MINEX III Report Card

Matcher 006A+0292

National Institute of
Standards and Technology
U.S. Department of Commerce

Last Updated: June 6, 2022

Participant Details

Company: Beijing EyeCool Technology Co., Ltd
Provided CBEFF PID: `006A 0292`
Provided Marketing Name: "*Eyecool Finger Minutiae Matcher v2.92*"

Date Application Received: 07/31/2019
Date First Submitted: 07/26/2019 (as generator version `0292`)
Date Validated: 07/26/2019
Date Completed: 07/26/2019

Library	Size (bytes)	MD5 Checksum
libminexiii_006A_0292.so	2345000	`3256e6665d8a8061ed0166078191456d`

Compliance Test Results

The following presents **PIV compliance** results per the criteria detailed in NIST Special Publication 800-76-2: Biometric Specifications for Personal Identity Verification.

It also includes **MINEX III compliance** results per the criteria detailed in sections 4 through 8 of the Minutiae Interoperability Exchange (MINEX) III Test Plan and Application Programming Interface.

PIV Level One: PASS
- Must match templates from all certified template generators with an $\text{FNMR}_{\text{FMR}}(0.01) \leq 0.01$ using two fingers (4.5.2.1-4). ✓
- Average template comparison time must be no more than 10 milliseconds (6.4). ✓

PIV Level Two: PASS
- Must pass PIV level one compliance. ✓
- Native template generator must pass level one compliance. ✓
- Must match templates from native template generator with an $\text{FNMR}_{\text{FMR}}(0.0001) \leq 0.02$ using one finger (4.5.3-2) ✓

MINEX III: PASS
- Must pass MINEX III validation. ✓
- Must pass PIV level two matcher compliance. ✓
- Matcher must produce at least 512 distinct comparison scores over the entire dataset when comparing templates from different subjects. (1241) ✓

Notes

- This report will be updated as new matching algorithms and template generators pass the compliance test. These updates will not change the PASS/FAIL decision above.
- NIST reserves the right to decertify a matcher if it later discovers the matcher violates MINEX III or PIV specifications in some previously undetected way.
- This is the "*best*" compliant submission from Beijing EyeCool Technology Co., Ltd, and is therefore a member of the pooled DET curves published throughout all MINEX III report cards.

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1 Introduction

This report card presents measurements of performance and interoperability for a single fingerprint matching algorithm submitted to NIST as part of the ongoing MINEX III Evaluation. It reports whether the matcher passes the technical requirements for MINEX III as described in Section 8 of the MINEX III Test Plan and Application Programming Interface. Full details on the ongoing MINEX III program can be found on the MINEX III homepage. Questions should be directed to minex@nist.gov.

2 Methodology

Testing is performed at a NIST facility. Each participant's submission is validated by NIST (https://github.com/usnistgov/minex/tree/master/minexiii/validation) before undergoing full testing to ensure it operates correctly. If the matcher passes the validation procedure, it is then used to compare standard fingerprint templates. Performance is assessed against templates created by a template generation algorithm submitted by the participant as well as templates created by other MINEX III compliant template generators.

2.1 Dataset

Testing is performed over a single dataset of sequestered fingerprint images. The images were collected by U.S. Visit at ports of entry into the United States. They consist of Live-scan plain impressions of left and right index fingers. WSQ [1] compression was applied to all images at a ratio of 15:1. The most recent capture of each subject was treated as the authentication sample, and the next most recent as the enrolled sample.

The dataset was divided into 533 767 mated and 1 067 530 non-mated subject pairings. Since both left and right index fingerprints are available for each subject, this provides 1 061 657 mated and 2 127 712 non-mated single-finger comparisons (after database consolidation). When left and right index fingers are fused at the score level [3, 7], the sets condense to 530 394 mated and 1 062 814 non-mated comparison scores.

2.2 Accuracy Metrics

Core matching accuracy is presented in the form of Detection Error Tradeoff (DET) plots [6], which show the trade-off between the False Match Rate (FMR) and the False Non-Match Rate (FNMR) as a decision threshold is adjusted. Formally, let m_i ($i = 1 \ldots M$) be the ith mated comparison score, and n_j ($j = 1 \ldots N$) the jth non-mated comparison score. Then the statistics are

$$\mathrm{FNMR}(\tau) = \frac{1}{M}\sum_{i=1}^{M} \mathbb{1}\{m_i < \tau\}, \tag{1}$$

$$\mathrm{FMR}(\tau) = \frac{1}{N}\sum_{j=1}^{N} \mathbb{1}\{n_j \geq \tau\}. \tag{2}$$

where $\mathbb{1}\{A\}$ is the indicator [4] of event A. Equations 1 and 2 define the curve parametrically with the decision threshold, τ, as the free parameter. In some figures and tables, FNMR is presented as a function of FMR. This relationship is determined by

$$\mathrm{FNMR}_{\mathrm{FMR}}(\alpha) = \min_{\tau} \{ \mathrm{FNMR}(\tau) \mid \mathrm{FMR}(\tau) \leq \alpha \}, \tag{3}$$

which reads as the smallest FNMR that can be achieved while maintaining an FMR less than or equal to α, the targeted FMR. This method of relating the two error statistics ensures FNMR is well-defined for all $0 \leq \alpha \leq 1$. When the matching algorithm produces only a few unique comparison scores, the maximum threshold, τ_0, that elicits an $\mathrm{FMR}(\tau_0) \leq \alpha$ may, in fact, be quite a bit lower than α. Thus, Equation 3 imposes a natural penalty on matching algorithms that produce overly discretized scores.

Some figures show *pooled* DET accuracy, which is a measure of the accuracy of the matcher against all compliant template generators. Accuracy is measured by concatenating all comparison scores involving the matcher together and computing FMR and FNMR using Equations 2 and 1. This roughly simulates performance for a biometric system that employs one matcher and templates created by several template generators.

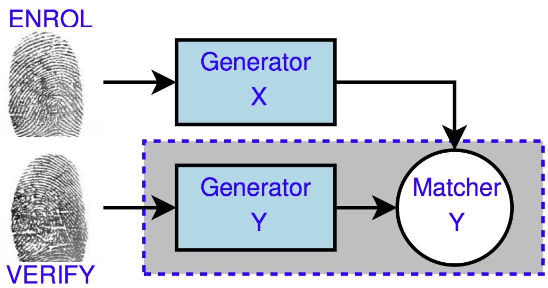

Figure 1: MINEX III Interoperability Test Setup

2.3 Interoperability

Interoperability is tested in a manner similar to *Scenario 1* from the MINEX Evaluation Report [5] (see Figure 1). An enrolment template is prepared using submission X. Submission Y is used to prepare the authentication template and perform the match. The authentication template is always prepared by the same submission used to compare the templates. However, enrolment templates need not originate from the same submission. When they do, we refer to it as "native" mode.

2.4 Uncertainty Estimation

Some figures in this report include boxplots that convey the uncertainty associated with a statistic. The boxplots are intended to show the expected variation in the observed value if one assumes repeated iid sampling from the same population. They are not intended to reflect how the statistic might change over different test data or even different sampling strategies over the same data.

Estimates of uncertainty are computed using the Wilson Score method [8] which overcomes certain problems associated with applying the Central Limit Theorem to a discretized estimator. We make several simplifying assumptions when applying the method to biometric identification. Most notably, separate searches against the same enrollment database are treated as independent samples, yet we know positive correlations exist due to Doddingtons Zoo [2]. We also report estimates of the variability of FNIR at a fixed FPIR when in fact it is the decision threshold that is fixed. Uncertainty with respect to what decision threshold corresponds to the targeted FPIR results in increased uncertainty about the true value of FNIR. However, our estimates of FPIR are fairly tight due to the large number of non-mated searches performed, so they are not expected to have a large impact on the estimates.

3 Results

This section details the performance of matcher 006A+0292 when it compares verification templates created by its own template generator to enrolment templates created by all MINEX III compliant template generators. Sections 3.1 and 3.2 present accuracy results for single finger and two finger matching respectively. Sections 3.4 and 3.5 present potentially useful statistics not directly related to the performance of the matcher.

3.1 Single Finger

Singe finger comparison results show the combined results for left and right index comparisons. For reference, *NIST Special Publication 800-76-2* requires that the matcher and template generator achieve a native accuracy of $\text{FNMR}_{\text{FMR}}(0.0001) \leq 0.02$.

