Ring Polarscope Mode Mixing

Mode Mixing

- An interferometer with a finite number of elements will only “see” a finite number of “beams” on the sky. Any linear combination of beams we call the “space of beams” (a Hilbert space).

- This space of beams will depends frequency. This frequency dependence of the Hilbert spaces is called “mode mixing” because it mixes frequency dependence and angle dependence.

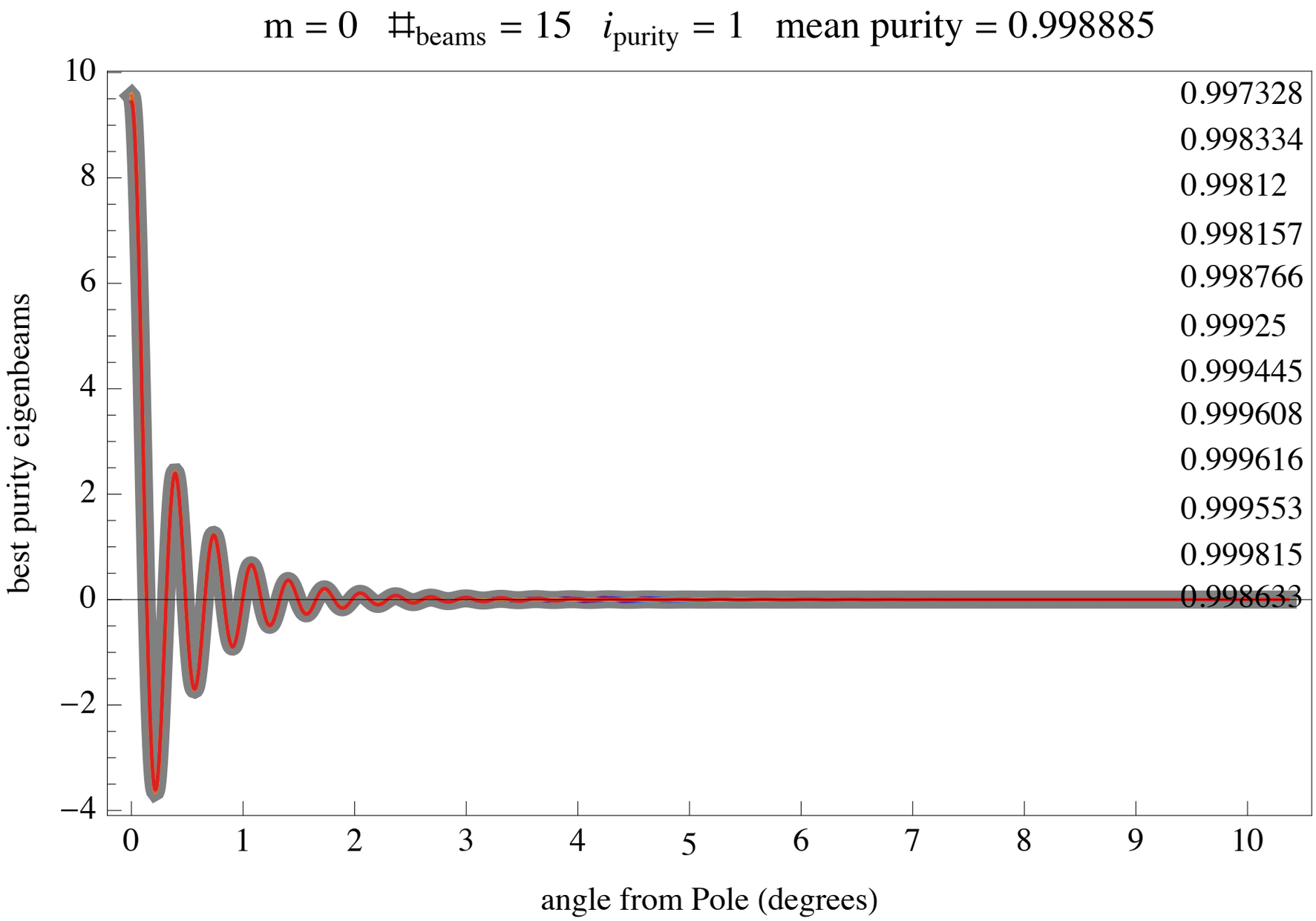
- To do foreground filtering we would prefer the amount of mode mixing to be minimized.

