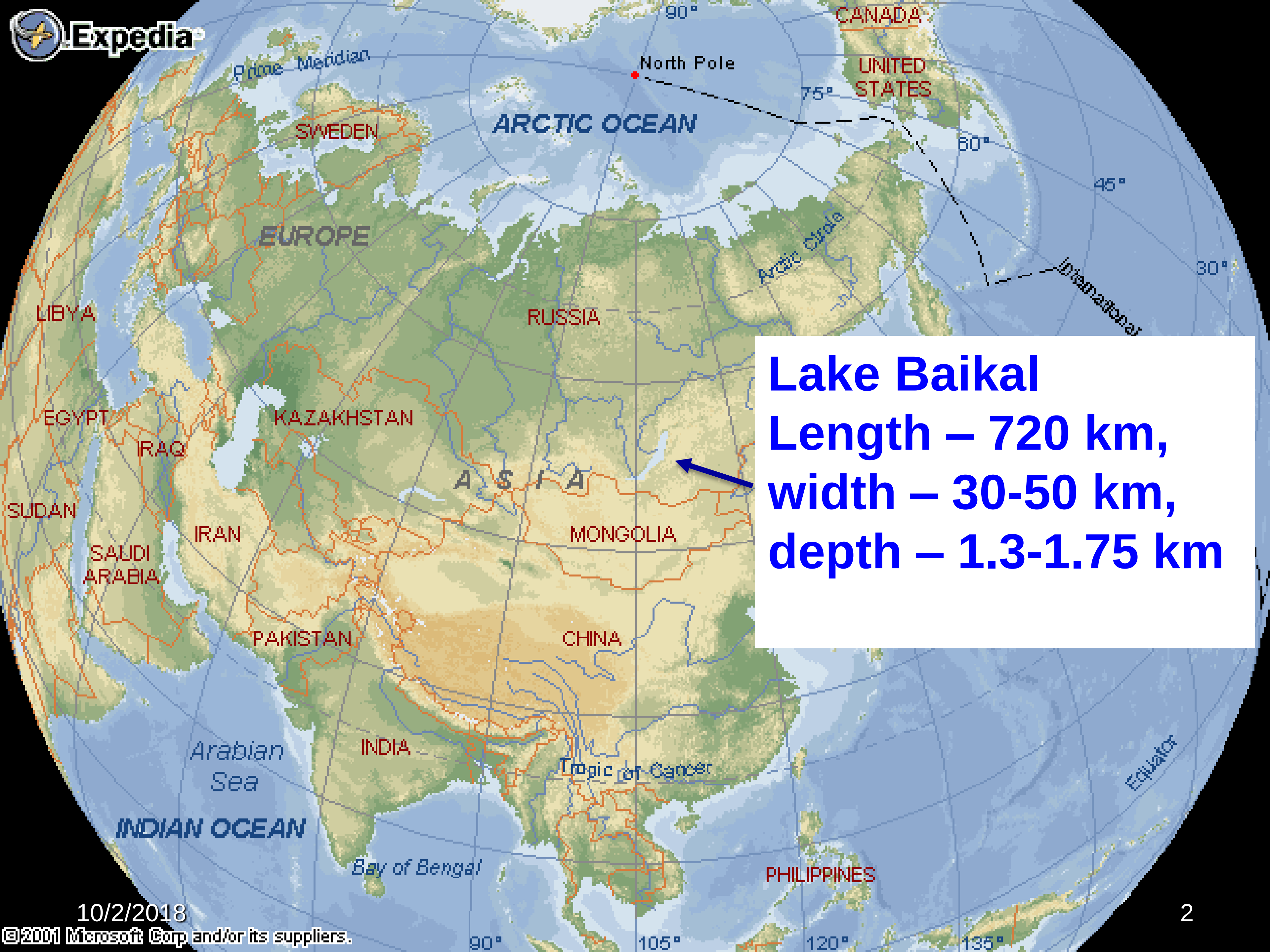
Environmental studies in Lake Baikal - basic facts and perspectives for interdisciplinary research.

N. Budnev, Irkutsk State University.



Lake Baikal
Length – 720 km,
width – 30-50 km,
depth – 1.3-1.75 km

Length – 720 km,

Width – 30-50 km

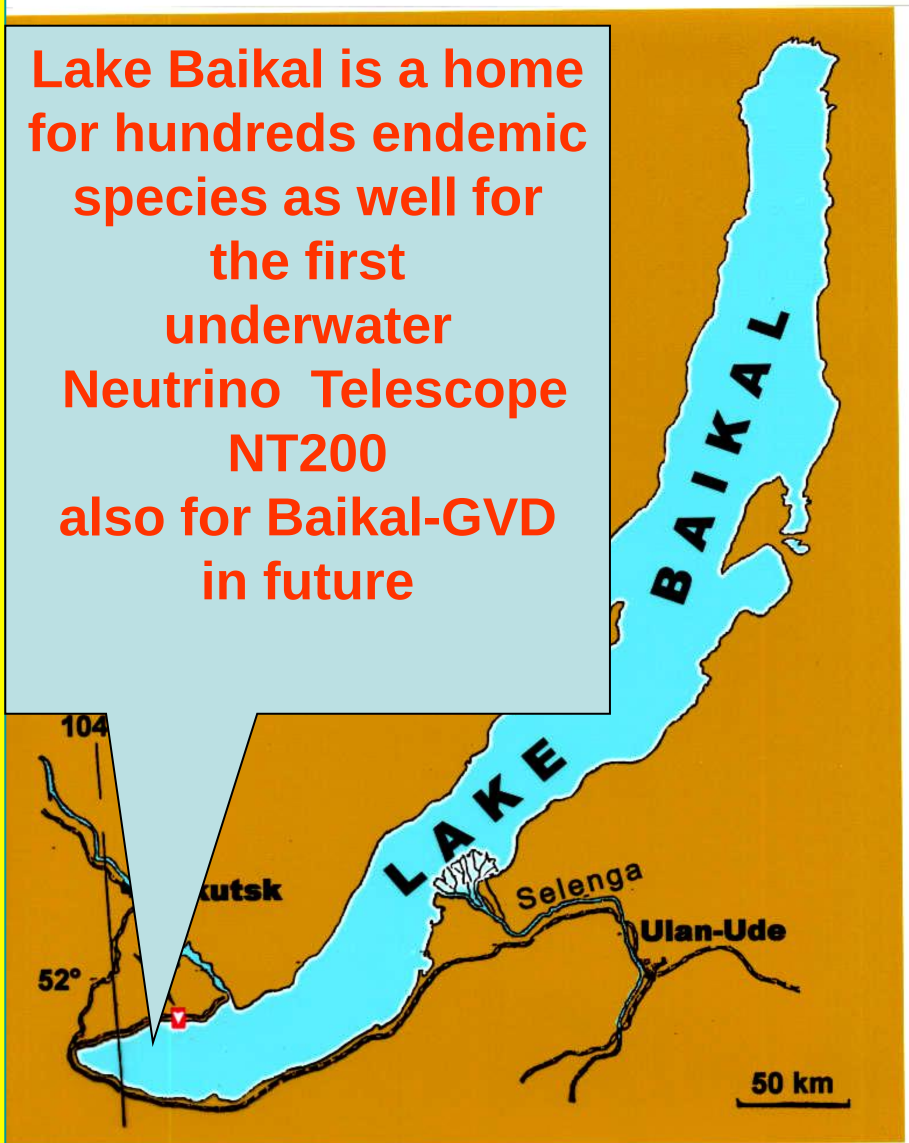
Maximum depth-
1750 m

Volume –23000 km^3

Age - 20 – 60
million year

20% of fresh water
(50% of drinking
water)
of whole world

The water body
of the lake is
fully oxygenated



Lake Baikal is a home for hundreds endemic species as well for the first underwater Neutrino Telescope NT200 also for Baikal-GVD in future

Why Baikal water is so clean?
Why conditions for life also for Cherenkov Neutrino detectors are so good?

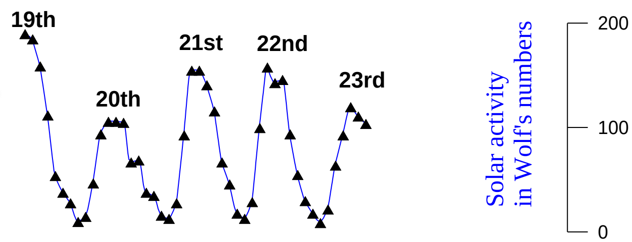
The early investigators of Lake Baikal were exiled Poles (since 1862y)

B.Dybovsky
(1835 - 1930)

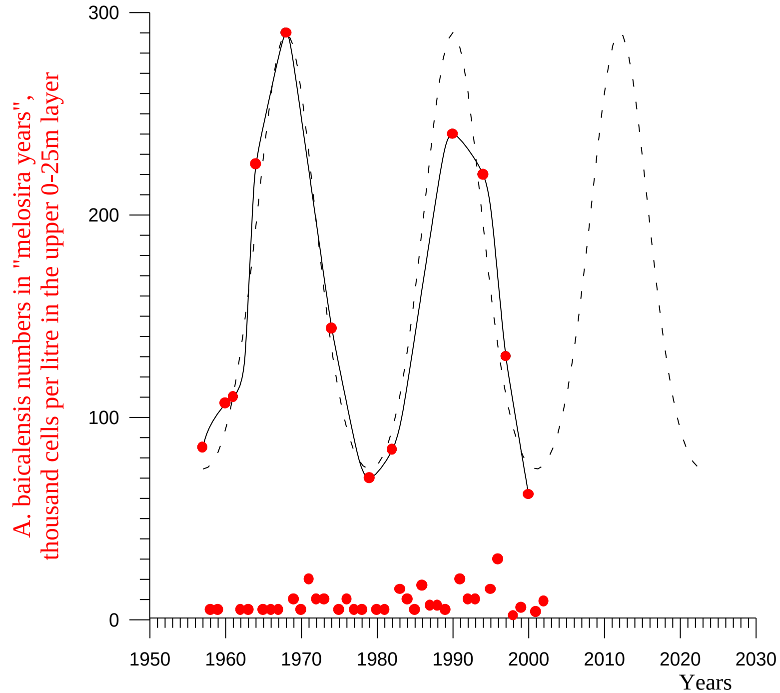
V.Godlevsky
(1831-1900)

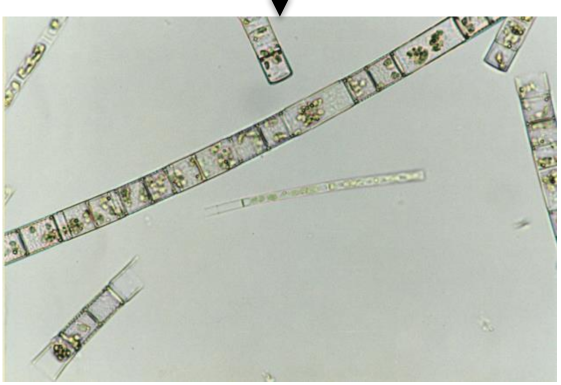
Productivity of the Baikal endemic aquatic plant- *Aulacoseira baicalensis* is in strong correlation with even solar cycles, why???

Solar activity



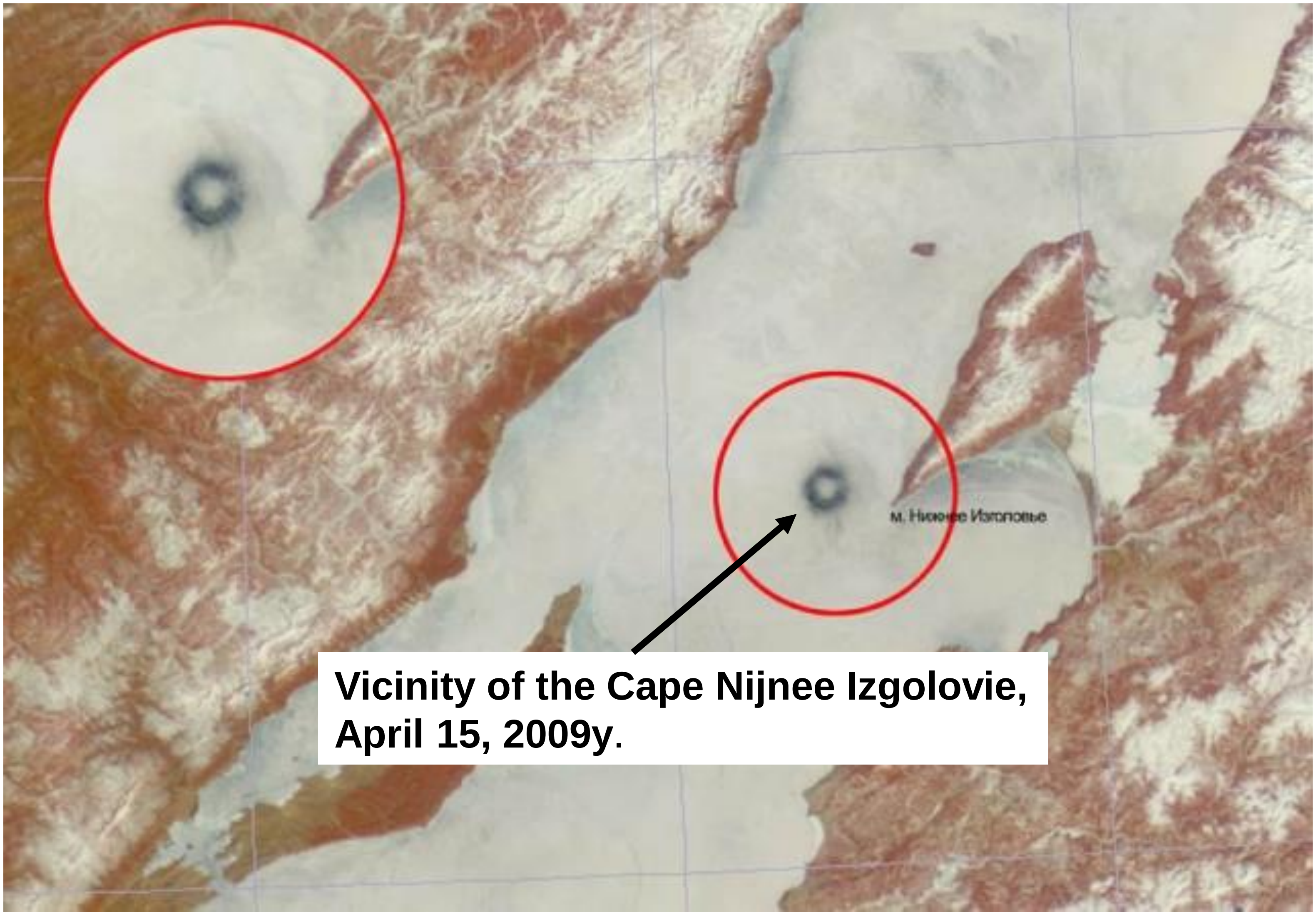
Productivity of *Aulacoseira baicalensis*





