

The NEMO project

- **Site selection for km³ deployment (completed in 2000)**
- **Long term characterisation of Capo Passero site**
- **Simulation of the detector performances**
- **R&D for technologies suitable for the km³:**
 - Data Transmission**
 - Front-end electronics and DAQ**
 - Mechanical layout and deployment procedures**
- **Construction of a 2000m depth Test Site near Catania (28 km)**

January 2000:

- **NEMO joined ANTARES for the construction of a 0.1 km² detector**

Next future:

- **NEMO-Antares towards a coordinated effort for the km³**

NEMO *Site Selection Activity*



INFN:

Bari, Bologna, Cagliari, Catania, Genova, LNF, LNS, Messina, Roma



CNR:

Istituto di Oceanografia Fisica (La Spezia)

Istituto di Biologia del Mare (Venezia)

Istituto Talassografico (Messina)

Istituto GEOMARE-SUD (Napoli)



Istituto Nazionale di Geofisica e Vulcanologia



Istituto Nazionale di Oceanografia e Geofisica Sperimentale (Trieste)



Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (Pavia)



Marina Militare Italiana



Saclant NATO Undersea Research Centre

The vessels for oceanographic campaigns



The Urania Vessel

62 m length
15 Researchers
10 Crew

The Urania Corvette
Italian Military Navy
60 m length
4 Researchers
100 crew



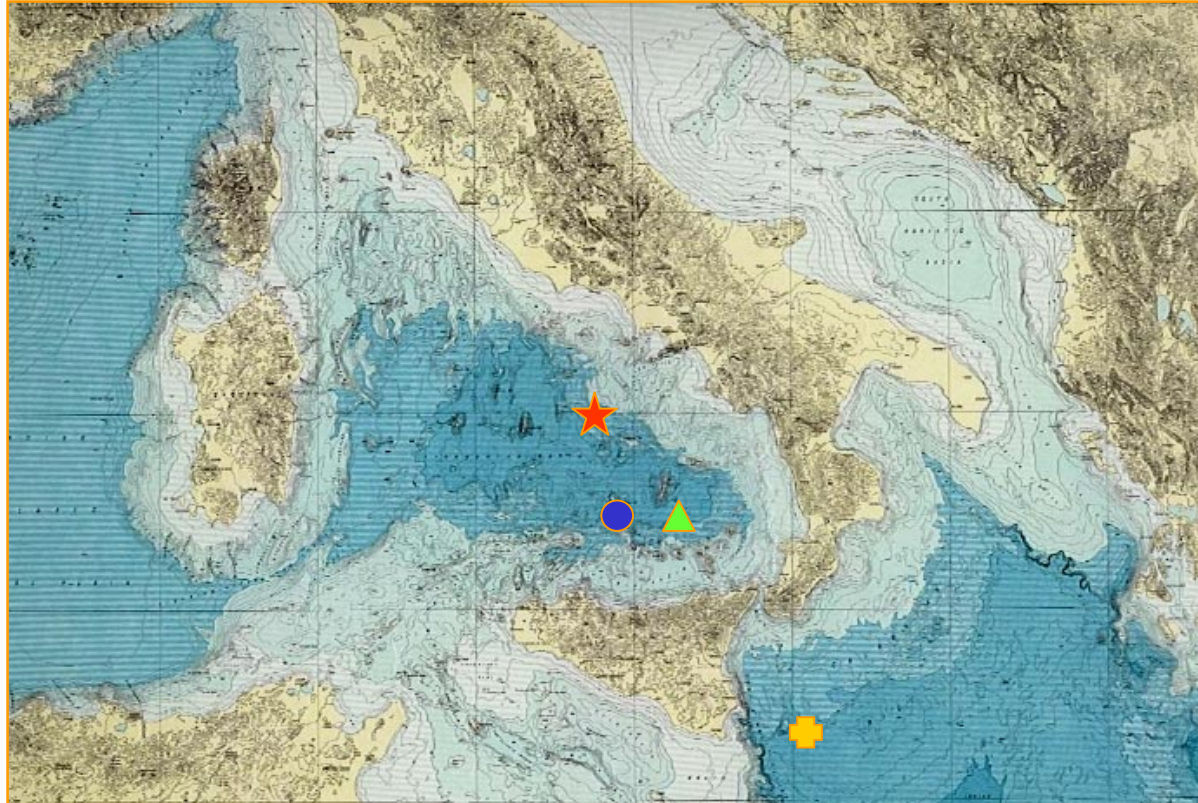
The Thetis Vessel

32 m length
9 Researchers
5 Crew

SH3D Helicopter
Italian Military Navy
4 Researchers
2 Crew

The Alliance Vessel
110 m length
20 Researchers

Investigated sites



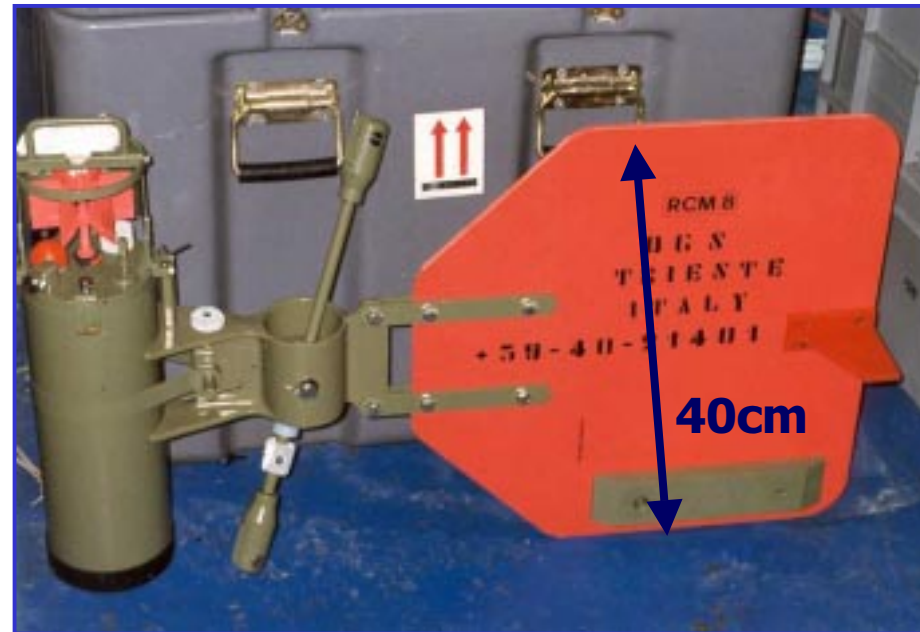
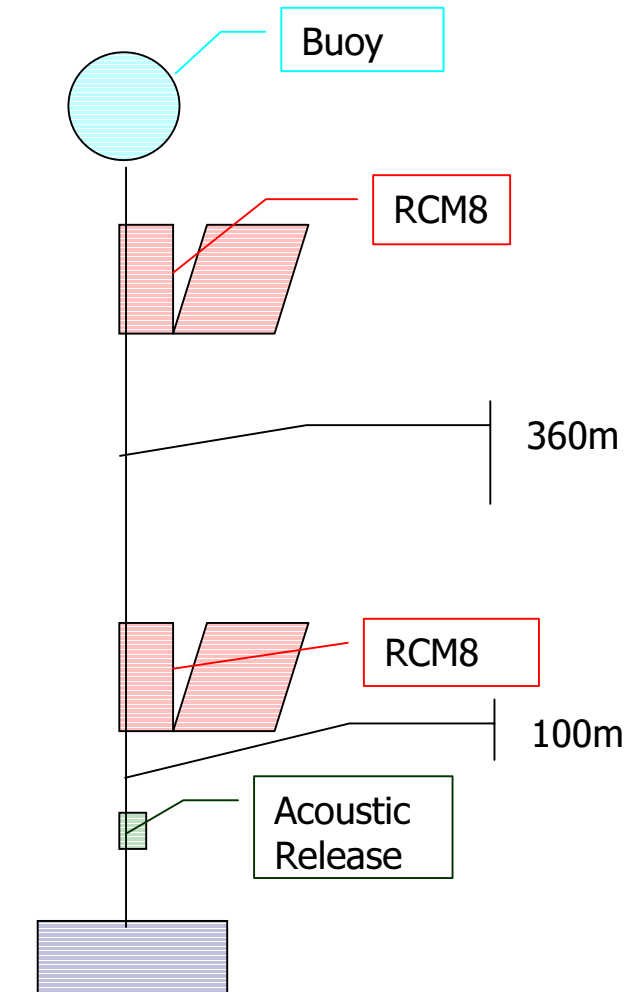
35° 50' N, 16° 10' E (3350m) in the Jonian Sea (*Capo Passero*)

39° 05' N, 13° 20' E (3400m) in the Tyrrhenian Sea (*Ustica*)

39° 05' N, 14° 20' E (3400m) in the Tyrrhenian Sea (*Alicudi*)

40° 40' N, 12° 45' E (3500m) in the Tyrrhenian Sea (*Ponza*)

Current metres

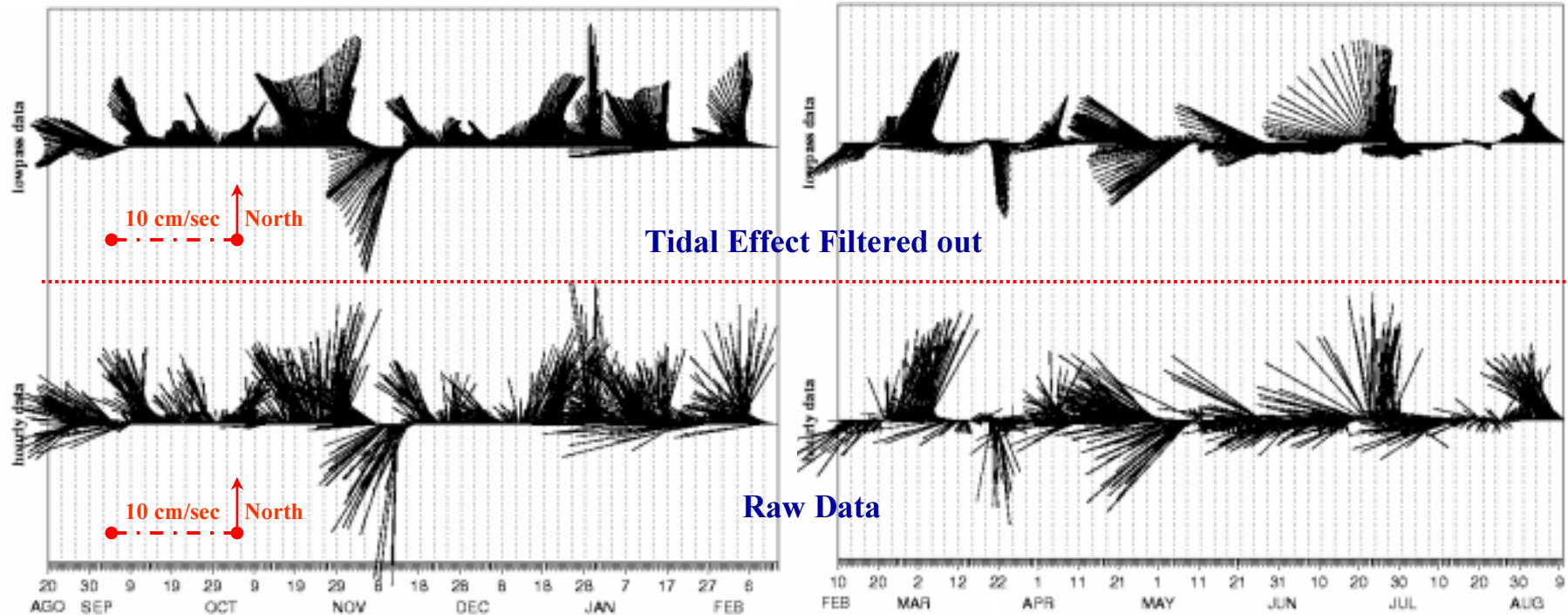


Current Metre Aanderaa RCM8

Current metre and sediment trap chain moored in Capo Passero

Deep Sea Current Measurements (August 1998 - running)

Detailed report available at INOGS



Preliminary analysis

Lat:36°30'N **Long:**15°50'E **Depth:** 3350m

current meter moored @ -3325m

Average current intensity: 3.6 cm/sec

RMS: 2.5 cm/sec

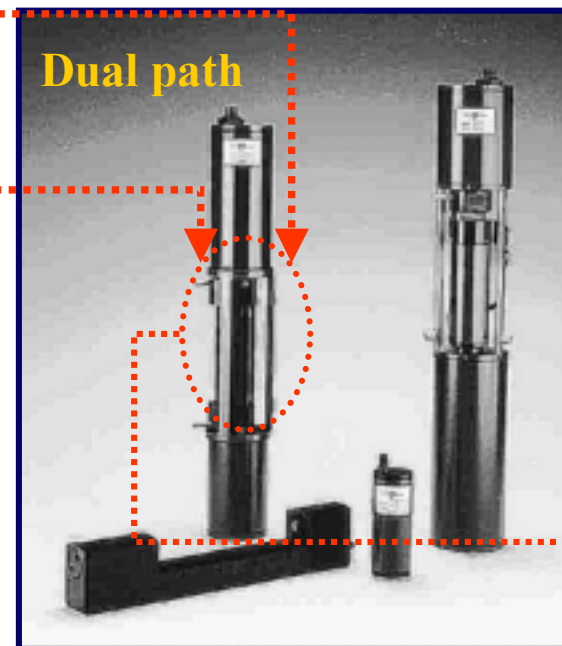
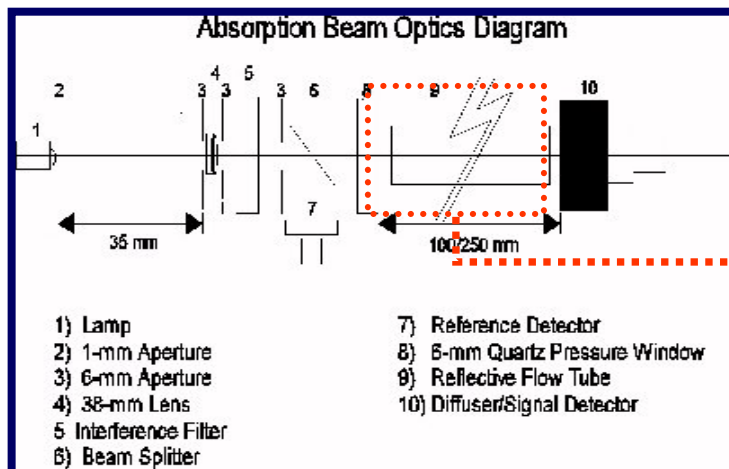
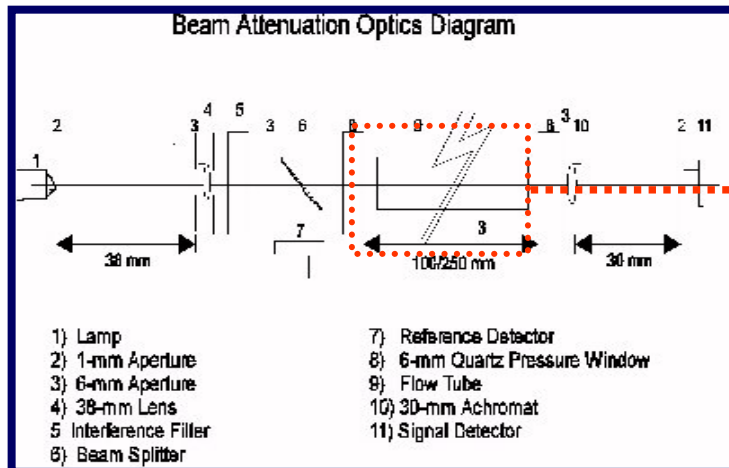
Average angle: 8° NW

WETLabs AC-9 Transmissometer

In situ Measurements of Inherent Optical Properties

412, 440, 488, 510, 532,
555, 650, 676, 715 nm

absorption(a)
scattering (b)
attenuation (c=a+b)

