Vortrag von Dr. habil. Hans-Dieter Langer
an der Fakultät für Forstwissenschaften und Waldökologie, Georg-August-Universität Göttingen am 2. Mai 2024
in englischer Sprache

The biological footprint of cosmic rays using forest-specific examples: Forest hydrology and tree habitus

In my lecture I would like first to introduce you to a forest biology application of cosmic radiation that has already been established in the USA, China and in other advanced lands since around 2006.

Then I will go into my private research since 1992 in the border area between physics of cosmic radiation and biology, using trees as an example of testing.

Please excuse me my 'Google translator' English, because as a GDR citizen I had no opportunity to learn this language at school or in western countries.

Forest hydrology

→ soil moisture measurement

until now:
Soil sample
(point measurement/calibration)

footprint-gap
new: → km-scale! →
(non-invasive)

until now:
Airborne and satellite methods

Zreda, M.; Desilets, D.; Ferre´, T. P. A. ; Scott, R. L.: Measuring soil moisture content non-invasively at intermediate spatial scale using cosmic-ray neutrons, GEOPHYS. RES. LETTERS 35, L21402 (2008)

(in the years around → COSMOS)

Zreda & Co. write:

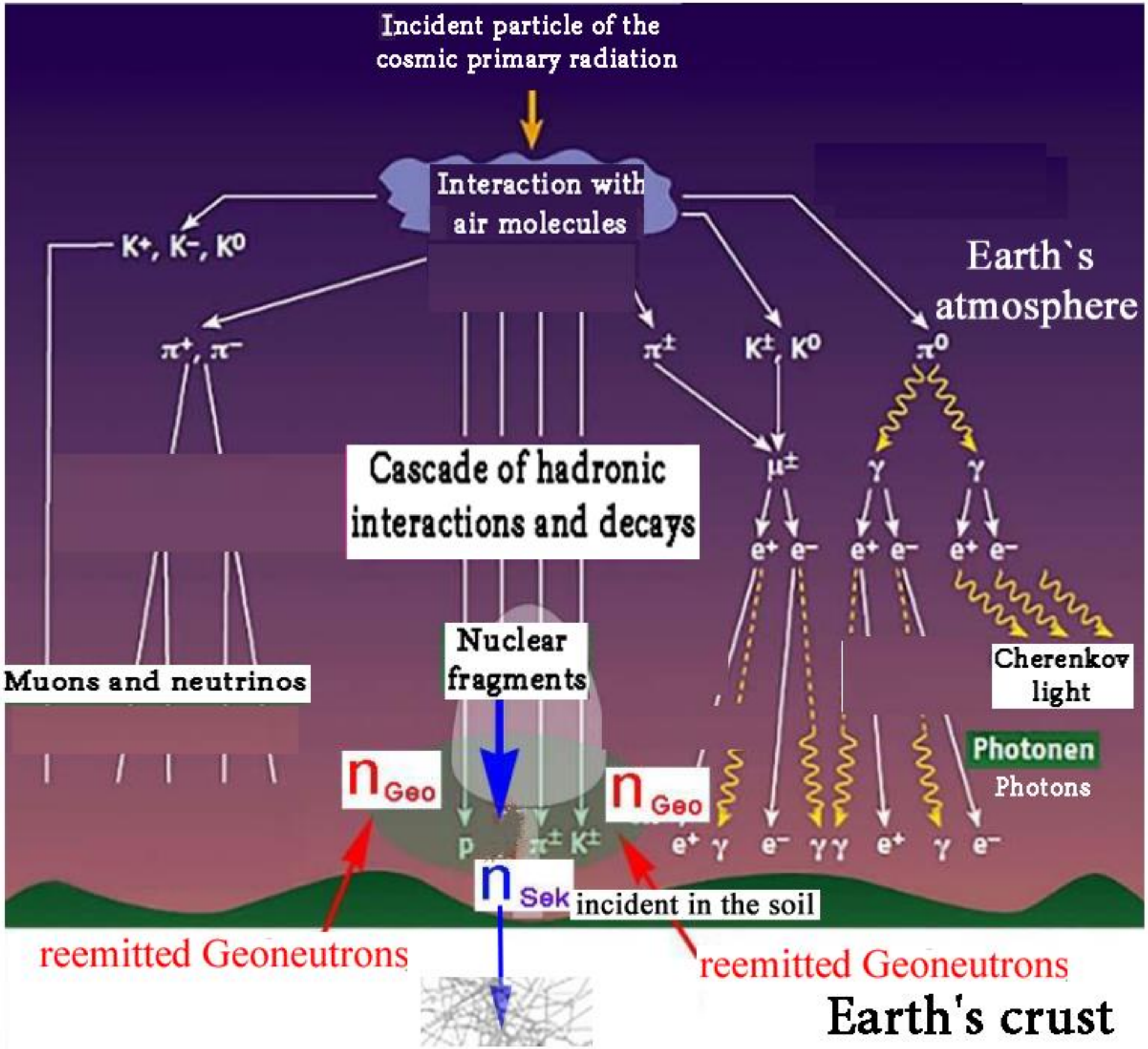
Cosmic secondary radiation is an important terrestrial neutron source.

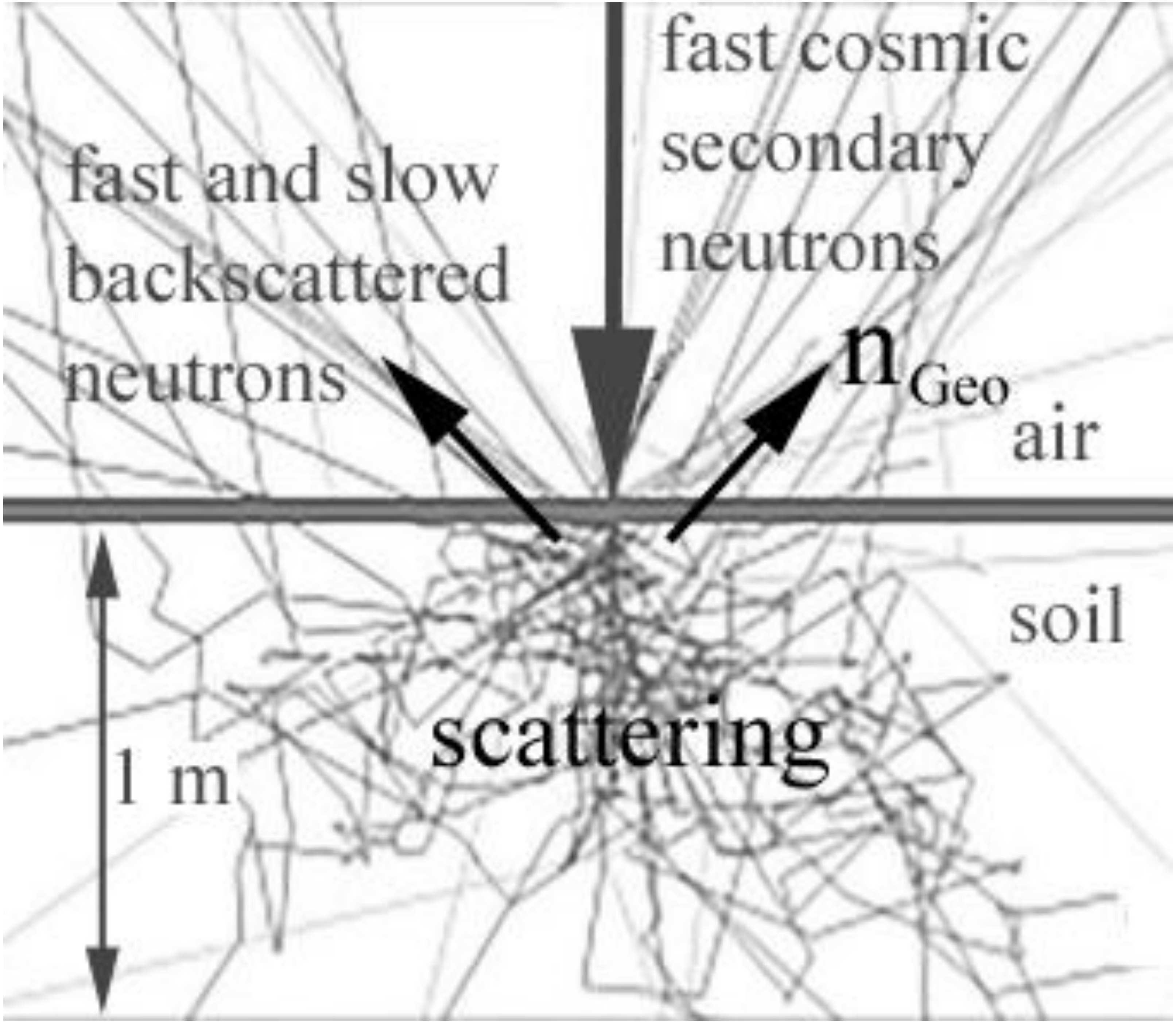
Because neutrons that are generated and moderated in the ground

Autor`s naming: - geoneutrons -

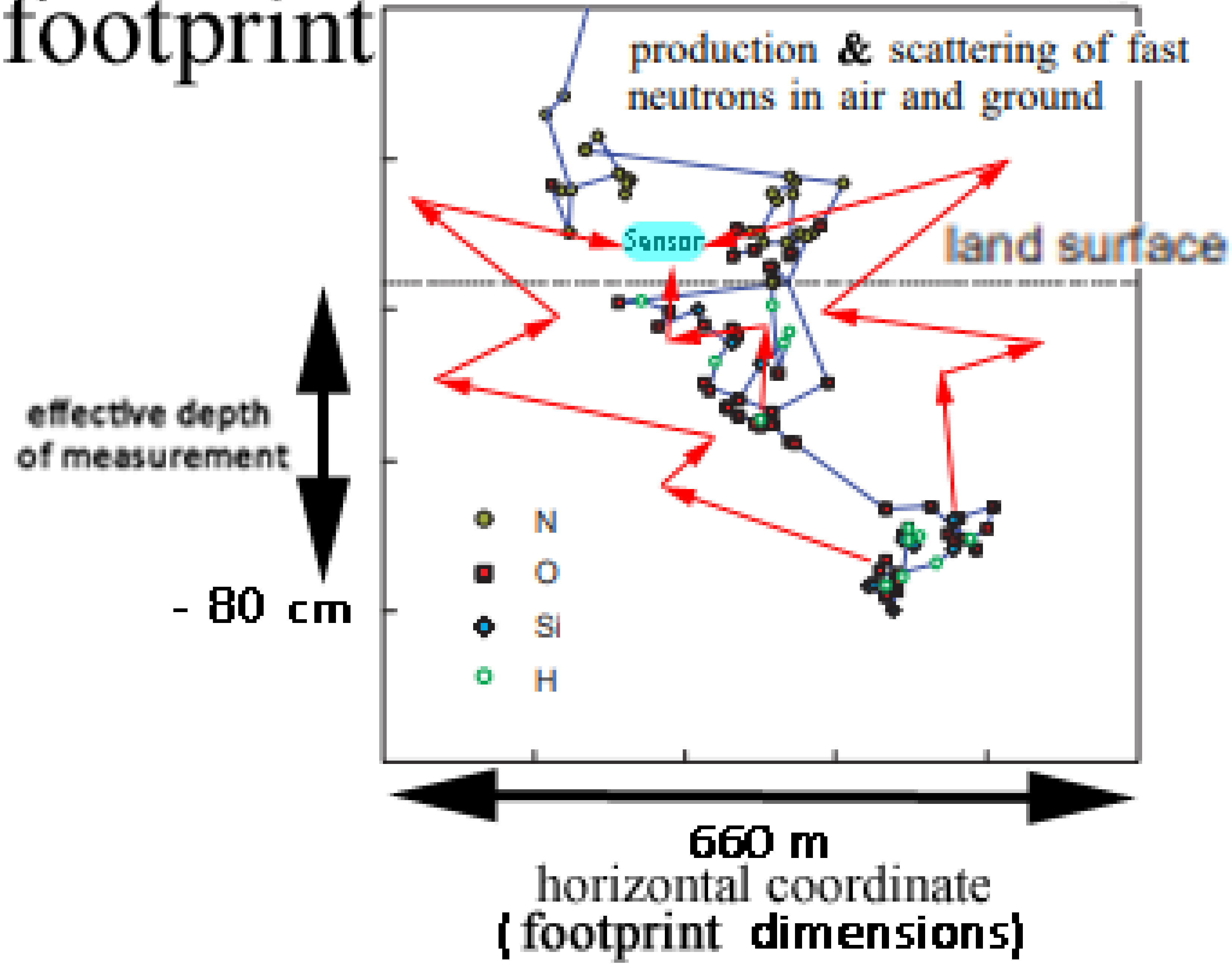
diffuse back into the air, this feasibility also applies in the case of non-invasive measurements above the ground surface.

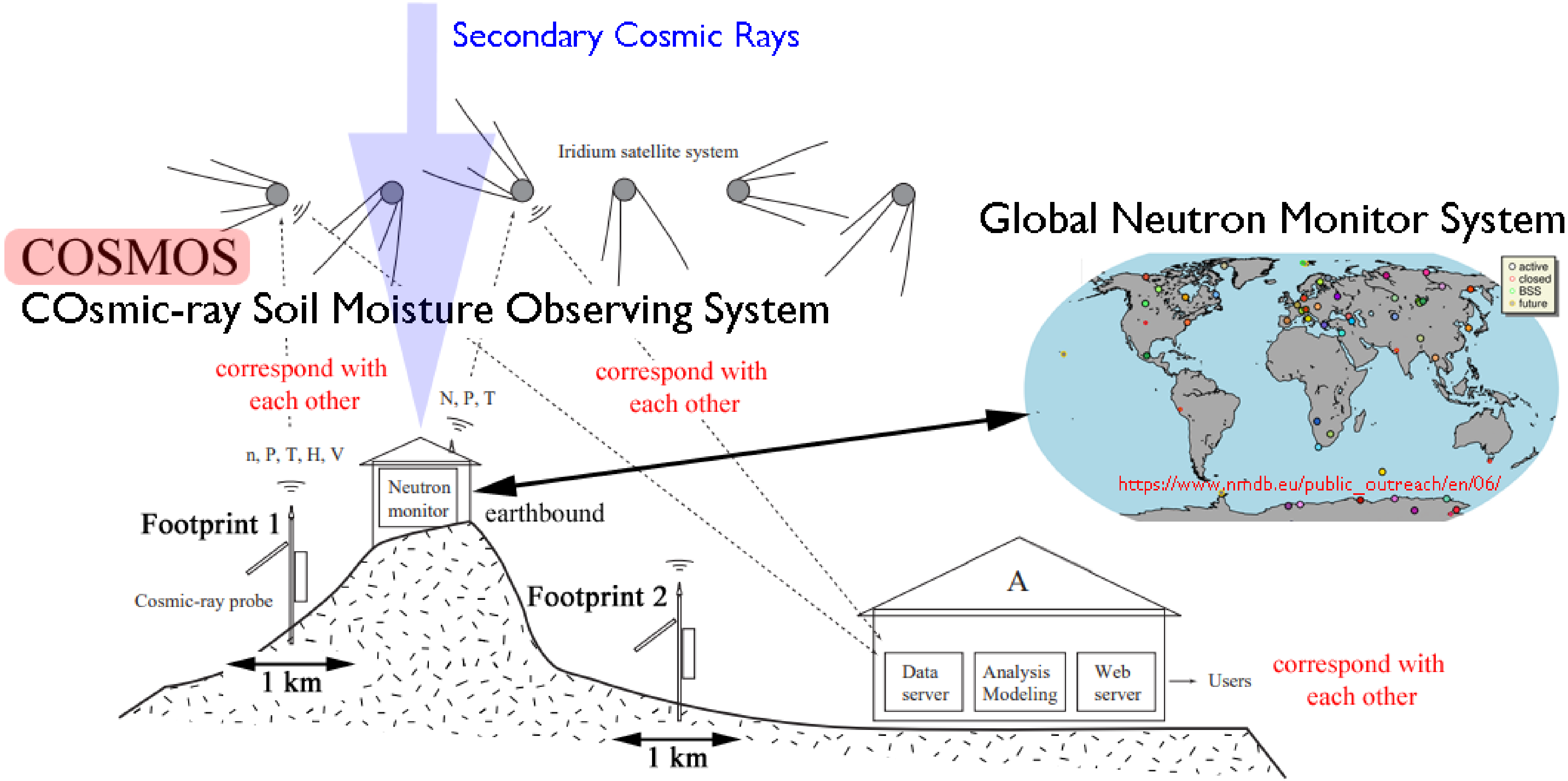
The measurement with a portable neutron detector placed a few meters above the ground takes ... suitable ... for studies of plant/soil interaction ...


