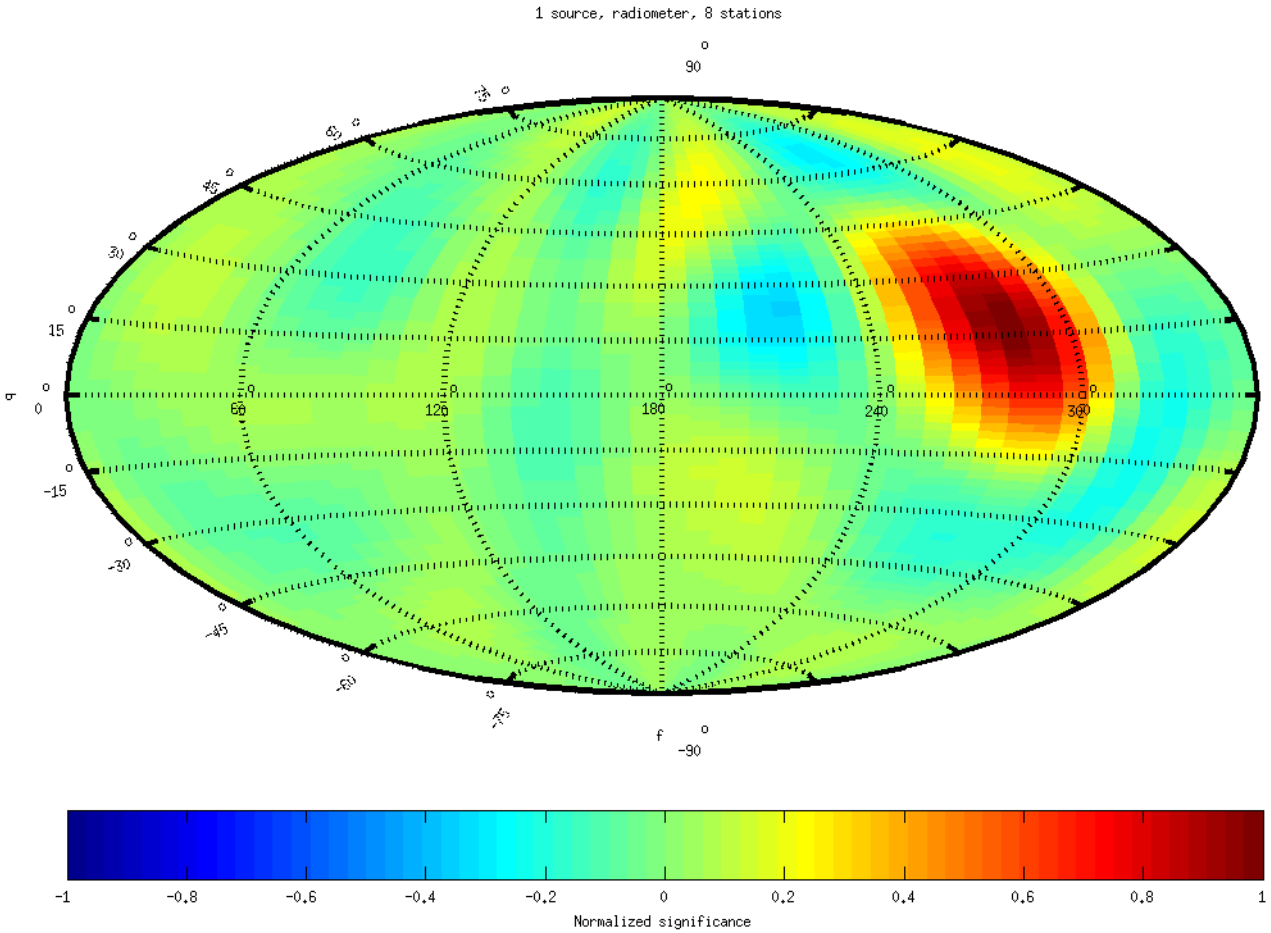
(theta, phi) = (-63.203634.6356) nstest13



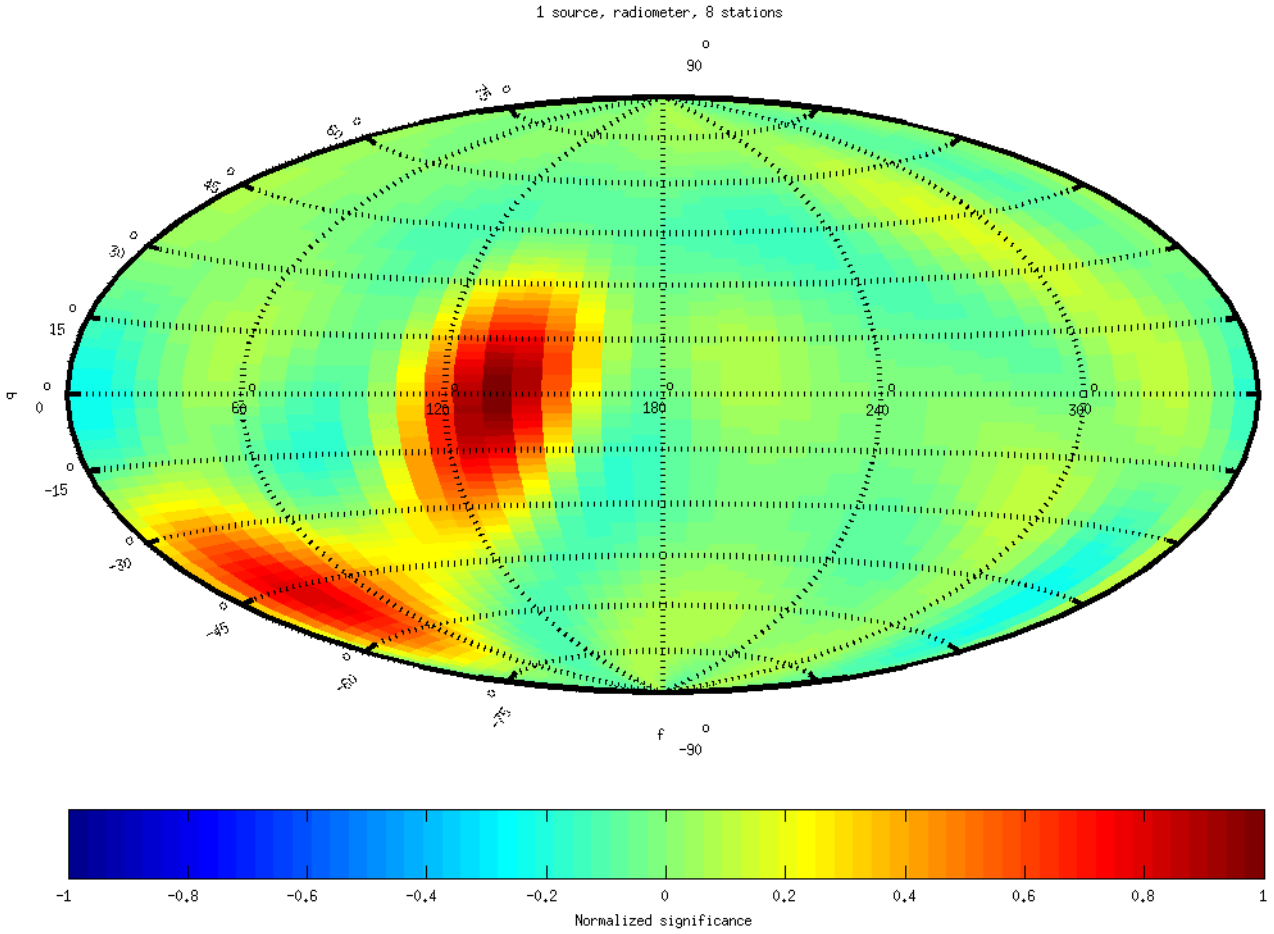
(theta, phi) = (8.1062, 243.8633) nstest 14



(theta, phi) = (27.3395, 249.6201) nstest15



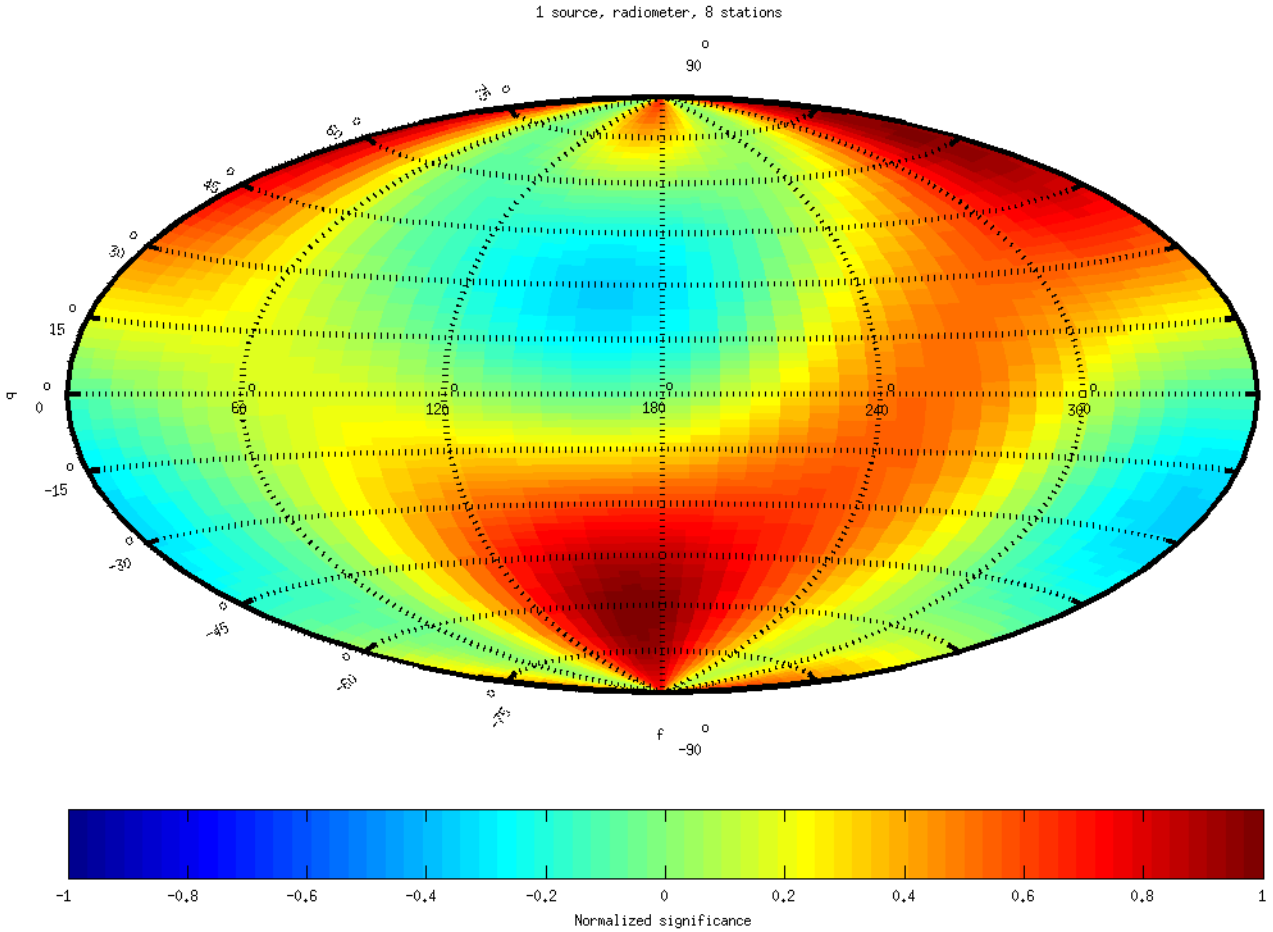
(theta, phi) = (-11.5677,127.6468) nstest16



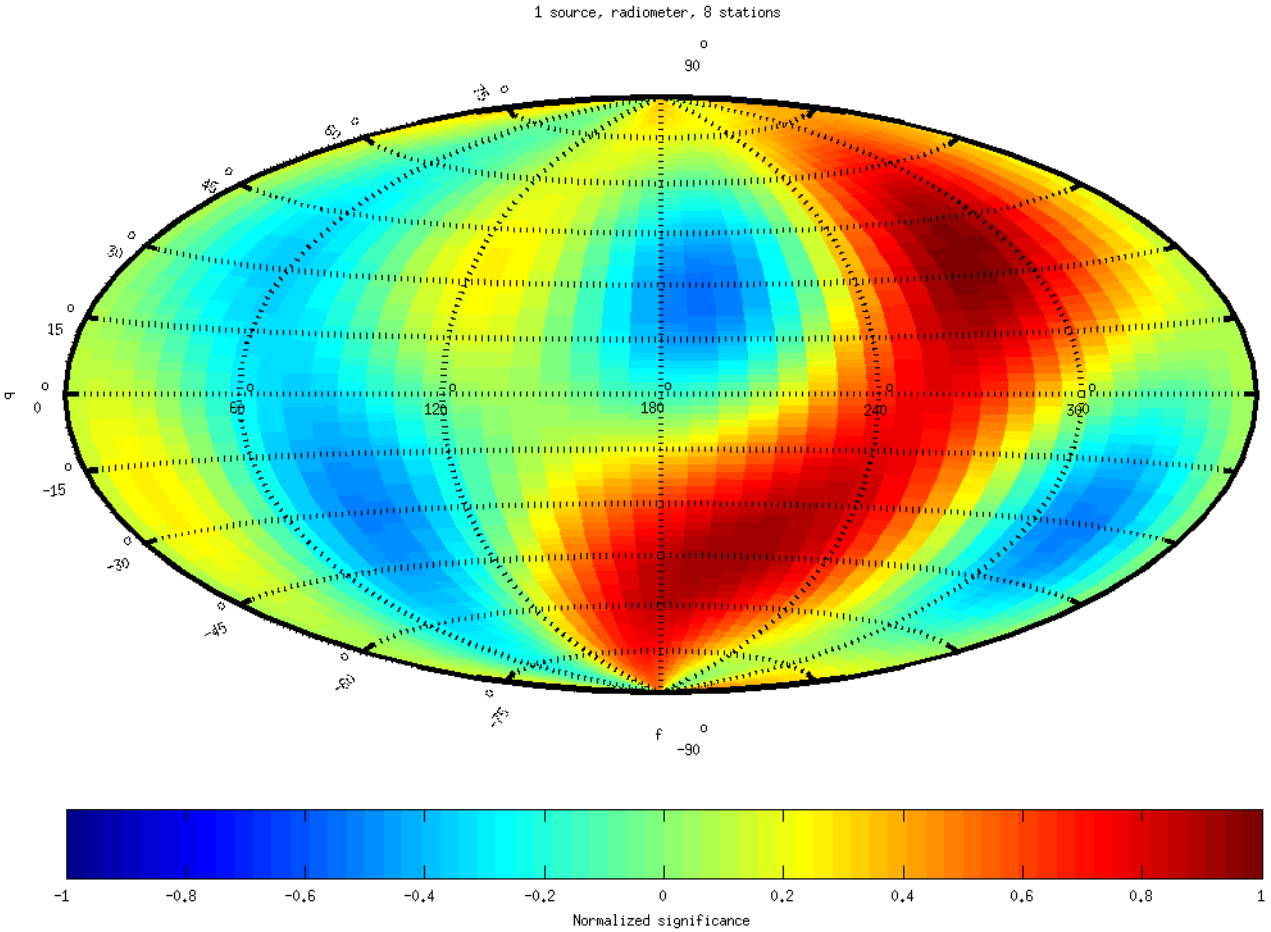
Frequency Dependence Testing

- In the following tests a source location of (theta, phi) = (8.1062, 243.8633) (from nstest14). The frequency of the injected data and of the recovery are varied. All other parameters are kept the same as before. f_analyse indicates the frequency of the injected data and of the recovery.