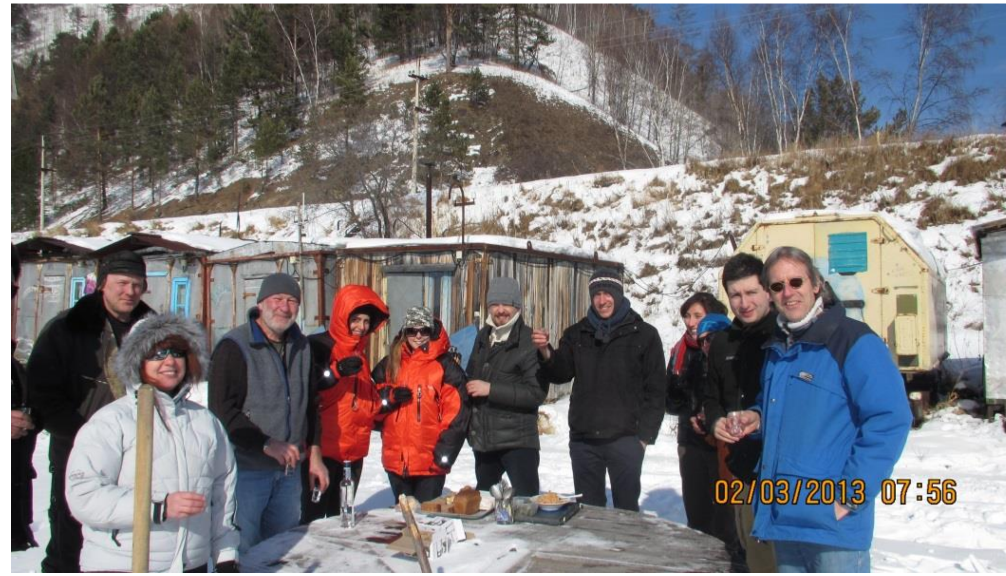
What are the reasons for so large variability **(hundreds times!!!)** of *Aulacoseira baicalensis* productivity?

A ring on the ice



Vicinity of the Cape Nijnee Izgolovie, April 15, 2009y.

The Baikal Neutrino project opened new possibilities for interdisciplinary site studies.



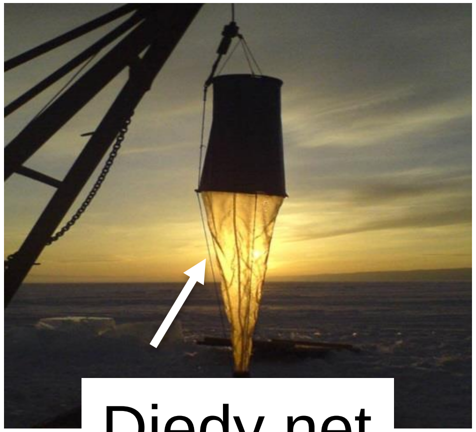
Strong ice cover during ~2 months

Very convenient platform for:

- installation of moorings with different scientific equipment including a neutrino telescope optical detectors and data loggers forinterdisciplinary researches;

- deployment of cable lines for power supply and data acquisition;

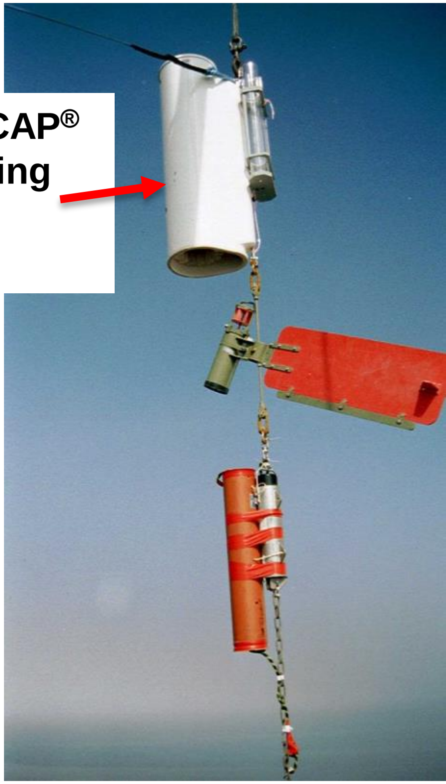
- *Shore cable deployment*



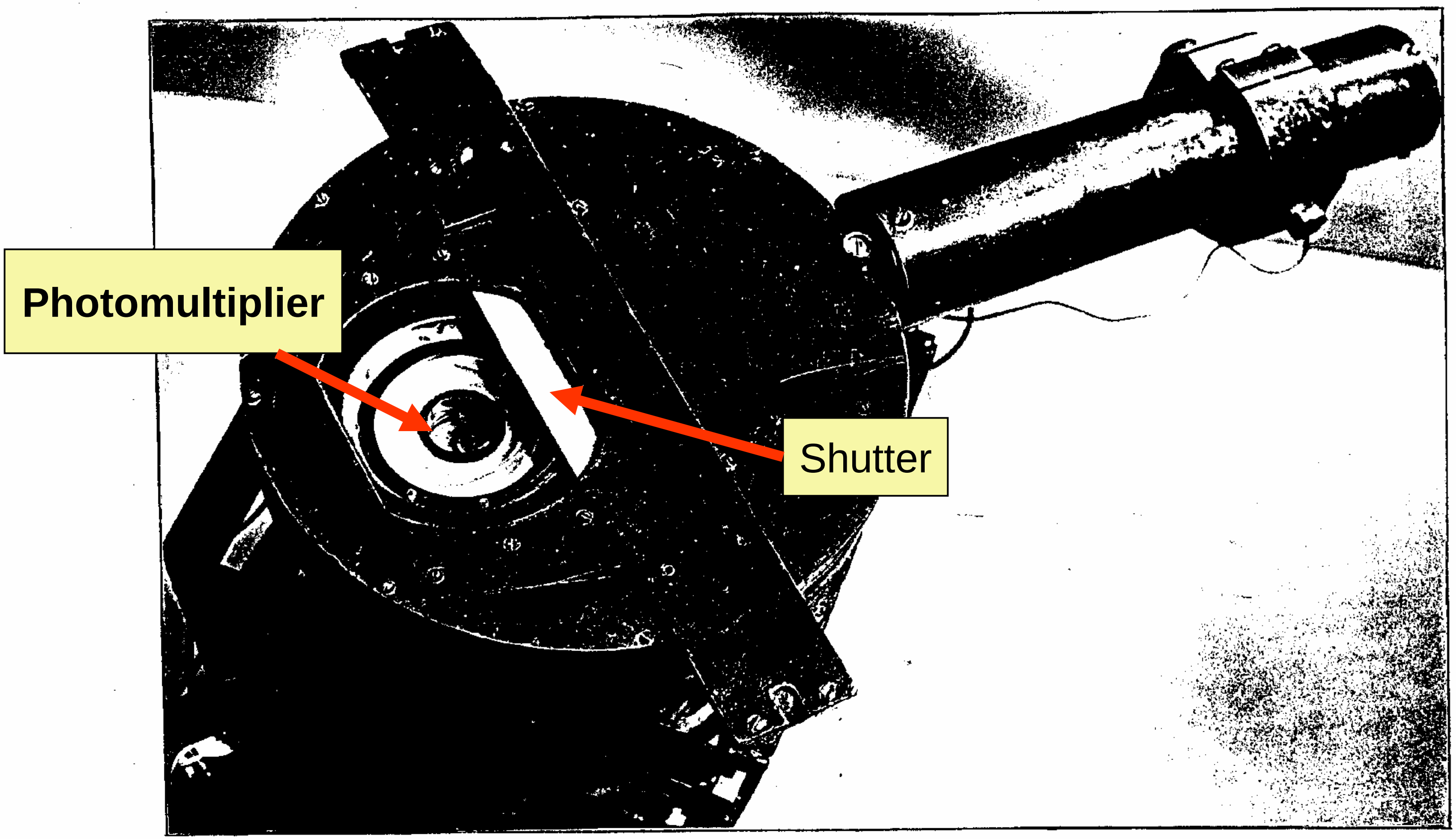
Djedy net

Dry mating

TECHNICAP® **sequencing trap**
(12 cups)



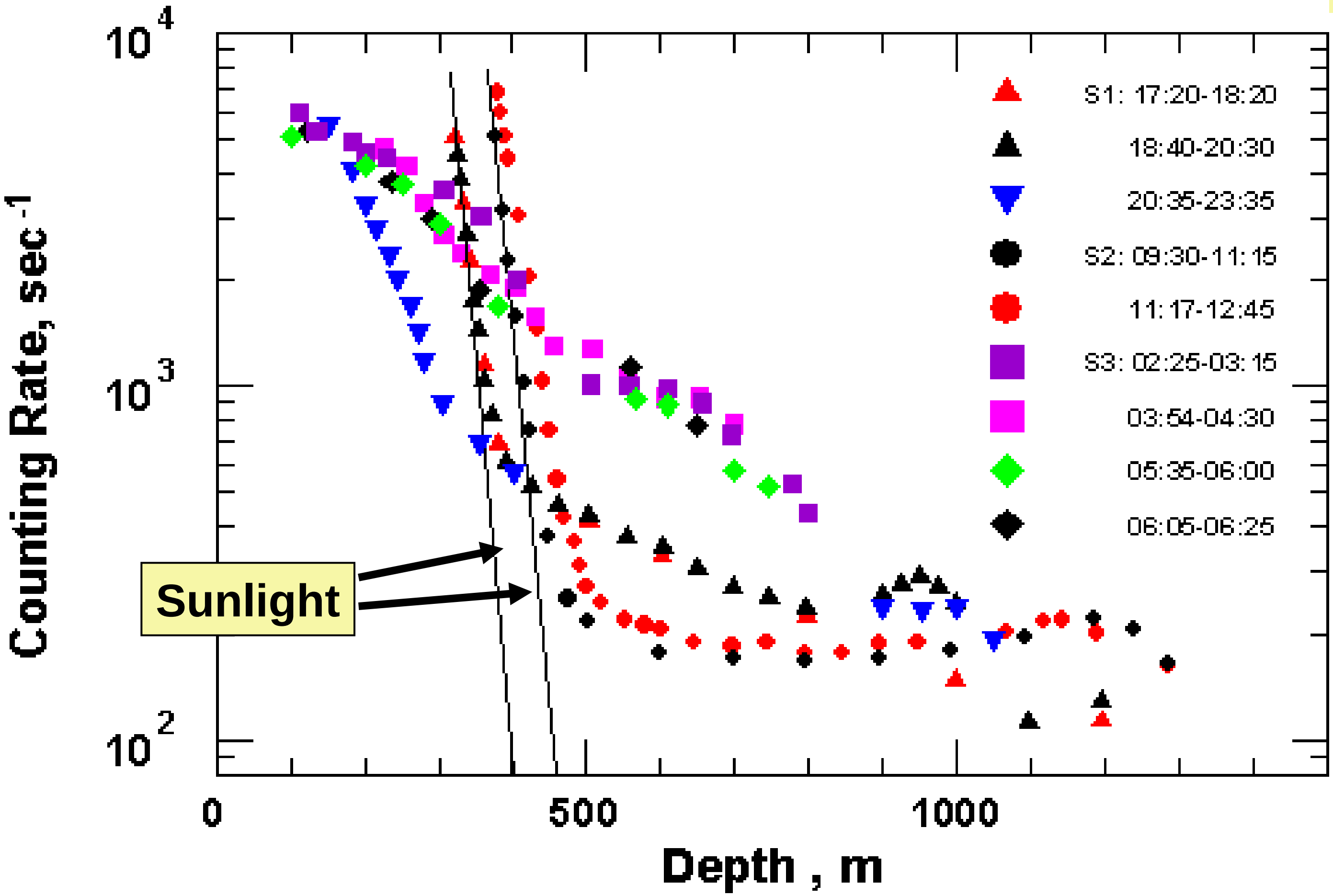
The Baikal water luminescence



A deep underwater photometer (1982y)

A sensitivity - E ~ 10 photon cm^{-2} sec^{-1}

Counting rate of the photometer versus depth in the Southern Basin of Lake Baikal.

