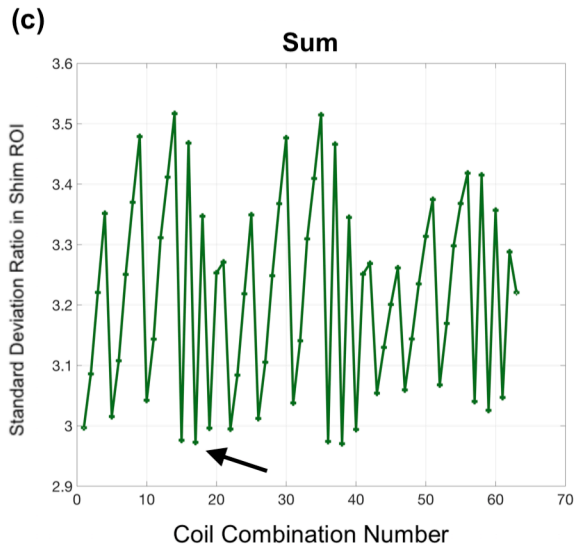
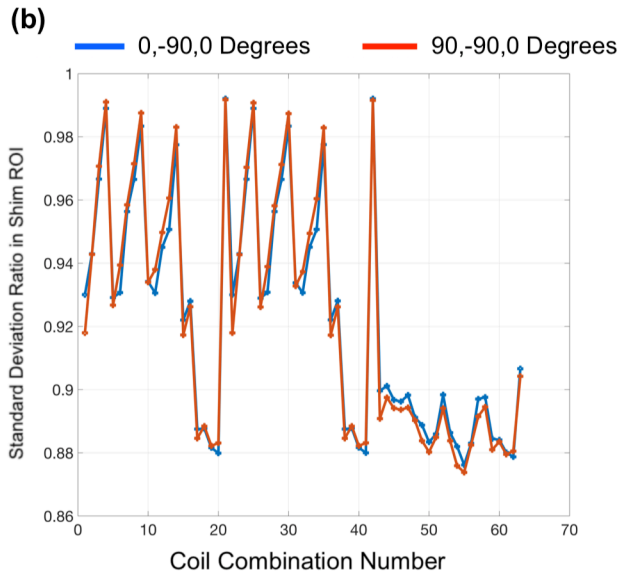
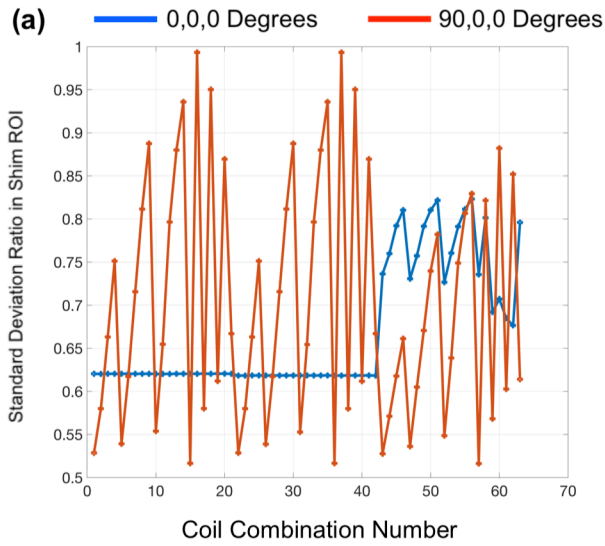


Supporting Information Figure S1

21 CN90 (blue) and 3 CN0 (red) coils considered for the shim optimization in pairs. All coils are shown in the magnet frame in the 0,0,0 orientation. In all coils, the leads were designed such that they were either along the needle's Y = 0 (for CN0) or Z = 0 (for CN90) axes to maintain orthogonality in the body of the needle. This was irrespective of the clearance from the beveled tip that caused some coils to be truncated. Truncation was not required for coils with clearance greater than ~6 mm.



