# Computerized system for aiding expert in physical match and shoeprints

Impression and Pattern Evidence Symposium 2010

- August, Florida USA

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# Daubert ruling (USA 1993)

1. The theory in question can be (and has been) tested.
2. Peer review and publication.
3. General acceptance in a particular scientific community.
4. The known or potential error rate.

# More Science!

## Making forensic science more scientific

The US Congress should create an office to study, standardize and certify those who apply science to crime as well as the techniques they use, urge **Peter Neufeld** and **Barry Scheck**.

***Nature 2010***

Article

## Why Experts Make Errors

***Itiel E. Dror***
***David Charlton***
***School of Psychology***
***University of Southampton***
***Southampton, United Kingdom***

Journal of Forensic Identification

The New York Times
nytimes.com

December 5, 2006
COMMENTARY

## When Questions of Science Come to a Courtroom, Truth Has Many Faces

By: Cornelia Dean

# The Goals of The Project

To assist the expert to reach an objective conclusion based on statistical calculations and to find the error rate.

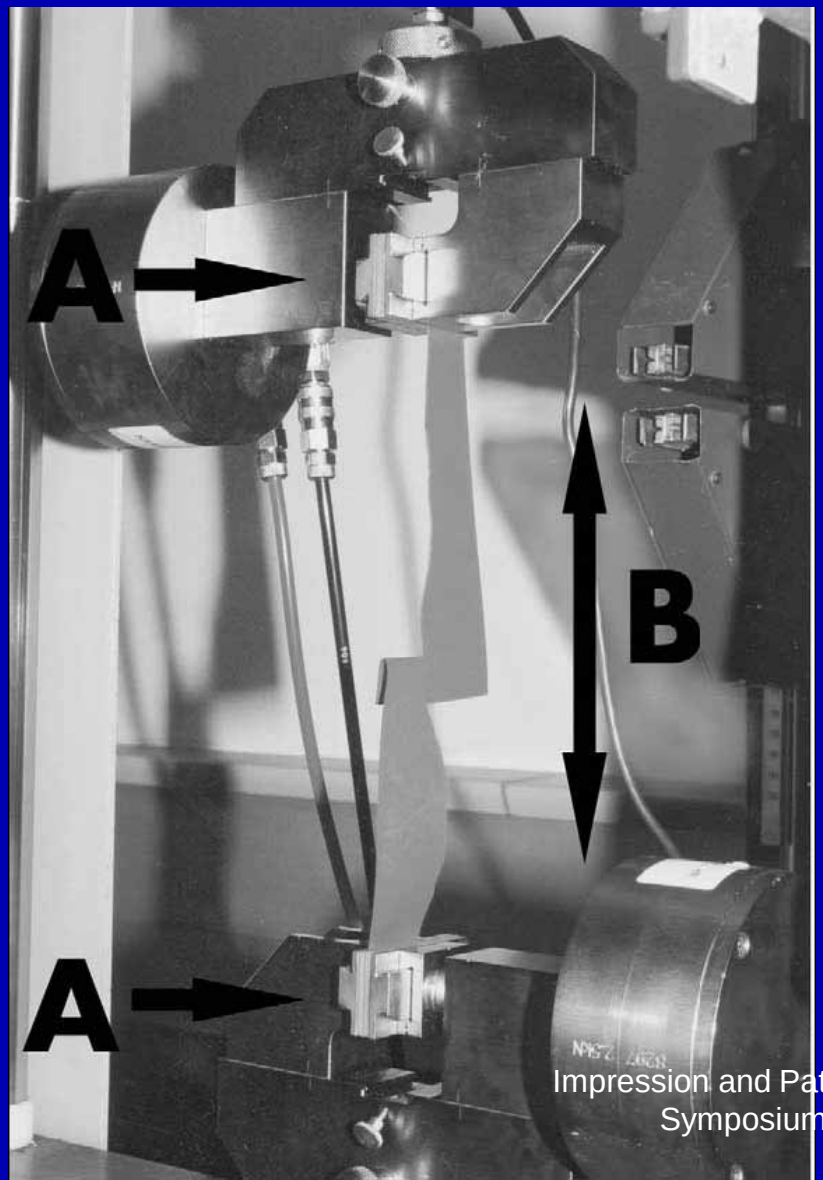
- Calculate the known or potential error rate of a physical match, based on the material and the length of the matching pieces.
- Sponsored by: NIJ, task no. 2558
  Assisted by the TSWG

# It’s a match!

# The Research Process

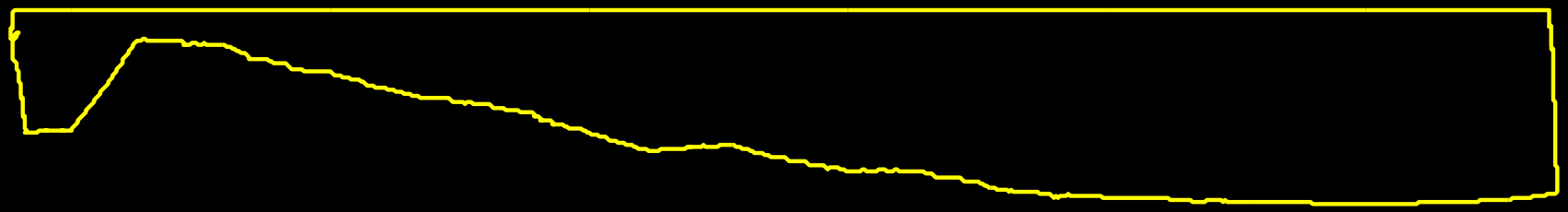
- Tearing pieces of different materials.
- Creating the contours data bases.
- Running computer comparisons of small segments against the whole data base.
- Dividing the comparison results in two: Matches and Mismatches.
- Deriving statistics and error rates for each material data base.

# Tearing pieces of different materials.




Zwick 1435 tensile machine:
(A) The specimen grips.
(B) Movement direction.

# The Torn Silicon and Computer Contour Representation



- Creating the contours data bases.

# Criteria for Evaluation of a Physical Match

- The length of the matching area.
- Amount of information in the torn piece.
- Uniqueness of the contour compared to the population of contours from the same material.

# Creating the database

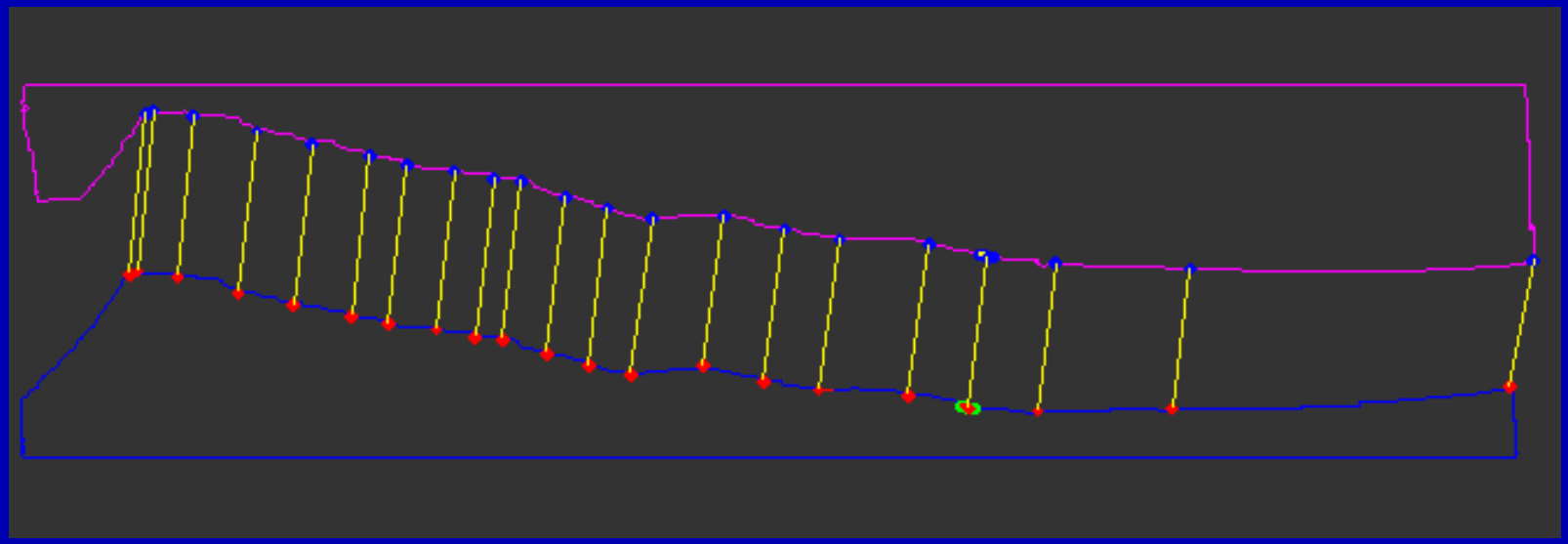
First : the quick step.

A comparison on one dimension is made: only the distance of the point from the next “right” point is counted, and marked as a “match”.

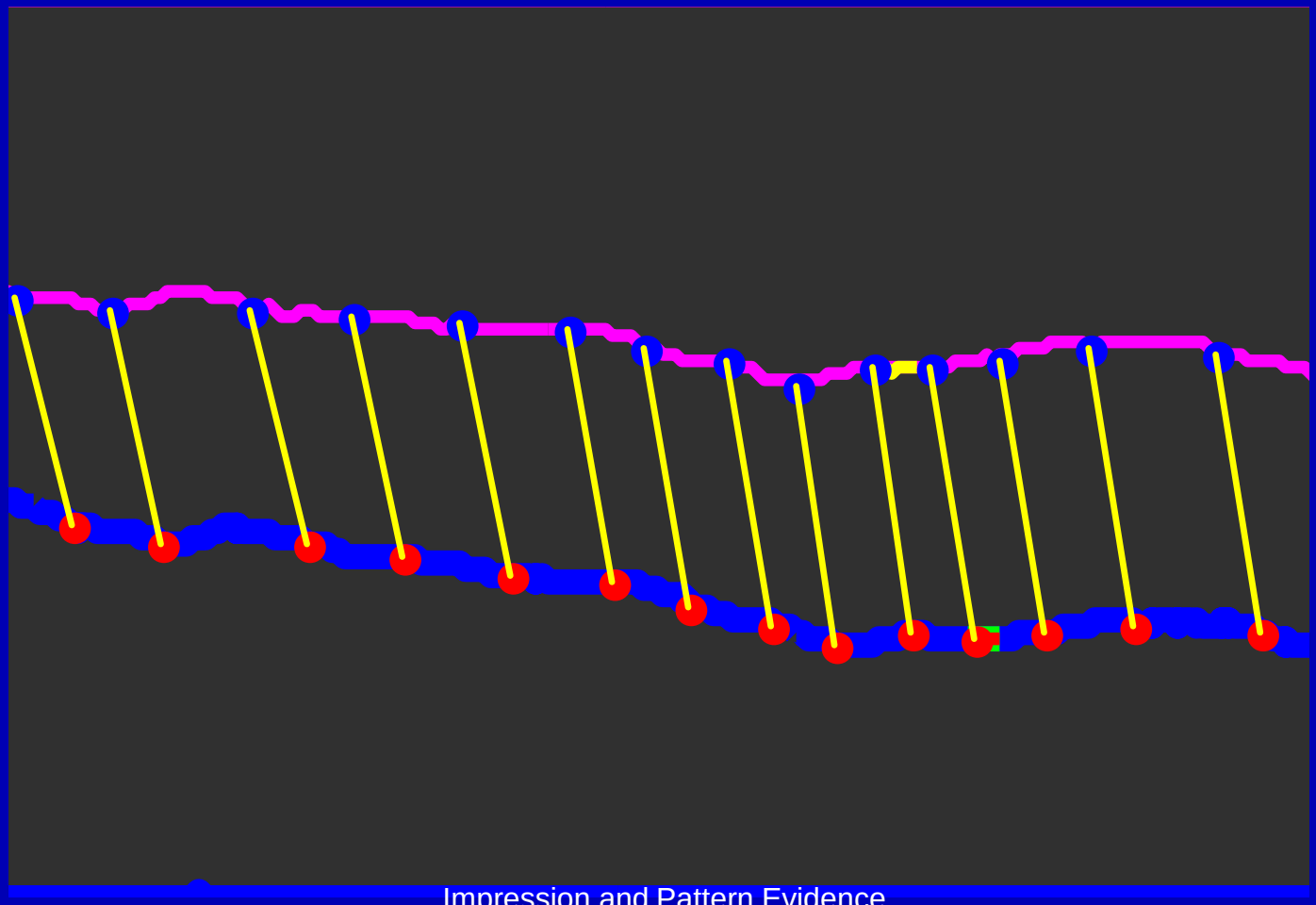
All the non matching results are counted as “non-matches”

# Creating the database- initial

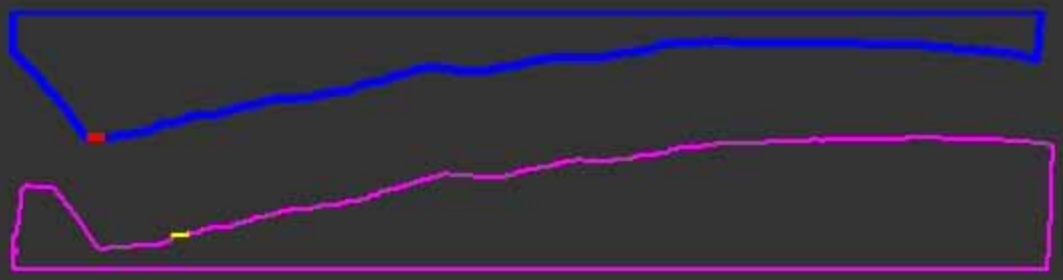
The database starts with an expert marking the right match on two torn pieces of silicon.



