NISTIR XXXX Draft

Ongoing Face Recognition Vendor Test (FRVT)

Part 1: Verification

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DISCLAIMER

Specific hardware and software products identified in this report were used in order to perform the evaluations described in this document. In no case does identification of any commercial product, trade name, or vendor, imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products and equipment identified are necessarily the best available for the purpose.

ABOUT THIS REPORT

This report is a draft NIST Interagency Report, and is open for comment. It documents the verification-track of the ongoing Face Recognition Vendor Test. The report will be updated continuously as new algorithms are evaluated, as new datasets are added, and as new analyses are included. Comments and suggestions should be directed to frvt@nist.gov.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

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FMR(T) "False match rate"

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1 News

2017-04-03

- NIST's evaluation of 1:1 algorithms will close on June 14 and reopen around October 2018.
- We expect to produce another edition of this FRVT report in late June.
- NIST's evaluation of 1:N identification algorithms is underway: Phase 1 evaluated 62 algorithms from 29 developers. The deadline for submission of algorithms to Phase 2 is June 21, 2018. The API and concept document is linked from here.

2 Changelog

2018-06-21

- Added results for algorithms from new developers Panasonic, Shenzhen IAIT / CASIA.
- Completed results for algorithms mentioned in the 2018-06-18 update.
- The next report is scheduled for October 2018.

2018-06-18

- Added results for algorithms from new developers Incode, Microfocus, RealNetworks, Visidon.
- Added results for new algorithms from Aware, Any Vision, Cogent, Gorilla, Integrated Systems, Lookman, Megvii / Face++, Ping An, Rank One, Synesis, Tiger IT, Tong Yi Transportation, Visionlabs, Vocord, Yisheng, Yitu.
- For the recent algorithms, some results are in-process and will be added in the next report, scheduled June 2018.
- We are in the process of retiring all results for the selfie and webcam datasets because the genuine pair images were taken on the same day and were thus poorly representative of many operations.
- We are in the process of replacing one wild dataset, with a entirely new, larger, but easier one.
- Given participation totals, performance tables have been split to span multiple pages. This should solve the crowding problem of plotting too many DETs on one graph. Many figures replaced by tiered graphs in which around 20 algorithms of similar accuracy are plotted per page. This gives much better visibility.

2018-04-03

- Added results for some algorithms applied to child exploitation images, including for the most accurate algorithm tested on that dataset so far.

2018-02-15

- Added results for algorithms from new developers Gorilla, Megvii.
- Added results for new algorithms from Dermalog, Neurotechnology, Visionlabs, Vocord.
- Retired results for early algorithms from those suppliers because FRVT lists only the two most recent algorithms per organization.
- Added a column to the FNMR summary Table 4 that gives FNMR for visa photos when FMR is set to 0.0001 for non-zero effort impostors i.e. those of the same sex, age group, and country of origin. This produces markedly higher FNMR over the zero-effort case because rejection of impostors becomes more difficult.

2018-01-24

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- Added results for first algorithms from Gemalto Cogent, Intellivision and Ultinous.
- Added full or partial results for new algorithms from Idemia (Morpho), NTechLab, Shaman, Tevian, and Toshiba, and from Fudan and ITMO universities.
- Added entries for Fudan University which had incorrectly been omitted from Tables 2 and 6.
- Retired results for itmo-001, ntechlab-001, vocord-001, and vigilantsolutions-001 - FRVT lists only the two most recent algorithms per organization.
- Added GPU vs CPU shape designators to the tradeoff summaries in Figures 1 and 2.

2017-12-14

- Added results for algorithms from Aware, RankOne, Shaman, and Tevian.
- Retired results for RankOne-000 - FRVT lists only the two most recent algorithms per organization.
- New description of wild images in section 5.2
- New Figure 59 showing FMR for impostors of same age, sex and worst-case region.

2017-11-16

- Added results for algorithms from 3DiVi, Dermalog, Neurotechnology and Ping An.
- Retired results for 3DiVi-000, dermalog-002, and neurotechnology-000 - FRVT lists only two algorithms per organization.
- Retired results for vcognition-001 as the algorithm was inoperable on at least one dataset.
- Added cross-pose recognition heatmaps for the wild images, Figures 22 and 23.
- Added Figure 26 to compare effect of providing whole vs. face-cropped child exploitation images.

2017-10-03

- Added results for algorithms from 3DiVi, Camvi, Idemia, Noblis, N-TechLab, and Visionlabs.
- Added partial results for two algorithms from Zhuhai Yisheng.
- The ntechlab-000 algorithm has been retired - FRVT lists only two algorithms per organization.
- Corrected fixed FMR operating point in the legends of some DET plots.

2017-08-22

- Added results for three additional algorithms, rankone-002, neurotechnology-001, and itmo-002.
- The algorithms dermalog-001 and rank-001 have been retired - FRVT lists only two algorithms per organization
- The algorithm tupel-001 has been retired as it is not operable on all datasets
- Clarified the tradeoff Figures 1 and 2 plot only genuine comparison durations.
- Corrected image type label in section 4.5

2017-08-07

- Added results for 5 new algorithms
- Added Figure 3 giving simulated example images.
- Added Figure 1 showing an alternative view of the same tradeoff data in Figure 2
- Added Figure **??** showing accuracy on visa images just for low FMR.

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- Added Figure 60 showing impostor distribution shifts from certain country pairs. Section 5.6.1 in this and prior reports documents high false match rates for individuals from certain countries. That effect, however, is often not confined to anomalously high impostor scores in the tails of the distribution, but arises from systematic shifts of the whole distribution. These shifts sometimes reach 2σ.

2017-07-29

- Added results for 8 new algorithms
- Added results for a child-exploitation dataset
- Added Table 4 a standalone tabulation of false non-match rates
- We have received additional CPU algorithms - Results should appear August 4, 2017
- We have received additional GPU algorithms - Results to appear as computational resources are released from the Face Recognition Prize Challenge

2017-06-19

- Added five new algorithms, three of which remain in-process
- Added results for a "wild" dataset of images similar to non-cooperative photojournalism images
- Added Table 6 a standalone tabulation of failure to enrol rates
- Added Fig. 2 showing tradeoff between FNMR, template size, template generation time, and match duration.
- Added Fig. 48 showing how FMR is concentrated in certain images.
- Restated cross-region false match rates at nominal FMR = 0.0001 instead of 0.001
- Improved DET legends.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

	Developer	Short	Seq.	Validation	Config[1]	Template		GPU	Comparison Time (ns)[3]	
	Name	Name	Num.	Date	Data (KB)	Size (B)	Time (ms)[2]		Genuine	Impostor
1	3DiVi	3divi	001	2017-06-22	190867	[68]4096 ± 0	[39]274 ± 47	Yes	[19]636 ± 19	[20]634 ± 16
2	3DiVi	3divi	002	2017-10-20	190867	[70]4096 ± 0	[40]279 ± 48	Yes	[21]692 ± 22	[24]707 ± 26
3	AnyVision	anyvision	002	2018-01-31	662659	[25]1024 ± 0	[33]248 ± 0	No	[78]74069 ± 188	[78]74019 ± 198
4	AnyVision	anyvision	004	2018-06-15	401001	[28]1024 ± 0	[48]355 ± 1	No	[40]1891 ± 51	[39]1829 ± 85
5	Aware	aware	001	2017-10-27	240240	[36]1572 ± 0	[73]656 ± 26	No	[46]2902 ± 51	[46]2810 ± 111
6	Aware	aware	002	2018-06-15	271312	[37]1572 ± 0	[67]582 ± 14	No	[25]810 ± 32	[26]812 ± 28
7	Ayonix	ayonix	000	2017-06-22	58505	[31]1036 ± 0	[1]18 ± 2	No	[16]621 ± 23	[19]620 ± 26
8	Camvi Technologies	camvitech	001	2017-09-13	118759	[29]1024 ± 0	[27]181 ± 6	No	[11]481 ± 16	[13]487 ± 23
9	Gemalto Cogent	cogent	000	2018-01-12	633812	[14]439 ± 0	[59]511 ± 7	No	[59]9541 ± 54	[59]9500 ± 51
10	Gemalto Cogent	cogent	001	2018-05-29	530508	[15]455 ± 0	[63]557 ± 7	No	[62]10477 ± 278	[62]10392 ± 75
11	Cyberextruder	cyberex	001	2017-08-02	121211	[6]256 ± 0	[82]893 ± 25	No	[32]1083 ± 16	[33]1079 ± 19
12	Cyberextruder	cyberex	002	2018-01-30	168909	[43]2048 ± 0	[61]532 ± 6	No	[38]1803 ± 14	[38]1779 ± 22
13	Dermalog	dermalog	004	2017-10-26	0	[3]128 ± 0	[20]149 ± 5	No	[12]490 ± 26	[12]471 ± 26
14	Dermalog	dermalog	005	2018-02-02	0	[2]128 ± 0	[15]130 ± 11	No	[13]499 ± 22	[14]500 ± 22
15	Digital Barriers	barriers	000	2017-05-31	157794	[53]2056 ± 0	[9]104 ± 0	No	[64]13232 ± 166	[64]13226 ± 146
16	Digital Barriers	barriers	001	2017-07-20	236915	[57]2056 ± 0	[42]294 ± 1	No	[63]12311 ± 164	[63]12347 ± 197
17	Fudan University	fudan	000	2017-11-22	202296	[21]534 ± 0	[7]84 ± 0	Yes	[37]1713 ± 28	[37]1715 ± 20
18	Fudan University	fudan	001	2018-01-11	345583	[39]1808 ± 0	[16]131 ± 0	Yes	[34]1288 ± 26	[34]1281 ± 22
19	Glory Ltd	glory	000	2018-06-06	0	[13]418 ± 0	[23]165 ± 2	No	[57]7003 ± 84	[57]6978 ± 71
20	Glory Ltd	glory	001	2018-06-08	0	[38]1726 ± 0	[52]393 ± 2	No	[60]9607 ± 128	[60]9539 ± 182
21	Gorilla Technology	gorilla	000	2018-02-13	98290	[75]4204 ± 0	[35]256 ± 14	No	[50]3875 ± 29	[50]3872 ± 51
22	Gorilla Technology	gorilla	001	2018-05-25	93768	[61]2156 ± 0	[22]160 ± 14	No	[48]3429 ± 145	[49]3288 ± 51
23	ID3 Technology	id3	001	2017-08-04	225574	[19]520 ± 0	[31]238 ± 19	No	[31]1058 ± 32	[32]1049 ± 28
24	ID3 Technology	id3	002	2017-08-04	225574	[18]520 ± 0	[57]482 ± 34	No	[33]1100 ± 59	[31]1048 ± 32
25	Incode Technologies Inc	incode	000	2018-06-01	23697	[26]1024 ± 0	[28]196 ± 9	No	[53]5175 ± 81	[53]4907 ± 77
26	Incode Technologies Inc	incode	001	2018-06-13	155416	[45]2048 ± 0	[58]499 ± 9	No	[56]6154 ± 96	[56]6045 ± 182
27	Innovatrics	innova	001	2017-07-25	0	[11]284 ± 0	[71]645 ± 5	No	[55]5506 ± 131	[54]4975 ± 308
28	Innovatrics	innova	003	2018-06-14	0	[20]530 ± 0	[34]250 ± 0	No	[65]15709 ± 134	[65]15193 ± 292
29	Intellivision	intellivision	001	2017-10-10	43692	[55]2056 ± 0	[4]62 ± 2	No	[44]2573 ± 91	[45]2544 ± 38
30	Is It You	isityou	000	2017-06-26	48010	[81]19200 ± 0	[11]113 ± 5	No	[81]237517 ± 1318	[81]237374 ± 1279
31	Innovation Systems	isystems	000	2018-01-11	209270	[24]1024 ± 0	[21]154 ± 4	No	[9]398 ± 14	[9]396 ± 16
32	Innovation Systems	isystems	001	2018-06-12	274621	[41]2048 ± 0	[41]291 ± 9	No	[14]557 ± 16	[16]564 ± 22
33	ITMO University	itmo	003	2018-01-23	579961	[60]2114 ± 0	[6]79 ± 2	Yes	[61]10038 ± 180	[61]10030 ± 134
34	ITMO University	itmo	004	2018-06-13	487023	[59]2100 ± 0	[55]436 ± 0	Yes	[58]8219 ± 100	[58]8214 ± 130
35	Lookman Electroplast Industries	lookman	002	2018-06-13	138200	[22]548 ± 0	[24]173 ± 1	No	[15]610 ± 19	[18]612 ± 22
36	Megvii/Face++	megvii	000	2018-02-13	1358915	[50]2048 ± 0	[77]785 ± 0	No	[67]19816 ± 158	[68]19805 ± 174
37	Megvii/Face++	megvii	001	2018-06-15	1361523	[48]2048 ± 0	[62]543 ± 0	No	[54]5228 ± 32	[55]5252 ± 60
38	Microfocus	microfocus	000	2018-06-13	103483	[9]256 ± 0	[37]263 ± 18	No	[1]202 ± 5	[1]203 ± 7
39	MicroFocus	microfocus	001	2018-06-13	104524	[8]256 ± 0	[38]264 ± 18	No	[2]215 ± 8	[2]217 ± 10
40	Idemia	Idemia	000	2017-07-11	100806	[1]116 ± 0	[10]109 ± 1	No	[30]993 ± 31	[30]1000 ± 34
41	Idemia	Idemia	002	2017-12-28	383021	[12]352 ± 0	[54]411 ± 7	No	[49]3620 ± 94	[44]2481 ± 65
42	Neurotechnology	neurotech	002	2017-11-02	280771	[63]2718 ± 0	[66]581 ± 6	No	[76]68738 ± 748	[76]68905 ± 993
43	Neurotechnology	neurotech	003	2018-02-02	339962	[77]5214 ± 0	[65]580 ± 5	No	[77]73589 ± 2548	[77]72837 ± 1546
44	Noblis	noblis	000	2017-07-05	713573	[32]1061 ± 0	[25]174 ± 20	Yes	[35]1343 ± 45	[35]1373 ± 56

Notes	
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2	The median template creation times are measured on Intel®Xeon®CPU E5-2630 v4 @ 2.20GHz processors or, for GPU-enabled implementations, NVidia Tesla K40.
3	The comparison durations, in nanoseconds, are estimated using std::chrono::high_resolution_clock which on the machine in (2) counts 1ns clock ticks. Precision is somewhat worse than that however. The ± value is the median absolute deviation times 1.48 for Normal consistency.

Table 1: Summary of algorithms and properties included in this report. The red superscripts give ranking for the quantity in that column.

	Developer	Short	Seq.	Validation	Config[1]	Template		GPU	Comparison Time (ns)[3]	
	Name	Name	Num.	Date	Data (KB)	Size (B)	Time (ms)[2]		Genuine	Impostor
45	N-Tech Lab	ntech	003	2017-12-29	1422738	[64] 2906 ± 1	[14] 128 ± 3	Yes	[70] 35327 ± 117	[70] 35371 ± 123
46	N-Tech Lab	ntech	004	2018-06-14	3752378	[65] 3482 ± 1	[78] 818 ± 11	No	[74] 38929 ± 81	[75] 38916 ± 111
47	Ping An Technology	Pingan	002	2017-09-25	442564	[80] 18436 ± 0	[17] 132 ± 7	Yes	[47] 3088 ± 32	[48] 3051 ± 28
48	Ping An Technology	Pingan	003	2017-05-25	714102	[46] 2048 ± 0	[80] 831 ± 31	No	[29] 962 ± 23	[29] 914 ± 38
49	Panasonic (SG)	psl	000	2018-06-18	260619	[49] 2048 ± 0	[70] 629 ± 11	No	[3] 280 ± 17	[3] 280 ± 17
50	Rank One Computing	rankone	003	2017-11-28	0	[5] 228 ± 0	[2] 37 ± 1	No	[4] 322 ± 20	[5] 324 ± 19
51	Rank One Computing	rankone	004	2018-06-12	0	[4] 133 ± 0	[5] 78 ± 1	No	[5] 340 ± 19	[4] 298 ± 17
52	Realnetworks Inc	realnetworks	000	2018-05-30	99044	[72] 4100 ± 0	[19] 144 ± 2	No	[43] 2458 ± 26	[43] 2467 ± 35
53	Samtech InfoNet Limited	samtech	000	2017-05-02	109774	[56] 2056 ± 0	[36] 262 ± 2	No	[52] 4550 ± 26	[52] 4541 ± 28
54	Shaman Software	shaman	000	2017-12-05	0	[69] 4096 ± 0	[72] 653 ± 16	No	[8] 380 ± 25	[7] 379 ± 31
55	Shaman Software	shaman	001	2018-01-13	0	[67] 4096 ± 0	[43] 294 ± 2	No	[18] 635 ± 19	[10] 441 ± 25
56	Shenzhen Inst. Adv. Integrated Tech. CASIA	SIAT	002	2018-06-13	486842	[52] 2052 ± 0	[64] 579 ± 0	No	[23] 769 ± 13	[25] 750 ± 13
57	Smilart	smilart	002	2018-02-06	111826	[27] 1024 ± 0	[26] 176 ± 16	No	[66] 18784 ± 136	[67] 18795 ± 151
58	Smilart	smilart	003	2018-06-18	576089	[44] 2048 ± 0	[46] 307 ± 16	No	[69] 30528 ± 237	[69] 30487 ± 298
59	Synesis	synesis	000	2018-02-09	340264	[17] 512 ± 0	[12] 117 ± 0	No	[24] 775 ± 206	[17] 568 ± 48
60	Synesis	synesis	001	2018-05-31	340264	[16] 512 ± 0	[13] 122 ± 0	No	[27] 828 ± 182	[23] 698 ± 44
61	Tevian	tevian	001	2018-01-19	682319	[42] 2048 ± 0	[32] 245 ± 13	No	[6] 350 ± 22	[6] 327 ± 13
62	Tevian	tevian	002	2018-06-14	724437	[51] 2049 ± 0	[44] 298 ± 15	No	[7] 369 ± 16	[8] 386 ± 25
63	TigerIT Americas LLC	tiger	001	2018-01-23	171041	[78] 8632 ± 0	[47] 312 ± 12	No	[80] 98339 ± 34	[80] 98327 ± 32
64	TigerIT Americas LLC	tiger	002	2018-06-13	341638	[54] 2056 ± 0	[53] 393 ± 20	No	[41] 2135 ± 29	[41] 2137 ± 38
65	TongYi Transportation Technology	tongyi	002	2017-07-15	625336	[58] 2058 ± 0	[49] 356 ± 35	No	[68] 29816 ± 281	[66] 17799 ± 127
66	TongYi Transportation Technology	tongyi	003	2018-05-15	1769974	[76] 4386 ± 0	[56] 468 ± 0	No	[75] 61793 ± 154	[73] 37122 ± 155
67	Toshiba	toshiba	000	2018-01-11	3893310	[40] 1812 ± 0	[60] 528 ± 3	Yes	[42] 2255 ± 60	[42] 2251 ± 53
68	Toshiba	toshiba	001	2018-01-11	3893310	[62] 2580 ± 0	[68] 615 ± 3	Yes	[45] 2900 ± 80	[47] 2881 ± 60
69	Ultinous	ultinous	000	2017-12-18	90803	[71] 4100 ± 0	[3] 53 ± 0	Yes	[51] 4263 ± 50	[51] 4262 ± 42
70	Ultinous	ultinous	001	2018-02-02	403572	[79] 12304 ± 0	[29] 200 ± 0	Yes	[72] 36357 ± 223	[72] 36332 ± 210
71	VCognition	vcog	002	2017-06-12	3229434	[82] 61504 ± 5	[50] 357 ± 25	No	[82] 296154 ± 3077	[82] 296436 ± 4183
72	Visidon	visidon	000	2018-06-13	213686	[30] 1028 ± 0	[18] 134 ± 3	No	[36] 1467 ± 19	[36] 1456 ± 16
73	Vigilant Solutions	vigilant	003	2018-01-23	343048	[35] 1548 ± 0	[79] 824 ± 3	No	[17] 634 ± 19	[21] 638 ± 17
74	Vigilant Solutions	vigilant	004	2018-06-14	343048	[34] 1548 ± 0	[81] 837 ± 6	No	[20] 686 ± 14	[22] 688 ± 17
75	VisionLabs	visionlabs	003	2018-02-02	639849	[10] 260 ± 0	[30] 231 ± 5	No	[10] 439 ± 23	[11] 454 ± 20
76	VisionLabs	visionlabs	004	2018-06-15	313016	[7] 256 ± 0	[45] 304 ± 0	No	[26] 827 ± 26	[27] 865 ± 32
77	Vocord	vocord	002	2017-06-07	918292	[33] 1330 ± 0	[76] 782 ± 36	Yes	[79] 83063 ± 517	[79] 83072 ± 714
78	Vocord	vocord	004	2018-06-15	1754886	[23] 896 ± 0	[69] 619 ± 1	Yes	[39] 1885 ± 66	[40] 1889 ± 71
79	Zhuhai Yisheng Electronics Technology	yisheng	001	2017-08-17	120112	[47] 2048 ± 0	[8] 103 ± 1	Yes	[28] 906 ± 31	[28] 905 ± 25
80	Zhuhai Yisheng Electronics Technology	yisheng	004	2018-06-12	486351	[66] 3704 ± 0	[51] 378 ± 12	No	[22] 693 ± 137	[15] 526 ± 34
81	Shanghai Yitu Technology	yitu	000	2017-05-23	2211068	[73] 4130 ± 0	[74] 672 ± 2	No	[71] 35352 ± 114	[74] 37848 ± 1773
82	Shanghai Yitu Technology	yitu	001	2018-06-12	2069440	[74] 4146 ± 0	[75] 751 ± 0	No	[73] 37810 ± 127	[71] 35486 ± 203

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Table 2: Summary of algorithms and properties included in this report. The red superscripts give ranking for the quantity in that column.

		FALSE NON-MATCH RATE (FNMR)															
	Algorithm	CONSTRAINED, COOPERATIVE										LESS CONSTRAINED, NON-COOPERATIVE					
	Name	VISA		VISA		VISAMC		MUGSHOT		WEBCAM		SELFIE		WILD		CHILD EXP	
	FMR	1E-06		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.01	
1	3divi-001	0.154	43	0.020	29	0.078	36	0.026	37	0.001	14	0.046	26	0.096	33	0.549	4
2	3divi-002	0.154	42	0.021	30	0.079	37	0.029	40	0.001	17	0.049	31	0.107	36	0.561	5
3	anyvision-002	0.090	32	0.039	46	0.066	33	0.030	41	0.012	32	0.075	37	-	48	0.696	20
4	anyvision-004	0.038	12	0.008	11	0.027	15	0.015	11	-	67	-	67	0.046	6	-	68
5	aware-001	0.309	60	0.054	55	0.197	62	0.042	56	0.004	23	0.046	27	-	73	0.952	45
6	aware-002	0.320	61	0.058	57	0.195	61	0.026	35	-	51	-	51	0.097	34	-	51
7	ayonix-000	0.487	71	0.230	76	0.435	74	0.306	74	0.172	45	0.360	46	-	69	0.843	41
8	camvi-001	0.538	74	0.183	74	0.382	73	0.321	75	0.106	43	0.268	45	-	63	0.763	33
9	cogent-000	0.084	29	0.012	18	0.043	25	0.015	10	0.001	12	0.014	8	0.072	24	0.759	31
10	cogent-001	0.039	13	0.006	7	0.018	8	0.014	4	-	71	-	71	0.080	26	-	72
11	cyberextruder-001	0.255	55	0.076	63	0.197	63	0.162	71	0.029	39	0.144	41	-	61	0.780	38
12	cyberextruder-002	0.134	38	0.027	36	0.081	39	0.038	51	0.010	28	0.023	15	0.097	35	0.610	10
13	dermalog-004	0.240	53	0.093	67	0.181	57	0.127	69	0.016	34	0.121	40	-	60	0.960	46
14	dermalog-005	0.182	47	0.066	59	0.153	51	0.069	63	0.027	38	0.072	36	0.081	27	0.684	15
15	digitalbarriers-000	0.463	70	0.161	71	0.368	71	0.181	72	0.045	42	0.170	42	-	59	0.771	35
16	digitalbarriers-001	0.502	73	0.155	70	0.468	78	0.038	49	0.029	40	0.115	38	-	50	0.731	24
17	fdu-000	0.058	23	0.016	25	0.039	24	0.017	21	0.001	16	0.009	4	0.113	37	0.706	22
18	fdu-001	0.044	16	0.017	26	0.035	21	0.020	27	0.001	10	0.014	9	0.078	25	0.657	12
19	glory-000	0.129	37	0.051	53	0.109	46	0.129	70	-	72	-	72	0.468	45	-	73
20	glory-001	0.108	35	0.041	47	0.090	42	0.093	67	-	62	-	62	0.418	44	-	63
21	gorilla-000	0.141	41	0.023	33	0.080	38	0.074	65	0.249	46	0.187	43	-	82	0.969	48
22	gorilla-001	0.076	27	0.016	24	0.049	28	0.026	36	-	61	-	61	0.055	14	-	62
23	id3-001	0.250	54	0.063	58	0.170	53	0.032	43	0.002	19	0.040	21	-	62	0.688	18
24	id3-002	0.239	52	0.057	56	0.161	52	0.029	39	0.003	21	0.037	17	-	49	0.686	17
25	incode-000	0.103	34	0.038	45	0.077	35	0.024	30	-	82	-	82	0.066	21	-	81
26	incode-001	0.077	28	0.029	37	0.055	30	0.016	19	-	79	-	79	0.061	16	-	80
27	innovatrics-001	0.183	48	0.034	42	0.108	45	0.039	52	0.001	13	0.043	23	-	51	0.815	40
28	innovatrics-003	0.048	20	0.012	19	0.035	22	0.018	22	-	68	-	68	0.134	39	-	69
29	intellivision-001	0.221	51	0.042	48	0.133	50	0.033	44	0.021	36	0.066	35	-	56	0.777	36
30	isityou-000	0.703	78	0.414	79	0.568	79	0.677	80	0.690	48	-	49	-	47	-	49
31	isystems-000	0.179	46	0.043	49	0.127	49	0.060	62	0.008	27	0.049	30	-	72	0.736	25
32	isystems-001	0.025	6	0.007	8	0.015	5	0.014	9	-	65	-	65	0.052	11	-	66
33	itmo-003	0.140	40	0.020	28	0.075	34	0.019	25	0.000	4	0.017	12	0.062	17	0.599	9
34	itmo-004	0.054	21	0.007	10	0.025	14	0.014	7	-	58	-	58	0.043	3	-	59
35	lookman-002	0.055	22	0.010	16	0.030	19	0.018	24	-	56	-	56	0.263	43	-	57
36	megvii-000	0.025	7	0.005	6	0.016	7	0.014	8	0.000	7	0.006	3	-	80	0.477	2
37	megvii-001	0.024	5	0.004	5	0.016	6	0.030	42	-	63	-	63	0.089	32	-	64
38	microfocus-000	0.562	77	0.249	78	0.466	77	0.391	78	-	81	-	81	0.255	42	-	82
39	microfocus-001	0.552	76	0.231	77	0.448	76	0.347	77	-	70	-	70	0.245	41	-	71
40	morpho-000	0.134	39	0.026	35	0.102	43	0.025	34	0.007	26	0.012	6	-	68	0.846	42
41	morpho-002	0.068	26	0.009	14	0.038	23	0.015	17	0.000	6	0.006	2	-	79	0.631	11
42	neurotechnology-002	0.166	45	0.036	43	0.112	47	0.037	48	0.000	9	0.020	14	0.063	18	0.683	14
43	neurotechnology-003	0.088	30	0.018	27	0.062	31	0.023	29	0.000	1	0.017	11	0.065	19	0.691	19
44	noblis-000	0.542	75	0.212	75	0.442	75	0.347	76	0.153	44	0.239	44	-	70	0.757	30
45	ntechlab-003	0.039	14	0.011	17	0.029	18	0.016	18	0.003	20	0.014	10	0.045	5	0.433	1
46	ntechlab-004	0.013	3	0.003	1	0.009	2	0.013	3	-	75	-	75	0.043	2	-	76
47	pa-002	0.286	58	0.086	66	0.185	58	0.038	50	0.010	29	0.043	25	-	77	0.722	23
48	pa-003	0.068	25	0.023	34	0.045	27	0.047	59	-	64	-	64	0.116	38	-	65
49	psl-000	0.033	10	0.014	22	0.022	10	0.015	16	-	55	-	55	0.057	15	-	56
50	rankone-003	0.184	49	0.038	44	0.117	48	0.024	31	0.000	8	0.040	22	-	66	0.777	37

Table 3: FNMR is the proportion of mated comparisons below a threshold set to achieve the FMR given in the header on the fourth row. FMR is the proportion of impostor comparisons at or above that threshold. The green column applies to impostors of the same sex, age group, and country of birth. All other columns use fully zero effort impostors Note that the webcam and selfie values apply to images collected on the same day, and that will often yield optimisticlly low FNMR values.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

		FALSE NON-MATCH RATE (FNMR)															
	Algorithm	CONSTRAINED, COOPERATIVE										LESS CONSTRAINED, NON-COOPERATIVE					
	Name	VISA		VISA		VISAMC		MUGSHOT		WEBCAM		SELFIE		WILD		CHILD EXP	
	FMR	1E-06		0.0001		0.0001		0.0001		0.0001		0.0001		0.0001		0.01	
51	rankone-004	0.102	33	0.015	23	0.055	29	0.017	20	-	52	-	52	0.083	28	-	52
52	realnetworks-000	0.046	18	0.012	20	0.032	20	0.020	28	-	53	-	53	0.048	7	-	53
53	samtech-000	0.443	68	0.161	72	0.342	70	0.040	54	0.021	37	0.063	34	-	75	0.765	34
54	shaman-000	0.977	80	0.913	81	0.930	81	0.968	82	0.992	49	0.997	48	-	54	0.962	47
55	shaman-001	0.462	69	0.136	68	0.335	69	0.080	66	0.030	41	0.115	39	-	71	0.899	43
56	siat-002	0.013	2	0.004	4	0.009	3	0.014	5	-	74	-	74	0.051	10	-	75
57	smilart-002	0.353	65	0.082	65	0.244	66	0.094	68	-	80	-	80	-	81	0.700	21
58	smilart-003	-	81	-	82	-	82	0.060	61	-	73	-	73	-	76	-	74
59	synesis-000	0.324	62	0.045	50	0.175	54	0.037	47	0.021	35	0.063	32	-	52	-	54
60	synesis-001	-	82	0.046	51	0.178	55	0.040	53	-	76	-	76	1.000	78	-	77
61	tevian-001	0.127	36	0.033	41	0.081	40	0.018	23	0.002	18	0.006	1	0.084	29	0.598	8
62	tevian-002	0.039	15	0.008	12	0.028	16	0.015	13	-	50	-	50	0.049	8	-	50
63	tiger-001	0.397	66	0.137	69	0.312	68	0.522	79	0.015	33	0.046	28	0.690	46	0.586	6
64	tiger-002	0.089	31	0.023	32	0.066	32	0.024	32	-	54	-	54	0.049	9	-	55
65	tongyitrans-002	0.066	24	0.030	38	0.044	26	0.035	45	0.010	30	0.063	33	-	67	0.746	27
66	tongyitrans-003	0.047	19	0.009	15	0.025	13	0.020	26	-	60	-	60	0.065	20	-	61
67	toshiba-000	0.290	59	0.069	61	0.191	60	0.035	46	0.001	15	0.040	19	-	55	0.743	26
68	toshiba-001	0.193	50	0.033	40	0.106	44	0.041	55	0.004	22	0.049	29	-	53	0.783	39
69	ultinous-000	0.348	64	0.076	64	0.234	65	0.070	64	0.005	24	0.040	20	-	58	0.945	44
70	ultinous-001	0.400	67	0.075	62	0.249	67	0.045	58	0.005	25	0.029	16	0.068	23	0.685	16
71	vcog-002	0.903	79	0.504	80	0.752	80	0.691	81	0.559	47	0.666	47	-	64	0.752	28
72	vd-000	0.497	72	0.172	73	0.379	72	0.208	73	-	59	-	59	0.142	40	-	60
73	vigilantsolutions-003	0.267	57	0.068	60	0.188	59	0.053	60	0.001	11	0.037	18	0.088	30	0.671	13
74	vigilantsolutions-004	0.260	56	0.054	54	0.178	56	0.025	33	-	57	-	57	0.067	22	-	58
75	visionlabs-003	0.029	8	0.009	13	0.018	9	0.015	15	0.000	5	0.017	13	0.052	12	0.524	3
76	visionlabs-004	0.046	17	0.007	9	0.022	11	0.013	1	-	78	-	78	0.042	1	-	79
77	vocord-002	0.034	11	0.013	21	0.023	12	0.015	12	0.011	31	0.012	7	-	74	0.762	32
78	vocord-004	0.017	4	0.003	3	0.010	4	0.015	14	-	69	-	69	0.044	4	-	70
79	yisheng-001	0.160	44	0.032	39	0.089	41	0.045	57	0.000	2	0.043	24	-	57	0.756	29
80	yisheng-004	0.333	63	0.048	52	0.199	64	0.028	38	-	66	-	66	0.089	31	-	67
81	yitu-000	0.033	9	0.021	31	0.028	17	0.014	6	0.000	3	0.012	5	-	65	0.586	7
82	yitu-001	0.007	1	0.003	2	0.005	1	0.013	2	-	77	-	77	0.054	13	-	78

Table 4: FNMR is the proportion of mated comparisons below a threshold set to achieve the FMR given in the header on the fourth row. FMR is the proportion of impostor comparisons at or above that threshold. The green column applies to impostors of the same sex, age group, and country of birth. All other columns use fully zero effort impostors Note that the webcam and selfie values apply to images collected on the same day, and that will often yield optimisticlly low FNMR values.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

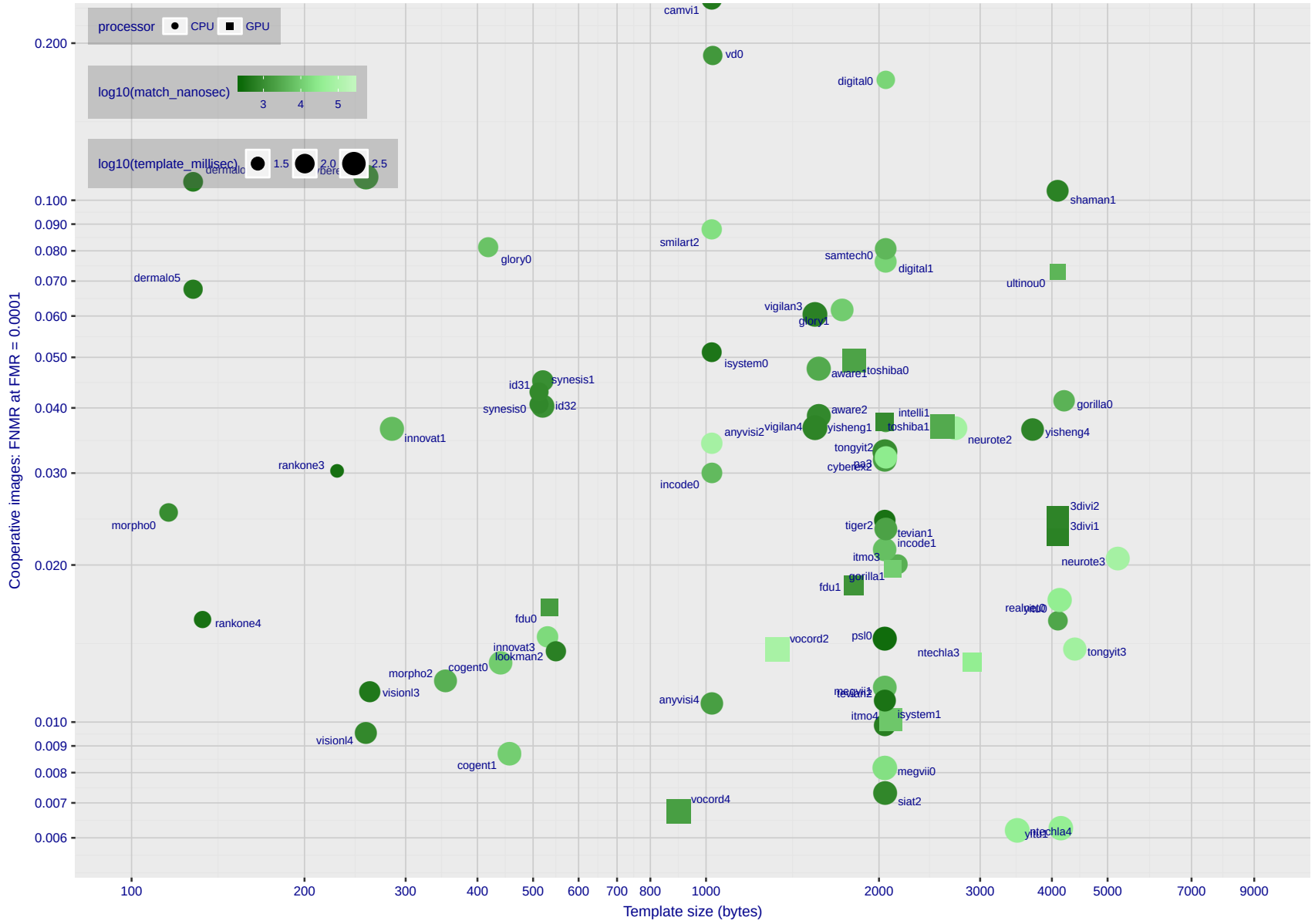


Figure 1: The points show false non-match rates (FNMR) versus the size of the encoded template. FNMR is the geometric mean of FNMR values for visa and mugshot images (from Figs. 12 and 16) at a false match rate (FMR) of 0.0001. The size of the points encodes template generation time - which spans at least one order of magnitude. The color of the points encodes one-to-one genuine template comparison duration - which span three orders of magnitude. Durations are measured on a single core of a c. 2016 Intel Xeon CPU E5-2630 v4 running at 2.20GHz.

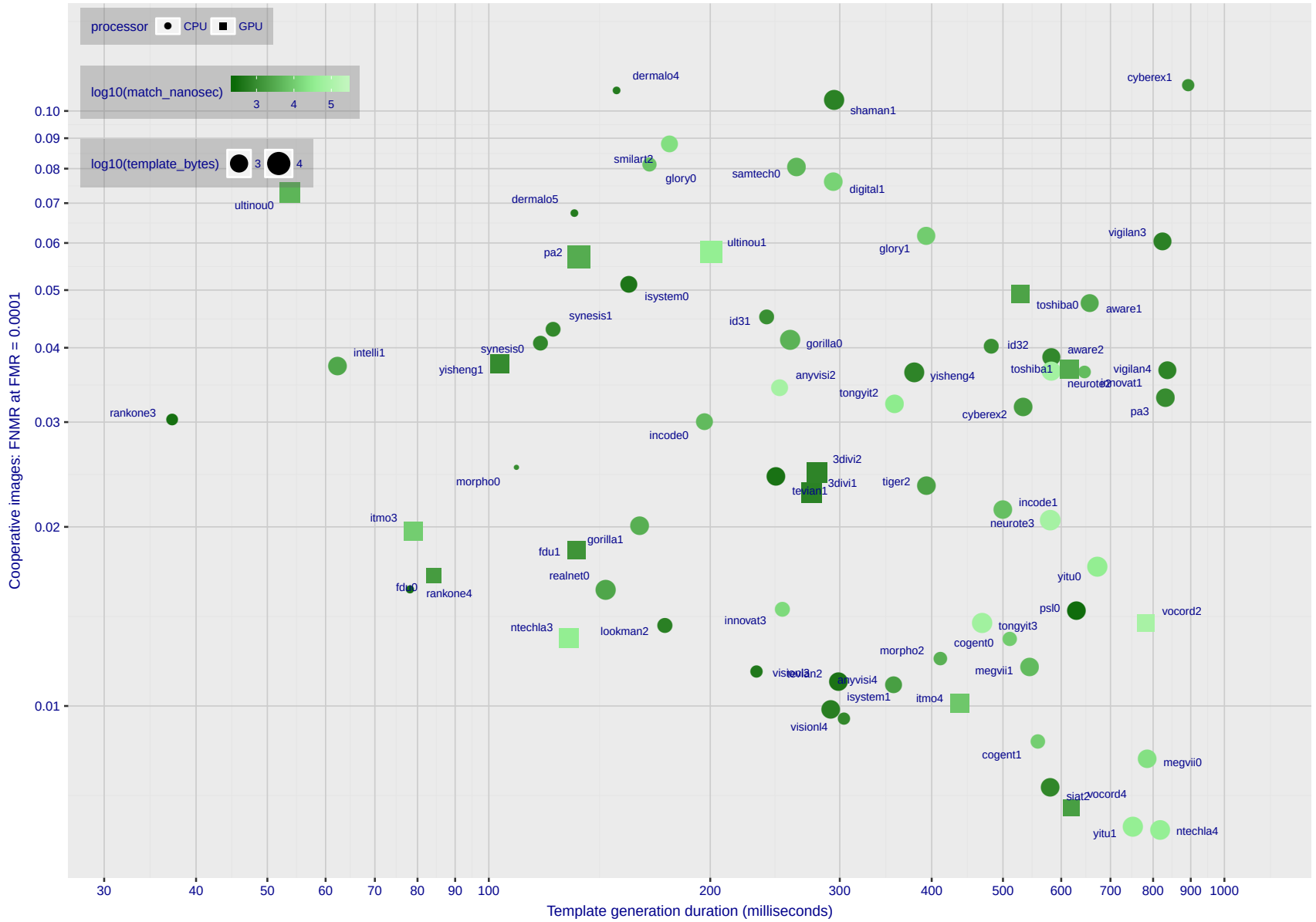


Figure 2: The points show false non-match rates (FNMR) versus the duration of the template generation operation. Some algorithms run on GPU, most on CPU - see Table 2. FNMR is the geometric mean of FNMR values for visa and mugshot images (from Figs. 12 and 16) at a false match rate (FMR) of 0.0001. Template generation time is a median estimated over 640 x 480 pixel portraits. It is measured on a single core of a c. 2016 Intel Xeon CPU E5-2630 v4 running at 2.20GHz. The size of the points encodes template size - which span two orders of magnitude. The color of the points encodes one-to-one genuine template comparison duration - which span three orders of magnitude.

3 Metrics

3.1 Core accuracy

Given a vector of N genuine scores, u, the false non-match rate (FNMR) is computed as the proportion below some threshold, T:

$$\text{FNMR}(T) = 1 - \frac{1}{N}\sum_{i=1}^{N} H(u_i - T) \tag{1}$$

where $H(x)$ is the unit step function, and $H(0)$ taken to be 1.

Similarly, given a vector of N impostor scores, v, the false match rate (FMR) is computed as the proportion above T:

$$\text{FMR}(T) = \frac{1}{N}\sum_{i=1}^{N} H(v_i - T) \tag{2}$$

The threshold, T, can take on any value. We typically generate a set of thresholds from quantiles of the observed impostor scores, v, as follows. Given some interesting false match rate range, $[\text{FMR}_L, \text{FMR}_U]$, we form a vector of K thresholds corresponding to FMR measurements evenly spaced on a logarithmic scale

$$T_k = Q_v(1 - \text{FMR}_k) \tag{3}$$

where Q is the quantile function, and FMR_k comes from

$$\log_{10}\text{FMR}_k = \log_{10}\text{FMR}_L + \frac{k}{K}\ [\log_{10}\text{FMR}_U - \log_{10}\text{FMR}_L] \tag{4}$$

Error tradeoff characteristics are plots of FNMR(T) vs. FMR(T). These are plotted with $\text{FMR}_U \rightarrow 1$ and FMR_L as low as is sustained by the number of impostor comparisons, N. This is somewhat higher than the "rule of three" limit $3/N$ because samples are not independent, due to re-use of images.

4 Datasets

4.1 Child exploitation images

- ▷ The number of images is on the order of 10^4.
- ▷ The number of subjects is on the order of 10^3.
- ▷ The number of subjects with two images on the order of 10^3.
- ▷ The images are operational. They are taken from ongoing investigations of child exploitation crimes. The images are arbitrarily unconstrained. Pose varies considerably around all three axes, including subject lying down. Resolution varies very widely. Faces can be occluded by other objects, including hair and hands. Lighting varies, although the images are intended for human viewing. Mis-focus is rare. Images are given to the algorithm without any cropping; faces may occupy widely varying areas.
- ▷ The images are usually large from contemporary cameras. The mean interocular distance (IOD) is 70 pixels.
- ▷ The images are of subjects from several countries, due to the global production of this imagery.
- ▷ The images are of children, from infancy to late adolescence.
- ▷ All of the images are live capture, none are scanned. Many have been cropped.
- ▷ When these images are input to the algorithm, they are labelled as being of type "EXPLOITATION" - see Table 4 of the FRVT API.

4.2 Visa images

- ▷ The number of images is on the order of 10^5.
- ▷ The number of subjects is on the order of 10^5.
- ▷ The number of subjects with two images on the order of 10^4.
- ▷ The images have geometry in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type. Pose is generally excellent.
- ▷ The images are of size 252x300 pixels. The mean interocular distance (IOD) is 69 pixels.
- ▷ The images are of subjects from greater than 100 countries, with significant imbalance due to visa issuance patterns.
- ▷ The images are of subjects of all ages, including children, again with imbalance due to visa issuance demand.
- ▷ Many of the images are live capture. A substantial number of the images are photographs of paper photographs.
- ▷ When these images are input to the algorithm, they are labelled as being of type "ISO" - see Table 4 of the FRVT API.

4.3 Mugshot images

- ▷ The number of images is on the order of 10^6.
- ▷ The number of subjects is on the order of 10^5.
- ▷ The number of subjects with two images on the order of 10^5.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

- ▷ The images have geometry in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The images are of variable sizes. The median IOD is 104 pixels. The mean IOD is 123 pixels.
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”mugshot” - see Table 4 of the FRVT API.

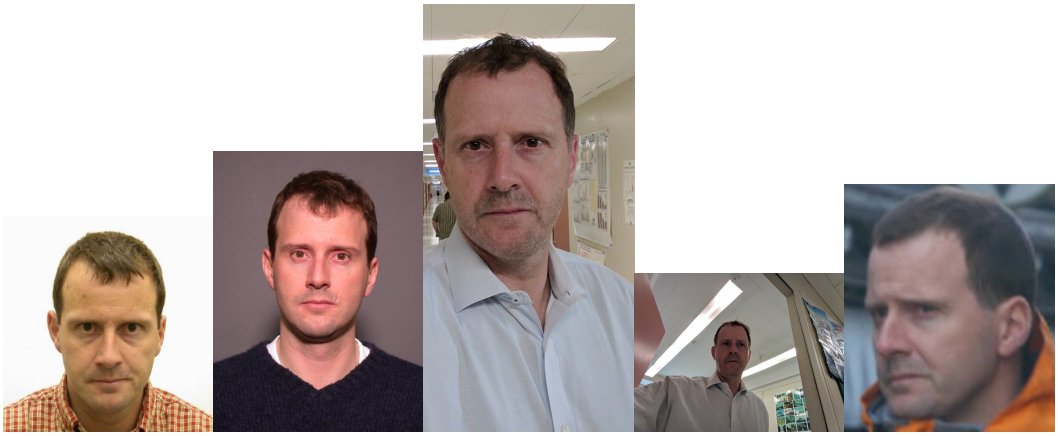
4.4 Selfie images

- ▷ The number of images is below 500.
- ▷ The number of subjects is below 500.
- ▷ All subjects have a selfie image, and a portrait image.
- ▷ The portrait images are in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The selfie images vary: taken with camera above and below eye level, with one hand or two hands. Pitch angles vary more than yaw angles, which are frontal. Some perspective distortion is evident.
- ▷ The images have mean IOD of 140 pixels.
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”WILD” - see Table 4 of the FRVT API.

4.5 Webcam images

- ▷ The number of images is below 1500.
- ▷ The number of subjects is below 1500.
- ▷ All subjects have a webcam image, and a portrait image.
- ▷ The portrait images are in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The webcam images are taken with camera at a typical head height, with mild pitch angles, low yaw angles, but some variation in range, such that low perspective distortion is sometimes evident.
- ▷ The images have mean IOD of 68 pixels (sd=12).
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”MUGSHOT” - see Table 4 of the FRVT API.

FNMR(T) “False non-match rate”
FMR(T) “False match rate”



(a) Visa (b) Mugshot (c) Webcam (d) Selfie (e) Wild

Figure 3: The figure gives simulated samples of image types used in this report.

4.6 Wild images

- The number of images is on the order of 10^5.
- The number of subjects is on the order of 10^3.
- The number of subjects with two images on the order of 10^3.
- The images include many photojournalism-style images. Images are given to the algorithm using a variable but generally tight crop of the head. Resolution varies very widely. The images are very unconstrained, with wide yaw and pitch pose variation. Faces can be occluded, including hair and hands.
- The images are of adults.
- All of the images are live capture, none are scanned.
- When these images are input to the algorithm, they are labelled as being of type "WILD" - see Table 4 of the FRVT API.

5 Results

5.1 Test goals

- To state overall accuracy.
- To compare algorithms.

5.2 Test design

Method: For wild images:

- The comparisons are of wild photos against wild photos.
- The number of genuine comparisons is on the order of 10^6.
- The number of impostor comparisons is on the order of 10^7.

- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of 10^4.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

Method: For visa images:

- ▷ The comparisons are of visa photos against visa photos.
- ▷ The number of genuine comparisons is on the order of 10^4.
- ▷ The number of impostor comparisons is on the order of 10^{10}.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates. However, later analysis is conducted on subsets.
- ▷ The number of persons is on the order of 10^5.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For mugshot images:

- ▷ The comparisons are of mugshot photos against mugshot photos.
- ▷ The number of genuine comparisons is on the order of 10^5.
- ▷ The number of impostor comparisons is on the order of 10^7.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of 10^6.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For selfie images:

- ▷ The comparisons are of selfie photos against portrait photos.
- ▷ The number of genuine comparisons is on the order of 10^2.
- ▷ The number of impostor comparisons is on the order of 10^8 selfies are compared with portraits of on the order of 10^6 other subjects.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of 10^6.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For webcam images:

- ▷ The comparisons are of webcam photos against portrait photos.
- ▷ The number of genuine comparisons is on the order of 10^3.
- ▷ The number of impostor comparisons is on the order of 10^9 webcams are compared with portraits of on the order of 10^6 other subjects.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of 10^6.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For child exploitation images:

- ▷ The comparisons are of unconstrained child exploitation photos against others of the same type.
- ▷ The number of genuine comparisons is on the order of 10^4.
- ▷ The number of impostor comparisons is on the order of 10^7.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of 10^3.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.
- ▷ We produce two performance statements. First, is a DET as used for visa and mugshot images. The second is a cumulative match characteristic (CMC) summarizing a simulated one-to-many search process. This is done as follows.
  - We regard M enrollment templates as items in a gallery.
  - These M templates come from $M > N$ individuals, because multiple images of a subject are present in the gallery under separate identifiers.
  - We regard the verification templates as search templates.
  - For each search we compute the rank of the highest scoring mate.
  - This process should properly be conducted with a 1:N algorithm, such as those tested in NIST IR 8009. We use the 1:1 algorithms in a simulated 1:N mode here to a) better reflect what a child exploitation analyst does, and b) to do show algorithm efficacy is better than that revealed in the verification DETs.

5.3 Failure to enrol

Algorithm	Failure to Enrol Rate[1]											
Name	CHILD-EXPLOIT		MUGSHOT		SELFIES		VISA		WEBCAM		WILD	
3divi-001	0.2006	24	0.0019	58	0.0202	34	0.0007	48	0.0020	25	0.0343	40
3divi-002	0.3103	35	0.0039	72	0.0376	41	0.0010	53	0.0027	34	0.0447	41
anyvision-002	0.4866	49	0.0070	81	0.0578	45	0.0090	83	0.0095	39	-	82
anyvision-004	-	82	0.0000	16	-	82	0.0004	29	-	82	0.0081	16
aware-001	0.1897	23	0.0010	45	0.0145	32	0.0002	15	0.0048	36	-	82
aware-002	-	82	0.0002	29	-	82	0.0006	40	-	82	0.0237	36
ayonix-000	0.0000	4	0.0109	83	0.0751	47	0.0137	85	0.0109	41	-	82
camvi-001	0.3931	44	0.0033	69	0.0231	36	0.0010	56	0.0027	35	-	82
cogent-000	0.2914	32	0.0011	47	0.0029	16	0.0005	38	0.0020	28	0.0078	15
cogent-001	-	82	0.0000	18	-	82	0.0004	31	-	82	0.0065	12
cyberextruder-001	0.5338	52	0.0036	71	0.0376	40	0.0029	72	0.0205	46	-	82
cyberextruder-002	0.2672	31	0.0026	66	0.0058	22	0.0028	71	0.0123	43	0.0334	39
dermalog-004	0.3110	36	0.0031	68	0.0087	29	0.0090	82	0.0020	32	-	82
dermalog-005	0.1796	21	0.0016	57	0.0000	10	0.0041	78	0.0014	21	0.0166	29
digitalbarriers-000	0.5469	53	0.0043	75	0.0925	48	0.0019	67	0.0184	45	-	82
digitalbarriers-001	0.5102	51	0.0044	76	0.0925	49	0.0018	66	0.0232	47	-	82
fdu-000	0.4992	50	0.0025	64	0.0029	19	0.0011	60	0.0020	29	0.0536	42
fdu-001	0.1380	20	0.0015	53	0.0000	9	0.0009	51	0.0007	13	0.0209	31
glory-000	-	82	0.0058	80	-	82	0.0013	63	-	82	0.1584	45
glory-001	-	82	0.0056	79	-	82	0.0010	52	-	82	0.1667	46
gorilla-000	0.1347	19	0.0009	42	0.0029	21	0.0004	34	0.0007	16	-	82
gorilla-001	-	82	0.0000	21	-	82	0.0004	33	-	82	0.0118	21
id3-001	0.3411	39	0.0043	73	0.0260	38	0.0043	81	0.0014	19	-	82
id3-002	0.3168	37	0.0030	67	0.0202	35	0.0032	73	0.0020	27	-	82
incode-000	-	82	0.0006	36	-	82	0.0035	74	-	82	0.0211	32
incode-001	-	82	0.0006	37	-	82	0.0035	75	-	82	0.0211	33
innovatrics-001	0.3392	38	0.0013	52	0.0087	28	0.0004	30	0.0027	33	-	82
innovatrics-003	-	82	0.0000	23	-	82	0.0005	35	-	82	0.0643	43
intellivision-001	0.5495	55	0.0052	77	0.0491	43	0.0042	79	0.0252	48	-	82
isityou-000	0.4714	46	0.0022	61	0.0665	46	0.0010	55	0.0116	42	-	82
isystems-000	0.4757	47	0.0025	65	0.0260	37	0.0010	54	0.0068	38	-	82
isystems-001	-	82	0.0003	33	-	82	0.0007	47	-	82	0.0130	22
itmo-003	0.3606	41	0.0023	63	0.0058	25	0.0008	49	0.0014	23	0.0189	30
itmo-004	-	82	0.0000	22	-	82	0.0004	32	-	82	0.0091	20
lookman-002	-	82	0.0000	5	-	82	0.0000	5	-	82	0.0000	2
megvii-000	0.0199	12	0.0007	39	0.0000	15	0.0003	17	0.0007	17	-	82
megvii-001	-	82	0.0043	74	-	82	0.0004	25	-	82	0.0153	26
microfocus-000	-	82	0.0012	51	-	82	0.0016	65	-	82	0.0220	35
microfocus-001	-	82	0.0012	50	-	82	0.0016	64	-	82	0.0220	34
morpho-000	0.0000	8	0.0000	10	0.0000	14	0.0000	11	0.0000	11	-	82
morpho-002	0.0572	16	0.0009	43	0.0000	6	0.0004	24	0.0007	12	-	82
neurotechnology-002	0.2043	25	0.0000	14	0.0058	24	0.0000	9	0.0014	22	0.0149	25
neurotechnology-003	0.2371	27	0.0011	46	0.0058	26	0.0005	36	0.0020	31	0.0162	28
noblis-000	0.0000	6	0.0000	9	0.0000	13	0.0000	10	0.0000	10	-	82
ntechlab-003	0.0926	18	0.0009	41	0.0029	20	0.0005	37	0.0007	15	0.0072	13
ntechlab-004	-	82	0.0000	13	-	82	0.0004	26	-	82	0.0050	10
pa-002	0.0000	1	0.0000	6	0.0000	11	0.0000	6	0.0000	8	-	82
pa-003	-	82	0.0000	8	-	82	0.0000	8	-	82	0.0000	3
psl-000	-	82	0.0000	11	-	82	0.0000	12	-	82	0.0000	4
rankone-003	0.0009	11	0.0001	28	0.0000	7	0.0000	14	0.0000	6	-	82

Table 5: FTE is the proportion of failed template generation attempts. Failures can occur because the software throws an exception, or because the software electively refuses to process the input image. This would typically occur if a face is not detected. FTE is measured as the number of function calls that give a non-zero error code, OR that give a "small" template. This is defined as one whose size is less than 0.3 times the median template size. This second rule is needed because some algorithms incorrectly fail to return a non-zero error code when template generation fails.

[1] *The effects of FTE are included in the accuracy results of this report by regarding any template comparison involving a failed template enrollment to produce a low similarity score. Thus higher FTE results in higher FNMR.*

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

Algorithm	Failure to Enrol Rate[1]											
Name	CHILD-EXPLOIT		MUGSHOT		SELFIES		VISA		WEBCAM		WILD	
rankone-004	-	82	0.0000	12	-	82	0.0000	13	-	82	0.0002	5
realnetworks-000	-	82	0.0000	25	-	82	0.0003	18	-	82	0.0064	11
samtech-000	0.5474	54	0.0052	78	0.0491	44	0.0042	80	0.0252	49	-	82
shaman-000	0.0000	5	0.0000	2	0.0000	3	0.0000	2	0.0000	3	-	82
shaman-001	0.0000	2	0.0000	1	0.0000	1	0.0000	1	0.0000	1	-	82
siat-002	-	82	0.0000	15	-	82	0.0004	28	-	82	0.0048	9
smilart-002	0.2422	28	0.0012	49	-	82	0.0011	59	-	82	-	82
smilart-003	-	82	0.0002	30	-	82	0.0011	57	-	82	-	82
synesis-000	0.4807	48	0.0022	62	0.0347	39	0.0007	46	0.0095	40	-	82
synesis-001	-	82	0.0034	70	-	82	0.0021	69	-	82	0.1134	44
tevian-001	0.3030	34	0.0011	48	0.0000	8	0.0012	61	0.0020	26	0.0304	37
tevian-002	-	82	0.0000	24	-	82	0.0005	39	-	82	0.0076	14
tiger-001	0.1847	22	0.4639	85	0.0087	27	0.0006	42	0.0000	7	0.6642	47
tiger-002	-	82	0.0000	20	-	82	0.0004	27	-	82	0.0082	17
tongyitrans-002	0.3609	42	0.0078	82	0.0462	42	0.0040	77	0.0055	37	-	82
tongyitrans-003	-	82	0.0001	26	-	82	0.0006	43	-	82	0.0135	23
toshiba-000	0.0000	7	0.0000	3	0.0000	5	0.0000	3	0.0000	5	-	82
toshiba-001	0.0000	3	0.0000	7	0.0000	12	0.0000	7	0.0000	9	-	82
ultinous-000	0.0007	9	0.0002	31	0.0000	2	0.0003	20	0.0000	2	-	82
ultinous-001	0.0007	10	0.0002	32	0.0000	4	0.0003	21	0.0000	4	0.0089	19
vcog-002	0.2209	26	0.0021	60	0.0087	30	0.0019	68	0.0007	14	-	82
vd-000	-	82	0.0000	4	-	82	0.0000	4	-	82	0.0000	1
vigilantsolutions-003	0.2538	30	0.0008	40	0.0058	23	0.0004	23	0.0014	20	0.0041	7
vigilantsolutions-004	-	82	0.0000	19	-	82	0.0004	22	-	82	0.0041	6
visionlabs-003	0.3010	33	0.0020	59	0.0087	31	0.0025	70	0.0014	24	0.0156	27
visionlabs-004	-	82	0.0000	17	-	82	0.0008	50	-	82	0.0088	18
vocord-002	0.3782	43	0.0015	54	0.0029	18	0.0037	76	0.0171	44	-	82
vocord-004	-	82	0.0005	34	-	82	0.0003	16	-	82	0.0044	8
yisheng-001	0.4277	45	0.0016	56	0.0173	33	0.0006	41	0.0020	30	-	82
yisheng-004	-	82	0.0006	38	-	82	0.0006	44	-	82	0.0327	38
yitu-000	0.3475	40	0.0015	55	0.0029	17	0.0013	62	0.0014	18	-	82
yitu-001	-	82	0.0001	27	-	82	0.0006	45	-	82	0.0135	24

Table 6: FTE is the proportion of failed template generation attempts. Failures can occur because the software throws an exception, or because the software electively refuses to process the input image. This would typically occur if a face is not detected. FTE is measured as the number of function calls that give a non-zero error code, OR that give a "small" template. This is defined as one whose size is less than 0.3 times the median template size. This second rule is needed because some algorithms incorrectly fail to return a non-zero error code when template generation fails.

[1] *The effects of FTE are included in the accuracy results of this report by regarding any template comparison involving a failed template enrollment to produce a low similarity score. Thus higher FTE results in higher FNMR.*

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

5.4 Recognition accuracy

Core algorithm accuracy is stated via:

- ▷ **Cooperative subjects**
  - The summary table of Figure 4;
  - The visa image DETs of Figures 12 and **??**;
  - The mugshot DETs of Figure 16 ;
  - The selfie-portrait DETs of Figure 17;
  - The webcam-portrait DETs of Figure 18;
- ▷ **Non-cooperative subjects**
  - The photojournalism DET of Figure 21
  - The sensitivity of photojournalism FNMR to relative yaw angles in Figure 22.
  - The sensitivity of photojournalism FMR to relative yaw angles in Figure 23.
  - The child-exploitation DET of Figure 24;
  - The child-exploitation CMC of Figure 25.

Figure 47 shows dependence of false match rate on algorithm score threshold. This allows a deployer to set a threshold to target a particular false match rate appropriate to the security objectives of the application.

Figure 52 likewise shows FMR(T) but for mugshots, and specially four subsets of the population.

Note that in both the mugshot and visa sets false match rates vary with the ethnicity, age, and sex, of the enrollee and impostor - see section 5.6.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

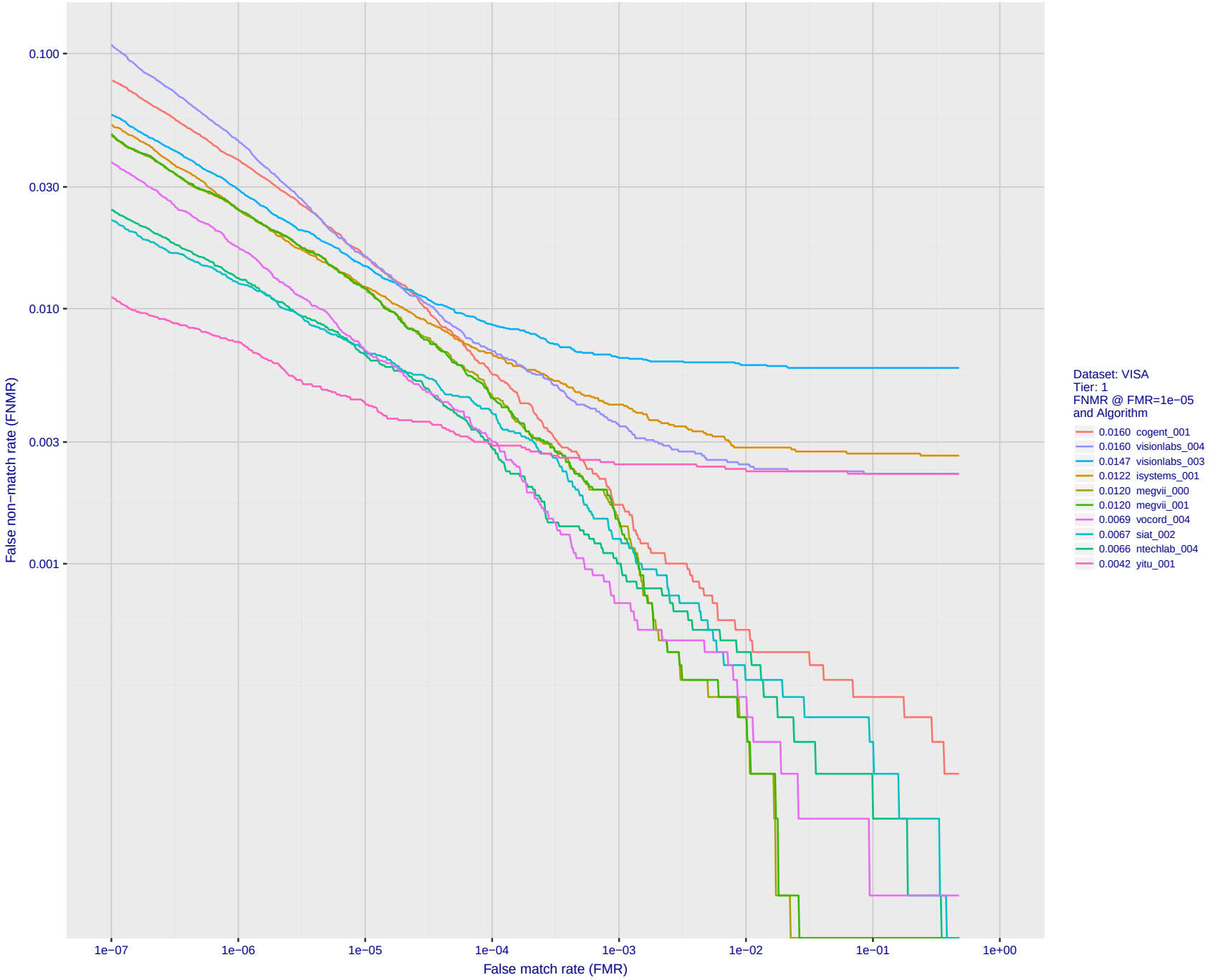


*Figure 4: For the visa images, detection error tradeoff (*DET*) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of* FMR*.*

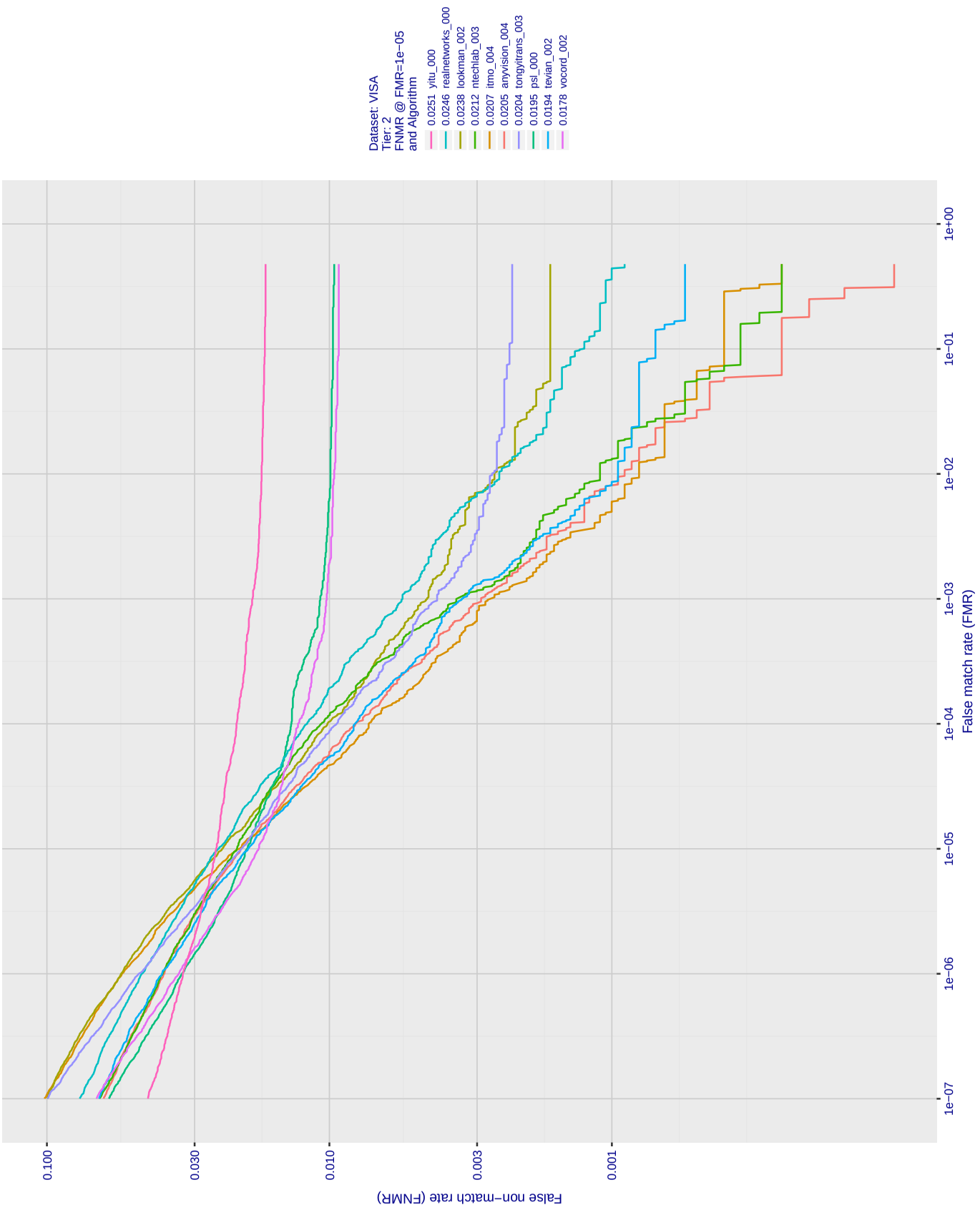


Figure 5: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

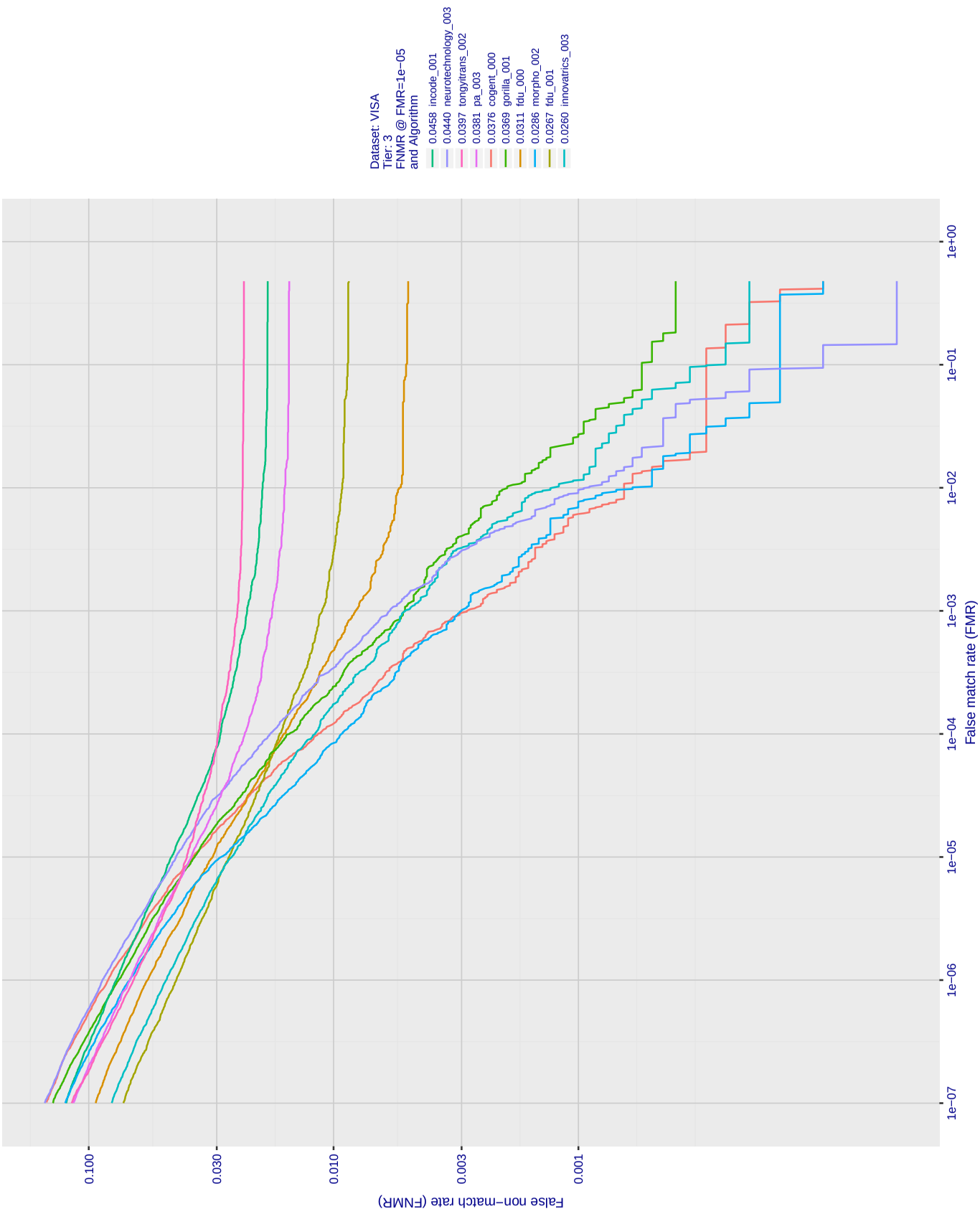


Figure 6: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

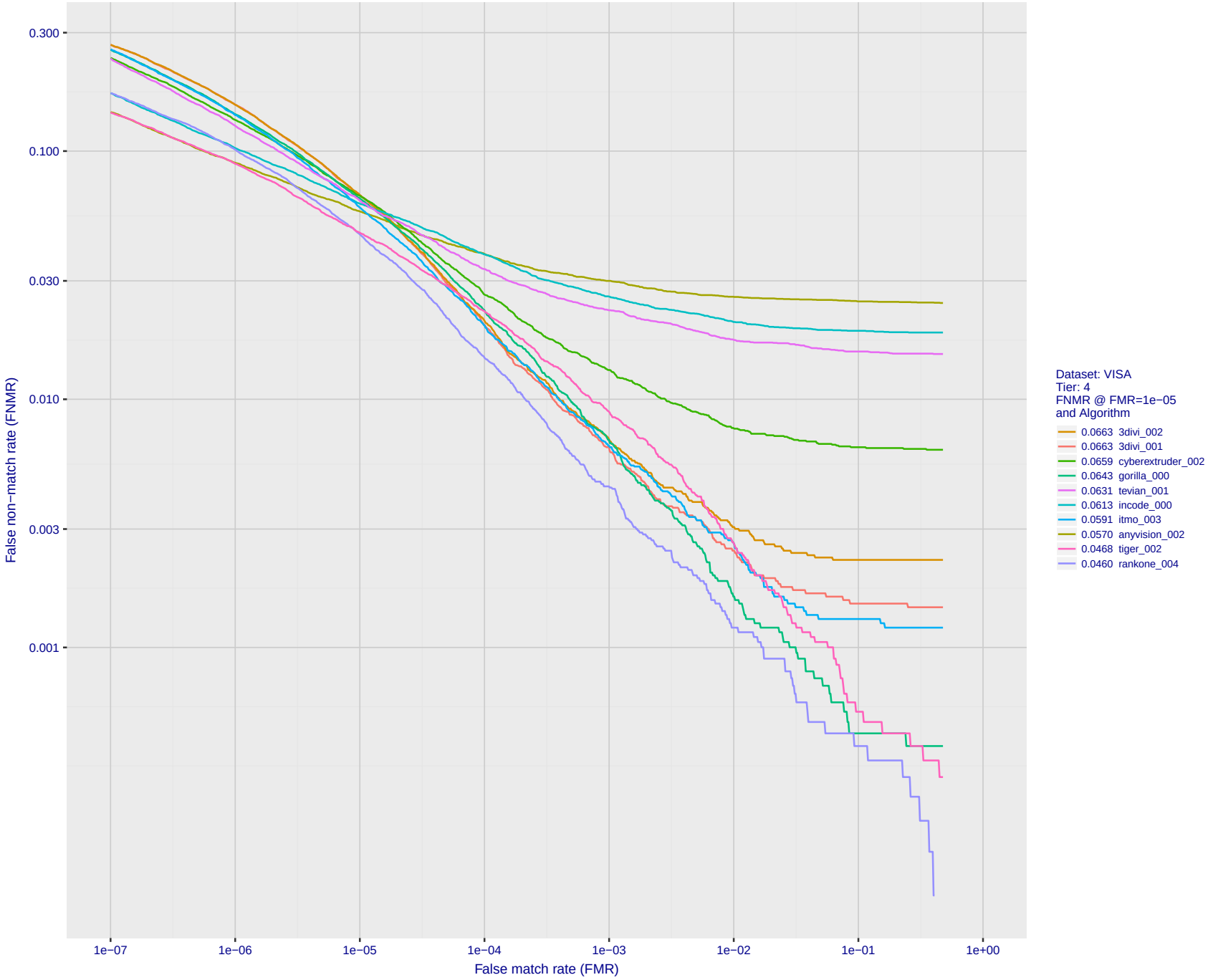


Figure 7: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.

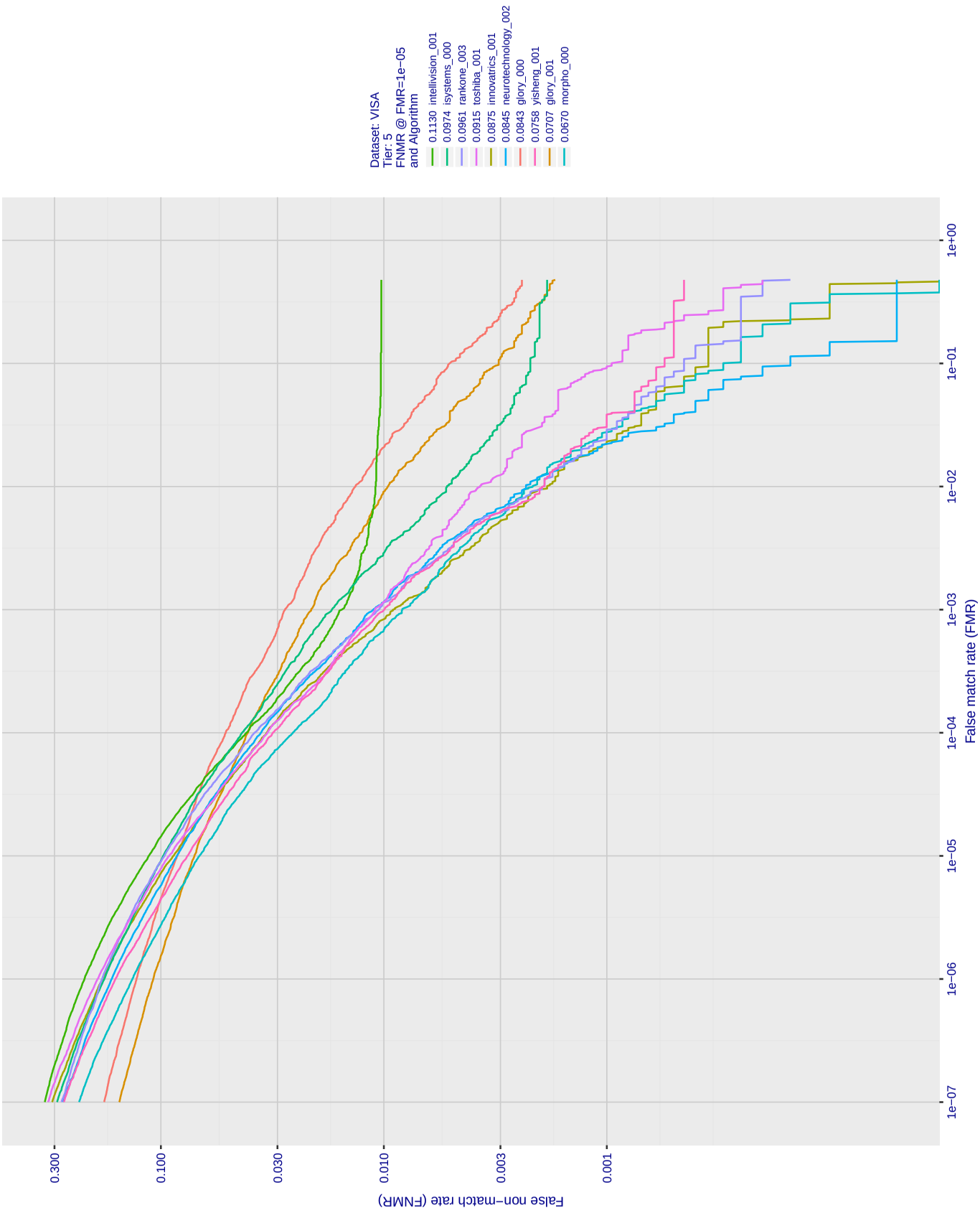


Figure 8: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

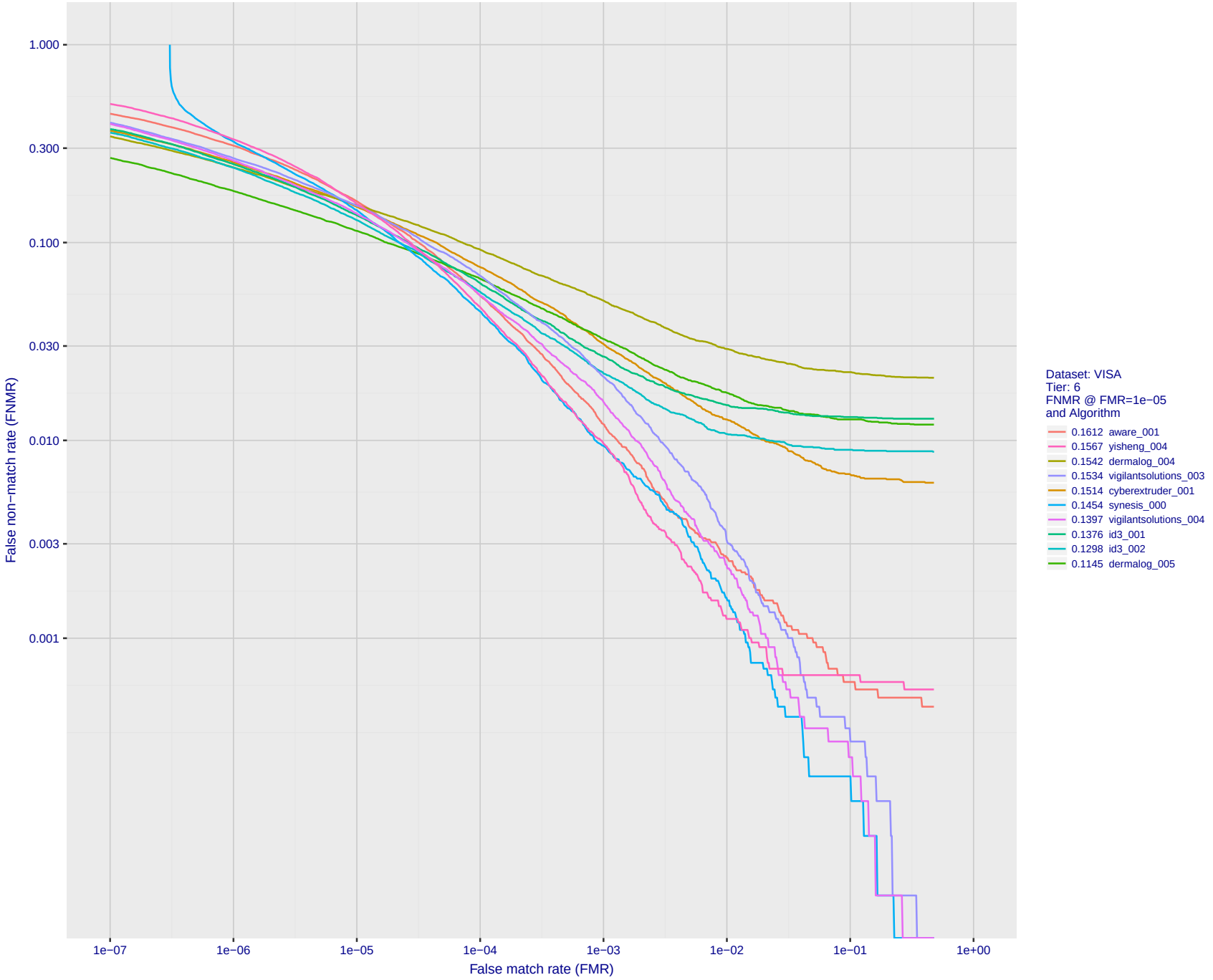


*Figure 9: For the visa images, detection error tradeoff (*DET*) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of* FMR*.*

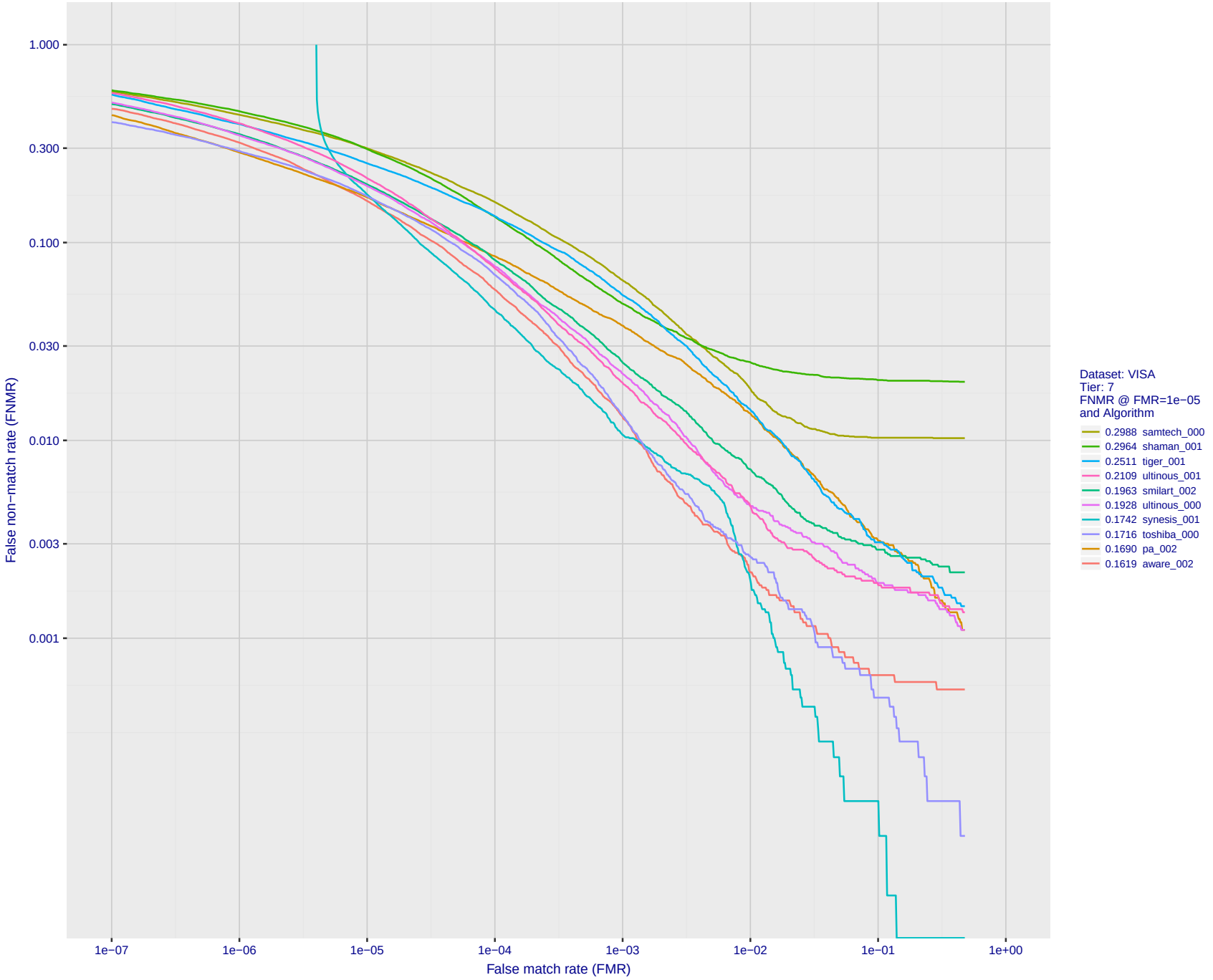


*Figure 10: For the visa images, detection error tradeoff (*DET*) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of* FMR*.*

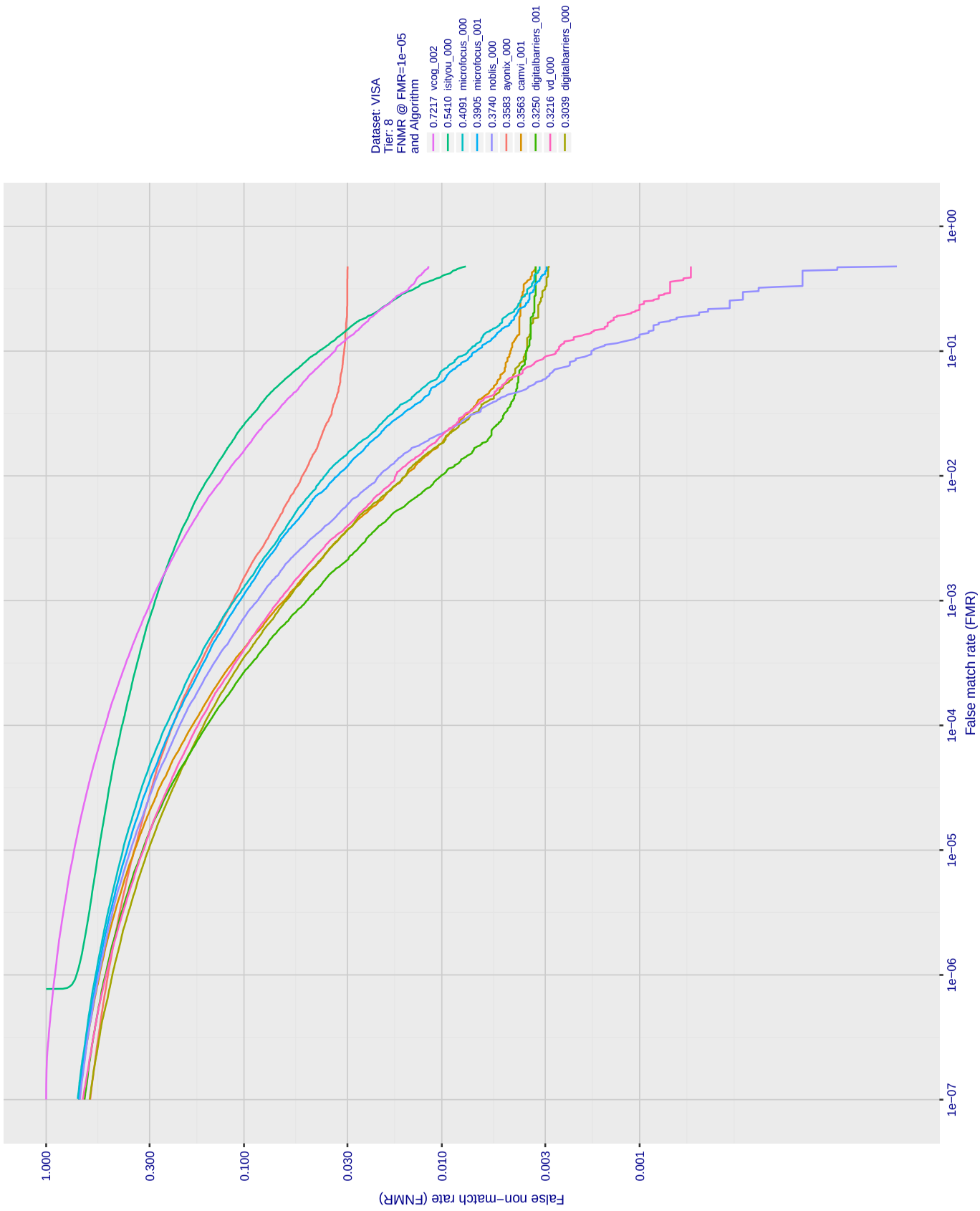


Figure 11: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

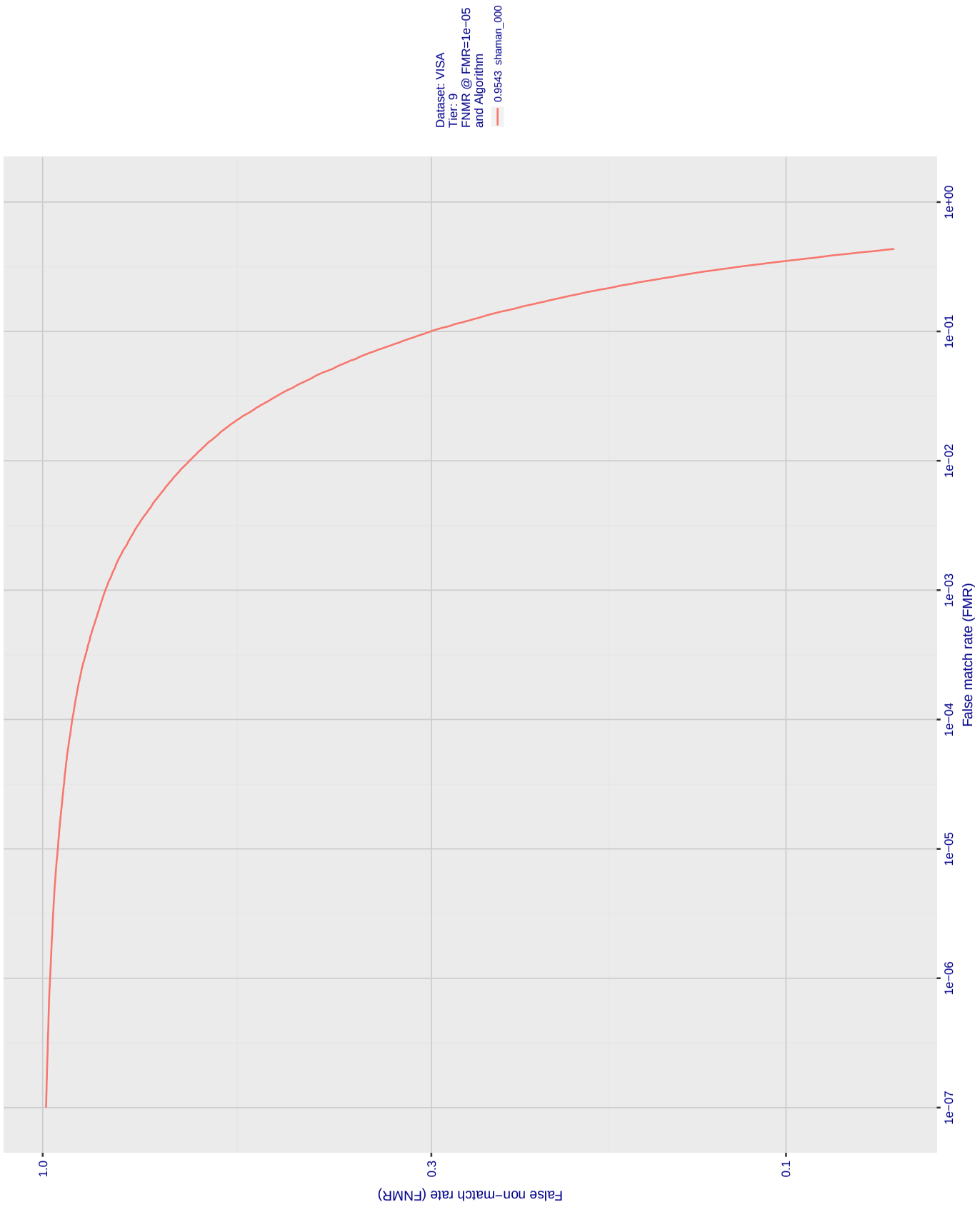


Figure 12: For the visa images, detection error tradeoff (DET) *characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of* FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

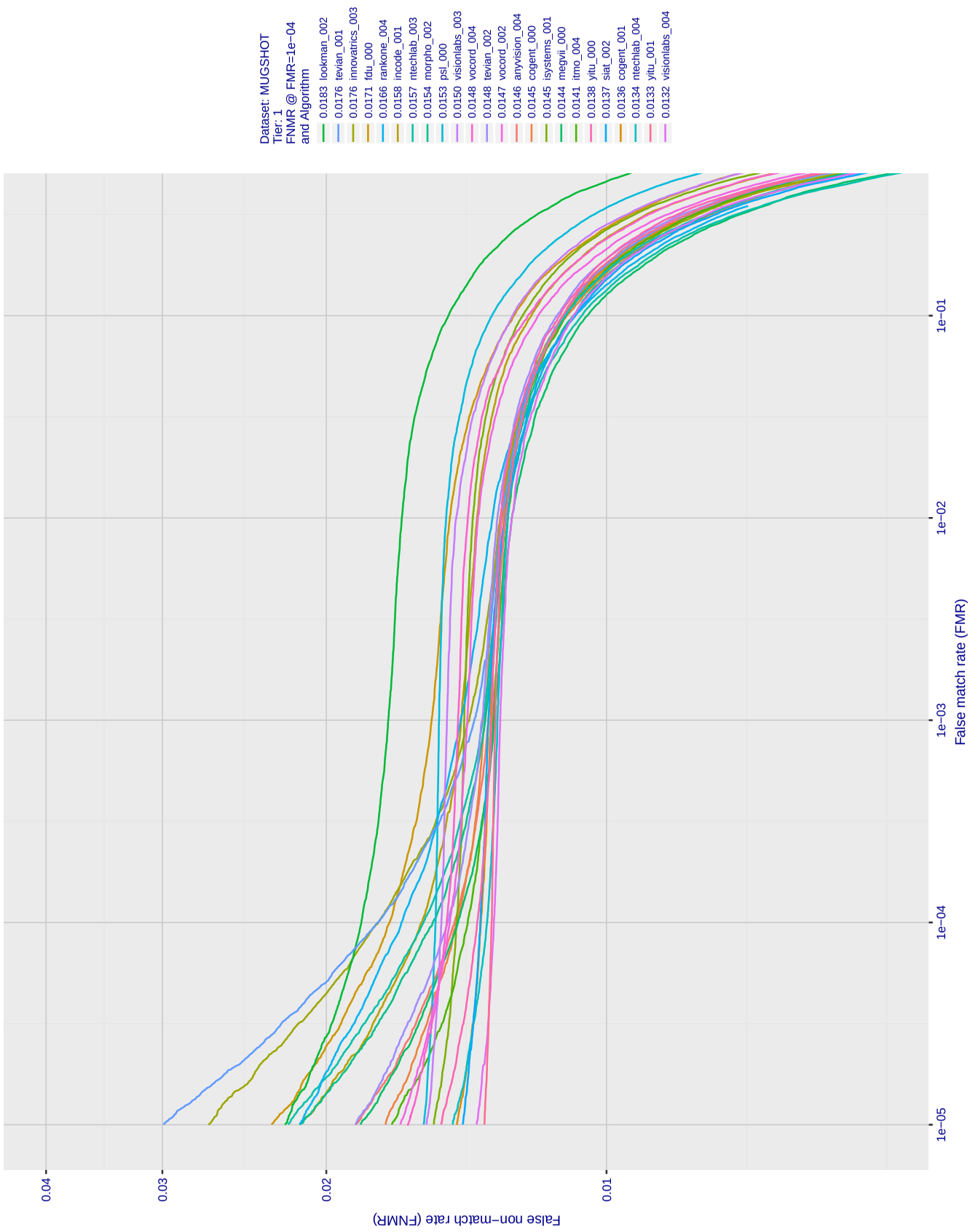


Figure 13: For the mugshot images, detection error tradeoff (DET) *characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of* FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

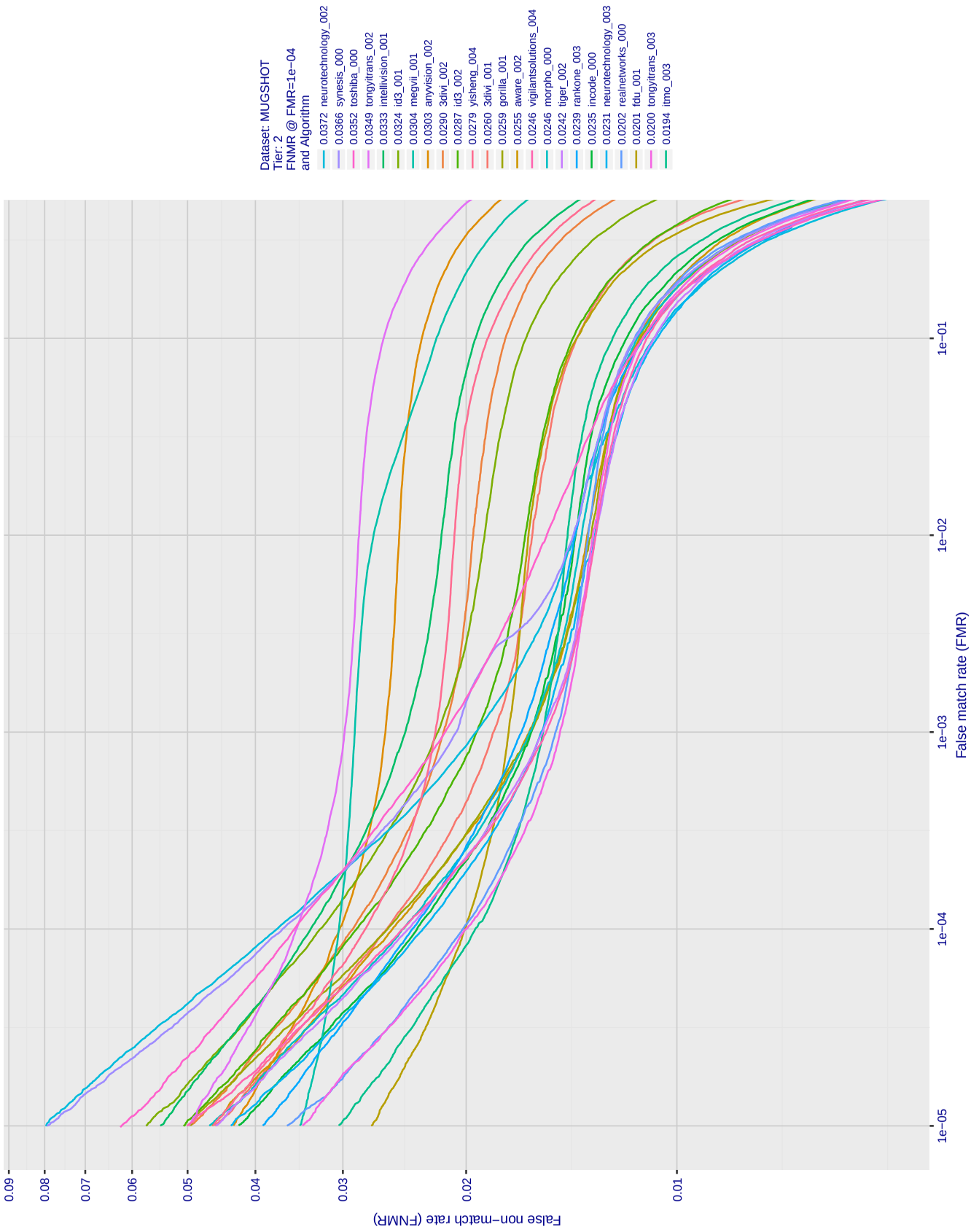


Figure 14: For the mugshot images, detection error tradeoff (DET) *characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of* FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

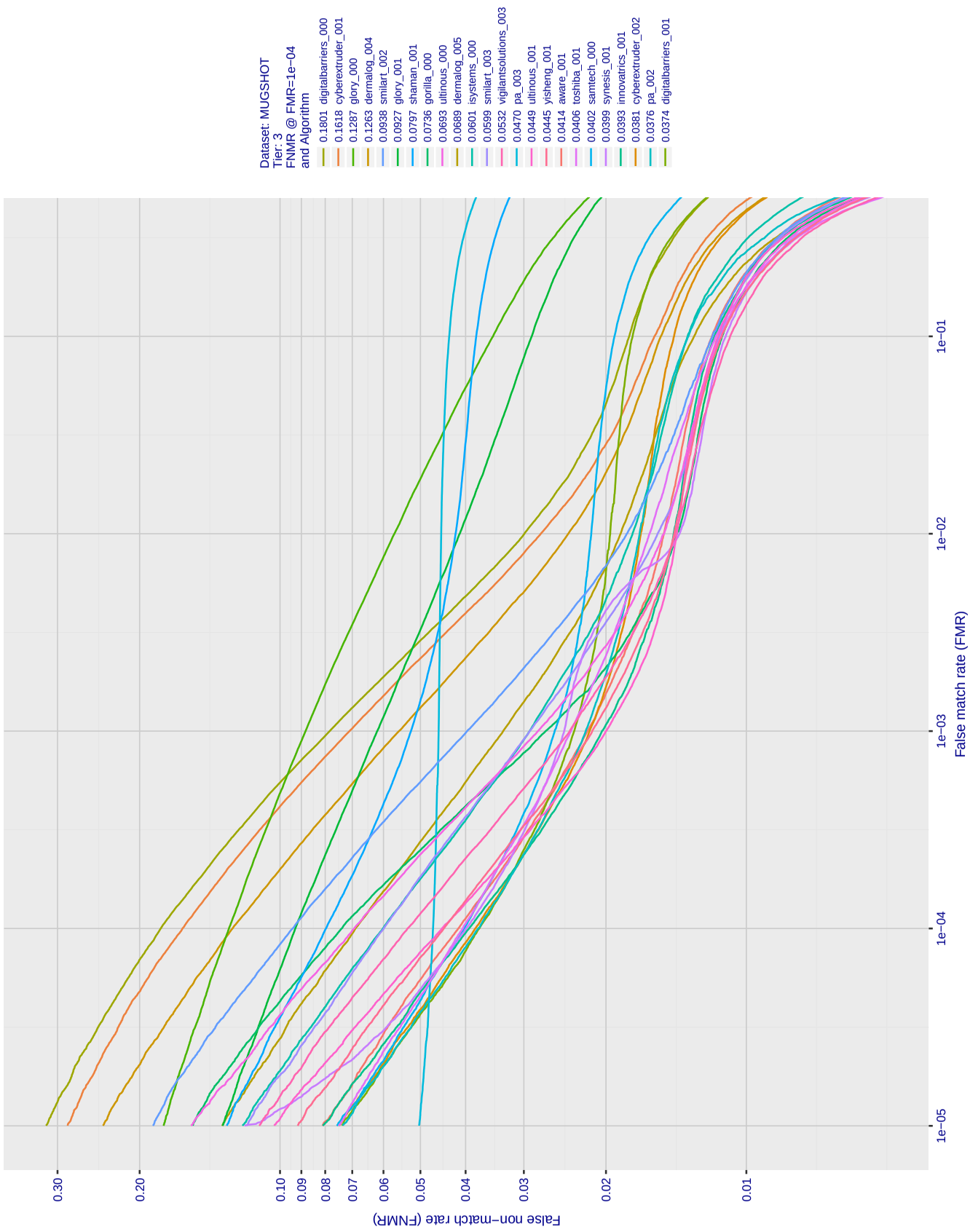


Figure 15: For the mugshot images, detection error tradeoff (DET) *characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of* FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

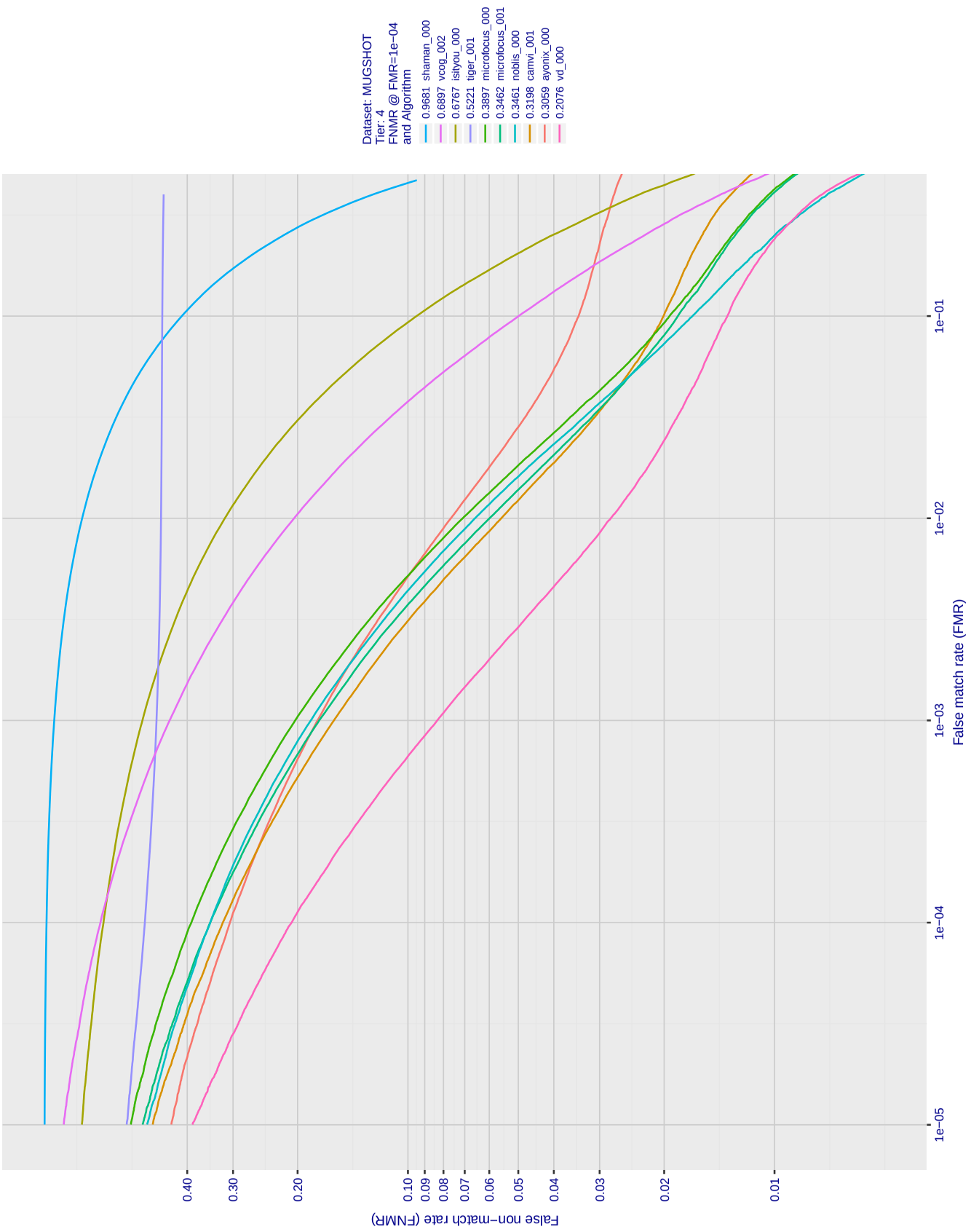


Figure 16: For the mugshot images, detection error tradeoff (DET) *characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of* FMR.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

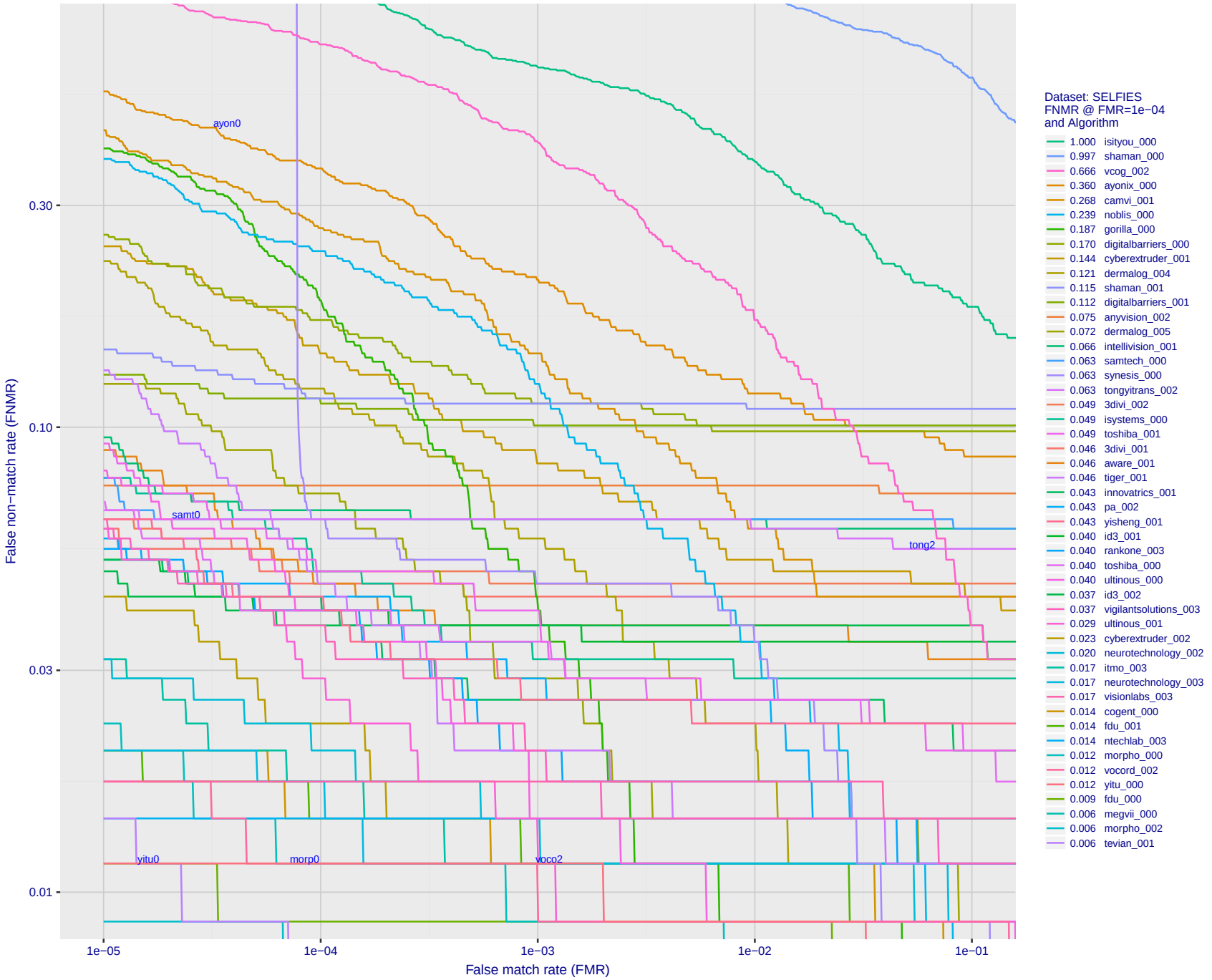


Figure 17: For the selfie-to-portrait comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR. Caution: The FNMR values here are optimistic statements of accuracy because the image pairs were collected on the same day. This is known across biometrics to give better accuracy, and is operationally relevant only in special cases.

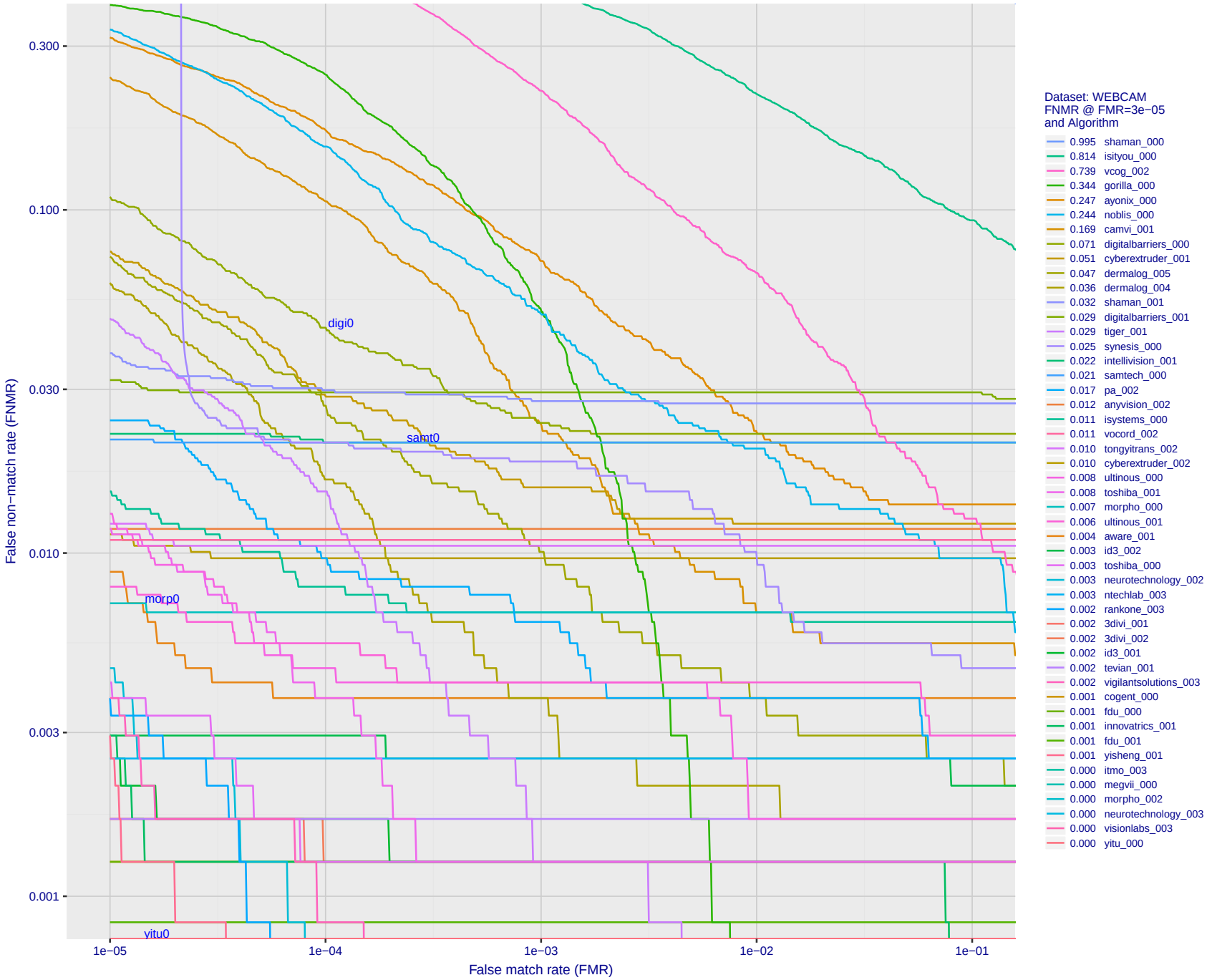


Figure 18: For the webcam-to-portrait comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR. Caution: The FNMR values here are optimistic statements of accuracy because the image pairs were collected on the same day. This is known across biometrics to give better accuracy, and is operationally relevant only in special cases.