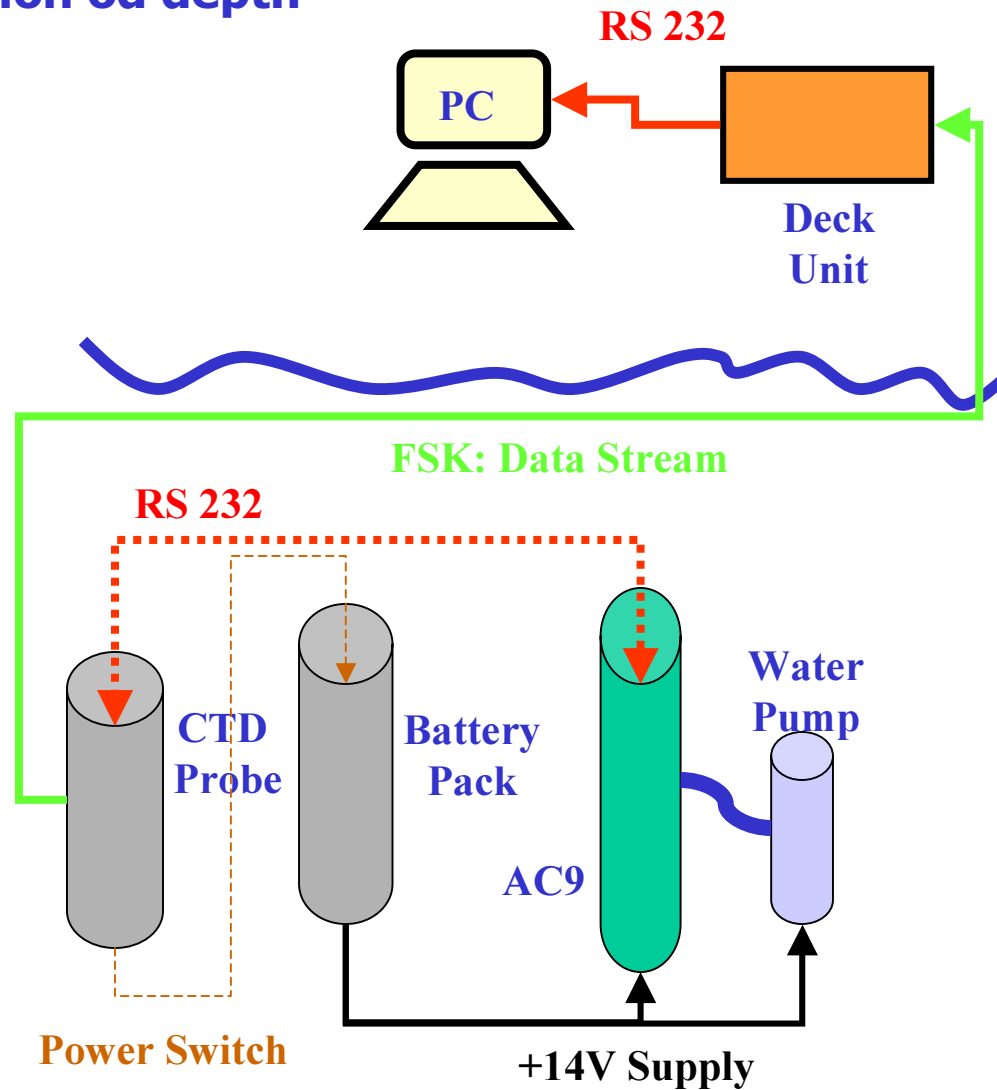


25cm long flow tube

"c" angular acceptance = 0.7°

Deep Sea DAQ

The DAQ is designed to acquire profiles of σ_t , σ_θ , salinity and temperature as a function of depth

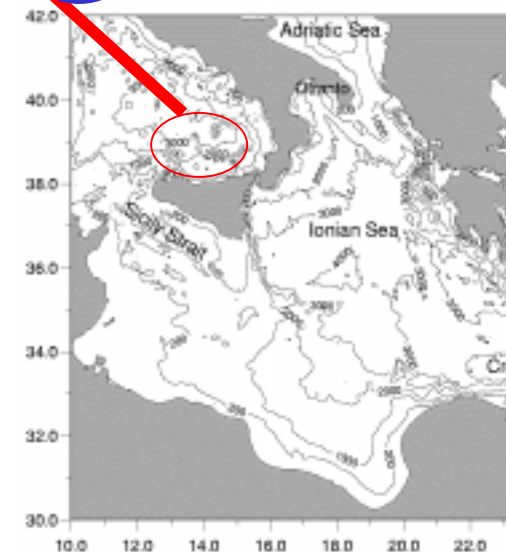


Ustica and Alicudi

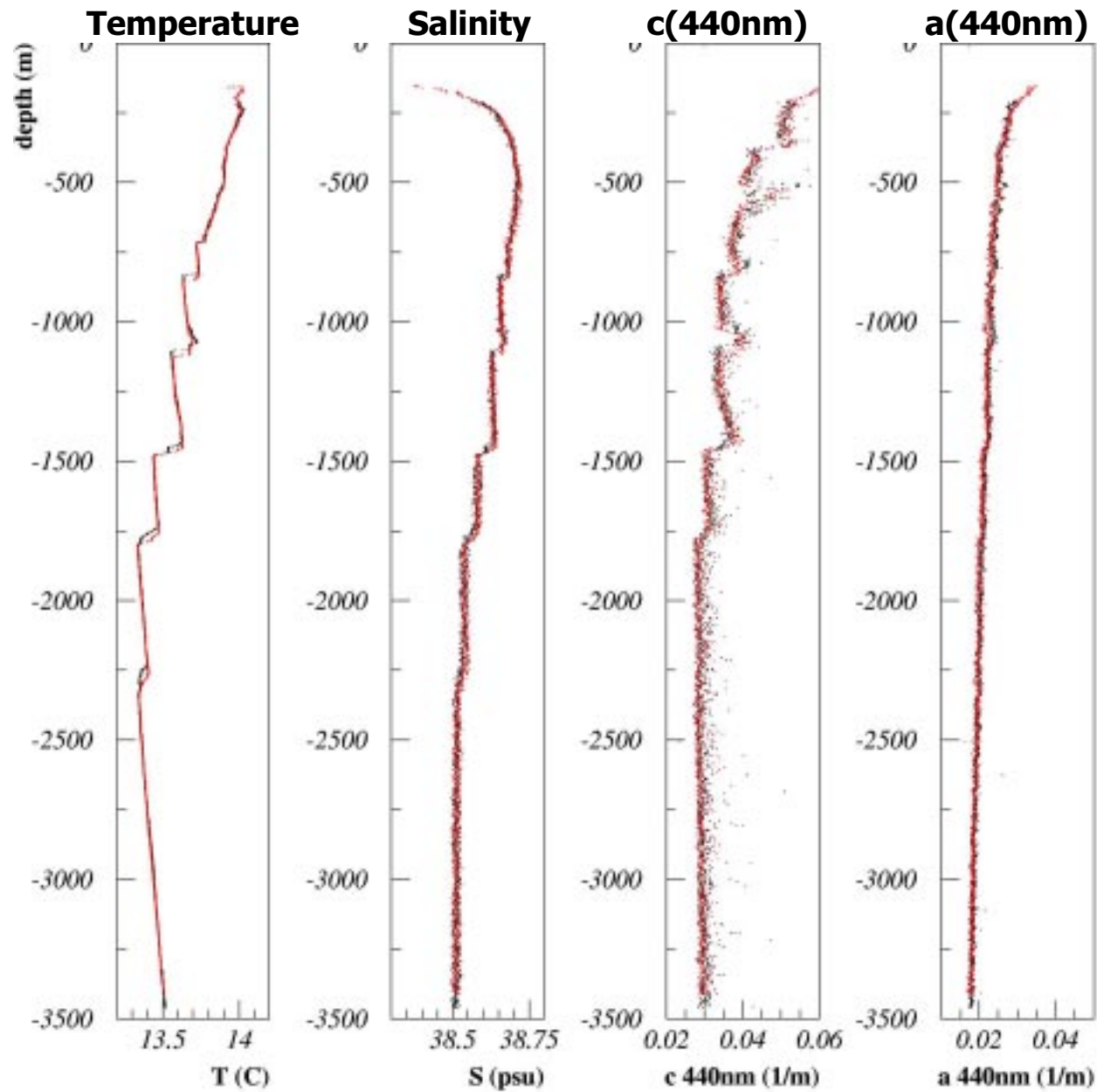


- **Ustica: $38^{\circ}58'N$ $13^{\circ}18'E$, depth 3388m (2: Dec '99)**
- **Alicudi: $38^{\circ}56'N$ $14^{\circ}16'E$, depth 3423m (2: Dec '99)**

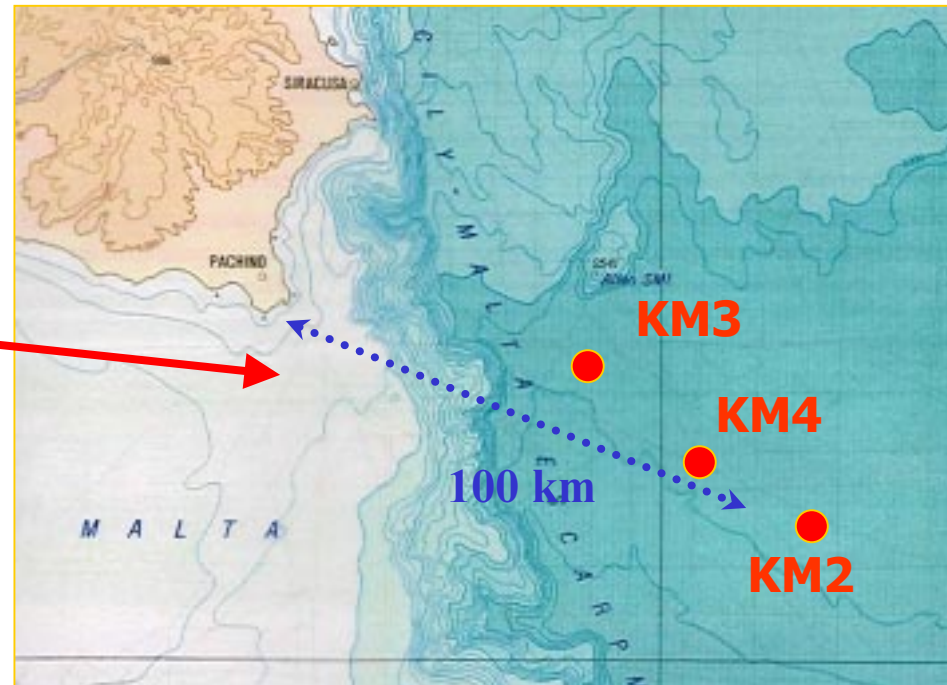
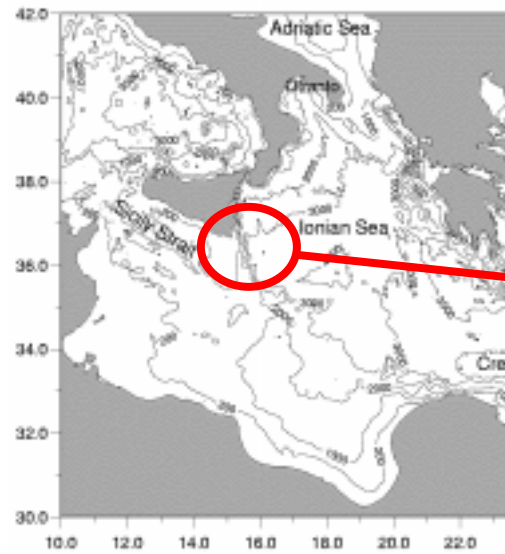
**Results published in [astro-ph/0109005](https://arxiv.org/abs/astro-ph/0109005)
accepted by NIM A**