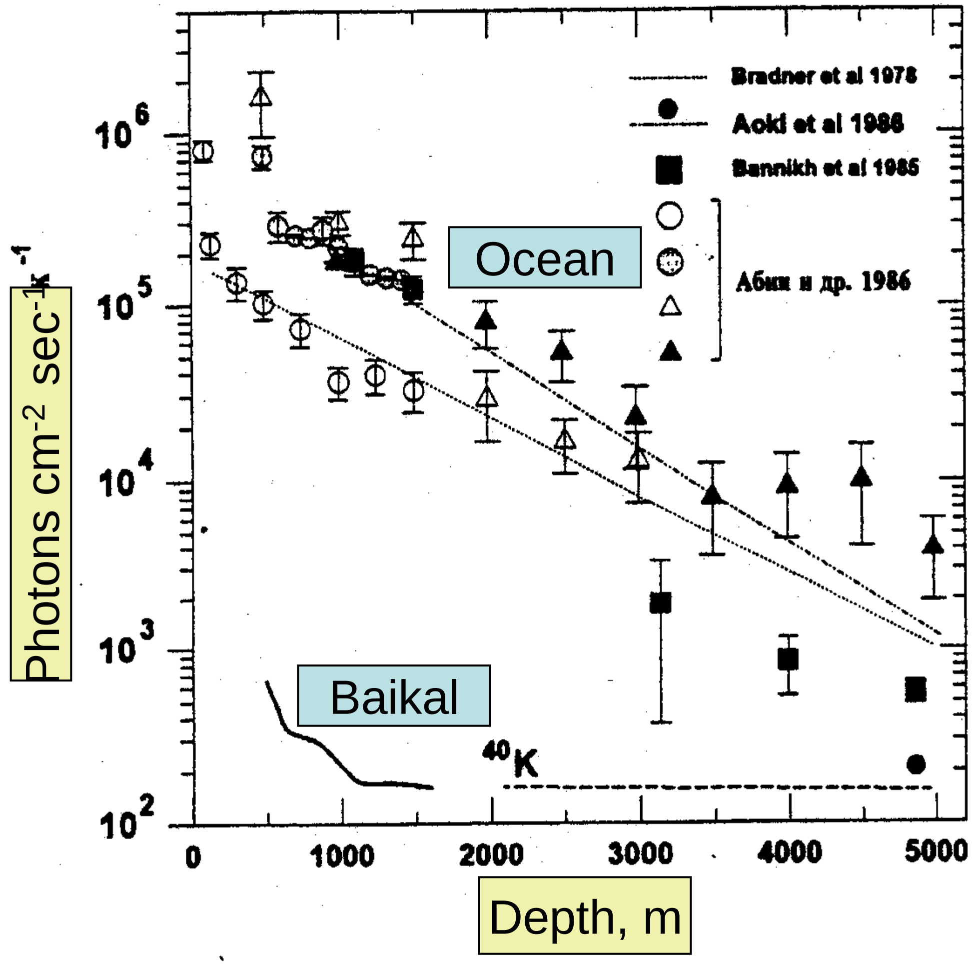


A light flux E(photon cm^{-2} sec^{-1}) = (3.5+/- 1) (N – N_t)

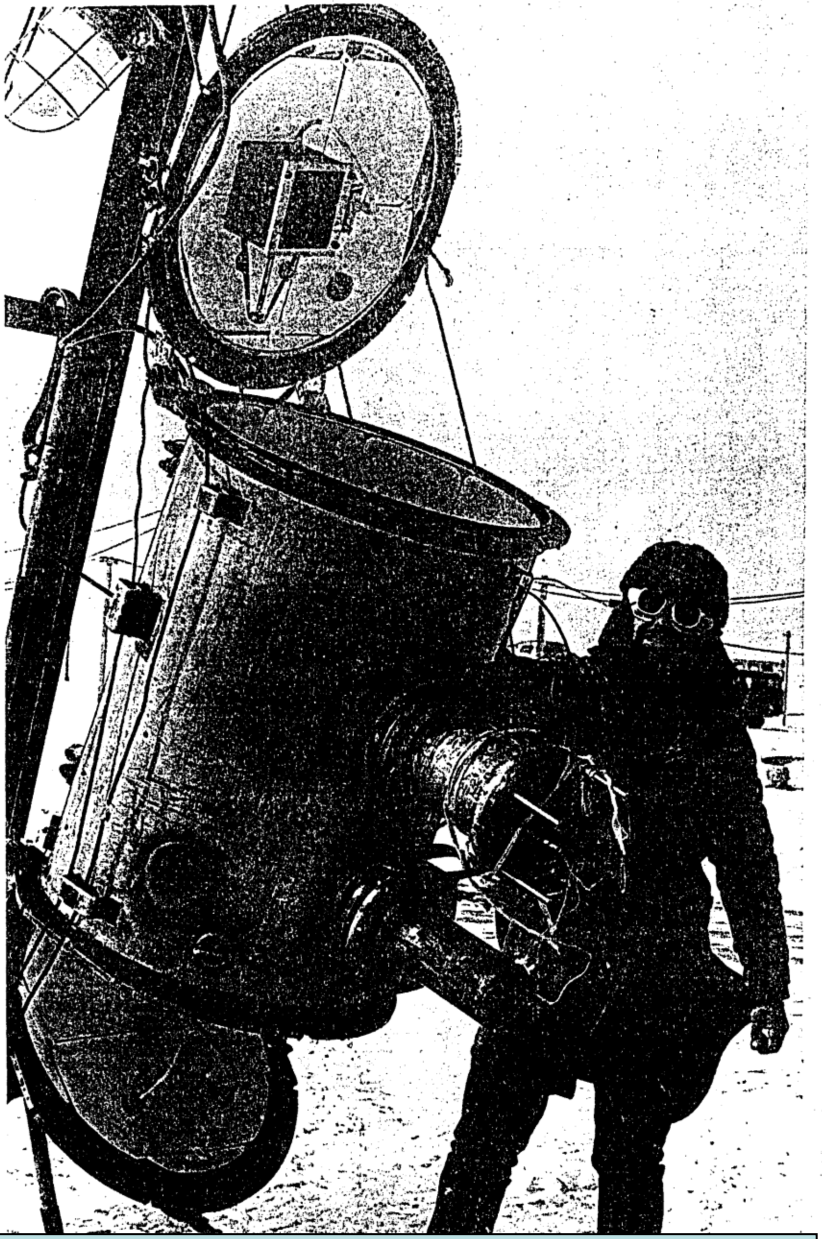
N - counting rate of photometer PMT FEU-130 (diameter 3 cm)

Nt - PMT dark counting rate, N_t =(17 +/- 2) 1/sec

Luminescence in ocean and Baikal water



At large depth the luminescence of Baikal water is of the same magnitude as contribution of K^{40} decays in light flux in a sea water.



Special bathyphotometer

A luminescence as the instrument to study the dynamical phenomena in Baikal water

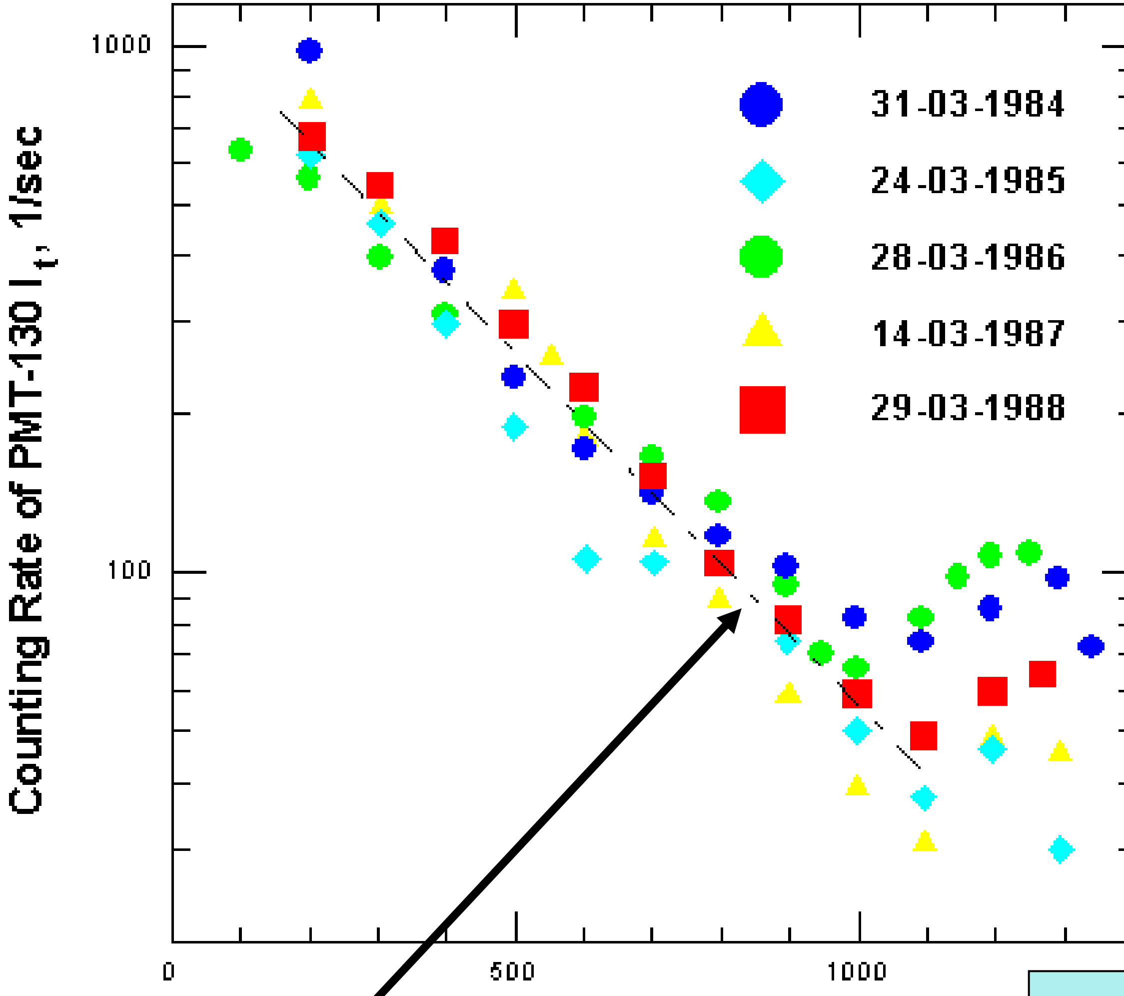
- A luminescence is a result of oxidization of dead organic material.
- A luminescence matter is produced by biology at shallow depth and then transported to deep layers by water currents, turbulence and due to sedimentation, at the same time matter loss its ability to luminescence .
- For stable productivity of the luminescence matter depth dependence of luminescence intensity should be:

$$N = N_0 \, Exp(- H/H_0), \text{ где } H_0 = v_z / t_l$$

v_z – a vertical water speed, t_l – a luminescence life time

The luminescence can be used as a natural indicator of the development of hydrobiological and hydrophysical phenomena in the Lake Baikal.

Results of some year measurement of the light field at Neutrino Telescope site in ice cover period

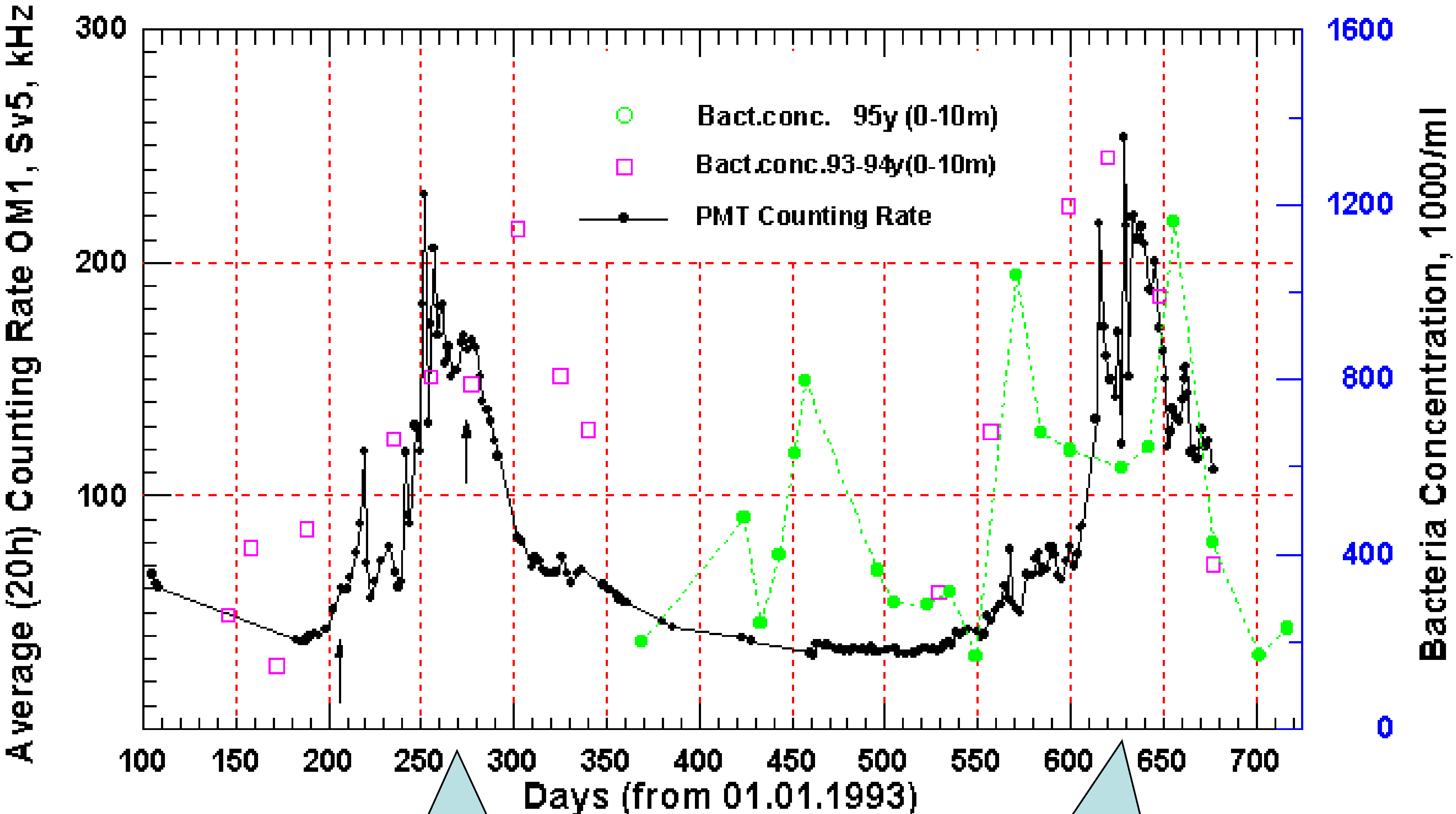


Depth

$N = N_0 \, Exp(- H/H_0)$, $H_0 = 320$ m, $t_l = 10$ days → $V_z = H_0/t_l \sim 0{,}2$ мм/с

Seasonal variations of Light field:

Counting rate of an optical module of NT-200 in 1993 -1994.

