# Evaluation of Method Parameters Affecting Magnetic Flux Measurement of Toners as a Screening Tool for Casework Application

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FSF Emerging Forensic Scientist Award

Paper Presentation

# Overview

- Background
- Research Questions
- Experimental Conditions
- Analytical Methods
- Results and Discussion
- Conclusions

# Background

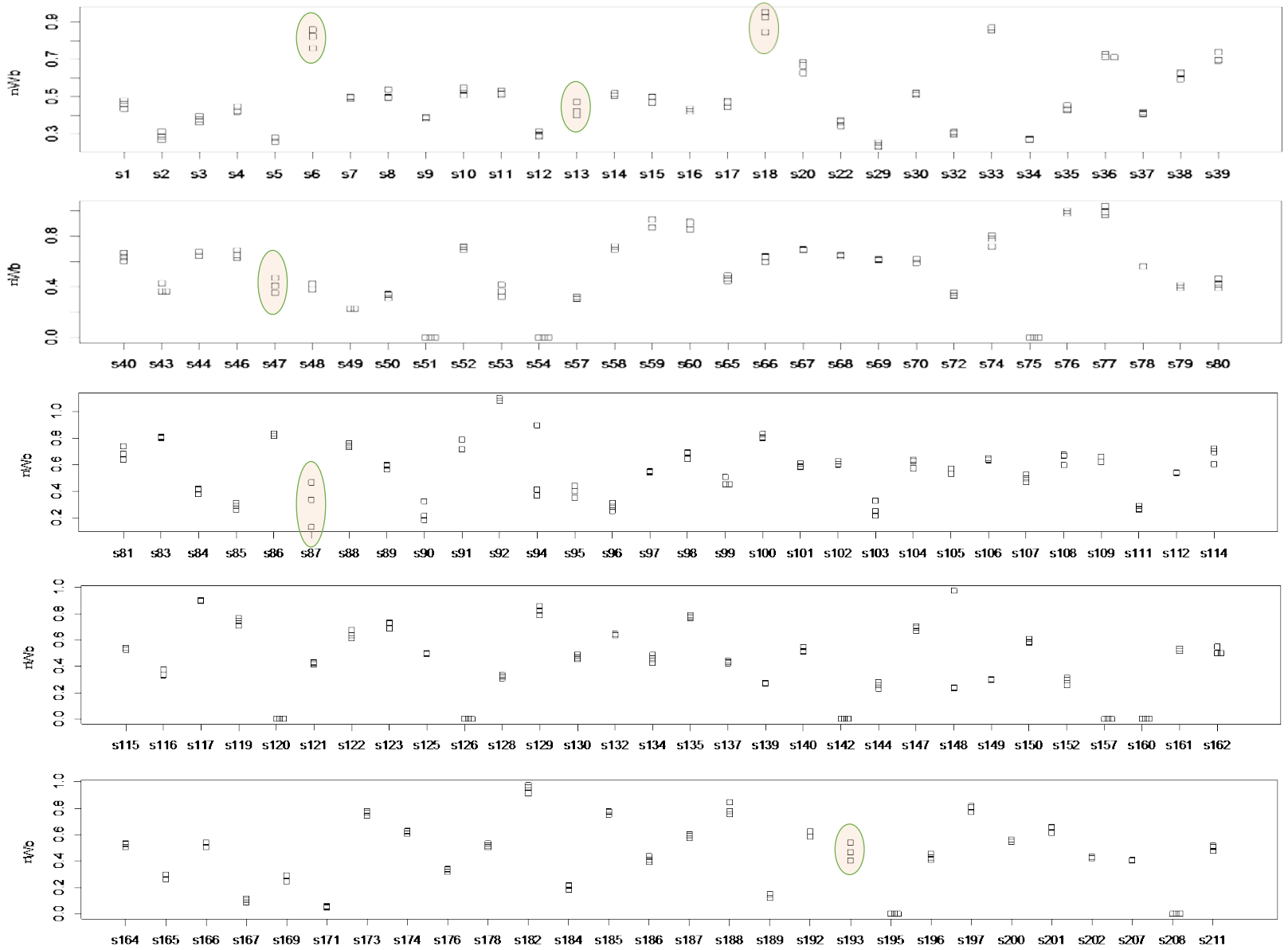
# Why Magnetic Flux?

- What is ‘Magnetic Flux’?
- Relevance?
- Initial Investigation in 2017 – Assessed
  - Stability of flux fields over time
  - Relationship between toner area and flux
  - Variation in a population

# Previous Work

- Initial Investigation - Concluded
  - Magnetic flux is stable over time
  - Relationship between flux and toner area allows for normalization of data
  - Variation present in toner populations allows for discrimination on the basis of flux measurement

# Research Questions




C. Polston, W. Mazzella, M. Furbach, and P. Buzzini. Evaluation of Instrument Sensitivity and Stability for Magnetic Flux Measurement Relative to Toner Area and a Screening Tool for Casework Application, AAFS 69th Annual Meeting in New Orleans, LA, 2017.