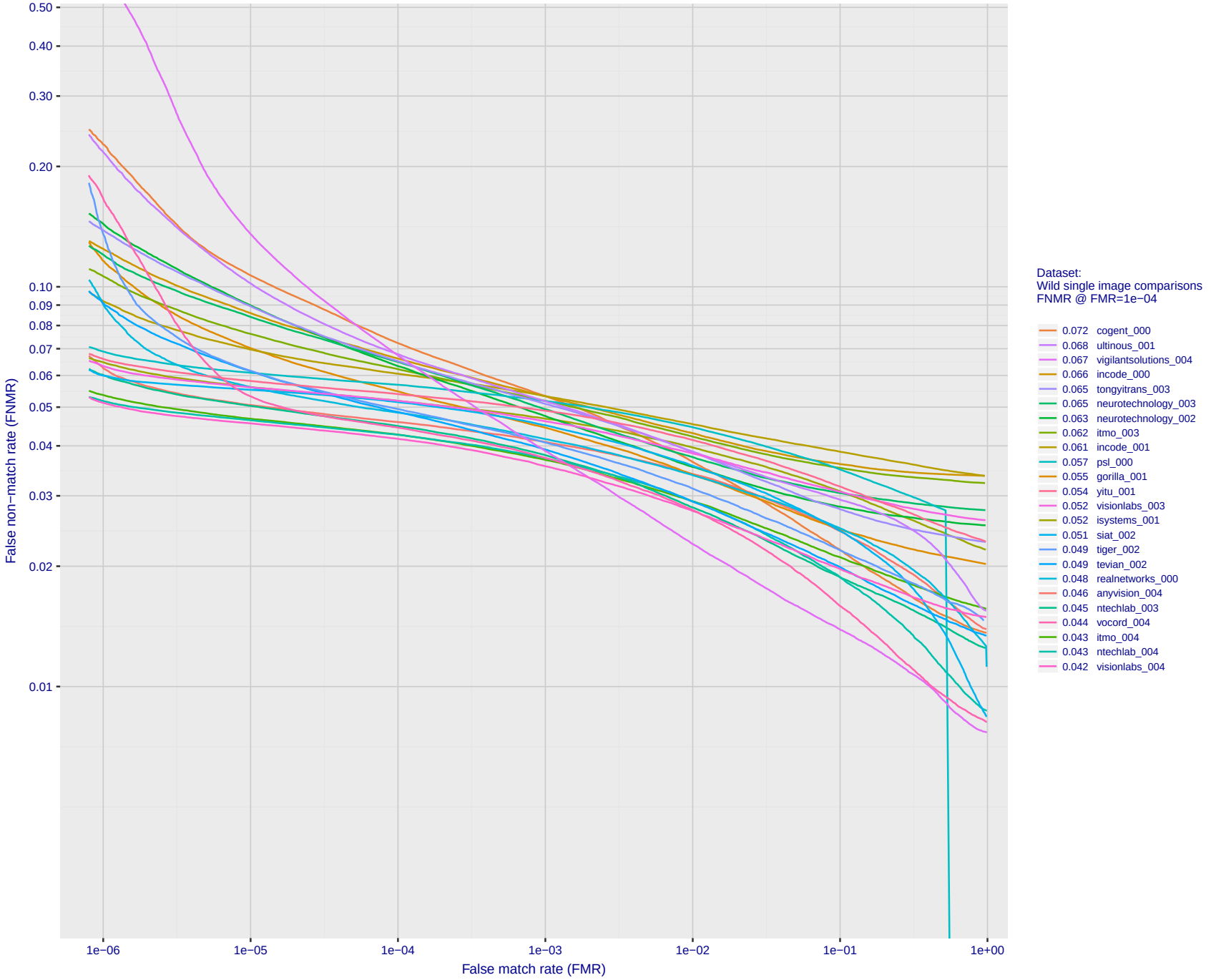


*Figure 19: For the 2018 wild image comparisons, detection error tradeoff (*DET*) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of* FMR*.*

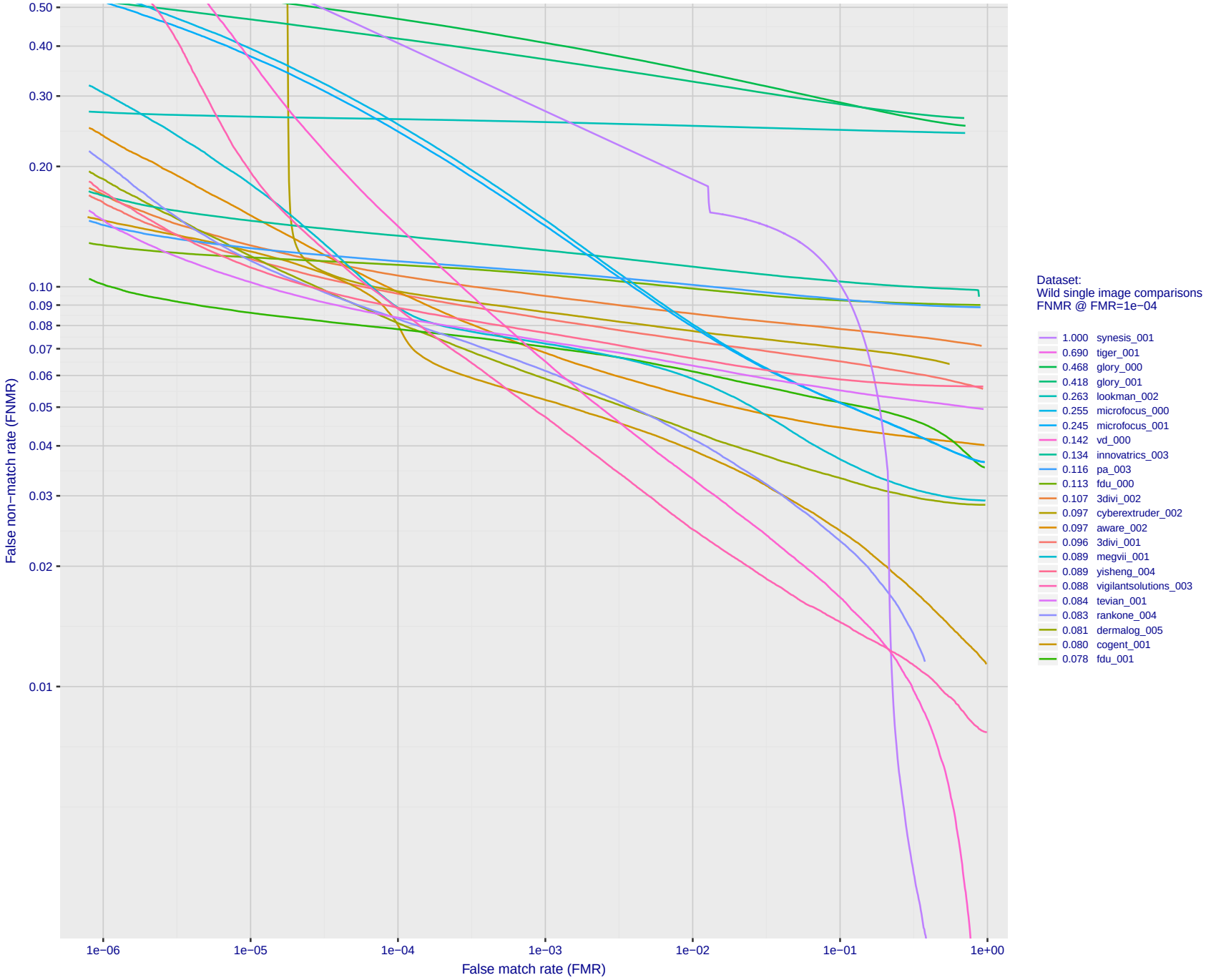


*Figure 20: For the 2018 wild image comparisons, detection error tradeoff (*DET*) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of* FMR*.*

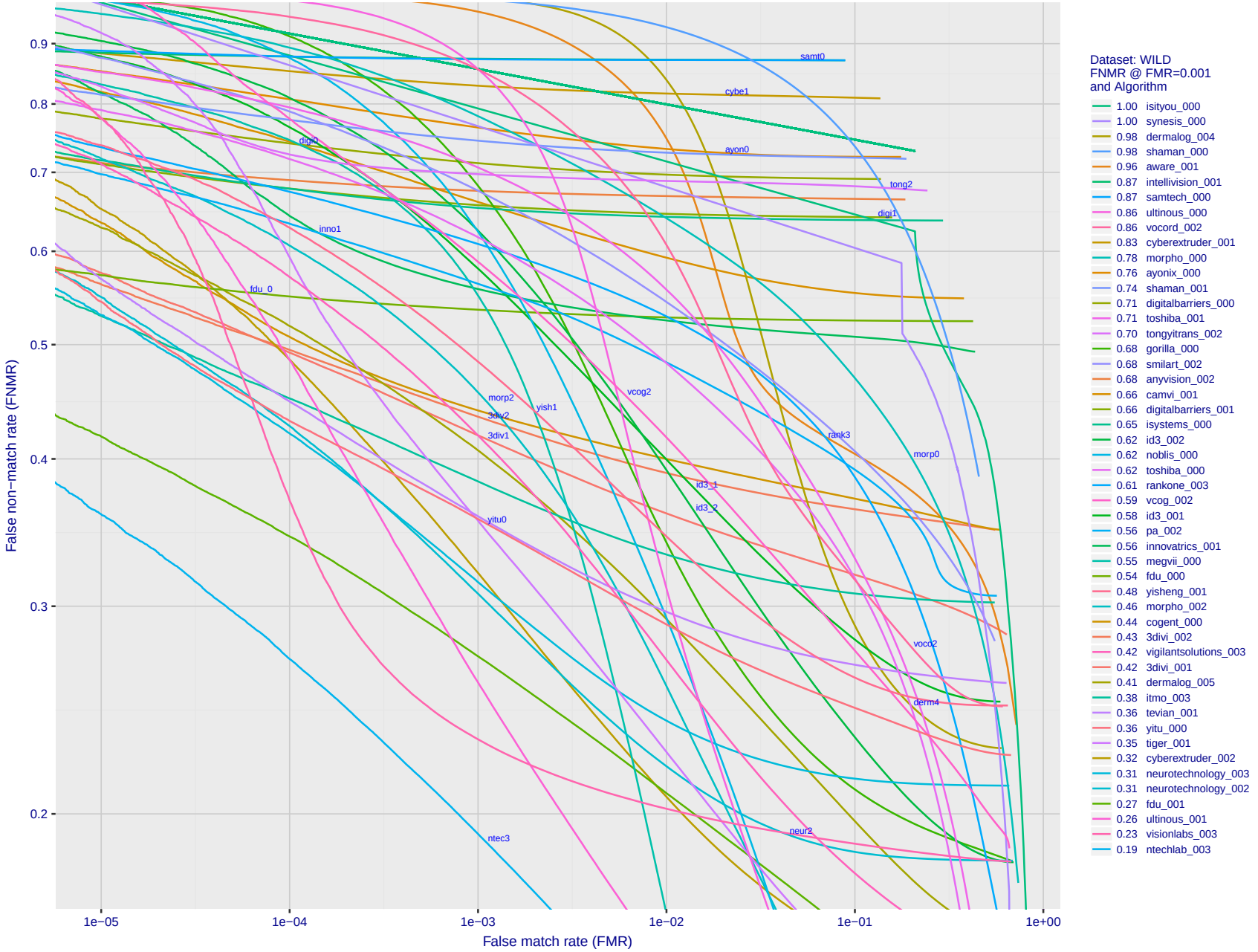


Figure 21: For the 2017 wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR.

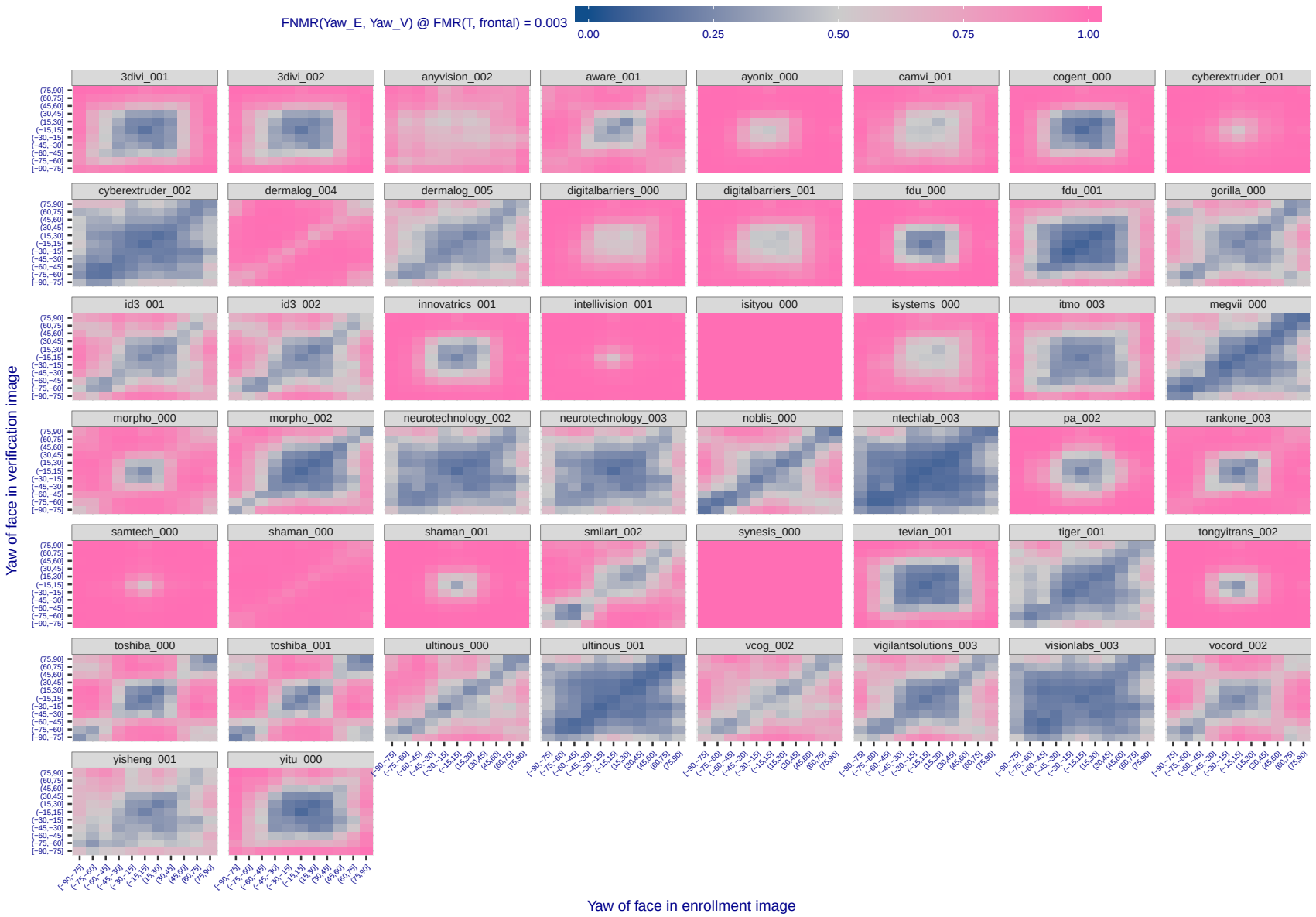


Figure 22: For wild images, the heatmap show FNMR *as a function of the yaw of the enrollment and verification images. The threshold is the same in all cells, and is set to the value that yeilds* FMR *= 0.003 on near frontal pairs i.e. where yaw is in the interval* $(-15, 15]$*. Poor algorithms give generally red figures. The better algorithms show a) diagonal dominance, indicating ability to authenticate when pairs have the same yaw angle, and b) off-diagonal cross-pose capability also. The yaw estimates are from an automated pose estimator, and are themselves noisy. The figure assumes that the pose estimates are not systematically incorrect.*

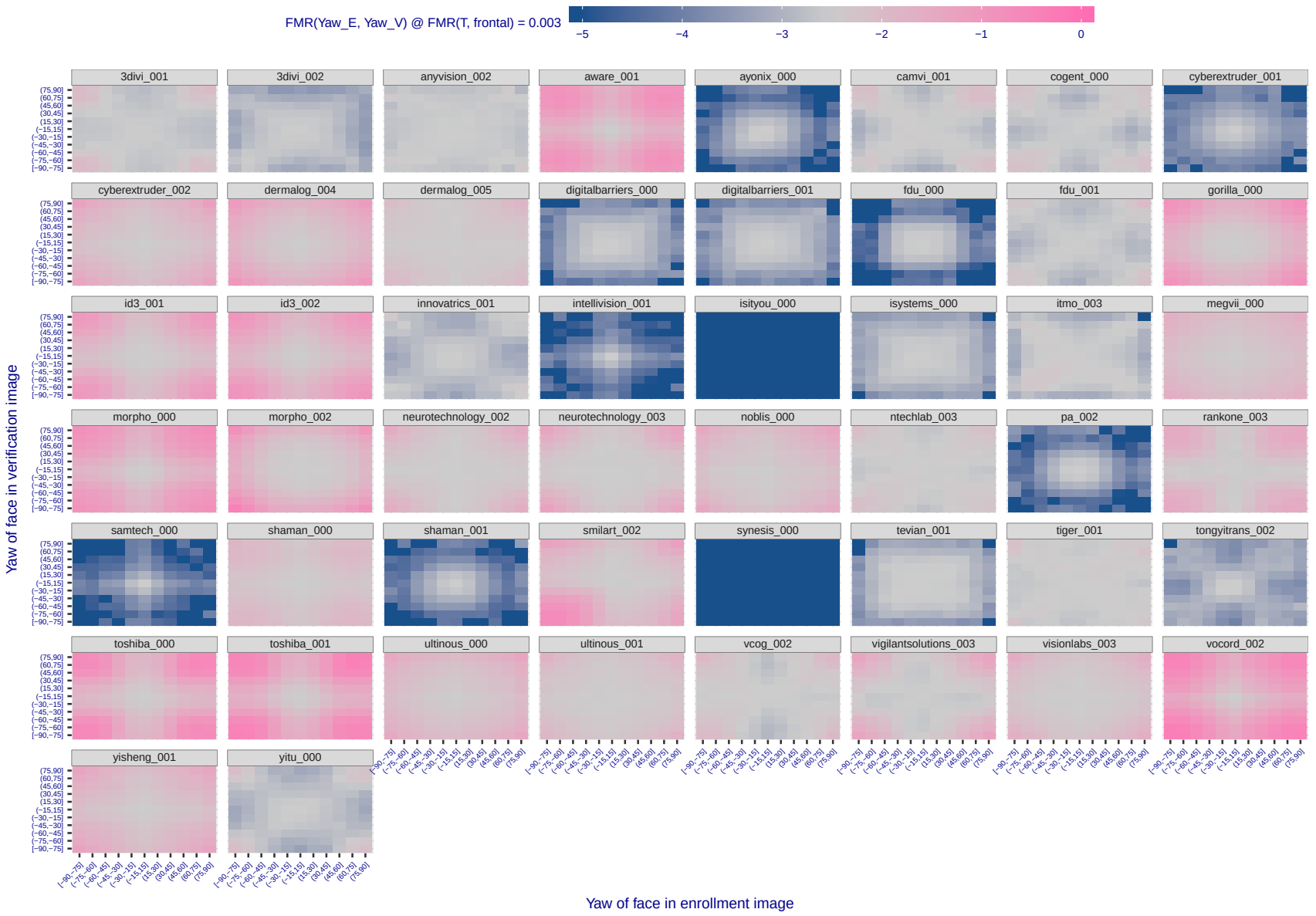


Figure 23: For wild images, the heatmaps show FMR *dependence on the yaw of the enrollment and verification images. The threshold is the same in all cells, and is set to the value that yields* FMR *= 0.003 on near frontal pairs, i.e. where yaw is in the interval* $(-15, 15]$*. Thus the center of each panel is grey. The desired behavior is that* FMR *does not vary with relative yaw. However, some algorithms gives elevated* FMR *when yaw differs. The yaw estimates are from an automated pose estimator, and are themselves noisy. The figure assumes that the pose estimates are not systematically incorrect.*

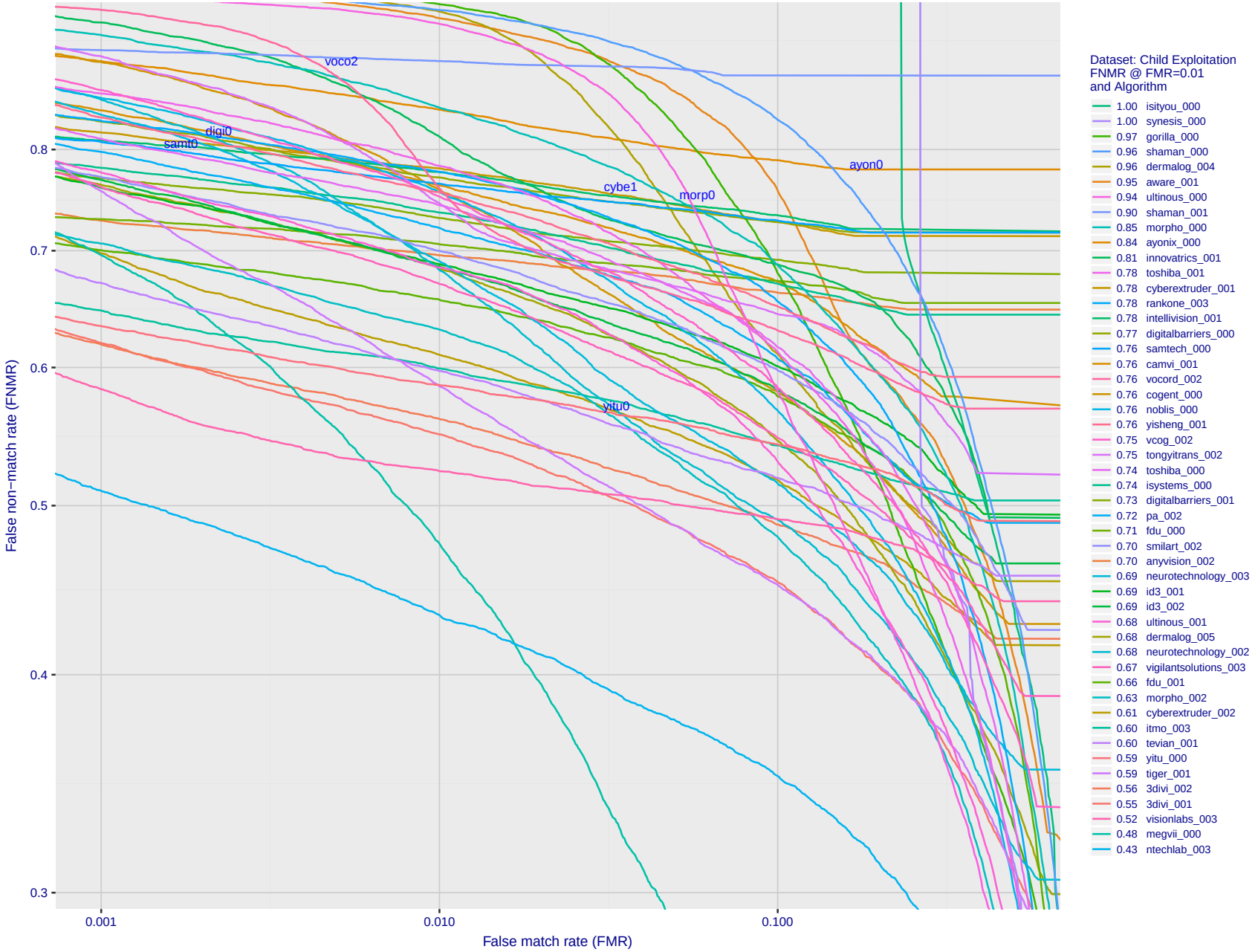


Figure 24: For child exploitation images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR. Accuracy is poor because many images have adverse quality characteristics, and because detection and enrollment fails.

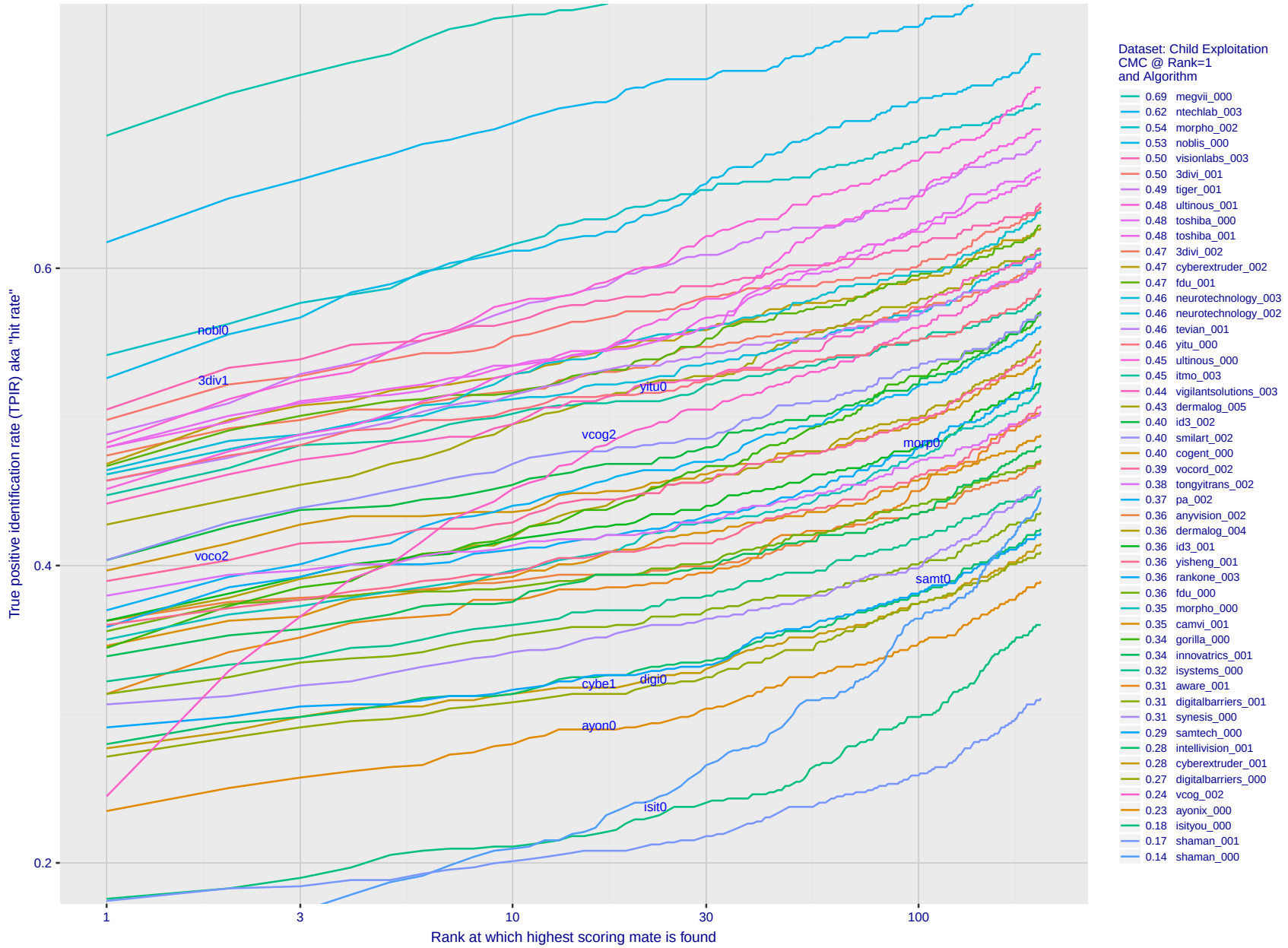


Figure 25: For child exploitation images, cumulative match characteristics (CMC) showing true positive identification rate vs. rank. This is simulation of a one-to-many search experiment - see discussion in section 5.2. The scales are logarithmic in order to show the effect of long candidate lists. Accuracy is poor but much improved relative to the 1:1 DETs of Fig. 24 because a search can succeed if any of a subject's several enrolled images matches the search image with a high score.

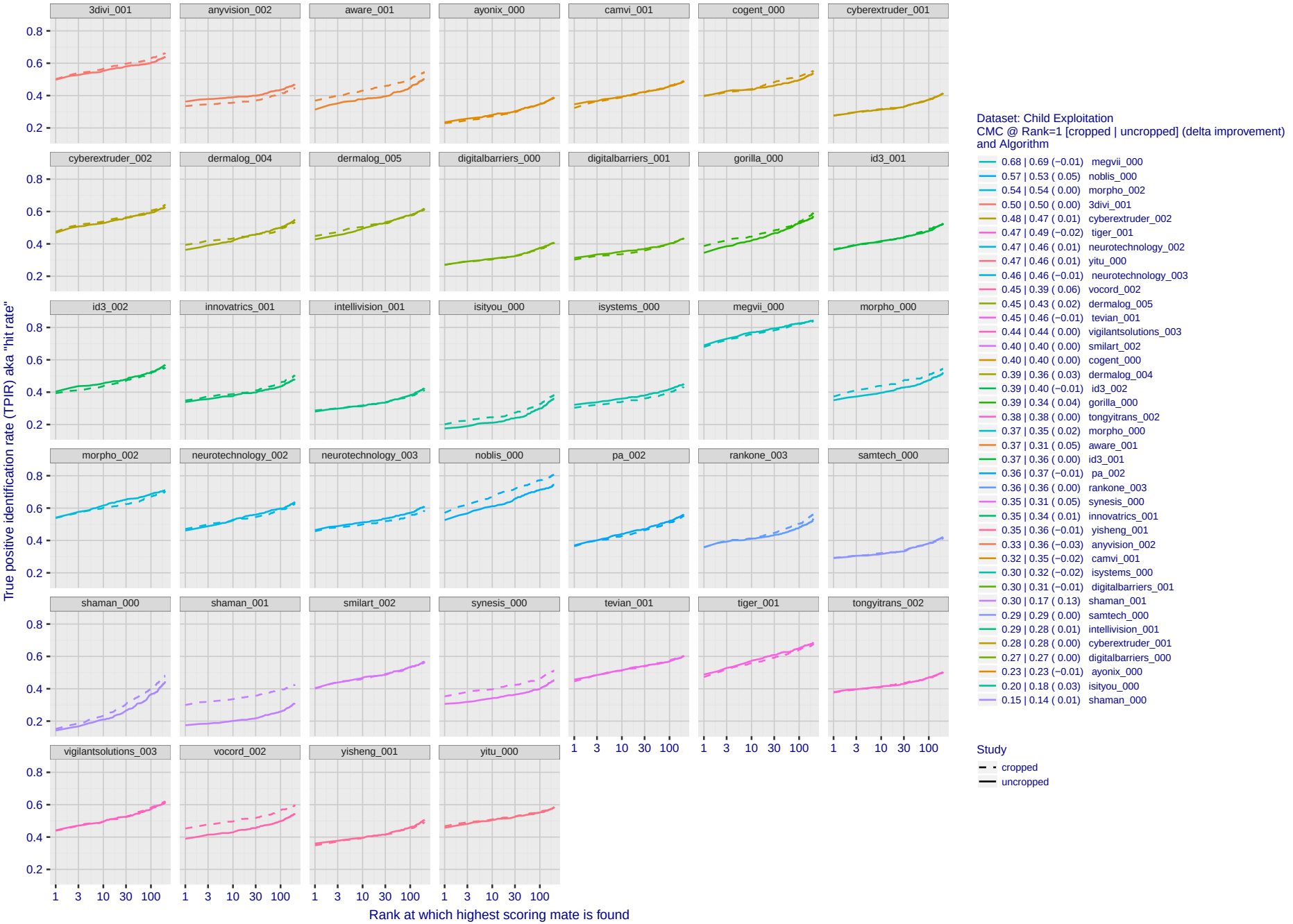


Figure 26: For child exploitation images, cumulative match characteristics (CMC) showing true positive identification rate vs. rank for two cases: 1. Whole image provided to the algorithm; 2. Human annotated rectangular region, cropped and provided to the algorithm. The difference between the traces is associated with detection of difficult faces, and fine localization.

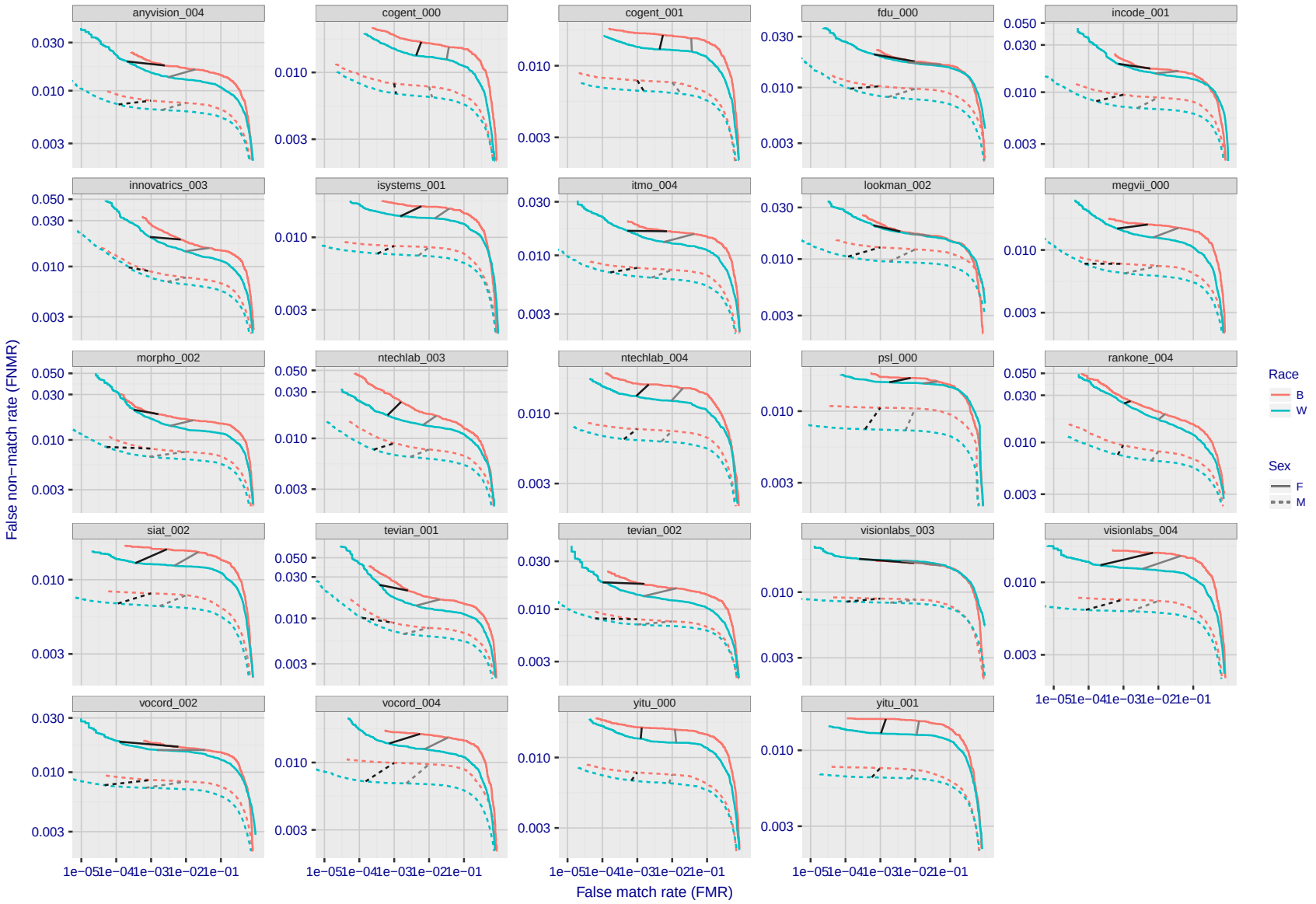


Figure 27: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 52. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

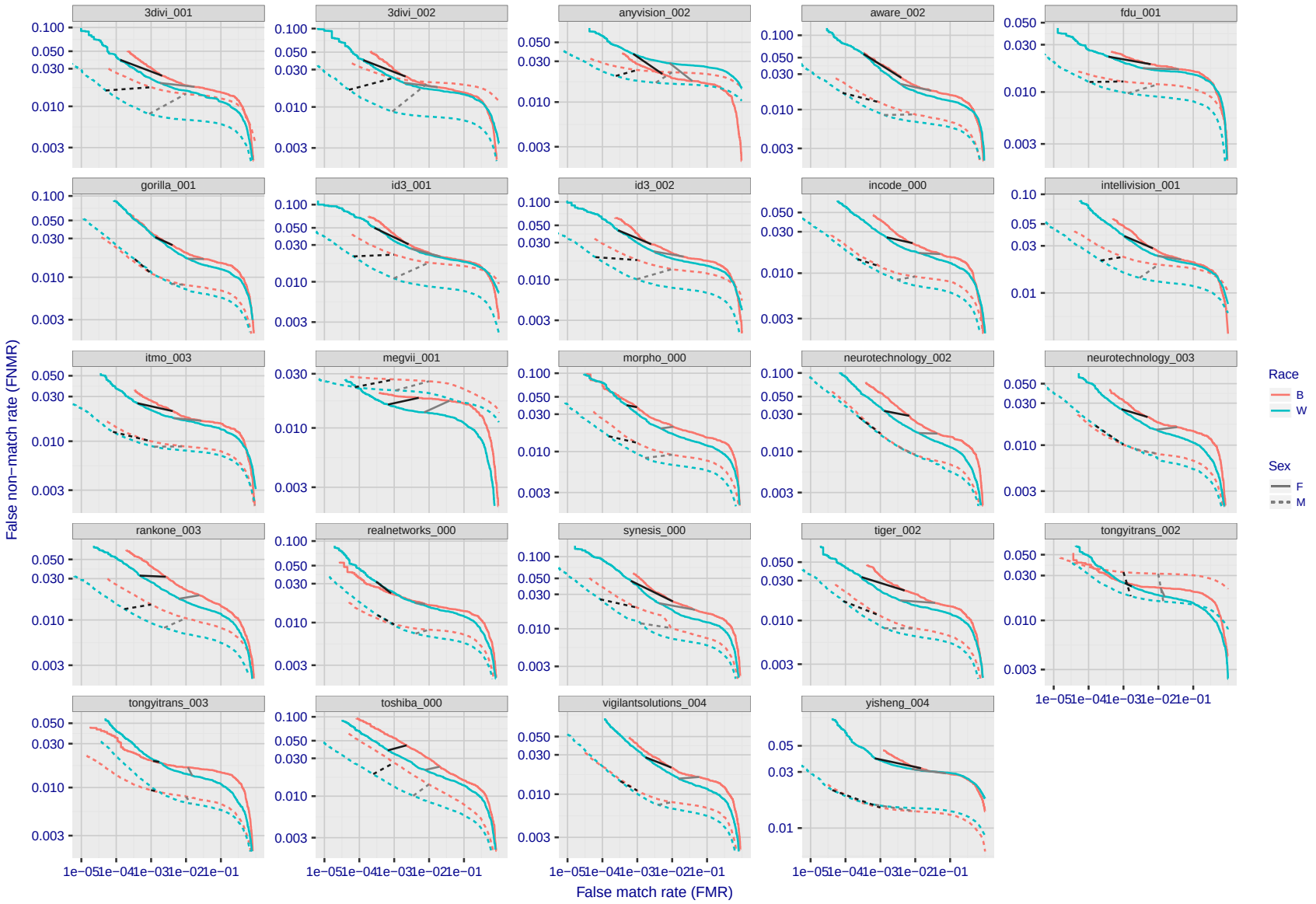


Figure 28: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 52. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

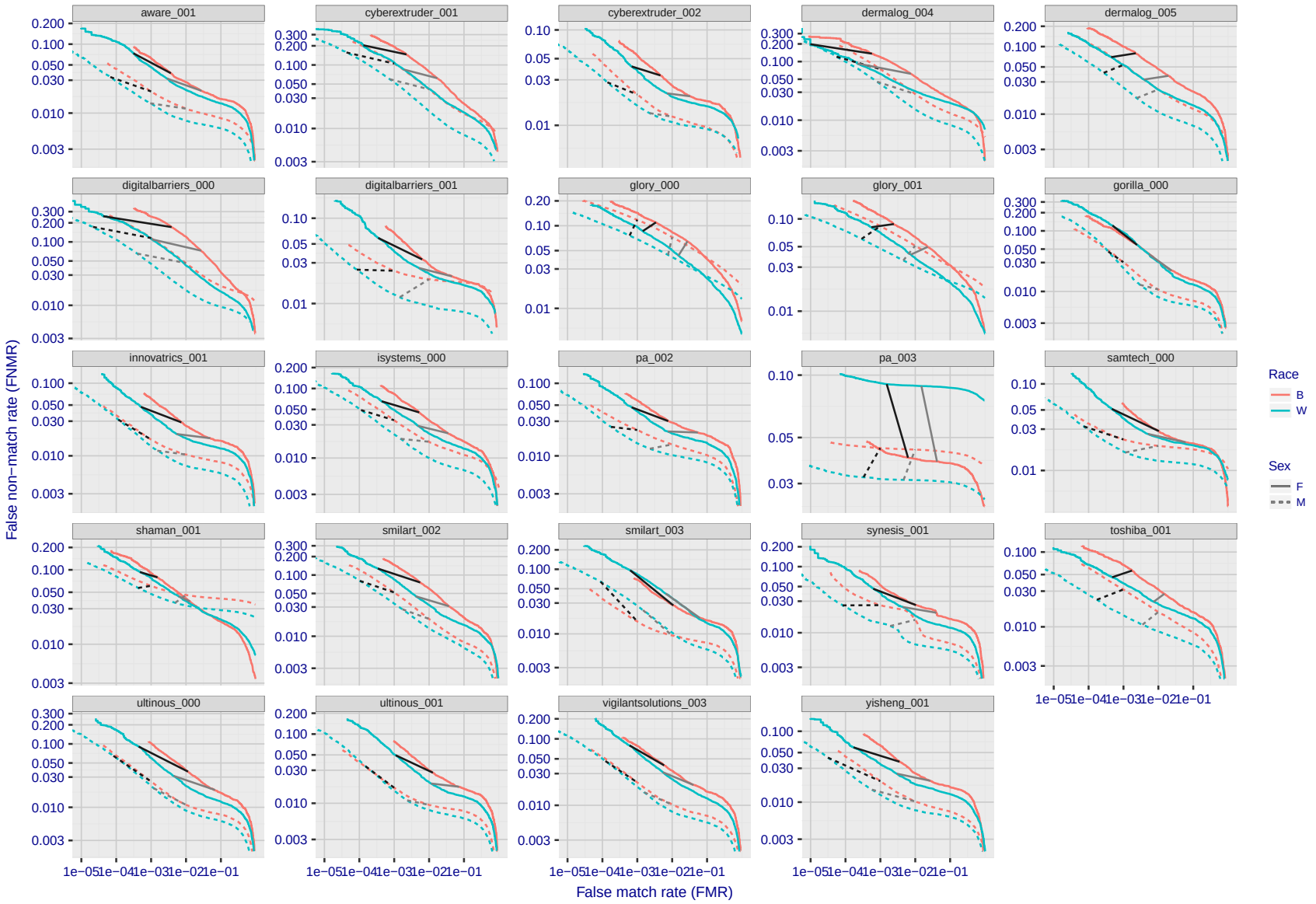


Figure 29: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 52. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

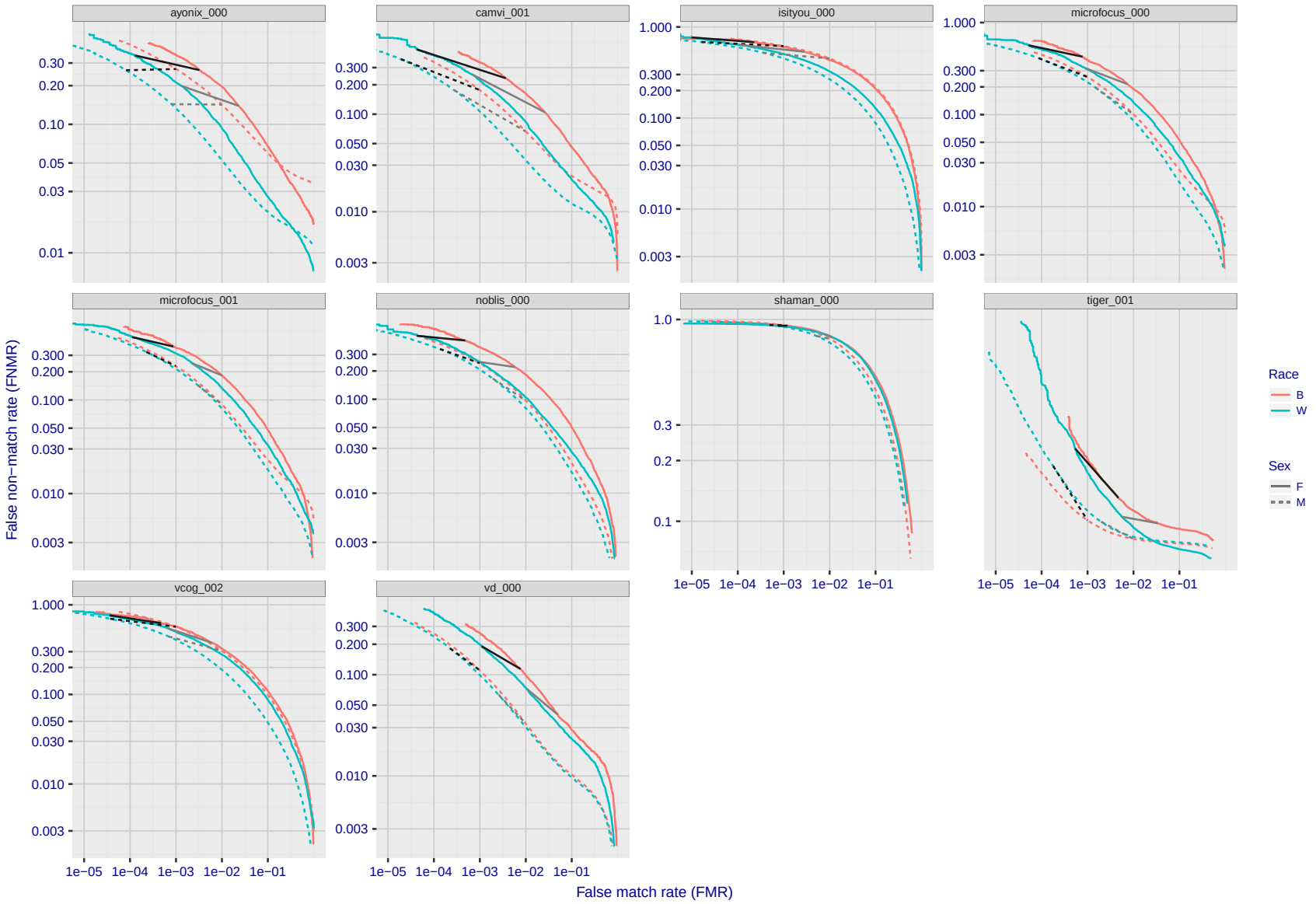


Figure 30: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 52. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

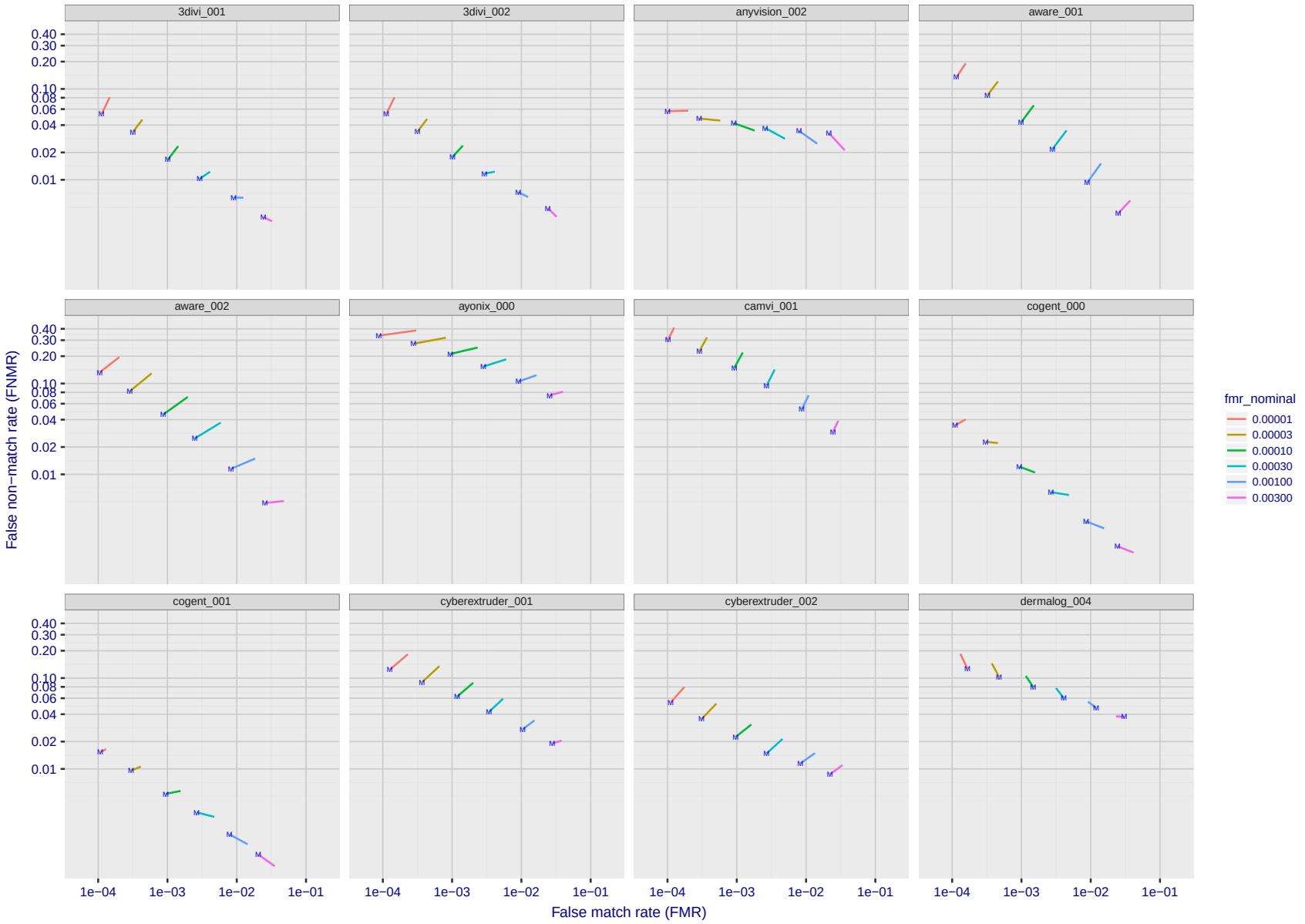


Figure 31: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

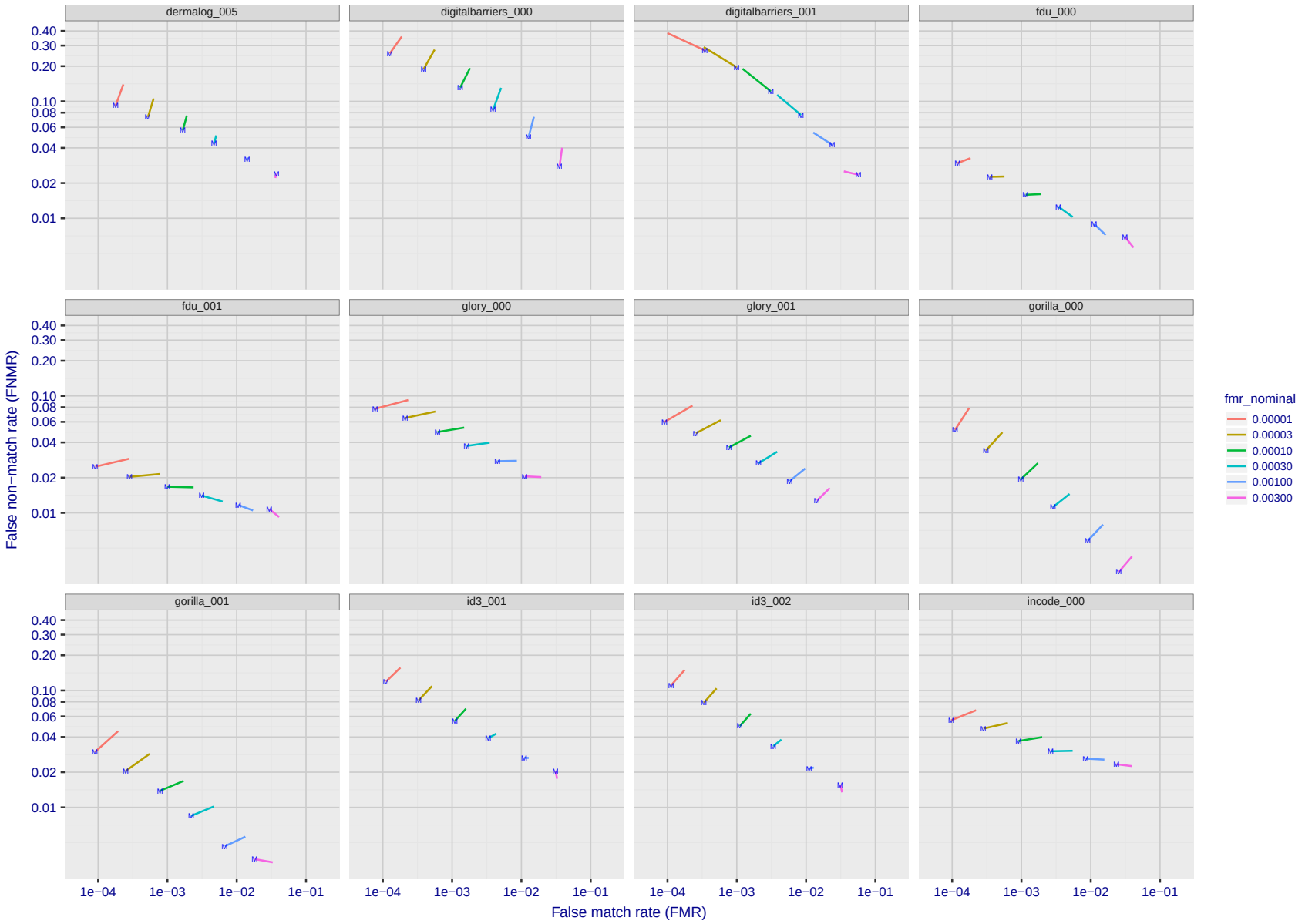


Figure 32: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

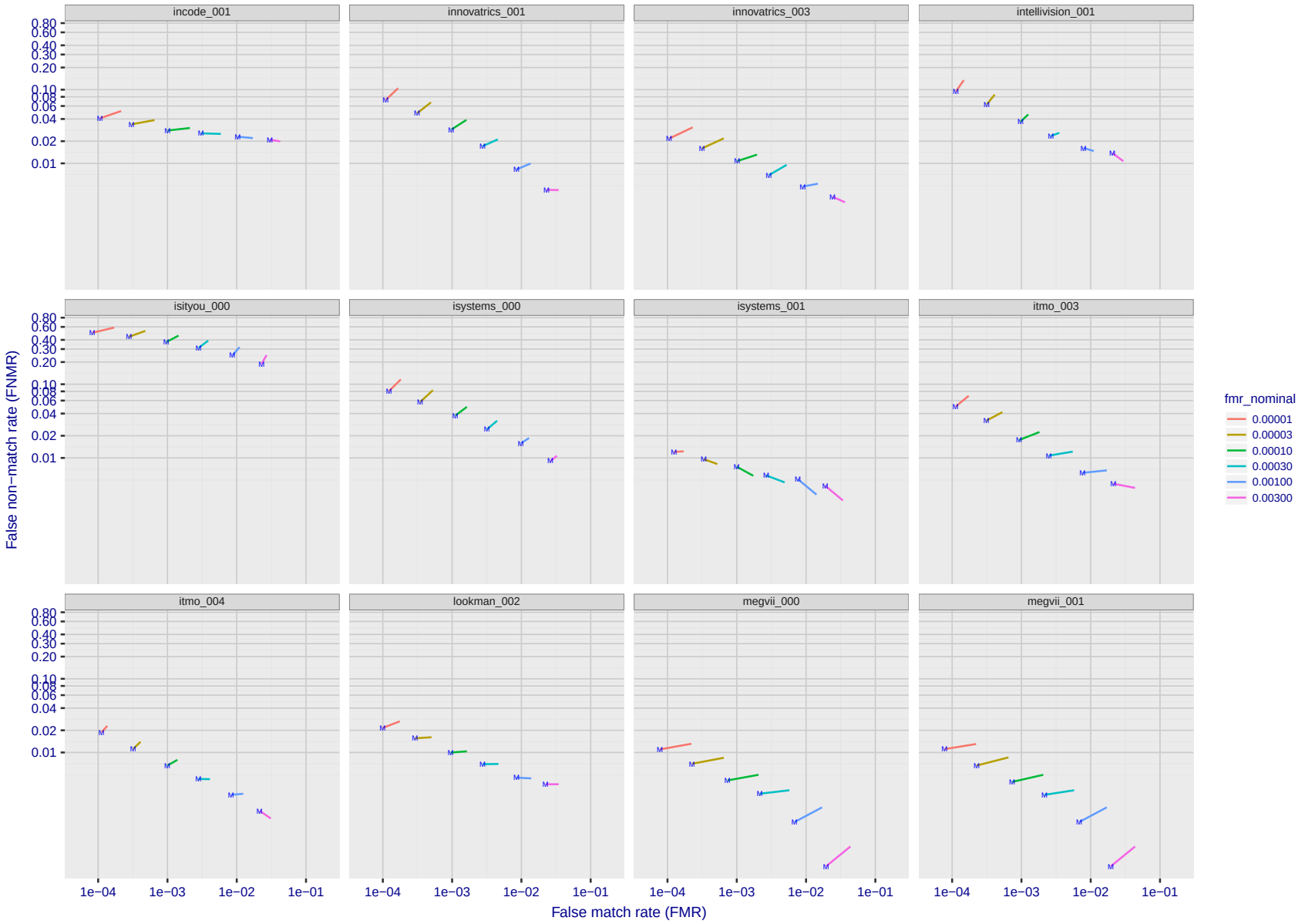


Figure 33: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

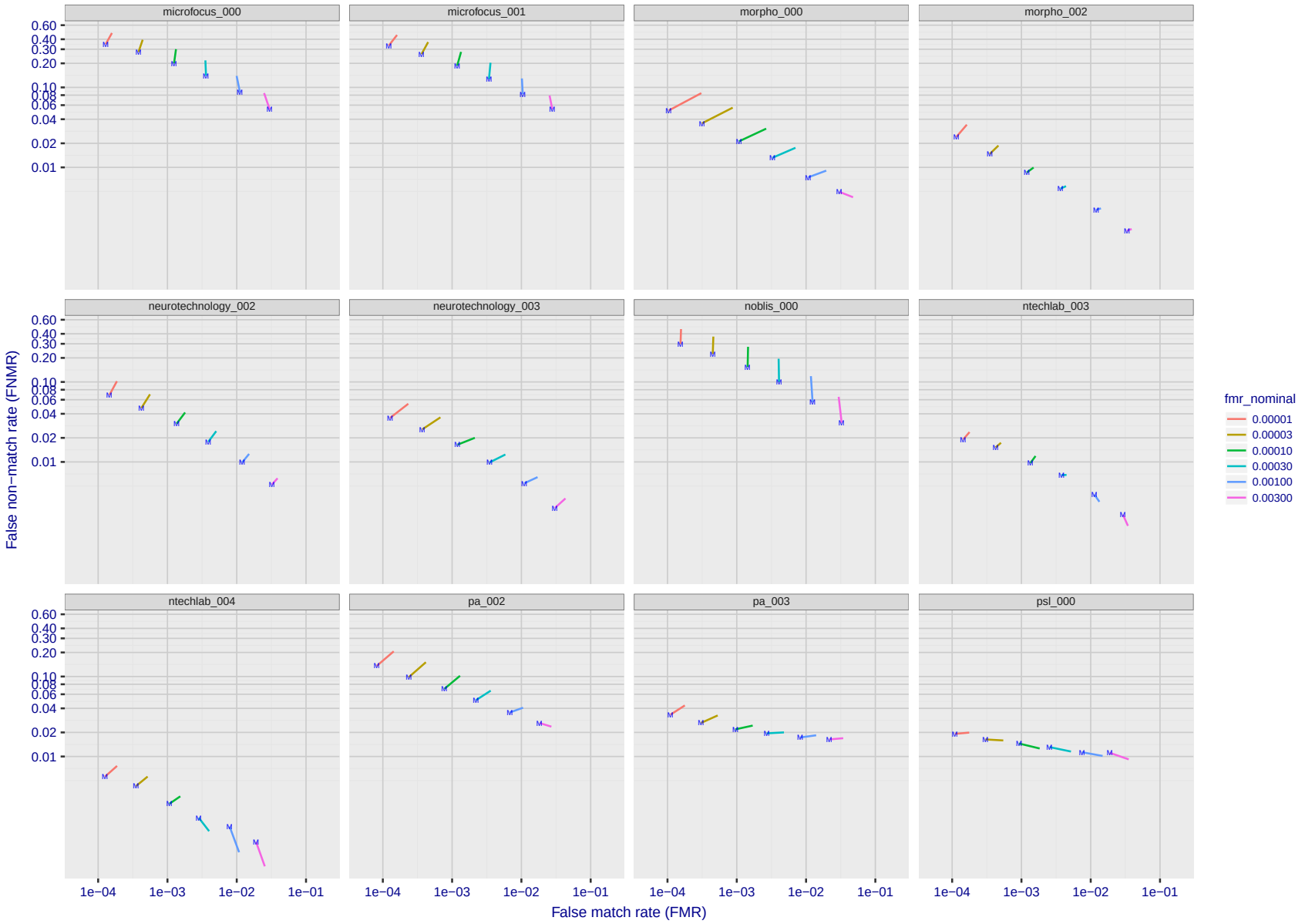


Figure 34: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

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FNMR(T) "False non-match rate"
FMR(T) "False match rate"

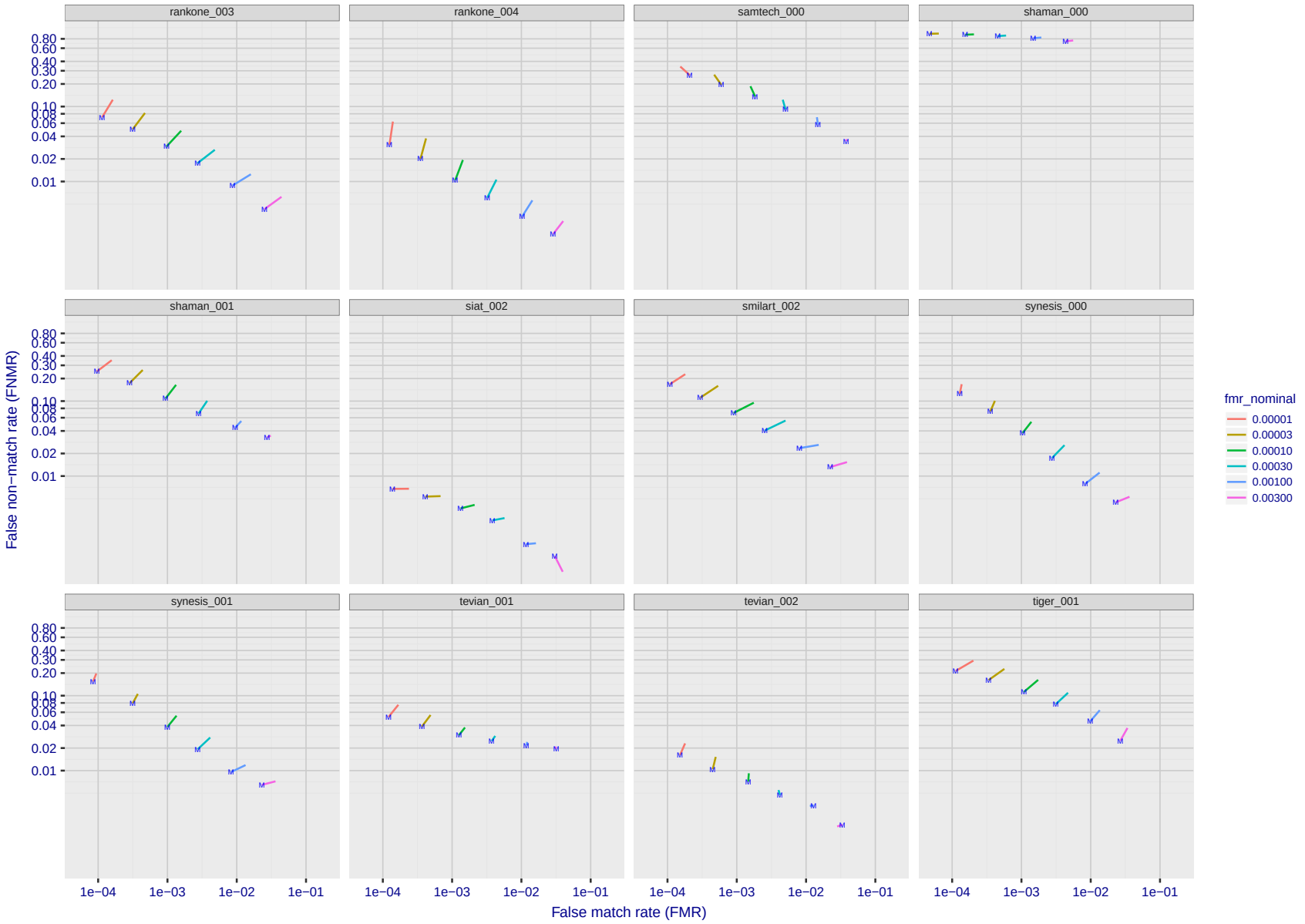


Figure 35: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

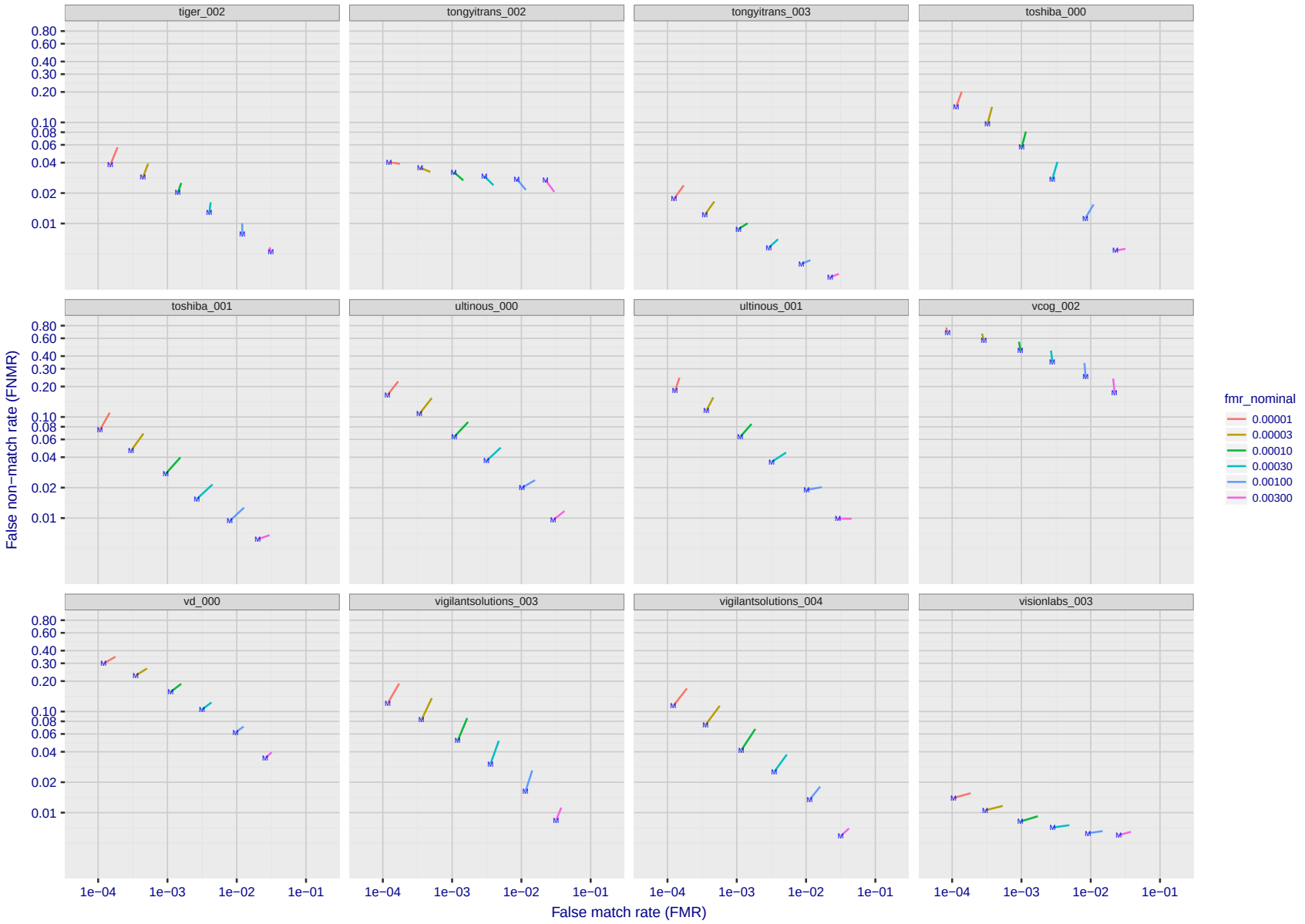


Figure 36: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

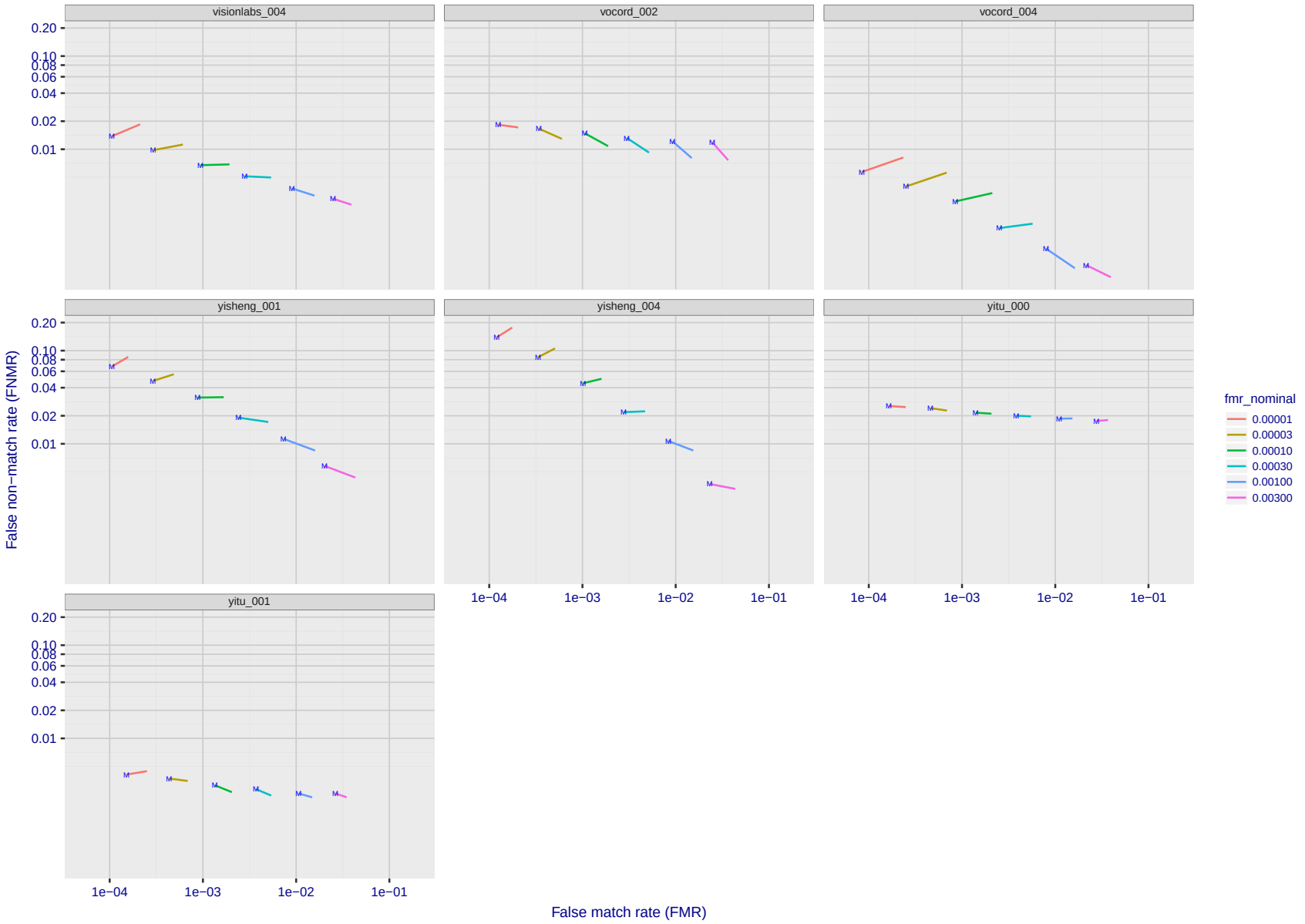


Figure 37: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).

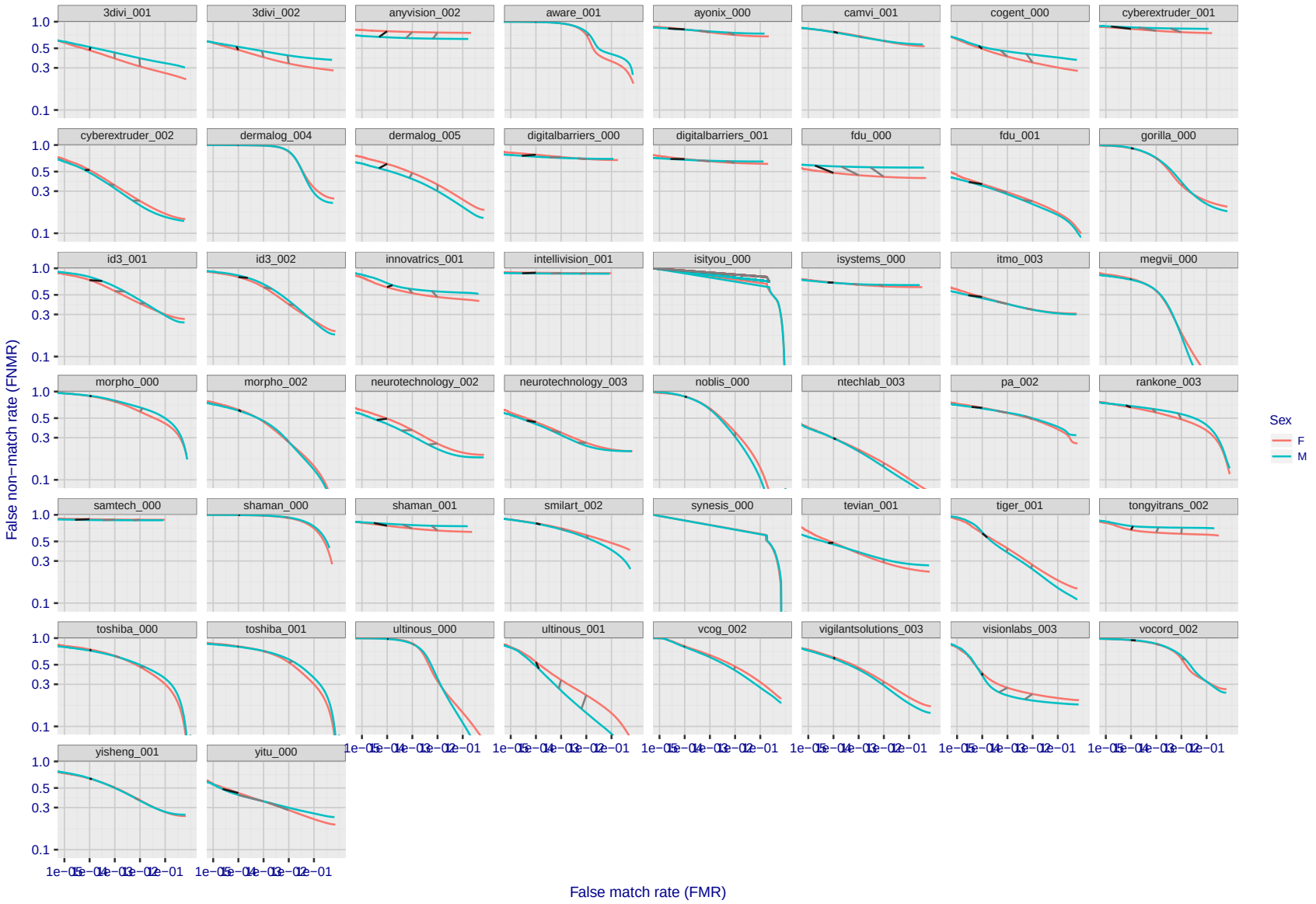


*Figure 38: For the wild image comparisons, detection error tradeoff (*DET*) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. Error rates are higher here than in the generic wild DET (Fig 21) becuase the impostor pairs here are same-sex only. The scales are logarithmic in order to show several decades of* FMR.

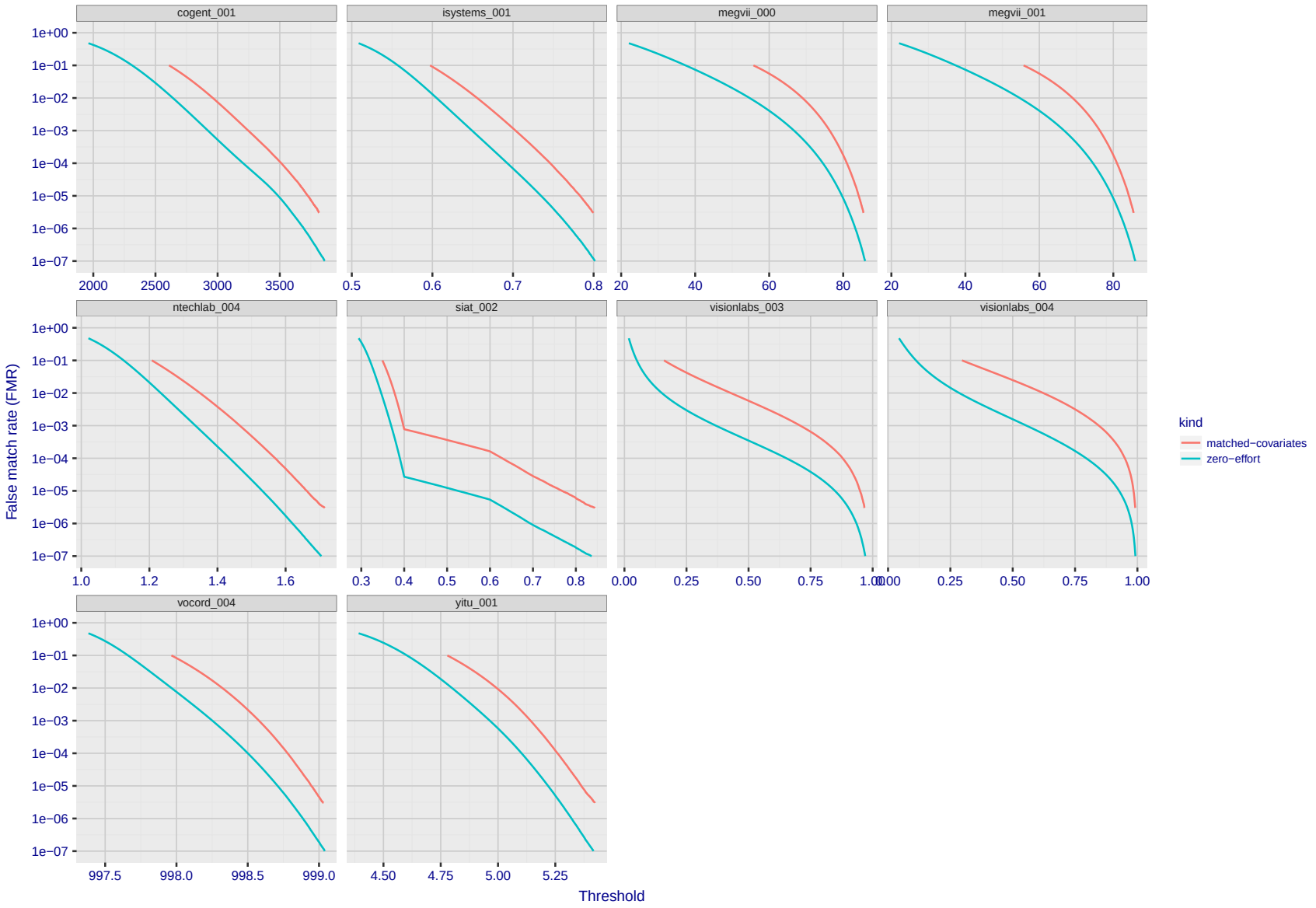


Figure 39: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

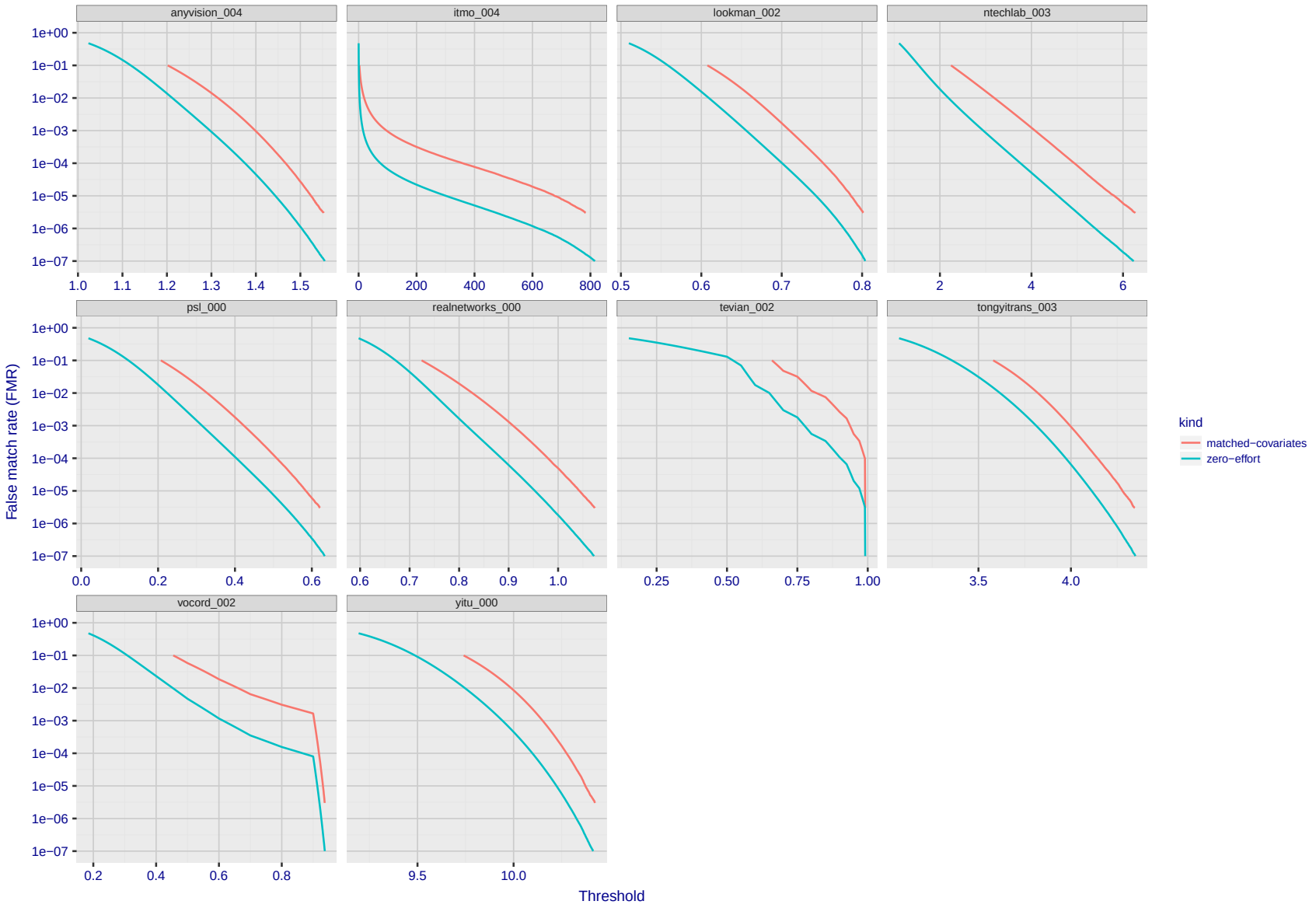


Figure 40: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

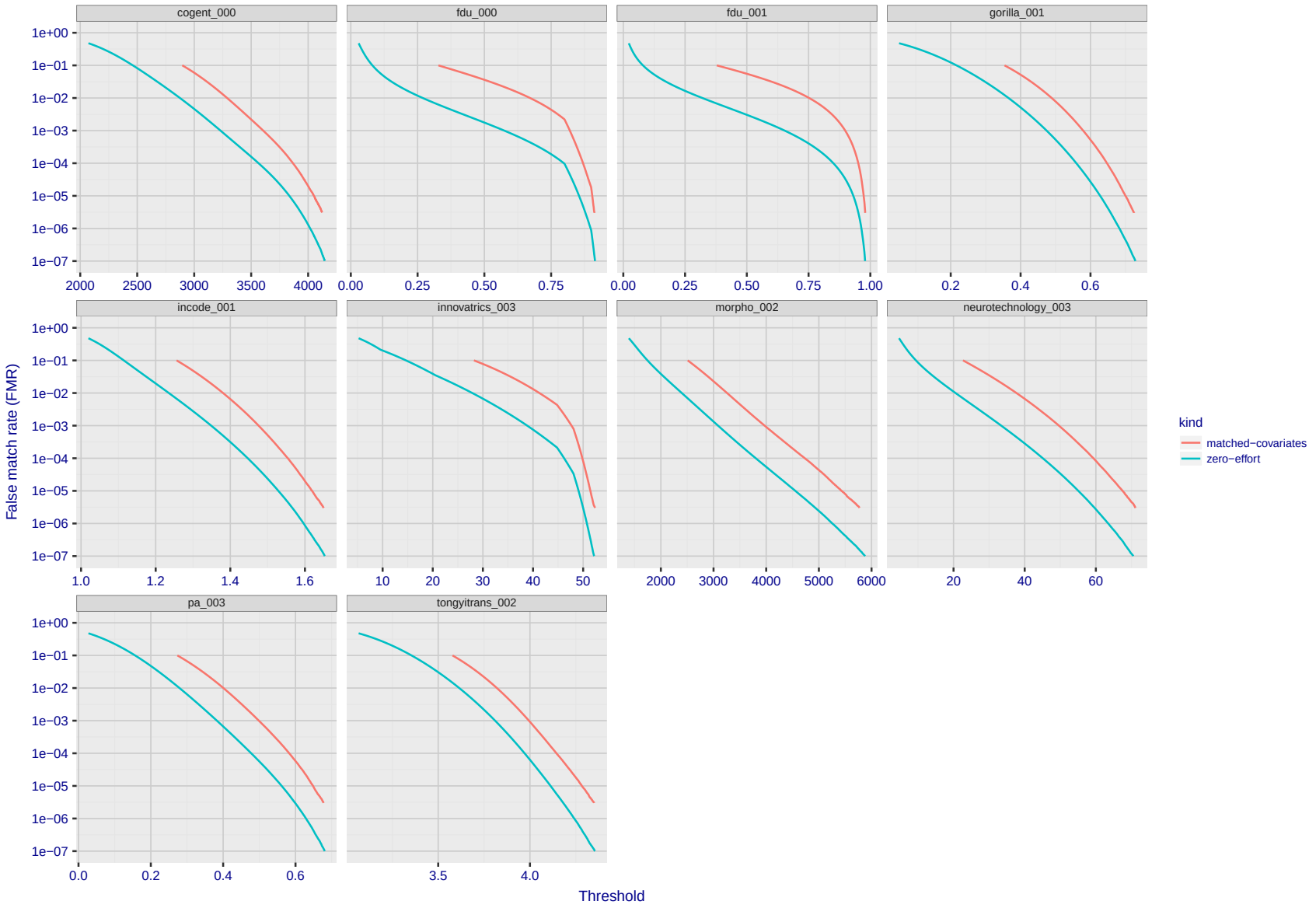


Figure 41: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

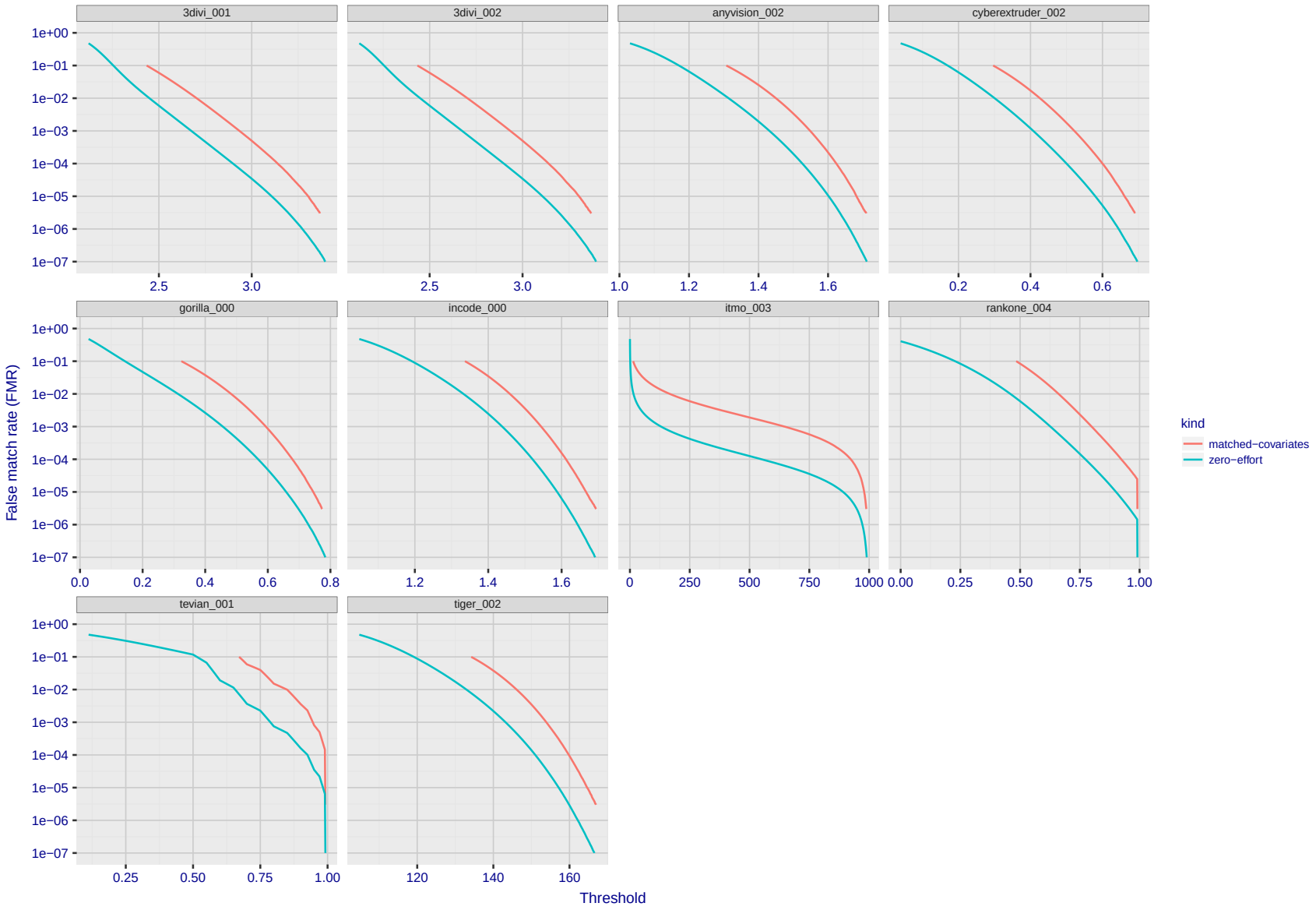


Figure 42: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

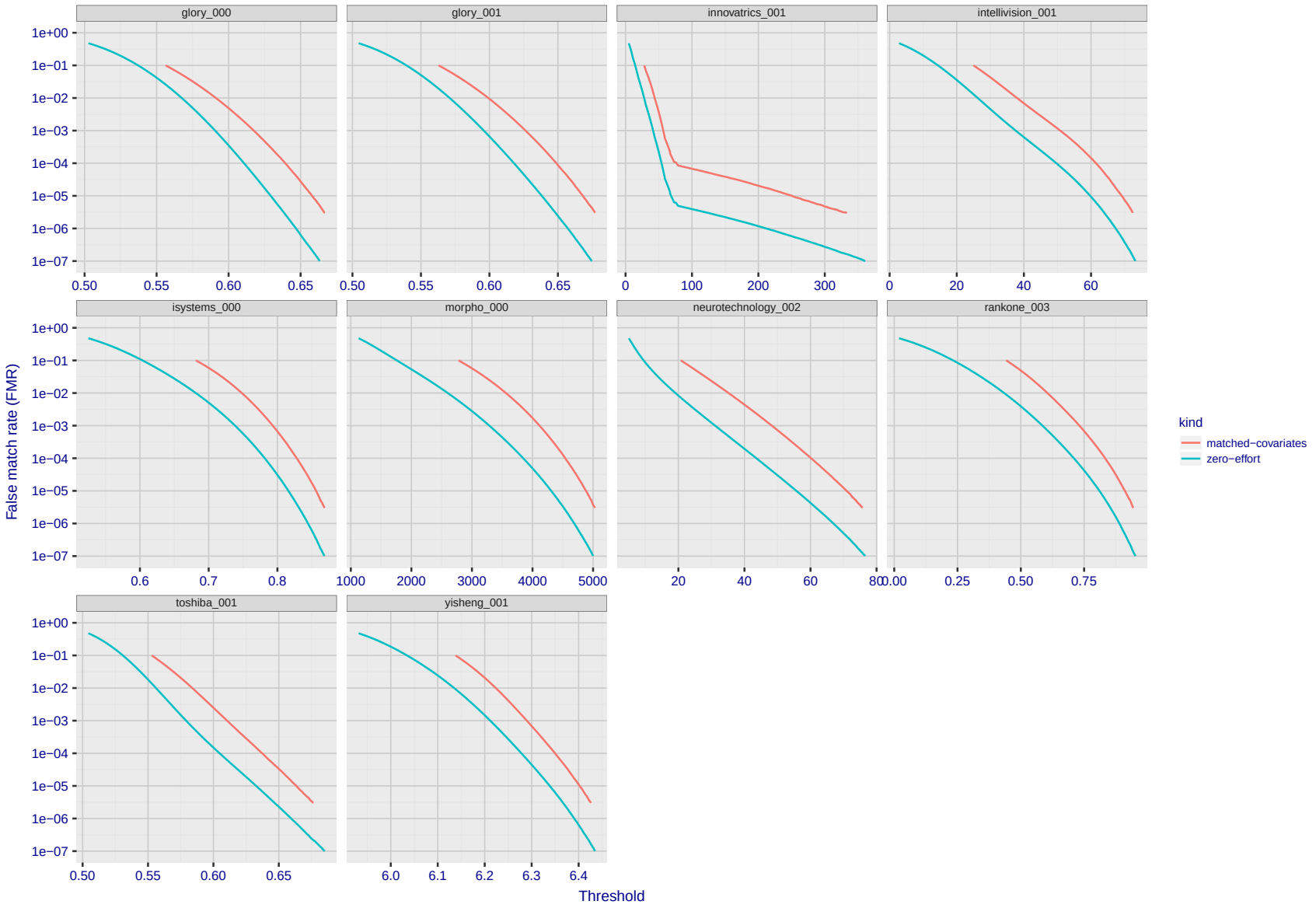


Figure 43: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

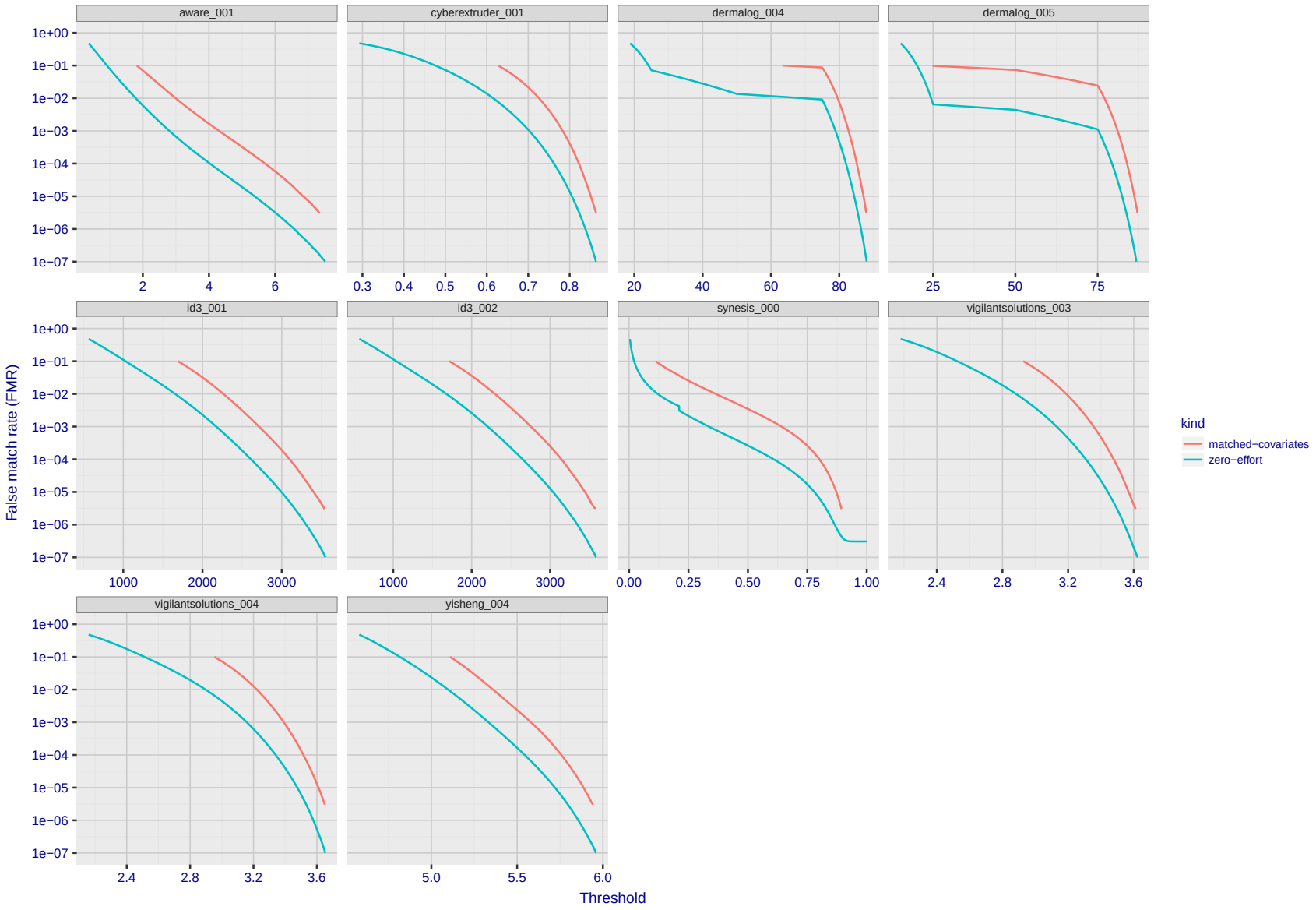


Figure 44: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

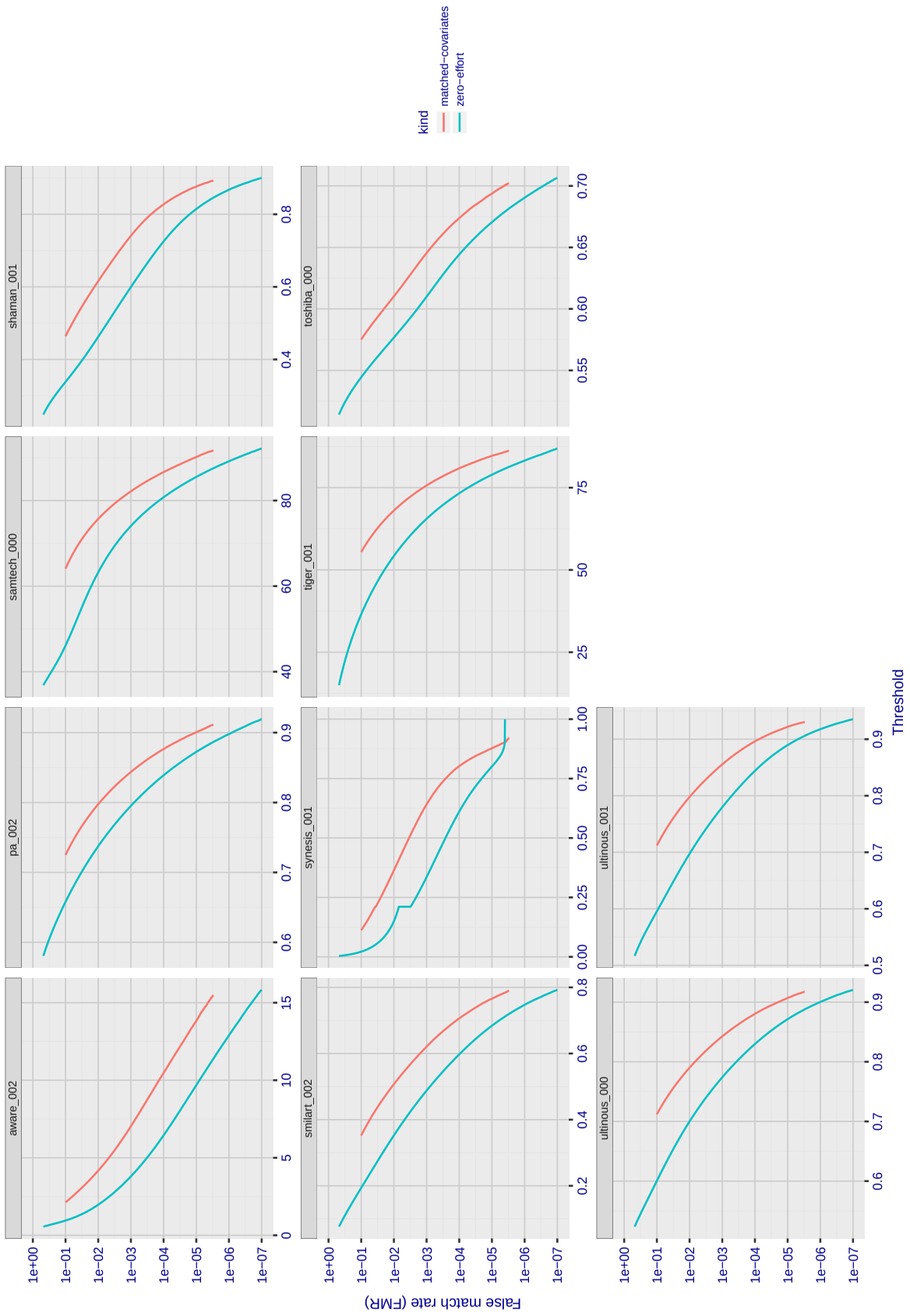


Figure 45: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

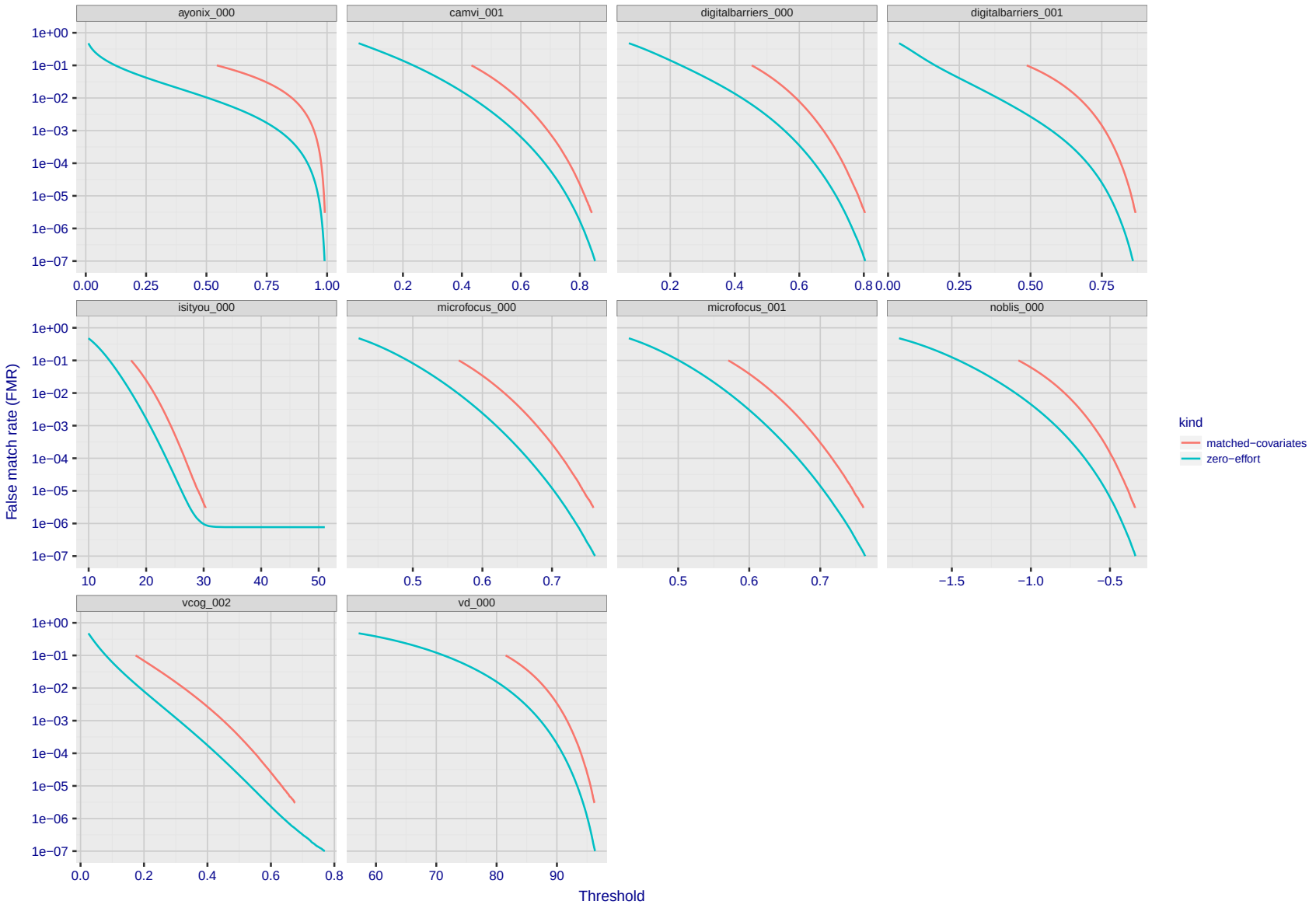


Figure 46: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

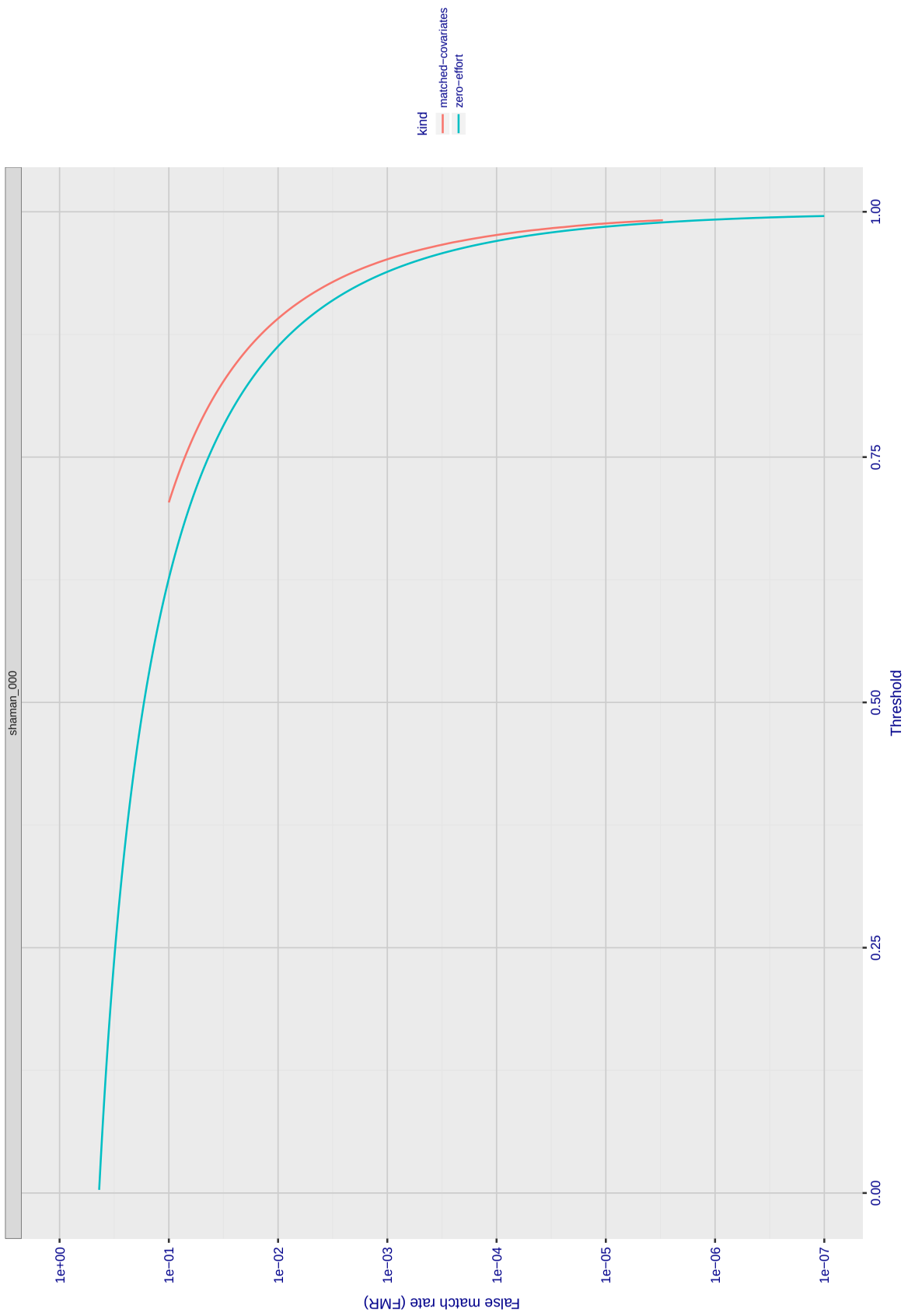


Figure 47: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

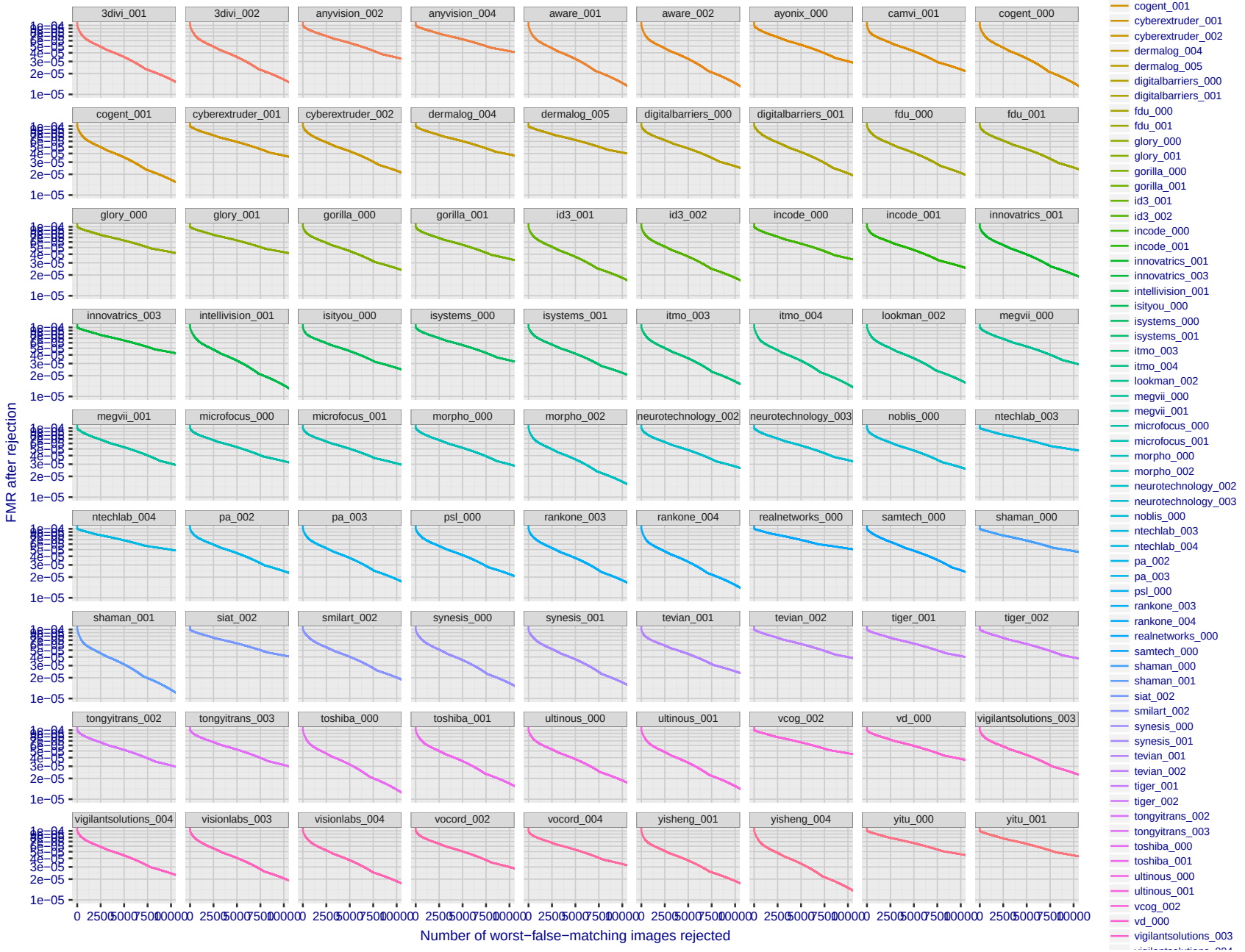


Figure 48: For the visa images, the curves show how false matches are concentrated in certain images. Specifically each line plots FMR(k) with k the number of images rejected in decreasing order of how many false matches that image was involved in. FMR$(0) = 10^{-4}$. In terms of the biometric zoo, the most "wolf-ish" images are rejected first i.e. those enrollment or verification images most often involved in false matches. A flatter response is considered superior. A steeply descending response indicates that certain kinds of images false match against others, e.g. if hypothetically images of men with particular mustaches would falsely match others.

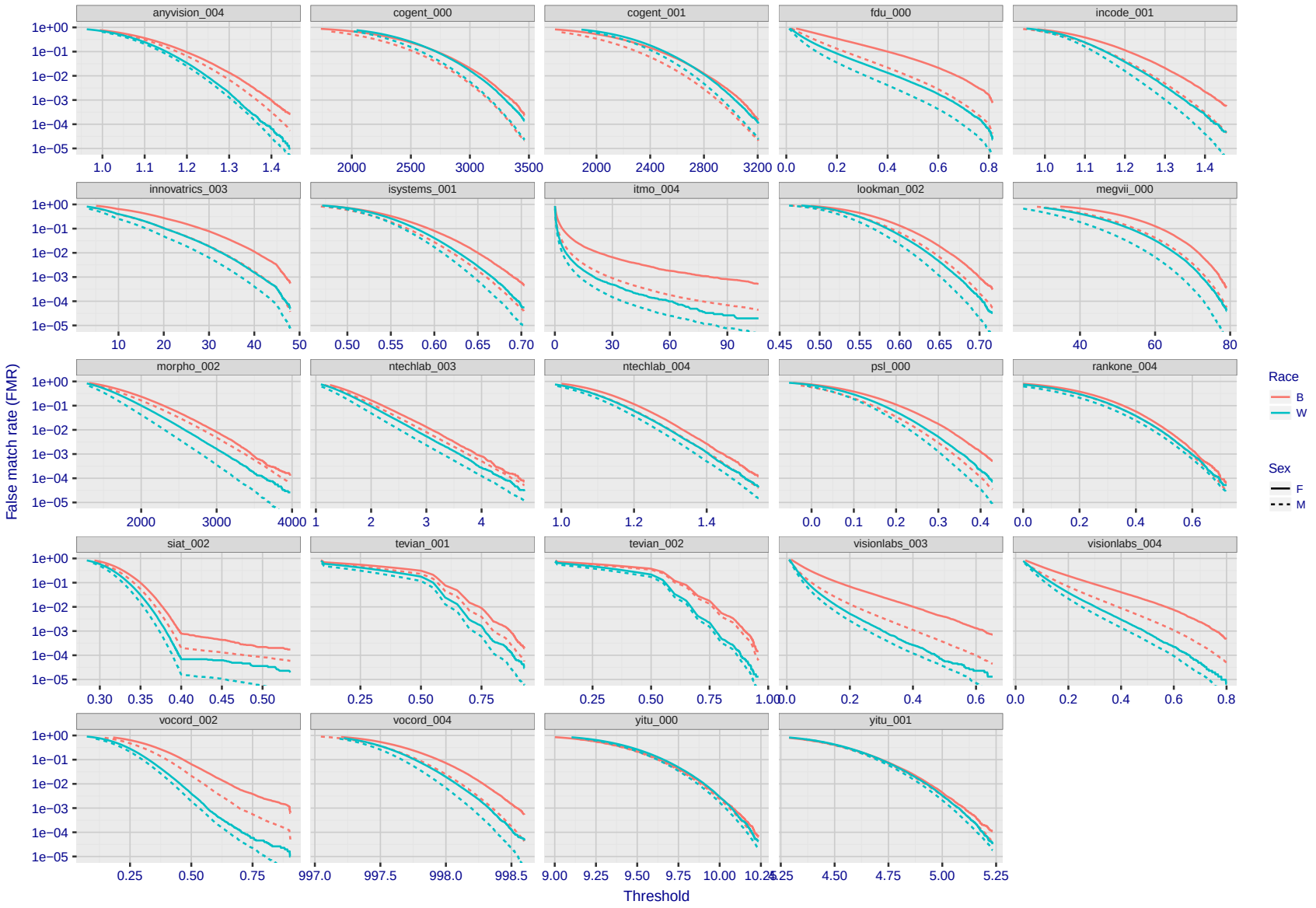


Figure 49: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.

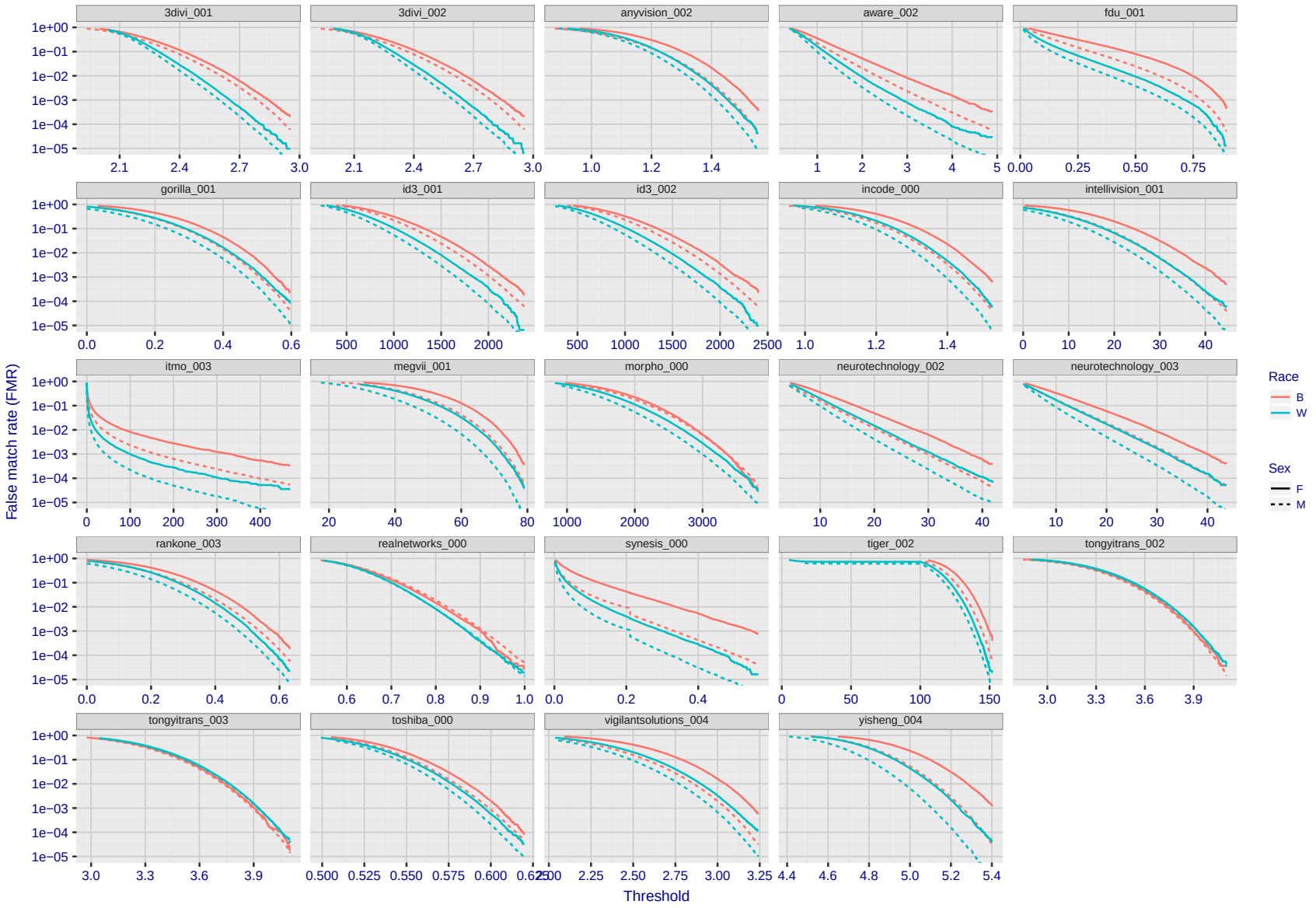


Figure 50: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.

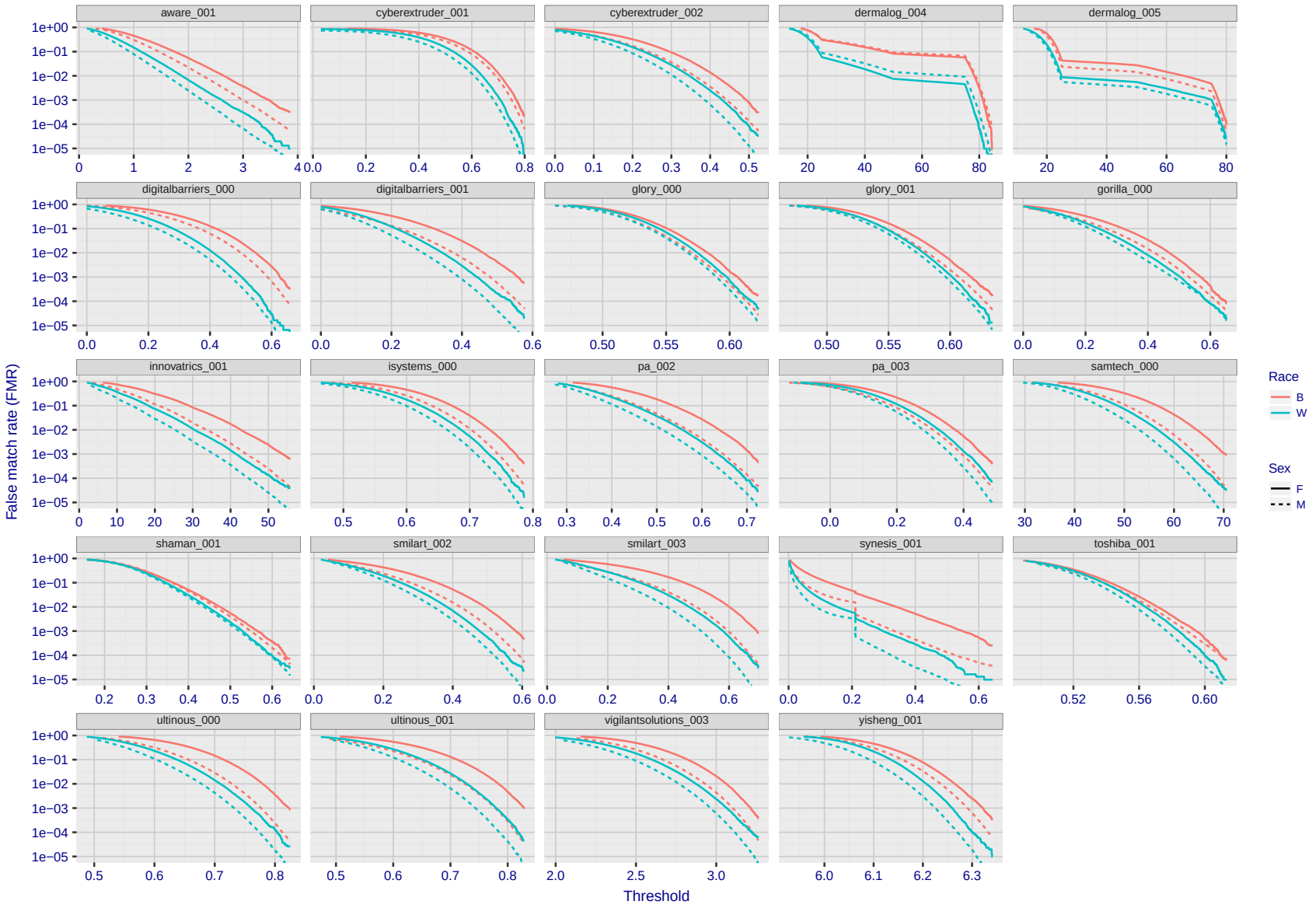


Figure 51: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.

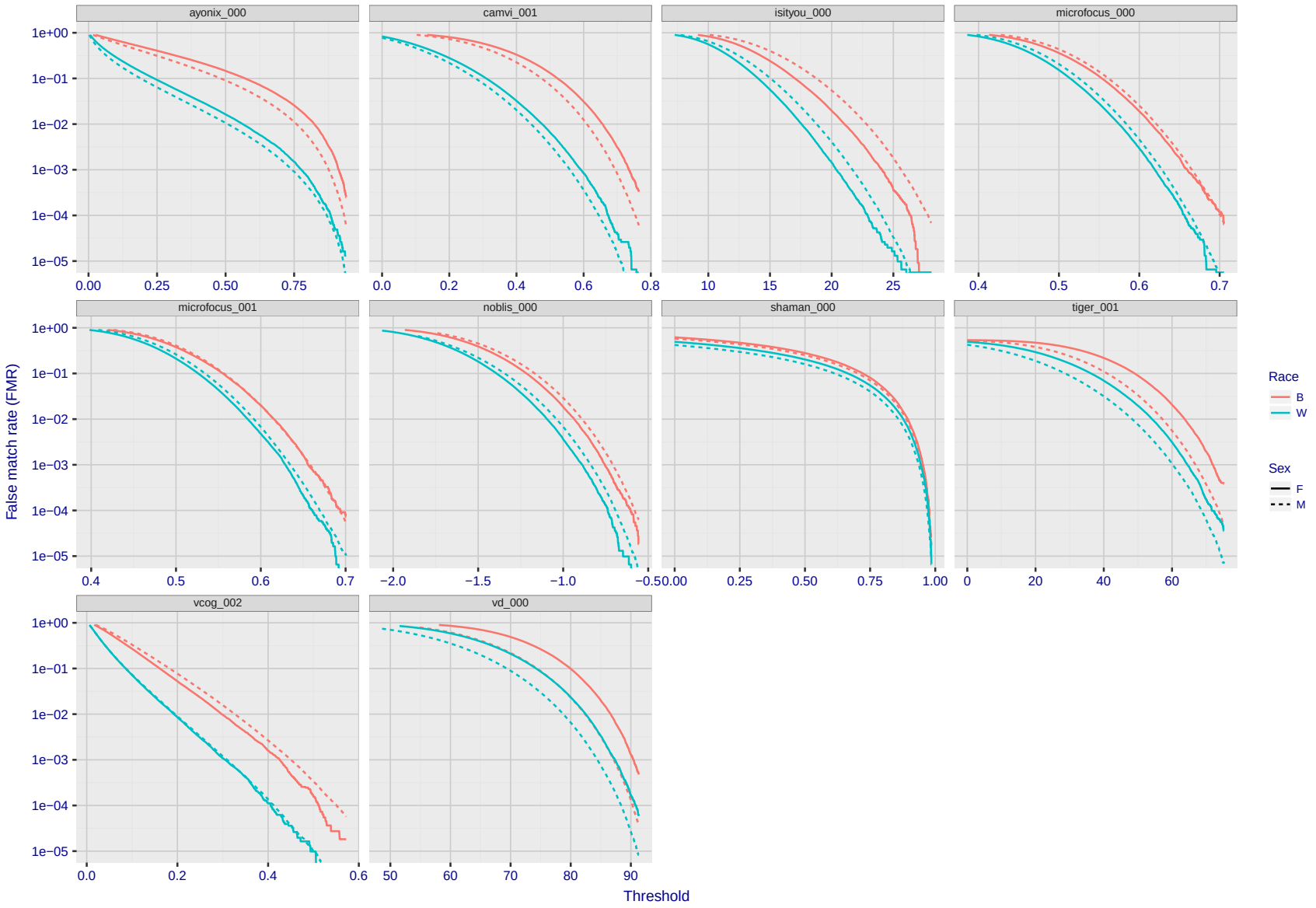


Figure 52: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.