# Creating the database – 1D



# Performing the match – 1/4 cm



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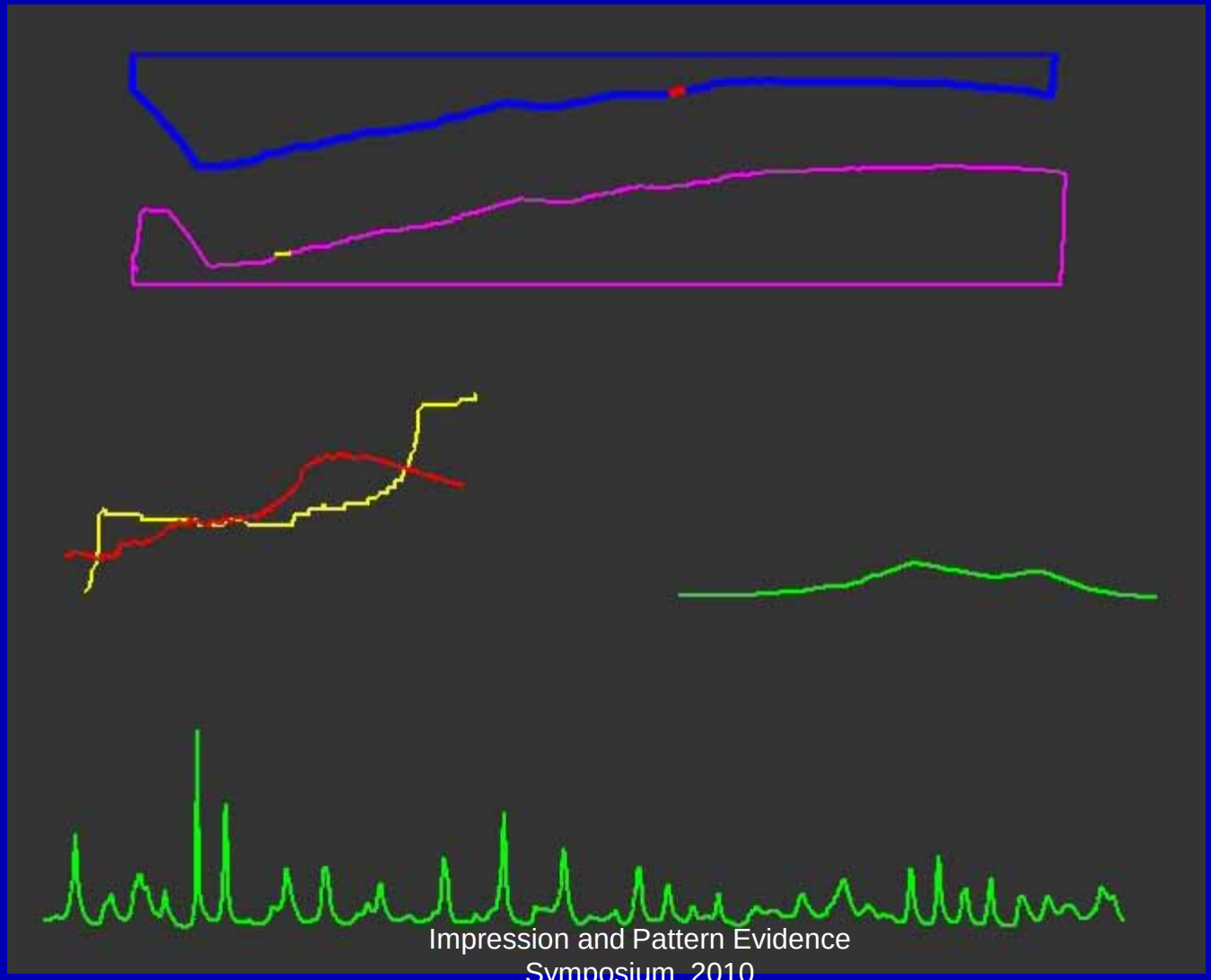
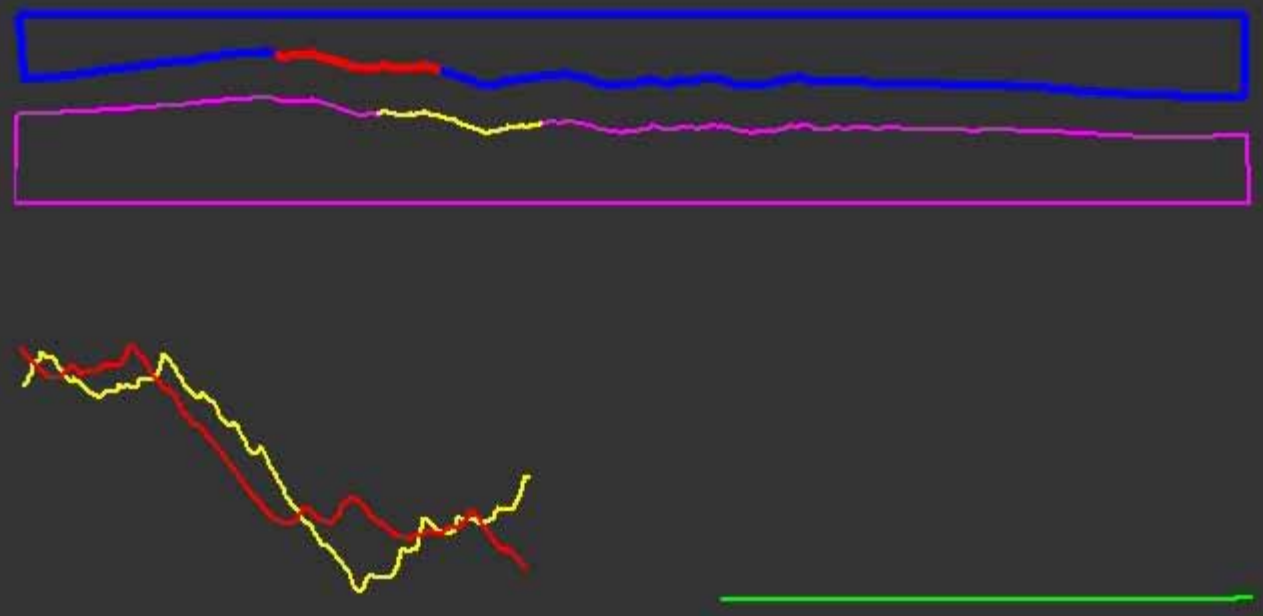