Incident particle of the
cosmic primary radiation
Interaction with
air molecules
K+, K-, K0
π+, π-
π±
K±, K0
π0
Earth`s
atmosphere
μ±
γ
γ
e+ e-
e+ e-
e+ e-
Cascade of hadronic
interactions and decays
Nuclear
fragments
Muons and neutrinos
Cherenkov
light
Photonen
Photons
n Geo
n Geo
p π± K±
e+ γ e- γγ e+ γ e-
n Sek incident in the soil
reemitted Geoneutrons
reemitted Geoneutrons
Earth's crust


fast cosmic secondary neutrons
fast and slow backscattered neutrons
n_{Geo}
air
soil
scattering
1 m

footprint

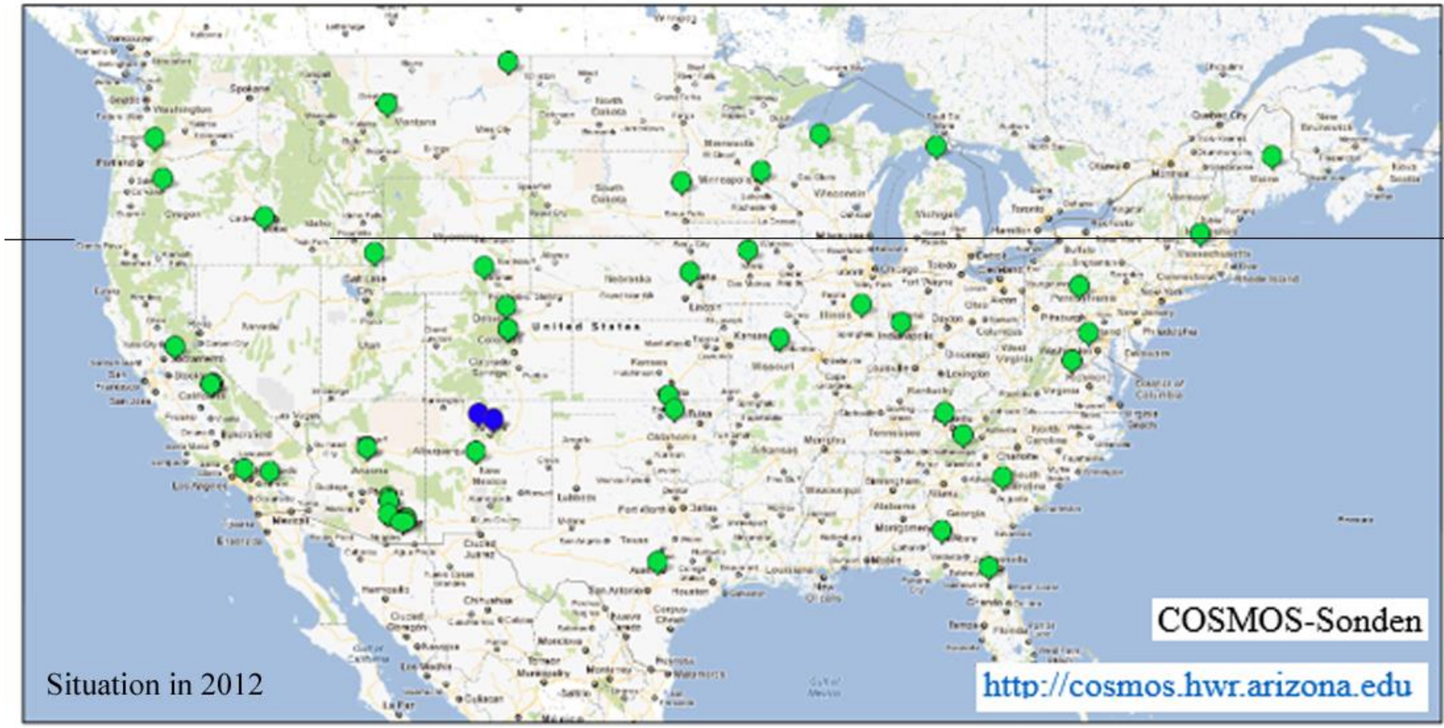

production & scattering of fast neutrons in air and ground
Sensor
land surface
effective depth of measurement
- 80 cm
N
O
Si
H
660 m
horizontal coordinate
(footprint dimensions)



The COSMOS consists of cosmic-ray probes that measure fast and thermal neutrons; neutron monitors that measure high-energy neutrons; a data transmission system (using Iridium satellite constellation); and computers for data acquisition and processing, analysis and modeling, and data and information dissemination. Key to abbreviations: n = fast neutron count rate; P = atmospheric pressure; T = air temperature; H = relative humidity; V = battery voltage; N = high-energy neutron count rate; A stands for Arizona where the COSMOS servers are located.

M. Zreda et al.: COSMOS: the COsmic-ray Soil Moisture Observing System (2012)

COsmic-ray Soil Moisture Observing System (or the COSMOS)



Physical backgrounds

Fast neutron production

$$\phi_E \sim \frac{1}{E \cdot \left(k_h \cdot \sigma_h \cdot \xi_h + \sum_{i=2}^{n} (k_i \cdot \sigma_i \cdot \xi_i)\right)}$$

ϕ_E *intensity of neutrons of energy E*

neutron source intensity

(number of fast neutrons produced)

k_h *number of hydrogen atoms in soil*

(h index for Hydrogen)

σ *elemental scattering cross-section*

ξ *elemental logarithmic energy decrement*

(i number of all other elements in soil that are important for scattering neutrons)

$$\xi = 1 + \frac{(A-1)^2}{2A} \ln \frac{A-1}{A+1}$$ *A atomic mass*

Element	A	σ	ξ
H	1.0079	22.02	1.000
O	15.9994	4.232	0.120
C	12.011	5.551	0.158
Si	28.0855	2.167	0.070
Na	22.9898	3.28	0.085
Ca	40.078	2.83	0.049
Al	26.9815	1.503	0.072
Fe	55.847	11.62	0.035
Mg	24.305	3.71	0.080
K	39.0983	1.96	0.050

Fundamental Connection

$$\theta_m = \frac{1}{a_1}\left(\frac{a_2}{(N/N_0) - a_3} - a_4\right)$$

θ_m gravimetric water content (kg kg^{-1})

N fast neutron count rate

N_0 fast neutron count rate over dry soil

a_1-a_4 constants (Calibration!)

corrections and other problems

temporal changes in atmospheric pressure

atmospheric water vapor in time and space

incoming neutron flux of secondary cosmic rays

other sources of water
(lattice water, atmospheric water vapor, vegetation water)

soil organic matter

surface water and ice

biomass above the earth's surface

real structure of soil/tree research

scientific potential & practical applications

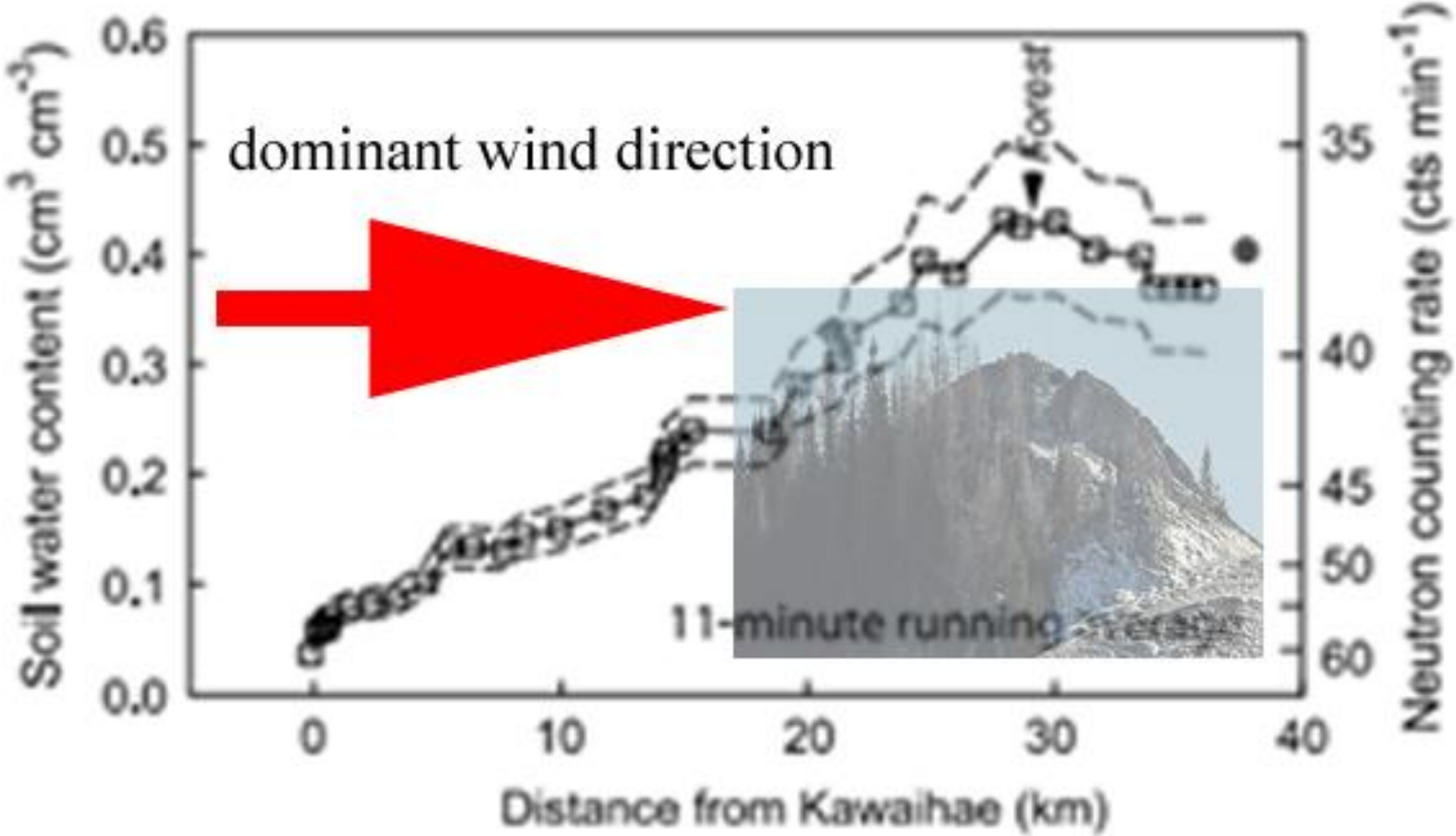
Advances in technology of cosmic neutron promise to expand both observation and opportunities for novel research not only in land surface hydrology.

Special achievements of the new multihectare-scale technology:

* detection of hydrogen (especially as water equivalent) and biological carbon in soil, air and biomass on a multi-hectare field scale,
* determining snow,
* distinguishing snow events from soil wetting rain events (using measurements in different energy bands),
* biomass determination,

advantages of the COSMOS network for mapping:

* temporal and spatial continuity,
* mapping over large areas,
* roving surveys (gradients in soil moisture, vegetation and soil development),
* selektive sensitivity to soil, air and biomass chemistry,
* very innovative market of neutron detectors.


dominant wind direction
Forest
11-minute running average
Soil water content (cm3 cm-3)
Neutron counting rate (cts min-1)
Distance from Kawaihae (km)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
10
20
30
40
35
40
45
50
60

However, in the author's opinion, geoneutrons still have also great scientific potential in the future, especially in biology, medicine, geophysics and settlement physics.

The author focused on this early on in his tree research - see his pre-publications - and believes that he has discovered a fundamentally new phenomenon, which he calls in relation to biophysical life processes:

field of research: **Neutronotropy**

real structure of soil/tree research

Pre-publications of H.-D. Langer:

The geophysical location problem of solitary trees - Results of systematic nature observations,
Zeitschrift des Museums für Naturkunde Chemnitz 20 (1997) 115

The geophysical location problem of solitary trees - A test tree that has a Neutron partial beam,
Zeitschrift des Museums für Naturkunde Chemnitz **26 (2003) 117**

Neutronotropy - A representation based on the reference system of trees
Publication submitted in 2003 to the Magazine Contributions for Forestry and Landscape ecology at the Eberswalde University of Applied Sciences,
not printed

Lecture: Observations and effects of natural terrestrial neutron radiation,
Forschungszentrum Jülich (2003)

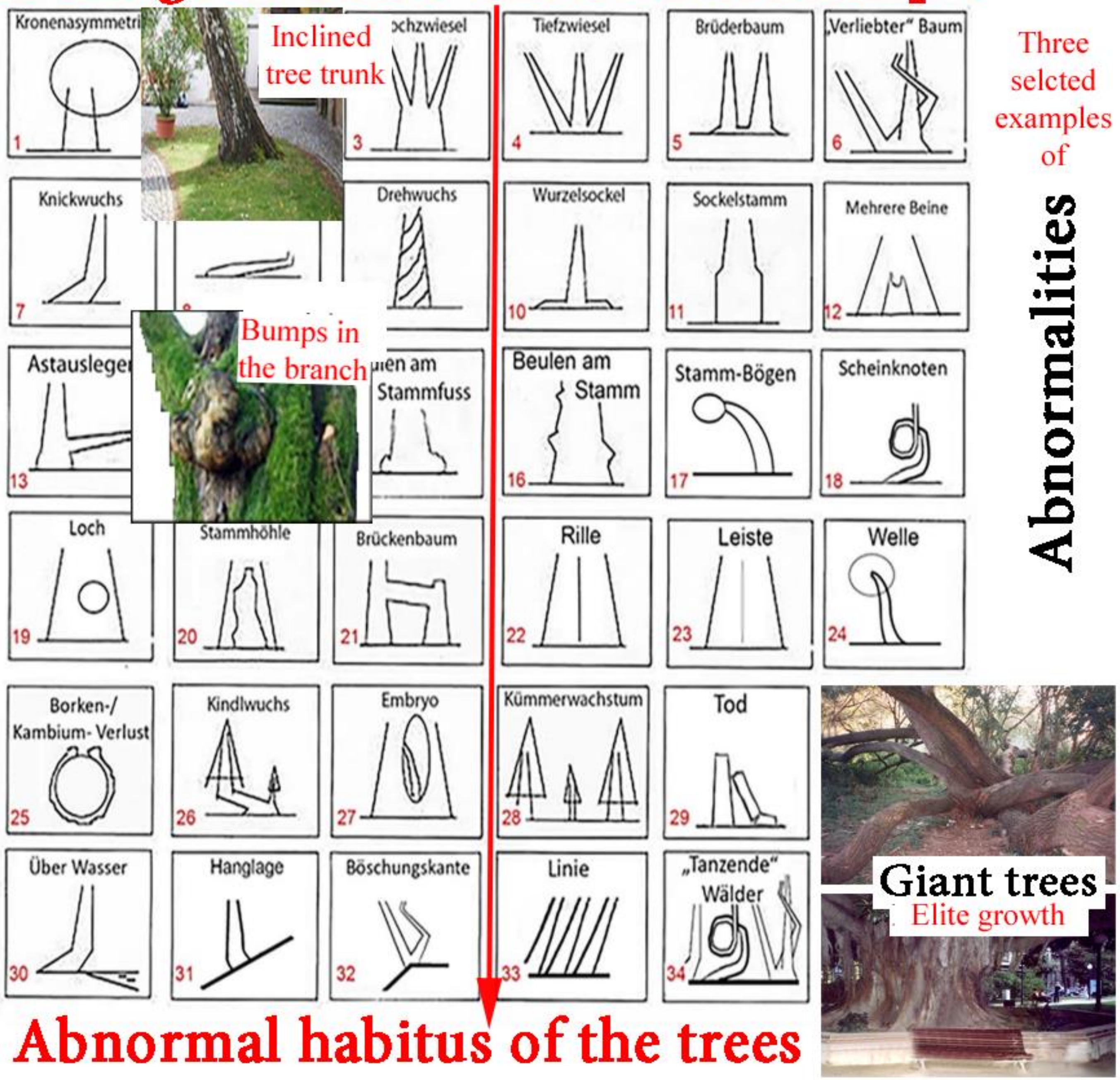
The geophysical location problem of trees - Gradient growth of trees in the field of geoneutrons,
Publication submitted in 2008 to the Zeitschrift des Museums für Naturkunde Chemnitz,
not printed

see also www.drhdl.de

Let me be a little proud of the fact that I was quicker than Zreda & Co. in recognizing the significance of geoneutrons.


The misery of the trees
Das Elend der Bäume
- Neutronotropie -
- Neutronotropy -
A contribution to the physics of life
Ein Beitrag zur Physik des Lebens
von Dr. Hans-Dieter Langer
2018

Work goal: cause-effect relationship ?



Abnormal habitus of the trees

Tree habitus

What is the cause of the abnormal tree growth? → Author's idea: The natural radioactivity in the biosphere!

Please remember:

The measurement with a portable neutron detector placed a few centimeters near a tree on the ground takes ... suitable ... for studies of plant/soil interaction.