5.5 Genuine distribution stability

5.5.1 Effect of birth place on the genuine distribution

Background: Both skin tone and bone structure vary geographically. Prior studies have reported variations in FNMR and FMR.

Goal: To measure false non-match rate (FNMR) variation with country of birth.

Methods: Thresholds are determined that give FMR = $\{0.001, 0.0001\}$ over the entire impostor set. Then FNMR is measured over 1000 bootstrap replications of the genuine scores. Only those countries with at least 140 individuals are included in the analysis.

Results: Figure 57 shows FNMR by country of birth for the two thresholds.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

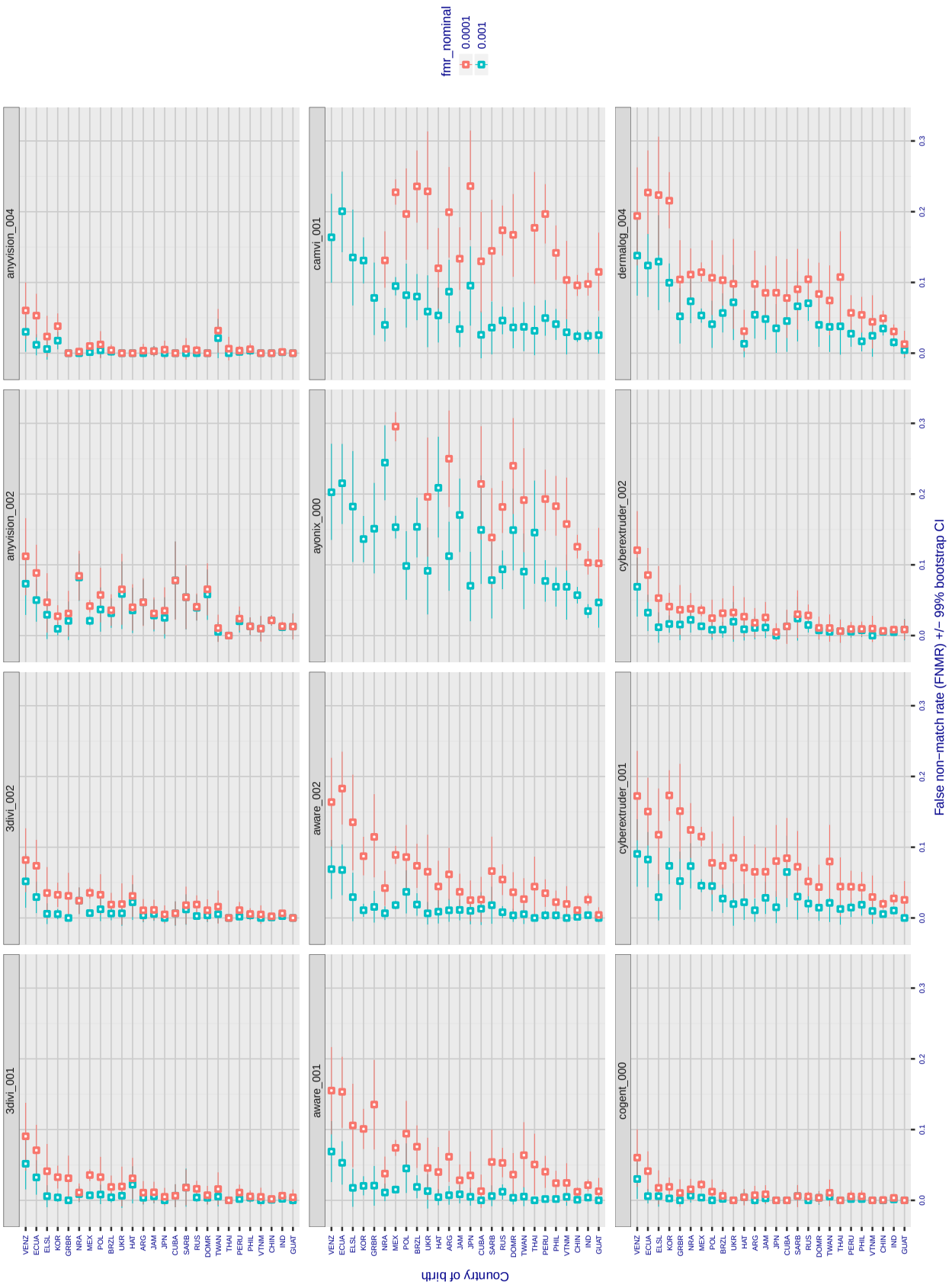


Figure 53: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = {0.001, 0.0001} computed over all on the order of 10^{10} impostor scores. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

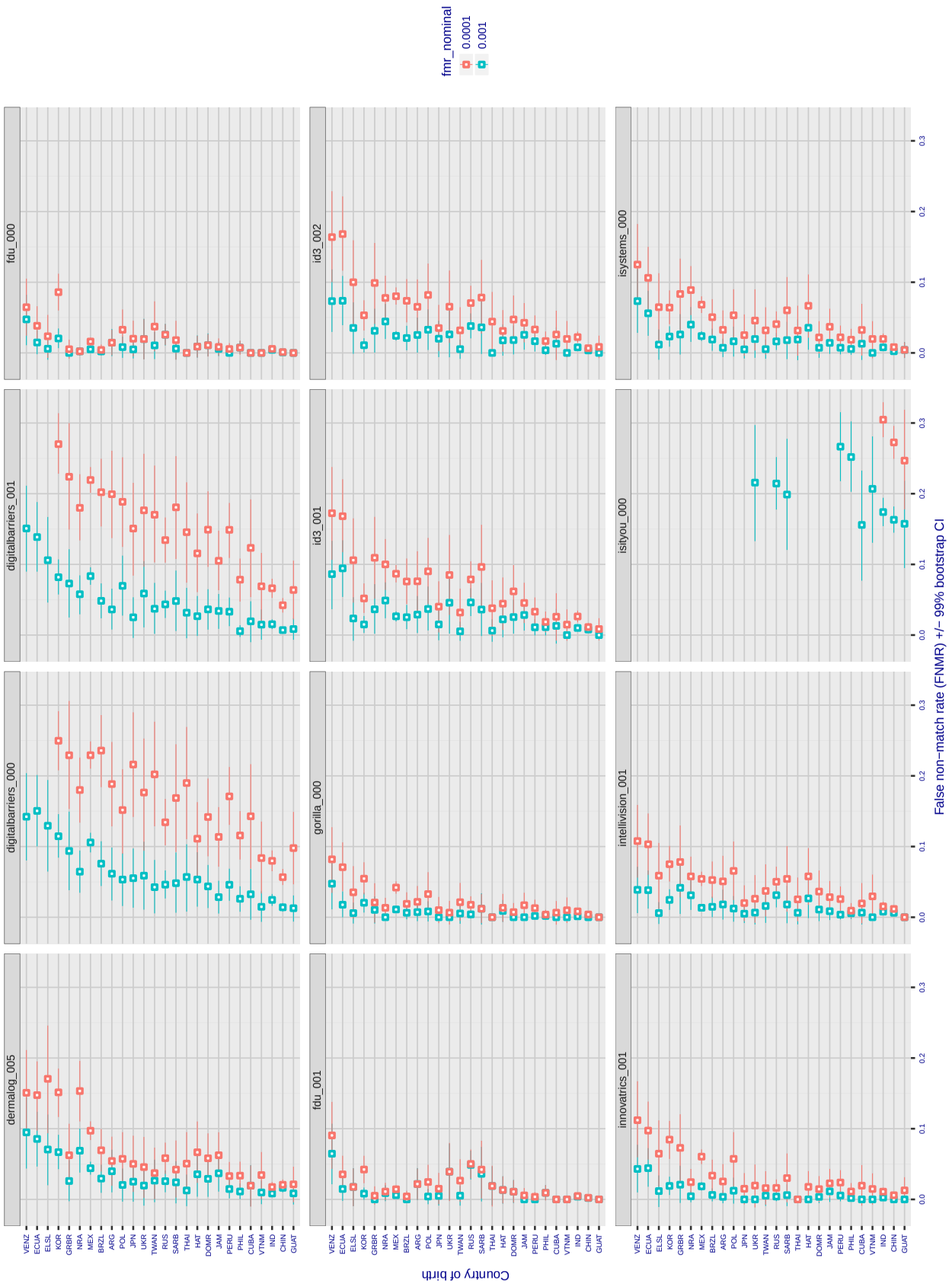


Figure 54: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of 10^{10} impostor scores. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

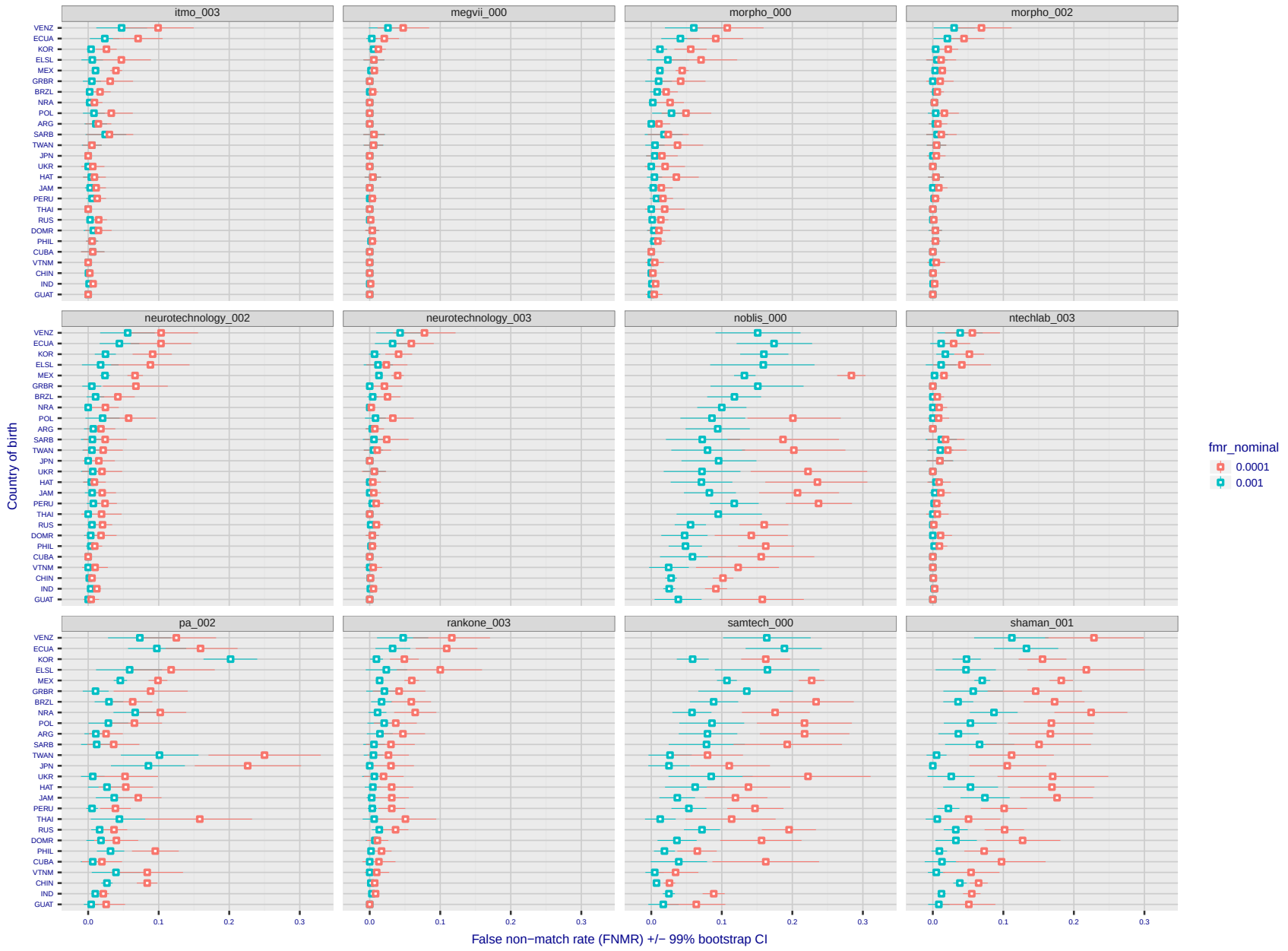


Figure 55: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of 10^{10} impostor scores. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race.

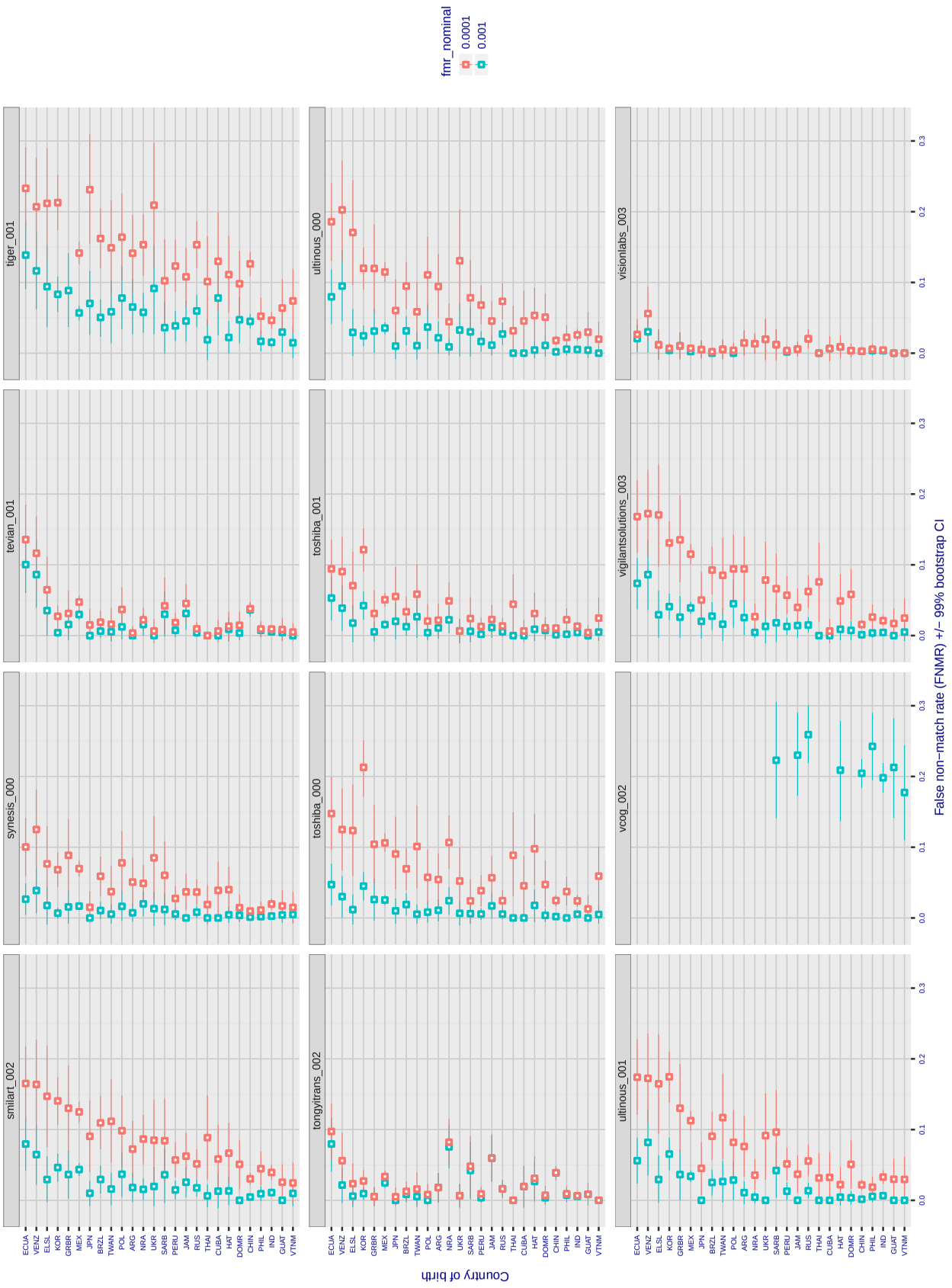


Figure 56: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of 10^{10} impostor scores. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

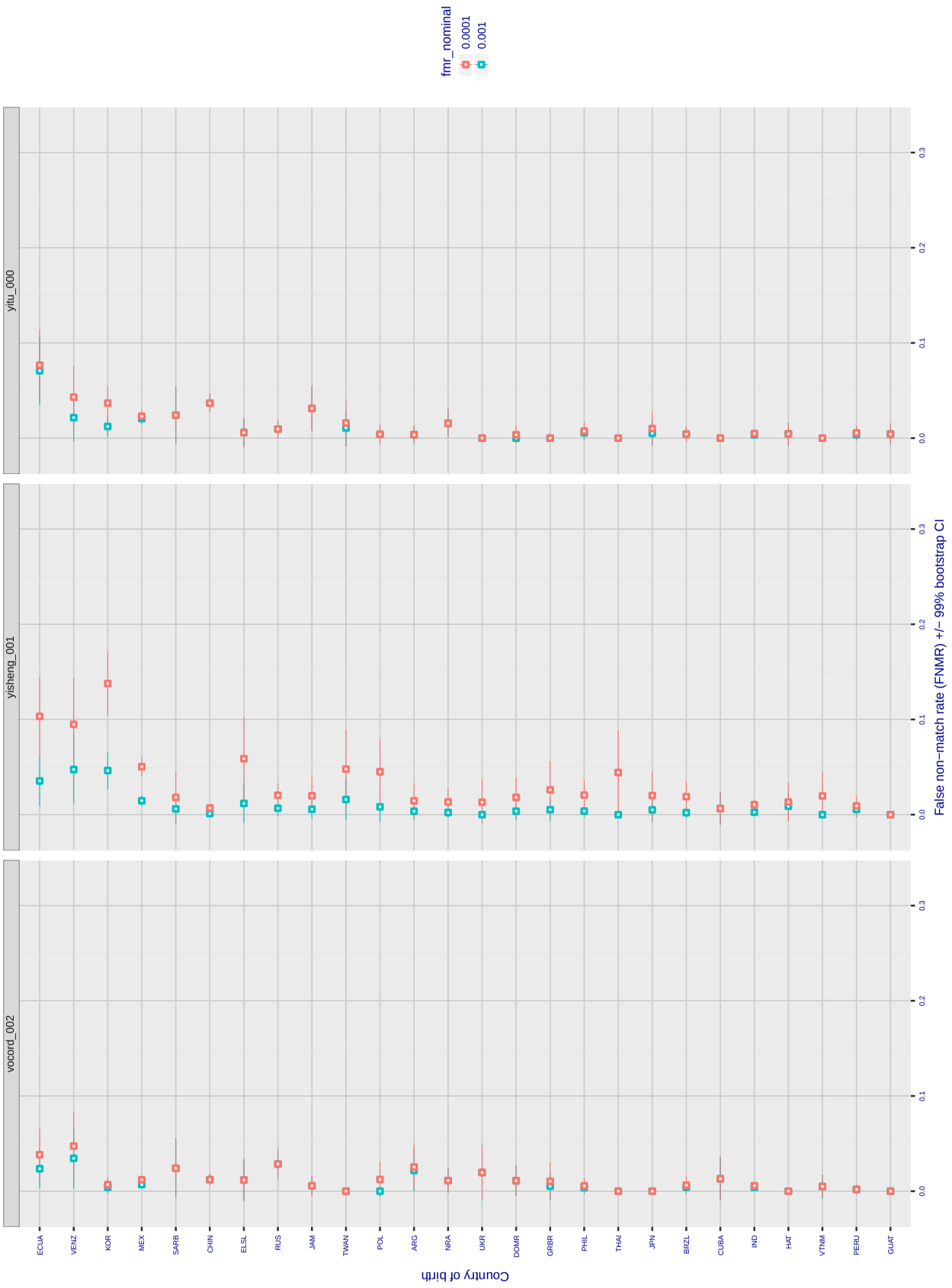


Figure 57: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of 10^{10} impostor scores. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

Caveats: The results may not relate to subject-specific properties. Instead they could reflect image-specific quality differences, which could occur due to collection protocol or software processing variations.

5.5.2 Effect of age on genuine subjects

Background: Faces change appearance throughout life. Face recognition algorithms have previously beeen reported to give better accuracy on older individuals (See NIST IR 8009).

Goal: To quantify false non-match rates (FNMR) as a function of age. We do not aim to quantify ageing effects here as the separation between two samples is limited to just a few years.

Methods: Using the visa images, thresholds are determined that give FMR = 0.001 and 0.0001 over the entire impostor set. Then FNMR is measured over 1000 bootstrap replications of the genuine scores.

Results: For the visa images, Figure 58 shows how false non-match rates for genuine users, as a function of age group.

The notable aspects are:

- ▷ Younger subjects give considerably higher FNMR. This is likely due to rapid growth and change in facial appearance.
- ▷ FNMR trends down throughout life. The last bin, AGE $>$ 72, contains fewer than 140 mated pairs, and may be affected by small sample size.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

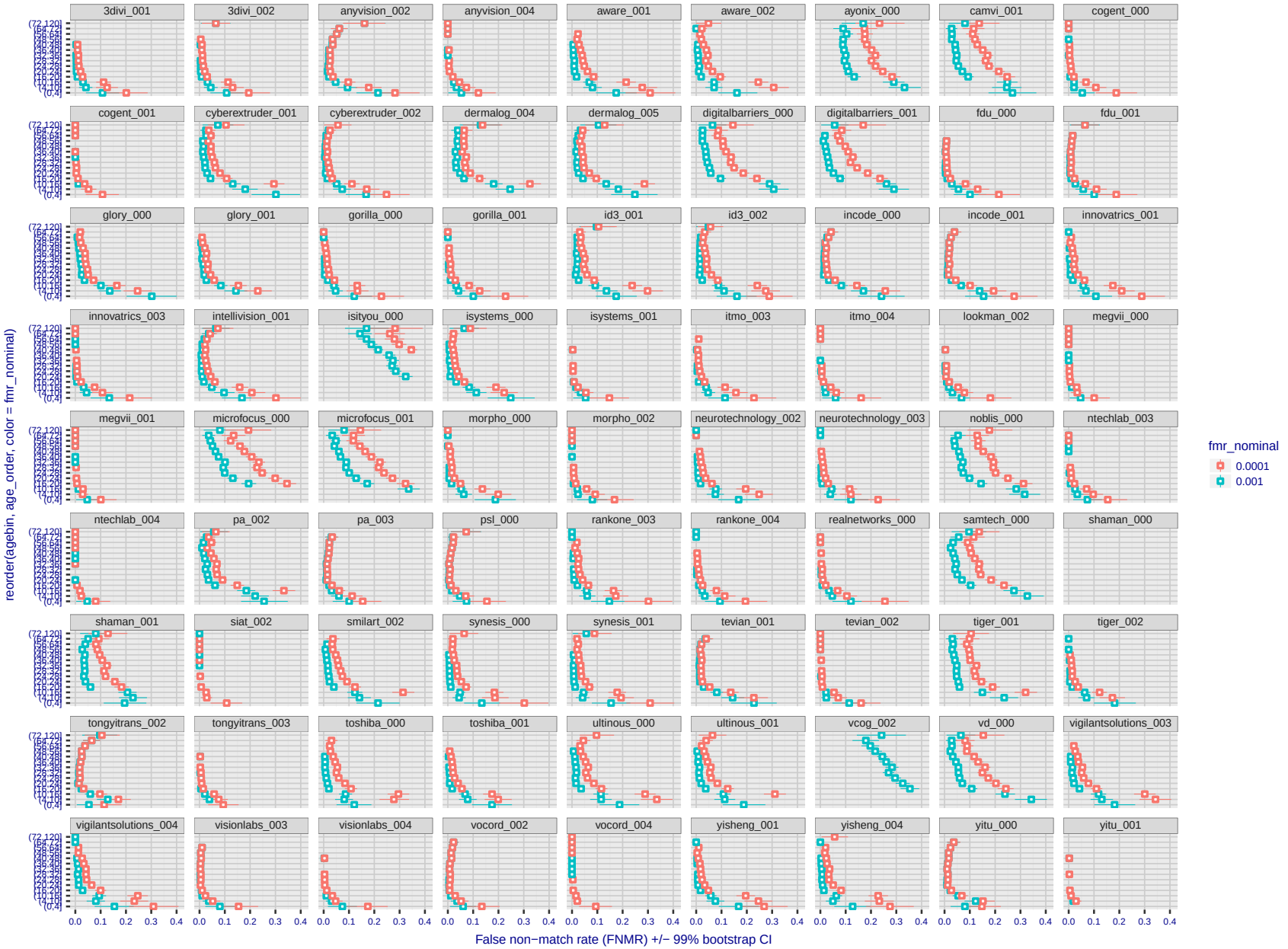


Figure 58: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of 10^{10} impostor scores. Given a pair of face images taken at different times, we assign a false non-match to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands. However the FNMR for the first and last bins are each computed over fewer than 150 comparisons.

Caveats: None.

5.6 Impostor distribution stability

5.6.1 Effect of birth place on the impostor distribution

Background: Facial appearance varies geographically, both in terms of skin tone, cranio-facial structure and size. This section addresses whether false match rates vary intra- and inter-regionally.

Goals:

- ▷ To show the effect of birth region of the impostor and enrollee on false match rates.
- ▷ To determine whether some algorithms give better impostor distribution stability.

Methods:

- ▷ For the visa images, NIST defined 10 regions: Sub-Saharan Africa, South Asia, Polynesia, North Africa, Middle East, Europe, East Asia, Central and South America, Central Asia, and the Caribbean.
- ▷ For the visa images, NIST mapped each country of birth to a region. There is some arbitrariness to this. For example, Egypt could reasonably be assigned to the Middle East instead of North Africa. An alternative methodology could, for example, assign the Philippines to *both* Polynesia and East Asia.
- ▷ FMR is computed for cases where all face images of impostors born in region r_2 are compared with enrolled face images of persons born in region r_1.

$$\text{FMR}(r_1, r_2, T) = \frac{\sum_{i=1}^{N_{r_1,r_2}} H(s_i - T)}{N_{r_1,r_2}} \tag{5}$$

  where the same threshold, T, is used in all cells, and H is the unit step function. The threshold is set to give FMR(T) = 0.001 over the entire set of visa image impostor comparisons.
- ▷ This analysis is then repeated by country-pair, but only for those country pairs where both have at least 1000 images available. The countries[1] appear in the axes of graphs that follow.
- ▷ The mean number of impostor scores in any cross-region bin is 33 million. The smallest number of impostor scores in any bin is 135000, for Central Asia - North Africa. While these counts are large enough to support reasonable significance, the number of individual faces is much smaller, on the order of $N^{0.5}$.
- ▷ The numbers of impostor scores in any cross-country bin is shown in Figure 189.

Results: Subsequent figures show heatmaps that use color to represent the base-10 logarithm of the false match rate. Red colors indicate high (bad) false match rates. Dark colors indicate benign false match rates. There are two series of graphs corresponding to aggregated geographical regions, and to countries. The notable observations are:

- ▷ The on-diagonal elements correspond to within-region impostors. FMR is generally above the nominal value of FMR = 0.001. Particularly there is usually higher FMR in, Sub-Saharan Africa, South Asia, and the Caribbean. Europe and Central Asia, on the other hand, usually give FMR closer to the nominal value.
- ▷ The off-diagonal elements correspond to across-region impostors. The highest FMR is produced between the Caribbean and Sub-Saharan Africa.
- ▷ Algorithms vary.

[1] These are Argentina, Australia, Brazil, Chile, China, Costa Rica, Cuba, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Germany, Ghana, Great Britain, Greece, Guatamala, Haiti, Hong Kong, Honduras, Indonesia, India, Israel, Jamaica, Japan, Kenya, Korea, Lebanon, Mexico, Malaysia, Nepal, Nigeria, Peru, Philippines, Pakistan, Poland, Romania, Russia, South Africa, Saudi Arabia, Thailand, Trinidad, Turkey, Taiwan, Ukraine, Venezuela, and Vietnam.

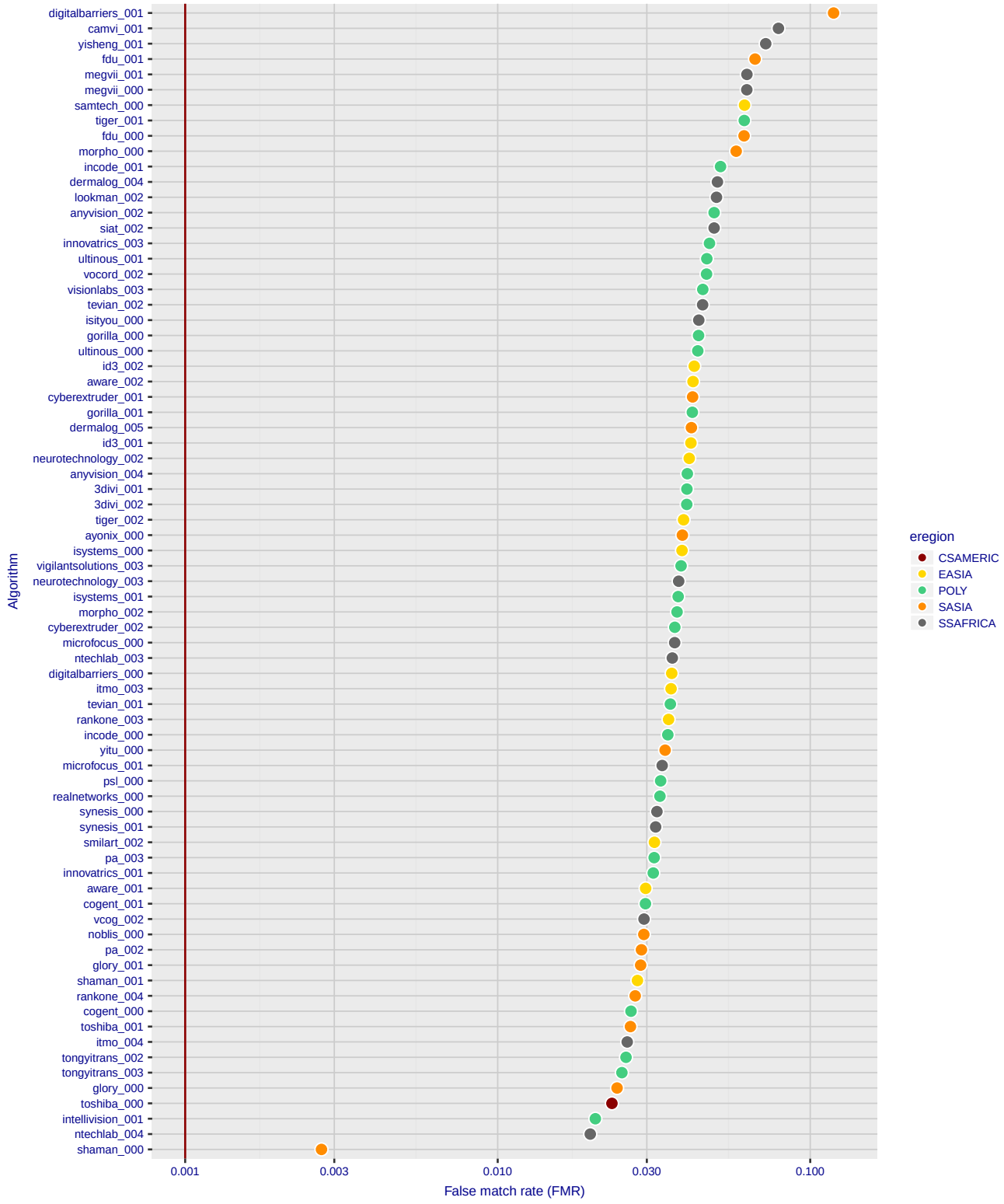


Figure 59: For the visa images, the dots show FMR for impostor comparisons of individuals of the same sex and same age group for the region of the world that gives the worst (highest) FMR when the threshold is set to give FMR = 0.001 (red vertical line) over all on the order of 10^{10} impostor scores i.e. zero-effort. The shift of the dots to right shows massive increases in FMR when impostors have the same sex, age, and region of birth. The color code indicates which region gives the worst case FMR. If the observed variation is due to the prevalence of one kind of images in the training imagery, then algorithms developed on one kind of data might be expected to give higher FMR on other kinds.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

▷ We computed the same quantities for a global FMR = 0.0001. The effects are similar.

Caveats:

▷ The effects of variable impostor rates on one-to-many identification systems may well differ from what's implied by these one-to-one verification results. Two reasons for this are a) the enrollment galleries are usually imbalanced across countries of birth, age and sex; b) one-to-many identification algorithms often implement techniques aimed at stabilizing the impostor distribution. Further research is necessary.

▷ In principle, the effects seen in this subsection could be due to differences in the image capture process. We consider this unlikely since the effects are maintained across geography - e.g. Caribbean vs. Africa, or Japan vs. China.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

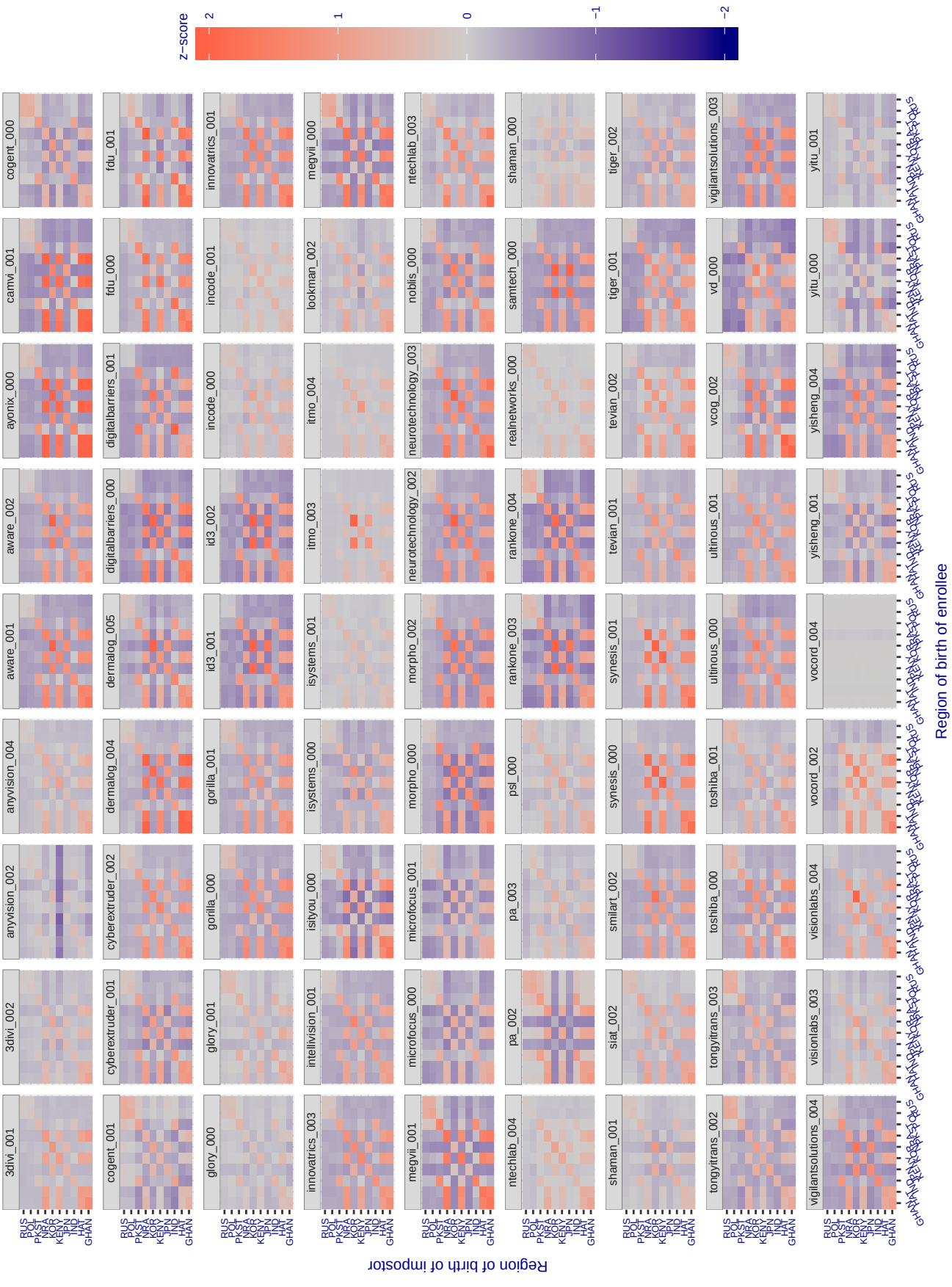


Figure 60: For visa images, the heatmap shows how the mean of the impostor distribution for the country pair (a,b) is shifted relative to the mean of the global impostor distribution, expressed as a number of standard deviations of the global impostor distribution. This statistic is designed to show shifts in the entire impostor distribution, not just tail effects that manifest as the anomalously high (or low) false match rates that appear in the subsequent figures. The countries are chosen to show that skin tone alone does not explain impostor distribution shifts. The reduced shift in Asian populations with the Yitu and TongYiTrans algorithms, is accompanied by positive shifts in the European populations. This reversal relative to most other algorithms, may derive from use of nationally weighted training sets. The Visionlabs algorithm appears most insensitive to country effects. The figure is computed from same-sex and same-age impostor pairs.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

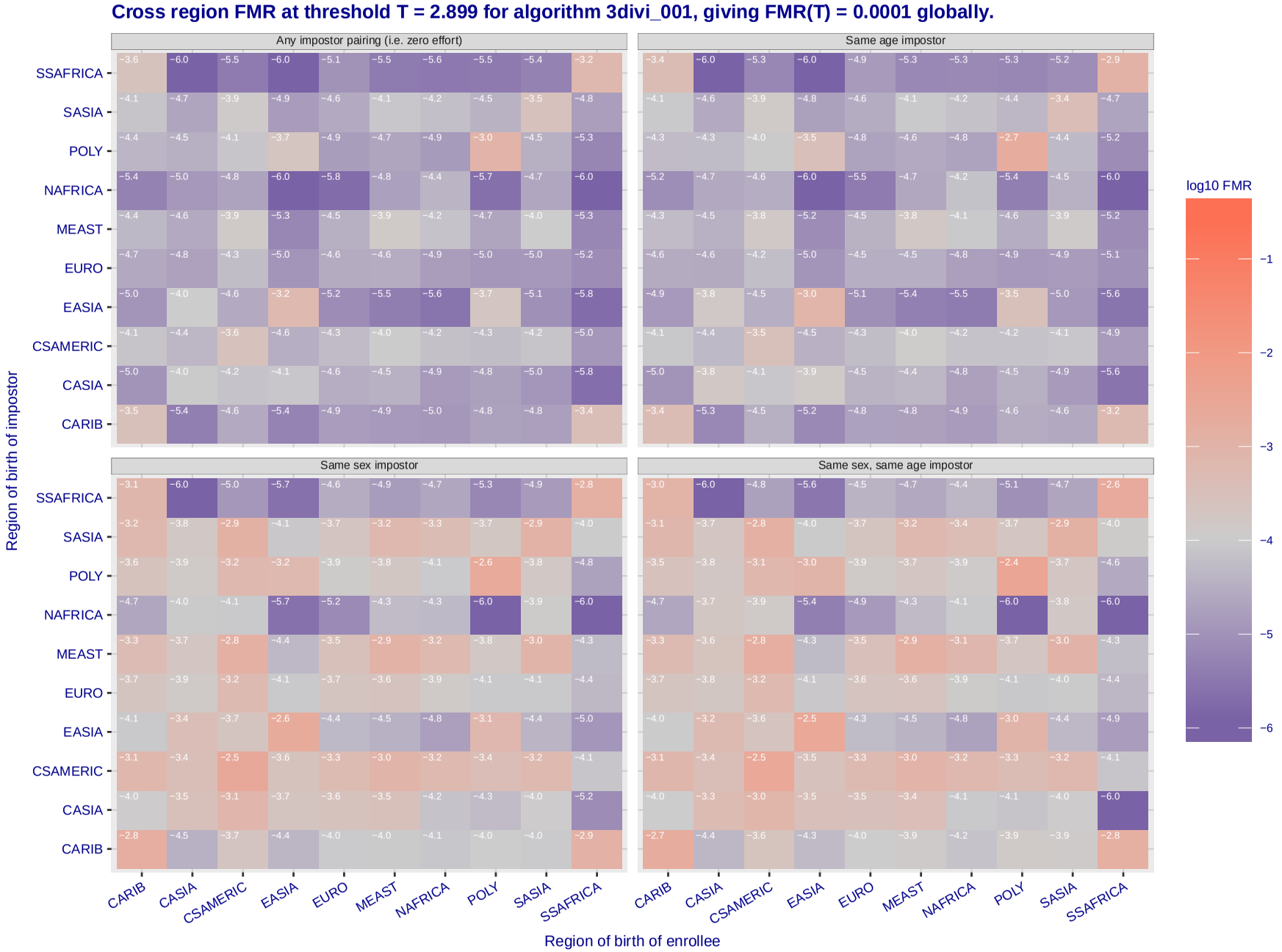


Figure 61: For algorithm 3divi-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

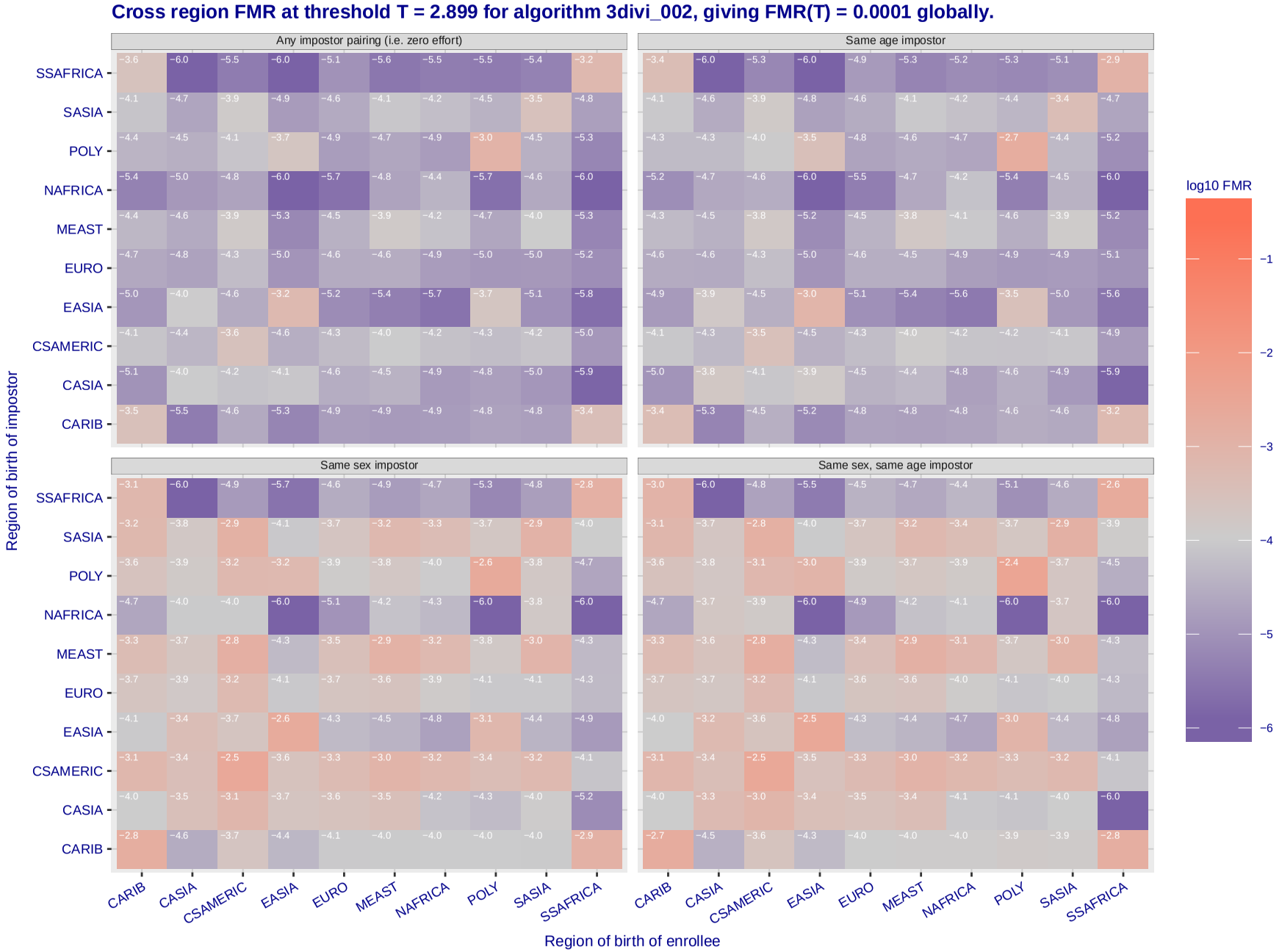


Figure 62: For algorithm 3divi-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

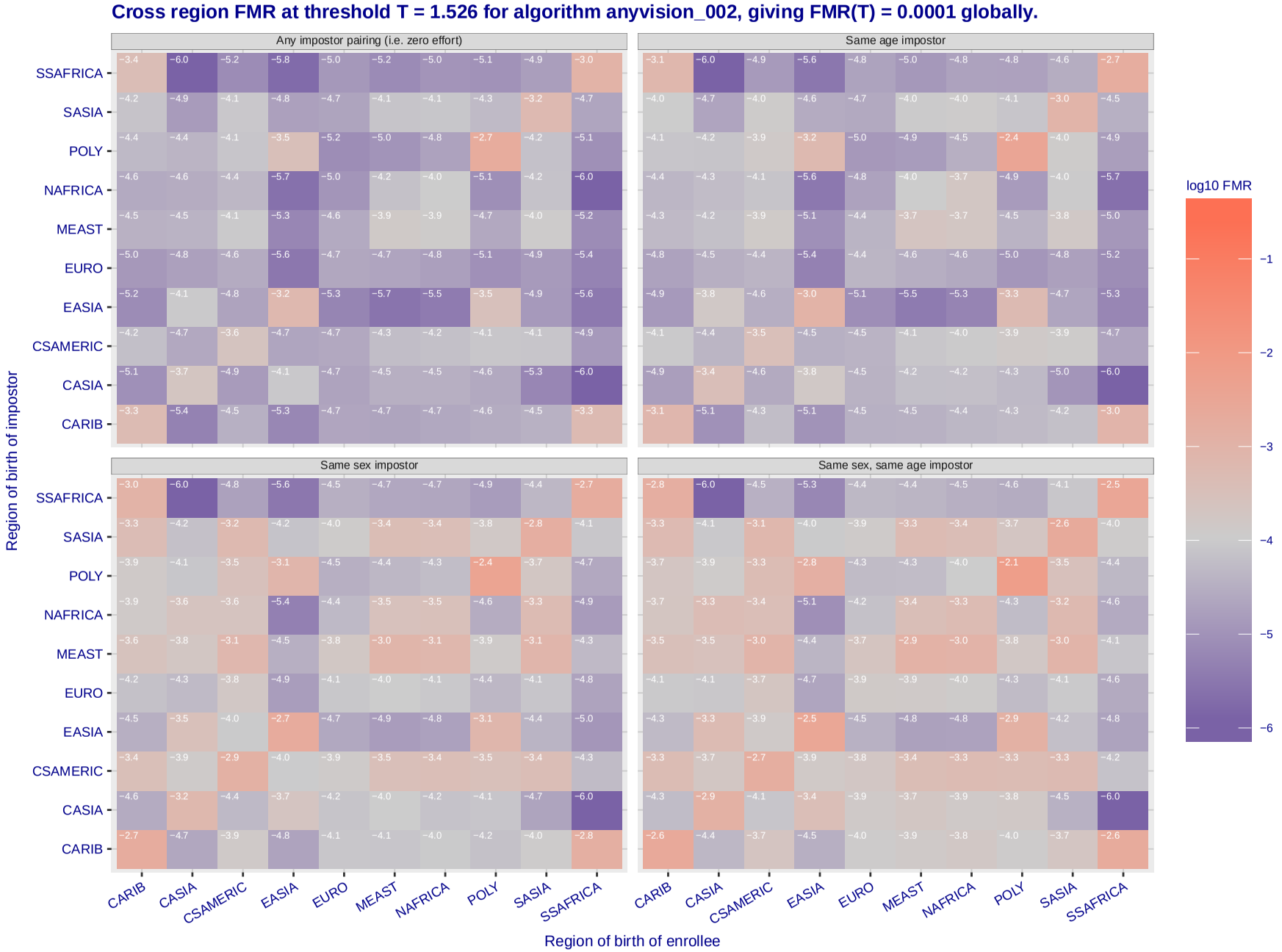


Figure 63: For algorithm anyvision-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

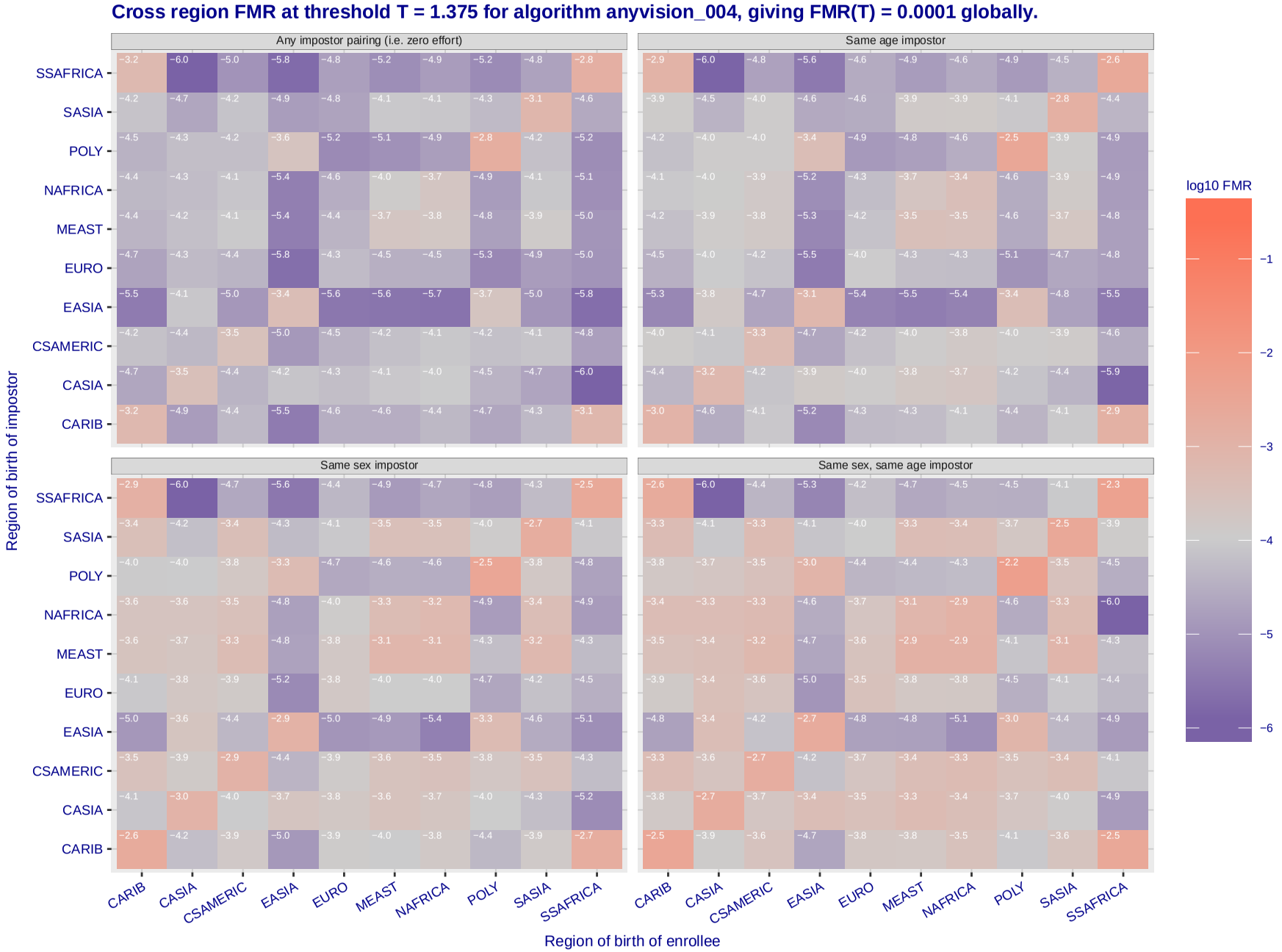


Figure 64: For algorithm anyvision-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

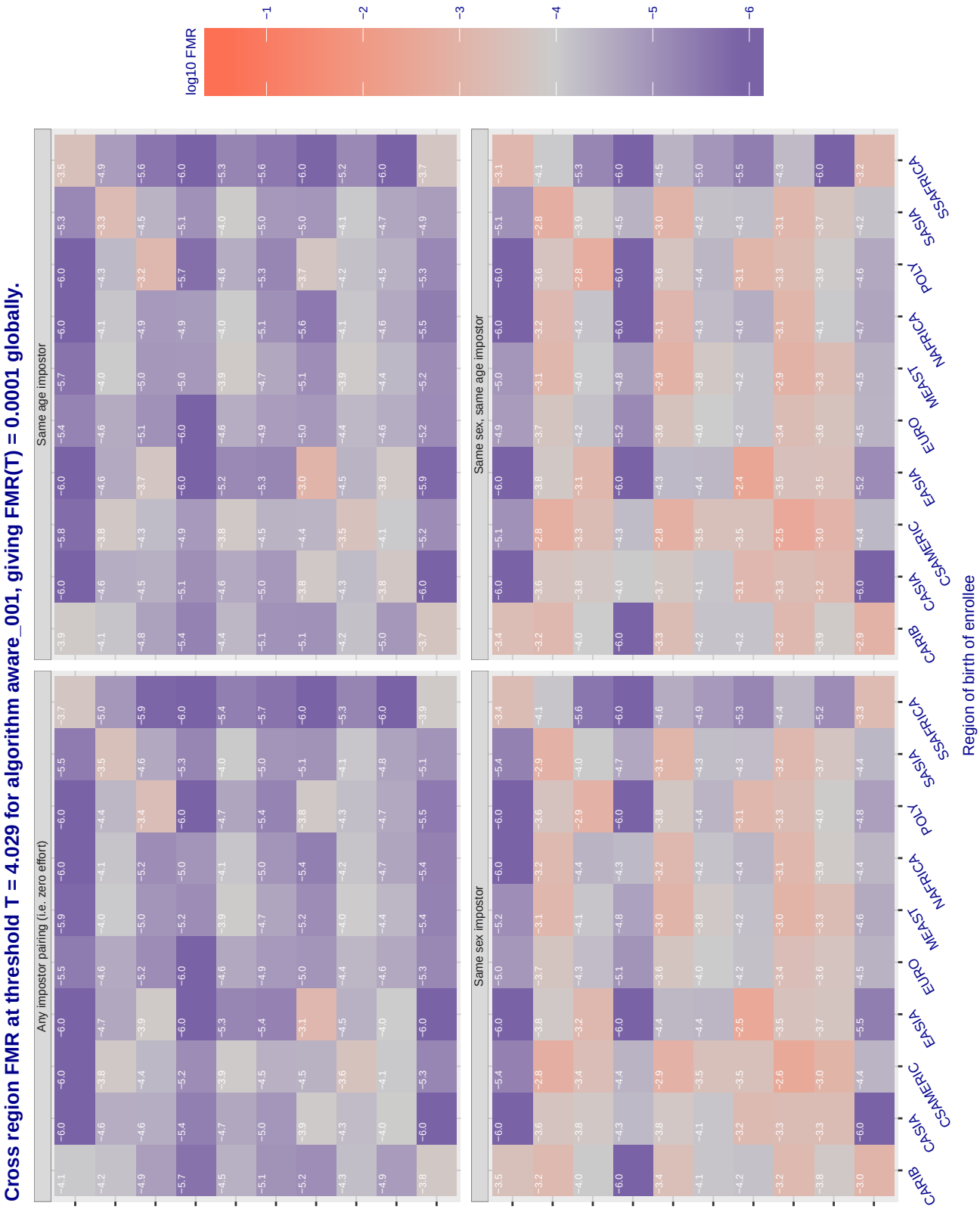


Figure 65: For algorithm aware-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

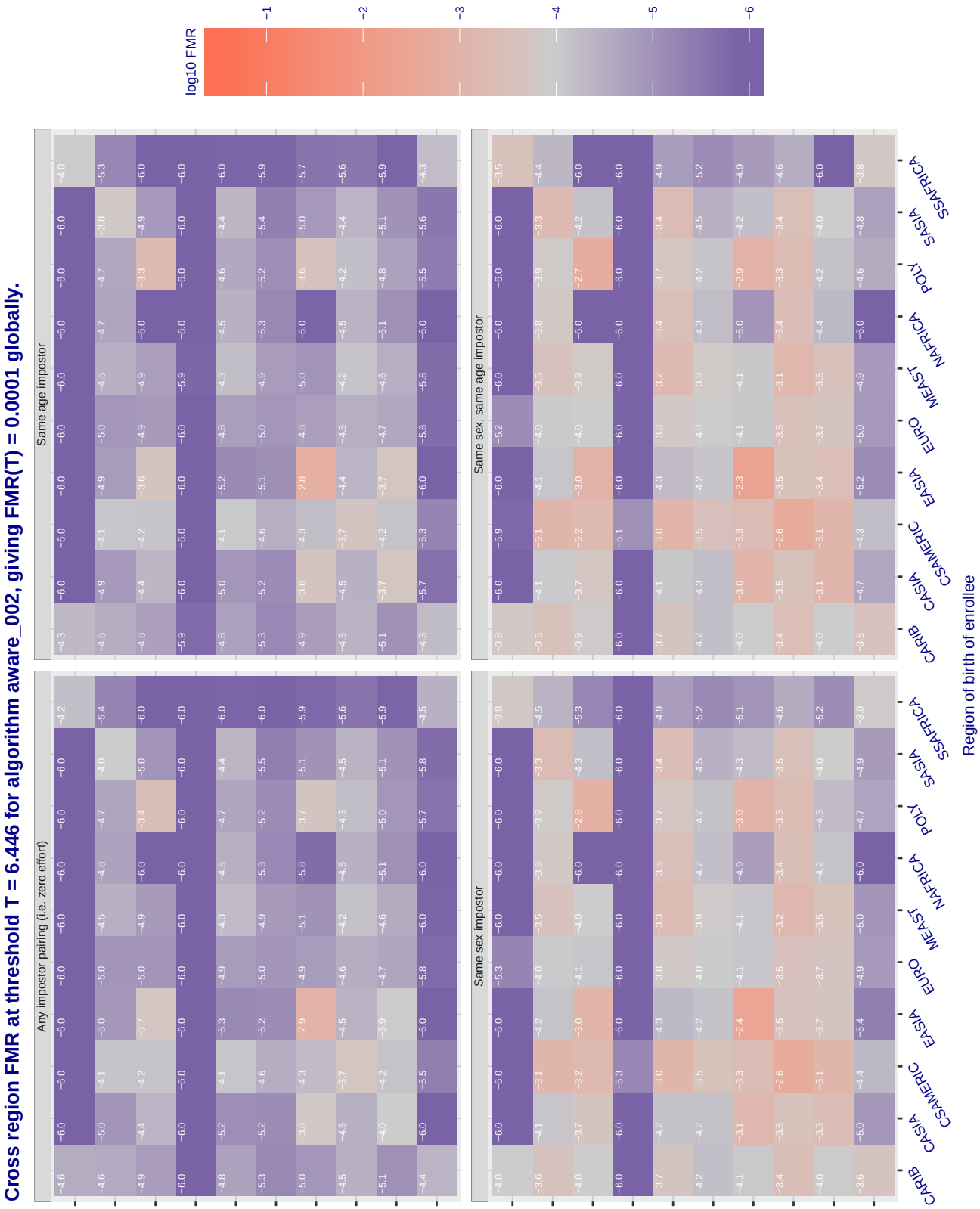


Figure 66: For algorithm aware-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

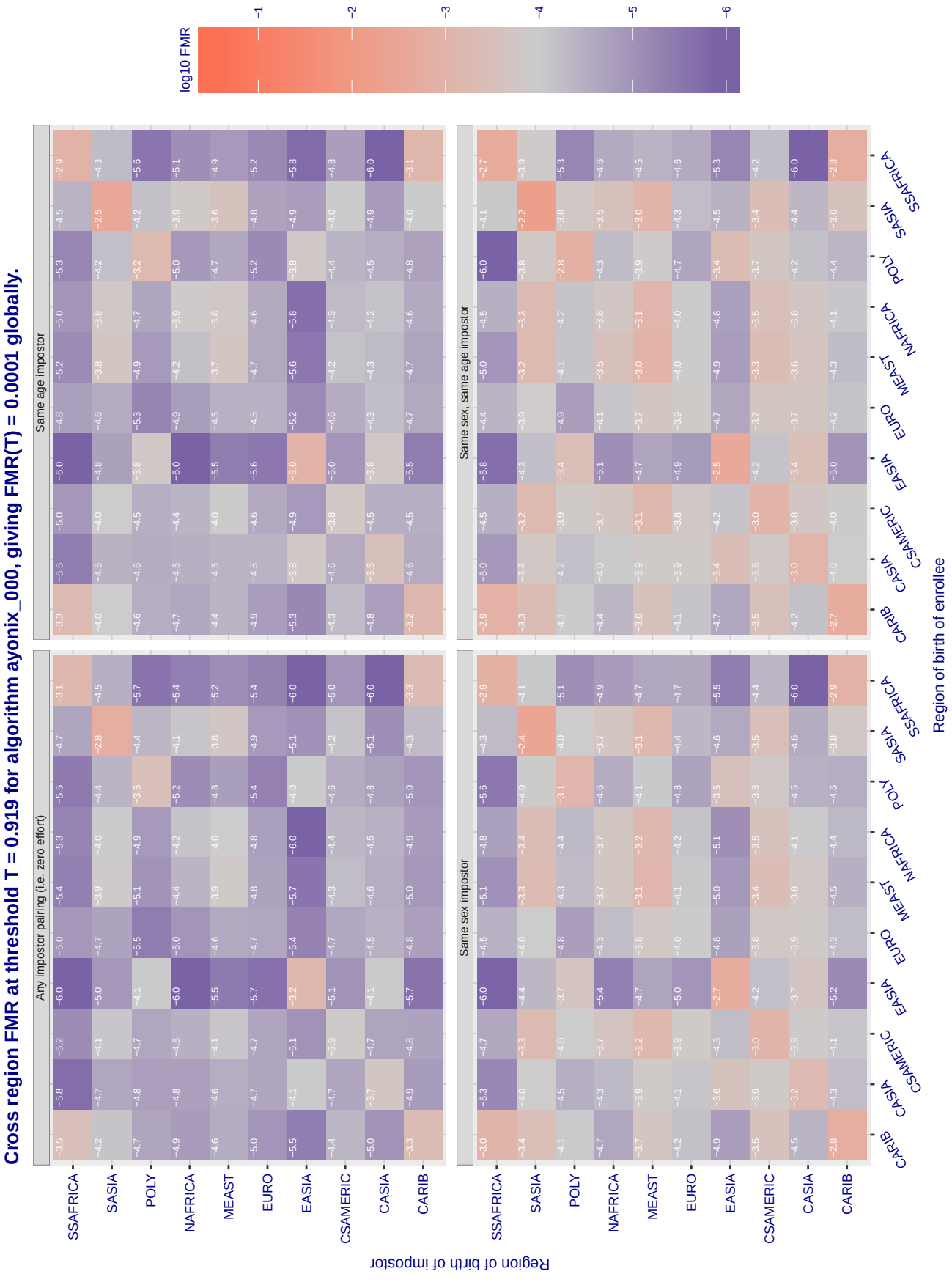


Figure 67: For algorithm ayonix-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

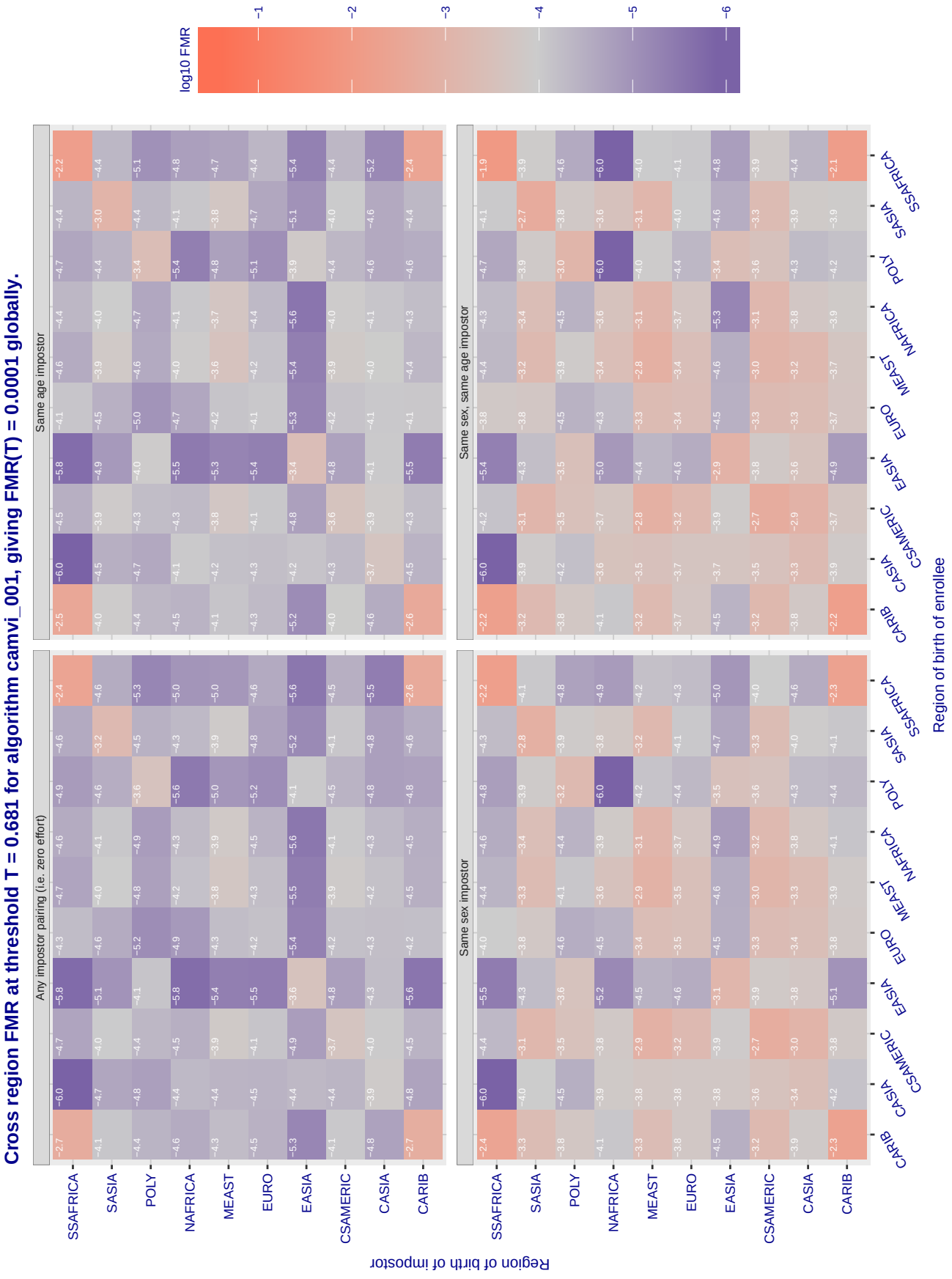


Figure 68: For algorithm camvi-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

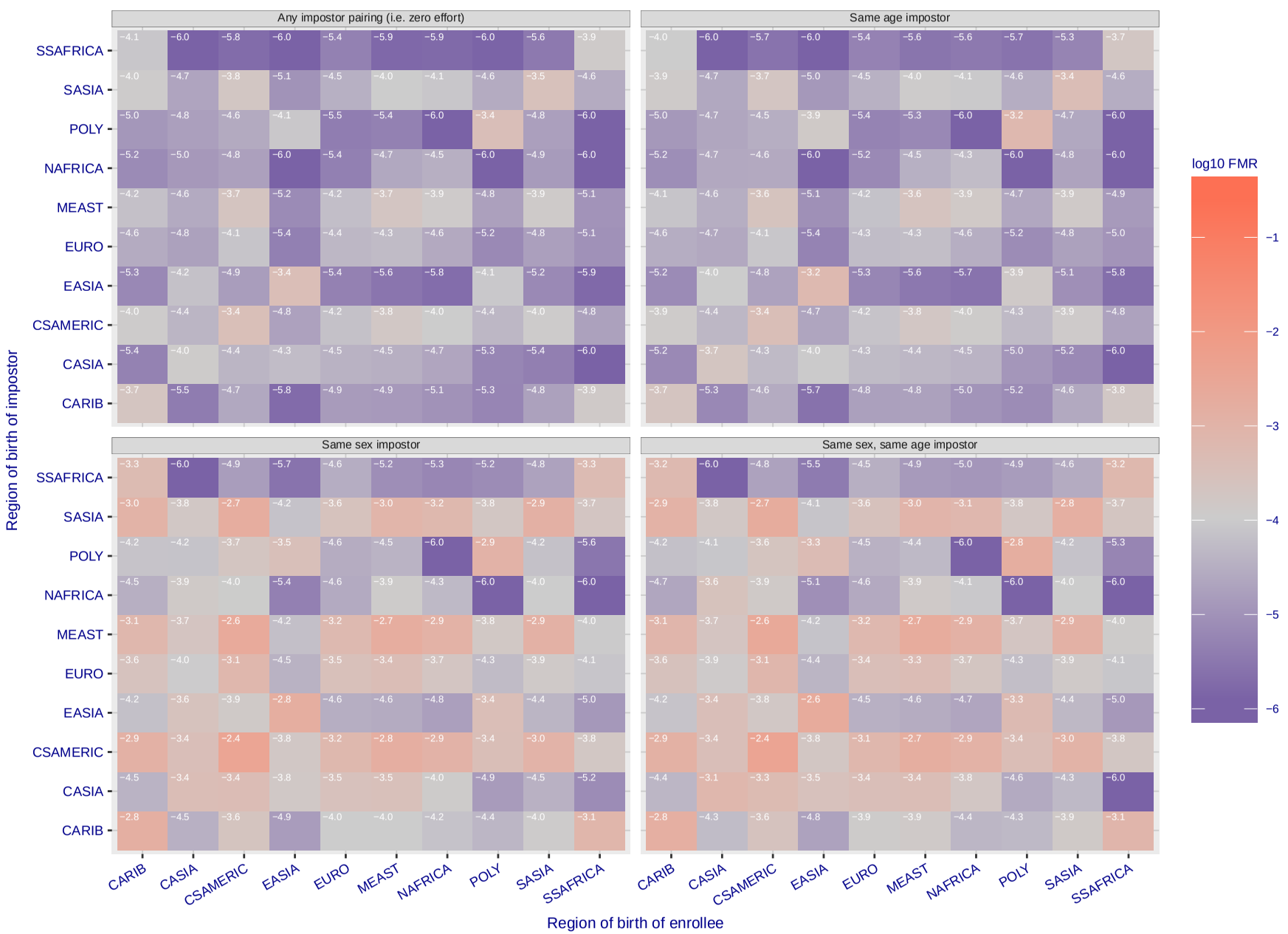


Figure 69: For algorithm cogent-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

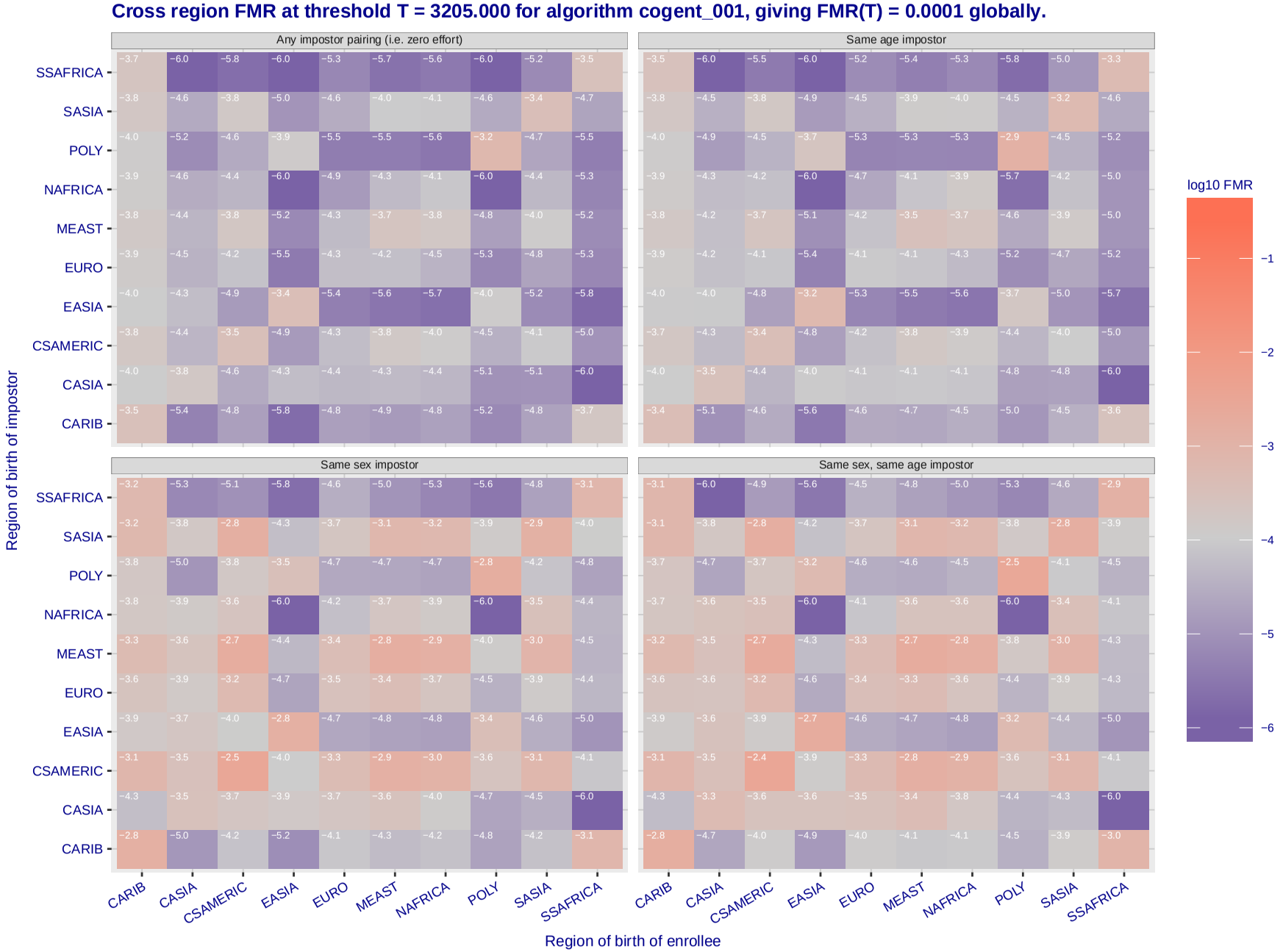


Figure 70: For algorithm cogent-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

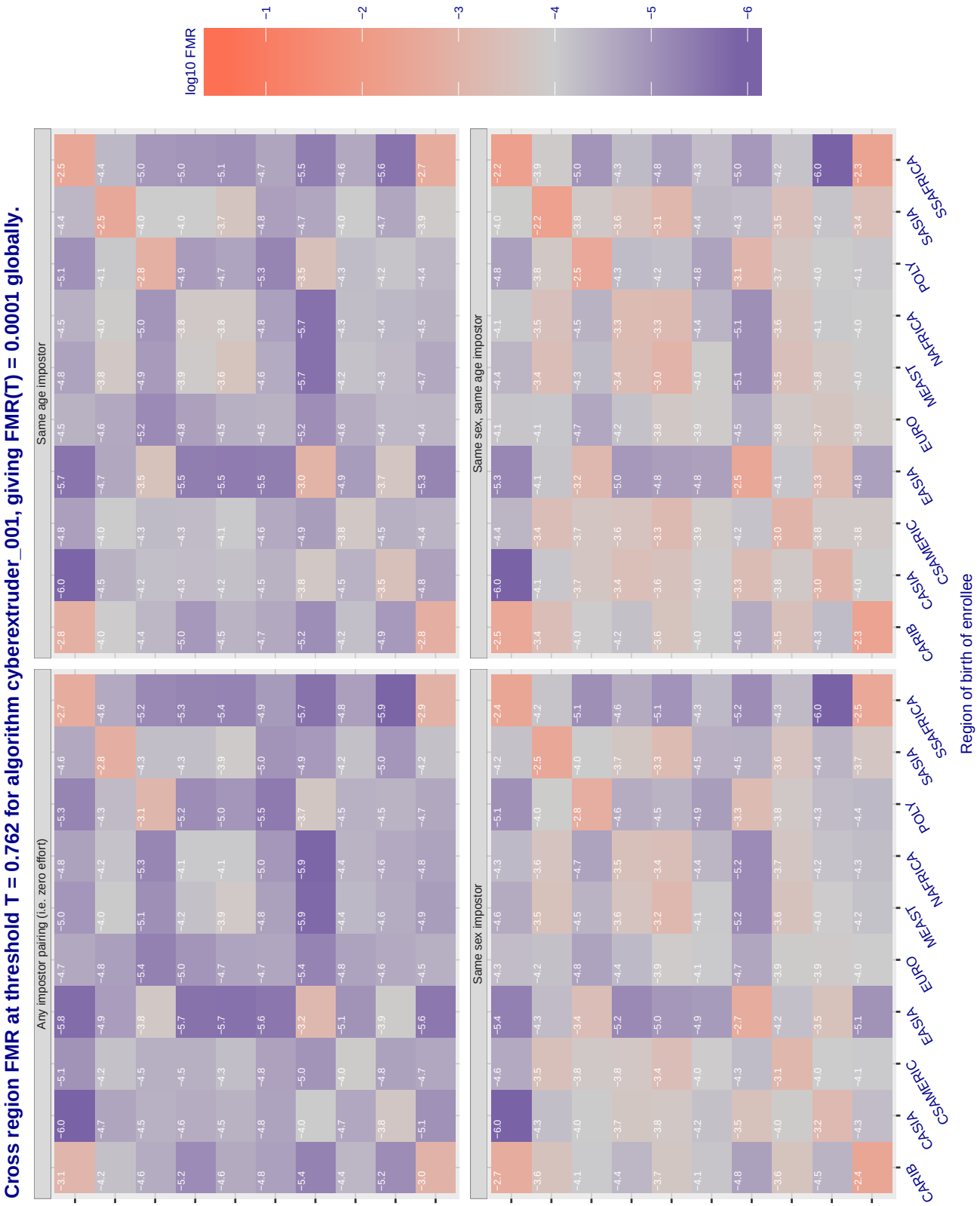


Figure 71: For algorithm cyberextruder-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

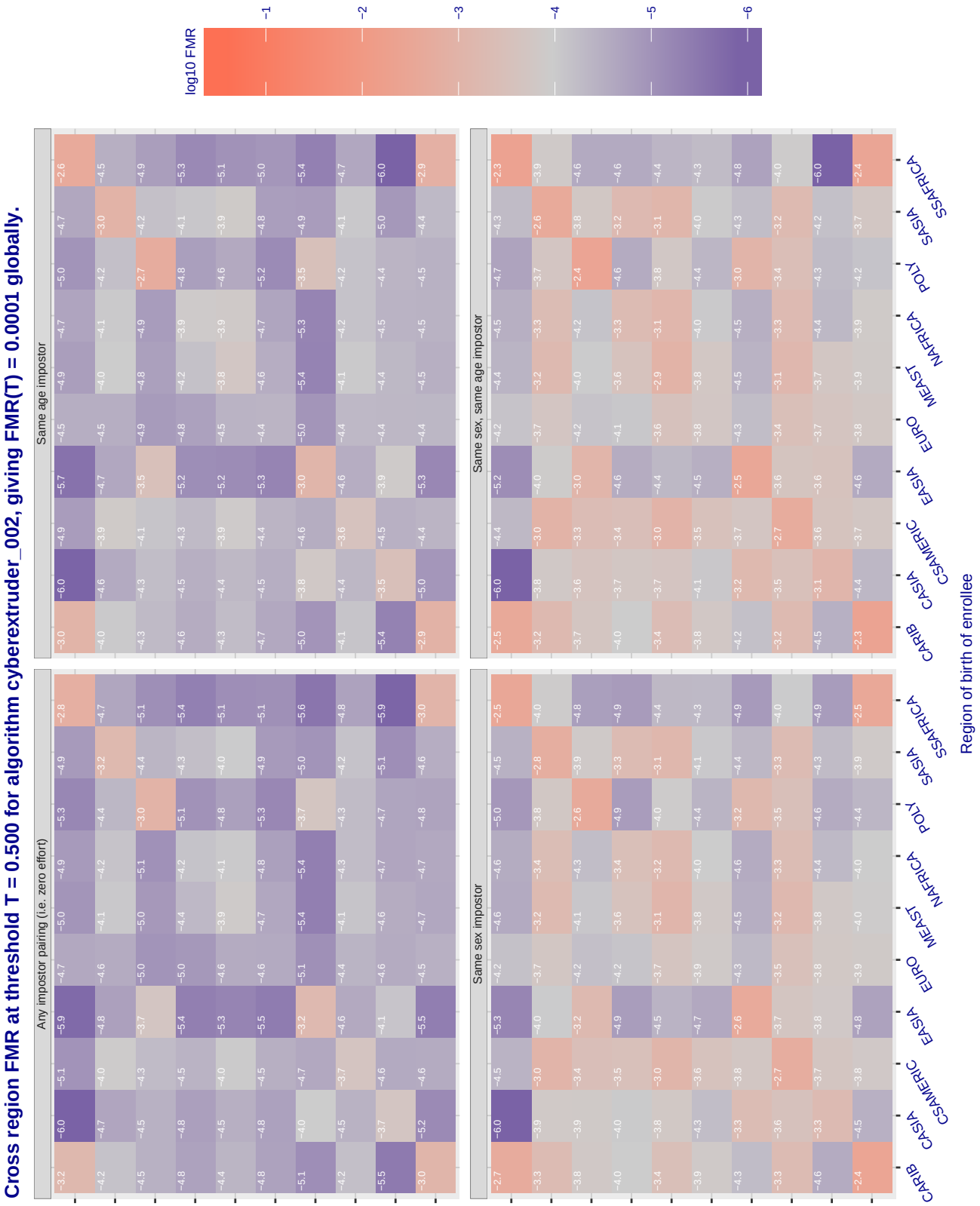


Figure 72: For algorithm cyberextruder-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

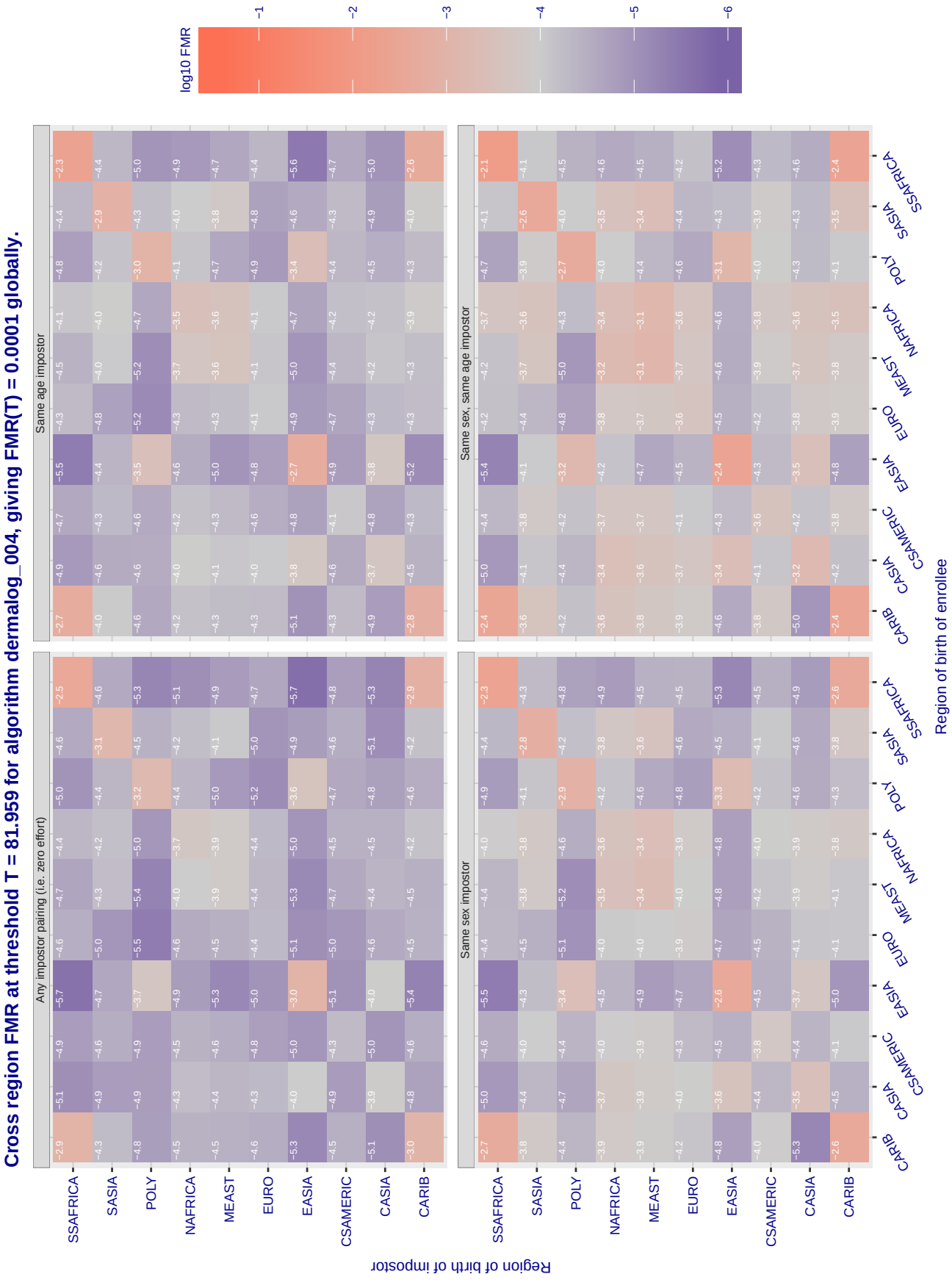


Figure 73: For algorithm dermalog-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

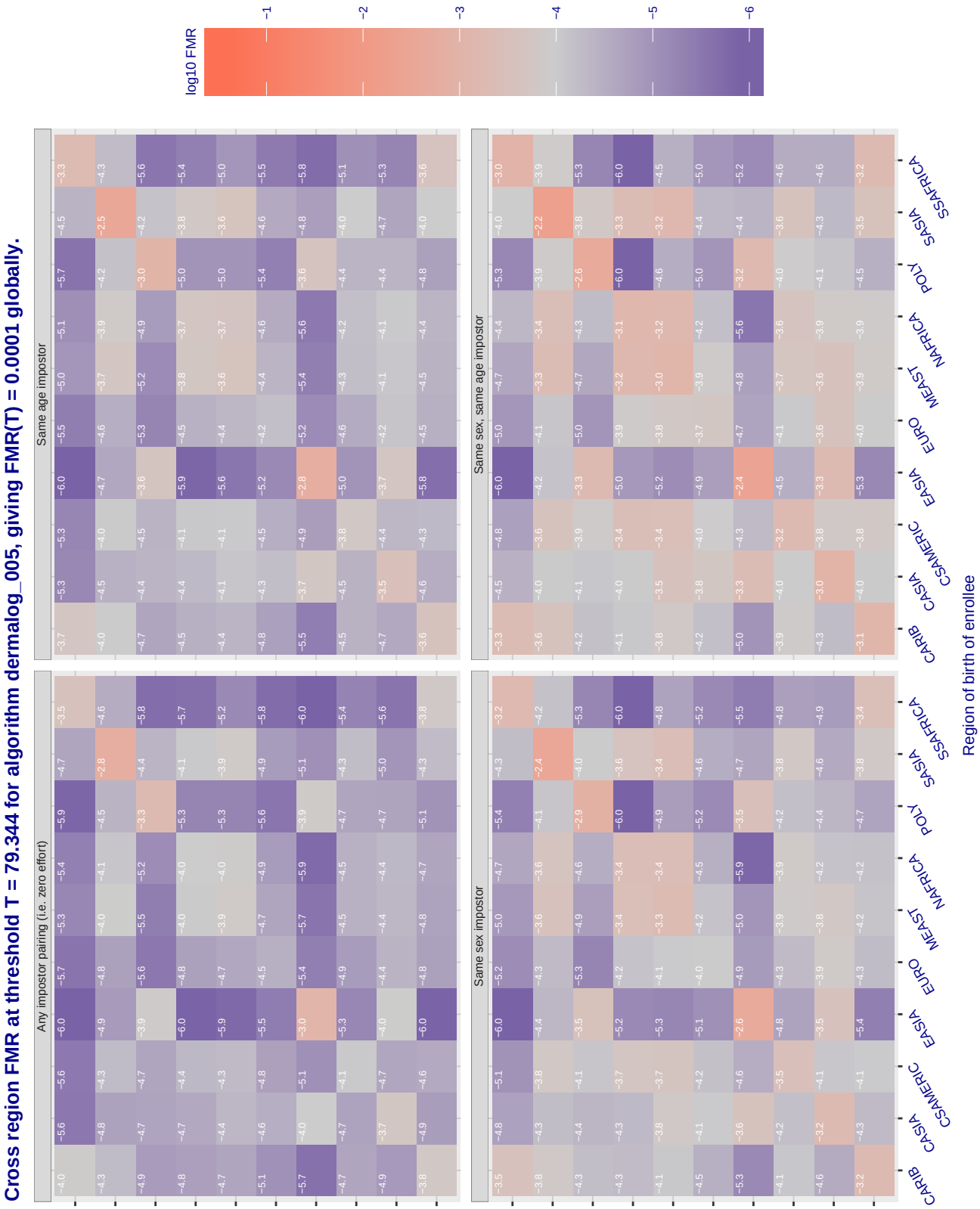


Figure 74: For algorithm dermalog-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

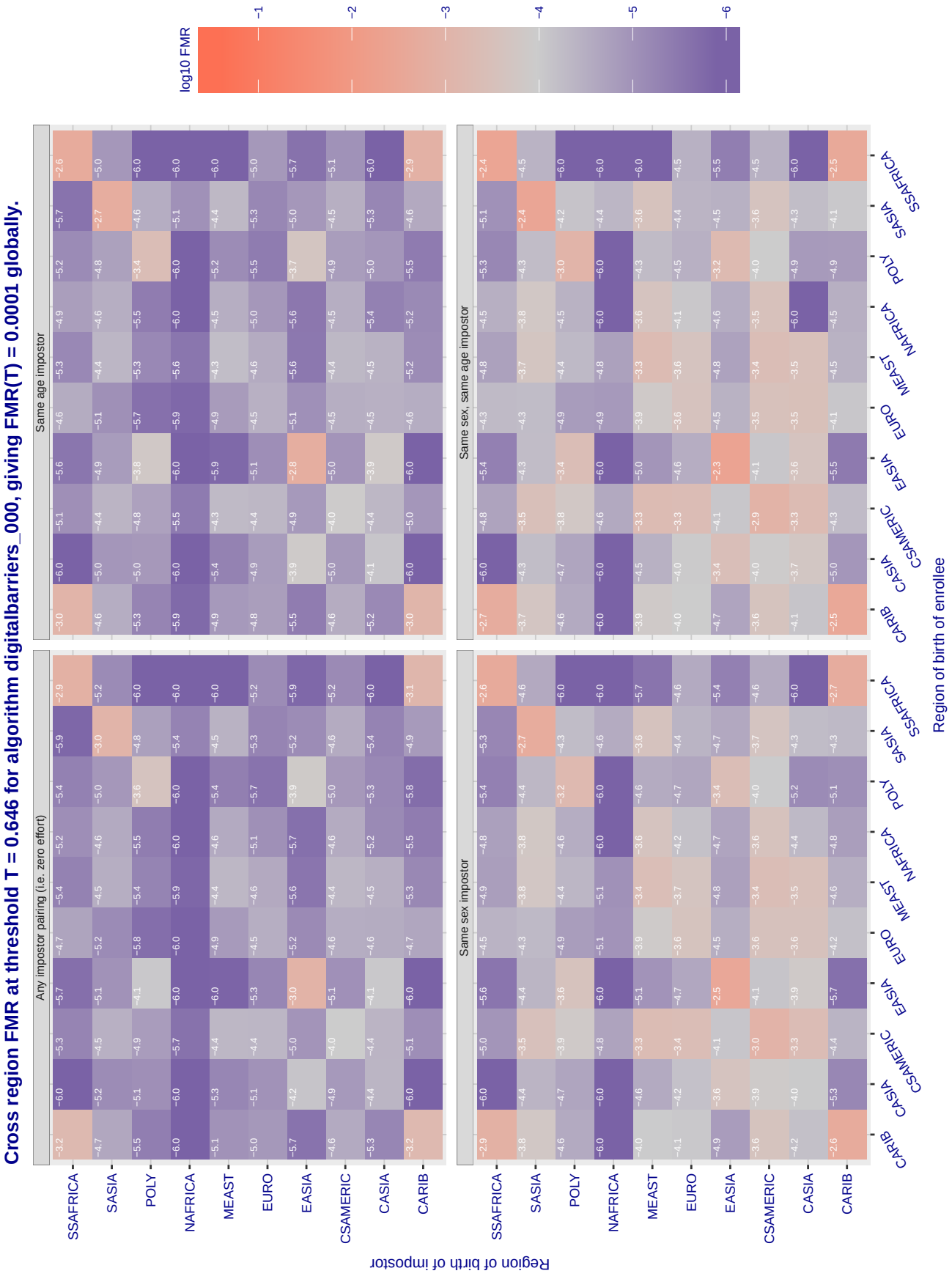


Figure 75: For algorithm digitalbarriers-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

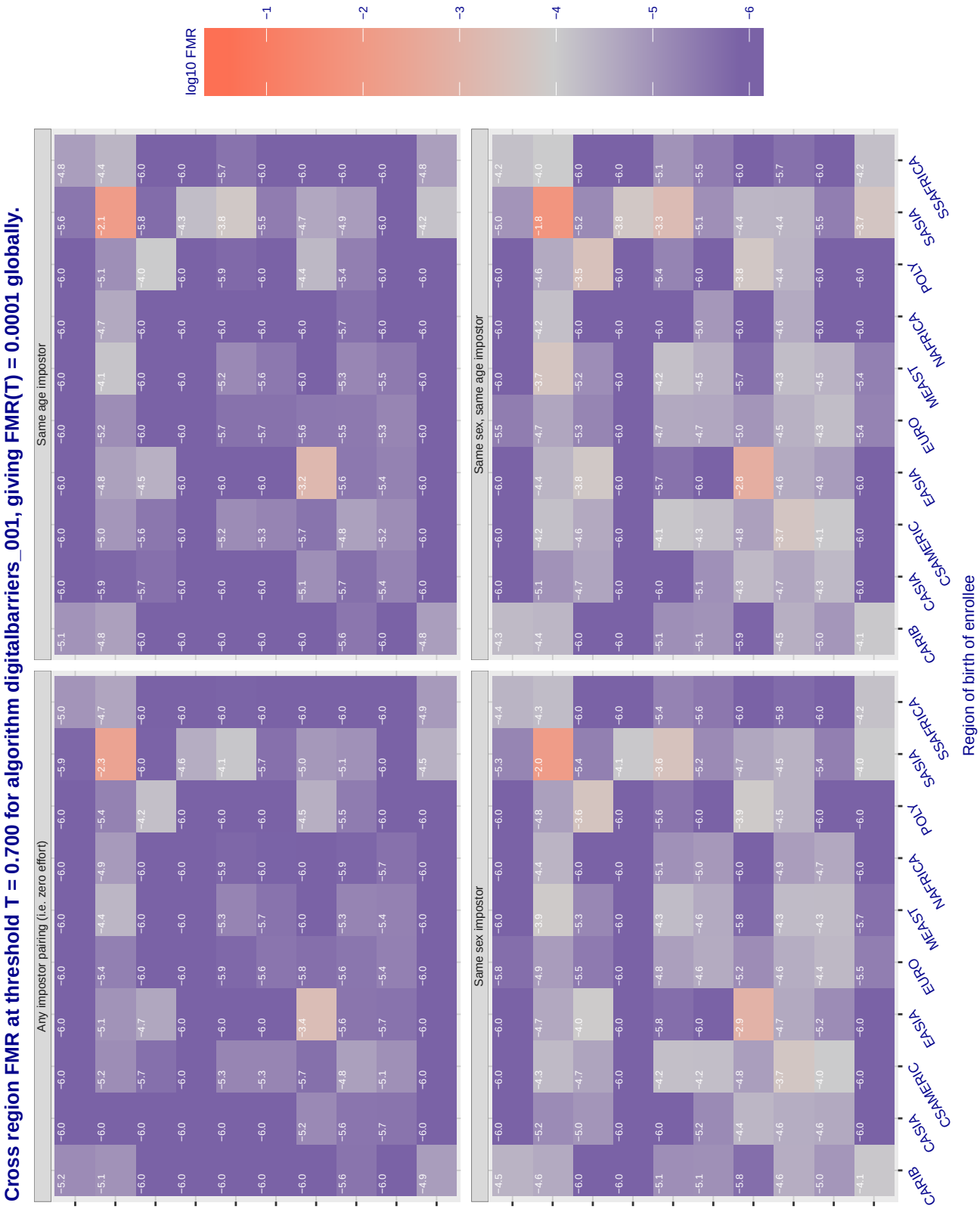


Figure 76: For algorithm digitalbarriers-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

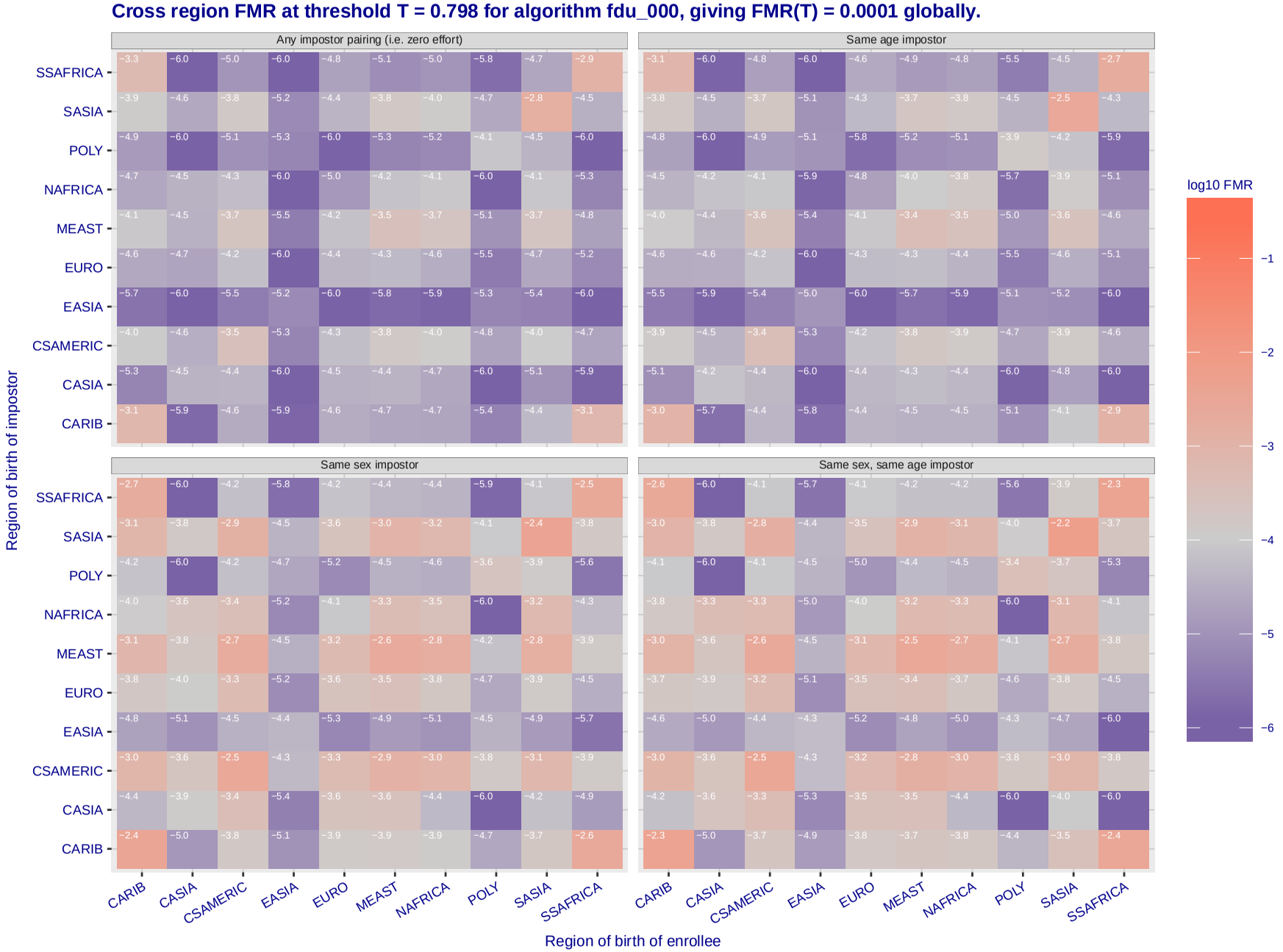


Figure 77: For algorithm fdu-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

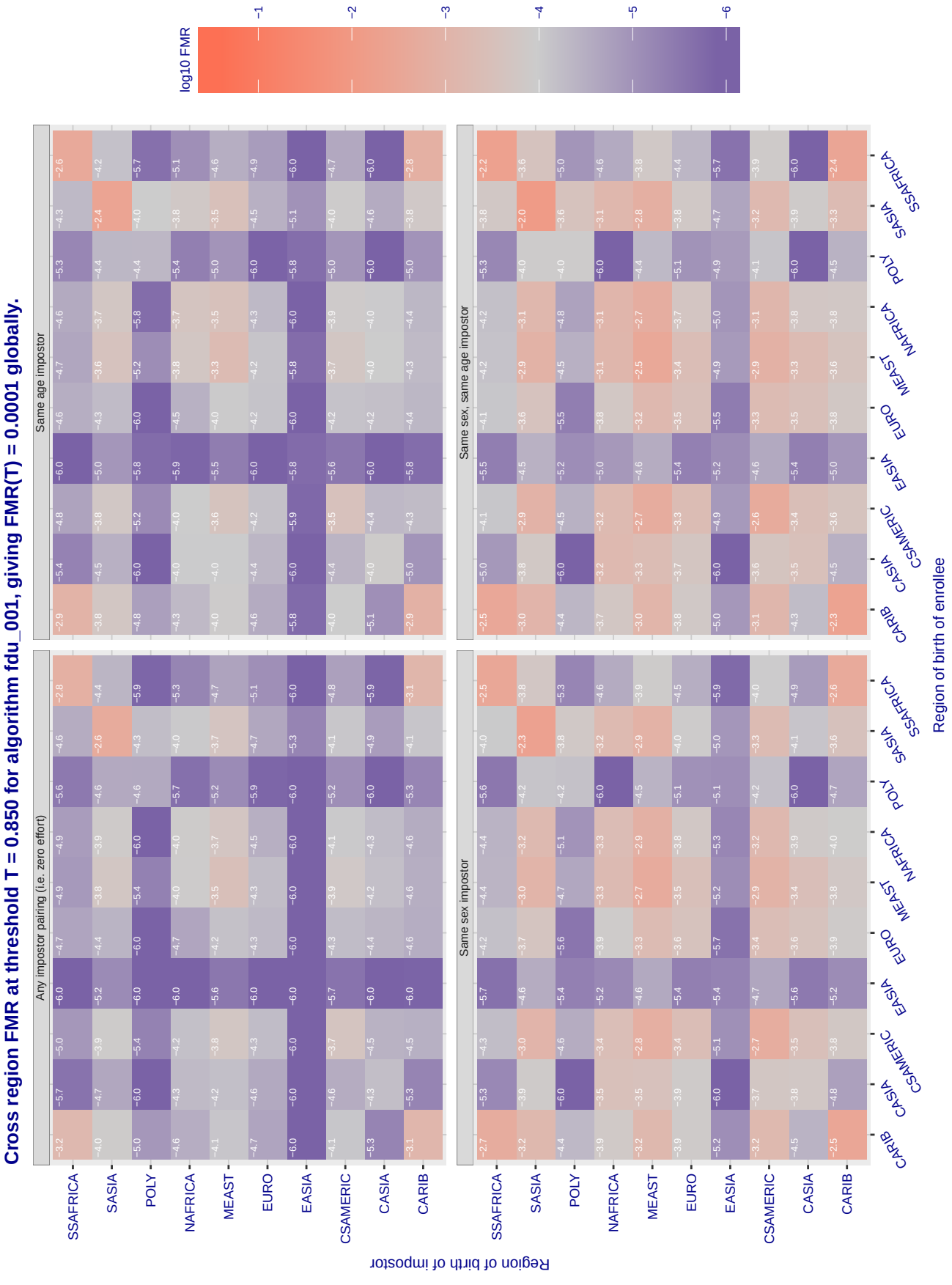


Figure 78: For algorithm fdu-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

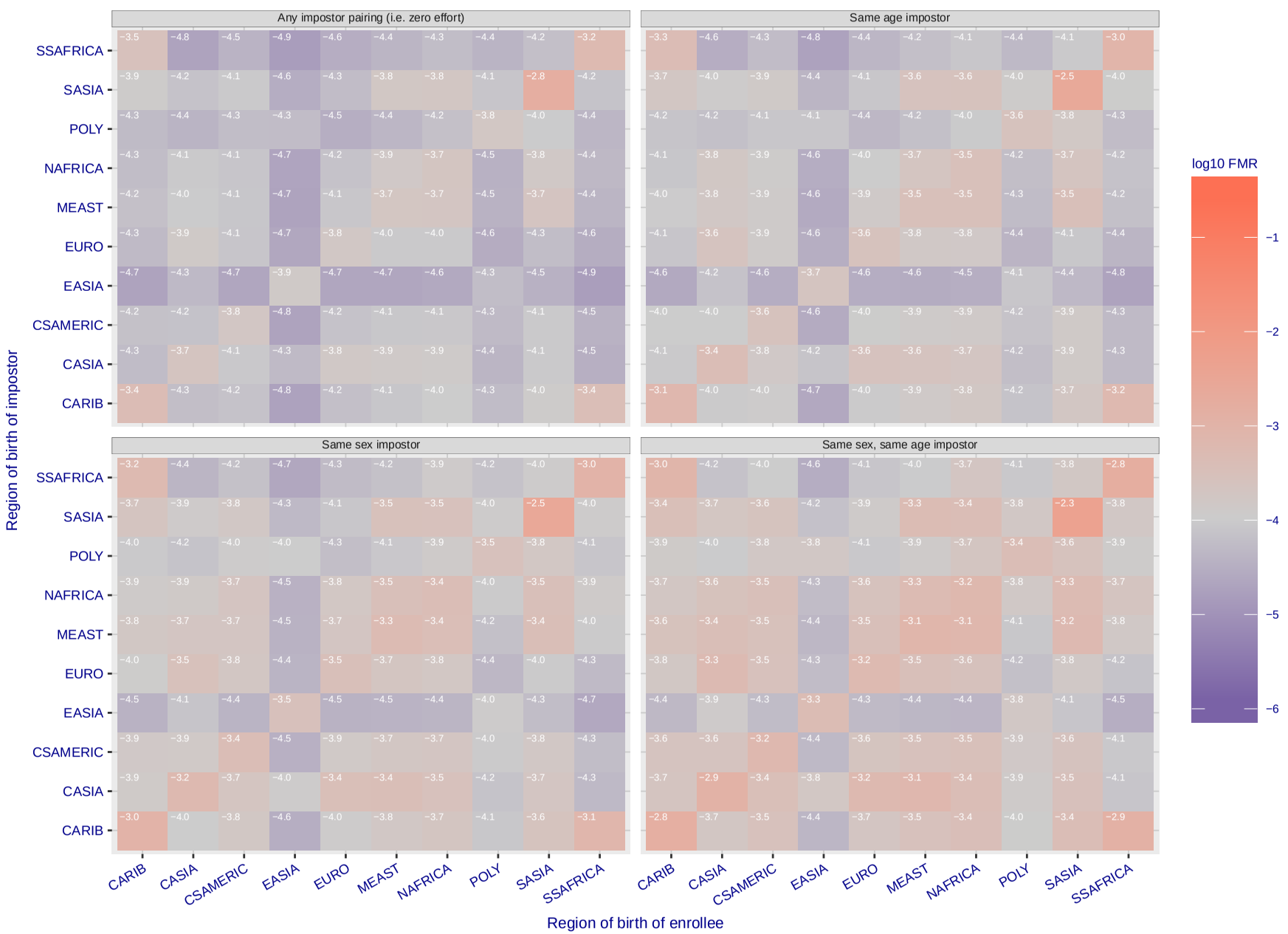


Figure 79: For algorithm glory-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

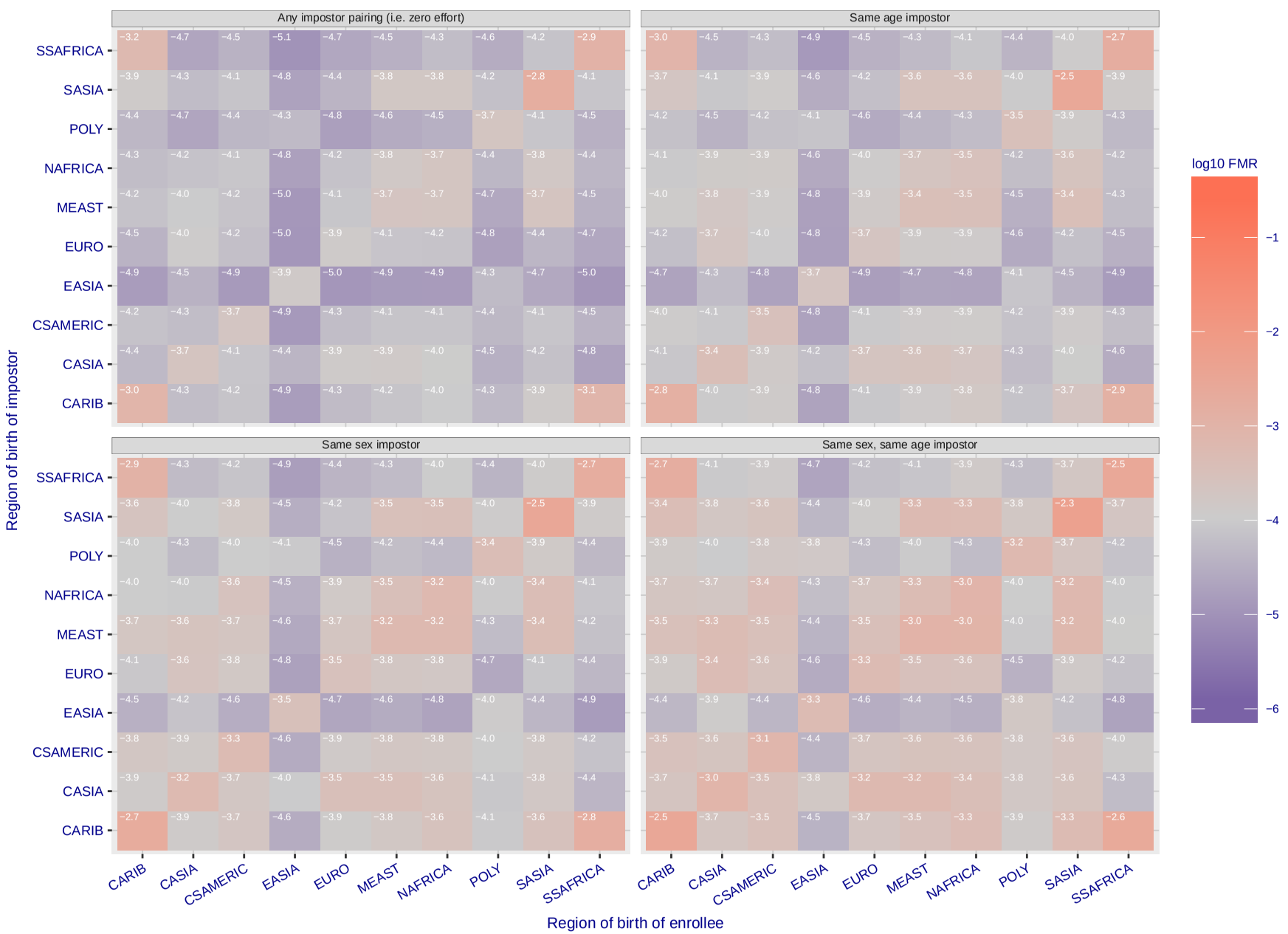


Figure 80: For algorithm glory-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

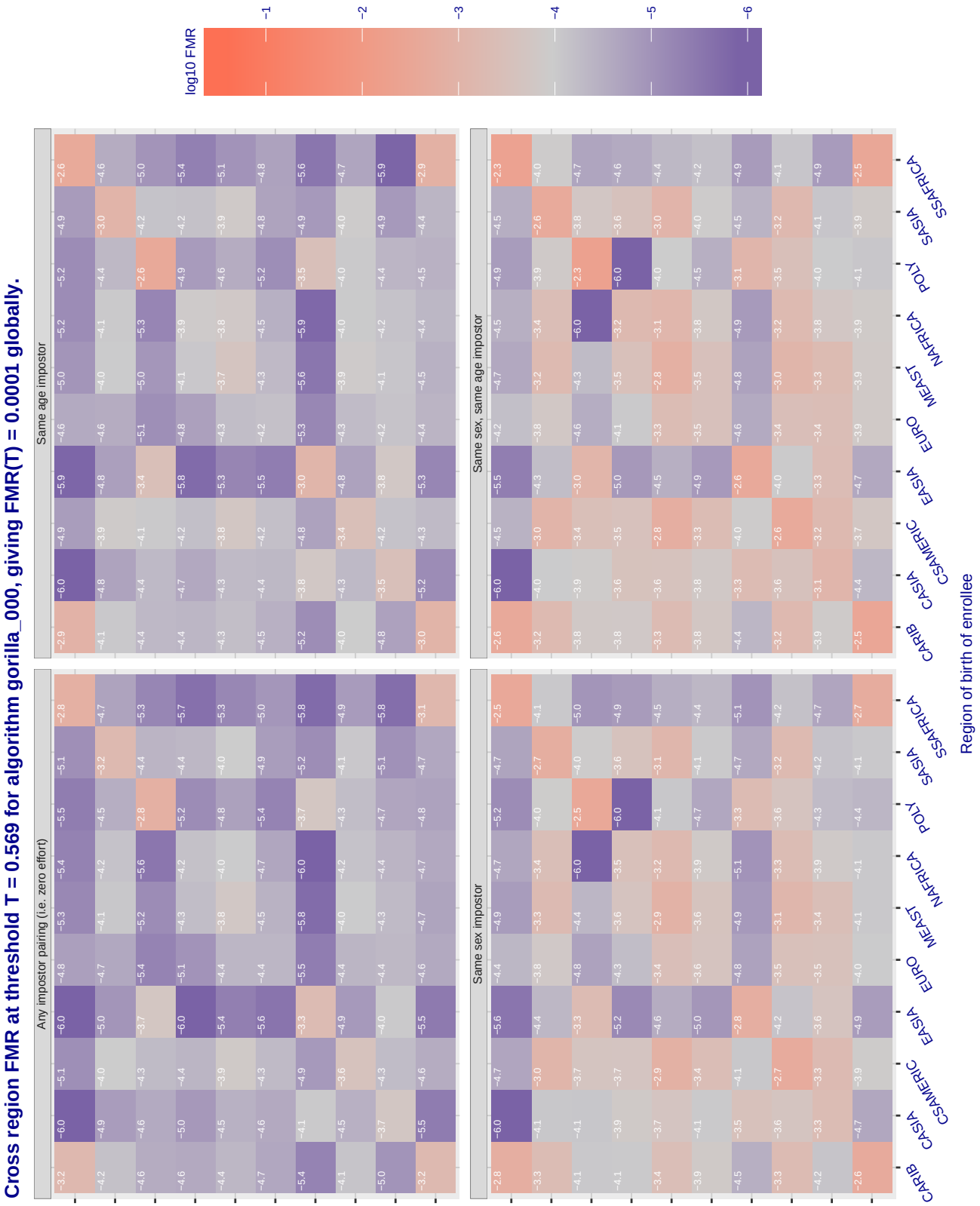


Figure 81: For algorithm gorilla-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

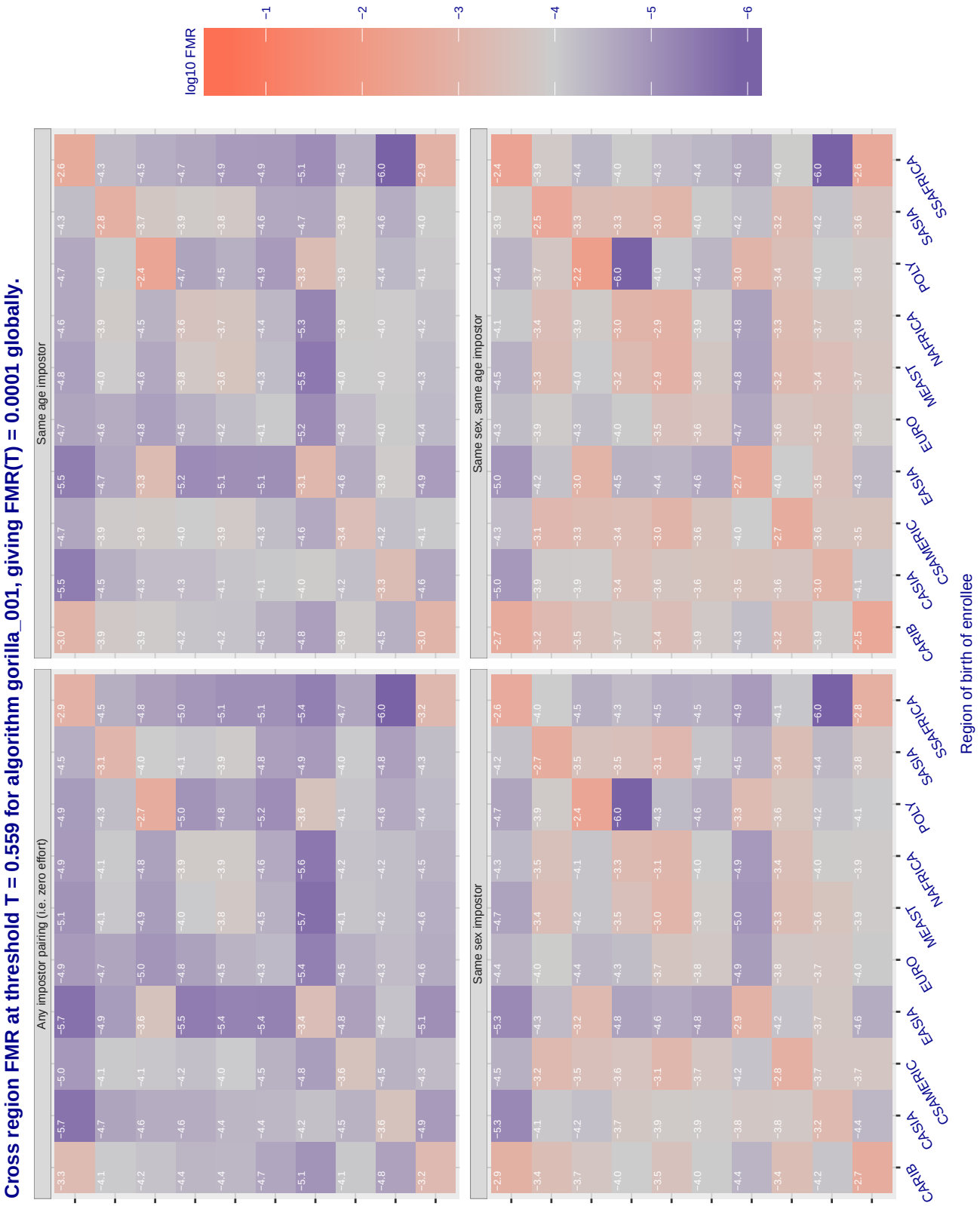


Figure 82: For algorithm gorilla-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

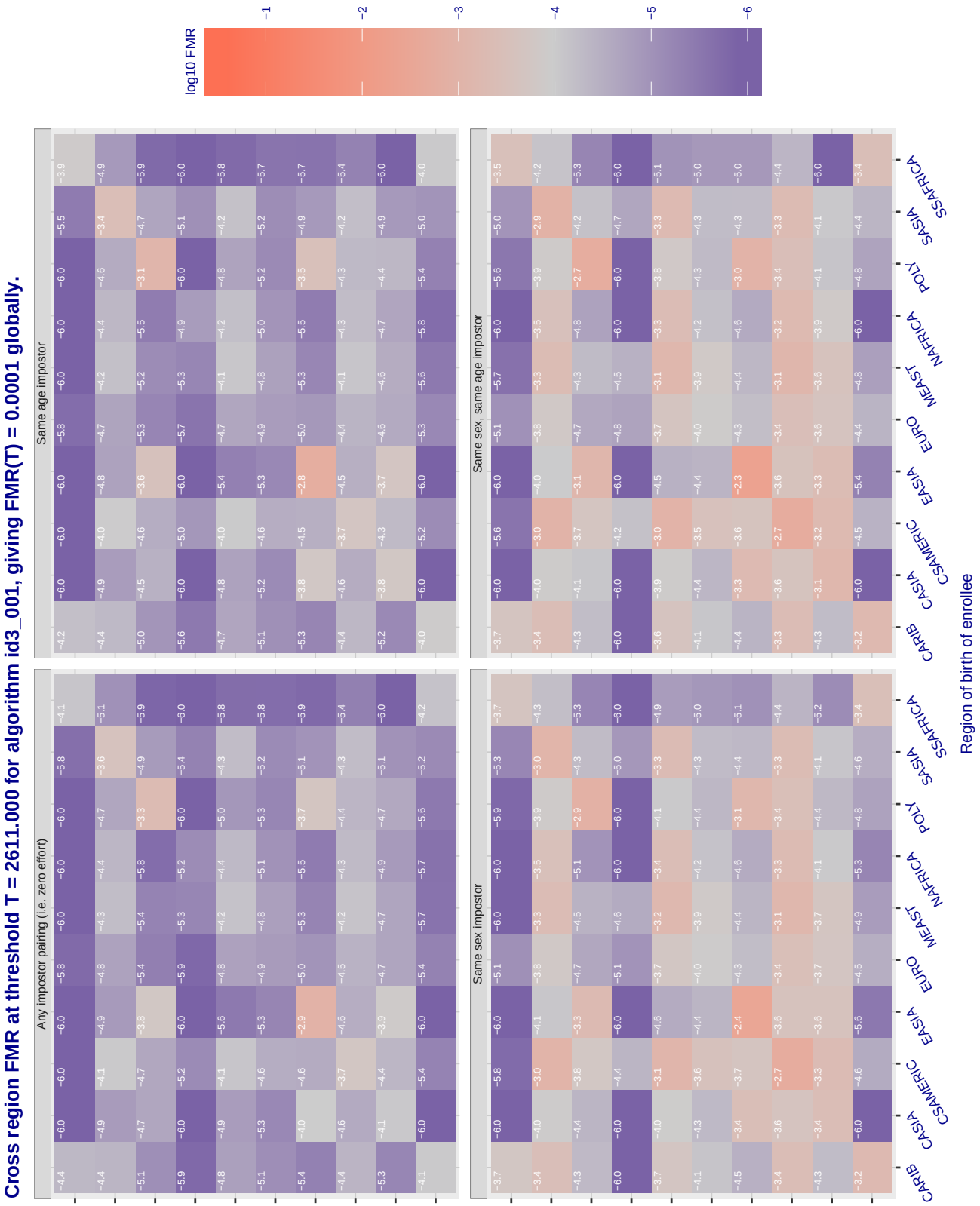


Figure 83: For algorithm id3-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

