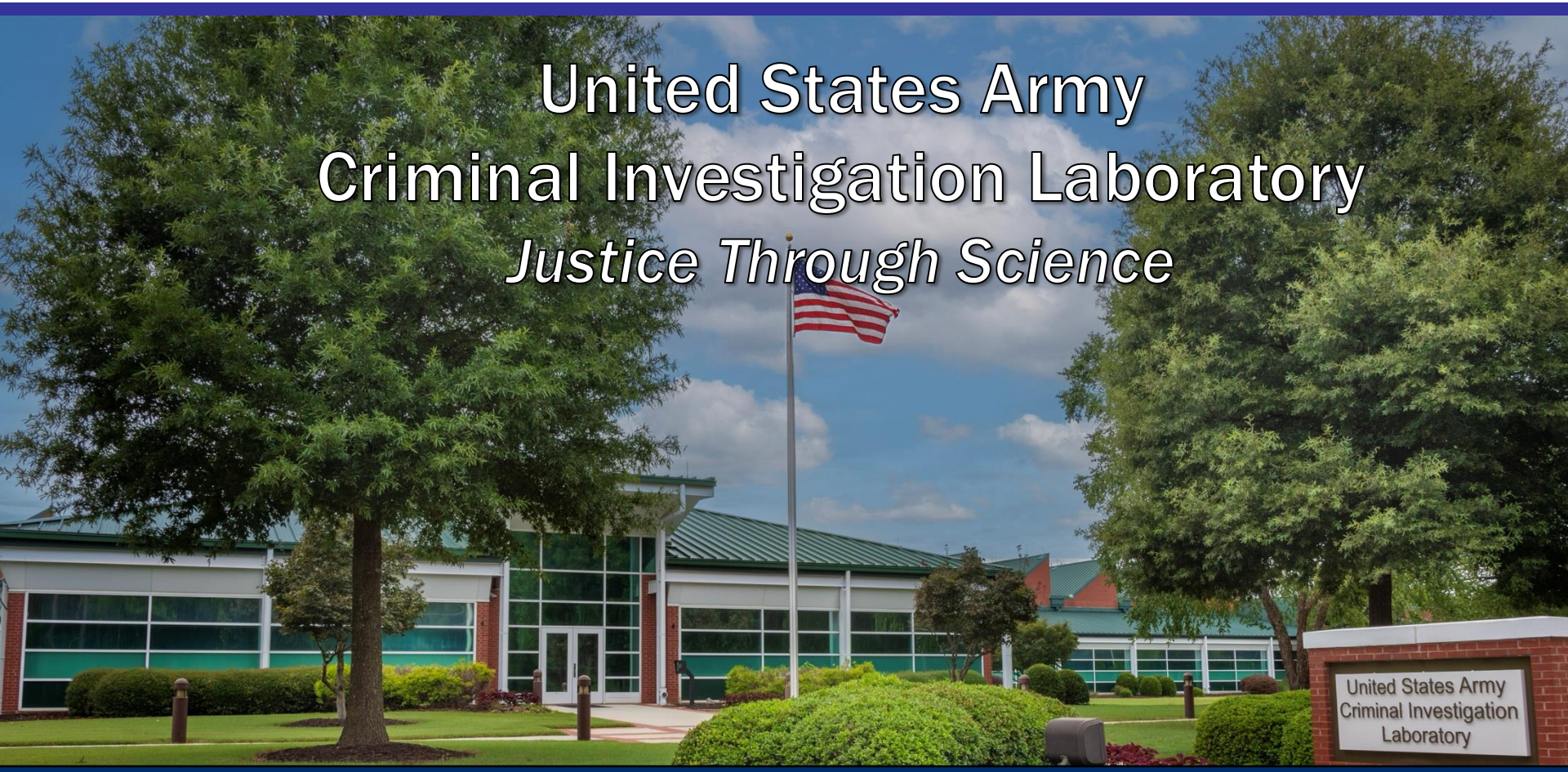

United States Army Criminal Investigation Laboratory

Justice Through Science

FRStat: Implementation and utilization of a statistical model for expressing latent print evidence in an American criminal justice system

Latent Print Branch
Tony Koertner, CLPE
1-3 April 2025

POC: Sarah Parsons, 404-469-4875

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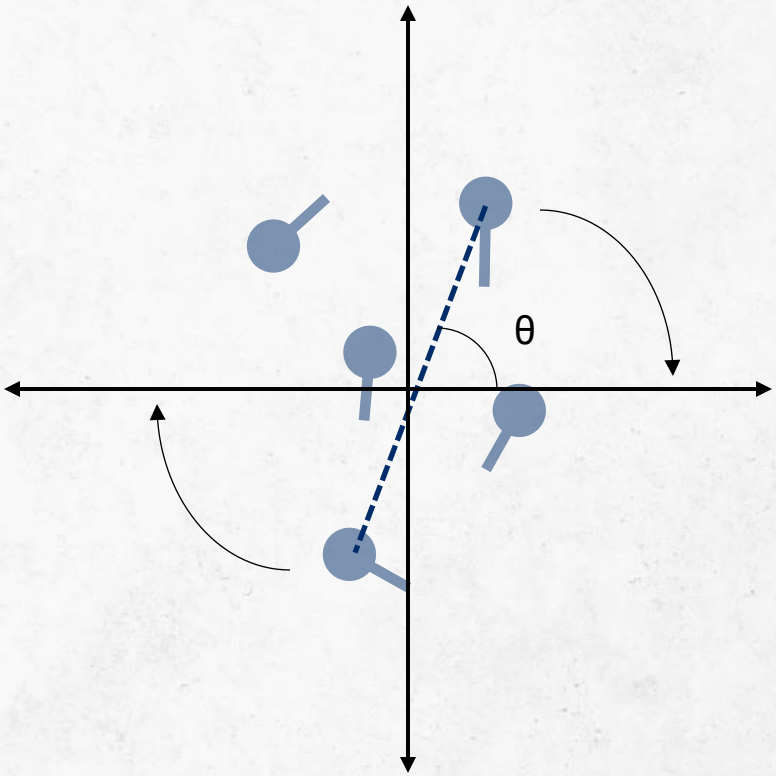
How Does it Work?

Latent Print

Record Print

How Does it Work?



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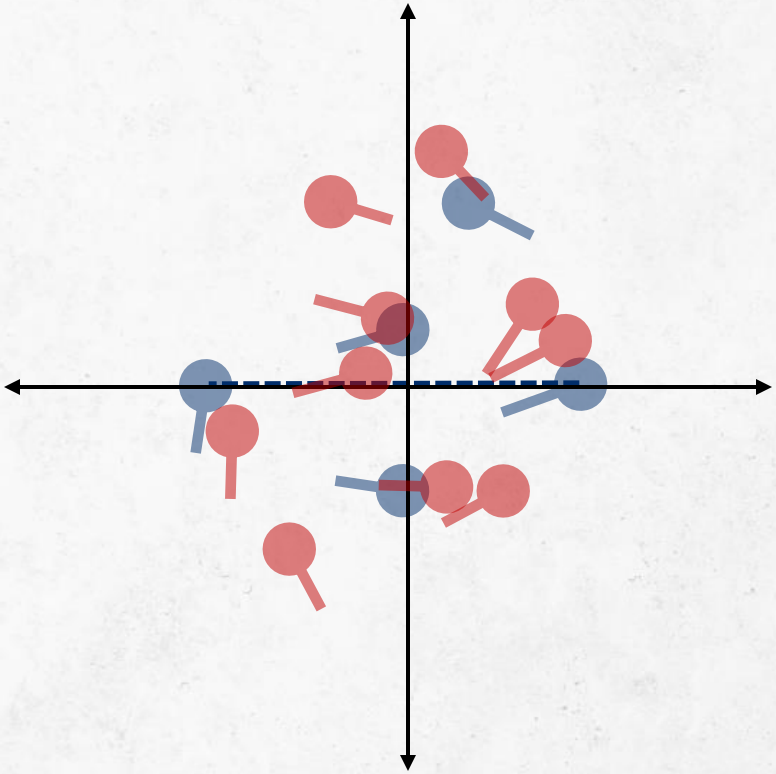