Equipment of my private research:

Szintimat 6134 (plastic scintilator!) measurement

Gamma 2 Dosimeter

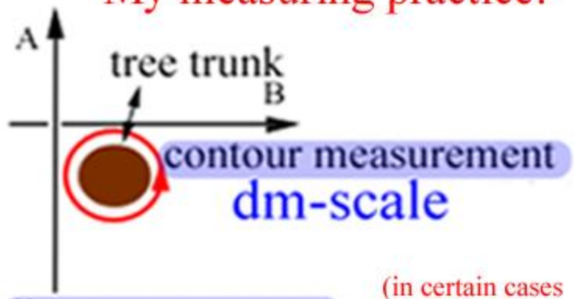
(mixed radiation)

Calibration of the Measurement equipment with: 241AmBe-(α,n)-neutron source & 252Cf fission neutron source

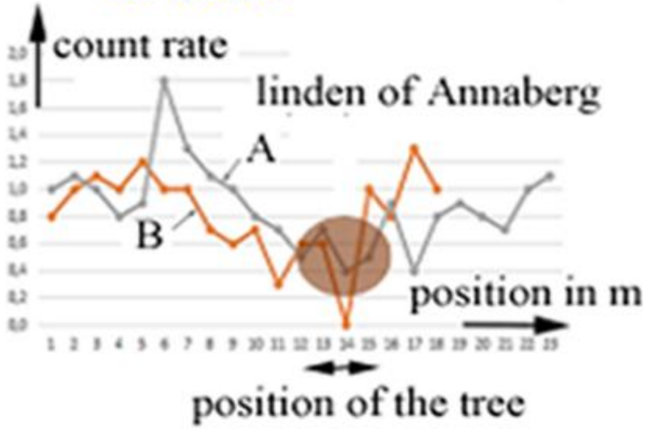
Selective comparison measurements (very time consuming!) with the neutron equivalent Probe Indicator Unit MK 16 NV (^{3}He-counter) :

→ only selectively (as control)

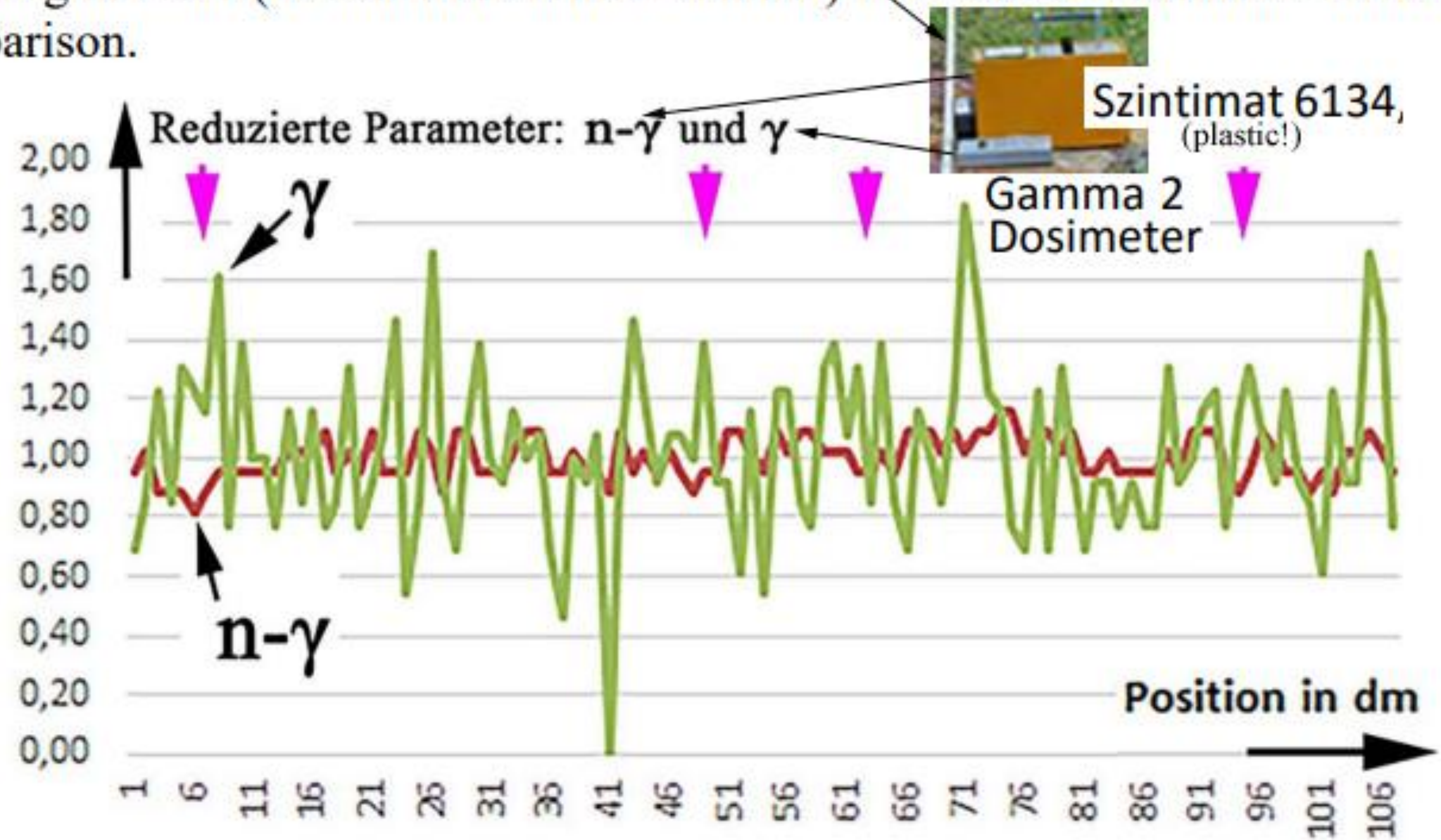
My measuring practice:



(in certain cases manual spatial measurement)



The diagram below shows an example of the (reduced!) n-**γ** and **γ** measurement data along a straight measurement line of approx. 10 m in length on grass soil (i.e. far from a tree location) have been determined for comparison.



Belisheva, N. K., u. Mitarb.: Correlation between the fusion dynamics of cells growing in vitro and variations of neutron intensity near the Earth´s surface, Doklady Biochem. and Biophys., 402 (2005) 254*:*

... that cell fusion *"can also be influenced by neutrons generated in the earth's crust"*

W. Friedt (2008) from the Federal Biological Research Center for Agriculture and Forestry:

"*The cell changes described must inevitably lead to an impairment of plant growth as a result of exposure to radiation.*"

„Even a single capture reaction damages the deoxyribonucleic acid in the cell nucleus to such an extent that the cell dies." Lindinger, M. (1998)

"A photon (X-ray beam) leads to a very loose ionization in the cell. ionization in the cell. A neutron, on the other hand, causes many dense ionization points in the cell nucleus, dense ionization points and therefore more damage." Streffer, Ch. (2002)

"Compared to conventional radiation - i.e. X-rays and gamma rays - neutrons produce considerably more non-repairable or difficult to repair DNA changes (double-strand breaks)."

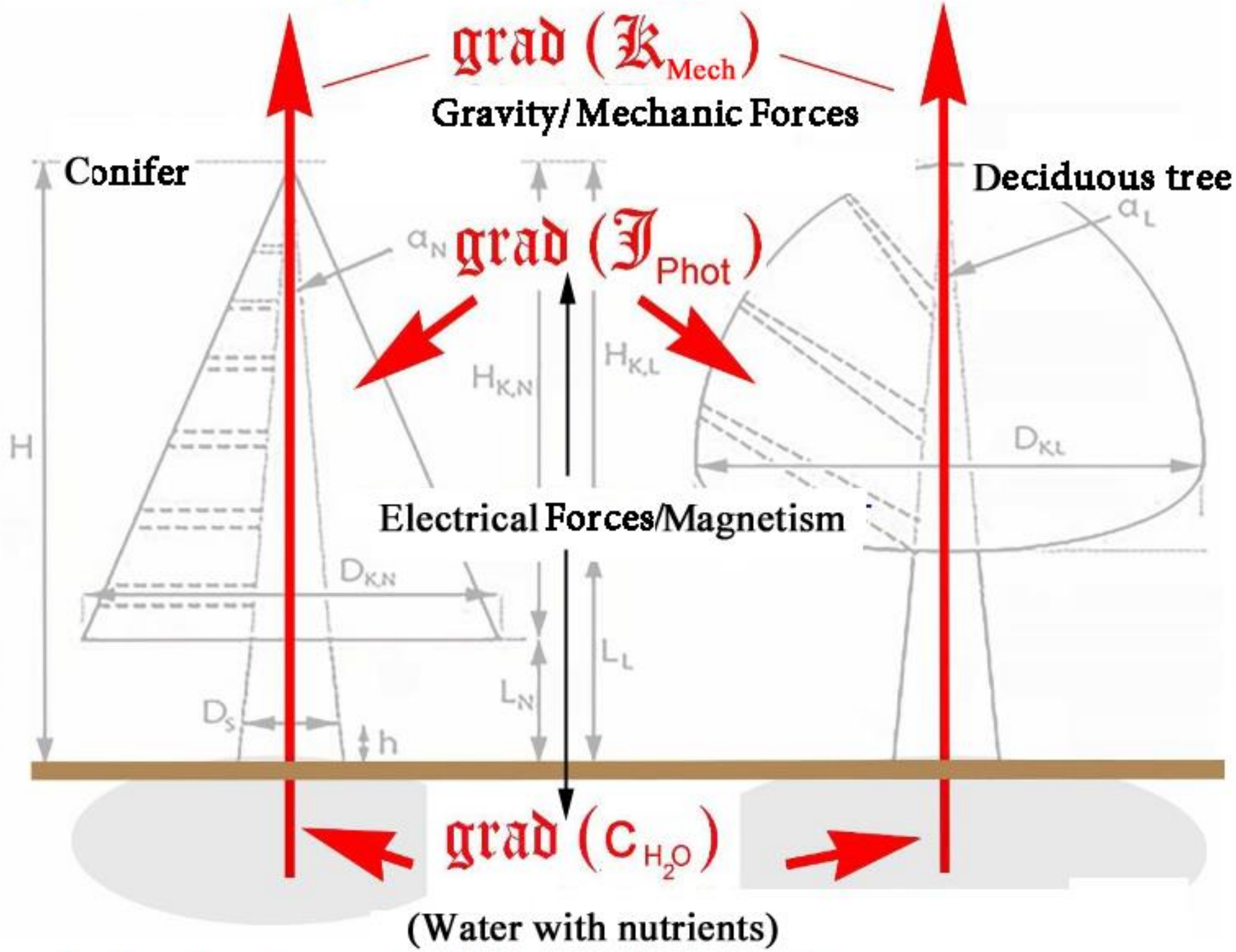
Molls, M. (2002)

Then came the realization "*that cell fusion can also be influenced by neutrons generated in the earth's crust*". Hewitt, V. L. (2017)

Stoupel, E., u. Mitarb.: Neutrons and sudden cardiac death, J. Basic & Clinical Physiol. & Pharmacol., 17 (2006) 45

Stoupel, E., u. Mitarb.: Are neutrons involved in the pathogenesis of life-threatening cardiac arrhythmias, J. Basic & Clinical Physiol. & Pharmacol., 17 (2006) 55

Trees grow in gradient fields

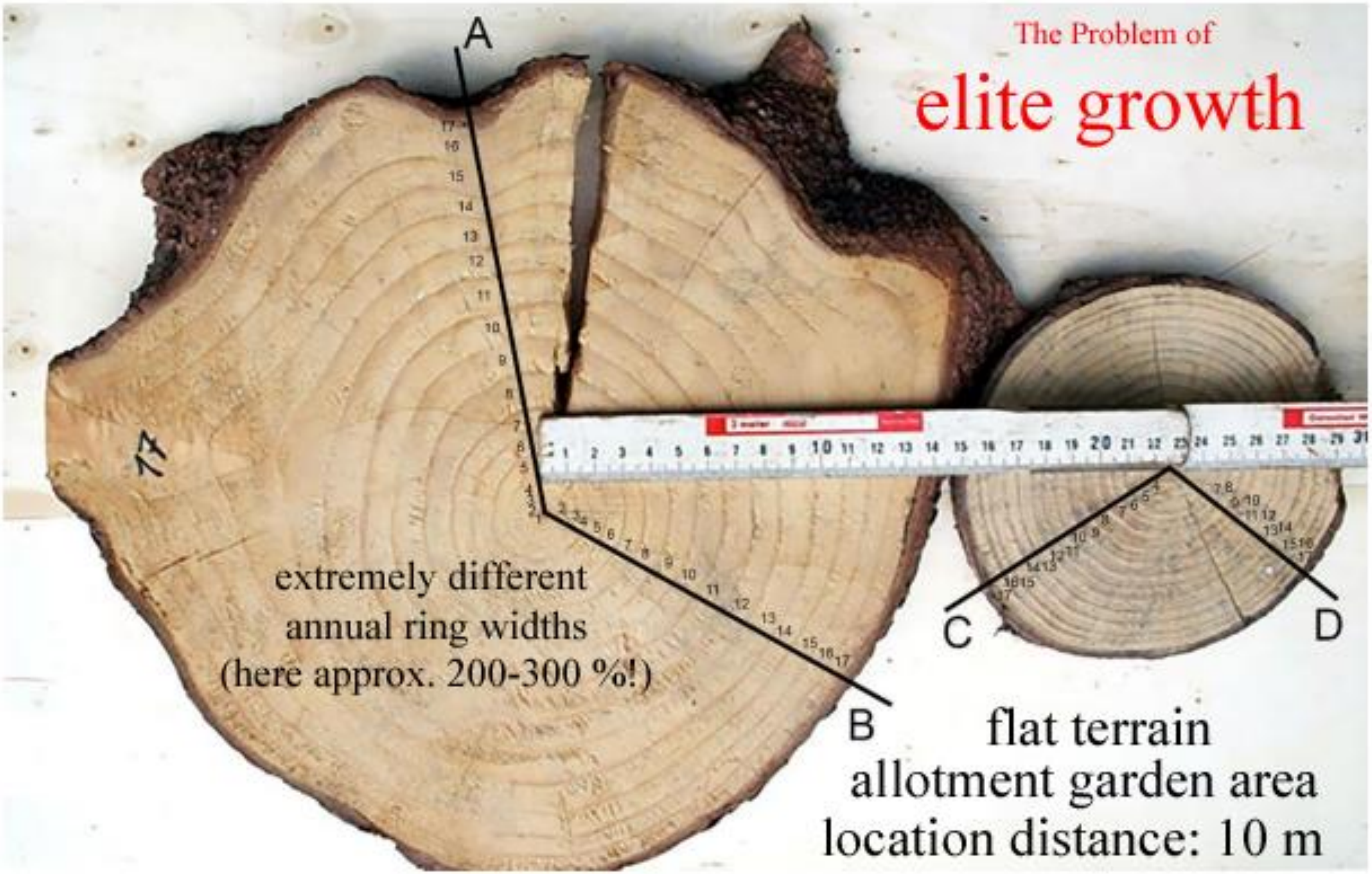


And nuclear forces should have no influence?

Nuclear Forces (Weak and Strong Force) ???