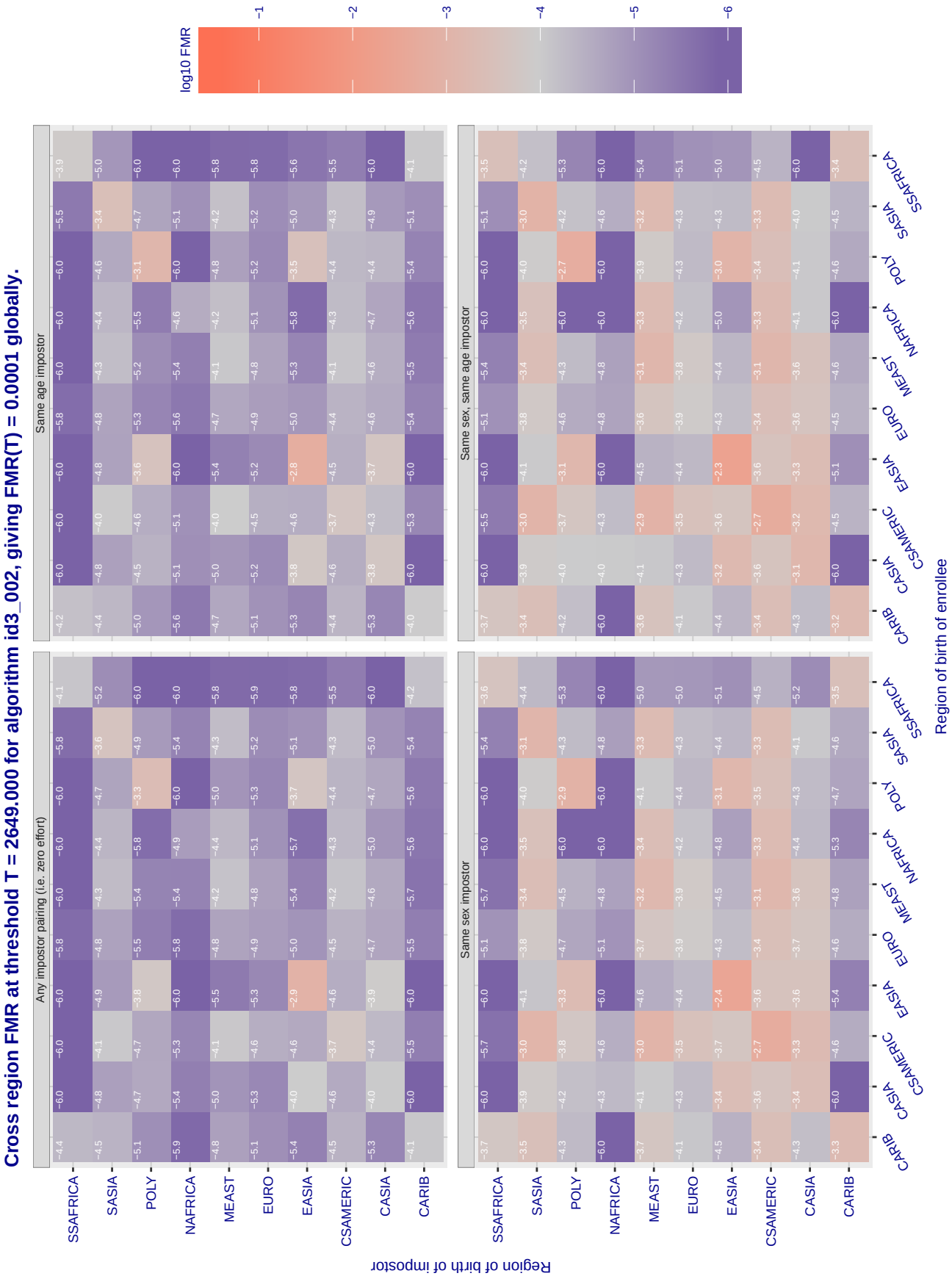


Figure 84: For algorithm id3-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

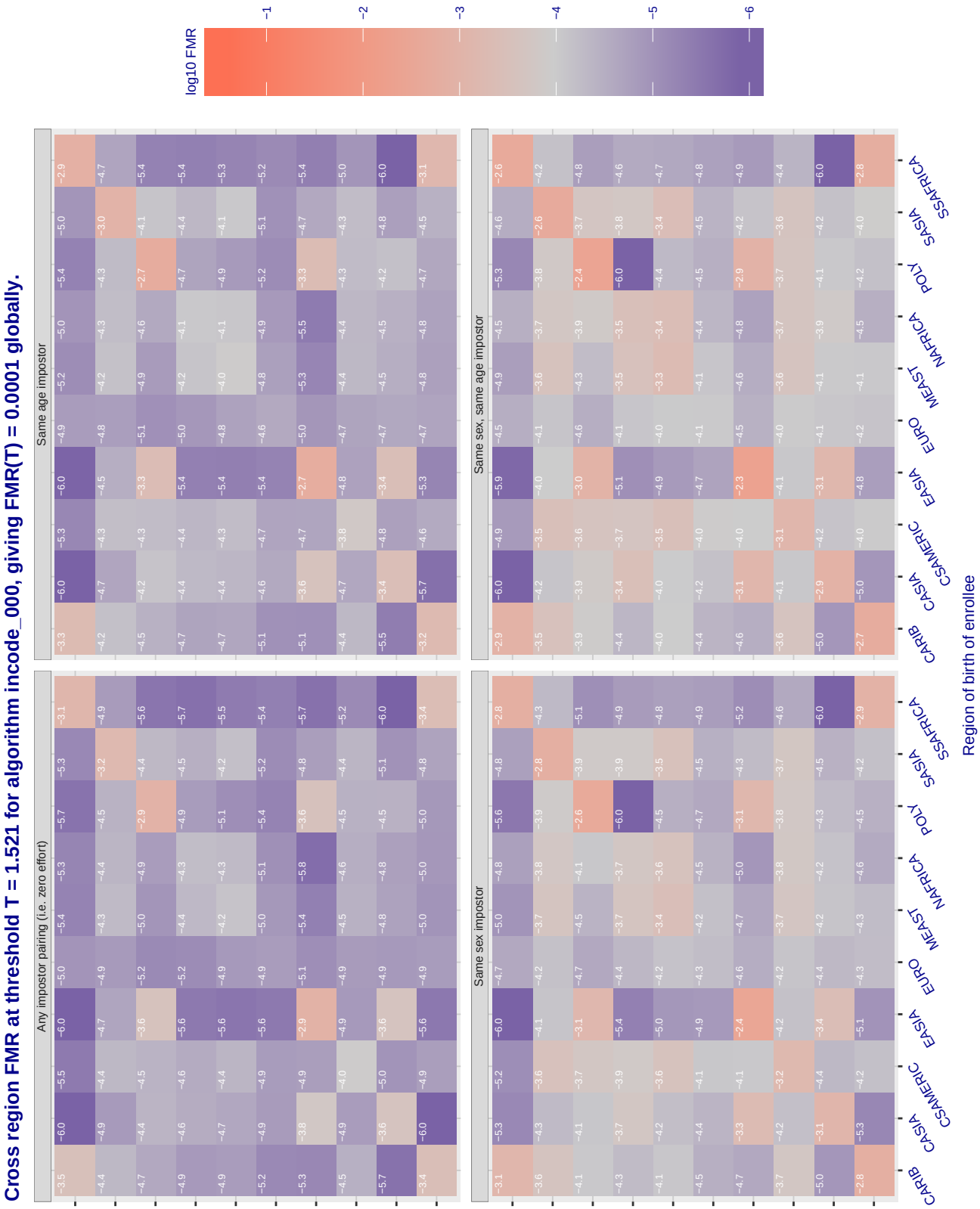


Figure 85: For algorithm incode-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

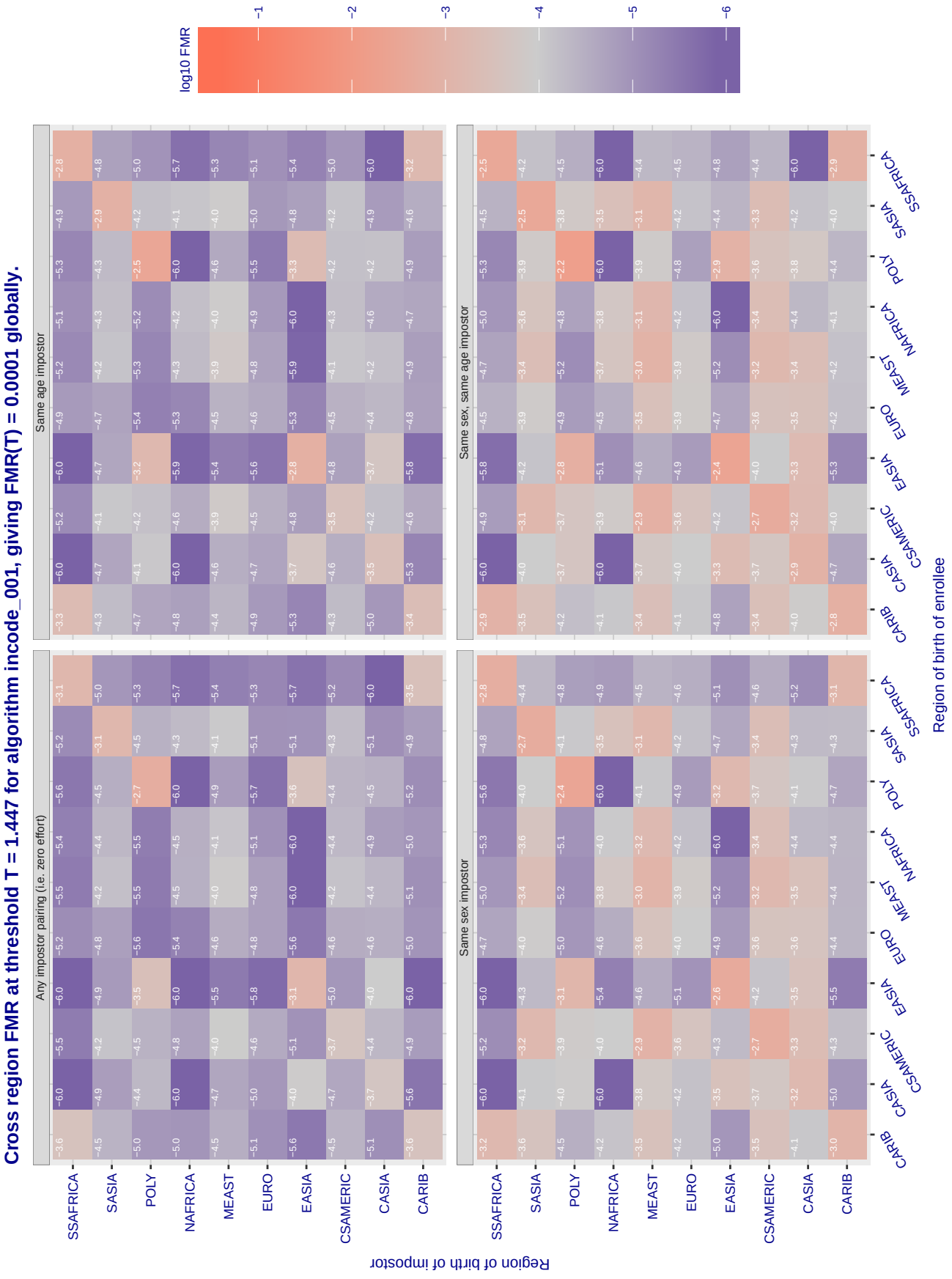


Figure 86: For algorithm incode-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

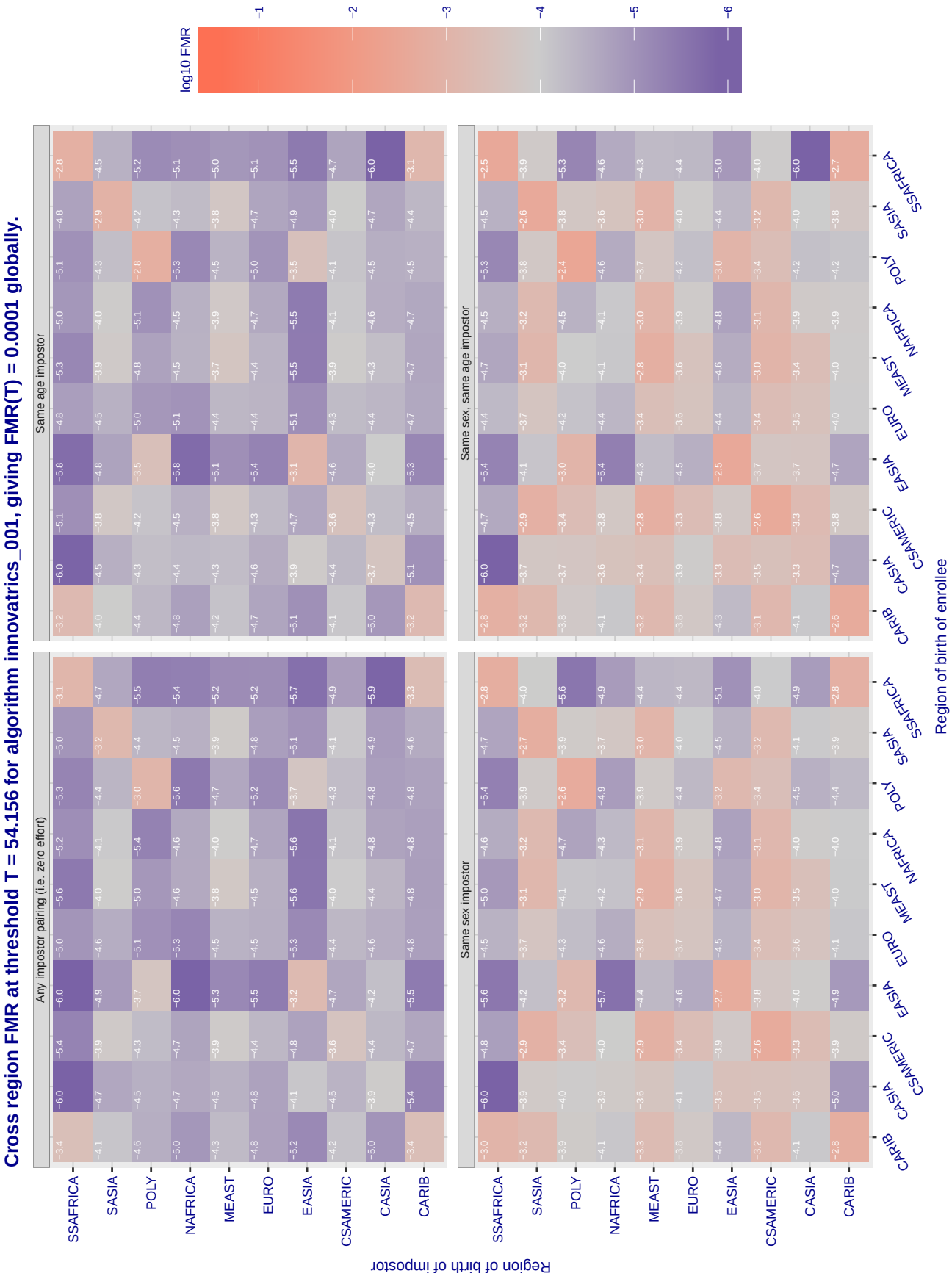


Figure 87: For algorithm innovatrics-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

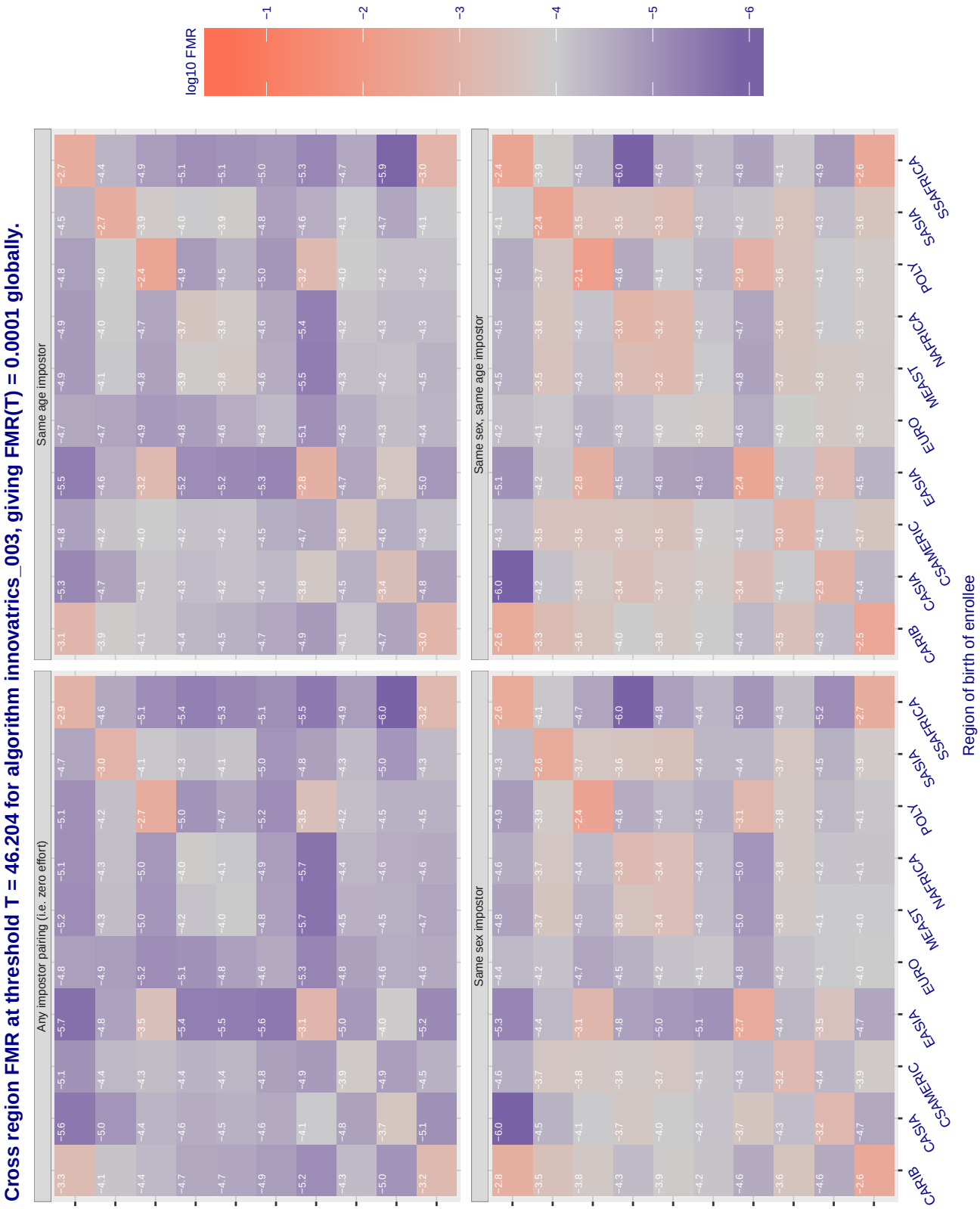


Figure 88: For algorithm innovatrics-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

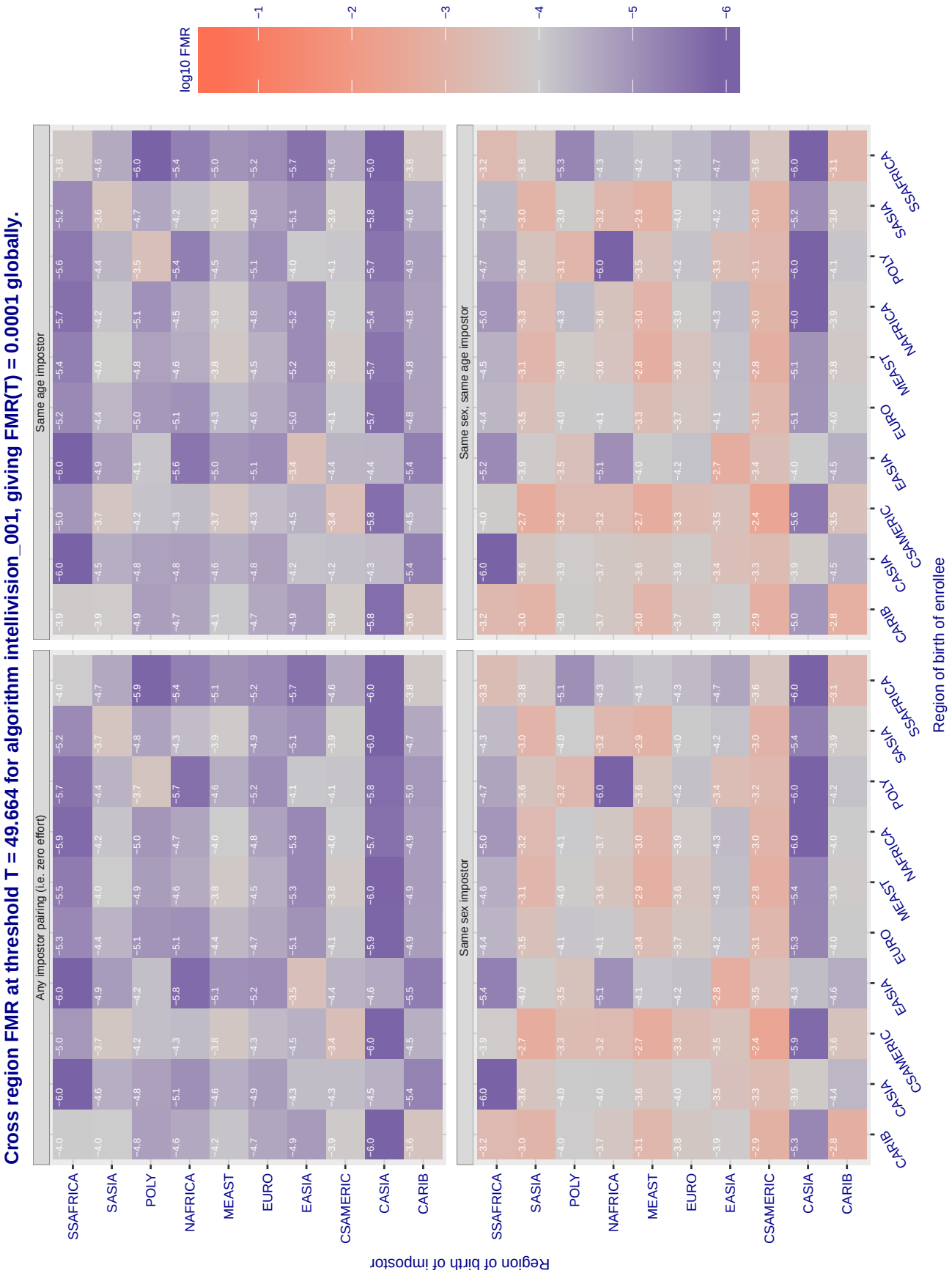


Figure 89: For algorithm intellivision-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

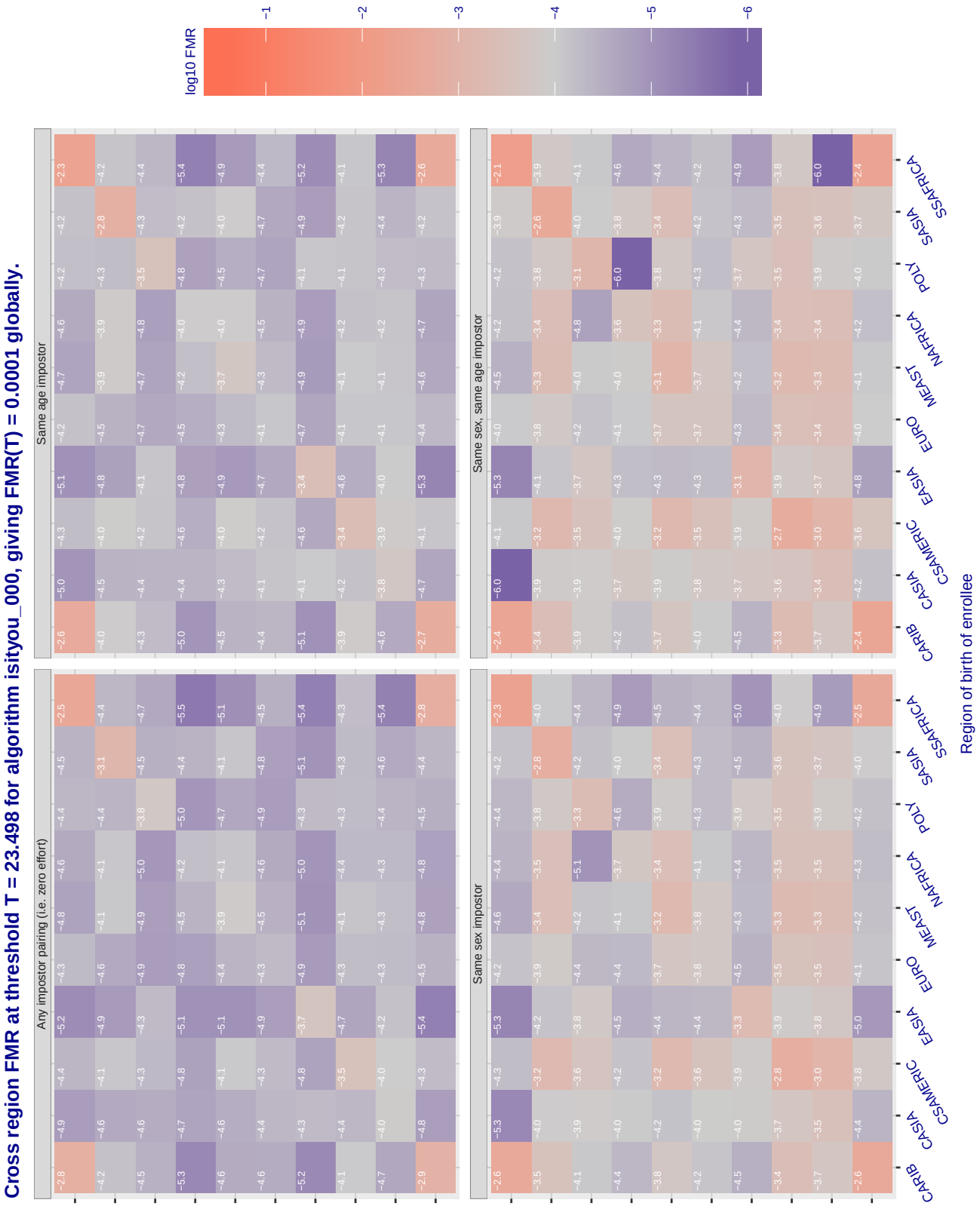


Figure 90: For algorithm isityou-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

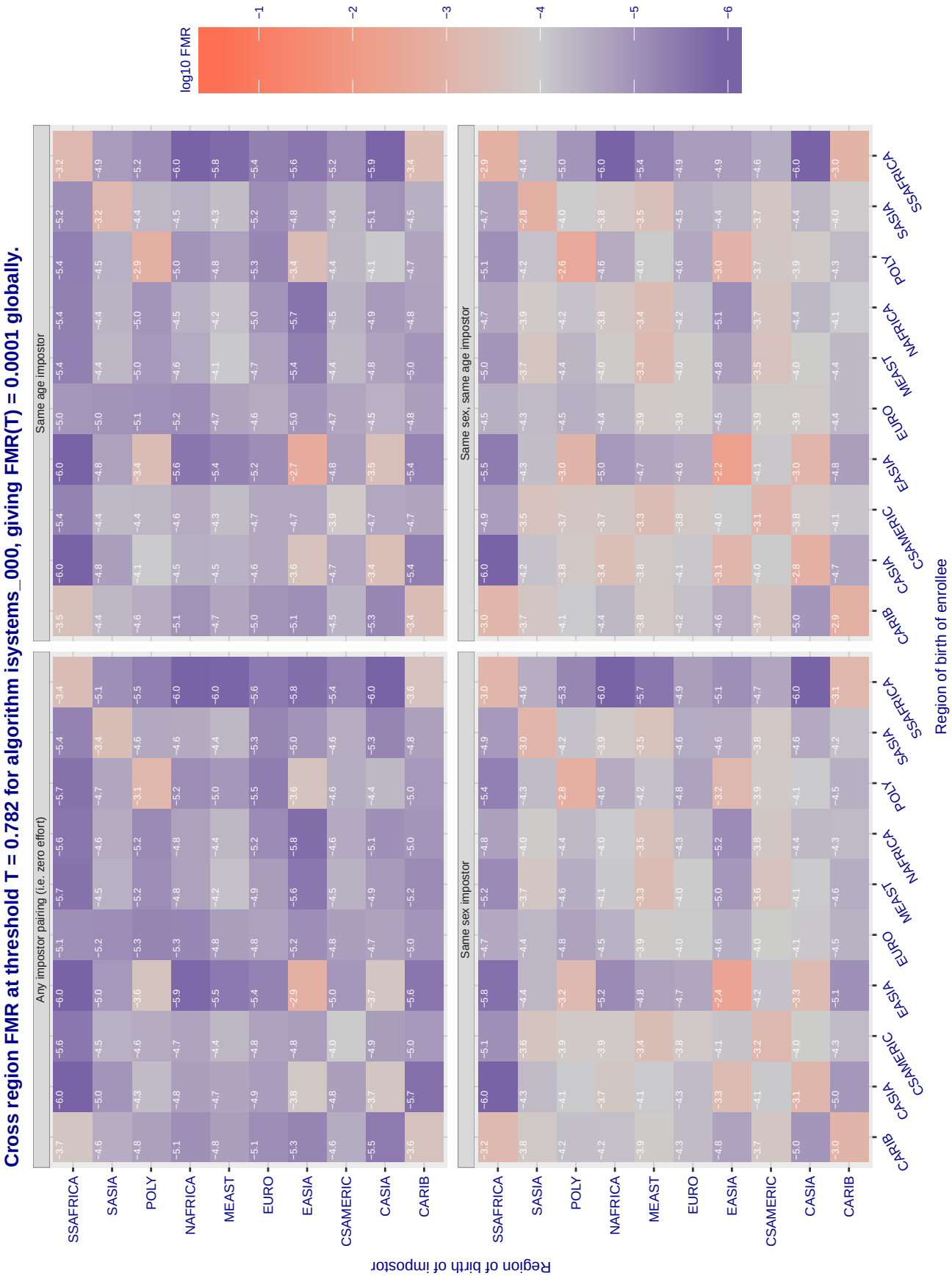


Figure 91: For algorithm isystems-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

Figure 92: For algorithm isystems-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

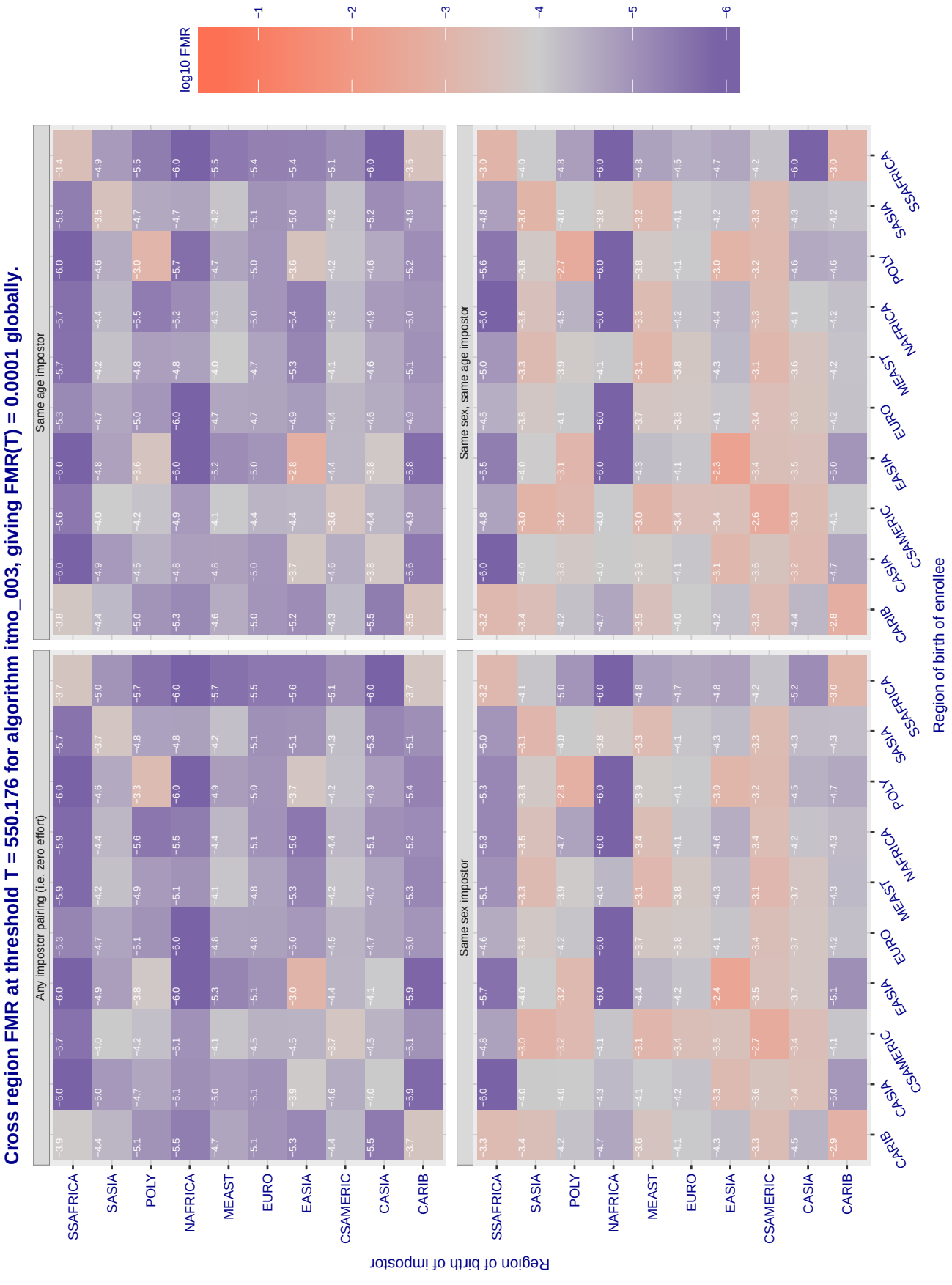


Figure 93: For algorithm itmo-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

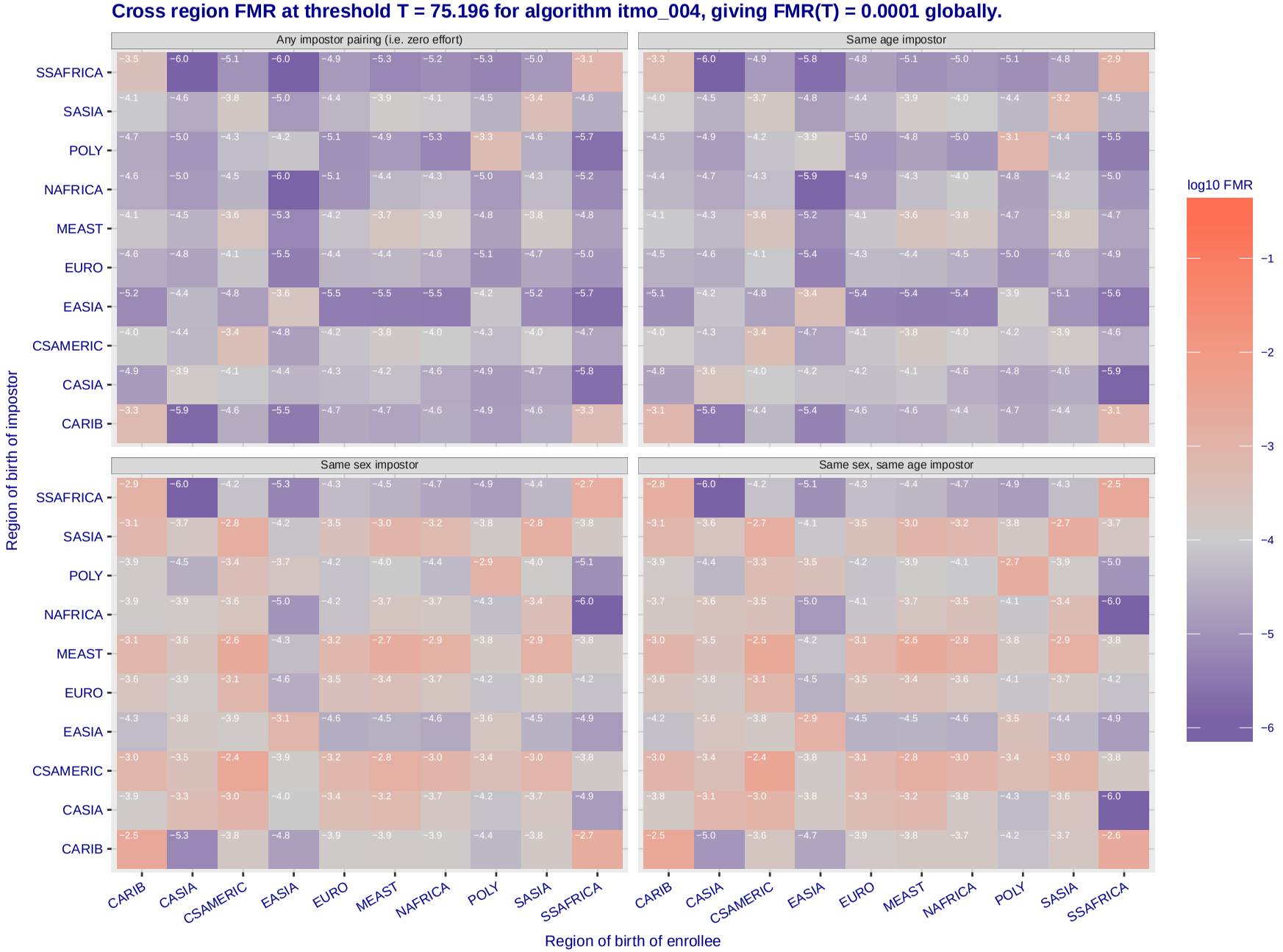


Figure 94: For algorithm itmo-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

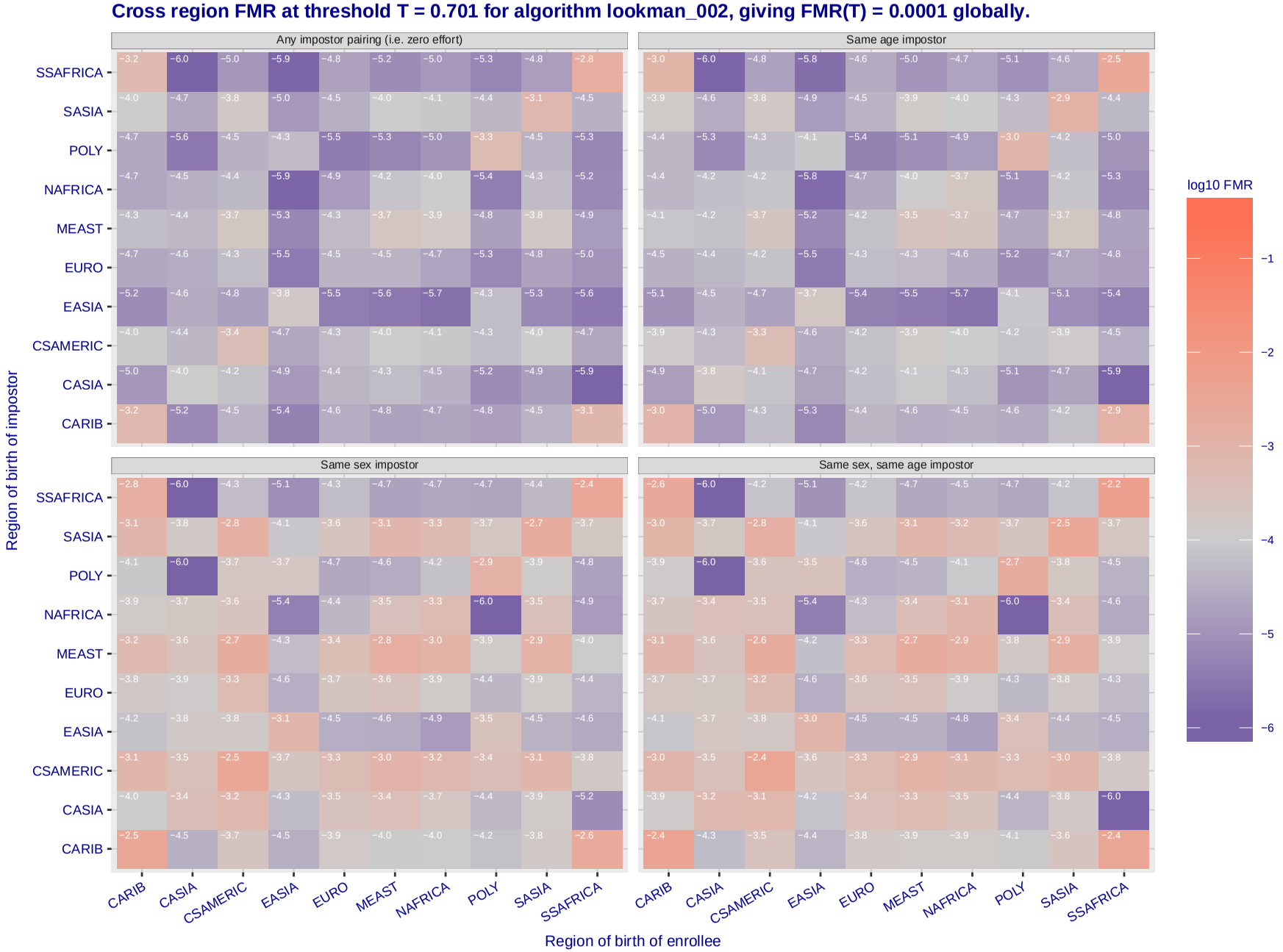


Figure 95: For algorithm lookman-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

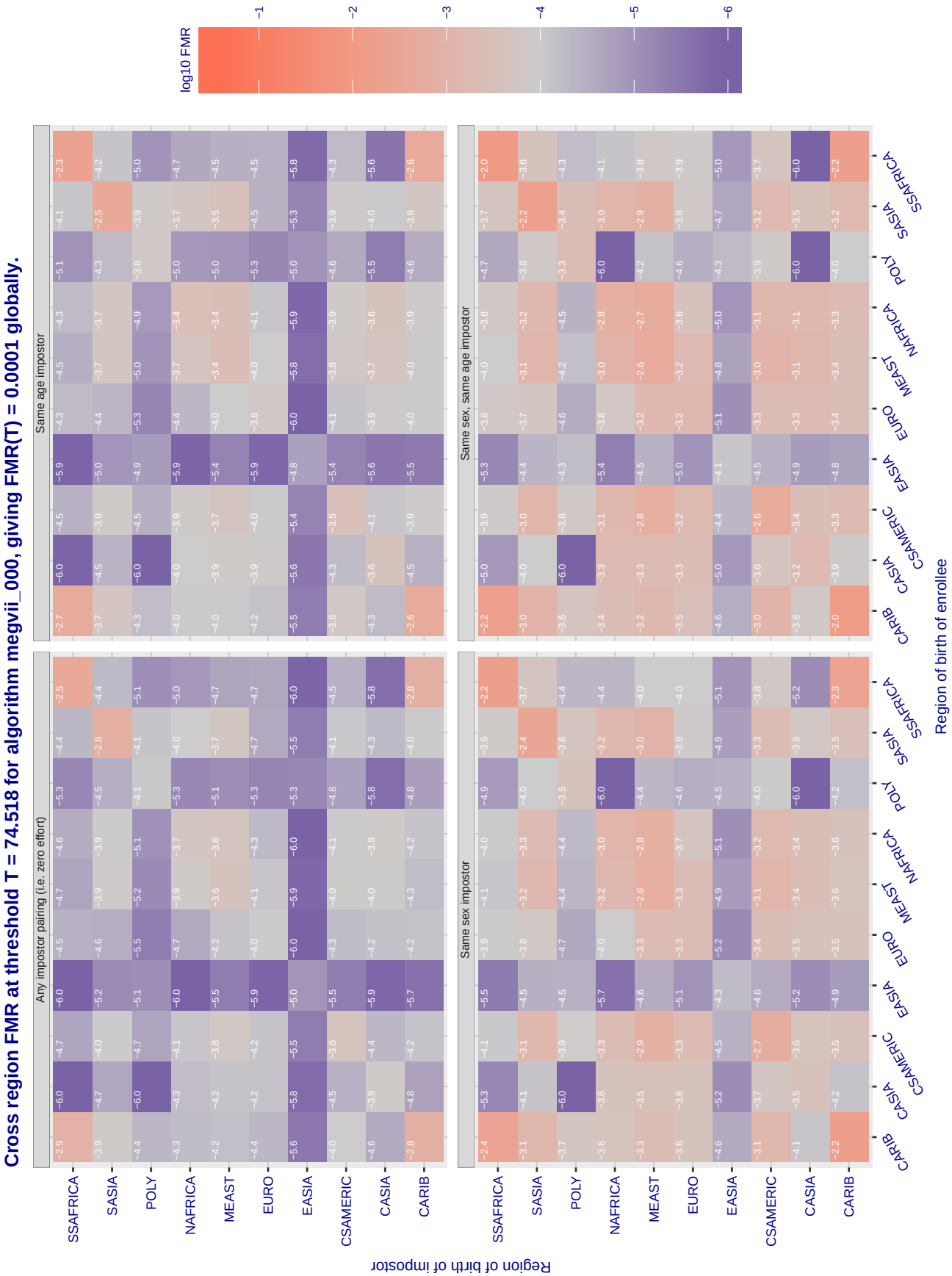


Figure 96: For algorithm megvii-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

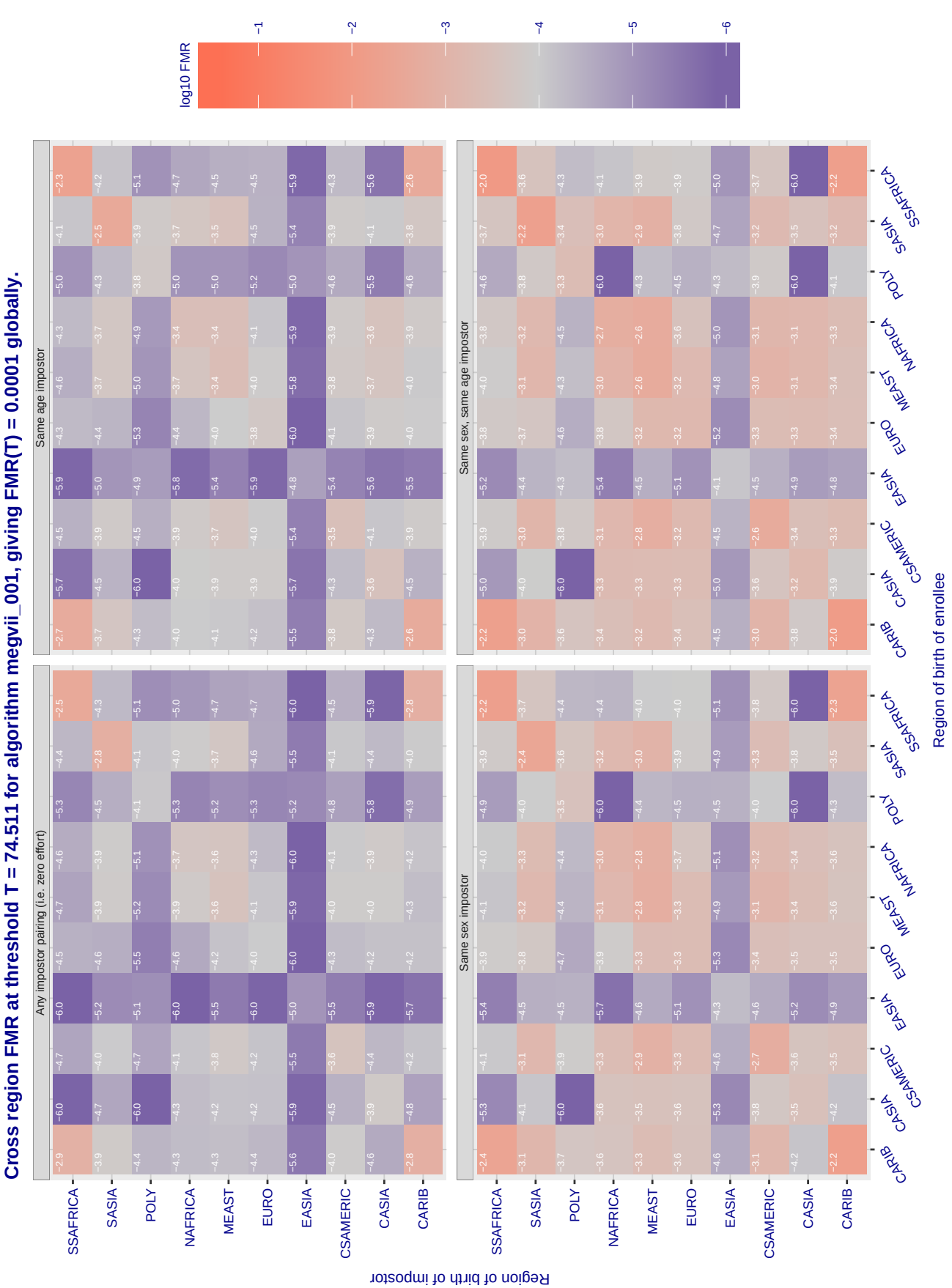


Figure 97: For algorithm megvii-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

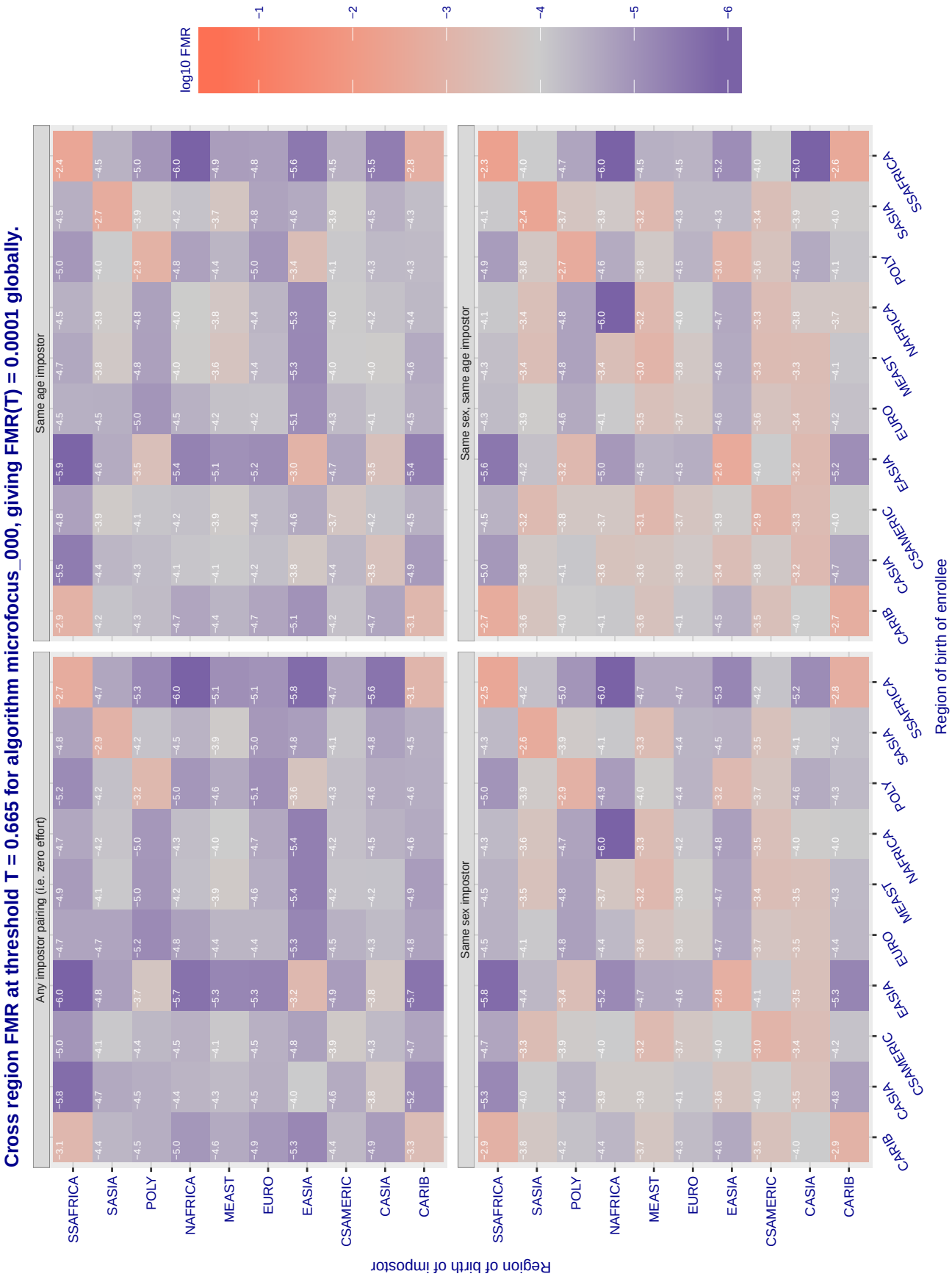


Figure 98: For algorithm microfocus-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

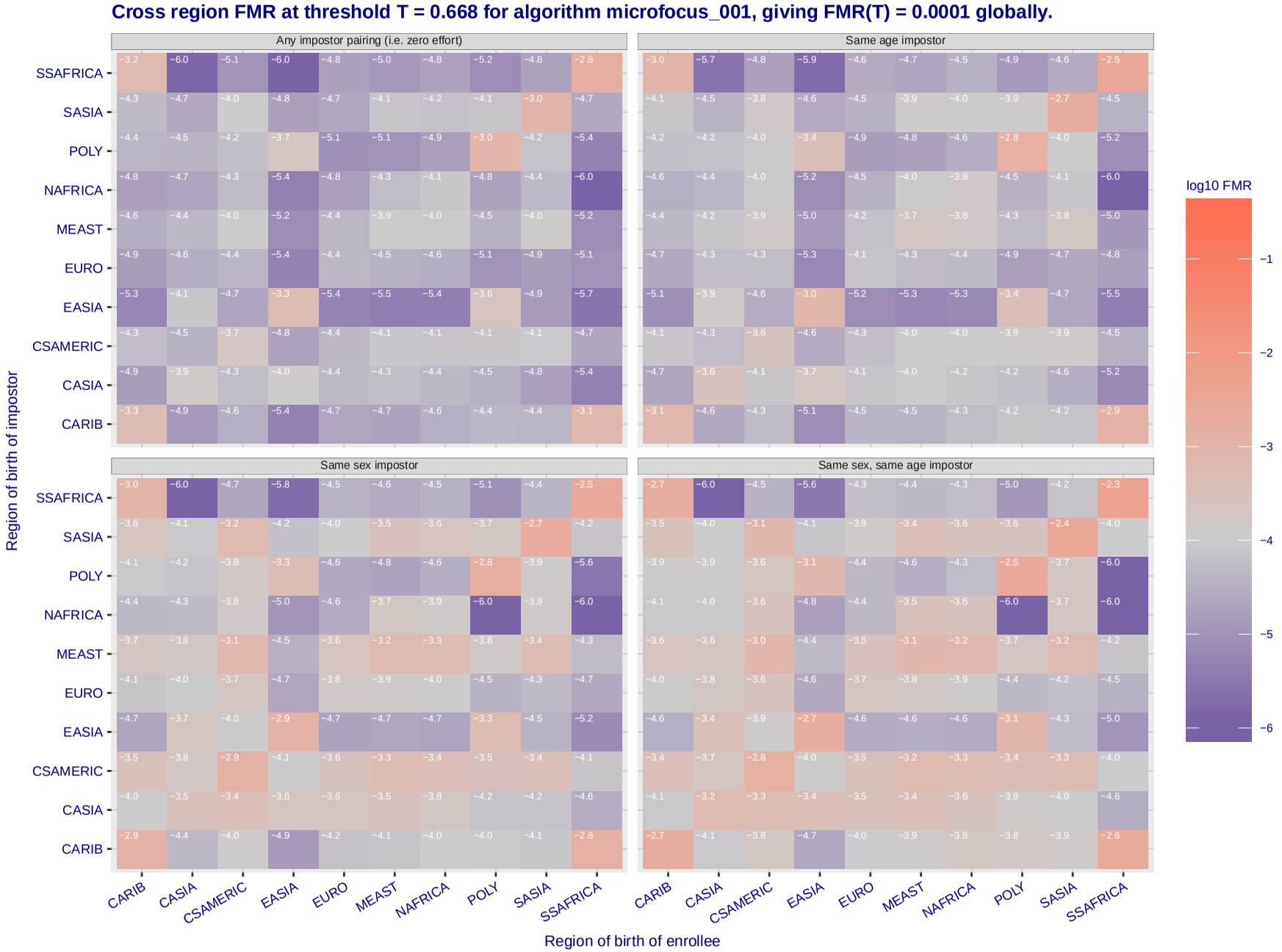


Figure 99: For algorithm microfocus-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

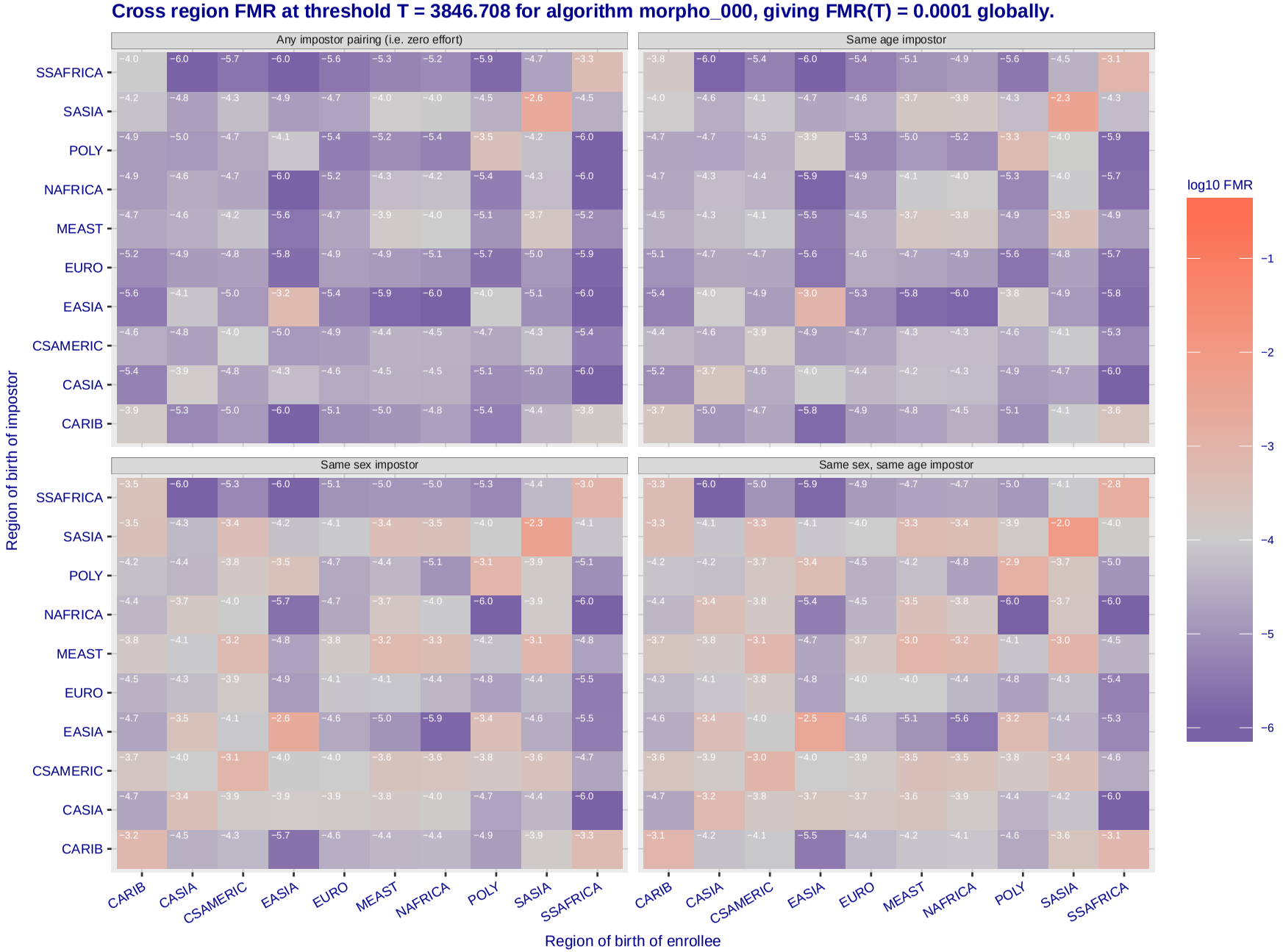


Figure 100: For algorithm morpho-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

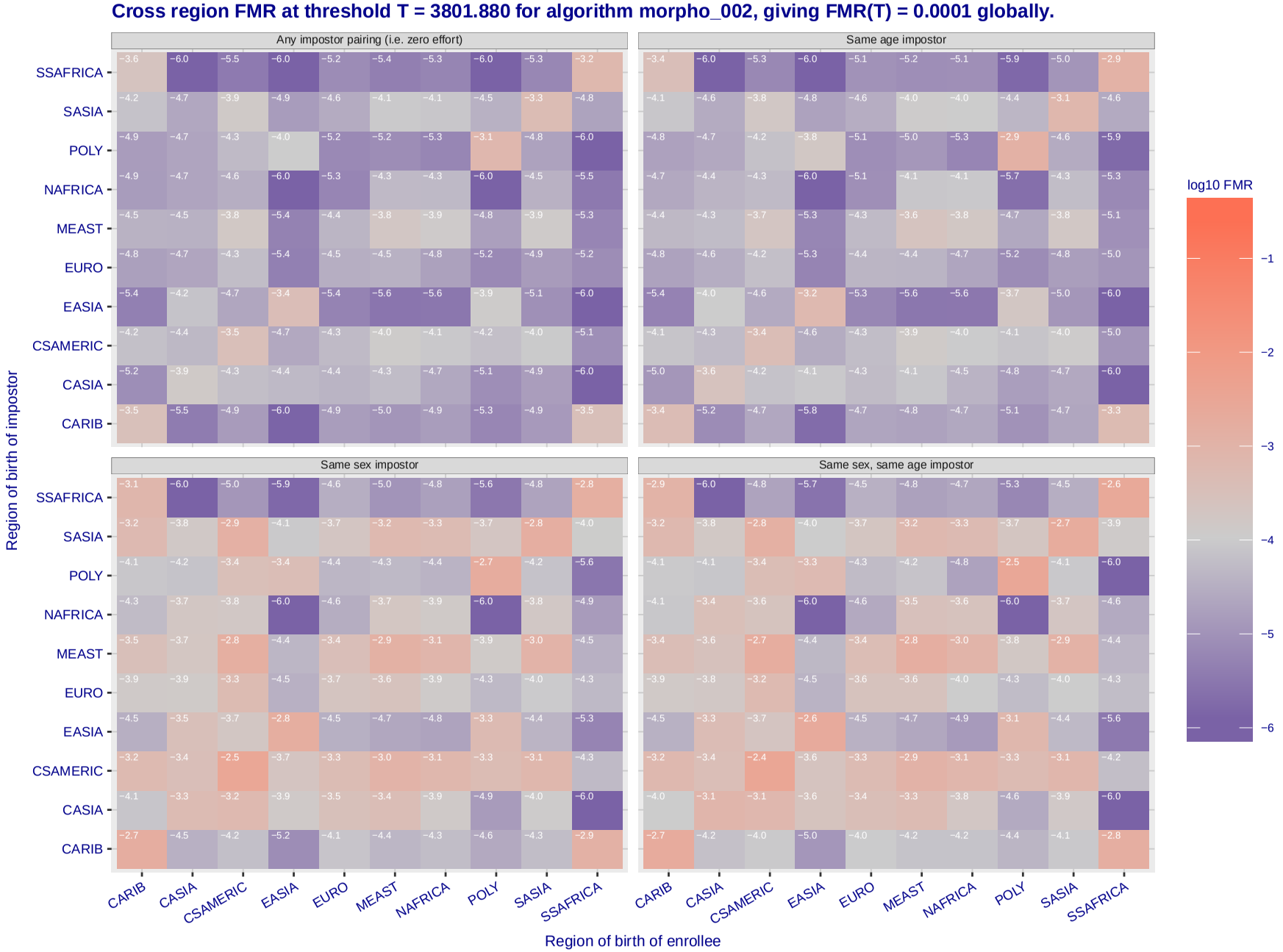


Figure 101: For algorithm morpho-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

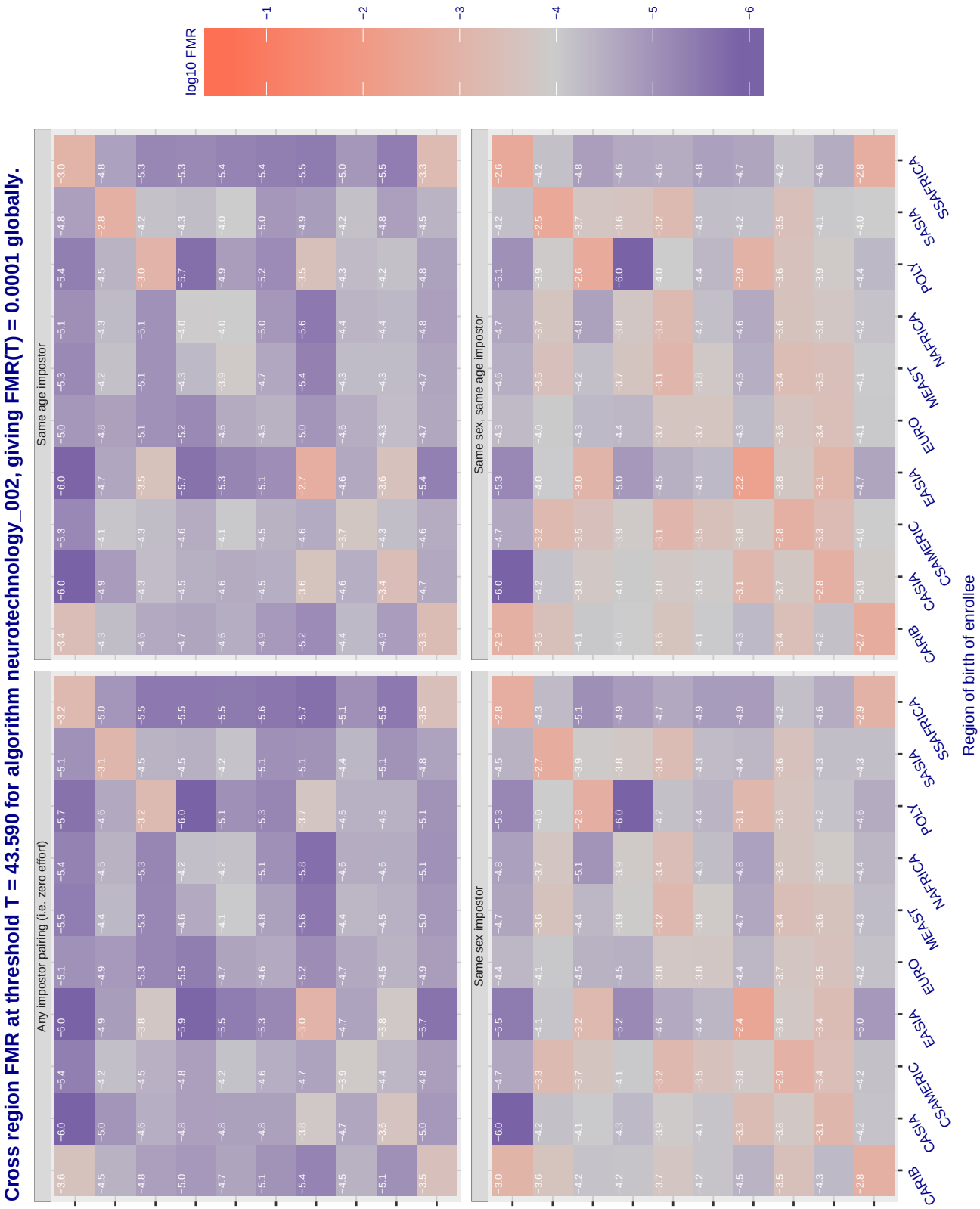


Figure 102: For algorithm neurotechnology-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

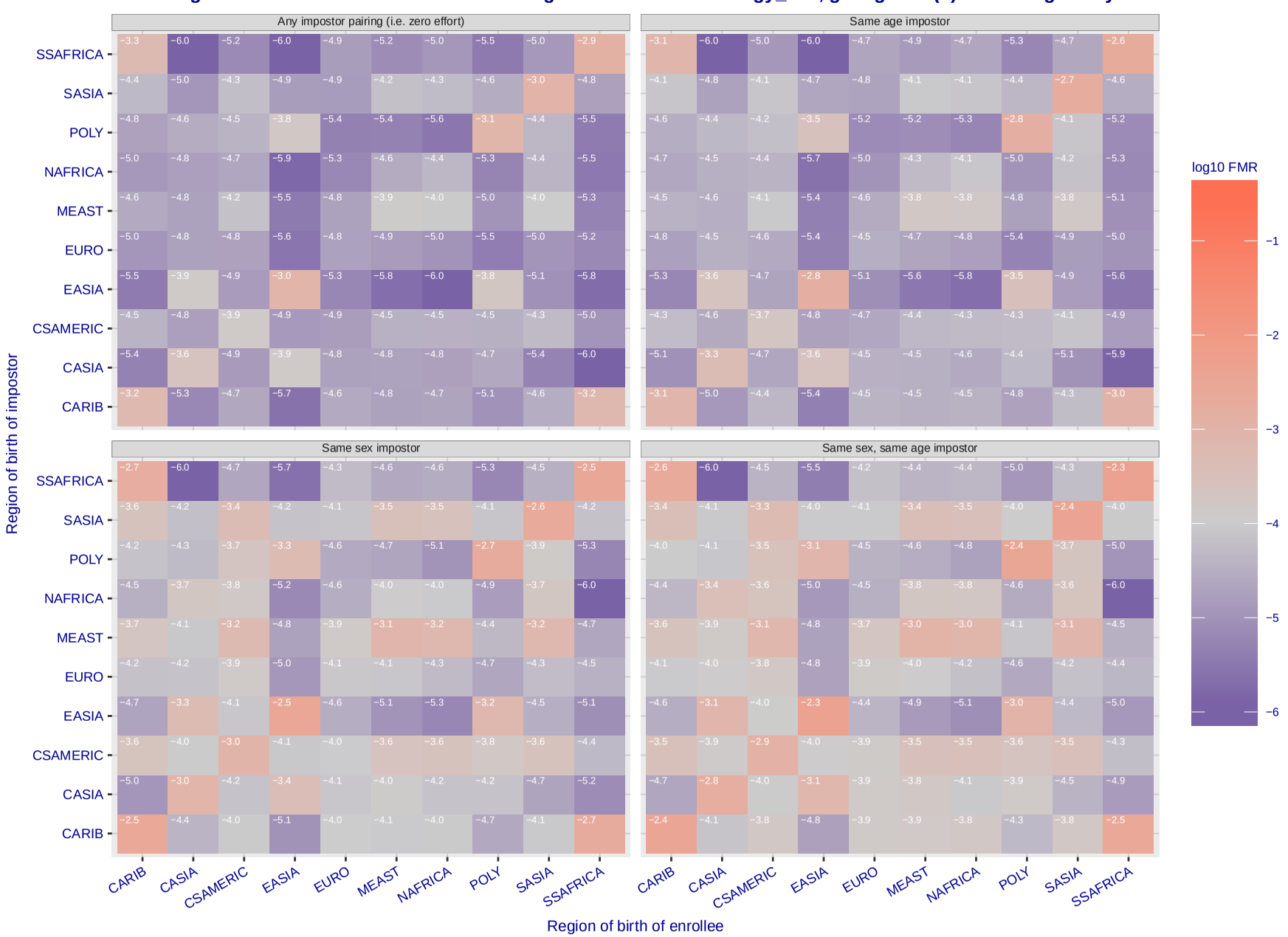


Figure 103: For algorithm neurotechnology-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

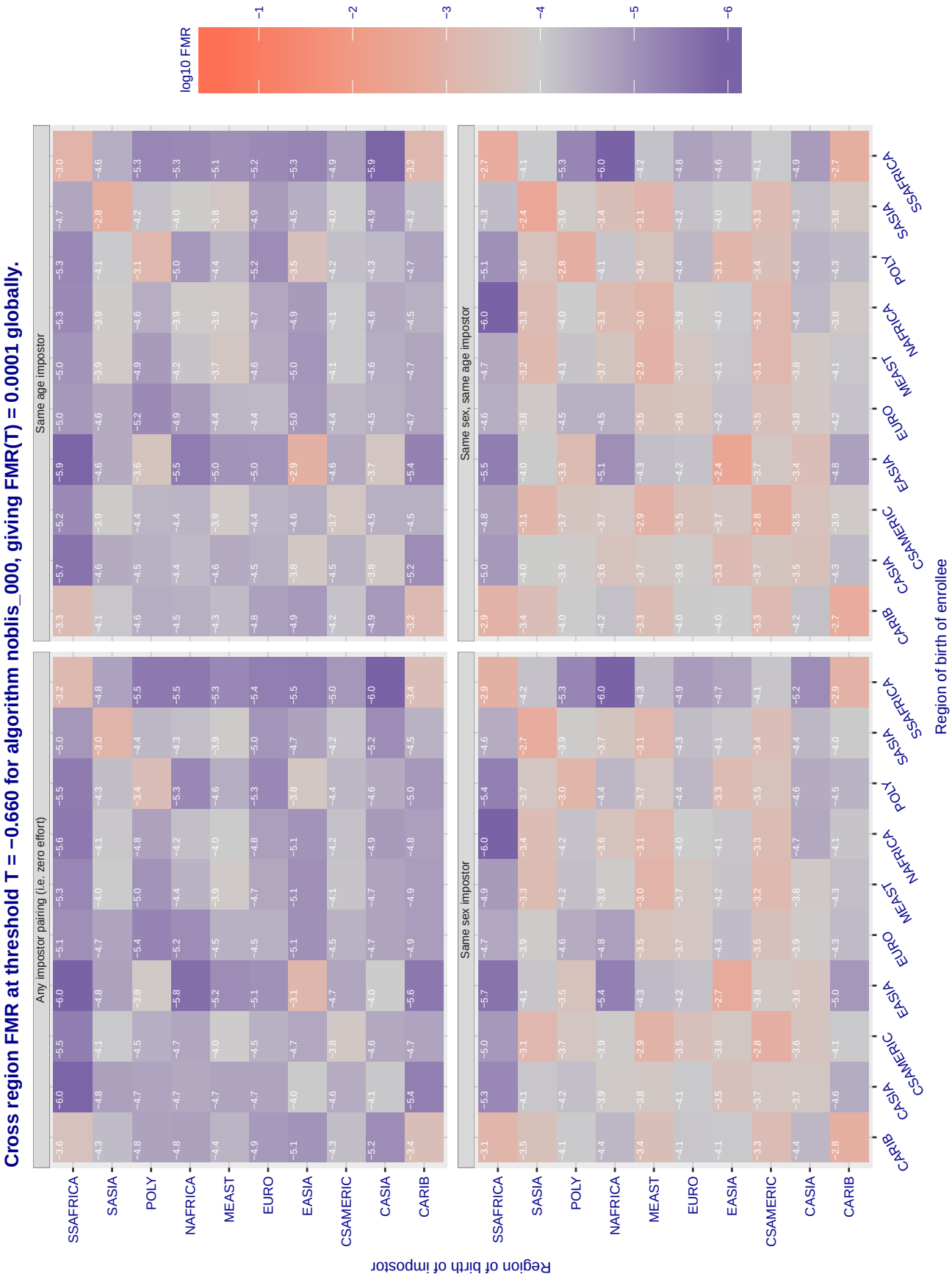


Figure 104: For algorithm noblis-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

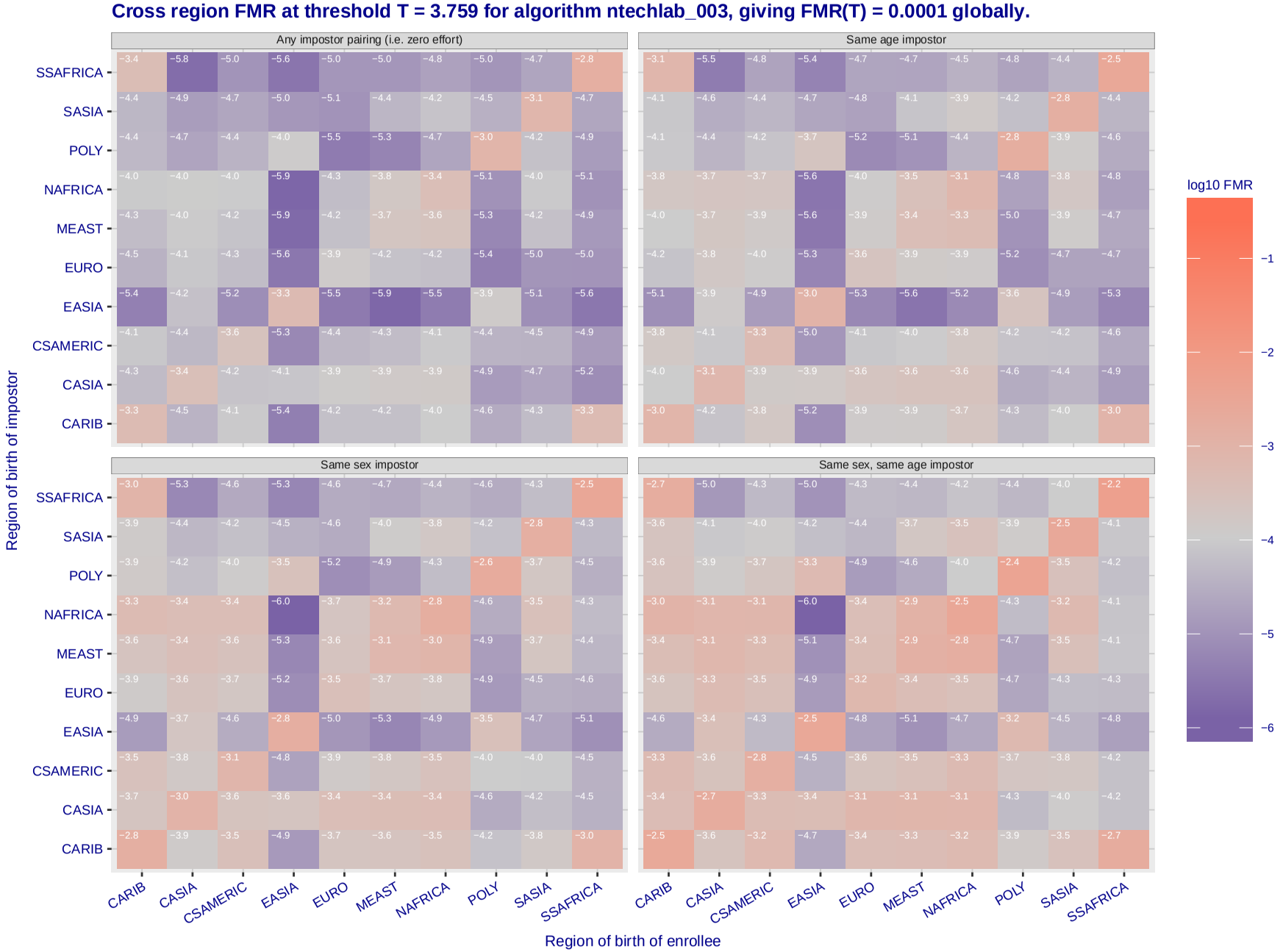


Figure 105: For algorithm ntechlab-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

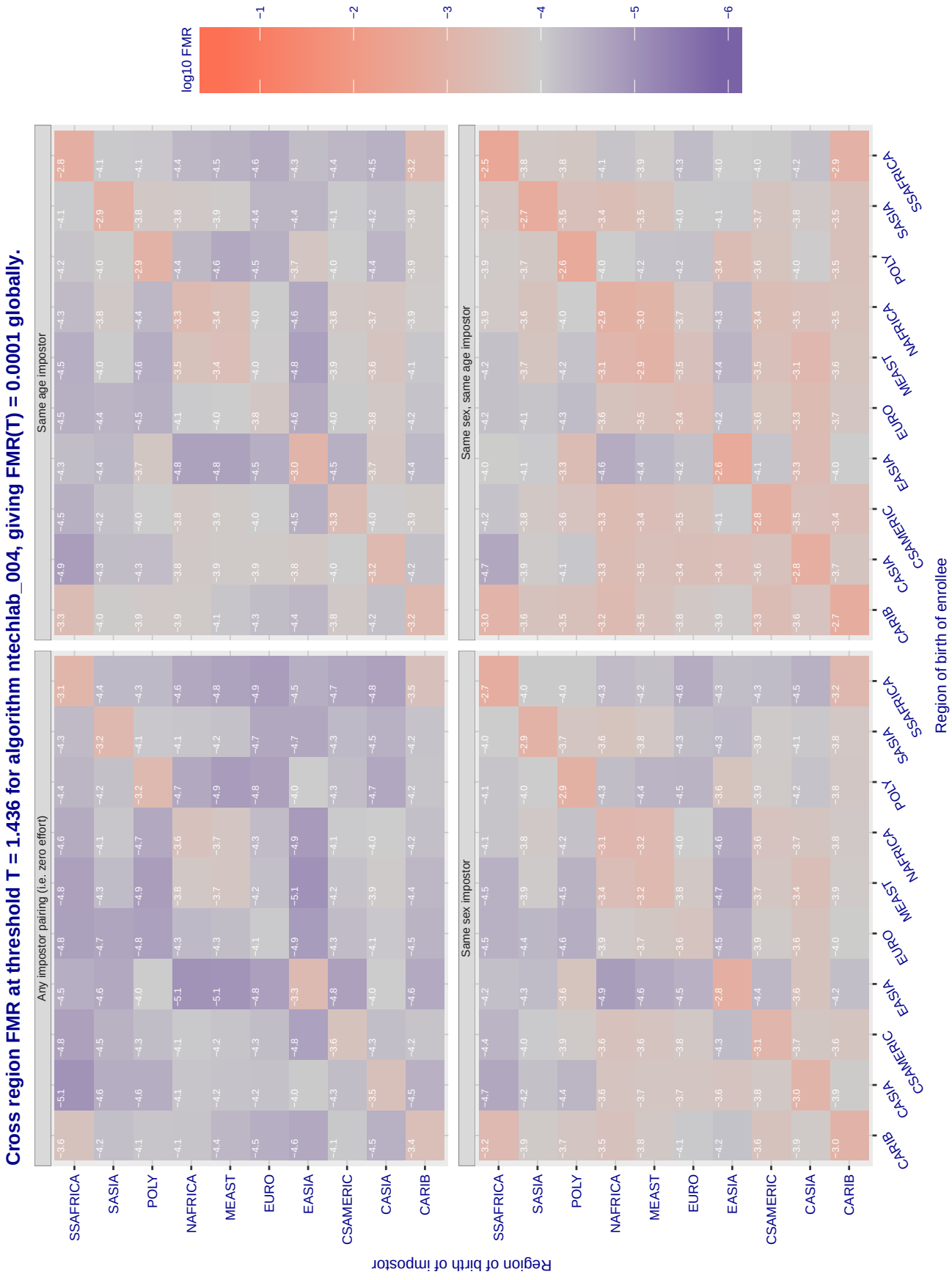


Figure 106: For algorithm ntechlab-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

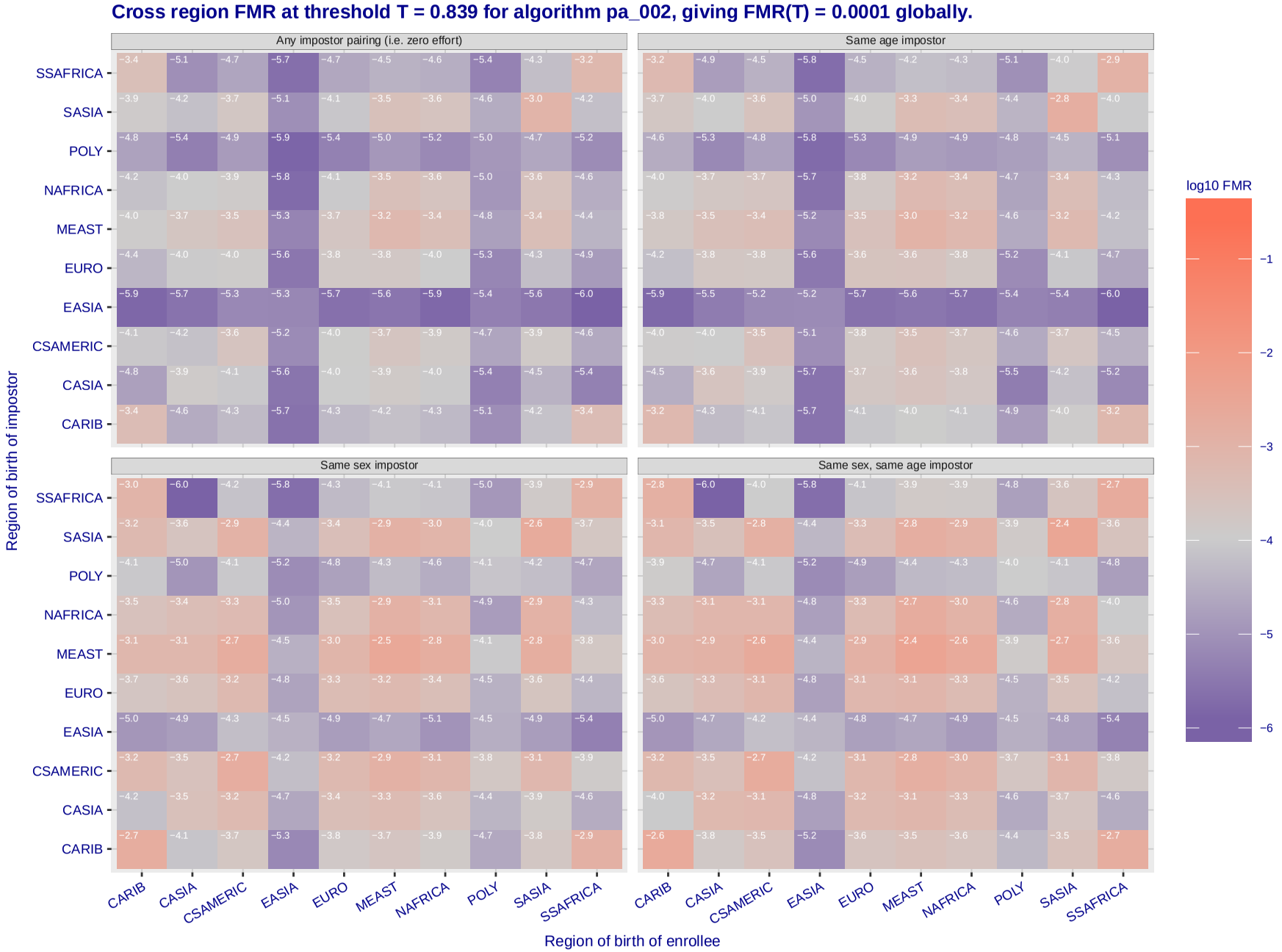


Figure 107: For algorithm pa-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

Figure 108: For algorithm pa-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

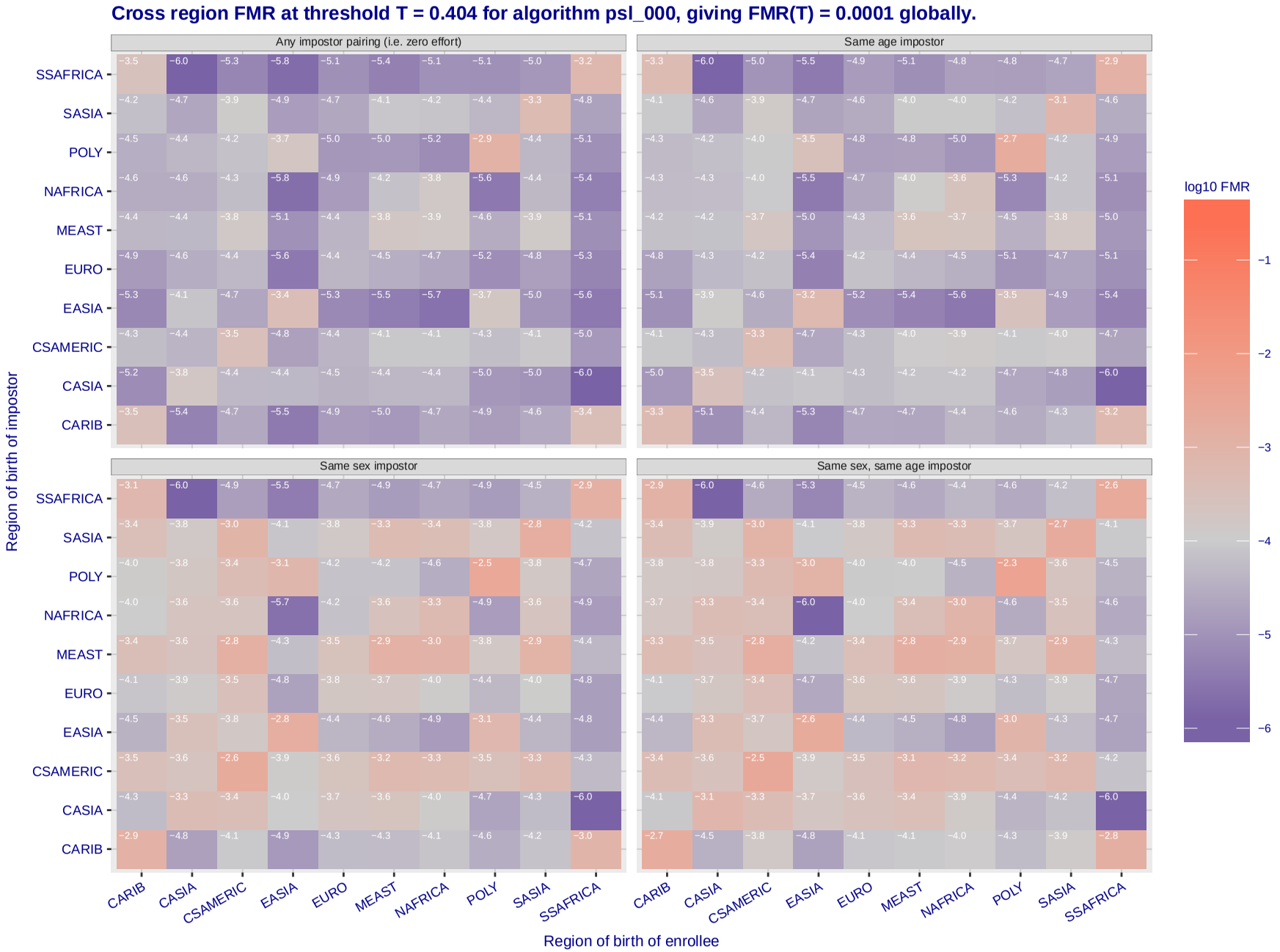


Figure 109: For algorithm psl-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

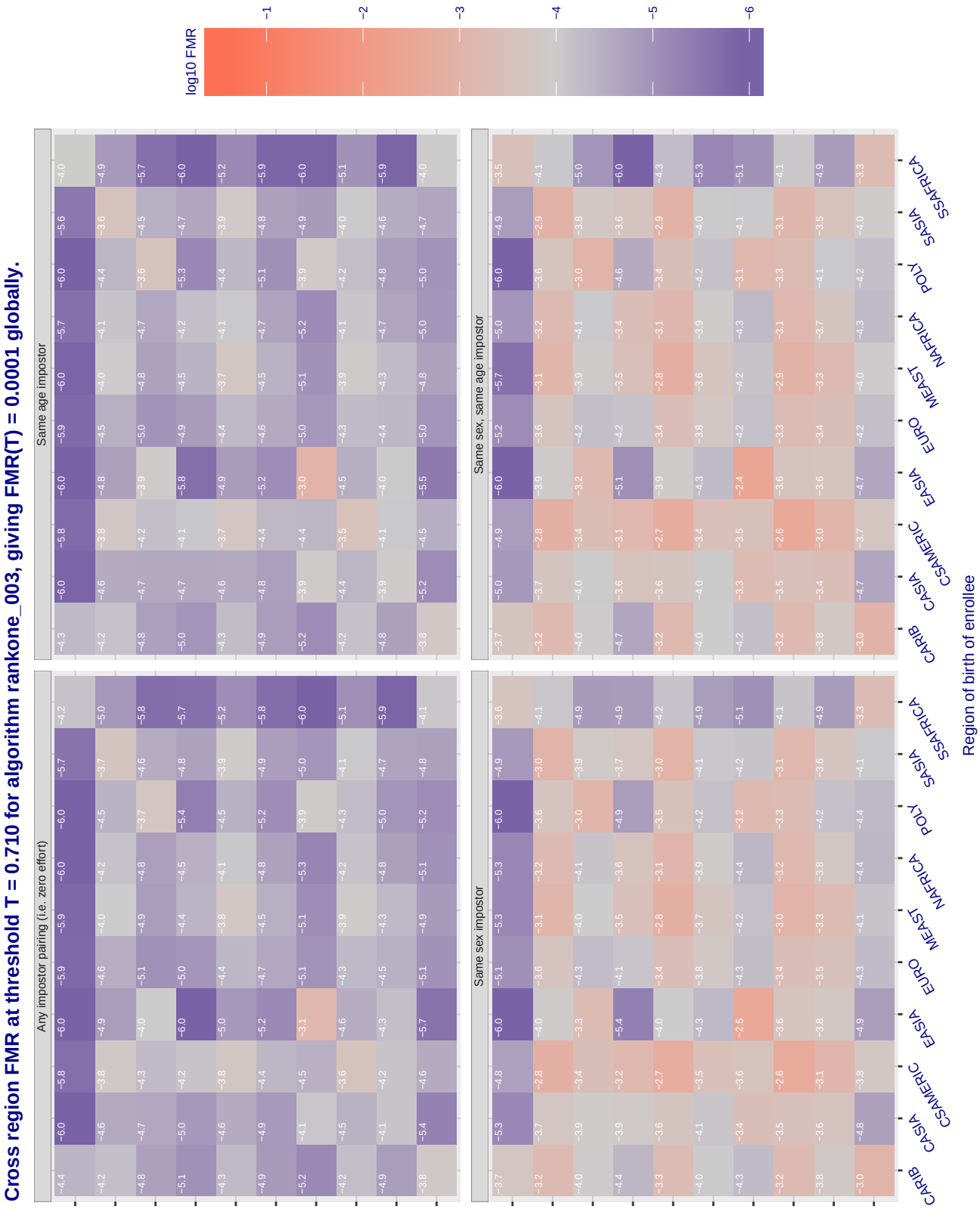


Figure 110: For algorithm rankone-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

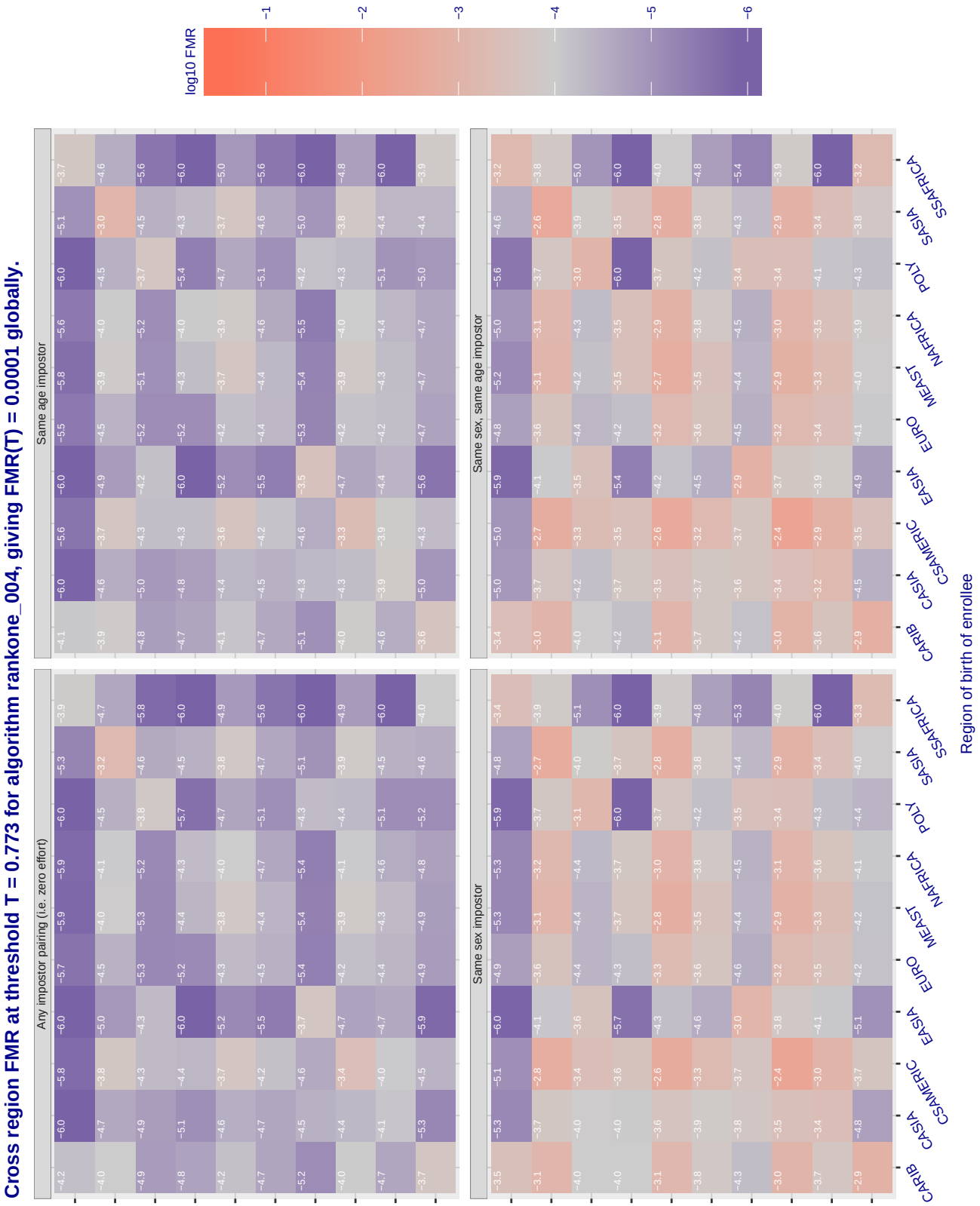


Figure 111: For algorithm rankone-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

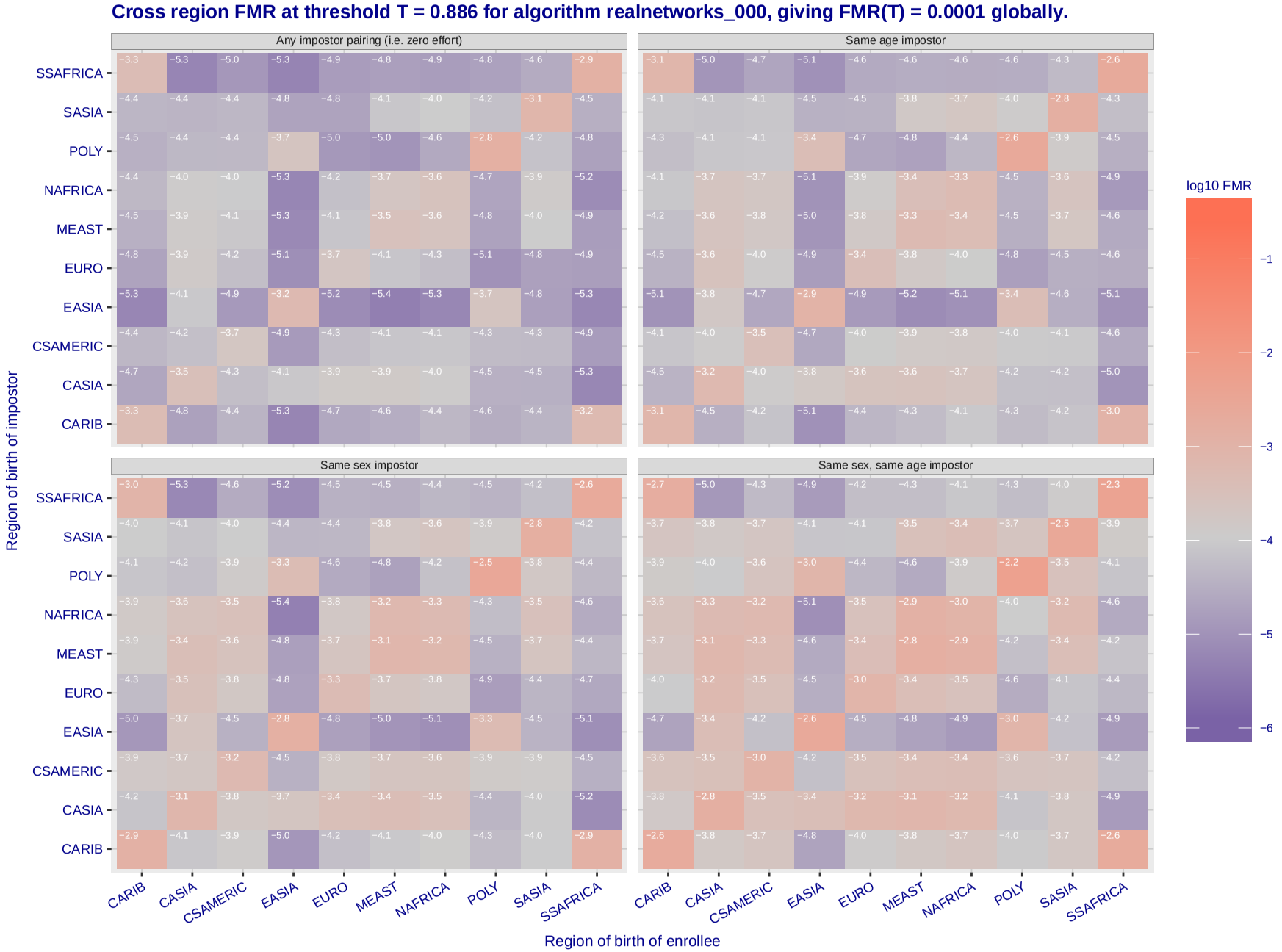


Figure 112: For algorithm realnetworks-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

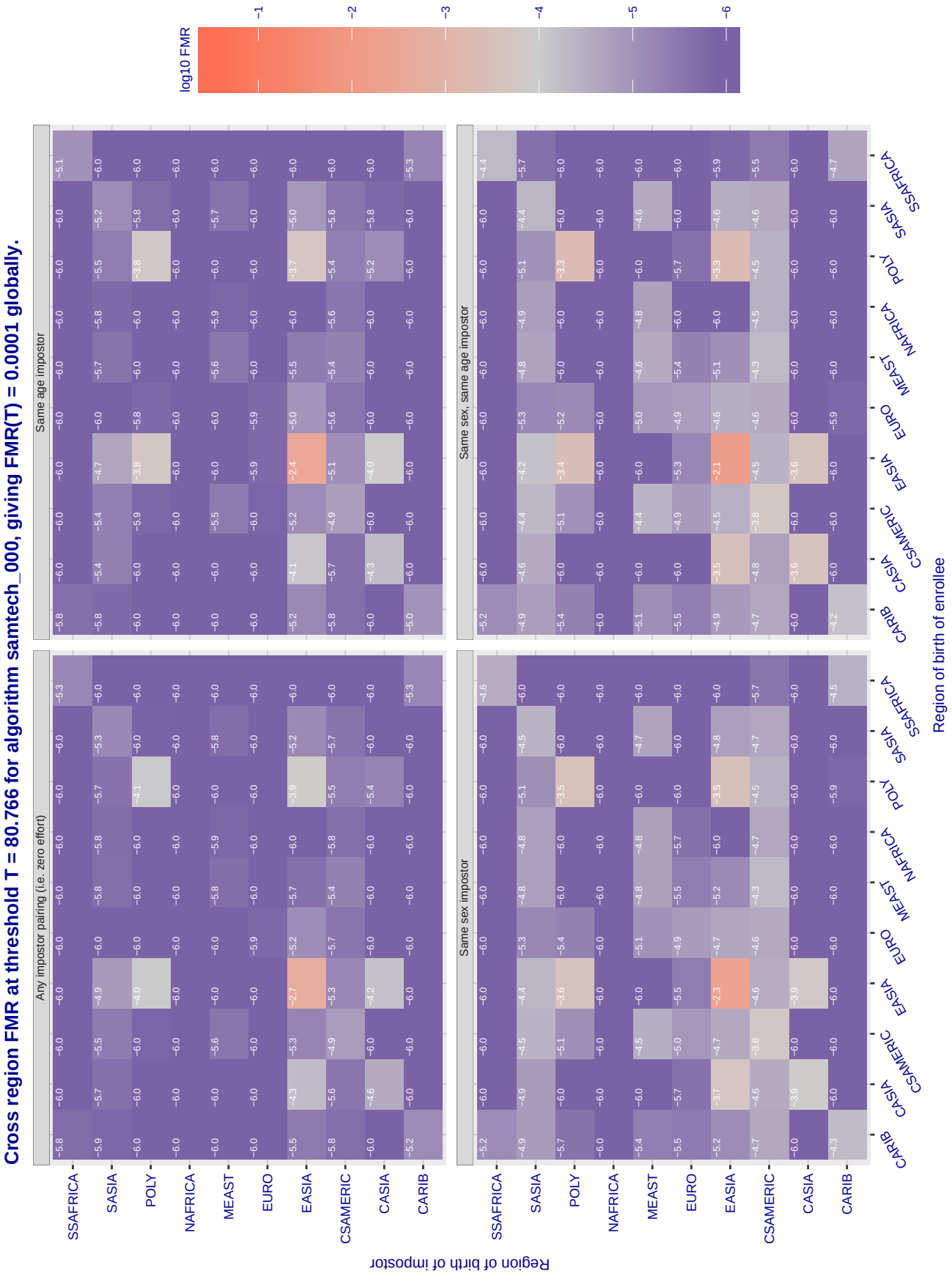


Figure 113: For algorithm samtech-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

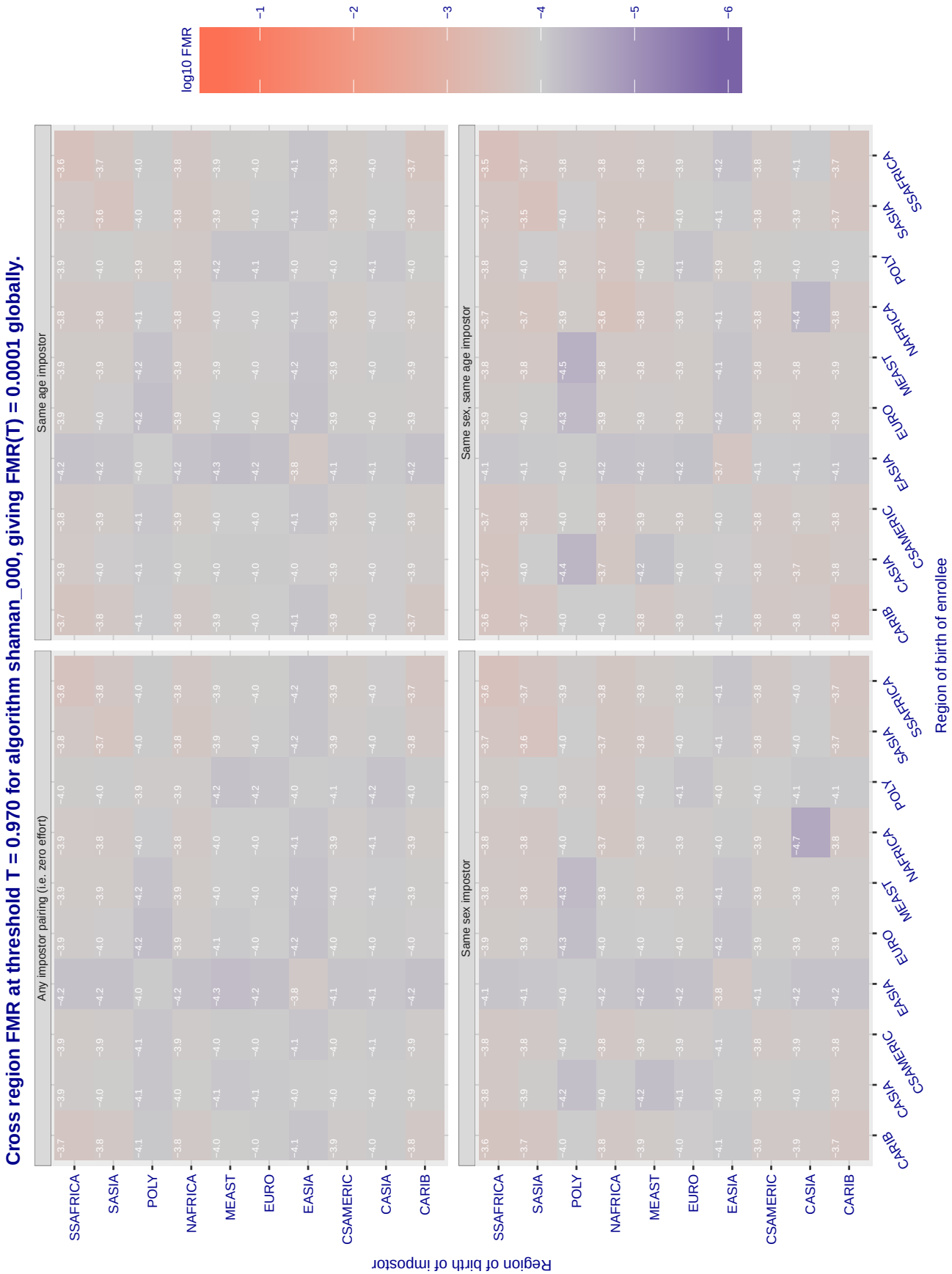


Figure 114: For algorithm shaman-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

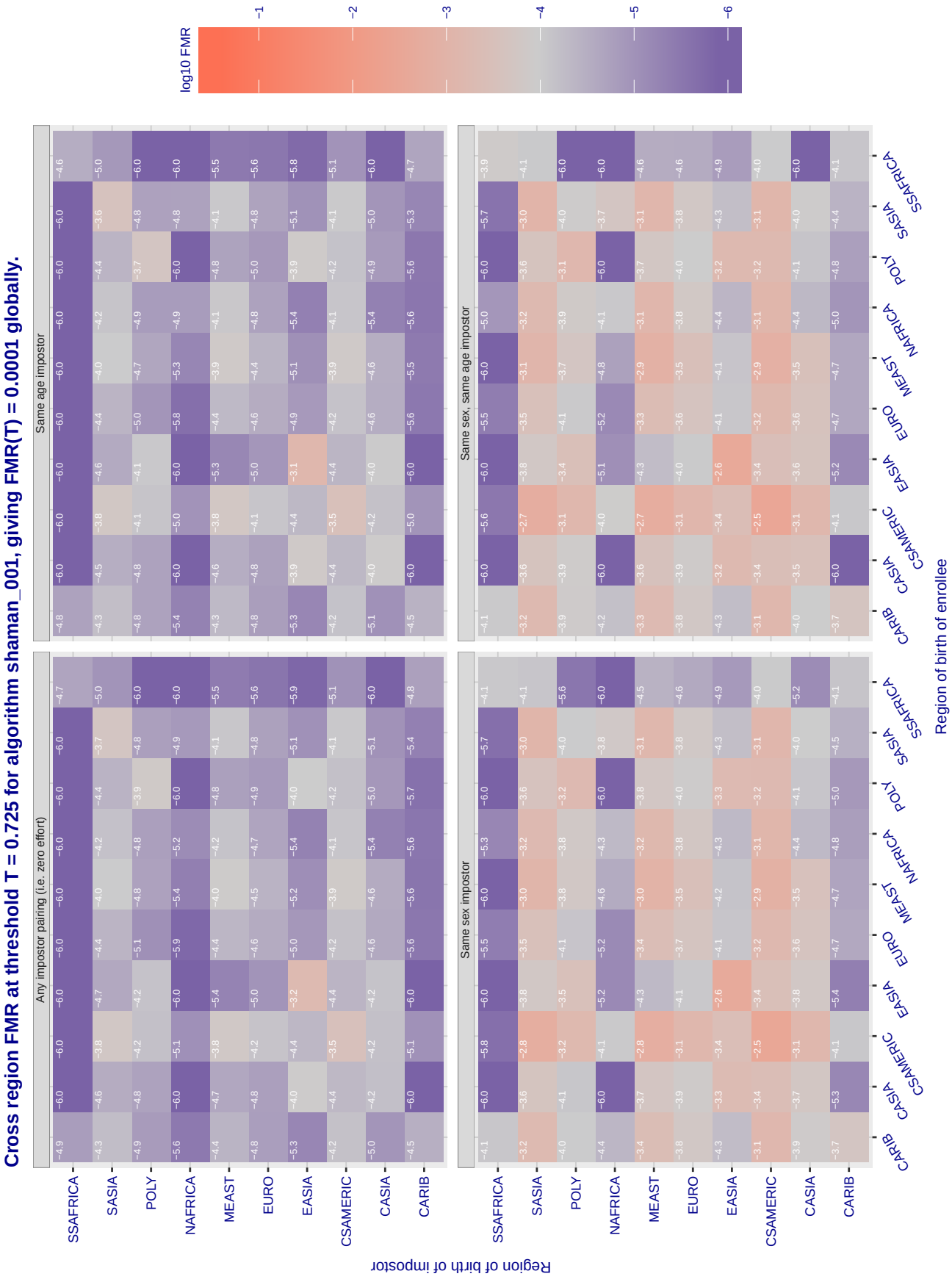


Figure 115: For algorithm shaman-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

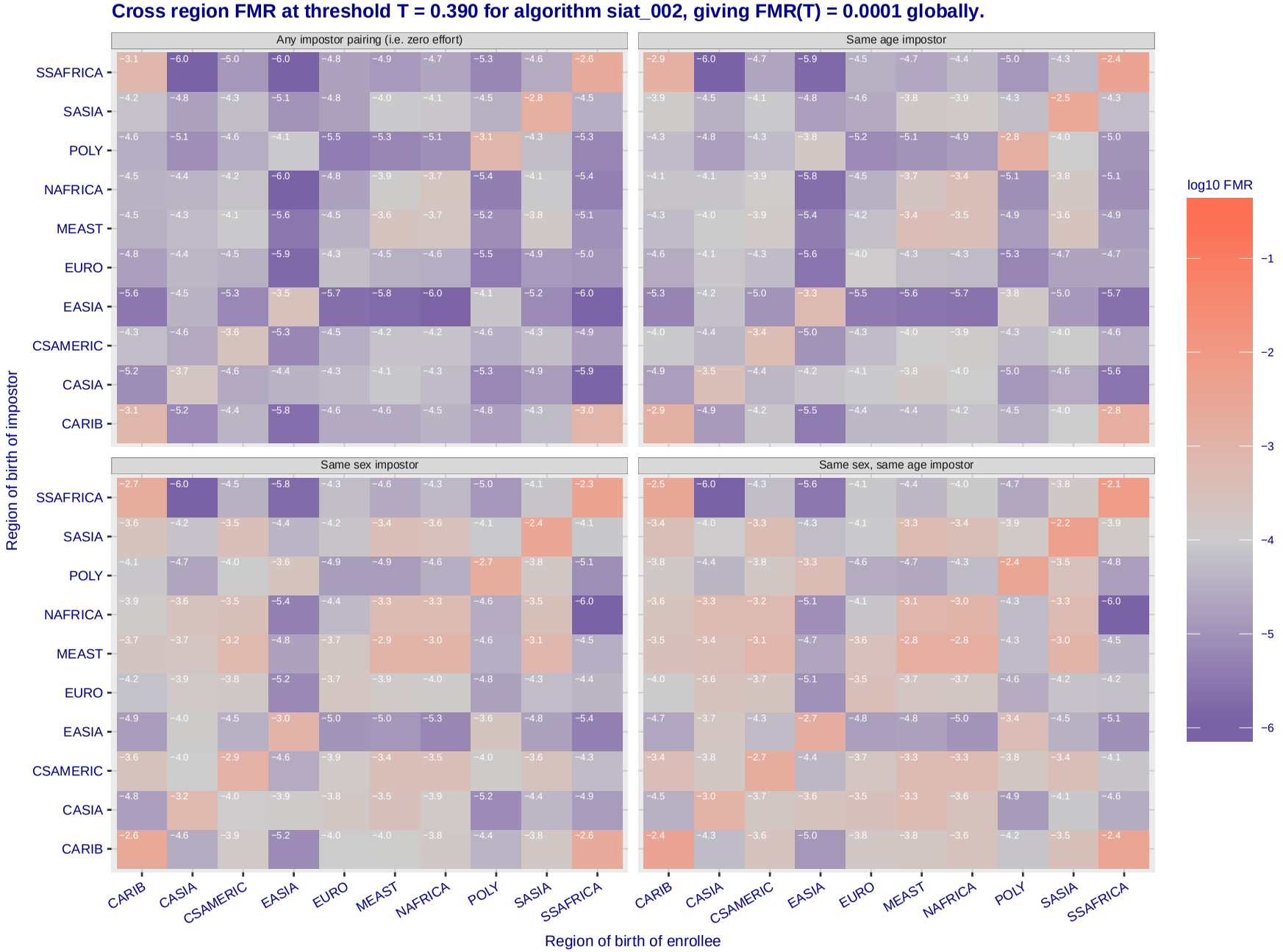


Figure 116: For algorithm siat-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

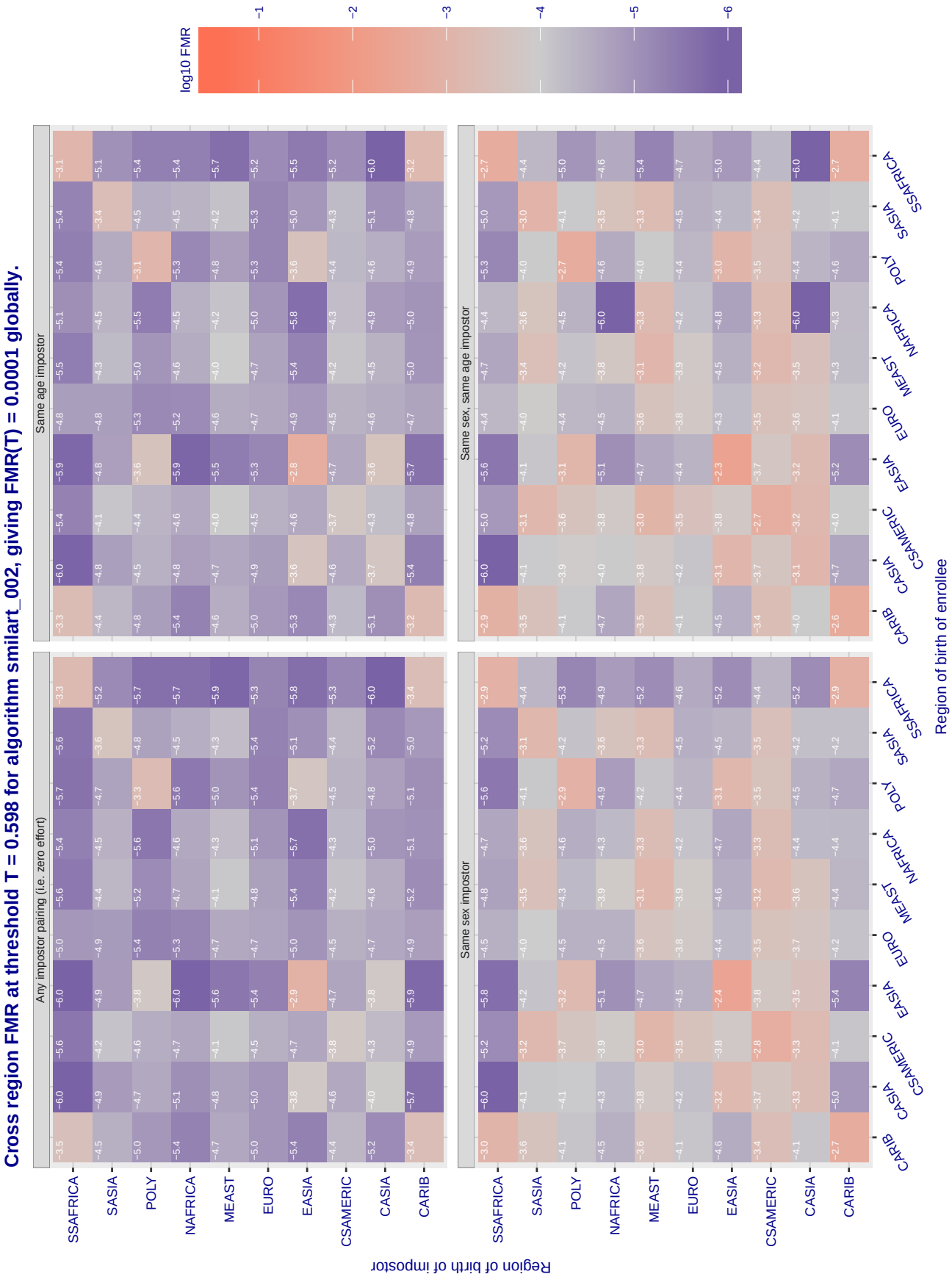


Figure 117: For algorithm smilart-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

Figure 118: For algorithm synesis-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

