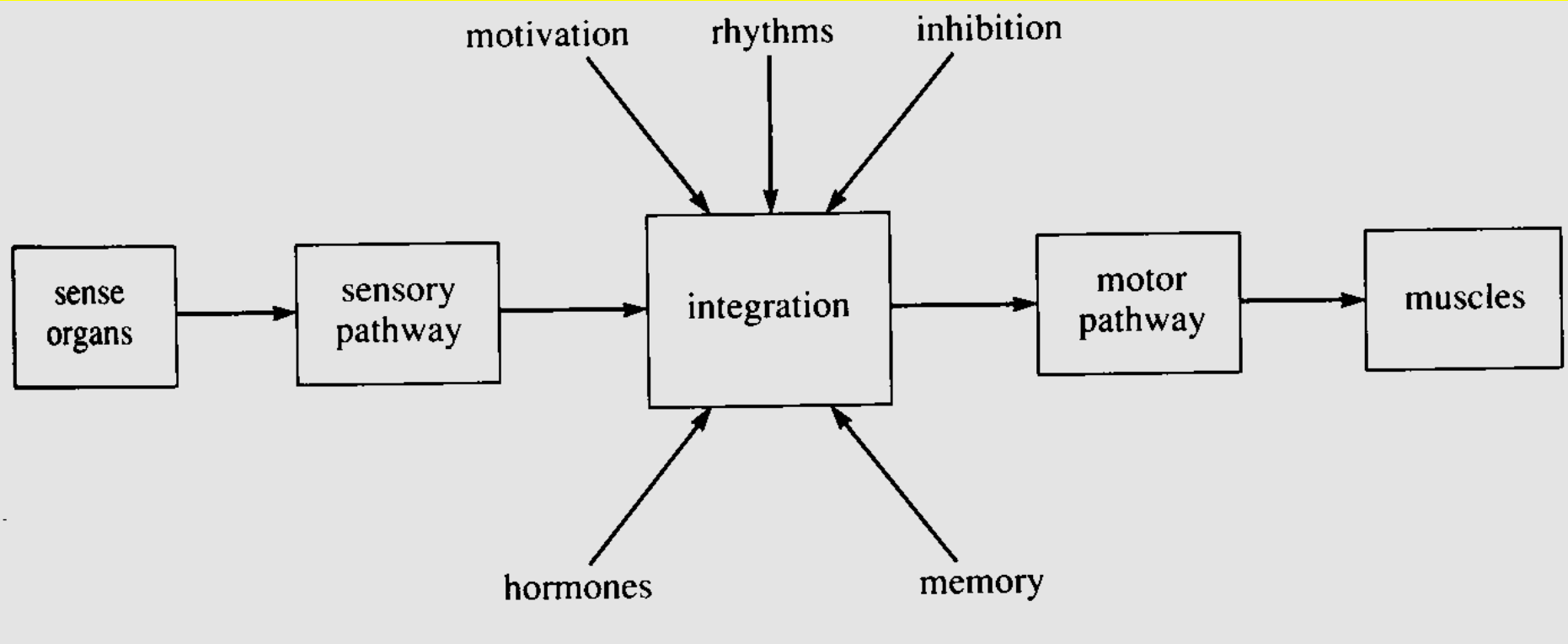
Neuroetologie a smyslová neurofyziologie
Behaviorální neurobiologie

http://nelson.beckman.uiuc.edu/courses/neuroethol/
http://web.neurobio.arizona.edu/gronenberg/nrsc581/index.html
http://instruct1.cit.cornell.edu/courses/bionb424/links.htm
http://www.biol.sc.edu/~vogt/courses/neuro/neurobehavior.html

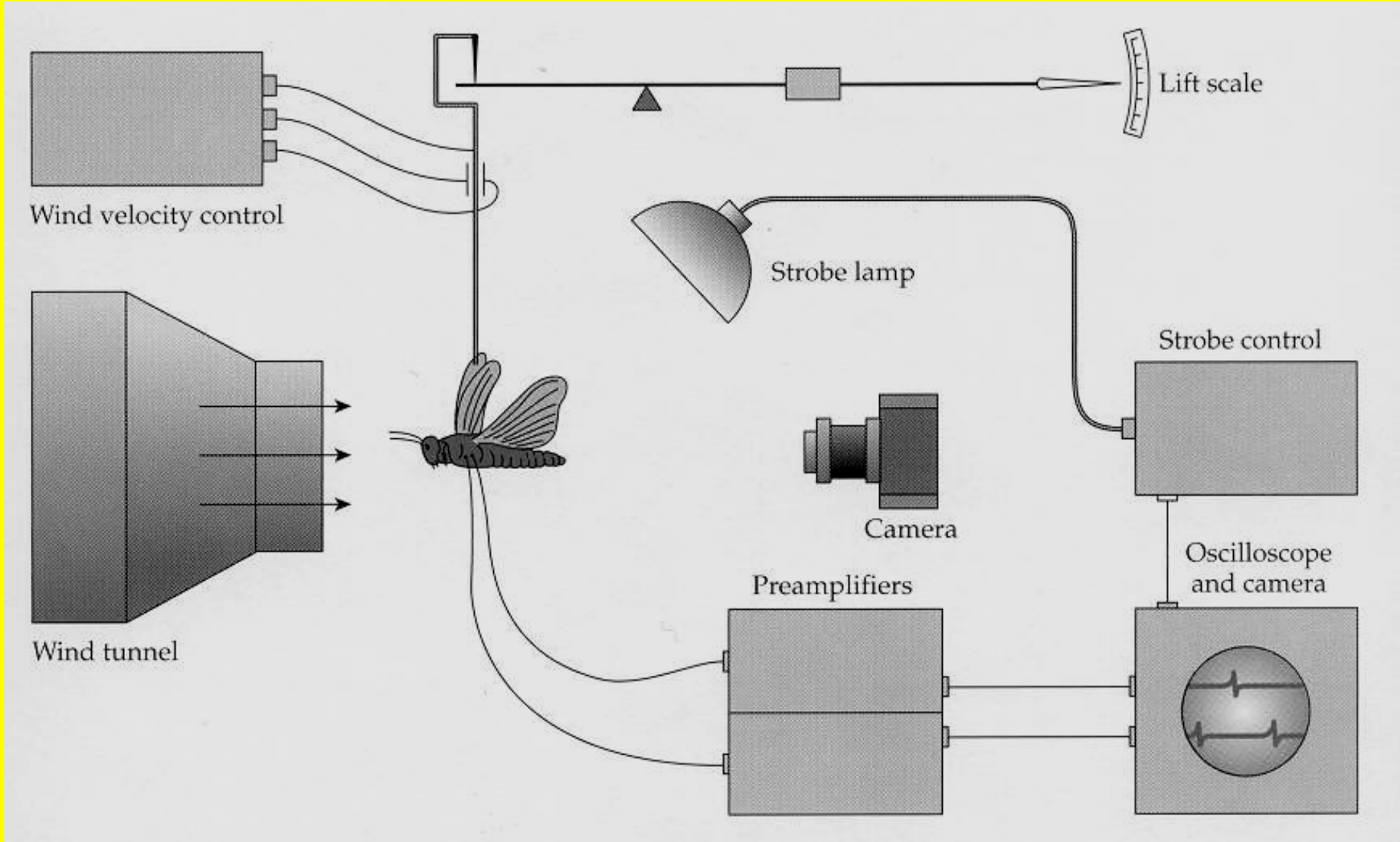
Vztah mezi nervovým systémem a chováním je velmi těsný



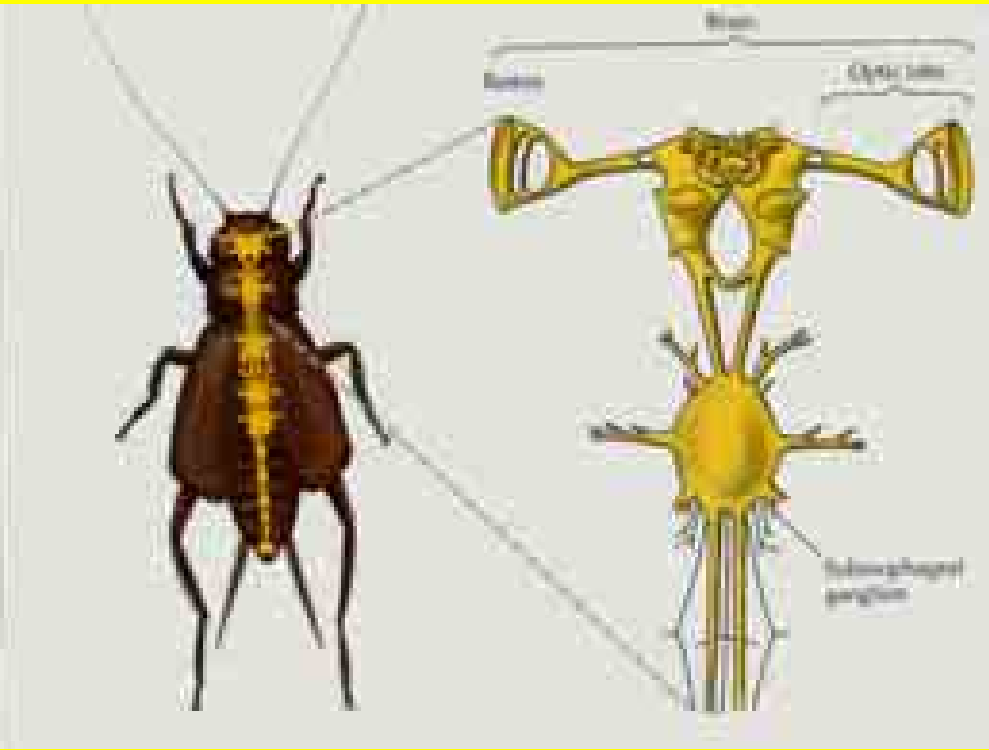
Problémy neurofyziologie se často zkoumají sledováním chování:

- Pohyb
- Cirkadiánní rytmy
- Smyslové schopnosti
- Působení drog a farmak
- Agresivita
- Stárnutí
- Paměť a učení ...

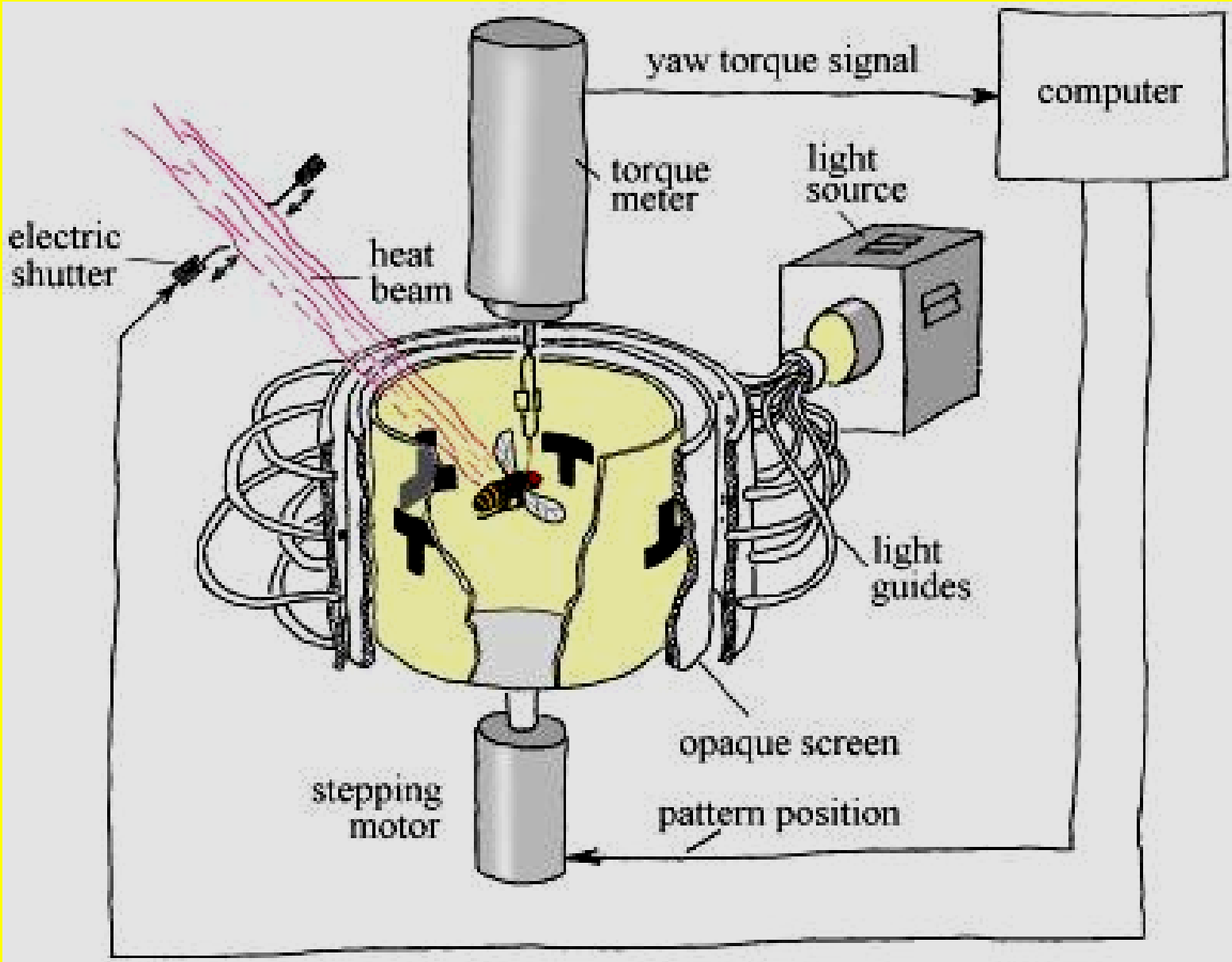
Pohyb

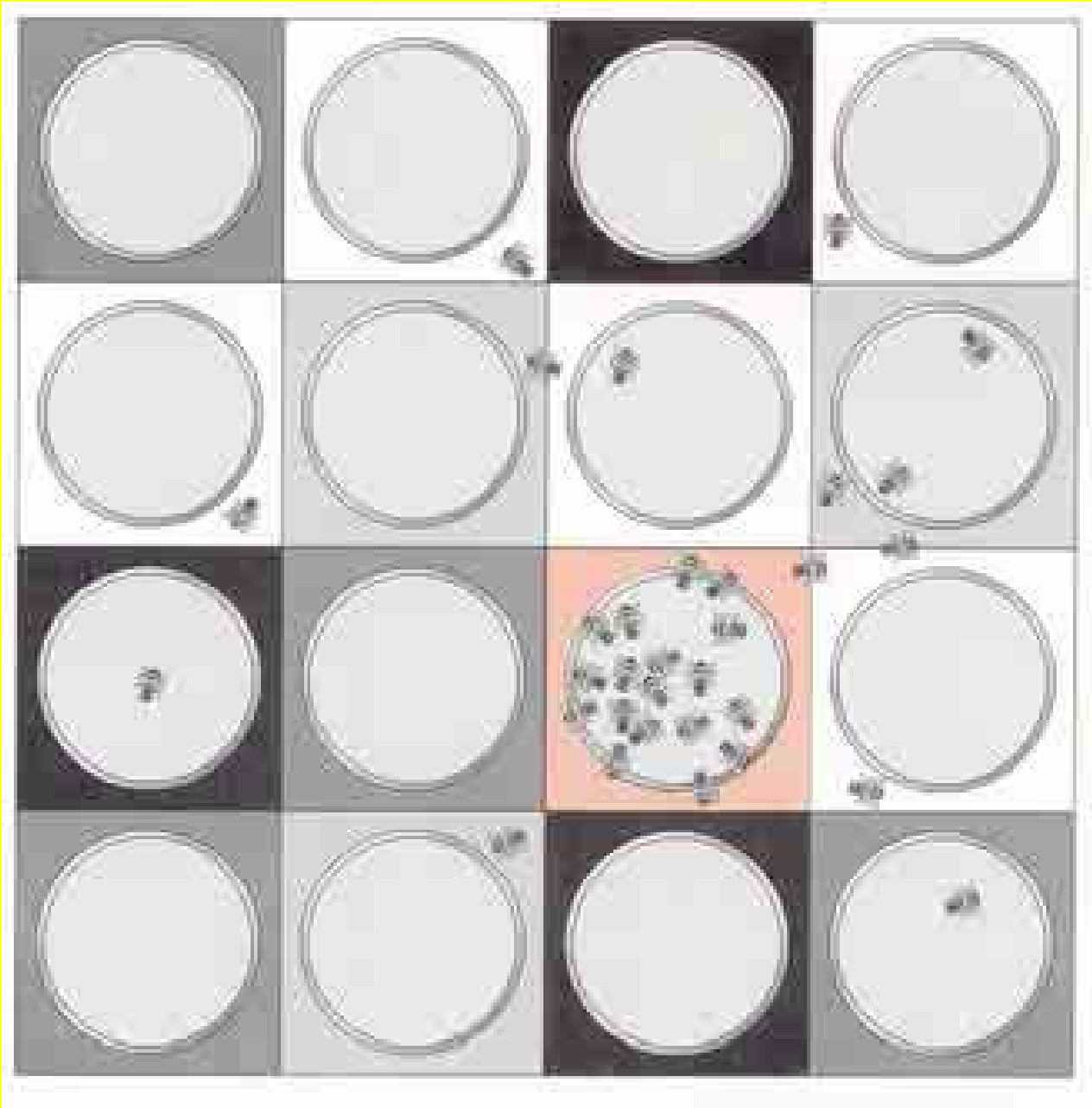

Lift scale
Wind velocity control
Strobe lamp
Strobe control
Camera
Oscilloscope
and camera
Preamplifiers
Wind tunnel

Cirkadiánní rytmy

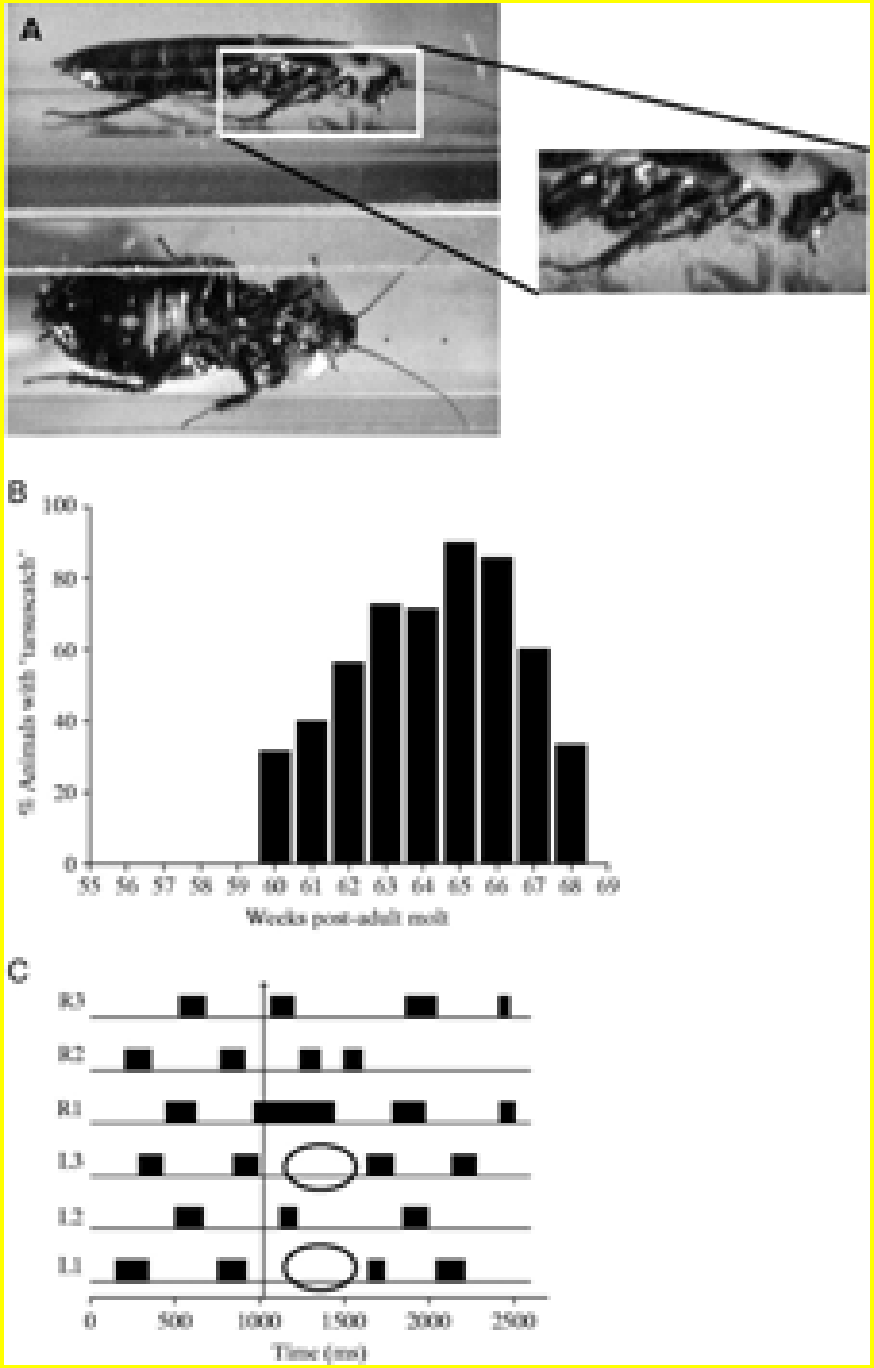


Smyslové schopnosti





Stárnutí


A
B
100
80
60
40
20
0
55 56 57 58 59 60 61 62 63 64 65 66 67 68 69
Weeks post-adult molt
C
R3
R2
R1
L3
L2
L1
0 500 1000 1500 2000 2500
Time (ms)

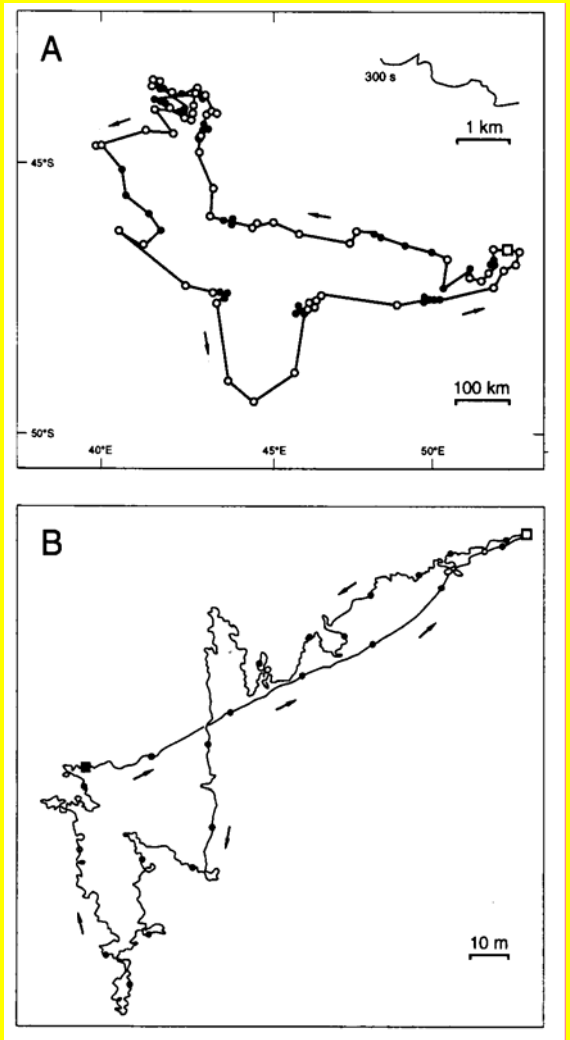
Agresivita

Působení drog a farmak

Mutace genu pro mateřské chování

Sociální deprivace

Orientace a navigace živočichů



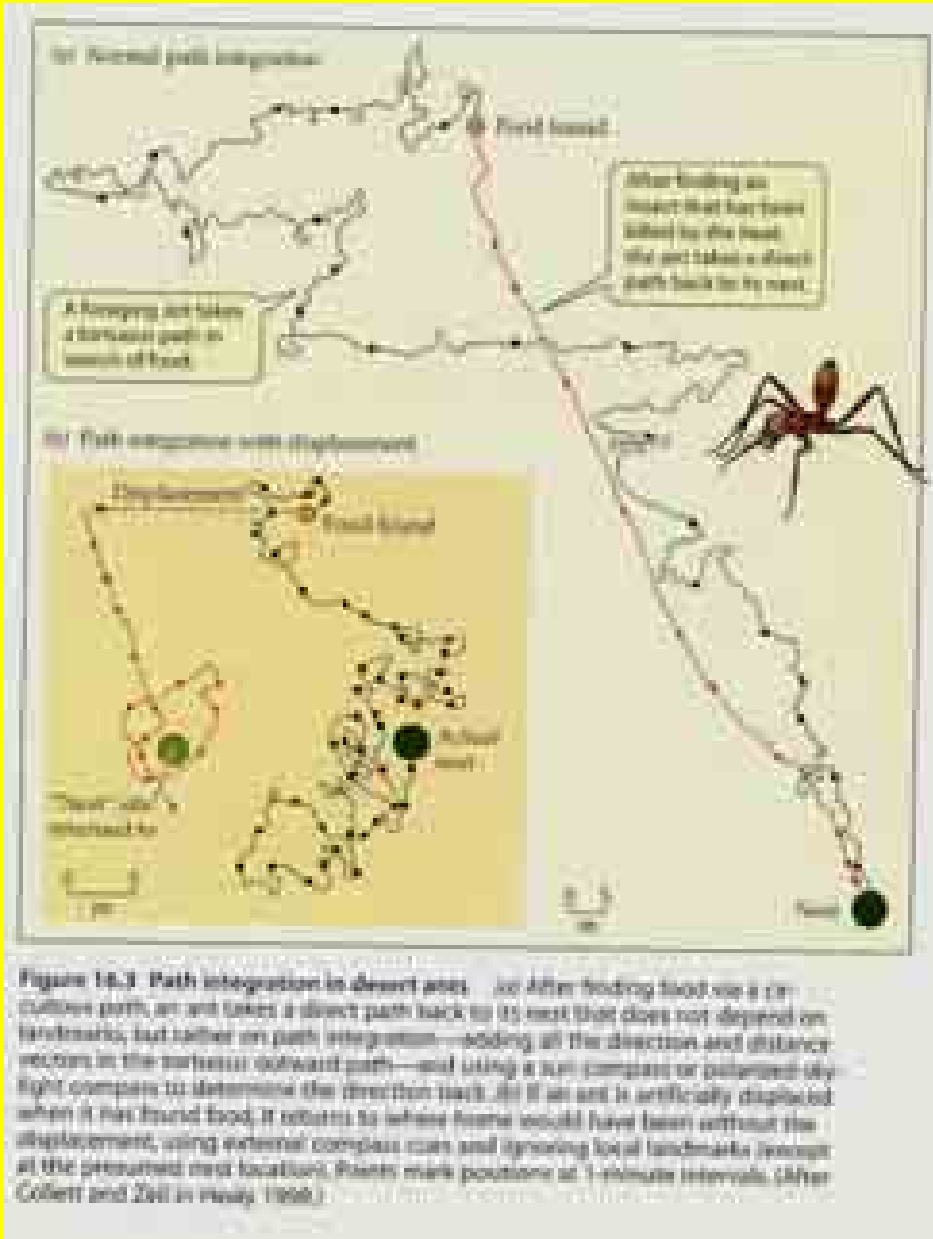


Figure 16.3 Path integration in desert ants. (a) After finding food via a circuitous path, an ant takes a direct path back to its nest that does not depend on landmarks, but rather on path integration—adding all the direction and distance vectors in the tortuous outward path—and using a sun compass or polarized sky light compass to determine the direction back. (b) If an ant is artificially displaced when it has found food, it returns to where home would have been without the displacement, using external compass cues and ignoring local landmarks (except at the presumed nest location). Points mark positions at 1-minute intervals. (After Collett and Zeil in Healy 1998.)

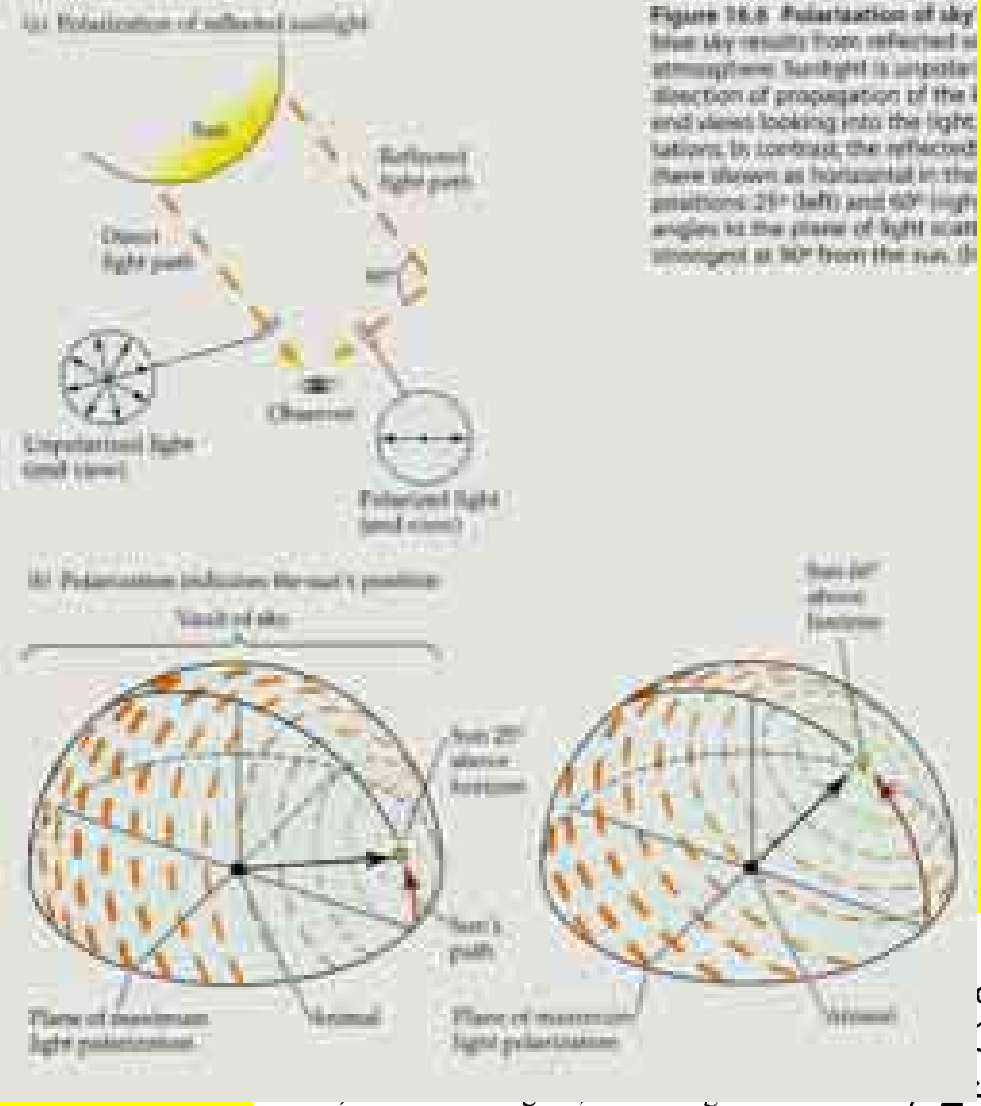
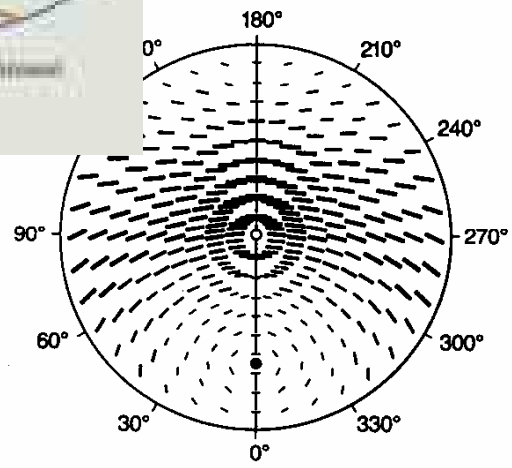
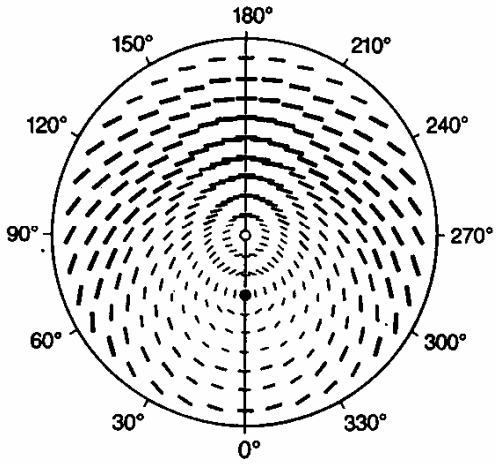


figure. The orientation and size of each black bar mark the angle and degree (percentage) of polarization, respectively. The open circle indicates the zenith. The solar meridian (the line from the zenith down to the horizon) and the anti-solar meridian represent the symmetry plane of the celestial E-vector pattern. From Wehner (1994a).





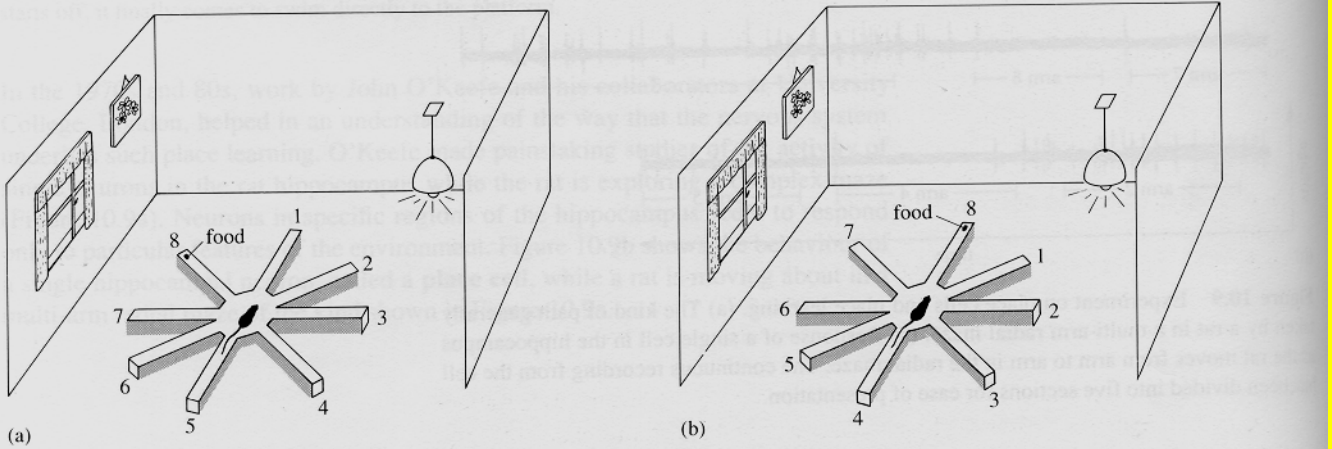
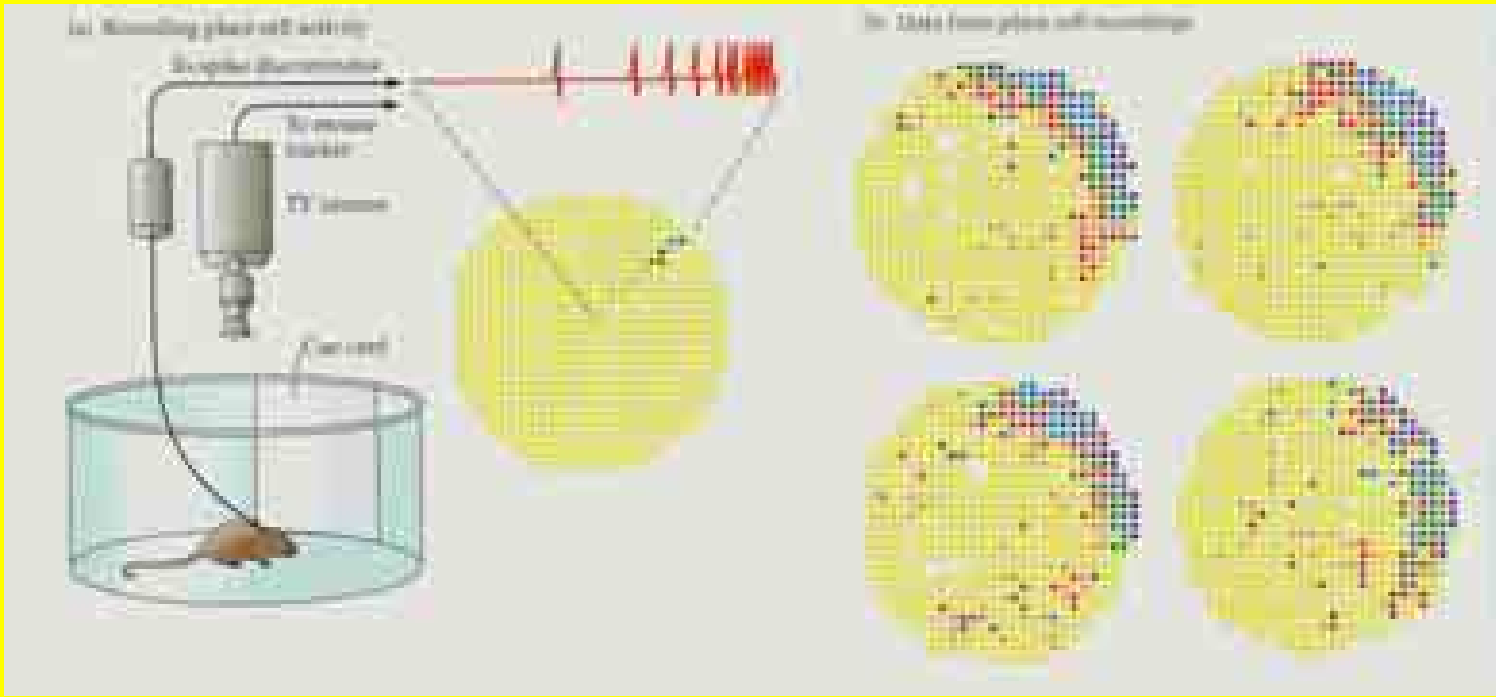
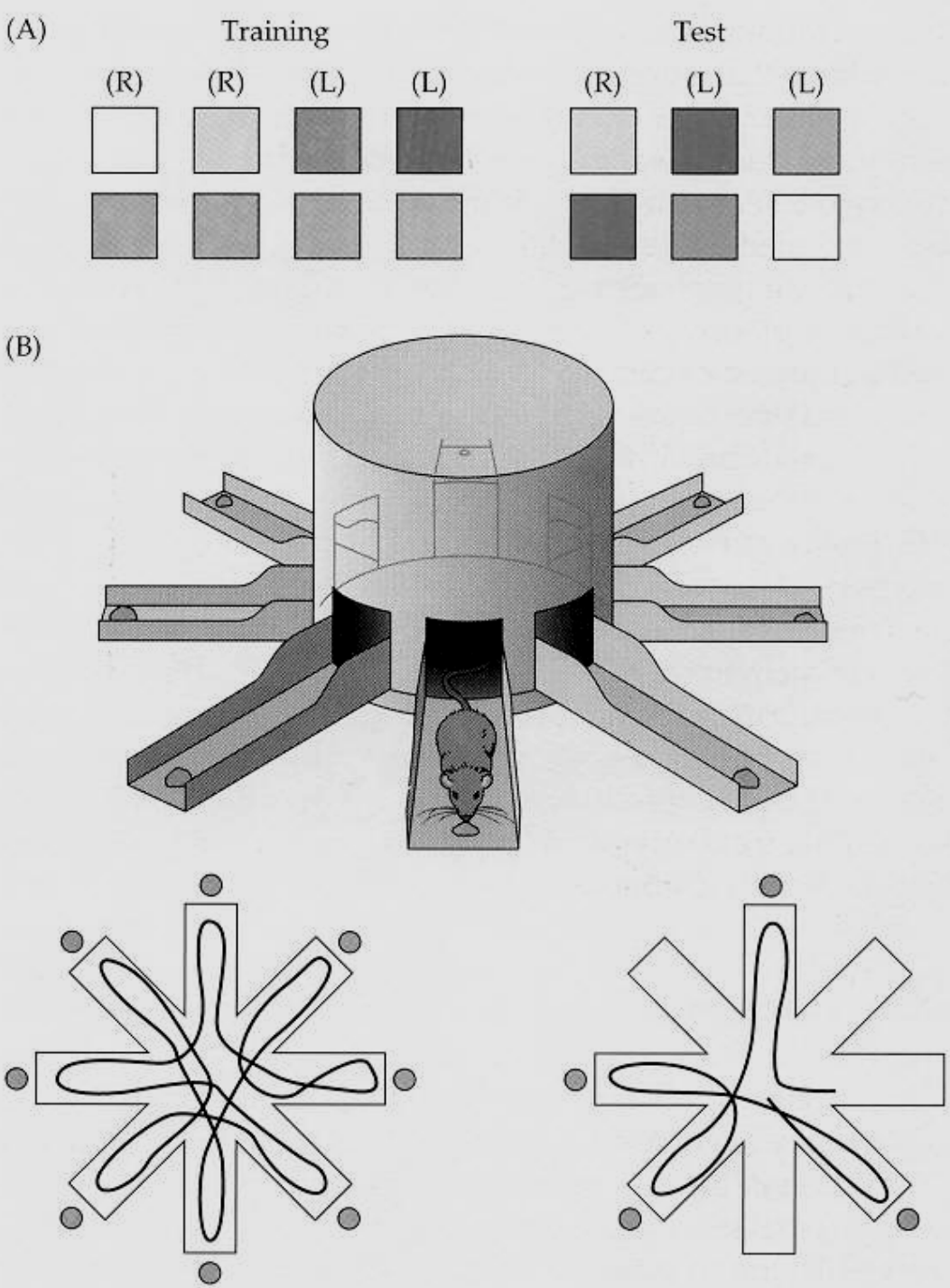
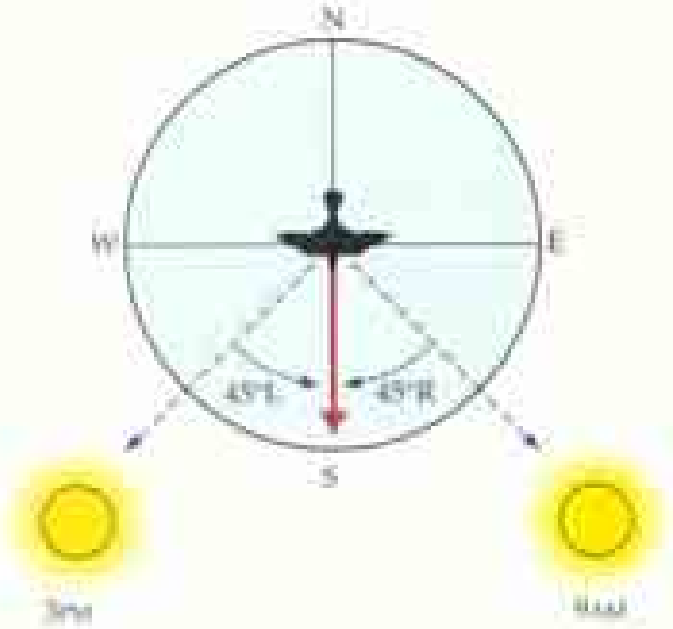


Figure 10.10 Maze used for demonstrating the existence of a cognitive map. (a) The rat depletes arms 1–7 of food. It is then removed from the maze for a short while. (b) The maze is rotated and the rat is returned.



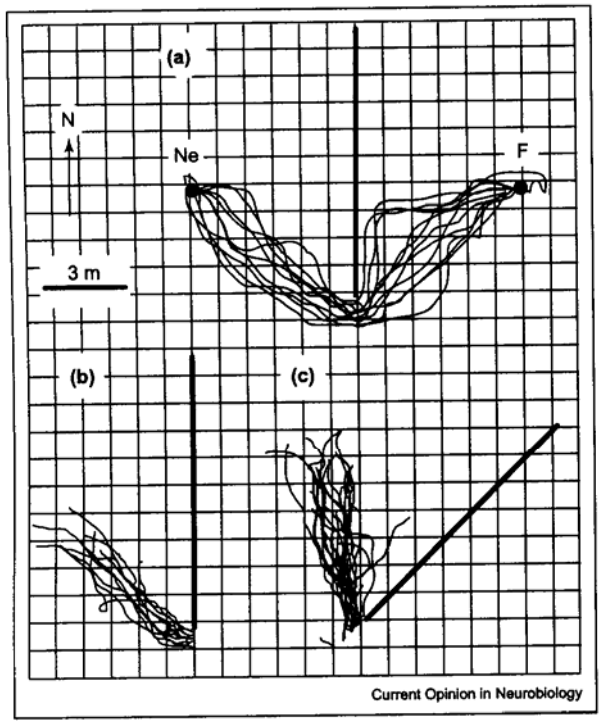

(A)
Training
Test
(R)
(R)
(L)
(L)
(R)
(L)
(L)
(B)

(a) Normal circadian clock



(b) Circadian clock set ahead 6 hours

Figure 1



Routes around a barrier. **(a)** Desert ants performed a detour around a 10 m long barrier on their homeward journey after visiting a feeder 10 m south of their nest. Returning ants about to enter their nest were taken to the end of an identical barrier on a test ground. **(b)** Barrier in test orientation: ants recreate the path that, in training, took them to the nest. **(c)** Barrier rotated through 45°. The ants' path is controlled by the barrier, rather than by their sky compass. (Redrawn from [15].)

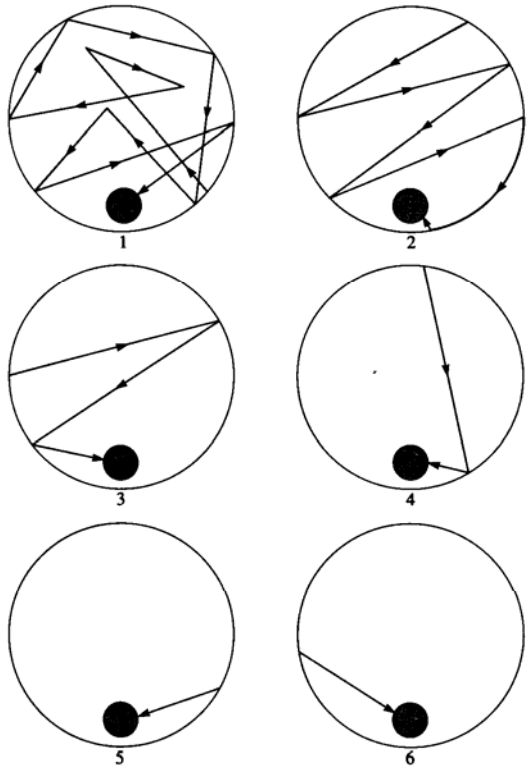
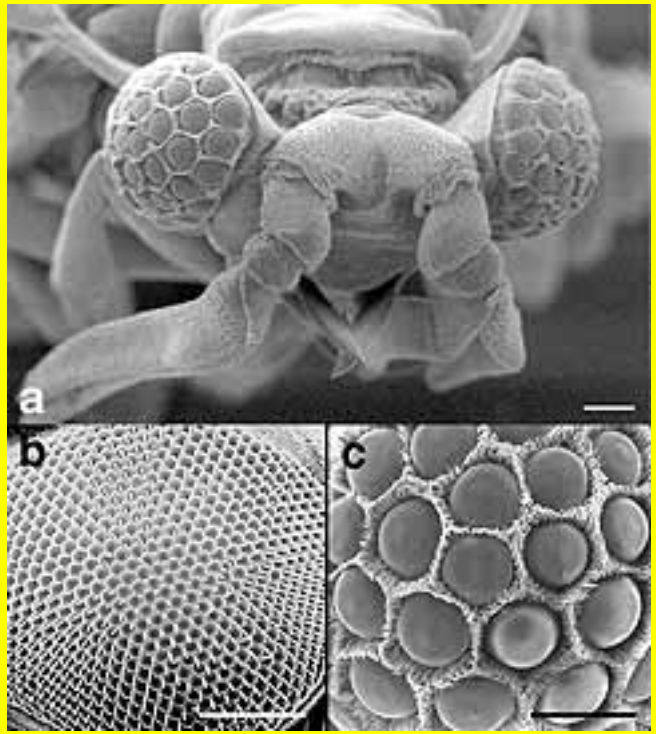


Figure 10.8 The rat's behaviour in the tank employed by Morris. The rat's route over six trials is shown. At first (1) the rat takes a while to locate the submerged platform. Over trials (2)–(6), the improvement in performance is clear. Note that, irrespective of where the rat starts off, it finally comes to swim directly to the platform.

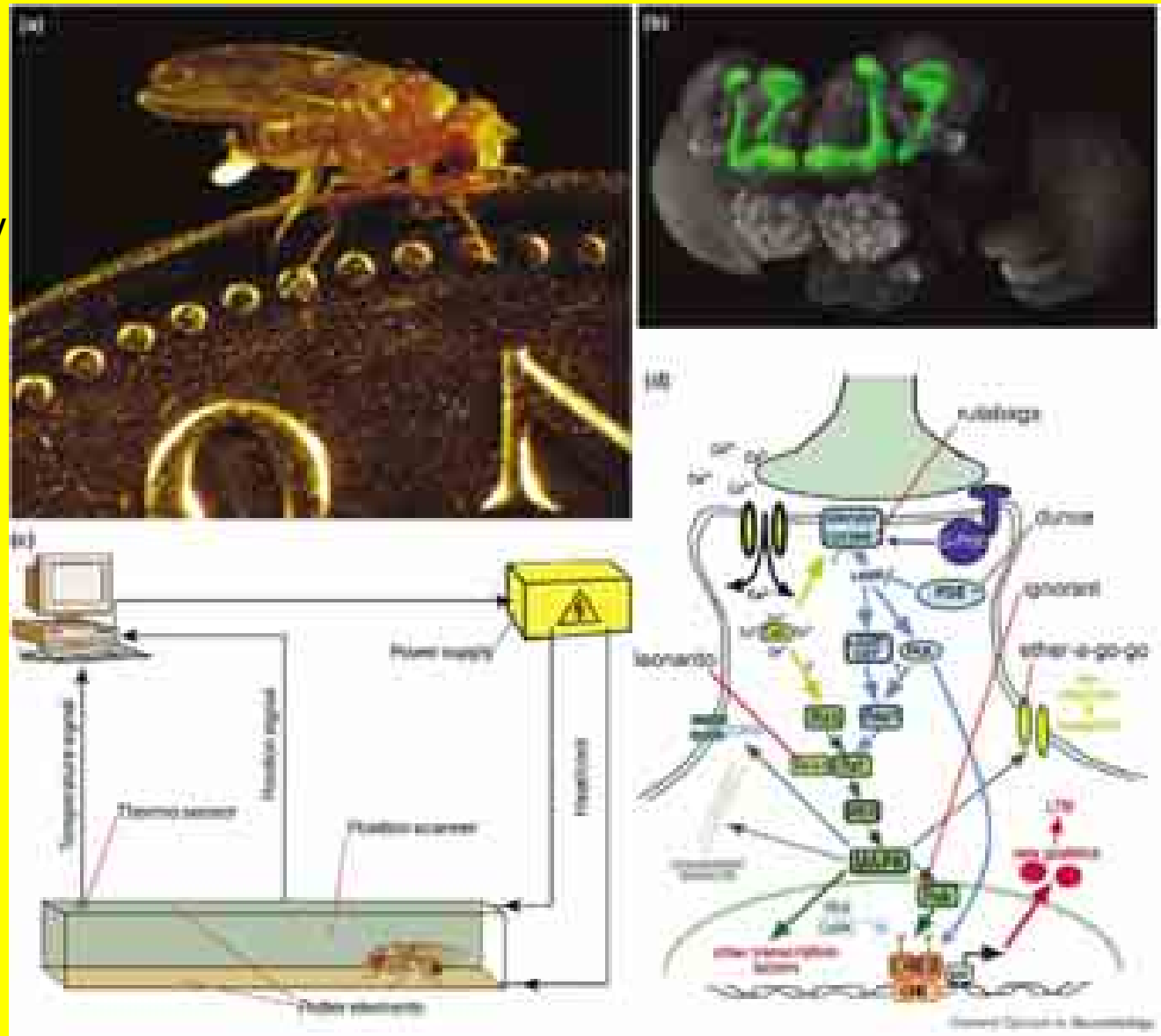
Insects as a model group for sensory neurophysiology

- Extraordinary sensory capabilities
- Simple and well described nervous system
- Easy accessible NS
- Durability of preparates
- Some species easily reared in lab
- Almost unlimited numbers of animals
- No animal rights paperwork yet



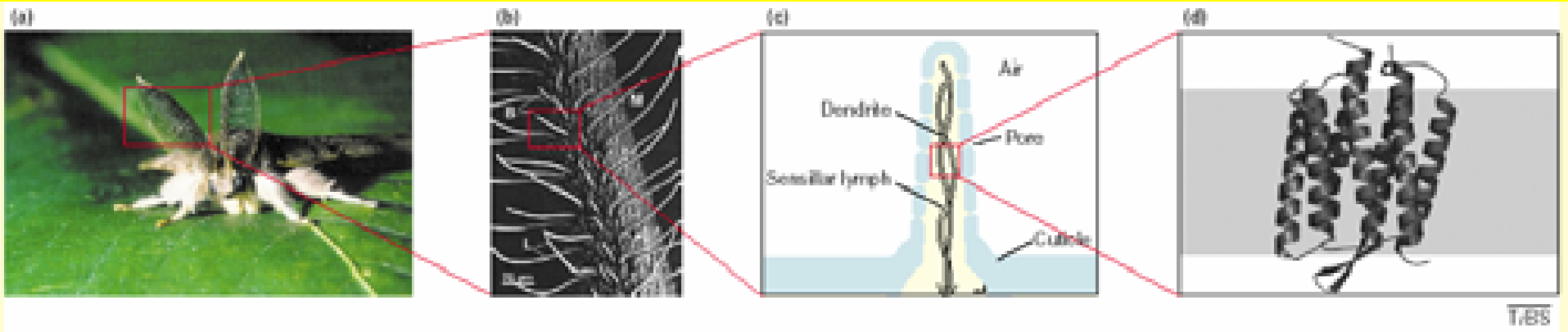
Behavioral assay precedes neuro- and molecular approaches

- Electrophysiology
- Immunohistochemistry
- Genetics
- Transcription factors
- Lesions
- etc.



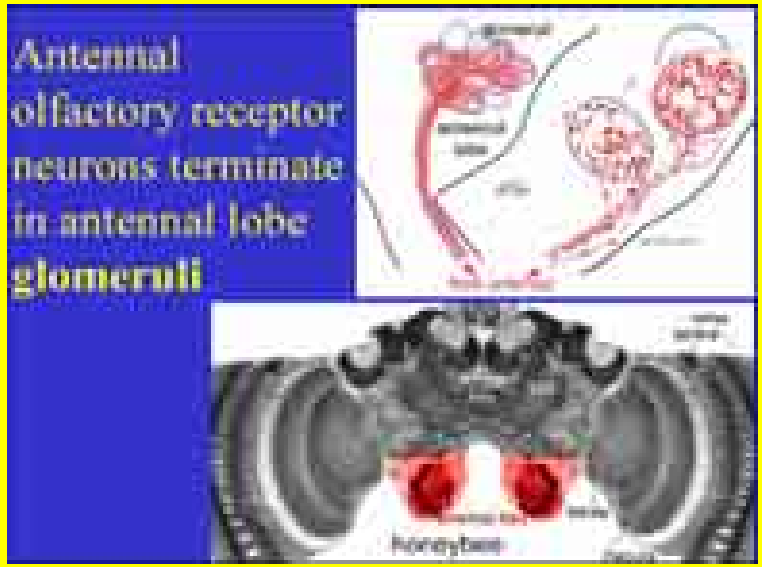
From: Brembs, B.“ : (2003) Operant conditioning in invertebrates. Current Opinion in Neurobiology, 13, 710-717.

