`papil111+0010`

Papil11 S.R.O.

Evaluation of Latent Friction Ridge Technology (ELFT)

Technical performance report of automated latent fingerprint feature extraction and search software.

Last Updated: 18 May 2026

Contents

Not Human Subjects Research
The National Institute of Standards and Technology's Research Protections Office reviewed the protocol for this project and determined it is "not human subjects research" as defined in 15 CFR 27, the Common Rule for the Protection of Human Subjects.

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U.S. DEPARTMENT OF COMMERCE

1 Participation Information

1.1 Names

Information in this section is provided by the participant.

- **Participant Name:** Papil11 S.R.O.
- **ELFT Identifier:** `papil111+0010`

1.2 Dates

- **Participation Agreement Date:** 23 March 2026
- **First Submission Date:** 23 March 2026 (as version `0009`)
- **Final Submission Date:** 04 May 2026 (as version `0010`)
- **Validation Date:** 04 May 2026
- **Completion Date:** 18 May 2026
- **Report Last Updated Date:** 18 May 2026

1.3 Supplied Libraries and Configurations

Testing was completed using *Ubuntu 24.04.3 LTS*. Files provided by Papil11 S.R.O. are listed in Table 1.

Table 1: Information regarding library and configuration files provided as part of `papil111+0010`.

Filename	MD5 Checksum	Size (MB)
fmw.p	`98b1bf21cf2b07f09a7a9a98fc0bb322`	46.9
fpw.p	`09d7bc923ca6beb2f269fe884549d4d5`	74.2
ftw.p	`ff91fb6a8abf18ef738b1c104e3bf9f9`	115.4
libelft_papil111_0010.so	`a7644c8c4a085a1d87c79bf0ba6f7cae`	4.5
libonnxruntime.so	`c9791f024848ee5483dc35aea75e1312`	19.2
libonnxruntime_providers_openvino.so	`59872b2115f5b846a4b1839da9260318`	0.5
libonnxruntime_providers_shared.so	`ee85062428eadcc3c8c78871dfd52b11`	0.0
libopenvino.so	`b007f5f219fa72b90f2606743b45bac1`	20.5
libopenvino_intel_cpu_plugin.so	`c07eb40c5fa3178f8bf7809e6e3bbfc1`	47.9
libopenvino_onnx_frontend.so	`50c3acb86d0871ab67082756fe188d5e`	6.0

2 Timing Sample

A fixed sample of images was randomly and proportionally selected from the ELFT datasets. The sample is used to assess whether an implementation adheres to the computational speed requirements from the ELFT Test Plan. These values are chosen in such a way that allows the implementation flexibility while allowing NIST to complete the evaluation in a reasonable amount of time. If an implementation exceeds the maximum allowable duration, the participant will be asked to reduce the processing time of their software prior to NIST completing the evaluation. As such, *all* published ELFT submissions conform to the published speed requirements.

2.1 Processor Details

All measurements in this section were performed on a machine equipped with Intel Xeon Gold 6254 Central Processing Units (CPUs). Each CPU features a 3.10 GHz base frequency and 24.75 MB of cache. Timing tests are all **single threaded**—implementations are not permitted to use more than one CPU core during any function measured here. As such, these values can be used to understand expected scaled performance. NIST testing code embraces the single-threaded nature of implementations to `fork` processes during other non-timed portions of this evaluation, allowing participants to write thread-unsafe code while still using NIST resources to their maximum efficiency. This CPU supports executing several families of processor intrinsic functions, including AVX-512[1].

2.2 Composition

Table 2 shows the quantity of each type of fingerprint image comprising the timing sample dataset.

Table 2: Number of images of each generalized finger position comprising the timing sample dataset.

Image Type	Quantity
Latent	243
Four Finger	476
Full Palm	40
Partial Palm	47
Single Finger	2 784

2.3 Feature Extraction

Features were extracted from all images depicted in Table 2 and stored in templates. If a sample contained EFS data, it was not included during this test.

2.3.1 Template Size

Table 3 and Figure 1 show the distribution of file sizes of templates. Failures of any kind reported during template generation result in NIST code writing 0 byte files. These files are excluded from the template size analysis in this section.

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[1] The complete set of advertised CPU flags is fpu, vme, de, pse, tsc, msr, pae, mce, cx8, apic, sep, mtrr, pge, mca, cmov, pat, pse36, clflush, dts, acpi, mmx, fxsr, sse, sse2, ss, ht, tm, pbe, syscall, nx, pdpe1gb, rdtscp, lm, constant_tsc, art, arch_perfmon, pebs, bts, rep_good, nopl, xtopology, nonstop_tsc, cpuid, aperfmperf, pni, pclmulqdq, dtes64, monitor, ds_cpl, vmx, smx, est, tm2, ssse3, sdbg, fma, cx16, xtpr, pdcm, pcid, dca, sse4_1, sse4_2, x2apic, movbe, popcnt, tsc_deadline_timer, aes, xsave, avx, f16c, rdrand, lahf_lm, abm, 3dnowprefetch, cpuid_fault, epb, cat_l3, cdp_l3, invpcid_single, intel_ppin, ssbd, mba, ibrs, ibpb, stibp, ibrs_enhanced, tpr_shadow, vnmi, flexpriority, ept, vpid, ept_ad, fsgsbase, tsc_adjust, bmi1, avx2, smep, bmi2, erms, invpcid, cqm, mpx, rdt_a, avx512f, avx512dq, rdseed, adx, smap, clflushopt, clwb, intel_pt, avx512cd, avx512bw, avx512vl, xsaveopt, xsavec, xgetbv1, xsaves, cqm_llc, cqm_occup_llc, cqm_mbm_total, cqm_mbm_local, dtherm, ida, arat, pln, pts, pku, ospke, avx512_vnni, md_clear, flush_l1d, arch_capabilities

Table 3: Template file size summary statistics as seen on the Timing Sample dataset, in kB.

Image Type	Minimum	25%	Median	Mean	75%	Maximum	Failures	Attempts
Latent	0.1	5.7	5.7	6.9	5.7	32.4	0	243
Single Finger	0.1	17.1	22.2	21.6	27.3	31.3	0	2 784
Four Finger	5.8	41.5	51.4	51.7	62.2	106.6	0	476
Partial Palm	0.1	58.6	124.7	116.5	166.8	249.3	0	47
Full Palm	23.0	269.0	319.0	309.7	374.2	476.7	0	40

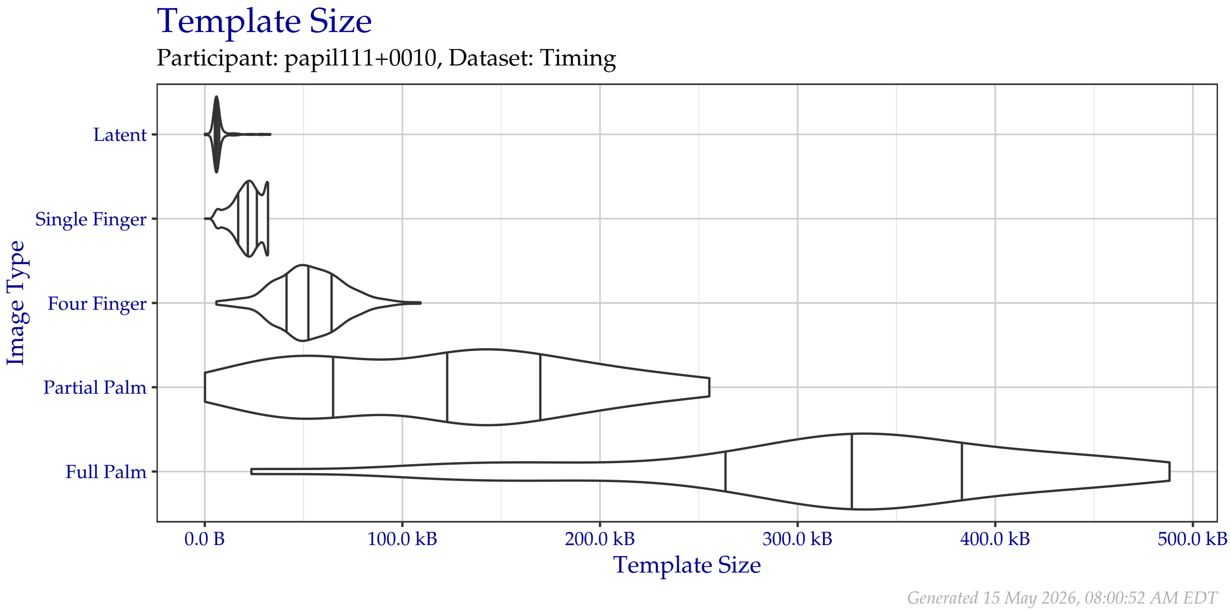


Figure 1: Violin plot of template file sizes as seen on the Timing Sample dataset. Vertical lines from left to right indicate the 25%, 50%, and 75% quantiles respectively.

2.3.2 Template Creation Duration

Table 4 and Figure 2 show the distribution of template creation durations in seconds. Failures of any kind reported during template generation result in NIST code writing 0 byte files, but only after the template creation method returns. These times are included in the template creation duration analysis in this section.

Table 4: Duration of template creation in seconds for images from the Timing Sample dataset.