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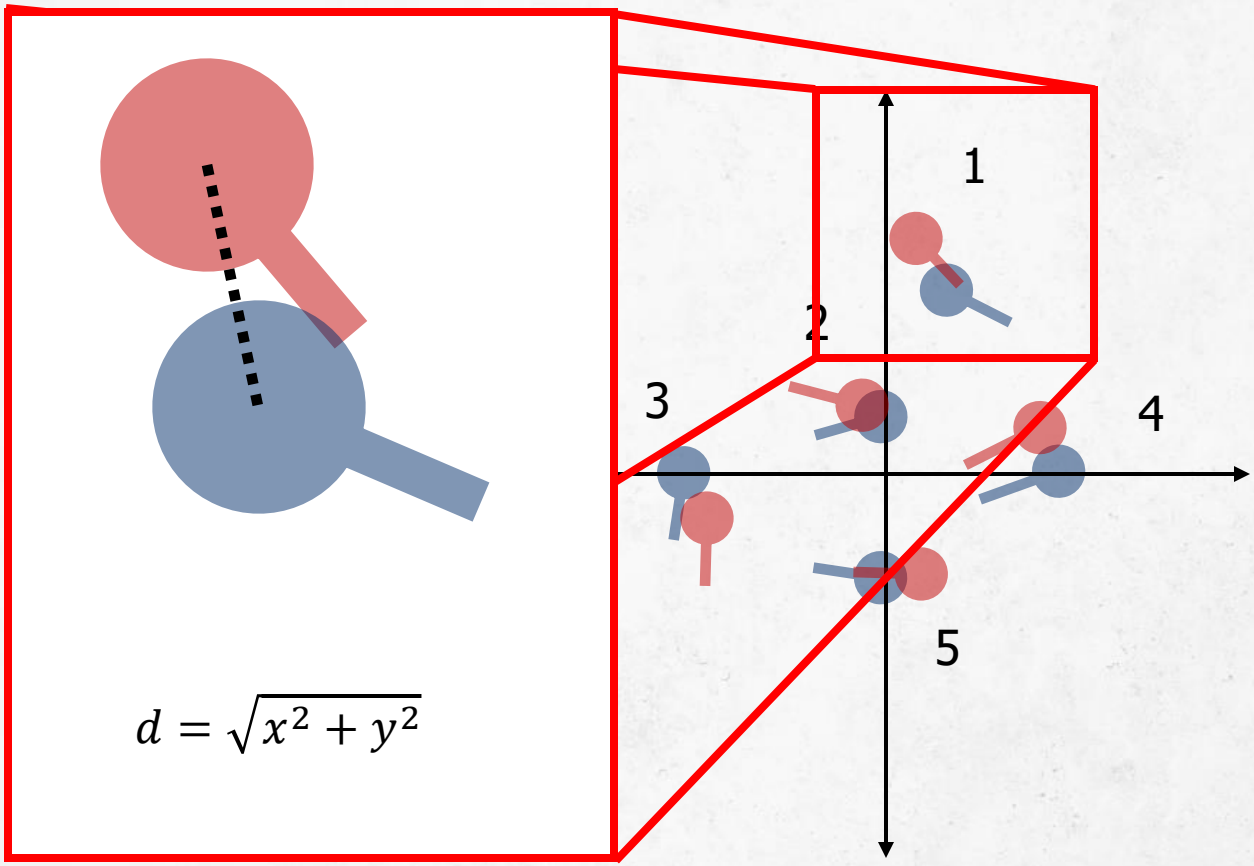

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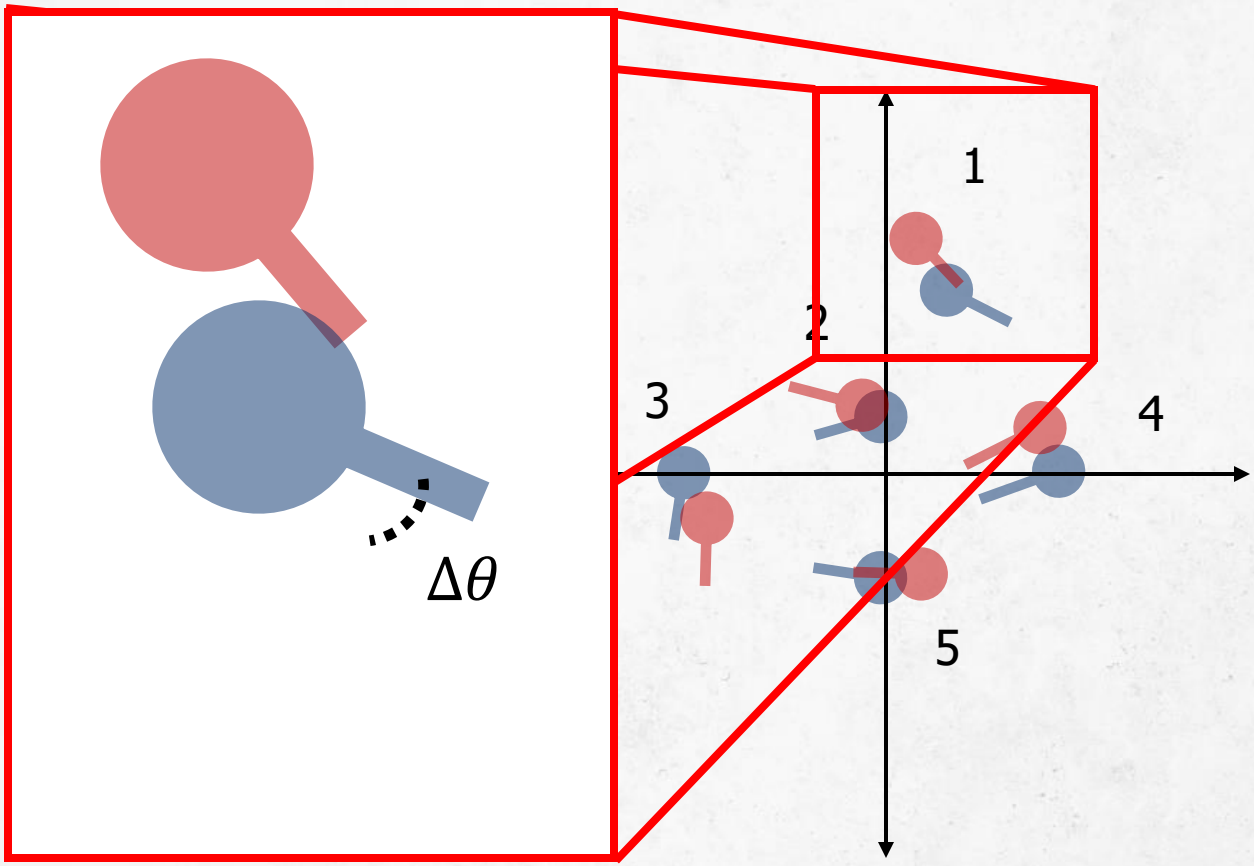
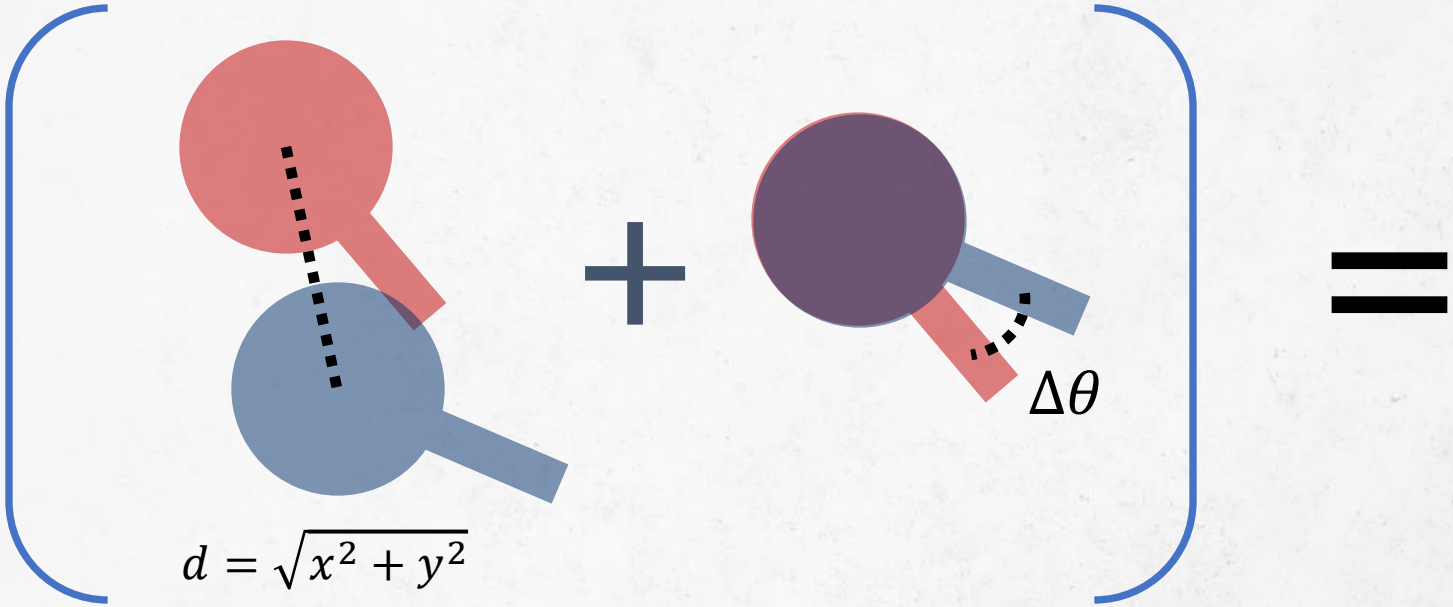


How Does it Work?