Insects as a model for analysis of reception and signal processing

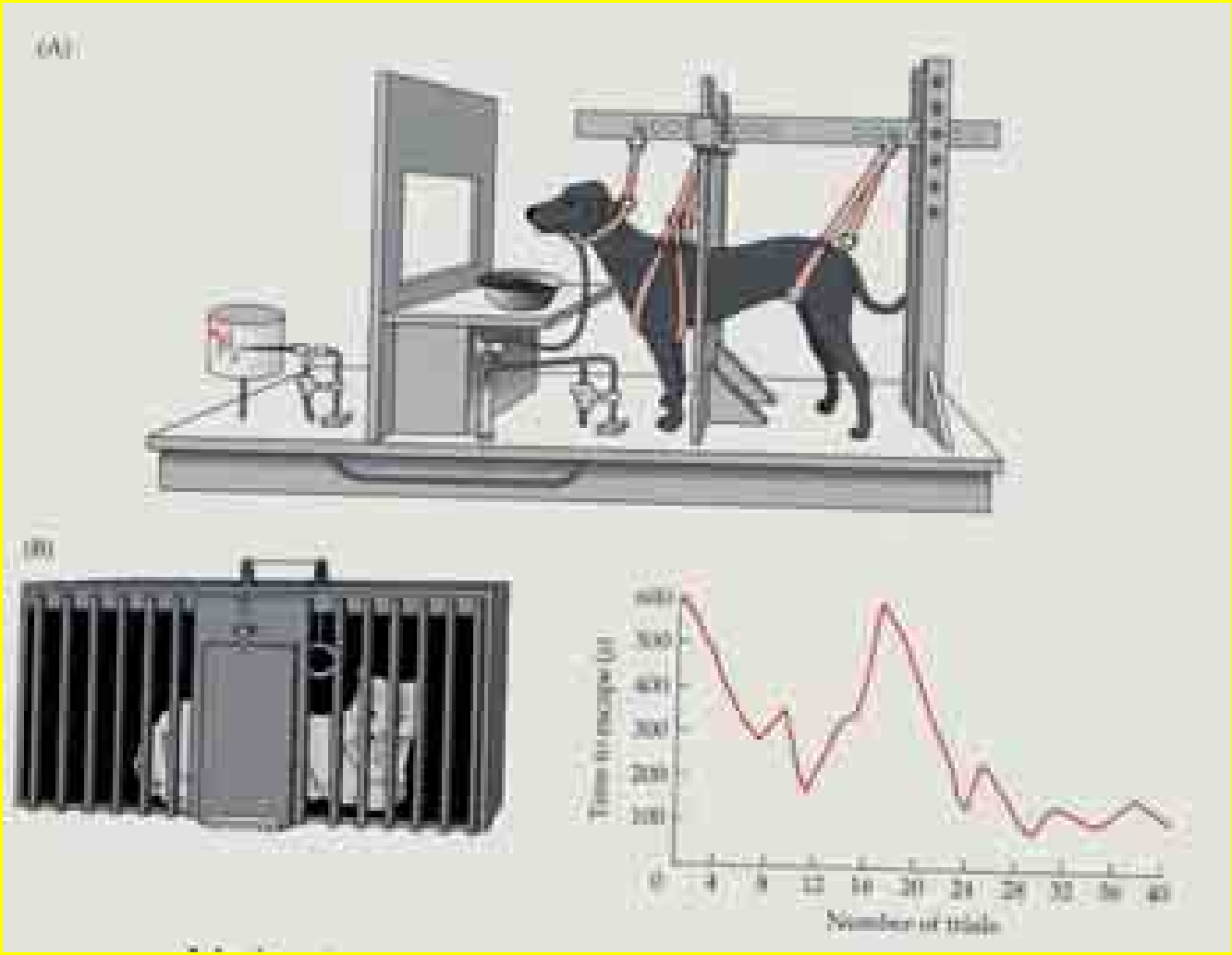


From: Tegoni.M, Campanacci, V., Cambillau, Ch.: (2004) Operant conditioning in invertebrates. TRENDS in Biochemical Sciences Vol.29 No.5 May 2004.

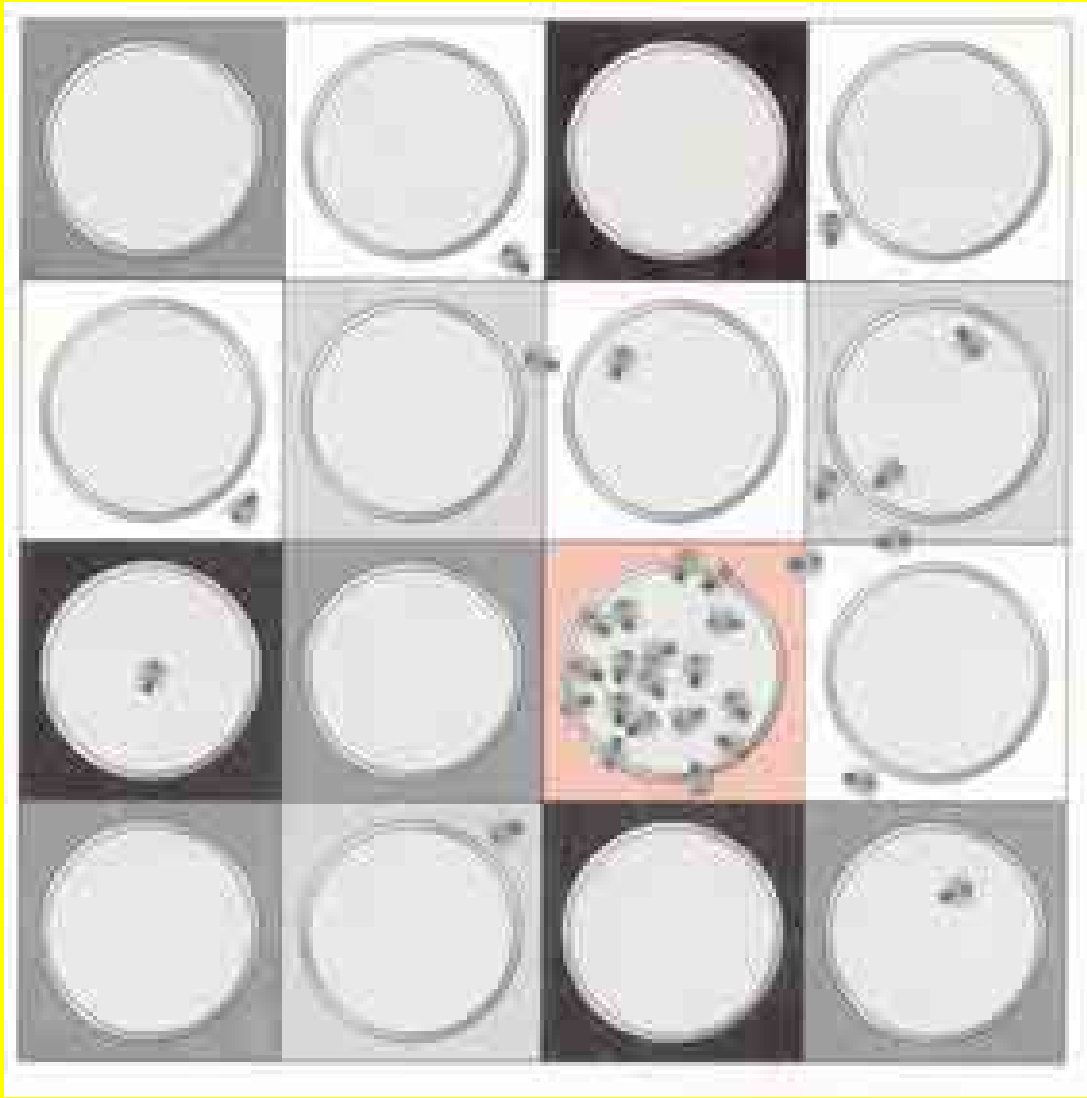
- Chemoreception
- Mechanoreception
- Polarised light
- IR detection
- Memory



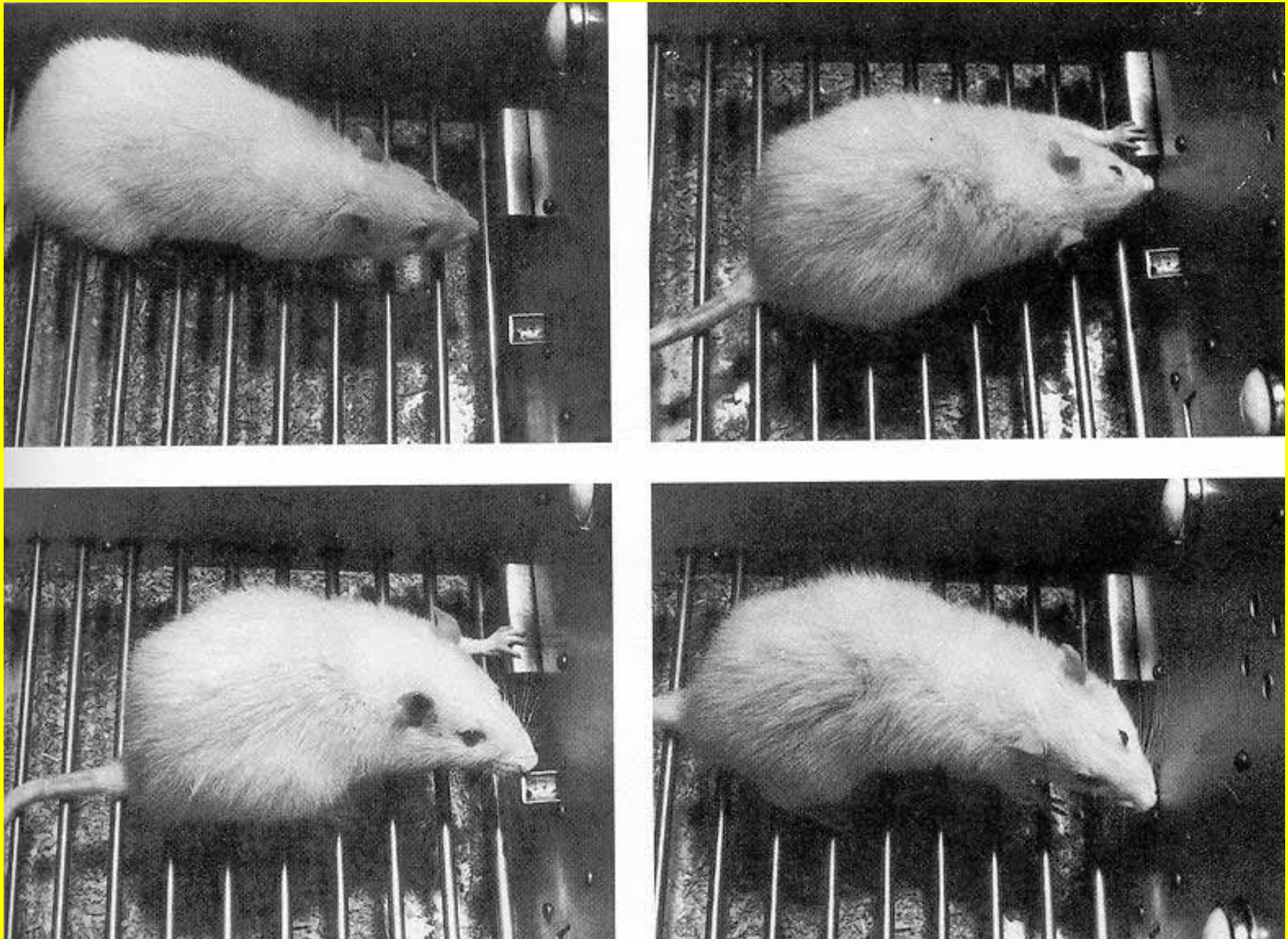
Vytvoření podmíněného spoje mezi dvěma podněty je metodou studia procesů paměti.

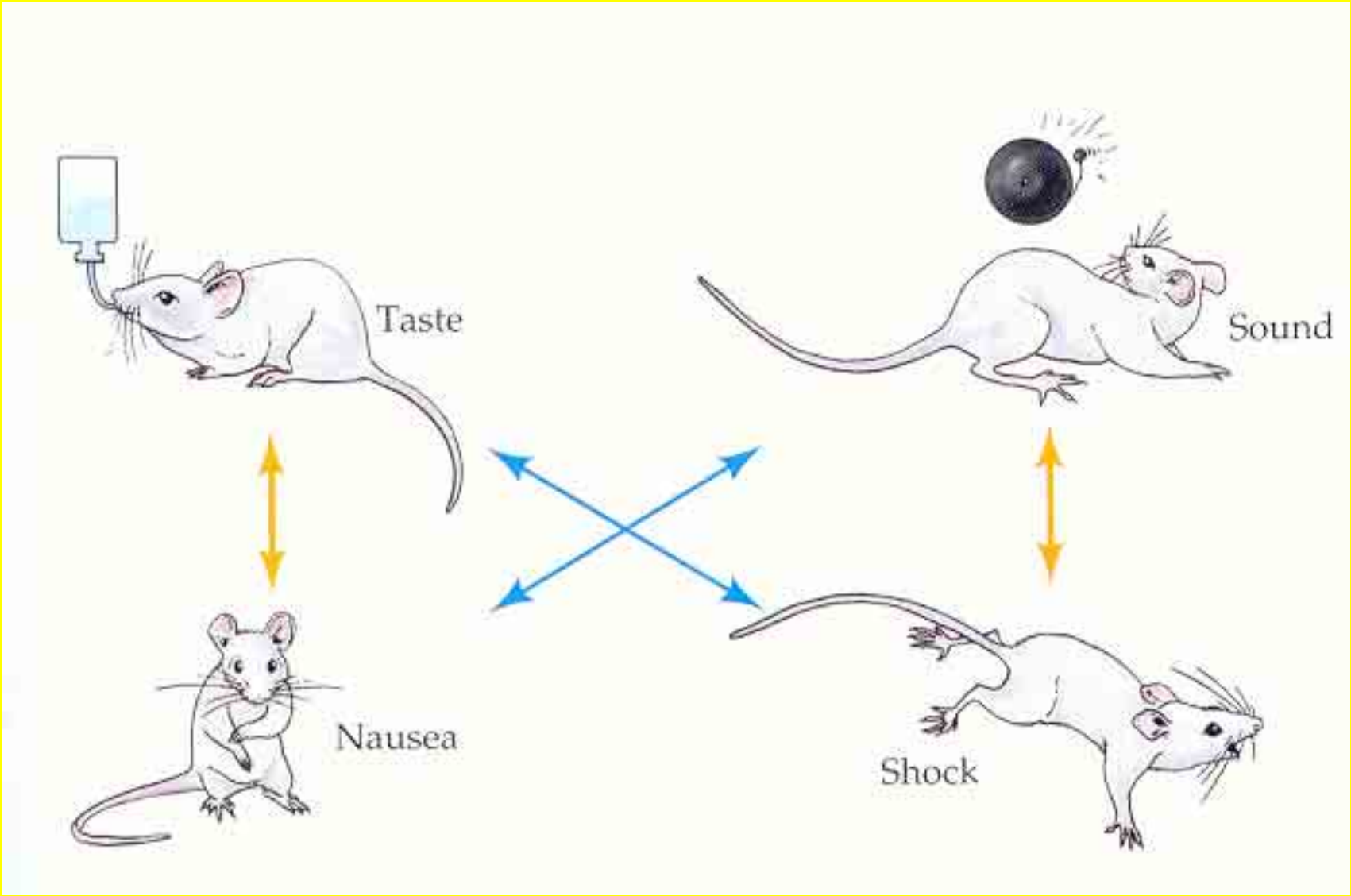


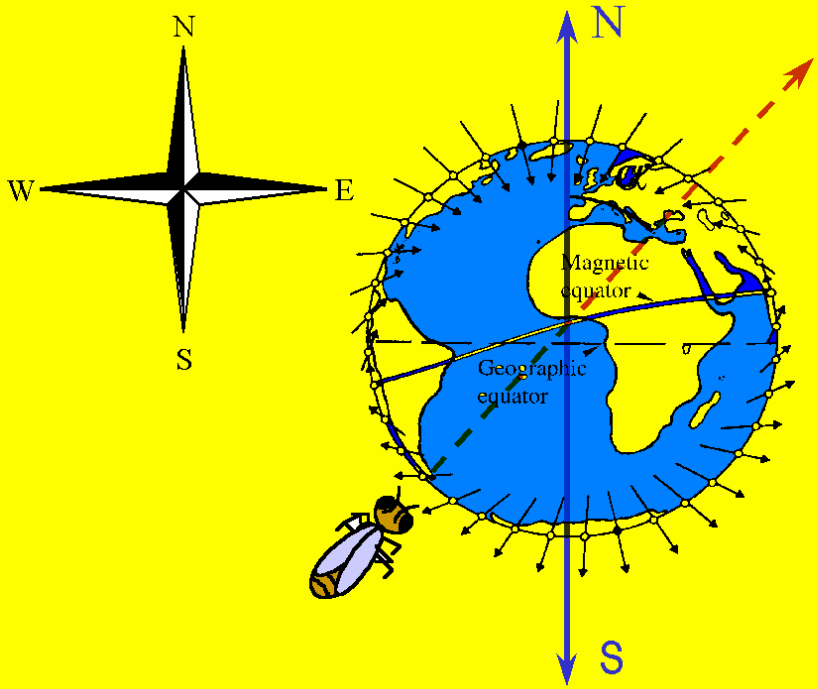
Vytvoření podmíněného spoje mezi dvěma podněty je také metodou studia smyslové percepce.



Odměna a trest

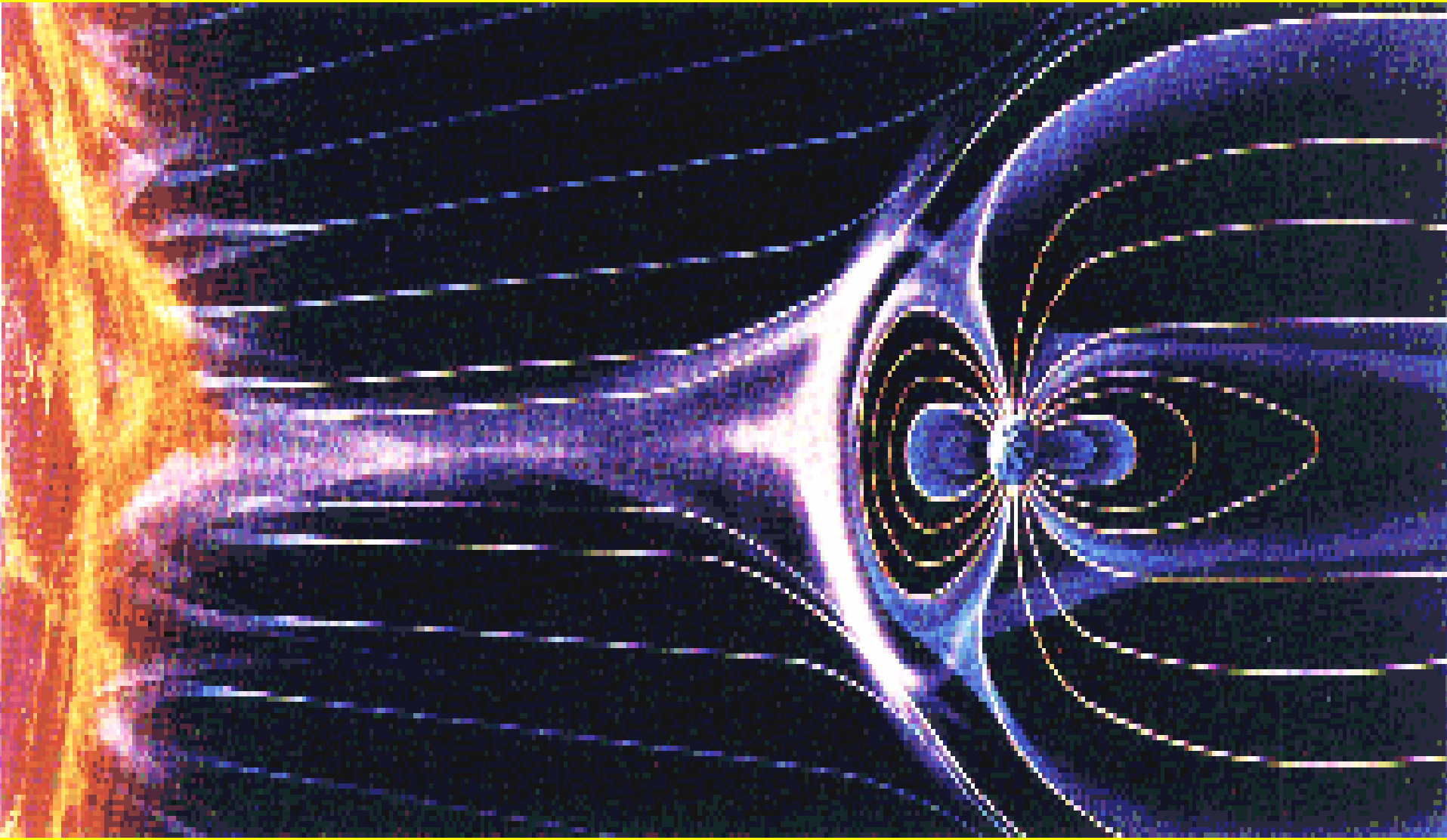



Taste
Sound
Nausea
Shock

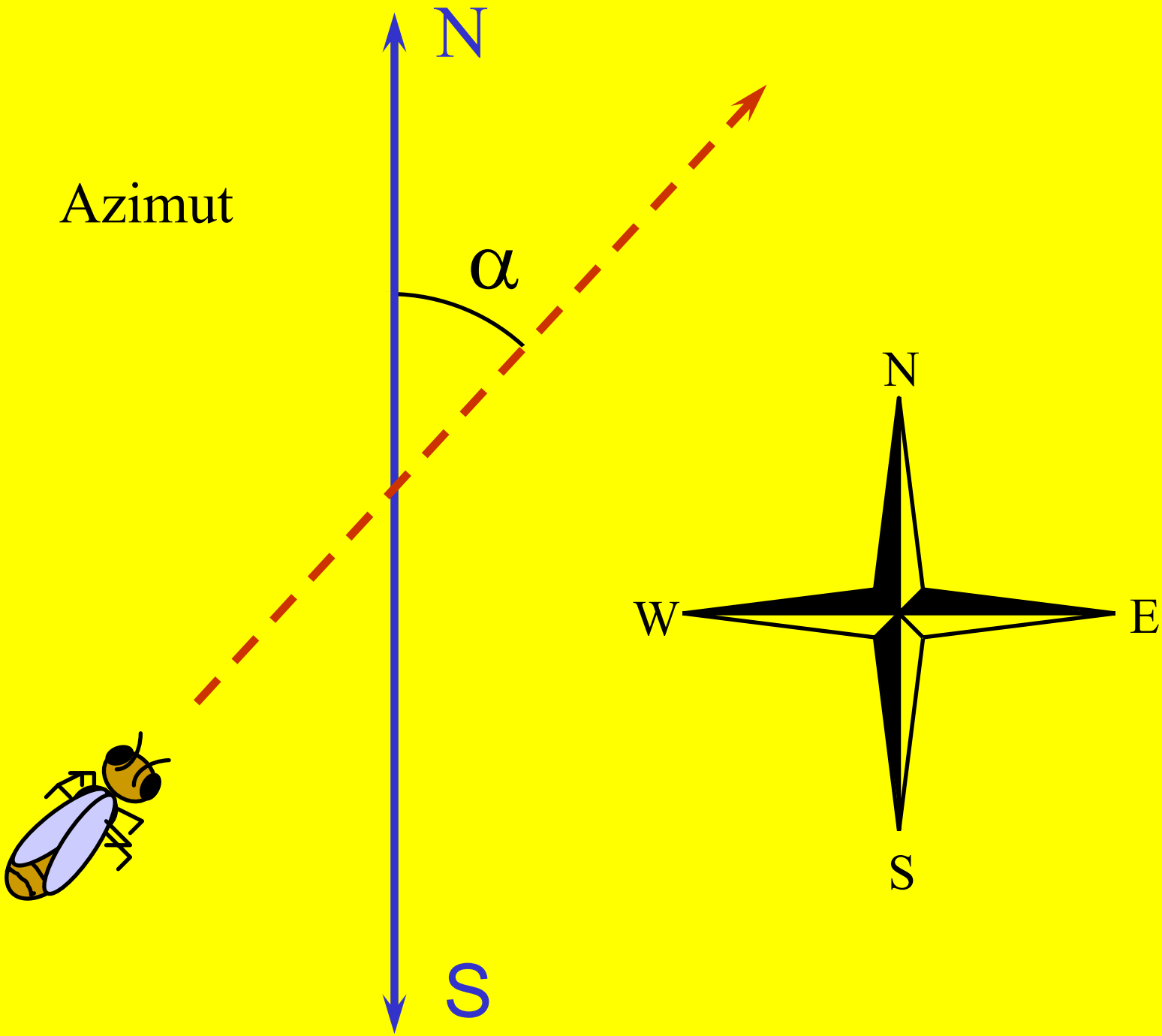


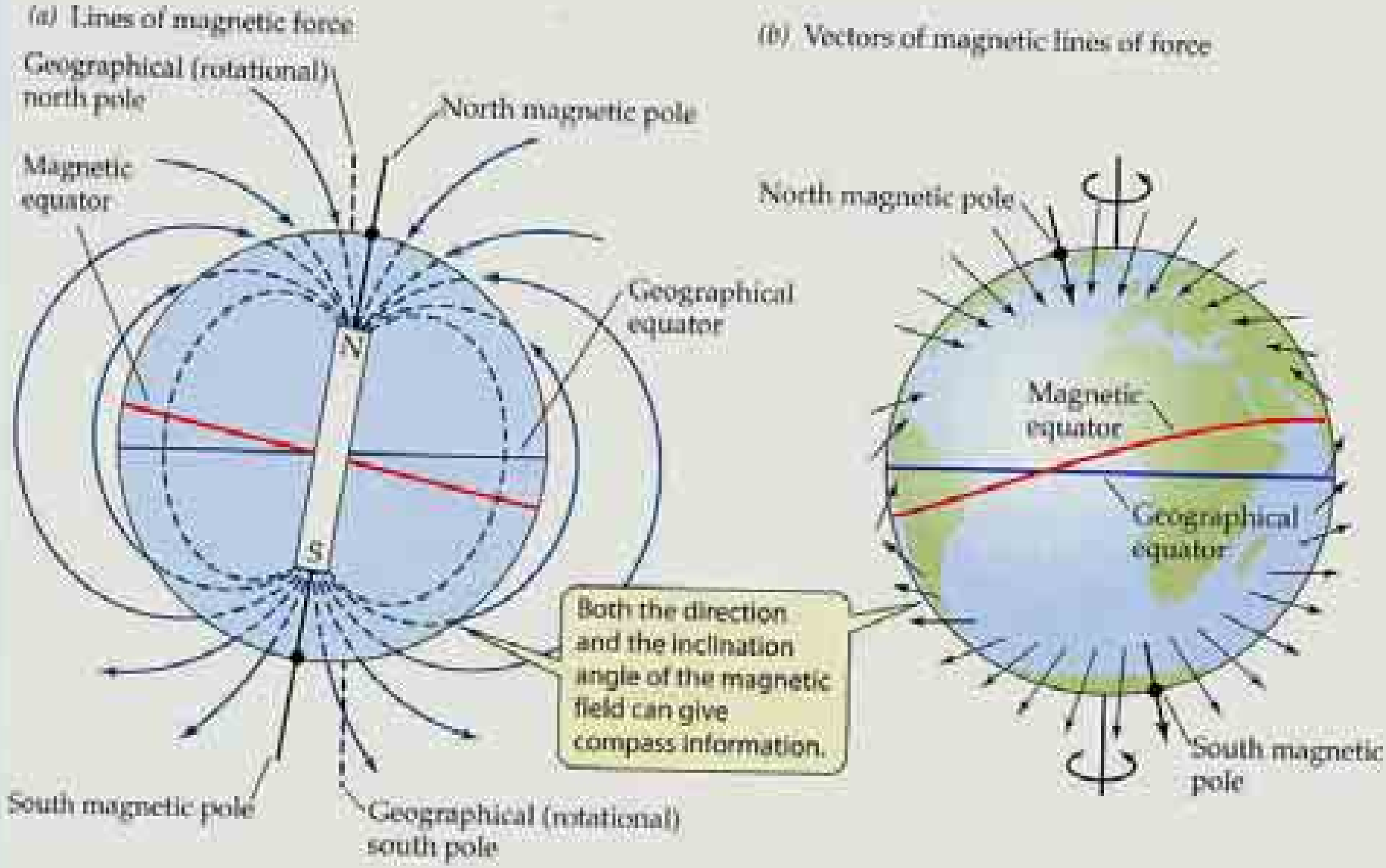
Kompasová orientace - magnetický smysl živočichů.

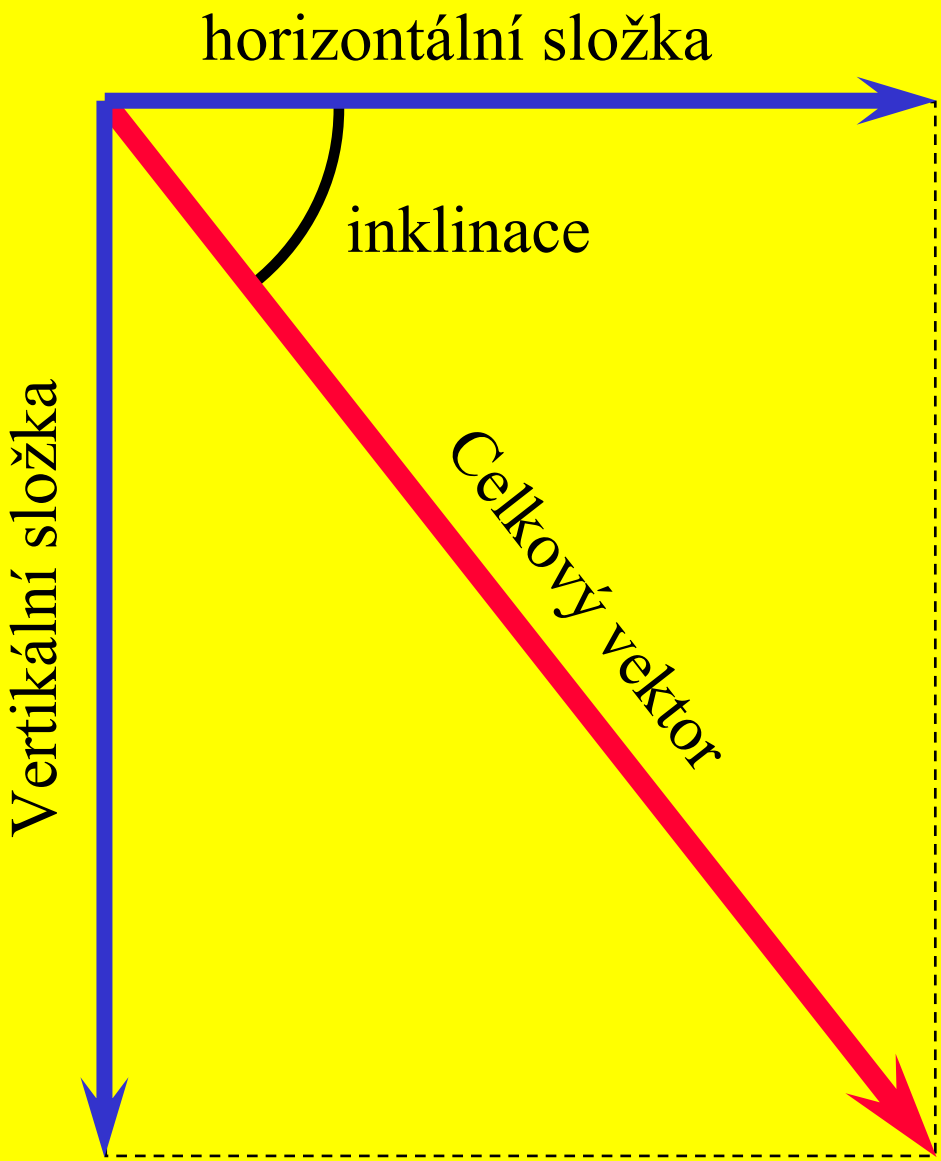
Zdroj pole	B (T)
MGP vznikající činností mozku	$10^{-12} – 10^{-14}$
Geomagnetické pole	10^{-5}
Nejsilnější permanentní magnety	$10^{-1} - 10^{0}$
Supravodivé elektromagnety	$10^{1} - 10^{2}$



Azimut




(a) Lines of magnetic force
Geographical (rotational) north pole
North magnetic pole
Magnetic equator
Geographical equator
N
S
South magnetic pole
Geographical (rotational) south pole
(b) Vectors of magnetic lines of force
North magnetic pole
Magnetic equator
Geographical equator
South magnetic pole
Both the direction and the inclination angle of the magnetic field can give compass information.


horizontální složka
inklinace
Vertikální složka
Celkový vektor

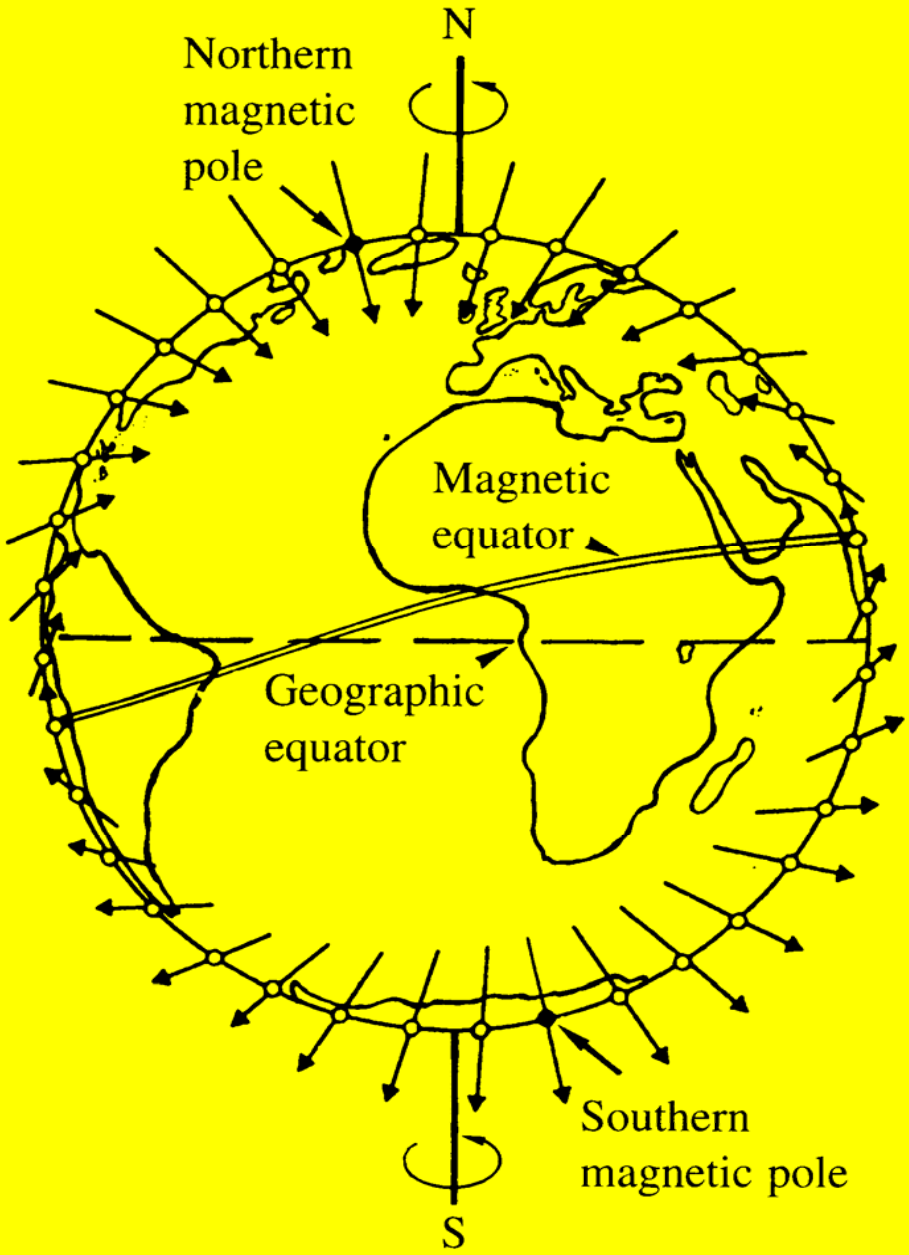


Fig. 1. Schematic view of the earth and the geomagnetic field.

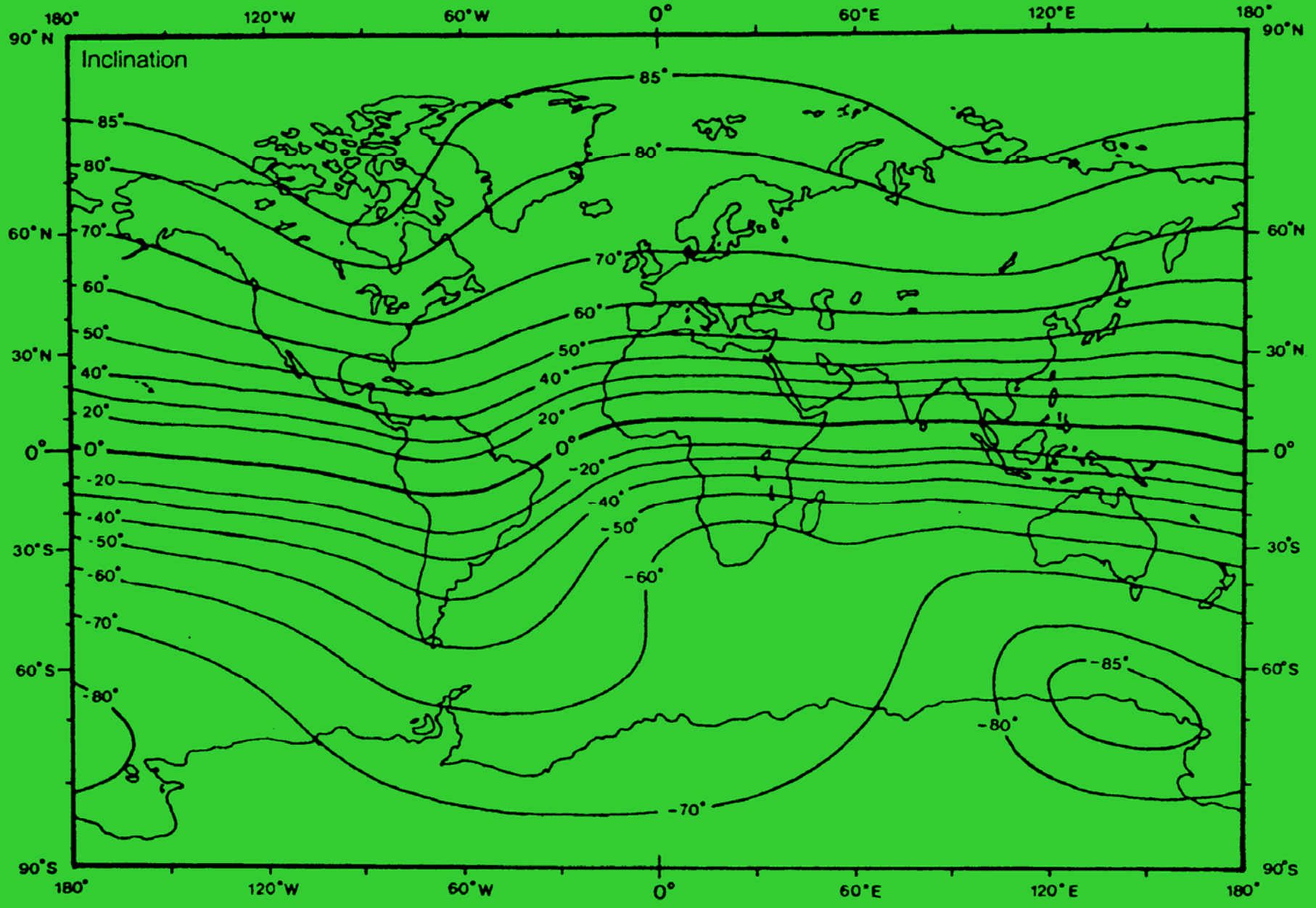
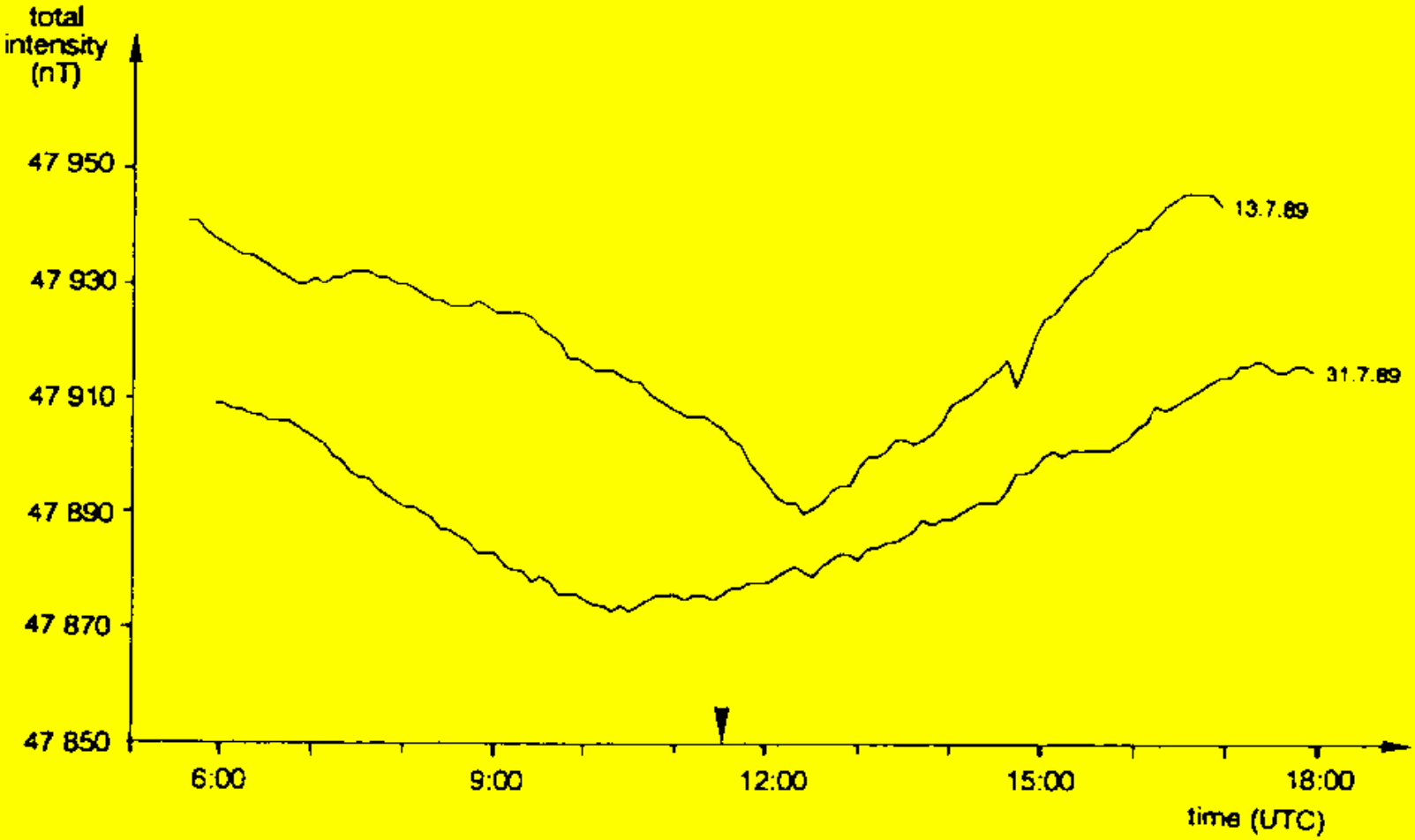
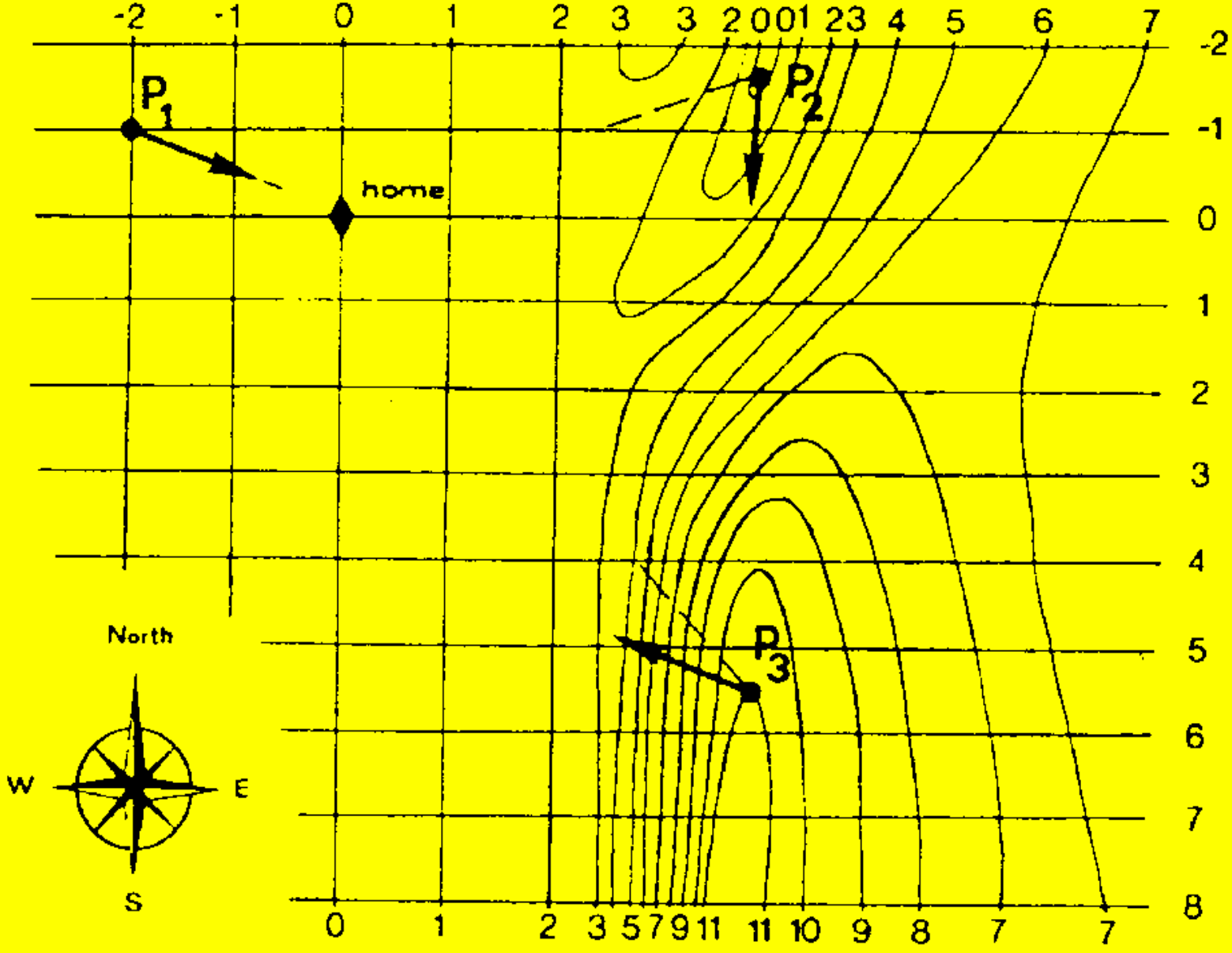


Fig. 1.3. Inclination or dip of the magnetic field of the earth (epoch 1965); *negative signs* designate upward inclination. (After SKILES 1985)

Denní variace GMP




-2 -1 0 1 2 3 3 2 0 0 1 2 3 4 5 6 7
-2 -1 0 1 2 3 4 5 6 7 8
P1
P2
P3
home
North
W
E
S
0 1 2 3 5 7 9 11 11 10 9 8 7 7

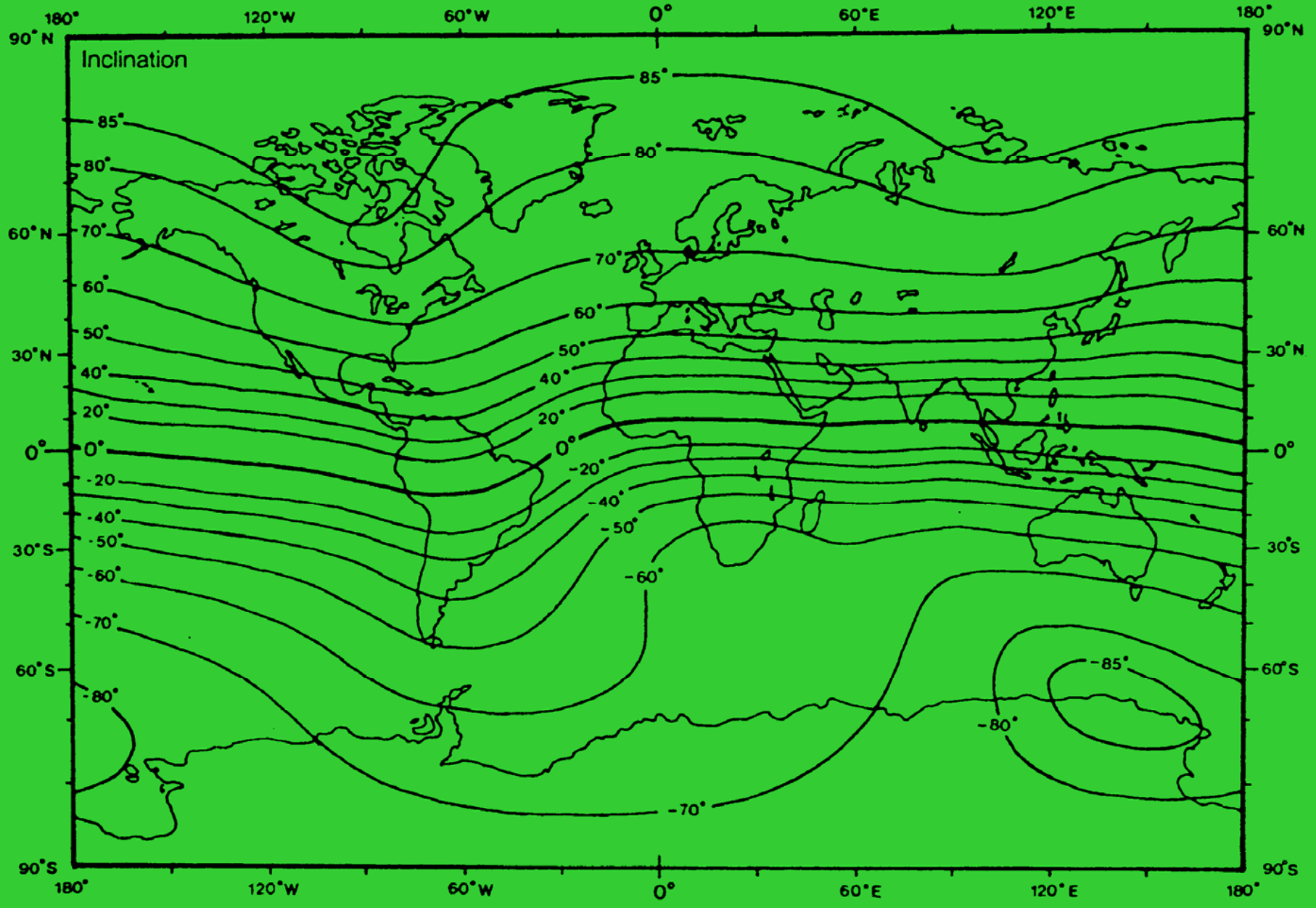


Fig. 1.3. Inclination or dip of the magnetic field of the earth (epoch 1965); *negative signs* designate upward inclination. (After SKILES 1985)