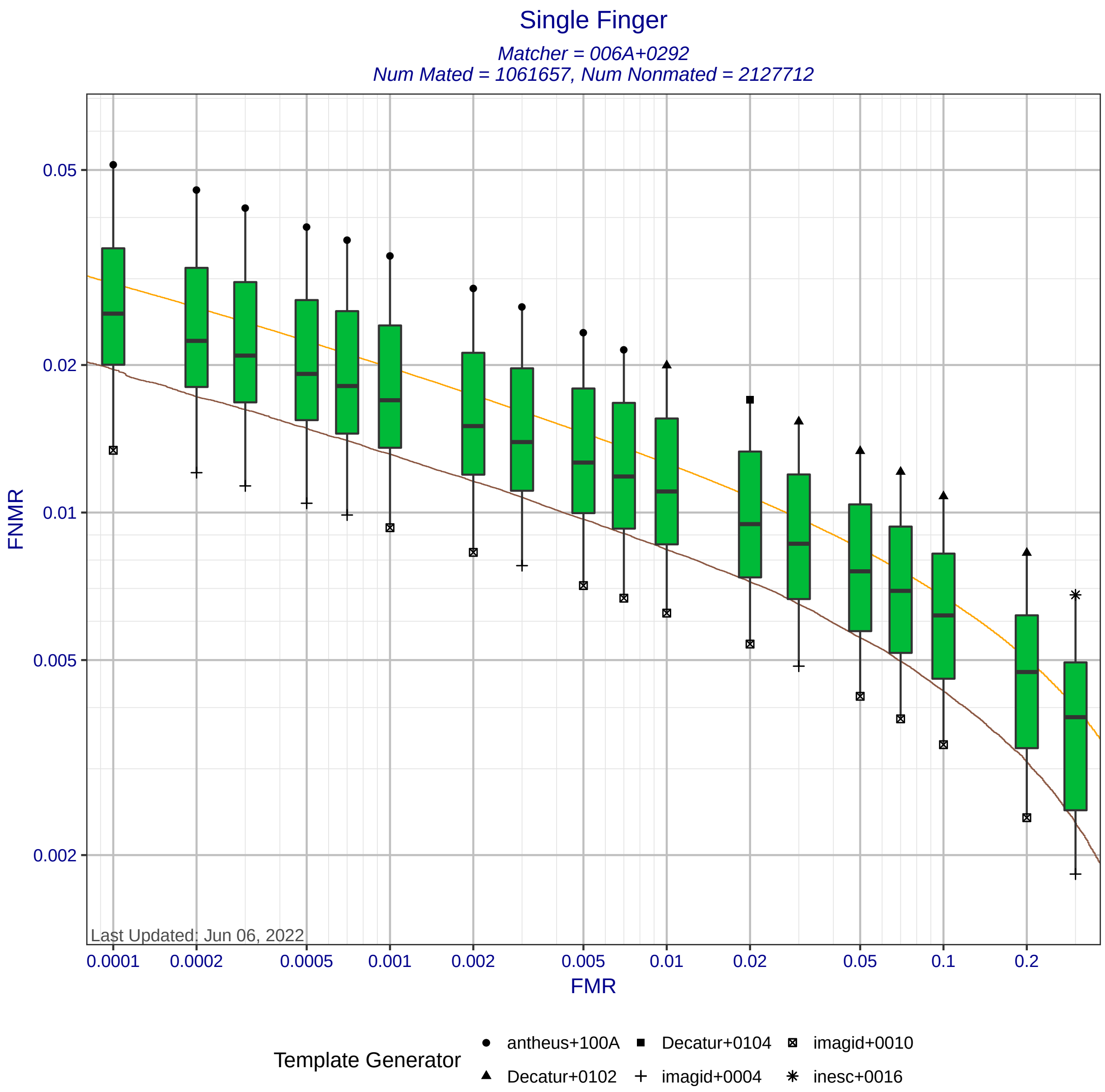

Figure 2: *Single finger DET statistics for matcher 006A+0292. Each box shows the distribution of FNMRs at a fixed FMR across all MINEX III compliant template generators. The ends of the whiskers show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators.*

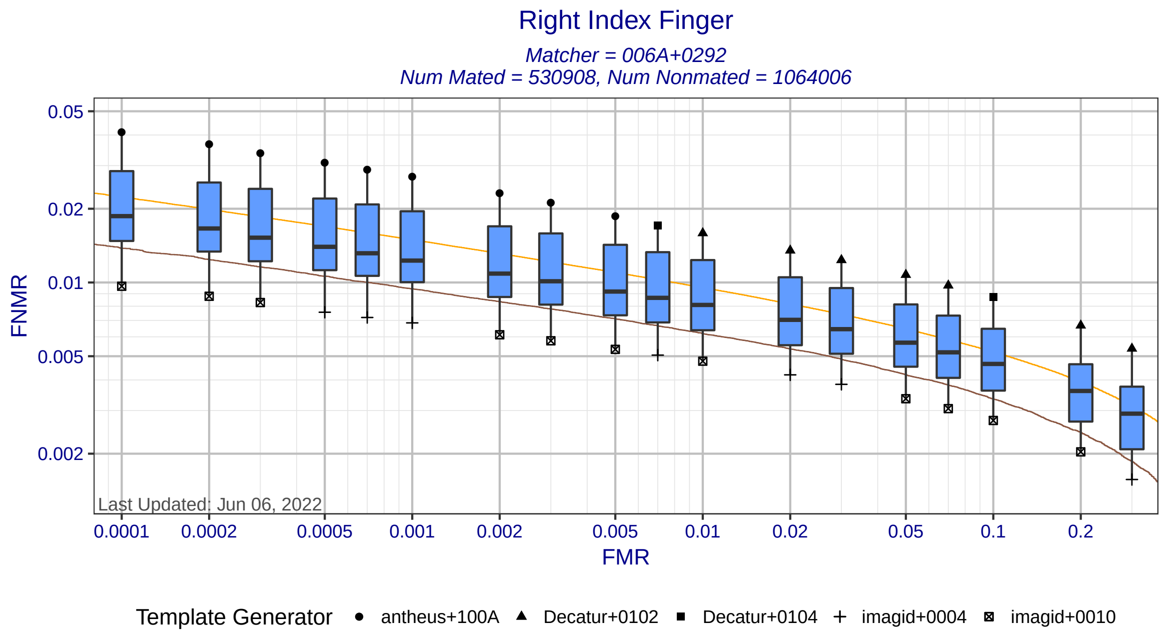

Figure 3: *Right index finger DET statistics for matcher 006A+0292. Each box shows the distribution of FNMR at a fixed FMR across all MINEX III compliant template generators. The ends of the whiskers show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators.*

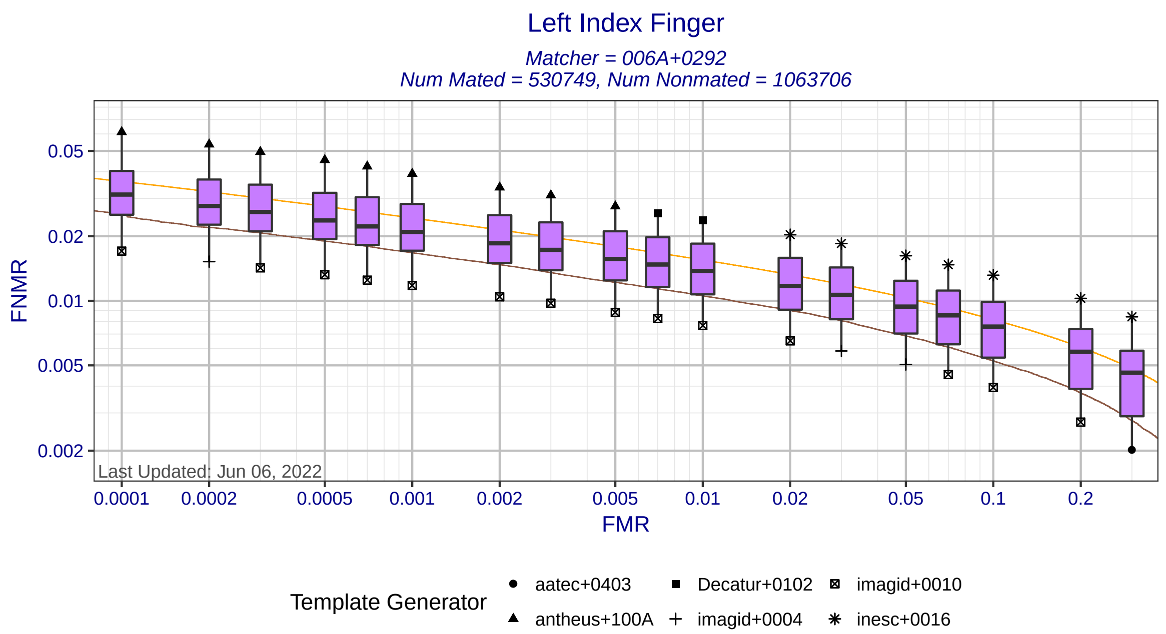

Figure 4: *Left index finger DET statistics for matcher 006A+0292. Each box shows the distribution of FNMRs at a fixed FMR across all MINEX III compliant template generators. The ends of whiskers show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators.*