# Performing the match – 4 cm



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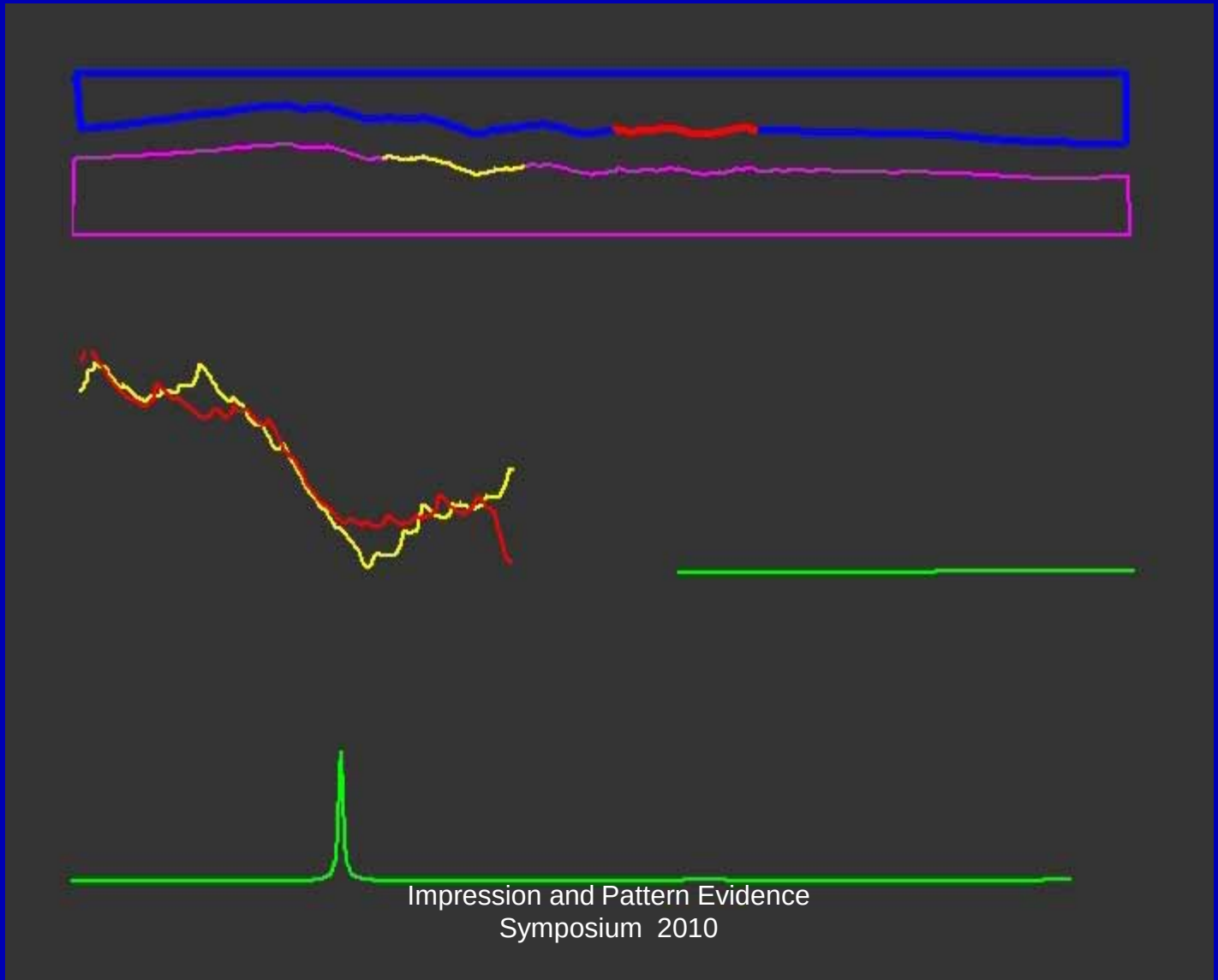
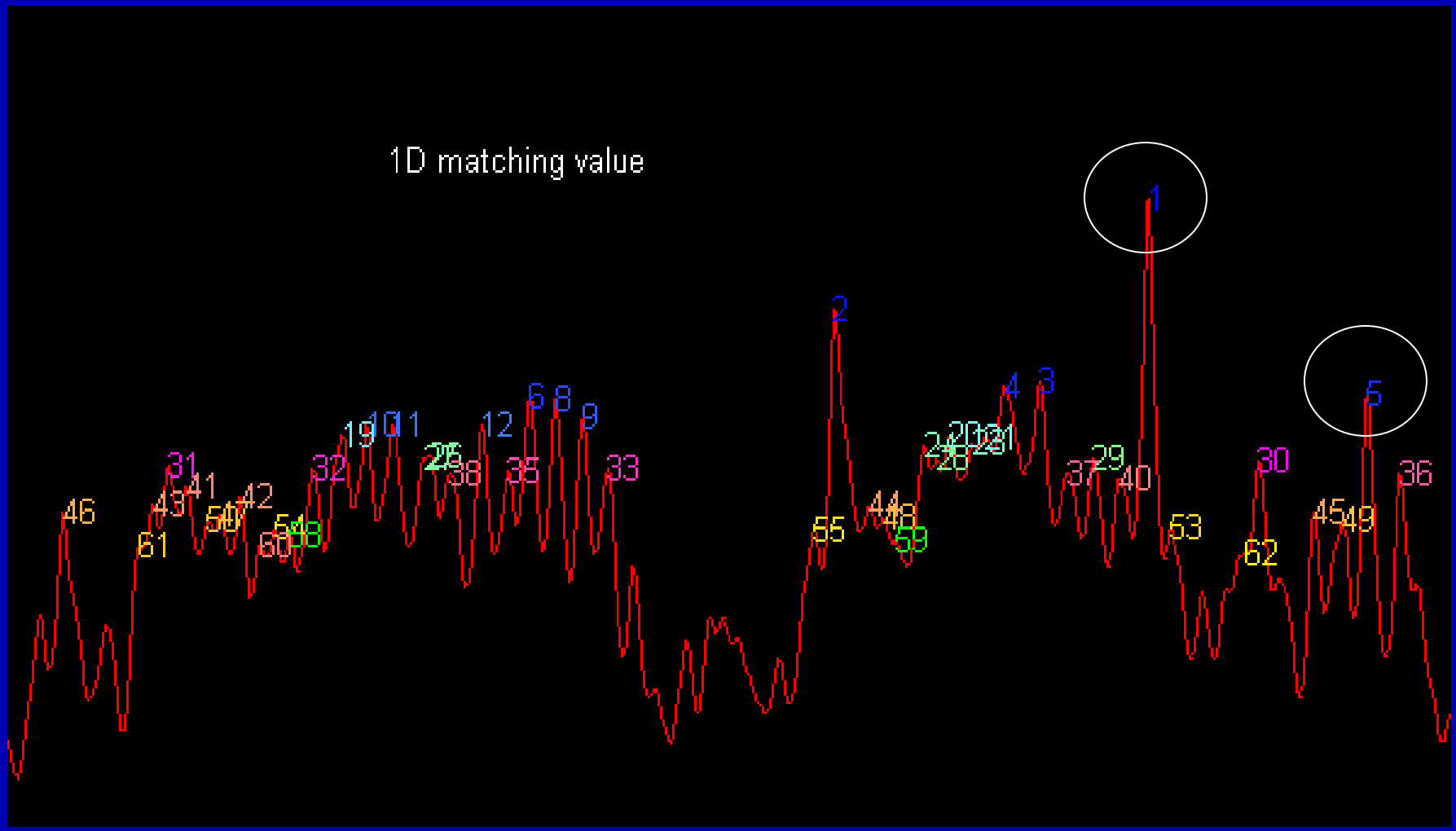
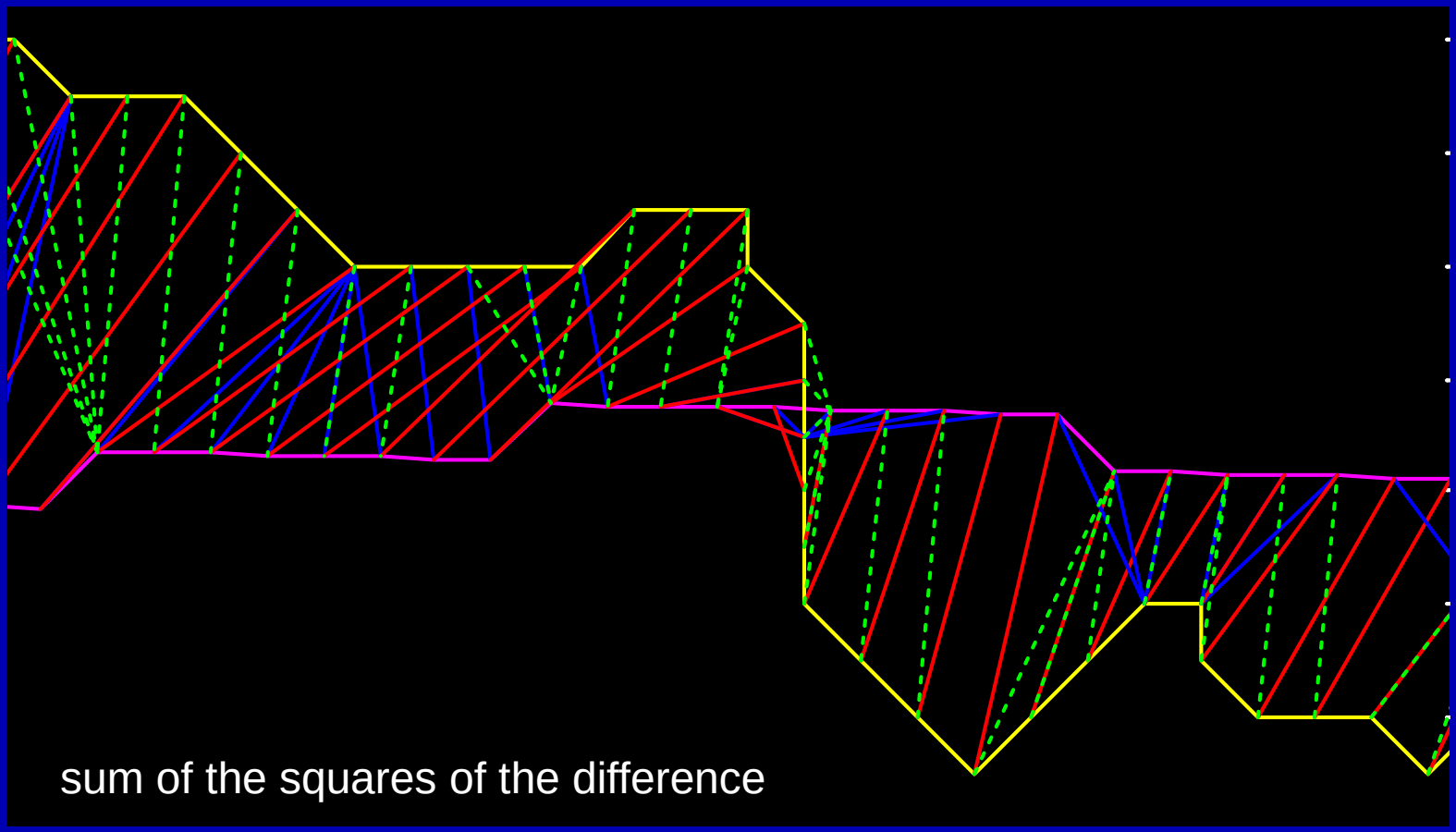