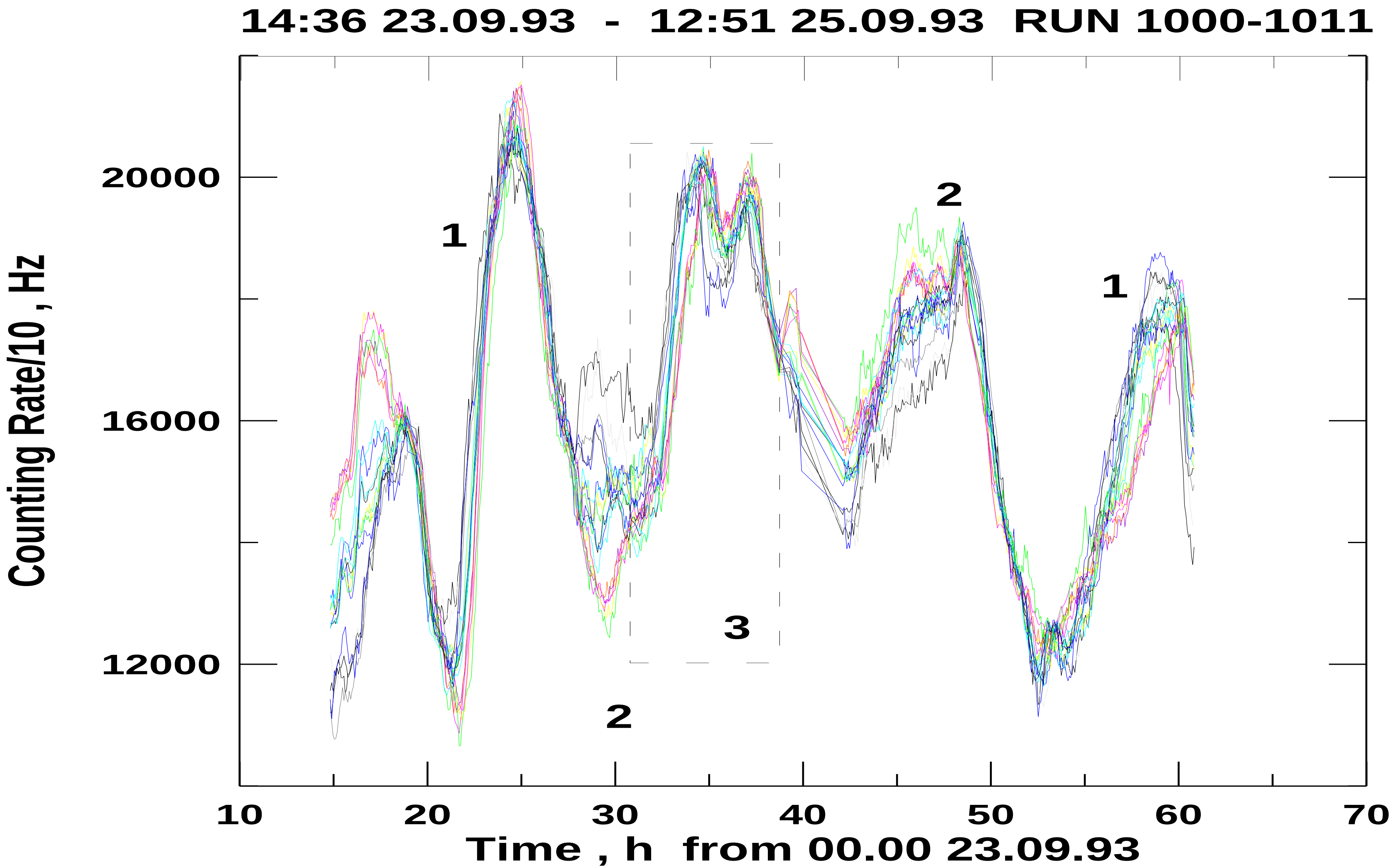


September, 1993

September, 1994

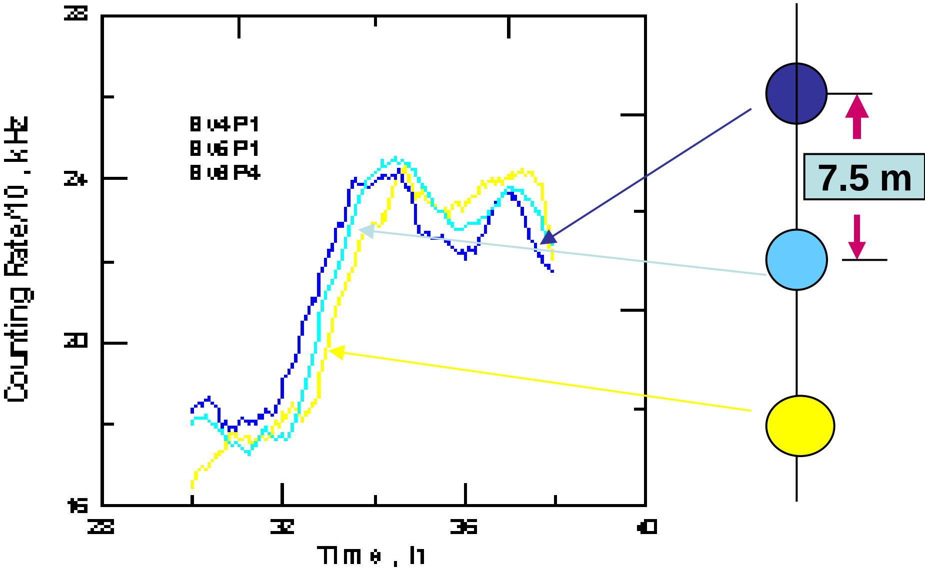
Large variations of Light field:

Counting rate of the 19 optical modules of NT-200 in September 1993.



Vertical water motion.

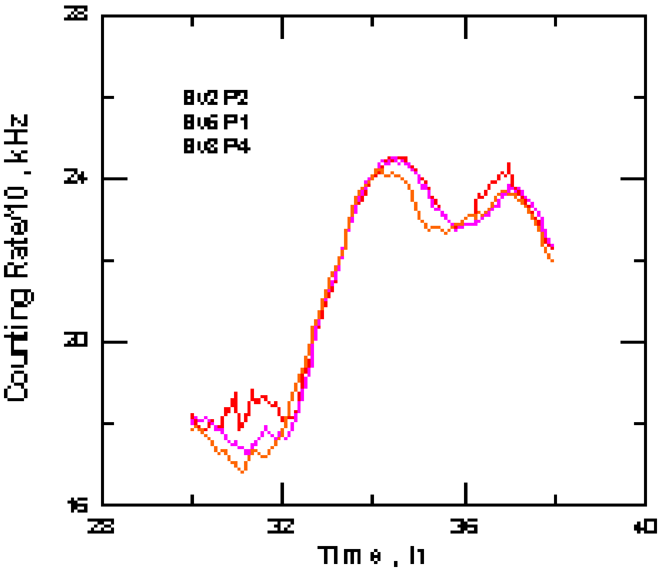
- Counting rate of the 3 optical modules of NT-200 situated
- on the same vertical string

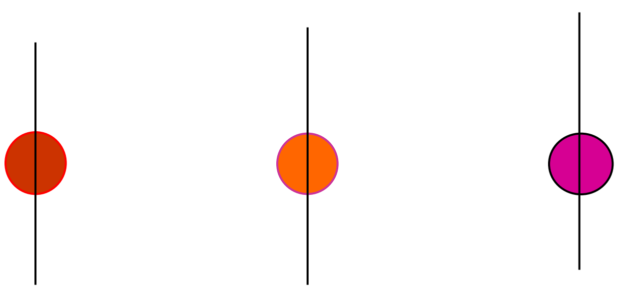


- V $_{vert}$ = 2 cm/s !!!!!!!!!

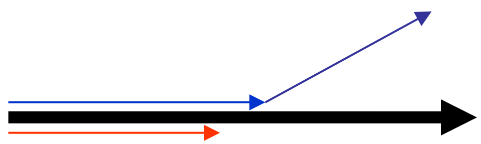
Counting rate of the 3 optical modules of NT-200 situated

- on the same depth on the different strings



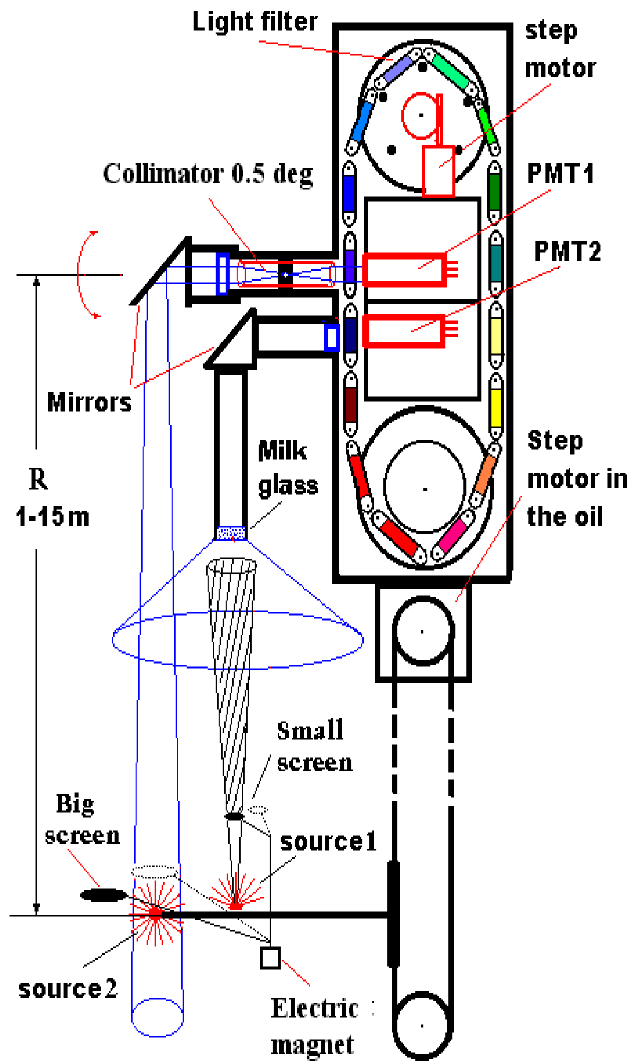


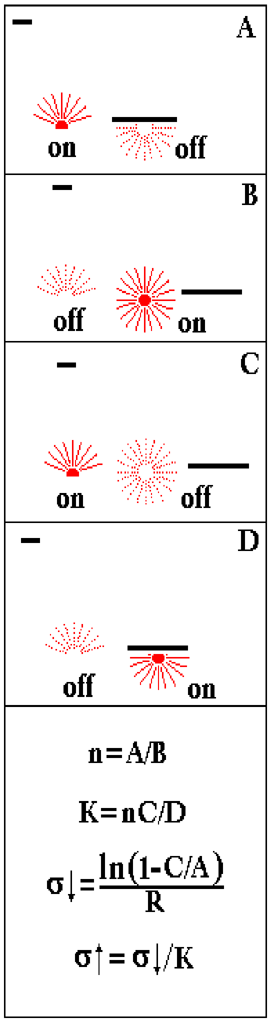
The Baikal water optical parameters



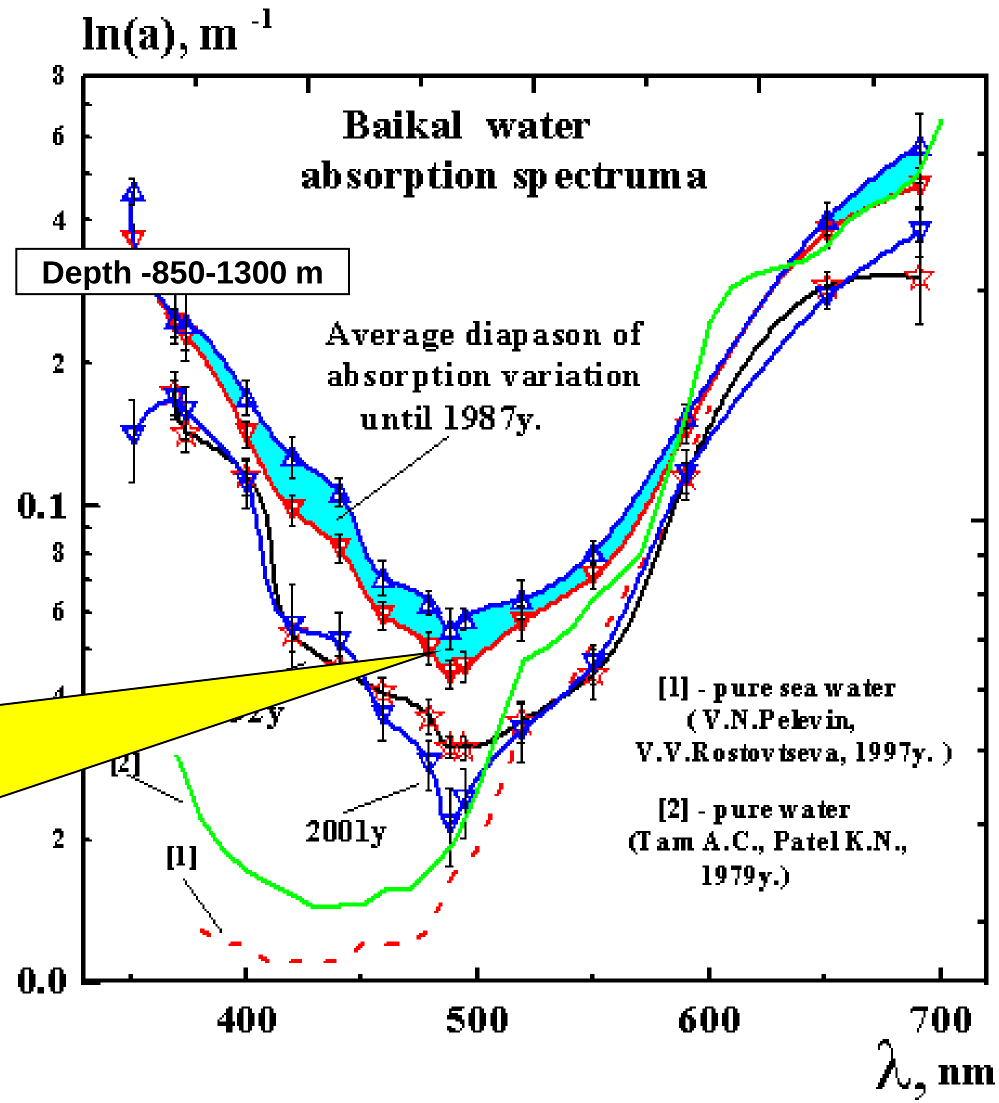
$$E(x) = E_0 \exp[-(a+b)x]$$

- E – photon flux
- a – absorption coefficient (depend on concentration of dissolved matter),
- b – scattering coefficient (depend on concentration of suspended matter),