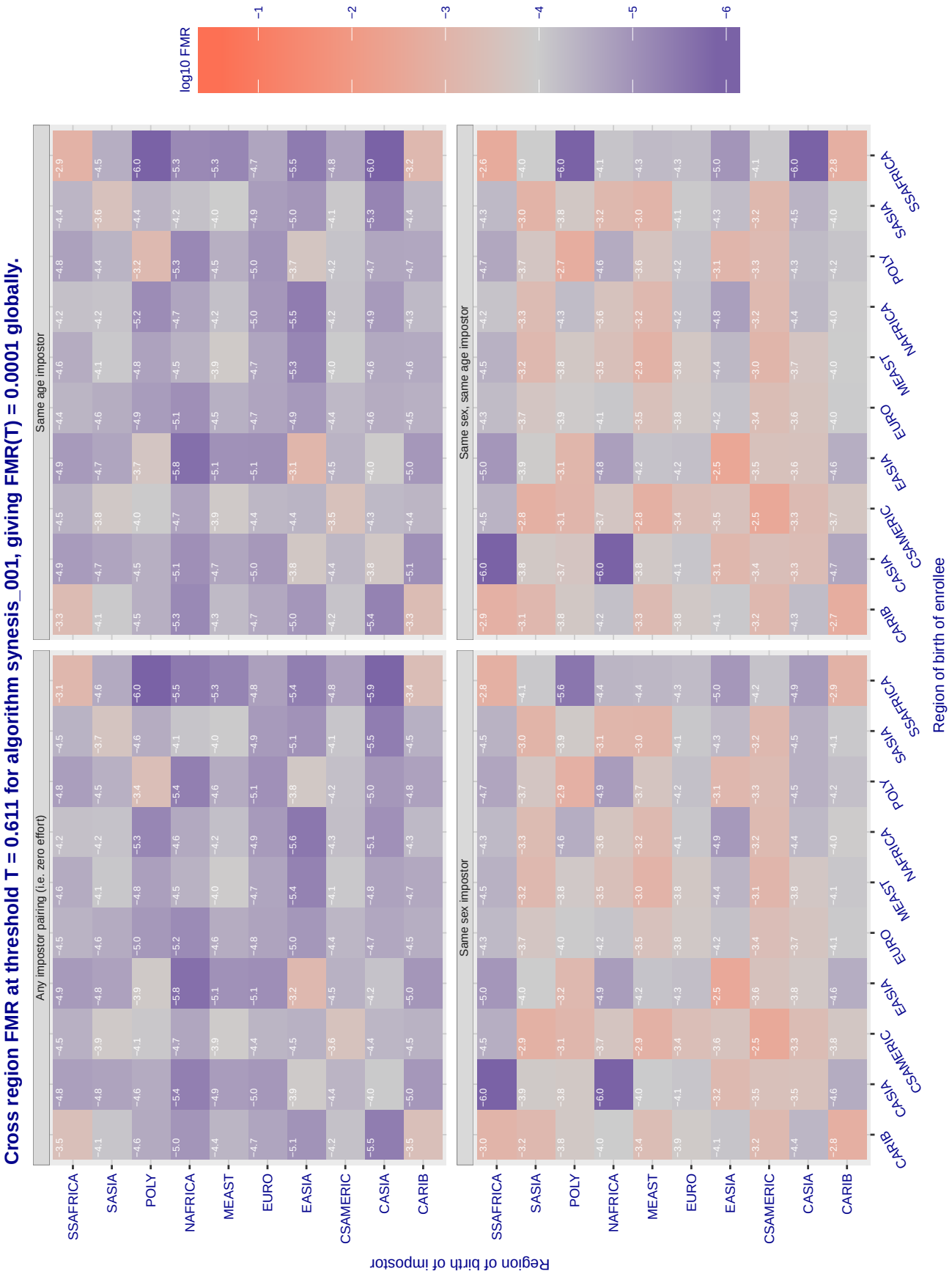


Figure 119: For algorithm synesis-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

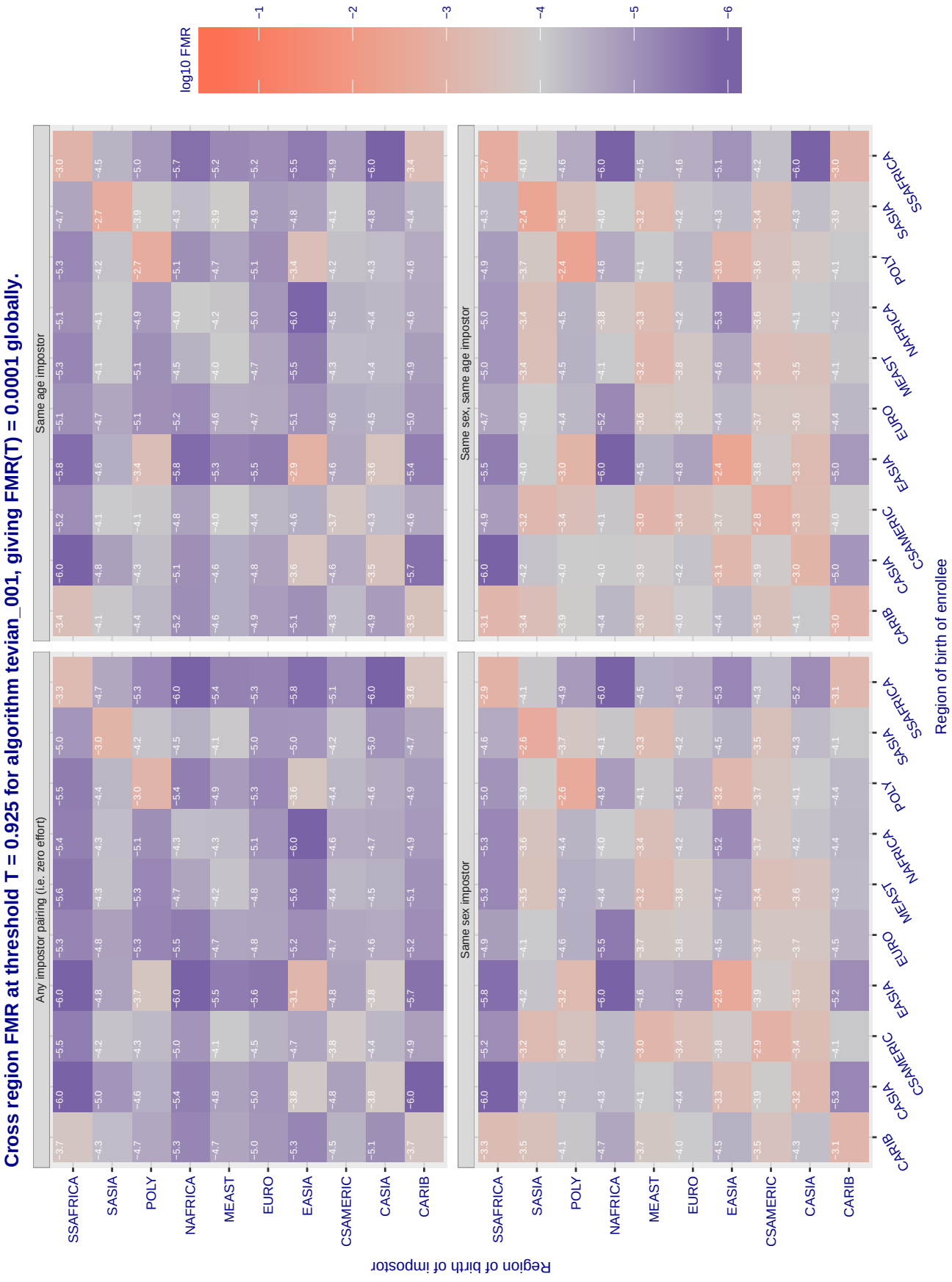


Figure 120: For algorithm tevian-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

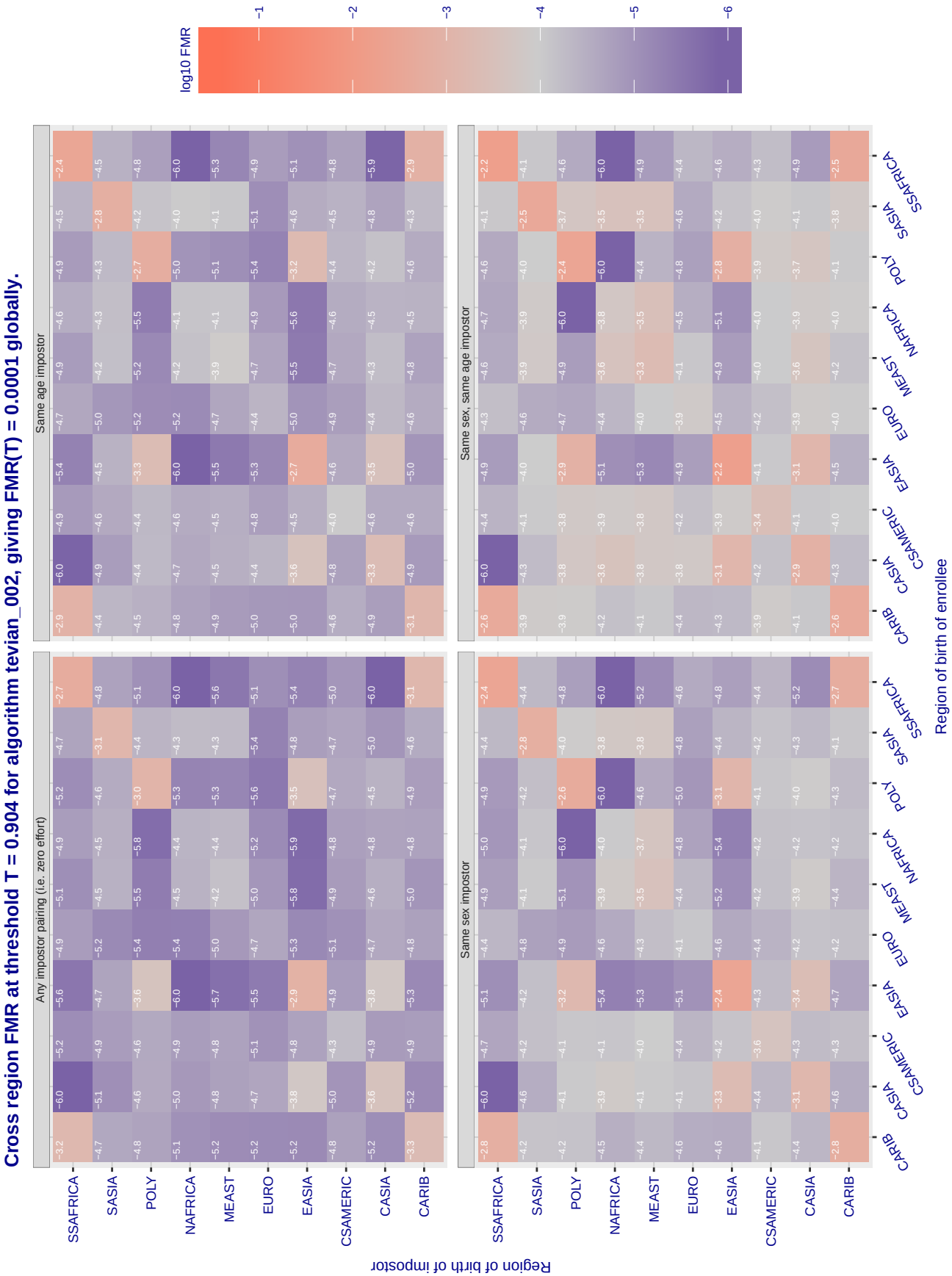


Figure 121: For algorithm tevian-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

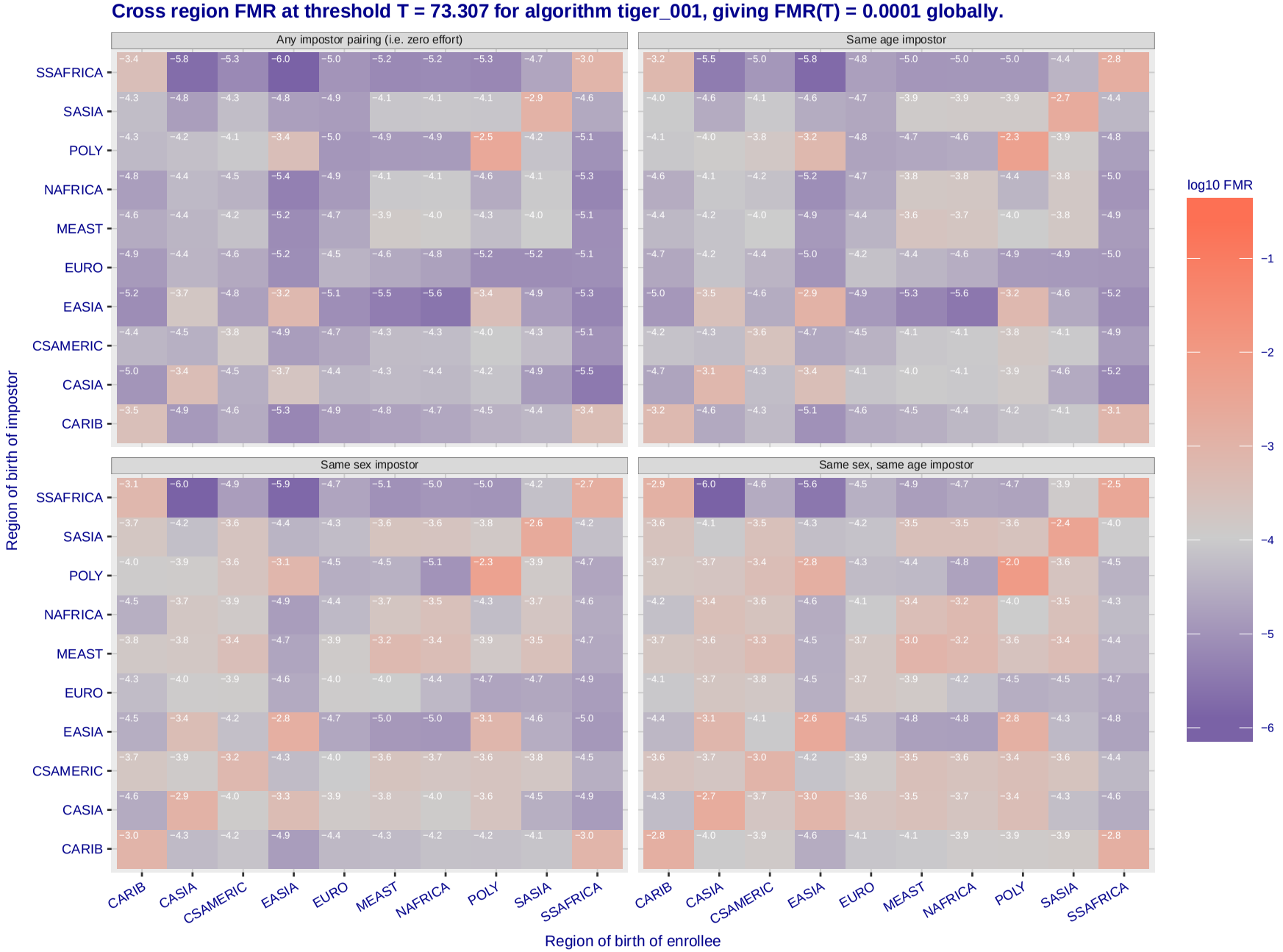


Figure 122: For algorithm tiger-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

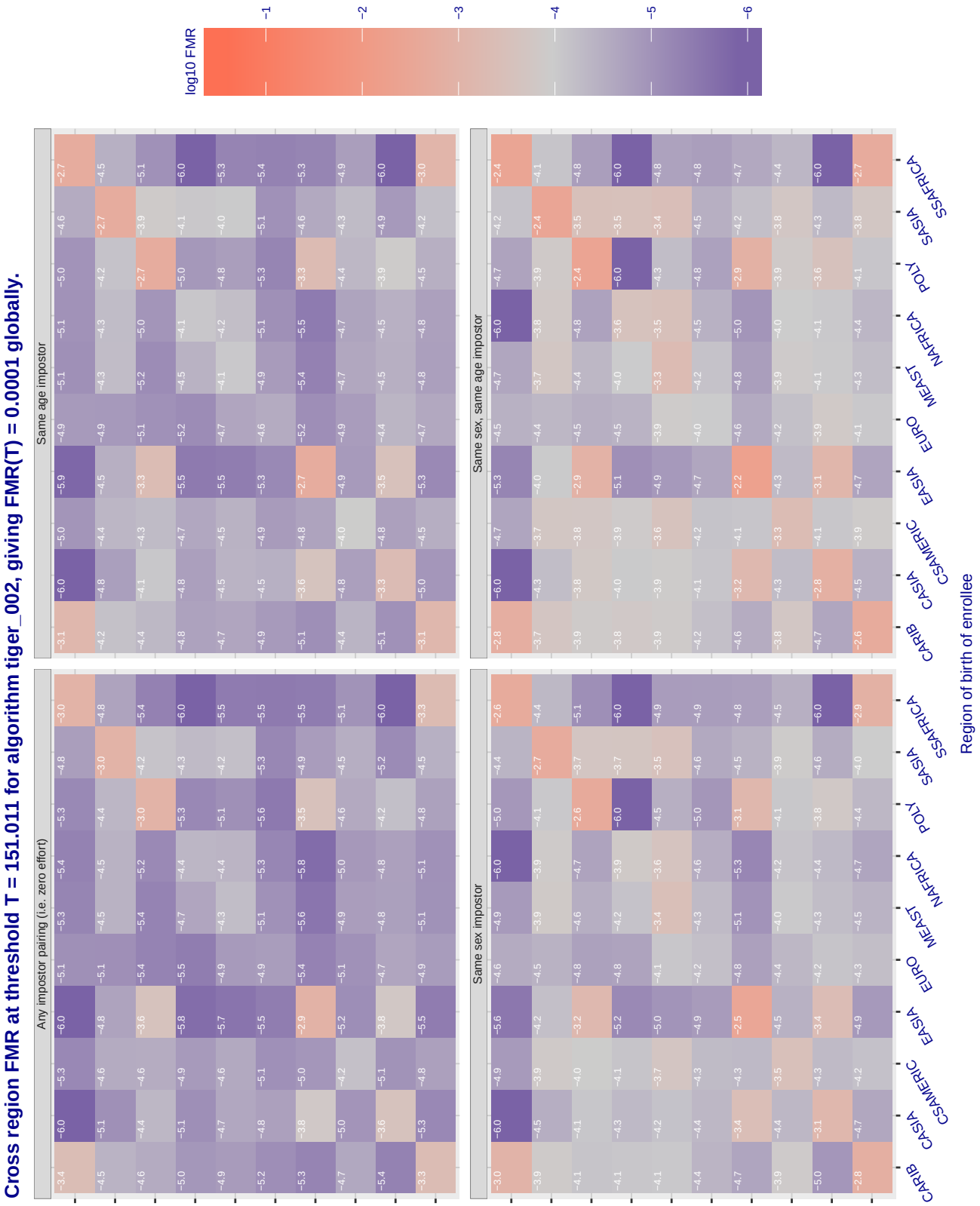


Figure 123: For algorithm tiger-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

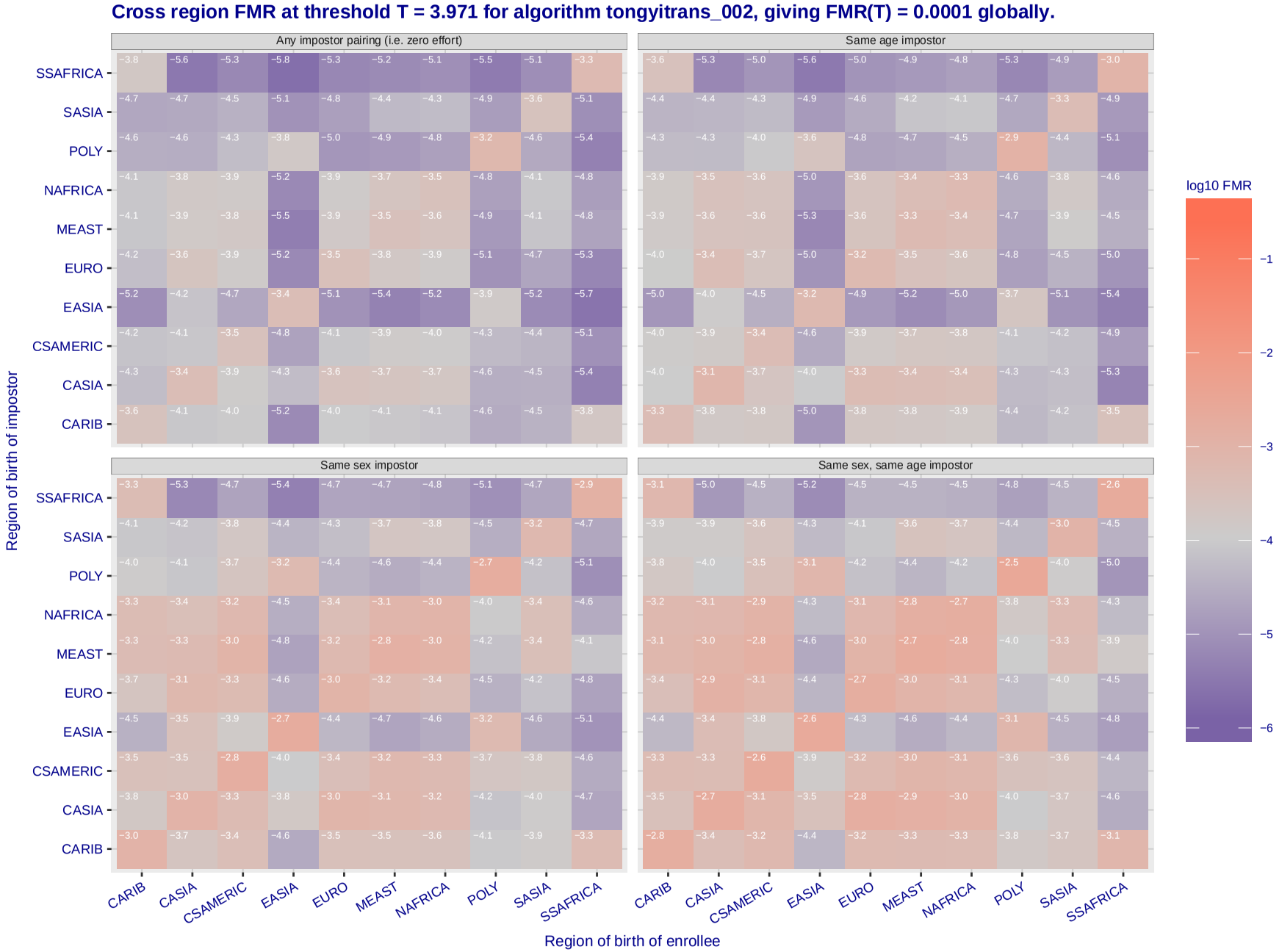


Figure 124: For algorithm tongyitrans-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

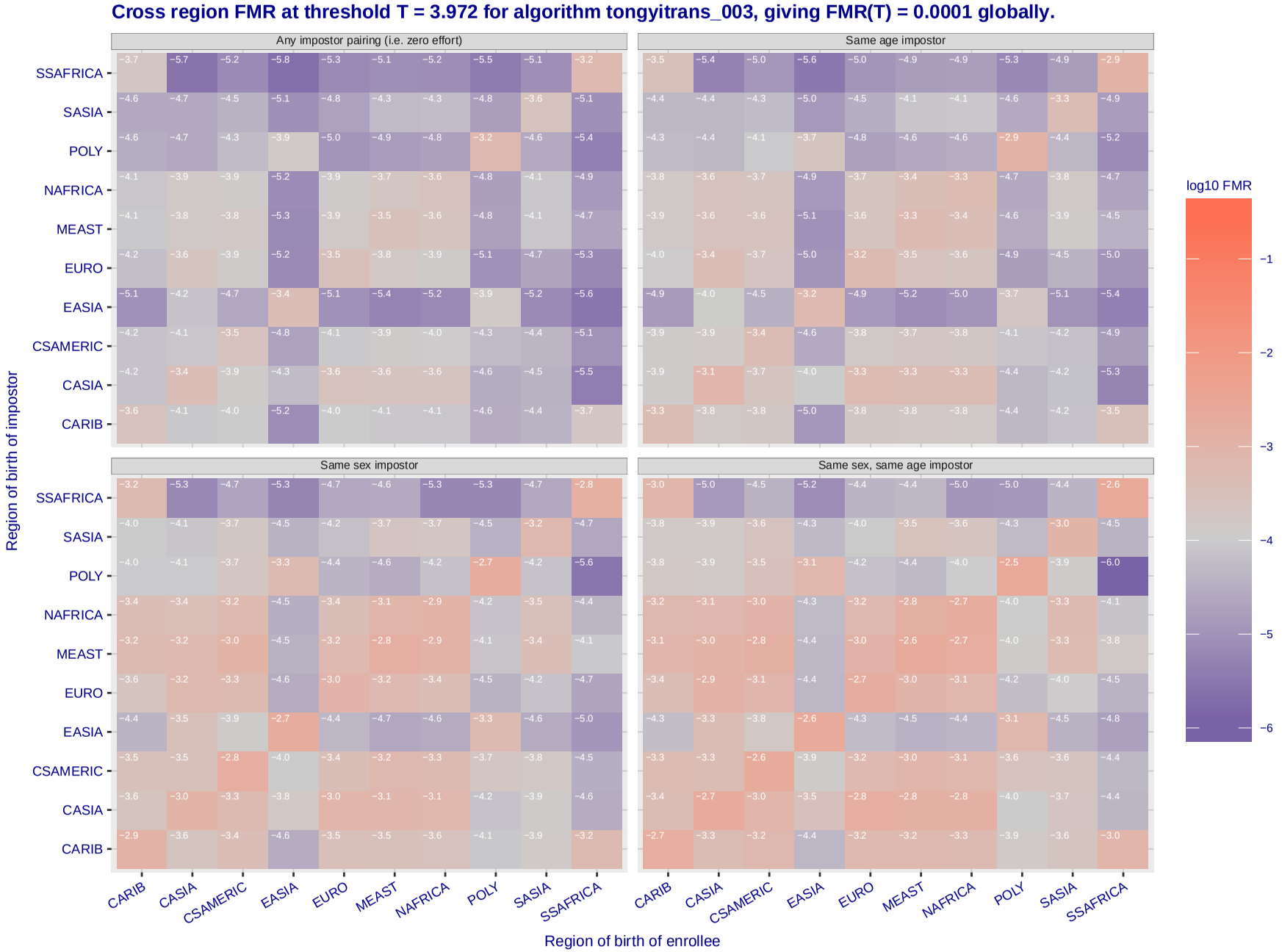


Figure 125: For algorithm tongyitrans-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

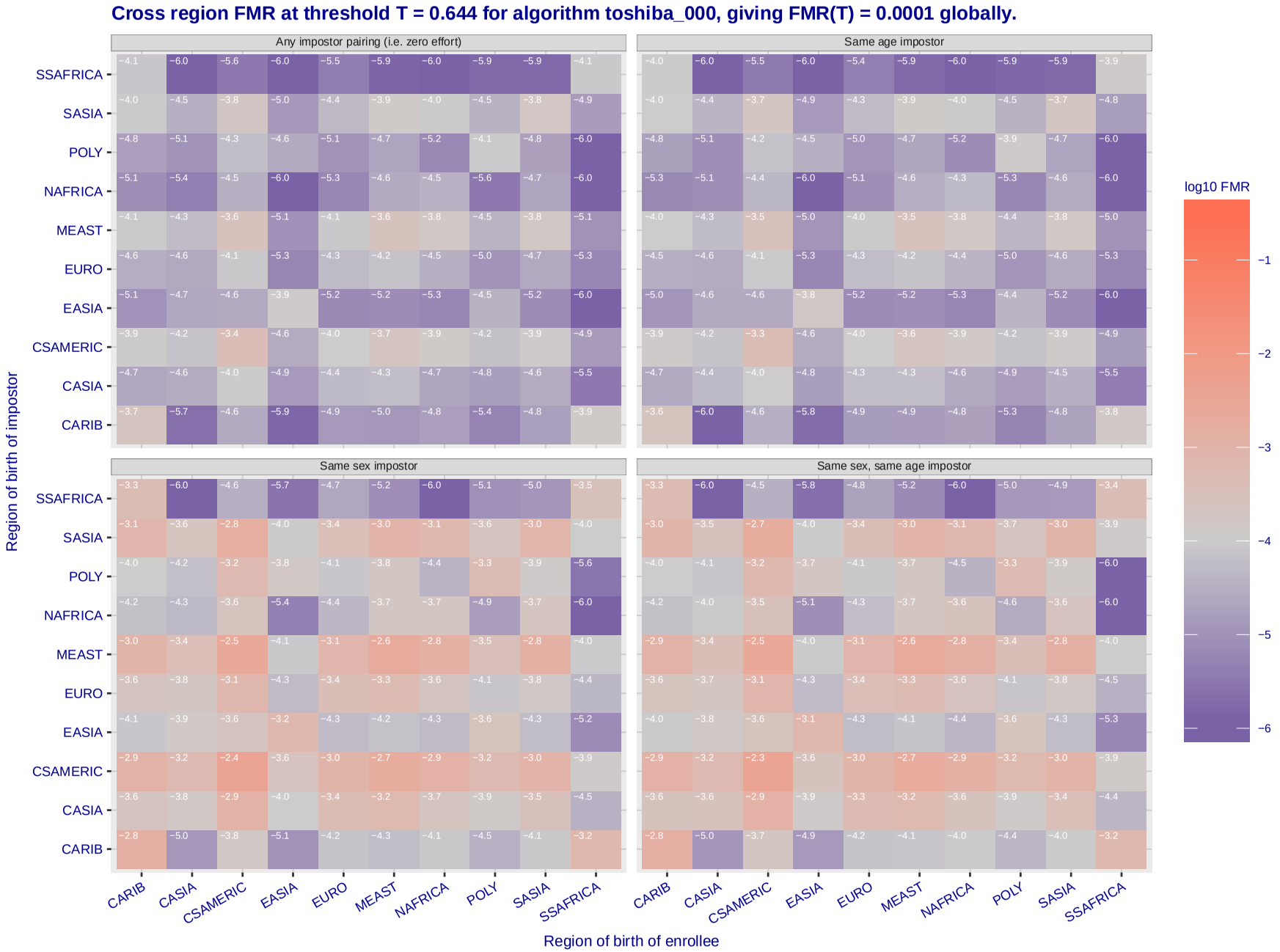


Figure 126: For algorithm toshiba-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

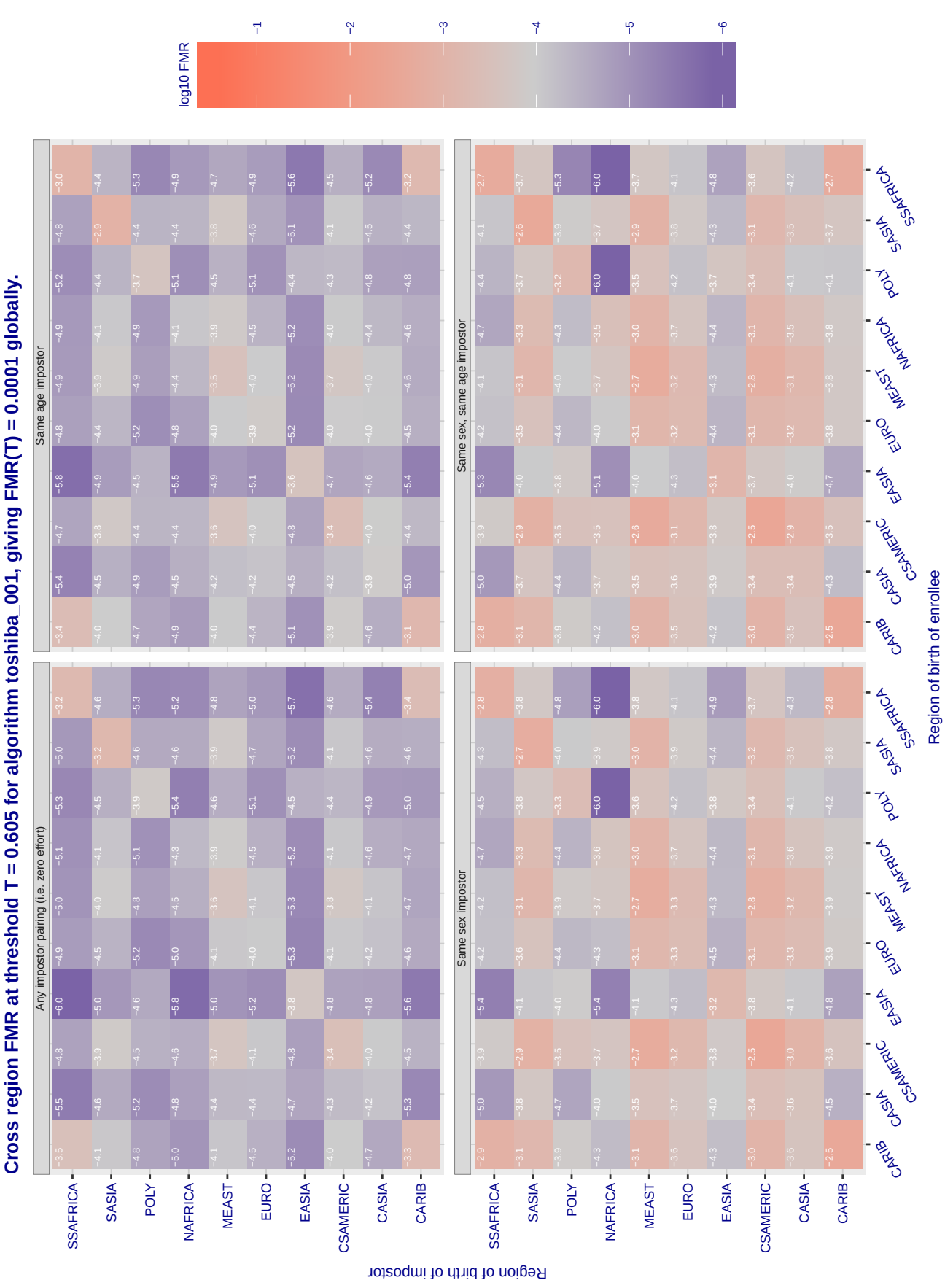


Figure 127: For algorithm toshiba-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

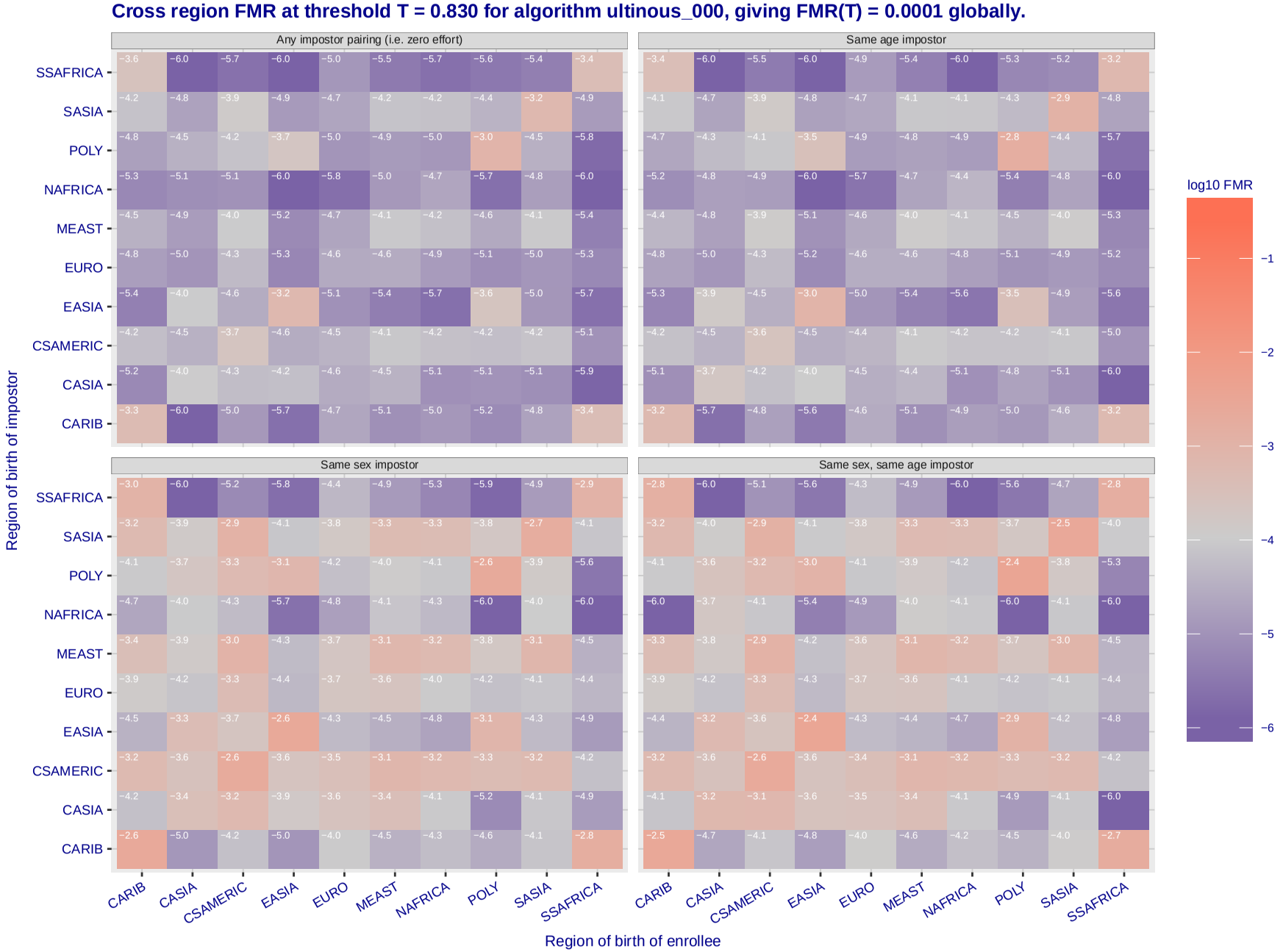


Figure 128: For algorithm ultinous-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

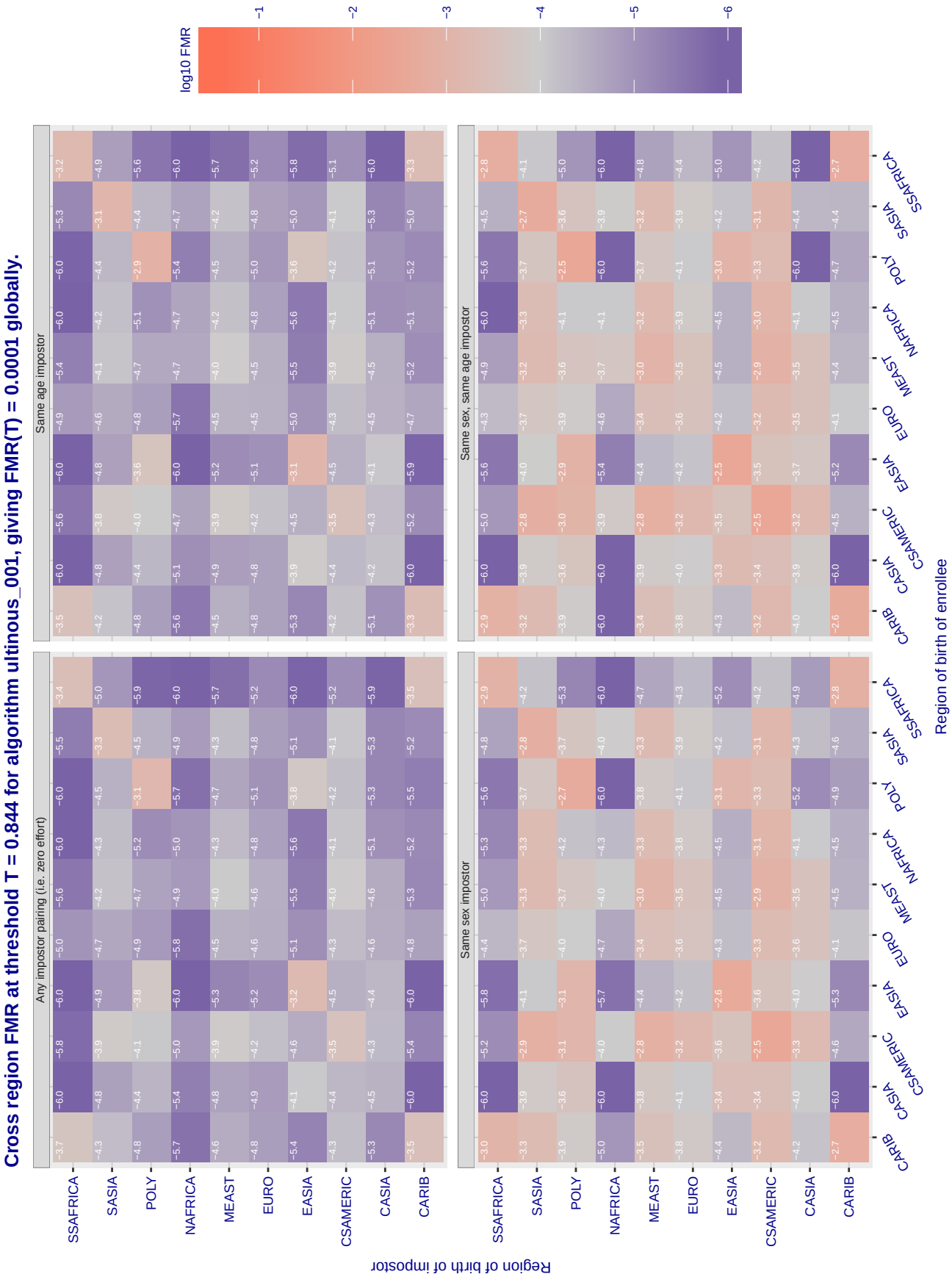


Figure 129: For algorithm ultinous-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

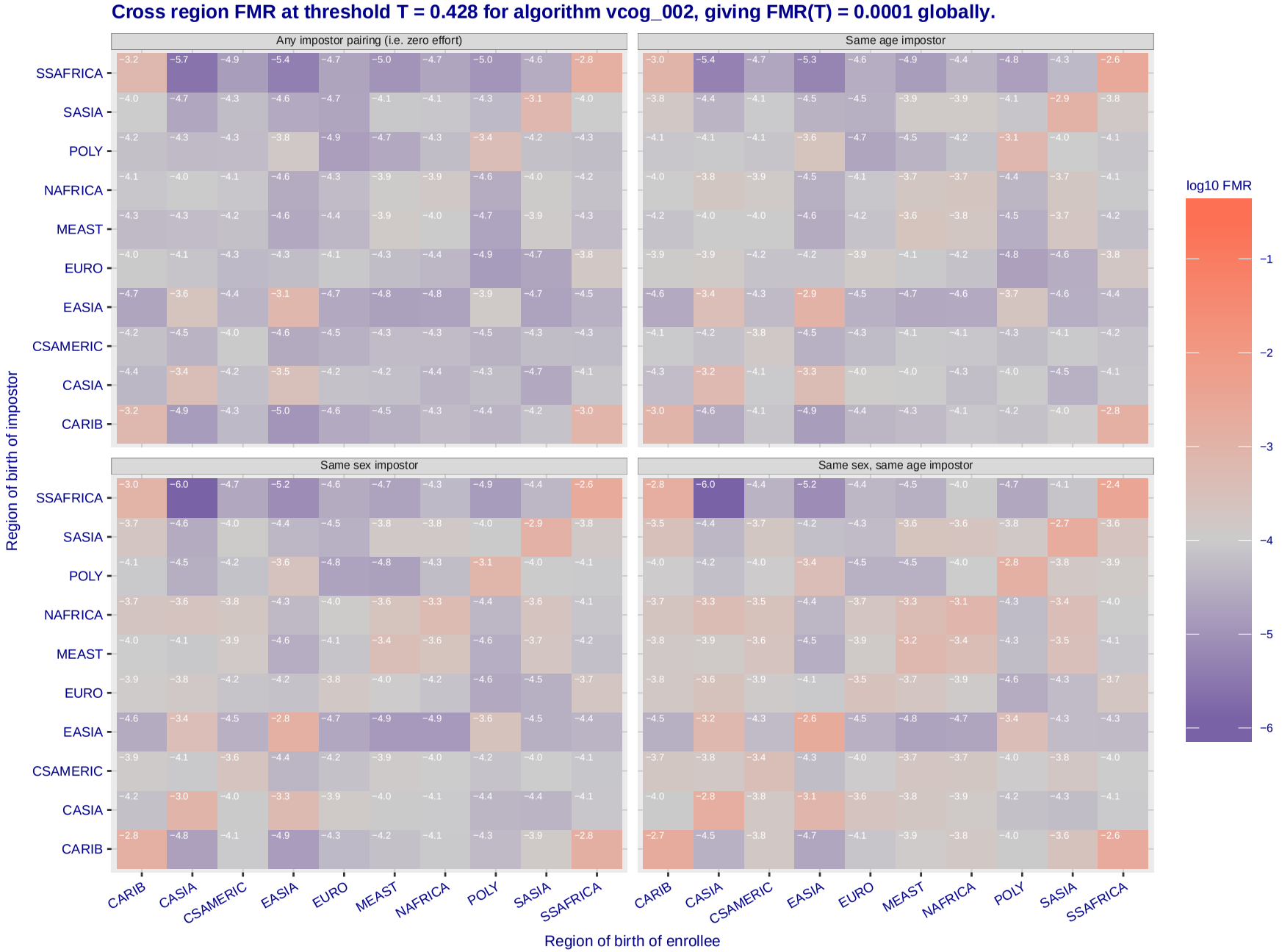


Figure 130: For algorithm vcog-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

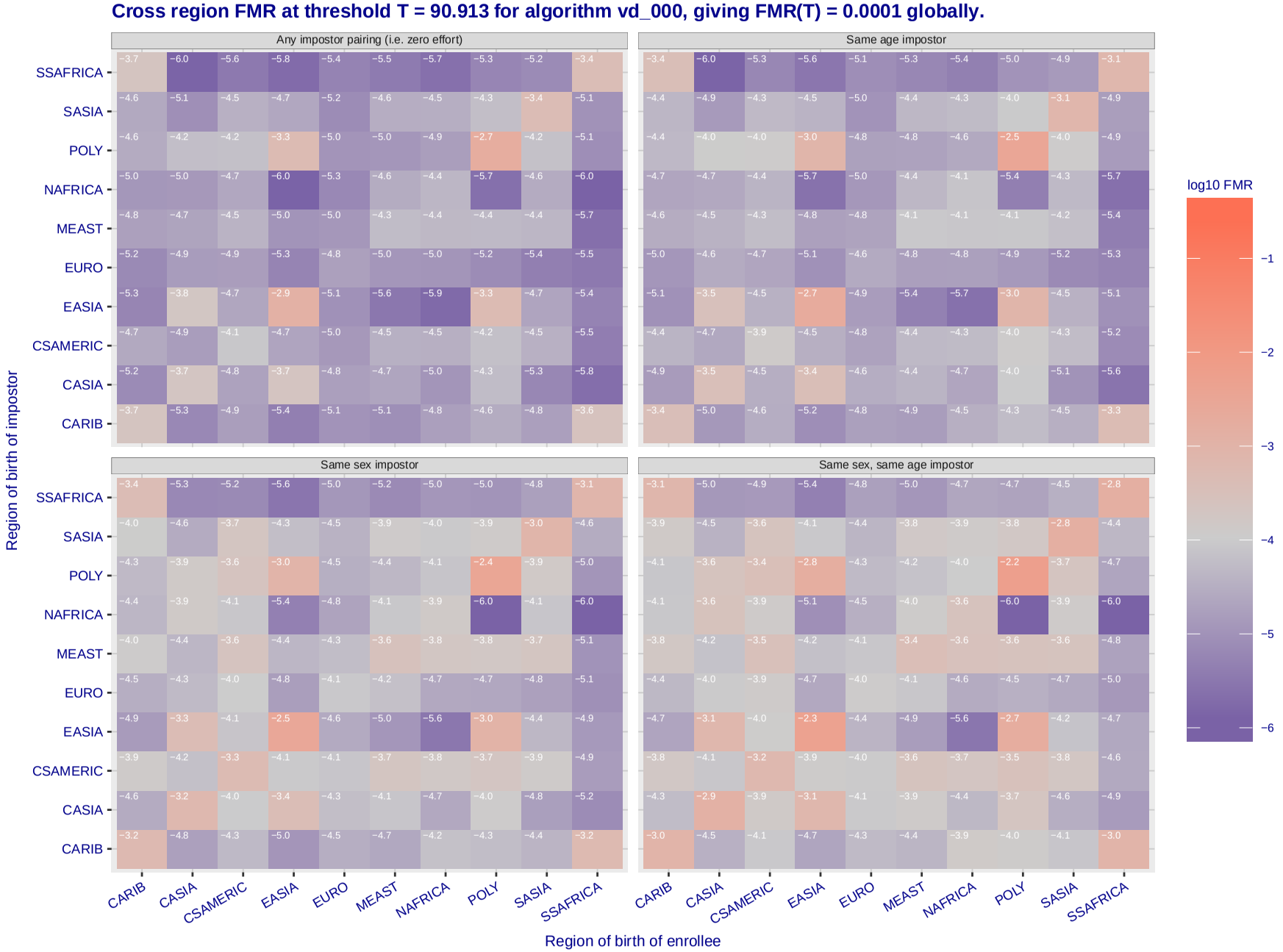


Figure 131: For algorithm vd-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

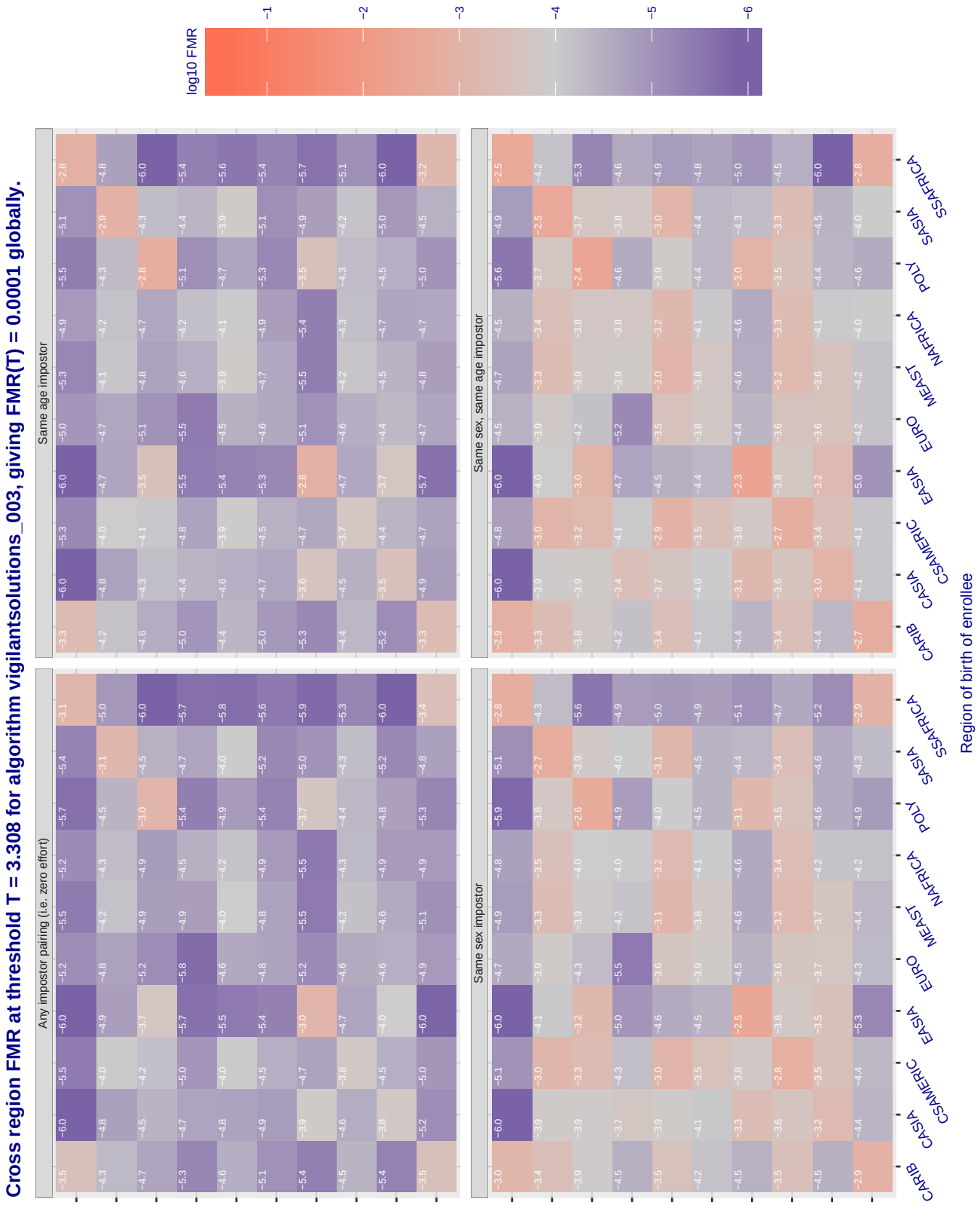


Figure 132: For algorithm vigilantsolutions-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

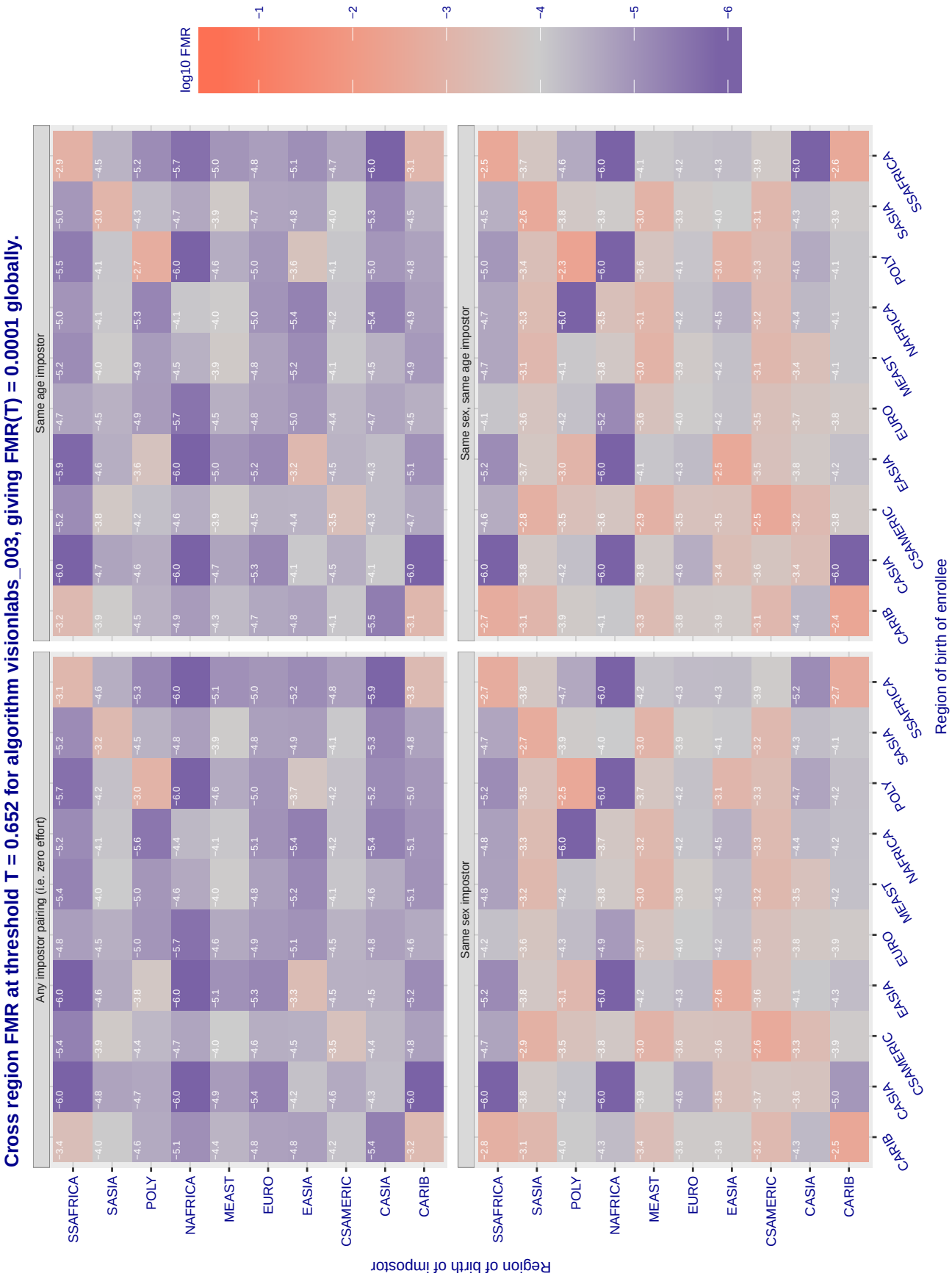


Figure 133: For algorithm visionlabs-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

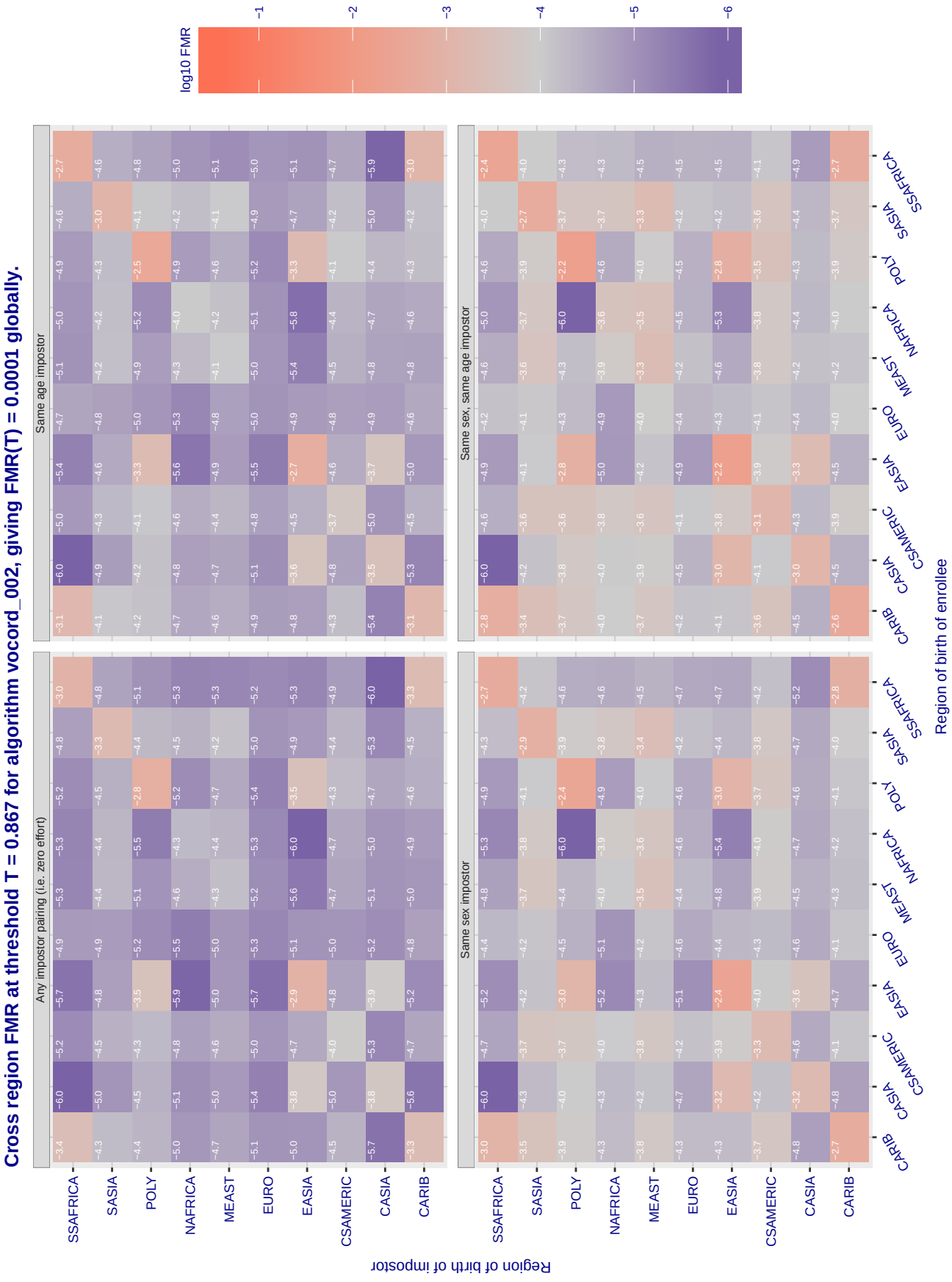


Figure 134: For algorithm vocord-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

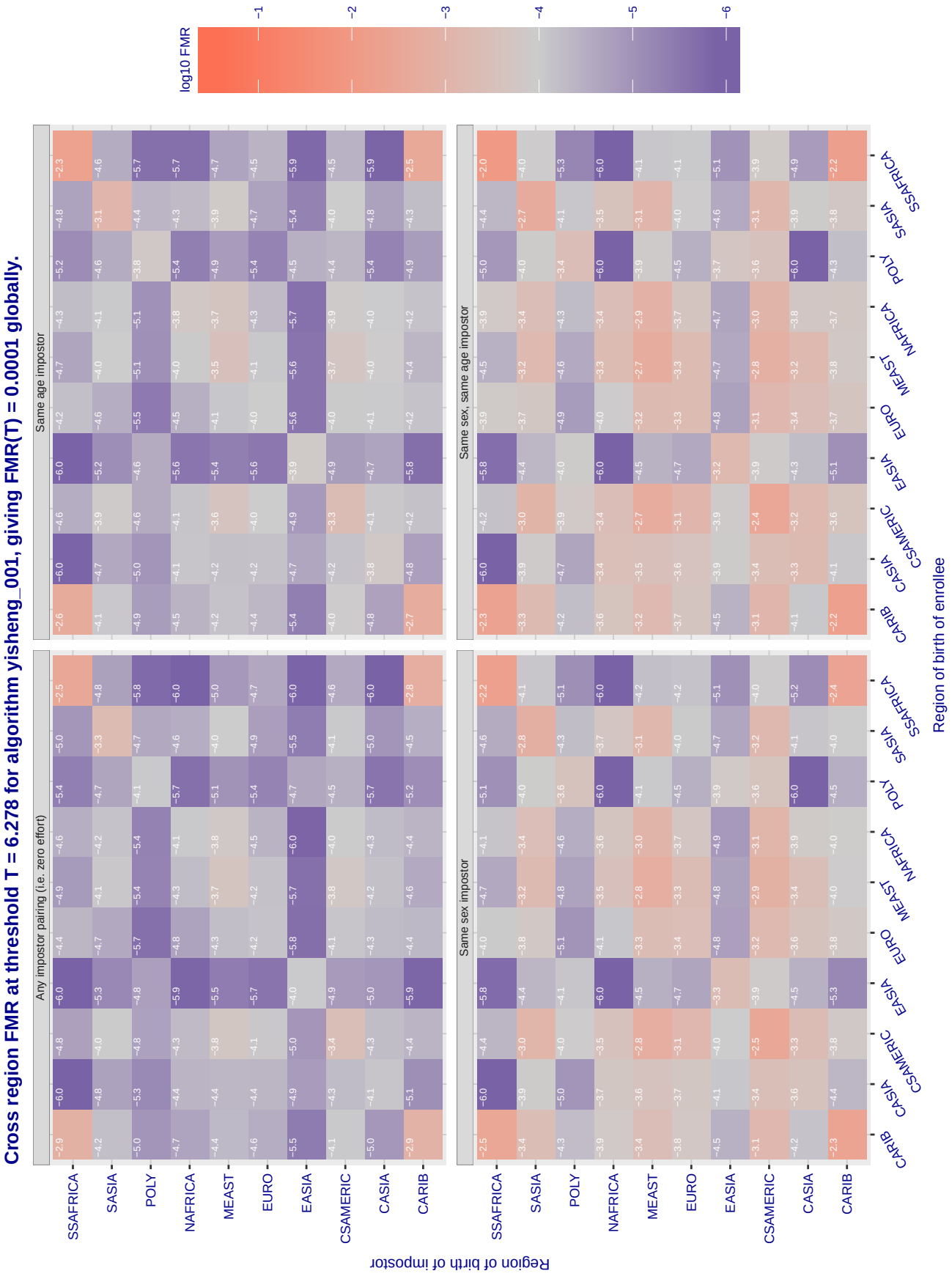


Figure 135: For algorithm yisheng-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

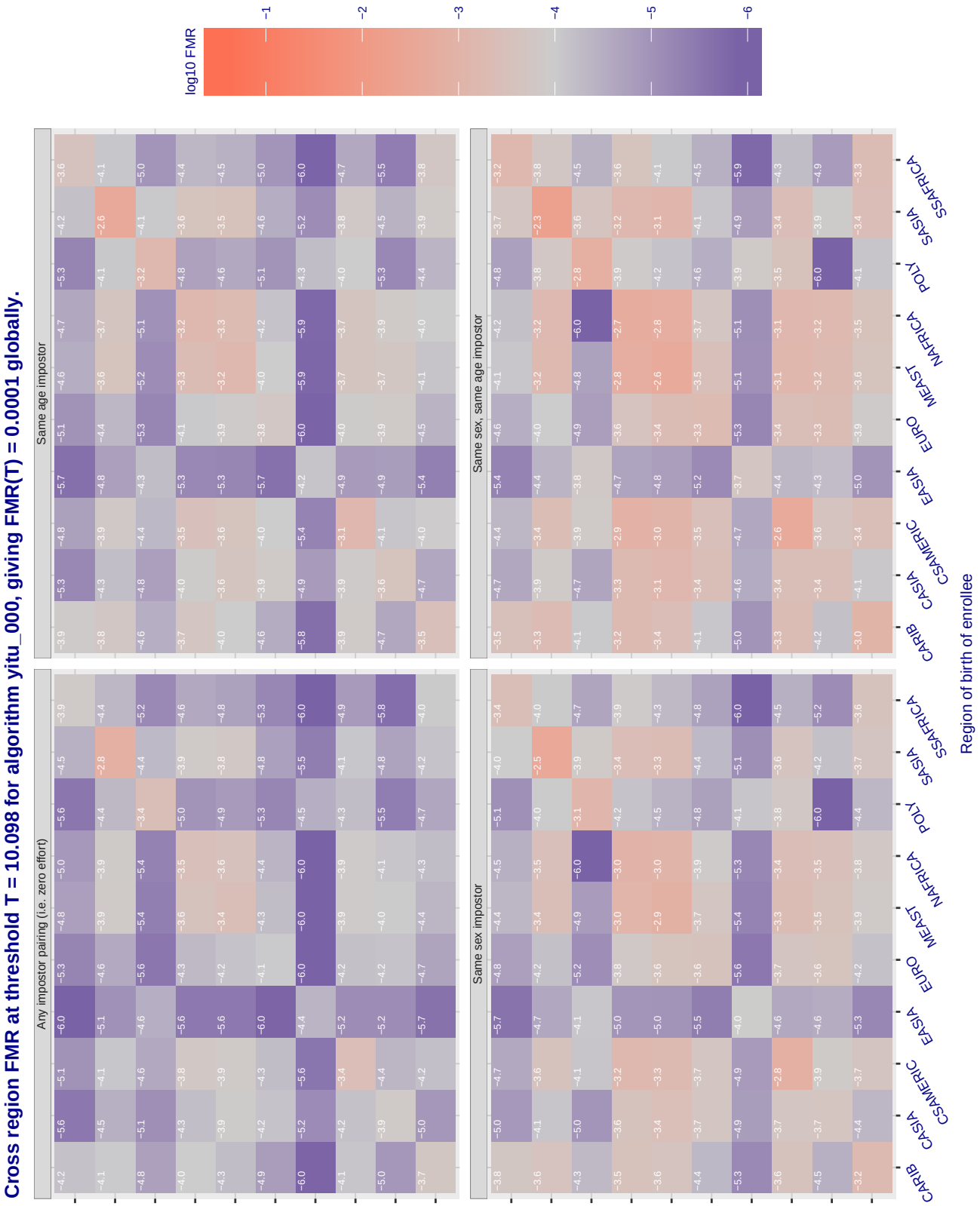


Figure 136: For algorithm yitu-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

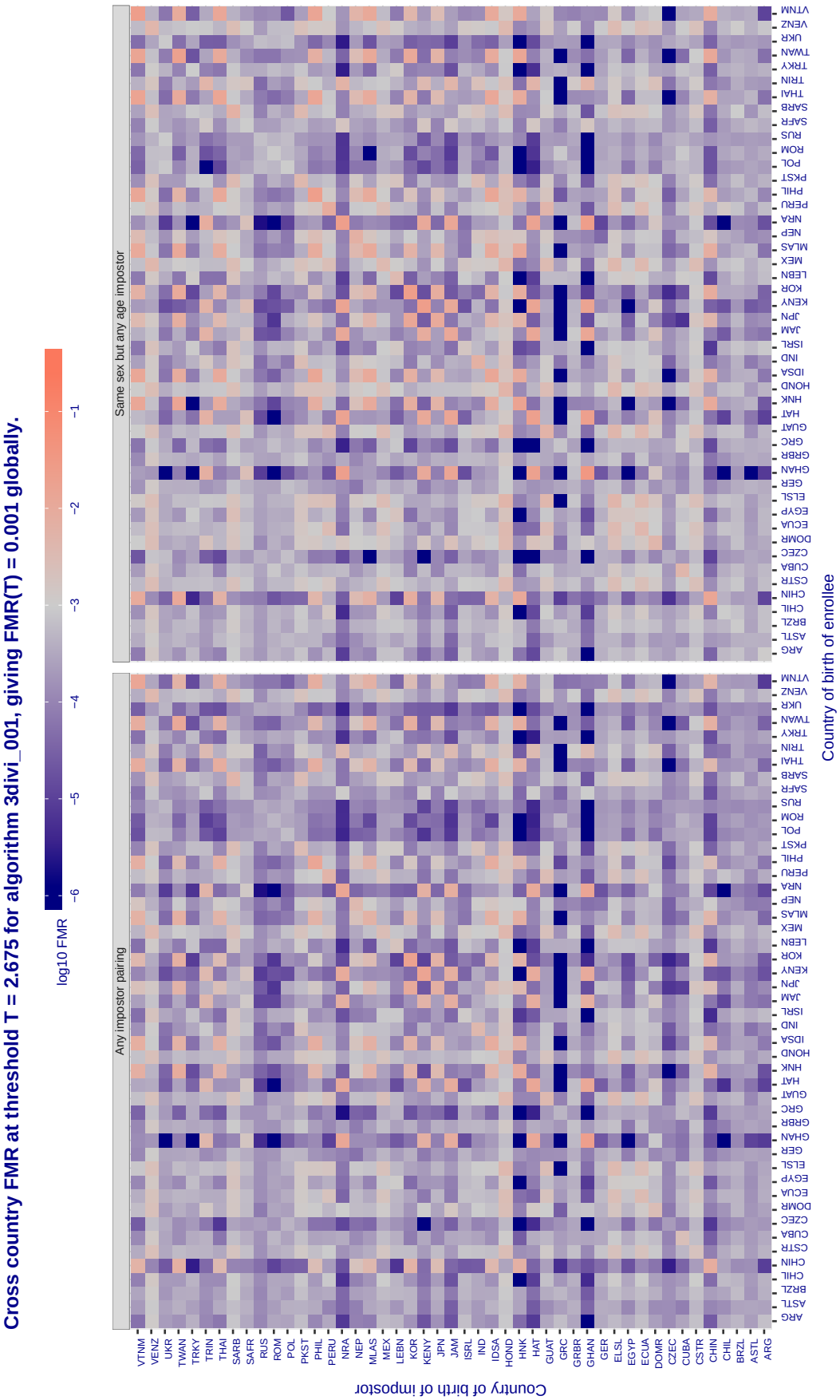


Figure 137: For algorithm 3divi-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

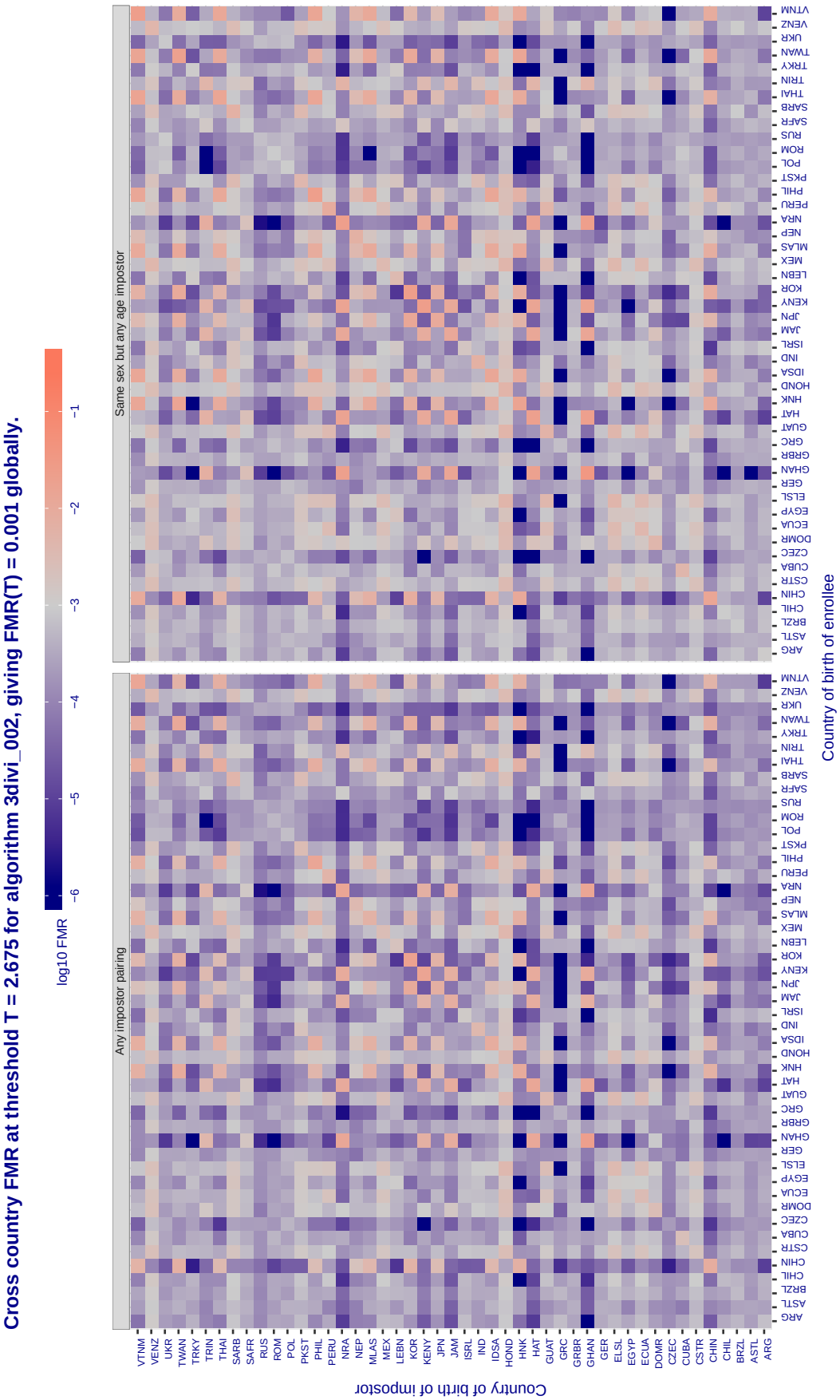


Figure 138: For algorithm 3divi-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

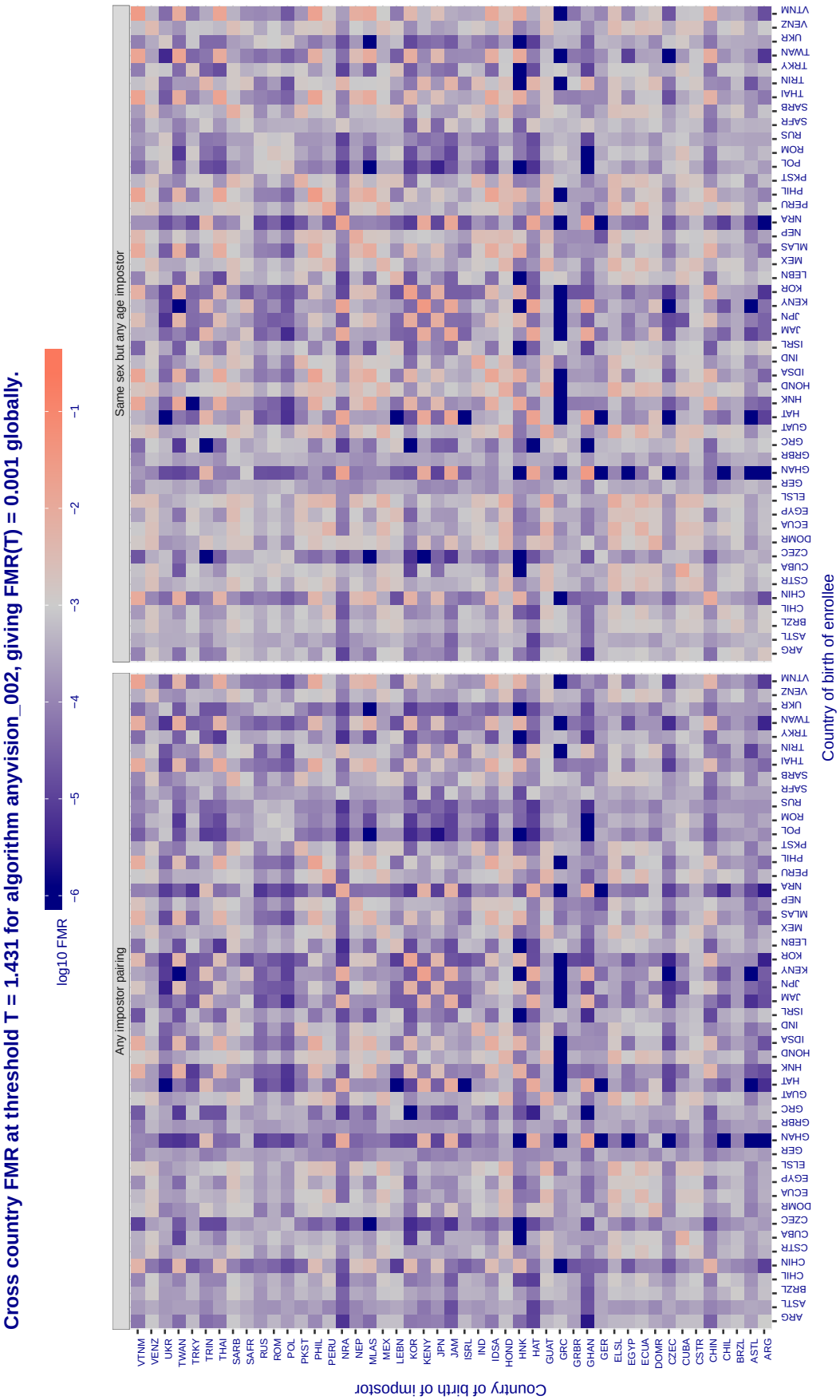


Figure 139: For algorithm anyvision-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

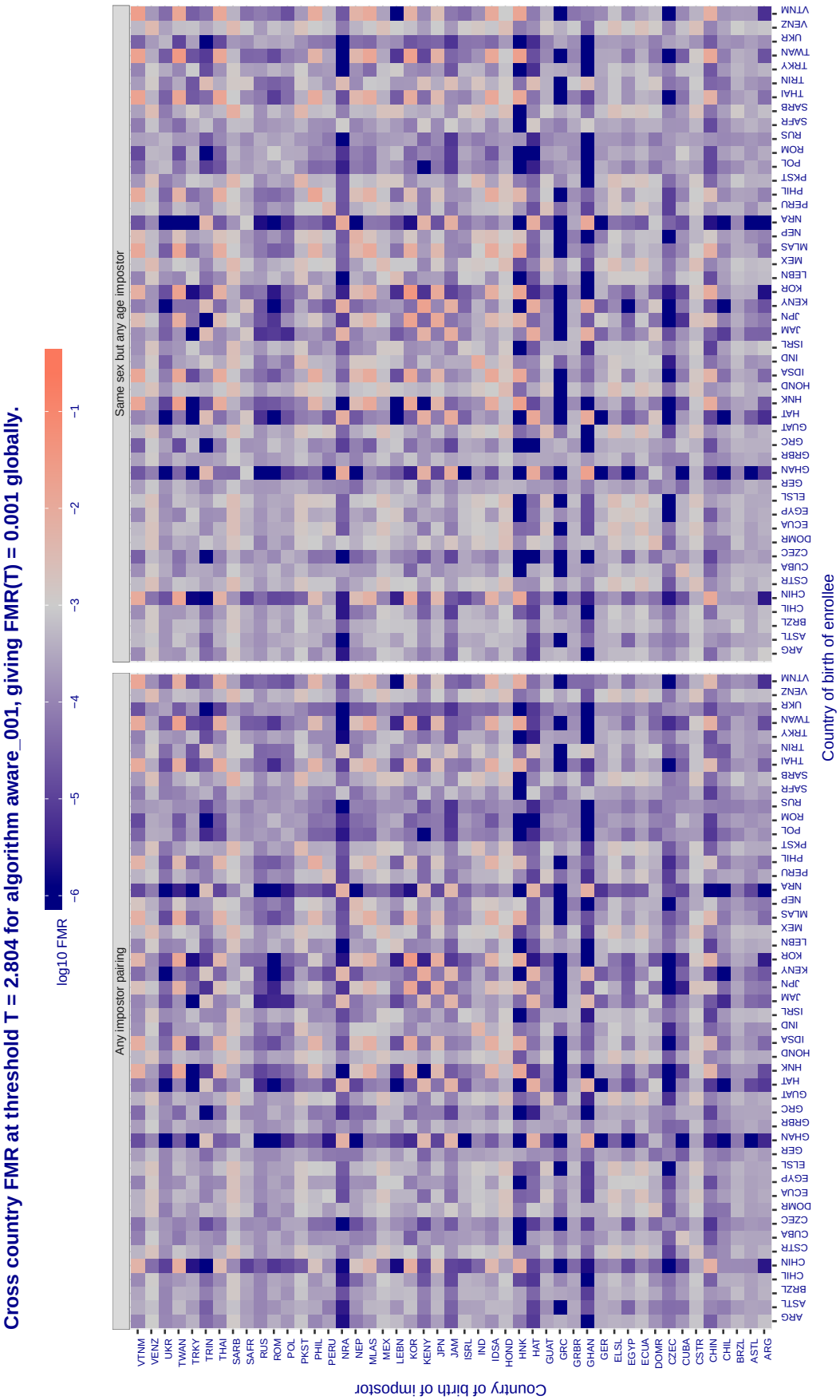


Figure 140: For algorithm aware-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

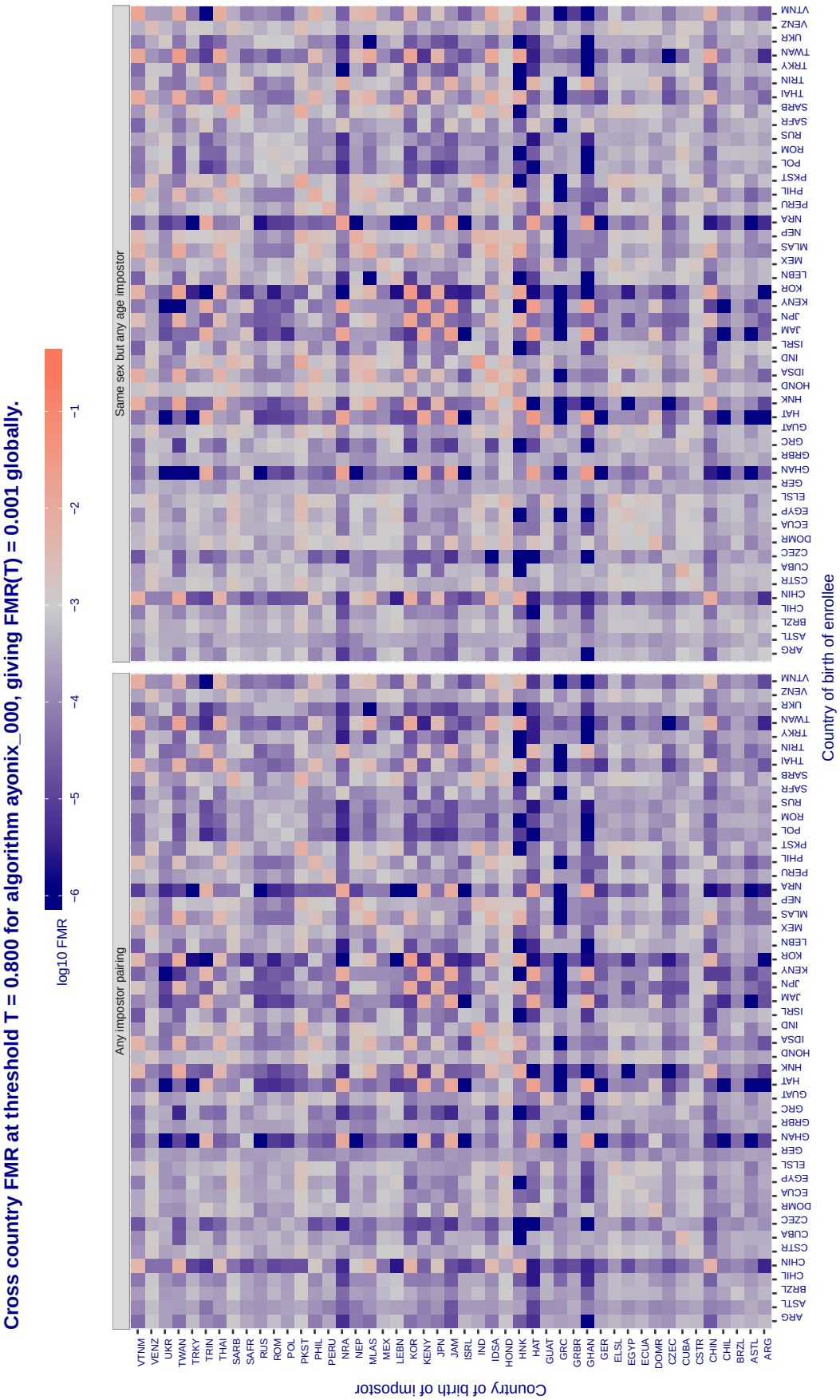


Figure 141: For algorithm ayonix-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

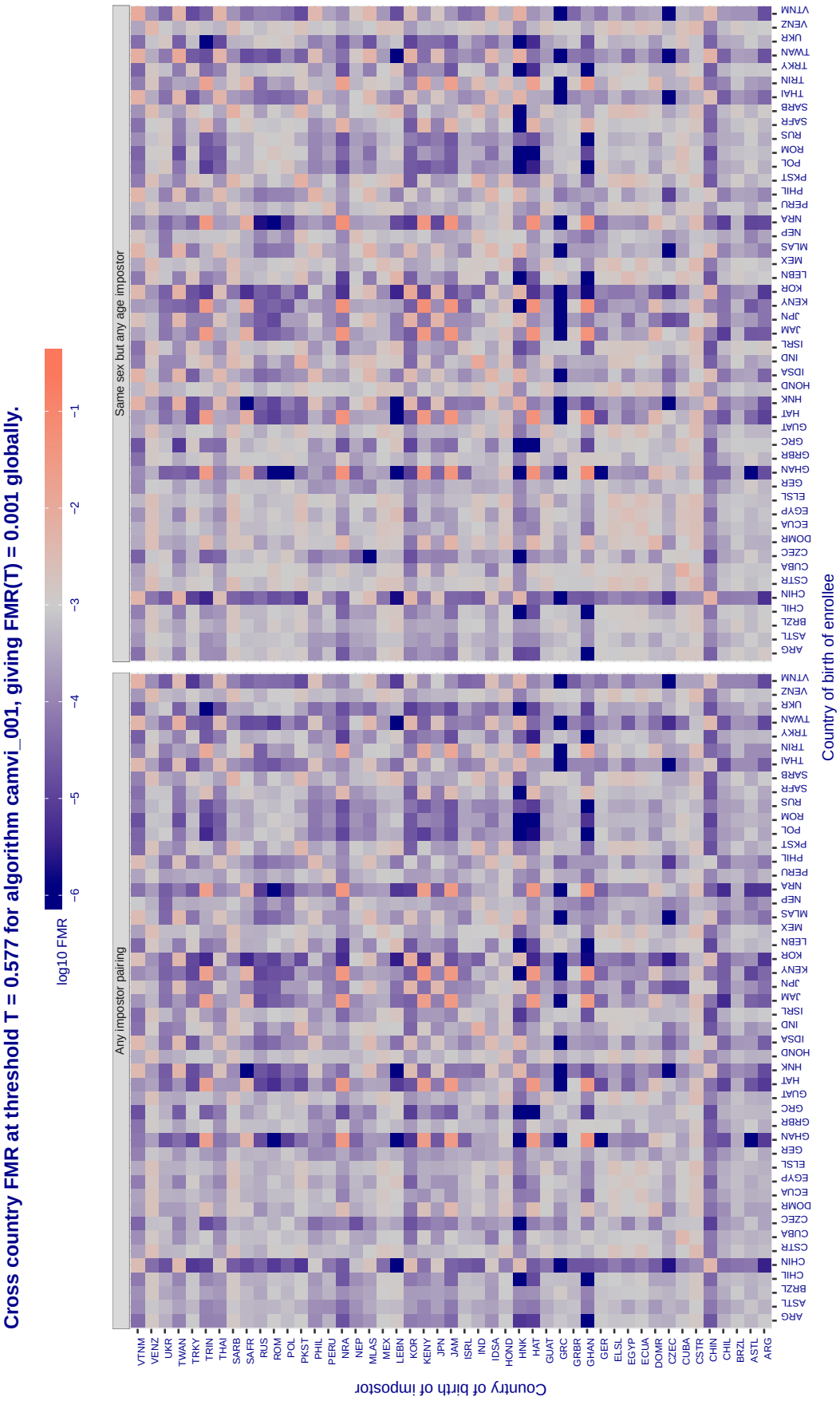


Figure 142: For algorithm camvi-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

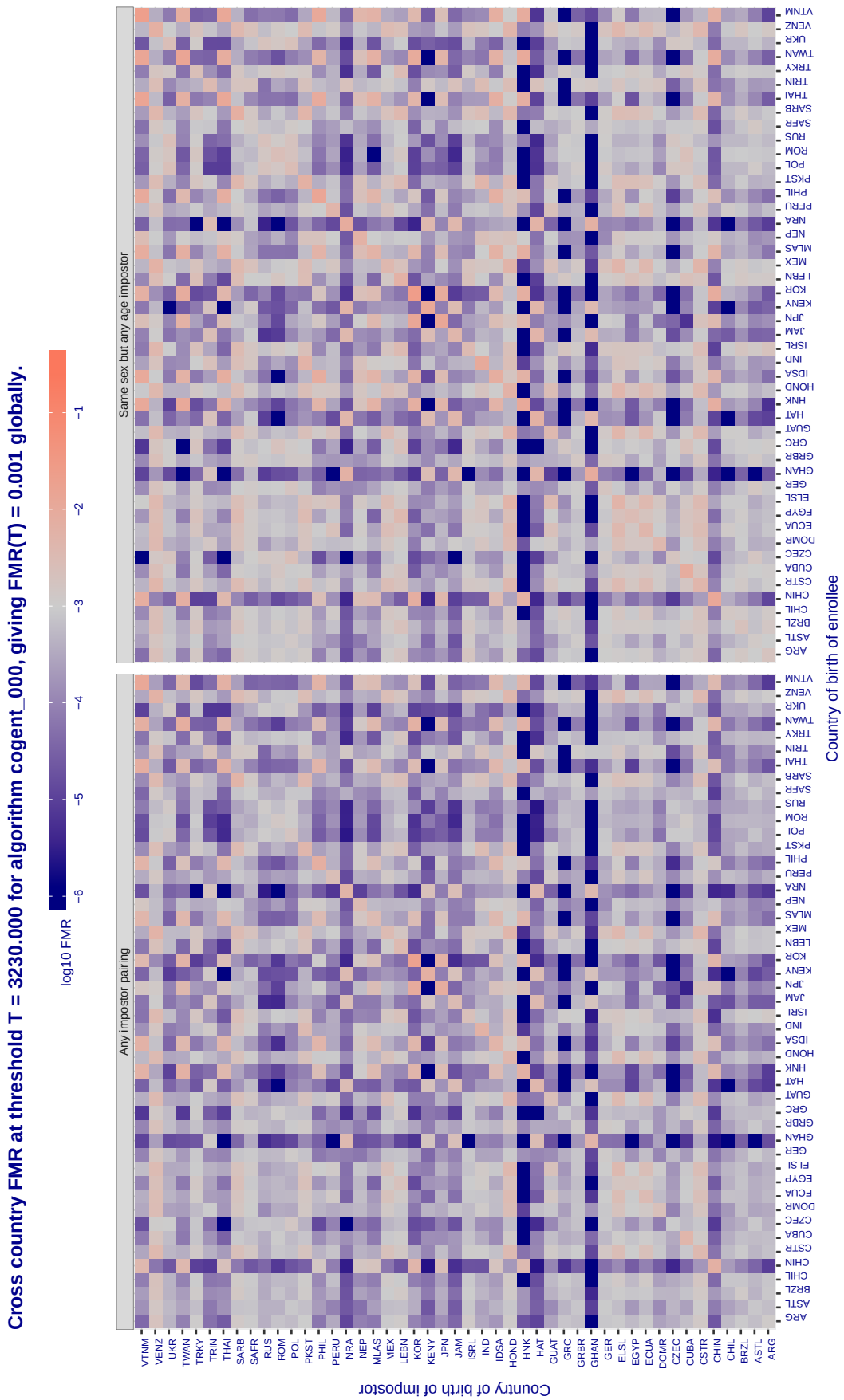


Figure 143: For algorithm cogent-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

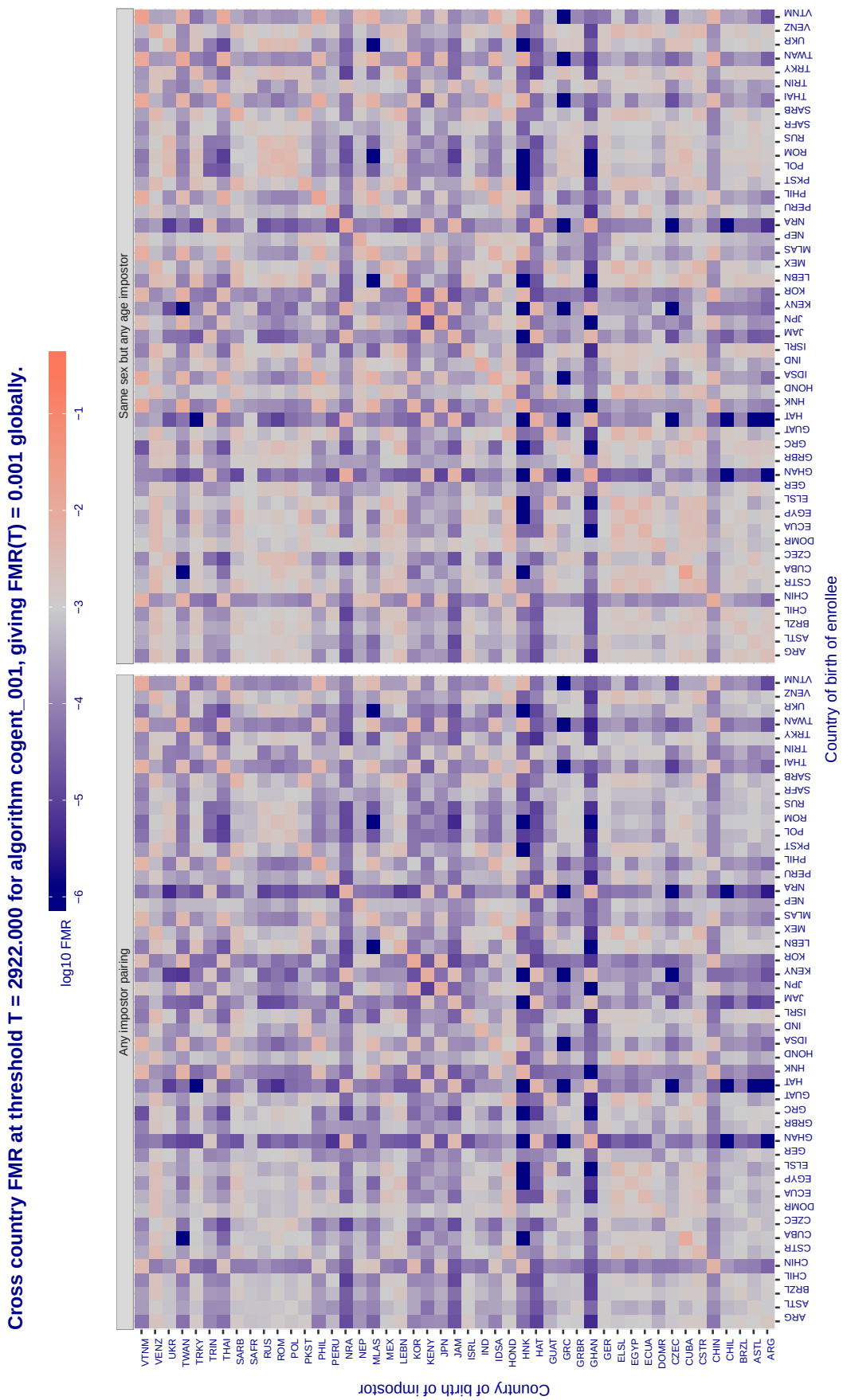


Figure 144: For algorithm cogent-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

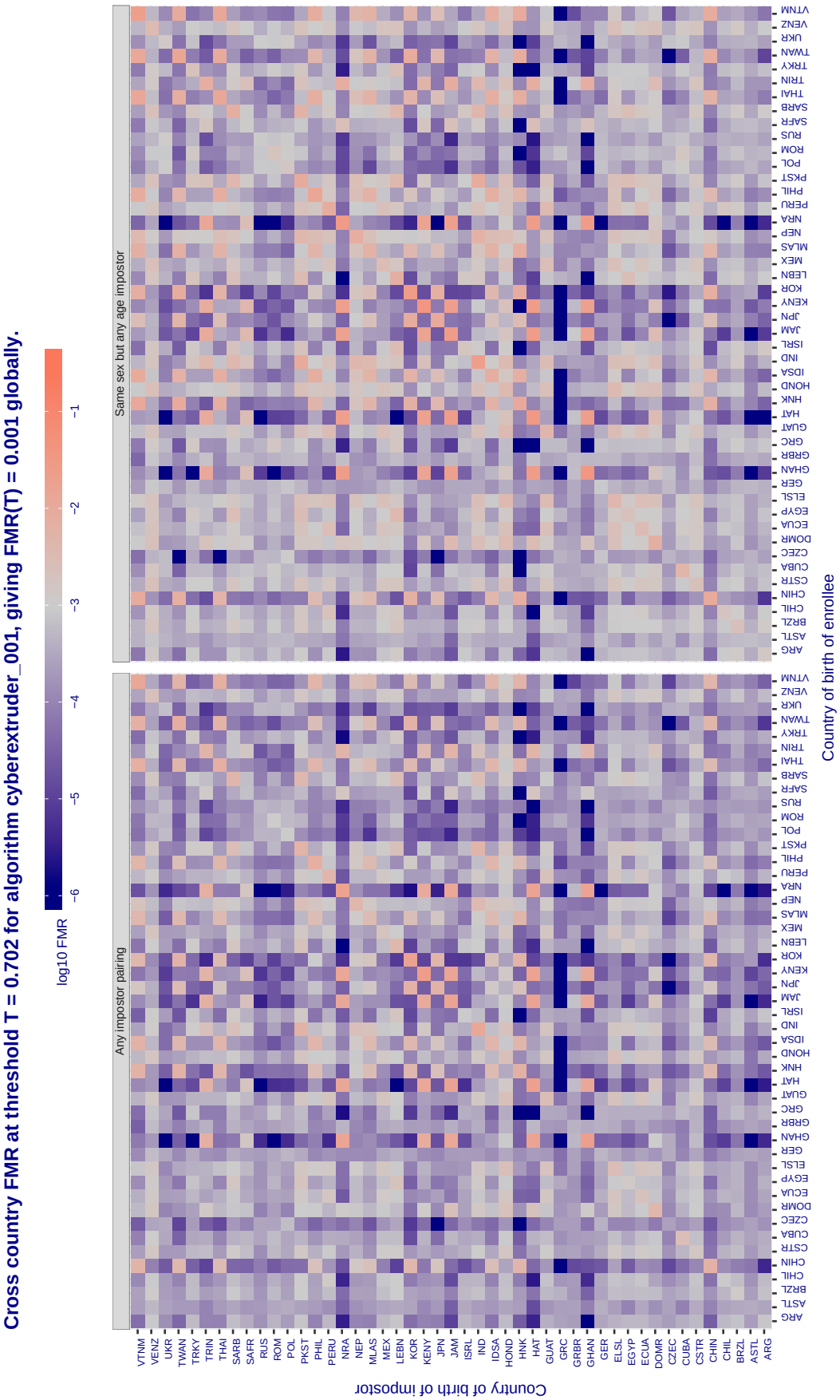


Figure 145: For algorithm cyberextruder-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

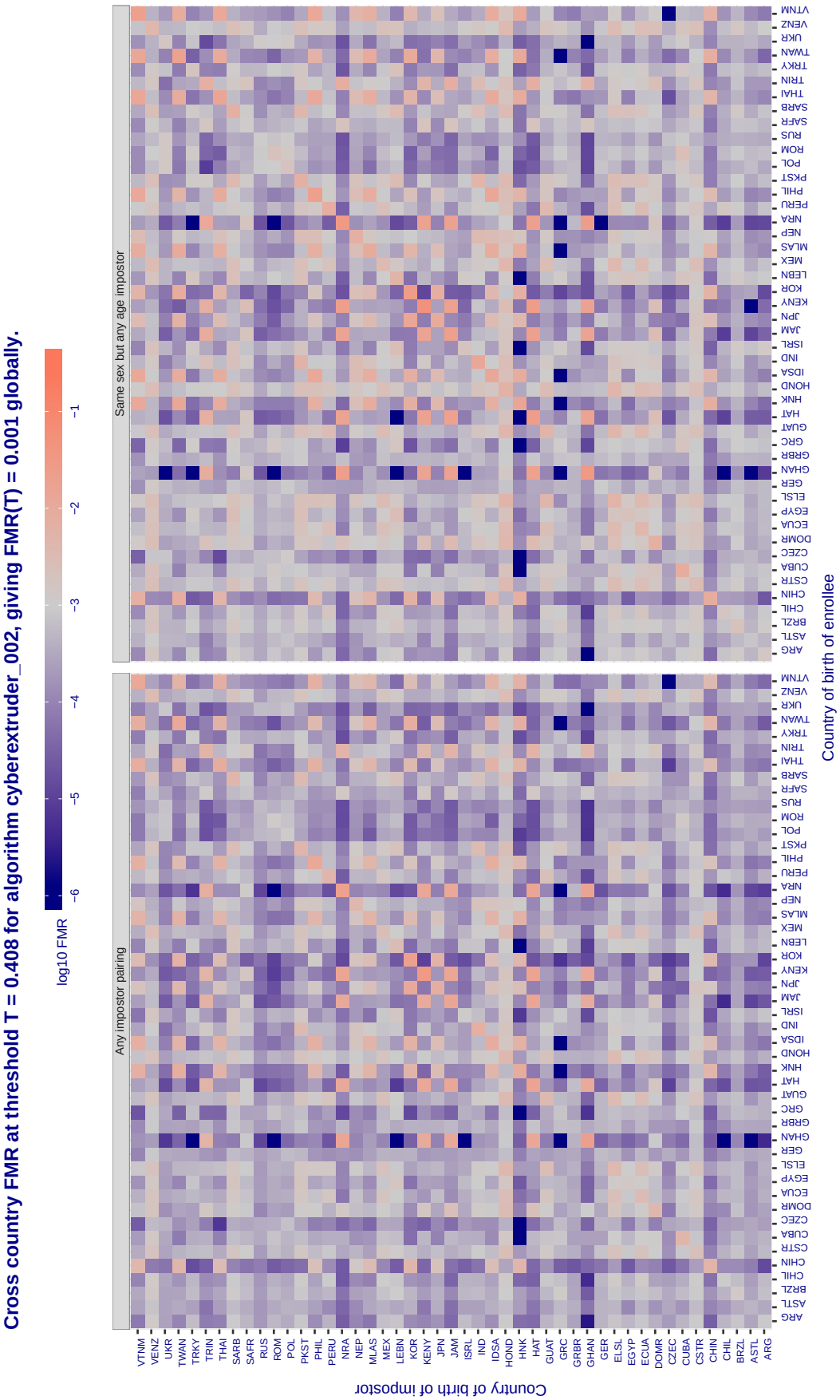


Figure 146: For algorithm cyberextruder-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

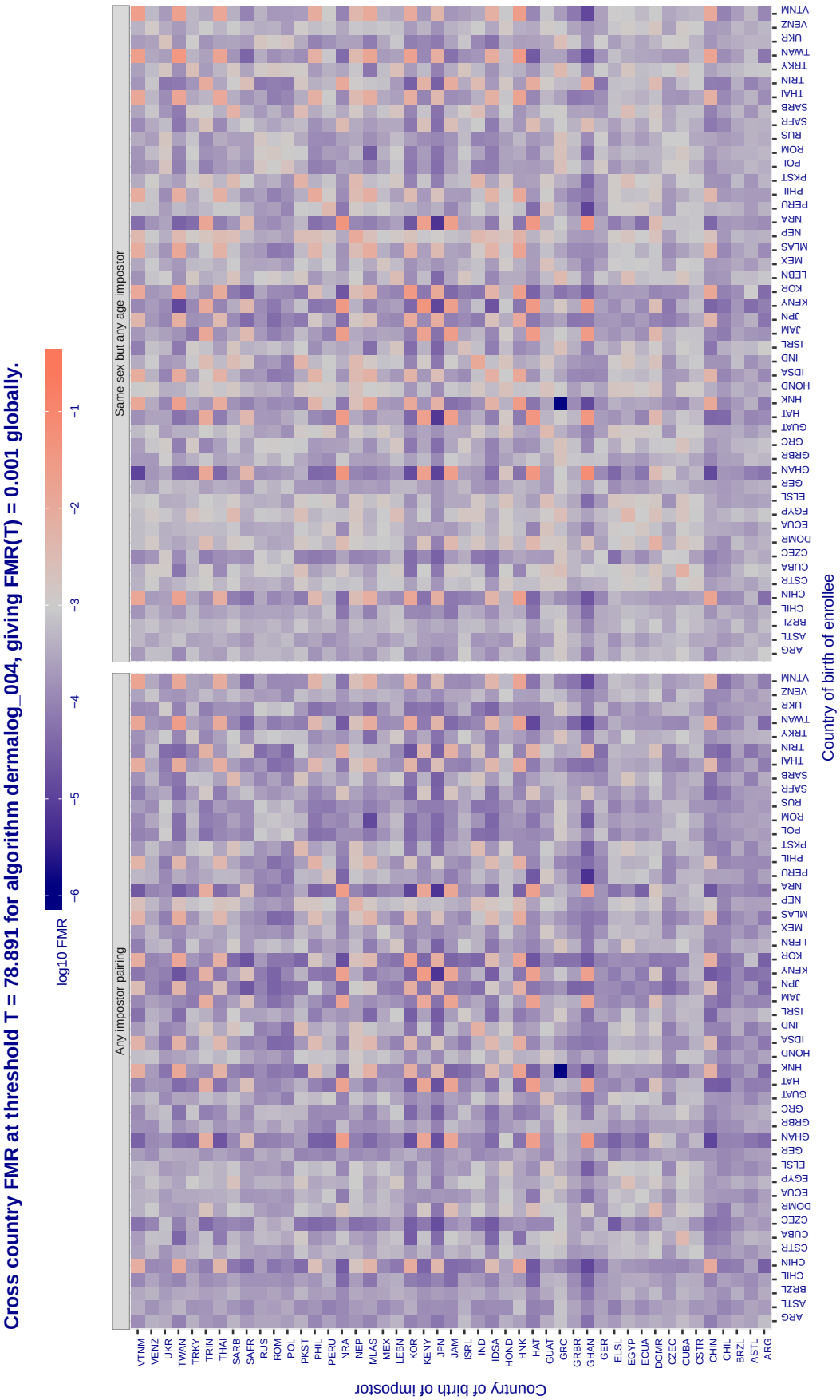


Figure 147: For algorithm dermalog-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

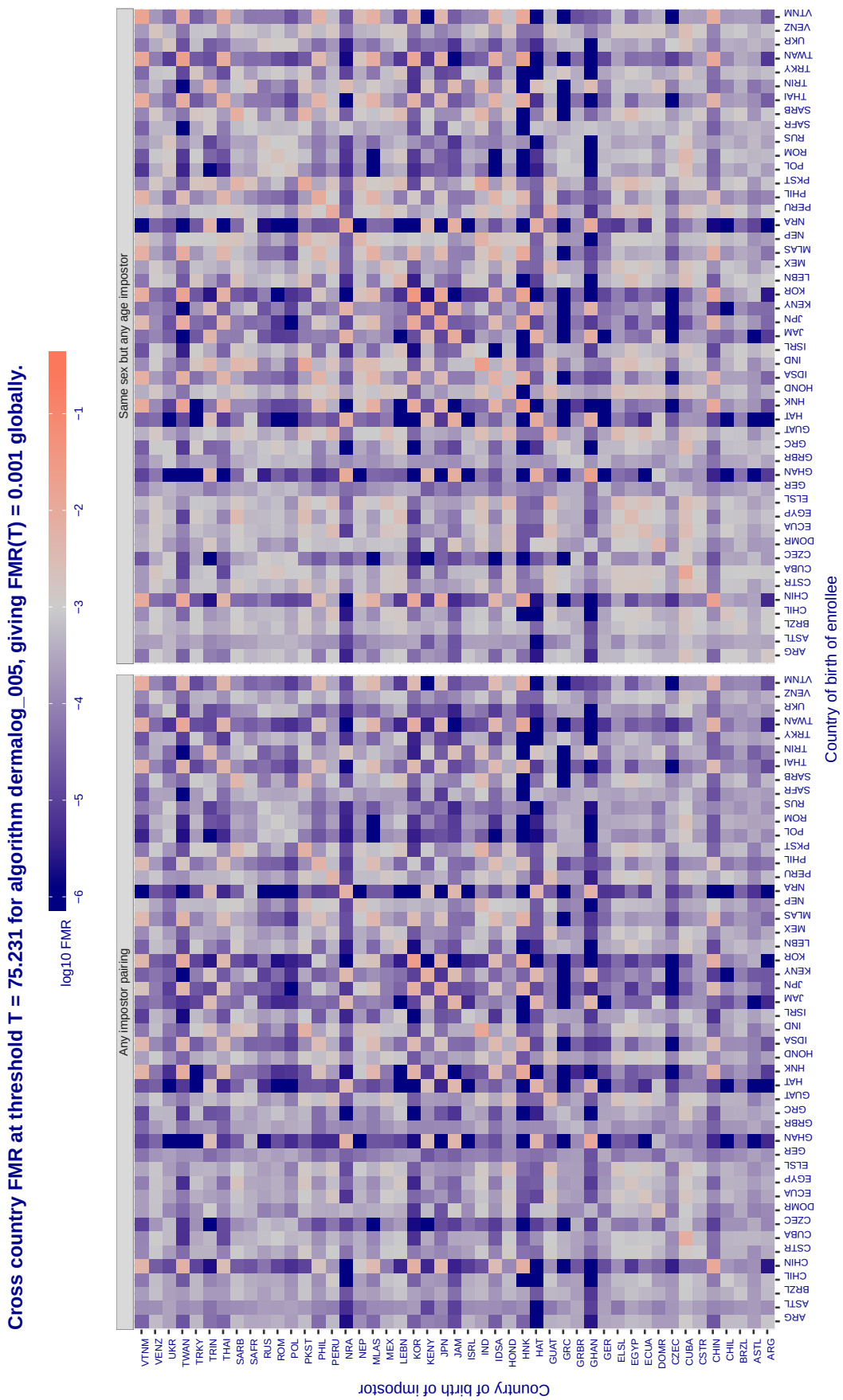


Figure 148: For algorithm dermalog-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

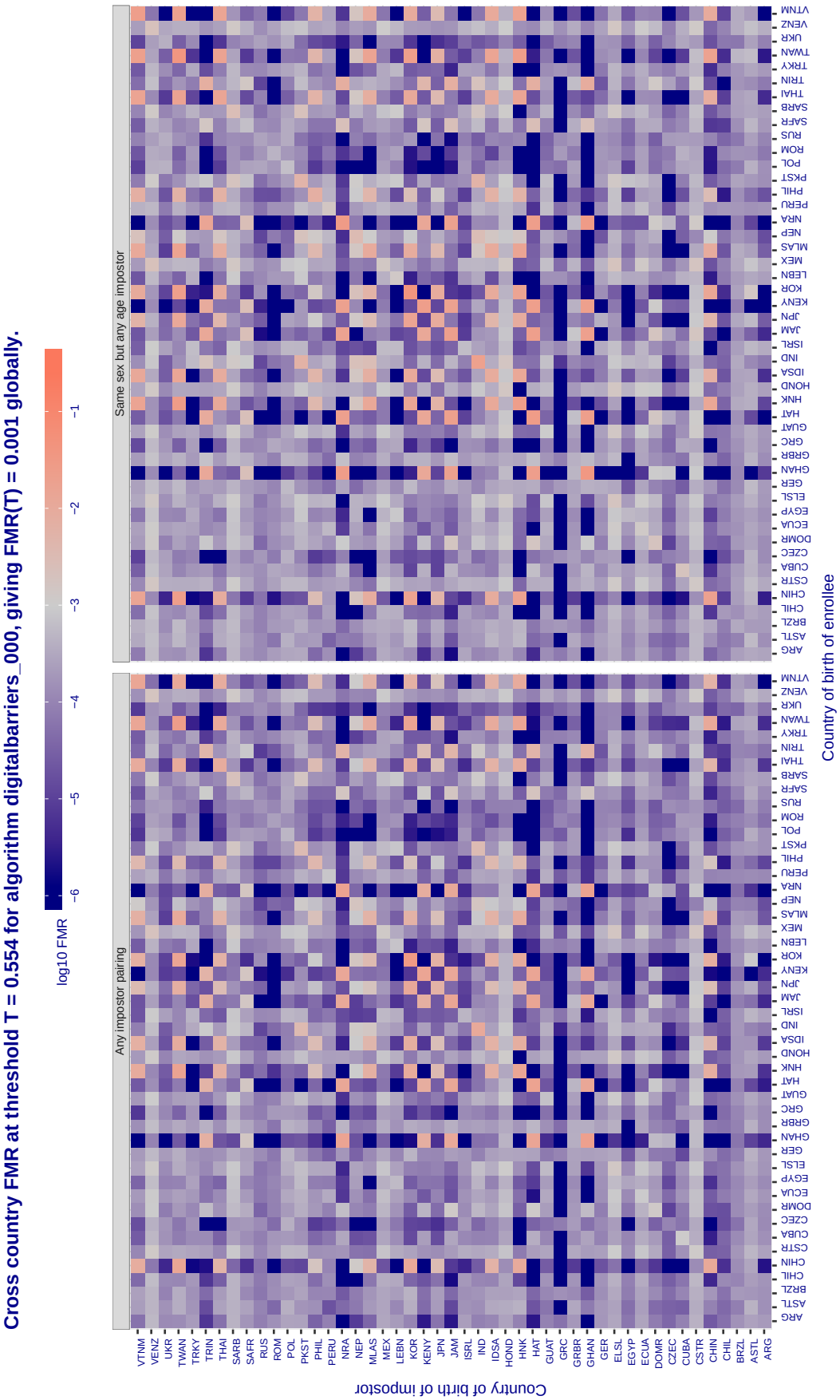


Figure 149: For algorithm digitalbarriers-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

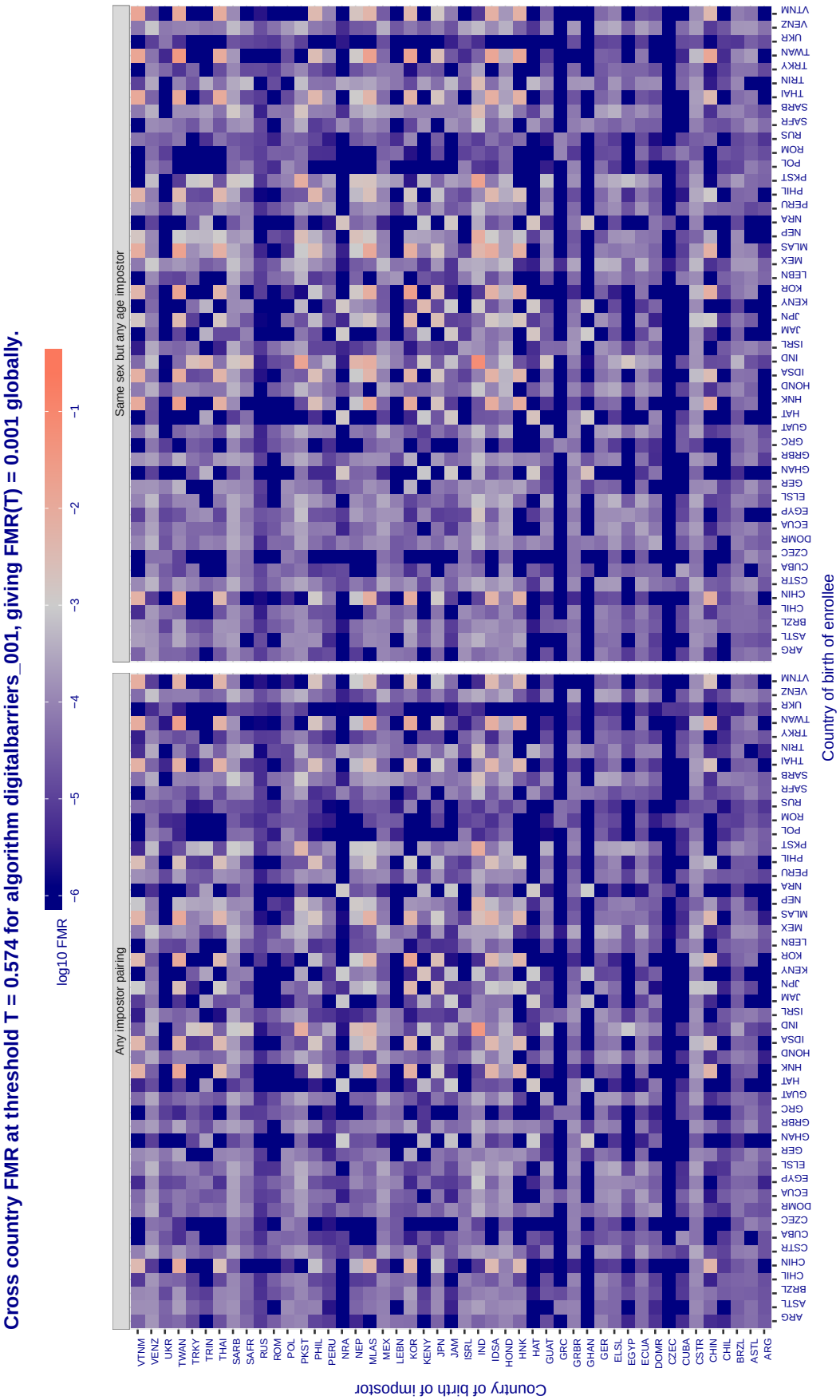


Figure 150: For algorithm digitalbarriers-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

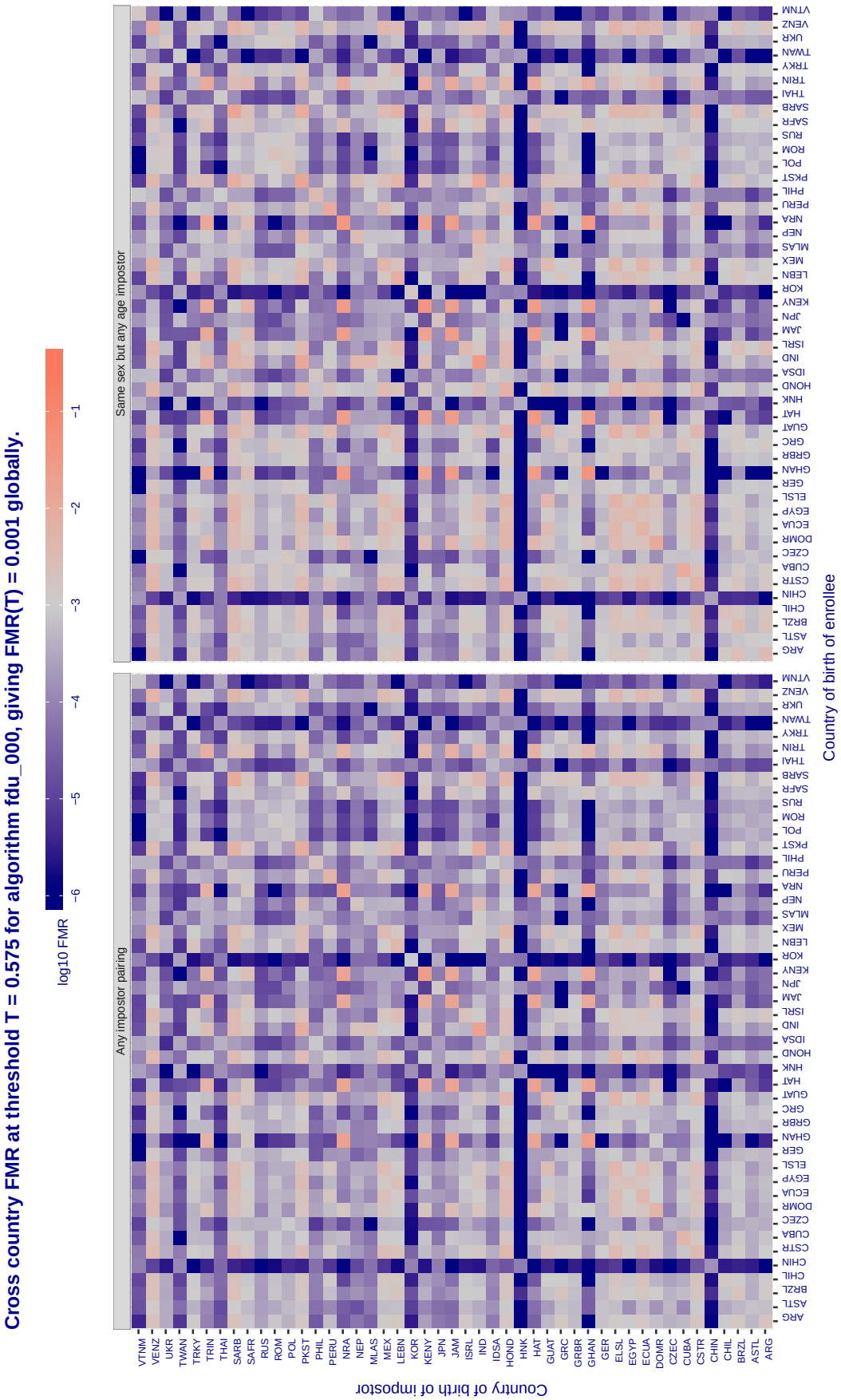


Figure 151: For algorithm fdu-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

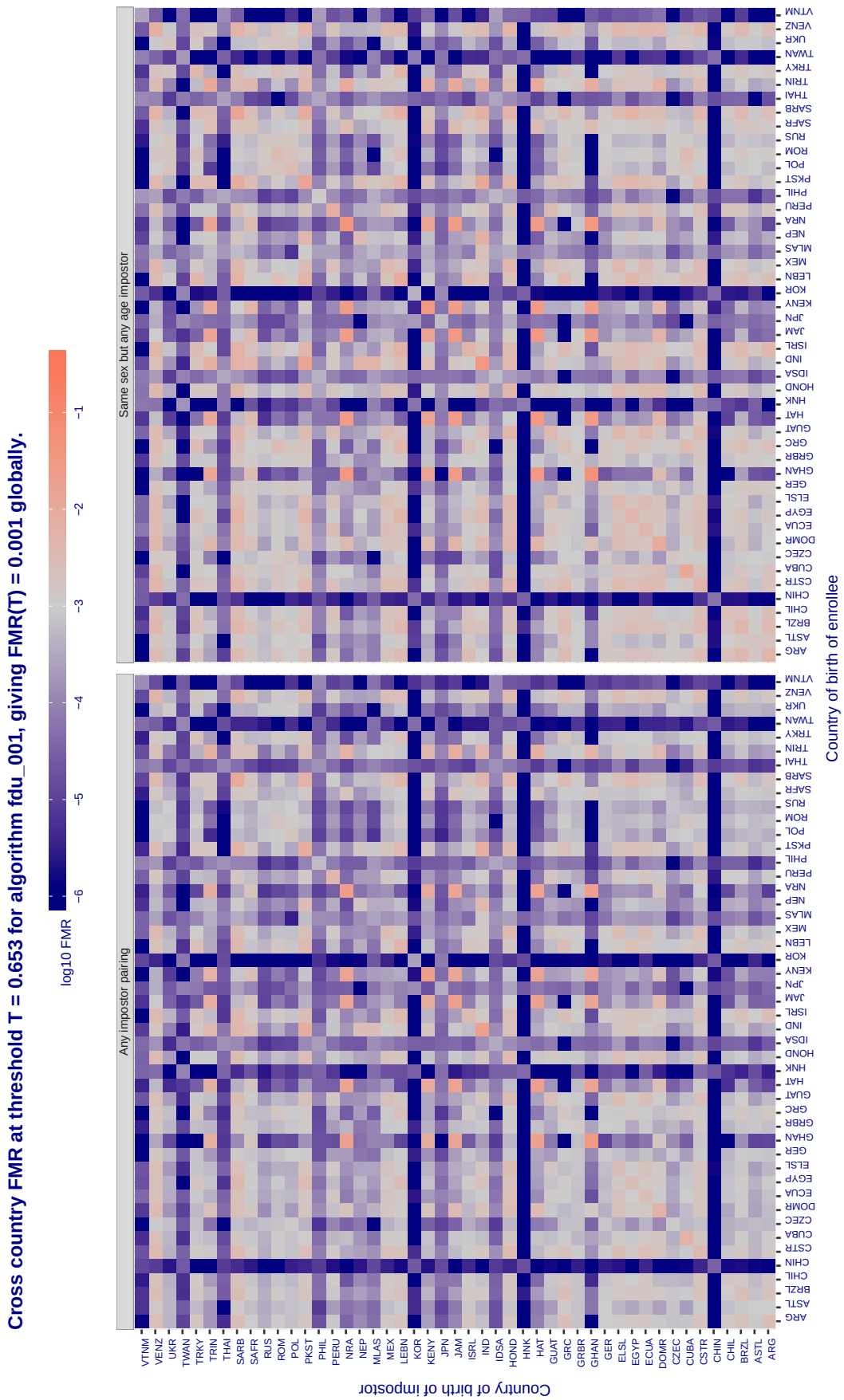


Figure 152: For algorithm fdu-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