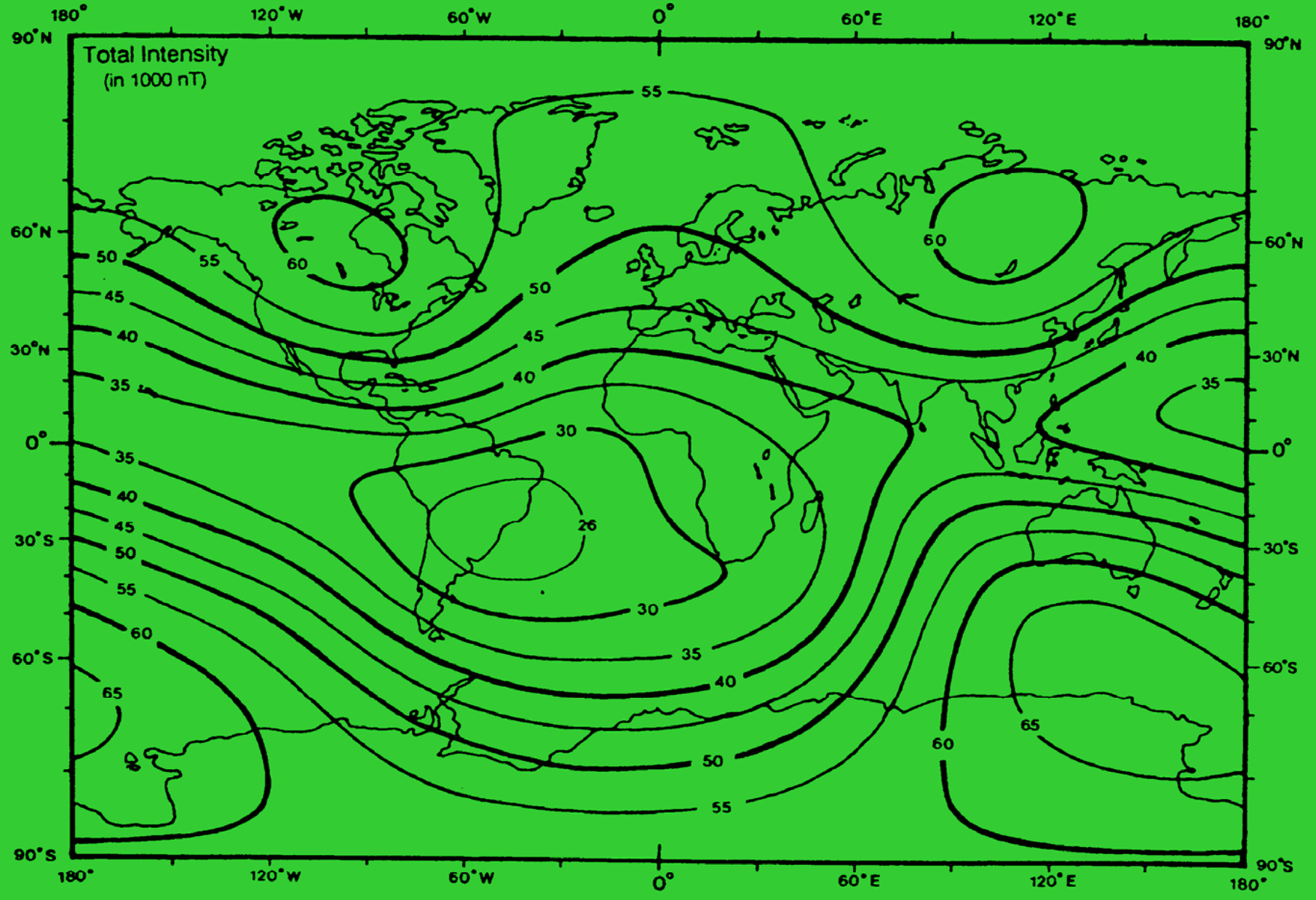
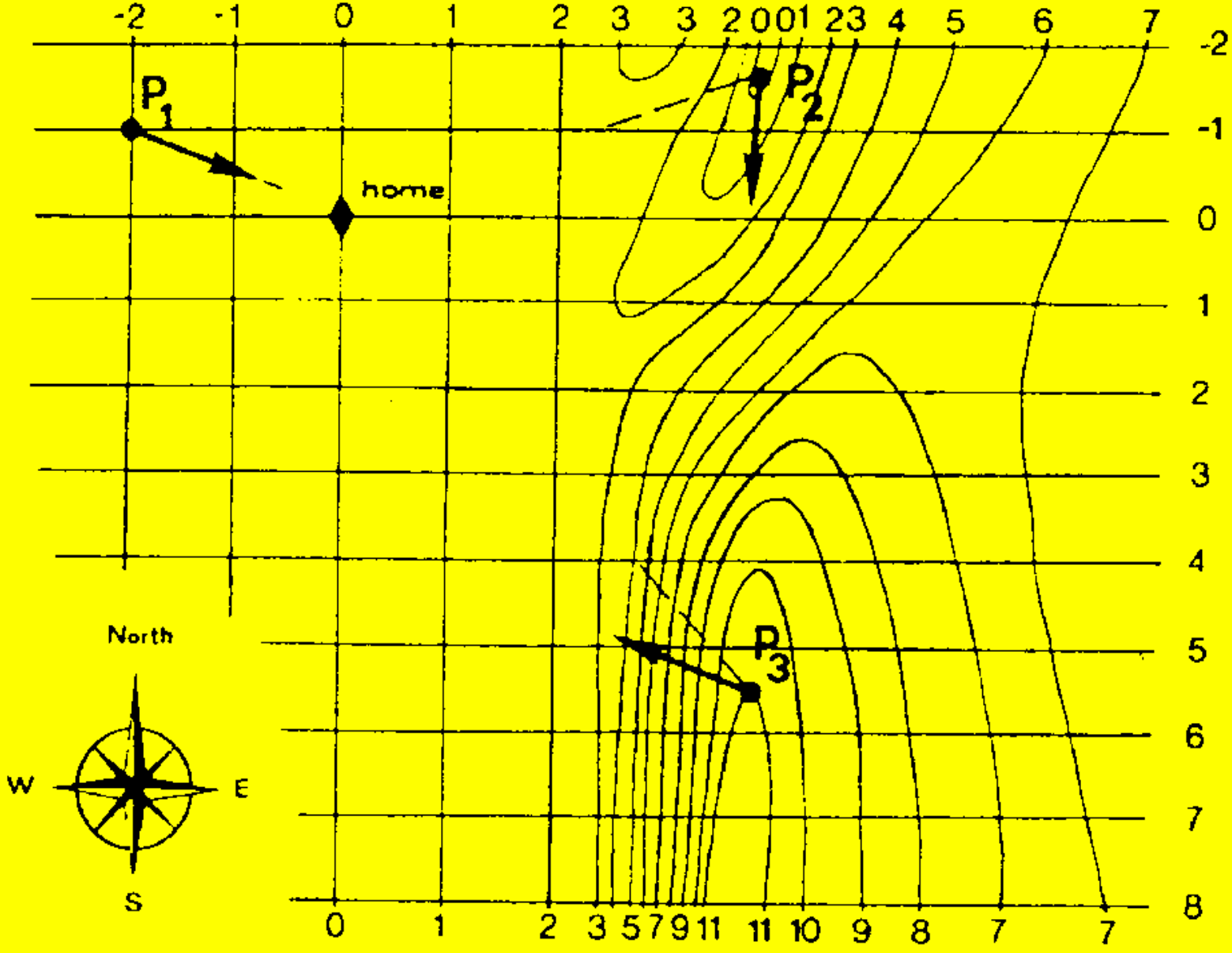


Fig. 1.4. Total intensity of the magnetic field of the earth (epoch 1965) in 1000 nT. (After SKILES 1985)

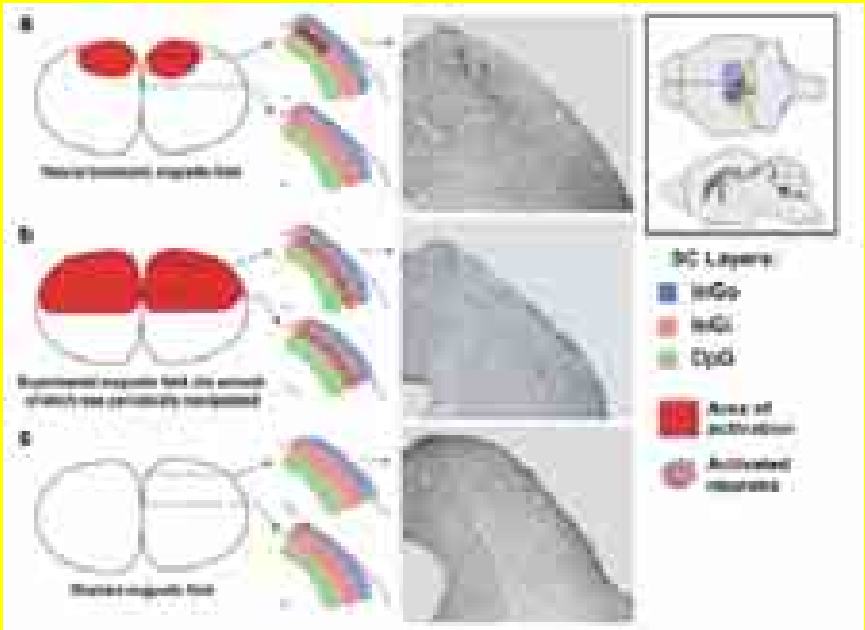

-2 -1 0 1 2 3 3 2 0 0 1 2 3 4 5 6 7
-2 -1 0 1 2 3 4 5 6 7 8
P1
P2
P3
home
North
W
E
S
0 1 2 3 5 7 9 11 11 10 9 8 7 7

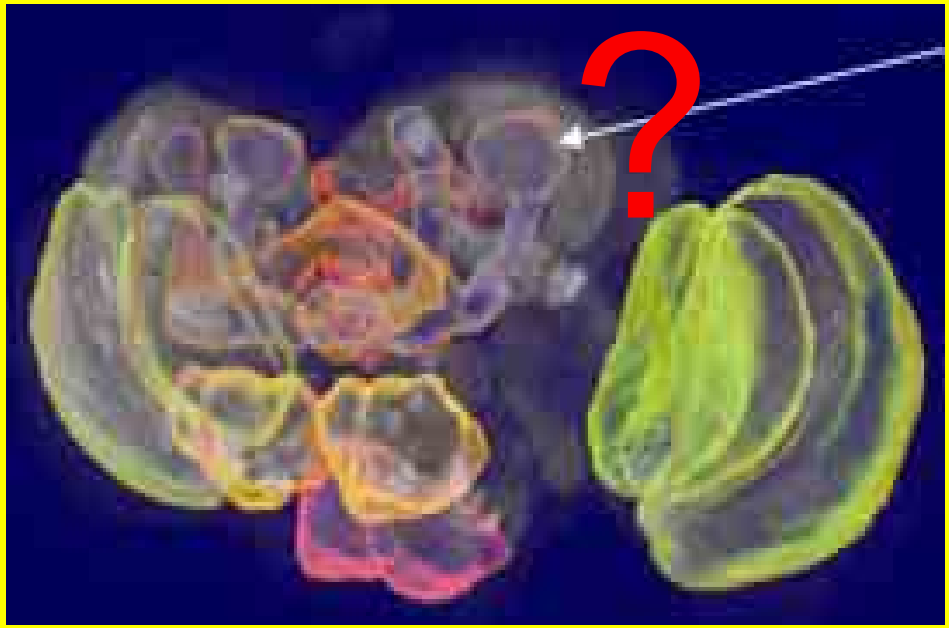
Měření GMP

Insect magnetoreception path quite unknown today

Vertebrate brain

Insect brain

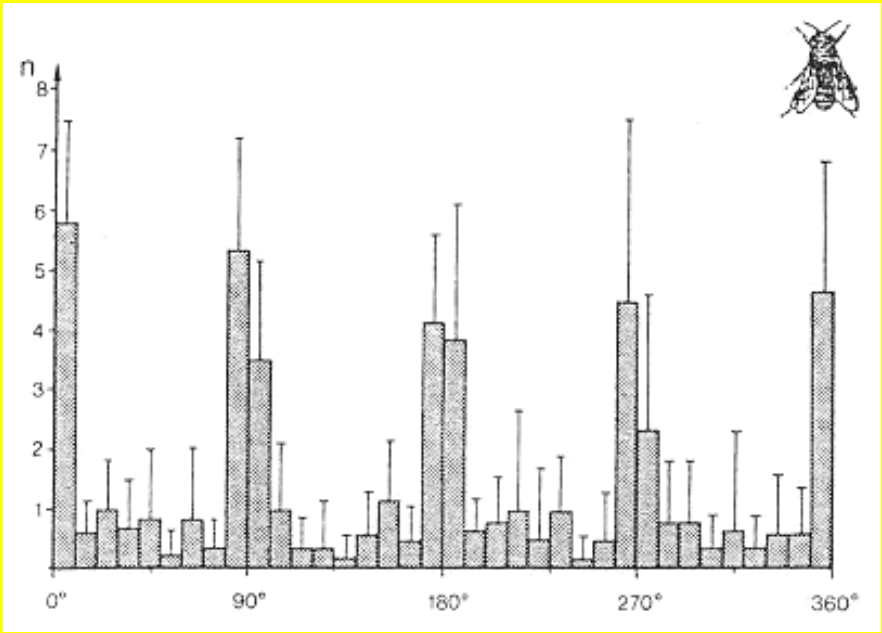




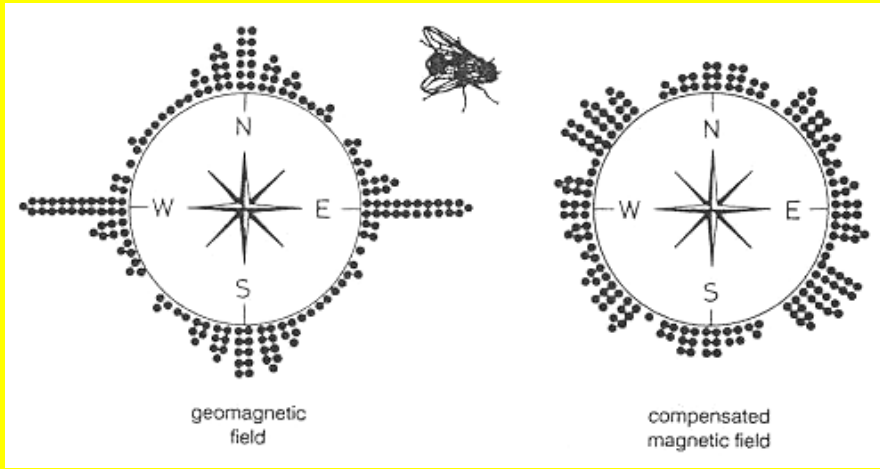
Nemec, P., H. Burda, et al. (2005). "Towards the neural basis of magnetoreception: a neuroanatomical approach." Naturwissenschaften **92**: 151-157.

A) Position behaviour

Alignement the body axis with the cardinal geomagnetic axes
Resting positions Termites, Flies, Cockroaches, Bees



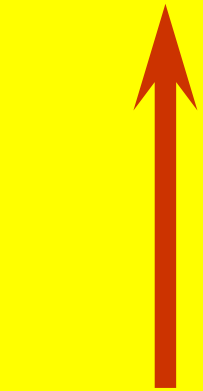
Altman, (1981)



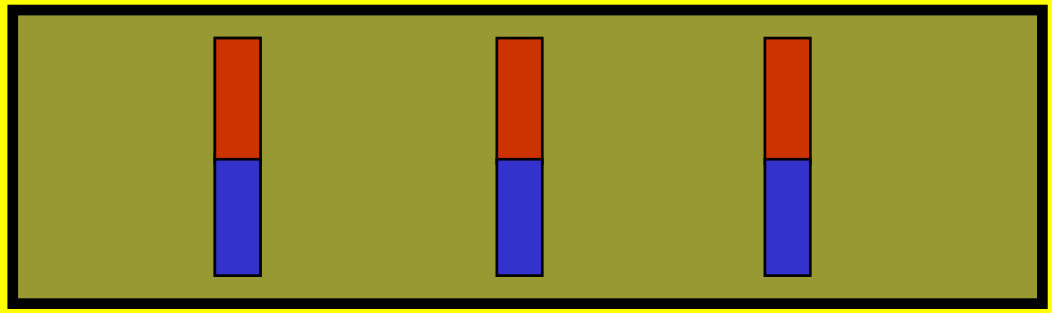
Becker, (1965)

Hypotézy transdukce

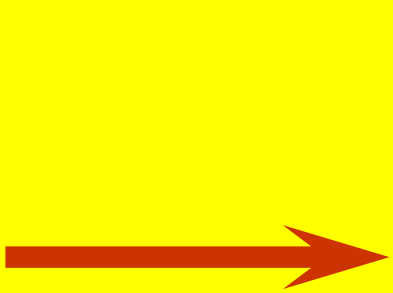
Směr vnějšího pole

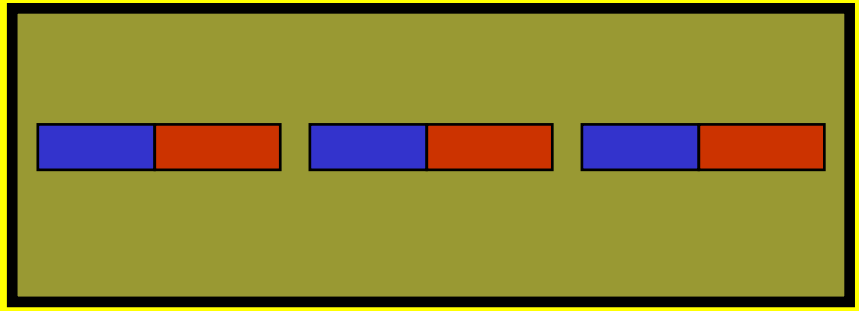


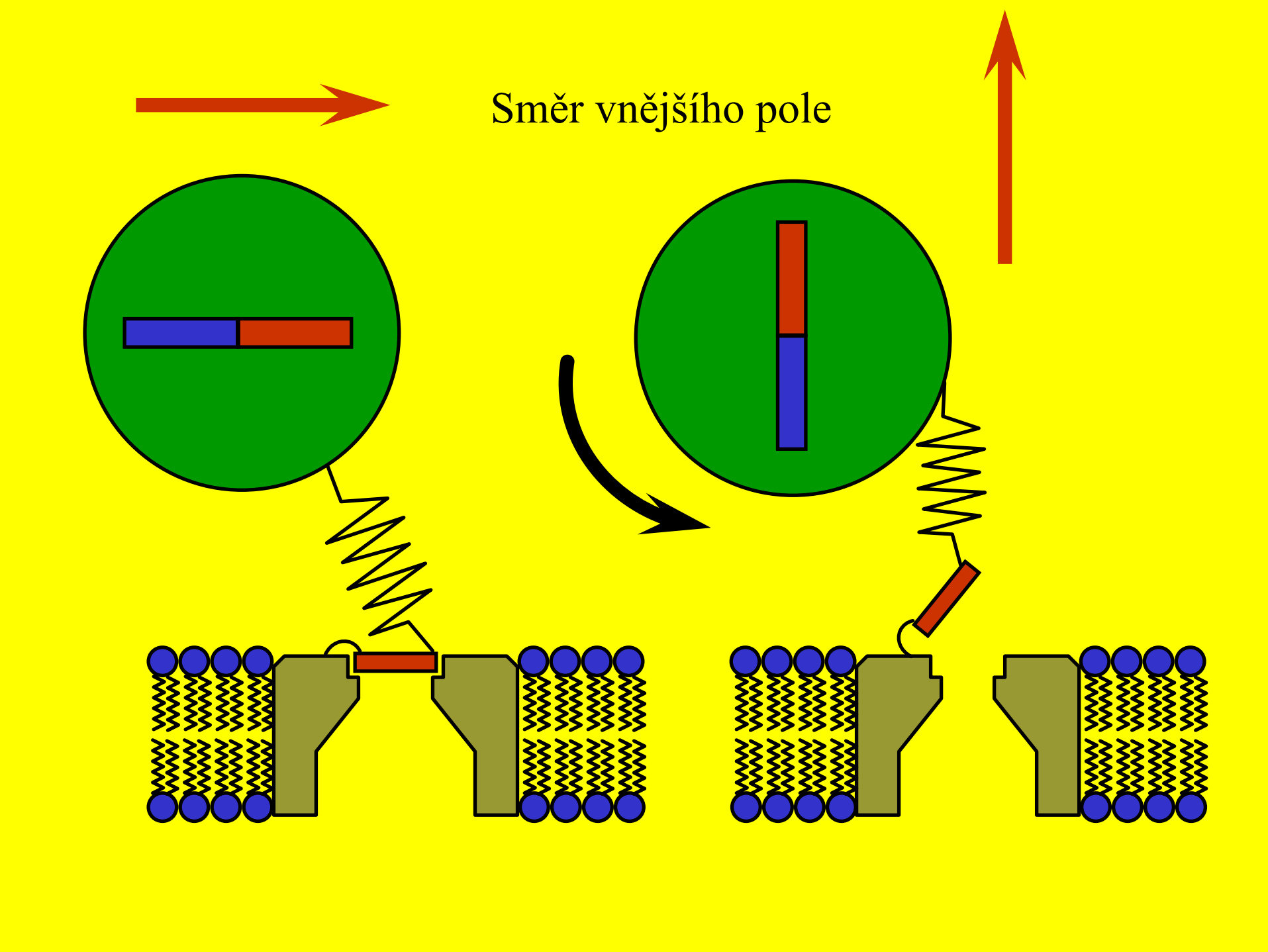
Expanze

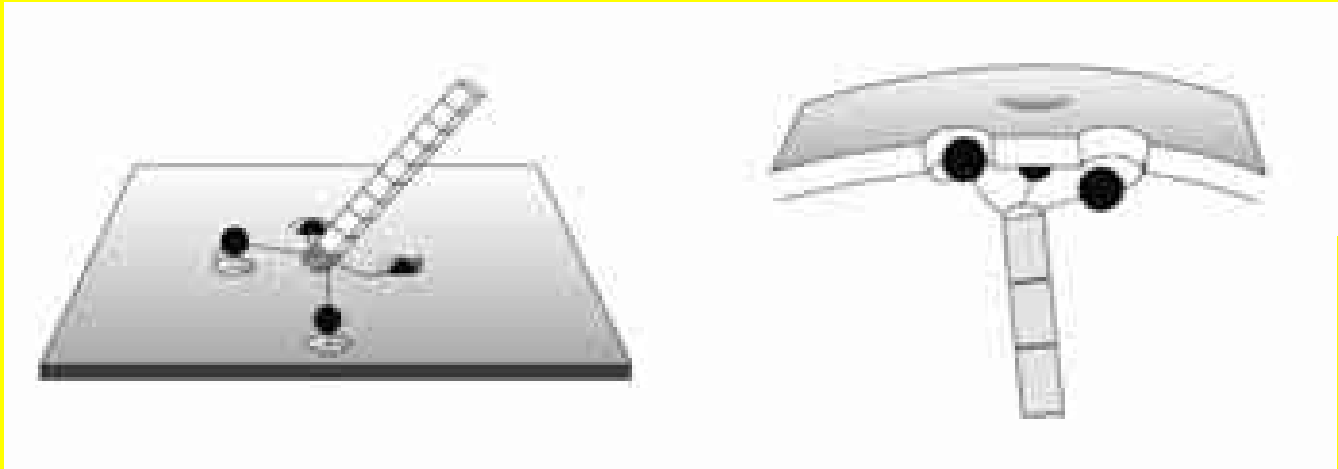


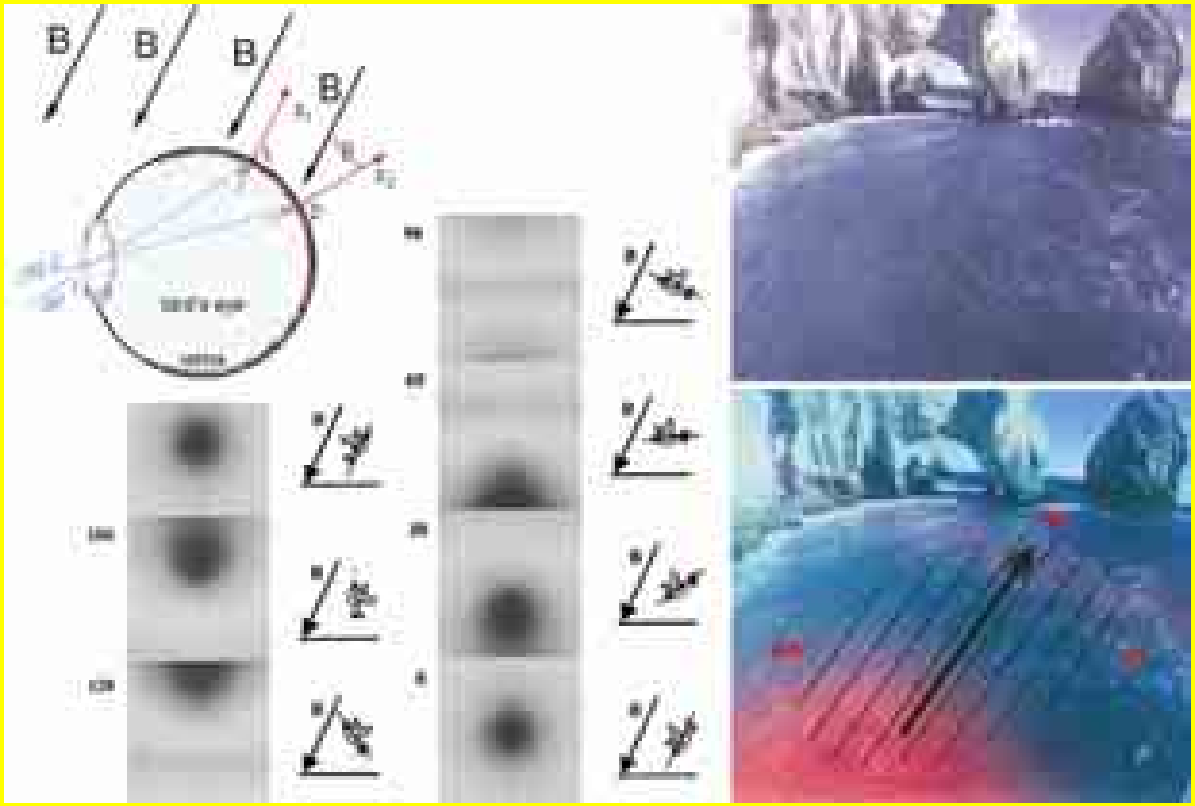
Kontrakce

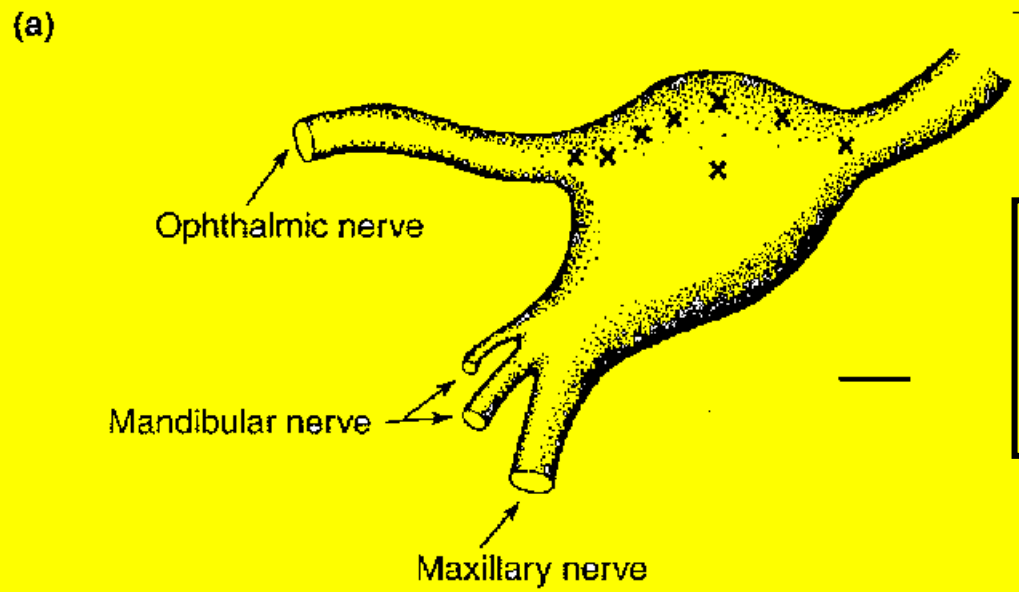




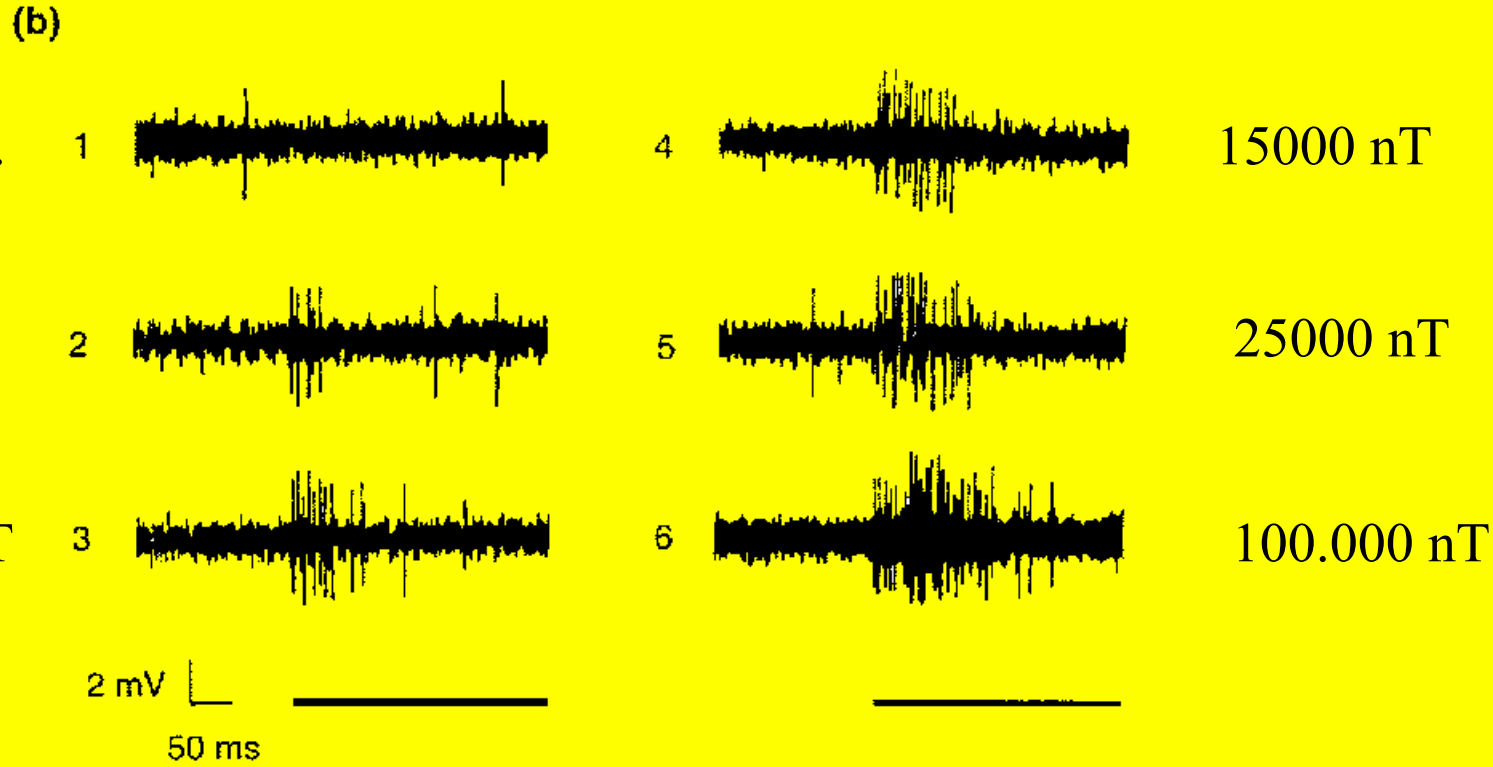

Směr vnějšího pole

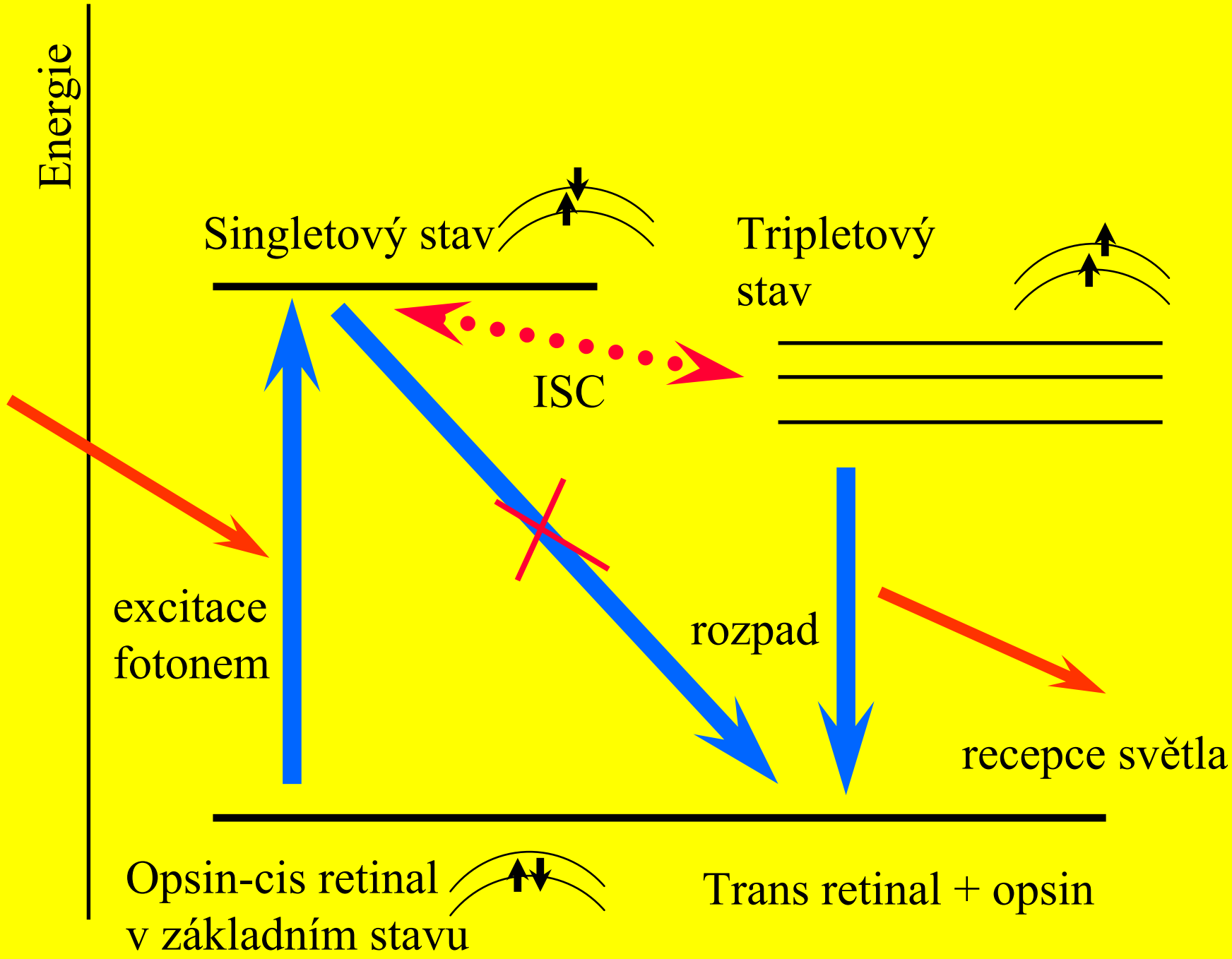



B
B
B
B

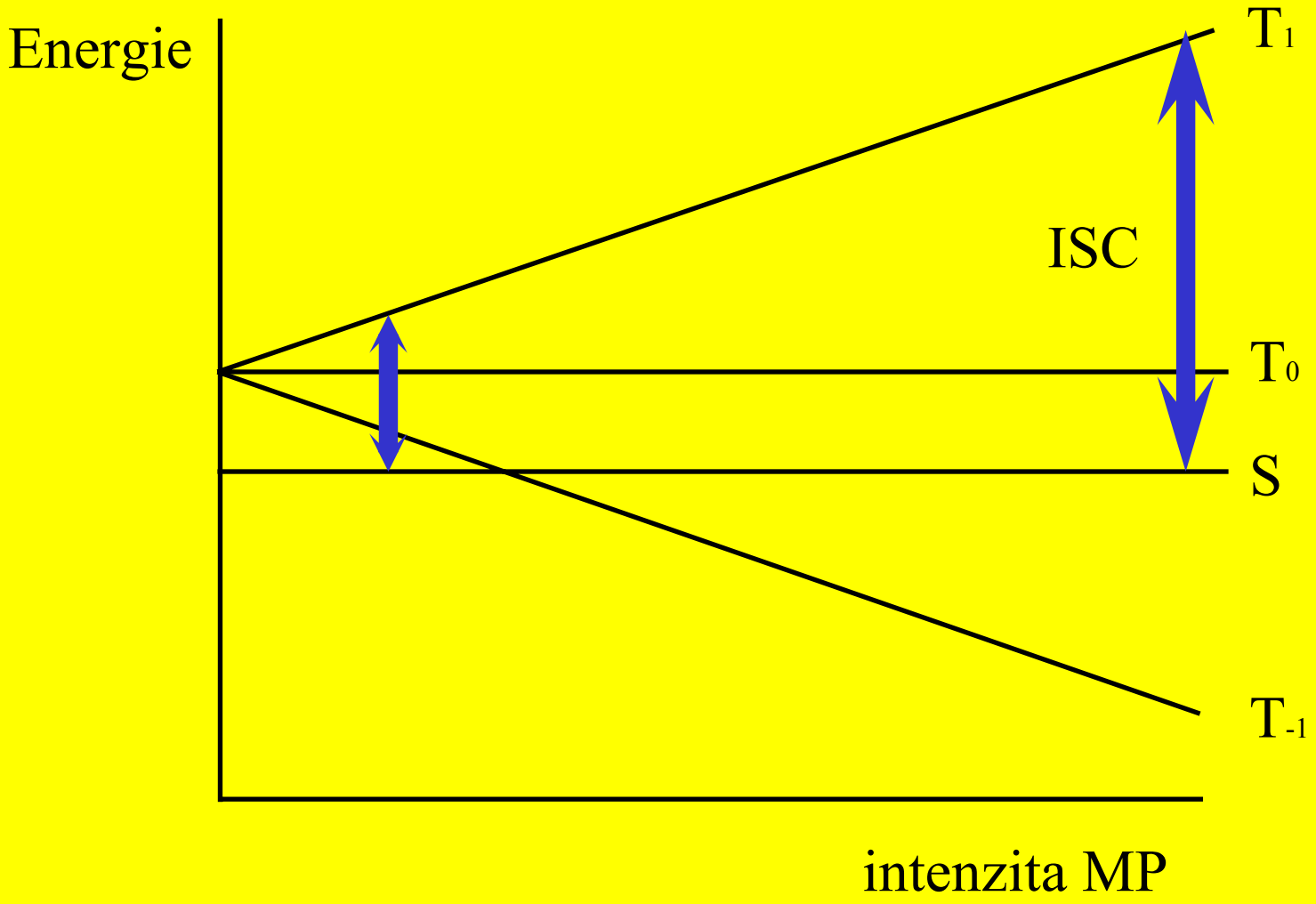


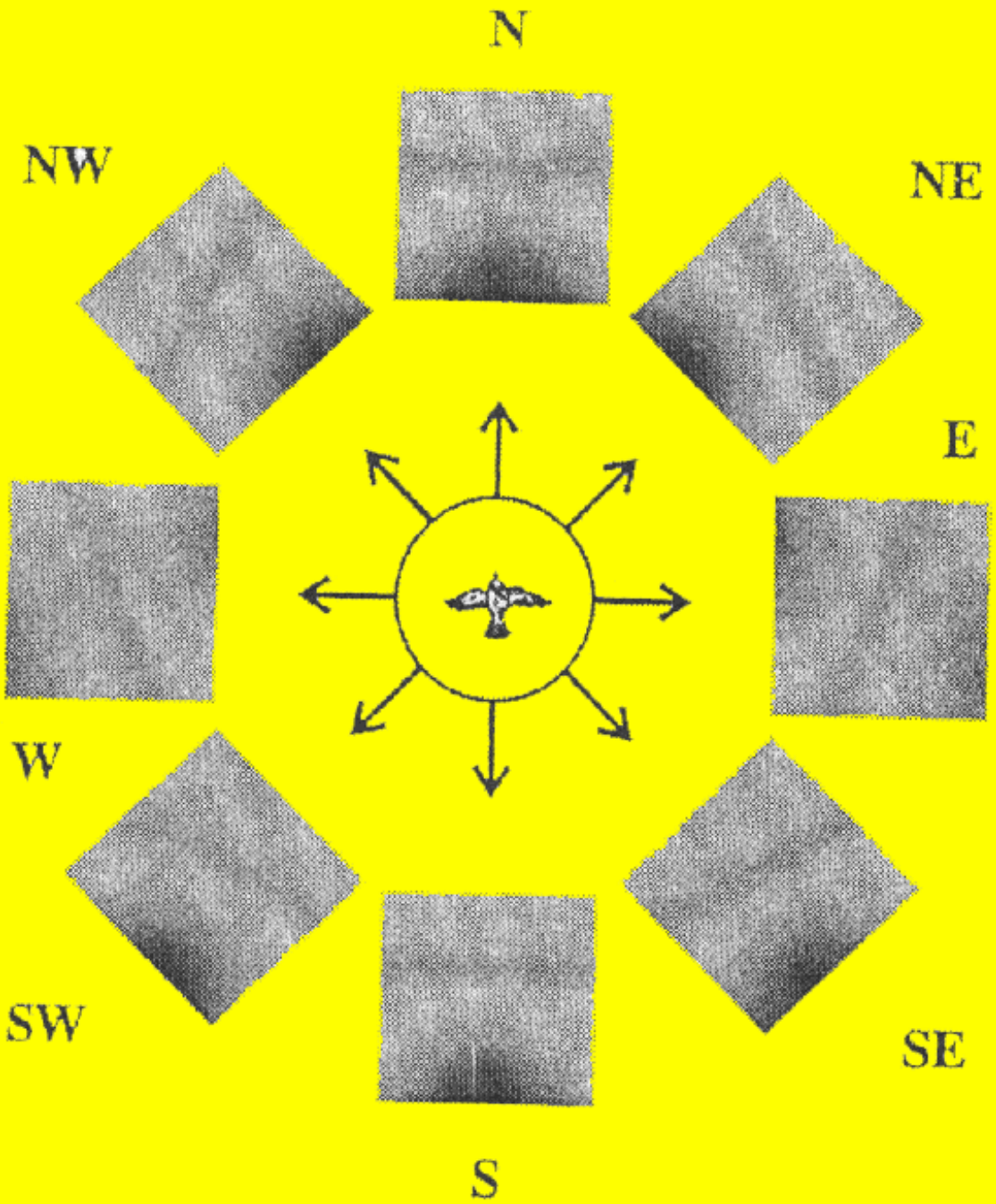
Trigeminální ganglium *Dolichornix*



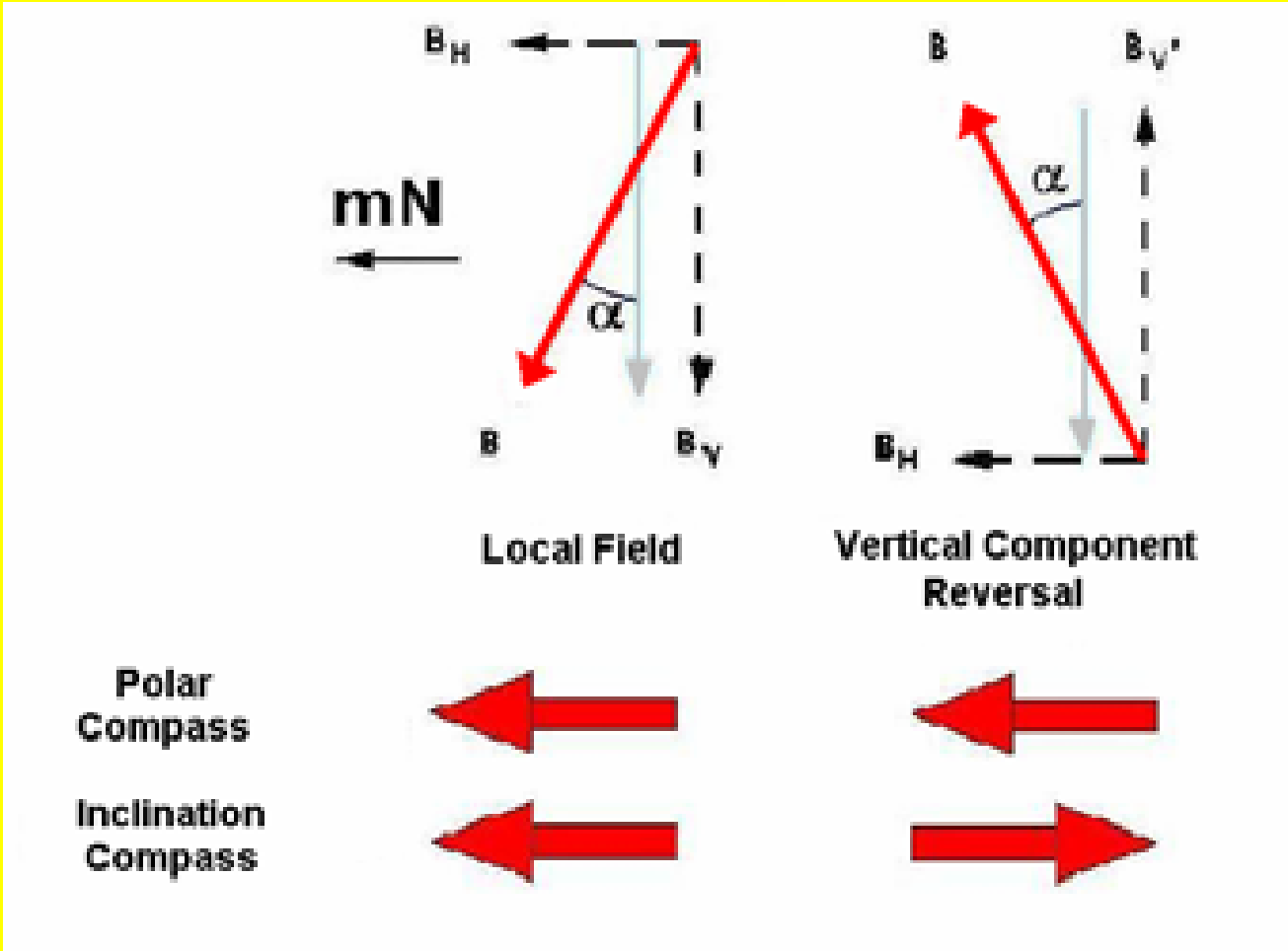

Energie
Singletový stav
Tripletový stav
ISC
excitace fotonem
rozpad
recepce světla
Opsin-cis retinal v základním stavu
Trans retinal + opsin

MP štěpí tripletní stavy
a mění pravděpodobnost přeskoků




N
NW
NE
E
W
SW
SE
S

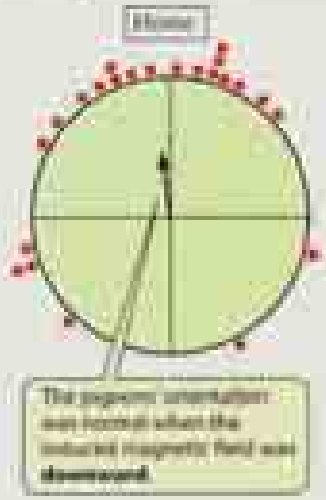
Polarity vs. Inclination



Metody výzkumu

(a) The experimental setup

(b) Magnet in normal orientation



(c) Magnet in reversed orientation

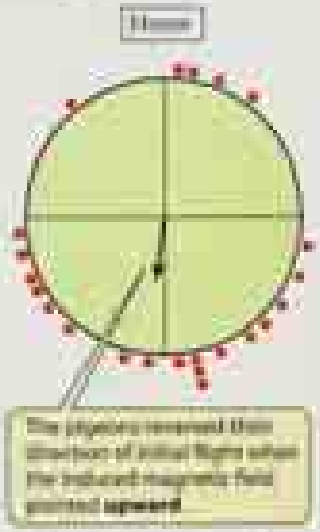
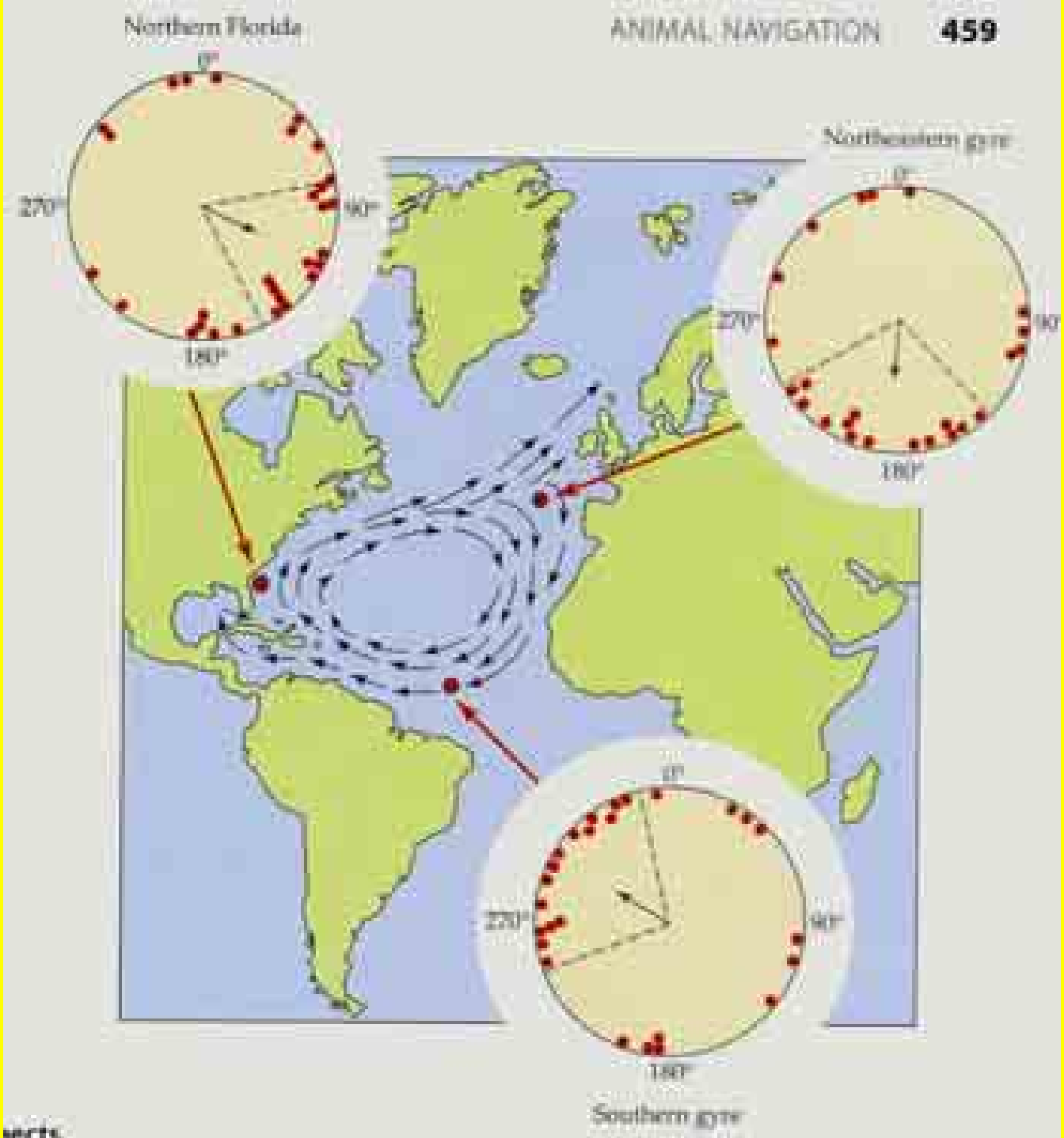
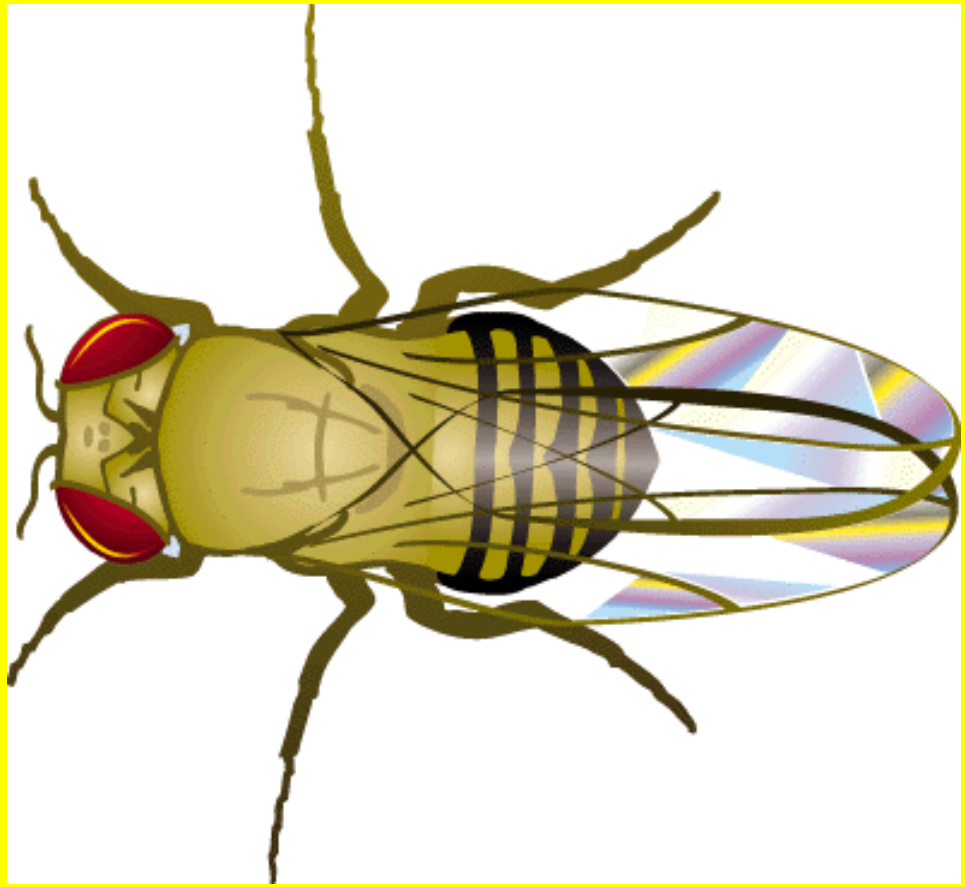


Figure 16.9 Changing the magnetic field changes the orientation of released pigeons (a) A small Helmholtz coil is shown attached to a pigeon's head, with a power pack on the pigeon's back. Reversing the direction of electrical current flow through the coil reverses the direction of the magnetic field. (b, c) Pigeons with Helmholtz coils were released south of home on overcast days. They interpreted the direction in which magnetic lines dip into Earth as north. Each dot outside the circle represents the direction in which a released pigeon vanished over the horizon. The arrow at the center is the mean vanishing bearing for the group. (After Walcott and Green 1974.)

