Power Spectra of SPIRE Maps

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on behalf of the SPIRE Map-Making WG

The algorithm

- Kindly provided by Jim Ingalls
- All images but 1 have same WCS
- It computes the inverse 2D FFT of the input map, normalizing to the total surface brightness of the image
- Create a map of *angular scale bins*, depending on map's size and resolution
    - As an option, it is possible to provide a beam map and compute a "de-convolved" power spectrum: results are still un-clear so not discussed here
- Compute average value in each k bin
- Fit power spectra results between k = [0.01, 1] arcmin^{-1}
- Used (where available) *truth* map's power spectrum as benchmark
    - N.B.: all *truth* maps are meant as simulated only data (no noise) but convolved with the instrument beam and reprojected on standard SPIRE pixel size maps (6 to 14 arcsec)

Dataset

	Case 2	Case 3	Case 4	Case 6	Case 7	Case 9	Case 10	Case 11	Case 12	Case 13
Truth	✓	✗	✓	✓	✗	✓	✓	✗	✗	✗
Naïve	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Naïve IA	✗	✗	✓	✗	✓	✗	✗	✓	✓	✗
Destriper P0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Destriper P1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scanamorphos	✓	✓	✓	✓	✓	✓	✓	✓	✓	?
Sanepic	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
Unimap	✗	✗	✗	✓	✗	✗	✓	✗	✓	?

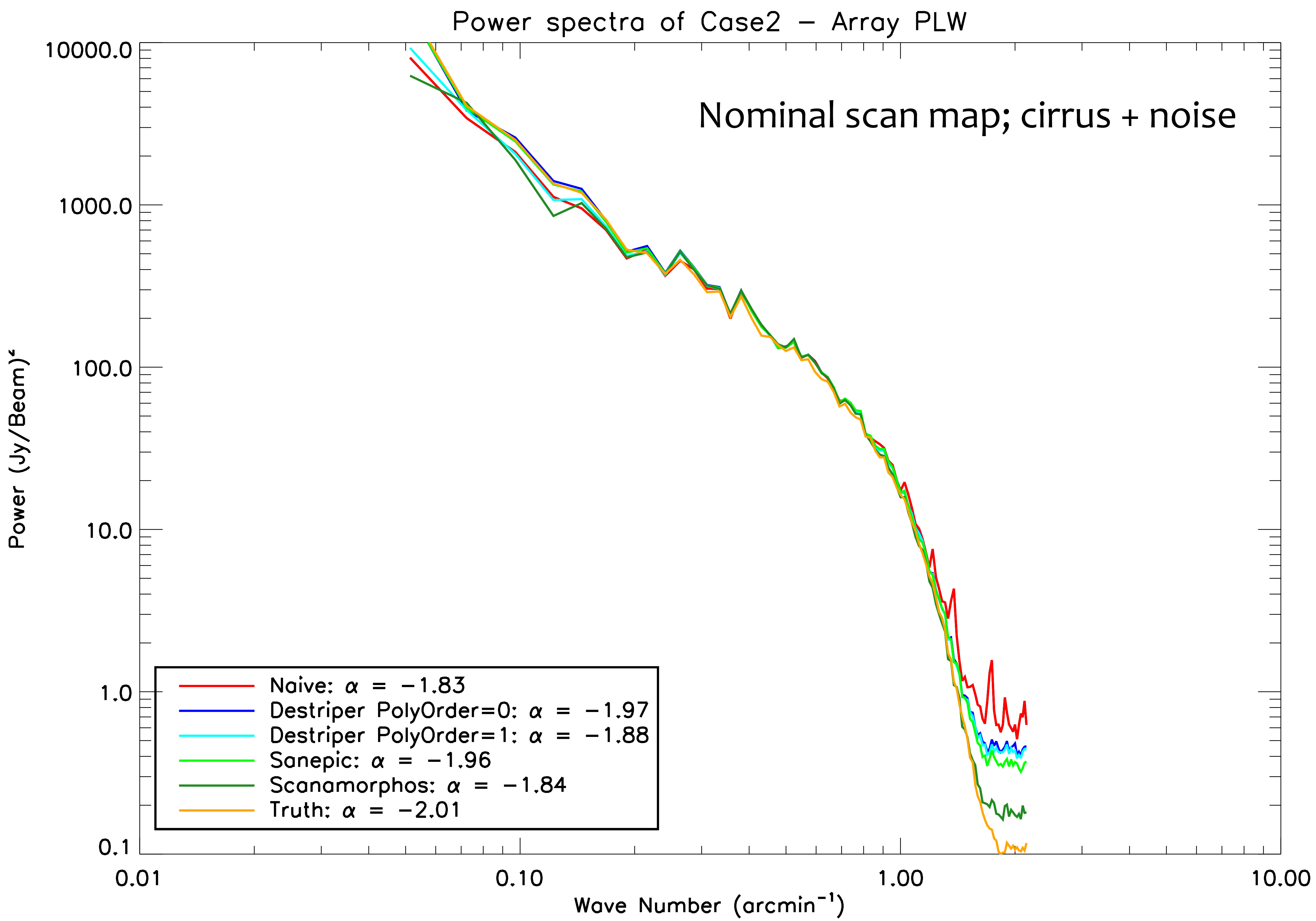
- Case 2: nominal; cirrus + noise
- Case 3: nominal; noise only
- Case 4: nominal; M51 + noise
- Case 6: fast scan; galactic centre + noise
- Case 7: fast scan; noise + cooler burp
- Case 9: parallel; galactic centre + noise
- Case 10: parallel; cirrus + noise
- Case 11: parallel; noise only
- Case 12: real obs; nominal; NGC628
- Case 13: real obs; parallel; HiGal L30

Dataset

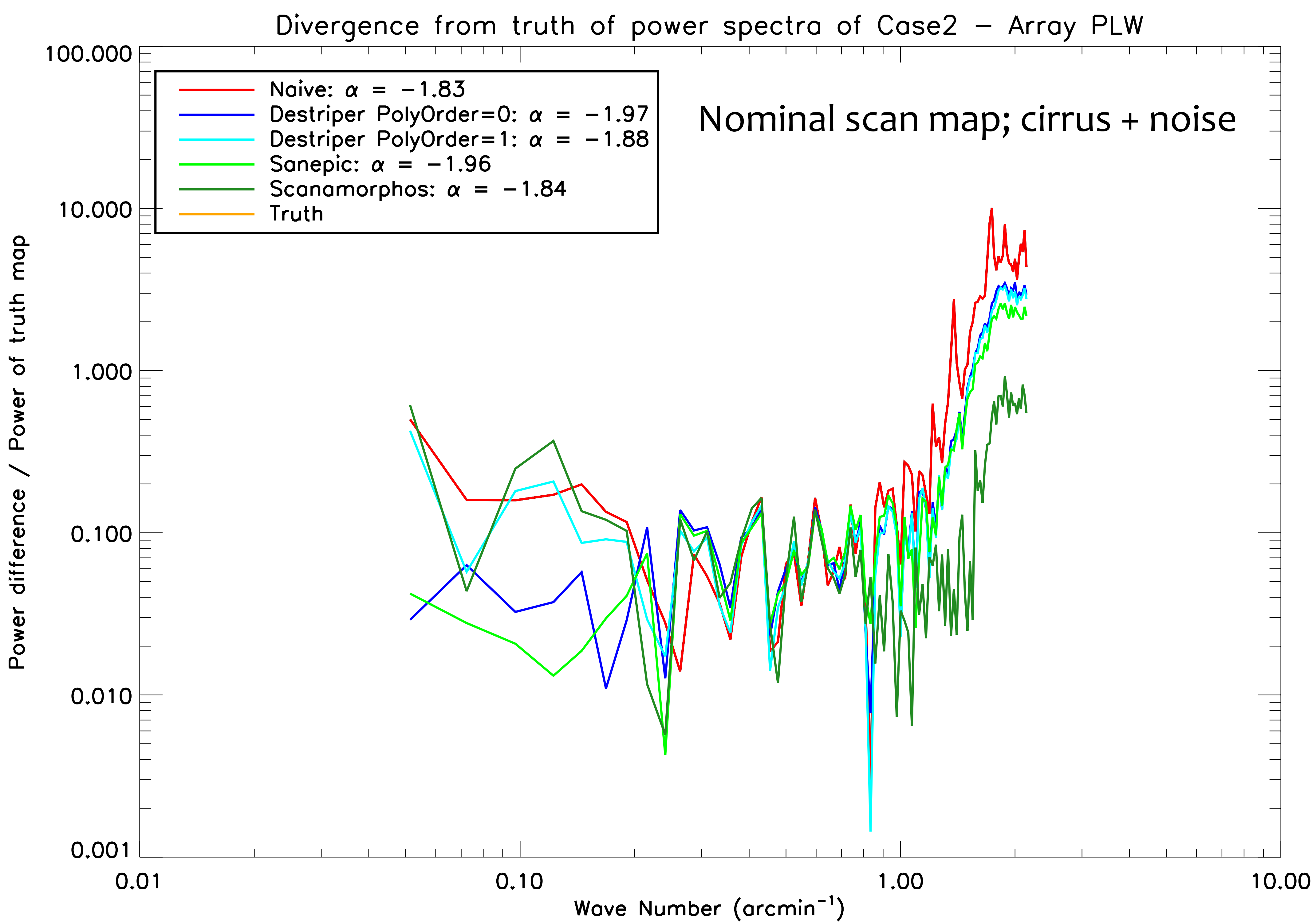
	Case 2	Case 3	Case 4	Case 6	Case 7	Case 9	Case 10	Case 11	Case 12	Case 13
Truth	✓	✗	✓	✓	✗	✓	✓	✗	✗	✗
Naïve	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Naïve IA	✗	✗	✓	✗	✓	✗	✗	✓	✓	✗
Destriper P0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Destriper P1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scana-morphos	✓	✓	✓	✓	✓	✓	✓	✓	✓	?
Sanepic	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
Unimap	✗	✗	✗	✓	✗	✗	✓	✗	✓	?