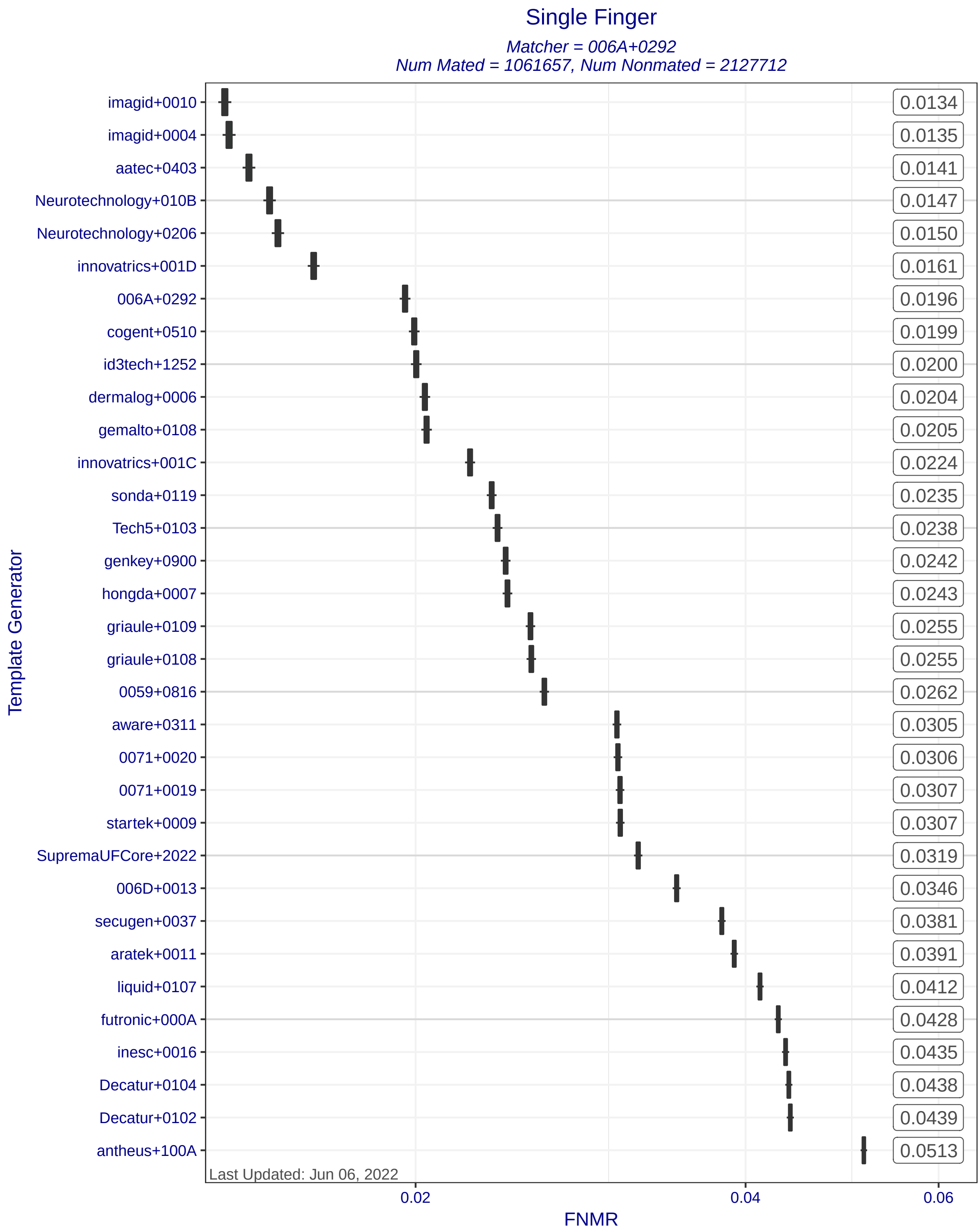

Figure 5: *Single finger FNMRs at FMR = 0.0001 when matcher 006A+0292 compares templates created by different template generators. The ends of the whiskers show the minimum and maximum FNMRs. Each box represents uncertainty about the true FNMR. The box edges mark the 50% confidence intervals while the whiskers mark the 90% confidence intervals. The numbers on the right show the actual computed FNMRs.*

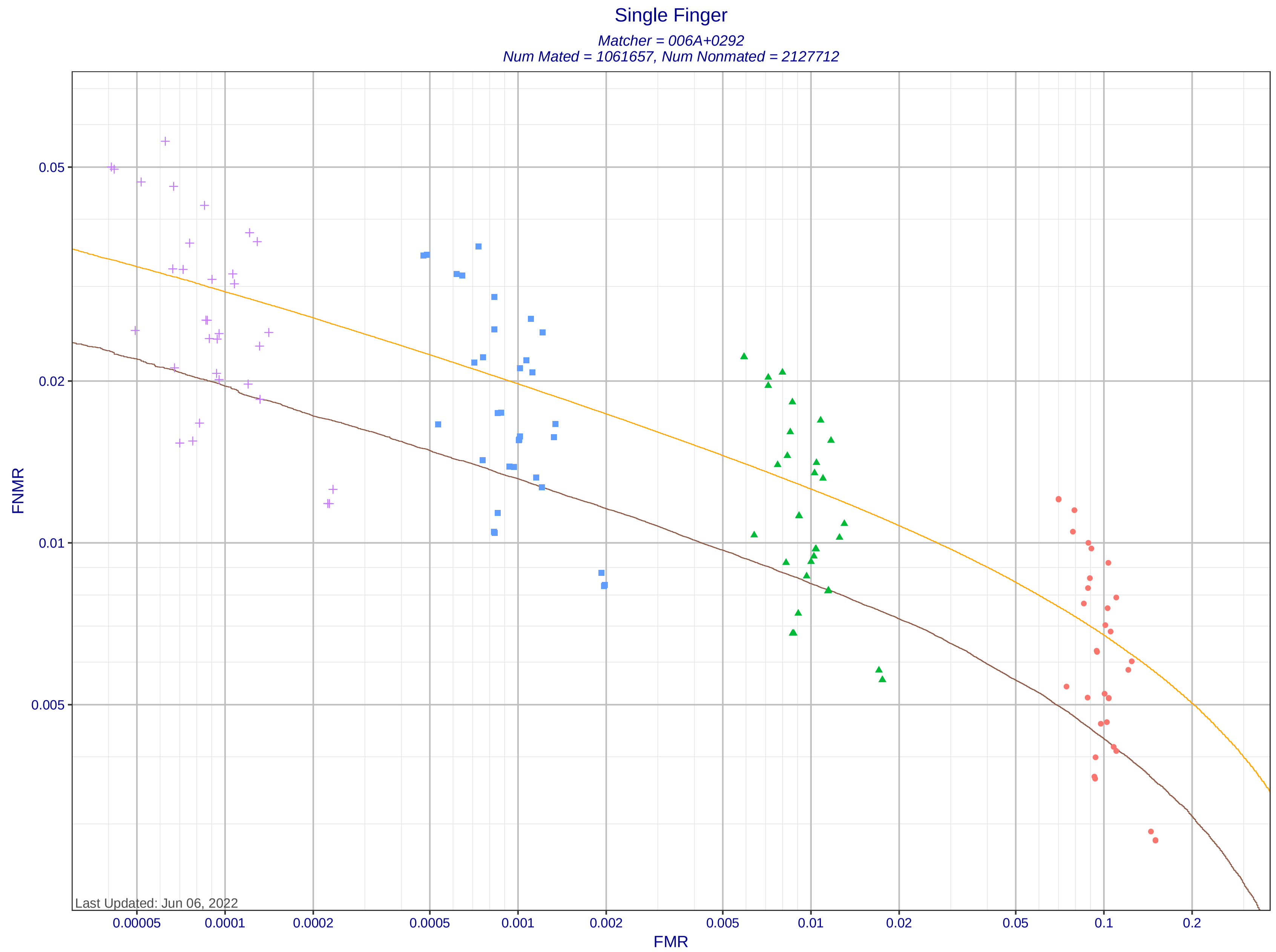

Figure 6: *Single finger DET accuracy for matcher 006A+0292. Each cluster of points represents the variation in FMR and FNMR across MINEX III compliant template generators at a fixed decision threshold. Each point corresponds to an (FMR, FNMR) pair for a specific template generator at a particular decision threshold. Four clusters are produced corresponding to four decision thresholds which produce pooled FMRs of* 10^{-1}, 10^{-2}, 10^{-3}, *and* 10^{-4}. *The orange DET curve shows pooled performance against all template generators.*

3.2 Two Finger

This section presents accuracy when matcher 006A+0292 compares templates created by all MINEX III compliant template generators. Two-finger fusion is achieved by averaging the scores for left and right index fingers for each person. *NIST Special Publication 800-76-2* requires the matcher to achieve an accuracy of $\mathrm{FNMR}_{\mathrm{FMR}}(0.01) \leq 0.01$ for all MINEX III compliant template generators.

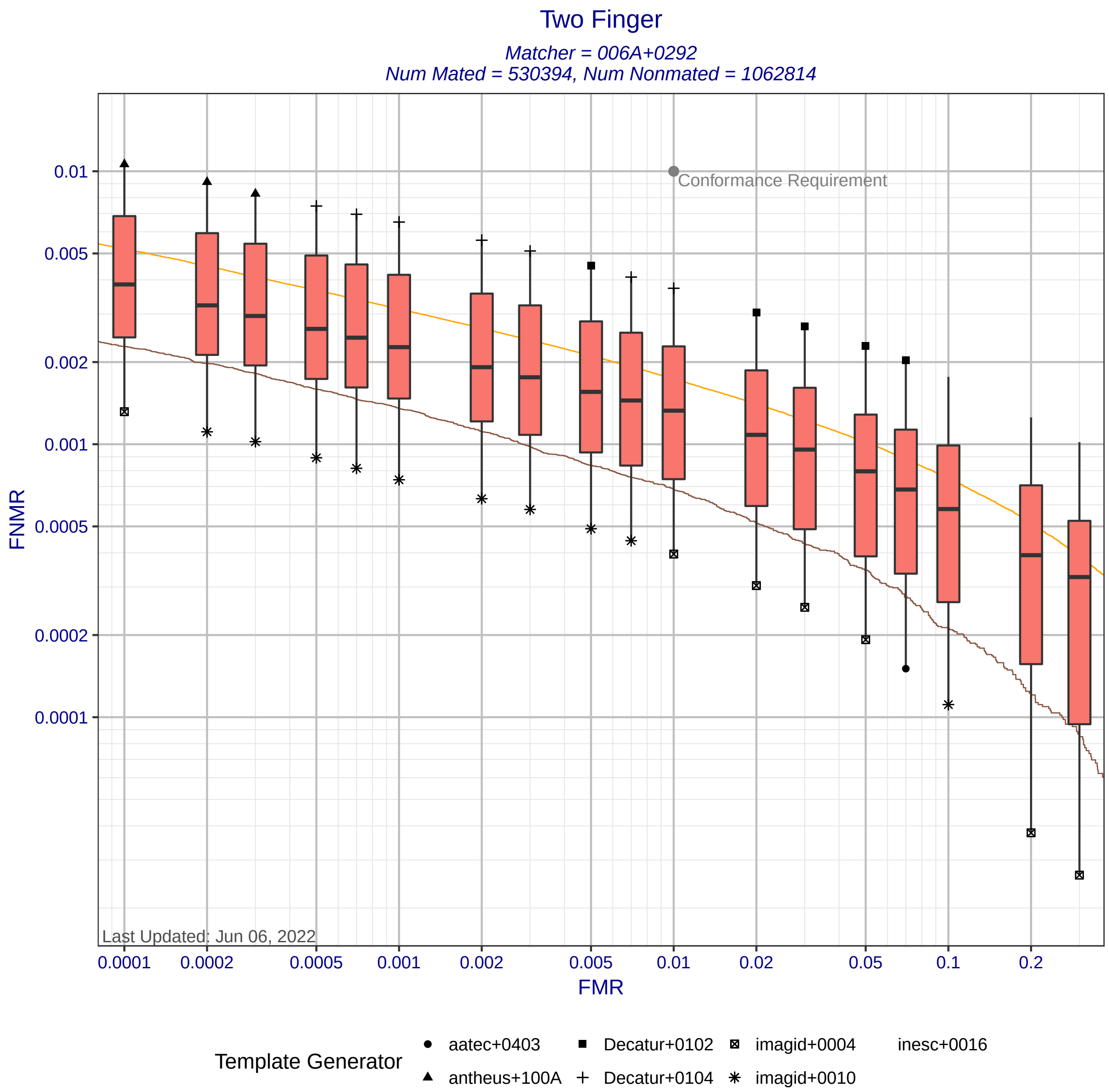

Figure 7: *Two finger DET statistics for matcher 006A+0292. Each box shows the distribution of FNMRs at a fixed FMR across all MINEX III compliant template generators. The whisker ends show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