Coil Combination Number	CN0	CN90
1	Flat No Turn Loop	0.5 Turn Flat Loop 2mm From Tip
2	Flat No Turn Loop	0.5 Turn Flat Loop 3mm From Tip
3	Flat No Turn Loop	0.5 Turn Flat Loop 4mm From Tip
4	Flat No Turn Loop	0.5 Turn Flat Loop 5mm From Tip
5	Flat No Turn Loop	1.5 Turn Flat Loop 2mm From Tip
6	Flat No Turn Loop	1.5 Turn Flat Loop 3mm From Tip
7	Flat No Turn Loop	1.5 Turn Flat Loop 4mm From Tip
8	Flat No Turn Loop	1.5 Turn Flat Loop 5mm From Tip
9	Flat No Turn Loop	1.5 Turn Flat Loop 6mm From Tip
10	Flat No Turn Loop	2.5 Turn Flat Loop 2mm From Tip
11	Flat No Turn Loop	2.5 Turn Flat Loop 3mm From Tip
12	Flat No Turn Loop	2.5 Turn Flat Loop 4mm From Tip
13	Flat No Turn Loop	2.5 Turn Flat Loop 5mm From Tip
14	Flat No Turn Loop	2.5 Turn Flat Loop 6mm From Tip
15	Flat No Turn Loop	0.5 Turn Angled Loop 3.85mm From Tip
16	Flat No Turn Loop	1 Turn Angled Loop 3.85mm From Tip
17	Flat No Turn Loop	1.5 Turn Angled Loop 3.85mm From Tip
18	Flat No Turn Loop	2 Turn Angled Loop 3.85mm From Tip
19	Flat No Turn Loop	2.5 Turn Angled Loop 3.85mm From Tip
20	Flat No Turn Loop	3 Turn Angled Loop 3.85mm From Tip
21	Flat No Turn Loop	Flat No Turn Loop 3.85mm From Tip
22	Split Loop	0.5 Turn Flat Loop 2mm From Tip
23	Split Loop	0.5 Turn Flat Loop 3mm From Tip
24	Split Loop	0.5 Turn Flat Loop 4mm From Tip
25	Split Loop	0.5 Turn Flat Loop 5mm From Tip
26	Split Loop	1.5 Turn Flat Loop 2mm From Tip
27	Split Loop	1.5 Turn Flat Loop 3mm From Tip
28	Split Loop	1.5 Turn Flat Loop 4mm From Tip
29	Split Loop	1.5 Turn Flat Loop 5mm From Tip
30	Split Loop	1.5 Turn Flat Loop 6mm From Tip
31	Split Loop	2.5 Turn Flat Loop 2mm From Tip
32	Split Loop	2.5 Turn Flat Loop 3mm From Tip
33	Split Loop	2.5 Turn Flat Loop 4mm From Tip
34	Split Loop	2.5 Turn Flat Loop 5mm From Tip
35	Split Loop	2.5 Turn Flat Loop 6mm From Tip
36	Split Loop	0.5 Turn Angled Loop 3.85mm From Tip
37	Split Loop	1 Turn Angled Loop 3.85mm From Tip
38	Split Loop	1.5 Turn Angled Loop 3.85mm From Tip
39	Split Loop	2 Turn Angled Loop 3.85mm From Tip
40	Split Loop	2.5 Turn Angled Loop 3.85mm From Tip
41	Split Loop	3 Turn Angled Loop 3.85mm From Tip
42	Split Loop	Flat No Turn Loop 3.85mm From Tip
43	1 Turn Angled Loop	0.5 Turn Flat Loop 2mm From Tip
44	1 Turn Angled Loop	0.5 Turn Flat Loop 3mm From Tip
45	1 Turn Angled Loop	0.5 Turn Flat Loop 4mm From Tip
46	1 Turn Angled Loop	0.5 Turn Flat Loop 5mm From Tip
47	1 Turn Angled Loop	1.5 Turn Flat Loop 2mm From Tip
48	1 Turn Angled Loop	1.5 Turn Flat Loop 3mm From Tip
49	1 Turn Angled Loop	1.5 Turn Flat Loop 4mm From Tip
50	1 Turn Angled Loop	1.5 Turn Flat Loop 5mm From Tip
51	1 Turn Angled Loop	1.5 Turn Flat Loop 6mm From Tip
52	1 Turn Angled Loop	2.5 Turn Flat Loop 2mm From Tip
53	1 Turn Angled Loop	2.5 Turn Flat Loop 3mm From Tip
54	1 Turn Angled Loop	2.5 Turn Flat Loop 4mm From Tip
55	1 Turn Angled Loop	2.5 Turn Flat Loop 5mm From Tip
56	1 Turn Angled Loop	2.5 Turn Flat Loop 6mm From Tip
57	1 Turn Angled Loop	0.5 Turn Angled Loop 3.85mm From Tip
58	1 Turn Angled Loop	1 Turn Angled Loop 3.85mm From Tip
59	1 Turn Angled Loop	1.5 Turn Angled Loop 3.85mm From Tip
60	1 Turn Angled Loop	2 Turn Angled Loop 3.85mm From Tip
61	1 Turn Angled Loop	2.5 Turn Angled Loop 3.85mm From Tip
62	1 Turn Angled Loop	3 Turn Angled Loop 3.85mm From Tip
63	1 Turn Angled Loop	Flat No Turn Loop 3.85mm From Tip

Supporting Information Figure S2

Results of shim optimization with 63 coil combinations (3 CN0 and 21 CN90 coils) in 4 orientations. Plots show the ratio of the standard deviation of the field after over before shimming in (a) 0,0,0 and 90,0,0 degree and (b) 0,-90,0 and 90,-90,0 degree needle orientations. (c) Sum of the four ratios and identification of combination 17 (Flat No Turn Loop CN0 and 1.5 Turn Angled Loop CN90, Black Arrow) as the best pair. It can be seen that many coil combinations perform well in certain orientations but fail in others.