- Case 2: nominal; cirrus + noise
- Case 3: nominal; noise only
- Case 4: nominal; M51 + noise
- Case 6: fast scan; galactic centre + noise
- Case 7: fast scan; noise + cooler burp
- Case 9: parallel; galactic centre + noise
- Case 10: parallel; cirrus + noise
- Case 11: parallel; noise only
- Case 12: real obs; nominal; NGC628
- Case 13: real obs; parallel; HiGal L30

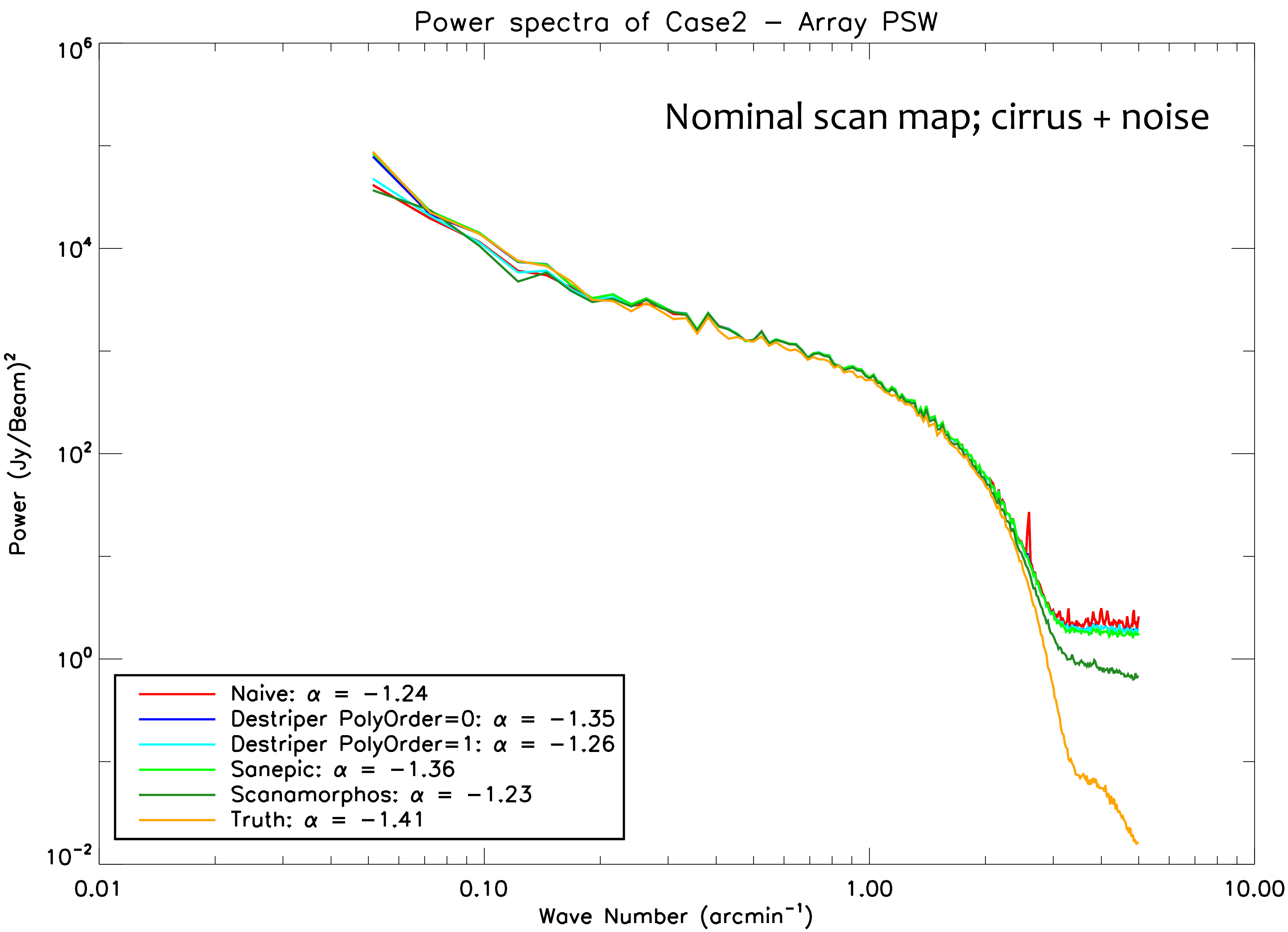
Case 2 - PLW


Power spectra of Case2 – Array PLW
Nominal scan map; cirrus + noise
Power (Jy/Beam)²
Wave Number (arcmin⁻¹)
10000.0
1000.0
100.0
10.0
1.0
0.1
0.01
0.10
1.00
10.00
Naive: α = −1.83
Destriper PolyOrder=0: α = −1.97
Destriper PolyOrder=1: α = −1.88
Sanepic: α = −1.96
Scanamorphos: α = −1.84
Truth: α = −2.01