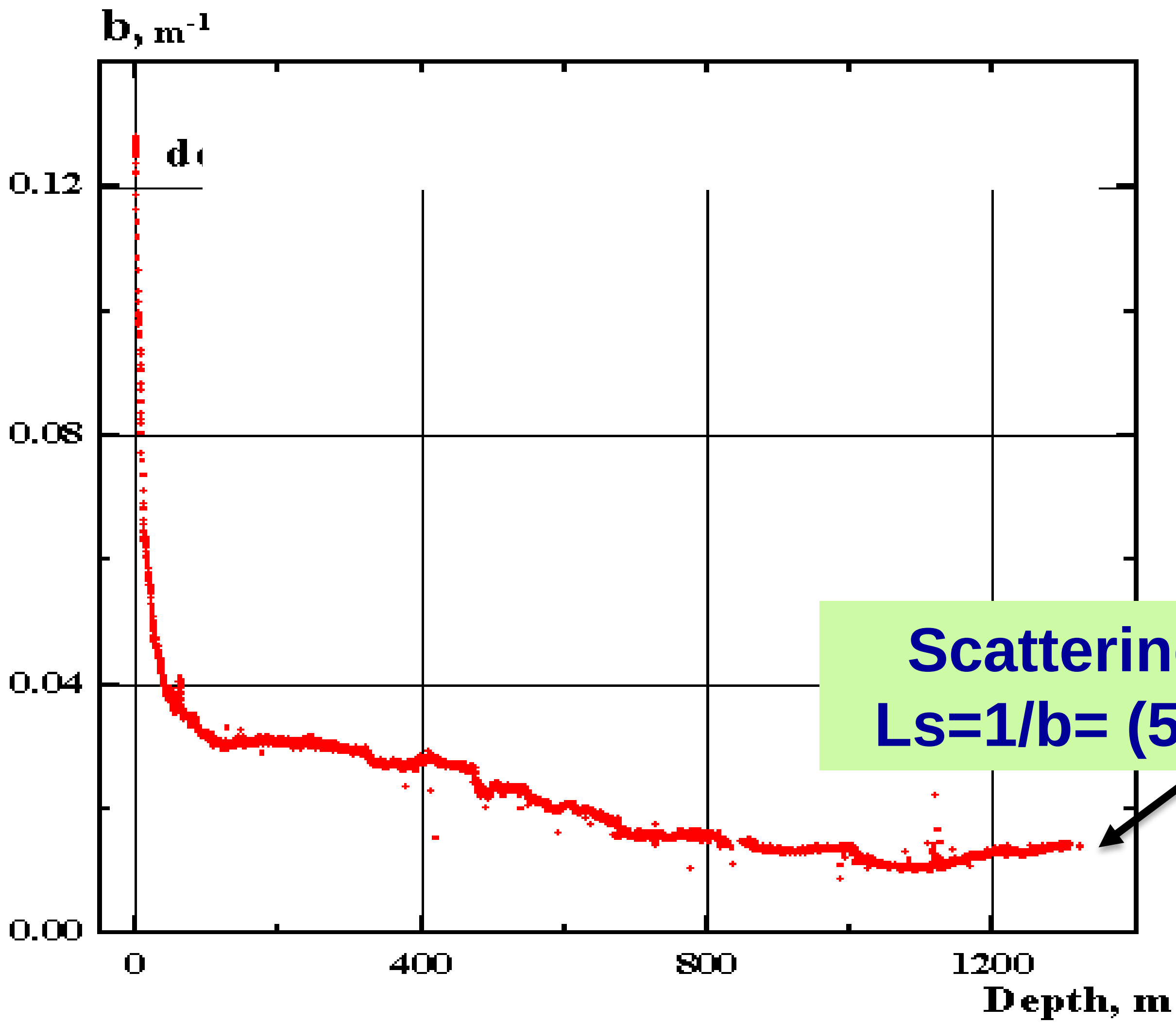


Absorption coefficient a at 1000 m depth



Typical value of the absorption length L_a=1/a =(20- 25) m for 480nm

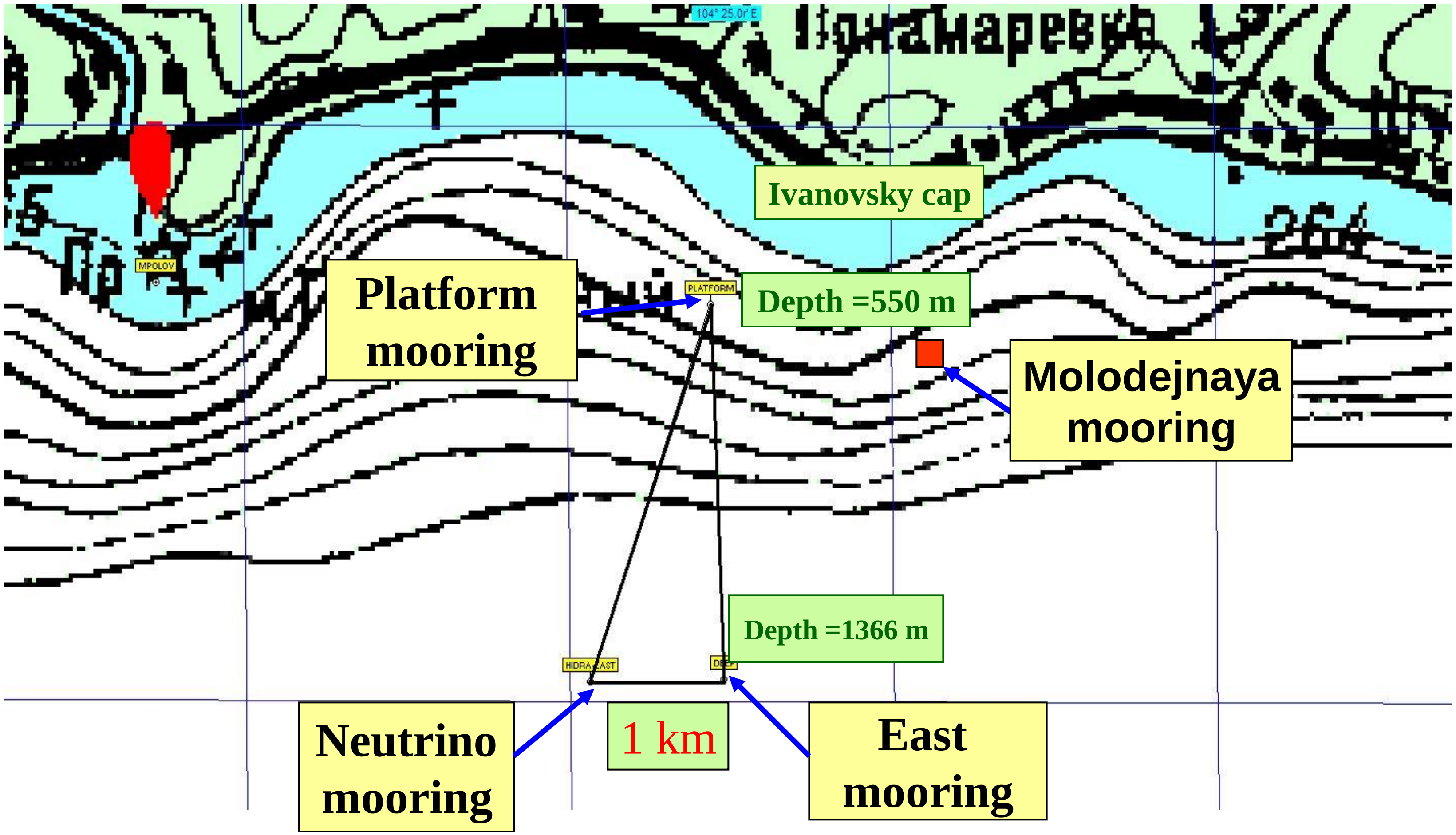
Typical depth dependence of the scattering coefficient *b(λ)* at Baikal neutrino telescope site



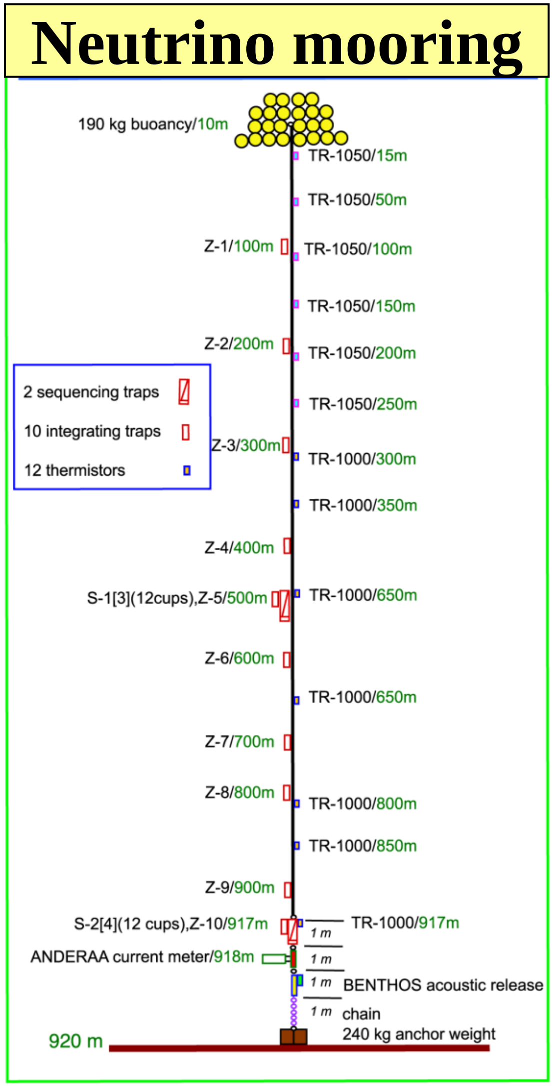
Scattering length
Ls=1/b= (50 – 70) m

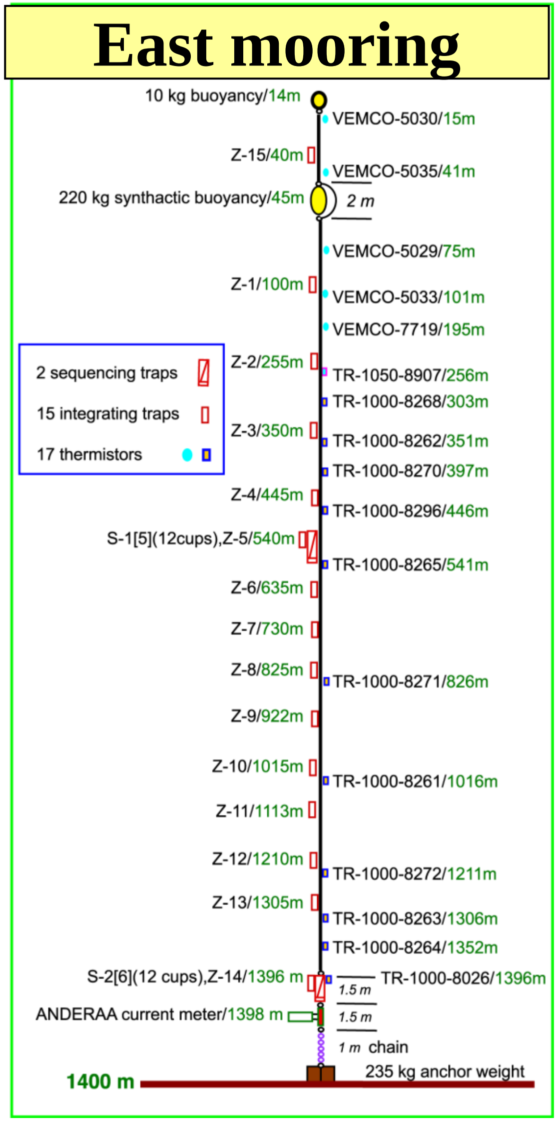
Hydro physical phenomena of heat and water exchange