The Tyrrhenian layers

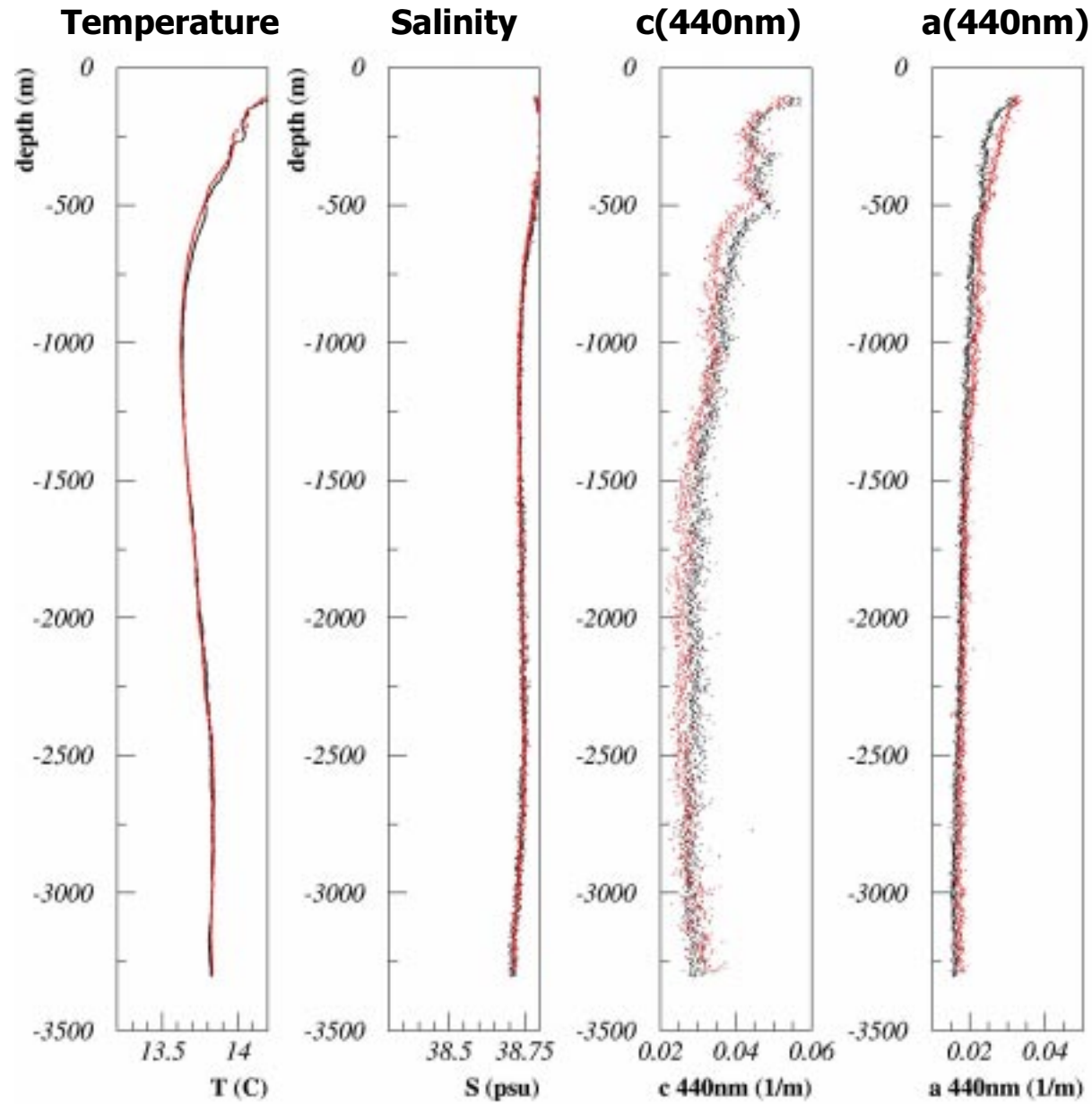


Capo Passero

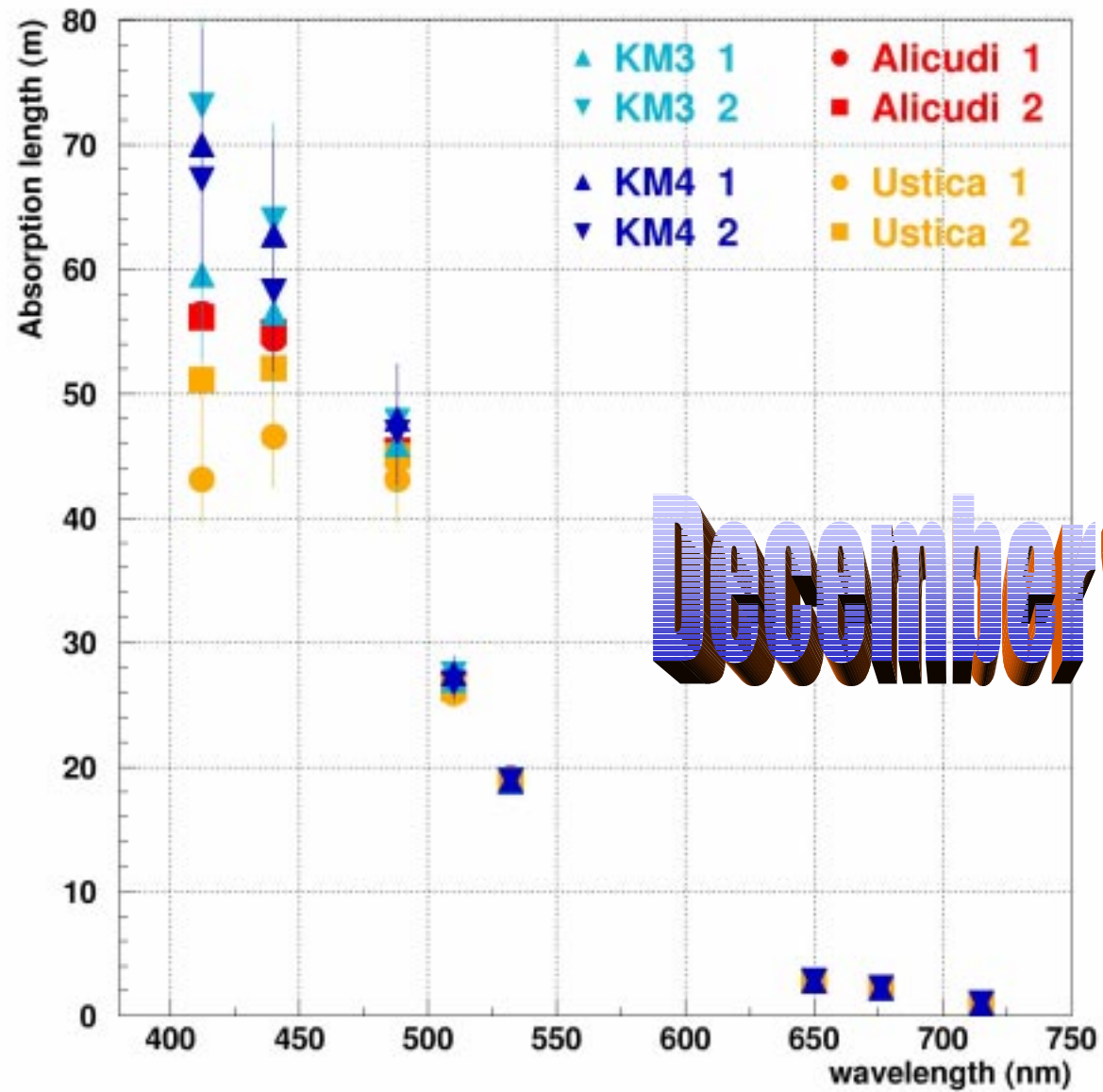


- **KM2** 36°10' N 16°19'E, depth 3350m
(1: Jan '99)
- **KM3** 36°30' N 15°50'E, depth 3345m
(1: Feb '99, 1: Aug'99, 2: Dec '99)
- **KM4** 36°19'N, 16°04'E, depth 3341m
(2: Dec '99, 2: March '00, contiuing)

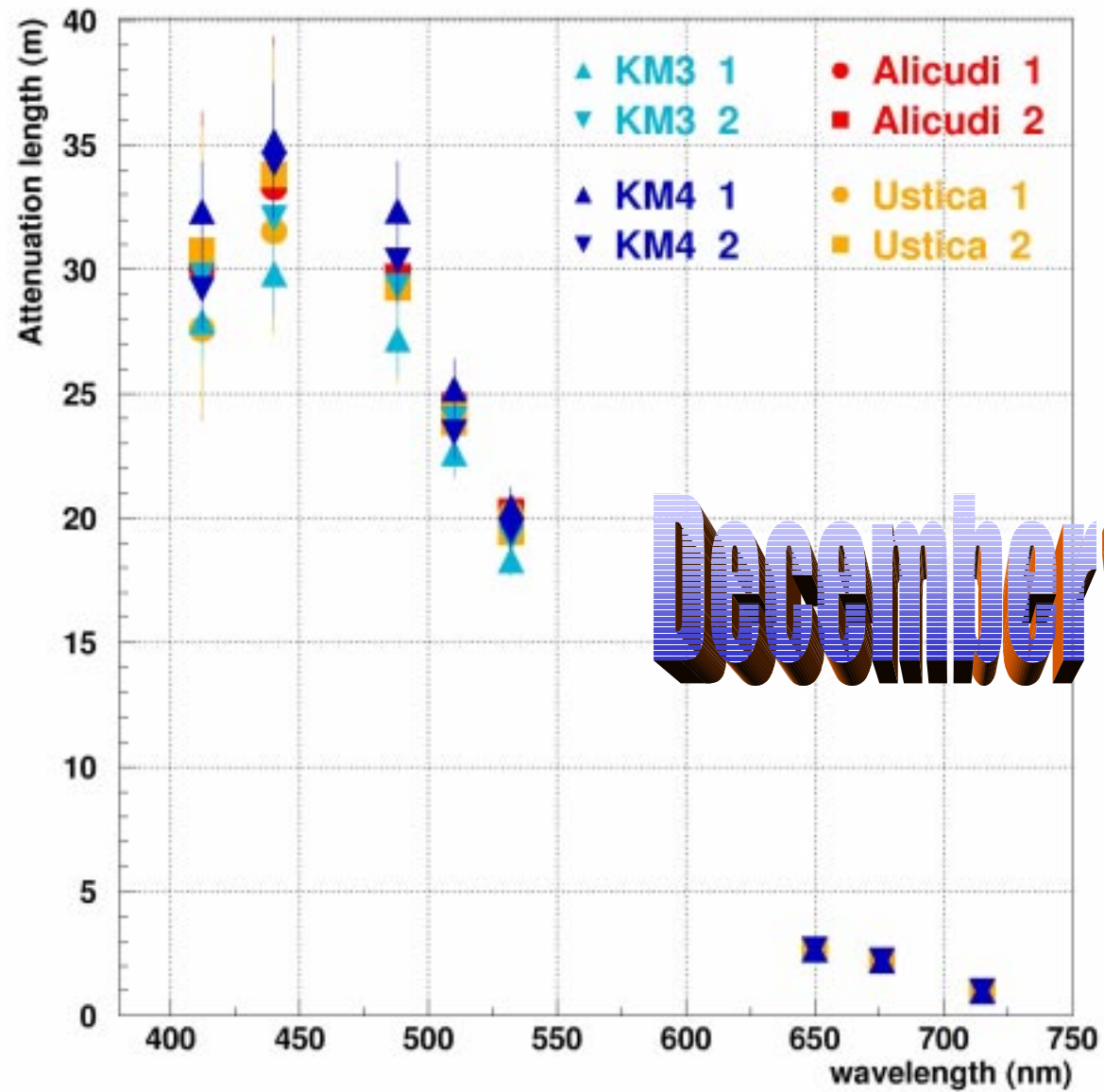
The Southern Ionian Sea: KM4



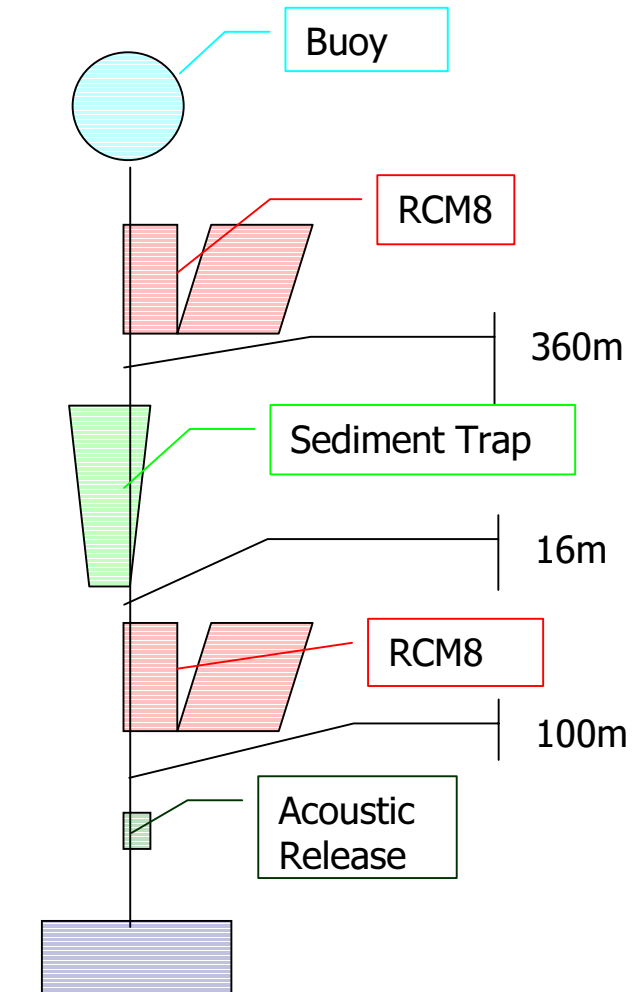
Comparison of 3000 m sites: L_a



Comparison of 3000 m sites: L_c



Sediment Trap



Current metre and sediment trap chain moored in KM4

Sedimentation

Low sedimentation rate was expected.

The Jonian Sea has a low biological activity



**Sedimentation Trap
(Technicap)**



Deep Sea measurements started in Capo Passero (KM4) in August 1999

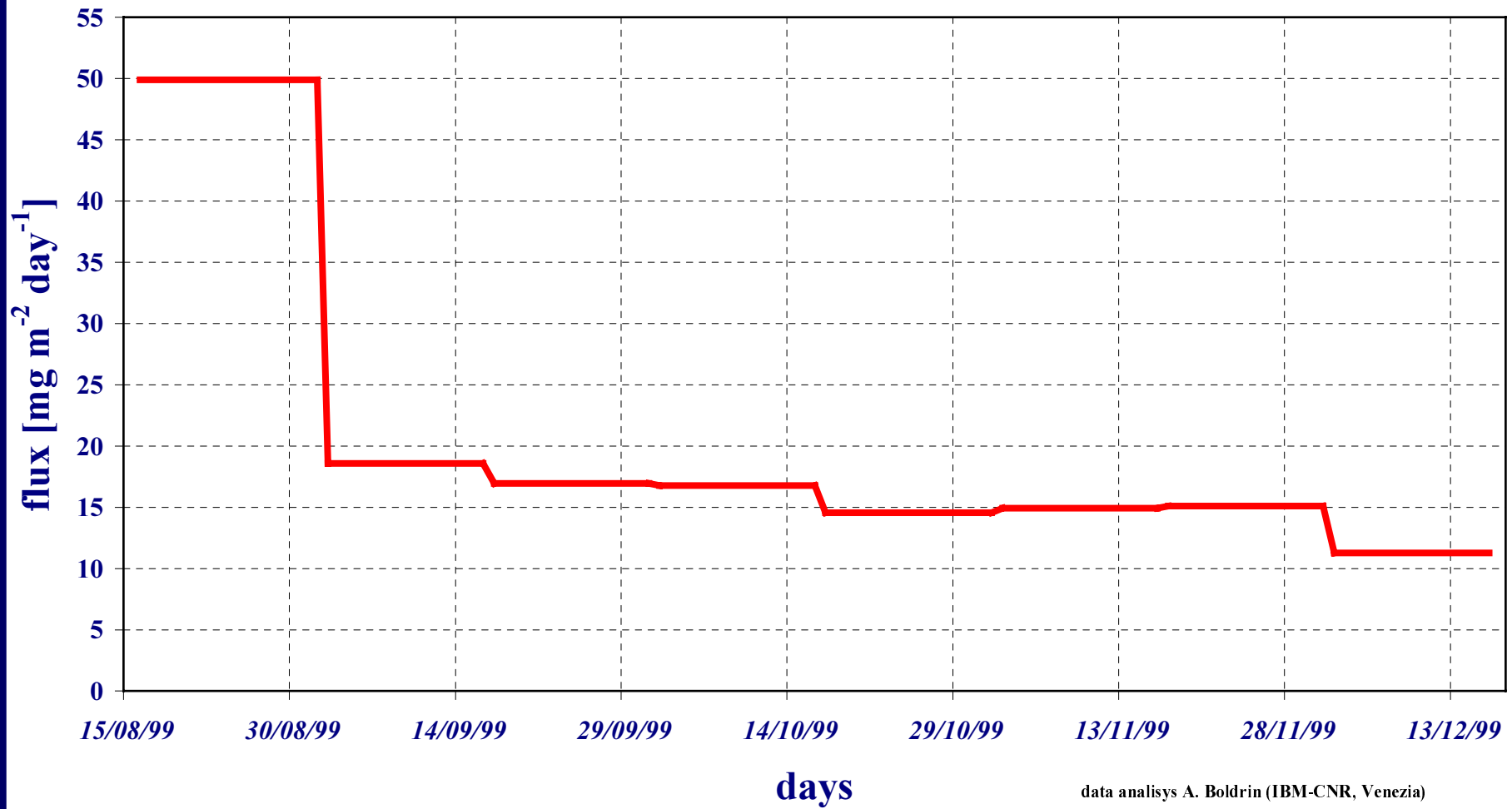
trap moored @ -3210m

Collected data are integrated over a 15 days period.

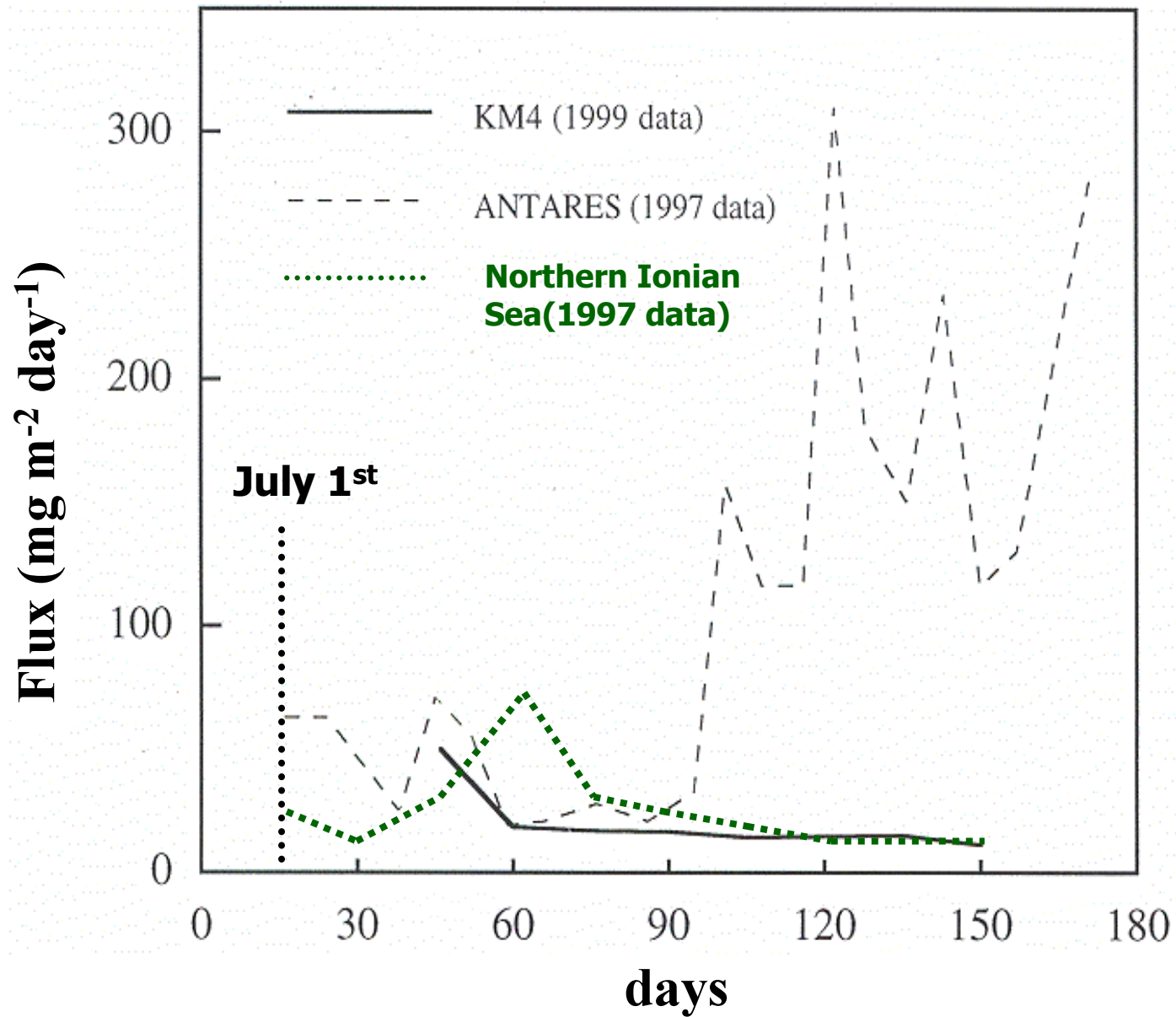
Sediment Trap re-deployed in August 2001, running