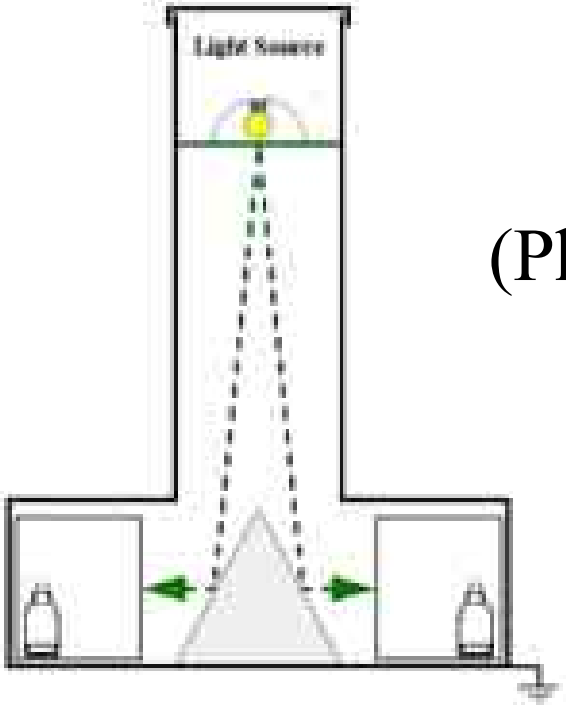

Northern Florida
0°
270°
90°
180°
Northeastern gyre
0°
270°
90°
180°
0°
270°
90°
180°
Southern gyre

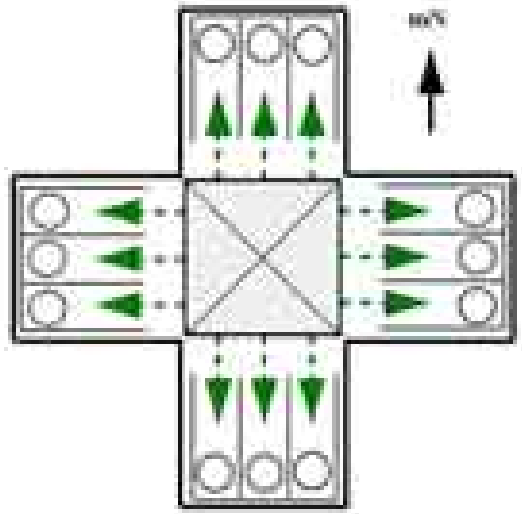

NW
NE
SW
SE
S
E



Training Rig

(Phillips and Sayeed, 1993)

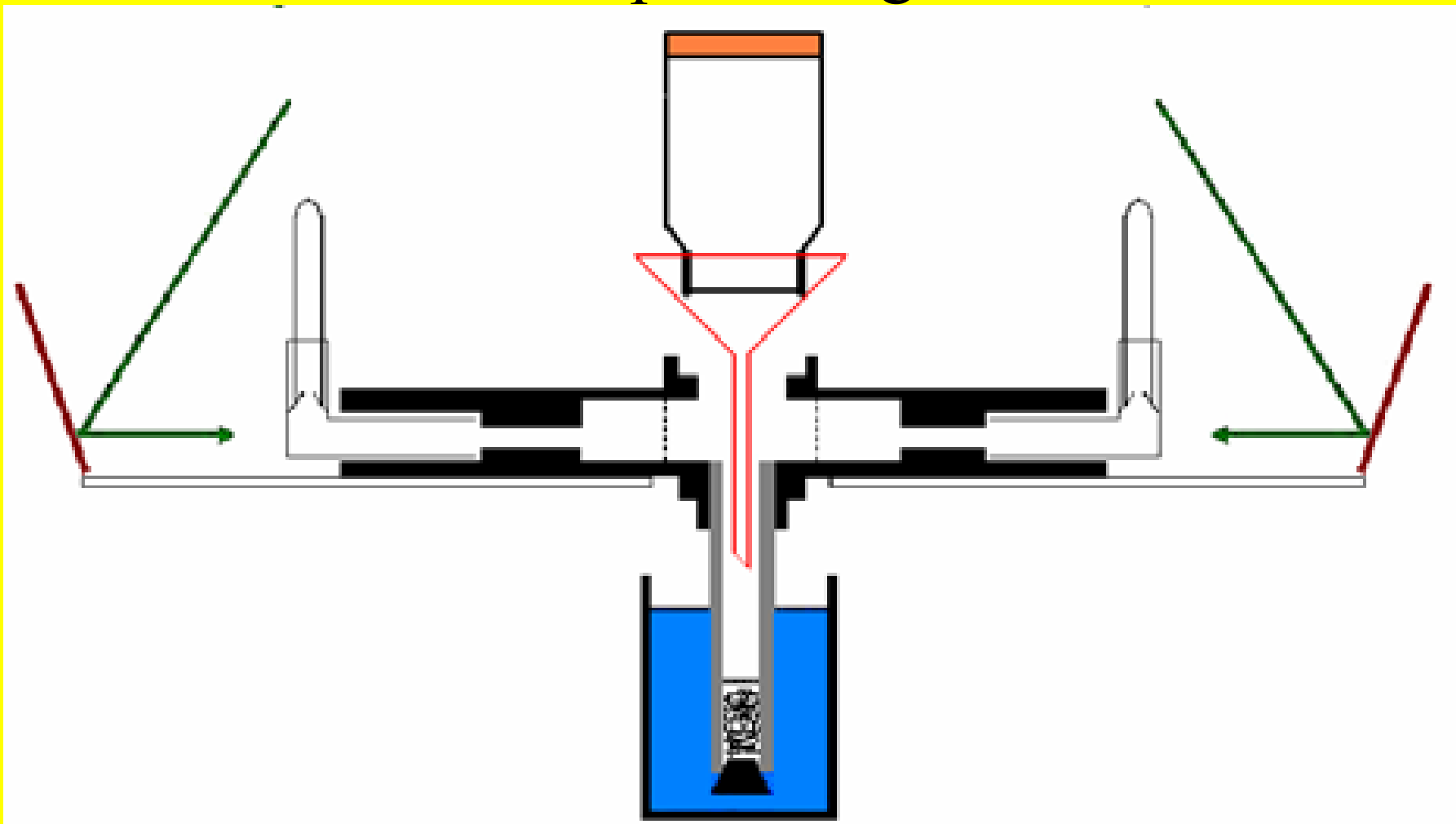




Magnetoreception in *Drosophila*

(Phillips and Sayeed, 1993)

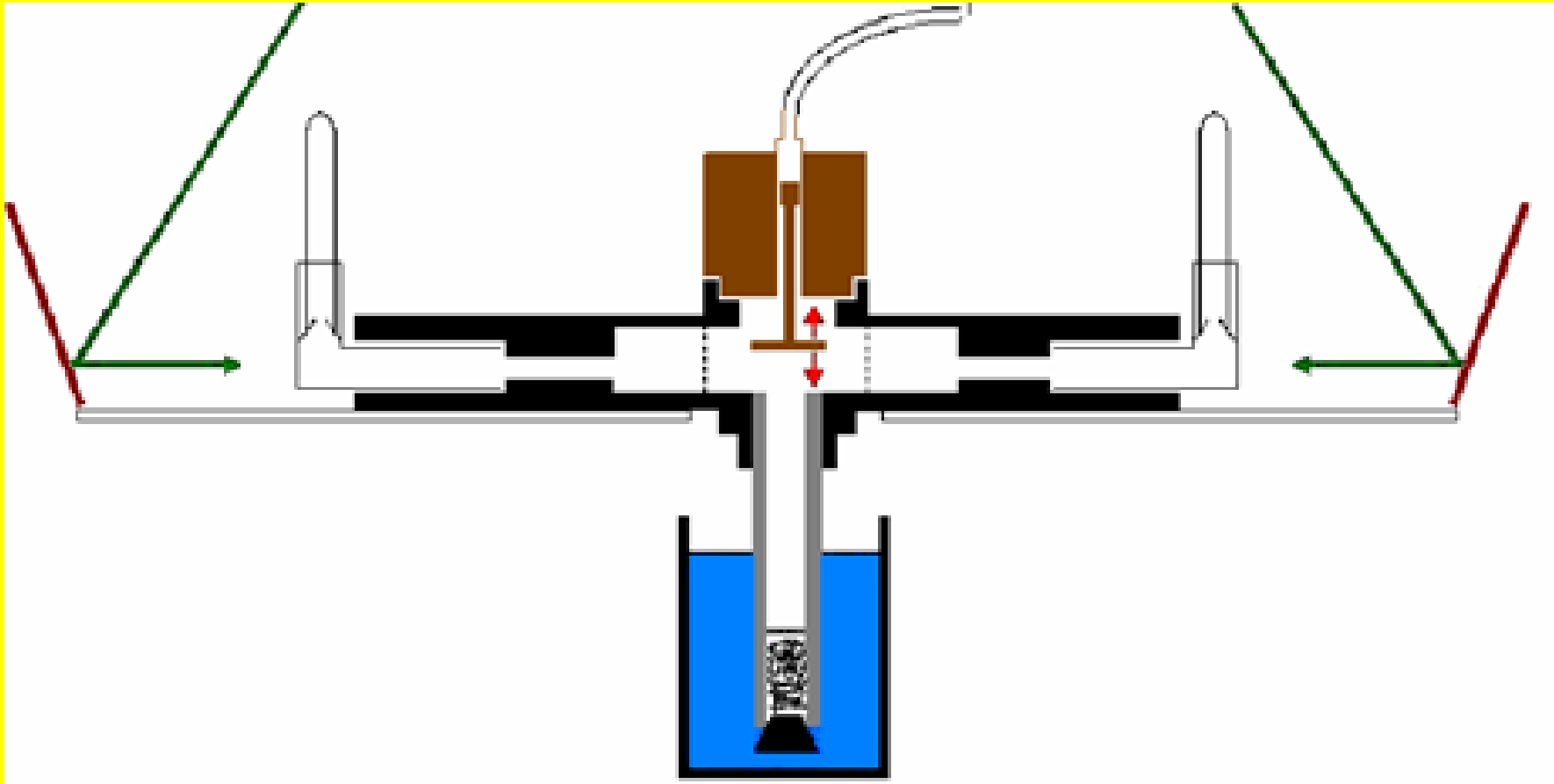
Top Loading



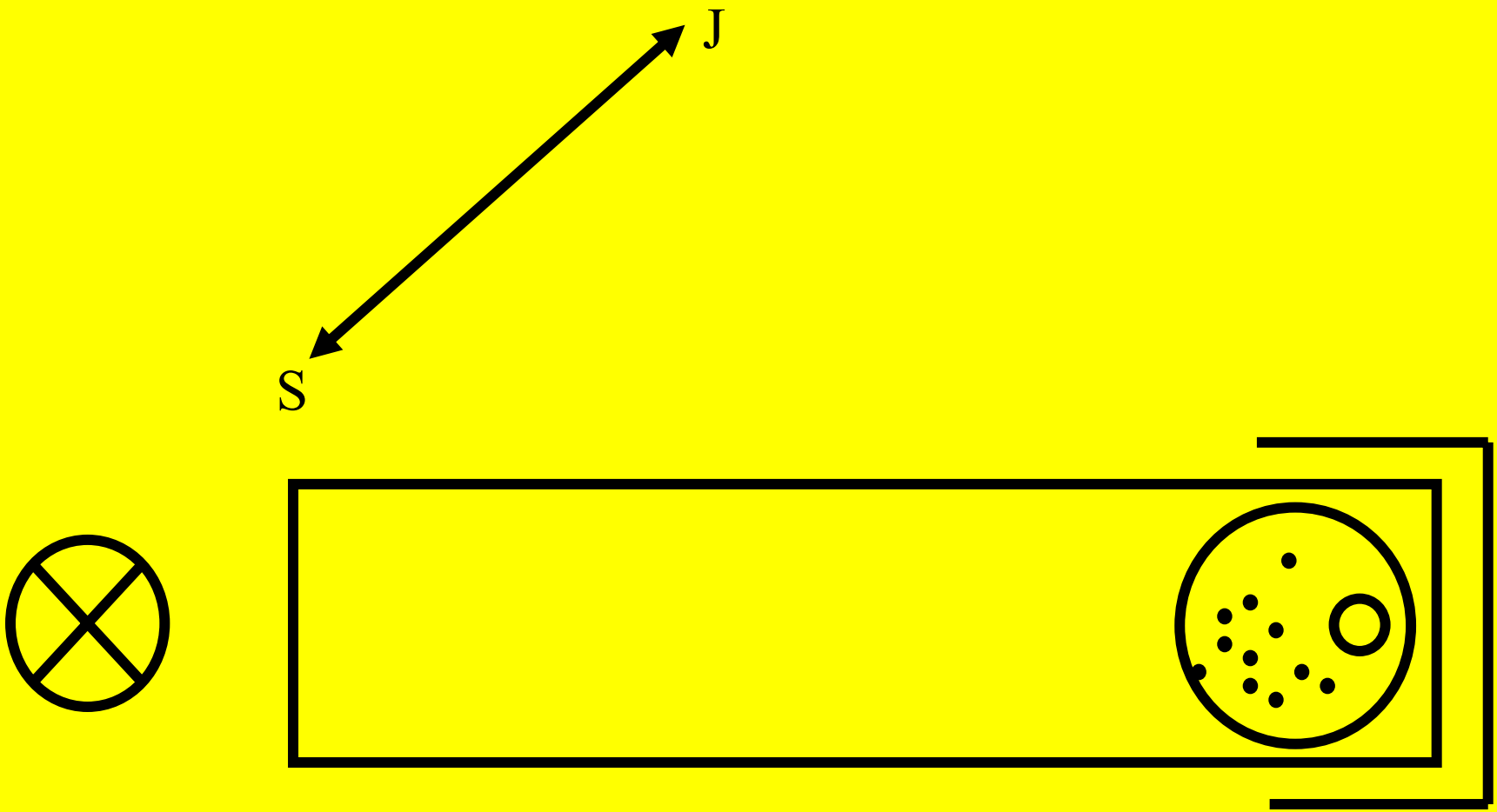
Magnetoreception in *Drosophila*

(Phillips and Sayeed, 1993)

Top Loading

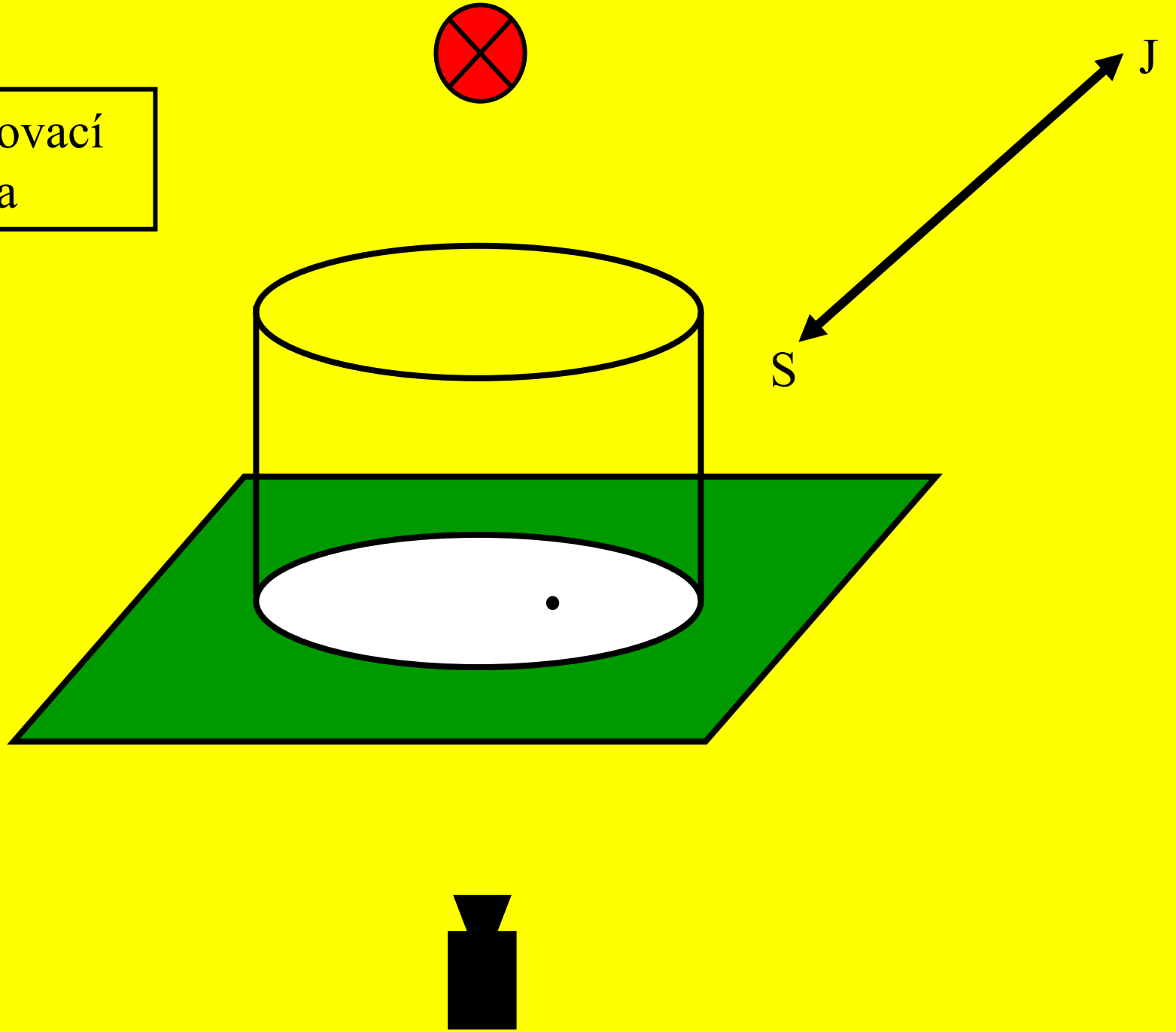


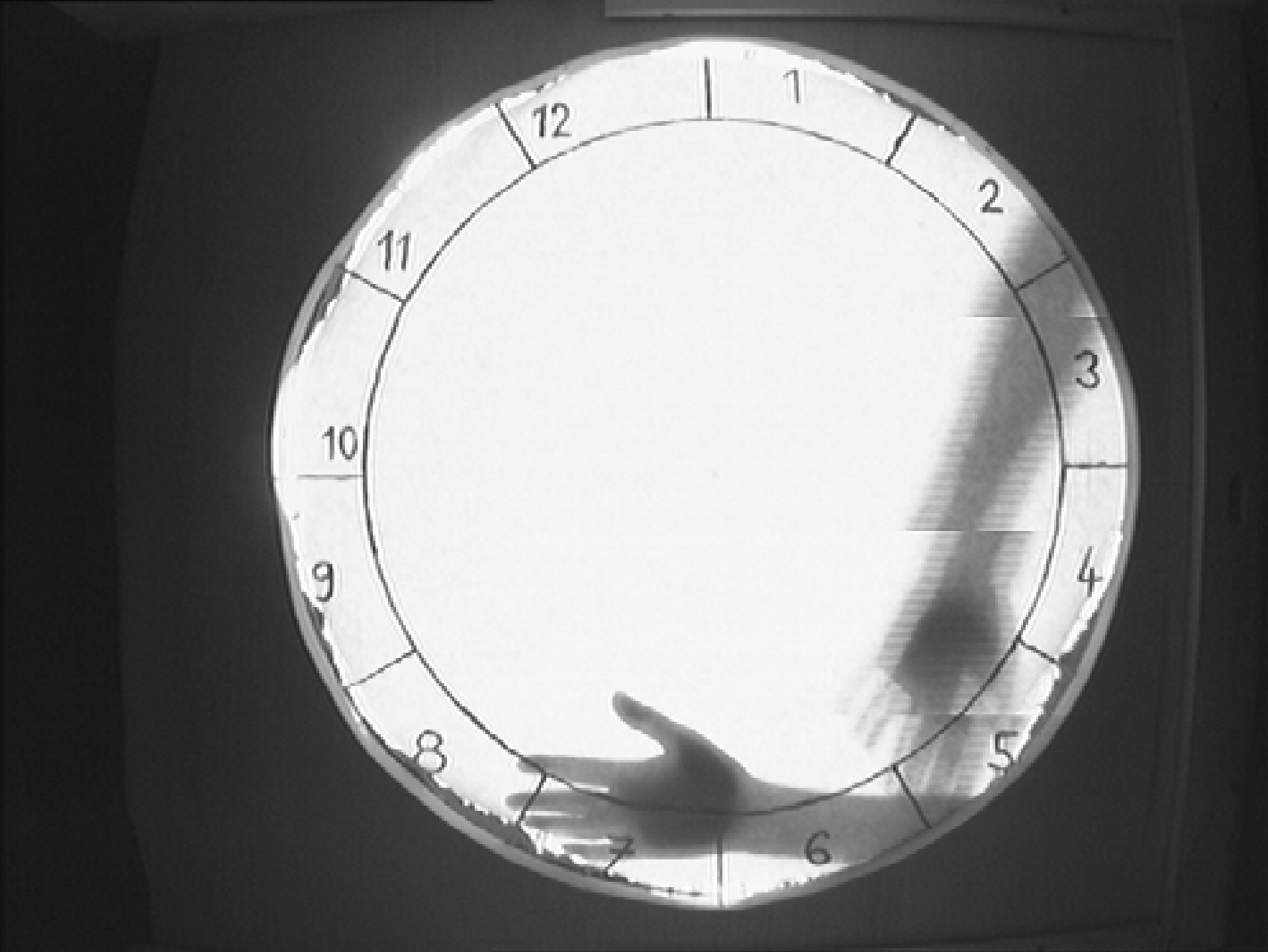
Magnetorecepce potemníka moučného - *Tenebrio molitor*



Trénovací tubus

Testovací aréna




12
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11


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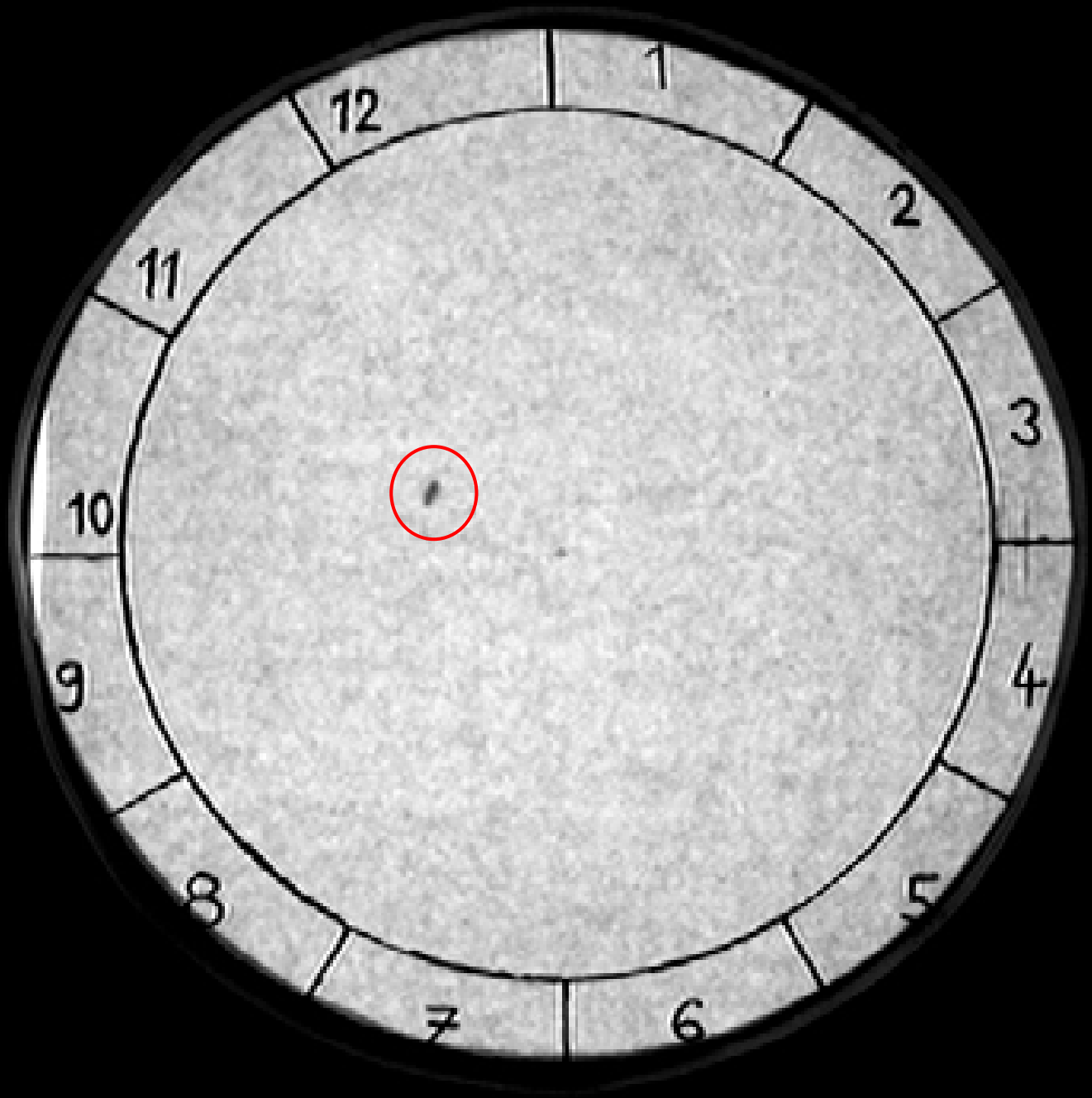
12


12
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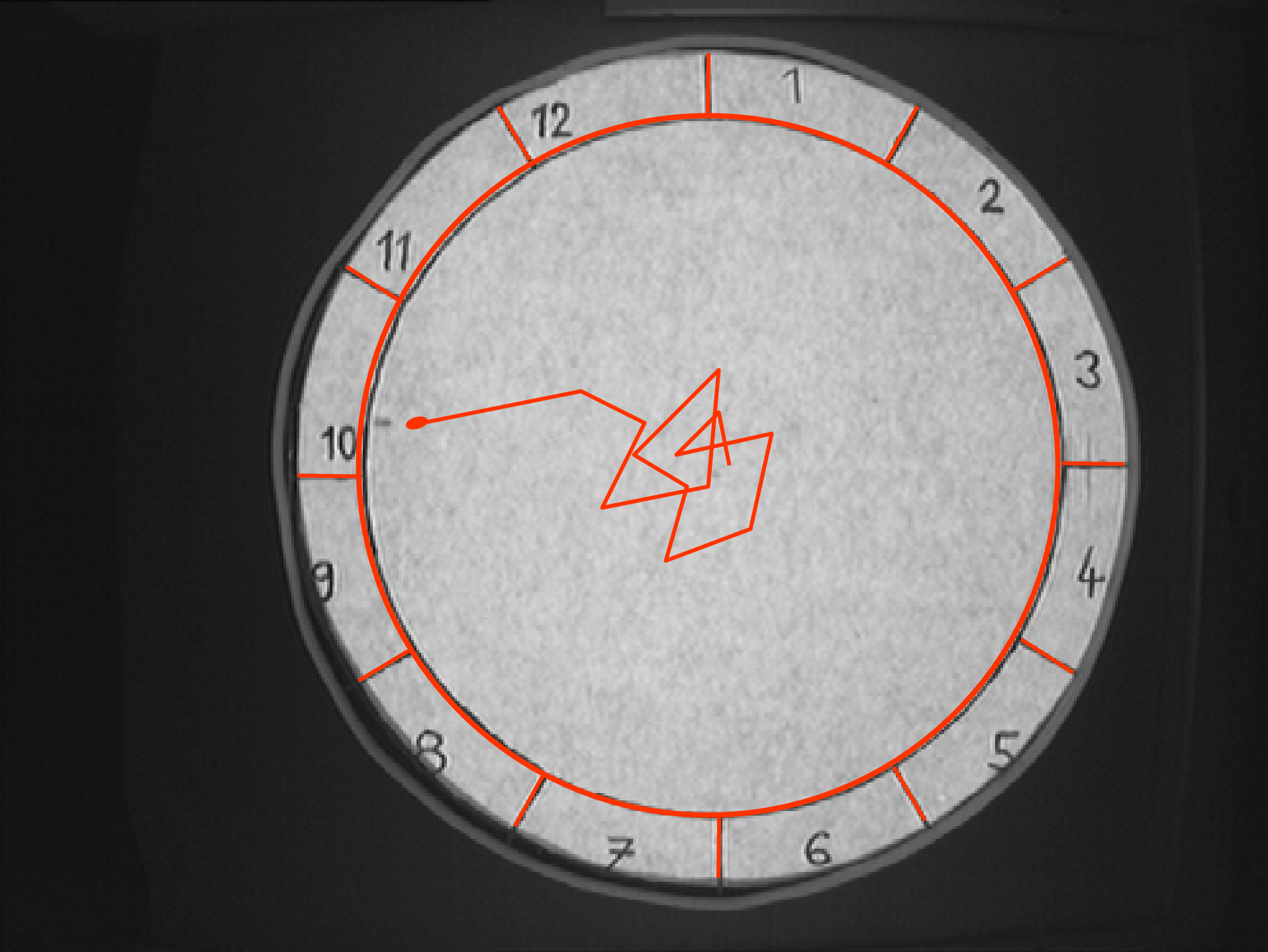
11
12


12
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12
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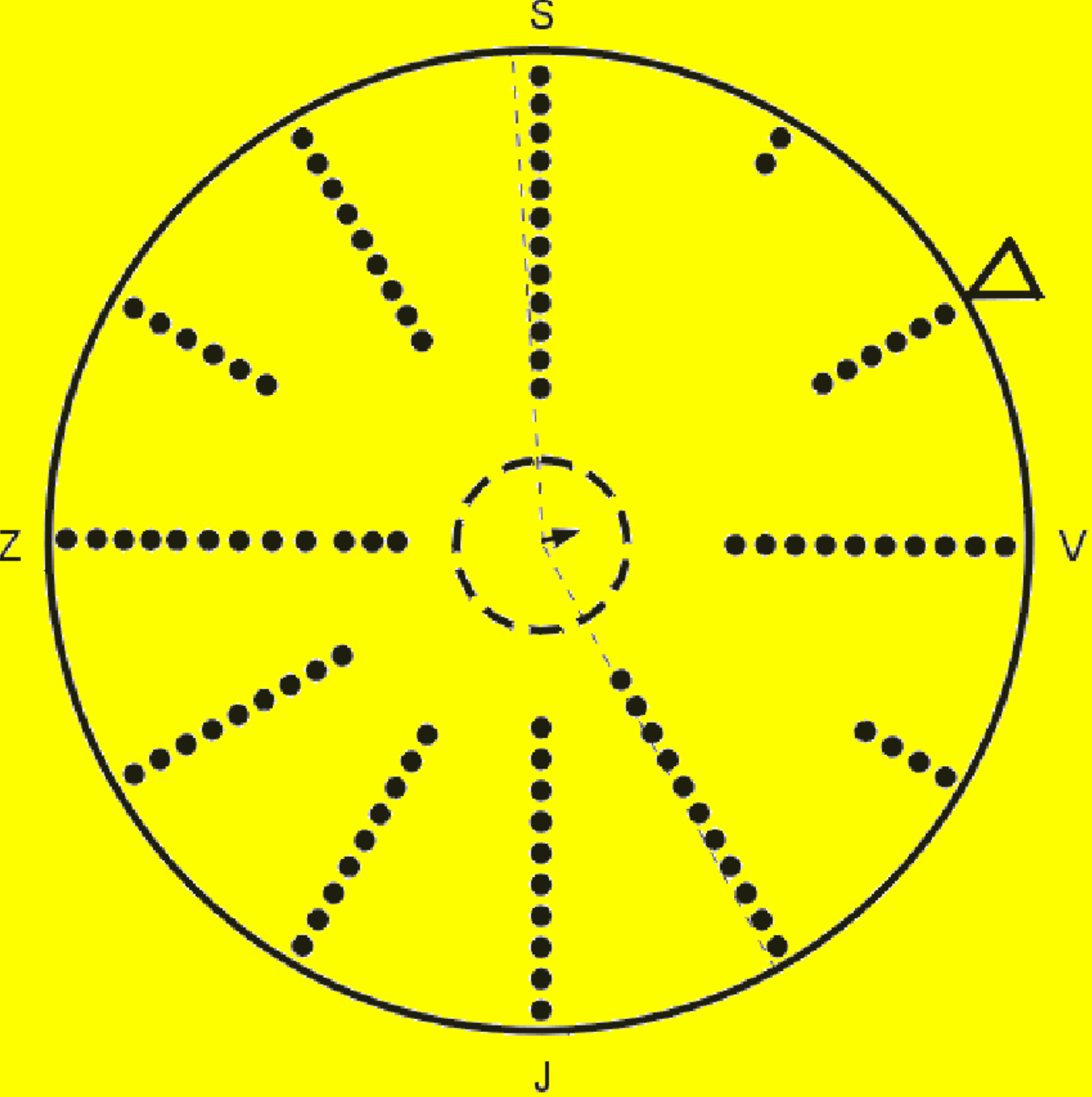
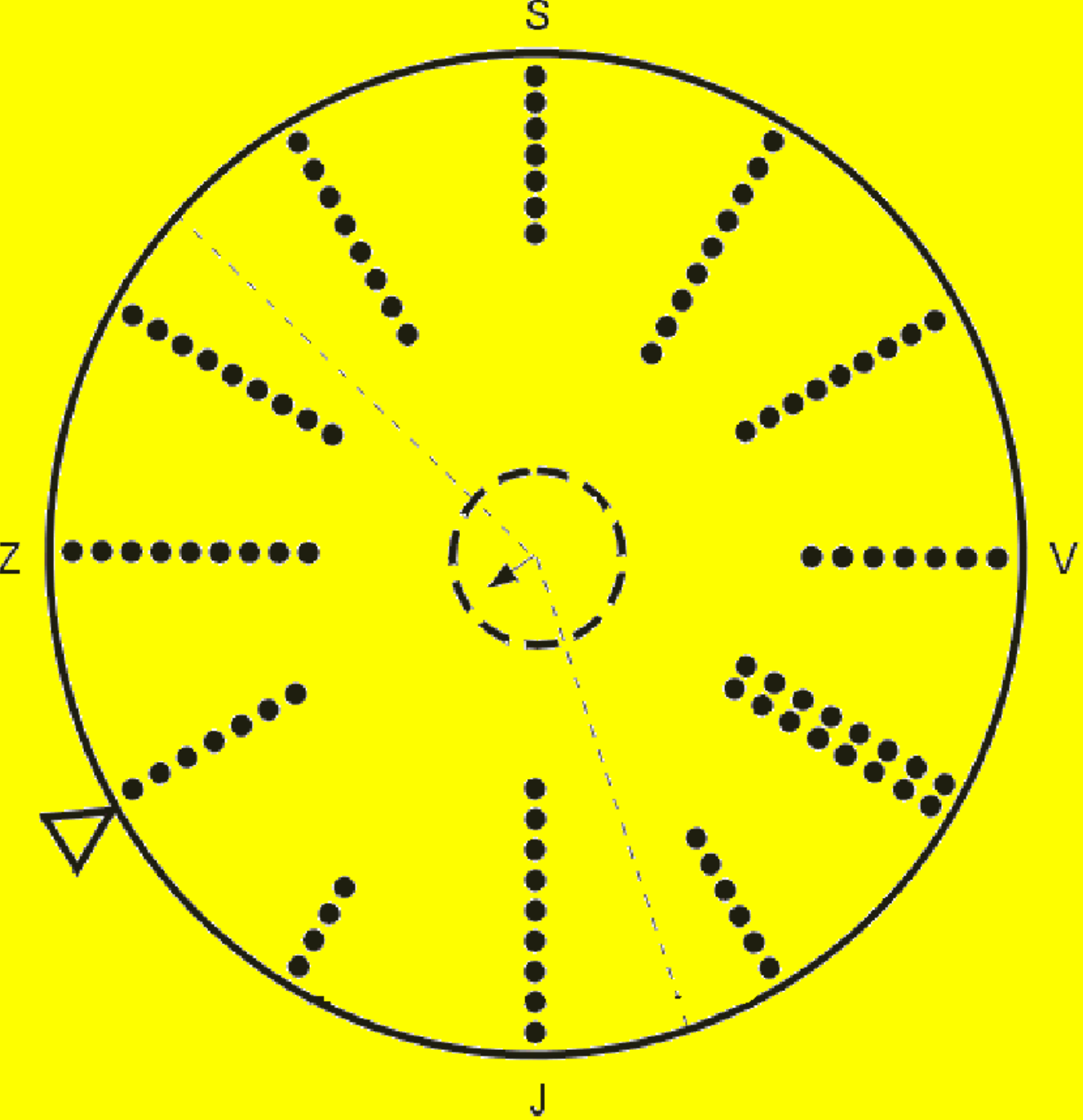
10