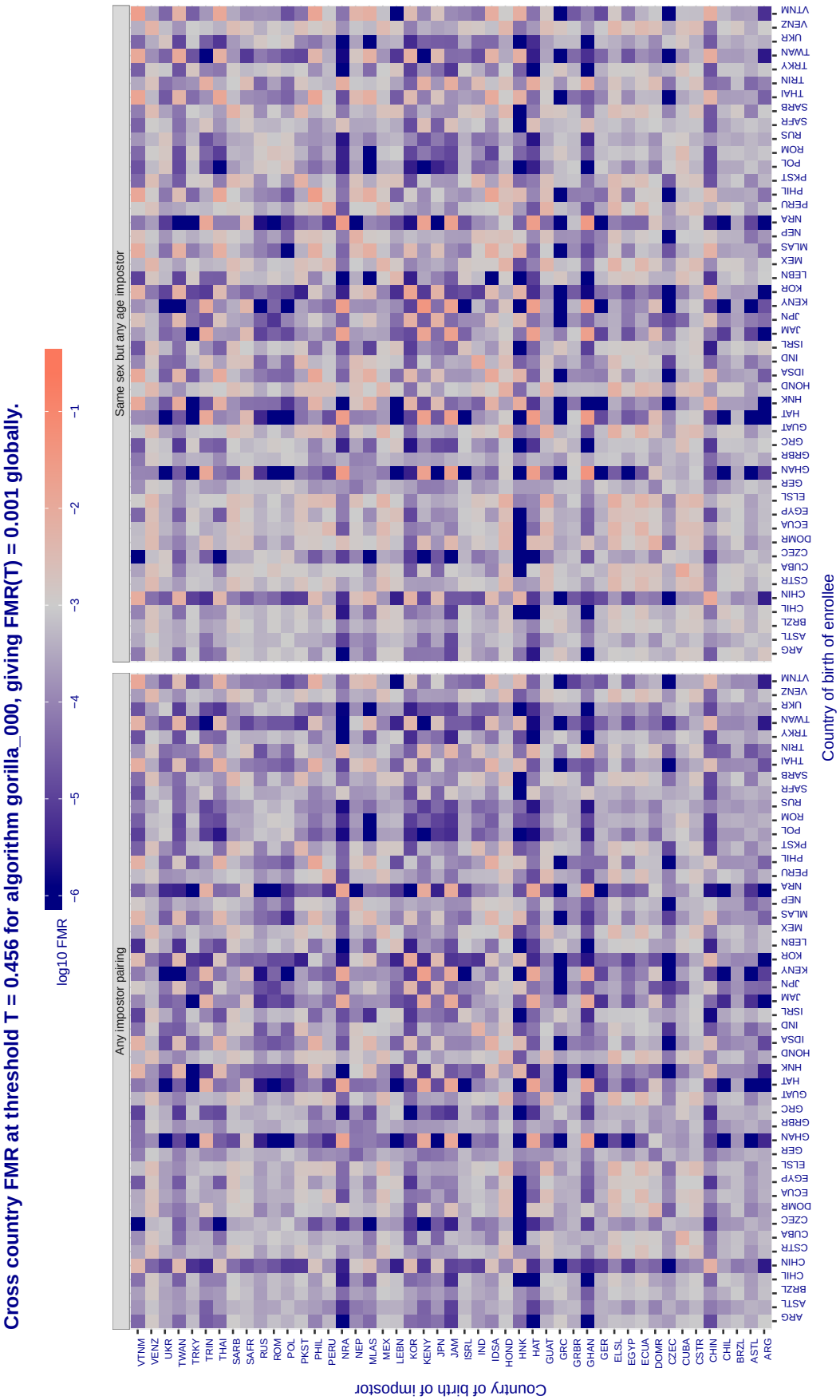


Figure 153: For algorithm gorilla-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

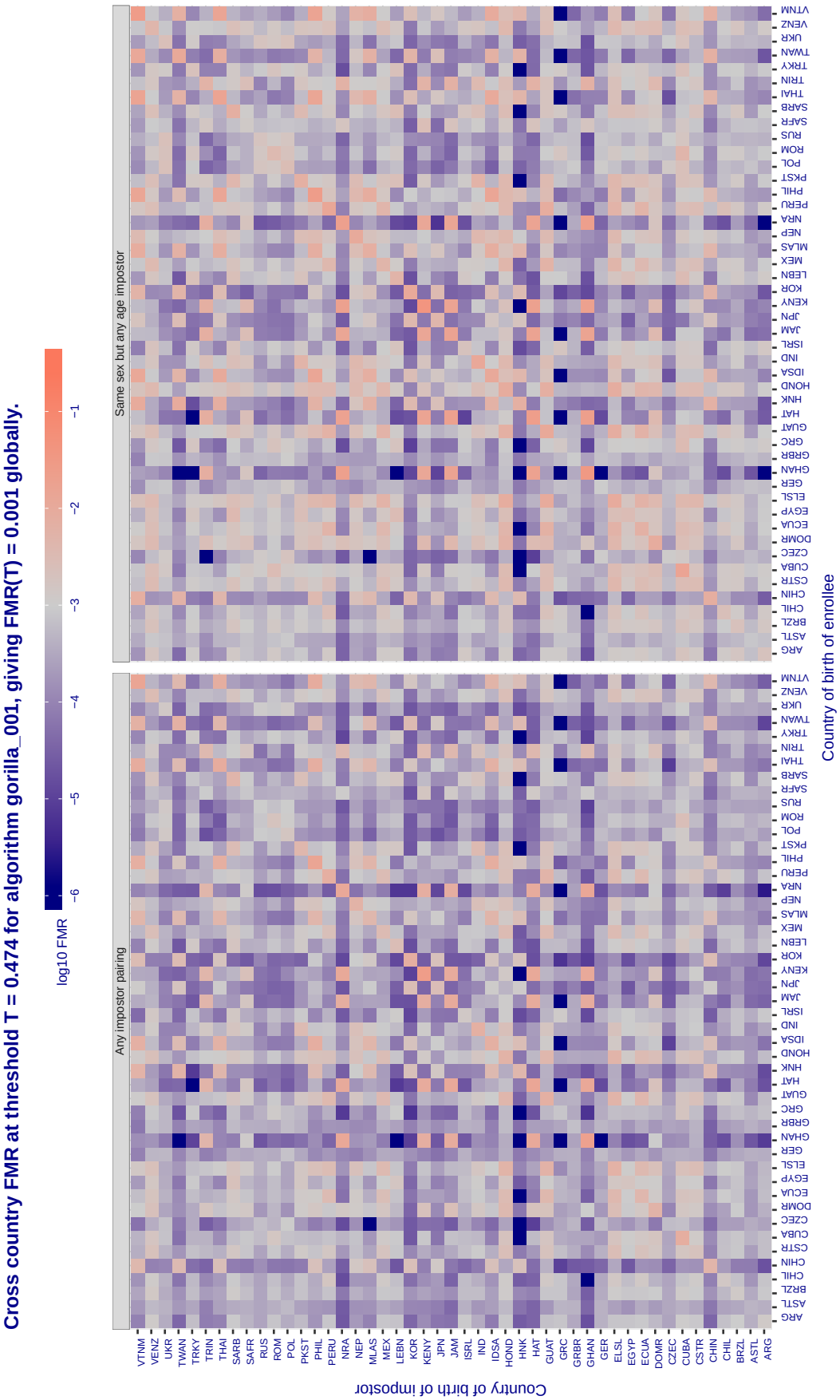


Figure 154: For algorithm gorilla-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

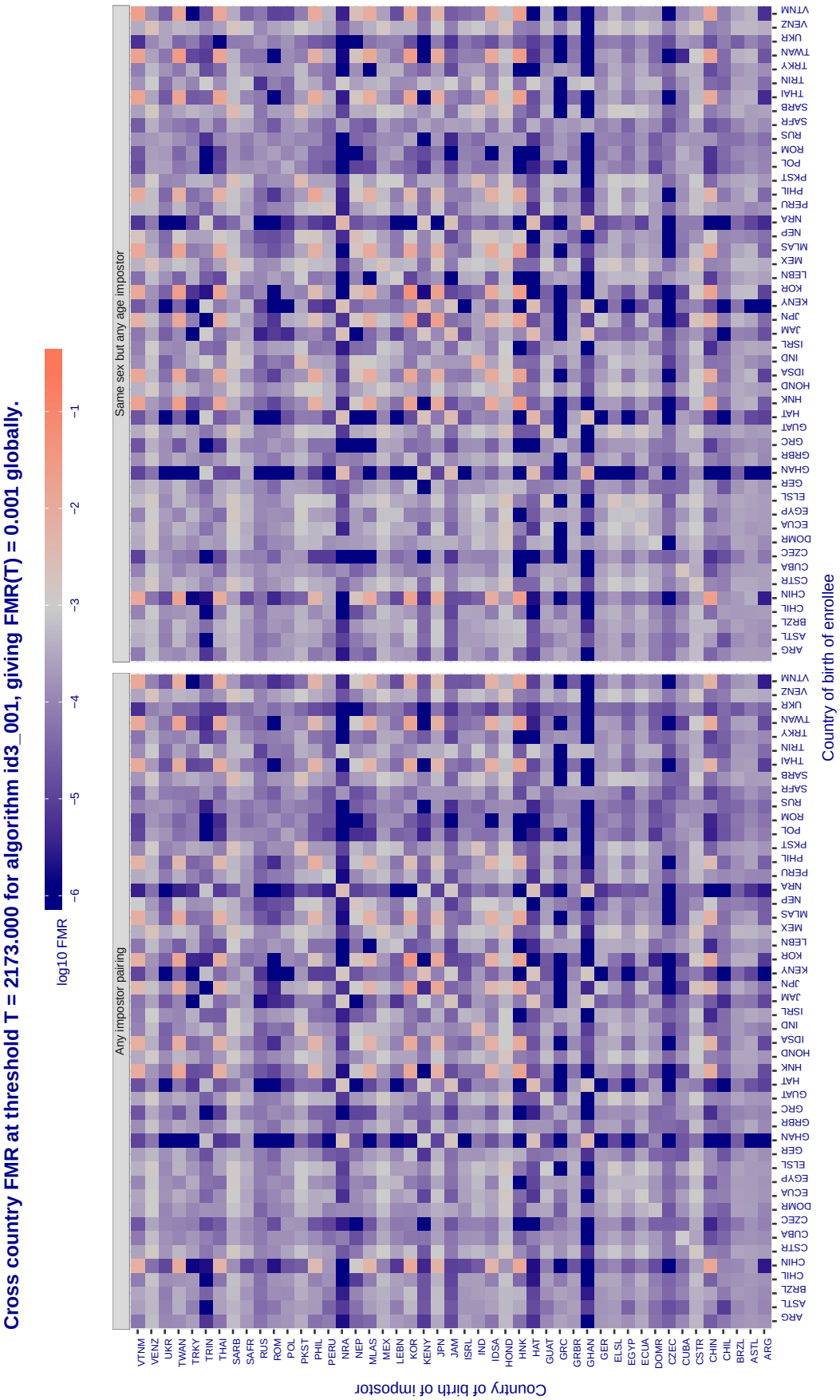


Figure 155: For algorithm id3-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

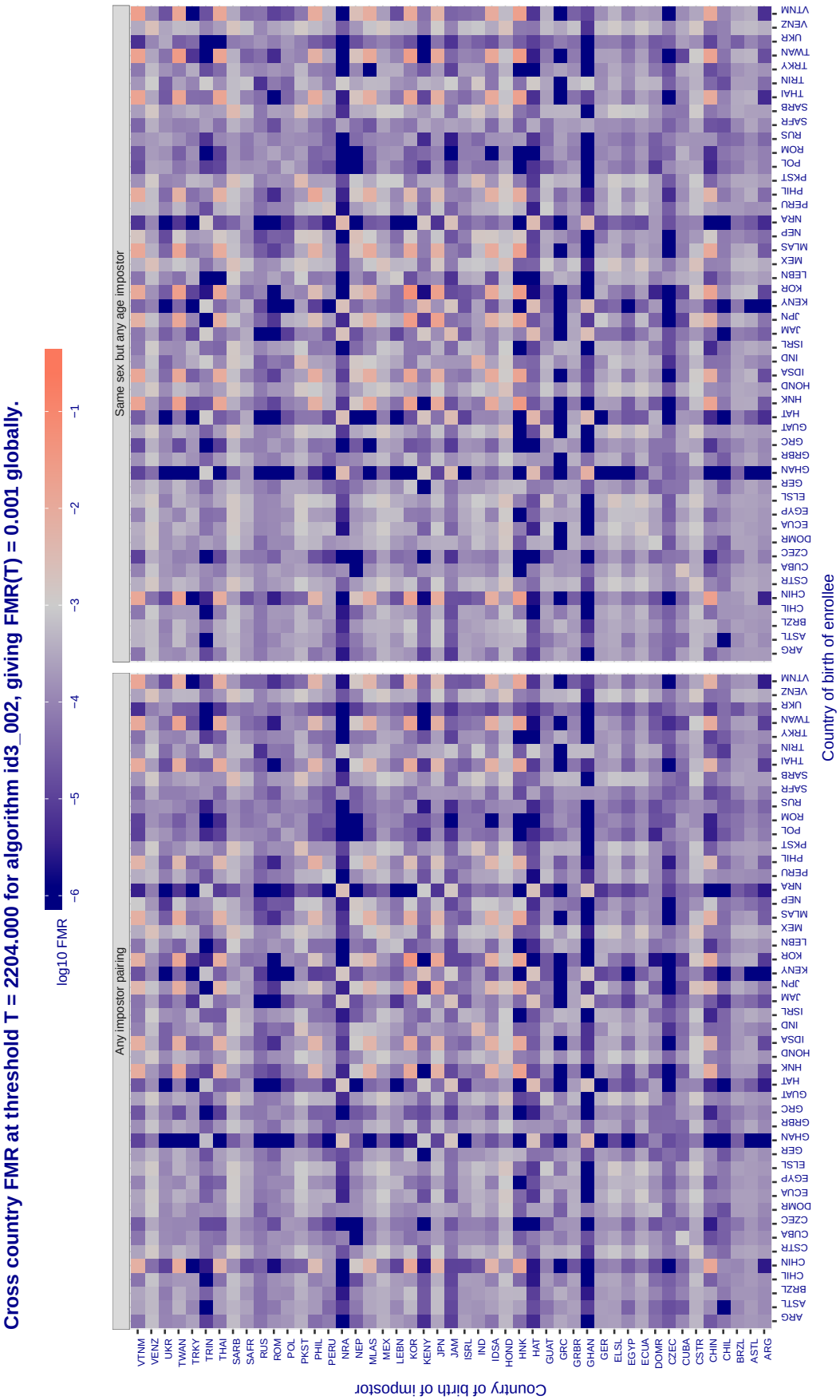


Figure 156: For algorithm id3-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

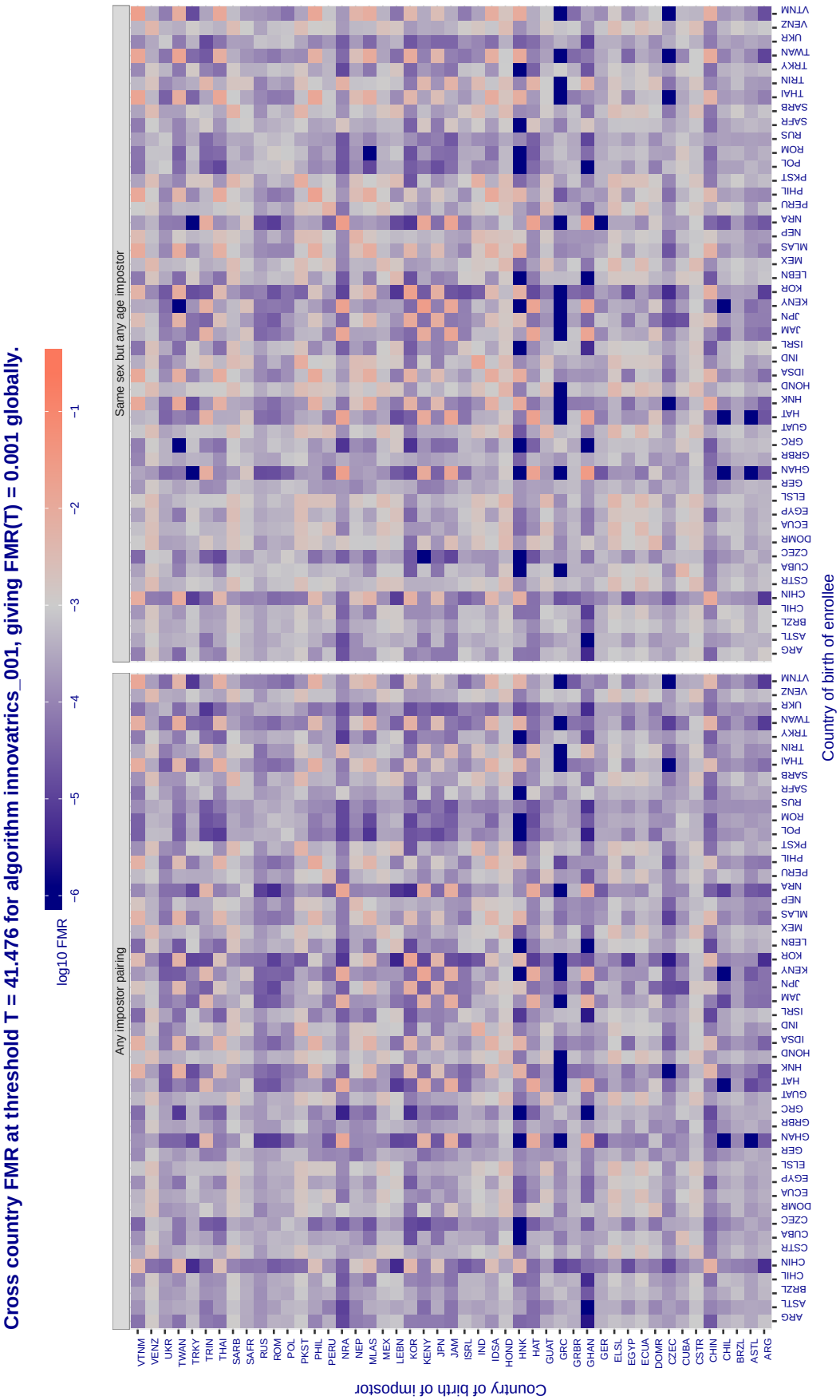


Figure 157: For algorithm innovatrics-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

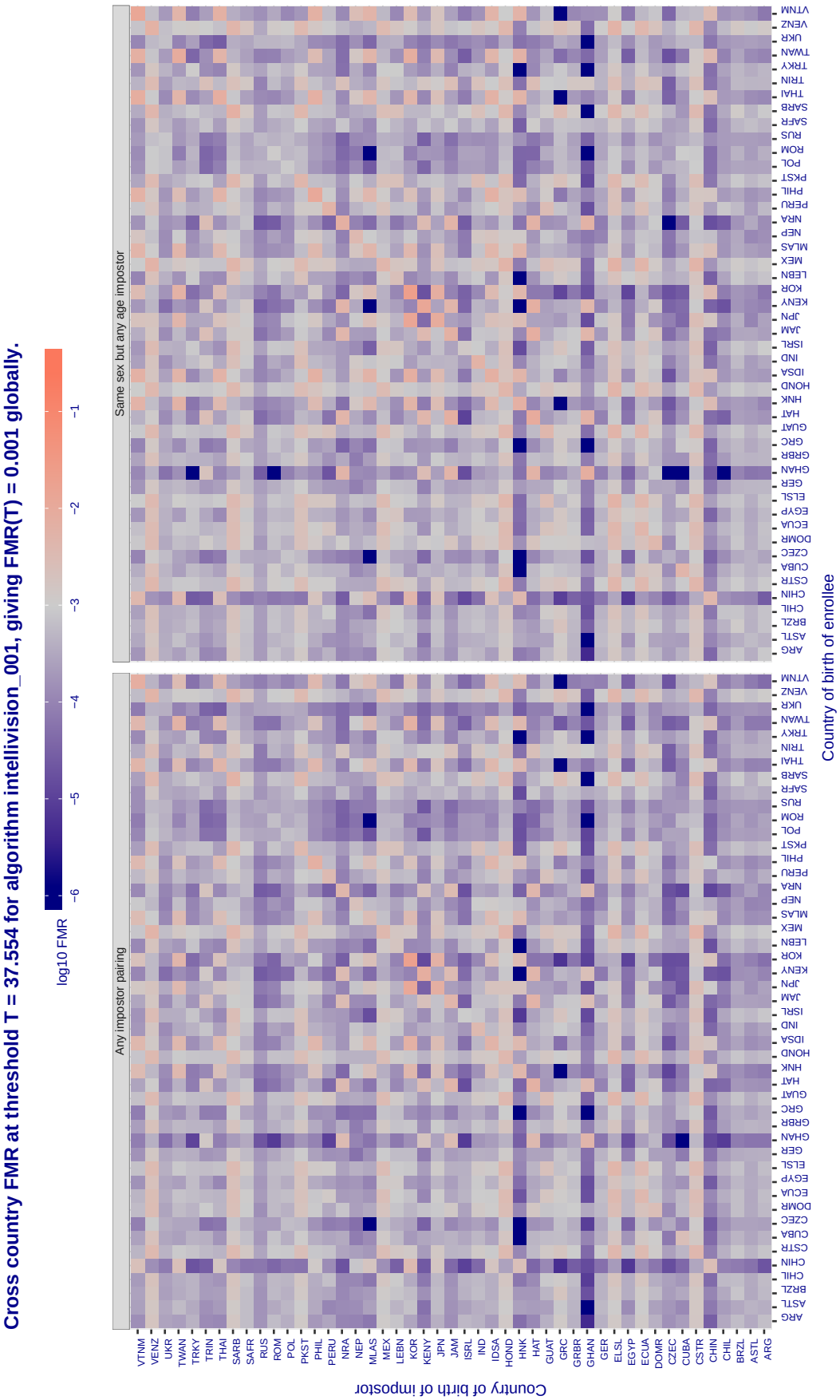


Figure 158: For algorithm intellivision-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

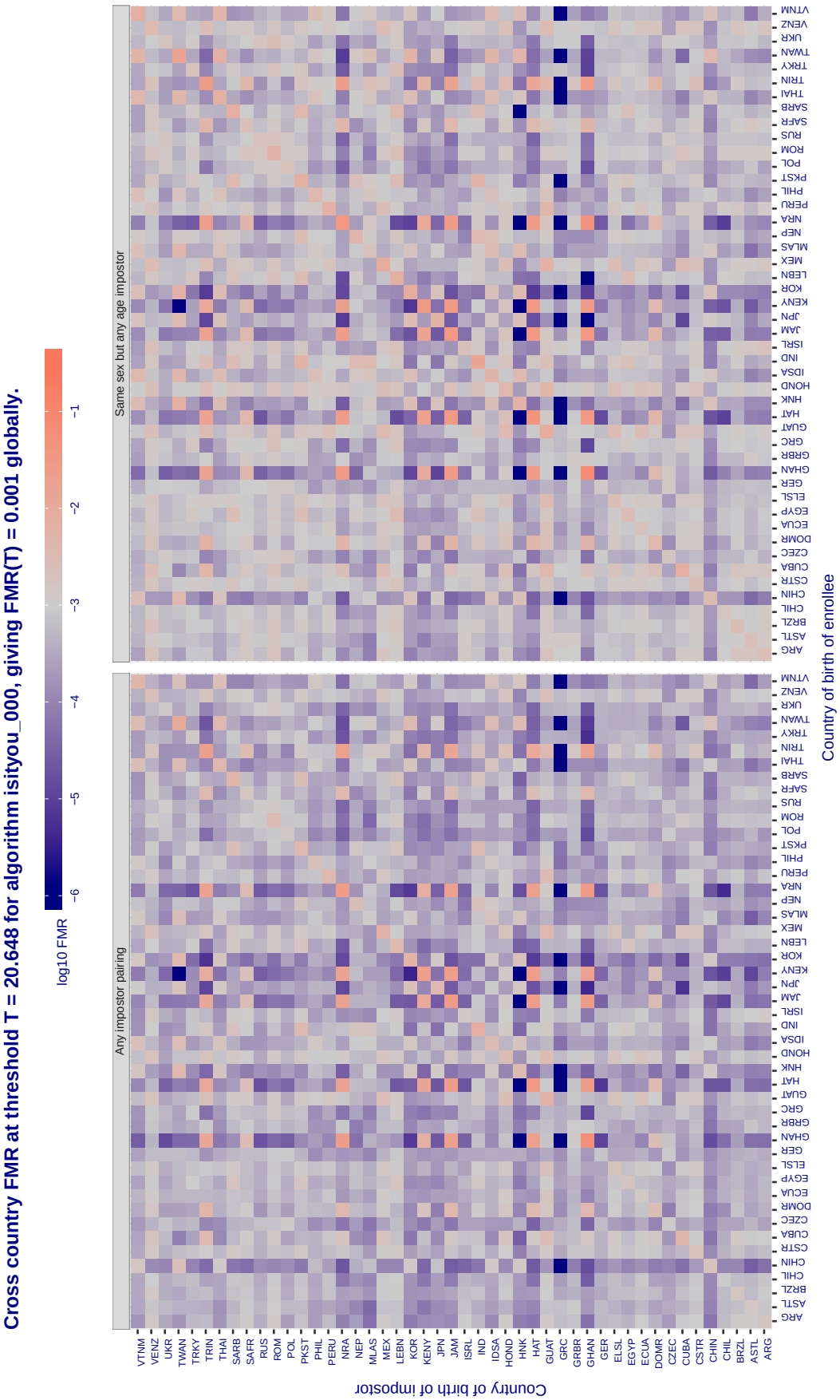


Figure 159: For algorithm isityou-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

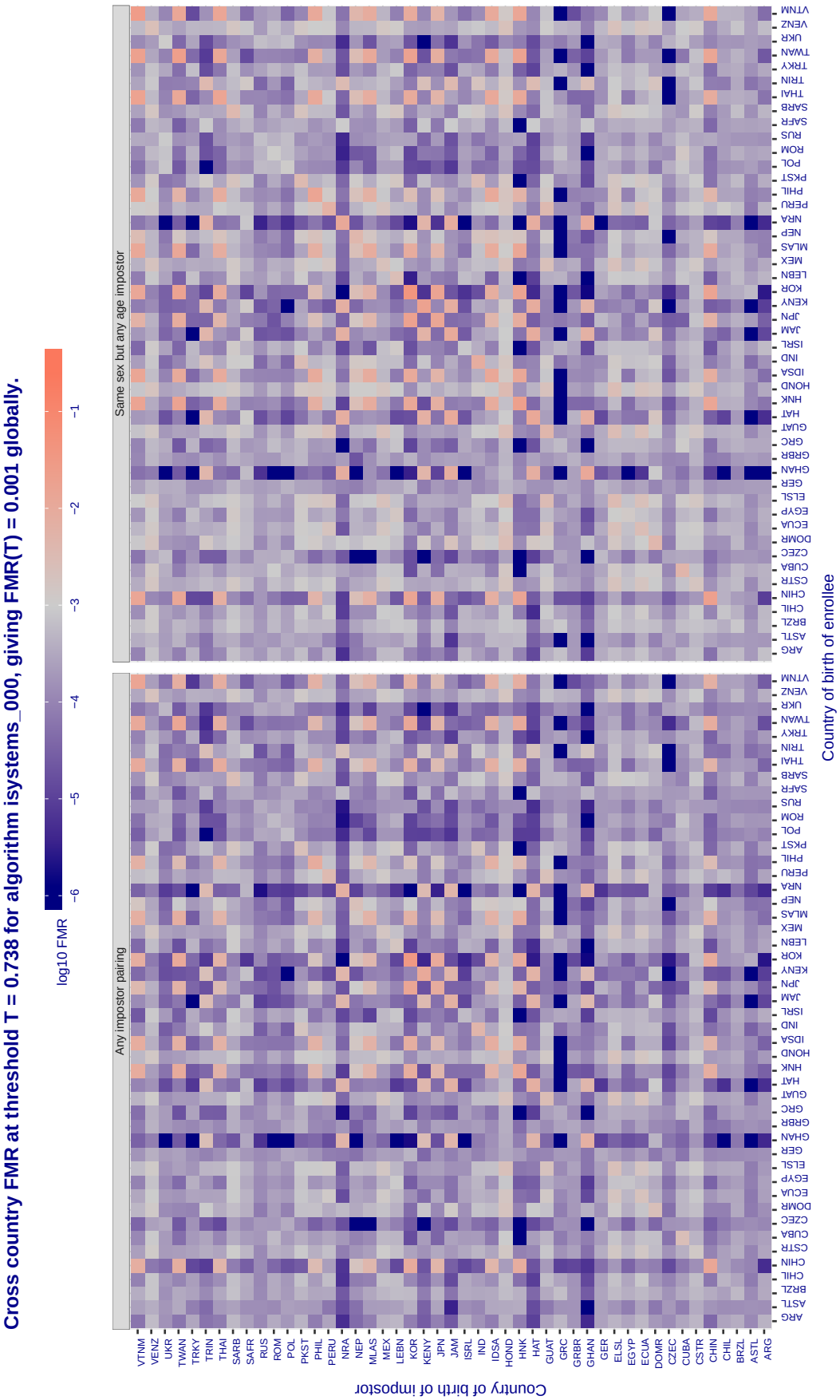


Figure 160: For algorithm isystems-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

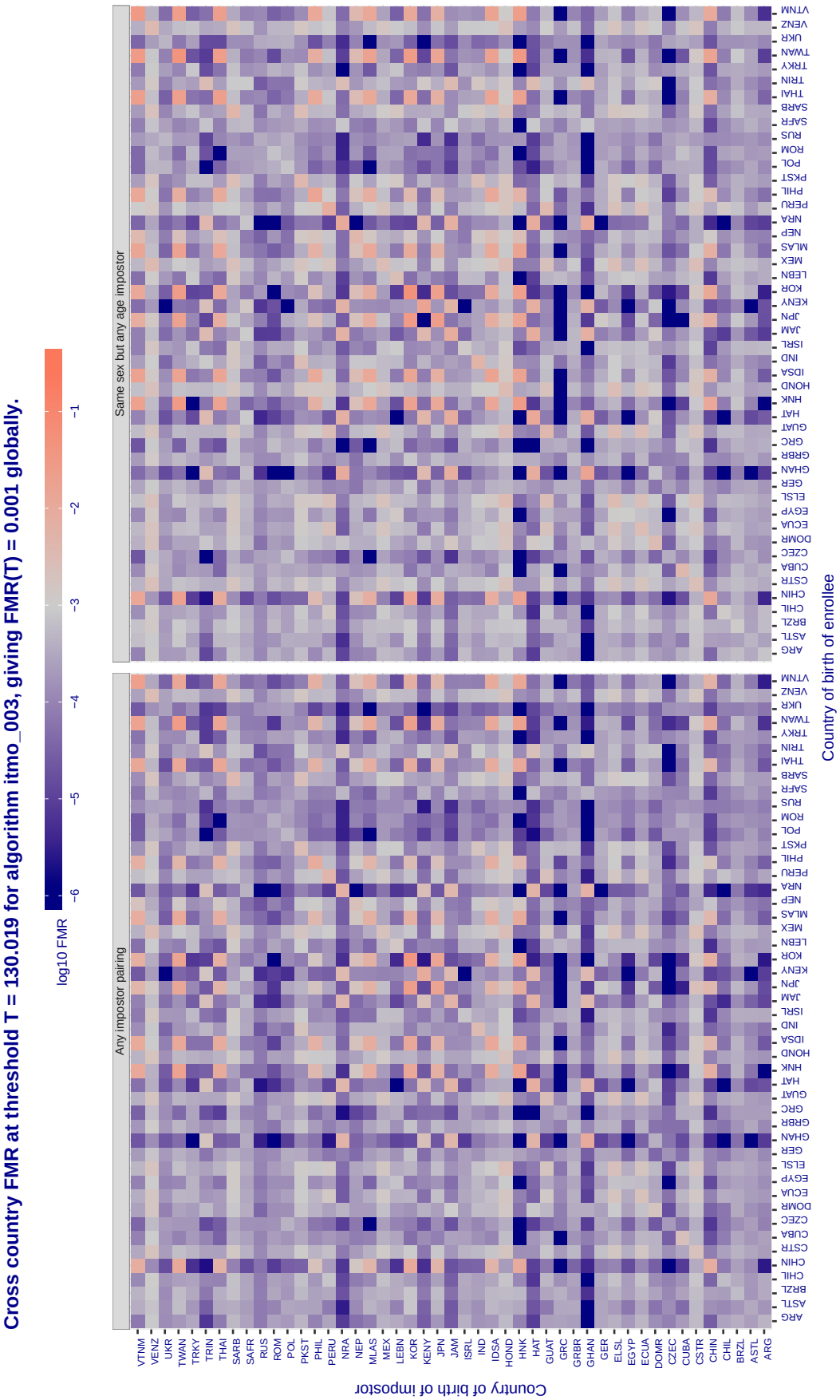


Figure 161: For algorithm itmo-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

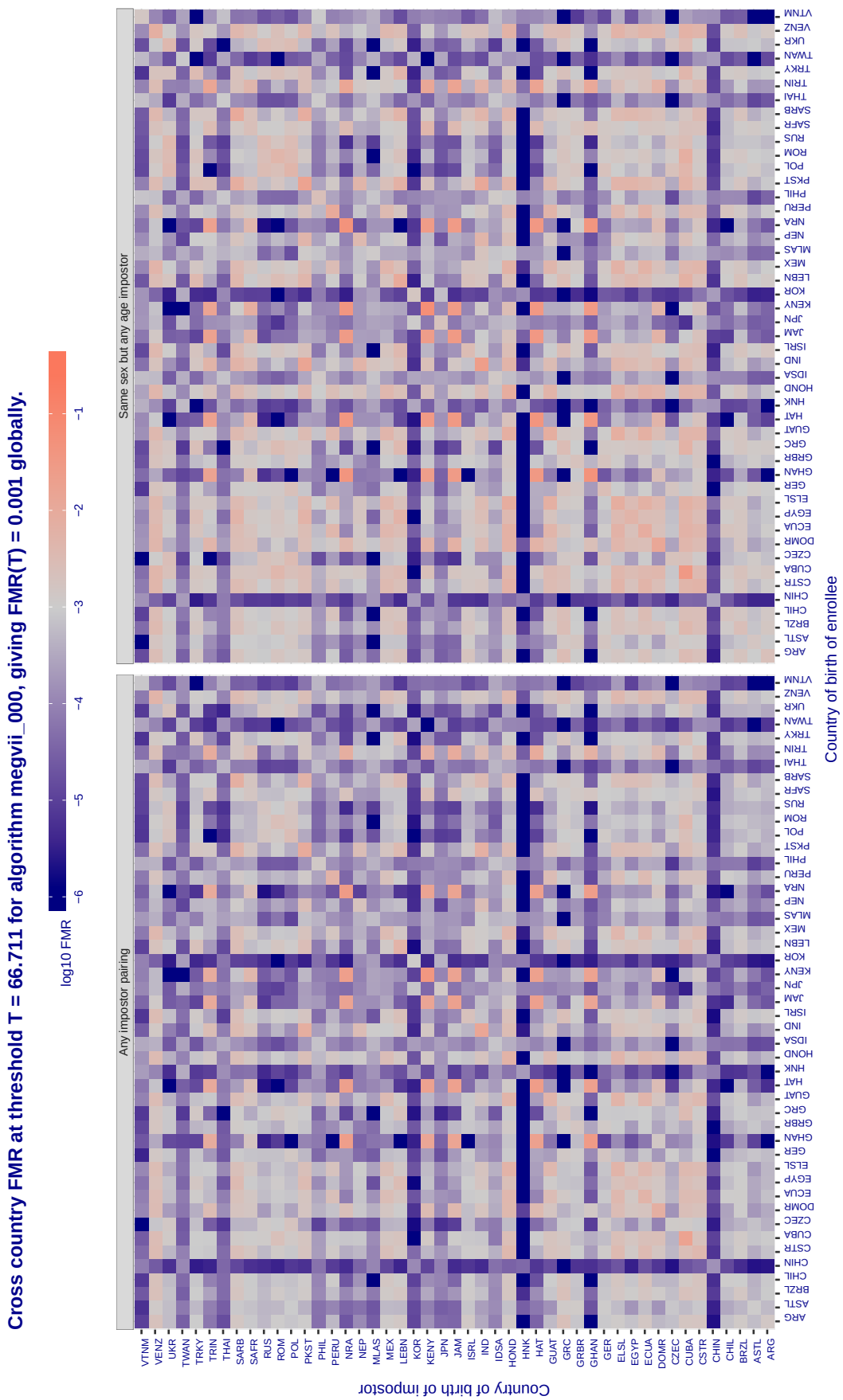


Figure 162: For algorithm megvii-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

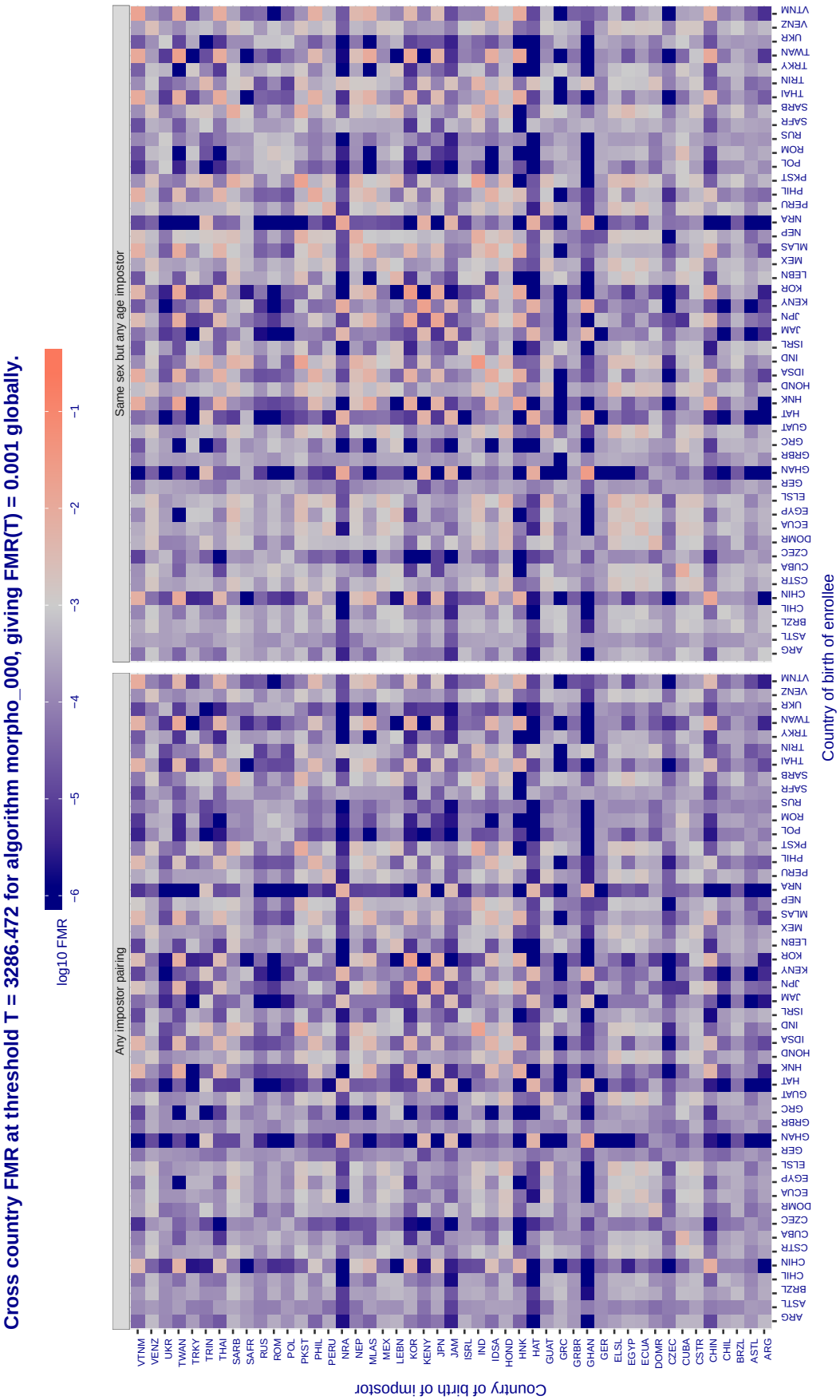


Figure 163: For algorithm morpho-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

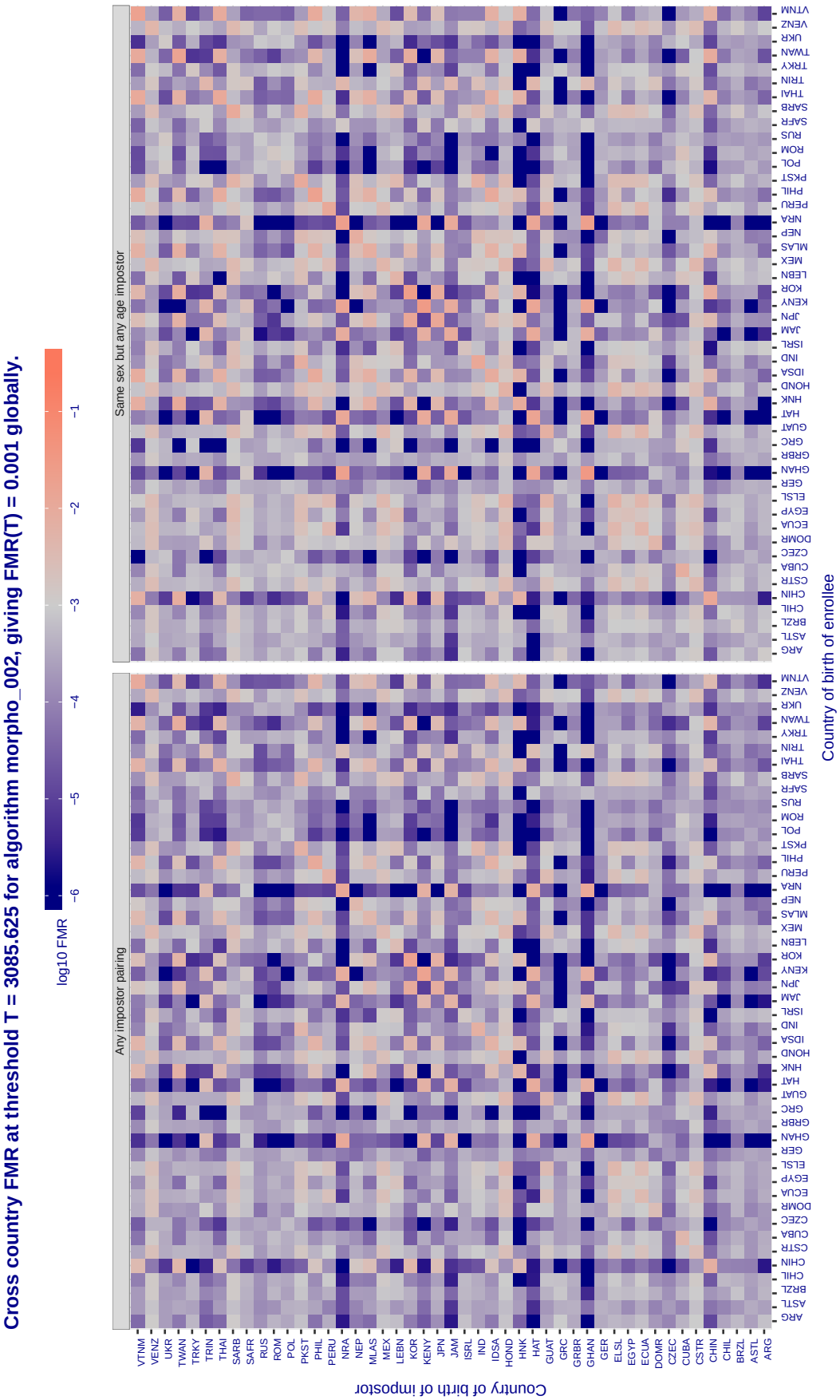


Figure 164: For algorithm morpho-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

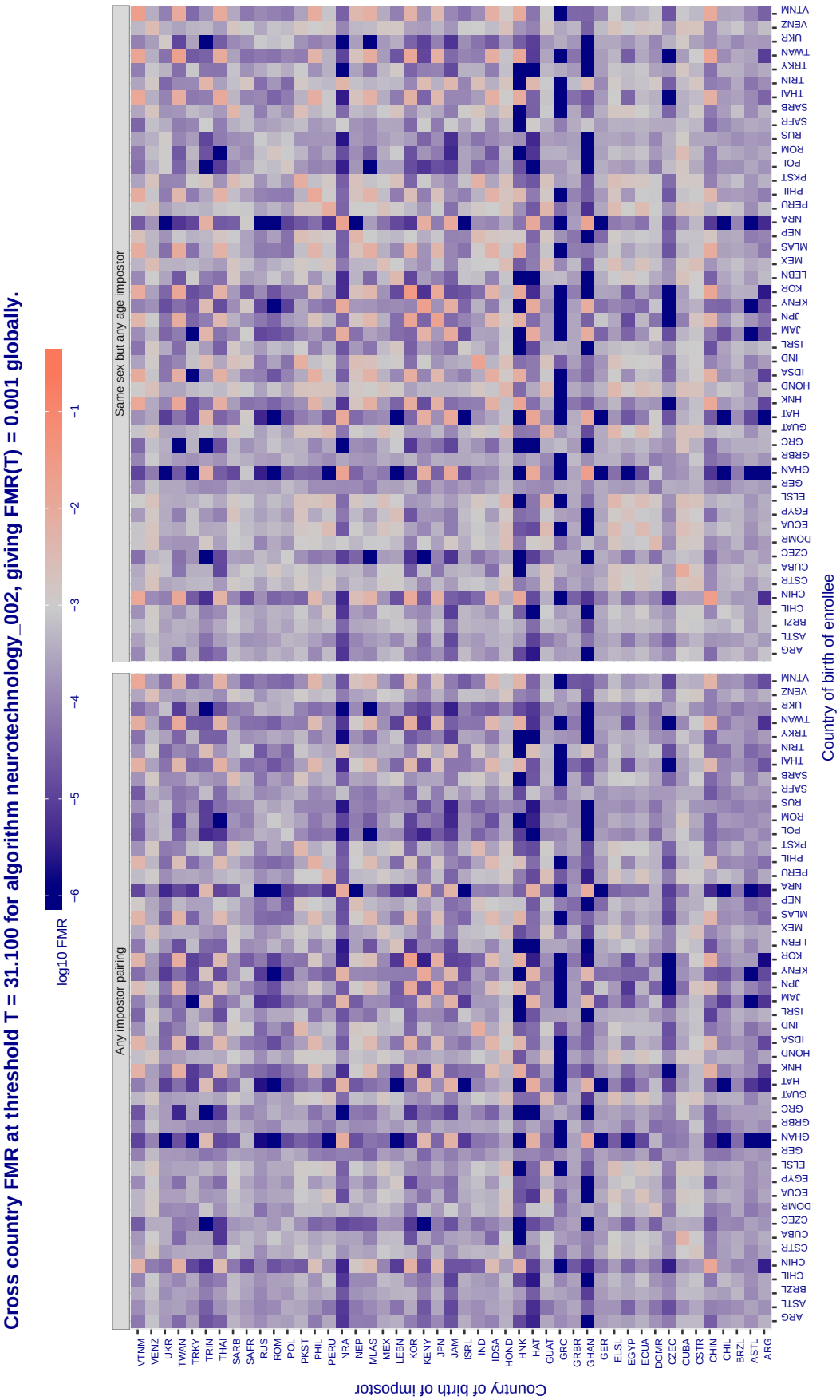


Figure 165: For algorithm neurotechnology-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

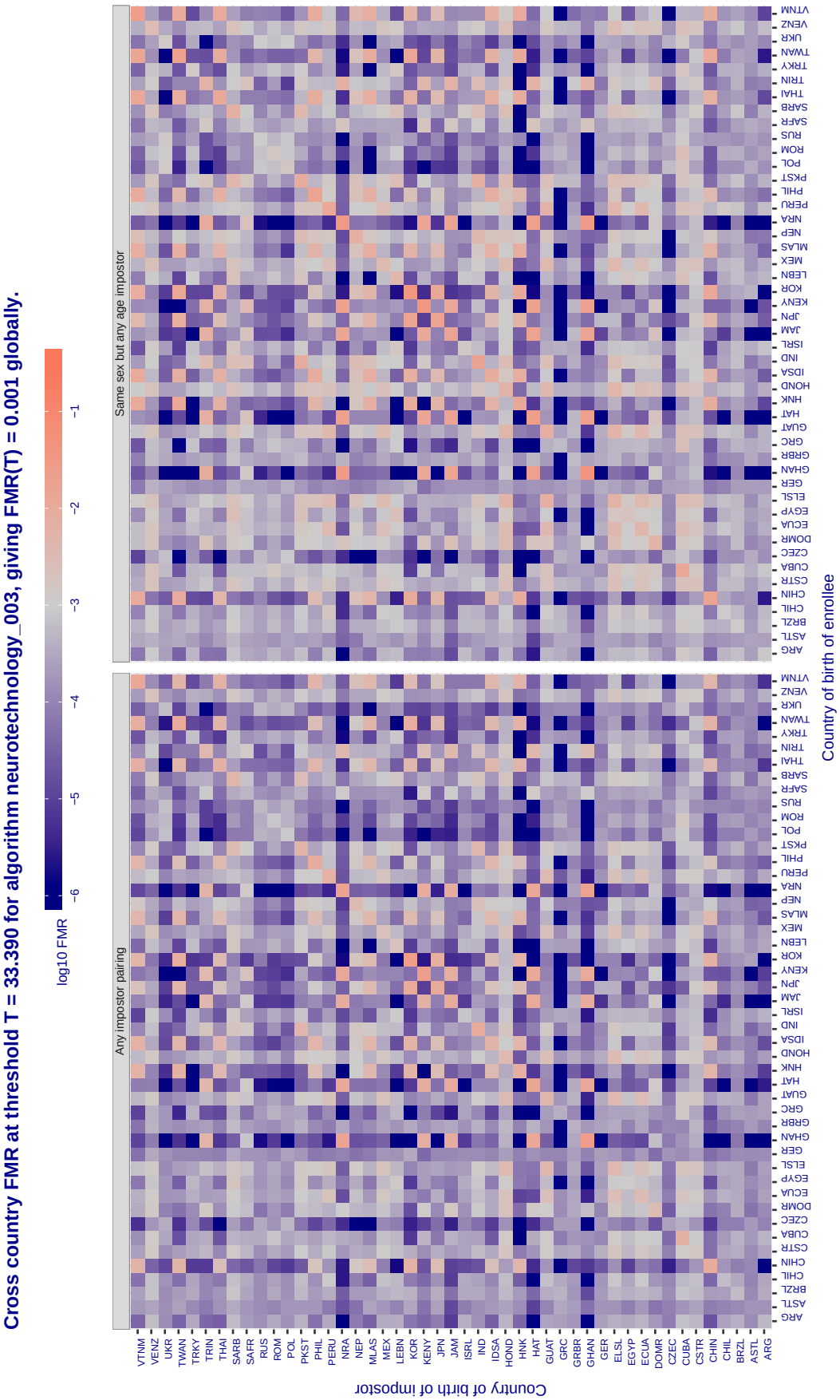


Figure 166: For algorithm neurotechnology-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

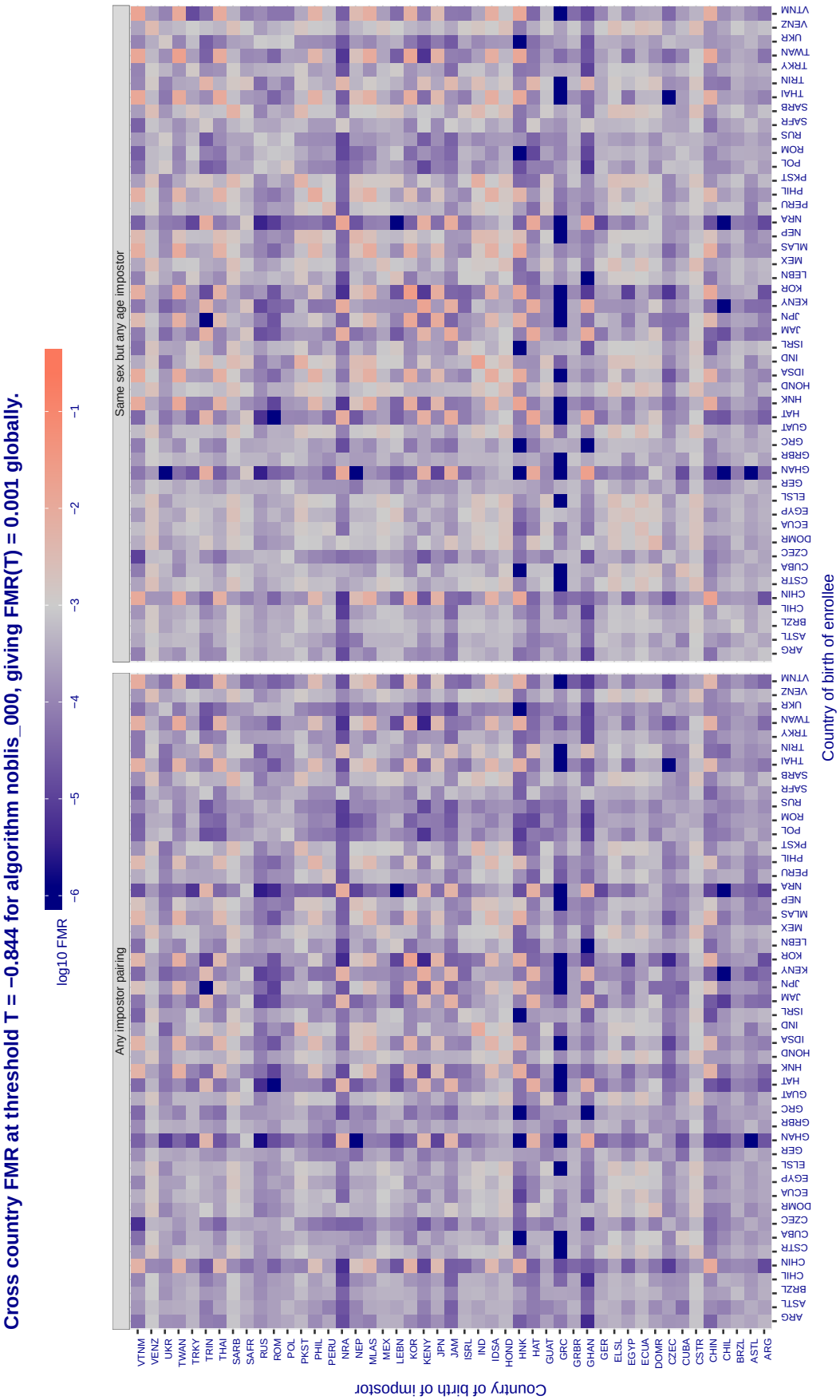


Figure 167: For algorithm noblis-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

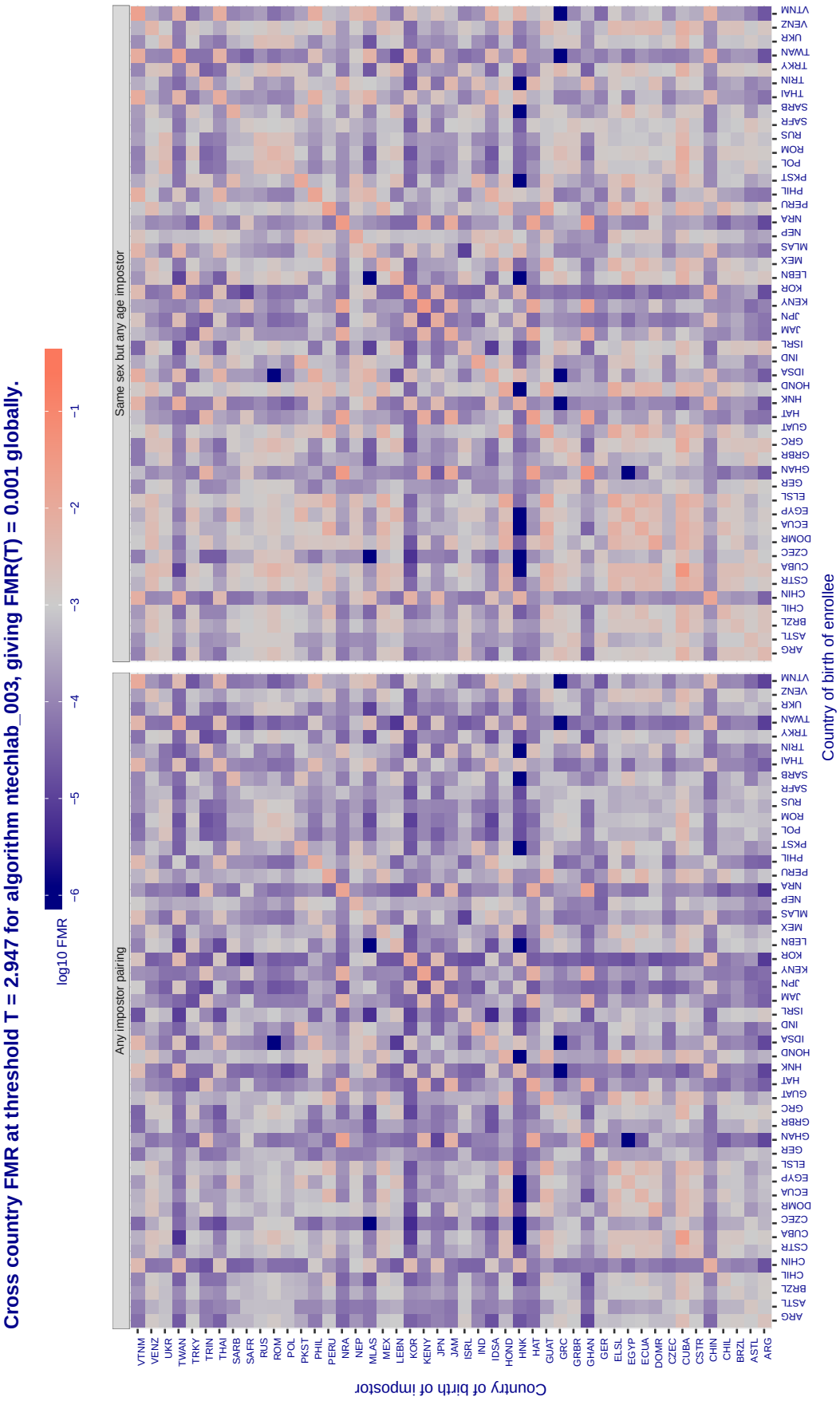


Figure 168: For algorithm ntechlab-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

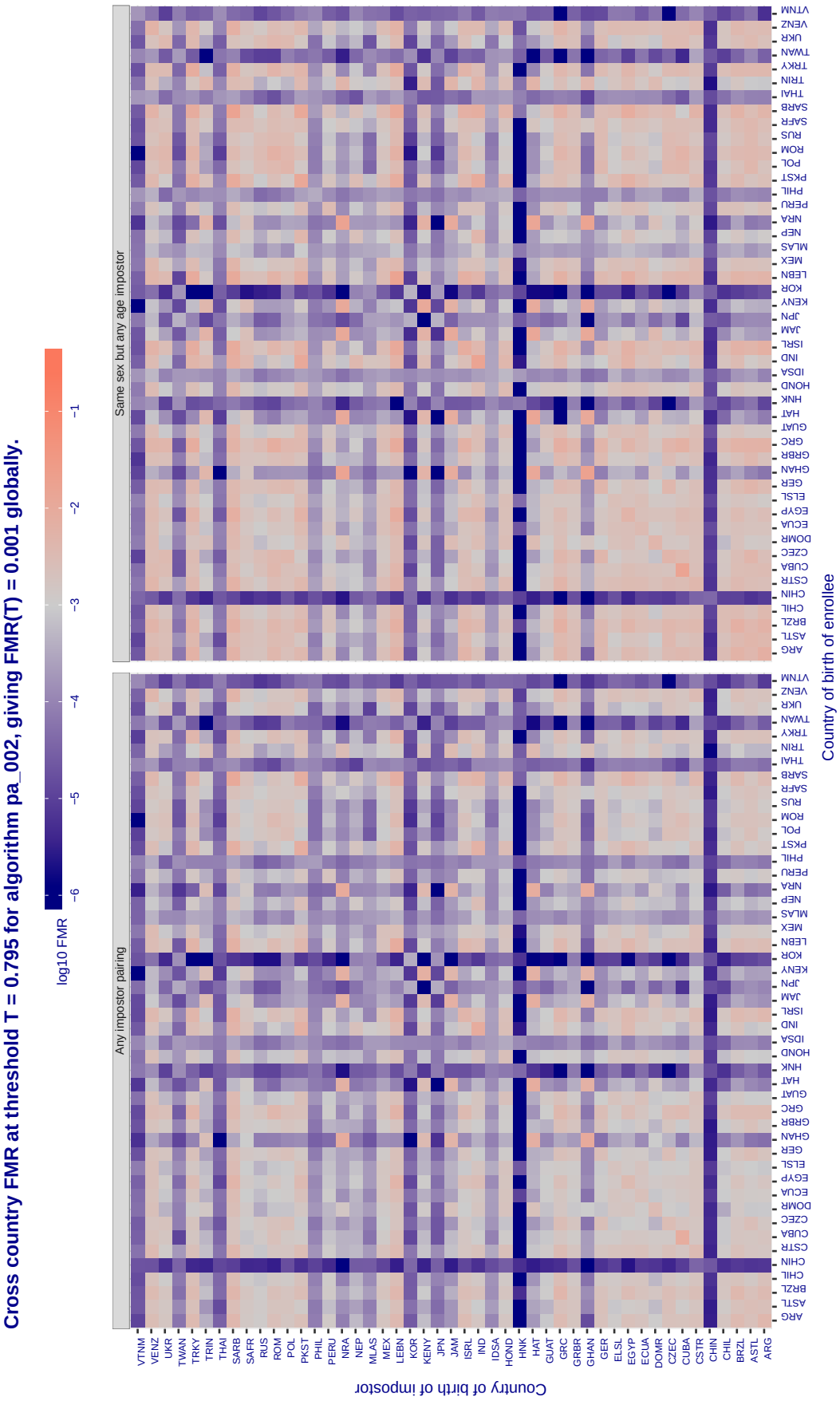


Figure 169: For algorithm pa-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

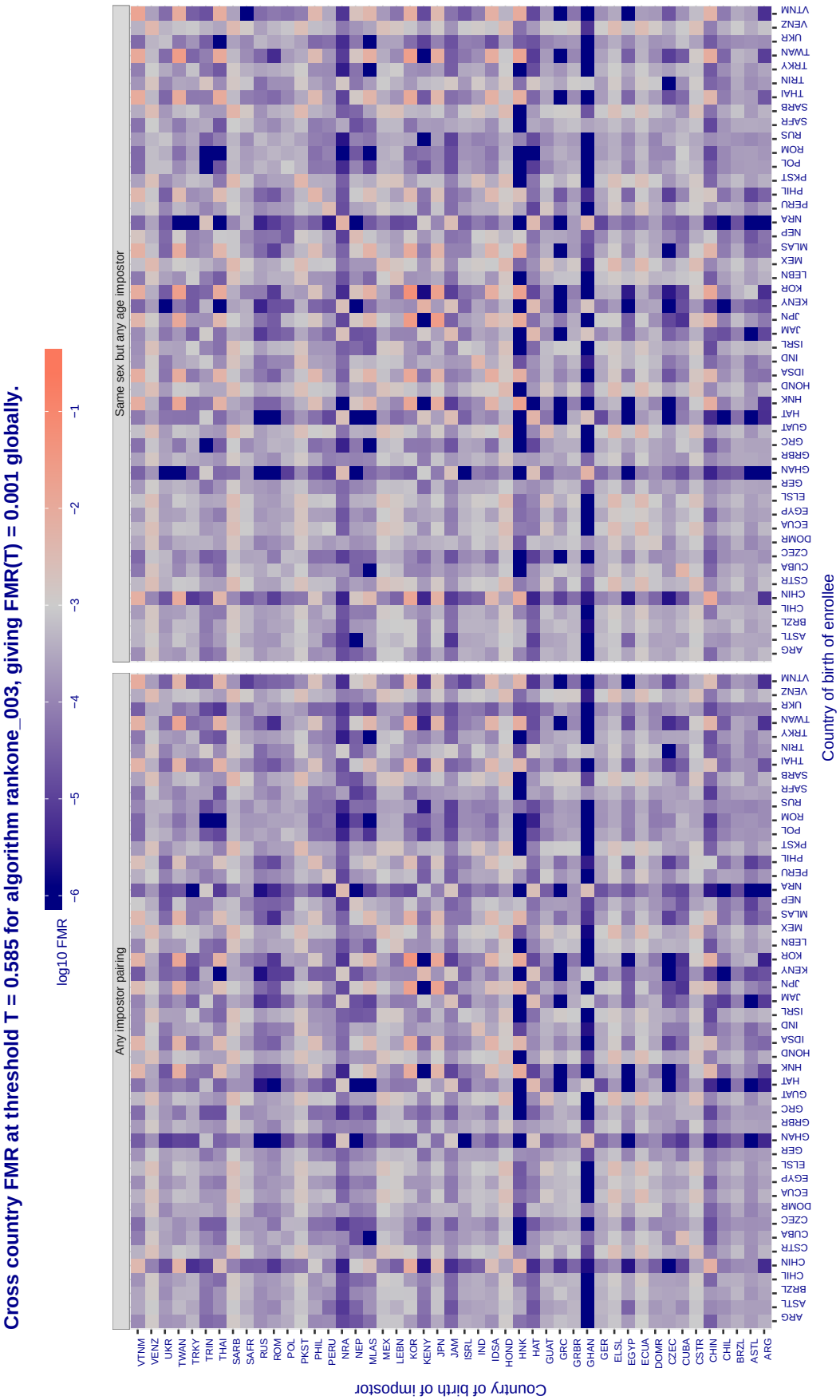


Figure 170: For algorithm rankone-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

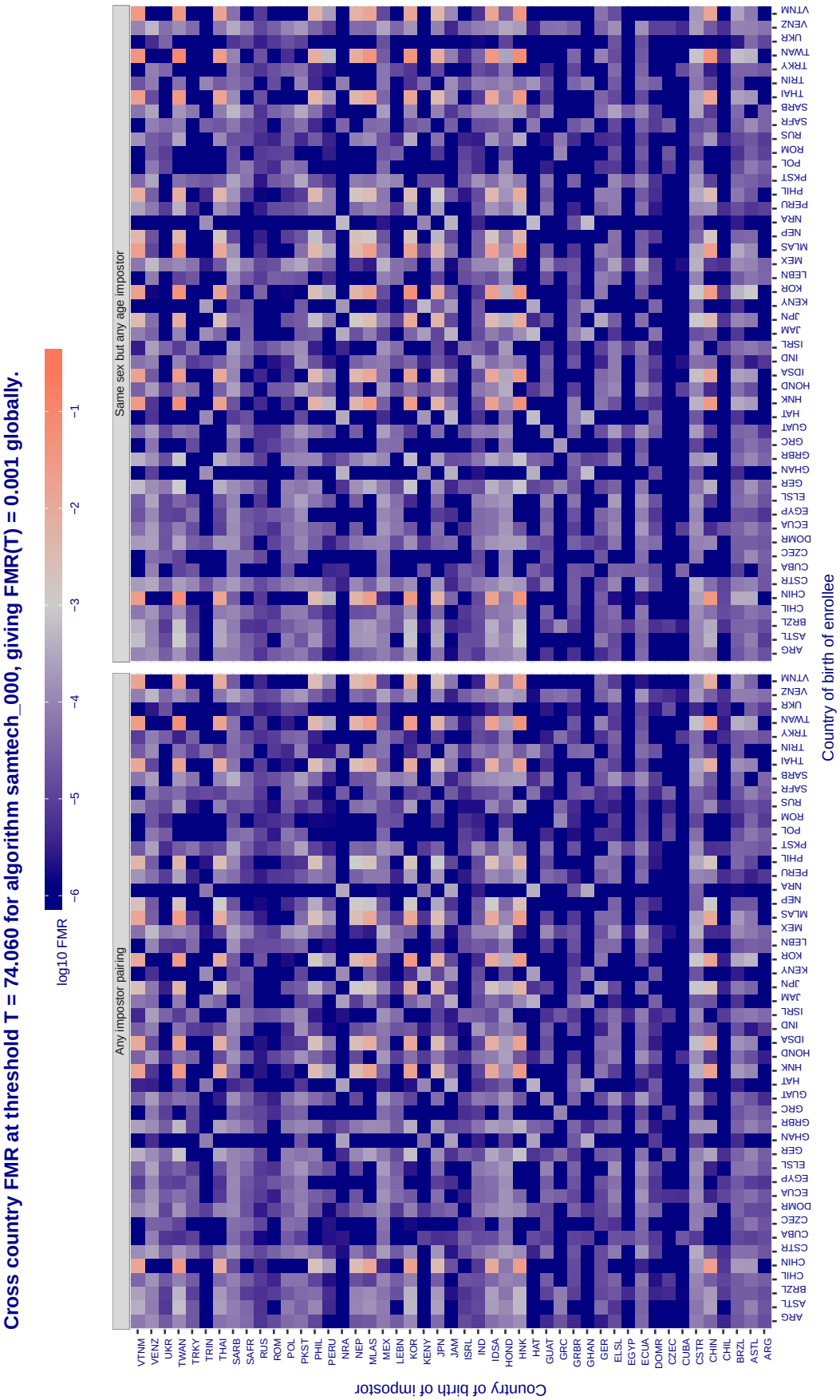


Figure 171: For algorithm samtech-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

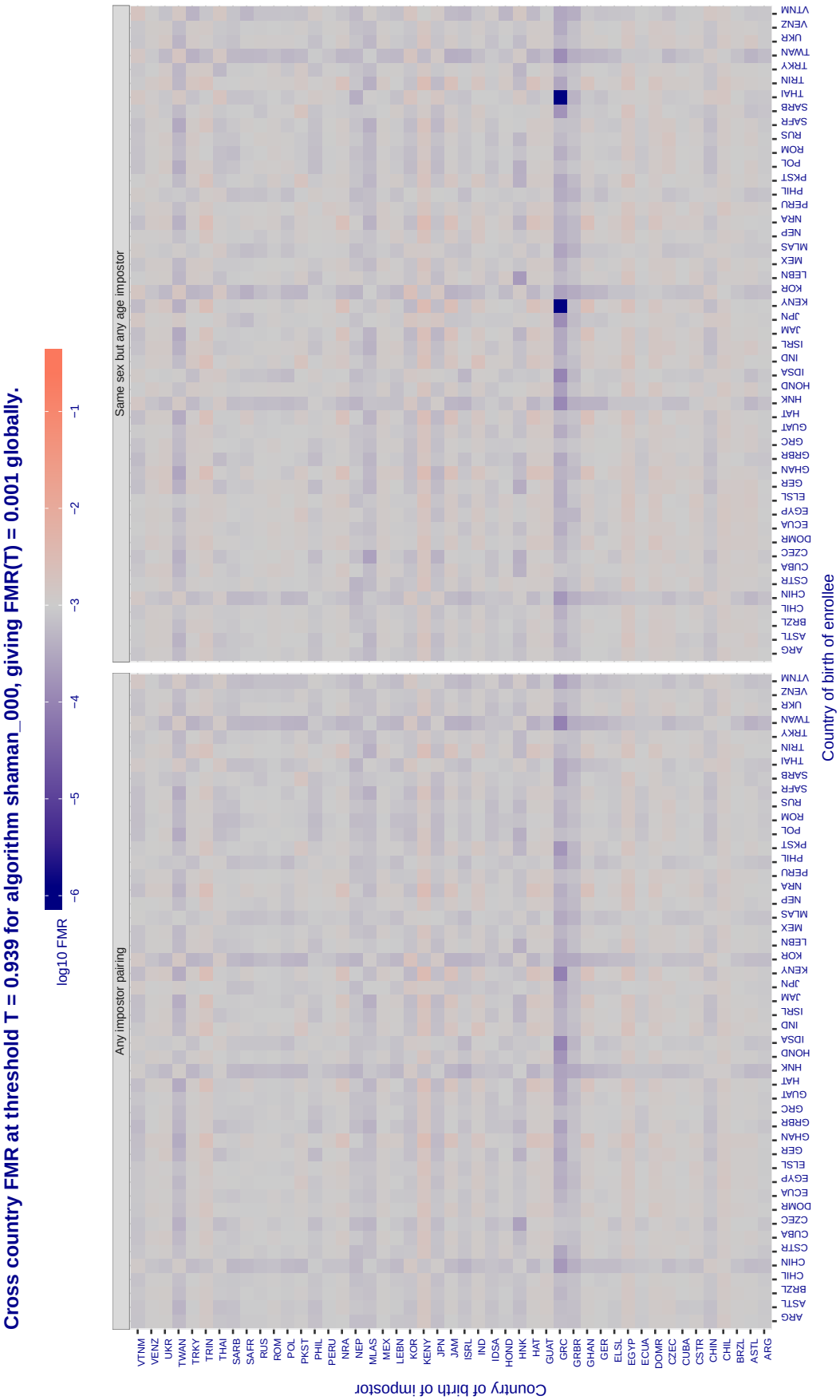


Figure 172: For algorithm shaman-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

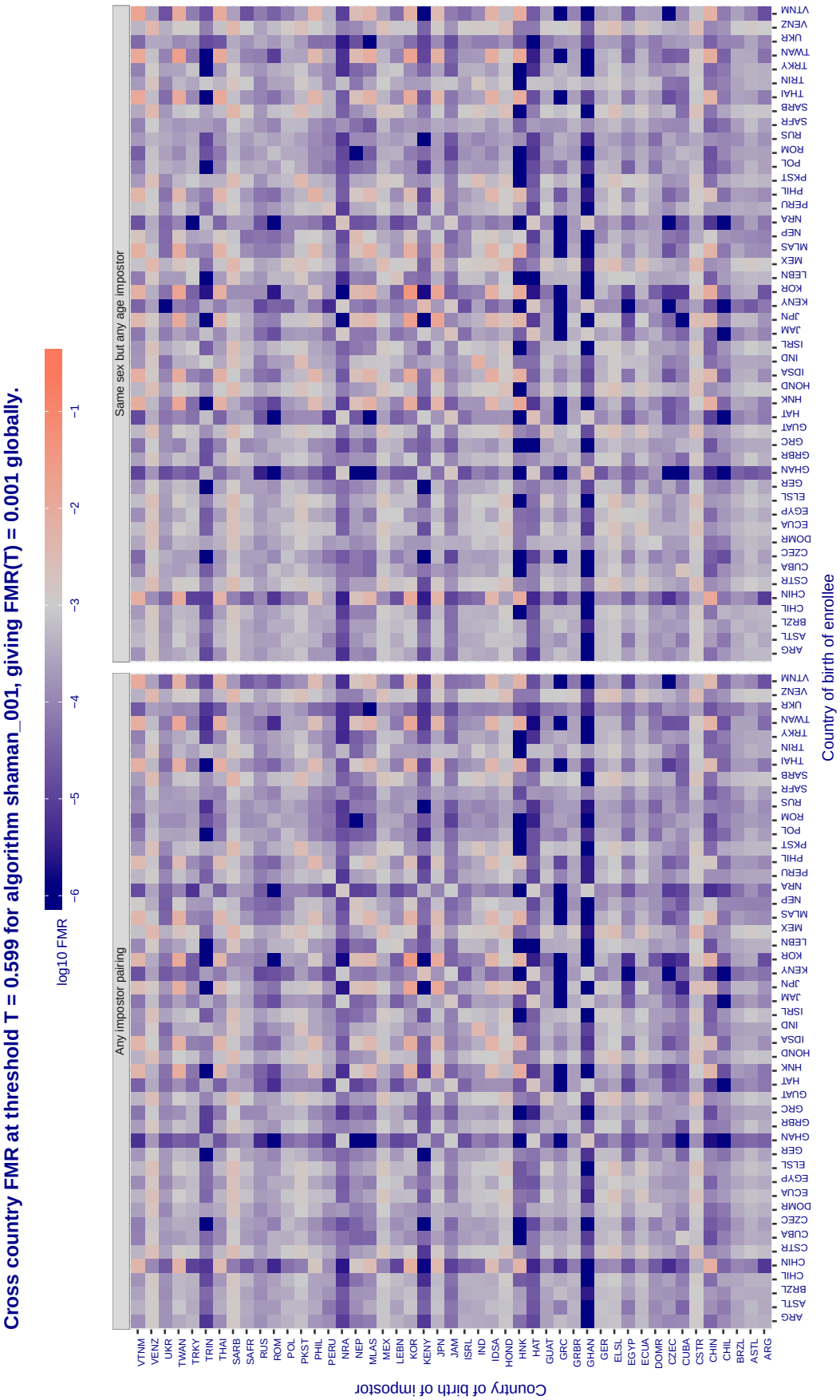


Figure 173: For algorithm shaman-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

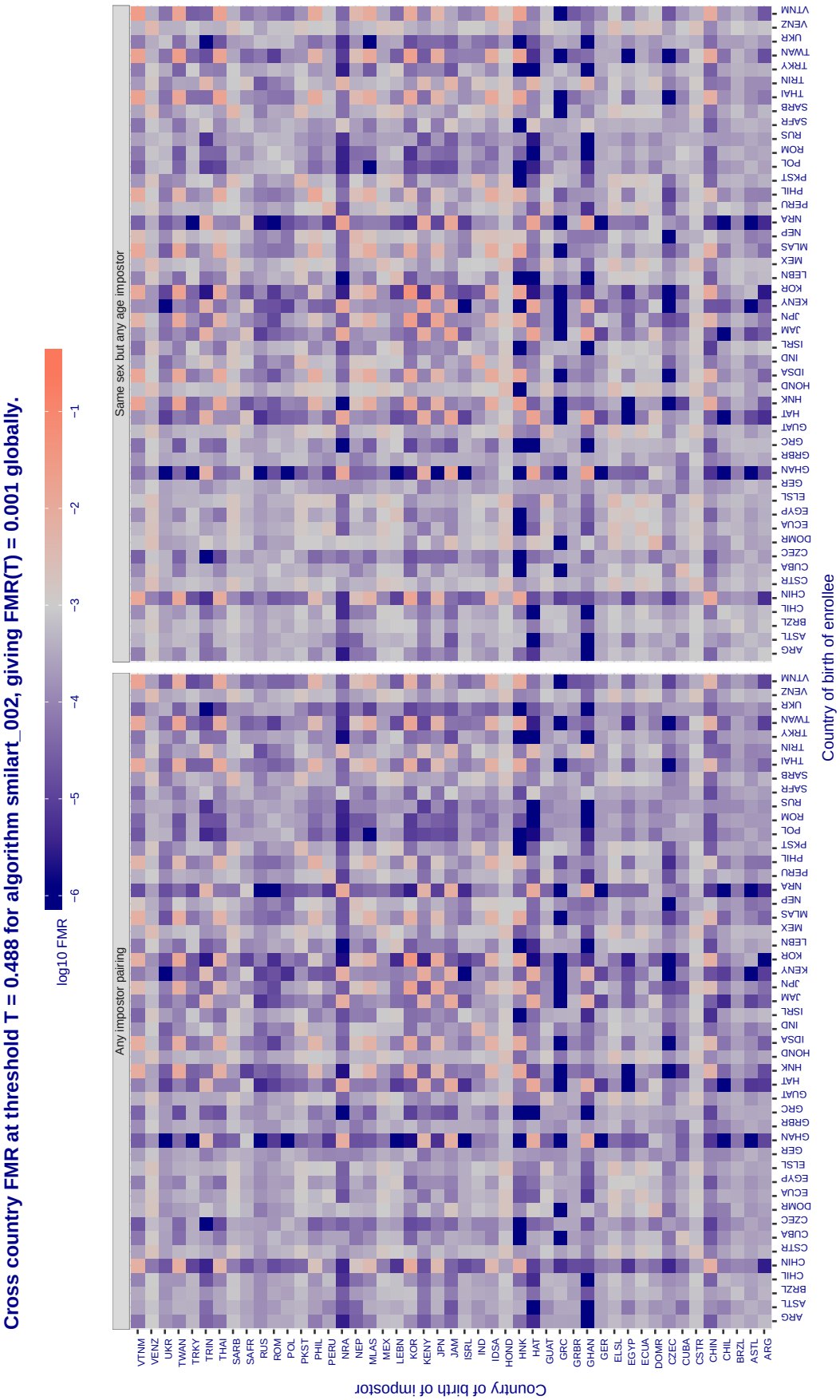


Figure 174: For algorithm smilart-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

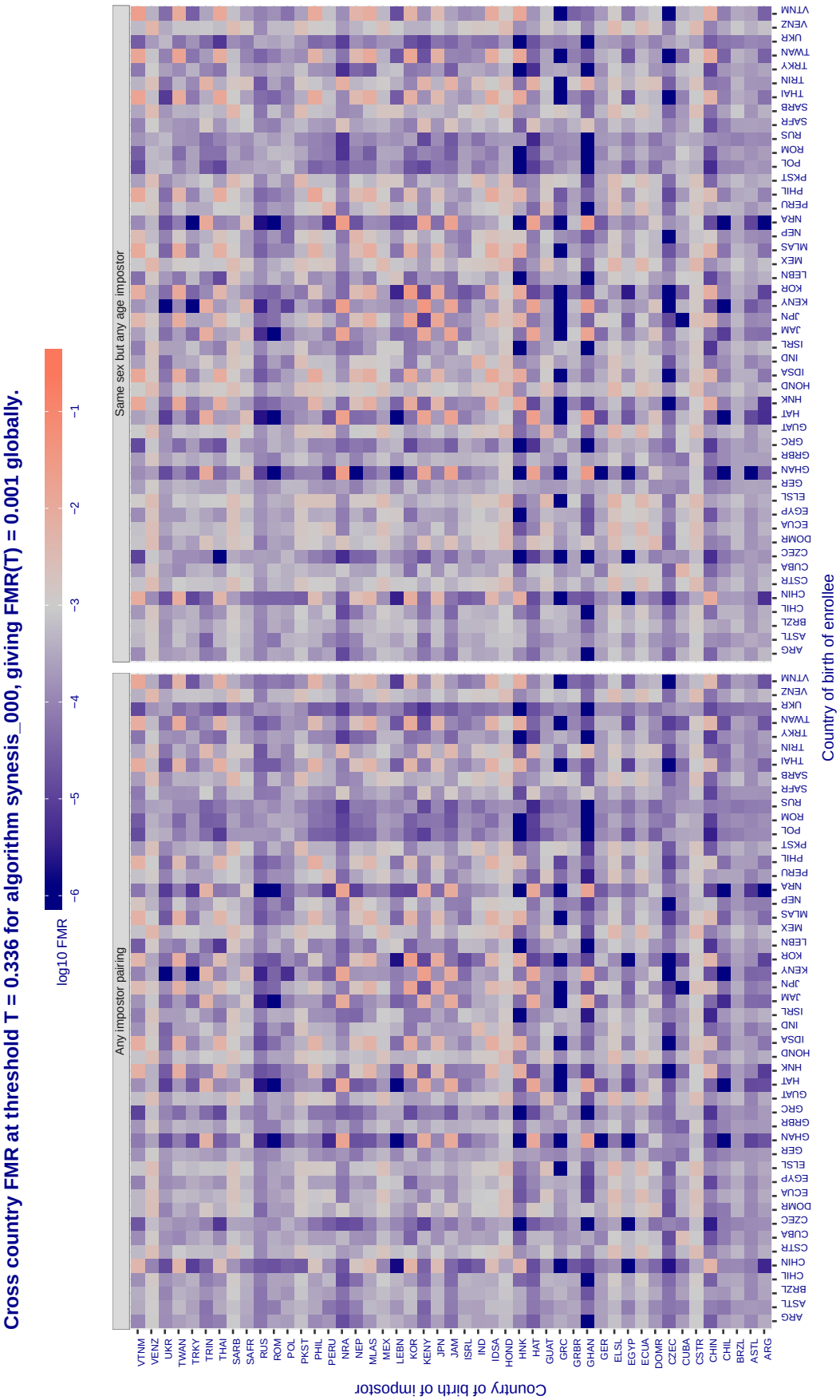


Figure 175: For algorithm synesis-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

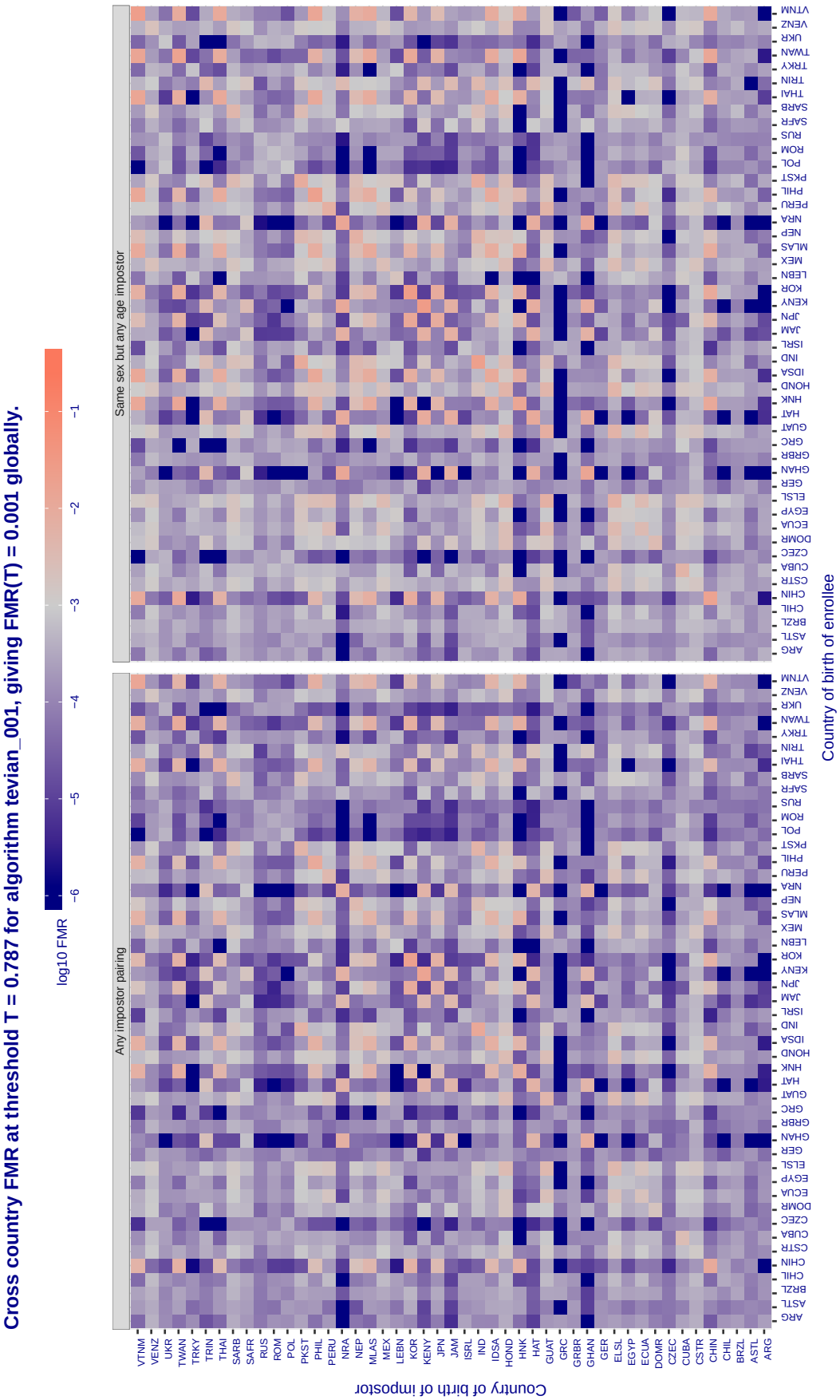


Figure 176: For algorithm tevian-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

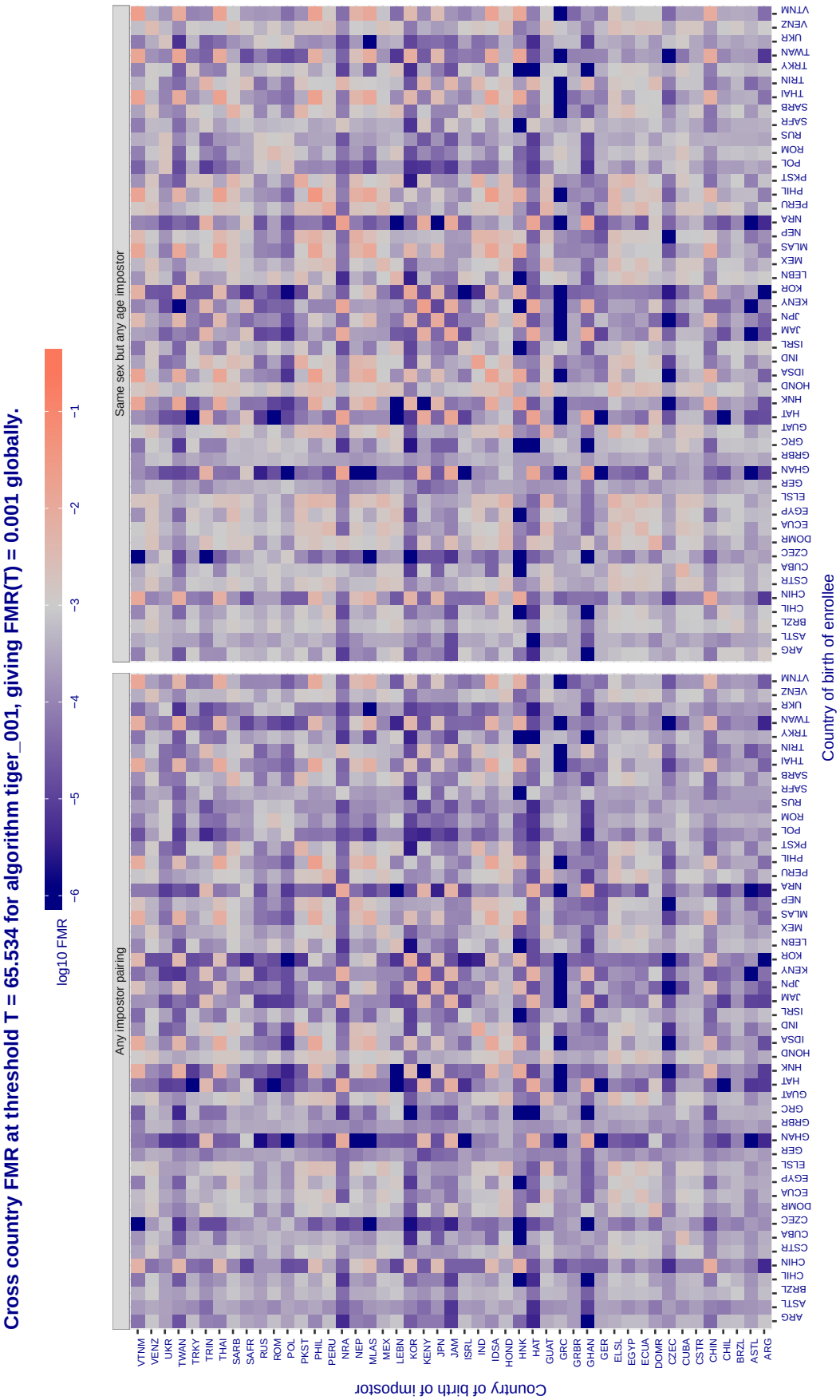


Figure 177: For algorithm tiger-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

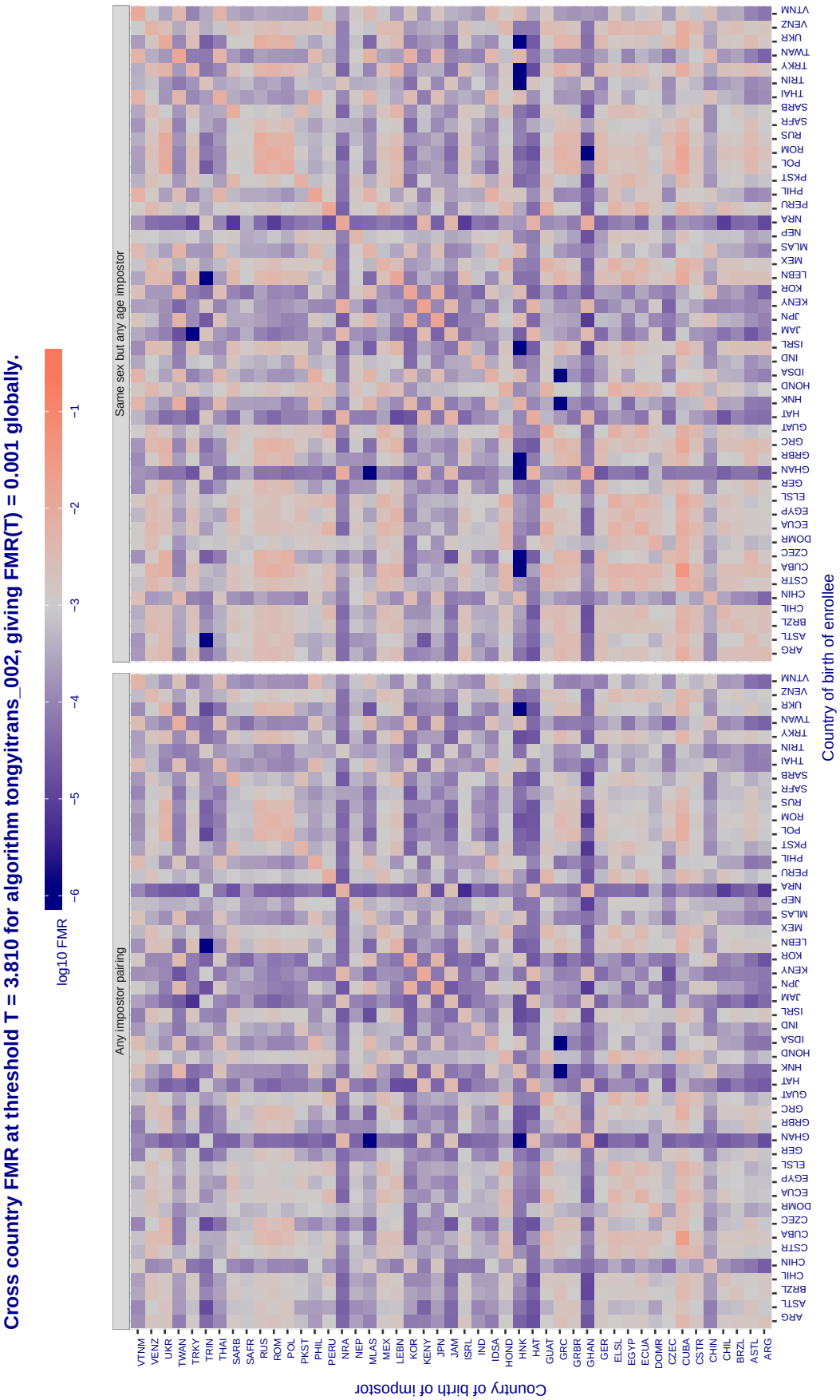


Figure 178: For algorithm tongyitrans-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

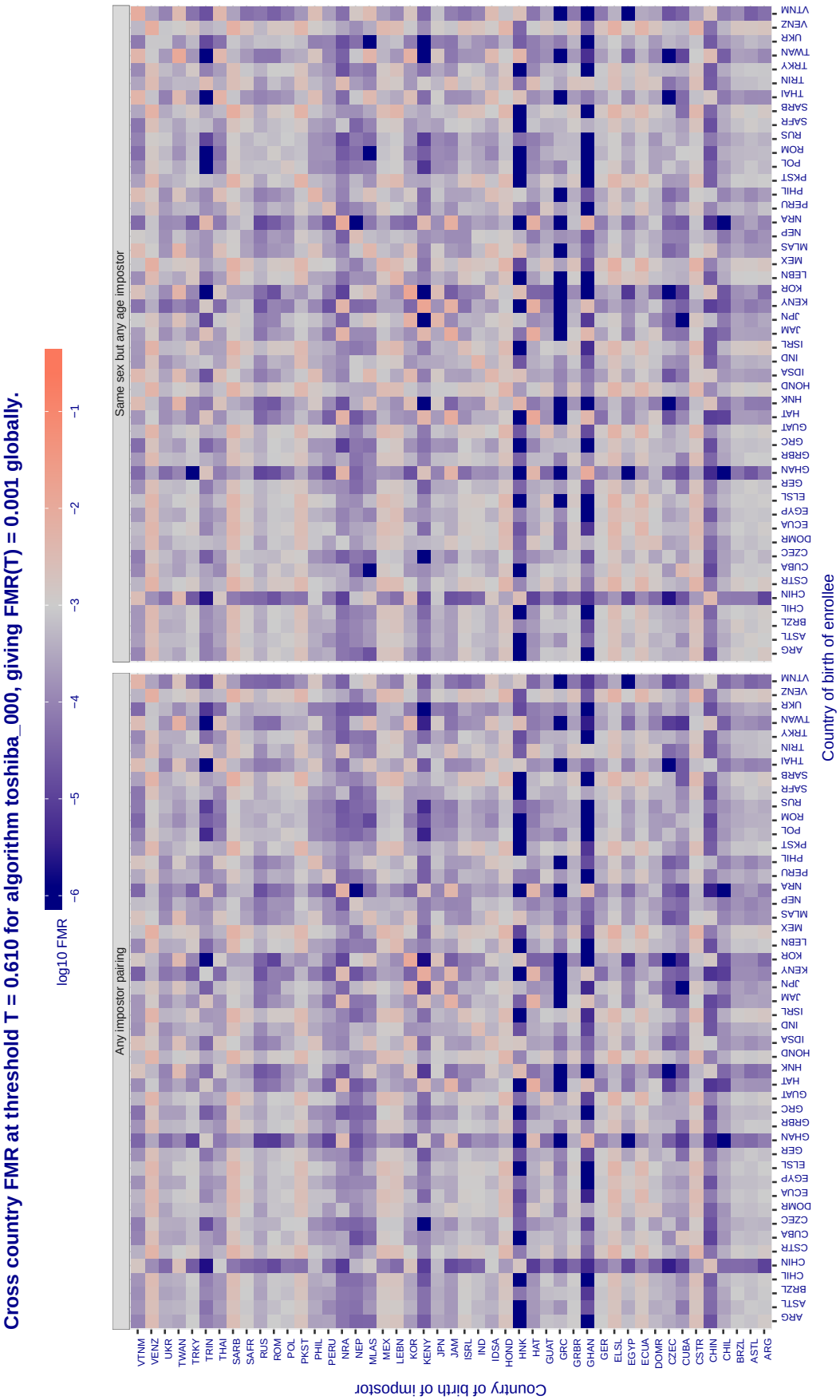


Figure 179: For algorithm toshiba-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

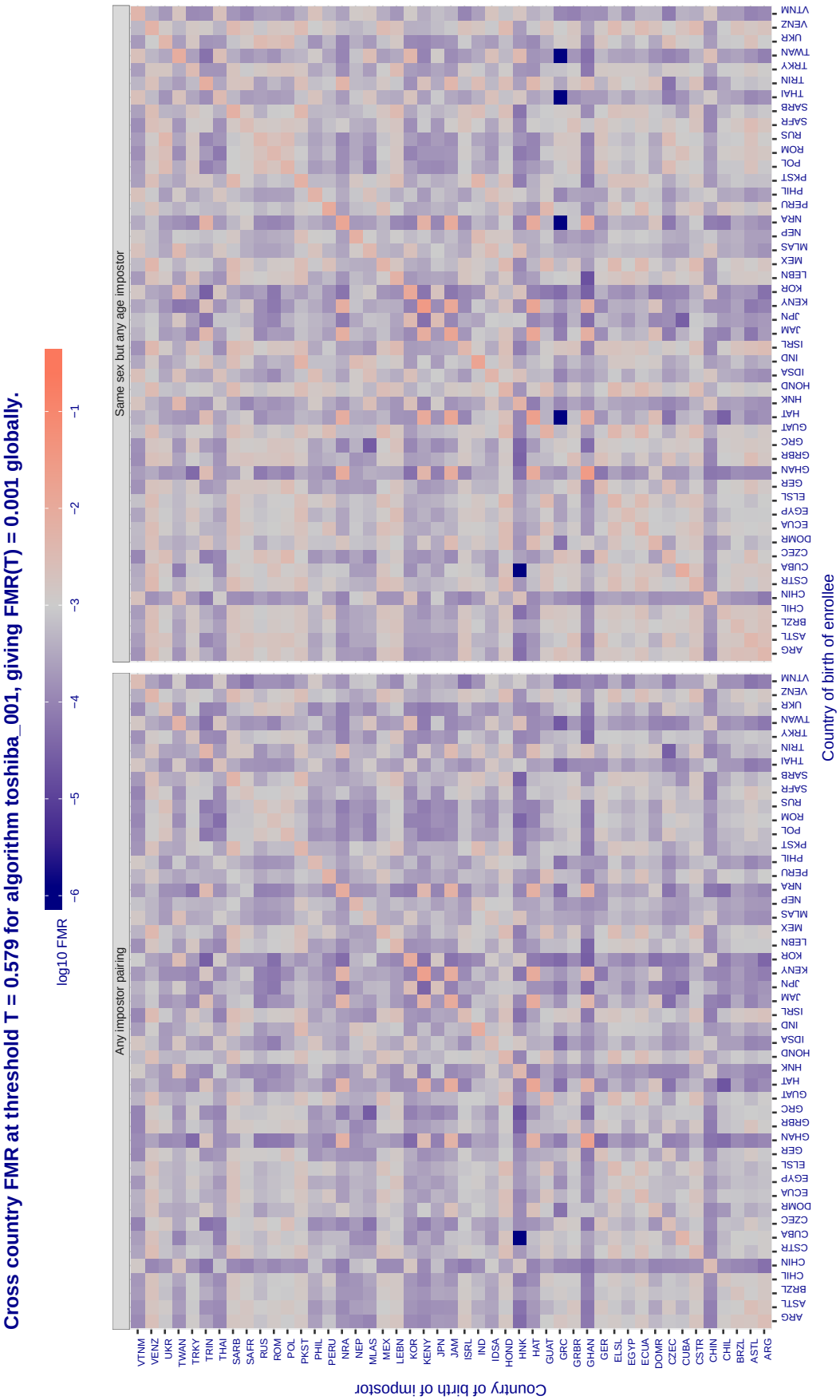


Figure 180: For algorithm toshiba-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

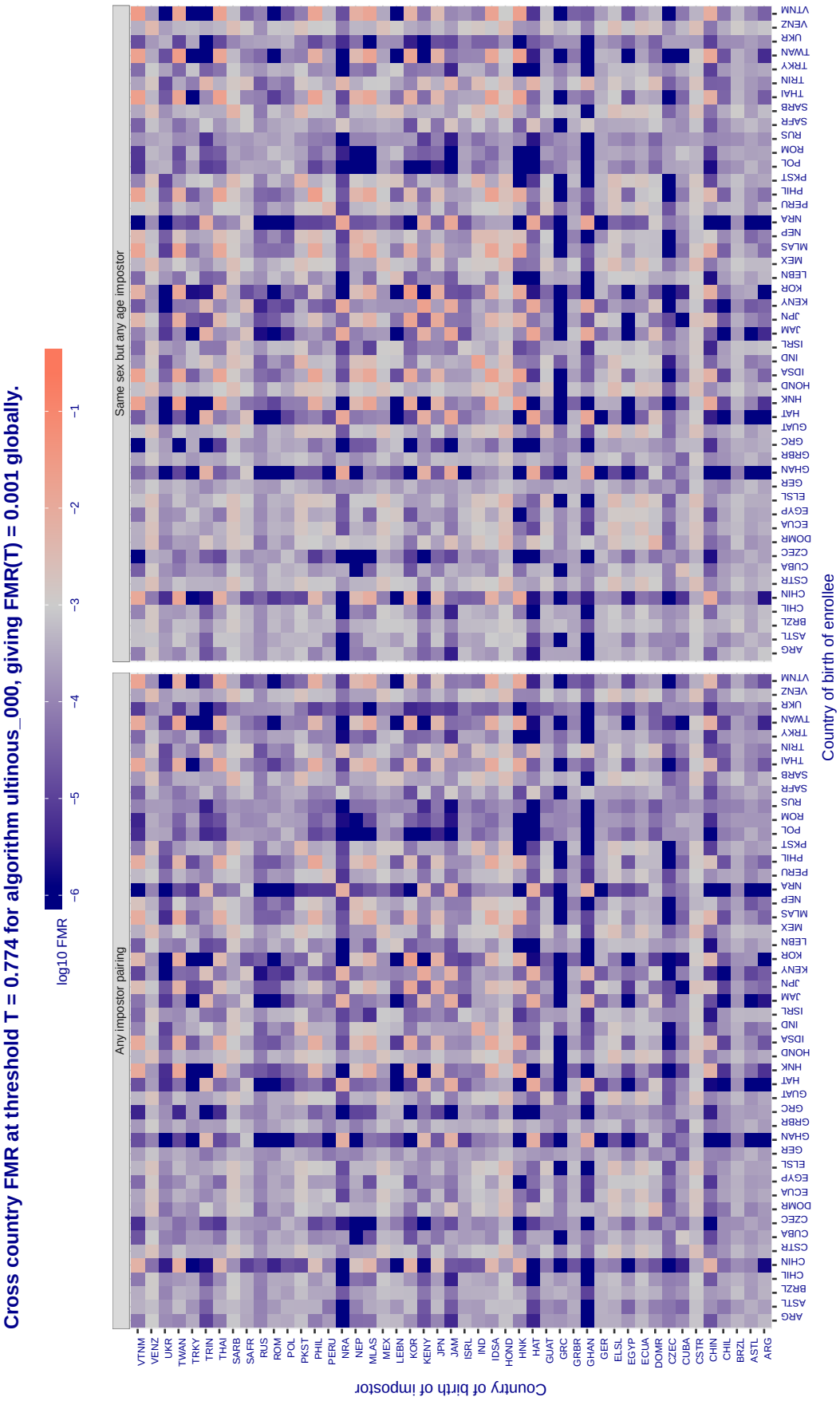


Figure 181: For algorithm ultinous-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

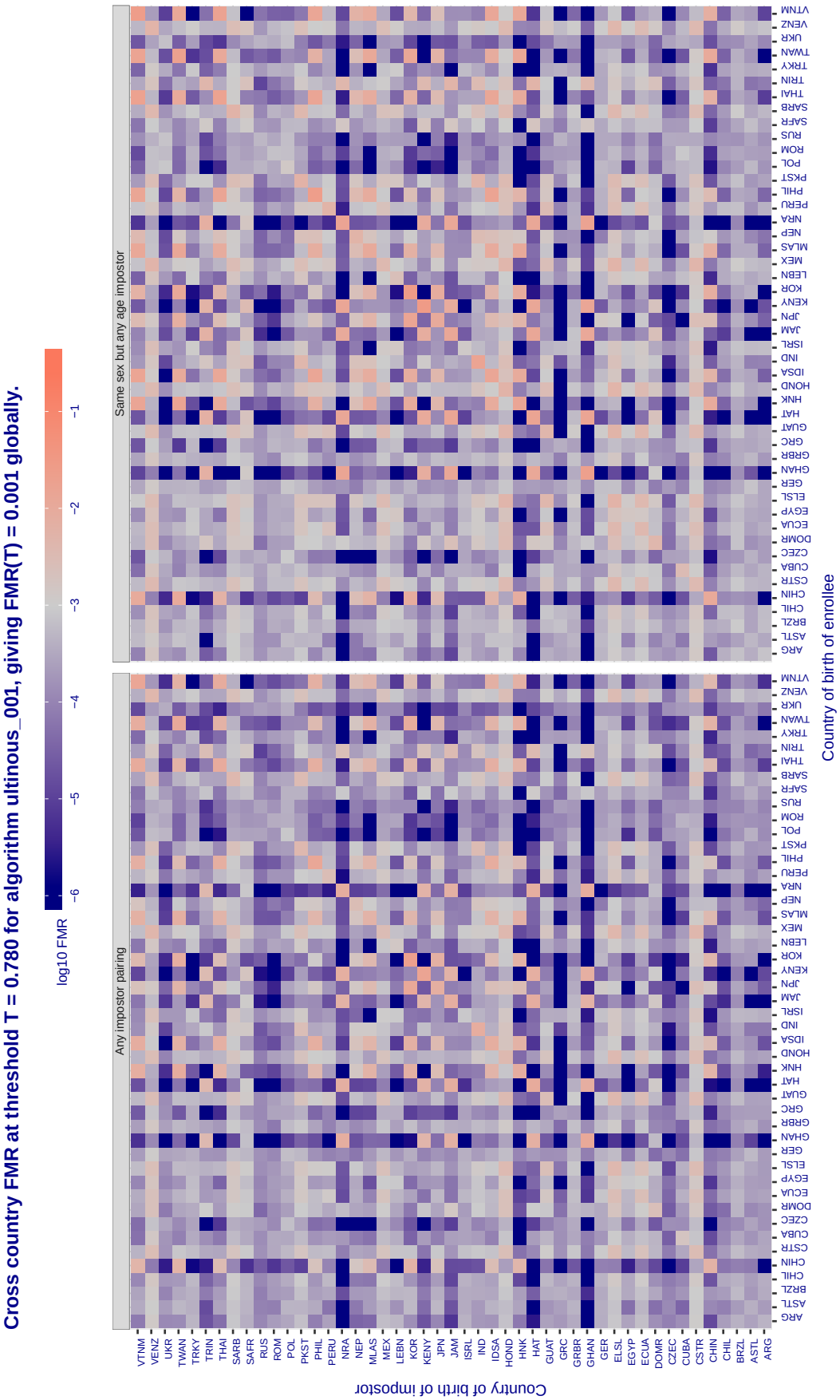


Figure 182: For algorithm ultinous-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

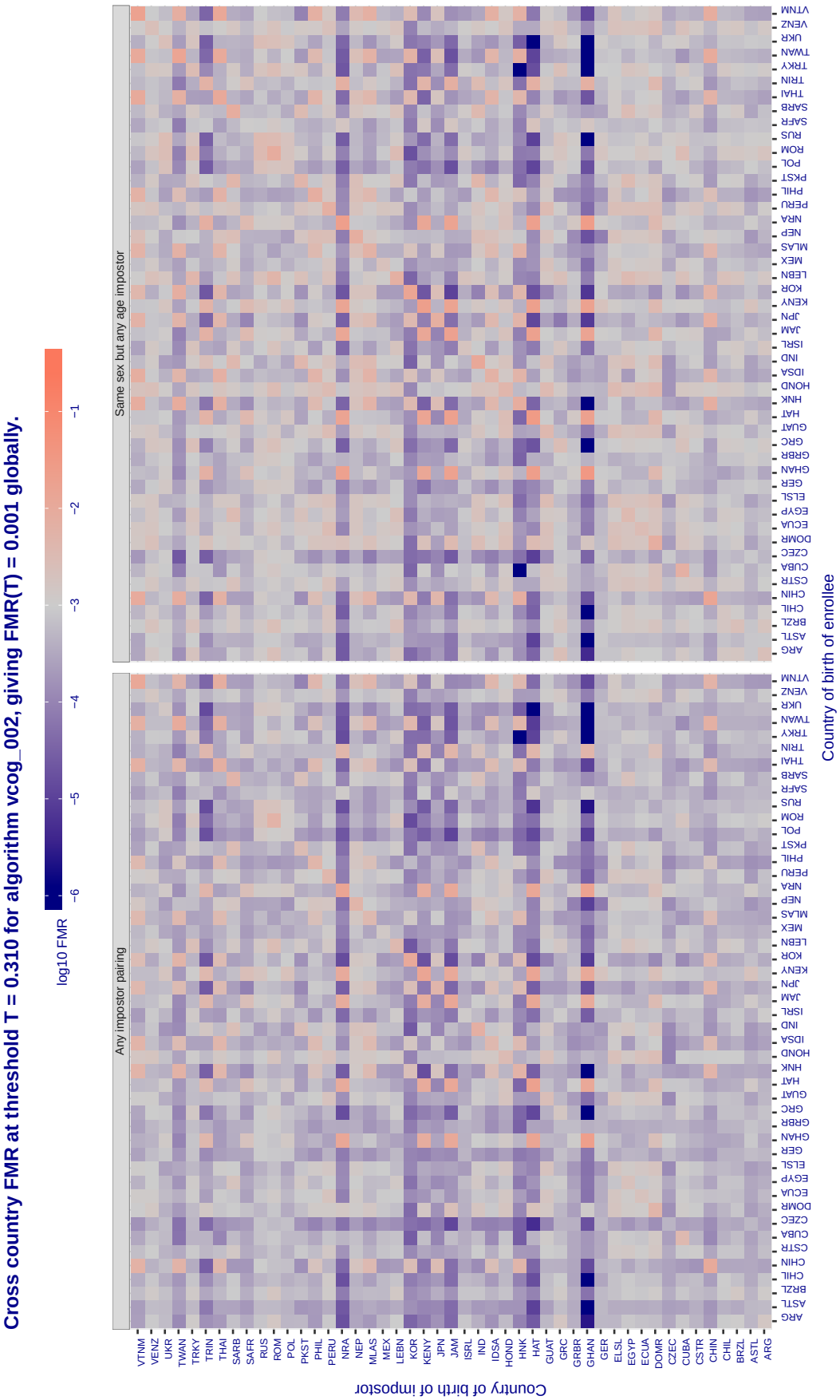


Figure 183: For algorithm vcog-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

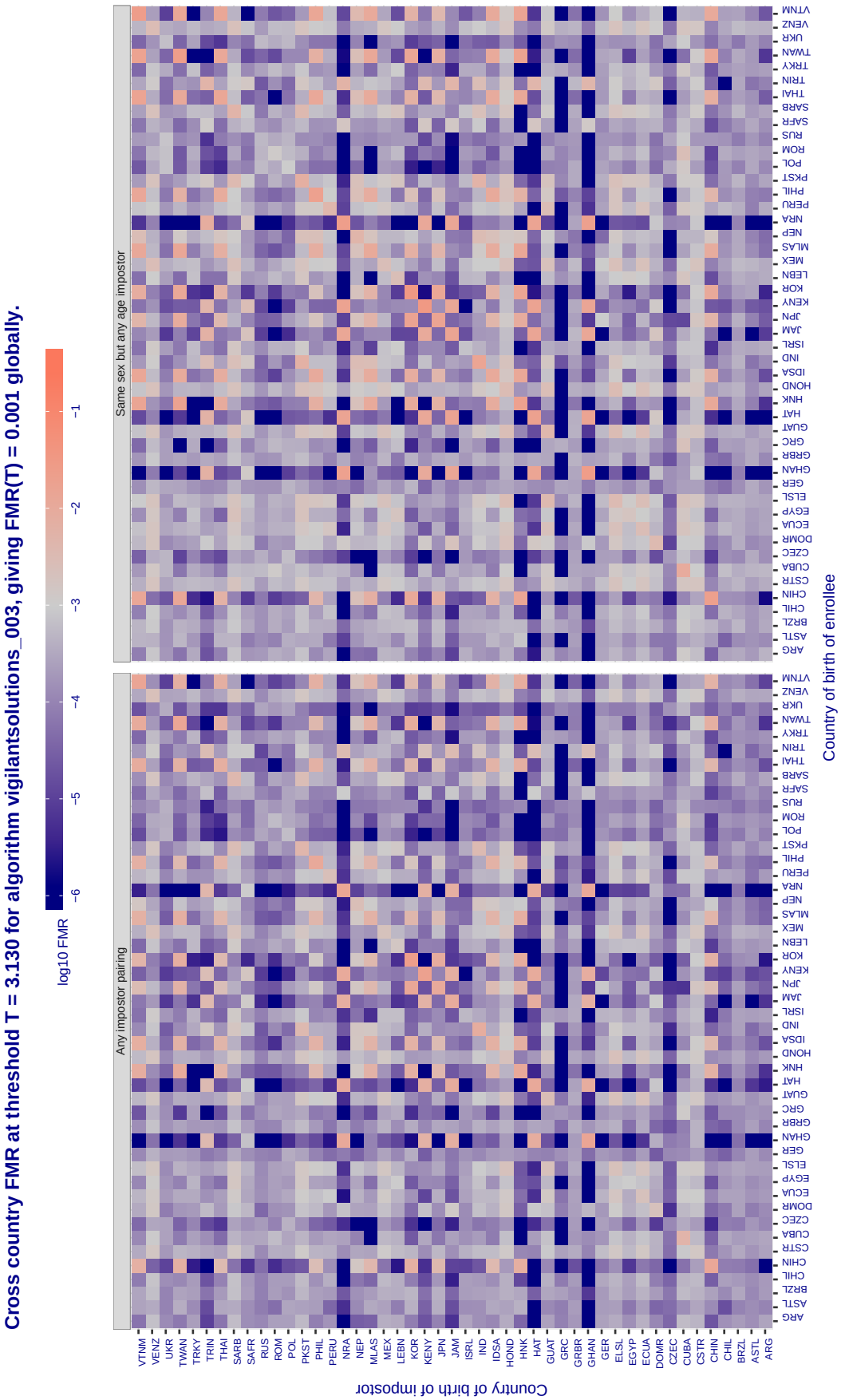


Figure 184: For algorithm vigilantsolutions-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

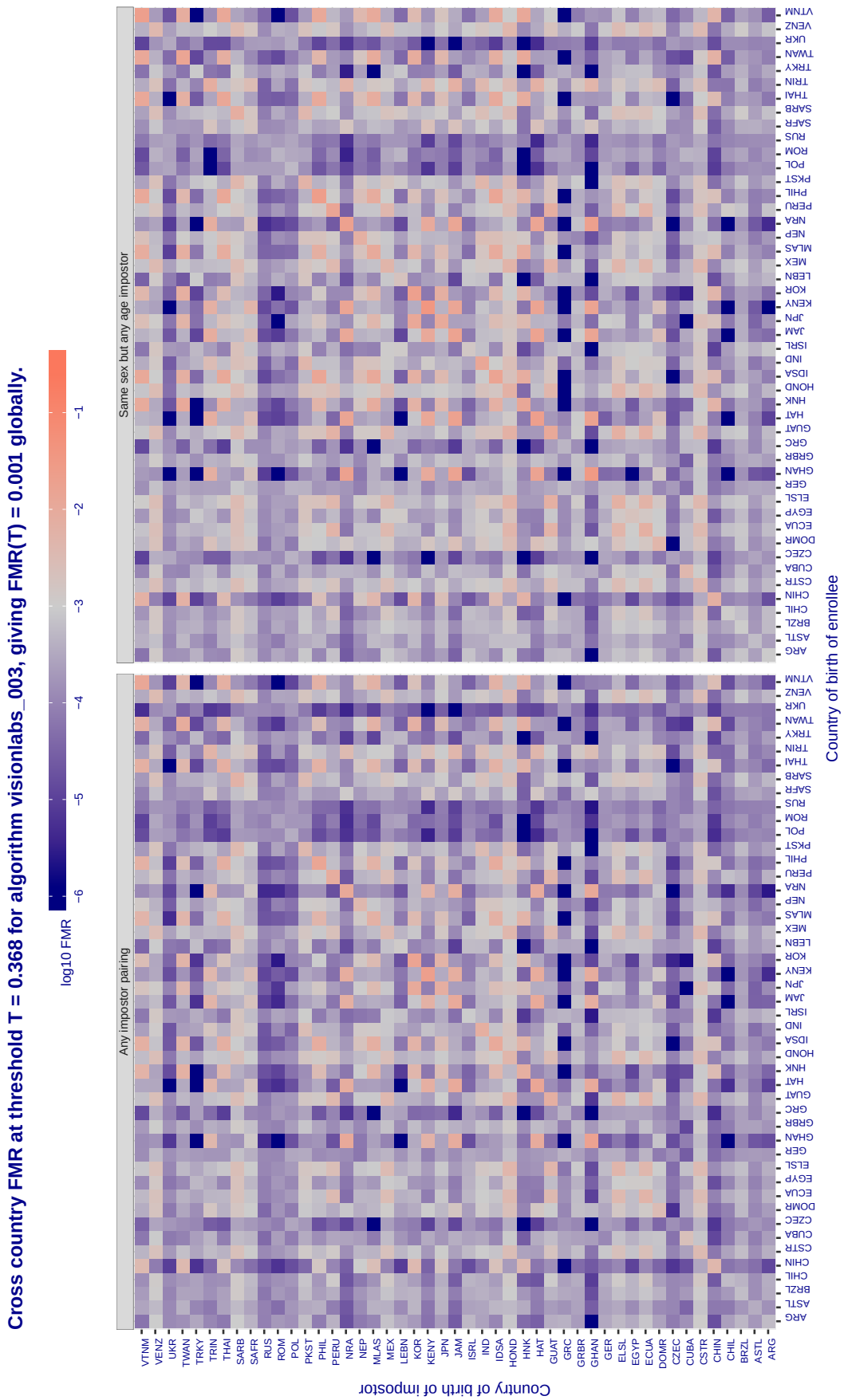


Figure 185: For algorithm visionlabs-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

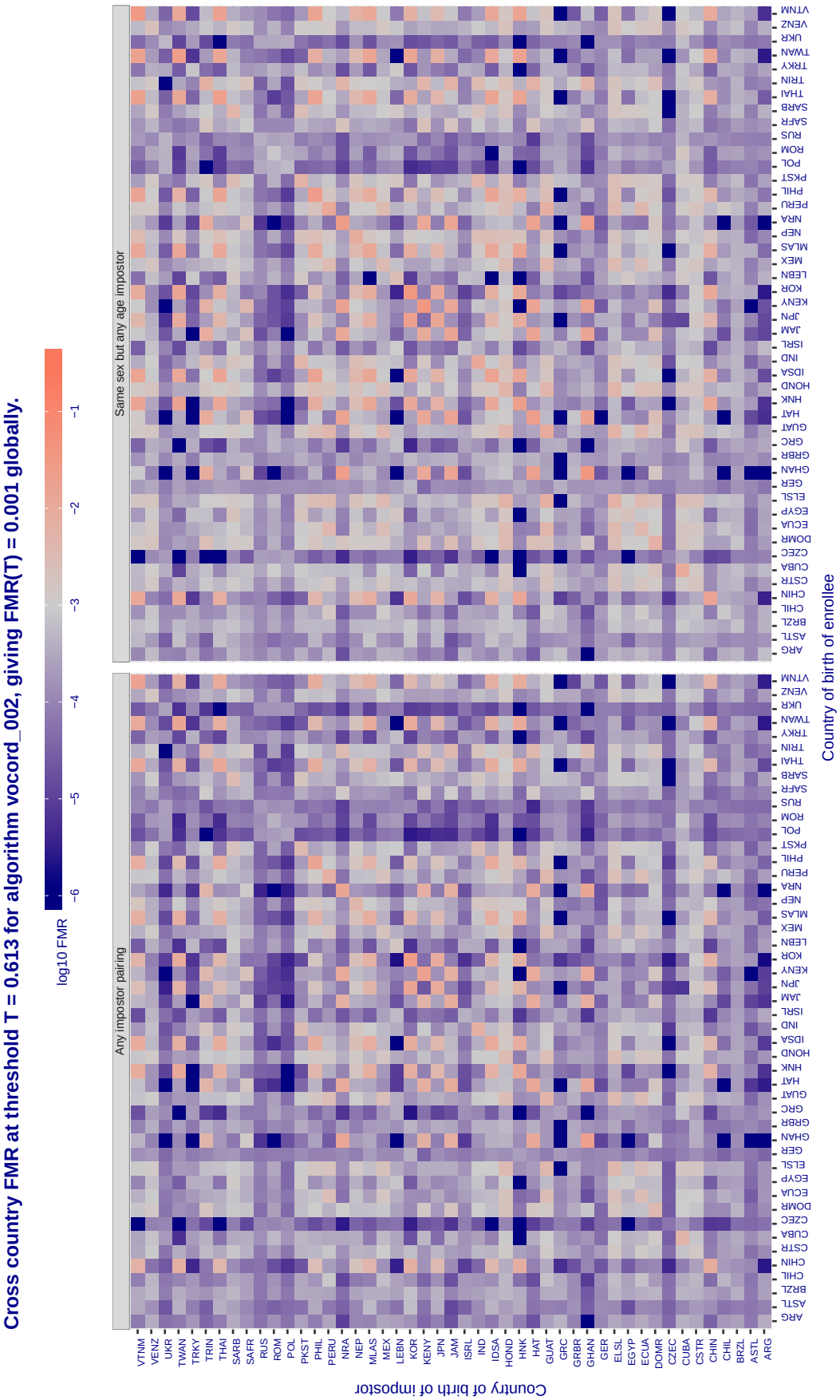


Figure 186: For algorithm vocord-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

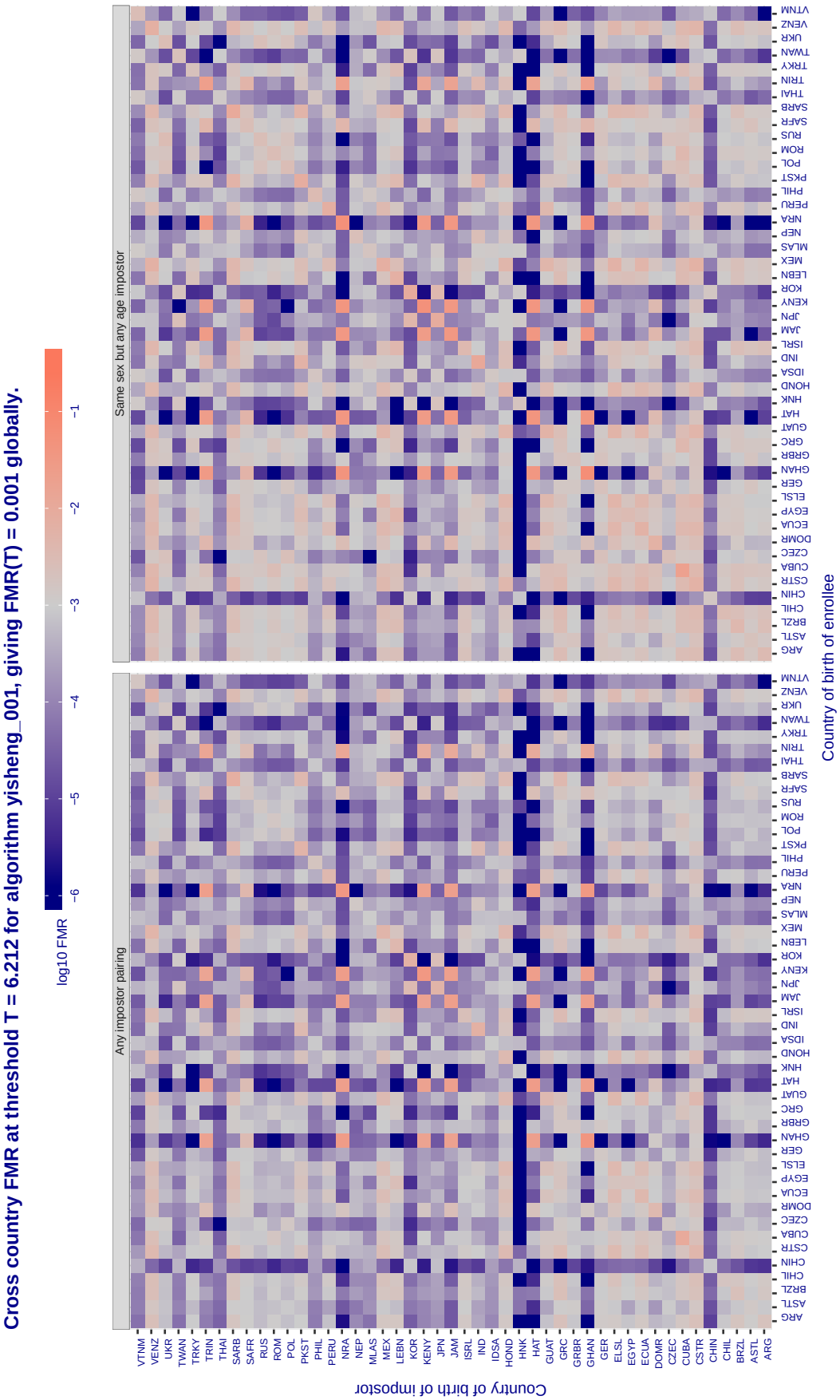


Figure 187: For algorithm yisheng-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

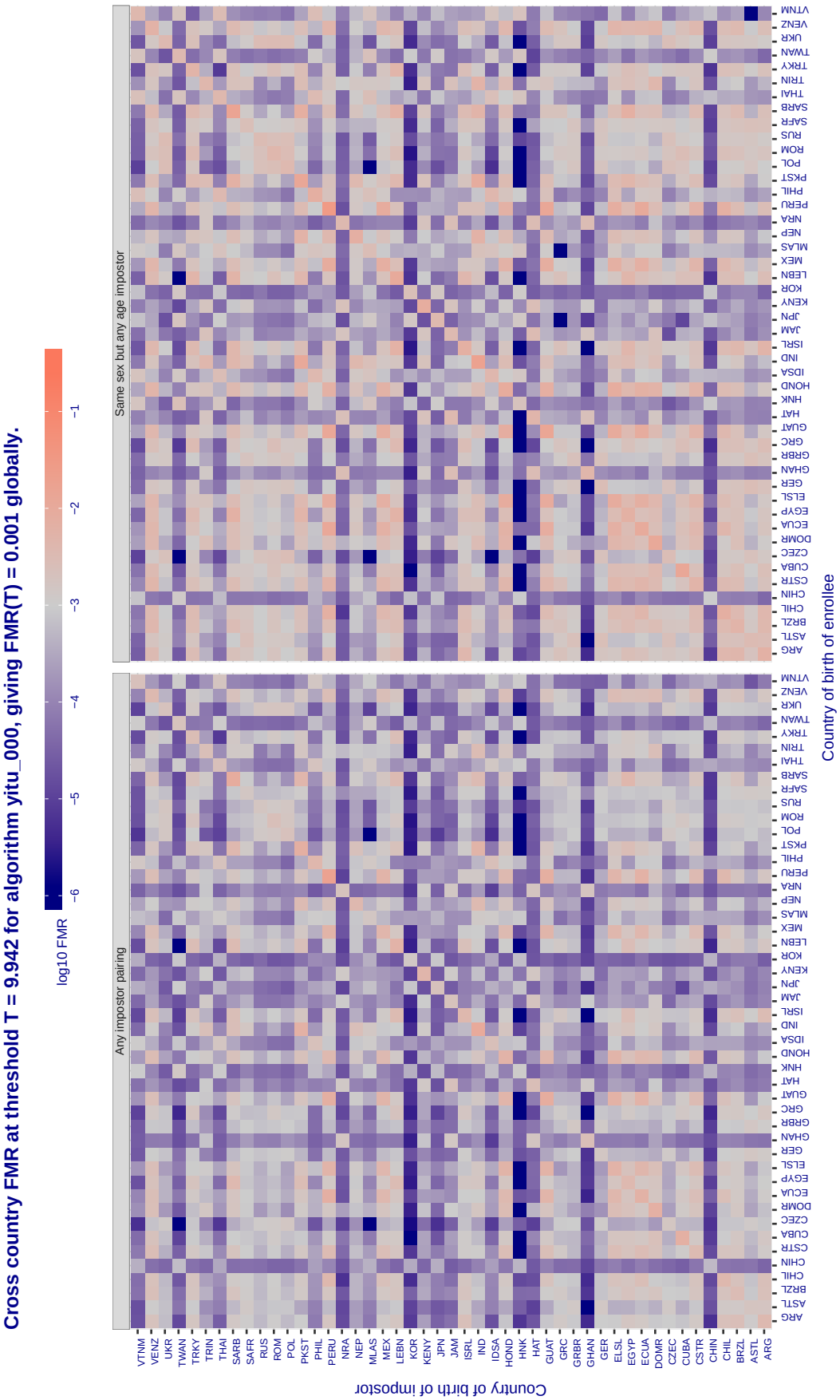


Figure 188: For algorithm yitu-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of 10^{10} impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

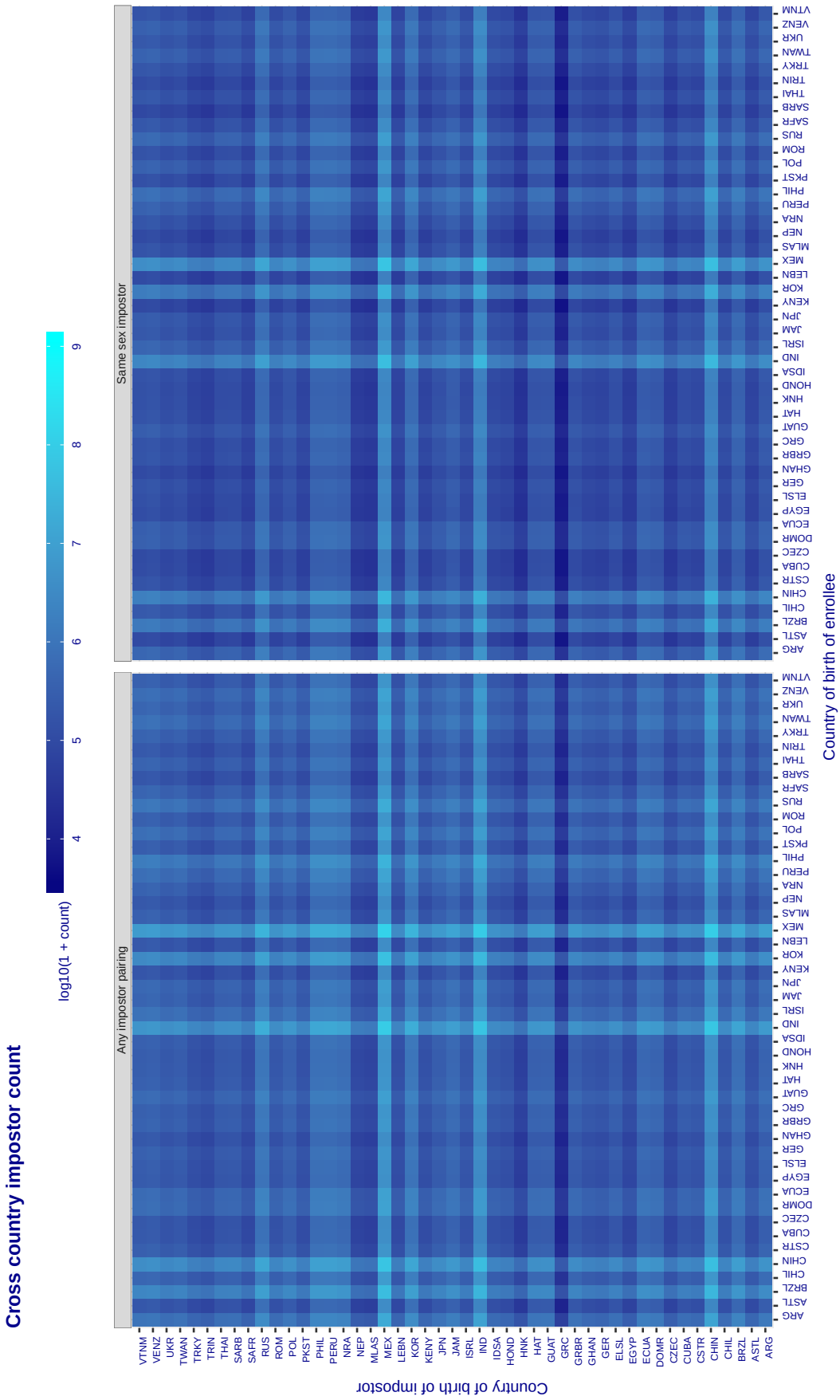


Figure 189: For visa images, the heatmap shows the count of impostor comparisons of faces from different individuals who were born in the given country pair.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

5.6.2 Effect of age on impostors

Background: This section shows the effect of age on the impostor distribution. The ideal behaviour is that the age of the enrollee and the impostor would not affect impostor scores. This would support FMR stability over sub-populations.