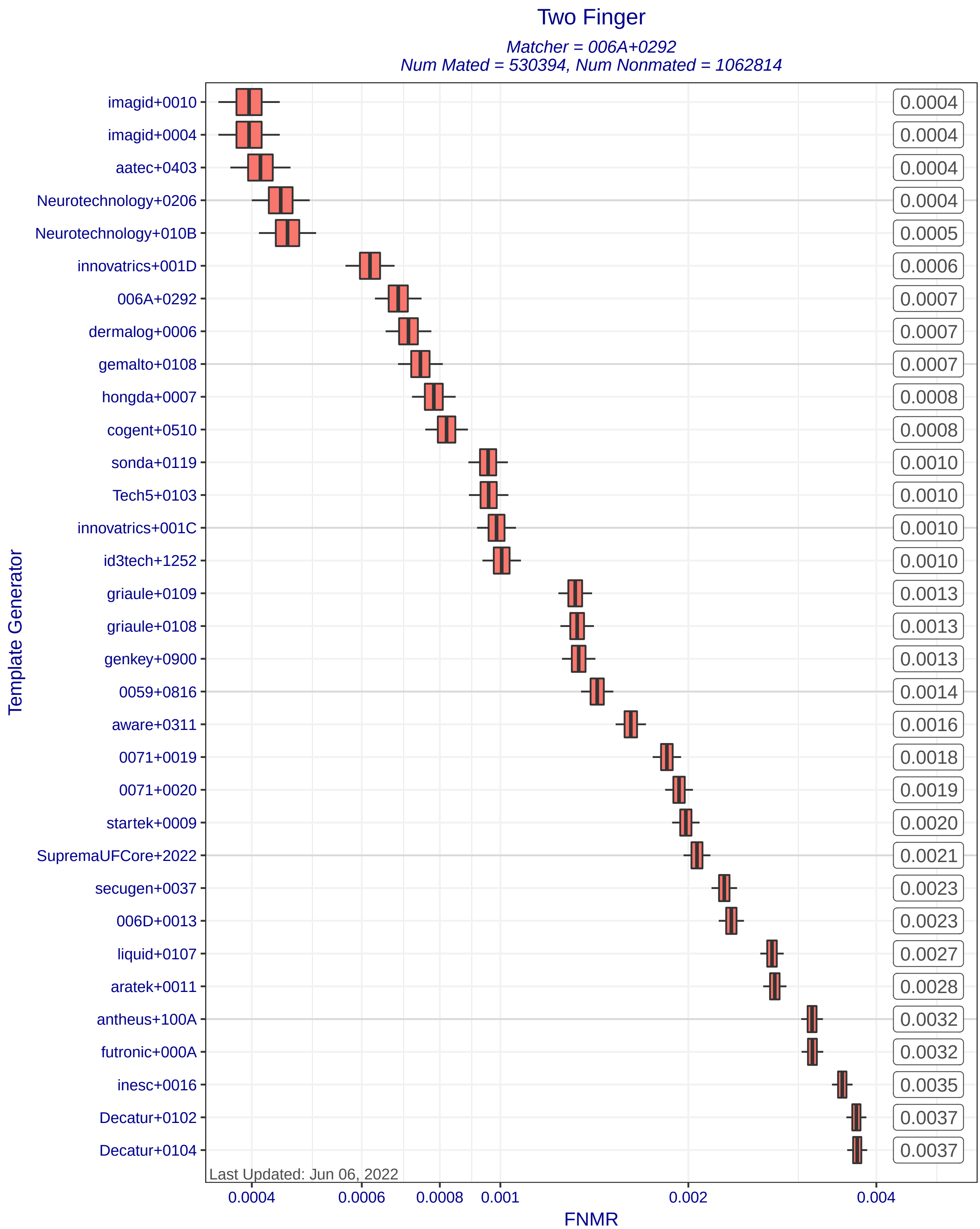

Figure 8: *Two finger FNMR at FMR=0.01 when matcher 006A+0292 compares templates created by different template generators. Each box represents uncertainty about the true FNMR. The box edges mark the 50% confidence intervals while the whiskers mark the 90% confidence intervals. The numbers on the right show the actual computed FNMRs. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

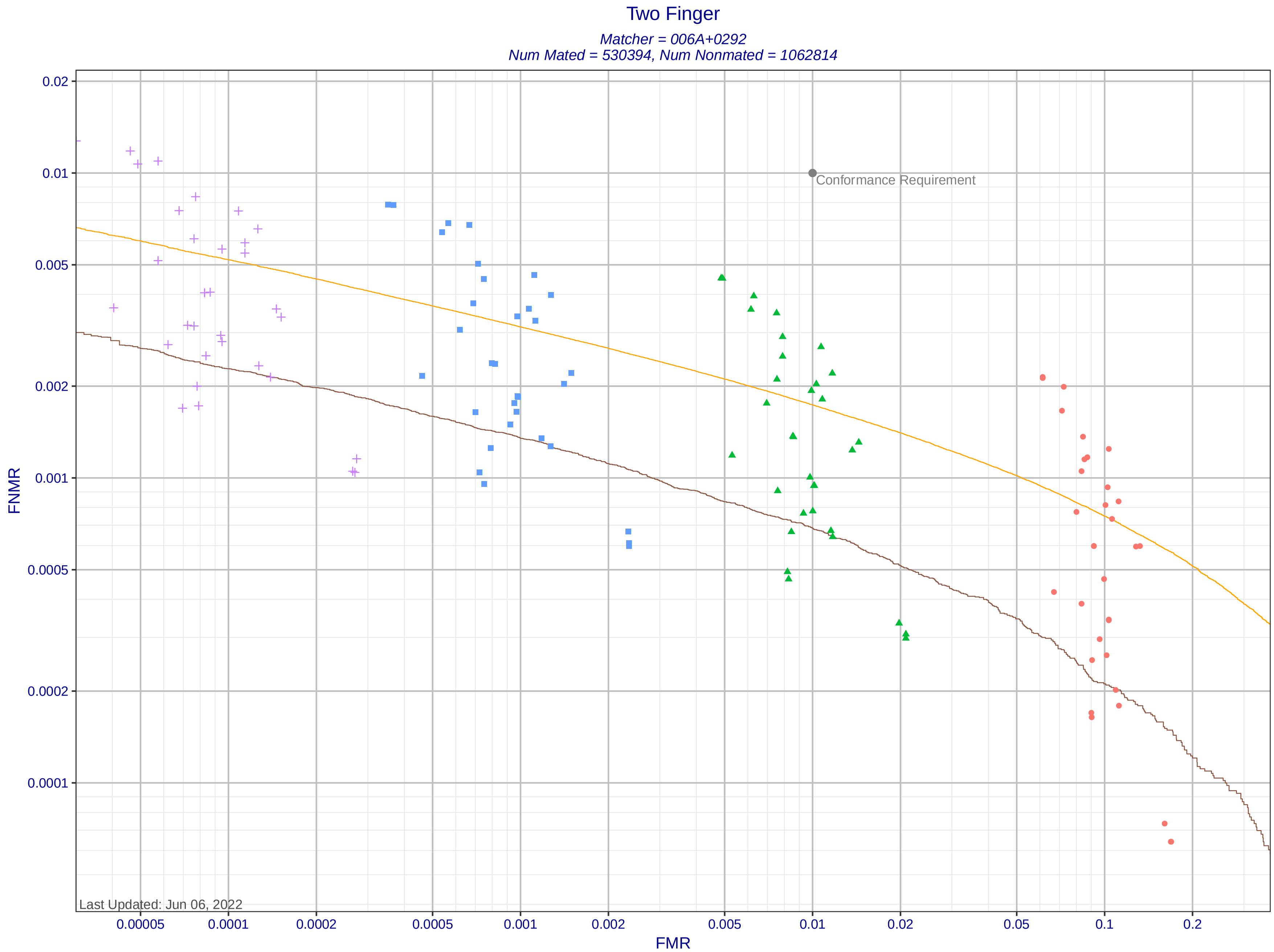

Figure 9: *Two finger DET accuracy for matcher 006A+0292. Each cluster of points represents the variation in FMR and FNMR across MINEX III compliant template generators at a fixed decision threshold. Each point corresponds to an (FMR, FNMR) pair for a specific template generator at a particular decision threshold. Four clusters are produced corresponding to four decision thresholds which produce pooled FMRs of* 10^{-1}, 10^{-2}, 10^{-3}, *and* 10^{-4}. *The orange DET curve shows pooled performance against all template generators. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

3.3 Match Times

To achieve PIV compliance, the matcher must average no more than 10 milliseconds (0.01 seconds) per comparison. Speeds are timed on a machine with an Intel Xeon E5-2680 CPU.