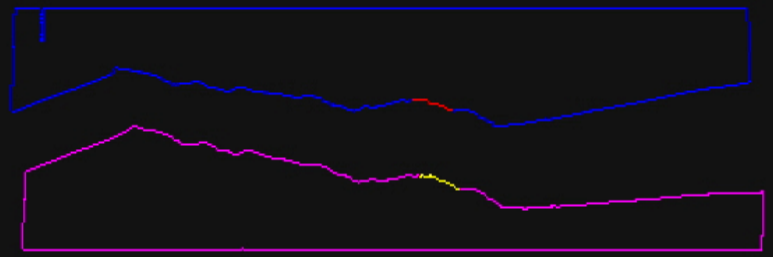
# One dimension graph-1D



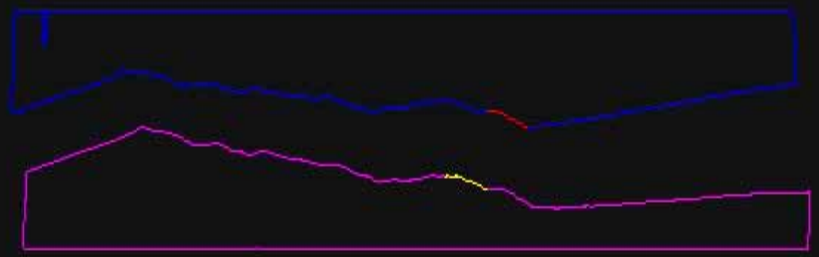
# Performing the match – 2D



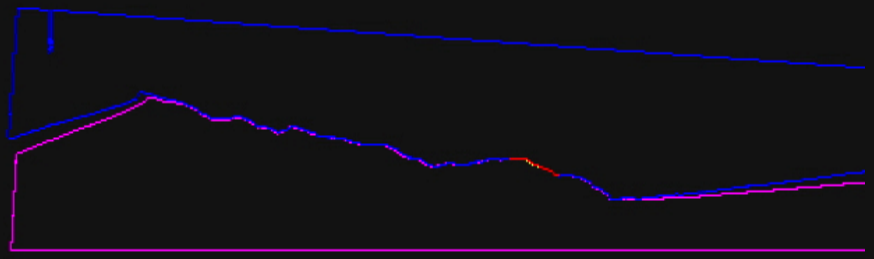
# 2D comparison on 1st and 5th

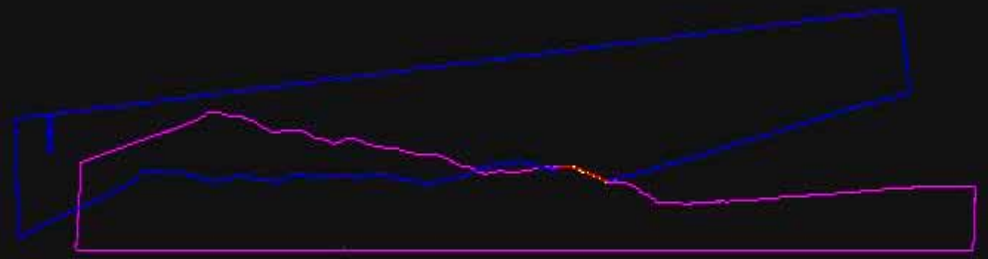


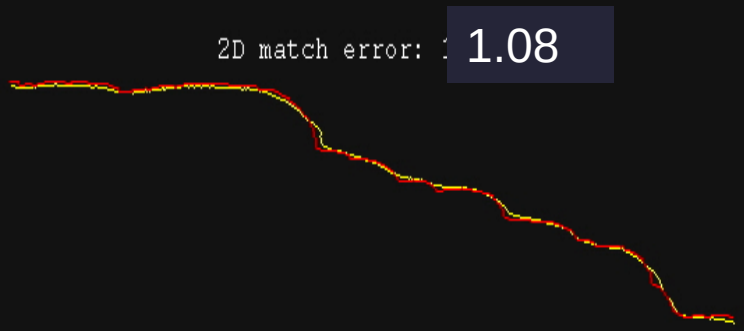
1st match



5th match

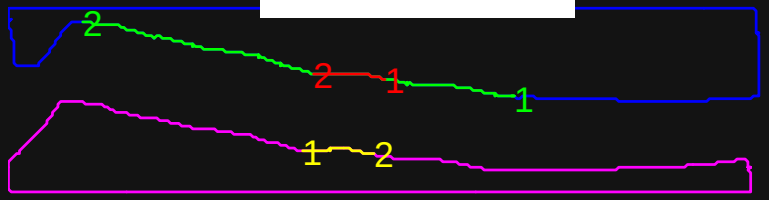


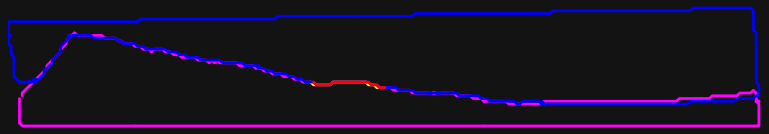




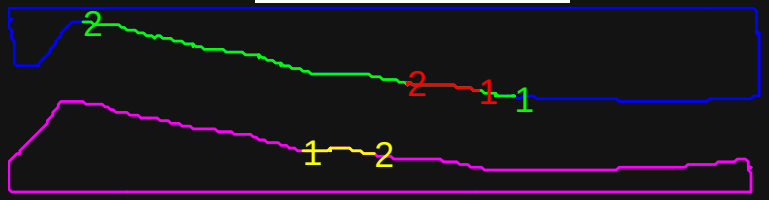

# Performing the match – 2D

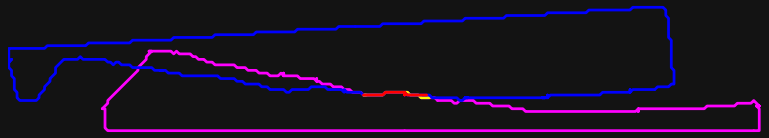
1st match



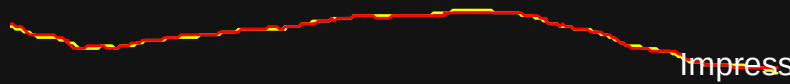
2nd match



2D match errors: 1.0825, 2.0614

2D match errors: 9.0136, 9.7406



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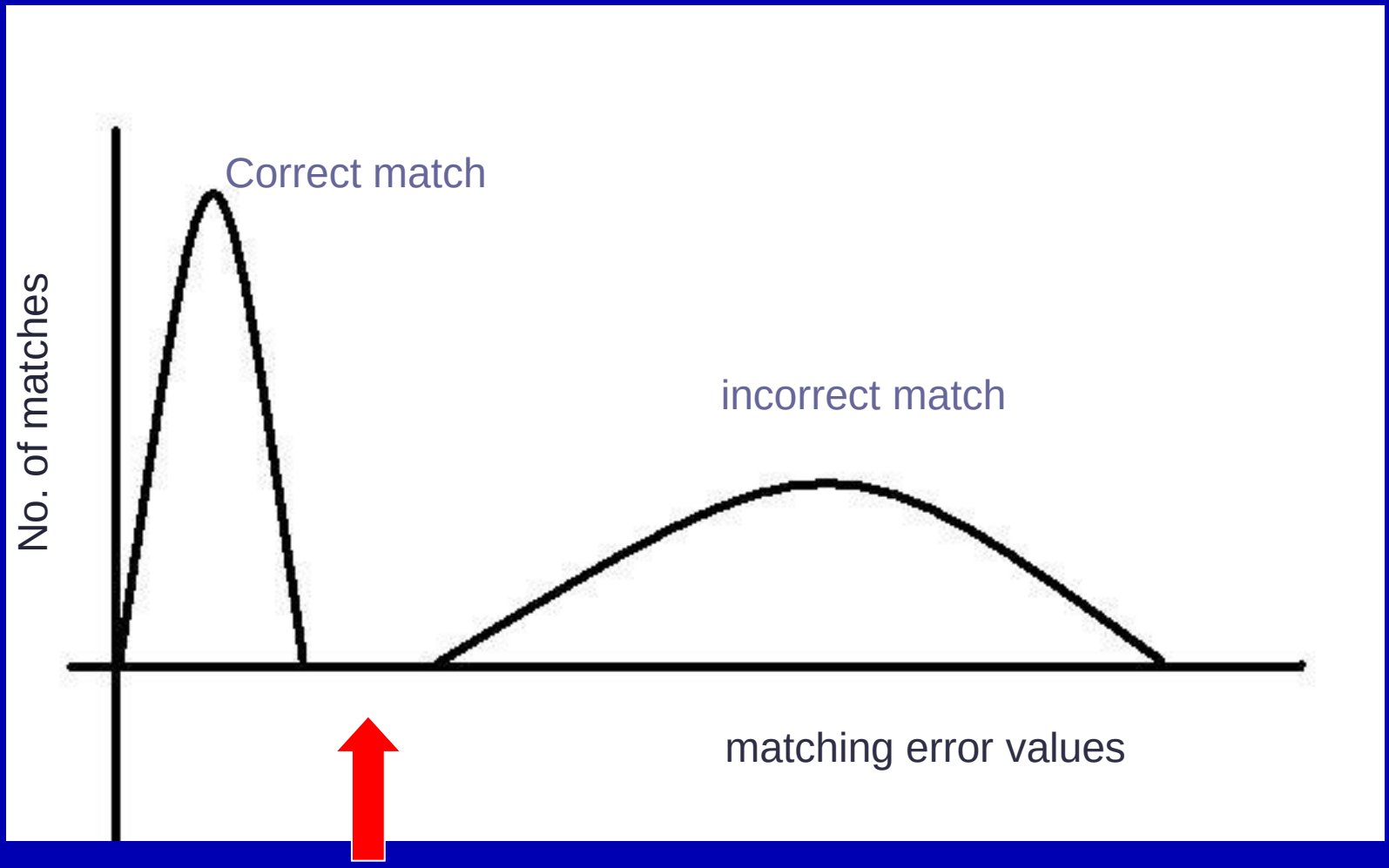
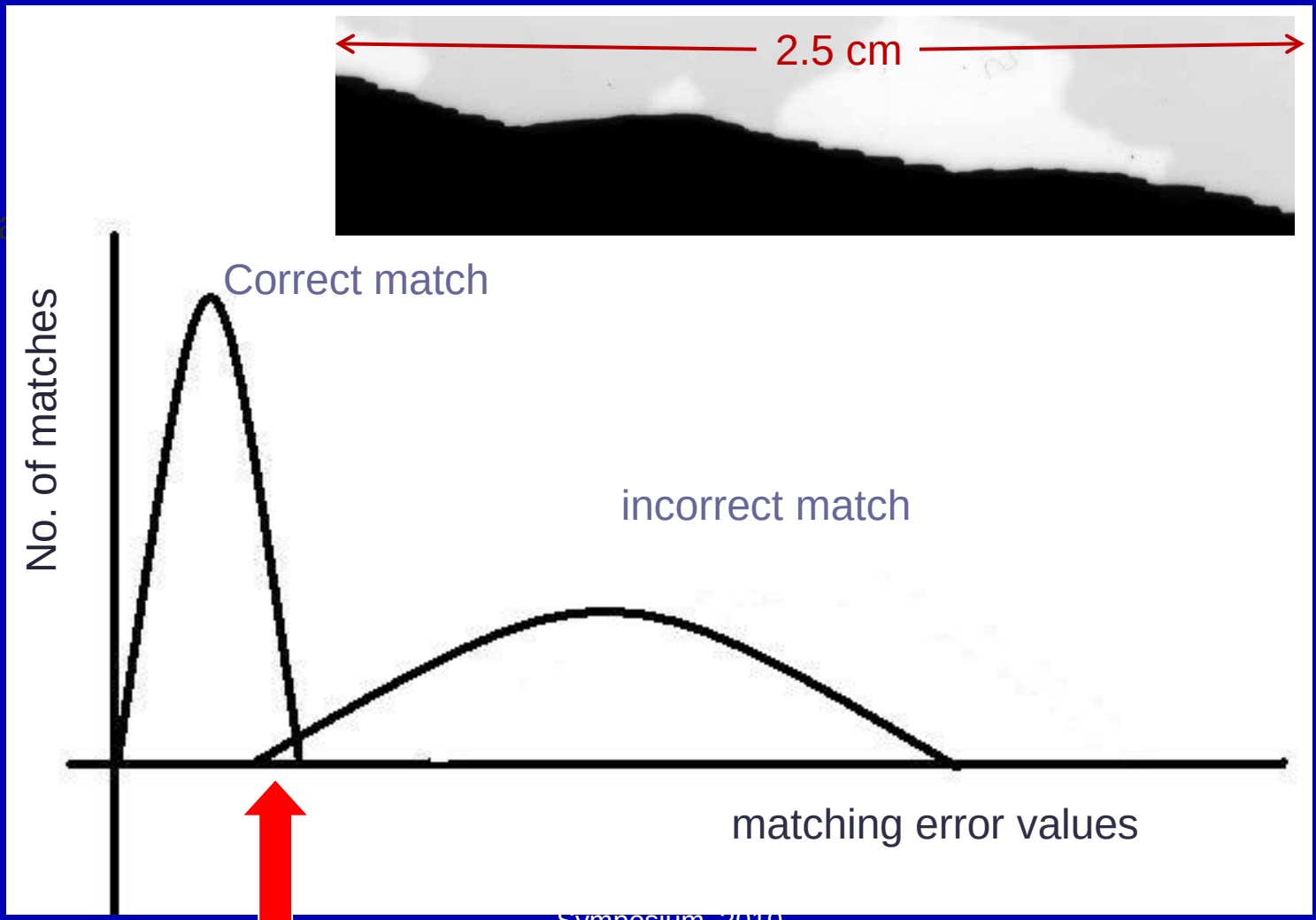
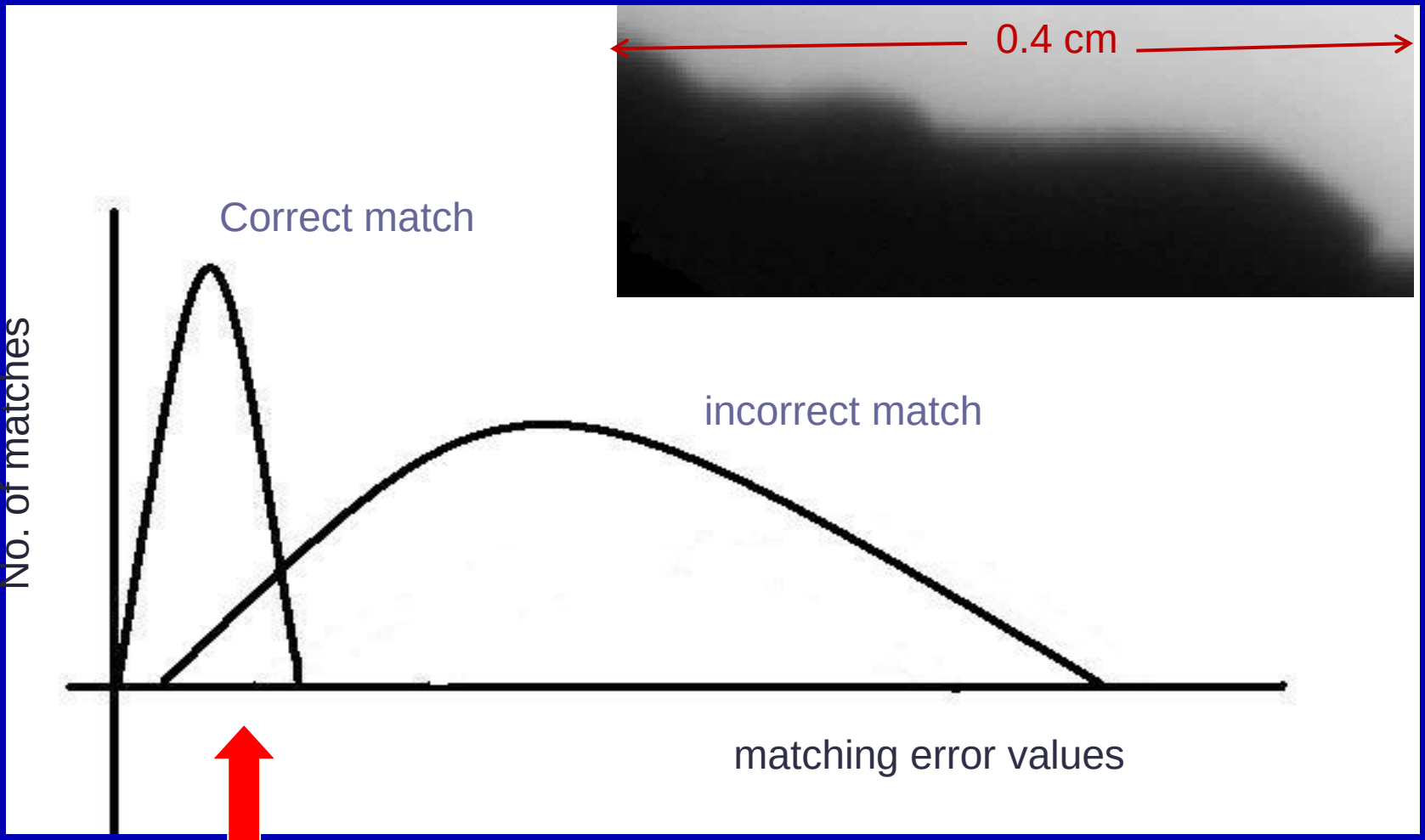
# Dividing the comparison results in two: Matches and Mismatches.