Výsledky



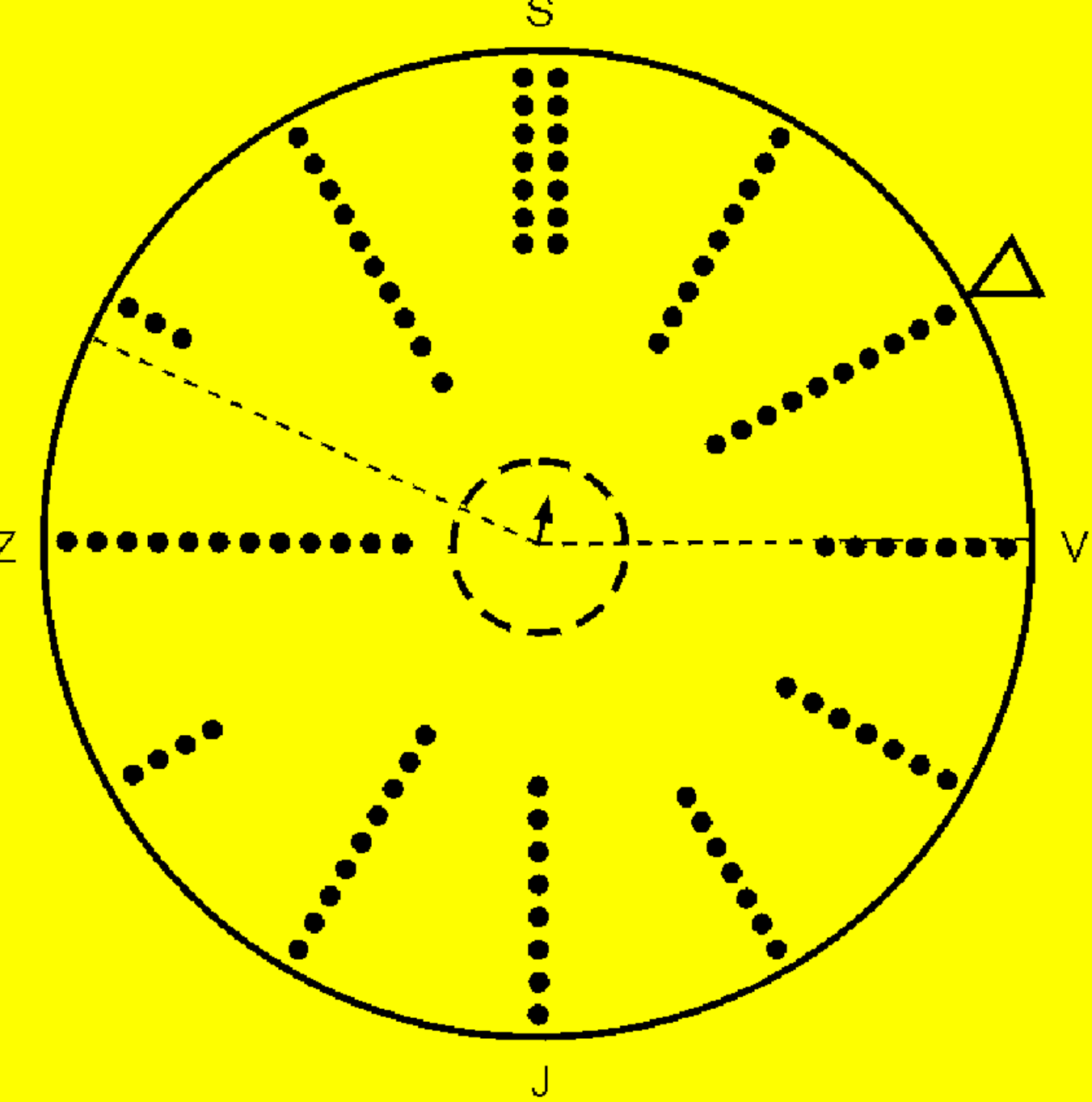
Tma
0% RH

N = 100
θ = 60°
Φ = 74,6°
r = 0,08
s = 78,0°



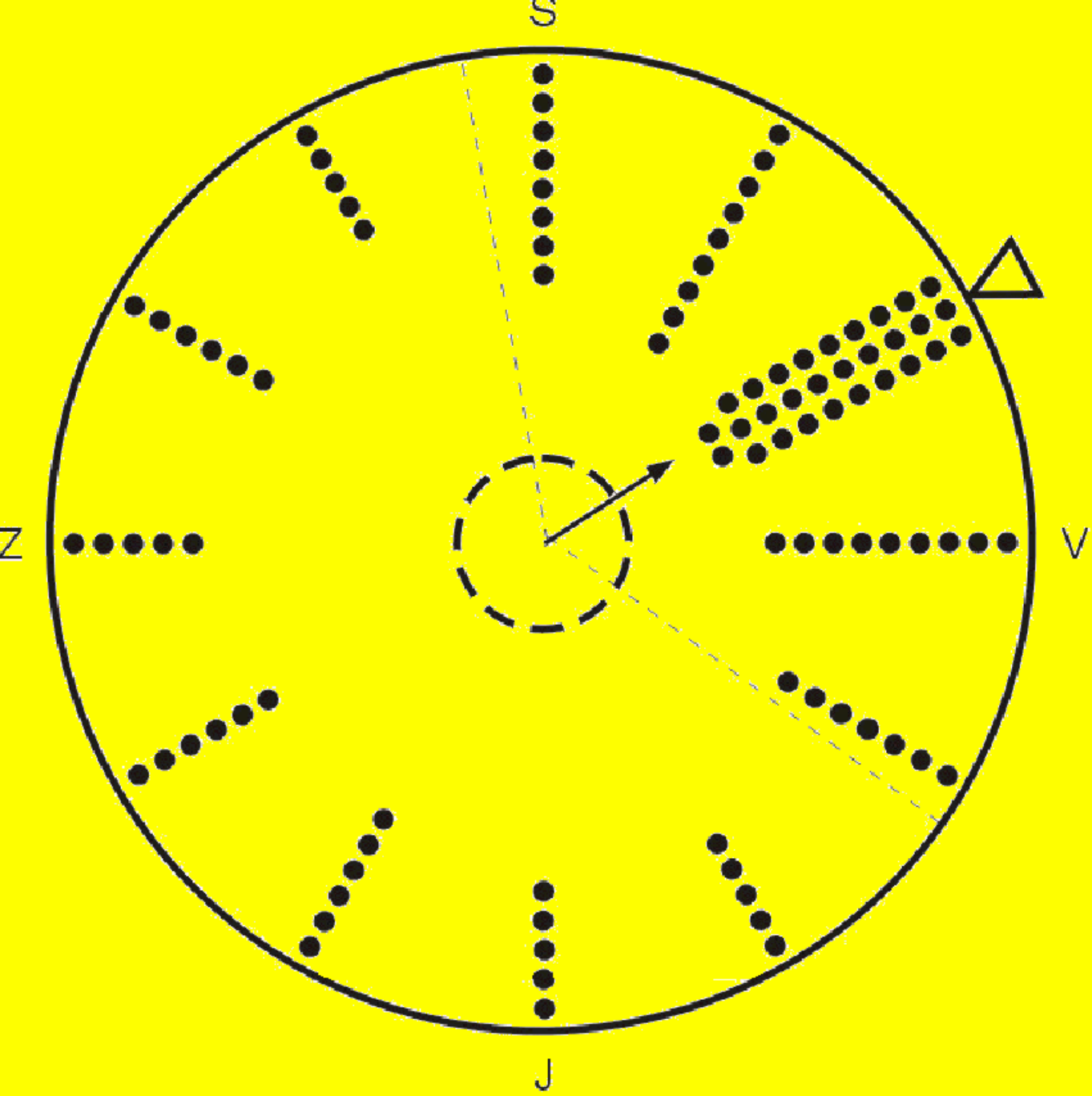
Tma
75% RH

N = 100
θ = 240°
Φ = 235,8°
r = 0,11
s = 76,5°



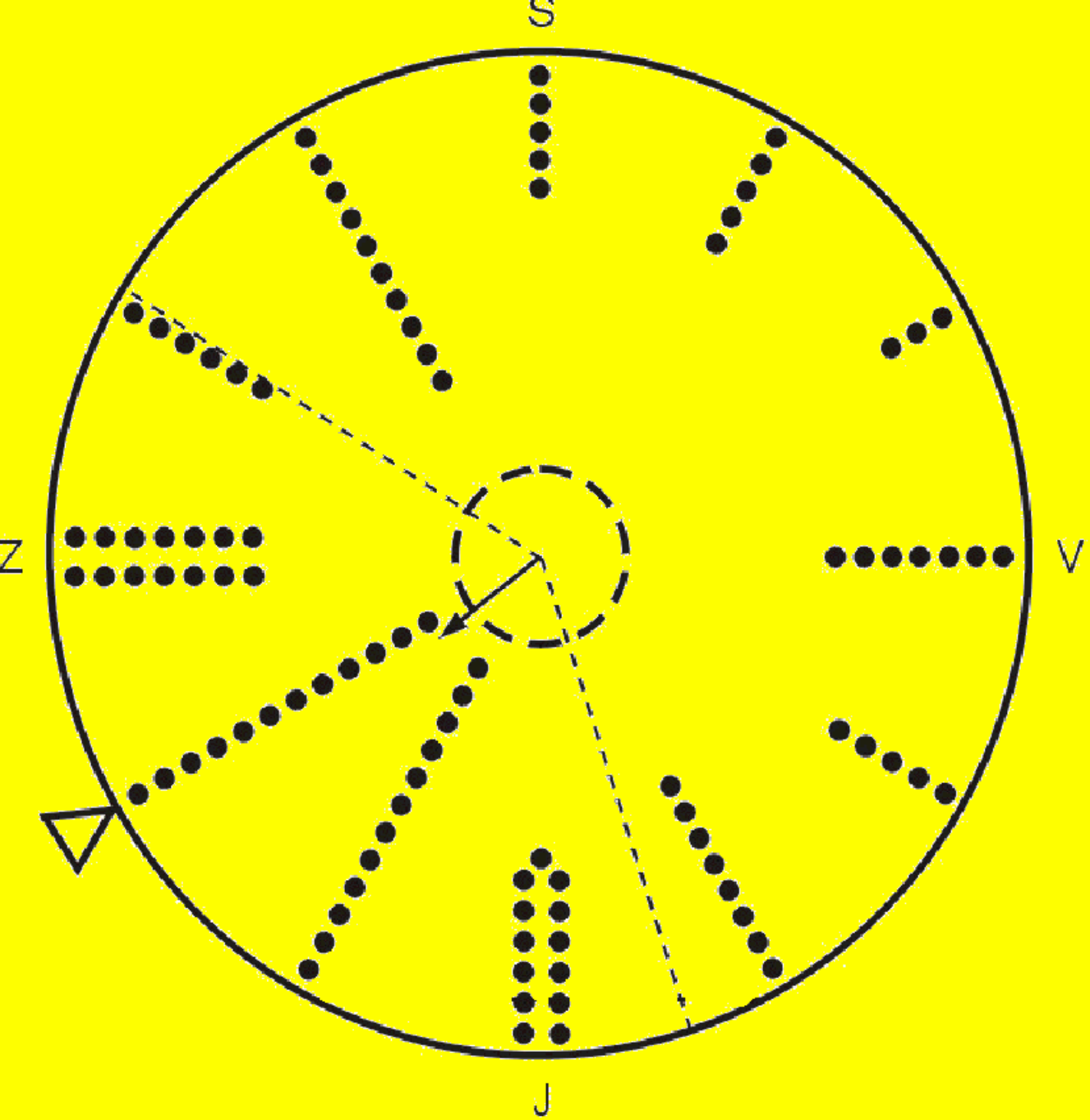
Tma
100% RH

N = 100
θ = 60°
Φ = 12,2°
r = 0,10
s = 76,9°



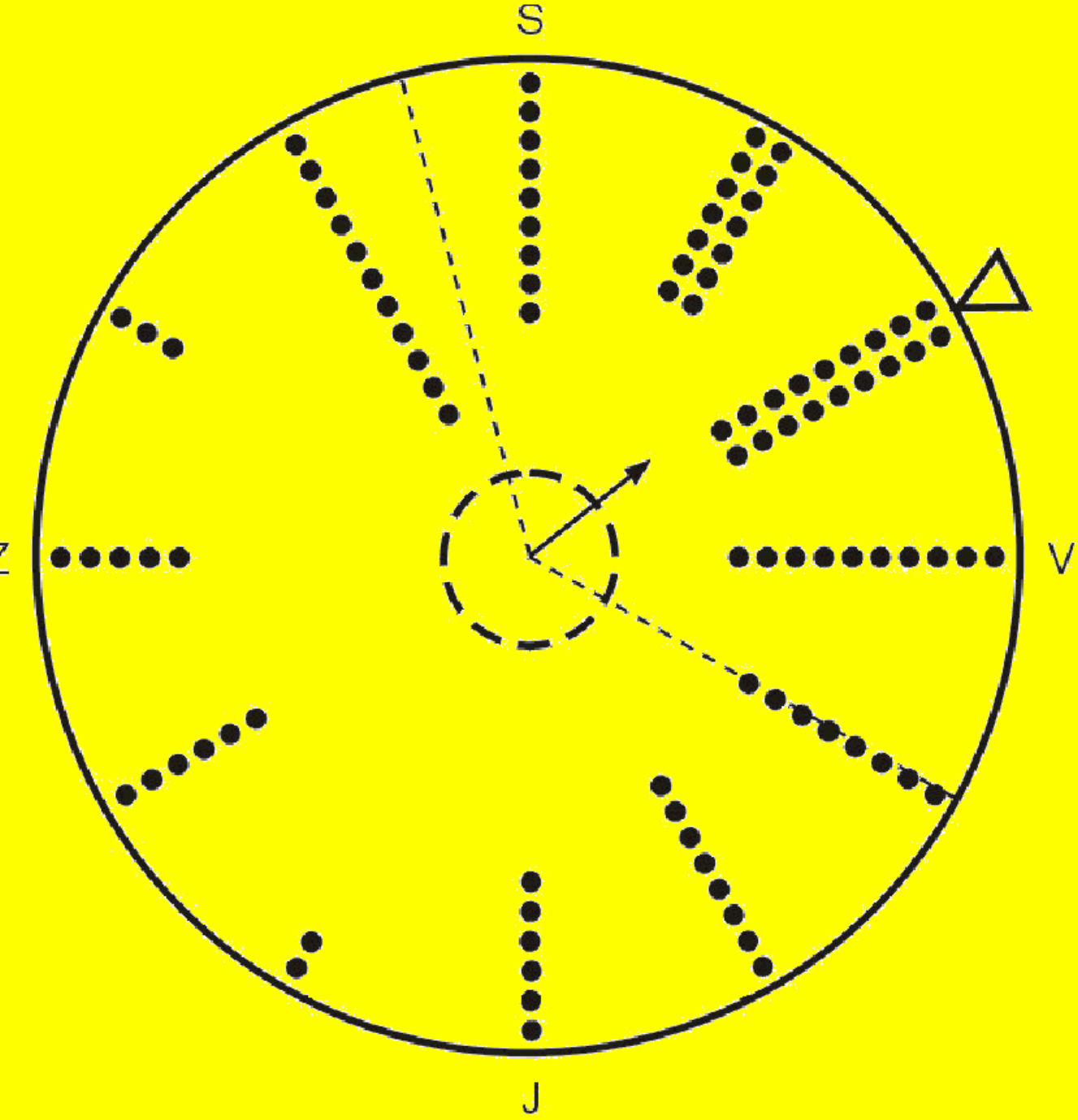
Světlo
0% RH

N = 100
θ = 60°
Φ = 57,1°
r = 0,31
s = 67,3°



Světlo
75% RH

N = 100
θ = 240°
Φ = 231,6°
r = 0,26
s = 69,7°



Světlo
100% RH

N = 100

θ = 60°

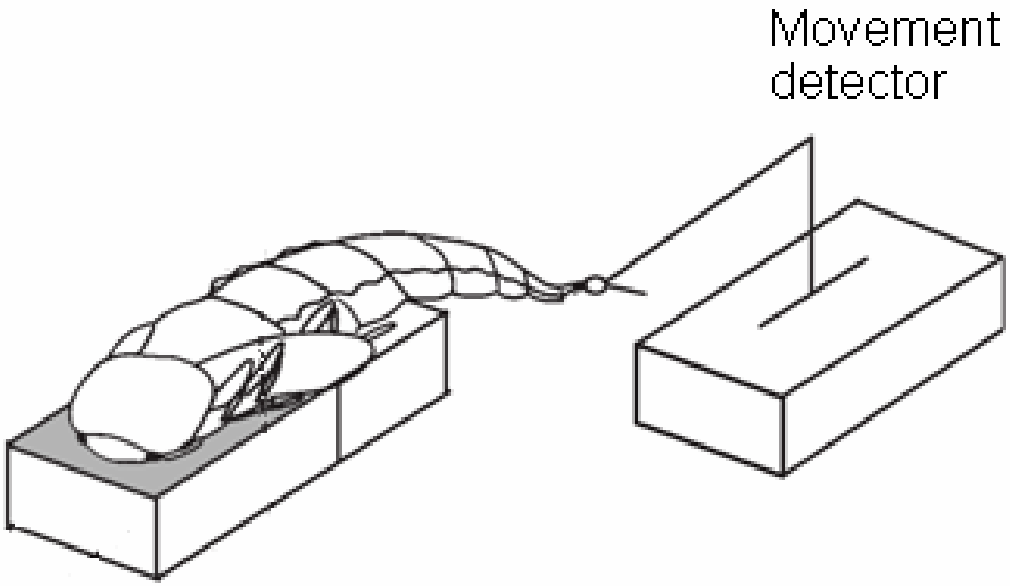
Φ = 51,9°

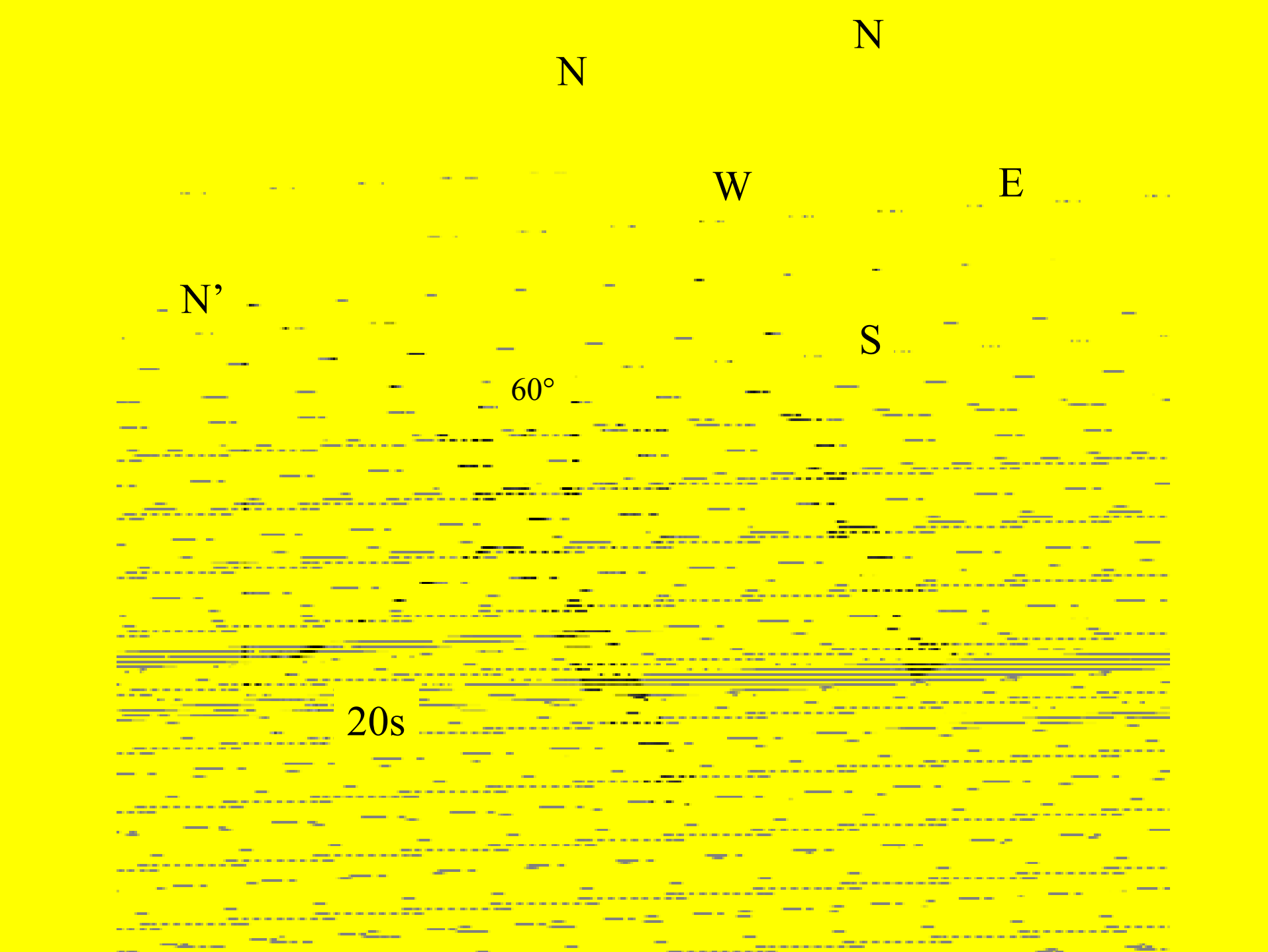
r = 0,31

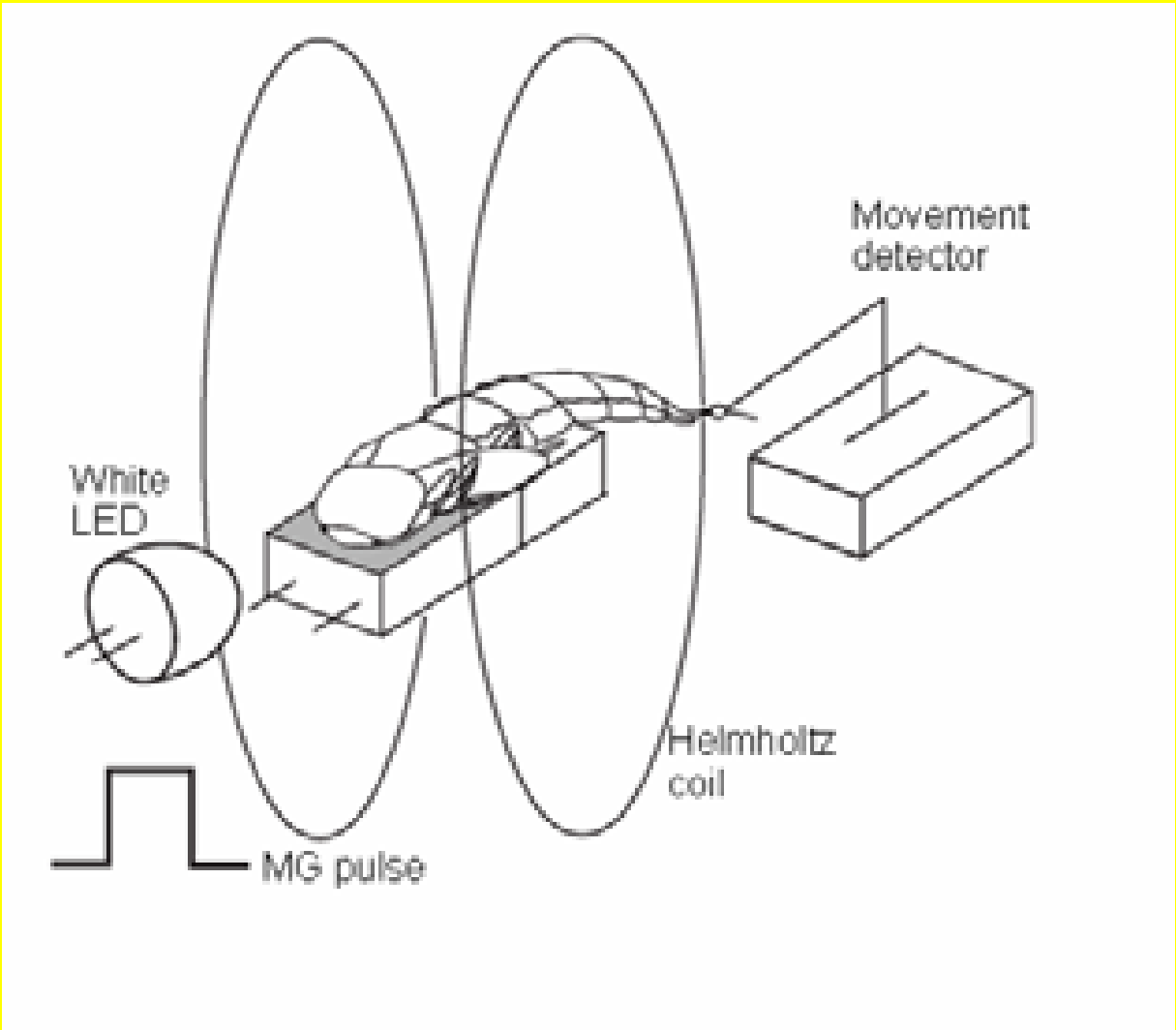
s = 67,3°

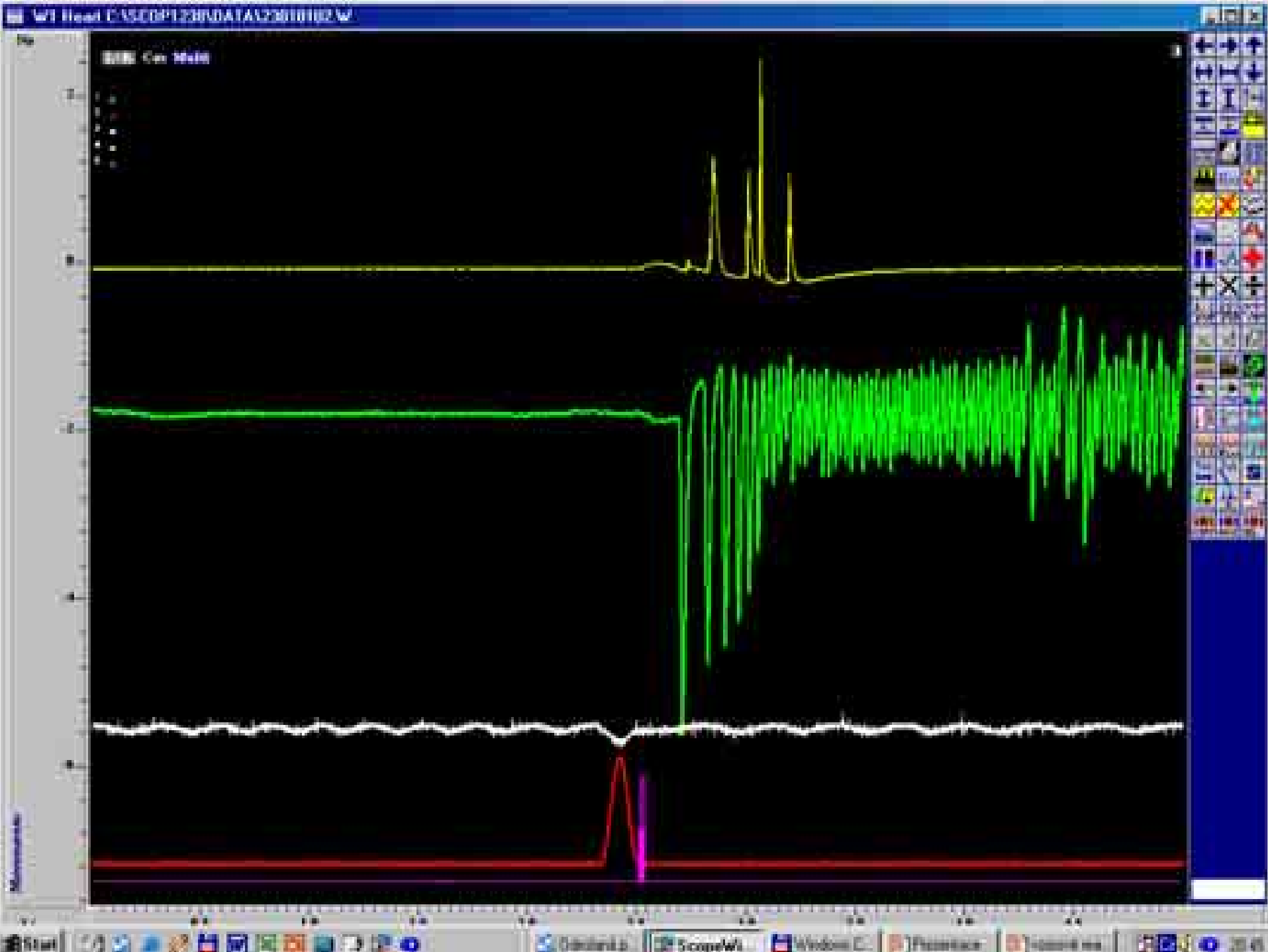
Software pro cirkulární statistiku

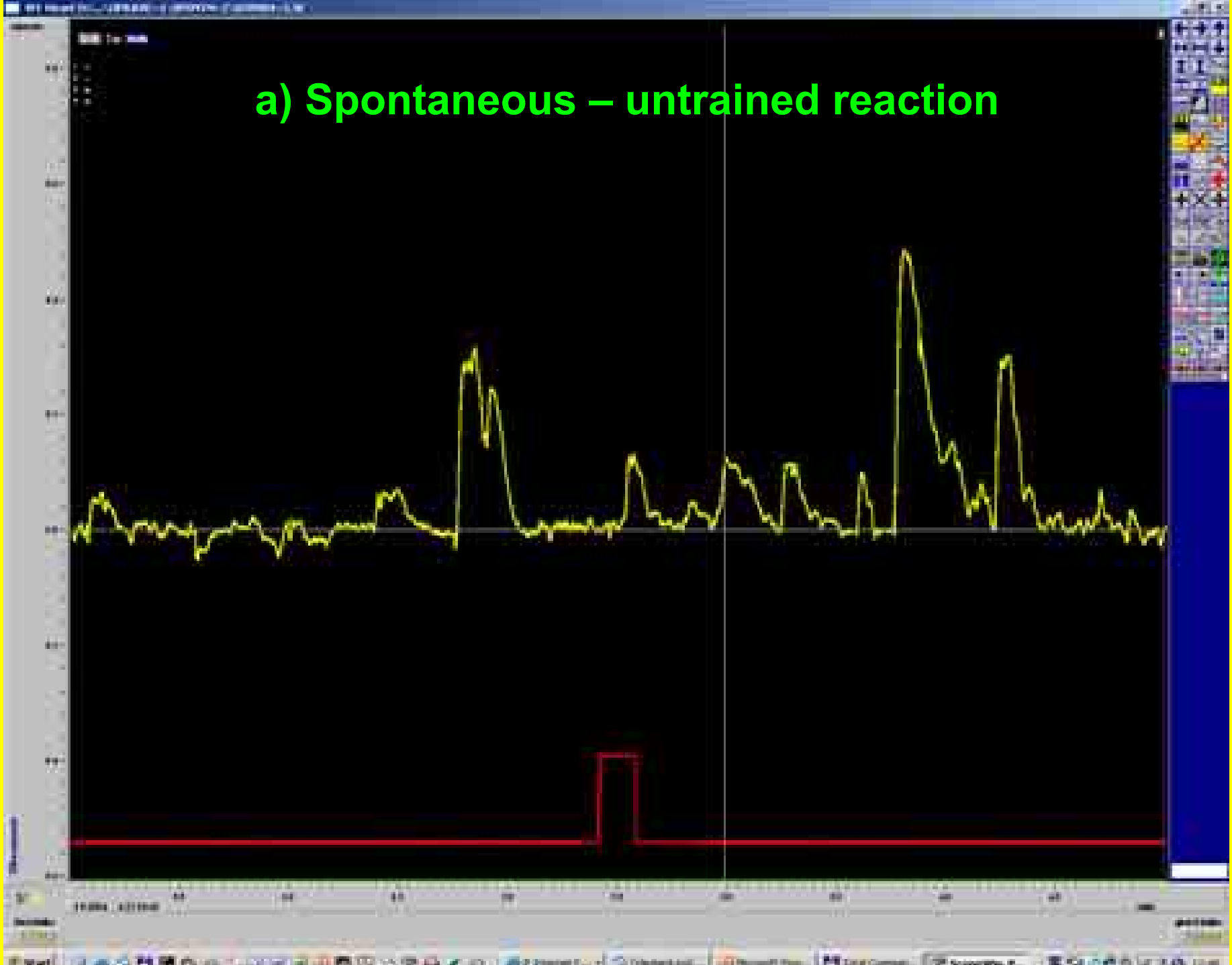
Etologie kukel

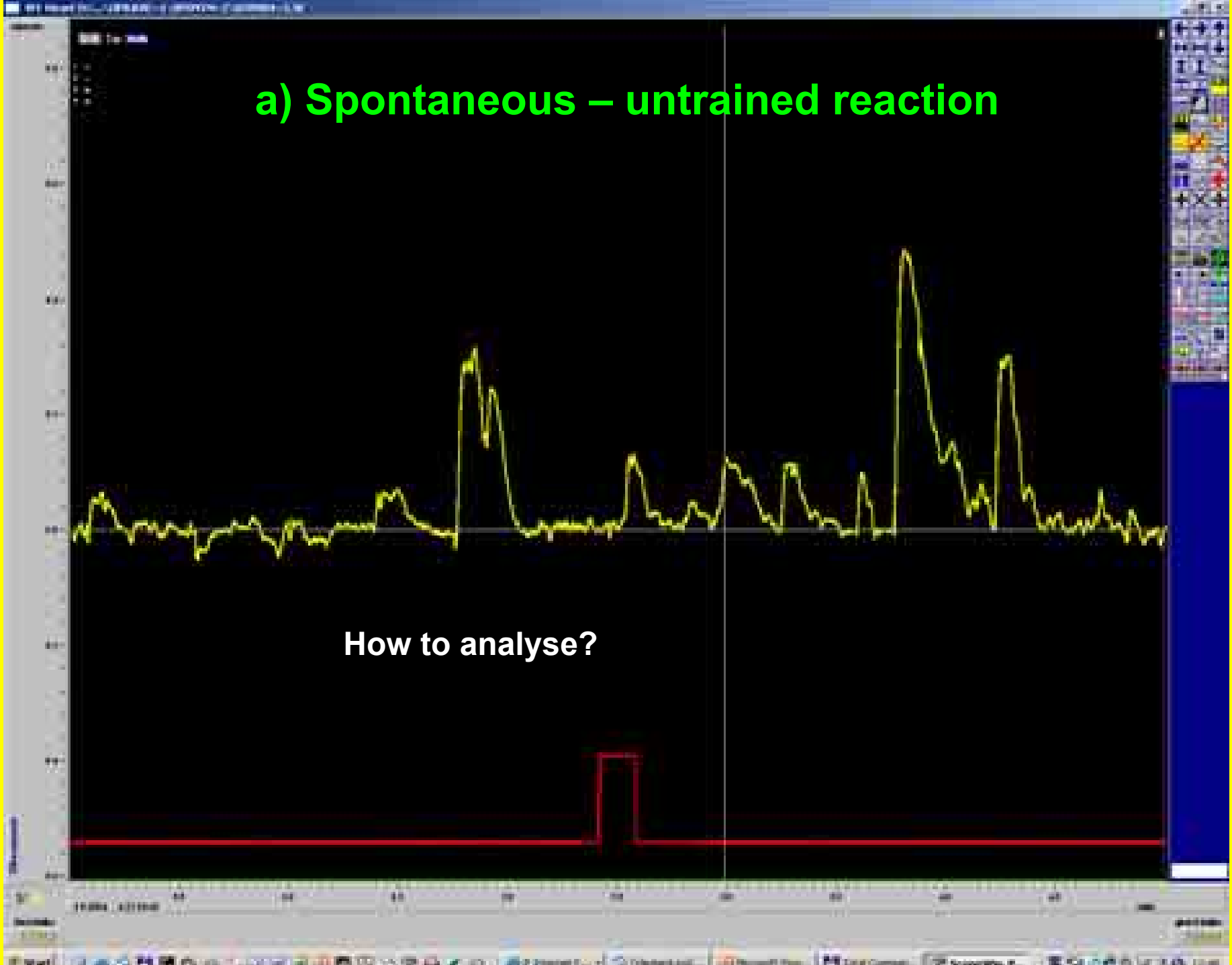

Movement
detector

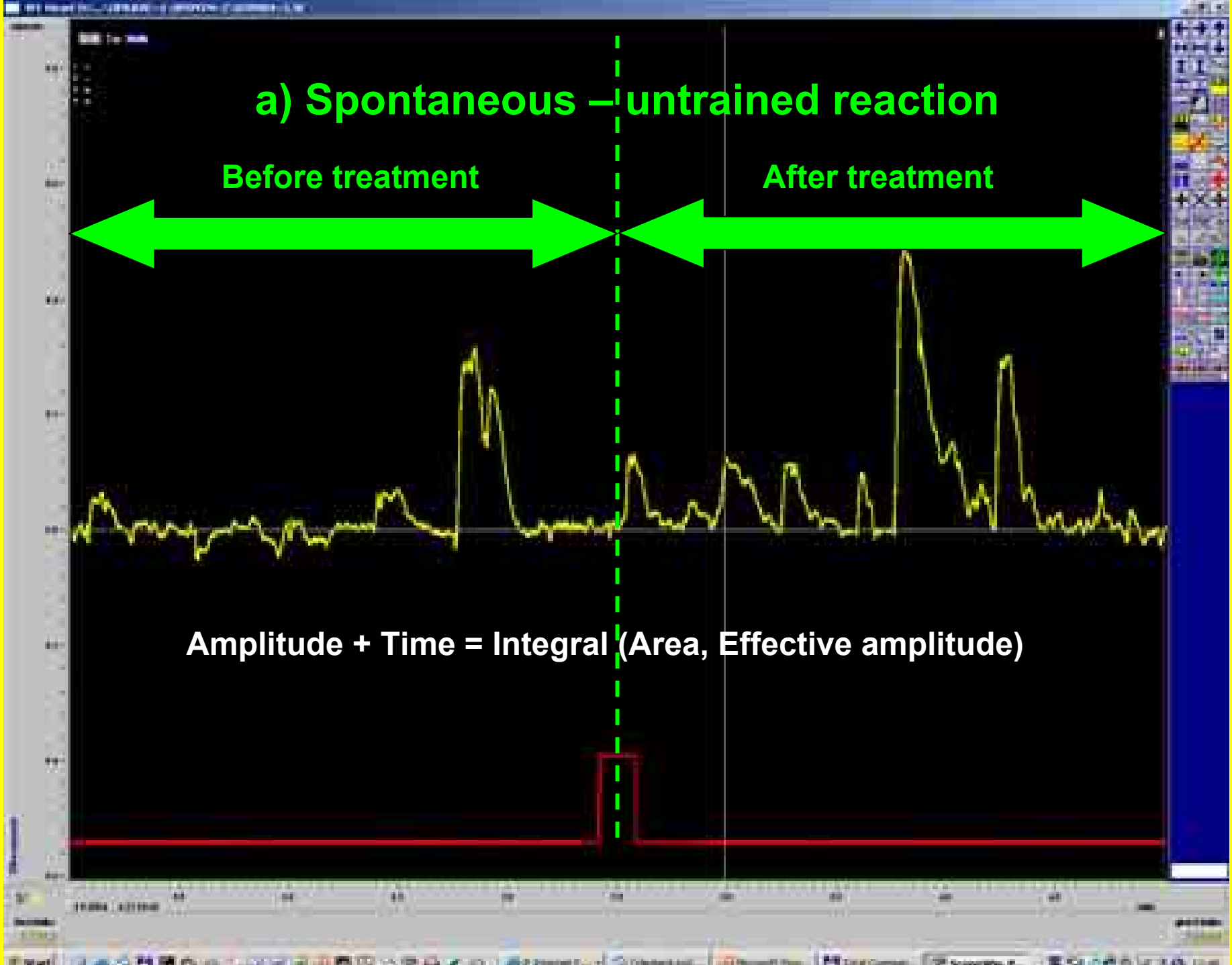

N
N
W
E
N’
S
60°
20s

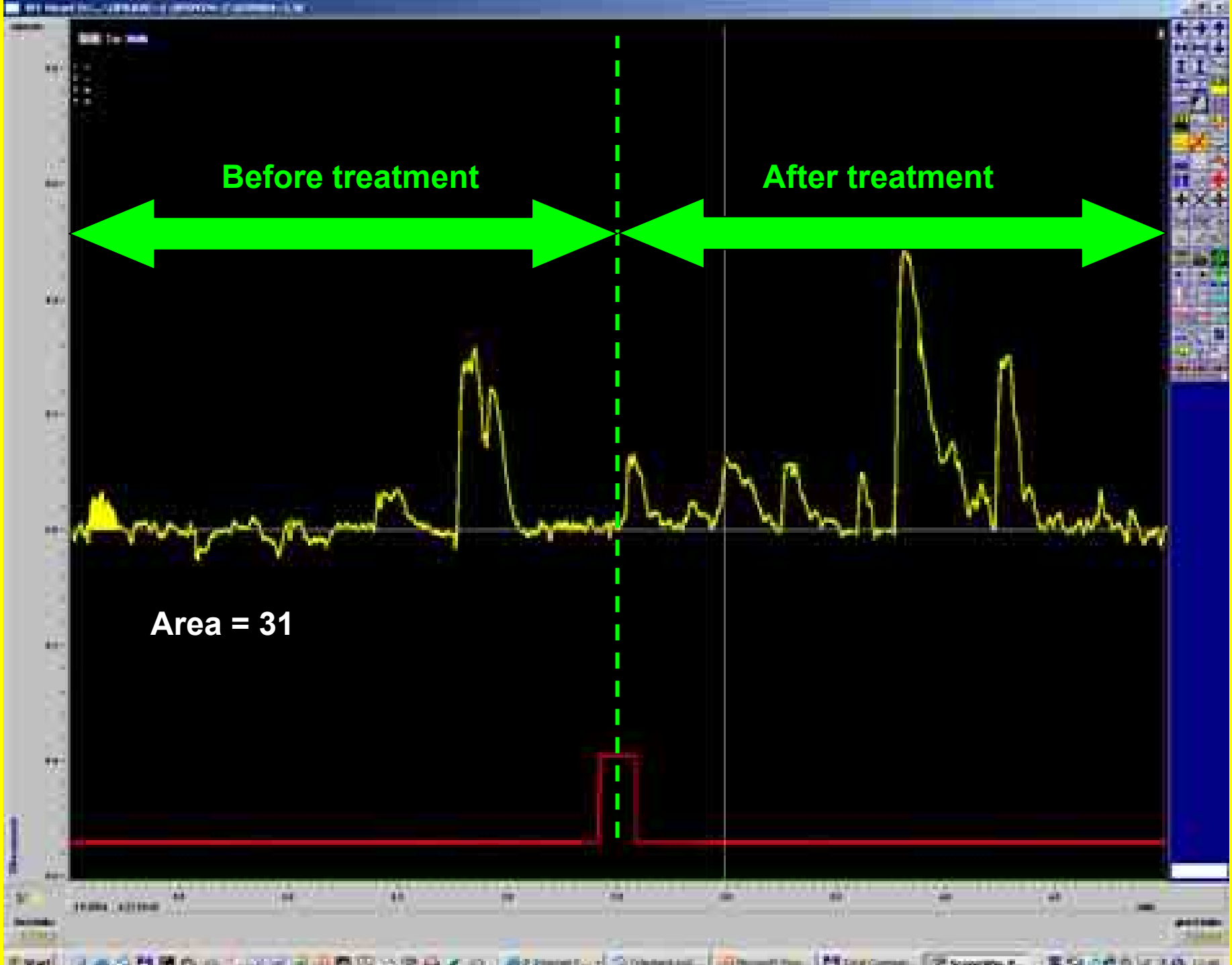

Movement
detector
White
LED
Helmholtz
coil
MG pulse

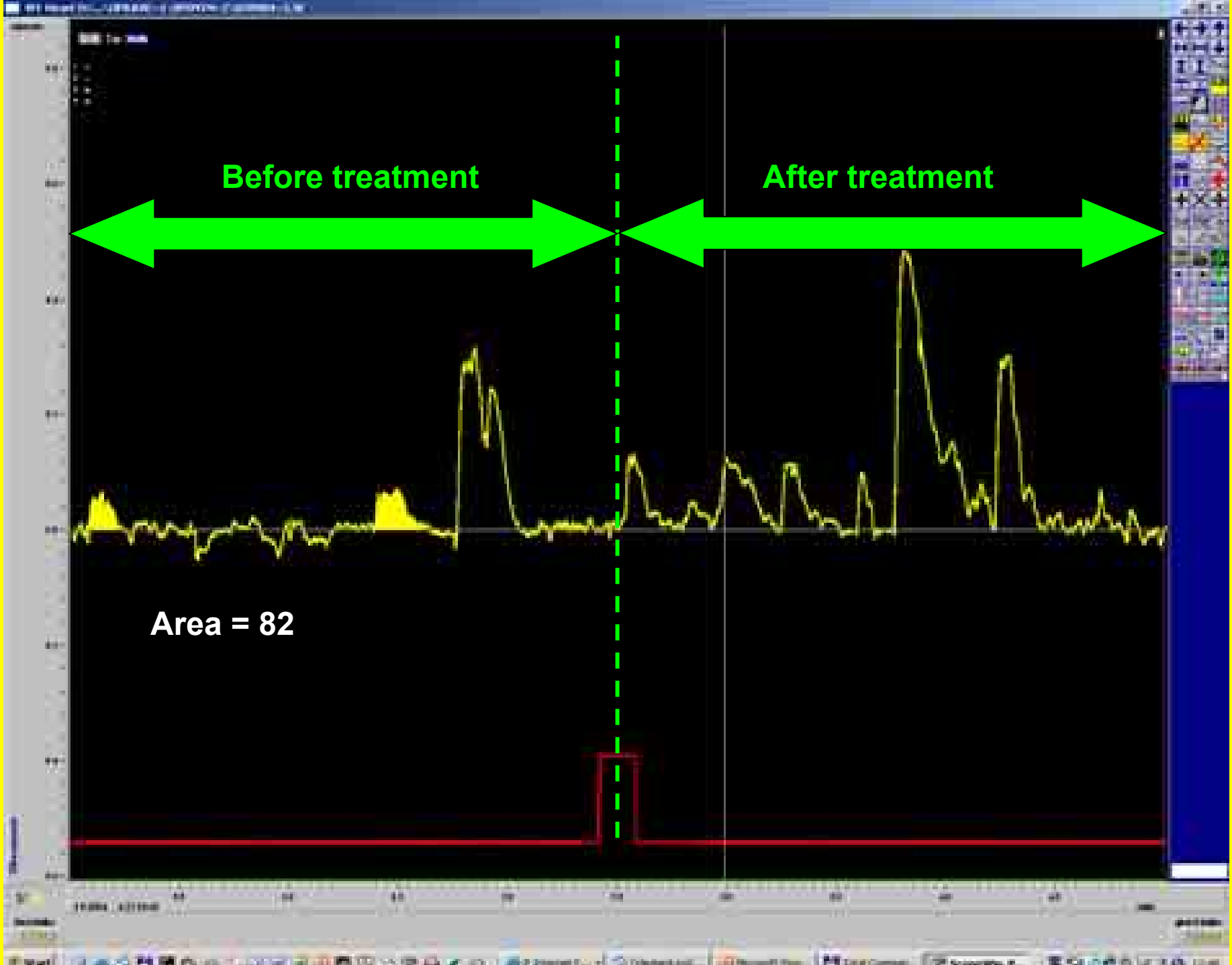


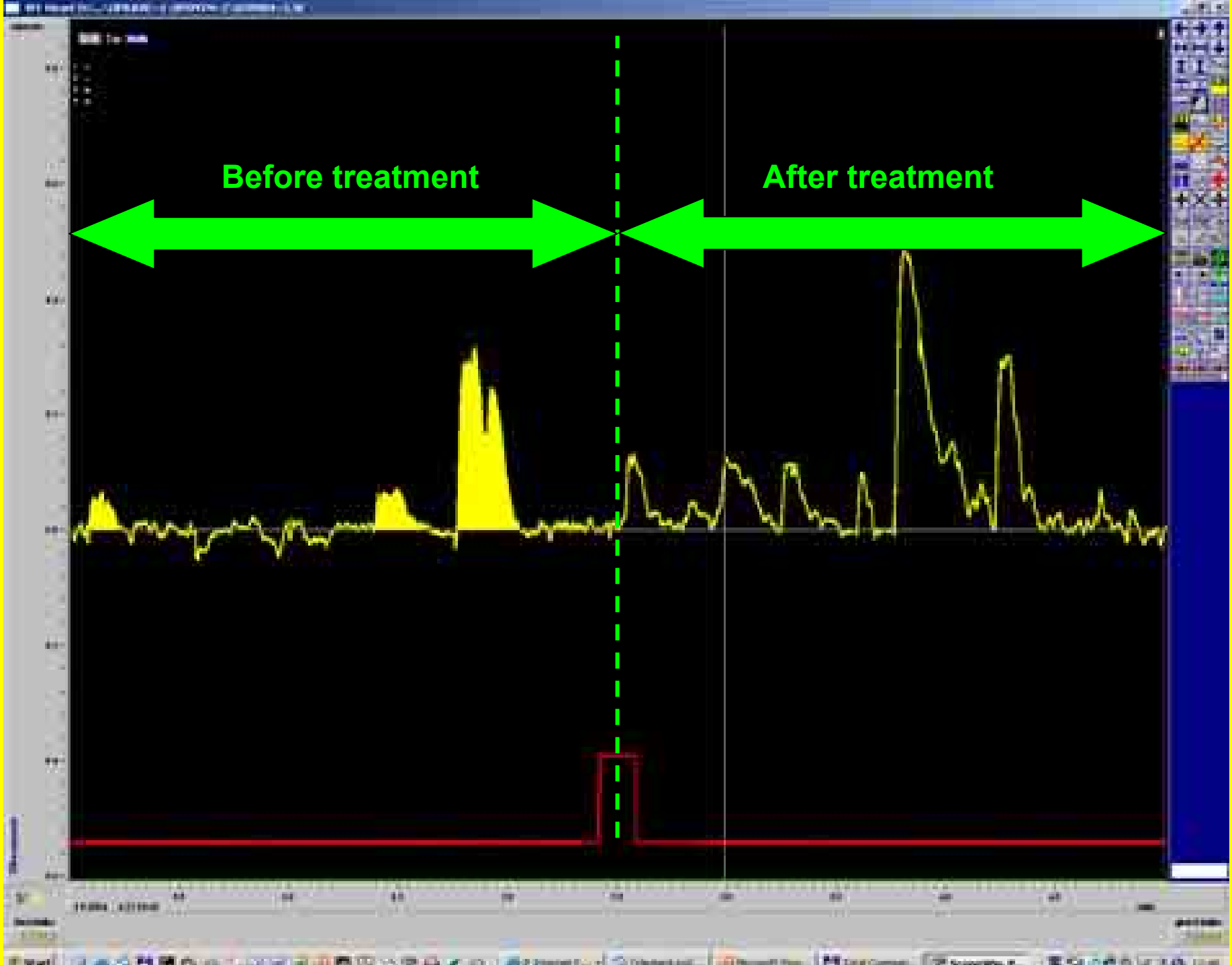

a) Spontaneous – untrained reaction

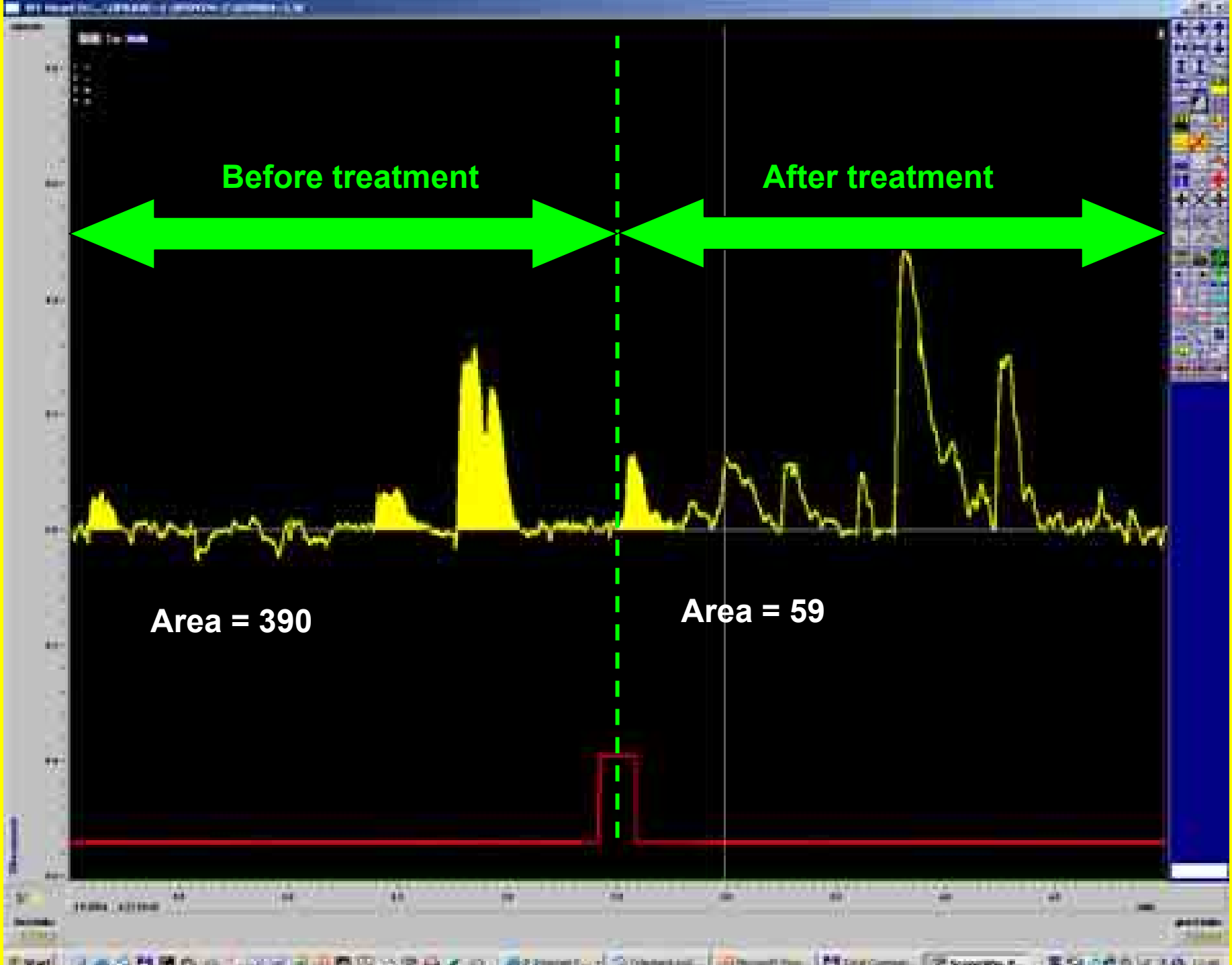

a) Spontaneous – untrained reaction
How to analyse?

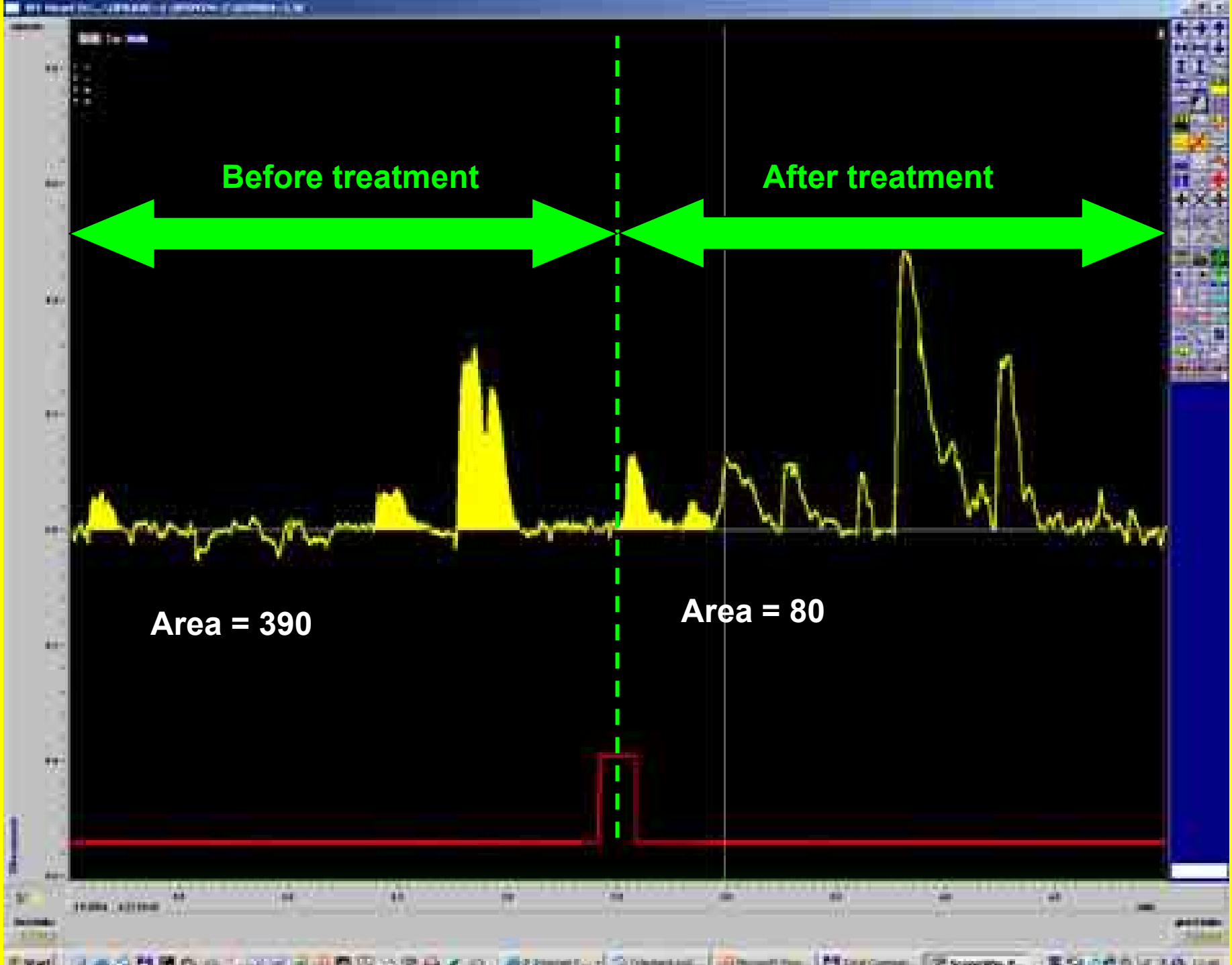

a) Spontaneous – untrained reaction
Before treatment
After treatment
Amplitude + Time = Integral (Area, Effective amplitude)