Case 2 - PLW Difference

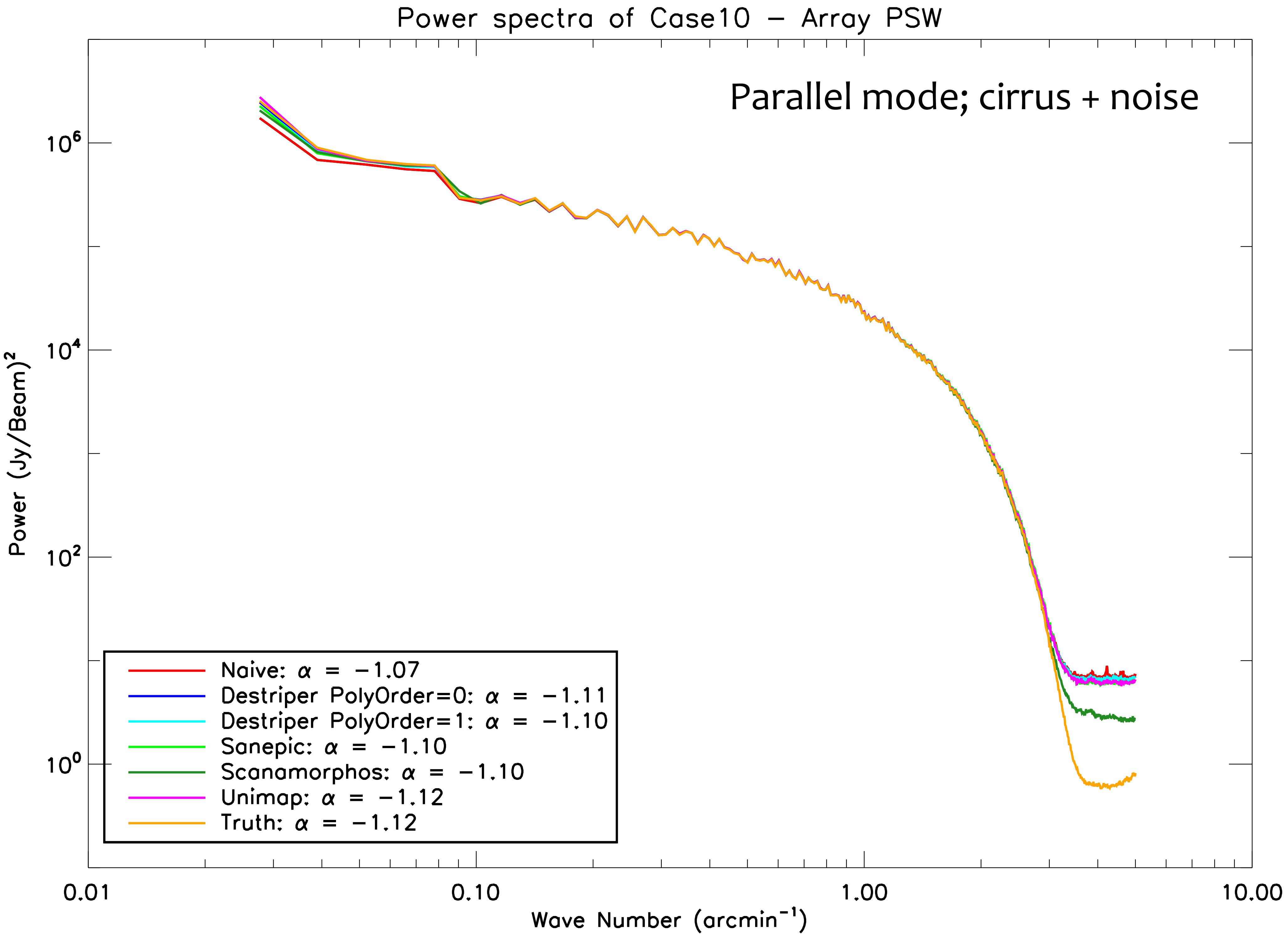


Case 2 - PSW

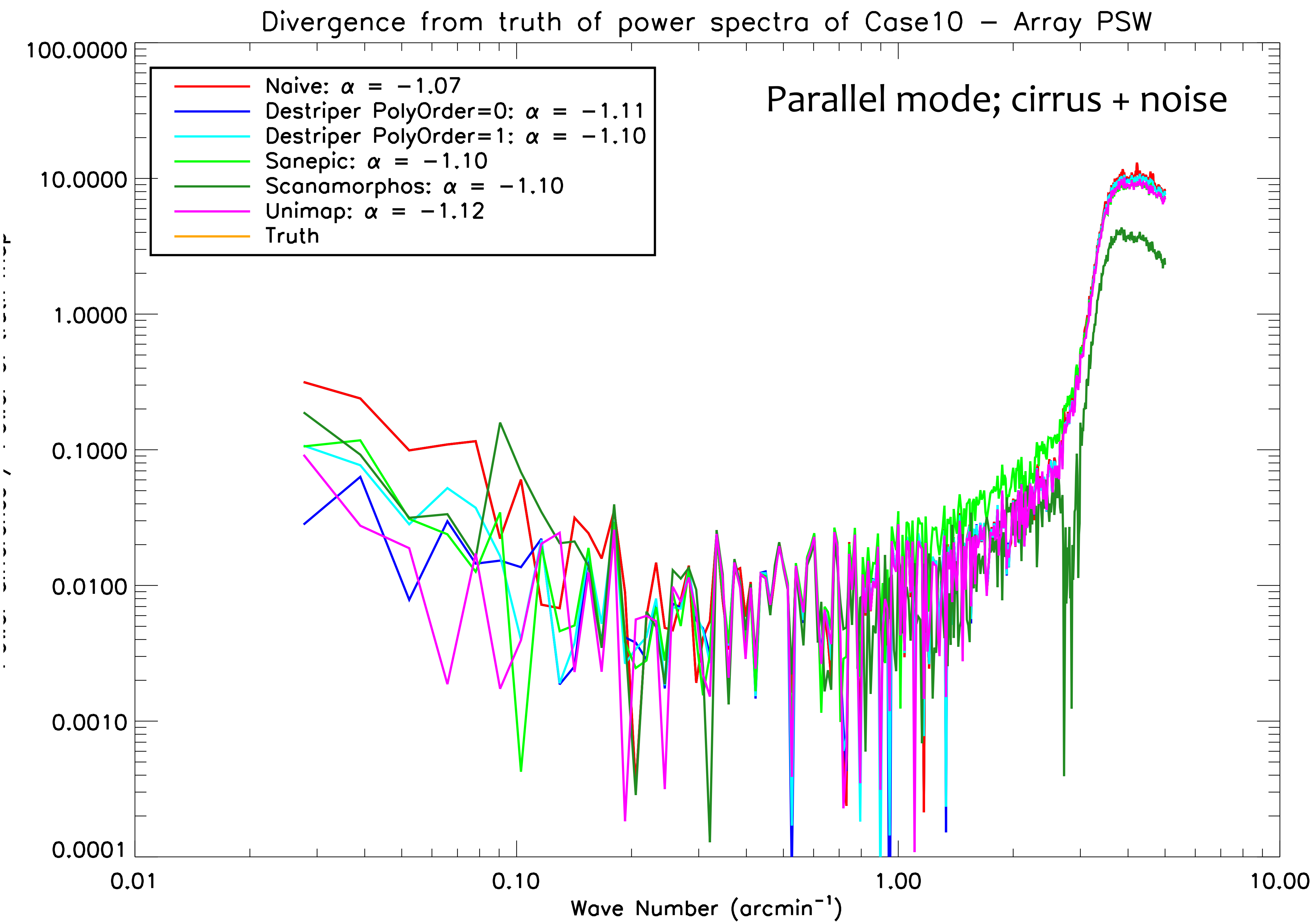


Power spectra of Case2 - Array PSW
Nominal scan map; cirrus + noise
Power (Jy/Beam)^2
Wave Number (arcmin^{-1})
10^6
10^4
10^2
10^0
10^{-2}
0.01
0.10
1.00
10.00
Naive: α = -1.24
Destriper PolyOrder=0: α = -1.35
Destriper PolyOrder=1: α = -1.26
Sanepic: α = -1.36
Scanamorphos: α = -1.23
Truth: α = -1.41

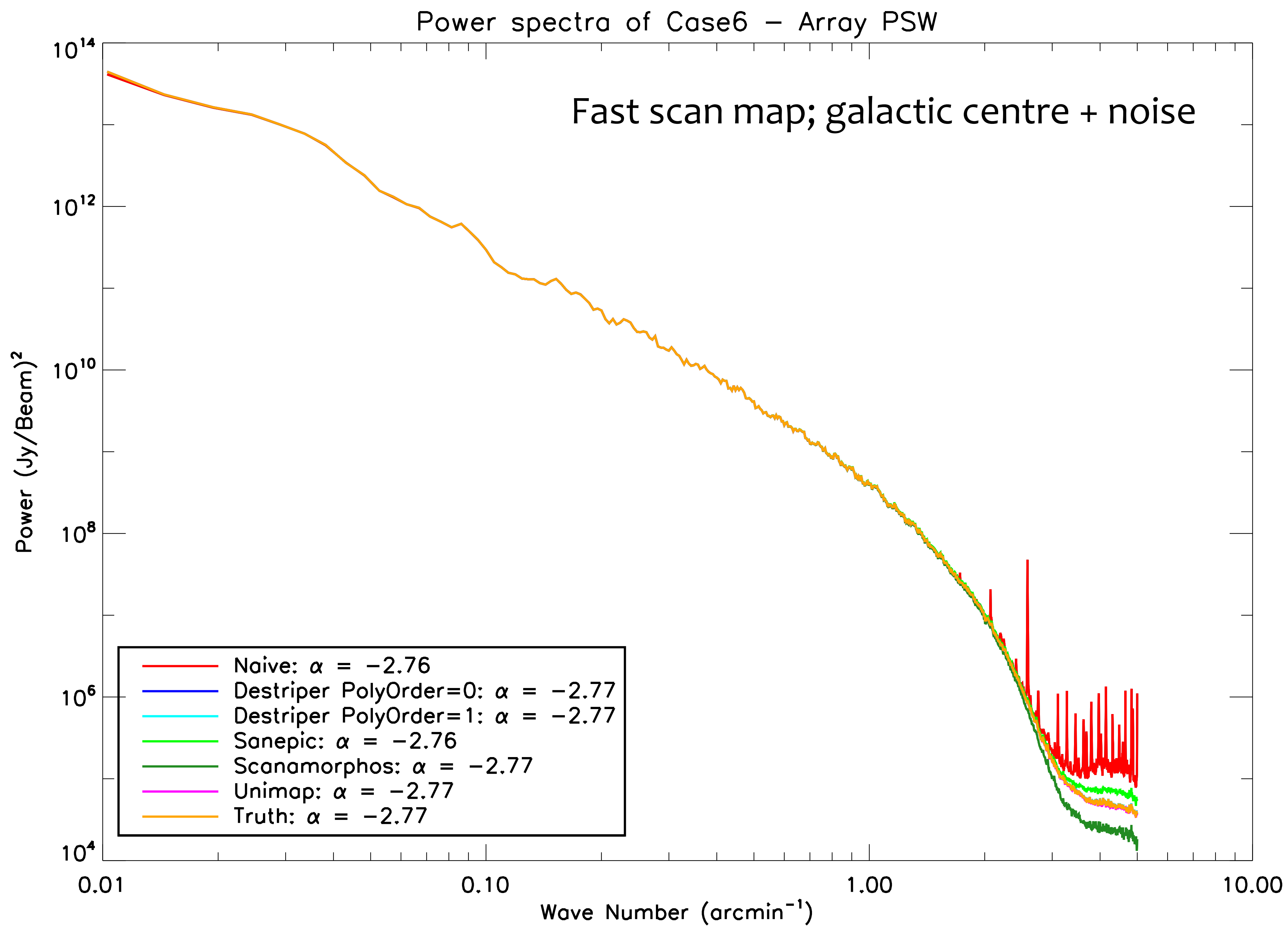
Case 10 - PSW


Power spectra of Case10 – Array PSW
Parallel mode; cirrus + noise
10^6
10^4
10^2
10^0
Power (Jy/Beam)^2
0.01
0.10
1.00
10.00
Wave Number (arcmin^{-1})
Naive: α = −1.07
Destriper PolyOrder=0: α = −1.11
Destriper PolyOrder=1: α = −1.10
Sanepic: α = −1.10
Scanamorphos: α = −1.10
Unimap: α = −1.12
Truth: α = −1.12