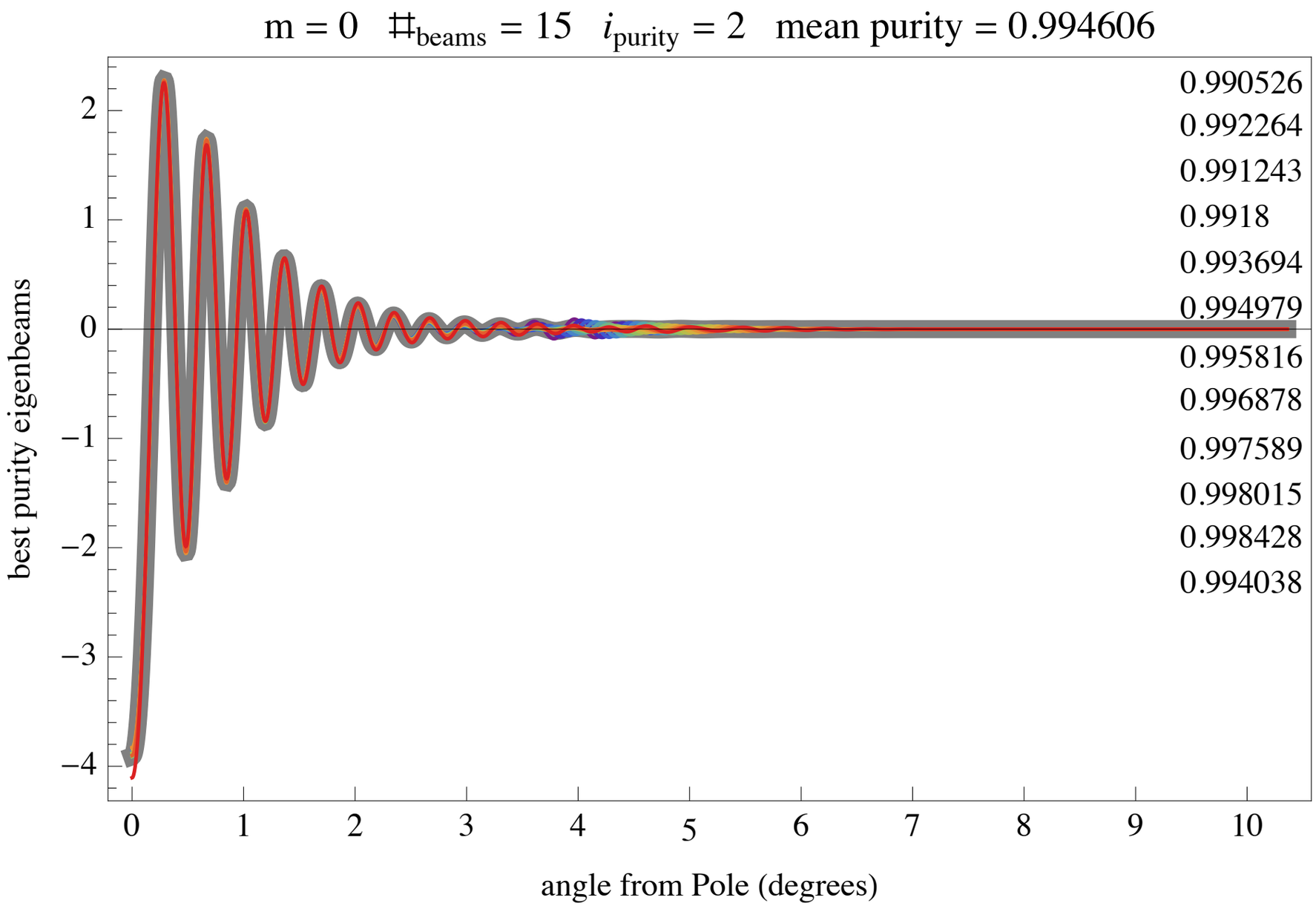
Purity

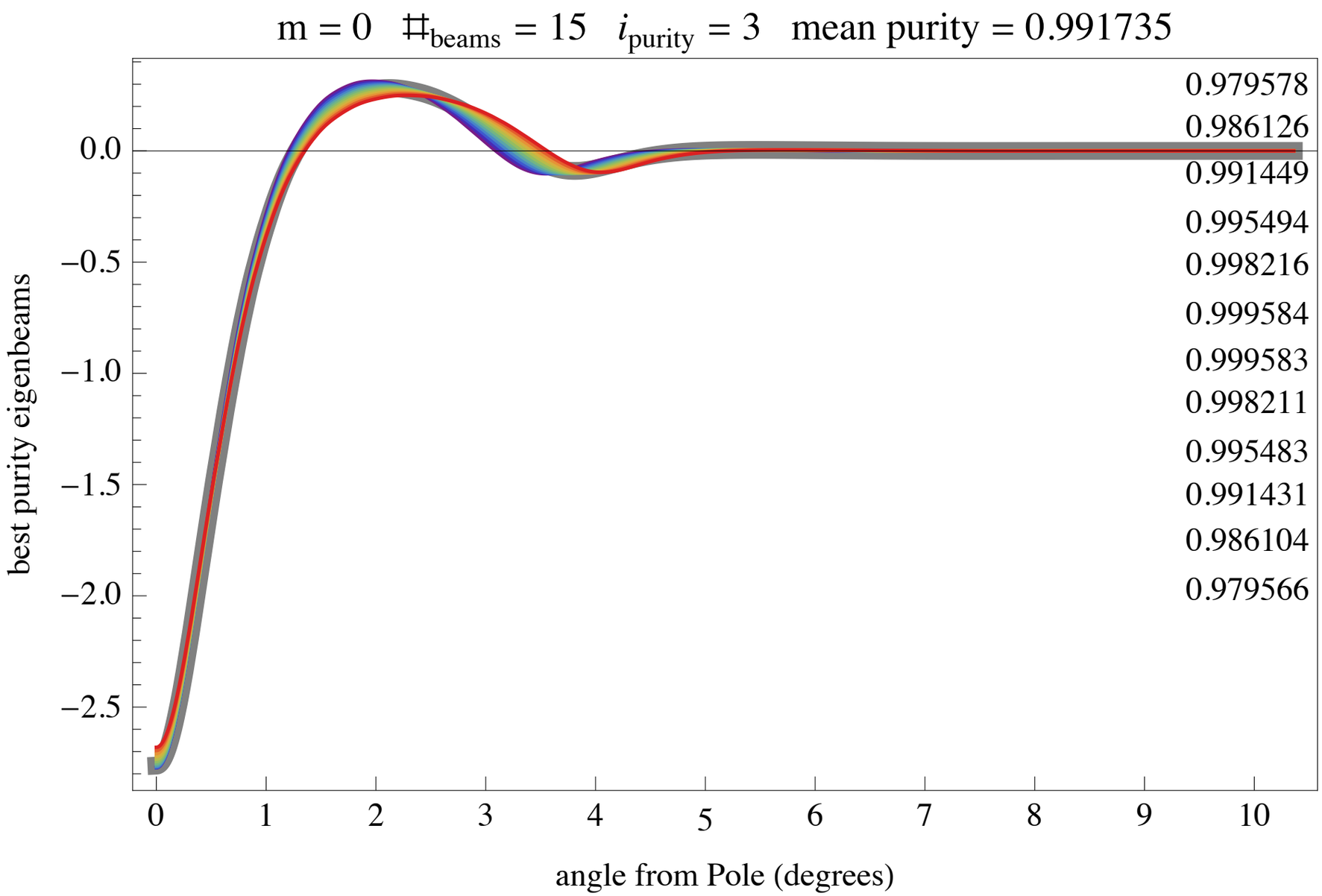
- To quantify the amount of mode mixing we define the purity, $\mathcal{P}$, which is the overlap integral of two normalized beams. Perfect overlap is purity 1.

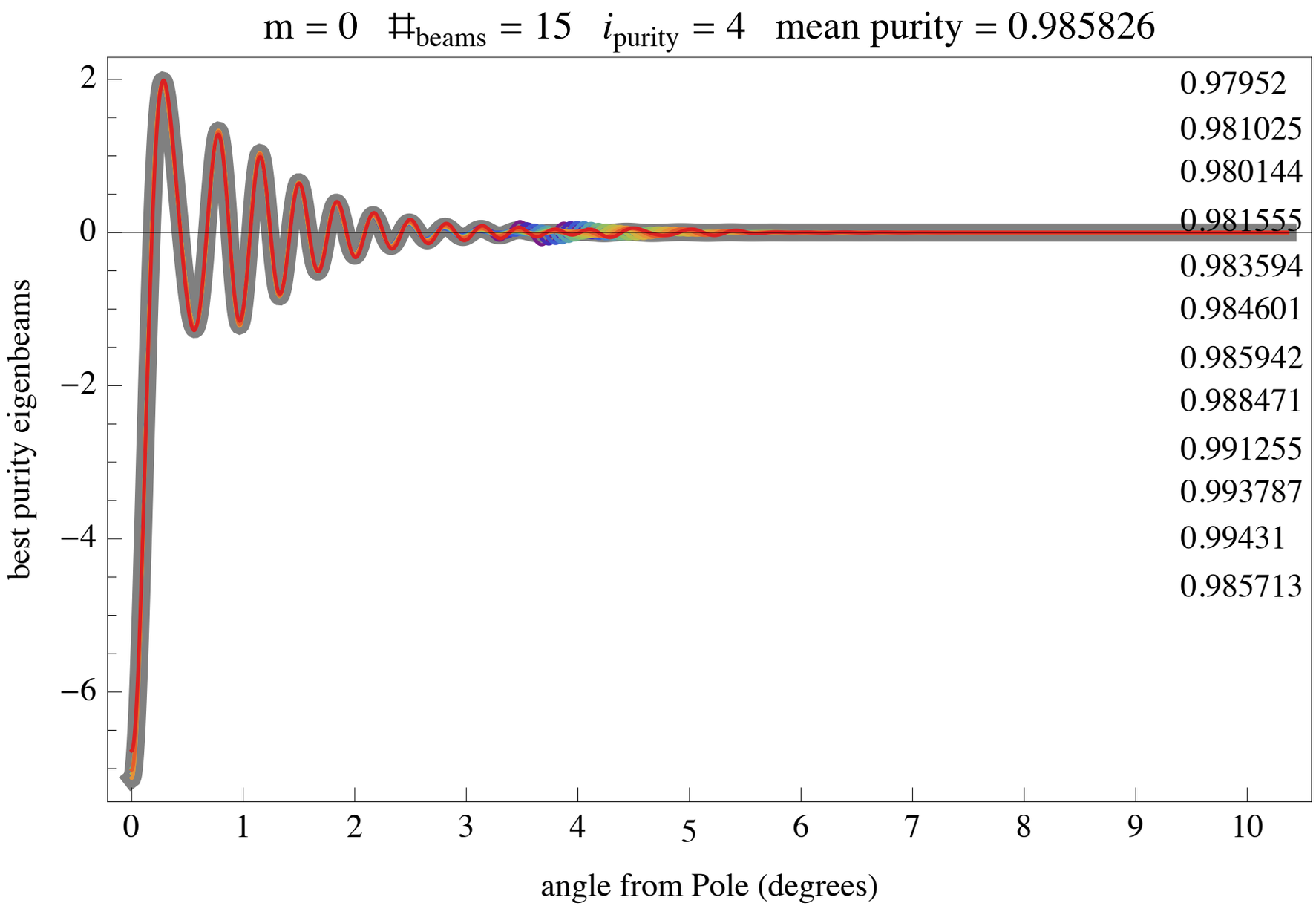
- The matrix of frequency averaged overlap integrals will have eigenmodes which we call mean purity eigemodes. The eigenvalues give the mean purity. These eigenvalues is a measure of the amount of mode mixing.

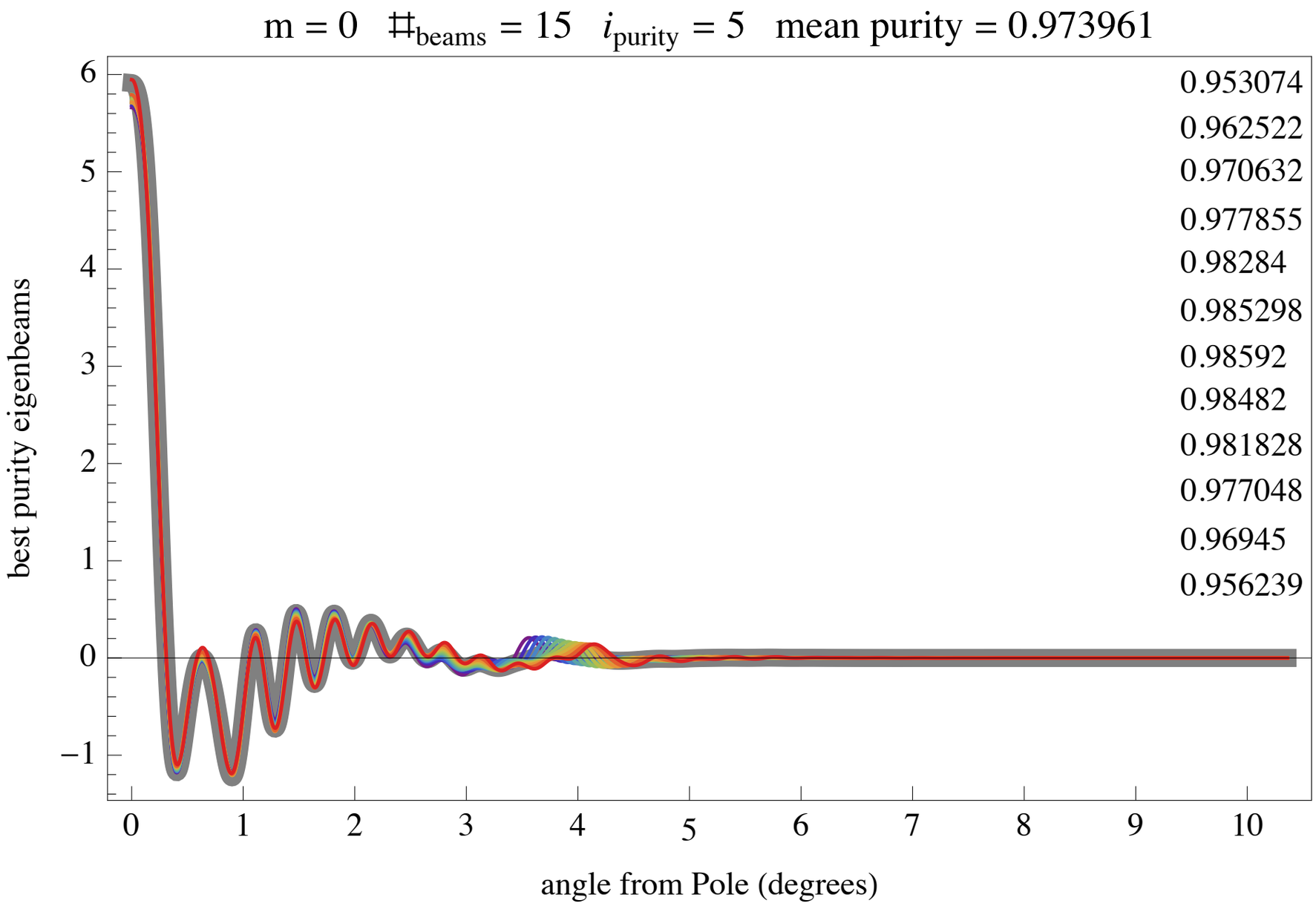
- The eigenmodes can be very close to unity so we define the “purity number” = $\mathbf{-\ln[1-\mathcal{P}]}$