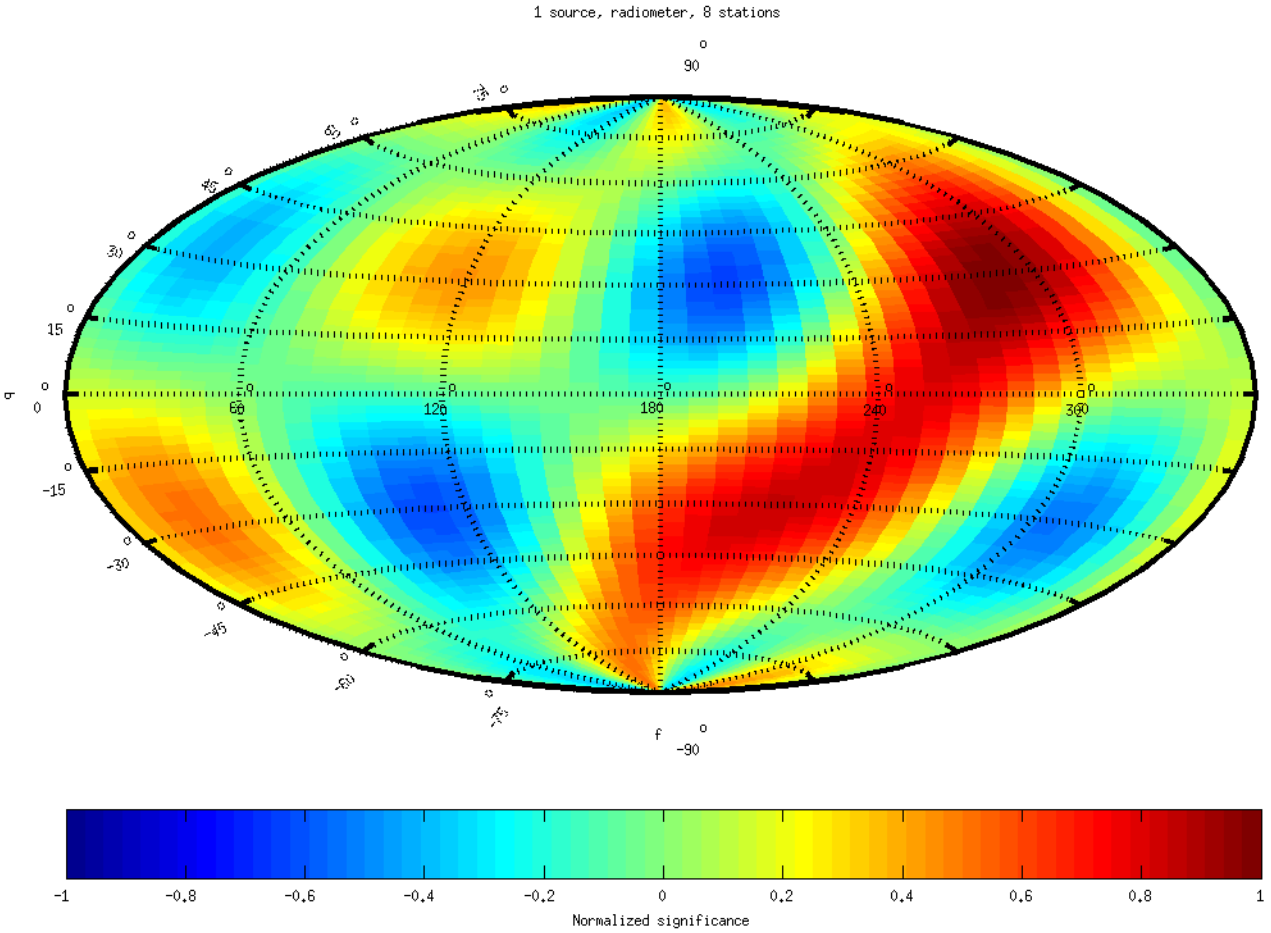
f_analyse = .001 Hz nstest17



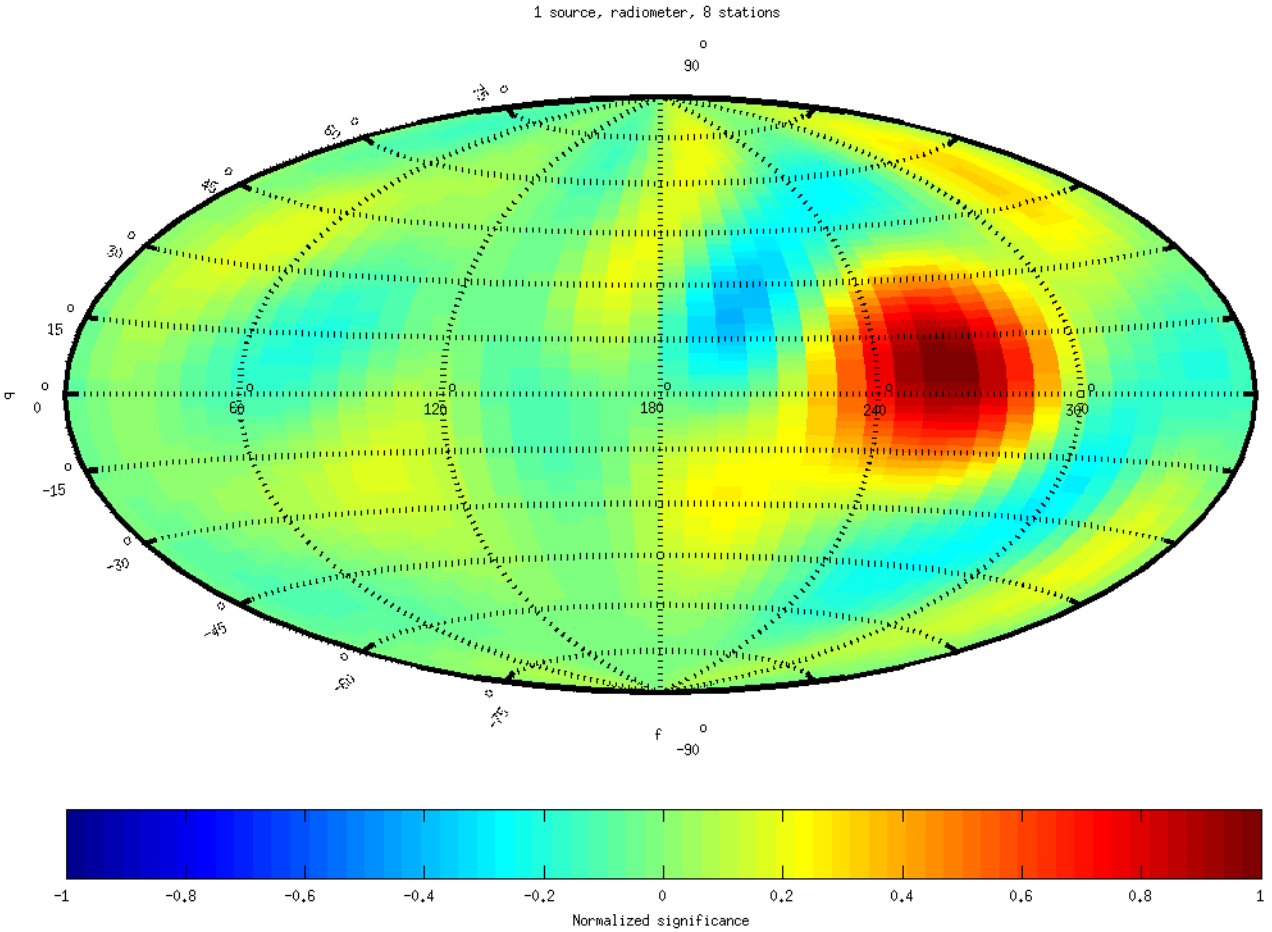
f_analyse = .01 Hz nstest18



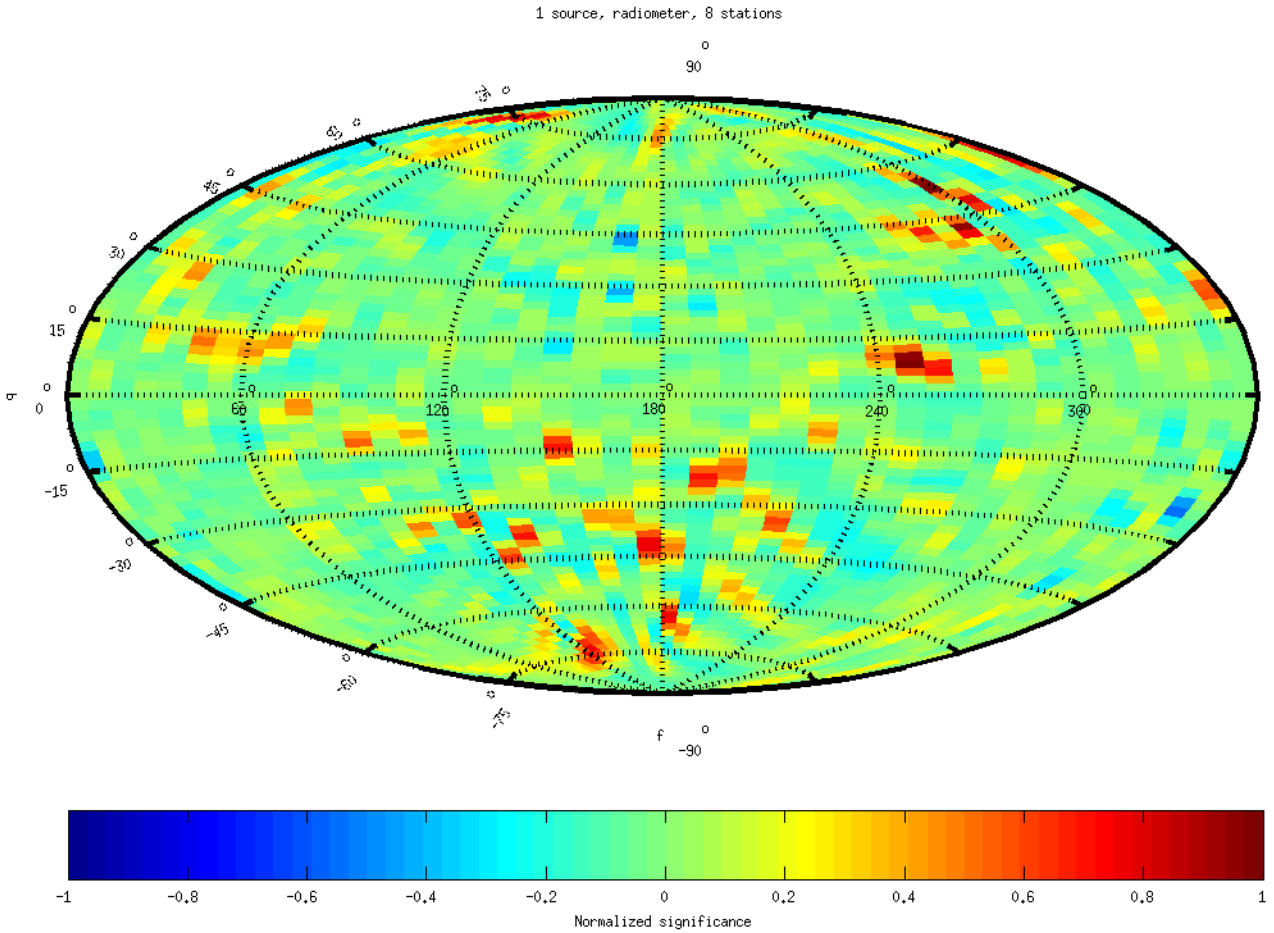
f_analyse = .1 Hz nstest19



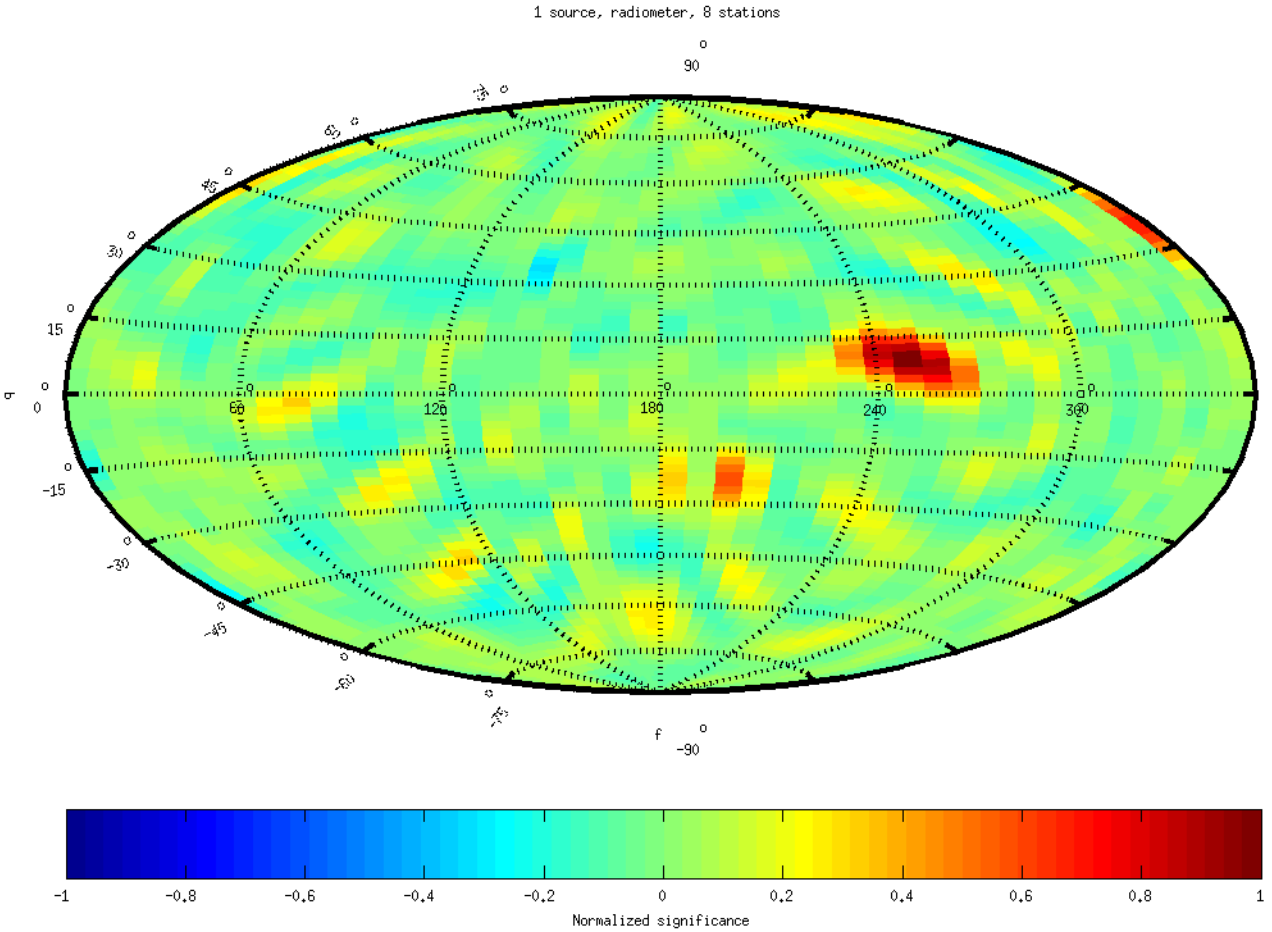
f_analyse = 1 Hz nstest20



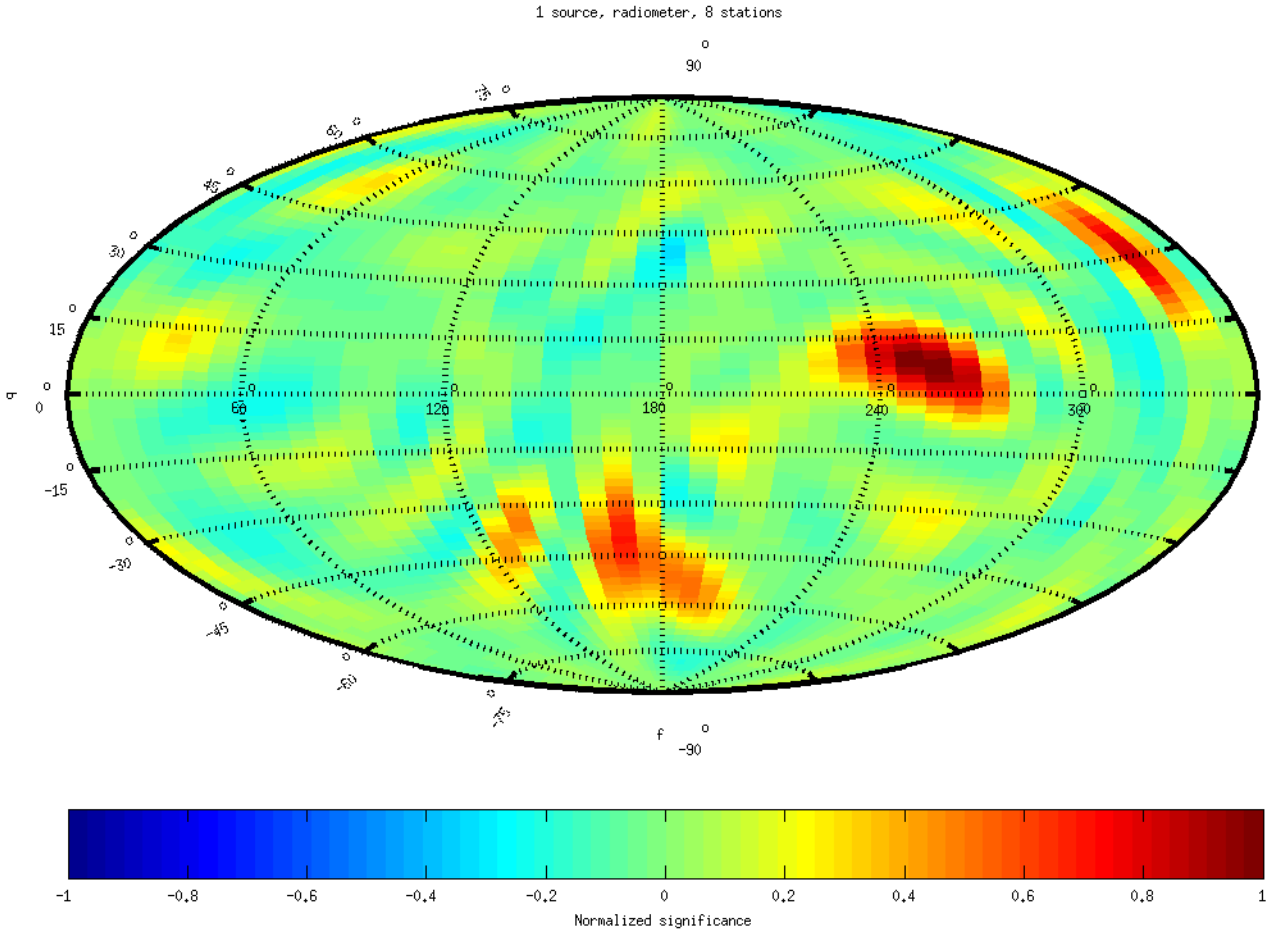
f_analyse = 10 Hz nstest21



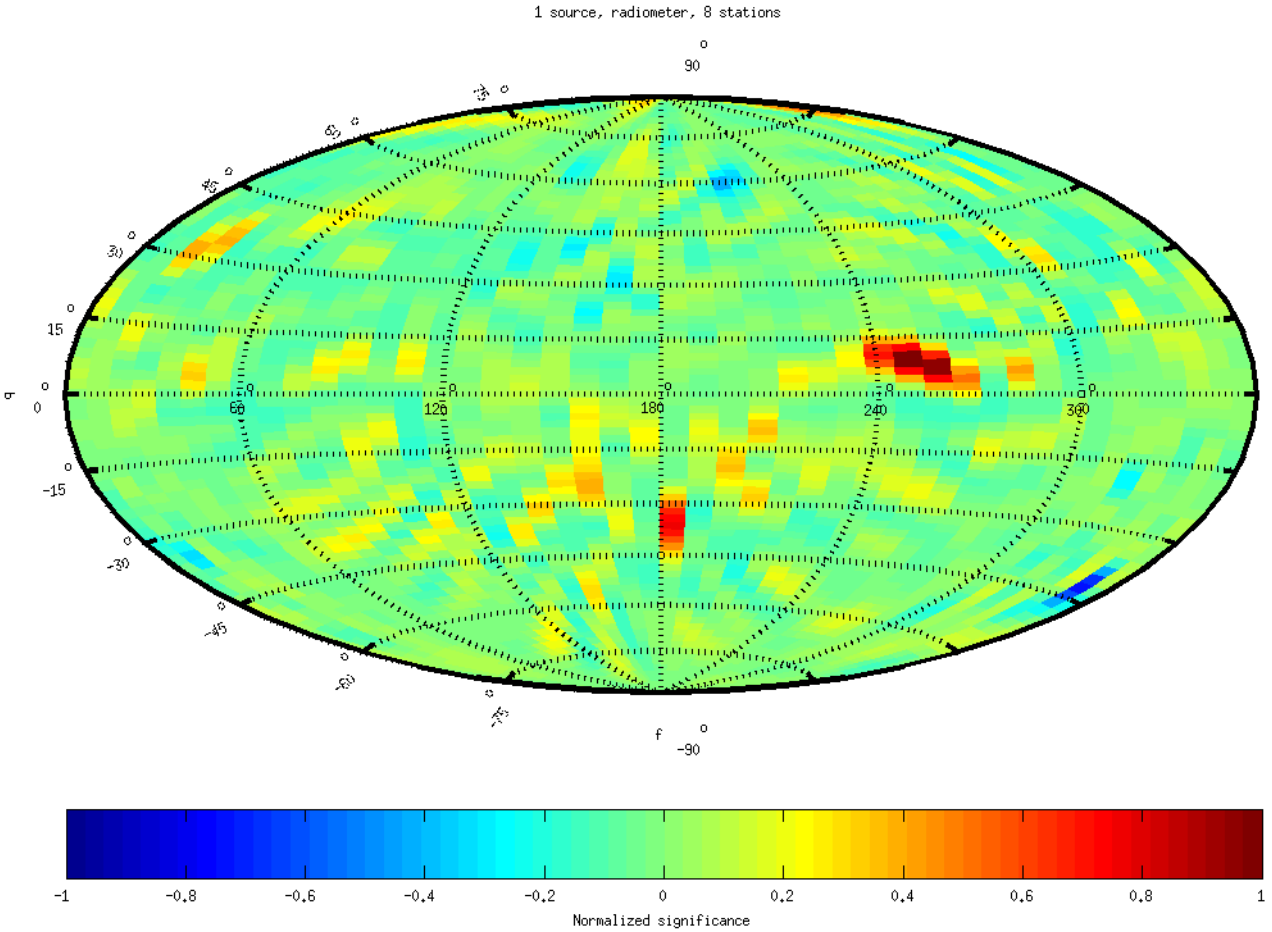
f_analyse = 5 Hz nstest22



f_analyse = 3 Hz nstest23



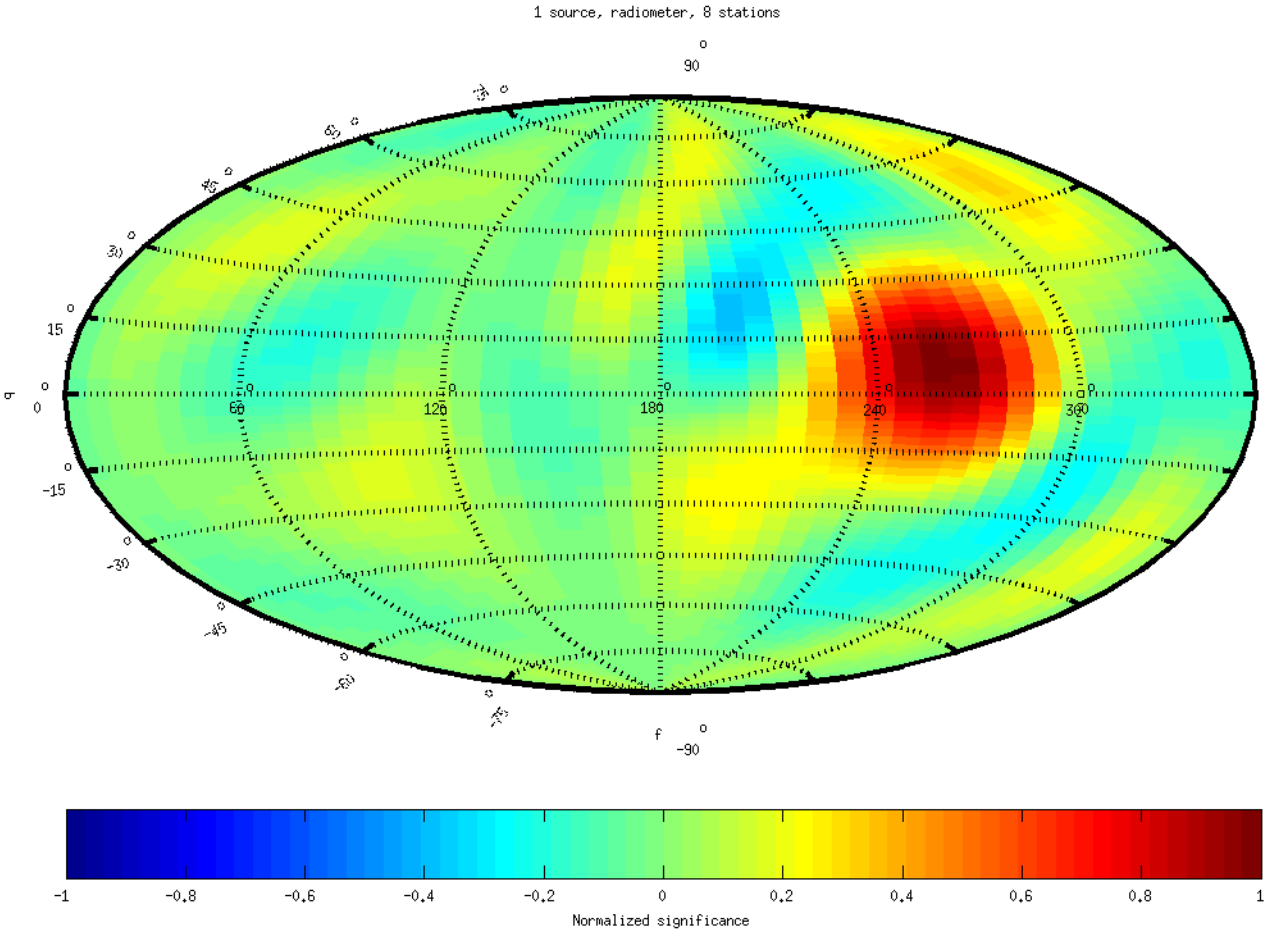
f_analyse = 7 Hz nstest24