For Each Minutiae Pairing



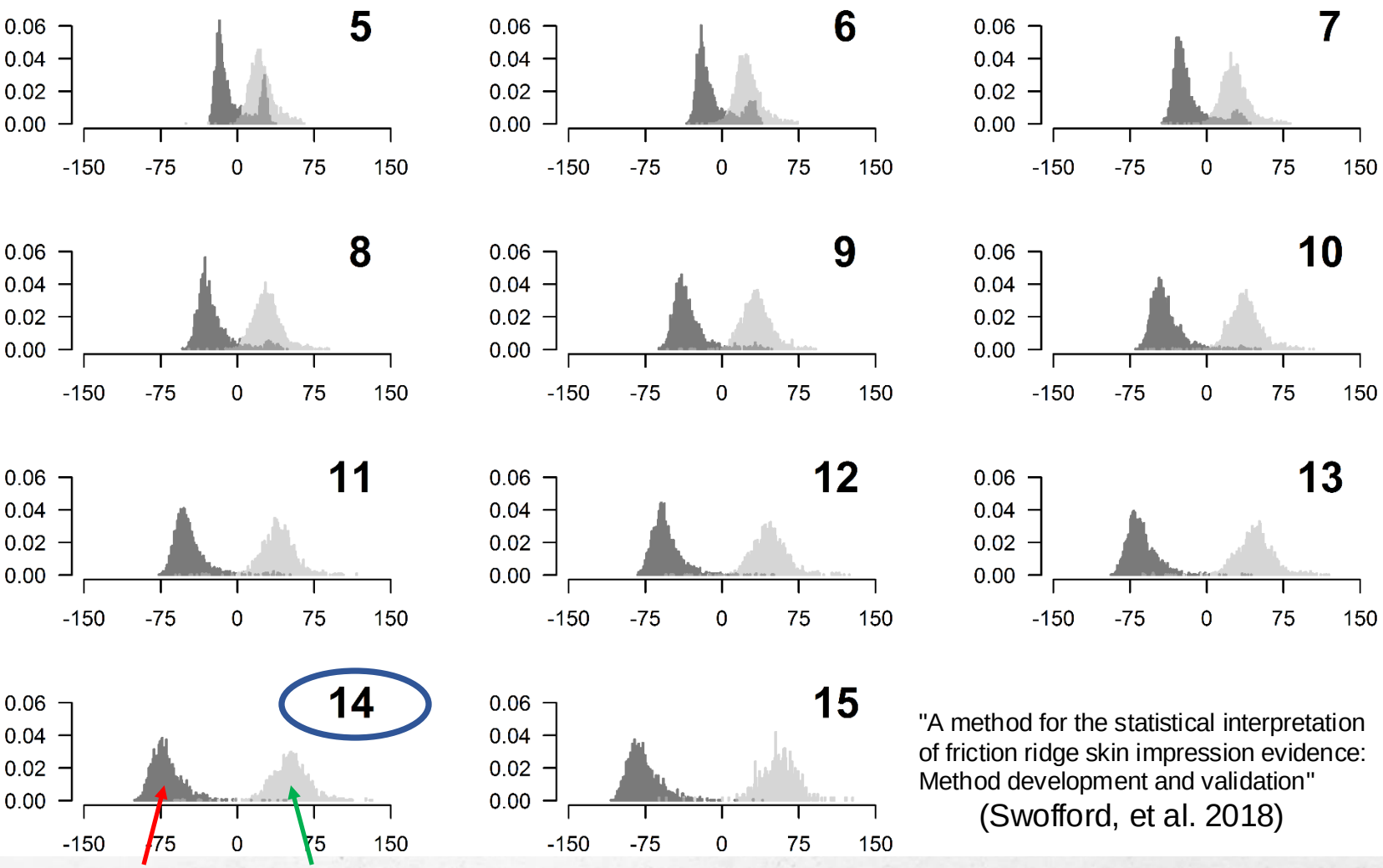
Global Similarity Statistic (i.e. “similarity score”)

FRStat Building Empirical Distributions

Same Source Scores from ~2000 Mated Pairs*	Number of Features	Different Source Scores from ~2000 Non-Mated Pairs*
2,000	5	2,000
2,000	6	2,000
2,000	7	2,000
2,000	8	2,000
2,000	9	2,000
2,000	10	2,000
2,000	11	2,000
2,000	12	2,000
2,000	13	2,000
2,000	14	2,000
2,000	15	2,000

*Note: approximate number of mated and non-mated pairs.

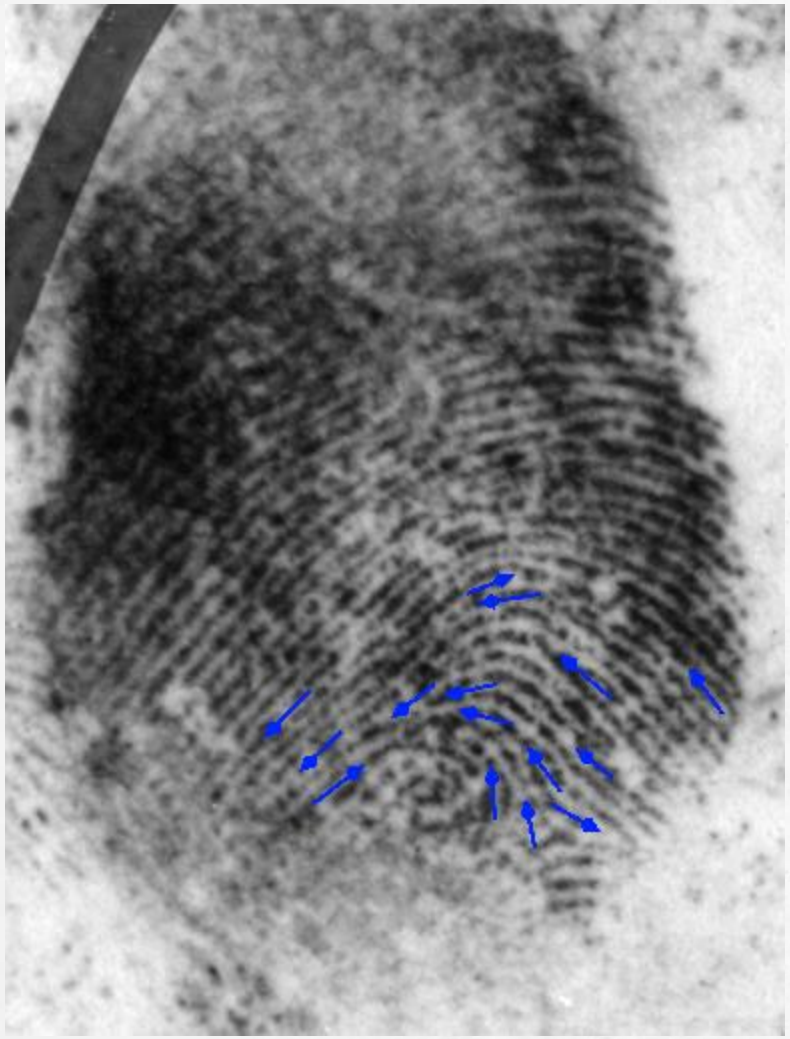
How Does it Work?