Sediments histo

Capo Passero KM4: Sedimentation Rate @ -3210m

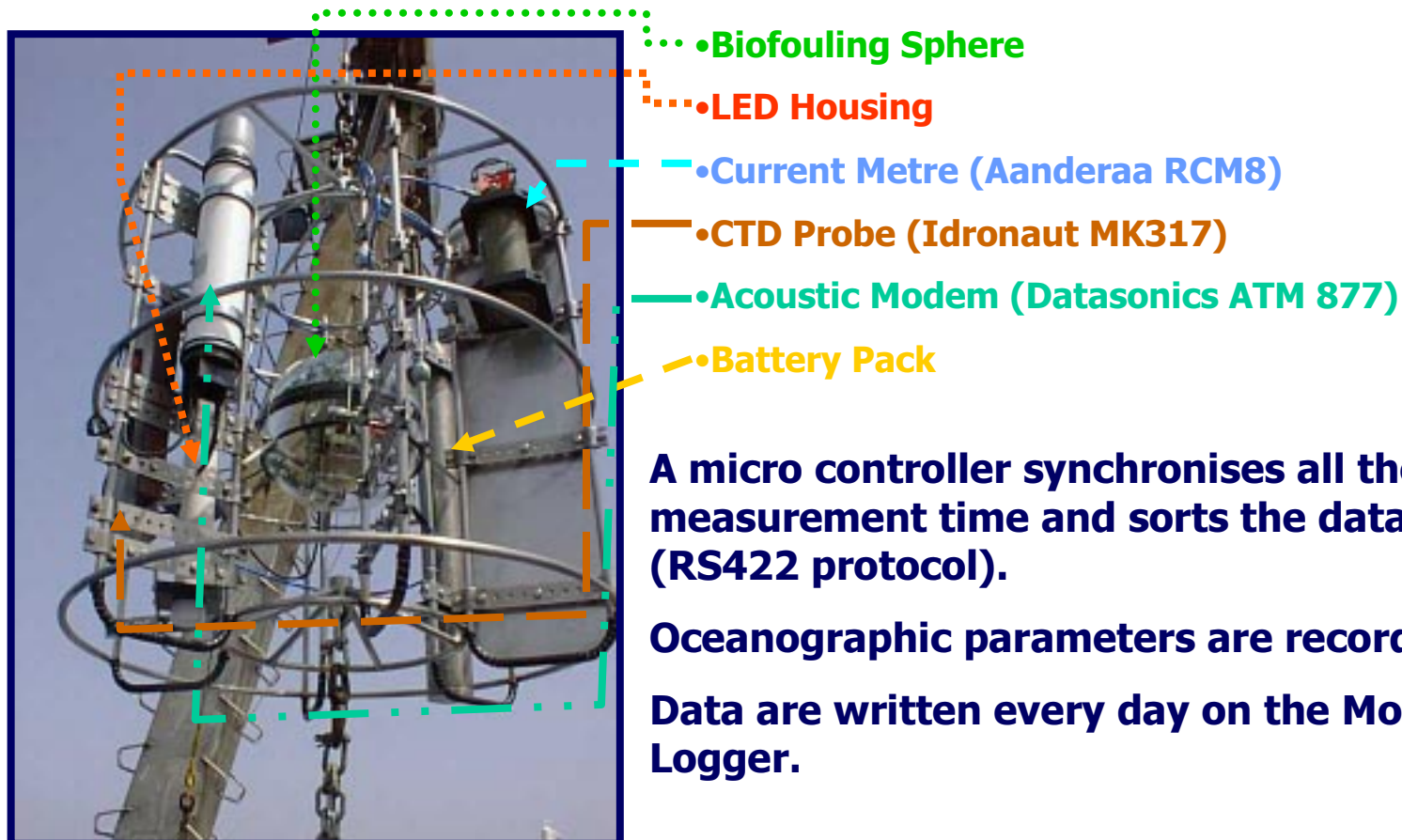


Sediments Comparison



Biofouling Station

Deployed in December 1999 in KM4 site



•Biofouling Sphere

•LED Housing

•Current Metre (Aanderaa RCM8)

•CTD Probe (Idronaut MK317)

•Acoustic Modem (Datasonics ATM 877)

•Battery Pack

A micro controller synchronises all the probes, sets measurement time and sorts the data stream (RS422 protocol).

Oceanographic parameters are recorded every 30'.

Data are written every day on the Modem Data Logger.

The Modem can be interrogated at any time.

Useful for relating Biofouling rate to currents, water salinity and temperature

Biofouling Sphere



- 16 Silicon PIN PhotoDiodes (1 mm²)
- 2 blue LED

1 measurement per day

Photodiodes up positions:

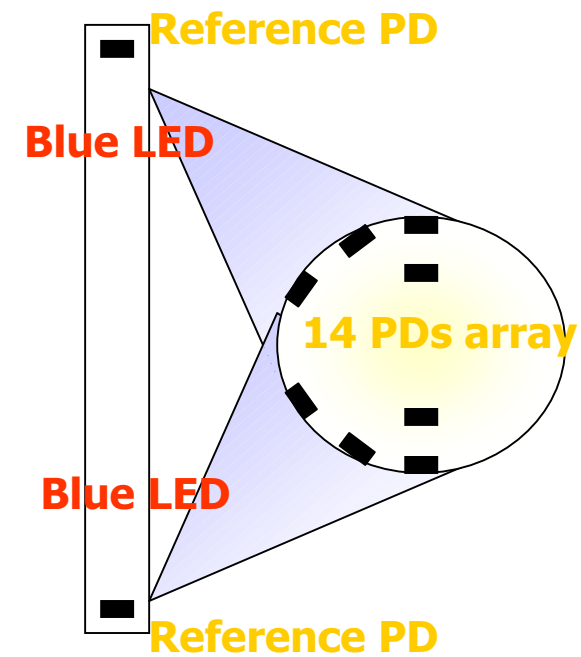
$$\vartheta = 5^{\circ}, 15^{\circ}, 30^{\circ}, 45^{\circ}, 60^{\circ}, 75^{\circ}$$

$$\vartheta, \varphi = 45^{\circ}, 30^{\circ}$$

Photodiodes low positions:

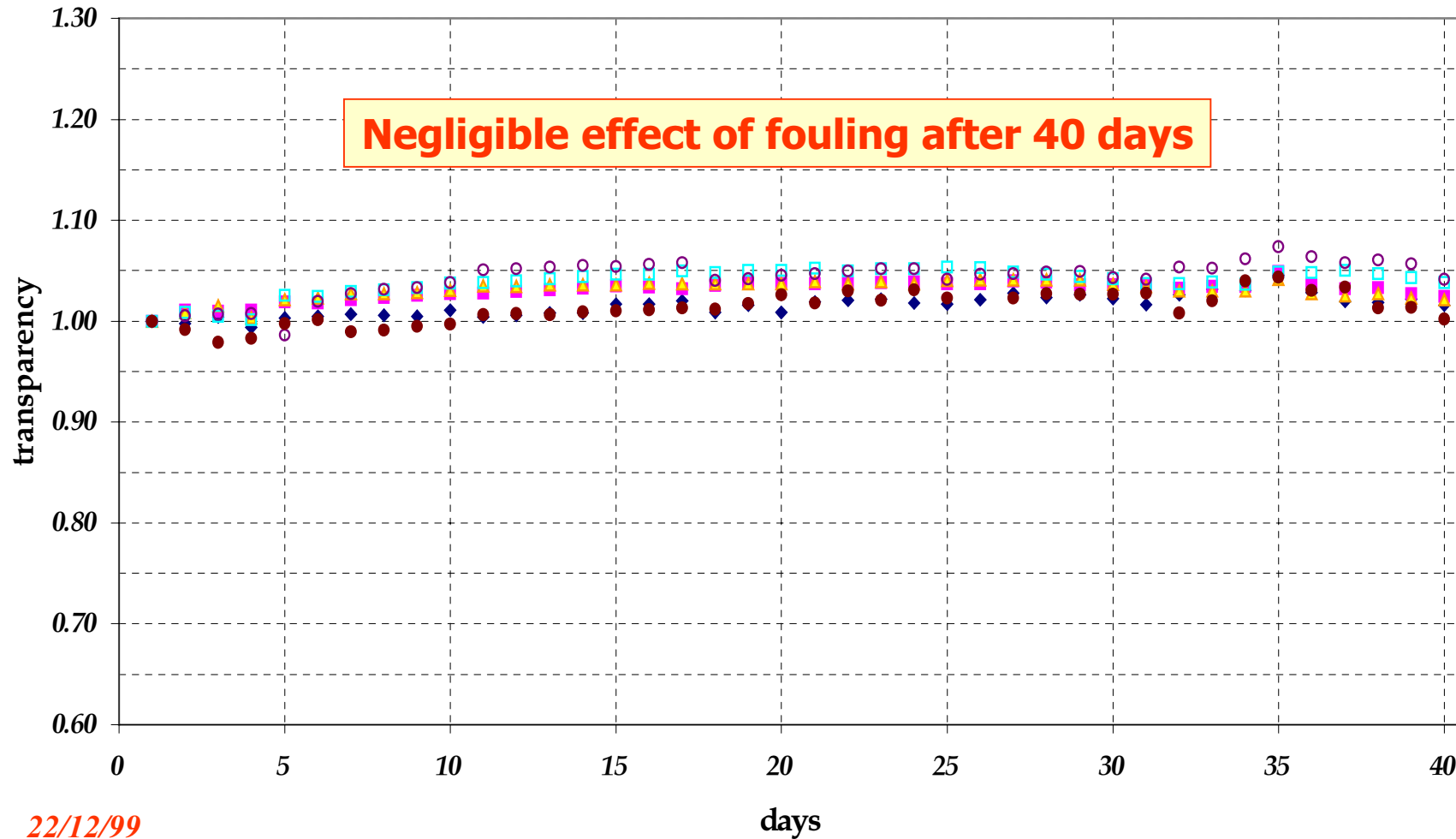
$$\vartheta = 105^{\circ}, 120^{\circ}, 135^{\circ}, 150^{\circ}, 165^{\circ}, 175^{\circ}$$