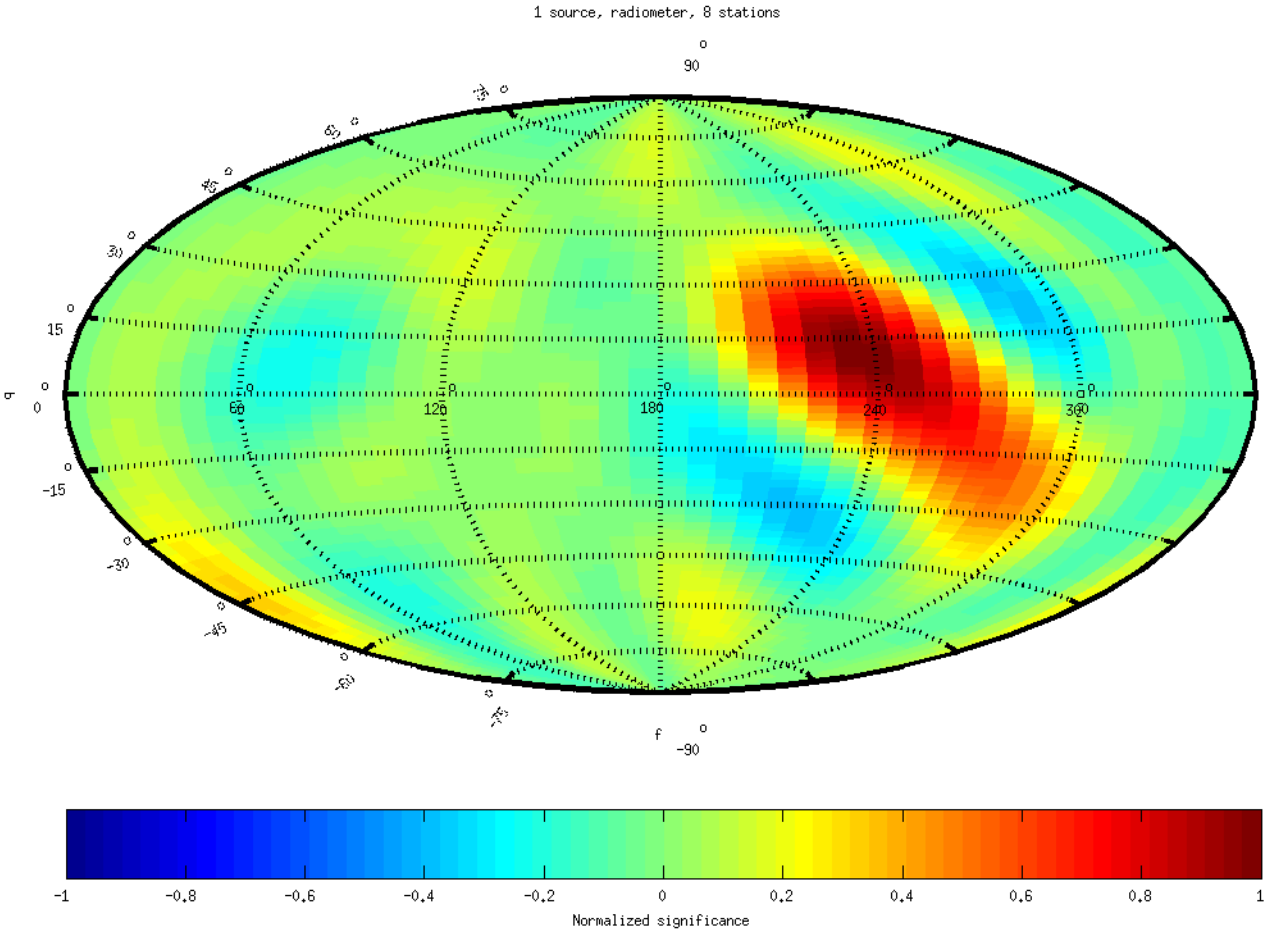
Polarization Testing

- A monochromatic source of either 1 Hz or 5 Hz Is used. Random polarizations are used. All other parameters are the same as before.

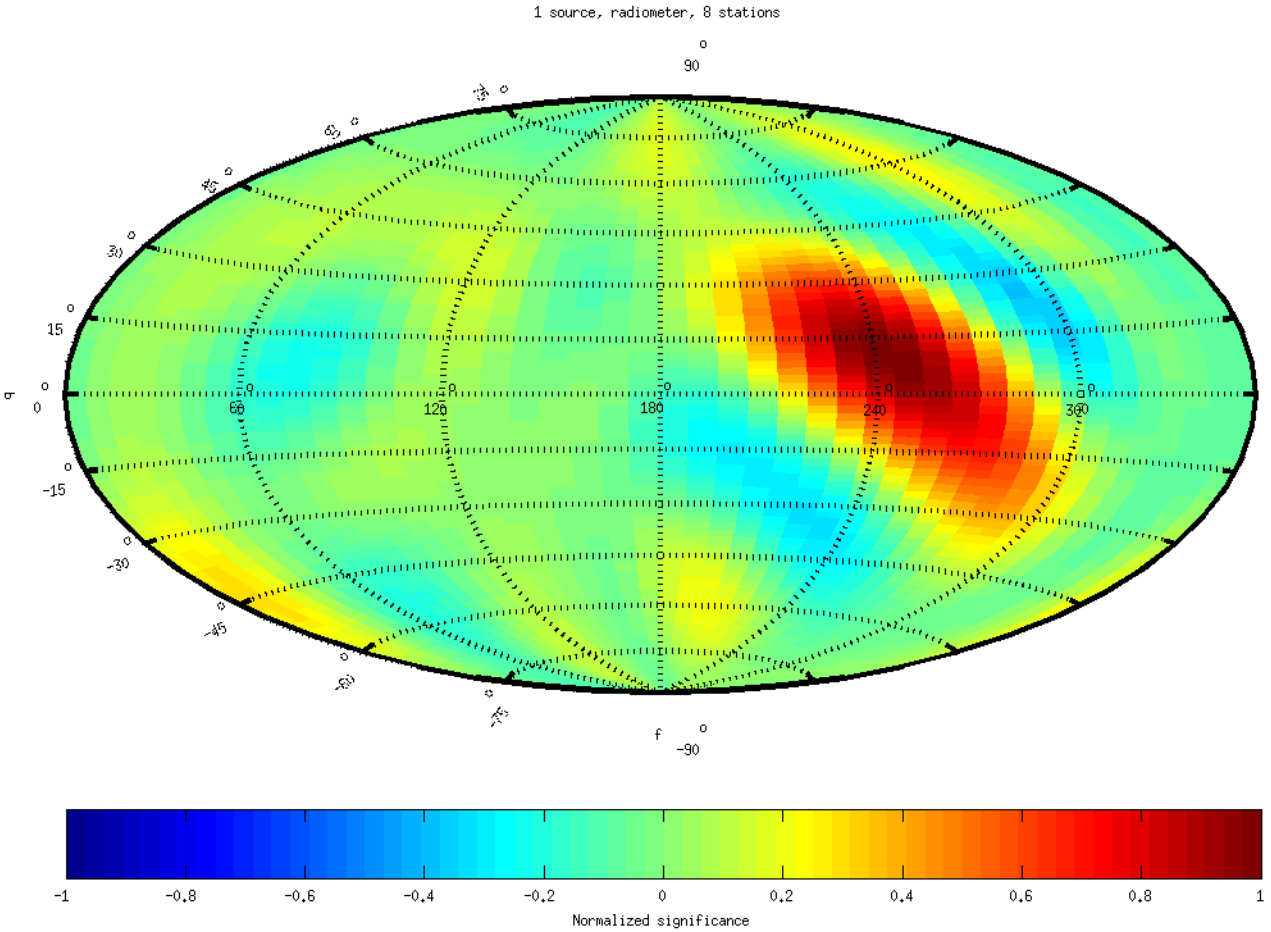
f_analyse = 1 Hz, psi = 40.2956 nstest25



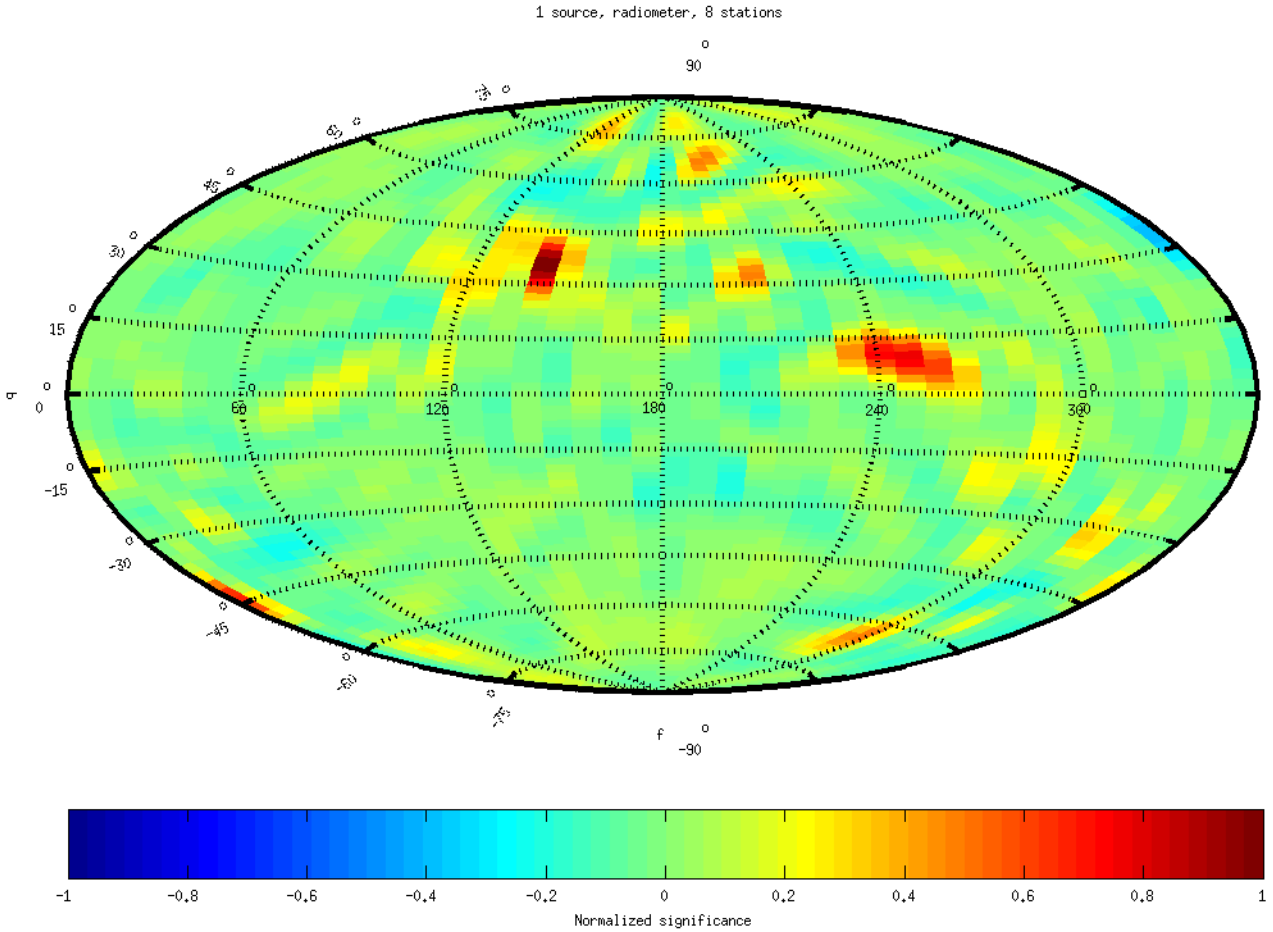
f_analyse = 1 Hz, psi = 138.0781 nstest26



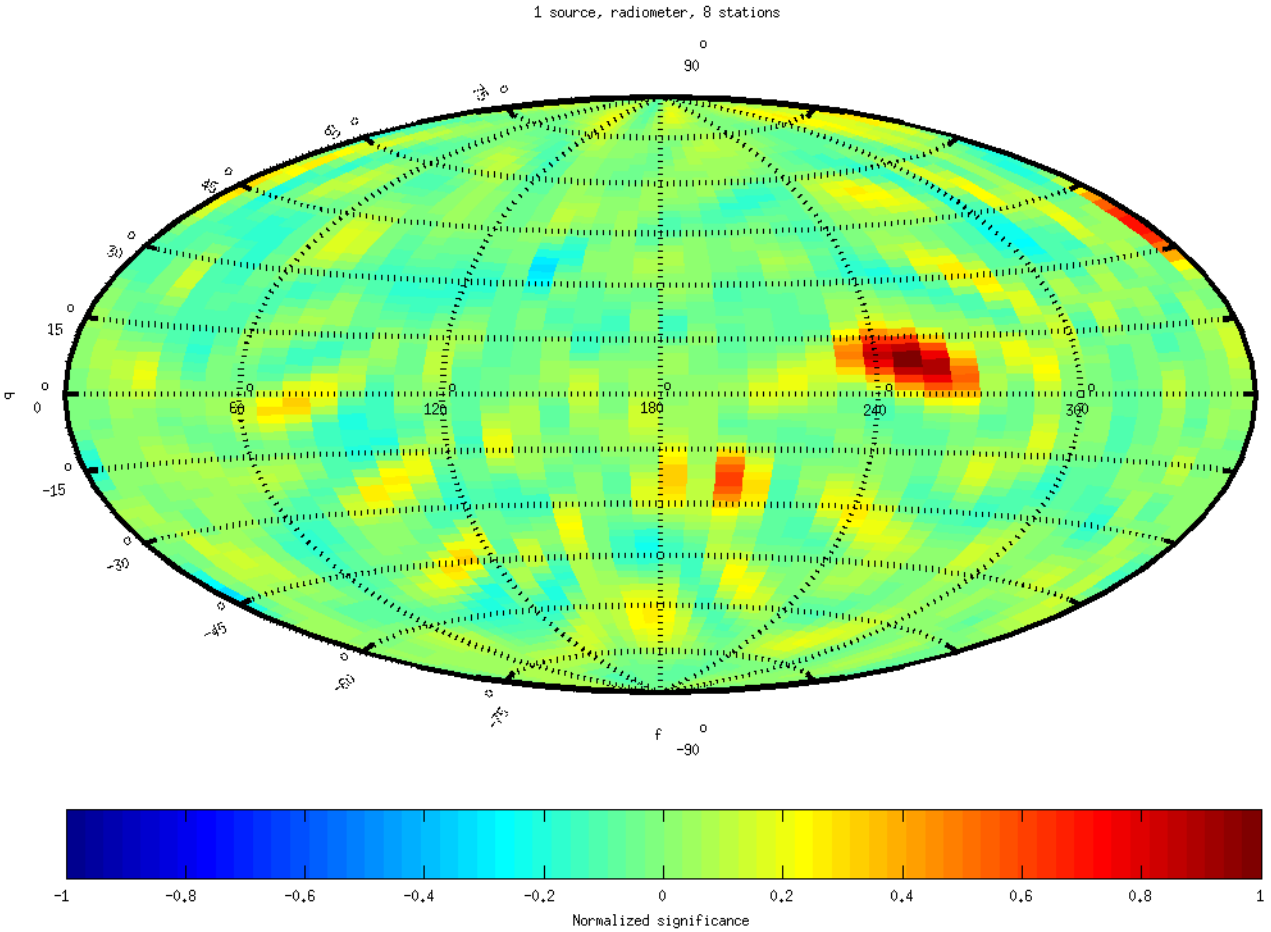
f_analyse = 1 Hz, psi = 190.9751 nstest27



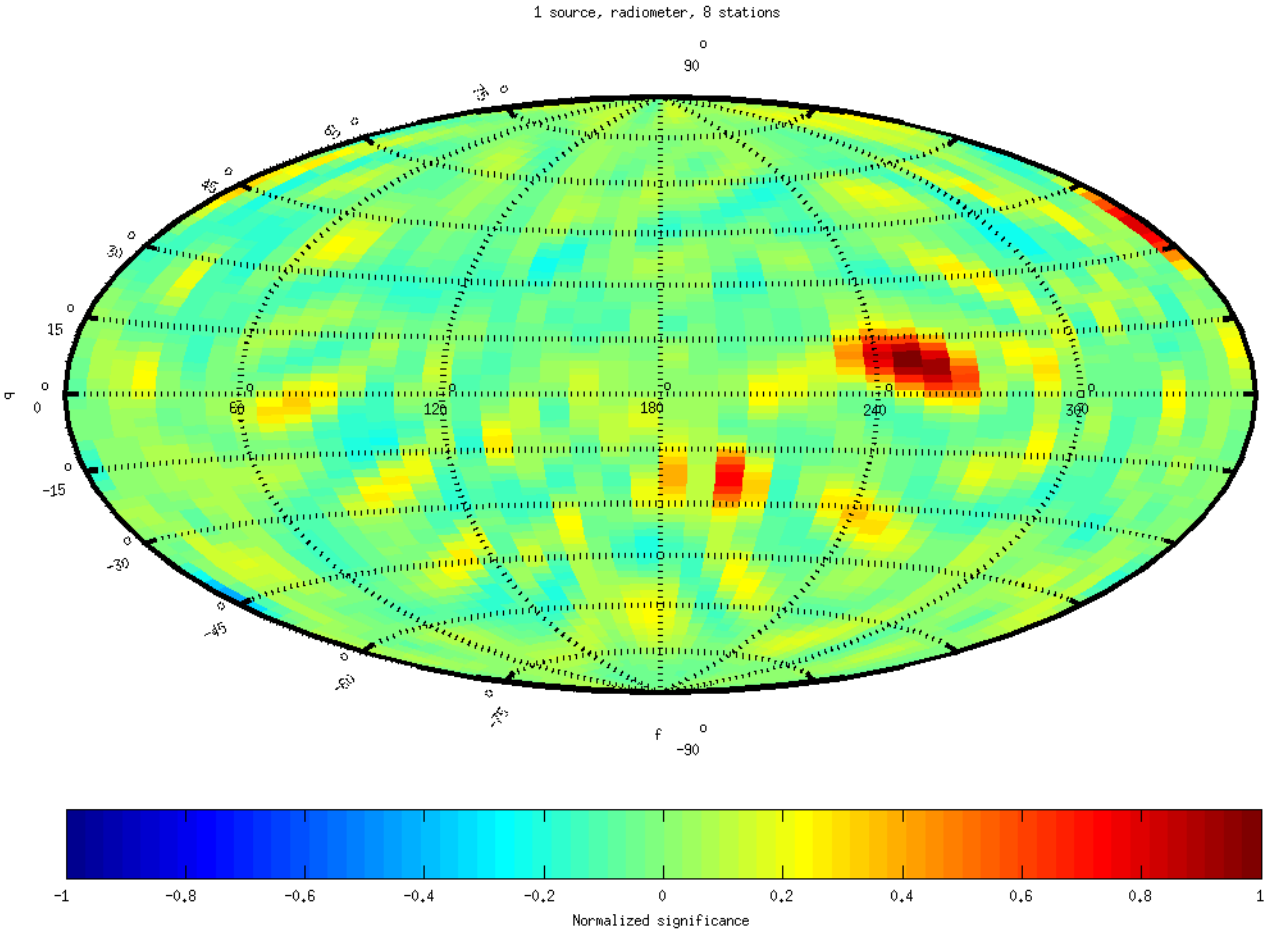
f_analyse = 5 Hz, psi = 220.9382 nstest28