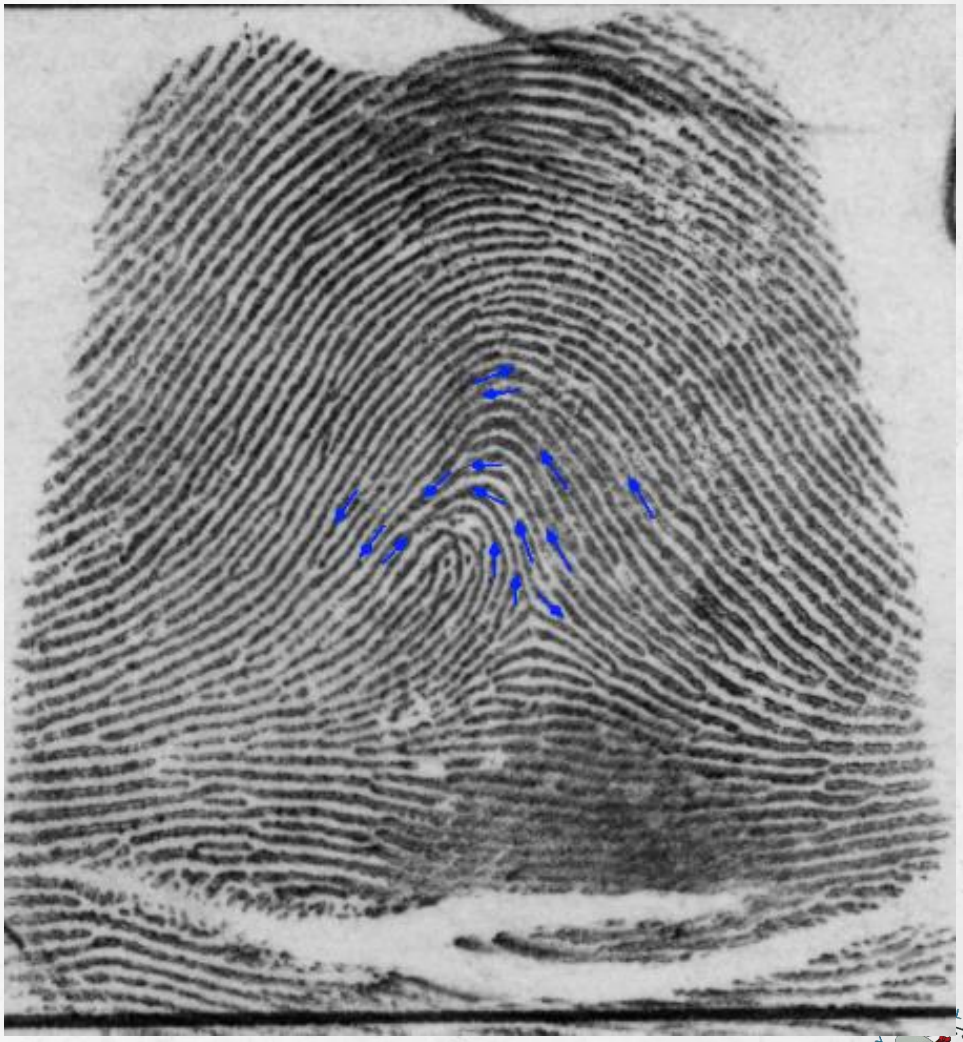
"A method for the statistical interpretation of friction ridge skin impression evidence: Method development and validation"
(Swofford, et al. 2018)