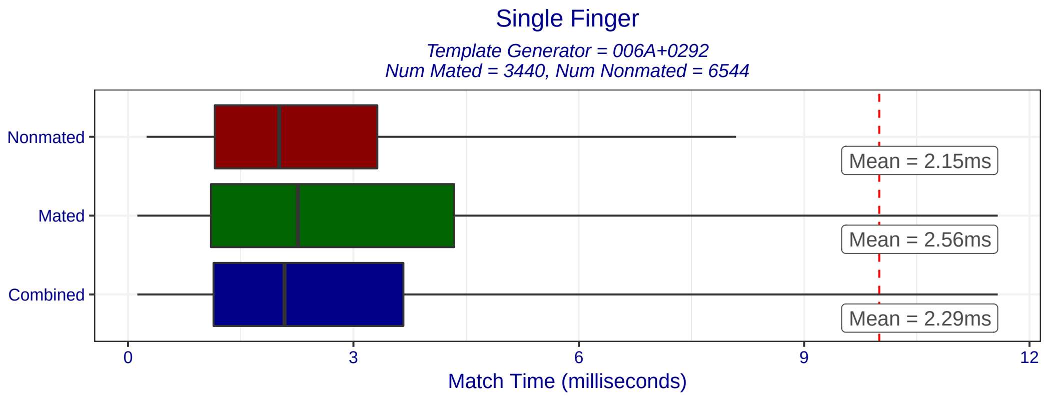

Figure 10: *Boxplot of match times for single finger comparisons. The box edges mark the 10th and 90th percentiles while the whiskers mark the maximum and minimum comparison times.*

3.4 Threshold Statistics

Results in this section are computed by concatenating comparison scores for matcher 006A+0292 across all MINEX III compliant template generators.

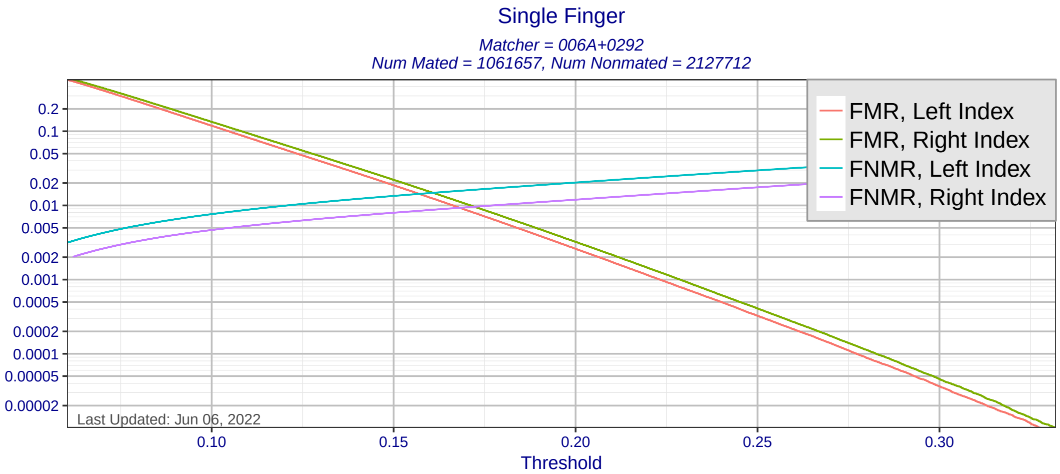

Figure 11: *Single finger FMR and FNMR as a function of score threshold for matcher 006A+0292 using templates created by all MINEX III compliant template generators. Separate curves are presented for left and right index fingers.*

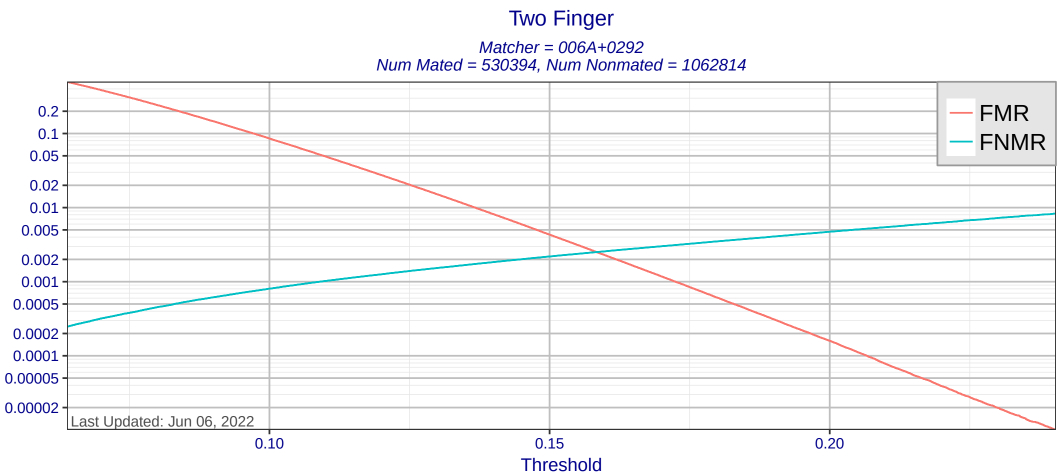

Figure 12: *Two finger FMR and FNMR as a function of score threshold for matcher 006A+0292 using templates created by all MINEX III compliant template generators. Score-level fusion is achieved by averaging scores for the left and right index fingers.*

	FMR=0.1	FMR=0.01	FMR=0.001	FMR=0.0001
Right index finger	0.10825	0.17125	0.22875	0.28250
Left index finger	0.10475	0.16625	0.22325	0.27725
Single finger	0.10650	0.16875	0.22625	0.28000
Two finger	0.09725	0.13675	0.17250	0.20662

Table 1: *Threshold calibration table. The cells show the thresholds corresponding to the FMR indicated by the column header.*

3.5 Q-Q Plot

The Q-Q plot compares two probability distributions. It plots the quantile of one distribution as a function of the other. If the curve follows the $y = x$ line, then the distributions are identical. If the FMR curve is above the $y = x$ line, then the left index finger tends to produce lower non-mated scores than the right index finger. If the FNMR curve is above the $y = x$ line, then the left index finger tends to produce lower mated scores than the right index finger. A jagged and/or truncated curve is indicative of discretized scores.

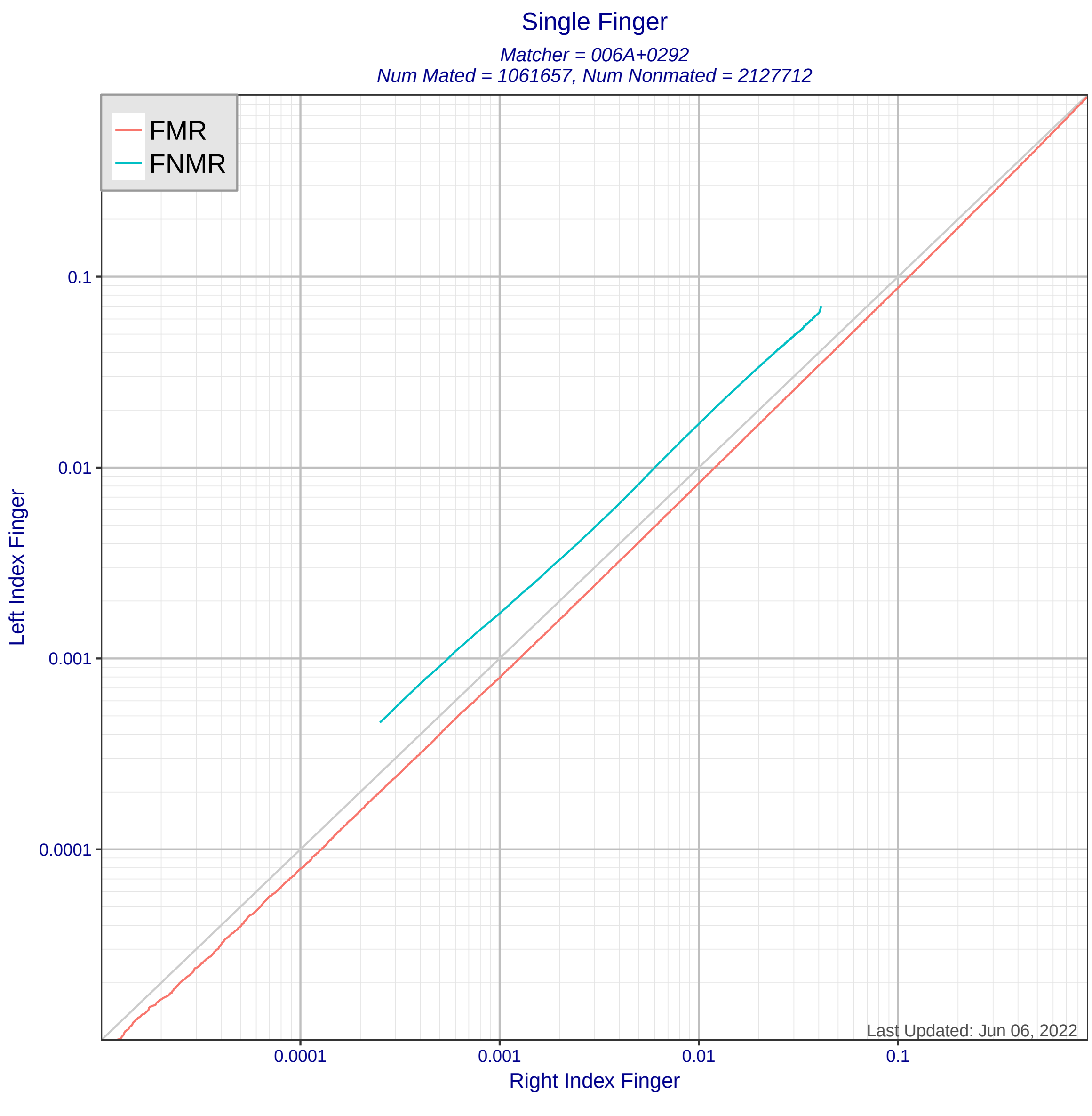

Figure 13: *Q-Q plot comparing score distributions for left and right index fingers.*

3.6 Effect of Minutia Count on Accuracy

This section shows how the number of minutia found in the samples affects recognition accuracy. To be robust to spoofing and other active attacks, the algorithm should not allow FMR to rise sharply as the number of available minutia decreases. Nor should it allow FMR to rise sharply as the number of detected minutia increases.