f_analyse = 5 Hz, psi = 50.8770 nstest29



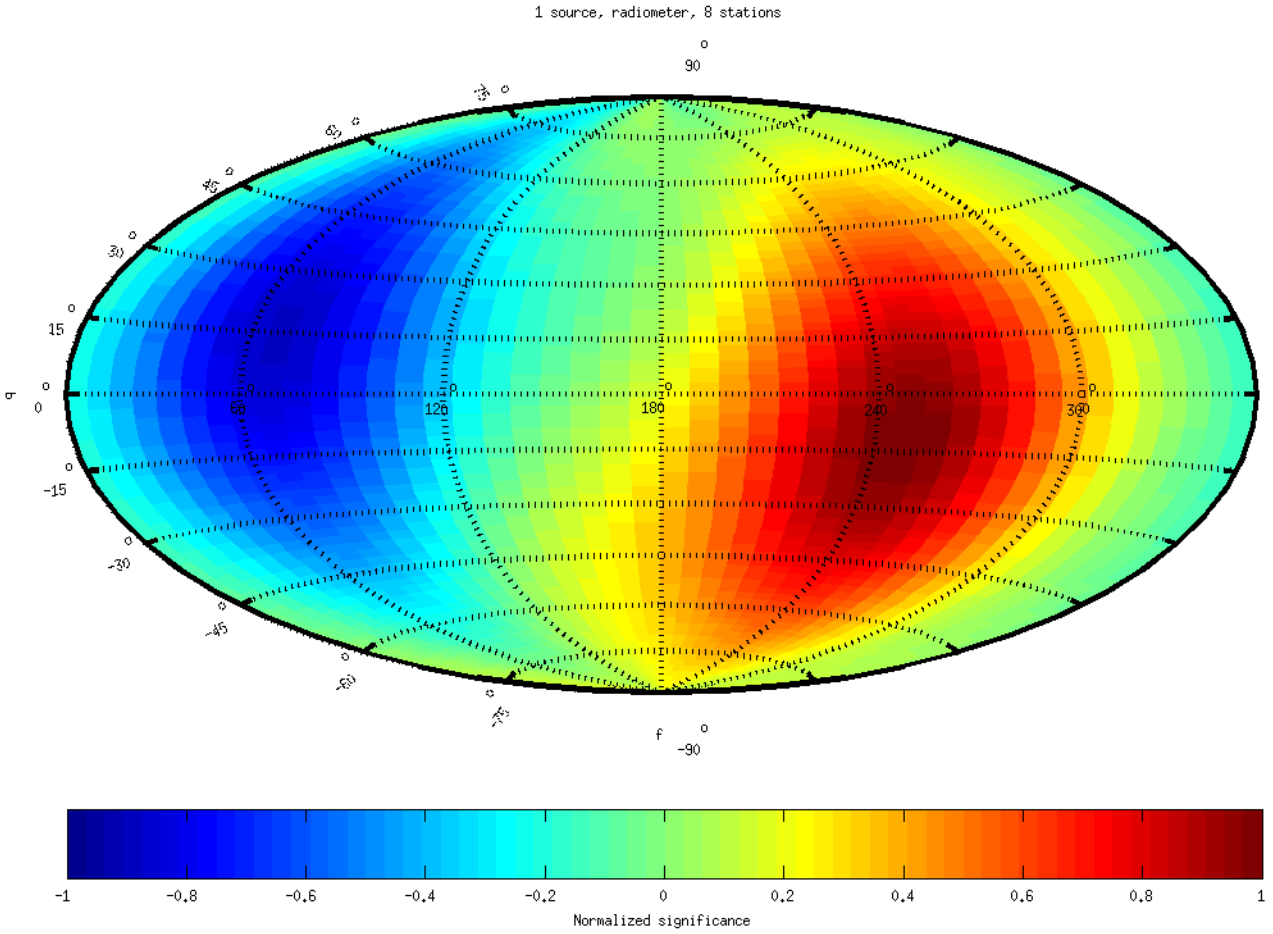
f_analyse = 5 Hz, psi =64.7787 nstest30



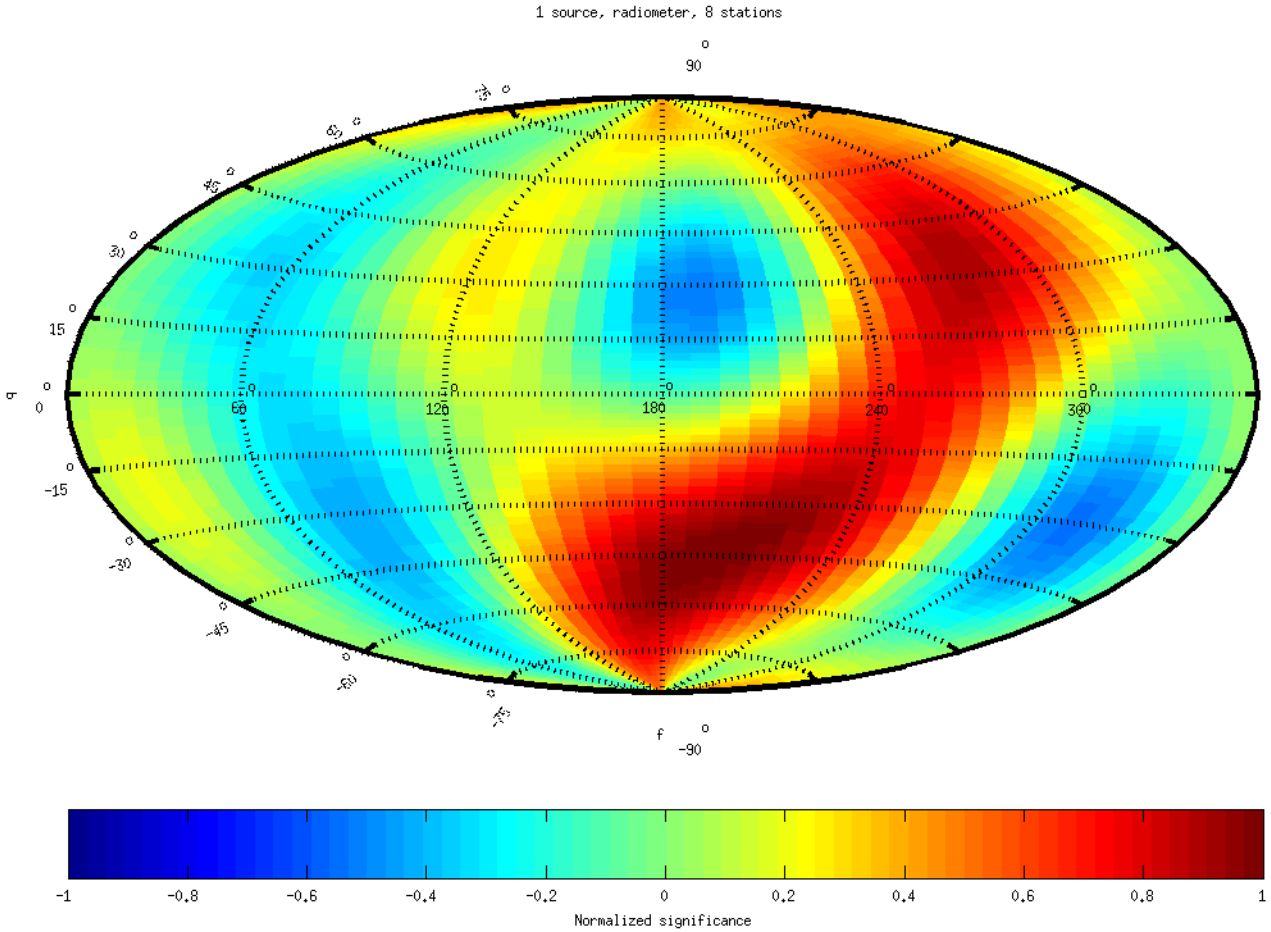
Broadband Signal Testing

- In the next series of tests, a broadband injection signal is used. f_analyse refers to the frequency at which the recovery was performed. All other parameters are kept constant, with psi being kept at 45.