Image Type	Minimum	25%	Median	Mean	75%	Maximum	Failures	Attempts
Latent	0.0	0.9	1.0	1.2	1.1	5.6	0	243
Single Finger	0.5	2.8	3.6	3.5	4.3	5.0	0	2 784
Four Finger	2.1	7.3	8.7	8.8	10.4	17.6	0	476
Partial Palm	7.4	15.4	23.9	23.2	30.3	41.0	0	47
Full Palm	13.7	49.3	56.2	55.1	64.4	79.3	0	40

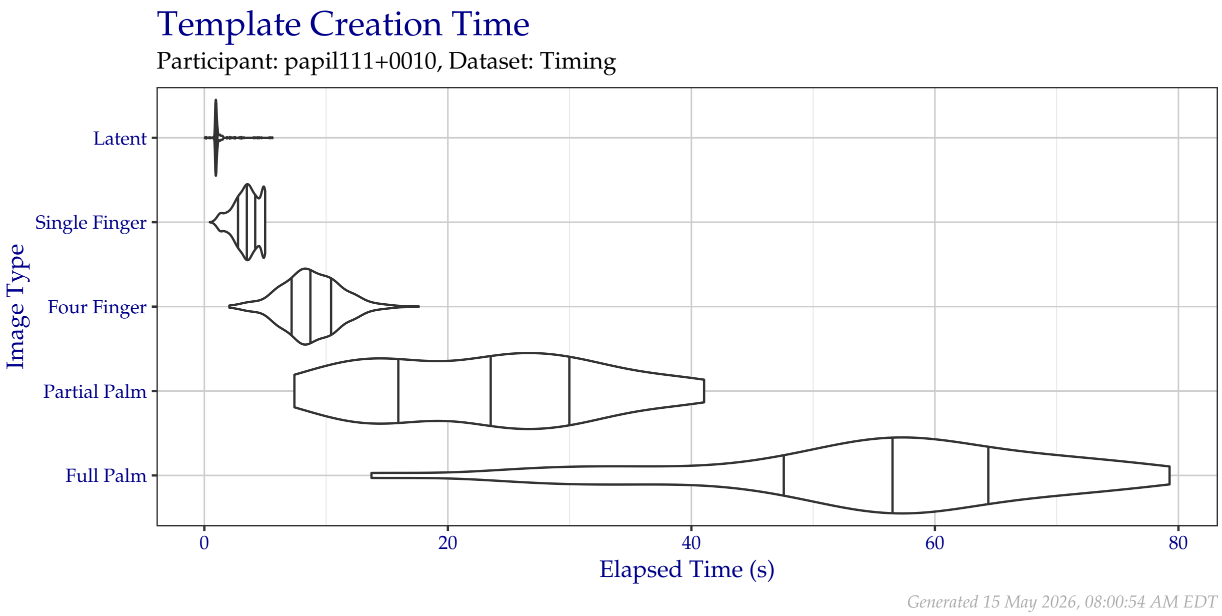


Figure 2: Violin plot of the duration of template creation in seconds for images from the Timing Sample dataset. Vertical lines from left to right indicate the 25%, 50%, and 75% quantiles respectively.

2.3.3 Template Creation Memory Consumption

Figure 3 shows the amount of RAM consumed by the single testing process as a function of time during the template creation procedure, including RAM consumed by the NIST testing apparatus.

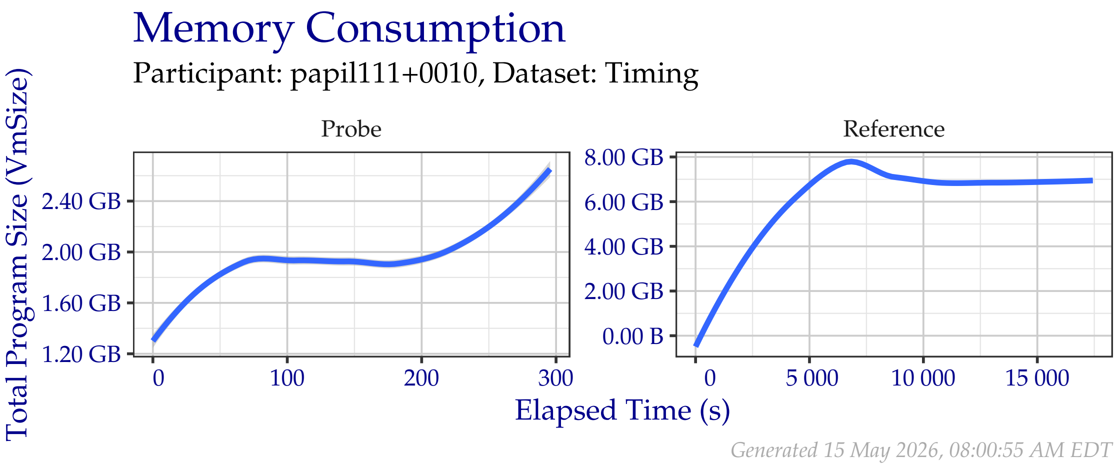


Figure 3: Amount of RAM used while creating templates in the Timing Sample dataset.

2.4 Enrollment Database

Reference templates are combined into a participant-defined database structure for optimal searching. Each database consisted of ≈ 1 600 000 distractor subjects. Each subject had at least one, but typically twenty, distal phalanges distributed over rolled and flat impression captures to enroll. ≈ 150 000 had one or more palm captures.

While the participant-defined enrollment database should contain information about all references, the file size may be significantly different than the space consumed by concatenation of all individual reference templates. Additionally, the participant-defined database structure may be a structure unique or especially optimized for this evaluation and not necessarily similar to a structure deployed operationally. The sum of file sizes for both types of reference storage are shown in Table 5.

Table 5: Sum of file storage needed to hold all distractor reference templates in the Timing Sample.

Storage Type	Size
Participant-Defined Enrollment Database	650.6 GB
Raw Templates on Disk	647.0 GB

2.5 Search

Out of the latent templates generated in Table 2, a fixed random sample of 24 of the resulting latent templates were searched against the enrollment database described in Subsection 2.4. The results presented in Subsection 2.5 are based on the measurements made on or during those 24 searches.

2.5.1 Search Duration

Table 6 and Figure 4 show the amount of time elapsed during searches of the fixed search probe set when searching against the enrollment database described in Subsection 2.4. While unsuccessful searches expend operator time, they are not included in this metric, because search failures typically occur instantaneously (e.g., a template indicates that a probe was of too poor quality to search), which can artificially lower the average search time.

ELFT defines maximum average search durations for participants based on the number of subjects in the enrollment database. Due to the potential for extended runtimes, NIST may choose to allow some discretion in the enforcement of maximum search durations during times of high demand for compute resources. For example, if a maximum average search duration was 4 hours, but after completing all searches, the average search duration was 4.5 hours, it may be prudent to continue the evaluation, since a resubmission may require regeneration of millions of templates and several thousand repeated searches.

Note: In March 2023, NIST lowered the number of searches from 100 to 25, with all 25 probes depicting a distal phalanx. It also doubled the average quantity of impressions per subject by combining previously separate plain and rolled impressions for each subject. ELFT does not mandate the strategy in which multiple impressions of the same reference finger are stored or searched in the enrollment database, but it does impose search time maximums on a per-subject basis, *not* per-impression. This means that in Table 6 and Figure 4, there may be average search durations *significantly* higher than the evaluation permitted maximum for implementations submitted prior to March 2023.

Note: In October 2023, NIST discovered a probe image in the search dataset contained invalid resolution information. This probe has been removed from the test, reducing the number of searches to 24. Evaluations run prior to this change will show total elapsed time measures including the now-omitted search.

Table 6: Search time durations of the search probe set from the Timing Sample dataset, in seconds. This data is visualized in Figure 4.

Mated?	Min	25%	Median	Mean	75%	Maximum	Failures	Searches
False	0	12 517	12 567	12 836	12 651	25 254	0	24
True	0	12 674	12 718	12 977	12 789	25 297	0	24

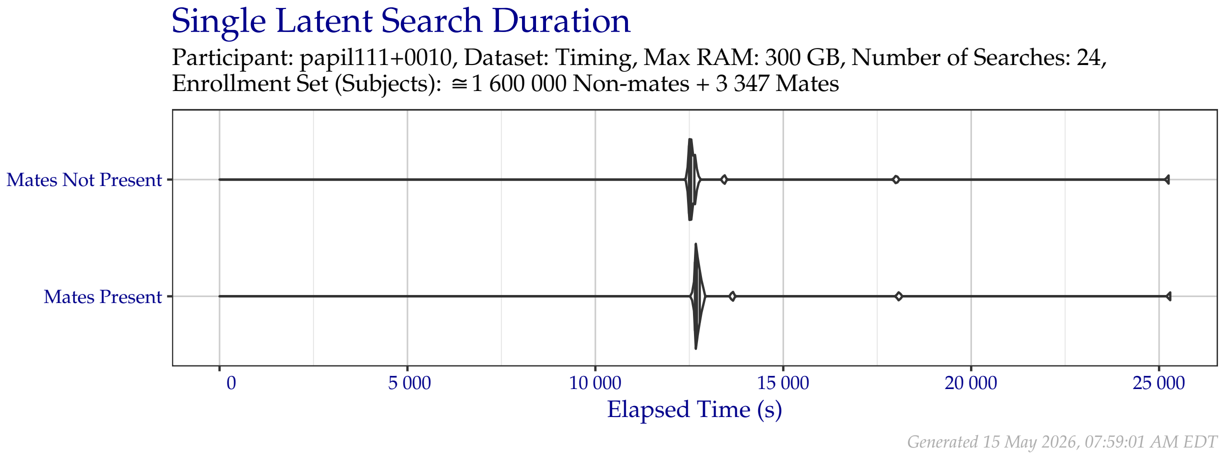


Figure 4: Violin plot of search time durations of the search probe set from the Timing Sample dataset. Vertical lines from left to right indicate the 25%, 50%, and 75% quantiles respectively.

2.5.2 Search Memory Consumption

Figure 5 shows the amount of RAM consumed by the single testing process as a function of time during the search procedure, including RAM consumed by the NIST testing apparatus. Implementations were permitted to use up to 300 GB of RAM (of a total available 384 GB) to load their enrollment database, the rest of which was stored on a local solid-state storage device. Note the different scales on each panel—implementations that do not change the contents of RAM may not show variation.