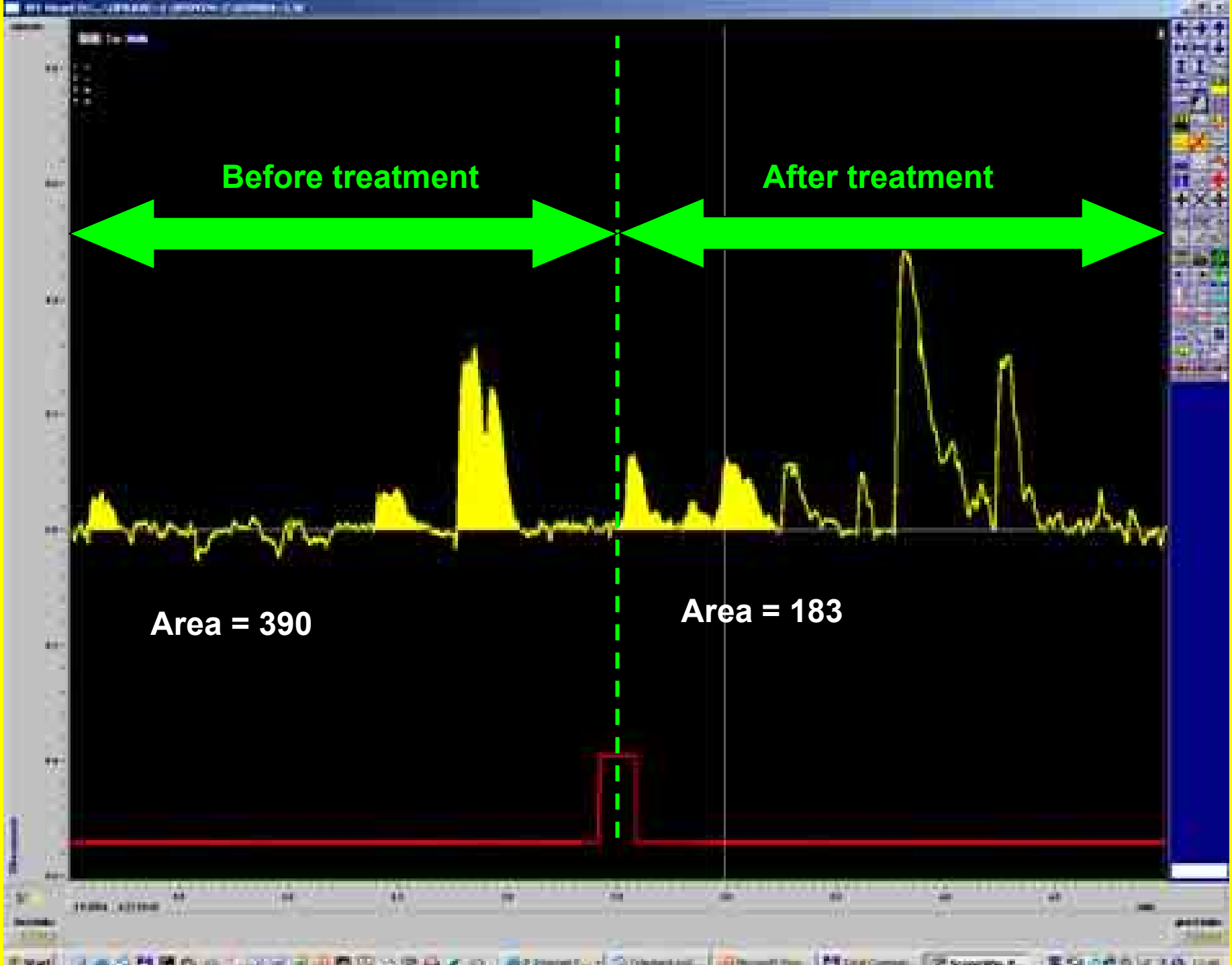

Before treatment
After treatment
Area = 31

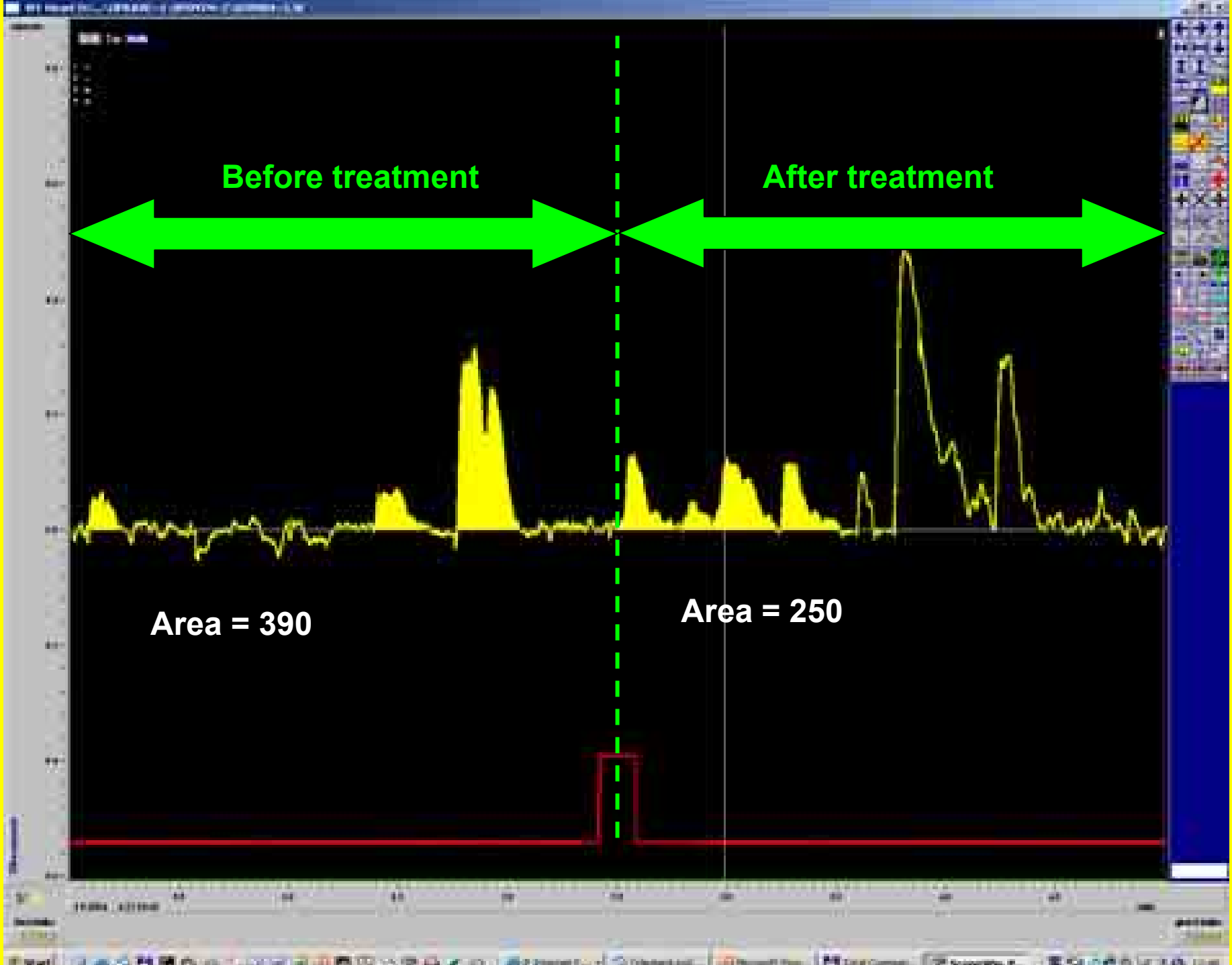

Before treatment
After treatment
Area = 82

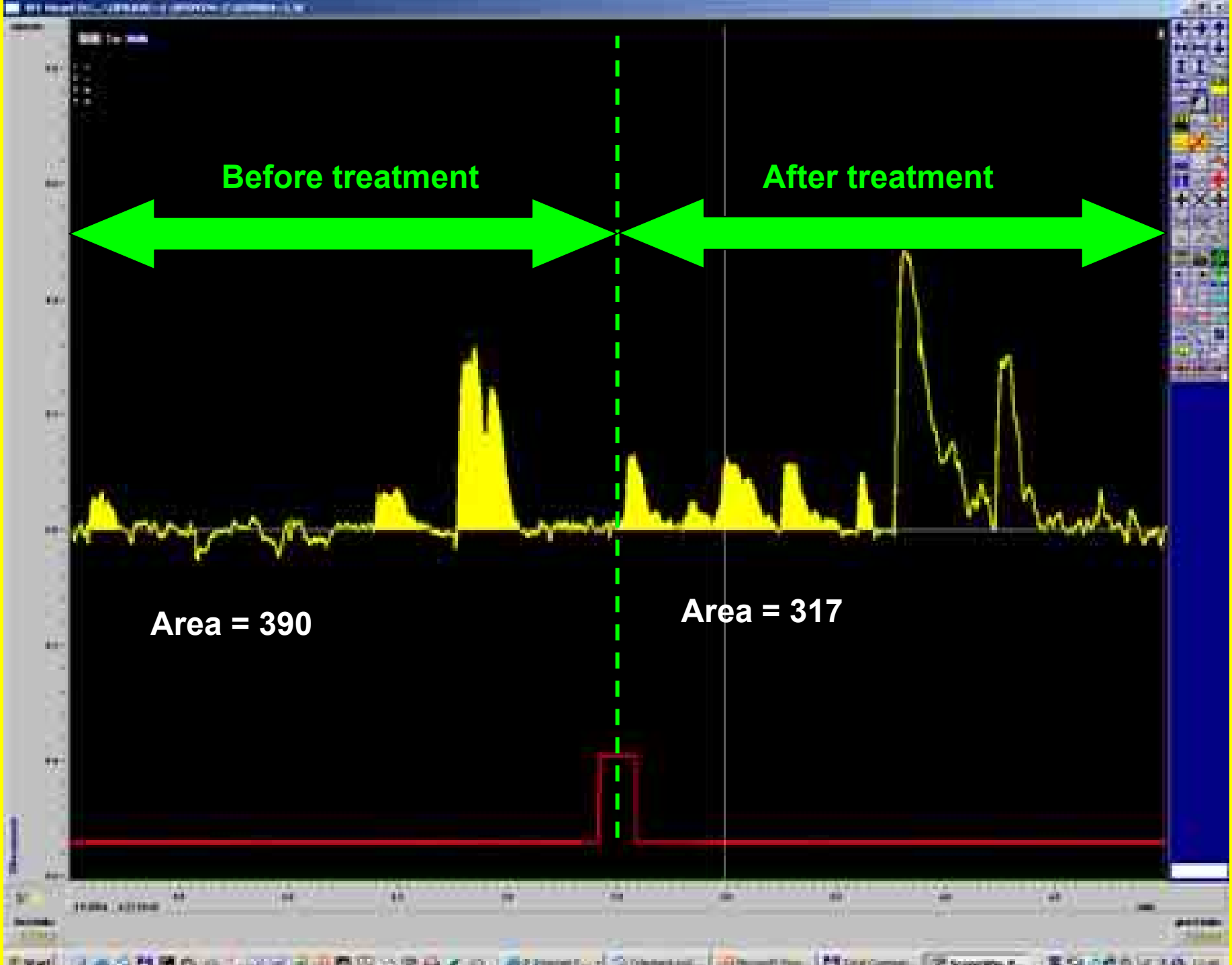

Before treatment
After treatment

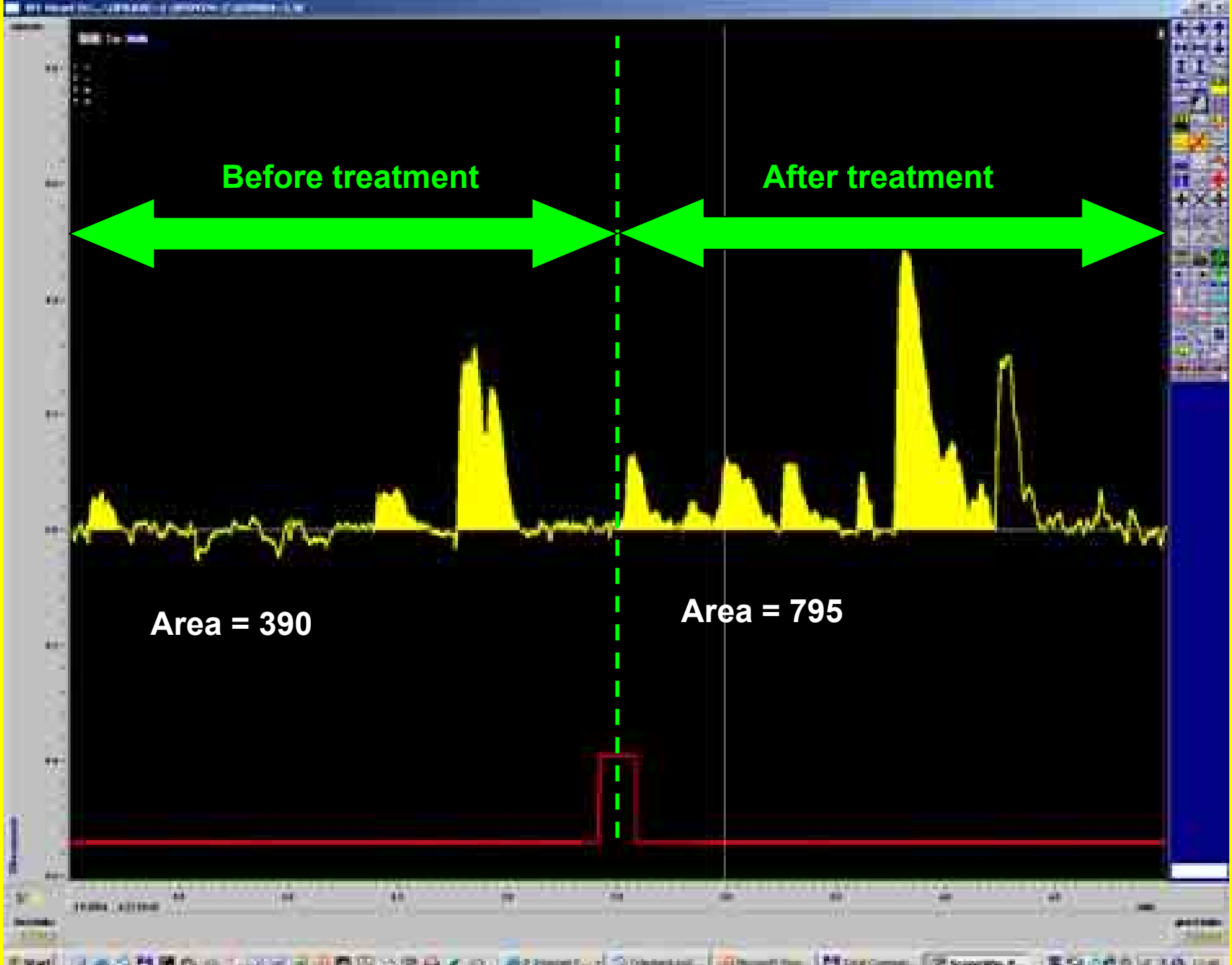

Before treatment
After treatment
Area = 390
Area = 59

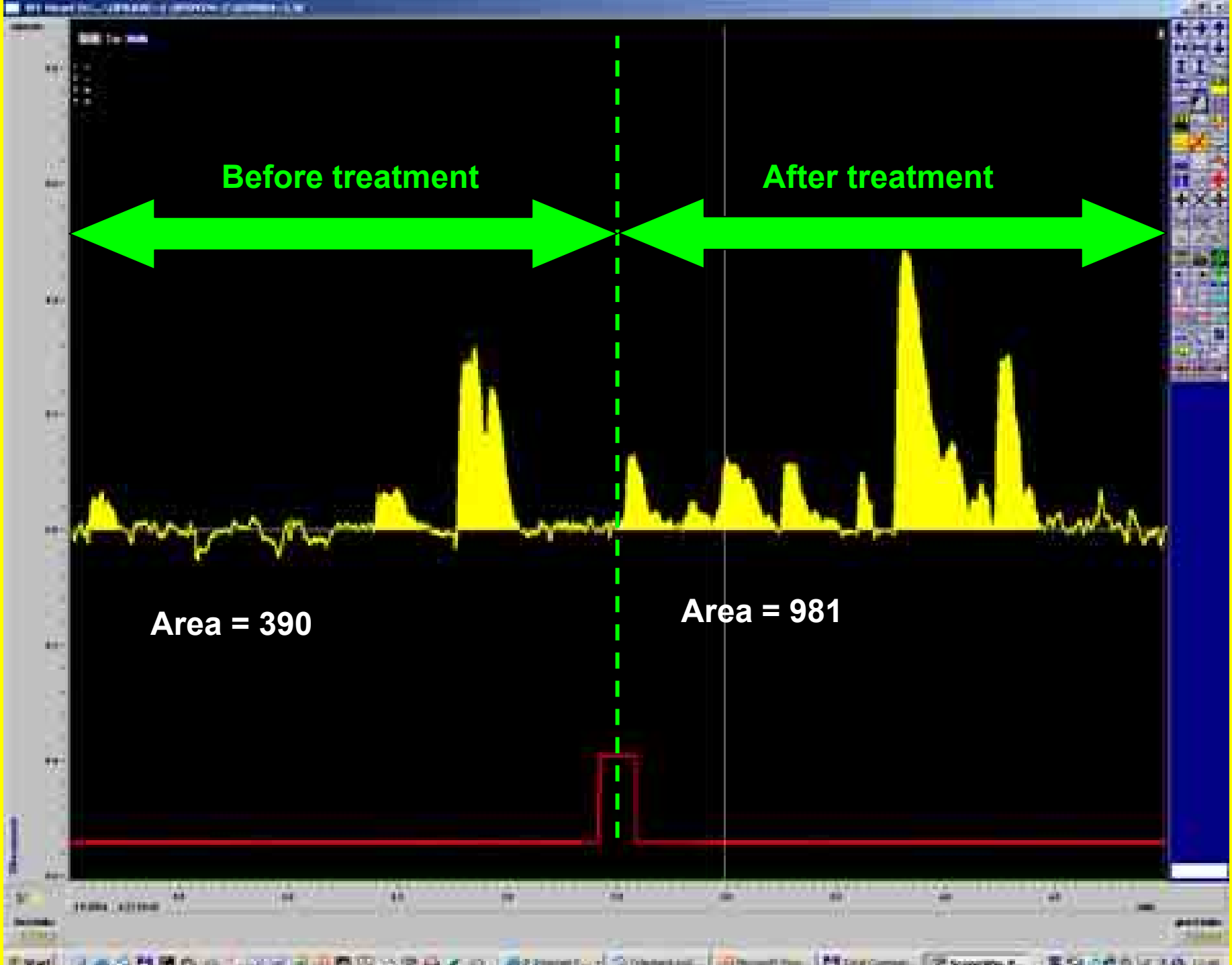

Before treatment
After treatment
Area = 390
Area = 80

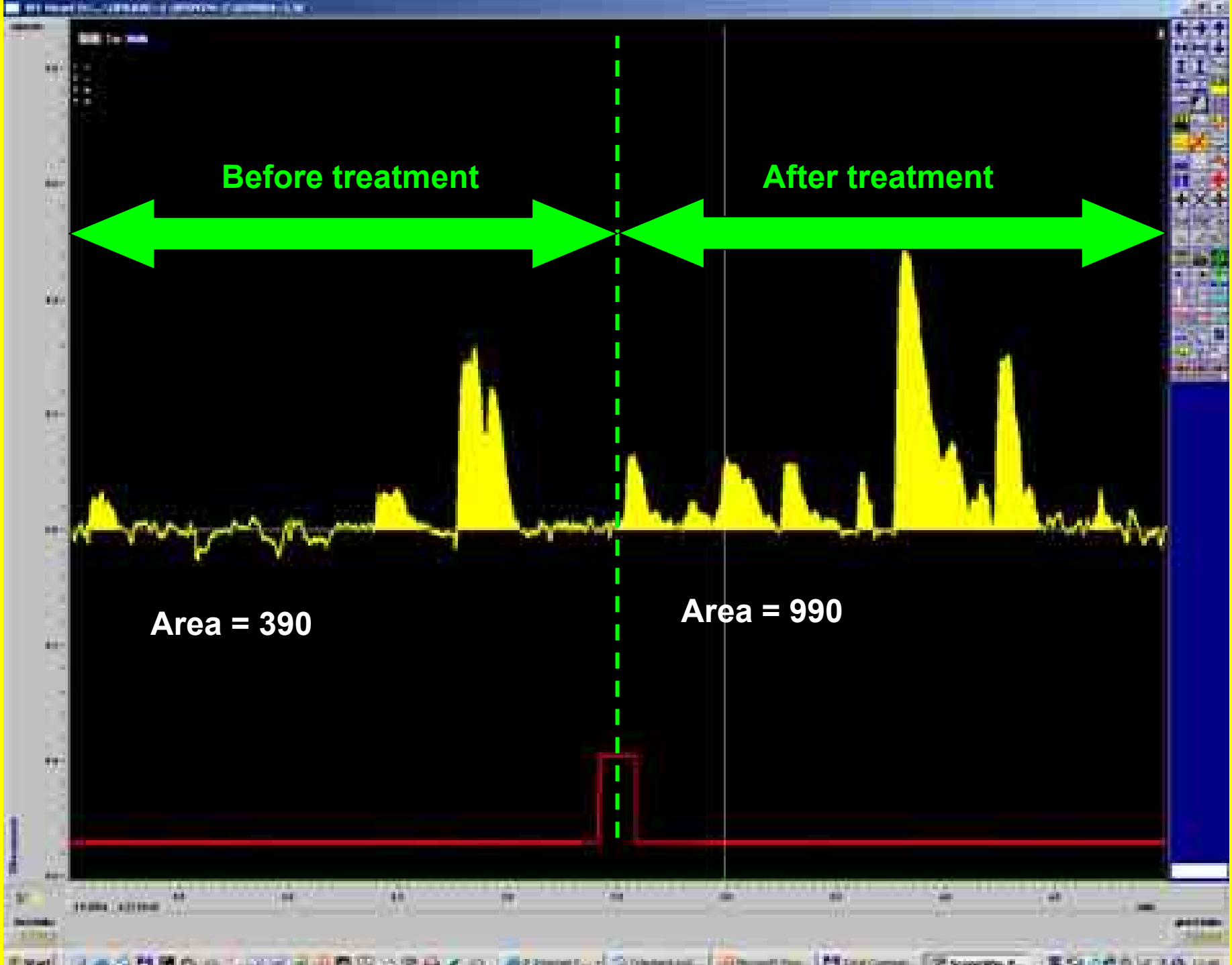

Before treatment
After treatment
Area = 390
Area = 183


Before treatment
After treatment
Area = 390
Area = 250

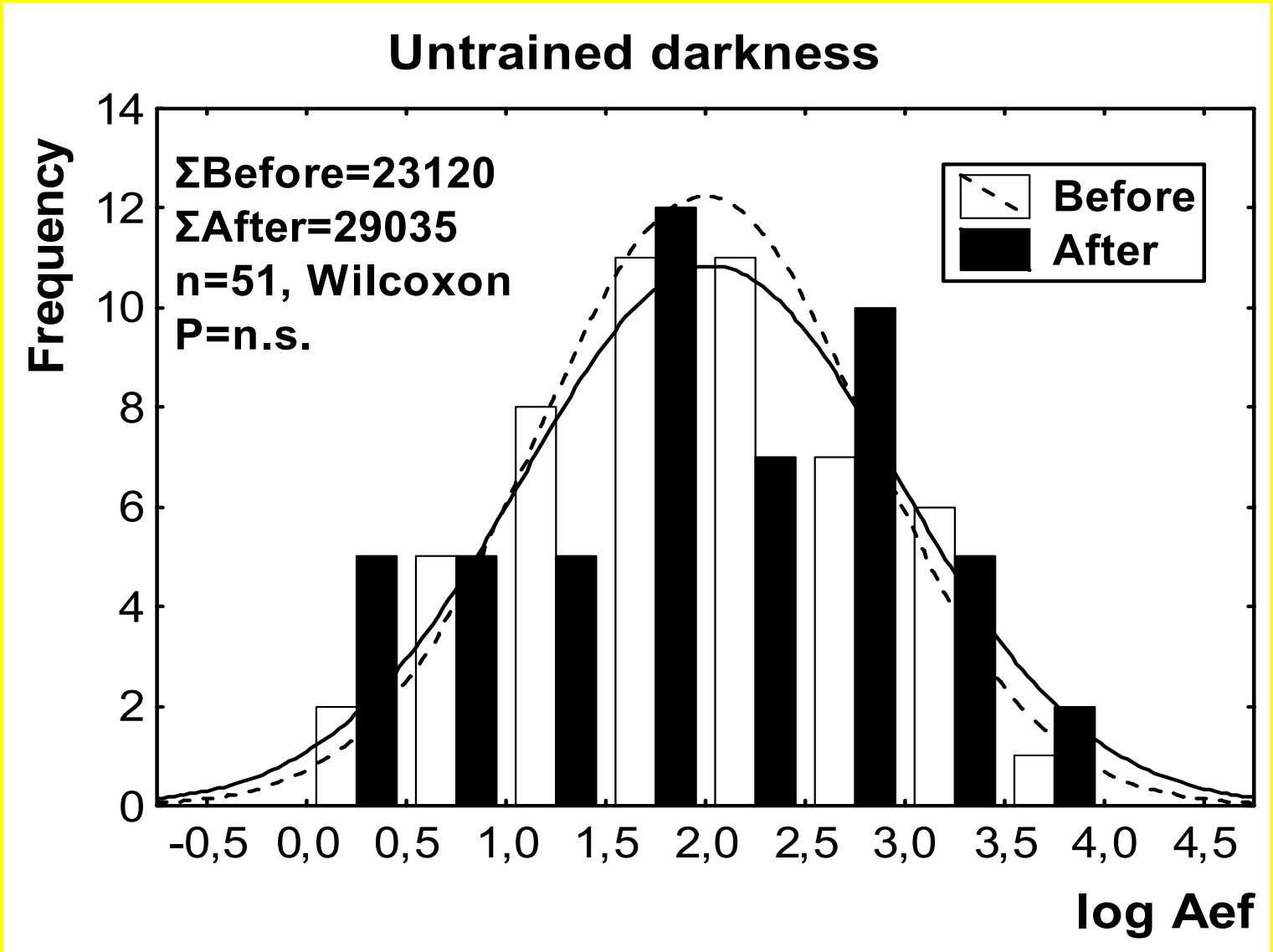

Before treatment
After treatment
Area = 390
Area = 317

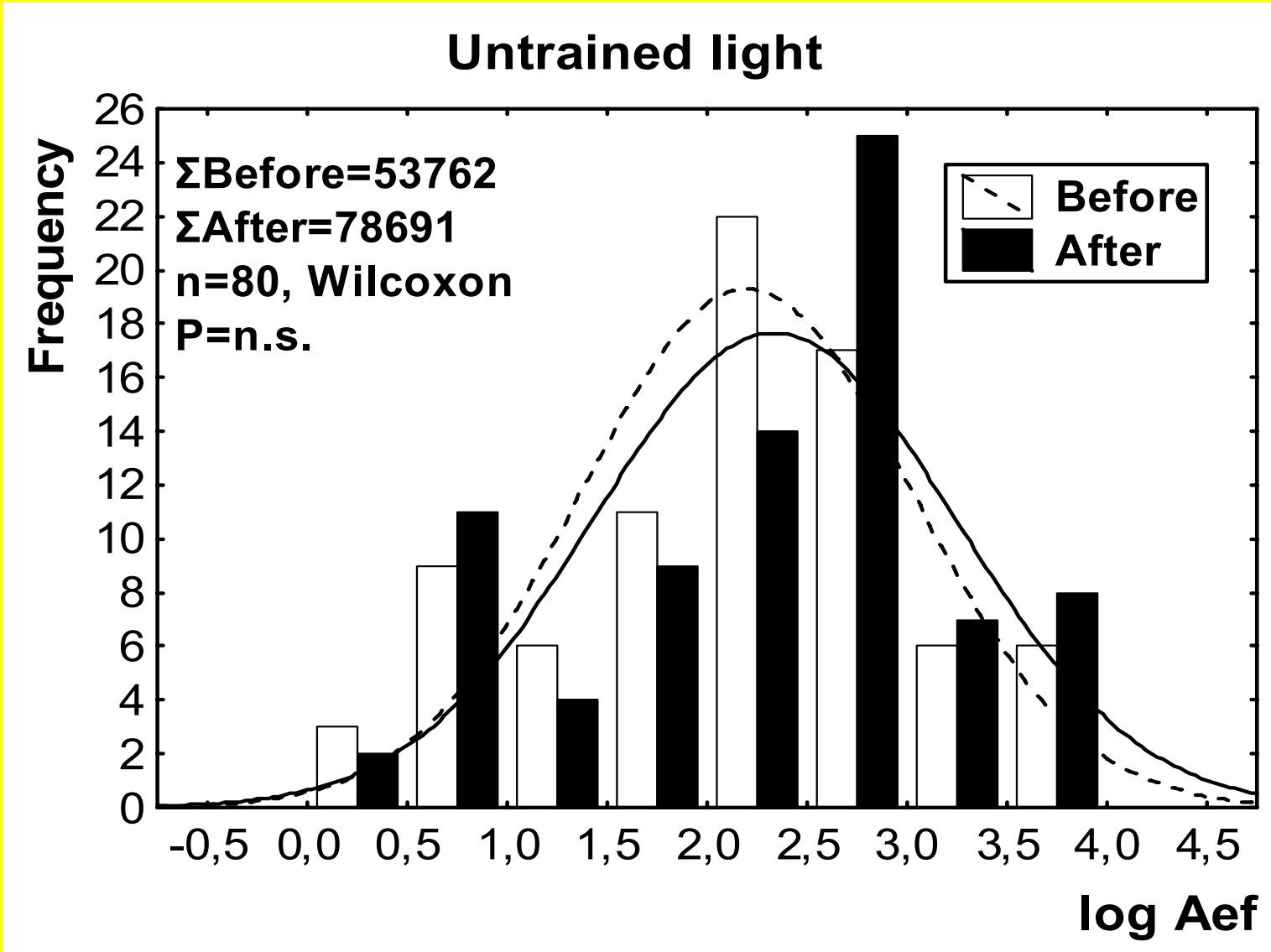

Before treatment
After treatment
Area = 390
Area = 795


Before treatment
After treatment
Area = 390
Area = 981


Before treatment
After treatment
Area = 390
Area = 990


Before treatment
After treatment
Area = 390
Area = 990
Wilcoxon pair test


Untrained darkness
ΣBefore=23120
ΣAfter=29035
n=51, Wilcoxon
P=n.s.
Before
After
Frequency
14
12
10
8
6
4
2
0
-0,5
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
4,0
4,5
log Aef


Untrained light
Frequency
ΣBefore=53762
ΣAfter=78691
n=80, Wilcoxon
P=n.s.
Before
After
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-0,5
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
4,0
4,5
log Aef

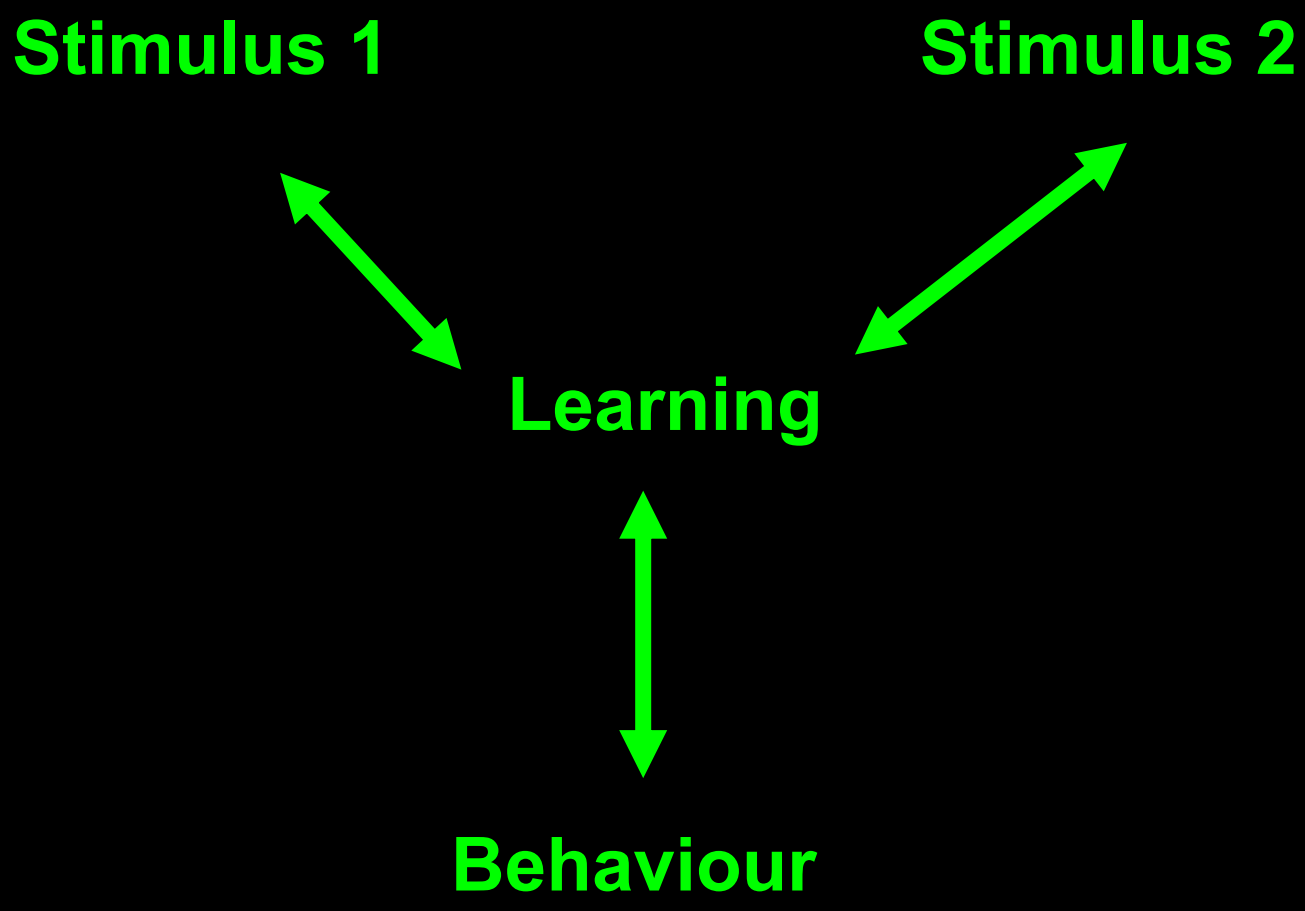
Conclusion:

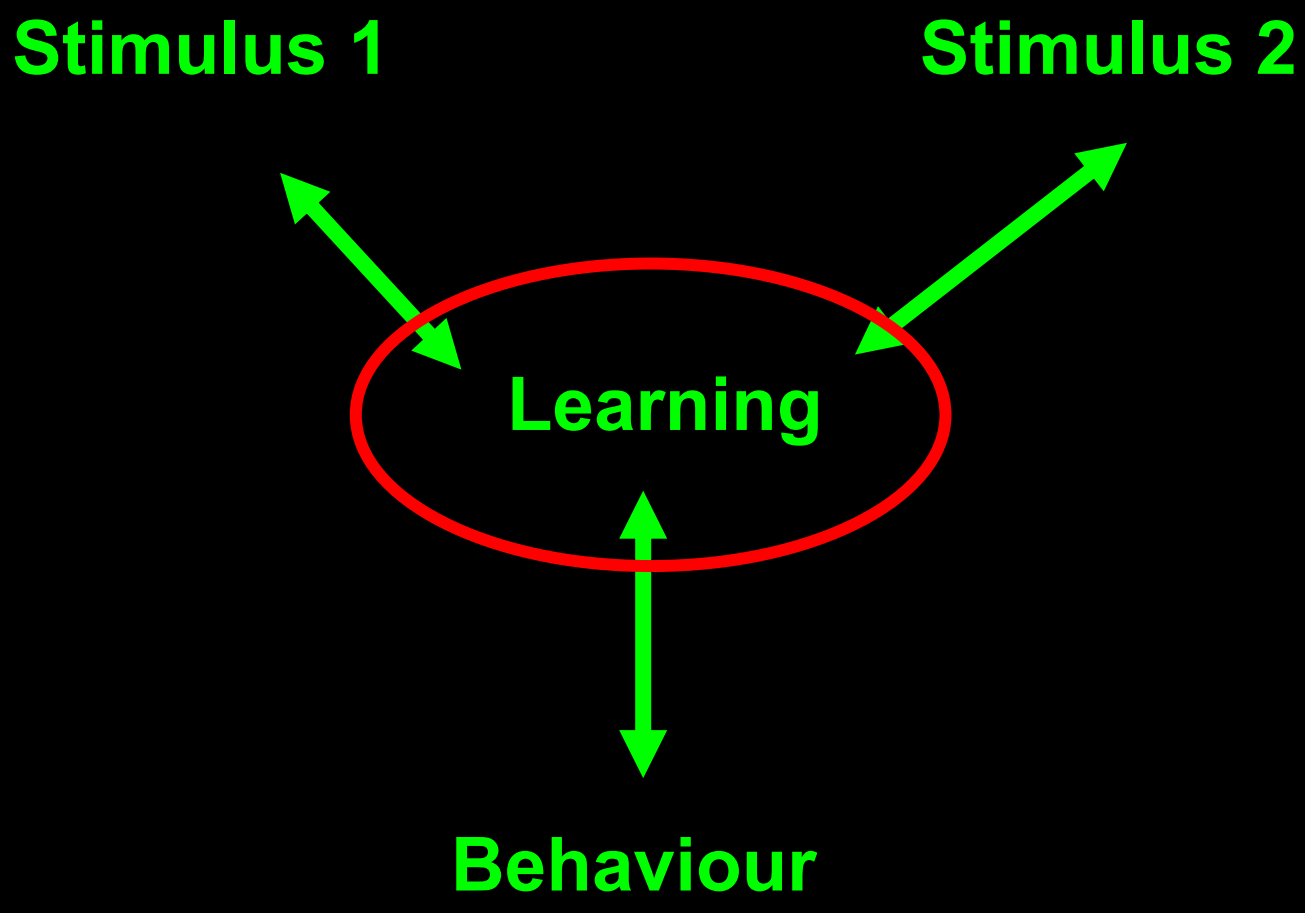
Animals did not react spontaneously:

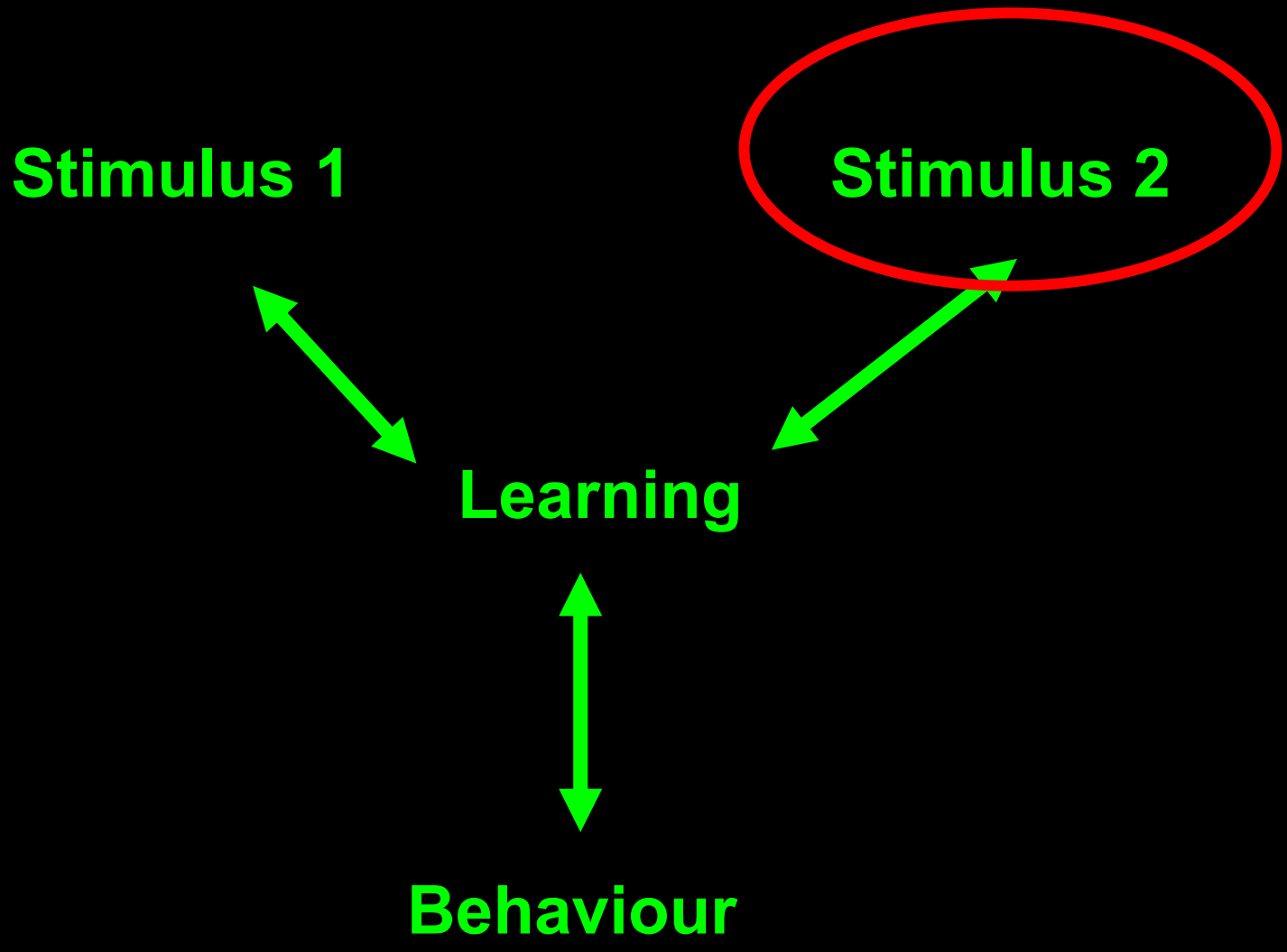
- **no perception ?**
- **no motivation ?**

Hypothesis:

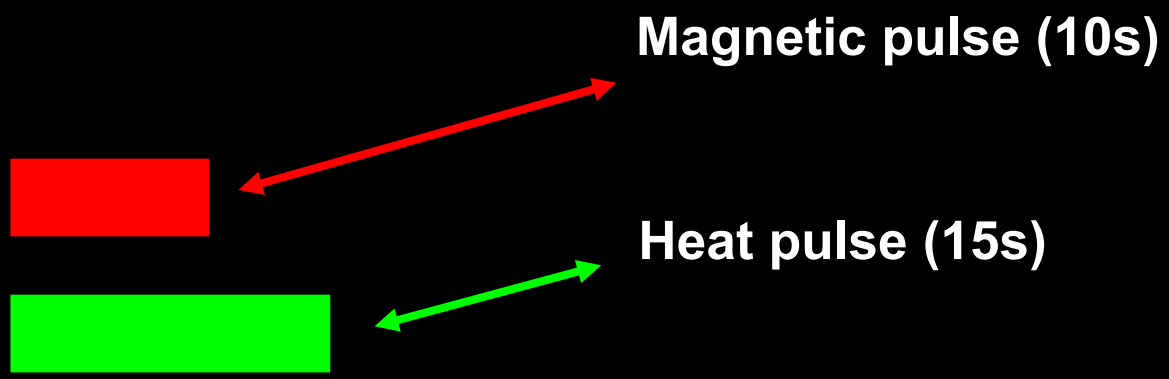
Provided pupae perceive MF, their reaction should be enhanced by negative reinforcement.


Stimulus 1
Stimulus 2
Learning
Behaviour


Stimulus 1
Stimulus 2
Learning
Behaviour

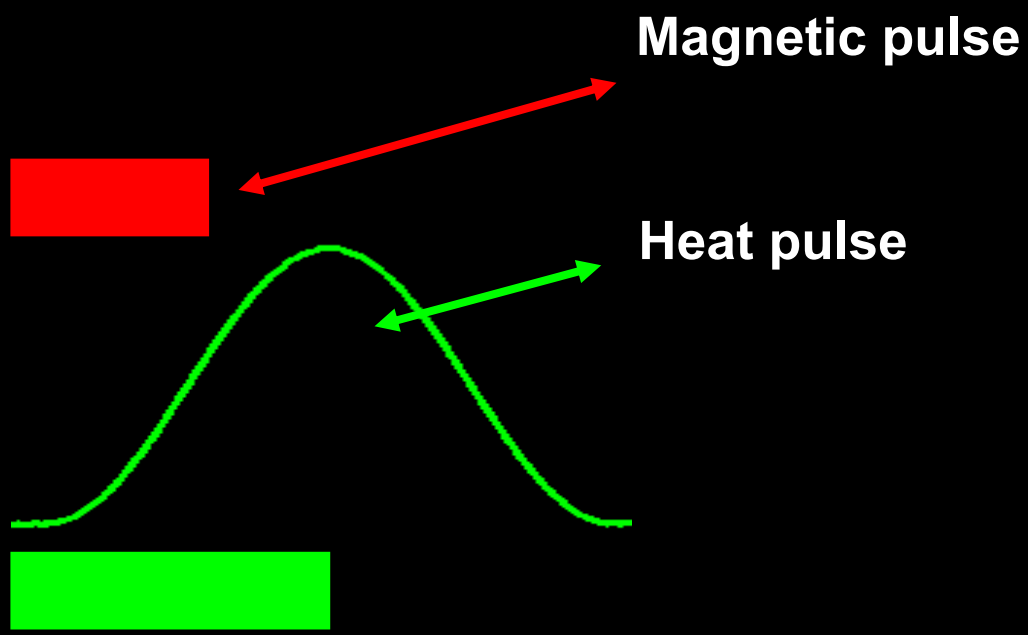

Stimulus 1
Stimulus 2
Learning
Behaviour

b) Trained – conditioned reaction

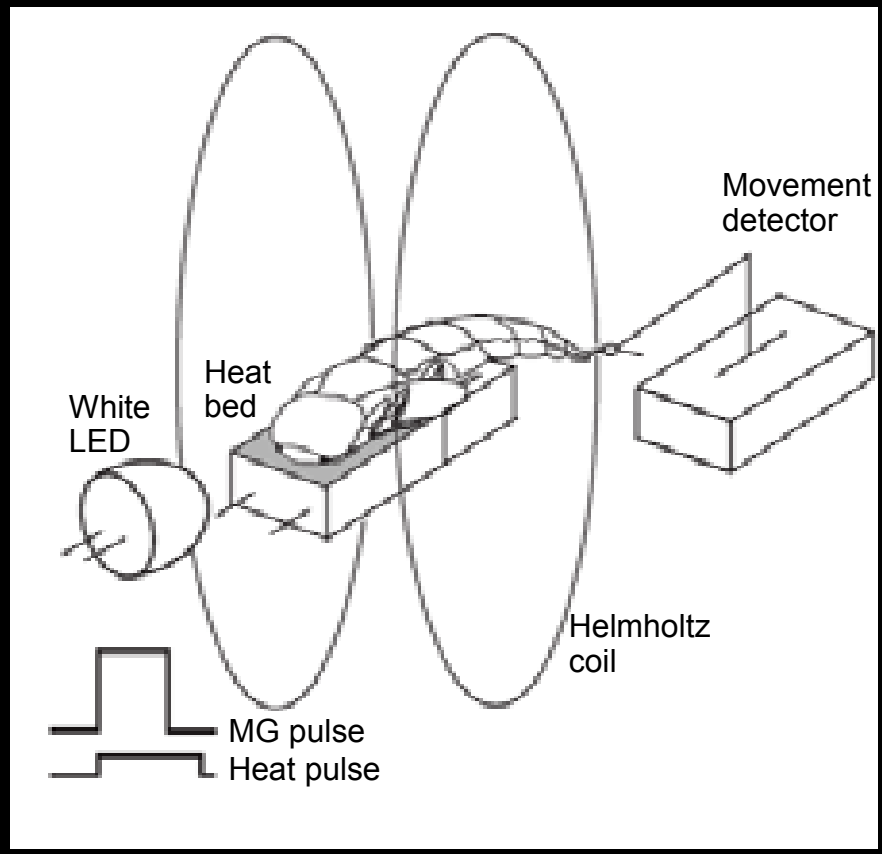


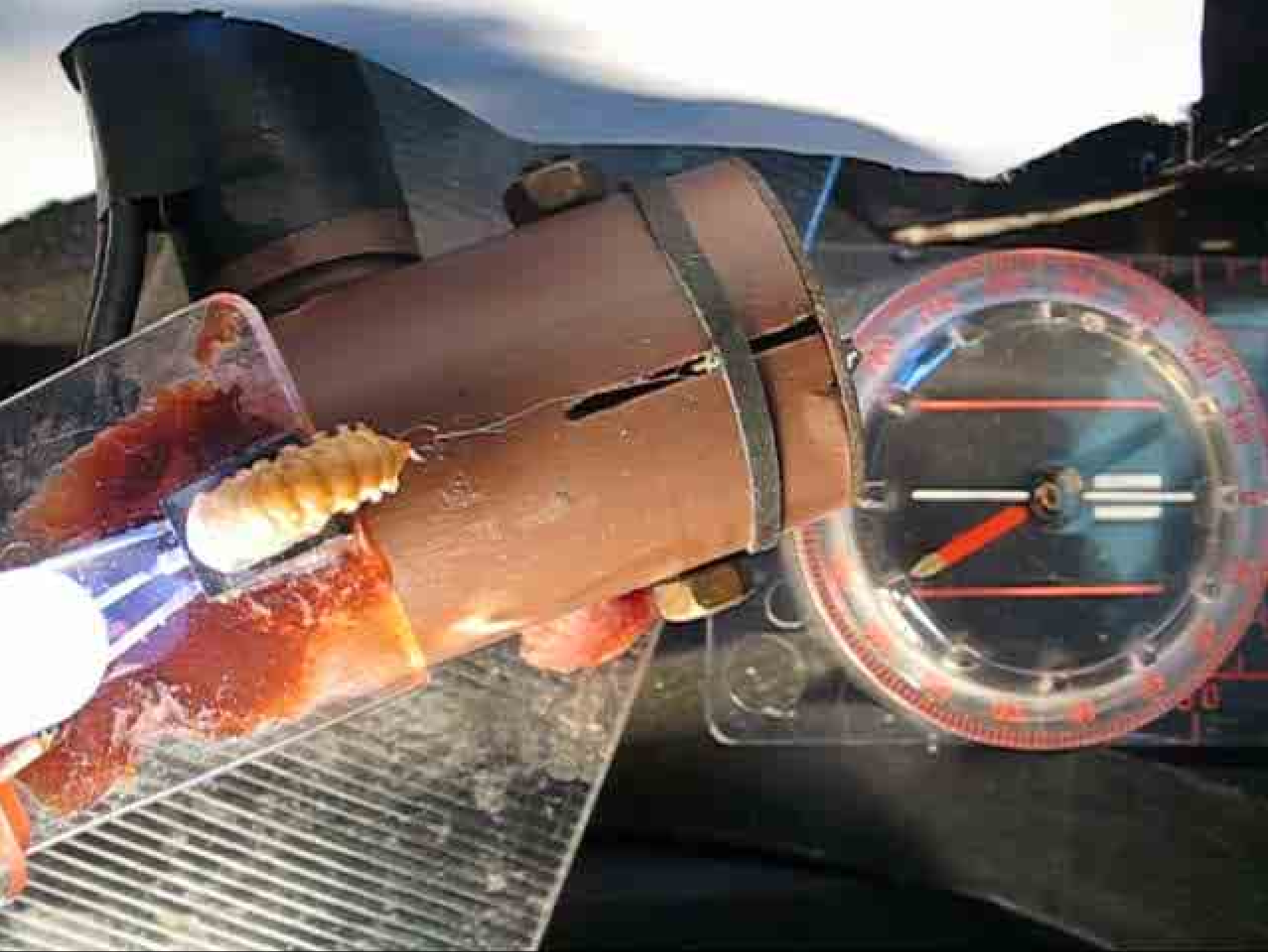
12 times per night

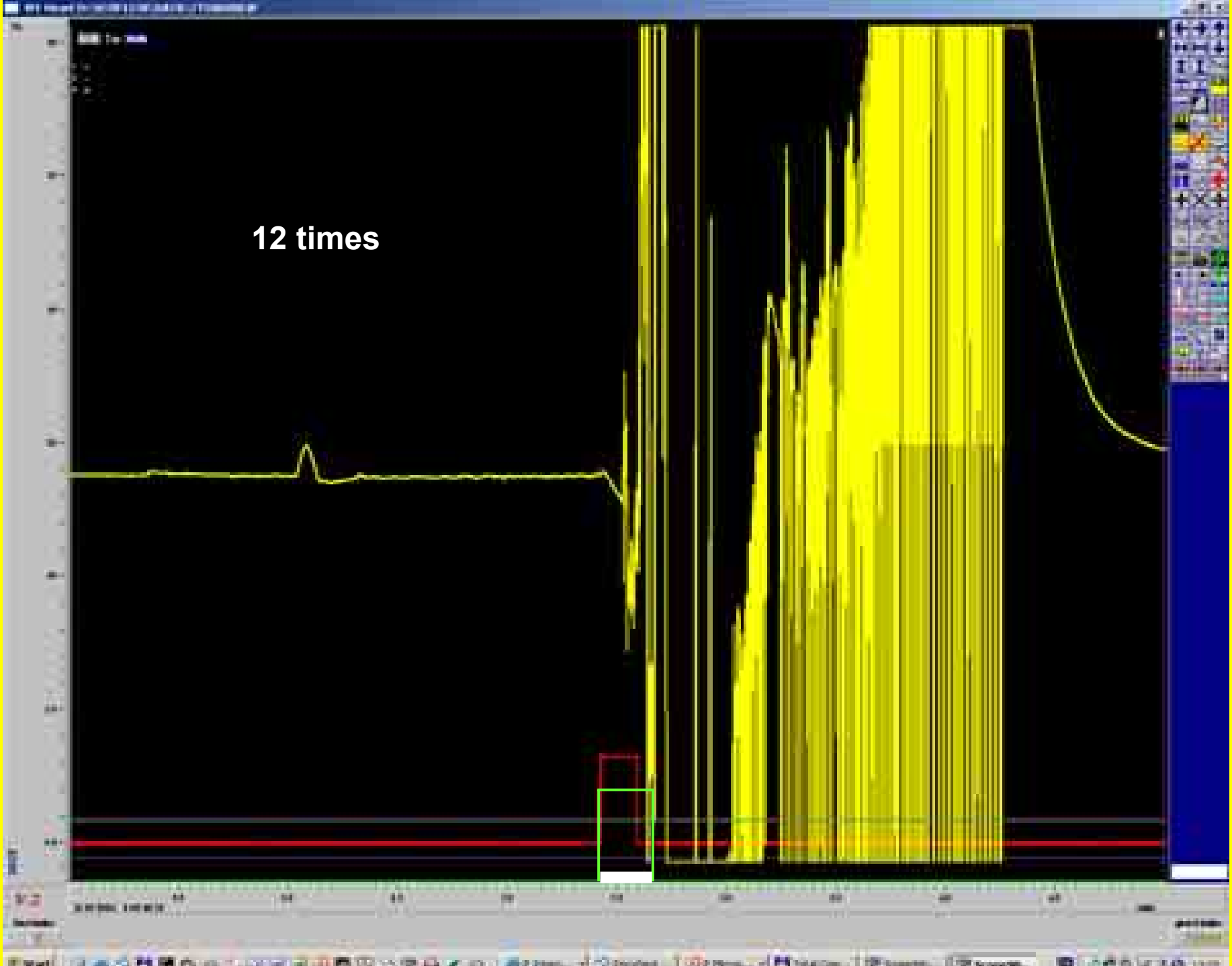
b) Trained – conditioned reaction

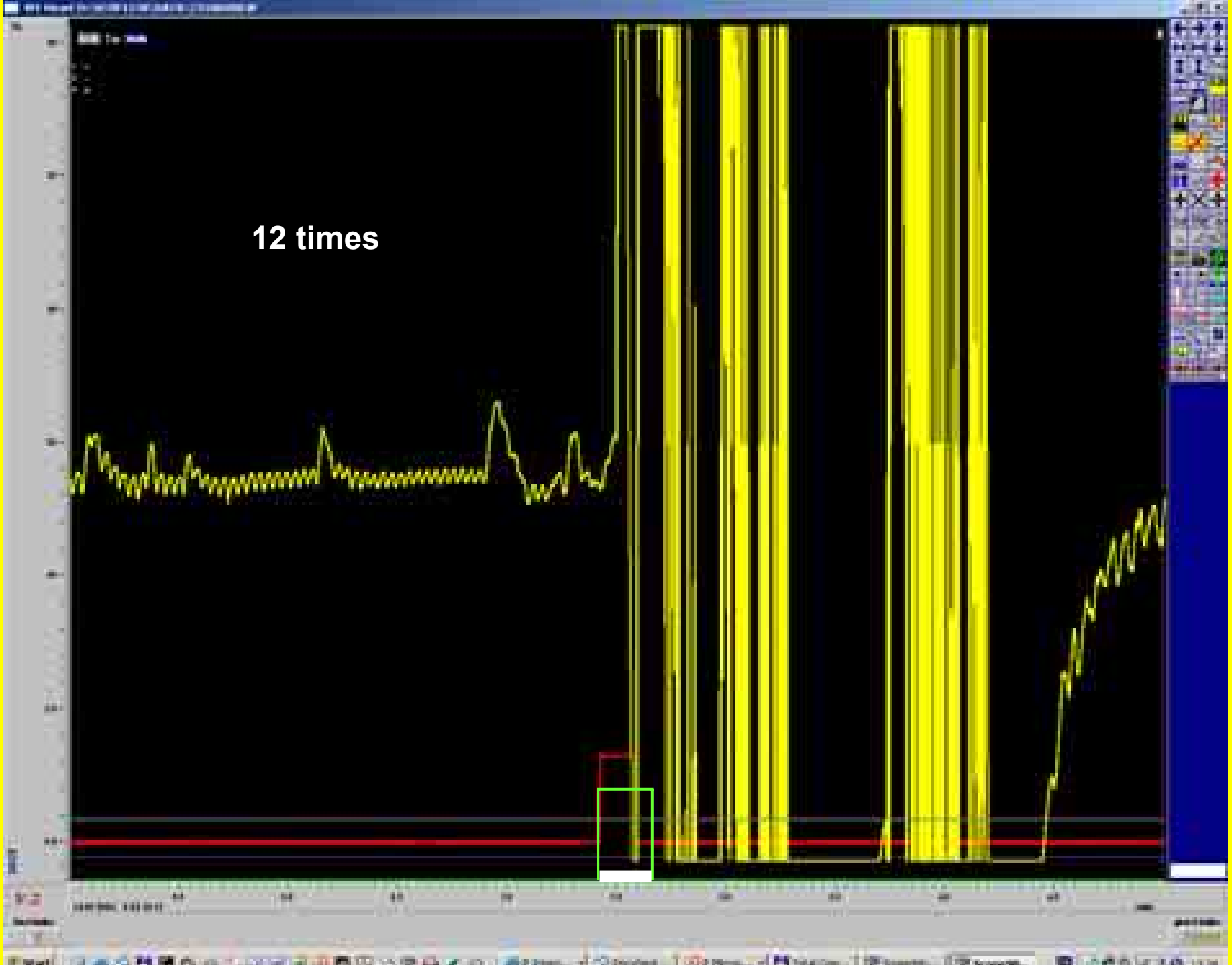


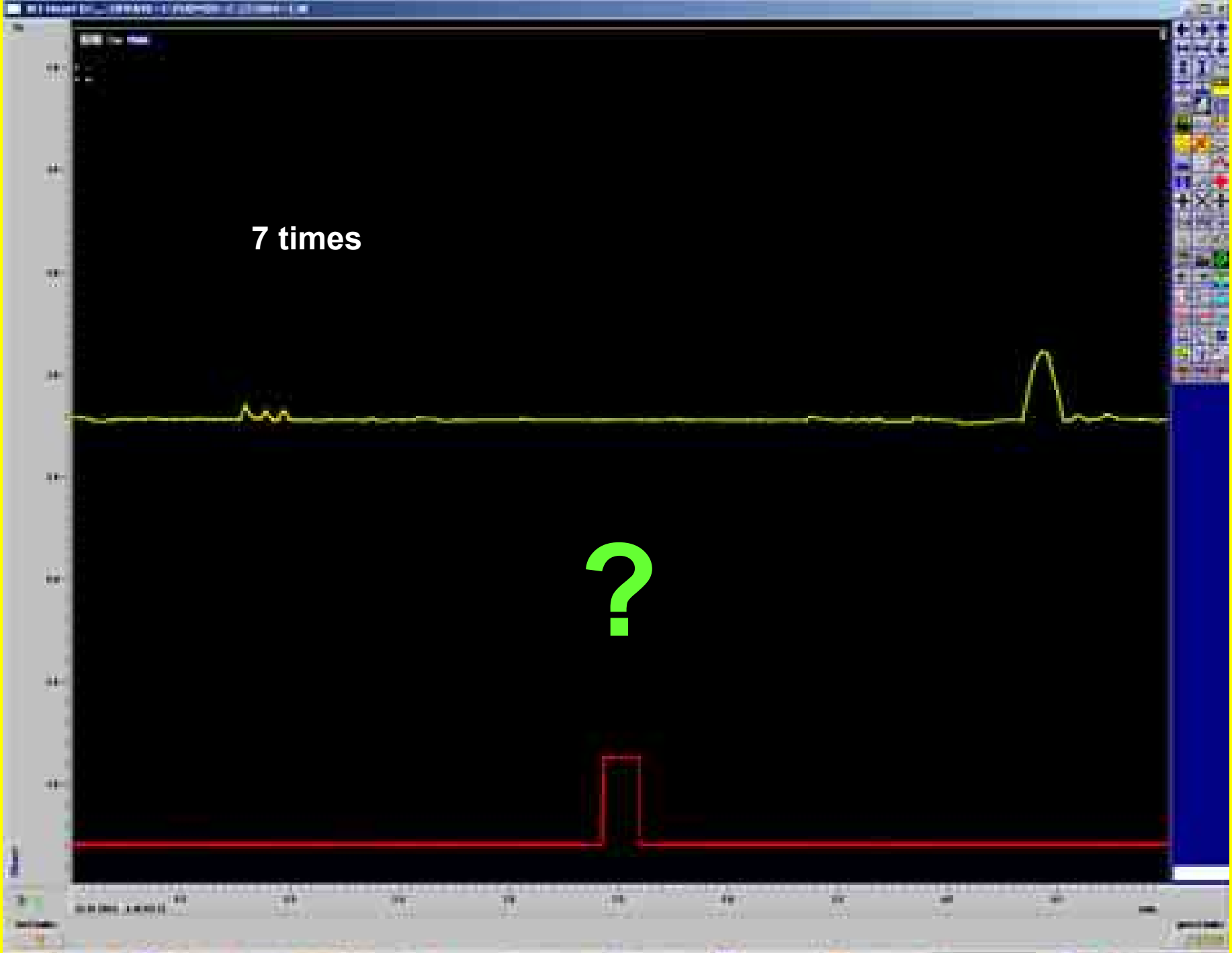
b) Trained – conditioned reaction

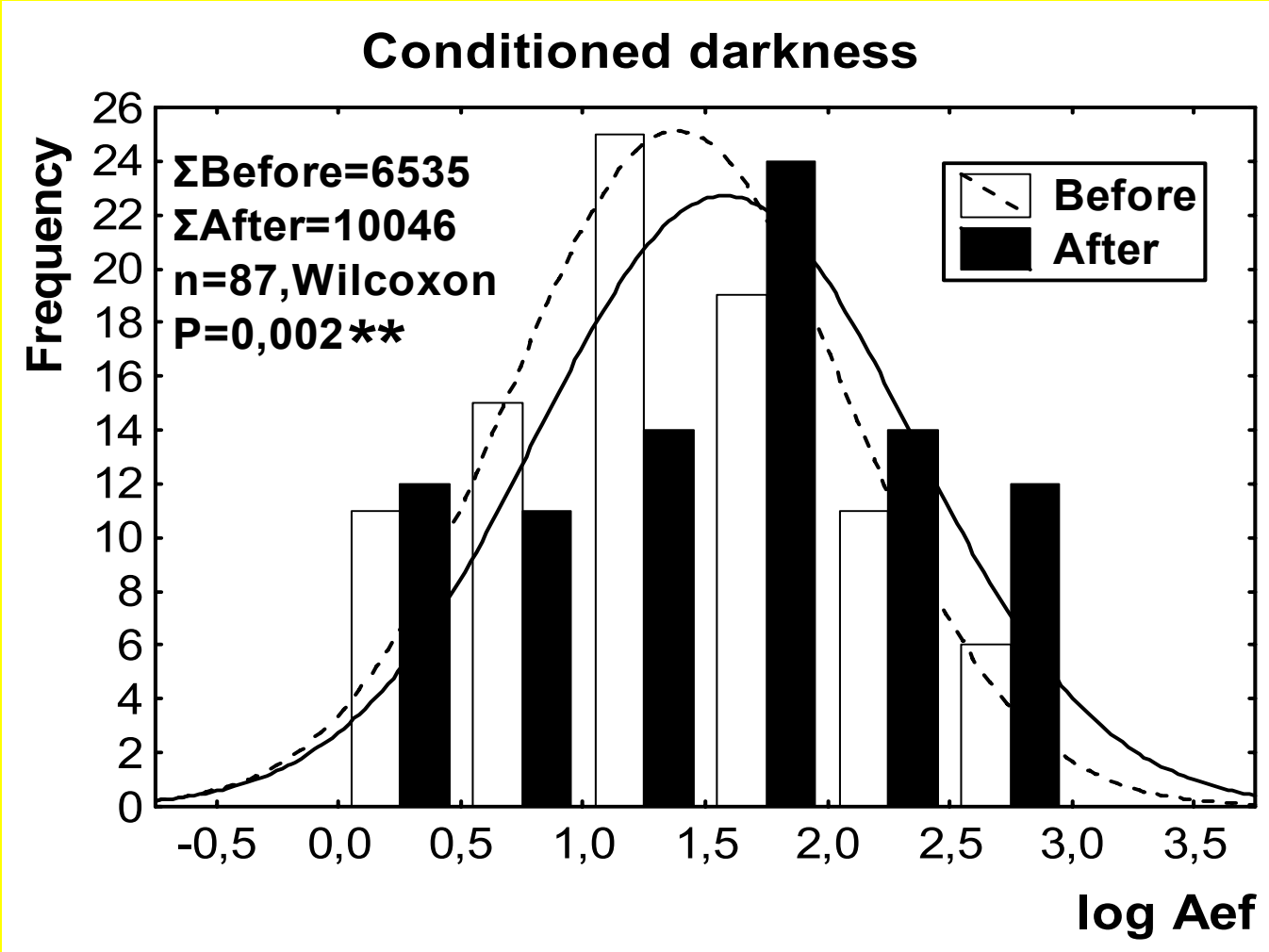




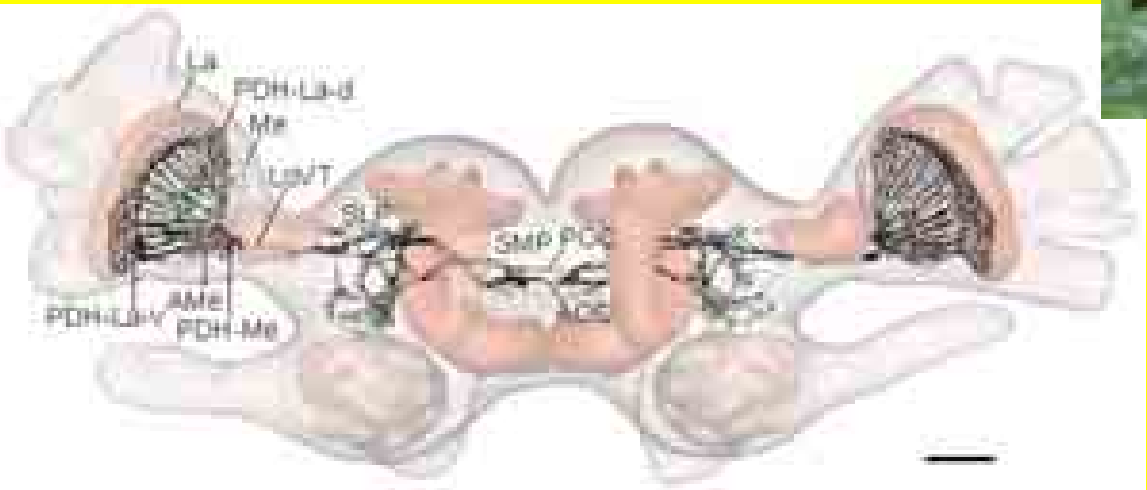

12 times


12 times


7 times
?