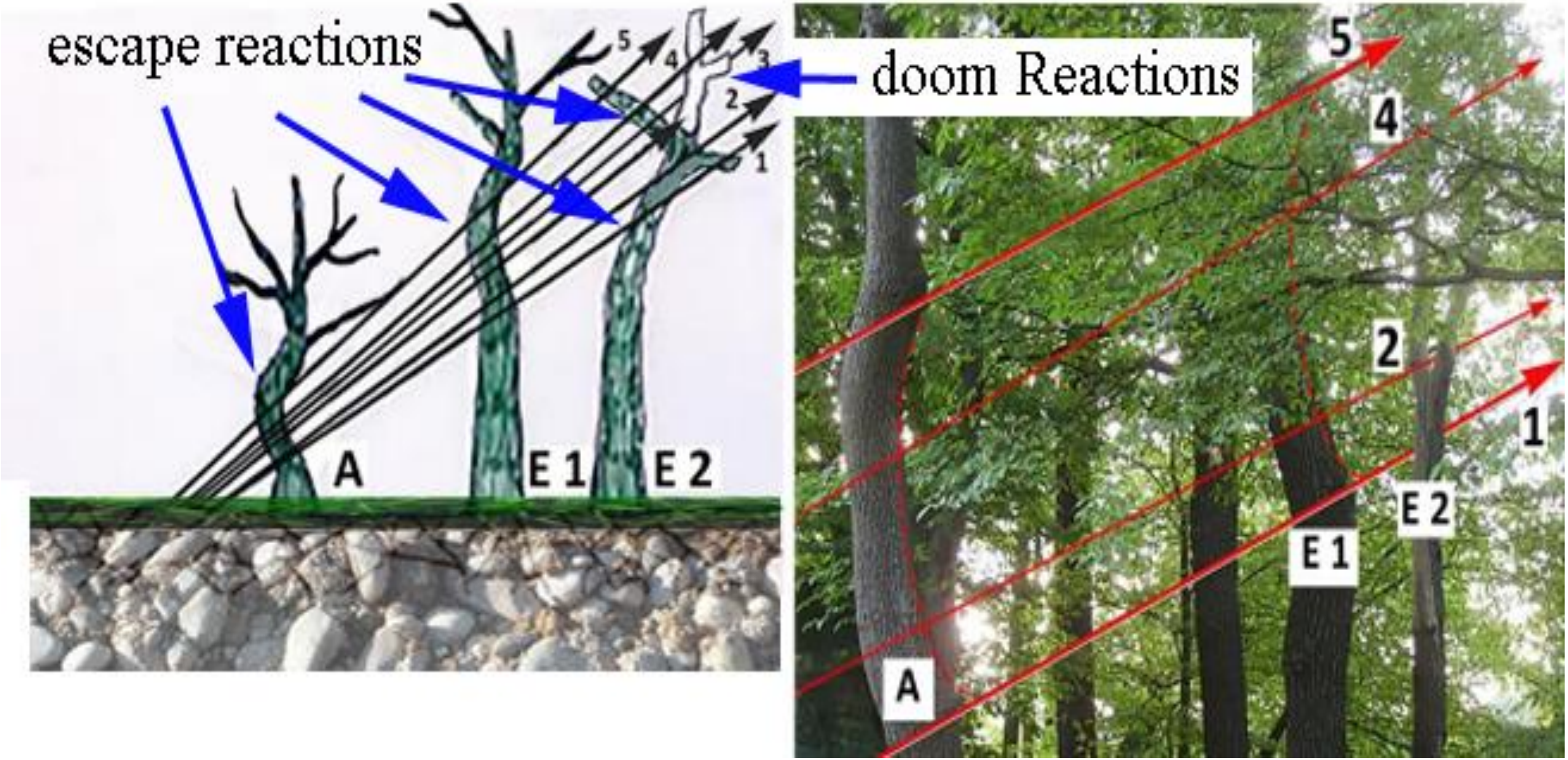
I think, yes!!!


Wolframslinde in Bad Kötzing/Bayerischer Wald
Wolframs lime tree in Bad Kötzting/Bavarian forest
Hollow and consisting only of bumps?
Bumpsgroups in the area of branches?
Kirchen-Esche zu Jachymov/Tschechien
Church ash in Jachymov/Czech Republic
Are bumps defense reactions?
Bump groups
Inclined tree trunks?
Bark losses and changes

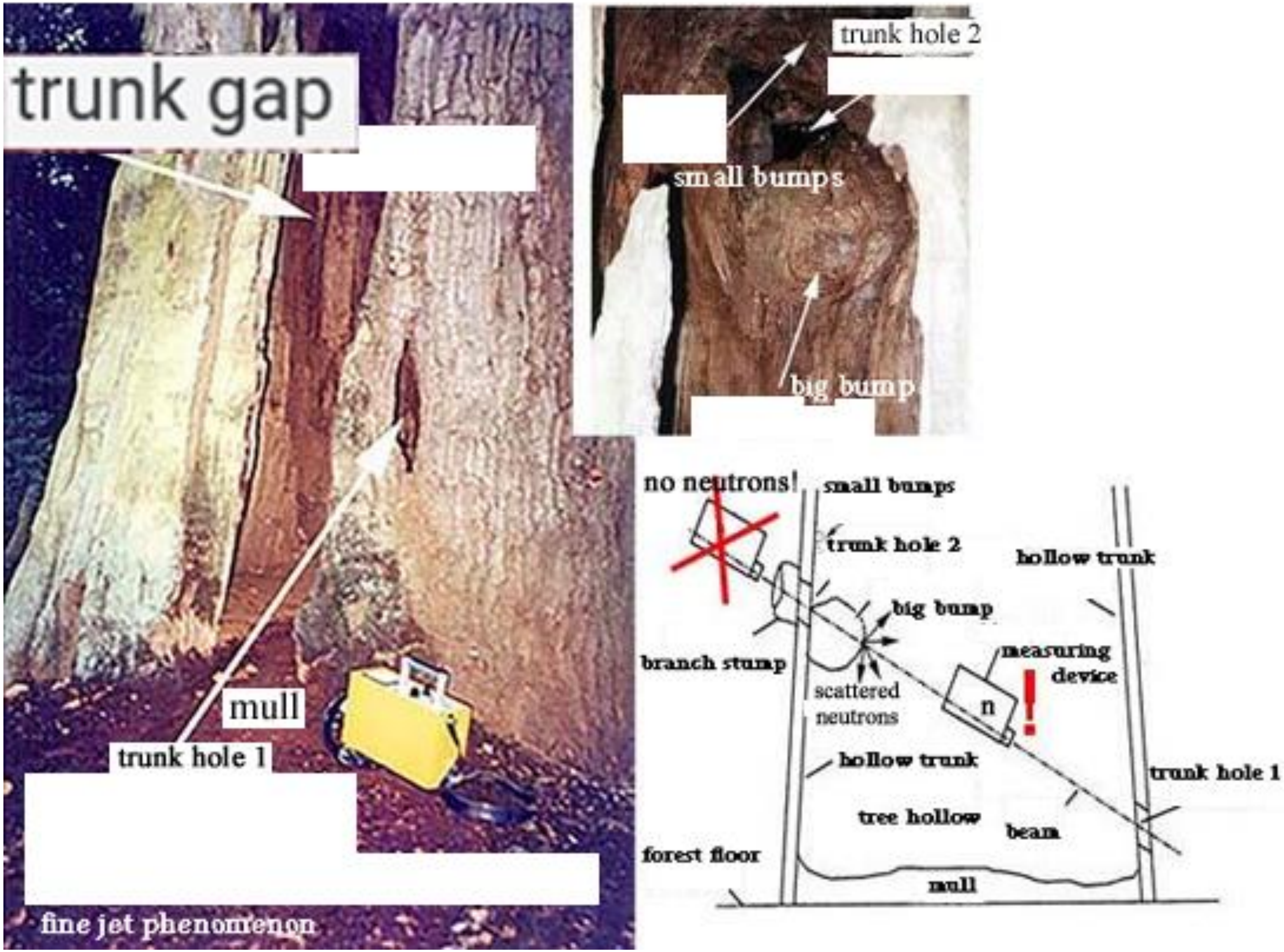


Tree slices of two pine trees: Grown under the same conditions?

Three trees depict a neutron beam array? (in Niederwiesa)



n_{Geo} fine beam



Selective application of the slow to fast neutron energy spectrum in tree research

Working hypotheses:

All neutrons backscattered from the soil into the biosphere are called geoneutrons.

Autor

The neutron energy spectrum also contain information about the spatial pattern.

Zreda et al.

The thermal (slow) geoneutron amount will depend on soil chemistry because of the presence of neutron absorbing elements in the soil, such as B, Cl, Ca, K and Gd, which affect slow neutrons, but not fast neutrons:

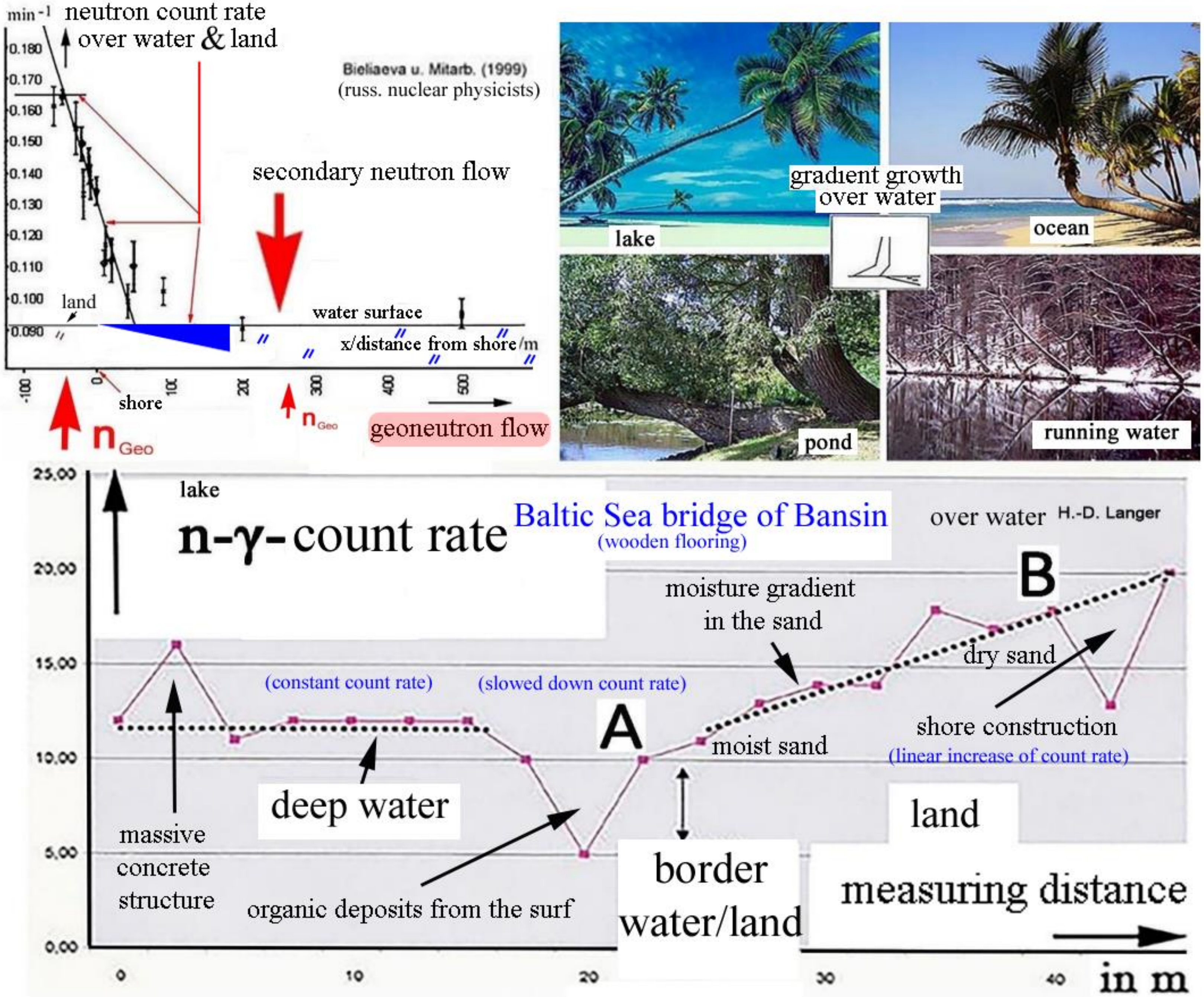
scientific knowledge

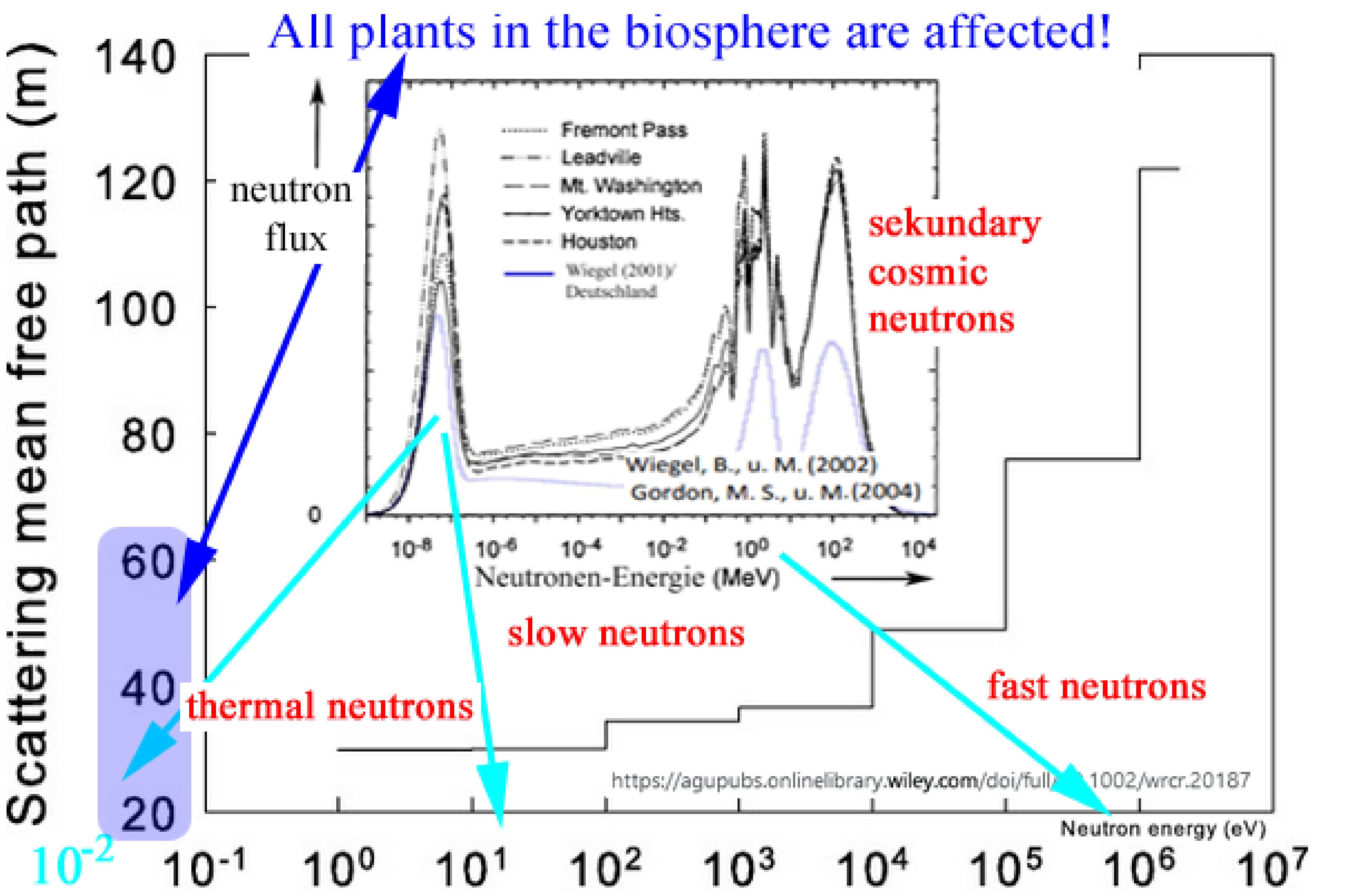
The author notes:

The slow and fast geoneutron amount will depend on the

real structure in the ground:

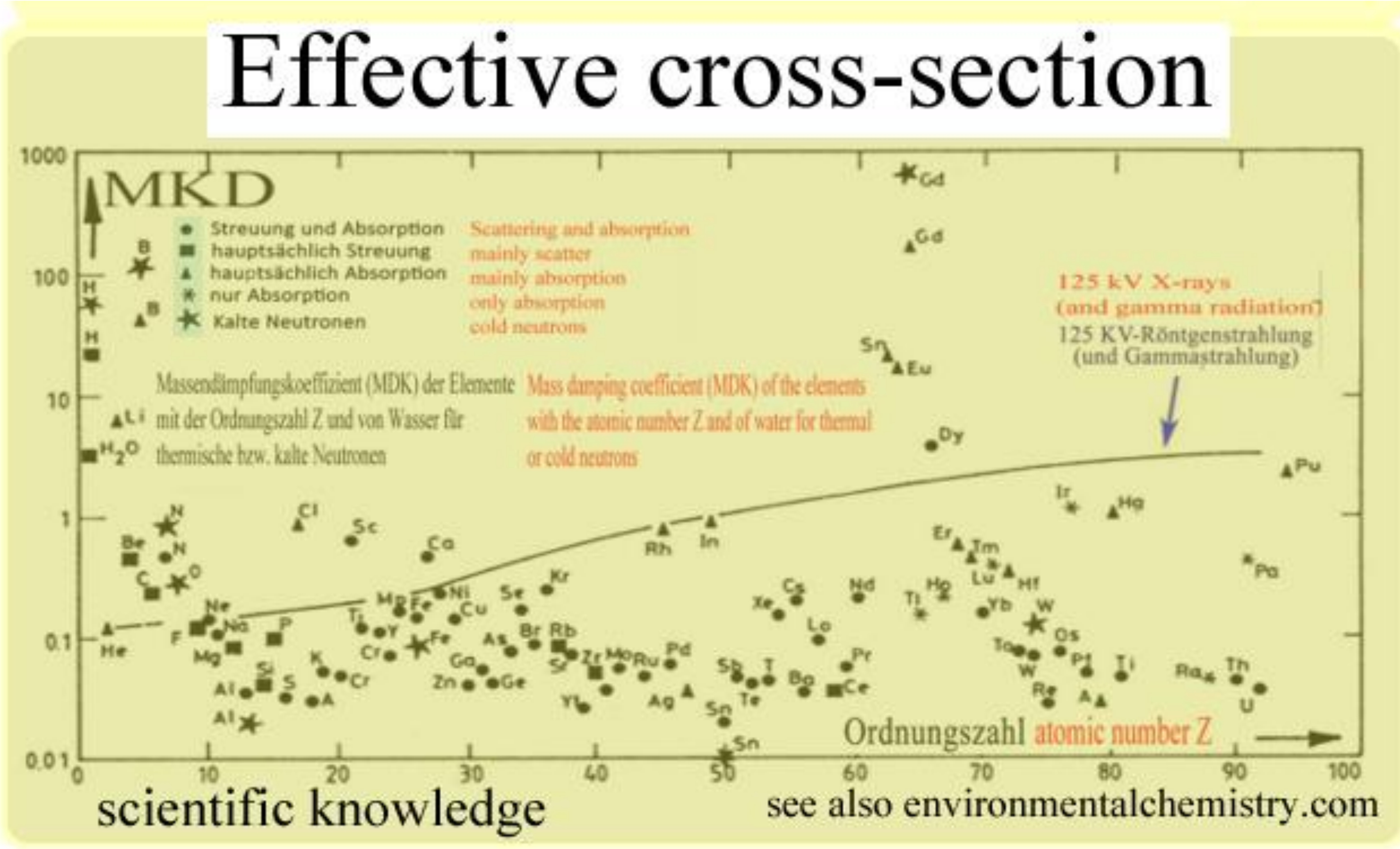
lateral and vertical layering, lateral homogeneity/inhomogeneity (mineral, biotic, water), inclusions, conglomerates, interfaces (porosity, grain boundaries, microcracks, cavities, ... **H content!!!**


min-1 neutron count rate
over water & land
Bieliaeva u. Mitarb. (1999)
(russ. nuclear physicists)
secondary neutron flow
land
water surface
x/distance from shore/m
shore
n Geo
n Geo
geoneutron flow
gradient growth
over water
lake
ocean
pond
running water
lake
n-γ-count rate
Baltic Sea bridge of Bansin
(wooden flooring)
over water
H.-D. Langer
B
moisture gradient
in the sand
dry sand
(constant count rate)
(slowed down count rate)
A
moist sand
shore construction
(linear increase of count rate)
deep water
land
massive
concrete
structure
organic deposits from the surf
border
water/land
measuring distance
in m

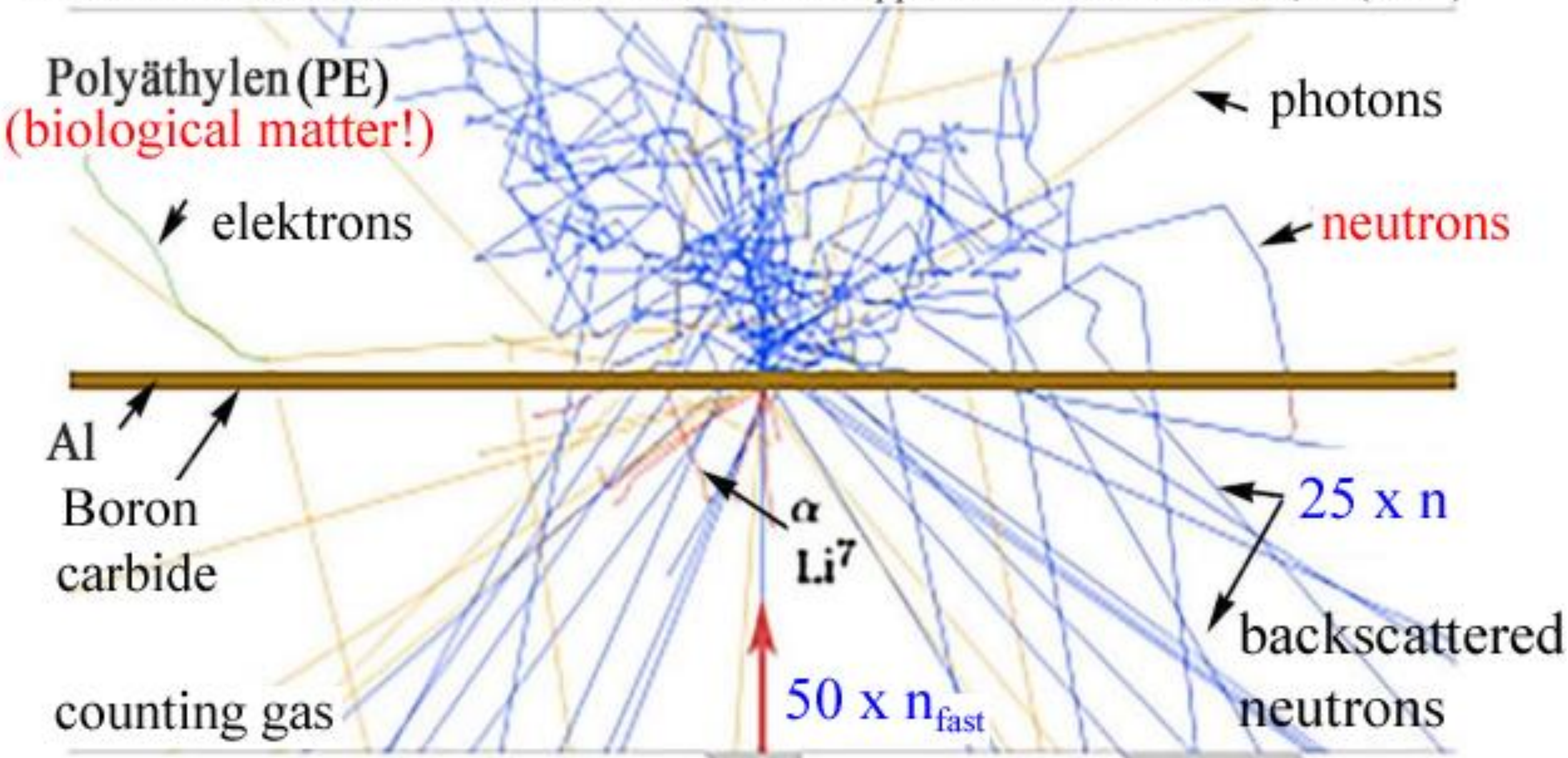


Neutron scattering mean free path in air at sea level as a function of energy according to elastic scattering cross sections for nitrogen and oxygen assuming an atmospheric density of 0.00122 g cm^{-3} and composition of 78% N and 22% O.

Slow neutrons:



Monte Carlo model calculations based on the Born approximation: Kittelmann, T. (2010)

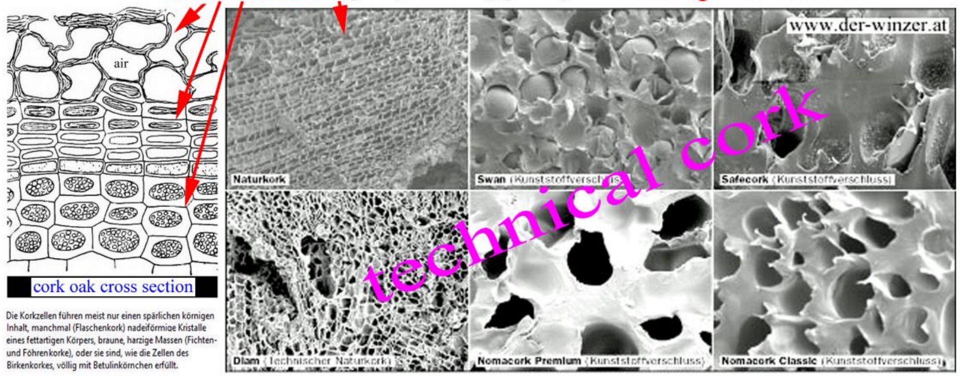


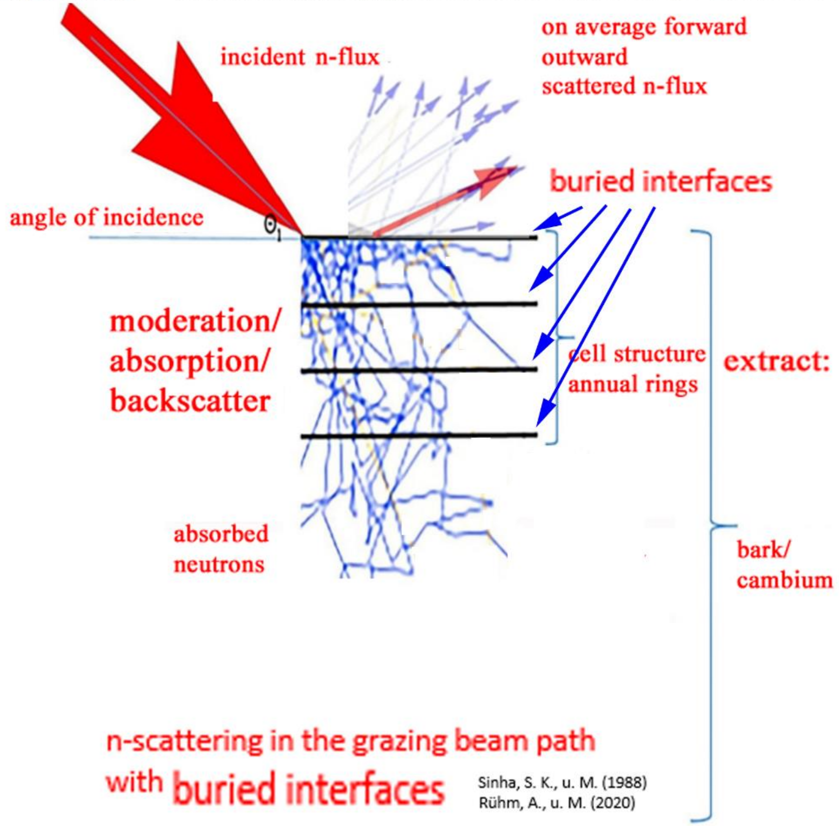
Simulated trajectories of 50 1.8Å neutrons (blue) starting in the center of the bottom edge of the figure (indicated by a red arrow) and travelling upwards through layers of counting gas, 2.5μm of enriched boron-carbide, 0.5mm of aluminium substrate (brown) and finally 10mm of polyethylene. As a result of neutron absorption, secondary particles are released in various locations: photons (orange), electrons (green) and α or Li^7 ions (red).

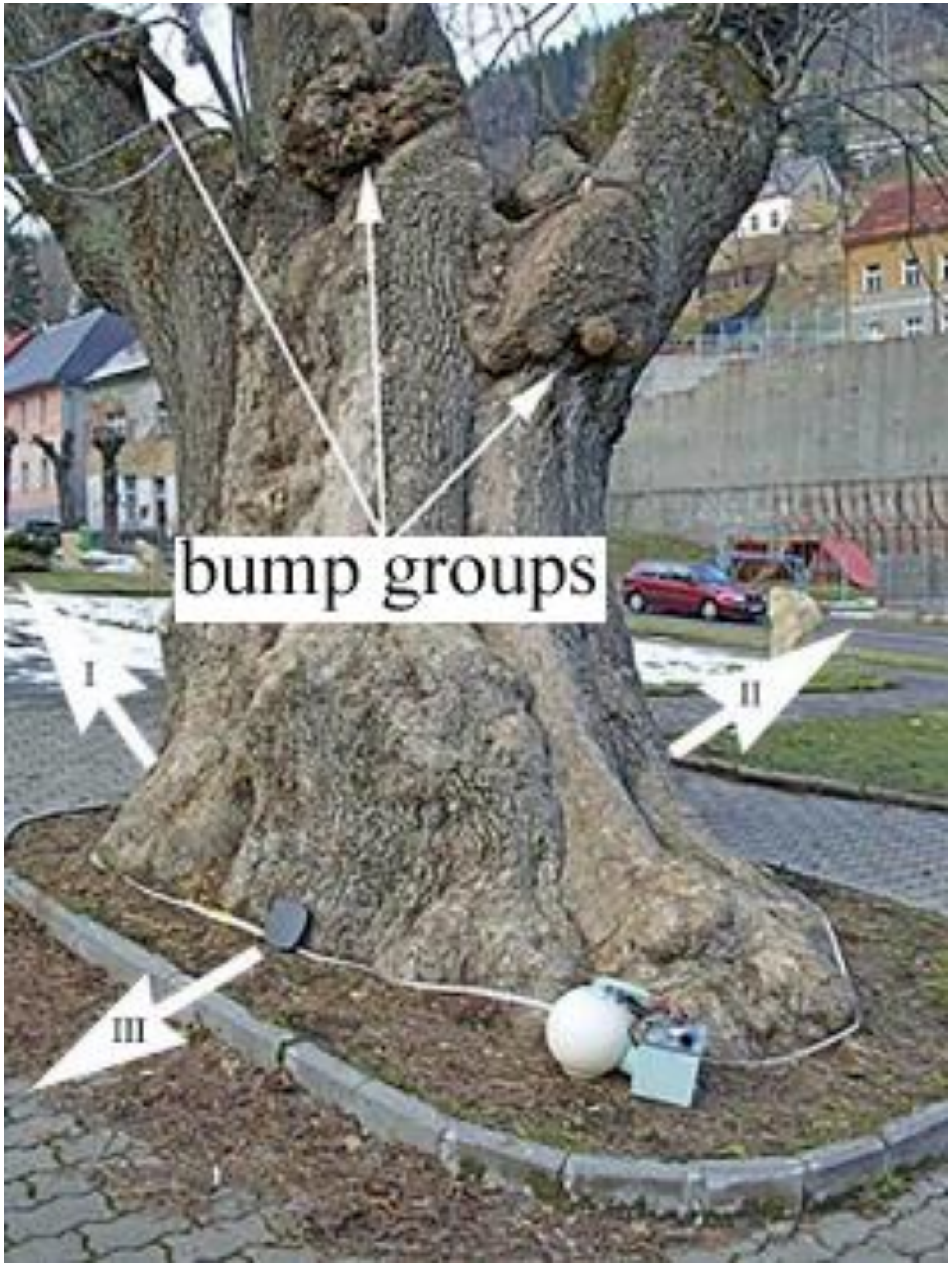
Real strukture of

bark, cork cells, cork oak

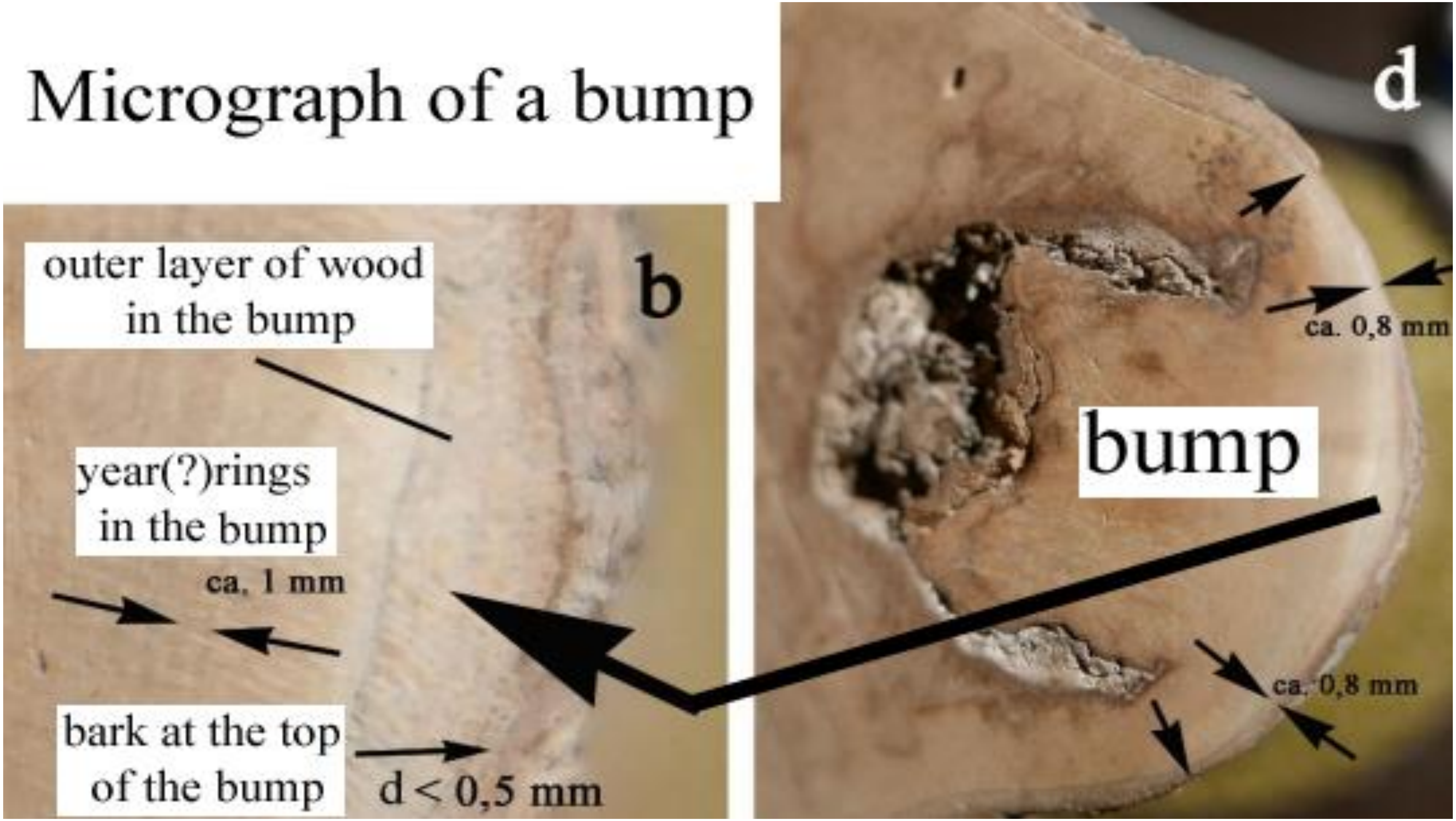
The bark protects the underlaying layers of the tree trunk from physical influences such as heat, frost, snow, rain, wind, sun, fire and mechanical influences and serves as a defense against all kinds of pests, including pathogens. **also against neutrons!!!** Autor