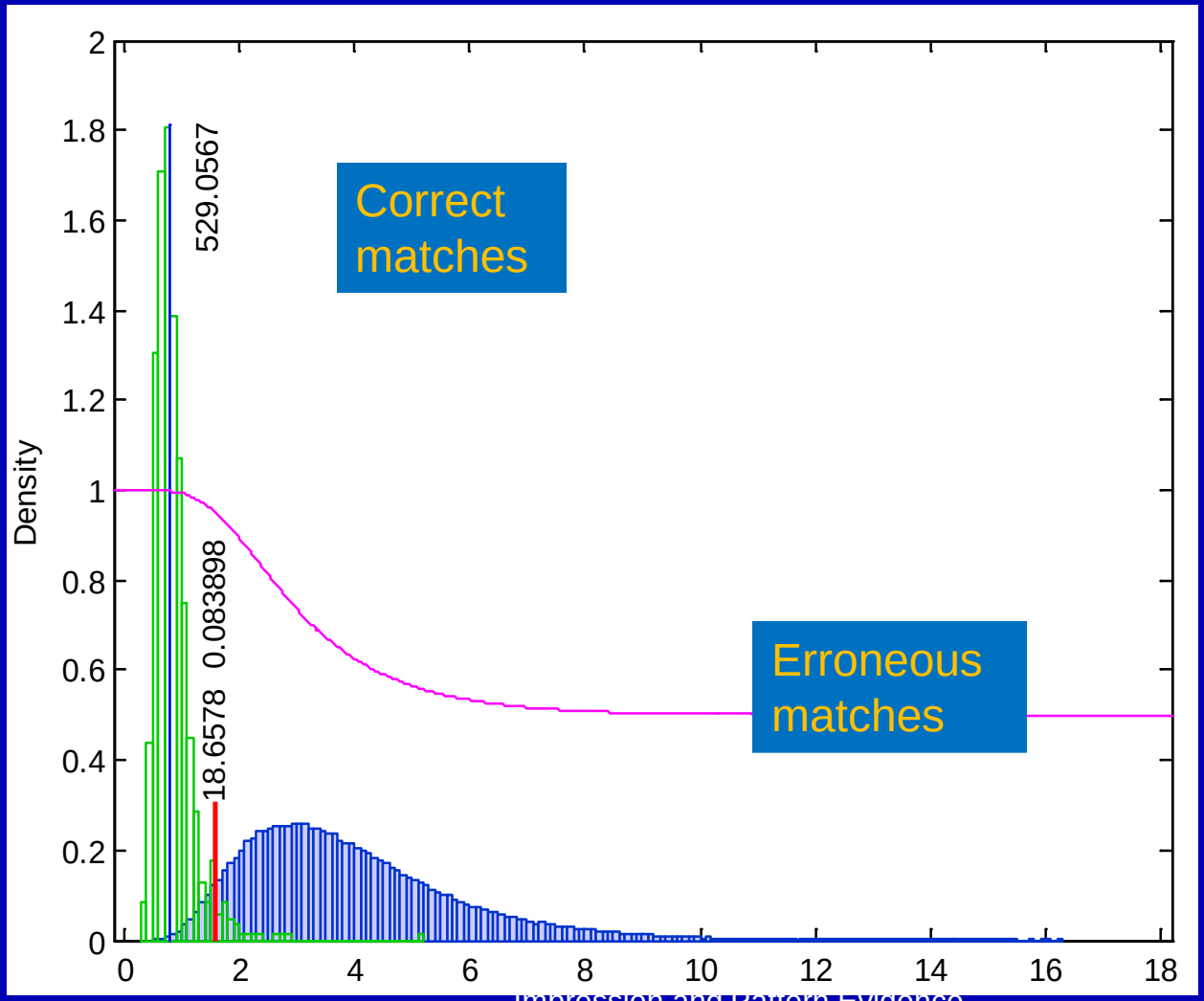
# Distribution of Matches – medium sections



# Distribution of Matches – Short Sections



# Creating the database for 0.25 cm silicon




matching error values

# The Research Process

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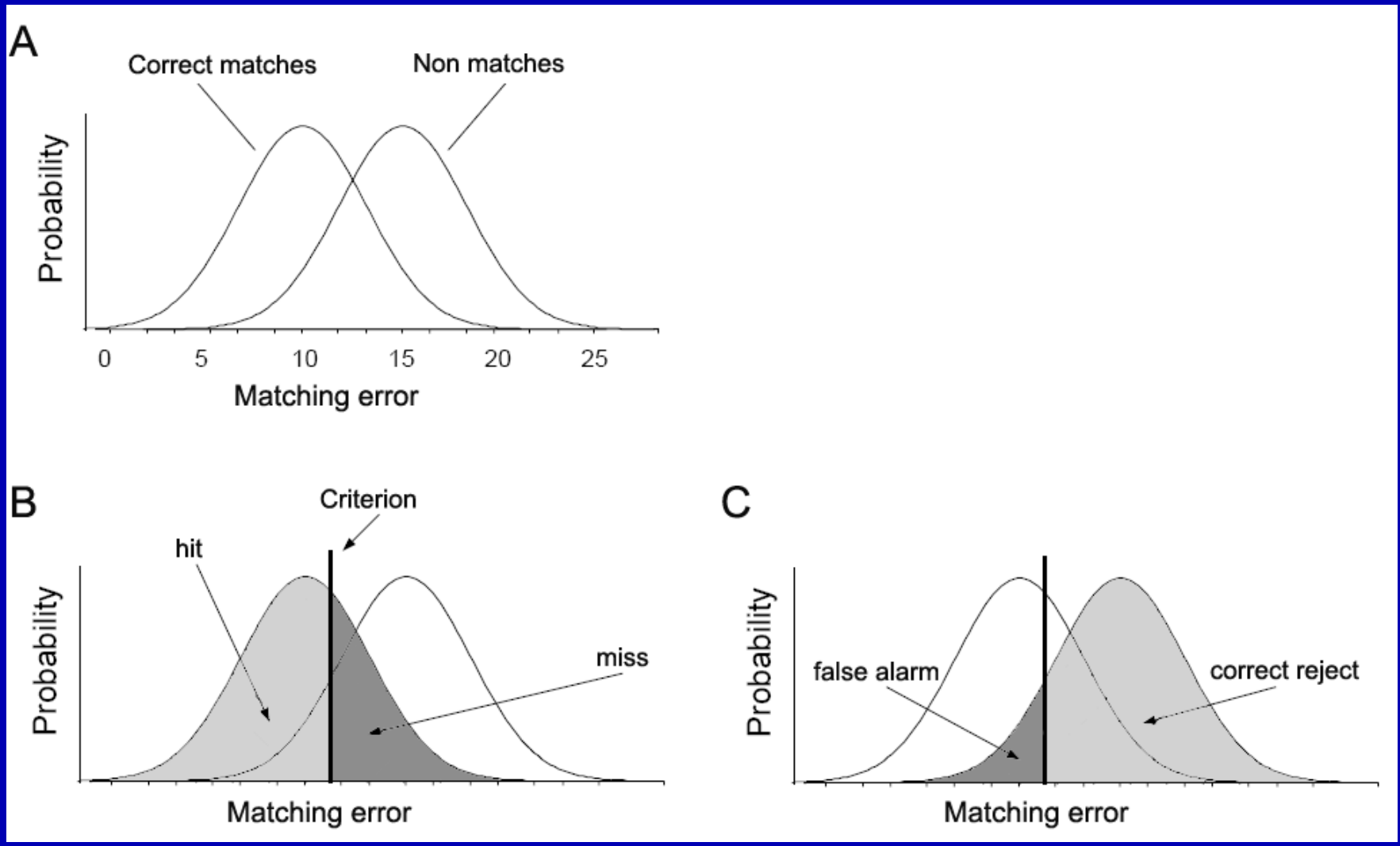
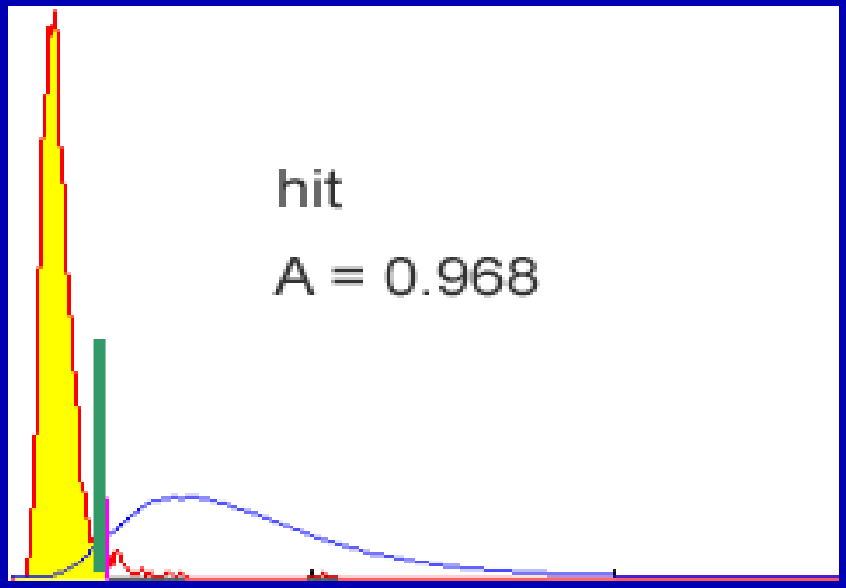
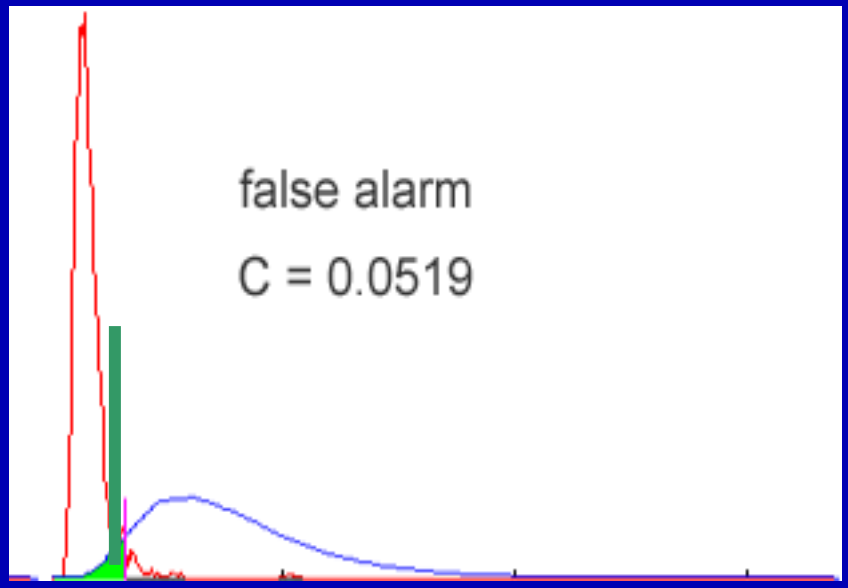
# Hit, rejection and in-between




- Deriving statistics and error rates for each material data base.

# Likelihood ratio: hits and false alarms.




LR= hit / false alarms

The optimal separation criterion: the value that minimizes the error rates of misses and false alarms .