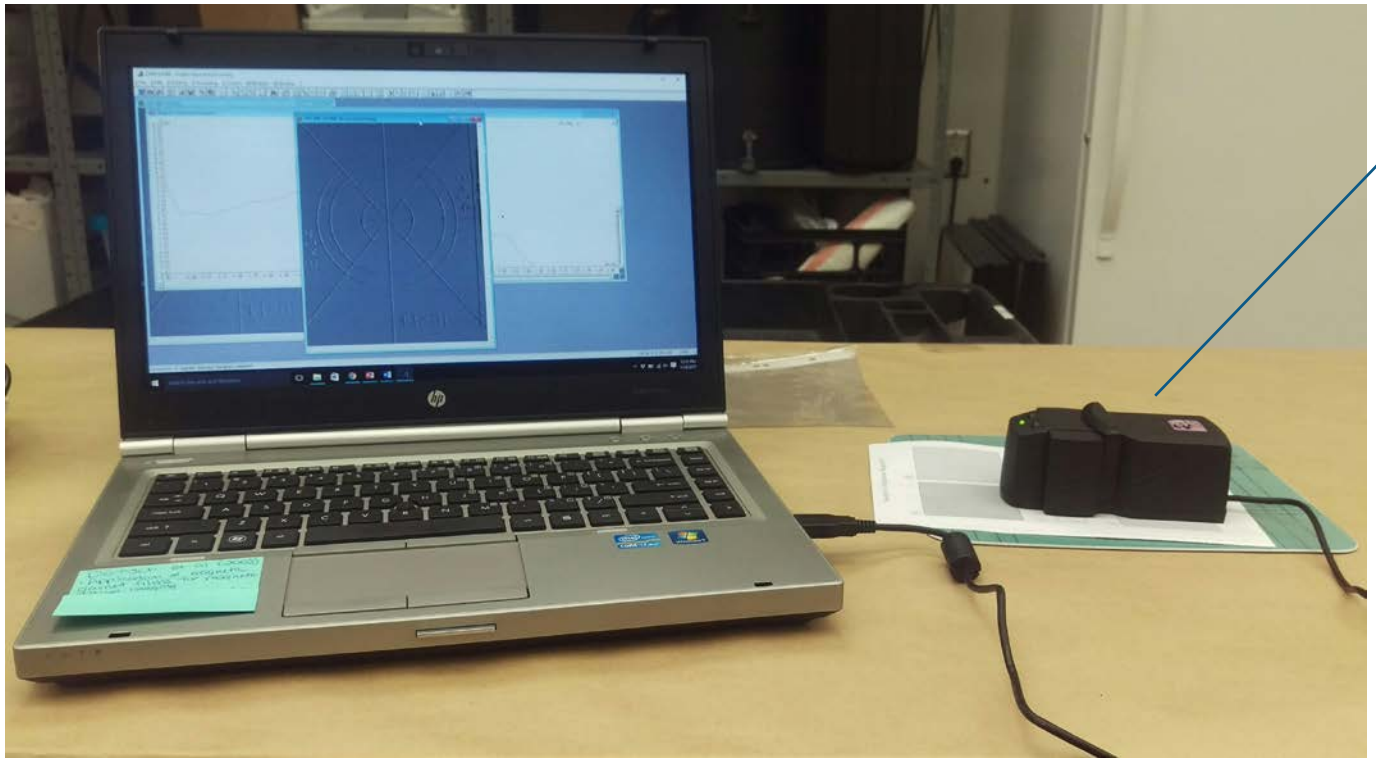
# Research Focus

- Evaluation of method reliability
  - Does the area of the sensor occupied affect the precision of magnetic flux measurements?
  - If so, what area of the sensor is optimal to ensure reproducibility?
  - Does the variation of the grey values during area determination have an effect on the precision of area measurements?
  - If so, how can this be controlled to ensure reproducibility of measurements?