Conditioned darkness
Frequency
ΣBefore=6535
ΣAfter=10046
n=87,Wilcoxon
P=0,002**
Before
After
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-0,5
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
log Aef

American cockroach
Periplanetta americana

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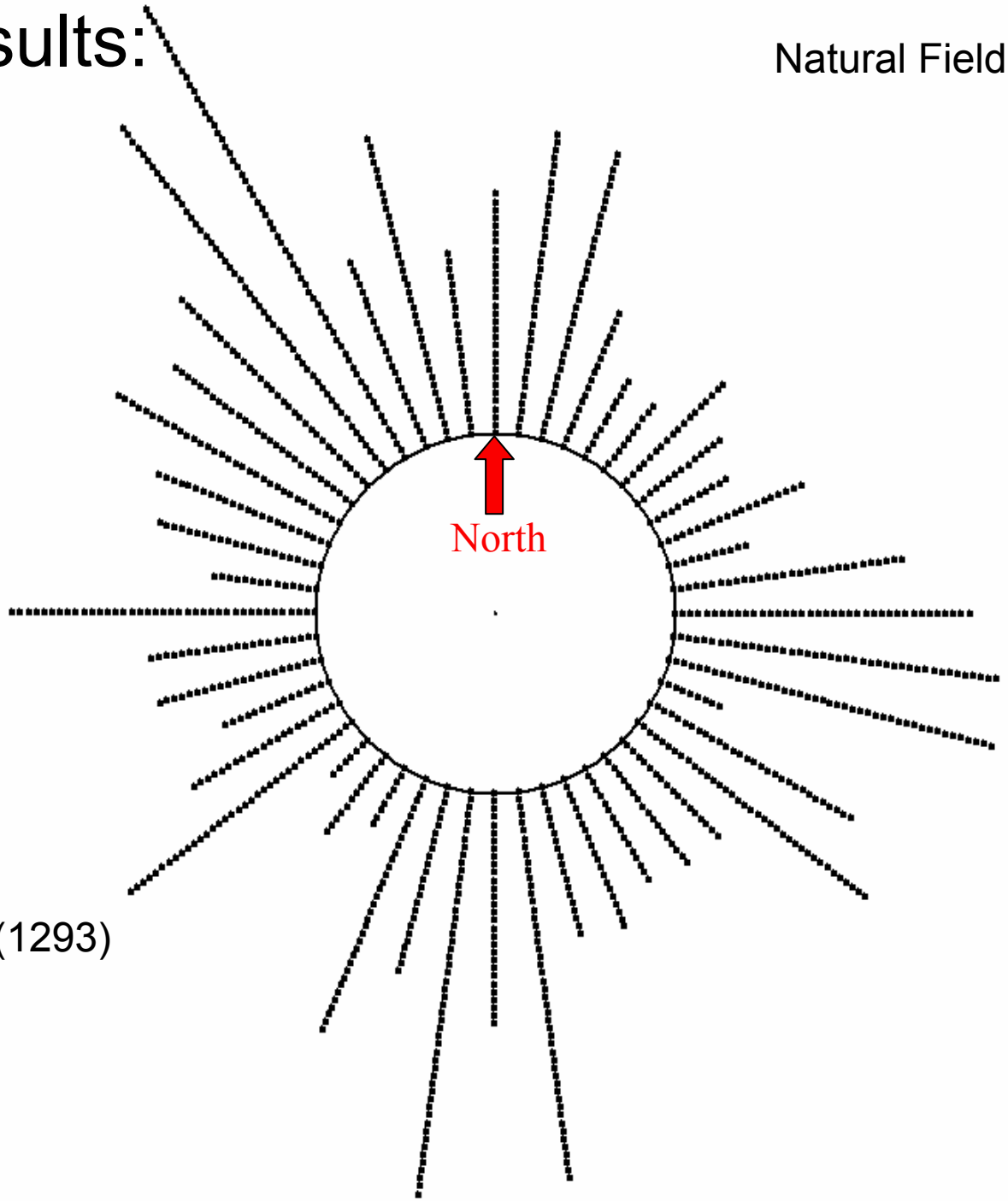
Methods:

2x4 Helmholtz coil system
rotating GMF 60°CW

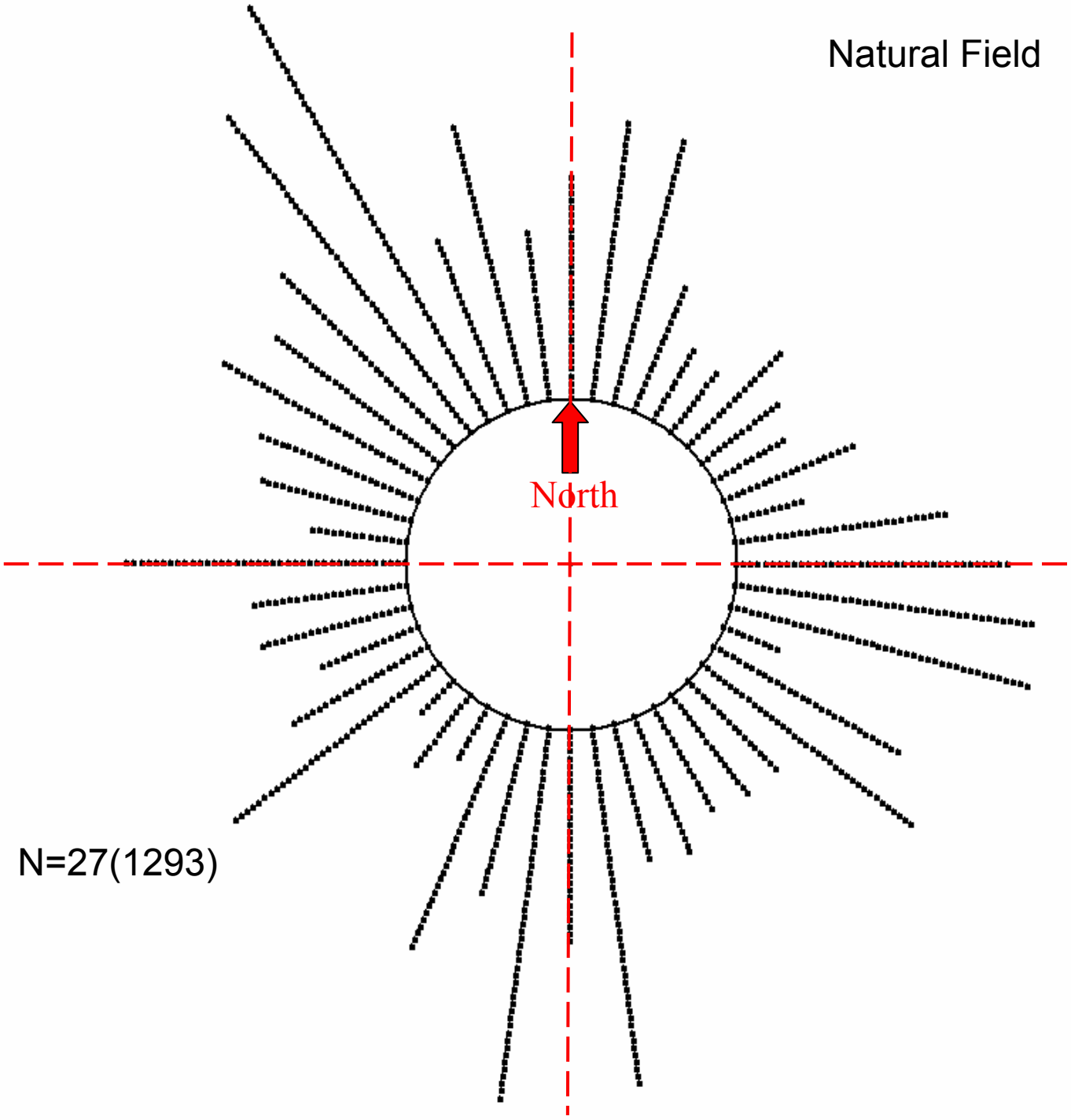
Results:

Natural Field

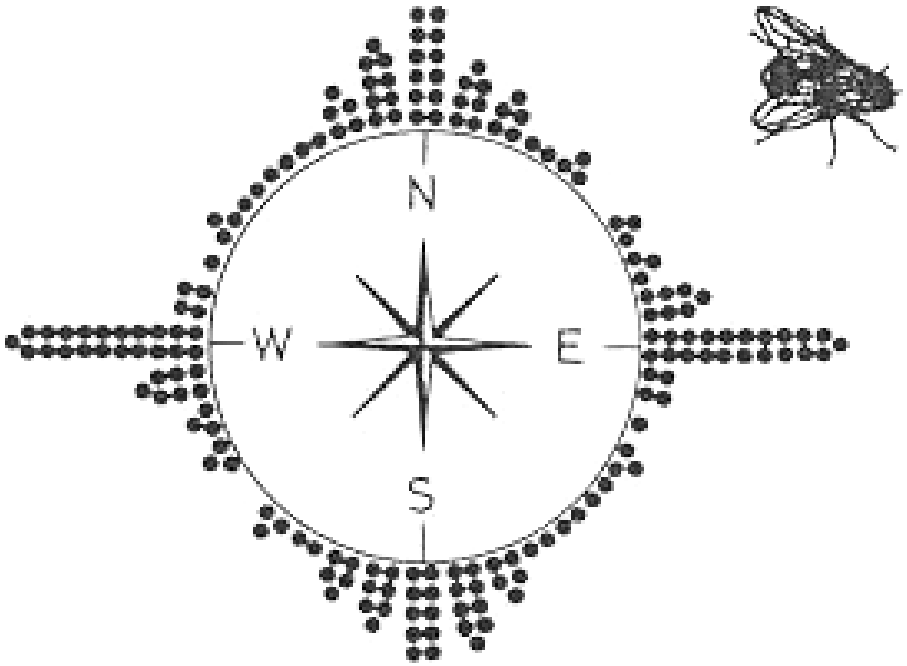


N=27(1293)

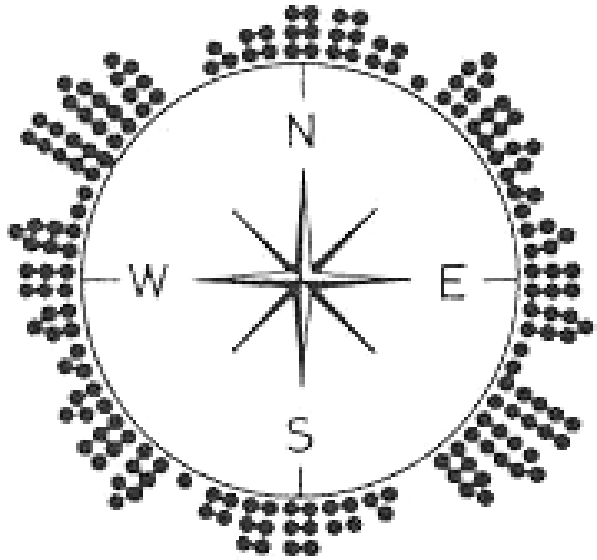
Natural Field



N=27(1293)



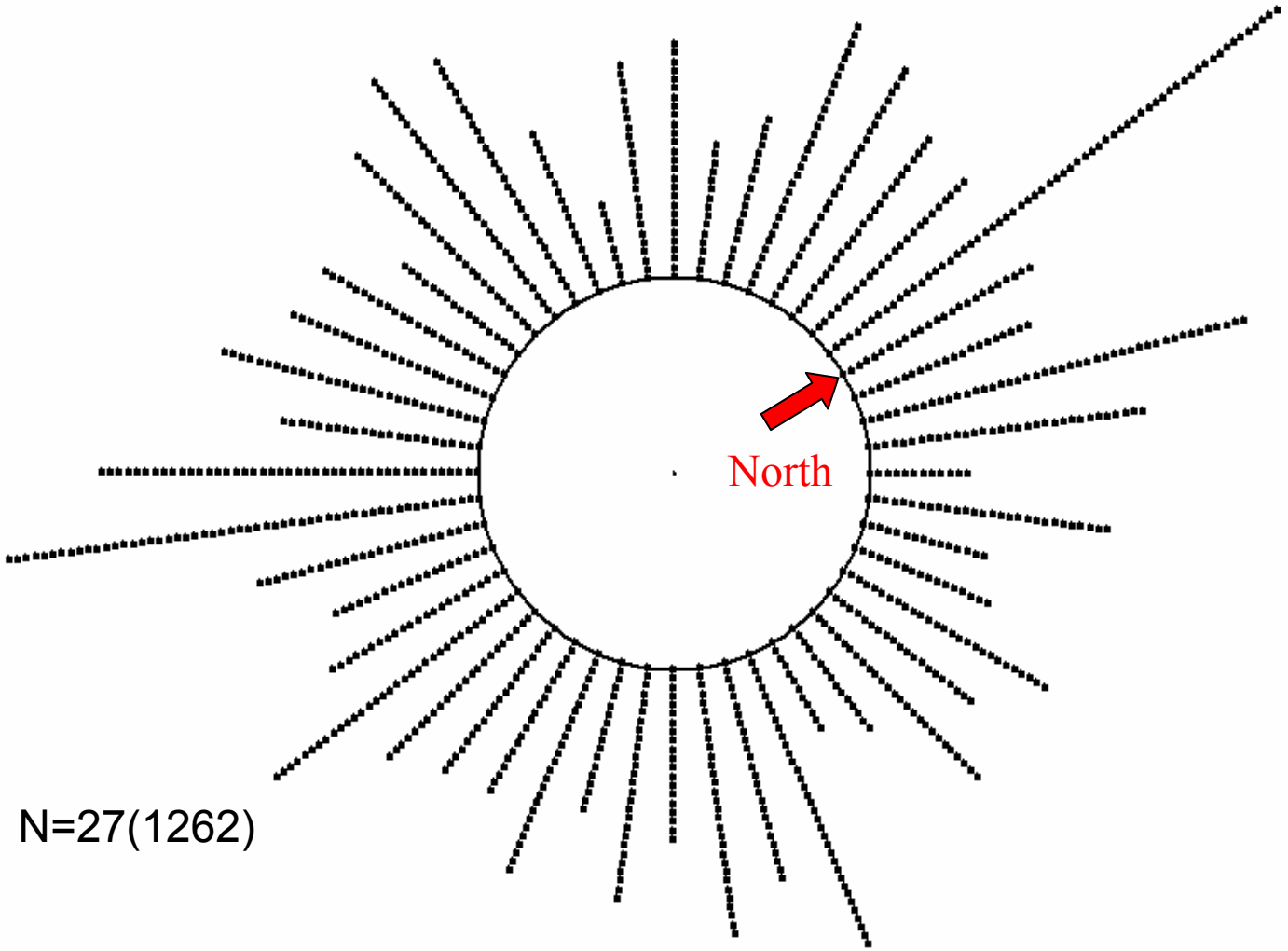
geomagnetic
field



compensated
magnetic field

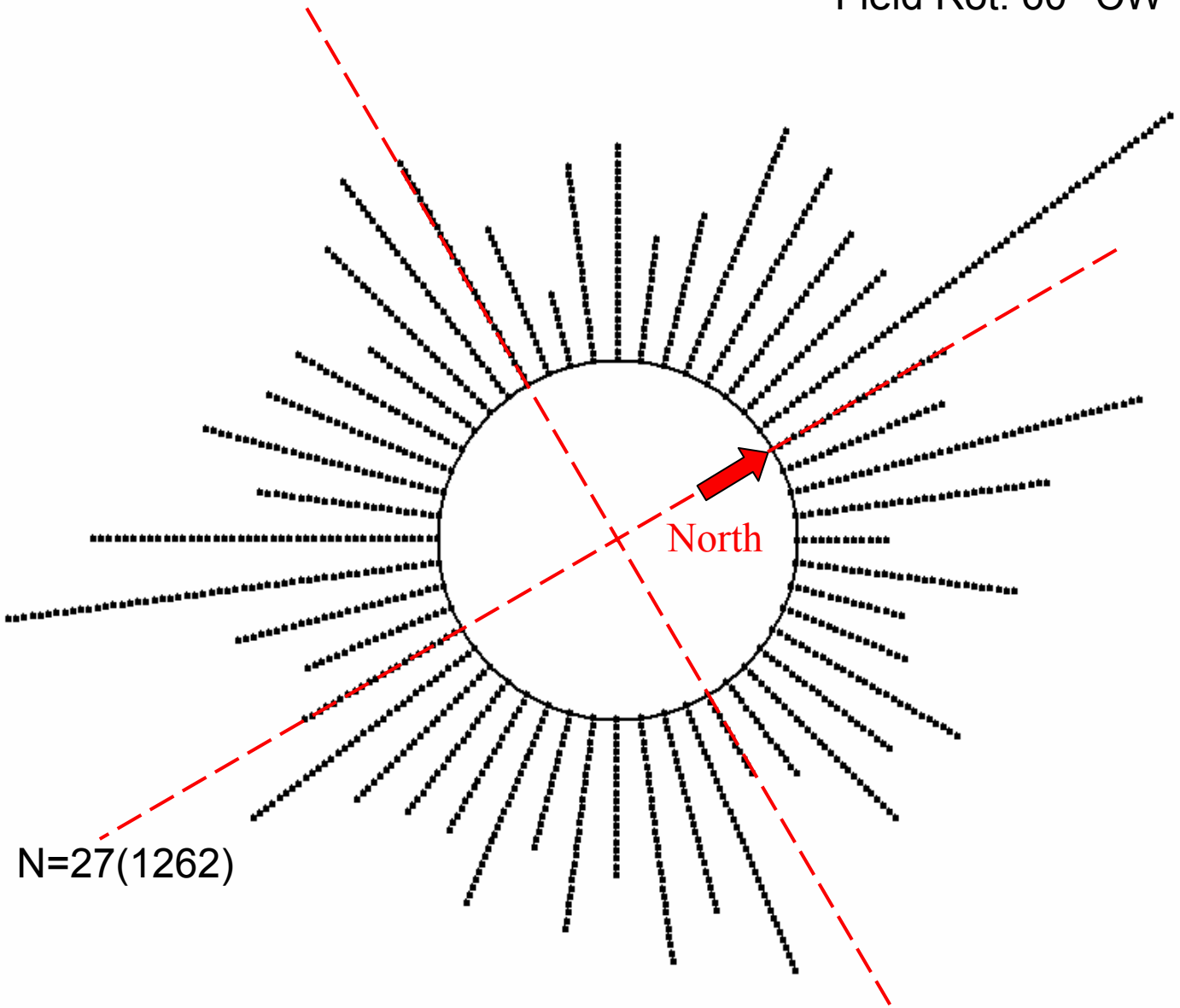
Becker, (1965)

Field Rot. 60° CW



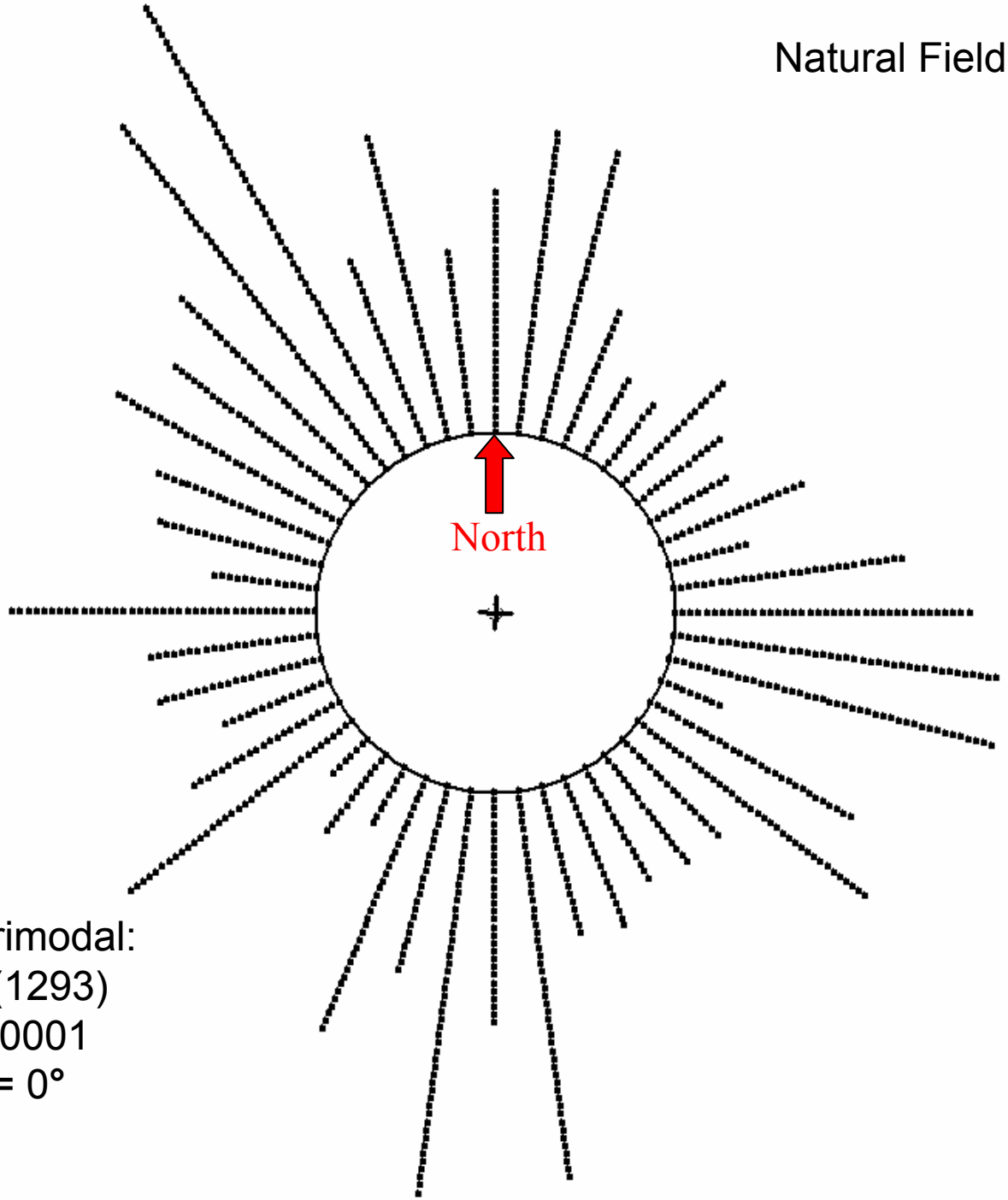
N=27(1262)

Field Rot. 60° CW



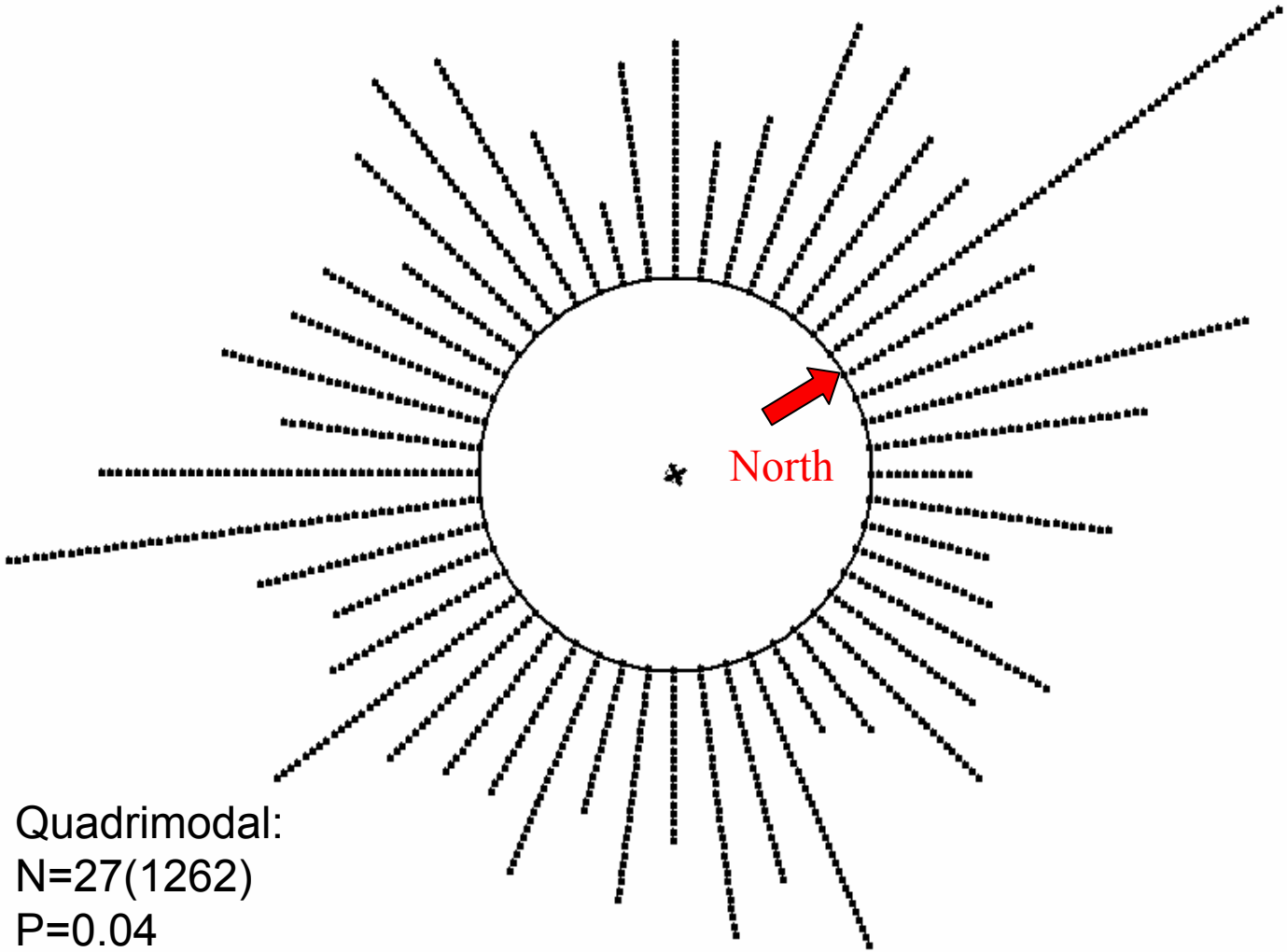
N=27(1262)

Natural Field



Quadrimodal:
N=27(1293)
P=0.00001
MVB = 0°

Field Rot. 60° CW

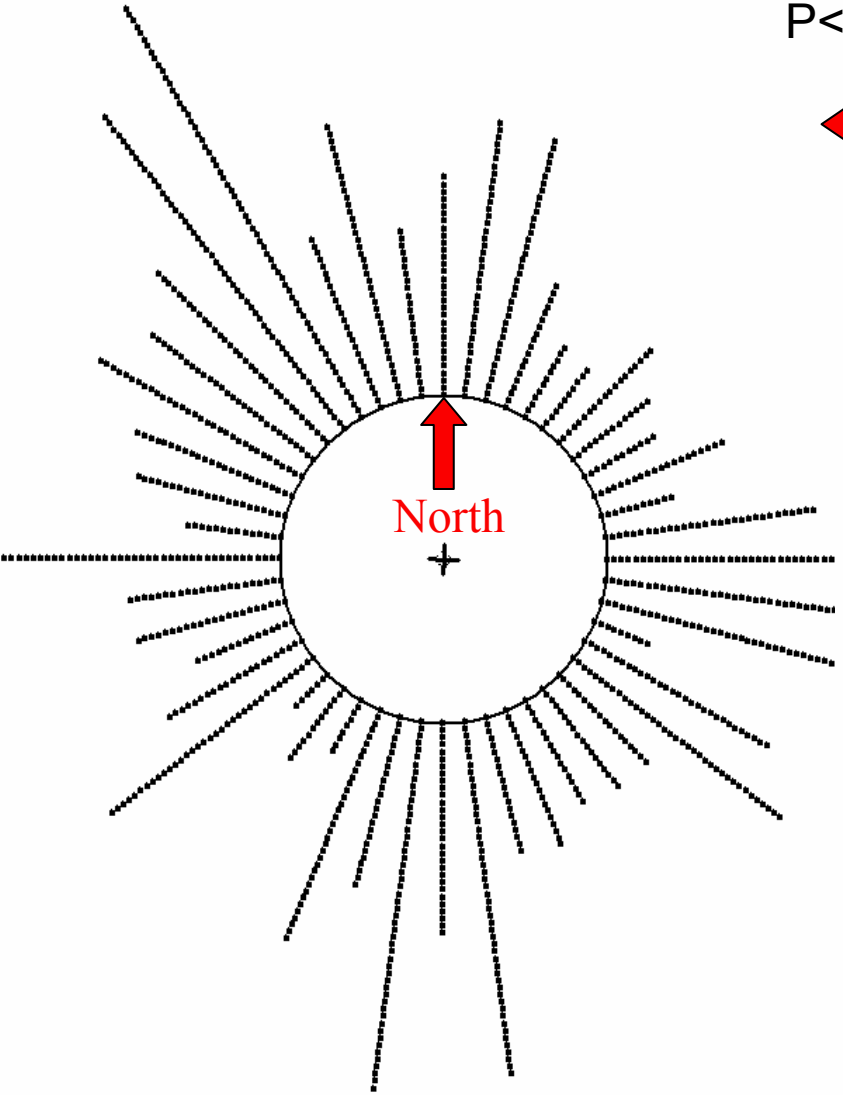


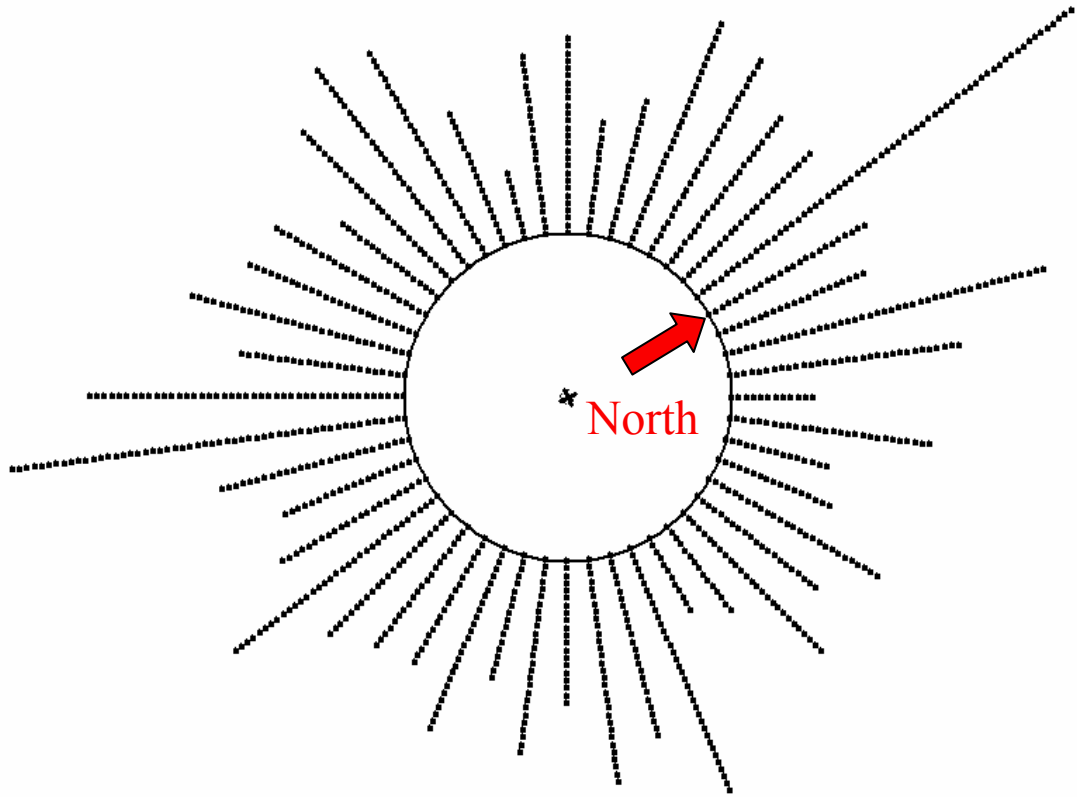
Quadrimodal:
N=27(1262)
P=0.04
MVB=67°

Natural Field

Field Rot. 60° CW

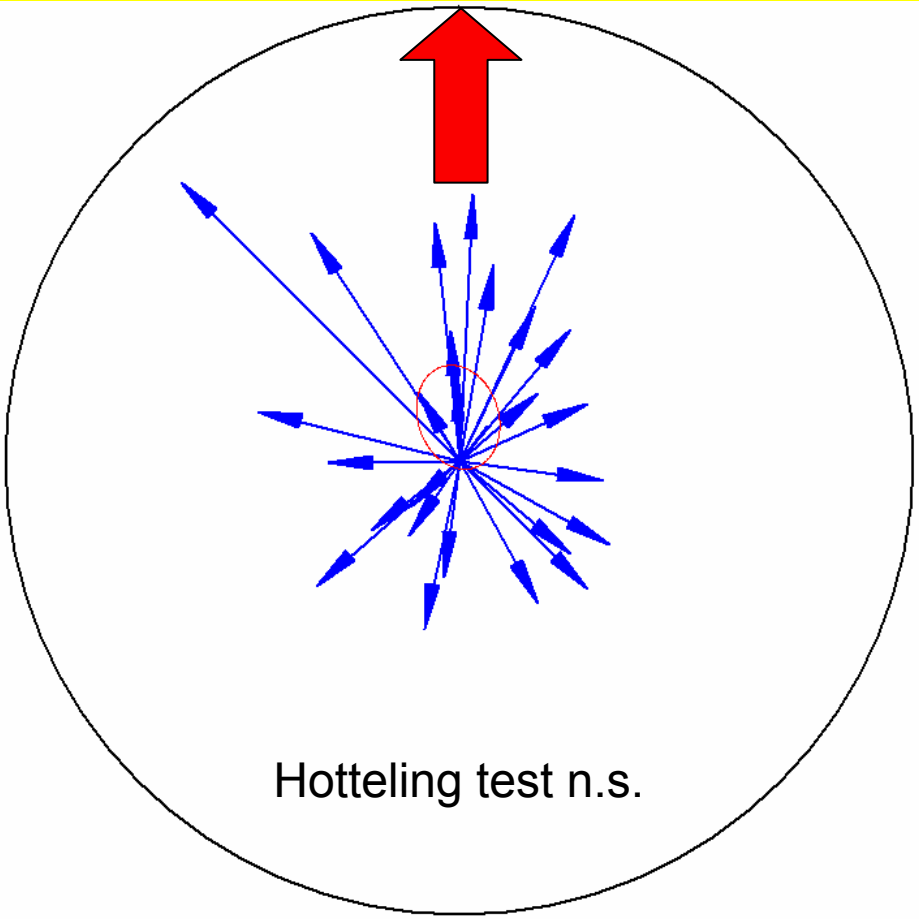
Mardia-Watson-Wheeler
P<0.000001



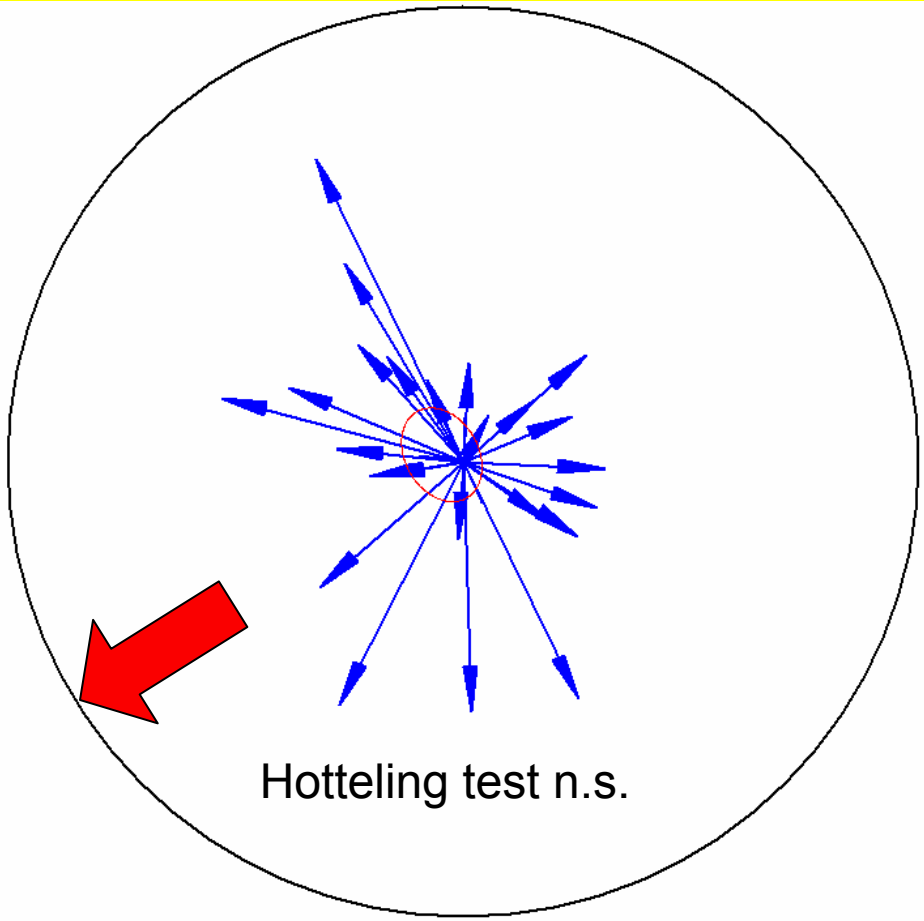


Quadrimodal orientation
Mean vectors distribution

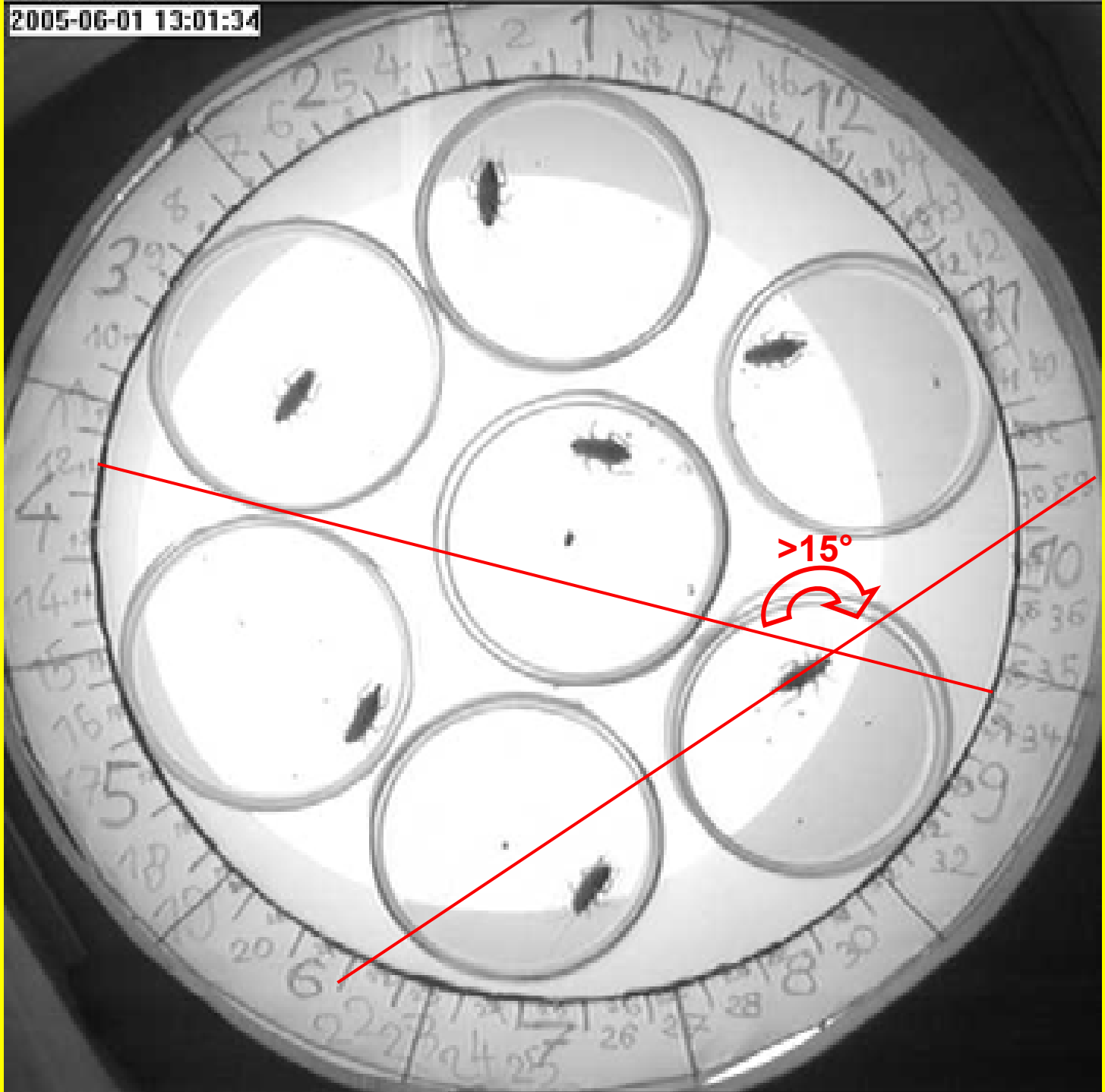
Natural Field



Field Rot. 60° CW



B) Body turns in rotating field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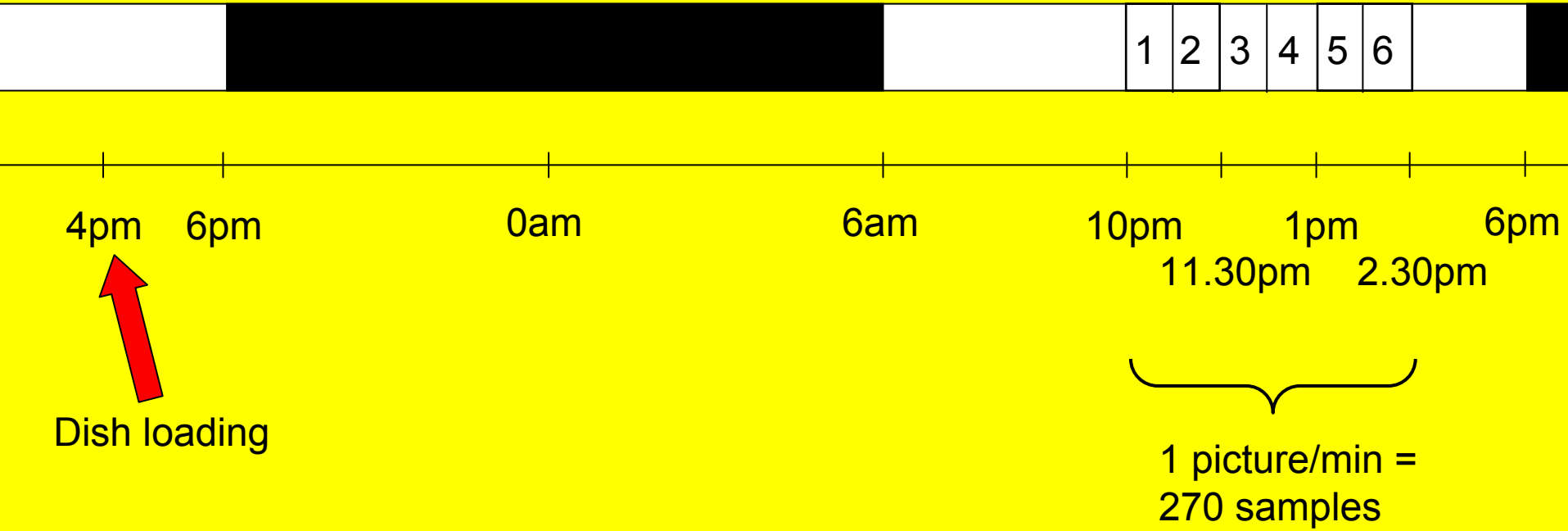
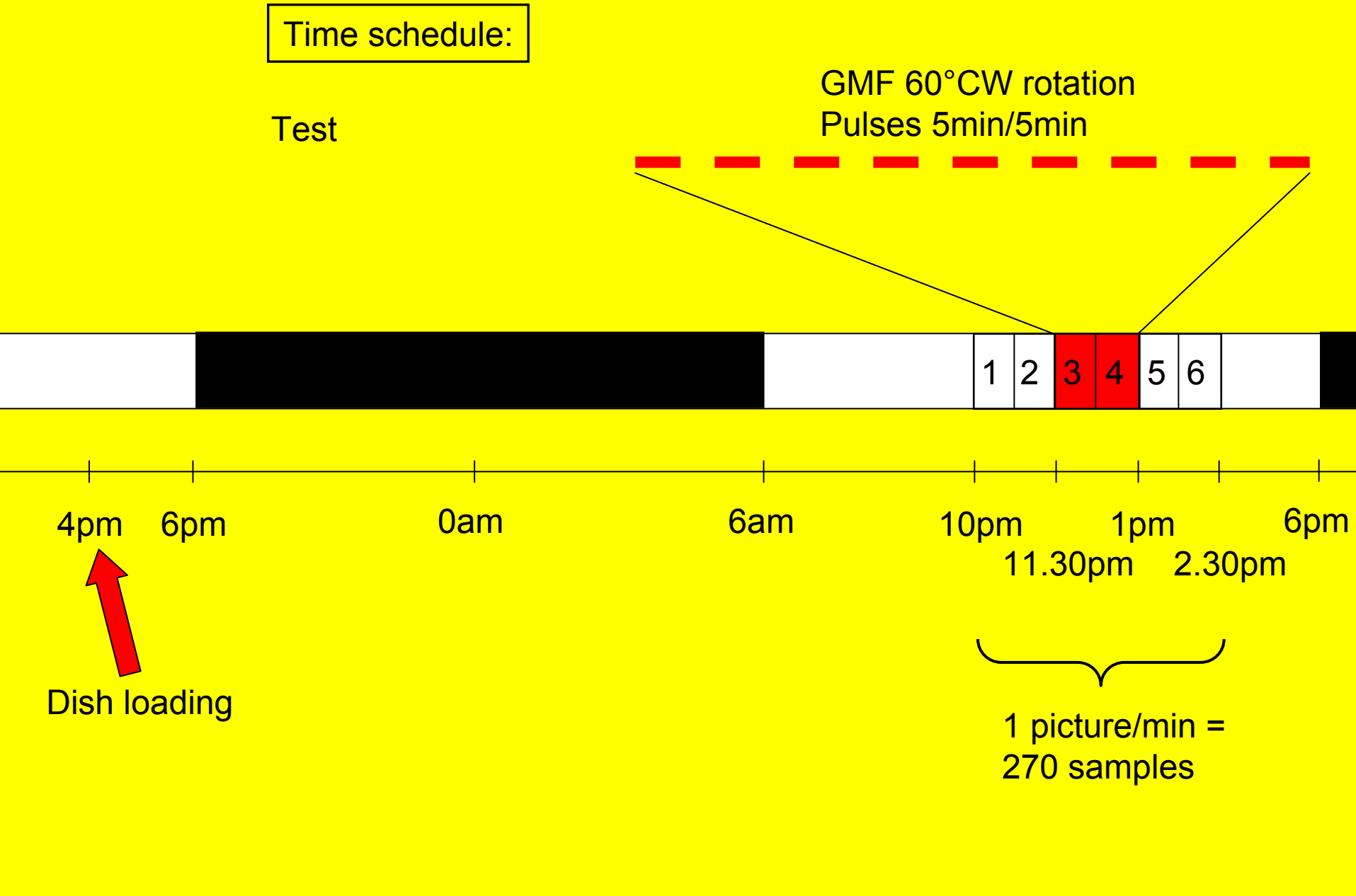
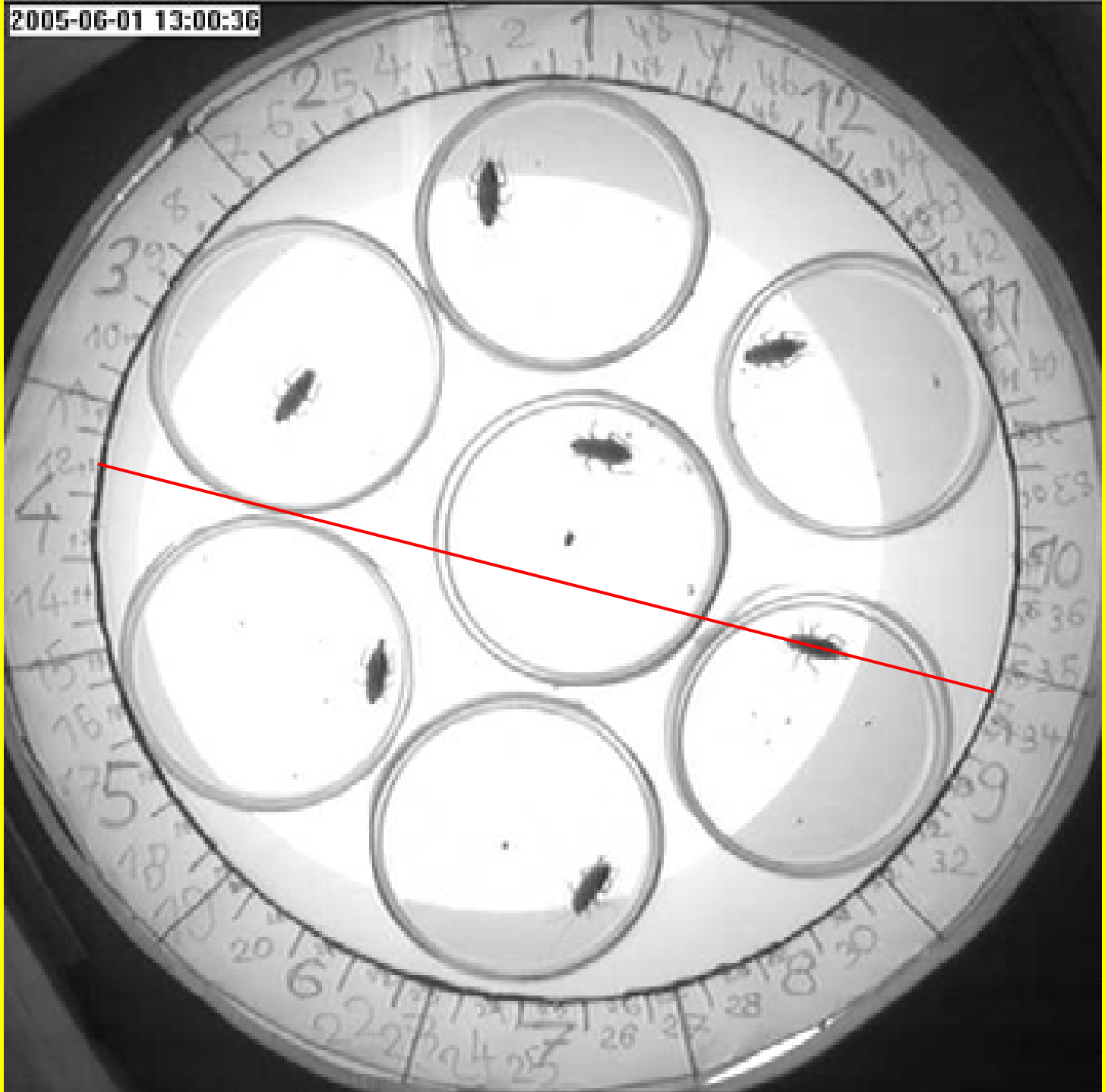
>15°

Time schedule:

Control




Time schedule:
Test
GMF 60°CW rotation
Pulses 5min/5min
1
2
3
4
5
6
4pm
6pm
0am
6am
10pm
1pm
6pm
11.30pm
2.30pm
Dish loading
1 picture/min =
270 samples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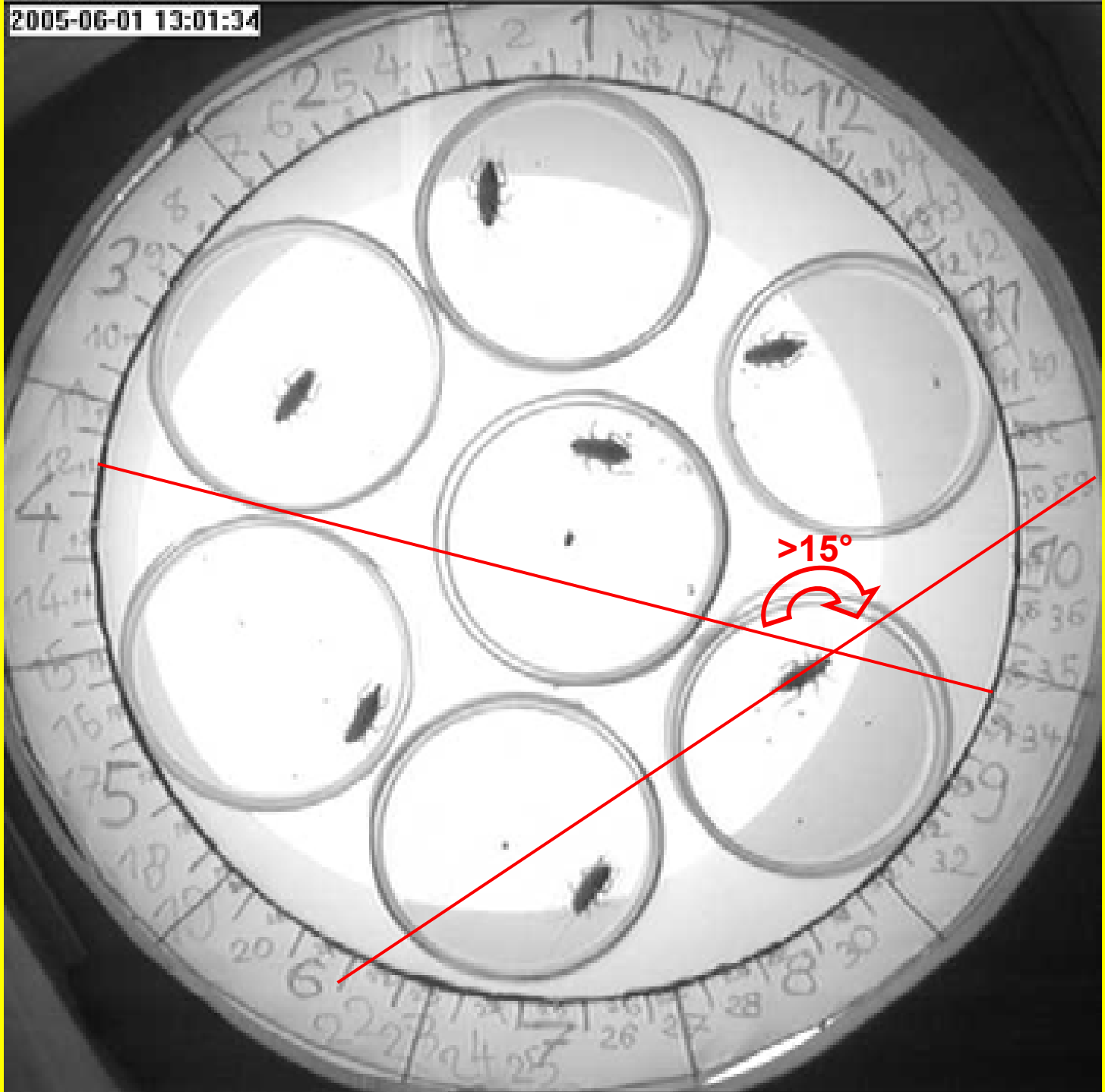
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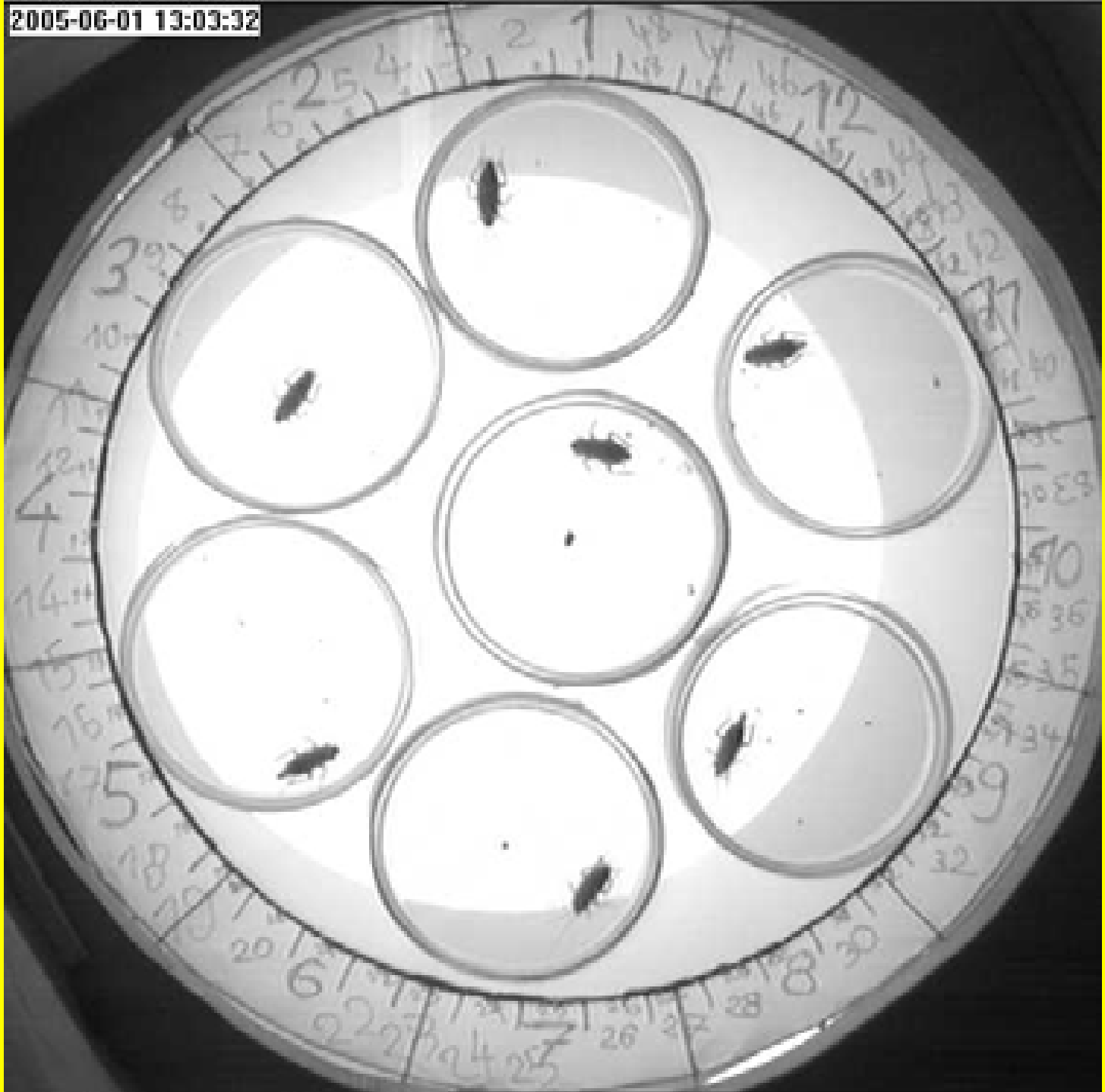
2005-06-01 13:02:33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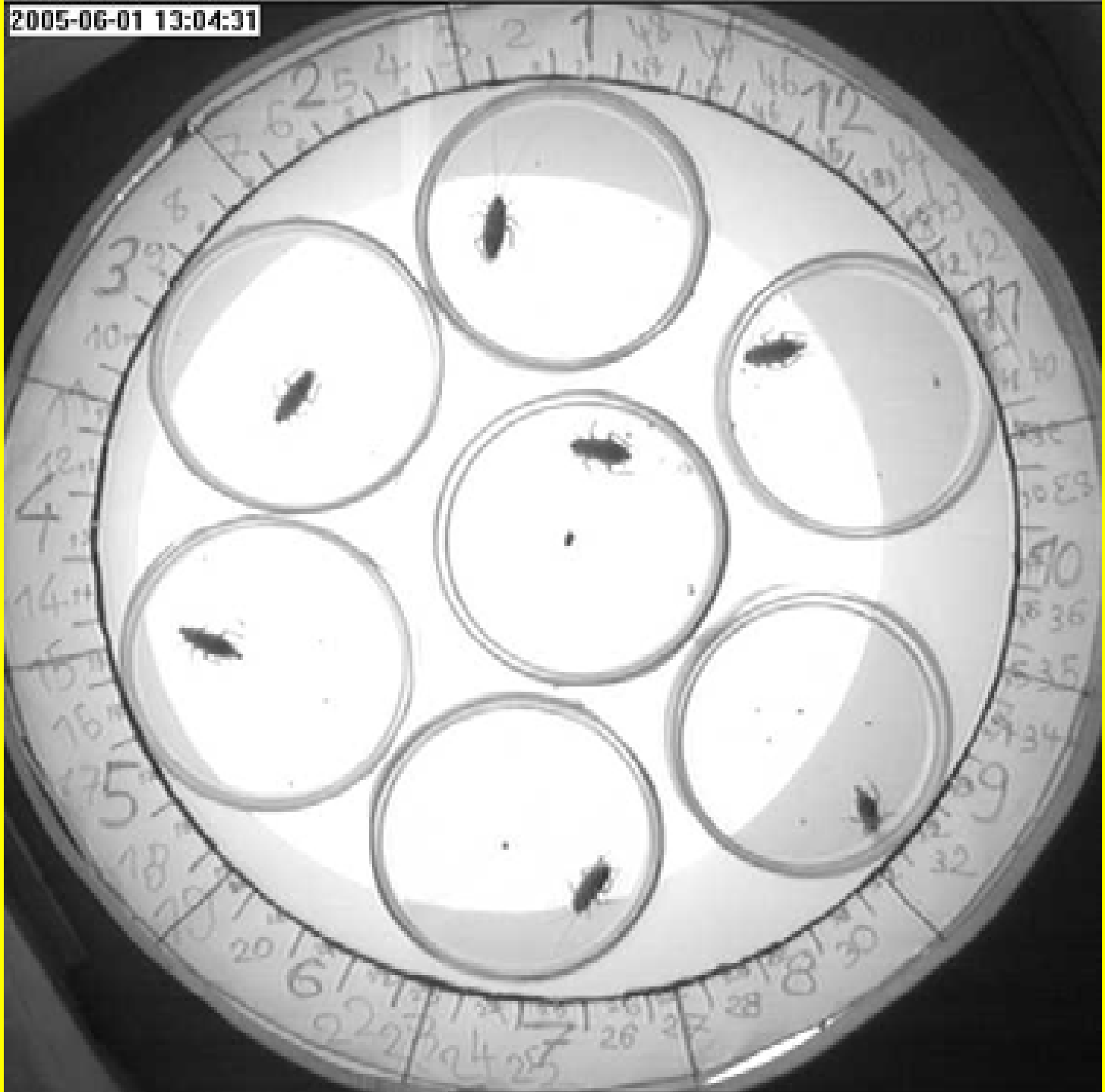
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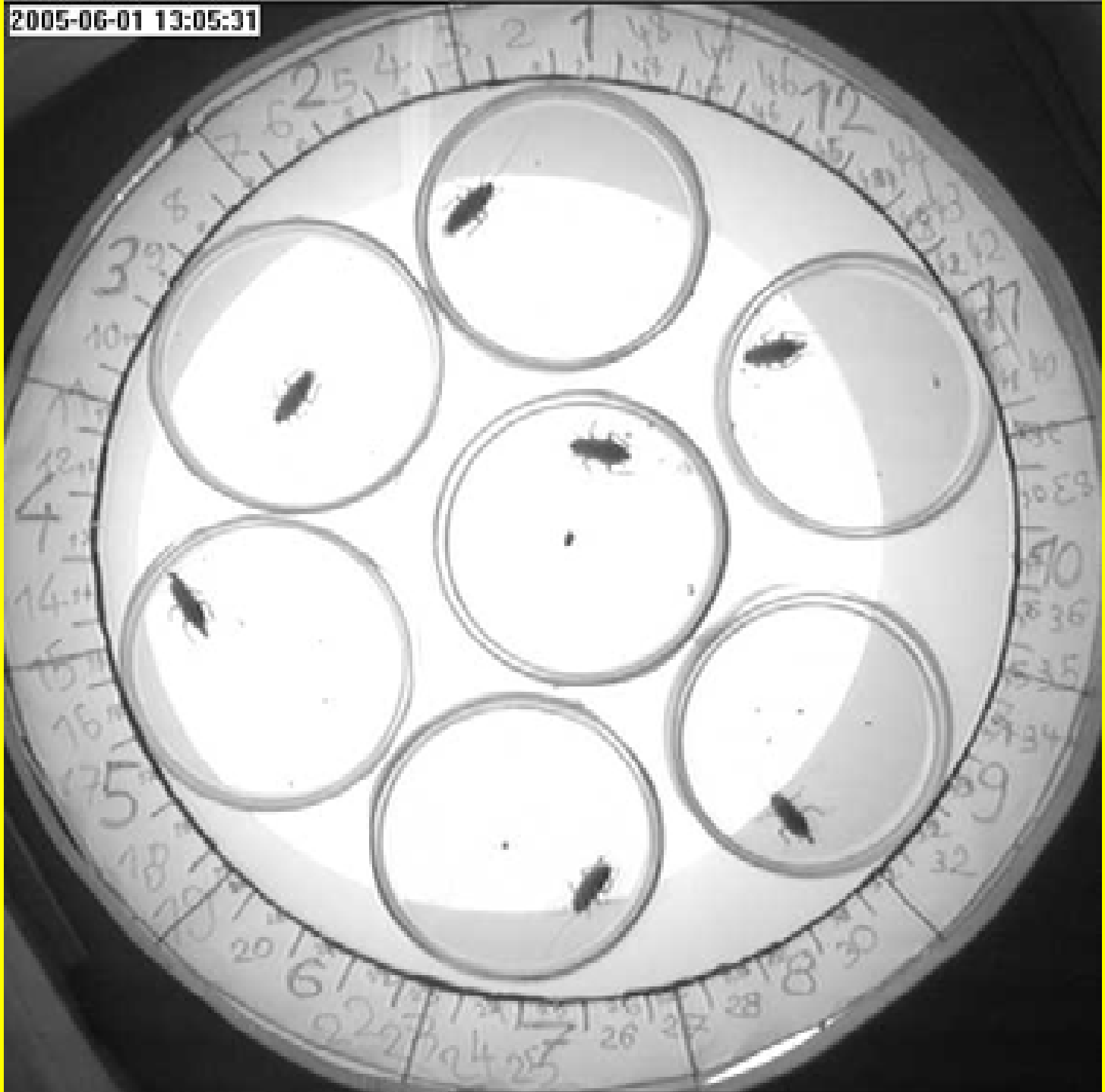
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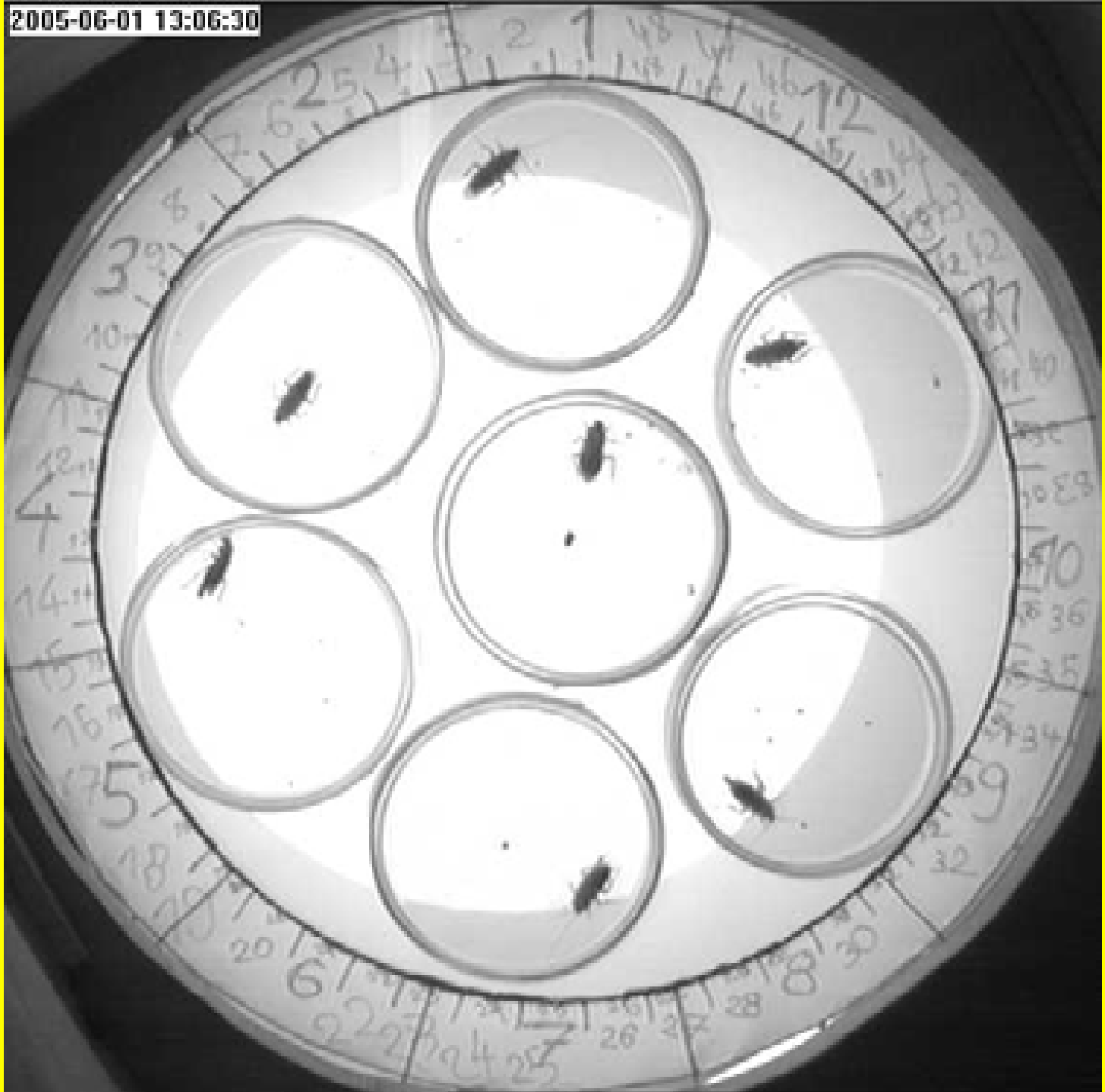
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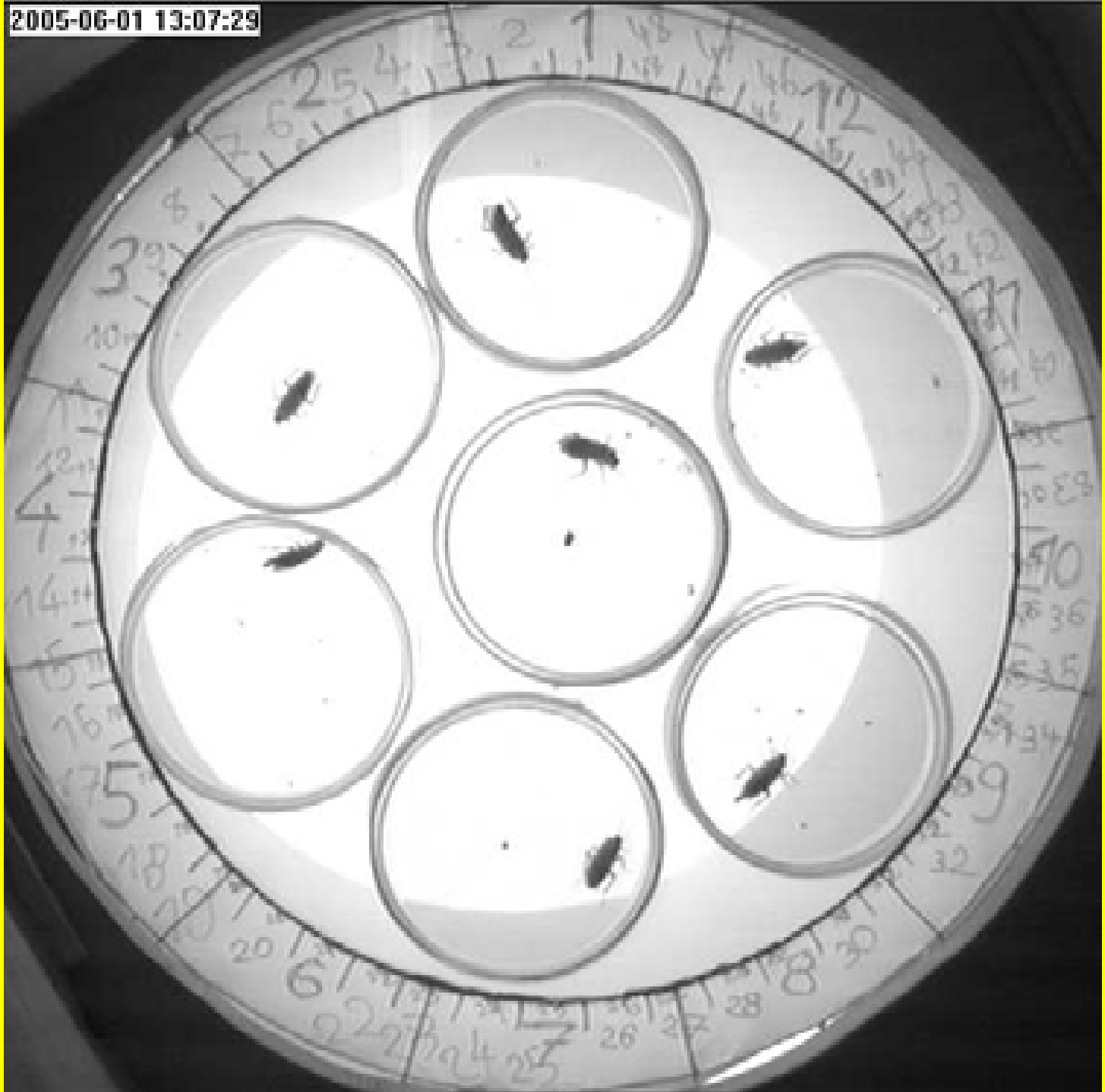
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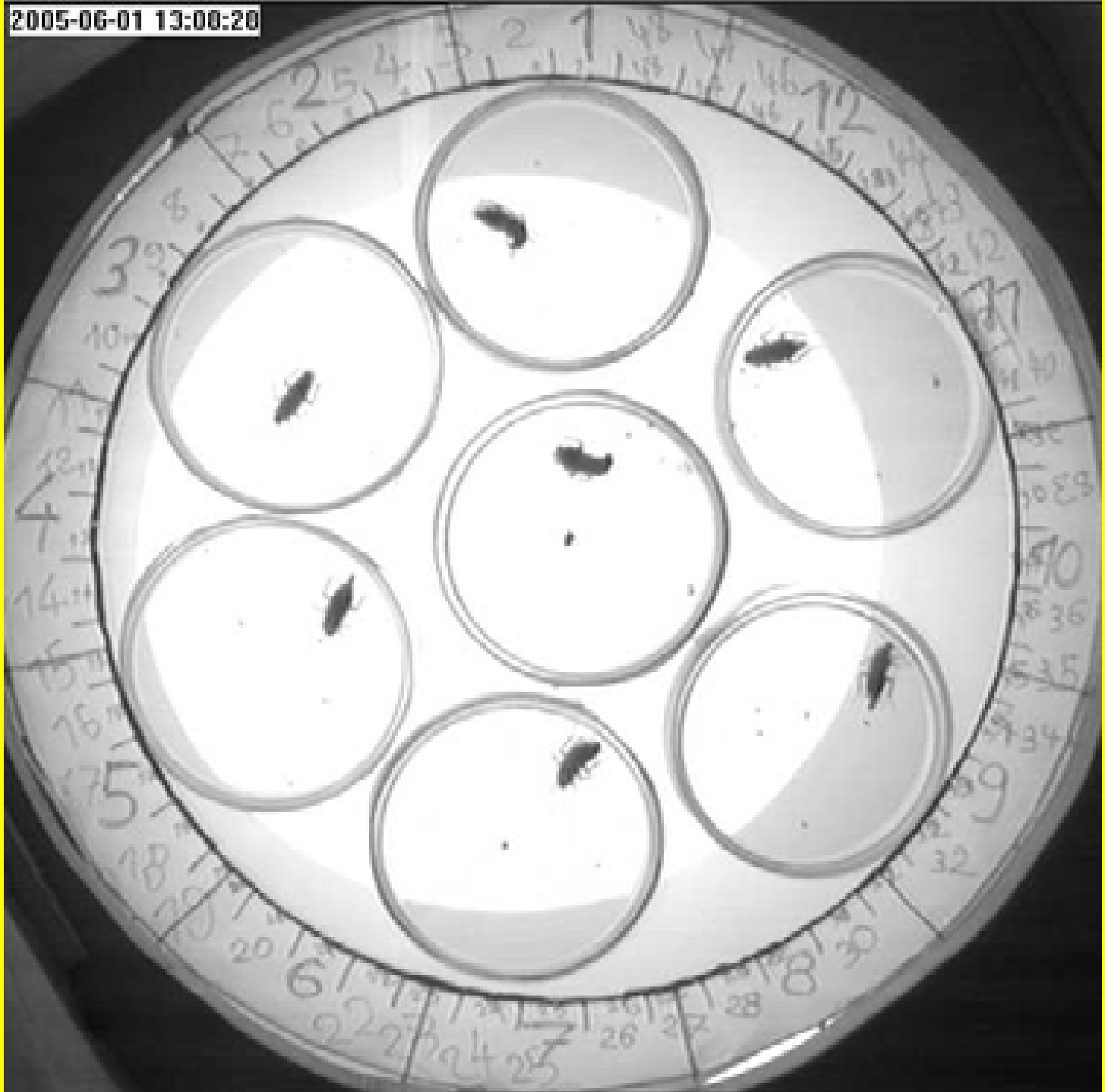
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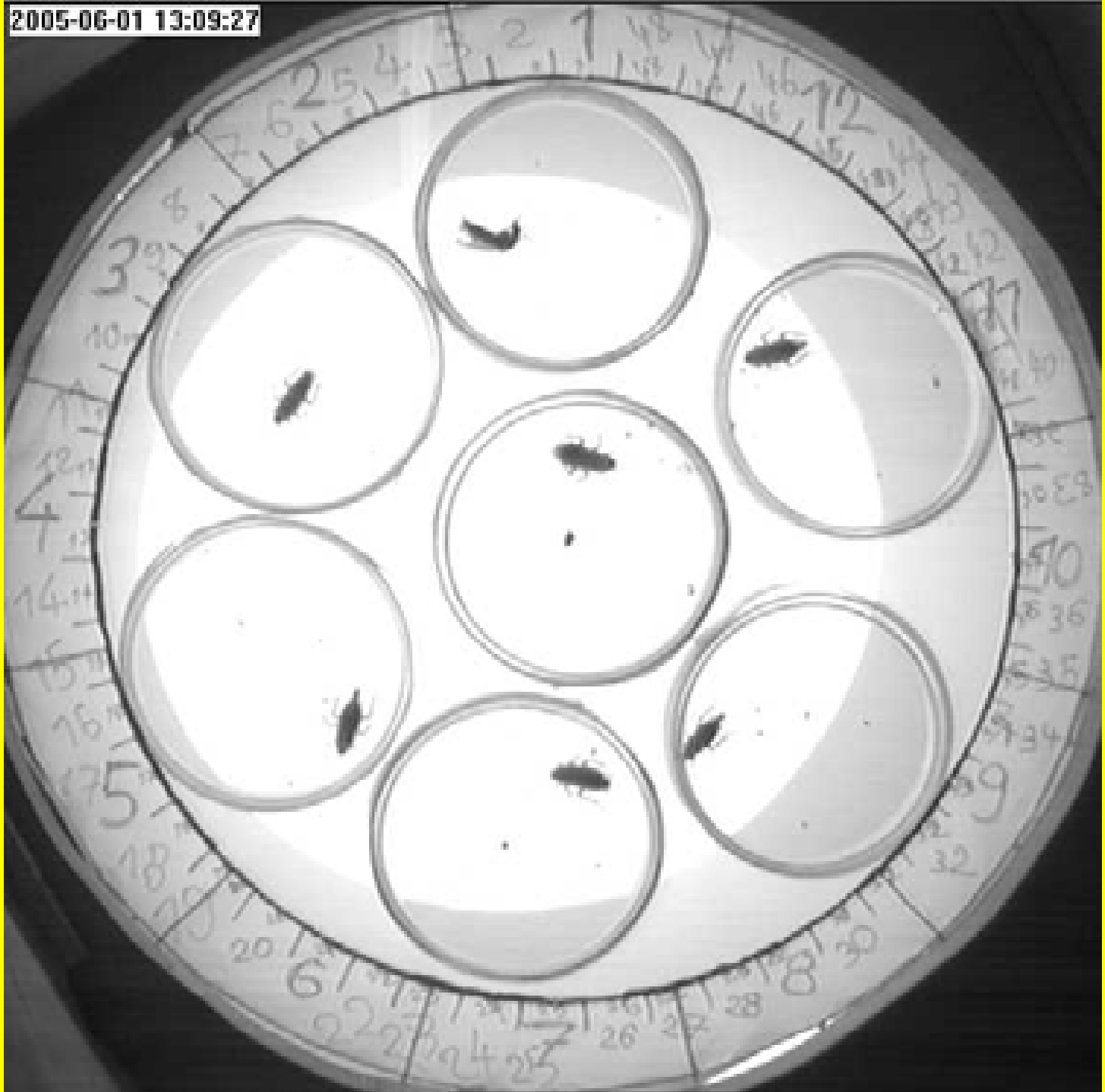
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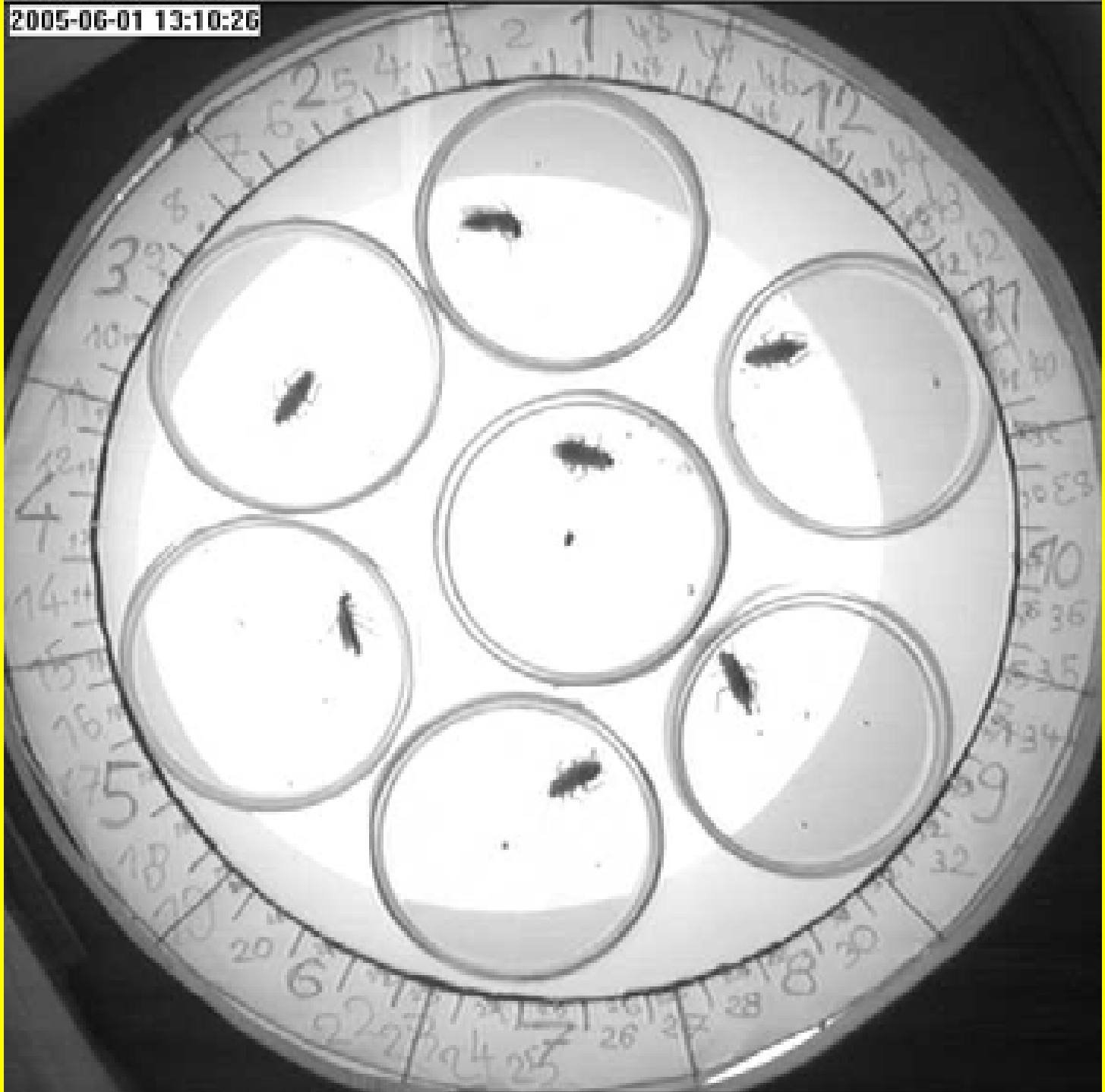
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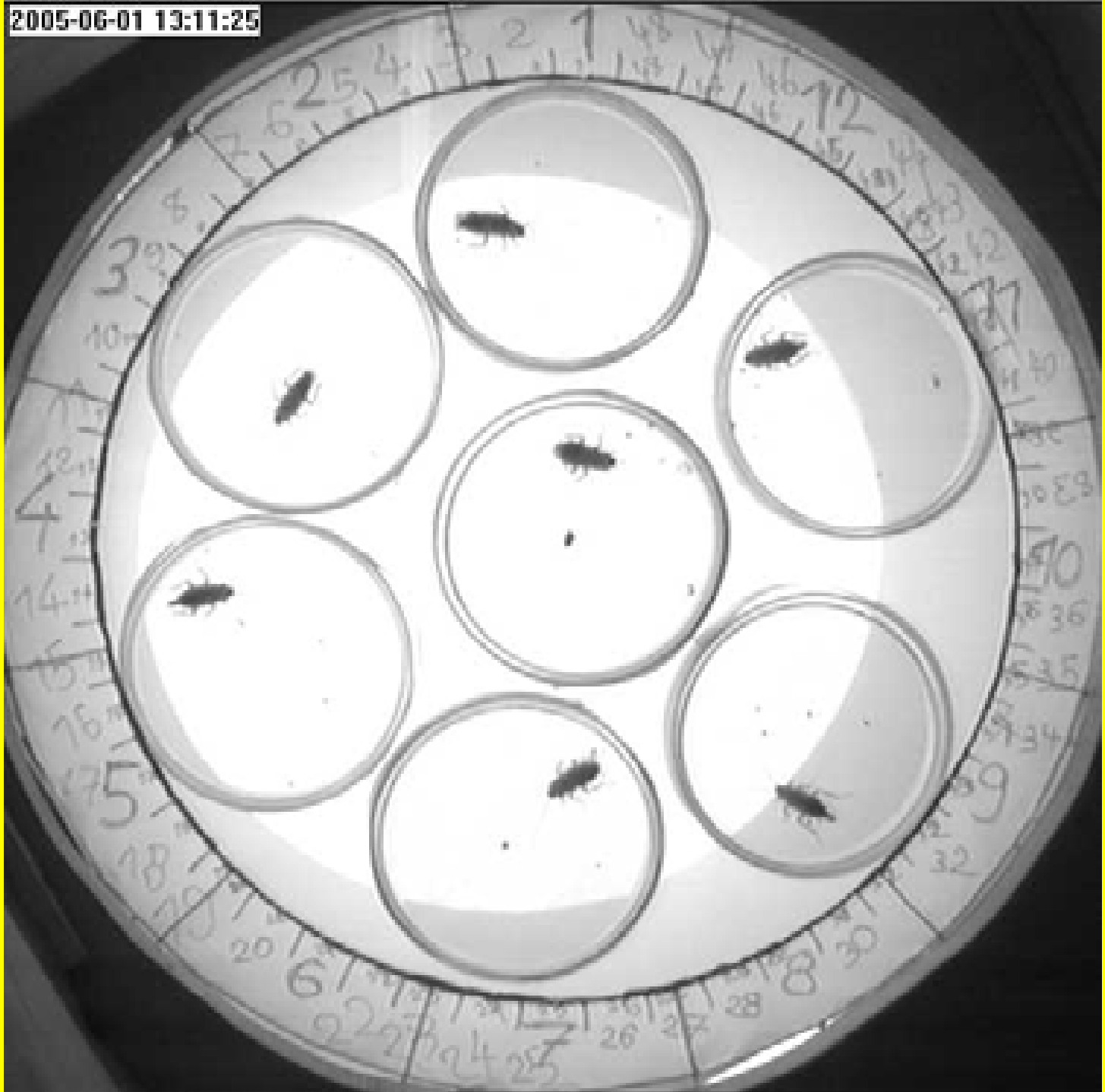
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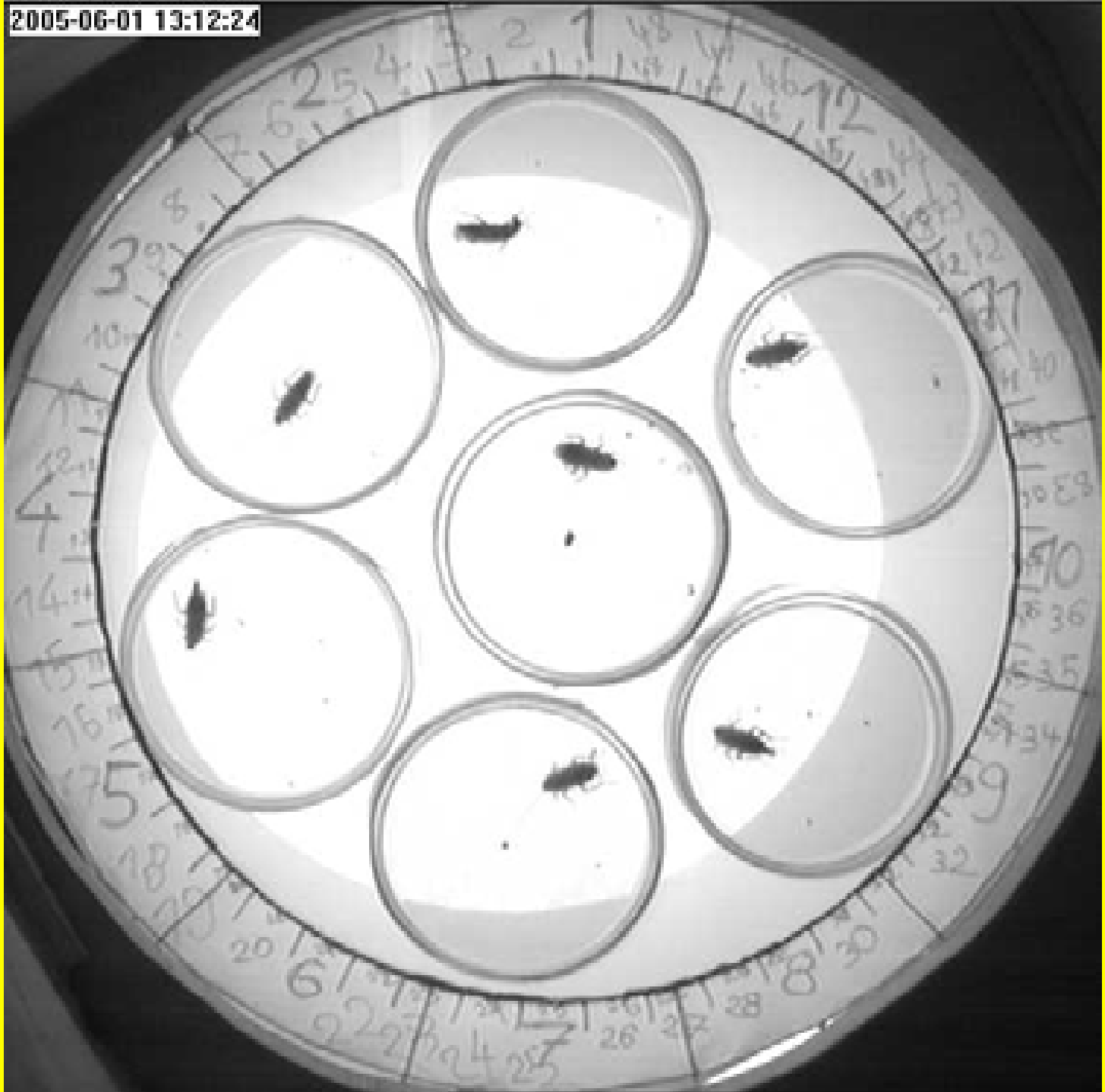
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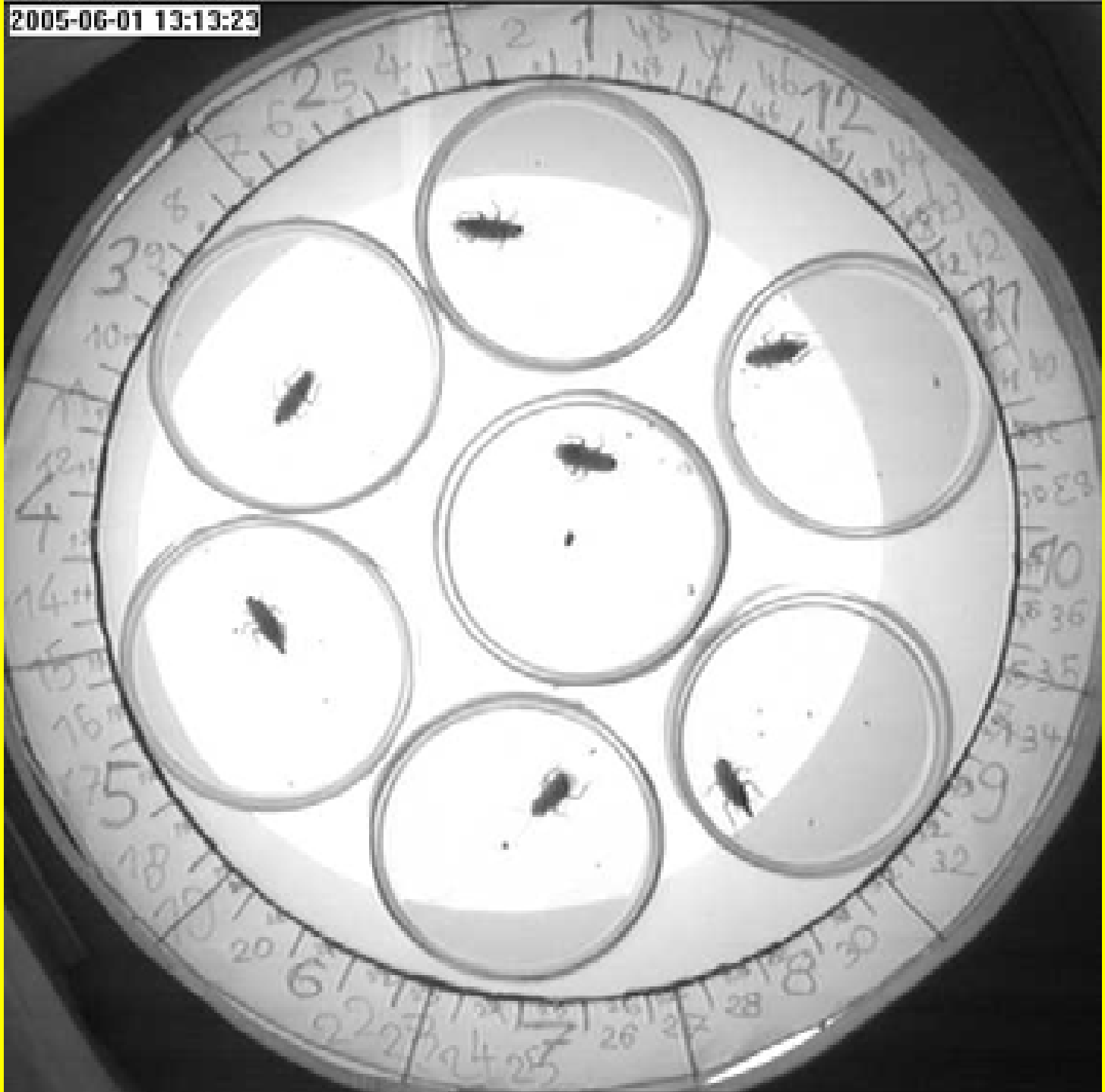
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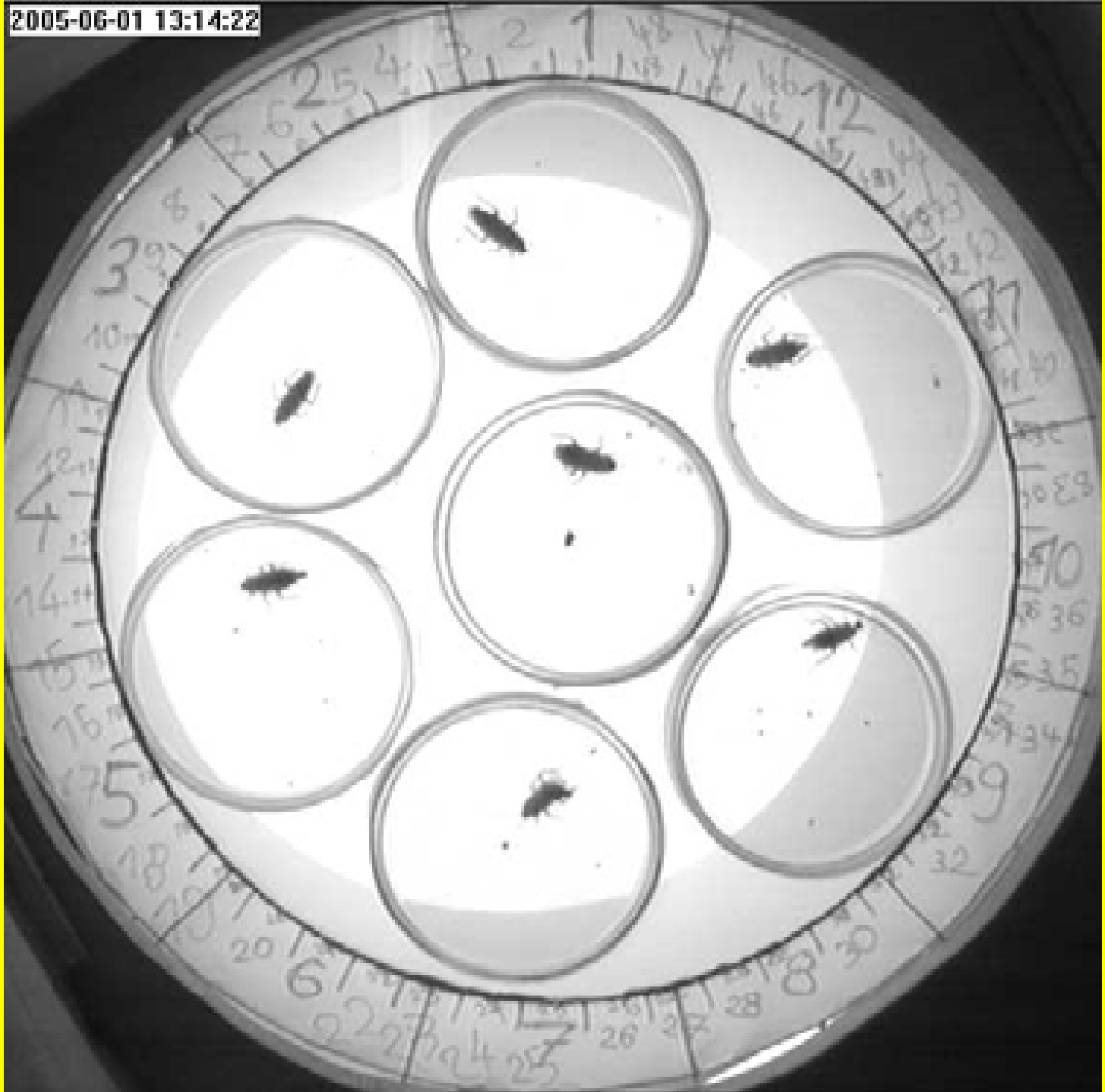
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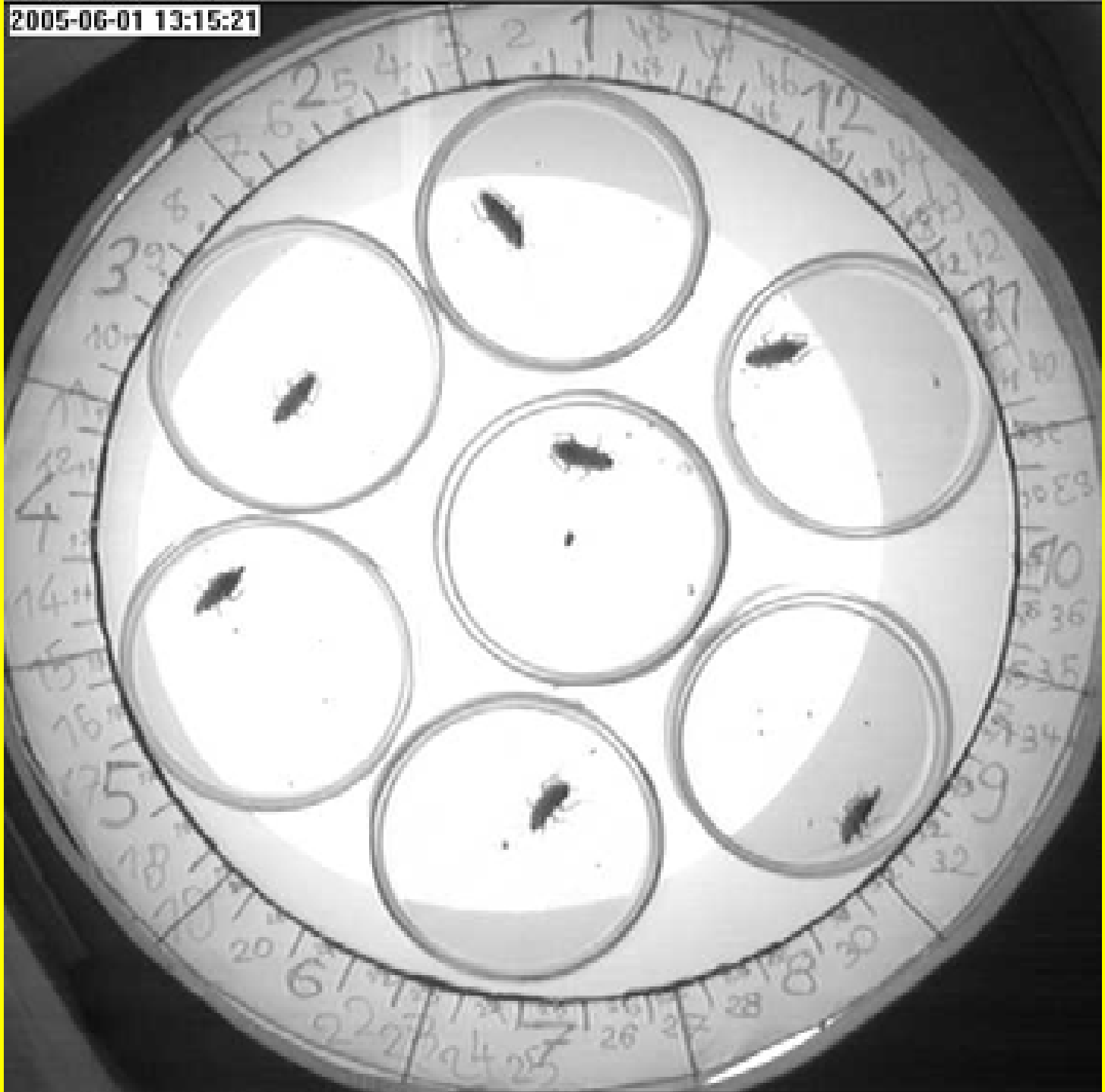
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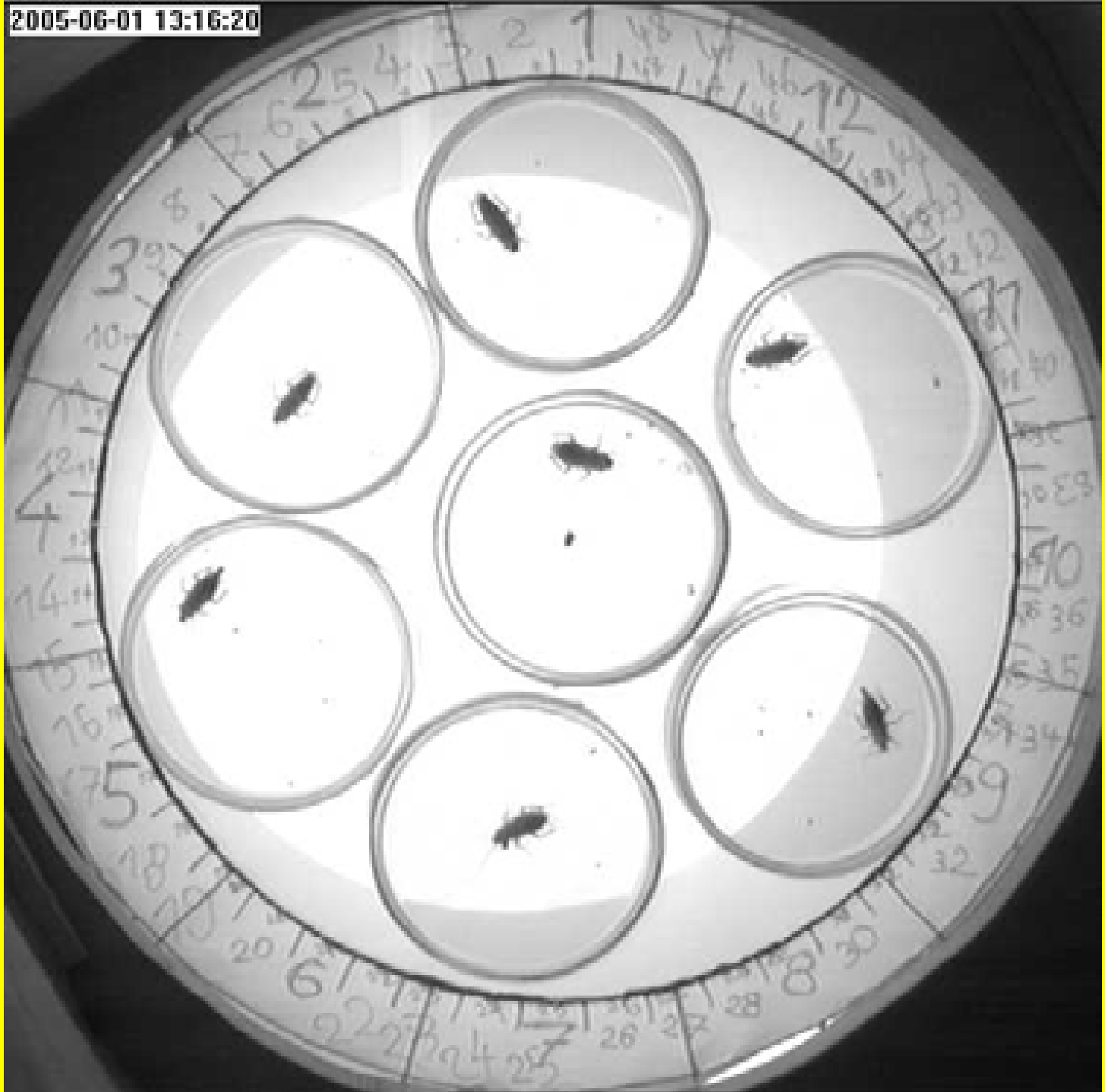
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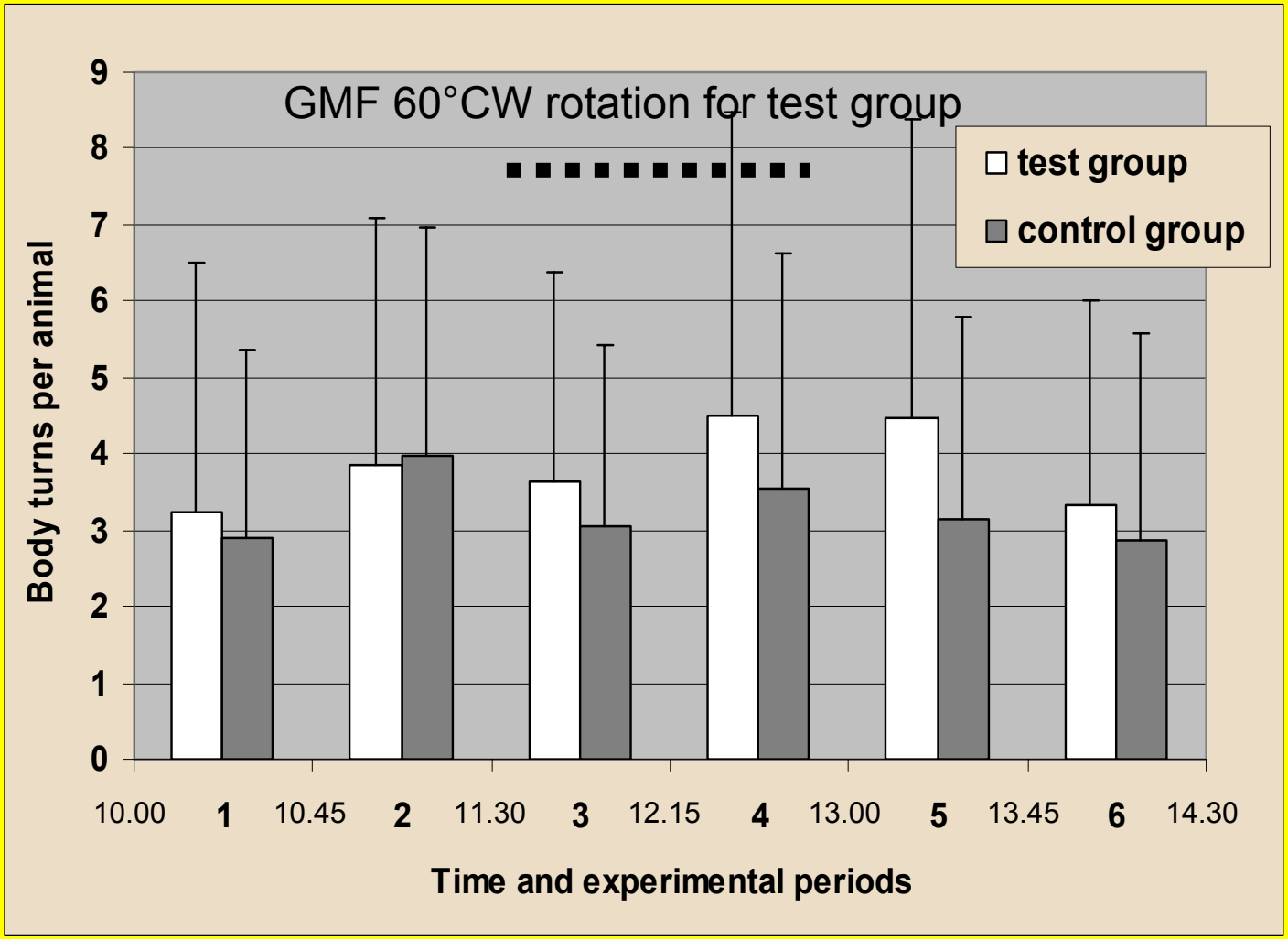

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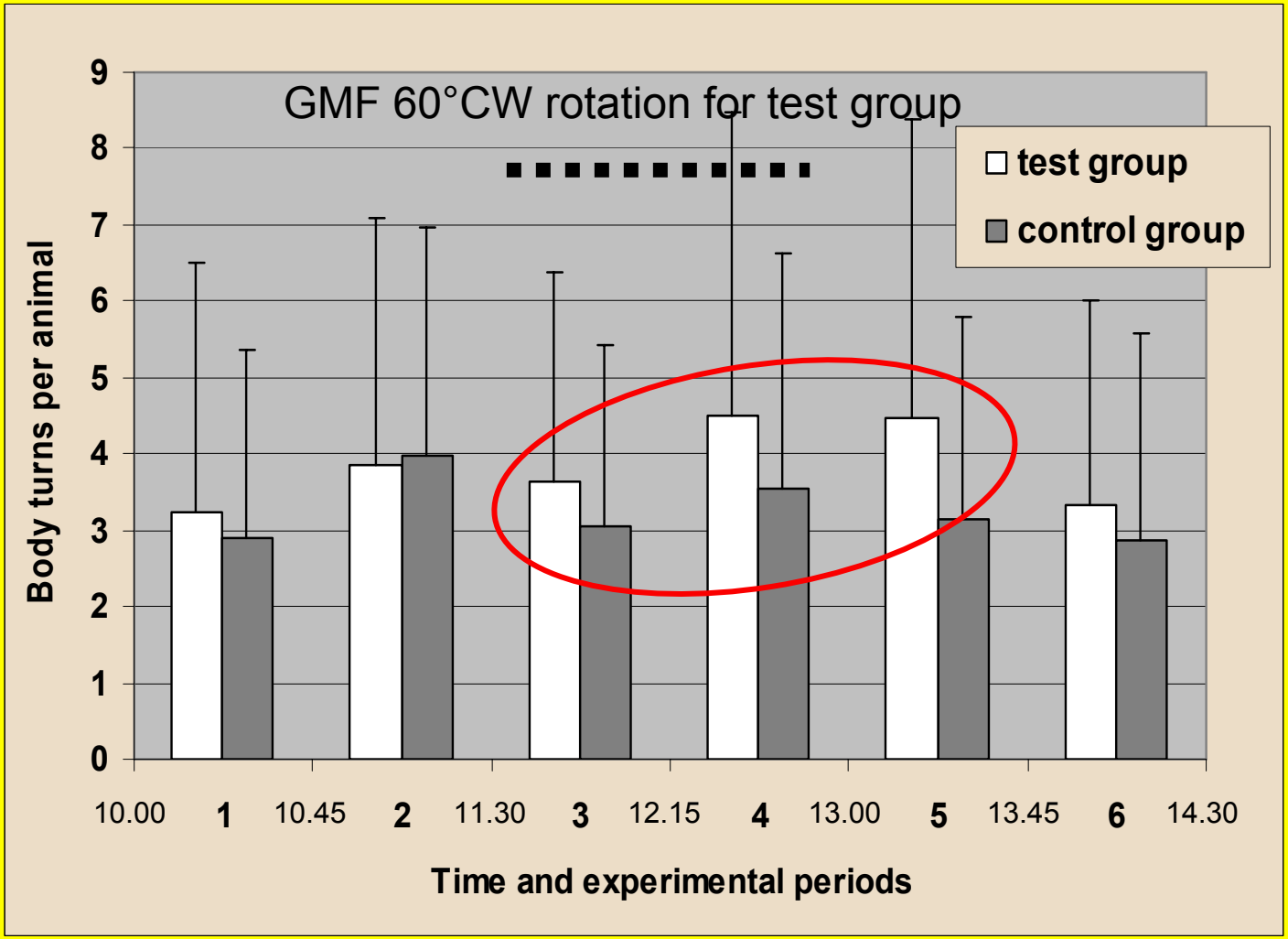
Results:



(n=62/66)

Projekt kryptochromy

- Metody reverzní genetiky – iRNA
- Chirurgie – léze, ablace
- Imunochistochemie