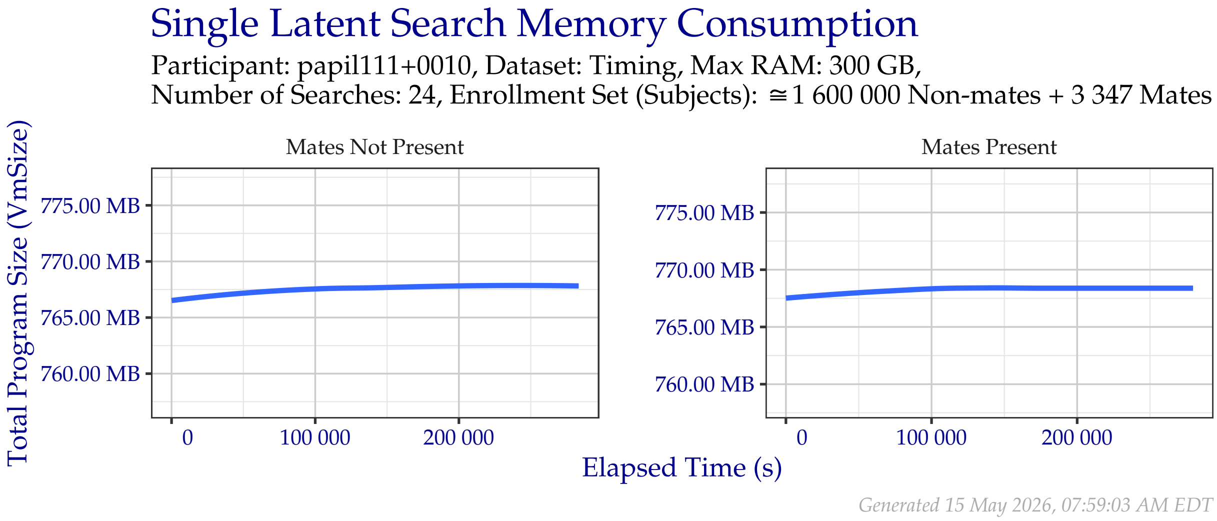


Figure 5: Amount of RAM used while searching templates in the Timing Sample dataset.

3 Metrics

3.1 Location

When a metric depicts search accuracy in this document, it is reported in terms of Location: Region and Subject.

- **Region**: The correct region of the correct subject was returned.
    - For search probes sourced from a distal phalanx (i.e., a "latent fingerprint"), the correct finger position 1–10 shall be returned.
    - For search probes sourced from a palm or a non-distal phalanx, the most localized region shall be returned. Some palm regions may be interchangeable based on the exemplars provided (e.g., a palm probe's source could reasonably be seen in a lower palm, hypothenar, and writer's palm exemplar). Credit is given for **Region** in this case.
- **Subject**: Any position from the correct subject is returned. This is designed to reward the situation where an implementation cannot ascertain the most localized region from the set of exemplars enrolled and may indicate segmentation error.

3.2 Cumulative Match Characteristic (CMC)

The Cumulative Match Characteristic (CMC) plots in this document show the false negative identification rate (FNIR) without respect for similarity score when searching probes against a enrollment database where a single mated identity for each search probe was present.

- $\approx$ 1 600 000 non-mated subjects were enrolled.
    - All subjects had at least one, but typically twenty, images containing distal phalanges. This typically included ten individually rolled impressions and "Identification Flat" captures featuring more than one distal phalanx per image that must be segmented by the implementation.
    - $\approx$ 150 000 had one or more palm captures to enroll.
- The requested size of the candidate list was always 100 subjects.
- All possible Extended Feature Set (EFS) data was provided when "Image + EFS" is listed for probes. The type and quantity of EFS data present varies for each sample in each dataset and may have been entirely omitted. Initial experiments show nominal (if any) change when EFS data was provided alongside exemplars.
- Probe impression type was always "Unknown Finger" or "Unknown Palm," as appropriate. Future studies may show results using the impression type "Unknown Friction Ridge" for both types of probes.
- The metric *hit rate* is equivalent to $1 -$ miss rate, or $1 -$ FNIR. For example, an FNIR of 0.1 indicates a hit rate of 0.9 (i.e., 90%).

3.3 Detection Error Tradeoff (DET)

The Detection Error Tradeoff (DET) plots in this document show the tradeoff between false positive and false negative identification rates when searching probes against a enrollment database where a single mated identity for each search probe was present.

- $\approx$ 1 600 000 non-mated subjects were enrolled.
    - All subjects had at least one, but typically twenty, images containing distal phalanges. This typically included ten individually rolled impressions and "Identification Flat" captures featuring more than one distal phalanx per image that must be segmented by the implementation.
    - $\approx$ 150 000 had one or more palm captures to enroll.
    - Non-mated similarity scores come from rank = 1 when searching probes against an enrollment dataset without any mated subjects enrolled.
- The requested size of the candidate list was always 100 subjects.
    - Mated similarity scores come from the correct location appearing at *any* rank.

- All possible EFS data was provided when “Image + EFS” is listed for probes. The type and quantity of EFS data present varies for each sample in each dataset and may have been entirely omitted. Initial experiments show nominal (if any) change when EFS data was provided alongside exemplars.
- Probe impression type was always “Unknown Finger” or “Unknown Palm,” as appropriate. Future studies may show results using the impression type “Unknown Friction Ridge” for both types of probes.

4 Non-mated Distractor Subjects

When searching probes in each of the subsequent sections, the non-mated distractor subjects that comprised the majority of each enrollment database remained the same. The results of Section 4 are based off of these distractor subjects.

4.1 Failures

Table 7 shows the number of failures to create reference templates for non-mated distractor subjects.

Table 7: Number of failures to create reference templates.

Distal Phalanx Impression Type	Failures	≈ Attempts
Mixed (Plain/Roll)	0	1 600 000

5 FBI Laboratory

The results of Section 5 are based on searches of the sequestered dataset *FBI Laboratory*. This dataset consists of 49 operational latent distal phalanx probes. Examiners at the FBI annotated several of the probe images with EFS features, possibly with algorithm assistance. These examiners then confirmed the ground truth mate. All probes searched were a single sample depicting a region from a distal phalanx. EFS data provided with the probe image *may* include:

- Pattern classification
- Minutia locations (unconfirmed source)

5.1 Failures

Table 8 shows the number of failures to create templates. Table 9 shows the number of failures to produce a candidate list.

Table 8: Number of failures to create templates.

Image Type	Content	Failures	Attempts
Exemplar	Image	0	38
Probe	EFS	0	48
Probe	Image	0	49
Probe	Image + EFS	0	49

Table 9: Number of failures to produce a candidate list. This number includes any failures to create a probe template from Table 8.

Probe Content	Failures	Attempts
EFS	0	48
Image	0	49
Image + EFS	0	49

5.2 CMC

5.2.1 Plots

5.2.1.1 All Probes The CMC plots in Figure 6 show the FNIR of `papil111+0010` when searching FBI Laboratory against enrollment database where a single mated identity for each search probe was present. The plots are faceted by whether probe EFS data was provided. Tabular versions of FNIR at select ranks can be viewed in Table 10.

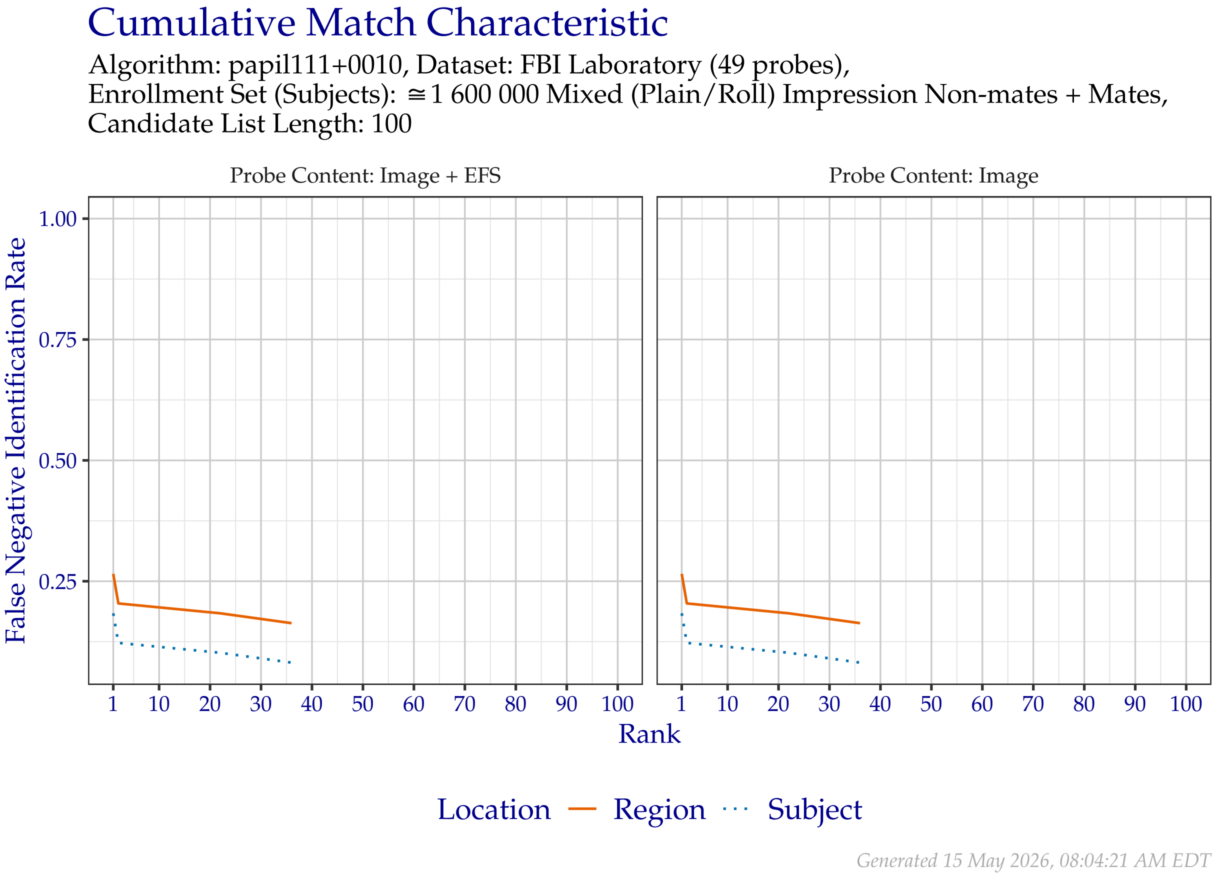


Figure 6: CMC when searching FBI Laboratory probes, faceted by whether probe EFS data was provided.

5.2.1.2 Probes with EFS Data Not all of the probes in the FBI Laboratory dataset contain EFS data. The plot in Figure 7 shows the CMC over *only* the probes that contained EFS data. This plot also differs from Figure 6 with the inclusion of a line for probes where no image was provided when creating the probe template, meaning the only information available was EFS data. Only the *region* success location is shown.