Goals:

- ▷ To show the effect of relative ages of the impostor and enrollee on false match rates.
- ▷ To determine whether some algorithms have better impostor distribution stability.

Methods:

- ▷ Define 14 age group bins, spanning 0 to over 100 years old.
- ▷ Compute FMR over all impostor comparisons for which the subjects in the enrollee and impostor images have ages in two bins.
- ▷ Compute FMR over all impostor comparisons for which the subjects are additionally of the same sex, and born in the same geographic region.

Results:

The notable aspects are:

- ▷ Diagonal dominance: Impostors are more likely to be matched against their same age group.
- ▷ Same sex and same region impostors are more successful. On the diagonal, an impostor is more likely to succeed by posing as someone of the same sex. If $\Delta \log_{10}$ FMR $= 0.2$, then same-sex same-region FMR exceeds the all-pairs FMR by factor of $10^{0.2} = 1.6$.
- ▷ Young children impostors give elevated FMR against young children. Older adult impostor give elevated FMR against older adults. These effects are quite large, for example if $\Delta \log_{10}$ FMR $= 1.0$ larger than a 32 year old, then these groups have higher FMR by a factor of $10^1 = 10$. This would imply an FMR above 0.01 for a nominal (global) FMR = 0.001.
- ▷ Algorithms vary.
- ▷ We computed the same quantities for a global FMR = 0.0001. The effects are similar.

Note the calculations in this section include impostors paired across all countries of birth.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

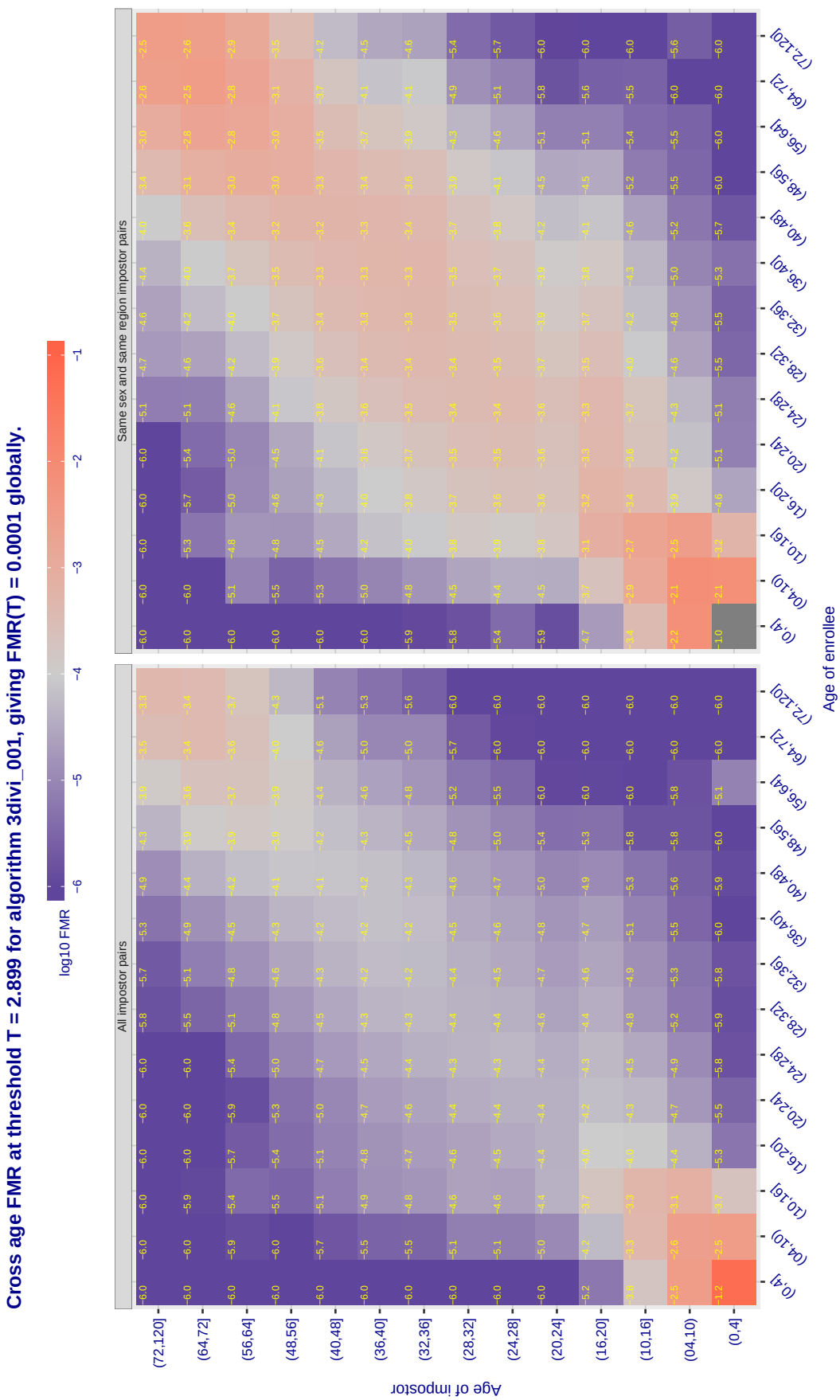


Figure 190: For algorithm 3divi-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

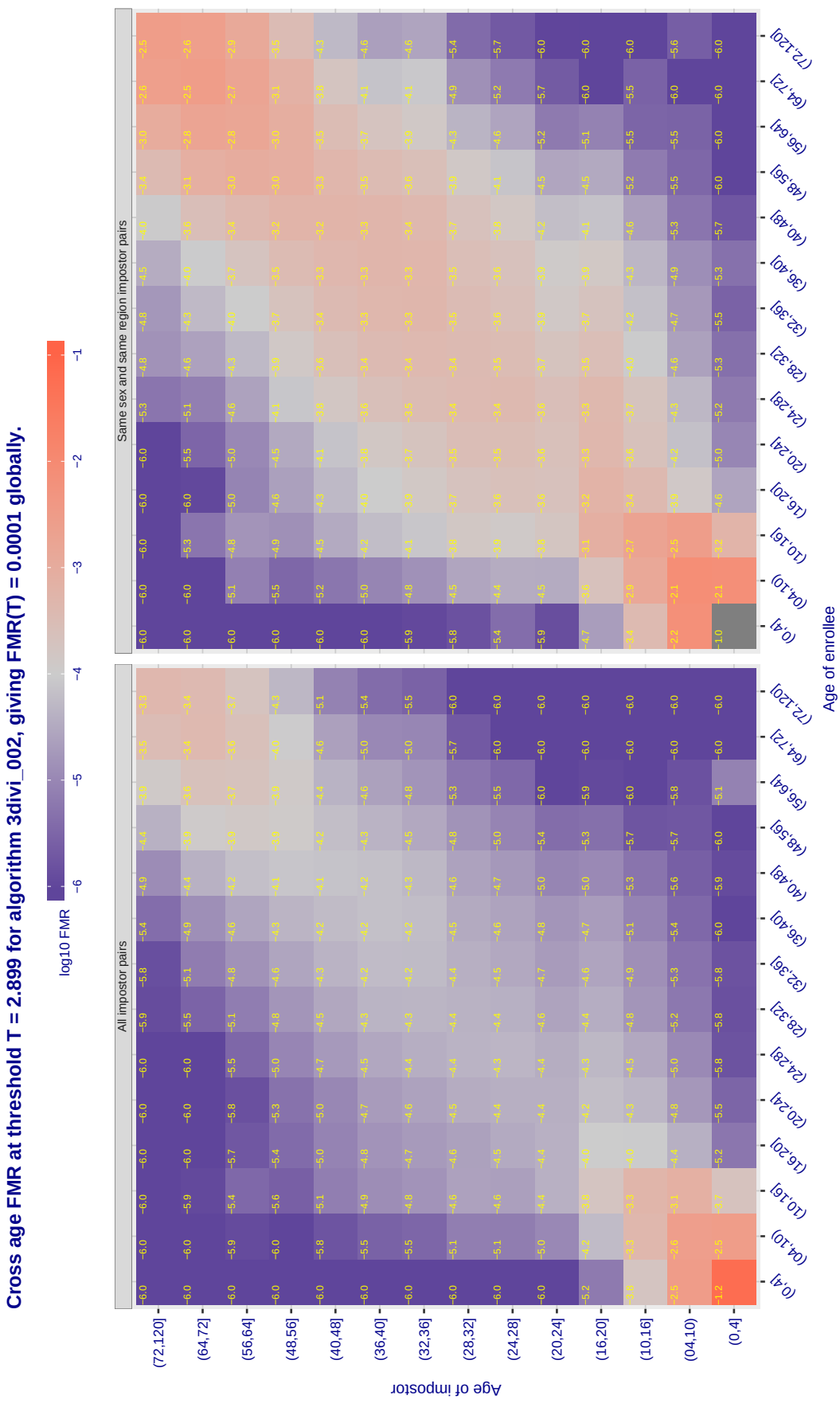


Figure 191: For algorithm 3divi-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

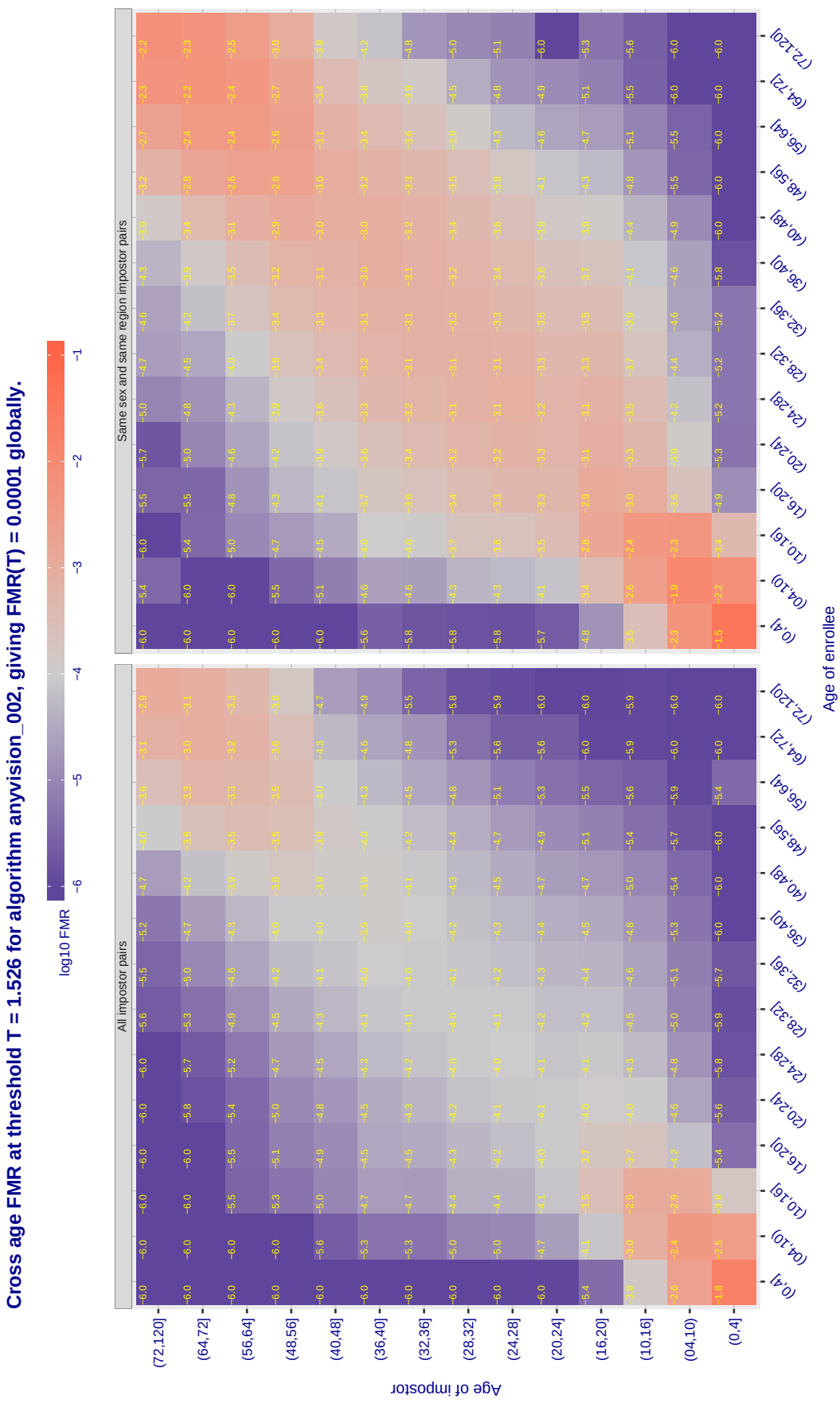


Figure 192: For algorithm anyvision-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

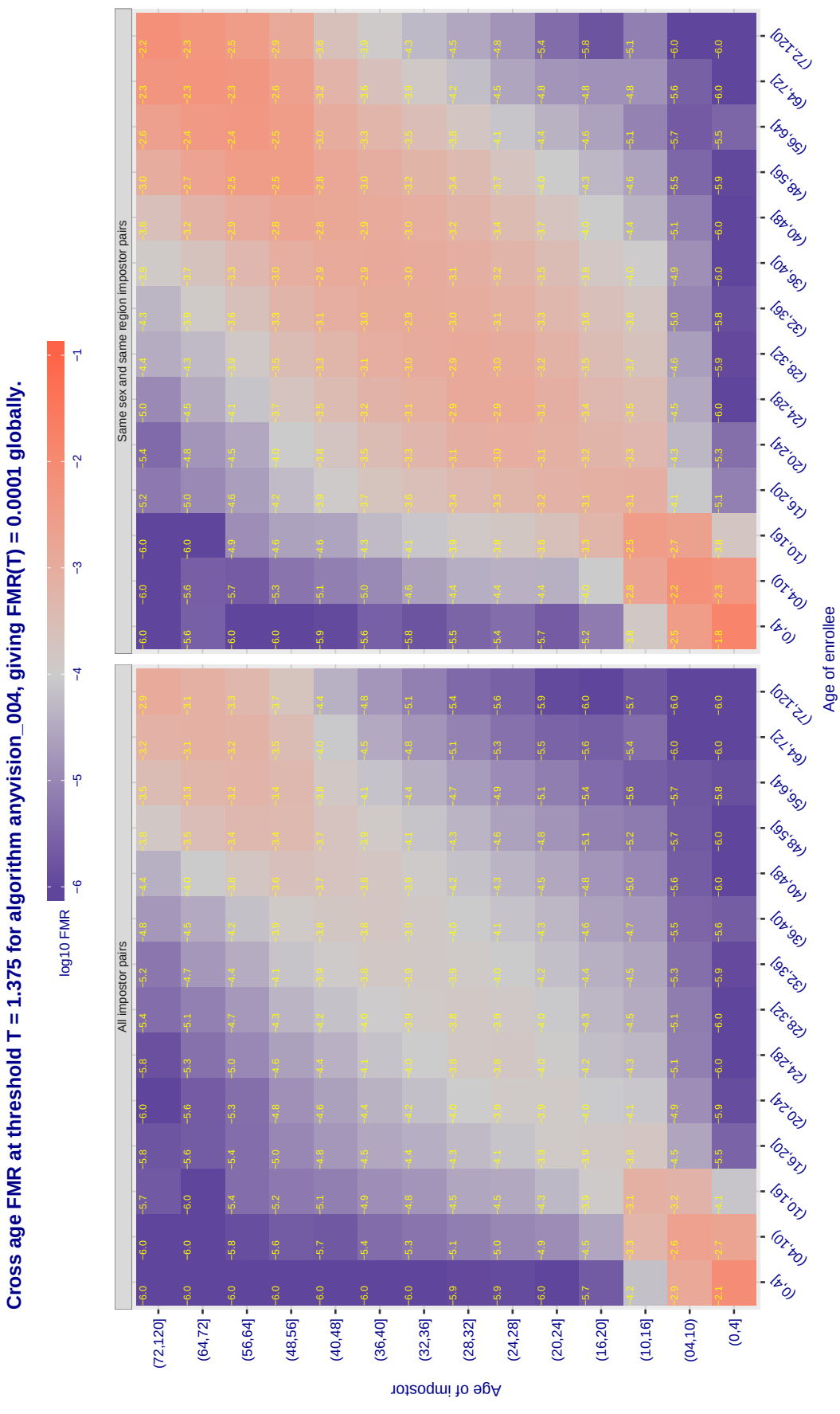


Figure 193: For algorithm anyvision-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

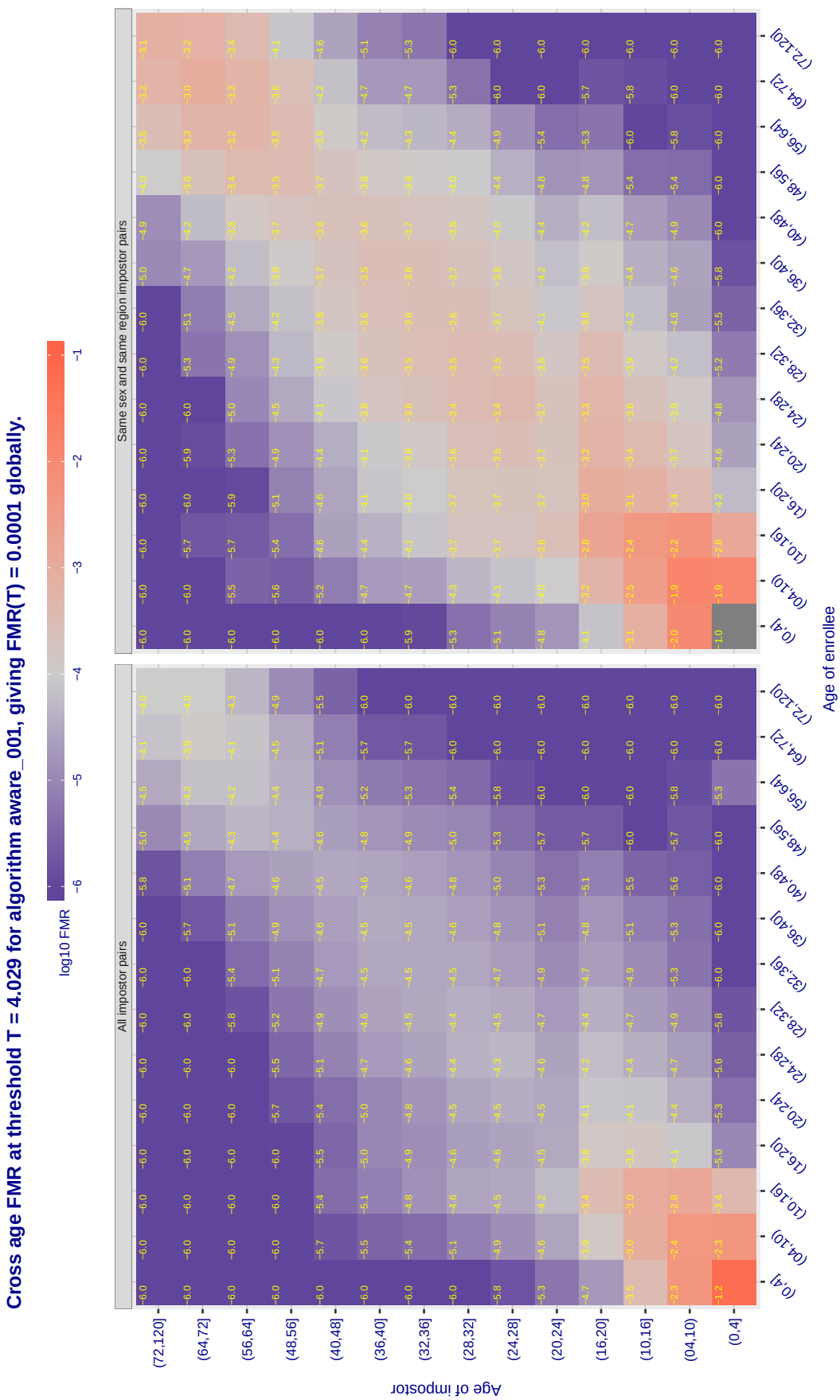


Figure 194: For algorithm aware-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

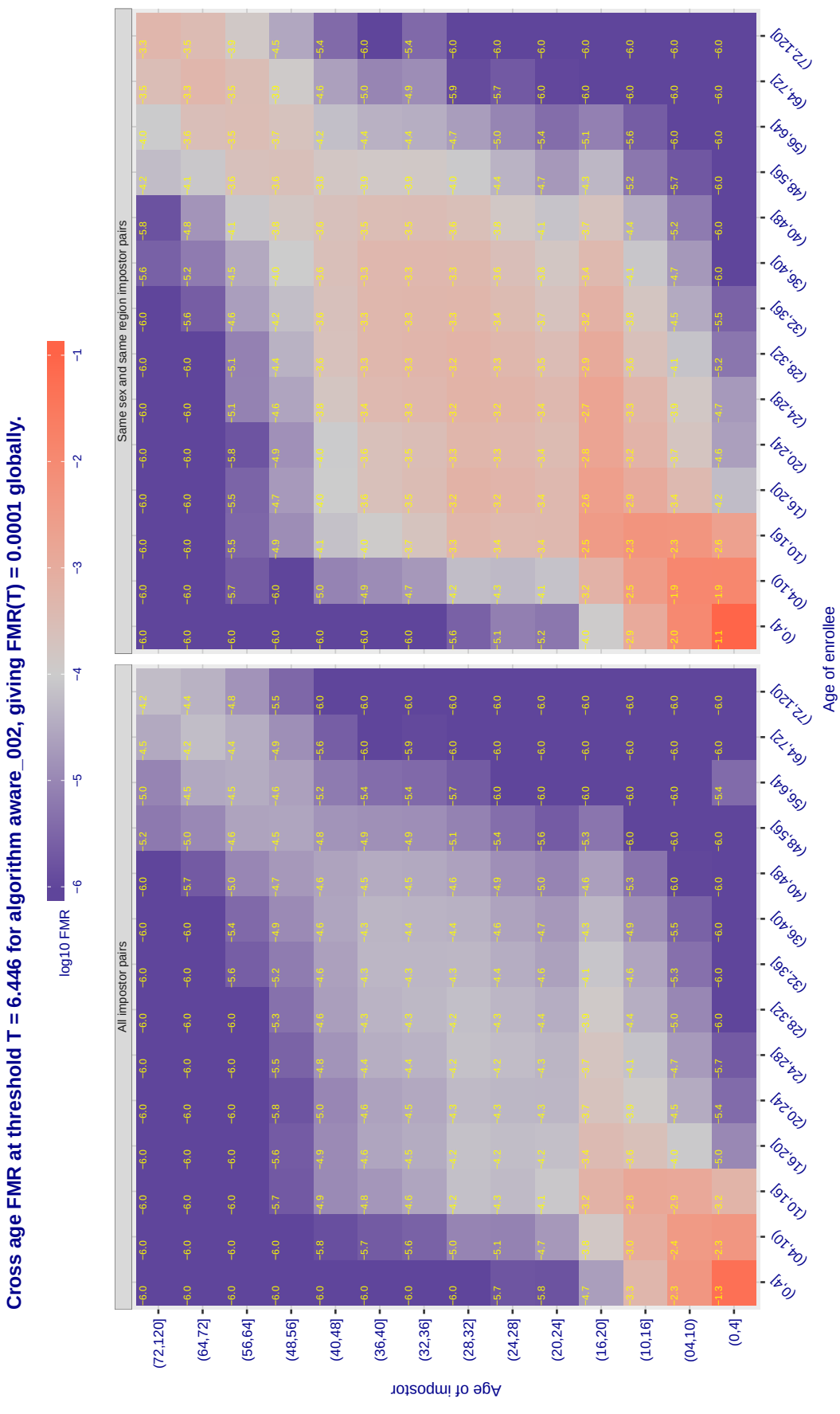


Figure 195: For algorithm aware-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

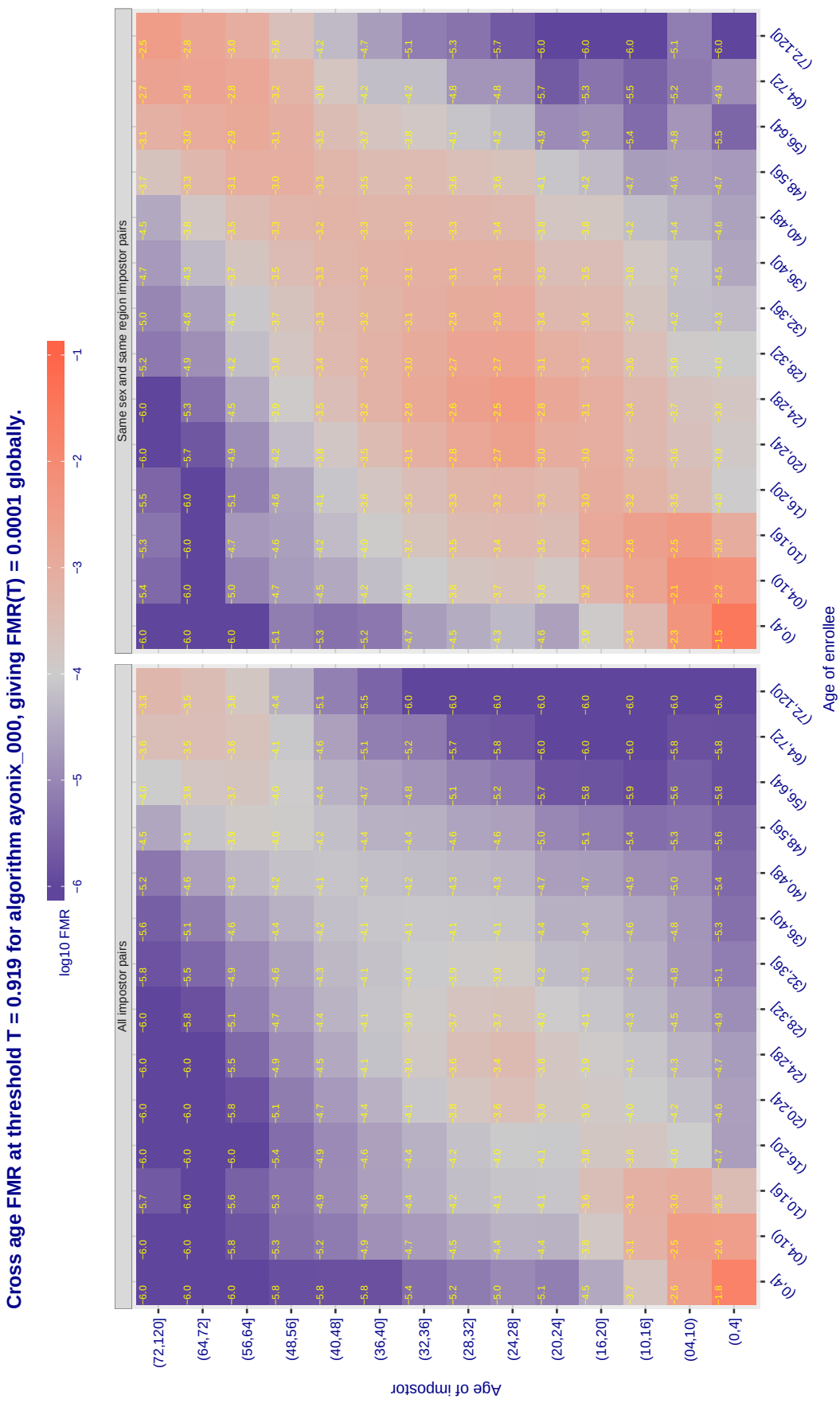


Figure 196: For algorithm ayonix-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

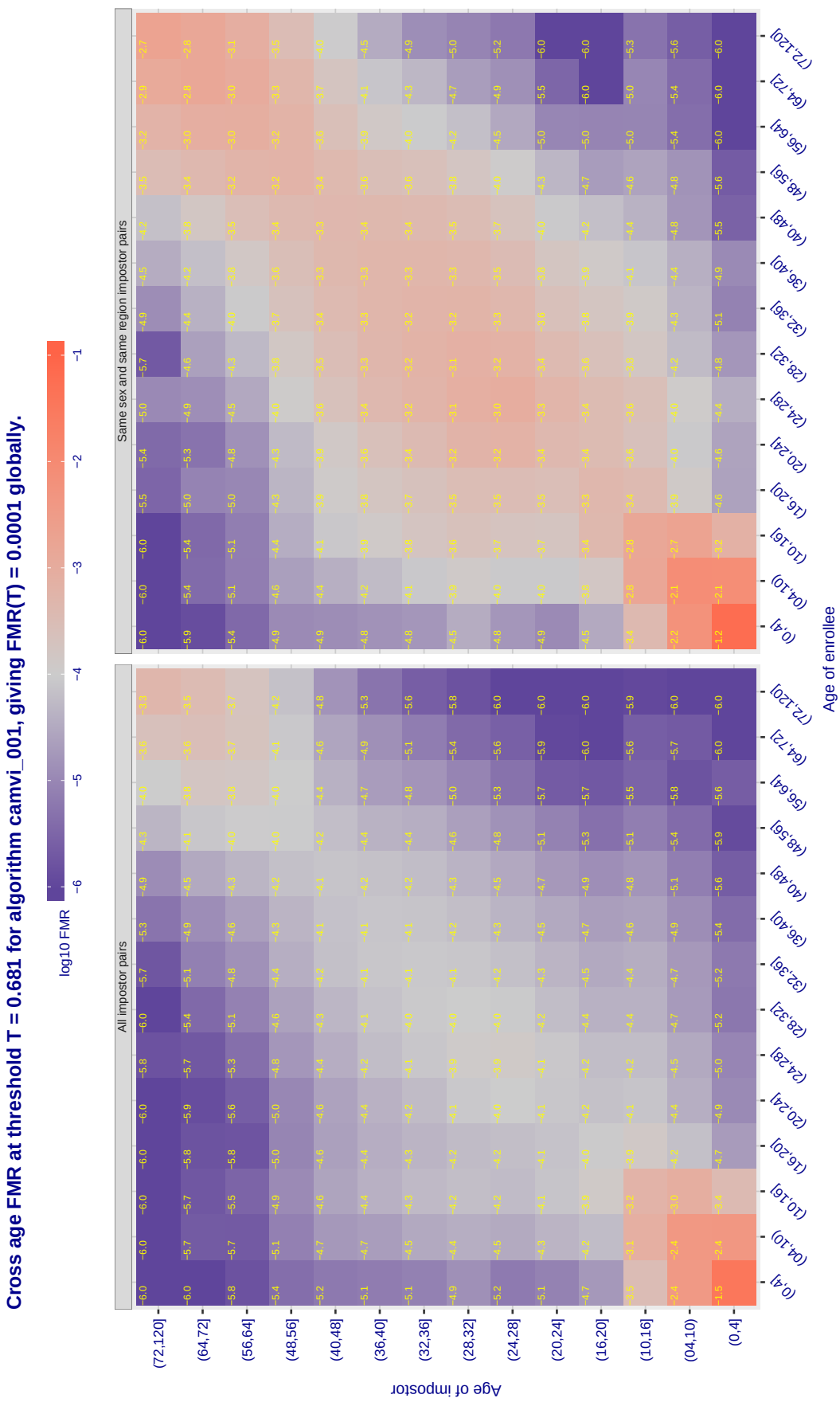


Figure 197: For algorithm camvi-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

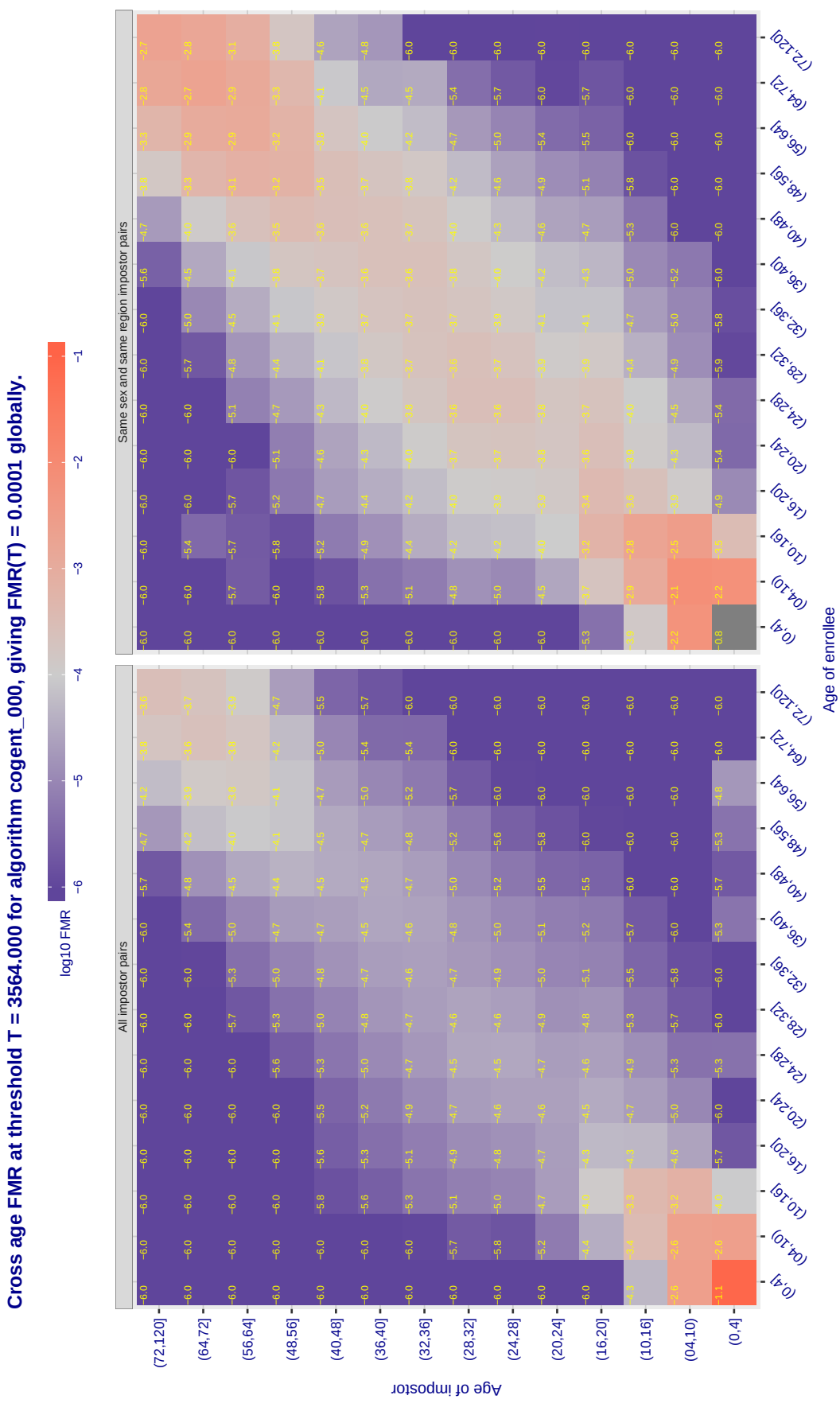


Figure 198: For algorithm cogent-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

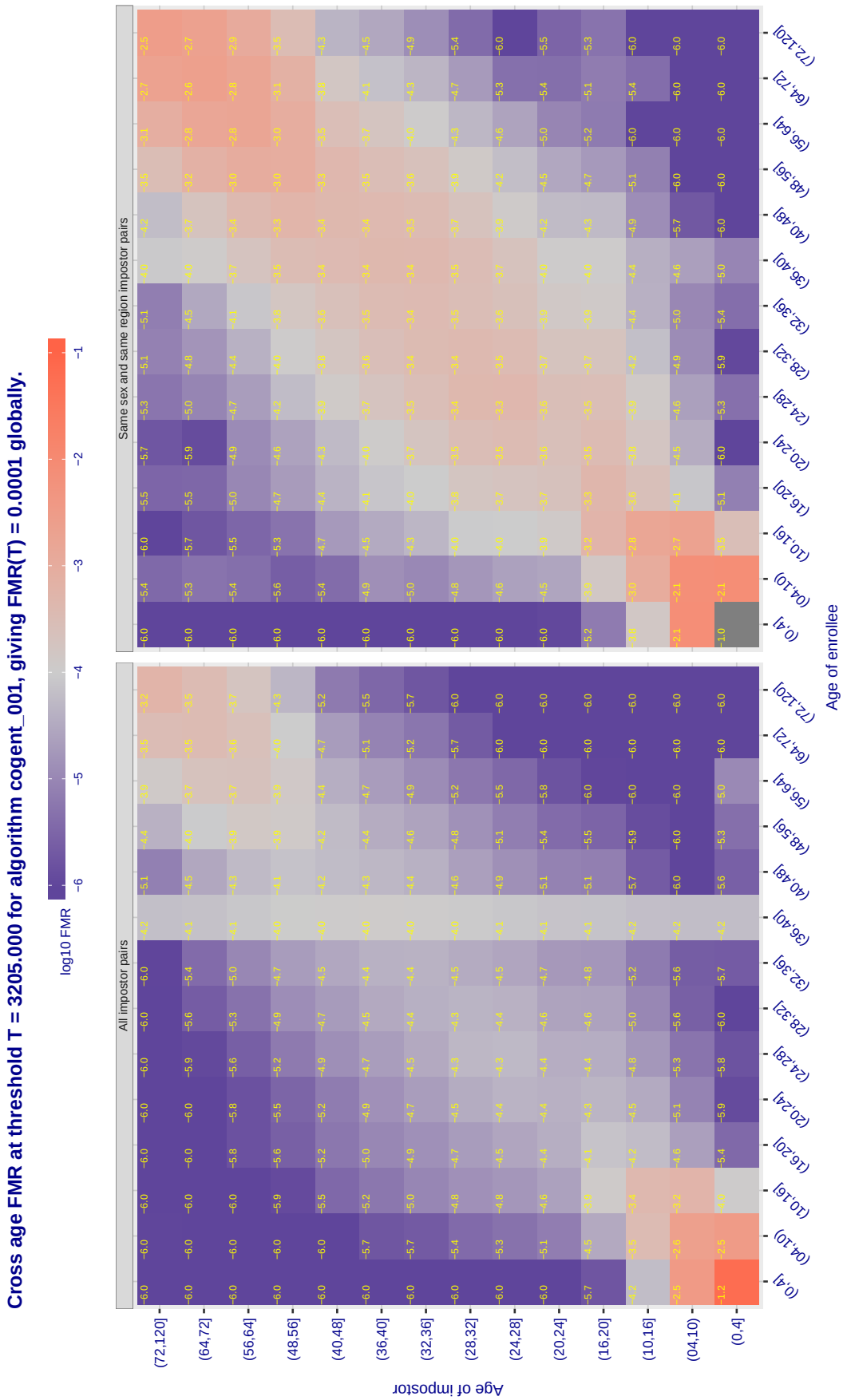


Figure 199: For algorithm cogent-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

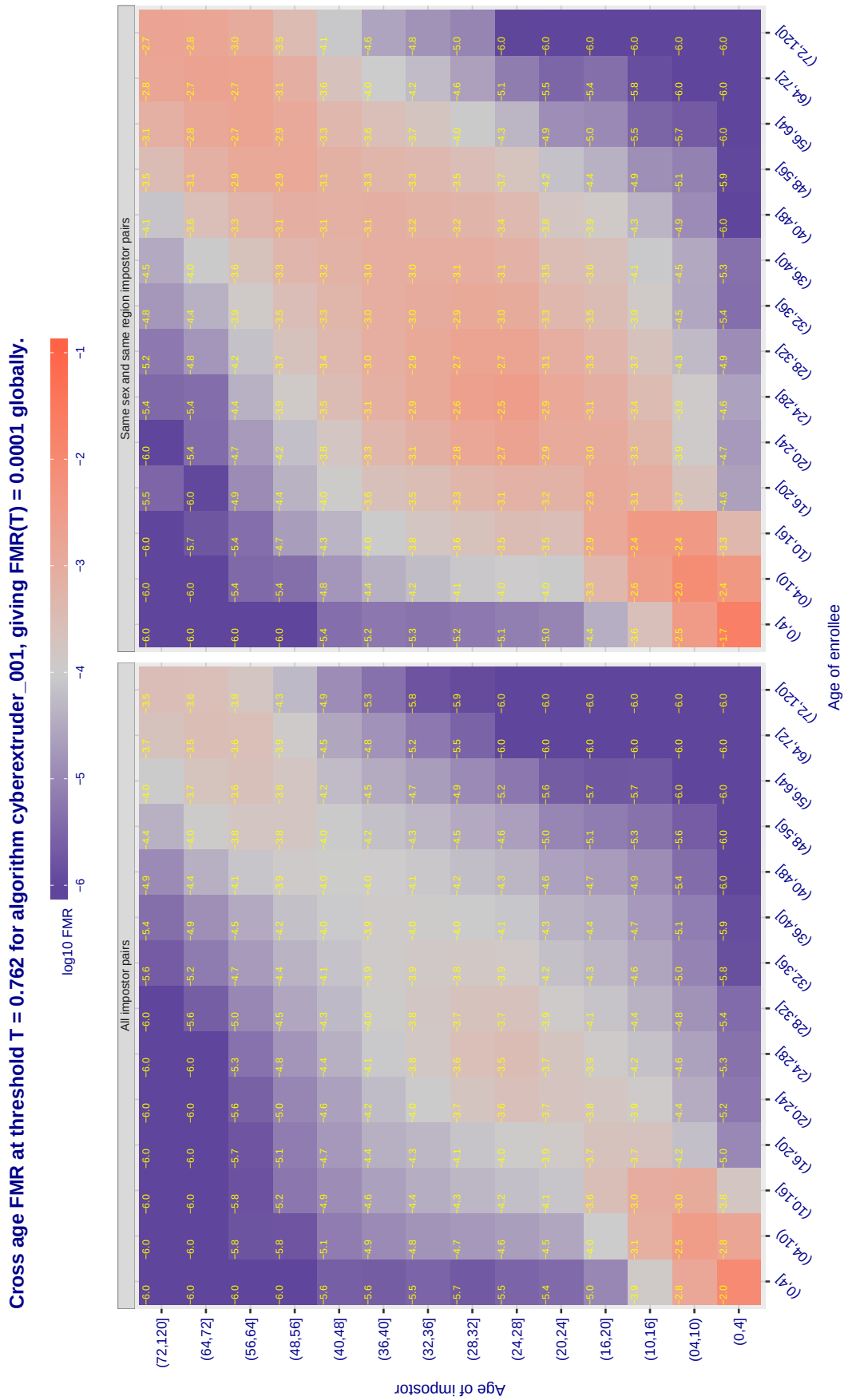


Figure 200: For algorithm cyberextruder-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

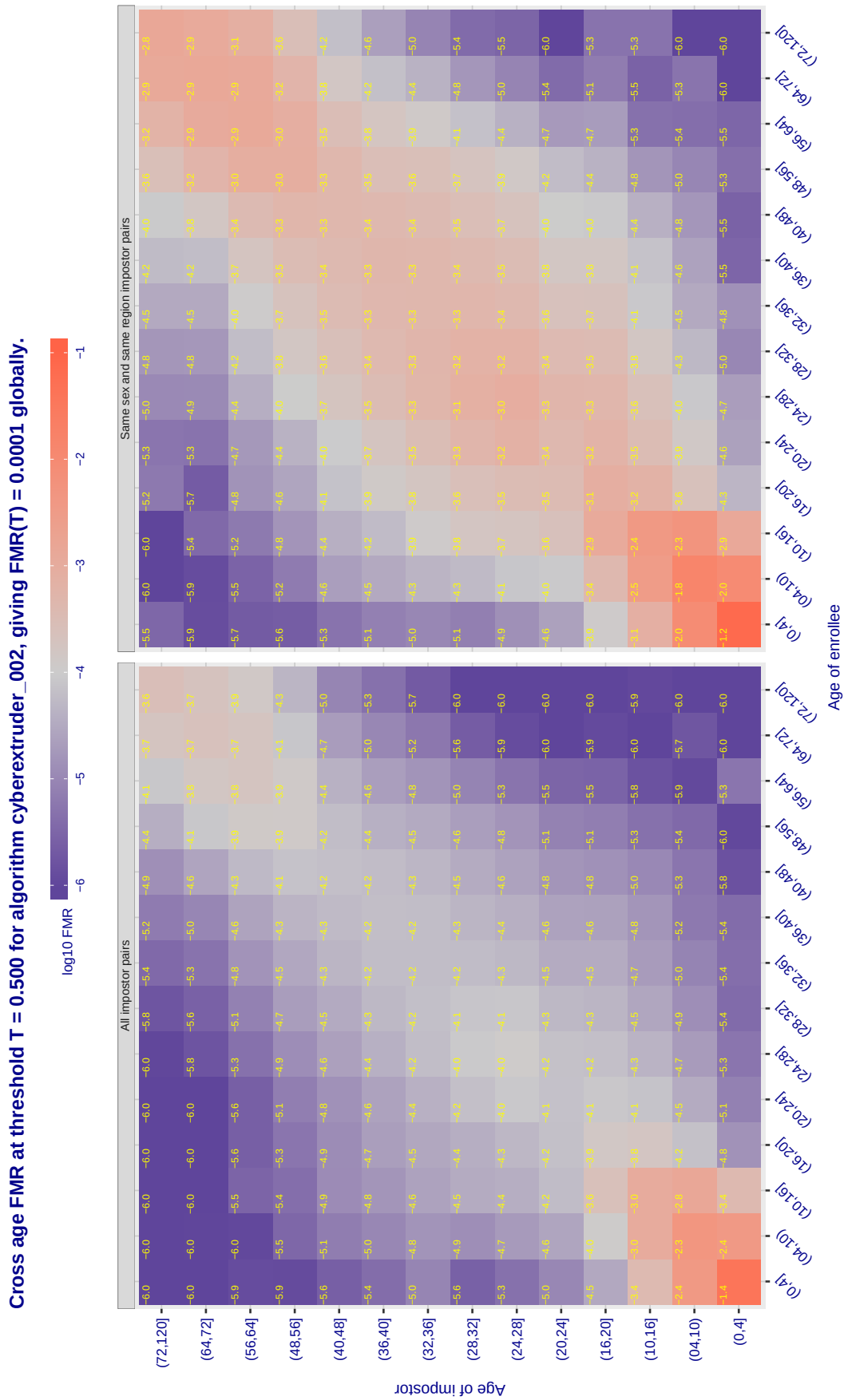


Figure 201: For algorithm cyberextruder-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

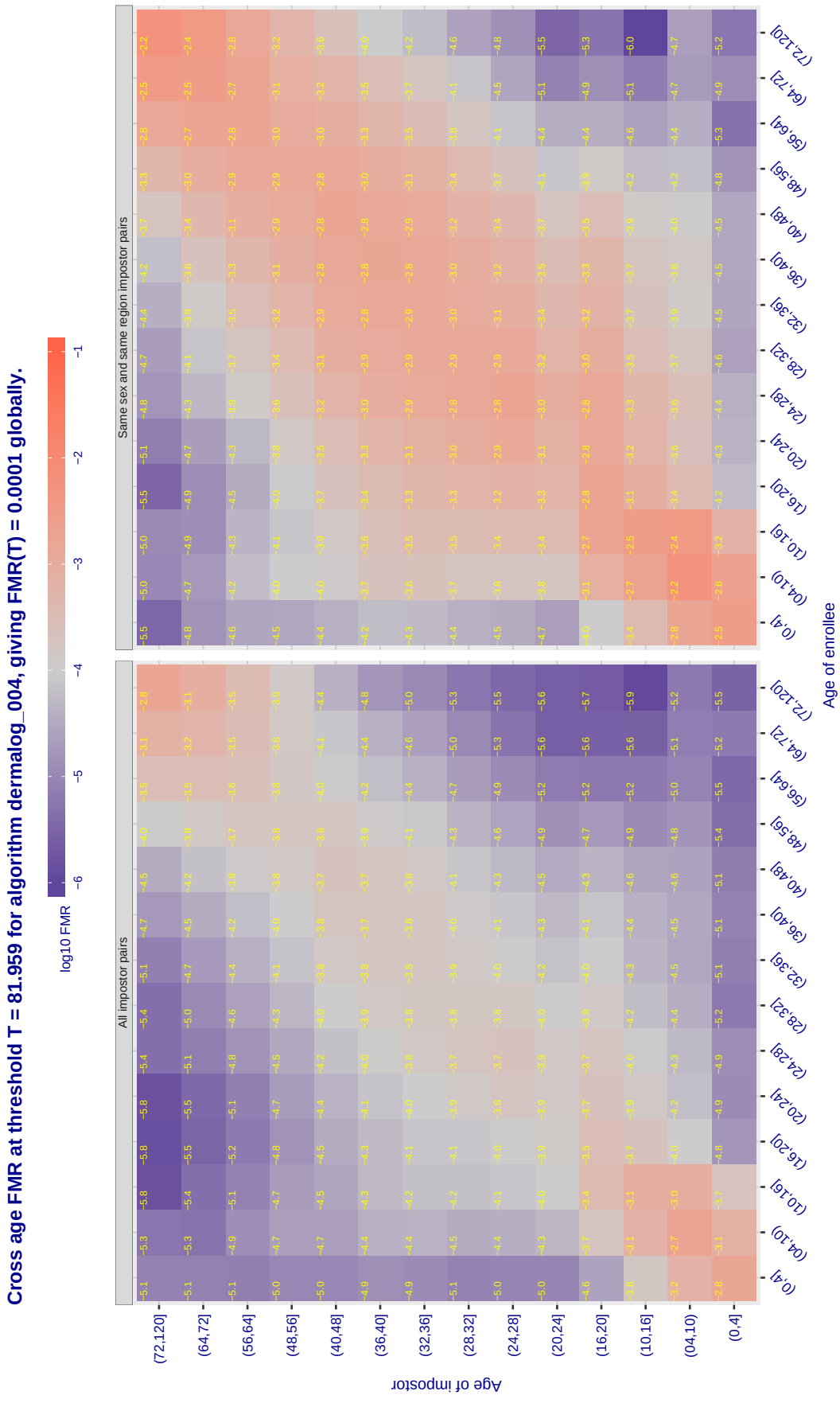


Figure 202: For algorithm dermalog-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

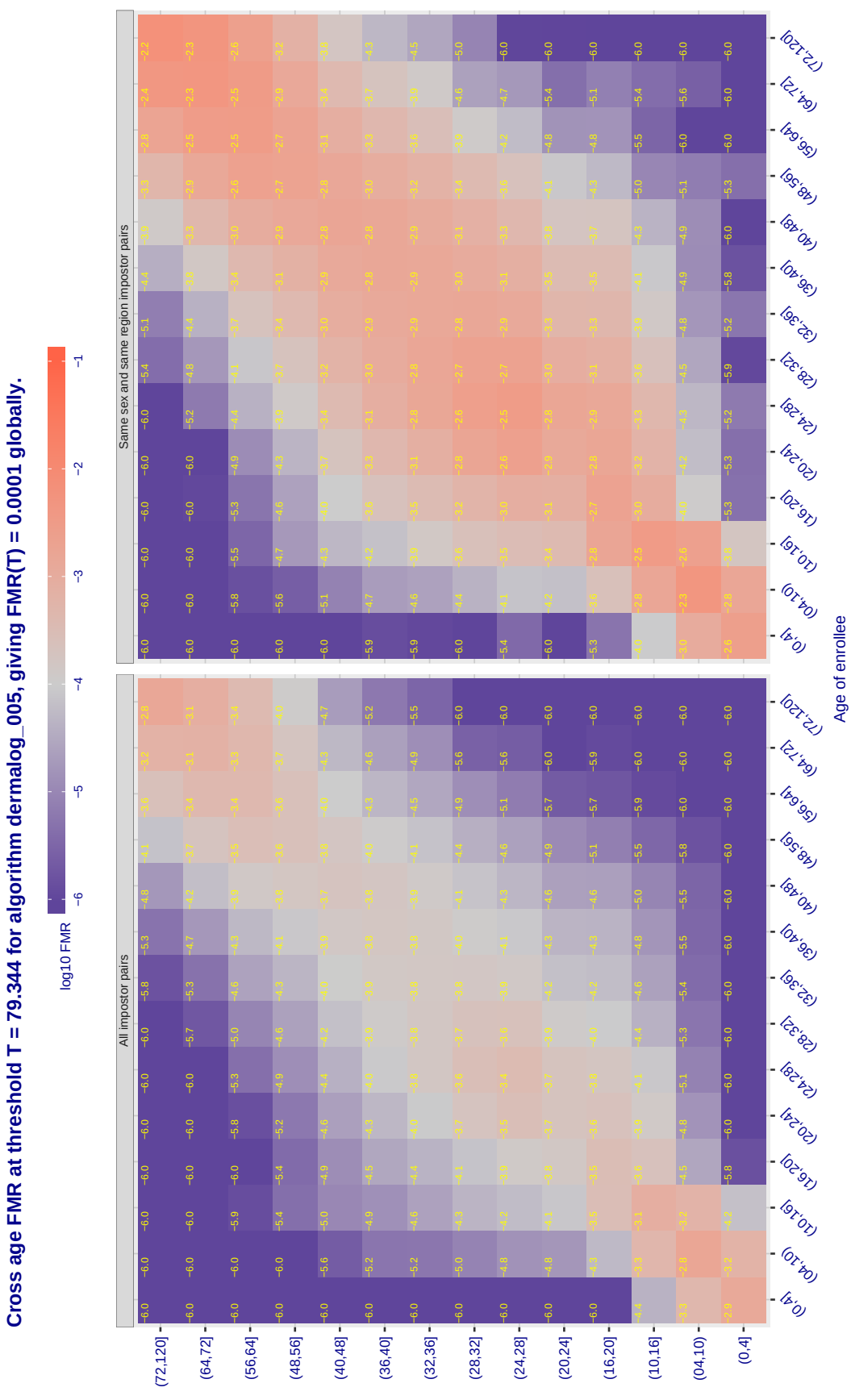


Figure 203: For algorithm dermalog-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

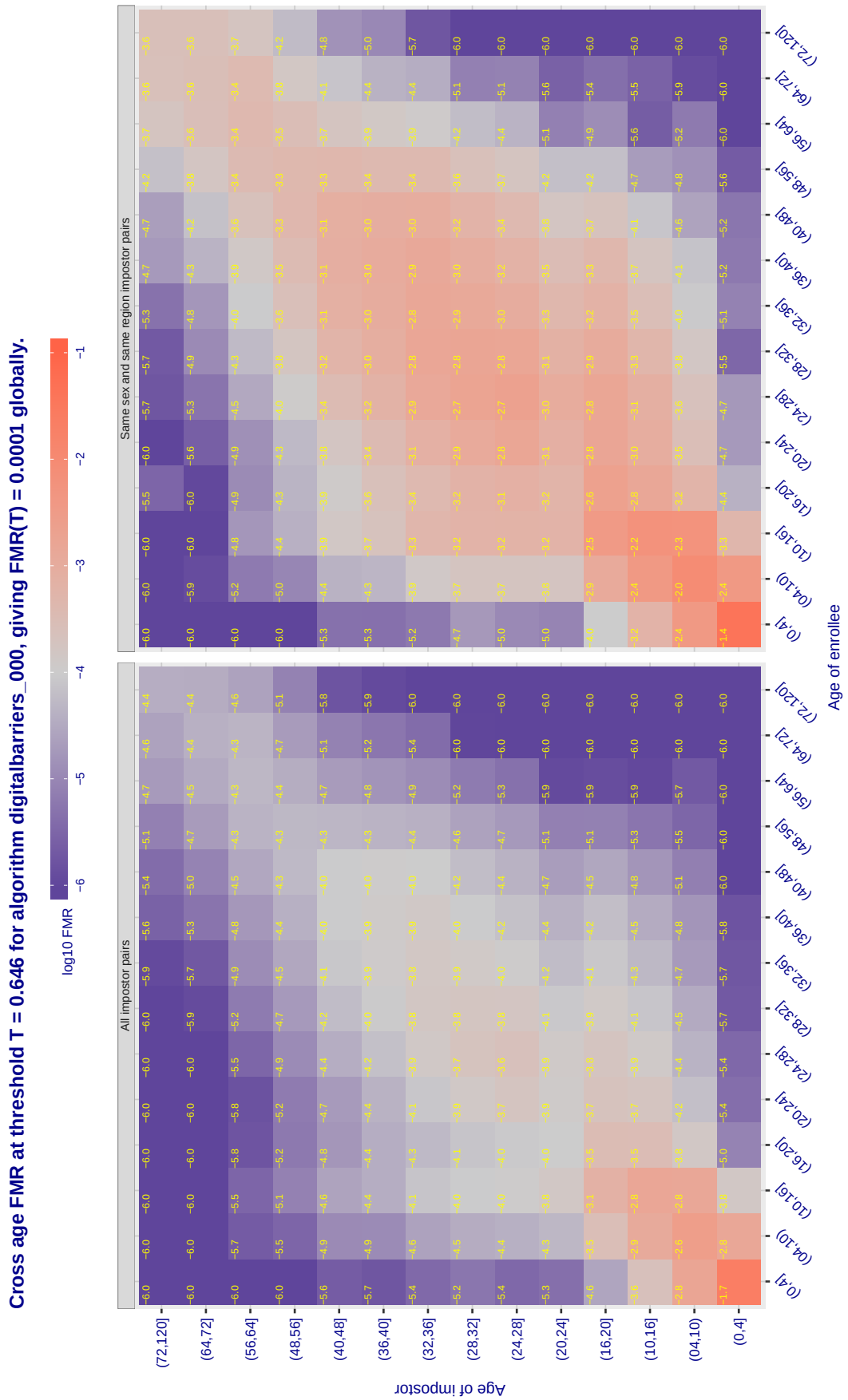


Figure 204: For algorithm digitalbarriers-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

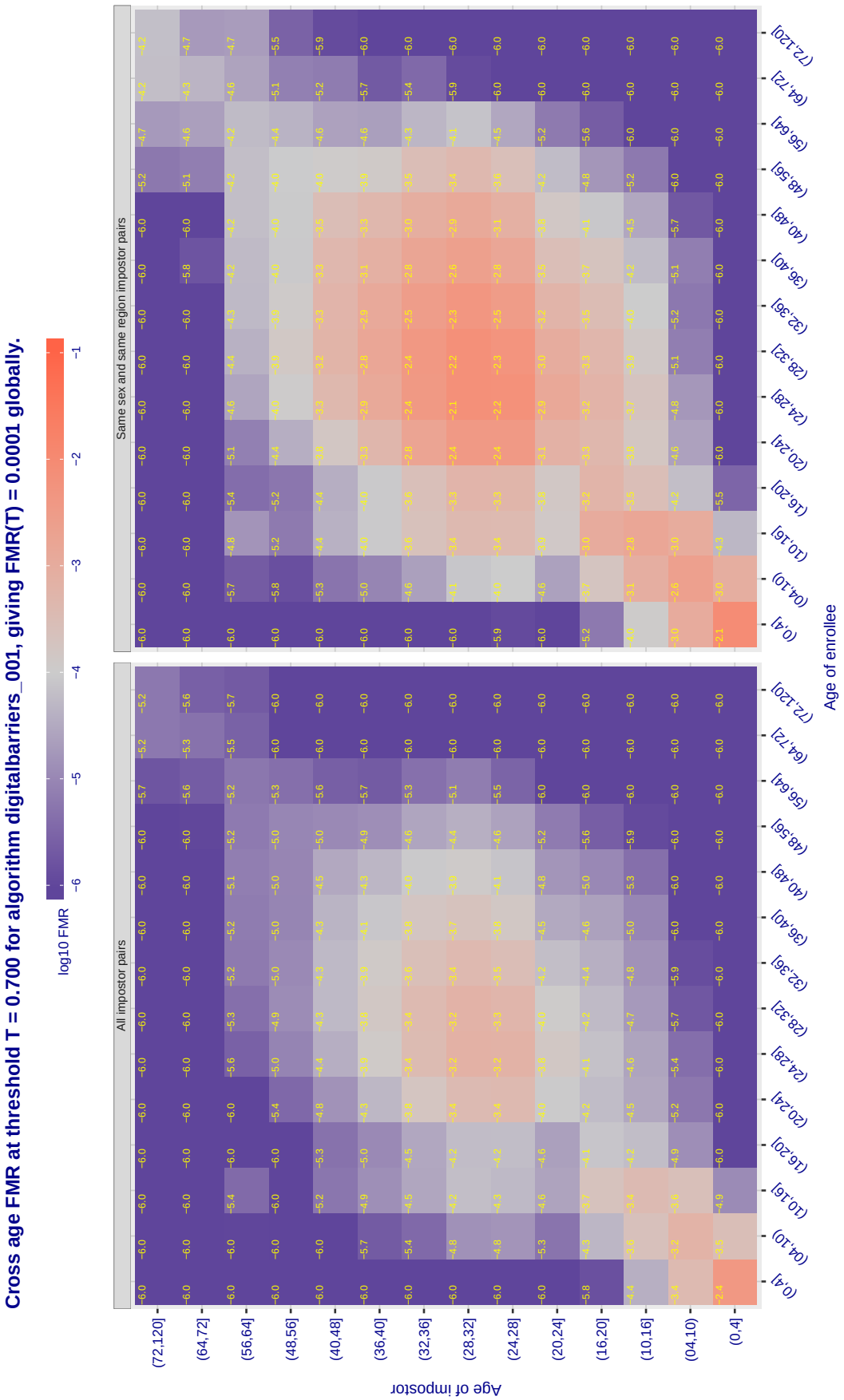


Figure 205: For algorithm digitalbarriers-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

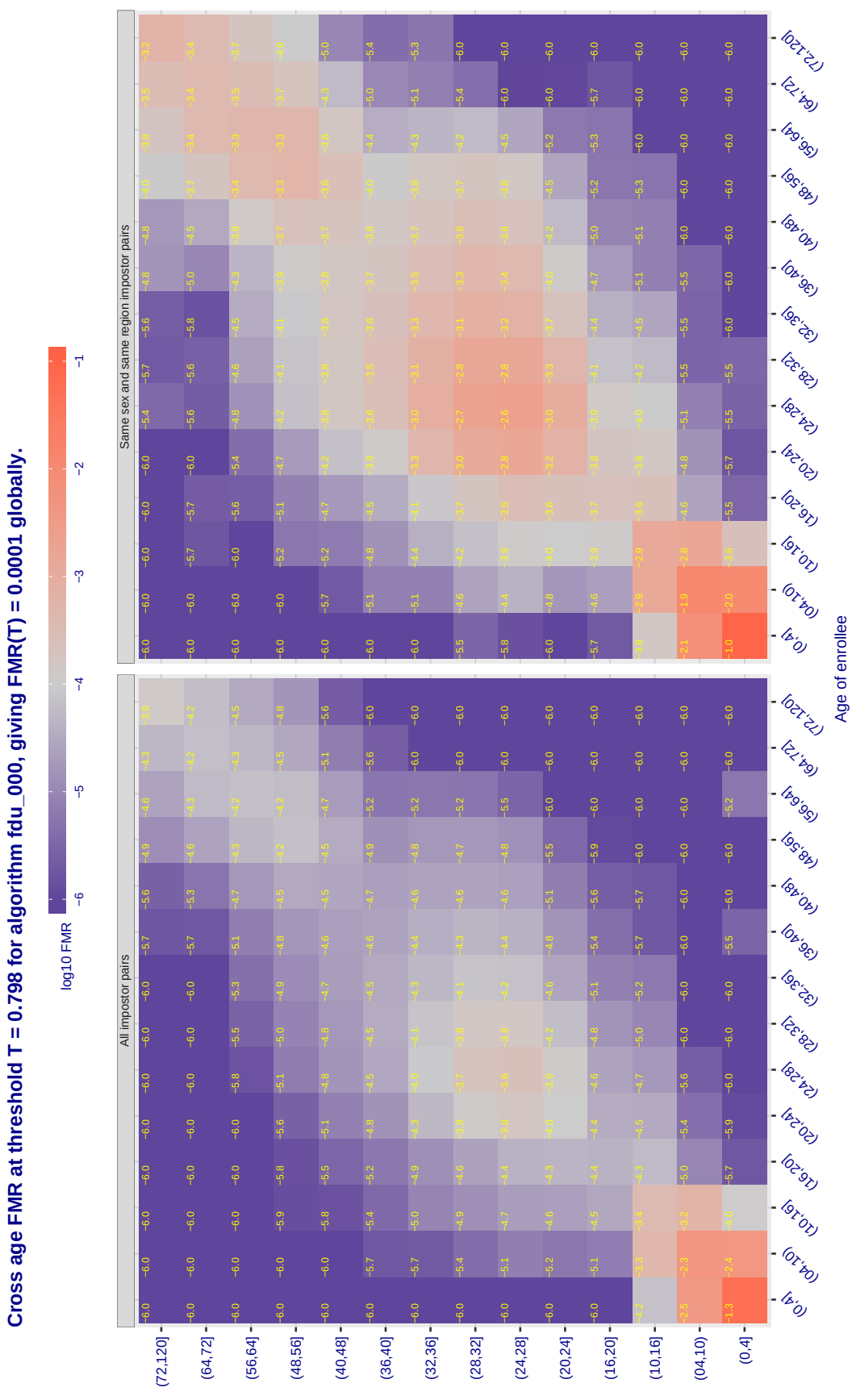


Figure 206: For algorithm fdu-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

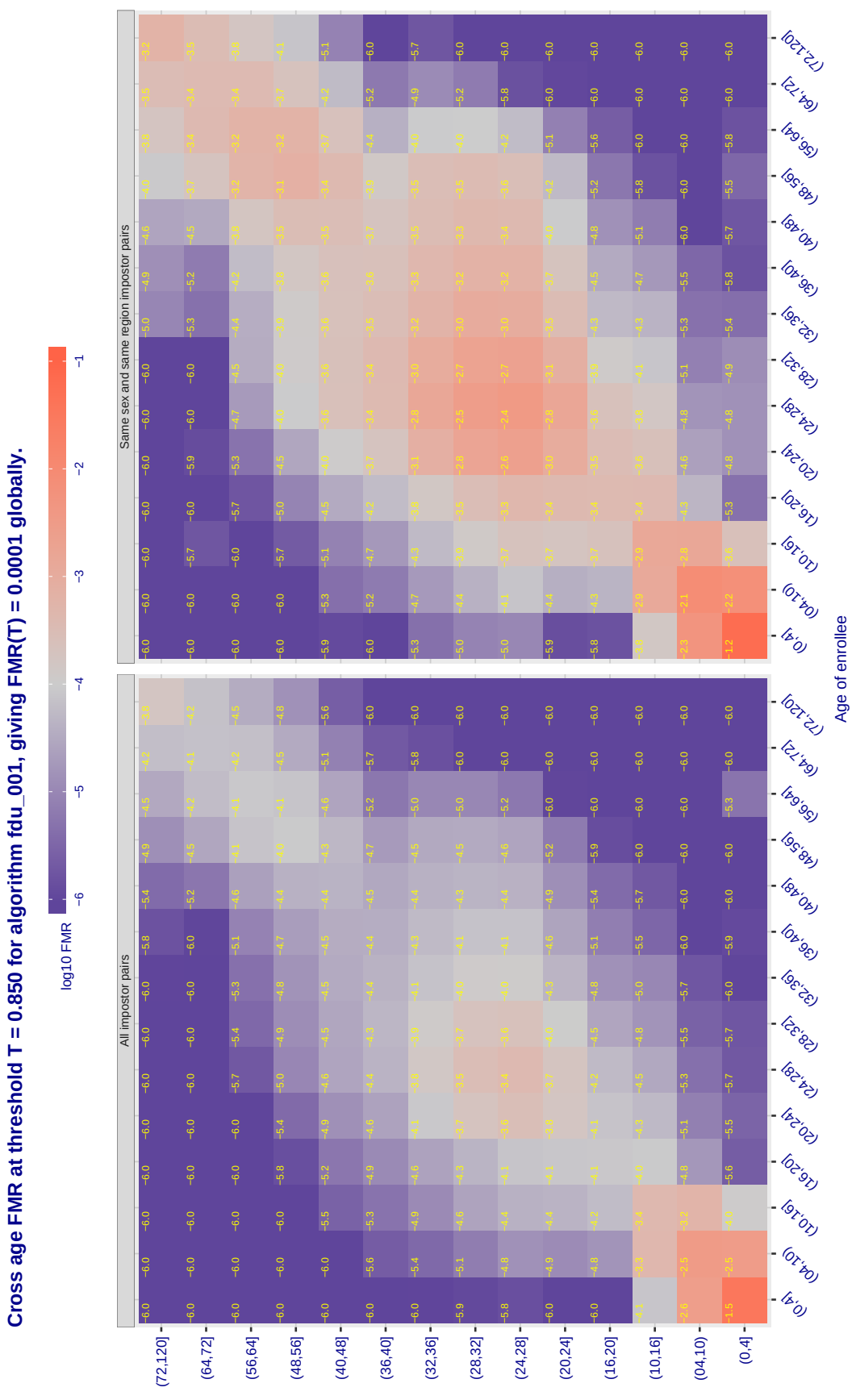


Figure 207: For algorithm fdu-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

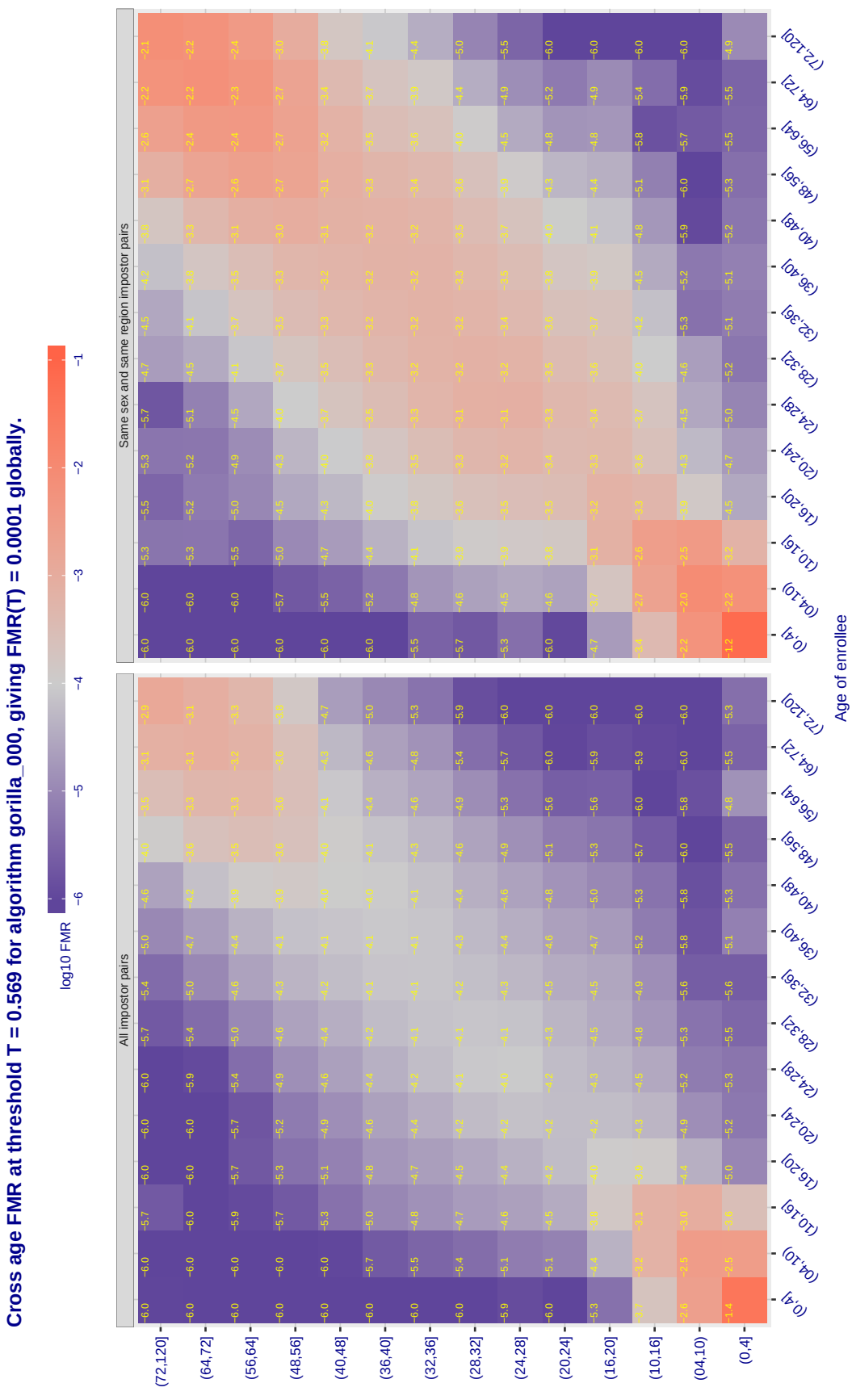


Figure 208: For algorithm gorilla-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

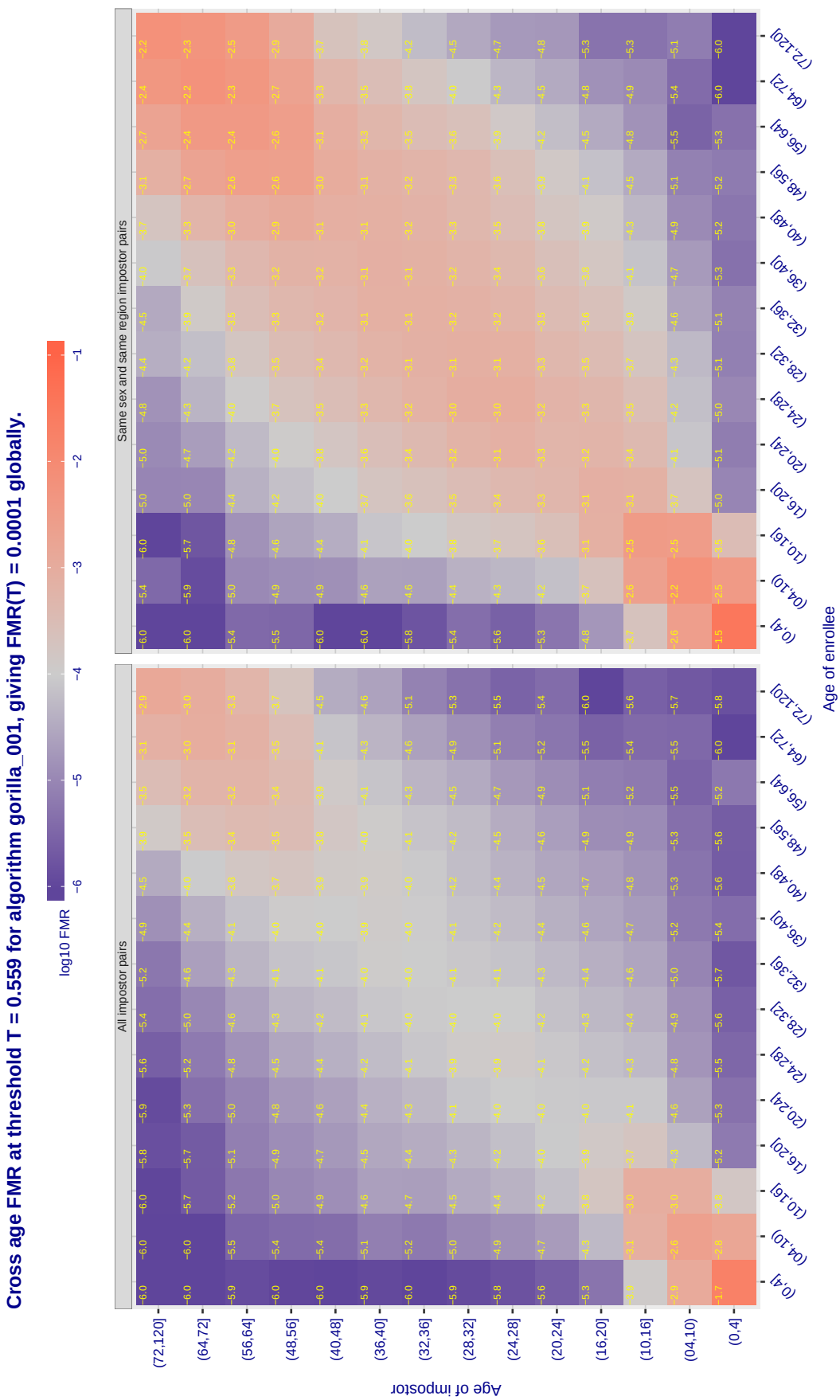


Figure 209: For algorithm gorilla-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

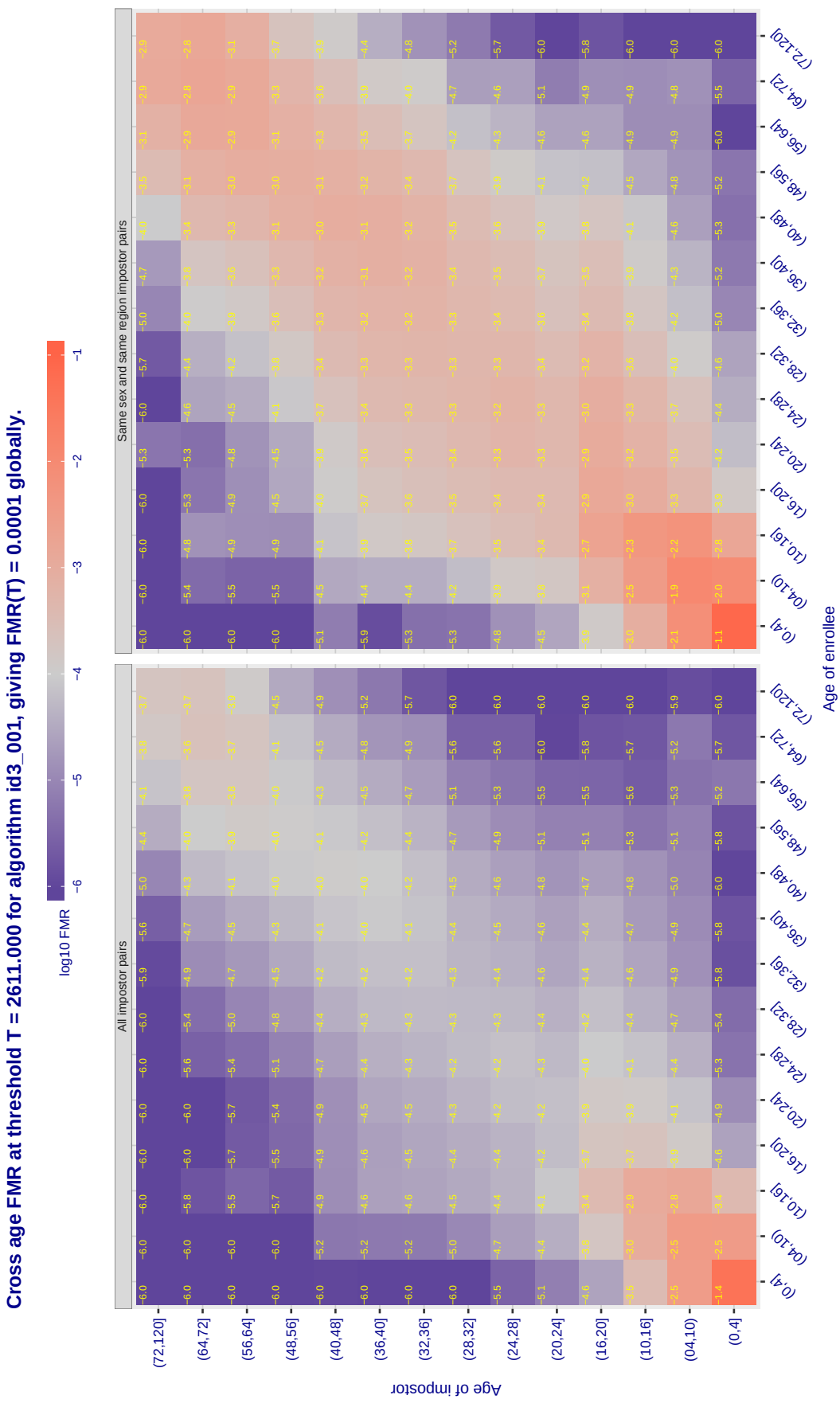


Figure 210: For algorithm id3-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

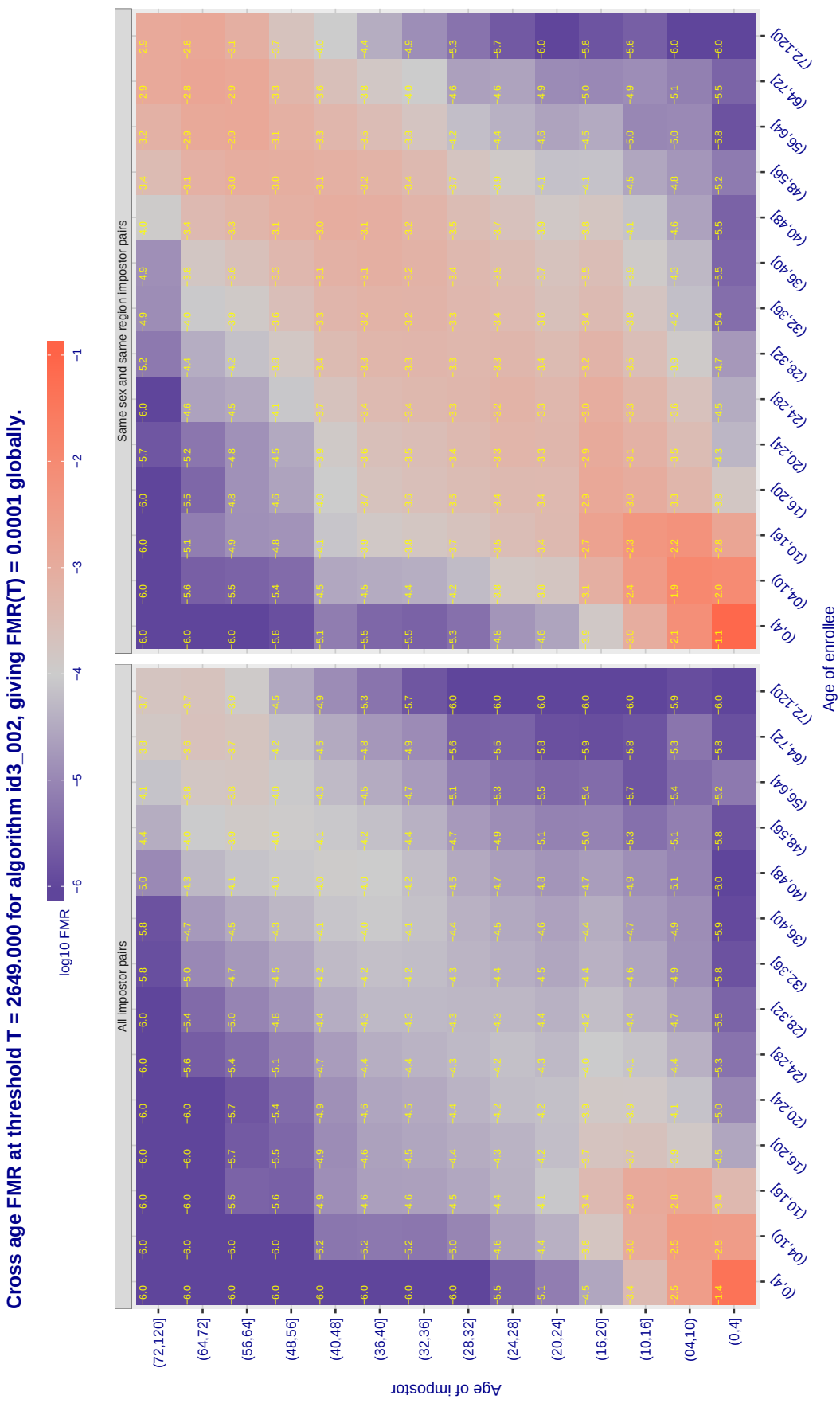


Figure 211: For algorithm id3-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

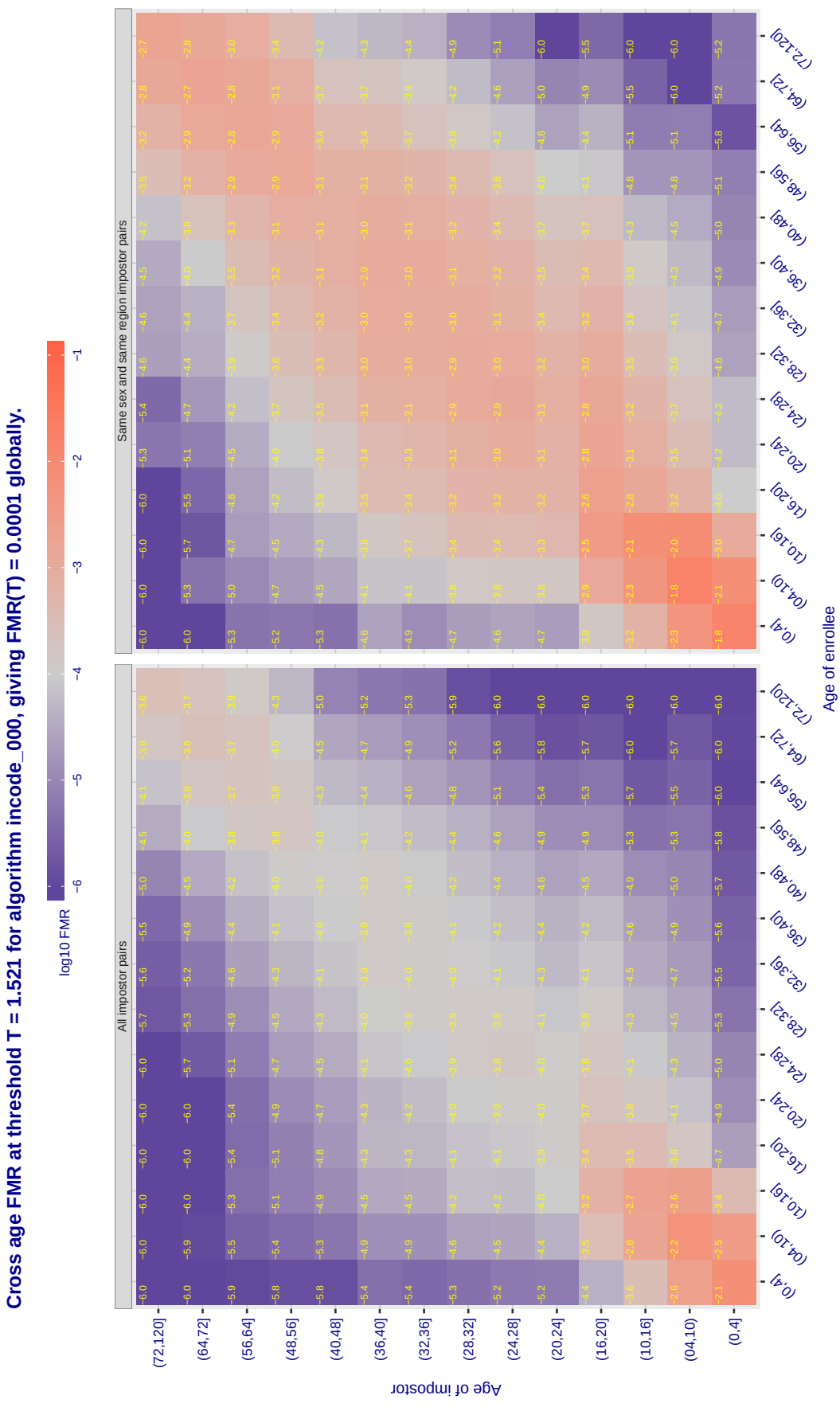


Figure 212: For algorithm incode-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

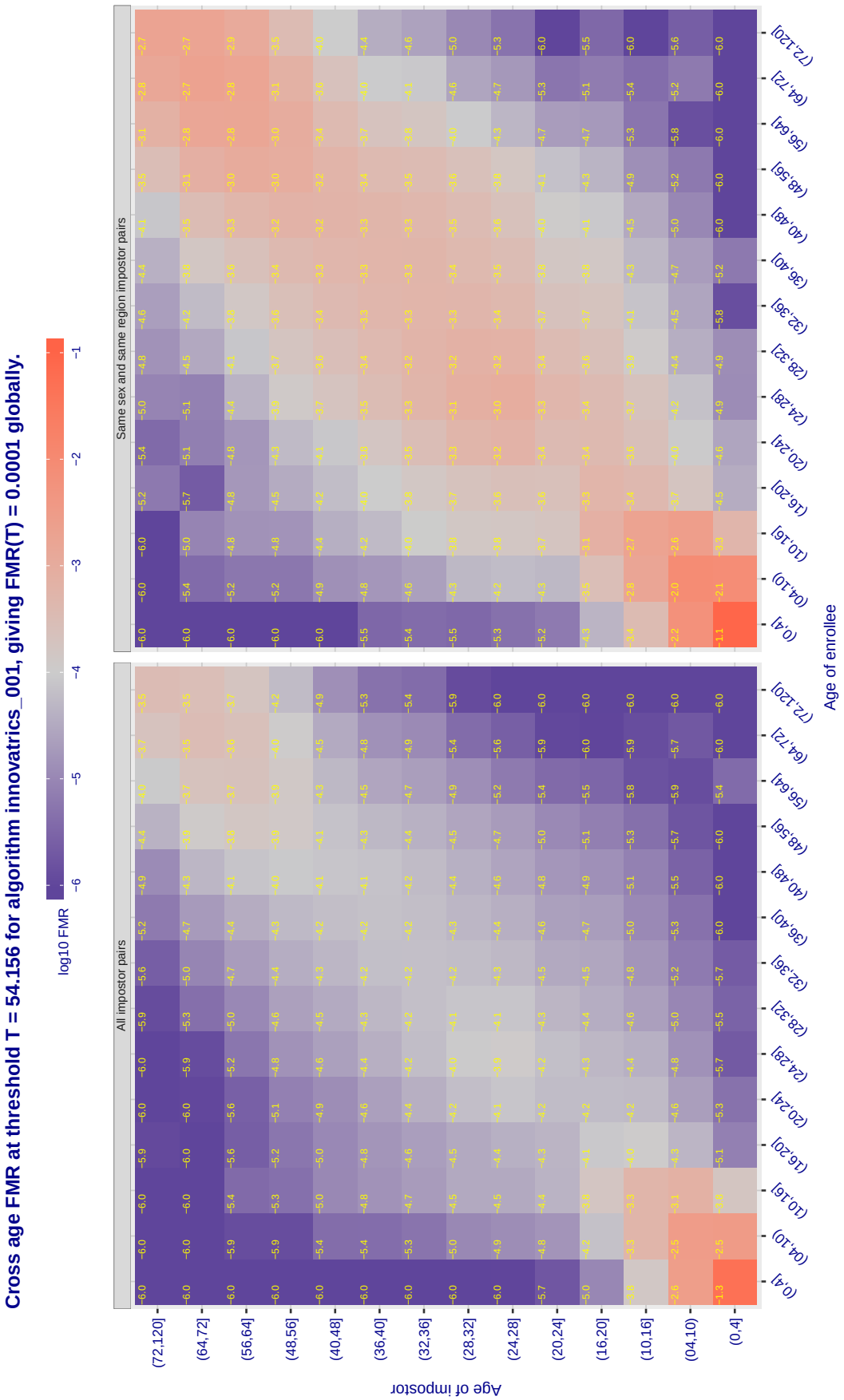


Figure 213: For algorithm innovatrics-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

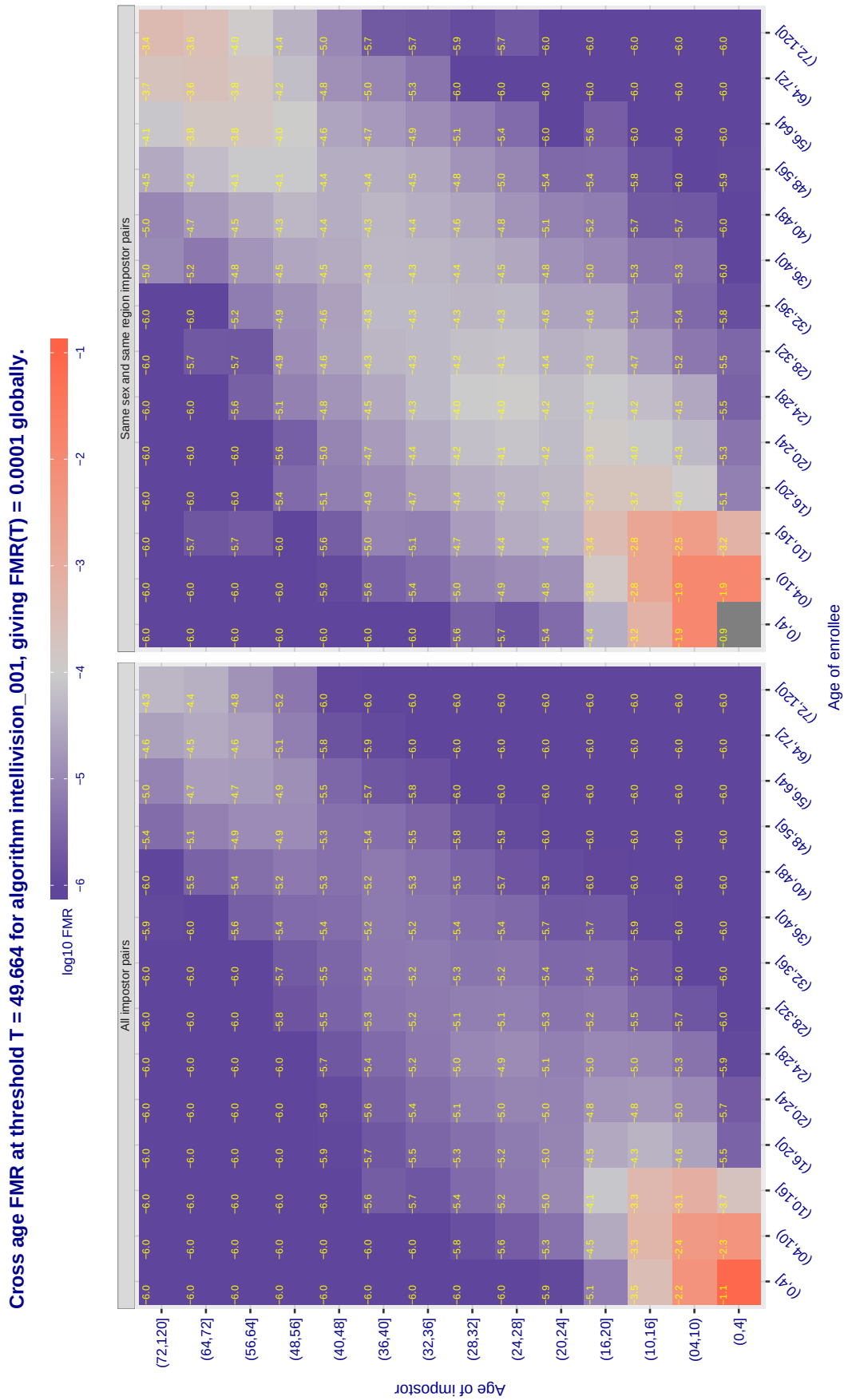


Figure 214: For algorithm intellivision-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

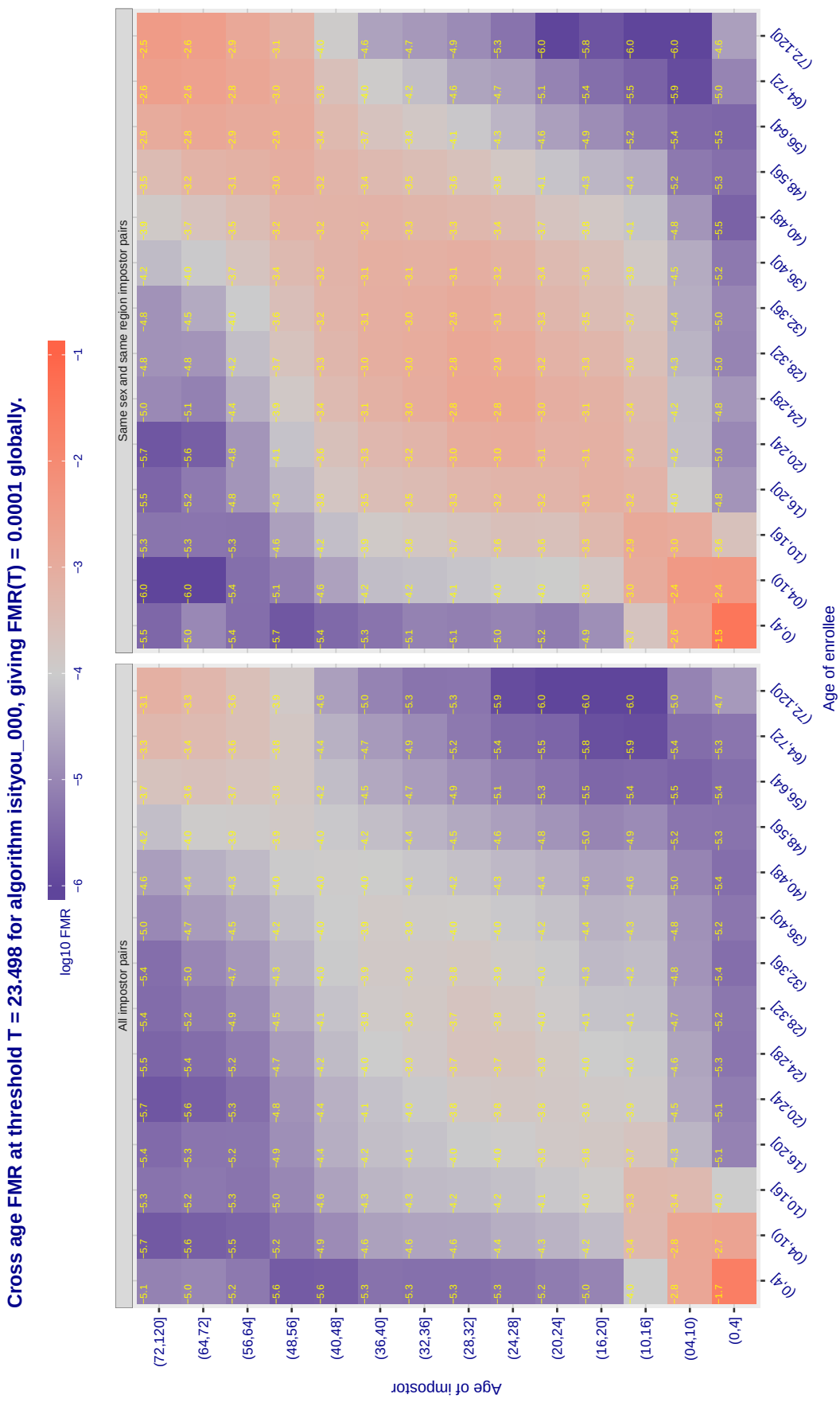


Figure 215: For algorithm isityou-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

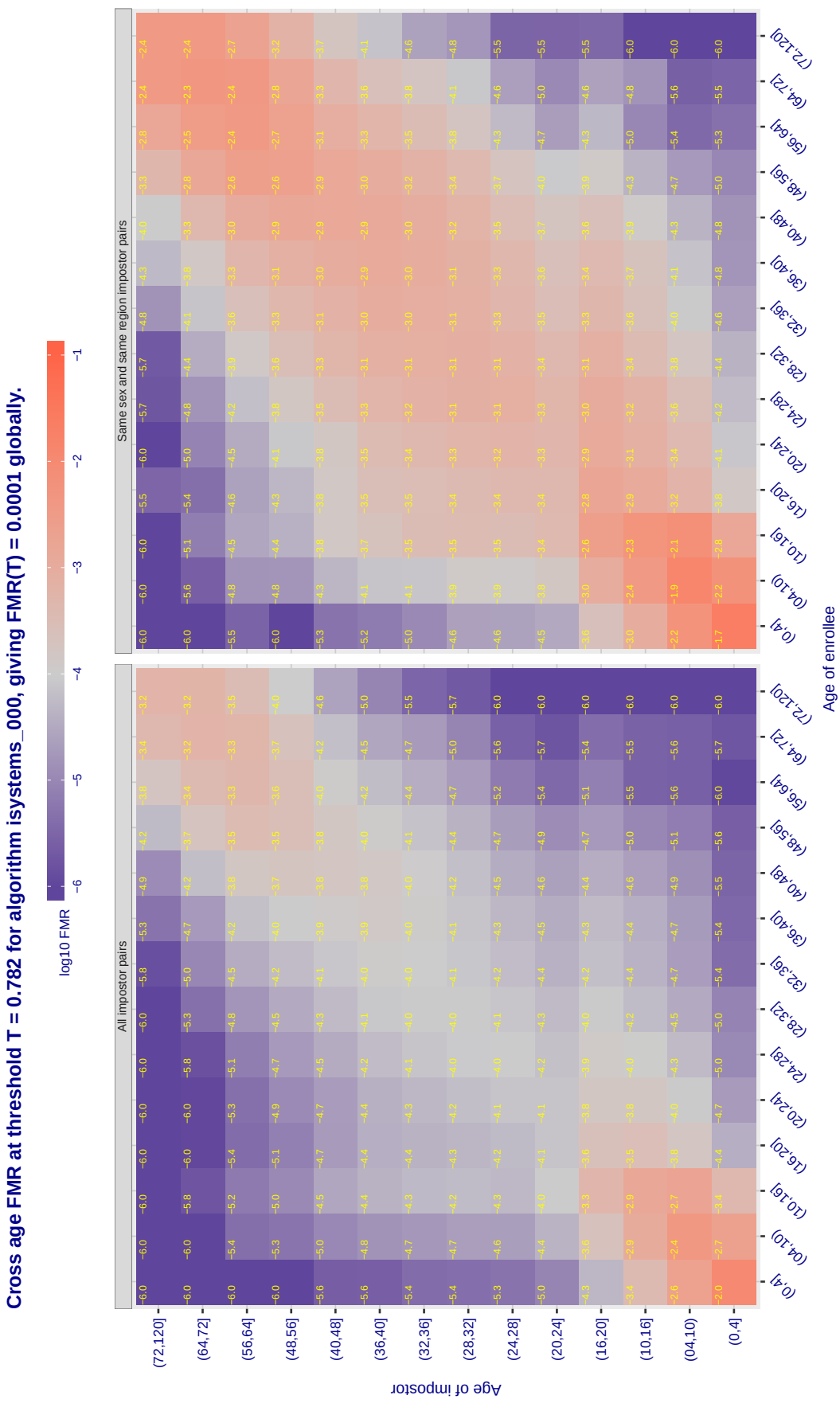


Figure 216: For algorithm isystems-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

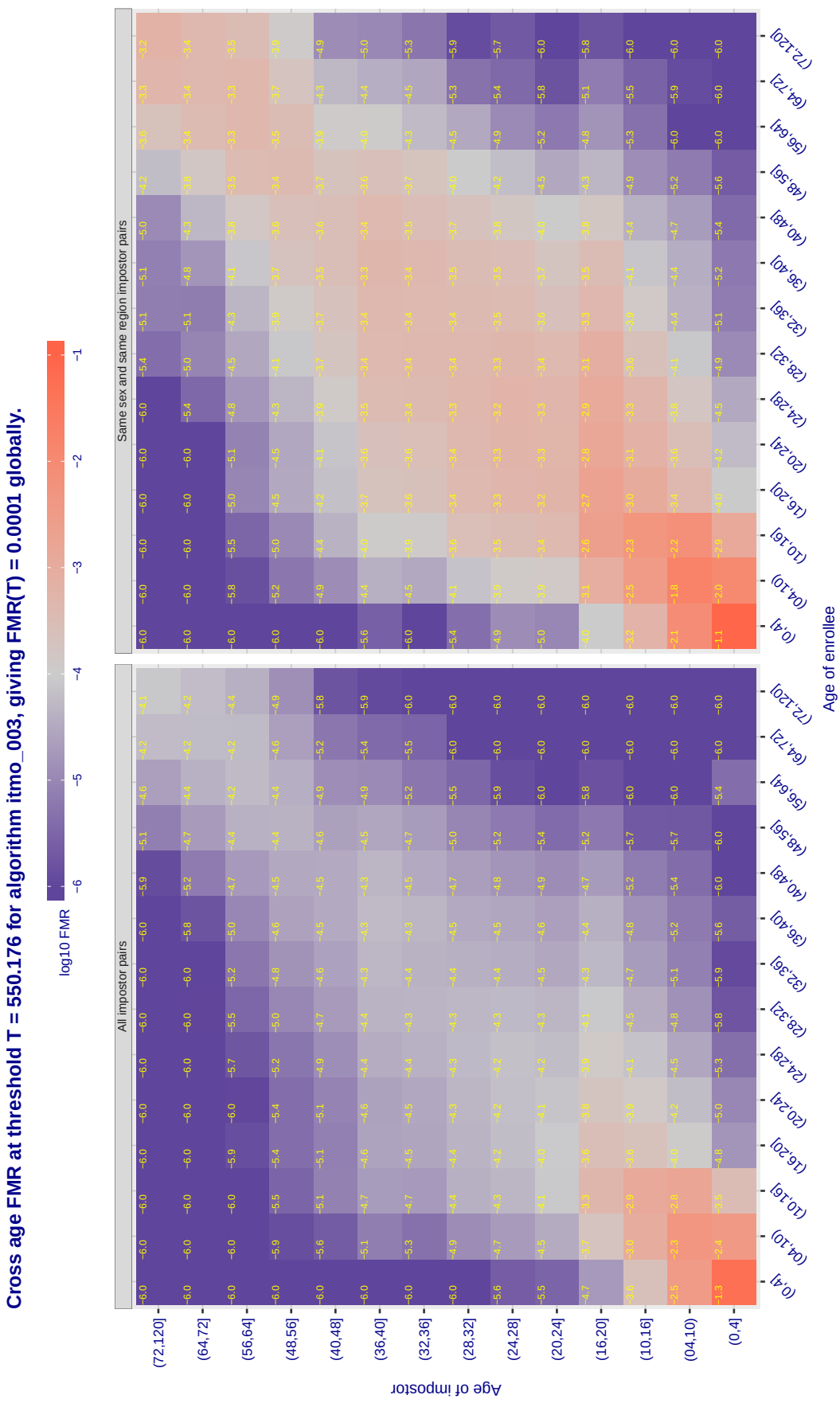


Figure 217: For algorithm itmo-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

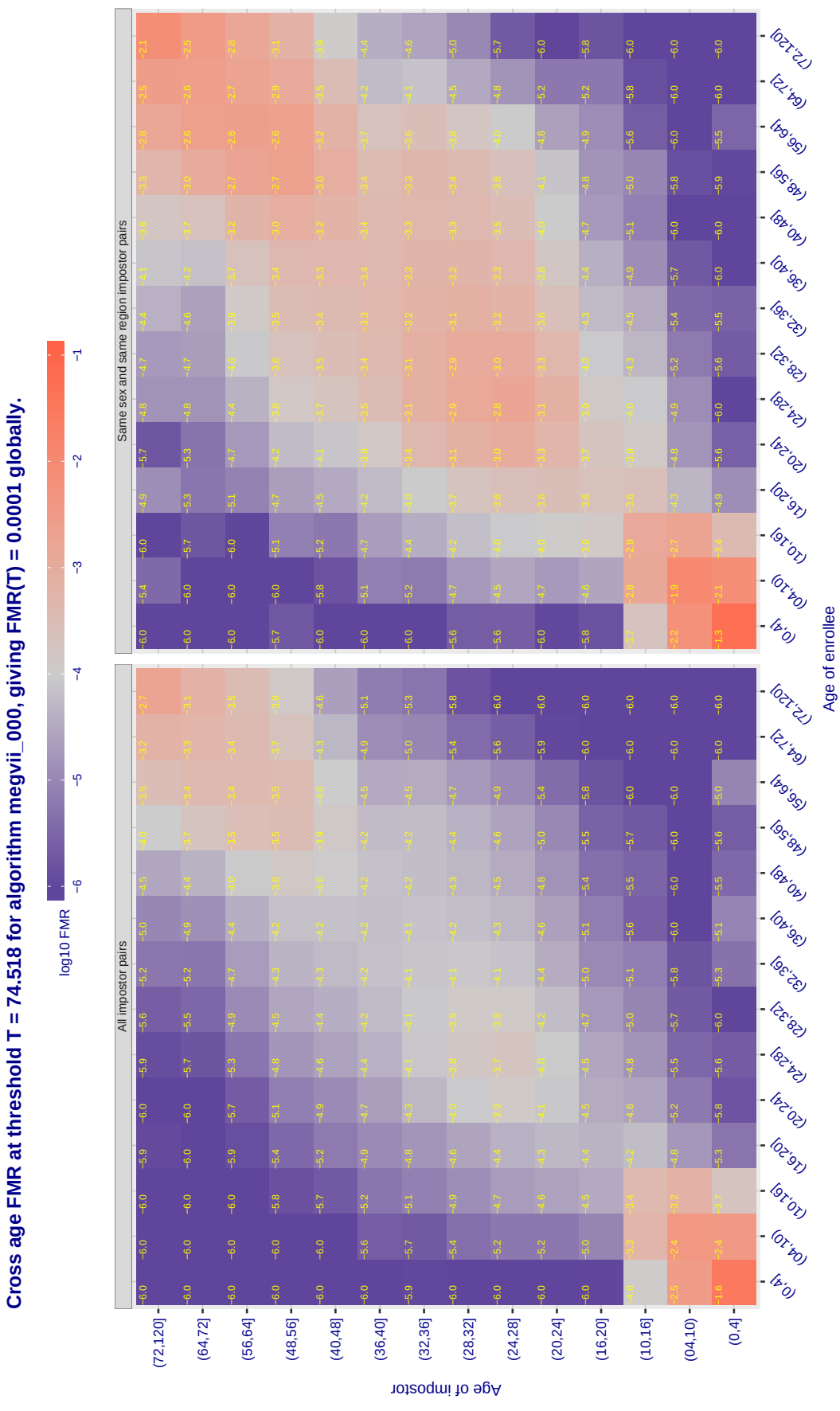


Figure 218: For algorithm megvii-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