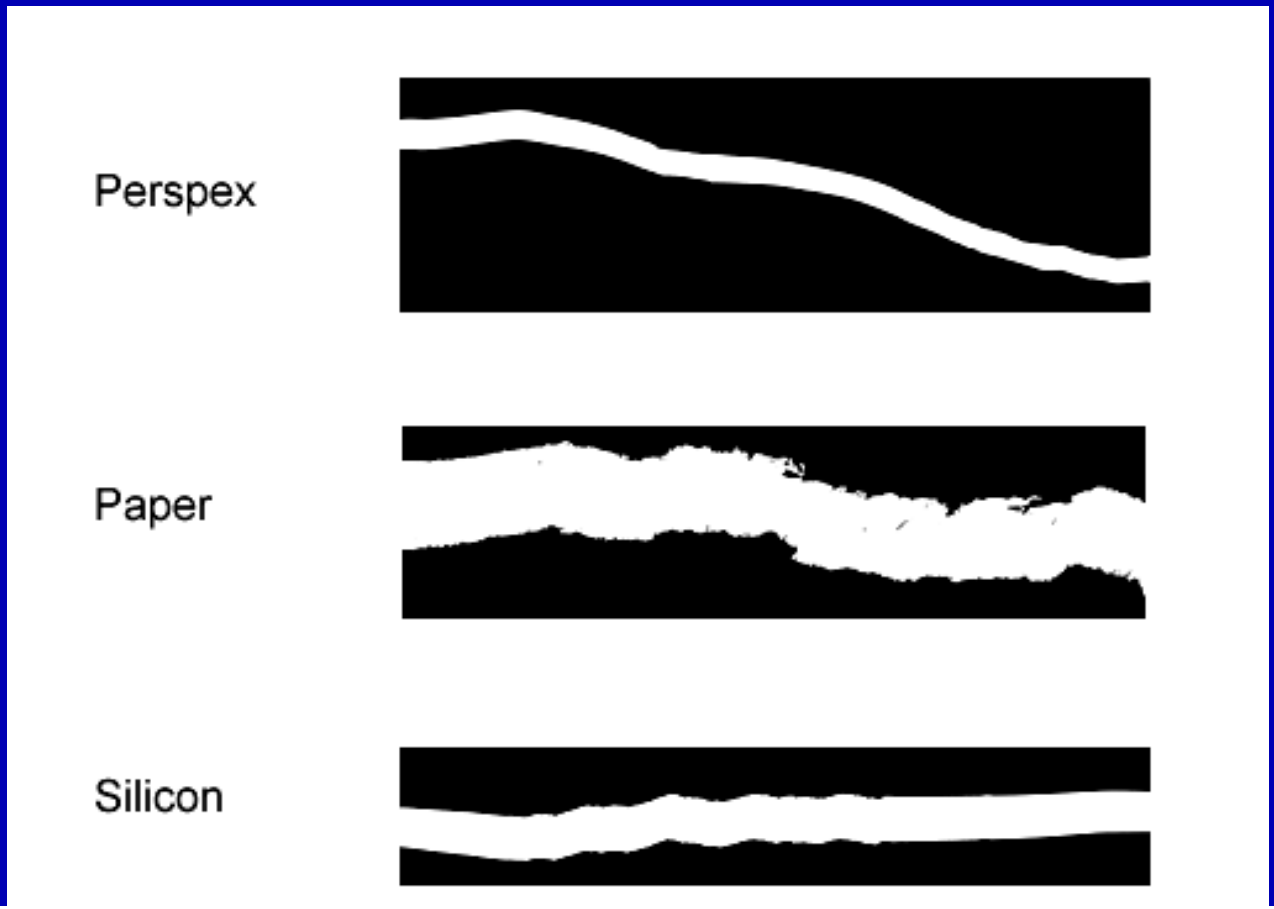
50% correct criterion:  half of the correct matches are left of this value

# The results for silicon

| Length (cm.) | Optimal separation | Positive LR (at the optimal) | Positive LR (at 50%) |
|---|---|---|---|
| 0.25 | .95 | 18.66 | |
| 1 | .996 | | $5.4\ e^{+10}$ |
| 3 | .999 | | $7.0\ e^{+16}$ |

The positive likelihood ratio (**hits/false alarms)**

# Amount of information




The influencing factors : information and noise.

Fracture lines contain characteristic material-based elements.

# The results for Perspex

| Length (cm.) | Optimal separation | Positive LR (at the optimal) | Positive LR (at 50%) |
|---|---|---|---|
| 1 | 0.66 | 5.6 | 24 |
| 2 | 1.58 | 7.56 | 97 |
| 5 | 3.04 | 45 | 819 |

# The results for paper

| Length (cm.) | Optimal separation | Positive LR (at the optimal) | Positive LR (at 50%) |
|---|---|---|---|
| 0.5 | 3.87 | 4.03 | 14 |
| 1 | 5.65 | 4.26 | 23 |
| 4 | 10.1 | 18.38 | 1213 |

# Perspex and Paper

- The noise/signal ratio is very important.
- The paper is very informative- but noisy.
- The Perspex is not noisy- but contains small amount of information.

# The results

- Creating the data bases- for each material.
- Running computer comparisons of the desired segment length against the whole data base.
- The calculated error rate can be easily demonstrated.

# The results

Theoretically?

Stone R.S. A Probabilistic model of Fractures in Brittle Metals. *AFTE Journal:*) ..our silicon fracture lines of 1 cm were 667 pixels long… we get $3^{67} \approx 9e31$

Leitão H.C.G. and Stolfi J (ceramics):

…for pieces 10.8 mm long…a true match will be about $1/2^{22} \approx 1/4{,}000{,}000$.

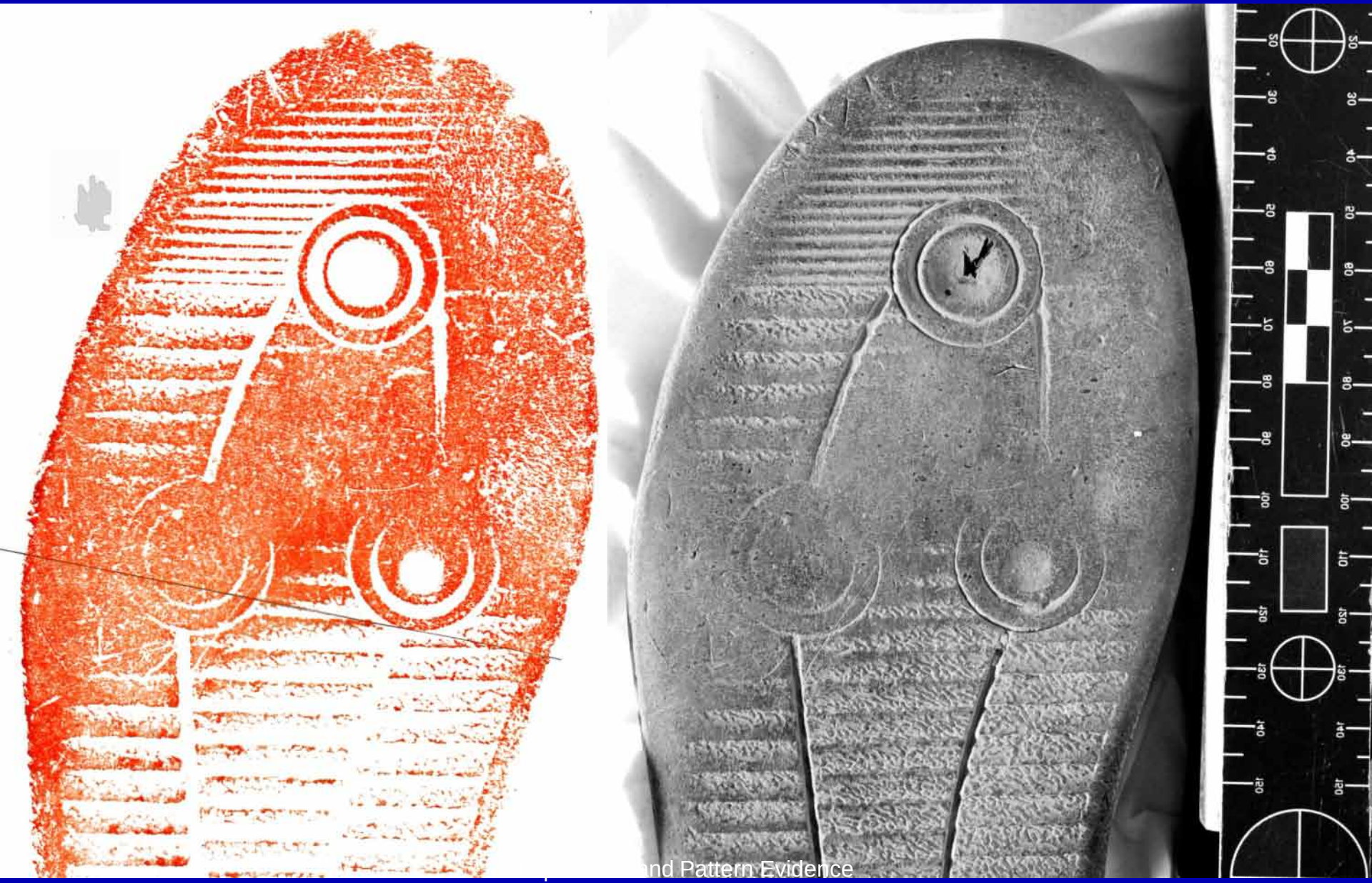
# The results

It must be emphasized: the only checked parameter in this research is the 2D contour, without any other supportive information.

the examinations conducted by the experts involves many more variables: the texture, the three dimensional fit, graphic patterns on the surface or outer border of the pieces.

# Next project: individual characteristics calculation

Sponsored by: NIJ, task no. 3211
Assisted by the TSWG



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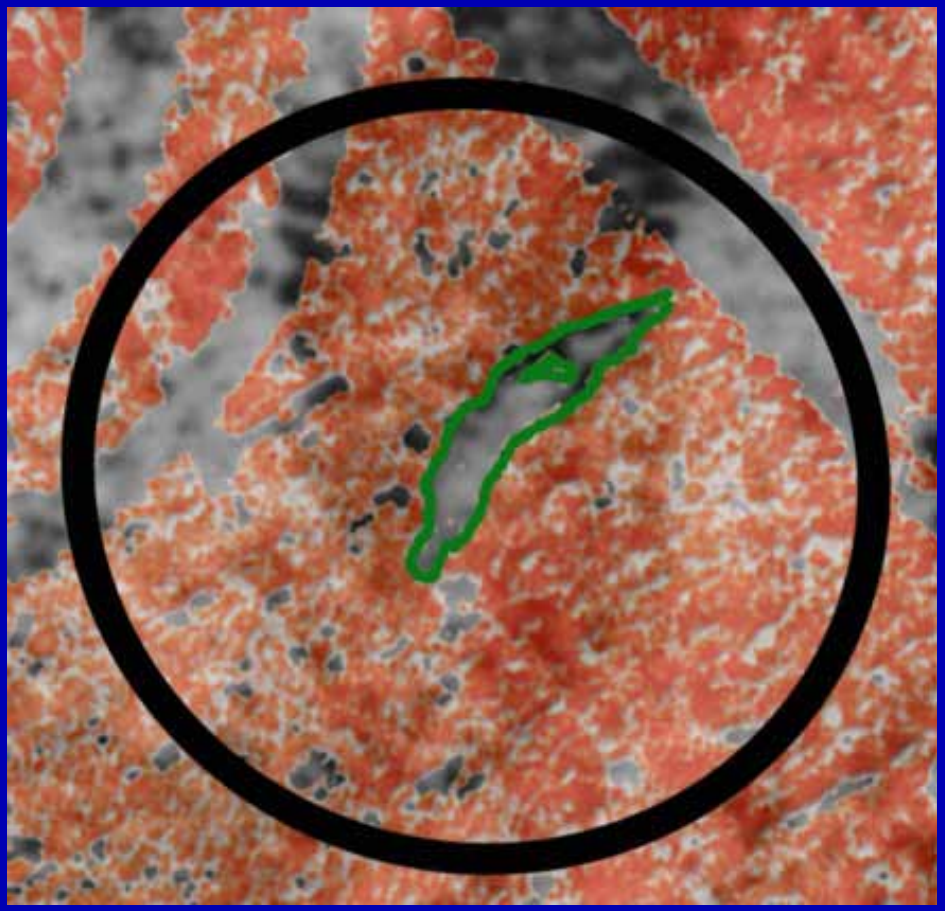