Three-dimensional long-term temperature monitoring

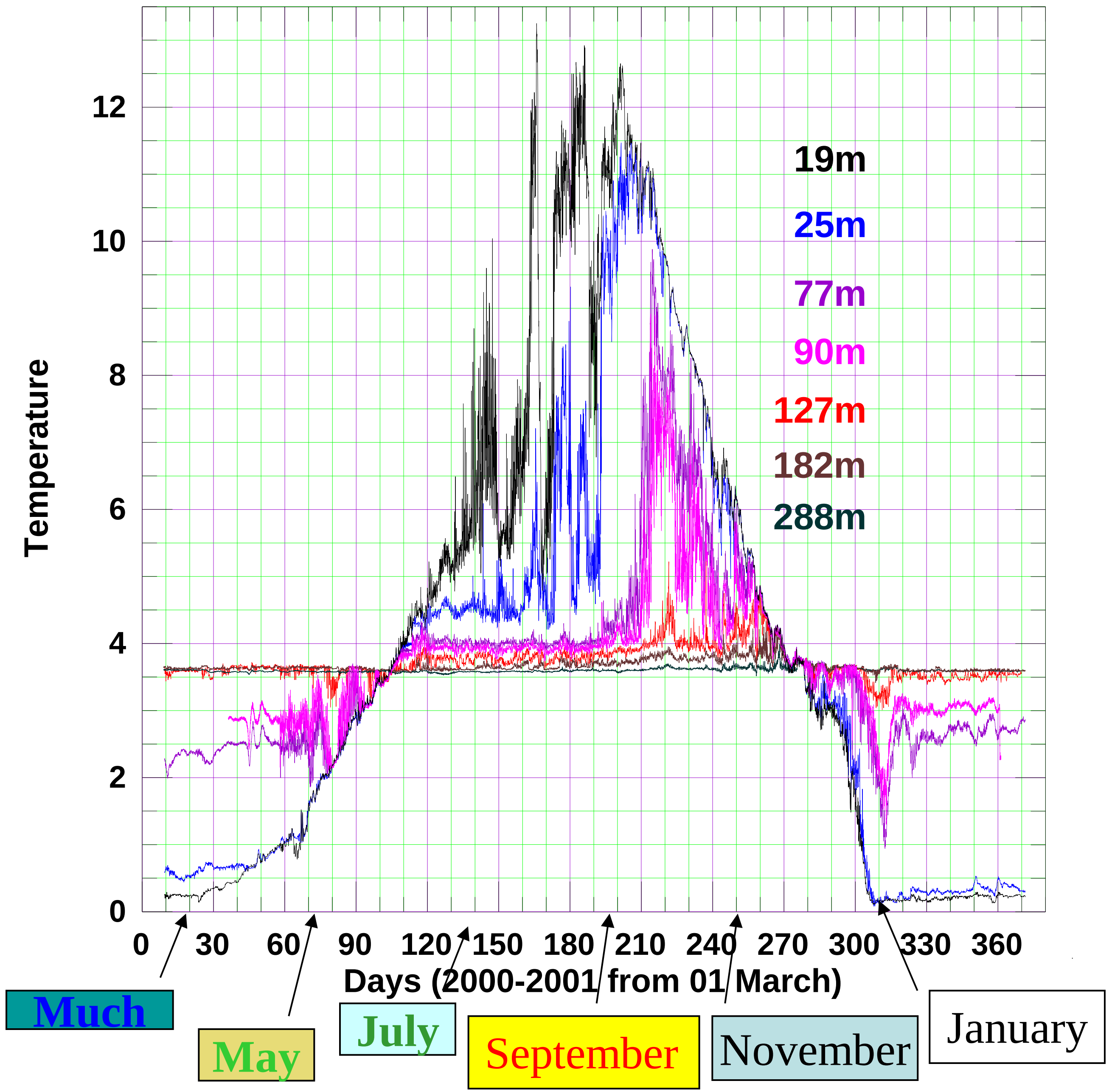


The instrumental moorings

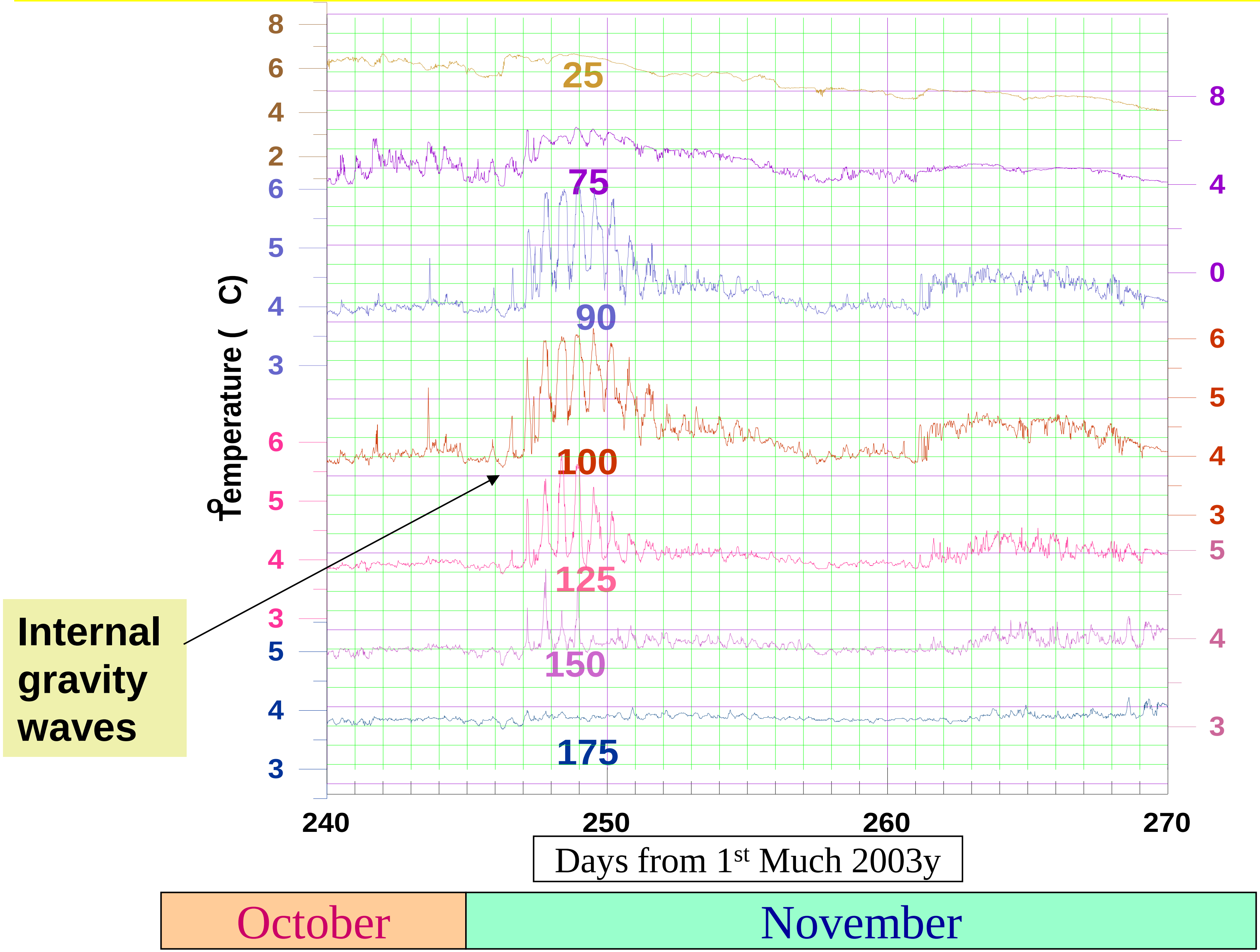




The temperature at the near-surface zone

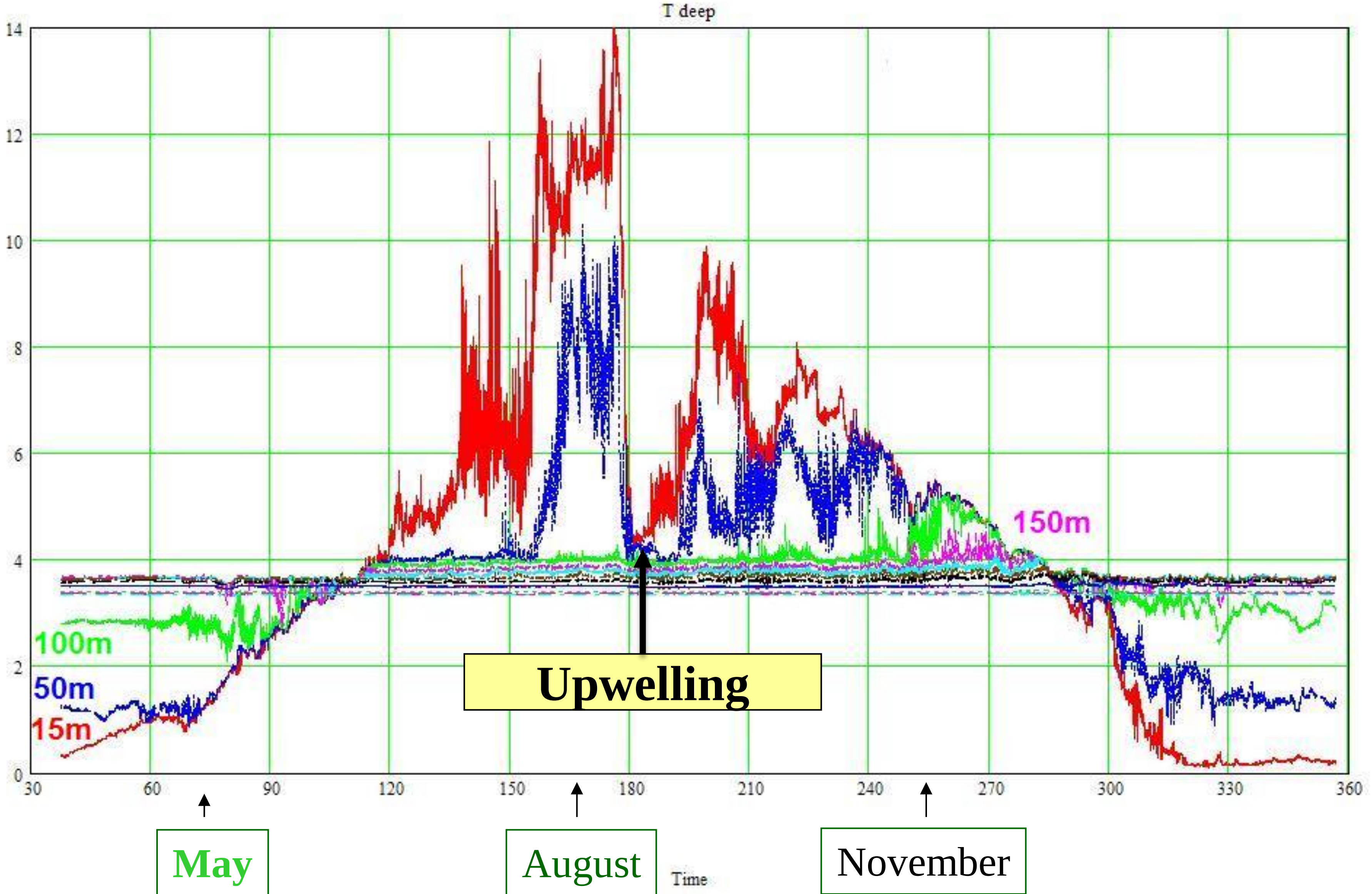


The inertial gravity waves excitation.