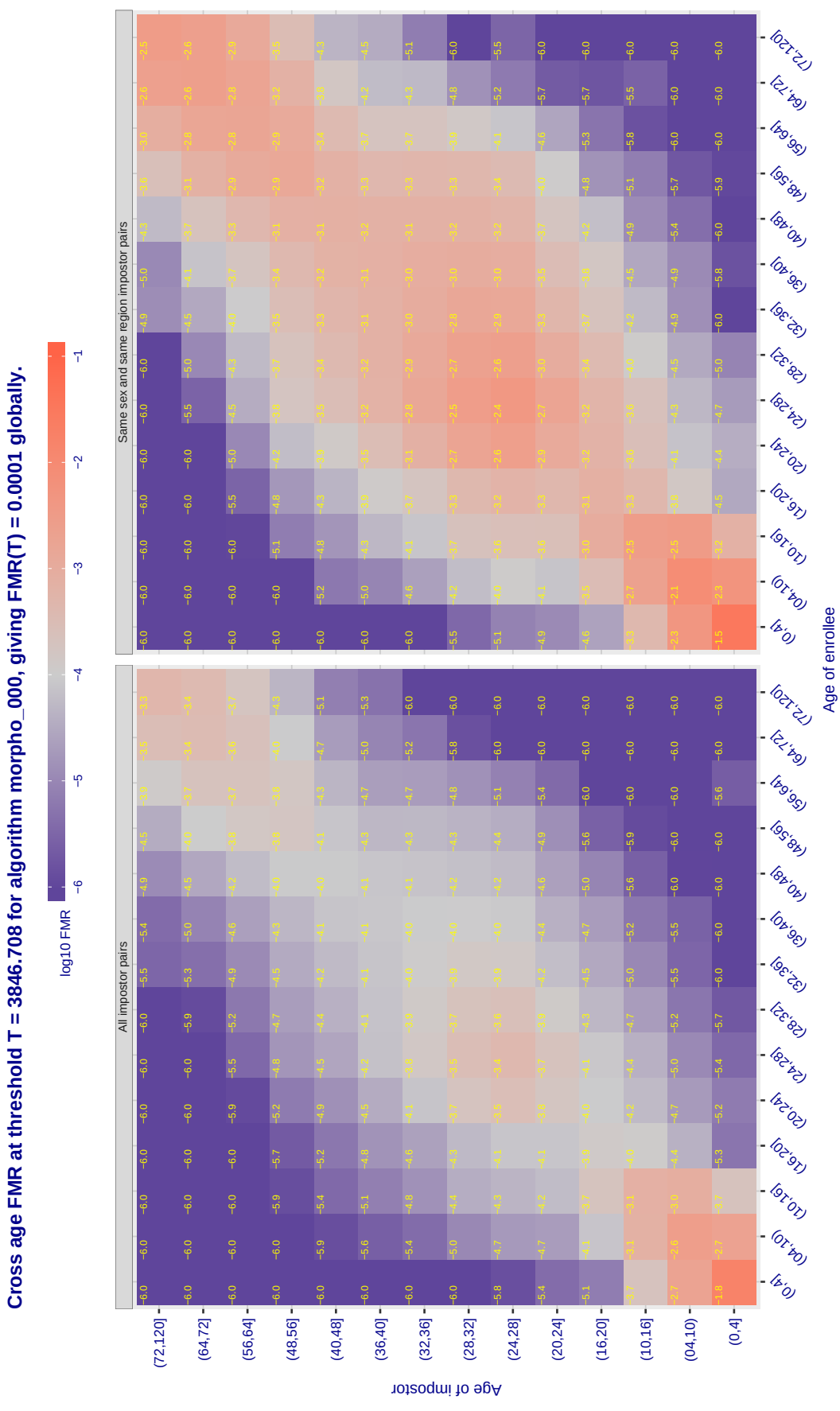


Figure 219: For algorithm morpho-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

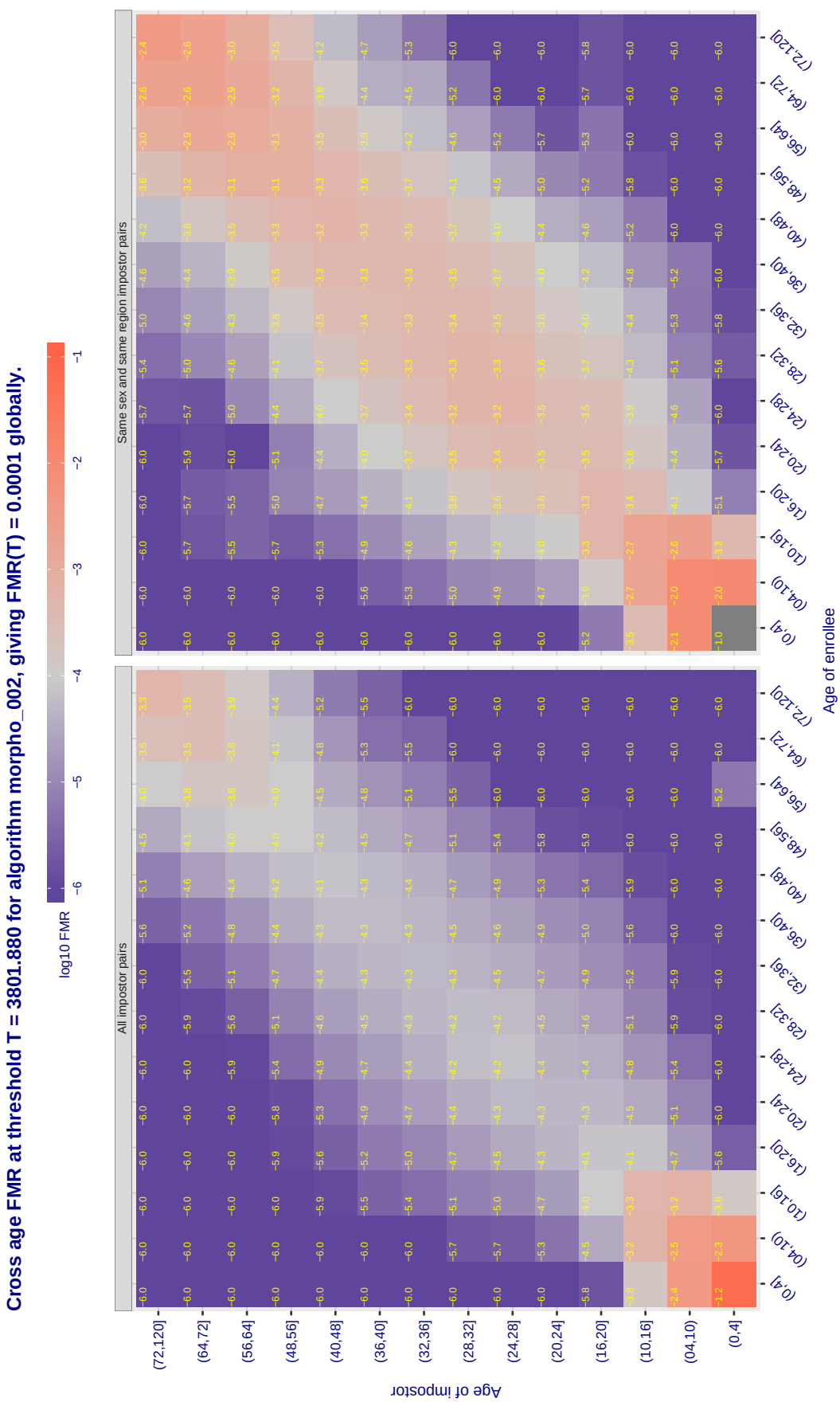


Figure 220: For algorithm morpho-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

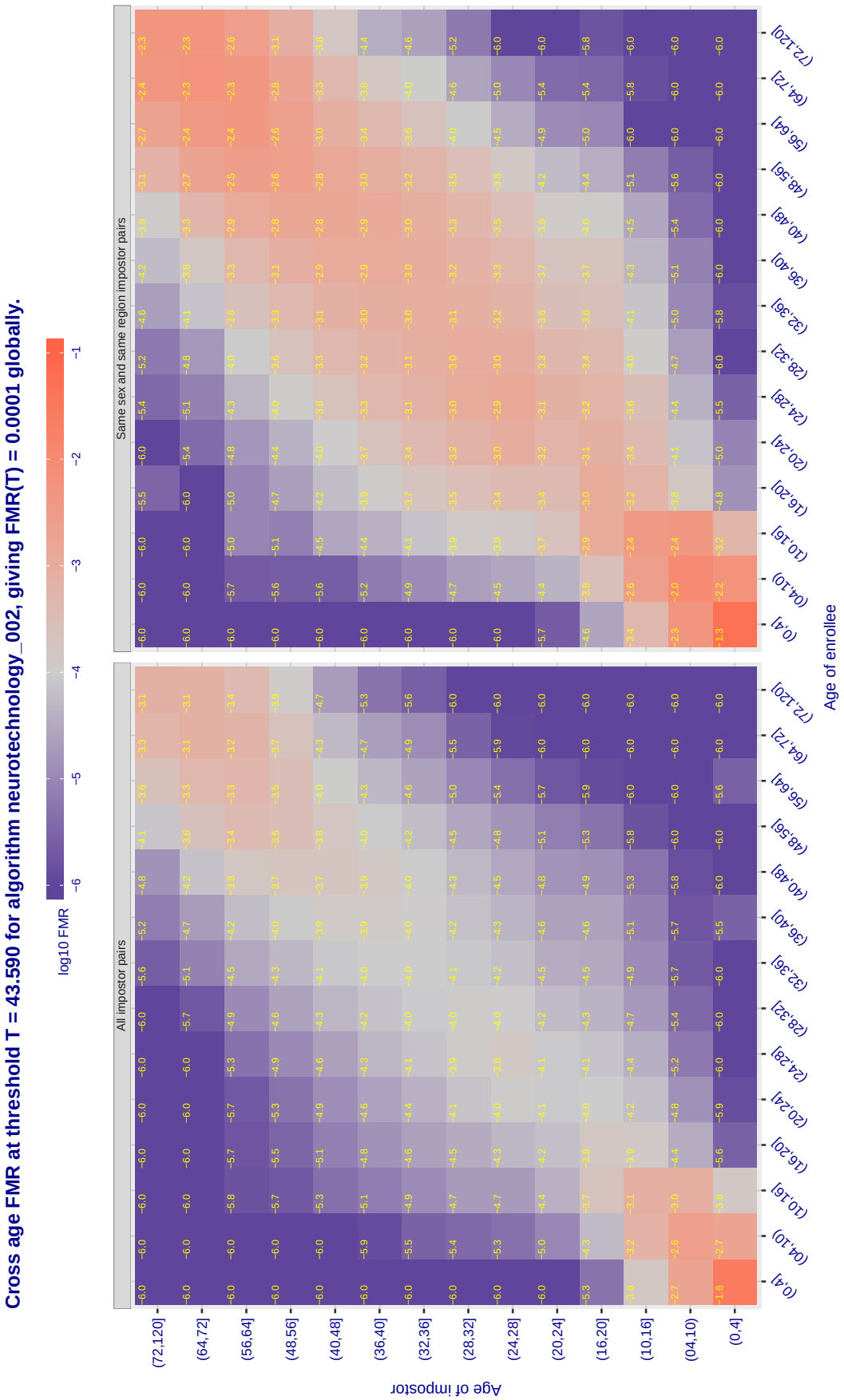


Figure 221: For algorithm neurotechnology-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

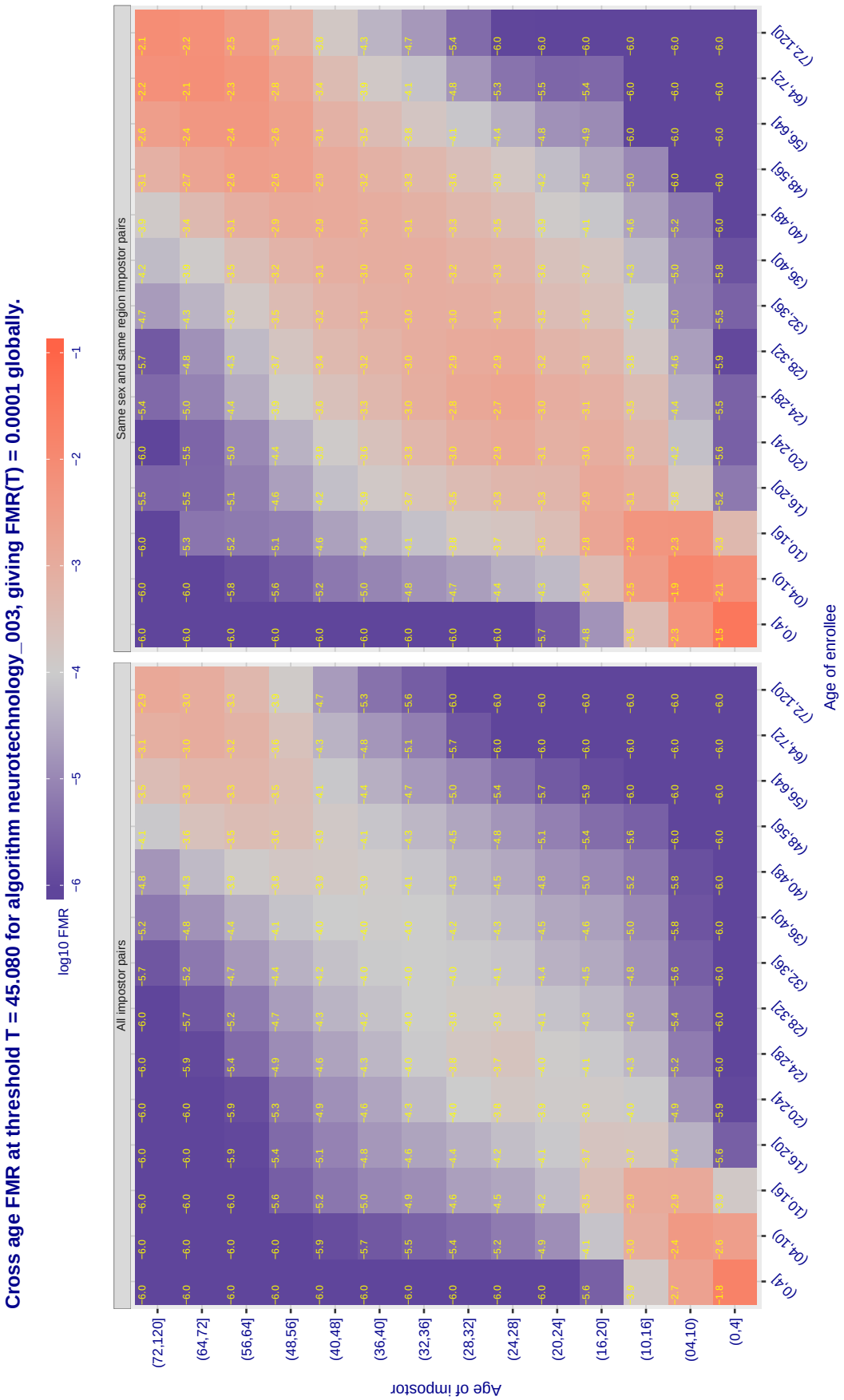


Figure 222: For algorithm neurotechnology-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

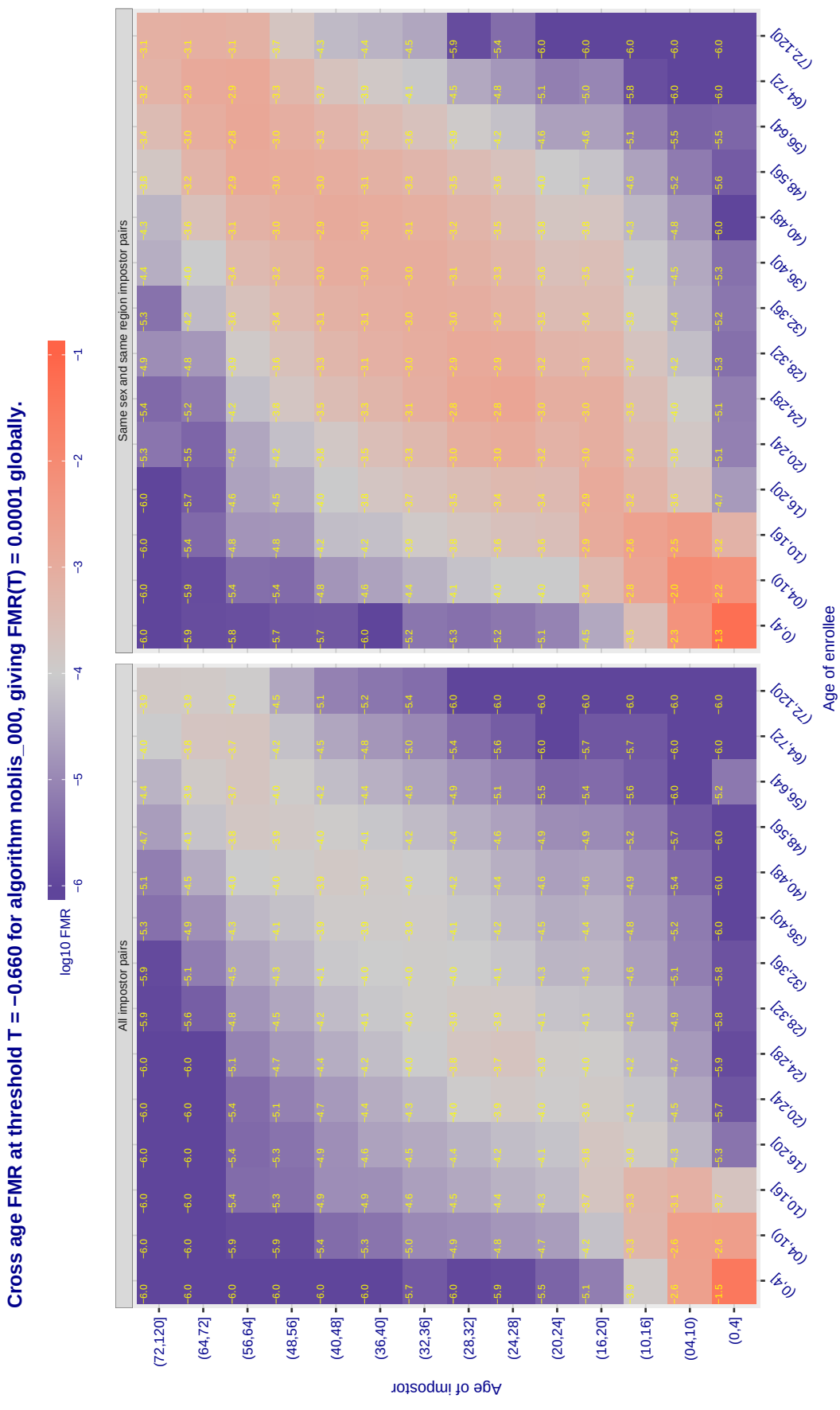


Figure 223: For algorithm noblis-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

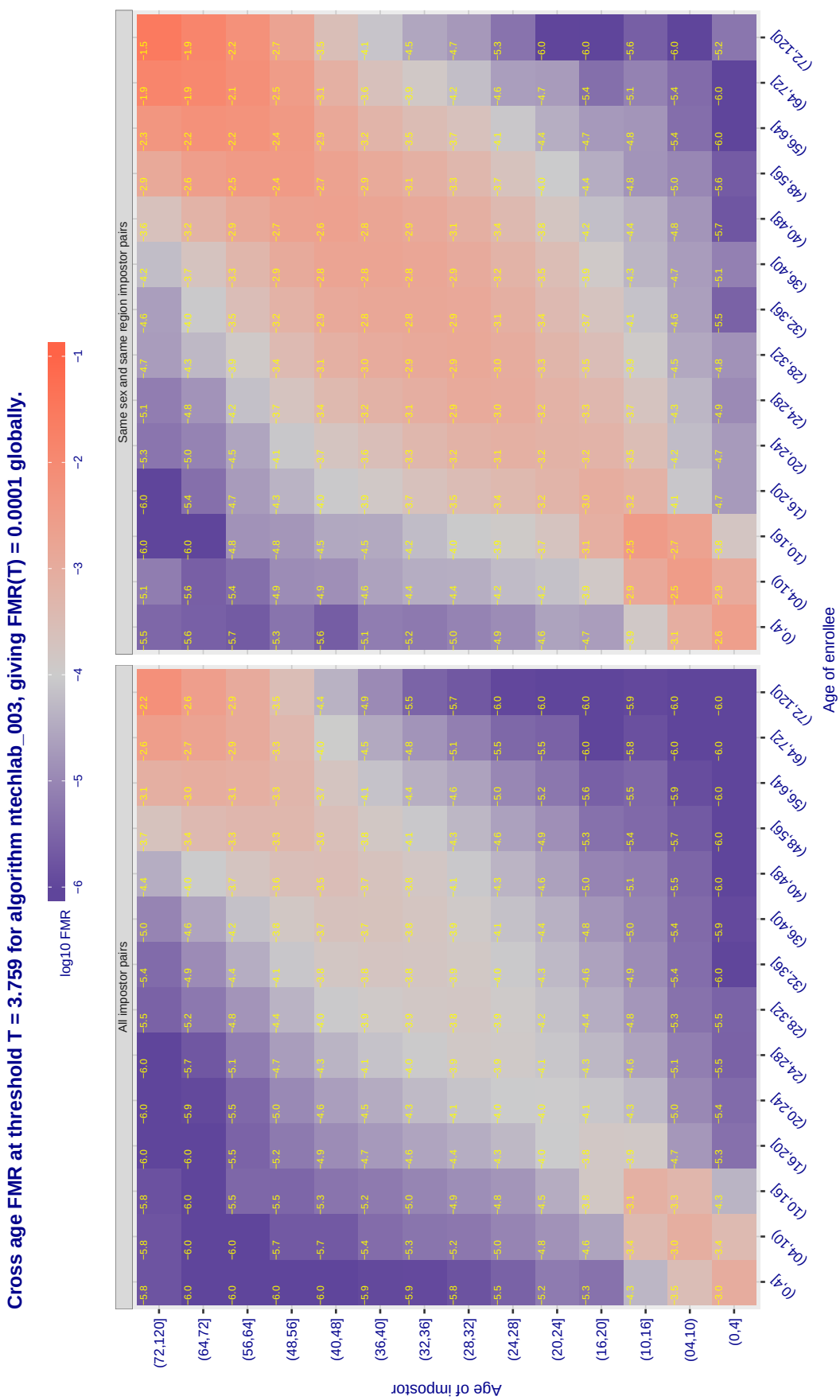


Figure 224: For algorithm ntechlab-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

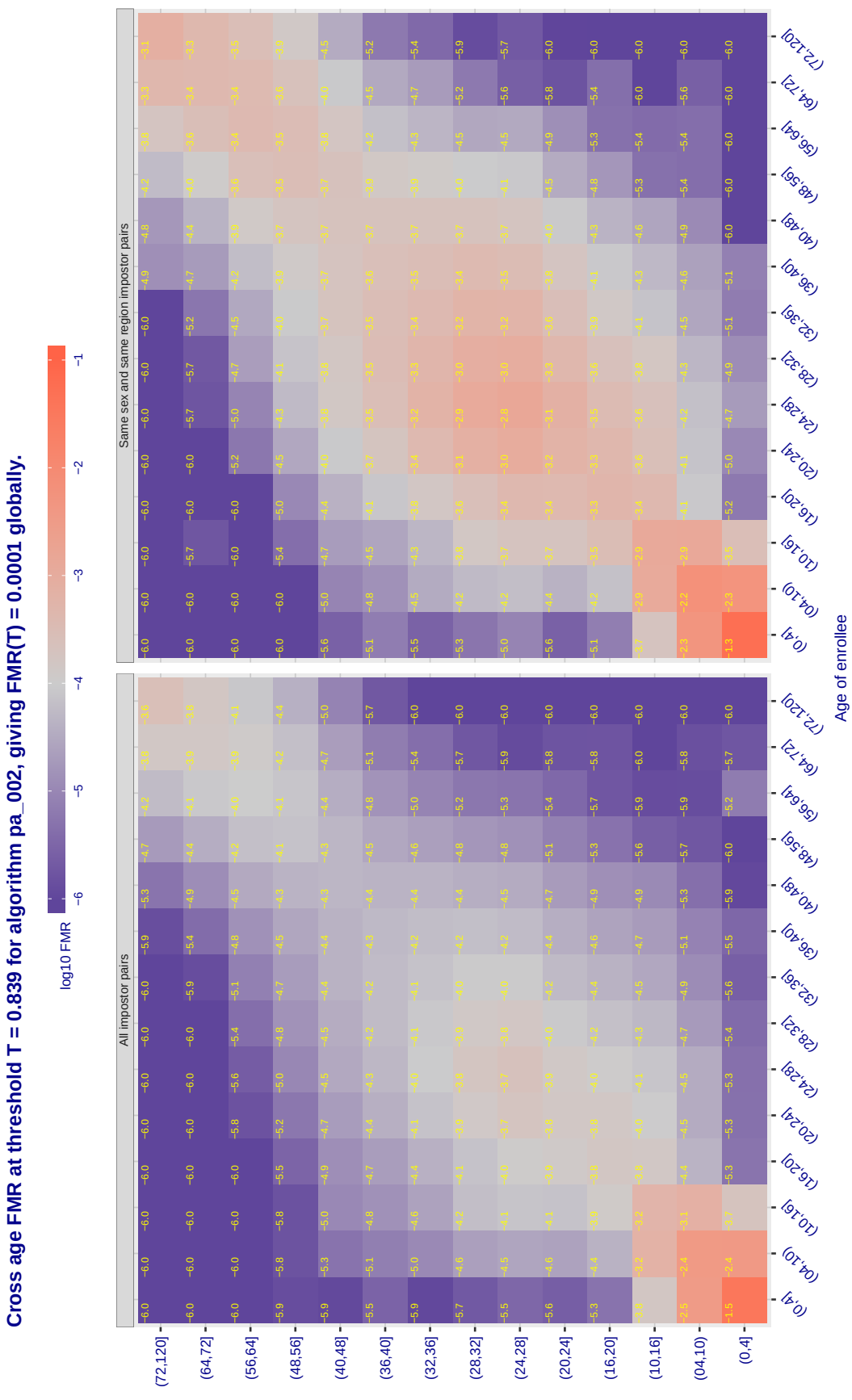


Figure 225: For algorithm pa-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

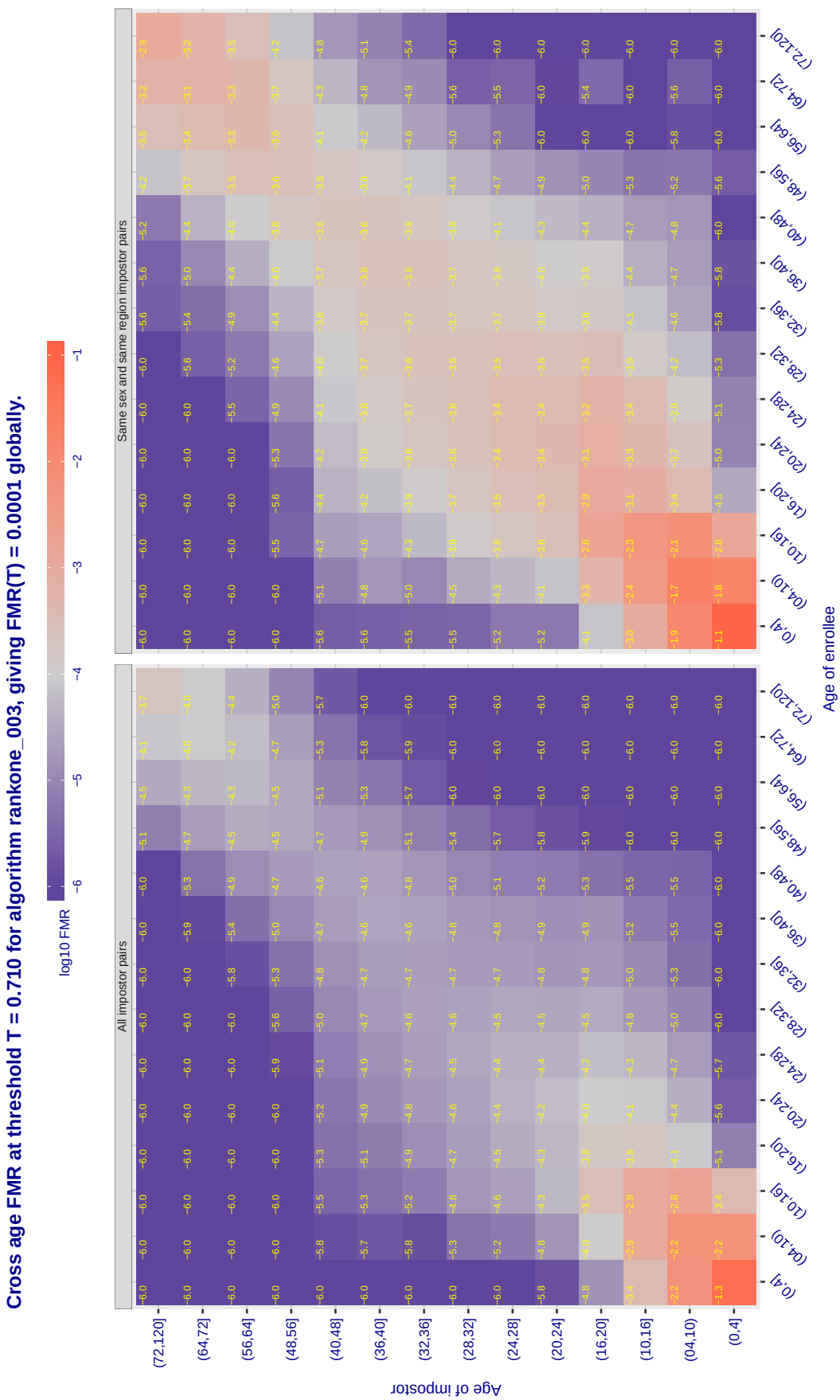


Figure 226: For algorithm rankone-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

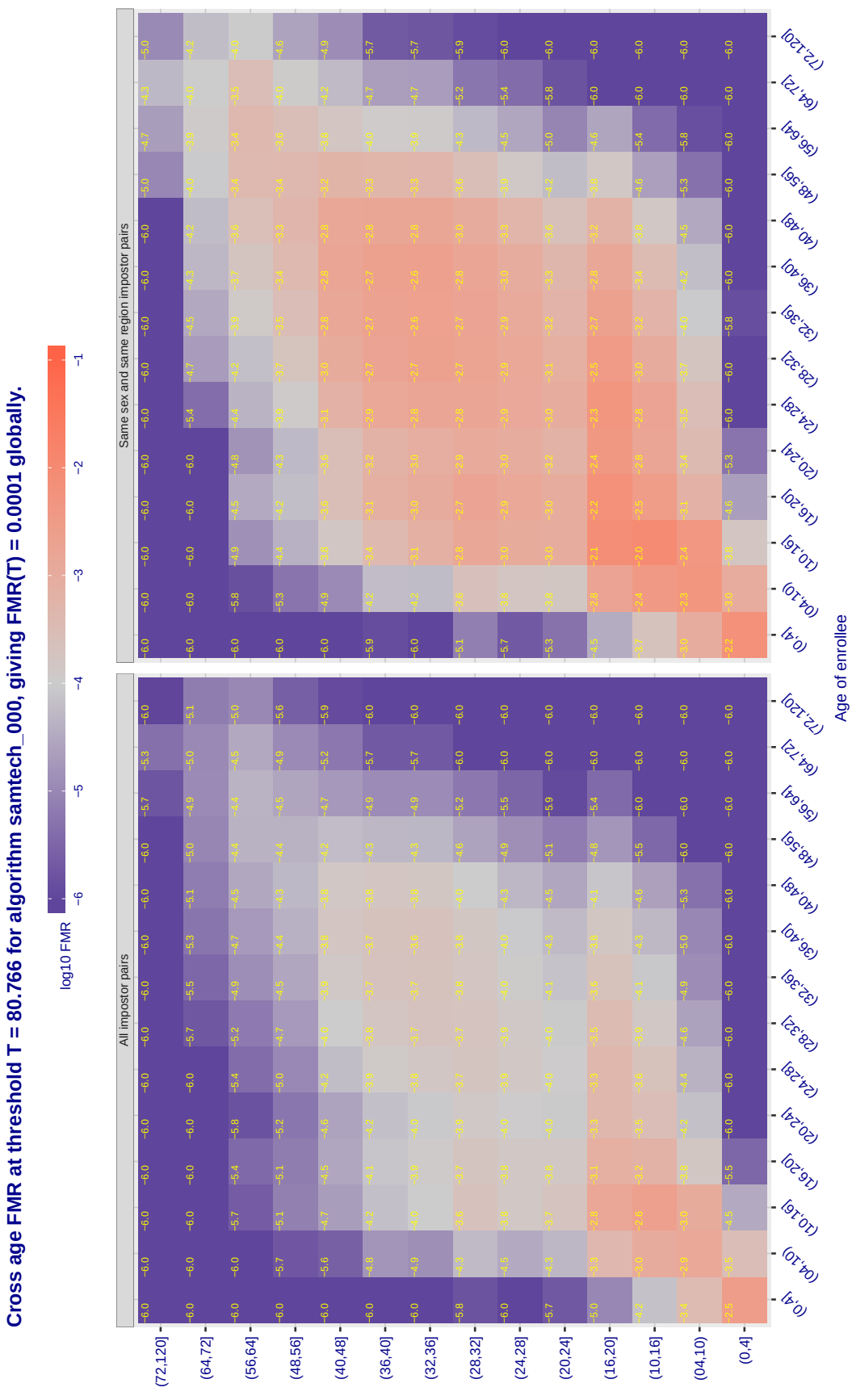


Figure 227: For algorithm samtech-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

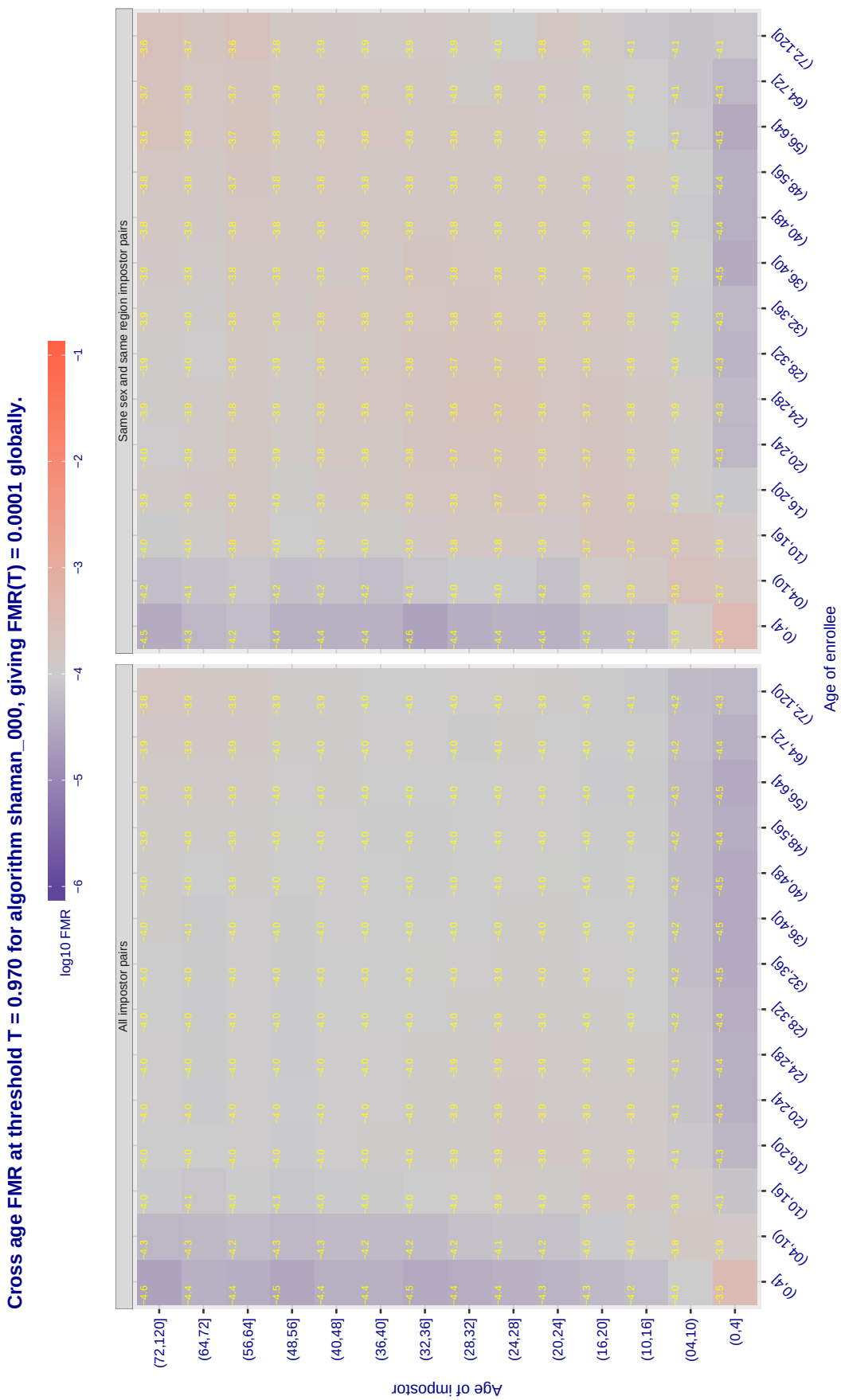


Figure 228: For algorithm shaman-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

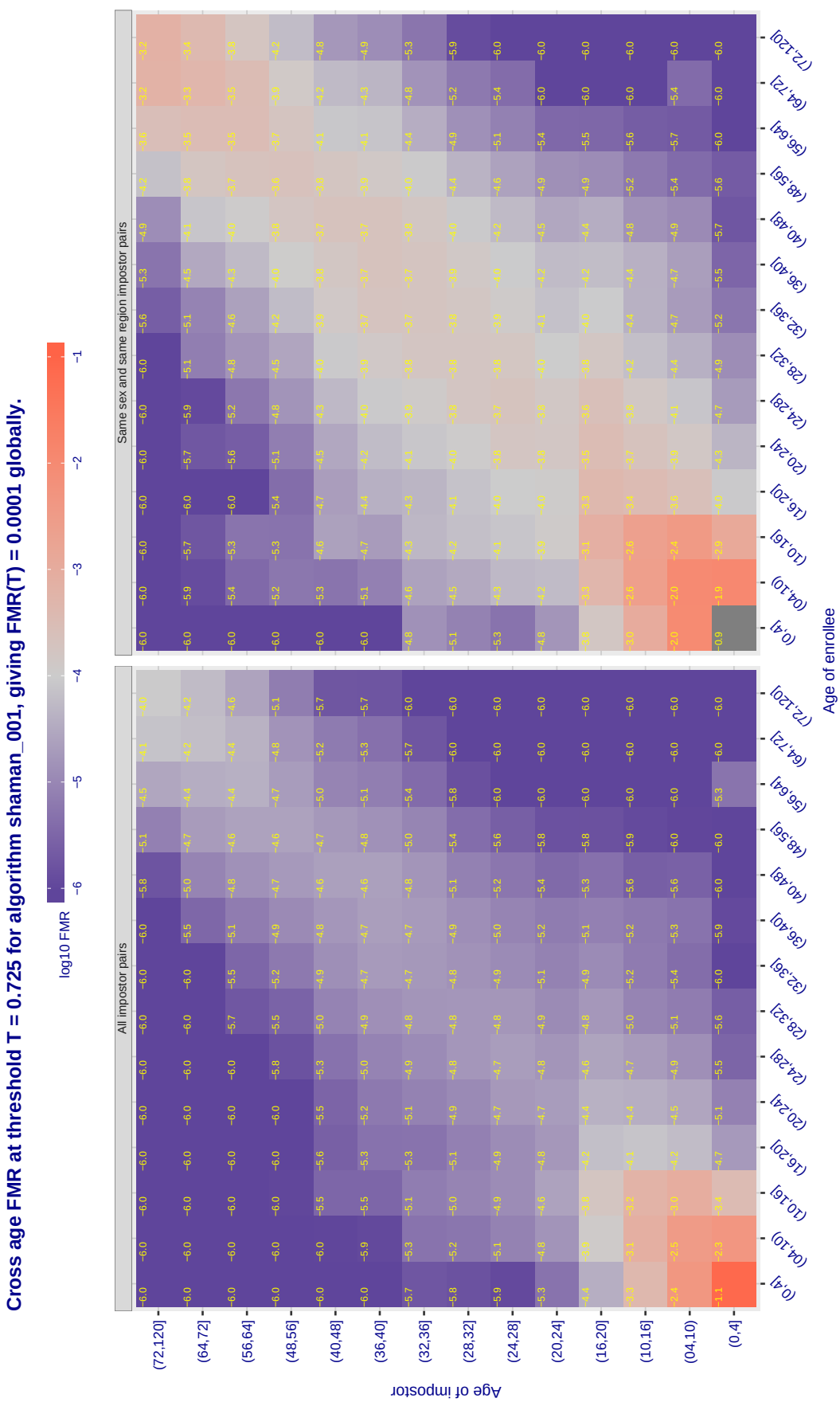


Figure 229: For algorithm shaman-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

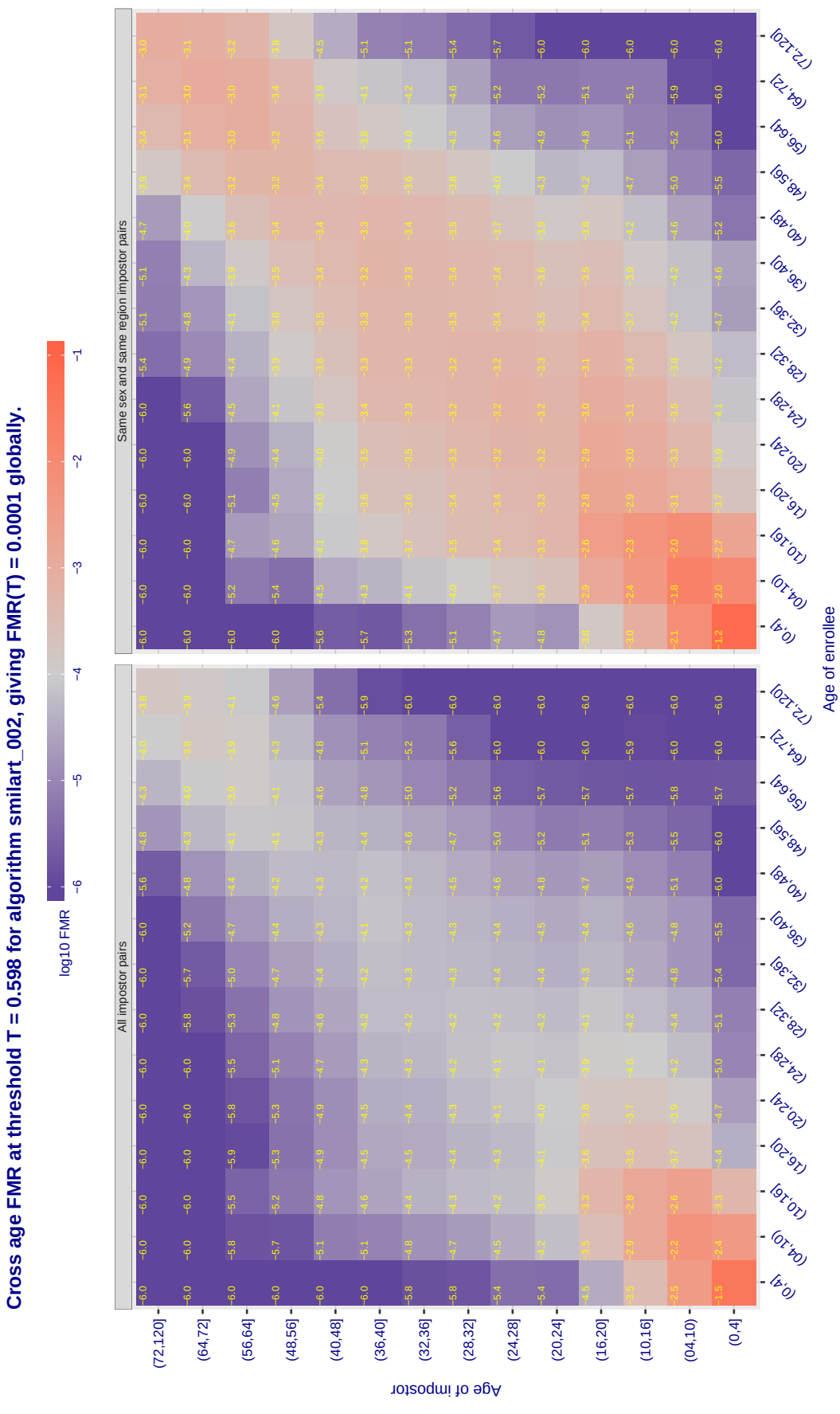


Figure 230: For algorithm smilart-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

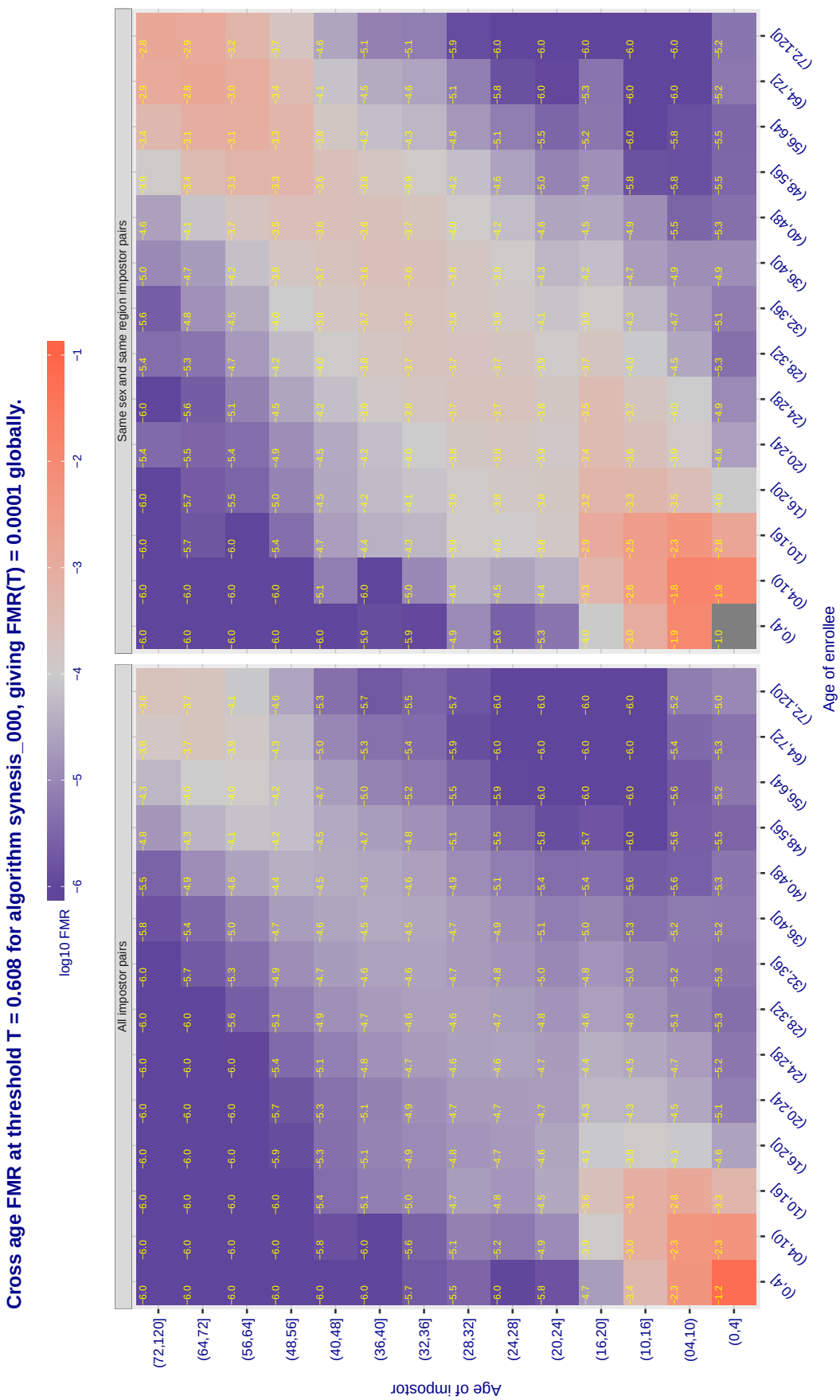


Figure 231: For algorithm synesis-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

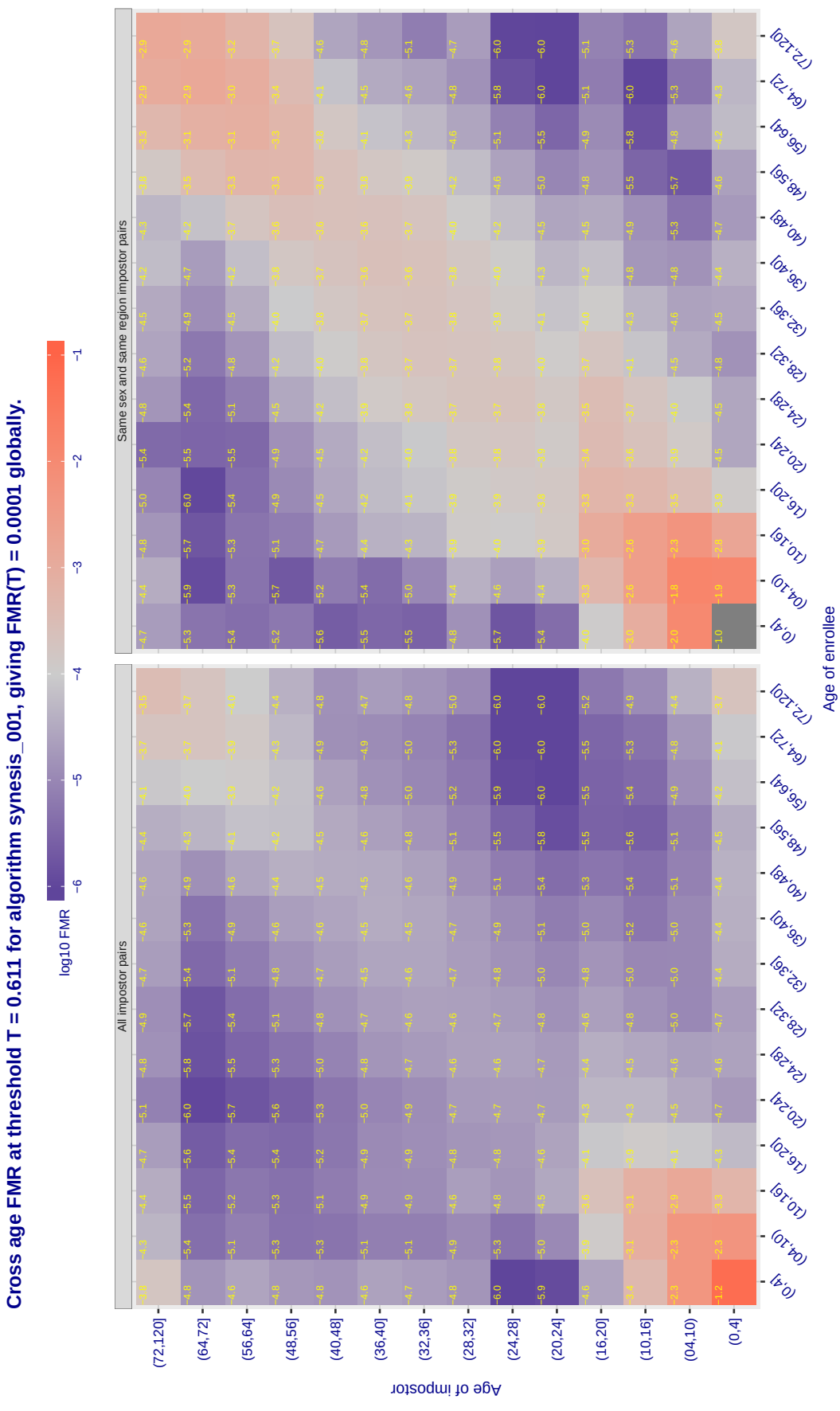


Figure 232: For algorithm synesis-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

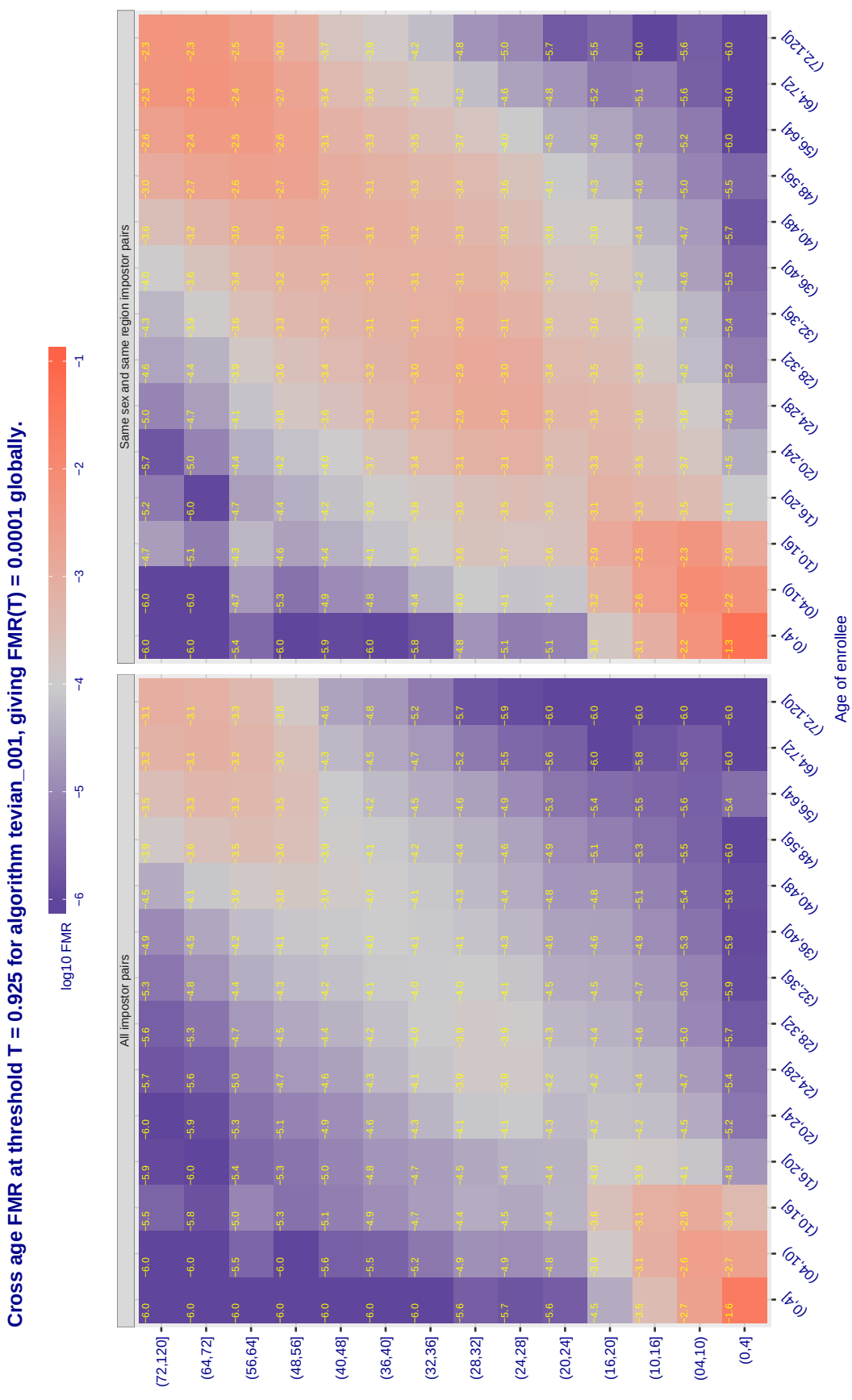


Figure 233: For algorithm tevian-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

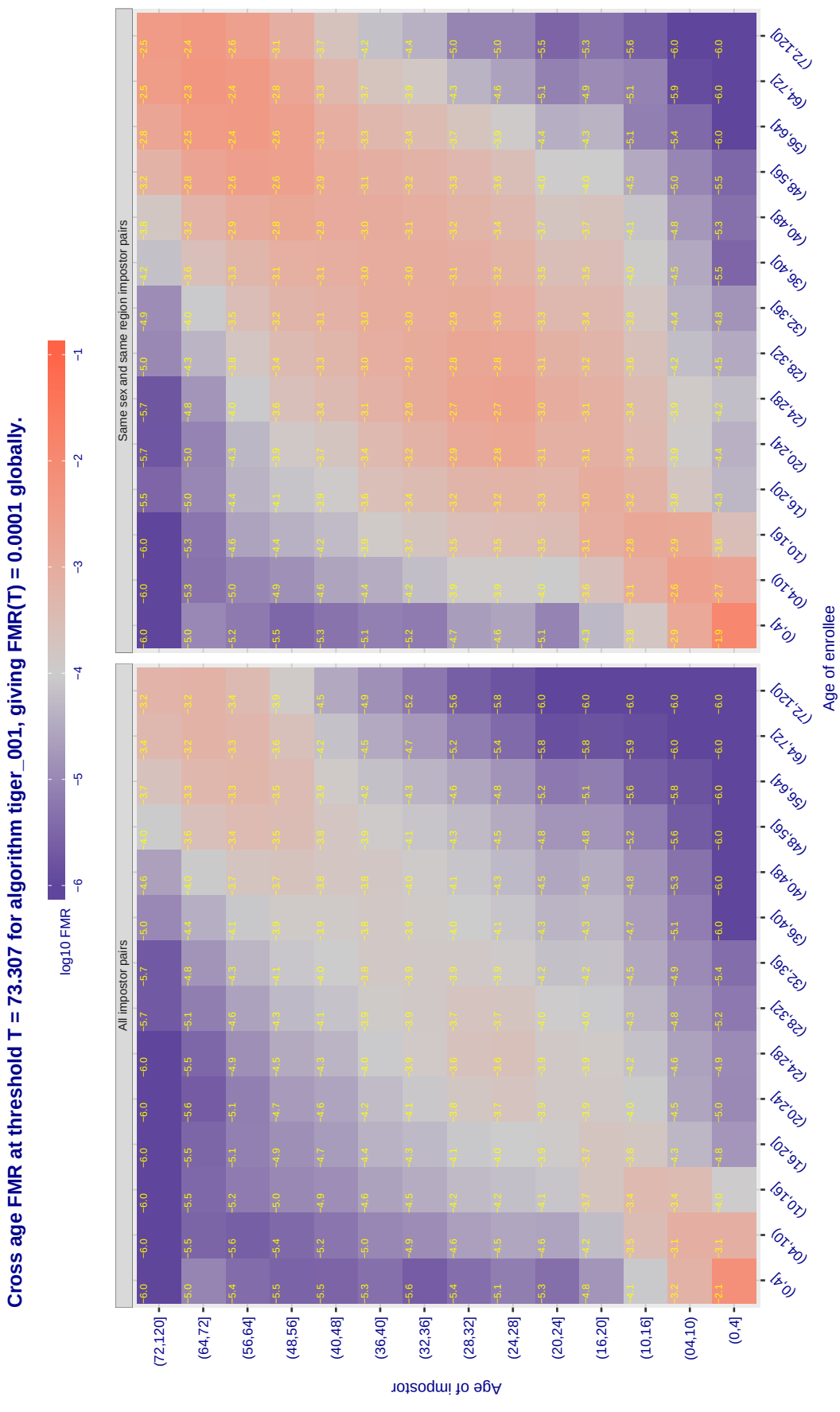


Figure 234: For algorithm tiger-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

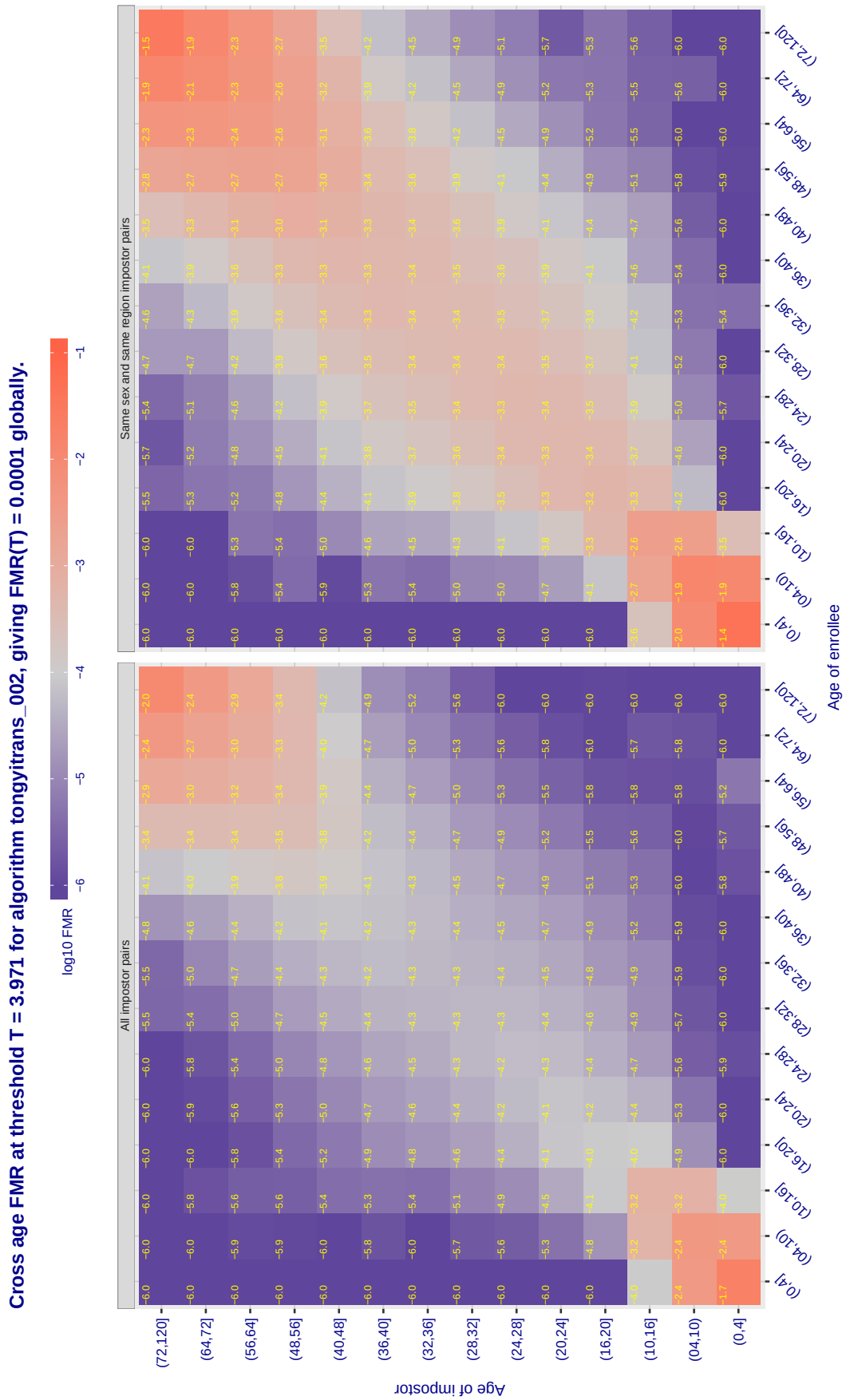


Figure 235: For algorithm tongyitrans-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

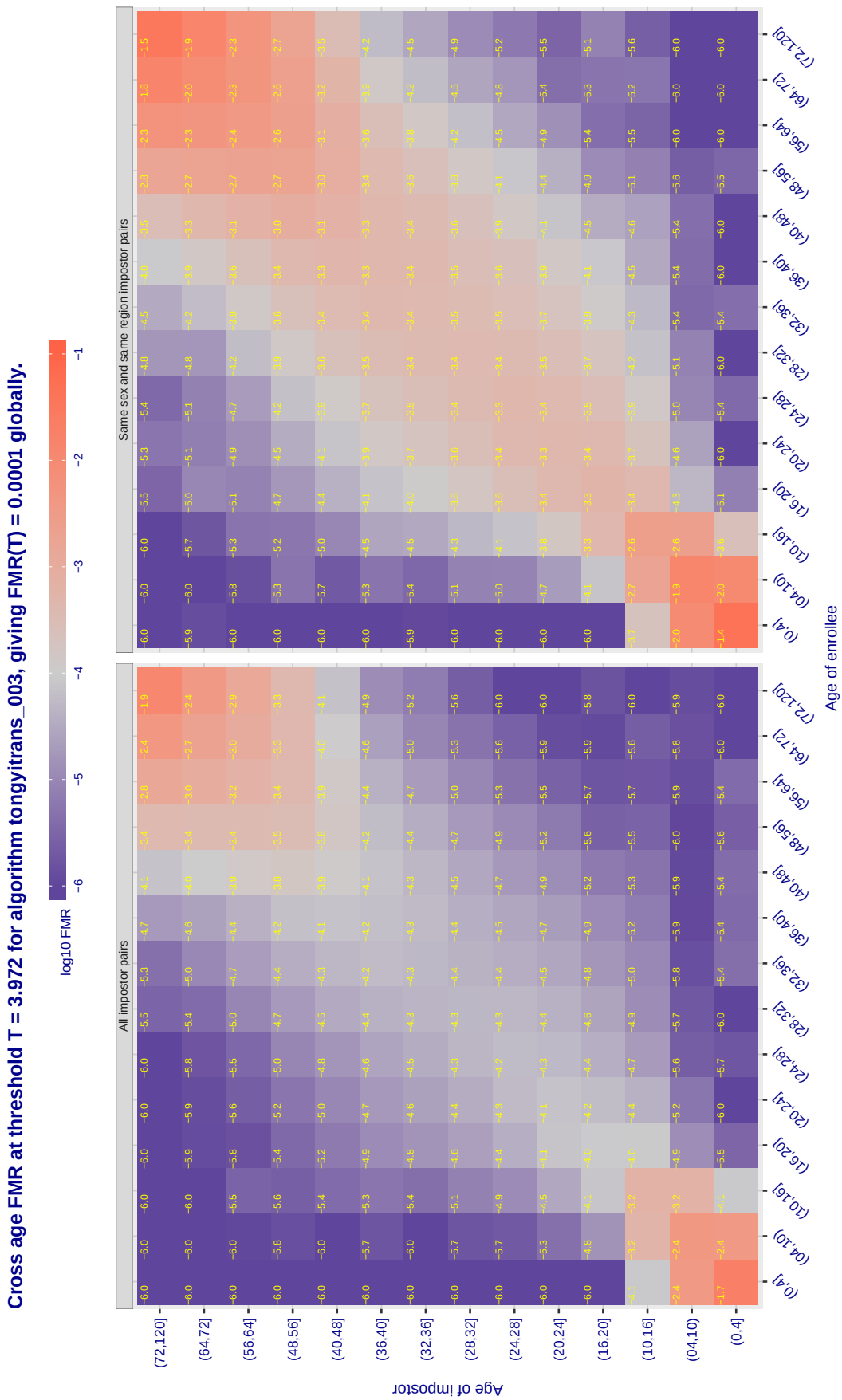


Figure 236: For algorithm tongyitrans-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

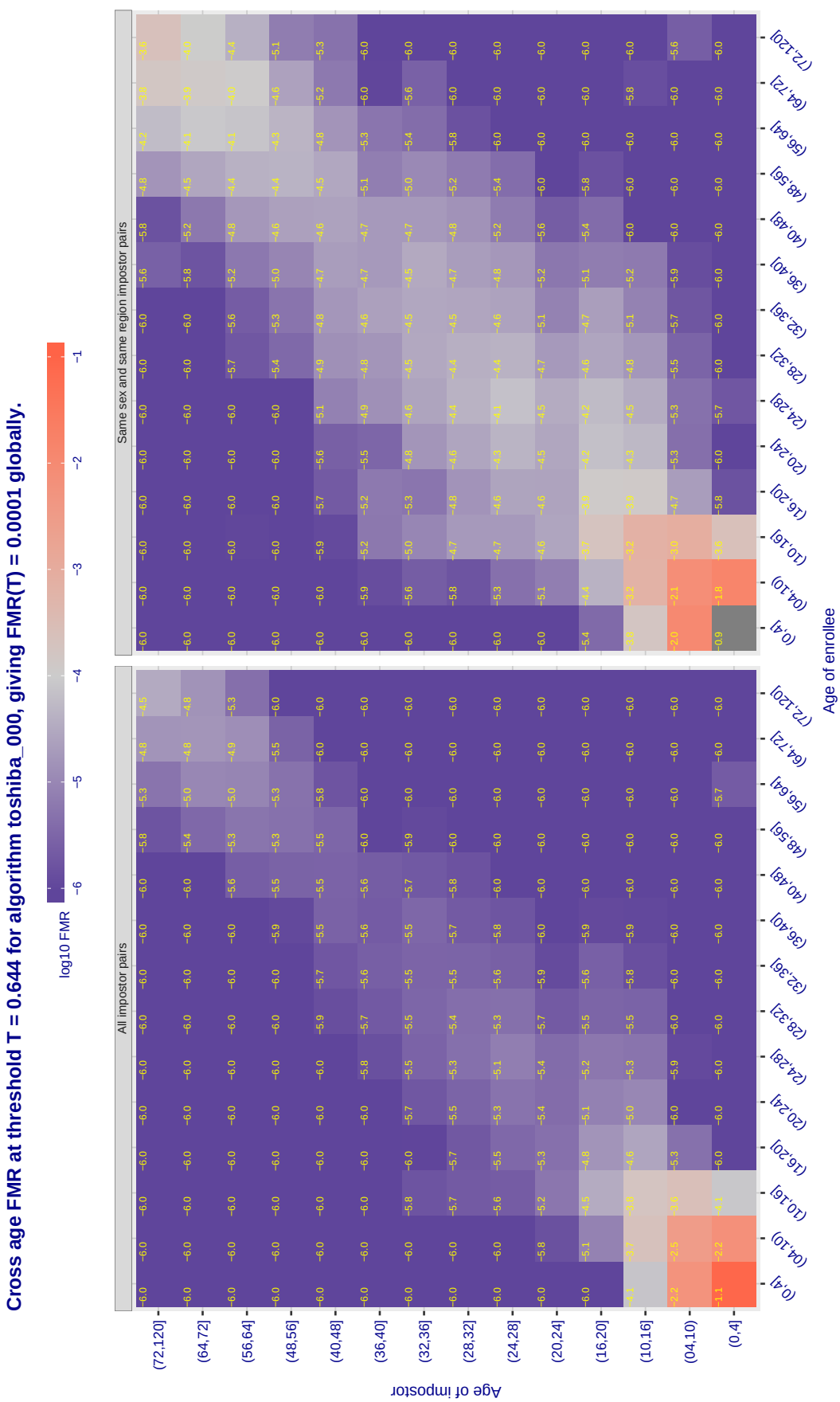


Figure 237: For algorithm toshiba-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

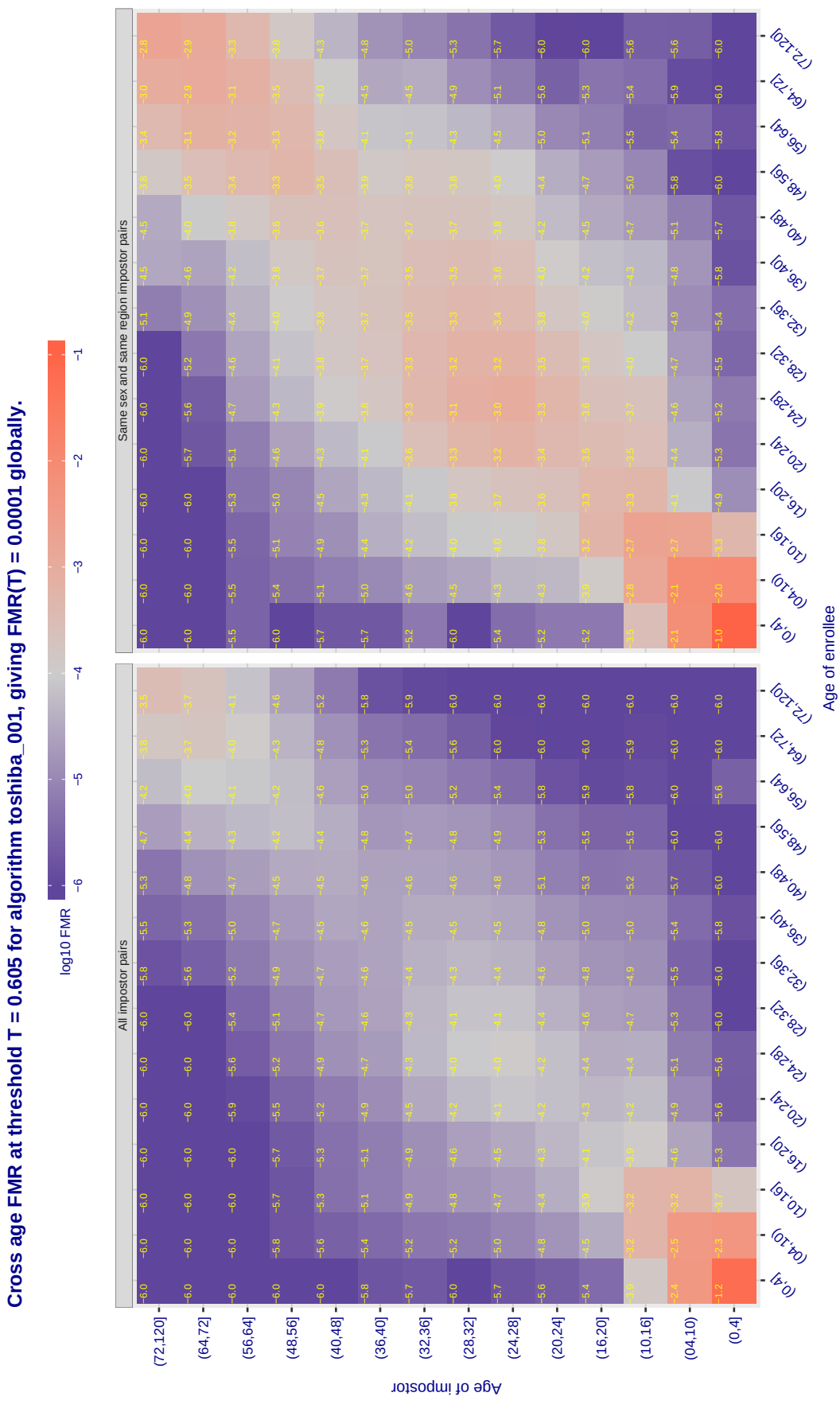


Figure 238: For algorithm toshiba-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

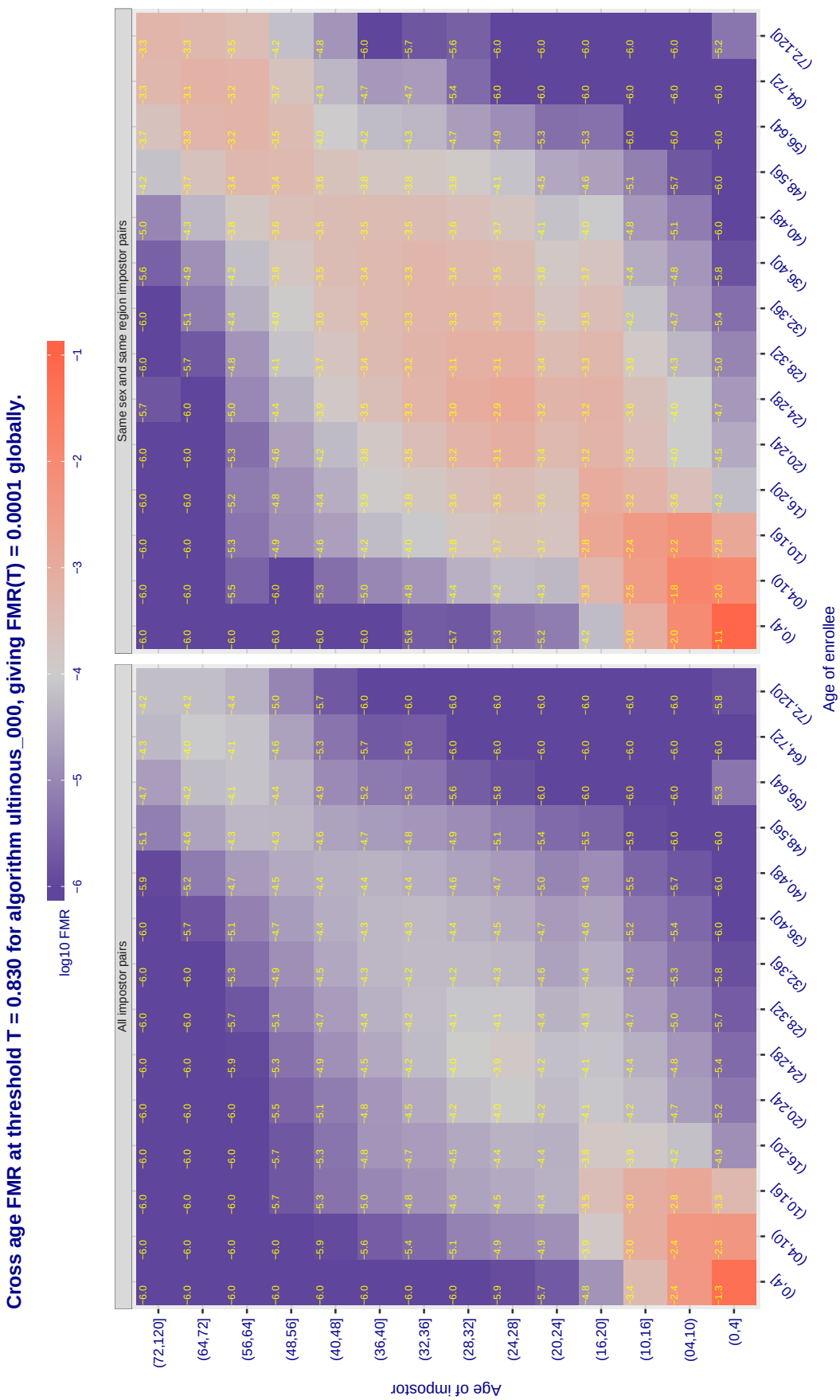


Figure 239: For algorithm ultinous-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

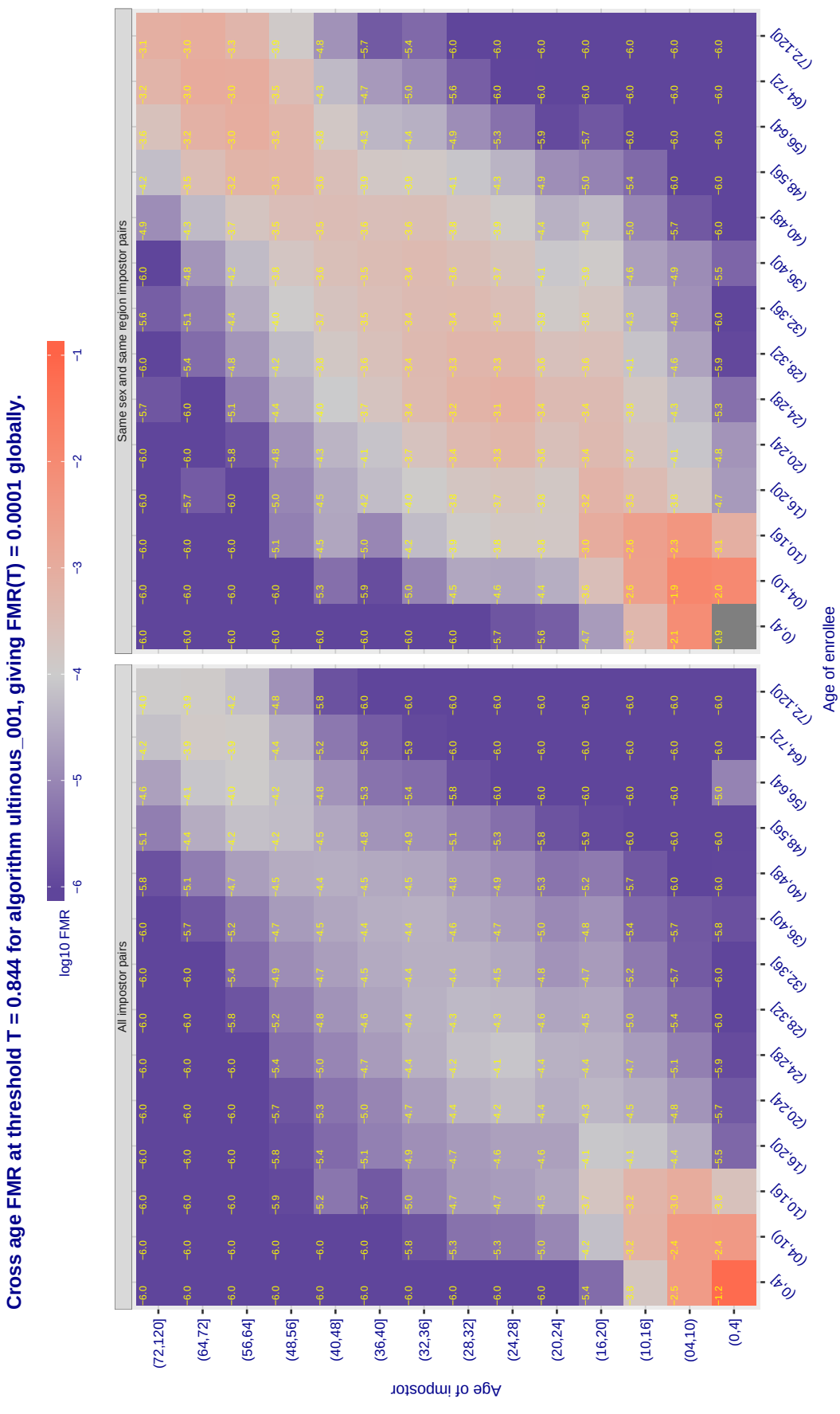


Figure 240: For algorithm ultinous-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

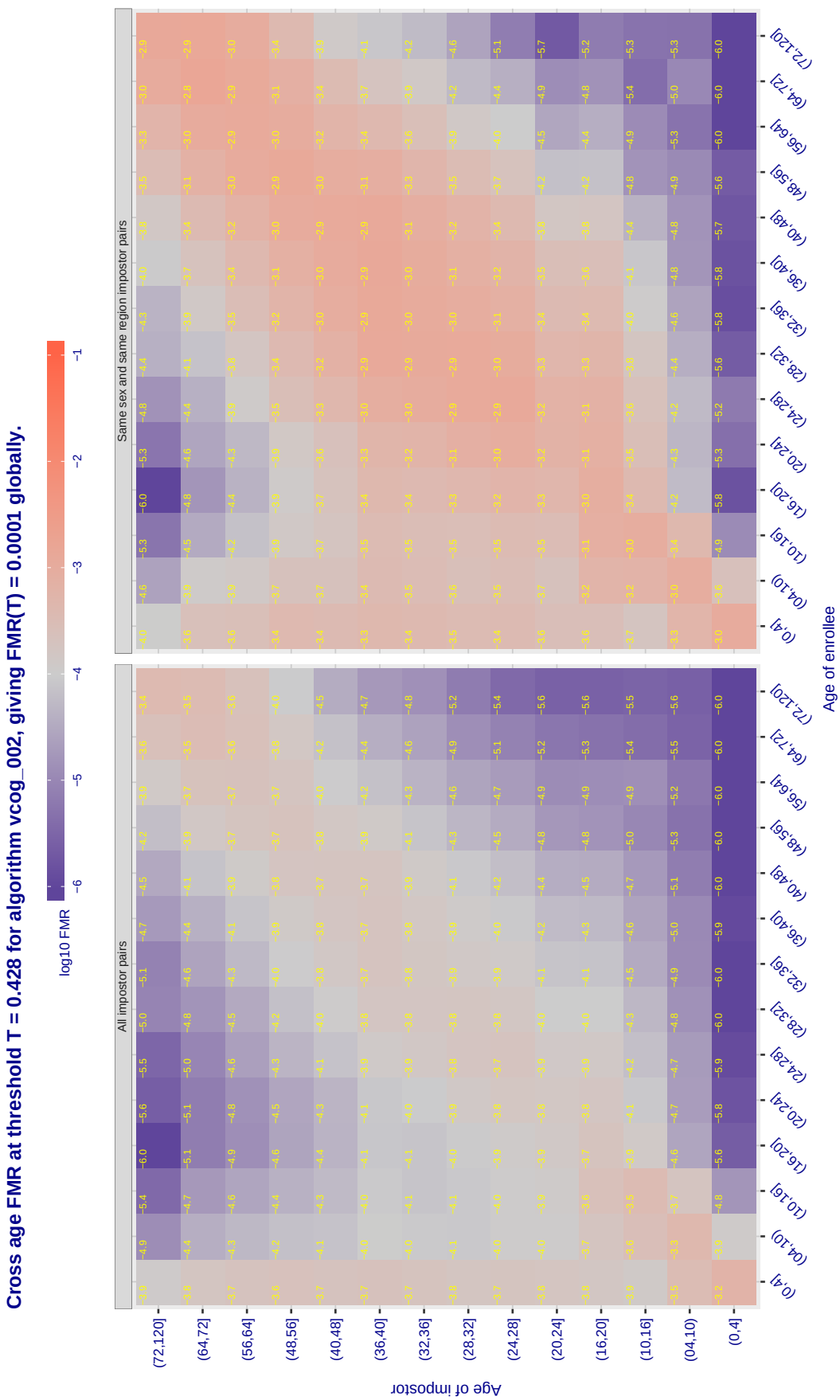


Figure 241: For algorithm vcog-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

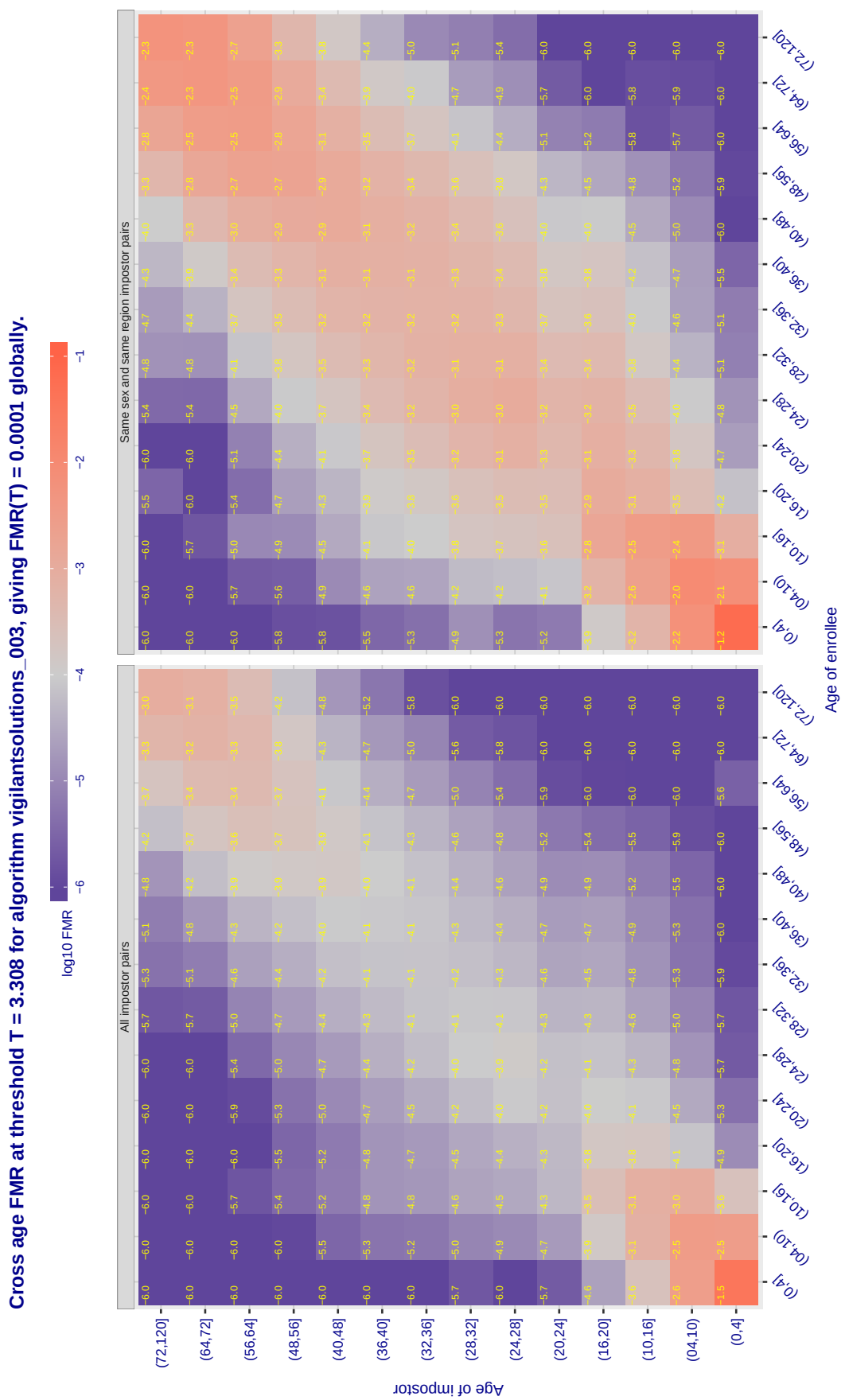


Figure 242: For algorithm vigilantsolutions-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

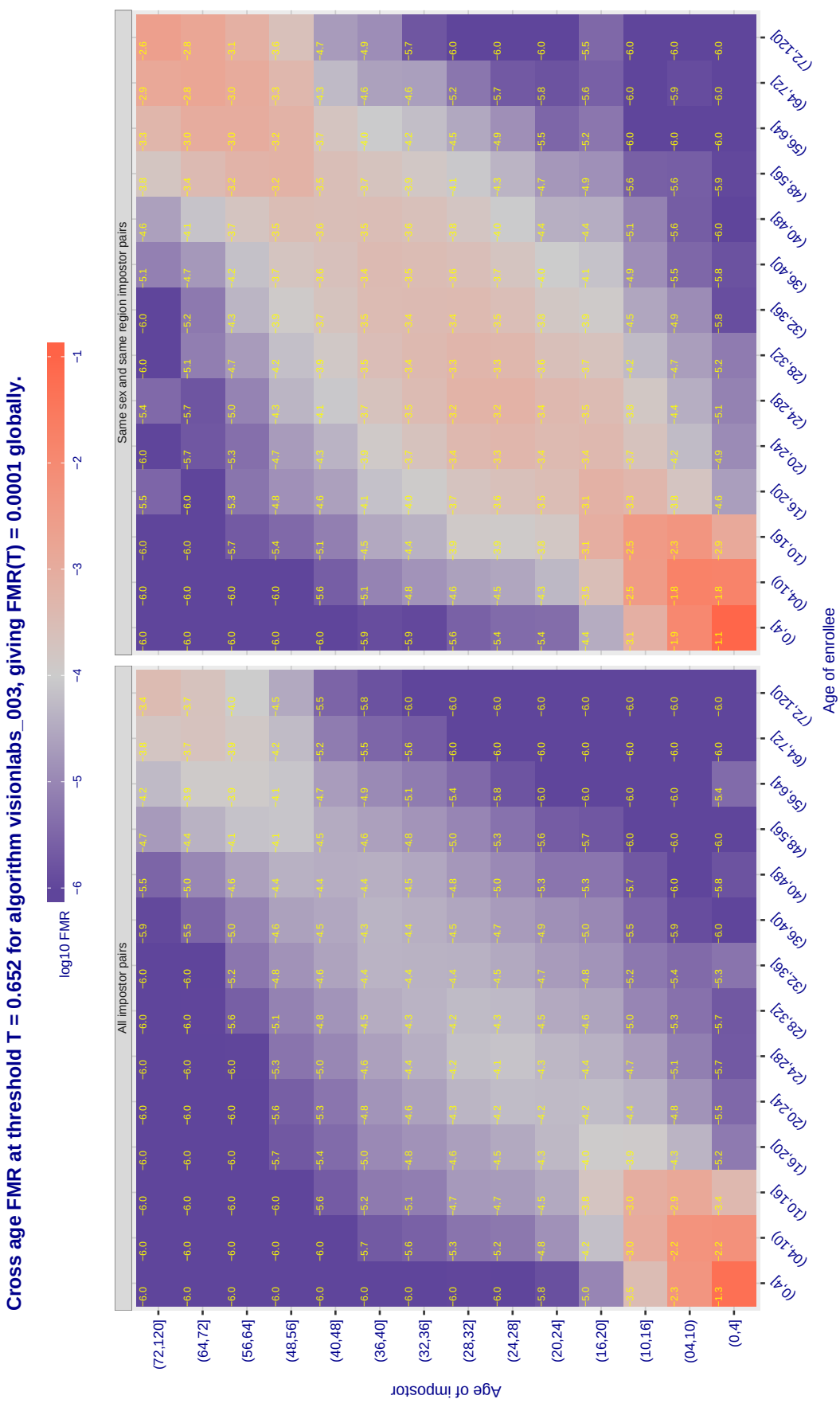


Figure 243: For algorithm visionlabs-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

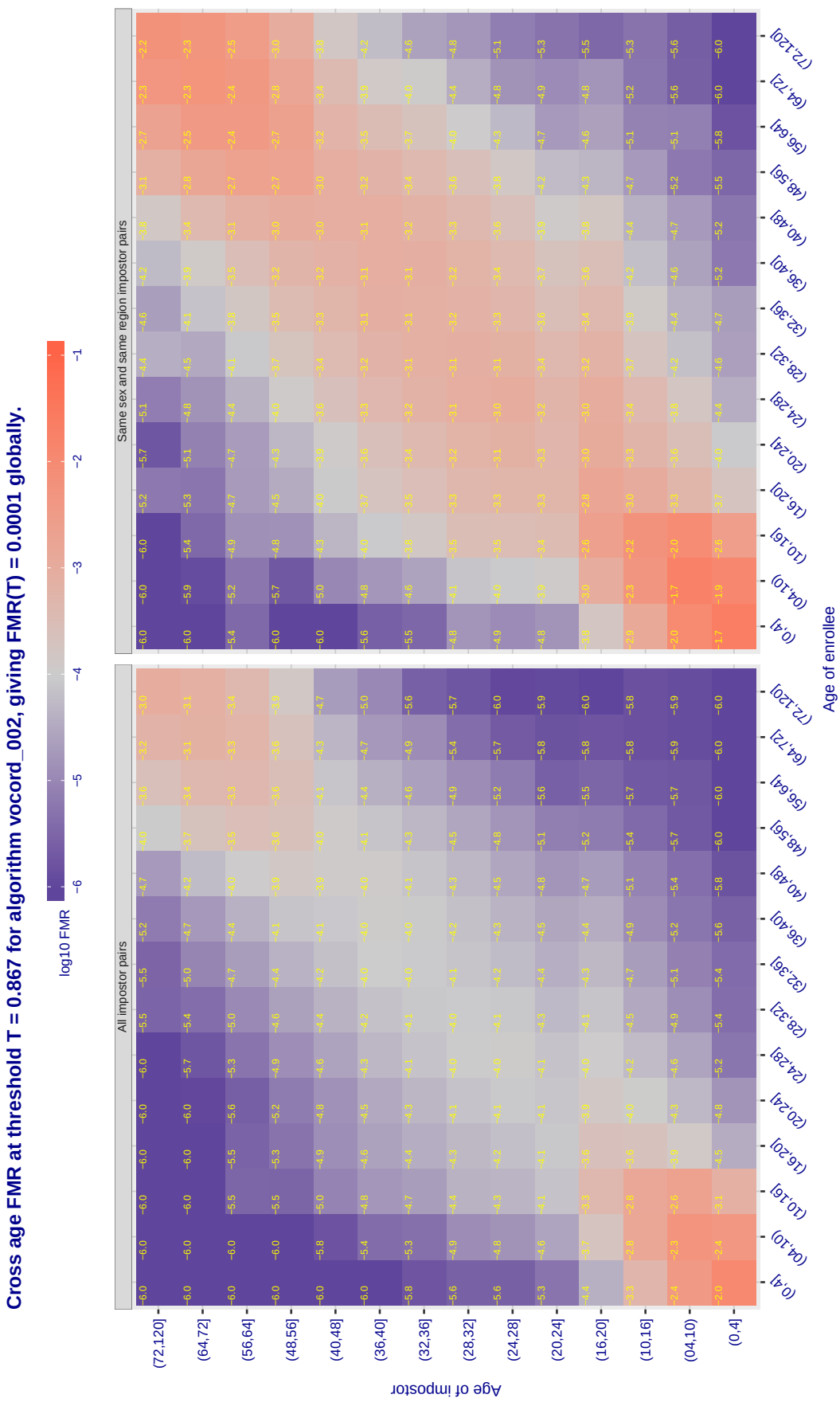


Figure 244: For algorithm vocord-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

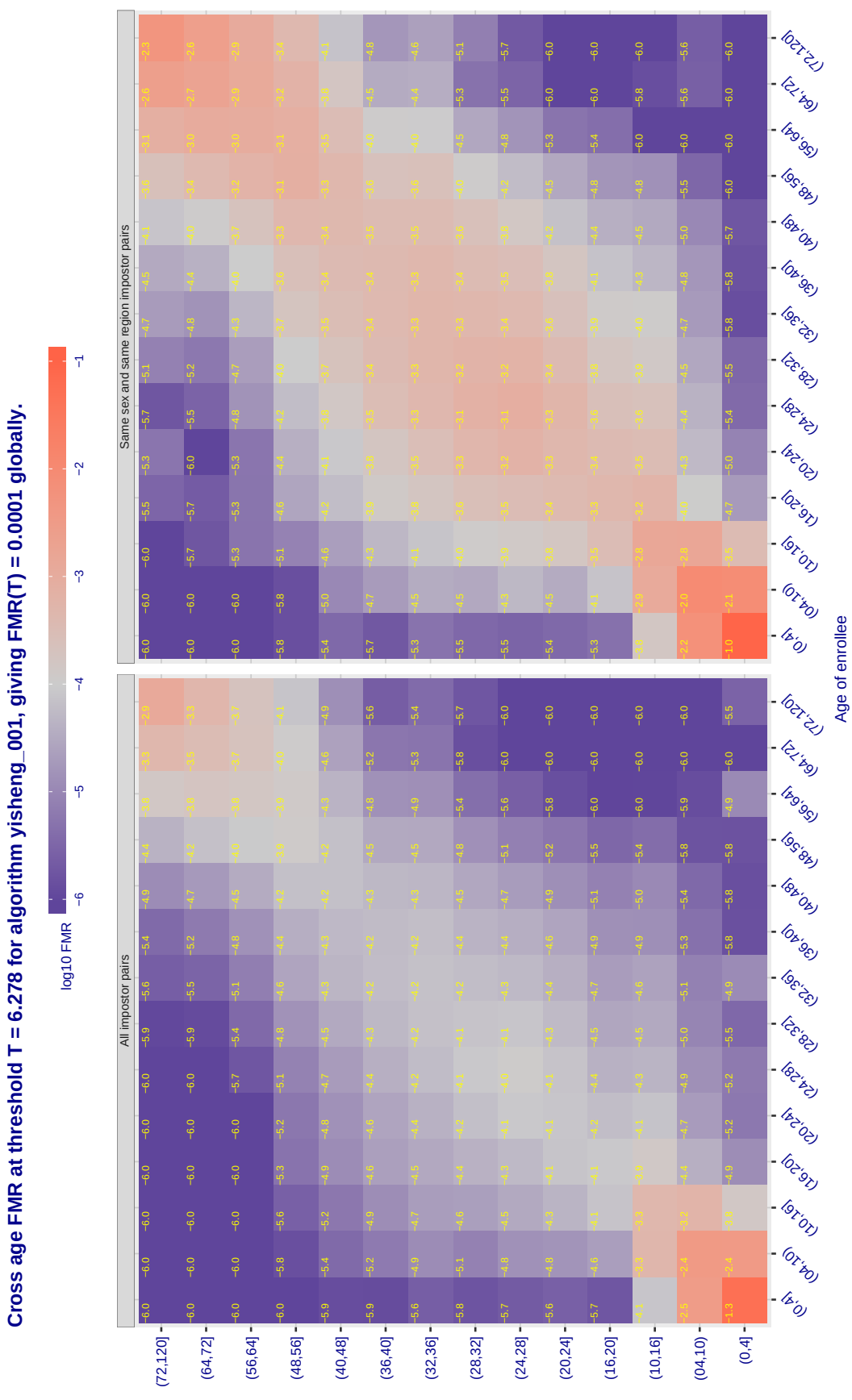


Figure 245: For algorithm yisheng-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

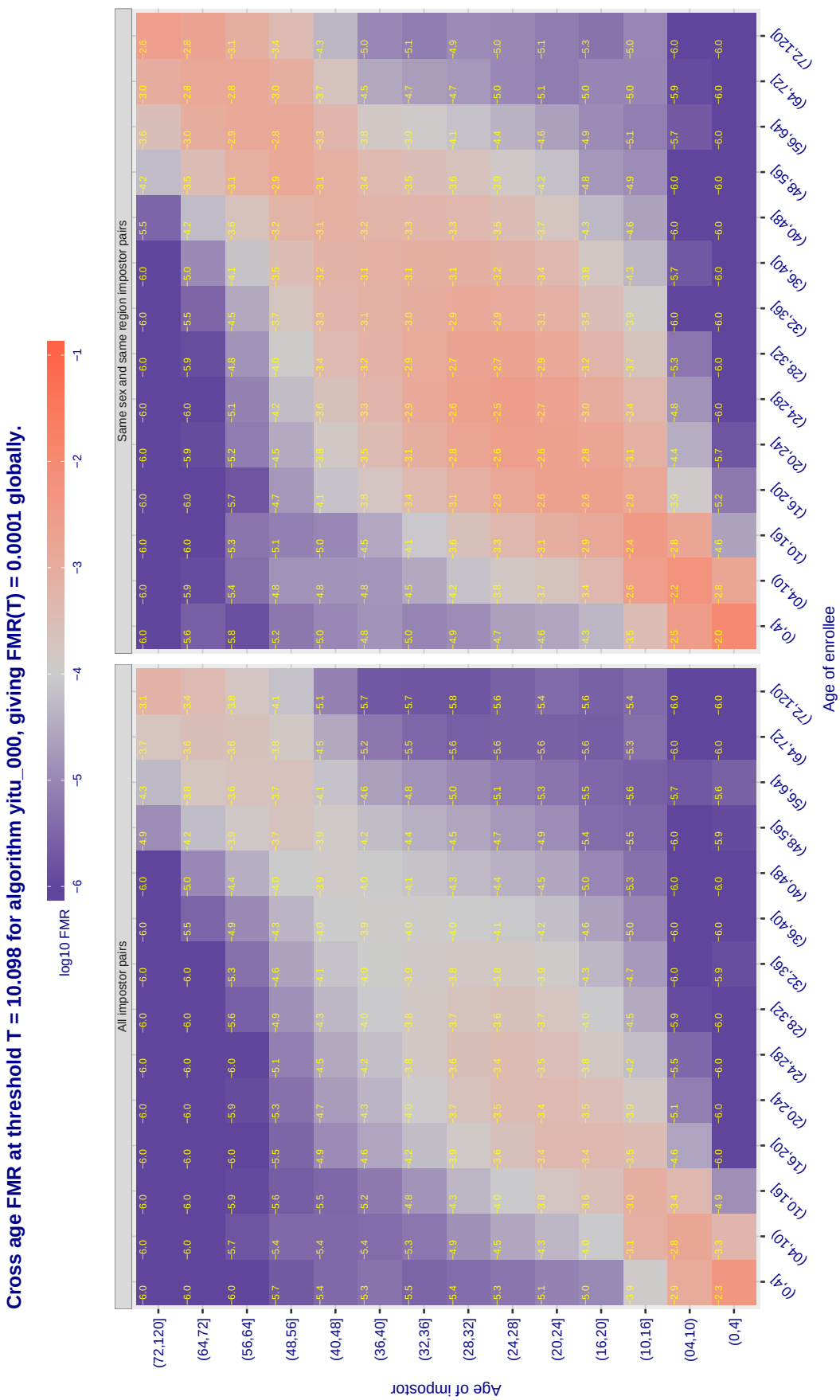


Figure 246: For algorithm yitu-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of 10^{10} impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

Accuracy Terms + Definitions

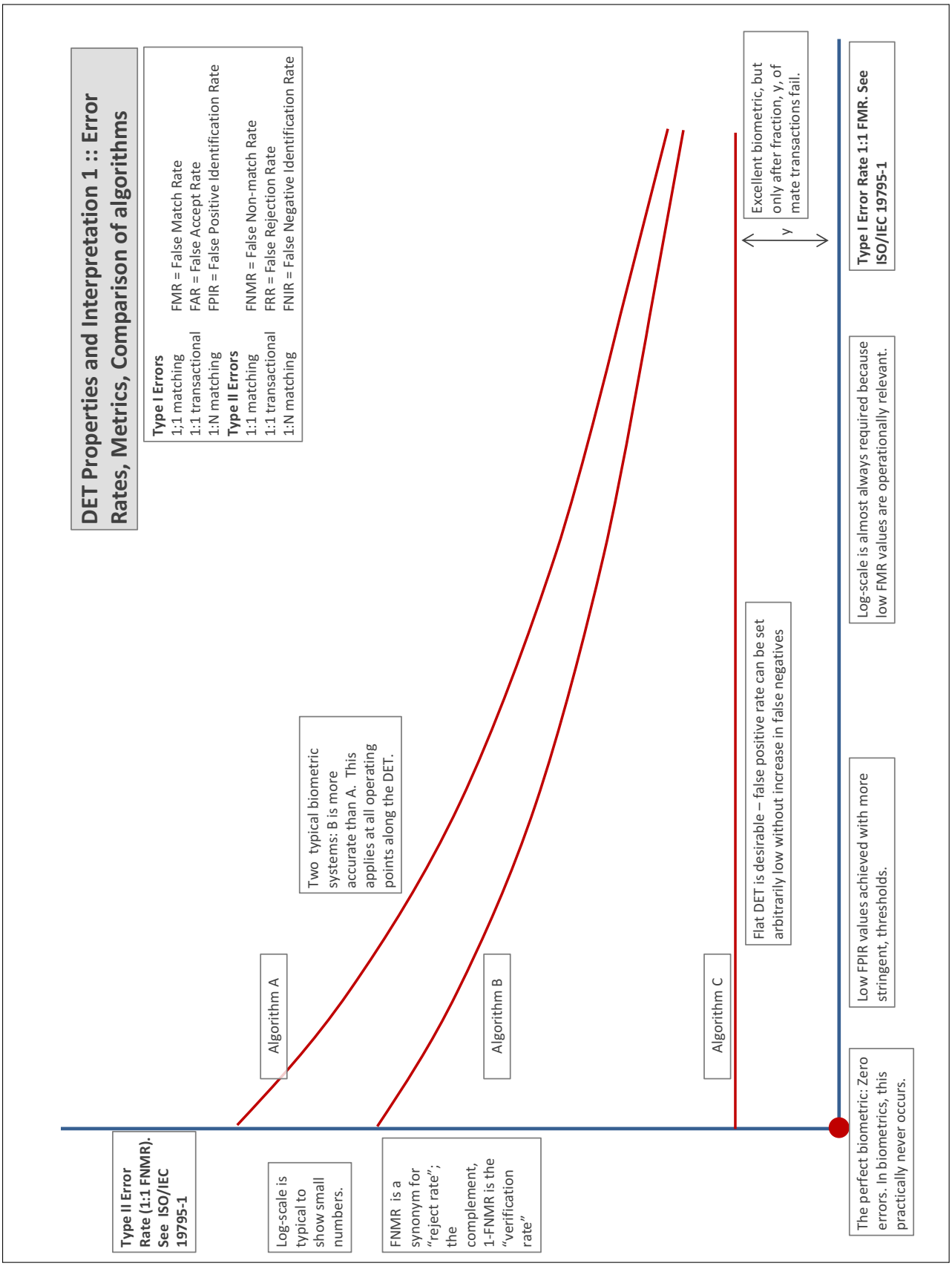
In biometrics, Type II errors occur when two samples of one person do not match – this is called a **false negative**. Correspondingly, Type I errors occur when samples from two persons do match – this is called a **false positive**. Matches are declared by a biometric system when the native comparison score from the recognition algorithm meets some **threshold**. Comparison scores can be either **similarity scores**, in which case higher values indicate that the samples are more likely to come from the same person, or **dissimilarity scores**, in which case higher values indicate different people. Similarity scores are traditionally computed by **fingerprint** and **face** recognition algorithms, while dissimilarities are used in **iris recognition**. In some cases, the dissimilarity score is a distance; this applies only when **metric** properties are obeyed. In any case, scores can be either **mate** scores, coming from a comparison of one person's samples, or **nonmate** scores, coming from comparison of different persons' samples. The words **genuine** or **authentic** are synonyms for mate, and the word **impostor** is used a synonym for nonmate. The words mate and nonmate are traditionally used in identification applications (such as law enforcement search, or background checks) while genuine and impostor are used in verification applications (such as access control).

A **error tradeoff** characteristic represents the tradeoff between Type II and Type I classification errors. For verification this plots false non-match rate (FNMR) vs. false match rate (FMR) parametrically with T.

The error tradeoff plots are often called **detection error tradeoff (DET)** characteristics or **receiver operating characteristic** (ROC). These serve the same function but differ, for example, in plotting the complement of an error rate (e.g. TMR = 1 – FNMR) and in transforming the axes most commonly using logarithms, to show multiple decades of FMR. More rarely, the function might be the inverse Gaussian function.

More detail and generality is provided in formal biometrics testing standards, see the various parts of ISO/IEC 19795 Biometrics Testing and Reporting. More terms, including and beyond those to do with accuracy, see ISO/IEC 2382-37 Information technology -- Vocabulary -- Part 37: Harmonized biometric vocabulary

FNMR(T) "False non-match rate"
FMR(T) "False match rate"



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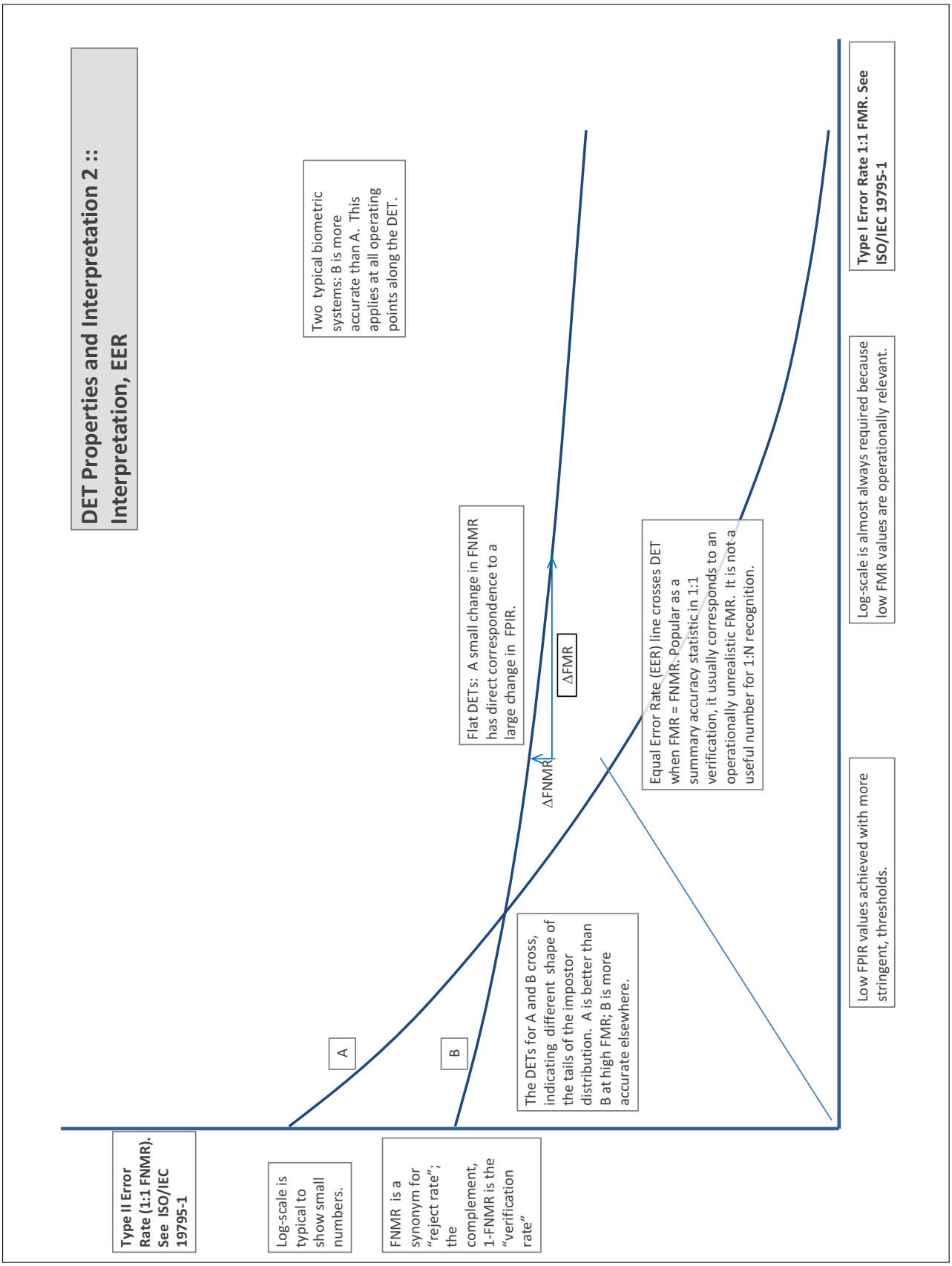

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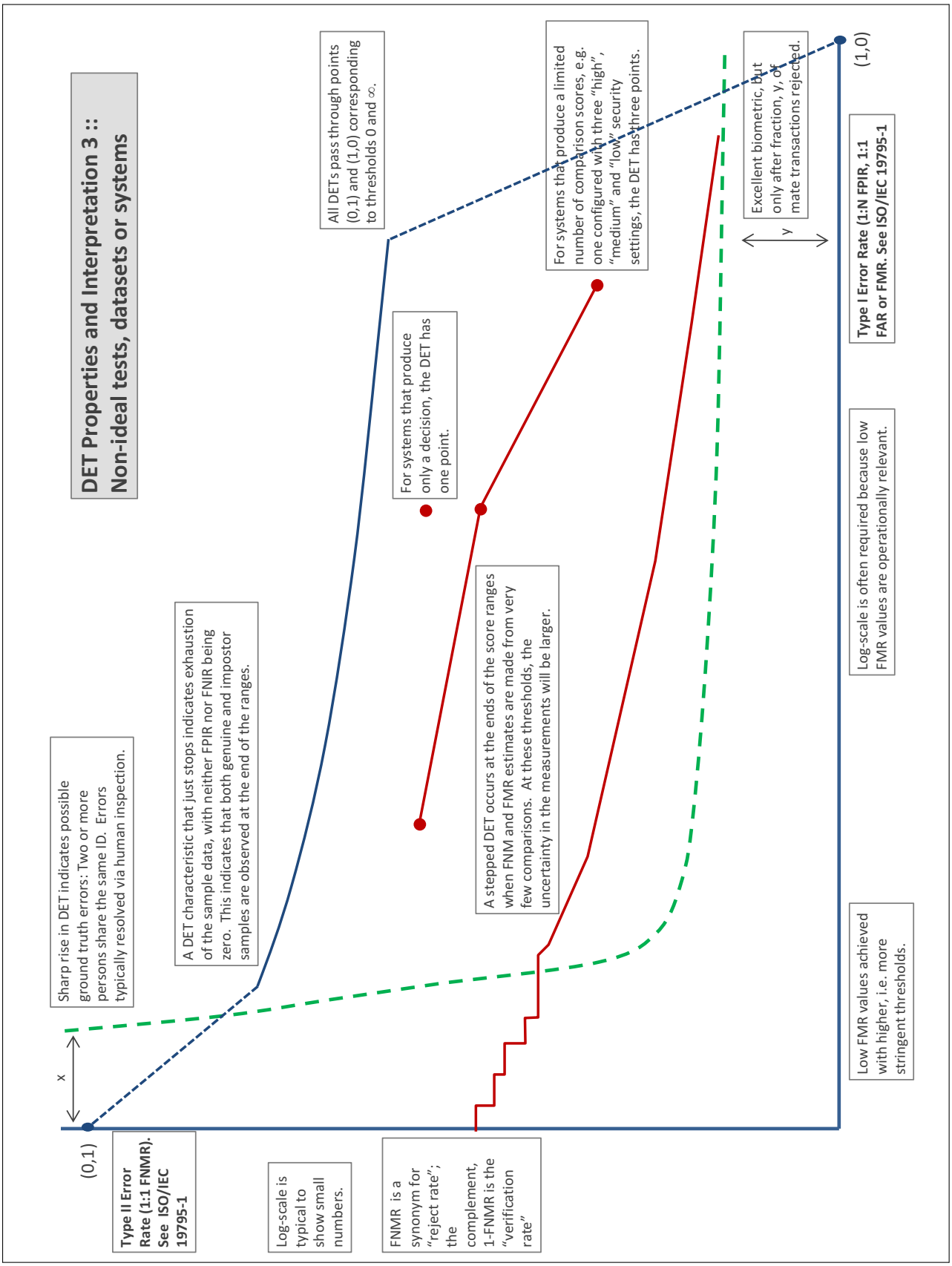

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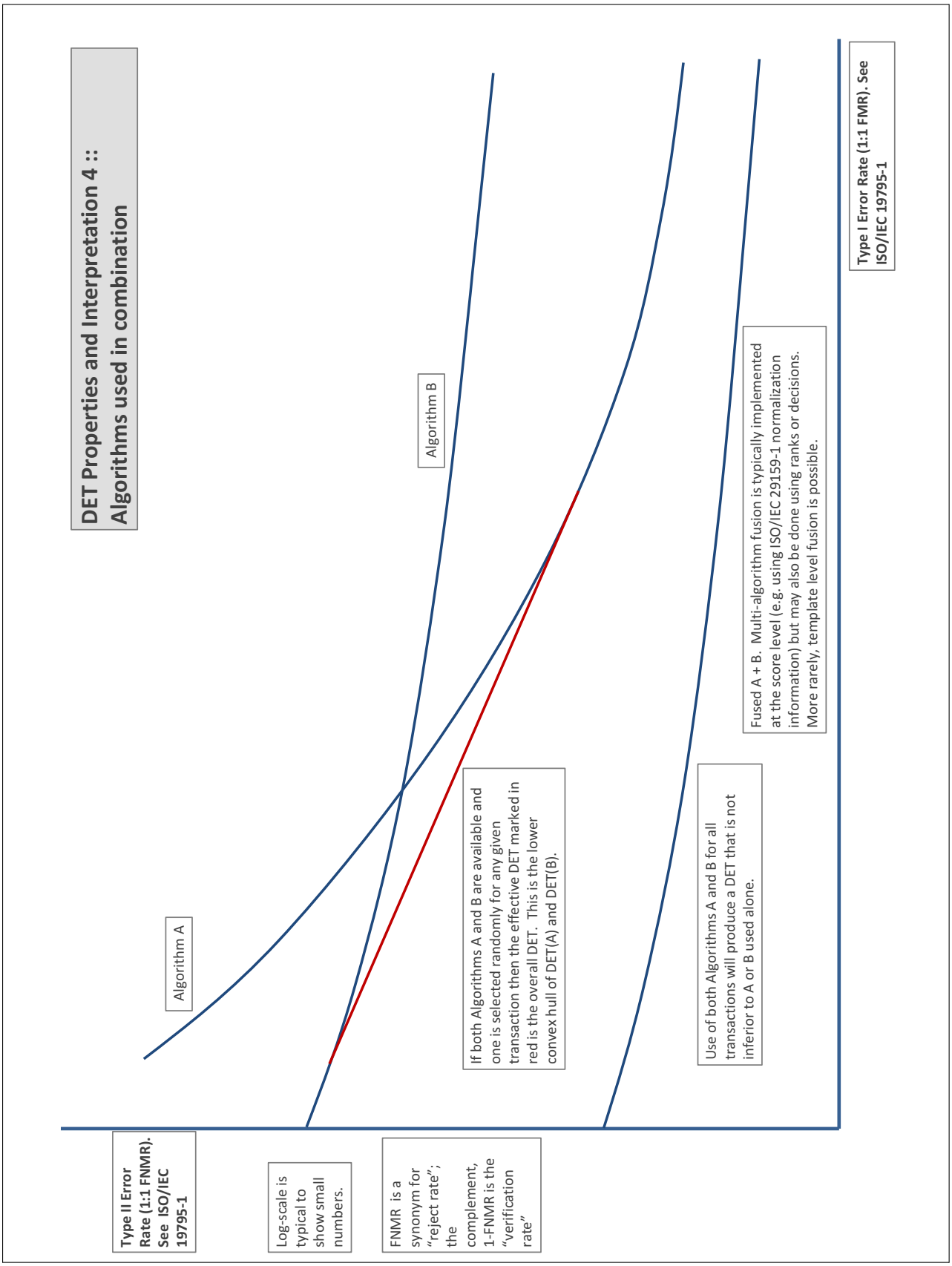

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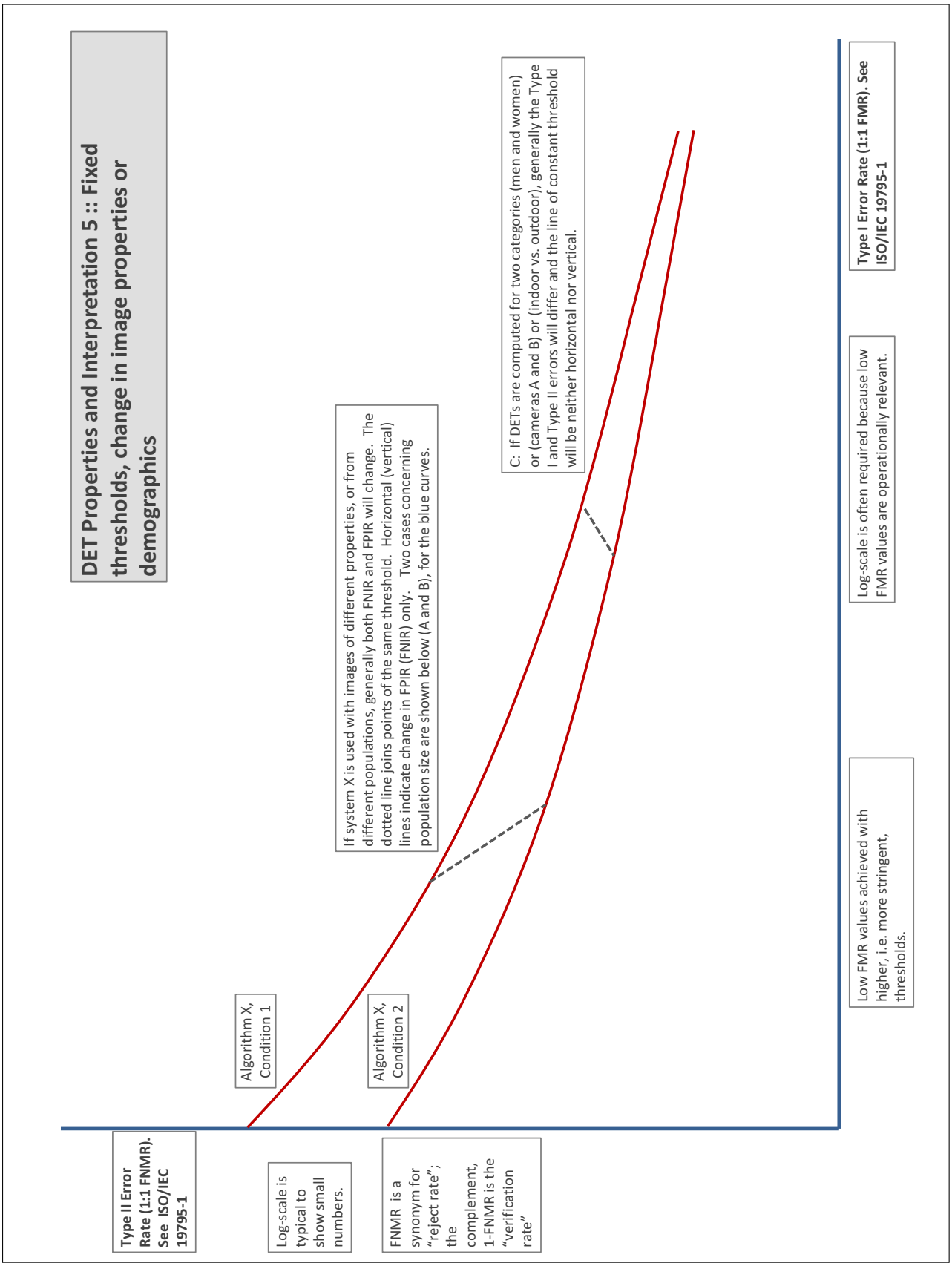

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