FRStat Interpretation and Reporting

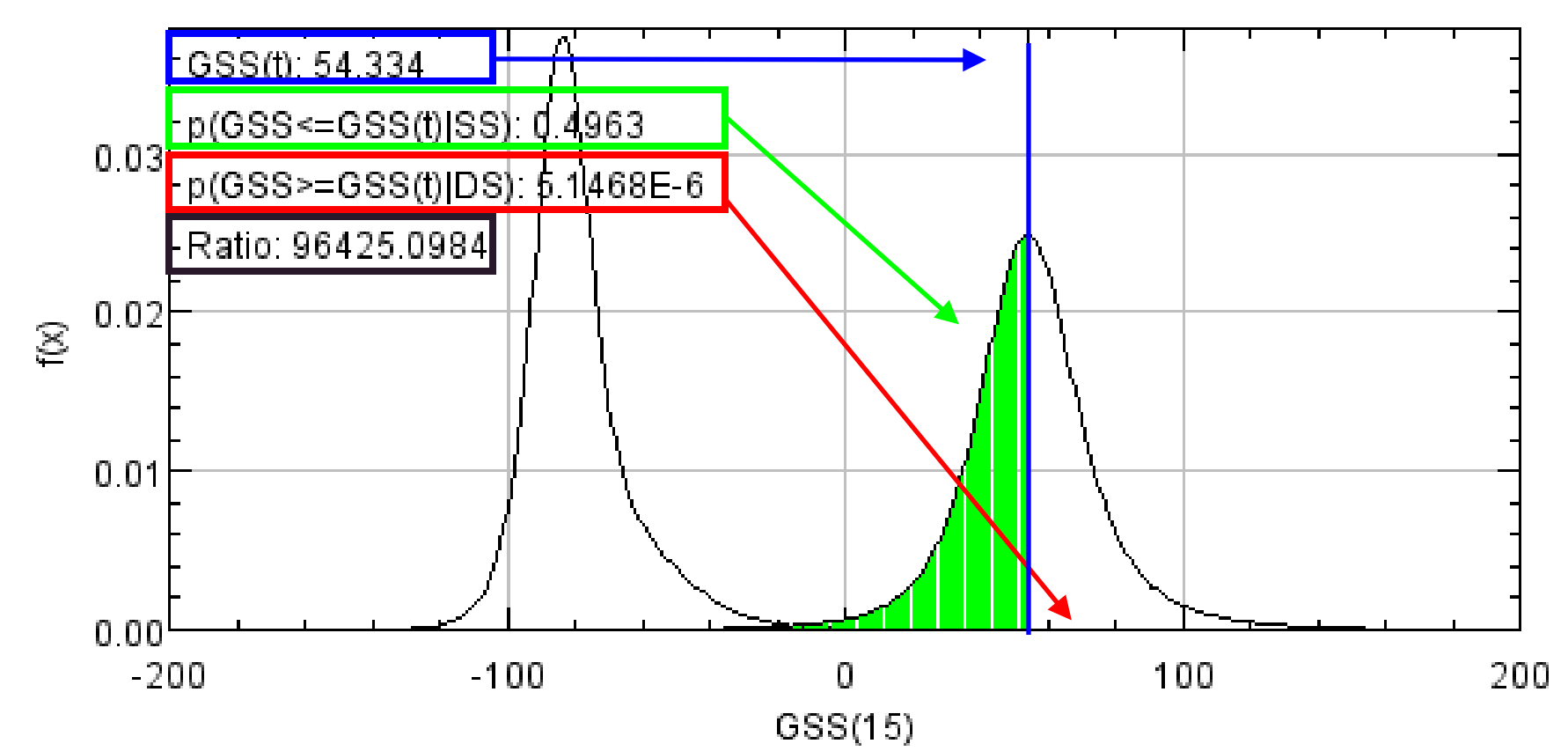
Latent Print



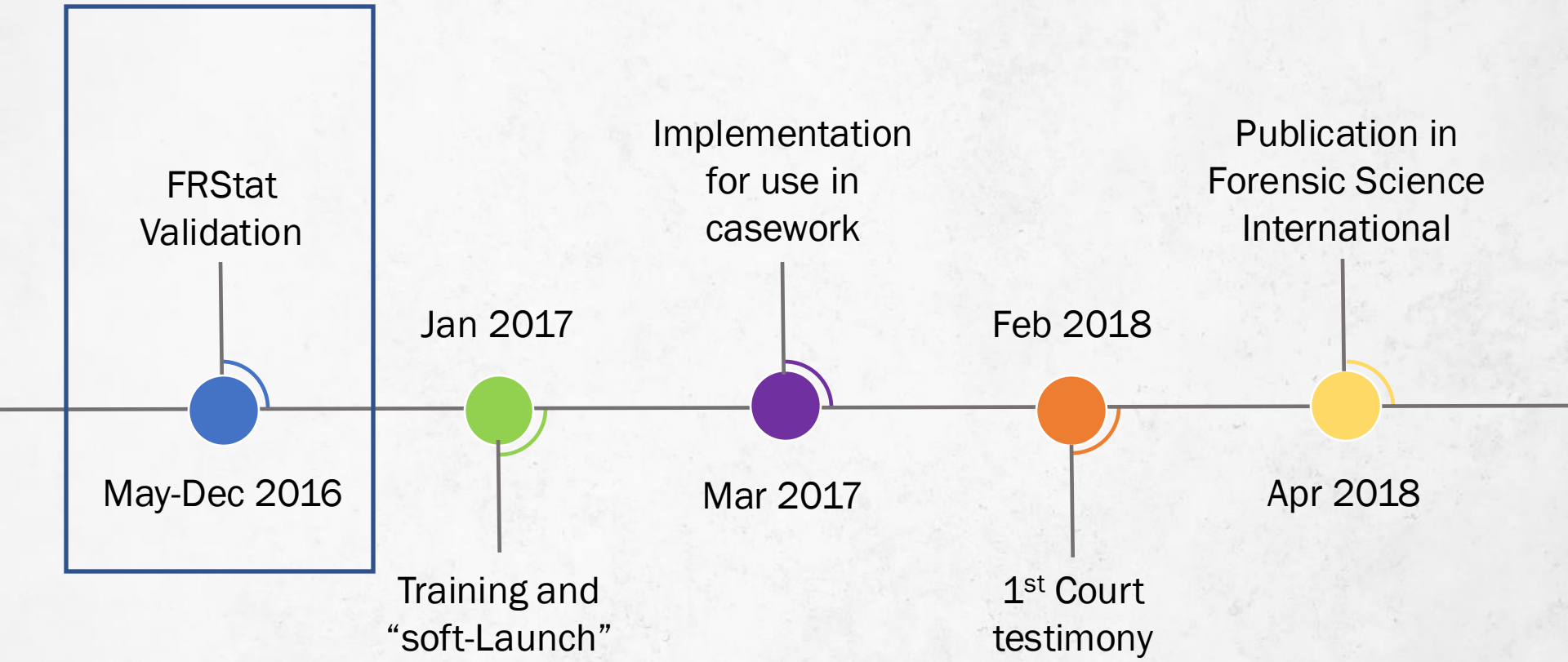
Record Print



FRStat Interpretation and Reporting



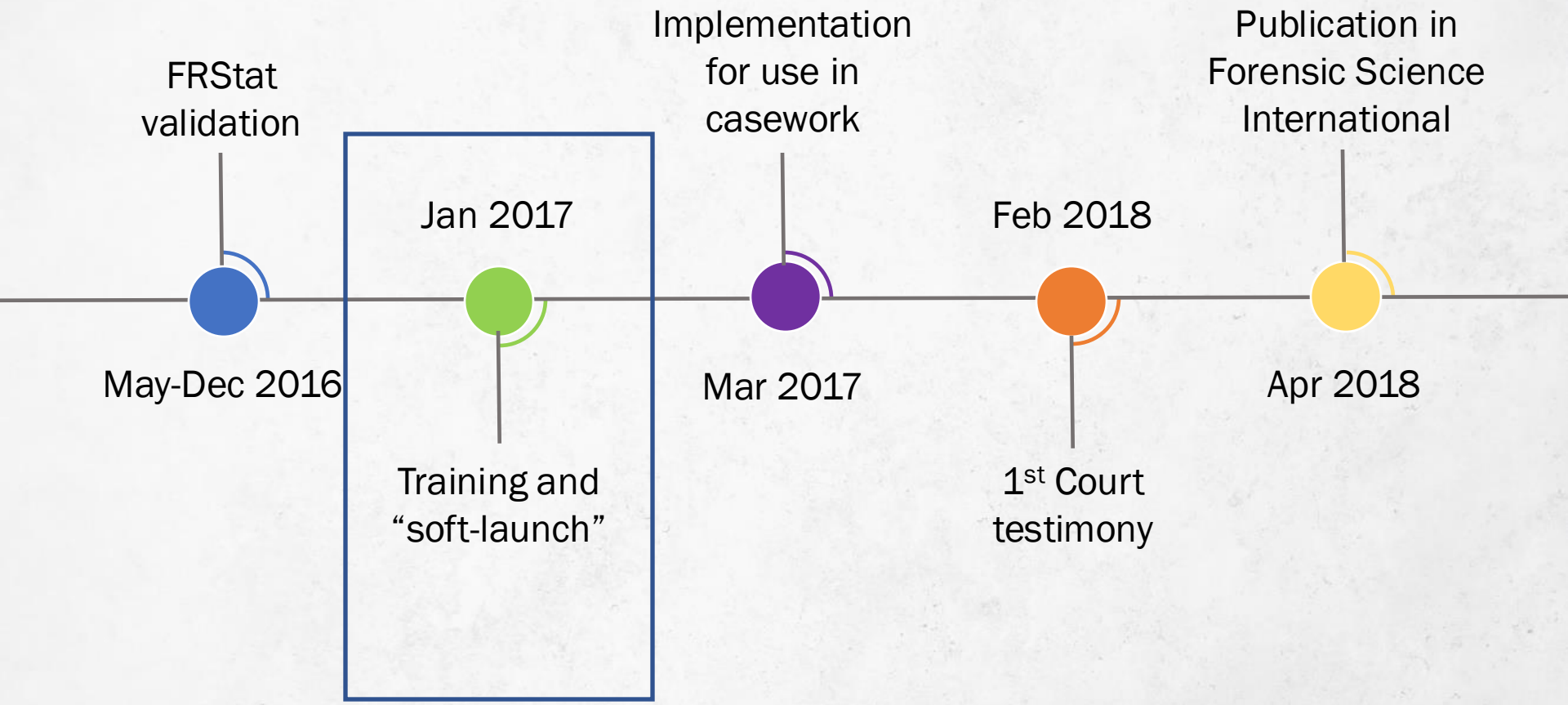
FRStat Implementation Timeline



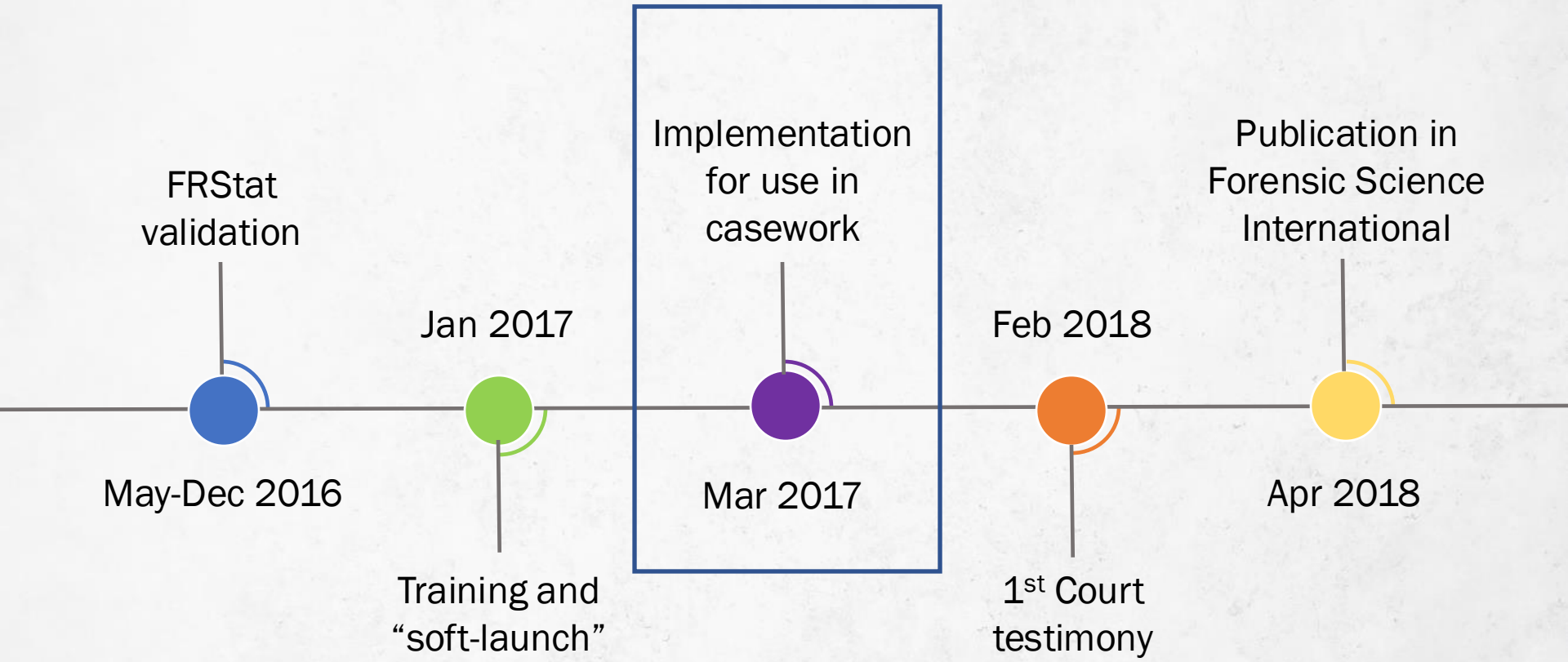
FRStat Validation (summary)

- Similarity calculations – distortion modeling:
  - Based on published data (Fagert & Morris, 2015)
- Probability distributions:
  - Modeled from empirically observed datasets
  - Tested for “goodness of fit” using Kolmogorov-Smirnov tests
  - Conservative tail estimations
- User variability:
  - Accounted for using iterative random sampling scheme based on empirically observed datasets
- Performance metrics:
  - Determined accuracy using variety of datasets
  - Often results in specificity rates greater than 99%
  - Robust to variety of casework conditions

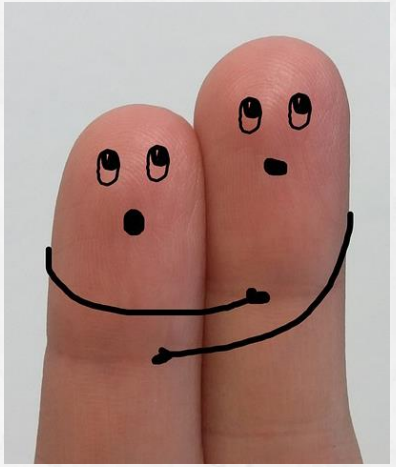
Implementation Timeline



FRStat Implementation Timeline



FRStat Examiner's Concerns



- Initial concerns from the USACIL LPE's
  - FRStat scores as LPEs expect them to be
    - "How is this a ratio of only '10' when it's a 15-point association?"
  - Existential crisis
    - "The managers value the FRStat score over my opinion"
  - Educational requirement for using FRStat
    - "Do I have be a statistician to testify to FRStat results?"
  - The lingering inappropriate comfort of posterior propositional reporting
    - "This score implies that there is a chance that I could be wrong! The agents in the field depend on us to tell them whether it's him or not! We cannot be uncertain!"
  - Jury interpretation
    - "Our results are going to be misinterpreted and we may not get an opportunity to fully explain!"