$$\vartheta, \varphi = 135^{\circ}, -30^{\circ}$$



Biofouling Data 40 days

KM4: Biofouling Data @-3300m

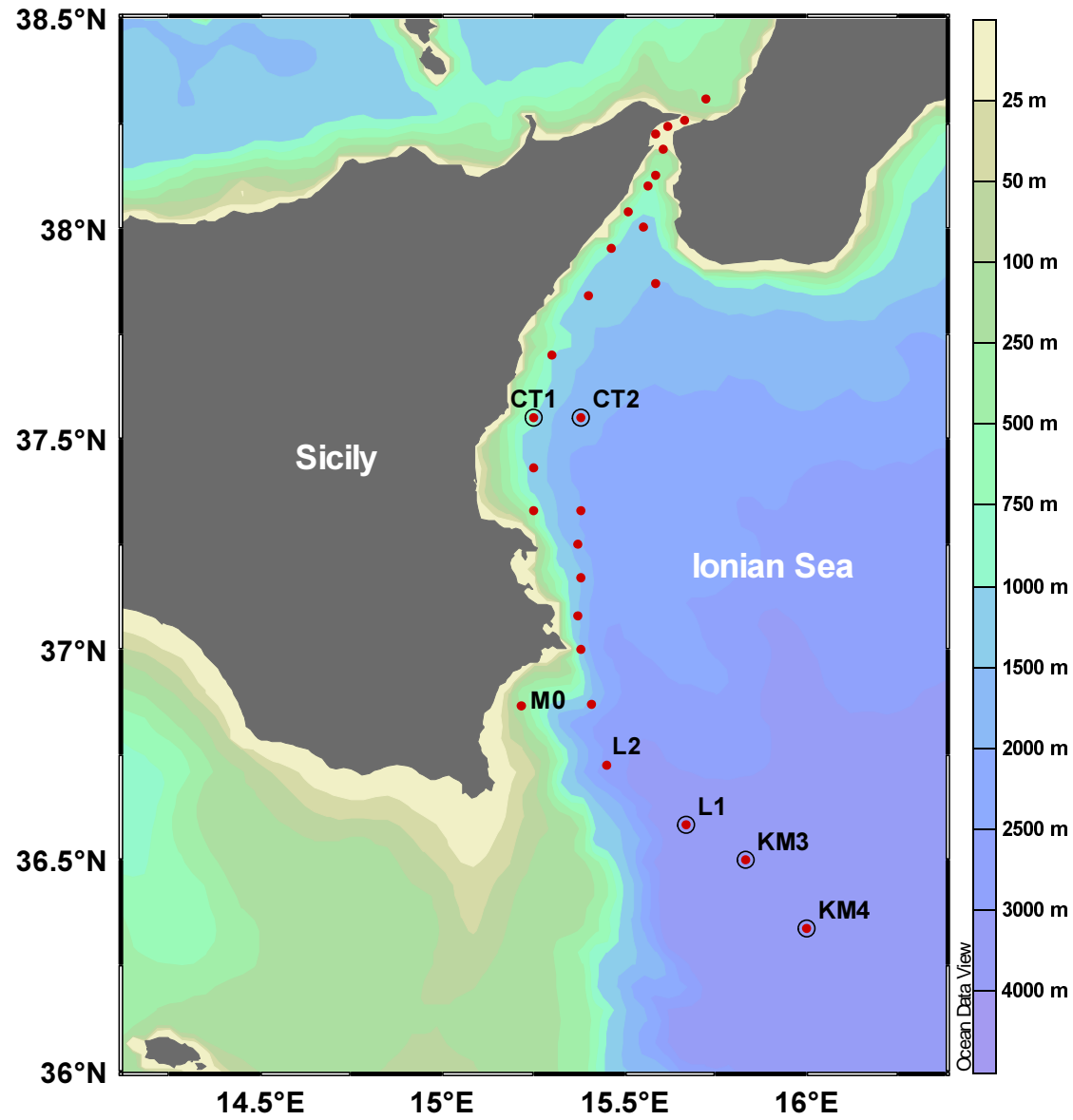


22/12/99

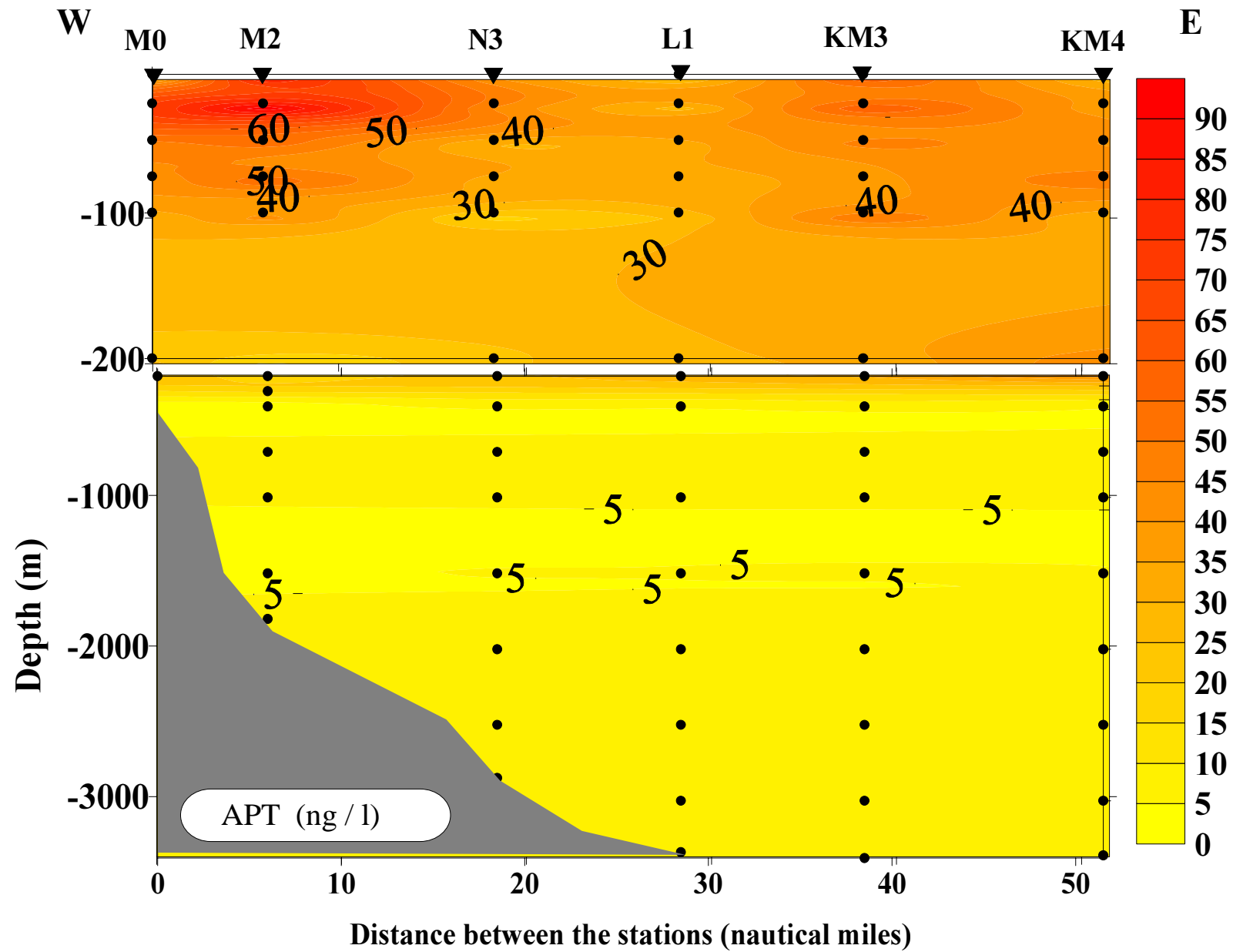
◆ *theta* 75° ■ *theta* 60° ▲ *theta* 45° □ *theta* 30° ○ *theta* 15° ● *theta* 5°

$$\text{Transparency} = \frac{(PD/reference)_t}{(PD/reference)_{\text{day}\#1}}$$

Biological Activity (Fall 1999)

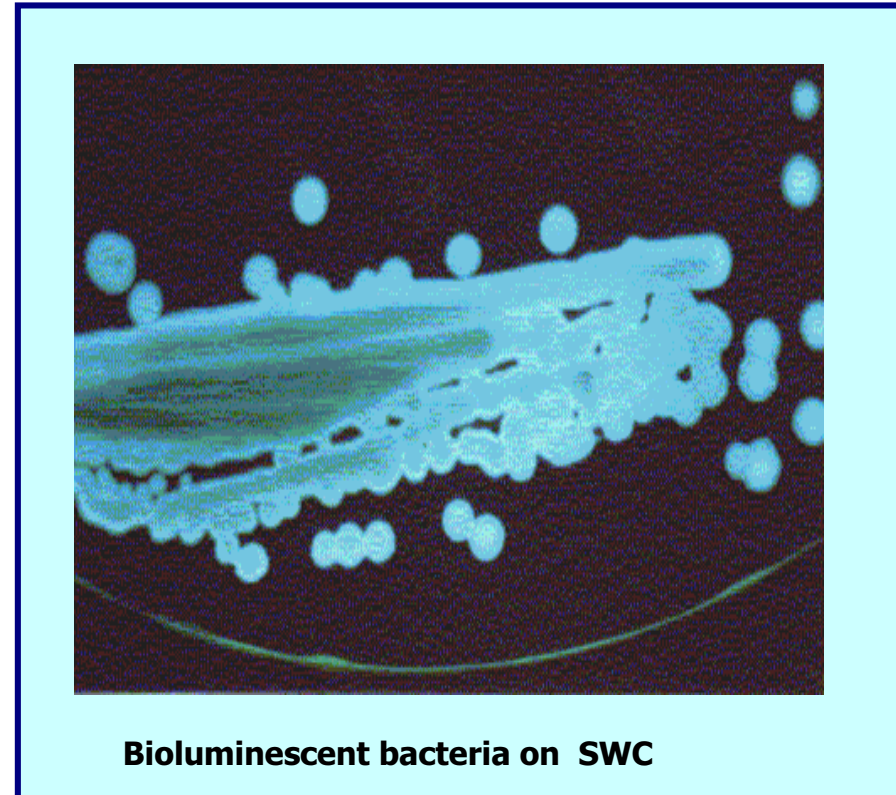
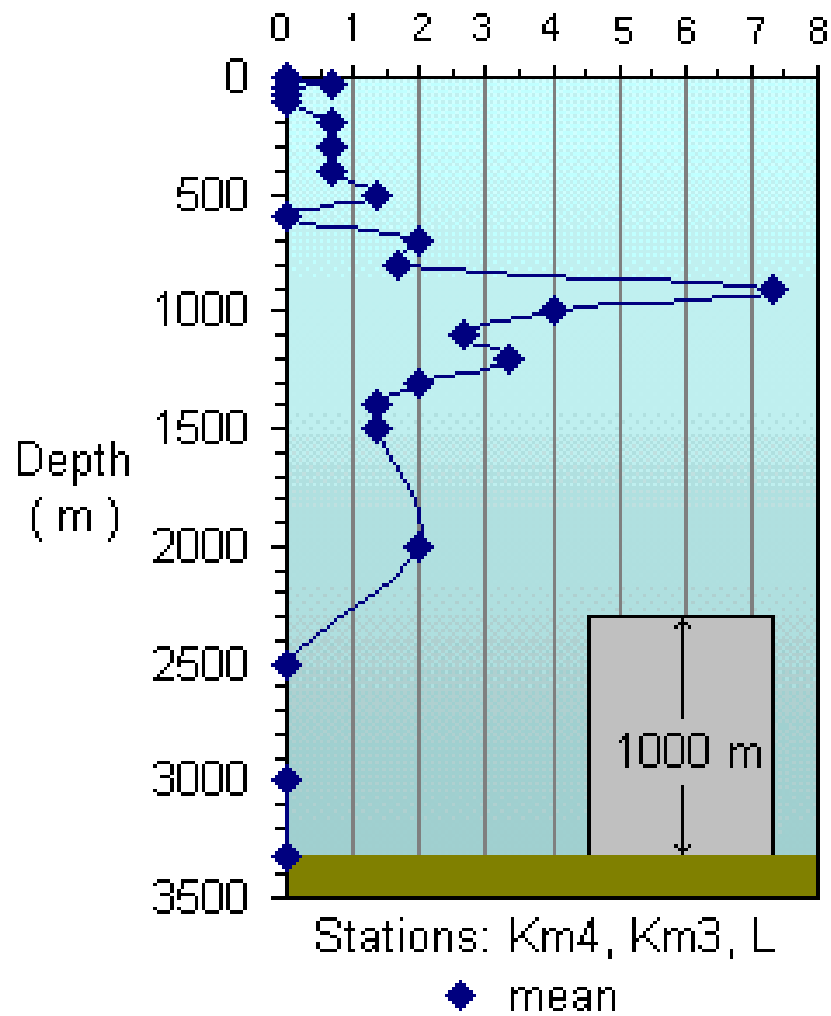


APT

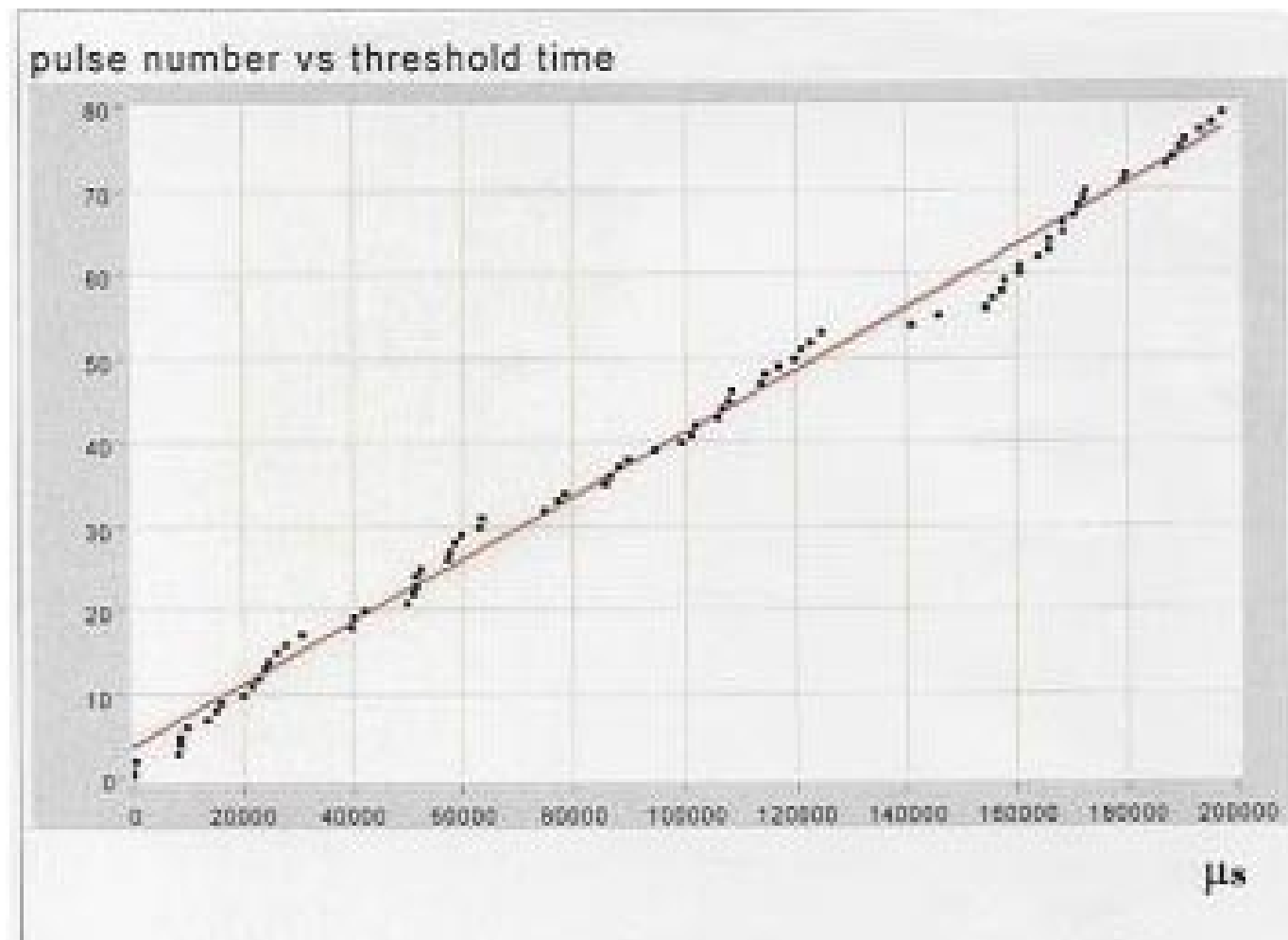


Bioluminescent bacteria

LUMINESCENT CULTIVABLE BACTERIA (CFU 100 ml⁻¹)



Optical Background data



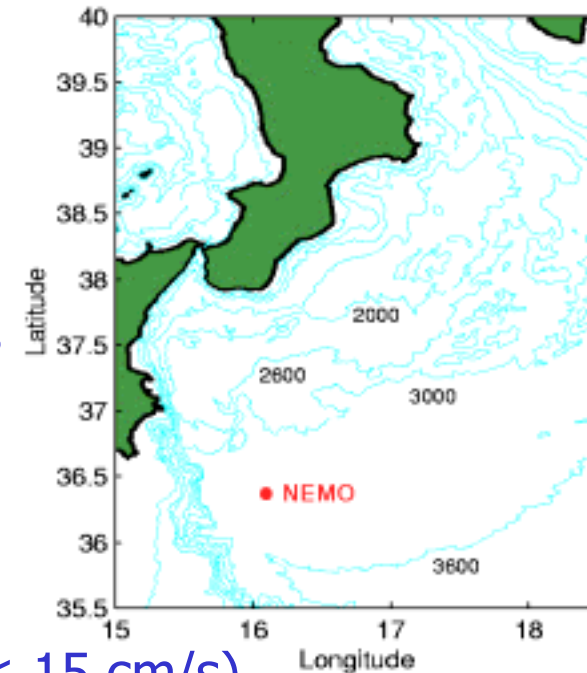
PMT: 2" EMI
Thershold: .16 p.e.
PMT noise: 50 Hz

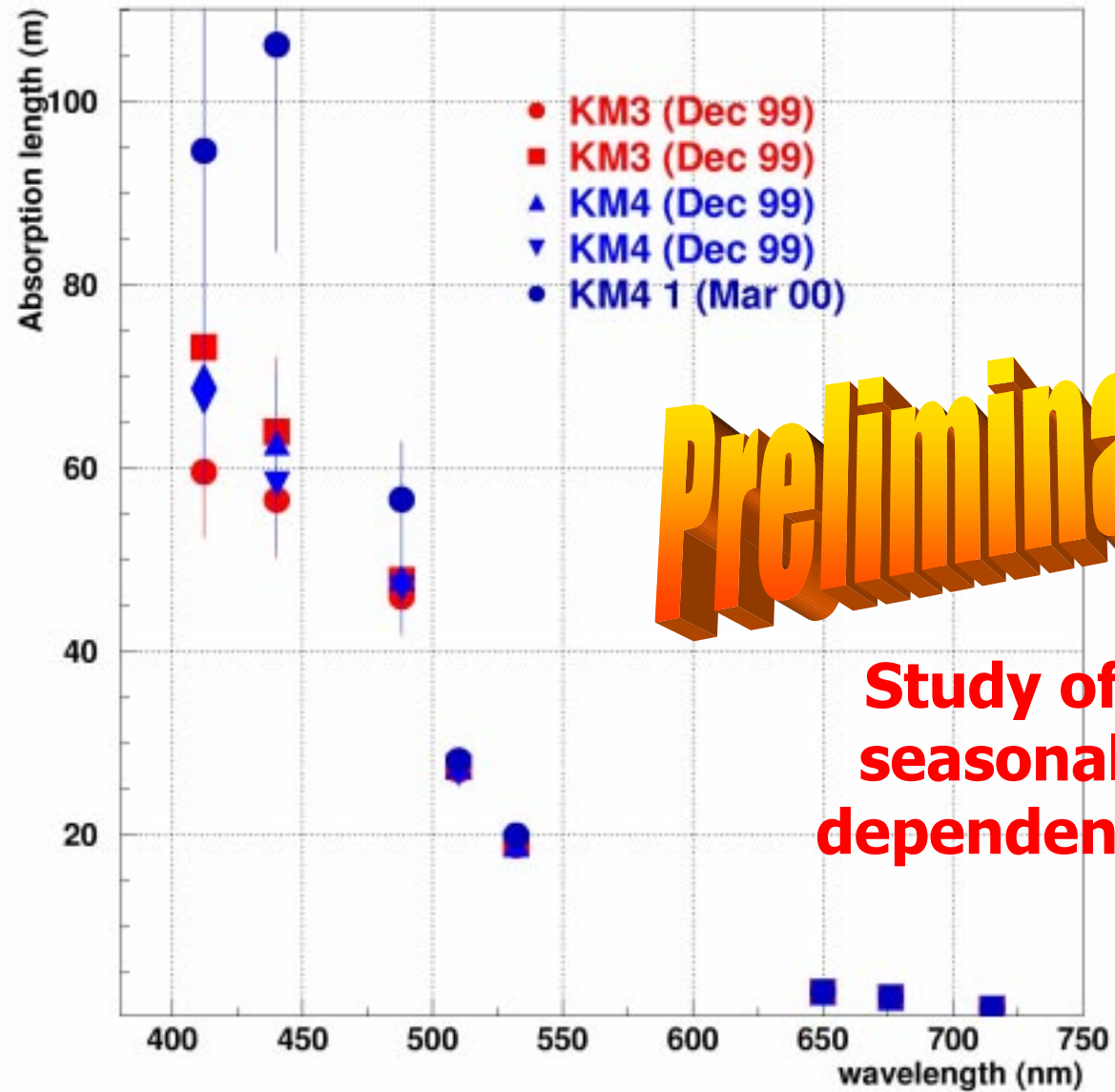
Capo Passero (March 2000) Measured Rate: $\sim 300 \div 350$ Hz