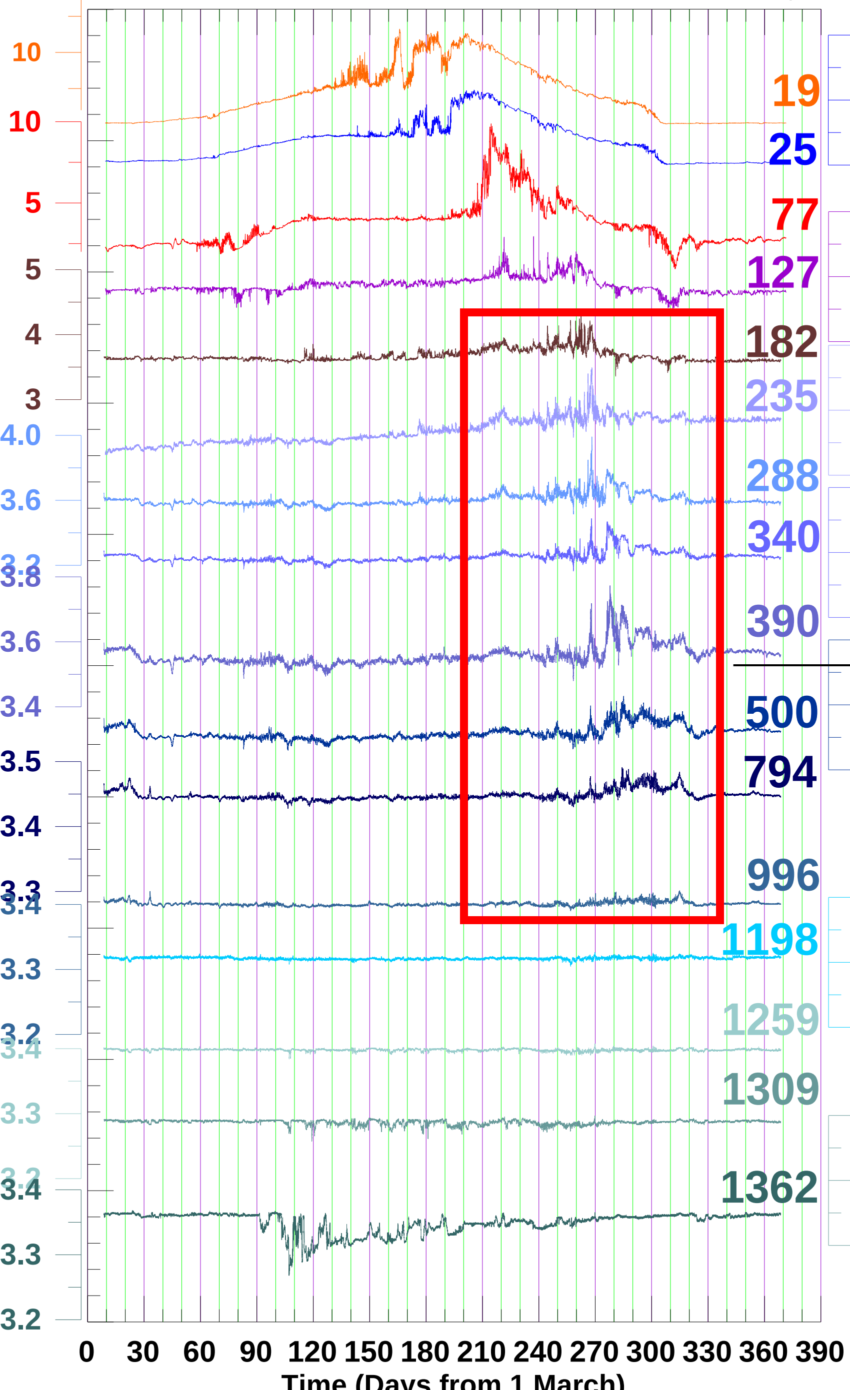


The temperature at the near-surface zone

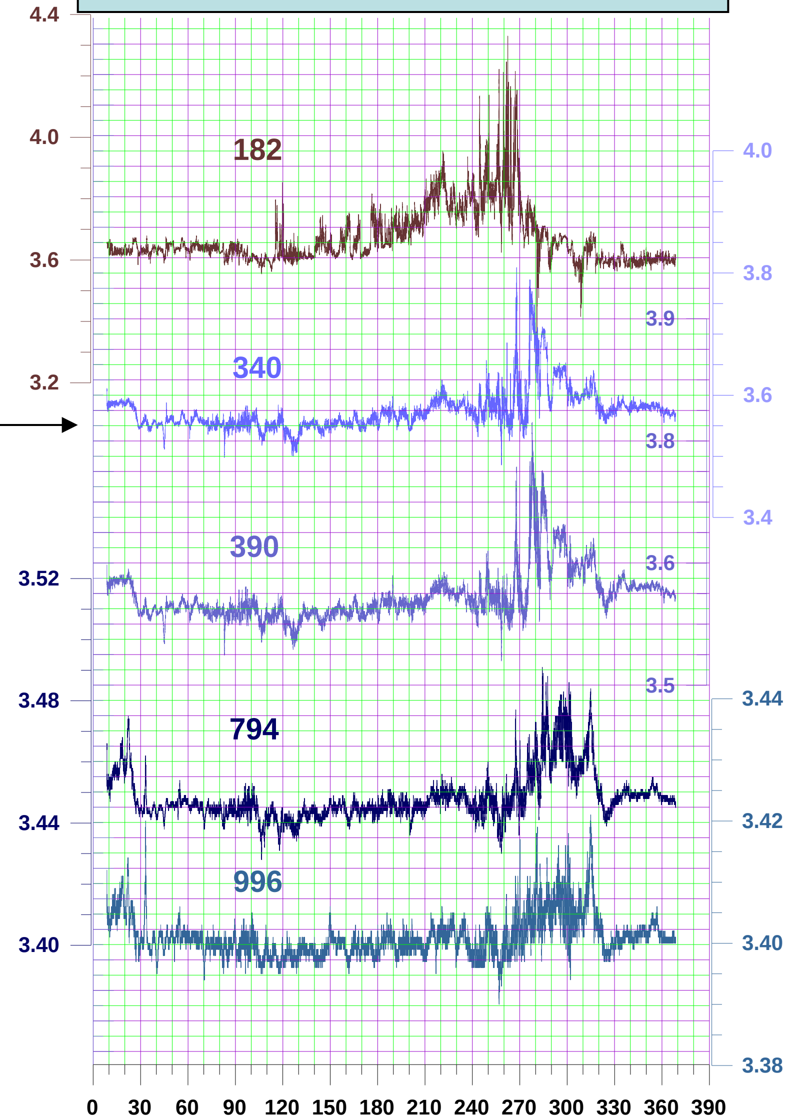
Deep east mooring

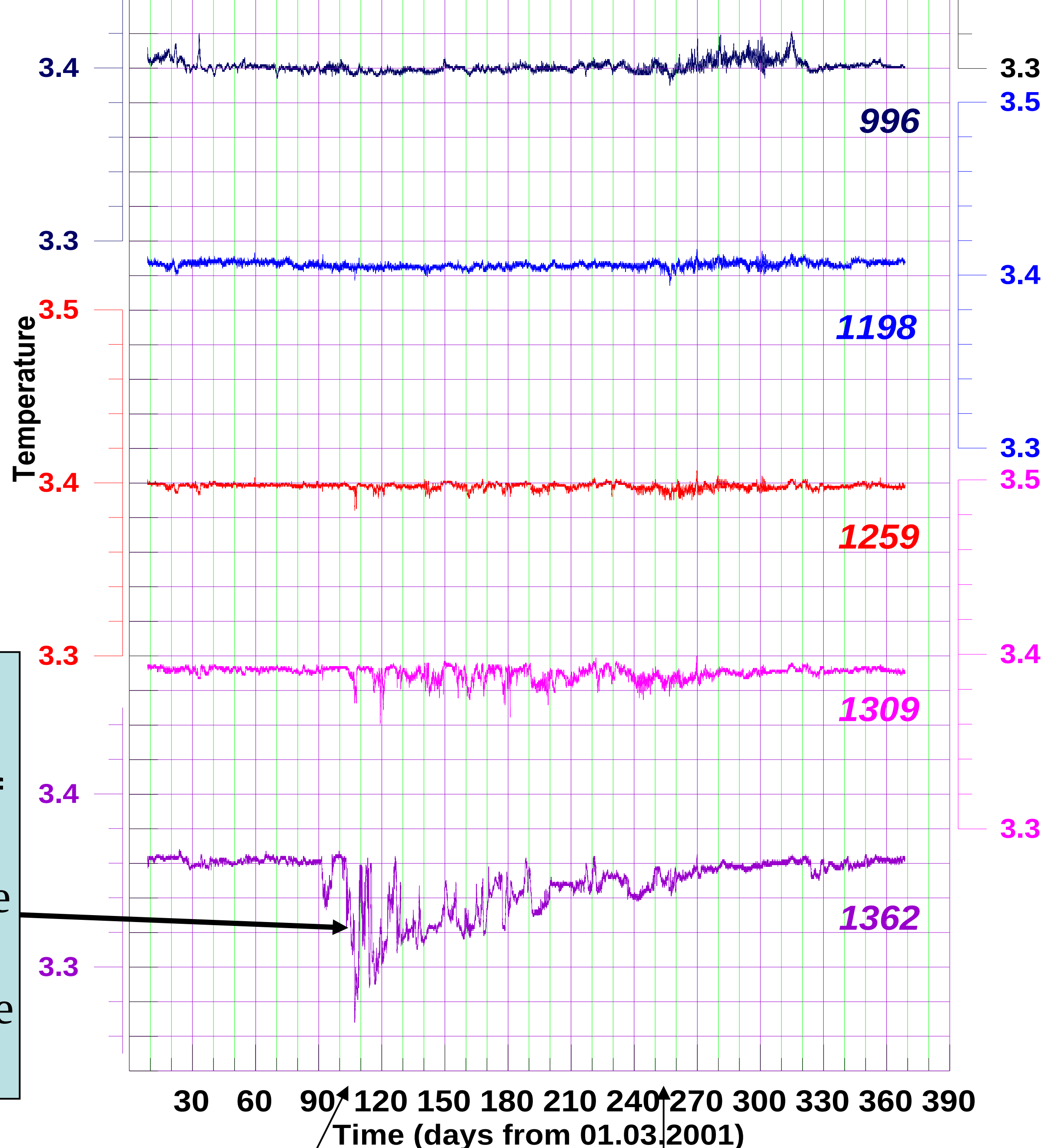


Vertical distribution of temperature 2000-2001y



Powerful intrusion of “warm” water





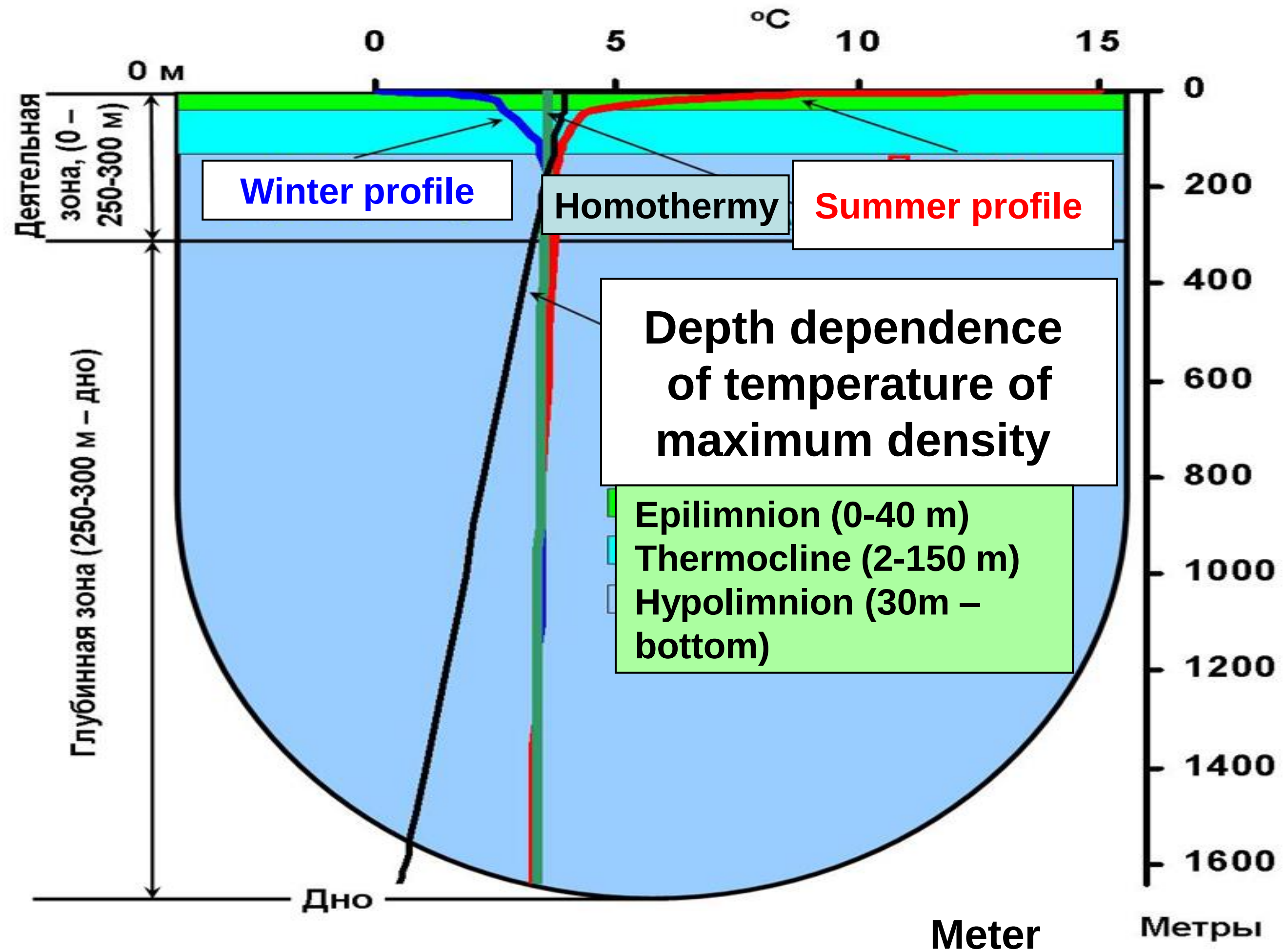
Powerful intrusion of cold water. Temperature decreased by 0.1 degree

June

November

Specific temperature depth dependence in Lake Baikal as primary cause for high vertical water transfer activity.

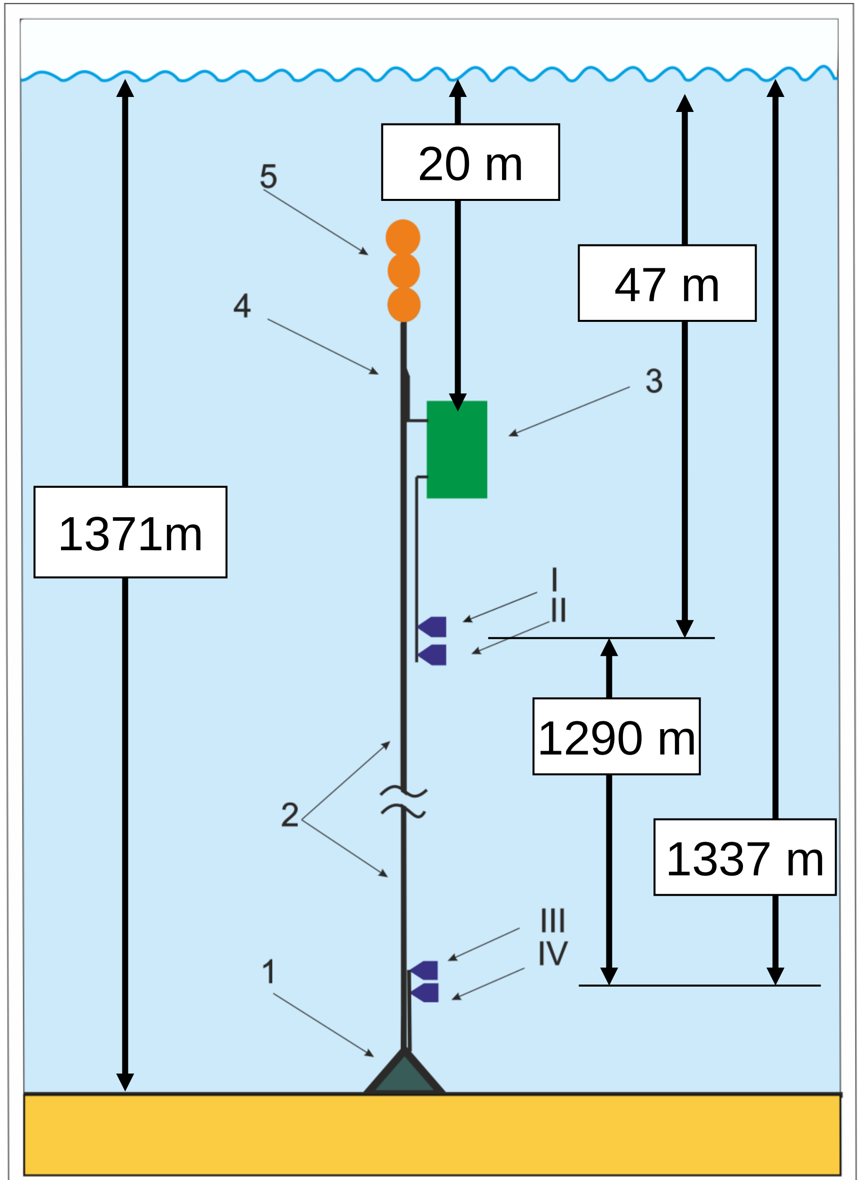
Hydro-physical processes of water circulation in Baikal are essential for oxygenation and for nutrients, organics and admixtures transfer.



$$T_{MD} = 3.9839 - 1.9911\cdot10^{-2}\cdot P - 5.822\cdot10^{-6}\cdot P^2 - (0.2219 + 1.106\cdot10^{-4}\cdot P)\cdot S$$

Long-term long base monitoring of Earth electromagnetic field (Ez).