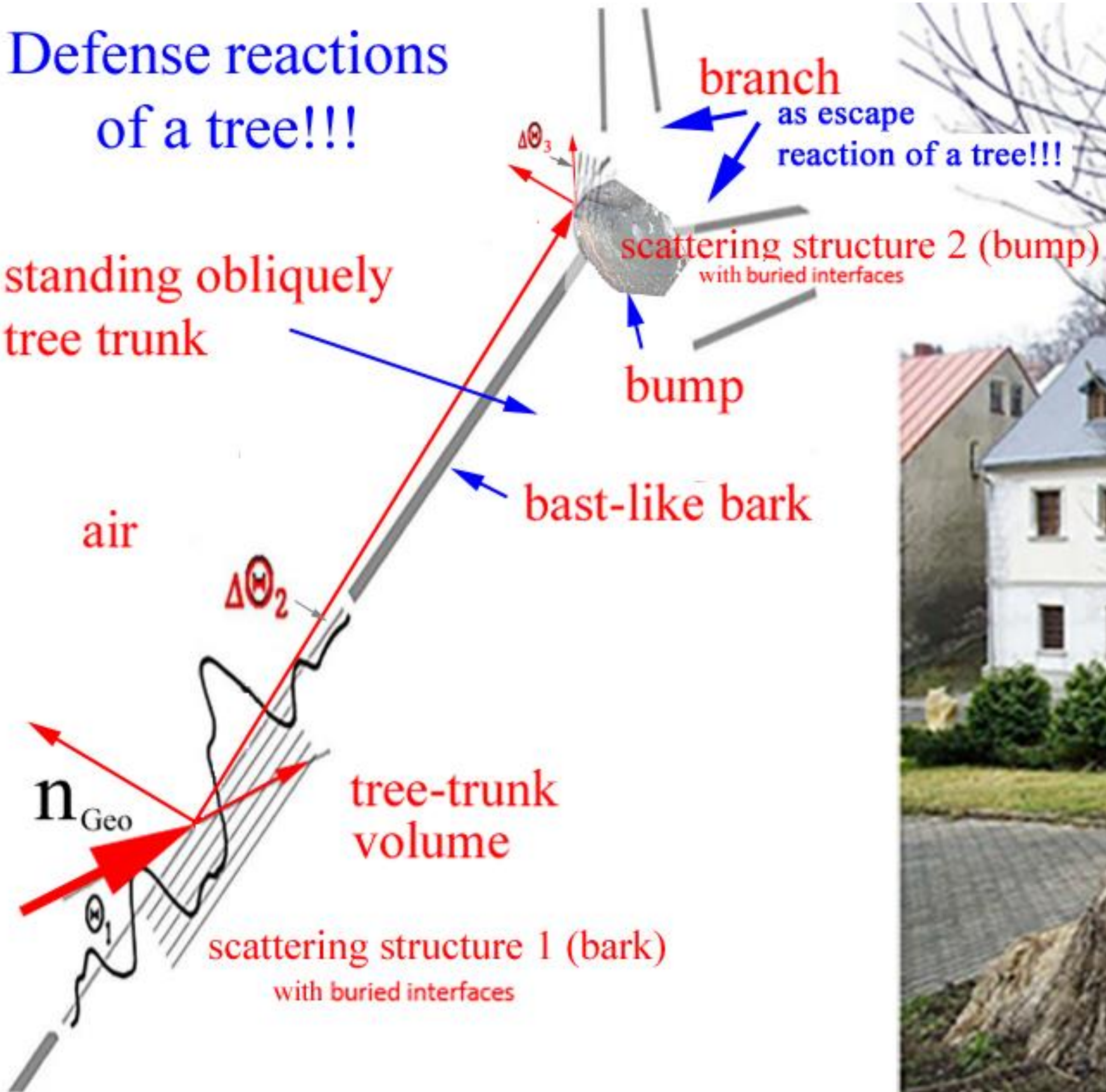


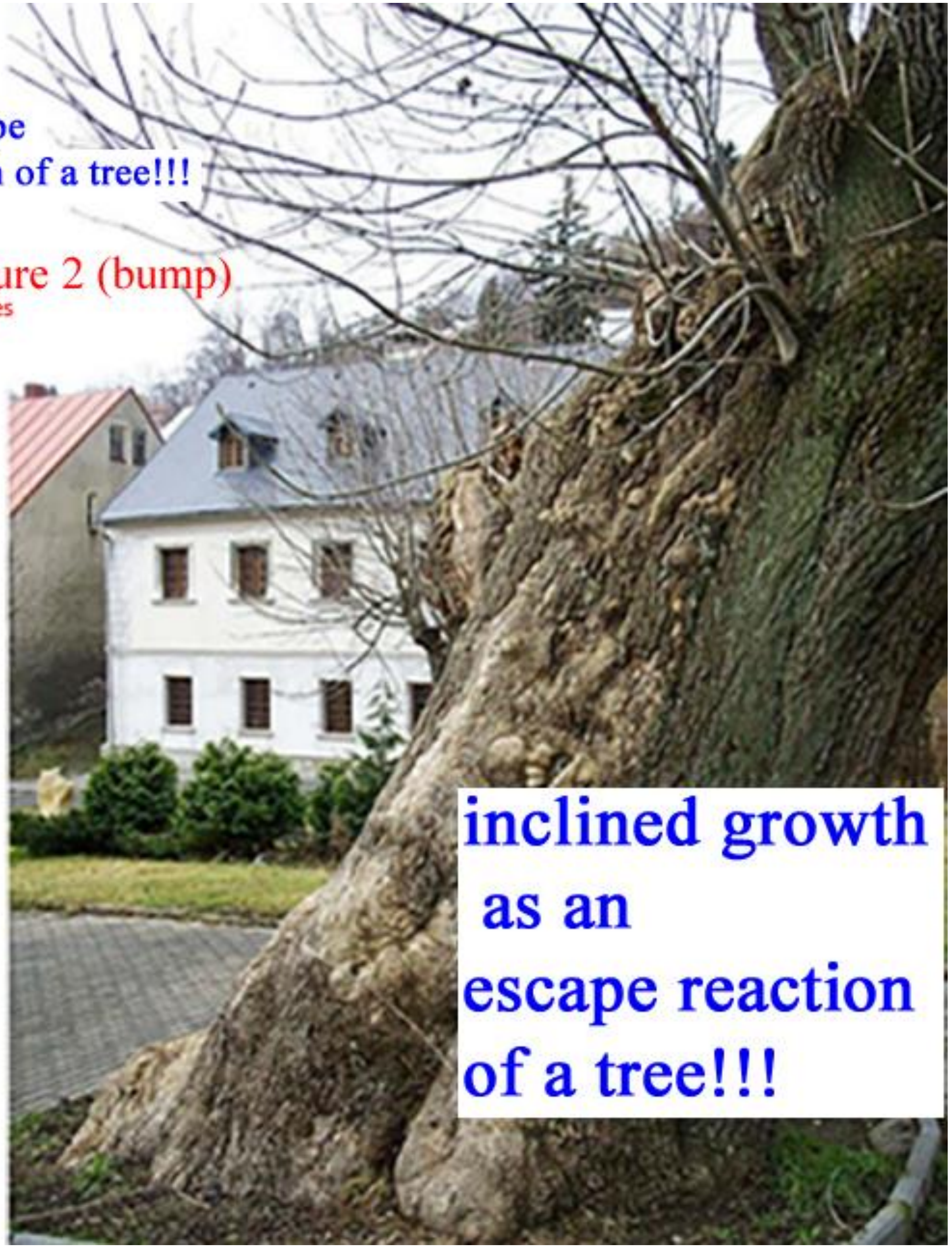

bump groups
I
II
III

Micrograph of a bump

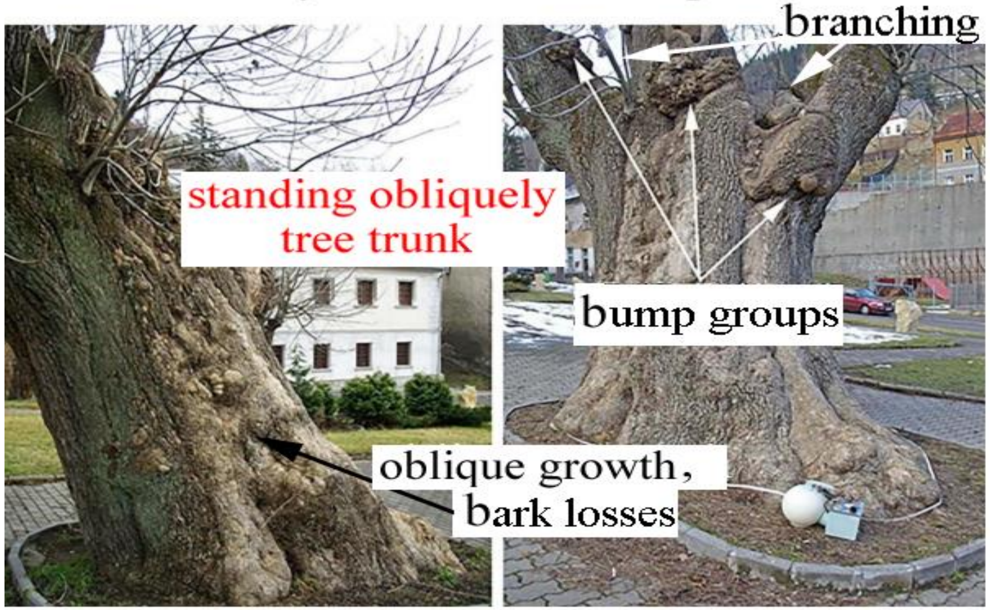


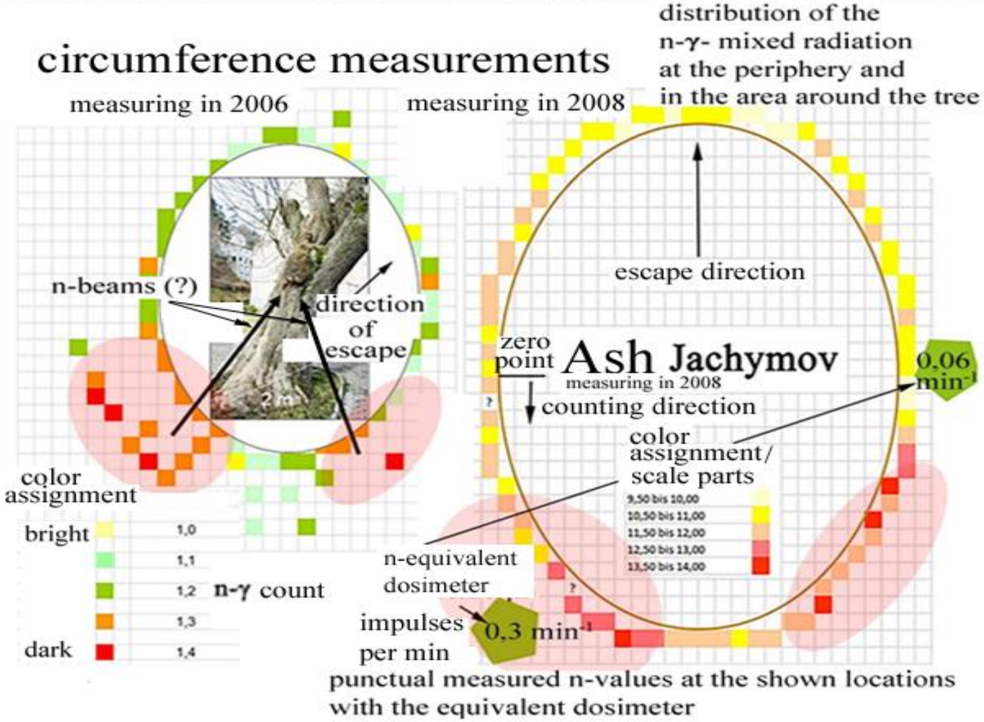
Defense reactions of a tree!!!





Ash in Jachymov/Czech Republic





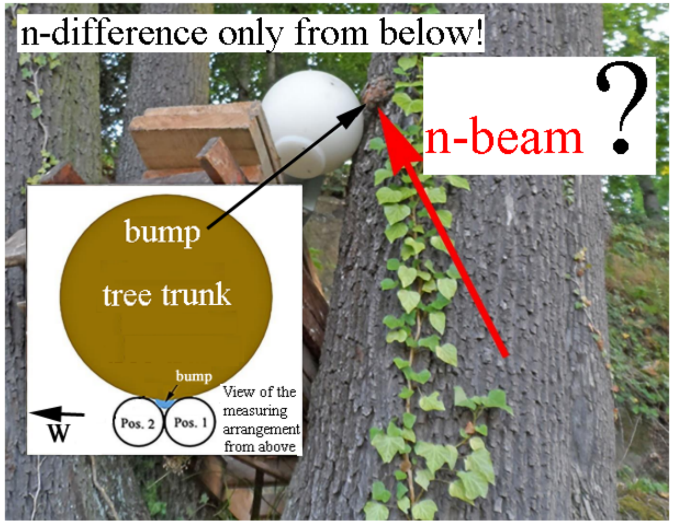
The protected area of the cambium is located behind the bump.

Fresh bumps are always directed downward!