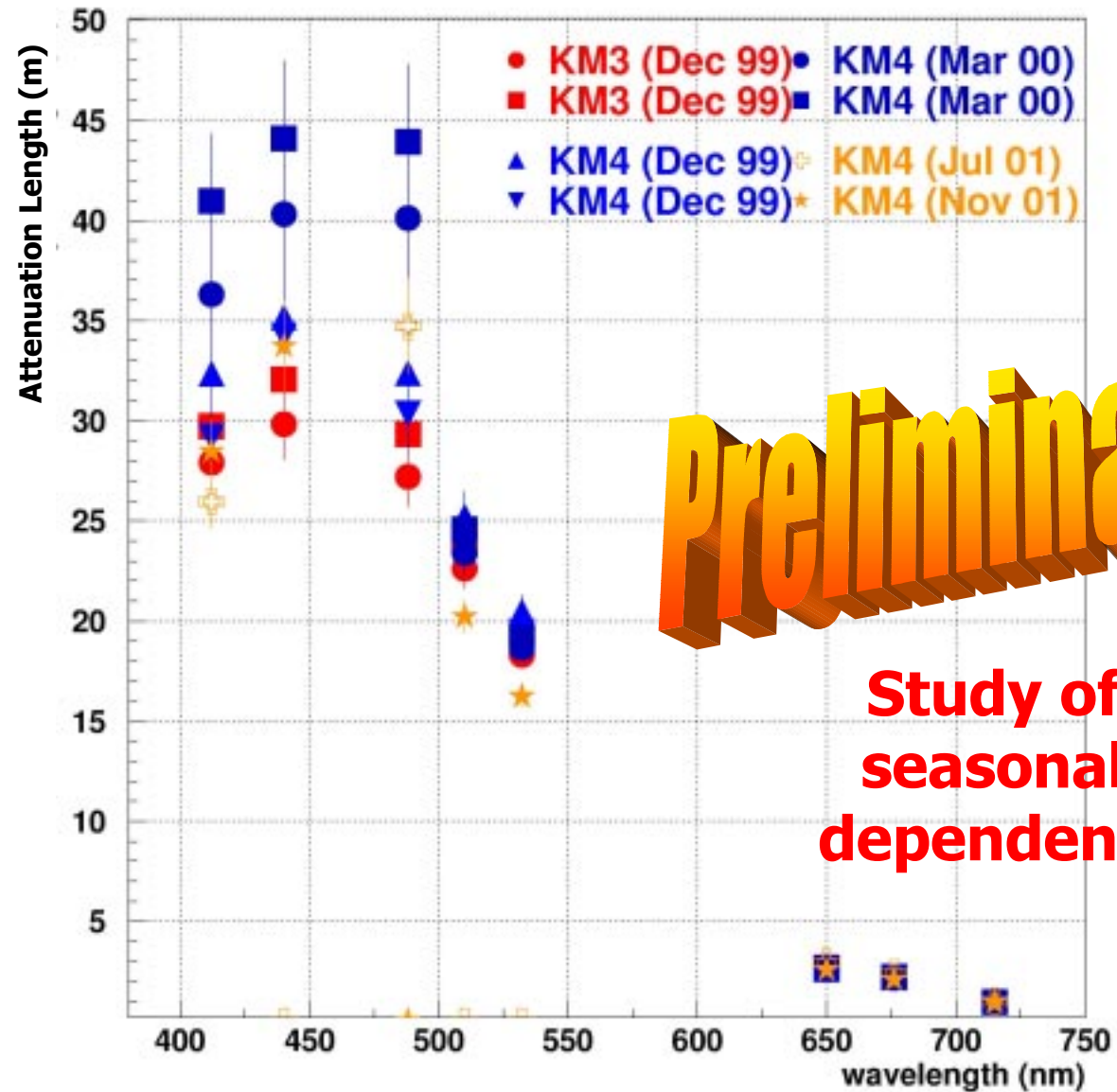
Capo Passero characteristics

distance from the coast ~ 80 km

- distance from shelf break >40 km
- close to ports, international airport, INFN LNS
- depth > 3300 m
- bathymetric profile is flat over 10 km²
- average current Intensity ~ 3 cm/sec (max < 15 cm/s)
- light attenuation length ~ 35 m (42 m in March)
- light absorption length ~ 70 (100 m in March)
- biological activity is low
- measured sedimentation rate and fouling rate are low



Seasonal dependence of L_a 

Seasonal dependence of L_c 

NEMO calendar of activities

August 1998	Capo Passero	currents
October 1998	Ponza	AC9 + CTD
January 1999	Capo Passero	AC9 + CTD + currents
	Matapan	AC9 + CTD
February 1999	Capo Passero	AC9 + CTD + currents
August 1999	Capo Passero	AC9 + CTD + sediments + currents+ bathymetry
	Catania	AC9 + CTD
December 1999	Ustica	AC9 + CTD
	Alicudi	AC9 + CTD
	Capo Passero	AC9 + CTD + currents + sediments + fouling + biology
	Catania	AC9 + CTD
March 2000	Capo Passero	AC9 + CTD + ⁴⁰K
June 2000	Toulon	AC9 + CTD
September 2000	Capo Passero	⁴⁰K + biology
December 2000	Capo Passero	accident to the current metre chain
March 2001	Baikal	AC9 + CTD
July 2001	Capo Passero	AC9 + CTD + DEWAS + currents + sediments
November 2001	Capo Passero	AC9 + CTD + NERONE

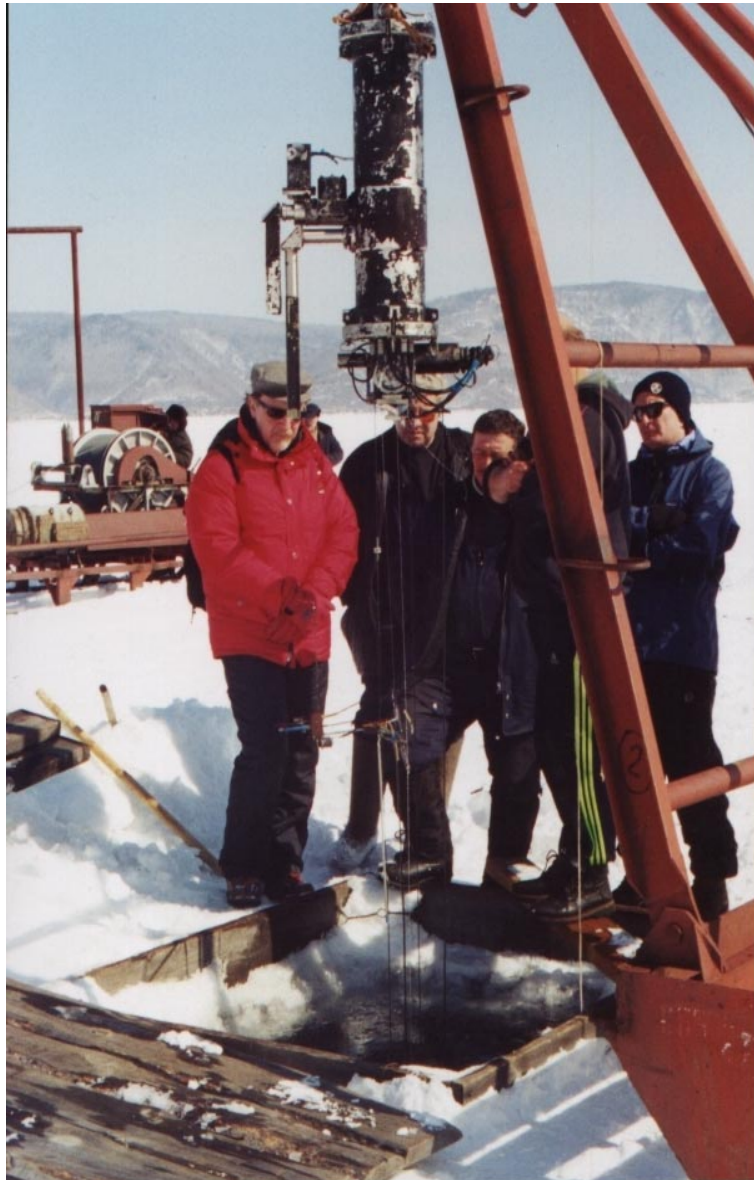
NEMO @ Lake Baikal



March 20-28 2001



Burkhan



19 wavelengths:
UV (291nm) – IR (750nm)

Isotropic source:
 r^{-2} dependence

Variable distance:
Few cm-20m at step 1 m
(no calibration required)

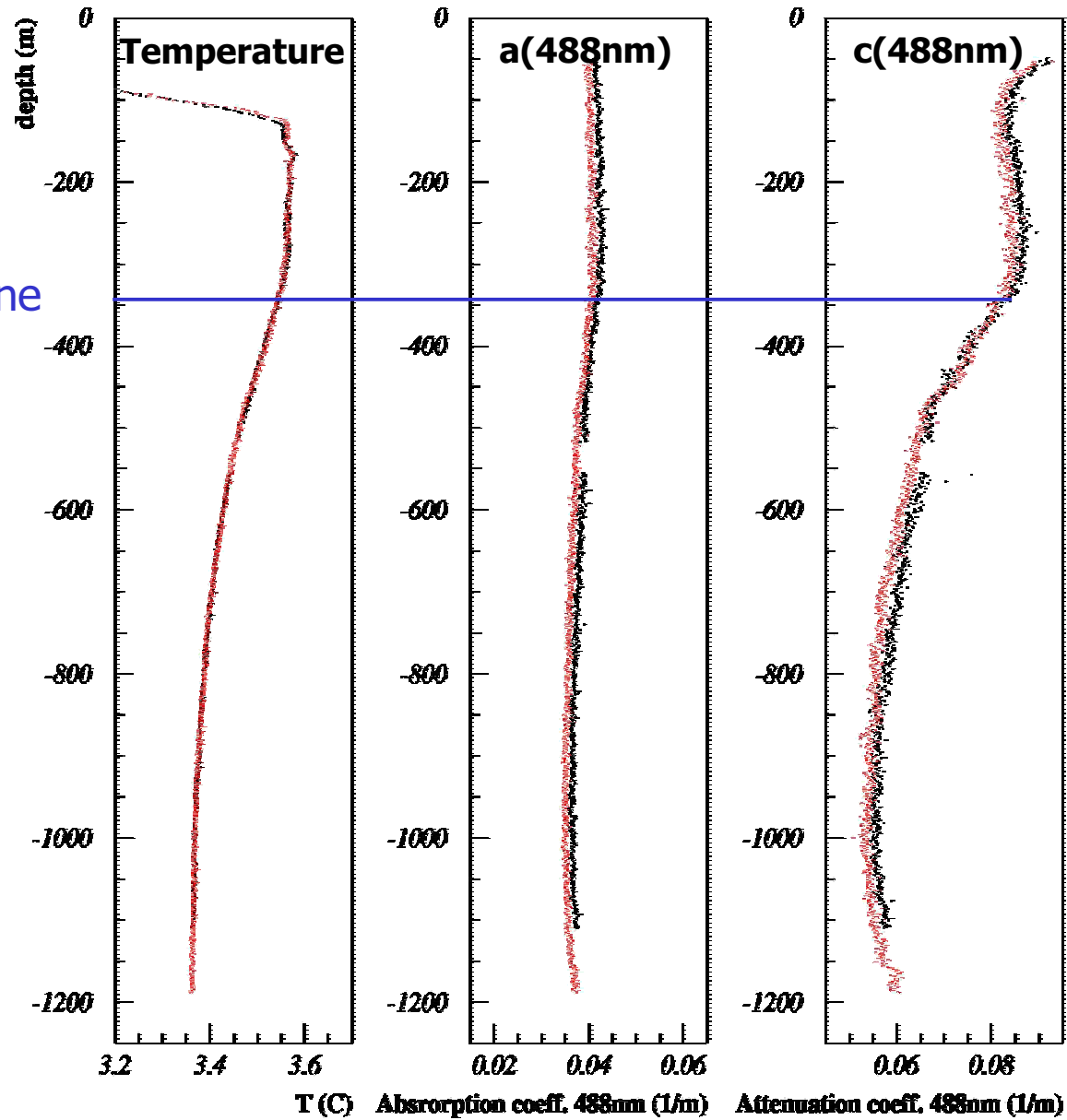
**Strongly dependent on
light source intensity:**
Large errors in IR and UV

**Measurements carried out at
fixed depth**

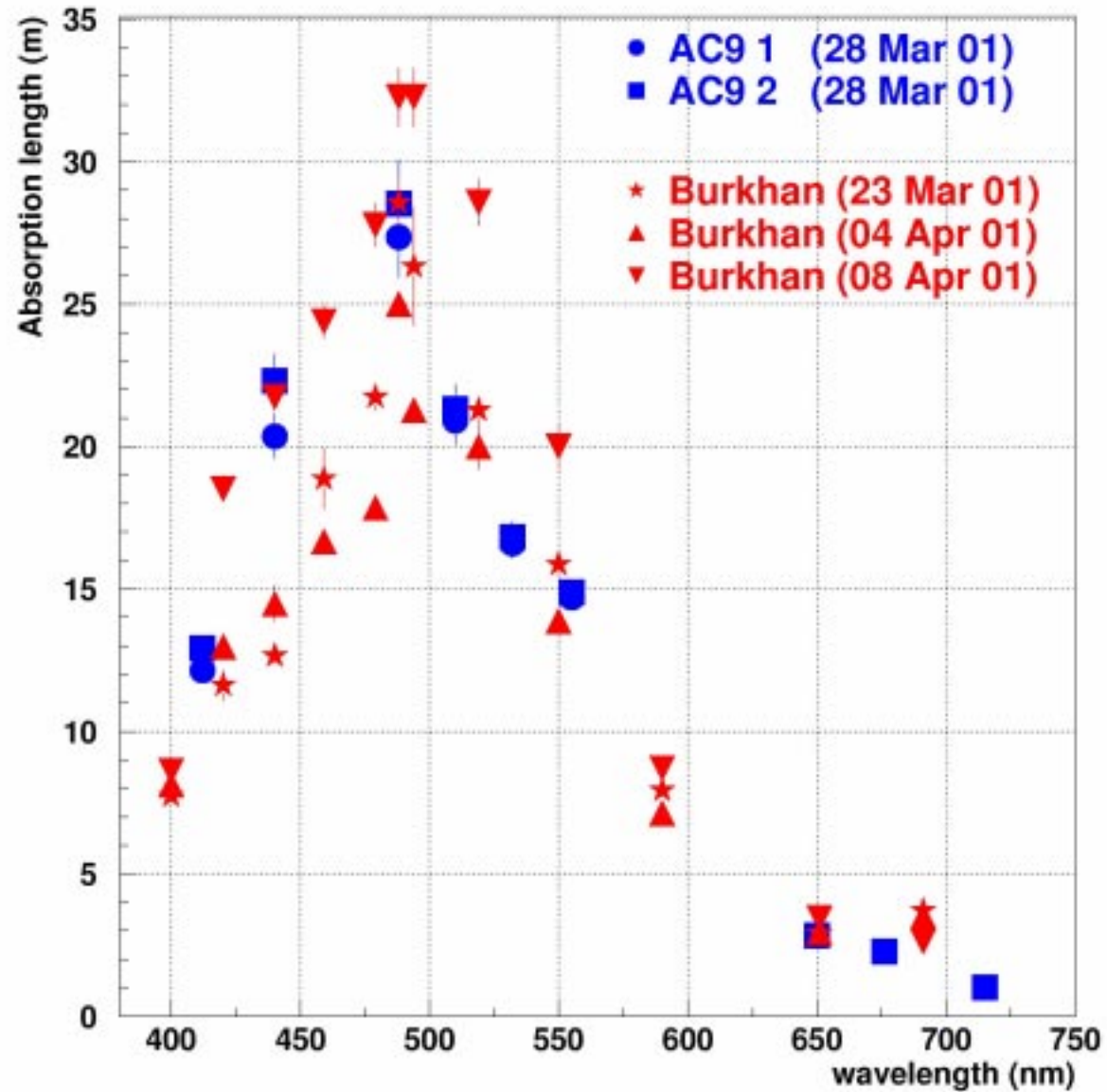
**Absorption and scattering cannot
be measured at the same time**