Case 10 - PSW Difference

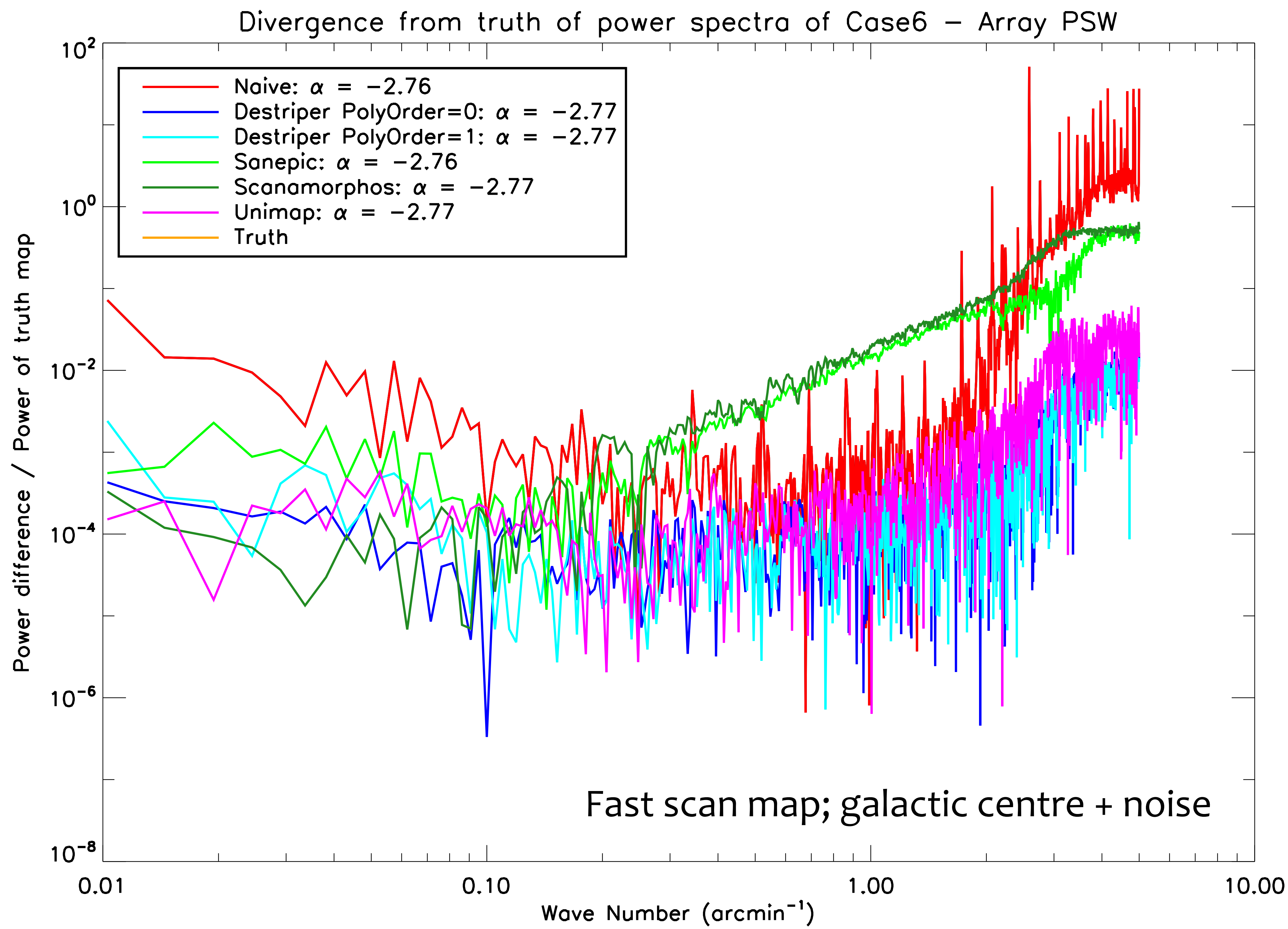


Case 6 - PSW

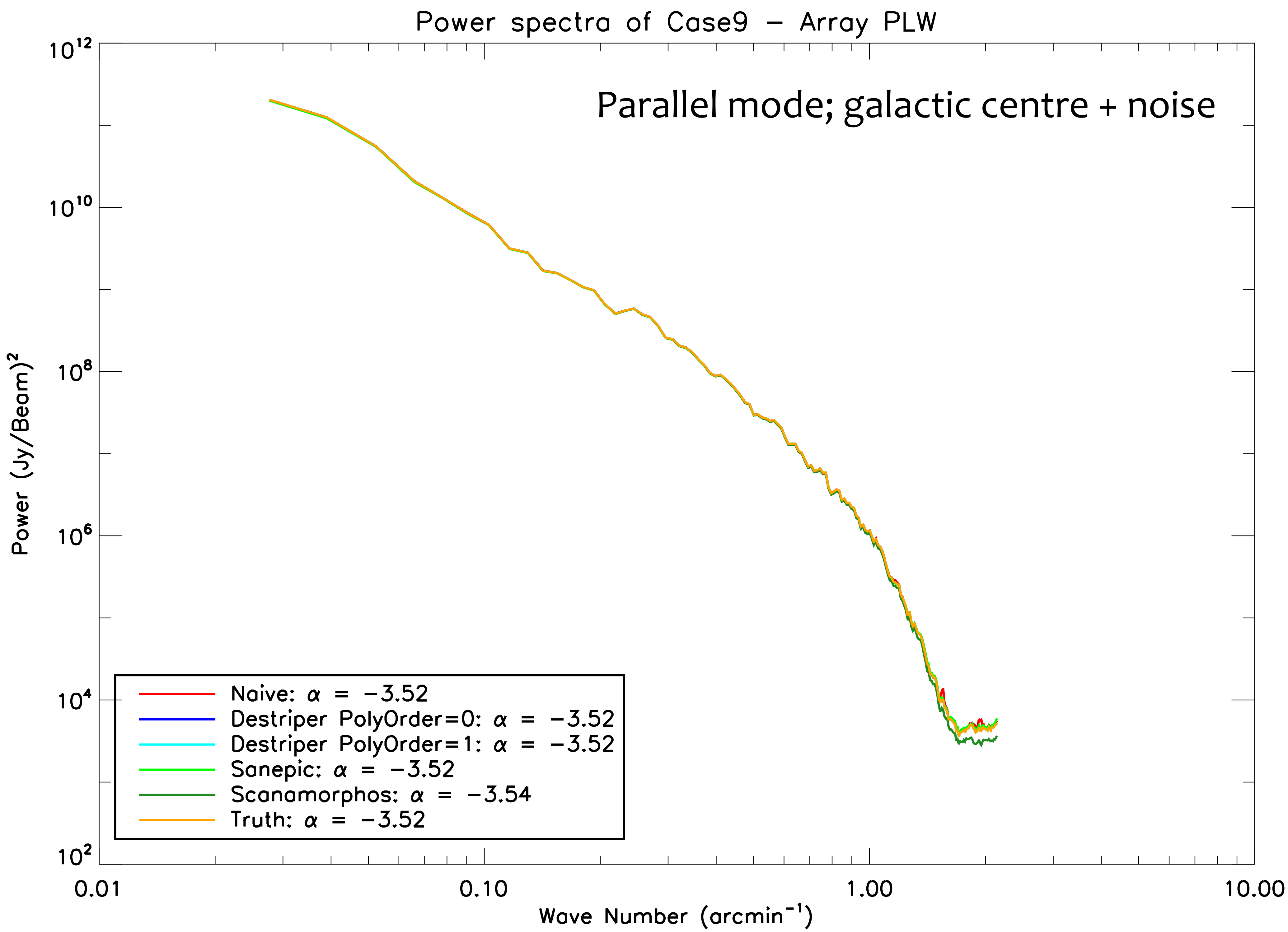


Power spectra of Case6 – Array PSW
Fast scan map; galactic centre + noise
Power (Jy/Beam)^2
10^{14}
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
0.01
0.10
1.00
10.00
Wave Number (arcmin^{-1})
Naive: α = −2.76
Destriper PolyOrder=0: α = −2.77
Destriper PolyOrder=1: α = −2.77
Sanepic: α = −2.76
Scanamorphos: α = −2.77
Unimap: α = −2.77
Truth: α = −2.77