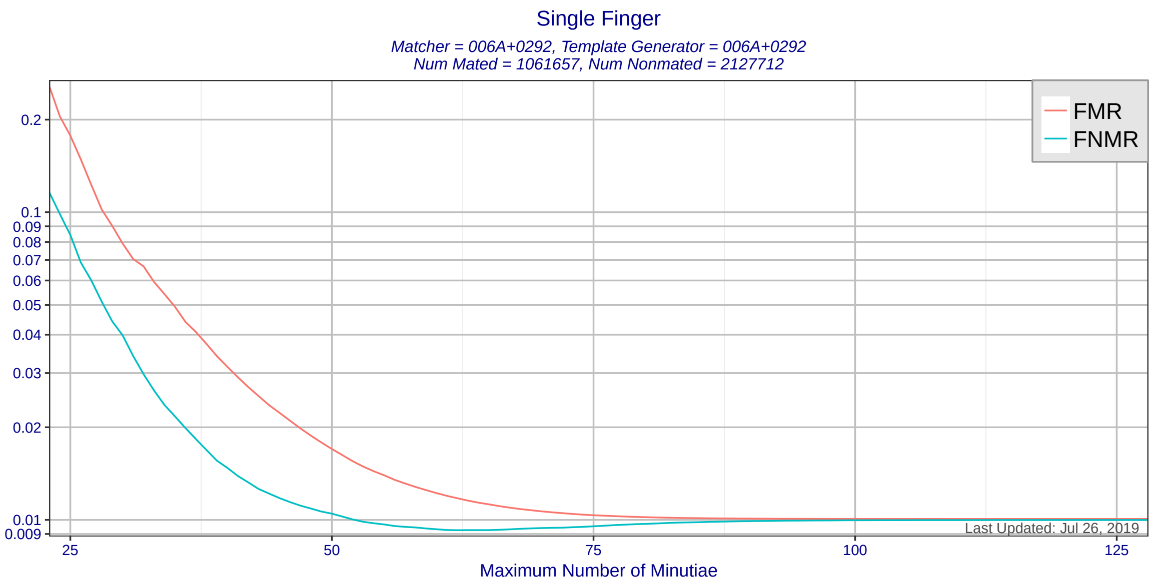

Figure 14: *FNMR and FMR as a function of the number of minutia found by the template generator. The vertical axis defines a filter criterion such that FNMR and FMR are computed over only those comparisons where at least one of the compared templates has* no more *than the specified number of minutia. The threshold is fixed separately for FNMR and FMR to elicit an error rate of approximately 0.01 over unfiltered comparisons.*

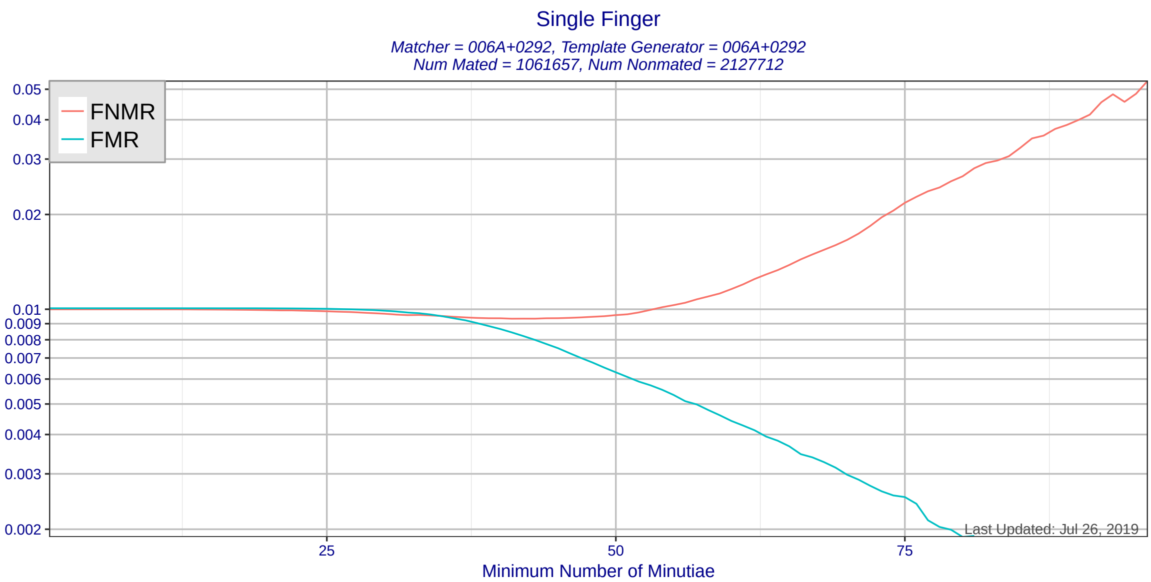

Figure 15: *FNMR and FMR as a function of the number of minutia found by the template generator. The vertical axis defines a filter criterion such that FNMR and FMR are computed over only those comparisons where at least one of the compared templates has* at least *the indicated number of minutia. The threshold is fixed separately for FNMR and FMR to elicit an error rate of approximately 0.01 over unfiltered comparisons.*

3.7 Comparison to Ongoing MINEX

MINEX III uses a larger set of comparisons than the older ongoing MINEX evaluation. Although this is generally good because it provides more accurate estimates of performance in MINEX III, it makes it more difficult to directly compare the results in this report to the archived ones from ongoing MINEX. The tables below report DET accuracy at fixed FMRs computed over the same set of comparisons that were used in ongoing MINEX. Ongoing MINEX reported FNMR at FMR $= 0.01$ for two-finger.

Table 2: *Single finger FNMRs at various FMRs when matcher 006A+0292 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
0059+0816	0.0116 ± 0.0004	0.0184 ± 0.0004	0.0275 ± 0.0005
006A+0292	0.0079 ± 0.0003	0.0126 ± 0.0004	0.0191 ± 0.0005
006D+0013	0.0175 ± 0.0004	0.0273 ± 0.0005	0.0418 ± 0.0007
0071+0019	0.0147 ± 0.0004	0.0239 ± 0.0005	0.0354 ± 0.0006
0071+0020	0.0146 ± 0.0004	0.0239 ± 0.0005	0.0353 ± 0.0006
aatec+0403	0.0060 ± 0.0003	0.0096 ± 0.0003	0.0141 ± 0.0004
antheus+100A	0.0222 ± 0.0005	0.0378 ± 0.0006	0.0584 ± 0.0008
aratek+0011	0.0193 ± 0.0005	0.0311 ± 0.0006	0.0456 ± 0.0007
aware+0311	0.0144 ± 0.0004	0.0230 ± 0.0005	0.0348 ± 0.0006
cogent+0510	0.0085 ± 0.0003	0.0135 ± 0.0004	0.0198 ± 0.0005
Decatur+0102	0.0226 ± 0.0005	0.0351 ± 0.0006	0.0526 ± 0.0007
Decatur+0104	0.0224 ± 0.0005	0.0353 ± 0.0006	0.0529 ± 0.0007
dermalog+0006	0.0083 ± 0.0003	0.0144 ± 0.0004	0.0218 ± 0.0005
futronic+000A	0.0201 ± 0.0005	0.0333 ± 0.0006	0.0506 ± 0.0007
gemalto+0108	0.0083 ± 0.0003	0.0142 ± 0.0004	0.0218 ± 0.0005
genkey+0900	0.0109 ± 0.0003	0.0176 ± 0.0004	0.0271 ± 0.0005
griaule+0108	0.0112 ± 0.0003	0.0180 ± 0.0004	0.0262 ± 0.0005
griaule+0109	0.0112 ± 0.0003	0.0180 ± 0.0004	0.0267 ± 0.0005
hongda+0007	0.0097 ± 0.0003	0.0168 ± 0.0004	0.0267 ± 0.0005
id3tech+1252	0.0090 ± 0.0003	0.0141 ± 0.0004	0.0221 ± 0.0005
imagid+0004	0.0058 ± 0.0003	0.0091 ± 0.0003	0.0144 ± 0.0004
imagid+0010	0.0058 ± 0.0003	0.0090 ± 0.0003	0.0141 ± 0.0004
inesc+0016	0.0208 ± 0.0005	0.0329 ± 0.0006	0.0471 ± 0.0007
innovatrics+001C	0.0098 ± 0.0003	0.0160 ± 0.0004	0.0242 ± 0.0005
innovatrics+001D	0.0068 ± 0.0003	0.0112 ± 0.0003	0.0167 ± 0.0004
liquid+0107	0.0190 ± 0.0005	0.0299 ± 0.0006	0.0449 ± 0.0007
Neurotechnology+010B	0.0059 ± 0.0003	0.0098 ± 0.0003	0.0147 ± 0.0004
Neurotechnology+0206	0.0060 ± 0.0003	0.0098 ± 0.0003	0.0151 ± 0.0004
secugen+0037	0.0182 ± 0.0004	0.0304 ± 0.0006	0.0440 ± 0.0007
sonda+0119	0.0099 ± 0.0003	0.0165 ± 0.0004	0.0255 ± 0.0005
startek+0009	0.0144 ± 0.0004	0.0225 ± 0.0005	0.0336 ± 0.0006
SupremaUFCore+2022	0.0157 ± 0.0004	0.0253 ± 0.0005	0.0368 ± 0.0006
Tech5+0103	0.0099 ± 0.0003	0.0165 ± 0.0004	0.0262 ± 0.0005