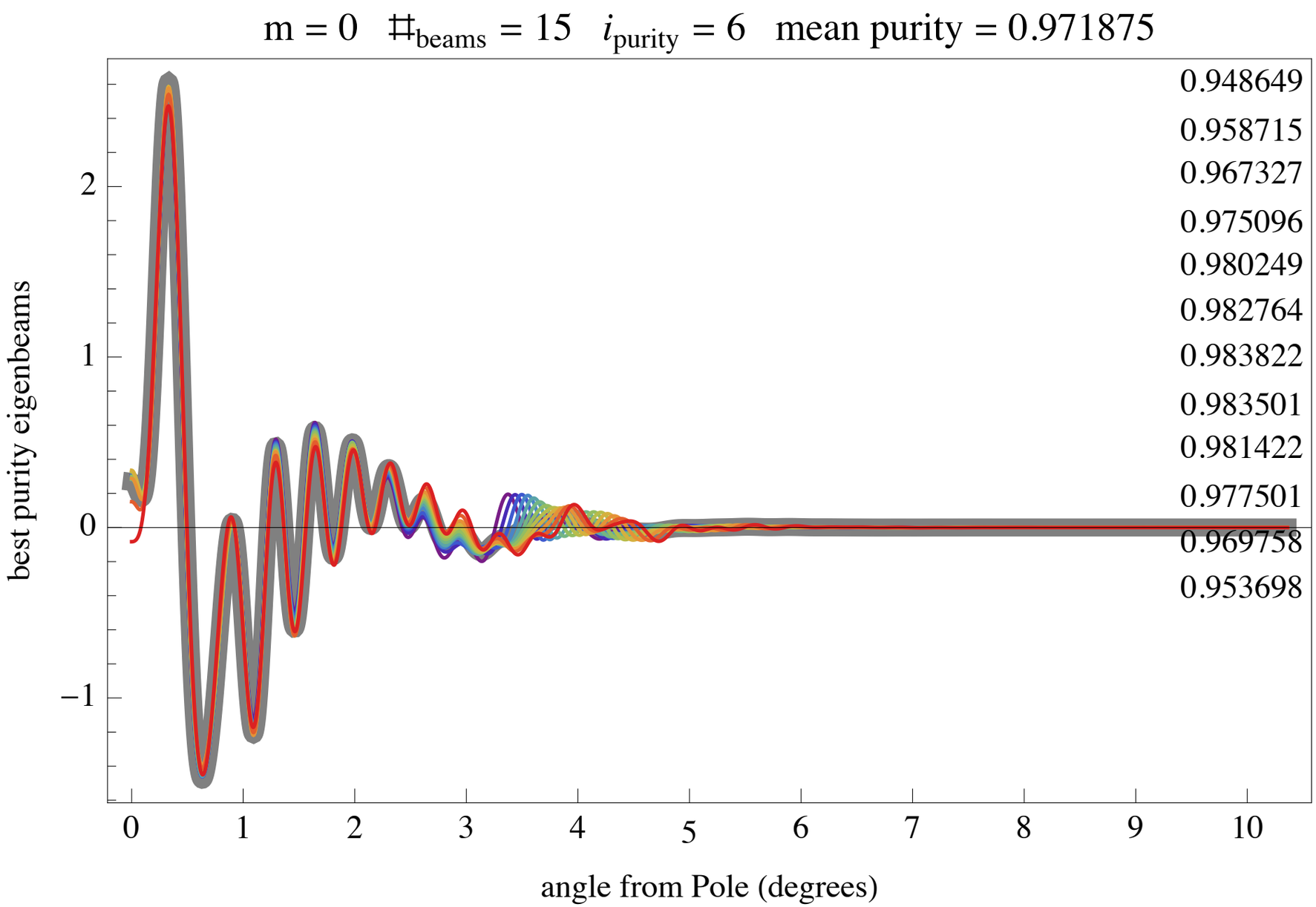

m = 0 #beams = 15 i purity = 1 mean purity = 0.998885
best purity eigenbeams
10
8
6
4
2
0
−2
−4
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)
0.997328
0.998334
0.99812
0.998157
0.998766
0.99925
0.999445
0.999608
0.999616
0.999553
0.999815
0.998633

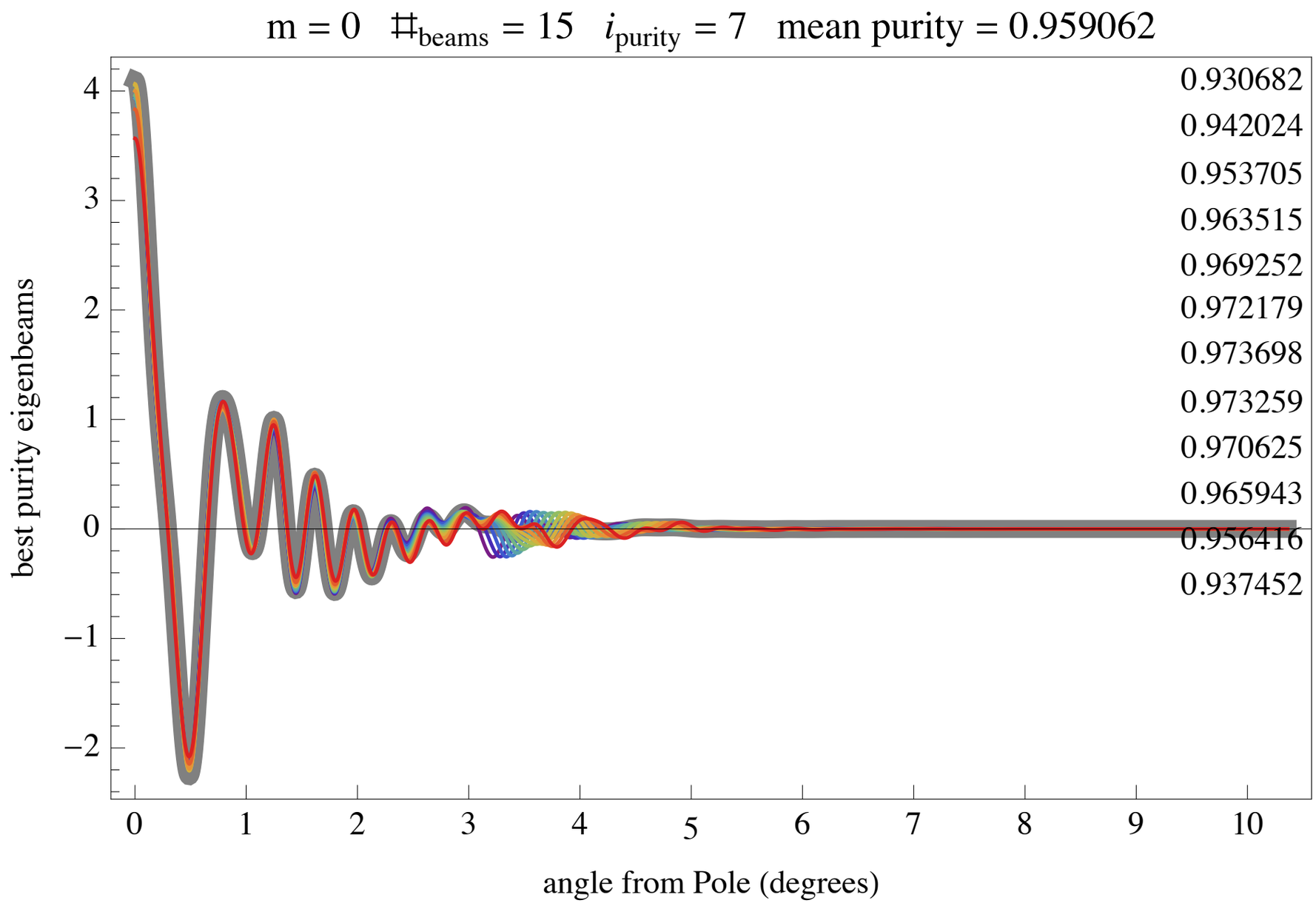

m = 0 ⌗beams = 15 i_{purity} = 2 mean purity = 0.994606
best purity eigenbeams
2
1
0
−1
−2
−3
−4
0.990526
0.992264
0.991243
0.9918
0.993694
0.994979
0.995816
0.996878
0.997589
0.998015
0.998428
0.994038
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)