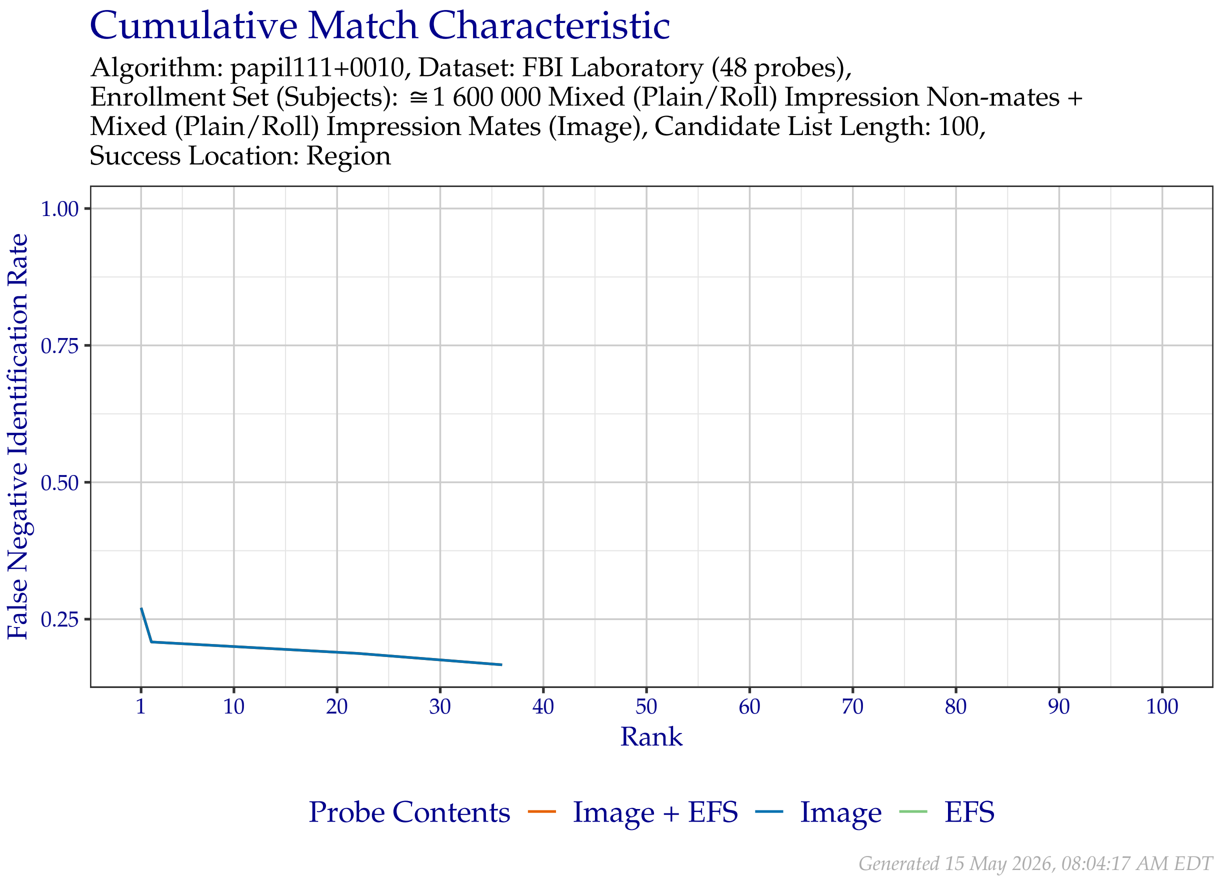


Figure 7: CMC of region location when searching only the FBI Laboratory probes that contained EFS data.

5.2.2 FNIR at Select Rank

5.2.2.1 All Probes The values in Table 10 correspond to Figure 6.

Table 10: Region FNIR values from CMC plotted in Figure 6.

Probe Content	Rank 1	Rank ≤ 2	Rank ≤ 5	Rank ≤ 10	Rank ≤ 50	Rank ≤ 100
Image	0.2653	0.2041	0.2041	0.2041	0.1633	0.1633
Image + EFS	0.2653	0.2041	0.2041	0.2041	0.1633	0.1633

5.2.2.2 Probes with EFS Data The values in Table 11 correspond to Figure 7.

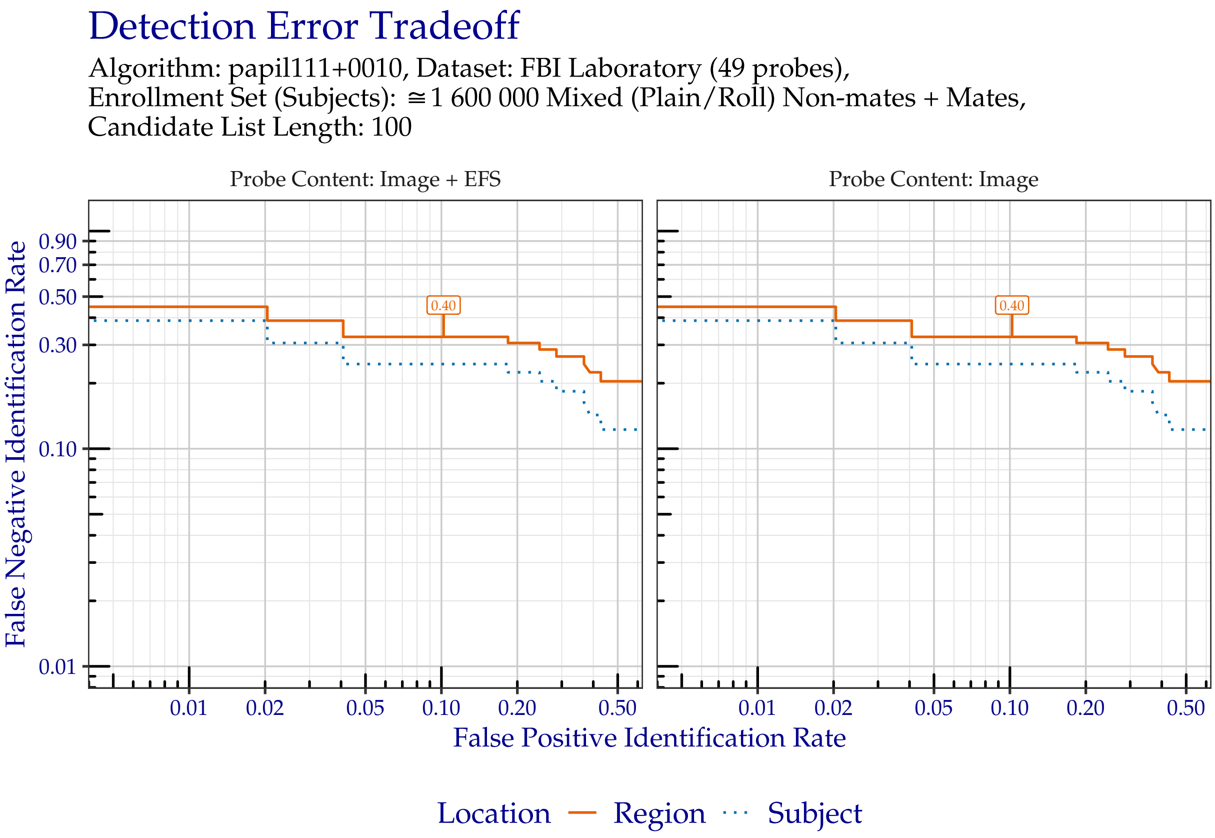
Table 11: Region FNIR values from CMC plotted in Figure 7.

Probe Content	Rank 1	Rank ≤ 2	Rank ≤ 5	Rank ≤ 10	Rank ≤ 50	Rank ≤ 100
EFS	NA	NA	NA	NA	NA	NA
Image	0.2708	0.2083	0.2083	0.2083	0.1667	0.1667
Image + EFS	0.2708	0.2083	0.2083	0.2083	0.1667	0.1667

5.3 DET

5.3.1 Plots

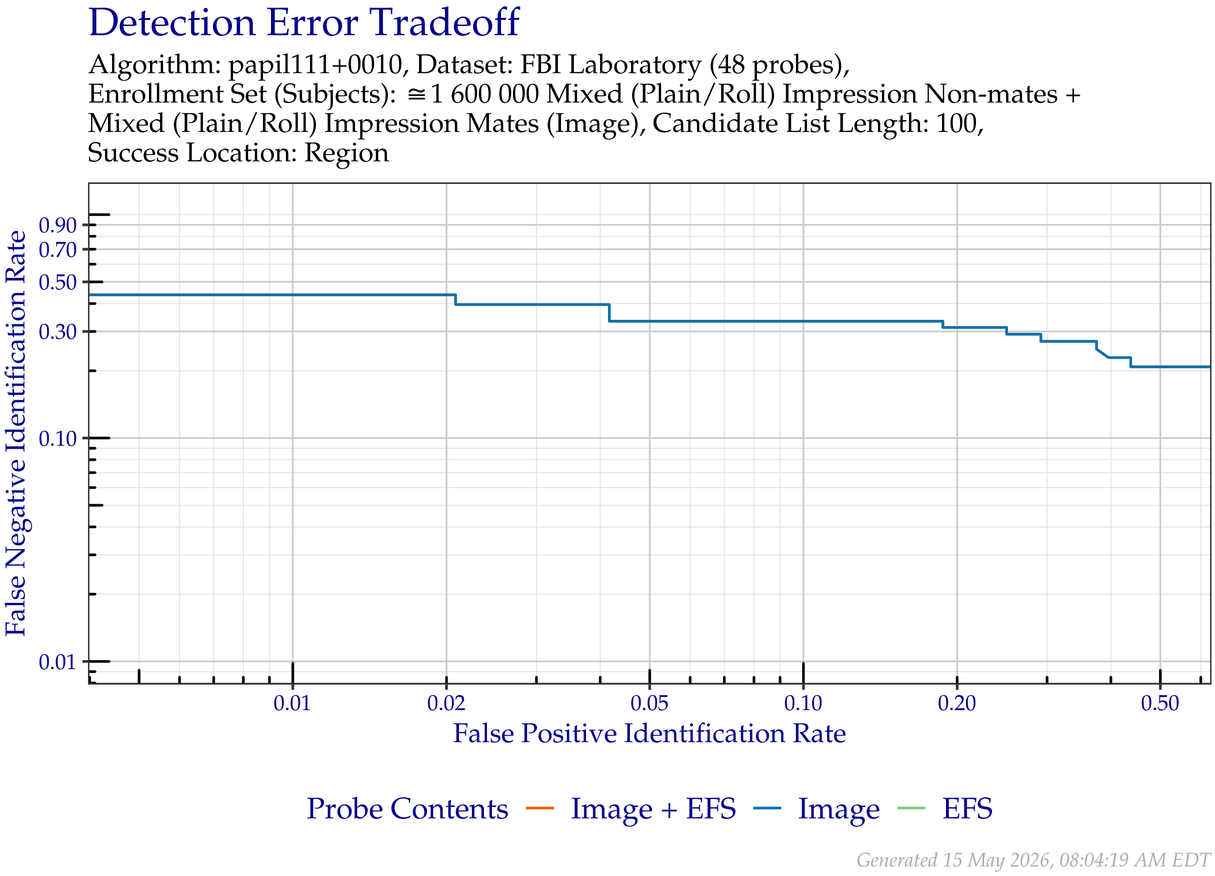
5.3.1.1 All Probes The DET plots in Figure 8 show the false positive and false negative identification rate tradeoffs of `papil111+0010` when searching FBI Laboratory against enrollment database where a single mated identity for each search probe was present. The plots are faceted by whether probe EFS data was provided. Tabular versions of FNIR at select FPIR can be viewed in Table 12. Annotated values indicate similarity scores from the Region line, which are tabulated in Table 14.