Table 3: *Two finger FNMRs at various FMRs when matcher 006A+0292 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
0059+0816	0.0014 ± 0.0002	0.0025 ± 0.0002	0.0041 ± 0.0003
006A+0292	0.0006 ± 0.0001	0.0011 ± 0.0002	0.0017 ± 0.0002
006D+0013	0.0027 ± 0.0002	0.0046 ± 0.0003	0.0076 ± 0.0004
0071+0019	0.0021 ± 0.0002	0.0038 ± 0.0003	0.0059 ± 0.0004
0071+0020	0.0021 ± 0.0002	0.0038 ± 0.0003	0.0066 ± 0.0004

Table 3: *(continued)*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
aatec+0403	0.00035 ± 0.00009	0.0008 ± 0.0001	0.0013 ± 0.0002
antheus+100A	0.0035 ± 0.0003	0.0066 ± 0.0004	0.0104 ± 0.0005
aratek+0011	0.0028 ± 0.0002	0.0052 ± 0.0003	0.0079 ± 0.0004
aware+0311	0.0017 ± 0.0002	0.0028 ± 0.0002	0.0042 ± 0.0003
cogent+0510	0.0007 ± 0.0001	0.0013 ± 0.0002	0.0022 ± 0.0002
Decatur+0102	0.0038 ± 0.0003	0.0071 ± 0.0004	0.0121 ± 0.0005
Decatur+0104	0.0039 ± 0.0003	0.0071 ± 0.0004	0.0114 ± 0.0005
dermalog+0006	0.0007 ± 0.0001	0.0014 ± 0.0002	0.0027 ± 0.0002
futronic+000A	0.0033 ± 0.0003	0.0063 ± 0.0004	0.0106 ± 0.0005
gemalto+0108	0.0007 ± 0.0001	0.0014 ± 0.0002	0.0025 ± 0.0002
genkey+0900	0.0014 ± 0.0002	0.0024 ± 0.0002	0.0040 ± 0.0003
griaule+0108	0.0013 ± 0.0002	0.0022 ± 0.0002	0.0040 ± 0.0003
griaule+0109	0.0013 ± 0.0002	0.0022 ± 0.0002	0.0040 ± 0.0003
hongda+0007	0.0007 ± 0.0001	0.0015 ± 0.0002	0.0030 ± 0.0003
id3tech+1252	0.0010 ± 0.0001	0.0018 ± 0.0002	0.0030 ± 0.0003
imagid+0004	0.00035 ± 0.00009	0.0006 ± 0.0001	0.0011 ± 0.0002
imagid+0010	0.00032 ± 0.00008	0.0006 ± 0.0001	0.0012 ± 0.0002
inesc+0016	0.0037 ± 0.0003	0.0064 ± 0.0004	0.0095 ± 0.0005
innovatrics+001C	0.0009 ± 0.0001	0.0018 ± 0.0002	0.0030 ± 0.0003
innovatrics+001D	0.0005 ± 0.0001	0.0010 ± 0.0001	0.0018 ± 0.0002
liquid+0107	0.0028 ± 0.0002	0.0047 ± 0.0003	0.0080 ± 0.0004
Neurotechnology+010B	0.00039 ± 0.00009	0.0008 ± 0.0001	0.0015 ± 0.0002
Neurotechnology+0206	0.00036 ± 0.00009	0.0007 ± 0.0001	0.0015 ± 0.0002
secugen+0037	0.0025 ± 0.0002	0.0047 ± 0.0003	0.0076 ± 0.0004
sonda+0119	0.0009 ± 0.0001	0.0018 ± 0.0002	0.0030 ± 0.0003
startek+0009	0.0019 ± 0.0002	0.0033 ± 0.0003	0.0058 ± 0.0004
SupremaUFCore+2022	0.0023 ± 0.0002	0.0039 ± 0.0003	0.0060 ± 0.0004
Tech5+0103	0.0009 ± 0.0001	0.0019 ± 0.0002	0.0036 ± 0.0003

4 Performance Tables

The following tables present accuracy numbers, including estimates of uncertainty in the form of 90% confidence bounds. These tables are provided because most of the figures in the main body of this report do not present numerical results.

Table 4: *Single finger FNMRs at various FMRs when matcher 006A+0292 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
0059+0816	0.0114 ± 0.0002	0.0175 ± 0.0002	0.0262 ± 0.0003
006A+0292	0.0084 ± 0.0001	0.0132 ± 0.0002	0.0196 ± 0.0002
006D+0013	0.0156 ± 0.0002	0.0241 ± 0.0002	0.0346 ± 0.0003
0071+0019	0.0135 ± 0.0002	0.0212 ± 0.0002	0.0307 ± 0.0003
0071+0020	0.0136 ± 0.0002	0.0212 ± 0.0002	0.0306 ± 0.0003
aatec+0403	0.0065 ± 0.0001	0.0098 ± 0.0002	0.0141 ± 0.0002
antheus+100A	0.0197 ± 0.0002	0.0334 ± 0.0003	0.0513 ± 0.0004
aratek+0011	0.0172 ± 0.0002	0.0265 ± 0.0003	0.0391 ± 0.0003
aware+0311	0.0133 ± 0.0002	0.0205 ± 0.0002	0.0305 ± 0.0003
cogent+0510	0.0088 ± 0.0001	0.0135 ± 0.0002	0.0199 ± 0.0002
Decatur+0102	0.0200 ± 0.0002	0.0306 ± 0.0003	0.0439 ± 0.0003
Decatur+0104	0.0199 ± 0.0002	0.0305 ± 0.0003	0.0438 ± 0.0003
dermalog+0006	0.0084 ± 0.0001	0.0136 ± 0.0002	0.0204 ± 0.0002
futronic+000A	0.0182 ± 0.0002	0.0291 ± 0.0003	0.0428 ± 0.0003
gemalto+0108	0.0086 ± 0.0001	0.0137 ± 0.0002	0.0205 ± 0.0002
genkey+0900	0.0107 ± 0.0002	0.0165 ± 0.0002	0.0242 ± 0.0002
griaule+0108	0.0110 ± 0.0002	0.0169 ± 0.0002	0.0255 ± 0.0003
griaule+0109	0.0110 ± 0.0002	0.0170 ± 0.0002	0.0255 ± 0.0003
hongda+0007	0.0095 ± 0.0002	0.0158 ± 0.0002	0.0243 ± 0.0002
id3tech+1252	0.0092 ± 0.0002	0.0138 ± 0.0002	0.0200 ± 0.0002
imagid+0004	0.0063 ± 0.0001	0.0094 ± 0.0002	0.0135 ± 0.0002
imagid+0010	0.0062 ± 0.0001	0.0093 ± 0.0002	0.0134 ± 0.0002
inesc+0016	0.0190 ± 0.0002	0.0290 ± 0.0003	0.0435 ± 0.0003
innovatrics+001C	0.0094 ± 0.0002	0.0148 ± 0.0002	0.0224 ± 0.0002
innovatrics+001D	0.0072 ± 0.0001	0.0111 ± 0.0002	0.0161 ± 0.0002
liquid+0107	0.0177 ± 0.0002	0.0277 ± 0.0003	0.0412 ± 0.0003
Neurotechnology+010B	0.0066 ± 0.0001	0.0101 ± 0.0002	0.0147 ± 0.0002
Neurotechnology+0206	0.0066 ± 0.0001	0.0101 ± 0.0002	0.0150 ± 0.0002
secugen+0037	0.0161 ± 0.0002	0.0255 ± 0.0003	0.0381 ± 0.0003
sonda+0119	0.0098 ± 0.0002	0.0155 ± 0.0002	0.0235 ± 0.0002
startek+0009	0.0140 ± 0.0002	0.0212 ± 0.0002	0.0307 ± 0.0003
SupremaUFCore+2022	0.0142 ± 0.0002	0.0221 ± 0.0002	0.0319 ± 0.0003
Tech5+0103	0.0098 ± 0.0002	0.0156 ± 0.0002	0.0238 ± 0.0002
Pooled	0.0126 ± 0.0002	0.0198 ± 0.0002	0.0293 ± 0.0003

Table 5: *Right index finger FNMRs at various FMRs when matcher 006A+0292 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
0059+0816	0.0081 ± 0.0002	0.0123 ± 0.0002	0.0187 ± 0.0003
006A+0292	0.0062 ± 0.0002	0.0094 ± 0.0002	0.0138 ± 0.0003
006D+0013	0.0125 ± 0.0003	0.0195 ± 0.0003	0.0285 ± 0.0004
0071+0019	0.0109 ± 0.0002	0.0173 ± 0.0003	0.0251 ± 0.0004
0071+0020	0.0110 ± 0.0002	0.0173 ± 0.0003	0.0250 ± 0.0004
aatec+0403	0.0049 ± 0.0002	0.0071 ± 0.0002	0.0101 ± 0.0002
antheus+100A	0.0157 ± 0.0003	0.0270 ± 0.0004	0.0411 ± 0.0004
aratek+0011	0.0130 ± 0.0003	0.0201 ± 0.0003	0.0304 ± 0.0004
aware+0311	0.0095 ± 0.0002	0.0147 ± 0.0003	0.0222 ± 0.0003
cogent+0510	0.0063 ± 0.0002	0.0097 ± 0.0002	0.0144 ± 0.0003
Decatur+0102	0.0159 ± 0.0003	0.0247 ± 0.0003	0.0354 ± 0.0004
Decatur+0104	0.0158 ± 0.0003	0.0247 ± 0.0003	0.0350 ± 0.0004
dermalog+0006	0.0067 ± 0.0002	0.0105 ± 0.0002	0.0157 ± 0.0003
futronic+000A	0.0138 ± 0.0003	0.0223 ± 0.0003	0.0334 ± 0.0004
gemalto+0108	0.0064 ± 0.0002	0.0100 ± 0.0002	0.0148 ± 0.0003
genkey+0900	0.0078 ± 0.0002	0.0119 ± 0.0002	0.0177 ± 0.0003
griaule+0108	0.0082 ± 0.0002	0.0128 ± 0.0003	0.0191 ± 0.0003
griaule+0109	0.0081 ± 0.0002	0.0127 ± 0.0003	0.0191 ± 0.0003
hongda+0007	0.0069 ± 0.0002	0.0112 ± 0.0002	0.0175 ± 0.0003
id3tech+1252	0.0070 ± 0.0002	0.0102 ± 0.0002	0.0148 ± 0.0003
imagid+0004	0.0048 ± 0.0002	0.0068 ± 0.0002	0.0098 ± 0.0002
imagid+0010	0.0048 ± 0.0002	0.0068 ± 0.0002	0.0097 ± 0.0002
inesc+0016	0.0144 ± 0.0003	0.0224 ± 0.0003	0.0340 ± 0.0004
innovatrics+001C	0.0075 ± 0.0002	0.0116 ± 0.0002	0.0175 ± 0.0003
innovatrics+001D	0.0055 ± 0.0002	0.0082 ± 0.0002	0.0120 ± 0.0002
liquid+0107	0.0132 ± 0.0003	0.0207 ± 0.0003	0.0315 ± 0.0004
Neurotechnology+010B	0.0051 ± 0.0002	0.0076 ± 0.0002	0.0109 ± 0.0002
Neurotechnology+0206	0.0051 ± 0.0002	0.0076 ± 0.0002	0.0113 ± 0.0002
secugen+0037	0.0123 ± 0.0002	0.0195 ± 0.0003	0.0294 ± 0.0004
sonda+0119	0.0072 ± 0.0002	0.0112 ± 0.0002	0.0170 ± 0.0003
startek+0009	0.0104 ± 0.0002	0.0158 ± 0.0003	0.0231 ± 0.0003
SupremaUFCore+2022	0.0110 ± 0.0002	0.0172 ± 0.0003	0.0250 ± 0.0004
Tech5+0103	0.0072 ± 0.0002	0.0112 ± 0.0002	0.0170 ± 0.0003
Pooled	0.0095 ± 0.0002	0.0150 ± 0.0003	0.0223 ± 0.0003