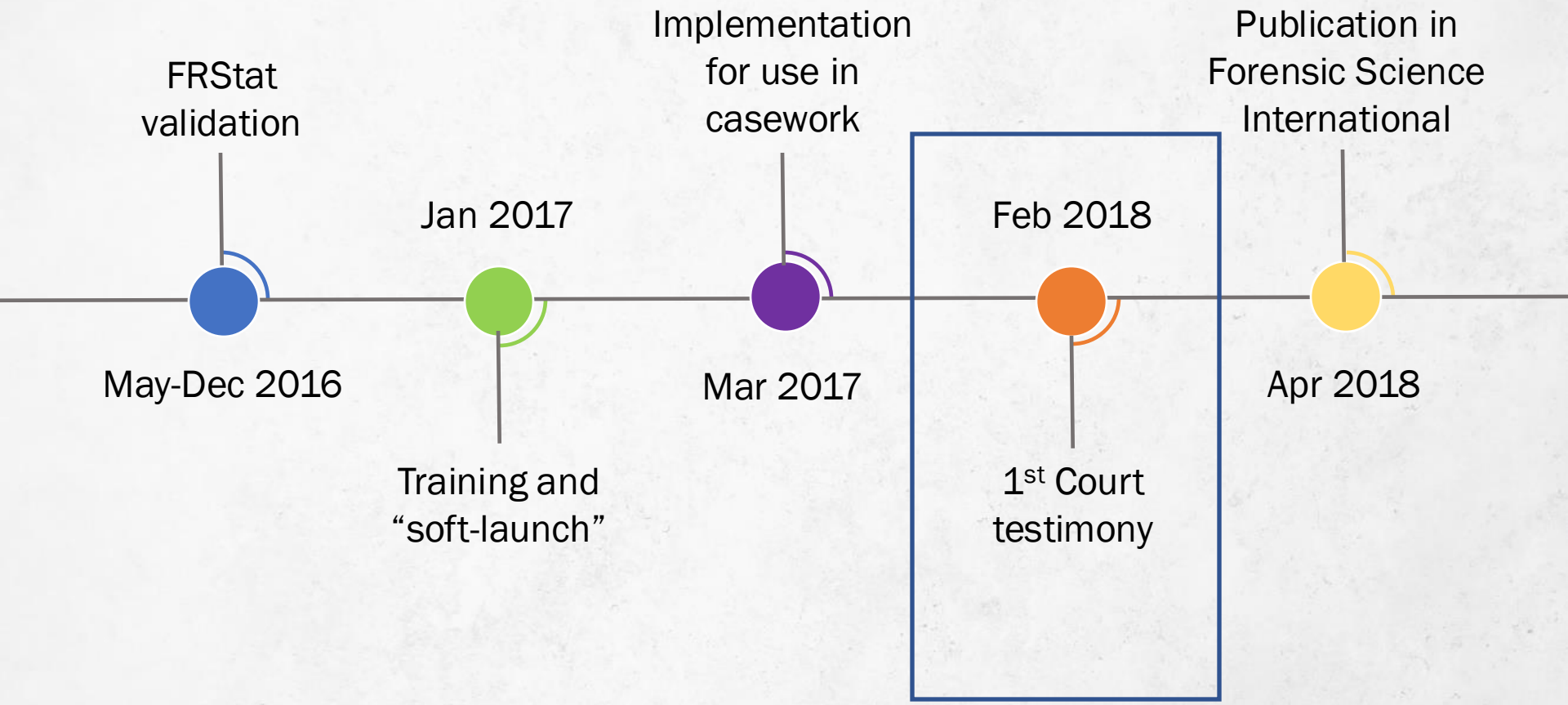
FRStat Examiner's Concerns

- The conversion of USACIL LPEs to disciples
  - Education
    - Understand the reasons we are making the change (NAS, PCAST, NIST human factors…)
    - Statistical courses offered
    - Moot court training
    - Appreciate the byline we wrote for ourselves in the long history of latent print examination history
  - Empowerment
    - Management and the laboratory have your back
    - Robust policies for utilization
  - Opportunity
    - Travel opportunities to teach the good word
    - Career advancement through committee or other special interest group engagements

Examiner's Acceptance

- FRStat Apologetics
  - Overtime, most USACIL LPEs became apologetics for the cause.
  - They discussed and defended the ~~faith~~ FRStat against those who don't understand or agree with it.

FRStat Implementation Timeline



FRStat General Acceptance

- Admissibility in court
  - FRStat was deemed relevant and reliable for evaluating latent print evidence in four U.S Court Martials (military court – Feb 2018)
  - USACIL testimony emphasizes the fact that a full traditional subjective assessment was conducted and that FRStat is a more objective tool used after an opinion of association has been reached.
    - "Icing on the cake"
  - As of February 2025, 8 FRStat testimonies.

FRStat Implementation Timeline

FRStat validation

May-Dec 2016

Jan 2017

Training and "soft-launch"

Implementation for use in casework

Mar 2017

Feb 2018

1st Court testimony

Publication in Forensic Science International

Apr 2018


Forensic Science International

A method for the statistical interpretation of friction ridge skin impression evidence: Method development and validation

H.J. Swofford, A.J. Koertner, F. Zemp, M. Ausdemore, A. Liu, M.J. Salyards

FRStat General Acceptance

- Transition to other forensic science service providers (FSSP)
  - Over 40 FRStat presentations given – by myself
  - Over 80 FSSP were sent the FRStat application via a non-disclosure agreement (NDA)
    - At this time FRStat was not open-source technology
  - Over 1000 open-source downloads
  - FRStat working groups set up to assist in installation, education and potential validation
  - Education provided
    - Intro to statistics
    - Review of FRStat validation
    - How to utilize FRStat – practicals

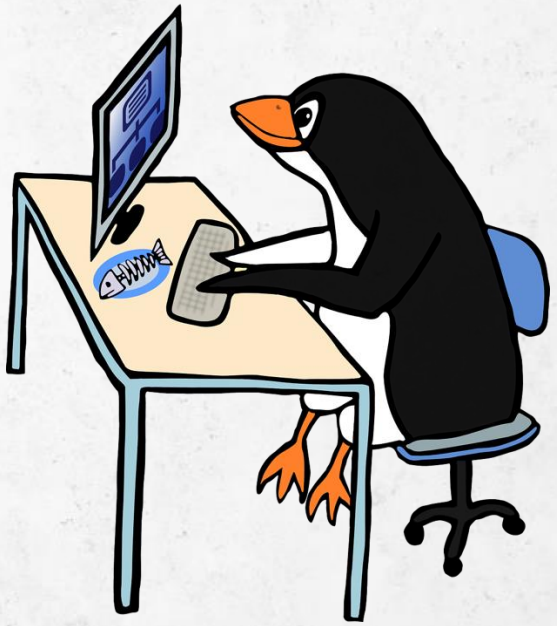
How much FRStat/statistics knowledge is necessary to utilize this application?

FRStat General Acceptance

For example:

...how much do you need to know about AFIS...

...to use AFIS?



FRStat General Acceptance

- Transition to other FSSP
  - How many FSSP are/or have ever used FRStat in casework? …Zero
  - Main concerns from FSSP LPEs:
    - The scores may understate the strength of the evidence
    - Does not provide the same result every time
    - It's still not entirely objective
    - Placement in work-flow
    - It takes too much time
    - Scared to testify to statistics
    - No one else is using it (only apostles)
    - Hesitation to CHANGE
    - Lack of official **technical support**

Is it the Army's mission to provide all the assistance necessary to keep FRStat functional outside USACIL?