Baikal Deep Water Setup



The primary contributions in *Ez* are:
water flows and
global electric circuit.
As well contributions of the solar activity variations

and earthquakes

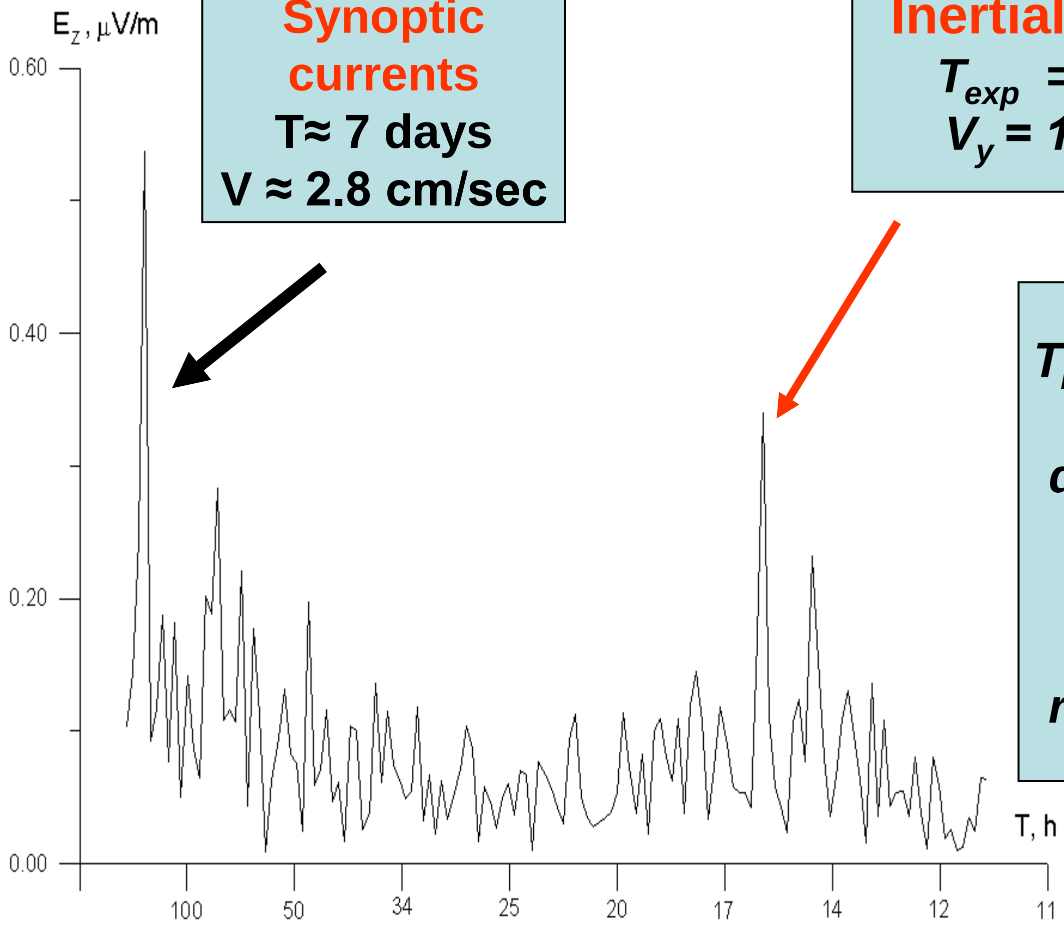
were detected.

1 – Anchor
2 – Cable
3 – Electronics unit, acceleration and temperature sensors
4 – Buoy rope
5 – Buoy
I, II – Top electrode detector
III, IV – Bottom electrode detector

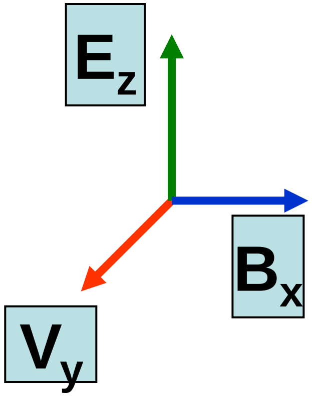
Spectrum of electric field strength, 2003-2004 years

Synoptic currents
T≈ 7 days
V ≈ 2.8 cm/sec

Inertial oscillations
T_{exp} = 15.7 hours
V_y = *1.76 см/sec*



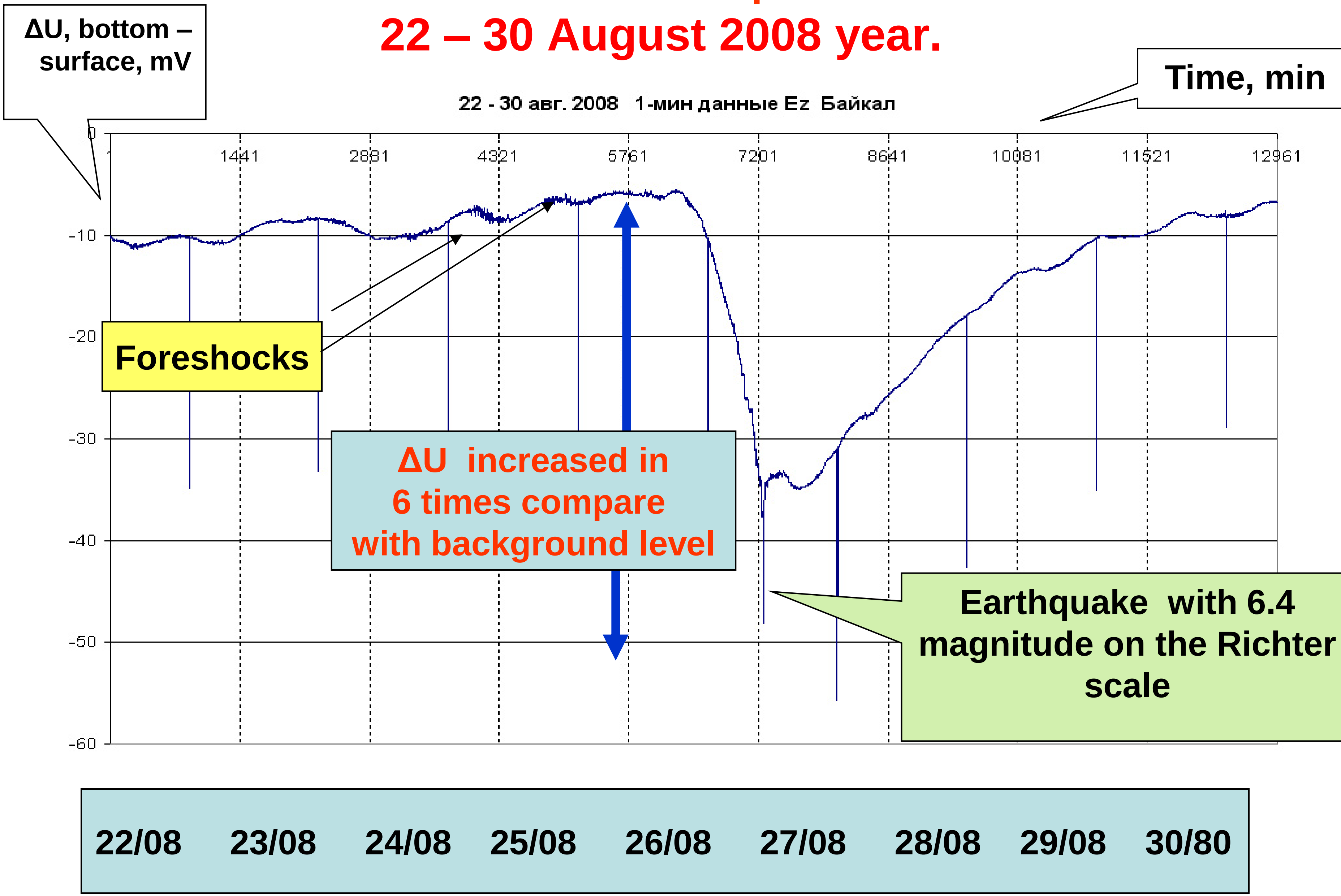
$T_{inertial}$ = 15.3 hours
Δ T ≈ 0, 4 hour
due to turbulence
hydrodynamic
resistance
with coefficient
r = 5, 35·10^{-5} sec^{-1}



Magnetohydrodynamic effect $E_z = - V_y \cdot B_x$

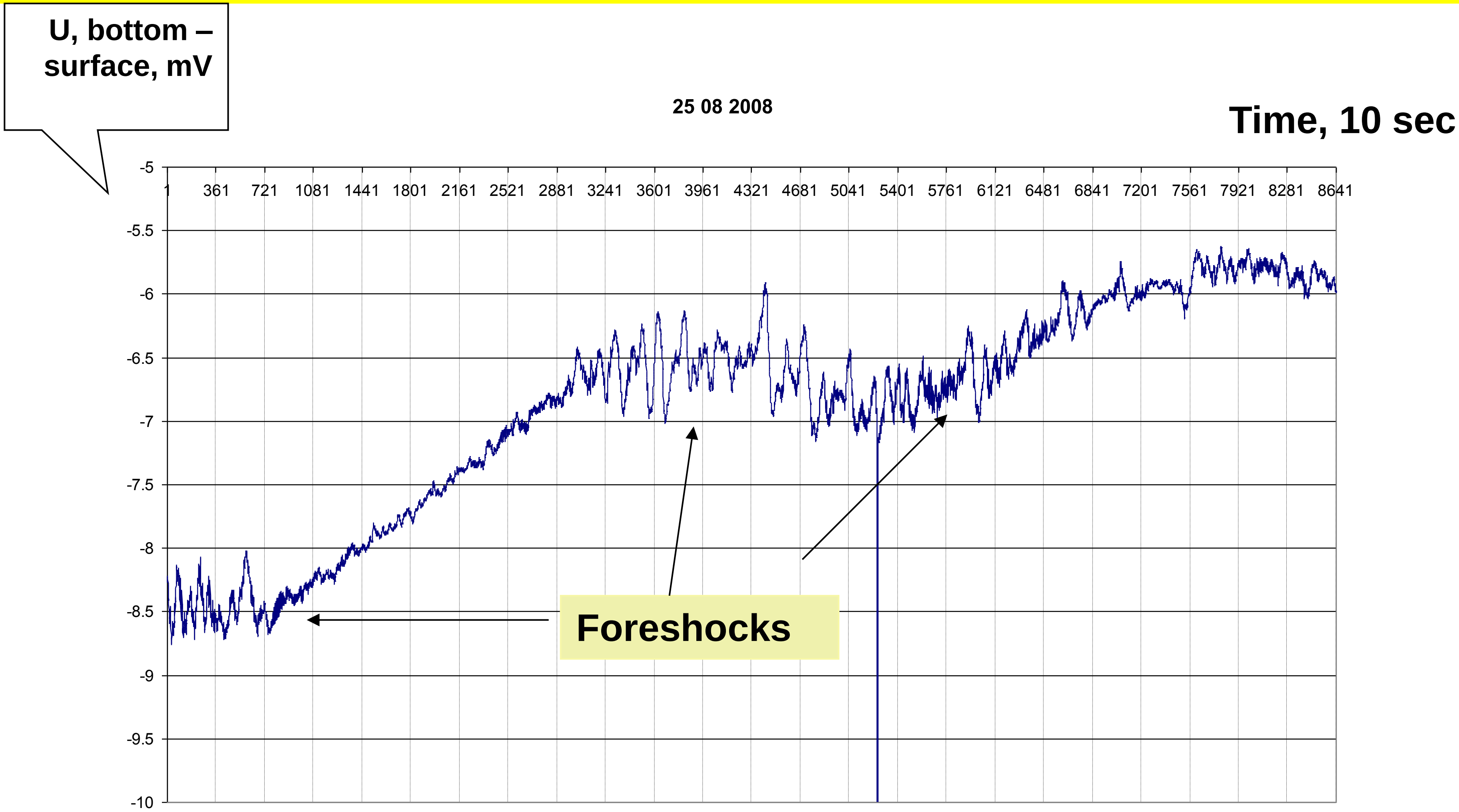
Surface – bottom electric potential difference

22 – 30 August 2008 year.



Surface – bottom electric potential difference

25 August 2008 year.



Summary

- **The Lake Baikal is the unique reservoir of drinking fresh water with endemic biology also it is good place for construction of a km3 scale neutrino telescope**
- **In framework of the Baikal neutrino experiment a lot of unique instruments, methods and technologies were designed which are suitable for interdisciplinary researches of the Lake.**
- **Creation of the km3 scale neutrino telescope Baikal-GVD will open many new opportunities for multi-disciplinary study of lake Baikal ecosystem.**


Welcome to Lake Baikal