Generated 15 May 2026, 08:04:23 AM EDT

Figure 8: DET when searching FBI Laboratory probes, faceted by whether probe EFS data was provided. Annotated values indicate similarity scores from the Region line.

5.3.1.2 Probes with EFS Data Not all of the probes in the FBI Laboratory dataset contain EFS data. The plot in Figure 9 shows the DET over *only* the probes that contained EFS data. This plot also differs from Figure 8 with the inclusion of a line for probes where no image was provided when creating the probe template, meaning the only information available was EFS data. Only the *region* success location is shown.


Detection Error Tradeoff

Algorithm: papil111+0010, Dataset: FBI Laboratory (48 probes),
Enrollment Set (Subjects): ≅1 600 000 Mixed (Plain/Roll) Impression Non-mates +
Mixed (Plain/Roll) Impression Mates (Image), Candidate List Length: 100,
Success Location: Region

Generated 15 May 2026, 08:04:19 AM EDT

Figure 9: DET of region location when searching only the FBI Laboratory probes that contained EFS data.

5.3.2 FNIR at Select FPIR

5.3.2.1 All Probes The values in Table 12 correspond to Figure 8.

Table 12: Region FNIR values corresponding to FPIR plotted in Figure 8.

Probe Content	FPIR = 0.1
Image	0.3265
Image + EFS	0.3265

5.3.2.2 Probes with EFS Data The values in Table 13 correspond to Figure 9.

Table 13: Region FNIR values corresponding to FPIR plotted in Figure 9.

Probe Content	FPIR = 0.1
Image	0.3333
Image + EFS	0.3333

5.3.3 Similarity Score Thresholds at Select FPIR

The values in Table 14 correspond to similarity score thresholds observed at the select FPIR values from Table 12.

Table 14: Similarity score thresholds corresponding to select FPIR values from Table 12.

Probe Content	FPIR = 0.1
Image	0.4
Image + EFS	0.4

6 FBI-Provided Solved Dataset #1

The results of Section 6 are based on searches of the sequestered dataset *FBI-Provided Solved Dataset #1*. This dataset consists of 516 operational probes collected from a particular type of crime. Examiners at the FBI annotated several of the probe images with EFS features, possibly with algorithm assistance. These examiners then confirmed the ground truth mate. All probes searched were a single sample depicting a region from a distal phalanx. EFS data provided with the probe image *may* include:

- Pattern classification
- Core locations (unconfirmed source)
- Delta locations (unconfirmed source)
- Minutia locations (unconfirmed source)

6.1 Failures

Table 15 shows the number of failures to create templates. Table 16 shows the number of failures to produce a candidate list.

Table 15: Number of failures to create templates.

Image Type	Content	Failures	Attempts
Exemplar	Image	0	173
Probe	EFS	0	285
Probe	Image	0	516
Probe	Image + EFS	0	516

Table 16: Number of failures to produce a candidate list. This number includes any failures to create a probe template from Table 15.

Probe Content	Failures	Attempts
EFS	0	285
Image	0	516
Image + EFS	0	516

6.2 CMC

6.2.1 Plots

6.2.1.1 All Probes The CMC plots in Figure 10 show the FNIR of `papil111+0010` when searching FBI-Provided Solved Dataset #1 against enrollment database where a single mated identity for each search probe was present. The plots are faceted by the mated impression type and whether probe EFS data was provided. Tabular versions of FNIR at select ranks can be viewed in Table 17.

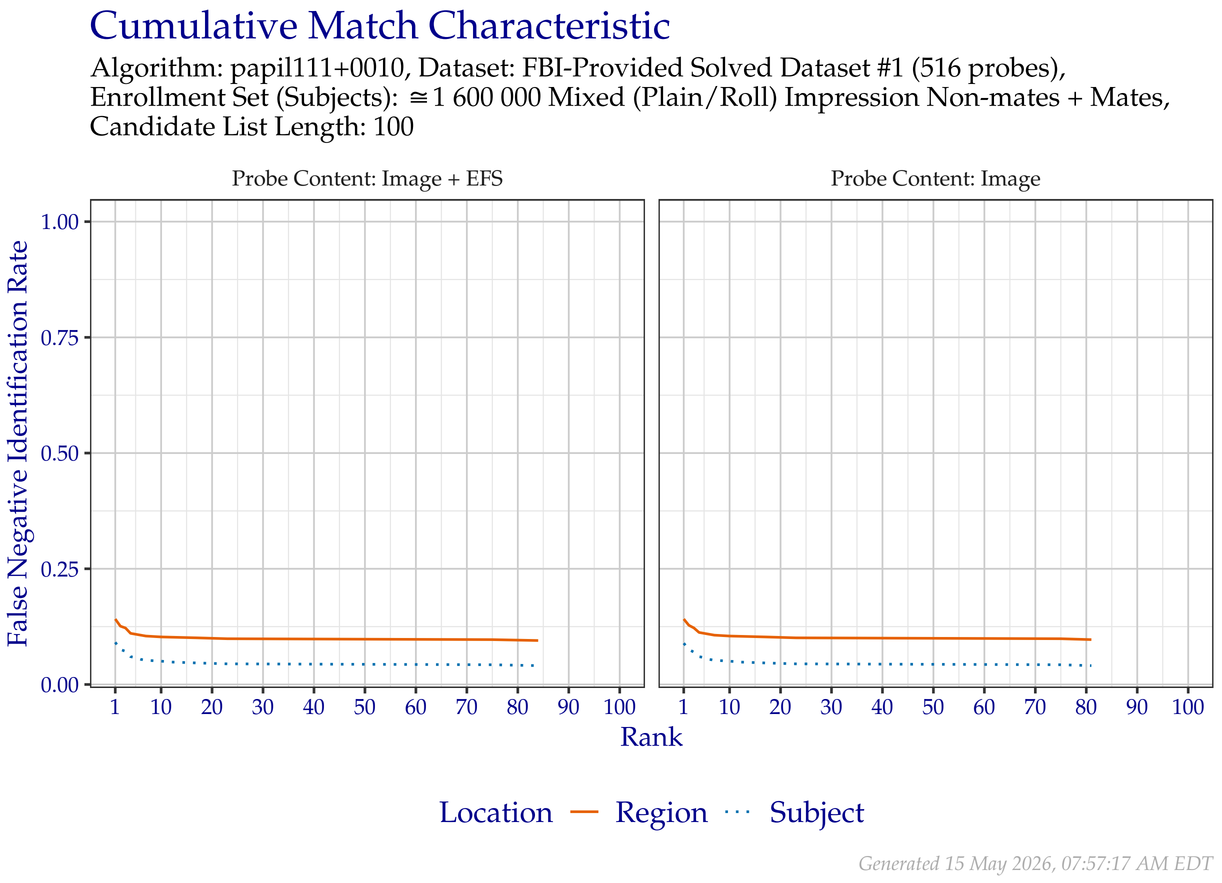


Figure 10: CMC when searching FBI-Provided Solved Dataset #1 probes, faceted by the mated impression type and whether probe EFS data was provided.

6.2.1.2 Probes with EFS Data Not all of the probes in the FBI-Provided Solved Dataset #1 dataset contain EFS data. The plot in Figure 11 shows the CMC over *only* the probes that contained EFS data. This plot also differs from Figure 10 with the inclusion of a line for probes where no image was provided when creating the probe template, meaning the only information available was EFS data. Only the *region* success location is shown.