Case 6 - PSW Difference

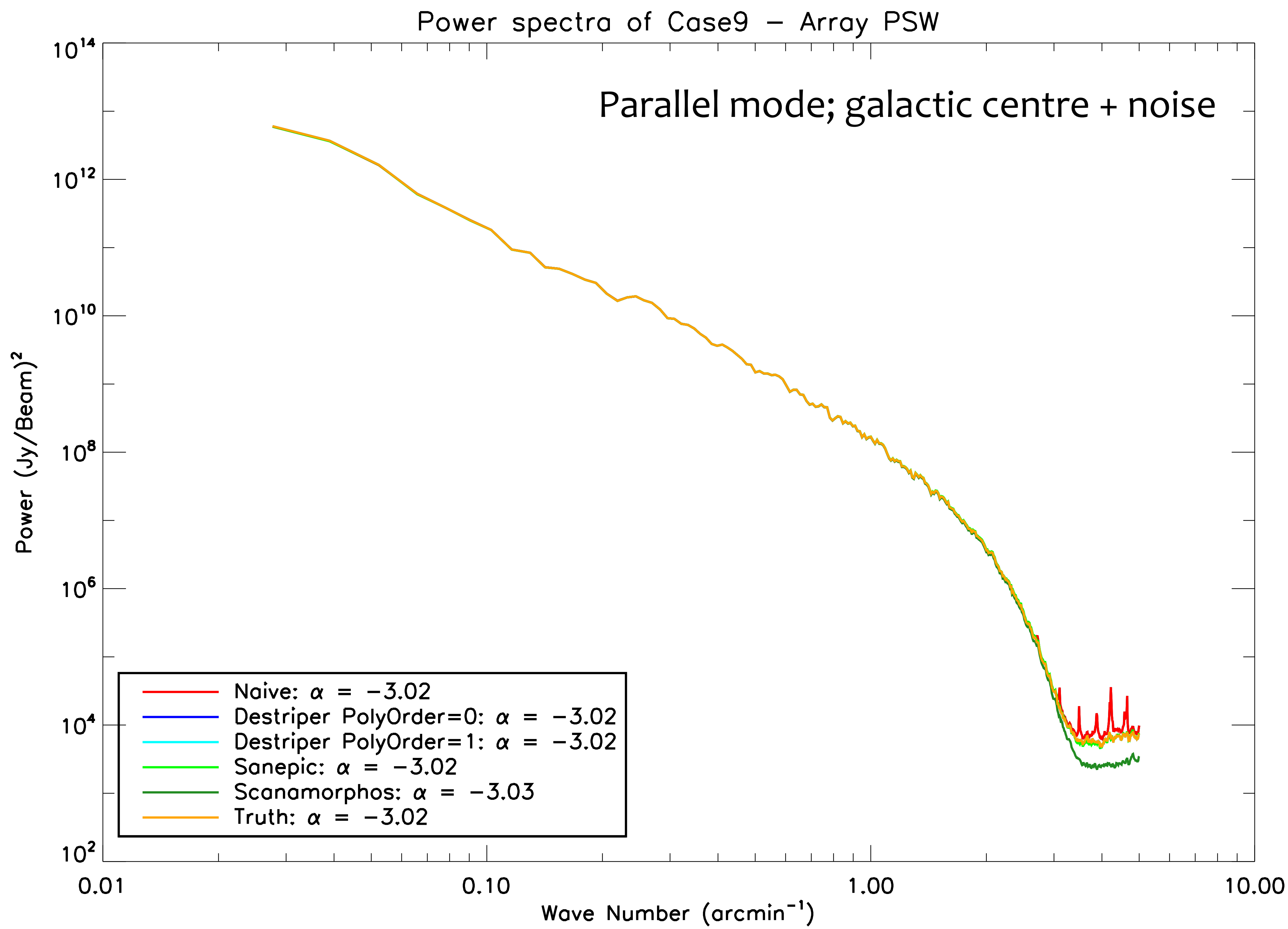


Case 9 - PLW

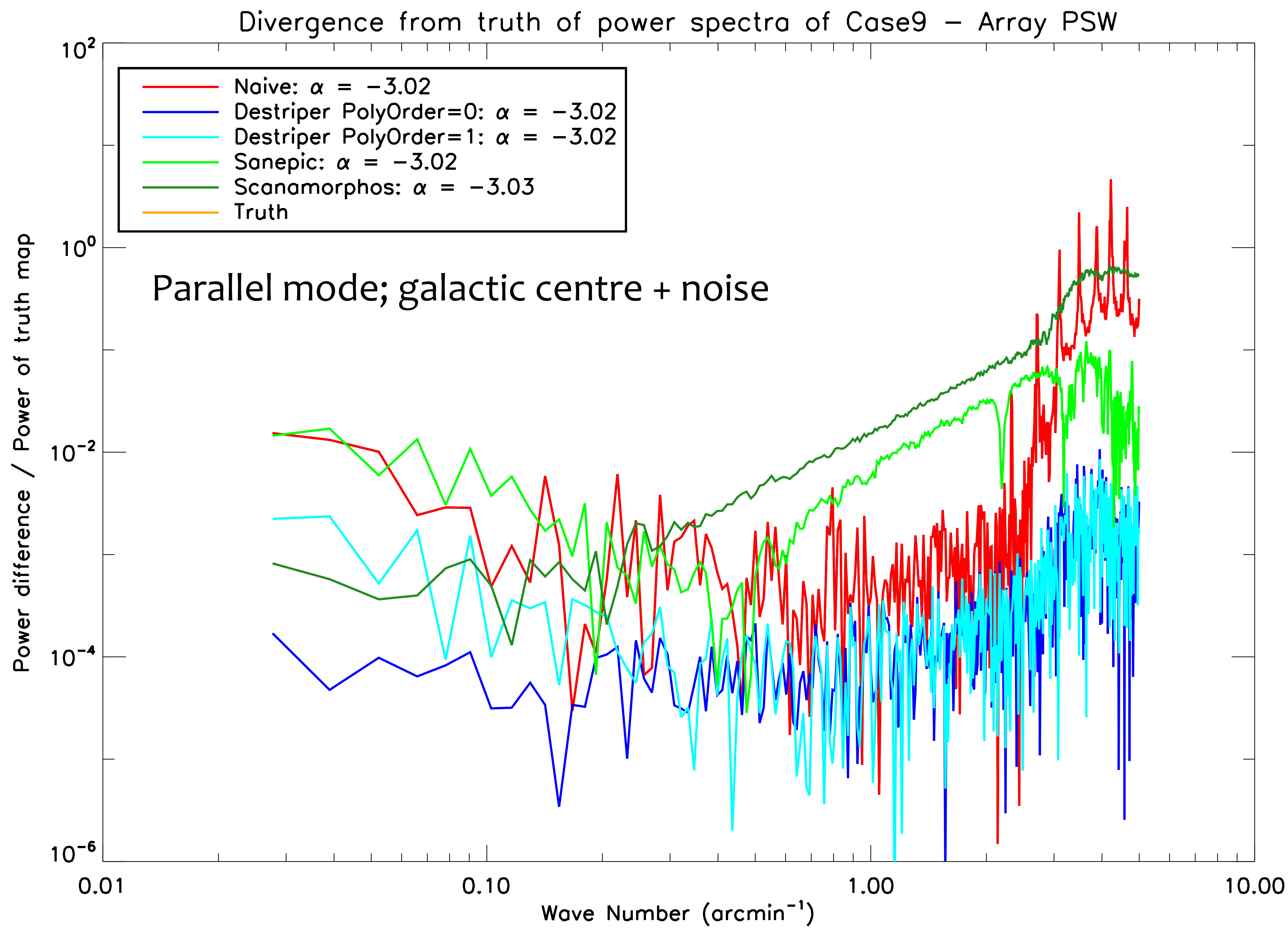


Power spectra of Case9 – Array PLW
Parallel mode; galactic centre + noise
Naive: α = −3.52
Destriper PolyOrder=0: α = −3.52
Destriper PolyOrder=1: α = −3.52
Sanepic: α = −3.52
Scanamorphos: α = −3.54
Truth: α = −3.52
Power (Jy/Beam)^2
Wave Number (arcmin^{-1})
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
0.01
0.10
1.00
10.00

Case 9 - PSW


Power spectra of Case9 – Array PSW
Parallel mode; galactic centre + noise
Power (Jy/Beam)^2
10^{14}
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
0.01
0.10
1.00
10.00
Wave Number (arcmin^{-1})
Naive: α = −3.02
Destriper PolyOrder=0: α = −3.02
Destriper PolyOrder=1: α = −3.02
Sanepic: α = −3.02
Scanamorphos: α = −3.03
Truth: α = −3.02