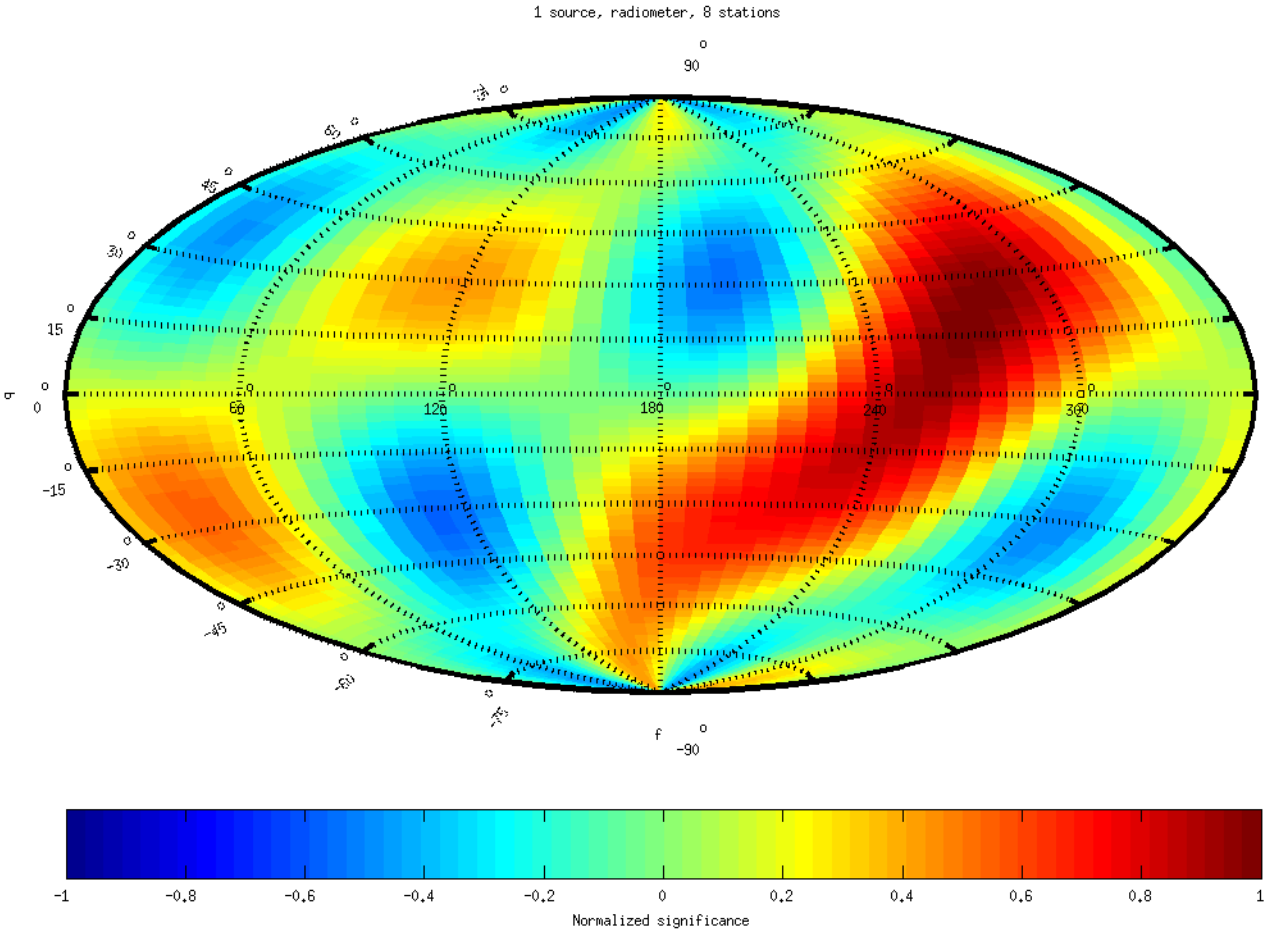
f_analyse = .001 Hz nstest31



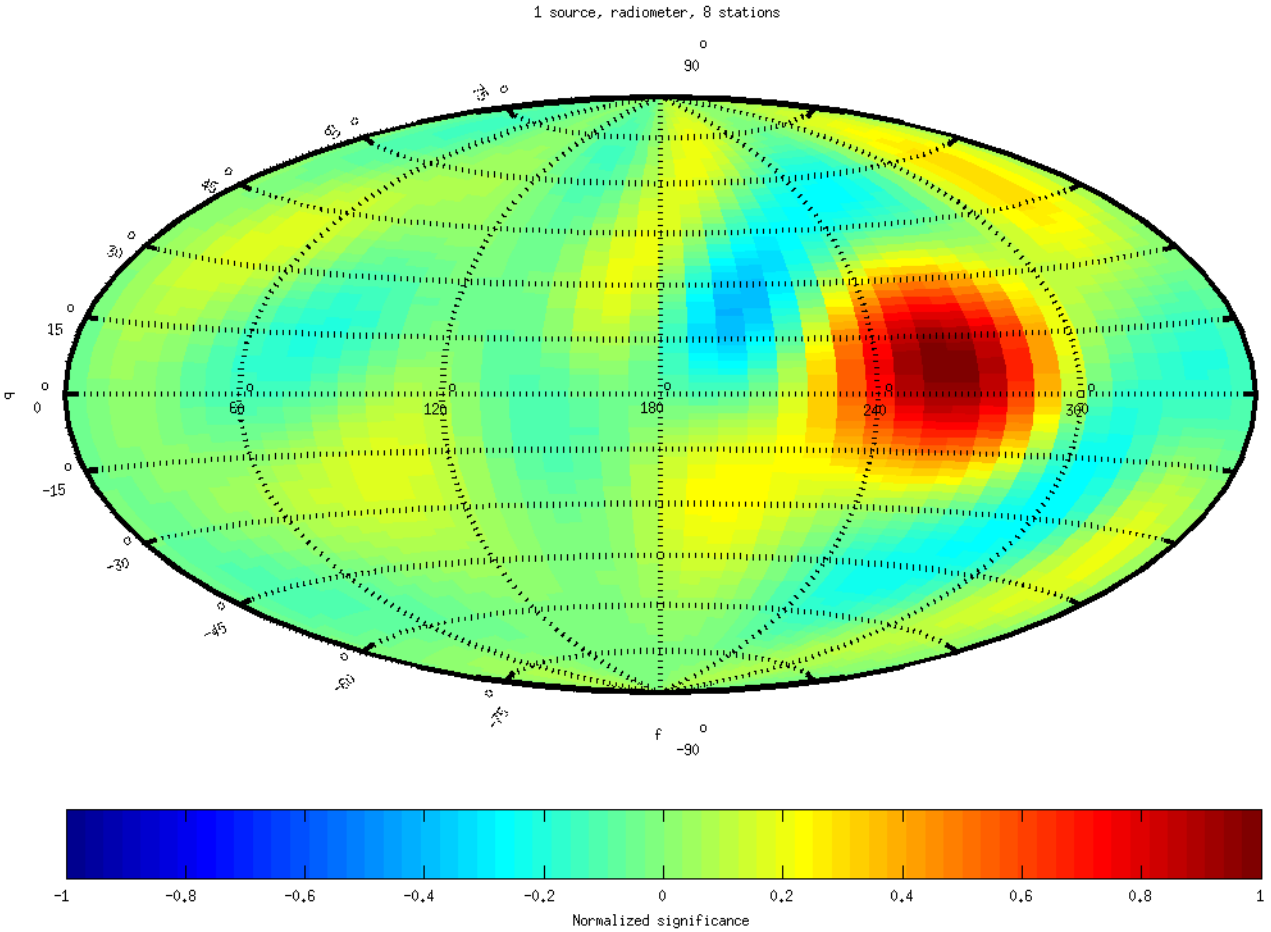
f_analyse = .01 Hz nstest32



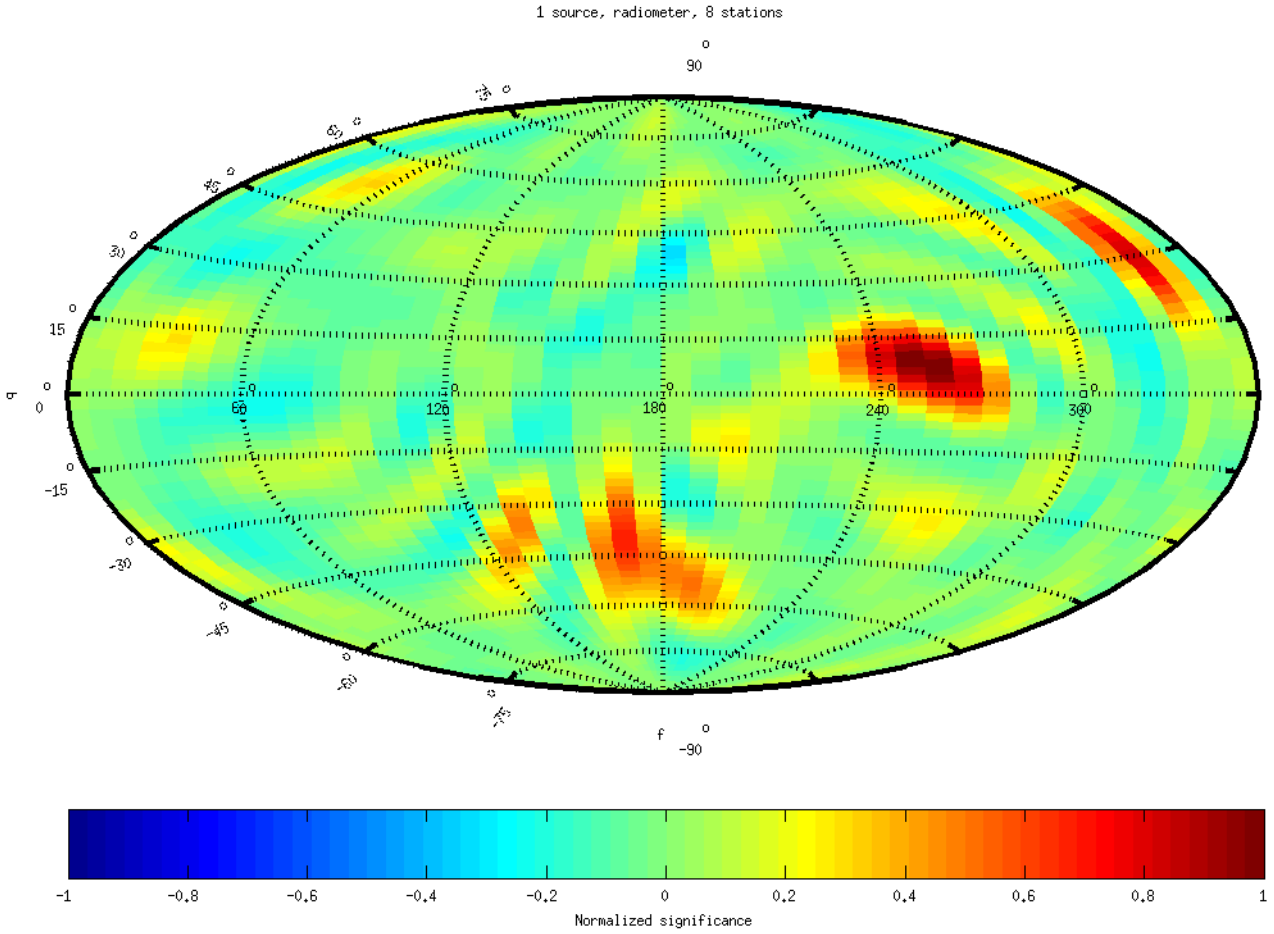
f_analyse = .1 Hz nstest33



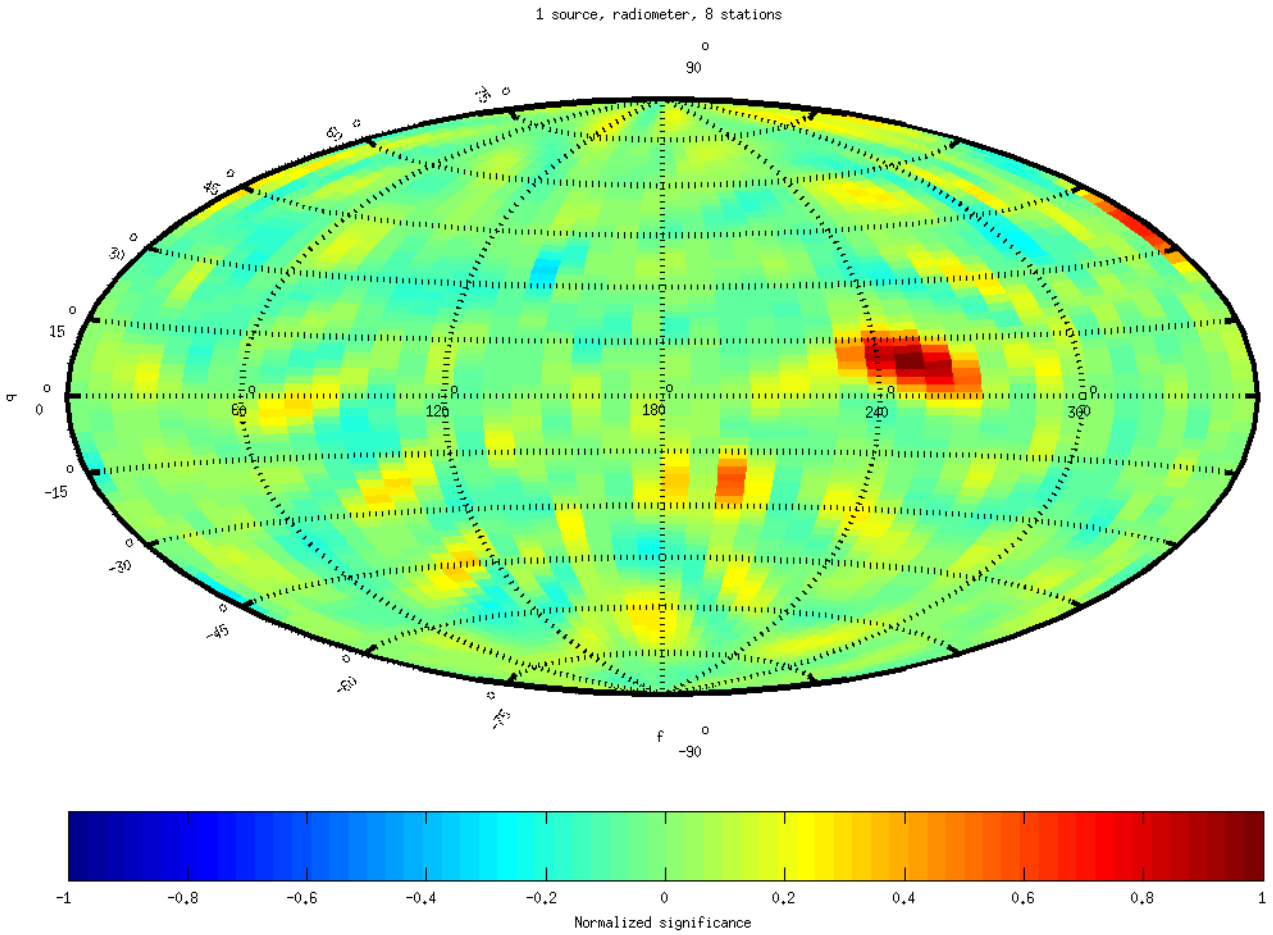
f_analyse = 1 Hz nstest34



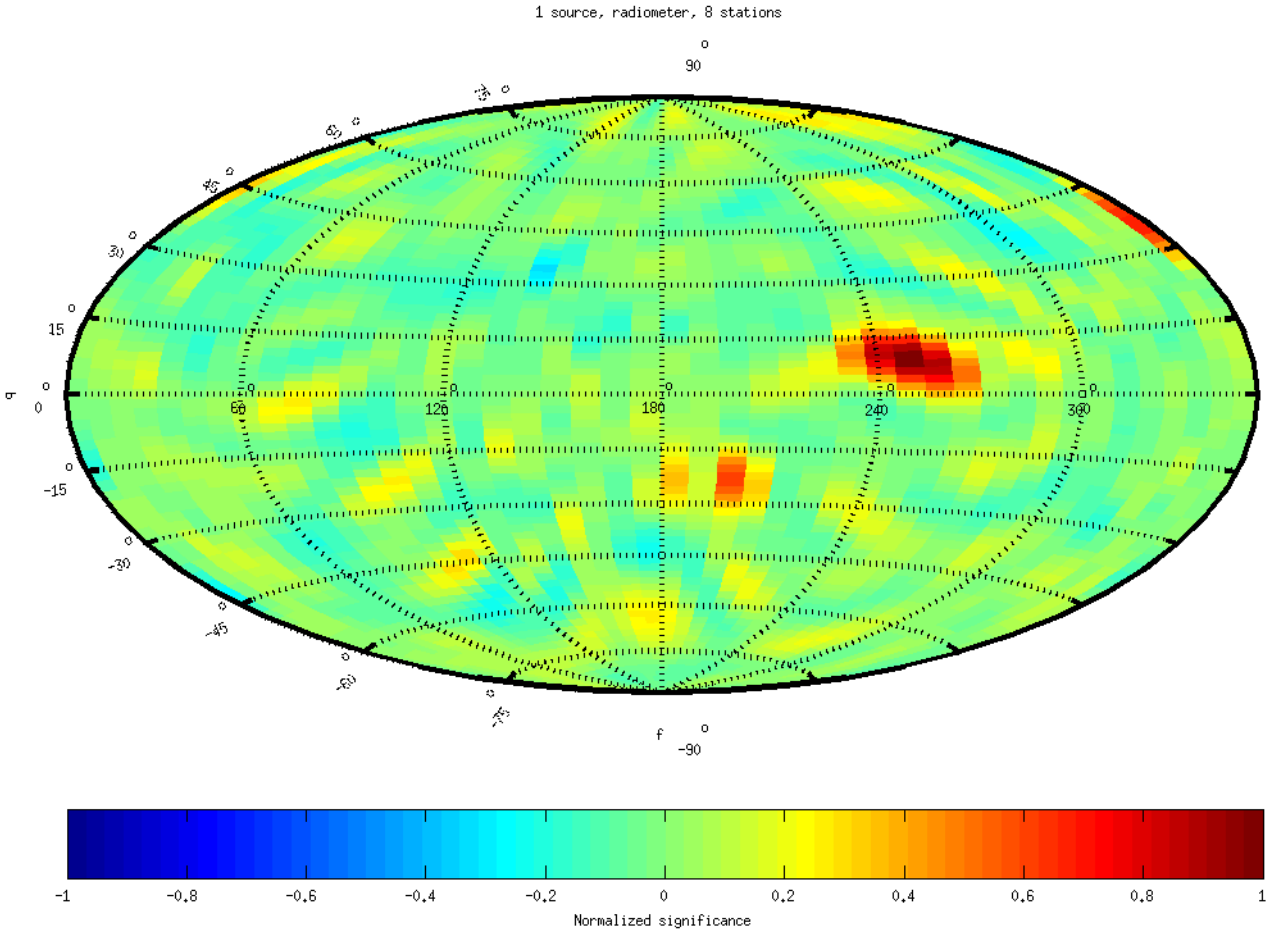
f_analyse = 3 Hz nstest35



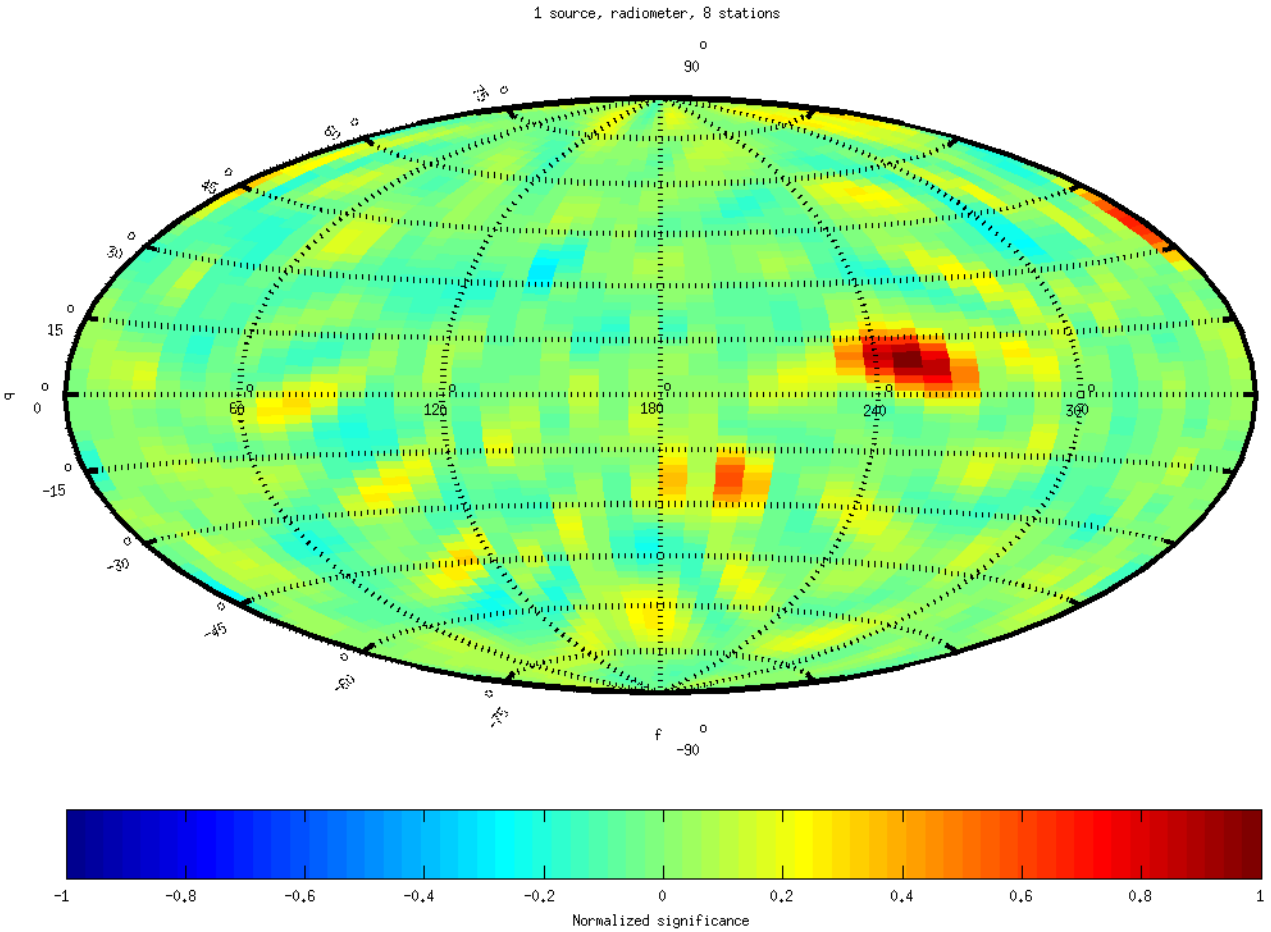
f analyse = 5 Hz nstest36



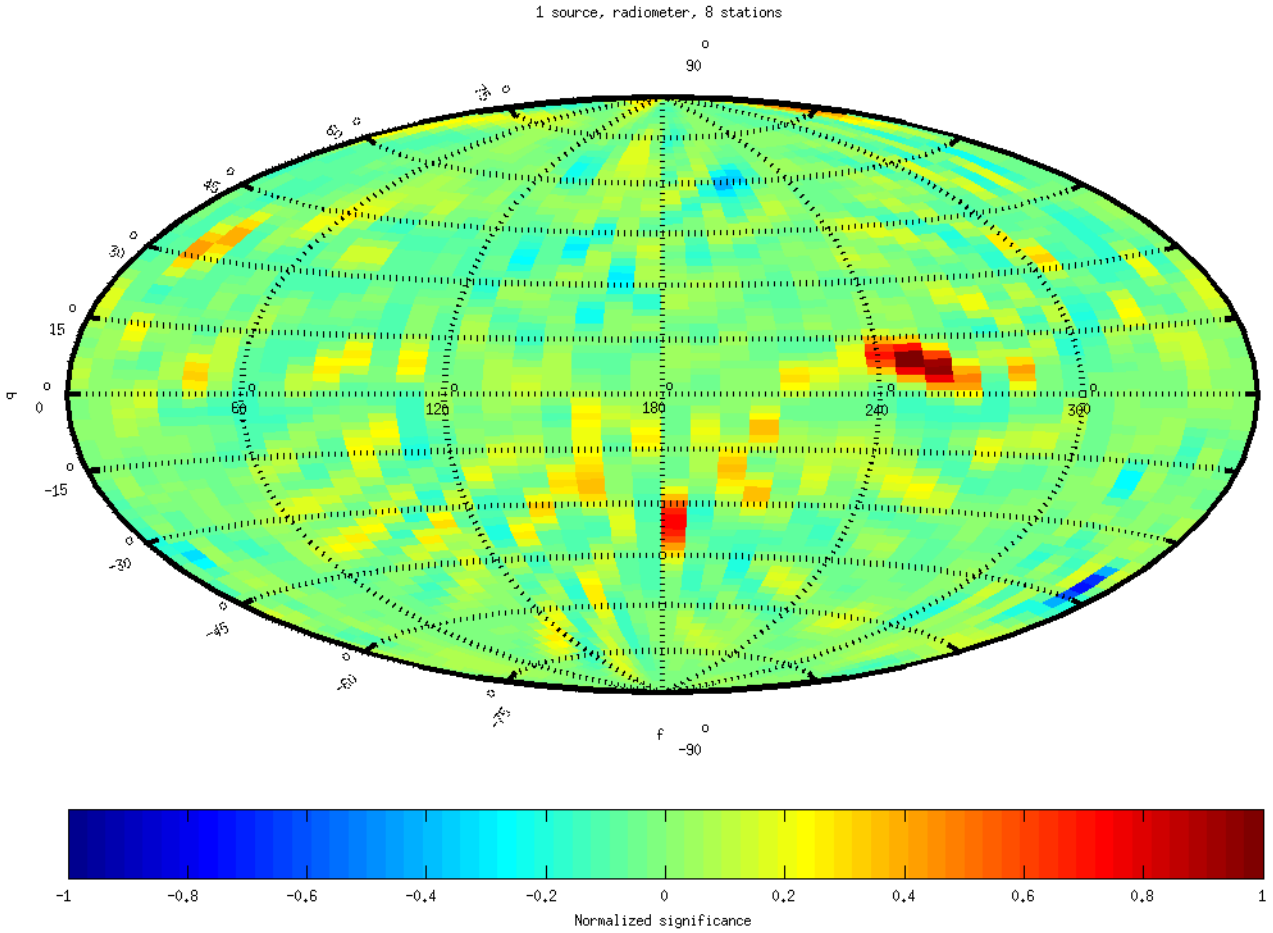
Repeat of nstest36 ***current image is nstest60



Repeat of nstest36 ***current image is nstest61



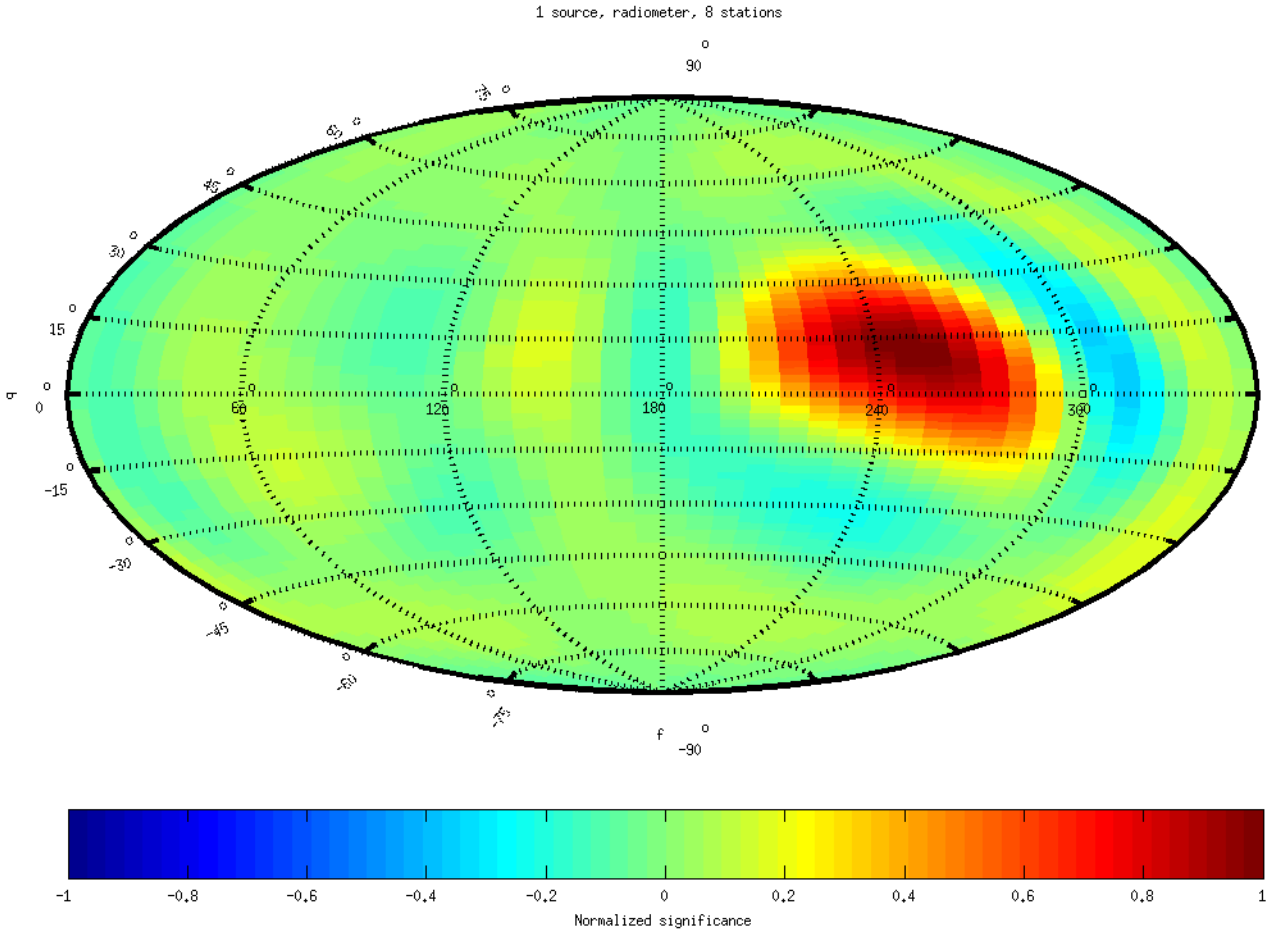
f_analyse = 7 Hz nstest37



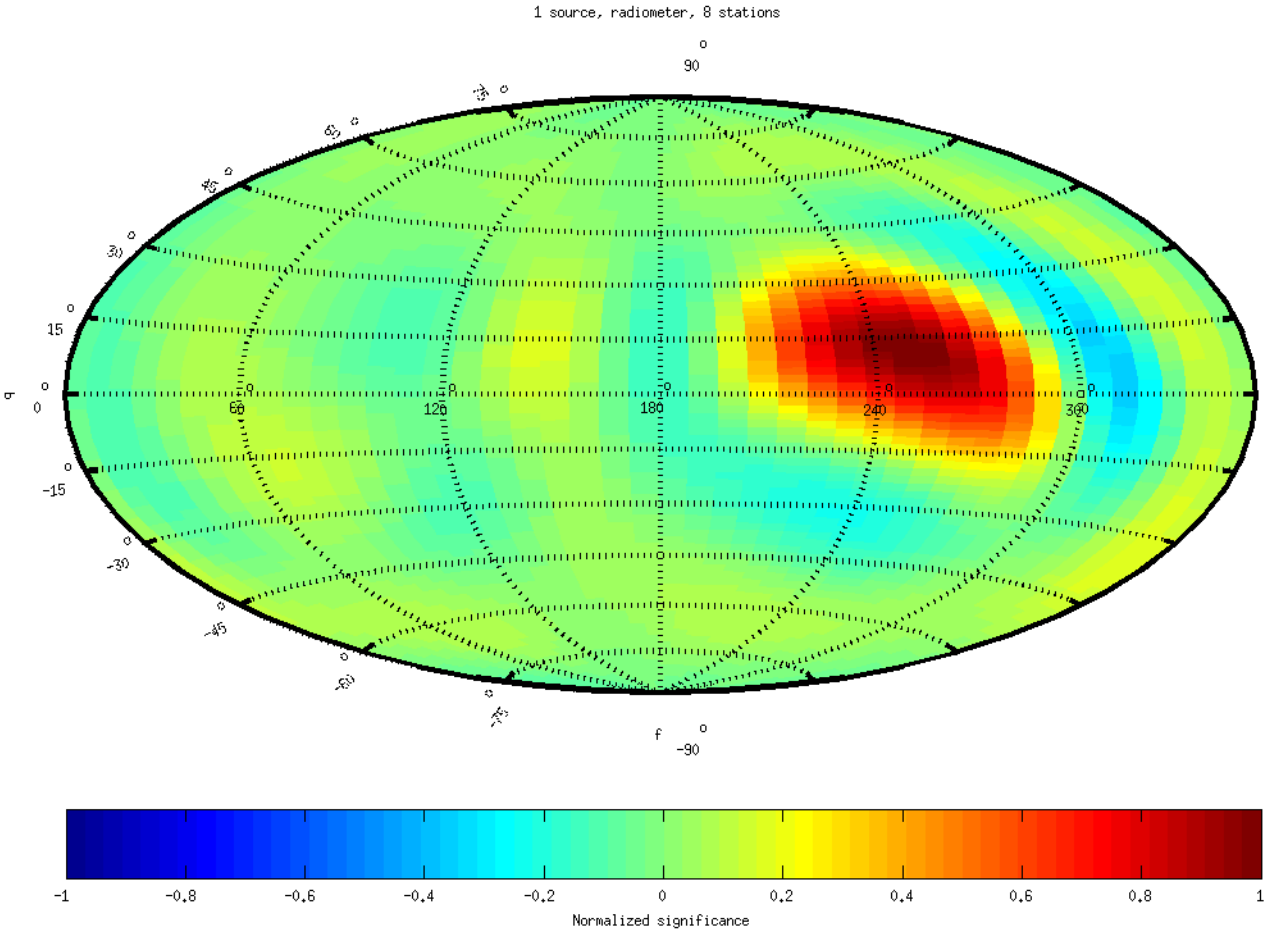
Broadband/Polarization Testing

- In this series of tests, the injection signal is again broadband. With the recovery performed at either 1 Hz or 3 Hz, the signal was equipped with random polarizations. All other parameters are the same as before.

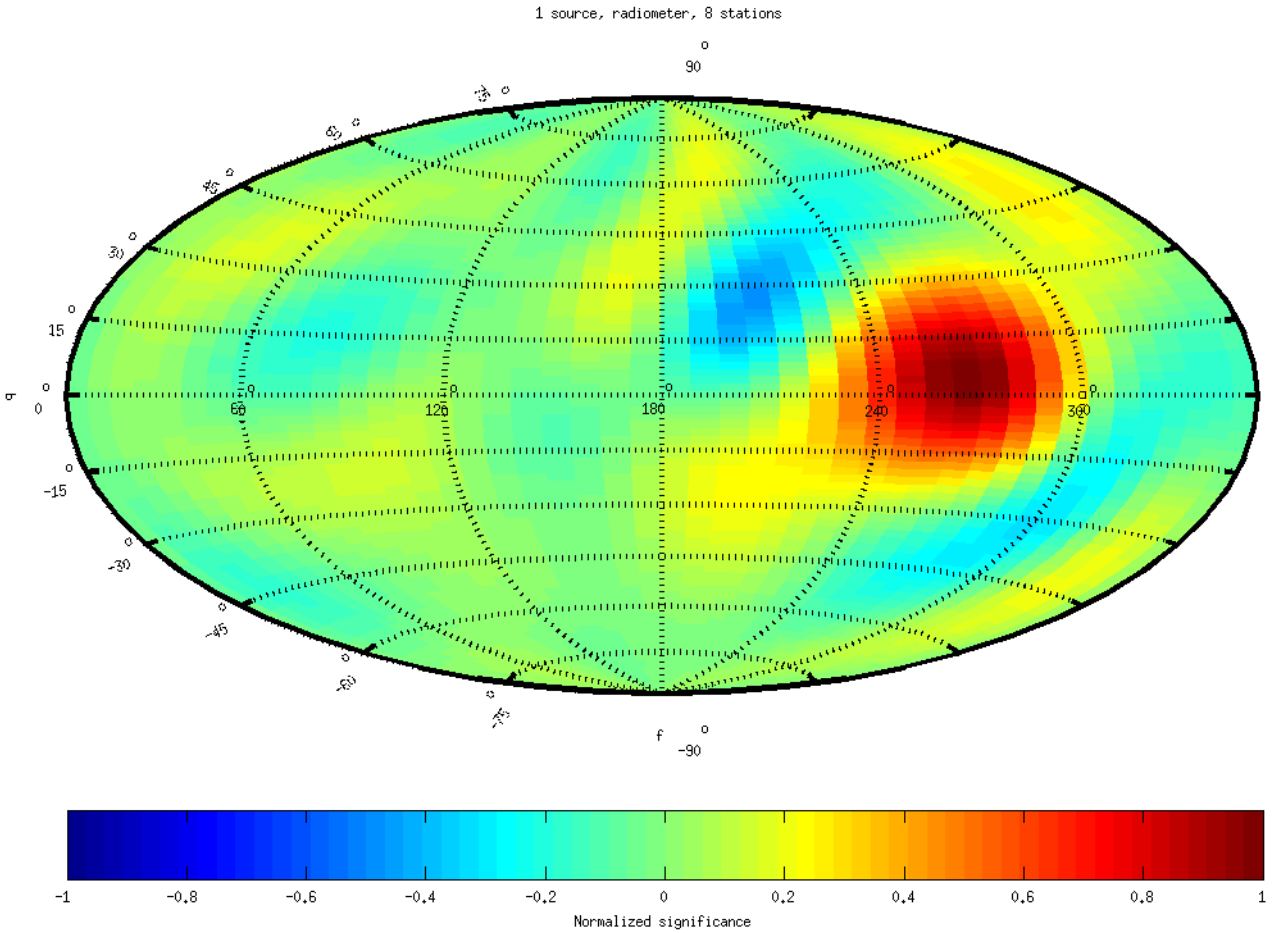
f_analyse = 1 Hz, psi = 264.7032 nstest38