The photo shows a own measuring arrangement to determine the n_{Geo} beam direction on a small bump:

branching effect = **escape reaction** ?

bump = **defensive reaction**

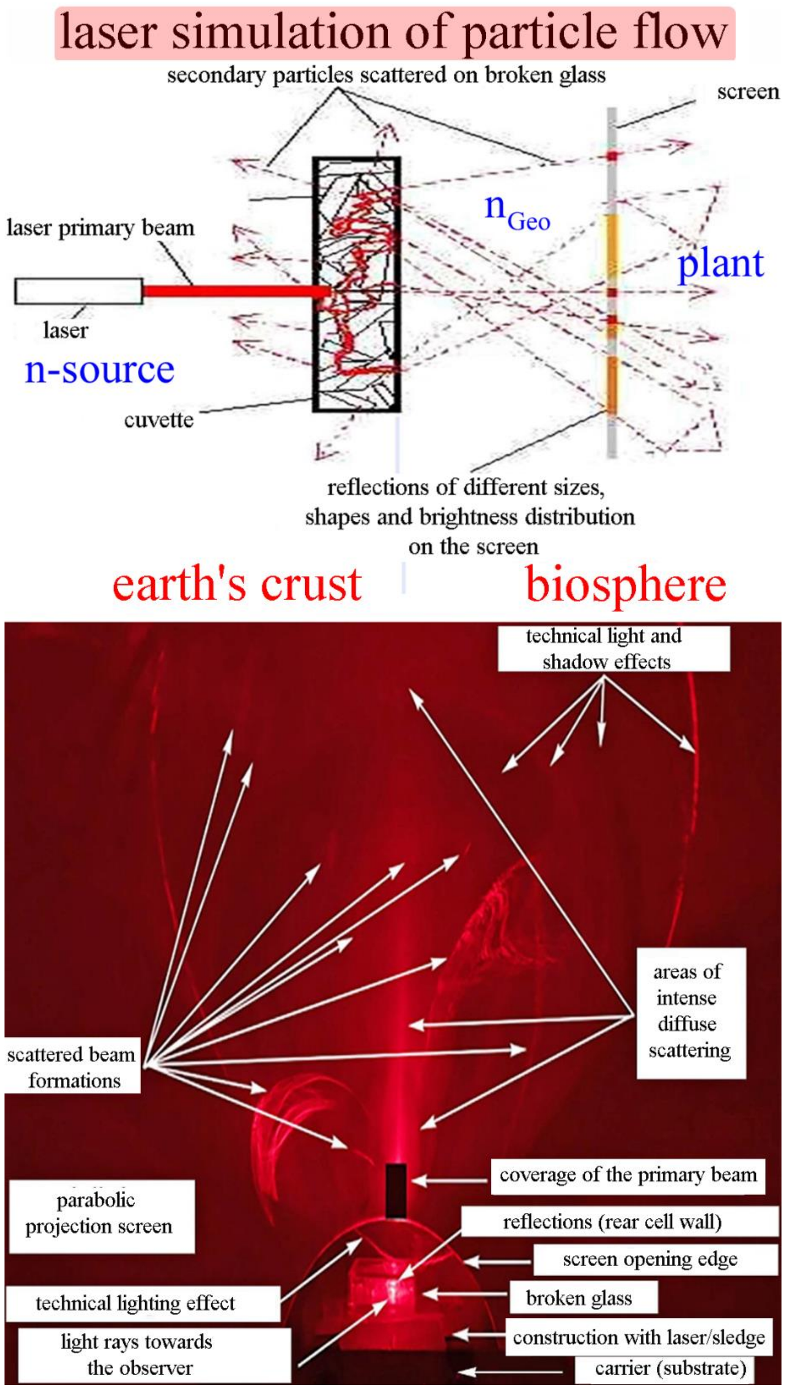


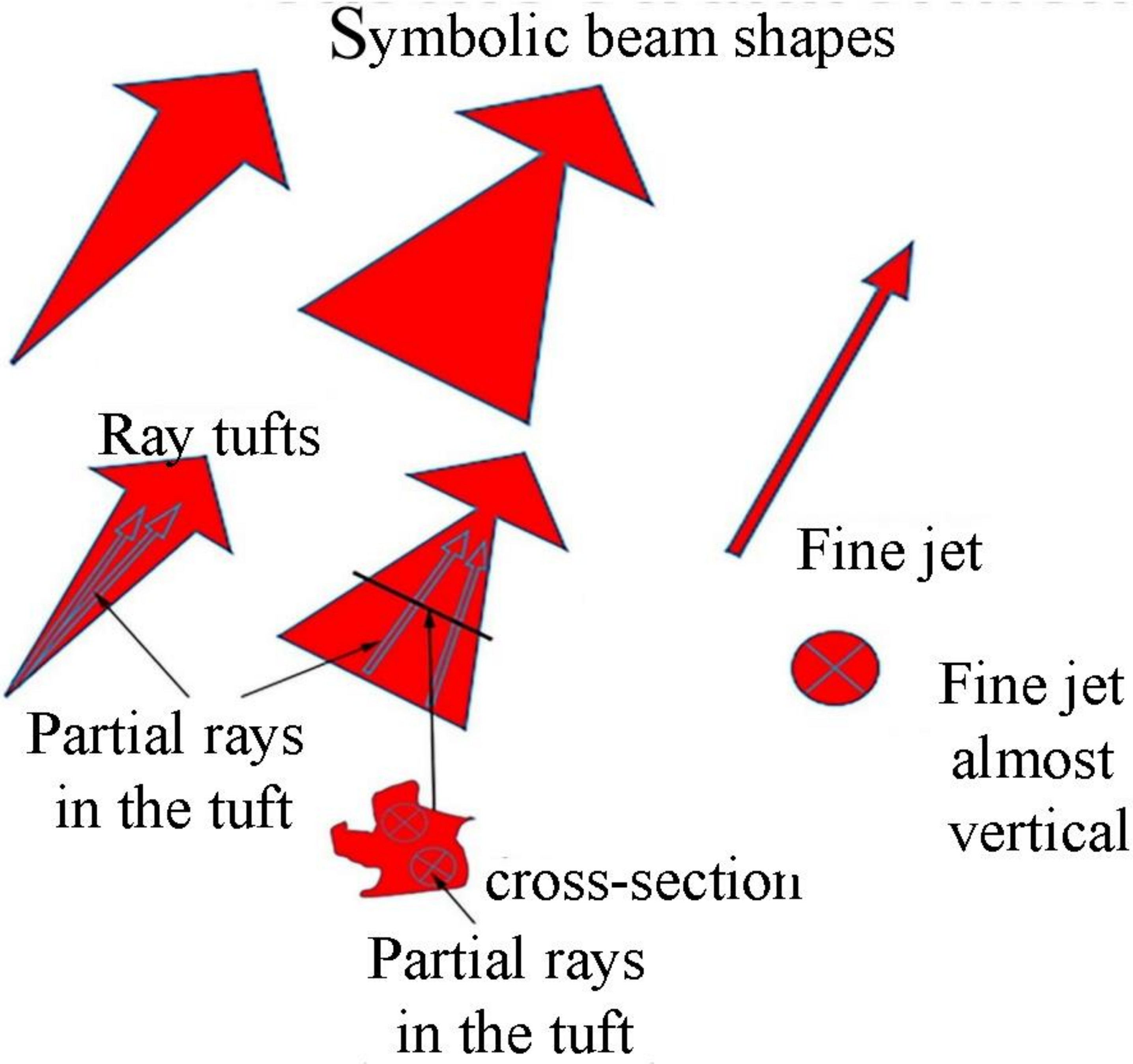
n-flow at the bump measured with the n-sonde

location/ date	Position 2 (West) time	duration /min	n/ number	n-flow /min	Position 1 (Ost) time	duration /min	n/ number	n-flow /min
03.07.2014	17.55-22.00	245	17	0,07				
04.07.2014	5.55-14.00	485	52	0,11				
					14.00-21.10	430	112	0,26
05.07.2014	11.00-14.40	280	13	0,05	14.45-16.45	120	20	0,17
					18.00-21.35	215	15	0,07
06.07.2014					7.15-21.00	825	143	0,17
07.07.2014	6.20-20.30	850	106	0,12				
16.07.2014	7.20-20.10	770	84	0,11				
17.07.2014					8.25-18.05	580	79	0,14
19.07.2014	5.15-10.45	330	92	0,28	15.15-17.30	135	24	0,18
20.07.2014					5.40-22.10	930	212	0,23
23.07.2014	7.45-19.00	630	80	0,13				
01.10.2014	12.10-19.20	430	31	0,07				
03.10.2014					8.50-21.30	760	88	0,12
02.11.2014					14.10-17.50	220	38	0,17
03.11.2014	7.45-16.45	540	59	0,11				
total :		4560	534			4215	731	
n-flow on average				0,12 min^{-1}				0,17 min^{-1}

The different neutron fluxes are crucial, namely 0.12 min-1 (Pos. 2/West) and 0.17 min-1 (Pos. 1/East), which were determined as average values. This difference of more than 40% must be interpreted as a very significant result and as evidence of an actually directed n-radiation from below (bottom right!). Note: Over the years the bump has continued to grow!

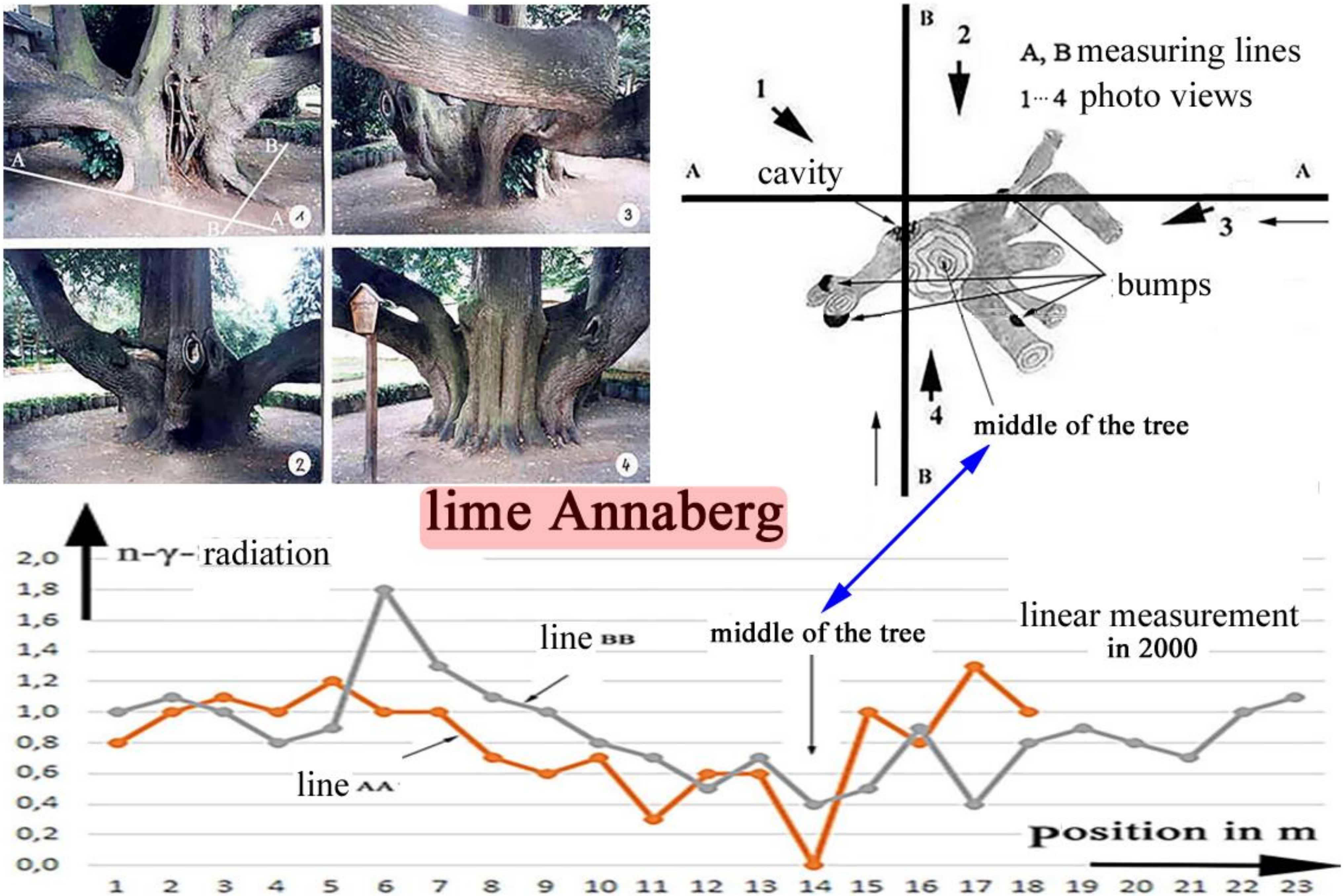
These results of the n measurement on the bump prove the existence of n_{Geo}- rays!


laser simulation of particle flow
secondary particles scattered on broken glass
screen
laser primary beam
n_{Geo}
plant
laser
n-source
cuvette
reflections of different sizes,
shapes and brightness distribution
on the screen
earth's crust
biosphere
technical light and
shadow effects
areas of
intense
diffuse
scattering
scattered beam
formations
coverage of the primary beam
parabolic
projection screen
reflections (rear cell wall)
screen opening edge
technical lighting effect
broken glass
light rays towards
the observer
construction with laser/sledge
carrier (substrate)



Symbolic beam shapes
Ray tufts
Fine jet
Fine jet
almost
vertical
Partial rays
in the tuft
cross-section
Partial rays
in the tuft

We look back in history and notice mysterious changes in tree shapes.



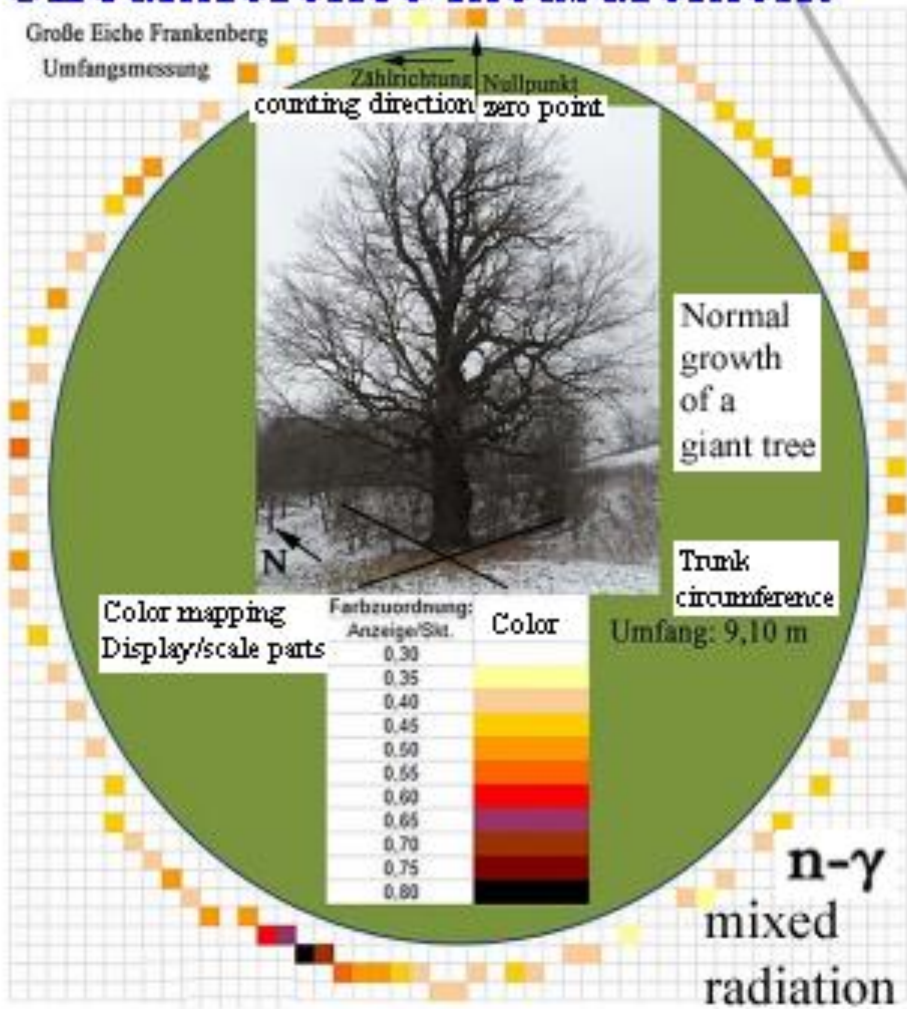
A
B
A, B measuring lines
1 ... 4 photo views
cavity
bumps
middle of the tree
lime Annaberg
n-γ- radiation
line BB
line AA
middle of the tree
linear measurement in 2000
position in m
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

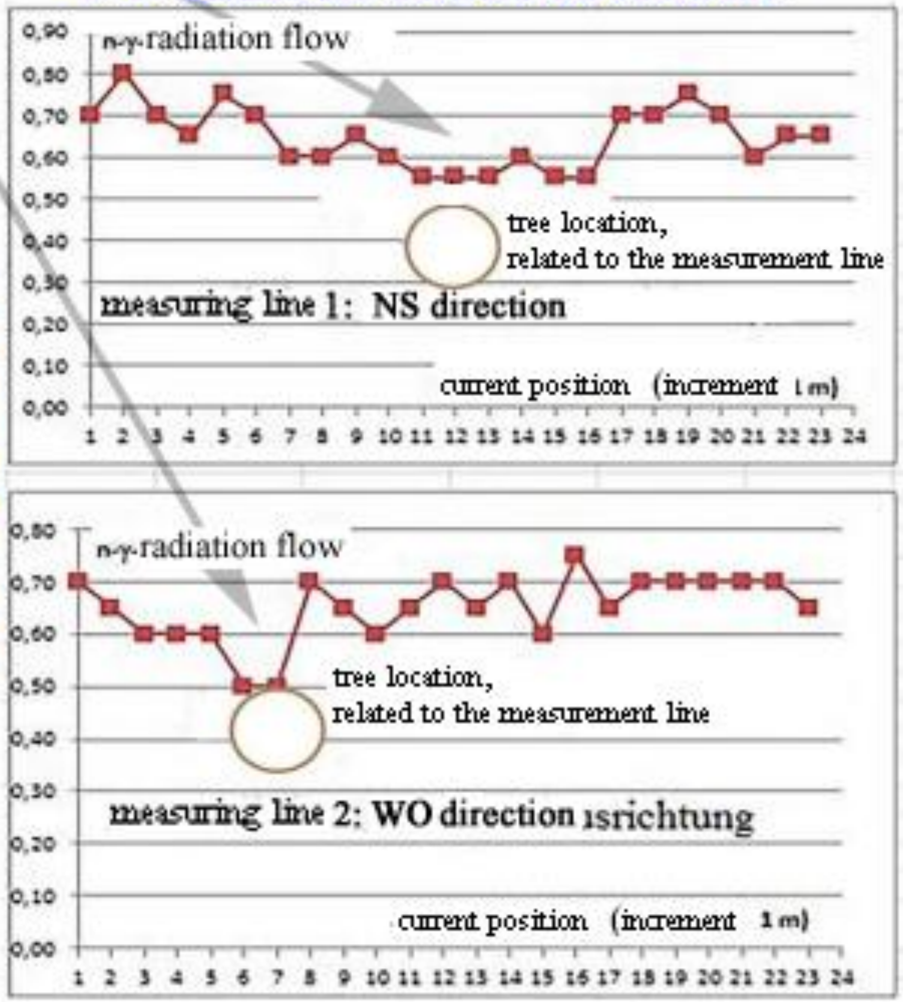
Note the relative n-gamma minima at the elite tree locations.