Case 9 - PSW Difference



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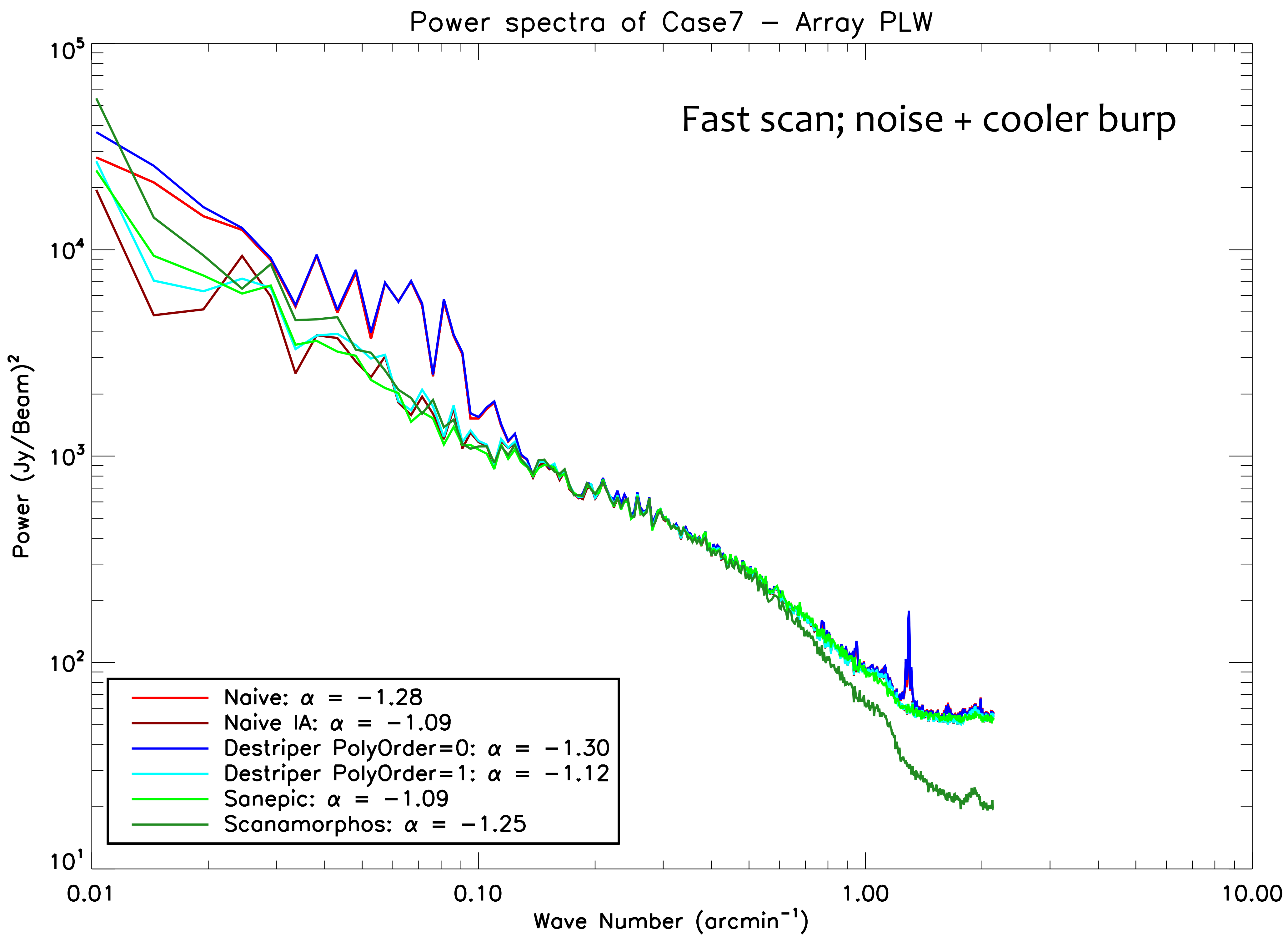
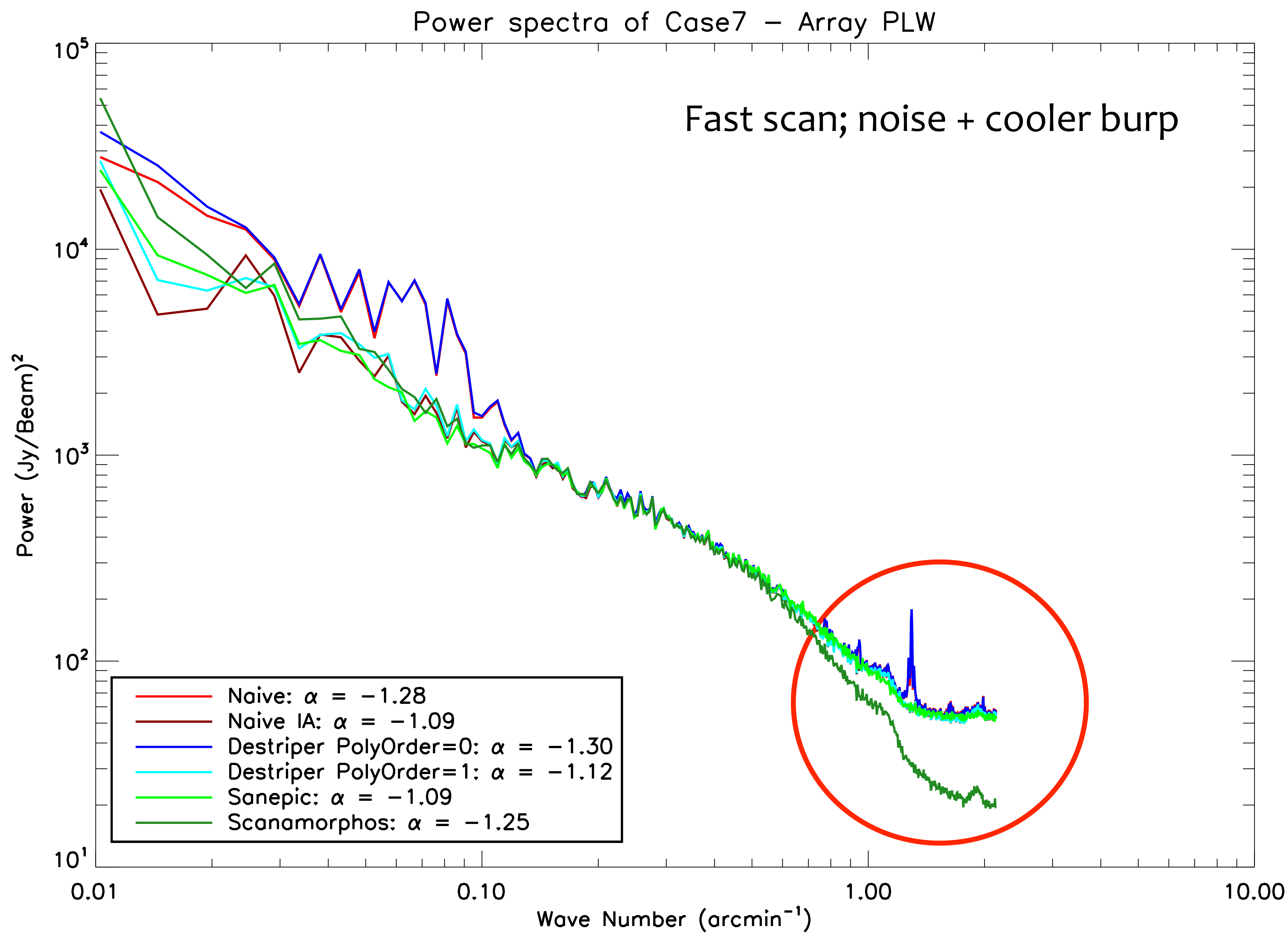
Case 7 - PLW



Case 7 - PLW

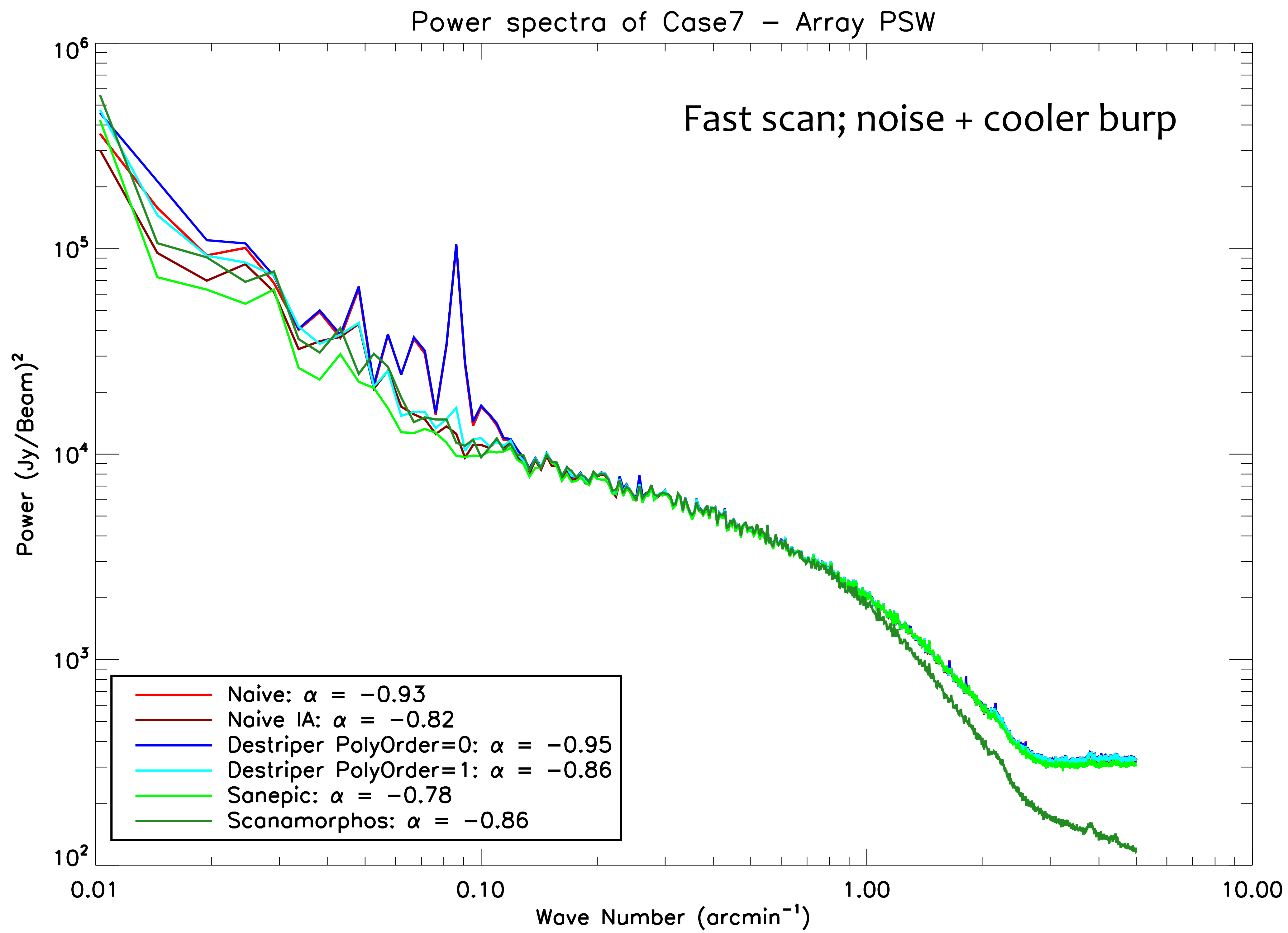


Power spectra of Case7 – Array PLW
Fast scan; noise + cooler burp
Power (Jy/Beam)^2
Wave Number (arcmin^{-1})
10^5
10^4
10^3
10^2
10^1
0.01
0.10
1.00
10.00
Naive: α = −1.28
Naive IA: α = −1.09
Destriper PolyOrder=0: α = −1.30
Destriper PolyOrder=1: α = −1.12
Sanepic: α = −1.09
Scanamorphos: α = −1.25