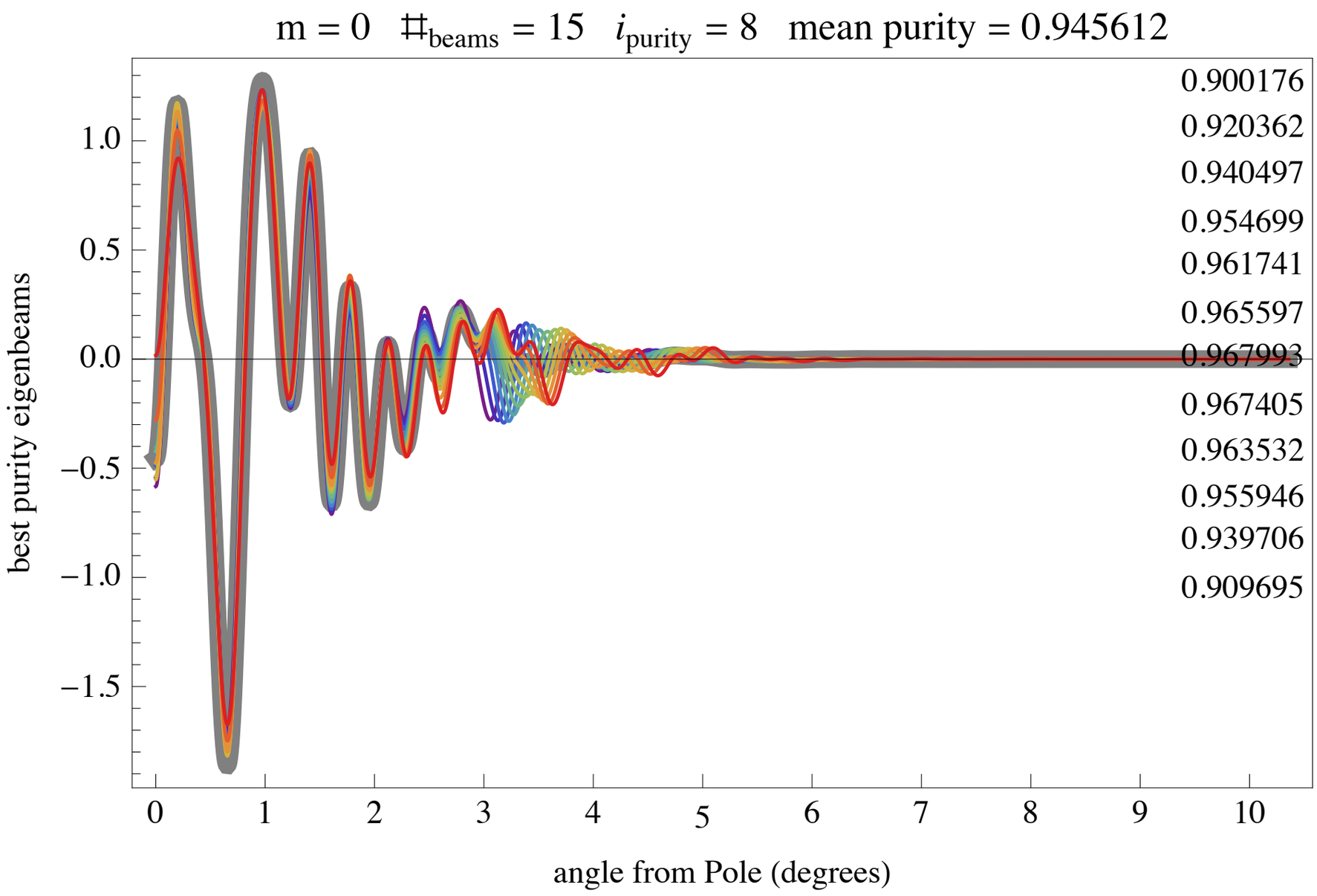

m = 0 ⌗beams = 15 ipurity = 3 mean purity = 0.991735
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
best purity eigenbeams
0.979578
0.986126
0.991449
0.995494
0.998216
0.999584
0.999583
0.998211
0.995483
0.991431
0.986104
0.979566
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)

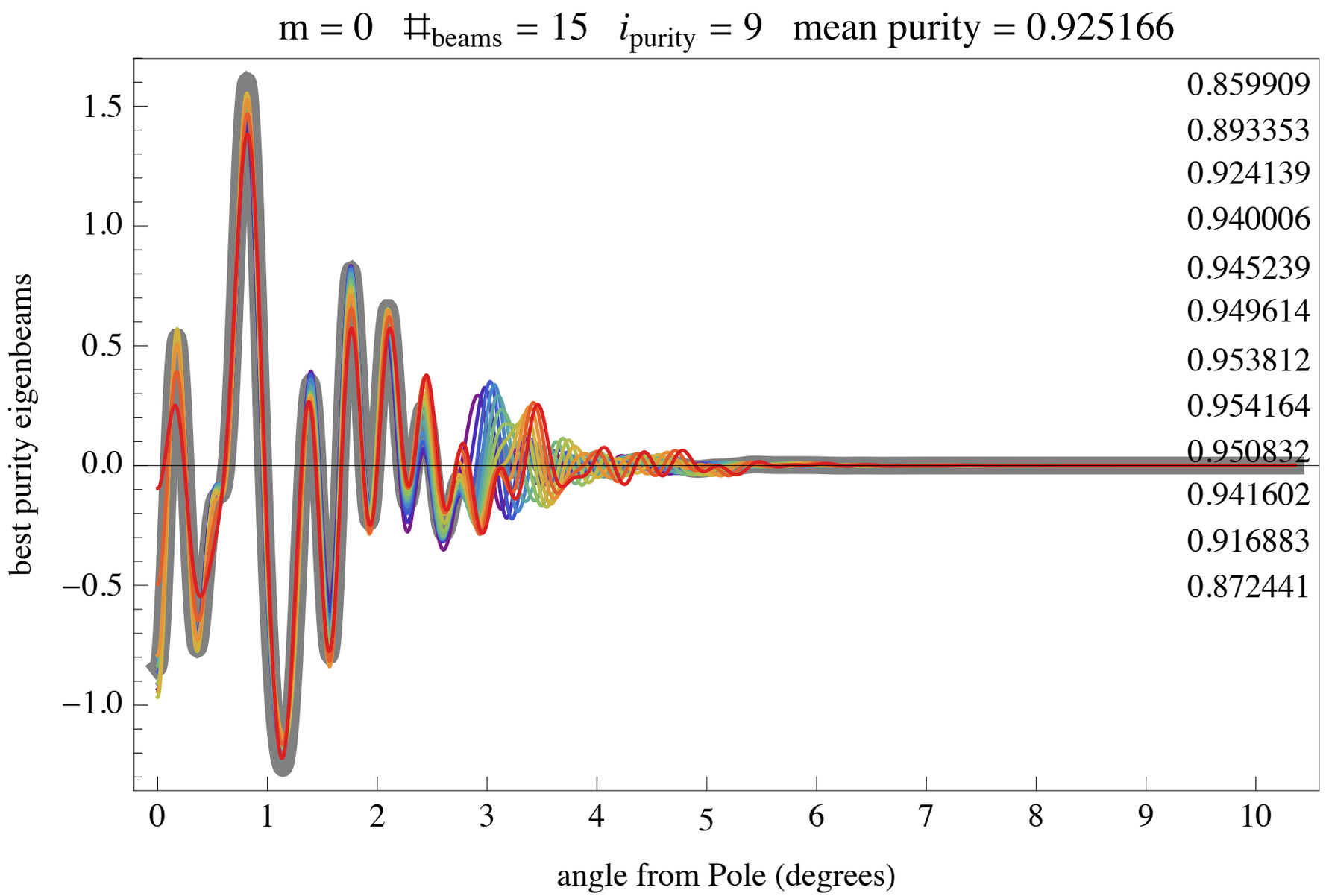

m = 0 ⌗beams = 15 ipurity = 4 mean purity = 0.985826
best purity eigenbeams
2
0
−2
−4
−6
0.97952
0.981025
0.980144
0.981555
0.983594
0.984601
0.985942
0.988471
0.991255
0.993787
0.99431
0.985713
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)