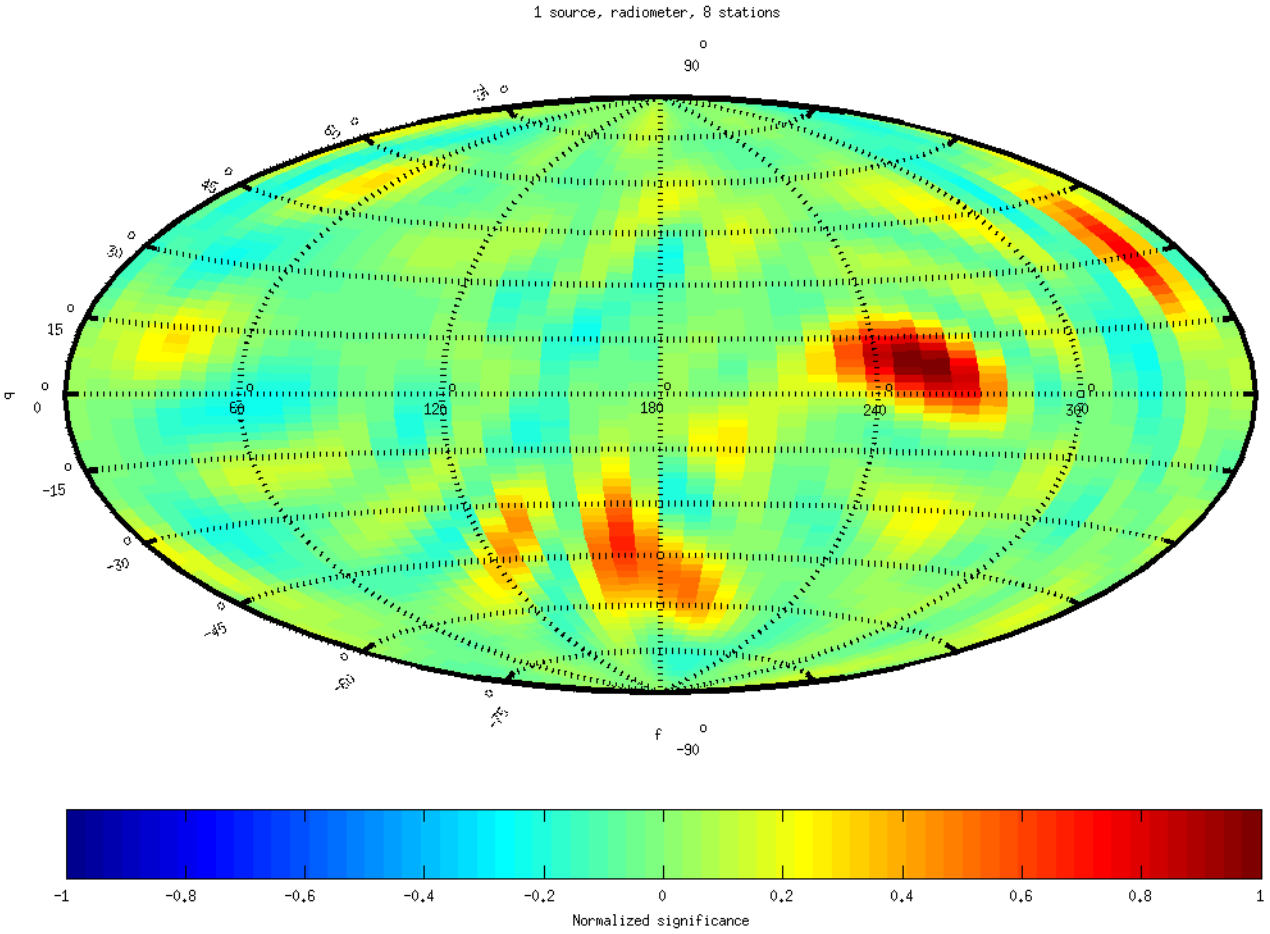
f_analyse = 1 Hz, psi = 104.2868 nstest39



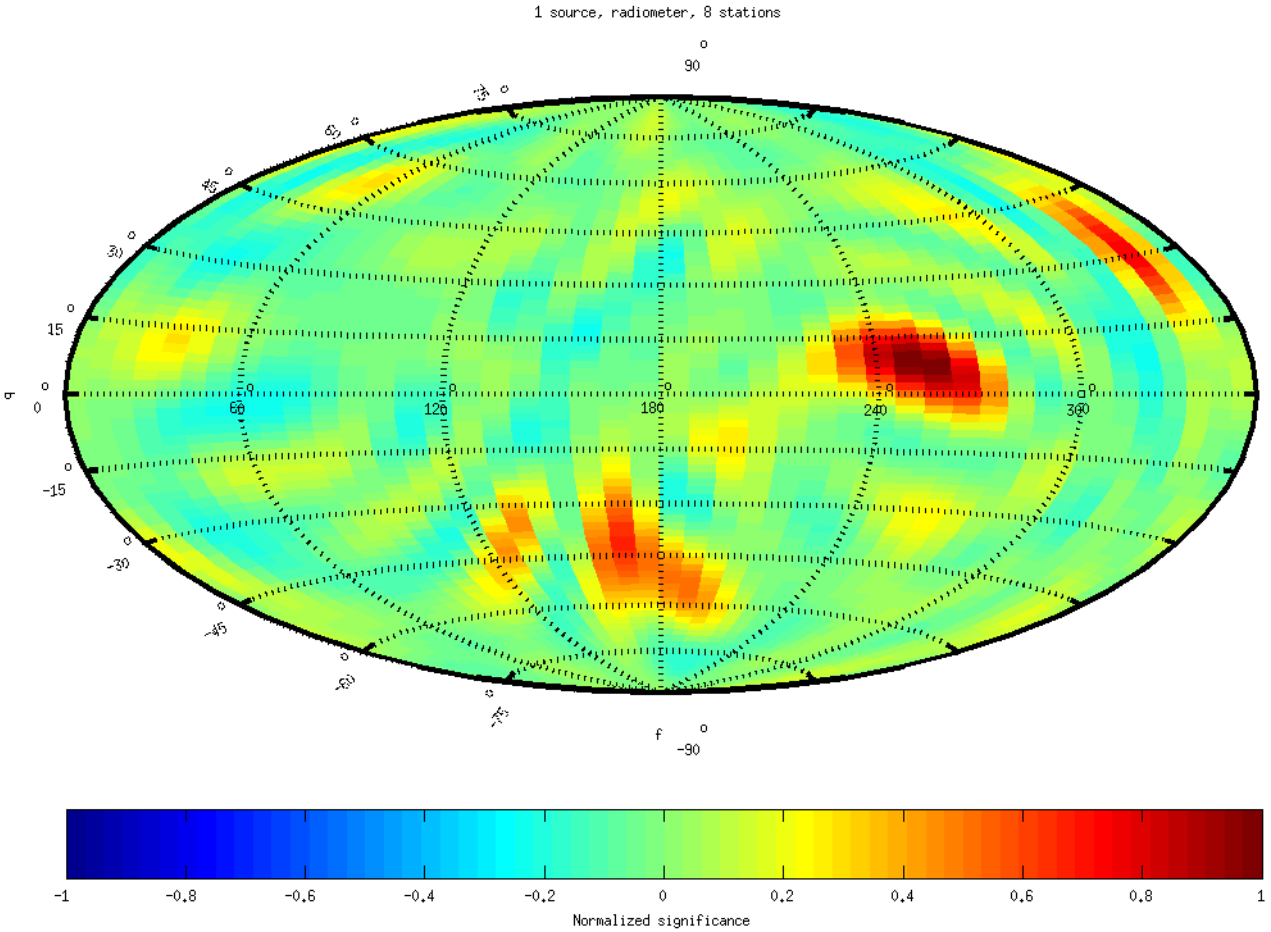
f_analyse = 1 Hz, psi = 66.0591 nstest40



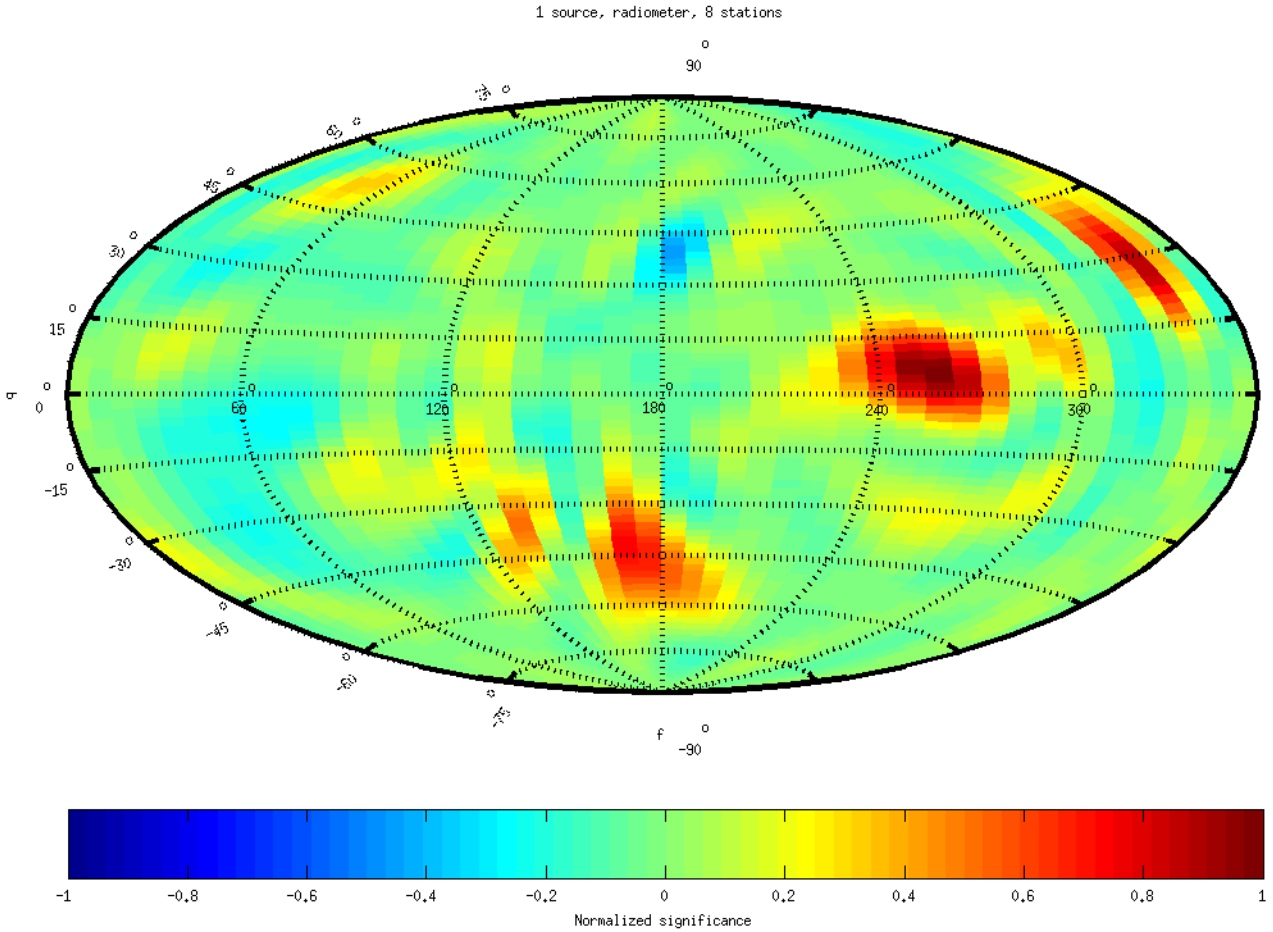
f_analyse = 3 Hz, psi = 31.6273 nstest41



f_analyse = 3 Hz, psi = 65.2960 nstest41



f_analyse = 3 Hz, psi = 97.7315 nstest42



Number of Detectors/Polarization Testing

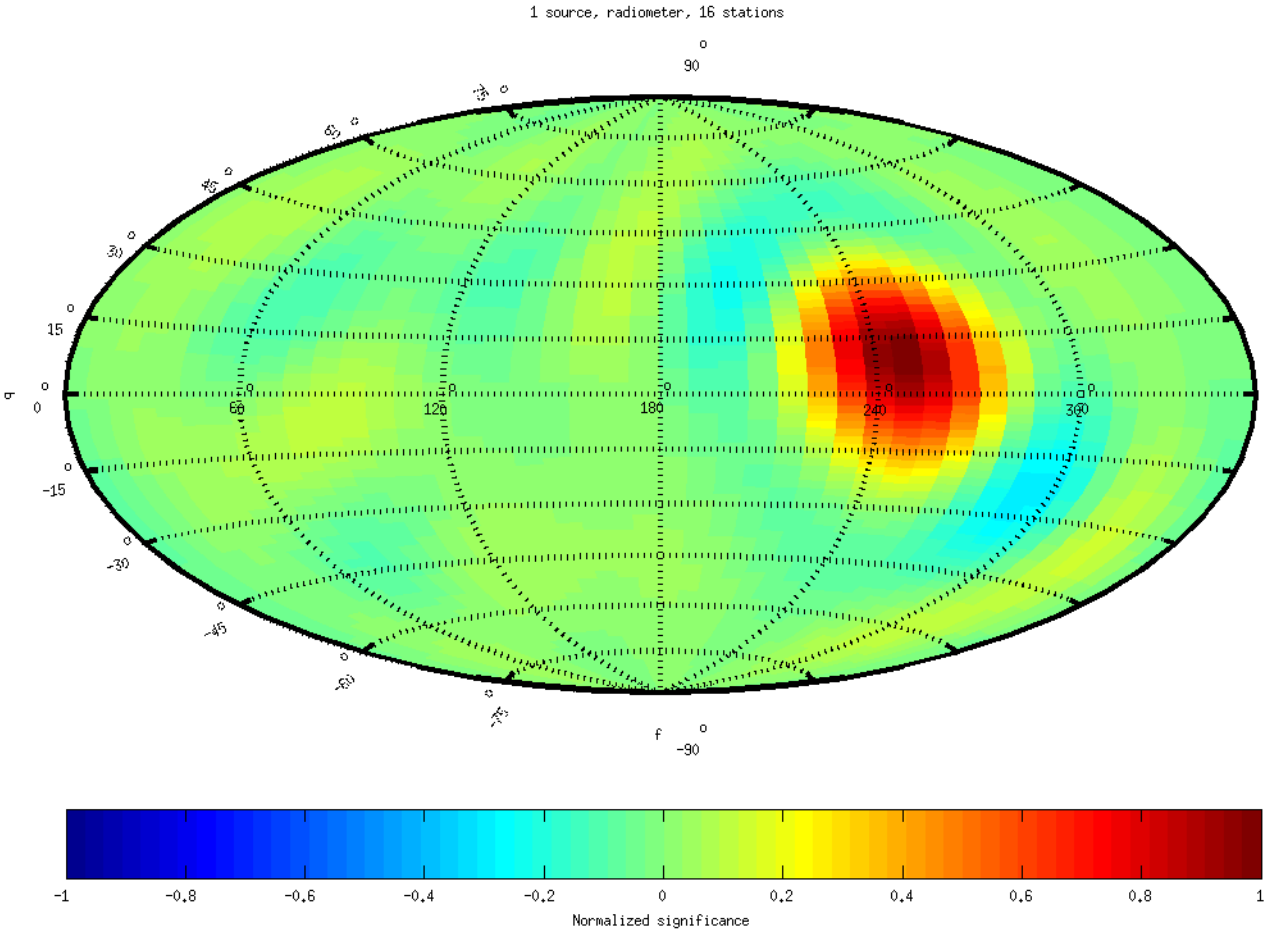
- Returning to a monochromatic source of frequency 1 or 3, for a certain number of detectors, the injection signal is equipped with random polarizations. All other parameters are the same as before.

16 Detectors

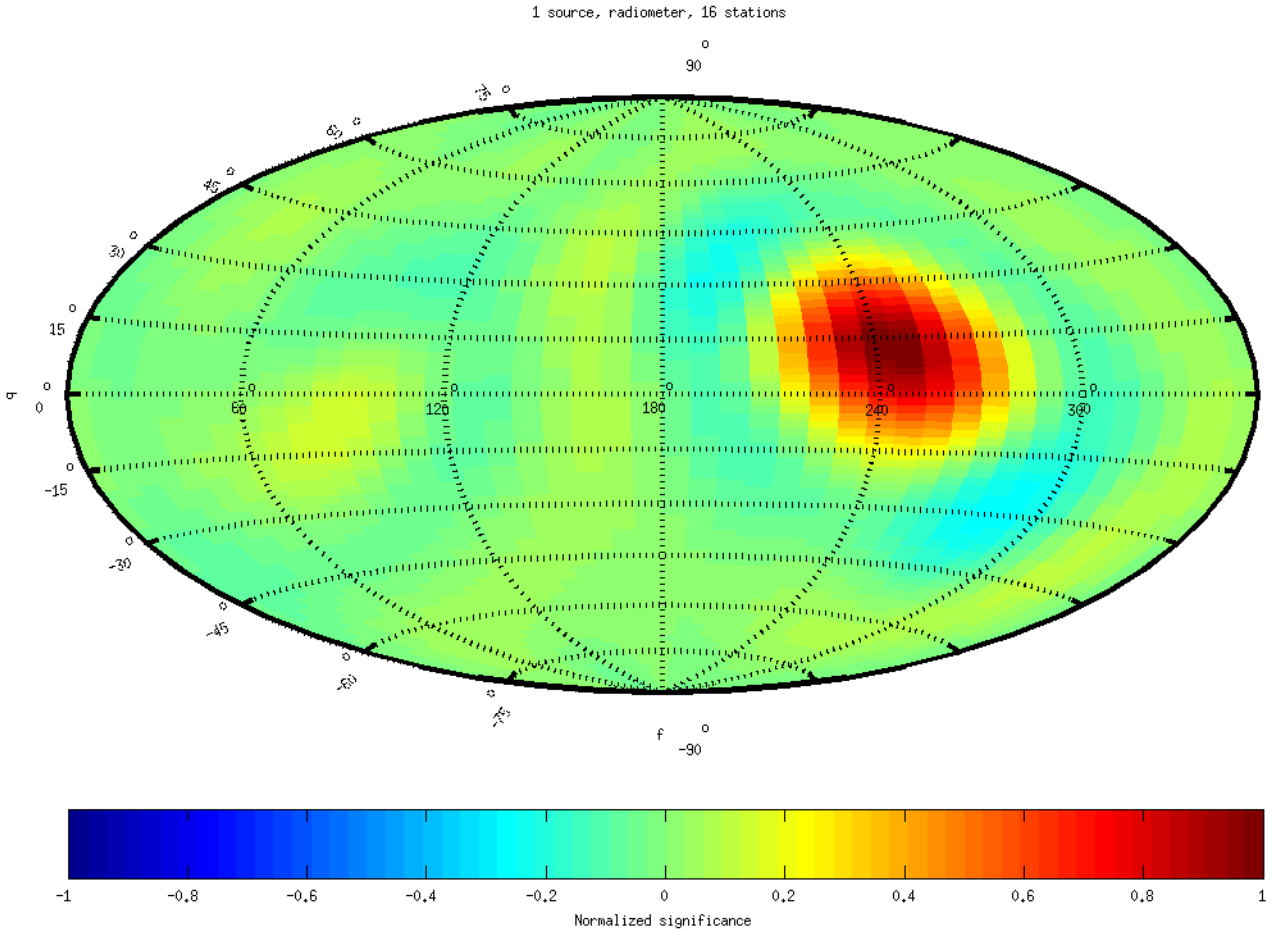
Multiplying this array by 1000 m gives the detector locations

1.0049	0.8696	1.5024
0.9540	1.4846	0.5536
1.7282	1.7792	1.8847
0.8537	0.4295	1.0085
0.7172	0.3935	1.1054
1.4601	1.3522	1.1130
0.8472	0.0663	1.3949
0.8863	0.5722	0.4442
0.0771	0.9183	0.2785
0.7568	0.8304	0.0098
0.6074	1.1076	1.0030
0.0887	0.9303	0.1124
1.9672	0.7449	1.2506
1.3730	1.7486	1.5732
0.5502	1.8365	1.0232
1.1078	1.7061	0.5809