Case 7 - PLW

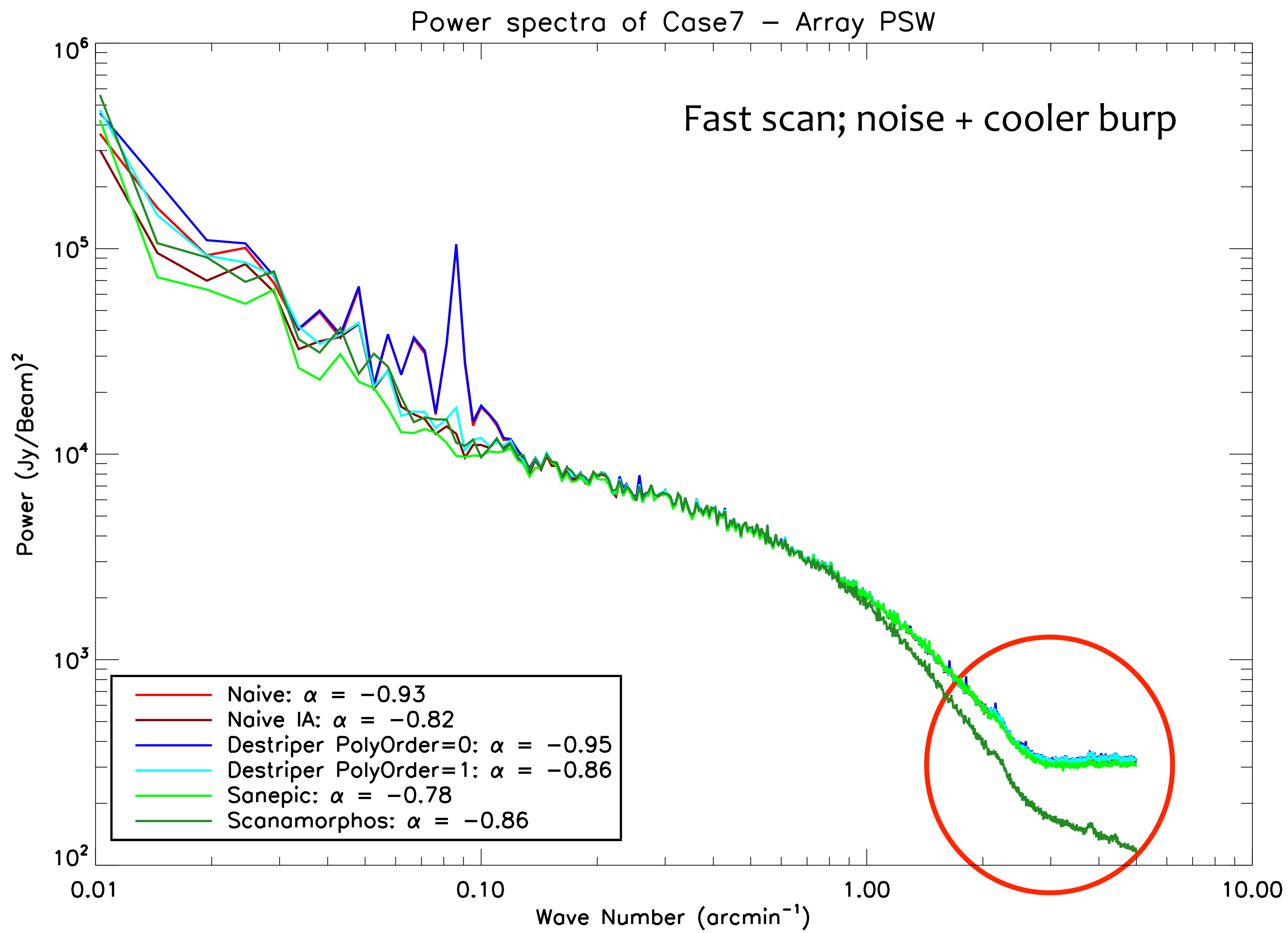
Power spectra of Case7 – Array PLW
Fast scan; noise + cooler burp
Power (Jy/Beam)^2
10^5
10^4
10^3
10^2
10^1
0.01
0.10
Naive: α = −1.28
Naive IA: α = −1.09
Destriper PolyOrder=0: α =
Destriper PolyOrder=1: α =
Sanepic: α = −1.09
Scanamorphos: α = −1.25

Case 7 - PSW



Power spectra of Case7 – Array PSW
Fast scan; noise + cooler burp
Power (Jy/Beam)^2
Wave Number (arcmin^{-1})
10^6
10^5
10^4
10^3
10^2
0.01
0.10
1.00
10.00
Naive: α = −0.93
Naive IA: α = −0.82
Destriper PolyOrder=0: α = −0.95
Destriper PolyOrder=1: α = −0.86
Sanepic: α = −0.78
Scanamorphos: α = −0.86