Table 6: *Left index finger FNMRs at various FMRs when matcher 006A+0292 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
0059+0816	0.0146 ± 0.0003	0.0224 ± 0.0003	0.0332 ± 0.0004
006A+0292	0.0105 ± 0.0002	0.0168 ± 0.0003	0.0254 ± 0.0004
006D+0013	0.0185 ± 0.0003	0.0283 ± 0.0004	0.0403 ± 0.0004
0071+0019	0.0158 ± 0.0003	0.0248 ± 0.0004	0.0358 ± 0.0004
0071+0020	0.0160 ± 0.0003	0.0248 ± 0.0004	0.0359 ± 0.0004
aatec+0403	0.0081 ± 0.0002	0.0125 ± 0.0003	0.0181 ± 0.0003
antheus+100A	0.0235 ± 0.0003	0.0391 ± 0.0004	0.0612 ± 0.0005
aratek+0011	0.0212 ± 0.0003	0.0327 ± 0.0004	0.0469 ± 0.0005
aware+0311	0.0169 ± 0.0003	0.0258 ± 0.0004	0.0384 ± 0.0004
cogent+0510	0.0113 ± 0.0002	0.0173 ± 0.0003	0.0251 ± 0.0004
Decatur+0102	0.0237 ± 0.0003	0.0360 ± 0.0004	0.0521 ± 0.0005
Decatur+0104	0.0237 ± 0.0003	0.0360 ± 0.0004	0.0523 ± 0.0005
dermalog+0006	0.0100 ± 0.0002	0.0164 ± 0.0003	0.0250 ± 0.0004
futronic+000A	0.0221 ± 0.0003	0.0354 ± 0.0004	0.0508 ± 0.0005
gemalto+0108	0.0107 ± 0.0002	0.0171 ± 0.0003	0.0262 ± 0.0004
genkey+0900	0.0134 ± 0.0003	0.0208 ± 0.0003	0.0303 ± 0.0004
griaule+0108	0.0138 ± 0.0003	0.0209 ± 0.0003	0.0313 ± 0.0004
griaule+0109	0.0138 ± 0.0003	0.0211 ± 0.0003	0.0315 ± 0.0004
hongda+0007	0.0120 ± 0.0002	0.0201 ± 0.0003	0.0311 ± 0.0004
id3tech+1252	0.0113 ± 0.0002	0.0173 ± 0.0003	0.0252 ± 0.0004
imagid+0004	0.0077 ± 0.0002	0.0118 ± 0.0002	0.0172 ± 0.0003
imagid+0010	0.0077 ± 0.0002	0.0118 ± 0.0002	0.0171 ± 0.0003
inesc+0016	0.0235 ± 0.0003	0.0352 ± 0.0004	0.0524 ± 0.0005
innovatrics+001C	0.0112 ± 0.0002	0.0179 ± 0.0003	0.0267 ± 0.0004
innovatrics+001D	0.0089 ± 0.0002	0.0138 ± 0.0003	0.0202 ± 0.0003
liquid+0107	0.0220 ± 0.0003	0.0343 ± 0.0004	0.0508 ± 0.0005
Neurotechnology+010B	0.0081 ± 0.0002	0.0125 ± 0.0003	0.0183 ± 0.0003
Neurotechnology+0206	0.0081 ± 0.0002	0.0125 ± 0.0003	0.0184 ± 0.0003
secugen+0037	0.0197 ± 0.0003	0.0312 ± 0.0004	0.0459 ± 0.0005
sonda+0119	0.0123 ± 0.0002	0.0195 ± 0.0003	0.0297 ± 0.0004
startek+0009	0.0174 ± 0.0003	0.0262 ± 0.0004	0.0379 ± 0.0004
SupremaUFCore+2022	0.0173 ± 0.0003	0.0268 ± 0.0004	0.0383 ± 0.0004
Tech5+0103	0.0123 ± 0.0002	0.0197 ± 0.0003	0.0301 ± 0.0004
Pooled	0.0155 ± 0.0003	0.0244 ± 0.0003	0.0360 ± 0.0004

Table 7: *Two finger FNMRs at various FMRs when matcher 006A+0292 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
0059+0816	0.00143 ± 0.00009	0.0024 ± 0.0001	0.0039 ± 0.0001
006A+0292	0.00069 ± 0.00006	0.00135 ± 0.00008	0.0023 ± 0.0001
006D+0013	0.0023 ± 0.0001	0.0042 ± 0.0001	0.0070 ± 0.0002
0071+0019	0.00185 ± 0.00010	0.0033 ± 0.0001	0.0056 ± 0.0002
0071+0020	0.00193 ± 0.00010	0.0034 ± 0.0001	0.0056 ± 0.0002
aatec+0403	0.00041 ± 0.00005	0.00084 ± 0.00007	0.00144 ± 0.00009
antheus+100A	0.0032 ± 0.0001	0.0061 ± 0.0002	0.0106 ± 0.0002
aratek+0011	0.0028 ± 0.0001	0.0047 ± 0.0002	0.0076 ± 0.0002
aware+0311	0.00162 ± 0.00009	0.0028 ± 0.0001	0.0046 ± 0.0002
cogent+0510	0.00082 ± 0.00006	0.00150 ± 0.00009	0.0025 ± 0.0001
Decatur+0102	0.0037 ± 0.0001	0.0064 ± 0.0002	0.0100 ± 0.0002
Decatur+0104	0.0037 ± 0.0001	0.0065 ± 0.0002	0.0100 ± 0.0002
dermalog+0006	0.00071 ± 0.00006	0.00142 ± 0.00008	0.0025 ± 0.0001
futronic+000A	0.0032 ± 0.0001	0.0056 ± 0.0002	0.0091 ± 0.0002
gemalto+0108	0.00074 ± 0.00006	0.00147 ± 0.00009	0.0024 ± 0.0001
genkey+0900	0.00133 ± 0.00008	0.0022 ± 0.0001	0.0037 ± 0.0001
griaule+0108	0.00133 ± 0.00008	0.0023 ± 0.0001	0.0039 ± 0.0001
griaule+0109	0.00132 ± 0.00008	0.0023 ± 0.0001	0.0038 ± 0.0001
hongda+0007	0.00078 ± 0.00006	0.00163 ± 0.00009	0.0029 ± 0.0001
id3tech+1252	0.00100 ± 0.00007	0.00175 ± 0.00009	0.0028 ± 0.0001
imagid+0004	0.00040 ± 0.00004	0.00075 ± 0.00006	0.00132 ± 0.00008
imagid+0010	0.00040 ± 0.00004	0.00074 ± 0.00006	0.00132 ± 0.00008
inesc+0016	0.0035 ± 0.0001	0.0061 ± 0.0002	0.0099 ± 0.0002
innovatrics+001C	0.00099 ± 0.00007	0.00182 ± 0.00010	0.0031 ± 0.0001
innovatrics+001D	0.00062 ± 0.00006	0.00119 ± 0.00008	0.00193 ± 0.00010
liquid+0107	0.0027 ± 0.0001	0.0047 ± 0.0002	0.0081 ± 0.0002
Neurotechnology+010B	0.00046 ± 0.00005	0.00097 ± 0.00007	0.00159 ± 0.00009
Neurotechnology+0206	0.00044 ± 0.00005	0.00089 ± 0.00007	0.00164 ± 0.00009
secugen+0037	0.0023 ± 0.0001	0.0042 ± 0.0001	0.0069 ± 0.0002
sonda+0119	0.00096 ± 0.00007	0.00183 ± 0.00010	0.0030 ± 0.0001
startek+0009	0.0020 ± 0.0001	0.0034 ± 0.0001	0.0056 ± 0.0002
SupremaUFCore+2022	0.0021 ± 0.0001	0.0036 ± 0.0001	0.0061 ± 0.0002
Tech5+0103	0.00096 ± 0.00007	0.00183 ± 0.00010	0.0030 ± 0.0001
Pooled	0.00174 ± 0.00009	0.0031 ± 0.0001	0.0052 ± 0.0002

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