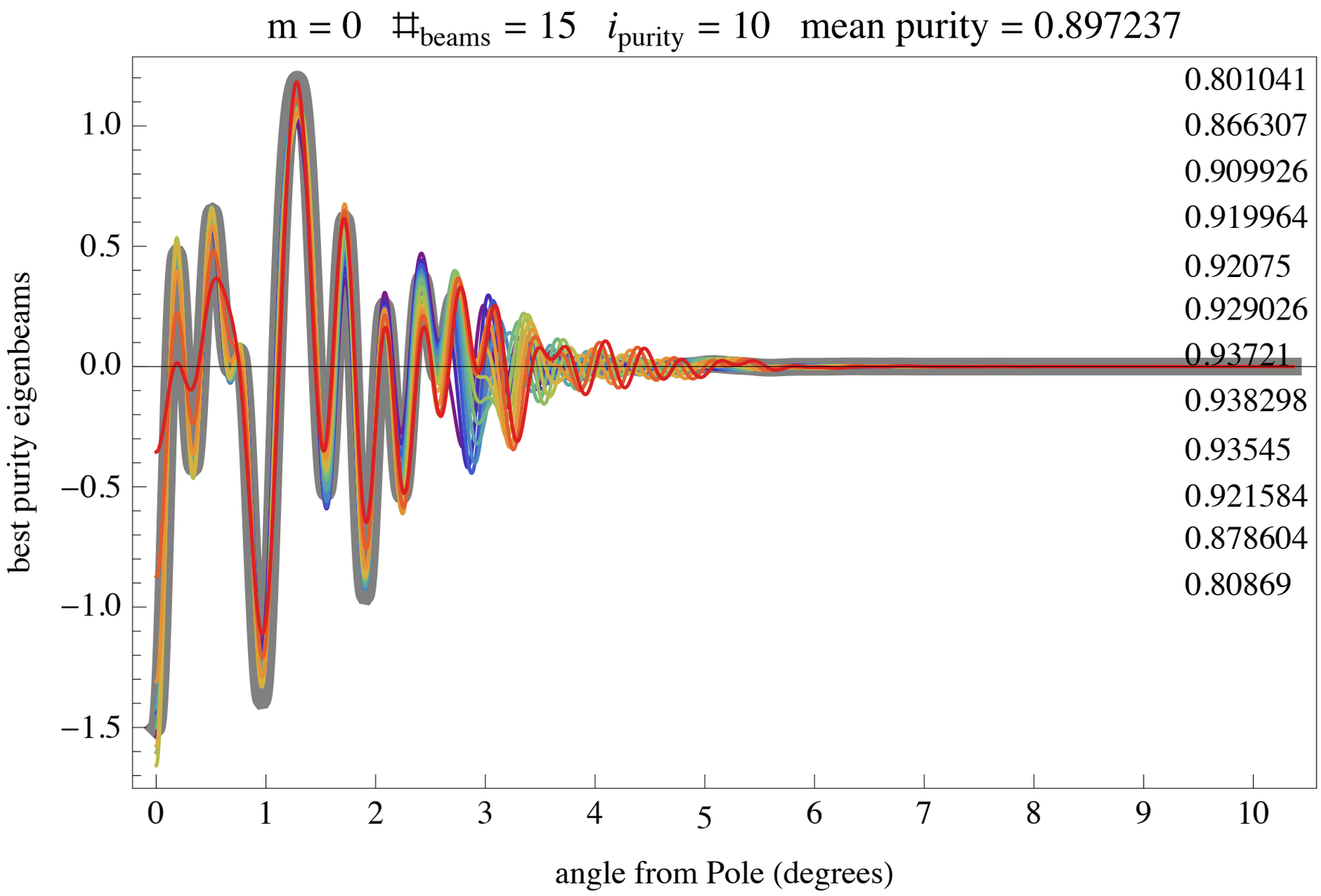

m = 0 ⌗beams = 15 ipurity = 5 mean purity = 0.973961
best purity eigenbeams
angle from Pole (degrees)
0.953074
0.962522
0.970632
0.977855
0.98284
0.985298
0.98592
0.98482
0.981828
0.977048
0.96945
0.956239


m = 0 ⌗beams = 15 ipurity = 6 mean purity = 0.971875
best purity eigenbeams
2
1
0
−1
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)
0.948649
0.958715
0.967327
0.975096
0.980249
0.982764
0.983822
0.983501
0.981422
0.977501
0.969758
0.953698

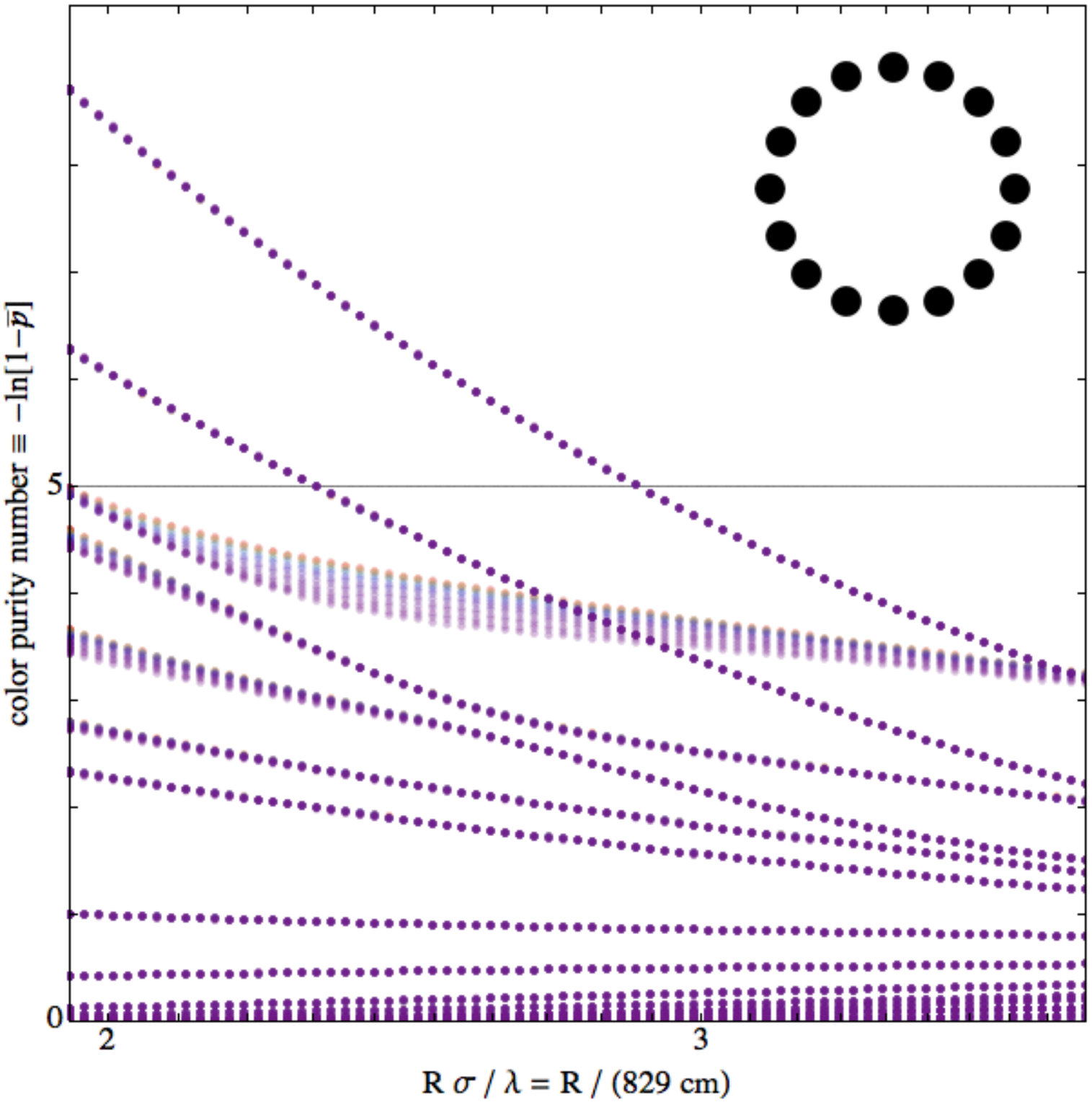

m = 0 ⌗beams = 15 i purity = 7 mean purity = 0.959062
best purity eigenbeams
angle from Pole (degrees)
0.930682
0.942024
0.953705
0.963515
0.969252
0.972179
0.973698
0.973259
0.970625
0.965943
0.956416
0.937452


m = 0 ⌗beams = 15 ipurity = 8 mean purity = 0.945612
best purity eigenbeams
1.0
0.5
0.0
−0.5
−1.0
−1.5
0.900176
0.920362
0.940497
0.954699
0.961741
0.965597
0.967993
0.967405
0.963532
0.955946
0.939706
0.909695
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)

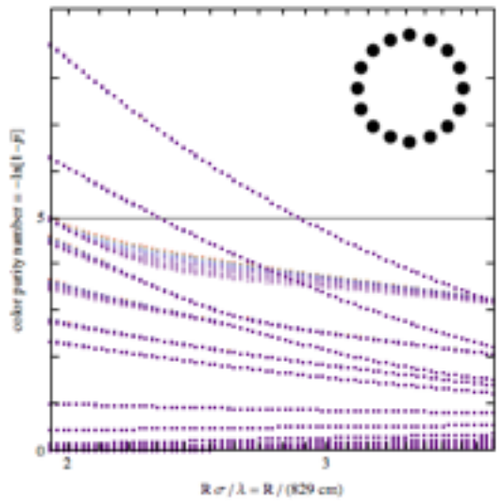

m = 0 ⌗beams = 15 i_{purity} = 9 mean purity = 0.925166
best purity eigenbeams
1.5
1.0
0.5
0.0
−0.5
−1.0
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)
0.859909
0.893353
0.924139
0.940006
0.945239
0.949614
0.953812
0.954164
0.950832
0.941602
0.916883
0.872441


m = 0 ⌗beams = 15 ipurity = 10 mean purity = 0.897237
best purity eigenbeams
1.0
0.5
0.0
−0.5
−1.0
−1.5
0.801041
0.866307
0.909926
0.919964
0.92075
0.929026
0.93721
0.938298
0.93545
0.921584
0.878604
0.80869
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)