Baikal: AC9 profiles at $\lambda=488\text{nm}$

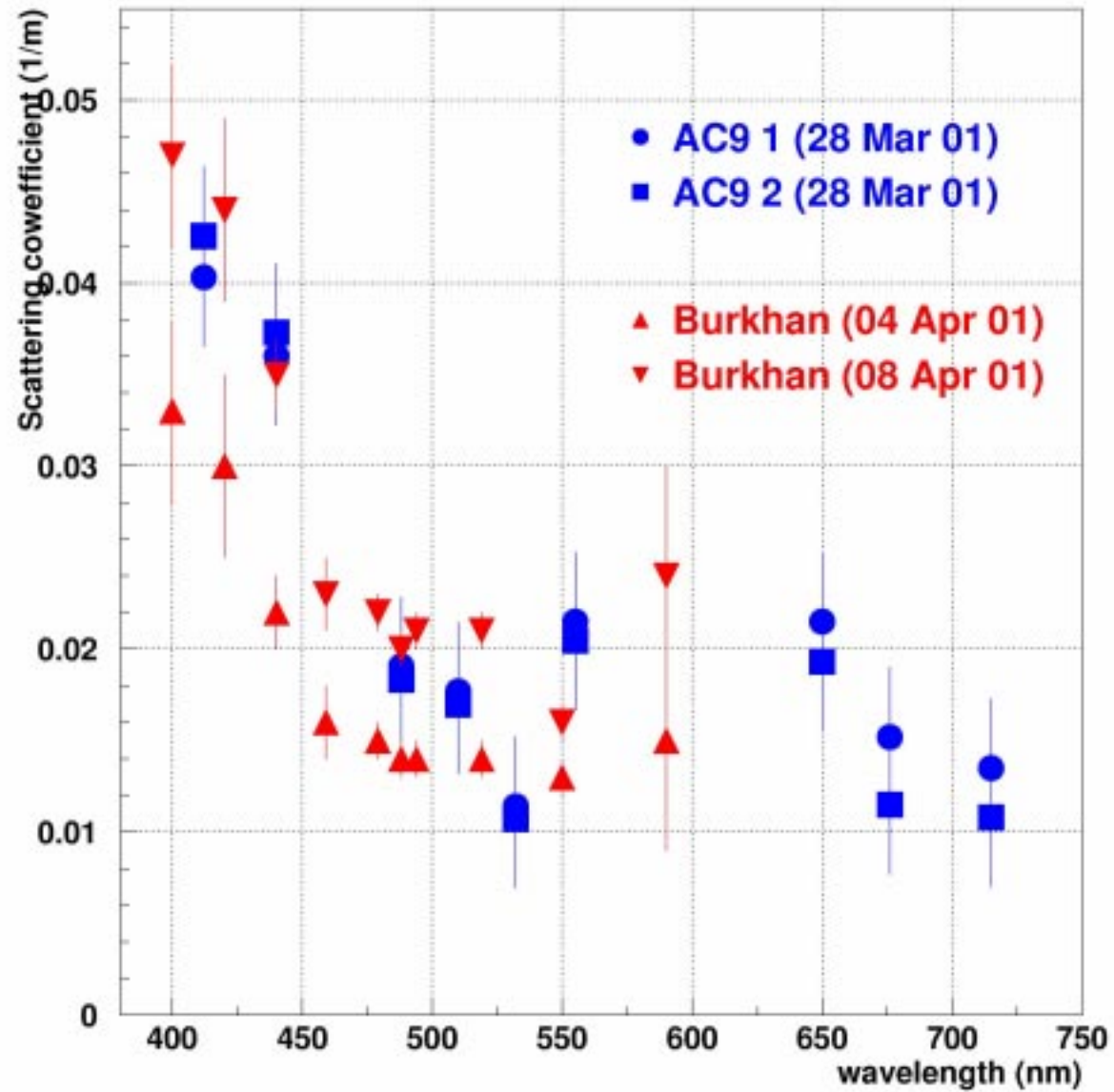
Thermocline



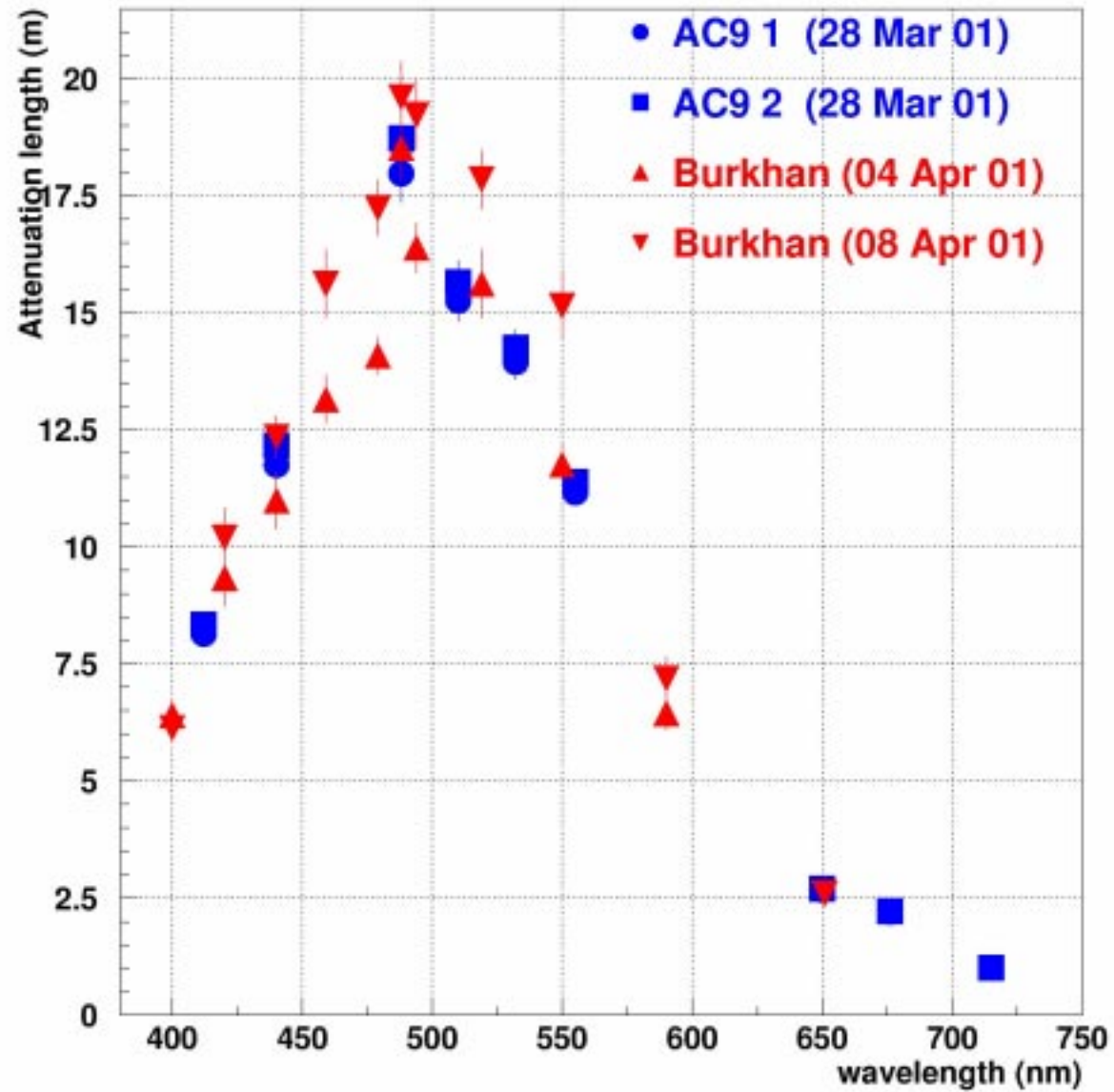
Absorption in Lake Baikal (1000 m)



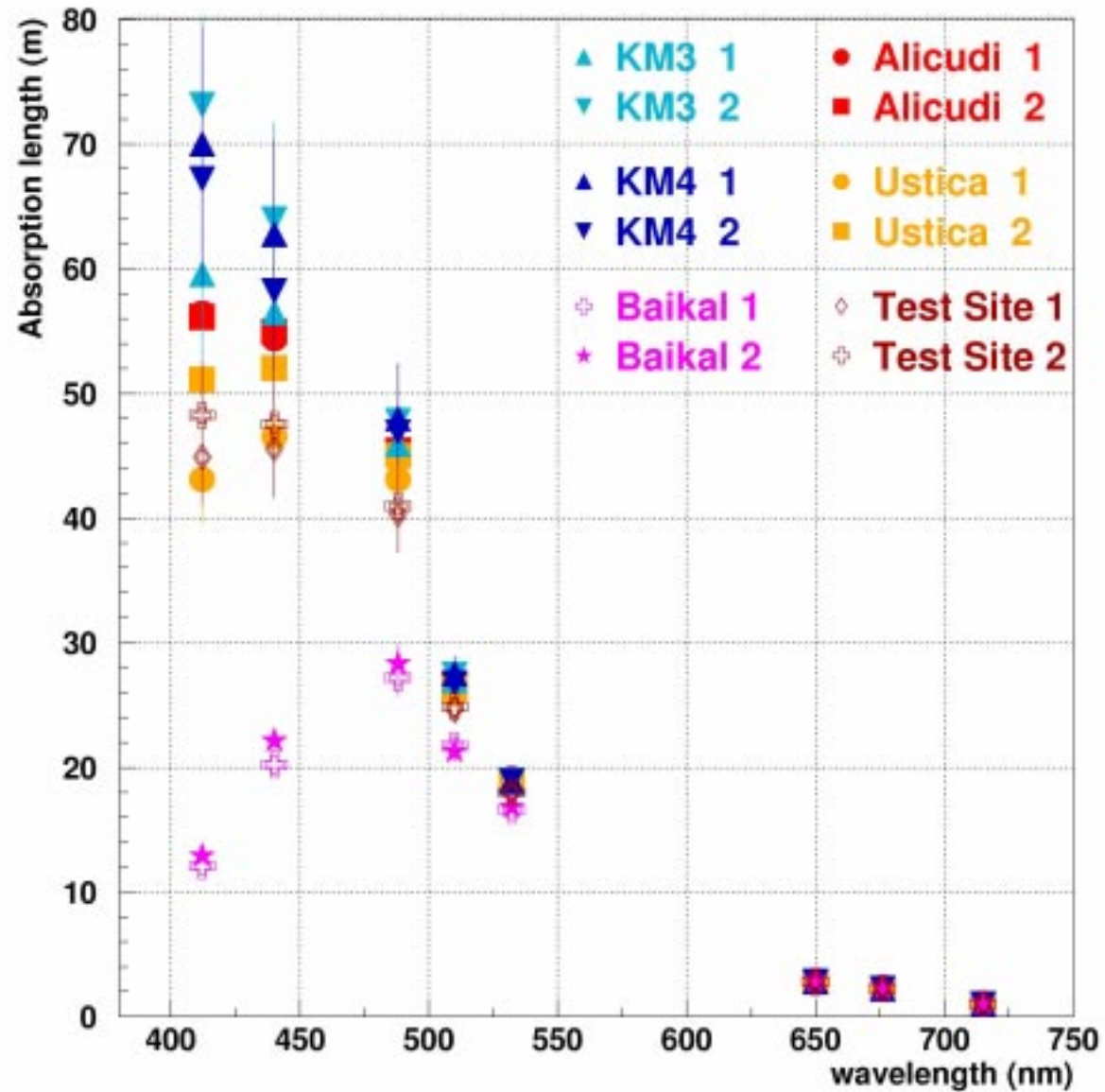
Scattering in Lake Baikal (1000 m)



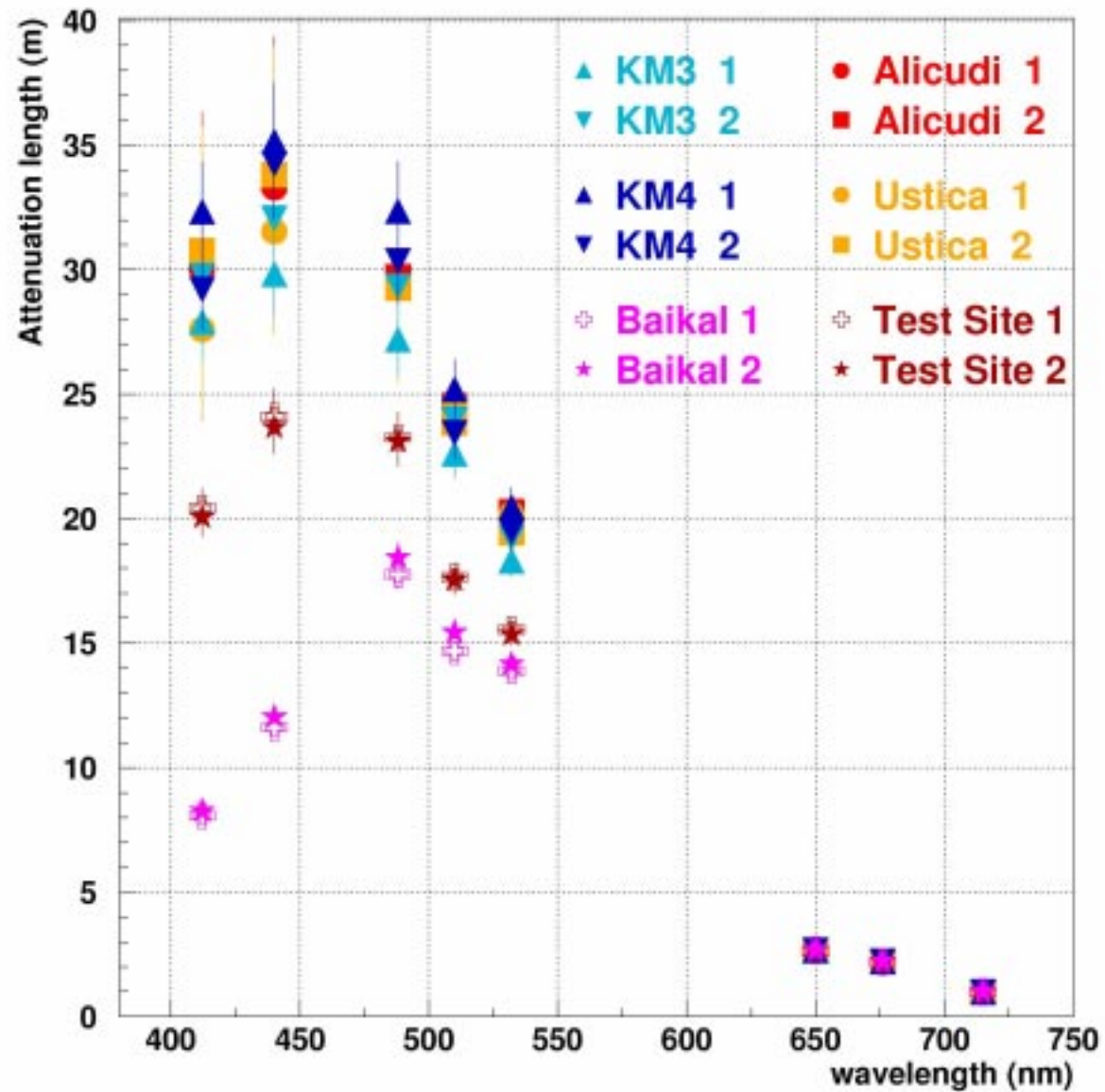
Attenuation Lake Baikal (1000 m)