# Experimental Conditions

# Instrumentation

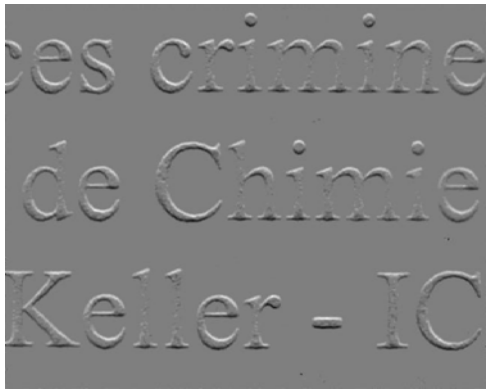
- Regula© Magmouse 4197
  - Used for all magnetic flux measurements
  - Positive and negative QC samples were used to monitor for proper instrument function



# Samples

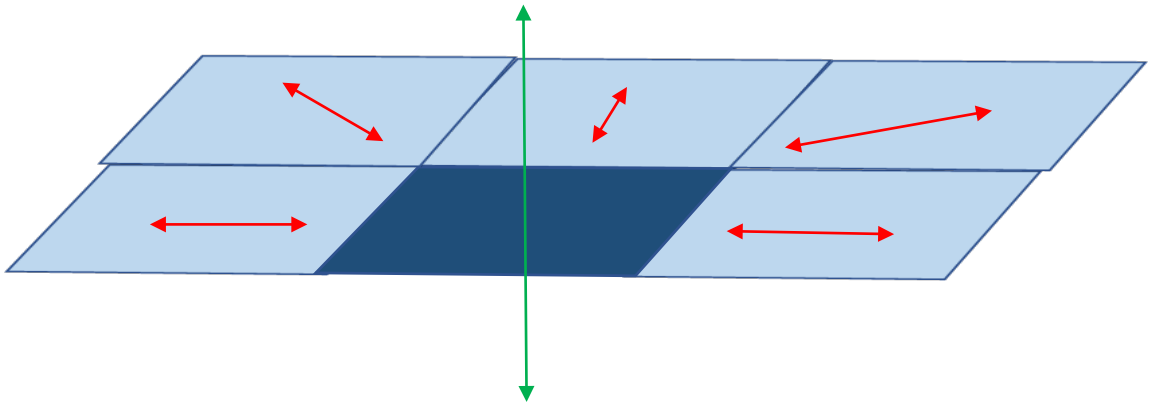
- 7 samples
- 3 different sites per sample
  - Sites were selected to provide a range of different areas
- 3 replicate trials
- Conducted in the span of 1 week
  - From July to August 2016
- 63 total measurements





# Key Concept

- Magneto-optical imaging sensor function



# Analytical Methods

# Test Area Determination

- Performed using Adobe® Photoshop® CC 2015

The scanned original image was overlaid with the image from the Regula® Magmouse 4197