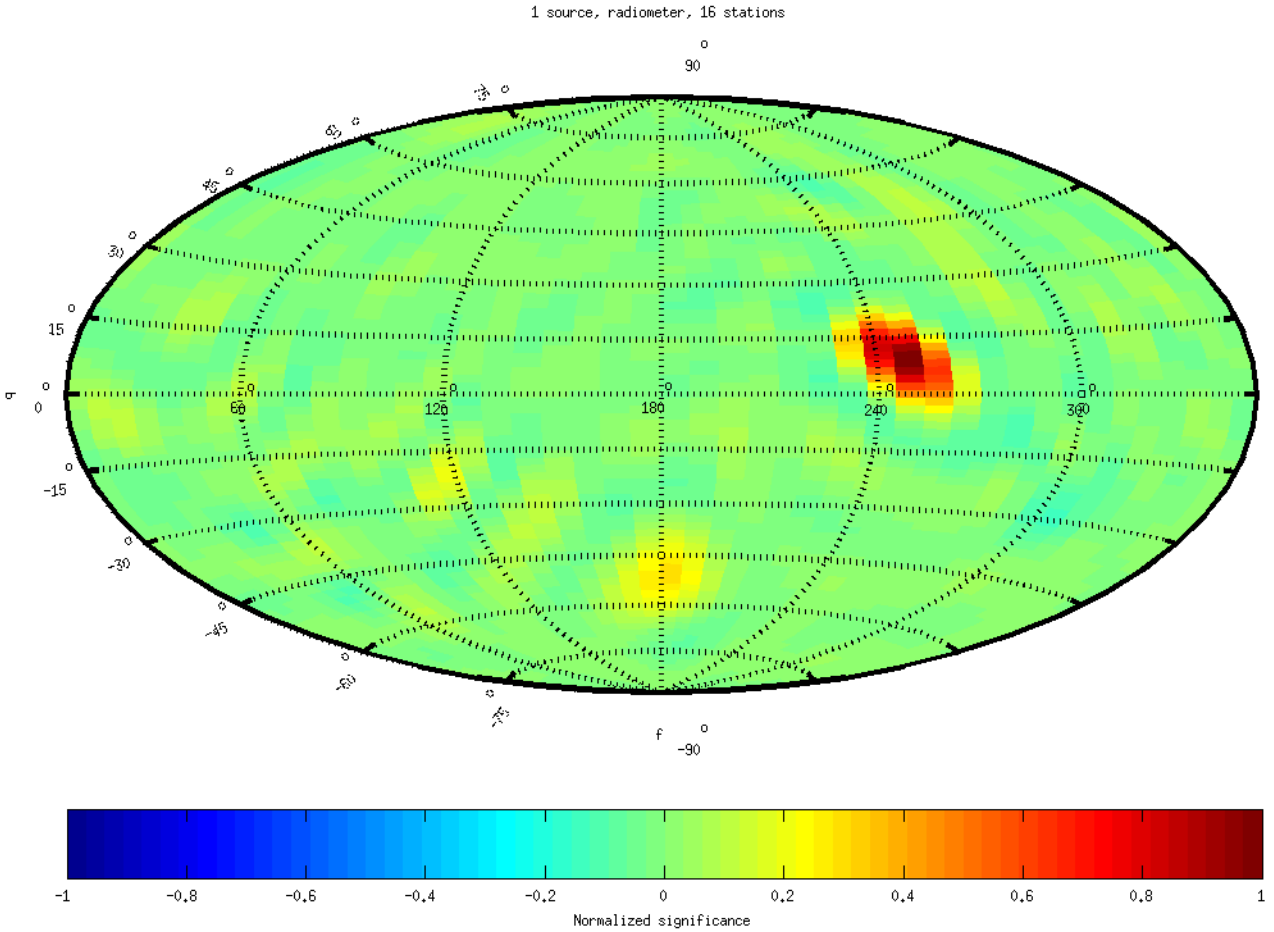
f_analyse = 1 Hz, psi = 321.7864 nstest44



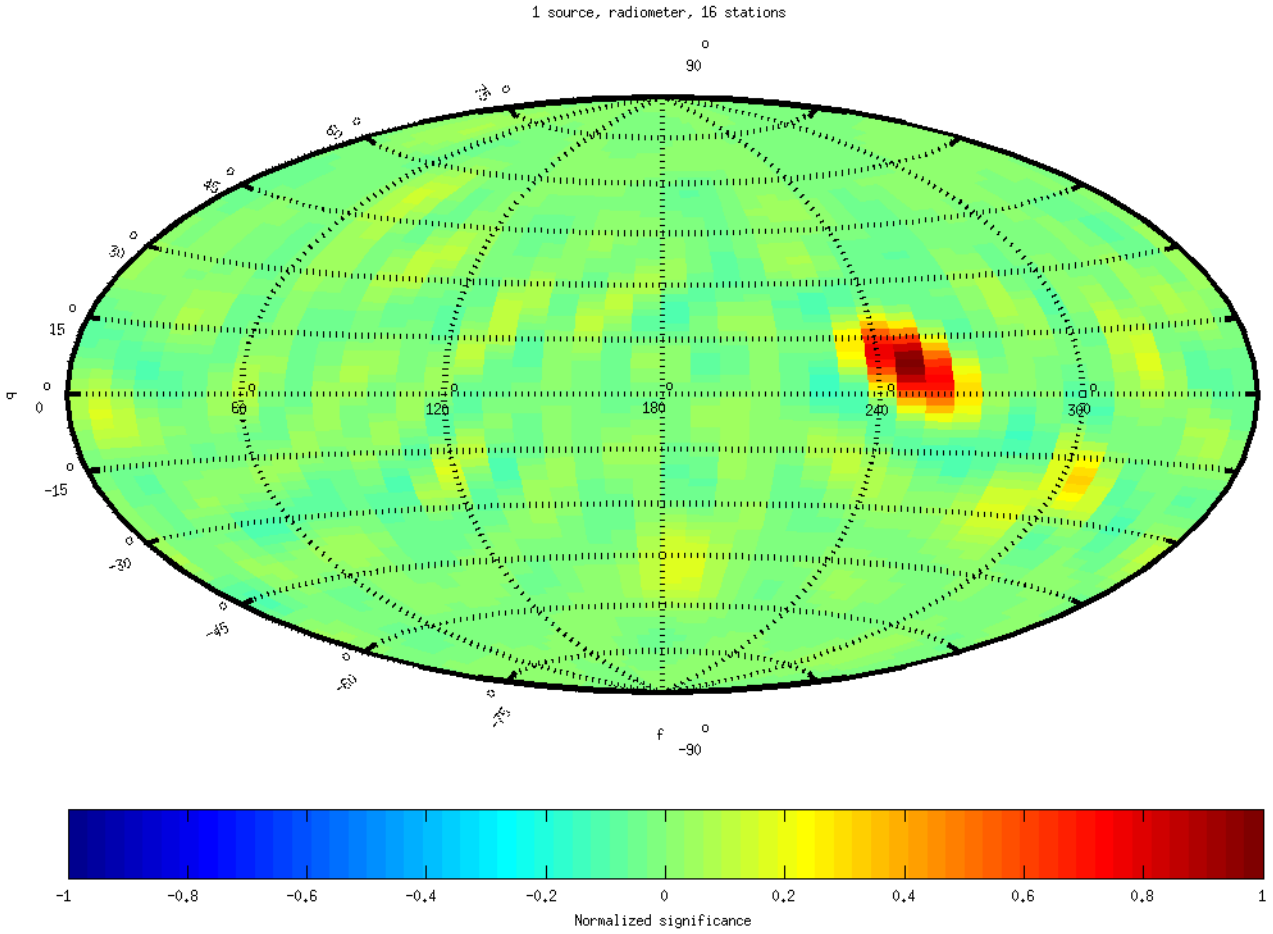
f_analyse = 1 Hz, psi = 281.0784 nstest45



f_analyse = 3 Hz, psi = 295.4467 nstest46



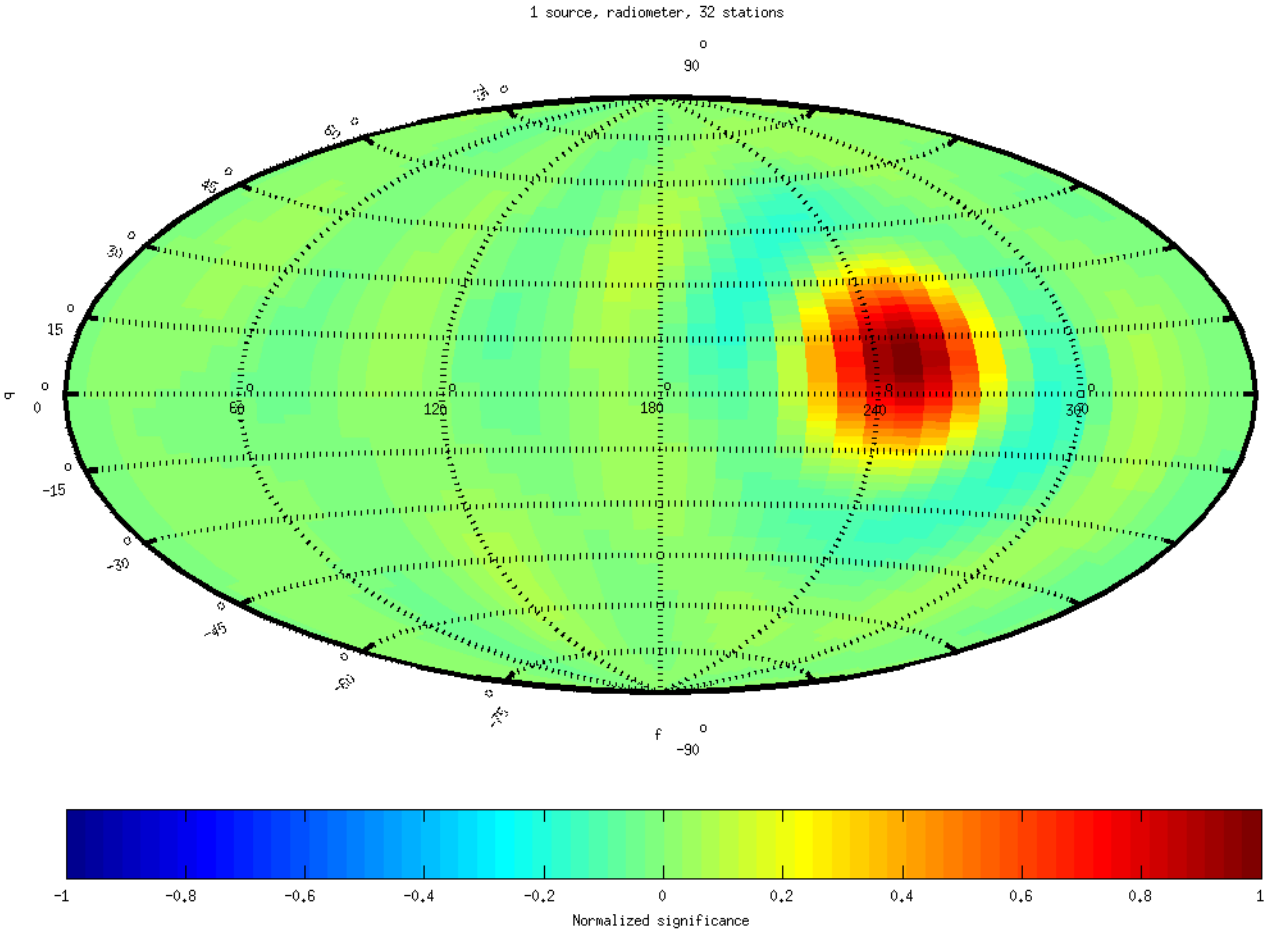
f_analyse = 3 Hz, psi = 90.0454 nstest47



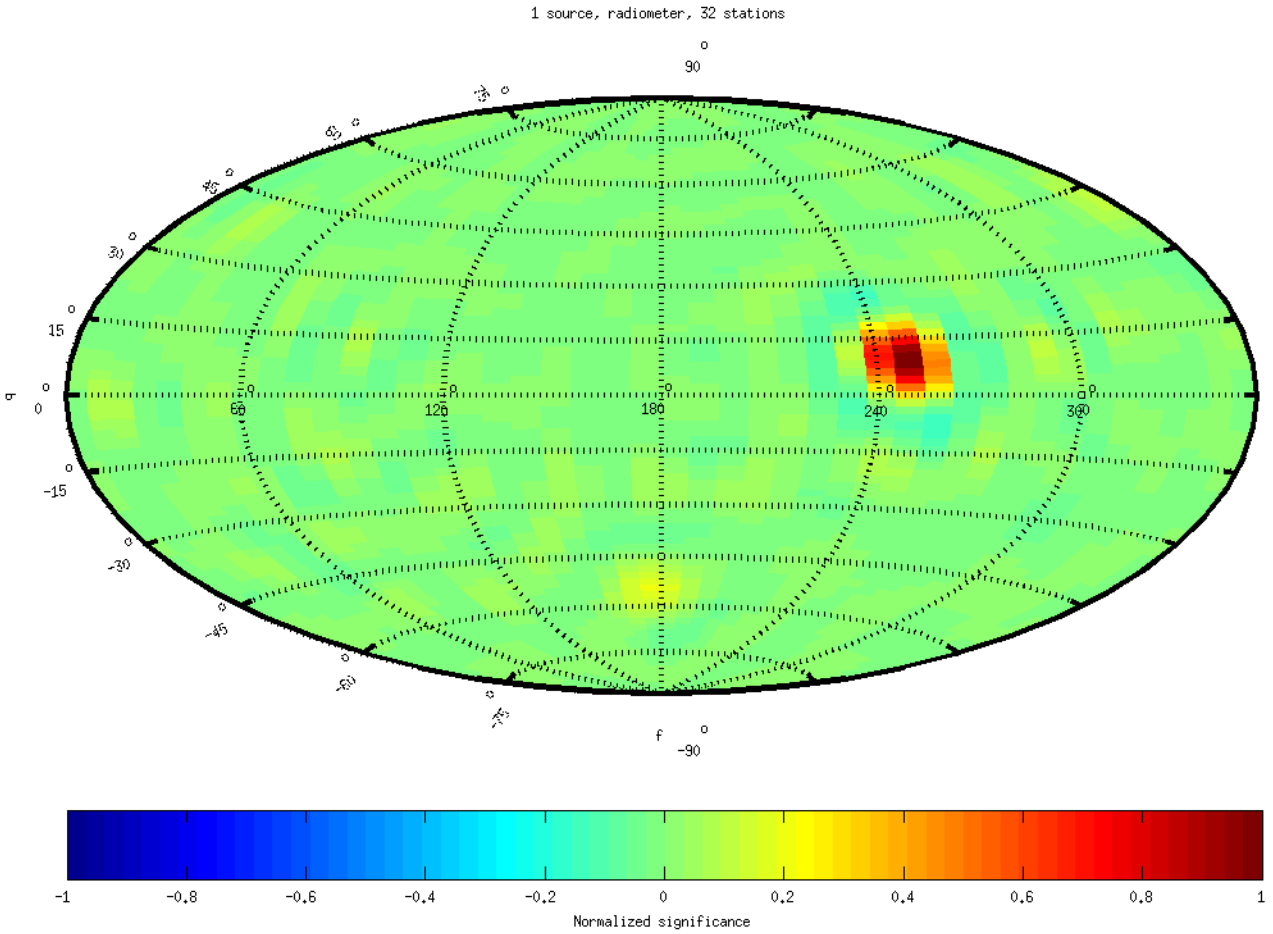
32 Detectors; Multiplying this array by 1000 m gives the detector locations

1.0049	0.8696	1.5024
0.9540	1.4846	0.5536
1.7282	1.7792	1.8847
0.8537	0.4295	1.0085
0.7172	0.3935	1.1054
1.4601	1.3522	1.1130
0.8472	0.0663	1.3949
0.8863	0.5722	0.4442
0.0771	0.9183	0.2785
0.7568	0.8304	0.0098
0.6074	1.1076	1.0030
0.0887	0.9303	0.1124
1.9672	0.7449	1.2506
1.3730	1.7486	1.5732
0.5502	1.8365	1.0232
1.1078	1.7061	0.5809
0.0094	0.9413	1.6537
1.9372	1.9708	0.2618
0.6468	0.7042	1.9955
1.7509	1.6374	1.1217
0.0904	0.2564	0.0551
0.9884	1.3599	0.5643
0.8514	1.4977	1.3285
1.0969	1.6837	0.9787
1.7185	0.4925	1.6350
1.9911	1.9055	1.7076
0.9881	1.3445	1.0704
0.1055	1.9273	1.7278
1.8164	0.8485	1.8223
1.1277	1.3868	1.5947
1.0463	1.9557	1.9045
0.3735	1.4004	1.9817

f_analyse = 1 Hz, psi = 321.7864 nstest50



f_analyse = 3 Hz, psi = 295.4467 nstest51



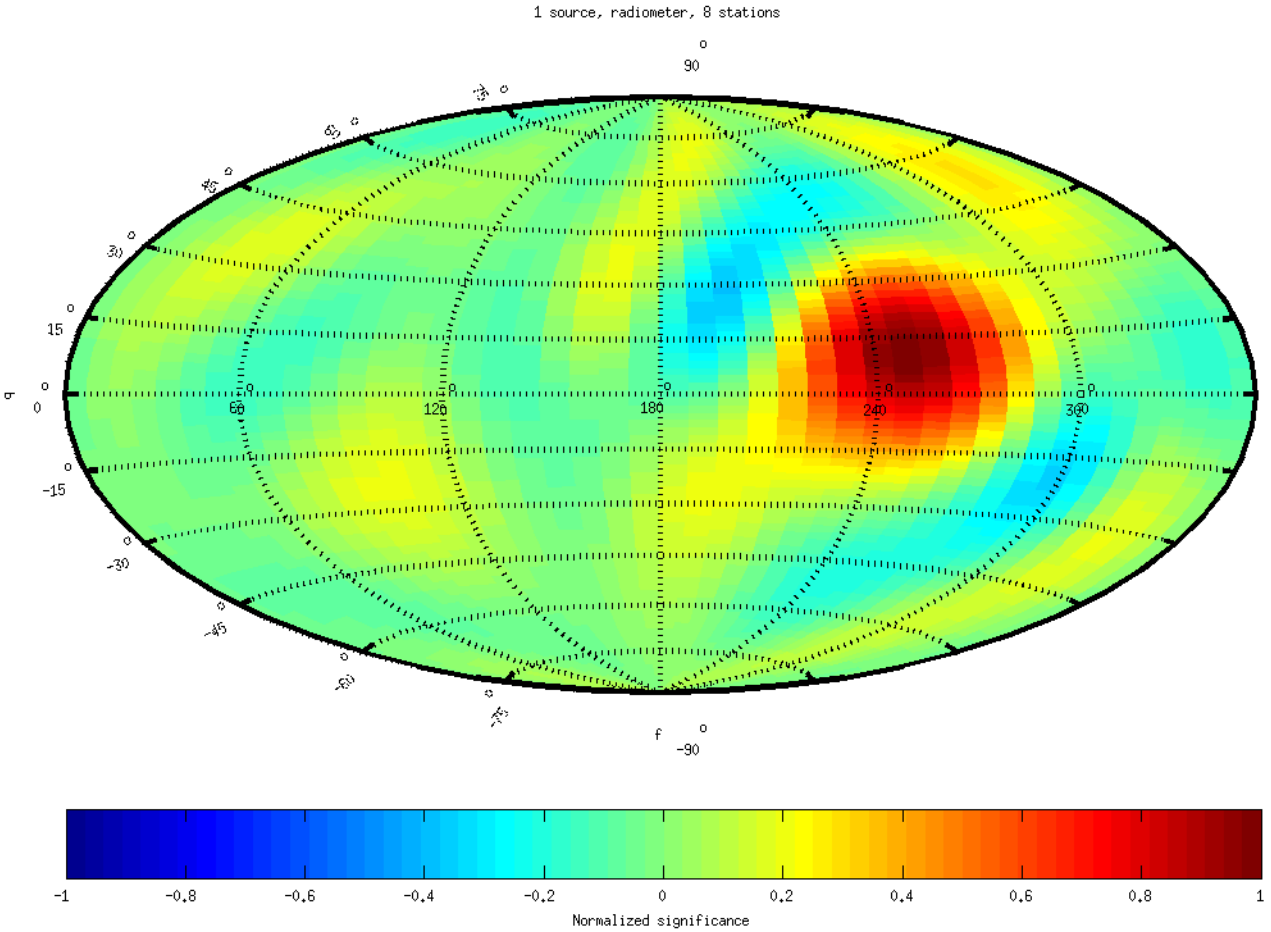
Broadband Number of Detectors/Polarization Testing

- This next series of tests are the same as before except that the injection signal is now broadband instead of monochromatic. The detector arrays are also the same.