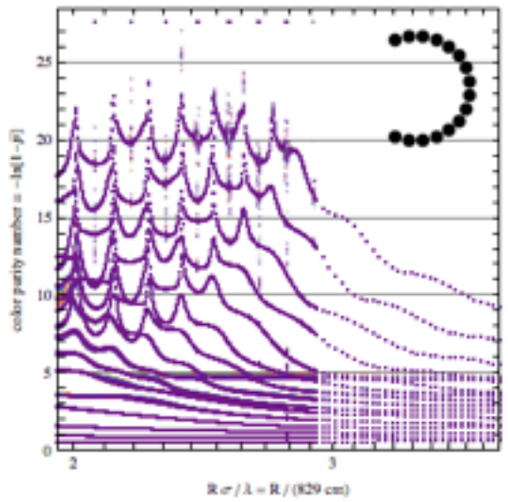
$\#_{\text{dish}} = 16 \quad \#_{\text{split}} = 0 \quad \nu \in [\,700\,,800\,]\ \text{MHz} \quad \text{spaced 630 cm}$



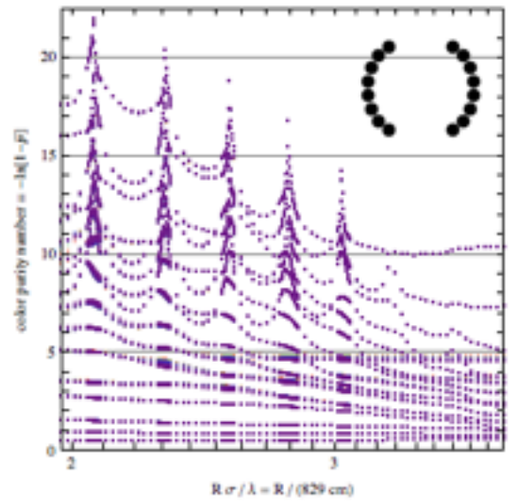
$\#_{dish} = 16$ $\#_{split} = 0$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm



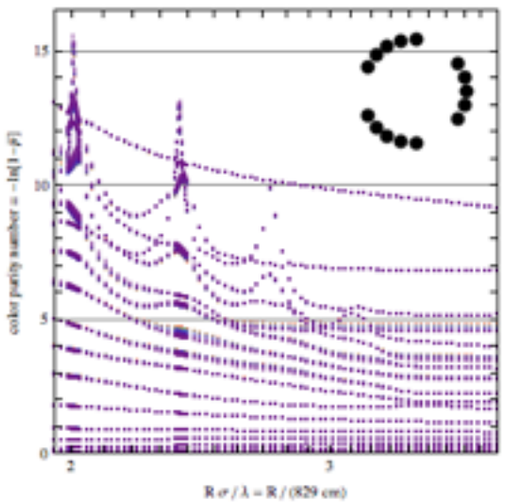
$\#_{dish} = 16$ $\#_{split} = 1$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm



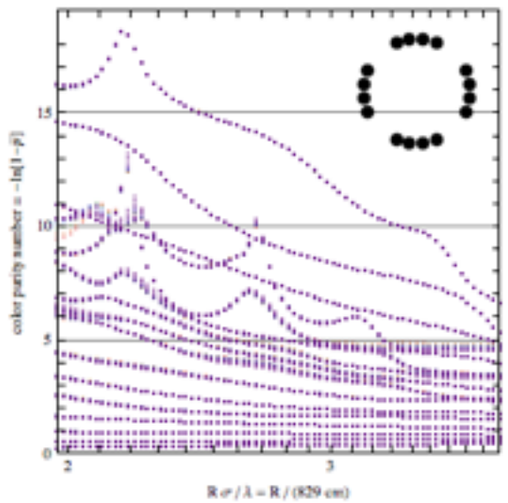
$\#_{dish} = 16$ $\#_{split} = 2$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm



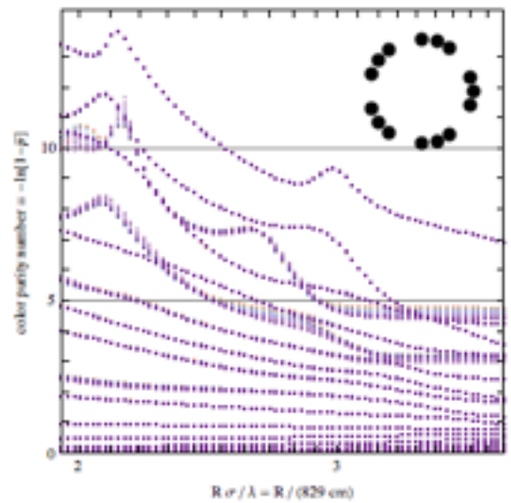
$\#_{dish} = 15$ $\#_{split} = 3$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm



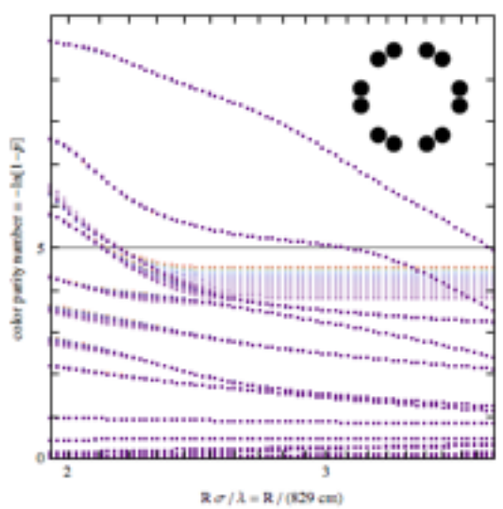
$\#_{dish} = 16$ $\#_{split} = 4$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm



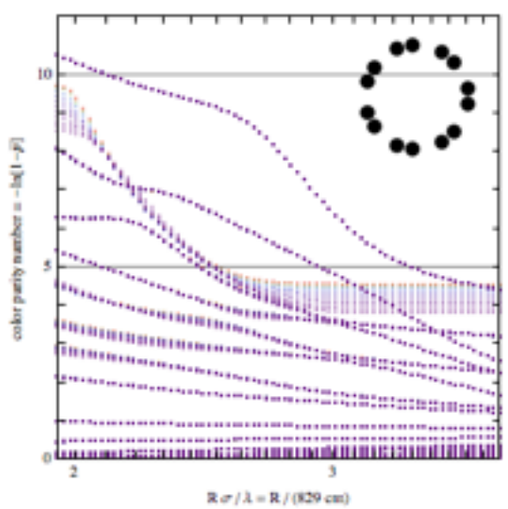
$\#_{dish} = 15$ $\#_{split} = 5$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm



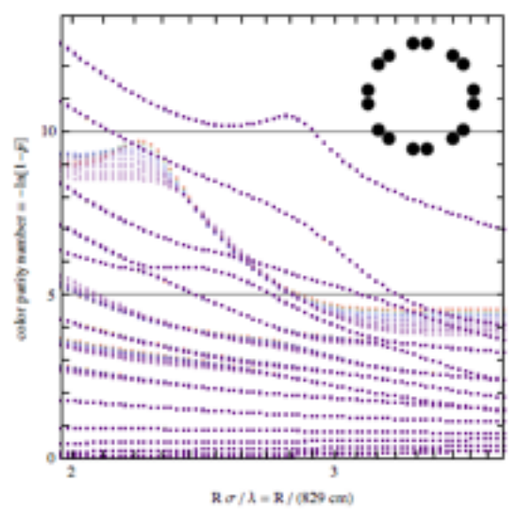
$\#_{dish} = 12$ $\#_{split} = 6$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm

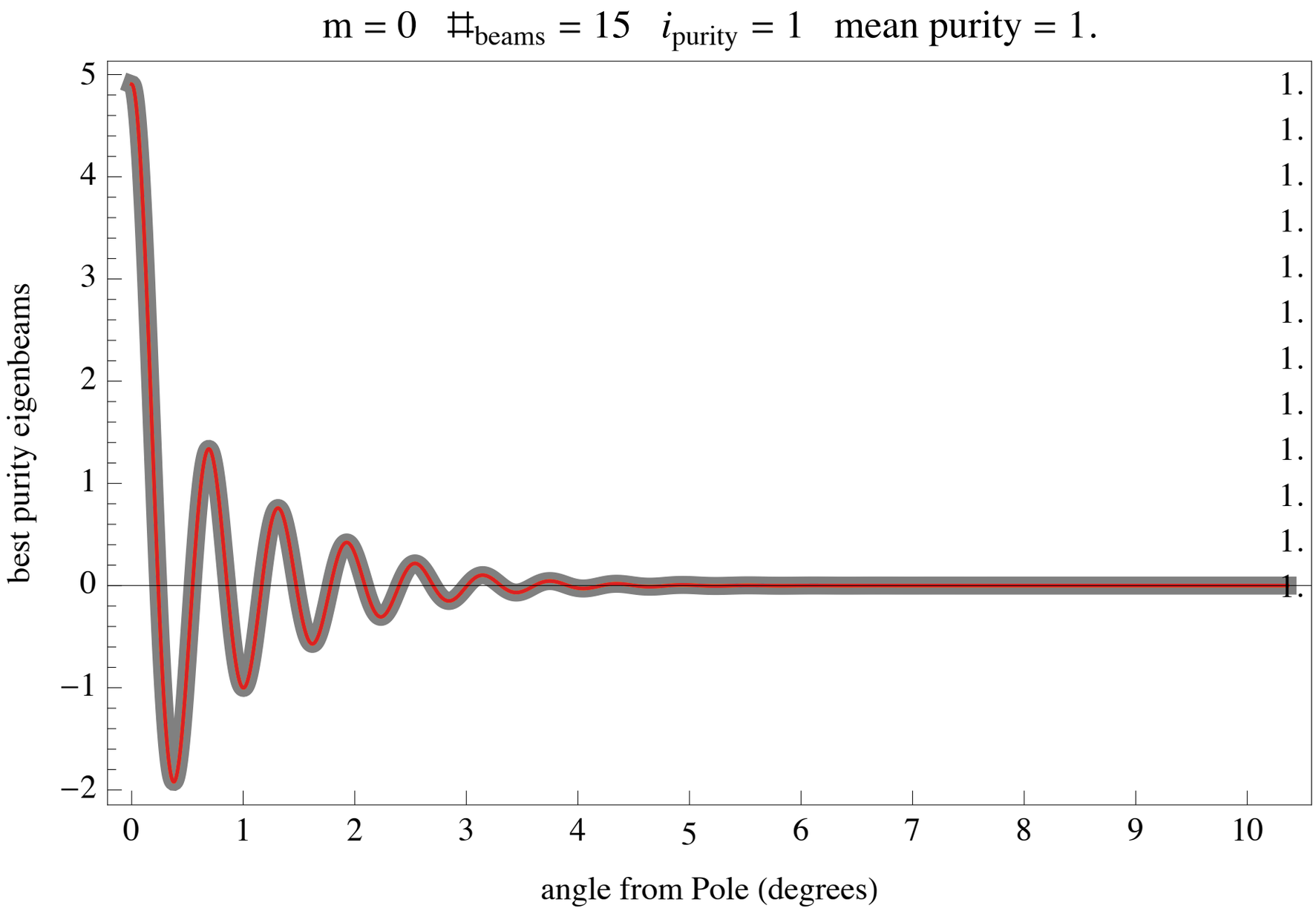


$\#_{dish} = 14$ $\#_{split} = 7$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm

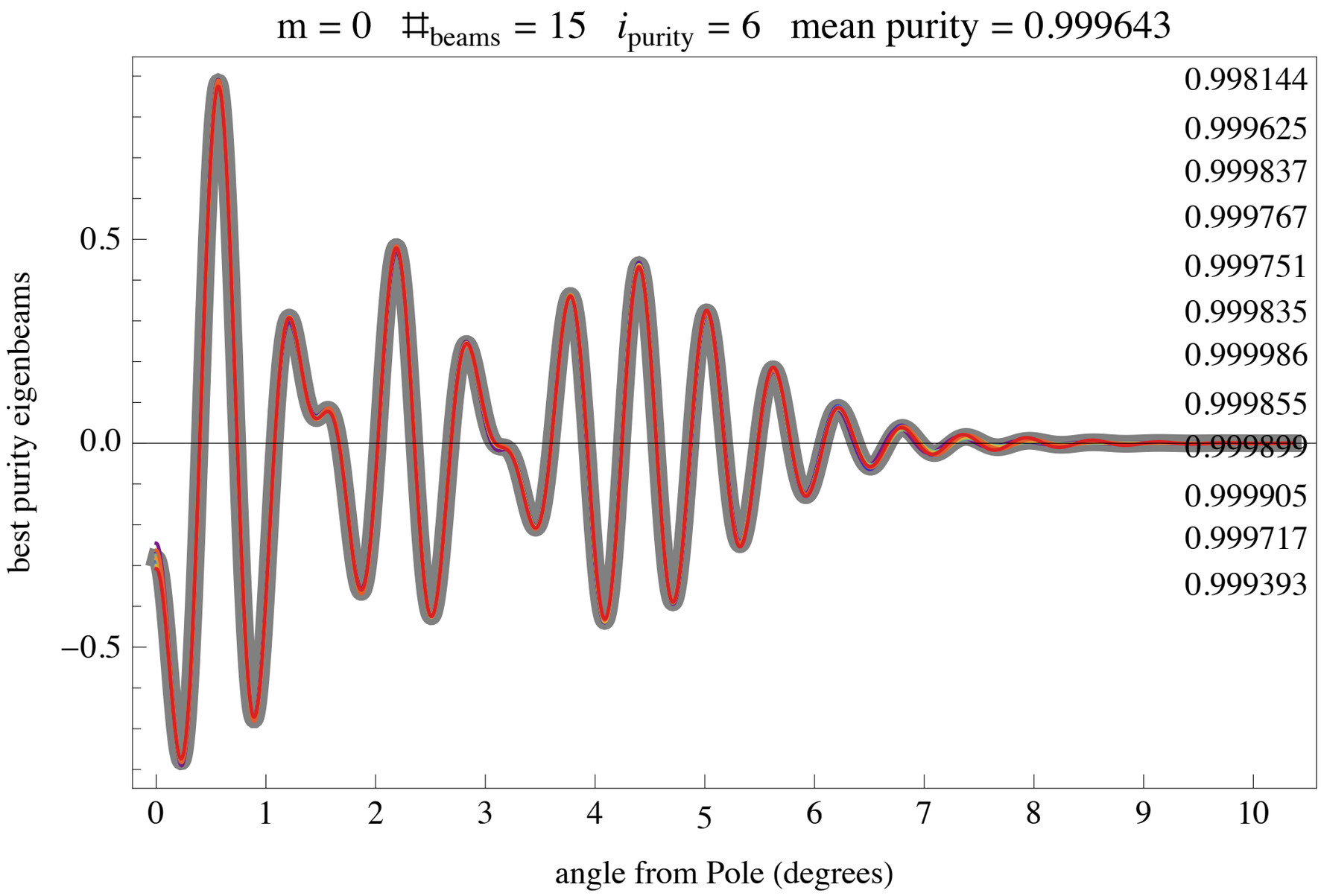


$\#_{dish} = 16$ $\#_{split} = 8$ $\nu \in [\,700\,,\,800\,]$ MHz spaced 630 cm

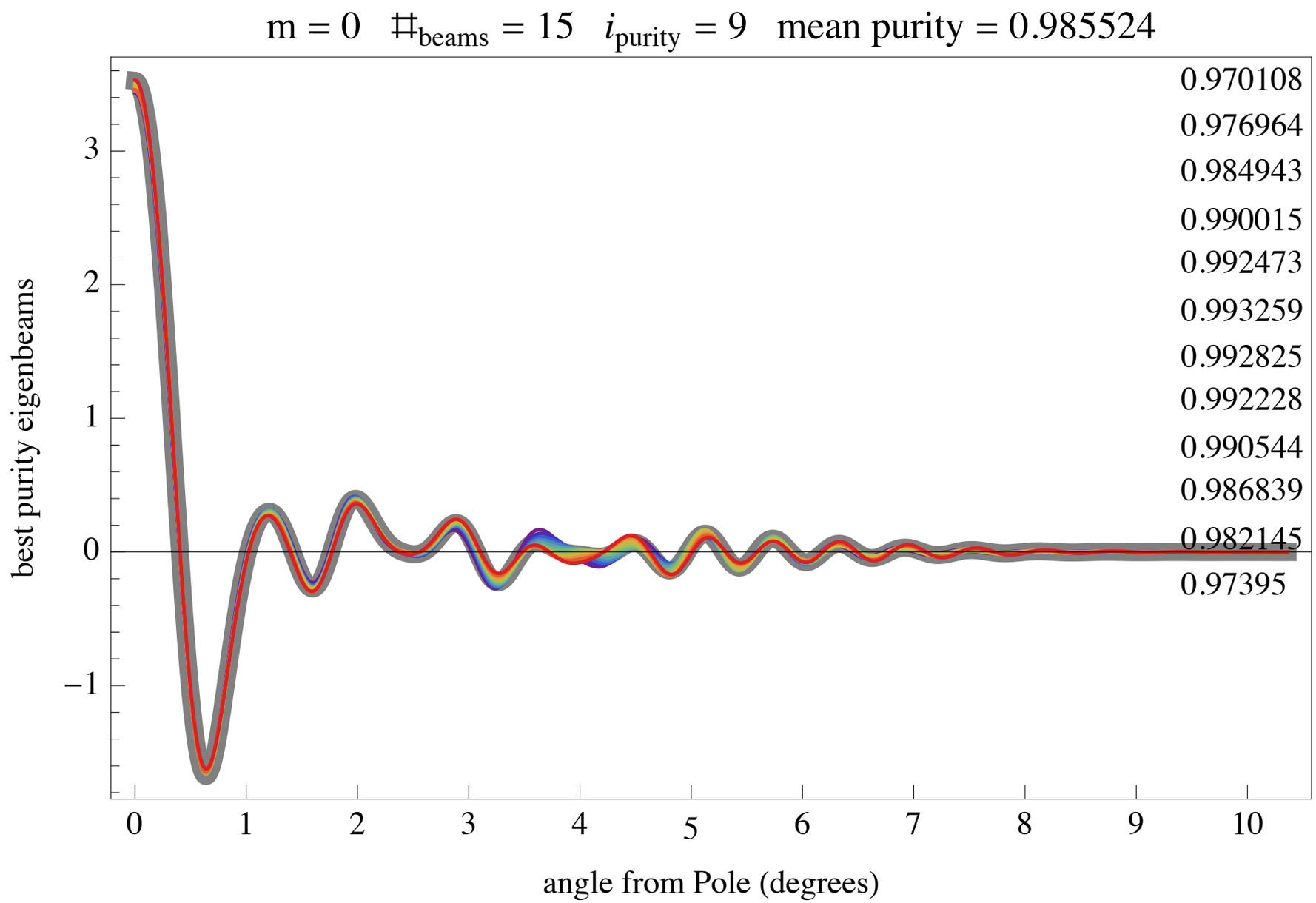


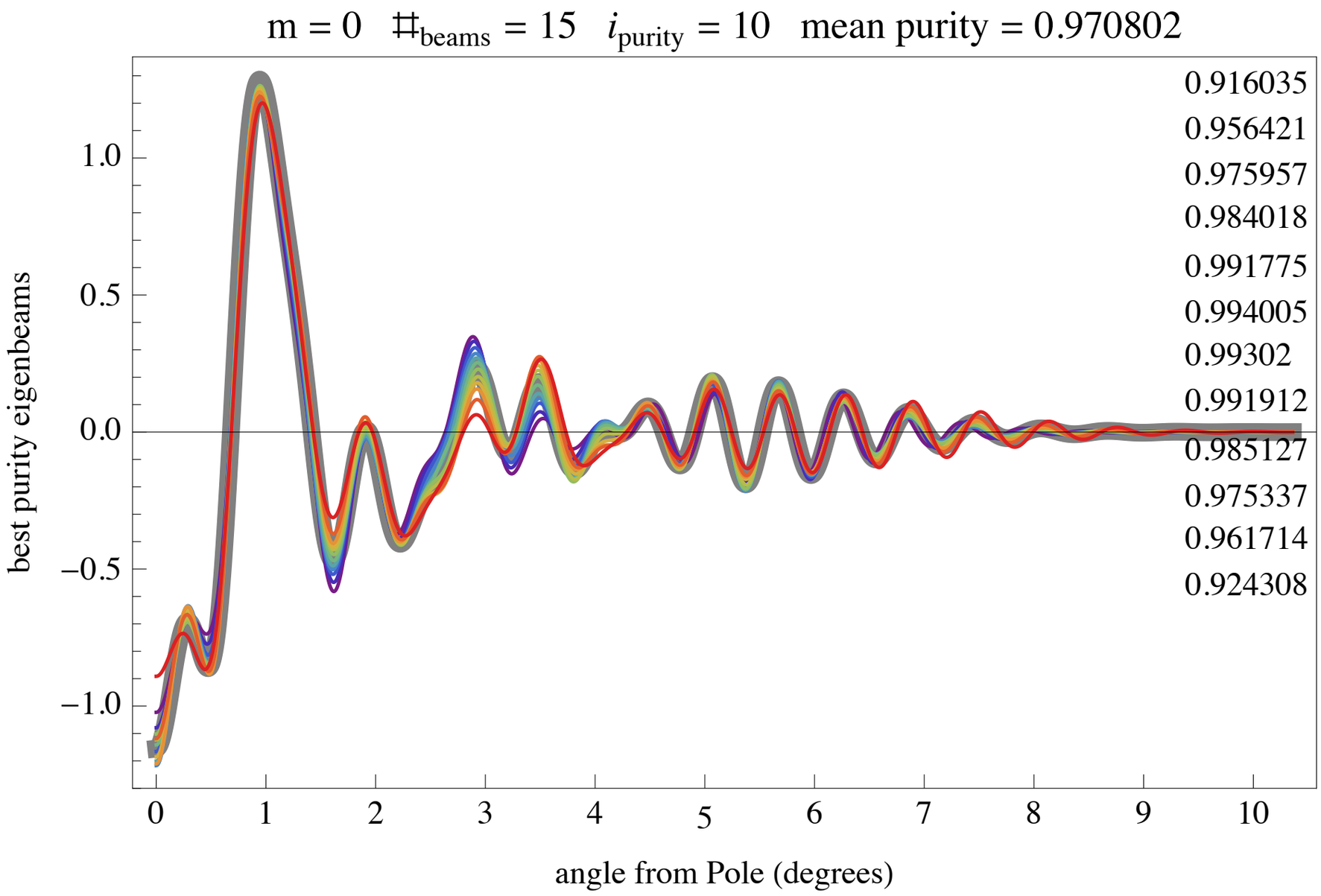

m = 0 ⌗beams = 15 ipurity = 1 mean purity = 1.
best purity eigenbeams
angle from Pole (degrees)
5
4
3
2
1
0
−1
−2
0
1
2
3
4
5
6
7
8
9
10
1.
1.
1.
1.
1.
1.
1.
1.
1.
1.
1.

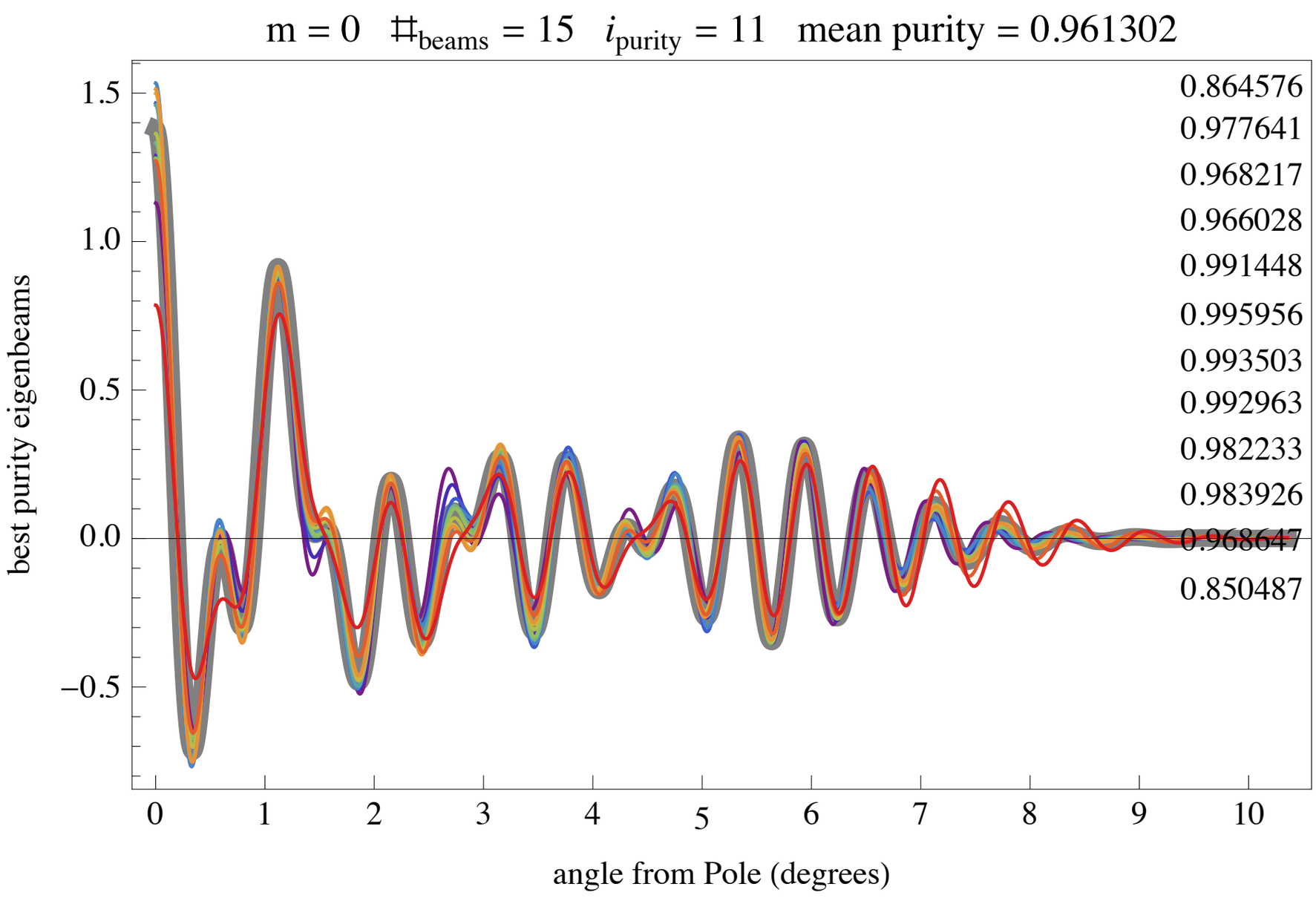
Skip to 6th purity eigenmode



Skip to 9th purity eigenmode




m = 0 ⌗beams = 15 ipurity = 10 mean purity = 0.970802
best purity eigenbeams
1.0
0.5
0.0
−0.5
−1.0
0.916035
0.956421
0.975957
0.984018
0.991775
0.994005
0.99302
0.991912
0.985127
0.975337
0.961714
0.924308
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)


m = 0 ⌗beams = 15 i_{purity} = 11 mean purity = 0.961302
best purity eigenbeams
1.5
1.0
0.5
0.0
−0.5
0.864576
0.977641
0.968217
0.966028
0.991448
0.995956
0.993503
0.992963
0.982233
0.983926
0.968647
0.850487
0
1
2
3
4
5
6
7
8
9
10
angle from Pole (degrees)