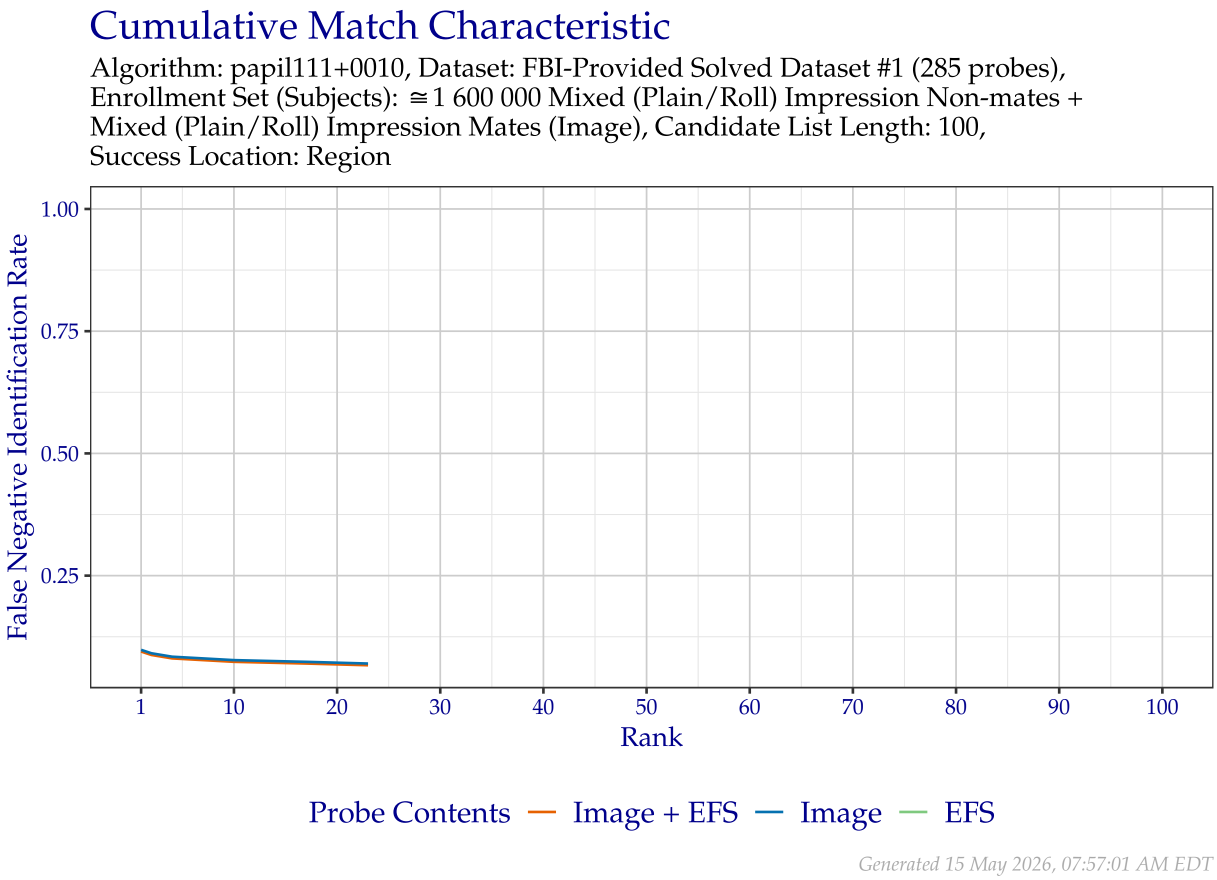


Figure 11: CMC of region location when searching only the FBI-Provided Solved Dataset #1 probes that contained EFS data.

6.2.2 FNIR at Select Rank

6.2.2.1 All Probes The values in Table 17 correspond to Figure 10.

Table 17: Region FNIR values from CMC plotted in Figure 10.

Probe Content	Rank 1	Rank ≤ 2	Rank ≤ 5	Rank ≤ 10	Rank ≤ 50	Rank ≤ 100
Image	0.1415	0.1279	0.1124	0.1047	0.1008	0.0969
Image + EFS	0.1415	0.1260	0.1105	0.1027	0.0988	0.0950

6.2.2.2 Probes with EFS Data The values in Table 18 correspond to Figure 11.

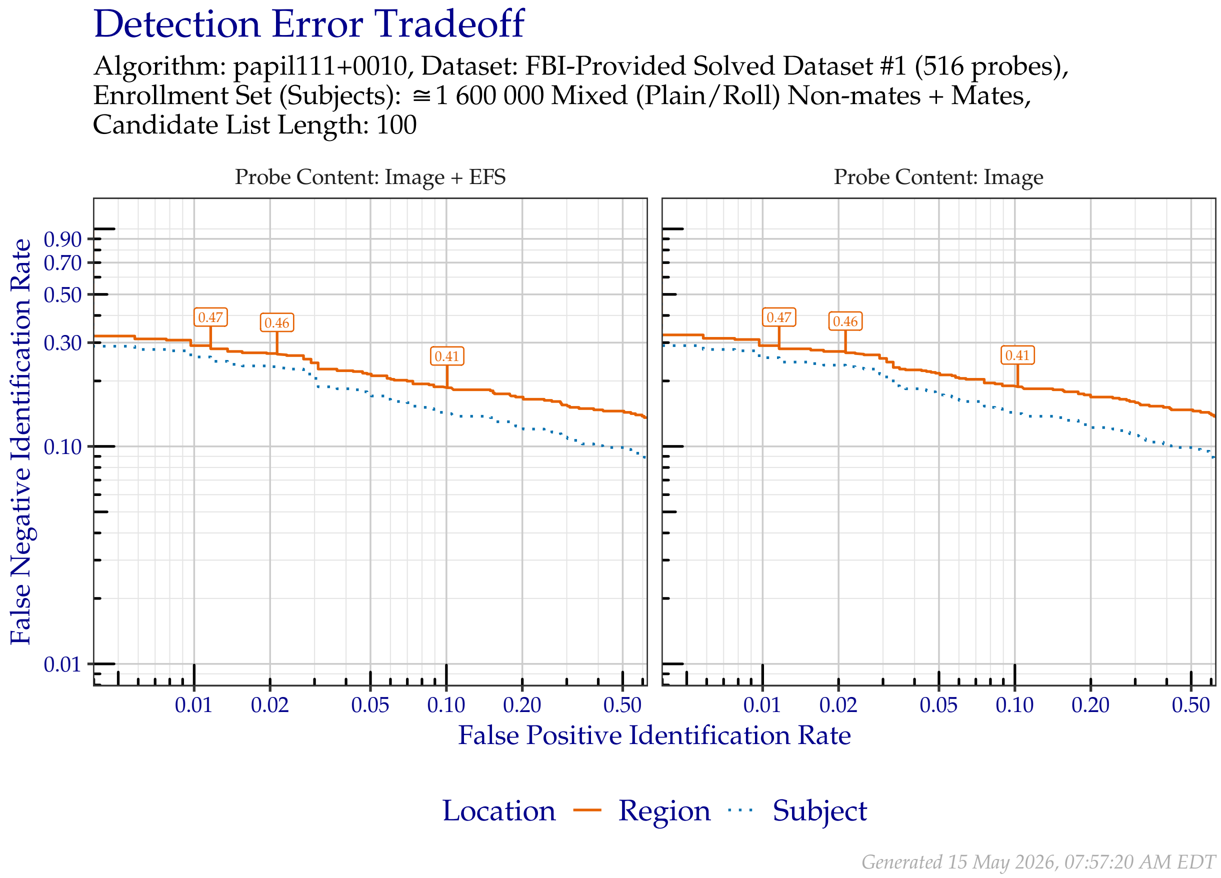
Table 18: Region FNIR values from CMC plotted in Figure 11.

Probe Content	Rank 1	Rank ≤ 2	Rank ≤ 5	Rank ≤ 10	Rank ≤ 50	Rank ≤ 100
EFS	NA	NA	NA	NA	NA	NA
Image	0.0982	0.0912	0.0842	0.0772	0.0702	0.0702
Image + EFS	0.0947	0.0877	0.0807	0.0737	0.0667	0.0667

6.3 DET

6.3.1 Plots

6.3.1.1 All Probes The DET plots in Figure 12 show the false positive and false negative identification rate tradeoffs of `papil111+0010` when searching FBI-Provided Solved Dataset #1 against enrollment database where a single mated identity for each search probe was present. The plots are faceted by the mated impression type and whether probe EFS data was provided. Tabular versions of FNIR at select FPIR can be viewed in Table 19. Annotated values indicate similarity scores from the Region line, which are tabulated in Table 21.



Detection Error Tradeoff

Algorithm: papil111+0010, Dataset: FBI-Provided Solved Dataset #1 (516 probes),
Enrollment Set (Subjects): ≅ 1 600 000 Mixed (Plain/Roll) Non-mates + Mates,
Candidate List Length: 100

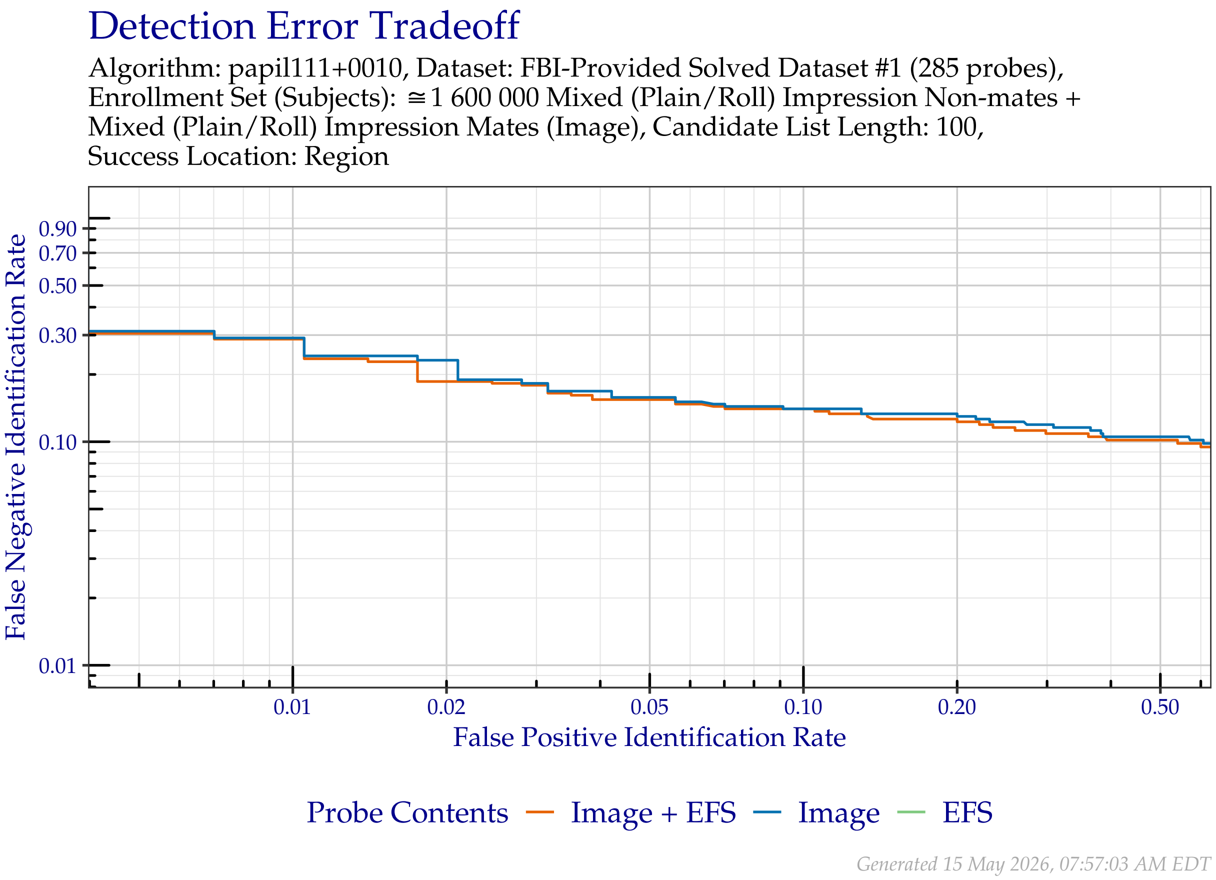
Probe Content: Image + EFS

Probe Content: Image

Generated 15 May 2026, 07:57:20 AM EDT

Figure 12: DET when searching FBI-Provided Solved Dataset #1 probes, faceted by the mated impression type and whether probe EFS data was provided. Annotated values indicate similarity scores from the Region line.