Summary of L_a measurements NEMO & Baikal sites



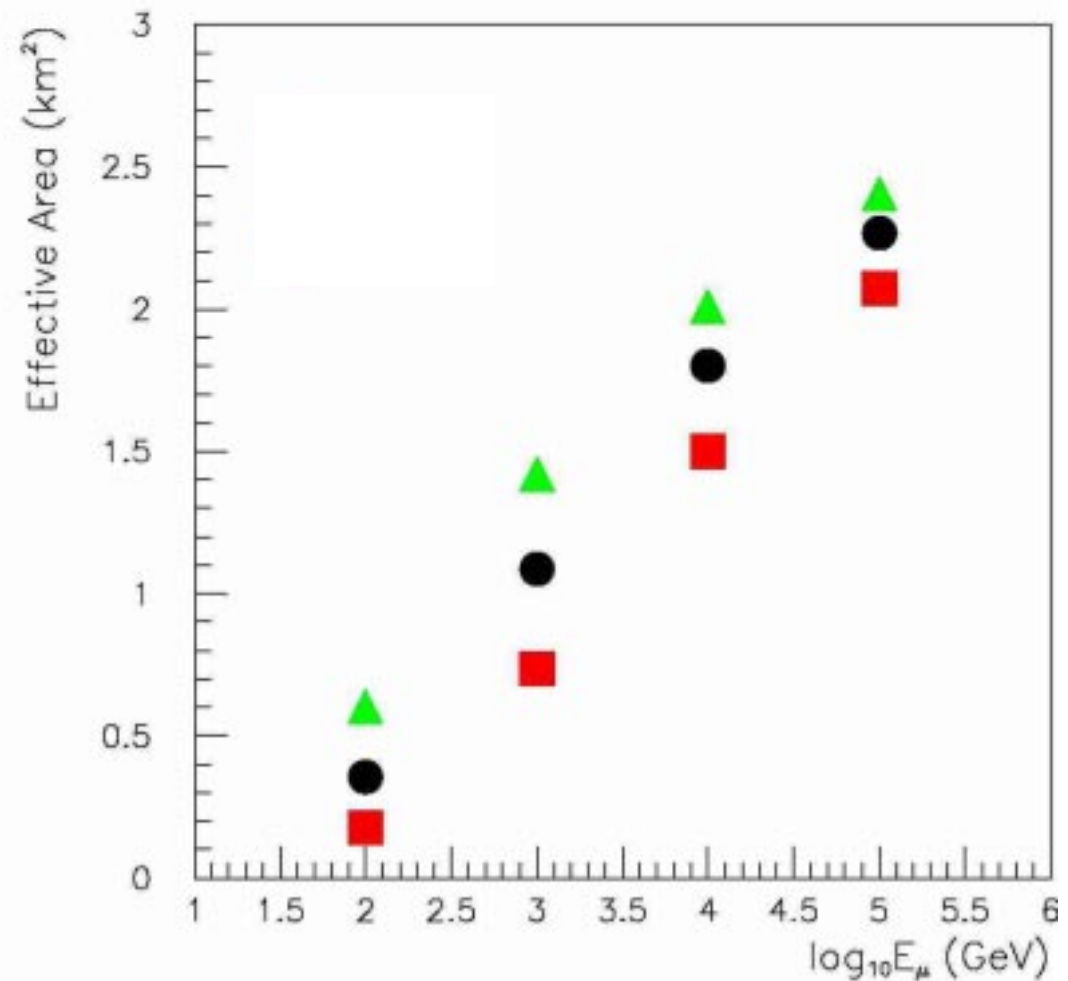
Summary of L_c measurements NEMO & Baikal sites



Effective Area vs optical properties

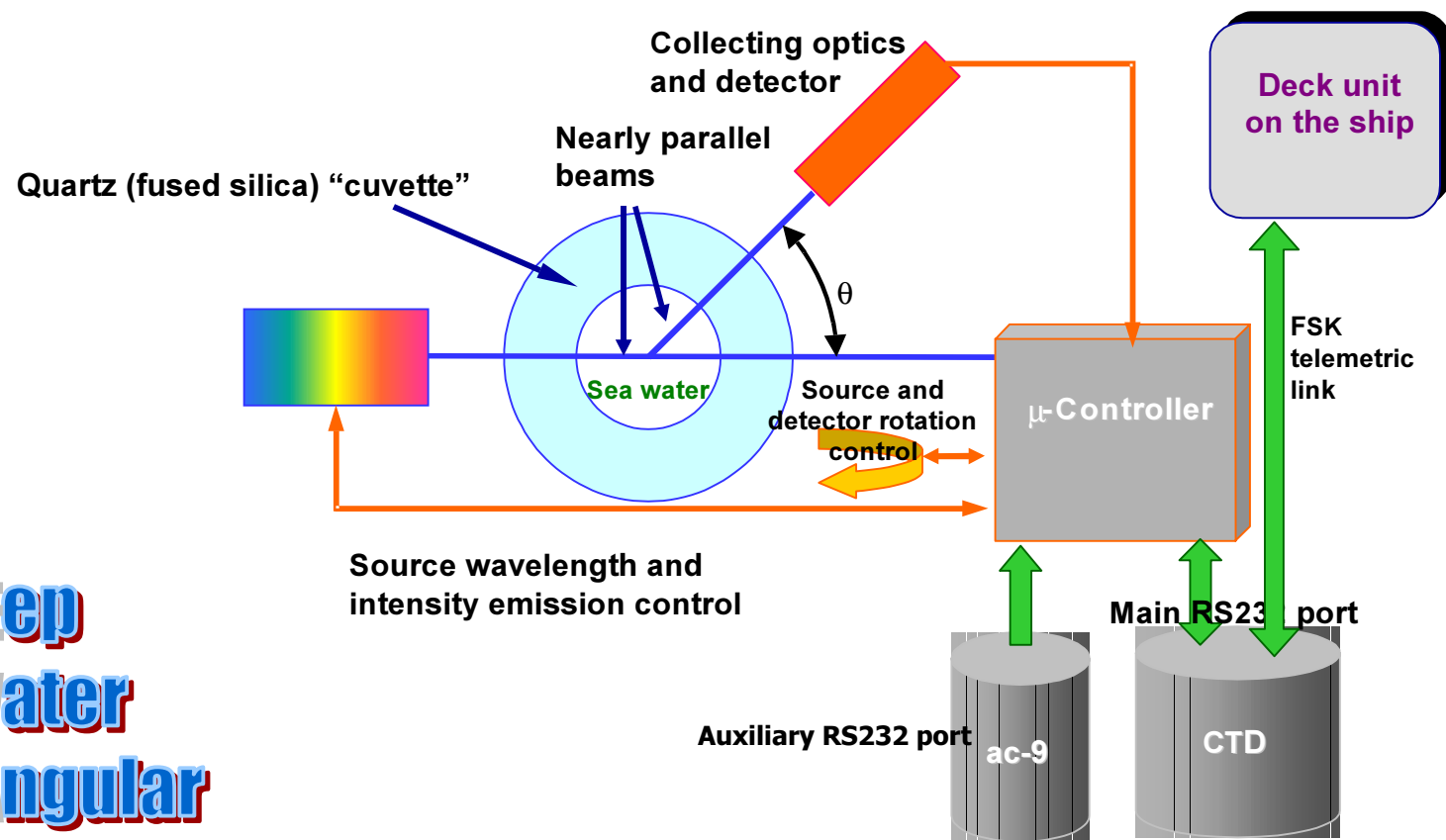
$H=600$ m, $N_{\text{strings}}=64$, $N_{\text{OM}}=4096$

- $d_z=40$ m, $d_{xy}=200$ m, $L_a=40$ m
- $d_z=40$ m, $d_{xy}=200$ m, $L_a=55$ m
- ▲ $d_z=40$ m, $d_{xy}=200$ m, $L_a=75$ m



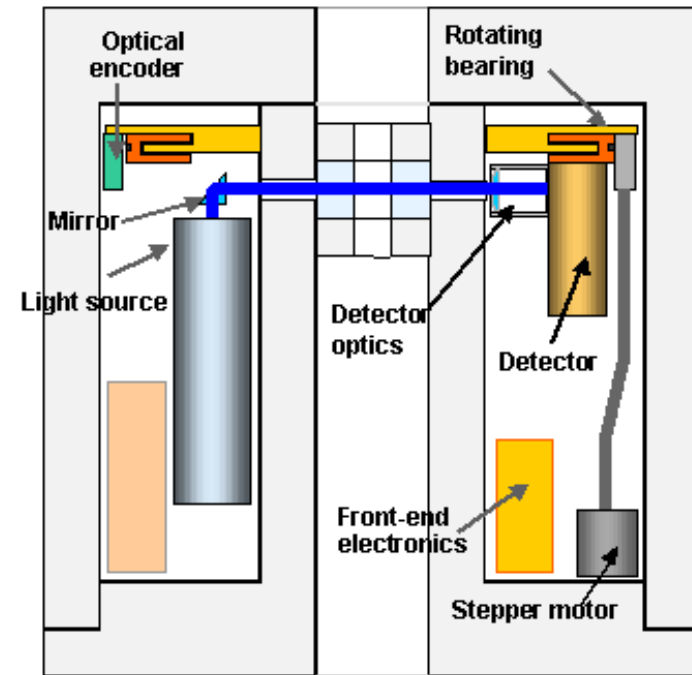
DEWAS

In situ Measurement of the Volume Scattering Function



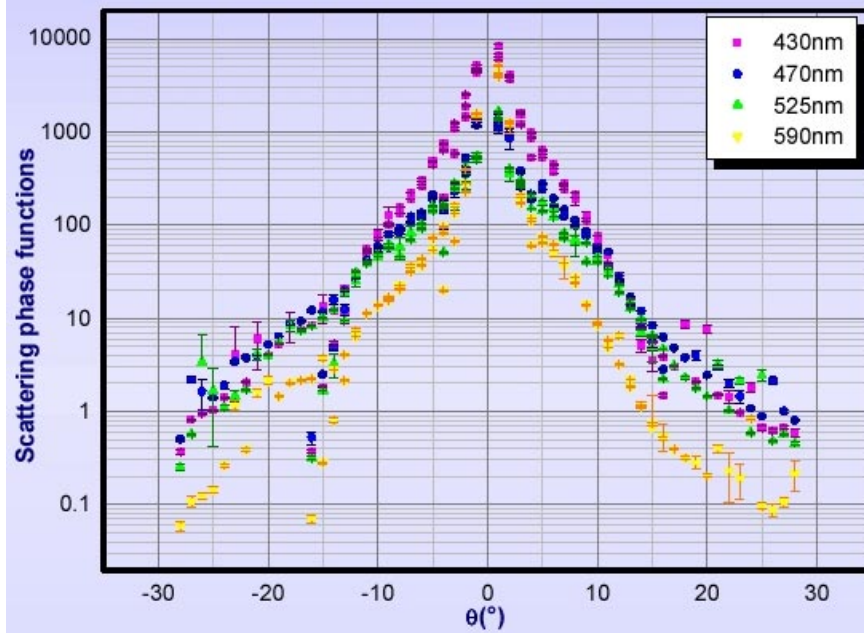
DEEP
Water
Angular
Scatter Meter

DEWAS Structure

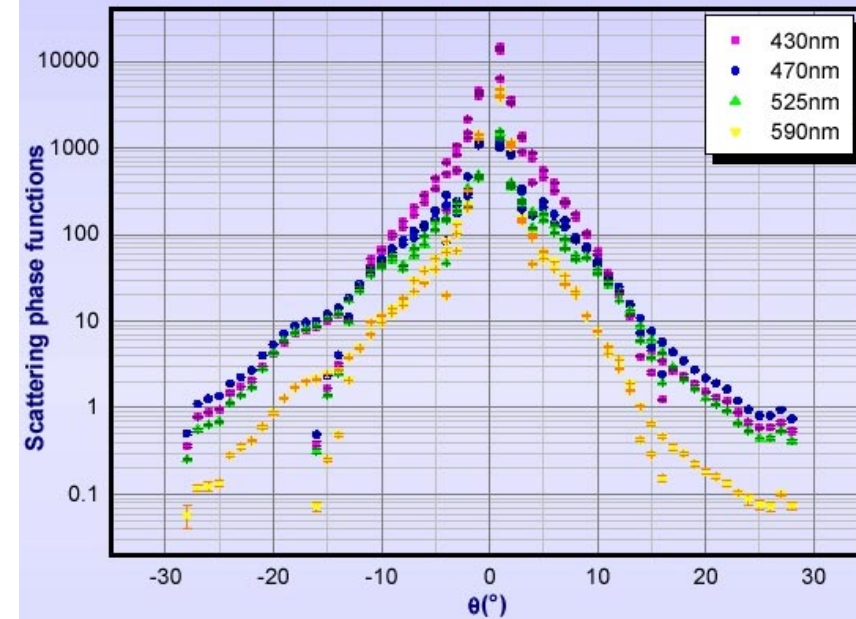


DEWAS Preliminary

27/07/01 Test Site 1600m - forward angles



26/07/01 KM4 3000m - forward angles

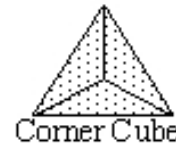


NERONE

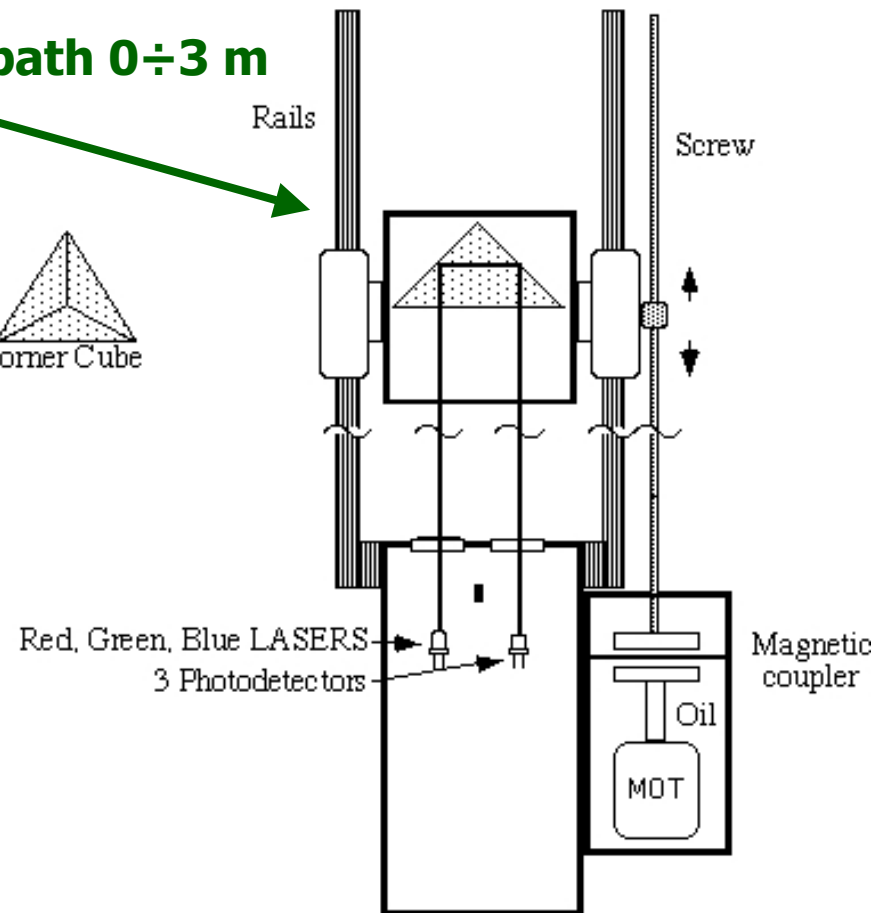
Attenuation meter for red-blue-green light



Variable optical path 0÷3 m



NERONE schematic



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