Impression and Pattern Evidence
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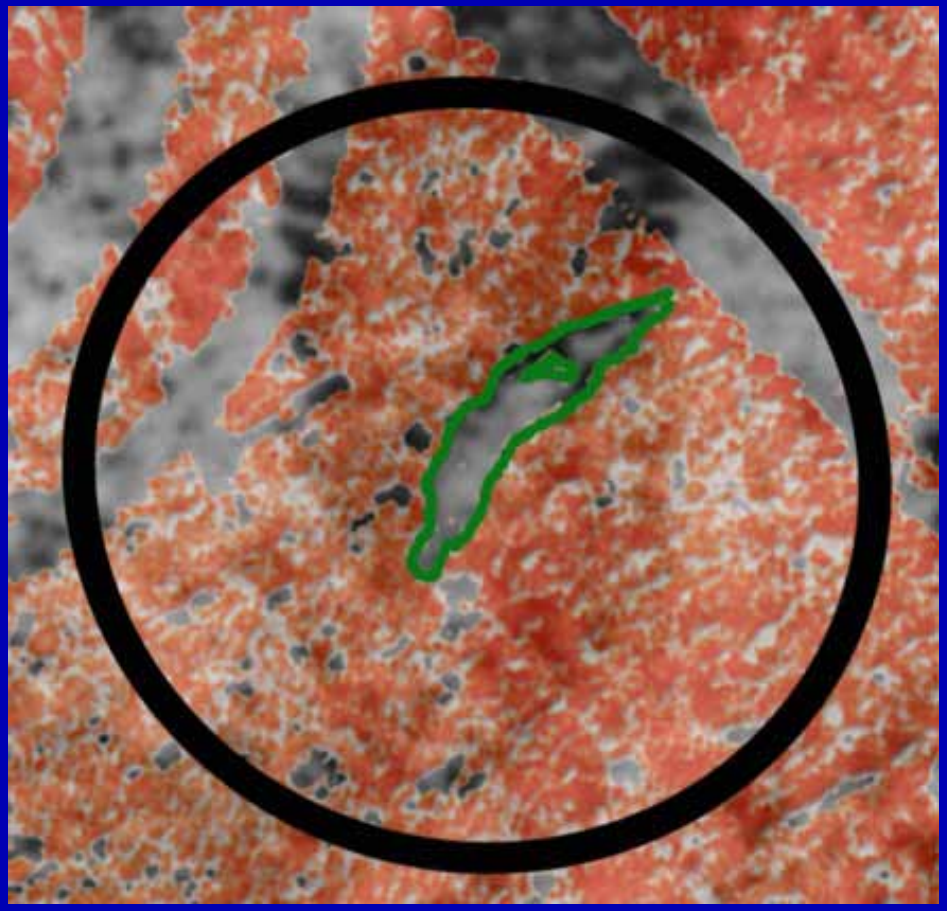
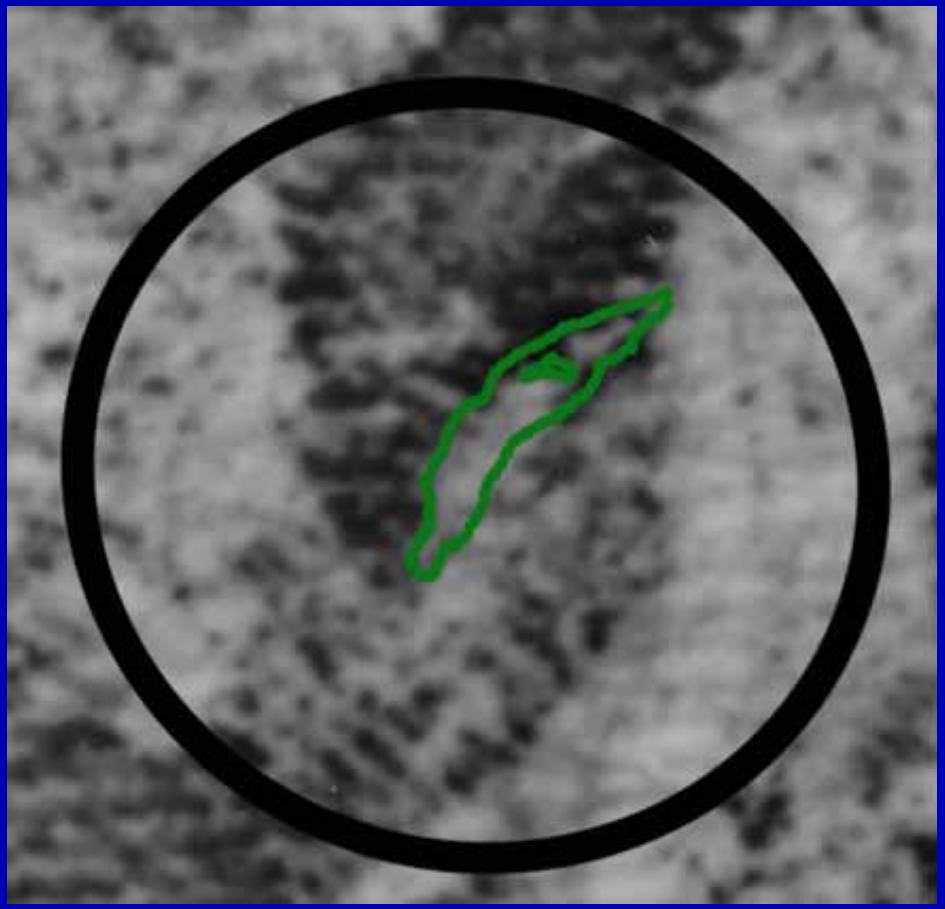
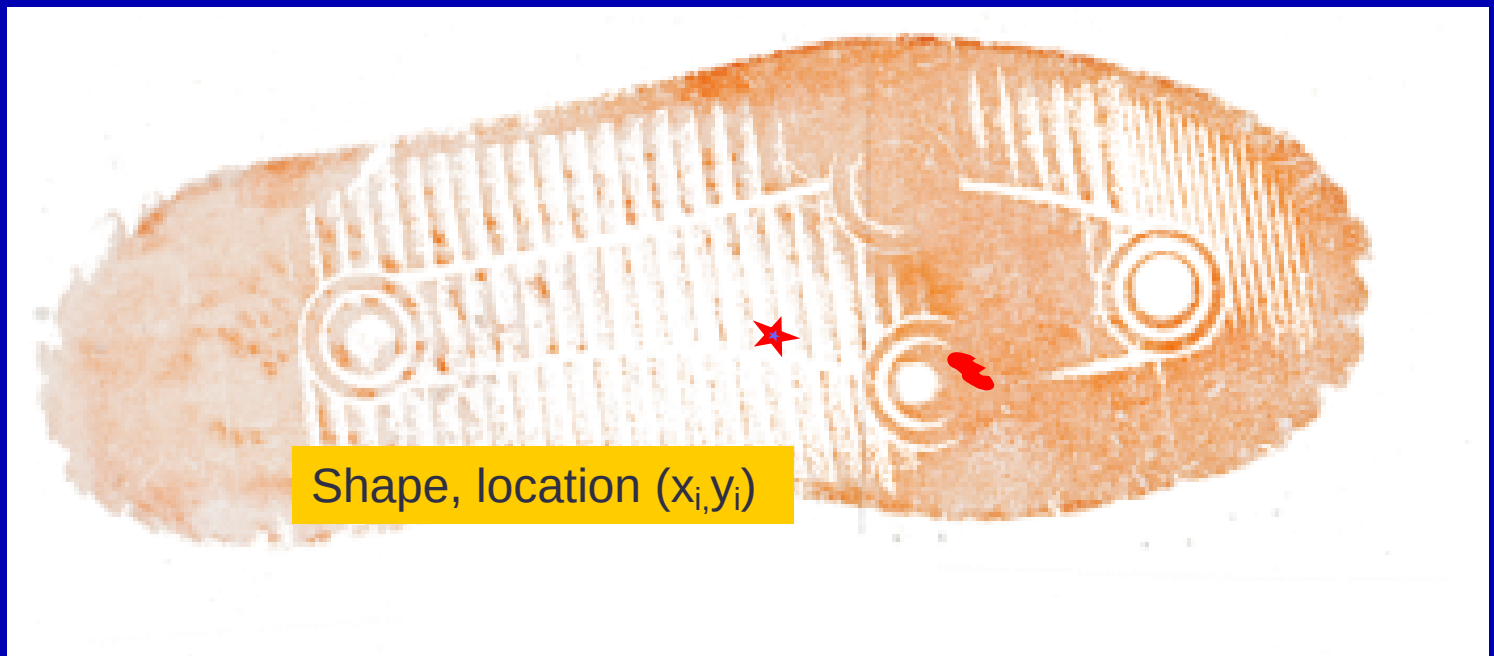




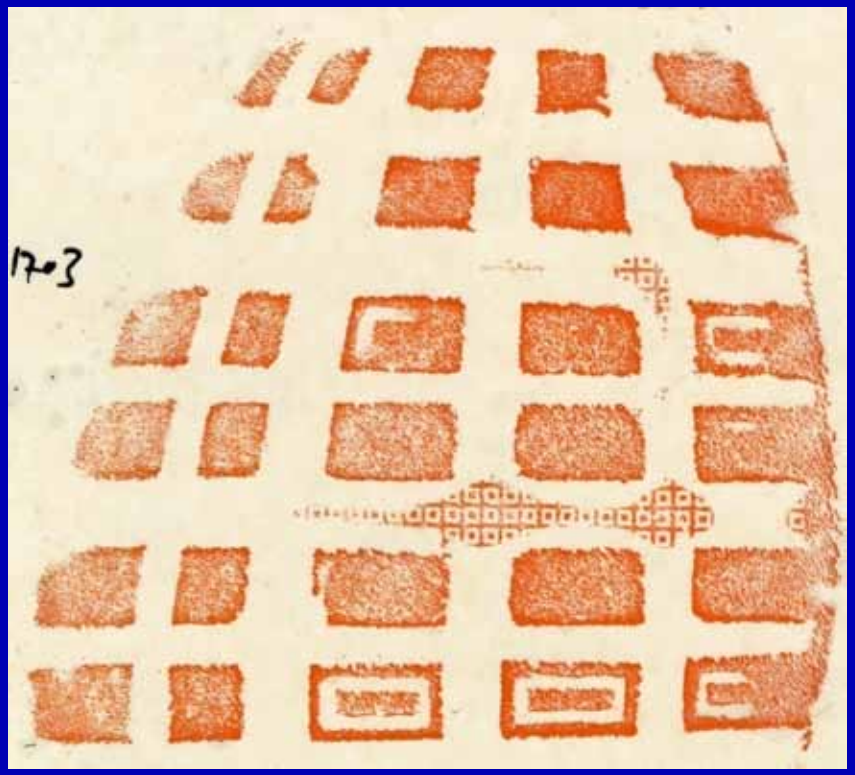
Impression and Pattern Evidence
Symposium 2010

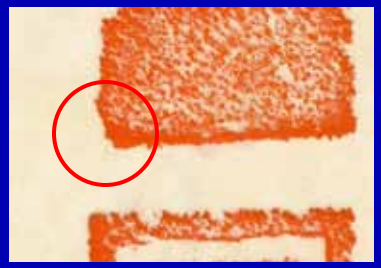
# Shape and location

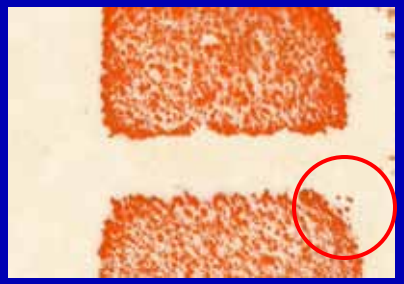


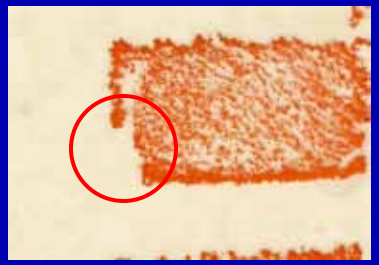

Fracture lines contain characteristic material-based elements.