6.3.1.2 Probes with EFS Data Not all of the probes in the FBI-Provided Solved Dataset #1 dataset contain EFS data. The plot in Figure 13 shows the DET over *only* the probes that contained EFS data. This plot also differs from Figure 12 with the inclusion of a line for probes where no image was provided when creating the probe template, meaning the only information available was EFS data. Only the *region* success location is shown.



Detection Error Tradeoff

Algorithm: papil111+0010, Dataset: FBI-Provided Solved Dataset #1 (285 probes), Enrollment Set (Subjects): ≅1 600 000 Mixed (Plain/Roll) Impression Non-mates + Mixed (Plain/Roll) Impression Mates (Image), Candidate List Length: 100, Success Location: Region

Generated 15 May 2026, 07:57:03 AM EDT

Figure 13: DET of region location when searching only the FBI-Provided Solved Dataset #1 probes that contained EFS data.

6.3.2 FNIR at Select FPIR

6.3.2.1 All Probes The values in Table 19 correspond to Figure 12.

Table 19: Region FNIR values corresponding to FPIR plotted in Figure 12.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.281	0.2694	0.188
Image + EFS	0.281	0.2655	0.186

6.3.2.2 Probes with EFS Data The values in Table 20 correspond to Figure 13.

Table 20: Region FNIR values corresponding to FPIR plotted in Figure 13.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.2421	0.1895	0.1404
Image + EFS	0.2351	0.1860	0.1404

6.3.3 Similarity Score Thresholds at Select FPIR

The values in Table 21 correspond to similarity score thresholds observed at the select FPIR values from Table 19.

Table 21: Similarity score thresholds corresponding to select FPIR values from Table 19.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.47	0.46	0.41
Image + EFS	0.47	0.46	0.41

7 DoD-Provided Dataset #1

The results of Section 7 are based on searches of the sequestered dataset *DoD-Provided Dataset #1*. This dataset consists of 5 257 probes collected operationally by the United States Department of Defense. All probes searched were a single sample depicting a region from a distal phalanx. No EFS data was provided. Only Subject-level ground truth information was provided.

7.1 Failures

Table 22 shows the number of failures to create templates. Table 23 shows the number of failures to produce a candidate list.

Table 22: Number of failures to create templates.

Image Type	Content	Failures	Attempts
Exemplar	Image	0	5 289
Probe	Image	0	5 257

Table 23: Number of failures to produce a candidate list. This number includes any failures to create a probe template from Table 22.

Probe Content	Failures	Attempts
Image	0	5 257

7.2 CMC

7.2.1 Plots

The CMC plots in Figure 14 show the FNIR of `papil111+0010` when searching DoD-Provided Dataset #1 against enrollment database where a single mated identity for each search probe was present. Tabular versions of FNIR at select ranks can be viewed in Table 24.

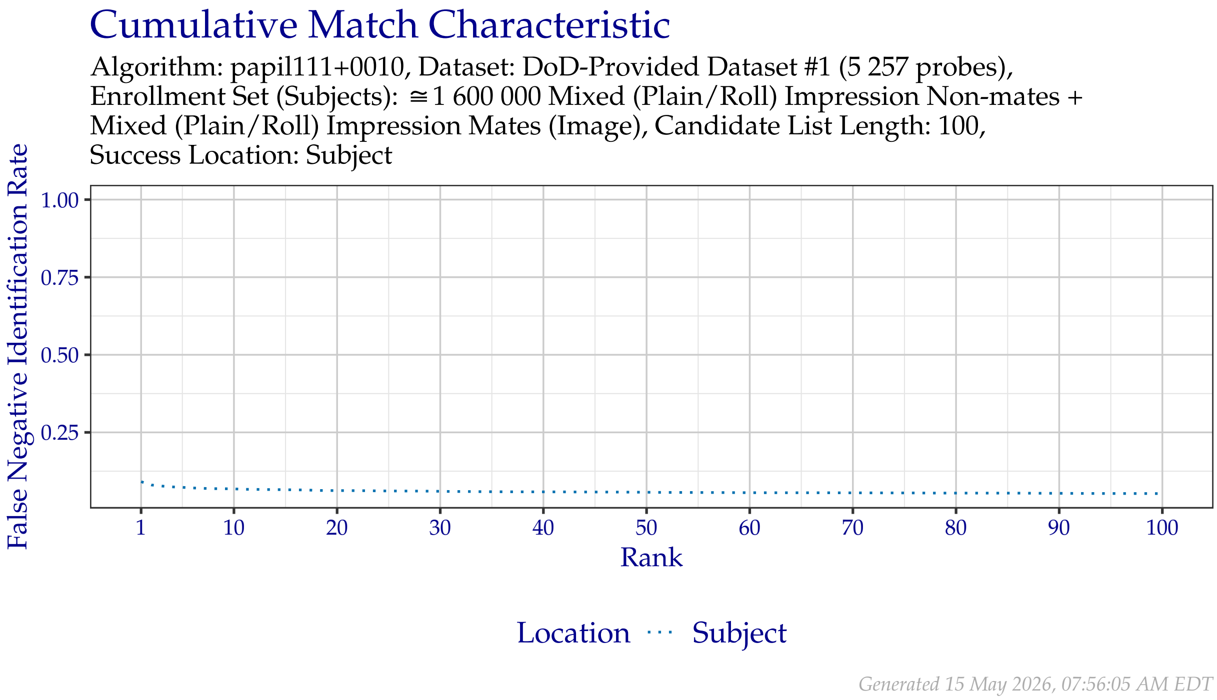


Figure 14: CMC when searching DoD-Provided Dataset #1 probes.

7.2.2 FNIR at Select Rank

The values in Table 24 correspond to Figure 14.

Table 24: Region FNIR values from CMC plotted in Figure 14.

Probe Content	Rank 1	Rank ≤ 2	Rank ≤ 5	Rank ≤ 10	Rank ≤ 50	Rank ≤ 100
Image	0.0911	0.0805	0.0729	0.0679	0.0571	0.0527

7.3 DET

7.3.1 Plots

The DET plots in Figure 15 show the false positive and false negative identification rate tradeoffs of `papil111+0010` when searching DoD-Provided Dataset #1 against enrollment database where a single mated identity for each search probe was present. Tabular versions of FNIR at select FPIR can be viewed in Table 25. Annotated values indicate similarity scores from the Subject line, which are tabulated in Table 26.

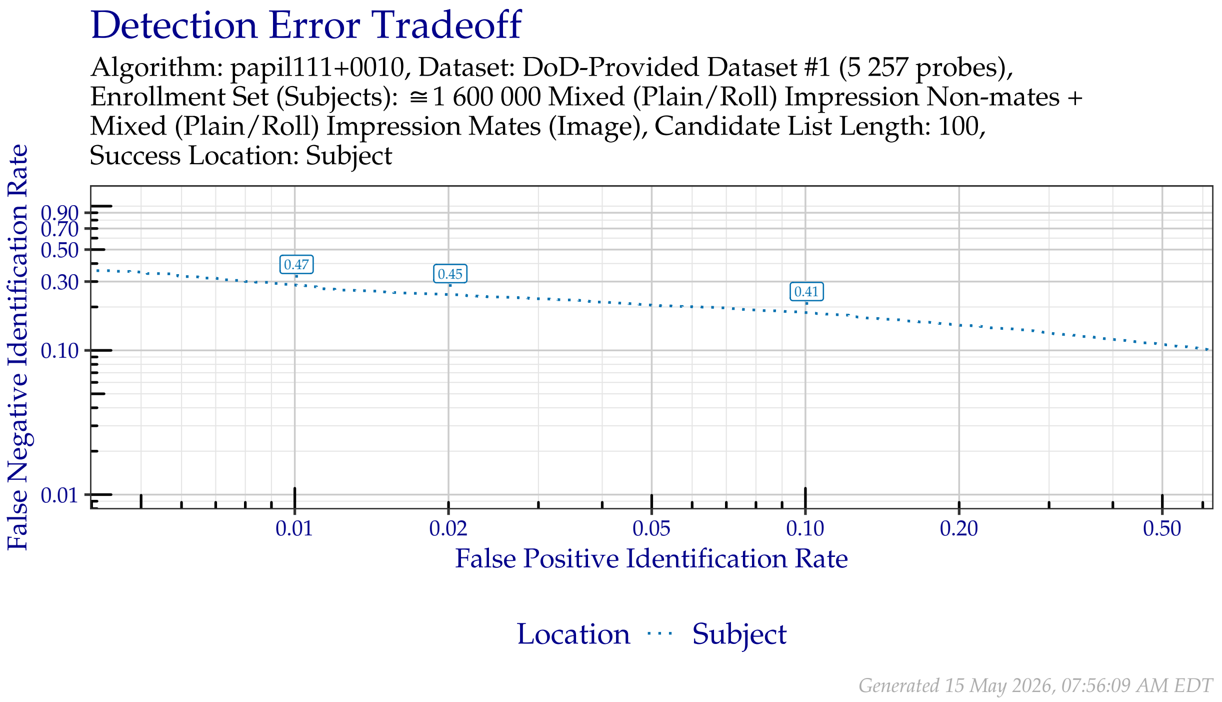


Figure 15: DET when searching DoD-Provided Dataset #1 probes. Annotated values indicate similarity scores from the Subject line.