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FRStat Criticisms

Law, Probability and Risk (2020) **19**, 1–20
Advance Access publication on April 28, 2020

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Defence against the modern arts: the curse of statistics: Part I—FRStat

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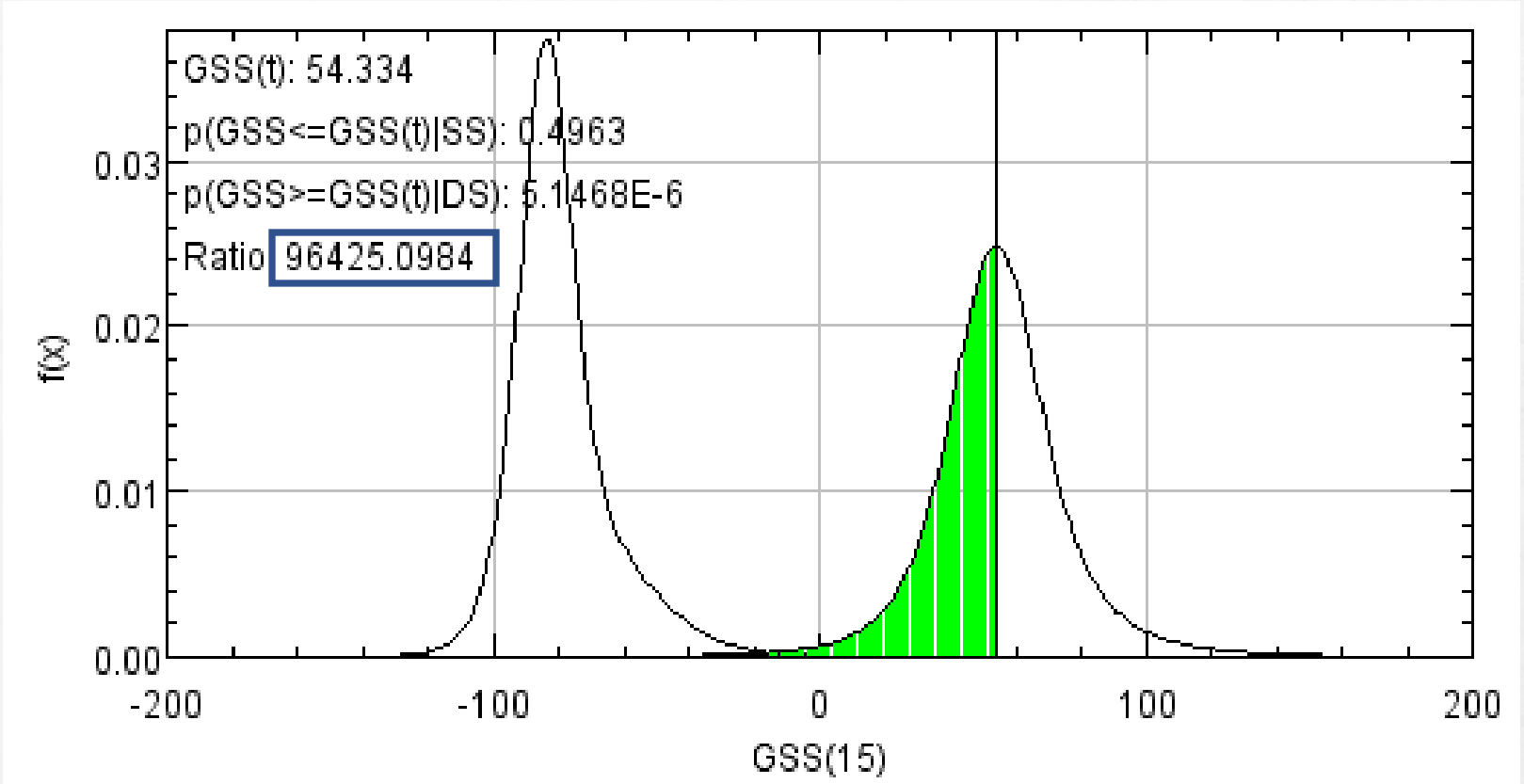
For several decades, legal and scientific scholars have argued that conclusions from forensic examinations should be supported by statistical data and reported within a probabilistic framework. Multiple models have been proposed to quantify and express the probative value of forensic evidence. Unfortunately, the use of statistics to perform inferences in forensic science adds a layer of complexity that most forensic scientists, court offices and lay individuals are not armed to handle. Many applications of statistics to forensic science rely on *ad hoc* strategies and are not scientifically sound. The opacity of the technical jargon that is used to describe these probabilistic models and their results, and the complexity of the techniques involved make it very difficult for the untrained user to separate the wheat from the chaff. This series of article is intended to help forensic scientists and lawyers recognize limitations and issues in tools proposed to interpret the results of forensic examinations. This article focuses on the tool proposed by the Latent Print Branch of the U.S. Defense Forensic Science Center (DFSC) and called FRStat. In this article, I explore the compatibility of the results outputted by FRStat with the language used by the DFCS to report the conclusions of their fingerprint examinations, as well as the appropriateness of the statistical modelling underpinning the tool and the validation of its performance.

Keywords: FRStat; fingerprint; statistics; validation.

FRStat Criticisms

- "The FRStat has a feel of a likelihood ratio (LR)" - Neumann
  - USACIL does not claim that the FRStat result is an LR



FRStat Criticisms

- "The FRStat has a feel of a likelihood ratio (LR)" - Neumann
  - USACIL does not claim that the FRStat result is an LR

FINAL REPORT

RESULTS OF EXAMINATION

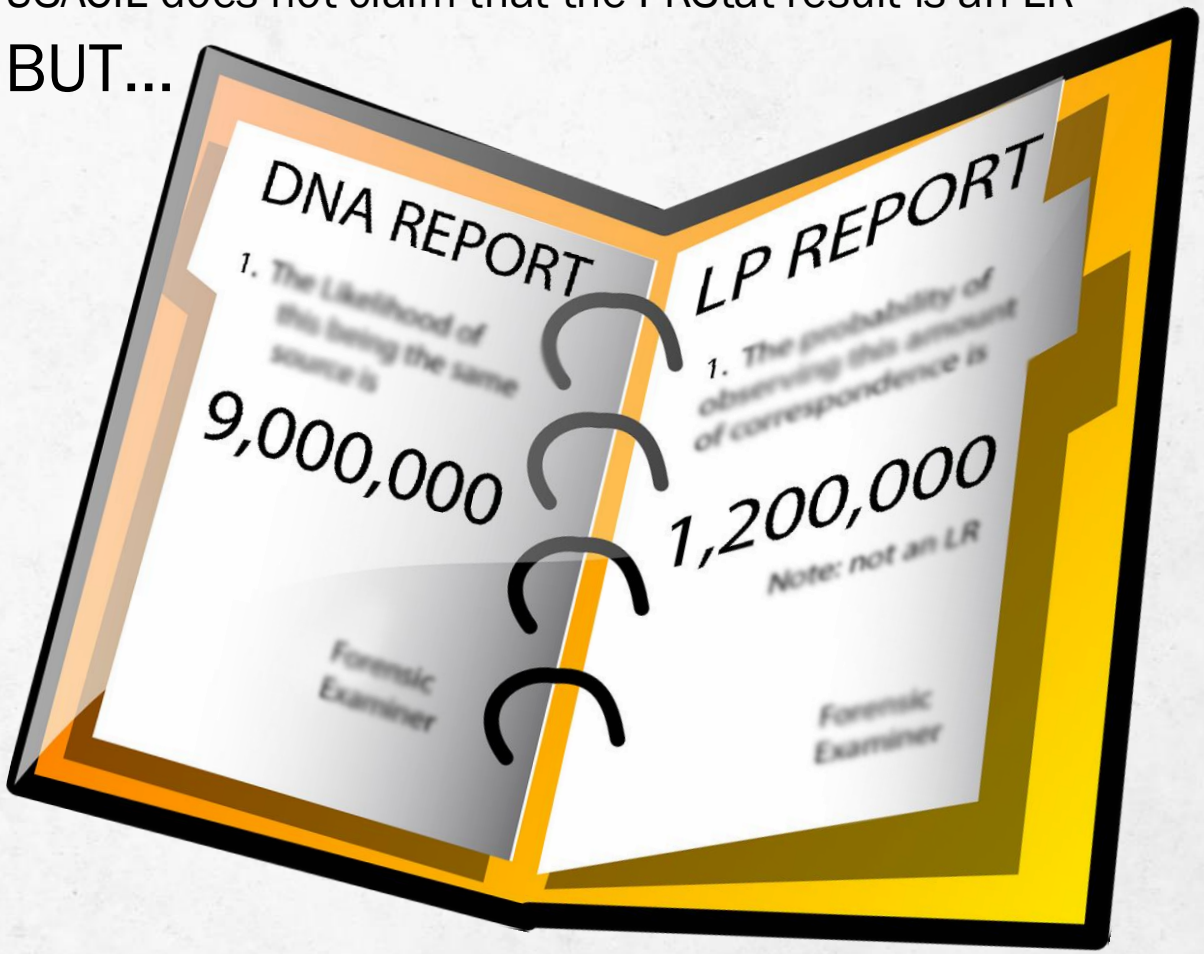
The latent print on Exhibit ## and the standards bearing the name XXXX have corresponding ridge detail. The probability of observing this amount of correspondence is approximately **96,000** times greater when impressions are made by the same source rather than by different sources.