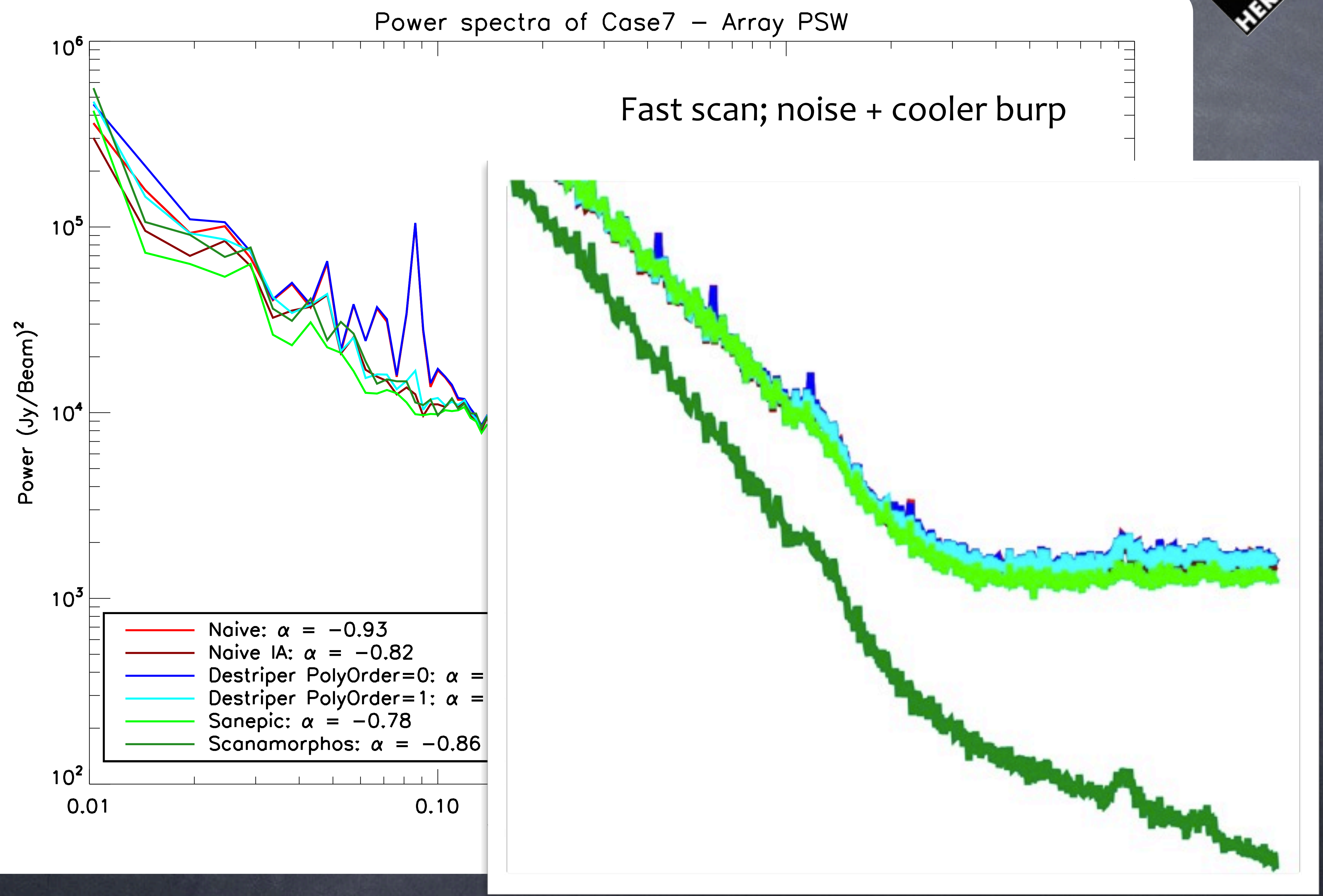
Case 7 - PSW



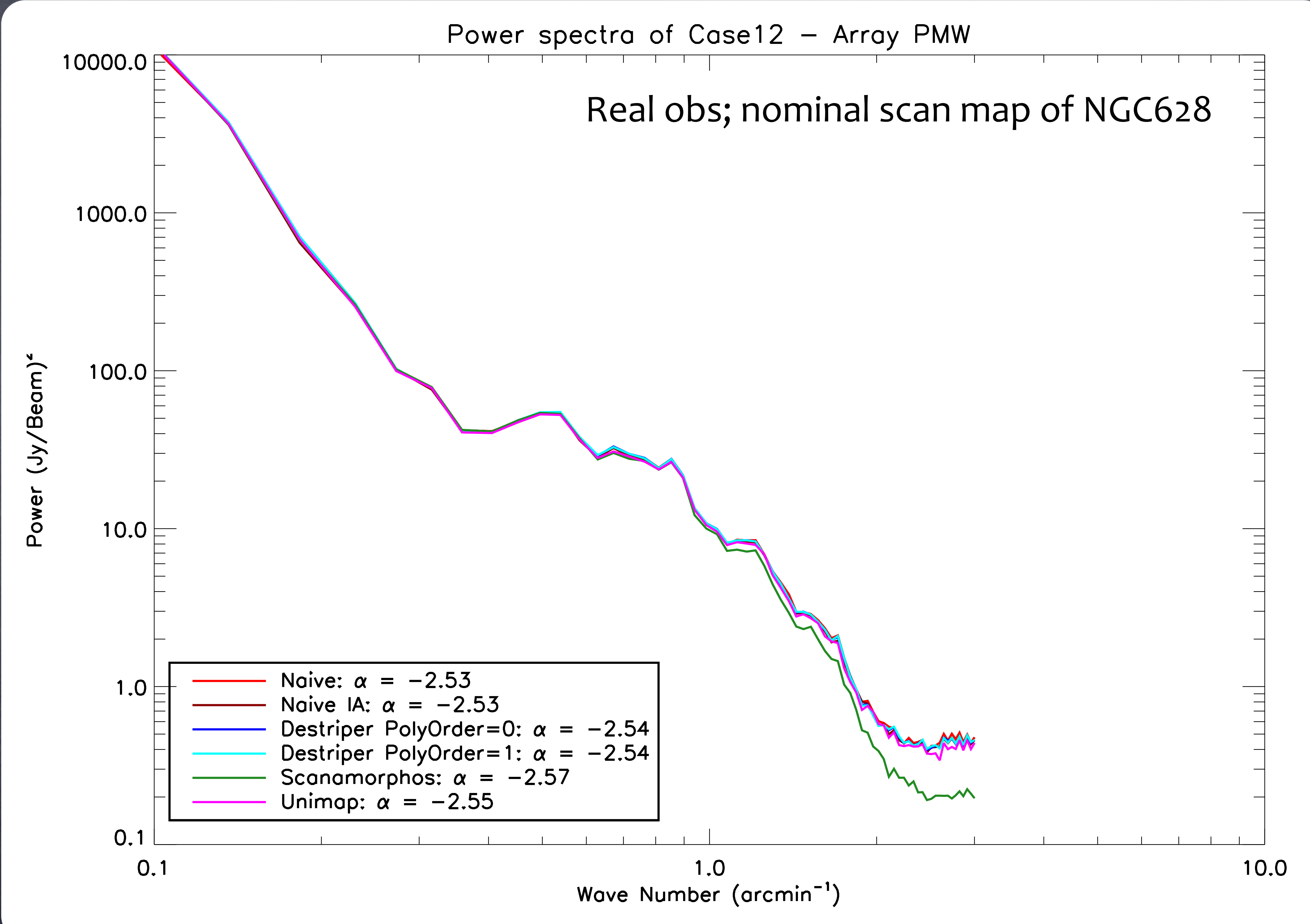
Power spectra of Case7 – Array PSW
Fast scan; noise + cooler burp
Power (Jy/Beam)^2
Wave Number (arcmin^{-1})
10^6
10^5
10^4
10^3
10^2
0.01
0.10
1.00
10.00
Naive: α = −0.93
Naive IA: α = −0.82
Destriper PolyOrder=0: α = −0.95
Destriper PolyOrder=1: α = −0.86
Sanepic: α = −0.78
Scanamorphos: α = −0.86

Case 7 - PSW

Fast scan; noise + cooler burp

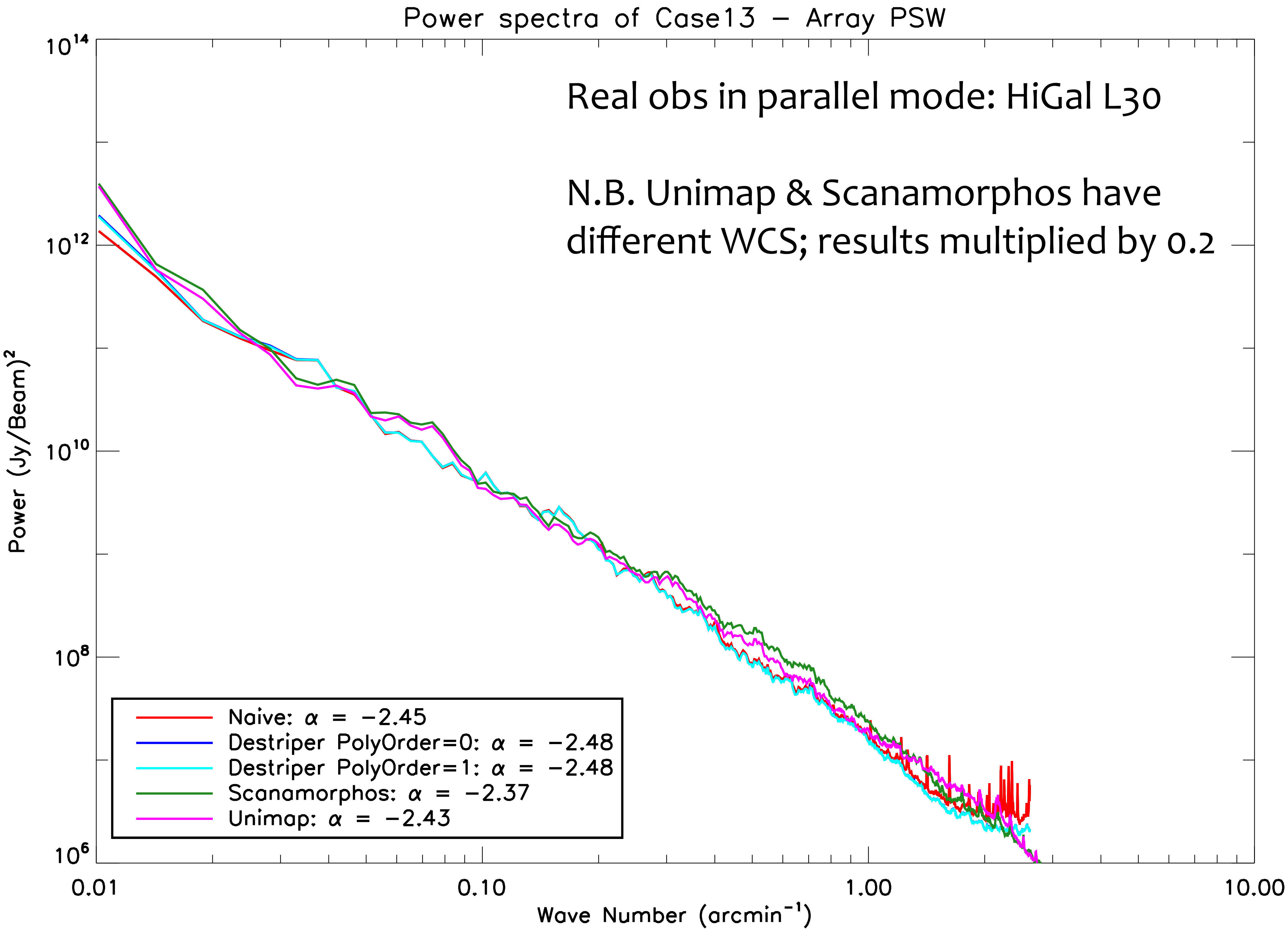


Case 12 - PMW



Power spectra of Case12 – Array PMW
Real obs; nominal scan map of NGC628
Power (Jy/Beam)²
Wave Number (arcmin⁻¹)
10000.0
1000.0
100.0
10.0
1.0
0.1
0.1
1.0
10.0
Naive: α = −2.53
Naive IA: α = −2.53
Destriper PolyOrder=0: α = −2.54
Destriper PolyOrder=1: α = −2.54
Scanamorphos: α = −2.57
Unimap: α = −2.55

Case 13 - PSW



Power spectra of Case13 – Array PSW
Real obs in parallel mode: HiGal L30
N.B. Unimap & Scanamorphos have different WCS; results multiplied by 0.2
Power (Jy/Beam)^2
10^{14}
10^{12}
10^{10}
10^{8}
10^{6}
0.01
0.10
1.00
10.00
Wave Number (arcmin^{-1})
Naive: α = −2.45
Destriper PolyOrder=0: α = −2.48
Destriper PolyOrder=1: α = −2.48
Scanamorphos: α = −2.37
Unimap: α = −2.43

Conclusions

- In the "central part" ($k = [0.1, 1]$ arcmin^{-1}), results among different map-makers vary little (~1% where I can very against the true map)

- Differences w.r.t. true map increase at $k > 1$ arcmin^{-1}:
  - HIPE destripers with 0th and 1st polynomial order, Sanepic and Unimap results are always very *close*
  - Scanamorphos is usually lower
  - *Automatic* HIPE naïve mapper is higher w.r.t. destripers *et al.*, but not as much as I would expect. Once it is ran in IA, it gives results in line with other map-makers

- At $k < 0.1$ arcmin^{-1}, the spread among map-makers is larger but they are (almost) always within few % of the truth power spectrum. HIPE destripers with 0th polynomial order is usually the closest to true

- Case 7 (noise-only map with cooler burp) is a case apart:
  - *Automatic* naïve mapper and destriper with 0th polynomial order perform worse: much higher at $k < 0.1$ and present a bump at $k \sim 2$ in PLW map. This is to be expected as they cannot correct the drift caused by the "cooler burp"
  - Others are similar at $k < 0.1$, but Scanamorphos is the lowest at $k > 1$ → less noise left?