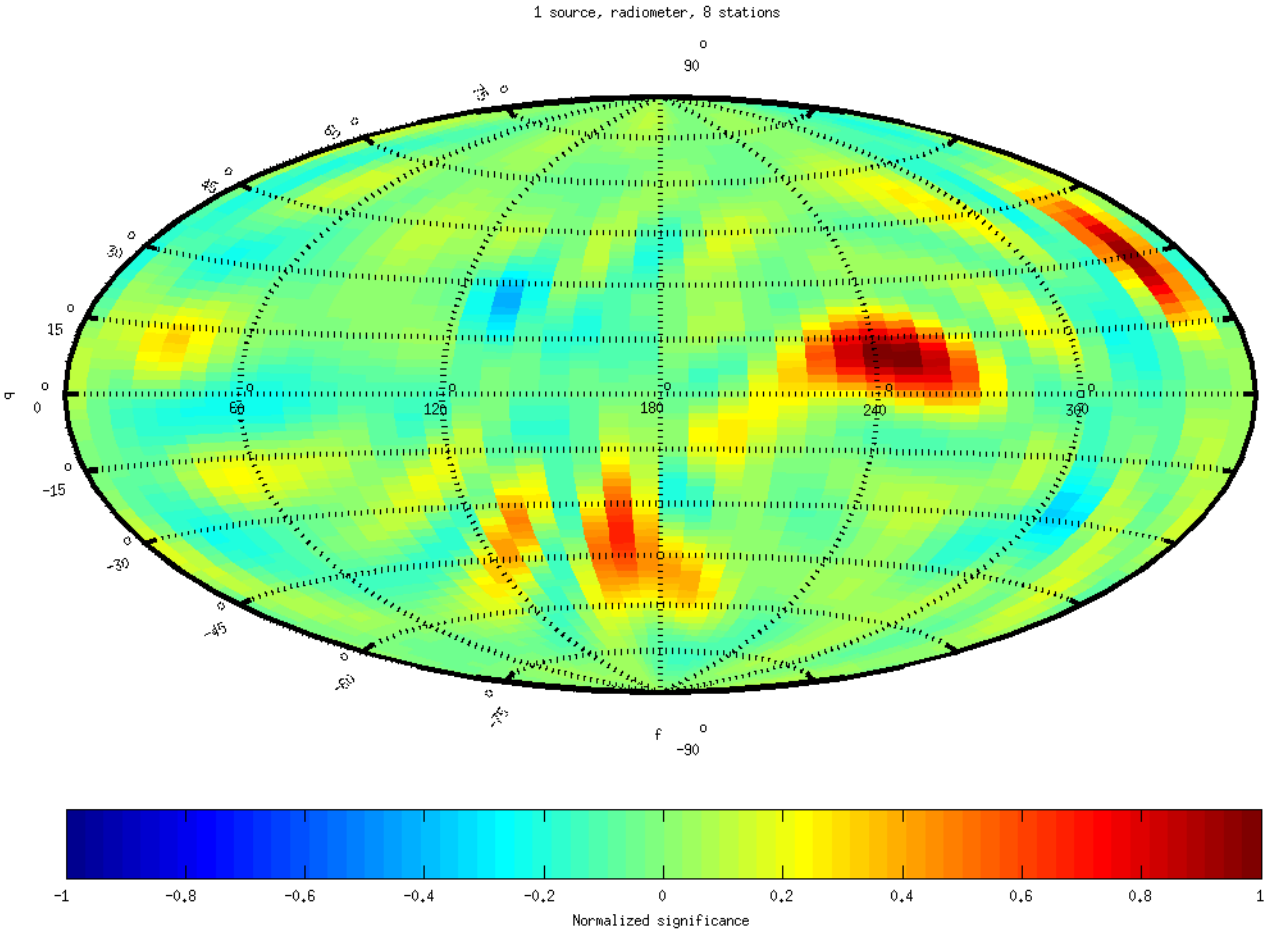
8 Detectors

- See previous 8 detector array

f_analyse = 1 Hz psi = 321.7864 nstest52



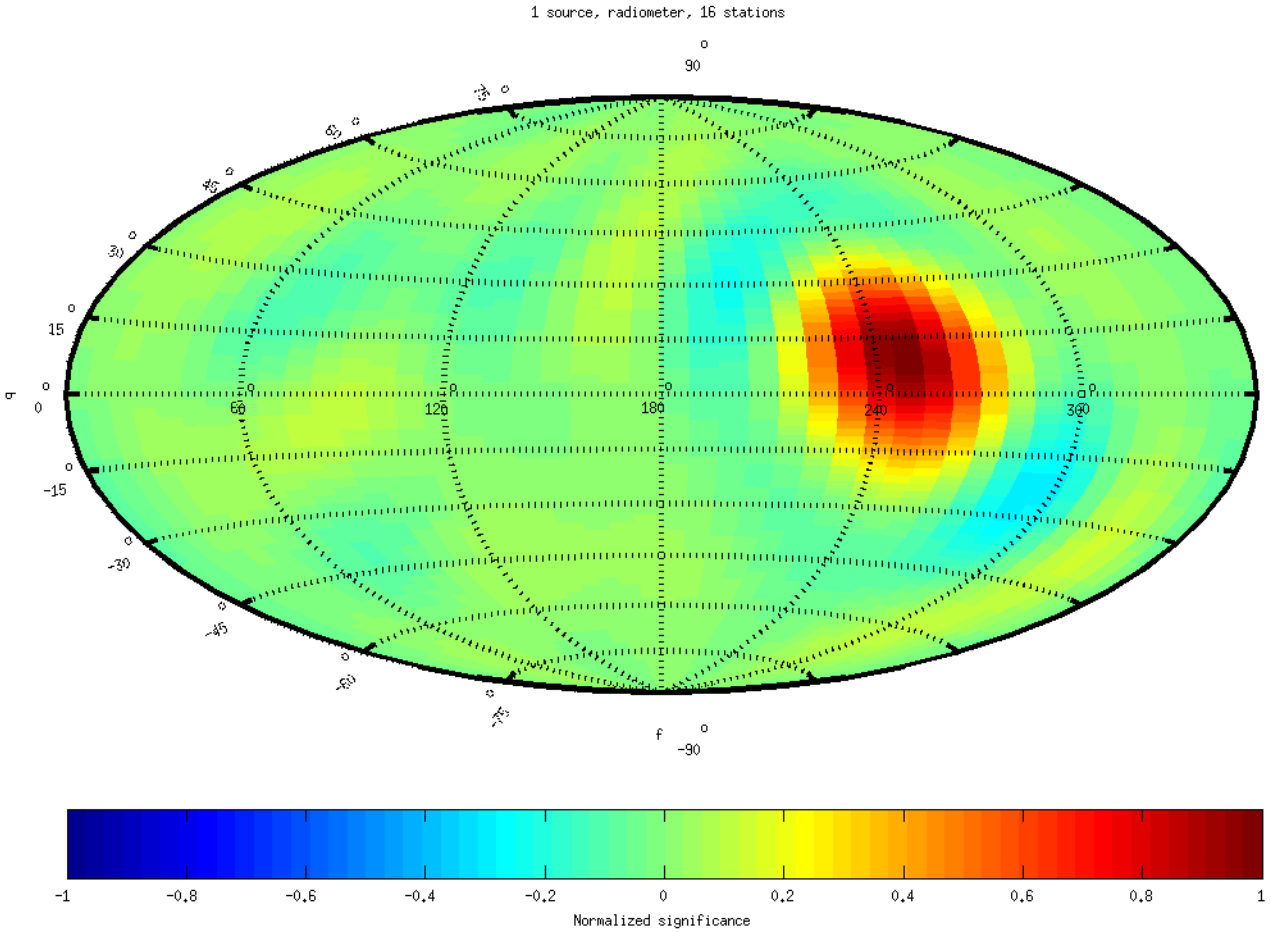
f_analyse = 3 Hz, psi = 295.4467 nstest53



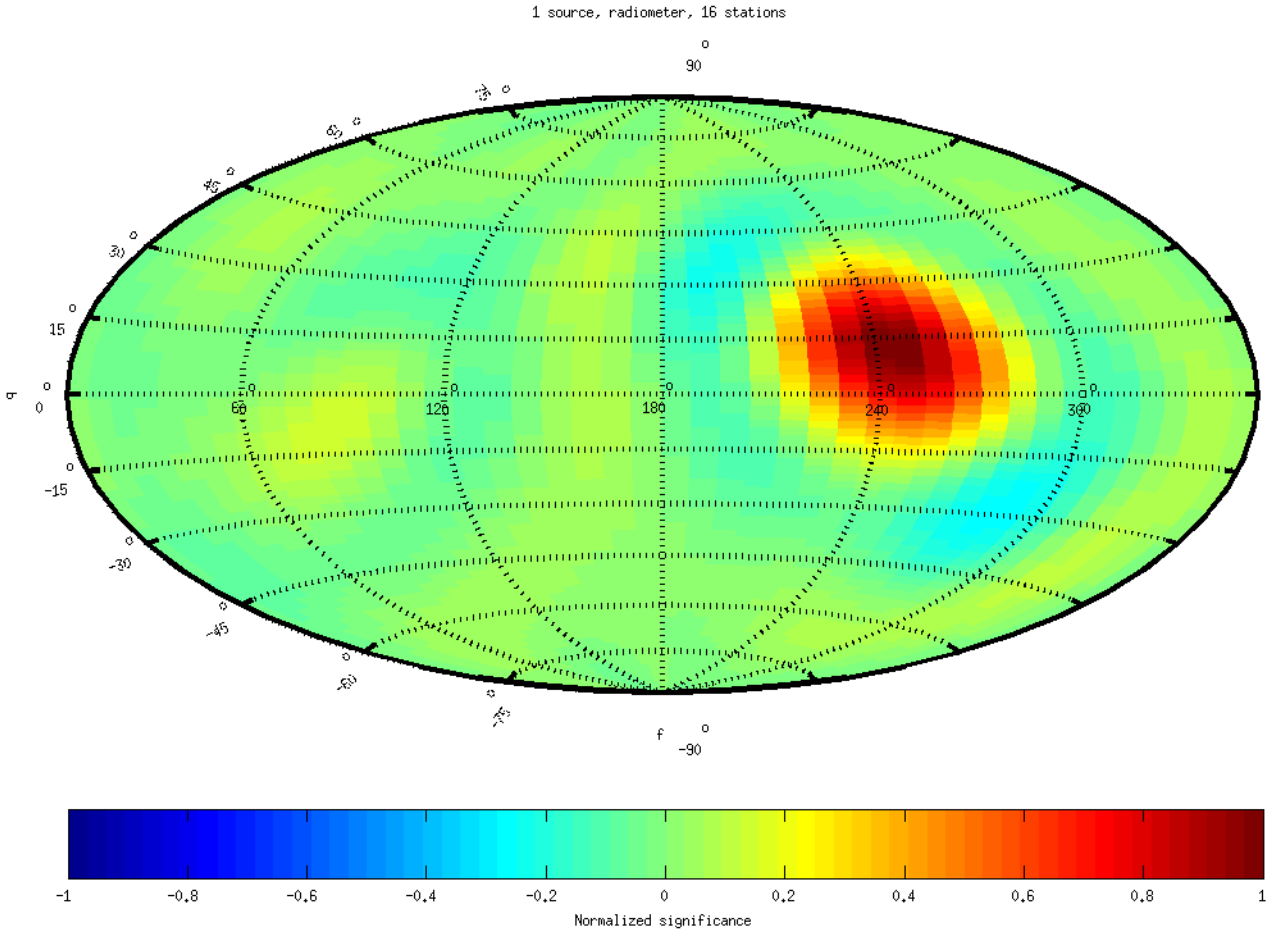
16 Detectors

- See previous 16 detector array

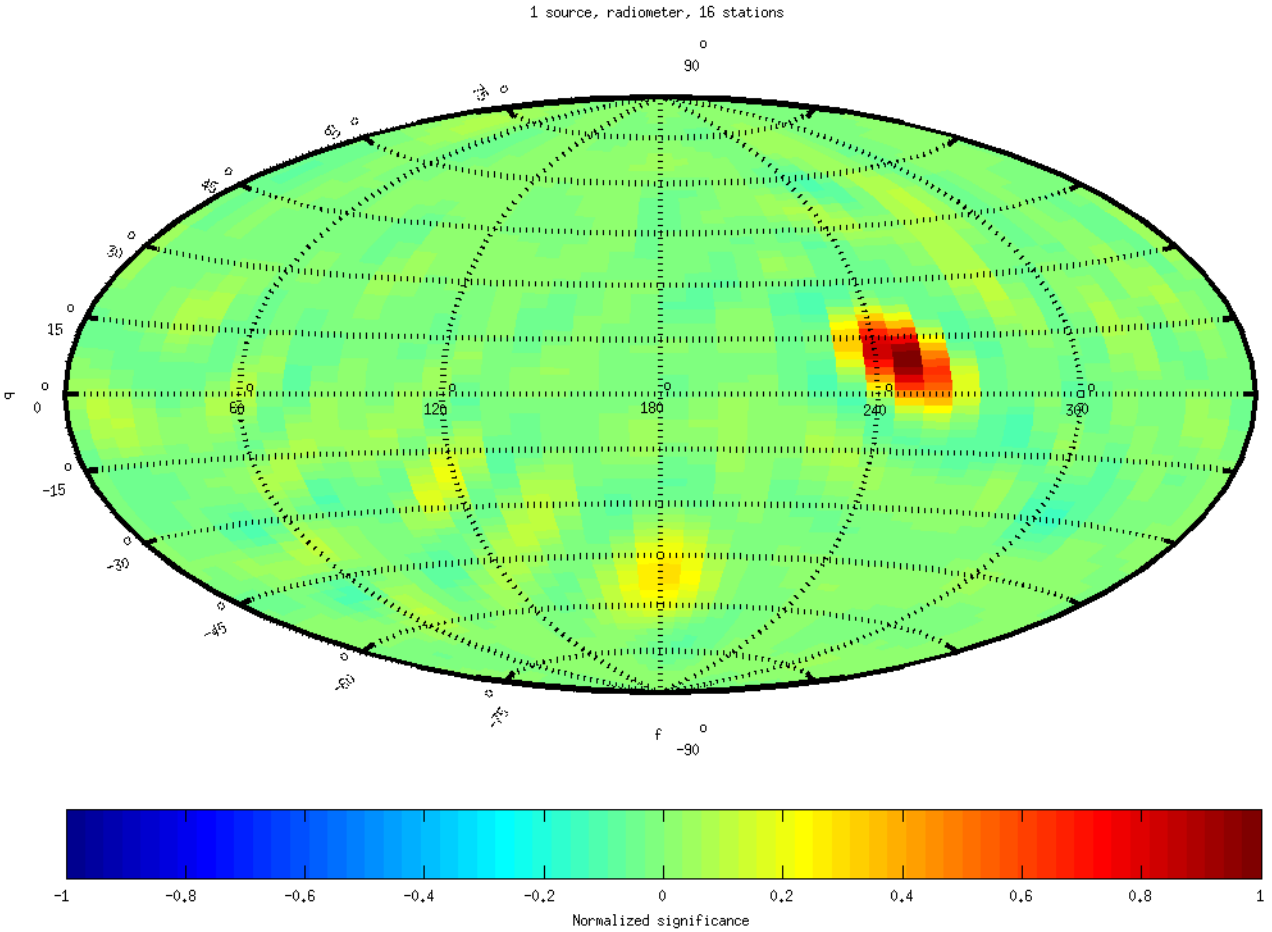
f_analyse = 1 Hz, psi = 321.7864 nstest54



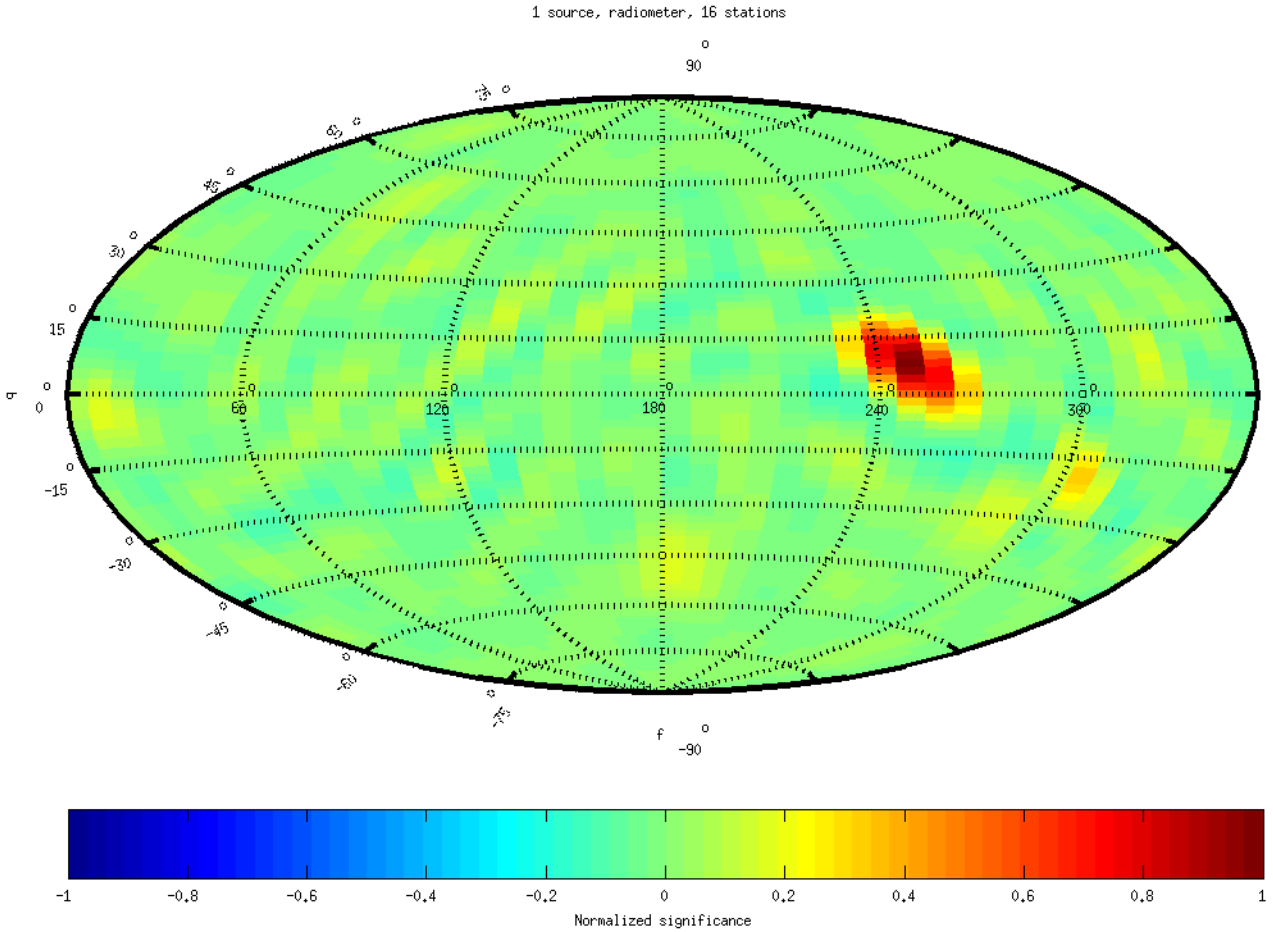
f_analyse = 1 Hz, psi = 281.0784 nstest55



f_analyse = 3 Hz, psi = 295.4467 nstest56



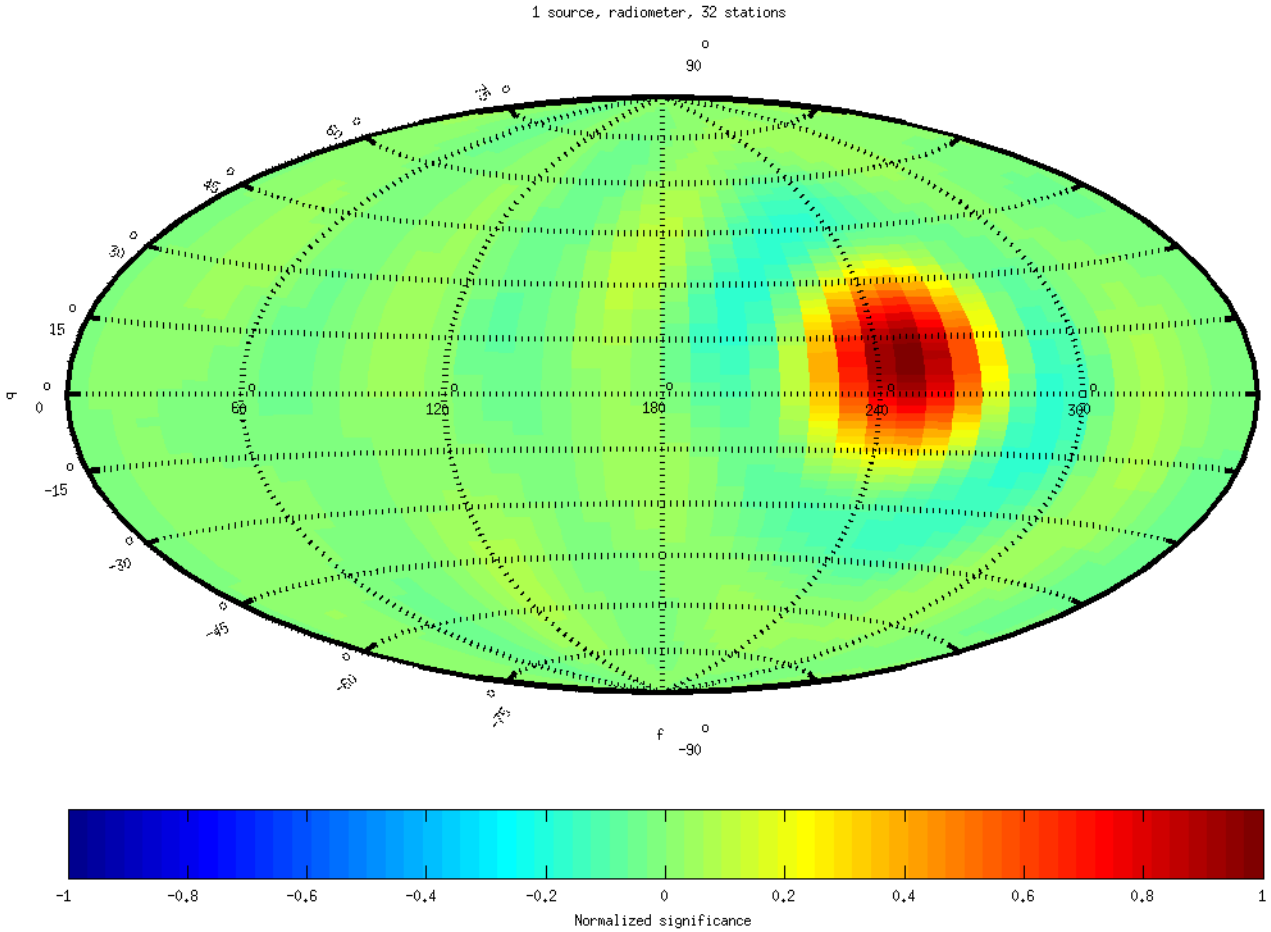
f_analyse = 3 Hz, psi = 90.0454
nstest57



32 Detectors

- See previous 32 detector array

f_analyse = 1 Hz, psi = 321.7864 nstest58



f_analyse = 3 Hz, psi = 295.4467 nstest59