TECHNICAL NOTE

The statistical calculations in this report were generated using *FRStat* software. Results equal to or greater than 10 indicate a positive association between two impressions. Correspondence is measured with respect to the spatial relationships and angles of the annotated ridge details and reflected as a similarity statistic. Uncertainty of measurement is calculated using an iterative random sampling scheme for the annotated details. The reported result is the lower bound of the 99% confidence interval. *FRStat* is not designed to evaluate all aspects of the impressions, such as pattern type, feature type, intervening ridge counts, and other details considered by an examiner; thus, the reported results indicate a conservative estimate for the statistical strength of an association between two impressions.

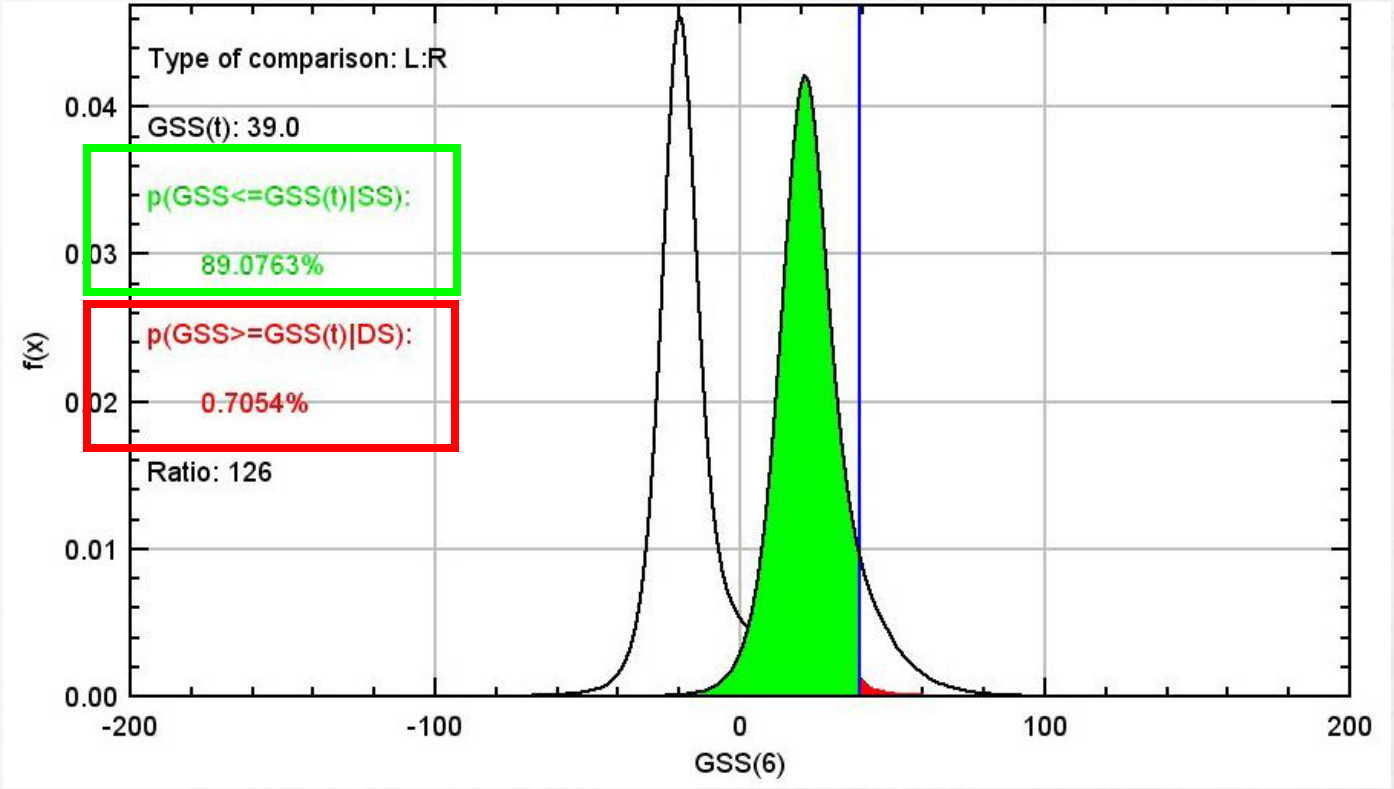
FRStat Criticisms

- "The FRStat has a feel of a likelihood ratio (LR)" - Neumann
  - USACIL does not claim that the FRStat result is an LR
  - BUT…

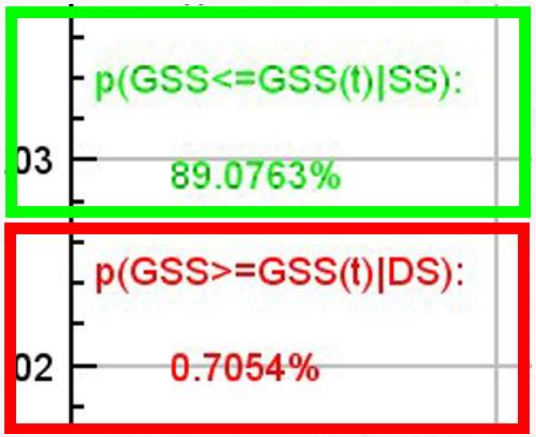


FRStat General Acceptance

- So, what did the USACIL do?
  - Evaluated the criticism(s)
  - Sought independent advice from statisticians



FRStat General Acceptance



"The latent print on Exhibit 1 and the standards bearing the name DOE have corresponding ridge detail. **This correspondence is greater than 89% of impressions made by the same source and less than 0.71% of impressions made by different sources.** This supports a positive association."

FRStat Lessons Learned

- Prophesies for a future LP statistical model
  - Express the weight of evidence within a generally accepted framework
  - Incorporate additional latent print features which examiners utilize in their examinations
    - Leverage some similarity metric?
      - Private vendors
  - Ease of implementation/validation
    - Small program footprint
    - No need for large agency-specific representative databases
  - Completely objective – or close to.
  - Support
    - Private vendors
  - Knowledge of limitations

FRStat Lessons Learned

- Who will create the most effective **demand**?
  - Additional critical reports
  - Forensic regulating bodies
    - OSACs?
  - Accreditation bodies
  - Daubert/court precedence
  - Latent print examiners
    - Time to reduce dogmatic thinking in the field – in leadership positions
    - Time to increase education requirements for new LPEs
    - Time to educate and reduce FEAR

How do we get LPEs to NEED a statistical model in the same way drug chemists NEED a GCMS?

Summary

- The implementation and utilization of a statistical model for expressing latent print evidence in the American criminal justice system has provided valuable lessons.
- This model utilizes [FRStat] statistical analysis to evaluate the probability of a match between a latent print and a known print, rather than relying solely on the subjective judgment of a trained examiner.
- One of the main lessons learned from this implementation is the importance of education and training for both the examiners and the legal community.
- It is also crucial to establish clear guidelines and protocols for the use of the model in order to maintain consistency and accuracy.
- Furthermore, this presentation has highlighted the need for ongoing research and development in the field of Latent Print examination, particularly in the integration of artificial intelligence.
- Overall, the implementation and utilization of a statistical model has the potential to greatly enhance the accuracy and reliability of latent print evidence analysis in the American criminal justice system.

References

- Neumann, C. (2020). Defence against the modern arts: the curse of statistics: Part 1-FRStat. *Law, Probability and Risk*, 1-20.

- Swofford, H. J., Koertner, A. J., Zemp, F., Ausdemore, M., Liu, A., & Salyards, M. J. (2018). A method for the statistical interpretation of friction ridge skin impression evidence: Method development and validation. *Forensic Science International*, 113-126.

- Swofford, H., Zemp, F., Liu, A., & Salyards, M. (2020). Letter to the Editors regarding Neumann, C. 'Defence against the modern arts: the curse of statistics: Part 1 - FRStat.' Law, Probability and Risk (2020) 19(1), 1-20. *Law, Probability and Risk*, 365-370.

Thanks for your attention!

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FRStat Download

Justice Through Science!