7.3.2 FNIR at Select FPIR

The values in Table 25 correspond to Figure 15.

Table 25: Subject FNIR values corresponding to FPIR plotted in Figure 15.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.2819	0.2435	0.1828

7.3.3 Similarity Score Thresholds at Select FPIR

The values in Table 26 correspond to similarity score thresholds observed at the select FPIR values from Table 25.

Table 26: Similarity score thresholds corresponding to select FPIR values from Table 25.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.47	0.45	0.41

8 IARPA N2N (Sequestered)

The results in Section 8 are based on searches of the dataset *IARPA N2N (Sequestered)*. Images in this dataset were collected during the IARPA Nail to Nail (N2N) Fingerprint Capture Challenge. The subjects whose fingerprints are the source of this data are **not** present in NIST Special Database 302.[2]

All probes searched were a single sample primarily depicting a single region from a distal phalanx. As is common, some probes may contain overlapping impressions or multiple touches. Only subject-level ground truth information is provided. All images in this dataset were analyzed by International Association for Identification (IAI) Certified Latent Print Examiners (CLPE) under guidance from NIST.

8.1 Suitable for Automated Searching

This section includes results from searches of fingermark images whose content was determined to be suitable for Automated Biometric Identification System (ABIS) searches by a CLPE[3]. For each image, three CLPE followed guidance from ANSI/ASB BPR 165 [1] to determine this level of utility. Images were downsampled to 1000 pixels per inch and quantized to a single grayscale color channel of 8 bits.

CLPE annotated all EFS data manually. CLPE were **not** provided with a mated exemplar source during probe annotation. When EFS data was provided to algorithms under test for this dataset, it could contain:

- Always:
    - Region of interest
    - Ridge quality map
- When ascertainable:
    - Complexity
    - Core locations
    - Delta locations
    - Examiner analysis assessment
    - Minutiae locations
    - Orientation
    - Pattern classification

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[2] Organizations who participated in the IARPA N2N Fingerprint Capture Challenge *may* have collected and retained exemplar fingerprints from these subjects with their own capture devices, but they have **not** received the images used in this test.

[3] This designation is often referred to as "of value for ABIS" [1].

8.1.1 Failures

Table 27 shows the number of failures to create templates. Table 28 shows the number of failures to produce a candidate list.

Table 27: Number of failures to create templates.

Image Type	Content	Failures	Attempts
Exemplar	Image	0	346
Probe	Image	0	2 272

Table 28: Number of failures to produce a candidate list. This number includes any failures to create a probe template from Table 27.

Probe Content	Failures	Attempts
Image	0	2 272

8.1.2 CMC

8.1.2.1 Plots The CMC plots in Figure 16 show the FNIR of `papil111+0010` when searching *IARPA N2N (Sequestered)* against enrollment database where a single mated identity for each search probe was present. Tabular versions of FNIR at select ranks can be viewed in Table 29.

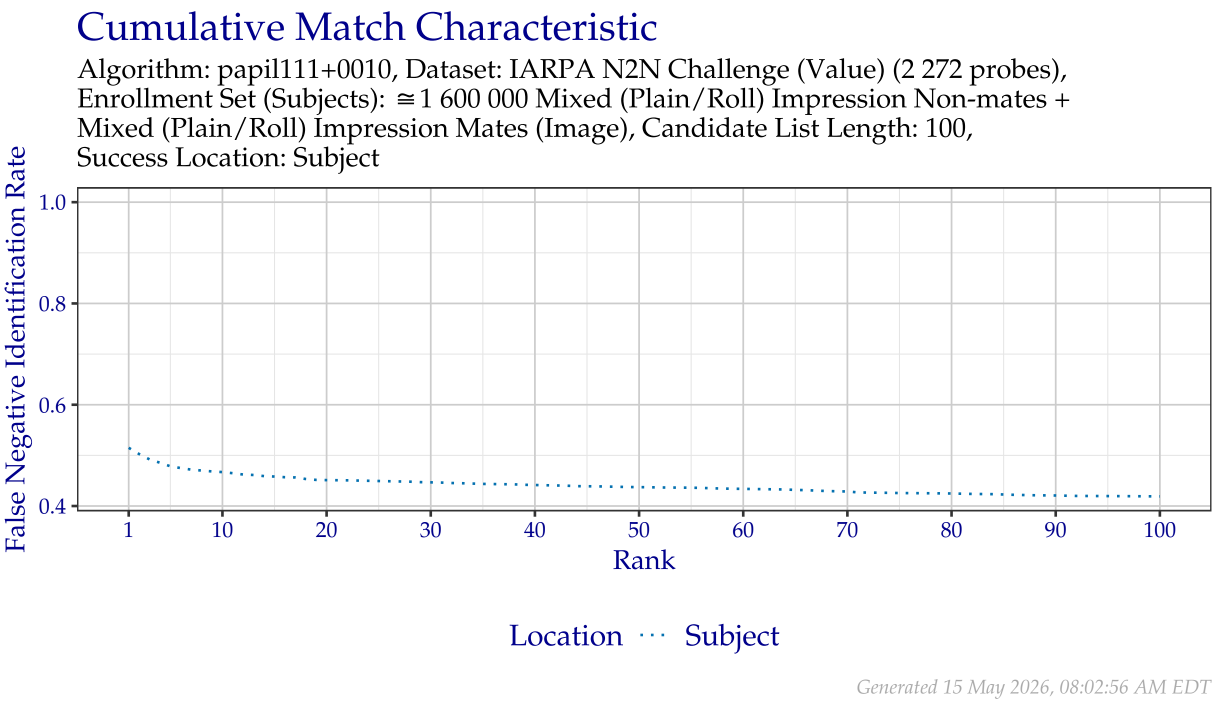

Figure 16: CMC when searching IARPA N2N (Sequestered) probes.

8.1.2.2 FNIR at Select Rank The values in Table 29 correspond to Figure 16.

Table 29: Region FNIR values from CMC plotted in Figure 16.

Probe Content	Rank 1	Rank ≤ 2	Rank ≤ 5	Rank ≤ 10	Rank ≤ 50	Rank ≤ 100
Image	0.515	0.5026	0.4784	0.467	0.4375	0.419

8.1.3 DET

8.1.3.1 Plots The DET plots in Figure 17 show the false positive and false negative identification rate tradeoffs of `papil111+0010` when searching *IARPA N2N (Sequestered)* against enrollment database where a single mated identity for each search probe was present. Tabular versions of FNIR at select FPIR can be viewed in Table 30. Annotated values indicate similarity scores from the Subject line, which are tabulated in Table 31.

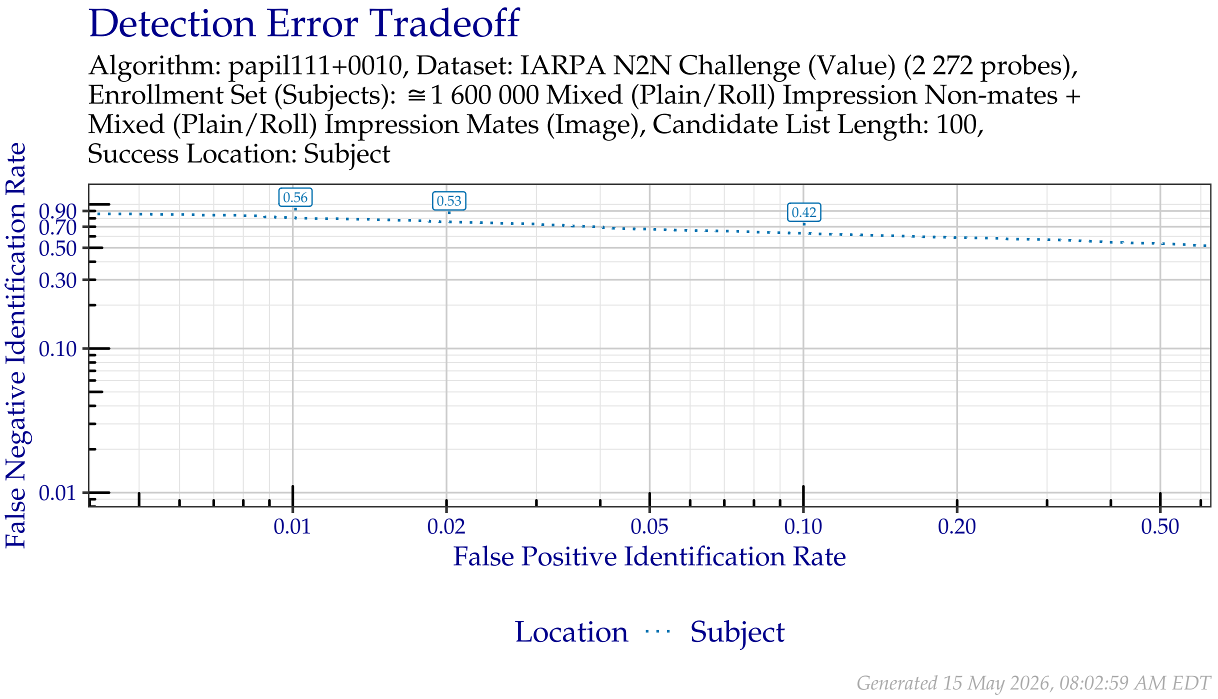

Figure 17: DET when searching IARPA N2N (Sequestered) probes. Annotated values indicate similarity scores from the Subject line.

8.1.3.2 FNIR at Select FPIR The values in Table 30 correspond to Figure 17.

Table 30: Subject FNIR values corresponding to FPIR plotted in Figure 17.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.8015	0.7557	0.6303

8.1.3.3 Similarity Score Thresholds at Select FPIR The values in Table 31 correspond to similarity score thresholds observed at the select FPIR values from Table 30.

Table 31: Similarity score thresholds corresponding to select FPIR values from Table 30.

Probe Content	FPIR = 0.01	FPIR = 0.02	FPIR = 0.1
Image	0.56	0.53	0.42

References

[1] "ANSI/ASB best practice recommendation 165: Best practice recommendation for analysis of friction ridge impressions," Academy Standards Board, 2024. Available: https://www.aafs.org/asb-standard/best-practice-recommendation-analysis-friction-ridge-impressions