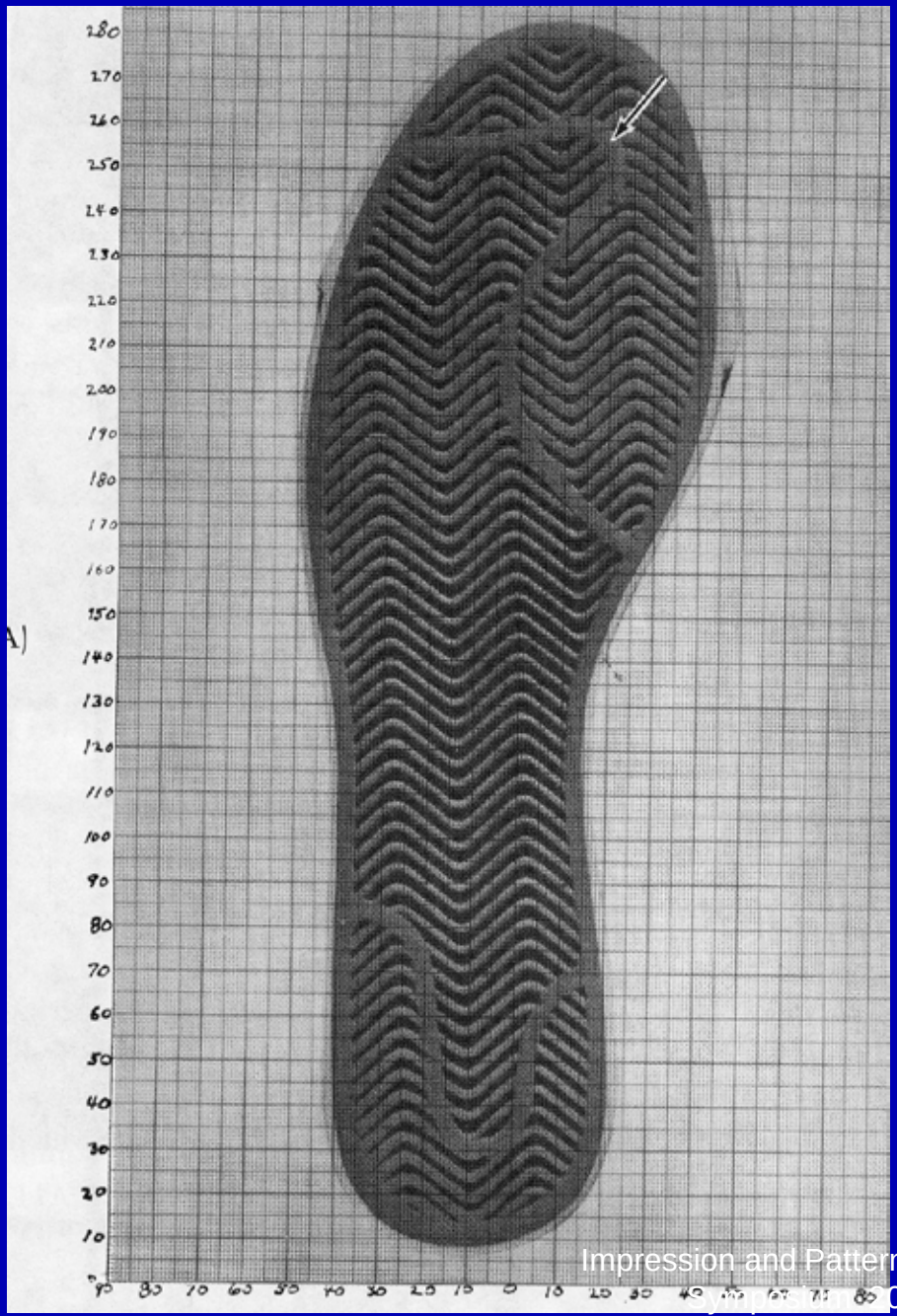
# materials based characteristics elements



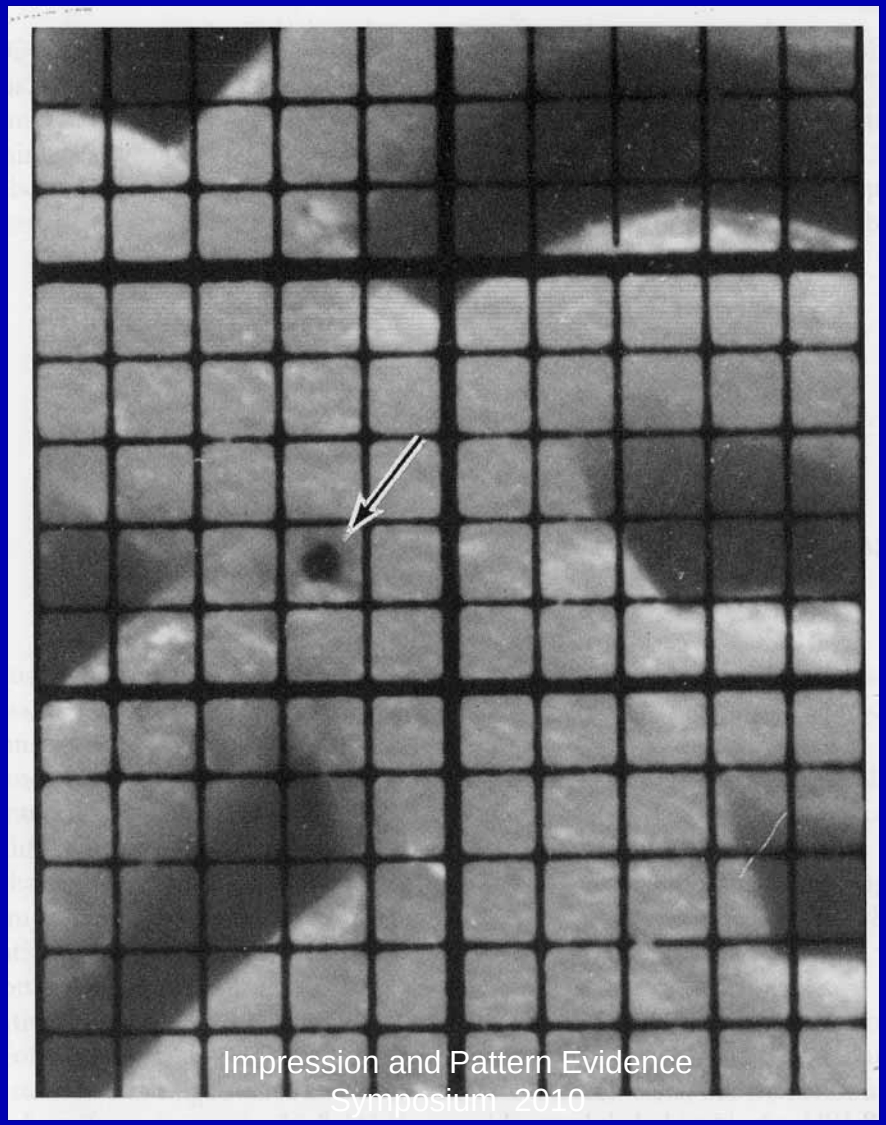






# A typical shoe on a grid

# A pinpoint characteristic



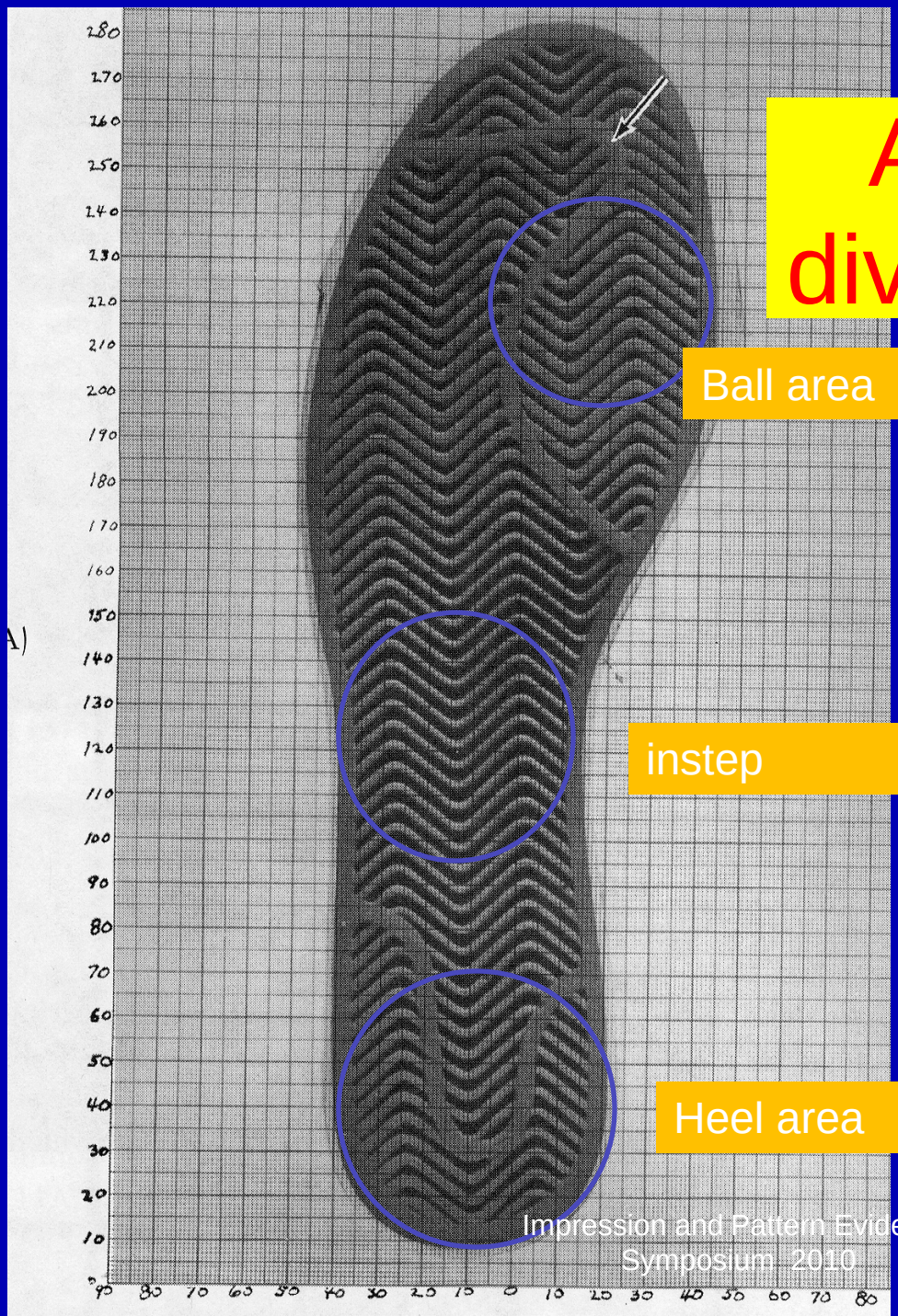
# Theoretical calculations

We put a grid of 16,000 sq. mm. on the shoe.
Assuming equal distribution etc.
…the chances for more than one characteristic are:

| Number of characteristics | Chance of combined occurrence |
|---|---|
| 2 | 1 out of 127,992,000 |
| 3 | 1 out of 683 billion |
| 4 | 1 out of 2.7 quadrillion |
| 5 | 1 out of 8.7 quintillion |
| 6 | 1 out of 23 sextillion |
| 7 | 1 out of 53 septillion |
| 8 | 1 out of 106 octillion |
| 9 | 1 out of 189 nontillion |
| 10 | 1 out of 300 decillion |

Source: Bodziak, pp 344

# A typical shoe divided into areas



# Flexible grid