↓

The two images were normalized and aligned

↓

The scanned image was cropped to the dimensions of the instrument image

↓

Pixel values representative of the toner were selected and measured

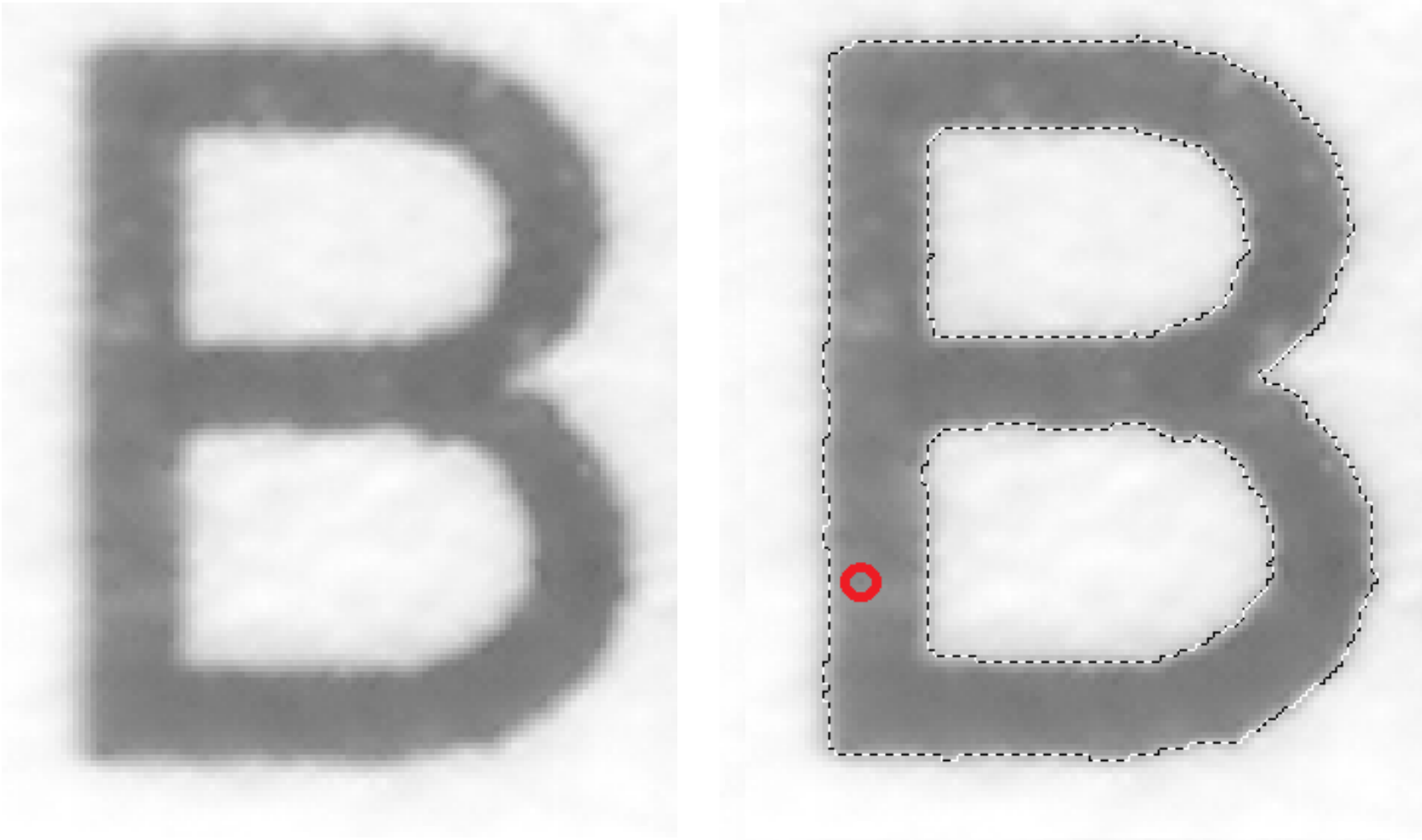
↓

A formula was applied to convert the area in pixels to the area in $mm^2$

# Walkthrough

# Key Concept

- Pixel selection using the magic wand tool



# Results and Discussion

# Sample Area Optimization

- Sample area can vary without impacting precision of results

- Precision is increased when sample area does not intersect with the margins of the sensor

**Sample B**

| Area Size | Intersect | Mean Flux/mm$^2$ | SD |
|---|---|---|---|
| Small | N | 0.73 | 0.03 |
| Medium | Y | 0.59 | 0.05 |
| Large | Y | 0.66 | 0.05 |
| | | Welch p-value | 0.096 |

**Sample D**

| Area Size | Intersect | Mean Flux/mm$^2$ | SD |
|---|---|---|---|
| Small | Y | 0.29 | 0.02 |
| Medium | N | 0.26 | 0.03 |
| Large | N | 0.30 | 0.01 |
| | | Welch p-value | 0.116 |

**Sample C**

| Area Size | Intersect | Mean Flux/mm$^2$ | SD |
|---|---|---|---|
| Small | N | 0.38 | 0.02 |
| Medium | Y | 0.39 | 0.03 |
| Large | Y | 0.42 | 0.03 |
| | | Welch p-value | 0.156 |

# Sample Area Optimization

- If text must intersect sensor for placement, large test areas are preferred
  - Impact of peripheral pixel distortion on overall flux calculation is minimized

| Sample A | | | |
|---|---|---|---|
| Area Size | Intersect | Mean Flux/mm$^2$ | SD |
| Small | N | 0.61 | 0.05 |
| Medium | Y | 0.55 | 0.04 |
| Large | Y | 0.52 | 0.03 |
| | | Welch p-value | 0.080 |

| Sample F | | | |
|---|---|---|---|
| Area Size | Intersect | Mean Flux/mm$^2$ | SD |
| Small | Y | 0.25 | 0.01 |
| Medium | Y | 0.25 | 0.02 |
| Large | Y | 0.29 | 0.002 |
| | | Welch p-value | 0.052 |

| Sample G | | | |
|---|---|---|---|
| Area Size | Intersect | Mean Flux/mm$^2$ | SD |
| Small | Y | 0.70 | 0.05 |
| Medium | Y | 0.77 | 0.02 |
| Large | Y | 0.79 | 0.01 |
| | | Welch p-value | 0.065 |

# Pixel Selection Optimization

- In 2017 investigation, pixel selection was not a controlled factor
  - Was identified at that time as a potential source of uncertainty
- Pixel selection process was optimized by:
  - Repeating the area determination for a sample under different conditions
  - mean grey value +/- 1
  - mean grey value +/- 0.5
  - mean grey value +/- 0.25

# Conclusions

# Conclusions

- Text area can vary as long as intersections with the sensor periphery are minimized
- If contact with the sensor periphery cannot be avoided, analysis of large text areas minimizes the effect of distortion on the calculation of the flux
- Changes in the mean grey value can affect the precision of results
- This type of error can be prevented through standard methodology which limits the SD of the mean grey value to 0.5

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# Questions

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