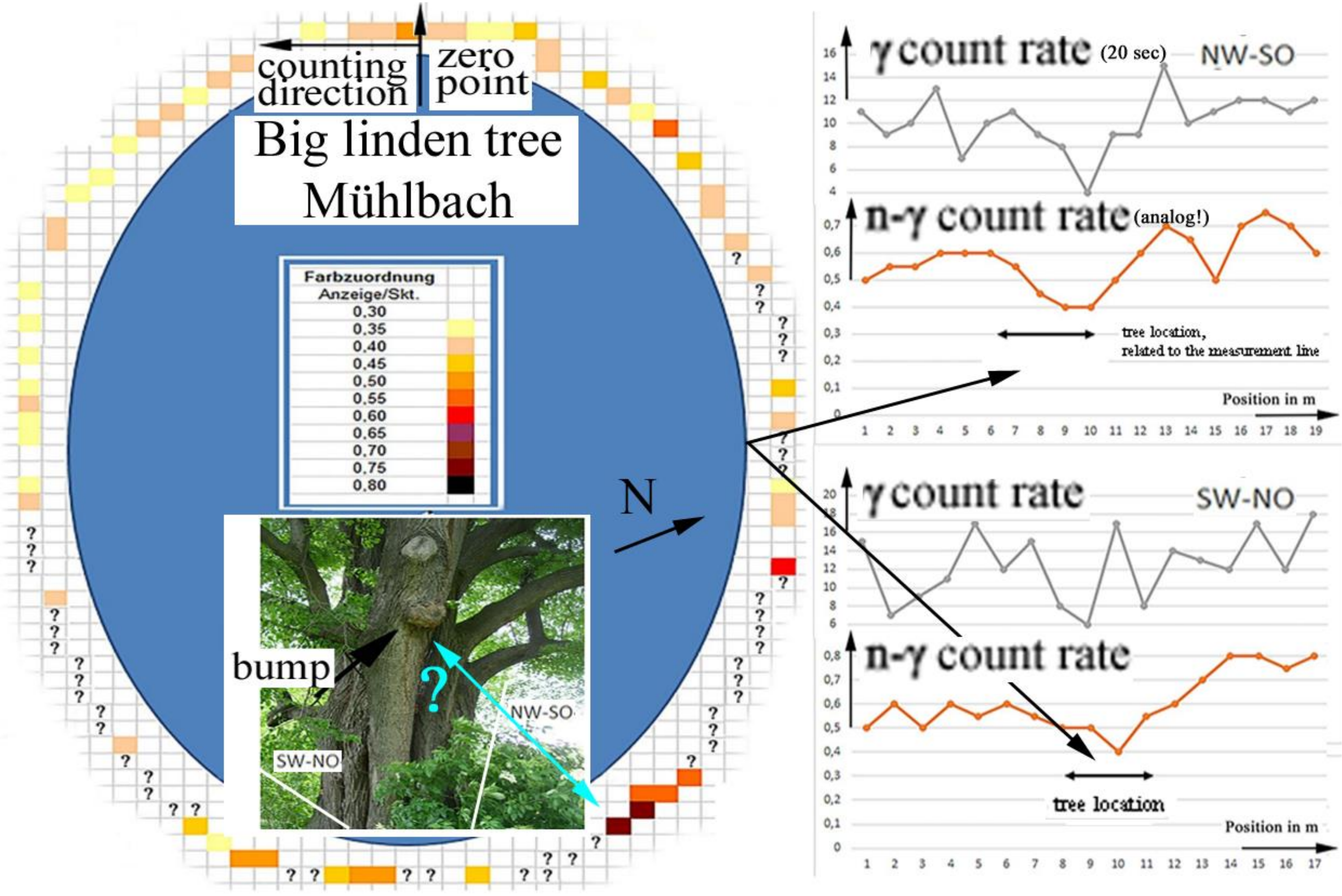
Means low neutron density high growth rate of the tree (elite-effect)?

Large oak tree at Frankenberg

Circumference measurement 90° Linear measurement

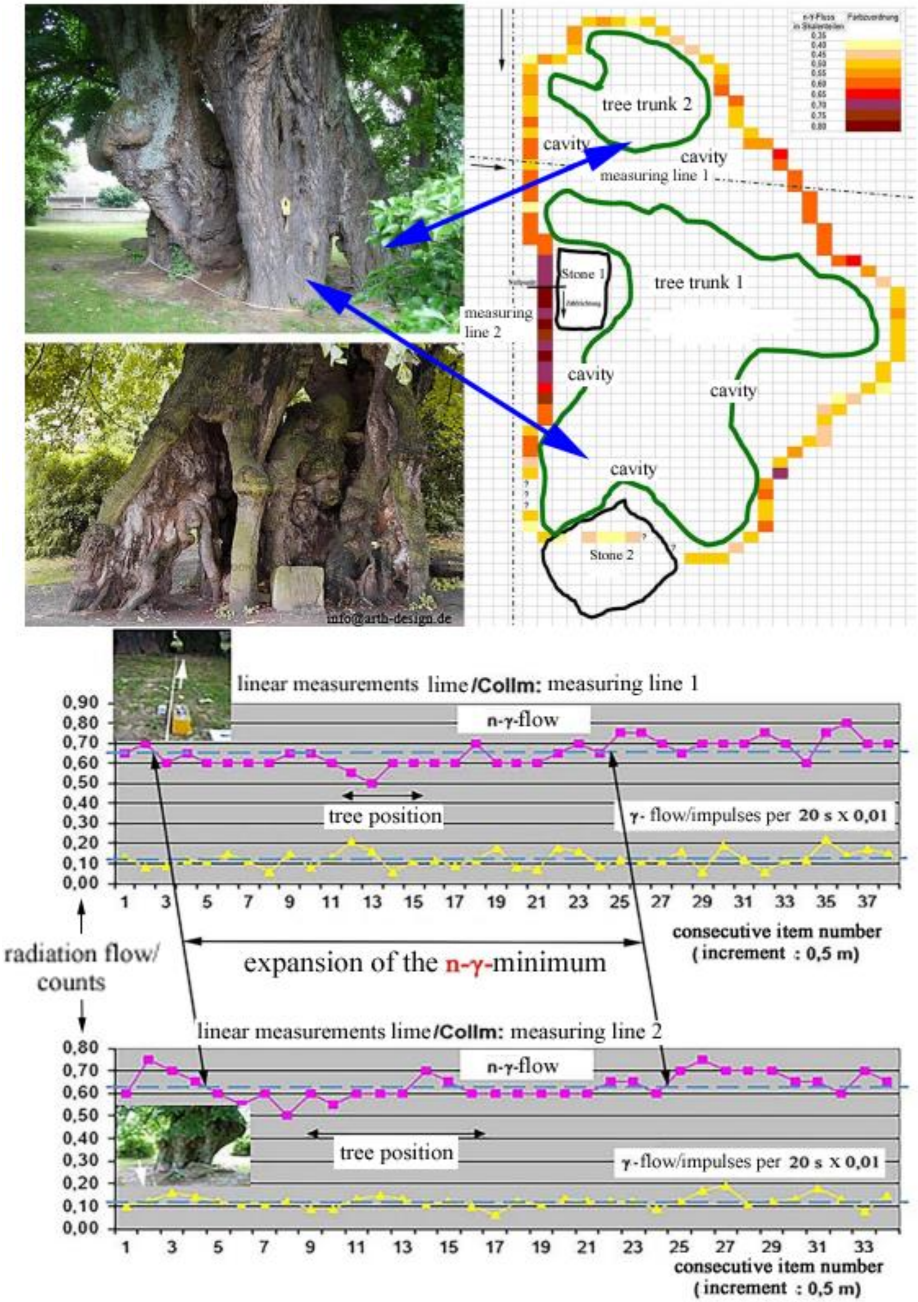




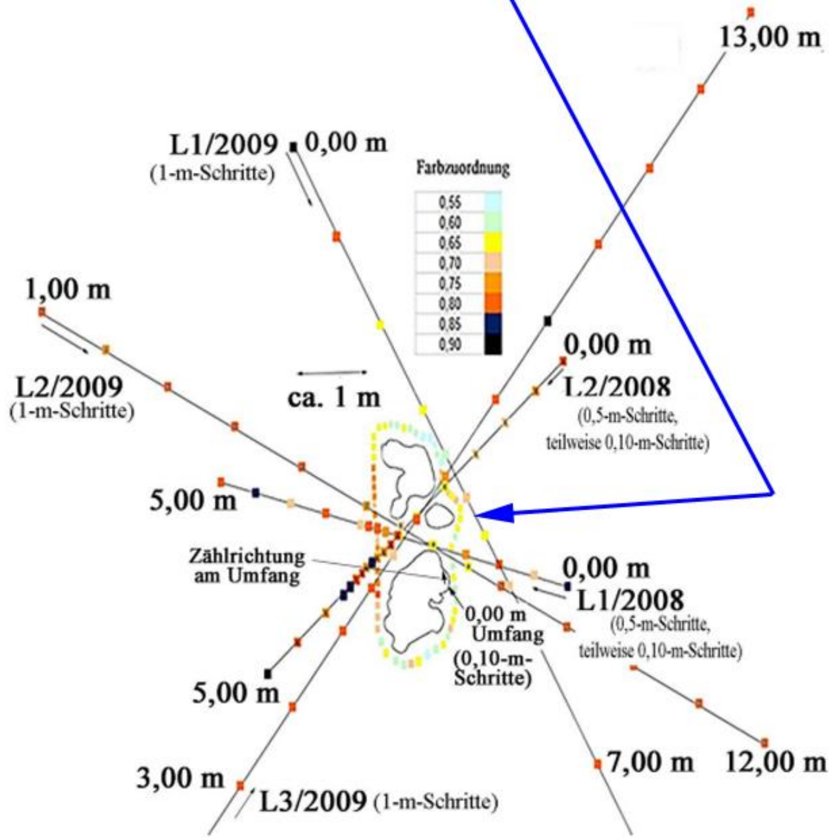


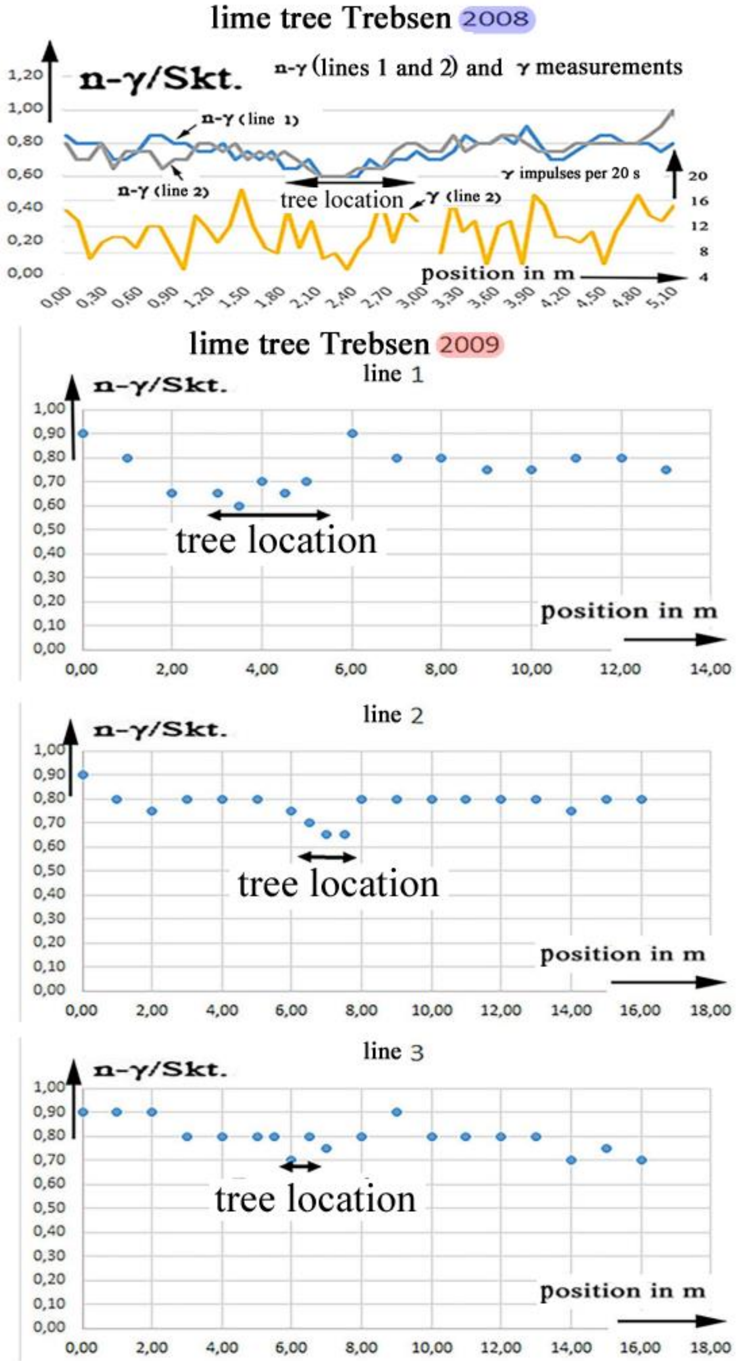
counting direction
zero point
Big linden tree
Mühlbach
Farbzuordnung
Anzeige/Skt.
0,30
0,35
0,40
0,45
0,50
0,55
0,60
0,65
0,70
0,75
0,80
N
bump
?
NW-SO
SW-NO
γ count rate (20 sec)
NW-SO
n-γ count rate (analog!)
tree location,
related to the measurement line
Position in m
γ count rate
SW-NO
n-γ count rate
tree location
Position in m

Cemetery linden tree to Collm



Cemetery linden tree at Trebsen





Conclusions/Tree giants (elite trees):

* The location (with multiple growth - annual rings! - amplification) correlates with a relative radiation minimum.

* In the vicinity of high radiation fluxes (neutron beams!) abnormal formations can be found.

* Giant trees (elite trees!) often develop a variety of abnormal shapes.

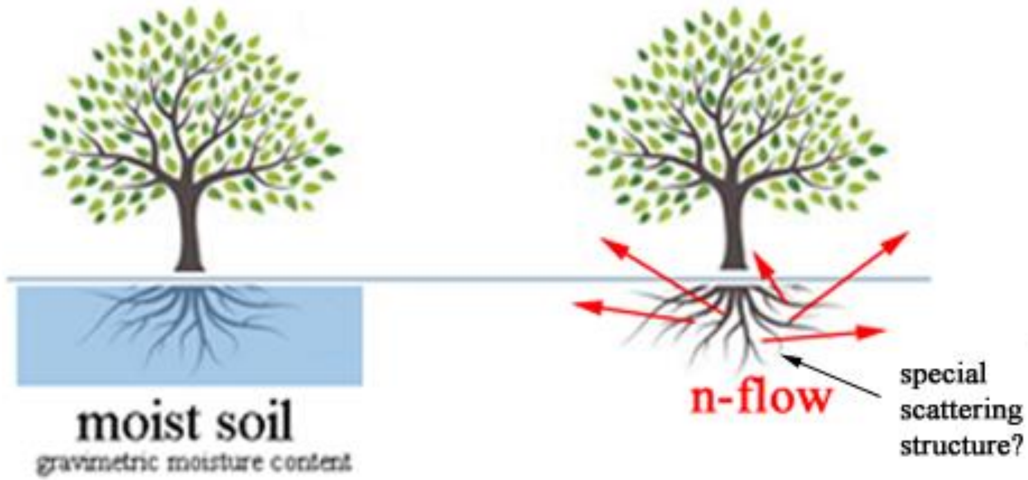
* Elite trees are comparatively much younger due to the extremely large annual growth.

Working hypothesis
elite effekt:

The reason for the increase of the growth strenght may be the lower radiation exposure at the minimum location.

Instead of focusing on molecular repair processes, the tree can concentrate its material and energy resources more on growth.

Models of minimum formation



The trees react with
flight, defense and doom reactions –

Neutronotropy.